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High Energy Resolution MachinES I

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Proposal for

The Construction of a

HIGH RESOLUTION CRYSTAL BACKSCATTERING SPECTROMETER

HERMES I

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Executive Summary

There is a need in the United States for a state-of-the-art, cold-neutron, crystal backscattering spectrometer (CBS) designed to investigate the structure and dynamics of condensed matter systems by the simultaneous utilization of long wavelength elastic diffraction and high-energy-resolution inelastic scattering. Cold neutron spectroscopy with CBS-type instruments has already made many important contributions to the study of atomic and molecular diffusion in biomaterials, polymers, semiconductors, liquid crystals, superionic conductors and the like. Such instruments have also been invaluable for ultra high resolution investigations of the low-lying quantum tunneling processes that provide direct insight into the dynamical response of solids at the lowest energies. Until relatively recently, however, all such instruments were located at steady-state reactors. This proposal describes HERMES I (High Energy Resolution Machines I) a CBS intended for installation at the LANSCE pulsed neutron facility of Los Alamos National Laboratory

The need for such an instrument was originally demonstrated by the success of the IRIS CBS at the ISIS pulsed neutron facility of the Rutherford Appleton Laboratory which made it clear that pulsed neutron and steady-state sources are equally effective for cold neutron spectroscopy. Intended originally as a quasielastic spectrometer for the study of diffusional motions, IRIS has had a major impact on the field of low energy inelastic spectroscopy as well by combining high resolution with a wide-enough energy transfer range to permit access to very-low-lying excitations in ground-state systems. (This Q,ω range is not accessible in equivalent, direct-geometry instruments because the energy transfer range is coupled to the incident neutron energy.) In fact so heavy is the demand for IRIS (it is currently oversubscribed by more than a factor of five) that only a few days per year are available to investigate new possible applications.

Including a white beam diffraction detector in a CBS adds to such instruments the capability of simultaneous diffraction and inelastic spectroscopy, thus - as recently demonstrated by experiments on IRIS - further enhancing their utility. And because IRIS-type instruments use neutrons with wavelengths as long as 25 Å, they have the attractive feature of extending the range of diffraction studies to long range magnetic periodicities and other types of large-scale structural ordering.

As explained in detail in the main text, we propose to construct an updated, high-performance CBS which incorporates neutron techniques developed during the decade since IRIS was built, i.e. improved supermirror technology, a larger area crystal analyzer and high efficiency wire gas detectors. The instrument is designed in such a way as to be readily adaptable to future upgrades. HERMES I, we believe, will substantially expand the range and flexibility of neutron investigations in the United States and open new and potentially fruitful directions for condensed matter exploration. This document describes a implementation plan with a direct cost range between $4.5 to 5.6 M and scheduled duration of 39-45 months for identified alternatives.

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1. Spectrometer Development Overview

1.1 Motivation

Crystal Backscattering Spectrometers (CBS) employing time-of-flight (TOF) methods are ideally suited for use at a neutron spallation source because of their simplicity of design, ease of operation and broad range of scientific applications. We propose to construct a CBS at LANSCE similar in concept to the IRIS spectrometer at the ISIS facility of the Rutherford Appleton Laboratory (RAL) in England. This proposed CBS-time-of-flight instrument, which we will hereafter refer to as HERMES I (for High Energy Resolution MachinES I), is expected to become the cornerstone of a broadly based scientific program that will include investigations of topics in biology, chemistry, geology, materials science and physics.

Our proposal is organized in the following way. We begin by summarizing the general classes of scientific problems that can be investigated with the proposed spectrometer. Then in the following sections we address the overall design and layout of the instrument and give a breakdown of the costs and a time schedule for the project.

It is important at the outset to make a number of points. First, the scientific demand for backscattering spectrometers is extremely high. Second, despite initial concerns that backscattering spectrometers at spallation sources would fail to perform as well as their reactor-based counterparts, it is now well established that count rates on IRIS are comparable to those on equivalent steady-state instruments, for example, IN5 at the Institut Laue-Langevin (ILL) (we note that requests for beam time at the IRIS spectrometer at the RAL typically exceed the time available by a factor of five, just as they do at the IN5, IN10 and IN16 spectrometers at the ILL). Third, an internal report prepared by a panel of neutron spectroscopists assembled at Los Alamos to consider what type of high resolution spectrometer would be most appropriate for construction at LANSCE recommends that a CBS be the "first high resolution instrument built at LANSCE." Fourth, no instrument of this type currently exists in the U. S. Fifth, HERMES I would complement the Chopper-based IN5-like multi-rotor chopper spectrometer and the IN10-like backscattering spectrometer at NIST, as well as the existing PHAROS chopper spectrometer at LANSCE, by providing access to the energy transfer range below 10 meV with an energy resolution in the 15μeV range and below. And finally, we note that PHAROS and IN5, being direct geometry spectrometers, cannot reach such energy transfers in the neutron energy loss part of the spectrum without increasing the incident energy and thus significantly degrading their resolution

1.1.1 Scientific Case

A CBS can address a broad range of scientific applications. We visualize it being used for many different fields of investigation such as the study of diffusion of hydrogen in metals and alloys, crystal-field excitations, self diffusion processes (in metals, intercalation compounds, mesoporous materials, liquid crystals, solutions and superionic conductors), reorientational motions and tunneling motions in molecular solids, atomic and molecular motions on surfaces and within porous media (as, for example, zeolites and pillared clays) and the dynamical response of quantum liquids, biological substances, magnetic, glassy, and polymer materials and microemulsions. Investigations of liquids and of structures with large repeat distances will also be possible with this type of instrument using banks of detectors placed in the forward and backward directions. This feature will make it possible to employ simultaneously the powerful techniques of elastic diffraction and inelastic spectroscopy.

Some examples of work relevant to the current interests of the SDT are given below.

1.1.2 Research Opportunities

1.1.2.1 Rotational Tunneling Spectroscopy

Investigations of the quantum reorientations of hydrogen-containing molecules, molecular groups and ions (e.g. methane or ammonia, methyl groups and ammonium ions) in both molecular solids and rare gas matrices provide detailed information relating to the local interaction potentials[1]. Recent investigations employing the improved resolution provided by crystal backscattering spectrometers have revealed that tunneling is not, in general, a single particle phenomenon but involves significant inter-molecular coupling and co-operative motions[2]. Studies of mixed deuterated/hydrogenated materials such as lutidine and calixarenes[3], where the effects of such coupling can be isolated and quantified, are currently providing more definite pictures of the basic interactions involved. In this regard, comparisons with quantum dynamics computer simulations have proved extremely helpful. Indeed, tunneling spectra are the primary source of information for the development of the semi-empirical interatomic potentials used to describe such interactions.

Apart from studies of molecules in bulk systems, a CBS can also be used to explore the tunneling motions of simple molecules adsorbed on surfaces. On high surface area substrates such as graphite [4] and MgO [5], even with a few tens of milligrams of adsorbate it is possible not only to investigate molecule-molecule and molecule-surface interactions but also to monitor the crossover from surface to bulk dynamics[6]. The excellent energy resolution of a CBS makes it an ideal instrument for such experiments.

Investigations to date have concentrated on the dynamics of molecules adsorbed on well-characterized crystalline surfaces. It is likely, however, that in the near future efforts will be made to explore the changes that occur when these surfaces are modified by the introduction of ordered and random dopants and impurities. Increased numbers of high resolution experiments in this field can be expected to lead to better theoretical descriptions of tunneling spectra as well as to an improved understanding of the local interaction potentials. Finally, we note that there is no other currently available experimental technique that provides similar direct access to tunneling frequencies and that measurements of this type serve as tests of some of the fundamental concepts of quantum mechanics.

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[2] C. J. Carlile and J. Penfold, The virtue of Cold Neutrons on Pulsed Sources, Neutron News 6, 5-13, 1995

[3] R Caciuffo et al , Studies of supramolecular complexes (calixarenes), Physica B 234-236, 115-120 (1997)

[4] A. Inaba et al, Tunneling of Methane Films on Graphite, J Chem Phys.103, 1627-1634 (1995)

[5] J. Z. Larese et al, Rotational Tunneling of Methane on MgO Surfaces: A Neutron Scattering Study, J. Chem. Phys. 95, 6997 (1991).

[6] J. Z. Larese et al, Rotational Tunneling Studies of Methane Films Adsorbed on MgO: Crossover from Two-to-Three Dimensions?, Physica B226, 221 (1996).

1.1.2.2 Quantum Liquids

The atomic-scale dynamical responses of liquid and solid ^{3}He and ^{4}He are of special interest because they are strongly interacting quantum systems. Both liquid ^{3}He and ^{4}He exhibit superfluid properties at low temperatures and serve as model systems for studies of strongly interacting fluids, critical phenomena, superconductivity and even - in the case of ^{3}He - for exploring big bang dynamics relating to the birth of the universe. A CBS is without equal as a device for measuring the dynamical structure factor, S(Q, w), of quantum liquids in the wave vector range $0.5 < Q < 3.0$ Å^{-1} where, for example, such collective excitations as phonons and rotons are observed in liquid ^{4}He.

Quantum liquids will undoubtedly continue to be of widespread interest for many years to come. Currently, for instance, there is much effort devoted to exploring the effects of disorder on the superfluid phase transition. Disorder can have a profound impact on phase changes, even to the extent of altering the universality class of the transition. Spatial disorder can be introduced by confining liquid helium in porous media, such as aerogels and xerogels. A CBS instrument is ideal for observing the small changes in the microscopic excitations that appear to be associated with the modified transport properties of such systems. For example, recent studies of helium in aerogel glass suggest that competition between the length scale set by roton-roton scattering and the length scale characterizing the porous media are responsible for the modified behavior [1,2].

A different kind of disorder can be introduced into superfluid ^{4}He by the addition of ^{3}He. This "statistical" type of disorder is very different from spatial disorder because ^{3}He atoms are fermions and therefore are not participants in the Bose-Einstein condensation which is responsible for the superfluid properties of ^{4}He. There is very little understanding of the microscopic effects of spatial and statistical disorder at the present time. High quality measurements are expected to be essential as further guides to the theory. Also multiphonon effects are important in distinguishing between the various theories. Resolving such effects can only be done with precision on a CBS.

[1] "Microscopic origins of superfluidity in confined geometries", P.E. Sokol, M.R. Gibbs, W.G. Stirling, R.T. Azuah, and M.A. Adams, Nature 379, 616 (1996)

[2] "Effects of Disorder on the Collective Excitations in Helium", R.M. Dimeo, P.E. Sokol, C. Anderson, W.G. Stirling, M.A. Adams, S. Hong, D. Brown, S.H. Lee, Phys. Rev. Lett. 79, 5274 (1997).

1.1.2.3 Porous Media/Chemistry

Details of the interactions of adsorbate molecules with microporous and mesoporous hosts are critical to developing a better understanding of catalytic enhancement of chemical reactions. Low frequency external modes of adsorbate molecules, for example, are sufficiently sensitive to local adsorption potentials to be used as microscopic probes of adsorption sites. Also, molecular diffusion often turns out to be the rate-limiting step in the reaction kinetics of such materials. Quasielastic and inelastic neutron scattering studies on a CBS are invaluable as probes of the wide range of times scales and energies involved in such processes.

Quasielastic scattering measurements on HERMES I (such as, for example, a recent study of benzene translational diffusion in zeolite NaX) could extend such measurements to long enough time scales to overlap with NMR studies. Furthermore, the ability to employ diffraction and spectroscopy simultaneously would be of real advantage in characterizing systems like these which are often prepared in-situ.

The low-frequency dynamics and diffusive motions of molecules are critical for a microscopic understanding of a wide variety of chemical processes such as catalytic reactions, separation, electrochemistry and energy storage. For rates faster than about 10^{-8} s these can only be studied by neutron scattering techniques and this range is complementary to that probed by NMR methods applied to the same systems [1]. Moreover, inelastic neutron scattering data are directly comparable with simulation studies by Molecular Dynamics and can thereby be related in a straightforward way to the underlying intermolecular forces. A thorough knowledge of the latter is critical to all efforts to design advanced materials and catalysts.

Porous Materials: Neutron scattering spectroscopies may be expected to play an increasingly important role in the study of guest-host interactions in layer compounds, microporous and mesoporous media [2]. For example, low-frequency "external" (or surface-specific) adsorbate vibrations are particularly sensitive to these forces and can often only be observed with neutrons. The details of molecular diffusion in layers, channels or cavities of such materials can readily be studied with a HERMES-type instrument. Such processes can often be the rate-limiting step for chemical reactions carried out in these materials.

Hydrogen Bonding: The importance of proton transfer in hydrogen bonds is currently being recognized in a wide variety of chemical and biological processes, such as enzyme catalysis [3] and energy transfer. NMR methods and high-resolution neutron scattering spectroscopy with backscattering spectrometers are the only experimental methods to observe proton transfer directly where neutron methods provide information in the spatial as well as time domain for such motion.

Electrochemistry: As there is an urgent need to develop more efficient and durable batteries neutron scattering spectroscopic studies of materials in which the charge transport occurs by protonic species are critical to such efforts. Recent experiments [4] on proton conductivities of certain metal oxide systems, for example, have demonstrated the utility of quasielastic neutron scattering for such investigation and could readily be carried out on a HERMES-type spectrometer.

[1] The complementarity of quasielastic neutron scattering and NMR methods in the study of molecular diffusion in zeolites was nicely demonstrated in the work on benzene in NaX: H. Jobic, M. Bee, J. Kärger, H. Pfeifer and J. Caro, J. Chem. Soc. Chem. Comm. 1990, 341.

[2] See articles by H. Jobic and F. Trouw in "Spectroscopic Applications of Inelastic Neutron Scattering: Theory and Practice", edited by J. Eckert and G. J. Kearley, Spectrochimica Acta 48A, 269-476 (1992).

[3] W.W. Cleland and M. M. Kreevoy, Science 264, 1887 (1994). See also, Proceedings of the Discussion Meeting of the Deutsche Bunsengesellschaft on "Hydrogen Transfer: Experiment and Theory" to be published in Ber. Bunsenges. Phys. Chem. (1998).

[4] Ch. Karmonik, Th. Matzke, R. Hempelmann and T. Springer, Z. Naturforschung 50a, 539, 1995.

1.1.2.4 Magnetism/Superconductivity

Despite many years of study, the fields of superconductivity and magnetism continue to provide new surprises as exemplified, for example, by the recent discoveries of high temperature superconductivity, giant magnetoresistance and colossal magnetoresistance. Apart from their basic scientific interest, magnetic materials like these, in which electron correlations produce macroscopic effects, are also central to new developments in such technologically important areas as power transmission and information storage.

It is generally agreed that neutrons are unequaled as probes of spin dynamics and magnetic fluctuations[1]. Recent studies of spin freezing and of the low energy excitations in the Kagomé-lattice-solid $SrCr_xGa_{12-x}O_{19}$ [2] and of the spin susceptibility of the CuO_2 planes in the high temperature superconductor $YBa_2Cu_3O_x$ illustrate the effectiveness of instruments like HERMES I in exploring the magnetic properties of these unusual systems. An important feature of HERMES I is that it will be possible to use it as a diffractometer to investigate magnetic ordering in crystalline materials with large plane spacings such as, for example, magnetic multilayers, transition metal complexes and magnetic spiral systems. As demonstrated on IRIS, a significant flux of long wavelength neutrons combined with backscattering detectors can open up new areas in neutron powder diffraction.

[1] "Seeing the spins in solids", G. Aeppli, Physics World, December, 1997, p34.

[2] S. H. Lee et al , Phys. Rev. Lett. 76, 4424 (1996).

1.1.2.5 Adsorbed Films

Adsorbed films serve as model systems for two dimensional physics. Studies of surface-adsorbed molecules such as H_2 Ar, Xe, O_2, and CH_4 have shown, for example, that two dimensional triple points are substantially reduced with respect to those in equivalent bulk phases [1]. The phase transitions of such films can also be quite different from those in their bulk equivalents and can even result in new phases, such as striped-domain-wall and hexatic phases. They are also of considerable technological interest. Adsorbed films of polymers, to give an example, play an important role in lubrication technology.

While thermodynamic measurements can identify the temperatures and coverages at which phase transitions occur in adsorbed films, characterization of the solid phases involved in, for example, D_2 adsorbed on high surface area substrates is best done with elastic neutron diffraction. Definitive identification and characterization of adsorbed liquid phases, on the other hand, is best done by using quasi-elastic neutron scattering measurements (such as those with adsorbed HD) at IN-5 at ILL-Grenoble and at MIBEMOL-Saclay[2,3], which pushed both instruments to the limits of their resolution and neutron flux. The availability of an instrument like HERMES I would spur the development of new high surface area substrates and would be ideal for characterizing hydrogen-containing molecular films physisorbed on them.

High-resolution quasielastic neutron spectrometers have also been shown to be very useful in investigating molecular diffusion (both translational and rotational) in adsorbed hydrocarbon films. Diffusive processes associated with phase transitions have been of particular interest in this area. For example, an energy resolution of ~70 meV or less is well-matched to the diffusive motions occurring near and above the melting transition in n-alkane monolayers adsorbed on basal-plane graphite surfaces [4]. High resolution quasielastic neutron scattering data have provided useful insights into such issues as: (i) whether conformational changes occur in adsorbed alkane molecules; and, if they do, their effect on the melting transition; (ii) whether these monolayers have plastic phases analogous to those in their bulk-solid counterparts, i.e., phases in which the molecules rotate about one of their symmetry axes but do not diffuse translationally; and (iii) whether solid and fluid monolayer phases coexist above the melting transition.

A CBS is an excellent choice for studies of selective adsorption which occurs, for example, in binary solutions of alkanes adsorbed on graphite(the longer solute molecule adsorbs at the expense of a shorter solvent molecule) [5]. Studies of adsorbed intermediate-sized alkanes $[CH_3(CH_2)_n\text{-}2CH_3; (20<n<40)]$ could have a significant impact on lubrication technology since these molecules are the main constituents of lubricant base stocks. The high resolution afforded by a CBS should make it possible to investigate not only the faster translational and rotational diffusion of the shorter solvent molecules but also the slower motions of the longer lubricating molecules which preferentially adsorb on the surfaces. Additionally, intermediate-sized alkanes can be viewed as prototypes for dynamical studies of more complex polymers at interfaces. Basic questions yet to be addressed at the atomic level include: how such complexes move so as to anchor, diffuse, and eventually desorb from a surface. Also, how do the solvent molecules present in the interfacial region affect these motions?

[1] J. Ma, D. L. Kingsbury, F. C. Liu, and O. E. Vilches, Phys. Rev. Letters, 61, 2348 (1988)

[2] M. Maruyama, M. Bienfait, F. C. Liu, Y. M. Liu, O. E. Vilches, and F. Rieutord, Surface Sci. 178, 333 (1992).

[3] Y. M. Liu, P. S. Ebey, O. E. Vilches, J. G. Dash, M. Bienfait, J. M. Gay, and G. Coddens, Phys. Rev. B, 54, 6307 (1996).

[4] "Quasielastic neutron scattering and molecular dynamics simulation studies of the melting transition in butane and hexane monolayers adsorbed on graphite", K. W. Herwig, Z. Wu, P. Dai, H. Taub, and F. Y. Hansen, J. Chem. Phys. 107, 5186 (1997).

[5] "Solvent Effects on the Monolayer Structure of Long n-Alkane Molecules Adsorbed on Graphite", K. W. Herwig, B. Matthies, and H. Taub, Phys. Rev. Lett. 75, 3154 (1995).

1.1.2.6 Geology

Quasielastic neutron scattering is an excellent way to explore the transport properties of water at low concentrations in rock. The water transport properties of rock at residual water saturation (where surface effects dominate the diffusive behavior) are not currently well understood [1], but are of critical importance to models of radioactive waste containment. To give a specific example, the feasibility of a high level nuclear waste repository at Yucca Mountain on the Nevada Test Site depends critically on minimal transport of water through the surrounding rock where it has to be taken into consideration that water-soluble radioactive waste could eventually leak from primary confinement systems. Thus, the diffusion coefficient of water at low level of saturation in various kinds of rock is of technological as well as academic interest. Following the example of neutron studies of the diffusion coefficients of water in clays [2], exploratory measurements of quasielastic neutron scattering in Yucca Mountain tuff and a Berea sandstone have recently been made. Preliminary findings suggest significant variations in the dominant transport process depending on the type of rock studied. The results from these and future measurements are expected to provide a better understanding of the water transport properties of various kinds of rocks [1] and to improve the reliability of models of low saturation fluid movement in large-scale, geologically-important ground formations [3] .

[1] "Evaluation of van Genuchten-Mualem relationships to estimate unsaturated hydraulic conductivity at low water contents", Khaleel, R., J. F. Relyea, and J. L. Conca, Water Resources Research, 31, 2659 (1995).

[2] "Structure and dynamics of intercalated water in clay minerals", Poinsignon, C., H. Estrade-Szwarckopf, J. Conrad, and A. J. Dianoux, Physica B, Condensed Matter, 156, 140 (1989).

[3] "Fluid configurations in partially saturated porous media", McCall, K. R., and R. A. Guyer, Physical Review B, 43, 808 (1991).

1.1.2.7 Biology

The study of large macromolecules, such as liquid crystals, polymers, and biological systems is an area in which neutron scattering may have the potential to make useful contributions. For example, relatively little is known about the low frequency dynamics of such biologically important systems as proteins and DNA even though there has been considerable speculation that their structural/dynamical response could be linked to their biomolecular function. Molecular distortions during slow motion, which are only now beginning to be explored, could well be part of this linkage and, if so, could lead to a better microscopic-scale understanding of the biological activity of such molecules.

Exploitation of the substantial difference between the scattering cross sections of hydrogen and deuterium is expected to be helpful in neutron studies of the dynamics of these large chain molecules. It is possible that isotopic substitution could, in some cases, allow the dynamical response of the molecule to be separated from that of the supporting medium. A case in point would be DNA in a hydrogenous medium. Another might be identification of the dynamical response of a particular section of a macromolecule, such as the head group in a liquid crystal. These possibilities have been little explored to date because of limited neutron intensities. The availability of high flux instruments such as HERMES I should encourage further efforts to explore the utility of neutrons as probes of the dynamics of macromolecular systems.

1.1.2.8 Other Research Opportunities

- Structural studies of medium-sized organic crystalline molecular solids, both powdered and single crystal

- Structural studies of small biomolecular crystalline solids up to unit cell sizes of 30,000Å^3, in powdered form, without the need for deuteration

- Structural studies of magnetic superstructures in metals and inorganic crystalline solids, powdered and single crystal

- Studies under high pressure at long wavelengths where cells become relatively transparent. Structures of colloidal and lyophilic liquid crystalline materials, of interest to the detergent industry, under production conditions such as shear

- Structural studies of magnetic ordering in topotaxial multilayers

- Simultaneous structural and spectroscopic studies of chemical intercalates and clathrates and matrix-isolated species

- Spectroscopic studies of tunneling phenomena at low temperature in molecular solids containing amine and methyl groups, methane molecules and ammonium ions with simultaneous monitoring of the structure

- Diffusional studies of hydrogen in metals, of sodium in superionic conductors, and of polymers, liquid and molecular crystals, biogels and biomembranes. The diffusion of oils in clays and water in geological and biological samples such as skin

- Crystalline electric field excitations in magnetic and high T_C superconducting materials

- Spin fluctuations in magnetic materials

1.2 Spectrometer Conceptual Design

1.2.1 Background

The Short-Pulse Spallation Source (SPSS) enhancement project at the Los Alamos Neutron Science Center (LANSCE) will increase the proton beam power delivered to the neutron production target from 80 kW to 160 kW. Concurrent with this project, it is also planned to add as many as seven new instruments to the existing complement of spectrometers and diffractometers using design and construction funds provided by the U.S. Department of Energy's Office of Defense Programs and Office of Energy Research (DOE-DP and DOE-ER). Following an initial LANSCE call for proposals for new instruments to be designed and built by Spectrometer Design Teams (SDT) composed of members of the neutron scattering community from universities, industry, and federal laboratories, a total of 20 SDT's submitted letters of intent. After review of the letters of intent, the Proposal Evaluation Committee recommended that nine SDT's be asked to prepare detailed proposals. The SDT submitting this proposal is one of the nine teams selected.

1.2.2 Monte Carlo Simulations

It has been suggested that HERMES share a partially-coupled liquid hydrogen moderator with a reflectometer and a diffractometer for small angle scattering studies. A partially-coupled moderator will increase the flux on sample, but there are reasons for believing that the broader pulse, reduced peak intensity, and longer decay constant of the pulse will have a detrimental effect on the resolution of the instrument. An important task of the HERMES SDT was therefore to evaluate the effect of using a partially-coupled moderator on intensity and resolution. This is a calculation that does not lend itself easily to analytical methods, especially if realistic models are to be used for neutron optical components. Monte Carlo methods, however, are particularly well suited to this purpose. Although HERMES is very similar in concept to the backscattering spectrometer IRIS at the Rutherford-Appleton Laboratory - a well-known and highly successful instrument in great demand worldwide - a number of fundamental questions remain to be resolved regarding such basic issues as the scaling of instrument performance with the length of the primary and secondary flight paths, the solid angle covered by the analyzer crystals, the crystal parameters, the sample size, and the secondary flight path collimation. As a first step toward producing an optimized design best suited to the conditions (moderator, space constraints, quality of available crystals, etc.) at LANSCE, we employed Monte Carlo to evaluate the effect of each of these parameters on instrument performance.

The Monte Carlo simulations were made using the MCLIB library of subroutines [1,2]. This library is maintained and developed by Los Alamos National Laboratory as a means of making detailed simulation of complex neutron optical elements and neutron scattering instruments.

The MCLIB library

The code, in its present form, derives from a library written by M. Johnson at the Rutherford-Appleton Laboratory in 1978 [3]. Major revisions and additions to the code were made over the years by LANL to produce MCLIB, which has since been used to simulate numerous instruments.

MCLIB is a library of FORTRAN subroutines that allows users to develop complex, modular models of neutron scattering instruments. It currently contains models for a large number of neutron optical elements such as choppers, collimators, filters, monochromators, apertures, slits, etc. as well as subroutines to generate, transport, scatter, and detect neutrons. A wide variety of source files, samples, and detectors are available to the general user.

Figure 1 shows a simplified flow chart summarizing the course of a typical simulation. Specifications from the instrument designer are used to generate a fixed-format instrument geometry file.

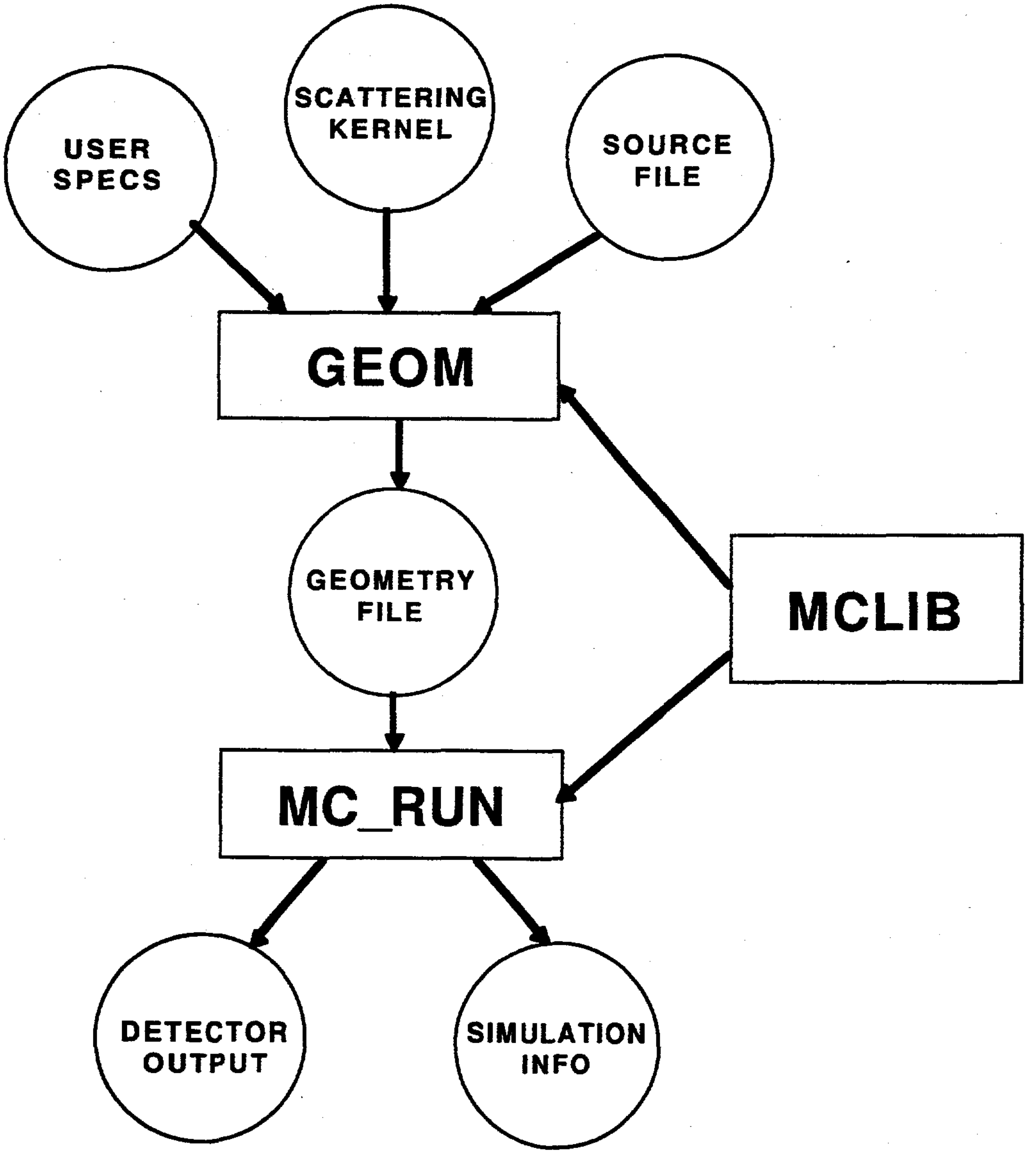

Figure 1 - Flow chart summarizing a typical Monte Carlo simulation based on MCLIB.

This file contains all the information about the instrument, and may either be produced by a program or through a web-based interface (http://bayberry.lanl.gov/lansce/welcome.html), which is under development[4]. This file (GEOM file) is used as an input to a second program, mc_run, which actually performs the Monte Carlo simulation. One of the output files produced by mc_run contains one or several histograms with neutrons detected in the instrument detector(s). A second contains information relevant to the course of the simulation, including such information as a simple neutron balance table, various normalization factors, and any anomalous condition occurring during the simulation. The detector output file is - in effect - a simulation of data that would be obtained from an actual experiment. More detailed descriptions of the MCLIB library and the mc_run code are available in references [1,2].

IRIS

The IRIS spectrometer at the ISIS facility views a decoupled liquid hydrogen moderator at an angle of 13°. In the range of wavelengths of interest, the moderator produces pulses with a full-width at half-maximum (FWHM) of about 120 μs; the repetition rate is 50 Hz. As shown in Fig. 2, IRIS itself is located at the downstream end of a 31.3 m long curved neutron guide (2.35 km radius of curvature) with its entrance window 1.7 m from the moderator. The guide cross-section (65 mm x 43 mm) is such that at wavelengths shorter than 9 Å the entrance window views the entire surface of the moderator. Gaps in the guide at 6.4 and 10 m provide space for bandwidth selection and frame overlap choppers. When it is necessary to increase the instrument bandwidth the choppers can be run at an integral fraction of the source frequency; the rate of data collection is, however, decreased proportionately. At the upstream end of the guide a converging supermirror section, 2.5 m long - terminating approximately 1 m upstream of the sample - focuses the beam down to a cross section of 32 mm x 21 mm.

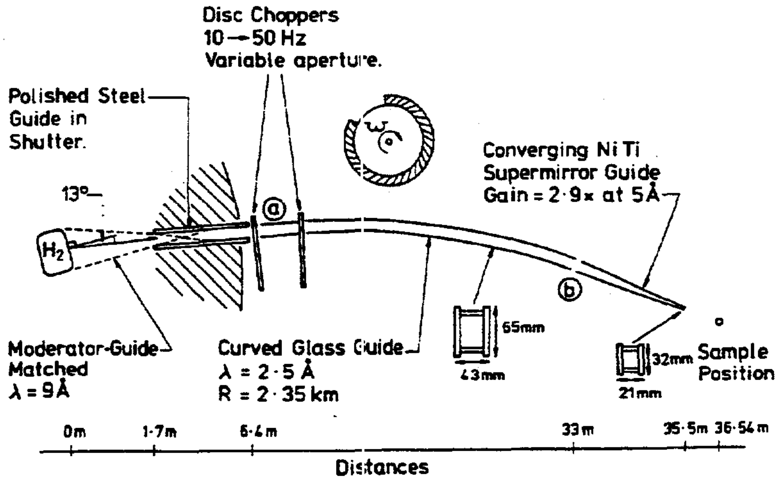

Figure 2 - The primary flight path of the IRIS spectrometer (from Ref. [5]).

Fig. 3 shows the sample-analyzer part of the instrument, which basically consists of a sample (36.54 m from the moderator) and two analyzer crystal banks composed of pyrolytic graphite and mica crystals, each with its associated banks of detectors. The analyzer crystals form pseudo-spherical arrays of 0.86 m radii (each covering a solid angle of approximately 0.6 sr) that focus neutrons Bragg backscattered at an angle of 175° on the banks of detectors. A more detailed description of IRIS can be found in reference [5].

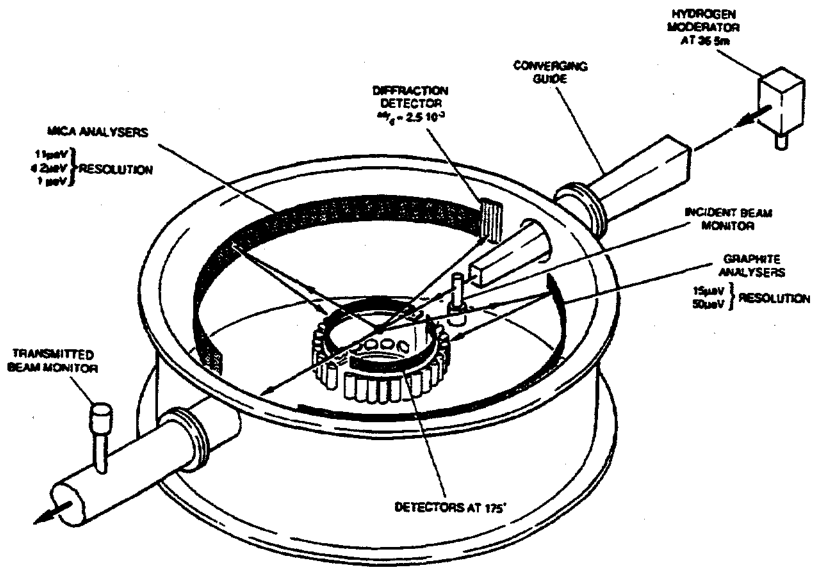

Figure 3 - Secondary flight path of the IRIS spectrometer (from Ref. [5]).

The energy resolution of the instrument is the convolution of three main components, [5]:

- Incident pulse time-of-arrival uncertainty, Δt/t, where t is the total time-of-flight from the moderator to the detector and Δt is the moderator pulse width.
- Analyzer crystals lattice spacing uncertainty, Δd/d.
- Backscattering angle uncertainty, Δq.

The time-of-arrival uncertainty depends mainly on the length of the primary flight path, the size of the sample and the time profile of the pulse produced by the moderator. Analyzer lattice spacing uncertainty is primarily a function of crystal quality. (For the pyrolytic graphite analyzers used at IRIS (2d=6.7078 Å), Δd/d is about $2x10^{-3}$. For the mica analyzers (2d=20.26 Å), Δd/d is less well known but is thought to be less than $2x10^{-3}$). The uncertainty in backscattering angle is a function of the analyzer spectrometer geometry and depends on the size and alignment of the detectors and analyzer crystals as well as on the length of the secondary flight path.

Computer models

Since HERMES is similar in basic concept to IRIS, the HERMES SDT decided to make a "first-pass" optimization of the energy resolution of the instrument over the largest possible momentum transfer range with the IRIS configuration.

Consideration of the main contributions to the resolution of the instrument (as outlined above) suggests a natural approach to such optimization studies. We started with the IRIS configuration described above but with a few minor modifications: (I) a straight guide, (ii) a repetition rate of 30 rather than 50 Hz and (iii) a detector bank with a somewhat smaller in radius (20 cm instead of 26 cm for IRIS) and with only 32 detectors on each side.

First, priority was given to comparing the performance of the instrument with decoupled and partially-coupled moderators since the effect of employing moderator pulses with long trailing edges (a consequence of partial coupling) was a matter of particular concern. Several simulations were run to examine the effect of changing the decay time constant, pulse width (FWHM), and peak intensity of the moderator neutron pulse on the elastic line shape as well as on line shapes resulting from inelastic processes, i.e. non-zero energy transfers.

A second set of simulations was then made to address the effect of the primary and secondary flight path lengths. This was followed by third that addressed concerns relating to the crystal analyzer geometry and to the influences of crystal quality (mosaic spread and lattice spacing uncertainty). Finally, we considered what improvements might result from the substitution of multilayer-coated supermirror guides for guides coated with ^{58}Ni.

As noted above, the effect on instrument performance of many of the parameters varied in these studies, such as neutron guide coating, mosaic spread of analyzer crystals and the time-energy dependence of the neutron pulse from the moderator, are too complex to be analyzed analytically and are best studied with Monte Carlo computer simulations. Since the reliability of such simulations depend crucially on the models on which they are based, it is essential to verify the results whenever possible by making comparisons with actual measurements. This was done by initially running the model simulations with parameters identical to those of IRIS and verifying that the observed elastic line shapes for low-index graphite and mica analyzer reflections were well-reproduced by the simulations.

In what follows we describe in detail the modeling of various components that needed to be incorporated into our simulation program.

The **source** files used were generated by a radiation transport code (LAHET/MCNP) from an accurate computer model of the LANSCE target station. We used two source files in particular. The first file, upgd0_10.tbl, describes the time-energy dependence of the neutron pulse emitted by a decoupled liquid hydrogen moderator. This file is a good model for the pre-upgrade decoupled moderator at LANSCE. The second file, upgd1_10.tbl, represents a coupled liquid hydrogen moderator; it is a description of the neutron pulse emitted by the moderator after completion of the SPSS enhancement project. In both cases, the source file contains the response of the moderator to a delta function (proton pulse). This response function is convoluted with the proton pulse to provide the actual time and energy profile of the neutron pulse emerging from the moderator. The proton pulse is assumed to be rectangular and 0.27 μs in width. Our studies were performed assuming a moderator of dimensions 12 x 12 cm. Fig. 4a shows the time-wavelength dependence of the neutron pulse from the decoupled moderator (upgd0_10.tbl). Fig. 4b is a similar plot for the partially coupled moderator (upgd1_10.tbl).

In our simulations the **sample** is assumed to be an isotropic scatterer. For simplicity, multiple scattering was ignored. A sample size, shape and (wavelength-dependent) transmission are specified along with a set of energy transfers, $\hbar\omega_i$, and a probability of scattering at each given energy transfer. By specific choices of these parameters it is possible to emulate scattering from samples composed - for example - of simple molecules thus making it possible to test particular features of the instrument such as its ability to resolve closely spaced features in the elastic diffraction profile or equivalent, closely-spaced features in the inelastic spectra.

The **detector** array in the proposed HERMES instrument consists of two banks of thirty-two 10 cm-high ^{3}He-filled tubes mounted on a cylindrical surfaces beneath the sample in an arrangement similar to that on IRIS. For purposes of simulation, an uncertainty in the place within the detector where the neutron is detected is specified along with a wavelength-dependent efficiency. All the features of a real detector are included: i.e. finite clock tick, linear or logarithmic time bins, delays, etc.

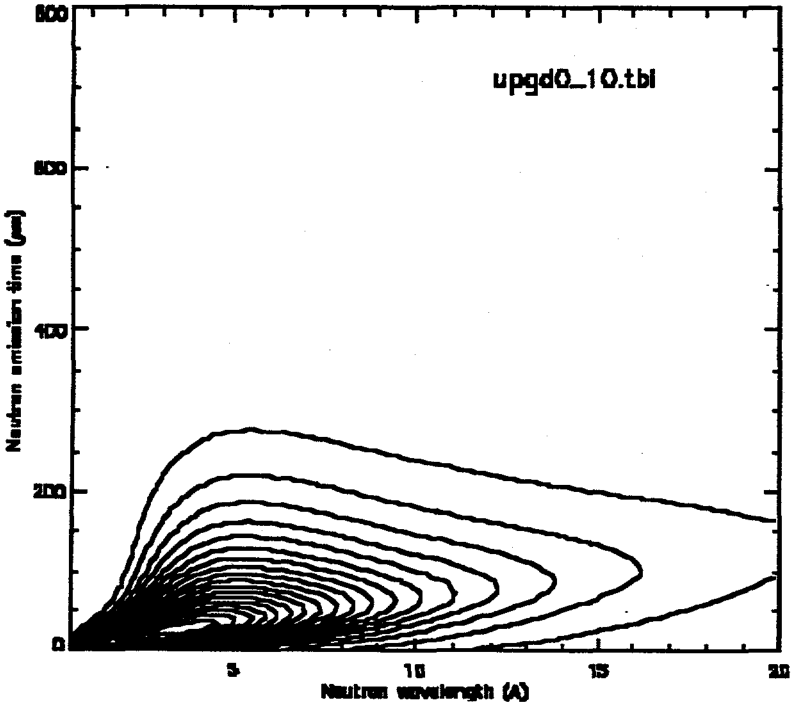

Figure 4a - Time-energy distribution of the neutron pulse emitted by the decoupled liquid hydrogen moderator used in our studies.

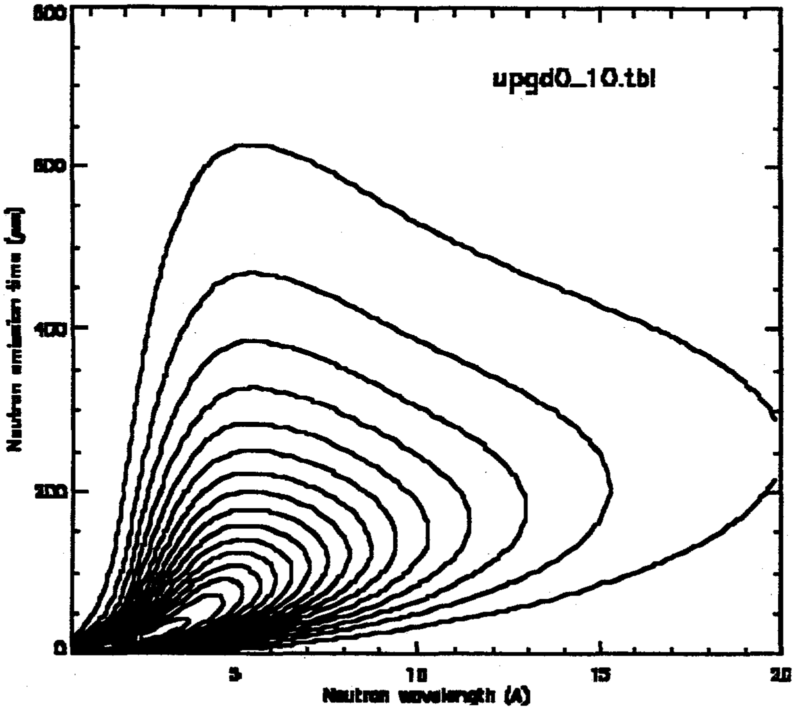

Figure 4b - Time-energy distribution of the neutron pulse emitted by the partially coupled liquid hydrogen moderator used in our studies.

In most cases the **neutron guide** coating was assumed to be ^{58}Ni. Its properties are described by specifying a complex scattering length, an energy-dependent absorption cross-section, an energy-independent total scattering cross-section and the number of scatterers per unit volume. These parameters determine the critical angle; i.e.

$$\theta_c = \sqrt{\frac{Nb_{coh}}{\pi}}\lambda$$

For ^{58}Ni, the atom density, N=0.091 at/Å^3 and the coherent scattering length is b_{coh}=1.44x10^{-4} Å, so that the critical angle is 0.1171 deg/ Å. As noted, the guide cross section is 6.3 x 4.2 cm^2 and the entrance window is 1.7 m from the moderator.

In the IRIS-like model we used, the **choppers** are located at 6.4 m and 10 m. (Their function is to reduce frame overlap and select a band of incident neutron wavelengths suitable for the analyzer crystals.) For our purposes they were assumed to be disk choppers, 0.3 m in radius with disk material that is perfectly absorbing. A Gaussian distribution with RMS 5 μs was introduced to simulate fluctuations in rotor speed. For simulations of the elastic lineshape, the choppers were phased so as to position the elastic line roughly in the middle of the counting frame.

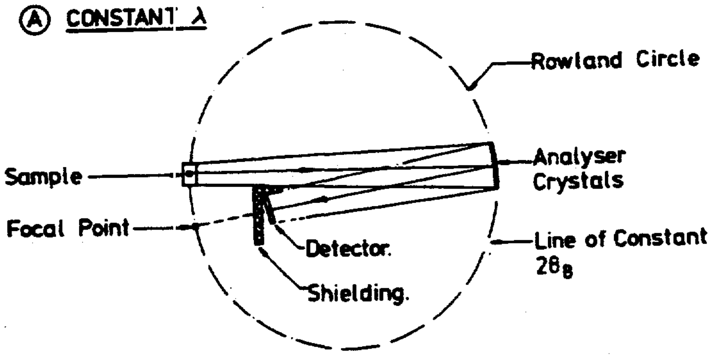

Figure 5 - Rowland geometry for the analyzers in backscattering geometry (from Ref.[5]).

The mica and graphite **analyzer crystal arrays** were assumed to be in the horizontal scattering plane mounded on a portion of spherical surface in the so-called Rowland circle geometry [6] (see Fig. 5) and to cover a range of scattering angles from 15° to 165°. It is important to note that the crystals are not oriented in the exact backscattering geometry (which would require the Bragg-reflected beam to pass through the sample). The Bragg angle at IRIS is 87.5° (2q=175°) - a value we used in most of our simulations. Actually, the analyzer is made up of small, flat crystals mounted on a spherical surface that defines their orientation. For simplicity, however, the slight asphericity this introduces was not taken into account; instead a smooth, spherical surface was assumed. Table I summarizes the effects of varying the properties of the crystals. Note that while the mosaic spread does not appear to be a critical parameter, the results are quite sensitive to the parameter describing the distribution of crystal plane spacings, Δd/d. (For Δd/d we chose a value that gave a quasielastic line with a full-width at half-maximum corresponding to the IRIS value. Plane spacing distributions can be assumed to be either Gaussian or Lorentzian in the program. In most of our simulations Lorentzian distributions were employed.)

Results

Neutron flux on sample

The neutron energy spectrum at the sample location is a useful characteristic of any instrument. Figure 6a shows the energy spectrum at the sample location for a primary flight path length, L_P=36 m. The energy spectrum is shown for both coupled and decoupled moderators.

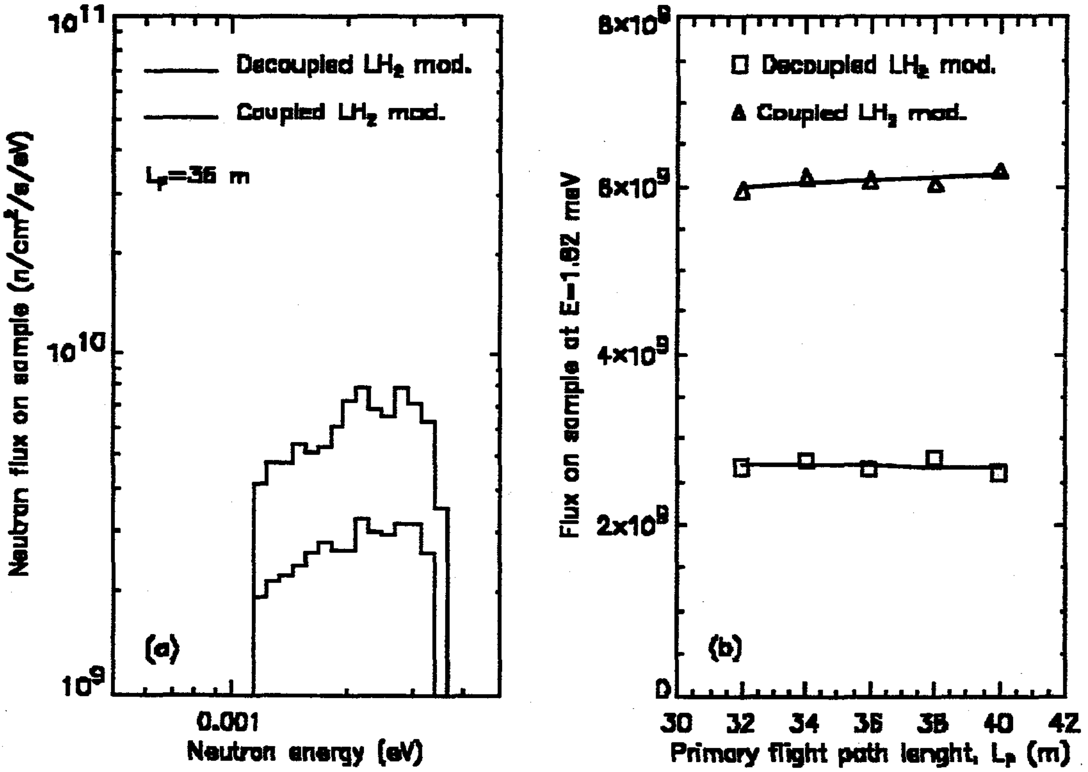

Figure 6 - Neutron energy spectrum at the sample location for different values of L_P. The guide is coated with ^{58}Ni.

In both cases, the range of wavelengths transmitted is from about 5 to 8.3 Å. Truncation of the spectrum by the choppers is evident in Figure 6a. Except for small flight path length dependent variations in spectral range, the energy spectra for different values of L_P are very similar. The spectral distributions (in n/cm^2/s/eV) at 1.82 meV (002 peak of the graphite analyzer) obtained at different values of L_P are plotted in Figure 6b. There is little significant variation. The average flux on sample obtained from the simulations for the decoupled moderator is 2.8×10^9 n/cm^2/s/eV and for the coupled moderator 6×10^9 n/cm^2/s/eV. (The sample, a right circular cylinder, 8 mm in radius and 8 mm thick, has an area of $\pi.(0.8\text{ cm})^2 = 2.011\text{ cm}^2$.) Assuming a useful bandwidth $\Delta E\approx100$ μeV and that the sample scatters 10% of the beam, the neutron count rate for the 002 elastic line is thus

2.8×10^9 (n/cm^2/s/eV) x 2.011 (cm^2) x 100×10^{-6} x 10% = 5.6×10^4 n/s

for the decoupled moderator, and

6×10^9 (n/cm^2/s/eV) x 2.011 (cm^2) x 100×10^{-6} x 10% = 1.2×10^5 n/s

for the coupled moderator. Making the reasonable assumptions that the sample scatters isotropically and that the graphite analyzer bank covers a solid angle of 0.3 sr (86 cm radius, 10 cm high, angular range from 15° to 165°), then the count rate at the analyzer bank is 1.3×10^3 n/s (decoupled moderator) or 2.9×10^3 (coupled moderator). Finally, assuming a crystal reflectivity of 0.2 and essentially 100 percent efficient detectors, the detector count rate turns out to be 267 n/s (decoupled moderator) and 580 n/s (coupled moderator).

These numbers will be useful in estimating count rates in the studies described below.

Primary flight path length, L_P

The primary flight path, i.e. the distance from the moderator to the sample is an important design parameter. Because $\Delta t_{mod}/t = v\Delta t_{mod}/L$, where Δt_{mod} is the moderator pulse width, v the velocity of the neutrons that are Bragg-reflected at the analyzer and L is the total distance traveled by the neutron, increasing L decreases the time-of-flight contribution to the resolution. It also decreases the flux on sample and thus there comes a point where increasing the primary flight path length becomes counterproductive. As a rough approximation, the time-of-flight error can be regarded as adding to the backscattering and the $\Delta d/d$ errors in quadrature. Clearly, at some point the uncertainty in the final neutron energy will be dominated by the latter two terms and insensitive to further increases in L. Figure 7 shows the computed PG002 elastic peaks for L_P=32, 36, and 40 m for the decoupled (Figs.7a, 7c, and 7e) and partially-coupled moderators (Figs.7b, 7d, and 7f). In these simulations the length of the secondary flight path from the sample to the analyzer to the detector was fixed at L_S=86 cm. Also, the choppers were kept at the same positions (z=6.4 m and z=10m) and were rephased to pass approximately the same bandwidth, the length of the convergent supermirror guide was kept constant and its position was fixed relative to the sample. Increases in the primary flight path length were simulated simply by increasing the length of the third guide section.

Varying L_P from 32 m to 40 m produces a modest (25%) effect. As evident in Fig. 8a, its impact on the resolution (as measured by the full width at half-maximum of the elastic peak - see below) is comparatively small for both moderators. It is practically insignificant for the decoupled moderator where, for example, the FWHM of the elastic peak is about 18 μeV at L_P=32 m and drops to about 17 μeV at L_P=40 m (a 6% variation). The coupled moderator is somewhat more sensitive to changes in L_P: the FWHM of the elastic peak varies from about 27 μeV at L_P=32 m to 21 μeV at L_P=40 m (a 22% variation). Note, however, that even at 40 m, the FWHM for the coupled moderator is larger than the FWHM for the decoupled moderator at 32 m. A significant decrease in the $\Delta t_{mod}/t$ error could thus only be obtained by a substantially increasing L_P. Given that 40 m is about the maximum primary flight path length that is admissible for HERMES because of floor space considerations.

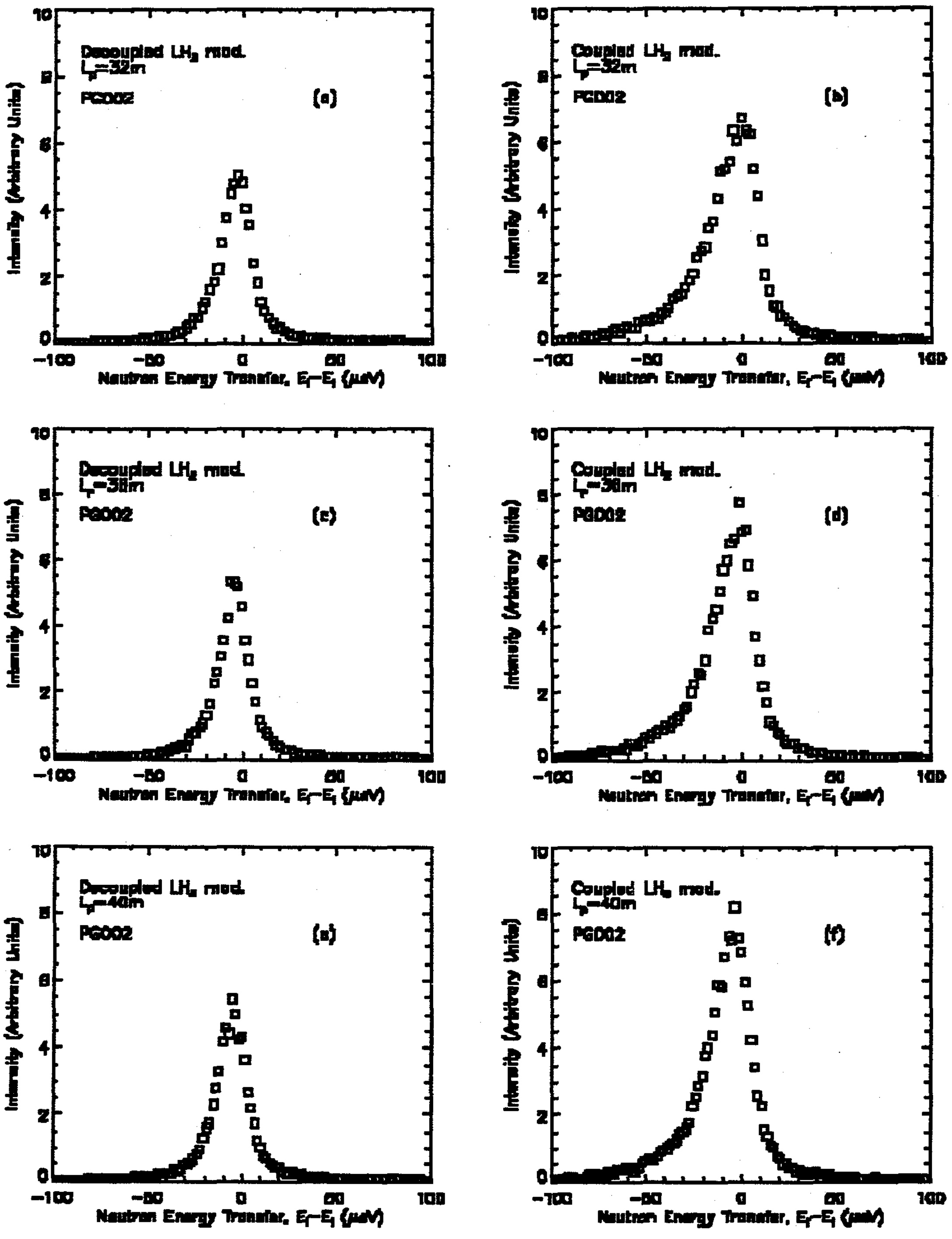

Figure 7 - Elastic lineshape for HERMES viewing a decoupled liquid hydrogen moderator (Figs. 7a, 7c, and 7e) and a coupled liquid moderator (Figs. 7b, 7d, and 7f). The lineshape is the 002 Bragg-reflection on graphite (l=6.7068 A). For each moderator, the lineshape for an instrument with primary flight path length, L_P=32, 36, and 40 m is shown.

There does not seem to be any advantage to choosing L_P outside the 32 m to 40 m range. (By extrapolating the fit to the FWHM for the coupled-moderator in Figure 8a, it is easy to see that L_P=45.7 m if the coupled moderator instrument is to match the resolution of the same instrument viewing a decoupled moderator at L_P=32m. Rather than trying to actually match resolutions, however, it is probably more relevant to ask how short L_P could be without too great a sacrifice in over-all resolution.)

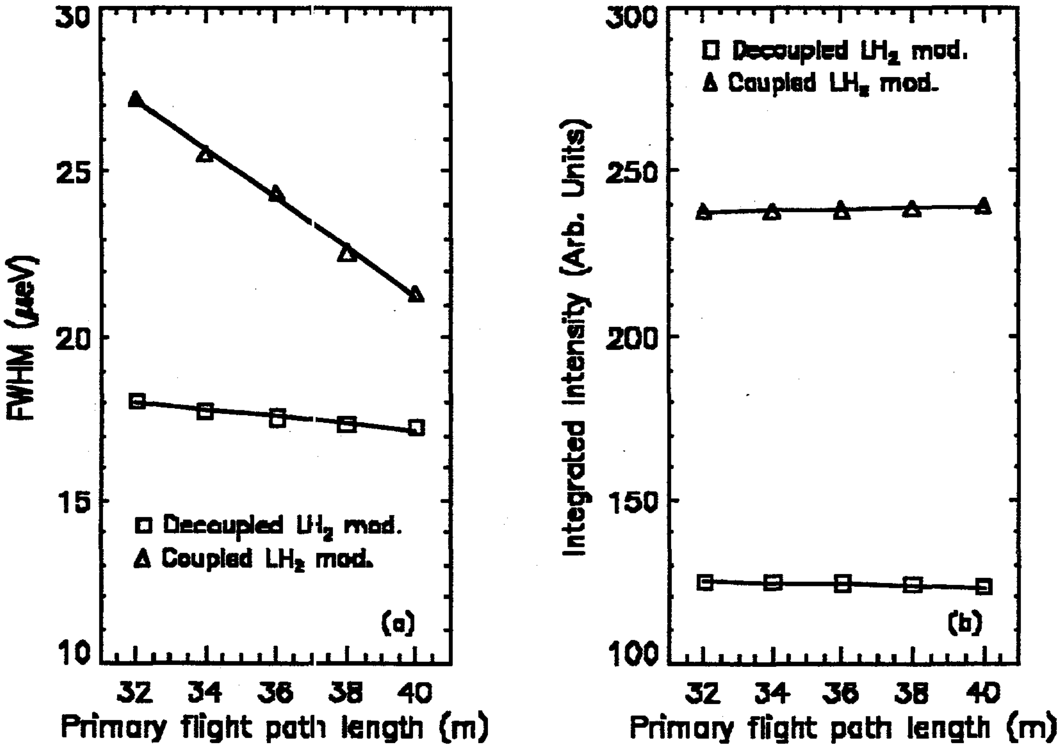

Figure 8 - (a) FWHM of the PG 002 lineshape for the decoupled (squares) and coupled (triangles) liquid hydrogen moderators; (b) Integrated intensity for the PG 002 lineshape for the decoupled (squares) and coupled (triangles) liquid hydrogen moderators. The factor of 1.9 between the integrated intensities matches the factor of 1.94 between the integrated intensities at the moderator.

Distortion of the elastic peak shape produced by coupling the moderator, as shown in Figure 7, poses a potentially more serious problem. At an analyzer energy of 1.82 meV (PG 002), the decoupled moderator produces a pulse with a FWHM of 100 ms, whereas the corresponding FWHM for the coupled moderator is 210 ms. (The latter value is somewhat larger than more accurate calulations of the pulse shape suggest, thus our results for the coupled moderator should probably be viewed as upper limits.) While a coupled moderator increases the integrated intensity (by a factor of 1.94 at 1.82 meV) it also produces a pulse with a long trailing edge, an increased rise time and a reduced peak intensity. It is clear from Figure 7 that the long trailing edge is quite detrimental to the elastic line shape which becomes broader and highly asymmetric. (At L_P=32 m, for instance, the FWHM for the decoupled and coupled moderator instruments is 50 % different (18 vs 27 μeV) In practice, this could significantly complicate the analysis of the quasielastic broadening associated with various kinds of diffusive motions. The long trailing edge might also make it difficult to identify a weak inelastic peak with a near-zero energy transfer. It could, of course, be argued that the counting statistics would be better because of the increased signal intensity from the coupled moderator. But while it is true that the integrated intensity increases by a factor of 1.9, Figure 8b shows that some of the extra intensity simply contributes to broadening the elastic peak rather than increasing its height. Thus it is far from clear that the increase in signal strength at a given energy transfer obtained with the coupled moderator can compensate for the effect of the long trailing edge on resolving power.

Probably the best way to evaluate the relative influence of line shape and intensity on instrument performance will be to create simulations of actual data from decoupled and coupled moderators and analyze both using Maximum Entropy methods. It may be that with a reasonable knowledge of the (distorted) elastic line shape it will still be possible to obtain the same amount of information from the data. Even so, there is little doubt that users will be less able to identify significant features in the incoming raw data.

It is important to emphasize that because the instrument resolution function is asymmetric (particularly in the coupled moderator case), the FWHM, which we have been using as a simple criterion for the instrument resolution, may overlook difficulties that a more careful, systematic analysis of the data would reveal. Nonetheless, the FWHM is an often-quoted parameter in the quasielastic neutron scattering literature, and, with this caveat in mind, we will continue to use it as a rough but convenient indicator of instrument resolution.

Analyzer crystals height

The analyzer is the heart of the spectrometer. Ideally, neutrons scattered by the sample should be incident on the analyzer crystals at the same angle regardless of the direction of scattering. If this condition could be fulfilled, it would guarantee that all neutrons Bragg-reflected by the analyzer have exactly the same energy (neglecting variations in crystal plane spacing). It is also important to keep the neutron flight paths from the sample to the analyzer to the detector the same for each neutron so that the process of converting arrival time in the detector to energy is accurate for all neutrons. To first order, these conditions are satisfied by the Rowland geometry [6] if the height of the analyzer is small compared to the diameter of the Rowland circle. However, since the sample scatters over 4π steradians, it is tempting from the intensity point of view to increase the solid angle intercepted by the analyzer by increasing the height of the analyzer crystal bank. This has several consequences. First, deviations from the ideal Rowland circle geometry lead to a possible loss in resolution. Second, the neutrons reflected by the analyzer crystals are no longer well-focused to a point (as they are to first-order in the ideal Rowland circle geometry). The beam spot size at the detector increases and it has to be larger. A larger detector is more susceptible to background and could lead to an increase in background levels. Third, the cost of the analyzer crystal bank increases quadratically with the radius of the bank and linearly with its height. For all these reasons it was not initially clear that a large analyzer bank would perform substantially better than a well-designed, smaller one.

To pursue this question we made a series of simulation studies focusing primarily on the effect of varying the height of the analyzer and on the resulting trade-off between intensity and resolution. We chose a primary flight path (moderator to sample) length of 36 m and fixed the radius of the analyzer bank at 86 cm. As mentioned above, the bank is an equatorial segment of a spherical surface in Rowland geometry limited above and below by two horizontal planes. What we refer to as the analyzer bank height H_A is the distance between these two planes (not the length of arc measured along the spherical surface). We looked at values of H_A=10, 15, 20, 25, 30 and 35 cm. (For larger values, the 20 cm-radius detector begins to block the view of the sample as seen by the analyzer crystals. To further increase the height, it would have been necessary to modify the Rowland geometry by lowering the detector further and/or changing its radius and reorienting the analyzer crystals. In all cases the detector height was fixed at 10 cm, i.e. large enough to capture the neutrons reflected by the analyzer crystals. As before, the study was performed for both decoupled and coupled moderators.

Figure 9 shows some of our results. For each moderator, we show the PG002 elastic lineshape for the smallest and largest analyzer height considered in our study, namely H_A=10 cm and H_A=35 cm, respectively. The gains in intensity due to the coupled moderator and to the larger solid angle subtended by the analyzer clearly illustrated by the plots shown in Figure 9.

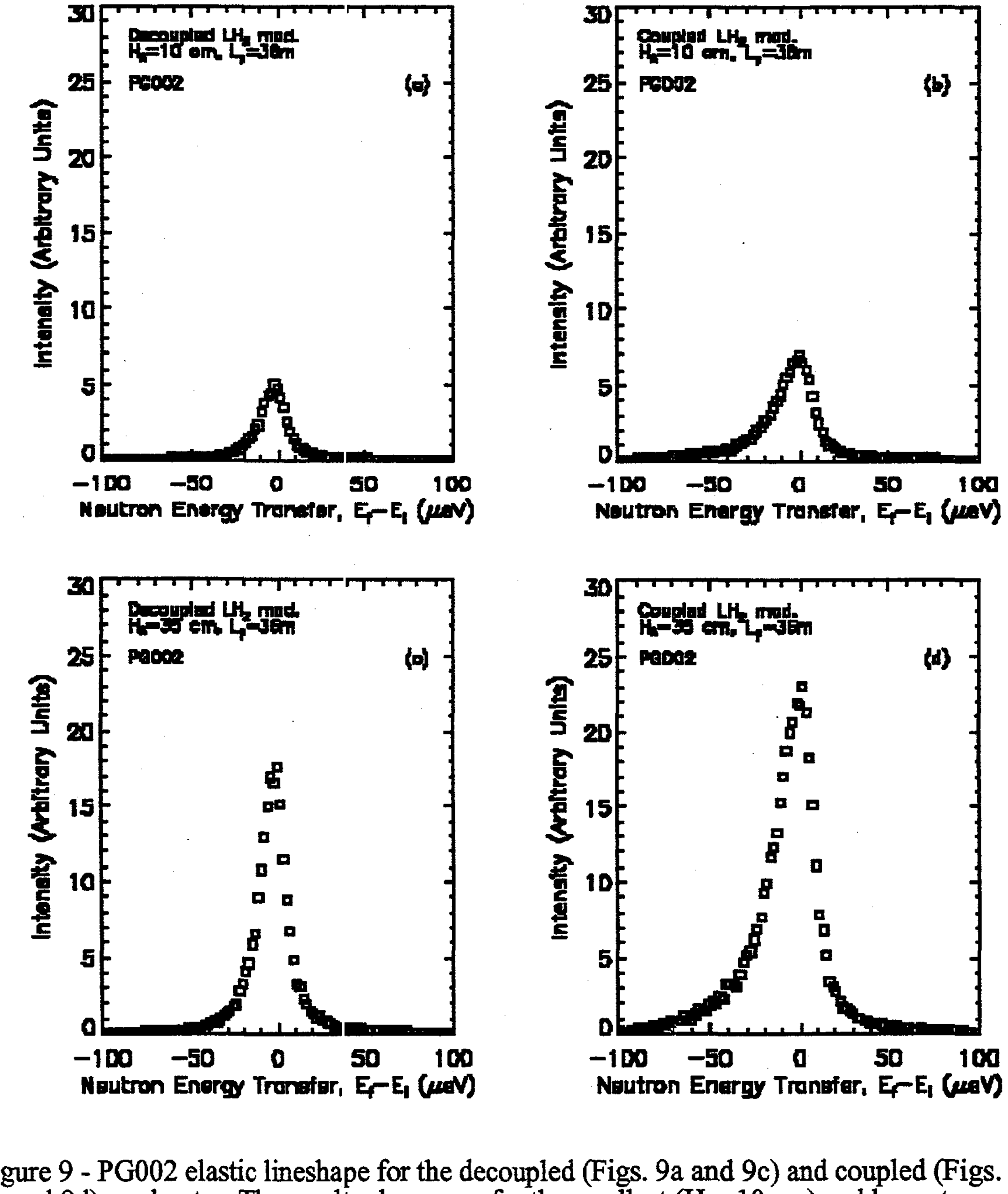

Figure 9 - PG002 elastic lineshape for the decoupled (Figs. 9a and 9c) and coupled (Figs. 9b and 9d) moderator. The results shown are for the smallest (H_A=10 cm) and largest (H_A=35 cm) analyzer height considered in our study.

In Figure 10a, we show the FWHM of the PG002 elastic line as a function of analyzer height, H_A. As before the instrument viewing the coupled moderator is more sensitive to the varied parameter in this case H_A. Whereas the FWHM of the elastic line for the decoupled instrument shows virtually no change for values of H_A between 10 and 35 cm, the FWHM for the coupled instrument exhibits a more pronounced H_A dependence: the FWHM is 24.5 μeV at H_A=10 cm and increases to 26.4 μeV at H_A=35 cm -an 8% variation.

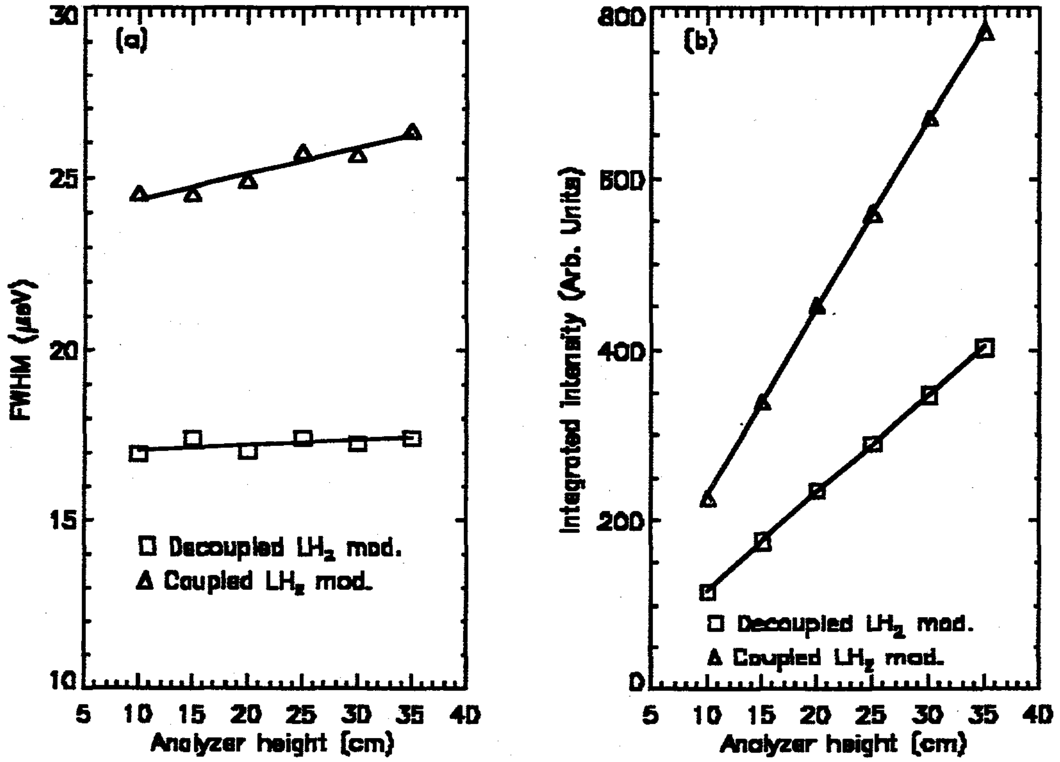

Figure 10 - (a) FWHM and (b) integrated intensity for the PG 002 elastic lineshape as a function of analyzer height. The primary flight path is 36 m; the analyzer radius is 86 cm.

An 8% increase is, however, not unreasonable, considering, as is evident in Figure 10b, that the increase in the solid angle subtended by the analyzer bank produces a very substantial increase in the (integrated) intensity. In the range of values of H_A considered here, the increase in intensity varies linearly with H_A, as might be expected. We note that the integrated intensity for the decoupled instrument with a 10 cm high analyzer bank is roughly equivalent to IRIS but by going to a coupled moderator and a 35 cm high analyzer bank the integrated intensity of the PG002 line at the detector is almost eight times larger. Necessarily, the price paid for this dramatic gain in intensity is poorer resolution (26 μeV versus 17 μeV: i.e. broadening of the lineshape is what produces a significant part of the gain.

It is evident from this study that at H_A=35 cm we are not too far from the idealized first order Rowland geometry. Notice however, that the 10 cm-high detector is close to being fully illuminated. Thus further increases in H_A, while they might still yield an acceptable resolution, would require an increase in the size of the detector which, as mentioned above, could impact negatively on the signal-to-background ratio. While on the subject of background it should also be noted that a well-known and significant source of background, thermal diffuse scattering from the analyzer crystals, was not included in our calculations. Cooling the crystals to a very low temperature can considerably reduce thermal diffuse scattering. The results presented here are therefore probably best viewed as representative of cooled crystals.

Use of supermirror guides

Although more expensive, supermirror guides can be expected to provide additional gains in intensity compared to the ^{58}Ni coating used in our simulations. In order to estimate this gain, we considered a spectrometer with L_P=36 m and an analyzer similar in size and geometry to IRIS. We ran the problem with ^{58}Ni coating in the guides, and repeated the simulation with a supermirror coating in the guides. The calculation was performed for the decoupled moderator only. Figure 11 shows the energy spectrum at the end of the converging supermirror guide. At 1.82 meV, the gain in intensity is a factor of 2.5. At the longest wavelength passed by the primary flight path, namely 8 Angstrom or so, the gain is a factor of 2. The parameters used to describe the scattering properties of the ^{58}Ni coating have been given above. The supermirror material is characterized by a bulk material scattering-length density $b=7.94x10^{10}$ cm^2, a supermirror multiplier of 10, and a reflectivity at the maximum supermirror limit of 1.

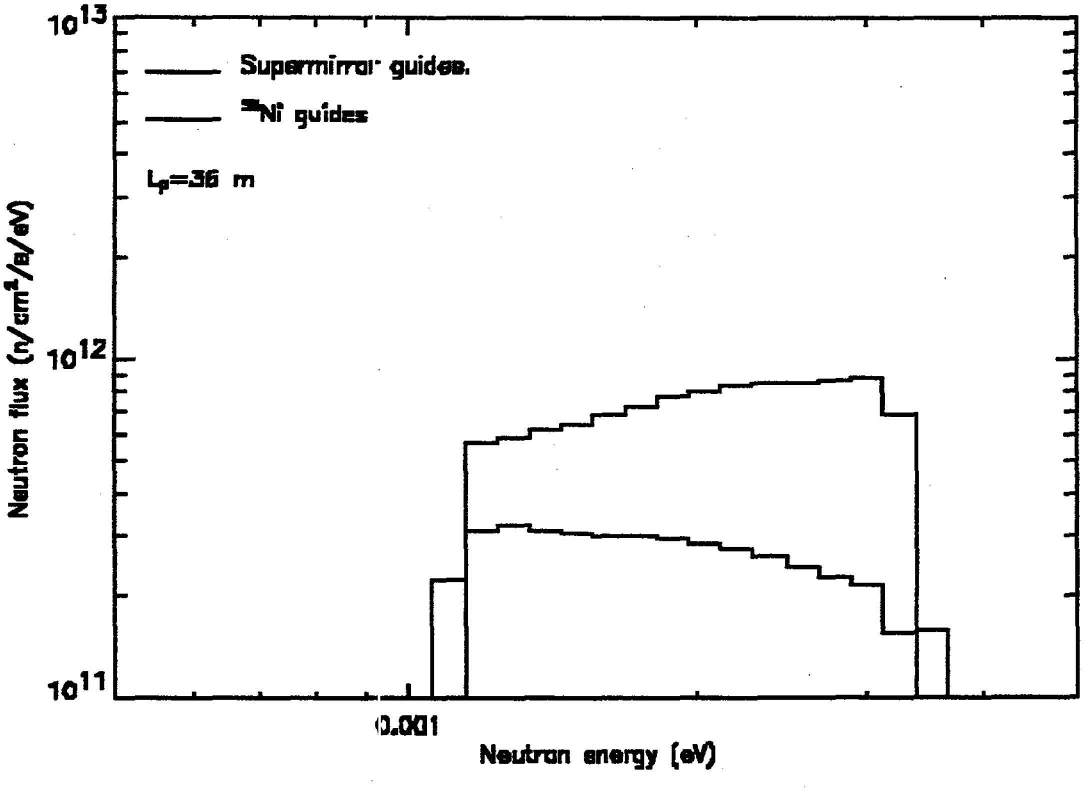

Figure 11 - Comparison of the neutron energy spectra at the end of the converging supermirror guide for a backscattering spectrometer with characteristics similar to that of IRIS with ^{58}Ni guides and supermirror guides. L_P=36 m.

Backscattering angle and secondary flight path length

The choice of backscattering angle has an important impact on the resolution of a backscattering spectrometer. Ideally, the Bragg angle of choice would be 90° ($2\theta = 180°$). But this would require the Bragg-reflected neutron to pass through the sample and would not only restrict (and complicate) the geometry of the secondary spectrometer but mandate the use of another (3rd) chopper just before the sample to distinguish between neutrons scattered directly into the detector and those scattered from the sample and Bragg reflected by the analyzer crystals to the detector. In the IRIS geometry, the detector bank is located a few centimeters below the sample, away from the direct white beam from the moderator. Thus the Bragg angle is necessarily less than 90°. The relative position of the sample and detector then determine the radius of the analyzer bank. More precisely, if the sample is at one of the foci of the Rowland circle and the detector center is located a distance d underneath the sample at the other focus, and if θ is the Bragg angle, the analyzer radius, R, is given - to a good approximation - by $R=d \tan\theta/2$. Table I summarizes R values for various deviations in angle from the exact backscattering geometry. In our simulations we set the detector bank radius at 10 cm. and located its center 7 cm below the sample.

q	R
2.5°	100.0 cm
2°	120.1 cm
1.5°	153.6 cm
1°	220.5 cm
0.5°	421.0 cm

Table I - Analyzer radius as a function of backscattering angle.

Conclusions

All of the simulations to date focused on the PG002 elastic line shape and were meant to explore the basic operating characteristics of instruments viewing coupled and decoupled moderators as neutron sources. Obviously, much more remains to be done to optimize the performance of HERMES: analysis of behavior at longer wavelengths, background calculations, studies of operation in the inelastic scattering mode, investigation of sample size effects, multiple scattering, etc. Some of this work is currently in progress. In particular, we are trying to develop a general model for thermal diffuse scattering that would provide a better representation of the physics of the analyzer crystals. We are also developing generalized sample subroutines that will allow us to explore the details of instrument performance (energy range, energy and momentum transfer resolution, intensity, signal-to-background ratio) more completely.

But even within the limited scope of these studies, it was possible to identify patterns that will be useful guides to further and more definitive design studies for HERMES. It is evident, for example, that an instrument viewing a coupled moderator will be more sensitive than one viewing a decoupled moderator to the choice of such parameters as the length of the primary flight path and the height of the analyzer crystals. It is also clear that the long trailing edge on the pulse produced by the coupled moderator has other effects besides simply broadening the elastic line. More complex data analysis techniques will evidently be required to determine the full extent to which this impacts on instrument performance. The added intensity obtained by switching to a coupled moderator doesn't, unfortunately, simply increase the detected intensity; part of the intensity gain comes about at the expense of broadening and distorting the elastic resolution function. Ultimately, further and more detailed simulations will be needed to determine if a coupled moderator is, or isn't, a good choice for HERMES. On the more positive side, however, it appears evident from the simulations already done that the HERMES analyzer bank could be considerably extended compared to IRIS with a very substantial gain in intensity and without an important loss of resolution.

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1.2.3 Beamline Description and Specifications

Instrument Description

Fig.1 shows the proposed layout of HERMES I on beamline 11a on the LANSCE experimental floor. It will be convenient in what follows to break the project down into five major elements: the choppers, the neutron guide system, the analyzer and detector system, the spectrometer tank assembly (including the beam monitors and beam stop) and the spectrometer control equipment and basic ancillary equipment needed to support the experimental program. In defining the general design parameters of HERMES I our objectives will be to optimize the energy resolution of the instrument over the largest possible momentum transfer range and provide a capability for carrying out studies of the structures and dynamical response of liquids and of diffraction from crystalline materials with large plane spacings. We have therefore designed a spectrometer tank flexible enough to accommodate future upgrades of the spectrometer such as, for instance, the addition of a bank of detectors at 90° for use in high pressure diffraction work and the addition of a polarization analysis capability. Our original assumption was that the instrument would be positioned to view a 25K liquid hydrogen moderator but, as described in the Monte Carlo section, we have also taken preliminary steps to explore the effects of viewing a coupled moderator. Also, as part of the planning process we either examined (or plan to examine) the relative effectiveness of different neutron guide coatings, analyzer crystals, detector types and locations and considered what would have to be done to add a polarization-analysis capability. It is important to add that in determining what features the instrument ought to have to be of greatest use to the scientific community our approach was to refer, where relevant, to the design of the IRIS spectrometer, the plans for the new OSIRIS instrument and the conceptual design study described in the LANL internal report mentioned in the introductory section and to supplement this basic perspective with our own assessment of current (and future) trends in research.

Below we give brief descriptions of each of the basic elements of the proposed HERMES spectrometer. This section is followed by section in which we give detailed estimates of the costs associated with design, construction and installation. Where possible, the estimates were derived from an average of four independent sources of information: (i) vendors, (ii) the RAL IRIS/OSIRIS experience, (iii) the PHAROS experience and (iv) personal knowledge of the costs associated with constructing and operating beamlines at other facilities.

1.2.3.1 Moderator

Based on the Monte Carlo simulations described earlier, our preliminary assessment is that an uncoupled moderator on beam path 11a is probably a better choice for the HERMES I spectrometer. We are aware that by using a coupled moderator and employing fast (counter rotating) choppers it would be possible to build a more versatile, variable-resolution instrument. While this is no doubt an attractive option, we believe that it would be more appropriately addressed after obtaining operating experience with a simpler, less-costly, updated IRIS-like spectrometer. Among other concerns, we note that an instrument which looks at an uncoupled moderator needs to have a flight path on the order of 10 meters longer (40 meters total length) to take fullest advantage of the higher flux without compromising resolution. This would probably mean relocating HERMES I on beamline 10 which would require the disassembly and relocation of the small angle scattering spectrometer. We believe that this alone could add as much as $1000 K to the cost of the project. On the other hand, the LANL management may wish to consider other moderator choices for beam path 11, for example, by using a liquid hydrogen-pelletized methane moderator, it should - at least in principle - be possible to produce pulses ~125 μsec in width with about three times the flux obtained from the uncoupled liquid hydrogen moderator.

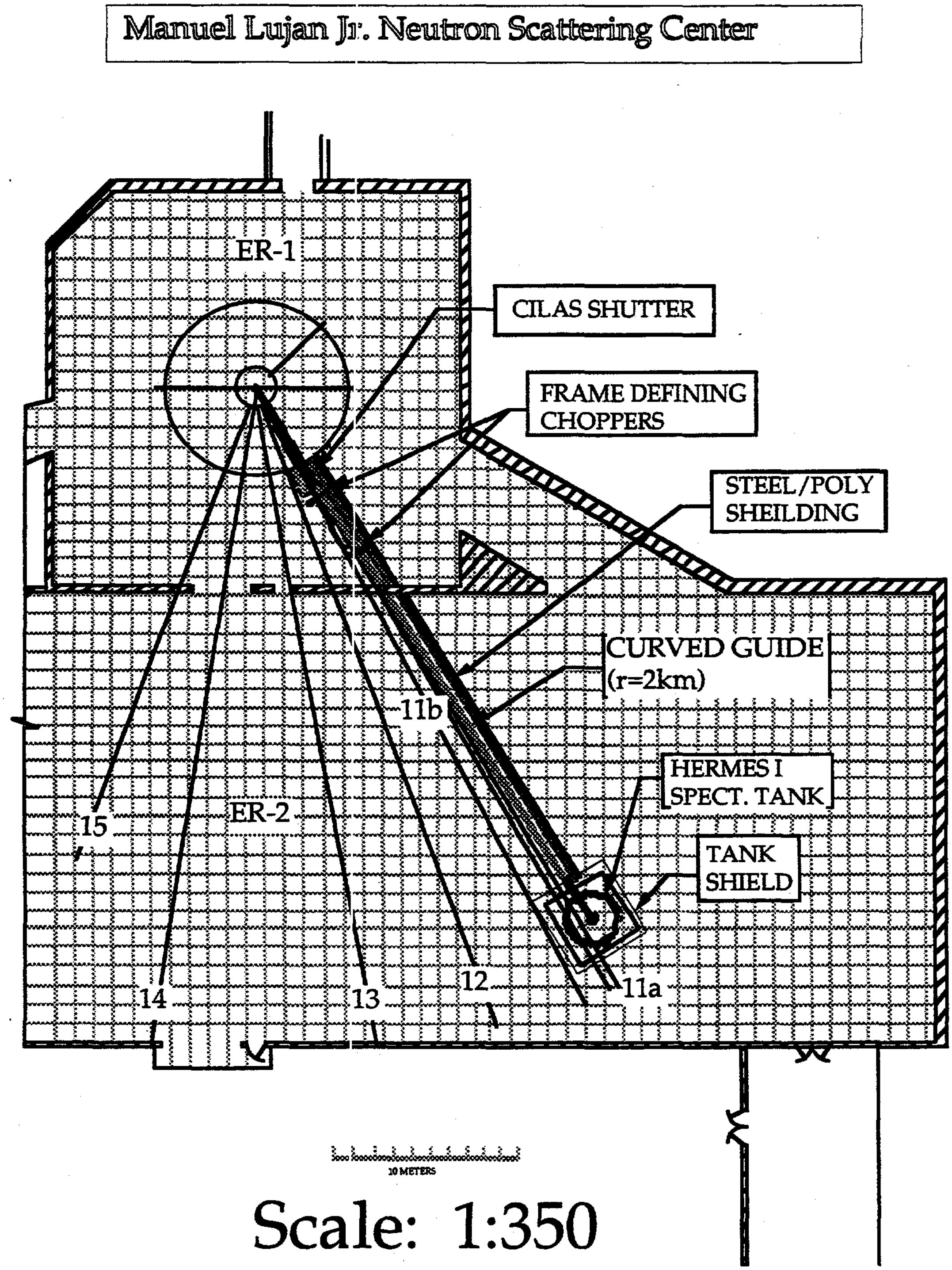


Figure 1 - Proposed layout for HERMES I

1.2.3.2 Flight Path

Neutron Guides and Shielding

To deliver the highest flux of neutrons from the liquid hydrogen moderator and, at the same time, achieve the desired energy resolution (see the instrument layout below), a guide will be needed to transport the neutrons from the source to the sample position about 30 m from the moderator. We propose using a curved guide with a radius of curvature of about 2 km. Some of the possible neutron optics options related to the guide system have been explored with Monte Carlo simulations but no final decision has yet been made as to whether it should have ^{58}Ni or supermirror coatings. Nonetheless, some of the parameters of the guide system can be specified at this time. Altogether, the guides should define a (curved) beam path somewhat more than 30 m long contained within an evacuated (and shielded) flight tube. Significant amounts of steel, boron and hydrocarbon material will need to be incorporated into the shielding. Also support stands with alignment fixtures will have to be provided for each guide section. Two cost estimates are given: one for ^{58}Ni and the other for supermirror coatings. Neither estimate makes allowance for either the possibility of introducing guide sections with curved surfaces or for the (more likely) possibility that a converging guide would be installed at the terminal end of the system. The estimated cost of the guide, vacuum flight tube and shielding is $30 K/m for ^{58}Ni and $35 K/m for supermirror guides. Hence for 35 m of neutron guide the net price should fall somewhere between $1.05 M and $1.225 M. The support stands, alignment fixtures and vacuum pumps can be expected to add an additional $15 K.1.2.3.3

1.2.3.3 Shutter and Beam Stop

Some years ago, a dual shutter insert was purchased by LANL for use at beam path 11. Our choice would be to use this as the HERMES shutter if it could be fitted with internal $3\theta_C$ supermirror guides. We plan to explore the feasibility of such retrofit with the OSMIC company in the near future. For this reason our shutter cost estimate contains a large contingency. As for the beam stop, it should be noted that we plan to mount a transmission monitor in it at the same distance downstream from the sample as the sample-to-detector distance in the backscattering section. Apart from this monitor, the beam stop will be a conventional construction item.

1.2.3.4 T_0 Chopper

Because space is at a premium in the region of ER-1 where beam path 11a exits from the biological shielding and because we are planning to use a curved guide together with a pair of frame defining choppers (which, we believe, will be sufficient to keep the background from "prompt " fast neutrons to a minimum), we are not currently planning to use a T_0 chopper. But if it becomes evident that there is both adequate room for such a chopper and a necessity to have one then we would expect to construct one similar to those presently in use at, for example, beam path 16.

1.2.3.5 Frame defining Choppers

The two variable-aperture disk choppers positioned sequentially along the neutron guide are basic, beam-defining elements of the spectrometer. Their purpose is to reduce the background due to fast neutrons, define the wavelength band of neutrons incident on the sample and eliminate frame overlap at the sample position. Together they function as a "variable bandpass filter" that determines the accessible energy transfer range. It is likely that the choppers would be similar in design to those used at ISIS and would be constructed by the SDT. Relatively simple in concept, each would consist of a pair of concentrically-mounted, boron-carbide-coated aluminum disks with a wedge-shaped sections removed. Adjustment of the widths of the beam-defining apertures would be done remotely by rotating the disk pair relative to one another. Our plan is to drive the choppers electronically with variable-speed DC servo motors operated with commercial speed controllers. Steps will be taken to construct a user-friendly computer interface to control their relative phasing thus assuring that changes of the energy transfer range could be easily made by users.

1.2.4 Spectrometer Description and Specifications

1.2.4.1 Spectrometer Tank and Shielding

The HERMES I analyzer tank (see figure below) will be a vacuum vessel fabricated from non-magnetic stainless steel (to avoid jeopardizing the future addition of a polarization analysis capability). The cryogenically-cooled, crystal analyzer banks will be mounted on its base. There will be a sample well at the top of the vessel (with the standard Lujan Center sample configuration) to provide easy experimental access for samples. We visualize the vessel as an octagonal chamber with an inscribed inner diameter of 2.4 m and a height of approximately 1.3 m. Each face will have an oval-shaped, o-ring-sealed access port, approximately 0.76 m wide and 1 m high. The ports are expected to serve many purposes:

- Allow access to the internal spectrometer volume at many convenient locations
- Allow for the future upgrades of the instrument such as additional detector banks at 90° for high pressure work
- Increase the structural integrity of the vessel and simplify manufacture
- Provide convenient locations to mount ancillary equipment such as vacuum pumps, electronic feed thrus, diagnostic equipment etc.
- Allow for easy interchange of ancillary equipment.

The backscattering detector bank will be mounted in such a way that it can be removed from the bottom of the chamber (for trouble shooting or maintenance) without breaking the main chamber vacuum. Our intention is to have a network of precisely located, tapped holes on the inside of the vessel (on the base plate, interior walls and ceiling) so that items such as detector banks, beam monitors, collimators, filters etc. can be easily mounted. Also the oval port flanges will be fitted with connections for main vacuum pumps, beam monitor and beam stop. A cantilevered support structure for the vacuum tank will be installed so that its base (on which the crystal analyzer banks are mounted) can be removed without moving either the guide or the shielding blockhouse.

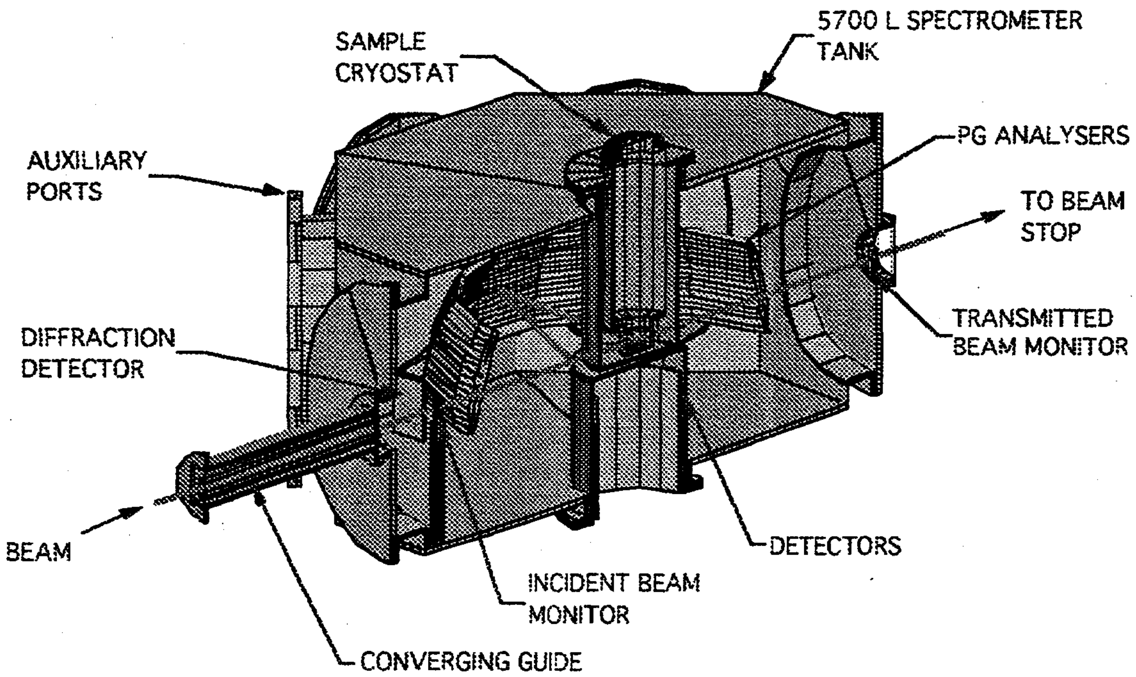


Figure 2 - The HERMES I Analyzer Tank

1.2.4.2 Backscattering Section

For inverted geometry spectrometers, the energy is defined after scattering by the sample takes place. The energy discrimination is made using an array of crystal analyzers that monochromatize the scattered neutrons, sending them back to the stationary detectors. The high energy resolution is achieved by locating the detectors close to backscattering. The energy resolution ($\Delta E/E$) is given by the convolution (¤) of several terms:

$\Delta E/E \sim 2\ [\Delta t_{mp}/t]\text{¤}[\ \Delta d/d]\text{¤}[\ \Delta\theta \cot\theta]$

where Δt_{mp} is the width of the moderator pulse, t, is the time of flight from moderator to detector, $\Delta d/d$ is the uncertainty in the lattice spacing of the analyzer crystal, θ is the Bragg angle, and $\Delta\theta$ is the overall uncertainty in the Bragg angle. Examination of the expression above suggests that the cot θ term has a dramatic effect on the energy resolution tending to zero as θ->90°. For optimum performance it is important to match the energy resolution of crystal analyzer or secondary spectrometer to that of the primary spectrometer (i.e. the region before the sample). Thus the crystal analyzers can be operated slightly off perfect backscattering. As mentioned above when all of the effects of the primary and secondary instrument are considered (for PG(002)) an energy resolution of about 18 μeV is realized using a Bragg angle of 87.5°. The momentum transfer range ΔQ is defined by the angular range covered in the scattering plane. Maximum coverage of the scattering plane with crystal analyzers is necessary in order to access both the low Q and to reach an acceptable high Q value. For example using the PG(002) analyzer energy of 1.82 meV neutrons and energy transfer range ΔE of -.8 to 10 meV can be acchievedand spanning an angular range of 5° to 160° in 2θ with the analyzer bank a ΔQ range of 0.1 to 1.80 Å is achieved.

1.2.4.2.1 Analyzer Sections

In our view, the most critical part of a CBS is the crystal analyzer bank which, as noted, has to be cooled to temperatures near 4K to minimize background. Pyrolytic graphite (PG), mica (M) and elastically deformed silicon (Si) crystals are all under consideration as possible analyzers. We propose a "torispherical" analyzer section containing an array of 5000 individual crystals positioned 85 cm from the sample. The array would have an overall height of about 30 cm and would cover a scattering angle range of approximately 165° in 2Θ. Each crystal would be aimed to reflect neutrons scattered by the sample to a custom-made, cylindrical ^{3}He gas wire detector underneath it. The detector would be mounted below the sample well and positioned to accept neutrons reflected from the analyzer crystals at an angle of about 175°, i.e. as close to the backscattering direction as possible. The user would be able to position either a movable, multibladed collimator or a beryllium filter between the detector and the crystal analyzer array for quasielastic scattering studies. Optimum performance may require that fixtures for individual crystal alignment be incorporated into the array support structure. Ultimately, two different crystal analyzer banks would be installed, one on each side of the sample. Our current thinking is that one would employ PG (providing 15-18 μeV resolution) and the other would use either M or Si (to provide 1-5 μeV resolution).

1.2.4.2.2 Detector/Electronics Assembly

Detector Construction

Gas multiwire proportional detectors, with their large dynamic range, are a good choice for the HERMES spectrometer. We propose using a detector of an advanced design employing technology developed by the Instrumentation Division of Brookhaven National Laboratory, a group that has extensive experience in the design and construction of ^{3}He gas wire proportional detectors. The device under consideration is a single unit detector package in the form of a truncated cone, which would sit below the sample plane. A multiwire proportional chamber with cylindrical symmetry, it would replace the usual arrangement of individual gas tubes increasing the efficiency of detection by about 25%. The basic layout would be as follows. The multiwire structure proper consists of a rear cathode wire plane, an anode wire plane, and a front cathode spaced about 3 mm from each other. The anode wires are vertical with a diameter of 15 microns and a pitch of about 6 mm; of order 100 anode wires are required to form the entire arc. For the cathode planes 50 micron wires are used. They have the same pitch as the anode wires. There is a drift space both behind and in front of the multiwire structure. At the back and front of the detector, the gas volume is enclosed by aluminum covers curved to form a truncated cone that provides a constant (radial) gas depth of 1.4 cm. This design, with the anode wire plane midway between the front and back detector wall, minimizes the overall electron drift time. Being approximately 6 mm thick, the front aluminum cover provides adequate strength for high pressure operation and at the same time transmits more than 90% of the incident neutrons. If higher count rates are encountered, or higher spatial resolution is needed it is possible to insert a second anode wire plane concentric with the first, together with one more cathode wire plane (one of the existing cathode planes is then common to the two anode planes). The entire electrode structure is immersed in a mixture of ^{3}He gas and a suitable quench gas such as carbon tetrafluoride. ^{3}He has an extremely high cross-section for thermal neutron absorption (about 9,000 barns at 3 ≈). The interaction produces a proton- triton pair:

$$n + 3He = p + 3H + 0.764 \text{ MeV}.$$

The primary ionization produced by the proton and triton drifts towards the nearest anode wire where multiplication occurs in the high electric field near the anode wire surface. Because of the large primary ionization, only a relatively low gas gain (about 10) is needed. In certain circumstances, it may even be possible to operate in the ionization mode. (A combination of low gas gain and very pure gas is essential for the longevity of the detector.)

Processing of Anode Signals

Each anode wire is, in effect, a detector and is read out by a preamplifier/shaping amplifier combination. The continuous gas volume that exists around the circumference of the detector not only increases the overall detection efficiency (compared to an equivalent array of proportional counter tubes) but also reduces the number of neutron events whose total energy deposit in the detector is reduced by "wall effects". In a continuous volume detector it is more likely that protons or tritons, which would have lost part of their energy in the wall of a conventional tube will spread this energy across adjacent anode wires. (The signal encoder is designed to add simultaneous signals from adjacent channels and thus generate a signal amplitude corresponding to the full charge of the proton/triton. A relatively simple logic is used to interrogate all possible pairs of adjacent channels to identify such events.) This mode of operation reduces the loss of sensitivity arising from threshold effects.

Gas Pressure and Purity

An operating gas mixture of 7 atm of ^{3}He and 2.5 atm of quench gas is used to obtain a high detector efficiency. (The quench gas limits the range of the proton and triton produced in the nuclear reaction, minimizing wall effects and those events in which primary charge is shared between adjacent anodes; i.e. events which , in any case, would be correctly analyzed as noted above). For reliable operation it is important to keep the helium-quench mixture as pure as possible. Because of the high cost of ^{3}He (nearly $150 per liter) it is normal practice in such detectors to operate them with a closed circulating system that contains a gas purifier with an oxygen absorber and a molecular sieve to absorb water vapor. A small pump circulates the gas at about 1 liter per minute, which is adequate for all normal operating conditions.

1.2.4.2.3 Collimator

There are modes of spectrometer operation in which Soller-type collimators will be needed in both the sample-to-analyzer and the analyzer-to-detector flight paths. We envision these as movable collimators, probably with gadolinium-coated, stretched-mylar blades. They will be mounted in a rotating assembly along with a Be filter which could alternatively be inserted in the sample-to-analyzer flight path.

1.2.4.3 Long Wavelength Diffraction Section

As mentioned above, a significant advantage of a white-beam crystal-analyzer-type instrument is that a diffraction pattern can be simultaneously recorded from a sample in conjunction with an inelastic investigation. We plan to locate a bank of detectors near the backscattering direction in the same plane as the crystal analyzers. If funding permits we would also like to construct a portable bank of detectors which could be moved to different locations within the scattering chamber (e.g. at 90° to the incoming beam or in the near-forward direction) for use in small angle scattering experiments or to investigate samples at high pressures. (It is important to keep in mind that a pulsed source diffractometer operates with the scattering angle 2Θ held fixed; the wavelength is varied by time-of-flight to cover the range of wave vectors of interest for a given system. For a crystalline powder sample with plane spacings, d, Bragg's Law becomes:

d= hT / (2 Π Lsin Θ)

where h is Plank's constant and T is the flight time for the path length, L. Thus in a pulsed source diffractometer, the range of flight times determines the range of accessible d spacings.) Long wavelength neutrons have been used at ISIS to study magnetic systems and other systems with large repeat distances. It is planned that a gas-wire chamber area detector be installed in the vacuum tank for this purpose at some future time.

1.2.4.3.1 Detector Assembly

At this time we intend to construct the bank of diffraction detectors using the same ^{3}He gas wire technology described above. In this case, however, a rectlinear arrangement of detector wires will be used very much like a side-by-side group of commercial ^{3}He is used on the powder diffraction instruments already at the Lujan Center. This bank of detectors will be located in the near backscattering position as shown schematically in the spectrometer tank diagram above. This bank will be mechanically similar to those detectors previously constructed by the BNL group for use at the HFBR, so reasonably rapid production should be possible.

1.2.4.4 Sample Region

As noted above, the sample chamber of HERMES I will be designed to conform to Lujan Center standards; i.e. a 75 cm diameter opening at a height of 60 cm above the center line of the incoming neutron beam. This configuration will match the NPD and PHAROS sample chambers and permit sample environment (SA) equipment to be easily moved from one instrument to another. The walls of the sample chamber will constructed of aluminum and be machined so that they are thin in the region traversed by the beam. Care will be taken to design the beam window region carefully since the integrity of the vacuum tank is extremely important to the operation of HERMES. Clearly a loss of vacuum would have a catastrophic effect on the analyzer crystal bank which operates at cryogenic temperatures.

1.2.4.5 Ancillary Equipment

Included under the heading of ancillary equipment are the sample goniometer, temperature controllers, a pumping station with a turbo pump, assorted vacuum/pressure gauges and sensors, a sample environment (helium cryostat, displex, gas handling system and furnace) and a crane to be used to move heavy equipment on and off the spectrometer.

1.2.4.5.1 Cryogenic Equipment

For diffraction experiments involving temperature-driven phase transitions, it will be important to have an APD displex system capable of operating between 6.5K and 350K with a cooling capacity of 0.5W @ 8K and 2.5W @ 20K and with a cool-down time of less than 60 minutes. For lower temperature (below 6.5K) a liquid He cryostat (50mm ILL) with an operating range of 2.2-320K will be needed. Also an Oxford Kelvinox dilution refrigerator will be required if the temperature range below 2.2K is to be experimentally accessible. All of these refrigerators will be equipped with multiple types of electrical and capillary feed-thrus to accommodate as many different kinds of experiments as possible.

1.2.4.5.2 High Temperature Equipment

We propose to provide a high temperature capability with two types of furnaces: a vacuum mirror furnace capable of 2000°C and a standard wire element vacuum furnace for lower temperature investigations. Both furnaces would be available for studies of high temperature phase transitions and melting processes.

1.2.4.5.3 Gas Handling Equipment

A gas handling System (GHS) capable of application to high resolution vapor pressure isotherm measurements and other thermodynamic studies is proposed for *in situ* sample studies. It will be designed to be totally interfaced with the graphic user interface (GUI) control system.

1.2.4.5.4 Temperature / Pressure Control / Regulation

We propose to control the refrigerator systems with commercial cryogenic temperature controllers completely interfaced to the GUI control system. Among such controllers would be the Conductus LTC-10 and LTC-21 and the RV-Elecktroniikka TS-530 (for low temperature work). Pressure control and regulation of the gas handling system will be done with capacitance manometers from MKS. (Many of the GUI interfaces and routines have already been written and are in use at BNL)

1.2.5 Instrument Platform and Crane

Provision must be made for the safe and efficient movement of ancillary equipment to and from the sample access well. HERMES I will therefore require a carefully designed instrument platform and sample loading, exchange and staging areas. An overhead crane for the spectrometer should be installed early in the project since it will be needed for the installation of the vacuum tank, its associated shielding and related components. The crane will also be essential for efficient day-to-day operation of the facility. It is our intention to use the roof of the shielding blockhouse (constructed from interlocking, double walled steel rectilinear forms filled with a polymer-boron mix) as the sample loading platform. Personnel access to this area would be by a flight of steel stairs. Experimental components (cryostats, ovens, displexs etc.) and other ancillary equipment would be moved to and from the floor with a dedicated boom crane.

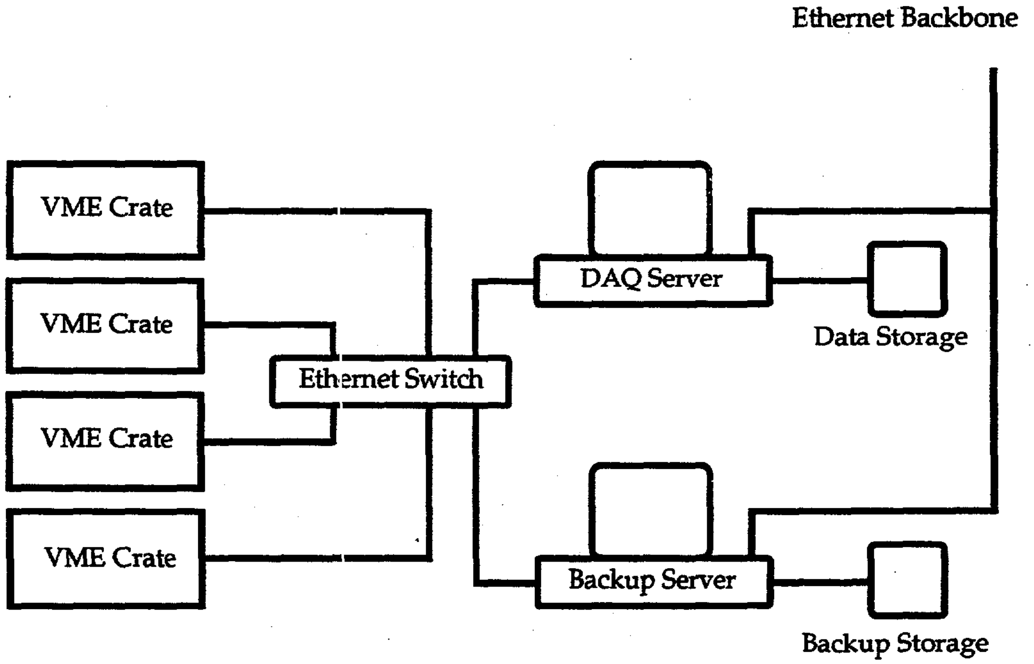
1.2.6 Spectrometer Control System

It is anticipated that a GUI-based operating system such as the LABVIEW commercial software from National Instruments running on a commercial PC system will be used to operate HERMES. Because the spectrometer control system will allow both local and remote operation, it will be necessary to have password protection to assure that only valid users have access to the system. Reliable, remote access systems of this kind are commercially available. In all likelihood the spectrometer control system program will be written by post-docs associated with the project. Initial development of a user- friendly operating system is anticipated to take about one year with upgrades being made on a more or less continuous basis throughout the project. Integration of the HERMES control system with the computing environment of the Lujan Center will be by standard network connections. Data will be stored on local disks in a hierarchical data format (HDF). In addition to operating the spectrometer and doing on-line preliminary data reduction, the resident computer will be interfaced to a variety of electronic devices, e.g. temperature controllers, pressure gauges, gas handling devices, etc., using standard serial and parallel connections.

1.2.6.1 Data Acquisition system

As was described above HERMES I will use at least two different types of ^{3}He gas wire proportional detectors. The proposed data acquisition system will conform to the standards developed at the Lujan Center. It will need to be able to record, process and store a time sliced record of detected neutron counts from both the ^{3}He cylindrical detector system and a bank of diffraction detectors located in the near backscattering position.

The proposed system for HERMES I (shown schematically) will consist of 4 VME crates each with a Motorola PowerPC 2600-1 200MhZ processor used as the system controller. The operating system running in the PowerPC will be the VxWorks real-time Tornado development environment for embedded processing from Wind River Systems. This system is a standard for data acquisition in high energy and nuclear physics. It was also used on the recent NASA Pathfinder mission to Mars proving its complete remote operation capabilities and reliability.



The data acquisition server will consist of a computer which will be the platform for developing the VxWorks code to be loaded into the PowerPC system controllers. It will also handle storage of the detector histogram data in the form of an appropriate hierarchical detector file (HDF). All control of the experiment settings will be performed using a graphical User Interface system like the commercial code LabView available from National Instruments. Auxiliary experimental equipment can be controlled via GPIB, serial RS232 or IE488 connections. Access to the data can also be provided using a browser such as Netscape running JAVA based code so that the experiment can be monitored or controlled from any location. It is anticipated that the system will be password protected for security during individual experiments. The server will also maintain all databases required for run control and experimental settings. Backups will be performed by a second backup server.

Communications between the crates and the data acquisition server will be performed over 100MhZ ethernet with a switched interface. This arrangement will provide more bandwidth than will be required for the expected data rates of 12.8 Mbytes/second peak for 32 detectors readout with a 10 μsec time slice interval after receiving and delaying the t_0 signal from LANCE. This represents an upper limit and is well below the maximum of the 20 Mbyte/second limit of VME. The actual pulsed data will be smaller because the data collection window will be determined by the chopper settings. Therefore time slices as low as 1 μsec will be possible. The front end electronics for the detectors will consist of one STR7200 32 channel 200MhZ VME based scaler with a 64Kbyte deep FIFO per crate. The data will be stored in a STR722 VME histogramming memory unit. This unit allows dual ported memory access so that the unit can be read while counting. The data can be monitored and updated on the data server computer while the experiment is collecting additional data. All of these modules are commercially available from Lecroy Research. The complete system can be built with 'off the shelf' hardware.

1.2.6.2 Graphical User Interface (GUI)

The operation of the HERMES I spectrometer is expected to be user friendly. We intend to develop an operating system which employs commercial code like LABVIEW from National Instruments in order to computer control instrument (this will include remote access like using a web Browser. Wherever possible commercial code and standard parts will be used to run HERMES I. The PI and his group have designed, developed and implemented several LABVIEW based neutron instruments including the operating system for TAMPA, and the HRNPD. These programs have been running for more than a year without problem,

1.2.6.3 Local Computer Architecture

The data acquisition server (DAS) will tentatively be a commercial PC capable of running Microsoft Windows NT and compatible with the use of the LABVIEW software. Two network adapters are needed; one to communicate with the VME crates (100 Mbit/s) and another for the Internet connection. Additional modules (i.e. serial and parallel cards, A/D converters and other DAQ cards) will be procured for communication with peripheral instruments as required. The DAS will perform the following functions: monitor and control the spectrometer, the chopper motor speed and phasing, the sample environment, and the data acquisition system. The DAS will also store the properly formatted hierarchical data files (HDF) and write that information to a local disk. It will also communicate with the archive server at the Lujan Center of the location of the files so that it can be archived automatically. A standard data compression algorithm will be used to reduce the size of the storage devices.

1.2.7 Data Analysis

Data analysis is another area where HERMES I benefits from the efforts made at ISIS for its predecessor IRIS. It is expected that one of the RA's associated with the project will be responsible for the design and development of the GUI based operating system and will be responsible for the data analysis packages, The SDT will benefit greatly from the assistance of D. Sivia from ISIS with the development of a suitable line fitting and the data analysis with a Labview data collection system. The analysis software package can use the current IRIS package as a starting point.

1.3 PROJECT COST & SCHEDULE

1.3.1 HERMES I Proposal Options

The HERMES I Project is proposed under three different scenarios or options. For these three options, the technical scope and technical delivery of the project remains unchanged. The differences in alternatives is the funding strategy, the timing of the release of funds, as well the amount of the fund release for HERMES I design, procurement, and installation. The Options are as follows:

1. BNL Accelerated Option with Early Start Funding and BNL Contributions
2. BNL Accelerated Option with Leveled Funding Requirements and BNL Contributions
3. Level of Effort Option without BNL Contribution

The BNL contribution includes labor to proceed with detailed design during the period before a decision is made about the restart of the HFBR. A table with the three options and the summary cost and schedule output for each option is presented in Table 1.3.1.

1.3.1.1 Option 1: BNL Accelerated Option

The BNL Accelerated Option is based on an "early start" schedule with no funding constraints. An Early Start Schedule is defined as project scope activities occurring as early as possible in the schedule without constraint. Labor contributions are made by BNL in order to proceed unimpeded with Conceptual and Detailed Design. Conceptual Design continues from the time of proposal submission and Detailed Design commences also with BNL contributed labor. The first fund requirements are 10/1/98 (FY 99) where procurement orders are released for all contracts, equipment, and material ($3,476,900).

Major Assumptions for this alternative are as follows:

- Conceptual Design will continue from proposal issuance to Proposal Presentation.
- Proposal presentation to LANCE/DOE is assumed to be Mid-March 1998.
- There will be sufficient indication from presentation that Detailed Design can and will proceed at that time.
- Release of funds required for procurement of all equipment and project support of procurement initiatives will be available on 9/30/98 for FY 99 operation.

- Responsibility for design, procurement, fabrication, and testing is per the assignment of responsibility project matrix.
- Installation and commissioning occurs over a 23month window. The schedule does not currently include LANL installation interfaces. The schedule will be subsequently adjusted for the LANL/BNL coordination efforts.

The scheduled operation date under this scenario is June of 2001 at a cost of $4.6M.

TABLE 1.3.1: HERMES PROJECT COST & SCHEDULE

	OPTION 1: ACCELERATED		OPTION 2: LEVEL FUNDING		OPTION 3: LEVEL OF EFFORT	
SUMMARY TASKS	SCHEDULE COMP. DATE	PROJECT COSTS	SCHEDULE COMP. DATE	PROJECT COSTS	SCHEDULE COMP. DATE	PROJECT COSTS
CONCEPTUAL DESIGN	7/3/98	$0	7/3/98	$0	3/18/99	INC. IN DETAILED DESIGN
DETAILED DESIGN	4/2/99	$93,923	4/2/99	$93,923	12/16/99	$259,961
PROCUREMENT	8/14/00	$3,476,900	3/1/01	$3,476,900	4/26/01	$3,602,000
INSTALLATION/TESTING	6/6/01	$403,442	12/21/01	$505,903	2/14/02	$730,557
PROJECT MANAGEMENT	6/6/01	$576,503	12/21/01	$688,357	2/14/02	$893,734
HERMES OPERATIONAL	6/6/01		12/21/01		2/14/02	
CONTINGENCY:		$563,555		$602,703	$27,668	$671,207
1) DESIGN: 15%		$14,088		$14,088	$10,912	$38,995
2) PROCUREMENT: 10%		$347,690		$347,690	$3,701	$360,200
3) INSTALLATION: 25%		$144,126		$172,089	$9,325	$182,639
4) PROJECT MGMT: 10%		$57,650		$68,836	$3,730	$89,373
TOTAL COSTS:		$5,114,323		$5,367,786	$249,329	$6,157,460
FY 98		$25,684		$30,169		$0
FY 99		$3,723,354		$2,283,992		$2,338,447
FY 00		$537,592		$1,660,692		$1,880,008
FY 01		$264,139		$700,693		$1,098,757
FY02		$0		$89,538		$169,212

1.3.1.2 Option 2: BNL Accelerated Option with Level Funding

The BNL Accelerated Option with Level Funding is also based on an "early start" schedule. Fund requirements are "spread" to conform to an annual ceiling of $2.3M. Labor contributions are also made by BNL in this alternative in order to proceed unimpeded with Conceptual and Detailed Design. Conceptual Design continues from the time of proposal submission and Detailed Design commences also with BNL contributed labor. Procurement of contracts, equipment, and material are constrained by FY 99, and FY 00 ceilings. In FY 99, procurement orders are placed for Choppers, the Neutron Guide System, and the Spectrometer Tank Assembly. The Analyzer and Detector procurements are delayed until FY 00 funding is made available.

Major assumptions for this alternative are as follows:

- Conceptual Design will continue from proposal issuance to Proposal Presentation.
- Proposal presentation to LANCE/DOE is assumed to be Mid-March 1998.
- There will be sufficient indication from the proposal presentation that Detailed Design can and will proceed at that time.
- Release of funds for Fiscal Years assume the following Cash Flow:

FY 99:	$2,300,000.00
FY 00:	$1,700,000.00
FY 01:	$700,000.00
FY 02:	$100,000.00

- Responsibility for design, procurement, fabrication, and testing is per the assignment of responsibility project matrix.
- Installation and commissioning occurs over a 14month window. The schedule does not currently include LANL installation interfaces. The schedule will be subsequently adjusted for the LANL/BNL coordination efforts.

With procurement schedule concessions made, the fund profiles for fiscal years stay within a $2.3M ceiling. The project schedule is impacted by 6 months at an additional cost of $200k

1.3.1.3 Option 3: Level of Effort Option with Level Funding

The Level of Effort Option is presented and is based on both BNL labor fund constraints in addition to modified fund level assumptions. Balance of Conceptual Design and Detailed Design is not contributed by BNL and is constrained by the release of FY 99 dollars (10/1/98). Fund requirements are "spread" to conform to an annual ceiling of $2.4M. Procurement of contracts, equipment, and material are also constrained by FY 99, and FY 00 ceilings. In FY 99, procurement orders are placed for Choppers, the Neutron Guide System, and the Spectrometer Tank Assembly. The Analyzer and Detector procurements are also delayed until FY 00 funding is made available.

Major assumptions for this alternative are as follows:

- Proposal presentation to LANCE/DOE is assumed to be Mid-March 1998.
- Conceptual Design will continue after FY 99 funding is made available (10/1/98).

  Release of funds for Fiscal Years assume the following Cash Flow:

FY 99:	$2,338,447.00
FY 00:	$1,880,008.00
FY 01:	$1,098,757.00
FY 02:	$169,212.00

- Responsibility for design, procurement, fabrication, and testing is per the assignment of responsibility project matrix.
- Installation and commissioning occurs over a 19month window. The schedule does not currently include LANL installation interfaces. The schedule will be subsequently adjusted for the LANL/BNL coordination efforts.

With BNL contributions and procurement schedule constraints imposed, the project schedule is impacted by an additional 3 months (compared with Option 2) at an additional cost of $1.2M.

1.3.2 Project Cost Summary

Project Costs for each of the three options are identified here. The estimated costs are in a "definitive" category, which means the level of confidence in the overall estimate is within +/- 20% at this stage of development. Contingency values have been assigned at 15% for design, 10% for procurement, 25% for installation, and 10% for project management.

Total costs for each of the options are:

- Option 1: $5,114,323
- Option 2: $5,367,786
- Option 3: $6,157,460

Project contingency ranges from $560k to $671k between the three options. Project costs and resources have been loaded in the Microsoft Project Schedule (excluding contingency) and will continue to be refined and adjusted based on project baseline progress. The project schedule attachments in section 1.3.6-1.3.6.8 include the current cost loading for the project. (See Appendix B: Section 1.3.2)

Table 1.3.2: Project Cost Summary

	OPTION 1: ACCELERATED WITH BNL CONTRIBUTION	OPTION 2: LEVEL FUNDING WITH BNL CONTRIBUTION	OPTION 3: LEVEL OF EFFORT WITH NO BNL CONTRIBUTION
SUMMARY TASKS	PROJECT COSTS	PROJECT COSTS	PROJECT COSTS
CONCEPTUAL DESIGN	$0	$0	INC. IN DETAILED DESIGN
DETAILED DESIGN	$93,923	$93,923	$259,961
PROCUREMENT	$3,476,900	$3,476,900	$3,602,000
INSTALLATION/TESTING	$403,442	$505,903	$730,557
PROJECT MANAGEMENT	$576,503	$688,357	$893,734
HERMES OPERATIONAL			
CONTINGENCY:	$563,555	$602,703	$671,207
1) DESIGN: 15%	14,088	14,088	38,995
2) PROCUREMENT: 10%	347,690	347,690	182,639
3) INSTALLATION: 25%	144,126	172,089	223,434
4) Project Mgmt: 10%	$57,650	$68,836	$89,373
TOTAL COSTS:	$5,114,323	$5,367,786	$6,157,460
FY 98	$25,684	$30,169	$0
FY 99	$3,723,354	$2,283,992	$2,338,447
FY 00	$537,592	$1,660,692	$1,880,008
FY 01	$264,139	$700,693	$1,098,757
FY 02	$0	$89,538	$169,212

1.3.3 Project Cost Control

During a time where dollars for program research are shrinking and competing with Environmental, Health, and Safety (ES&H) Project Initiatives, it is imperative that immediate identification and control of project costs to the approved baseline be established and maintained. The Project Execution Plan (Baseline) will establish Organizational Breakdown Structure (OBS) management of funds for Work Breakdown Structure (WBS) project activities. In most projects, the ability to influence costs decreases as a function of project time. SDT Comprehensive involvement in Detailed Project Planning, accurate design which minimizes contract change, and scope change management during the early phases of the project will effect the biggest reductions in project cost. However, cost control and attention to cost and schedule detail is constant throughout the project and is supported by the level of Project Management Support and expertise identified for this project.

Monthly cost performance will be evaluated against the baseline budget using Actual Cost of Work Performed (ACWP) compared to BCWP/BCWS for all Work Breakdown Structure Categories. Variance analysis and identification of trends in scope, schedule, and cost, are exercised in the project management plan via scope control (Work Breakdown Structure Dictionary), and accurate project forecasts for costs and schedule. Accrual accounting will be used to the maximum extent feasible to ensure timely costing of completed incremental work. Cost variances above the reporting thresholds will be reported monthly with proper corrective action plans.

1.3.4 Summary Cost Assumptions

The following summary assumptions and clarifications apply to all three proposed options:

The cost estimates for procurement activities are in 1998 dollars. BNL support staff dollars assume a 4.5% salary esculation factor (includes fringe) for design, project management, and installation support.

The estimated total overhead for labor ($ 1.2 M) and procurement ($ 300 K) is not included in the costs identified in the project summary.

1.3.5 BNL Contributions to HERMES I Project

BNL is committed to providing a world class instrument at the LANL facility. In "going the extra mile" BNL is committing resources and equipment in an effort to reduce the overall cost of this project. The BNL contributions are summarized by WBS categories as follows:

BNL CONTRIBUTIONS BY PROJECT WORK BREAKDOWN STRUCTURE	BNL LABOR / MATERIAL CONTRIBUTIONS
CONCEPTUAL DESIGN	INC. IN DETAILED DESIGN
DETAILED DESIGN	$196,038
PROCUREMENT	$125,100
INSTALLATION / TESTING	$327,115
PROJECT MANAGEMENT	$317,231
TOTAL BNL CONTRIBUTIONS:	$965,484

BNL is contributing 20% of the projected costs of the project via staff ($840K) and equipment ($125K) for this project.

1.3.6 Project Schedule Summary

The summary schedule completion dates associated with performance of the three proposed alternative options are as follows:

	OPTION 1: ACCELERATED	OPTION 2: LEVEL FUNDING	OPTION 3: LEVEL OF EFFOR
SUMMARY TASKS	SCHEDULE COMPLETION DATE	SCHEDULE COMPLETION DATE	SCHEDULE COMPLETION DATE
CONCEPTUAL DESIGN	7/3/98	7/3/98	3/18/99
DETAILED DESIGN	4/2/99	4/2/99	12/16/99
PROCUREMENT	8/14/00	3/1/01	4/26/01
INSTALLATION / TESTING	6/6/01	12/21/01	2/14/02
PROJECT MANAGEMENT	6/6/01	12/21/01	2/14/02
HERMES OPERAIONAL	**6/6/01**	**12/21/01**	**2/18/02**

The scheduled completion dates vary 8 months from the accelerated option (6/01) to the Level of Effort Option 3 (2/02). Schedules presented in this proposal for all of the options are:

- Project Summary Schedule
- Project Management Schedule
- Detail Tracking Schedule

1.3.7 Project Summary Schedule (Level 1)

The project summary schedules for each of the three options is provided herein. The summary schedule indicates start and finish dates and summary logic for the major HERMES I activities at Work Breakdown Structure Level 2 Activity for the three proposed alternatives. This schedule is a summary or roll-up of many other discrete activities at lower levels of the WBS. The summary schedule will contain approved project milestones for the HERMES I Program. The major milestones represent completion of key deliverables or activities which have been proposed and approved by LANL/DOE and represent commitments which require formal LANL/DOE approval (Baseline Change) for any proposed modification. (See Appendix B: Section 1.3.7)

1.3.8 Project Management Schedule (Level 2)

The Project Management Schedules for each of the three proposed alternatives are attached. This schedule is intended to provide a summary of WBS activities which identifies the summary project critical path, cost, and progress information for management use. (See Appendix B: Section 1.3.8)

1.3.9 Detailed HERMES I Tracking Schedule

The HERMES I Detailed Tracking Schedule consists of activities of a sufficient "degree of detail" necessary to identify, logically constrain, and resource activities within the expectations of the WBS scope element (WBS dictionary). In some cases, a WBS level 3 activity breakout is sufficient, whereas for more complex scope items, WBS level 4-5 detailing may be necessary. The Project Manager will decide upon the level of detail required for effective identification and monitoring of the scope item. The proposed tracking schedules for the Accelerated, Level Funding, and Level of Effort Schedules are attached. (See Appendix B: Section 1.3.9)

1.3.10 HERMES I Schedule Control

Schedule performance will be measured against the baseline schedule using Budgeted Cost of Work Performed (BCWP) compared to Budgeted Cost of Work Scheduled (BCWS) for WBS activities. Once the Project Baseline is approved, the Baseline will be frozen in Microsoft Project. During the course of the project, forecast accomplishment of Major Milestone dates will be compared to baseline milestone dates. Potential milestone variances will be addressed and proper corrective action taken and reported on a monthly basis. Major Milestones completed on or prior to baseline schedule shall be considered "on schedule" unless otherwise indicated. Control Milestones completed within two weeks of baseline schedule shall be considered "on schedule".

1.4 Acquisition Strategy

The SDT will continue to evaluate available procurement alternatives for each of the required components which increases the quality of the material/equipment/service at Lowest Technically Qualified Bidder (LTQB) requirements. It is BNL intention to capitalize on existing successful design and material and equipment vendors which have been successfully used previously by Spectrometer Development Managers. The procurement and delivery schedules will be appropriately detailed and coordinated between BNL and LANSCE to mitigate potential inefficiencies in equipment deliveries, staging, and installation preparations. A WBS element (1.1: BNL/LANSCE Interface) is identified which prepares an Interface Plan for Installation preparations, testing, storage, etc.

The preliminary Procurement Responsibility Matrix is shown here:

		RESPONSIBILITY				
WBS	ITEM DESCRIPTION	DESIGN RESP.	PROCURE MAT'L	FABRICATE	ASSEMBLE LOCATION	TEST LOCATION
1.4.1	DISK CHOPPERS	BNL/ISIS	BNL/ISIS	BNL/ISIS	LANL	LANL
1.4.2	NEUTRON GUIDE SYSTEM	BNL				
1.4.3	ANALYZER AND DETECTOR SECTION					
1.4.3.1	ANALYZER SECTIONS	BNL	BNL	BNL	BNL	LANL
1.4.3.2	DETECTOR SECTION	BNL INSTR.	BNL INSTR.	BNL INSTR.	BNL INSTR.	LANL
1.4.4	SPECTROMETER TANK ASSEMBLY					
	ANALYZER TANK	BNL	BNL	BNL	LANL	LANL
	HOSES,VALVES	BNL	BNL	BNL	LANL	LANL
	SCAFFOLDING	LANL	LANL	LANL	LANL	LANL
	BEAM STOP, DUMP PIPE, MONITOR	BNL	BNL	BNL	LANL	LANL
1.4.5	SPECTROMETER CONTROL					
	GUI OPERATING SYSTEM	BNL	BNL	BNL	BNL	LANL
1.4.6	ANCILLARY EQUIPMENT	BNL	BNL	N/A	LANL	LANL
	CRANE	BNL	BNL	CONTR.	LANL	LANL

The PI/PM/TD will continue to develop the procurement strategy for each spectrometer component. BNL Procurement Division along with the PI/PM/TD input and criteria will administer the procurement activity associated with HERMES I.

Current forecasts and breakout of procurements are contained in the following Table 1.4.1

TABLE 1.4.1: HERMES I

WBS	ITEM DESCRIPTION	CONTRAC	MAT. /	FAB.	TOTAL	ASSUMPTIONS
	TOTAL COSTS				**$3,602.1**	
1.1	**DISK CHOPPERS**	$142.0			**$142.5**	CONTRACT WITH ISIS TO PROVIDE 2
	VARIABLE APERTURE DISK CHOPPERS (2)	$0.0	$0.0	$0.0	$0.0	CONTRACT WITH ISIS TO PROVIDE 2
	MOTOR SPEED CONTROLLERS	$0.0	$0.0	$0.0	$0.0	CONTRACT WITH ISIS TO PROVIDE 2
	CHOPPER PLATFORM	$0.0	$0.0	$0.0	$0.0	CONTRACT WITH ISIS TO PROVIDE 2
1.2	**NEUTRON GUIDE SYSTEM**				**$1,607.1**	
	SUPERMIRROR GUIDES	$0.0	$924.0	$0.0	$924.0	ASSUME CONTRACT WITH OSMIC FOR
	VACUUM FLIGHT TUBE	$0.0	$300.0	$0.0	$300.0	ASSUME PSU TO FABRICATE
	GUIDE SHIELDING					
	PRIMARY SHIELDING	$50.0	$0.0	$0.0	$50.0	ASSUME LANL TO PROVIDE/CONTRACT
	SECONDARY SHIELDING	$250.0	$0.0	$0.0	$250.0	ASSUME LANL TO PROVIDE/CONTRACT
	SUPPORT STANDS	$0.0	$21.4	$0.0	$21.4	ASSUME PENN STATE U. MACHINE SHOP
	ALIGNMENT FIXTURES	$0.0	$14.3	$40.0	$54.3	BNL TO PROCURE/FABRICATE
	VACUUM PUMPS	$0.0	$7.4	$0.0	$7.4	BNL TO PROCURE (ALCATEL BID)
1.3	**ANALYZER AND DETECTOR SECTION**				**$933.8**	
	ANALYZER SECTIONS				**$635.2**	
	GRAPHITE ANALYZER CRYSTALS	$0.0	$300.0	$0.0	$300.0	BID FROM ADVANCED CERAMICS
	MECHANICAL SUPPORTS	$0.0	$18.6	$40.0	$58.6	BNL TO FABRICATE
	FIXING MECHANISM	$0.0	$4.3	$8.0	$12.3	BNL TO FABRICATE
	IMPRESSED SHIELDING DISCS	$0.0	$21.4	$45.0	$66.4	BNL TO FABRICATE
	ALIGNMENT DEVICES	$0.0	$21.4	$46.0	$67.4	BNL TO FABRICATE
	CRYOGENICS/COOLING	$0.0	$130.5	$0.0	$130.5	BNL PROCURED, QUOTE RECEIVED
	DETECTOR SECTION				$298.7	OPTION He TUBES VS. ELECTRONICS: USED
	He TUBES (120)	$0.0	$189.2	$0.0	$189.2	BNL PROCURE
	ELECTRONIC CHANNELS	$0.0	$30.4	$28.0	$58.4	BNL PROCURE/FABRICATE
	CABLES	$0.0	$5.7	$4.0	$9.7	BNL PROCURE/FABRICATE
	MECHANICAL MOUNTS	$0.0	$14.3	$10.0	$24.3	BNL PROCURE/FABRICATE
	MOVABLE COLLIMATOR	$0.0	$7.1	$10.0	$17.1	BNL PROCURE/FABRICATE
1.4	**SPECTROMETER TANK ASSEMBLY**		$189.2		**$444.9**	
	ANALYZER TANK	$0.0	$100.0	$108.7	$208.7	BNL PROCURE/FABRICATE
	VACUUM PUMPS,GAUGES,FRAMES	$0.0	$54.4	$0.0	$54.4	BNL PROCURE
	INSTRUMENT SHIELD "HUTCH" + ACCESS	$142.5	$0.0	$0.0	$142.5	LANL DESIGN/BUILD
	BEAM STOP, DUMP PIPE, MONITOR	$0.0	$14.3	$25.0	$39.3	BNL PROCURE/FABRICATE

TABLE 1.4.1: CONT

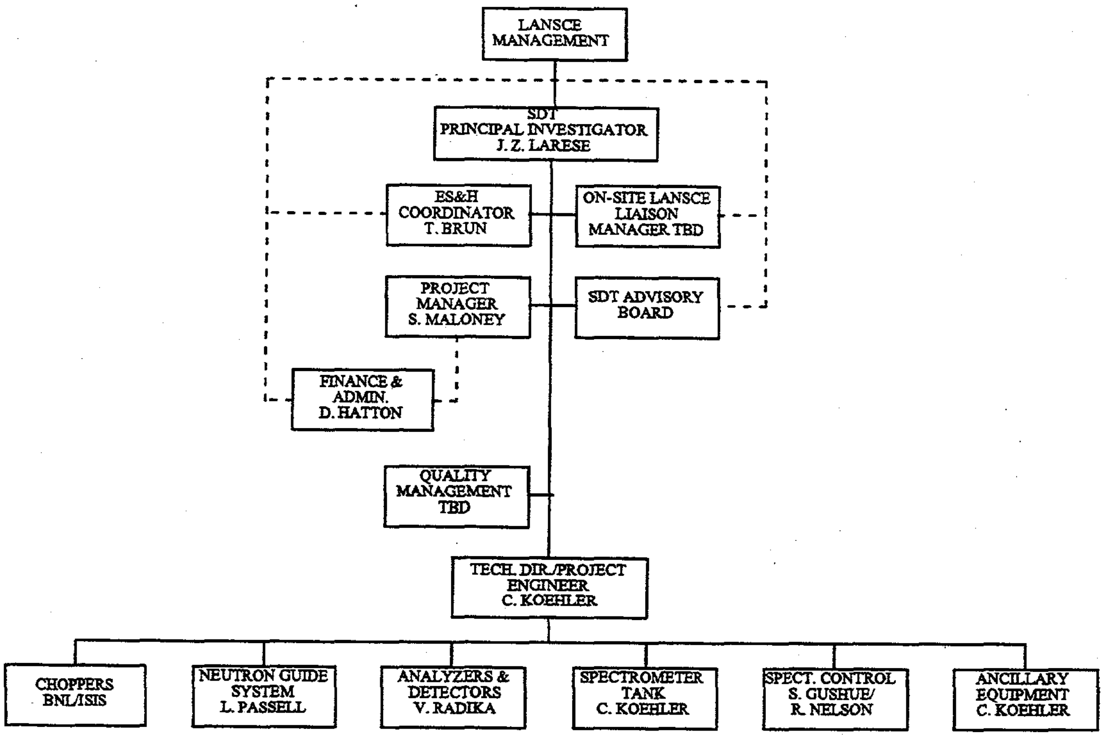
		PROCUREMENT				
WBS	ITEM DESCRIPTION	CONTRAC	MAT. /	FAB.	TOTAL	ASSUMPTIONS
1.5	**SPECTROMETER CONTROL**					
	GUI OPERATING SYSTEM	**$0.0**	**$163.1**	**$0.0**	**$163.1**	**BNL PROCURE/PROGRAM**
1.6	**ANCILLARY EQUIPMENT**				**$310.6**	
	SAMPLE GONIOMETER	$0.0	$54.4		$54.4	BNL PROCURE
	TEMPERATURE CONTROLLERS	$0.0	$7.1		$7.1	BNL PROCURE
	PUMPING STATION	$0.0	$21.4		$21.4	BNL PROCURE
	VACUUM/PRESSURE GAUGES/SENSORS	$0.0	$27.2		$27.2	BNL PROCURE
	SAMPLE ENVIRONMENT	$0.0				
	HELIUM CRYOSTAT	$0.0	$50.0	$0.0	$50.0	BNL CONTRIBUTED EQUIPMENT
	DISPLEX	$0.0	$25.0	$0.0	$35.2	BNL CONTRIBUTED EQUIPMENT
	GAS HANDLING SYSTEM	$0.0	$40.0	$0.0	$40.0	BNL CONTRIBUTED EQUIPMENT
	FURNACE	$0.0	$38.0	$0.0	$38.0	BNL PROCURE
	CRANE	$0.0	$24.3	$13.0	$37.3	BNL PROCURE/LANL PREP/INSTALL

2. Spectrometer Development Team

To design and build the spectrometer we have brought together a spectrometer development team from academia, the national laboratories and industry with a broad range of interests, talents and experience. The team has neutron spectroscopists with - in total - more than 300 years of neutron scattering experience and persons expert in such diverse fields as wire neutron detector design and construction, computer modeling and interfacing and mechanical and electronic engineering. Individual team members have been personally involved in the design, construction, installation and implementation phases of such neutron instruments as IRIS, OSIRIS, QENS, CHEX, HIPD, FDS, TAMPA and HRPND. Our objective is to construct a state-of-the-art, user-friendly, remotely-operable CBS on the time-line we have outlined and within the proposed budgetary guidelines.

2.1 Organizational Chart

HERMES
HIGH RESOLUTION BACKSCATTERING SPECTROMETER
ORGANIZATIONAL BREAKDOWN STRUCTURE
(OBS)



2.2 SDT Advisory Board

The SDT Advisory Board (SAB) is a project oversight committee which will be chartered to conduct periodic reviews of project technical and commercial progress. The Advisory Board will have organizational ties to both the Principal Investigator as well as LANSCE Management. The SAB will work with the Principal Investigator to assure the implementation of a quality instrument and will assist in the solicitation and coordination of research activity for HERMES.

The SAB will:

- Establish the mission and policy of the SAB
- Promote neutron research in their respective fields
- Solicit Proposals for operation and research of HERMES
- Elect a SAB chairman
- Advise LANSCE Management on ES&H and other issues the SAB deems appropriate (per procedure)
- Provide technical assistance and interface coordination between the PI and LANSCE Management
- The SAB will review and provide official comment on the quarterly project status report.

2.3 Principal Investigator (PI) and LANSCE Project Liaison Manager (LPLM)

The SDT Principal Investigator (PI) as the above organizational breakdown structure indicates, is the primary interface between the SDT, Advisory Board, and LANSCE. This individual is responsible to LANSCE Management for the technical and commercial delivery of the HERMES Project. The PI is also responsible for the ES&H and Quality management of the project. The PI has direct reports from the Project Manager, the Project Technical Director, the Project ES&H Coordinator, and Quality Management. Also with reporting relationship to both the PI and LANSCE is the On-site LANSCE Project Liaison Manger (LPLM). The LPLM is responsible to the PI for the site coordination of HERMES activities.

2.4 Project Manager

The HERMES I Project Manager will be responsible for implementing all project management activities required to meet program objectives. These activities will include verification of scope, preparation of schedules, budget estimates and scoping documentation necessary to establish a program scope, cost and schedule baseline. Thereafter the baseline will be maintained through periodic update of schedules and evaluation of cost, schedule and technical performance. The Project Manager will implement baseline control to maintain scope, cost and schedule within the baseline or prepare baseline change proposals where modifications of the baseline are warranted. The PM is responsible to the PI for all project reporting and management activities. The Project Manager is accountable to the PI for the commercial delivery of the project.

2.5 Project Technical Director

The Technical Director also reports directly to the PI and works with the Project Manager. This individual is responsible for the technical delivery of the project. The TD assures the content and quality of the design specifications as well as managing the work scope to assure conformance to project design and specifications. The TD is responsible for all component WBS items and the WBS Managers. The TD is responsible for the "system integration" activities relating to HERMES. The TD is responsible to manage the work scope according to project baseline requirements. The TD is ultimately responsible for the Start-Up and Test Plan and ensures that plans and documentation required by LANSCE management are submitted in a timely fashion.

2.6 ES&H Officer/Quality Management

This individual also has direct reporting relationship to the PI. The ES&H Officer is responsible to develop for approval, the ES&H activities necessary to support HERMES installation and operation activities. The ES&H Officer is not responsible for the project ES&H. The Work Scope Managers retain that responsibility. The role of the ES&H officer is to provide and facilitate the site ES&H requirements to the WBS managers in order that the scope of work contained in the WBS is performed to LANSCE ES&H expectations. The ES&H Officer will develop, with the PI, PM, and TD, the ES&H Plan for submission and approval by LANSCE Management. The ES&H officer will review project documentation and provide guidance to scope managers on ES&H issues. On the Organizational Breakdown Structure (OBS) the ES&H Officer also has independent reporting the LANSCE Management to assure that an open communication exists between BNL and LANSCE regarding ES&H issues.

A Quality Management Plan will be developed and submitted for approval by LANSCE management and will establish the specific quality expectations and quality requirements of the project.

2.7 WBS Managers

Identified in the Organization Chart are OBS Managers which mirror Work Breakdown Structure (WBS) Level 3 Activities. The organization is structured for single point accountability to WBS elements. The Neutron Guide System (NGS) WBS Manager is responsible for delivery of WBS items 1.2.3 Conceptual Design, 1.4.2 Procurement Specification, 1.5.3 installation and 1.6.2 Start-up and Testing of the Neutron Guide System. The WBS Manager is responsible for cradle to completion activities for the NGS including cost and schedule performance to Project Baseline expectations.

HERMES I activities will be carried out under the direction of the assigned WBS Manager using planned resources in accordance with the approved baseline schedule. WBS Managers will meet regularly with, and report progress to the SDT Principal Investigator and Project Manager.

2.8 Finance & Administration Support

Included in this proposal are provisions for F&A support of the HERMES Project. The F&A Manager works with the Project Manager to establish the budgeting and accounting roadmap and process for the HERMES Project. The F&A manager will establish cost accounts for the project, will assist in procurement coordination, will interface with and extract from LANSCE , project costs required for integration in the overall cost plan and cost report. The F&A manager will work with the WBS Managers to properly identify cost components of the WBS. The F&A manager will also identify and track overhead rates for project activity which are in compliance with the negotiated procurement strategy between LANSCE and BNL. The F&A Manager will work closely with cognizant people at both LANSCE and the Albuquerque operations office to establish and to maintain the necessary budget controls.

2.9 SDT Members and Expertise (Vitae)

The listing below is a condensed description of the members of the SDT's relevant experience. Among the members are: T. Brun, J. Eckert and L. Daemen (Los Alamos National Laboratory), C. Carlile (Rutherford Appleton Laboratory), J. Carpenter and F. Trouw (Argonne National Laboratory), A. Cheetham (UCSB), H. Glyde (Univ. of Delaware), J. Z. Larese and L. Passell (Brookhaven National Laboratory), K. R. McCall (Univ. of Nevada, Reno), M. Popovici (MURR), P. Sokol (Penn State Univ.), H. Taub (Univ. of Missouri) and O. Vilches (Univ. of Washington).

T. Brun (Los Alamos National Laboratory)
Area of Expertise: Design and construction of neutron scattering instruments (QENS,UCN, triple axis spectrometers and polarized diffractometers) and neutron guides. Neutronic performance of spallation neutron sources. Phonons and Rare-Earth Form Factors Magnetic critical scattering, Magnetic materials, Hydrogen in Metals, Zeolites, and Fast-Ion Conductors
Relevant Experience: M.S. 1962 in Electrical Engineering Technical University of Denmark, Ph. D. 1970 in Solid State Physics from Iowa State University, 1962-1964: Staff, Physics department, Riso, 1964-1970: Staff, Physics Department, Ames Laboratory, 1970-1988: Solid State Science Division, ANL, 1989-present: Staff, Neutron Scattering Center, LANL 1990-1995: Group leader, Neutron Scattering Center, 1994-1996: Task leader for target upgade design.

C. Carlile (Rutherford Appleton Laboratory)
Area of Expertise: Neutron Instrumentation on Reactor & Pulsed Sources; Tunneling Spectroscopy.
Relevant Experience: PhD 1974 University of Birmingham. Builder of Rotating Crystal Spectrometer, Herald Reactor; Instrument Scientist Slow Chopper Spectrometer Ispra Italy; Instrument Co-responsible IN4 ILL, Design team for IN6 ILL; Designer & Builder of IRIS at ISIS; Design team of PRISMA ISIS; Conceptual Design team of MARI ISIS; Conceptual design of OSIRIS at ISIS. Presently Head of ISIS Spectroscopy &

Support Division (1994 on) with responsibilty for 45 staff, 7 scheduled instruments and 3 capital instrument build projects (MAPS, OSIRIS & TOSCA) - all international collaborations. Member of ILL Scientific Council (1995 on).

John M. Carpenter (Argonne National Laboratory)
Areas of expertise: nuclear reactors; radiation detection; neutron physics; pulsed spallation source systems, target, moderator, neutron scattering instrument concept development, design, construction, operation and characterization; neutron diffraction and inelastic scattering in glassy solids.
Relevant experience: PhD 1963, Nuclear Engineering, U Michigan. Institute for Science and Technology, U. Michigan, Postdoctoral Fellow 1963-4. Department of Nuclear Engineering, U. Michigan, Faculty, 1964-1975, Full Professor, 1973. Argonne National Laboratory, Senior Physicist, 1975- date. Sabbatical and leave experience: MTR reactor (1965), Los Alamos National Laboratory (1973) , Japanese Laboratory for High Energy Physics (1982, 1993), Rutherford-Appleton Laboratory (periodically, from 1997). Conceived pulsed spallation neutron sources, built ZING-P (1973), ZING-P' (1977), IPNS (1981). Co-founder ICANS (1977). Conceived t-o-f SANS, time-focusing in: powder diffraction, single crystal diffraction, deep inelastic scattering, chopper spectroscopy.

Luke L. Daemen (Los Alamos National Laboratory)
Area of expertise: Condensed matter physics, neutron scattering, radiation transport in matter, Monte Carlo techniques.
Relevant experience: 1988-1990: Director Postdoctoral Fellow at the Center for Materials Science, Los Alamos National Laboratory; 1991: Visiting Scientist at the ISIS facility of the Rutherford-Appleton Laboratory, Didcot, England; 1991-present Staff Member at the Manuel Lujan, Jr. Neutron Scattering Center, Los Alamos National Laboratory. Carries out experiments at the LANSCE and WNR facilities (LANL), Intense Pulsed Neutron Source (ANL), ISIS (RAL). Heads the LANL team developing Monte Carlo tools for neutron scattering instrument design. Carried out many moderator design studies (including experimental studies) for a variety of spallation neutron sources.

J. Eckert (Los Alamos National Laboratory)
Area of Expertise: Molecular ligands in inorganic andorganometallic chemistry; H-bonding and proton transfer in molecular solids; dynamics of adsorbed molecules in 2-D (layer compounds) and 3-D hosts (zeolites, clays) incl. heterogeneous catalysis.
Relevant Experience: Ph.D. Princeton University 1975; scientific staff member at the Neutron Scattering Center at Los Alamos National Laboratory since 1979. Wide range of experience in applying neutron scattering techniques to complex problems in chemistry, incl. novel studies of chemical binding of small molecular ligands in organometallic compounds. Organized the Int.'l Conference on Neutron Scattering in Santa Fe, NM in 1985, and the Second Symposium on "Hydrogen and Quantum Mechanical Phenomena in the Coordination Sphere of Transition Metals" in 1995.

H. Glyde (Univ. of Delaware)
Area of Expertise: Condensed Matter Physics, Neutron scattering studies of excitations in disordered and bulk quantum liquids. Theory of excitations in quantum fluids and solids and disordered systems.
Relevant Experience: D. Phil Oxford University 1964. CIBA Fellow, Free University of Brussels and SERC FEllow, University of Sussex,UK 1965-69. Physicist, Atomic Energy of Canada Ltd. 1969-75. Chair, Department of Physics, University of Delaware 1982-89, 1994-present, Chercher Invite, Institut Laue Langevin, 1975, 1976, 1986.1997.

J. Z. Larese (Brookhaven National Laboratory)
Area of expertise: Structure and dynamics of atomic and molecular films on surfaces using neutron and X-ray scattering, NMR and helium atom scattering techniques. Design and development of novel materials and instrumentation.
Relevant Experience: PhD., 1982, Wesleyan University; Postdoc fellow, 1982-1985, Penn State University; Scientist, 1985-Present, Brookhaven National Laboratory, with Tenure(1992); Group leader, Materials Chemistry/Neutron Section, 1988-Present, BNL; Adjunct Prof. of Physics, Wesleyan Univ. 1994-present; Adjunct Prof. of Physics, Univ. of Missouri, KC 1992-94; Spokesperson for H5 beamline at HFBR and Chemistry Beamline X7B at NSLS. Designer and Builder TAMPA multidetector powder diffractometer at H5 . Carries out neutron and x-ray research at HFBR, ILL, ISIS, and NSLS.

K. R. McCall (Univ. of Nevada, Reno)
Area of Expertise: Elasticity of inhomogeneous, porous, and disordered materials, such as rock and concrete. Transport of fluids in porous media, including quantum fluids adsorbed on polycarbonate filters, water in porous glass, and oil in rock.
Relevant Experience: PhD 1992 in Physics at the Univ. of Massachusetts/Amherst; 1991 - 1994, Postdoctoral Fellow, Los Alamos National Laboratory; 1994, College Assist. Prof. of Physics, New Mexico State University; 1994 - 1995, Staff Scientist, Los Alamos National Laboratory; 1995, Research Assist. Prof. of Physics, University of New Mexico; 1996 -present, Assist. Professor of Physics, and Grad. Faculty of Hydrologic Sciences, University of Nevada, Reno.

L. Passell (Brookhaven National Laboratory)
Area of expertise: Neutron Instrument design. Neutron Scattering studies of liquid helium, magnetic systems and adsorbed films.
Relevant Experience: PhD.,1955, University of California, Berkeley; Scientist, 1955-61, Lawrence Livermore Radiation Lab; Staff Scientist, 1961-63, Risø National Laboratory; Senior Scientist, 1963- 1996; Brookhaven National Laboratory, 1996-Present, Emeritus, Brookhaven National Laboratory. Member of numerous advisory committees and steering committees for neutron facilities around the world.

M. Popovici (MURR)
Area of expertise: Neutron and X-ray optics and monochromators, design of scattering instruments, phase transitions by neutron scattering, materials characterization by neutron and X-ray diffraction.
Relevant Experience: Ph.D. 1971 Bucharest, Romania. Research scientist, then senior research scientist: 1961-1977 Institute of Atomic Physics, Bucharest, 1977-1990 Institute of Nuclear Power Reactors, Pitesti, 1990-1991 Institute of Physics and Technology of Materials, Bucharest; 1991-present research scientist Missouri University Research Reactor. Extended the resolution formalism of Cooper & Nathans to bent crystal neutron spectrometers, developed corresponding computer codes. Carried out neutron scattering experiments at steady state reactors (Romania, Czechoslovakia, Yugoslavia, US), and pulsed reactors (xUSSR). Design and implementation of high resolution two-axis and three-axis focusing neutron arrangements, and of instruments for pulsed reactors. Design and fabrication of monochromator units with bent perfect silicon.

P. Sokol (Penn State Univ.)
Area of Expertise: Condensed matter physics, neutron and x-ray scattering, quantum liquids and solids, and phase transitions in resticted geometries.
Relevant Experience: PhD. 1981 from the Ohio State University. 1982-1984 Postdoctoral fellow at University of Illinois at Urbana-Champaign, 1984-1988 Assistant Professor of Physics at Harvard University, 1988-1997 Associate Professor of Physics at

The Pennsylvania State University, 1997- Professor of Physics at The Pennsylvania State University, 1994-1995 Visiting Professor of Physics at Keele University. Carries out experiments using at NIST, IPNS, NSLS, ISIS, ILL, and Daresbury. Designed, constructed and operated the PHOENIX spectrometer at IPNS (1986-1994)

H. Taub (Univ. of Missouri)
Area of Expertise: Condensed matter physics with emphasis on surface physics. Studies of the structure, phase transitions, and dynamics of adsorbed films by neutron scattering, LEED, x-ray diffraction, and STM techniques.
Relevant Experience: Ph.D. 1971 from Cornell University. 1971-1973 Associate Research Scientist, Department of Physics, New York University. 1973-1975 Assistant Physicist, Department of Physics, Brookhaven National Laboratory. Member Department of Physics & Astronomy, University of Missouri-Columbia: 1975-1980 Assistant Professor, 1980-1984 Associate Professor, 1984-present Professor. Served on advisory and review panels for neutron and x-ray scattering in the U.S. 1981-present Member Executive Committee Midwest Analytical Team for Research Instrumentation of X Rays. 1988-present Member Chemistry Department Participating Research Team, High Flux Beam Reactor, Brookhaven National Laboratory. 1990-present Member Executive Committee Midwest Universities Collaborative Access Team, Advanced Photon Source, Argonne National Laboratory.

F. Trouw (Argonne National Lab)
Area of Expertise: Physical chemistry, neutron and X-ray scattering, molecular sieve materials, diffusion of adsorbates, molecular spectroscopy.
Relevant Experience: D. Phil. 1986 from Oxford University, England. 1986-1988 Postdoctoral fellow at Argonne National Laboratory, 1988-1991 Assistant Chemist at Argonne, 1991- Chemist at Argonne (all Argonne appointments were at the Intense Pulsed Neutron Source).Carried out experiments at the Harwell, ILL and IPNS. Rebuilt the QENS spectrometer in 1988, and have operated this instrument in the user program since that time. Built the HIPD diffractometer, the CHEX spectrometer and designing QENS Upgrade, a second generation inverse geometry spectrometer.

O. Vilches (Univ. of Washington)
Area of Expertise: Thermodynamic measurements in physisorbed quantum fluids and solids, specifically 3He, 4He, mixtures of 3He and 4He, and various molecular hydrogens. Elastic and quasi-elastic neutron scattering measurements at LLB-Saclay and ILL-Grenoble on films of deuterium hydride, deuterium, hydrogen, and hydrogen-deuterium monolayer and bilayer mixtures. Technical experience in cryogenics and refrigeration, especially construction and operation of dilution refrigerators.
Relevant Experience: Doctorate in Physics, 1966, U. de Cuyo (Argentina). Post-doctoral fellow, 1965-67, U. of Illinois, 1967-68, UC San Diego. Assist. Prof.,1968, U. of Washington. Currently Prof. of Physics, U. of Washington, and Visiting Professor, Faculte des Sciences de Luminy, Marseille, France.

3.0 PROJECT MANAGEMENT

The project will be managed in accordance with BNL's Implementation Plan for DOE O 430.1, "Life Cycle Asset Management". A Project Execution Plan (Project Baseline) will be developed and available for presentation in March 1998 for review and approval. The plan will indicate the discrete scope, BNL/LANL interfaces, detailed cost estimate and resource loading, updated schedules (Level 1,2,3), change control methods, methods of execution, expansion of responsible parties and lines of authority.

BNL has the technical, scientific, and project management experience in undertaking a project of this magnitude. As BNL has an acute scientific stake in the timely and cost-effective performance of this project, the project management tools which are essential for optimum management of this project will be utilized with the commensurate expertise.

The system that is proposed for preparing, tracking, and maintaining the baseline are, as requested in the proposal guidelines, Microsoft Project and Microsoft Office Products (Word for WBS Dictionary, Excel for Comprehensive Cost Report with links to Resource Loaded Schedule in Microsoft Project). However, BNL has the experience and ability to conform to whatever tracking and reporting tools which LANL/DOE prefer.

The Project Management System will, at all times, establish work performance accountability (OBS) and correlation to Scope (WBS), and Budgetary Control. Overall project management, quality assurance, design, and installation will be managed by BNL with the appropriate or "to be coordinated" interface with LANL (ES&H, QA, Installation Support, Schedule Coordination).

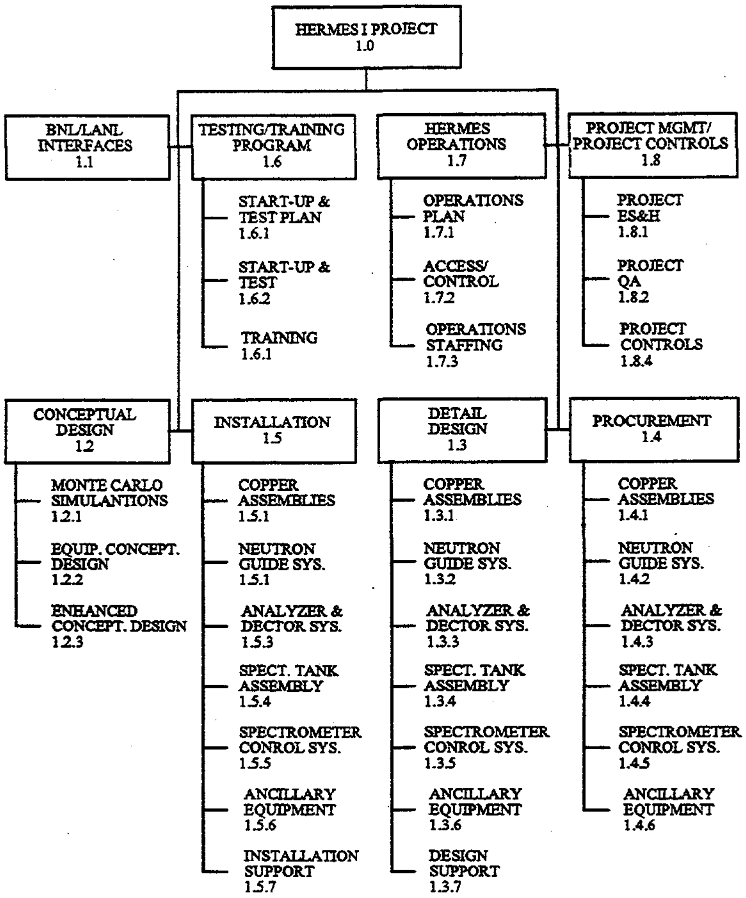
3.1 HERMES I SCOPE OF WORK

The Work Breakdown Structure (WBS) is a hierarchical representation of project scope that is organized into functional areas for effective management and control. The WBS will be the method by which HERMES I scope will be managed. The preliminary WBS for HERMES I is indicated here. The WBS will expand based on further design developments and integration of Work Authority between LANL and BNL

3.2 HERMES WBS DICTIONARY

The WBS dictionary is the scope description document for HERMES I. The WBS dictionary will be submitted as part of the Project Execution Plan (Baseline) and will be a "living document" which will be maintained throughout the HERMES project. Changes in HERMES I scope will be reflected as changes to the WBS Dictionary and evaluated for resource and schedule impacts and incorporated via Baseline Change Control. The WBS Dictionary includes a description and identification of project scope, deliverables, and expectations.

HERMES I WORK BREAKDOWN STRUCTURE (WBS)



3.3 Funds Management, Accounting and Work Authorization

The basis of this Project Management Plan assumes that BNL is provided with funding for the management and execution of the HERMES Project. The Principal Investigator assumes authority and accountability for Fund Management. The Project Manager and Financial & Administration Manager will assist the PI in establishing the accounting mechanism and required fund integration and disbursement for planned activities. The PI retains execution authority for expenditures against the HERMES Budget. A work authorization procedure will be established as part of the Project Execution Plan (Baseline) which establishes fiscal authority for fund disbursement for WBS activities.

Monthly expenditures will be tracked using the BNL financial system. Costs borne by outside organizations will be managed and reported by the PM/F&A Manager. The monthly cost report will be developed and contain commensurate level of detail in order to assess cost performance against the Management Tracking Schedule Activities.

Also, a project forecast will be maintained in Microsoft Project/Excel which identifies the balance of monthly expenditures by WBS category in order to provide a "heads up" to the LANSCE fund manager as well as the PI and TD.

3.4 Project Baseline Management

The Project Baseline will be a key management tool that forms the basis of performance for the Project. The baseline will be a document consisting of a detailed description of the Program scope and deliverables (WBS Dictionary), a detailed schedule indicating specific task durations and milestone completion dates and a resource/cost estimate based on the scope and schedule. All assumptions and qualifying factors necessary to understand the relationship of the scope, cost and schedule will be provided.

The Baseline Document will be reviewed and approved by the BNL Management, then submitted to LANL/DOE for review and approval. Once approved, the baseline will be used by BNL to manage and plan project activities and measure performance toward project objectives. Maintenance of the project baseline is critical to project success and will be performed in accordance with the baseline change control process.

3.5 Performance Monitoring

Overall project performance monitoring will be performed by the Principal Investigator via the Project Manager. The direct responsibility for project scope, cost and schedule will be held by the WBS Manager at WBS Level 2. The WBS Manager shall verify that the technical deliverables, resource utilization and schedule progress are in accordance with the baseline. This will be carried out through regular meetings with staff performing the activity, monitoring costs against a dedicated account for the task in the BNL Financial System and comparing technical progress against the baseline schedule. The WBS Manager will meet monthly, at a minimum, with the Project Manager to review progress and prepare a monthly performance report for the activity.

It is proposed that HERMES project performance be formally reviewed quarterly by Program Management at LANCE at a special meeting dedicated to this purpose. Provisions are included in the cost profile to support this requirement. The quarterly review will include review of overall program status, problems, corrective actions, and performance for the current and cumulative periods by the PI/PM. The PI/PM will present completed milestones since the last meeting and up-coming major milestones.

3.6 Baseline Control

Management of the HERMES project and valid measurement of performance is dependent on maintaining the Program Baseline. Baseline maintenance requires adherence to the baseline change control process outlined below:

The initial baseline consisting of detailed scope, cost estimate, cost basis, schedule with logic (dependencies) and milestone log for each account (to be managed by a WBS Manager) is prepared by the PI/PM and approved by LANCE/DOE.

Any change to baseline scope, cost or schedule milestones exceeding thresholds identified in the Project Baseline will require submittal of a baseline change proposal for approval by the appropriate authority.

3.7 Directed Changes

In the event that LANCE/DOE directs changes to the HERMES I baseline or tasks BNL with additional activities beyond planned activities and normal on-going level of effort, the impact of the change will be assessed by the PI/PM and reported to LANCE/DOE. Depending on the magnitude of the change, BNL may submit a directed change request to LANCE requesting either additional resources to address additional scope or accelerated schedule, or a revised schedule due to resource limitations.

3.8 Contingency Management

The Total Estimate at Completion (TEC) of the HERMES project shall include approved contingency amounts (estimated above to be between 10-20%) of the Baseline Project Estimate (BPE). The contingency is assumed to be controlled by LANCE. Identification of requests to use WBS Level 2 contingencies will be officially requested of LANCE and applied to accounts to address unforeseen scope and cost variances in accordance with approved change control procedures.

3.9 Review and Reporting

The flow and availability of project information for this project must be "real time" due to the distance constraints imposed by BNL project management. An immediate effort for BNL is to establish the information, reporting, and control lines of project communication and authority.

HERMES I project reports will be prepared monthly and quarterly to support monthly and quarterly management reviews. The report will address the following criteria:

- Summary technical, schedule, cost status, and progress.
- Discussion of problems, issues, and resolution plans (if any).
- Variance analysis and corrective action (if needed).
- Discussion of Baseline Status, pending changes

Monthly and Quarterly Reports will be submitted within 20 days after the end of the reporting period.

BNL review of the HERMES status will be held monthly and presented to LANSCE Mgmt.. The PI/PM will be responsible for coordination and presentation of reviews with support from WBS Managers. The content of reviews will include overall technical, schedule and cost status as well as focused briefings on active or critical WBS tasks presented by the WBS Managers.

3.10 Management and Independent Assessment

In order to ensure that the HERMES Project is progressing toward its objective of establishing recognized excellence in spectrometer research, independent assessments of the project will be performed.

Independent assessments of the progress, status and performance of HERMES will be performed semi-annually by the HERMES Advisory Board. The Advisory Board will consist of outside experts in related fields who will perform a benchmark assessment of the HERMES. If appropriate, additional LANSCE management representation will also be included on the board. In addition, the Advisory Board will review and officially comment on the Detailed Design Report, the Project Execution Plan (Baseline), the ES&H and Quality Management Plans as well as the Start-Up and Test Plan.

3.11 Test & Inspection Plan/Turnover Documentation

A formal Test & Inspection Plan will be written by the Technical Director and will be reviewed by the PM, Advisory Board, and LANSCE Management and approved by the PI. This plan establishes the basis for commissioning activities at the facility. The plan is developed as a comprehensive program to establish that the instrument and all its components have undergone a rigorous test program and perform according to LANSCE procedural requirements, equipment specification, and SDT member expectations.

All Test files will be maintained by the TD. As part of the LANSCE interface WBS, the identification of required documentation and configuration control will be established and included in the Project Execution Plan/Baseline. The turnover documentation plan will include the steps taken and the specific document turnover requirements in order to effectuate a painless process for transfer of design, procurement, equipment performance parameters, and operational requirements of the HERMES spectrometer. The TD/LPLM.

3.12 ES&H Issues and Documentation

While LANSCE management retains ultimate responsibility and authority for safety considerations, all members of the SDT will work with LANSCE and their home institutions to ensure that the spectrometer is designed, constructed, installed and operated in a safe and environmentally compliant manner. All spectrometer construction and operations activities will be conducted such that every possible measure is taken to protect the health and safety of all the SDT members, the general users of the spectrometer, and the public, as well as to minimize accidental damage to property, the Lujan Center, or the environment. Close interaction with the Lujan Center operations and safety personnel will be essential to achieving compliance with LANSCE ES&H requirements. The Spectrometer Development Project Leader will be called upon to facilitate these interactions, as required.

Working with the Spectrometer Development Project Leader, the SDT PI will organize periodic spectrometer safety reviews throughout the entire spectrometer development process. The SDT understands that a formal safety review will be performed by LANSCE management prior to any spectrometer installation or deployment activities at the Lujan Center.

An SDT Safety Committee presently headed by the TD will work with the Spectrometer Development Project Leader and Lujan Center personnel on the development of safe operating procedures pertaining to the beam-line operation and other day-to-day safety requirements. Documented procedures will be approved by LANSCE management prior to operation of the spectrometer. The SDT will also comply with the requirement of LANSCE to review and approve the safety aspects of all the experimental programs on the beam line in advance of their execution.

The members of the SDT will attend and comply with requirements of safety orientation training as specified by LANSCE prior to beginning work on the experimental floor of the Lujan Center or in other associated buildings.

In summary, the SDT members and the users of the spectrometer will comply with the health and safety policy regulations and requirements of Los Alamos National Laboratory and LANSCE. the SDT members fully understand that activities at LANSCE will not be allowed to proceed if they are considered unsafe or are not in compliance with established safety procedures.

3.13 Quality Assurance

The HERMES SDT recognizes that quality assurance and quality control (QA/QC) are integral parts of the design, procurement, fabrication, and installation activities therefore, particular attention will be given to items that can affect safety during operation, the performance, construction, installation, and consequently the quality of the science performed by the SDT and operational reliability of the spectrometer.

The following steps will be implemented to guarantee quality assurance:

A review of the Conceptual Design will be conducted to assess the design with respect to the scientific mission of the SDT.

The QA/QC documents developed by an SDT will be reviewed by the Spectrometer Development Project Leader to ensure their compliance with Spectrometer Development Project QA/QC requirements

Advance planning of procurements will be instituted to avoid incomplete specifications or delays, either of which might result in increased cost or schedule slip.

Procurements, fabrications, and services will be accepted only after ensuring that the specified quality requirements have been met. Some delays are inevitable; the challenge is to have early-warning systems and contingency plans.

LANL, BNL, industrial, and national standards will be utilized by the SDT, where appropriate.

Responsibility for quality resides with the task leader in charge of a specific WBS element. The SDT PI will oversee the QA/QC activities of the SDT. The SDT PI intends to use additional guidance on QA/QC matters from the available organizations in the member institutions and from LANSCE.

4. HERMES I User program

4.1 General Guidelines

It is the desired goal of the SDT to promote the advantages and application of neutron diffraction and high resolution inelastic techniques within the general scientific community by providing easy access to individual investigators independent of their prior neutron scattering experience. This aim is aided by the fact that numerous members of the SDT already function at national user facilities and are therefore familiar with the successful user programs in place (i.e. at IPNS, ISIS and NSLS). The SDT's strategy will be to "advertise" the attributes of the HERMES I spectrometer and the power of neutron scattering techniques whenever possible by presenting seminars, workshops, poster sessions in concert with LANSCE and the SDT members home institutions. By these efforts and by producing significant scientific results we hope to engender a recognition among the US Scientific community a true understanding of the "power and necessity" of neutron techniques in solving both fundamental and practical problems in science and technology.

4.2 Beamtime Allocation

We believe that the detailed split between the two components to beam time allocation namely General User (GU) and SDT time needs to be reexamined as the final funding profile for HERMES I instrument is better understood. While details of this financial commitment will only be available near the completion of the project we propose that a 75% SDT / 25% GU division of beamtime allowcation be used as a general formula (based on the very successful User program in place at the NSLS). We believe that the GU time should be allocated following a formal review process to be determined by LANSCE.

4.3 Access and Training

Users have to participate in the experiments they plan to execute in conjunction with at least one experienced member of the staff responsible for the operation of the HERMES I instrument who is in residence at LANSCE. Users will be trained initially by a LANSCE scientific staff member in the routine operation of the instrument. Subsequent to this training and the completion of a comprehensive examination which includes questions probing the individuals understanding of health and safety issues as well as the opration of the instrument the user will have access to the necessary facilities. Troubleshooting and instrumental breakdowns will require the assistance of LANSCE staff member ultimately responsible for the operation of HERMES I. Users can expect to be instructed in the use of all data collection and analysis software necessary for the retrevial and processing of their data to their home institution.

4.4 Staffing

The HERMES I SDT belives that continued support from DOE/BES for the 4 permanent members of the SDT located at LANSCE is essential for the SDT to fulfill its mission. This staffing model is based on the current situation at ISIS where the experimental turn around time is typically 2-3 days. Such a team could consist of one PhD level and one MS level scientist, a BS engineer and one electro-mechanical technician.

General Conclusions

We have outline a scientific case for the need of a high resolution inelastic spectrometer capable of probing a wide range of scientific problems in areas ranging from physics, chemistry, geology and biology. This need is also documented by the fact that instruments of this type located at other institutions throughout the world receive request for beamtime that exceed the number of days available by factors of three-to-five. It is our belief that this demand not diminish but, will grow as new methods for applying these high resolution techniques are in the areas of soft matter, biology and engineering are developed. This SDT presents a team which has a broad base and a wide range of complementary expertise with representation from both the university and national laboratory. The SDT is committed to bringing this task to completion on time and within the budget presented.

Appendix A: LETTERS IN SUPPORT OF HERMES I

Brookhaven National Laboratory
Director's Office, Bldg. 460
40 Brookhaven Avenue
Upton, NY 11973-5000
January 12, 1998

Dr. John Larese
Chemistry Department
Brookhaven National Laboratory
Upton, NY 11973

Dear John:

I am writing to strongly support your Spectrometer Development Team proposal to build HERMES1, a backscattering spectrometer, at the spallation neutron source at Los Alamos.

BNL has a 50-year history in the area of neutron science, and it is important for the Laboratory to develop a balanced neutron scattering program with the increasing availability of new or enhanced spallation sources to complement our reactor based program at the HFBR. With our wide expertise in constructing spectrometers at both the HFBR and the NSLS and with your experience using ISIS, I am confident that we can deliver a state of the art backscattering spectrometer to LANSCE. In addition, our long experience with operating user facilities will ensure that the SDT will be a valuable asset to the user community in the U.S.

I look forward to your success with the HERMES1 proposal and the continued success in your research program.

Sincerely,

John H. Marburger
President
Brookhaven Science Associates

Research School of Chemistry
The Australian National University

Telephone: 61 26 2493637 (School)
61 26 2493578 (Direct)
Fax: 61 26 2494903 (Direct)
E-Mail: JWW@rsc.anu.edu.au

CANBERRA
ACT 0200
Australia

Professor J.W. White CMG., FAA., FRS.
Dean

7 January 1998

Dear John,

HERMES I - *A Needed Instrument*

I am very glad to support the next steps in the development of HERMES I. The attached information shows some of the power of such an instrument based on my own experience and that of the wide variety of users in Europe who have found very high resolution inelastic scattering spectroscopy indispensible to their work. For work in chemistry, magnetism and biology the combination of excellent energy resolution and high d space resolution in diffraction is amost valuable on the pulsed source versions.

The recent promising results from the newly reconstructed IRIS instrument and the forshadowed performance of OSIRIS, approaching the testing phase (also at ISIS (UK), there is an obvious need for similar instruments in USA. The pulsed source instruments are most effective diffractometers for large unit cell work, and with a flux of about one hundred times that of IRIS (as expected for OSIRIS), quite small samples can be used and this may be very interesting for biological work. HERMES I should be built to at least equal this performance.

A most interesting possibility is that with the availability of polarised helium filters, general polarisation analysis and polarised neutron diffraction from dilute magnetic systems may be accessible. Work on magnetic clusters by Philip Reynolds in my laboratory could be very interesting and leads to the use of long wavelength diffraction as a new tool for inorganic chemistry.

Yours sincerely,

John White

John White

Dr John Z. Larese
Brookhaven National Laboratory,
USA

ARGONNE NATIONAL LABORATORY
9700 South Cass Avenue, Argonne, Illinois 60439

Advanced Photon Source

January 12, 1998

Dr. John Z. Larese
Chemistry Department
Building 555A
Brookhaven National Laboratory
Upton, NY 11973-5000

Dear John,

I was most interested in seeing your plans for the HERMES-1 backscattering wave-of-flight spectrometer proposal for LANSCE. I would enthusiastically support such a proposal, as it seems to me that it is exactly the right kind of machine to build in a facility such as LANSCE. It is well matched to the unique capabilities of neutrons - it accesses time-scales for dynamics of condensed matter systems (0.1 to 10 nsecs) which are difficult to obtain by any other technique (particularly over the range of wavevector transfers possible here), and it is also matched to the pulsed nature of the source.

I fully subscribe to the items briefly described in your description as important scientific areas to be probed with such an instrument. I would just add that, in general, the short wavelength dynamics of complex fluids systems, or what we generally term "soft condensed matter," is still largely unexplored and is a field containing all kinds of important problems relevant both to basic science and chemical technology. Some examples are the diffusion of macromolecules (including proteins) through gels and porous media, polymer reptation, glass transitions and normal and interface modes in layered microemulsions, liquid crystals and the like. Research on the diffusion of molecules in and out of catalysts and catalyst support systems could also make vital use of such an instrument.

In summary, I do believe such an instrument would be a very important facility for the scientific community in the United States.

With best regards,

Sunil K. Sinha
Associate Division Director
Experimental Facilities Division

SKS/ro

UNIVERSITY OF DELAWARE

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January 20, 1998

Dr. John Z. Larese
Department of Chemistry
Brookhaven National Laboratory
Upton, Long Island 11973-5000

RE: HERMES I Spectrometer

Dear Dr. Larese,

It is a pleasure to write an enthusiastic letter supporting the proposal to build the HERMES I neutron scattering spectrometer at the LANCE facility, Los Alamos National Laboratory. There are several reasons to be enthusiastic.

Firstly, this time of flight spectrometer will be competitive with the high resolution time of flight spectrometers IRIS at the Rutherford Appleton Laboratory, UK, and IN5 and IN6 at the Institute Laue Langevin, France. These are the best spectrometers of their kind in the world. At the present time there are no spectrometers competitive with IRIS, for example, in the USA.

Secondly, HERMES I will enable precision measurements of low energy excitations in a wide spectrum of materials. Low energy excitations play a pivotal role in quantum systems, motions of large molecules in biological systems, large molecules on surfaces and in soft polymeric materials.

There are several faculty at the University of Delaware in the physics, chemistry, biological sciences, chemical and materials engineering departments who will want to use this spectrometer for their research on the above systems. Dr. Glyde, who has done experiments on both IRIS and IN6 is immediately interested to explore quantum fluids. As others become aware of the potential of HERMES I and its availability in the USA, they will want to use it. I see applications particularly in biology and polymeric materials at Delaware.

In short, the proposed HERMES I spectrometer, combined with ready access at LANL, is an important and unique addition to the scientific infrastructure of the USA and of direct interest to scientists and engineers at Delaware.

Yours sincerely,

Costel Denson

Costel D. Denson
Vice Provost for Research

PROF. DR. DIETER RICHTER
DIREKTOR AM INSTITUT FÜR FESTKÖRPERFORSCHUNG
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Dr. John Z. Larese
Chemistry Department
Building 555A
Brookhaven National Laboratory
Upton
New York 11973-5000

USA

Datum: 22. December 1997

Backscattering spectrometer at LANSCE

Dear John,

I hear that you are planning to build an IRIS-type backscattering spectrometer at LANSCE and you ask me for a letter of support.

As you may know during most of my scientific career I have been using frequently the backscattering spectrometer and I am convinced about its scientific value. Thus, I would endorse such a project very much.

Let me be a little bit more specific. High resolution quasielastic neutron scattering by now is a well demonstrated technique with numerous references. Let me just categorize different fields of science where high resolution backscattering has recently been applied.

1. Simple liquids
2. H in metals
3. Clays and intercalates
4. Surface adsorption
5. Vacancy dynamics
6. Polymer dynamics in particular close to the glass transition
7. Tunneling processes
8. Quantum fluids
9. Biophysics and biochemistry

In all these fields backscattering has made considerable impact and will make further impact in the future.

Let me say a few words about the complementarity of an IRIS-type spectrometer and the conventional backscattering machine as it is built at NIST. While the NIST version of a backscattering machine will provide higher energy resolution than IRIS, it delivers this resolution in a relatively narrow energy range (± 50 μeV). The advantage of an IRIS-type machine is the tunability of the dynamic range. With such a machine high resolution experiments can be performed over a very large dynamic range. Inelastic features like tunneling transitions or the roton in He can be accessed with very high resolution.

Similarly, in disordered materials like in glass forming liquids the dynamic features are distributed over a very broad dynamic range. Here line shape analysis is crucially important and requires experiments over a large dynamic range. This also holds true for the dynamics of biological matter where also distributions of relaxation processeses are observed requiring the large dynamic range.

Finally, I like to address the success of IRIS at the Rutherford Appleton Laboratory. This instrument is one of the most oversubscribed machines because of its high flexibility and the very broad range of applications.

Thus, I like to encourage you to build such an instrument which will be an extremely useful tool for scientists of many different fields. It will be particular useful in future growth areas like biology and soft matter science providing at the same time opportunities in classical applications of neutron scattering like metal physics, magnetism or the dynamics of disordered materials.

With best regards,

D. Richter

D. Richter

INSTITUT MAX VON LAUE - PAUL LANGEVIN

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Fax N° 001.516.344.5815
Dr. John Z. Larese
Chemistry Department
Building 555A
Brookhaven Natl. Laboratory
Upton, New York 11973-5000
ETATS UNIS

Grenoble, le 15.12.1997

V/lettre du

Notre référence à rappeler : RS/bs Dir-97.117

Dr. Larry Passell informed me about your plan to submit an application to build an "IRIS type" spectrometer for the Los Alamos pulsed spallation source. Here I reply to his request to express my opinion about the scientific case of such a spectrometer.

Historically TOF spectrometers have - I believe - even existed before the three-axis spectrometers which matured quickly into the working horses of inelastic spectroscopy from crystalline samples. One of the reasons for the success story of TAS was that it answered immediately in Physics language: $S (Q, \omega)$. In contrast to this, TOF data came in many channels, constant angle rather than Q, a whole series of corrections and treatments...

If this was a problem long ago, it is no more today. Computers and algorithms exist to give an immediate view on $S (Q, \omega)$ measured with TOF. Even more: I know from our own experiments on ^{3}He (which is not the easiest sample) that it is perfectly possible to measure in absolute numbers, thus comparing e.g. neutron $S (Q, \omega)$ to X-ray $S (Q)$.

I begin my assessment from the experience at ILL and developments thereafter.

From the early beginning a high and a highest resolution spectrometer were built at ILL: IN5, a two-chopper TOF machine with 20..50 μeV resolution and the backscattering instrument IN10 with 1 μeV.

Today we have:

			typical resolution
IN6	X-tal chopper-TOF		~ 100 μeV
IN5	disk choppers-TOF		~ 20 μeV
IN10	backscattering	$\Delta E \sim \pm 10$ μeV	1μeV

IN10B	backscattering	$\Delta E \leq 1$ meV	~ 2.3 μeV
IN16	backscattering		0.3 μeV
IN11	spin echo		neV
IN15	spin echo		neV

The sheere number reveals their popularity and demand within the user community.

Further development: IN5 (conceived in 1967) proliferated: An improved instrument has been built by R. Lechner and is operational at HMI Berlin, a second "child" grew up nursed by John Copley at NIST. An upgrade IN5B is foreseen at ILL.

Backscattering instruments grew up in Jülich, recently at NIST. Spin echo in Jülich, HMI, LLB.

The spectrometer IRIS at ISIS, UK, is an amazing and logical combination of TOF and backscattering. The high resolution backscattering analyser is combined with a very large flight path which can, of course, only be realised with a long neutron guide in the incoming beam. It thus combines the high resolution with the flexibility of the TOF E_i in particular a wide dynamic range. In contrast to E_{final} TOF the ω–range is practically not limited. This offers the unique possibility to scan in the same run ω with a very good resolution of say 10 μeV around $\omega = 0$ and to reach with coarser resolution (in down scattering) up to higher ω's. Thus sum rules, like the f-sum rule can be verified directly: an additional path to absolute measurements.

IRIS has been very successful indeed, especially the cooled analysers improved the contrast considerably.

What is the science which opens up to TOF spectrometers, in particular to a high resolution instrument?

The trend from simple physics-samples in crystal form to complex chemistry-samples or soft matter is obvious.

The first backscattering instruments were a solution searching for a problem. A problem tunneling spectroscopy developed immediately thereafter. Quasielastic scattering QENS can offer far more than just a diffusion constant. A combination of different diffusive motions can be disentangled from an overlap of several Lorenzians. The study of the elastic incoherent structure factor EISF, i.e. the Q dependence of the true elastic intensity (from a fit of elastic + QENS) is capable of showing the closed orbit $G\ (r,\infty)$ of a single proton under the influence of molecular motion.

Collective motions of large molecular groups let it be in polymers or even in biological systems show up in the very low frequency part of the spectrum.

The scientific opportunities for an IRIS type spectrometer will be enormous, spanning a wide range of interests and attracting many scientists.

An IRIS type spectrometer offers a unique combination of very good resolution, broad scanning range and considerable flexibility.

Last but not least, I underline the possibility to develop such an instrument with the option of polarisation analysis.

I encourage you very much to undertake this development and fully support its scientific case.

Reinhard Scherm

Ø Dr. L. Passell

INSTITUT MAX VON LAUE - PAUL LANGEVIN

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1/12/98
BNL
DIRECTORS OFFICE

Grenoble, le 7 January 1998 V/lettre du

Notre référence à rappeler :
DIR-DS AJL/jmw 98/02

Dear Dr. McWhan,

Proposed backscattering spectrometer at LANSCE

I am very happy to give my support to the proposal to build a backscattering spectrometer at LANSCE. Such an instrument is an essential part of the repertoire of any major neutron facility designed to serve a large user community. ILL now has two such instruments and they both continue to be oversubscribed. The continuing excellence of the scientific programmes on the instruments gives continuous pressure for the upgrade of the spectrometers and in both cases the performance has been progressively improved and the range of scientific applications widened. I note that a backscattering spectrometer is currently under construction at NIST.

There is need also for a spectrometer at LANSCE for two reasons. The first is simply a question of scientific demand - I am completely convinced that the instrument at NIST will be unable to satisfy the demand, which will grow rapidly once the technique is available to the community. Secondly, the pulsed source instrument is in some senses complementary to a reactor instrument in that it covers a range of resolution and energy transfer overlapping the backscattering and time-of-flight reactor spectrometers. The IRIS instrument at ISIS has demonstrated supremely well the efficacy of such an instrument. It should not be forgotten that a decade ago, when we were building IRIS (I was then head of the ISIS facility), it was widely regarded as something of a risk - spallation sources were not supposed to be well suited for high resolution cold neutron spectrometers. This fear has proved to be without foundation, as the enormous success of and demand for the spectrometer will testify.

Although I have insufficient information to comment on relative priorities within an instrument package based on some fixed total budget, I am convinced that at some stage LANSCE really must have a backscattering spectrometer to address what will continue to be an important area of neutron scattering applications.

I hope my remarks may be useful to you.

With best regards,

Yours sincerely,

Alan Leadbetter

Prof. A. J. Leadbetter

UNIVERSITY OF MISSOURI-COLUMBIA

College of Arts and Science
Department of Physics & Astronomy

223 Physics Building
Columbia, Missouri 65211
Telephone (573) 882-3335
FAX (573) 882-4195

December 22, 1997

Dr. J.Z.Larese
Brookhaven National Laboratory
P.O. Box 5000
Upton, NY 11973-5000

Dear Dr. Larese,

This is a letter of support for your proposed construction of a high resolution crystal backscattering neutron spectrometer (HERMES I), to be operated at the neutron spallation source at Los Alamos National Laboratory (LANSCE).

Both Haskell Taub in the Department of Physics and Astronomy here and Mihai Popovici at our Research Reactor Center (MURR) have been invited to participate in this project. Dr. Popovici has made important contributions to the field of neutron beam optics, and Dr. Taub is well known in the neutron scattering community for his studies of the structure, phase transitions, and dynamics of adsorbed hydrocarbon films. The large dynamic range and high energy resolution of HERMES I will make it possible for Professor Taub to extend this work to investigations of the dynamics of polymers near interfaces - work that could greatly impact on technologies related to coatings, adhesion, and lubrication.

We believe HERMES I represents an important addition to the neutron scattering facilities available in this country, with a high potential for producing important new science, and we strongly support the funding of your proposal.

Sincerely,

David Cowan

David L. Cowan
Department of Physics, Professor and Chair

an equal opportunity institution

NEC

NEC Research Institute, Inc.
4 Independence Way
Princeton, New Jersey 08540
Tel. 609-520-1555
Fax 609-951-2481

December 11, 1997

John Z. Larese
Chemistry Department
Brookhaven National Laboratory
Upton, NY 11973-5000

Dear John:

This is to express my enthusiasm for the Hermes I instrument which you intend to construct at the Los Alamos Neutron Science Center. The analogous British instrument, IRIS, located at the Rutherford Appleton Laboratory near Oxford, is one of the most oversubscribed neutron scattering instruments in the world. As such, it has an extraordinarily broad base of users in disciplines ranging from solid state chemistry to low temperature physics. None of these users really has sufficient time to complete more than some very short projects each year, and so an additional instrument of its type would have a large impact not only in the U.S., which has no such machine at present, but also internationally.

In my role as a scientist at NEC, we have recently used IRIS to investigate spin valve arrays, which might eventually be optimized for practical applications in the electronics industry. The IRIS experiments have radically transformed our understanding of these arrays, and we would be very eager to increase our use of IRIS-like capabilities for further work on related problems. The oversubscription of IRIS means that little beam time is available, and so that the atomic-scale spin images which we rely on IRIS for do not appear at the rate at which they should in the rapidly developing field of magnetoelectronics. Hermes I should allow us to greatly accelerate our neutron research in this exciting field.

Sincerely,

Gabriel Aeppli

GA:kah

Kenneth W. Hunter, Jr.
ice President for Research
d Dean of the Graduate School

UNIVERSITY
OF NEVADA
RENO

Office of the
Vice President for Research
and Dean of the Graduate School/326
239 Getchell Library
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FAX: (702) 784-6064

January 12, 1998

Dr. John Larese
Department of Chemistry
Brookhaven National Laboratory
P.O. Box 5000
Upton, NY 11973-5000

Dear Dr. Larese:

I am writing to support the development of the high resolution backscattering spectrometer HERMES I, at Los Alamos National Laboratory. The resolution and intensity that HERMES I will provide for neutron scattering studies is available only in Europe today. Meanwhile, the applications for neutron scattering studies have broadened to include diverse fields such as geophysics, biology, and materials science, as well as physics and chemistry. The HERMES I spectrometer will provide an important facility for research in areas of growth at the University of Nevada, such as porous media and fluid transport. I strongly support this project.

In support of the HERMES I project, the Physics Department at the University of Nevada will make the machine shop available for building components of the new spectrometer.

Sincerely yours,

Kenneth W. Hunter, Jr.
Vice President for Research

lh

PENNSTATE

1855

Rodney A. Erickson
Vice President for Research
Dean of the Graduate School

The Pennsylvania State University
304 Old Main
University Park, PA 16802-1504

(814) 863-9580
Fax: (814) 863-9659
E-mail: rae@psu.edu

January 6, 1998

Dr. John Larese
Department of Chemistry
Brookhaven National Laboratory
P.O. Box 5000
Upton, NY 11973-5000

Dear Dr. Larese:

I am writing to support the development of the new spectrometer HERMES on the upgraded spallation source at Los Alamos National Laboratory. This new spectrometer will have an important impact on many areas where Penn State has strong research programs, such as quantum liquids, magnetism, superconductivity and porous media. At present, there is no instrument with similar capabilities available in the US and the most innovative and groundbreaking work can only be carried out at European facilities.

The HERMES spectrometer, when located at the upgraded spallation neutron source at Los Alamos, will provide a world class facility for inelastic neutron scattering that is second to none. This spectrometer, with its high resolution and intensity, will certainly foster many innovative studies in areas such as physics, chemistry, biology, geology and materials science, which are not now possible in the US. These areas are important not only to fundamental scientific studies but also to developing new technologies for the future.

The Pennsylvania State University strongly supports this project. We will make our machine shop and other facilities available to this project and will provide matching for this project in the amount of 15% of any shop charges for work done at PSU.

In summary, this new spectrometer will provide unique capabilities and I strongly recommend this project to you.

Sincerely,

Rodney A. Erickson

CLRC

Dr Andrew Taylor
Director, Science
Head, ISIS Facility
Rutherford Appleton Laboratory
Chilton Didcot
Oxfordshire
OX11 0QX
Switchboard +44 (0)1235 821900
Telephone +44 (0)1235 446681
Fax +44 (0)1235 445383
E Mail adt@isise.rl.ac.uk

Dr J Z Larese
Chemistry Dept. - Bldg. 555
Brookhaven National Laboratory
Box 5000
Upton
NY 11973-5000
USA

7th January 1998

Dear John,

The HERMES - I Spectrometer

I am very pleased that you are leading the initiative to build a microvolt resolution spectrometer at LANSCE. As you know in Europe there are a number of spectrometers with such capabilities and the demand for such instruments has been consistently high and shows no signs of diminishing. Rather the reverse, since the scientific applications continue to expand.

It is heartening to see that you are building upon the significant instrumental advances which the IRIS spectrometer has achieved here at ISIS over the past decade and I am pleased you have Colin Carlile on board. It is now accepted that cold neutrons on pulsed sources provide data rates which exceed even our most optimistic estimates and puts present day pulsed sources on a par with the best reactors even in this area.

I wish you well with the HERMES project and look forward to seeing the first spectra.

Good luck
Yours sincerely

Dr A D Taylor
Head, ISIS Facility

COUNCIL FOR THE CENTRAL LABORATORY

UNIVERSITY OF WASHINGTON
College of Arts & Sciences, Dean's Office
Box 353765
SEATTLE, WASHINGTON 98195-3765

Gary D. Christian *Divisional Dean of Sciences*

January 15, 1998

Dr. John Z. Larese
Dept. of Chemistry Building 555
Brookhaven National Laboratory
Upton, NY 11973

Dear Dr. Larese:

As Divisional Dean of Sciences at the University of Washington, I express my support for the proposal you head to obtain funding for the constructions of a crystal backscattering spectrometer, HERMES I, at the Los Alamos Neutron Science Center. This short note also expresses my support for the participation of Professor Oscar E. Vilches of our Department of Physics in such a team.

Prof. Vilches has been involved for several years in elastic and quasi-elastic neutron scattering experiments using the facilities available in France at Saclay and ILL-Grenoble. He currently has support from the Division of Materials Research of the NSF for the complementary research done in Seattle, and from the Division of International Programs of the NSF for partial support of his students to travel to France to do those experiments. A facility available in the United States will result in a larger participation by Prof. Vilches and his students in the running of those experiments, as well as entice other researchers at the University of Washington to use the new spectrometer. In addition, Prof. Vilches, very knowledgeable in the cryogenics field, will participate in the design of several of the cryogenic facilities needed for the full utilization of the spectrometer.

Sincerely yours,

Gary D. Christian

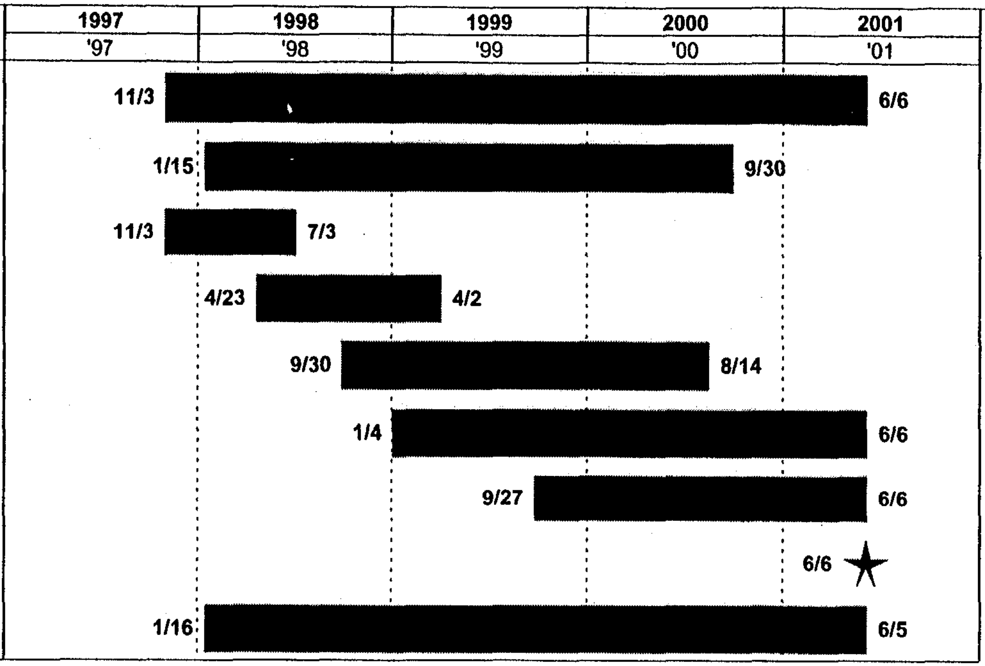
cc. Prof. Stephen Ellis, Chair, Physics
Prof. Oscar E. Vilches

Telephone: (206) 543-5340 FAX: (206) 543-5462 e-mail: christia@chem.washington.edu

Appendix B:

HERMES 1
PROPOSAL OPTION 1
SUMMARY SCHEDULE: LEVEL 1

ID	WBS	Task Name	PROJECT COSTS
1	1	HERMES I PROJECT: ACCELERATED OPTION	$4,550,769.23
2	1.1	SUMMARY PROJECT REQUIREMENTS/MILESTONES	$0.00
9	1.2	CONCEPTUAL DESIGN	$0.00
61	1.3	DETAILED DESIGN	$93,923.08
111	1.4	PROCUREMENT	$3,476,900.00
157	1.5	INSTALLATION: LANL	$403,442.31
207	1.6	TESTING PROGRAM	$0.00
211	1.7	HERMES OPERATIONAL	$0.00
212	1.8	PROJECT MANAGEMENT	$576,503.84

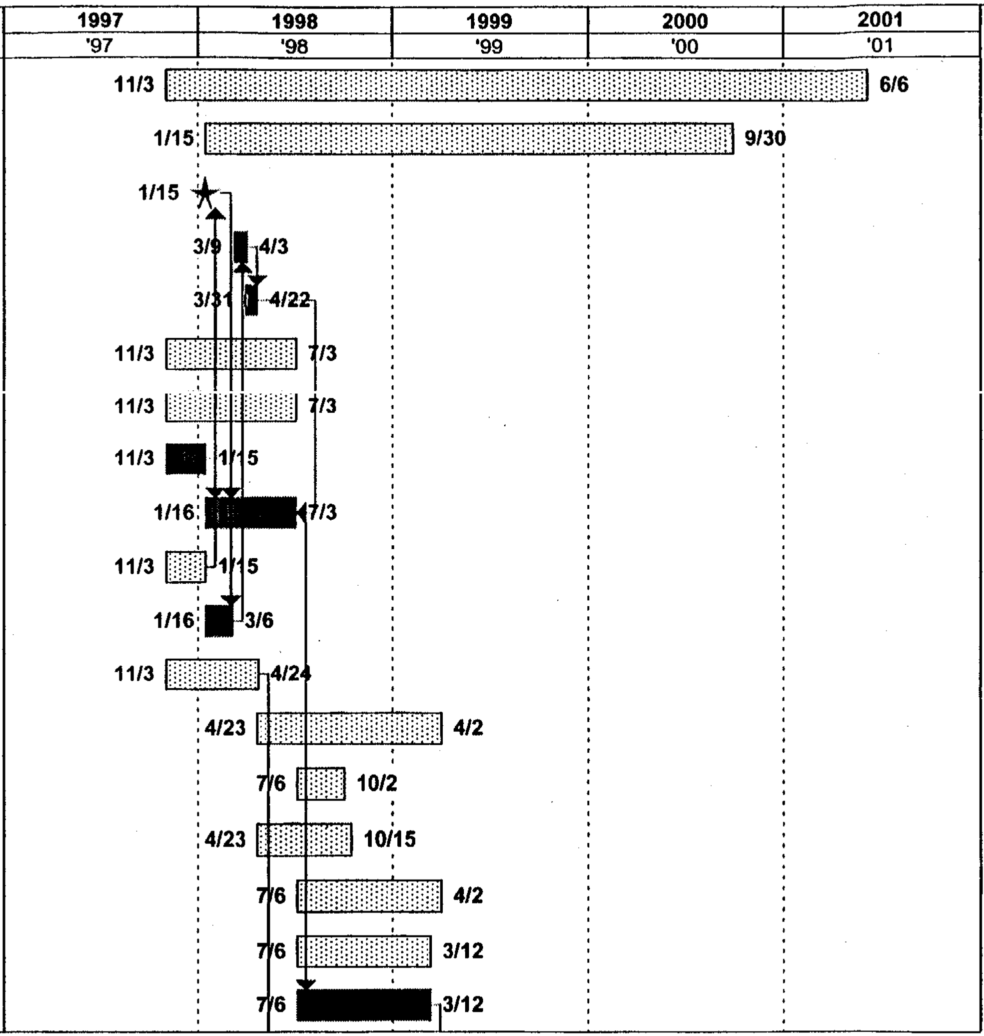


Project: HERMES I
Date: Sun 6/9/159

Task	■	Milestone	★	Rolled Up Milestone	☆
Task Progress	☐	Summary	■	Rolled Up Progress	■
Critical Task	▨	Rolled Up Task	■		
Critical Task Progress	☐	Rolled Up Critical Task	▨		

HERMES 1
PROPOSAL OPTION 1
MANAGEMENT SCHEDULE: LEVEL 2

ID	WBS	Task Name	PROJECT COSTS
1	1	HERMES I PROJECT: ACCELERATED OPTION	$4,550,769.23
2	1.1	SUMMARY PROJECT REQUIREMENTS/MILESTONES	$0.00
3	1.1.1	SPECTROMETER PROPOSALS DUE	$0.00
4	1.1.2	PROPOSAL PRESENTATION TO LANL	$0.00
5	1.1.3	LANL/DOE DECISION TO PROCEED	$0.00
9	1.2	CONCEPTUAL DESIGN	$0.00
10	1.2.1	MONTE CARLO SIMULATIONS	$0.00
11	1.2.1.1	PRELIMINARY MONTE CARLO SIMULATIONS TO SUPPORT	$0.00
12	1.2.1.2	FINAL MONTE CARLO SIMULATIONS	$0.00
13	1.2.2	EQUIPMENT CONCEPTUAL DESIGN	$0.00
59	1.2.3	ENHANCED CONCEPTUAL DESIGN	$0.00
60	1.2.4	BNL CONCEPTUAL DESIGN SUPPORT (CONTRIBUTED)	$0.00
61	1.3	DETAILED DESIGN	$93,923.08
62	1.3.1	CHOPPER ASSEMBLIES (2): FRAME	$0.00
66	1.3.2	NEUTRON GUIDE SYSTEM	$0.00
73	1.3.3	ANALYZER & DETECTOR SECTIONS	$0.00
74	1.3.3.1	ANALYZER SECTIONS	$0.00
75	1.3.3.1.1	GRAPHITE ANALYZER CRYSTALS	$0.00

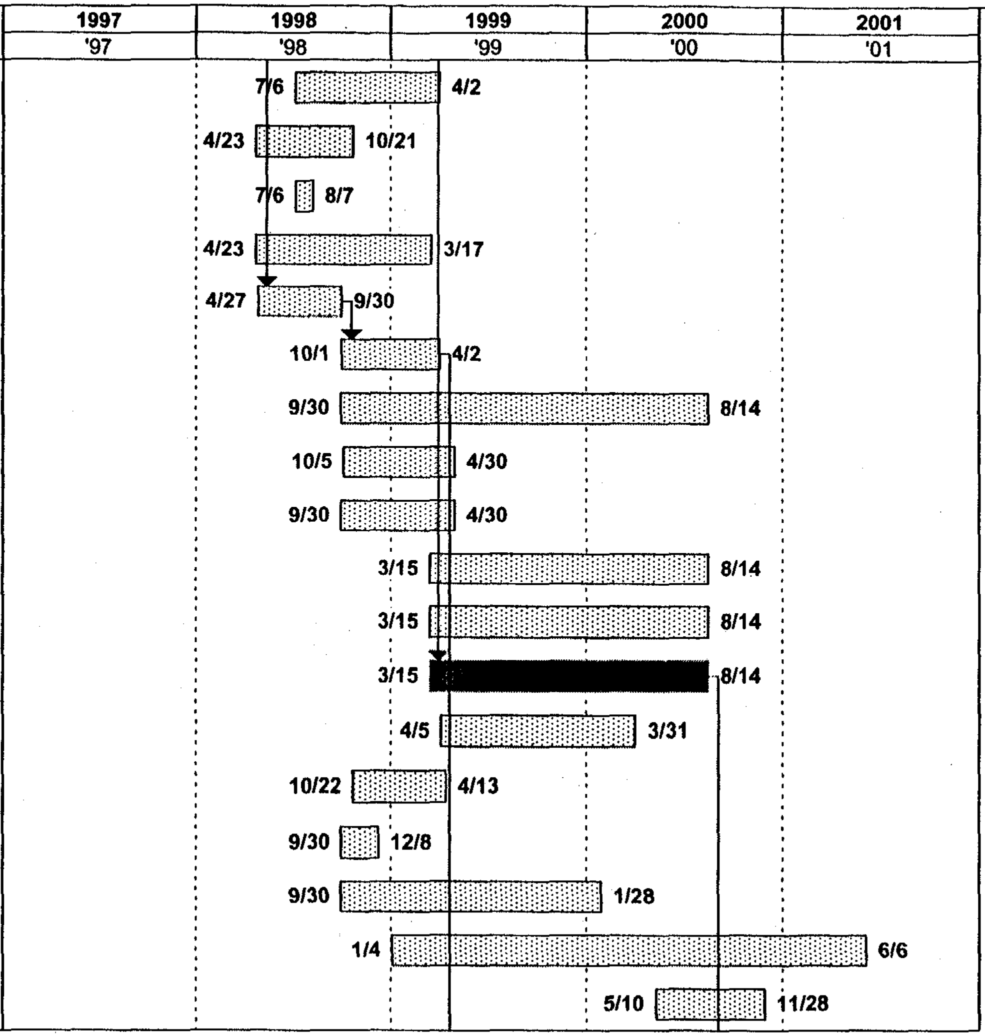


Task	▨	Milestone	★	Rolled Up Milestone	☆
Task Progress	■	Summary	▨	Rolled Up Progress	■
Critical Task	■	Rolled Up Task	▨		
Critical Task Progress	☐	Rolled Up Critical Task	■		

Project: HERMES I
Date: Sun 6/9/159

HERMES 1
PROPOSAL OPTION 1
MANAGEMENT SCHEDULE: LEVEL 2

ID	WBS	Task Name	PROJECT COSTS
82	1.3.3.2	DETECTOR SECTIONS	$0.00
89	1.3.4	SPECTROMETER TANK ASSEMBLY	$0.00
94	1.3.5	SPECTROMETER CONTROL SYSTEM	$0.00
98	1.3.6	ANCILLARY EQUIPMENT	$0.00
109	1.3.7	BNL DETAILED DESIGN SUPPORT (CONTRIBUTED)	$0.00
110	1.3.8	BNL DETAILED DESIGN SUPPORT	$93,923.08
111	1.4	PROCUREMENT	$3,476,900.00
112	1.4.1	CHOPPER ASSEMBLIES (3): TO, FRAME	$142,500.00
116	1.4.2	NEUTRON GUIDE SYSTEM	$1,607,100.00
123	1.4.3	ANALYZER & DETECTOR SECTIONS	$933,900.00
124	1.4.3.1	ANALYZER SECTION	$635,200.00
125	1.4.3.1.1	GRAPHITE ANALYZER CRYSTALS	$300,000.00
131	1.4.3.2	DETECTOR SYSTEM	$298,700.00
137	1.4.4	SPECTROMETER TANK ASSEMBLY	$444,900.00
142	1.4.5	SPECTROMETER CONTROL SYSTEM	$163,100.00
146	1.4.6	ANCILLARY EQUIPMENT	$185,400.00
157	1.5	INSTALLATION: LANL	$403,442.31
158	1.5.1	CHOPPER ASSEMBLIES (3): TO, FRAME	$0.00

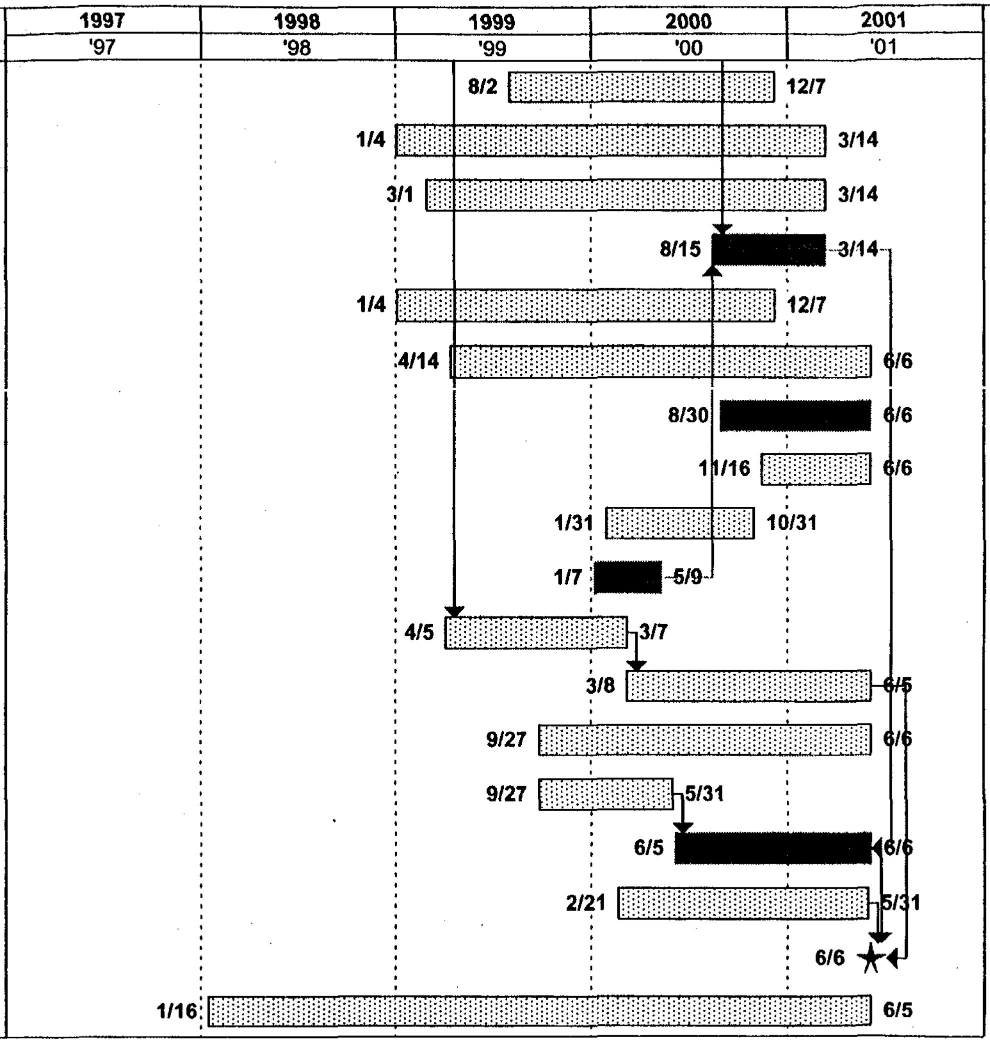


Project: HERMES I
Date: Sun 6/9/159

Task	▨	Milestone	★	Rolled Up Milestone	☆
Task Progress	■	Summary	▨	Rolled Up Progress	■
Critical Task	■	Rolled Up Task	▨		
Critical Task Progress	□	Rolled Up Critical Task	■		

HERMES 1
PROPOSAL OPTION 1
MANAGEMENT SCHEDULE: LEVEL 2

ID	WBS	Task Name	PROJECT COSTS
162	1.5.2	NEUTRON GUIDE SYSTEM	$0.00
169	1.5.3	ANALYZER & DETECTOR SECTIONS	$0.00
170	1.5.3.1	ANALYZER SECTION	$0.00
171	1.5.3.1.1	GRAPHITE ANALYZER CRYSTALS	$0.00
178	1.5.3.2	DETECTOR SECTION	$0.00
185	1.5.4	SPECTROMETER TANK ASSEMBLY	$0.00
189	1.5.4.4	INSTRUMENT SHIELD "HUTCH"	$0.00
190	1.5.5	SPECTROMETER CONTROL SYSTEM	$0.00
194	1.5.6	ANCILLARY EQUIPMENT	$0.00
204	1.5.7	INSTRUMENT CRANE	$0.00
205	1.5.8	BNLTECH STAFF SUPPORT	$172,192.31
206	1.5.9	BNL STAFF INSTALLATION/TESTING SUPPORT	$231,250.00
207	1.6	TESTING PROGRAM	$0.00
208	1.6.1	DEVELOP START-UP & TEST PLAN	$0.00
209	1.6.2	START-UP/TEST/READINESS ASSESSMENT	$0.00
210	1.6.3	TRAINING PROGRAM	$0.00
211	1.7	HERMES OPERATIONAL	$0.00
212	1.8	PROJECT MANAGEMENT	$576,503.84

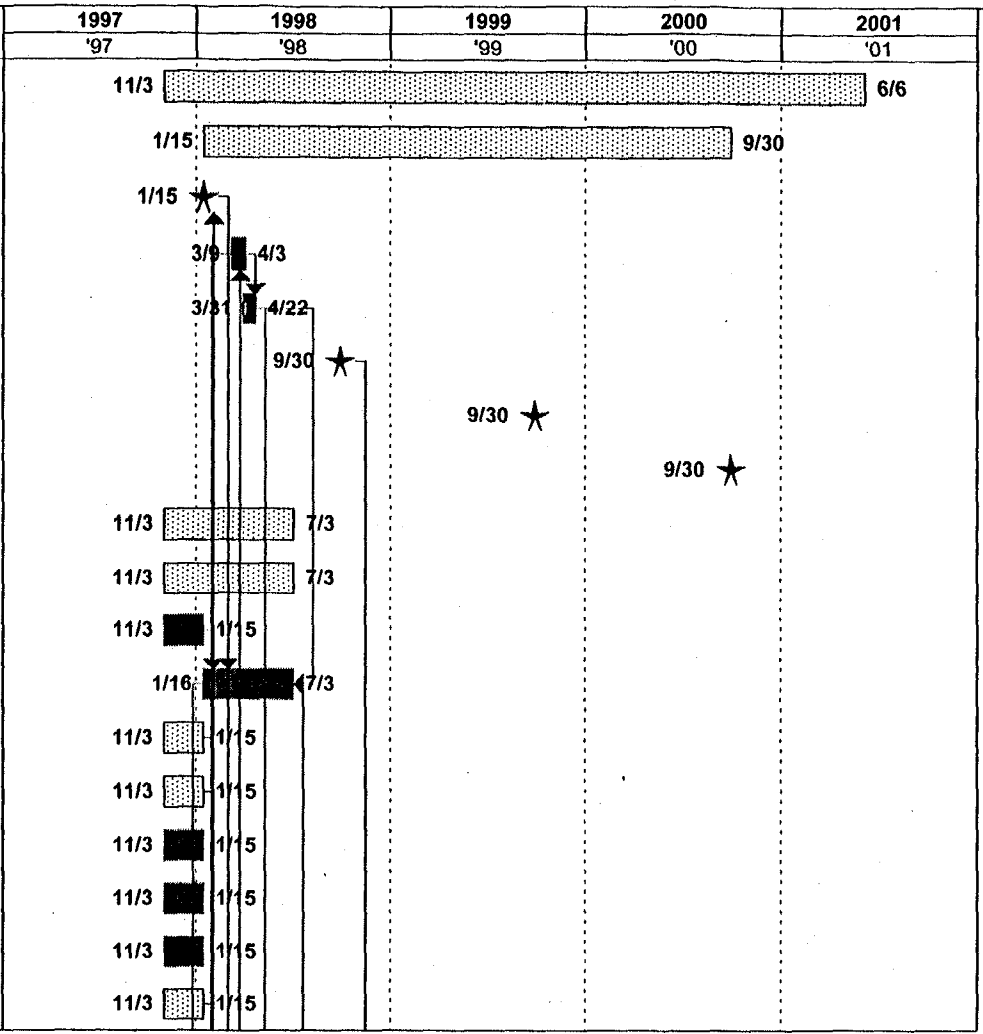


Project: HERMES I
Date: Sun 6/9/159

Task	▨	Milestone	★	Rolled Up Milestone	☆
Task Progress	■	Summary	▨	Rolled Up Progress	■
Critical Task	■	Rolled Up Task	▨		
Critical Task Progress	☐	Rolled Up Critical Task	■		

HERMES 1
PROPOSAL OPTION 1
DETAILED SCHEDULE: LEVEL 3

ID	WBS	Task Name	PROJECT COSTS
1	1	HERMES I PROJECT: ACCELERATED OPTION	$4,550,769.23
2	1.1	SUMMARY PROJECT REQUIREMENTS/MILESTONES	$0.00
3	1.1.1	SPECTROMETER PROPOSALS DUE	$0.00
4	1.1.2	PROPOSAL PRESENTATION TO LANL	$0.00
5	1.1.3	LANL/DOE DECISION TO PROCEED	$0.00
6	1.1.4	FUNDING RELEASE FOR FY 99	$0.00
7	1.1.5	FUNDING RELEASE FOR FY 00	$0.00
8	1.1.6	FUNDING RELEASE FOR FY 01	$0.00
9	1.2	CONCEPTUAL DESIGN	$0.00
10	1.2.1	MONTE CARLO SIMULATIONS	$0.00
11	1.2.1.1	PRELIMINARY MONTE CARLO SIMULATIONS TO SUPPORT	$0.00
12	1.2.1.2	FINAL MONTE CARLO SIMULATIONS	$0.00
13	1.2.2	EQUIPMENT CONCEPTUAL DESIGN	$0.00
14	1.2.2.1	CHOPPER ASSEMBLIES (3): TO, FRAME	$0.00
15	1.2.2.1.1	CHOPPER WHEEL	$0.00
16	1.2.2.1.2	MOTOR SPEED CONTROL UNIT	$0.00
17	1.2.2.1.3	CHOPPER PLATFORM	$0.00
18	1.2.2.2	NEUTRON GUIDE SYSTEM	$0.00

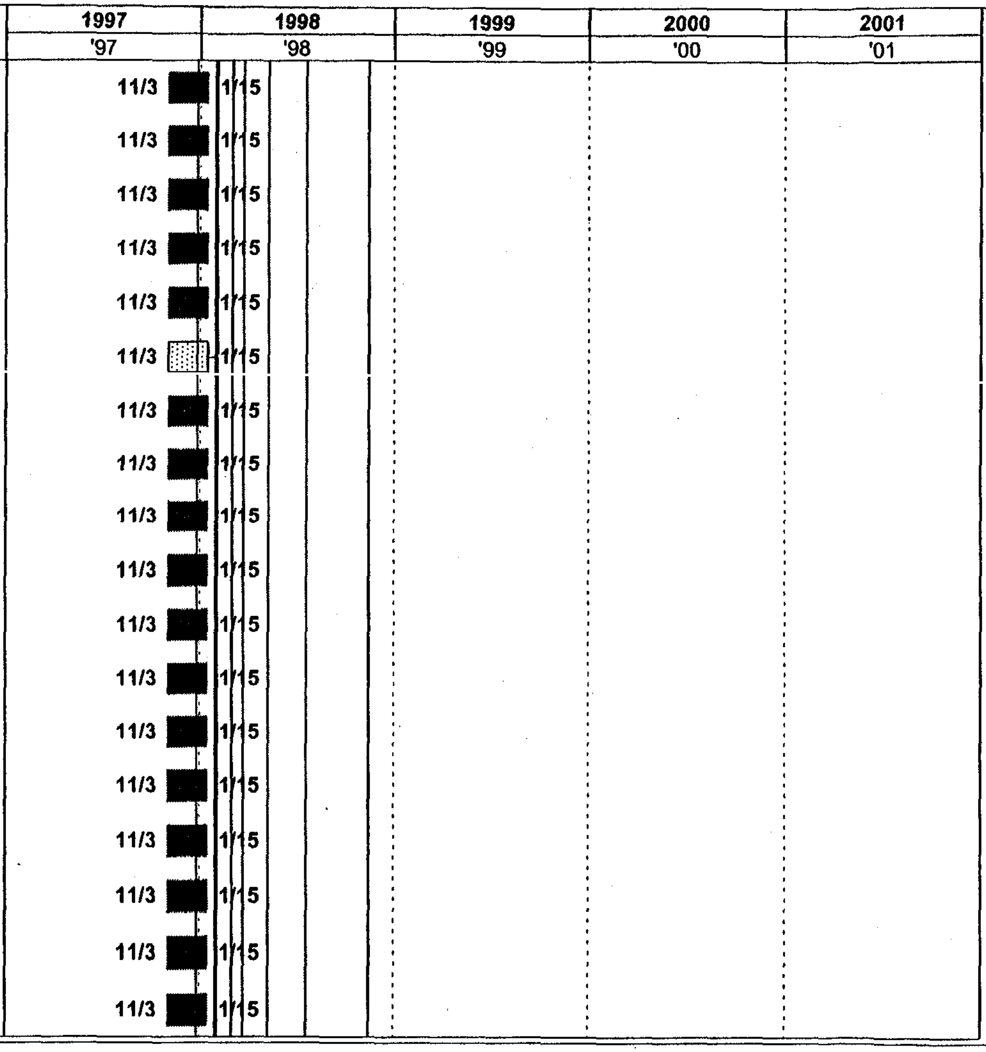


Project: HERMES I
Date: Sun 6/9/159

Task	▨	Milestone	★	Rolled Up Milestone	☆
Task Progress	■	Summary	▨	Rolled Up Progress	■
Critical Task	■	Rolled Up Task	▨		
Critical Task Progress	☐	Rolled Up Critical Task	■		

HERMES 1
PROPOSAL OPTION 1
DETAILED SCHEDULE: LEVEL 3

ID	WBS	Task Name	PROJECT COSTS
19	1.2.2.2.1	SUPERMIRROR GUIDES	$0.00
20	1.2.2.2.2	VACUUM FLIGHT TUBES	$0.00
21	1.2.2.2.3	GUIDE SHIELDING	$0.00
22	1.2.2.2.4	VACUUM PUMPS	$0.00
23	1.2.2.2.5	ALIGNMENT FIXTURES/STANCHIONS	$0.00
24	1.2.2.3	ANALYZER & DETECTOR SECTIONS	$0.00
25	1.2.2.3.1	GRAPHITE ANALYZER CRYSTALS	$0.00
26	1.2.2.3.2	MECHANICAL SUPPORTS	$0.00
27	1.2.2.3.3	FIXING MECHANISM	$0.00
28	1.2.2.3.4	IMPRESSED SHIELDING DISCS	$0.00
29	1.2.2.3.5	ALIGNMENT DEVICES	$0.00
30	1.2.2.3.6	CRYOGENICS/MAIN RESERVOIR	$0.00
31	1.2.2.3.7	FLUID SUPPLY & CONTROL	$0.00
32	1.2.2.3.8	He TUBES (120)	$0.00
33	1.2.2.3.9	ELECTRONIC CHANNELS	$0.00
34	1.2.2.3.10	CABLES	$0.00
35	1.2.2.3.11	MECHANICAL MOUNTS	$0.00
36	1.2.2.3.12	SERVICE TROLLEY	$0.00



Project: HERMES I
Date: Sun 6/9/159

Task	▨	Milestone	★	Rolled Up Milestone	☆
Task Progress	■	Summary	▨	Rolled Up Progress	■
Critical Task	■	Rolled Up Task	▨		
Critical Task Progress	☐	Rolled Up Critical Task	■		

HERMES 1
PROPOSAL OPTION 1
DETAILED SCHEDULE: LEVEL 3

ID	WBS	Task Name	PROJECT COSTS	1997 '97	1998 '98	1999 '99	2000 '00	2001 '01
37	1.2.2.3.13	MOVABLE COLLIMATORS	$0.00	11/3	1/15			
38	1.2.2.4	SPECTROMETER TANK ASSEMBLY	$0.00	11/3	1/15			
39	1.2.2.4.1	ANALYZER TANK	$0.00	11/3	1/15			
40	1.2.2.4.2	VACUUM PUMP/GAUGES, FRAMES/HOSES/VALVES	$0.00	11/3	1/15			
41	1.2.2.4.3	BEAM STOP/DUMP PIPE/MONITOR	$0.00	11/3	1/15			
42	1.2.2.4.4	INSTRUMENT SHIELD "HUTCH"	$0.00	11/3	1/15			
43	1.2.2.5	SPECTROMETER CONTROL SYSTEM	$0.00	11/3	1/15			
44	1.2.2.5.1	DATA ACQUISITION SYSTEM	$0.00	11/3	1/15			
45	1.2.2.5.2	GRAPHICAL USER INTERFACE	$0.00	11/3	1/15			
46	1.2.2.5.3	COMPUTER EQUIPMENT	$0.00	11/3	1/15			
47	1.2.2.5.4	POWER SUPPLY	$0.00	11/3	1/15			
48	1.2.2.6	ANCILLARY EQUIPMENT	$0.00	11/3	1/15			
49	1.2.2.6.1	SAMPLE GONIOMETER	$0.00	11/3	1/15			
50	1.2.2.6.2	TEMPERATURE CONTROLLERS	$0.00	11/3	1/15			
51	1.2.2.6.3	PUMPING STATION	$0.00	11/3	1/15			
52	1.2.2.6.4	VACUUM/PRESSURE GAUGES/SENSORS	$0.00	11/3	1/15			
53	1.2.2.6.5	SAMPLE ENVIRONMENT	$0.00	11/3	1/15			
54	1.2.2.6.5.'	HELIUM CRYOSTAT	$0.00	11/3	1/15			

Project: HERMES I
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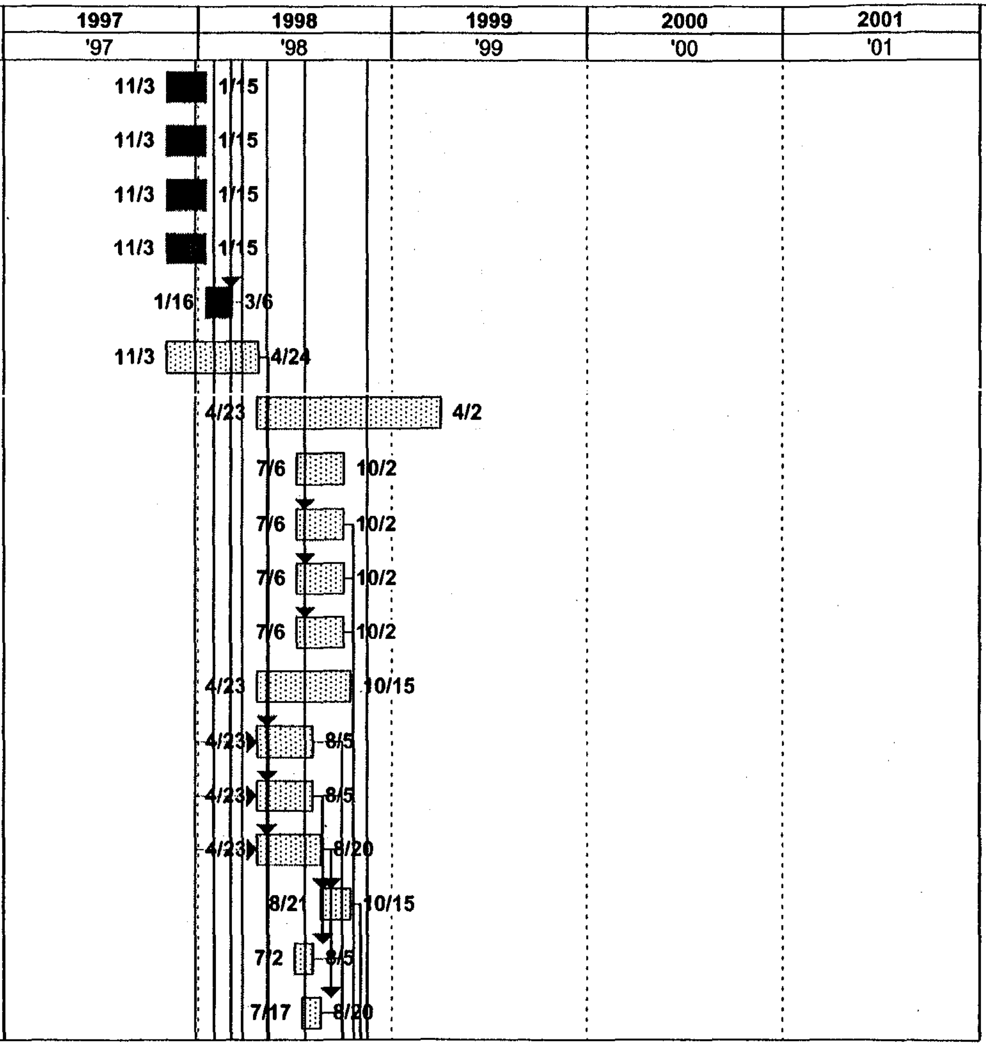
Task	▨	Milestone	★	Rolled Up Milestone	☆
Task Progress	■	Summary	▨	Rolled Up Progress	■
Critical Task	■	Rolled Up Task	▨		
Critical Task Progress	□	Rolled Up Critical Task	■		

HERMES 1
PROPOSAL OPTION 1
DETAILED SCHEDULE: LEVEL 3

ID	WBS	Task Name	PROJECT COSTS
55	1.2.2.6.5.	DISPLEX	$0.00
56	1.2.2.6.5.	GAS HANDLING SYSTEM	$0.00
57	1.2.2.6.5.	FURNACE	$0.00
58	1.2.2.6.6	INSTRUMENT CRANE	$0.00
59	1.2.3	ENHANCED CONCEPTUAL DESIGN	$0.00
60	1.2.4	BNL CONCEPTUAL DESIGN SUPPORT (CONTRIBUTED)	$0.00
61	1.3	DETAILED DESIGN	$93,923.08
62	1.3.1	CHOPPER ASSEMBLIES (2): FRAME	$0.00
63	1.3.1.1	CHOPPER WHEEL	$0.00
64	1.3.1.2	MOTOR SPEED CONTROL UNIT	$0.00
65	1.3.1.3	CHOPPER PLATFORM	$0.00
66	1.3.2	NEUTRON GUIDE SYSTEM	$0.00
67	1.3.2.1	SHUTTER	$0.00
68	1.3.2.2	SUPERMIRROR GUIDES	$0.00
69	1.3.2.3	VACUUM FLIGHT TUBES	$0.00
70	1.3.2.4	GUIDE SHIELDING (PRIMARY/SECONDARY)	$0.00
71	1.3.2.5	VACUUM PUMPS	$0.00
72	1.3.2.6	ALIGNMENT FIXTURES/STANCHIONS	$0.00



Project: HERMES I
Date: Sun 6/9/159

Task ▨
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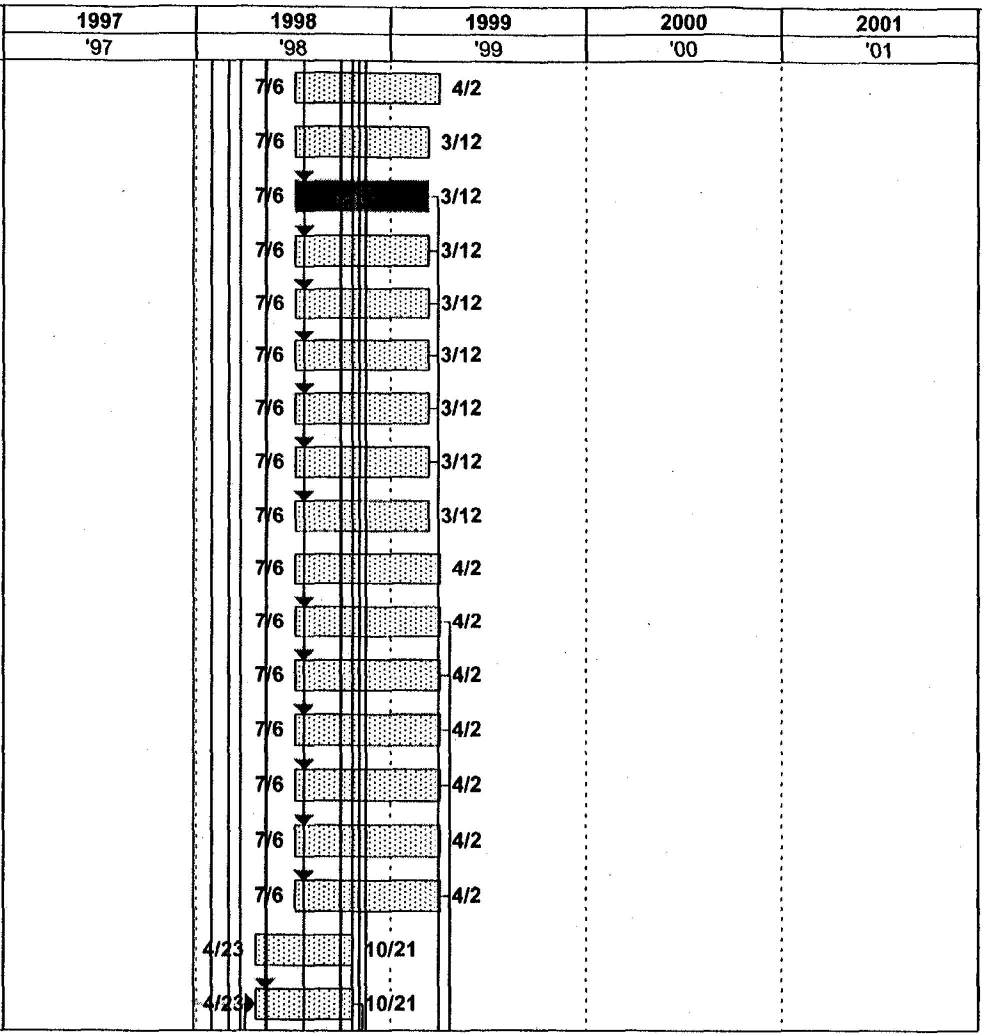
Critical Task ■
Critical Task Progress ☐
Milestone ★
Summary ▨
Rolled Up Task ▨
Rolled Up Critical Task ■
Rolled Up Milestone ☆
Rolled Up Progress ■

HERMES I
PROPOSAL OPTION 1
DETAILED SCHEDULE: LEVEL 3

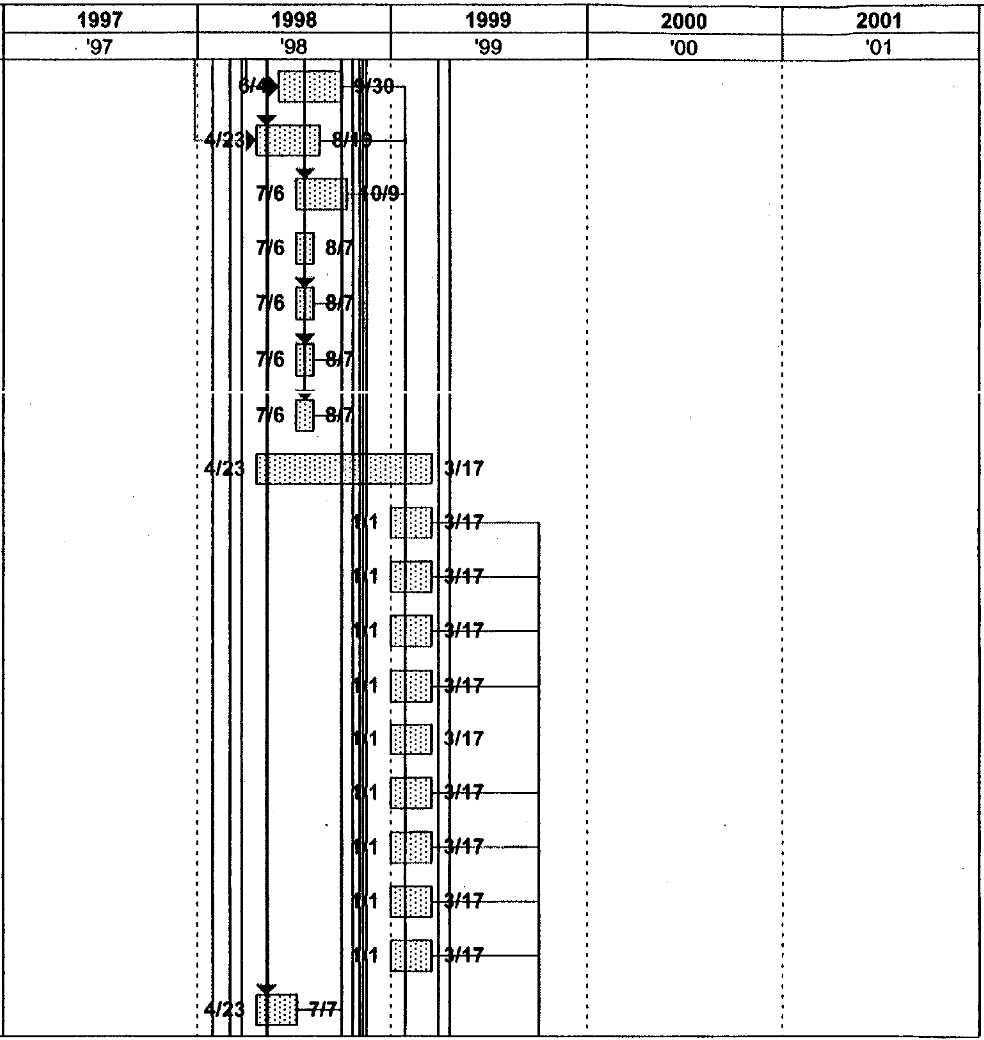
ID	WBS	Task Name	PROJECT COSTS
73	1.3.3	ANALYZER & DETECTOR SECTIONS	$0.00
74	1.3.3.1	ANALYZER SECTIONS	$0.00
75	1.3.3.1.1	GRAPHITE ANALYZER CRYSTALS	$0.00
76	1.3.3.1.2	MECHANICAL SUPPORTS	$0.00
77	1.3.3.1.3	FIXING MECHANISM	$0.00
78	1.3.3.1.4	IMPRESSED SHIELDING DISCS	$0.00
79	1.3.3.1.5	ALIGNMENT DEVICES	$0.00
80	1.3.3.1.6	CRYOGENICS/MAIN RESERVOIR	$0.00
81	1.3.3.1.7	FLUID SUPPLY & CONTROL	$0.00
82	1.3.3.2	DETECTOR SECTIONS	$0.00
83	1.3.3.2.1	He TUBES (120)	$0.00
84	1.3.3.2.2	ELECTRONIC CHANNELS	$0.00
85	1.3.3.2.3	CABLES	$0.00
86	1.3.3.2.4	MECHANICAL MOUNTS	$0.00
87	1.3.3.2.5	SERVICE TROLLEY	$0.00
88	1.3.3.2.6	MOVABLE COLLIMATORS	$0.00
89	1.3.4	SPECTROMETER TANK ASSEMBLY	$0.00
90	1.3.4.1	ANALYZER TANK	$0.00



Task	▨	Milestone	★	Rolled Up Milestone	☆
Task Progress	■	Summary	▨	Rolled Up Progress	■
Critical Task	■	Rolled Up Task	▨		
Critical Task Progress	☐	Rolled Up Critical Task	■		

HERMES 1
PROPOSAL OPTION 1
DETAILED SCHEDULE: LEVEL 3

	'S	Task Name	PROJECT COSTS
	.4.2	VACUUM PUMP/GAUGES, FRAMES/HOSES/VALVES	$0.00
	1.3.4.3	BEAM STOP/DUMP PIPE/MONITOR	$0.00
93	1.3.4.4	INSTRUMENT SHIELD "HUTCH"/ACCESS SCAFFOLDING	$0.00
94	1.3.5	SPECTROMETER CONTROL SYSTEM	$0.00
95	1.3.5.1	DATA ACQUISITION SYSTEM	$0.00
96	1.3.5.2	GRAPHICAL USER INTERFACE	$0.00
97	1.3.5.3	COMPUTER EQUIPMENT	$0.00
98	1.3.6	ANCILLARY EQUIPMENT	$0.00
99	1.3.6.1	SAMPLE GONIOMETER	$0.00
100	1.3.6.2	TEMPERATURE CONTROLLERS	$0.00
101	1.3.6.3	PUMPING STATION	$0.00
102	1.3.6.4	VACUUM/PRESSURE GAUGES/SENSORS	$0.00
103	1.3.6.5	SAMPLE ENVIRONMENT	$0.00
104	1.3.6.5.1	HELIUM CRYOSTAT	$0.00
105	1.3.6.5.2	DISPLEX	$0.00
106	1.3.6.5.3	GAS HANDLING SYSTEM	$0.00
107	1.3.6.5.4	FURNACE	$0.00
108	1.3.6.6	INSTRUMENT CRANE	$0.00



Project: HERMES I
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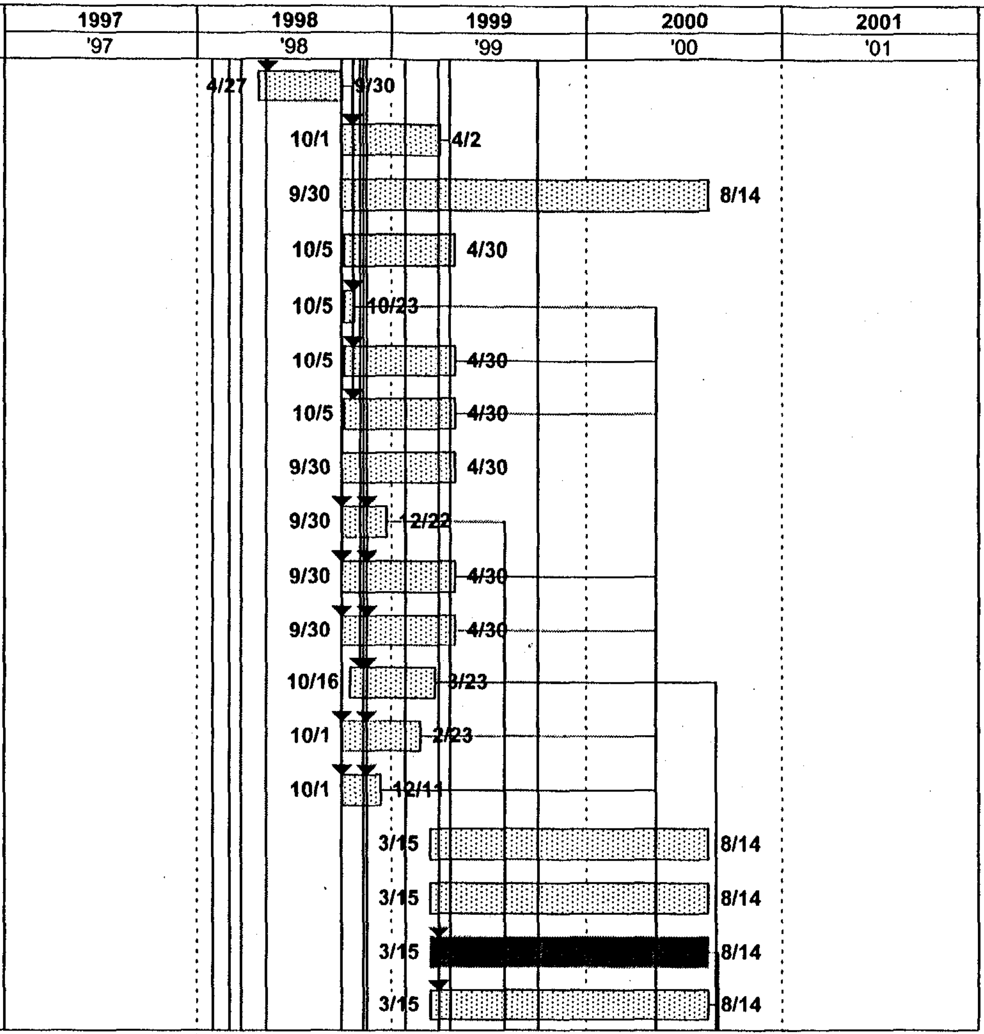
Task	▨	Milestone	★	Rolled Up Milestone	☆
Task Progress	■	Summary	▨	Rolled Up Progress	■
Critical Task	■	Rolled Up Task	▨		
Critical Task Progress	☐	Rolled Up Critical Task	■		

HERMES 1
PROPOSAL OPTION 1
DETAILED SCHEDULE: LEVEL 3

ID	WBS	Task Name	PROJECT COSTS
109	1.3.7	BNL DETAILED DESIGN SUPPORT (CONTRIBUTED)	$0.00
110	1.3.8	BNL DETAILED DESIGN SUPPORT	$93,923.08
111	1.4	PROCUREMENT	$3,476,900.00
112	1.4.1	CHOPPER ASSEMBLIES (3): TO, FRAME	$142,500.00
113	1.4.1.1	CHOPPER WHEEL	$142,500.00
114	1.4.1.2	MOTOR SPEED CONTROL UNIT	$0.00
115	1.4.1.3	CHOPPER PLATFORM	$0.00
116	1.4.2	NEUTRON GUIDE SYSTEM	$1,607,100.00
117	1.4.2.1	SHUTTER	$0.00
118	1.4.2.2	SUPERMIRROR GUIDES	$924,000.00
119	1.4.2.3	VACUUM FLIGHT TUBES	$300,000.00
120	1.4.2.4	GUIDE SHIELDING (PRIMARY/SECONDARY)	$300,000.00
121	1.4.2.5	VACUUM PUMPS	$7,400.00
122	1.4.2.6	ALIGNMENT FIXTURES/STANCHIONS	$75,700.00
123	1.4.3	ANALYZER & DETECTOR SECTIONS	$933,900.00
124	1.4.3.1	ANALYZER SECTION	$635,200.00
125	1.4.3.1.1	GRAPHITE ANALYZER CRYSTALS	$300,000.00
126	1.4.3.1.2	MECHANICAL SUPPORTS	$58,600.00



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Task Progress	■	Summary	▨	Rolled Up Progress	■
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Critical Task Progress	☐	Rolled Up Critical Task	■		

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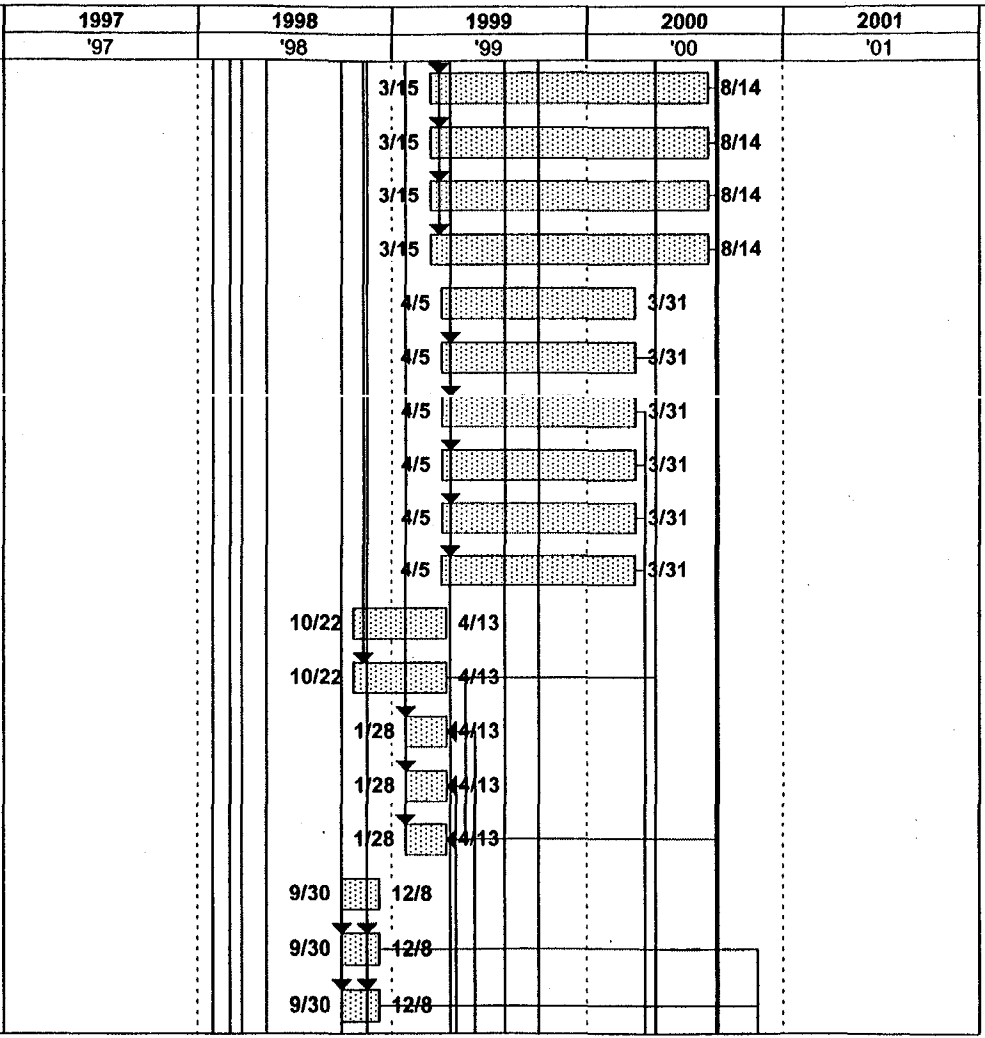
PROPOSAL OPTION 1
DETAILED SCHEDULE: LEVEL 3

ID	WBS	Task Name	PROJECT COSTS
127	1.4.3.1.3	FIXING MECHANISM	$12,300.00
128	1.4.3.1.4	IMPRESSED SHIELDING DISCS	$66,400.00
129	1.4.3.1.5	ALIGNMENT DEVICES	$67,400.00
130	1.4.3.1.6	CRYOGENICS/MAIN RESERVOIR	$130,500.00
131	1.4.3.2	DETECTOR SYSTEM	$298,700.00
132	1.4.3.2.1	He TUBES (120)	$189,200.00
133	1.4.3.2.2	ELECTRONIC CHANNELS	$58,400.00
134	1.4.3.2.3	CABLES	$9,700.00
135	1.4.3.2.4	MECHANICAL MOUNTS	$24,300.00
136	1.4.3.2.5	MOVABLE COLLIMATORS	$17,100.00
137	1.4.4	SPECTROMETER TANK ASSEMBLY	$444,900.00
138	1.4.4.1	ANALYZER TANK	$208,700.00
139	1.4.4.2	VACUUM PUMP/GAUGES, FRAMES/HOSES/VALVES	$54,400.00
140	1.4.4.3	BEAM STOP/DUMP PIPE/MONITOR	$39,300.00
141	1.4.4.4	INSTRUMENT SHIELD "HUTCH"	$142,500.00
142	1.4.5	SPECTROMETER CONTROL SYSTEM	$163,100.00
143	1.4.5.1	DATA ACQUISITION SYSTEM	$163,100.00
144	1.4.5.2	GRAPHICAL USER INTERFACE	$0.00



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Task	▨	Milestone	★	Rolled Up Milestone	☆
Task Progress	▬	Summary	▨	Rolled Up Progress	▬
Critical Task	■	Rolled Up Task	▨		
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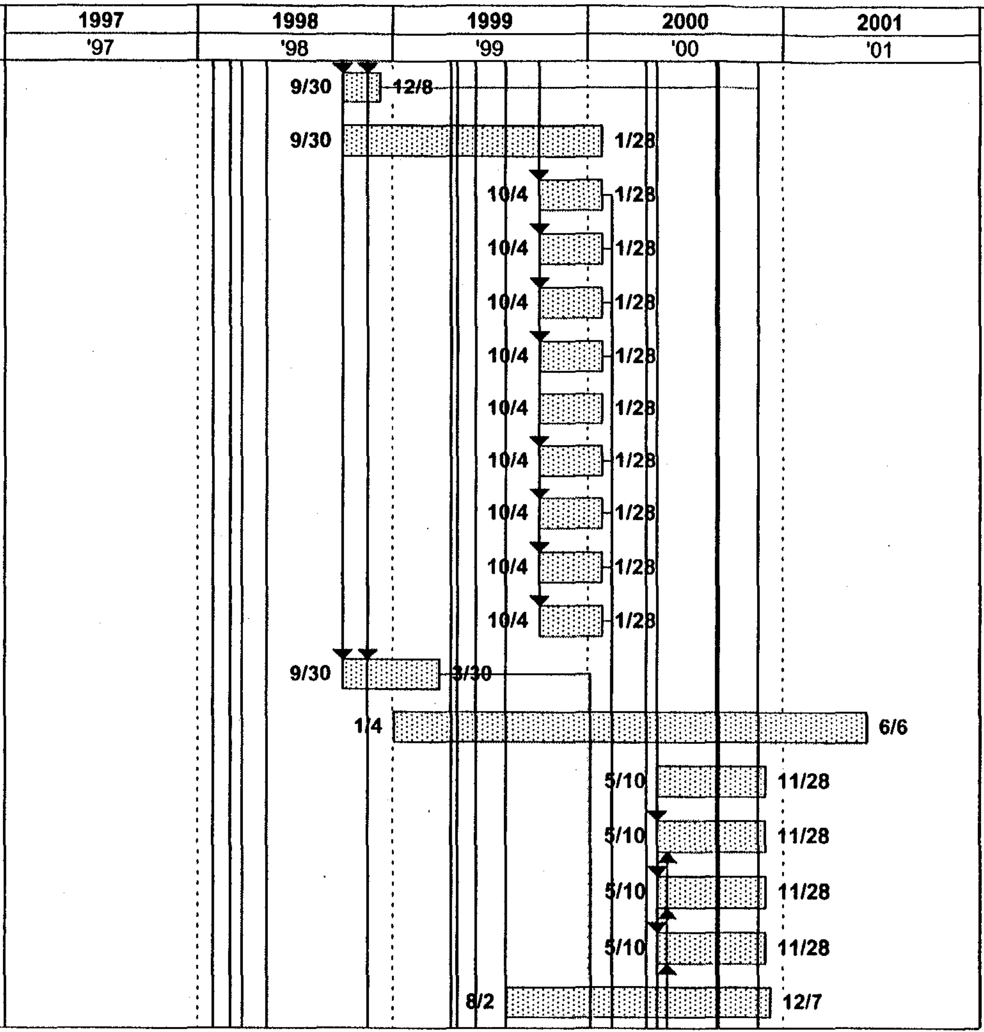
HERMES 1
PROPOSAL OPTION 1
DETAILED SCHEDULE: LEVEL 3

ID	WBS	Task Name	PROJECT COSTS
145	1.4.5.3	COMPUTER EQUIPMENT	$0.00
146	1.4.6	ANCILLARY EQUIPMENT	$185,400.00
147	1.4.6.1	SAMPLE GONIOMETER	$54,400.00
148	1.4.6.2	TEMPERATURE CONTROLLERS	$7,100.00
149	1.4.6.3	PUMPING STATION	$21,400.00
150	1.4.6.4	VACUUM/PRESSURE GAUGES/SENSORS	$27,200.00
151	1.4.6.5	SAMPLE ENVIRONMENT	$38,000.00
152	1.4.6.5.1	HELIUM CRYOSTAT	$0.00
153	1.4.6.5.2	DISPLEX	$0.00
154	1.4.6.5.3	GAS HANDLING SYSTEM	$0.00
155	1.4.6.5.4	FURNACE	$38,000.00
156	1.4.6.6	INSTRUMENT CRANE	$37,300.00
157	1.5	INSTALLATION: LANL	$403,442.31
158	1.5.1	CHOPPER ASSEMBLIES (3): TO, FRAME	$0.00
159	1.5.1.1	CHOPPER WHEEL	$0.00
160	1.5.1.2	MOTOR SPEED CONTROL UNIT	$0.00
161	1.5.1.3	CHOPPER PLATFORM	$0.00
162	1.5.2	NEUTRON GUIDE SYSTEM	$0.00



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Task	▨	Milestone	★	Rolled Up Milestone	☆
Task Progress	■	Summary	▨	Rolled Up Progress	■
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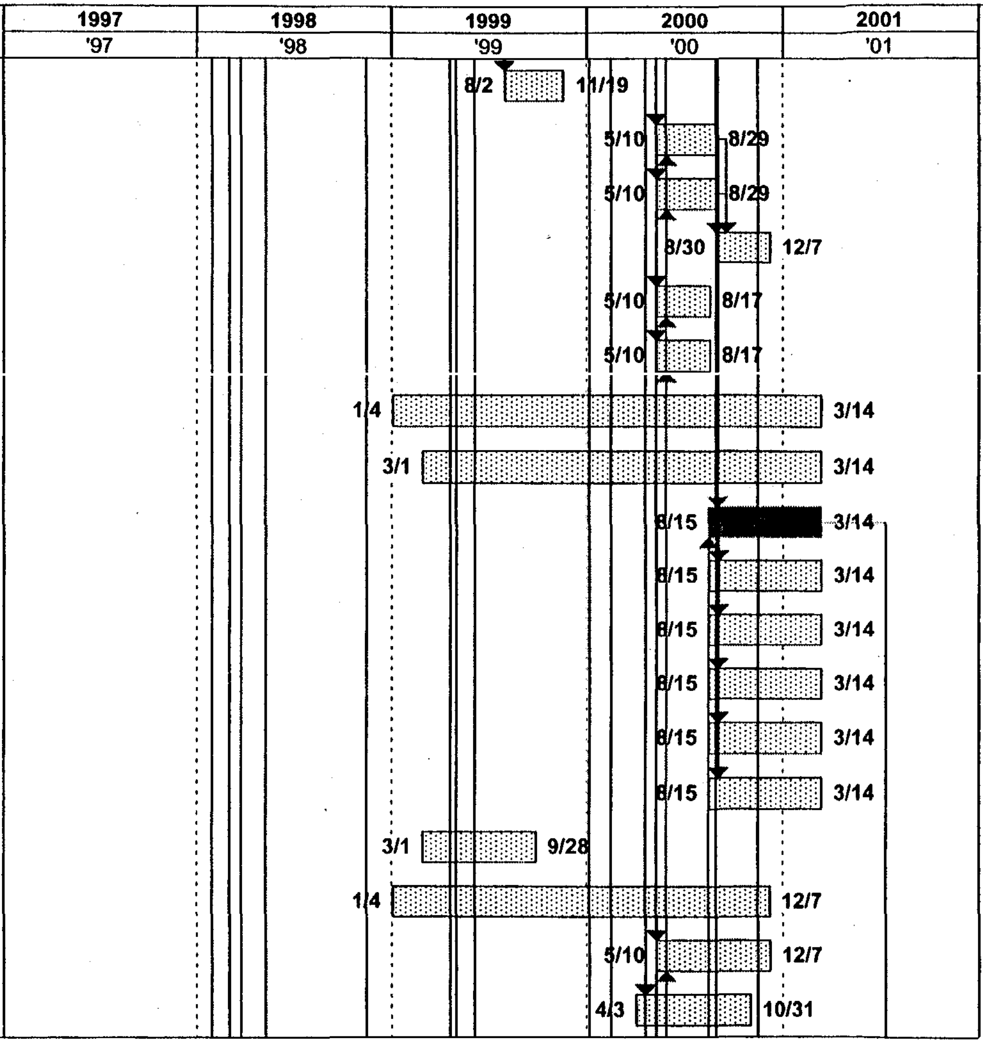
HERMES 1
PROPOSAL OPTION 1
DETAILED SCHEDULE: LEVEL 3

ID	WBS	Task Name	PROJECT COSTS
163	1.5.2.1	SHUTTER	$0.00
164	1.5.2.2	SUPERMIRROR GUIDES	$0.00
165	1.5.2.3	VACUUM FLIGHT TUBES	$0.00
166	1.5.2.4	GUIDE SHIELDING (PRIMARY/SECONDARY)	$0.00
167	1.5.2.5	VACUUM PUMPS	$0.00
168	1.5.2.6	ALIGNMENT FIXTURES/STANCHIONS	$0.00
169	1.5.3	ANALYZER & DETECTOR SECTIONS	$0.00
170	1.5.3.1	ANALYZER SECTION	$0.00
171	1.5.3.1.1	GRAPHITE ANALYZER CRYSTALS	$0.00
172	1.5.3.1.2	MECHANICAL SUPPORTS	$0.00
173	1.5.3.1.3	FIXING MECHANISM	$0.00
174	1.5.3.1.4	IMPRESSED SHIELDING DISCS	$0.00
175	1.5.3.1.5	ALIGNMENT DEVICES	$0.00
176	1.5.3.1.6	CRYOGENICS/MAIN RESERVOIR	$0.00
177	1.5.3.1.7	FLUID SUPPLY & CONTROL	$0.00
178	1.5.3.2	DETECTOR SECTION	$0.00
179	1.5.3.2.1	He TUBES (120)	$0.00
180	1.5.3.2.2	ELECTRONIC CHANNELS	$0.00



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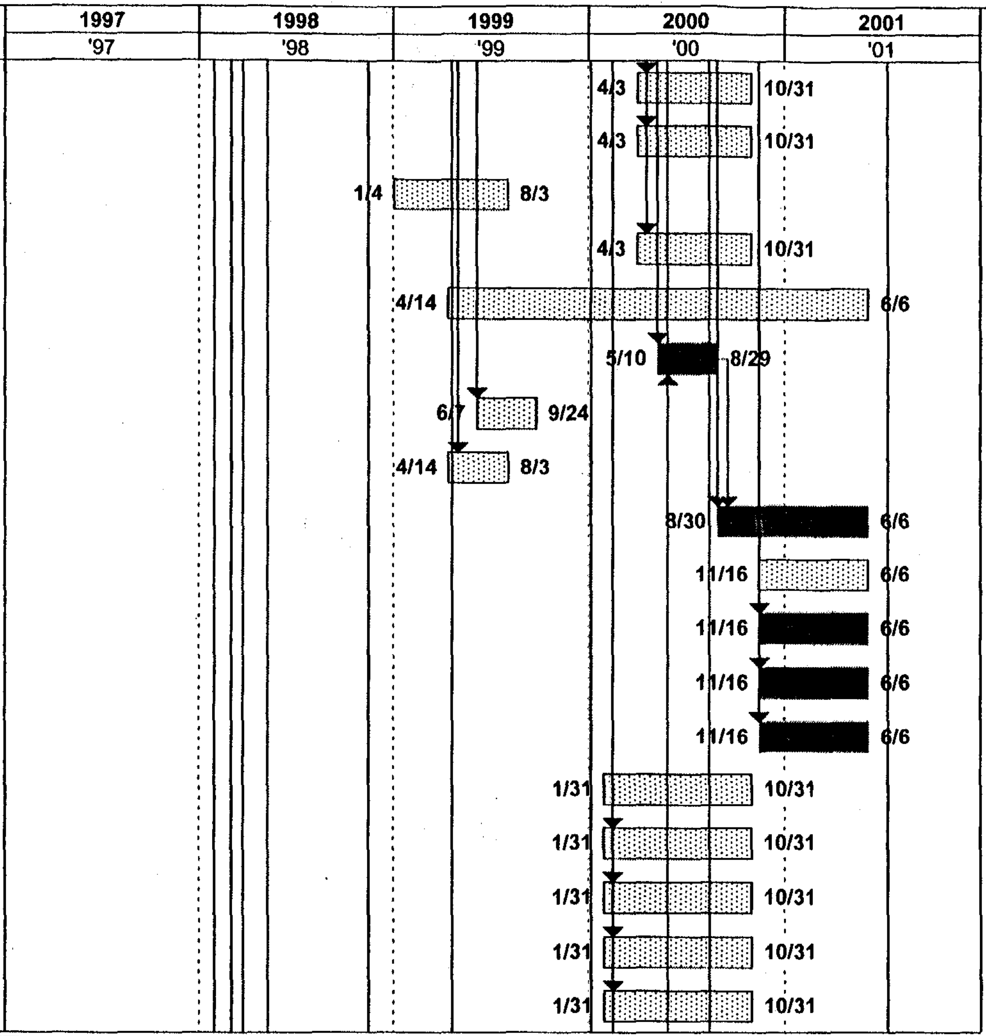
Task	▨	Milestone	★	Rolled Up Milestone	☆
Task Progress	■	Summary	▨	Rolled Up Progress	■
Critical Task	■	Rolled Up Task	▨		
Critical Task Progress	□	Rolled Up Critical Task	■		

HERMES 1
PROPOSAL OPTION 1
DETAILED SCHEDULE: LEVEL 3

ID	WBS	Task Name	PROJECT COSTS
181	1.5.3.2.3	CABLES	$0.00
182	1.5.3.2.4	MECHANICAL MOUNTS	$0.00
183	1.5.3.2.5	SERVICE TROLLEY	$0.00
184	1.5.3.2.6	MOVABLE COLLIMATORS	$0.00
185	1.5.4	SPECTROMETER TANK ASSEMBLY	$0.00
186	1.5.4.1	ANALYZER TANK	$0.00
187	1.5.4.2	VACUUM PUMP/GAUGES, FRAMES/HOSES/VALVES	$0.00
188	1.5.4.3	BEAM STOP/DUMP PIPE/MONITOR	$0.00
189	1.5.4.4	INSTRUMENT SHIELD "HUTCH"	$0.00
190	1.5.5	SPECTROMETER CONTROL SYSTEM	$0.00
191	1.5.5.1	DATA ACQUISITION SYSTEM	$0.00
192	1.5.5.2	GRAPHICAL USER INTERFACE	$0.00
193	1.5.5.3	COMPUTER EQUIPMENT	$0.00
194	1.5.6	ANCILLARY EQUIPMENT	$0.00
195	1.5.6.1	SAMPLE GONIOMETER	$0.00
196	1.5.6.2	TEMPERATURE CONTROLLERS	$0.00
197	1.5.6.3	PUMPING STATION	$0.00
198	1.5.6.4	VACUUM/PRESSURE GAUGES/SENSORS	$0.00



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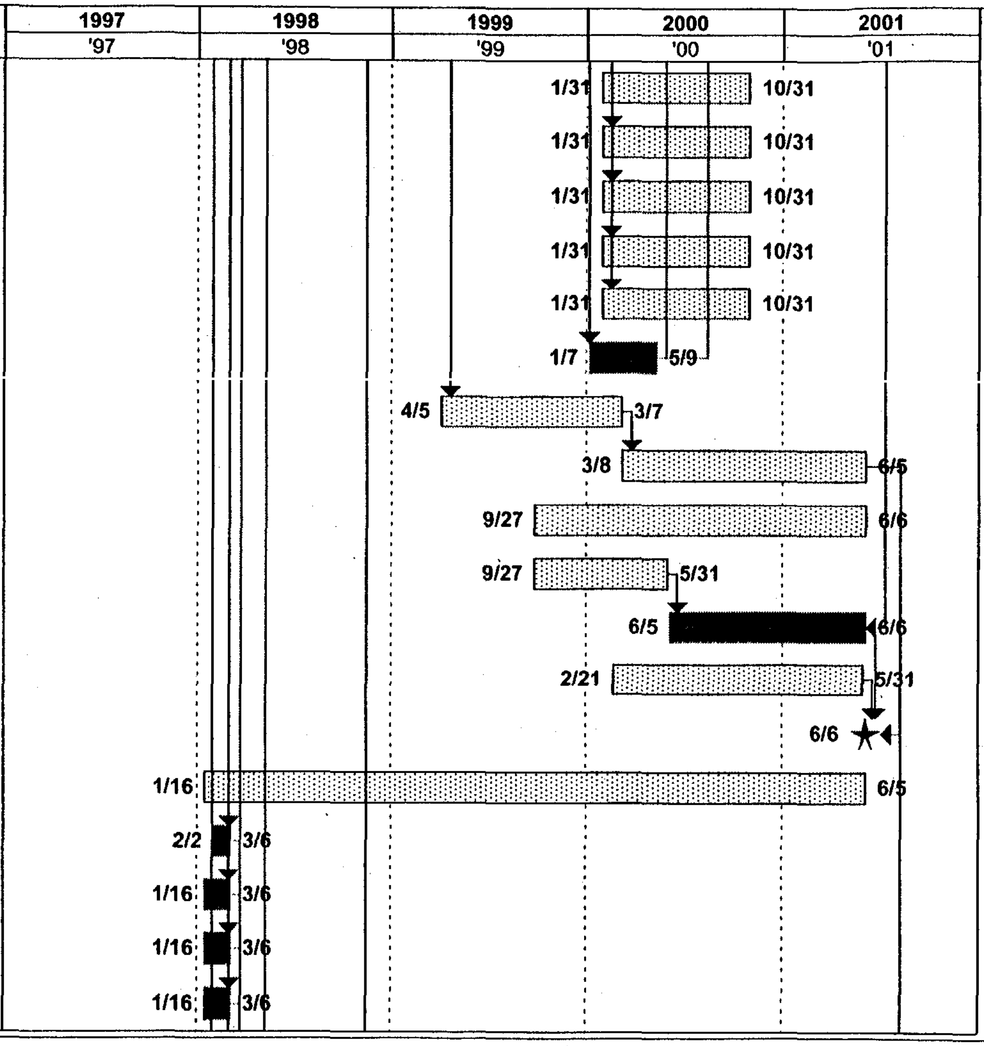
Date: Sun 6/9/159

Task	▨	Milestone	★	Rolled Up Milestone	☆
Task Progress	■	Summary	▨	Rolled Up Progress	■
Critical Task	■	Rolled Up Task	▨		
Critical Task Progress	☐	Rolled Up Critical Task	■		

HERMES 1
PROPOSAL OPTION 1
DETAILED SCHEDULE: LEVEL 3

ID	WBS	Task Name	PROJECT COSTS
199	1.5.6.5	SAMPLE ENVIRONMENT	$0.00
200	1.5.6.5.1	HELIUM CRYOSTAT	$0.00
201	1.5.6.5.2	DISPLEX	$0.00
202	1.5.6.5.3	GAS HANDLING SYSTEM	$0.00
203	1.5.6.5.4	FURNACE	$0.00
204	1.5.7	INSTRUMENT CRANE	$0.00
205	1.5.8	BNLTECH STAFF SUPPORT	$172,192.31
206	1.5.9	BNL STAFF INSTALLATION/TESTING SUPPORT	$231,250.00
207	1.6	TESTING PROGRAM	$0.00
208	1.6.1	DEVELOP START-UP & TEST PLAN	$0.00
209	1.6.2	START-UP/TEST/READINESS ASSESSMENT	$0.00
210	1.6.3	TRAINING PROGRAM	$0.00
211	1.7	HERMES OPERATIONAL	$0.00
212	1.8	PROJECT MANAGEMENT	$576,503.84
213	1.8.1	ESTABLISH LANL/BNL INTERFACES	$0.00
214	1.8.2	LEVEL 2 COST & SCHEDULE	$0.00
215	1.8.3	FINALIZE DETAILED PROCUREMENT STRATEGY	$0.00
216	1.8.4	QUALITY ASSURANCE PLAN	$0.00



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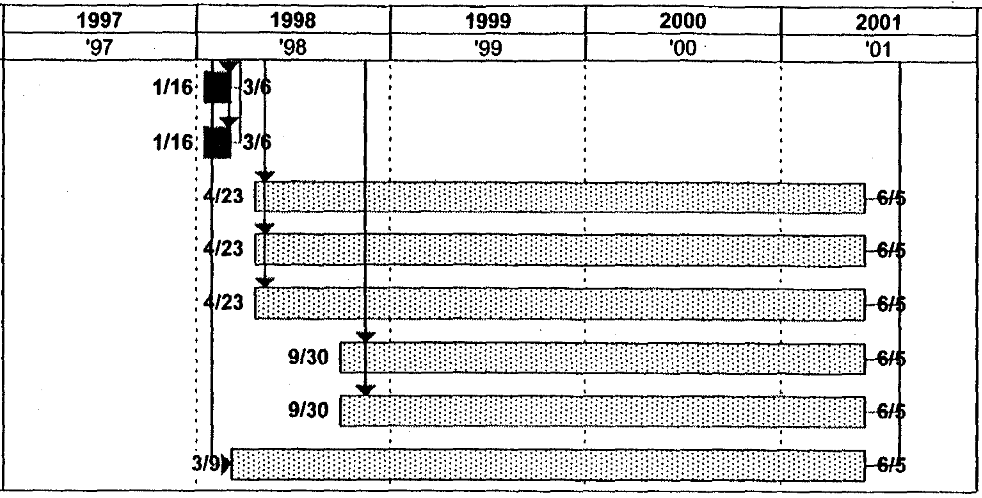
Task ▨
Task Progress ■
Critical Task ■
Critical Task Progress ☐
Milestone ★
Summary ▨
Rolled Up Task ▨
Rolled Up Critical Task ■
Rolled Up Milestone ☆
Rolled Up Progress ■

HERMES 1
PROPOSAL OPTION 1
DETAILED SCHEDULE: LEVEL 3

ID	WBS	Task Name	PROJECT COSTS
217	1.8.5	ES&H PLAN	$0.00
218	1.8.6	PREP/ISSUE PROJECT EXECUTION PLAN	$0.00
219	1.8.7	MONTHLY PROGRESS STATUS/REPORTS: TECHNICAL/COST/SCHEDULE	$0.00
220	1.8.8	QUARTERLY REVIEW	$0.00
221	1.8.9	BASELINE CHANGE MANAGEMENT	$0.00
222	1.8.10	BNL PROJECT MANAGEMENT STAFF (INCLUDING LANL LIAISON)	$403,846.15
223	1.8.11	BNL NEUTRON TECHNICIANS	$0.00
224	1.8.12	BNL TRAVEL	$172,657.69



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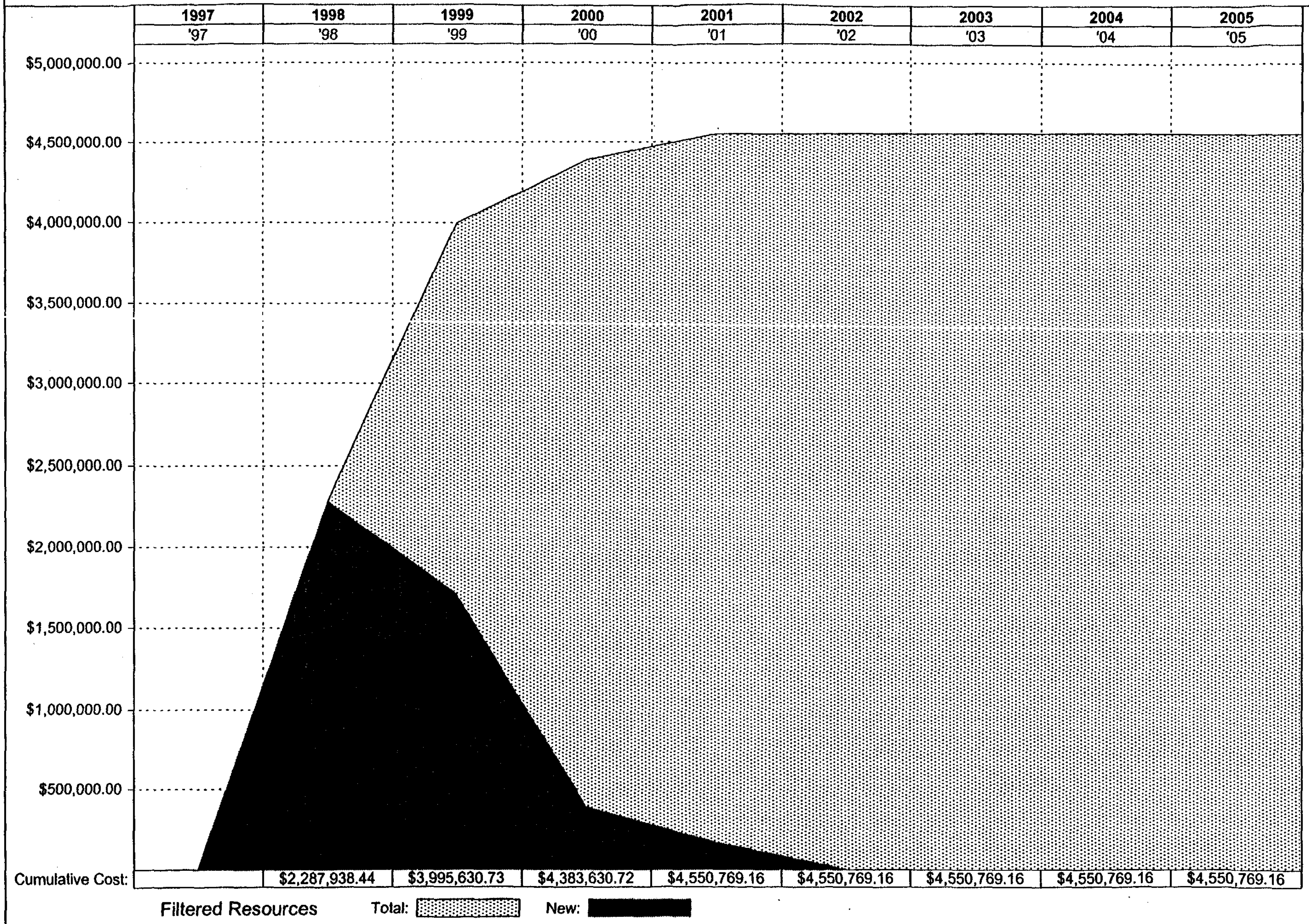
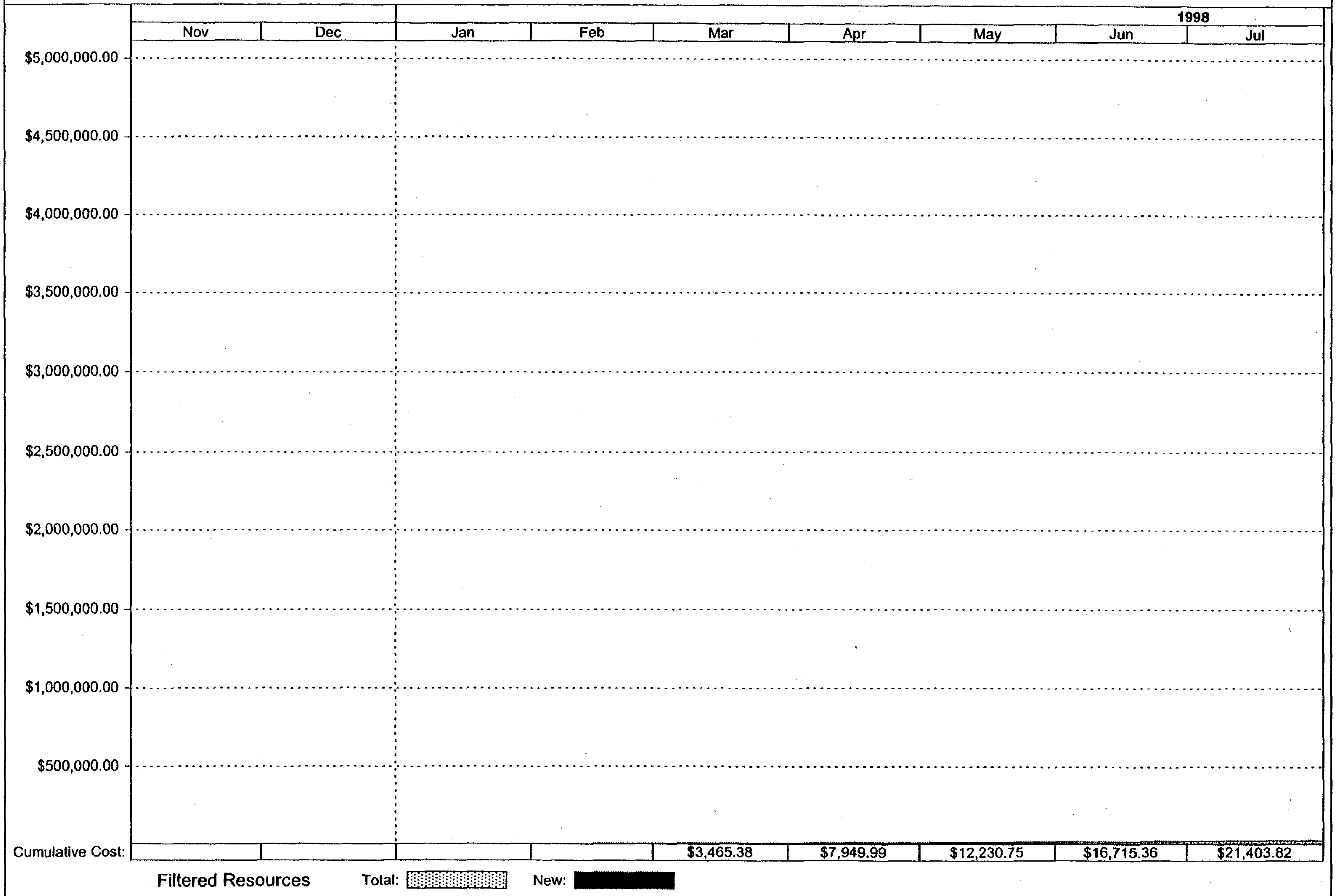
Task	▨	Milestone	★	Rolled Up Milestone	☆
Task Progress	■	Summary	▨	Rolled Up Progress	■
Critical Task	■	Rolled Up Task	▨		
Critical Task Progress	☐	Rolled Up Critical Task	■		

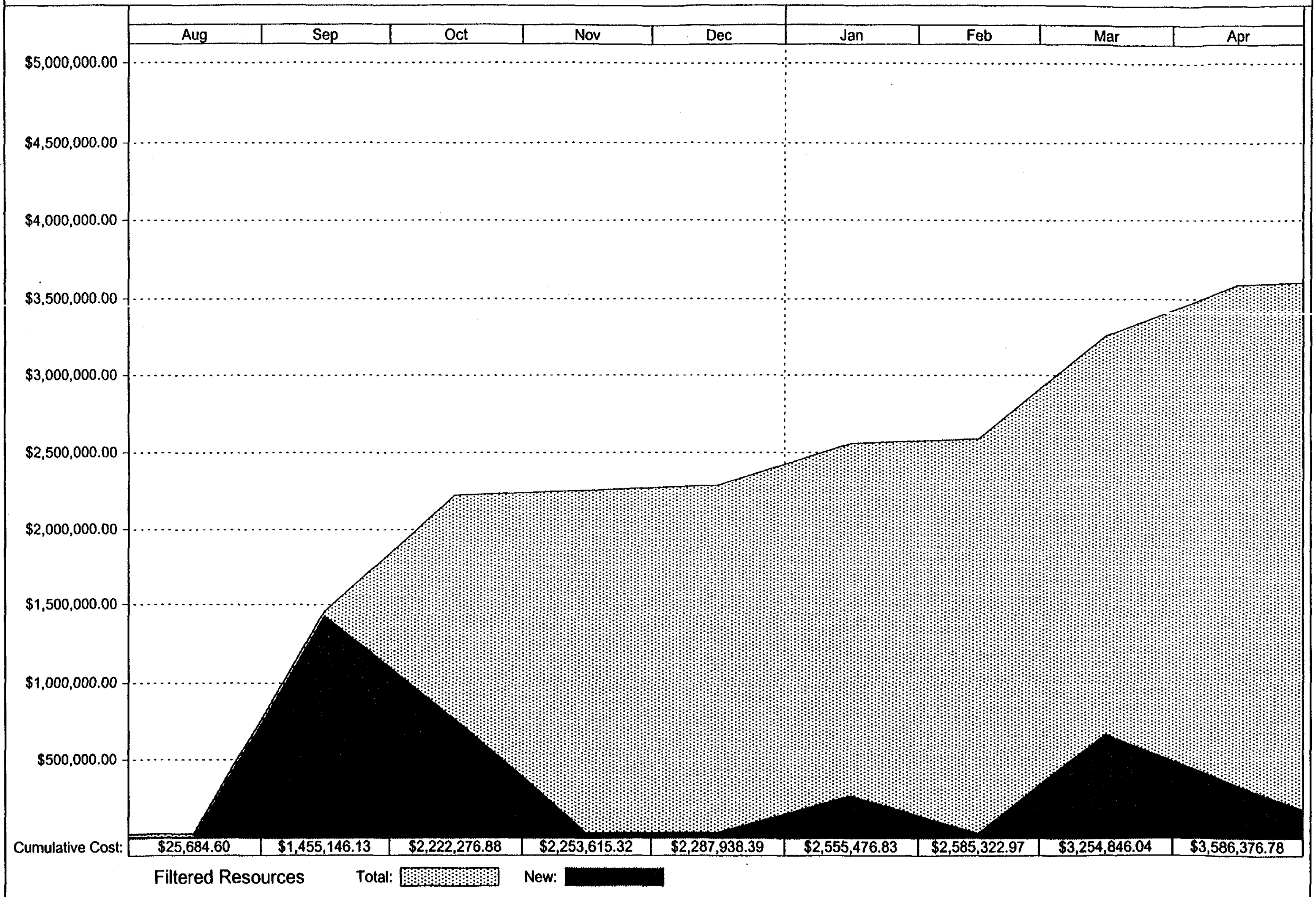
HERMES I
PROPOSAL OPTION 1
COST CURVE



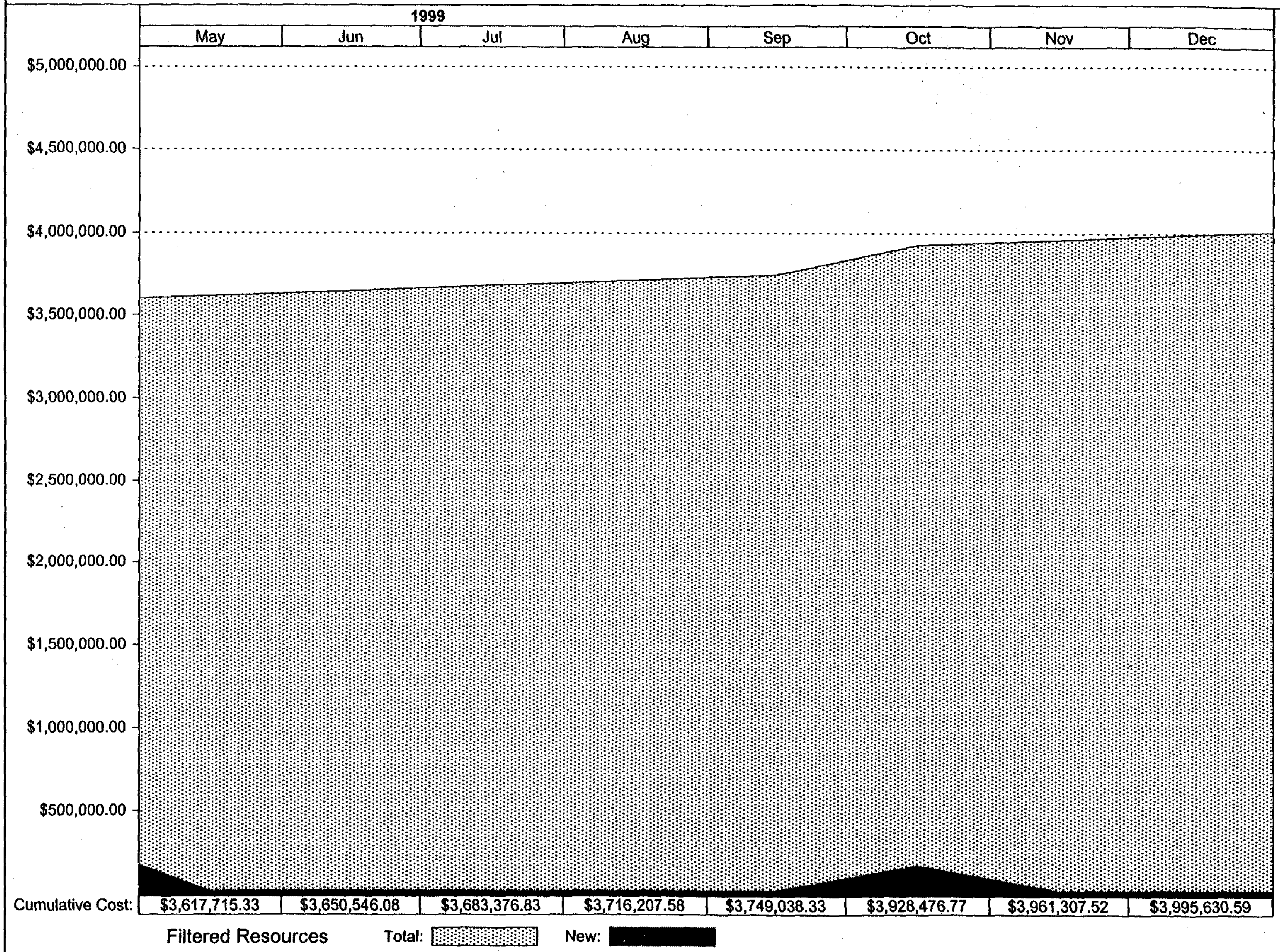
HERMES I
PROPOSAL OPTION 1
COST CURVE



HERMES I
PROPOSAL OPTION 1
COST CURVE

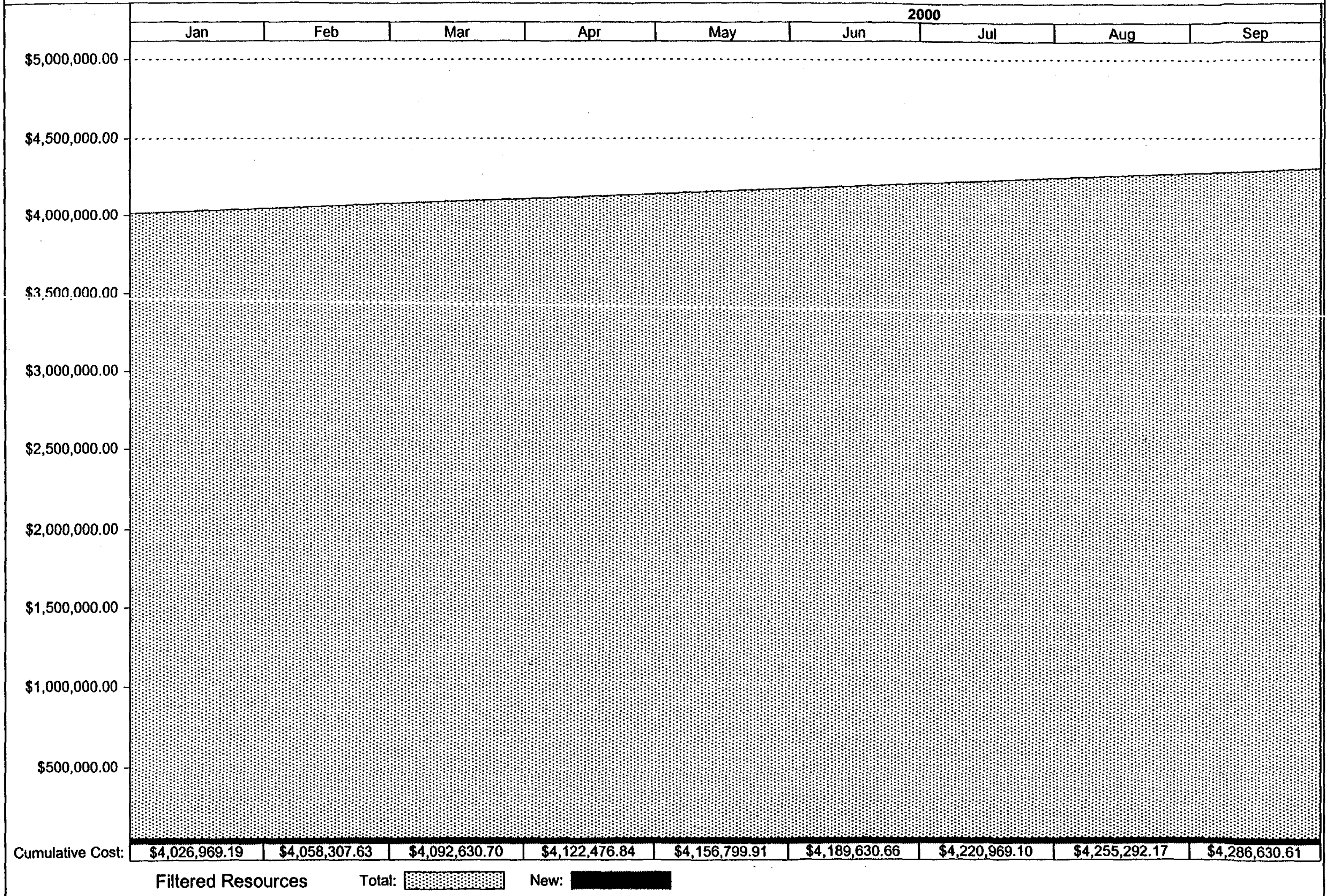


HERMES I
PROPOSAL OPTION 1
COST CURVE



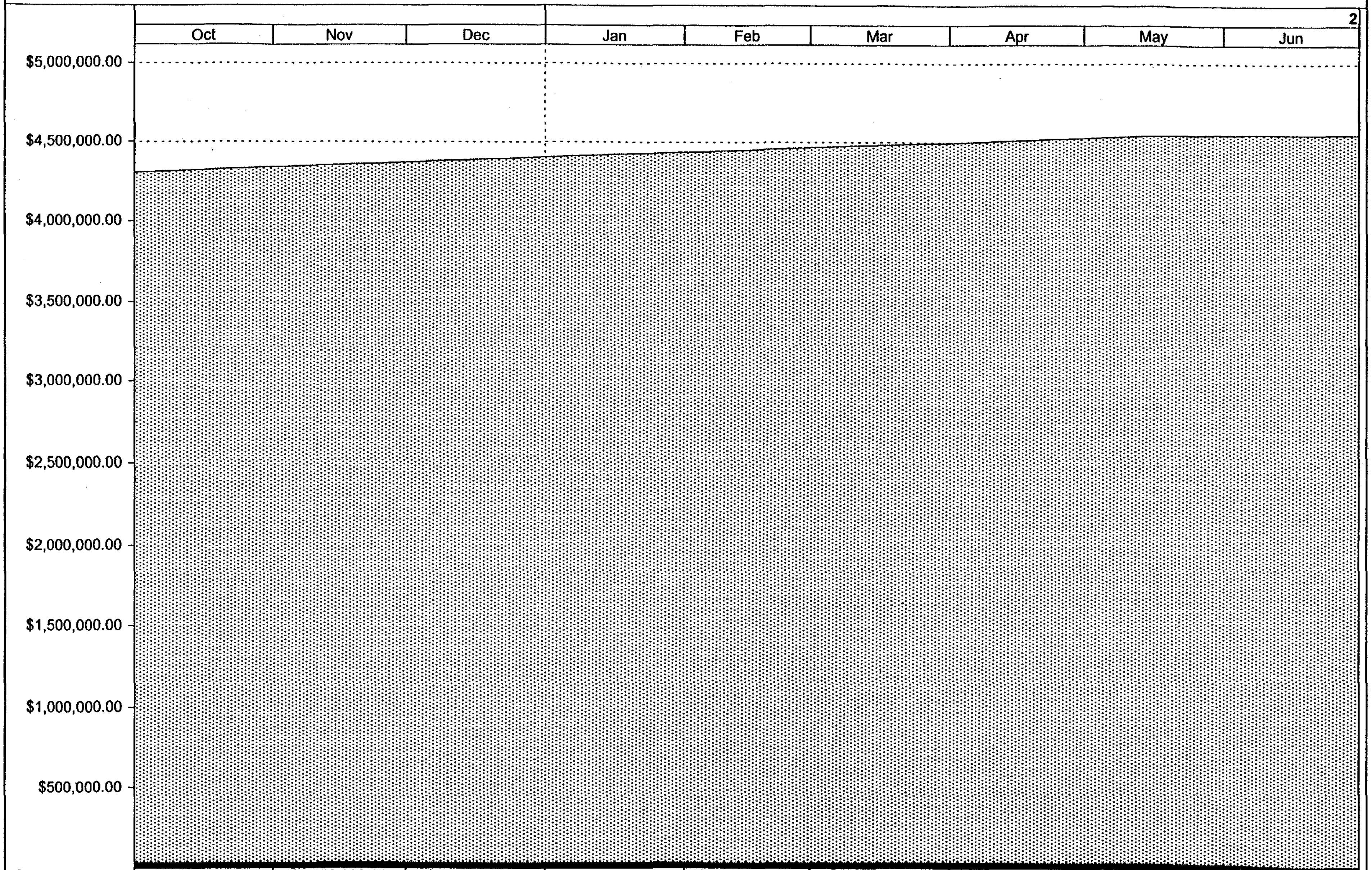
	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Cumulative Cost:	$3,617,715.33	$3,650,546.08	$3,683,376.83	$3,716,207.58	$3,749,038.33	$3,928,476.77	$3,961,307.52	$3,995,630.59

HERMES I
PROPOSAL OPTION 1
COST CURVE



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Cumulative Cost:	$4,026,969.19	$4,058,307.63	$4,092,630.70	$4,122,476.84	$4,156,799.91	$4,189,630.66	$4,220,969.10	$4,255,292.17	$4,286,630.61

HERMES I
PROPOSAL OPTION 1
COST CURVE

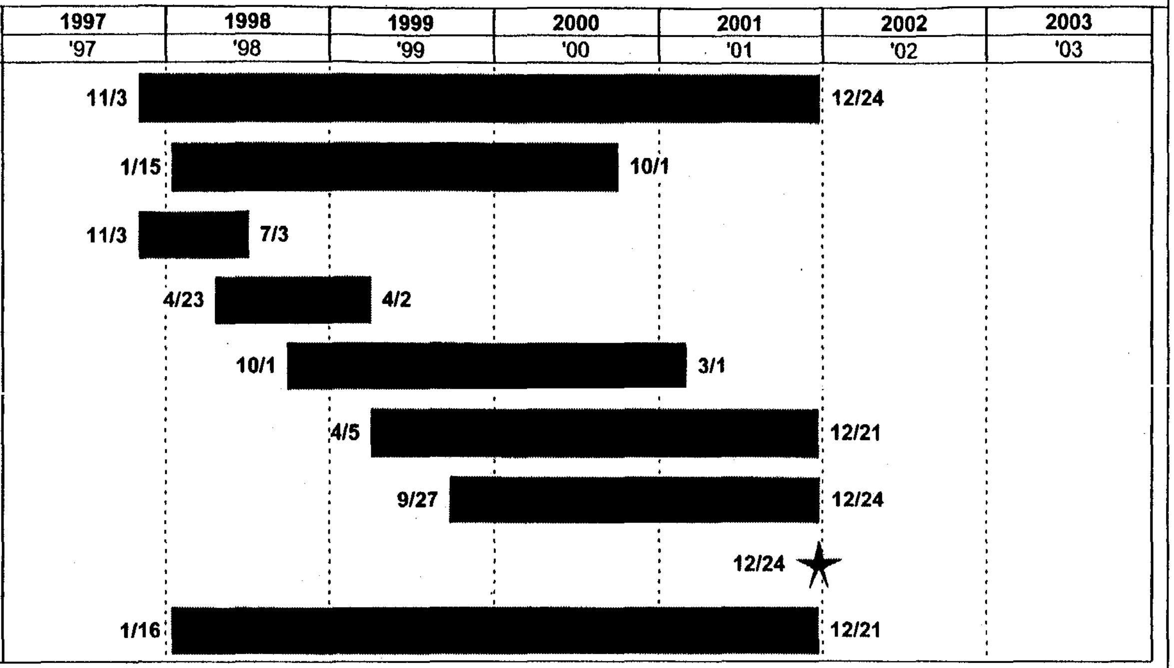


Cumulative Cost:	$4,319,461.49	$4,352,292.24	$4,383,630.68	$4,417,953.75	$4,447,799.89	$4,480,630.64	$4,511,969.08	$4,546,292.15	$4,550,769.05

Filtered Resources Total: ▨ New: ■

HERMES I
PROPOSAL OPTION 2
SUMMARY SCHEDULE: LEVEL 1

ID	WBS	Task Name	PROJECT COSTS
1	1	HERMES I PROJECT: LEVEL FUNDING OPTION WITH BNL CONTRIBUTION	$4,765,084.62
2	1.1	SUMMARY PROJECT REQUIREMENTS/MILESTONES	$0.00
9	1.2	CONCEPTUAL DESIGN	$0.00
61	1.3	DETAILED DESIGN	$93,923.08
111	1.4	PROCUREMENT	$3,476,900.00
157	1.5	INSTALLATION: LANL	$505,903.85
205	1.6	TESTING/TRAINING PROGRAM	$0.00
209	1.7	HERMES OPERATIONAL	$0.00
210	1.8	PROJECT MANAGEMENT	$688,357.69

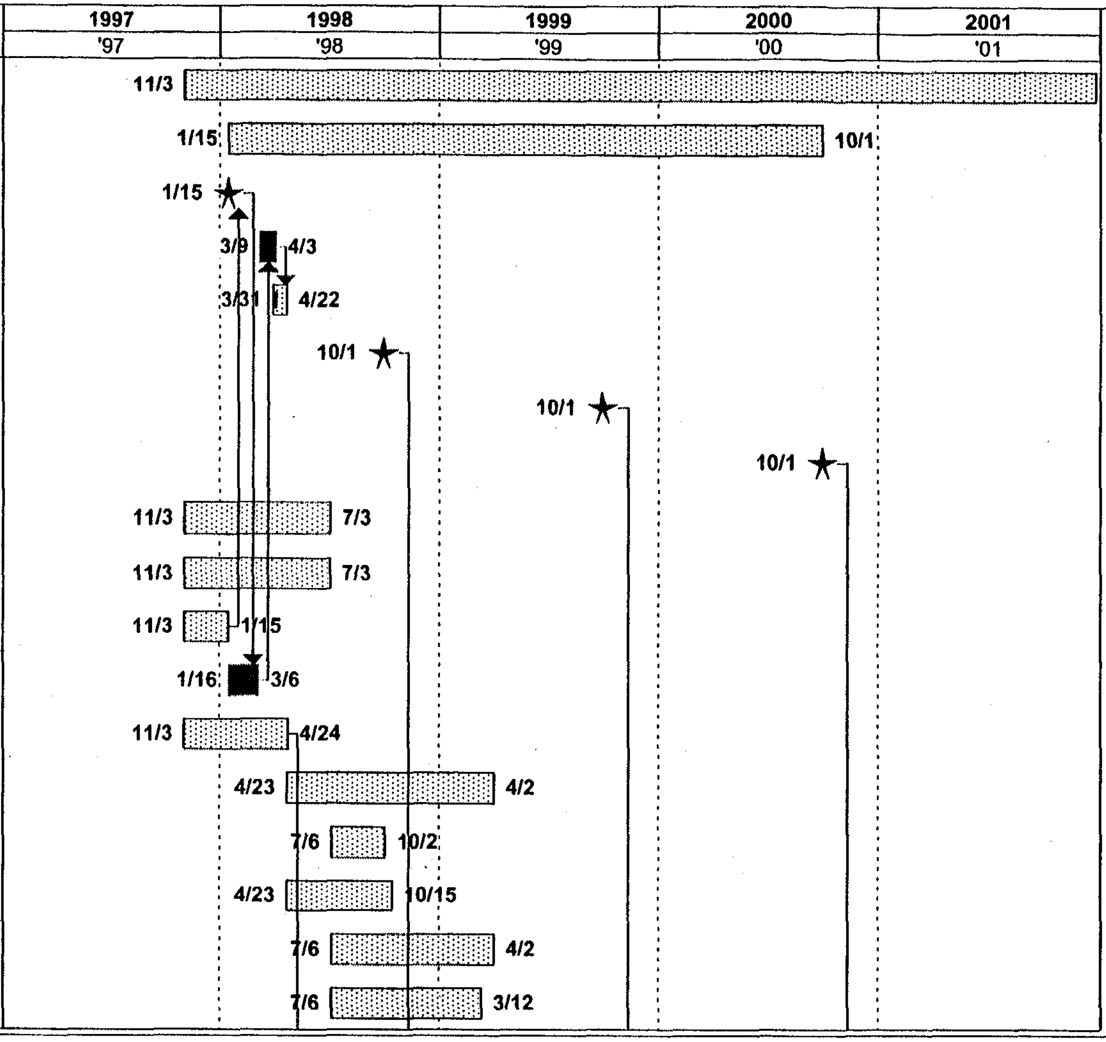


Project: HERMES I
Date: Sun 6/9/159

Task	■	Milestone	★	Rolled Up Milestone	☆
Task Progress	☐	Summary	■	Rolled Up Progress	■
Critical Task	■	Rolled Up Task	■		
Critical Task Progress	☐	Rolled Up Critical Task	■		

HERMES I
PROPOSAL OPTION 2
MANAGEMENT SCHEDULE: LEVEL 2

ID	WBS	Task Name	PROJECT COSTS
1	1	HERMES I PROJECT: LEVEL FUNDING OPTION WITH BNL CONTRIBUTION	$4,765,084.62
2	1.1	SUMMARY PROJECT REQUIREMENTS/MILESTONES	$0.00
3	1.1.1	SPECTROMETER PROPOSALS DUE	$0.00
4	1.1.2	PROPOSAL PRESENTATION TO LANL	$0.00
5	1.1.3	LANL/DOE DECISION TO PROCEED	$0.00
6	1.1.4	FUNDING RELEASE FOR FY 99	$0.00
7	1.1.5	FUNDING RELEASE FOR FY 00	$0.00
8	1.1.6	FUNDING RELEASE FOR FY 01	$0.00
9	1.2	CONCEPTUAL DESIGN	$0.00
10	1.2.1	MONTE CARLO SIMULATIONS	$0.00
13	1.2.2	EQUIPMENT CONCEPTUAL DESIGN	$0.00
59	1.2.3	ENHANCED CONCEPTUAL DESIGN	$0.00
60	1.2.4	BNL CONCEPTUAL DESIGN SUPPORT (CONTRIBUTED)	$0.00
61	1.3	DETAILED DESIGN	$93,923.08
62	1.3.1	CHOPPER ASSEMBLIES (2): FRAME	$0.00
66	1.3.2	NEUTRON GUIDE SYSTEM	$0.00
73	1.3.3	ANALYZER & DETECTOR SECTIONS	$0.00
74	1.3.3.1	ANALYZER SECTIONS	$0.00

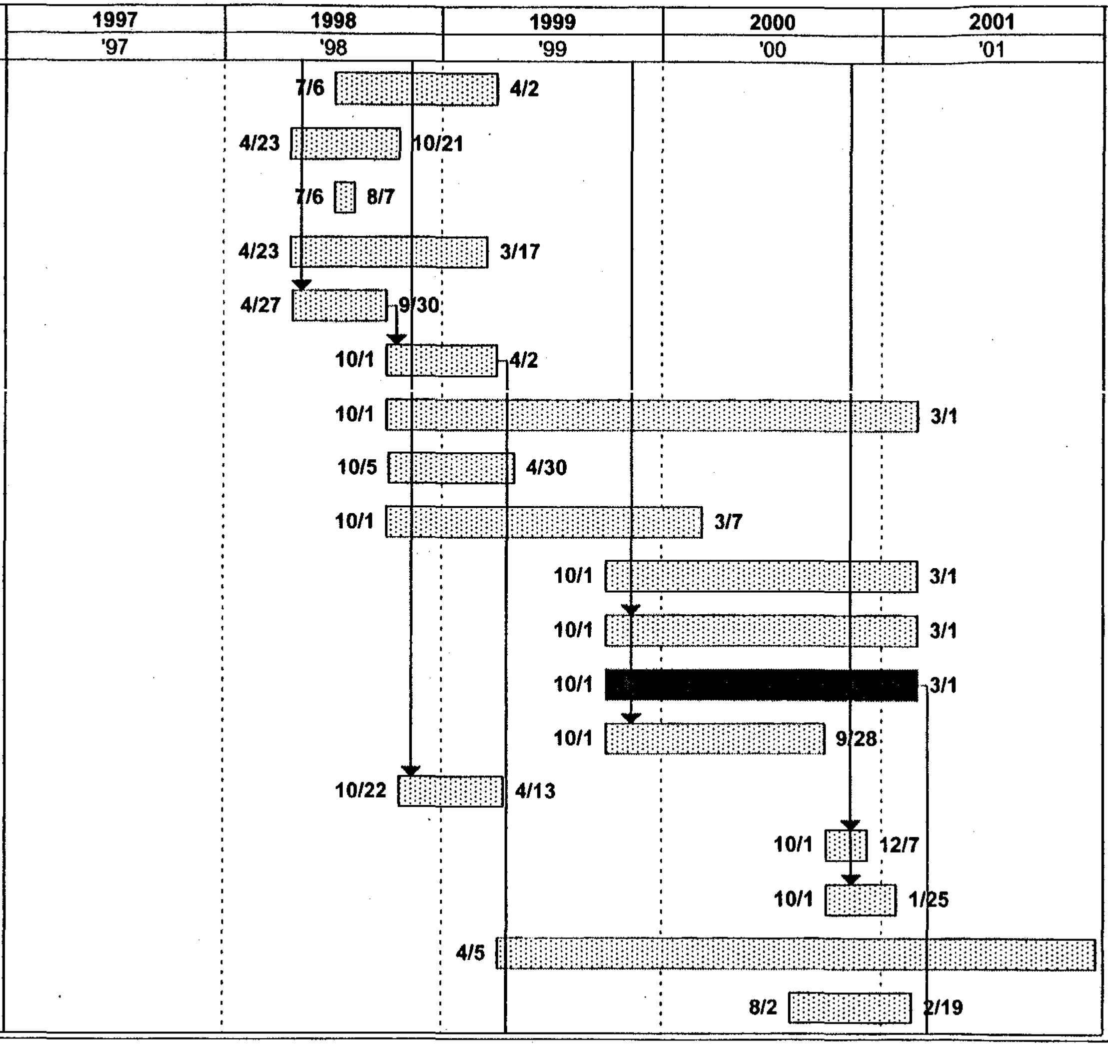


Project: HERMES I
Date: Sun 6/9/159

Task ▨
Task Progress ■
Critical Task ■
Critical Task Progress ☐
Milestone ★
Summary ▨
Rolled Up Task ▨
Rolled Up Critical Task ■
Rolled Up Milestone ☆
Rolled Up Progress ■

HERMES I
PROPOSAL OPTION 2
MANAGEMENT SCHEDULE: LEVEL 2

ID	WBS	Task Name	PROJECT COSTS
82	1.3.3.2	DETECTOR SECTIONS	$0.00
89	1.3.4	SPECTROMETER TANK ASSEMBLY	$0.00
94	1.3.5	SPECTROMETER CONTROL SYSTEM	$0.00
98	1.3.6	ANCILLARY EQUIPMENT	$0.00
109	1.3.7	BNL DETAILED DESIGN SUPPORT (CONTRIBUTED)	$0.00
110	1.3.8	BNL DETAILED DESIGN SUPPORT	$93,923.08
111	1.4	PROCUREMENT	$3,476,900.00
112	1.4.1	CHOPPER ASSEMBLIES (3): TO, FRAME	$142,500.00
116	1.4.2	NEUTRON GUIDE SYSTEM	$1,607,100.00
123	1.4.3	ANALYZER & DETECTOR SECTIONS	$933,900.00
124	1.4.3.1	ANALYZER SECTION	$635,200.00
125	1.4.3.1.1	GRAPHITE ANALYZER CRYSTALS	$300,000.00
131	1.4.3.2	DETECTOR SYSTEM	$298,700.00
137	1.4.4	SPECTROMETER TANK ASSEMBLY	$444,900.00
142	1.4.5	SPECTROMETER CONTROL SYSTEM	$163,100.00
146	1.4.6	ANCILLARY EQUIPMENT	$148,100.00
157	1.5	INSTALLATION: LANL	$505,903.85
158	1.5.1	CHOPPER ASSEMBLIES (3): TO, FRAME	$0.00

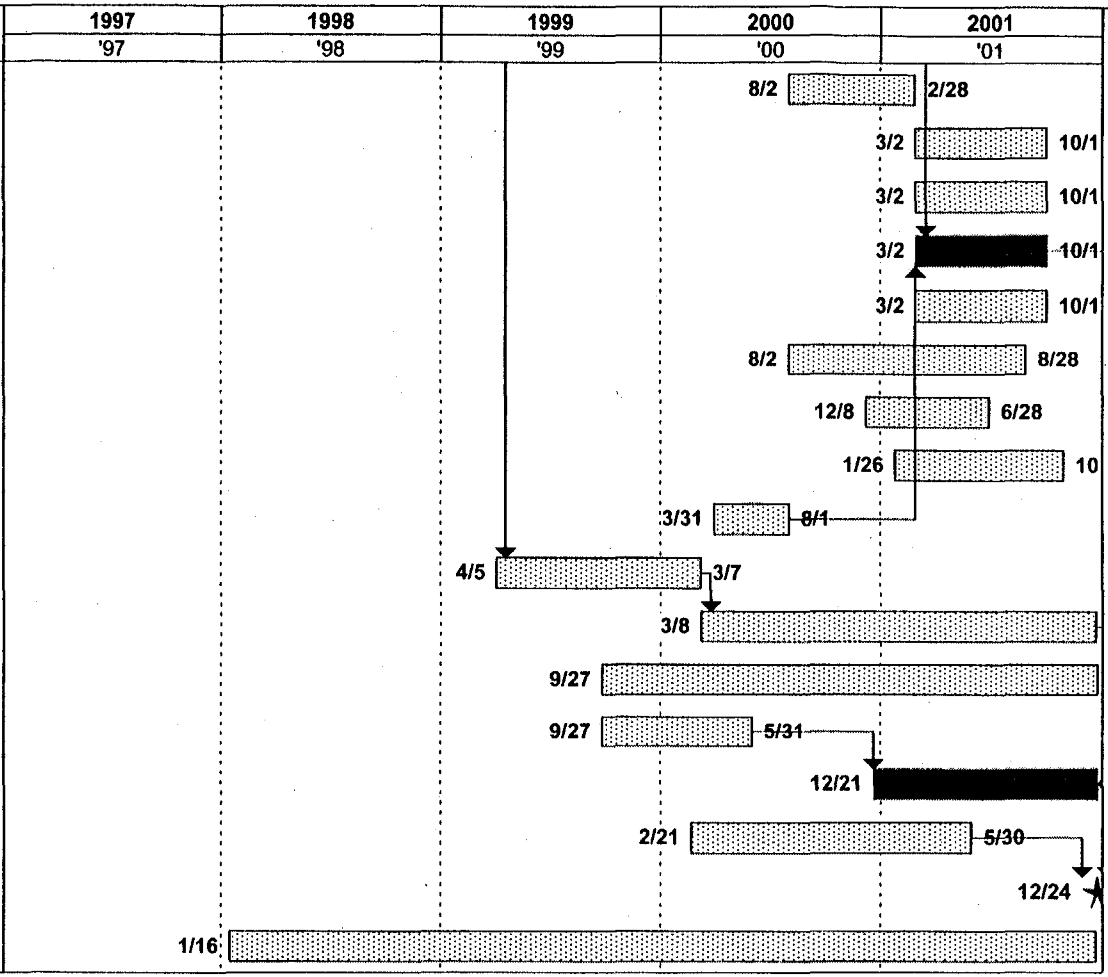


Project: HERMES I
Date: Sun 6/9/159

Task	▨	Milestone	★	Rolled Up Milestone	☆
Task Progress	■	Summary	▨	Rolled Up Progress	■
Critical Task	■	Rolled Up Task	▨		
Critical Task Progress	☐	Rolled Up Critical Task	■		

HERMES I
PROPOSAL OPTION 2
MANAGEMENT SCHEDULE: LEVEL 2

ID	WBS	Task Name	PROJECT COSTS
162	1.5.2	NEUTRON GUIDE SYSTEM	$0.00
169	1.5.3	ANALYZER & DETECTOR SECTIONS	$0.00
170	1.5.3.1	ANALYZER SECTION	$0.00
171	1.5.3.1.1	GRAPHITE ANALYZER CRYSTALS	$0.00
177	1.5.3.2	DETECTOR SECTION	$0.00
183	1.5.4	SPECTROMETER TANK ASSEMBLY	$0.00
188	1.5.5	SPECTROMETER CONTROL SYSTEM	$0.00
192	1.5.6	ANCILLARY EQUIPMENT	$0.00
202	1.5.7	INSTRUMENT CRANE	$0.00
203	1.5.8	BNLTECH STAFF SUPPORT	$172,192.31
204	1.5.9	BNL STAFF INSTALLATION/TESTING	$333,711.54
205	1.6	TESTING/TRAINING PROGRAM	$0.00
206	1.6.1	DEVELOP START-UP & TEST PLAN	$0.00
207	1.6.2	START-UP/TEST/READINESS ASSESSMENT	$0.00
208	1.6.3	TRAINING PROGRAM	$0.00
209	1.7	HERMES OPERATIONAL	$0.00
210	1.8	PROJECT MANAGEMENT	$688,357.69

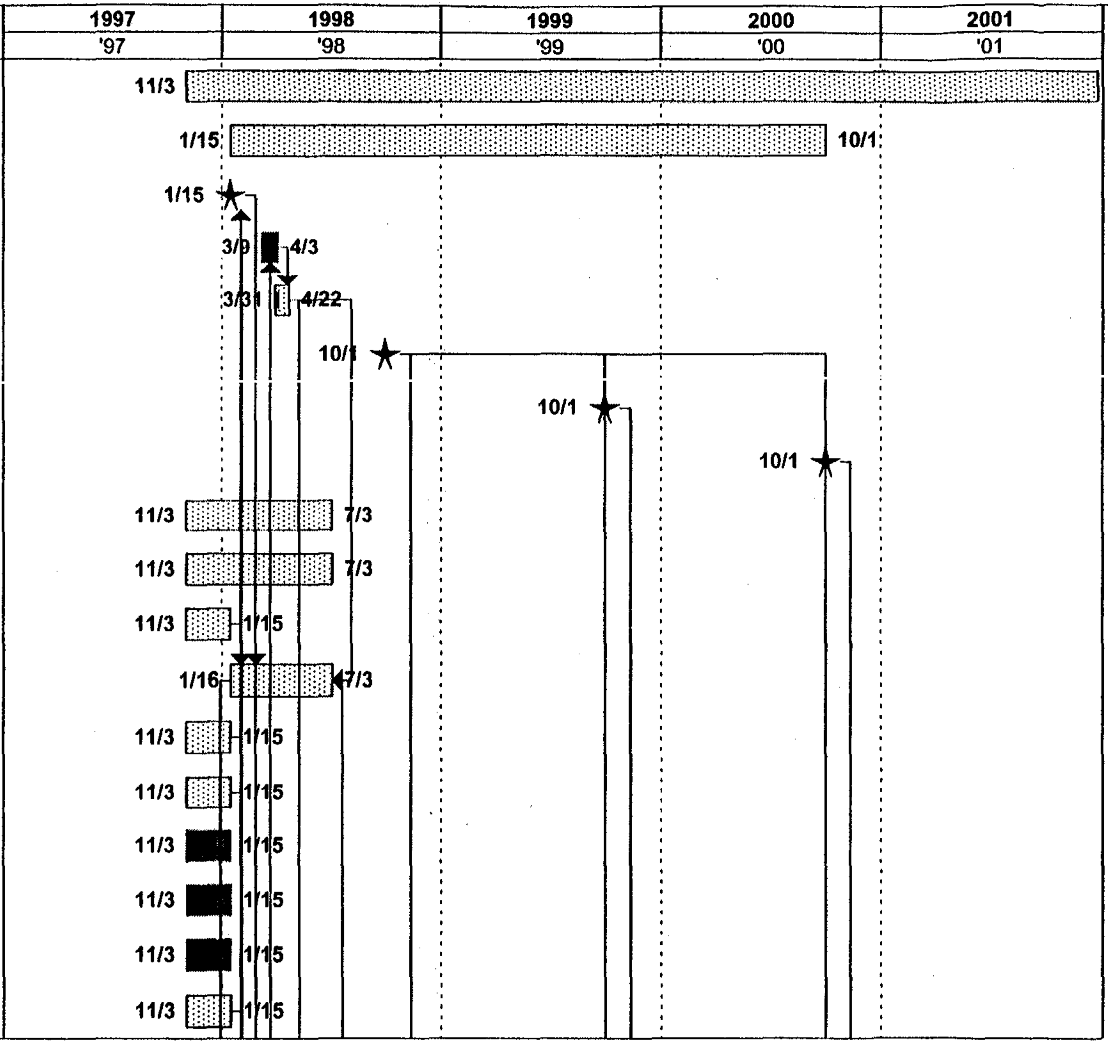


Project: HERMES I
Date: Sun 6/9/159

Task	▨	Milestone	★	Rolled Up Milestone	☆
Task Progress	■	Summary	▨	Rolled Up Progress	■
Critical Task	■	Rolled Up Task	▨		
Critical Task Progress	□	Rolled Up Critical Task	■		

HERMES I
PROPOSAL OPTION 2
DETAILED SCHEDULE: LEVEL 3

ID	WBS	Task Name	PROJECT COSTS
1	1	HERMES I PROJECT: LEVEL FUNDING OPTION WITH BNL CONTRIBUTION	$4,765,084.62
2	1.1	SUMMARY PROJECT REQUIREMENTS/MILESTONES	$0.00
3	1.1.1	SPECTROMETER PROPOSALS DUE	$0.00
4	1.1.2	PROPOSAL PRESENTATION TO LANL	$0.00
5	1.1.3	LANL/DOE DECISION TO PROCEED	$0.00
6	1.1.4	FUNDING RELEASE FOR FY 99	$0.00
7	1.1.5	FUNDING RELEASE FOR FY 00	$0.00
8	1.1.6	FUNDING RELEASE FOR FY 01	$0.00
9	1.2	CONCEPTUAL DESIGN	$0.00
10	1.2.1	MONTE CARLO SIMULATIONS	$0.00
11	1.2.1.1	PRELIMINARY MONTE CARLO SIMULATIONS TO	$0.00
12	1.2.1.2	FINAL MONTE CARLO SIMULATIONS	$0.00
13	1.2.2	EQUIPMENT CONCEPTUAL DESIGN	$0.00
14	1.2.2.1	CHOPPER ASSEMBLIES (3): TO, FRAME	$0.00
15	1.2.2.1.1	CHOPPER WHEEL	$0.00
16	1.2.2.1.2	MOTOR SPEED CONTROL UNIT	$0.00
17	1.2.2.1.3	CHOPPER PLATFORM	$0.00
18	1.2.2.2	NEUTRON GUIDE SYSTEM	$0.00

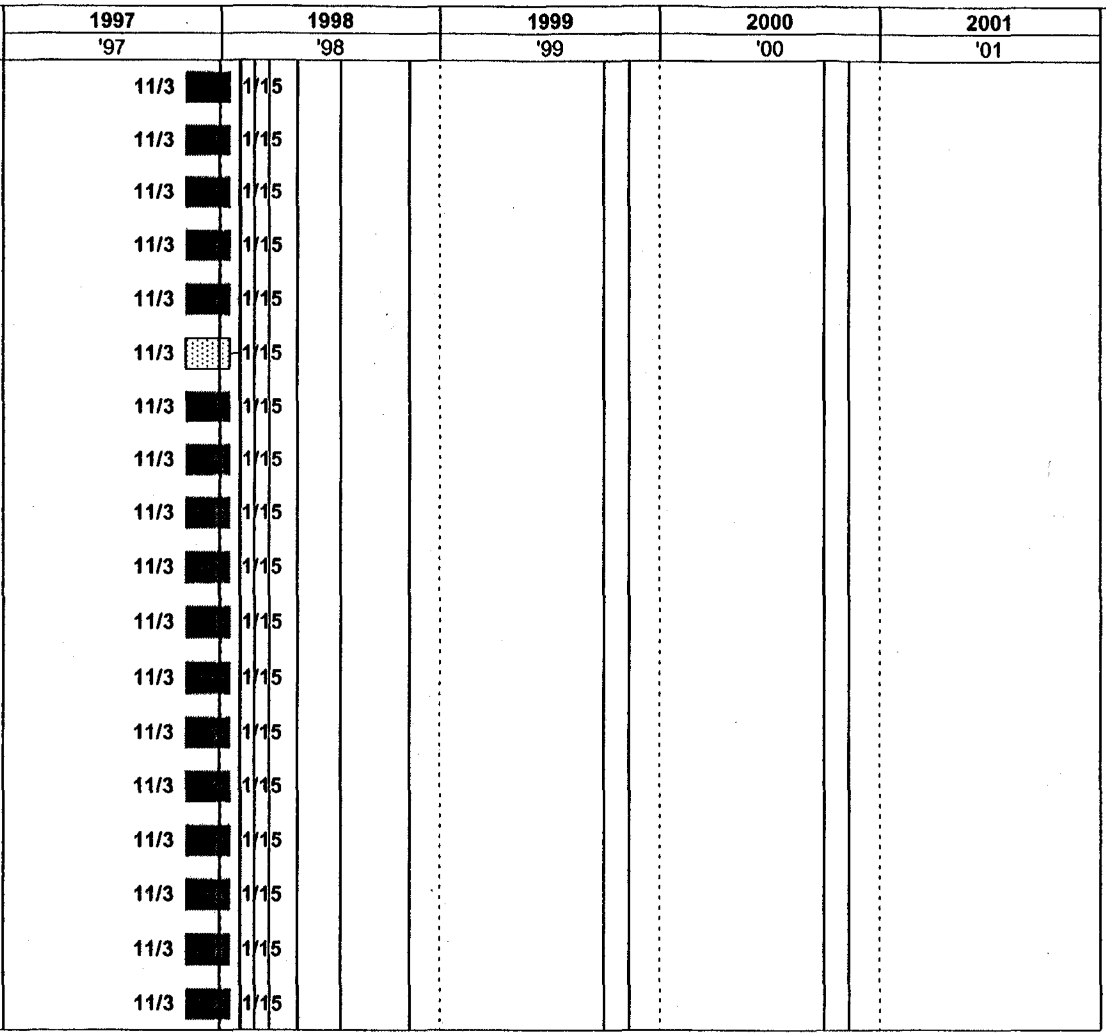


Project: HERMES I
Date: Sun 6/9/159

Task	▨	Milestone	★	Rolled Up Milestone	☆
Task Progress	■	Summary	▨	Rolled Up Progress	■
Critical Task	■	Rolled Up Task	▨		
Critical Task Progress	☐	Rolled Up Critical Task	■		

HERMES I
PROPOSAL OPTION 2
DETAILED SCHEDULE: LEVEL 3

ID	WBS	Task Name	PROJECT COSTS
19	1.2.2.2.1	SUPERMIRROR GUIDES	$0.00
20	1.2.2.2.2	VACUUM FLIGHT TUBES	$0.00
21	1.2.2.2.3	GUIDE SHIELDING	$0.00
22	1.2.2.2.4	VACUUM PUMPS	$0.00
23	1.2.2.2.5	ALIGNMENT FIXTURES/STANCHIONS	$0.00
24	1.2.2.3	ANALYZER & DETECTOR SECTIONS	$0.00
25	1.2.2.3.1	GRAPHITE ANALYZER CRYSTALS	$0.00
26	1.2.2.3.2	MECHANICAL SUPPORTS	$0.00
27	1.2.2.3.3	FIXING MECHANISM	$0.00
28	1.2.2.3.4	IMPRESSED SHIELDING DISCS	$0.00
29	1.2.2.3.5	ALIGNMENT DEVICES	$0.00
30	1.2.2.3.6	CRYOGENICS/MAIN RESERVOIR	$0.00
31	1.2.2.3.7	FLUID SUPPLY & CONTROL	$0.00
32	1.2.2.3.8	He TUBES (120)	$0.00
33	1.2.2.3.9	ELECTRONIC CHANNELS	$0.00
34	1.2.2.3.10	CABLES	$0.00
35	1.2.2.3.11	MECHANICAL MOUNTS	$0.00
36	1.2.2.3.12	SERVICE TROLLEY	$0.00

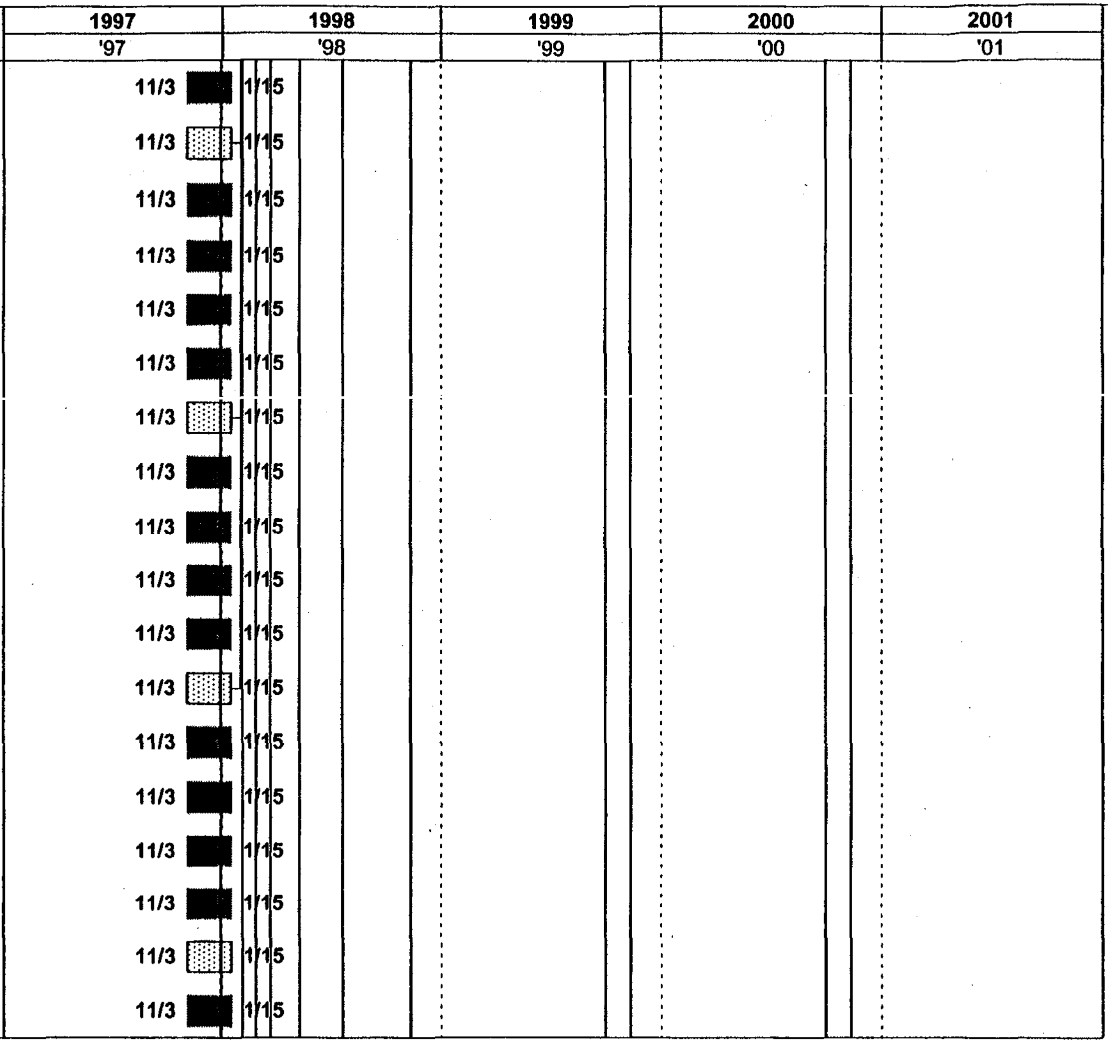


Project: HERMES I
Date: Sun 6/9/159

Task	▨	Milestone	★	Rolled Up Milestone	☆
Task Progress	▬	Summary	▨	Rolled Up Progress	▬
Critical Task	■	Rolled Up Task	▨		
Critical Task Progress	☐	Rolled Up Critical Task	■		

HERMES I
PROPOSAL OPTION 2
DETAILED SCHEDULE: LEVEL 3

ID	WBS	Task Name	PROJECT COSTS
37	1.2.2.3.13	MOVABLE COLLIMATORS	$0.00
38	1.2.2.4	SPECTROMETER TANK ASSEMBLY	$0.00
39	1.2.2.4.1	ANALYZER TANK	$0.00
40	1.2.2.4.2	VACUUM PUMP/GAUGES,	$0.00
41	1.2.2.4.3	BEAM STOP/DUMP PIPE/MONITOR	$0.00
42	1.2.2.4.4	INSTRUMENT SHIELD "HUTCH"	$0.00
43	1.2.2.5	SPECTROMETER CONTROL SYSTEM	$0.00
44	1.2.2.5.1	DATA ACQUISITION SYSTEM	$0.00
45	1.2.2.5.2	GRAPHICAL USER INTERFACE	$0.00
46	1.2.2.5.3	COMPUTER EQUIPMENT	$0.00
47	1.2.2.5.4	POWER SUPPLY	$0.00
48	1.2.2.6	ANCILLARY EQUIPMENT	$0.00
49	1.2.2.6.1	SAMPLE GONIOMETER	$0.00
50	1.2.2.6.2	TEMPERATURE CONTROLLERS	$0.00
51	1.2.2.6.3	PUMPING STATION	$0.00
52	1.2.2.6.4	VACUUM/PRESSURE GAUGES/SENSORS	$0.00
53	1.2.2.6.5	SAMPLE ENVIRONMENT	$0.00
54	1.2.2.6.5.'	HELIUM CRYOSTAT	$0.00

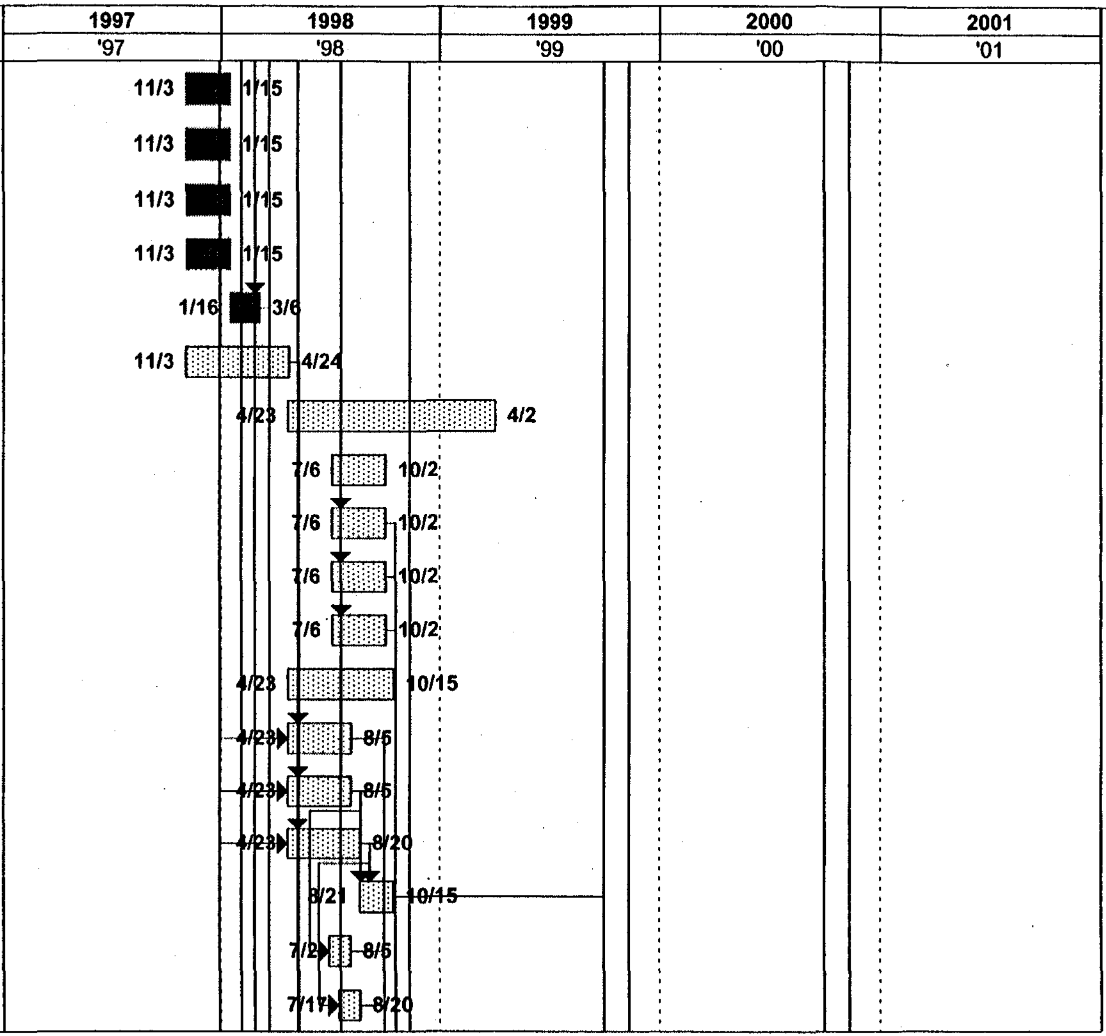


Project: HERMES I
Date: Sun 6/9/159

Task ▨
Task Progress ■
Critical Task ■
Critical Task Progress ☐
Milestone ★
Summary ▨
Rolled Up Task ▨
Rolled Up Critical Task ■
Rolled Up Milestone ☆
Rolled Up Progress ■

HERMES I
PROPOSAL OPTION 2
DETAILED SCHEDULE: LEVEL 3

ID	WBS	Task Name	PROJECT COSTS
55	1.2.2.6.5.	DISPLEX	$0.00
56	1.2.2.6.5.	GAS HANDLING SYSTEM	$0.00
57	1.2.2.6.5.	FURNACE	$0.00
58	1.2.2.6.6	INSTRUMENT CRANE	$0.00
59	1.2.3	ENHANCED CONCEPTUAL DESIGN	$0.00
60	1.2.4	BNL CONCEPTUAL DESIGN SUPPORT (CONTRIBUTED)	$0.00
61	1.3	DETAILED DESIGN	$93,923.08
62	1.3.1	CHOPPER ASSEMBLIES (2): FRAME	$0.00
63	1.3.1.1	CHOPPER WHEEL	$0.00
64	1.3.1.2	MOTOR SPEED CONTROL UNIT	$0.00
65	1.3.1.3	CHOPPER PLATFORM	$0.00
66	1.3.2	NEUTRON GUIDE SYSTEM	$0.00
67	1.3.2.1	SHUTTER	$0.00
68	1.3.2.2	SUPERMIRROR GUIDES	$0.00
69	1.3.2.3	VACUUM FLIGHT TUBES	$0.00
70	1.3.2.4	GUIDE SHIELDING (PRIMARY/SECONDARY)	$0.00
71	1.3.2.5	VACUUM PUMPS	$0.00
72	1.3.2.6	ALIGNMENT FIXTURES/STANCHIONS	$0.00

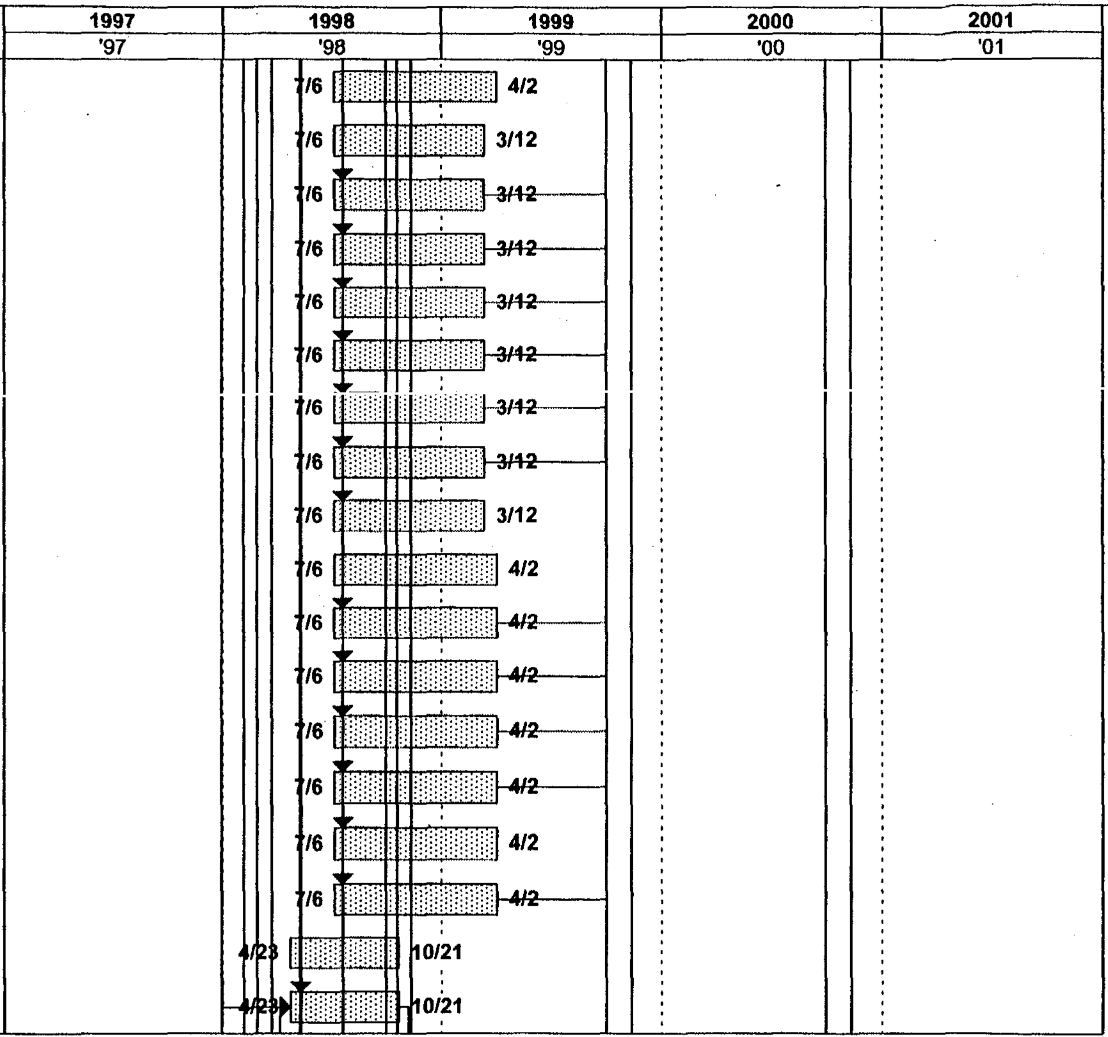


Project: HERMES I
Date: Sun 6/9/159

Task	▨	Milestone	★	Rolled Up Milestone	☆
Task Progress	■	Summary	▨	Rolled Up Progress	■
Critical Task	■	Rolled Up Task	▨		
Critical Task Progress	☐	Rolled Up Critical Task	■		

HERMES I
PROPOSAL OPTION 2
DETAILED SCHEDULE: LEVEL 3

ID	WBS	Task Name	PROJECT COSTS
73	1.3.3	ANALYZER & DETECTOR SECTIONS	$0.00
74	1.3.3.1	ANALYZER SECTIONS	$0.00
75	1.3.3.1.1	GRAPHITE ANALYZER CRYSTALS	$0.00
76	1.3.3.1.2	MECHANICAL SUPPORTS	$0.00
77	1.3.3.1.3	FIXING MECHANISM	$0.00
78	1.3.3.1.4	IMPRESSED SHIELDING DISCS	$0.00
79	1.3.3.1.5	ALIGNMENT DEVICES	$0.00
80	1.3.3.1.6	CRYOGENICS/MAIN RESERVOIR	$0.00
81	1.3.3.1.7	FLUID SUPPLY & CONTROL	$0.00
82	1.3.3.2	DETECTOR SECTIONS	$0.00
83	1.3.3.2.1	He TUBES (120)	$0.00
84	1.3.3.2.2	ELECTRONIC CHANNELS	$0.00
85	1.3.3.2.3	CABLES	$0.00
86	1.3.3.2.4	MECHANICAL MOUNTS	$0.00
87	1.3.3.2.5	SERVICE TROLLEY	$0.00
88	1.3.3.2.6	MOVABLE COLLIMATORS	$0.00
89	1.3.4	SPECTROMETER TANK ASSEMBLY	$0.00
90	1.3.4.1	ANALYZER TANK	$0.00

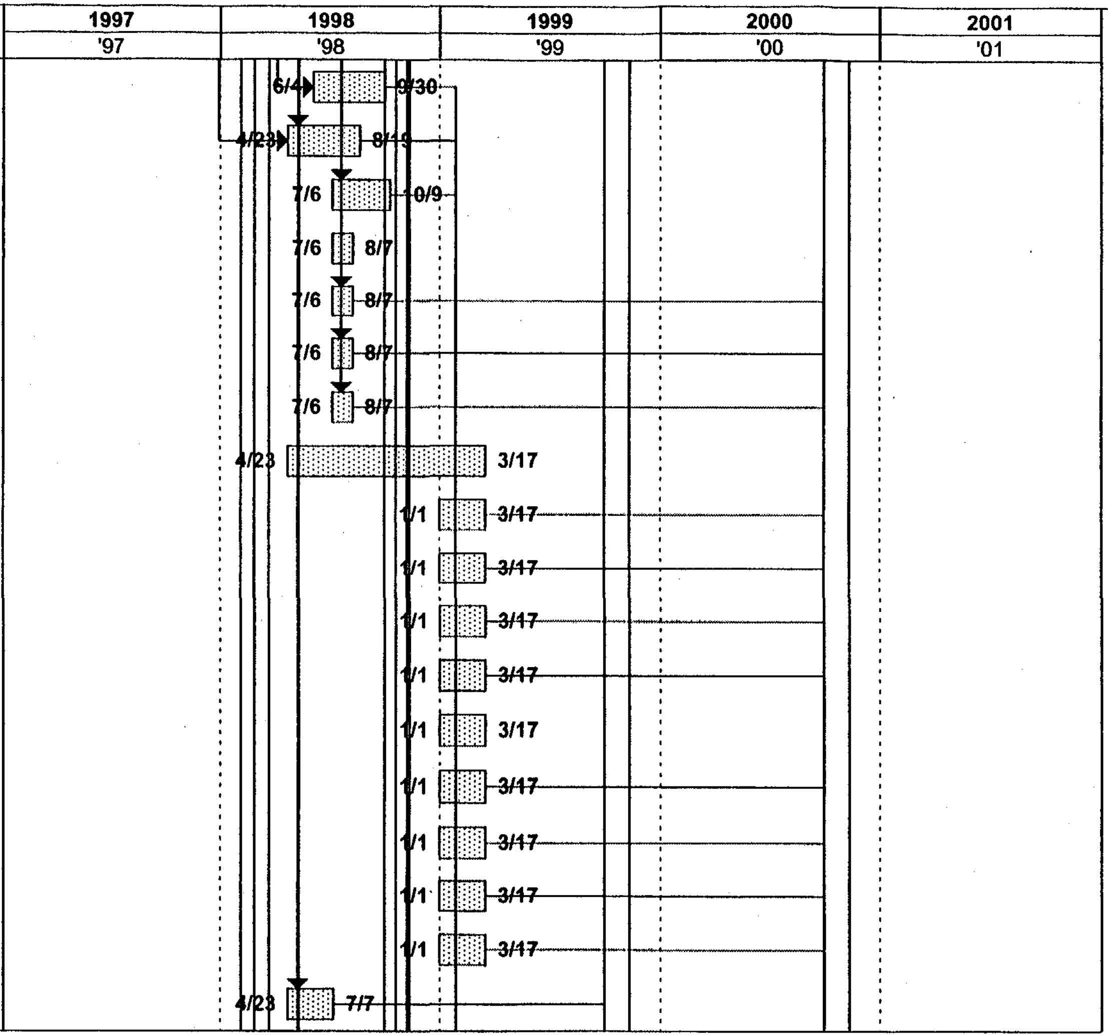


Project: HERMES I
Date: Sun 6/9/159

Task	▨	Milestone	★	Rolled Up Milestone	☆
Task Progress	■	Summary	▨	Rolled Up Progress	■
Critical Task	■	Rolled Up Task	▨		
Critical Task Progress	□	Rolled Up Critical Task	■		

HERMES I
PROPOSAL OPTION 2
DETAILED SCHEDULE: LEVEL 3

ID	WBS	Task Name	PROJECT COSTS
91	1.3.4.2	VACUUM PUMP/GAUGES, FRAMES/HOSES/VALVES	$0.00
92	1.3.4.3	BEAM STOP/DUMP PIPE/MONITOR	$0.00
93	1.3.4.4	INSTRUMENT SHIELD "HUTCH"/ACCESS	$0.00
94	1.3.5	SPECTROMETER CONTROL SYSTEM	$0.00
95	1.3.5.1	DATA ACQUISITION SYSTEM	$0.00
96	1.3.5.2	GRAPHICAL USER INTERFACE	$0.00
97	1.3.5.3	COMPUTER EQUIPMENT	$0.00
98	1.3.6	ANCILLARY EQUIPMENT	$0.00
99	1.3.6.1	SAMPLE GONIOMETER	$0.00
100	1.3.6.2	TEMPERATURE CONTROLLERS	$0.00
101	1.3.6.3	PUMPING STATION	$0.00
102	1.3.6.4	VACUUM/PRESSURE GAUGES/SENSORS	$0.00
103	1.3.6.5	SAMPLE ENVIRONMENT	$0.00
104	1.3.6.5.1	HELIUM CRYOSTAT	$0.00
105	1.3.6.5.2	DISPLEX	$0.00
106	1.3.6.5.3	GAS HANDLING SYSTEM	$0.00
107	1.3.6.5.4	FURNACE	$0.00
108	1.3.6.6	INSTRUMENT CRANE	$0.00

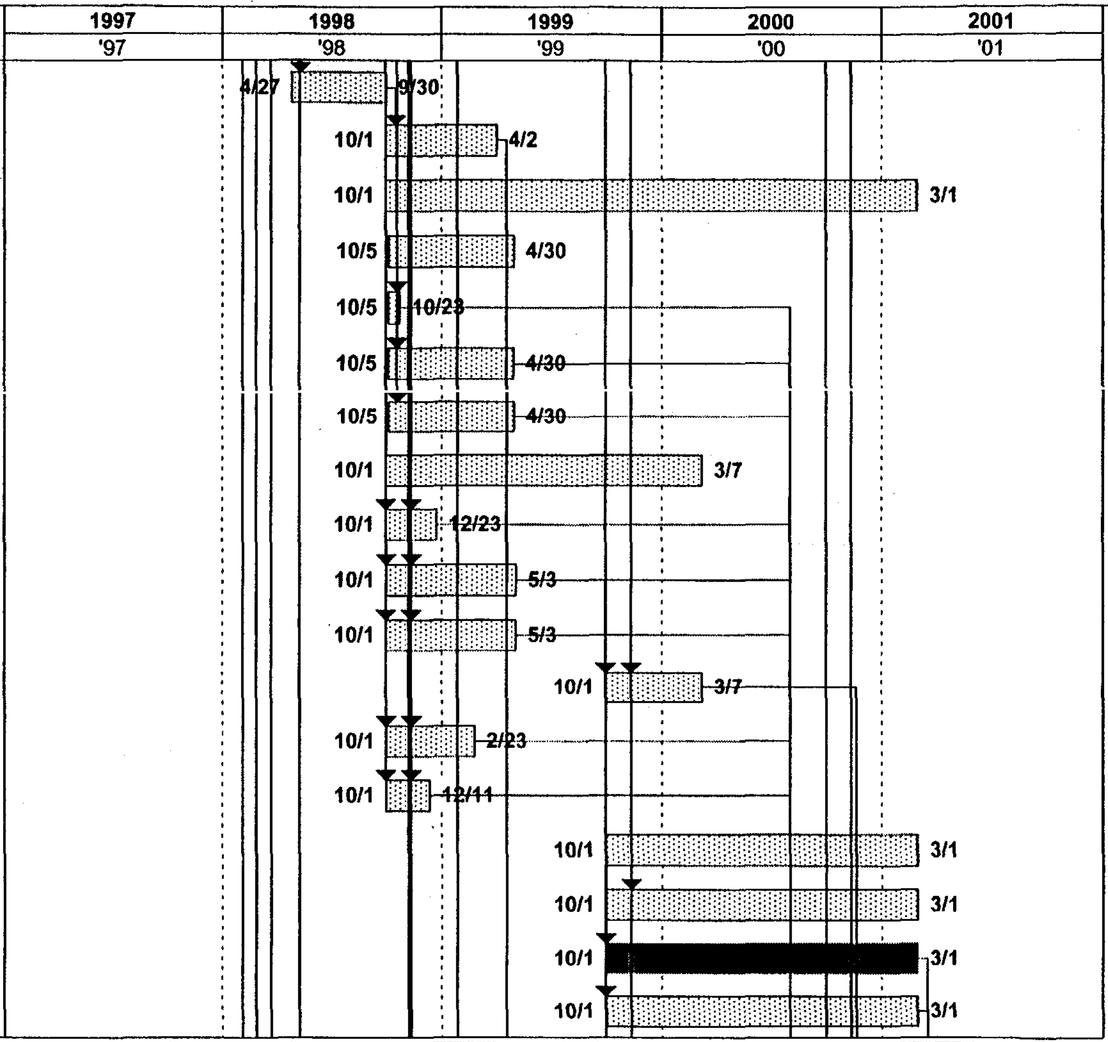


Project: HERMES I
Date: Sun 6/9/159

Task	▨	Milestone	★	Rolled Up Milestone	☆
Task Progress	■	Summary	▨	Rolled Up Progress	■
Critical Task	■	Rolled Up Task	▨		
Critical Task Progress	□	Rolled Up Critical Task	■		

HERMES I
PROPOSAL OPTION 2
DETAILED SCHEDULE: LEVEL 3

ID	WBS	Task Name	PROJECT COSTS
109	1.3.7	BNL DETAILED DESIGN SUPPORT (CONTRIBUTED)	$0.00
110	1.3.8	BNL DETAILED DESIGN SUPPORT	$93,923.08
111	1.4	PROCUREMENT	$3,476,900.00
112	1.4.1	CHOPPER ASSEMBLIES (3): TO, FRAME	$142,500.00
113	1.4.1.1	CHOPPER WHEEL	$142,500.00
114	1.4.1.2	MOTOR SPEED CONTROL UNIT	$0.00
115	1.4.1.3	CHOPPER PLATFORM	$0.00
116	1.4.2	NEUTRON GUIDE SYSTEM	$1,607,100.00
117	1.4.2.1	SHUTTER	$0.00
118	1.4.2.2	SUPERMIRROR GUIDES	$924,000.00
119	1.4.2.3	VACUUM FLIGHT TUBES	$300,000.00
120	1.4.2.4	GUIDE SHIELDING (PRIMARY/SECONDARY)	$300,000.00
121	1.4.2.5	VACUUM PUMPS	$7,400.00
122	1.4.2.6	ALIGNMENT FIXTURES/STANCHIONS	$75,700.00
123	1.4.3	ANALYZER & DETECTOR SECTIONS	$933,900.00
124	1.4.3.1	ANALYZER SECTION	$635,200.00
125	1.4.3.1.1	GRAPHITE ANALYZER CRYSTALS	$300,000.00
126	1.4.3.1.2	MECHANICAL SUPPORTS	$58,600.00

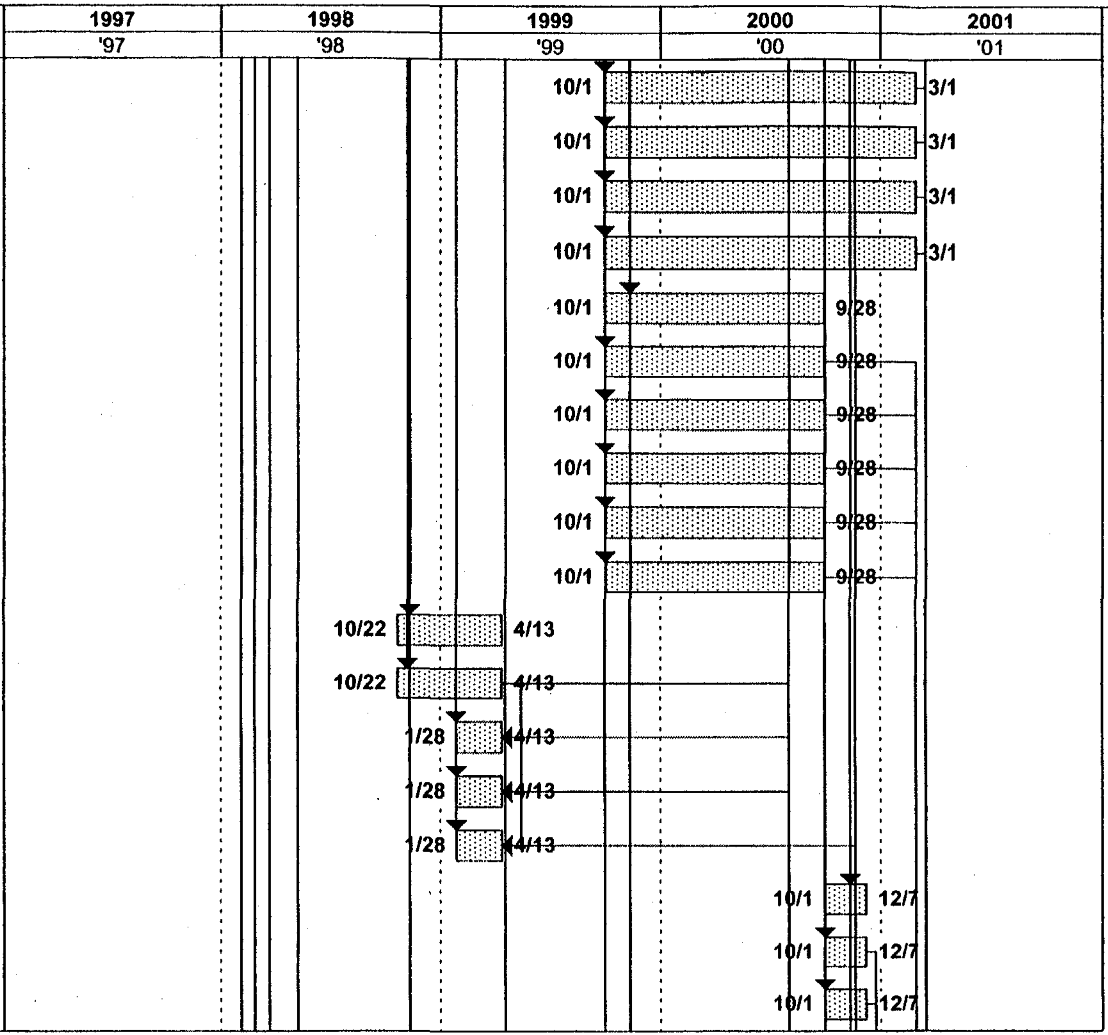


Project: HERMES I
Date: Sun 6/9/159

Task	▨	Milestone	★	Rolled Up Milestone	☆
Task Progress	■	Summary	▨	Rolled Up Progress	■
Critical Task	■	Rolled Up Task	▨		
Critical Task Progress	☐	Rolled Up Critical Task	■		

HERMES I
PROPOSAL OPTION 2
DETAILED SCHEDULE: LEVEL 3

ID	WBS	Task Name	PROJECT COSTS
127	1.4.3.1.3	FIXING MECHANISM	$12,300.00
128	1.4.3.1.4	IMPRESSED SHIELDING DISCS	$66,400.00
129	1.4.3.1.5	ALIGNMENT DEVICES	$67,400.00
130	1.4.3.1.6	CRYOGENICS/MAIN RESERVOIR	$130,500.00
131	1.4.3.2	DETECTOR SYSTEM	$298,700.00
132	1.4.3.2.1	He TUBES (120)	$189,200.00
133	1.4.3.2.2	ELECTRONIC CHANNELS	$58,400.00
134	1.4.3.2.3	CABLES	$9,700.00
135	1.4.3.2.4	MECHANICAL MOUNTS	$24,300.00
136	1.4.3.2.5	MOVABLE COLLIMATORS	$17,100.00
137	1.4.4	SPECTROMETER TANK ASSEMBLY	$444,900.00
138	1.4.4.1	ANALYZER TANK	$208,700.00
139	1.4.4.2	VACUUM PUMP/GAUGES, FRAMES/HOSES/VALVES	$54,400.00
140	1.4.4.3	BEAM STOP/DUMP PIPE/MONITOR	$39,300.00
141	1.4.4.4	INSTRUMENT SHIELD "HUTCH"	$142,500.00
142	1.4.5	SPECTROMETER CONTROL SYSTEM	$163,100.00
143	1.4.5.1	DATA ACQUISITION SYSTEM	$163,100.00
144	1.4.5.2	GRAPHICAL USER INTERFACE	$0.00

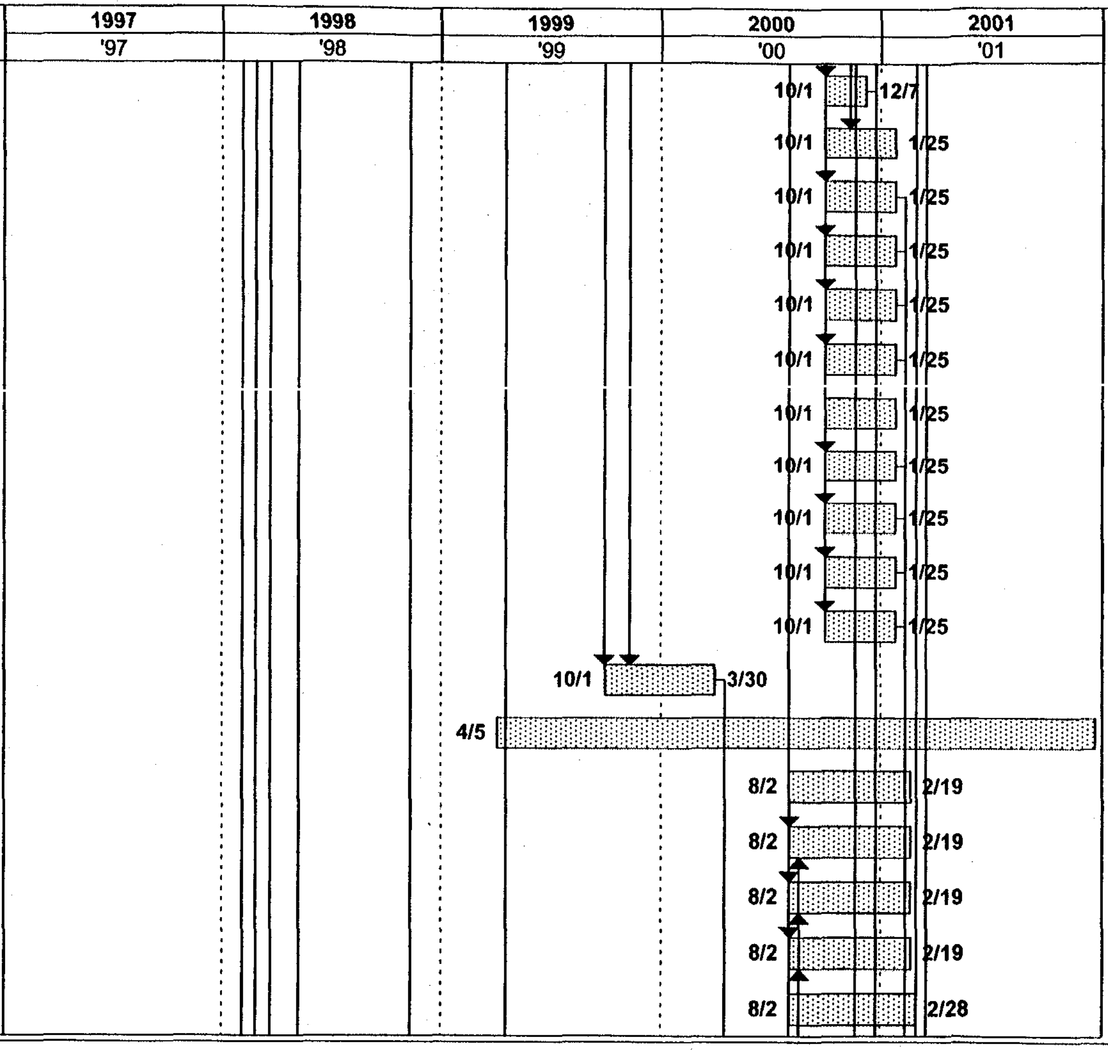


Project: HERMES I
Date: Sun 6/9/159

Task	▨	Milestone	★	Rolled Up Milestone	☆
Task Progress	■	Summary	▨	Rolled Up Progress	■
Critical Task	■	Rolled Up Task	▨		
Critical Task Progress	☐	Rolled Up Critical Task	■		

HERMES I
PROPOSAL OPTION 2
DETAILED SCHEDULE: LEVEL 3

ID	WBS	Task Name	PROJECT COSTS
145	1.4.5.3	COMPUTER EQUIPMENT	$0.00
146	1.4.6	ANCILLARY EQUIPMENT	$148,100.00
147	1.4.6.1	SAMPLE GONIOMETER	$54,400.00
148	1.4.6.2	TEMPERATURE CONTROLLERS	$7,100.00
149	1.4.6.3	PUMPING STATION	$21,400.00
150	1.4.6.4	VACUUM/PRESSURE GAUGES/SENSORS	$27,200.00
151	1.4.6.5	SAMPLE ENVIRONMENT	$38,000.00
152	1.4.6.5.1	HELIUM CRYOSTAT	$0.00
153	1.4.6.5.2	DISPLEX	$0.00
154	1.4.6.5.3	GAS HANDLING SYSTEM	$0.00
155	1.4.6.5.4	FURNACE	$38,000.00
156	1.4.7	INSTRUMENT CRANE	$37,300.00
157	1.5	INSTALLATION: LANL	$505,903.85
158	1.5.1	CHOPPER ASSEMBLIES (3): TO, FRAME	$0.00
159	1.5.1.1	CHOPPER WHEEL	$0.00
160	1.5.1.2	MOTOR SPEED CONTROL UNIT	$0.00
161	1.5.1.3	CHOPPER PLATFORM	$0.00
162	1.5.2	NEUTRON GUIDE SYSTEM	$0.00

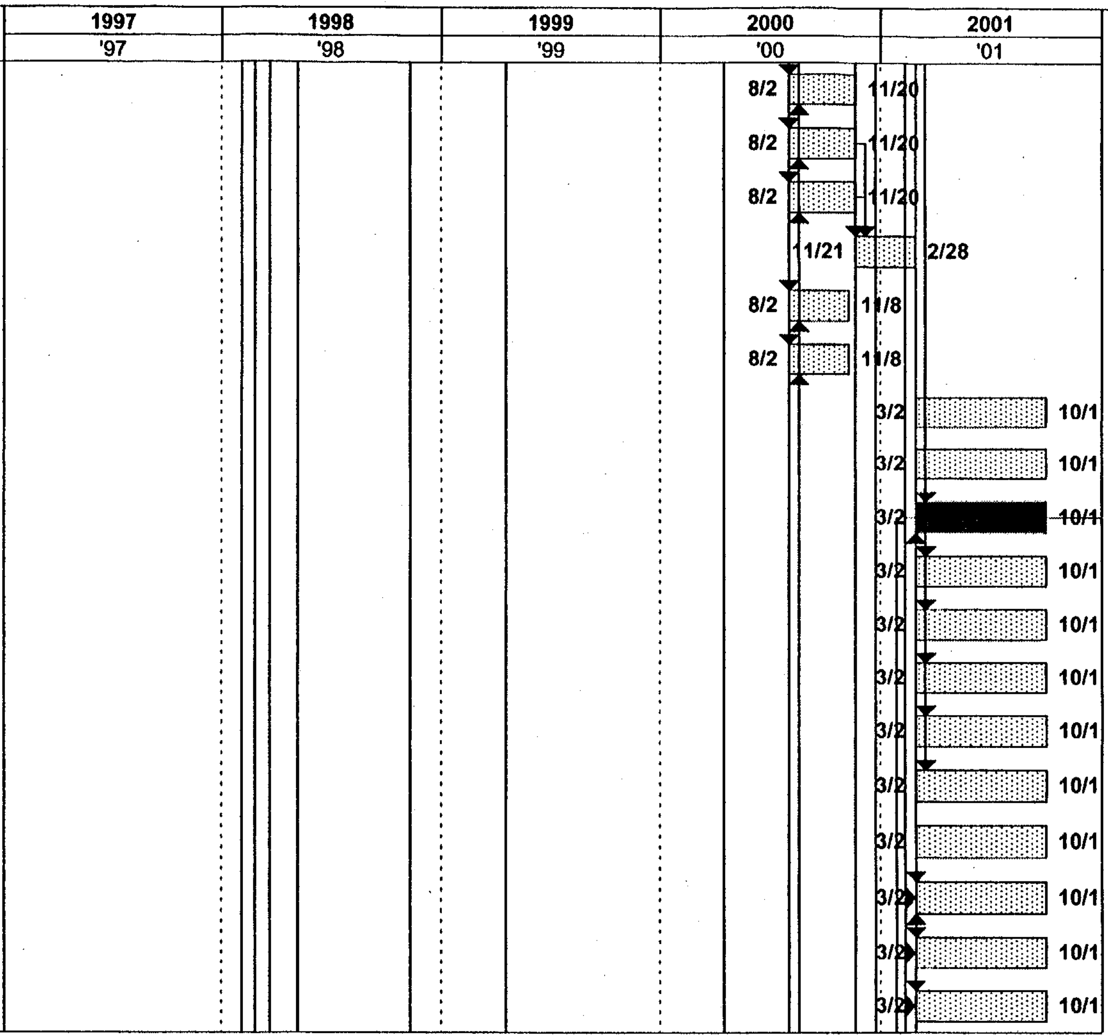


Project: HERMES I
Date: Sun 6/9/159

Task	▨	Milestone	★	Rolled Up Milestone	☆
Task Progress	■	Summary	▨	Rolled Up Progress	■
Critical Task	■	Rolled Up Task	▨		
Critical Task Progress	□	Rolled Up Critical Task	■		

HERMES I
PROPOSAL OPTION 2
DETAILED SCHEDULE: LEVEL 3

ID	WBS	Task Name	PROJECT COSTS
163	1.5.2.1	SHUTTER	$0.00
164	1.5.2.2	SUPERMIRROR GUIDES	$0.00
165	1.5.2.3	VACUUM FLIGHT TUBES	$0.00
166	1.5.2.4	GUIDE SHIELDING (PRIMARY/SECONDARY)	$0.00
167	1.5.2.5	VACUUM PUMPS	$0.00
168	1.5.2.6	ALIGNMENT FIXTURES/STANCHIONS	$0.00
169	1.5.3	ANALYZER & DETECTOR SECTIONS	$0.00
170	1.5.3.1	ANALYZER SECTION	$0.00
171	1.5.3.1.1	GRAPHITE ANALYZER CRYSTALS	$0.00
172	1.5.3.1.2	MECHANICAL SUPPORTS	$0.00
173	1.5.3.1.3	FIXING MECHANISM	$0.00
174	1.5.3.1.4	IMPRESSED SHIELDING DISCS	$0.00
175	1.5.3.1.5	ALIGNMENT DEVICES	$0.00
176	1.5.3.1.6	CRYOGENICS/MAIN RESERVOIR	$0.00
177	1.5.3.2	DETECTOR SECTION	$0.00
178	1.5.3.2.1	He TUBES (120)	$0.00
179	1.5.3.2.2	ELECTRONIC CHANNELS	$0.00
180	1.5.3.2.3	CABLES	$0.00

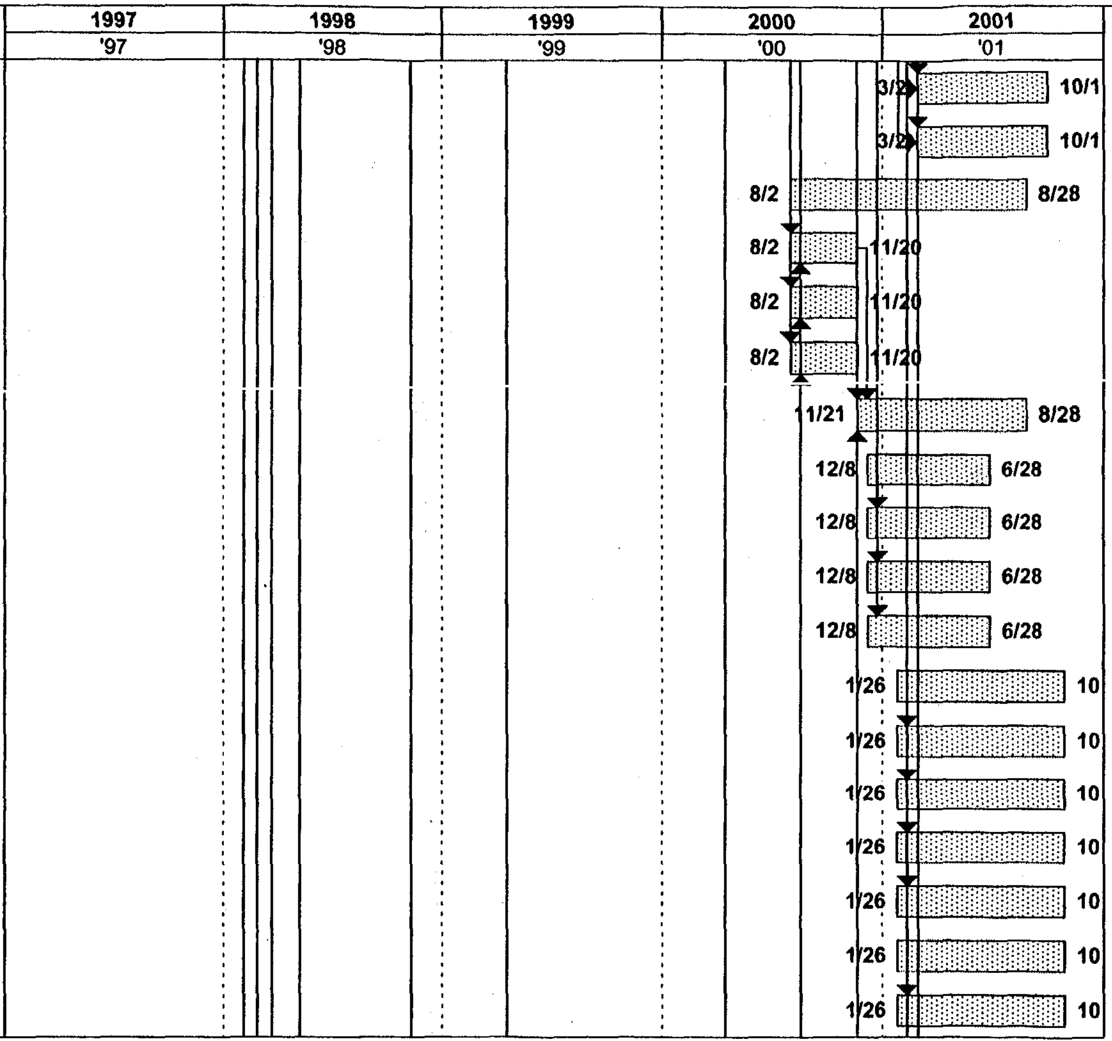


Project: HERMES I
Date: Sun 6/9/159

Task	▨	Milestone	★	Rolled Up Milestone	☆
Task Progress	■	Summary	▨	Rolled Up Progress	■
Critical Task	■	Rolled Up Task	▨		
Critical Task Progress	☐	Rolled Up Critical Task	■		

HERMES I
PROPOSAL OPTION 2
DETAILED SCHEDULE: LEVEL 3

ID	WBS	Task Name	PROJECT COSTS
181	1.5.3.2.4	MECHANICAL MOUNTS	$0.00
182	1.5.3.2.5	MOVABLE COLLIMATORS	$0.00
183	1.5.4	SPECTROMETER TANK ASSEMBLY	$0.00
184	1.5.4.1	ANALYZER TANK	$0.00
185	1.5.4.2	VACUUM PUMP/GAUGES, FRAMES/HOSES/VALVES	$0.00
186	1.5.4.3	BEAM STOP/DUMP PIPE/MONITOR	$0.00
187	1.5.4.4	INSTRUMENT SHIELD "HUTCH"	$0.00
188	1.5.5	SPECTROMETER CONTROL SYSTEM	$0.00
189	1.5.5.1	DATA ACQUISITION SYSTEM	$0.00
190	1.5.5.2	GRAPHICAL USER INTERFACE	$0.00
191	1.5.5.3	COMPUTER EQUIPMENT	$0.00
192	1.5.6	ANCILLARY EQUIPMENT	$0.00
193	1.5.6.1	SAMPLE GONIOMETER	$0.00
194	1.5.6.2	TEMPERATURE CONTROLLERS	$0.00
195	1.5.6.3	PUMPING STATION	$0.00
196	1.5.6.4	VACUUM/PRESSURE GAUGES/SENSORS	$0.00
197	1.5.6.5	SAMPLE ENVIRONMENT	$0.00
198	1.5.6.5.1	HELIUM CRYOSTAT	$0.00

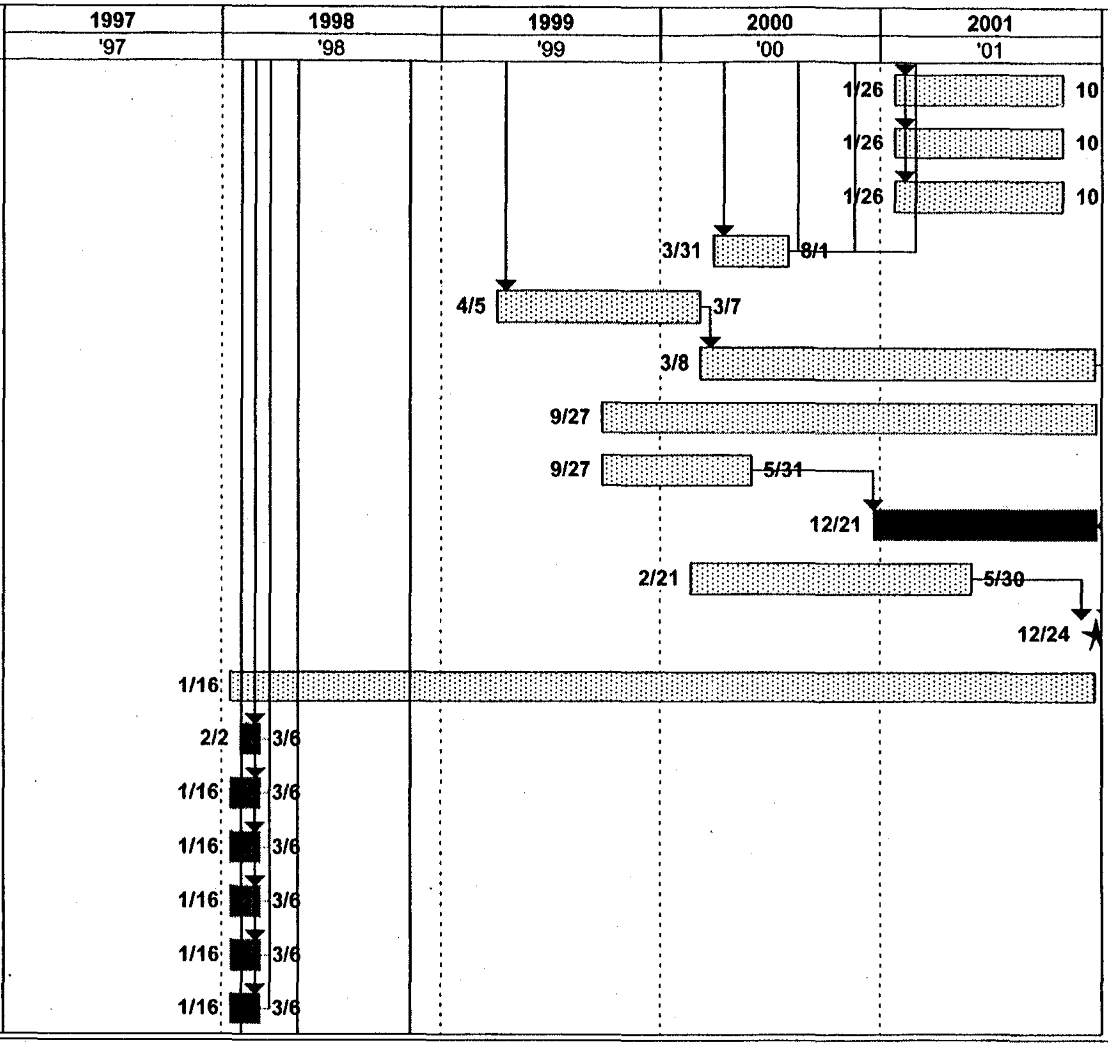


Project: HERMES I
Date: Sun 6/9/159

Task	▨	Milestone	★	Rolled Up Milestone	☆
Task Progress	■	Summary	▨	Rolled Up Progress	■
Critical Task	■	Rolled Up Task	▨		
Critical Task Progress	☐	Rolled Up Critical Task	■		

HERMES I
PROPOSAL OPTION 2
DETAILED SCHEDULE: LEVEL 3

ID	WBS	Task Name	PROJECT COSTS
199	1.5.6.5.2	DISPLEX	$0.00
200	1.5.6.5.3	GAS HANDLING SYSTEM	$0.00
201	1.5.6.5.4	FURNACE	$0.00
202	1.5.7	INSTRUMENT CRANE	$0.00
203	1.5.8	BNLTECH STAFF SUPPORT	$172,192.31
204	1.5.9	BNL STAFF INSTALLATION/TESTING	$333,711.54
205	1.6	TESTING/TRAINING PROGRAM	$0.00
206	1.6.1	DEVELOP START-UP & TEST PLAN	$0.00
207	1.6.2	START-UP/TEST/READINESS ASSESSMENT	$0.00
208	1.6.3	TRAINING PROGRAM	$0.00
209	1.7	HERMES OPERATIONAL	$0.00
210	1.8	PROJECT MANAGEMENT	$688,357.69
211	1.8.1	ESTABLISH LANL/BNL INTERFACES	$0.00
212	1.8.2	LEVEL 2 COST & SCHEDULE	$0.00
213	1.8.3	FINALIZE DETAILED PROCUREMENT STRATEGY	$0.00
214	1.8.4	QUALITY ASSURANCE PLAN	$0.00
215	1.8.5	ES&H PLAN	$0.00
216	1.8.6	PREP/ISSUE PROJECT EXECUTION PLAN	$0.00

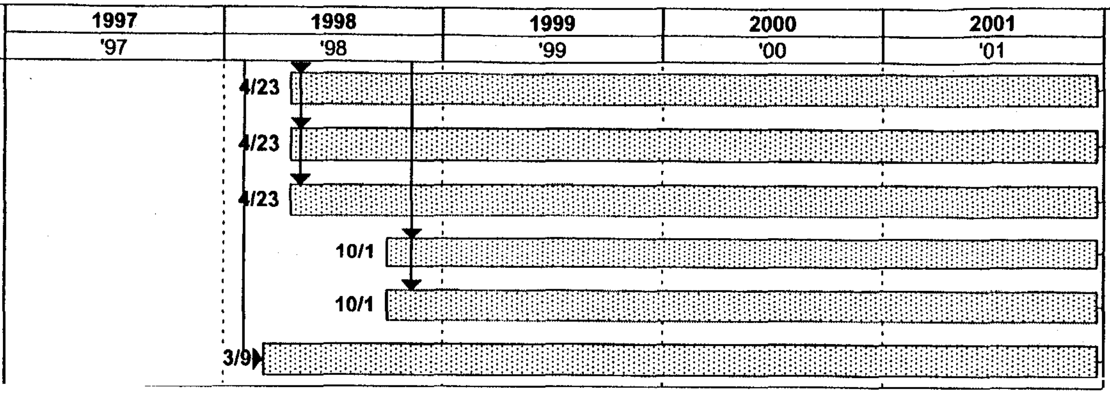


Project: HERMES I
Date: Sun 6/9/159

Task	▨	Milestone	★	Rolled Up Milestone	☆
Task Progress	■	Summary	▨	Rolled Up Progress	■
Critical Task	■	Rolled Up Task	▨		
Critical Task Progress	☐	Rolled Up Critical Task	■		

HERMES I
PROPOSAL OPTION 2
DETAILED SCHEDULE: LEVEL 3

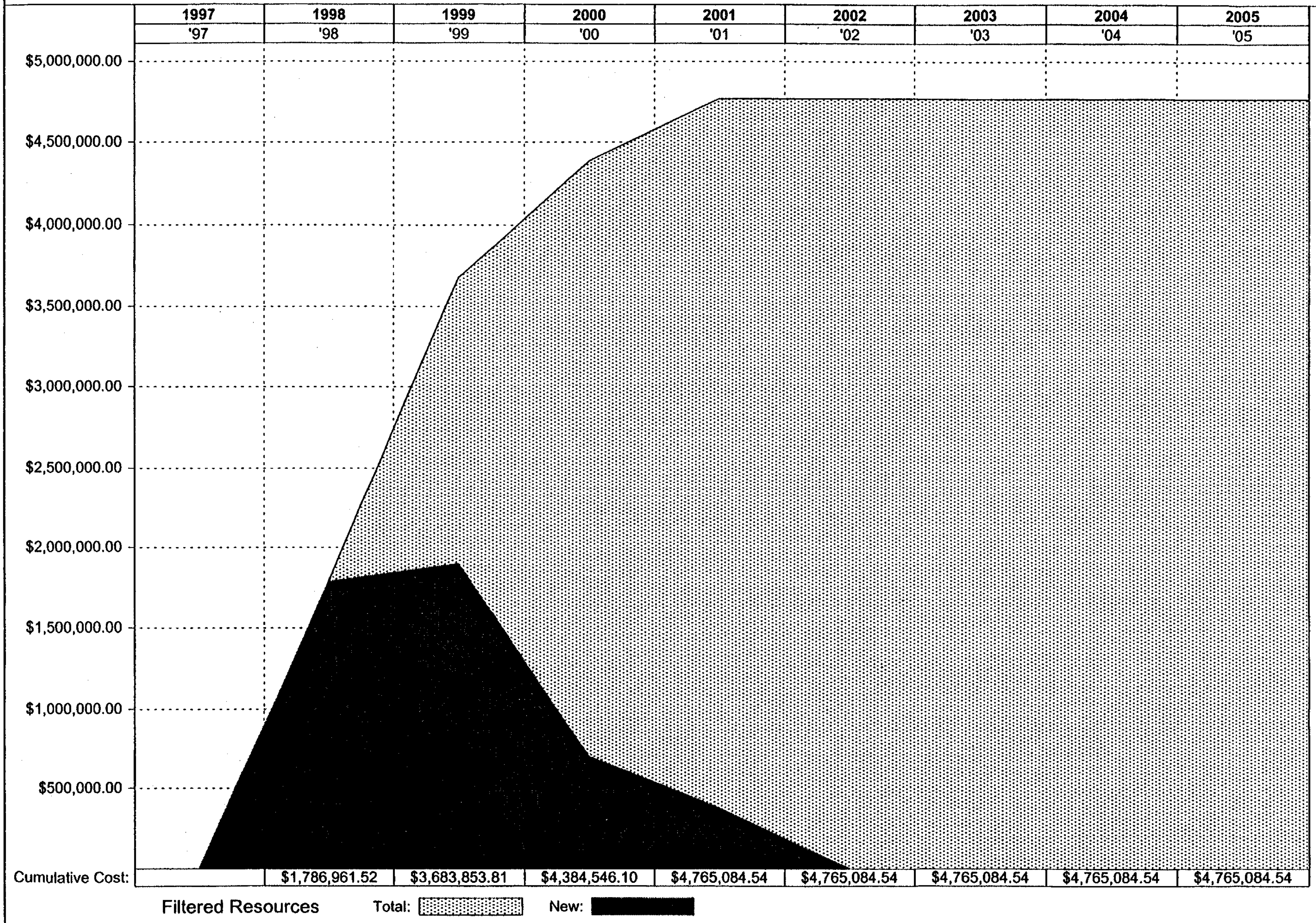
ID	WBS	Task Name	PROJECT COSTS
217	1.8.7	MONTHLY PROGRESS STATUS/REPORTS:	$0.00
218	1.8.8	QUARTERLY REVIEW	$0.00
219	1.8.9	BASELINE CHANGE MANAGEMENT	$0.00
220	1.8.10	BNL PROJECT MANAGEMENT STAFF (INCLUDING LANL	$486,346.15
221	1.8.11	BNL NEUTRON TECHNICIANS	$0.00
222	1.8.12	BNL TRAVEL	$202,011.54



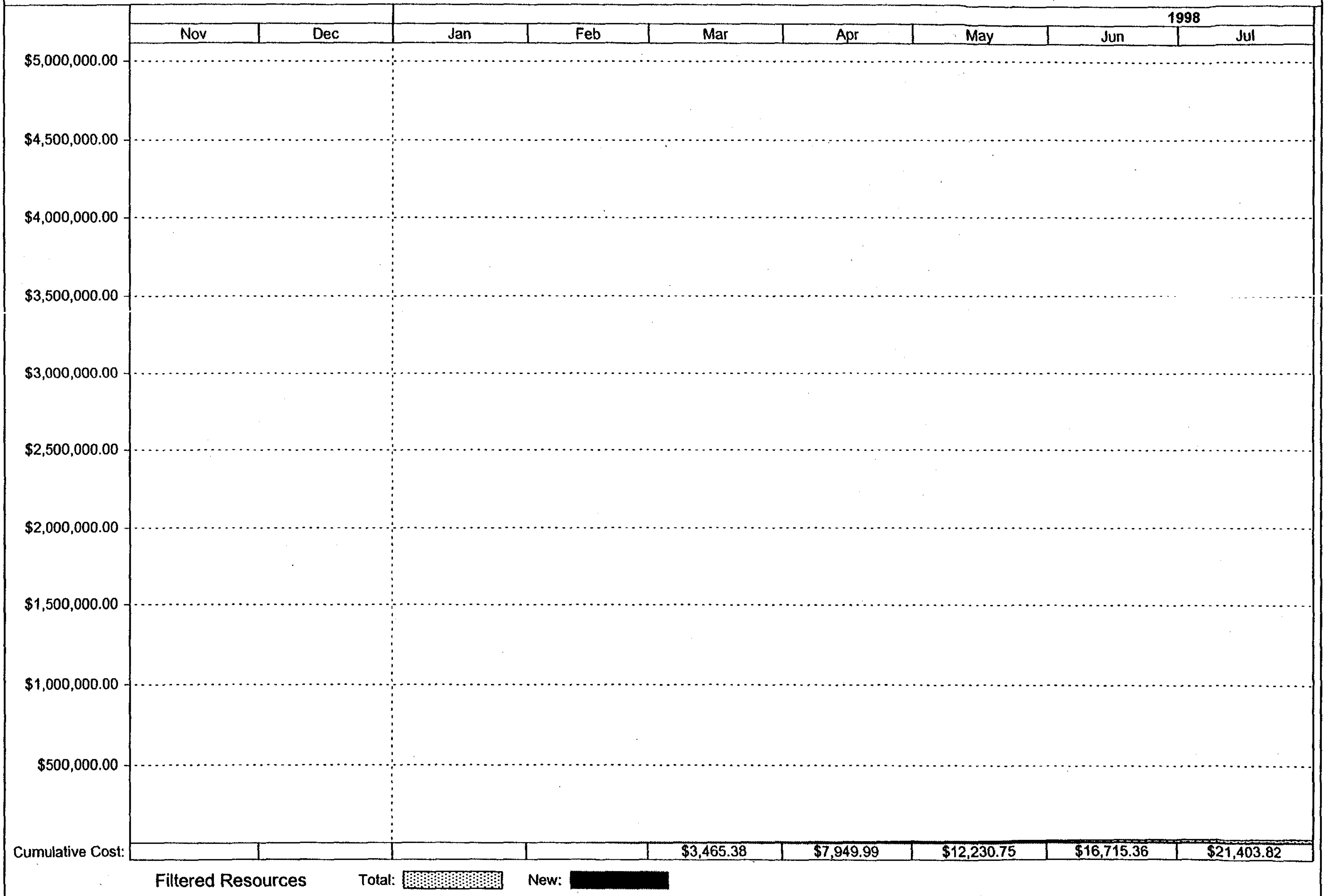
Project: HERMES I
Date: Sun 6/9/159

Task	▨	Milestone	★	Rolled Up Milestone	☆
Task Progress	■	Summary	▨	Rolled Up Progress	■
Critical Task	■	Rolled Up Task	▨		
Critical Task Progress	□	Rolled Up Critical Task	■		

HERMES 1
PROPOSAL OPTION 2
COST CURVE

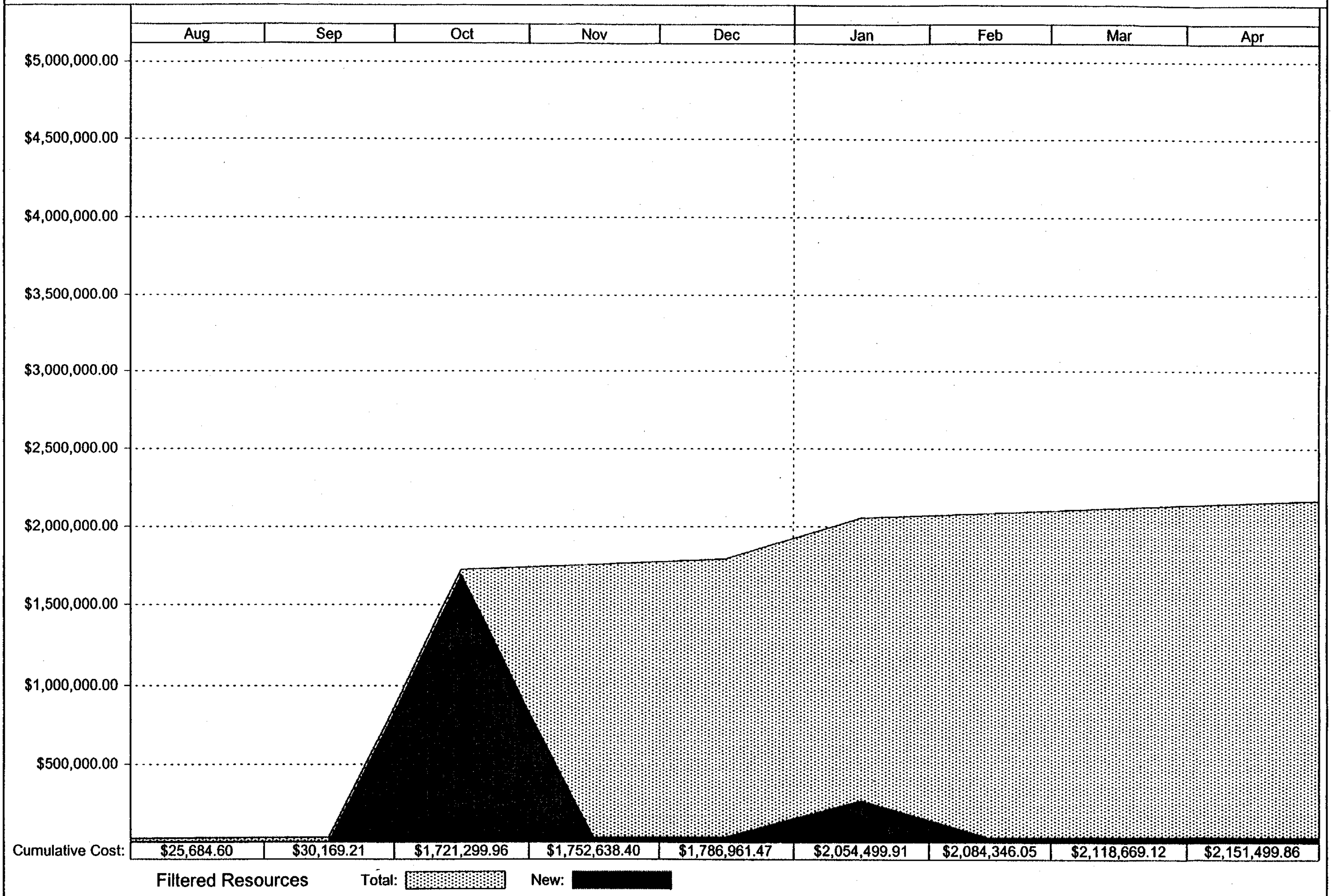


HERMES 1
PROPOSAL OPTION 2
COST CURVE

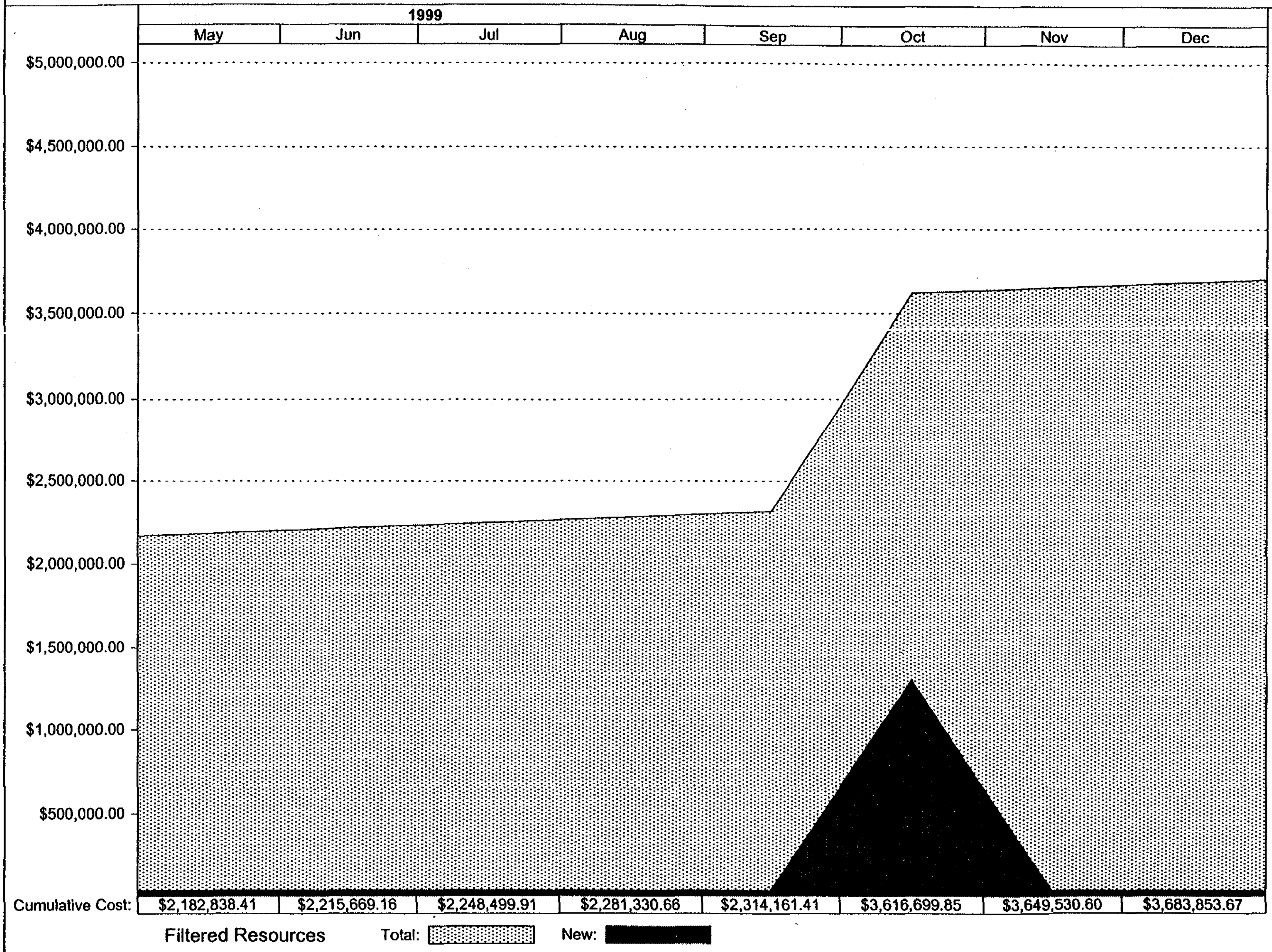


	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul
Cumulative Cost:					$3,465.38	$7,949.99	$12,230.75	$16,715.36	$21,403.82

HERMES 1
PROPOSAL OPTION 2
COST CURVE

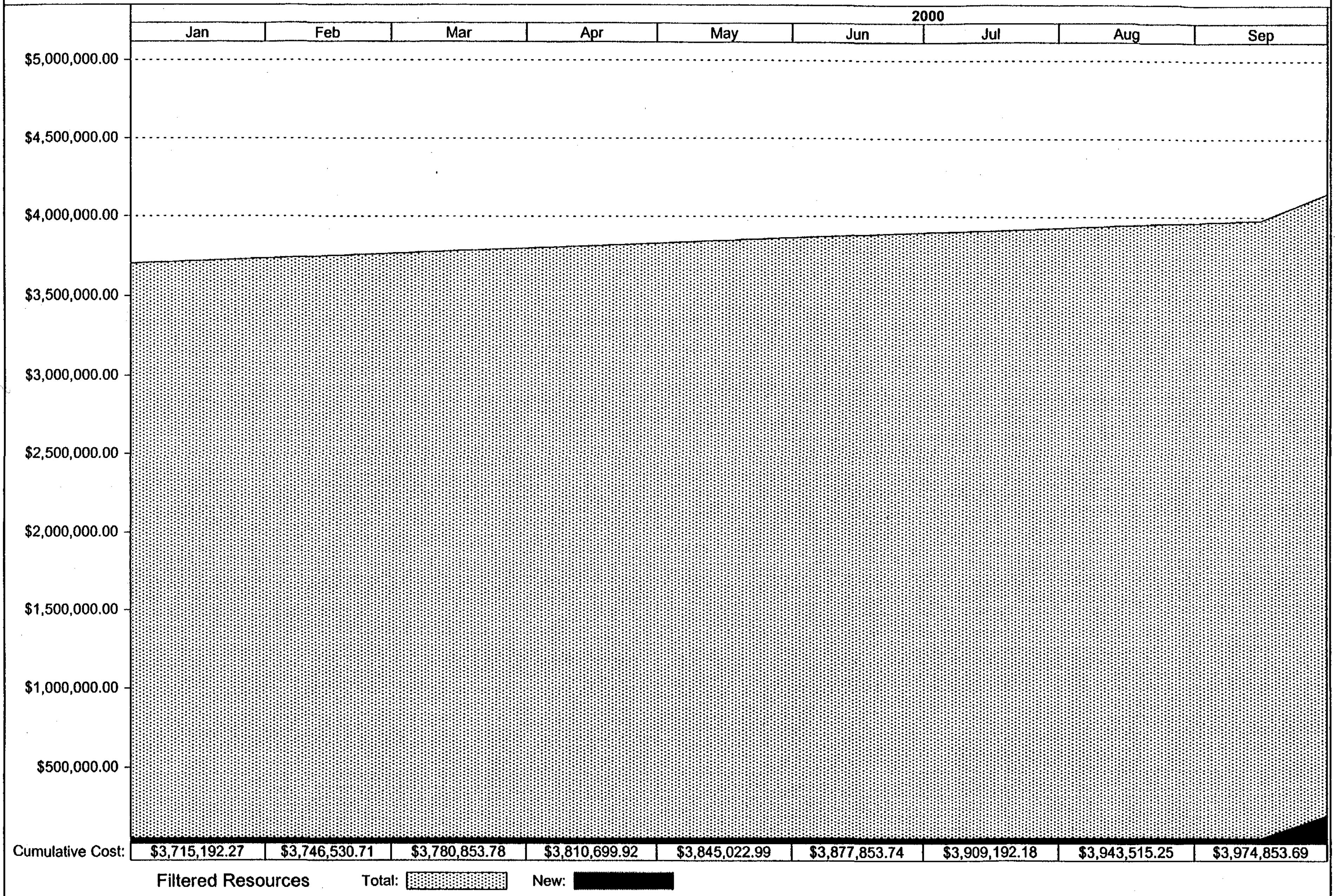


HERMES 1
PROPOSAL OPTION 2
COST CURVE



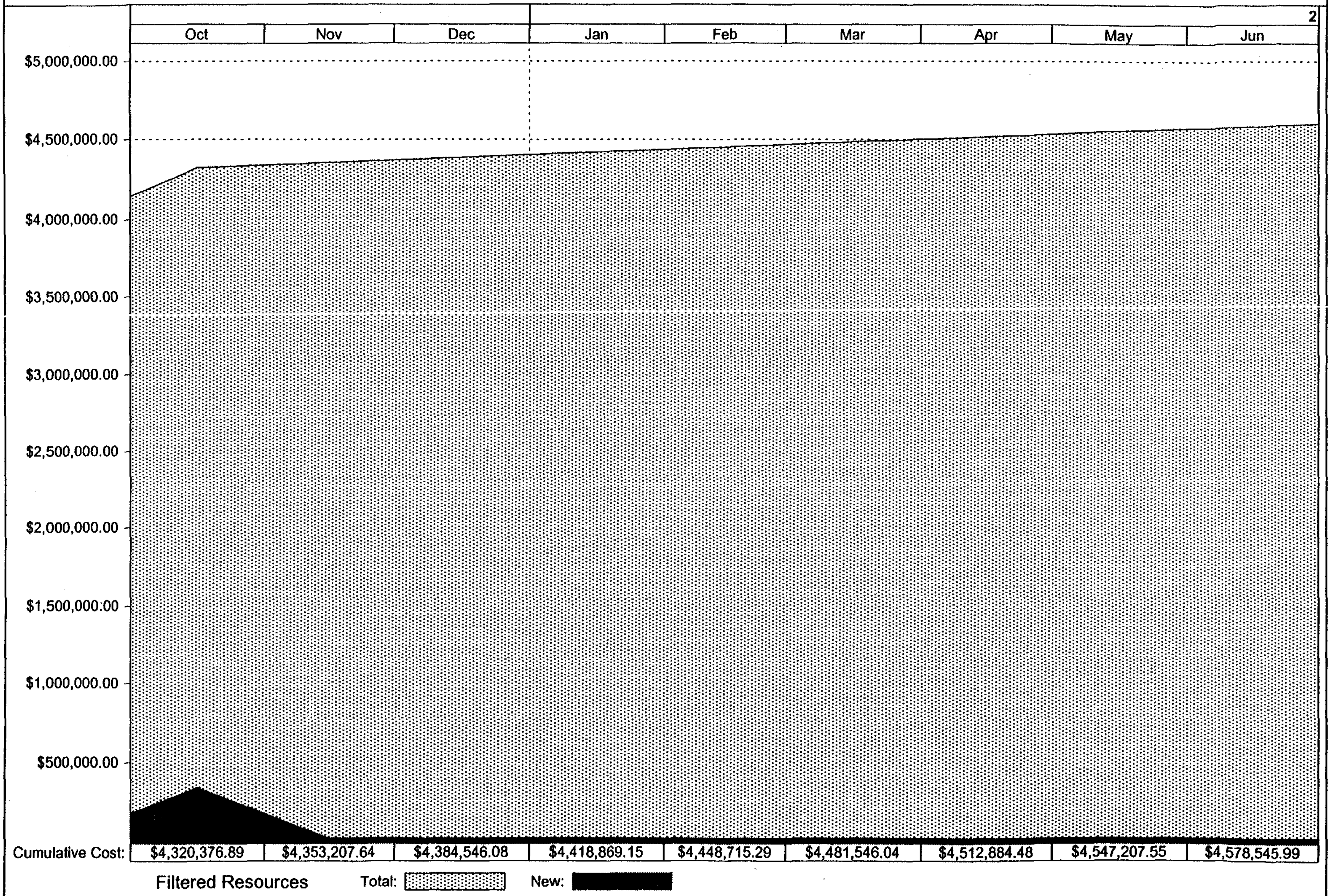
	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Cumulative Cost:	$2,182,838.41	$2,215,669.16	$2,248,499.91	$2,281,330.66	$2,314,161.41	$3,616,699.85	$3,649,530.60	$3,683,853.67

HERMES 1
PROPOSAL OPTION 2
COST CURVE



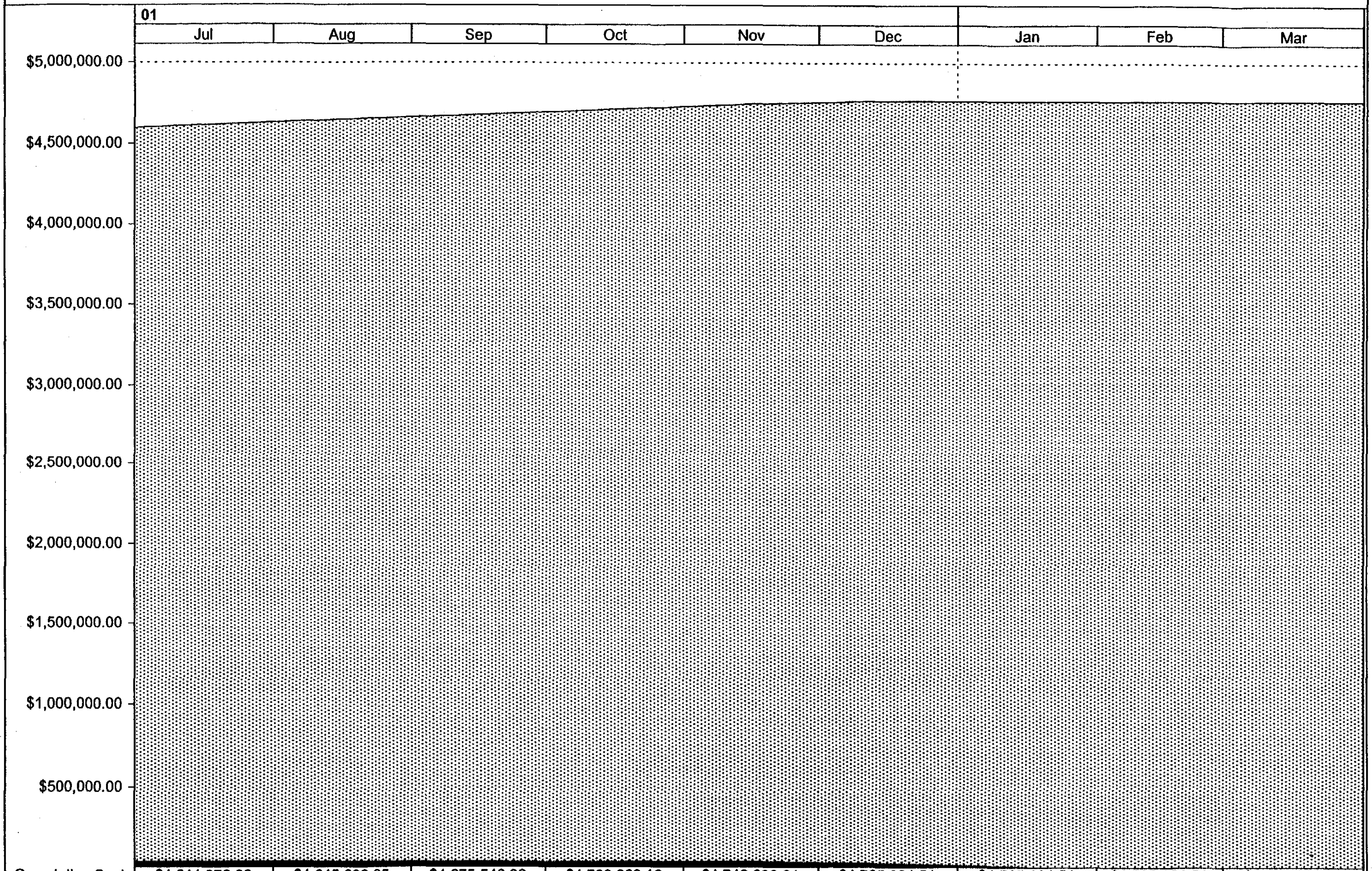
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Cumulative Cost:	$3,715,192.27	$3,746,530.71	$3,780,853.78	$3,810,699.92	$3,845,022.99	$3,877,853.74	$3,909,192.18	$3,943,515.25	$3,974,853.69

HERMES 1
PROPOSAL OPTION 2
COST CURVE



Cumulative Cost:	$4,320,376.89	$4,353,207.64	$4,384,546.08	$4,418,869.15	$4,448,715.29	$4,481,546.04	$4,512,884.48	$4,547,207.55	$4,578,545.99

HERMES 1
PROPOSAL OPTION 2
COST CURVE

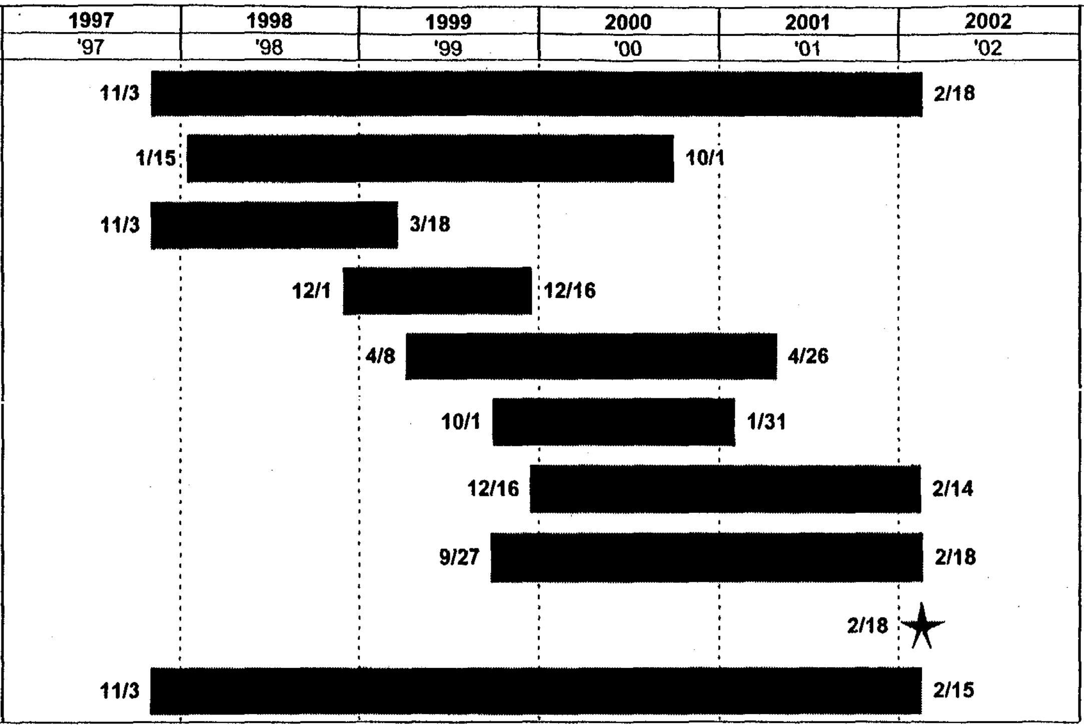


	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar
Cumulative Cost:	$4,611,376.88	$4,645,699.95	$4,675,546.09	$4,709,869.16	$4,742,699.91	$4,765,084.51	$4,765,084.51	$4,765,084.51	$4,765,084.51

Filtered Resources Total: ▨ New: ■

HERMES 1
PROPOSAL OPTION 3
SUMMARY SCHEDULE: LEVEL 1

ID	WBS	Task Name	PROJECT COSTS
1	1	HERMES I PROJECT: LEVEL OF EFFORT OPTION	$5,486,253.84
2	1.1	SUMMARY PROJECT REQUIREMENTS/MILESTONES	$0.00
8	1.2	CONCEPTUAL DESIGN	$0.00
60	1.3	DETAILED DESIGN	$259,961.54
109	1.4	PROCUREMENT	$3,602,000.00
155	1.5	INSTALLATION PREPARATIONS	$0.00
158	1.6	INSTALLATION: LANL	$730,557.69
206	1.7	TESTING/TRAINING PROGRAM	$0.00
210	1.8	HERMES OPERATIONAL	$0.00
211	1.9	PROJECT MANAGEMENT	$893,734.61

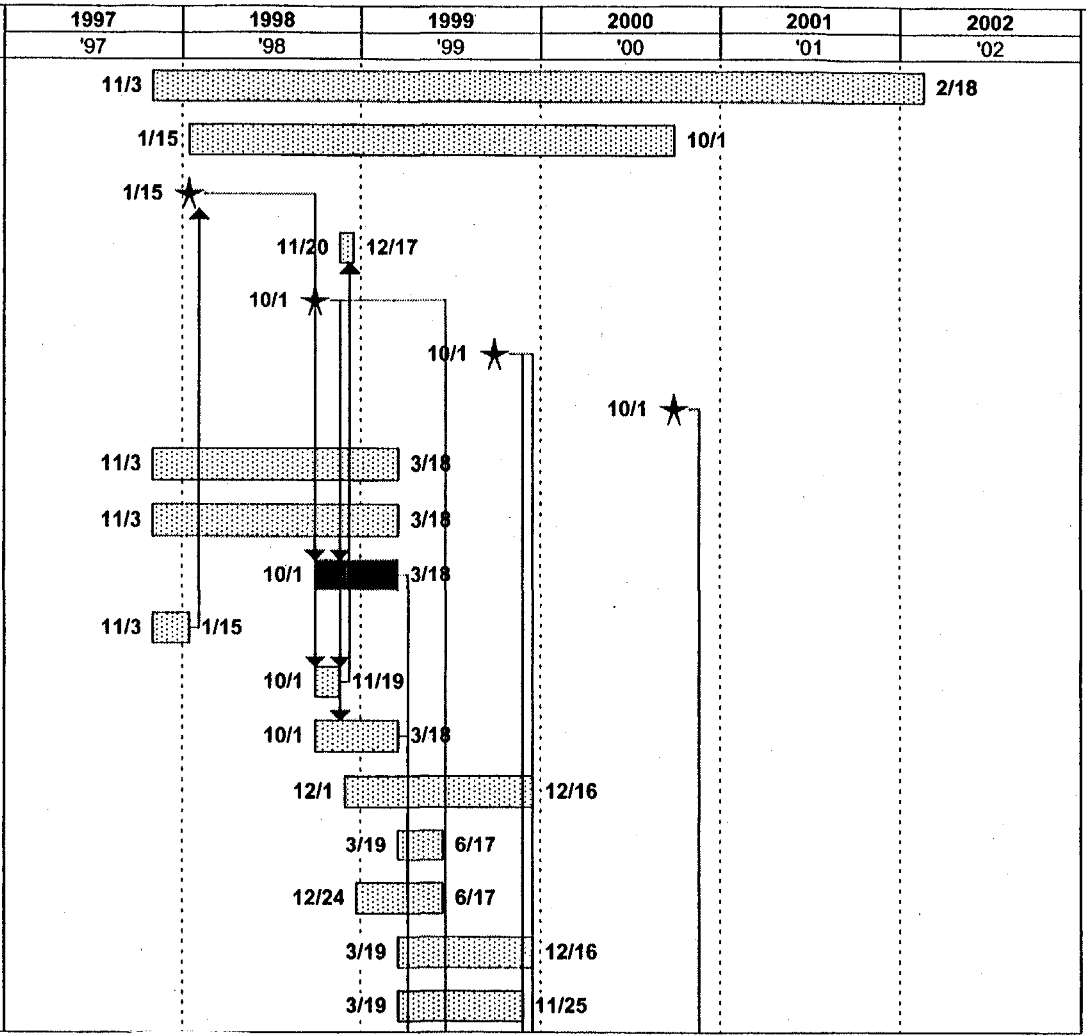


Project: HERMES I
Date: Sun 6/9/159

Task	■	Milestone	★	Rolled Up Milestone	☆
Task Progress	☐	Summary	■	Rolled Up Progress	■
Critical Task	■	Rolled Up Task	■		
Critical Task Progress	☐	Rolled Up Critical Task	■		

HERMES 1
PROPOSAL OPTION 3
MANAGEMENT SCHEDULE: LEVEL 2

ID	WBS	Task Name	PROJECT COSTS
1	1	HERMES I PROJECT: LEVEL OF EFFORT OPTION	$5,486,424.90
2	1.1	SUMMARY PROJECT REQUIREMENTS/MILESTONES	$0.00
3	1.1.1	SPECTROMETER PROPOSALS DUE	$0.00
4	1.1.2	PROPOSAL PRESENTATION TO LANL	$0.00
5	1.1.3	FUNDING RELEASE FOR FY 99	$0.00
6	1.1.4	FUNDING RELEASE FOR FY 00	$0.00
7	1.1.5	FUNDING RELEASE FOR FY 01	$0.00
8	1.2	CONCEPTUAL DESIGN	$0.00
9	1.2.1	MONTE CARLO SIMULATIONS	$0.00
11	1.2.1.2	FINAL MONTE CARLO SIMULATIONS	$0.00
12	1.2.2	EQUIPMENT CONCEPTUAL DESIGN	$0.00
58	1.2.3	ENHANCED CONCEPTUAL DESIGN	$0.00
59	1.2.4	BNL CONCEPTUAL DESIGN SUPPORT	$0.00
60	1.3	DETAILED DESIGN	$252,554.42
61	1.3.1	CHOPPER ASSEMBLIES (2): FRAME	$0.00
65	1.3.2	NEUTRON GUIDE SYSTEM	$0.00
72	1.3.3	ANALYZER & DETECTOR SECTIONS	$0.00
73	1.3.3.1	ANALYZER SECTIONS	$0.00

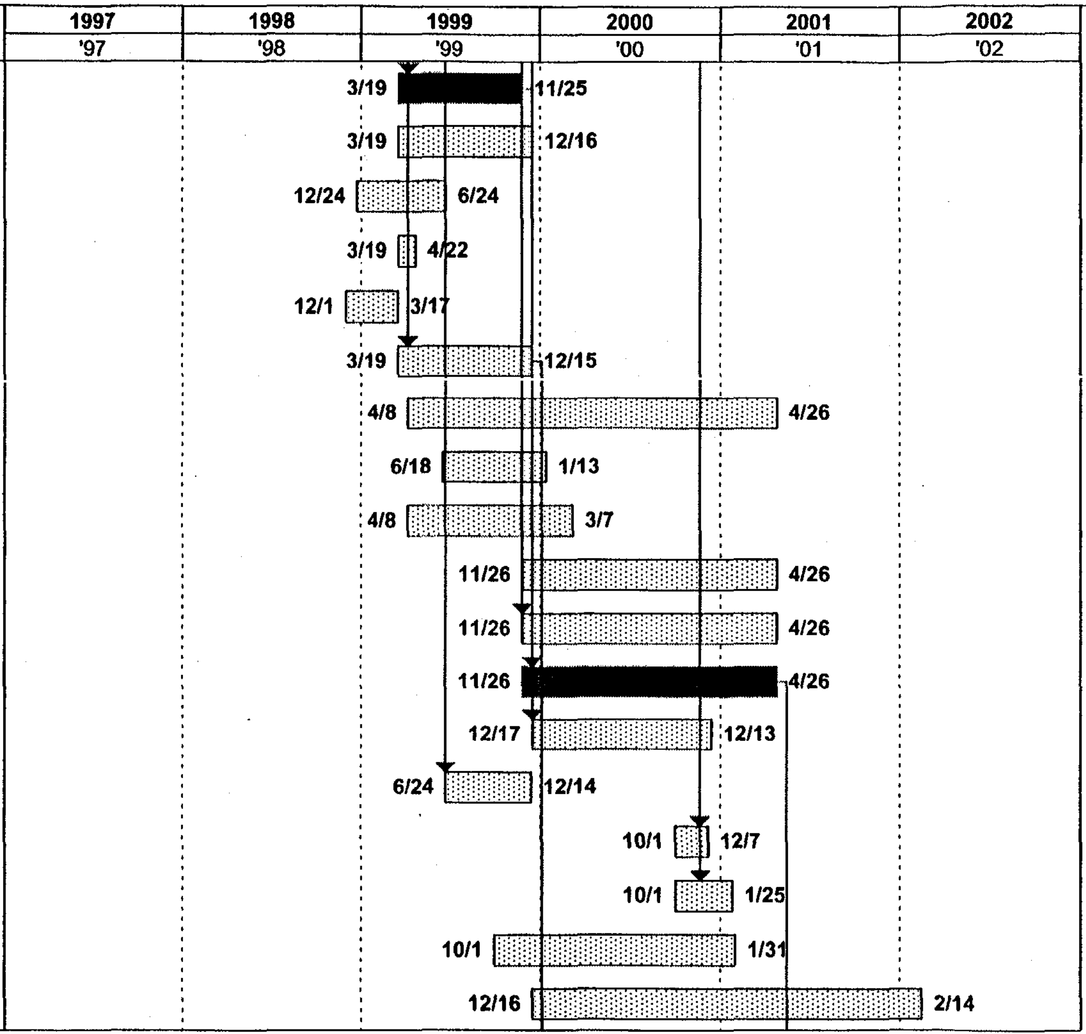


Project: HERMES I
Date: Sun 6/9/159

Task ▨
Task Progress ■
Critical Task ■
Critical Task Progress ☐
Milestone ★
Summary ▨
Rolled Up Task ▨
Rolled Up Critical Task ■
Rolled Up Milestone ☆
Rolled Up Progress ■

HERMES 1
PROPOSAL OPTION 3
MANAGEMENT SCHEDULE: LEVEL 2

ID	WBS	Task Name	PROJECT COSTS
74	1.3.3.1.1	GRAPHITE ANALYZER CRYSTALS	$0.00
81	1.3.3.2	DETECTOR SECTIONS	$0.00
88	1.3.4	SPECTROMETER TANK ASSEMBLY	$0.00
93	1.3.5	SPECTROMETER CONTROL SYSTEM	$0.00
97	1.3.6	ANCILLARY EQUIPMENT	$0.00
108	1.3.7	BNL DETAILED DESIGN SUPPORT	$252,554.42
109	1.4	PROCUREMENT	$3,602,000.00
110	1.4.1	CHOPPER ASSEMBLIES (3): TO, FRAME	$142,500.00
114	1.4.2	NEUTRON GUIDE SYSTEM	$1,607,100.00
121	1.4.3	ANALYZER & DETECTOR SECTIONS	$933,900.00
122	1.4.3.1	ANALYZER SECTION	$635,200.00
123	1.4.3.1.1	GRAPHITE ANALYZER CRYSTALS	$300,000.00
129	1.4.3.2	DETECTOR SYSTEM	$298,700.00
135	1.4.4	SPECTROMETER TANK ASSEMBLY	$444,900.00
140	1.4.5	SPECTROMETER CONTROL SYSTEM	$163,100.00
144	1.4.6	ANCILLARY EQUIPMENT	$273,200.00
155	1.5	INSTALLATION PREPARATIONS	$0.00
158	1.6	INSTALLATION: LANL	$738,135.87

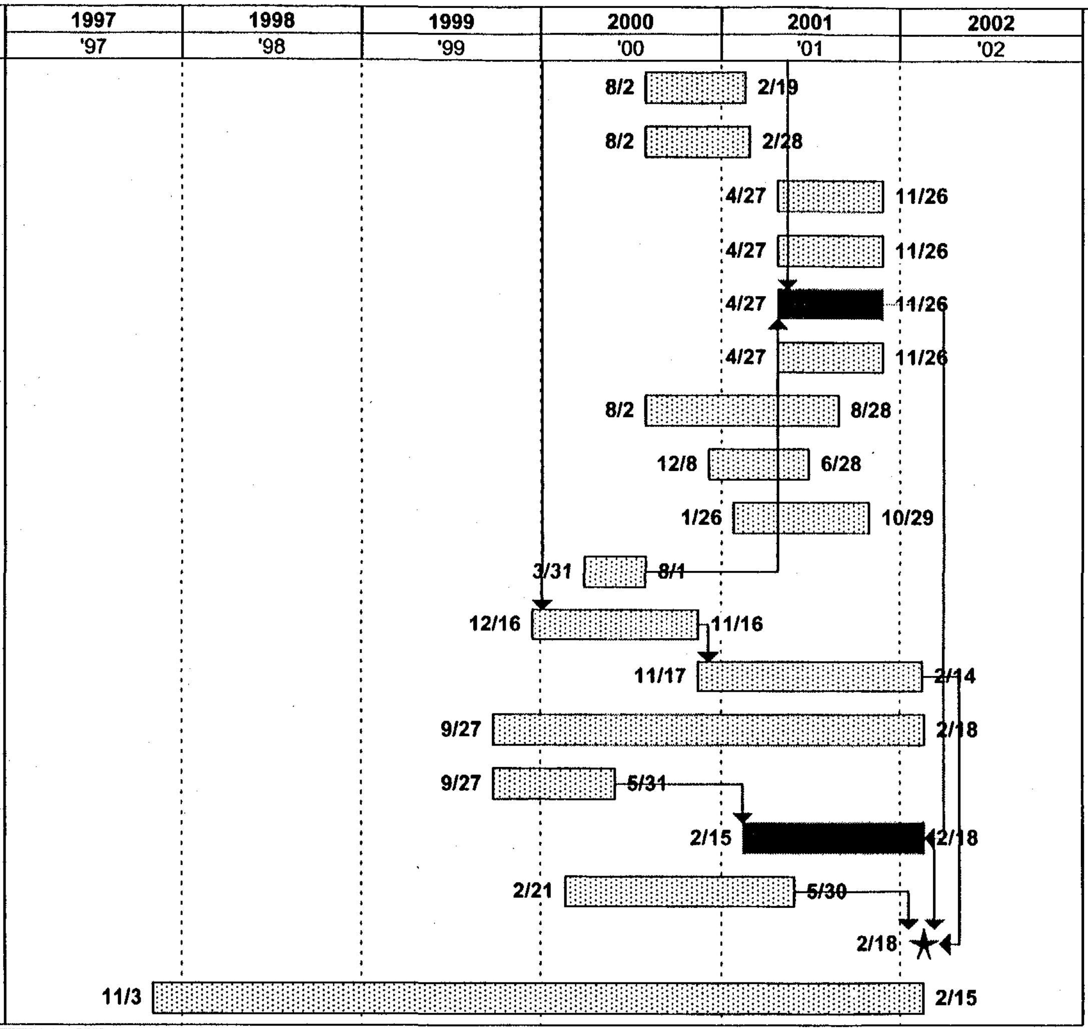


Project: HERMES I
Date: Sun 6/9/159

Task	▨	Milestone	★	Rolled Up Milestone	☆
Task Progress	■	Summary	▨	Rolled Up Progress	■
Critical Task	■	Rolled Up Task	▨		
Critical Task Progress	☐	Rolled Up Critical Task	■		

HERMES 1
PROPOSAL OPTION 3
MANAGEMENT SCHEDULE: LEVEL 2

ID	WBS	Task Name	PROJECT COSTS
159	1.6.1	CHOPPER ASSEMBLIES (3): TO, FRAME	$0.00
163	1.6.2	NEUTRON GUIDE SYSTEM	$0.00
170	1.6.3	ANALYZER & DETECTOR SECTIONS	$0.00
171	1.6.3.1	ANALYZER SECTION	$0.00
172	1.6.3.1.1	GRAPHITE ANALYZER CRYSTALS	$0.00
178	1.6.3.2	DETECTOR SECTION	$0.00
184	1.6.4	SPECTROMETER TANK ASSEMBLY	$0.00
189	1.6.5	SPECTROMETER CONTROL SYSTEM	$0.00
193	1.6.6	ANCILLARY EQUIPMENT	$0.00
203	1.6.7	INSTRUMENT CRANE	$0.00
204	1.6.8	BNLTECH STAFF SUPPORT	$315,042.12
205	1.6.9	BNL STAFF INSTALLATION/TESTING	$423,093.75
206	1.7	TESTING/TRAINING PROGRAM	$0.00
207	1.7.1	DEVELOP START-UP & TEST PLAN	$0.00
208	1.7.2	START-UP/TEST/READINESS ASSESSMENT	$0.00
209	1.7.3	TRAINING PROGRAM	$0.00
210	1.8	HERMES OPERATIONAL	$0.00
211	1.9	PROJECT MANAGEMENT	$893,734.61

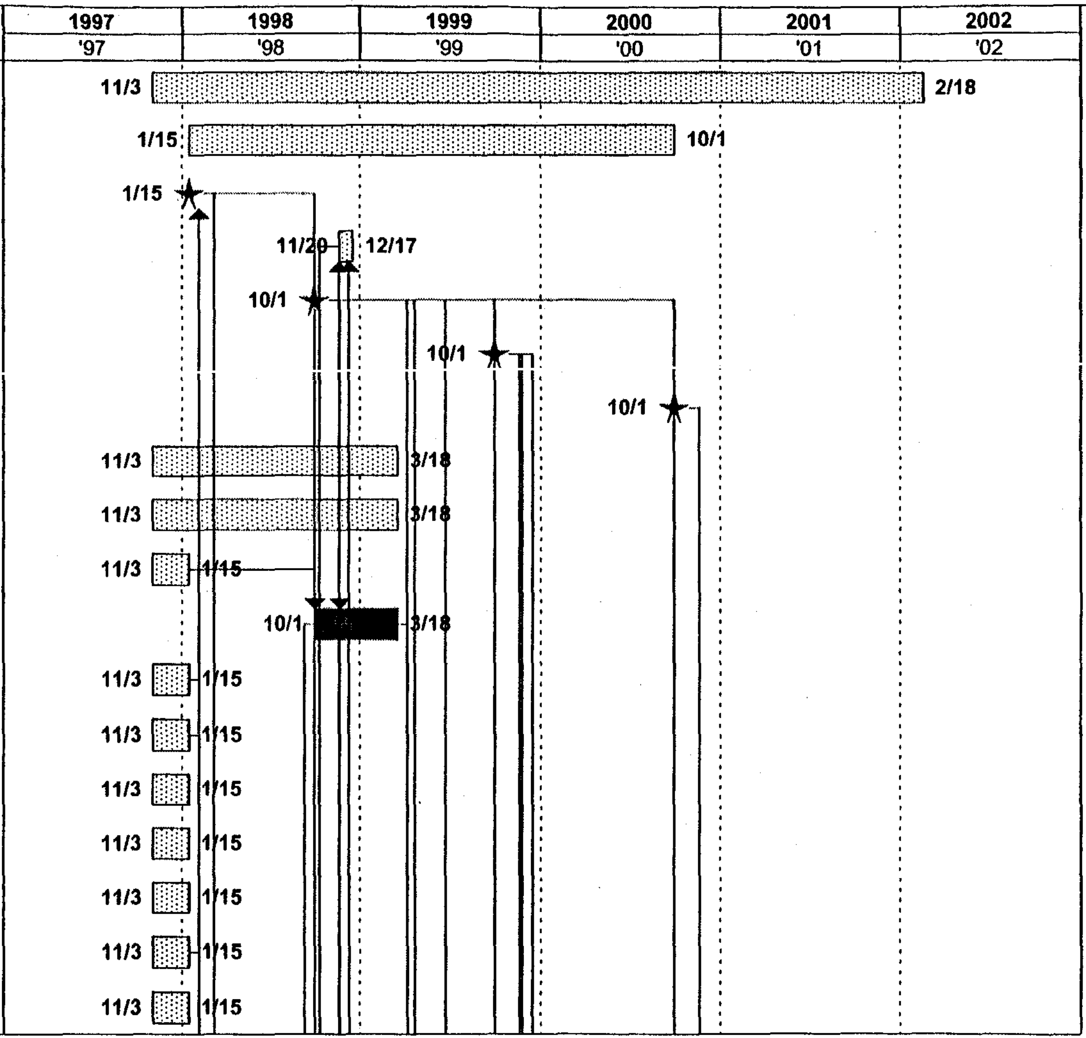


Task	▨	Milestone	★	Rolled Up Milestone	☆
Task Progress	■	Summary	▨	Rolled Up Progress	■
Critical Task	■	Rolled Up Task	▨		
Critical Task Progress	☐	Rolled Up Critical Task	■		

Project: HERMES I
Date: Sun 6/9/159

HERMES 1
PROPOSAL OPTION 3
DETAILED SCHEDULE: LEVEL 3

ID	WBS	Task Name	PROJECT COSTS
1	1	HERMES I PROJECT: LEVEL OF EFFORT OPTION	$5,486,424.90
2	1.1	SUMMARY PROJECT REQUIREMENTS/MILESTONES	$0.00
3	1.1.1	SPECTROMETER PROPOSALS DUE	$0.00
4	1.1.2	PROPOSAL PRESENTATION TO LANL	$0.00
5	1.1.3	FUNDING RELEASE FOR FY 99	$0.00
6	1.1.4	FUNDING RELEASE FOR FY 00	$0.00
7	1.1.5	FUNDING RELEASE FOR FY 01	$0.00
8	1.2	CONCEPTUAL DESIGN	$0.00
9	1.2.1	MONTE CARLO SIMULATIONS	$0.00
10	1.2.1.1	PRELIMINARY MONTE CARLO SIMULATIONS TO SUPPORT	$0.00
11	1.2.1.2	FINAL MONTE CARLO SIMULATIONS	$0.00
12	1.2.2	EQUIPMENT CONCEPTUAL DESIGN	$0.00
13	1.2.2.1	CHOPPER ASSEMBLIES (3): TO, FRAME	$0.00
14	1.2.2.1.1	CHOPPER WHEEL	$0.00
15	1.2.2.1.2	MOTOR SPEED CONTROL UNIT	$0.00
16	1.2.2.1.3	CHOPPER PLATFORM	$0.00
17	1.2.2.2	NEUTRON GUIDE SYSTEM	$0.00
18	1.2.2.2.1	SUPERMIRROR GUIDES	$0.00



Project: HERMES I
Date: Sun 6/9/159

Task ▨
Task Progress ■
Critical Task ■
Critical Task Progress □
Milestone ★
Summary ▨
Rolled Up Task ▨
Rolled Up Critical Task ■
Rolled Up Milestone ☆
Rolled Up Progress ■

HERMES 1
PROPOSAL OPTION 3
DETAILED SCHEDULE: LEVEL 3

ID	WBS	Task Name	PROJECT COSTS	1997 '97	1998 '98	1999 '99	2000 '00	2001 '01	2002 '02
19	1.2.2.2.2	VACUUM FLIGHT TUBES	$0.00	11/3 ▨	1/15				
20	1.2.2.2.3	GUIDE SHIELDING	$0.00	11/3 ▨	1/15				
21	1.2.2.2.4	VACUUM PUMPS	$0.00	11/3 ▨	1/15				
22	1.2.2.2.5	ALIGNMENT FIXTURES/STANCHIONS	$0.00	11/3 ▨	1/15				
23	1.2.2.3	ANALYZER & DETECTOR SECTIONS	$0.00	11/3 ▨	1/15				
24	1.2.2.3.1	GRAPHITE ANALYZER CRYSTALS	$0.00	11/3 ▨	1/15				
25	1.2.2.3.2	MECHANICAL SUPPORTS	$0.00	11/3 ▨	1/15				
26	1.2.2.3.3	FIXING MECHANISM	$0.00	11/3 ▨	1/15				
27	1.2.2.3.4	IMPRESSED SHIELDING DISCS	$0.00	11/3 ▨	1/15				
28	1.2.2.3.5	ALIGNMENT DEVICES	$0.00	11/3 ▨	1/15				
29	1.2.2.3.6	CRYOGENICS/MAIN RESERVOIR	$0.00	11/3 ▨	1/15				
30	1.2.2.3.7	FLUID SUPPLY & CONTROL	$0.00	11/3 ▨	1/15				
31	1.2.2.3.8	He TUBES (120)	$0.00	11/3 ▨	1/15				
32	1.2.2.3.9	ELECTRONIC CHANNELS	$0.00	11/3 ▨	1/15				
33	1.2.2.3.10	CABLES	$0.00	11/3 ▨	1/15				
34	1.2.2.3.11	MECHANICAL MOUNTS	$0.00	11/3 ▨	1/15				
35	1.2.2.3.12	SERVICE TROLLEY	$0.00	11/3 ▨	1/15				
36	1.2.2.3.13	MOVABLE COLLIMATORS	$0.00	11/3 ▨	1/15				

Project: HERMES I
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Task	▨	Milestone	★	Rolled Up Milestone	☆
Task Progress	▬	Summary	▨	Rolled Up Progress	▬
Critical Task	■	Rolled Up Task	▨		
Critical Task Progress	☐	Rolled Up Critical Task	■		

HERMES 1
PROPOSAL OPTION 3
DETAILED SCHEDULE: LEVEL 3

ID	WBS	Task Name	PROJECT COSTS	1997 '97	1998 '98	1999 '99	2000 '00	2001 '01	2002 '02
37	1.2.2.4	SPECTROMETER TANK ASSEMBLY	$0.00	11/3 ▨	1/15				
38	1.2.2.4.1	ANALYZER TANK	$0.00	11/3 ▨	1/15				
39	1.2.2.4.2	VACUUM PUMP/GAUGES, FRAMES/HOSES/VALVES	$0.00	11/3 ▨	1/15				
40	1.2.2.4.3	BEAM STOP/DUMP PIPE/MONITOR	$0.00	11/3 ▨	1/15				
41	1.2.2.4.4	INSTRUMENT SHIELD "HUTCH"	$0.00	11/3 ▨	1/15				
42	1.2.2.5	SPECTROMETER CONTROL SYSTEM	$0.00	11/3 ▨	1/15				
43	1.2.2.5.1	DATA ACQUISITION SYSTEM	$0.00	11/3 ▨	1/15				
44	1.2.2.5.2	GRAPHICAL USER INTERFACE	$0.00	11/3 ▨	1/15				
45	1.2.2.5.3	COMPUTER EQUIPMENT	$0.00	11/3 ▨	1/15				
46	1.2.2.5.4	POWER SUPPLY	$0.00	11/3 ▨	1/15				
47	1.2.2.6	ANCILLARY EQUIPMENT	$0.00	11/3 ▨	1/15				
48	1.2.2.6.1	SAMPLE GONIOMETER	$0.00	11/3 ▨	1/15				
49	1.2.2.6.2	TEMPERATURE CONTROLLERS	$0.00	11/3 ▨	1/15				
50	1.2.2.6.3	PUMPING STATION	$0.00	11/3 ▨	1/15				
51	1.2.2.6.4	VACUUM/PRESSURE GAUGES/SENSORS	$0.00	11/3 ▨	1/15				
52	1.2.2.6.5	SAMPLE ENVIRONMENT	$0.00	11/3 ▨	1/15				
53	1.2.2.6.5.	HELIUM CRYOSTAT	$0.00	11/3 ▨	1/15				
54	1.2.2.6.5.	DISPLEX	$0.00	11/3 ▨	1/15				

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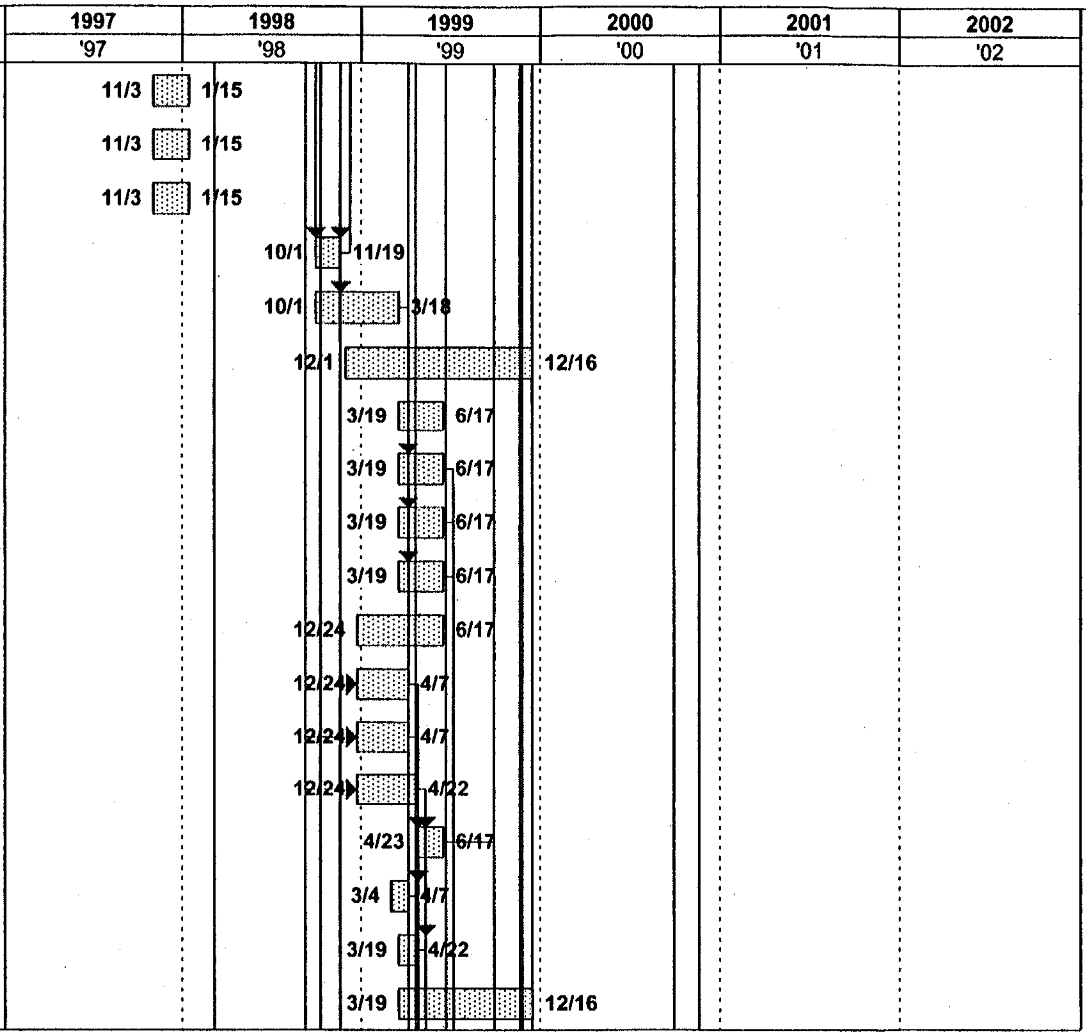
Task	▨	Milestone	★	Rolled Up Milestone	☆
Task Progress	■	Summary	▨	Rolled Up Progress	■
Critical Task	■	Rolled Up Task	▨		
Critical Task Progress	□	Rolled Up Critical Task	■		

HERMES 1
PROPOSAL OPTION 3
DETAILED SCHEDULE: LEVEL 3

ID	WBS	Task Name	PROJECT COSTS
55	1.2.2.6.5.	GAS HANDLING SYSTEM	$0.00
56	1.2.2.6.5.	FURNACE	$0.00
57	1.2.2.6.6	INSTRUMENT CRANE	$0.00
58	1.2.3	ENHANCED CONCEPTUAL DESIGN	$0.00
59	1.2.4	BNL CONCEPTUAL DESIGN SUPPORT	$0.00
60	1.3	DETAILED DESIGN	$252,554.42
61	1.3.1	CHOPPER ASSEMBLIES (2): FRAME	$0.00
62	1.3.1.1	CHOPPER WHEEL	$0.00
63	1.3.1.2	MOTOR SPEED CONTROL UNIT	$0.00
64	1.3.1.3	CHOPPER PLATFORM	$0.00
65	1.3.2	NEUTRON GUIDE SYSTEM	$0.00
66	1.3.2.1	SHUTTER	$0.00
67	1.3.2.2	SUPERMIRROR GUIDES	$0.00
68	1.3.2.3	VACUUM FLIGHT TUBES	$0.00
69	1.3.2.4	GUIDE SHIELDING (PRIMARY/SECONDARY)	$0.00
70	1.3.2.5	VACUUM PUMPS	$0.00
71	1.3.2.6	ALIGNMENT FIXTURES/STANCHIONS	$0.00
72	1.3.3	ANALYZER & DETECTOR SECTIONS	$0.00



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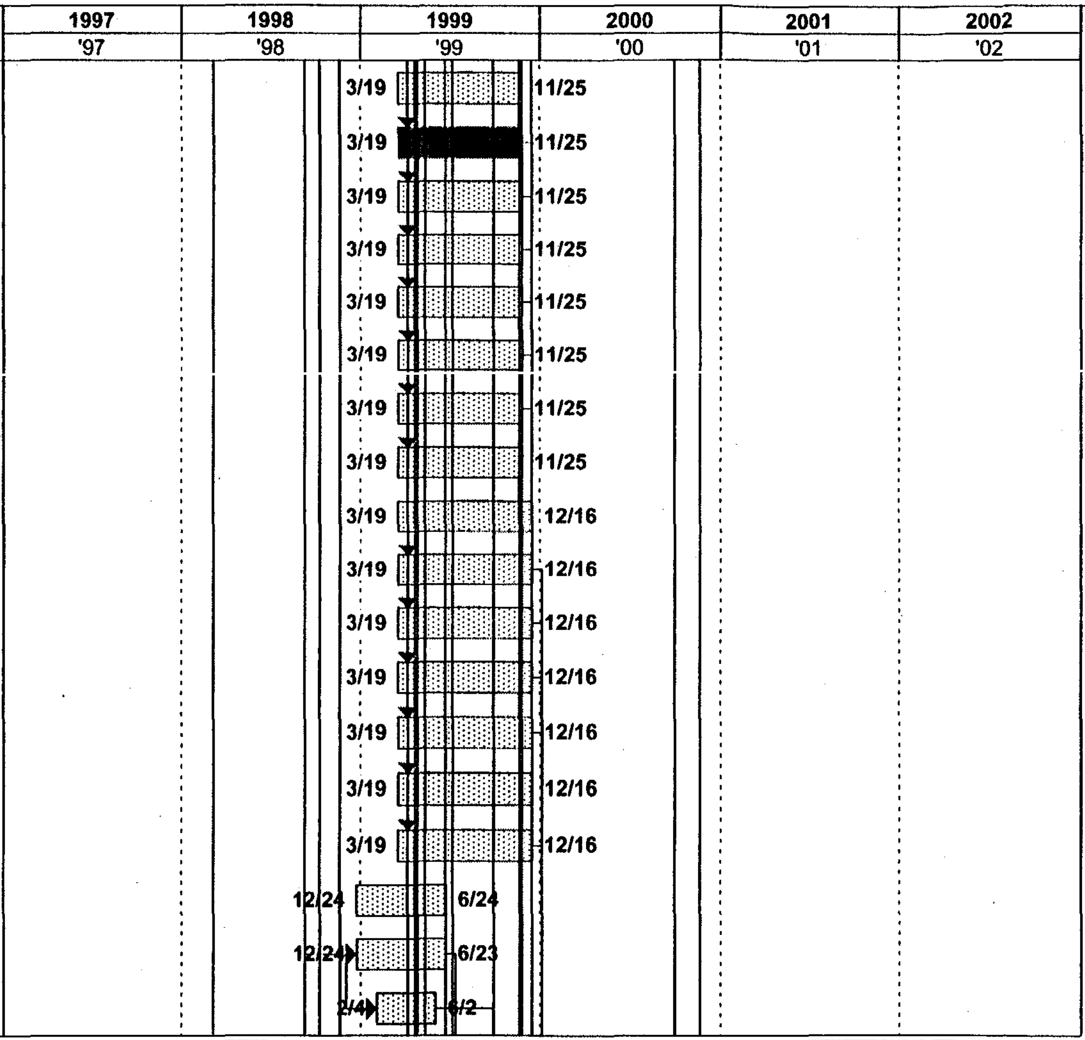
Task	▨	Milestone	★	Rolled Up Milestone	☆
Task Progress	■	Summary	▨	Rolled Up Progress	■
Critical Task	■	Rolled Up Task	▨		
Critical Task Progress	☐	Rolled Up Critical Task	■		

HERMES 1
PROPOSAL OPTION 3
DETAILED SCHEDULE: LEVEL 3

ID	WBS	Task Name	PROJECT COSTS
73	1.3.3.1	ANALYZER SECTIONS	$0.00
74	1.3.3.1.1	GRAPHITE ANALYZER CRYSTALS	$0.00
75	1.3.3.1.2	MECHANICAL SUPPORTS	$0.00
76	1.3.3.1.3	FIXING MECHANISM	$0.00
77	1.3.3.1.4	IMPRESSED SHIELDING DISCS	$0.00
78	1.3.3.1.5	ALIGNMENT DEVICES	$0.00
79	1.3.3.1.6	CRYOGENICS/MAIN RESERVOIR	$0.00
80	1.3.3.1.7	FLUID SUPPLY & CONTROL	$0.00
81	1.3.3.2	DETECTOR SECTIONS	$0.00
82	1.3.3.2.1	He TUBES (120)	$0.00
83	1.3.3.2.2	ELECTRONIC CHANNELS	$0.00
84	1.3.3.2.3	CABLES	$0.00
85	1.3.3.2.4	MECHANICAL MOUNTS	$0.00
86	1.3.3.2.5	SERVICE TROLLEY	$0.00
87	1.3.3.2.6	MOVABLE COLLIMATORS	$0.00
88	1.3.4	SPECTROMETER TANK ASSEMBLY	$0.00
89	1.3.4.1	ANALYZER TANK	$0.00
90	1.3.4.2	VACUUM PUMP/GAUGES, FRAMES/HOSES/VALVES	$0.00



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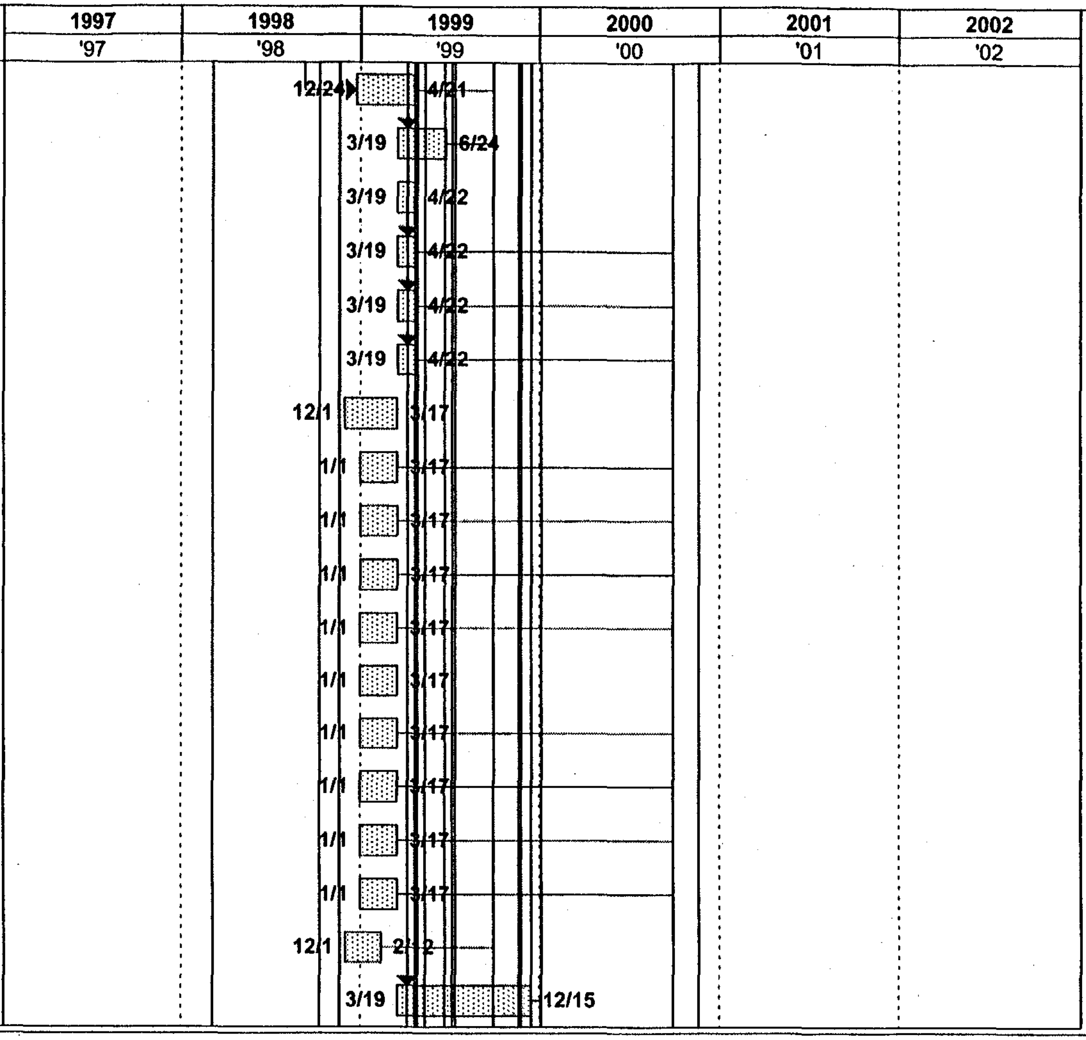
Task	▨	Milestone	★	Rolled Up Milestone	☆
Task Progress	■	Summary	▨	Rolled Up Progress	■
Critical Task	■	Rolled Up Task	▨		
Critical Task Progress	☐	Rolled Up Critical Task	■		

HERMES 1
PROPOSAL OPTION 3
DETAILED SCHEDULE: LEVEL 3

ID	WBS	Task Name	PROJECT COSTS
91	1.3.4.3	BEAM STOP/DUMP PIPE/MONITOR	$0.00
92	1.3.4.4	INSTRUMENT SHIELD "HUTCH"/ACCESS	$0.00
93	1.3.5	SPECTROMETER CONTROL SYSTEM	$0.00
94	1.3.5.1	DATA ACQUISITION SYSTEM	$0.00
95	1.3.5.2	GRAPHICAL USER INTERFACE	$0.00
96	1.3.5.3	COMPUTER EQUIPMENT	$0.00
97	1.3.6	ANCILLARY EQUIPMENT	$0.00
98	1.3.6.1	SAMPLE GONIOMETER	$0.00
99	1.3.6.2	TEMPERATURE CONTROLLERS	$0.00
100	1.3.6.3	PUMPING STATION	$0.00
101	1.3.6.4	VACUUM/PRESSURE GAUGES/SENSORS	$0.00
102	1.3.6.5	SAMPLE ENVIRONMENT	$0.00
103	1.3.6.5.1	HELIUM CRYOSTAT	$0.00
104	1.3.6.5.2	DISPLEX	$0.00
105	1.3.6.5.3	GAS HANDLING SYSTEM	$0.00
106	1.3.6.5.4	FURNACE	$0.00
107	1.3.6.6	INSTRUMENT CRANE	$0.00
108	1.3.7	BNL DETAILED DESIGN SUPPORT	$252,554.42



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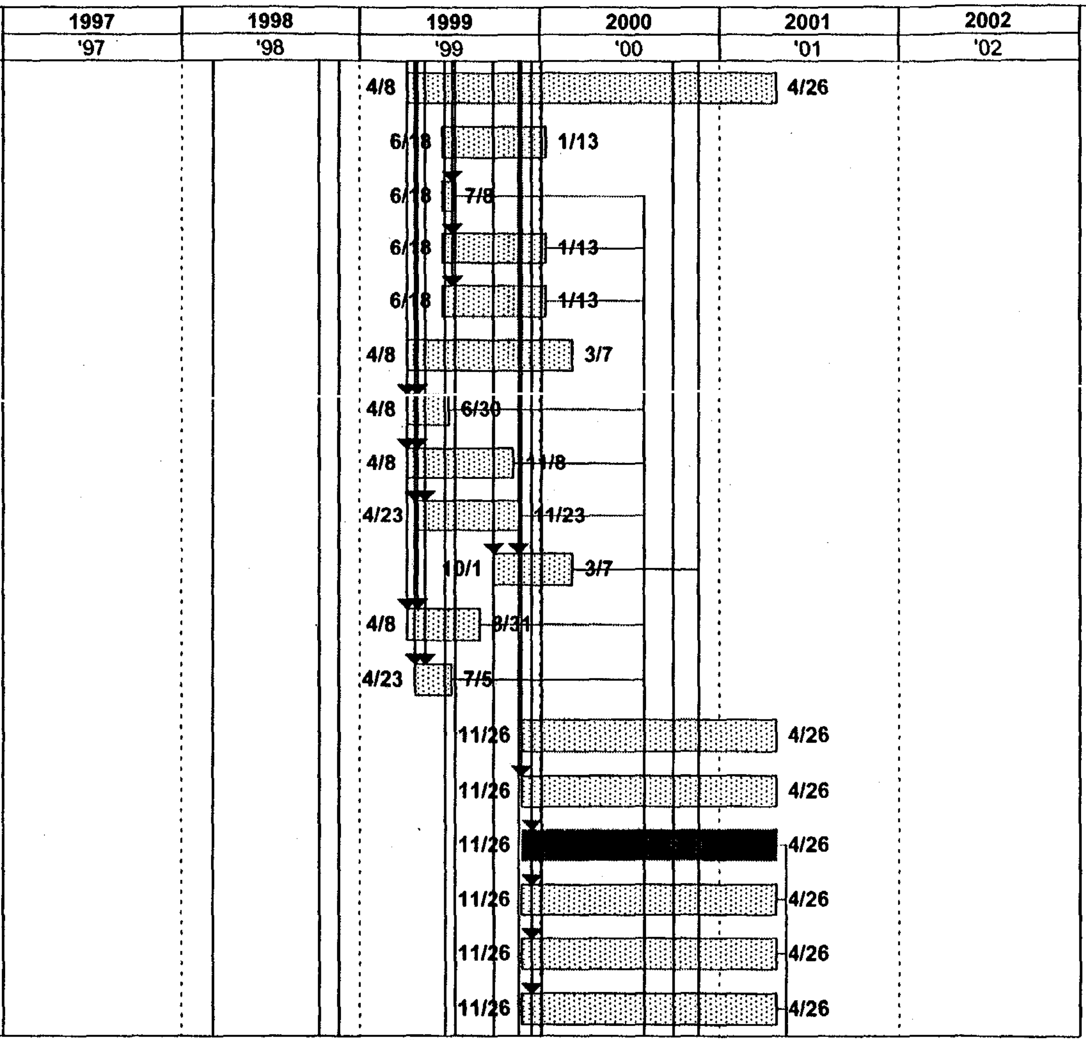
Task	▨	Milestone	★	Rolled Up Milestone	☆
Task Progress	■	Summary	▨	Rolled Up Progress	■
Critical Task	■	Rolled Up Task	▨		
Critical Task Progress	☐	Rolled Up Critical Task	■		

HERMES 1
PROPOSAL OPTION 3
DETAILED SCHEDULE: LEVEL 3

ID	WBS	Task Name	PROJECT COSTS
109	1.4	PROCUREMENT	$3,602,000.00
110	1.4.1	CHOPPER ASSEMBLIES (3): TO, FRAME	$142,500.00
111	1.4.1.1	CHOPPER WHEEL	$142,500.00
112	1.4.1.2	MOTOR SPEED CONTROL UNIT	$0.00
113	1.4.1.3	CHOPPER PLATFORM	$0.00
114	1.4.2	NEUTRON GUIDE SYSTEM	$1,607,100.00
115	1.4.2.1	SHUTTER	$0.00
116	1.4.2.2	SUPERMIRROR GUIDES	$924,000.00
117	1.4.2.3	VACUUM FLIGHT TUBES	$300,000.00
118	1.4.2.4	GUIDE SHIELDING (PRIMARY/SECONDARY)	$300,000.00
119	1.4.2.5	VACUUM PUMPS	$7,400.00
120	1.4.2.6	ALIGNMENT FIXTURES/STANCHIONS	$75,700.00
121	1.4.3	ANALYZER & DETECTOR SECTIONS	$933,900.00
122	1.4.3.1	ANALYZER SECTION	$635,200.00
123	1.4.3.1.1	GRAPHITE ANALYZER CRYSTALS	$300,000.00
124	1.4.3.1.2	MECHANICAL SUPPORTS	$58,600.00
125	1.4.3.1.3	FIXING MECHANISM	$12,300.00
126	1.4.3.1.4	IMPRESSED SHIELDING DISCS	$66,400.00



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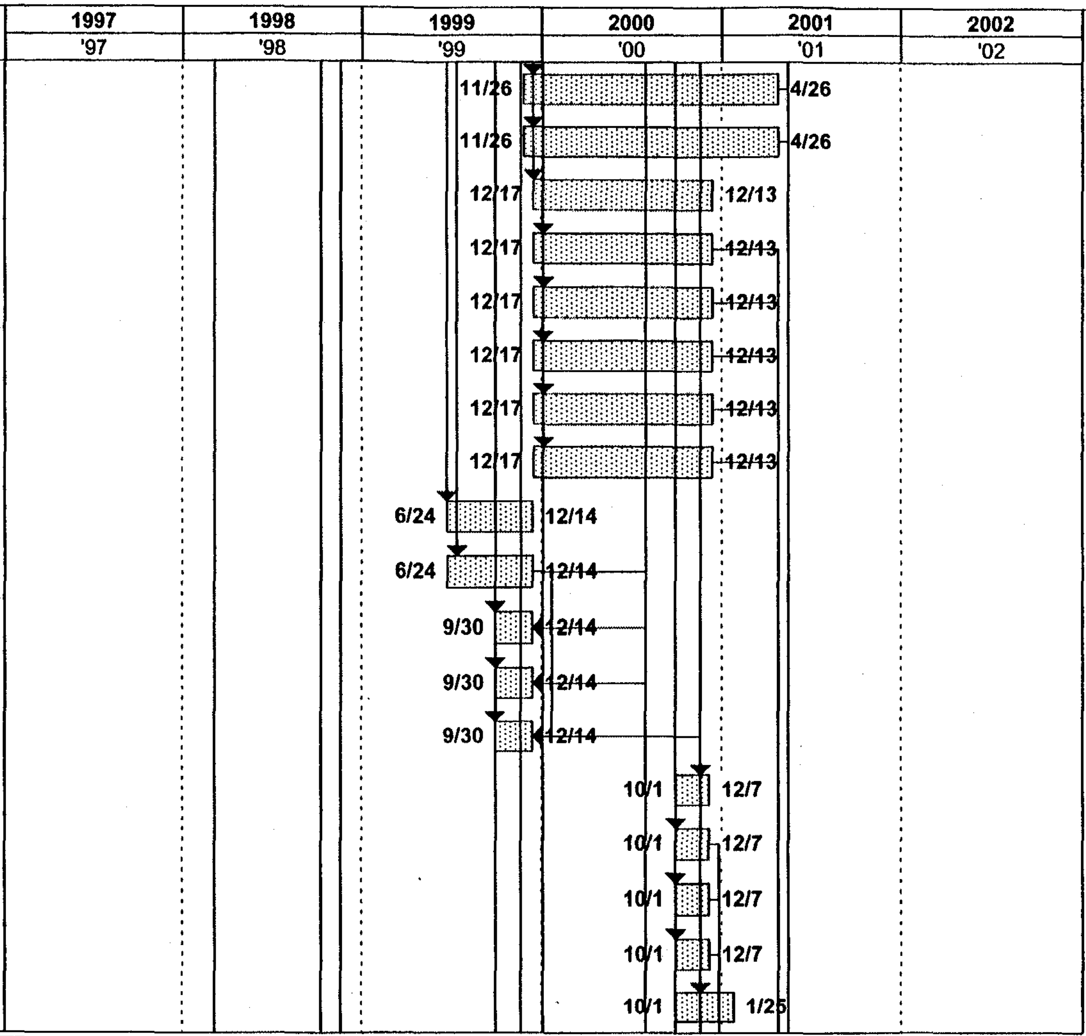
Task	▨	Milestone	★	Rolled Up Milestone	☆
Task Progress	■	Summary	▨	Rolled Up Progress	■
Critical Task	■	Rolled Up Task	▨		
Critical Task Progress	☐	Rolled Up Critical Task	■		

HERMES 1
PROPOSAL OPTION 3
DETAILED SCHEDULE: LEVEL 3

ID	WBS	Task Name	PROJECT COSTS
127	1.4.3.1.5	ALIGNMENT DEVICES	$67,400.00
128	1.4.3.1.6	CRYOGENICS/MAIN RESERVOIR	$130,500.00
129	1.4.3.2	DETECTOR SYSTEM	$298,700.00
130	1.4.3.2.1	He TUBES (120)	$189,200.00
131	1.4.3.2.2	ELECTRONIC CHANNELS	$58,400.00
132	1.4.3.2.3	CABLES	$9,700.00
133	1.4.3.2.4	MECHANICAL MOUNTS	$24,300.00
134	1.4.3.2.5	MOVABLE COLLIMATORS	$17,100.00
135	1.4.4	SPECTROMETER TANK ASSEMBLY	$444,900.00
136	1.4.4.1	ANALYZER TANK	$208,700.00
137	1.4.4.2	VACUUM PUMP/GAUGES, FRAMES/HOSES/VALVES	$54,400.00
138	1.4.4.3	BEAM STOP/DUMP PIPE/MONITOR	$39,300.00
139	1.4.4.4	INSTRUMENT SHIELD "HUTCH"	$142,500.00
140	1.4.5	SPECTROMETER CONTROL SYSTEM	$163,100.00
141	1.4.5.1	DATA ACQUISITION SYSTEM	$163,100.00
142	1.4.5.2	GRAPHICAL USER INTERFACE	$0.00
143	1.4.5.3	COMPUTER EQUIPMENT	$0.00
144	1.4.6	ANCILLARY EQUIPMENT	$273,200.00



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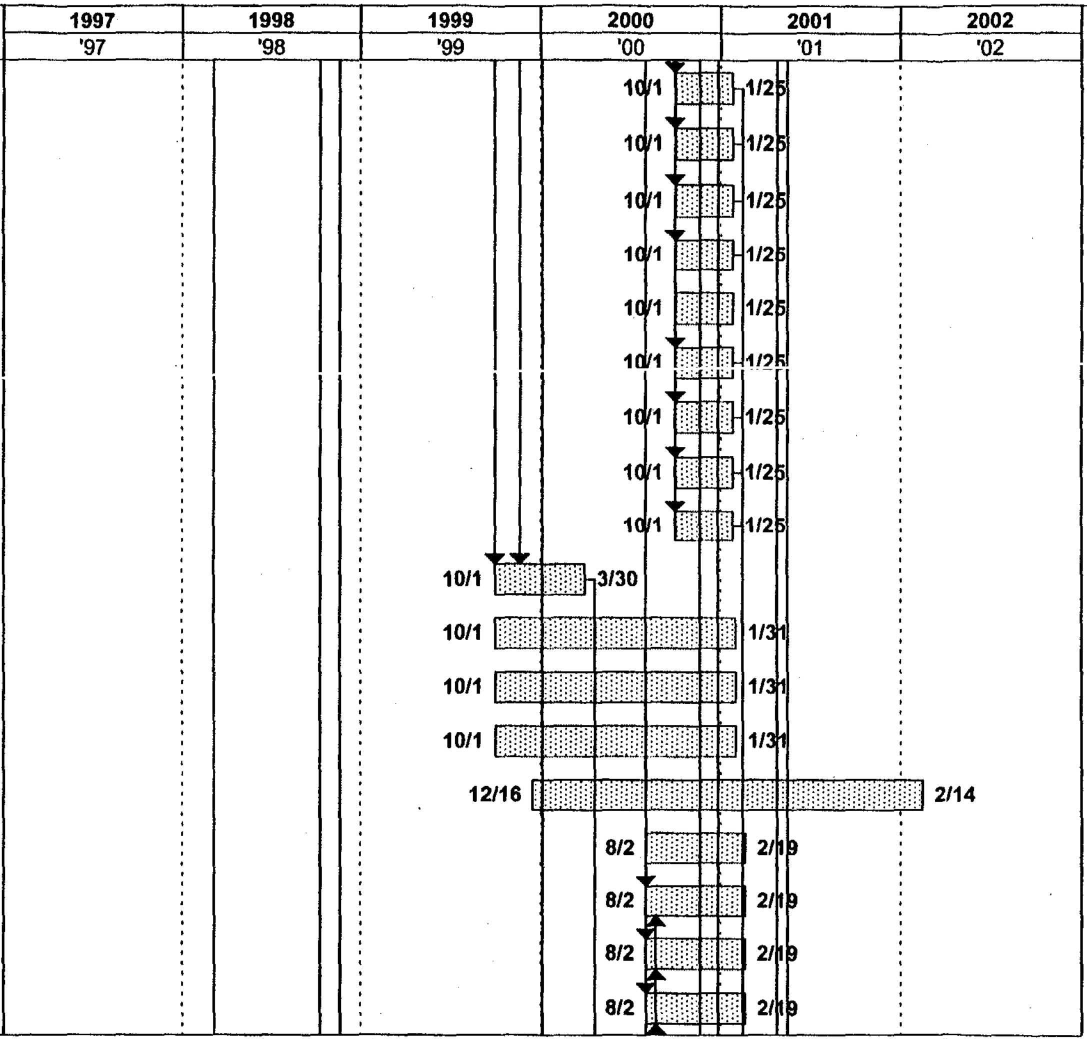
Task	▨	Milestone	★	Rolled Up Milestone	☆
Task Progress	■	Summary	▨	Rolled Up Progress	■
Critical Task	■	Rolled Up Task	▨		
Critical Task Progress	☐	Rolled Up Critical Task	■		

HERMES 1
PROPOSAL OPTION 3
DETAILED SCHEDULE: LEVEL 3

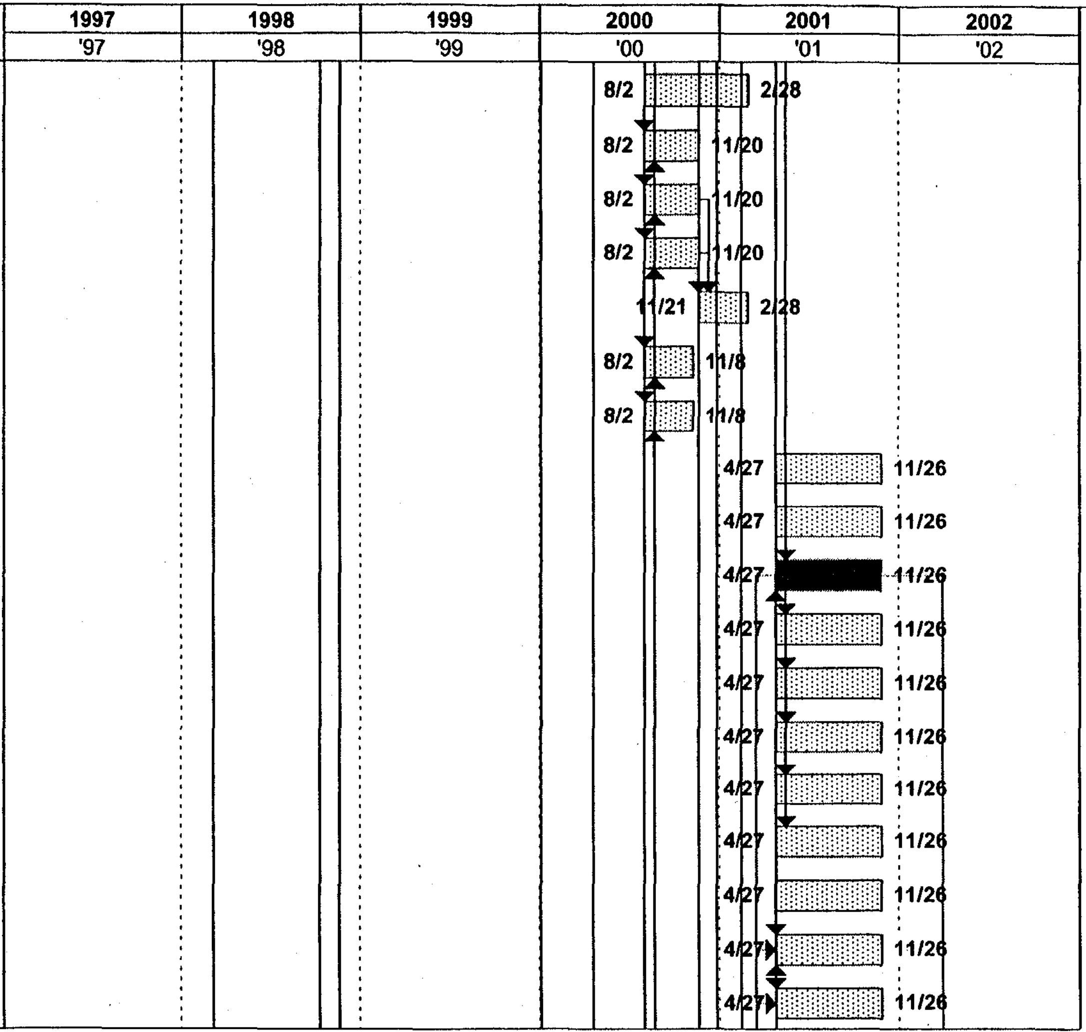
ID	WBS	Task Name	PROJECT COSTS
145	1.4.6.1	SAMPLE GONIOMETER	$54,400.00
146	1.4.6.2	TEMPERATURE CONTROLLERS	$7,100.00
147	1.4.6.3	PUMPING STATION	$21,400.00
148	1.4.6.4	VACUUM/PRESSURE GAUGES/SENSORS	$27,200.00
149	1.4.6.5	SAMPLE ENVIRONMENT	$163,100.00
150	1.4.6.5.1	HELIUM CRYOSTAT	$54,400.00
151	1.4.6.5.2	DISPLEX	$27,200.00
152	1.4.6.5.3	GAS HANDLING SYSTEM	$43,500.00
153	1.4.6.5.4	FURNACE	$38,000.00
154	1.4.7	INSTRUMENT CRANE	$37,300.00
155	1.5	INSTALLATION PREPARATIONS	$0.00
156	1.5.1	BNL:	$0.00
157	1.5.2	LANL:	$0.00
158	1.6	INSTALLATION: LANL	$738,135.87
159	1.6.1	CHOPPER ASSEMBLIES (3): TO, FRAME	$0.00
160	1.6.1.1	CHOPPER WHEEL	$0.00
161	1.6.1.2	MOTOR SPEED CONTROL UNIT	$0.00
162	1.6.1.3	CHOPPER PLATFORM	$0.00



Task ▨
Task Progress ■
Critical Task ■
Critical Task Progress ☐
Milestone ★
Summary ▨
Rolled Up Task ▨
Rolled Up Critical Task ■
Rolled Up Milestone ☆
Rolled Up Progress ■

HERMES 1
PROPOSAL OPTION 3
DETAILED SCHEDULE: LEVEL 3

ID	WBS	Task Name	PROJECT COSTS
163	1.6.2	NEUTRON GUIDE SYSTEM	$0.00
164	1.6.2.1	SHUTTER	$0.00
165	1.6.2.2	SUPERMIRROR GUIDES	$0.00
166	1.6.2.3	VACUUM FLIGHT TUBES	$0.00
167	1.6.2.4	GUIDE SHIELDING (PRIMARY/SECONDARY)	$0.00
168	1.6.2.5	VACUUM PUMPS	$0.00
169	1.6.2.6	ALIGNMENT FIXTURES/STANCHIONS	$0.00
170	1.6.3	ANALYZER & DETECTOR SECTIONS	$0.00
171	1.6.3.1	ANALYZER SECTION	$0.00
172	1.6.3.1.1	GRAPHITE ANALYZER CRYSTALS	$0.00
173	1.6.3.1.2	MECHANICAL SUPPORTS	$0.00
174	1.6.3.1.3	FIXING MECHANISM	$0.00
175	1.6.3.1.4	IMPRESSED SHIELDING DISCS	$0.00
176	1.6.3.1.5	ALIGNMENT DEVICES	$0.00
177	1.6.3.1.6	CRYOGENICS/MAIN RESERVOIR	$0.00
178	1.6.3.2	DETECTOR SECTION	$0.00
179	1.6.3.2.1	He TUBES (120)	$0.00
180	1.6.3.2.2	ELECTRONIC CHANNELS	$0.00



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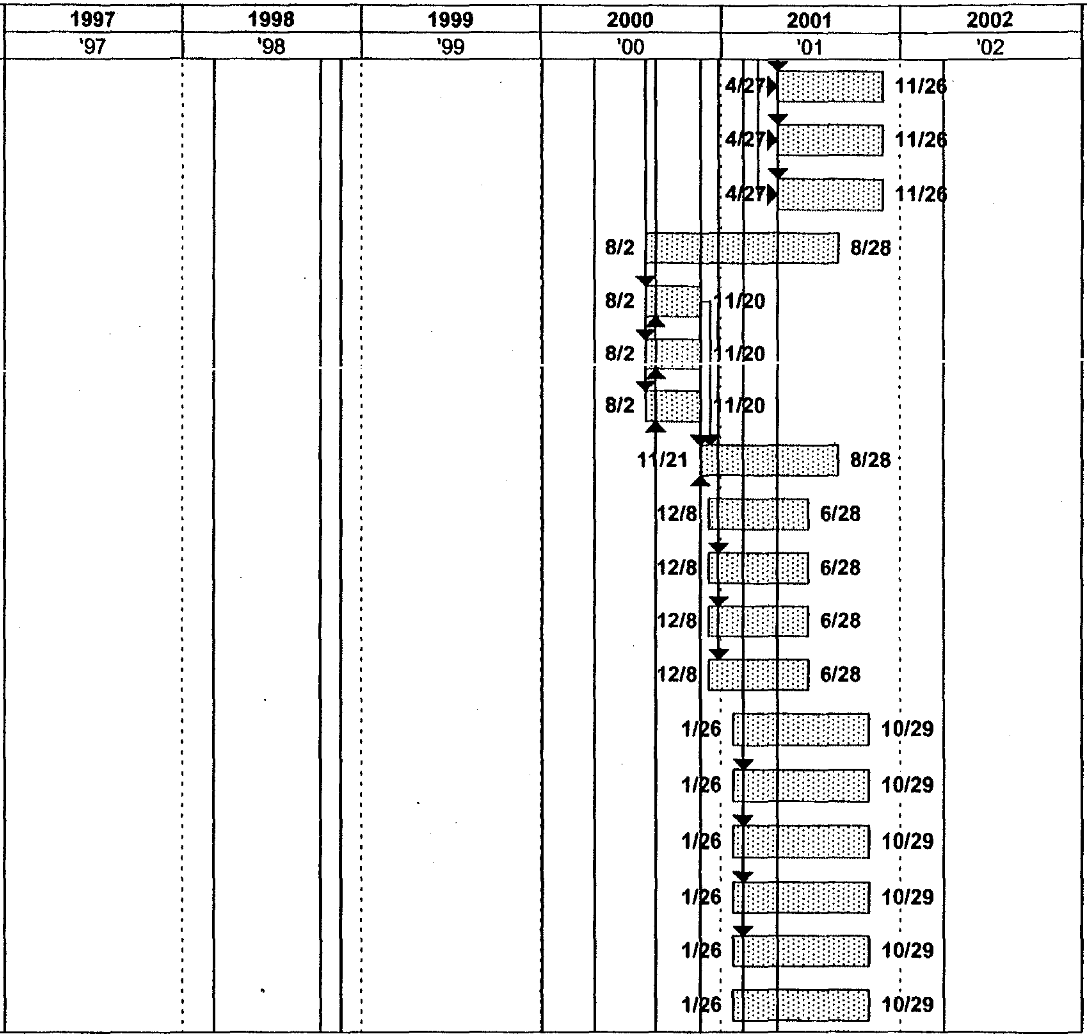
Task	▨	Milestone	★	Rolled Up Milestone	☆
Task Progress	■	Summary	▨	Rolled Up Progress	■
Critical Task	■	Rolled Up Task	▨		
Critical Task Progress	☐	Rolled Up Critical Task	■		

HERMES 1
PROPOSAL OPTION 3
DETAILED SCHEDULE: LEVEL 3

ID	WBS	Task Name	PROJECT COSTS
181	1.6.3.2.3	CABLES	$0.00
182	1.6.3.2.4	MECHANICAL MOUNTS	$0.00
183	1.6.3.2.5	MOVABLE COLLIMATORS	$0.00
184	1.6.4	SPECTROMETER TANK ASSEMBLY	$0.00
185	1.6.4.1	ANALYZER TANK	$0.00
186	1.6.4.2	VACUUM PUMP/GAUGES, FRAMES/HOSES/VALVES	$0.00
187	1.6.4.3	BEAM STOP/DUMP PIPE/MONITOR	$0.00
188	1.6.4.4	INSTRUMENT SHIELD "HUTCH"	$0.00
189	1.6.5	SPECTROMETER CONTROL SYSTEM	$0.00
190	1.6.5.1	DATA ACQUISITION SYSTEM	$0.00
191	1.6.5.2	GRAPHICAL USER INTERFACE	$0.00
192	1.6.5.3	COMPUTER EQUIPMENT	$0.00
193	1.6.6	ANCILLARY EQUIPMENT	$0.00
194	1.6.6.1	SAMPLE GONIOMETER	$0.00
195	1.6.6.2	TEMPERATURE CONTROLLERS	$0.00
196	1.6.6.3	PUMPING STATION	$0.00
197	1.6.6.4	VACUUM/PRESSURE GAUGES/SENSORS	$0.00
198	1.6.6.5	SAMPLE ENVIRONMENT	$0.00



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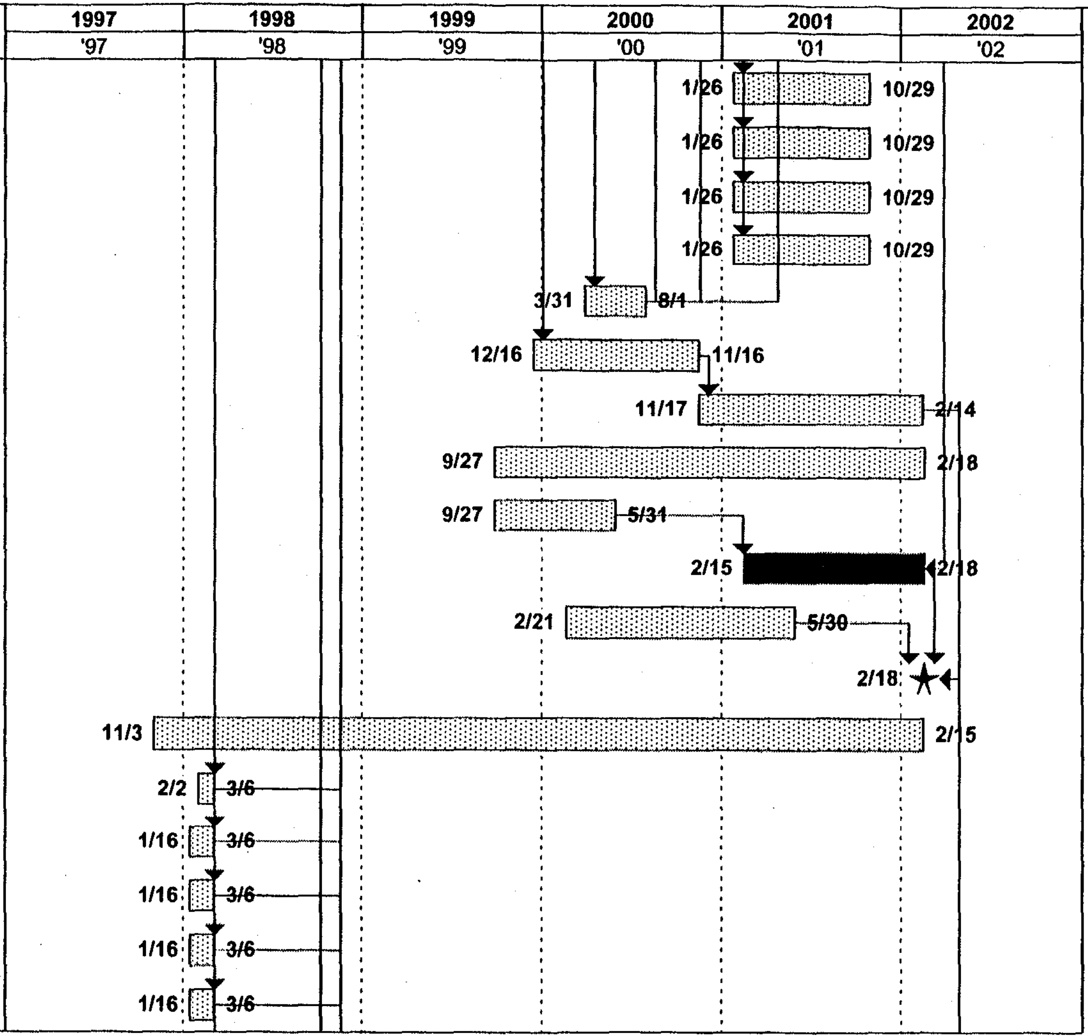
Task	▨	Milestone	★	Rolled Up Milestone	☆
Task Progress	■	Summary	▨	Rolled Up Progress	■
Critical Task	■	Rolled Up Task	▨		
Critical Task Progress	□	Rolled Up Critical Task	■		

HERMES 1
PROPOSAL OPTION 3
DETAILED SCHEDULE: LEVEL 3

ID	WBS	Task Name	PROJECT COSTS
199	1.6.6.5.1	HELIUM CRYOSTAT	$0.00
200	1.6.6.5.2	DISPLEX	$0.00
201	1.6.6.5.3	GAS HANDLING SYSTEM	$0.00
202	1.6.6.5.4	FURNACE	$0.00
203	1.6.7	INSTRUMENT CRANE	$0.00
204	1.6.8	BNLTECH STAFF SUPPORT	$315,042.12
205	1.6.9	BNL STAFF INSTALLATION/TESTING	$423,093.75
206	1.7	TESTING/TRAINING PROGRAM	$0.00
207	1.7.1	DEVELOP START-UP & TEST PLAN	$0.00
208	1.7.2	START-UP/TEST/READINESS ASSESSMENT	$0.00
209	1.7.3	TRAINING PROGRAM	$0.00
210	1.8	HERMES OPERATIONAL	$0.00
211	1.9	PROJECT MANAGEMENT	$893,734.61
212	1.9.1	ESTABLISH LANL/BNL INTERFACES	$0.00
213	1.9.2	LEVEL 2 COST & SCHEDULE	$0.00
214	1.9.3	FINALIZE DETAILED PROCUREMENT STRATEGY	$0.00
215	1.9.4	QUALITY ASSURANCE PLAN	$0.00
216	1.9.5	ES&H PLAN	$0.00



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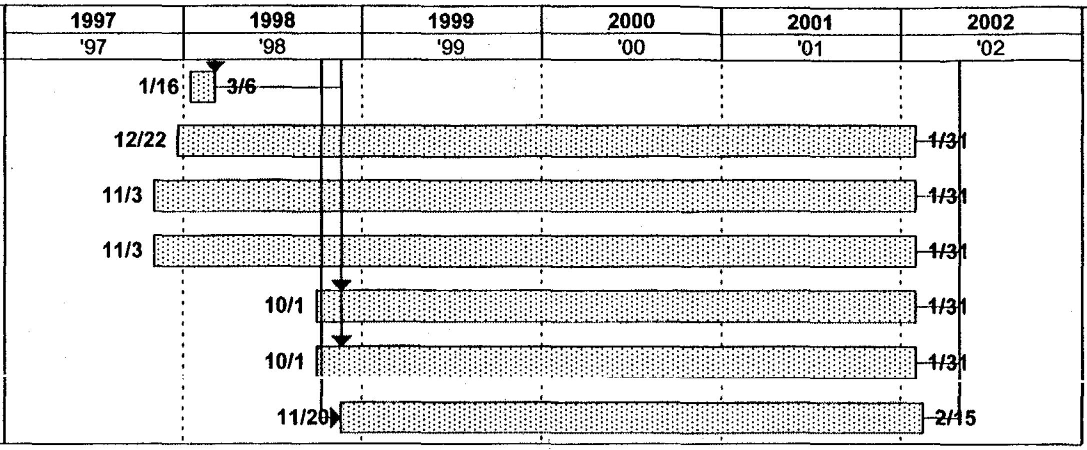
Task	▨	Milestone	★	Rolled Up Milestone	☆
Task Progress	■	Summary	▨	Rolled Up Progress	■
Critical Task	■	Rolled Up Task	▨		
Critical Task Progress	☐	Rolled Up Critical Task	■		

HERMES 1
PROPOSAL OPTION 3
DETAILED SCHEDULE: LEVEL 3

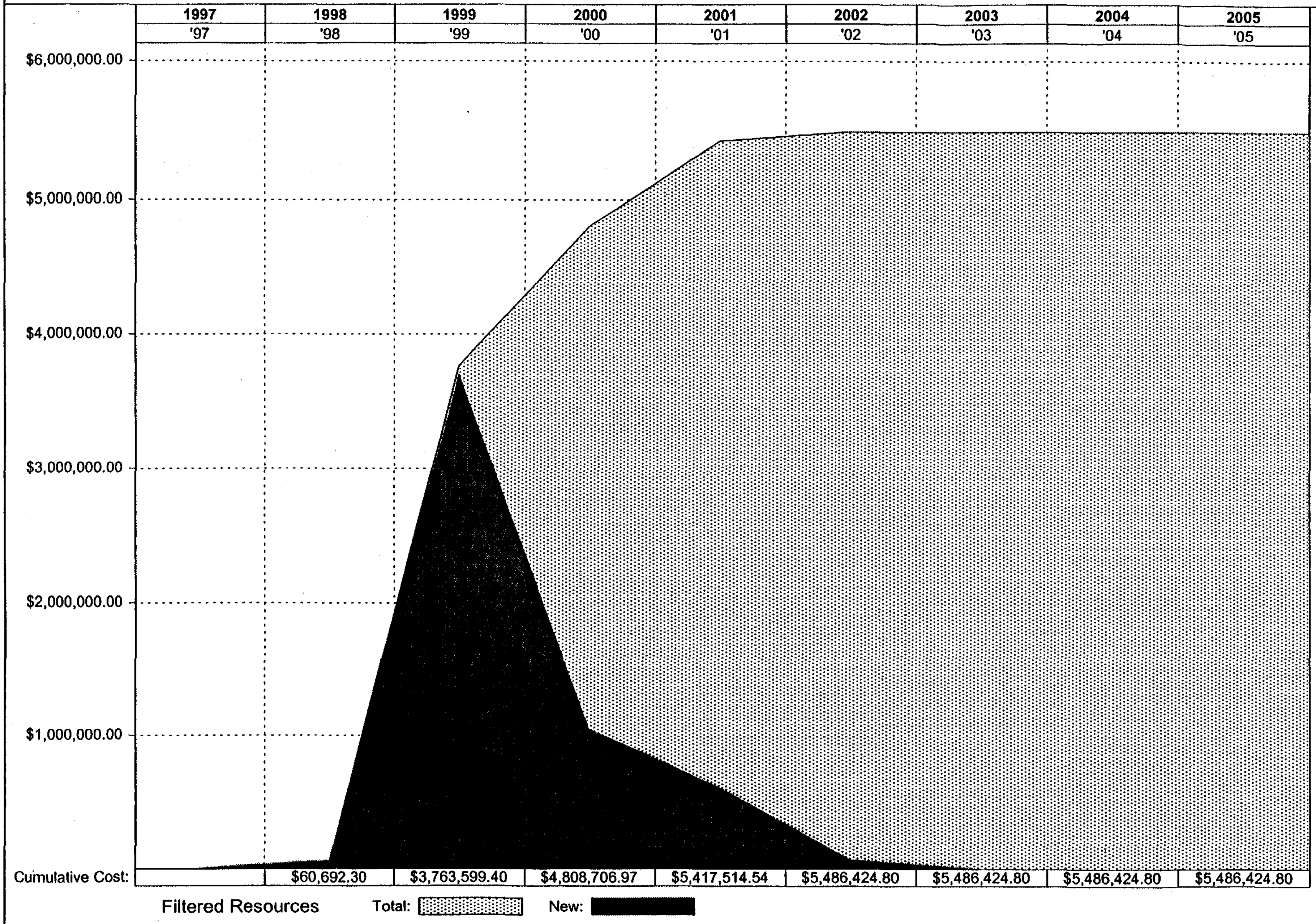
ID	WBS	Task Name	PROJECT COSTS
217	1.9.6	PREP/ISSUE PROJECT EXECUTION PLAN	$0.00
218	1.9.7	MONTHLY PROGRESS STATUS/REPORTS:	$0.00
219	1.9.8	QUARTERLY REVIEW	$0.00
220	1.9.9	BASELINE CHANGE MANAGEMENT	$0.00
221	1.9.10	BNL PROJECT MANAGEMENT STAFF (INCLUDING LANL	$721,076.92
222	1.9.11	BNL NEUTRON TECHNICIANS	$0.00
223	1.9.12	BNL TRAVEL	$172,657.69



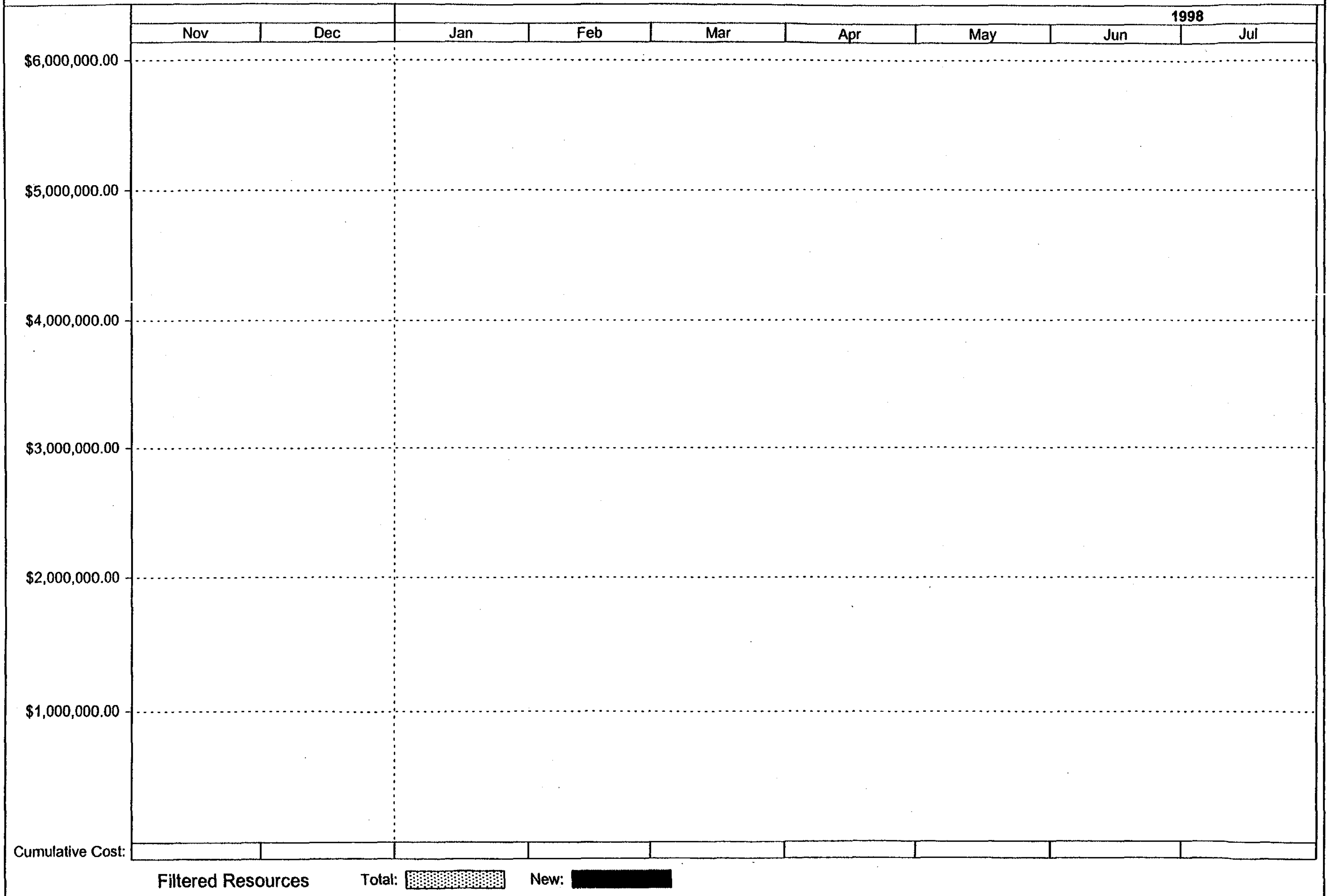
Project: HERMES I
Date: Sun 6/9/159

Task	▨	Milestone	★	Rolled Up Milestone	☆
Task Progress	■	Summary	▨	Rolled Up Progress	■
Critical Task	■	Rolled Up Task	▨		
Critical Task Progress	☐	Rolled Up Critical Task	■		

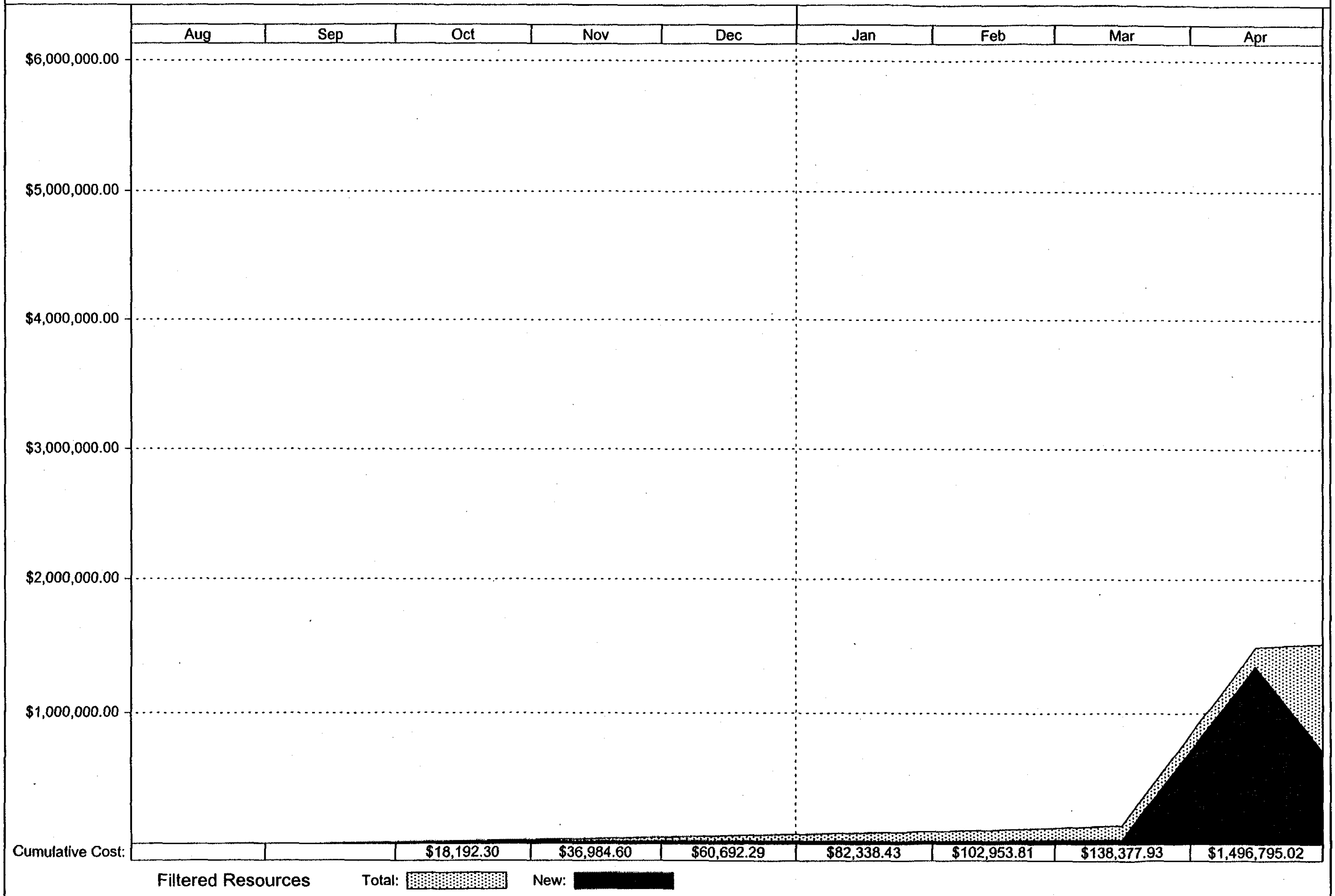
HERMES 1
PROPOSAL OPTION 3
COST CURVE



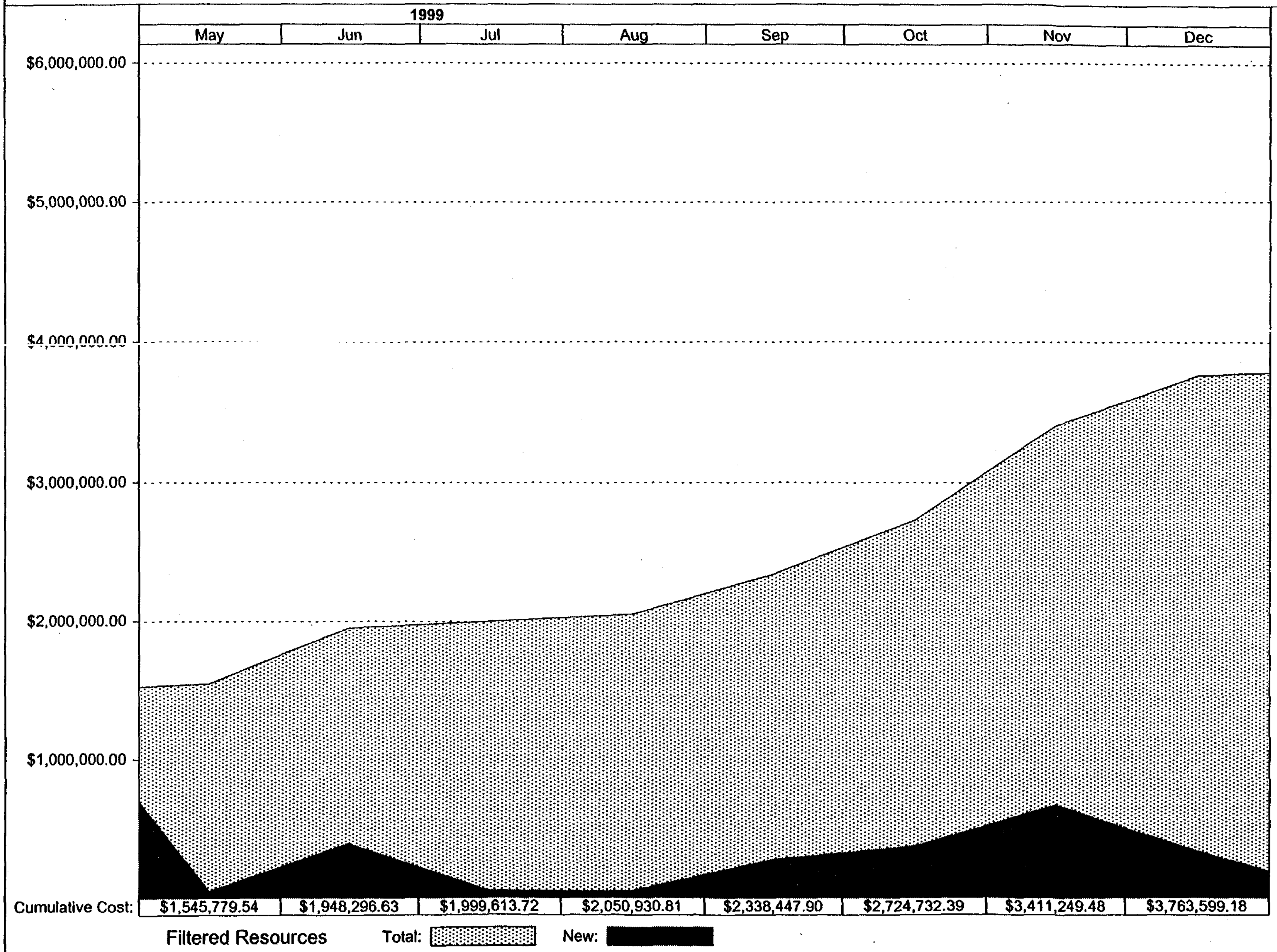
HERMES 1
PROPOSAL OPTION 3
COST CURVE



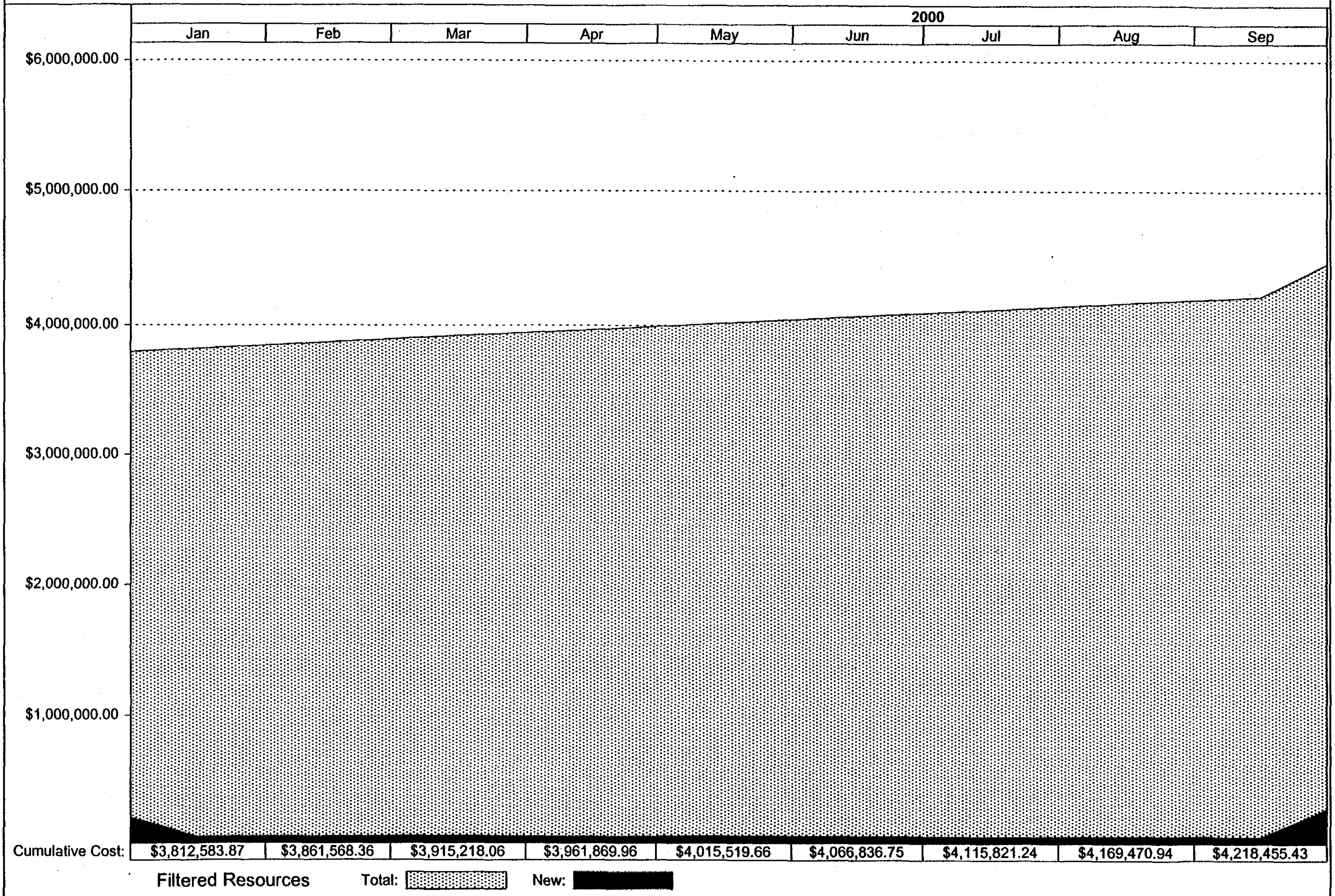
HERMES 1
PROPOSAL OPTION 3
COST CURVE



HERMES 1
PROPOSAL OPTION 3
COST CURVE

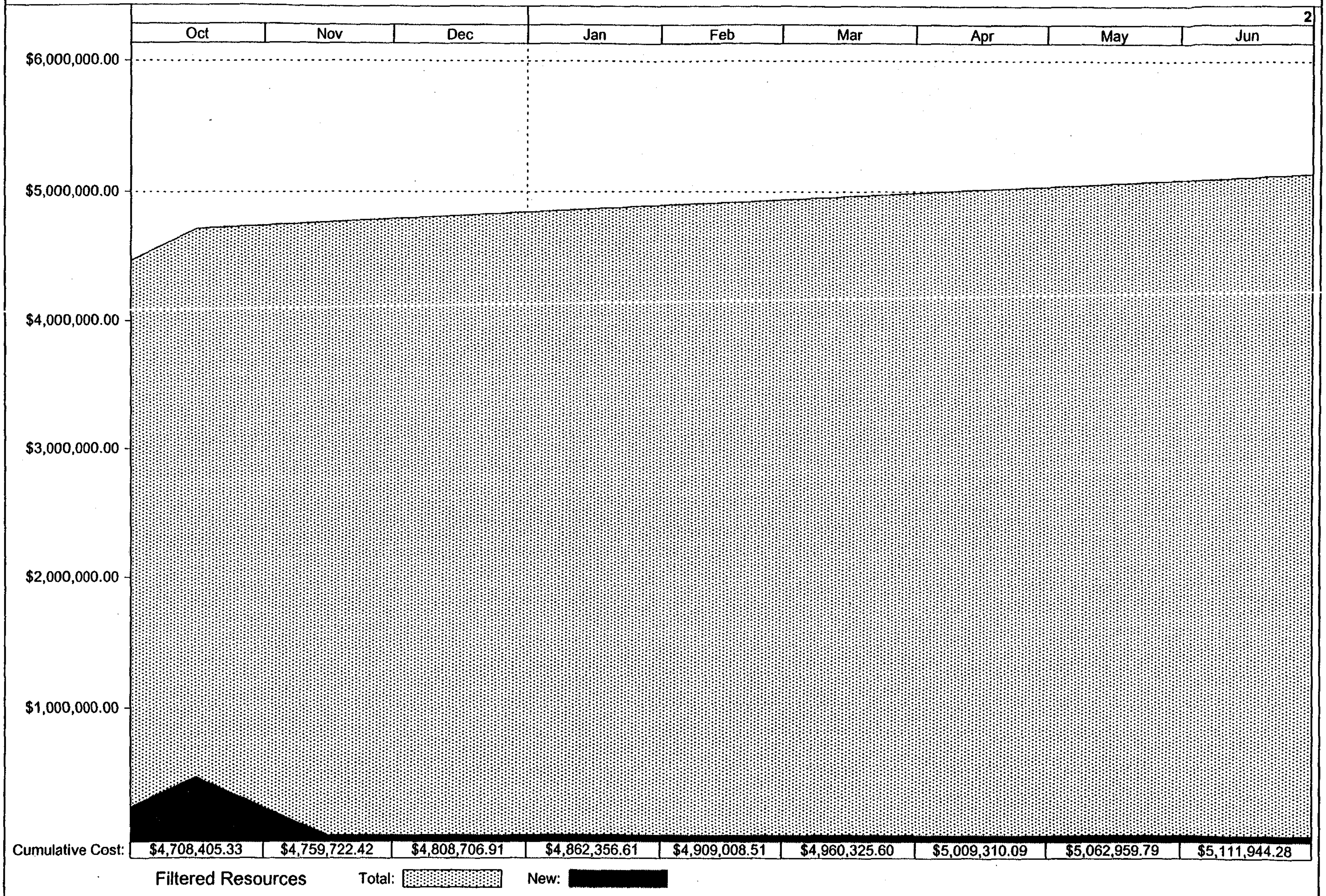


H[illegible]ES 1
PROPOSAL OPTION 3
COST CURVE



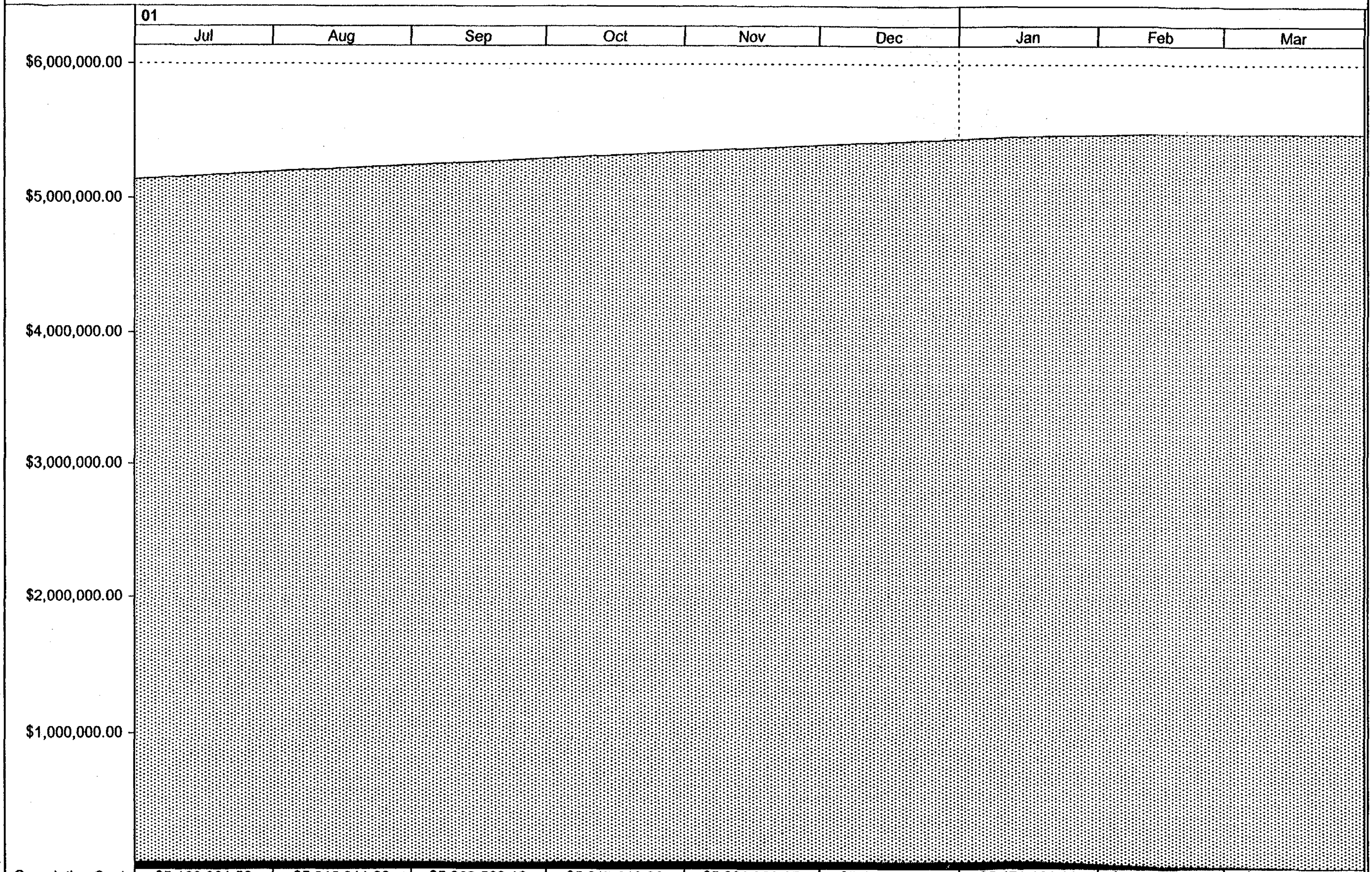
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Cumulative Cost:	$3,812,583.87	$3,861,568.36	$3,915,218.06	$3,961,869.96	$4,015,519.66	$4,066,836.75	$4,115,821.24	$4,169,470.94	$4,218,455.43

HERMES 1
PROPOSAL OPTION 3
COST CURVE



	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun
Cumulative Cost:	$4,708,405.33	$4,759,722.42	$4,808,706.91	$4,862,356.61	$4,909,008.51	$4,960,325.60	$5,009,310.09	$5,062,959.79	$5,111,944.28

HERMES 1
PROPOSAL OPTION 3
COST CURVE



	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar
Cumulative Cost:	$5,163,261.56	$5,216,911.26	$5,263,563.16	$5,317,212.86	$5,368,529.95	$5,417,514.44	$5,471,164.14	$5,486,424.70	$5,486,424.70

Filtered Resources Total: ▨ New: ■