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ARGONNE NATIONAL LABORATORY
9700 South Cass Avenue
Argonne, Illinois 60439

ANL/APS/CP-6

PROCEEDINGS OF THE SIXTH USERS MEETING FOR THE ADVANCED PHOTON SOURCE

Held at Argonne National Laboratory
May 25-26, 1994

December 1994

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U.S. DEPARTMENT OF ENERGY
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FOREWORD

Despite a downpour minutes before it began, the tour of the Advanced Photon Source (APS) facility was the undisputed highlight of the Fifth Users Meeting for the APS, held on October 14-15, 1992. More than 320 prospective users attended the two-day conference at Argonne National Laboratory (ANL), which was sponsored by the Advanced Photon Source, the ANL Division of Educational Programs, and The University of Chicago Board of Governors for Argonne National Laboratory.

The participants came to hear about construction and R&D progress, talk with representatives of major funding agencies, visit vendor displays, listen to scientific presentations, and, above all, walk the APS site to gain a sense of perspective and share the excitement of APS staff members at a point midway in APS construction. At the APSUO business meeting, six new members were elected to the APSUO Steering Committee. The current membership of the Steering Committee is shown below:

APSUO Steering Committee

Roy Clarke, *Chair* (Univ. of Michigan)
Alan Goldman, *Vice Chair* (Iowa State Univ./Ames Lab.)

Michael Bedzyk (ANL/MSD; Northwestern)
George Brown (Univ. of Calif., Santa Cruz)
Philip Coppens (SUNY, Buffalo)
Kevin D'Amico (X-ray Analytics)
John Faber, Jr. (Amoco Res. Center)
Gene Ice (ORNL)
William Orme-Johnson (MIT)
Mark Rivers (The Univ. of Chicago/CARS)
Ian Robinson (Univ. of Illinois at Urbana-Champaign
Heinz Robota (Allied Signal Res. and Technol)
Albert Thompson (LBL)

Bob Batterman, *ex officio* (CHESS)
Arthur Bienenstock, *ex officio* (SSRL)
Brian Kincaid, *ex officio* (ALS)
Denis McWhan, *ex officio* (NSLS)

Stephen Durbin, Past Chair, *ex officio* (Purdue Univ.)

Program Committee for the Sixth Users Meeting

Alan Goldman (Chair)
Michael Bedzyk
Ian Robinson
Al Thompson

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Proceedings of the Sixth Users Meeting for the Advanced Photon Source

ABSTRACT

The Sixth Users Meeting for the Advanced Photon Source (APS) was held on May 25-26, 1994, at Argonne National Laboratory. Scientists and engineers from universities, industry, and national laboratories came to review the status of the facility and to look ahead to the types of forefront science that will be possible when the APS is completed. The presentations at the meeting included an overview of the project, advances in synchrotron radiation applications, and technical developments at the APS. In addition, there was a graduate student/postdoctoral poster session, various demonstrations and displays, several vendors displaying their wares, a tour of the APS Experiment Hall and three follow-up workshops: Coherent X-ray Scattering, Microfocusing Technology and Applications, and CAT Optics. The actions taken at the 1994 Business Meeting of the Advanced Photon Source Users Organization are also documented.

WELCOMING REMARKS

Alan Schriesheim
Director, Argonne National Laboratory

It is a pleasure to see this group. I have watched the construction of this project with some considerable interest and amazement, beginning with the leveling of the field, examining all the arrowheads and Indian burial grounds, and chasing off the Canada geese. It has been a remarkable sight to see the actual facility being erected. Those of you who have had some limited contact with what it takes to actually build something in the current era have some idea of the pleasure that one gets when you run an institution such as this and see that this nation can actually build something and not only pass pieces of paper back and forth.

So it is with some considerable pleasure that I welcome this group today, and it is with some considerable interest that I look forward to a meeting that we will have in the new facility and the new auditorium. That will really be a remarkable achievement, an asset for this laboratory, an asset for the region, an asset for the nation, and, of course, an asset for the technical world.

I will say that the nation has decided that this particular project is a project that is on the A list. I wander around Washington, and I have not found anyone who I consider to be a person of good judgment who has not evinced strong support for this project. Again, those of you who wander around Washington in this year know that that is really an achievement in itself because people are looking every place for a dollar to transfer to someone else. We generally find people who are more than willing to look for dollars to support this activity. I continue to look forward to that occurring.

It is with great pleasure that the laboratory is involved in this. We are particularly fortunate in this state to have a Congressional delegation whom I can call on the phone and who will actually answer my phone calls and who are exceptionally supportive and active and involved, and a regional delegation who are the same.

While I have the opportunity, I want to commend the Department of Energy for its foresight in getting involved in these synchrotron projects, and I especially wanted to commend the Department of Energy for its continuing good managerial involvement. It has been a pleasure to work with the Department on this project. Finally before I leave I will express the obvious. We wouldn't be where we are today without exceptional leadership in terms of the facility construction and the development of the Users programs, and that is due to the really remarkable foresight of the managerial and technical teams that Dave [Moncton] has assembled. In addition, you folks also show good judgment in being involved in this project and so I commend you also.

Status Report on the Advanced Photon Source — Spring 1994

by

David E. Moncton

Associate Laboratory Director for the Advanced Photon Source
Argonne National Laboratory, 9700 South Cass Avenue, Argonne, IL 60439 U.S.A.

1. Opening Remarks

The photograph in Figure 1 was taken exactly four years ago today. It shows an undisturbed, 79-acre site at Argonne. All that you see in the next photograph (Fig. 2) has been constructed on that site in the last four years.

Our goal in designing and constructing the Advanced Photon Source (APS) has always been to provide a facility which, to the greatest extent possible, maximizes the user's time here. That philosophy has, we feel, been manifested in the buildings and technical components alike.

Fig. 1. The APS site on May 25, 1990.

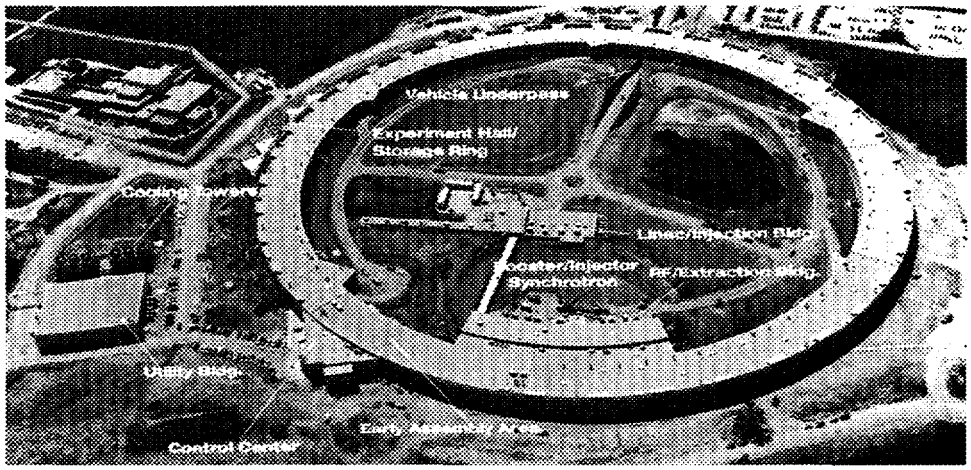

Fig. 2. The APS site on May 12, 1994.

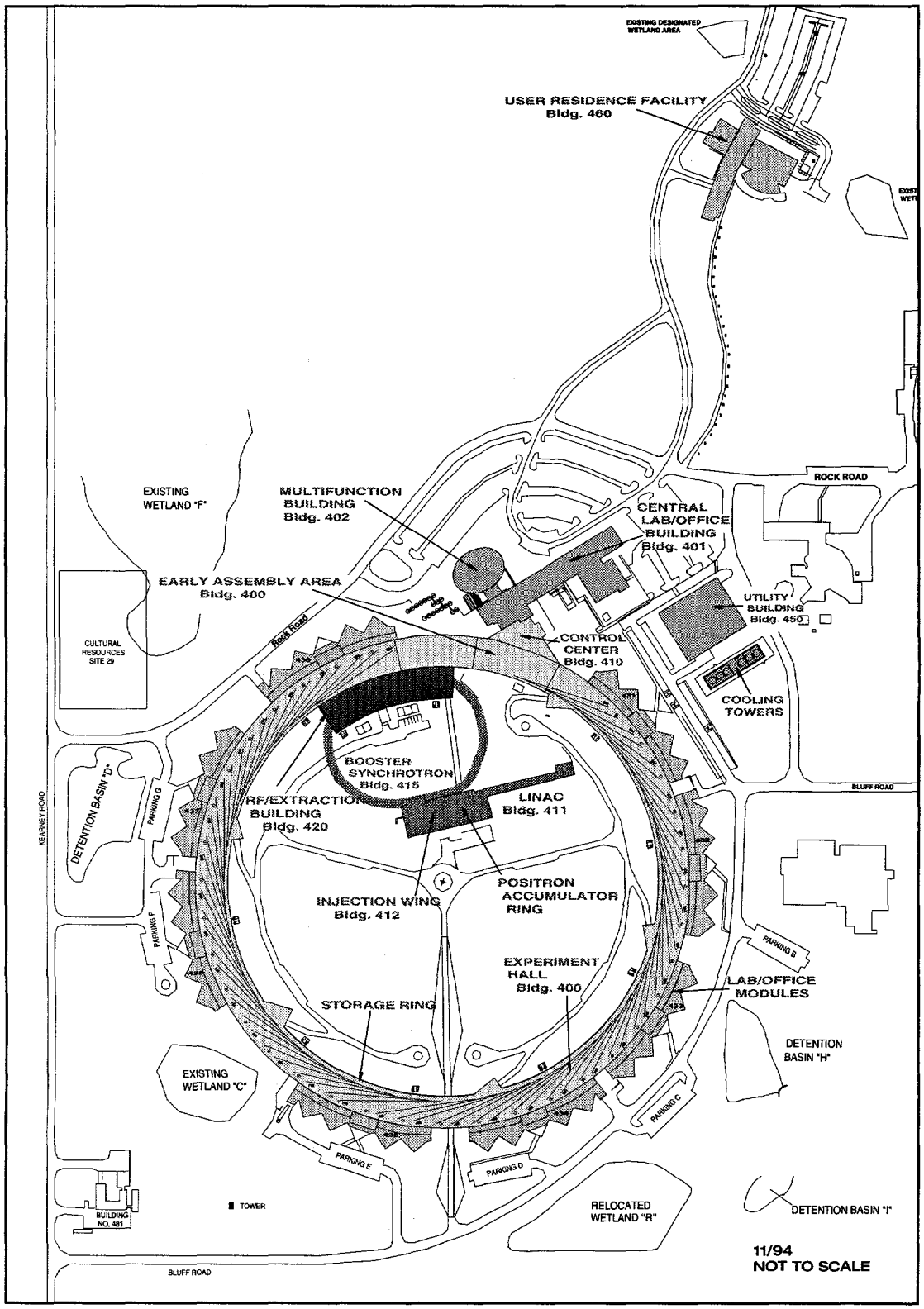

Fig. 3. Plan view of the Advanced Photon Source.

Fig. 4. Interior of the APS experiment hall.

2. Facility Construction

2.1 Conventional Facilities

One result of that philosophy has been our awareness of the need to provide adequate conventional facilities in support of the experimental program. We wanted the user lab/office modules (LOM) to be as efficient as possible. For instance, they are located in close proximity to the experiment hall (Fig. 3). They have space for shop facilities. A number of truck locks have been designed into the facility so that users can bring equipment conveniently to their beamline without leaving a door open to the weather. The first and second LOMs are under construction at this moment. They are scheduled for completion by October of this year. The next two LOMs (of a planned eight) are scheduled for occupancy in December of 1994. We have also issued a notice to proceed on the fifth module, which should be available in 1995. Construction of the remaining three LOMs will be decided based on availability of contingency funds and scientific imperatives. The fifth module is one more than was called for in the original project scope. It is being constructed at no increase in the project total estimated cost.

The experiment hall (Fig. 4) has been designed to be stable and quiet. We worked hard to reduce the noise in the experiment hall. We believe it will be a pleasant place to work, where one be will be able to hear a colleague from two feet away without shouting. The HVAC system is designed so that the zones match the topology of each sector, providing some control over the distribution of the air in each sector to offset any beamline hot spots created by equipment. Suffice it to say that the buildings are meeting all of our objectives, and we are proud of our Conventional Facilities Group for achieving that goal and doing so on schedule.

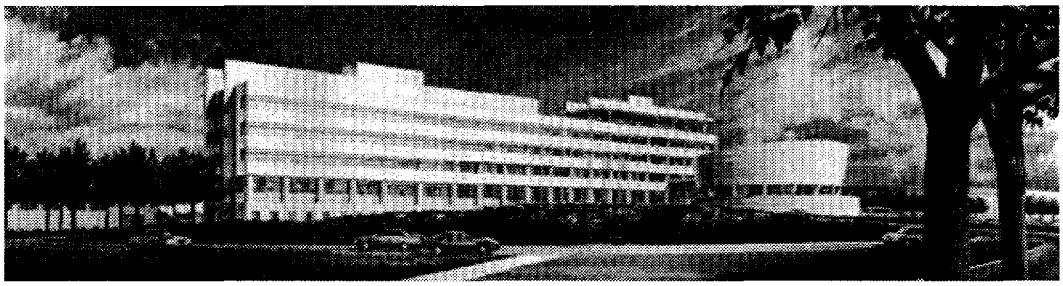

Fig. 5. Artist's rendering of the APS central laboratory/office building.

2.2 Central Laboratory/Office Building

A 170,000-sq-ft central laboratory/office building (CLO), which will be located adjacent to the experiment hall, is scheduled for completion in September of 1995. The CLO (Fig. 5) will have a 550-seat flexible meeting facility, offices for APS staff and long-term visitors, and a number of amenities for users, including various conference rooms and and 44 laboratories, each 500-sq ft, located in a 4-story wing.

2.3 User Residence Facility

Detailed design for a user residence facility (URF) is on-going. The URF (Fig. 6) is being completely funded by the State of Illinois in what we think is a remarkable commitment. Illinois Governor Jim Edgar came to Argonne recently and presented a check in the amount of $1.5 M for design of the URF. We plan to finish the design by midsummer, at which point we hope to have received the balance of the State appropriation in the amount of $17.4 M for construction. We're very grateful to the State of Illinois for following through on a promise made several years ago by a previous administration.

The multistory, 140,000-sq-ft URF is to have a capacity of 240 beds — 160 in single, hotel-type rooms, and an additional 80 beds in 24 quad units. The URF is designed to operate like a hotel, with staff present 24 hours a day. Users can check in or check out and interact with the staff at any time. The URF will have a dining facility to provide dinner for 200 people at a seating, a meeting room, a user lounge, and various support facilities including a laundry. An innovative

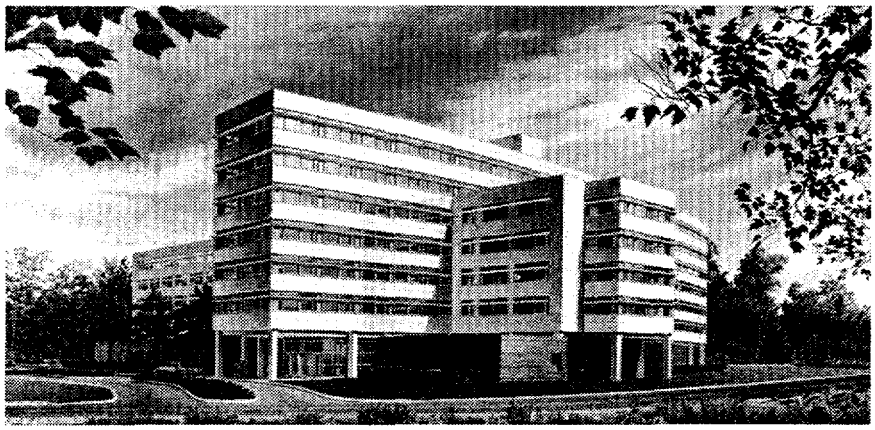

Fig. 6. Artist's rendering of the APS user residence facility.

consideration is the network of fiber-optic data links that will connect work stations in every room to the residents' experiments, allowing residents to monitor their experiments at any time.

In developing the rate structure for the URF, we have decided to run the facility on a full cost recovery basis. We believe that will be possible because the building is being funded by the State of Illinois. Since we will have no mortgage, we expect to use the resulting financial flexibility to provide a discounted room rate for students. If you can think of anything else that might make this building user friendly, please let us know.

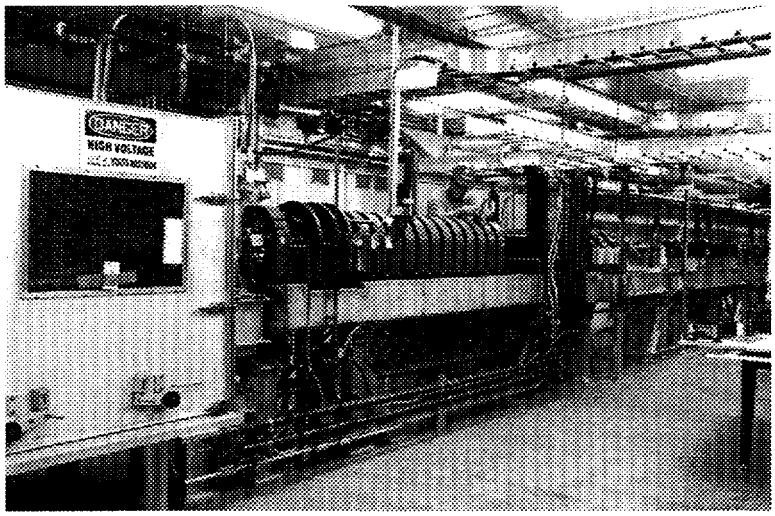

Fig. 7. The APS electron gun and electron linac.

3. Accelerator Systems

3.1 Accelerator Commissioning

The first electron beam at the APS was accelerated in October of 1993. The electron linac (Fig. 7) is now operating at the design energy of 200 MeV and is performing very well. All modulators and accelerating sections in the positron linac (Fig. 8) are operating. This segment of the linac has been used to accelerate electrons (we are not yet producing positrons) to energies near 400 MeV for injection into the positron accumulator ring (PAR). We hope to produce and accelerate positrons in late summer or early fall of this year. Meanwhile, we are commissioning the rest of the booster complex with electrons. PAR commissioning with electrons began in February (Fig. 9). We achieved a few turns of stored beam in April and, in fact, injected into the booster (Fig. 10) and achieved one turn. So we can now say that particles have traveled through the entire injection system. We haven't done any significant synchrotron commissioning at this point, other than running some of the subsystems and working on the controls and diagnostics, which are functioning extremely well.

As for the storage ring, it is approximately 60% installed. By the end of last week, 115 out of 200 girders were in place in the tunnel (Fig. 11). One can enter the storage ring tunnel and walk

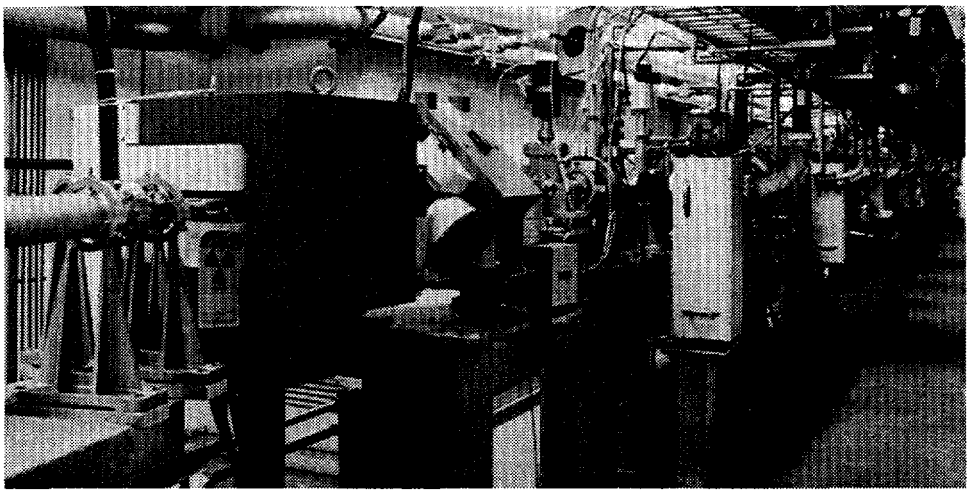

Fig. 8. Looking upstream along the APS positron linac.

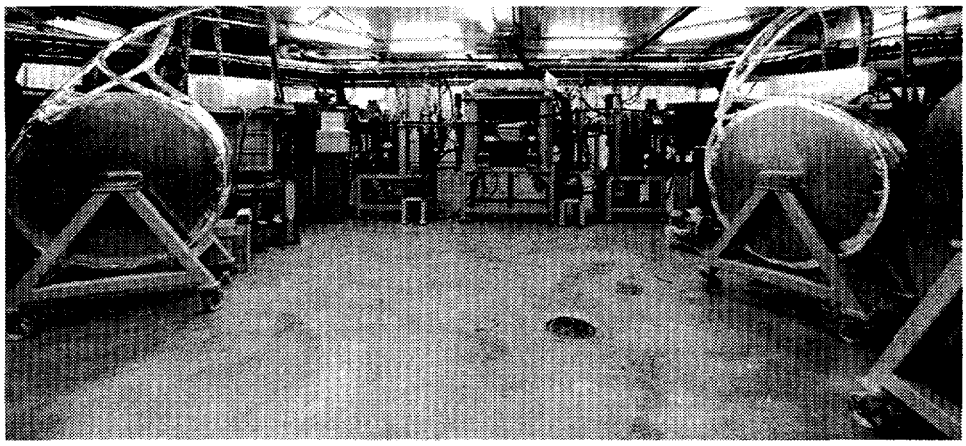

Fig. 9. The APS positron accumulator ring.

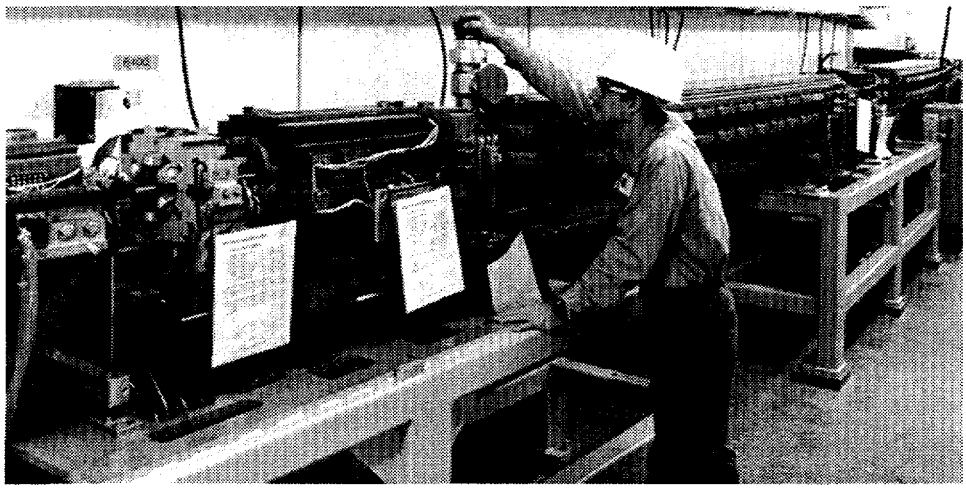

Fig. 10. The APS booster synchrotron.

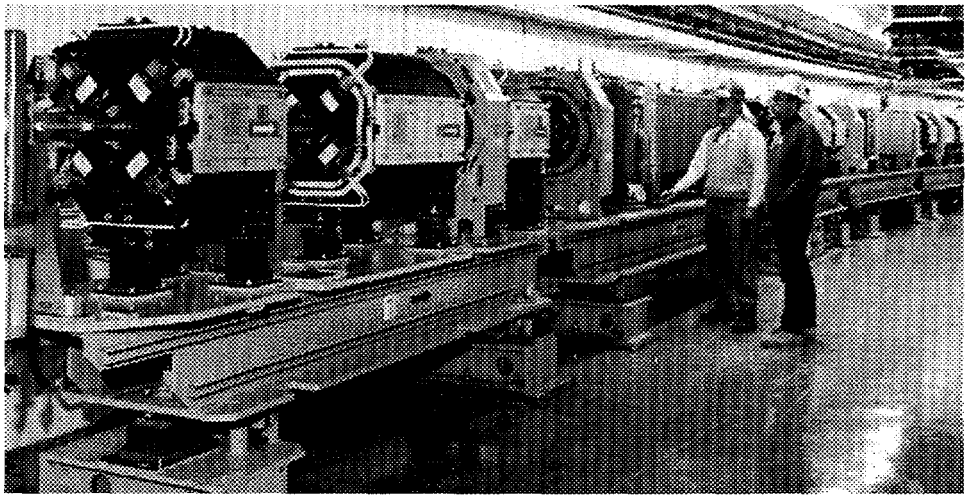

Fig. 11. One sector of installed APS storage ring girders.

for quite a distance past seemingly endless sections of storage-ring girders. That is a source of great pleasure for all of us. We are anticipating completion of storage-ring girder installation in September of this year, followed by various other activities directed at completing the storage ring by mid to late November. That schedule should allow us to meet the January 1, 1995, start-of-commissioning milestone. I'm very pleased that the Accelerator Systems Division has not flinched from the challenge of getting this complex machine into that tunnel on that time scale and beginning commissioning. If you encounter someone from the Accelerator Systems Division during this meeting, you might want to congratulate them on their success so far.

3.2 Control System Software

In addition to a great deal of work on hardware, there has also been extensive effort directed at software development. One result has been our codevelopment (with Los Alamos National Laboratory) of the EPICS (or Experimental Physics and Industrial Control System) software. This high-performance, distributed run-time environment for data acquisition and control has proven to be a great success. EPICS is being used to run all of our accelerators and beamlines. It is designed for ease of use and has been adopted by a number of other accelerator laboratories. When Governor Edgar visited us to deliver the $1.5 M for the URF, we took advantage of his presence to help debug the EPICS system. We invited the Governor to push a button that sent a signal via EPICS to fire the first official pulse of electrons in the linac (Fig. 12). The feed from video cameras, which we were assured were looking at the fluorescent screens, started flashing. All we asked was that the linac appear to be running, and I think it actually was.

4. Experimental Facilities

4.1 Insertion Devices

There is a tremendous amount of work going on in the Experimental Facilities Division (XFD), as you will see during your visit. Some highlights include completion of the first production

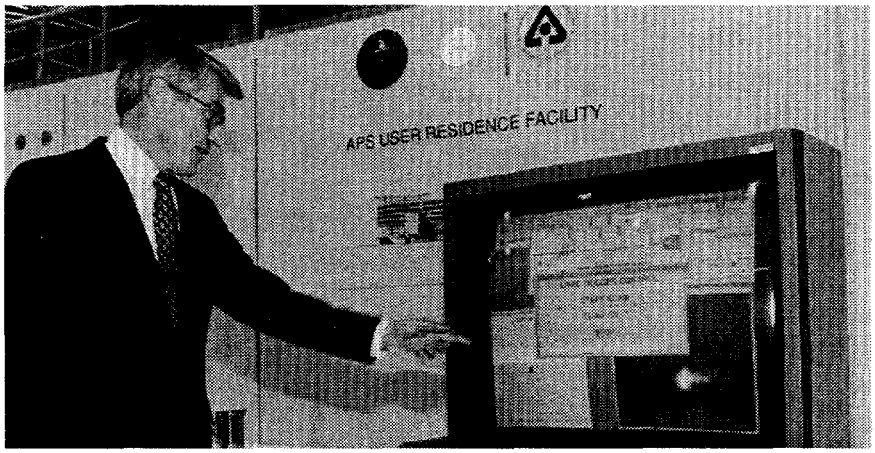

Fig. 12. Illinois Governor Jim Edgar firing the first APS linac electrons.

APS Undulator A by the vendor, STI Optronics. The device is measuring up very well in vendor tests. Its field characteristics are 10% in excess of our requirements, so we are sure that Undulator A is going to yield the kind of performance that we've all been hoping for. By implementing some mechanical improvements, we have eliminated the so-called "brilliance gap." As a result, these IDs are going to provide a wide range of spectral tunability at brilliance levels in the 10^{18} and the 10^{17} regime. Work is also proceeding on the design for wigglers.

4.2 Front-End Components

All of the bid packages for front-end components have been awarded and some of the first articles have been received. As part of the facility tour, you will be able to see the front-end prototype that has been assembled by the XFD Mechanical Engineering Group (Fig. 13). This prototype is being used to refine the design and also to train technicians. This way, when front-end installation begins in the storage ring, we will be able to make efficient use of the limited time that is going to be available due to the fact that this activity will be interleaved with storage ring commissioning.

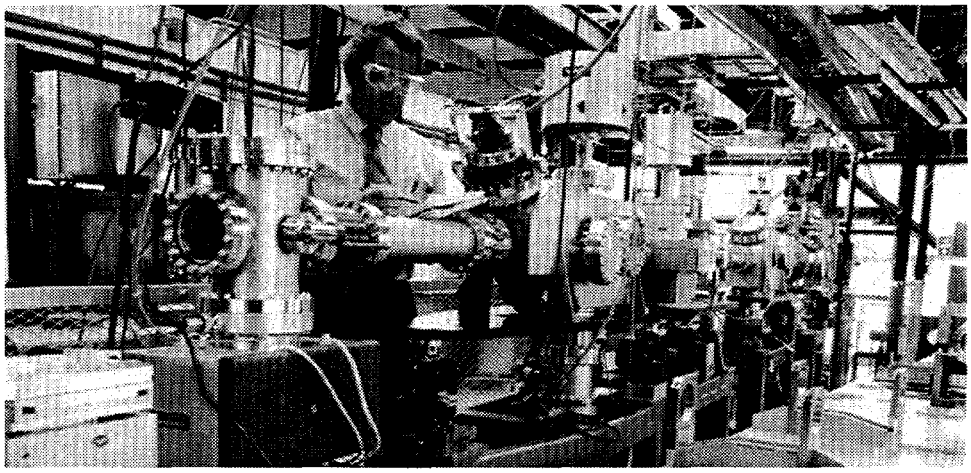

Fig. 13. Prototype APS front end.

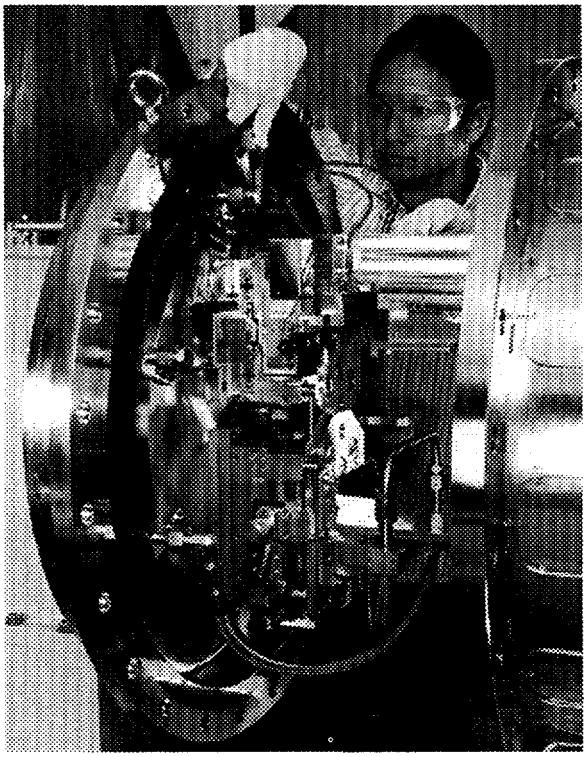

Fig. 14. Kohzu vacuum/mechanical housing for inclined-geometry monochromating crystals.

4.3 Monochromators

Another highlight of the year from the Experimental Facilities Division is the success of the inclined monochromating crystal. This double-crystal monochromator, the basic crystal-carrying assembly, was built by Kohzu. It has been integrated with our liquid-gallium-cooled, inclined crystal geometry and is ready for test (Fig. 14). It, too, is available for you to observe during the course of the meeting.

As you can imagine, many other achievements have been attained by the Divisions. Tomorrow you will hear about them in considerably more detail, including specific planning dates for storage ring commissioning, for undulator installation, and for beam availability throughout the course of 1995 and early 1996.

We continue to be very interested in joining our resources with those of ESRF and the Japanese Super Photon Ring 8-GeV (SPring-8) in order to deal with some of these challenging problems, particularly that of high heat loads. The advent of diamond crystals affords an opportunity to combine some of the high-heat-load engineering with diamond crystal technology to devise monochromators that work at extreme levels of thermal load. The Japanese have made arrangements with their Sumitomo Laboratory to produce diamond crystals, and we find that a very attractive prospect. Diamond crystals are actually in use at ESRF, but there is also experience here in the U.S., primarily at NSLS. There is an active effort around the world to develop diamond monochromators. It will require a very substantial effort to build a robust monochromator based on a readily available supply of diamonds if we're going to count on this kind of technology. There are a number of other projects where the three laboratories can benefit from each other's expertise.

5. Operations Objectives

5.1 Operating Energy

As the Project moves forward, we feel more and more assured that our principle performance goals will, in fact, be achieved. We are not planning to operate at 7.5 GeV, but we believe we can if we so desire. In fact, where appropriate we have used this higher energy as a design parameter to ensure that we could reach 7.5 GeV if need be. This approach affords a comfort margin that is important psychologically if nothing else, but that also might well be important technically. The machine can operate at 300 mA at 7 GeV, or 200 mA at 7.5 GeV. Of course, the

initial plans are for 100 mA/7 GeV operation. We do not, at this point, have the technology needed to cool a monochromator crystal being heated by beam currents that are substantially higher than 100 mA. That is a long-term R&D objective. But we believe that all of the storage-ring components, including the shielding, the crotch absorbers, and all the storage-ring hardware, can tolerate as much as 300 mA. So, the challenge is in the optics. We believe that the accelerator issues, while not trivial, are now taken care of.

5.2 Beam Stability

Beam stability is extremely important, as you know. We are doing many things to address that concern, such as designing the entire complex to operate in top-off mode in order to provide constant current to the users. We are quite confident that we will easily achieve the 10% of emittance specifications that we have advertised for many years. The PAR seems to be working very well. We needed the PAR in order to take full advantage of the high-frequency linac and to achieve fast injections with positrons. By adding that ring to the accelerator complex, our injection rates were increased to the degree that we can achieve 100-mA currents in less than a minute. That is being done regularly with electrons at the European Synchrotron Radiation Facility (ESRF) in France. It is a real pleasure for the ESRF user community to see injection occur in less than a minute following a beam loss. That way, your whole experimental team doesn't diffuse away to the coffee pot and then require another hour for recollection. They get the beam right back and nobody has time to leave. (If that's a disadvantage, let us know.) As difficult as it is to achieve that kind of injection with electrons, it is more difficult with positrons because only a few positrons are produced in the target for every thousand electrons. The accumulator ring will also provide extremely clean bunches for timing experiments.

6. Collaborative Access Teams

6.1 Memoranda of Understanding

The Proposal Evaluation Board (PEB) has to date approved 20 of our 35 sectors for use by 15 Collaborative Access Teams (CAT). The number of sectors that we currently plan to instrument in the first phase is 16. There is an obvious difference between these two numbers. We will have to rectify this gap by securing funds for additional front ends and insertion devices. The number of sectors where we have actually entered into formal Memoranda of Understand (MOU) as of this date is nine. The number of sectors for which we expect to have signed MOUs by the beginning of August 1994 is 14. So we are still within our first-phase capability. The CATs requesting the remaining six sectors are faced with funding problems. It will be some time before they arrive here looking for front ends. In the meantime we will be working on the funding to provide additional front ends and insertion devices for the storage ring.

6.2 CAT Funding

Our CATs have had remarkable success obtaining financial support in a very difficult climate for funding. Teams have raised some $115,000,000 so far, which is approximately 60% of the initial estimate for construction of 14 sectors. That success is enabling these 14 sectors to proceed with design and construction of 28 beamlines. We believe that the majority of those beam-

lines will exist when the APS begins operations in 1996. We do not foresee two or three years of operations with only a small number of beamlines on the floor. Rather, we expect to have on the order of 20 or so beamlines relatively soon with the balance to follow in good time.

6.3 Foreign Participation in Research at APS

We now have international participation from Canada, which has membership in two of our CATs. We are in discussions with research institutions in Israel, Taiwan, and Australia about the possibility of their involvement at APS. Israel has expressed some interest in developing a full sector, although they may also join with another group. The other two countries are interested primarily in collaborations of various sorts rather than in developing their own sector. Recently, the Japanese have expressed curiosity as to whether we would accept a proposal from their industry to do research at the APS. It is an interesting question, particularly for the Department of Energy people in the audience, as to whether we would like to do that or not.

7. Concluding Remarks

All of the accomplishments noted here (and more) have been realized by many individuals, including one large group of people who have labored on our behalf over the life of the project. Users, obviously, have a vested interest in this facility. Those of us on the Project are paid to do this job, so that's at least one motivation, although we have others. But the people I'm addressing right now are not paid and they are, in most cases, without any direct interest in using this facility. These people come here and give us their counsel. They have worked very hard over the last six or seven years to assist in bringing this project to its current stage. So, as we move closer to the day when the APS begins operations, it is very appropriate to thank all the members of our various advisory committees for their splendid work.

Summarized Excerpts* from "The Possible Simplicity of Undulator Beam Research"

by
Jens Als-Nielsen
European Synchrotron Radiation Facility

For the past eighteen months at the ESRF, we have had beam in the ring and several beamlines with insertion devices have been commissioned or are in the process of being commissioned. When I was invited to come over to the meeting here—and I appreciate it very much, it is a great place and a great honor for me—there were essentially two choices. Either I could flash through a number of experiments at a number of beamlines during that commissioning period, or I could concentrate on one beamline, the one where I put my own efforts, and tell you about our good and bad experiences of commissioning an undulator beamline. Obviously, I picked the last choice.

. . . I want to tell you about the Troika concept. The basic philosophy is that the undulator radiation is such a precious source and can do almost anything for you, so it should feed more than one instrument. You can do that if you have several monochromator stations. For example, we have a vertical, double monochromator of the more conventional type, and then upstream other monochromators that are x-ray transparent so that the beam can continue to be used further downstream. At the same time, because they are transparent, they don't absorb much power. That may be one solution to the heat load problem that we've been hearing about. This is killing two birds with one stone. You get more use of your undulator radiation, and, at the same time, there is a solution to the heat load problem, at least at the ESRF levels of heat load.

So, I would like to go through some of these components along that beamline. . . . I will describe an extremely simple device that can be used to diagnose the energy dependence and the angular dependence of the undulator radiation. Then I will come back to the diamond crystals and also tell you how we have been able to focus the very well collimated undulator radiation. Finally, I hope to have time to mention a few of the experiments that we have been able to carry out during this commissioning period. That is the outline. . . .

. . . As soon as the undulator is in the beamline and you can open the beam, you want to characterize the undulator radiation. Is the spectrum [the same] as you calculated? Do you have the number of photons you should have according to calculations? Where is the beam? . . . One way to characterize the beam is to use an extremely simple spectrometer device.

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* These excerpts were summarized from a videotape of the meeting.

In the beamline, you introduce two cooled Be windows with He gas in between. As the undulator radiation comes through, it will be Compton scattered. If you look at 90° with a solid state detector, then you will simply see the undulator spectrum with, of course, a slightly distorted energy scale. It is distorted by the Compton energy shift, which is not very much. Helium gas is nice because, at 90°, you don't have to go to too high an energy before all the scattering is Compton. The cross section, of course, is known. Thus the count rate you get in the solid state detector, if you know about the apertures, can be directly translated into the number of photons in that spectrum. So, I think that is a simple spectrometer.

We tried a little bit of that, and comparison of the measured undulator spectrum, which only takes a few seconds, to the predicted spectrum resulted in quite good agreement. This is a way to quickly measure the undulator spectrum, and therefore you can do it at several positions of the aperture and quickly find the central cone of the radiation. Remember, when commissioning the undulator, it is a three parameter problem: . . . the two angular coordinates . . . plus the energy.

A very simple way of producing an aperture in the undulator beam that can take the heat load is to introduce a pair of cylinders that can be turned around a point. In one position, you get the full aperture and the full beam through. When the cylinders are turned, they close with respect to the beam. The beam footprint on the these cylinders has some length and that reduces the heat load problem. They are one inch in diameter and are chromium-plated hollow copper cylinders with water cooling. Such a pair of cylinders is quite a nice slit, and, at least at ESRF undulator beams, they can easily stand the heat load. There is one set for the vertical collimation, and another set for the horizontal collimation. The whole assembly is in a vacuum box. They are currently in use on the Troika beamline and also on the machine diagnostic beamline. So, that is one way of doing the initial commissioning of the undulator spectrum, and it may be nice to leave it there for monitoring the undulator performance.

Now, I will talk a little about the diamond monochromator and its performance. One problem is the heat load problem we have heard about already. One can compare the advantage of diamond versus silicon. Consider that a thin disk of diamond or silicon is put in the x-ray beam, which has a certain power and power density. That will heat the crystal within a central area. Imagine that the crystal is cooled at the periphery. Ask what is the temperature difference between the cool area and the hot area, and how you can estimate how much the crystal will distort under that heat load.

When you compare silicon to diamond, there is a considerable difference. First of all, diamond only absorbs a relatively small fraction of the power in the beam. So the power deposited in that optical element is less than in silicon. Second, the heat conductivity of diamond is superb. It is the best heat conductivity of any material known to mankind. Finally, the thermal expansion parameter of diamond is a little bit better than it is for silicon. So all

together, there is an advantage of more than two orders of magnitude in the relative figure of merit between silicon and diamond.

The only problem with diamond is its availability. We were lucky in the beginning of 1992 to get a diamond crystal through a colleague I had at CERN, where they use diamonds for a completely different purpose. I was able to borrow that diamond crystal, and we have it. It is mounted on a copper cylinder plated with chromium. One problem is strain-free mounting of such a thin crystal. We learned from the Brookhaven group to use indium-gallium and just let the diamond crystal float on that. It is held quite firmly by the surface tension of the liquid indium-gallium. It is as simple as that.

Apart from the fact that the diamond is transparent so that you can have several of them downstream and that you don't have any heat load problem, there is another advantage of diamond. When you put the diamond into the beam and you have a plate glass window so that you can look at it, then the diamond, [because of] the nitrogen impurities in it, fluoresces in the visible [and can be viewed through the window]. In this way, you can see the x-ray beam quite clearly, which is very convenient because then you know that you are hitting the center of the diamond. It is a wonderful fluorescent material to put in the direct undulator beam. That is an extra benefit.

We examined the performance of this diamond crystal at the Troika beamline in the following way. The face of the diamond was (1,0,0), so therefore when we used the (1,1,1) reflection, this becomes the asymmetric Laue configuration. The crystal is at an angle with respect to the incident beam therefore there is a difference between the width of the incident beam and the out coming beam. That is the compression factor b, which describes the asymmetry. Then we examine the diamond crystal with a silicon (2,2,0) crystal, which is cut asymmetrically in such a way that the b factor becomes extreme and that means that the receiving Darwin width of the silicon crystal becomes very small. Therefore when you rock the silicon crystal, what you really see is only the Darwin width of the diamond crystal. You can neglect the silicon Darwin width for this asymmetric cut. The results show that the width of the rocking curves is very close to the theoretical width of diamond crystal, asymmetrically cut as we have it. We have done this investigation at several beam sizes. If we open the beam size, the width increases. However, the broadening is not due to the extra heat load but is due to slight imperfections in that diamond crystal. But the broadening is not much, and therefore, for most practical purposes, the diamond crystal performs very well although not perfectly. . . .

. . . I would now like to spend a little time on some experiments we did to look at how to focus the undulator beam by simple means. In our setup, we have a (1,0,0) diamond crystal face used in the asymmetric Laue consideration [i.e., (1,1,1)] reflecting into a second crystal of germanium (2,2,0). Diamond (1,1,1) and Ge (2,2,0) have almost the same lattice distance. So the exit beam from the germanium will be almost parallel to the synchrotron beam - but not quite. If we would like to do better than that, we put in a tangentially focusing mirror.

The Ge (2,2,0) crystal produces focusing in the vertical plane by sagittal bending, and the horizontal focusing is produced by the mirror. In order to limit the mirror size, we use a W:Si multilayer mirror whose length is only about 20 cm. In this way, we have the possibility not only to focus but to have any angle that we want in the exit beam. If we want a parallel beam, if we want a focused beam, if we want a line focused beam, or if we want a point focused beam—we can do all of that. . . .

. . . I would like to emphasize that the multilayer is a nice way of mirroring an x-ray beam. A student of mine who is working at the ESRF in the Optics Group has measured a number of these multilayers and found that they provide quite respectable reflectivities up to 100 keV. . . .

. . . Let me now tell you a little more about certain experiments that we have been doing. One experiment that we have been doing quite recently is maybe a little bit of a surprise to you. It is not the kind of experiment you think you can do at an undulator, but it turns out that you can.

We have some people who are interested in Quick EXAFS. They are catalyst people and they would like to be able to obtain an EXAFS spectrum within a second and then, in the following second, another EXAFS spectrum, and so on—Quick EXAFS. I thought a little about that and have here a very simple way of doing Quick EXAFS. The idea is that instead of a double monochromator (which all EXAFS experiments have), you have a single monochromator—just a diamond and then a 2θ arm after the diamond. You couple them mechanically in 1:5 or 1:10 and then drive them from the same step module so they always move in 1:2 with each power module. And then you have a simple EXAFS setup with an incident ion chamber and an outgoing ion chamber and the copper sample between the two ion chambers, etc.

The other thing that is a little unconventional is—how do you record these data, how do you get these data stored without spending too much time? The idea is to use a multichannel analyzer (MCA) in its multichannel scalar mode. So you just use the pulses to the stepping motor. You use that as the address for the channel that you want to put it in. All of that is commercially available, cheap, and you just use the stepping pulses to address the channel and the input here, and you get an EXAFS spectrum. It all works out quite nicely.

But let me come back to how to do that at an undulator. First of all, we didn't pick an odd harmonic to do it on; we did it at an even harmonic, the second harmonic at a certain gap. As an example, we took a Quick EXAFS spectrum of a standard copper foil, and, within three seconds, we obtained a quite respectable EXAFS spectrum with all the significant features from copper.

Then we did it (two days ago actually) on a real catalyst system, which was a mixture of copper oxide and zinc oxide on an aluminum support. We obtained EXAFS spectra taken as we heated the catalyst to 160° C and let in the reaction gas. We then observed what happens . . . with time. There were three seconds between each of the spectra, and one can see quite clearly that copper

oxide is reduced to metallic copper at a certain point. So, the message of Quick EXAFS is that you can do it, it is simple to do, and you can do it perfectly well at an undulator.

Conclusions:

1. SR [synchrotron radiation] research is <u>not</u> easy — but challenging and rewarding.

2. During commissioning, build up the beamline gradually with simple modules (e.g., the He gas Compton spectrometer)

3. Undulator radiation is so precious that it deserves multiple instruments.

4. Focusing by simple means is possible (add-on Bragg-Fresnel crystals or capillary tubes yield submicron beam size).

5. Coherent x-ray experiments and fixed wavelength diffraction are obvious from third-generation undulator sources.

6. Spectroscopy research (MAD, resonant magnetic scattering, EXAFS, etc.) is certainly feasible from an undulator source.

So as far as I'm concerned, undulators are wonderful, and that is where you should put the emphasis.

Coherent X-Ray Scattering

Ron Pindak
AT&T Bell Laboratories

Collaborators:

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Steve Dierker, *Univ. of Michigan*
Ian Robinson, *Univ. of Illinois*

Brian Stephenson, Steve Brauer, *IBM Research*
Mark Sutton, *McGill Univ.*
Simon Mochrie, *MIT*
Jens Als-Nielsen, G. Grübel, D. Abernathy, *ESRF*

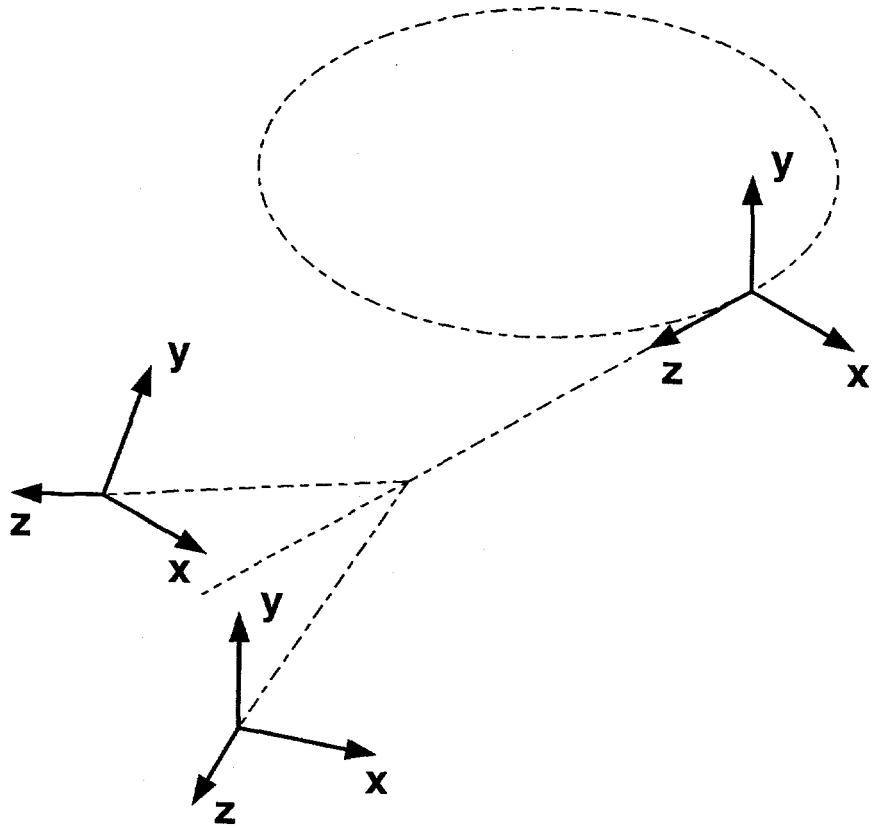
OUTLINE

- **Requirements to Work with Synchrotron Beams in the Transverse and Longitudinal Coherence Limit.**

- **Fraunhofer Diffraction from Pinholes:**
  Results form measurements on the *ESRF "Troika"* undulator beamline and the *NSLS X25* wiggler beamline will be used to make coherent photon flux comparisons.

- **Coherent Scattering From Samples:**
  a) Importance of keeping Path Length Differences (PLDs) introduced by the scattering geometry less than the longitudinal beam coherence.
  b) Considerations for optimizing signal.
  c) Illustrate with coherent scattering results from crystalline domains in $K_{0.3}MoO_3$ (*X25, NSLS*).

- **Preliminary Results on Diamond Crystals Both as Monochromators and Samples** (*"Troika", ESRF*).


y
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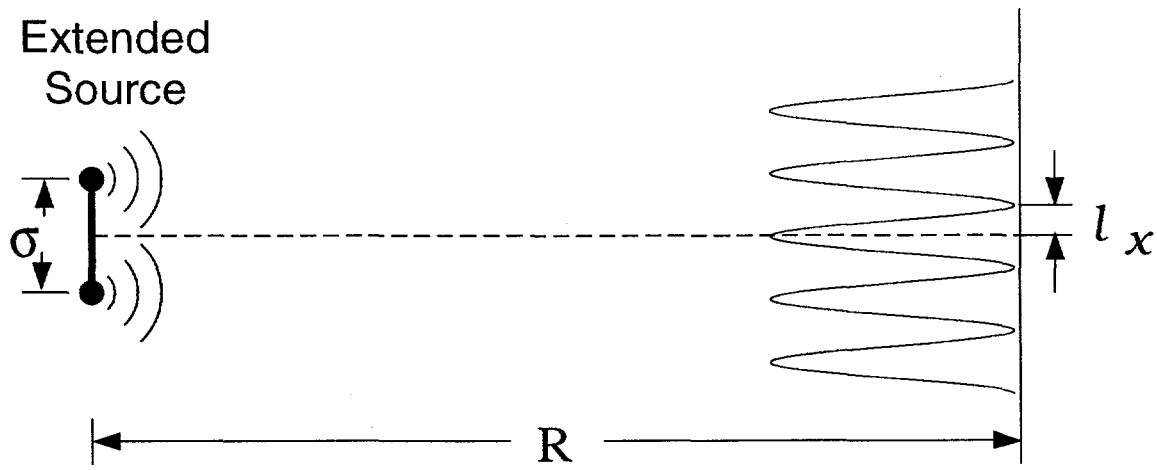
TRANSVERSE COHERENCE LENGTH (l_x) :

Finite Source Size ⇒ Loss of Tranverse Phase Coherence



$$l_x = \lambda R / 2\sigma$$

⇒ Need an aperture of size $L < l_x$ to isolate the coherent fraction of the beam.

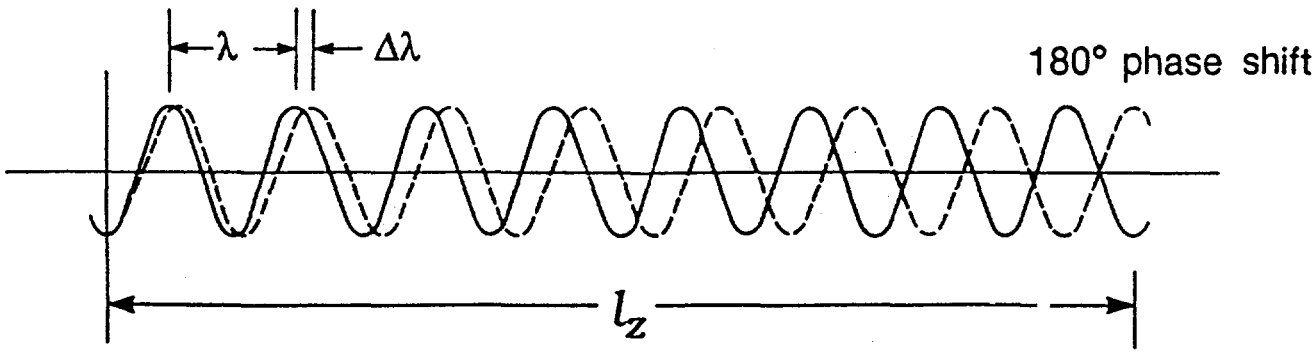
SOURCE SPECIFICATIONS :

(E = 8 KeV, λ = 1.5 Å)

	NSLS X25 Wiggler	**ESRF** "Troika" Undualtor	**APS** Undulator A
σ_x (mm)	0.820	0.435	0.342
σ_y (mm)	0.038	0.096	0.091
$\sigma_{x'}$ (mrad)	2.0	0.019	0.024
$\sigma_{y'}$ (mrad)	0.1	0.012	0.009
Brilliance (ph/s/mm^2/mr^2/0.1%BW)	1×10^{16}	5×10^{17}	2×10^{18}
R (m) [source to pinhole]	28	45	45
l_x (µm)	2.6	7.8	9.8
l_y (µm)	55	35	37
L (µm) [collimat. pinhole]	3.0	8.0	10.0
Ω (µrad) [angle collimat.]	0.11	0.18	0.22
Coherent Fraction	9×10^{-7}	6×10^{-4}	8×10^{-4}
Flux (ph/s/0.01%BW) [through pinhole]	2.4×10^{6}	4.2×10^{8}	1.9×10^{9}

LONGITUDINAL COHERENCE LENGTH (l_z) :

Finite Bandwidth $\Rightarrow$ Loss of Longitudinal Phase Coherence

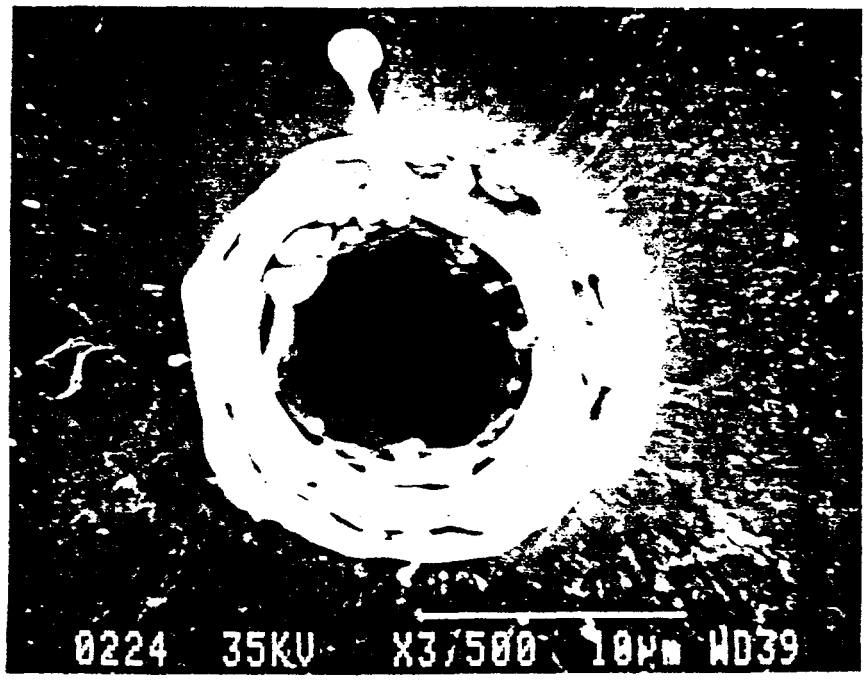


$$l_z = N\lambda = (N - 1/2)(\lambda + \Delta\lambda)$$
$$\Rightarrow N = (\lambda + \Delta\lambda) / 2\Delta\lambda$$
$$l_z = \lambda^2 / 2\Delta\lambda$$

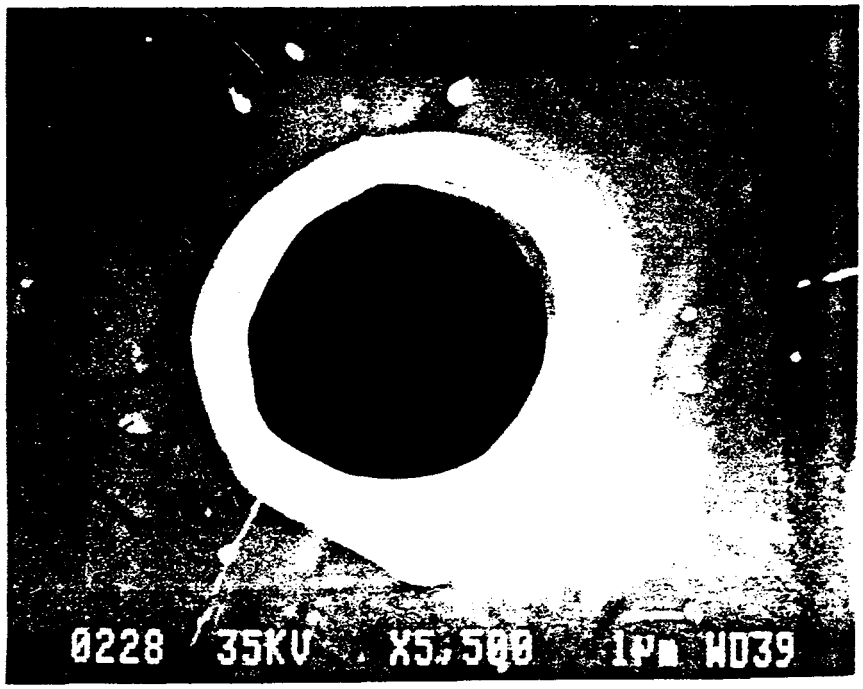
$\Delta\lambda/\lambda$	l_z (μm)	Coherent Flux * (photons / sec)
2.0×10^{-2}	0.004	4.0×10^{11}
1.4×10^{-4}	0.54	3.0×10^{9}
1.0×10^{-6}	76.0	2.0×10^{7}

* Expected for APS Undulator A

6 μm Pinhole in 25 μm Pt



(Front)



(Back)

Pinhole laser oblated by:
Dean Jorgensen, *Optimation*

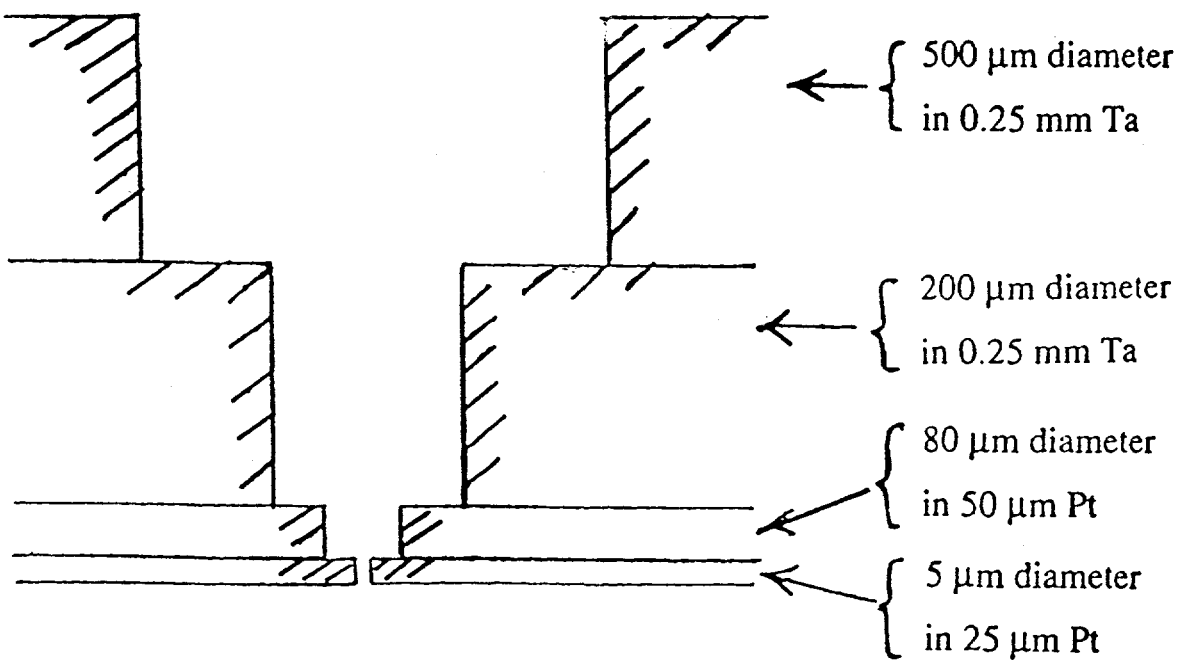
For a 1 mm beam on a 5 μm pinhole,

$$\frac{\text{Area of pinhole}}{\text{Area of beam}} \cong 3 \times 10^{-5}$$

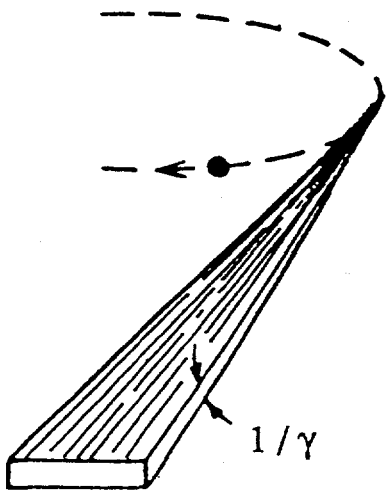
⇒ If a disc is 10 absorption lengths thick, then <u>same</u> flux through disc as pinhole

Absorption length for Pt at 8 Kev ≅ 2.2 μm

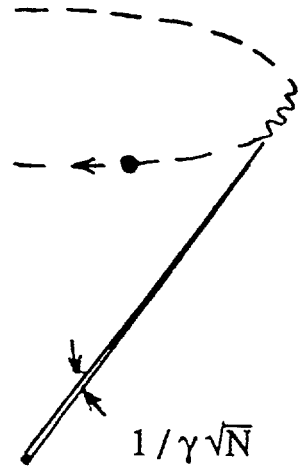
∴ Need backing apertures.

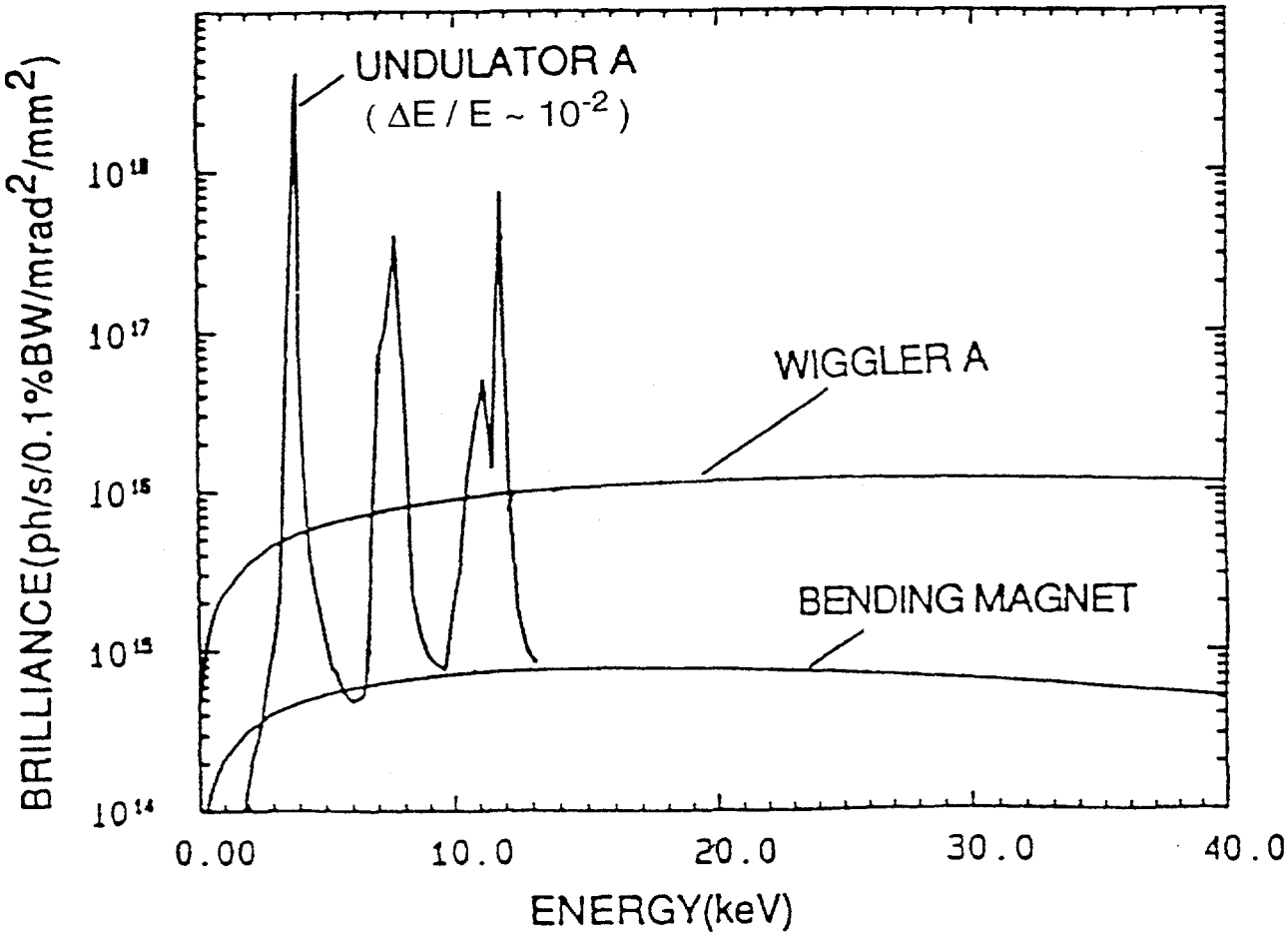


BENDING MAGNET SOURCE



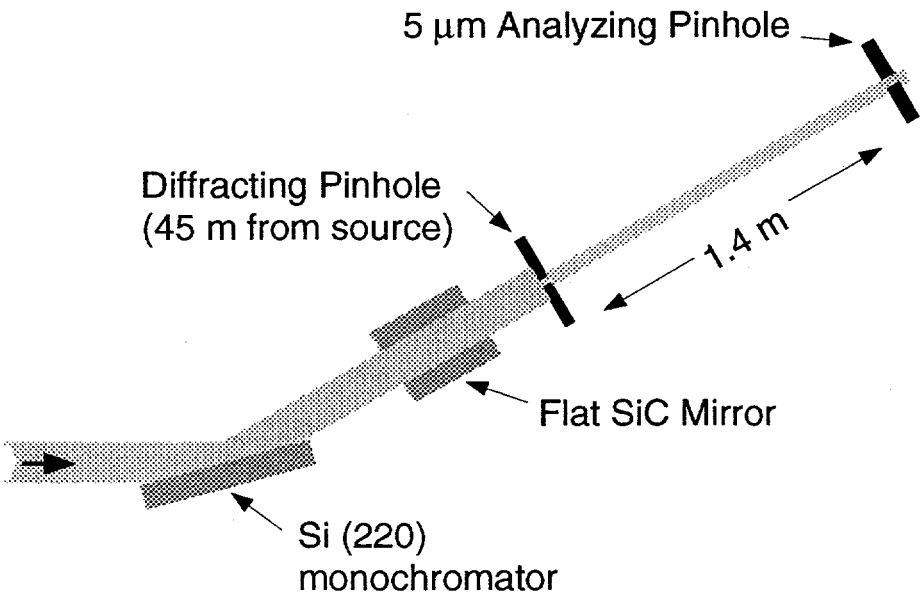
UNDULATOR SOURCE

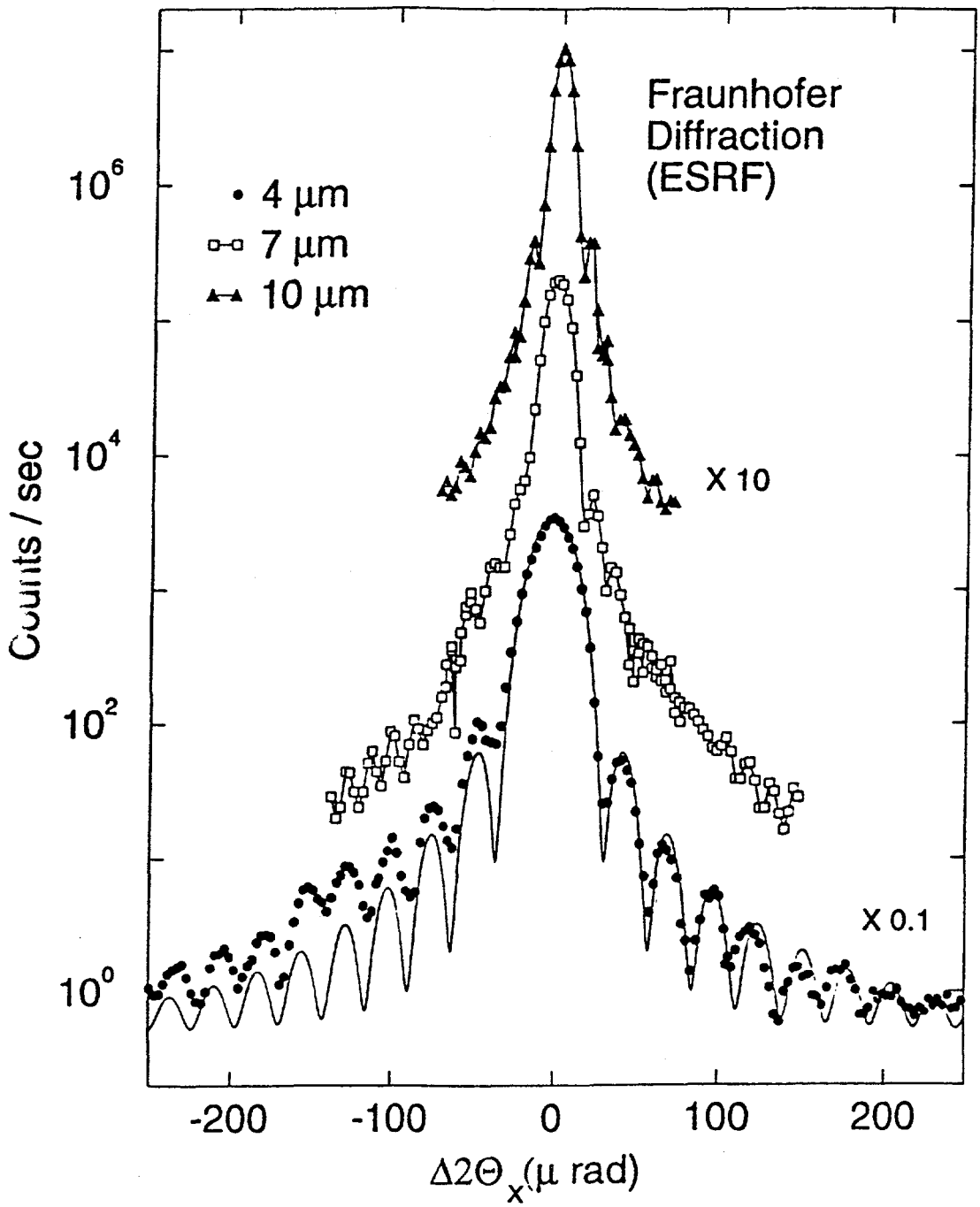




FRAUNHOFER DIFFRACTION SET-UP
ESRF "TROIKA" BEAMLINE

- $\lambda = 1.08$ Å, E = 11.8 KeV
- Primary slits (27m from source) set to make
  $l_x = l_y \sim 10$ µm.
- $l_z \sim 1$ µm

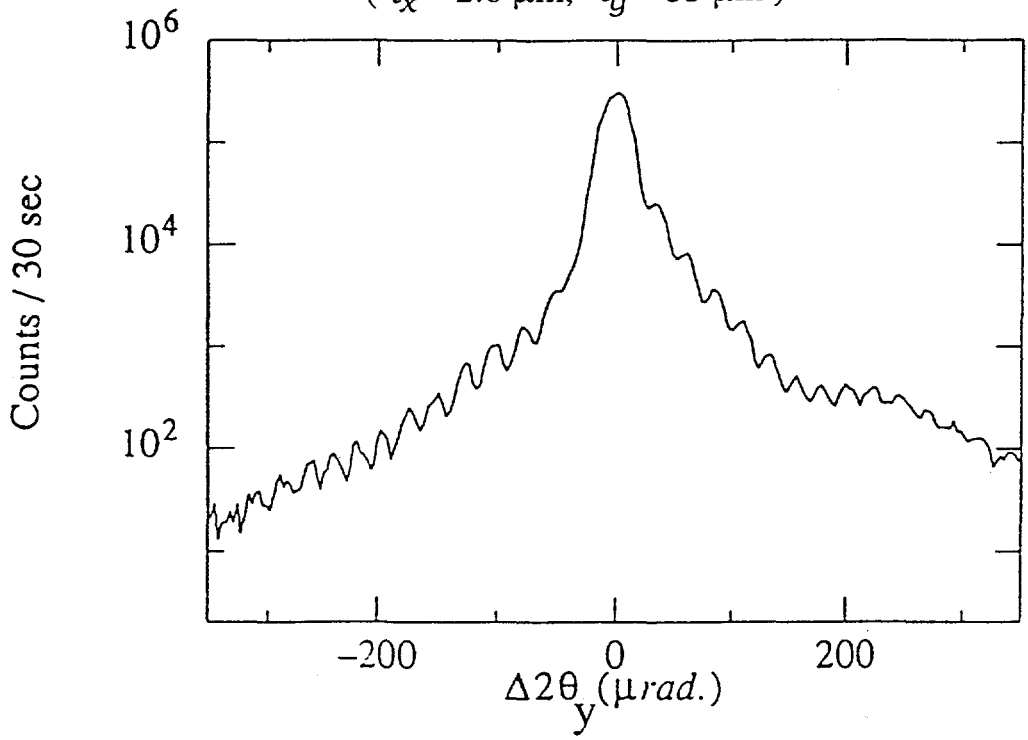


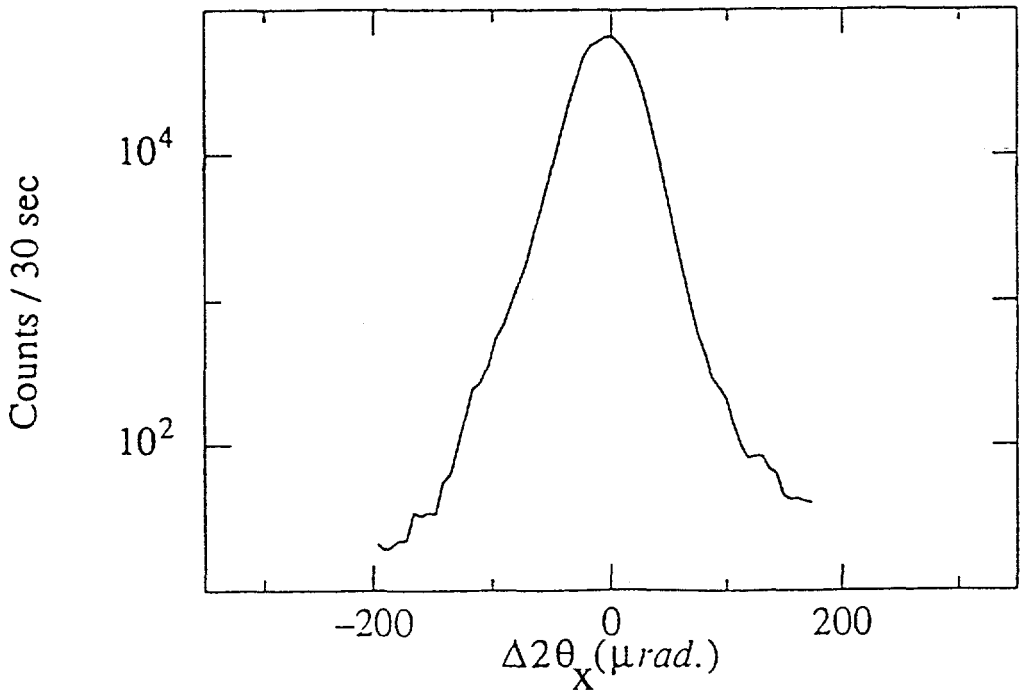

Fraunhofer
Diffraction
(ESRF)
4 μm
7 μm
10 μm
X 10
X 0.1
Counts / sec
10^6
10^4
10^2
10^0
-200
-100
0
100
200
$\Delta 2\Theta_x$(μ rad)

Fraunhofer Diffraction, Main Beam

5 μm incident × 5 μm analyzer

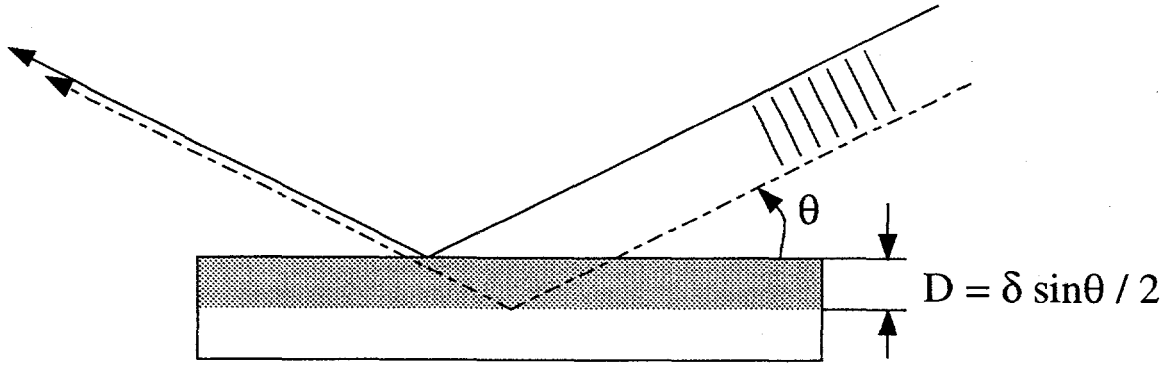
($l_x = 2.6\ \mu m$, $l_y = 55\ \mu m$)



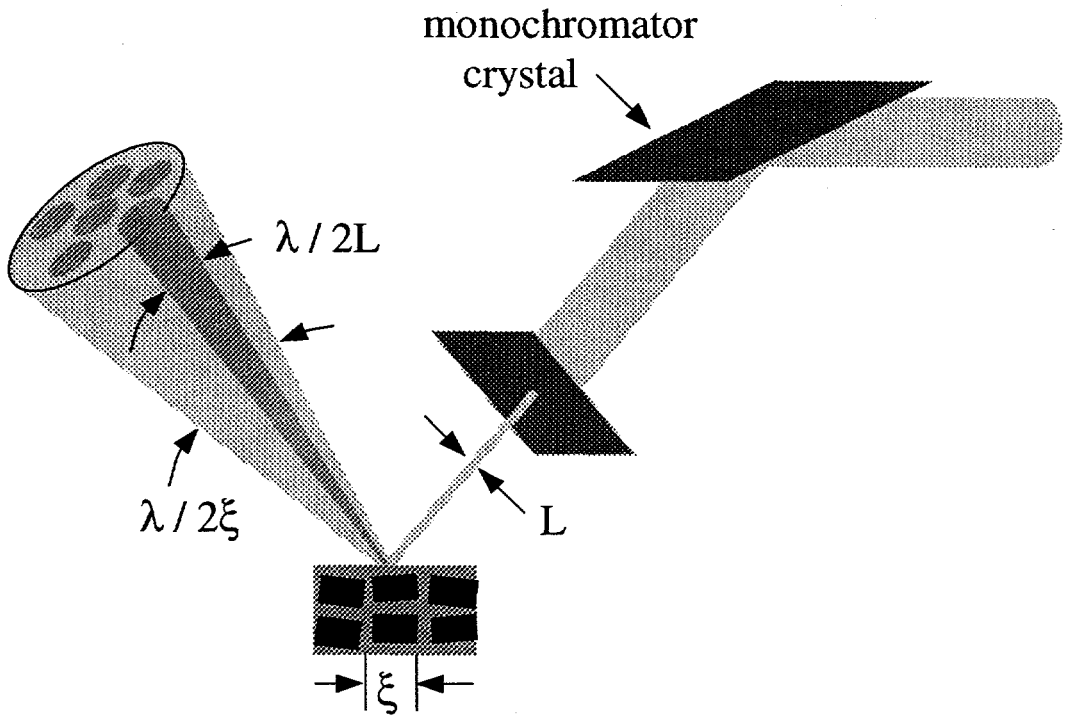


EXPERIMENTAL COMPARISONS

	NSLS	TROIKA
λ	1.5 Å	1.0 Å
$\Delta\lambda / \lambda$	1.4×10^{-4} Si(111)	5.9×10^{-5} Si(220)
Collimating Pinhole	5 μm	10 μm
Flux (ph/s) [through pinhole]	3×10^{5}	3×10^{7}



PLD = 2D sinθ = δ $\sin^2\theta$
where δ is the absorption length



For coherent scattering: $L < l_x, l_y$ *and* $PLD < l_z = \lambda^2 / 2\,\Delta\lambda$.

At a distance R = 1 meter from the sample,

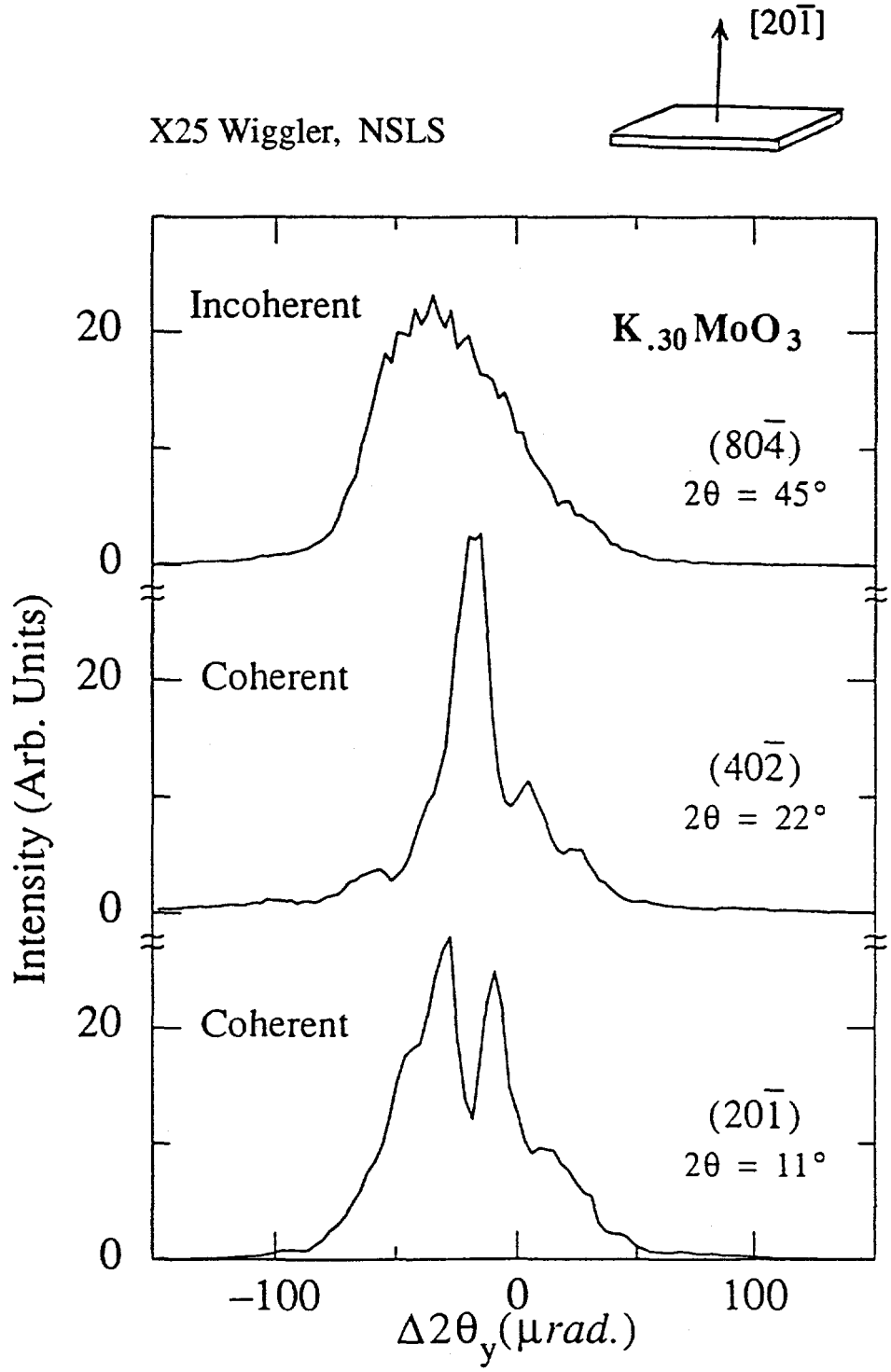
speckle size = R λ /2 L = 25 μm (λ = 1.5 Å, L = 3 μm) .

"Blocks" could represent:

- Domain walls in incommensurate systems as charge density waves, ferroelectrics, adsorbates.
- Internal segments of polymers or viruses.
- Colloidal particles.
- Order-disorder fluctuations near a critical point.
- Crystalline domains.

X-ray Photon Correlation Spectroscopy (XPCS)

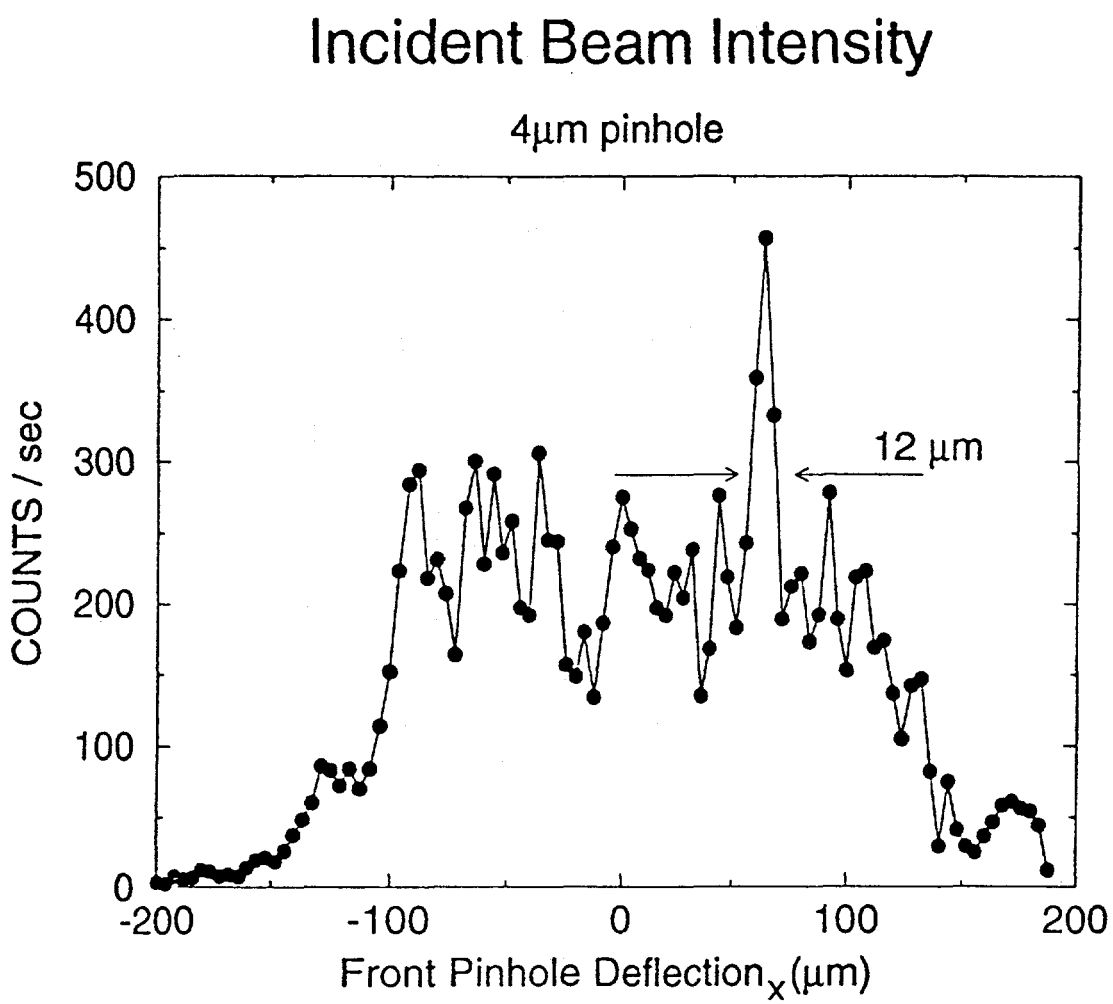
- Study dynamics of "block" fluctuations or motion by analyzing the time evolution of their speckle pattern.
- Similar to visible light PCS, but with x-rays can probe length scales down to interatomic spacings.



For $\Delta\lambda / \lambda = 1.4 \times 10^{-4}$, $\lambda = 1.5$ Å, $l_z = \lambda^2 / 2\,\Delta\lambda = 0.5$ μm.

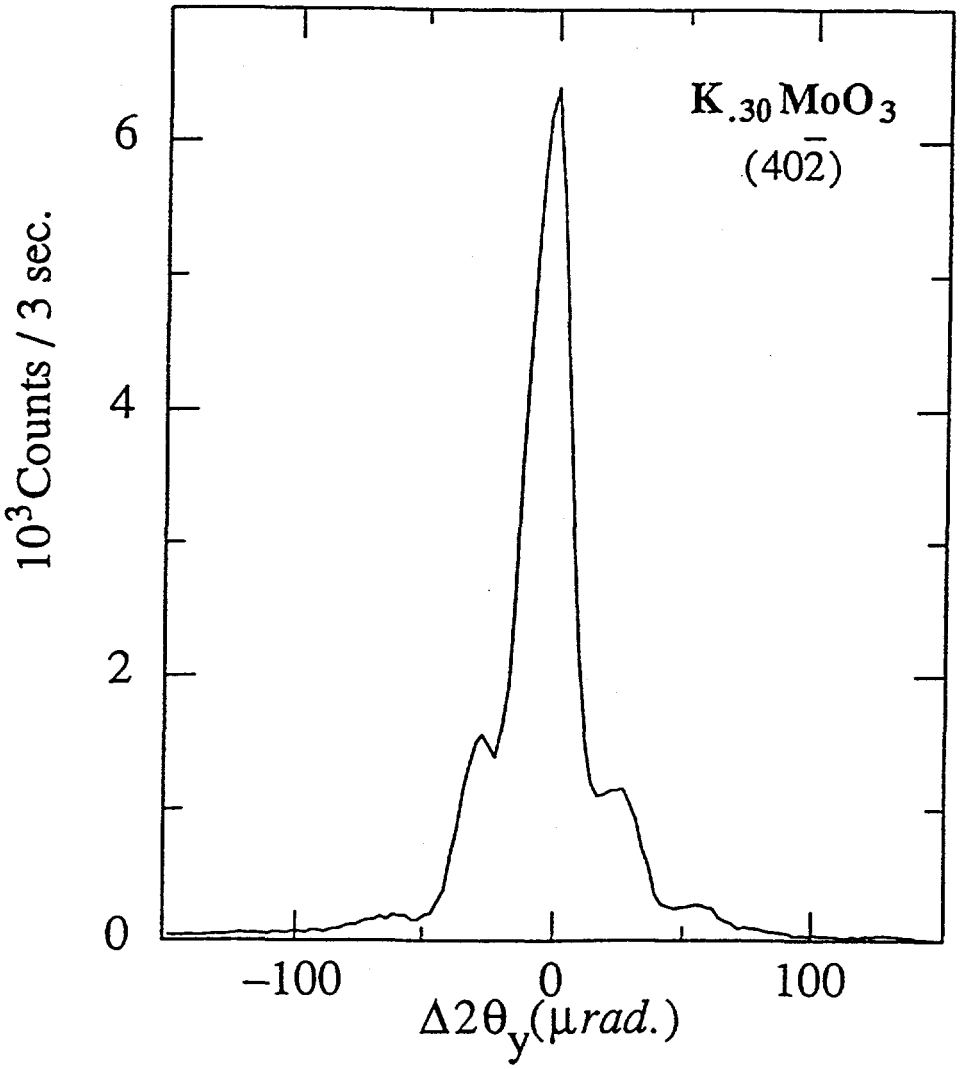
For $K_{0.3}MoO_3$, $\delta = 20$ μm.

$\Rightarrow$ PLD $= \delta \sin^2\theta < l_z$ provided $2\theta < 19^o$.


Incident Beam Intensity
4μm pinhole
500
400
300
200
100
0
COUNTS / sec
12 μm
-200
-100
0
100
200
Front Pinhole Deflection$_x$ (μm)

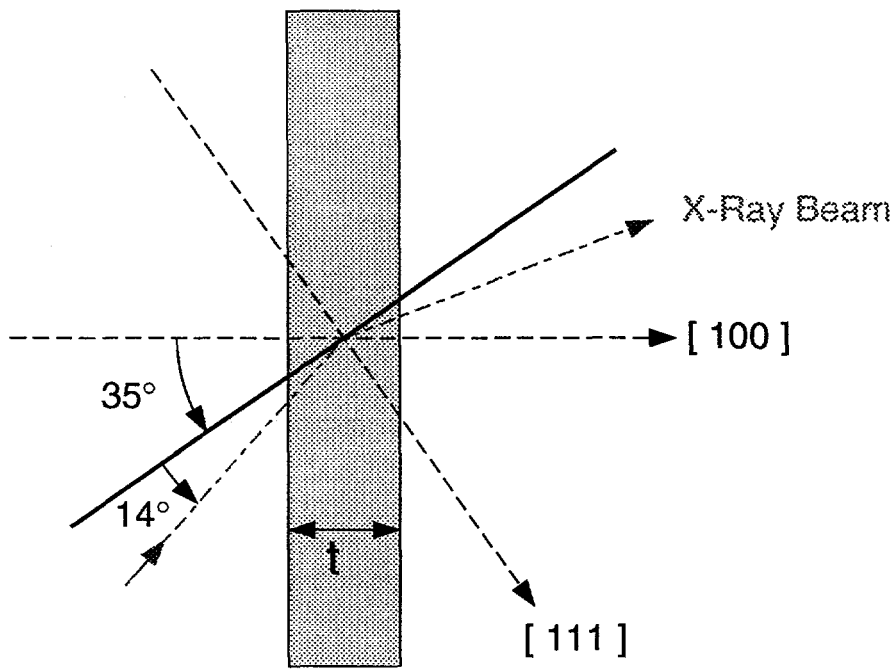
Coherent Diffraction: Single Domain

10 μm incident x 5 μm analyzer
X25 Wiggler, NSLS



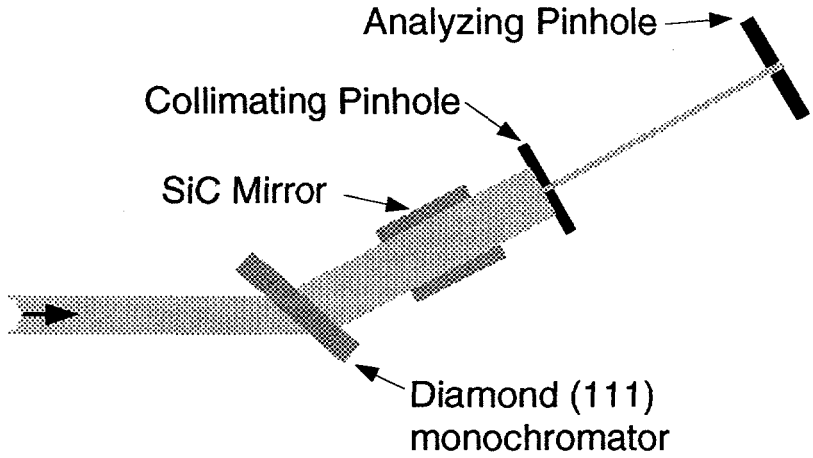
$I_{CDW} / I_{BRAGG} \sim 10^{-3} \Rightarrow$ a few counts/sec in CDW peak.

(100) DIAMOND CRYSTALS
diffract from the (111) *planes*

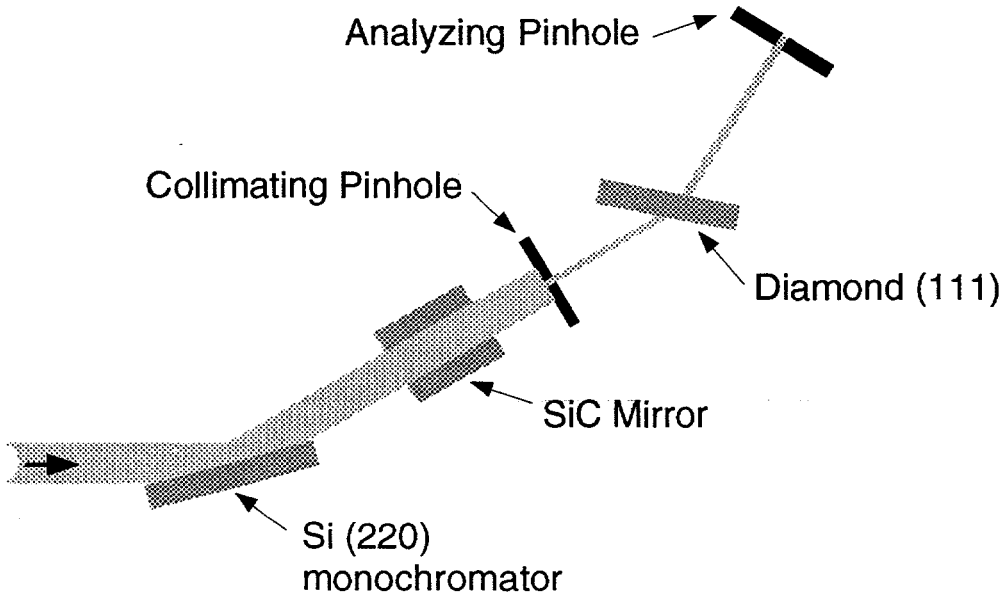


t = 400 μm (synthetic diamond)
t = 202 μm (natural diamond)

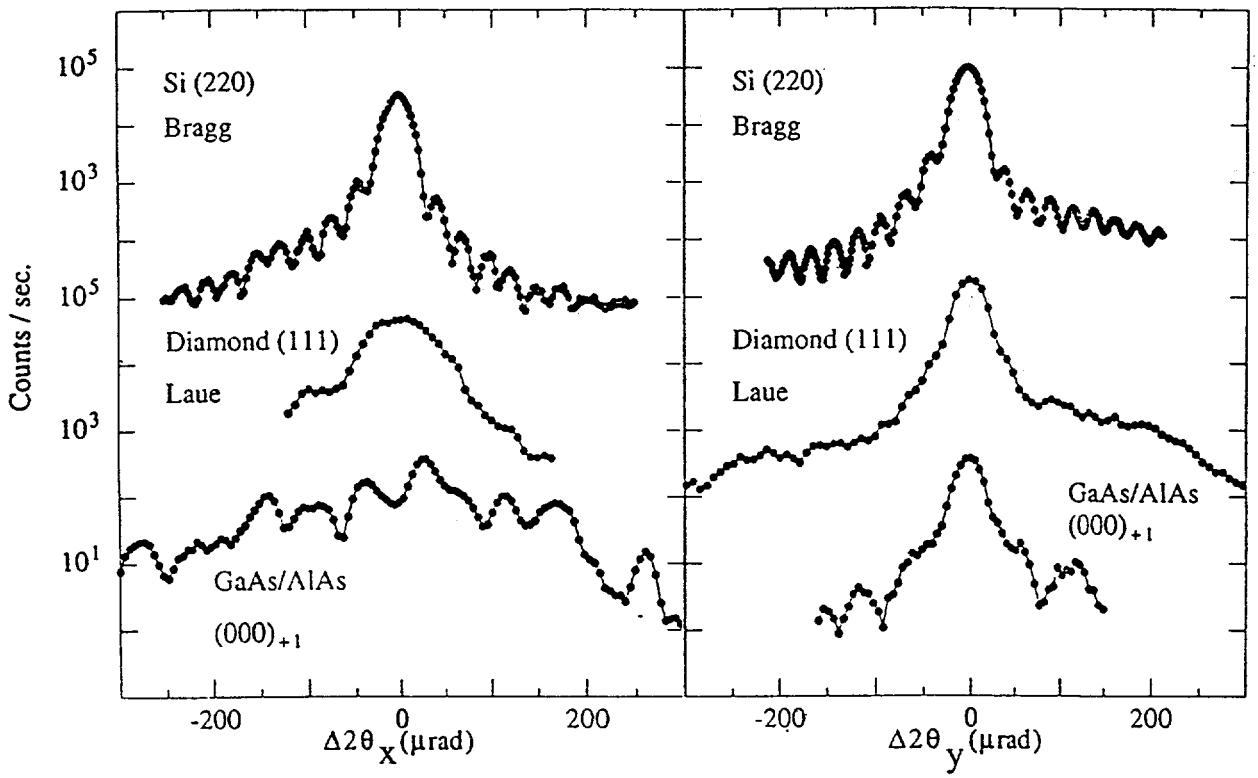
DIAMOND AS MONOCHROMATOR



DIAMOND AS SAMPLE

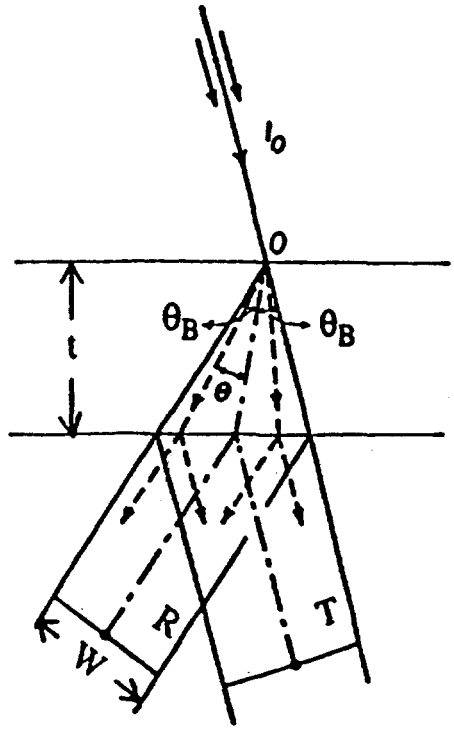


Scans parallel and perpendicular to the scattering plane using a 4 μm collimating pinhole and a 5 μm analyzer pinhole from *(top)* a Si (220) monochromator in Bragg geometry , *(middle)* a Diamond (111) monochromator in asymmetric Laue geometry & *(bottom)* a speckle-pattern from a GaAs/AlAs multilayer .



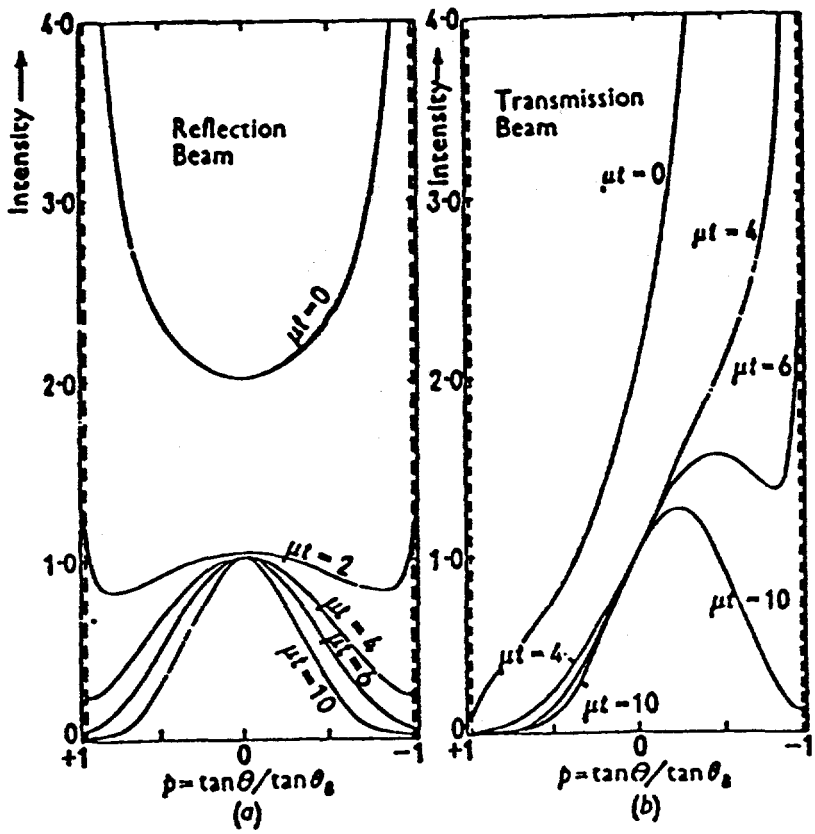
X-ray energy flow in an ideally diffracting crystal in dynamical theory

[Norio Kato, *Acta Cryst.* **13**, 349 (1960)]



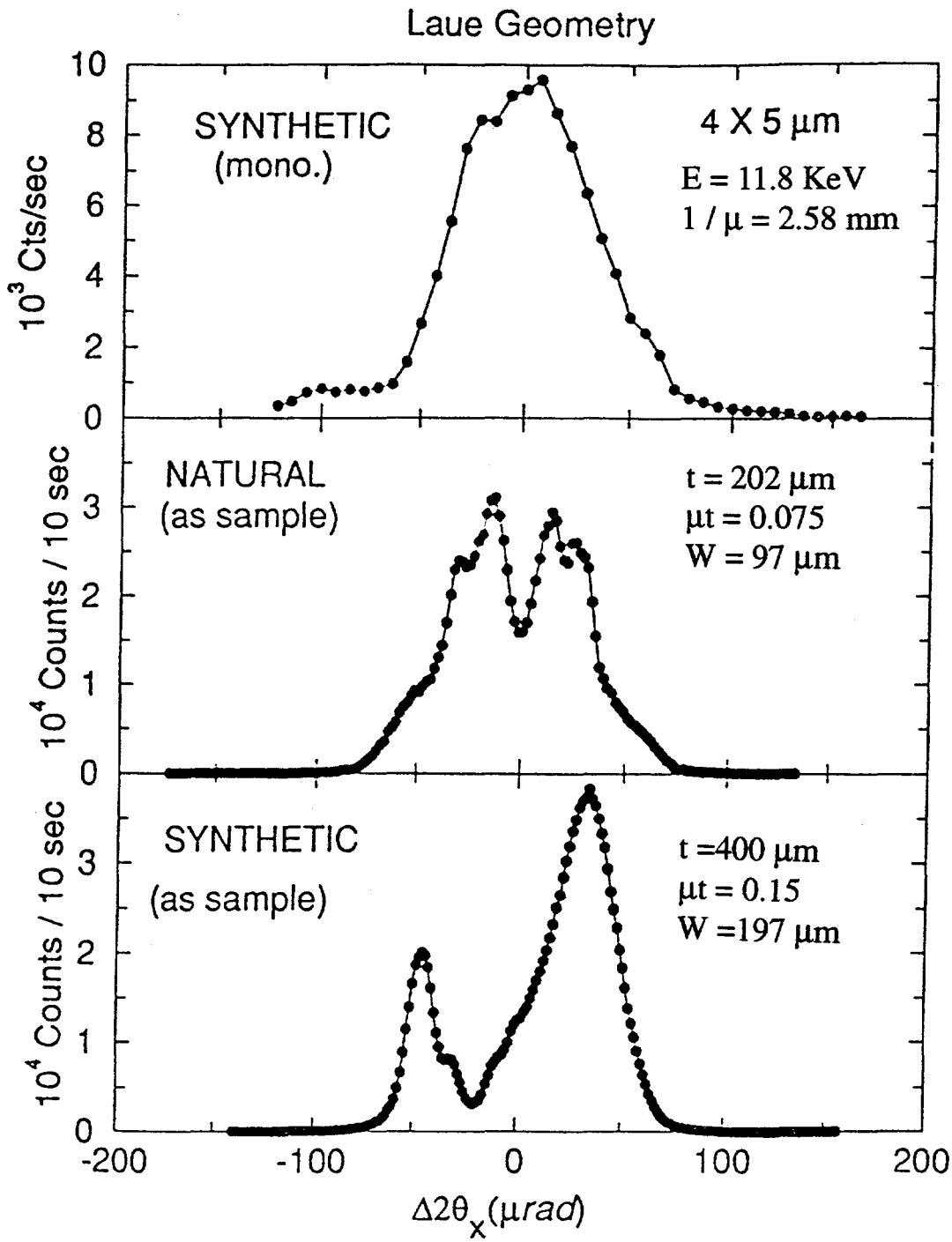
$W = 2\,t\,\sin(2\theta_B)$

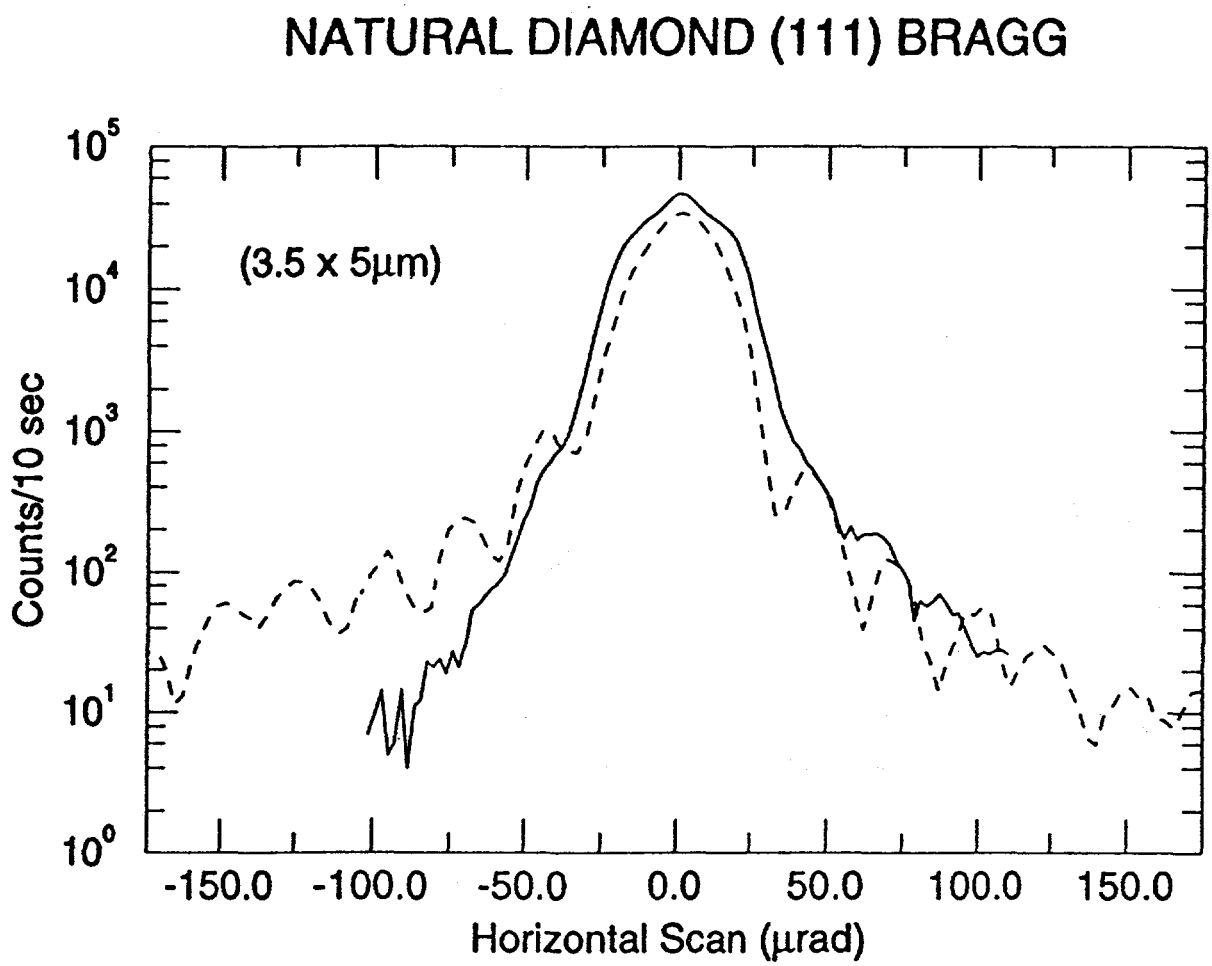
Diffracted beam (*R*) and transmitted beam (*T*) due to a single crystal.



Theoretical spatial intensity profiles of a reflection beam (*a*) and a transmission beam (*b*), in the symmetrical Laue case.

Diamond Mono. Crystals




NATURAL DIAMOND (111) BRAGG
(3.5 x 5μm)
Counts/10 sec
10^5
10^4
10^3
10^2
10^1
10^0
-150.0
-100.0
-50.0
0.0
50.0
100.0
150.0
Horizontal Scan (μrad)

X-ray Science with Polarized Radiation

Kenneth D. Finkelstein
Cornell High Energy Synchrotron Source (CHESS) and
Department of Applied and Engineering Physics,
Cornell University, Ithaca, New York 14853.

Collaborators

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S. Shastri		
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5/25/94

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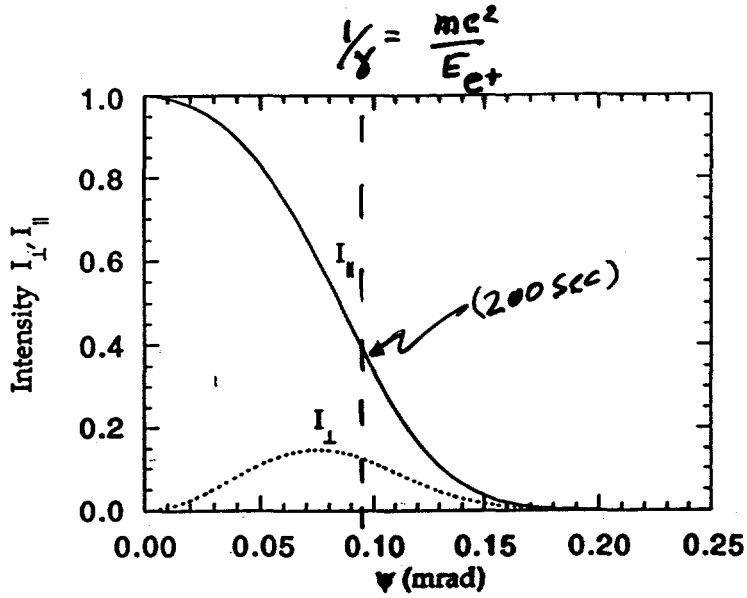
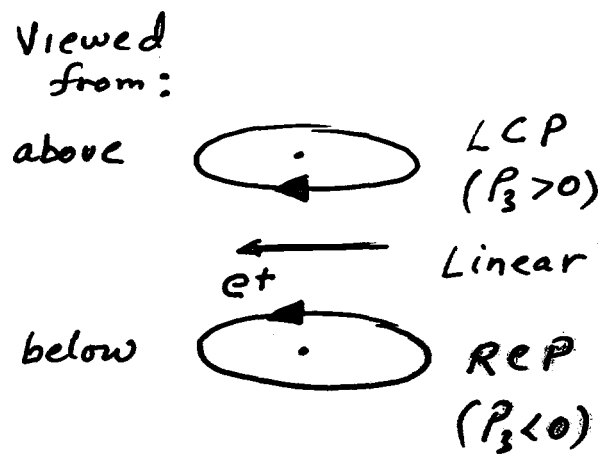
Introduction

Polarization Properties of Synchrotron Radiation

Bend magnet radiation is linearly polarized in the orbit plane of the storage ring, but contains elliptical polarization when viewed above or below this plane. Blume[1] defines the Stokes-Poincare parameters (P_1, P_2, P_3) which characterize respectively the degree of 0 and 90 degree linear polarization, +/-45 degree tilted linear polarization and left/right-handed circular polarization in an x-ray beam. The fraction of unpolarized intensity is given by $P_0=1-(P_1^2+P_2^2+P_3^2)^{1/2}$.

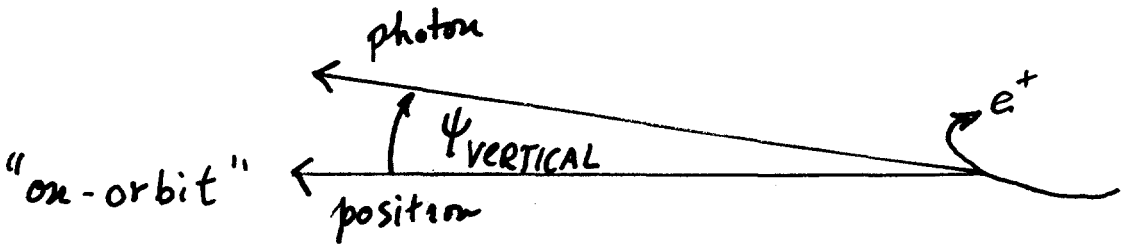
Linear polarization: σ (HORIZ), π (VERT.) are 90° phase shifted.





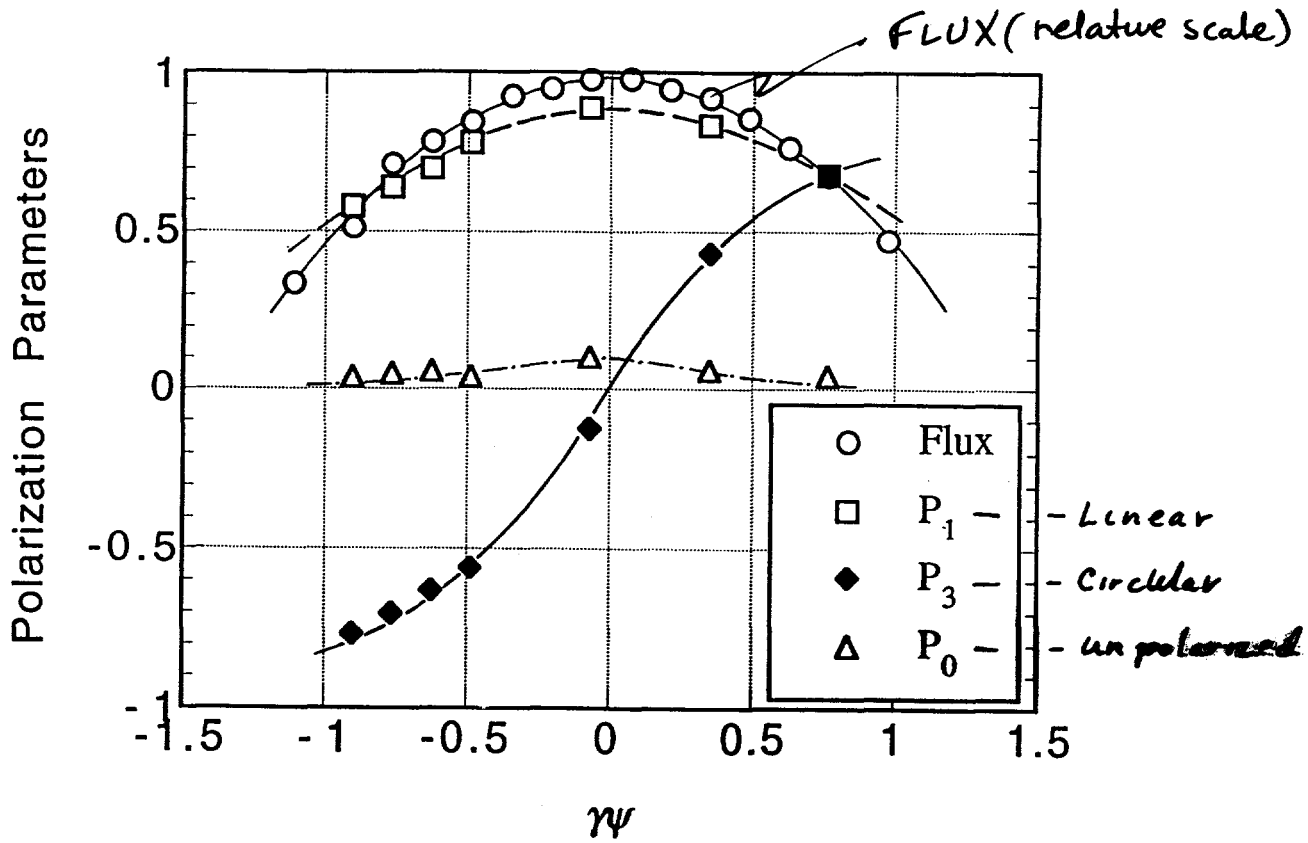
(SAME SITUATION HOLDS AT APS)

Figure B.1 Normalized intensity of the σ ($I_{\parallel}$) and π ($I_{\perp}$) polarizations as a function of the off axis angle ψ for 8keV photons at the CHESS D-line. (FROM[2] J.C. LANG (1993))



Measurements of the linear and circular polarization components of bend magnet radiation made by Qun Shen③ at CHESS F3 station. The beam is made monochromatic at 7.1keV by a double bounce silicon (111) monochromator and passed through a 0.25mm high by 1mm wide slit about 25meters from the positron source.

(70% mono reflectivity)



Intensity falls with Linear Polarization

Circular handedness reverses across $\gamma\psi \simeq 0$

* A measureable unpolarized intensity exists "on axis"

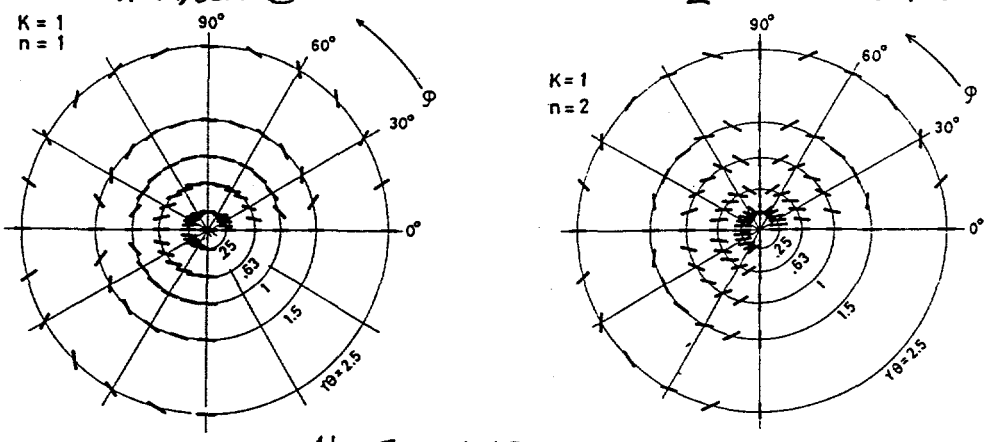
* The monochromator, source and slit size, and source divergence ⇒ changes in $\vec{P}$.

Other Sources

Wigglers: Linearly polarized sigma (or horizontal component) on axis, with the pi (or vertical component) becoming unpolarized well above and below the orbit plane.

Undulators: Mainly linearly polarized, but with a complicated energy, and angle dependence.

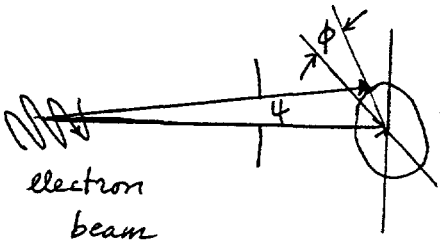
1st HARMONIC *Polarization of Undulator Radiation* 2nd Harmonic L187

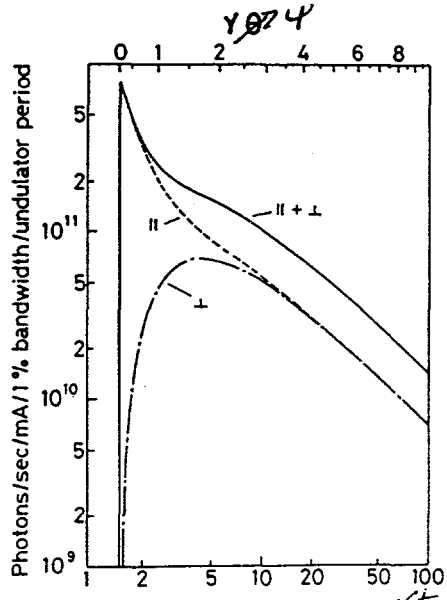


(a) At Fixed Energy (b)

Fig. 2(a) and (b). Dependence of the direction of linear polarization on the observing direction for the first harmonic (Fig. 2(a)) and the second harmonic (Fig. 2(b)) with $K=1$. Each circle represents a contour of $\gamma\theta$, the aximuth is ϕ and the direction of each bar inserted indicates the plane of polarization.

ψ = polar angle
ϕ = azimuth





λ/λ_0 At 1st Harmonic "Peak"

From: H. Kitamura (4) (1980)

1st HARMONIC

$$\frac{\lambda}{\lambda_0} = 1 + (\gamma\psi)^2 + \left(\frac{K^2}{2}\right)$$

K = deflection parameter in units of $\frac{1}{\gamma}$

Fig. 4. Spectra of the radiation from an undulator ($K=1$, the first harmonic). The abscissa represents the wavelength, normalized by $\lambda_0 = \lambda_n/(2\gamma^2)$. The broken line represents the intensity $N_{//}$ of the parallel component, the dot-dash line is the intensity $N_\perp$ of the perpendicular component, and the solid line is the sum of both components.

APS: What to Expect

Comparison to lower emittance machines

As you have seen, one can obtain $P_1>0.90$ at a first generation machine. Further, the monochromator can strongly influence the purity of x-ray polarization on a sample. On the face of it then, bend magnets at third generation machines will increase the available high purity flux, but not by much. On the other hand as discussed below, undulator and high brightness wiggler beams will permit phase plates to attain extremely high throughput.

As pointed out to me by D. McWhan at this meeting, certain measurements will benifit significantly from an increase in P_1 from 0.9 to 0.99. Most notable are magnetic scattering experiments where L and S (the orbital and spin components of angular momentum in magnetic materials) are to be seperately determined. Another example of this sensitivity to polarization purity occurs in the method of x-ray scattering from ferro-magnetics discussed at the end of this talk.

Beam Manipulation and Preparation

Control of the polarization can be achieved with Bragg diffracting linear polarizers and phase plates for elliptical polarization. Phase plates should be capable of providing high intensity beams by using high brightness insertion devices as the source. Several phase plates that have been tested are:

Bragg - Laue type at high energies Mills (5) APS, CHESS

Bragg transmission type at medium energy Ishikawa (6) PF, LURE, ESRF, APS

Bragg reflection type also medium energy Batterman (7) CHESS

Experimental measurements where circular polarization is important:

X-ray magnetic circular dichroism
Resonant and non-resonant magnetic scattering
Magnetic Compton Scattering
Determination of the phase of structure factors in crystallography
Nuclear Bragg scattering

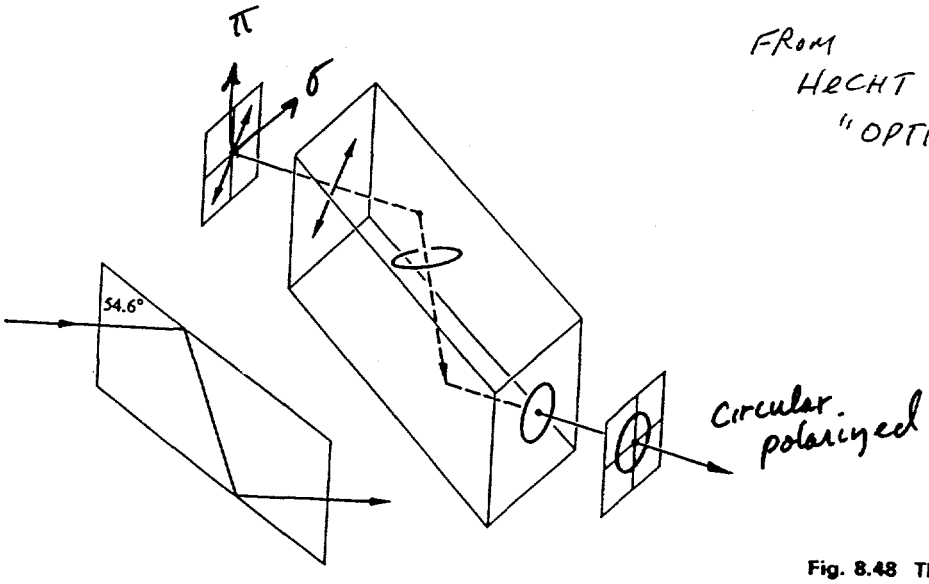
Important qualities for elliptically polarized beams and sources:

Stability
High intensity
High polarization purity
Controllable polarization content (flipping of the helicity)
Energy tunable (diverse energy ranges)
Good angular collimation
Practical: initial cost, flexibility, reproducible performance

In general, they all benifit* from a high brightness source

* THROUGHPUT, P_3

CHESS/APS Undulator run: Bragg Reflection Phase Plate Performance

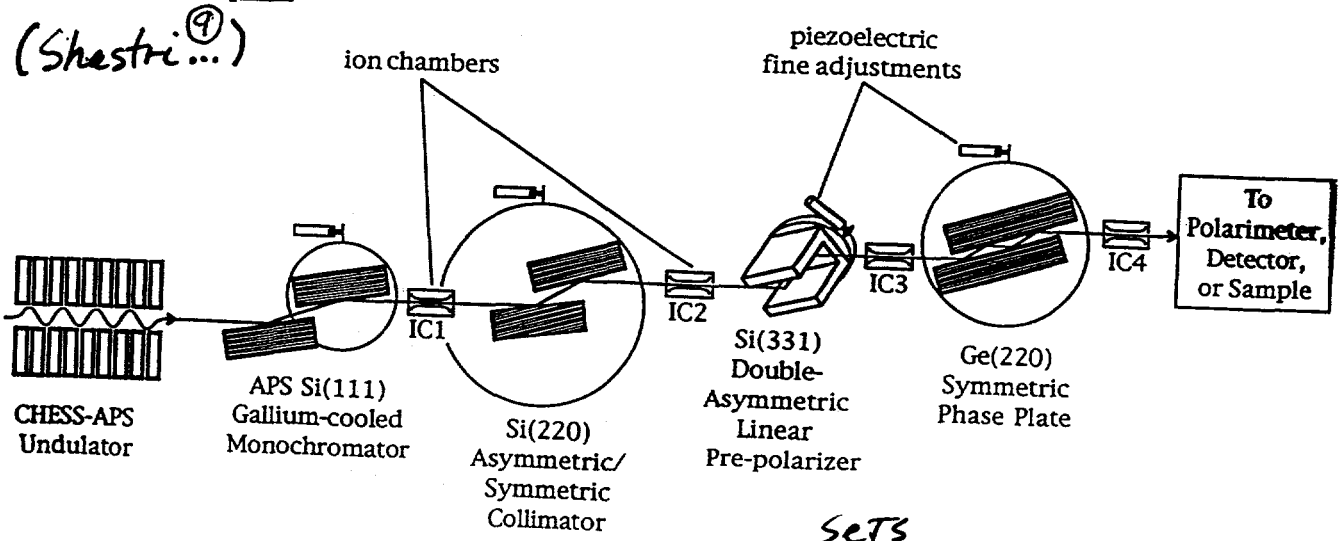


FROM HECHT + ZAJAC (8) "OPTICS"

Fig. 8.48 The Fresnel rhomb.

Crystal Optics

(Shastri ... (9))



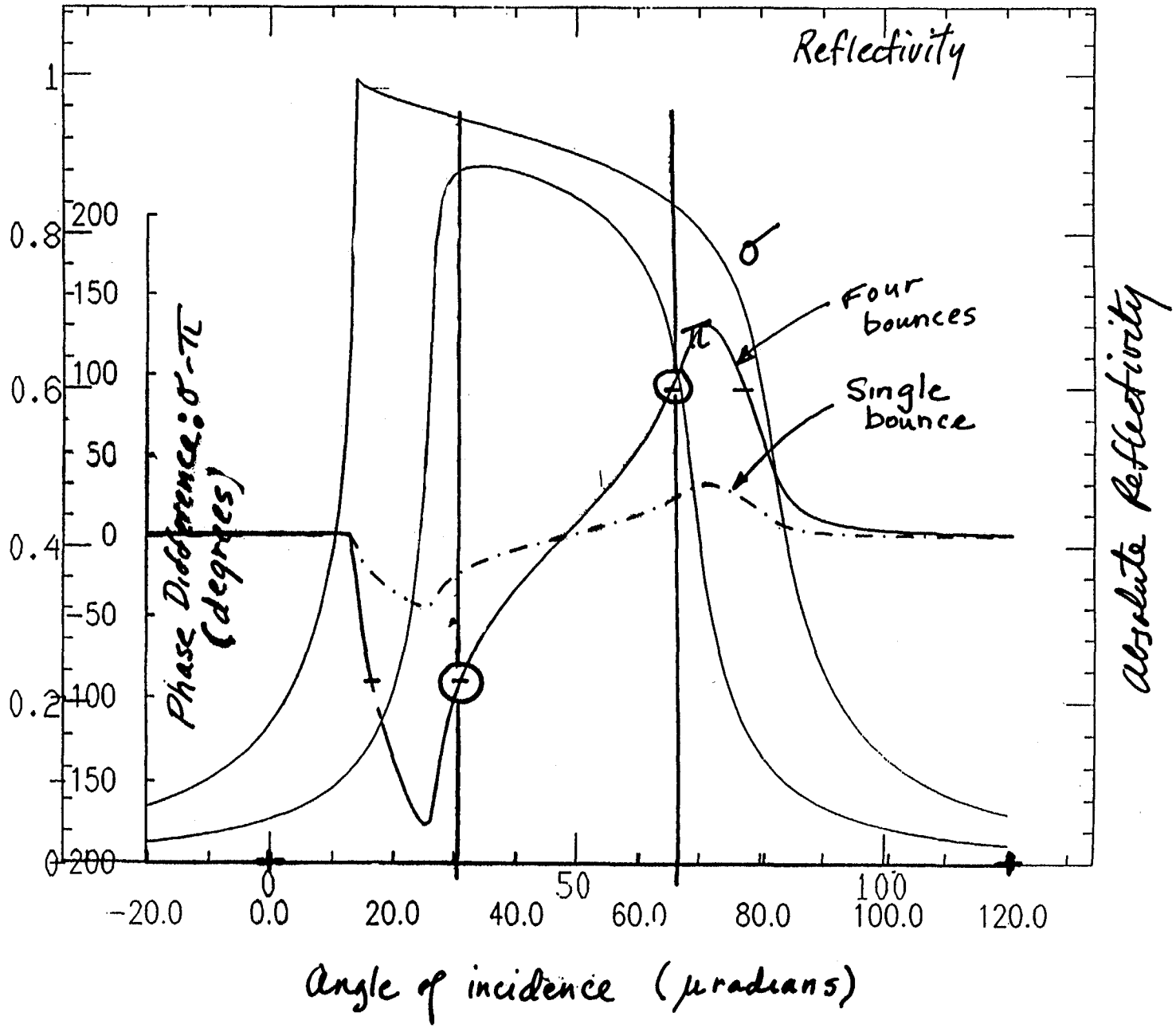
(not typically required)

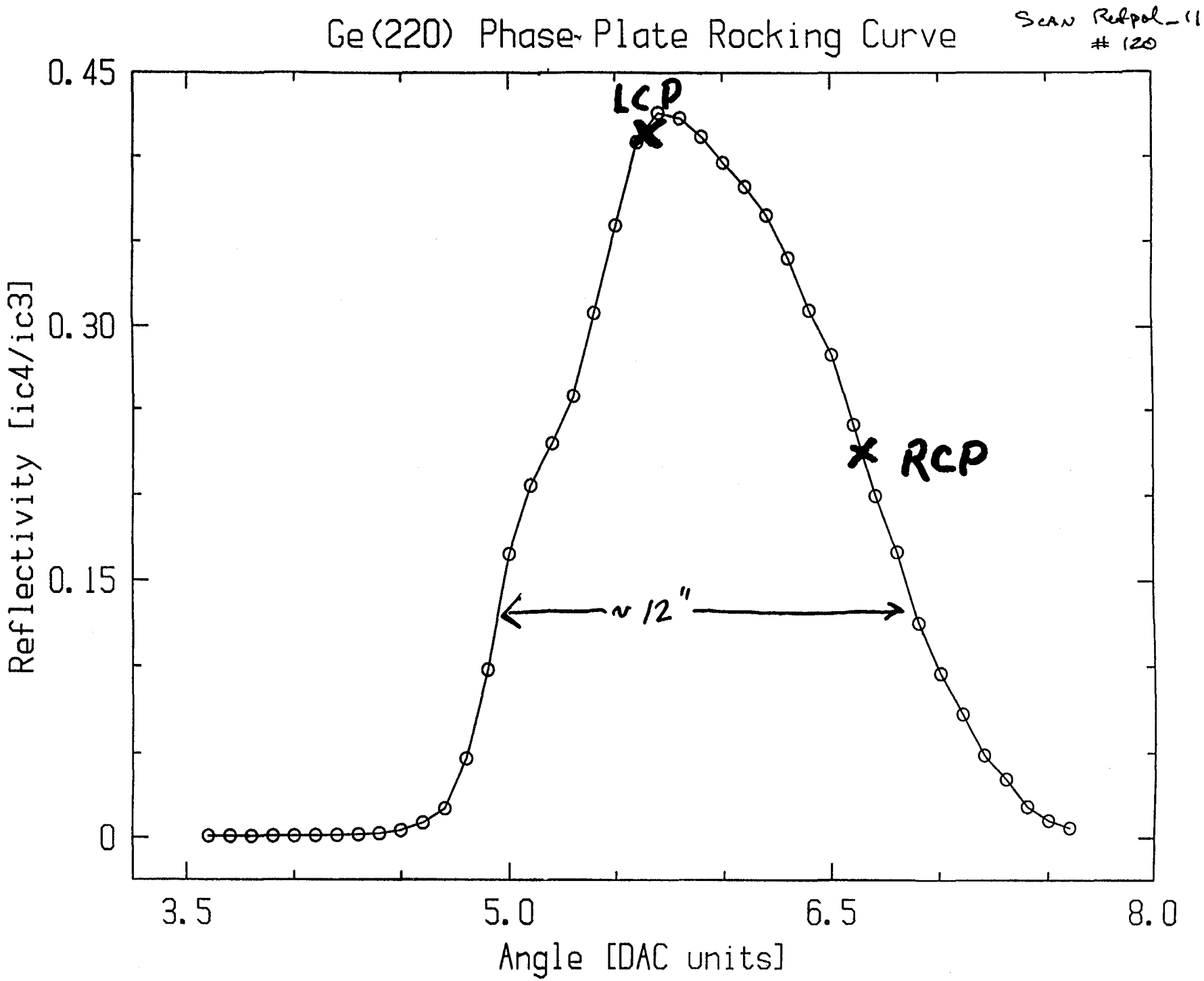
SETS THE "45°-LINEAR" POLARIZATION

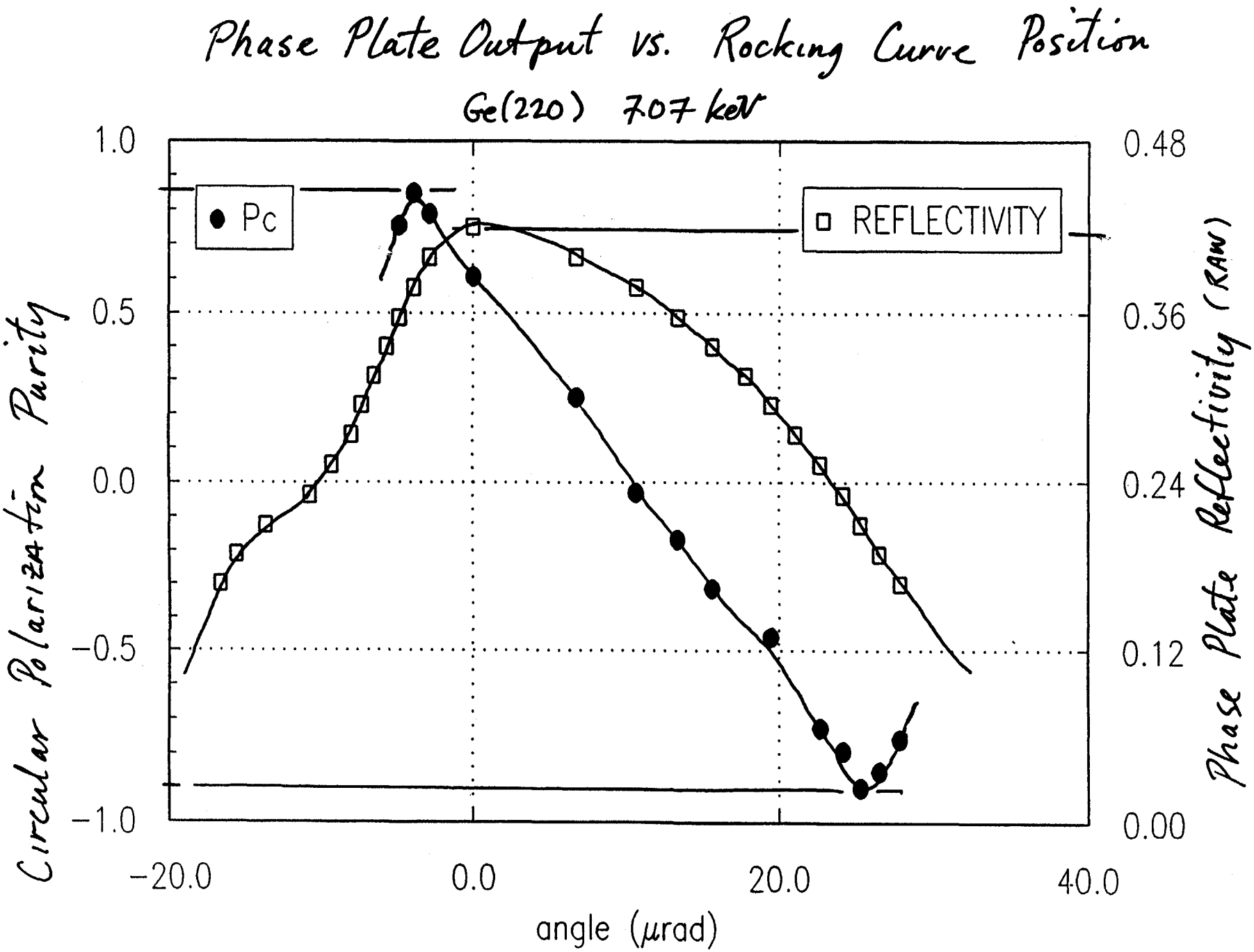
5×10^{11} p/s ⟶ 2×10^{8} p/s (expected 3×10^{8})

at APS (10^{10} p/s w/o trying)

Perfect Crystal Ge (220) Reflection (7.1 keV)
(no convolution with incident divergence)




Ge(220) Phase-Plate Rocking Curve
Scan Refpol_11
120
LCP
RCP
~ 12"
0.45
0.30
0.15
0
Reflectivity [ic4/ic3]
3.5
5.0
6.5
8.0
Angle [DAC units]


Phase Plate Output vs. Rocking Curve Position
Ge(220) 707 keV
Pc
REFLECTIVITY
Circular Polarization Purity
Phase Plate Reflectivity (RAW)
1.0
0.5
0.0
−0.5
−1.0
0.48
0.36
0.24
0.12
0.00
−20.0
0.0
20.0
40.0
angle (μrad)

Polarization Analysis

Complete Characterization by Multi-beam Bragg Diffraction

(10)

(Qun Shen)

(1) Linear Polarization:

usual linear polarization analysis

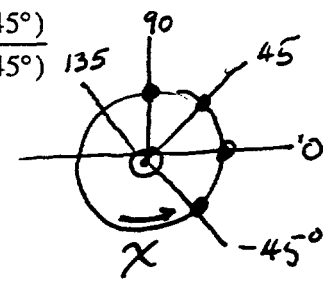
$$I(\chi) = \frac{I_o}{2}\left[(1+\cos^2 2\theta)+(P_1\cos 2\chi + P_2 \sin 2\chi)(1-\cos^2 2\theta)\right], \qquad (1)$$

P_1, P_2

$$\begin{bmatrix} P_1 \\ P_2 \end{bmatrix} = \frac{1+\cos^2 2\theta}{\sin^2 2\theta}\begin{bmatrix} P_1(2\theta) \\ P_2(2\theta) \end{bmatrix}.$$

$$P_1(2\theta) = \frac{I(0°)-I(90°)}{I(0°)+I(90°)}$$

$$P_2(2\theta) = \frac{I(45°)-I(-45°)}{I(45°)+I(-45°)}$$



(2) Circular Polarization:

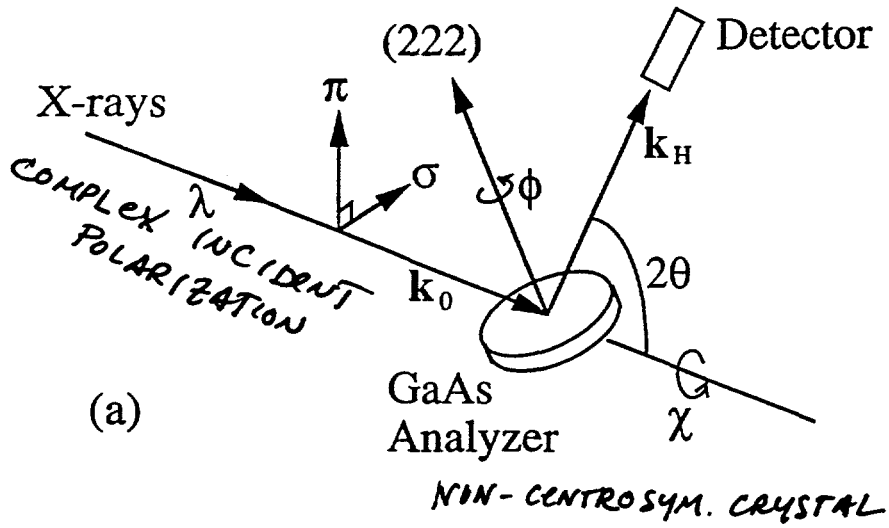
$$\begin{aligned} I_{\text{int}} = I\cdot B(\phi)\,\{ \quad & \cos\delta\,[A_{\sigma\sigma} + A_{\pi\pi}\cos 2\theta] \\ & + P_1\cos\delta\,[A_{\sigma\sigma} - A_{\pi\pi}\cos 2\theta] \\ & + P_2\cos\delta\,[A_{\pi\sigma} + A_{\sigma\pi}\cos 2\theta] \\ & + P_3\sin\delta\,[-A_{\pi\sigma} + A_{\sigma\pi}\cos 2\theta]\,\}, \end{aligned} \qquad (3)$$

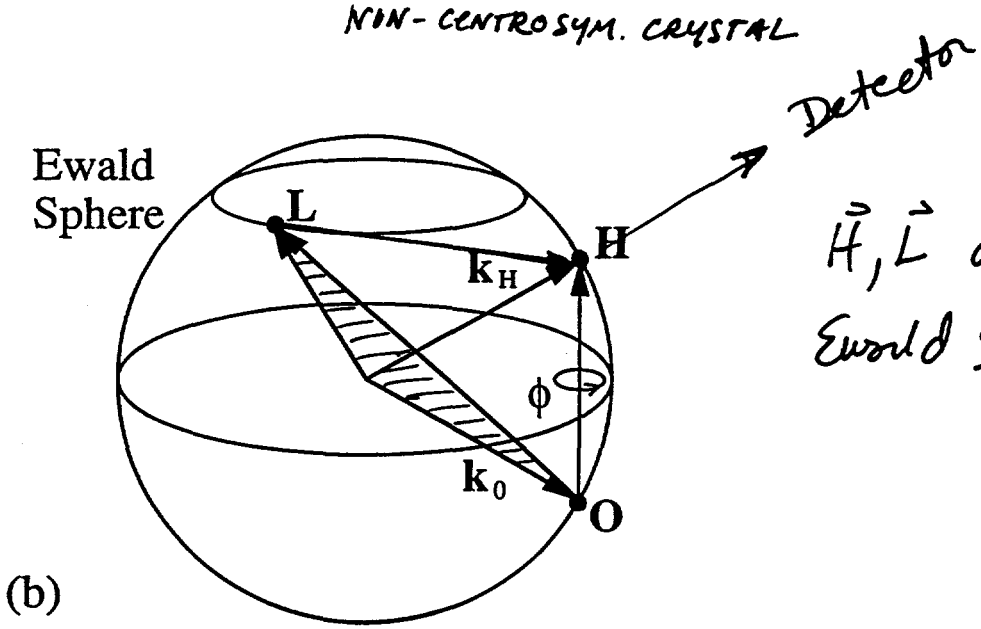
where, I is the usual two-beam diffracted intensity, $B(\phi) = -1/[\,2\cos\theta\,\lambda(L\cdot\sigma)\Delta\phi\,]$ defines the deviation in azimuthal angle $\Delta\phi$ from the full multi-beam excitation with an effective Lorentzian factor, and $A_{\sigma\sigma}$, $A_{\sigma\pi}$, $A_{\pi\sigma}$ and $A_{\pi\pi}$ represent the strengths for $\sigma\rightarrow\sigma$, $\sigma\rightarrow\pi$, $\pi\rightarrow\sigma$ and $\pi\rightarrow\pi$ scattering, respectively, in the MBD process. For maximum sensitivity to circular polarizations, we choose an MBD reflection with $\delta\approx\pm 90°$, which simplifies eq.(3) to

$\Rightarrow P_3$

$$I_{\text{int}} = I\cdot B(\phi)\;\; P_3\sin\delta\,[-A_{\pi\sigma} + A_{\sigma\pi}\cos 2\theta] \qquad (4)$$

Phase sensitive Interference



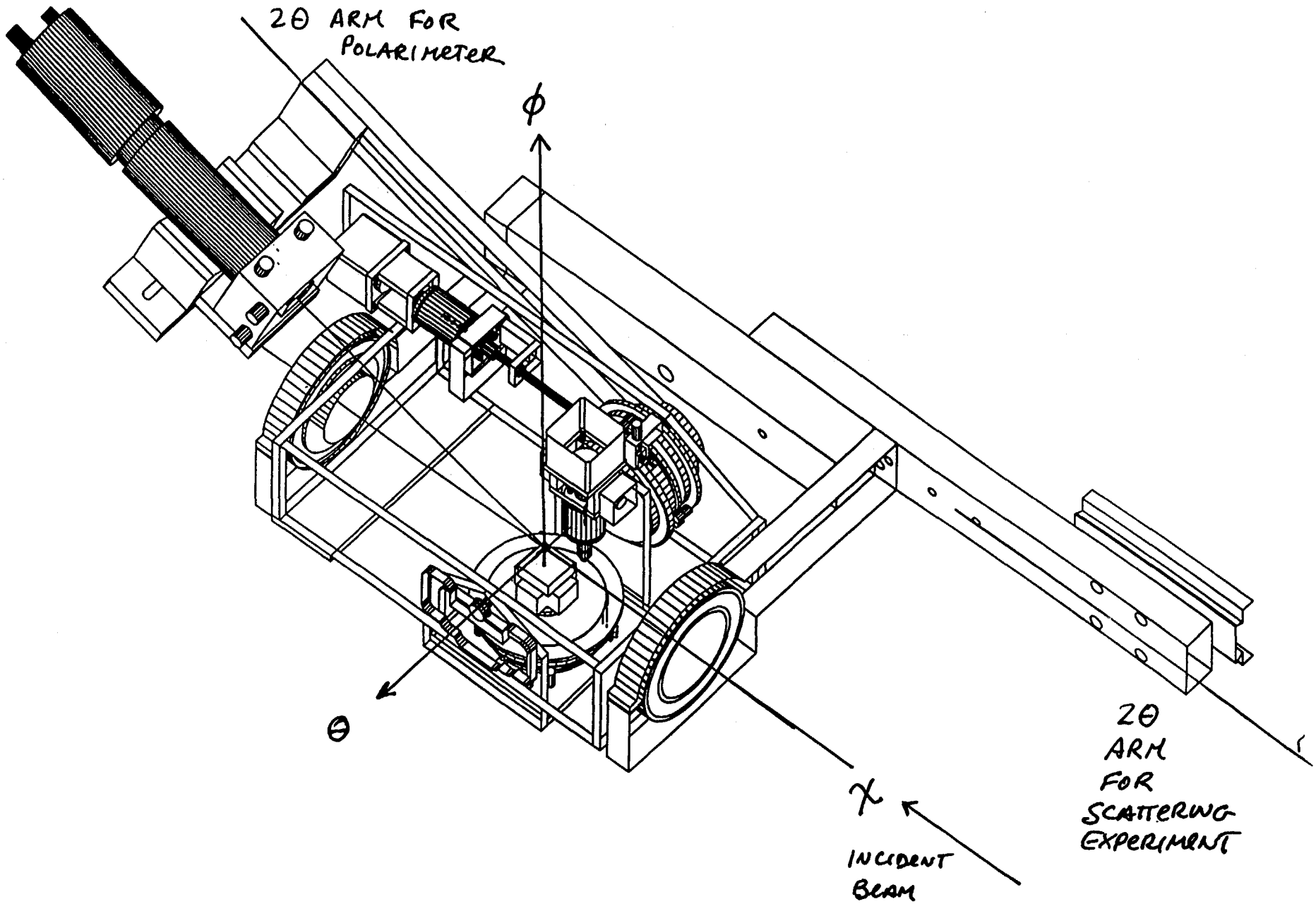


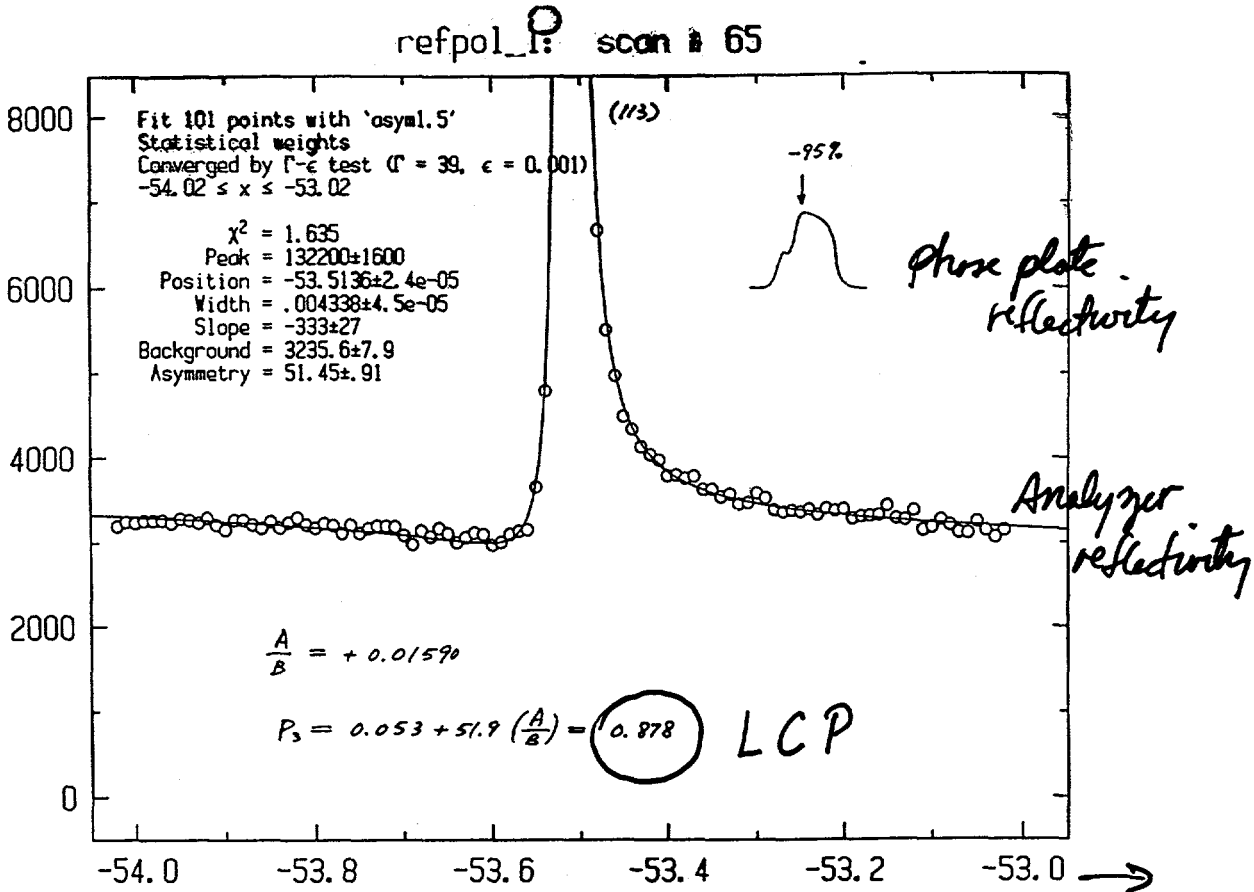
$\vec{H}, \vec{L}$ on Ewald Sphere

- The $\vec{L}, \vec{k}_0$ plane is <u>not</u> parallel to $\vec{H}, \vec{k}_0$
- σ, π incident are mixed into σ', π' in $\vec{L}\vec{k}_0$ plane ($\hat{\sigma}' = a_1\hat{\sigma} + b_1\hat{\pi}$, $\hat{\pi}' = a_2\hat{\sigma} + b_2\hat{\pi}$)
- The complex structure factors change the phase of $\sigma, \pi, \sigma', \pi'$

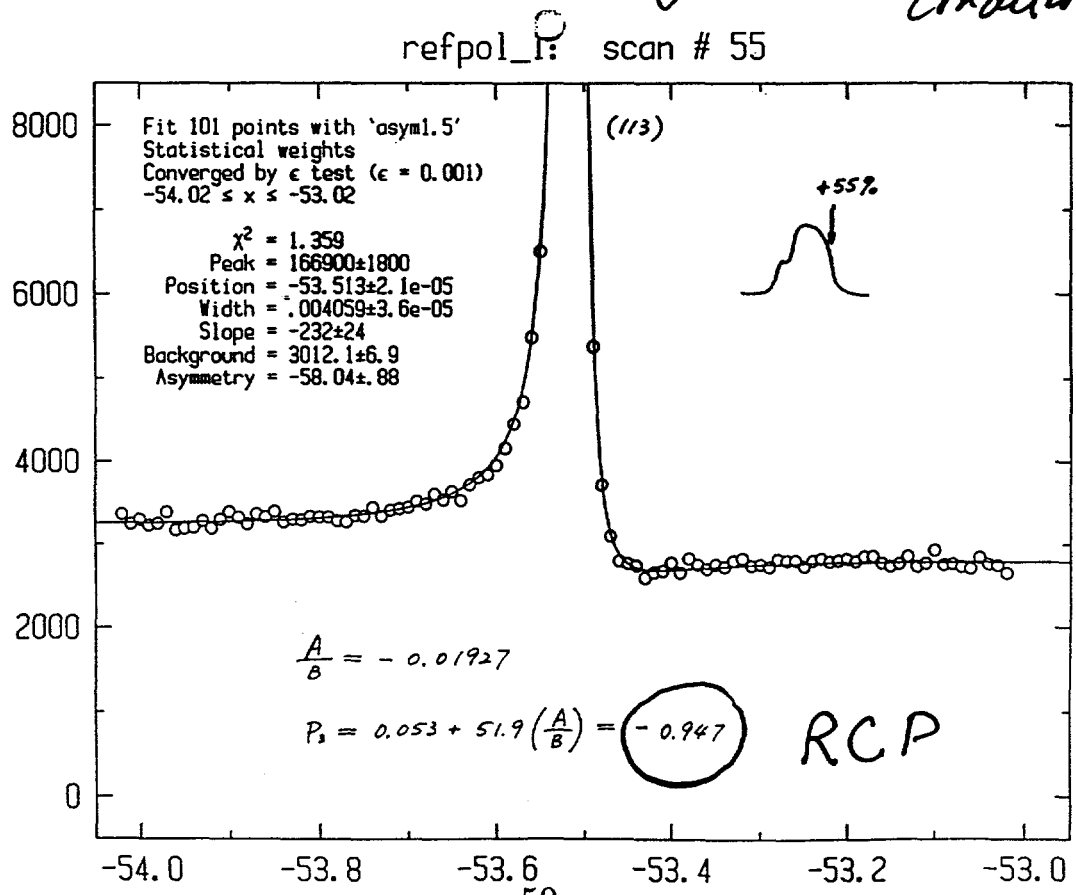
$\Rightarrow$ Results in Phase Sensitive Interference

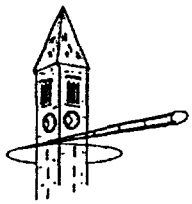
CHESS Multi-purpose Polarimeter (FINKELSTEIN) 1994 (11)





Rotate through the multi-beam conductor





X-ray Science with Polarized Radiation

July 24-25, 1994
Cornell University, Ithaca, NY. 14853, USA.

TENTATIVE PROGRAM

Sunday morning, July 24:

B.W. Batterman (CHESS, USA):	Welcome and opening remarks;
V. Belyakov (Surf.-Vac. Res. Ctr, Russia):	General overview;
E. Isaacs (AT&T Bell Labs, USA):	Magnetic scattering on heavy fermion systems;
P. Carra (ESRF):	Theory on dichroism and resonant elastic scattering;
G. Drager (Halle, Germany):	Polarization dependent XANES;
K. Finkelstein (CHESS, USA):	Elastic resonant scattering on metal oxides;

Sunday afternoon, July 24:

E. Gluskin (APS, USA):	Advances on special insertion devices;
T. Ishikawa (U. Tokyo, Japan):	Overview on perfect crystal phase retarders;
C. Malgrange (U. Paris, France):	Magnetic circular dichroism using energy dispersive phase plate;

POSTER VIEWING.

Dinner cruise on Cayuga Lake.

Monday morning, July 25:

U. van Buerck (TU. München, Germany):	Nuclear resonant scattering;
M.J. Cooper (U. Warwick, UK):	Magnetic Compton scattering;
C.T. Chen (AT&T Bell Labs, USA):	Polarization phenomena in soft x-ray spectroscopy;
M. Hamrick (Rice U., USA):	Quasi-elastic resonant scattering;
C-C. Kao (NSLS, USA):	Resonant raman scattering;
Y. Ma (U. Washington, USA):	Resonant inelastic scattering as a band-structure probe;
M. Hart (U. Manchester, UK):	Concluding remarks.

Resonant (Near-edge) Diffraction

Templeton[12] has pioneered the study of anisotropic anomalous x-ray scattering which is sensitive to the environment of resonating atoms in a crystal. More recently Kirfel[13] has demonstrated the influence of this effect on birefringence, pleochroic transmission and anistropic fluoresence in non-cubic structures. At CHESS we have been studying the multi-pole nature of x-ray scattering using polarization analysis as a tool for understanding near-edge structure. Recent work by Hamrick[14], Blume[15], and Carra[16] has helped to put these effects on a firm theoretical foundation.

$\hbar\omega$; photon polarization $\hat{\varepsilon}, \hat{\varepsilon}'$; wavevectors $\vec{k}, \vec{k}'$

Coherent Scattering (initial = final state of scatterer)

$$H_{\substack{\text{elect-photon} \\ \text{" - atom}}} = H_{0\,\text{ATOM}} + \frac{r_0}{2}\vec{A}^2_{\text{photon}} - \frac{e}{mc}\vec{p}_{\text{electron}}\cdot\vec{A}$$

Thomson Scattering

"Anomalous Scattering"

<u>Differential Scattering Xsection:</u>

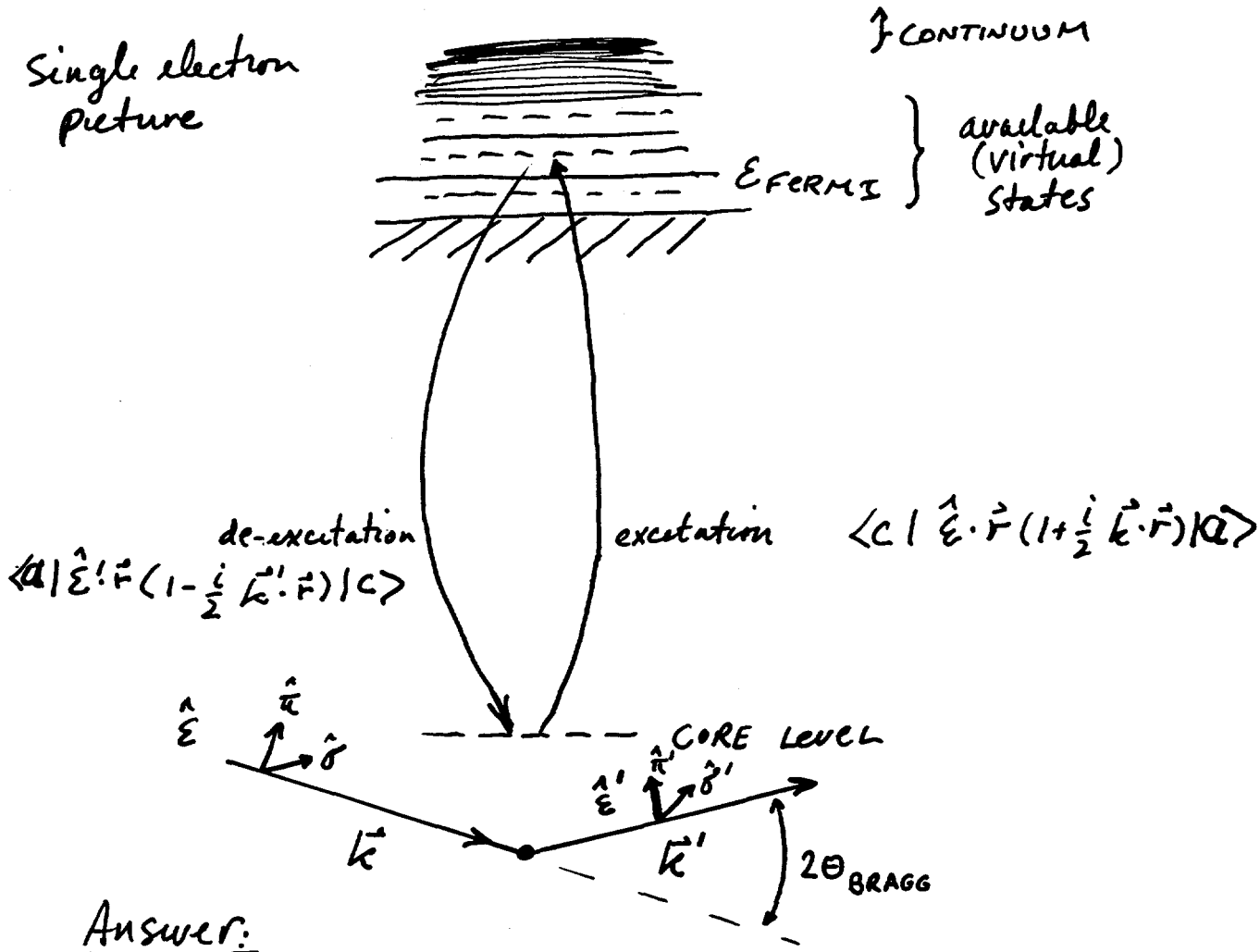
$$\frac{d\sigma}{d\Omega'} = |A|^2 \quad \text{where} \quad A = -r_0 \sum_{R_{\text{ATOMS}}} e^{i\vec{k}\cdot\vec{R}} \Bigg\{ \sum_{r_{\substack{\text{atomic}\\ \text{elect.}}}} \langle i | e^{i\vec{k}\cdot\vec{r}} | i \rangle \hat{\varepsilon}'\cdot\hat{\varepsilon}$$

$$+ m \sum_{\substack{c \\ \text{excited states}}} \frac{(E_c - E_a)^3}{k^3\omega} \frac{\langle a | \overbrace{\sum_j \hat{\varepsilon}'\cdot\vec{r}_j}^{\text{dipole}} \overbrace{(1 - \tfrac{i}{2}\vec{k}'\cdot\vec{r}_j)}^{\text{Quadrupole}} | c \rangle \langle c | \overbrace{\sum_l \hat{\varepsilon}\cdot\vec{r}_l}^{\text{dipole}} \overbrace{(1 + \tfrac{i}{2}\vec{k}\cdot\vec{r}_l)}^{\text{Quad.}} | a \rangle}{E_a - E_c + \hbar\omega - i\Gamma_c/2} \Bigg\}$$

$$A = A_{\text{Thomson}} + A^{dd}_{\text{reson.}} + A^{dq}_{\text{reson.}} + A^{qq}_{\text{reson.}}$$

Question:

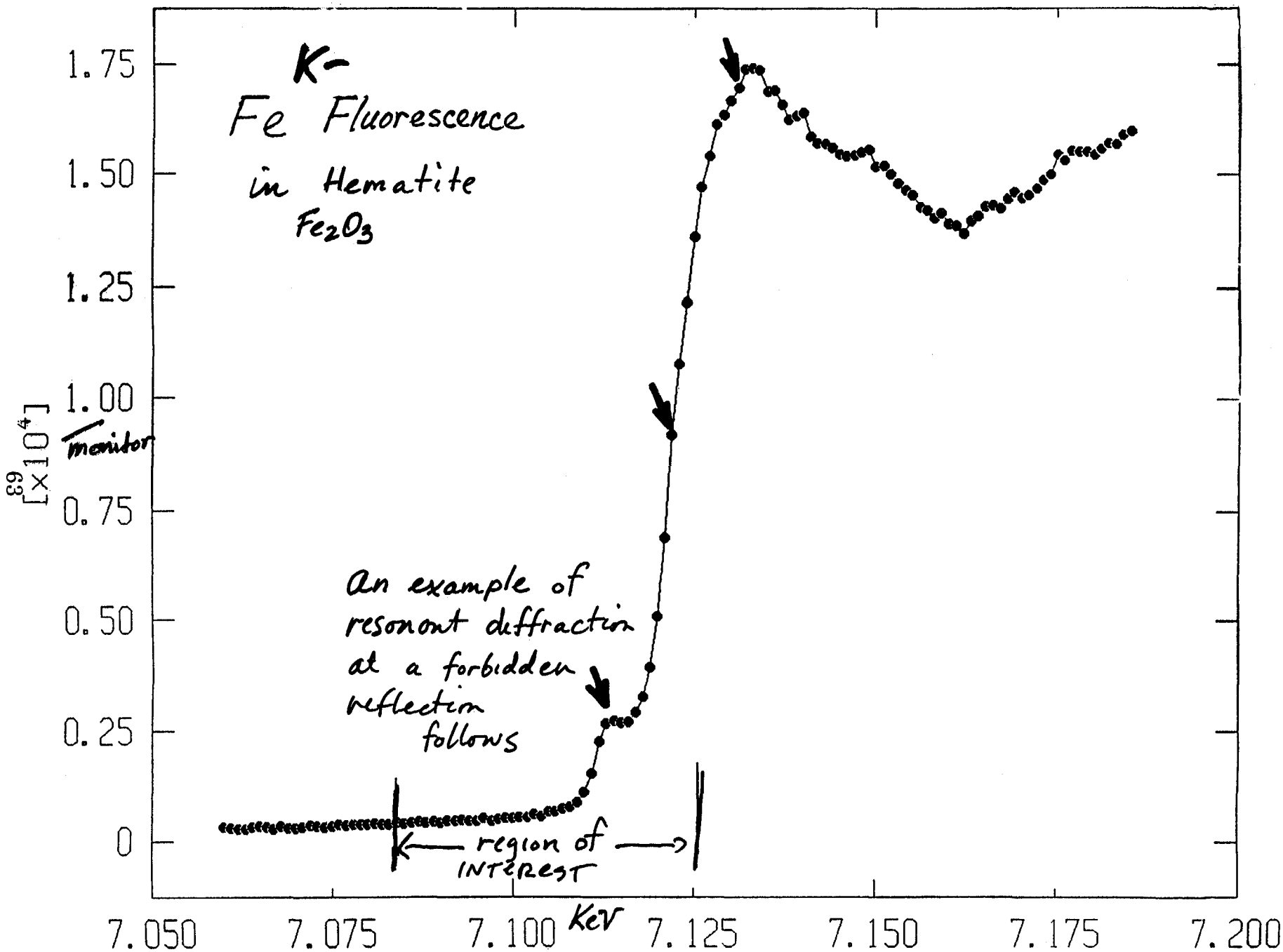
What can I learn about these states $|c\rangle$; the available (valence) states of the atom with a core hole?



Answer:

$A_{reson.}$ is sensitive to the projections of the spacial distribution of $|c\rangle$ and the energy level distribution around ε_F.

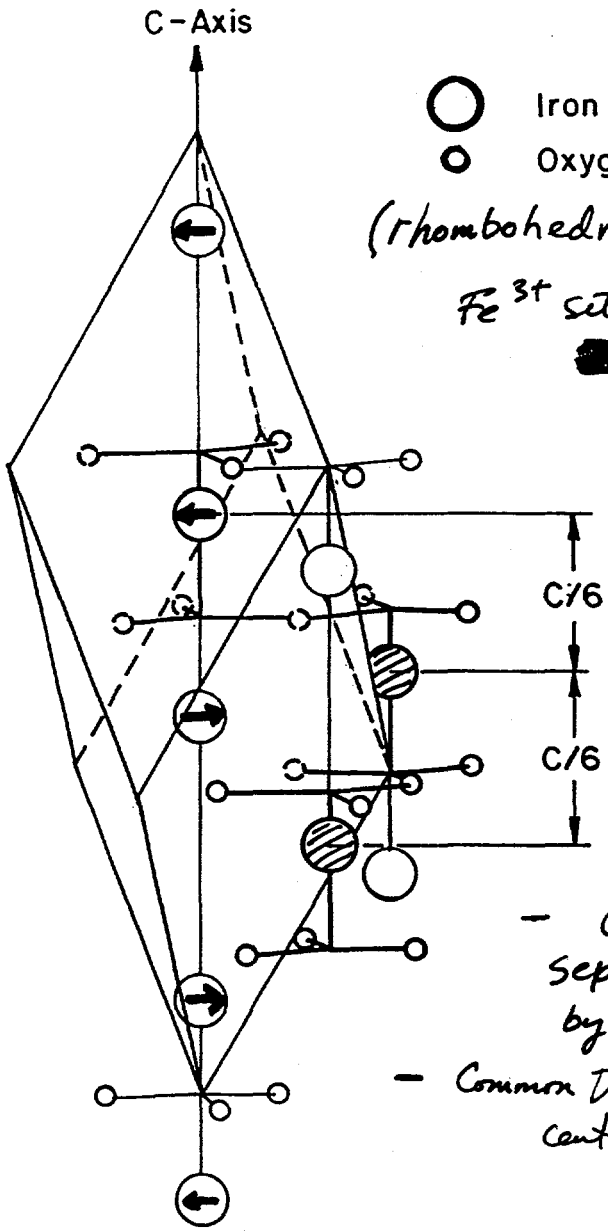
Two Phases: Bragg Phase $e^{i\vec{K}\cdot\vec{R}}$, "anomalous" phase


K-
Fe Fluorescence
in Hematite
Fe_2O_3
An example of
resonant diffraction
at a forbidden
reflection
follows
region of
INTEREST
1.75
1.50
1.25
1.00
0.75
0.50
0.25
0
$\frac{63}{monitor}$ [$\times 10^4$]
7.050
7.075
7.100
7.125
7.150
7.175
7.200
KeV

Hematite (α-Fe_2O_3) Fe^{3+} $R\bar{3}c$

(Finkelstein et.al (1992)) (17), (18)

2220492-001

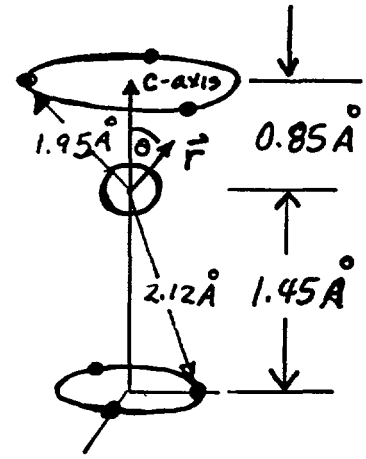


(rhombohedral unit cell)

C_3

Fe^{3+} site symmetry: 3.

3-fold about the c-Axis



- Glide Plane ⇒ "Octahedra" separated by c/6 are rotated by ~180° about the c-axis
- Common Displacement of Iron atom, from center of "Octahedra", at each site.

Crystalline electric potential for $|\vec{r}| < |\vec{R}_{\text{iron-oxygen}}|$

$$V(\vec{r}) = V(r,\theta,\phi) = V_{00} + \underline{V_{10} + V_{30}} + V_{3,\pm 3} + \text{higher order (odd)}$$

$$+ \underline{V_{CUBIC}} + V_{20} + V_{4\pm 3} + \text{higher order (even)}$$

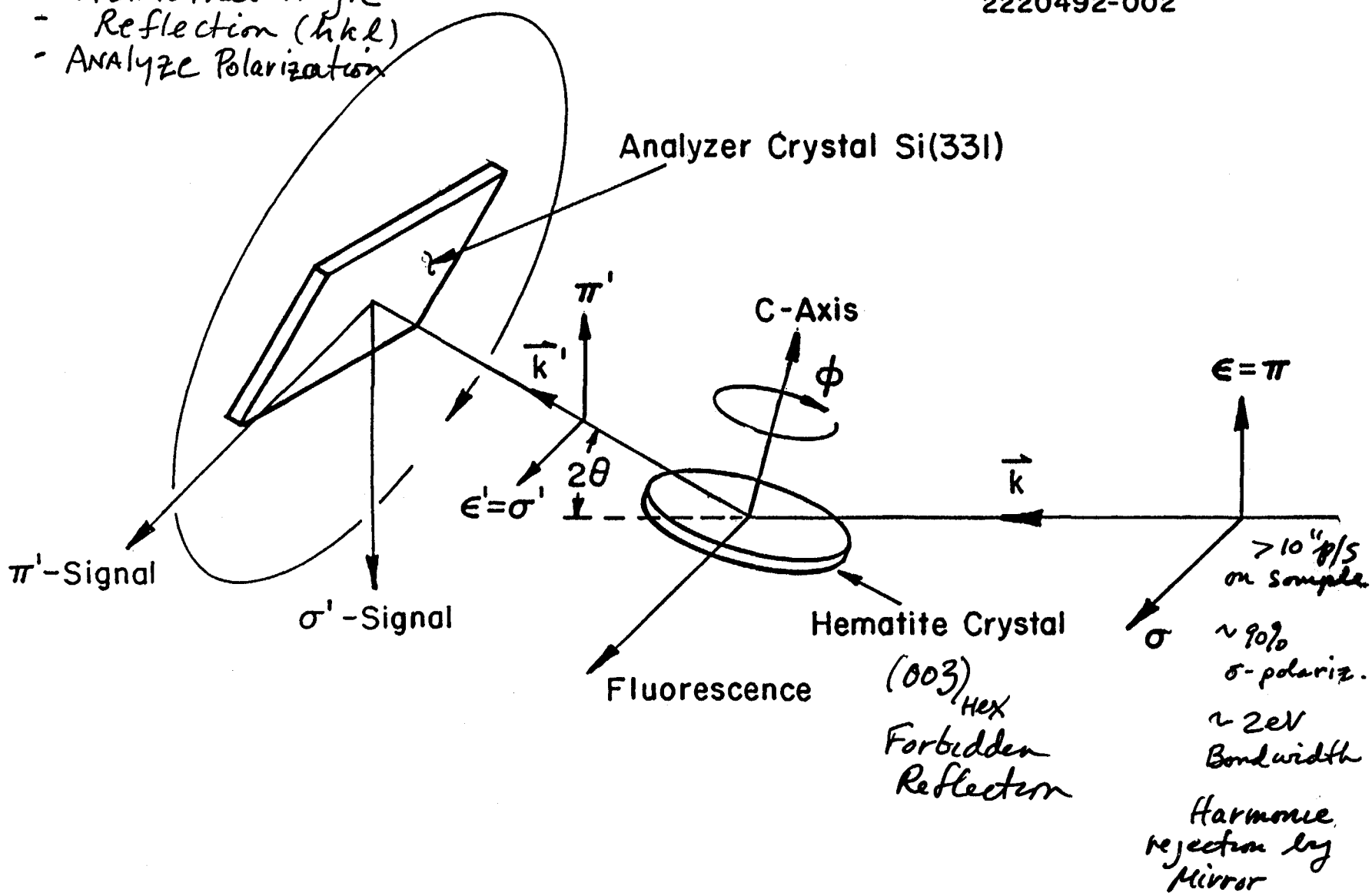
⇒ Dipole Transitions E1/E1 **and** 4p/3d mixing ⇒ E1/E2

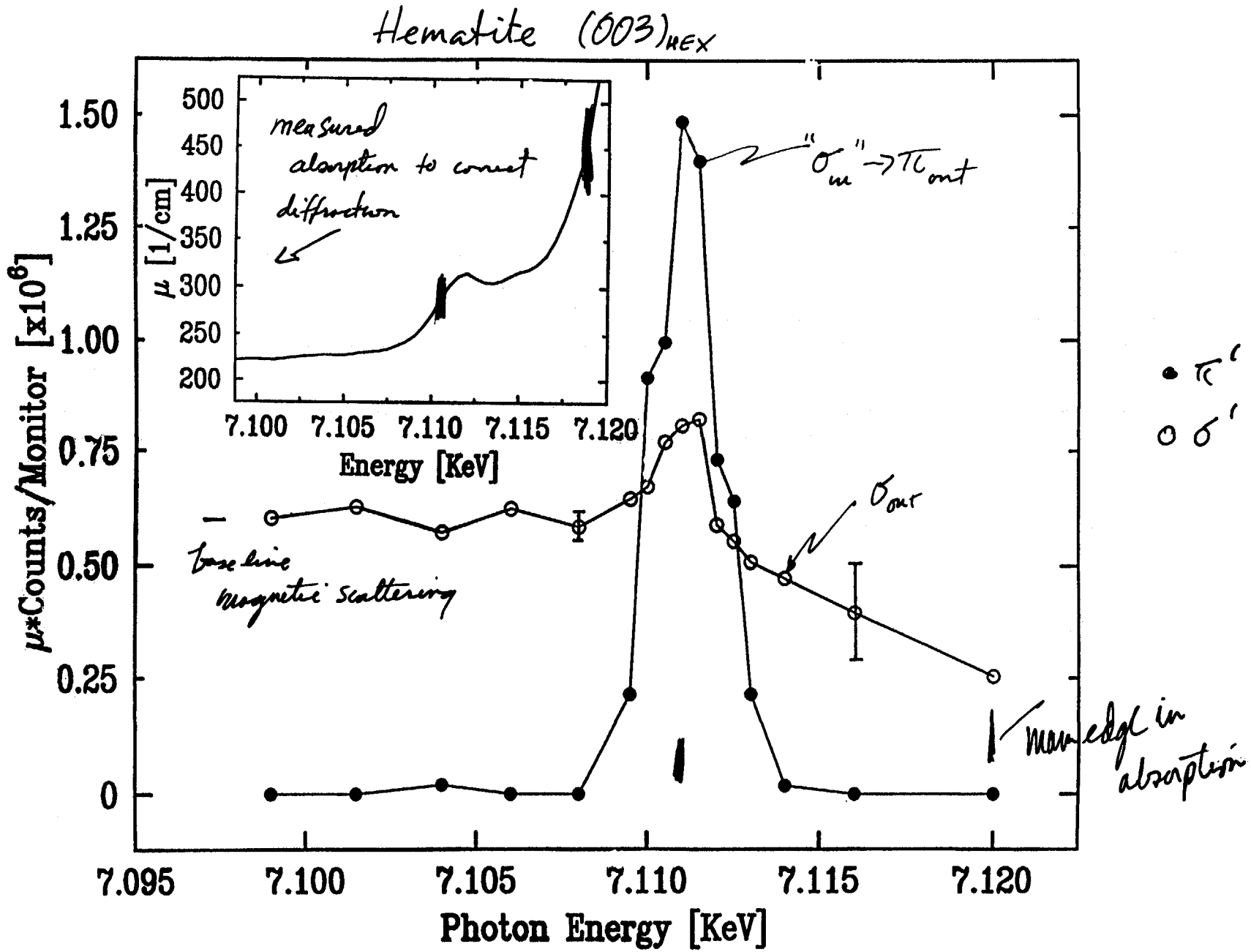
quadrupole Transitions E2/E2

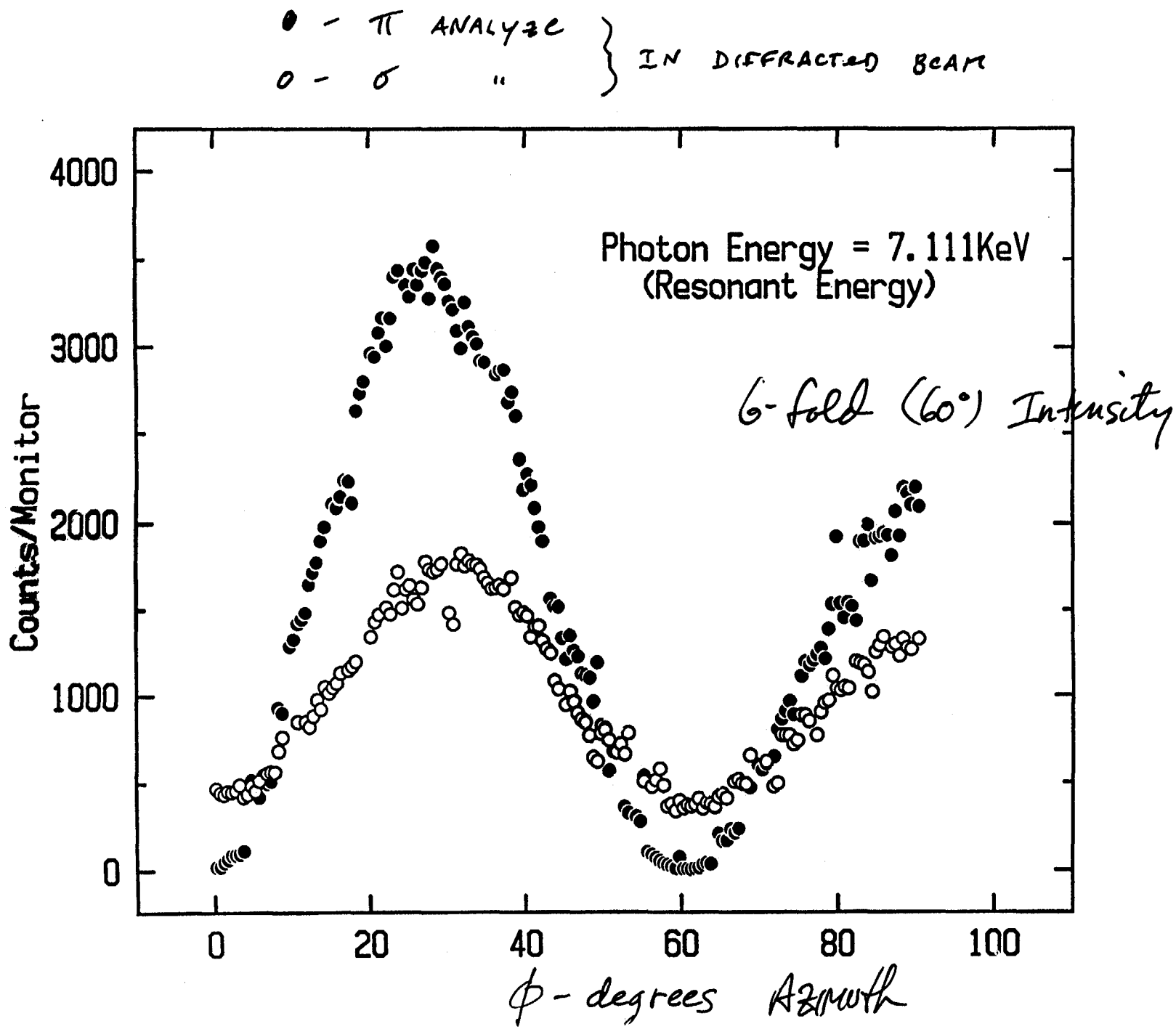
Experimental Arrangement

4 Handles (Knobs to turn):
- incident photon energy
- Azimuthal Angle
- Reflection (hkl)
- Analyze Polarization

2220492-002




Hematite (003)HEX
μ*Counts/Monitor [x10^6]
1.50
1.25
1.00
0.75
0.50
0.25
0
7.095
7.100
7.105
7.110
7.115
7.120
Photon Energy [KeV]
μ [1/cm]
500
450
400
350
300
250
200
7.100
7.105
7.110
7.115
7.120
Energy [KeV]
measured absorption to correct diffraction
"σ_in" → π_out
σ_out
baseline magnetic scattering
wavedgl in absorption
π'
σ'

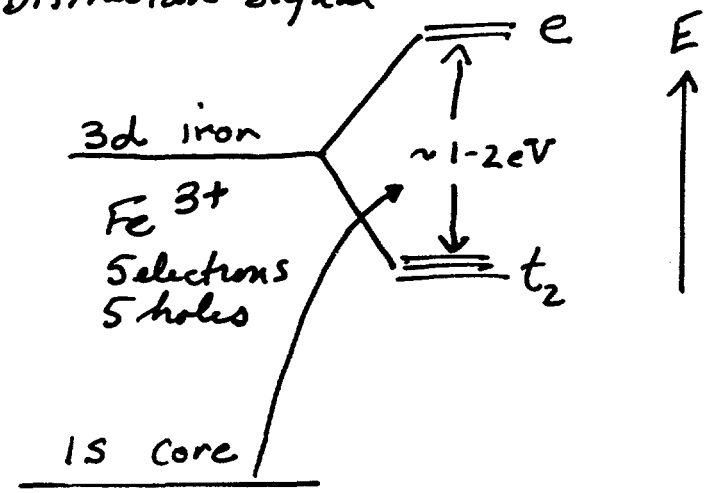

● - π ANALYZE
○ - σ "
IN DIFFRACTED BEAM
Photon Energy = 7.111KeV
(Resonant Energy)
6-fold (60°) Intensity
Counts/Monitor
4000
3000
2000
1000
0
0
20
40
60
80
100
φ - degrees Azimuth

Resonant Scattering below K-edge

Hematite Fe_2O_3 M. Hamrich[14] (1992)

1) Forbidden Reflection → Allowed
2) Location in Energy 10 eV below inflection
3) $\hat{\sigma} \rightarrow \hat{\pi}'$ Scattering
4) 6-fold Intensity variation w/ Azimuth
5) Magnitude of Diffraction Signal ~ 0.07 r_0

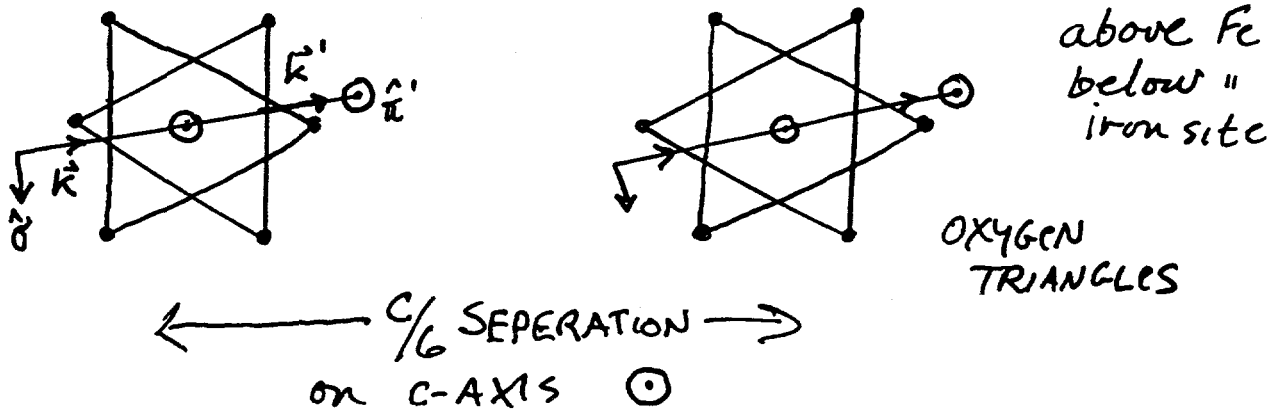
Consider Octahedral Field of Oxygens ⇒



e States point toward Oxygen

t_2 " " between "

View Scattering from Above:

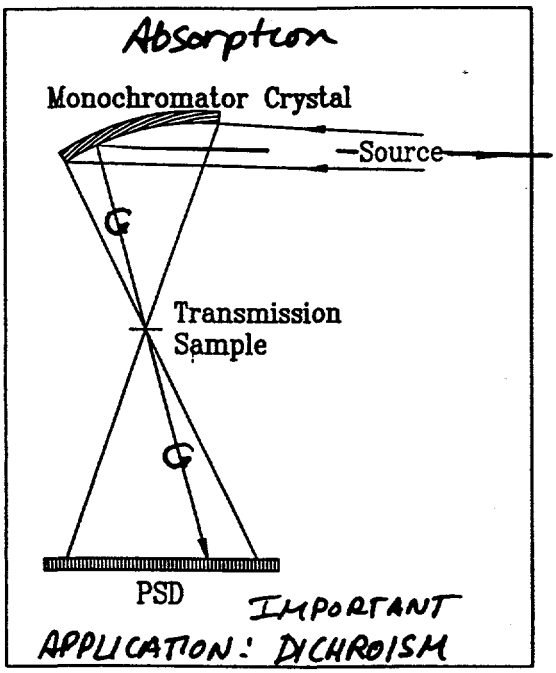


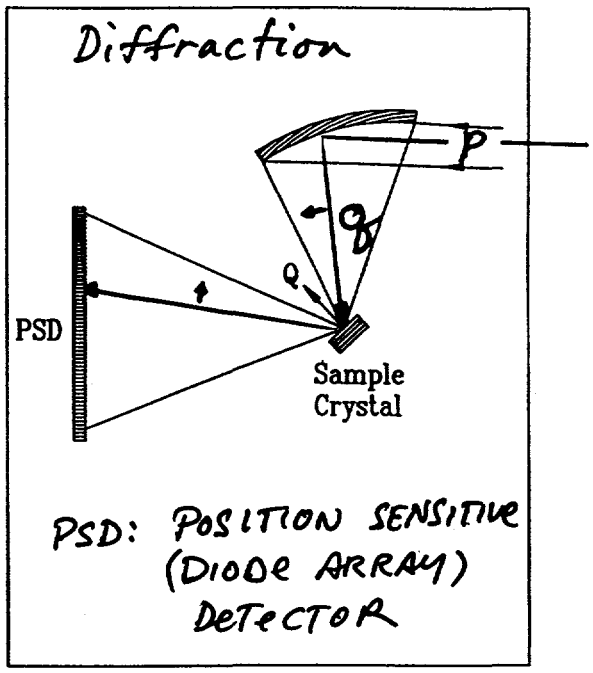
Some Recent Results using Energy Dispersive Methods

"Polychromator" for XAS: Matsushita (1981) [19]
Fontaine (1985) [20]
⋮
LURE, ESRF, SSRL, CHESS, NSLS

Asym, Focusing, HORIZONTAL DIFFRACTION MONO
SMALL FOCUS, $\Delta E \sim 100 - 1000$ eV, FLUX $\gtrsim$ COMPARABLE TO 2-BOUNCE

Parallel Data Collection (over Energy)





Dispersion Match Mono output to Sample Q

$$\frac{\delta\lambda}{\delta\theta_{SAMPLE}} = \frac{\delta\lambda}{\delta\theta_{MONO}} \underbrace{\frac{1}{2}\left(1 - \frac{q}{p}\frac{\sin(\theta-\alpha)}{\sin(\theta+\alpha)}\right)}_{f(\theta_{MONO},\ q/p,\ \alpha_{MIS\text{-}CUT})}$$

(FINKELSTEIN [21])

Problem:

Study Resonant Magnetic Scattering in a ferro (ferri) magnet: $HoFe_2$

To Measure the angular dependence of two features seen in CMXD at the holmium L_{III} (L_{II}) edge.

(Below: Quadrupole $2p \to 4f$ atomic-like ? CARRA,
Above: Dipole $2p \to 5d$ band-like ? Wang)

FOR DIPOLE (RES) AT AN ALLOWED REFLECTION*

CARRA (1989) (22)

(de Bergevin (23) CoPt)

at resonance

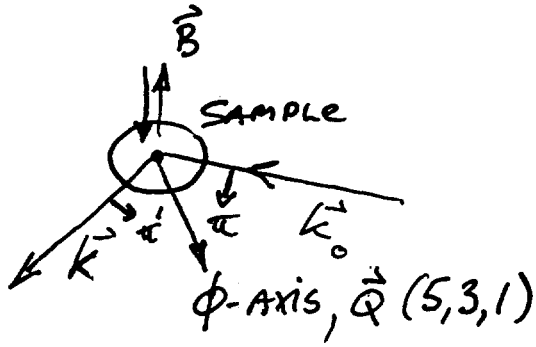
$$f_{SCATT} \sim \underbrace{(f_{0_{Ho}} - a f_{0_{Fe}}) + (f'_{Ho} - a f'_{Fe})}_{A} \pm \underbrace{\hat{m}\cdot(\hat{e}_f \times \hat{e}_0)}_{B} b_{Ho} + \underbrace{i\,(f''_{Ho} - a f''_{Fe})}_{C}$$

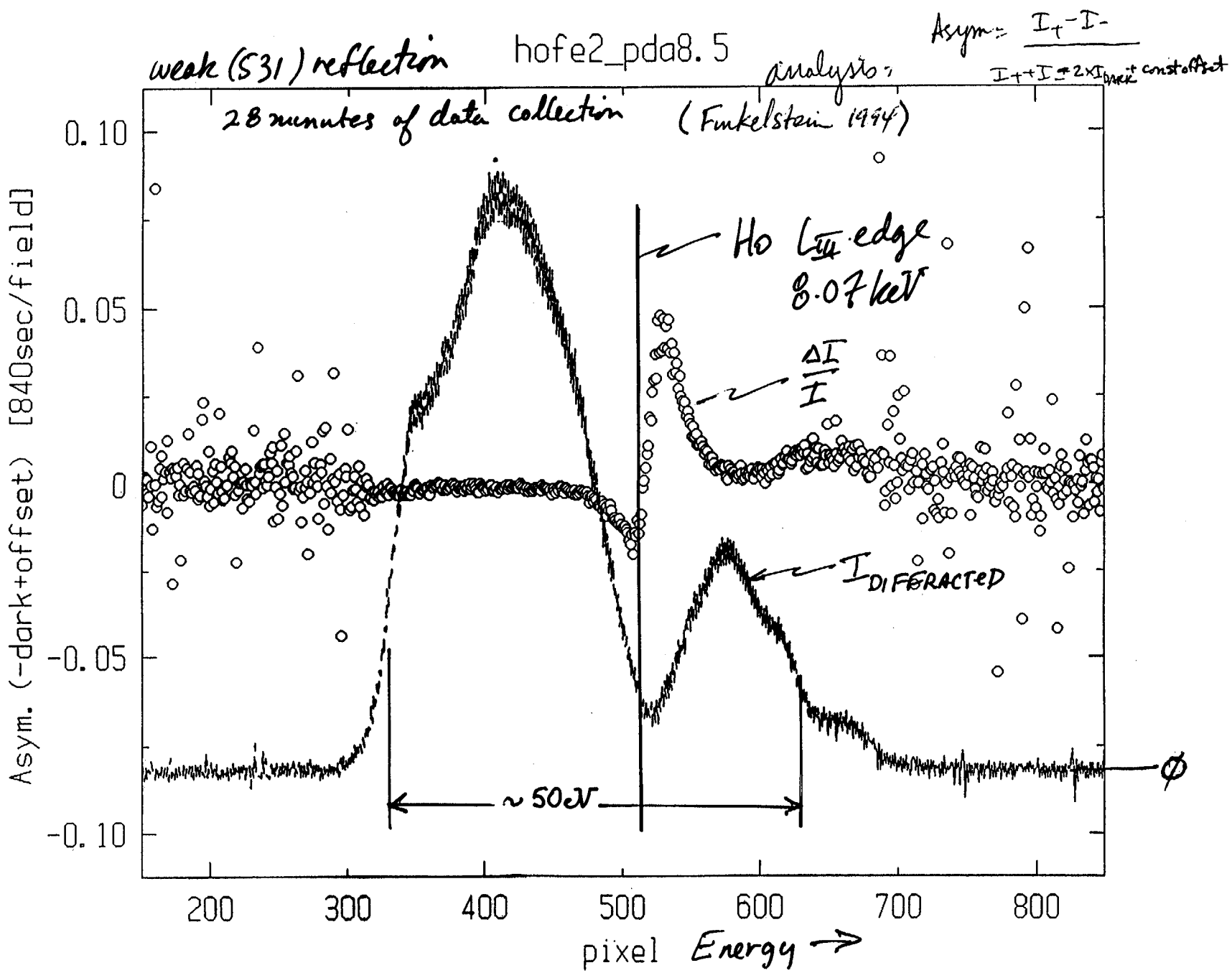
$$I \sim |A \pm B + iC|^2$$

b_{Ho} ~ related to magnetic polarization

$$\frac{\Delta I}{I} = \frac{I_+ - I_-}{I_+ + I_-} = \frac{AB}{A^2 + B^2 + C^2} \sim \frac{\tan 2\theta_B \, b_{Ho} A}{A^2 + B^2} \sim 1\text{-}25\%$$

also gives sign of b_{Ho}




weak (531) reflection
hofe2_pda8.5
Asym = $\frac{I_+ - I_-}{I_+ + I_- - 2 \times I_{back} + const\ offset}$
analysis:
28 minutes of data collection
(Funkelstein 1994)
Ho L_{III} edge
8.07 keV
$\frac{\Delta I}{I}$
$I_{DIFFRACTED}$
~ 50eV
Asym. (-dark+offset) [840sec/field]
0.10
0.05
0
-0.05
-0.10
200
300
400
500
600
700
800
pixel
Energy →

Conclusions

There is a lot of interesting science to be done that will take advantage of the polarization properties of synchrotron radiation. This talk has illustrated several examples: near edge x-ray diffraction, and magnetic scattering. Other important areas are magnetic Compton scattering, circular magnetic x-ray dichroism, and angle (and polarization) dependent x-ray absorption spectroscopy to name a few.

The APS will provide high intensity, high purity polarized beams over a wide energy range.

High brightness sources are essential if x-ray phase plates are to attain high throughput.

The polarization state of an x-ray beam can be determined quickly and accurately by using a combination of single and multiple-beam Bragg diffraction.

Using the "handles" of: energy tunability, polarization selection, angle-dependence, and **Q**-space selectivity, diffraction methods can provide enhanced sensitivity in the study of electronic and magnetic structure.

References

1. M. Blume and D.Gibbs, Phys. Rev. B 37, 3615 (1988).

2. J.C. Lang, Ph.D. Thesis, Iowa State University (1993).

3. Qun Shen and K.D. Finkelstein, Rev. Sci. Instrum. 64, 3451 (1993).

4. H. Kitamura, Japn. J. of Appl. Phys., 19, L185 (1980).

5. D.M. Mills, Nucl. Instrum. Methods A 266, 531 (1988).

6. T. Ishikawa, et.al., Rev. Sci. Instrum. 63, 1098 (1992).

7. B.W. Batterman, Phys. Rev.B, 45,12677 (1992).

8. E. Hecht and A. Zajac, *Optics* Addison-Wesley Publishing Co (1974).

9. S. Shastri, Ph. D. Thesis, Cornell University (1994).

10. Qun Shen and K.D. Finkelstein, ibid.

11. K.D. Finkelstein, C. Staffa, and Qun Shen, Nucl. Instrum. Methods A (in press).

12. D.H. Templeton, in *Handbook on Synchrotron Radiation Vol. 3,* edited by G. Brown and D.E. Moncton (Elsevier Science, New York, 1991).

13. A. Kirfel, in *X-ray Resonant Scattering*, C. Sparks and G. Materlik, eds., (Elsevier Science, New York, 1994).

14. M. Hamrick, J.P. Hannon, G.T. Trammell (private communication).

15. M. Blume, in *X-ray Resonant Scattering*, C. Sparks and G. Materlik, eds., (Elsevier Science, New York, 1994).

16. P. Carra and B.T. Thole, submitted for publication (1993).

17. K.D. Finkelstein, Qun Shen, and S. Shastri, Phys. Rev. Lett. 69, 1612 (1992).

18. K.D. Finkelstein, M. Hamrick, Qun Shen, in *X-ray Resonant Scattering*, C. Sparks and G. Materlik, eds., (Elsevier Science, New York, 1994).

19. T. Matsushita and P. Phizackerley, Jpn. J. Appl. Phys. 48, 2567 (1981).

20. H. Tolentino, et.al., J. Appl. Cryst. 21, 15 (1988).

21. K.D. Finkelstein and M. Sutton, Nucl. Instrum. Methods A (in press).

22. P. Carra, M. Altarelli, and F. de Bergevin, Phys. Rev. B 40, 7324 (1989).

23. F. de Bergevin, et.al, Phys.Rev. B 46, 10772 (1992).

X-RAY MICROBEAMS:
CREATION METHODS AND EXPERIMENTAL APPLICATIONS

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1. Introduction

Many of today's most scientifically interesting samples can only be prepared in volumes that are too small to probe with conventional x-ray characterization techniques. The existence of tiny samples and the need for higher-resolution x-ray imaging provide the motivation for x-ray microbeam development. Here, microbeams are defined as x-ray beams with a cross-sectional dimension less than 10 μm. Since the performance of microbeam x-ray optics depends largely on the brilliance of the x-ray source, the construction of increased-brilliance synchrotron sources has fueled the interest in developing microbeam optics.

Microfocused or condensed x-ray beams provide smaller beam-confinement and increased intensity-enhancement. X-ray beam confinement offers increased spatial-resolution and improved signal-to-noise ratios, while the enhanced intensity can provide unprecedented elemental and micro-volume scattering sensitivity. Some of the many x-ray characterization techniques that can benefit from the use of x-ray microbeams include fiber diffraction, protein crystallography, microbeam spectroscopy, microdiffraction, x-ray imaging, strain mapping, and grain size determination. The potential to obtain structural information on crystals, fibers, and powders of smaller dimensions than ever before is driving the development of microbeam x-ray optics to produce even smaller and more intense x-ray beams than currently available.

2. Microbeam Creation Methods

The methods used to create microbeams of x rays can be divided into three main categories: apertures, diffraction-based optics, and reflection-based optics. A discussion of the principles of operation, specific methods, and state-of-the-art achievements for each category follows.

2.1 Apertures

Apertures are the simplest method used to create x-ray microbeams. The most common types include: slits, straight capillaries, and metal collimators. Because these devices have no focusing or condensing features in their operation, there is no enhancement of the transmitted x-ray intensity (flux/area). Accordingly, the divergence of the x-ray beam is unaffected by apertures, except for the outer high-angles being cut off.

One of the state-of-the-art aperture microbeam facilities is the X26A microprobe beamline at NSLS of Brookhaven National Laboratory. At this station, an 8 μm by 8 μm full-width-at-half-maximum (FWHM) hard x-ray beam (energy > 5 keV) is created using a pair of tungsten-faced slits. Using a single slit they have measured beam confinement as small as 1 μm FWHM. Because they are simple and easy to use, apertures will continue to be prominent in the field of microbeams.

2.2 Diffraction-Based Optics

Diffraction-based optics focus x rays by either Bragg diffraction or Fresnel diffraction. The most common Bragg-diffraction microbeam optics are multilayer mirrors and bent crystals. The most common Fresnel-diffraction device is the phase zone plate. Another more recently developed microbeam optic is the Bragg-

Fresnel (BF) lens, which utilizes both types of diffraction. Diffraction devices are monochromatic with varying amounts of bandpass. The bandwidth transmitted through a Bragg device depends on the number of crystal layers diffracting. For a Fresnel device, the bandpass is predetermined by an upstream monochromating optic. Since diffraction-based optics are focusing devices, their focused beam size depends on the size of the x-ray source. The diffraction-based optics that will be discussed below are multilayer mirrors, phase zone plates, and BF lenses.

Multilayer mirrors are wide band-pass optics due to the small number of synthetically-deposited layers (~10-100) in their construction. The relatively large Bragg diffraction angle (compared to glancing reflection angles for regular mirrors) allows a large total angular acceptance. Multilayer mirrors are usually constructed in a curved "saucer-like" shape, or are prepared flat and then bent into this shape. The mirrors are typically used in a Kirkpatrick-Baez (KB) configuration in which two mirrors are arranged consecutively at right angles to one another and provide focusing in two dimensions. The resultant beam size and the focusing efficiency depend on the perfection of the mirror-surface curvature and the quality of the multilayer characteristics, such as surface aberrations and layer-thickness consistency.

Using a single multilayer mirror, a spatial resolution of 1 μm FWHM (in one dimension) has been achieved with hard x rays by the Lawrence Berkeley Laboratory (LBL) group at the Advanced Light Source (ALS). They routinely use two mirrors in the KB configuration to achieve a 2 μm by 2 μm FWHM beam with 10-keV x rays. *(2)* The intensity gain with this setup has been measured as a factor of 70 increase over the flux/area that would be present if no focusing had taken place.

Phase Zone plates are Fresnel-diffraction devices that consist of circular zones with equal areas and alternating compositions in a "jelly-roll" formation. The two adjacent zone materials are chosen to produce a phase shift of π relative to each other as the x rays pass through. This phase shift causes the diffracted x rays from all zones to constructively interfere. The demagnification ability of the zone plate is determined by the width of the outermost zone. So far, zone plates have had outer diameters on the order of 100 μm, which makes their total angular acceptance small. The intensity gain from a zone plate is proportional to the demagnification and the focusing efficiency, which is the transmitted fraction of x rays in the first order focus.

Using 8-keV x rays, the Advanced Photon Source (APS) group at Argonne National Laboratory have achieved a focal spot size of 0.65 μm by 0.65 μm with a zone plate. *(3)* The focusing efficiency of this optic was 33%. Smaller focal spot sizes have been achieved with phase zone plates using soft x-rays. A spatial resolution of 30 nm using 400-eV x rays has been demonstrated by Anderson *et al. (4).*

The newest diffraction-based microbeam optic is the BF lens. This device makes use of Bragg diffraction from linear crystalline ridges with surface areas that are distributed in a Fresnel configuration. The result is that the Bragg scattered x rays are Fresnel diffracted into a focal point. As in the case of zone plates, the demagnification of a BF lens depends on the width of the outermost zone (ridge). However, compared to phase zone plates, the Bragg diffraction nature and larger physical size of BF lenses allow large incident angles, hence possessing a large total angular acceptance.

An example of the present state-of-the-art resolution achieved with BF lenses is the creation of a 0.8 μm FWHM (in one dimension) x-ray beam at the European Synchrotron Radiation Facility (ESRF). *(5)* This result is preliminary, but the focusing potential for a BF lens is definitely promising.

The focusing ability of diffraction-based microbeam optics will certainly be improved at the APS. With the increased brilliance, the APS will have smaller source sizes and more collimated beams. The smaller source sizes translate into smaller focused beam sizes while the increased collimation will allow greater focusing efficiencies. The net result will be smaller x-ray beams with higher intensity gains.

2.3 Reflection-Based Optics

Reflection-based optics operate by the principle of total external reflection from the reflecting surfaces. As long as the incident angle of an x ray on the reflecting surface does not exceed the critical value, the reflectivity is close to 1. The value of the critical angle depends on the energy of the x rays and the density of the reflecting material. Since a reflecting optic set to a certain incident angle will pass all energies with critical angles less than the incident angle, these devices are low pass filters.

The most common type of reflection-based optic is the standard total-reflection mirror. For the purpose of creating microbeams of x rays, precision bent mirrors are used to concentrate the reflected rays into a focal spot. These mirrors can be simply made of thin pieces of plate glass, provided that the surface is sufficiently smooth. Single-bounce reflection optics are focusing devices, hence the focal spot size depends on the source size.

Using a properly-shaped glass plate bent to approximate an ellipse, a one-dimensional spatial resolution of 2 μm FWHM has been observed by the DND-CAT on the X18A beamline at NSLS of Brookhaven National Laboratory. *(6)* Two of these mirrors have been used in the KB configuration to produce a focused beam with a spot size of 5 μm by 5 μm FWHM and an intensity gain of about 250.

The focusing ability of a bent mirror depends on the perfection of the bent profile and the collimation of the incident x-ray beam. With the smaller source size and improved collimation at the APS, bent mirrors will provide a simple, low-cost alternative to many of the other microbeam optics. The final reflection-based microbeam optic, covered below, is a tapered glass capillary.

3. Tapered Capillaries

3.1 Monocapillaries

Glass capillaries have been used in the propagation of x rays for more than 50 years. *(7)* In 1988, Stern *et al.* *(8)* proposed using tapered glass capillaries to condense and confine x rays. Since that time, monocapillary (single-bore tubing) x-ray concentrators have been used to make hard x-ray beams with diameters as small as 50 nm and intensity gains approaching 1000. *(9,10)*

The x ray flux entering a tapered glass capillary is condensed by multiple reflections off the internal glass wall as the x rays pass through the bore of the needle-like tube. As the diameter of the tube decreases, the flux density increases. If the incident angles between an x ray and the glass wall remain below the critical angle for total external reflection, then the x ray is transmitted through the glass tube to the small end. The gain in flux density is thus determined by the ratio of the entrance and exit opening areas, multiplied by the transmission fraction for the device. It has been shown using Liousville's theorem and emittance arguments that tapered glass capillaries can have intensity gains as high as 10^5. *(11)*

A tapered glass capillary is a non-imaging optical device. This feature allows tapered glass capillaries to condense x-rays into spot sizes that are independent of the source size. It is important to point out that the beam diameter is smallest directly at the tip of the glass tube. One of the attractive characteristics of glass x-ray concentrators is their achromatic property, which allows them to condense light of any wavelength.

Several experiments have been carried out to demonstrate the experimental possibilities of monocapillary x-ray concentrators. *(9)* The first experiment was a Laue diffraction experiment on a biological specimen of lysozyme. Using a 5.6-μm diameter x-ray beam, a Laue diffraction pattern was observed from a 150-μm thick sample in a 300-sec exposure. The x-ray beam had a 25-keV energy cutoff from an upstream mirror. The diffraction pattern had a structural resolution of 2.2 Å and used the smallest x-ray beam ever employed for biological crystal diffraction. Using a microbeam like this will now allow the structures of protein molecules and viruses that only crystallize in tiny volumes to be probed as never before.

In a separate experiment, a 0.31-μm diameter x-ray beam with an intensity gain of 31 and a high energy cutoff of 25 keV was used to observe Laue diffraction from a 500-Å thick single-crystal, gold foil. This experiment showed diffraction from the smallest diffracting volume ever observed (5×10^{-3} μm^3) with hard x rays. Being able to obtain useful information from such small samples will allow the study of grain boundaries or micro-crystals, for example, to take place.

To demonstrate the imaging resolution possible with glass x-ray concentrators, a lithographically-prepared, 1000-Å thick, gold pattern was imaged. The capillary used for this experiment had a small-end opening of 100 nm and an intensity gain of 50. The pattern was shaped like a tuning fork with 0.3-μm wide features. An analysis of the image gave an imaging resolution of 50 nm. This is the highest resolution hard x-ray image to date.

3.2 Polycapillaries

One of the latest developments in the area of capillary optics has been the use of polycapillary tubing. Tapered glass polycapillaries operate on the same physical principles as tapered monocapillaries. For the purpose of making microbeams on the scale of 10 μm, ray-tracing has shown that a much shorter length (1/5) tapered polycapillary will perform just about as well as a tapered monocapillary, provided that the two concentrators have the same entrance and exit diameters. This may be a significant advantage for polycapillaries, considering that models of the ideal tapered monocapillary for condensing x-ray beams from 1 mm down to 10 μm are on the order of ten feet long. Another advantage for tapered polycapillaries is the existence of a "focal spot" located several centimeters beyond the tip. This "focal spot" can provide working room for experiments where it is impossible to place the sample immediately next to the tip.

We have drawn tapered polycapillaries from glass tubing with 336 open channels in the bore. A 460-μm diameter polycapillary was tapered down to 150 μm. A minimum in the FWHM of the exiting x-ray beam was measured 6-cm beyond the capillary tip. *(12)* Subsequent polycapillary drawings have produced tips as small as 10 μm. With the development of better drawing techniques, polycapillaries are most likely to find success in producing 10 micron-sized x-ray beams.

The outlook for tapered glass capillaries at the APS is promising. As the performance of these optical devices depends strongly on the collimation of the entering x-ray beam, the high brilliance of the APS should lead to much better transmissions, and hence higher intensity gains. The relatively inexpensive construction and the extremely high potential for intensity gains and confinement give tapered glass capillaries a solid position in the field of microbeam optics.

	X-Ray Beam Dimension (μm)	Relative Area of X-Ray Beam
Slits	8 x 8	25,600
Bent Mirrors	5 x 5	10,000
Multilayer Mirrors	2 x 2	1600
Zone Plates	0.65 x 0.65	170
Concentrators	0.05 x 0.05	1

4. Conclusion

A summary of the current state-of-the-art spatial-resolutions for each of the microbeam optics discussed in this paper is given in the table above. However, in determining the experimental resolution for the application of a particular microbeam technique, the absolute x-ray intensity at the position of the sample should be considered. Because of differing setup geometries, some of these techniques have to be positioned further down stream than others. This can lead to impressive intensity gains, but less attractive total fluxes.

One can see by the breadth of this report that the field of microbeam x-ray optics is currently made up by a wide variety of methods, each with attractive characteristics that are different from the others. While not every type of microbeam optic has been covered, those that are most popularly being considered for use at the APS have been mentioned. Since the operating and performance characteristics of all the microbeam techniques are so varied, it is likely that each technique will find a niche and be present on the APS floor.

5. References

1. A microprobe facility on the X-26A beamline of NSLS at Brookhaven National Laboratory, routinely uses an 8 μm by 8 μm aperture for experiments with hard x rays (M. Rivers, CARS, University of Chicago, private communication).

2. "Center For X-Ray Optics-1989," *LBL-28001 UC-411* (University of California, Berkeley, CA, 1990), pp. 4-15.

3. W. B. Yun *et al.*, *Proc. Soc. Photo-Opt. Instrum. Eng.* **1740**, 117 (1993).

4. E. H. Anderson and D. Kern, in *X-ray Microscopy III*, A. G. Michette, G. R. Morrison, C. J. Buckley, Eds. (Springer-Verlag, New York, 1992), pp. 75-78.

5. A 0.8-μm beam at 15 keV has been made at the European Synchrotron Radiation Facility, Grenoble, France, from a Bragg-Fresnel lens designed by A. Snigirv and V. Aristov (C. Riekel, private communication).

6. A 5 μm by 5 μm beam was made with a pair of bent mirrors in the KB configuration using 6-keV x rays at the X18A beamline of NSLS at Brookhaven National Laboratory (P. Georgopoulos, DND-CAT, Northwestern University, private communication).

7. F. Jentzsch and E. Nähring, *Z Tech. Phys.* **12**, 185 (1931).

8. E. Stern, Z. Kalman, A. Lewis, and K. Lieberman, *Appl. Opt.* **27**, 5135 (1988).

9. D. H. Bilderback, S. A. Hoffman, and D. J. Thiel, *Science* **263**, 201 (1994).

10. S. A Hoffman, D. J. Thiel, and D. H. Bilderback, *Opt. Eng.* **33**, 303 (1994).

11. D. J. Thiel, E. A. Stern, D. H. Bilderback, and A. Lewis, *Physica B* **158**, 314 (1989).

12. S. A. Hoffman, D. J. Thiel, and D. H. Bilderback, *Nucl. Instrum. Meth. A* (in press).

A Modern Method for the Solving of Macromolecular Structures: A Case History -- A ribosomal protein fragment

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Biology Department
Brookhaven National Laboratory

The scheme for determination of a particular protein structure:

Use molecular genetic methods to clone and express a particular protein or protein fragment.

Expect to use anomalous-dispersion from specially placed heavy atoms in the structure to determine phases.

This latter depends on the use of a versatile synchrotron x-ray beamline and an adequate x-ray monochromator.

The difficulty encountered in this example:

Crystals cannot be grown of an interesting protein.

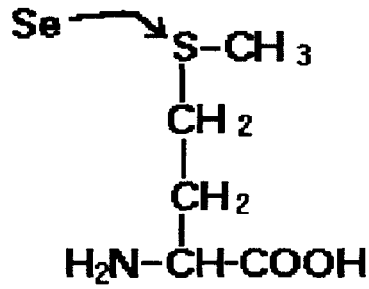
More information:

The protein is known to be flexible (UV spectroscopy on tyrosine residues shows motion).

Treatment with proteases produces two fragments.

The Solution:

Engineer two cleanly separated fragments that can be grown in abundance in *E. coli.*



Grow in a strain of the organism that requires methionine -- feed it Se-Met.

Use diffraction data collected from crystals of a fragment with the Se atoms incorporated: Beamline X12-C at the NSLS was employed. Data were measured at three wavelengths near to the Se K-absorption edge. Used the "Friedel Flip" method to get anomalous differences.

The structure was easy to solve -- the experimental electron density showed clear resolution of nearly all the individual atoms in the structure.

A not-exhaustive list of detectors used for MAD projects:

Detector	Group	Place	Example Projects
Video	Ramakrishnan	NSLS	GH5
Multi-wire	Kahn/Fourme	LURE	Lectin, Parvalbumin
	Phizackerly	SSRL	Cu-protein, Myoglobin
IP, Weiss.	Hendrickson, others	PF	Many
IP, Rot'n	Hendrickson, others	NSLS	Several
IP, MAR Res.	Ramakrishnan	NSLS	Ribo. Prot.

MAD Phasing: The state of the field

Fourteen structures have been published that depended only on MAD phasing. Another 2-3 used MAD phases in combination with isomorphous replacement.

About half of these depended on Hendrickson's idea of using Se-met protein.

One used a brominated nucleic acid.

About five depended on natural first-row transition elements.

The rest are heavy-atom derivatives of atoms in the Z = 75 range.

There are 8-9 structures that are known to have been solved but are not published.

This example -- Ramakrishnan's ribosomal protein fragment.

Kuriyan has two, including a variant of his DNA polymerase.

Hendrickson has four including:

Structure for which data were measured in January, chain was traced by 3rd week in Feb, paper due out next month.

Structure with one ytterbium atom to phase a single molecular unit of approximately 800,000 daltons.

Installation and Commissioning Plans for the Insertion Devices, Front Ends, and Beamlines

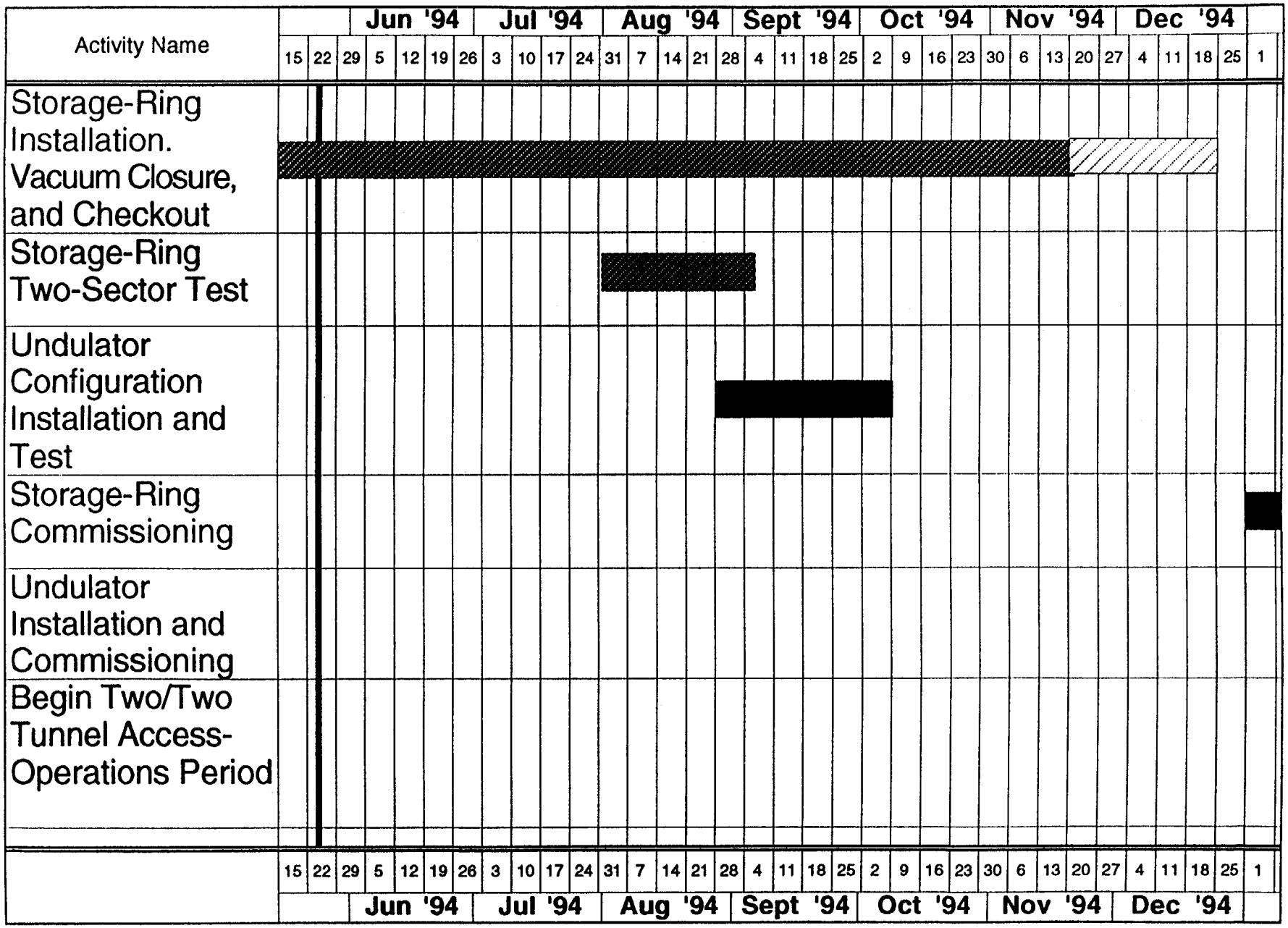
Gopal Shenoy
Experimental Facilities Division
Advanced Photon Source

Contributors to this presentation:

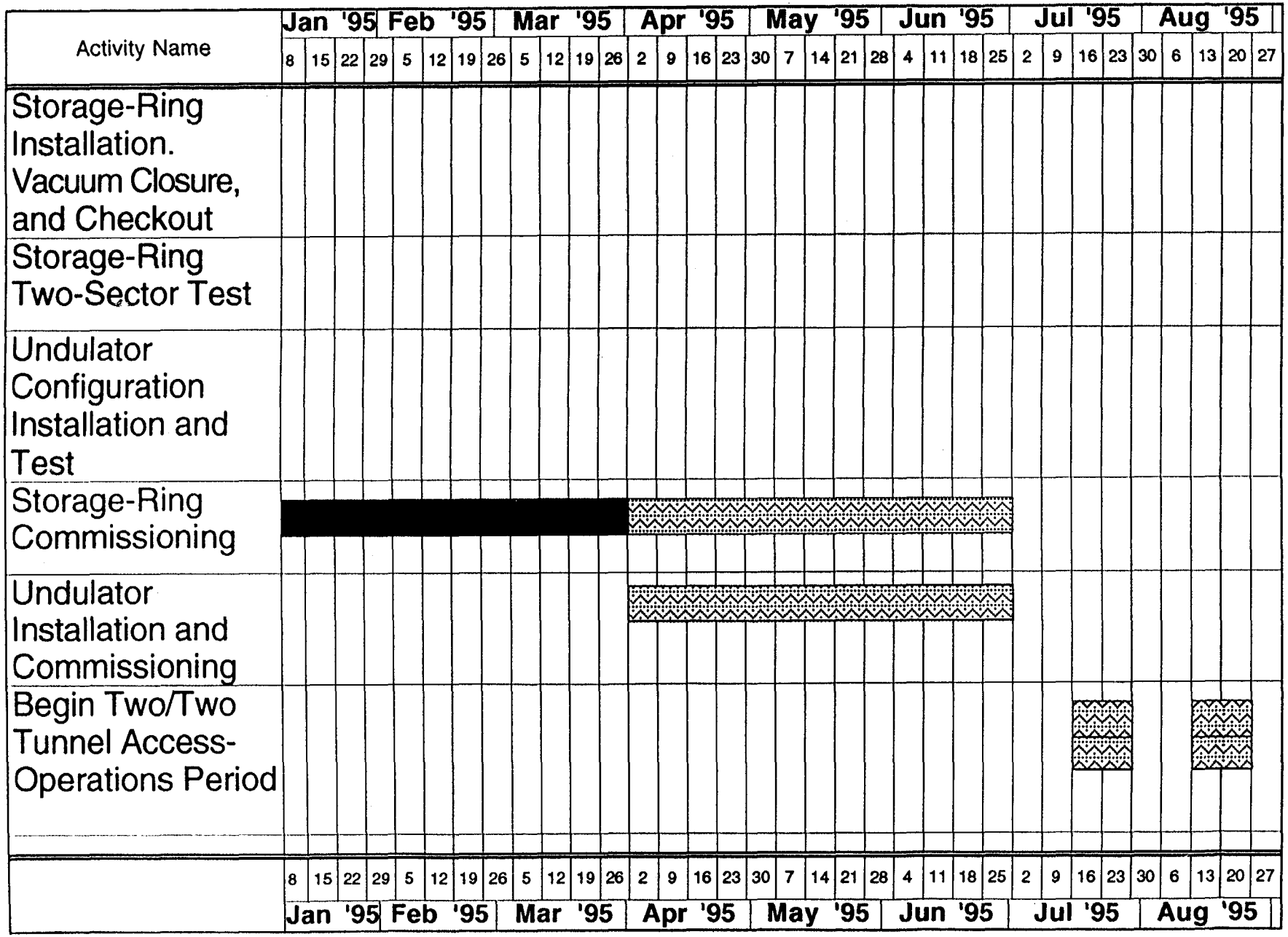
Yeldez Amer
Glenn Decker
Patric Den Hartog
Glen Lawrence

What is the Overall Plan for the Commissioning of the Storage Ring, Insertion Devices, Front Ends, and Beamlines?

Schedule for Installlation and Commissiong of Major Activities



Schedule for Installlation and Commissiong of Major Activities



What is the Two-Sector Test?

Objectives of the Two-Sector Test:

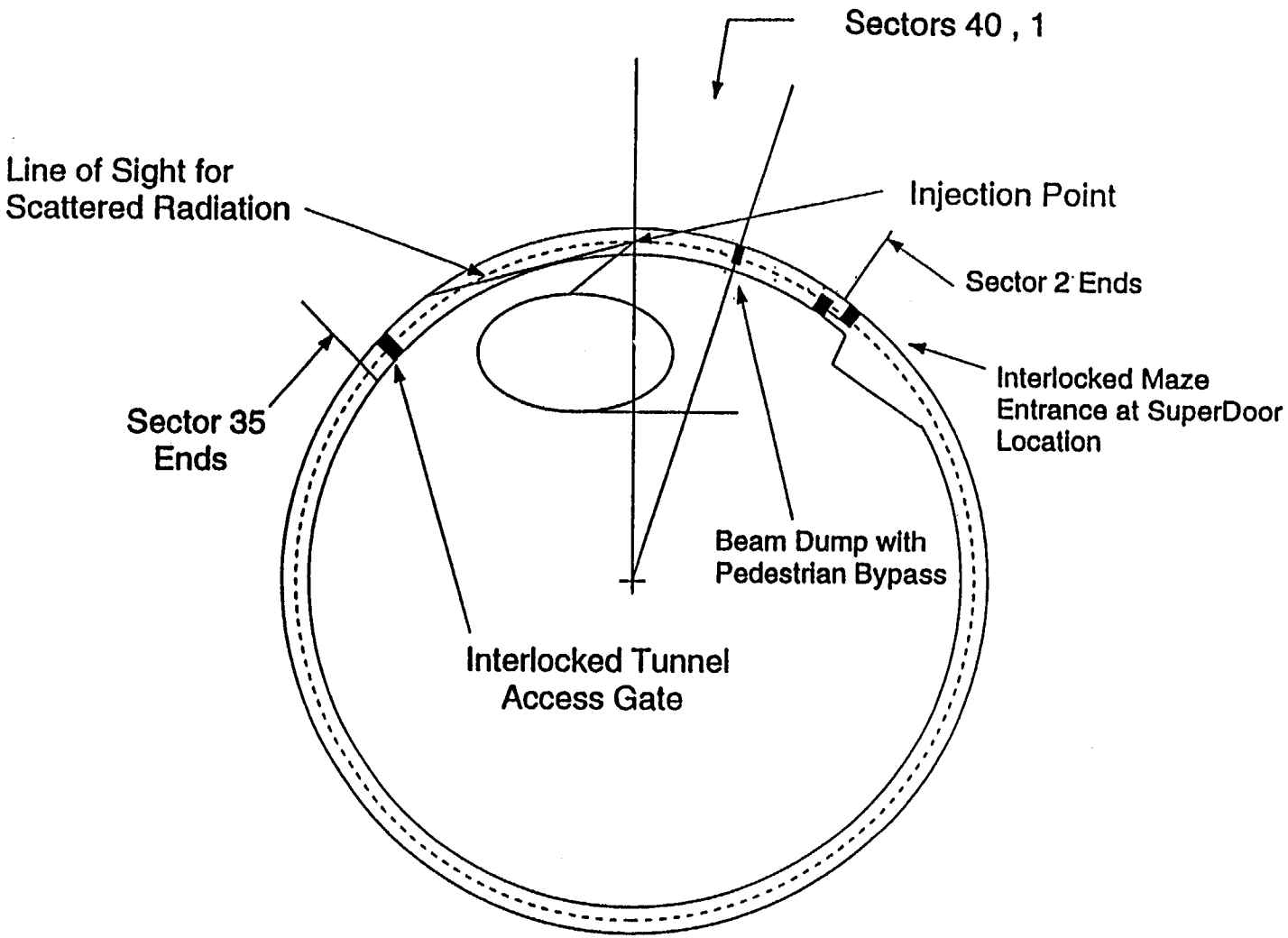
1. Test the performance of the high energy transport line

2. Evaluate the performance of the storage-ring hardware and vacuum in the presence of the beam

3. Verify the shielding calculations

4. Investigate injection losses at the high-dispersion sections of the storage ring

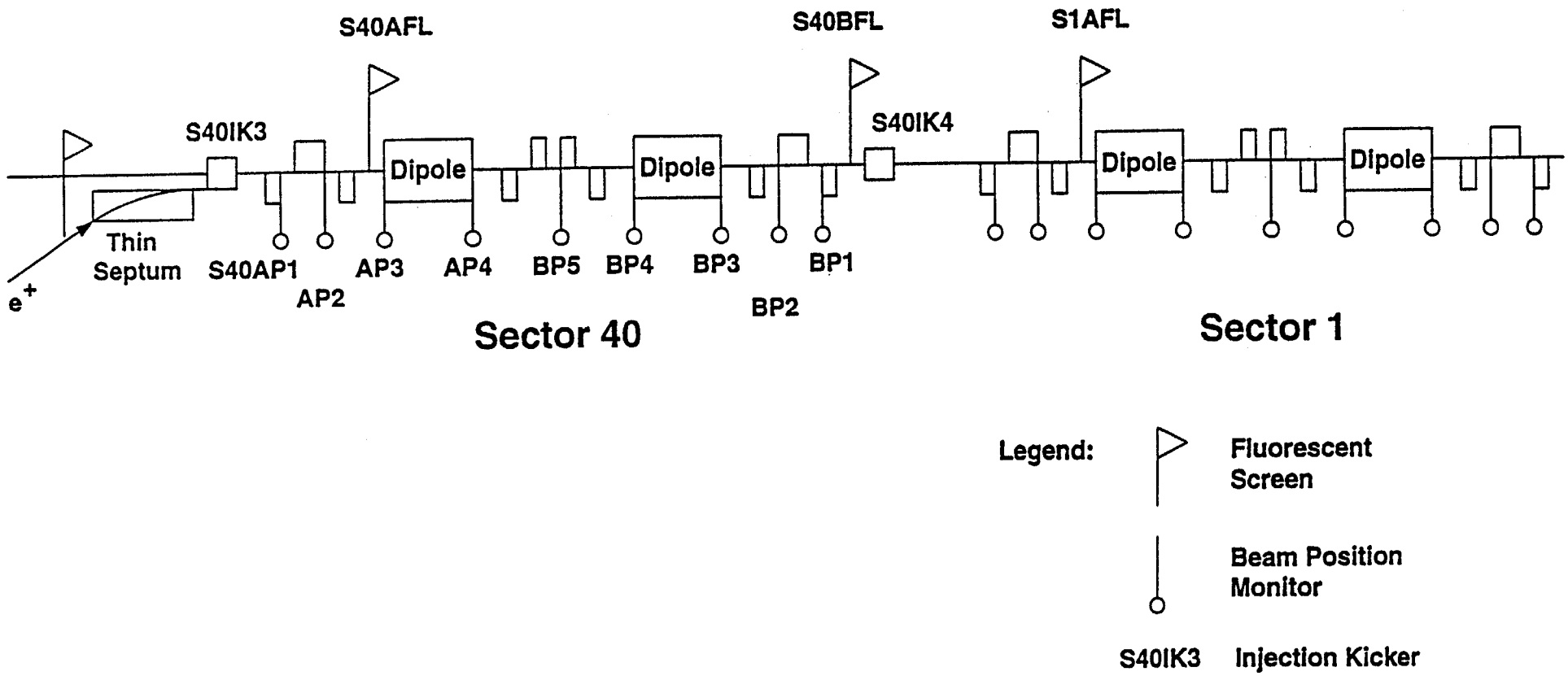
5. Evaluate the performance of the diagnostics monitors



Shielding and Exclusion Zone Plan For Two-Sector Injection Test

(Not to scale - distance between access gate and maze is 7 sectors)

Positron Beam Diagnostics for the APS Storage-Ring Two-Sector Test



What is Insertion Device Configuration Installation?

Objectives of the ID Configuration Installation:

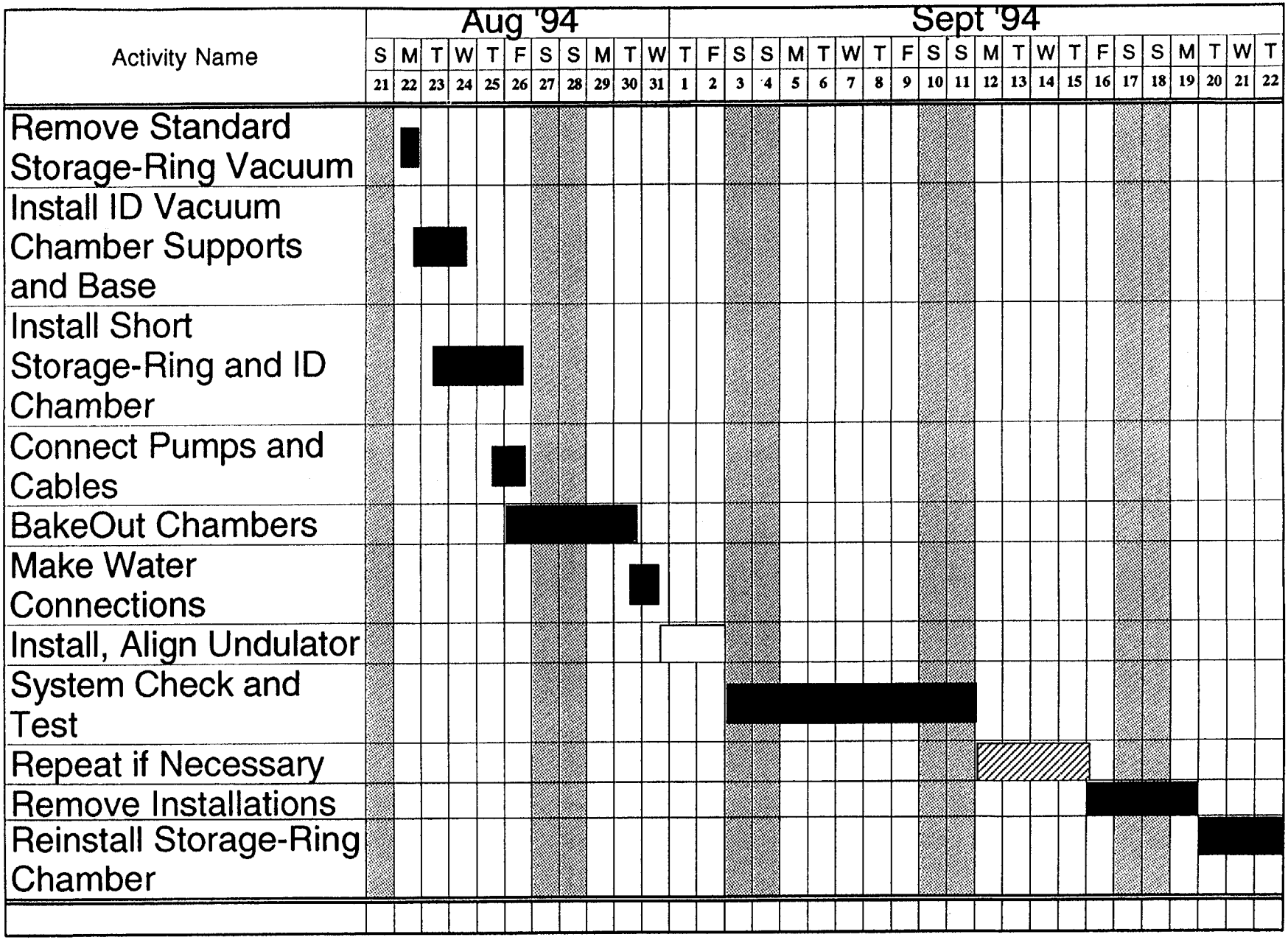
1. Ensure the compatibility of the ID vacuum chamber in section 6 of the storage ring

2. Check out installation procedures for the ID vacuum chamber and the ID

3. Train the installation crew

4. Evaluate the vacuum and ID motion performance in actual location

Insertion Device Configuration Installation and Test



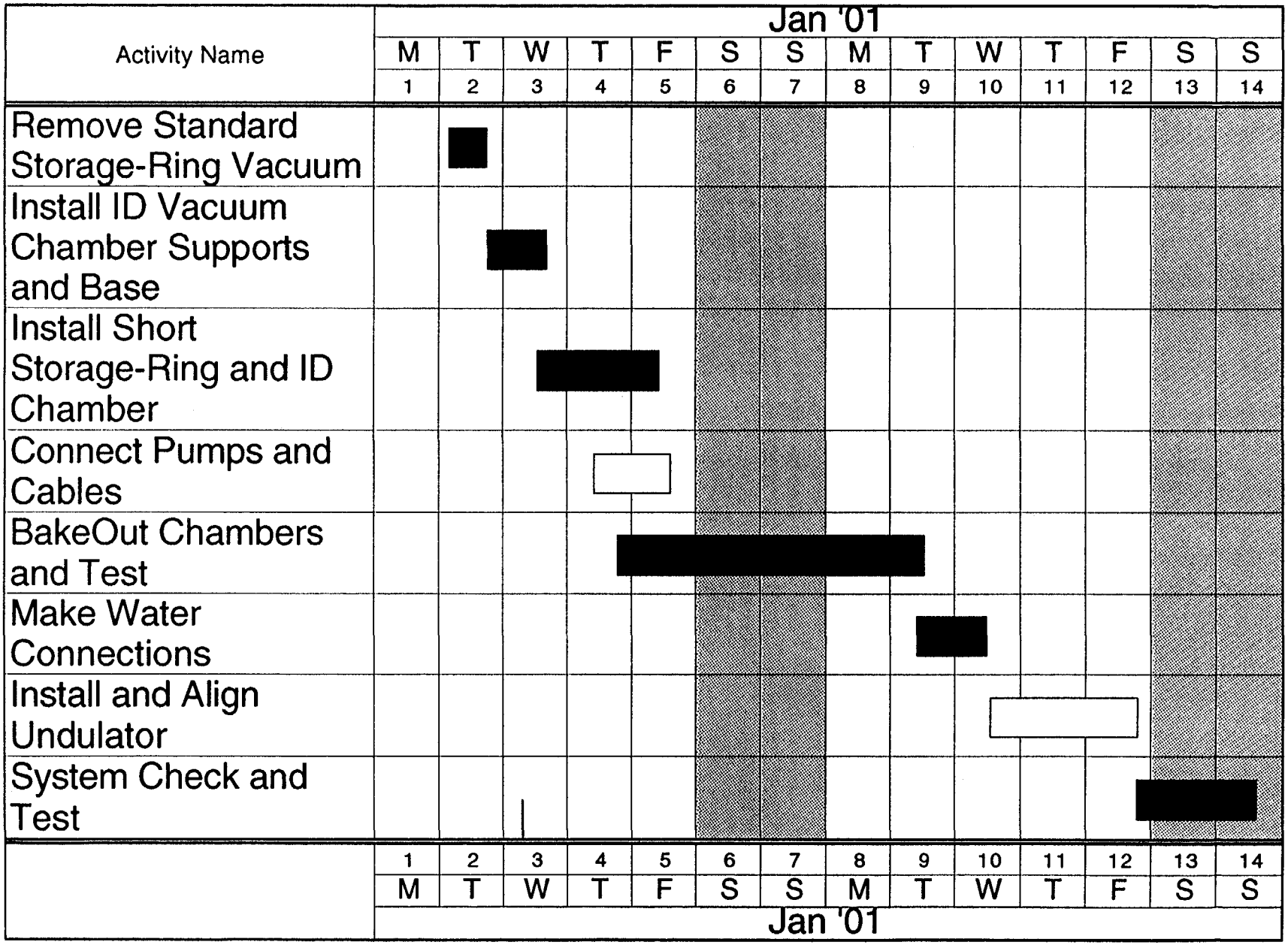
What is Two/Two Operation?

During this period, the storage-ring tunnel will be accessible for installation activities for a period of two weeks, followed by two weeks of operation.

In the present plan, the two/two operation will begin in July of 1995 and end in February of 1996.

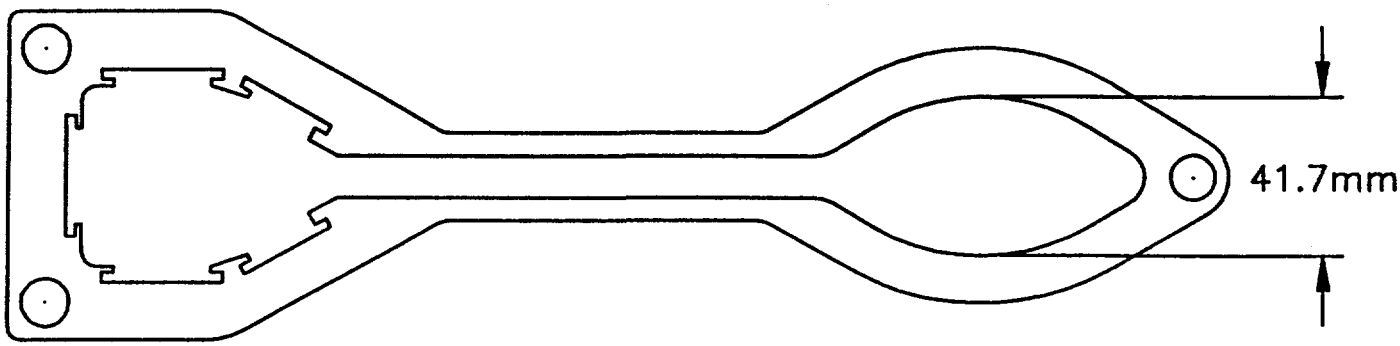
How Long Does It Take to Install an ID Vacuum Chamber?

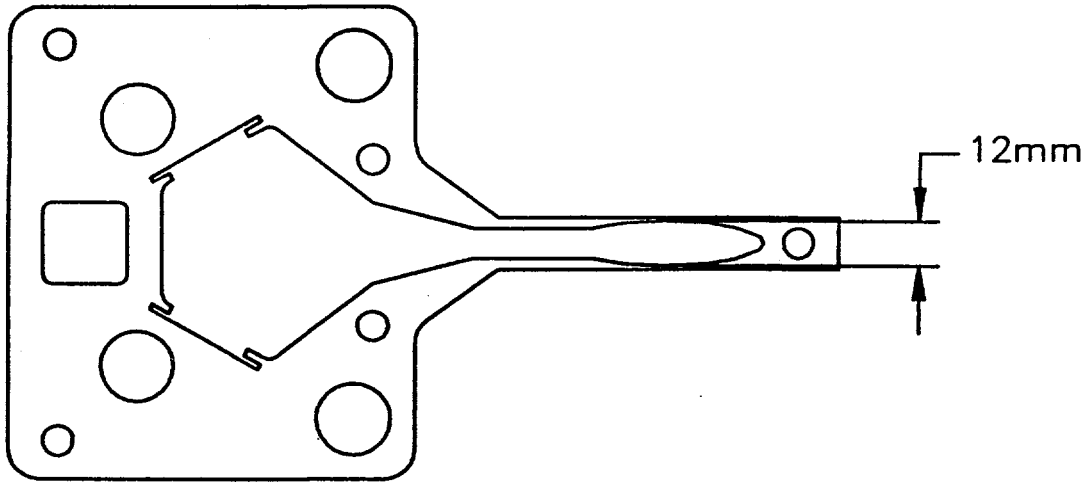
Two Week Insertion Device Vacuum Chamber Installation Schedule

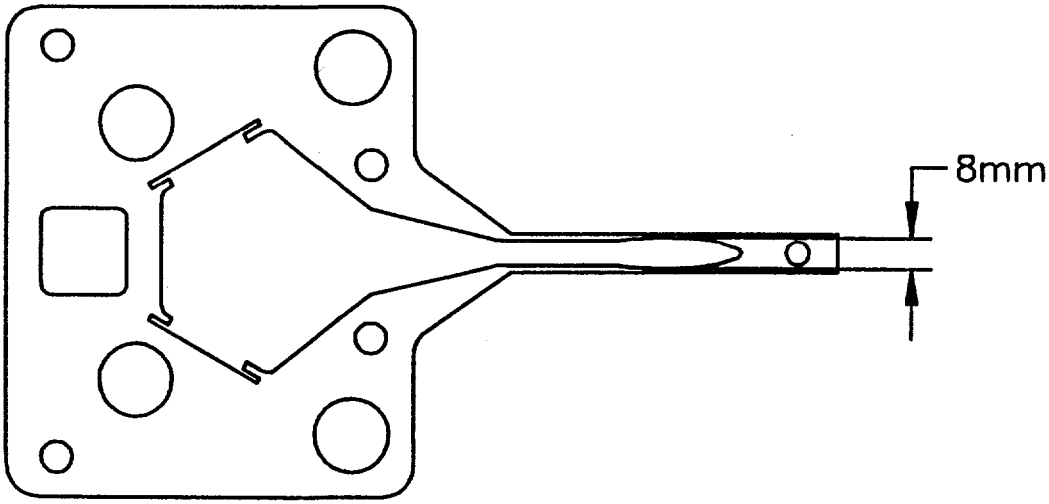


What is the Sequence of Installation of 12-mm- and 8-mm-aperture ID Vacuum Chambers?

ADVANCED PHOTON SOURCE

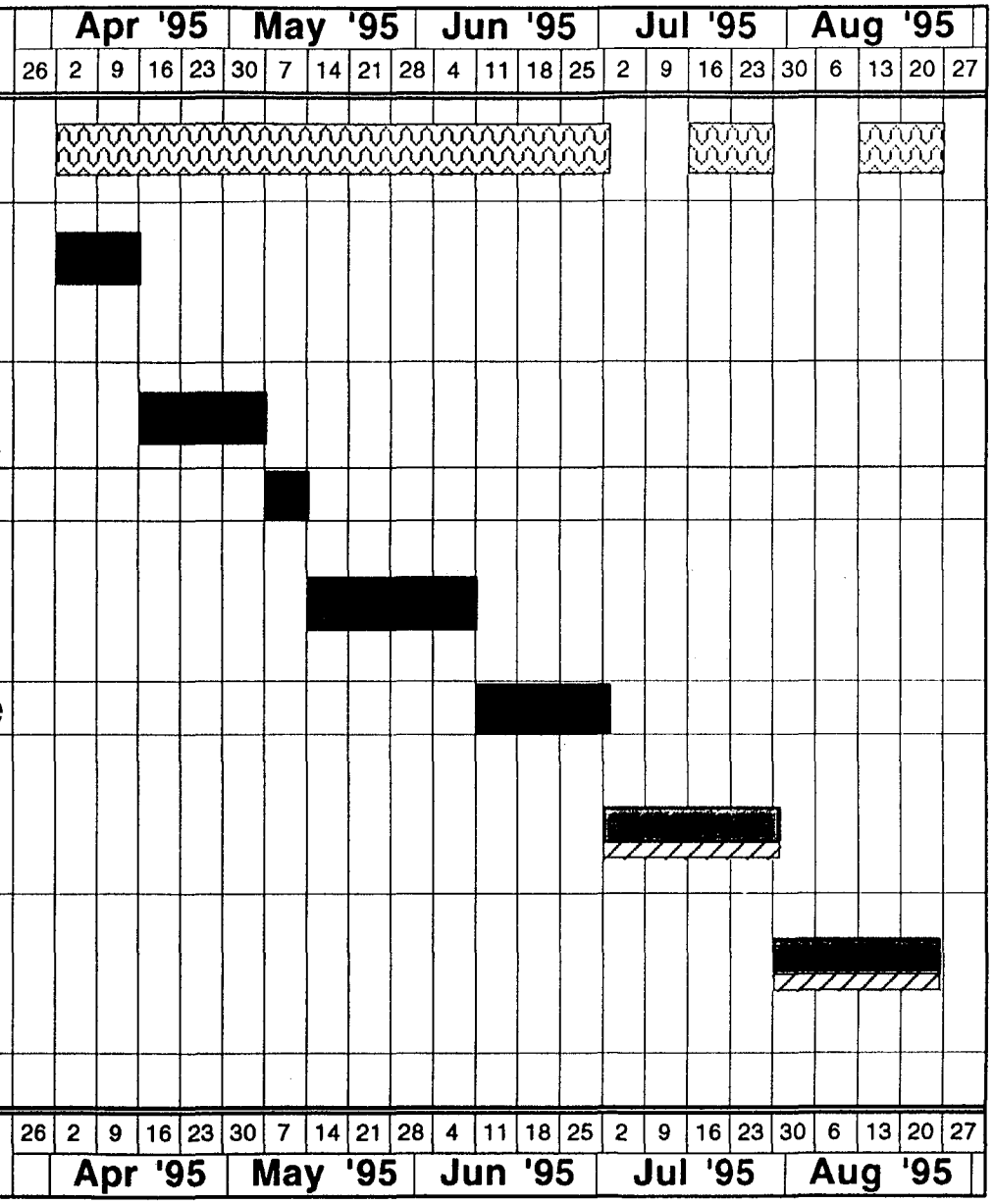






ID Vacuum Chamber Installation Schedule

Untitled	Activity Name
	Storage Ring Commissioning
1	Install 2.5-m-long 12-mm ID Vacuum Chamber
2	Commission Storage Ring
3	Install U-A
4	Commission Storage Ring, ID, and Front End
5	Commission Beamline
6	Repeat Steps 1-5 with 2.5-m-long 8-mm ID Vacuum Chamber
7	Repeat Steps 1-5 with 5-m-long 8-mm ID Vacuum Chamber



What ID Vacuum Chambers Will Be Ready and How Many?

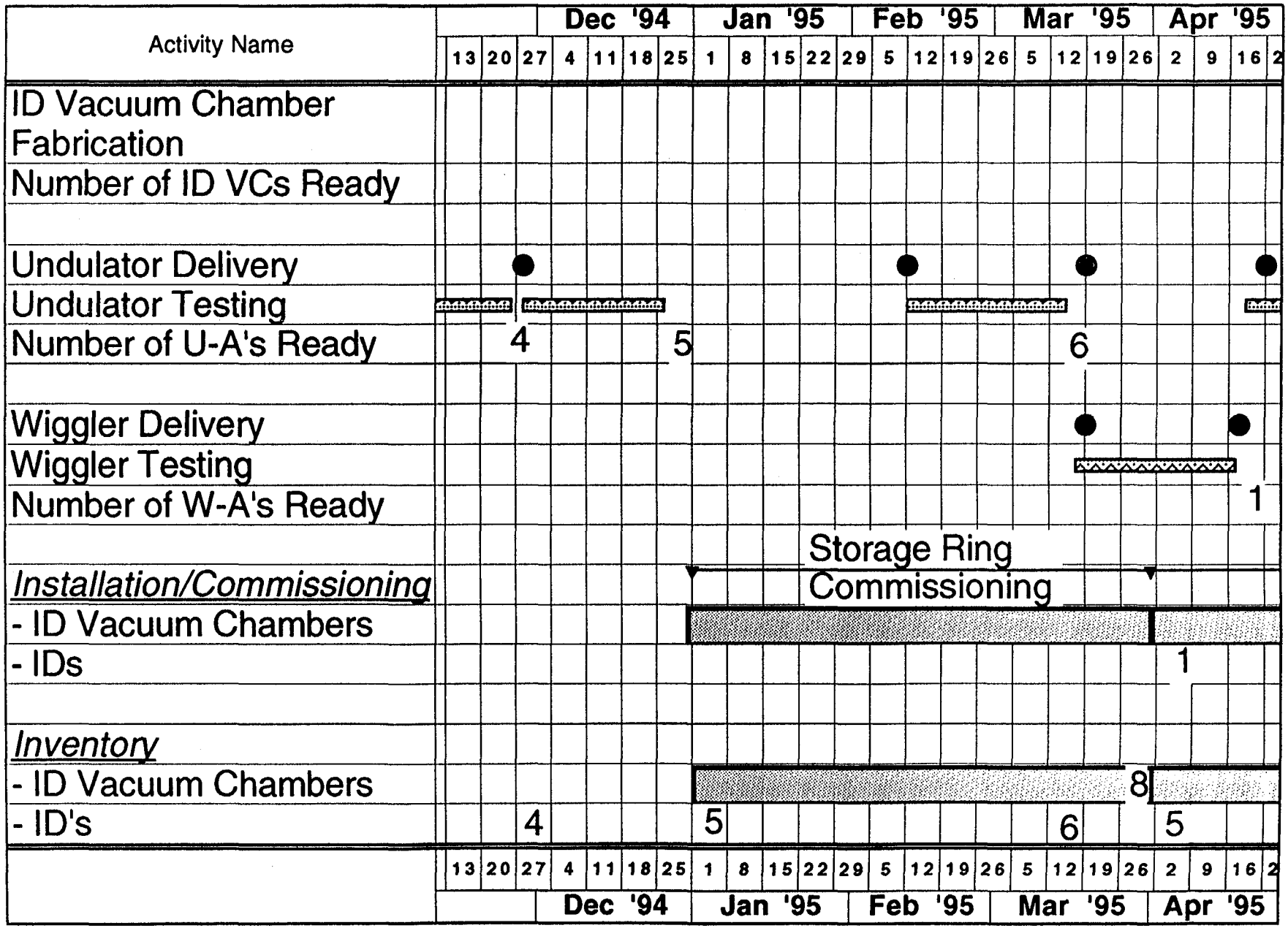
What Is the ID Delivery Schedule?

What Is the ID Commissioning Schedule?

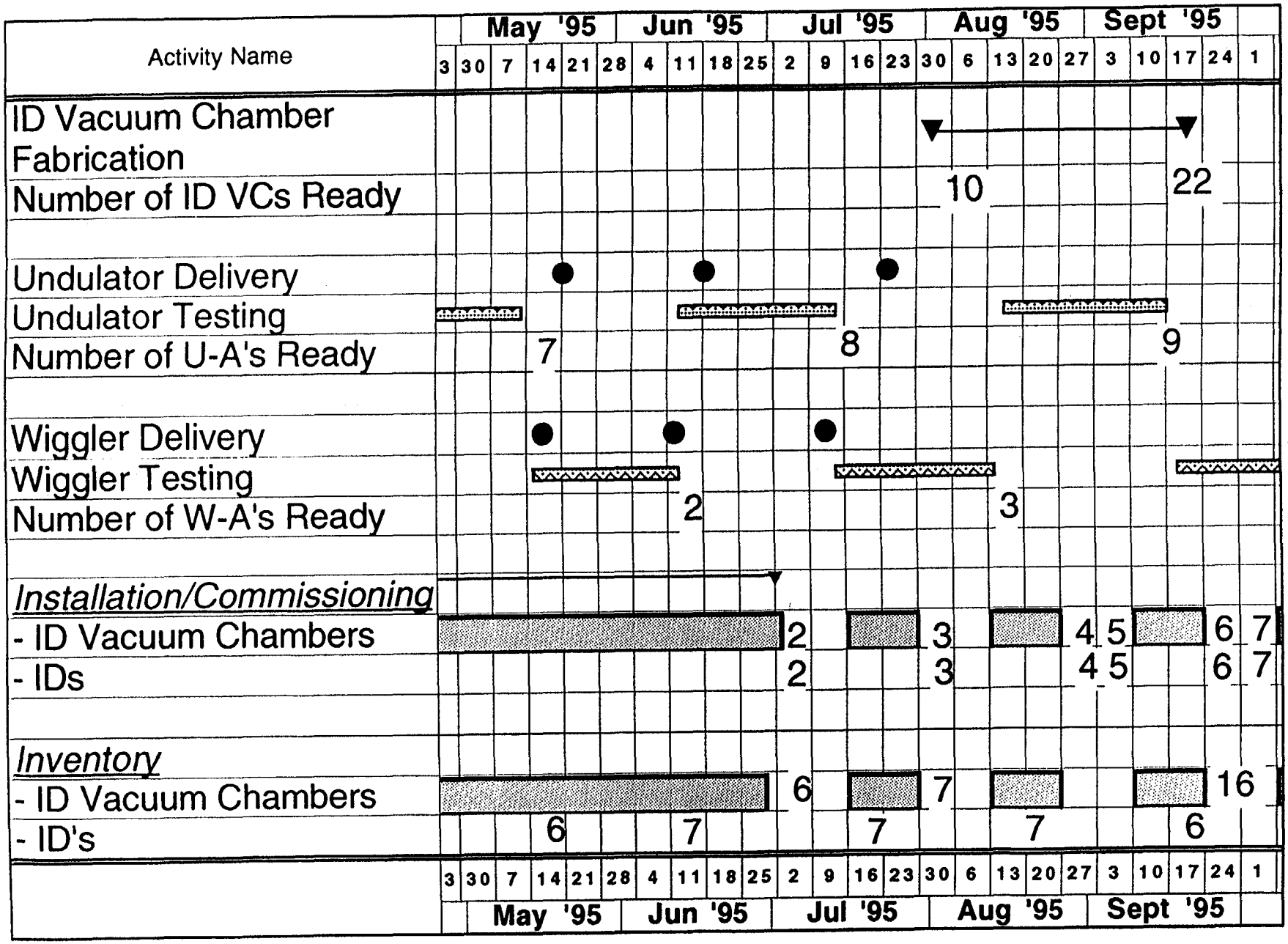
Insertion Device Delivery, Installation and Commissioning Schedule

Activity Name	Jun '94					Jul '94				Aug '94					Sept '94				Oct '94					
	29	5	12	19	26	3	10	17	24	31	7	14	21	28	4	11	18	25	2	9	16	23	30	6
ID Vacuum Chamber Fabrication				12 mm	▲	8 mm		▼	▼	▼	▼	▼	▼	▼										
Number of ID VCs Ready					1			2	3	4	5	6	7	8										
Undulator Delivery									●					●				●				●		
Undulator Testing																								
Number of U-A's Ready													1					2				3		
Wiggler Delivery																								
Wiggler Testing																								
Number of W-A's Ready																								
Installation/Commissioning																								
- ID Vacuum Chambers																								
- IDs																								
Inventory																								
- ID Vacuum Chambers																								
- ID's													1									3		
	29	5	12	19	26	3	10	17	24	31	7	14	21	28	4	11	18	25	2	9	16	23	30	6
	Jun '94					Jul '94				Aug '94					Sept '94				Oct '94					

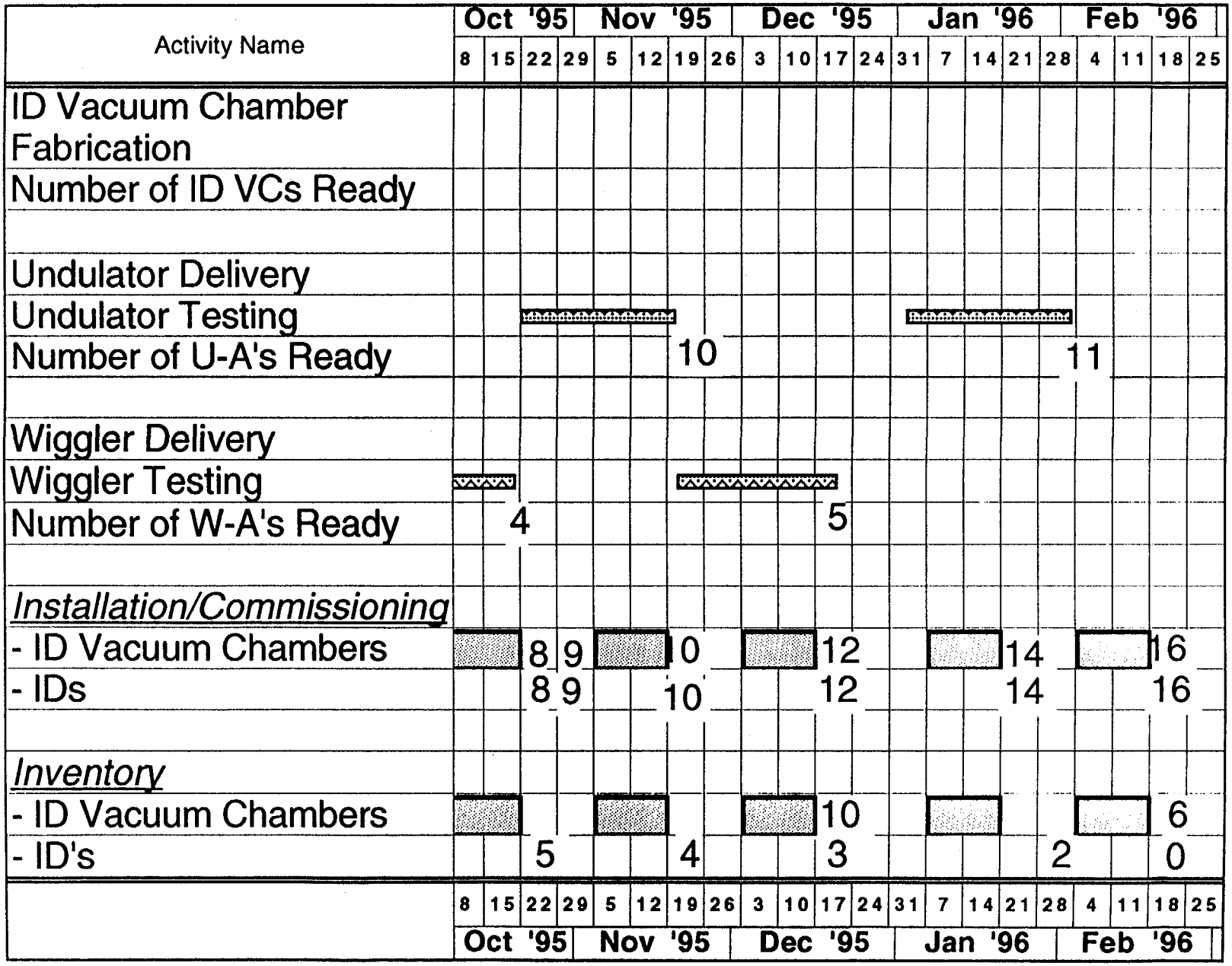
Insertion Device Delivery, Installation and Commissioning Schedule



Insertion Device Delivery, Installation and Commissioning Schedule

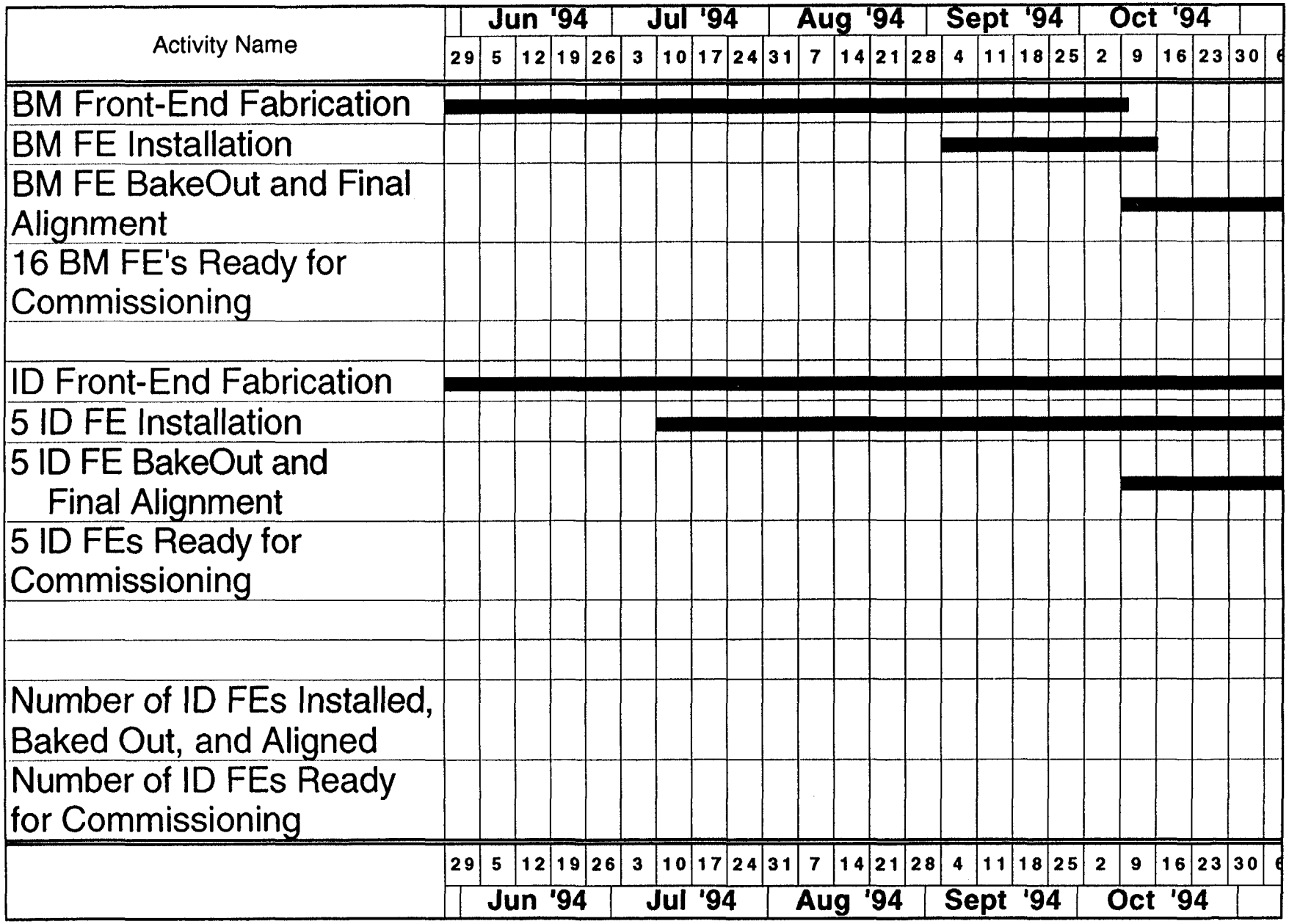


Insertion Device Delivery, Installation and Commissioning Schedule

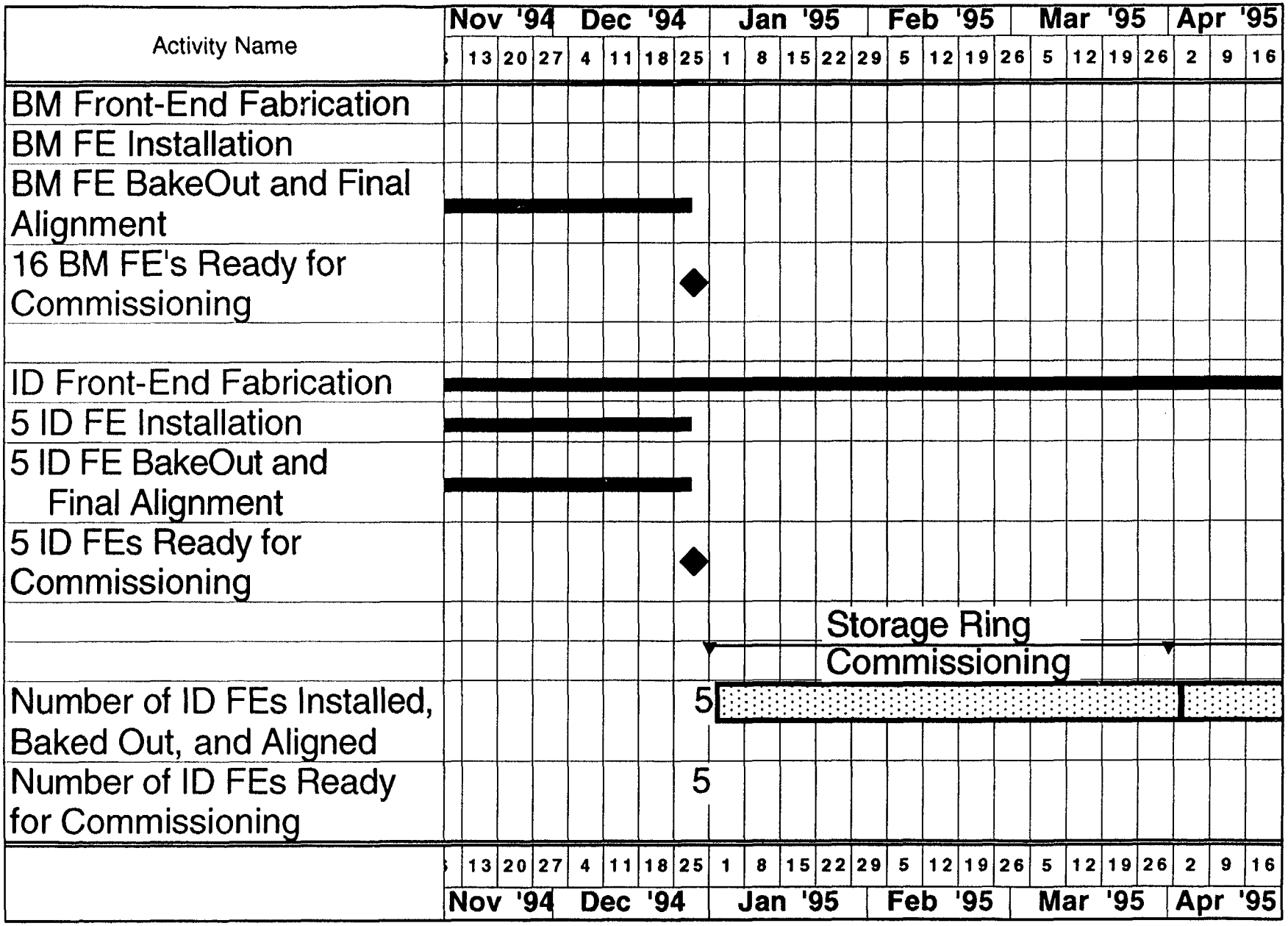


Is There a Similar Commissioning Schedule for the Front Ends?

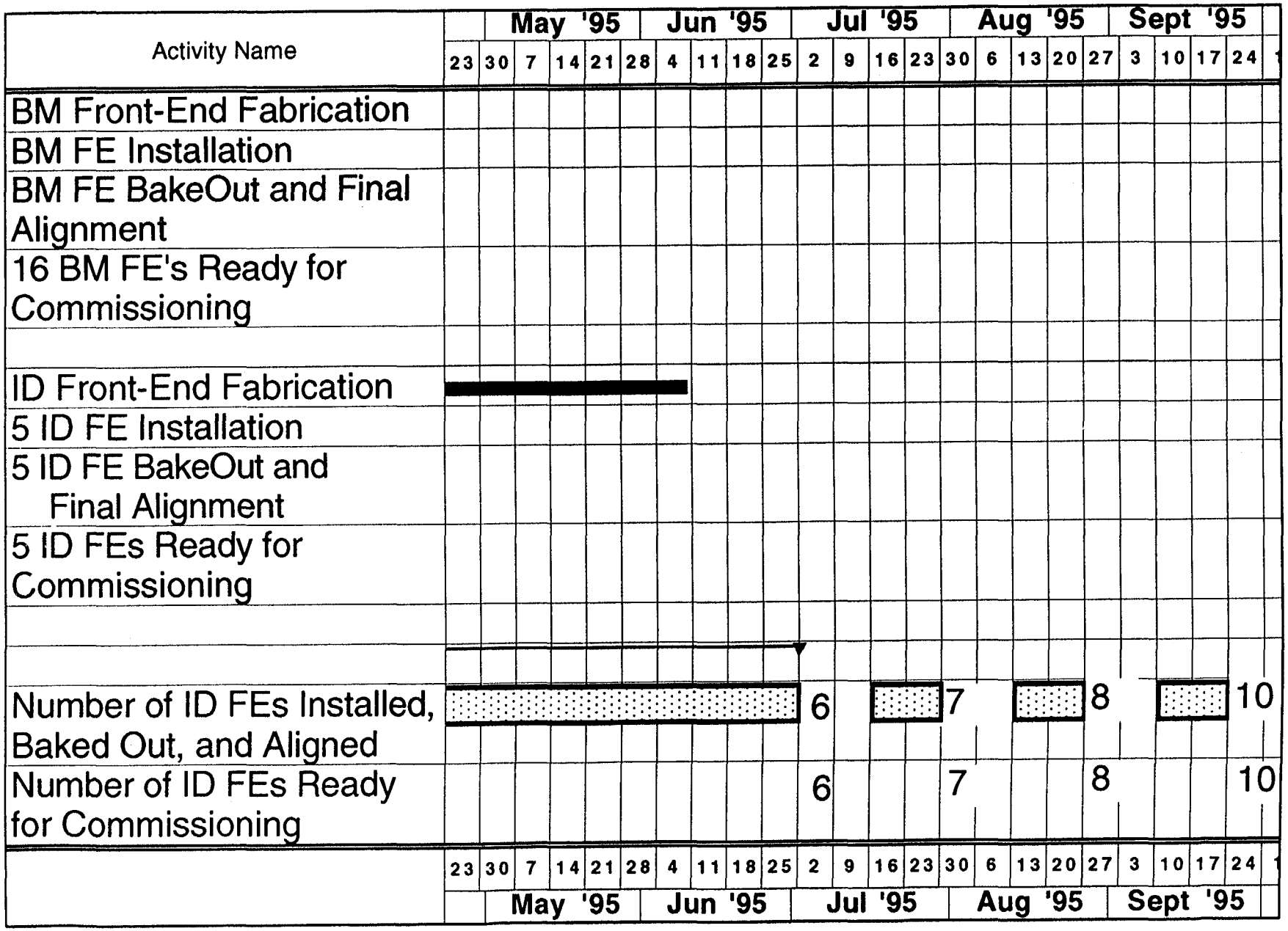
Front-End Fabrication, Installation, and Commissioning Schedule



Front-End Fabrication, Installation, and Commissioning Schedule



Front-End Fabrication, Installation, and Commissioning Schedule

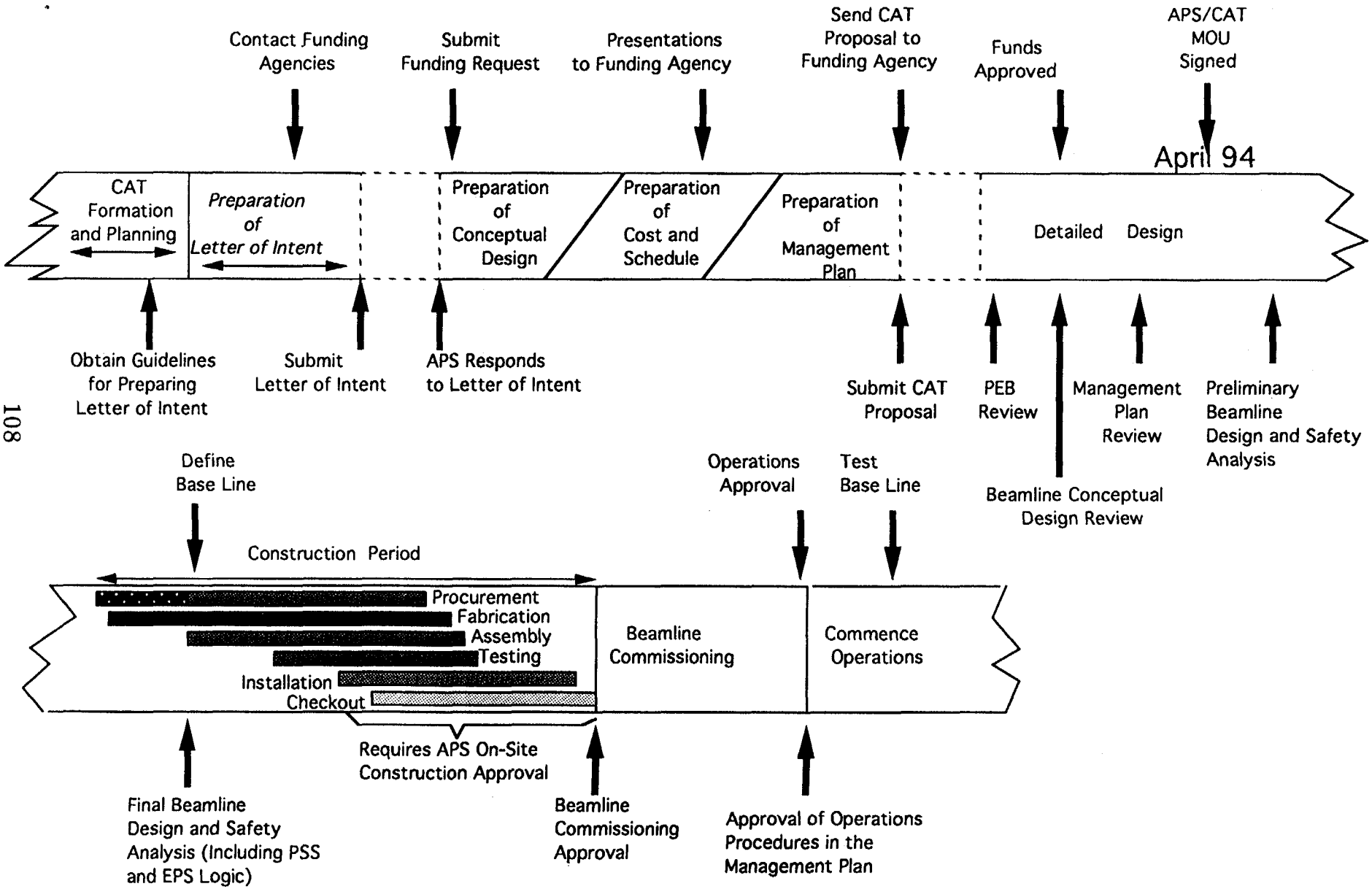


Front-End Fabrication, Installation, and Commissioning Schedule

Activity Name	Oct '95				Nov '95				Dec '95				Jan '96				Feb '96			
	8	15	22	29	5	12	19	26	3	10	17	24	31	7	14	21	28	4	11	18	25
BM Front-End Fabrication																					
BM FE Installation																					
BM FE BakeOut and Final Alignment																					
16 BM FE's Ready for Commissioning																					
ID Front-End Fabrication																					
5 ID FE Installation																					
5 ID FE BakeOut and Final Alignment																					
5 ID FEs Ready for Commissioning																					
Number of ID FEs Installed, Baked Out, and Aligned			11				12				13					14				15	
Number of ID FEs Ready for Commissioning			11				12				13					14				15	
	8	15	22	29	5	12	19	26	3	10	17	24	31	7	14	21	28	4	11	18	25
	Oct '95				Nov '95				Dec '95				Jan '96				Feb '96				

What Are the Steps Involved before a CAT Can Begin Beamline Installation on the APS Experiment Hall Floor?

LOGICAL STEPS IN CAT BEAMLINE DEVELOPMENT



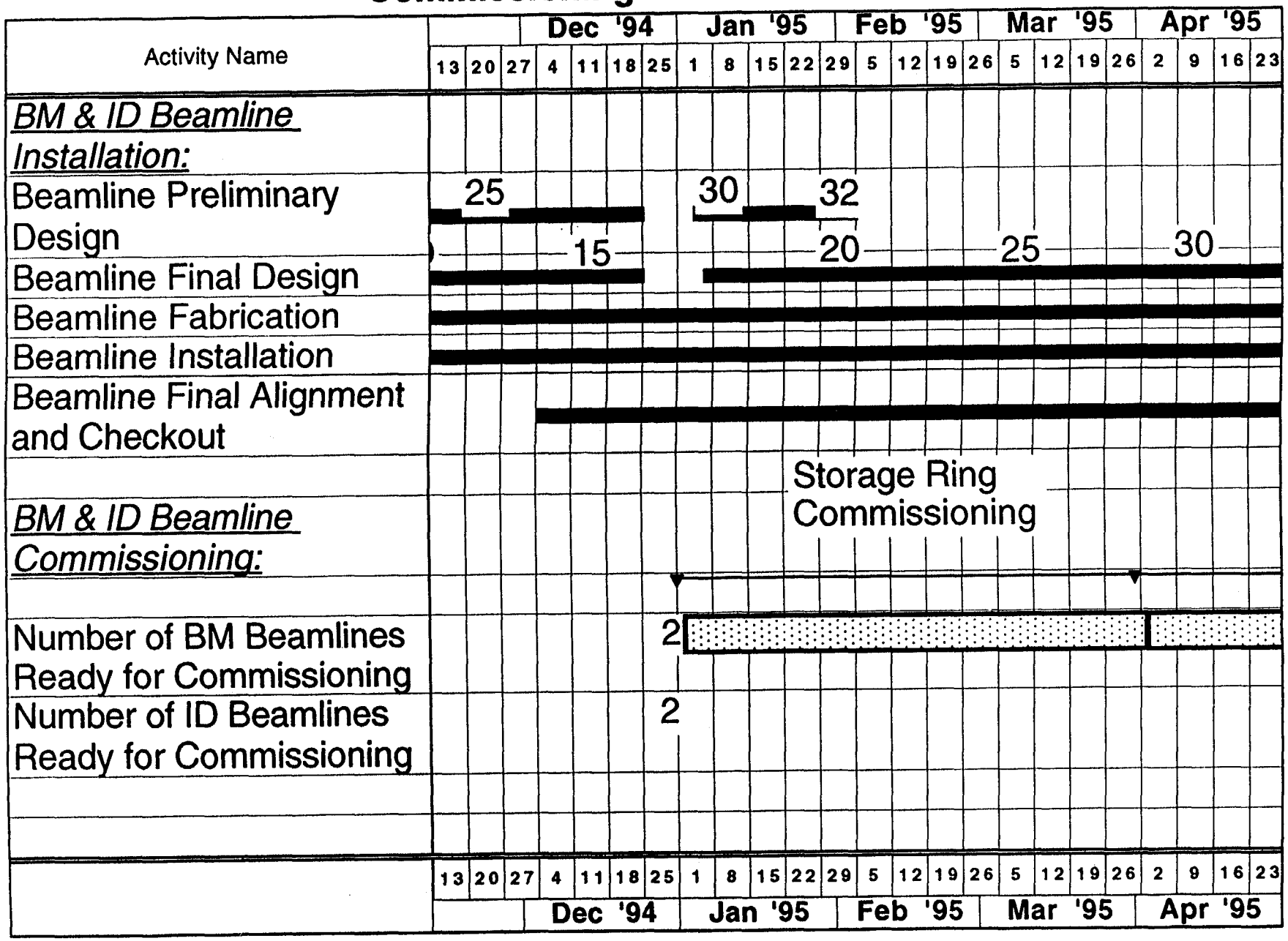
When Should the Beamlines Be Ready?

Is There a CAT Beamline Commissioning Plan?

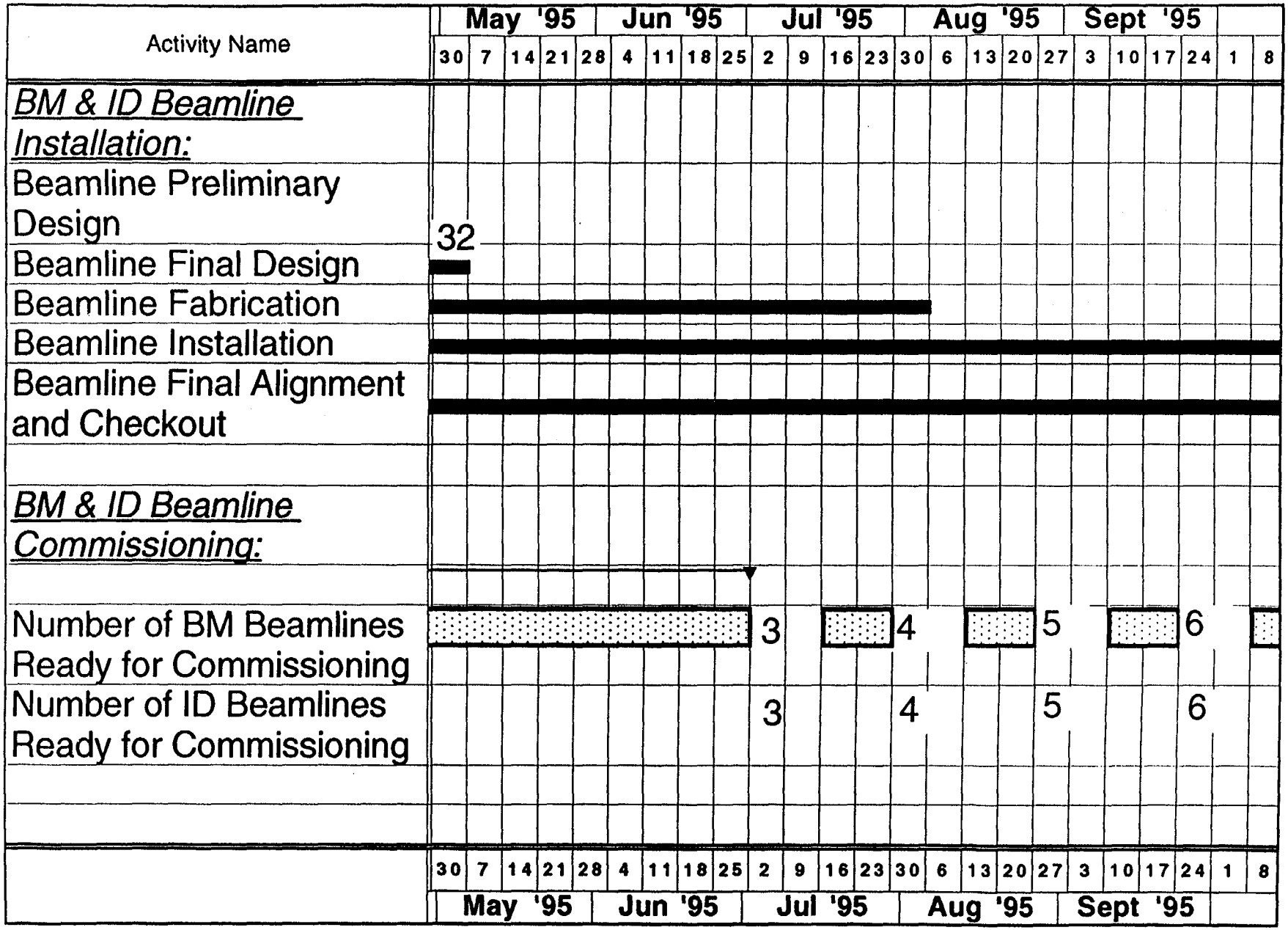
CAT Beamline Design Review, Fabrication, Installation and Commissioning Schedule

Activity Name	Jun '94					Jul '94				Aug '94					Sept '94				Oct '94					
	29	5	12	19	26	3	10	17	24	31	7	14	21	28	4	11	18	25	2	9	16	23	30	6
BM & ID Beamline Installation:																								
Beamline Preliminary Design		1	2	3	4	5					10					15					20			
Beamline Final Design															1	2	3	4	5					10
Beamline Fabrication																								
Beamline Installation																								
Beamline Final Alignment and Checkout																								
BM & ID Beamline Commissioning:																								
Number of BM Beamlines Ready for Commissioning																								
Number of ID Beamlines Ready for Commissioning																								
	29	5	12	19	26	3	10	17	24	31	7	14	21	28	4	11	18	25	2	9	16	23	30	6
	Jun '94					Jul '94				Aug '94					Sept '94				Oct '94					

CAT Beamline Design Review, Fabrication, Installation and Commissioning Schedule



CAT Beamline Design Review, Fabrication, Installation and Commissioning Schedule



CAT Beamline Design Review, Fabrication, Installation and Commissioning Schedule

Activity Name	Nov '95							Dec '95				Jan '96				Feb '96			
	15	22	29	5	12	19	26	3	10	17	24	31	7	14	21	28	4	11	18	25
BM & ID Beamline Installation:																				
Beamline Preliminary Design																				
Beamline Final Design																				
Beamline Fabrication																				
Beamline Installation																				
Beamline Final Alignment and Checkout																				
BM & ID Beamline Commissioning:																				
Number of BM Beamlines Ready for Commissioning		8				10				12					14				16	
Number of ID Beamlines Ready for Commissioning		8				10				12					14				16	
	15	22	29	5	12	19	26	3	10	17	24	31	7	14	21	28	4	11	18	25
	Nov '95							Dec '95				Jan '96				Feb '96				

Summary of the Presentation

1. The APS plans for the installation of ID vacuum chambers, IDs, and beamline front ends are aggressive and are on time at present.

2. According to the present plan, the commissioning of the IDs and the front ends will begin in April 1994 and be completed in February 1996.

3. Those beamlines that are ready first to receive radiation will be commissioned first.

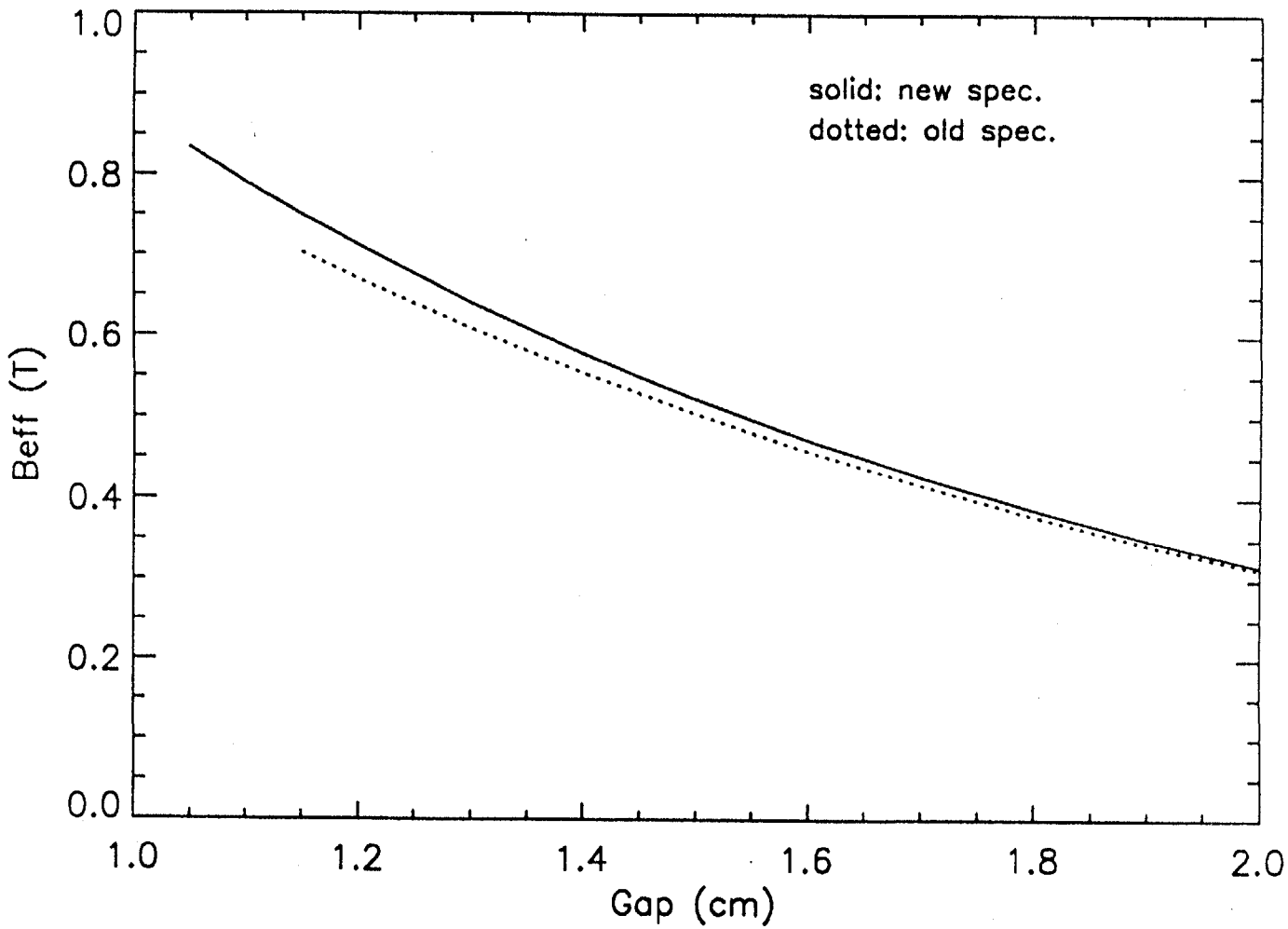
APS Undulator A Performance Enhancements

Efim Gluskin
Experimental Facilities Division
Advanced Photon Source

OUTLINE

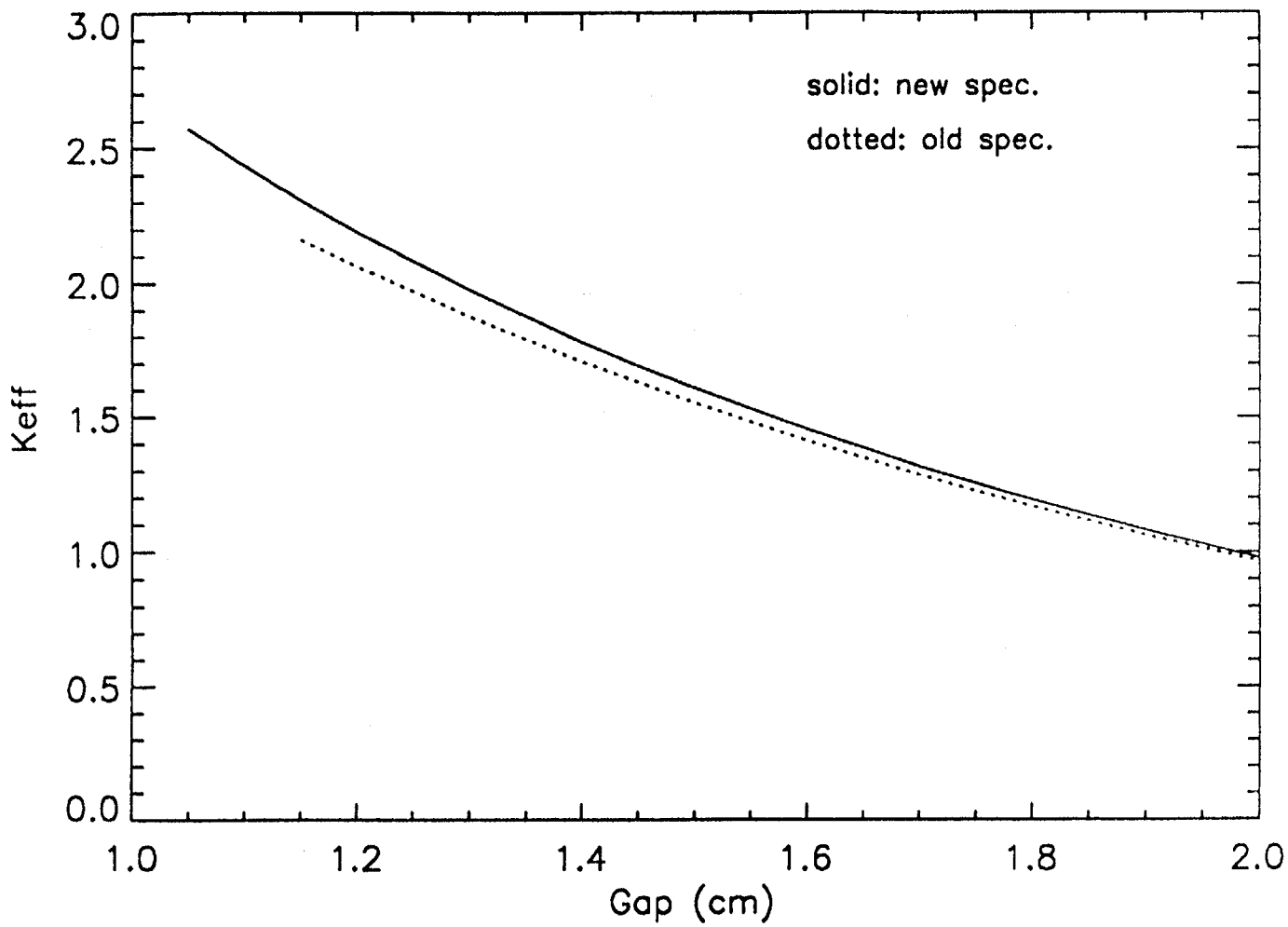
- Introduction
- Magnetic field enhancement
- Results of the ID vacuum chamber developments
- Undulator A spectral characteristics - updated

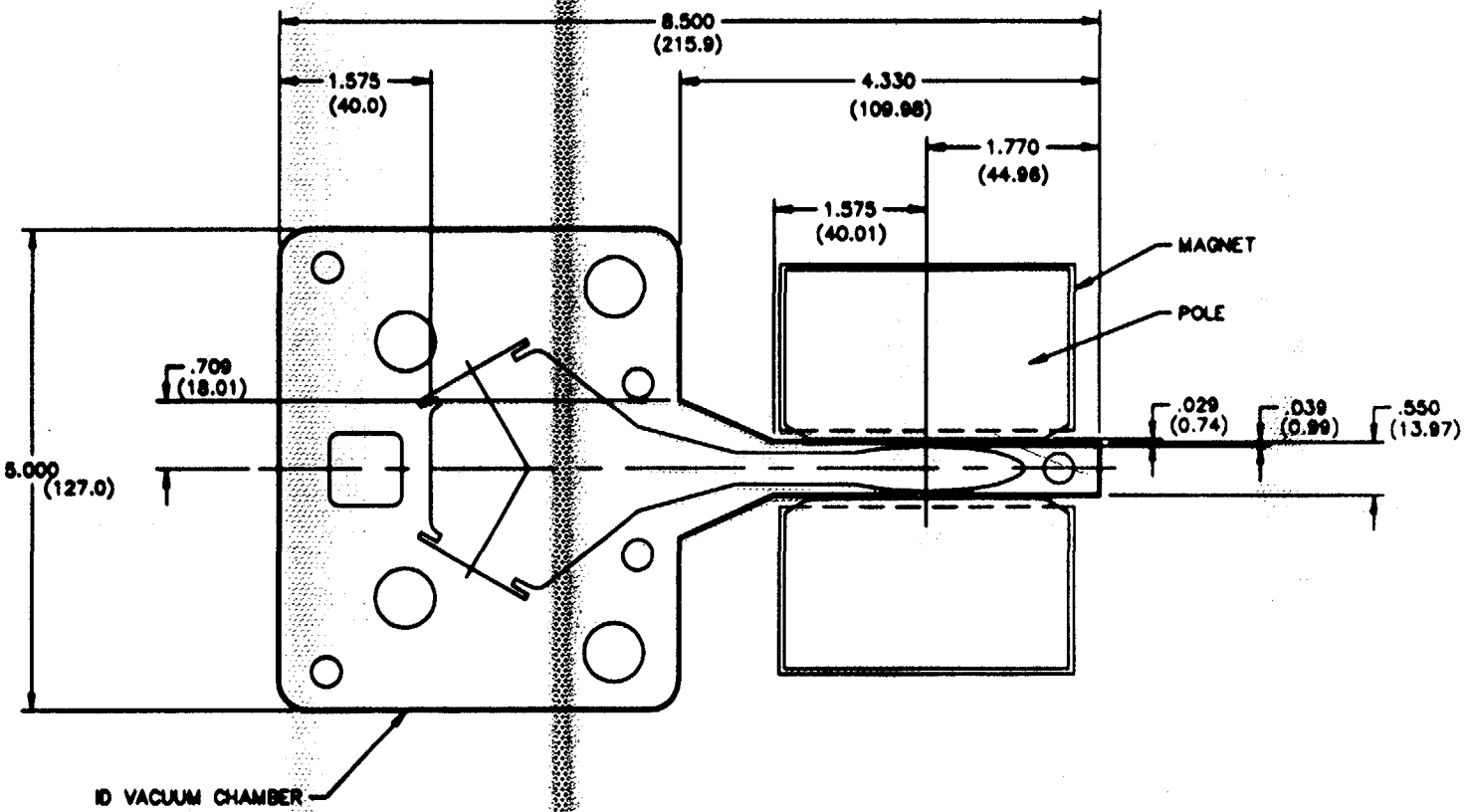
  Phase errors and magnetic measurements
- X-ray power output
- First results of the magnetic measurements of the first Undulator A: performance prediction



Effective magnetic field as a function of gap

ADVANCED PHOTON SOURCE





ITEM	DWG/PART NUMBER	NOMENCLATURE OR DESCRIPTION	MATERIAL / SPEC	QTY

PARTS LIST

S05551

ARGONNE NATIONAL LABORATORY

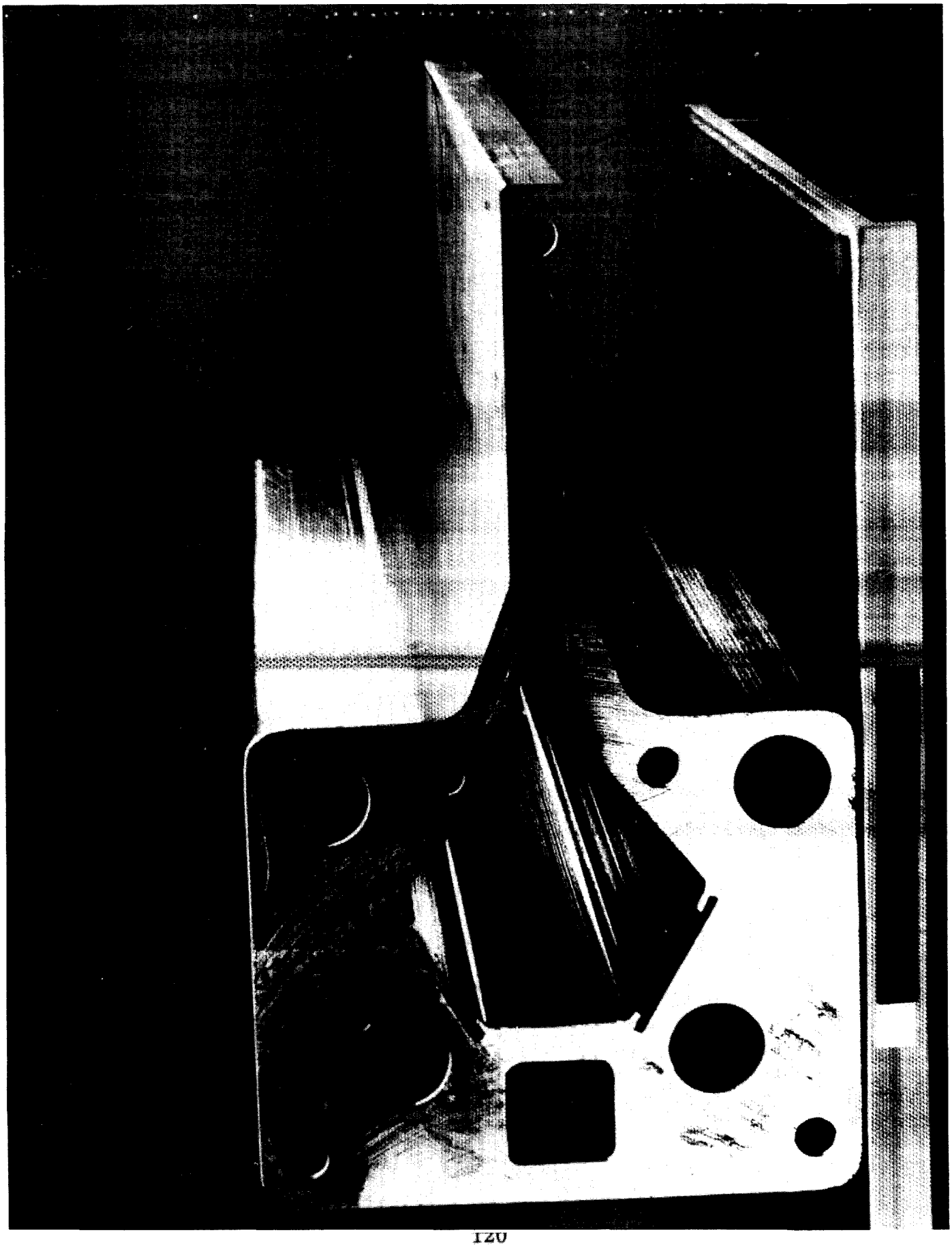
RH PIECH

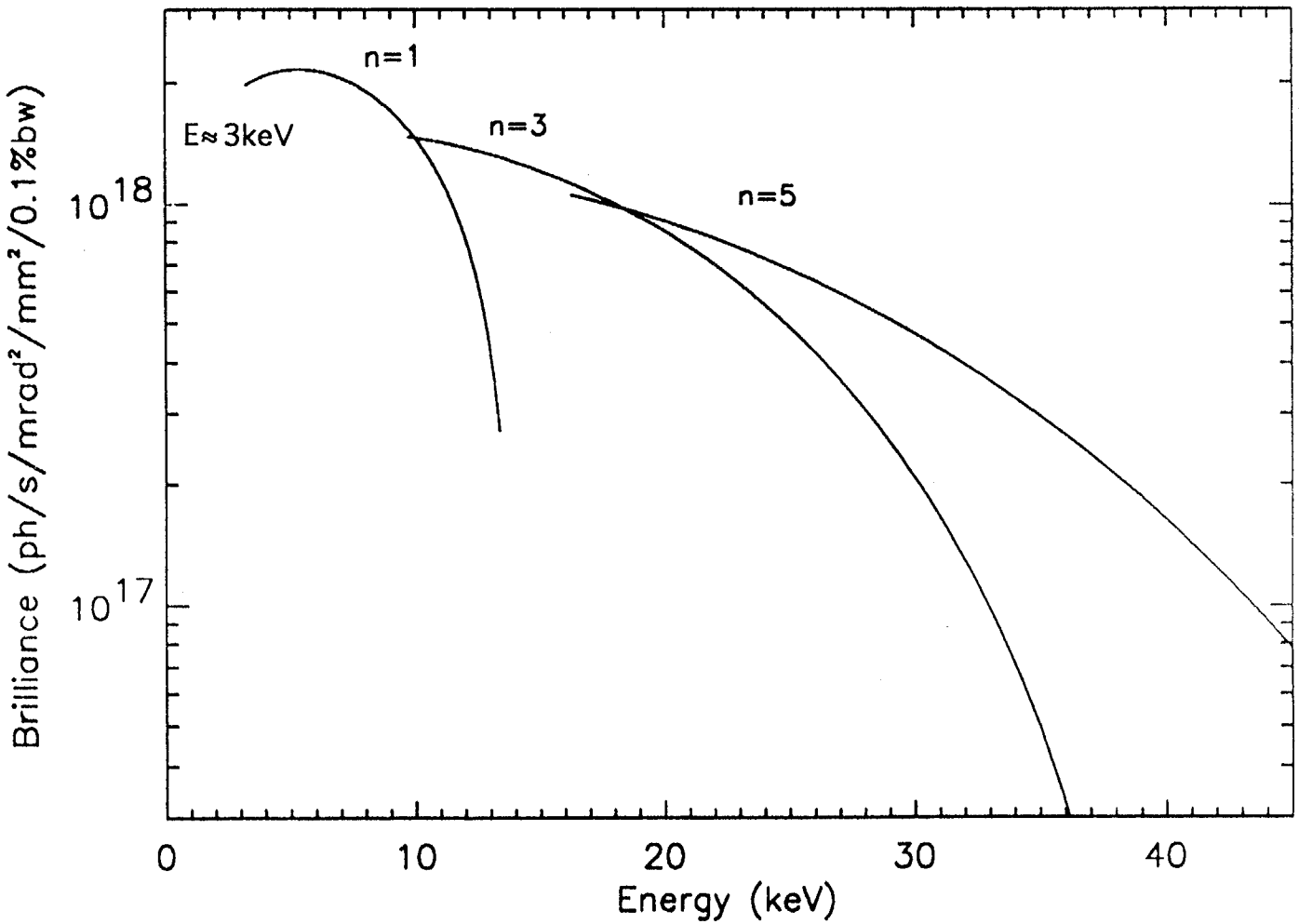
RH PIECH

ADVANCED PHOTON SOURCE
EXPERIMENTAL FACILITIES
TECHNICAL COMPONENTS
INSERTION DEVICE
VACUUM CHAMBER & ID MAGNET
STRUCTURE CROSS SECTION

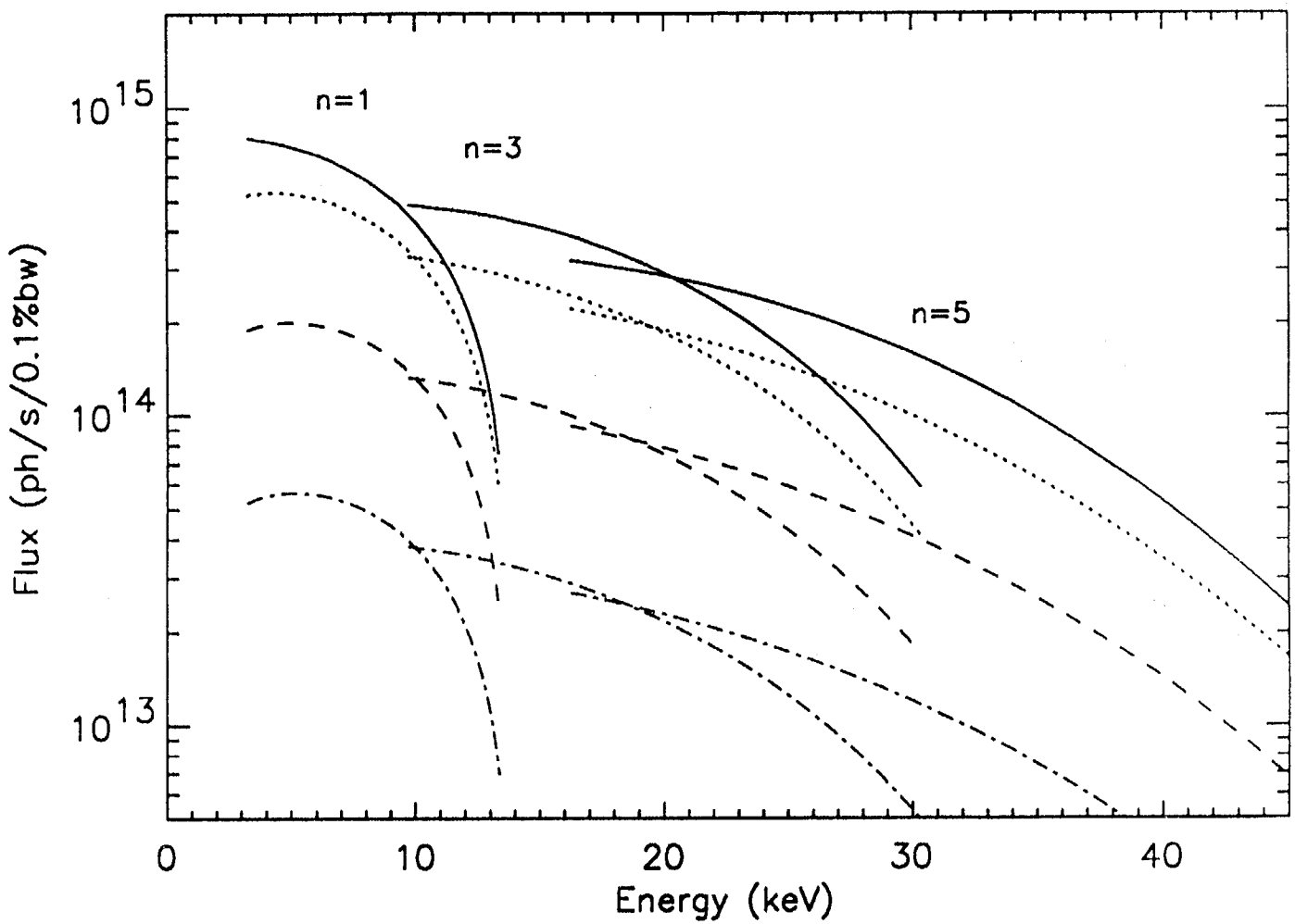
1:1

C

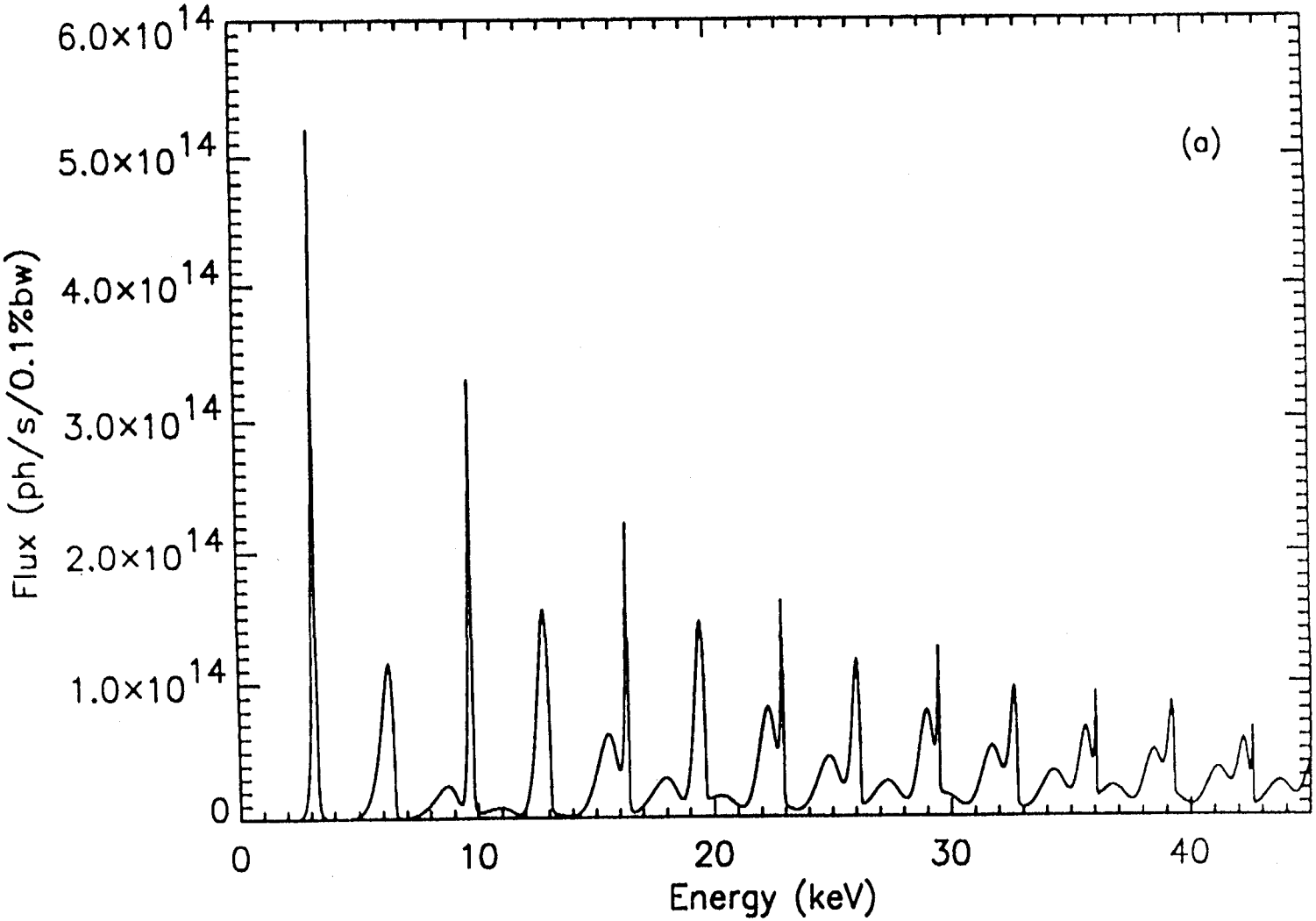




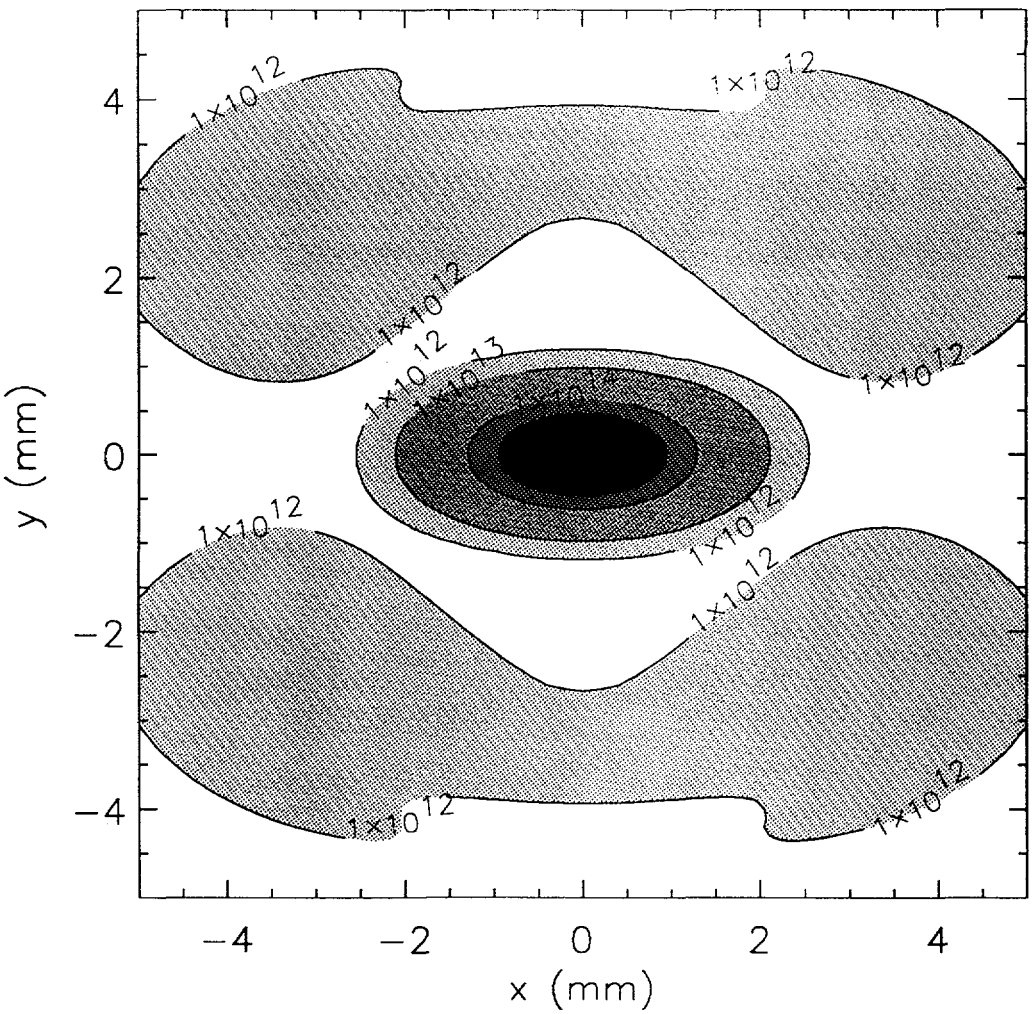
Undulator A tuning curves

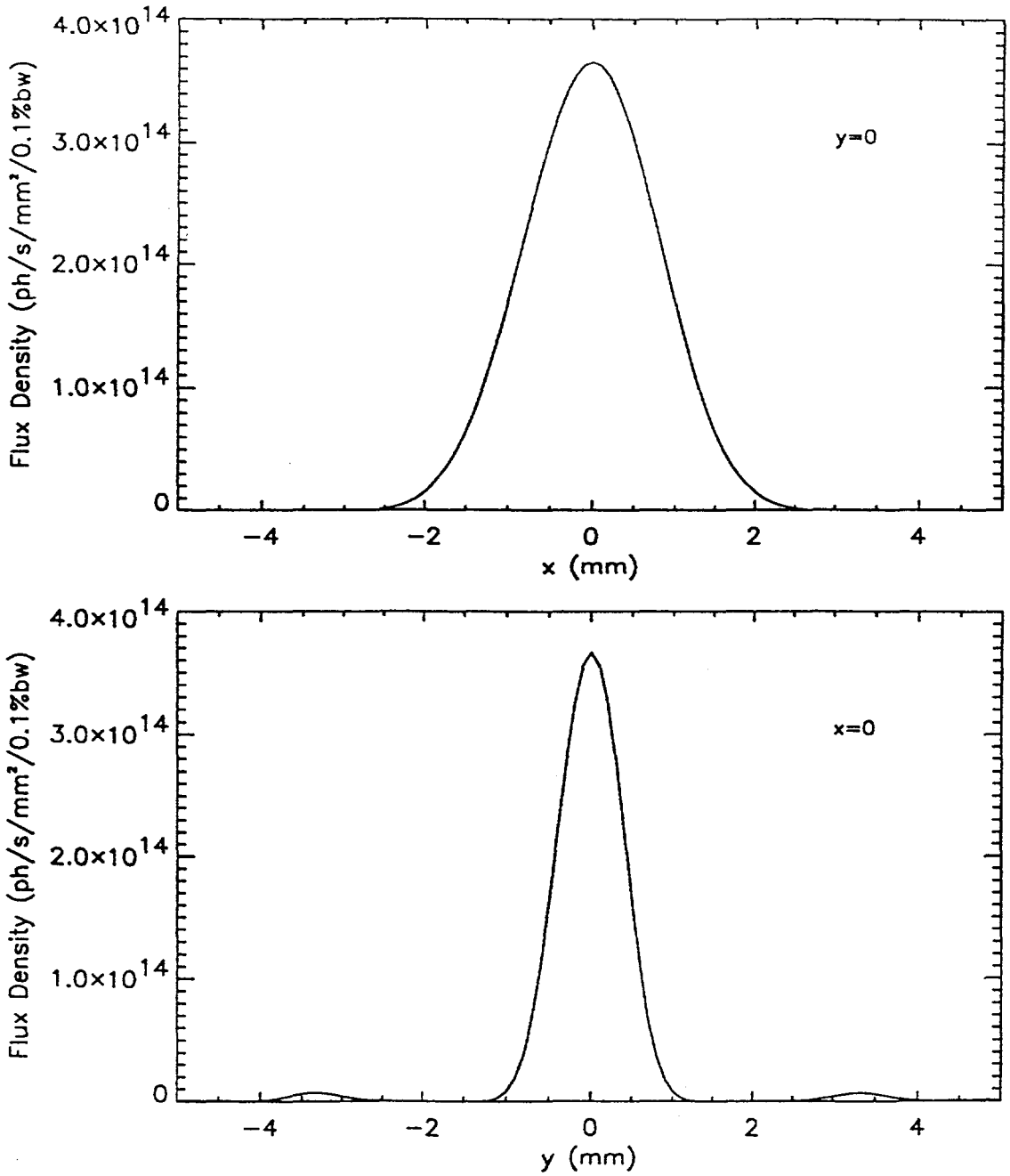


Tuning curves for different apertures

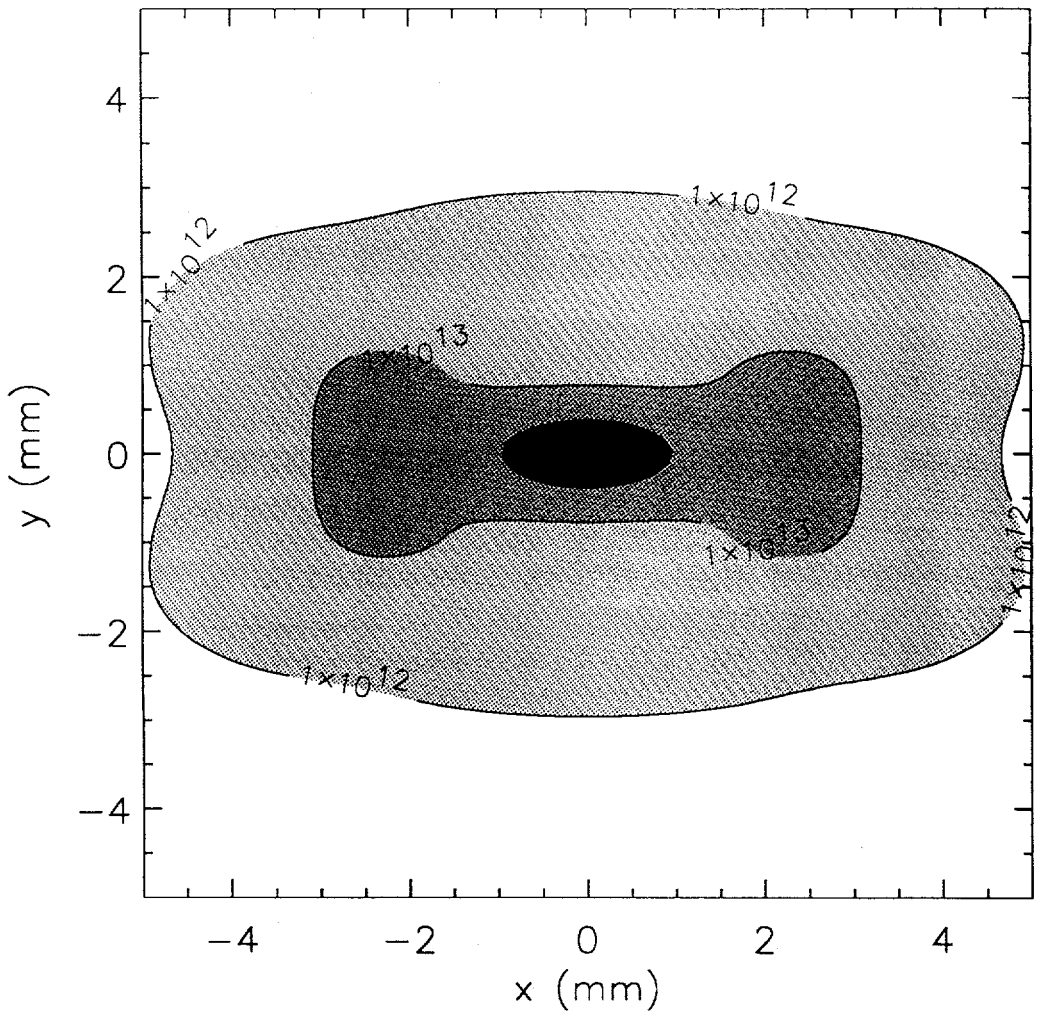


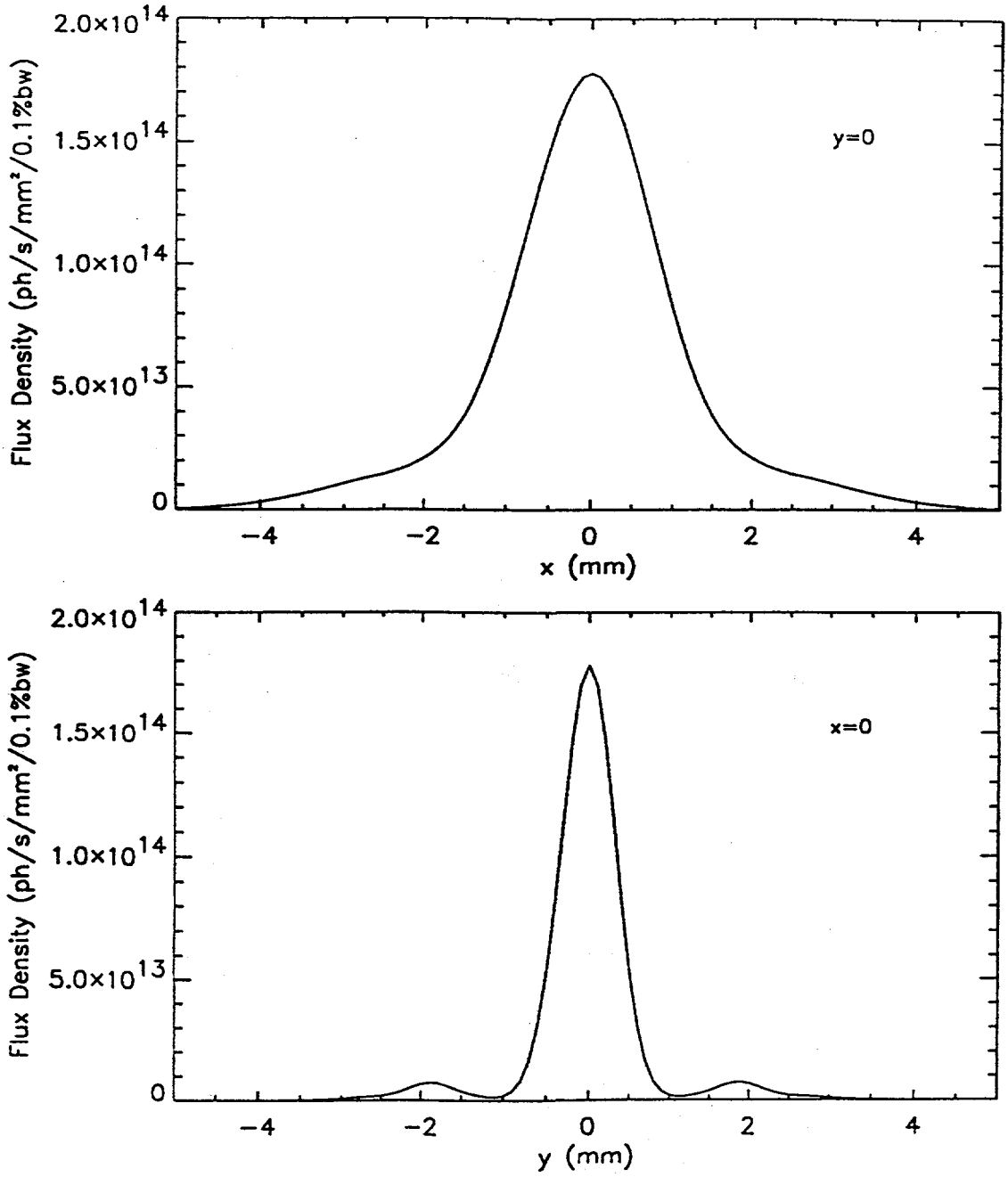
Spectral flux through 2.5 x 1.0 mm aperture


1×10^12
1×10^12
1×10^12
1×10^12
1×10^12
1×10^13
1×10^14
1×10^12
1×10^12
1×10^12
1×10^12
1×10^12
1×10^12
4
2
0
−2
−4
y (mm)
−4
−2
0
2
4
x (mm)

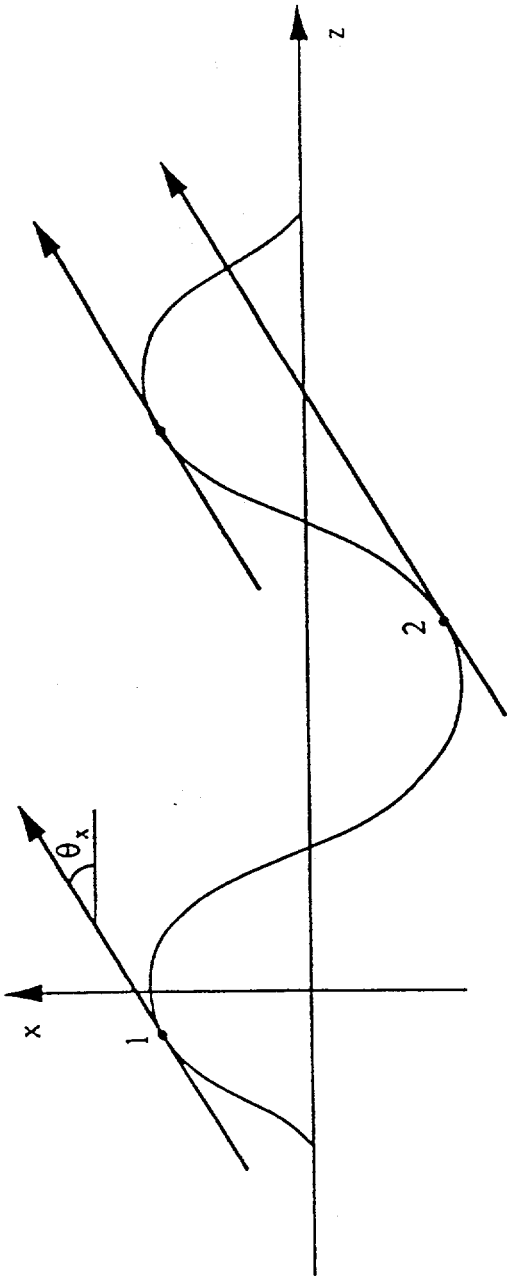


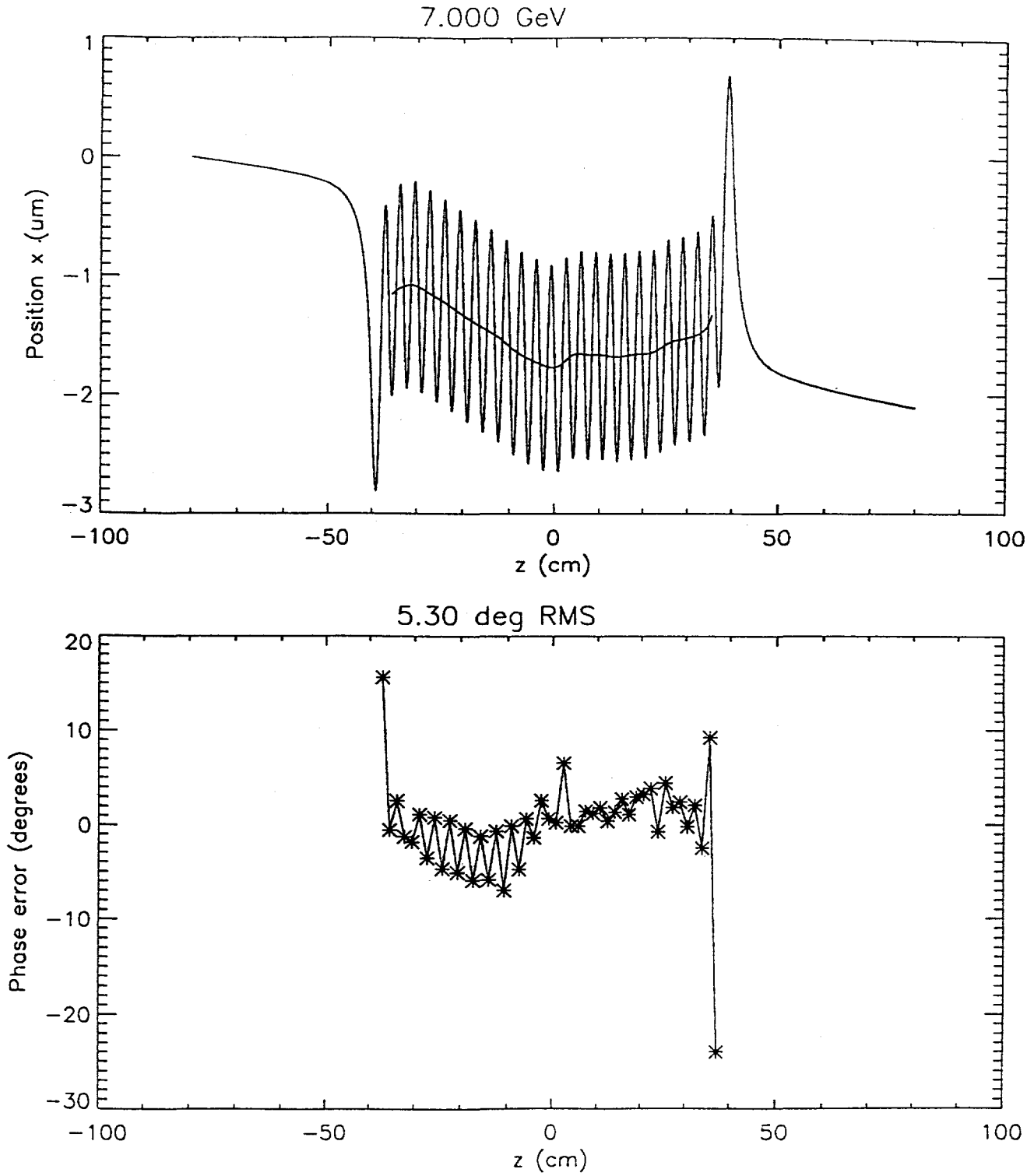
Flux density profiles - 1st harmonic


1×10^12
1×10^12
1×10^13
1×10^13
1×10^12
1×10^12
4
2
0
−2
−4
y (mm)
−4
−2
0
2
4
x (mm)

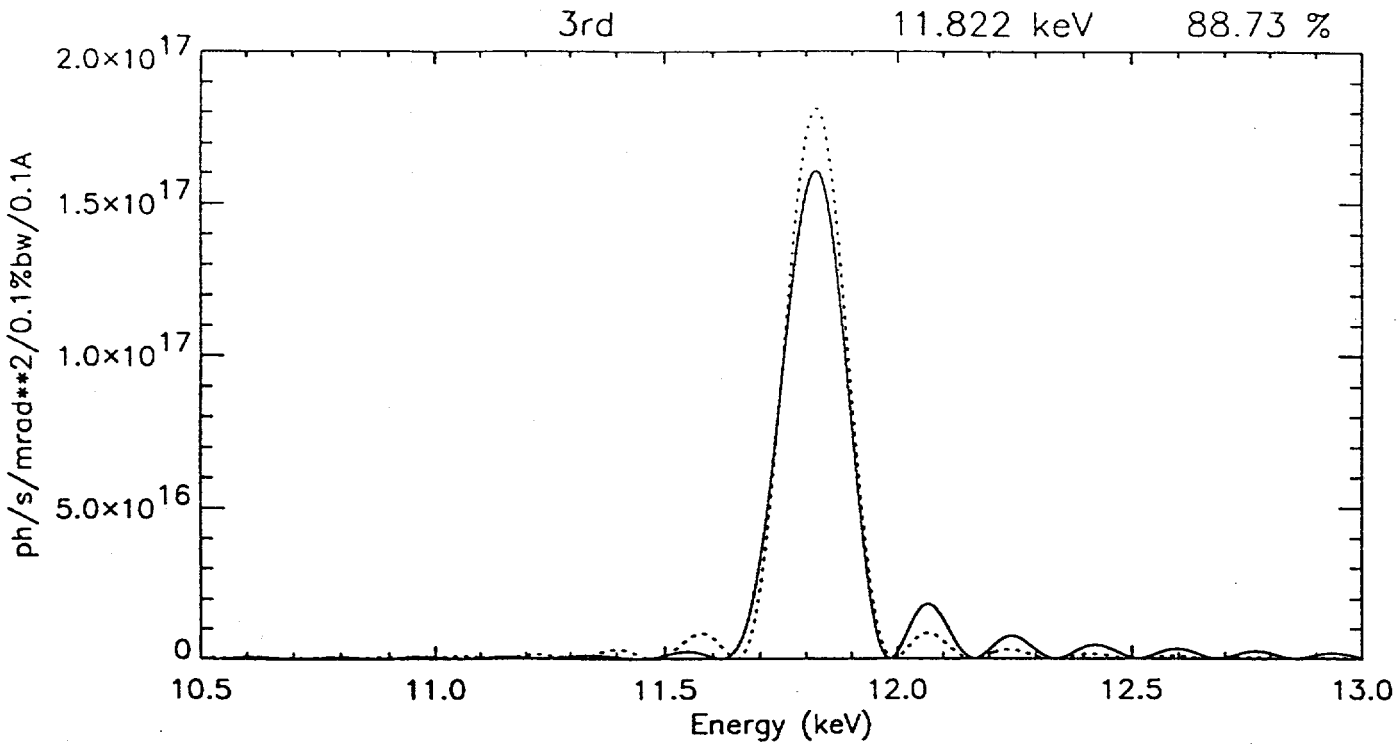


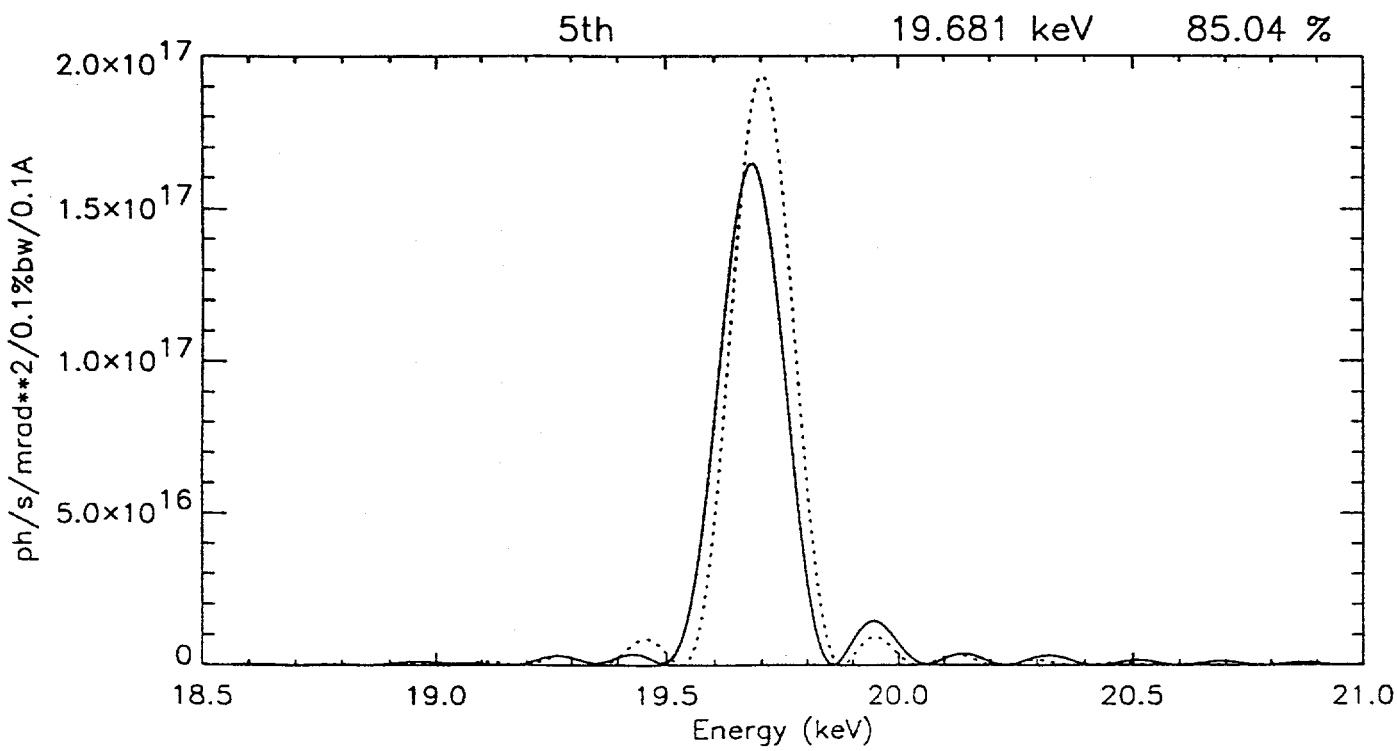
Flux density profiles - 3rd harmonic


x
z
1
2
θ_x

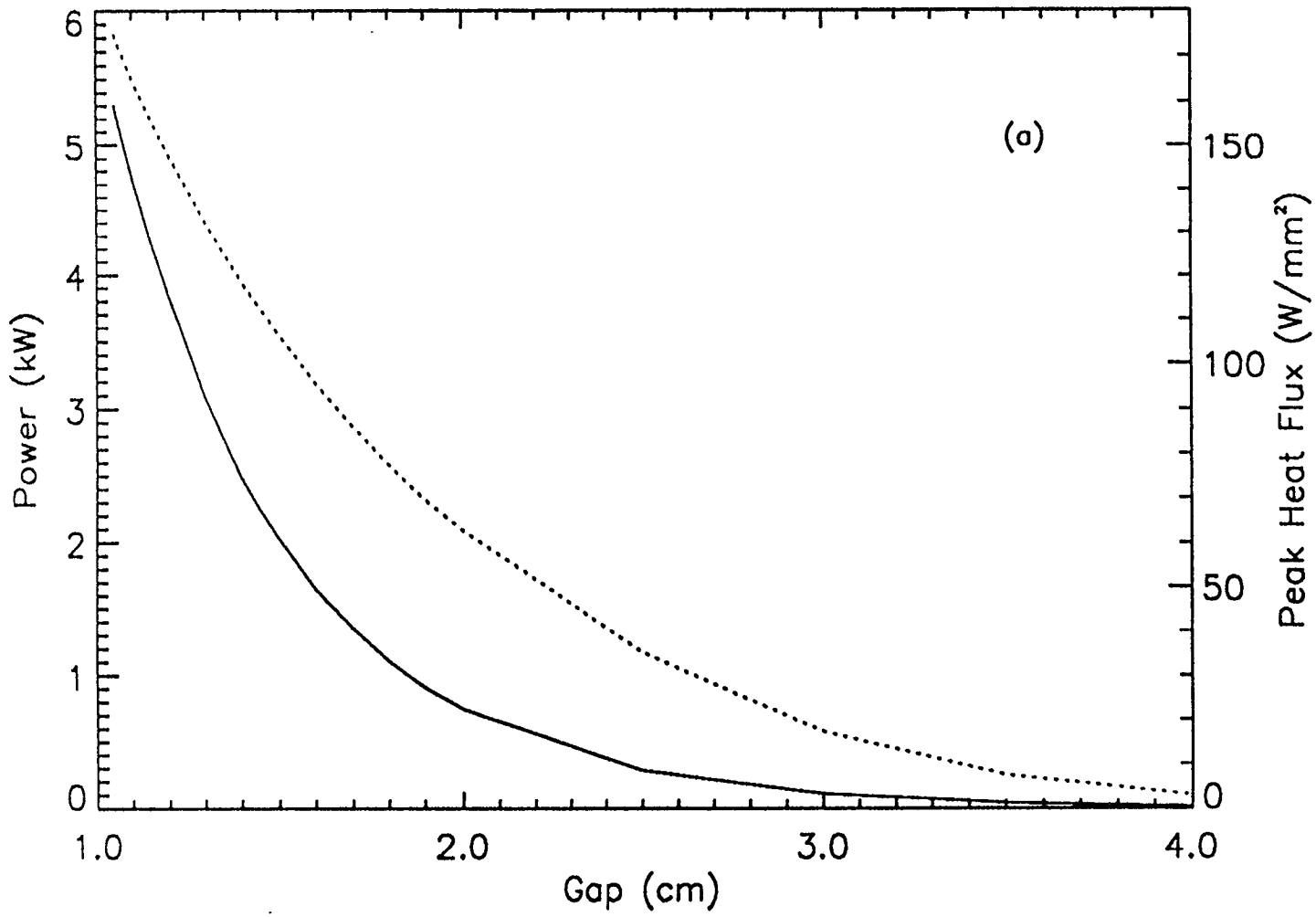


Second field integral and phase errors
for the "wedge-pole" undulator

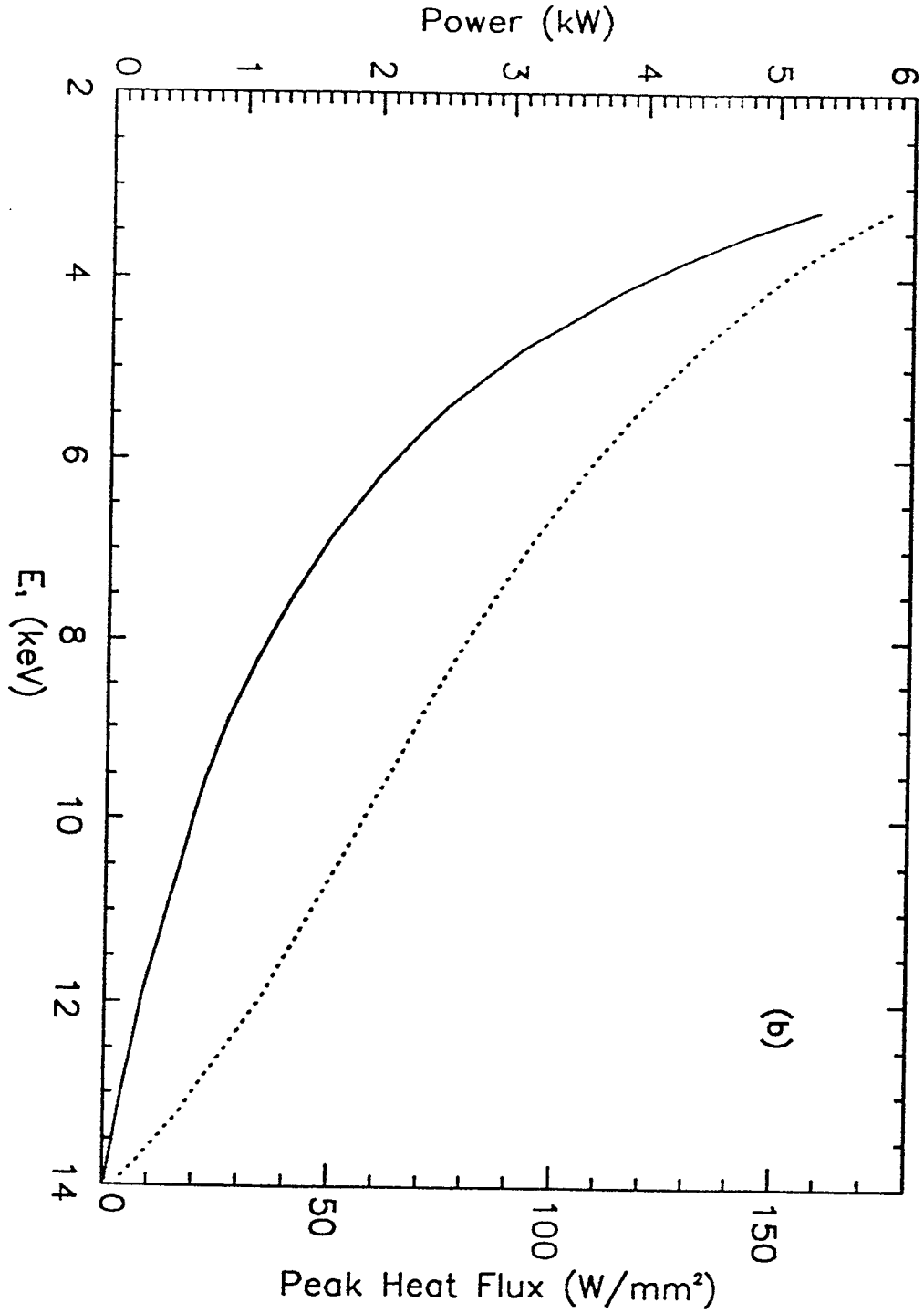


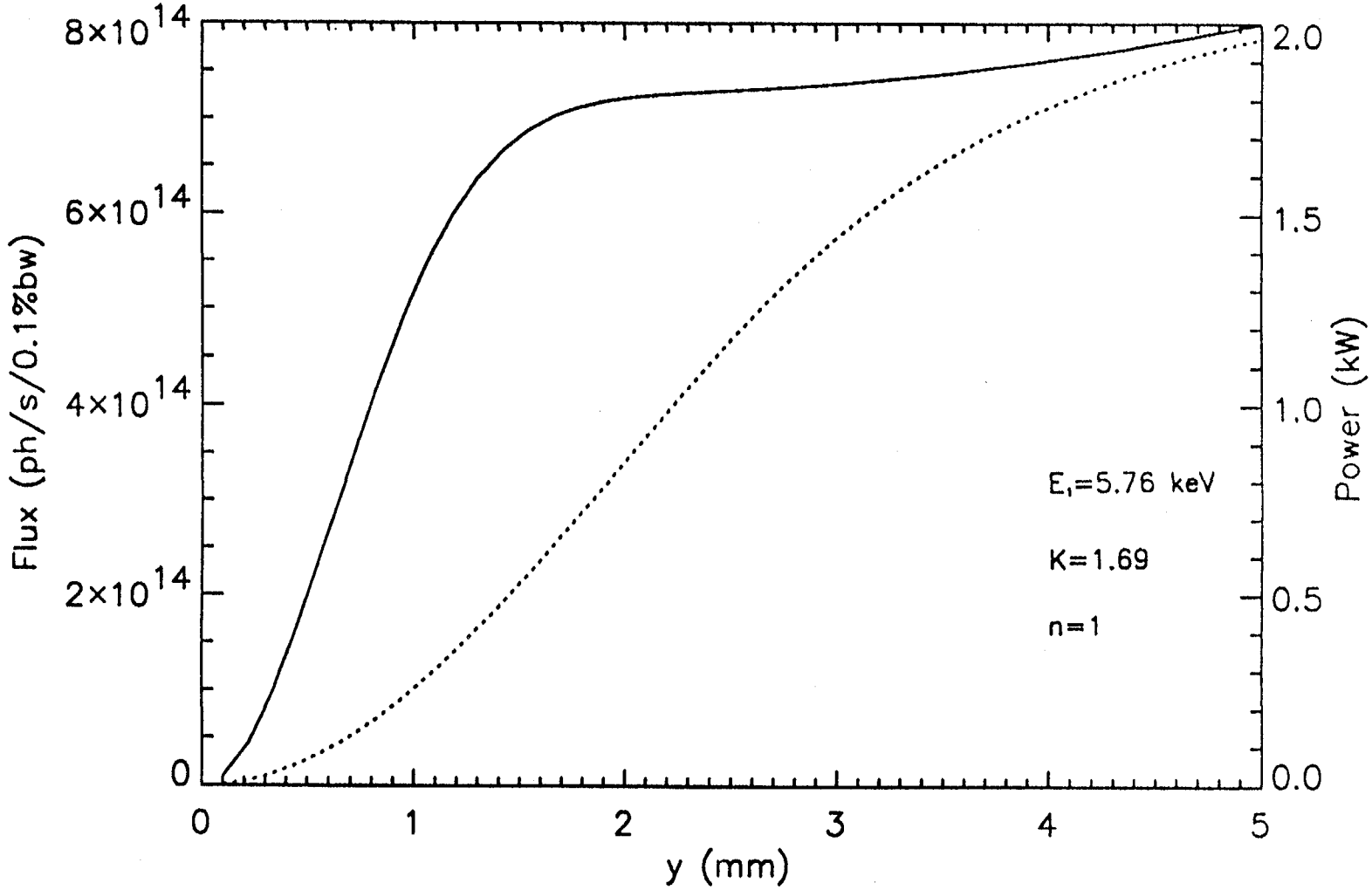


Brilliance for the ideal (dotted) and the "wedge-pole" (solid) undulators

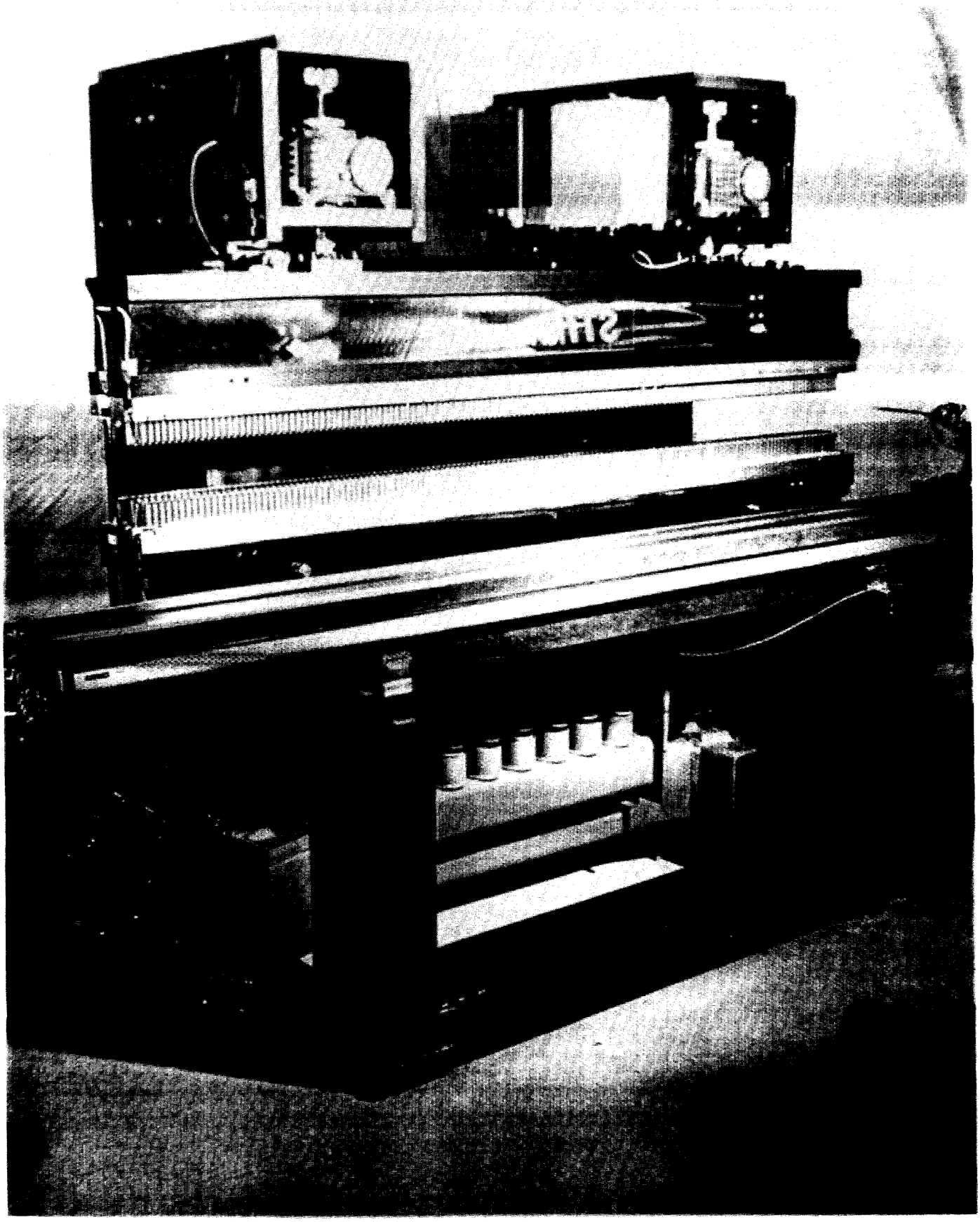


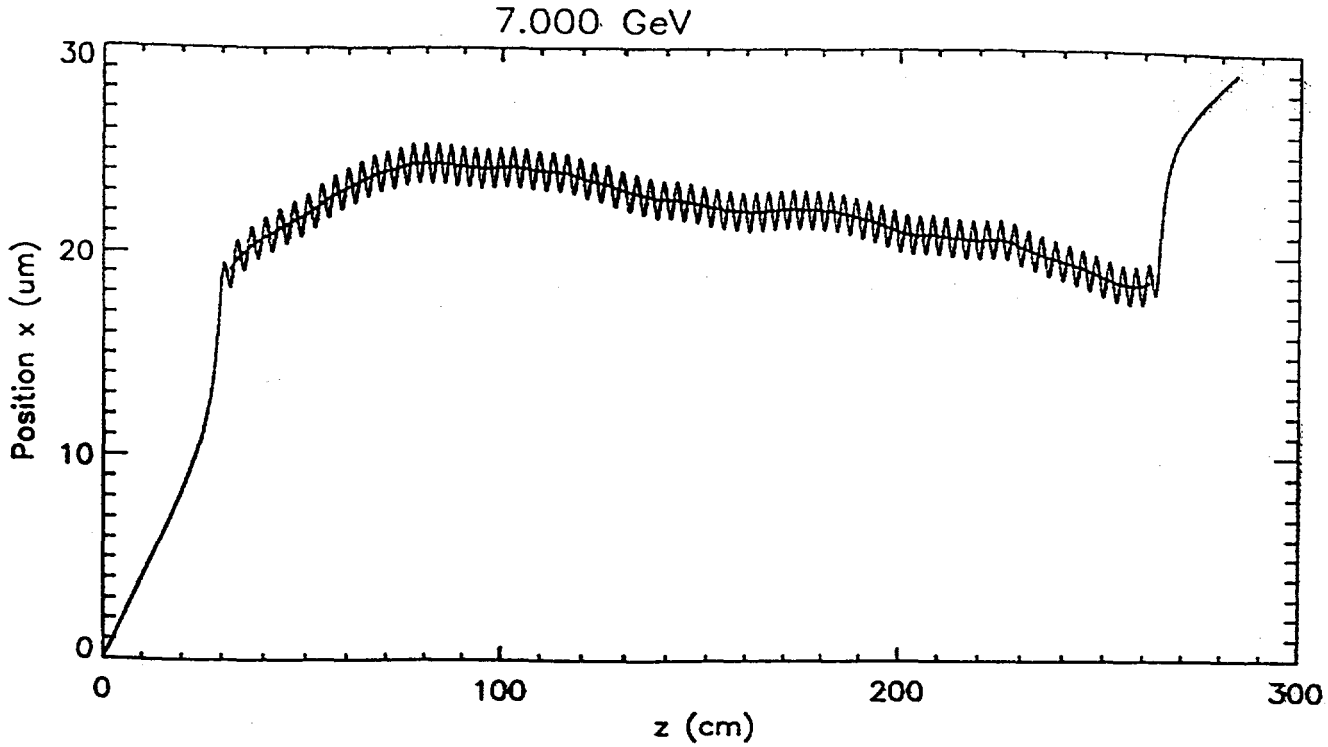
Total emitted power (solid) and peak heat flux (dotted) versus gap

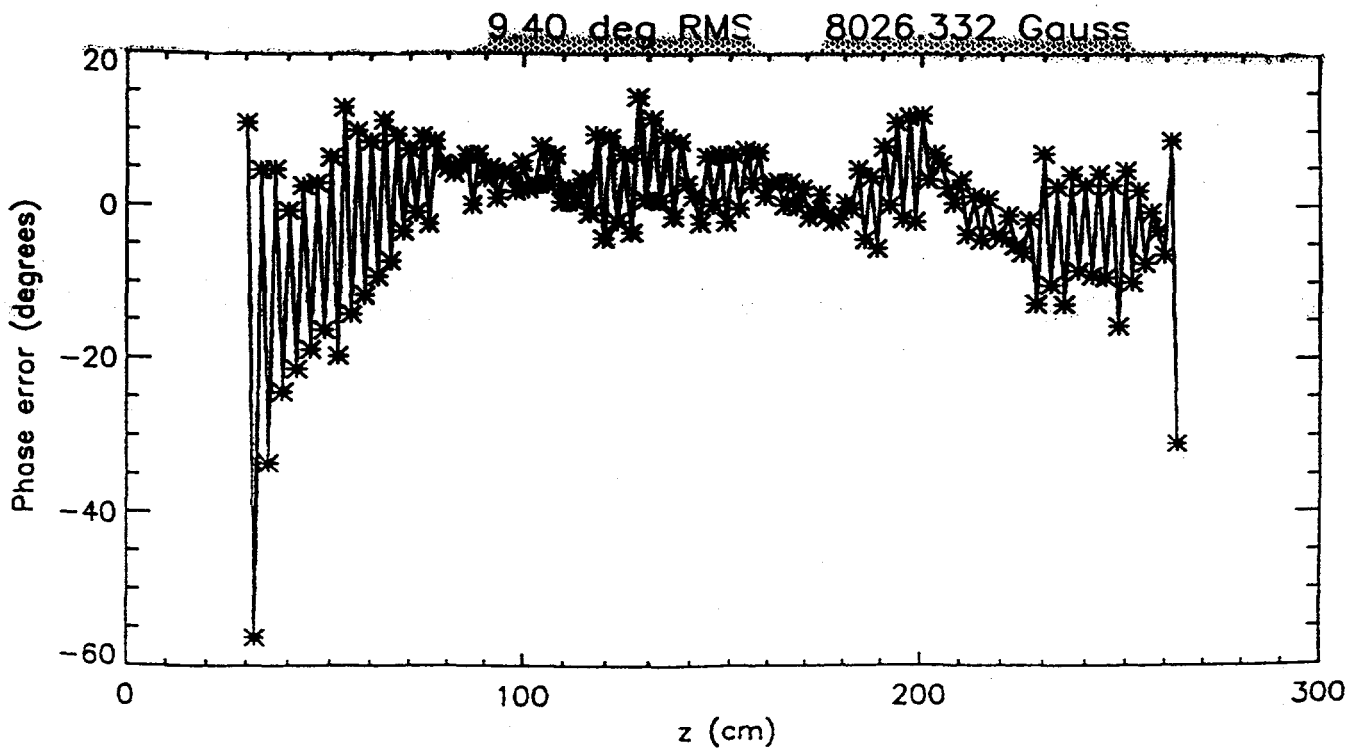

Power (kW)
0
1
2
3
4
5
6
2
4
6
8
10
12
14
E_t (keV)
0
50
100
150
Peak Heat Flux (W/mm²)
(b)

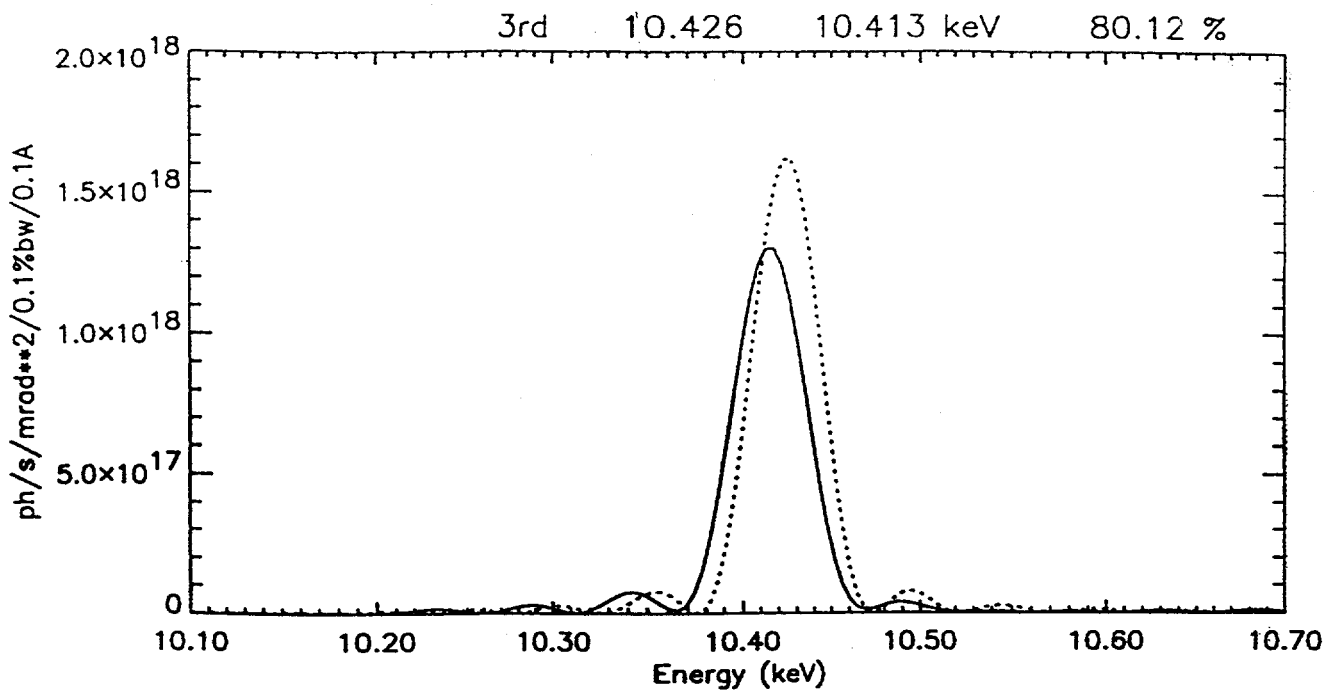


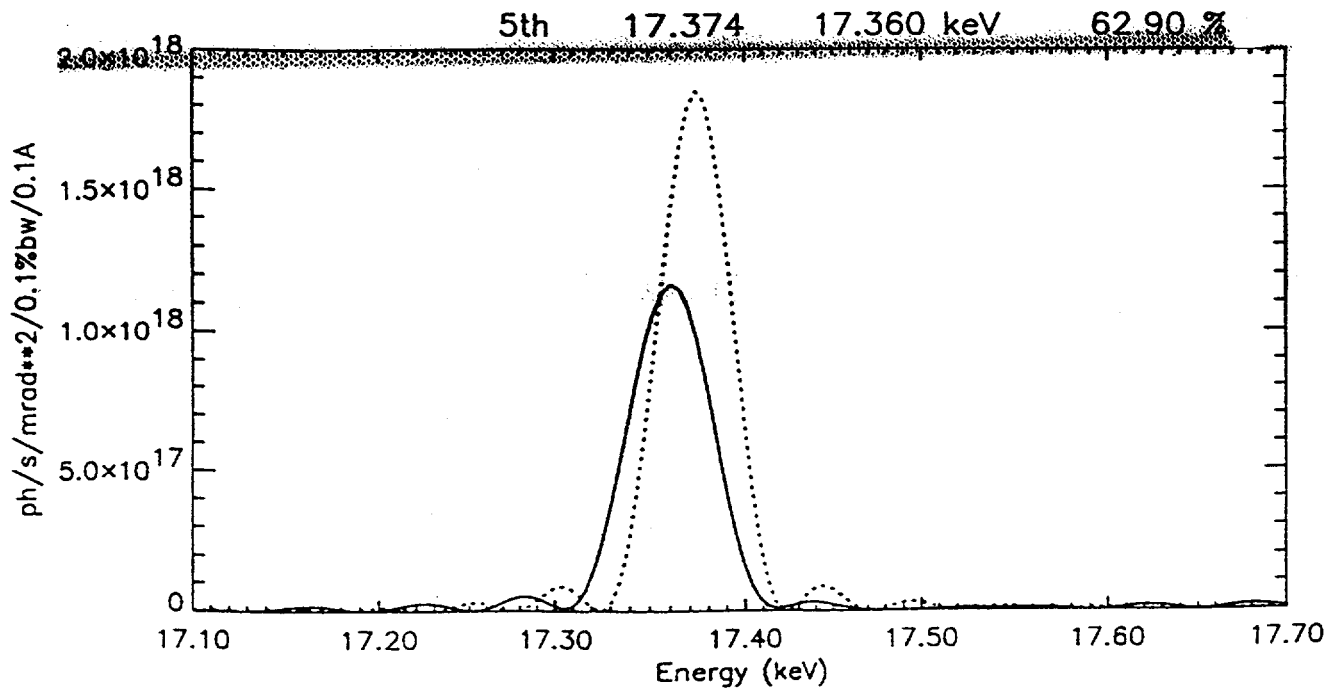
Flux (solid) and power (dotted) transmitted through aperture vs. vertical aperture size

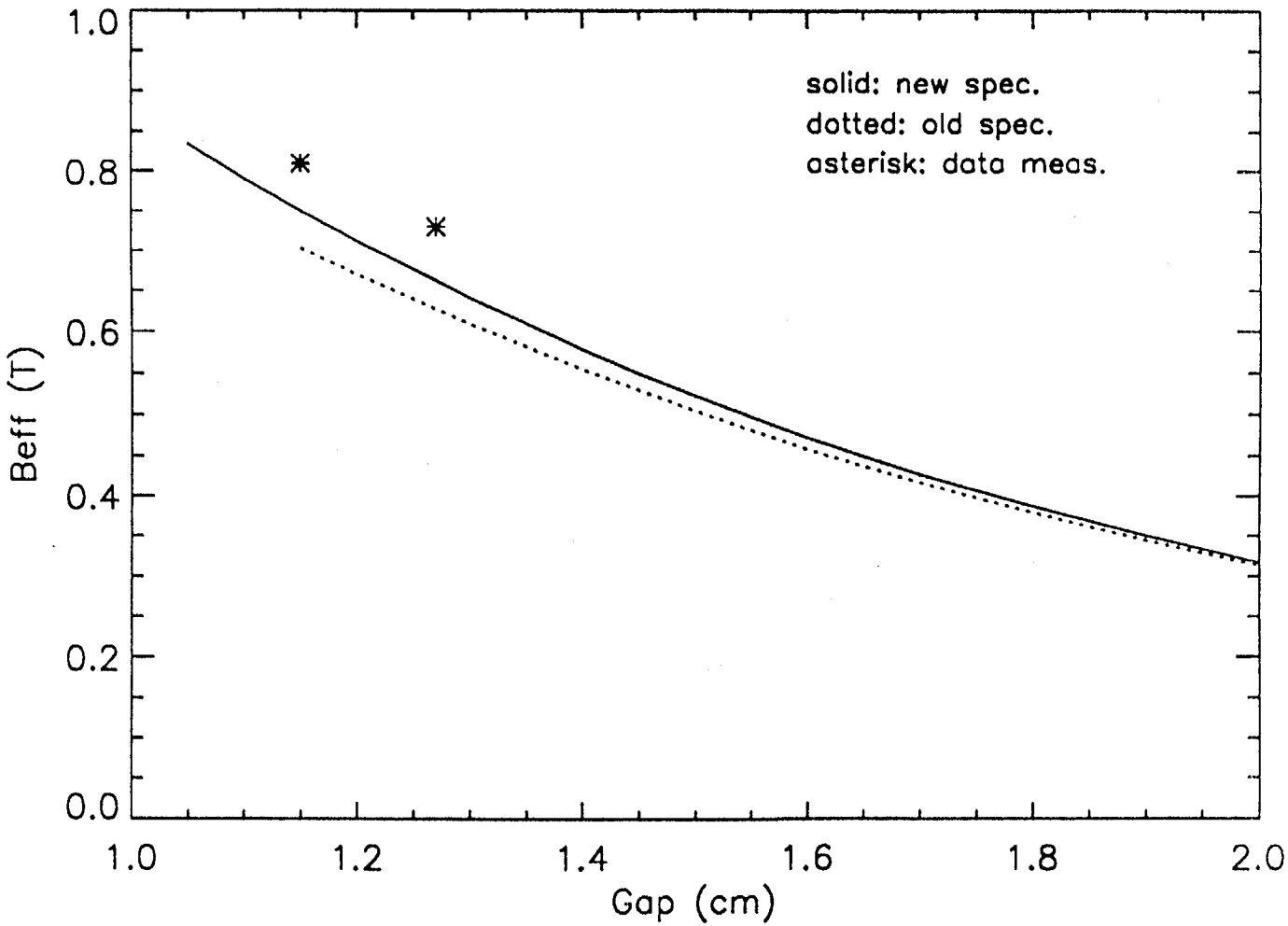



7.000 GeV
Position x (um)
z (cm)
0
10
20
30
0
100
200
300


9.40 deg RMS 8026.332 Gauss
Phase error (degrees)
z (cm)
20
0
-20
-40
-60
0
100
200
300


3rd 10.426 10.413 keV 80.12 %
2.0×10^18
1.5×10^18
1.0×10^18
5.0×10^17
0
ph/s/mrad**2/0.1%bw/0.1A
10.10
10.20
10.30
10.40
10.50
10.60
10.70
Energy (keV)


5th 17.374 17.360 keV 62.90 %
2.0×10^18
1.5×10^18
1.0×10^18
5.0×10^17
0
ph/s/mrad**2/0.1%bw/0.1A
17.10
17.20
17.30
17.40
17.50
17.60
17.70
Energy (keV)


solid: new spec.
dotted: old spec.
asterisk: data meas.
Beff (T)
Gap (cm)
1.0
0.8
0.6
0.4
0.2
0.0
1.0
1.2
1.4
1.6
1.8
2.0

FIRST OPTICS MONOCHROMATOR PERFORMANCE AND OTHER HHL OPTICS R&D

Dennis M. Mills

Sixth Users Meeting for the APS
May 25-26, 1994

High Heat Load Monochromator

Program Goal

To procure a high heat load crystal monochromator system that can deliver the undulator beam to the sample with minimal loss of brilliance with:

- APS operating at 7 GeV and 100 mA
- a 2.5-m ID with k=2.17 (4.2 keV first harmonic)

Solution for Program Goal

The measured data and modeling indicate that a crystal in the inclined geometry (with appropriate inclination angle) cooled with liquid gallium will meet the needs of this near-term goal. The following should be noted:

- Liquid gallium has been selected as the coolant for its superior physical properties (as compared to water) such as thermal conductivity and high boiling point.
- The inclined crystal geometry has been chosen for its reduction in surface power loading and improved heat flow.

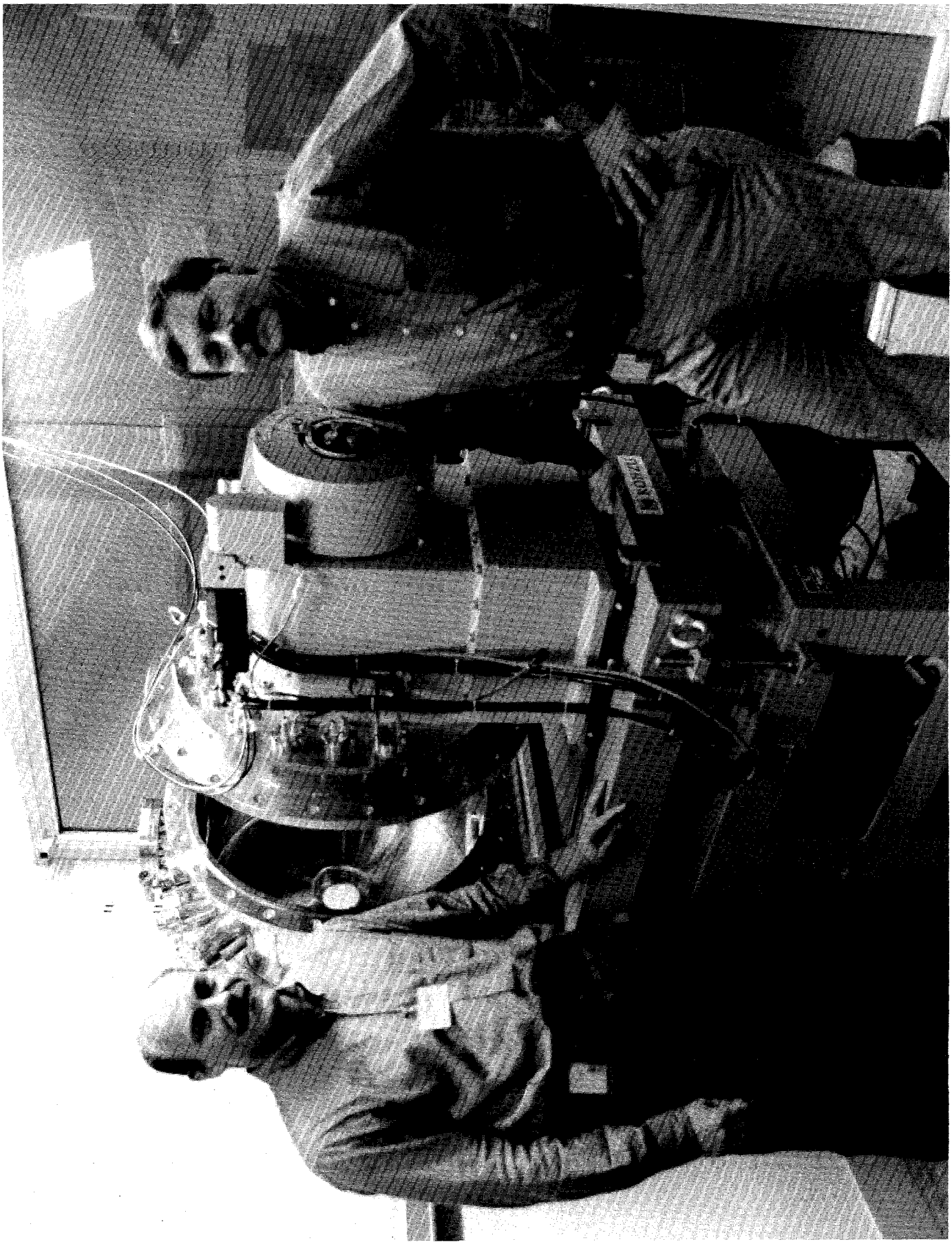
HHL Monochromator - Mechanical/Vacuum

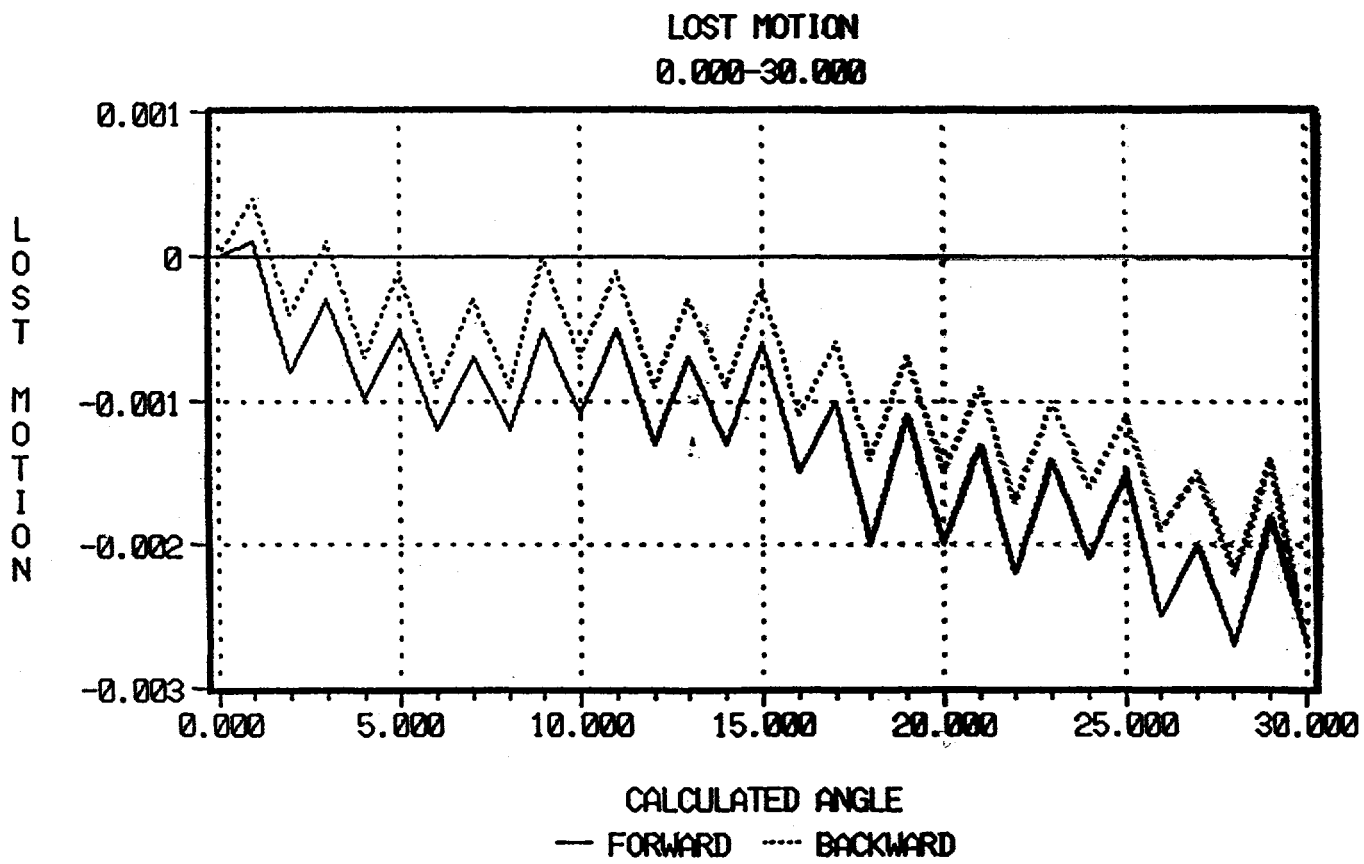
Design Goals:

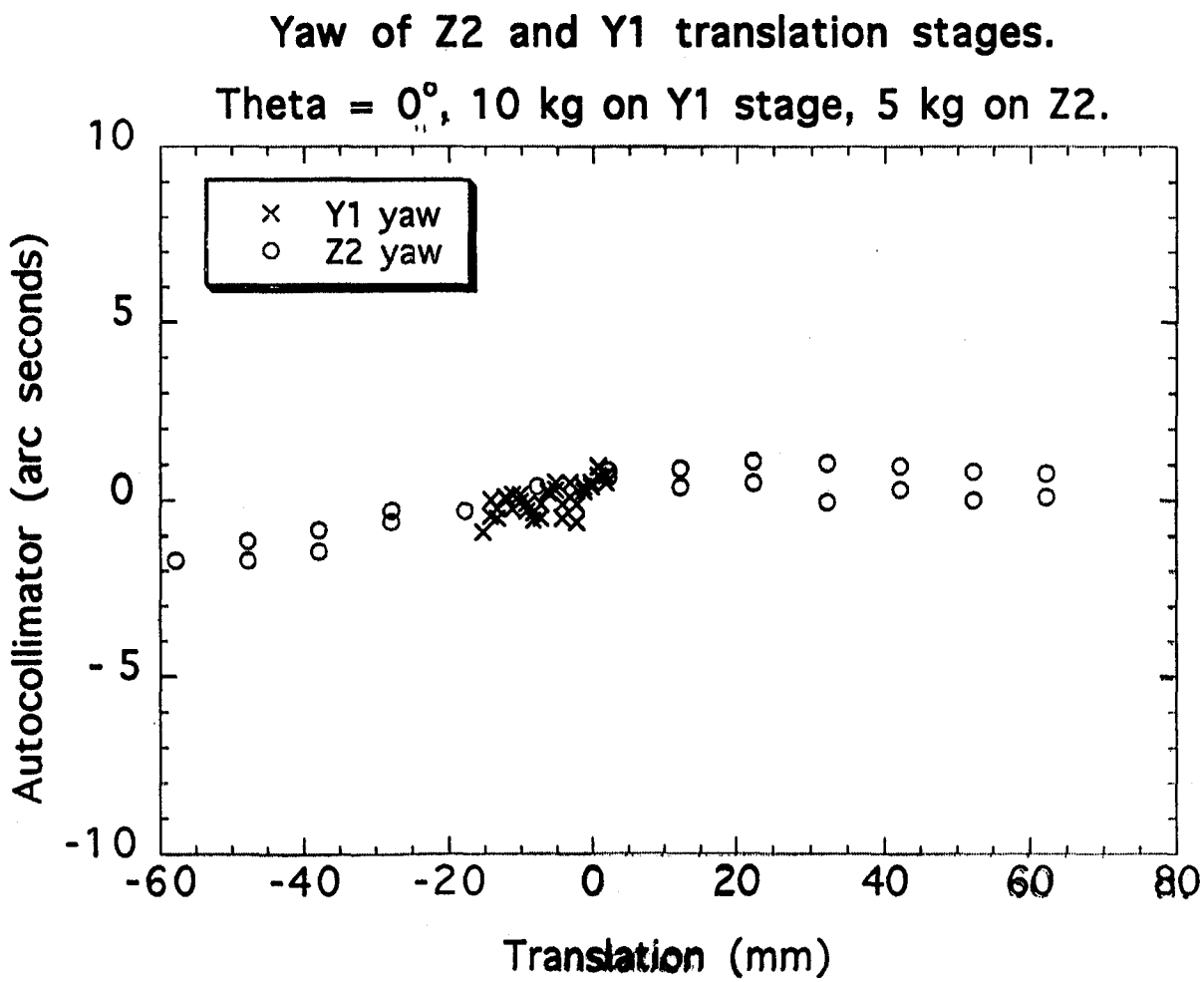
- fixed exit operation
- 35 mm offset
- tunable from 4-20 keV with Si (111)
- high vacuum (10^{-6} - 10^{-7} torr) compatible
- design independent of final crystal configuration
- operation with 2.5 m ID @ 7 GeV & 100 ma

Current Status:

The mechanical/vacuum portion of the APS monochromator was delivered by Kohzu Seiki in January 1994 and we have begun testing of the mechanics. We also have motions (step motors, servo-motors,) encoders, gallium pump read-out, and vacuum pumps and read-outs under EPICS control.




LOST MOTION
0.000-30.000
0.001
0
-0.001
-0.002
-0.003
LOST MOTION
0.000
5.000
10.000
15.000
20.000
25.000
30.000
CALCULATED ANGLE
FORWARD
BACKWARD


Yaw of Z2 and Y1 translation stages.
Theta = 0°, 10 kg on Y1 stage, 5 kg on Z2.
Y1 yaw
Z2 yaw
Autocollimator (arc seconds)
10
5
0
-5
-10
-60
-40
-20
0
20
40
60
80
Translation (mm)

Power Density on the Crystal Surface

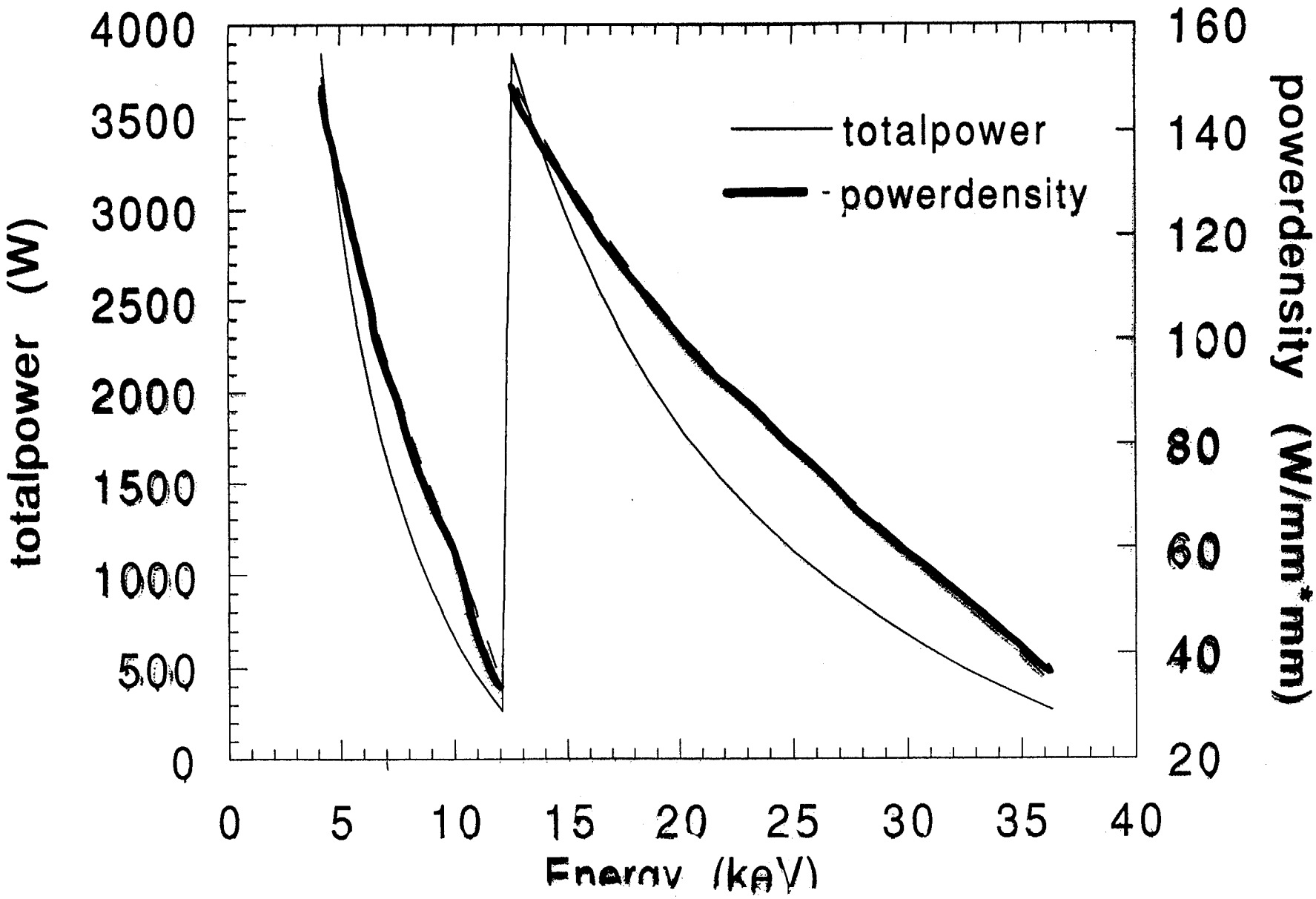
From the simulations and experimental results, we have ascertained that the maximum surface power density that our current cooling schemes (i.e., slotted crystals with liquid gallium coolant at 1 - 2 gpm) can handle without substantial thermal distortion on the crystal is about

4 or 5 watts/mm^2.

Initial finite element analysis of the APS Undulator A thermal loading on back-cooled inclined silicon monochromators has shown that, at closed gap and 4.2 keV (worst case power loading) and with an inclination angle of 85°, the thermally induced slope error is 40 microradians. This is with a heat flux of

6.1 watts/mm^2.

Undulator A, 3.3 cm period, 30 m from source



ANL/APS/TB-4

High Heat Load Monochromator Specifications

by Wah Keat Lee and Dennis Mills

February 1993

Advanced Photon Source

146

Argonne National Laboratory, Argonne, Illinois 60439
operated by The University of Chicago
for the United States Department of Energy under Contract W-31-109-Eng-38

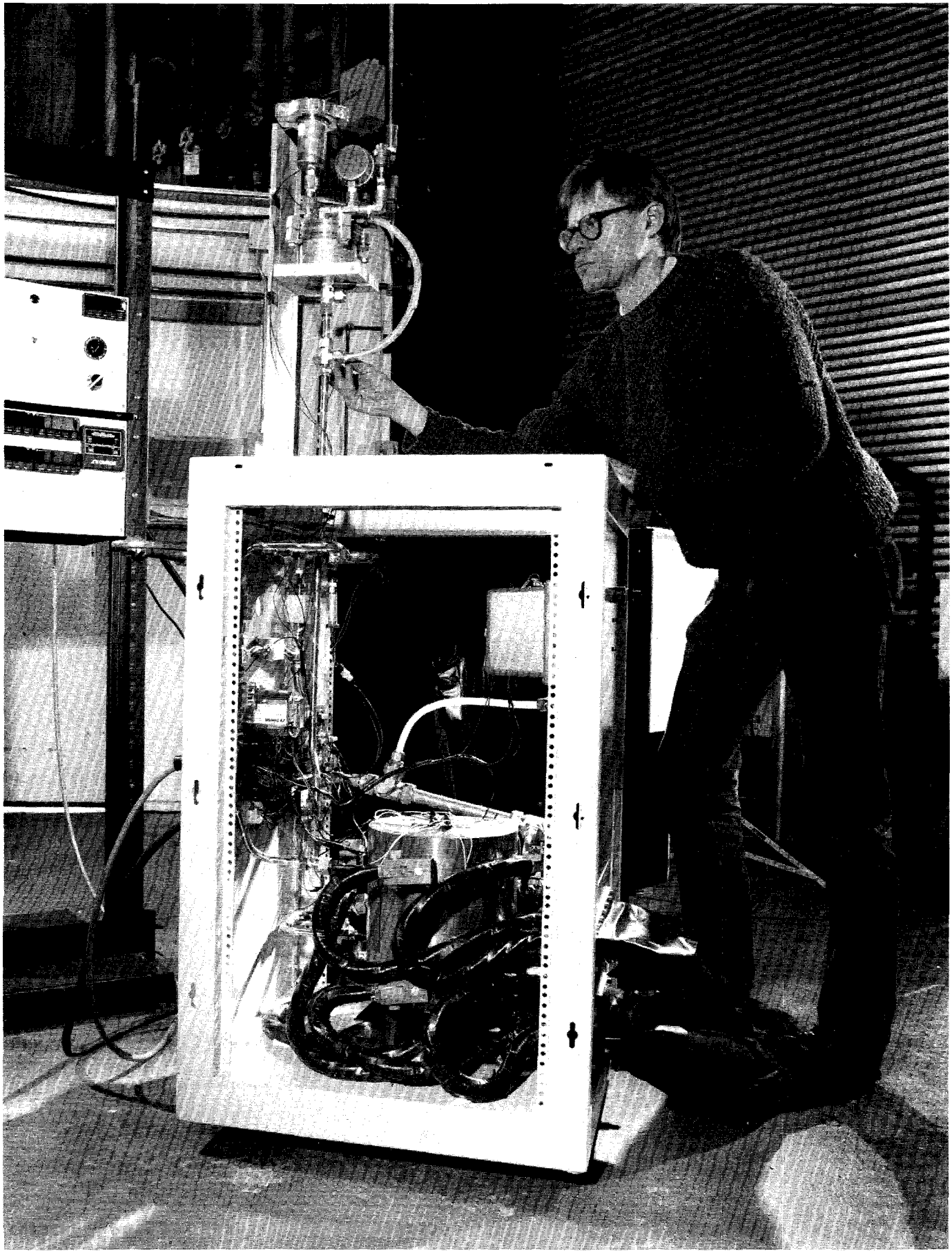
Liquid Gallium Pump

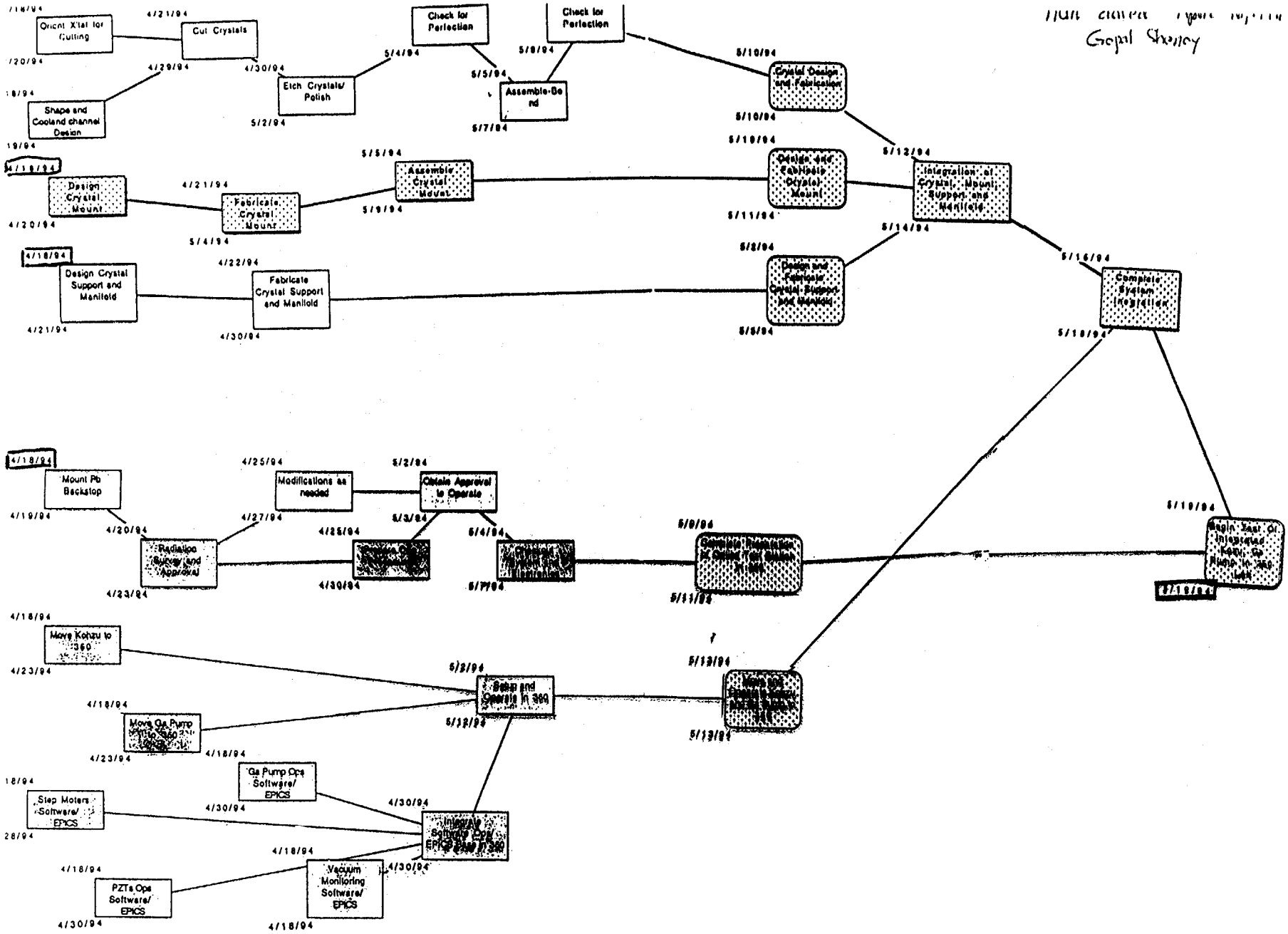
Performance Specifications

- Volume flow rate of 4 gallons per minute (gpm) while operating with a head pressure of 75 pounds per square inch (psi)
- Gallium temperature controllable between 40°C and 70°C and regulated to ±3°C with any heat load from 0 to 5 kwatts
- System should be able to withstand internal pressures of 200 psi and be able to be operated under vacuum (<1 torr)
- A gallium-to-water heat exchanger capable of removing 5 kW of power (with a 10 KW option) with water cooling of <5 gpm and 80 psi

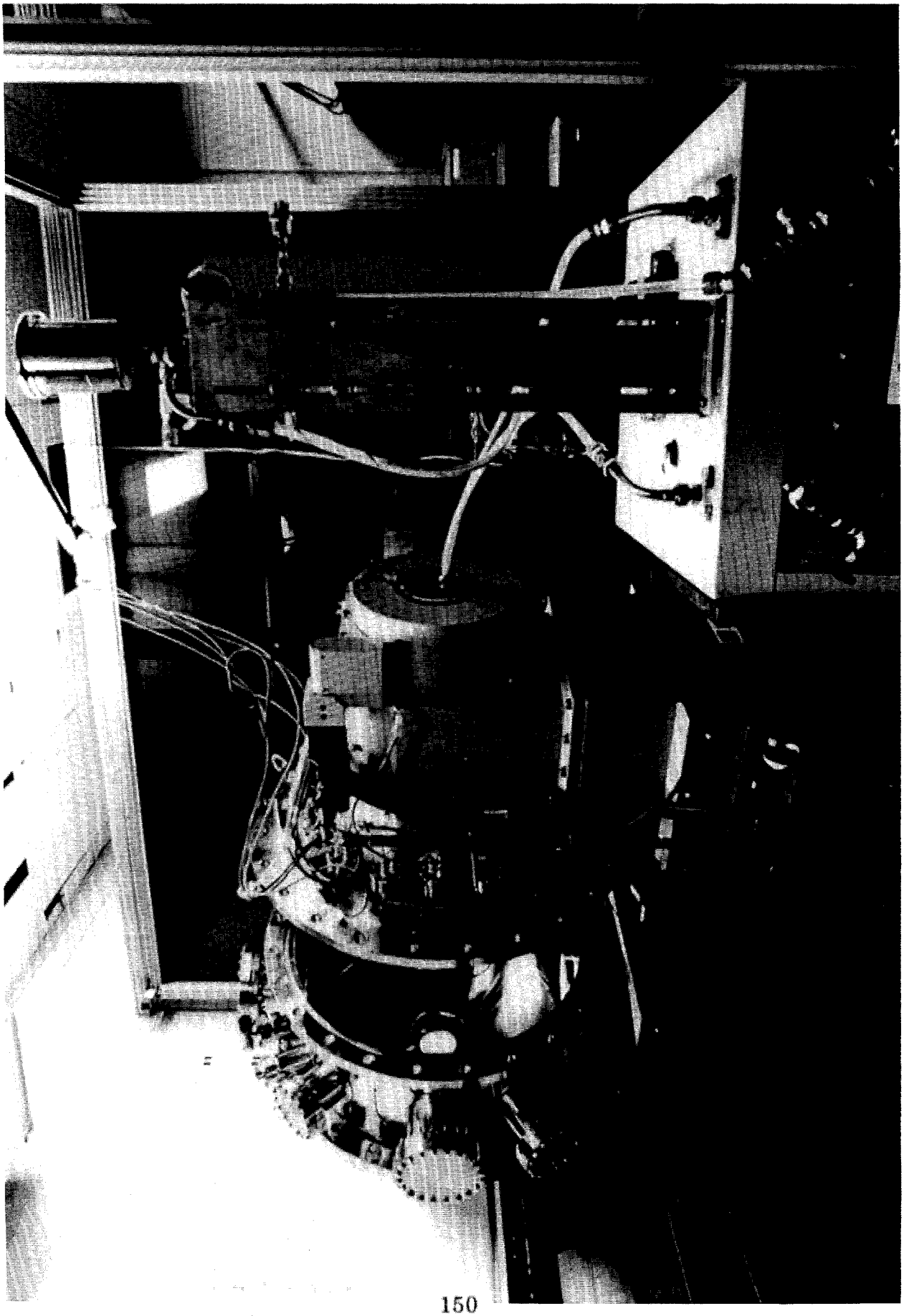
Current Status:

A commercially fabricated DC current pump was delivered by Qmax and passed acceptance tests here at ANL March 1994. We found the "settling time" with a ΔPower of 1kW was several minutes with a temperature excursion of <3°C. Displays can be readout through EPICS and we plan to have the pump under EPICS control in the next several months.

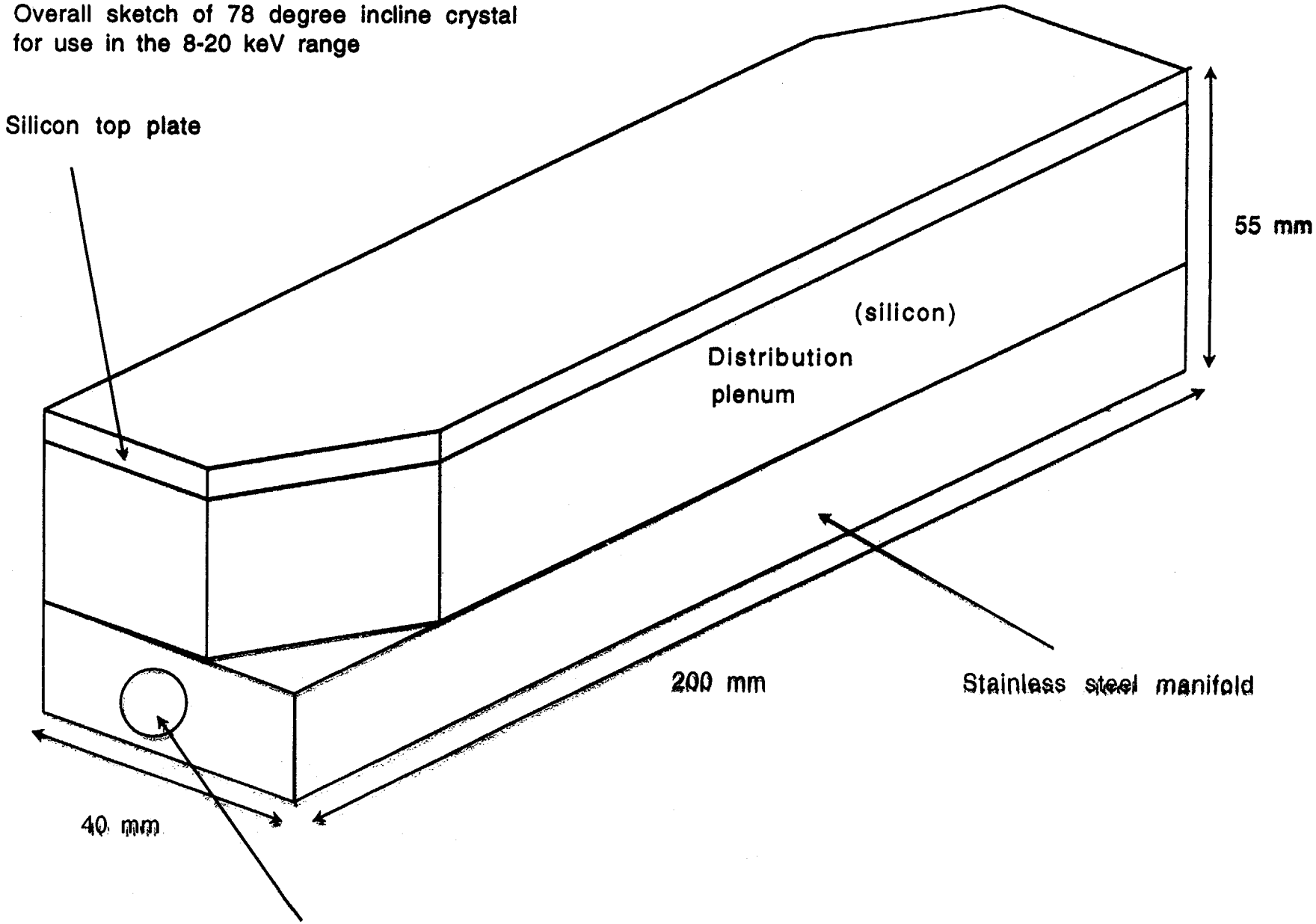




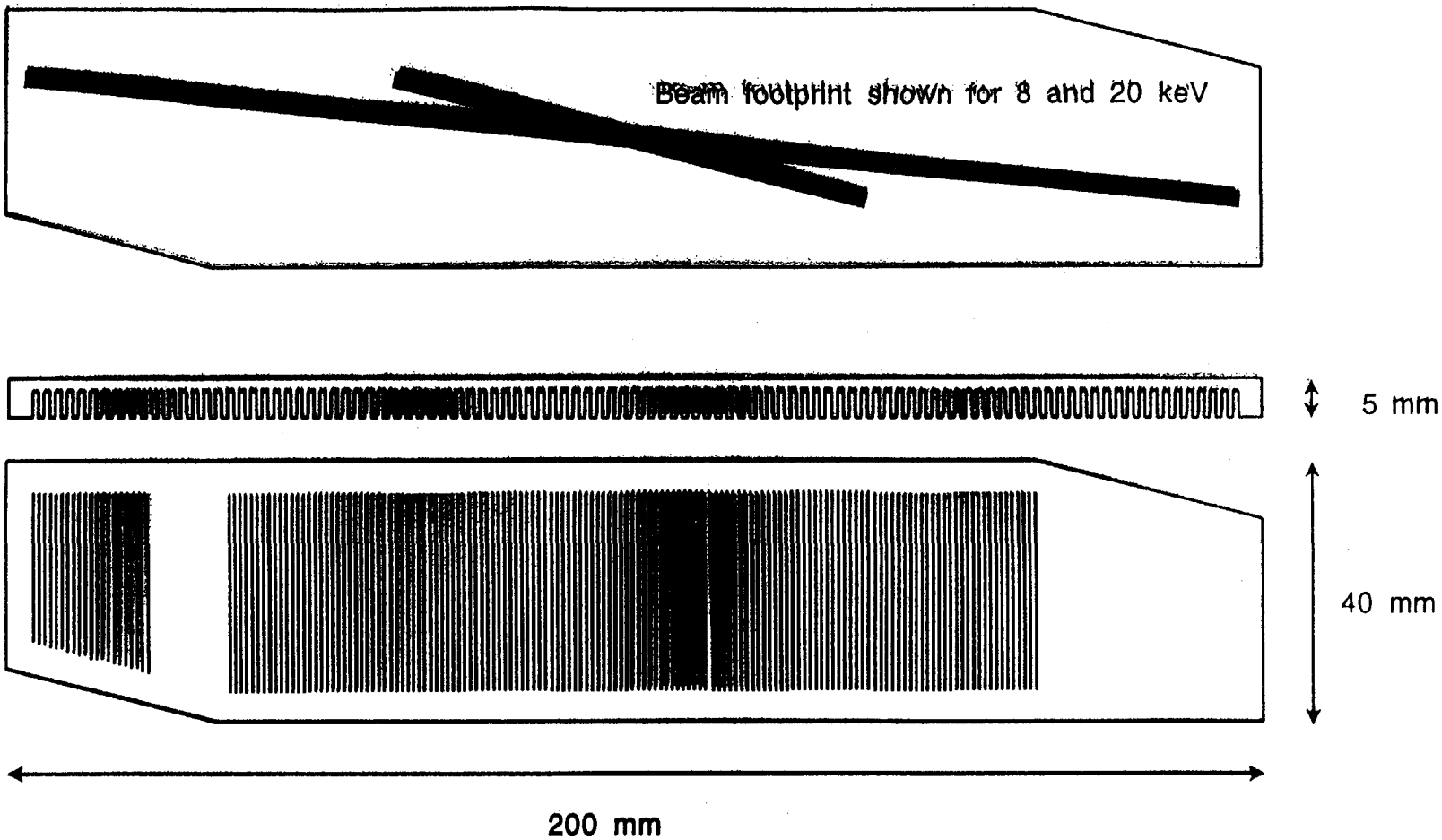
Gopal Shenoy



Overall sketch of 78 degree incline crystal
for use in the 8-20 keV range



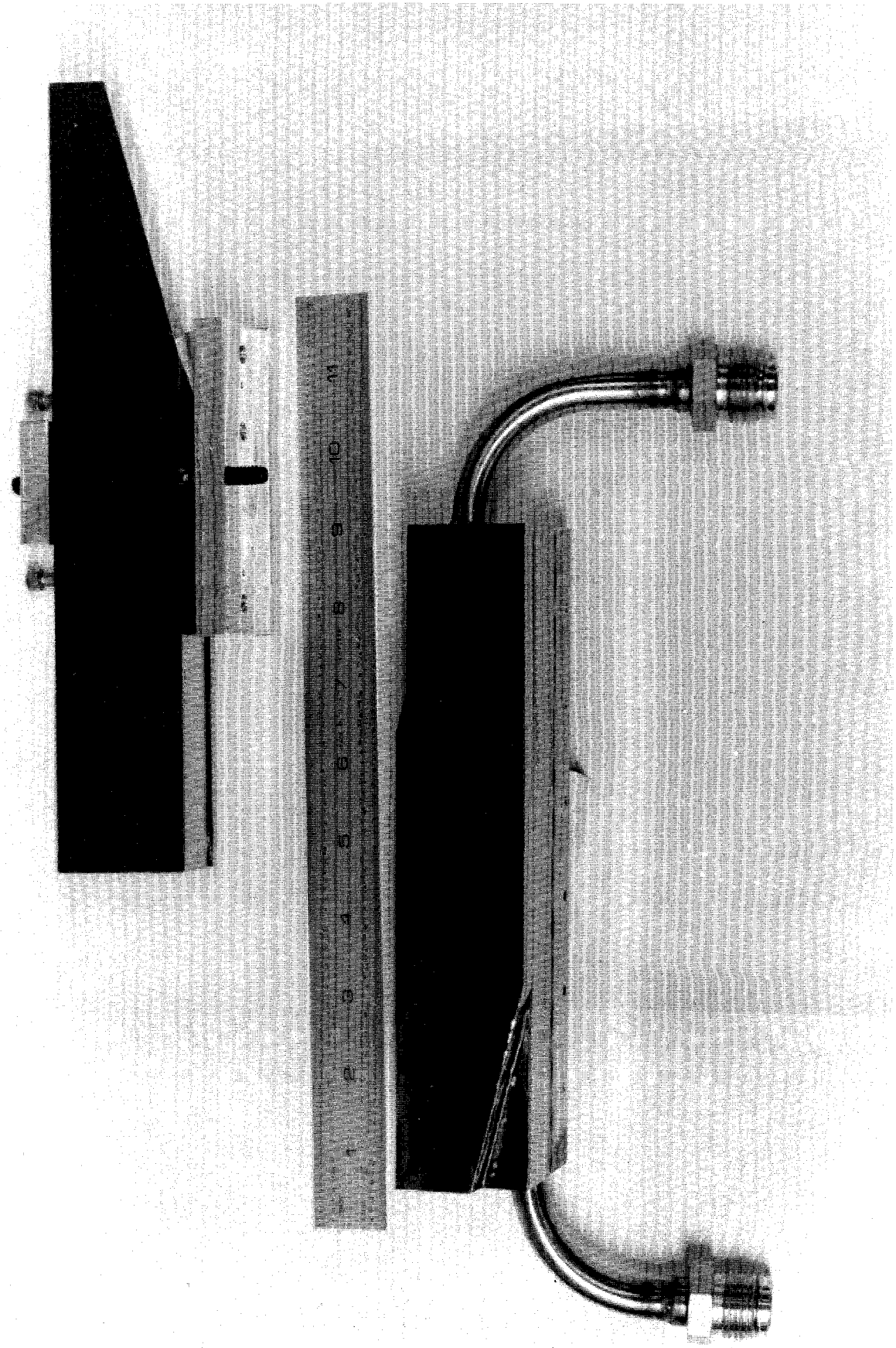
file:Si11178inclinextal.12

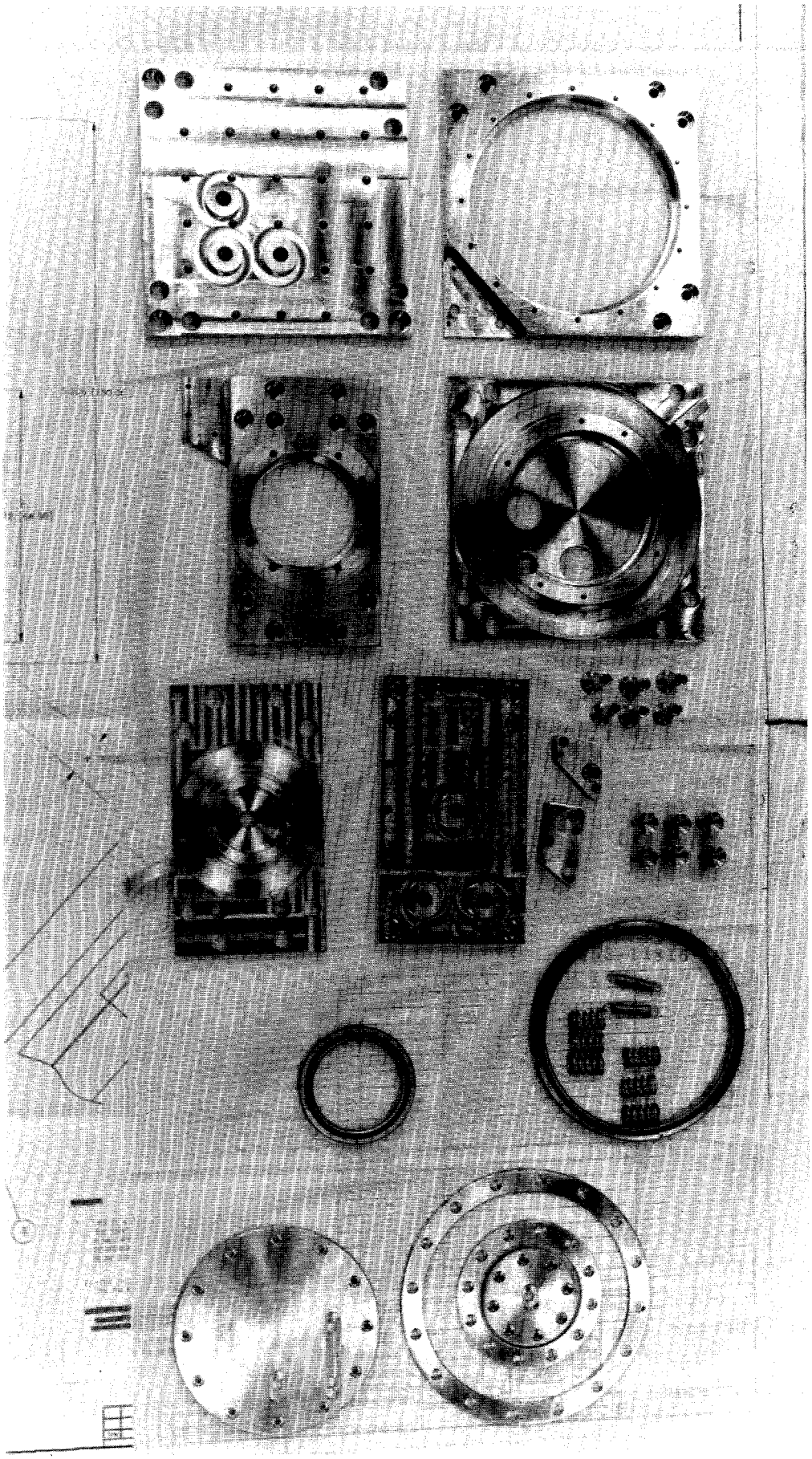


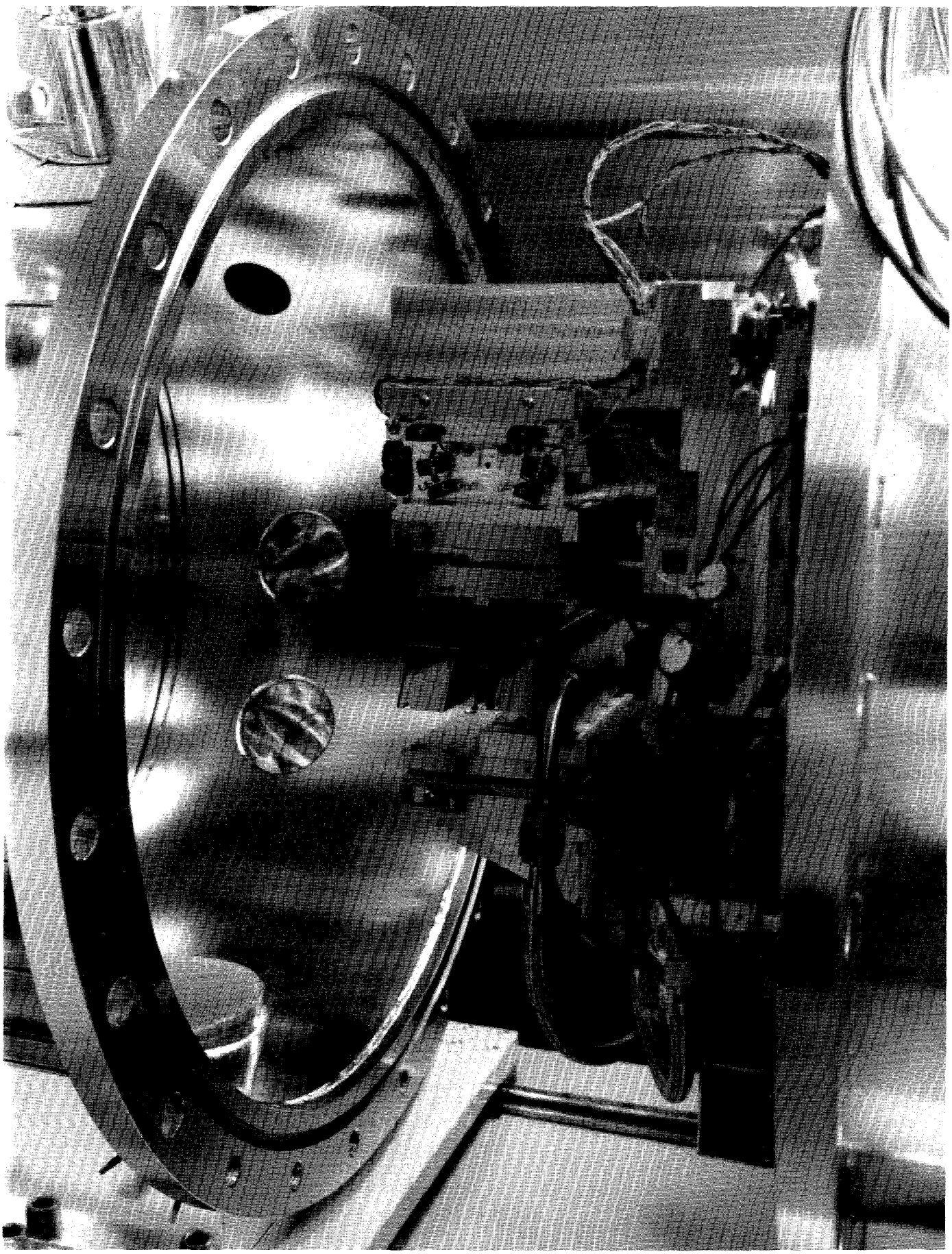
Silicon top plate

Channels and ribs 1mm wide, 4 mm deep
Slots made with high speed mill (60000 rpm)

file:Si11178incline35mmoff.10







Additional Activities and Tests Planned for High Heat Load Monochromator/Crystals/Ga Pumping System

1. Further tests of mechanics of monochromator and of mono/crystal/pump system (examine flow induced vibrations and possible approaches for mitigation of any problems)

2. Fabricate and in-house test of 85° inclined xtal

3. Replace prototype 78° inclined crystal with frit-bonded crystal assembly

4. Test inclined crystals with high heat flux source (at CHESS with APS mirror, hopefully Summer 94)

5. Complete monochromator control system under EPICS (scanning capability/synchronous motor moves, PZT) and incorporate control of liquid gallium pump under EPICS

6. Improve prototype crystal mounts for ease of use and rapid changes of crystals.

7. Begin development of feedback electronics for maintaining stability of diffracted beam

Summary of High Heat Load Monochromator/Crystal/Gallium System

- We currently have in hand a HHL monochromator system that will work for many Undulator beamline designs at the APS and could be installed today if the APS were running.

- Final and complete testing can best occur when the APS is operational with undulator radiation. Until that time, we have been working with other facilities to simulate the thermal loadings expected at the APS.

- While we have tried to carry one approach to completion there are other approaches that we are investigating.

- We encourage Users to come to us with ideas, particularly when APS can provide support in terms of expertise, unique capabilities, and/or equipment.

APS Staff Working on High Heat Load Optics

Crystals:

Lahsen Assoufid	-	FEA, HHL exp. program
Bob Blasdell	-	ray-tracing inclined crystal, diamond monochromator pgm., crystal bonding program
Patricia Fernandez	-	laser simulation, HHL exp. program (on leave)
Wah-Keat Lee	-	exp. program, inclined crystal monochromator design, crystal bonding program
Dennis Mills	-	group leader
Shawn Rogers	-	FEA modeling, cryogenic cooling
Robert Smither	-	liquid gallium pump, asymmetric crystals

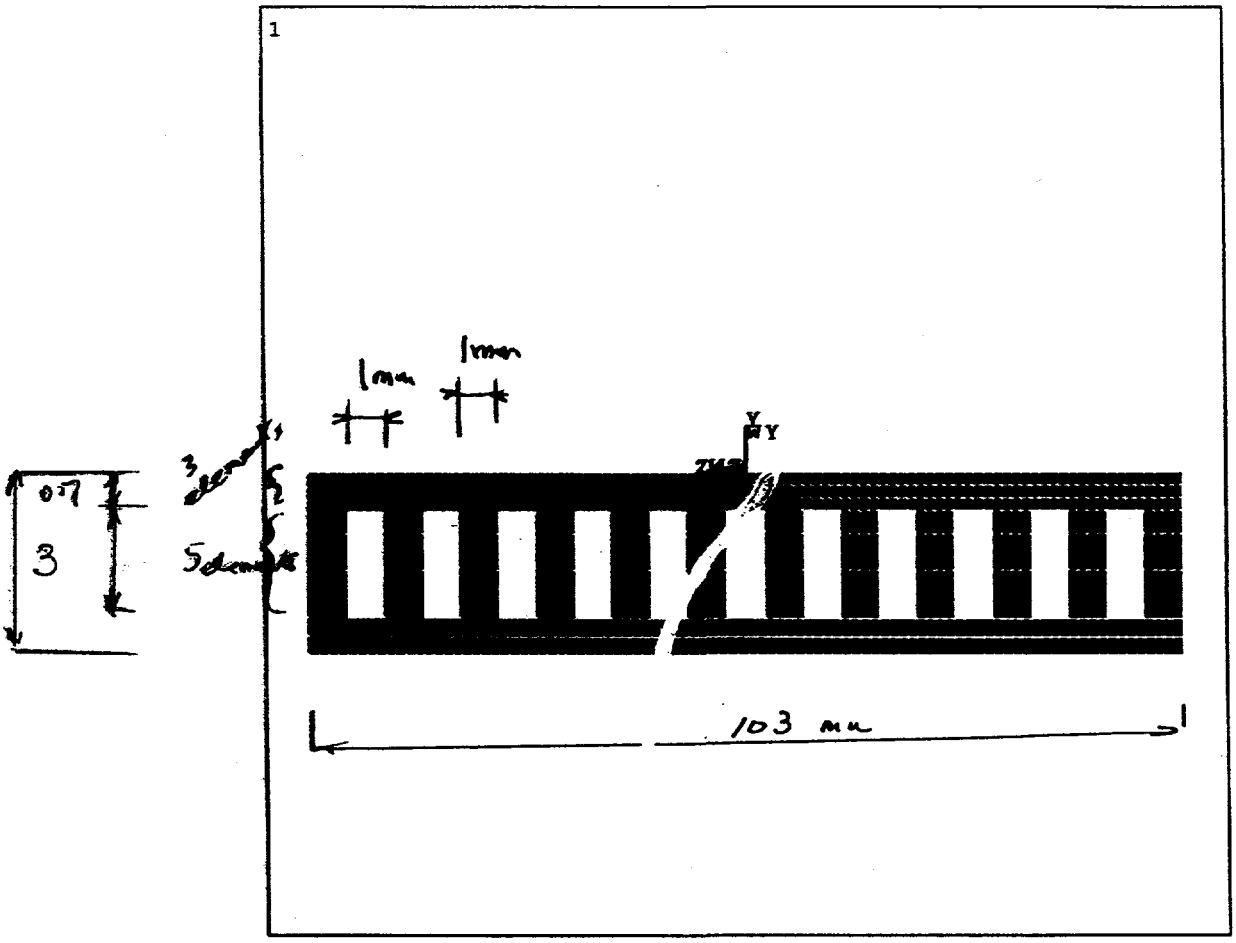
Mirrors:

Lahsen Assoufid	-	analysis and design for focusing mirror for high power density
Ali Khounsary*	-	analysis & design of HHL mirror
Kevin Randall*	-	design of HHL mirror
George Srajer*	-	specs. and procure. for focusing mirror for high power density
Wenbing Yun*	-	design for HHL mirror

Technicians: Al Paugys
Dale Ferguson

We will add a Post Doc. in June. In addition I have requested an additional Mech. Eng. be assigned to this activity starting ASAP.

* not full time HHL staff


1
1mm
1mm
Y
3
5
3
103 mm

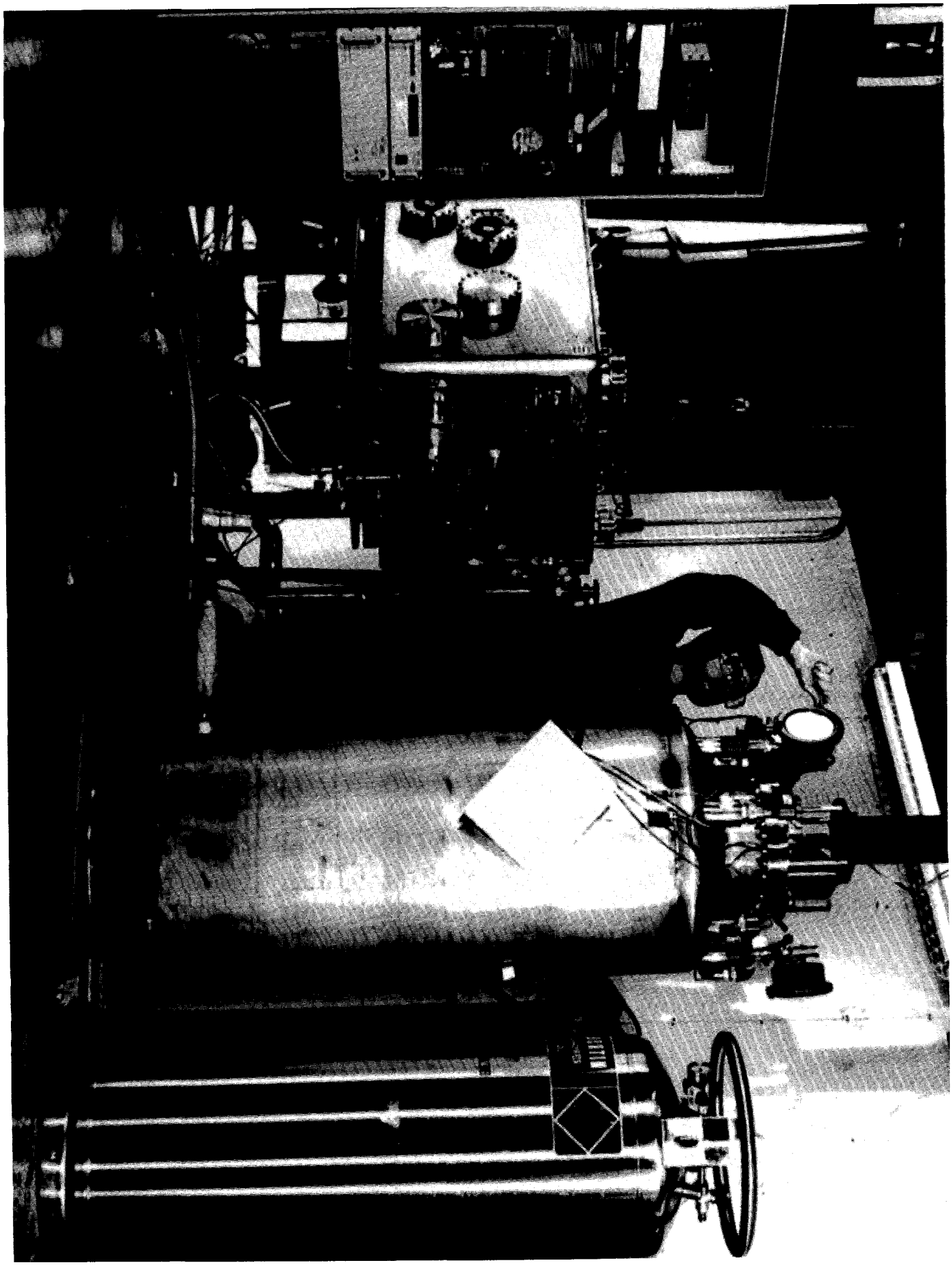
Ongoing R&D Activities

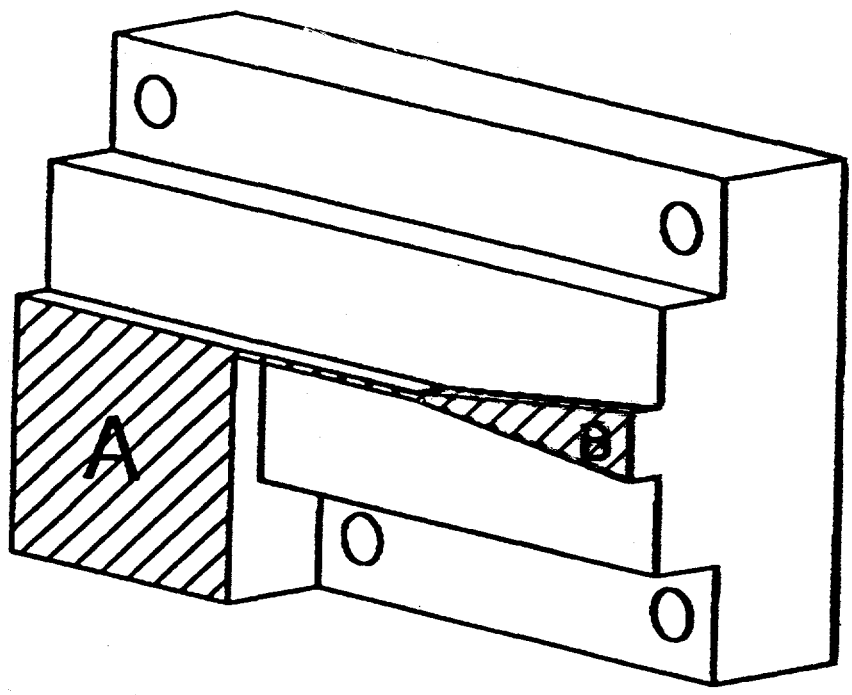
Experimental: Monochromators and Crystals

- Tests of Kohzu monochromator **(Lee, Mills)**
- Test prototype inclined crystal on focused wiggler beam at CHESS **(Lee)**
- Test of coolant distribution manifolds (for the reduction of flow induced vibrations) **(Lee)**
- Test (commercial) DC liquid gallium pump at synchrotron source **(Smither)**

- Re-design and re-test Rocketdyne crystals with optimized pin/post pattern heat exchanger **(Smither)**

- Test of thick cryogenically cooled crystals in-house and at CHESS in the Summer 94 time frame **(Rogers)**
- Tests and improvements of closed loop cryogenic system **(Rogers)**
- A thin cryogenically compatible crystal has been designed and is being fabricated. In-house and HHL tests are planned for summer. **(Rogers and Knapp, MSD)**



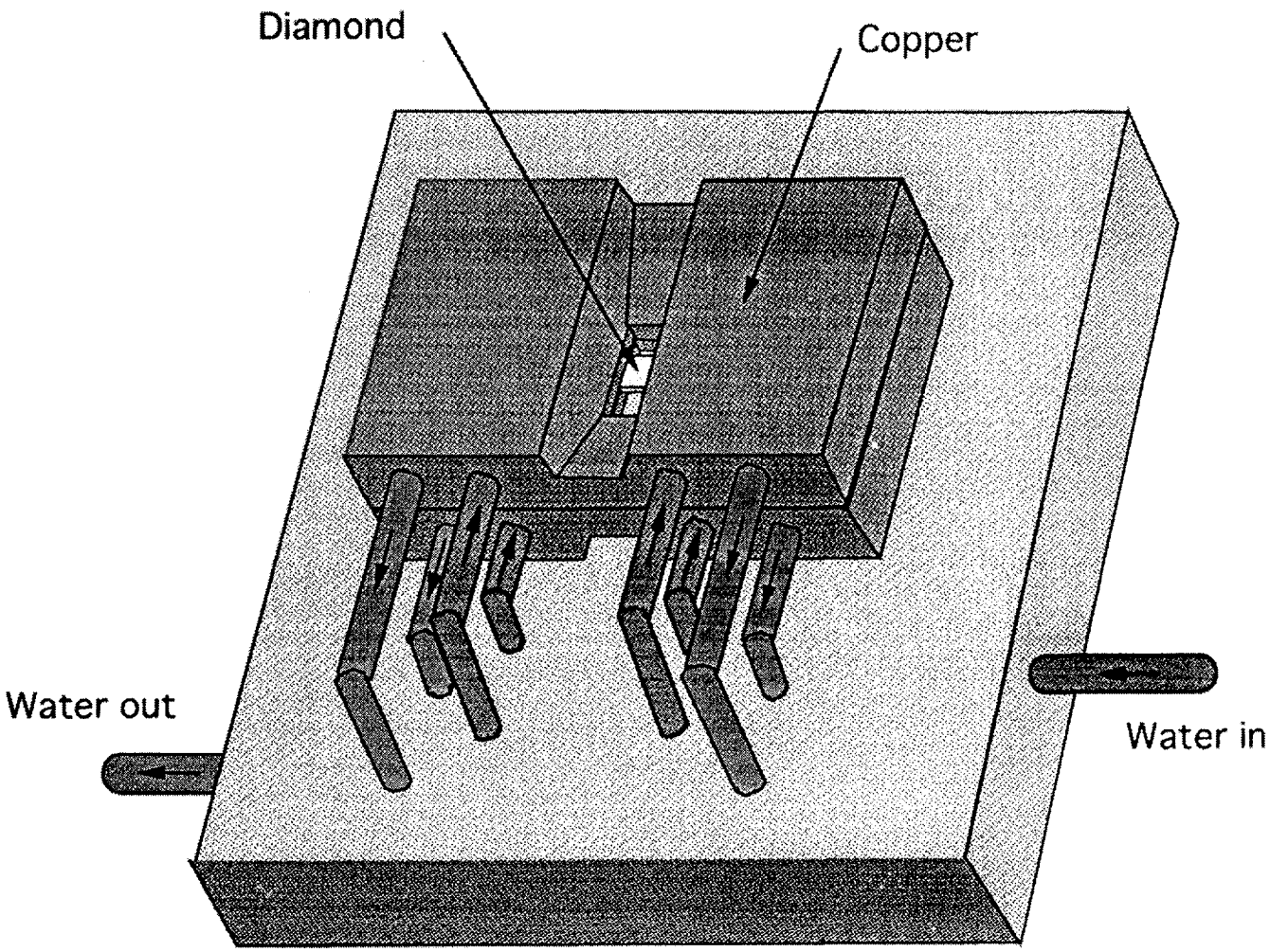


Perspective view of one half of the proposed crystal.

- Expand and accelerate R&D program in use of diamonds as first optical components. In collaboration with the ESRF and SPring-8, encourage and work with single crystal diamonds growers to increase size and perfection **(Blasdell)**

- Test of variable asymmetric crystal in the Summer 94 time frame. **(Smither)**

- In collaboration with HASYLAB, test various HHL x-ray optical components on DORIS III wiggler beamline (early 1995) **(Lee, Smither)**



Edge Cooled Diamond Monochromator Design

Experimental: Mirrors and Multilayers

- Fabrication of a cooled prototype mirror **(Khounsary, Randall, and Yun)**

  Specifications:

Type	horizontally deflecting
Angle of incidence	1.25°
Size	300 x 100 x 61 mm
Shape	cylinder (ρ = 1400m)
Surface roughness	3 Å rms
Slope error	<2 μradians rms (no power)
	<3 μradians rms (power)
Max. heat flux	3.2 watts/mm^2
Incident power.	2 kW
Coatings	Ni, Pt, Rh
Substrate	silicon
Cooling	water

  Expected delivery date is now June 1994.

- Install, test and evaluation of CHESS high heat load mirror. The HHL mirror for the CHESS wiggler is about to be delivered. (Expected delivery date is now mid June). Plans are being made for installation in June. **(Srajer, Assoufid)**

Comparison of power and power densities from various synchrotron sources

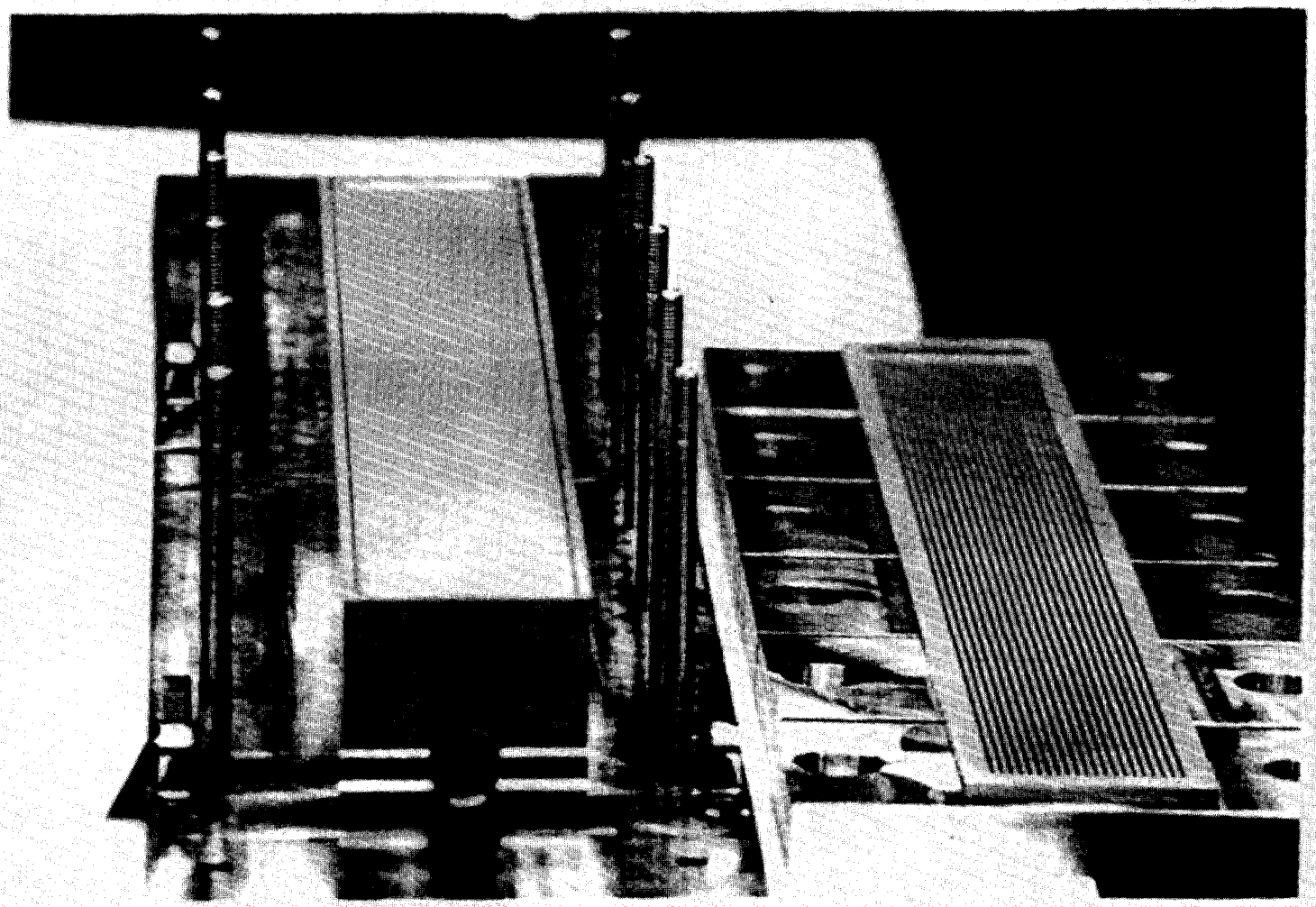
Source	Power (kW)	Power Density (w/mm^2)
CHESS F-2 wiggler (unfocused)	1.0	15
APS/CHESS prototype undulator	0.4	50
NSLS X-25 wiggler (focused)	0.04	120
CHESS A-2 wiggler (focused)	**0.7**	**150-200**
APS Undulator A (slit)	0.8	150
APS Undulator A (no slit)	3.8	150

In addition to using this mirror for producing a test beam, we plan to examine mirror figure distortions under thermal loads. Heat loadings similar to that expected at the APS can be achieved by increasing the angle of incidence over that typically used in actual operation. Our plan is to attempt to optically monitor thermal distortions *in situ.*

Specifications for CHESS Wiggler Mirror:

Size	1200 x 80 mm
Shape	bent cylinder (torus)
Surface roughness	3 Å rms
Slope error	1 μradians rms (no power)
	2 μradians rms (power)
Max. heat flux	0.5 watts/mm^2
Max. power abs.	2 kW
Meridional radius	∞ to 2.2 km (variable)
Sagittal radius	3.88 ±0.02 cm
Coatings	Ni with 300 Å Pt
Substrate	Glidcop
Cooling	water

MIRROR SUBSTRATE CONFIGURATION

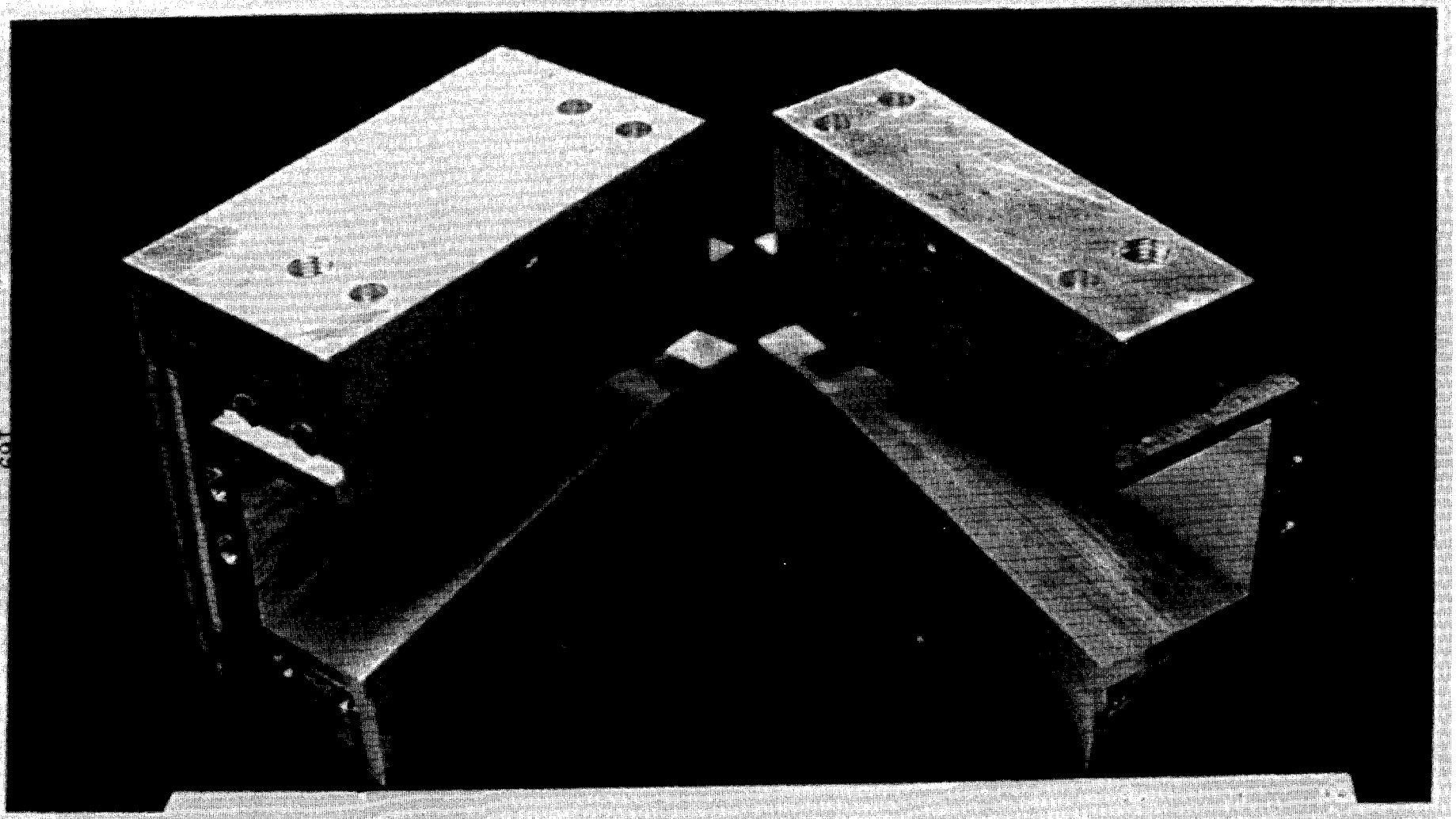


- Mirror face plate with water channels and body mounted in braze fixture.

Photon Sciences
International Incorporated

ADVANCED PHOTON SOURCE HIGH HEAT LOAD PROGRAM.

WHITE BEAM MASK BODY



- OFHC Copper Body Details

ADVANCED PHOTON SOURCE HIGH HEAT LOAD PROGRAM.

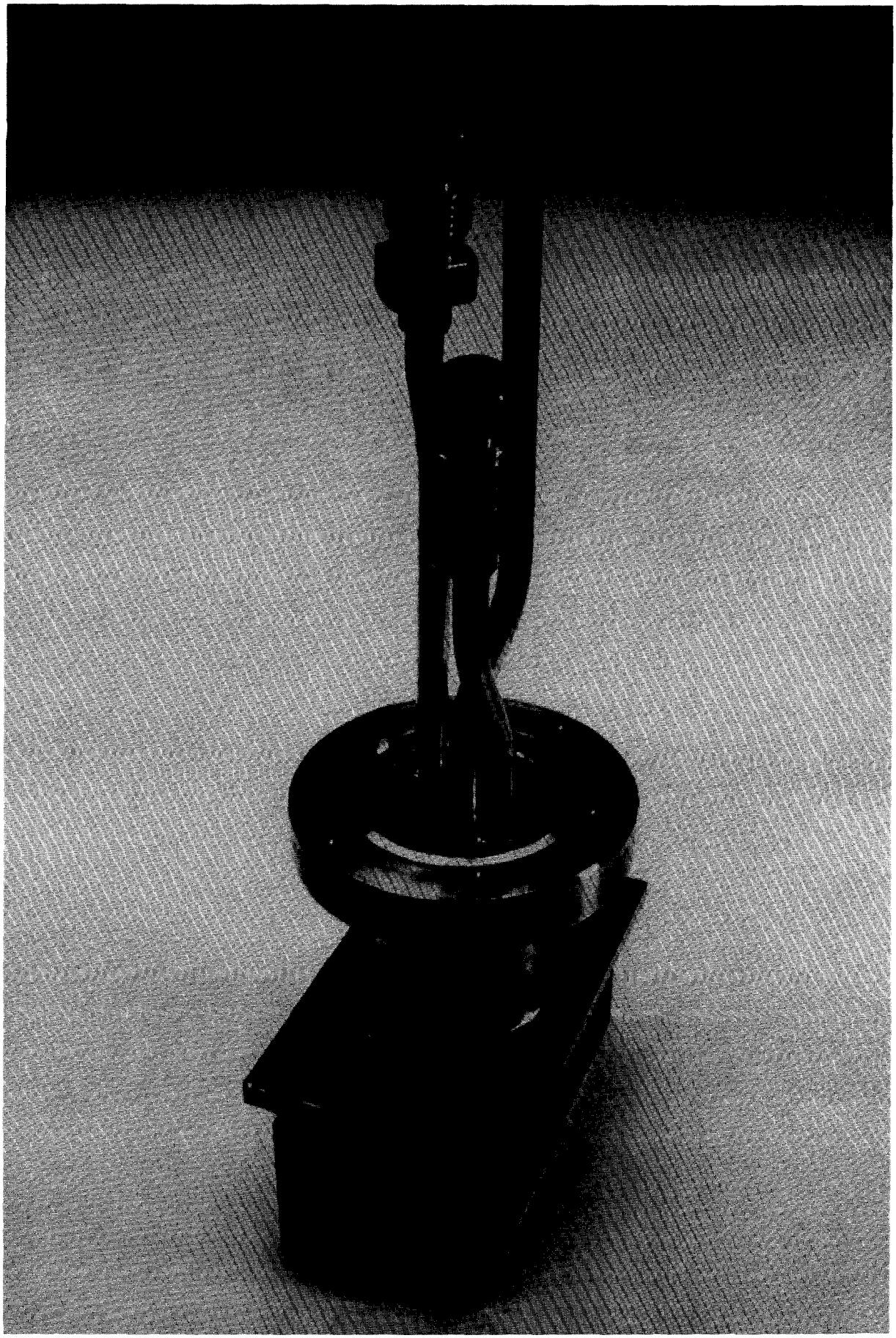
Photon Sciences
International Incorporated

- Complete tests and evaluation of micro-channel cooled substrates for multilayers. **(Khounsary, Yun)**

Specifications:

Angle of incidence	0.5° - 6° (30 ev < E < 4 kev)
Size	90 x 45 x 43 mm
Shape	flat
Surface roughness	1 Å rms
Slope error	<2 μradians rms (no power)
Max. heat flux	1.5 watts/mm^2
Incident power.	360 watts
Substrate	silicon
Cooling	water thru μchannels

The unpolished unit has been delivered and tested in-house for vacuum compatibility and pressure induced distortions from the coolant. It has now been sent back for final polishing for acceptance of multilayer deposition. Expected delivery date is end of July.



Modeling:

- Modeling of warm Si inclined crystal for Undulator A and flat crystals for BM and Wiggler A source. This is currently being summarized and written up for distribution. **(Assoufid)**

- FEA of diamond crystal with Undulator A **(Assoufid)**

- Continue FEA of thin crystals (Si, diamond) at room temperature and cryogenic temperatures with APS undulator power and power densities **(Assoufid and Rogers)**

ANL/APS/TB-19

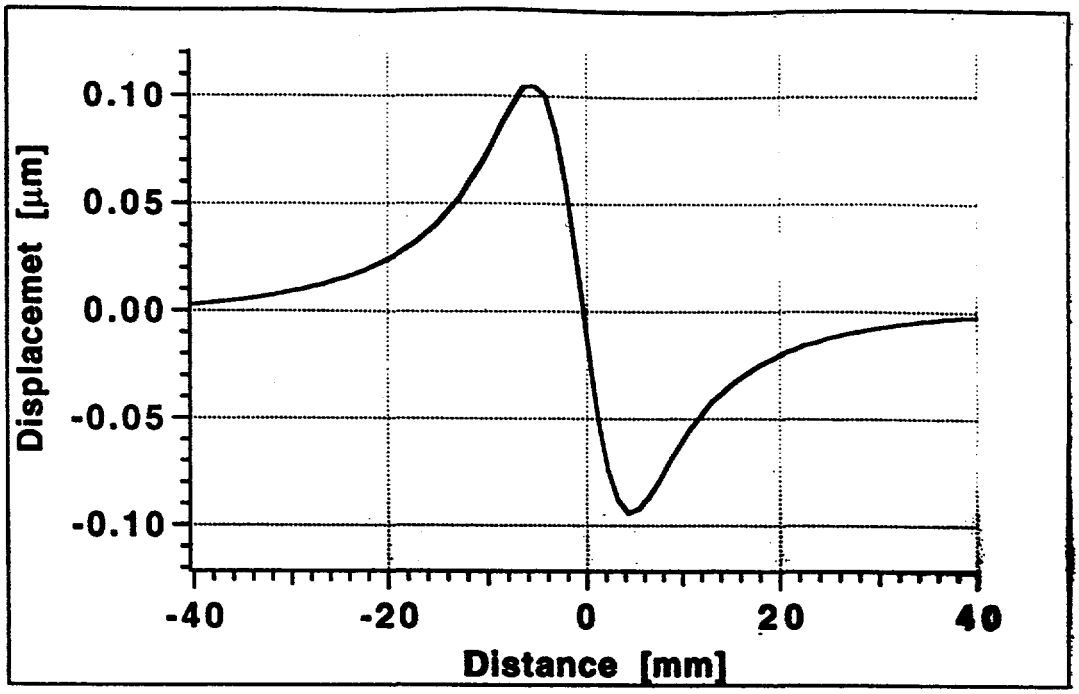
A Finite Element Analysis of Room Temperature Silicon Crystals for the Advanced Photon Source Bending-Magnet and Insertion-Device Beams

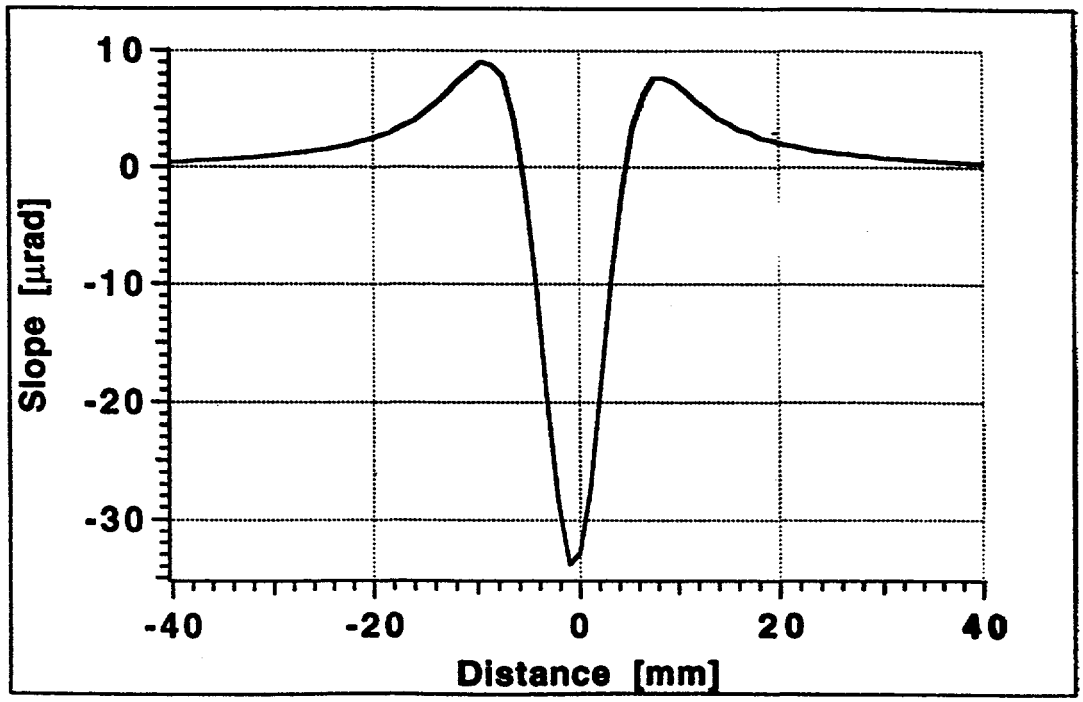
by L. Assoufid, W.-K. Lee, and D.M. Mills

August 1994

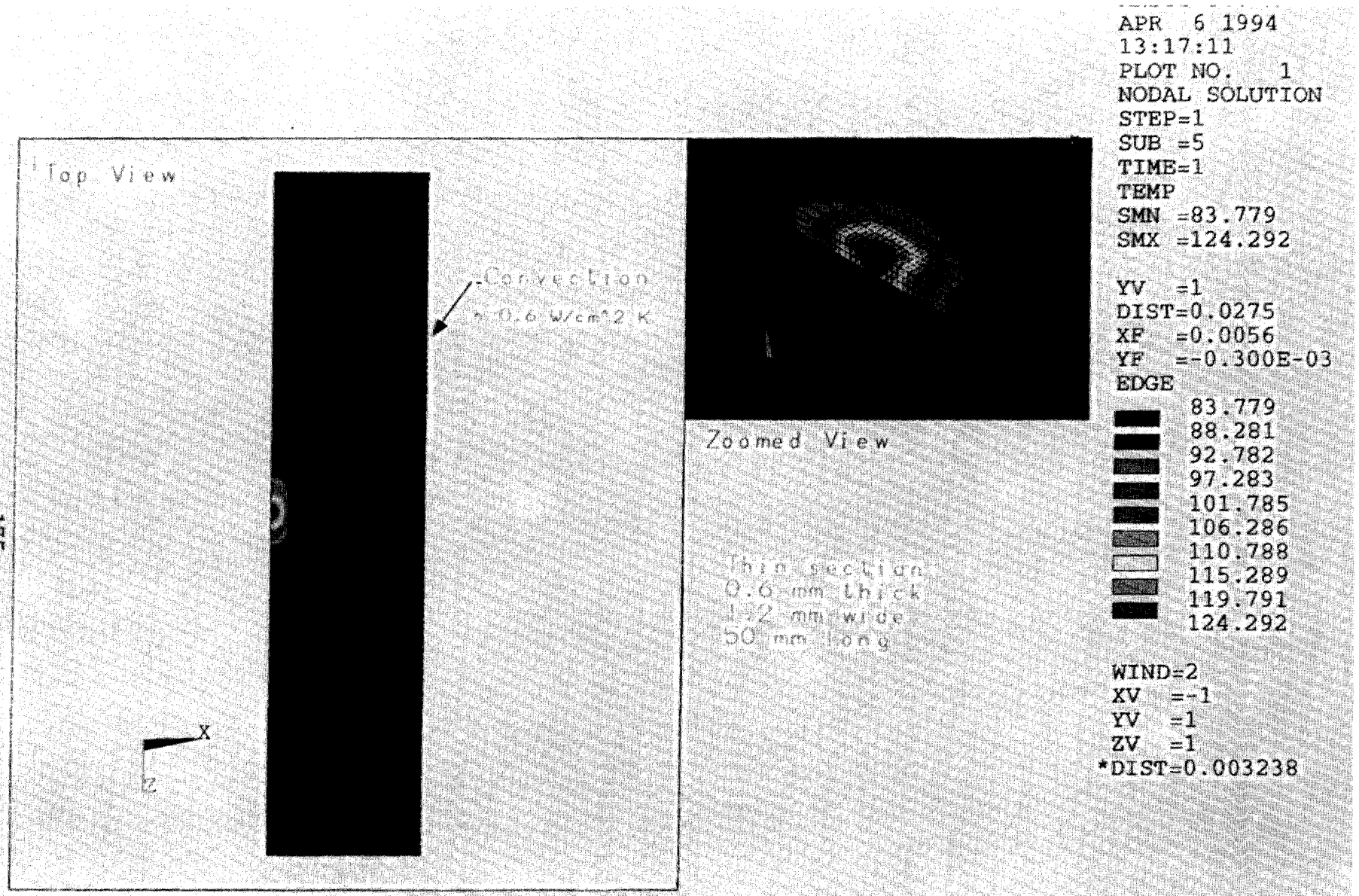
Advanced Photon Source

Argonne National Laboratory
operated by The University of Chicago for the U.S. Department of Energy under Contract W-31-109-Eng-38

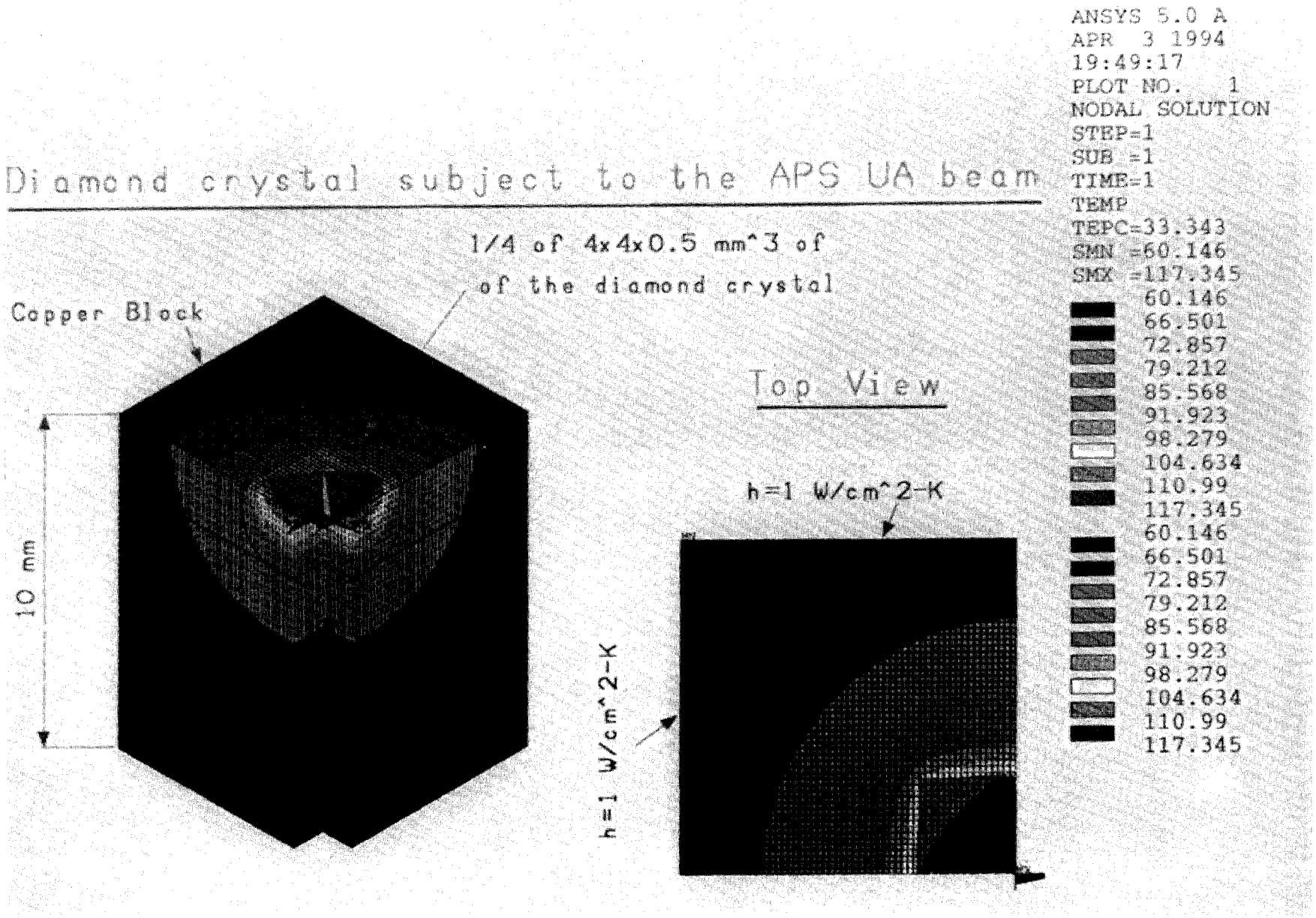




Inclined crystal with no slits: displacement and slope along the crystal main axis, normal to the planes of diffraction.
April 10, 1994



Thin cryogenic crystal,Si<111>,3.866 keV,K=2.33,I=100 mA Power=65 W


Diamond crystal subject to the APS UA beam
1/4 of 4x4x0.5 mm^3 of
of the diamond crystal
Copper Block
10 mm
Top View
h=1 W/cm^2-K
h=1 W/cm^2-K
ANSYS 5.0 A
APR 3 1994
19:49:17
PLOT NO. 1
NODAL SOLUTION
STEP=1
SUB =1
TIME=1
TEMP
TEPC=33.343
SMN =60.146
SMX =117.345
60.146
66.501
72.857
79.212
85.568
91.923
98.279
104.634
110.99
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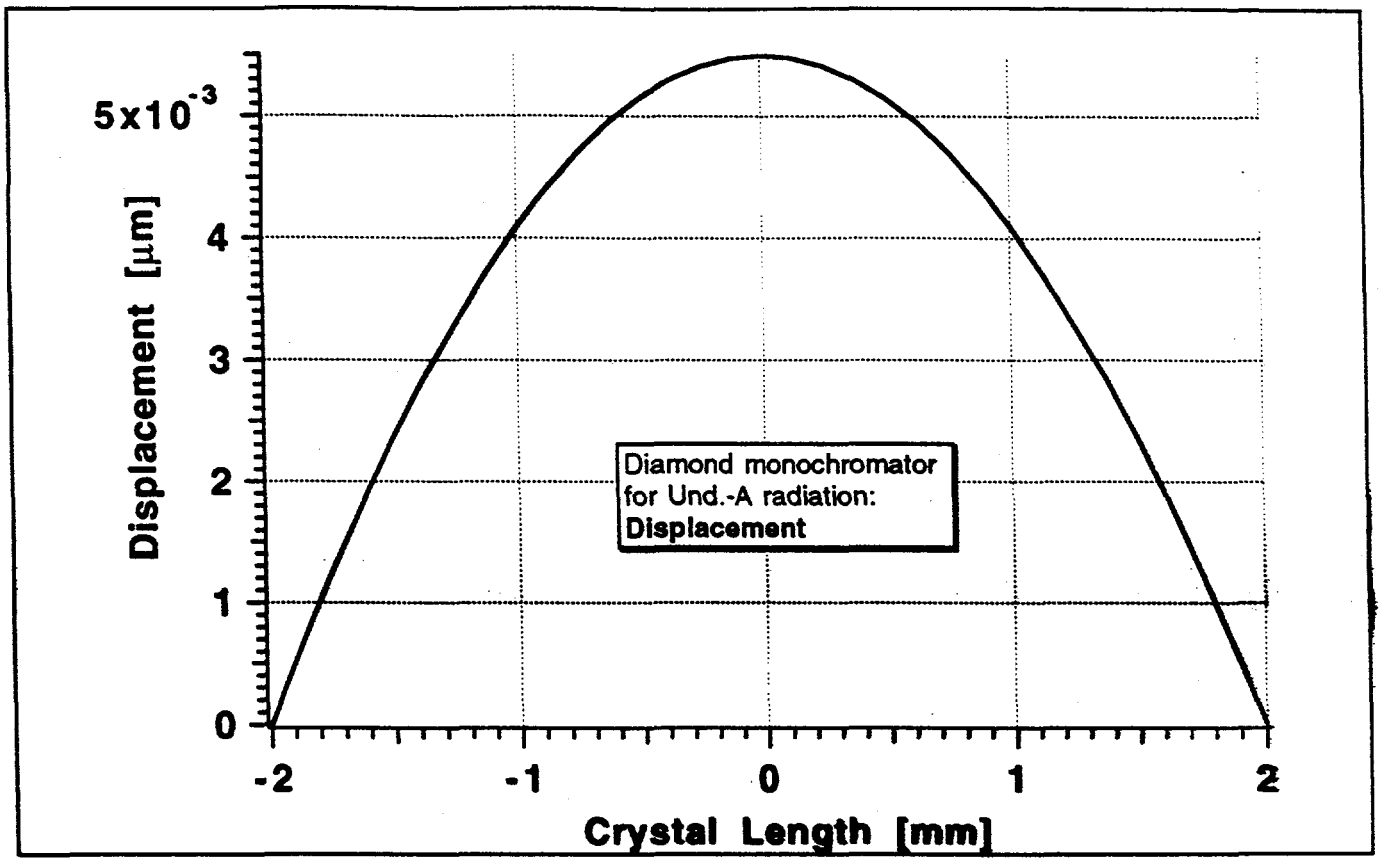
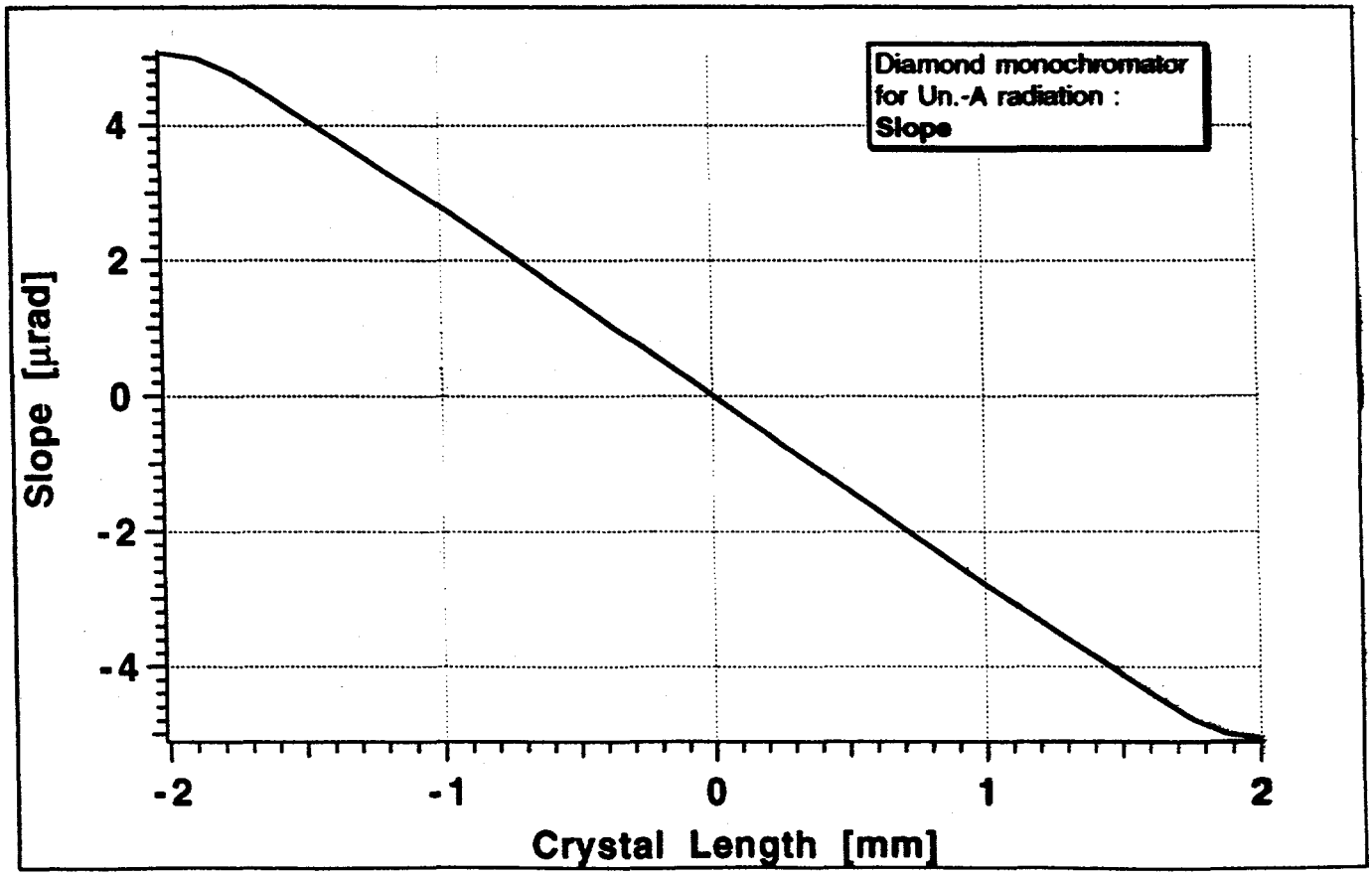
85.568
91.923
98.279
104.634
110.99
117.345


5x10^-3
4
3
2
1
0
Displacement [µm]
Diamond monochromator
for Und.-A radiation:
Displacement
-2
-1
0
1
2
Crystal Length [mm]


Diamond monochromator
for Un.-A radiation :
Slope
4
2
0
-2
-4
Slope [µrad]
-2
-1
0
1
2
Crystal Length [mm]

PERSONNEL SAFETY SYSTEM

A User's Perspective

Sixth Users Meeting
May 25-26, 1994

Advanced Photon Source
Experimental Facilites Division

R. Parry 5/94

PERSONNEL SAFETY SYSTEM

A User's Perspective

Meet Safety Requirements
Meet User Requirements
Input From User Community
KISS Design
Transparent Operation
Beamline Independence

Standard PSS Components
- Beamline (On/Off Line Control)
- Door (Security)
- Access (Comfort Keys)
- Mode (Mono vs. White)
- User (Primary Interface)
- Search Box

Exp. Station Components
Search and Secure Procedure

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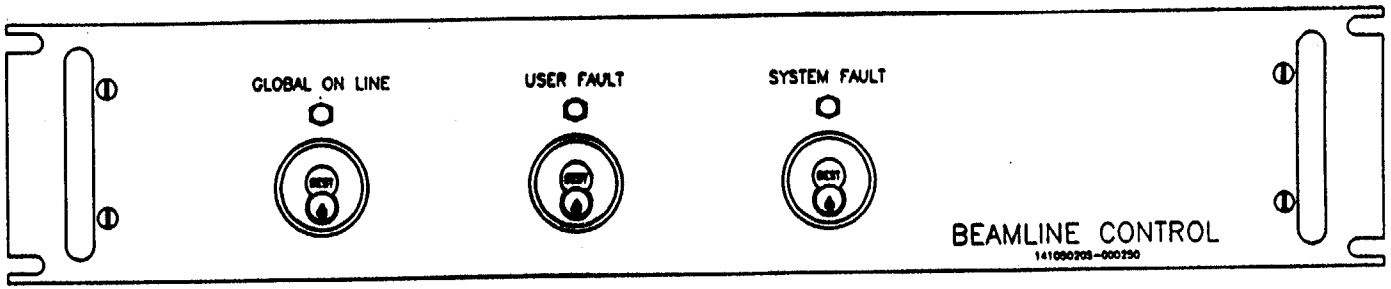
PERSONNEL SAFETY SYSTEM

A User's Perspective

BEAMLINE CONTROL



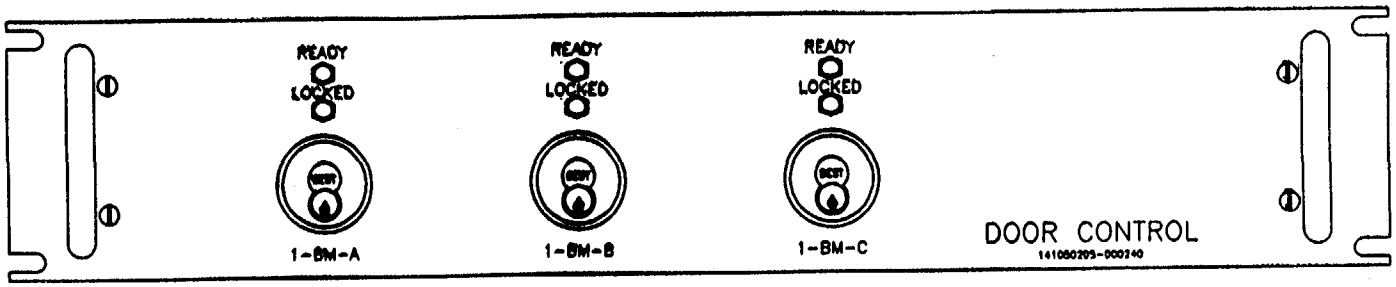
GLOBAL BEAMLINE CONTROL
FOR EXTENDED SHUTDOWNS
CONTROLLED BY APS PERSONNEL

R. Parry 5/94

PERSONNEL SAFETY SYSTEM

A User's Perspective

DOOR CONTROL



OPTIONAL
SECURITY FUNCTION
TO LOCK EXP. STA.

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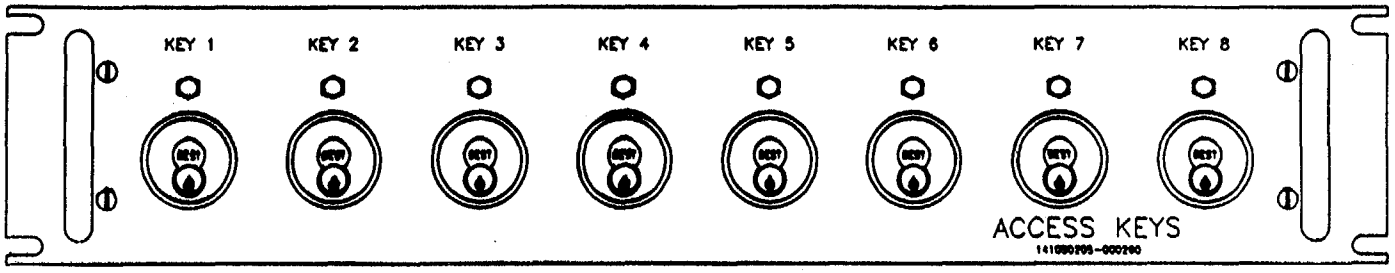
PERSONNEL SAFETY SYSTEM

A User's Perspective

ACCESS KEYS



OPTIONAL

COMFORT KEYS

FOR INDIVIDUAL ACCESS

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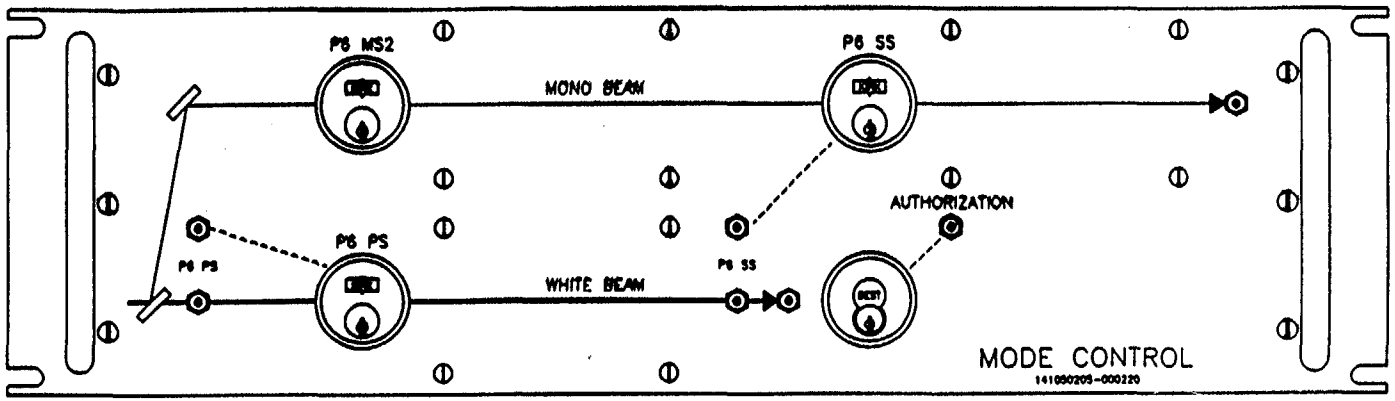
PERSONNEL SAFETY SYSTEM

A User's Perspective

MODE CONTROL



CONTROLS MONO vs. WHITE BEAM

ADDITIONAL LEVEL OF SAFETY ABOVE PSS

MECHANICALLY CONTROLLED KEY SYSTEM

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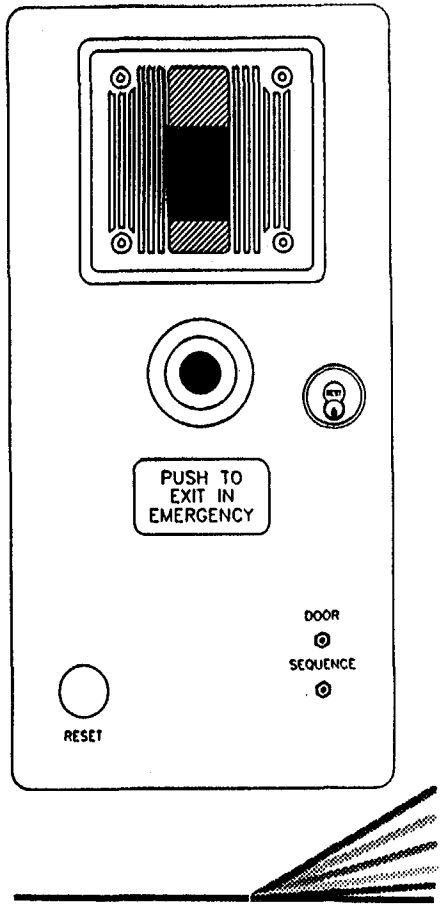
PERSONNEL SAFETY SYSTEM

A User's Perspective

SEARCH BOX

PRIMARY INTERFACE
FREQUENT USE
EMERGENCY EXIT
LOCAL STATUS
MIN. ONE PER EXP. STA.
VISUAL ALARM
AUDIBLE ALARM

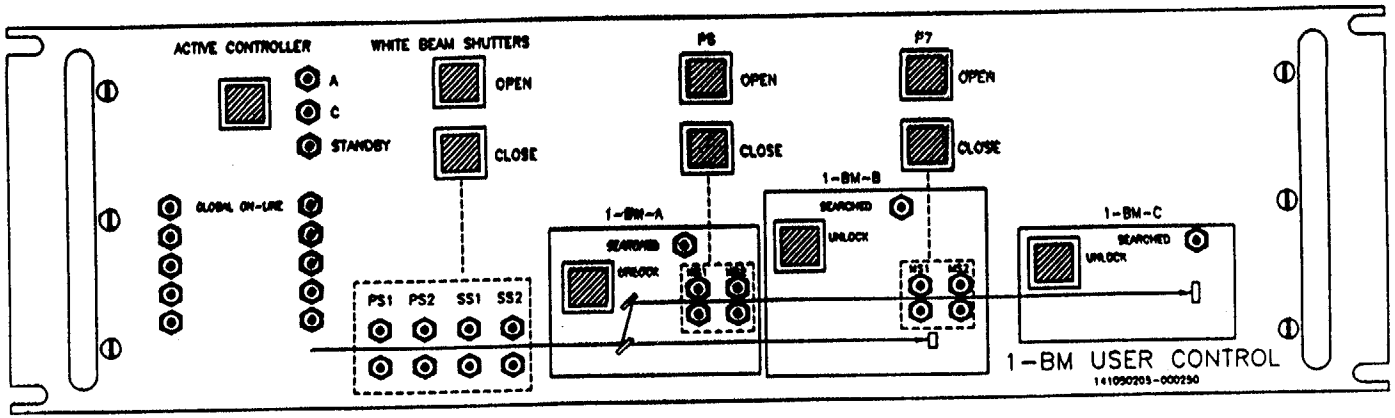


R. Parry 5/94

PERSONNEL SAFETY SYSTEM

A User's Perspective

USER CONTROL



PRIMARY INTERFACE
FREQUENT USE
GUI HARDWARE PANEL

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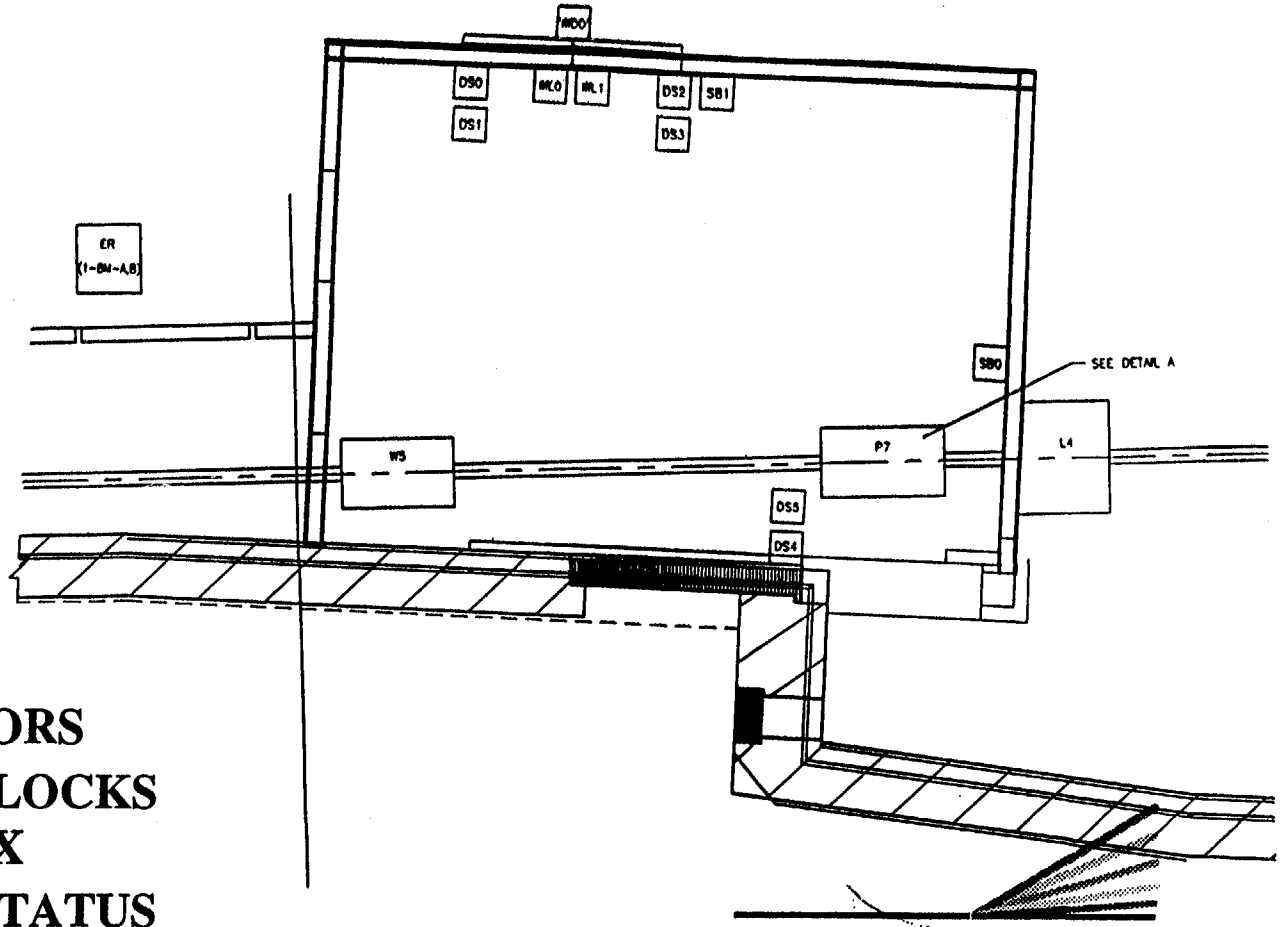
PERSONNEL SAFETY SYSTEM

A User's Perspective

TYPICAL EXPERIMENTAL STATION



DOOR SENSORS
MAGNETIC LOCKS
SEARCH BOX
MARQUEE STATUS

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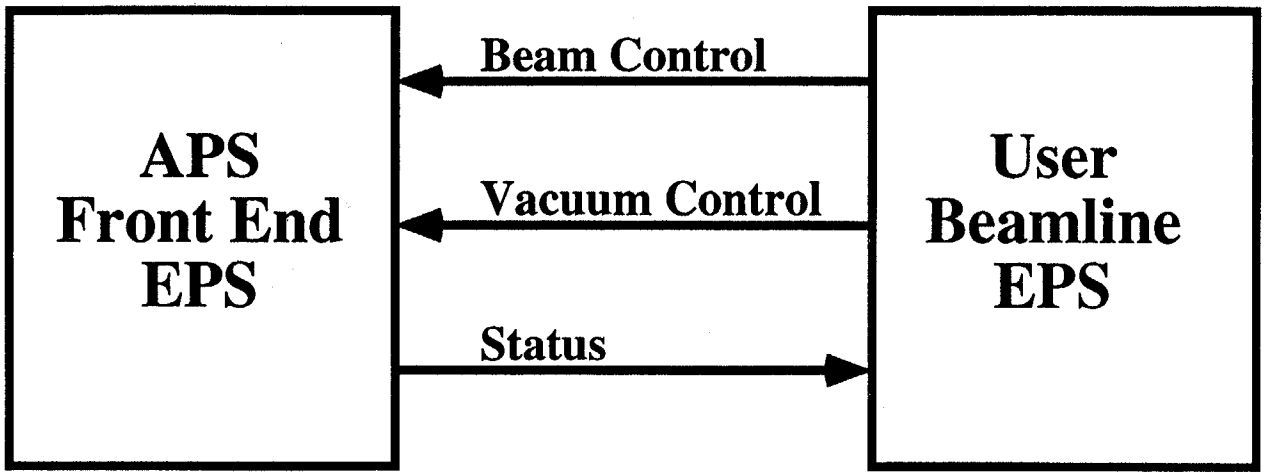
EQUIPMENT PROTECTION SYSTEM

A User's Perspective

Two Systems



User Requests to Inhibit Beam or to Control Vacuum Valves Come Through Front End EPS

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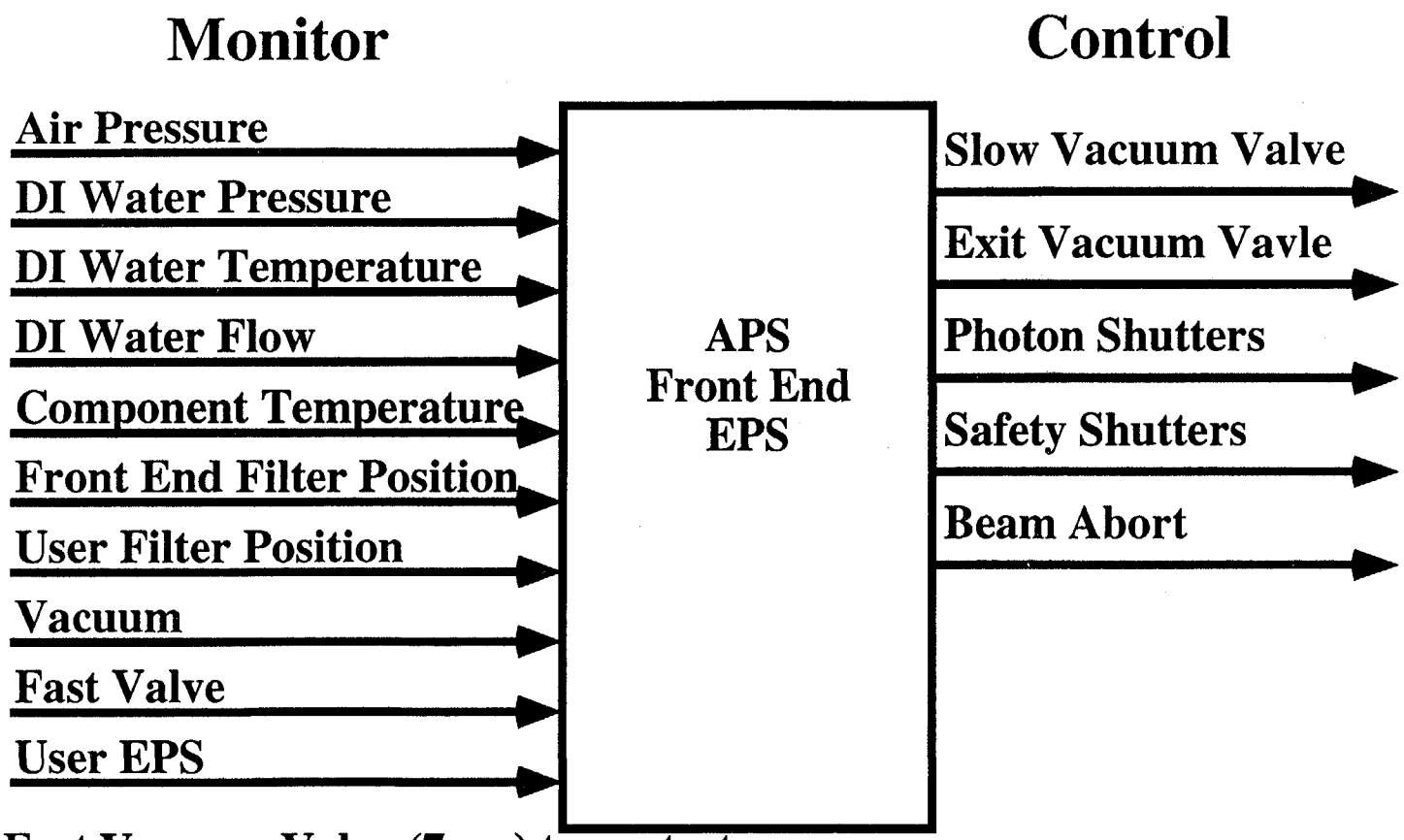
EQUIPMENT PROTECTION SYSTEM

A User's Perspective



Fast Vacuum Valve (7 ms) to protect Machine from loss of vacuum is independent subsystem.

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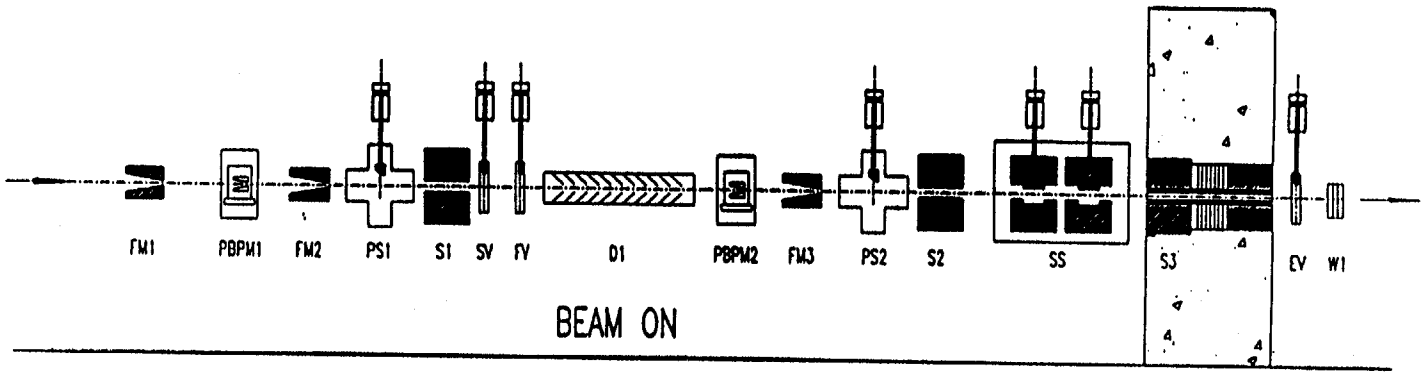
SYSTEM LOGIC

A User's Perspective

EPS / PSS CONTROL COMPONENTS



PBPM1 - PHOTON BEAM POSITION MONITOR 1 FM1 FM2 FM3 - FIXED MASKS PS1 - PHOTON SHUTTER 1 S1 S2 S3- COLLIMATORS SV - SLOW UHV VALVE FV - FAST VALVE
D1 - DELAY LINE PBPM2 - PHOTON BEAM POSITION MONITOR 2 PS2 - PHOTON SHUTTER 2 SS - SAFETY SHUTTERS EV - EXIT VALVE W1 - WINDOWS

PSS NORMALLY CONTROLS ONLY PS2, SS1, SS2
EPS CONTROLS ONLY PS2 TO INHIBIT BEAM
EPS CONTROLS EXIT VALVE TO INSURE VACUUM

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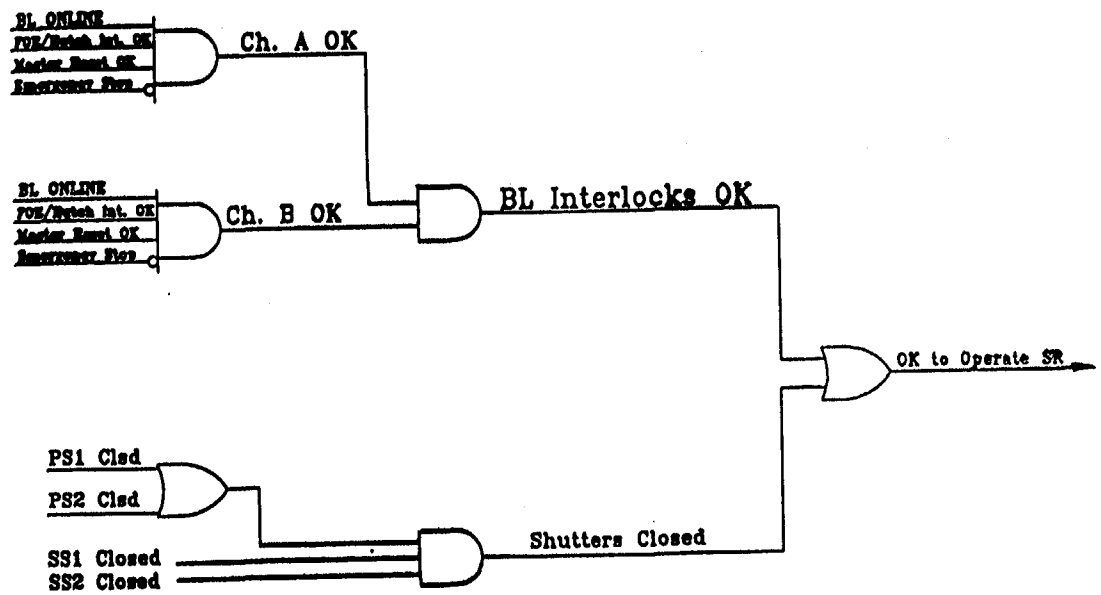
SYSTEM LOGIC

A User's Perspective

STORAGE RING ENABLE LOGIC



BEAMLINE SECURE OR OFF-LINE ENABLES STORAGE RING
BEAMLINE / STORAGE RING INDEPENDENCE

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SYSTEM LOGIC

A User's Perspective

Experimental Floor Personnel Safety by [illegible] Matrix for the AP8 XBI CAT BAII

The Event	Conditions	Front End				P9				P7				Ring Dump	Comments
		PS1	PS2	PS3	PS4	Shutter	Shutter	WhN	Mono	Mono PS1	Mono PS2	WhN	Mono		
Secure Power Failure		In	In	In	In	In	Shuts Down	Shuts Down	Shuts Down	In	In	(In)	Shuts Down	No	PLC is on UPS - entirely shutdown
PLC Fault		In	In	In	In	In	Shuts Down	Shuts Down	Shuts Down	In	In	(In)	Shuts Down	No	PE Shutter also monitored by the SR-ACIS
Front End Off Line (for repair, testing, upgrade, etc.)	No e⁻ beam in the Storage Ring													No	PS5 inhibits Ring Fill through the SR-ACIS
Beamline Off Line			In	In	In									No	PS2 and PE SS's mechanically disabled IN
Ring Fill Mode	Beamline is On Line		In	In	In									No	PS2 and PE SS's disabled IN by the SR-ACIS
Inadvertent Closure of a PE Safety Shutter			In											No	PS1 backs PS2
FOE Entry	Storage Ring has Beam		In	In	In									No	
White Beam Hutch Experiment	White Beam Mode, FOE & Wh.Hutch Secured	Out	Out	Out	Out		(Out)	Out	(Down)			(In)	(Up)	No	P9 MonoPS1, P9 SStop, and P7 SStop are mechanically locked
White Beam Hutch: Stopping the Beam Only	White Beam Mode						(Out)	In	(Down)			(In)	(Up)	No	No Hutch entry
White Beam Hutch Entry	White Beam Mode		In	In	In		(Out)	In	(Down)			(In)	(Up)	No	
White Beam Hutch Experiment	Mono Beam Mode, FOE & Wh.Hutch Secured	Out	Out	Out	Out	Out	Out	(In)	(Up)	In	In			No	P9 Wh.Stop and SStop are mechanically locked
White Beam Hutch Entry	Mono Beam Mode					In	In	(In)	(Up)					No	P9 Wh.Stop and SStop are mechanically locked
White Beam Hutch Entry	Mono Beam Goes Through							(In)	(Up)				Down	No	No experiment in the Hutch
White Beam Hutch: Stopping the Beam Only	Mono Beam Mode					In		(In)	(Up)					No	No Hutch entry
Mono Beam Hutch Experiment	FOE Secured	Out	Out	Out	Out	Out	Out	(In)	(Up)	Out	Out		Down	No	P9 Wh.Stop and SStop are mechanically locked
Mono Beam Hutch: Stopping the Beam Only								(In)	(Up)	In			(Down)	No	P7 Mono PS's are redundant, No Hutch entry
Mono Beam Hutch Entry or Access into a Shielded Cabinet	Wh. Hutch is in Passthrough Mode							(In)	(Up)	In	In		(Down)	No	
Mono Beam Hutch Entry or Access into a Shielded Cabinet	Wh. Hutch is in Mono Beam Mode							(In)	(Up)					No	
Mono Beam Hutch Entry or Access into a Shielded Cabinet	Wh. Hutch is in White Beam Mode											(In)	(Up)	No	
Violation of Shielded Cabinet Security			In	In	In									No	Warning sounds. Should the Sys. fail or down in PE a beam in PE and PS is being IN while P7 on, Ring will be dumped. PS1 backs PS2. PE PS1 & SS's disabled IN by the PS1 - Manual Reset required
Inside or outside FOE/Wh.Hutch Emerg. Beam Stop button pressed	FOE/Wh.Hutch is in Access Mode		(In)	(In)	(In)									No	Warning sounds. Should the Sys. fail or down in PE a beam in PE and PS is being IN while P7 on, Ring will be dumped. PS1 backs PS2. PE PS1 & SS's disabled IN by the PS1 - Manual Reset required
Inside or outside FOE/Wh.Hutch Emerg. Beam Stop button pressed	PE Shutters are IN		(In)	(In)	(In)									No	FOE/Wh.Hutch Shutters, Doors open. Warning sounds. Should the Sys. fail or down in PE a beam in PE is being IN while P7 on, Ring will be dumped. PS1 backs PS2. PE PS1 & SS's disabled IN - Manual Reset required
Inside FOE/White Hutch Emergency Beam Stop button pressed	PE Shutters are OUT		In	In	In									Yes	FOE/Wh.Hutch Shutters, Doors automatically open. PE PS1 & SS's disabled IN - Manual Reset required
Inside Mono Hutch Emergency Beam Stop button pressed	Wh. Hutch is in Passthrough Mode		In	In	In			(In)	(Up)	(In)	(In)			No	Doors are open. PE PS1 & SS's disabled IN - Manual Reset required. PS1 backs PS2
Outside Mono Hutch Emergency Beam Stop Button pressed	Wh. Hutch is in Passthrough Mode		In	In	In			(In)	(Up)					No	Doors auto. open. PE PS1 & SS's disabled IN - Manual Reset required. PS1 backs PS2
Inside or outside Mono Hutch Emergency Beam Stop Button pressed	Wh. Hutch is in Mono Beam Mode							(In)	(Up)					No	Doors automatically open. Warning sounds
Inside or outside Mono Hutch Emergency Beam Stop Button pressed	Wh. Hutch is in White Beam Mode											(In)	(Up)	No	Doors automatically open. Warning sounds
Inside Mono Hutch Emergency Beam Stop Button pressed	Wh.Hutch is in Passthrough Mode and not both P7 MonoPS's detected IN		In	In	In	(Out)	(Out)	(In)	(Up)	(In)	(In)			Yes	Doors automatically open. PE PS1 & SS's disabled IN - Manual Reset required
Both PS3 Chain Trip - one or more PE Shutters not detected IN	FOE/Wh.Hutch is in Access Mode		(In)	(In)	(In)									Yes	Warning sounds. PE PS1 & SS's disabled IN - Manual Reset required
One PS3 Chain Trips - one PE shutter not detected IN	FOE/Wh.Hutch is in Access Mode		(In)	(In)	(In)									No	Warning sounds. Should the Sys. fail or down in PE a beam in PE and PS is being IN while P7 on, Ring will be dumped. PS1 backs PS2. PE PS1 & SS's disabled IN by the PS1 - Manual Reset required
One PS3 Chain Trips - both PE SS's not detected IN	FOE/Wh.Hutch is in Access Mode		(In)	(In)	(In)									Yes	Warning sounds. PE PS1 & SS's disabled IN - Manual Reset required
One PS3 Chain Trips - 3rd PS and 1 SS in the PE not detected IN	FOE/Wh.Hutch is in Access Mode	In	(In)	(In)	(In)									No	Warning sounds. All PE Shutters Disabled IN - Manual Reset required
One or both PS5 Chains Trip	FOE/Hutch is in Secured Mode		In	In	In									No	FOE/Hutch secureness and gaps locked. PE PS1 & SS's disabled IN - Manual Re required
Both Chains Trip - one or both P7 MonoPS's not detected IN	Wh.Hutch is Passthrough Mode, Mono Hutch in Access Mode		In	In	In					(In)	(In)			Yes	PE PS1 & SS's disabled IN - Manual Re required
One Chain Trips - both P7 MonoPS's not detected IN	Wh.Hutch is Passthrough Mode, Mono Hutch in Access Mode		In	In	In					(In)	(In)			Yes	PE PS1 & SS's disabled IN - Manual Re required

TRUTH TABLE

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ADVANCED PHOTON SOURCE

HOW TO DESIGN A BEAMLINE USING APS STANDARD COMPONENTS:

TOOLS AND TECHNIQUES

Deming Shu

Experimental Facilities Division

Advanced Photon Source

Argonne National Laboratory

ADVANCED PHOTON SOURCE

CONTENTS:

- Step by Step Design of a SR Beamline
- Use of the APS Beamline Standard Components To Speed Up the Design Process
- The APS Standard Components Design Toolbox For Autocad V.12 X-ref Function

ACKNOWLEDGMENTS : APS XFD ENGINEERING GROUP

ADVANCED PHOTON SOURCE

- Step by Step Design of a SR Beamline

  -- Preparation

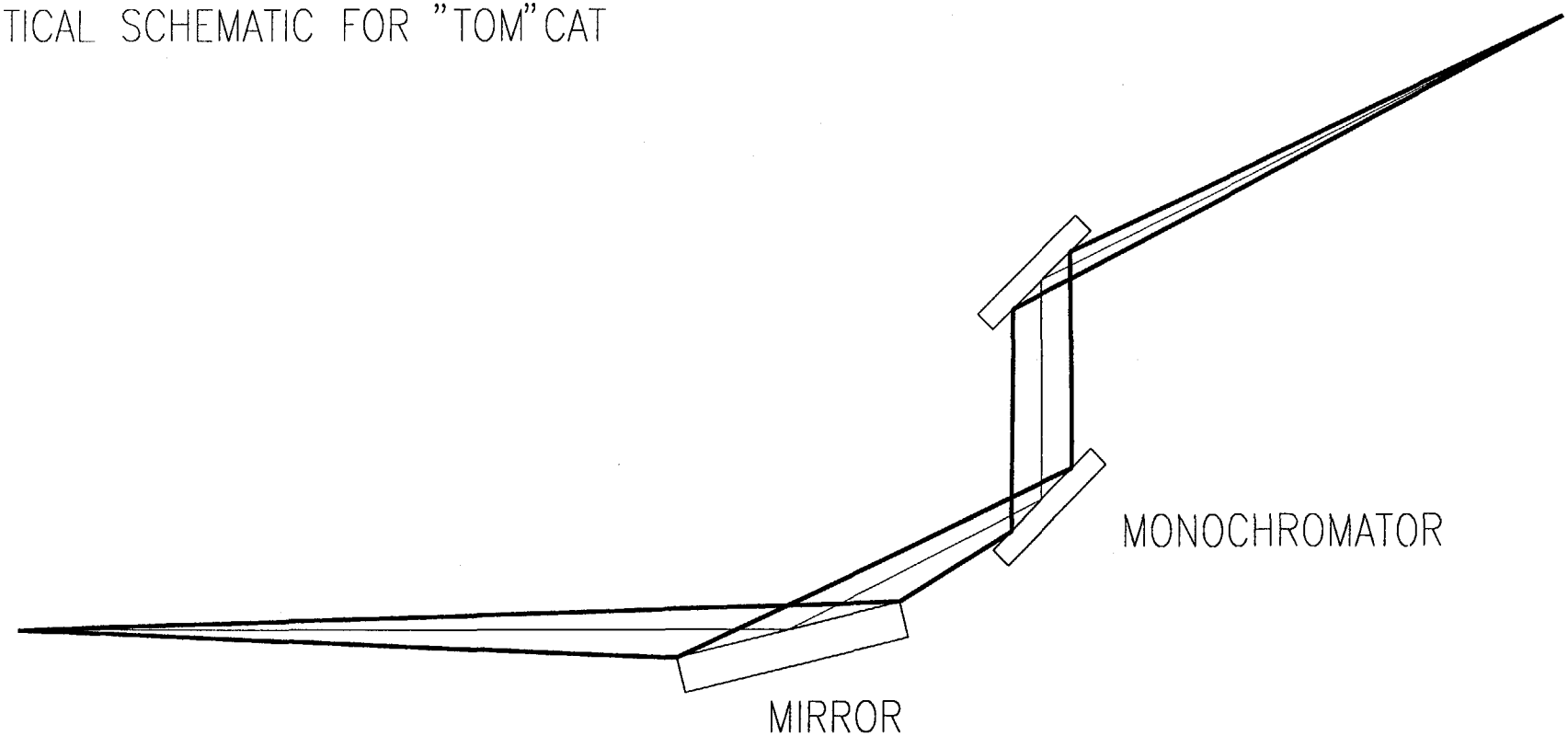
  -- Design Process

  -- Verification

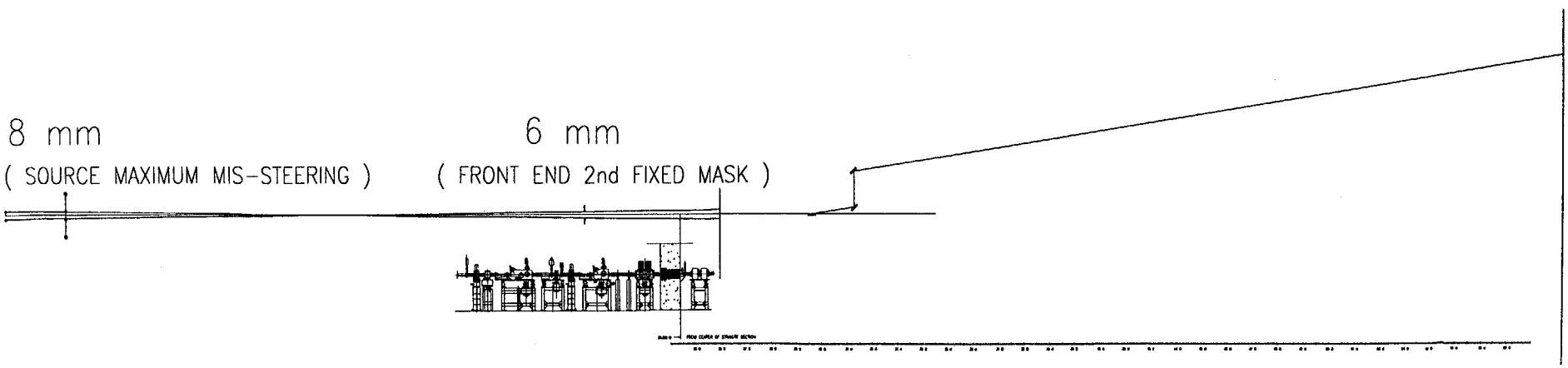
-- Preparation

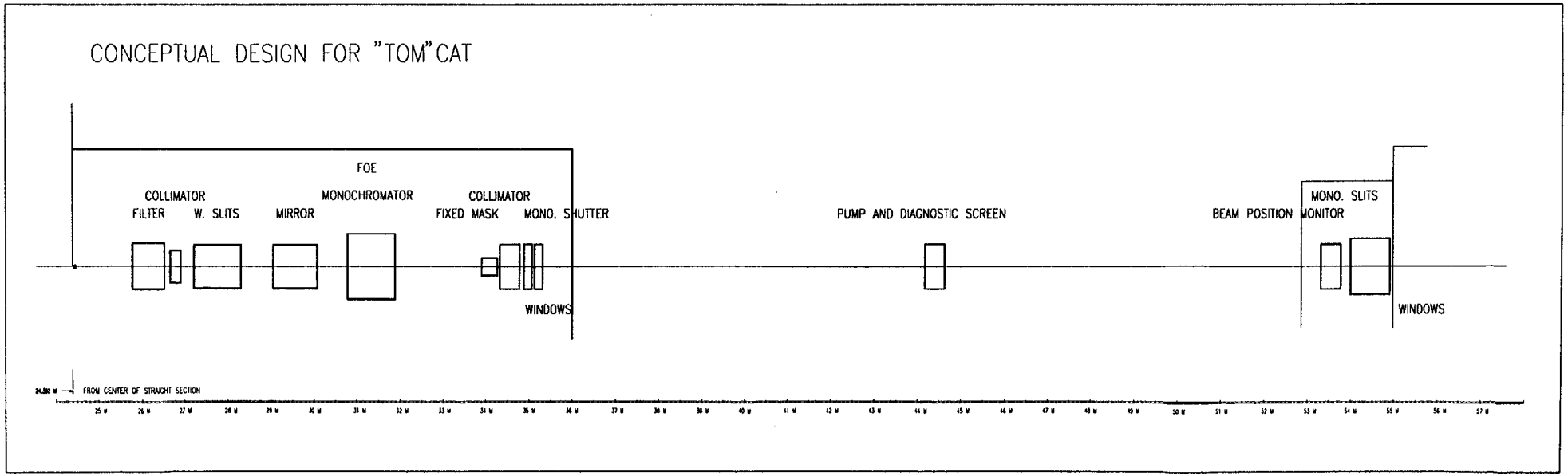
- Optical Schematic (Mirrors, Monochromators)
- Optical Aperturing (Masks, Slits, Shutters)
- Bremsstrahlung Shielding (Collimators)
- Vacuum Branching (Valves, Windows)

OPTICAL SCHEMATIC FOR "TOM" CAT

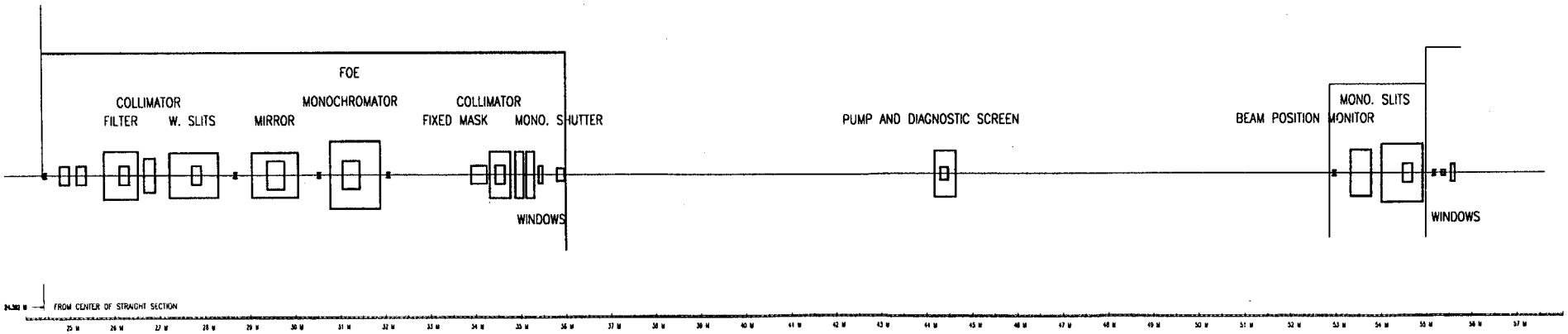


VERTICAL OPTICAL APERTURING FOR "TOM" CAT




CONCEPTUAL DESIGN FOR "TOM"CAT
FOE
COLLIMATOR
FILTER
W. SLITS
MIRROR
MONOCHROMATOR
COLLIMATOR
FIXED MASK
MONO. SHUTTER
WINDOWS
PUMP AND DIAGNOSTIC SCREEN
BEAM POSITION MONITOR
MONO. SLITS
WINDOWS
FROM CENTER OF STRAIGHT SECTION

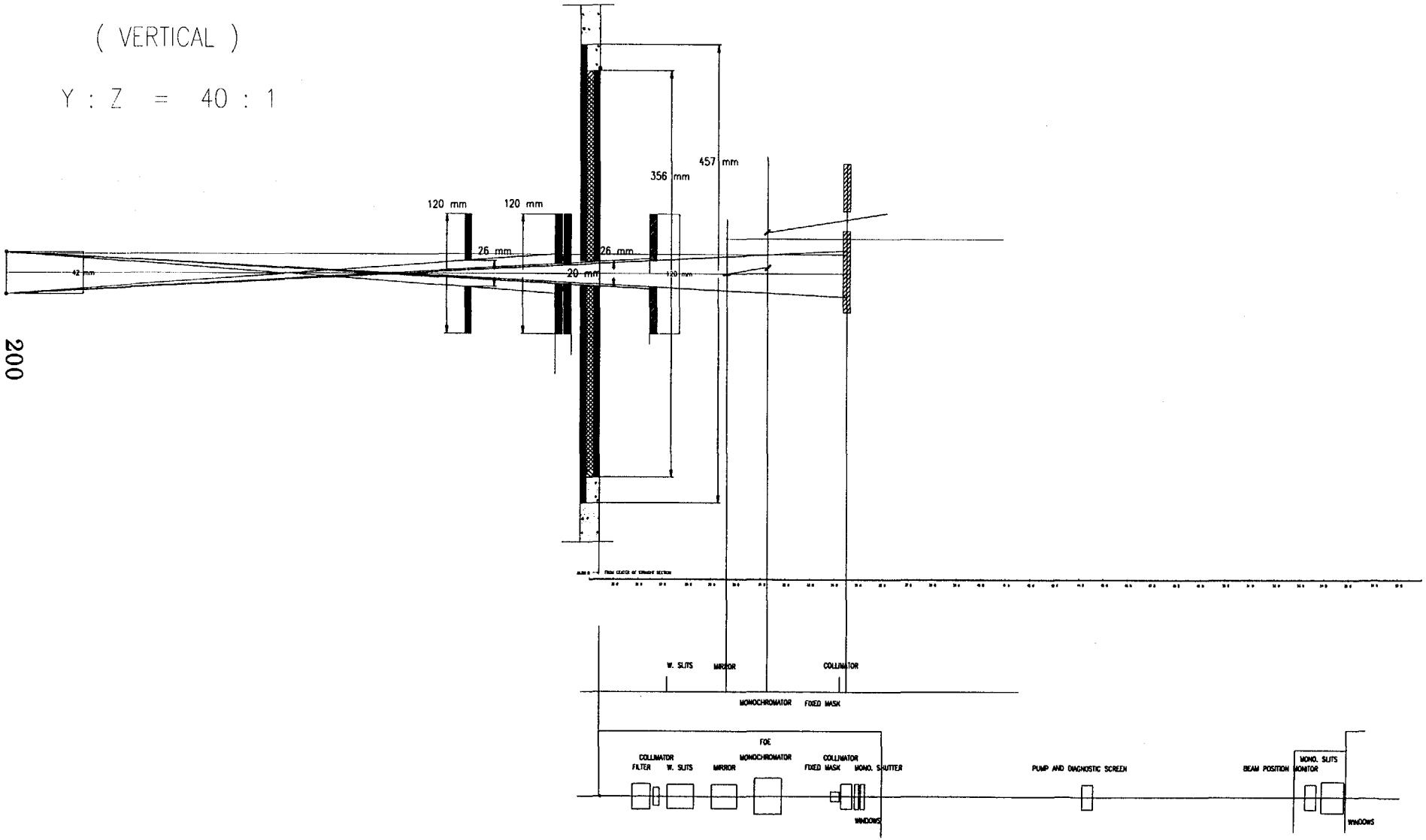
CONCEPTUAL DESIGN FOR "TOM"CAT
WITH VACUUM BRANCHING AND PUMPING SYSTEM



BREMSSTRAHLUNG RAY-TRACING FOR "TOM"CAT

(VERTICAL)

Y : Z = 40 : 1

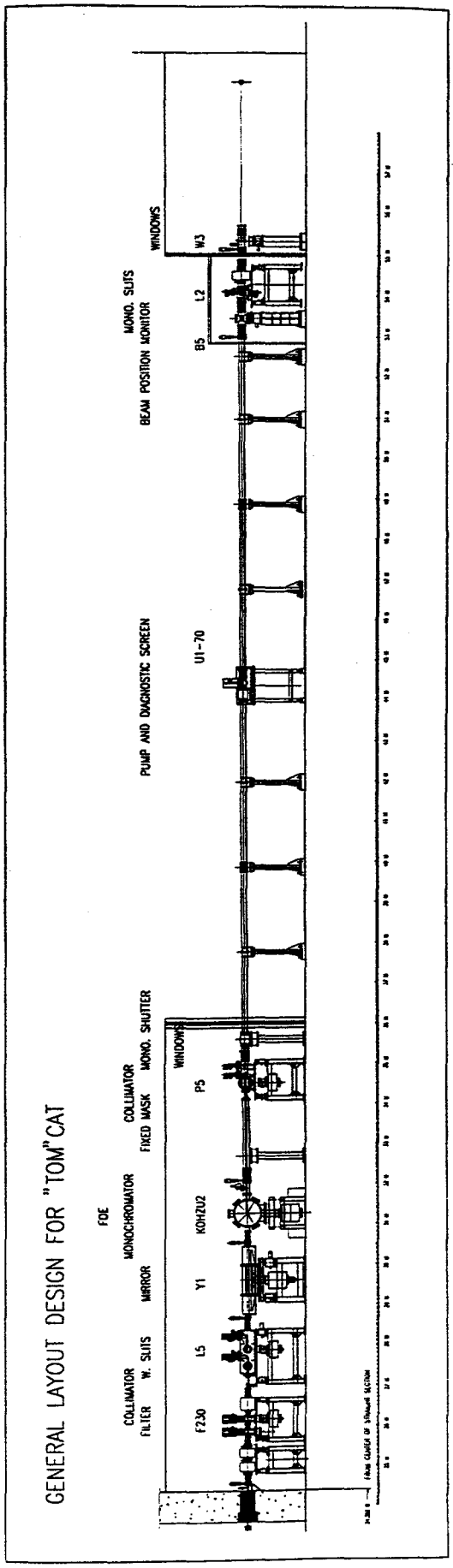


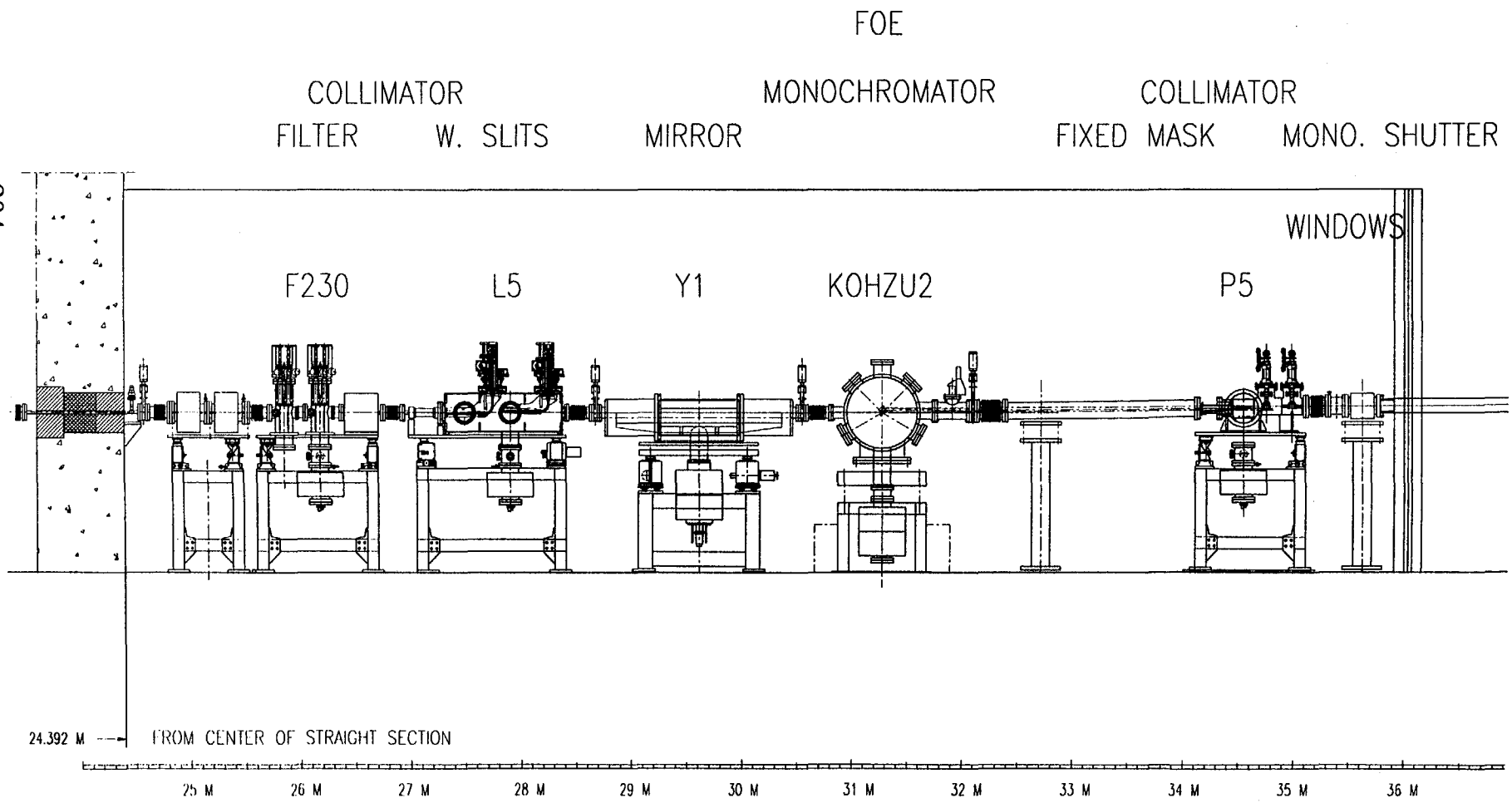
-- Design Process

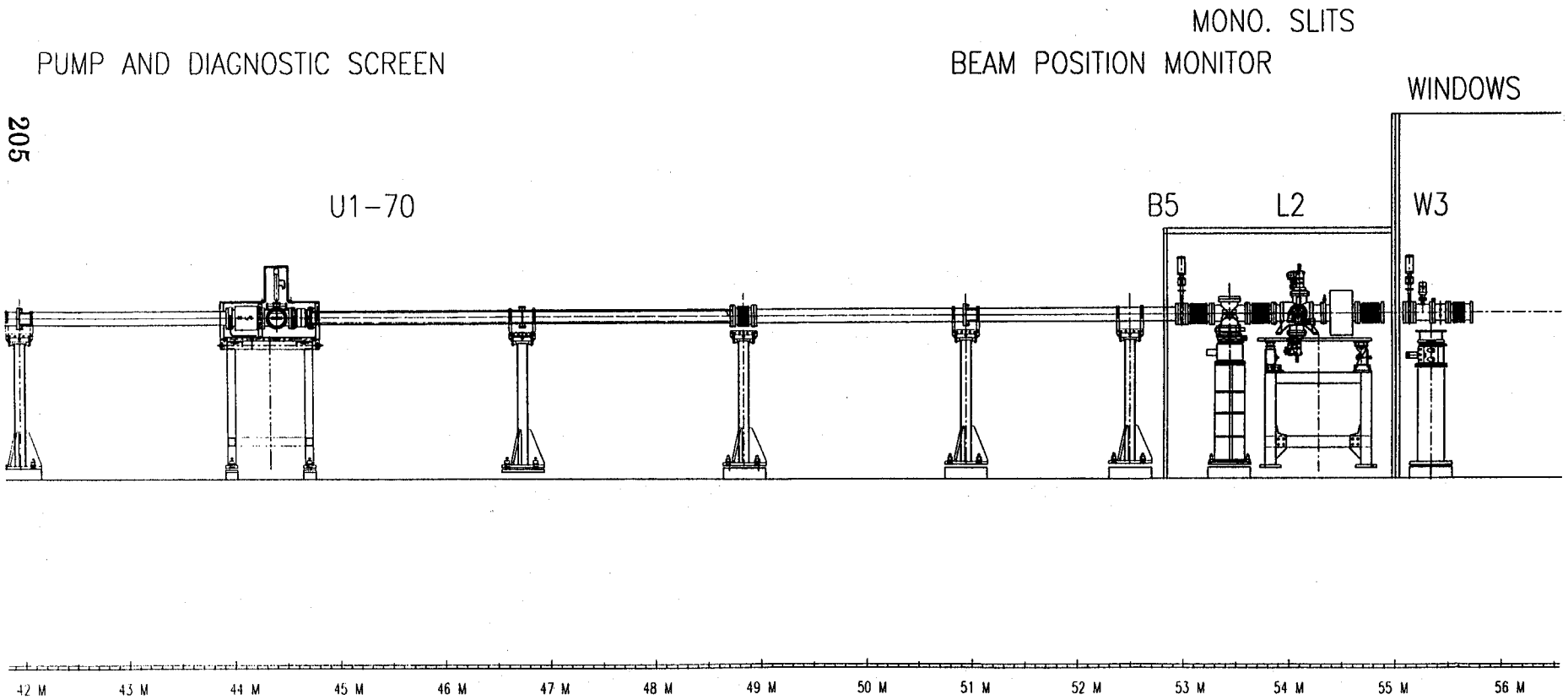
- Preliminary Layout Design
- Main Components Design and Development
  Thermal and Structure Analysis
- General Layout Design

-- Verification

- Optical Ray-tracing
- Bremsstrahlung Ray-tracing
- Vacuum Calculations


GENERAL LAYOUT DESIGN FOR "TOM"CAT
COLLIMATOR
FILTER
W. SLITS
MIRROR
MONOCHROMATOR
FIXED MASK
MONO. SHUTTER
COLLIMATOR
F230
L5
Y1
KOHZU2
P5
WINDOWS
FDE
PUMP AND DIAGNOSTIC SCREEN
U1-70
BEAM POSITION MONITOR
MONO. SLITS
B5
L2
W3
WINDOWS


FOE
COLLIMATOR
MONOCHROMATOR
COLLIMATOR
FILTER
W. SLITS
MIRROR
FIXED MASK
MONO. SHUTTER
WINDOWS
F230
L5
Y1
KOHZU2
P5
24.392 M
FROM CENTER OF STRAIGHT SECTION
25 M
26 M
27 M
28 M
29 M
30 M
31 M
32 M
33 M
34 M
35 M
36 M


PUMP AND DIAGNOSTIC SCREEN
U1-70
MONO. SLITS
BEAM POSITION MONITOR
WINDOWS
B5
L2
W3
42 M
43 M
44 M
45 M
46 M
47 M
48 M
49 M
50 M
51 M
52 M
53 M
54 M
55 M
56 M

ADVANCED PHOTON SOURCE

- The APS Standard Components Design Toolbox
  For Autocad V.12 External Reference

TOOLBOXS.DWG --- Sideview Library

TOOLBOXT.DWG --- Topview Library

Part 1 Main Components

Filters
Slits
Shutters
Photon Beam Position monitors
Monochromators
Mirrors
Transports
Scales
Front End Information
Shielding Wall

Part 2 Sub-Components

Actuators
Bellows
Windows
Support Tables
Valves

Part 3 Experimental Stations

Standard Shielding Panels

ADVANCED PHOTON SOURCE

- File Names

  Sideview --- NAMESS.DWG (L2SS.DWG)

  Topview --- NAMETT.DWG (L2TT.DWG)

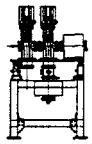
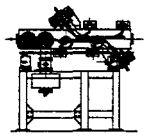
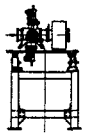
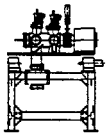
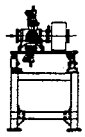
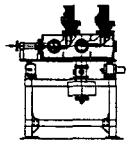
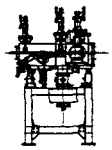
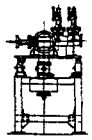
Main Components with Support Struture	L2SS.DWG
Support Structure Only (for L2)	TL2.DWG
Components Only	L2-20SS.DWG

- Reference Base Point is Set

  On the Components Upstream Flange Center

APS BEAMLINE DESIGN TOOLBOX (SIDEVIEW)

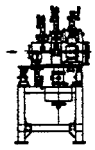
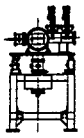
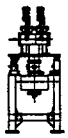
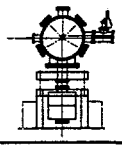
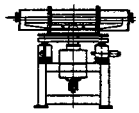
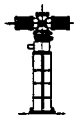
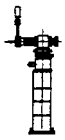
PART 1 MAIN COMPONENTS

FILTERS		F230 F-F 575 mm + 452 mm O.A. 13 mm (V) X 76 mm (H)	ID BEAMLINE FILTERS WITH COLLIMATOR K1 AND BELLOWS
SLITS		L1 F-F 1750 mm O.A. (IN) 8.5 mm (V) X 70 mm (H) O.A. (OUT) 0-8.5 mm (V) X 0-60 mm (H)	ID U/W WHITE BEAM H&V SLITS
SLITS		L2 F-F 465 mm + 320 mm O.A. 0-30 mm (V) X 0-30 mm (H)	WITH ION PUMP WITH ION PUMP
SLITS		L3 F-F 600 mm + 475 mm O.A. 0-30 mm (V) X 0-30 mm (H)	BM WHITE BEAM H&V SLITS WITH COLLIMATOR K1 AND VALVE
SLITS		L4 F-F 465 mm + 320 mm O.A. 0-30 mm (V) X 0-120 mm (H)	BM MONO. BEAM H&V SLITS
SLITS		L5 F-F 1490 mm O.A. (IN) 20 mm (V) X 35 mm (H) O.A. (OUT) 0-7 mm (V) X 0-7 mm (H)	UNDULATOR WHITE BEAM H&V SLITS
SHUTTERS		P4 F-F 1150 mm O.A. 13.3 mm (V) X 80 mm (H) B.A. 18 mm (V) X 80 mm (H)	ID INTEGRAL SHUTTERS/STOPS WHITE BEAM MOVEABLE STOP WITH KIRK KEY BREMSSTRAHLUNG MOVEABLE STOP WITH KIRK KEY DOUBLE MONO. BEAM SHUTTERS
SHUTTERS		P5 F-F 982 mm O.A. 10 mm (V) X 80 mm (H) B.A. 10 mm (V) X 80 mm (H)	ID INTEGRAL SHUTTERS/STOPS WHITE BEAM FIXED MASK BREMSSTRAHLUNG FIXED STOP DOUBLE MONO. BEAM SHUTTERS

S07758 TOOLBOXS.DWG 04-12-1994

APS BEAMLINE DESIGN TOOLBOX (SIDEVIEW)

PART 1 MAIN COMPONENTS

SHUTTERS		P6 F-F 918 mm O.A. 13.3 mm (V) X 120 mm (H) B.A. 18 mm (V) X 120 mm (H)	BM INTEGRAL SHUTTERS/STOPS WHITE BEAM MOVEABLE STOP WITH KIRK KEY BREMSSTRAHLUNG MOVEABLE STOP WITH KIRK KEY DOUBLE MONO. BEAM SHUTTERS
SHUTTERS		P7 F-F 948 mm O.A. 13.3 mm (V) X 120 mm (H) B.A. 18 mm (V) X 120 mm (H)	BM INTEGRAL SHUTTERS/STOPS WHITE BEAM FIXED MASK BREMSSTRAHLUNG FIXED STOP DOUBLE MONO. BEAM SHUTTERS
SHUTTERS		P8 F-F 480 mm O.A. 13.3 mm (V) X 120 mm (H)	DOUBLE MONO. BEAM SHUTTERS
KOHZU MONOCHROMATOR		KOHZU2 F-F 939 mm + 310 mm	ID MONOCHROMATOR WITH DIAGNOSTIC SCREEN
MIRROR		Y1 F-F 1800 mm	UNDULATOR VERTICAL REFLECTION
PBPM		B5 F-F 835 mm O.A. 27 mm (V) X 72 mm (H)	PHOTON BEAM POSITION MONITOR
PBPM		B5W3 F-F 640 mm O.A. 8.8 mm (V) X 72 mm (H)	MONO. BEAM POSITION MONITOR WITH VALVE AND WINDOWS
PUMPS		60PMP F-F 317 mm	60 L/S IN LINE ION PUMP

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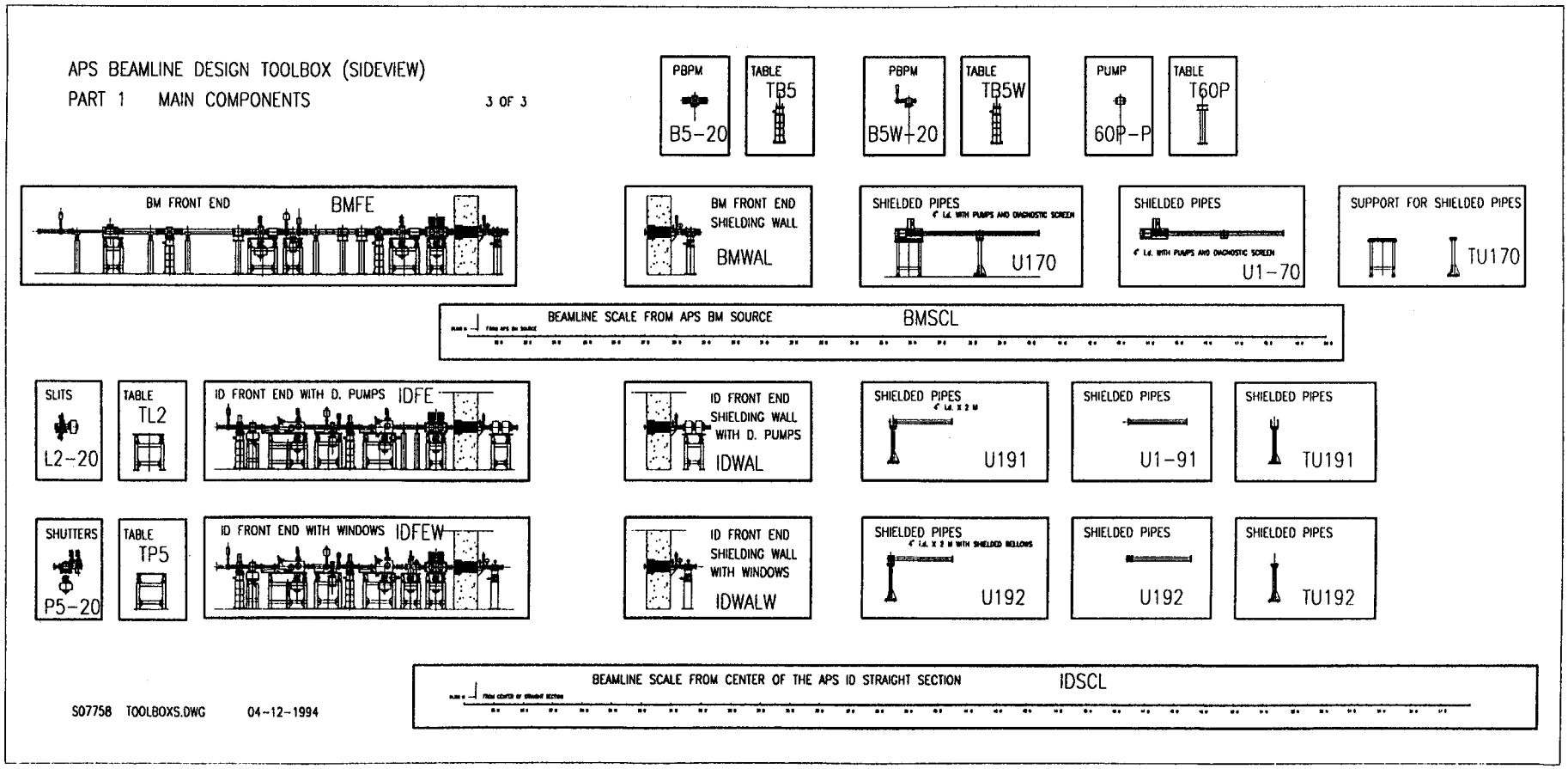
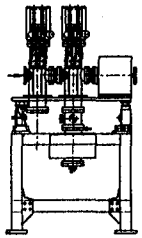

APS BEAMLINE DESIGN TOOLBOX (SIDEVIEW)
PART 1 MAIN COMPONENTS
3 OF 3
PBPM
B5-20
TABLE
TB5
PBPM
B5W-20
TABLE
TB5W
PUMP
60P-P
TABLE
T60P
BM FRONT END
BMFE
BM FRONT END SHIELDING WALL
BMWAL
SHIELDED PIPES
U170
SHIELDED PIPES
U1-70
SUPPORT FOR SHIELDED PIPES
TU170
BEAMLINE SCALE FROM APS BM SOURCE
BMSCL
SLITS
L2-20
TABLE
TL2
ID FRONT END WITH D. PUMPS
IDFE
ID FRONT END SHIELDING WALL WITH D. PUMPS
IDWAL
SHIELDED PIPES
U191
SHIELDED PIPES
U1-91
SHIELDED PIPES
TU191
SHUTTERS
P5-20
TABLE
TP5
ID FRONT END WITH WINDOWS
IDFEW
ID FRONT END SHIELDING WALL WITH WINDOWS
IDWALW
SHIELDED PIPES
U192
SHIELDED PIPES
U192
SHIELDED PIPES
TU192
BEAMLINE SCALE FROM CENTER OF THE APS ID STRAIGHT SECTION
IDSCL
S07758 TOOLBOXS.DWG 04-12-1994

FILTERS



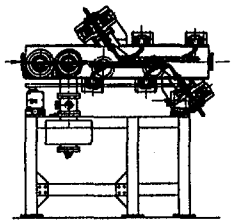
F230

F-F 575 mm + 452 mm
O.A. 13 mm (V) X 76 mm (H)

ID BEAMLINE FILTERS

WITH COLLIMATOR K1 AND BELLOWS

SLITS

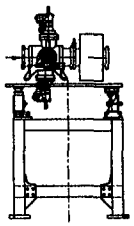


L1

F-F 1750 mm
O.A. (IN) 8.5 mm (V) X 70 mm (H)
O.A. (OUT) 0-8.5 mm (V) X 0-60 mm (H)

ID U/W WHITE BEAM H&V SLITS

SLITS



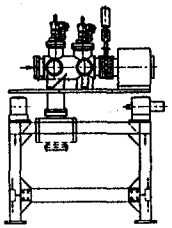
L2

F-F 465 mm + 320 mm
O.A. 0-30 mm (V) X 0-30 mm (H)

WITH ION PUMP

WITH ION PUMP

SLITS



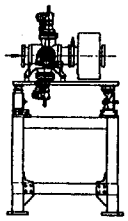
L3

F-F 600 mm + 475 mm
O.A. 0-30 mm (V) X 0-30 mm (H)

BM WHITE BEAM H&V SLITS

WITH COLLIMATOR K1 AND VALVE

SLITS

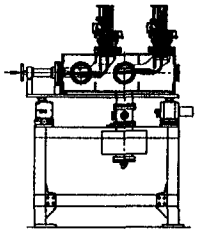


L4

BM MONO. BEAM H&V SLITS

F-F 465 mm + 320 mm
O.A. 0-30 mm (V) X 0-120 mm (H)

SLITS

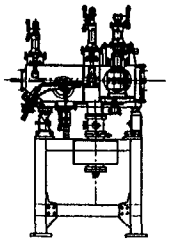


L5

UNDULATOR WHITE BEAM H&V SLITS

F-F 1490 mm
O.A. (IN) 20 mm (V) X 35 mm (H)
O.A. (OUT) 0-7 mm (V) X 0-7 mm (H)

SHUTTERS



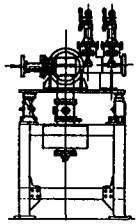
P4

ID INTEGRAL SHUTTERS/STOPS

F-F 1150 mm
O.A. 13.3 mm (V) X 80 mm (H)
B.A. 18 mm (V) X 80 mm (H)

WHITE BEAM MOVEABLE STOP WITH KIRK KEY
BREMSSTRAHLUNG MOVEABLE STOP WITH KIRK KEY
DOUBLE MONO. BEAM SHUTTERS

SHUTTERS



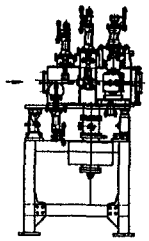
P5

ID INTEGRAL SHUTTERS/STOPS

F-F 982 mm
O.A. 10 mm (V) X 80 mm (H)
B.A. 10 mm (V) X 80 mm (H)

WHITE BEAM FIXED MASK
BREMSSTRAHLUNG FIXED STOP
DOUBLE MONO. BEAM SHUTTERS

SHUTTERS



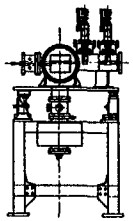
P6

F-F 918 mm
O.A. 13.3 mm (V) X 120 mm (H)
B.A. 18 mm (V) X 120 mm (H)

BM INTEGRAL SHUTTERS/STOPS

WHITE BEAM MOVEABLE STOP WITH KIRK KEY
BREMSSTRAHLUNG MOVEABLE STOP WITH KIRK KEY
DOUBLE MONO. BEAM SHUTTERS

SHUTTERS



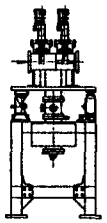
P7

F-F 948 mm
O.A. 13.3 mm (V) X 120 mm (H)
B.A. 18 mm (V) X 120 mm (H)

BM INTEGRAL SHUTTERS/STOPS

WHITE BEAM FIXED MASK
BREMSSTRAHLUNG FIXED STOP
DOUBLE MONO. BEAM SHUTTERS

SHUTTERS

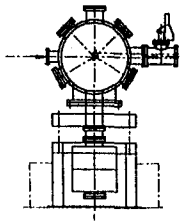


P8

F-F 480 mm
O.A. 13.3 mm (V) X 120 mm (H)

DOUBLE MONO. BEAM SHUTTERS

KOHZU
MONOCHROMATOR

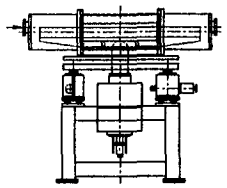
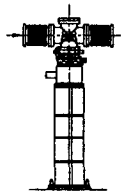
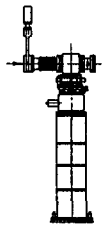
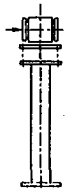


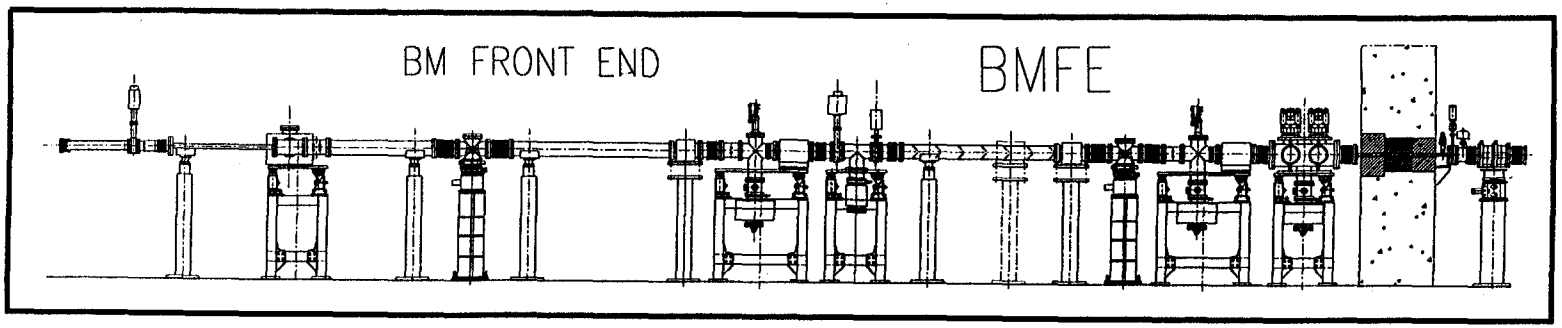
KOHZU2

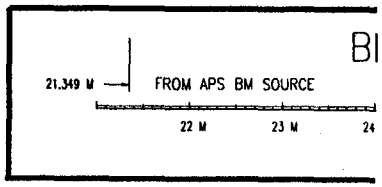
F-F 939 mm + 310 mm

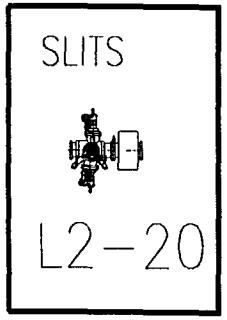
ID MONOCHROMATOR

WITH DIAGNOSTIC SCREEN

MIRROR		Y1 F-F 1800 mm	UNDULATOR VERTICAL REFLECTION
PBPM		B5 F-F 835 mm O.A. 27 mm (V) X 72 mm (H)	PHOTON BEAM POSITION MONITOR
PBPM		B5W3 F-F 640 mm O.A. 8.8 mm (V) X 72 mm (H)	MONO. BEAM POSITION MONITOR WITH VALVE AND WINDOWS
PUMPS		60PMP F-F 317 mm	60 L/S IN LINE ION PUMP


BM FRONT END
BMFE


BI
21.349 M
FROM APS BM SOURCE
22 M
23 M
24


SLITS
L2-20

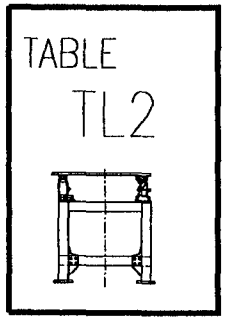
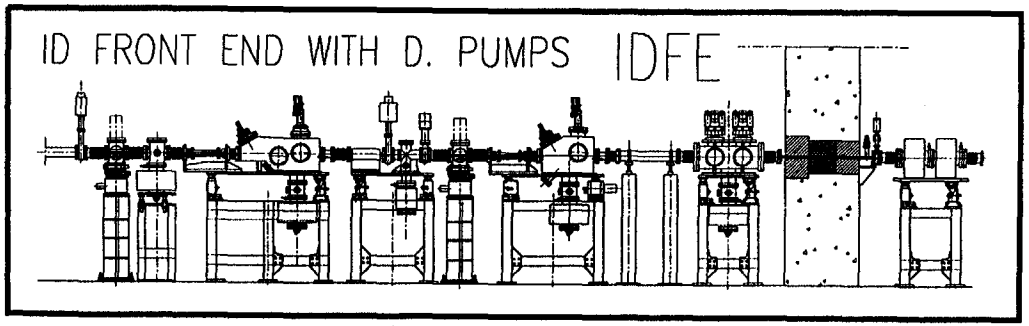
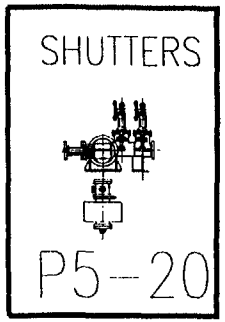


TABLE
TL2


ID FRONT END WITH D. PUMPS
IDFE


SHUTTERS
P5-20

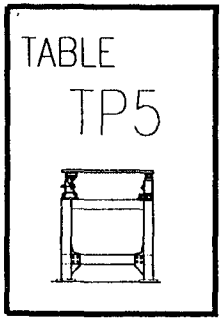
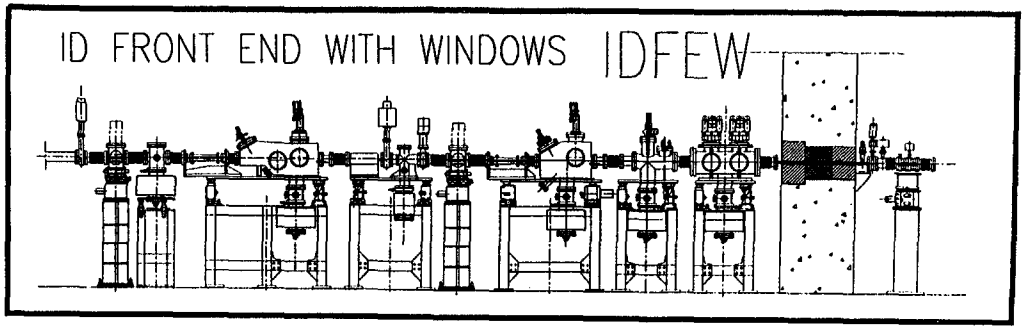
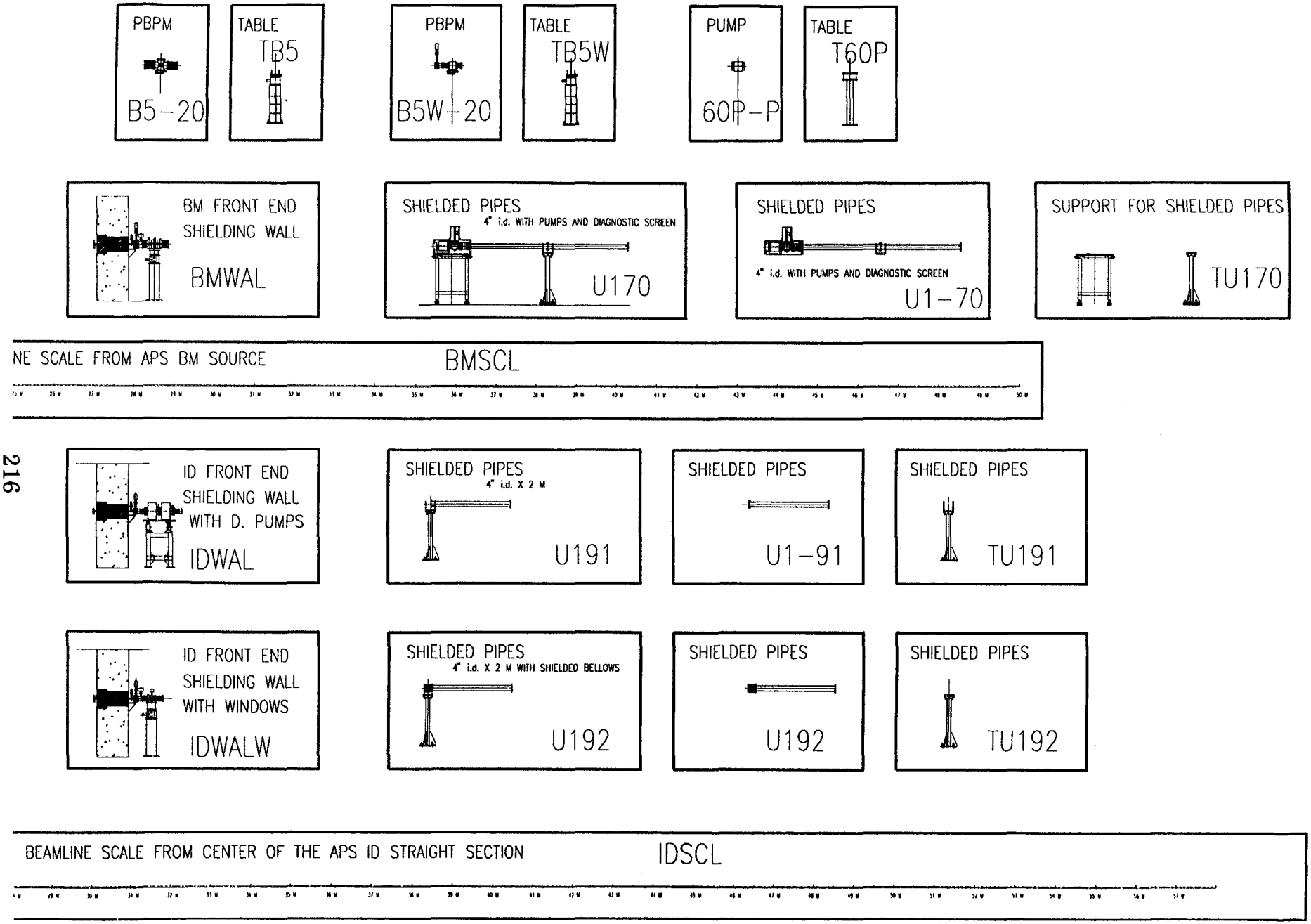


TABLE
TP5


ID FRONT END WITH WINDOWS
IDFEW


PBPM
B5-20
TABLE
TB5
PBPM
B5W-20
TABLE
TB5W
PUMP
60P-P
TABLE
T60P
BM FRONT END
SHIELDING WALL
BMWAL
SHIELDED PIPES
4" i.d. WITH PUMPS AND DIAGNOSTIC SCREEN
U170
SHIELDED PIPES
4" i.d. WITH PUMPS AND DIAGNOSTIC SCREEN
U1-70
SUPPORT FOR SHIELDED PIPES
TU170
NE SCALE FROM APS BM SOURCE
BMSCL
ID FRONT END
SHIELDING WALL
WITH D. PUMPS
IDWAL
SHIELDED PIPES
4" i.d. X 2 M
U191
SHIELDED PIPES
U1-91
SHIELDED PIPES
TU191
ID FRONT END
SHIELDING WALL
WITH WINDOWS
IDWALW
SHIELDED PIPES
4" i.d. X 2 M WITH SHIELDED BELLOWS
U192
SHIELDED PIPES
U192
SHIELDED PIPES
TU192
BEAMLINE SCALE FROM CENTER OF THE APS ID STRAIGHT SECTION
IDSCL

APS BEAMLINE DESIGN TOOLBOX (SIDEVIEW)

PART 2 SUB-COMPONENTS BELLOWS

BELLOWS	V2-82	6" CF X 4" I.D. X 210 mm
BELLOWS	V2-83	6" CF X 4" I.D. X 175 mm
BELLOWS	V2-84	6" CF X 4" I.D. X 110 mm
BELLOWS	V2-85	12" X 6" CF X 4" I.D. X 200 mm
BELLOWS	V2-86	6" CF X 4" I.D. X 230 mm
BELLOWS	V2-87	8" X 6" CF X 4" I.D. X 200 mm
BELLOWS	V2-88	12" X 8" CF X 4" I.D. X 200 mm
BELLOWS	V2-89	6" CF X 4" I.D. X 250 mm W/2.75" PORT
BELLOWS	V2-91	10" X 8" CF X 6" I.D. X 200 mm
BELLOWS	V2-92	12" X 8" CF X 6" I.D. X 200 mm
BELLOWS	V2-93	8" CF X 6" I.D. X 200 mm
BELLOWS	V2-94	8" CF X 6" I.D. X 250 mm
BELLOWS	V2-95	8" CF X 6" I.D. X 230 mm

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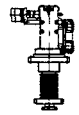
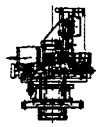
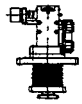
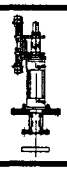
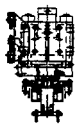
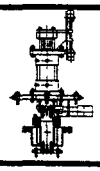
APS BEAMLINE DESIGN TOOLBOX (SIDEVIEW)

PART 2 SUB-COMPONENTS ACTUATORS

LINEAR ACTUATORS		A1-82	STEPPING MOTOR DRIVEN 6.75" CF -- 30 mm
LINEAR ACTUATORS		A1-85	STEPPING MOTOR DRIVEN X - Z 25 mm FOR L5 SLITS
LINEAR ACTUATORS		A1-86	STEPPING MOTOR DRIVEN 8" CF -- 30 mm
LINEAR ACTUATORS		A2-82	HEAVY LOAD STEPPING MOTOR DRIVEN 10" CF -- 70 mm
LINEAR ACTUATORS		A3-81	PNEUMATIC DRIVEN 8" CF -- 31 mm
LINEAR ACTUATORS		A3-83	PNEUMATIC DRIVEN 8" CF -- 70 mm
LINEAR ACTUATORS		A4-81	PNEUMATIC DRIVEN 8" CF -- 33 mm
LINEAR ACTUATORS		A4-82	PNEUMATIC DRIVEN 8" CF -- 35 mm

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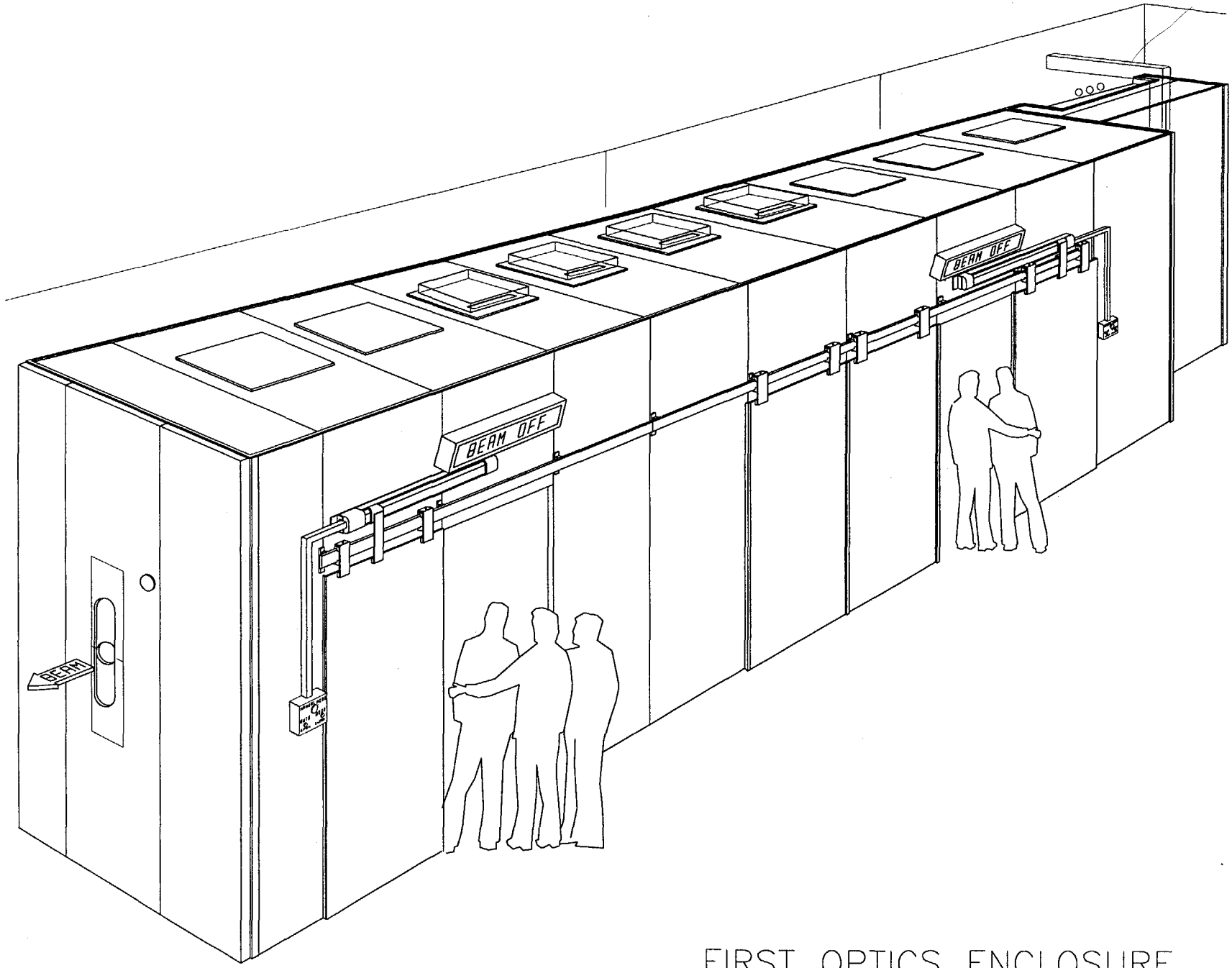
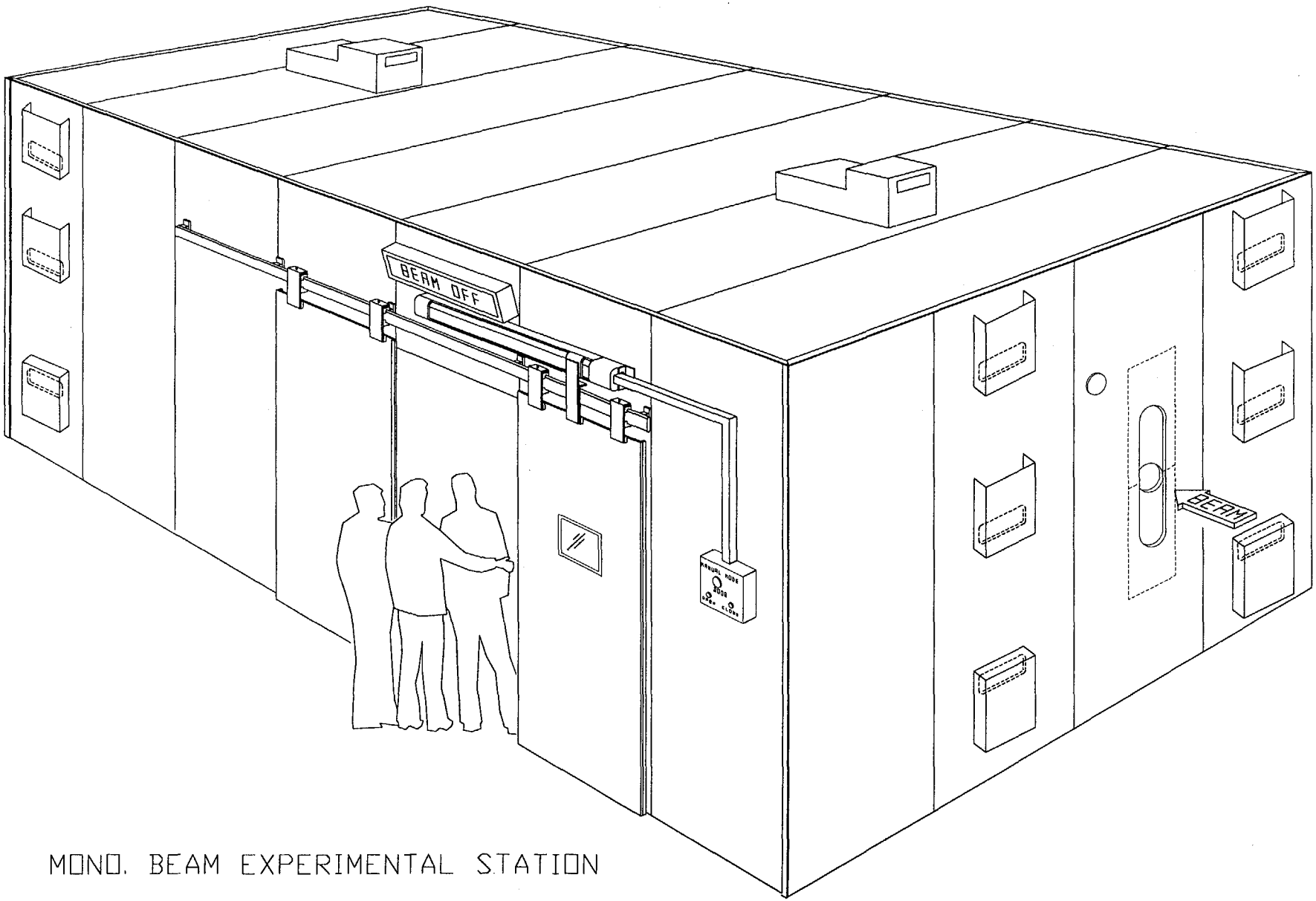


FIRST OPTICS ENCLOSURE



MONO. BEAM EXPERIMENTAL STATION

Mirrors as First Optic at the APS

May 26, 1994

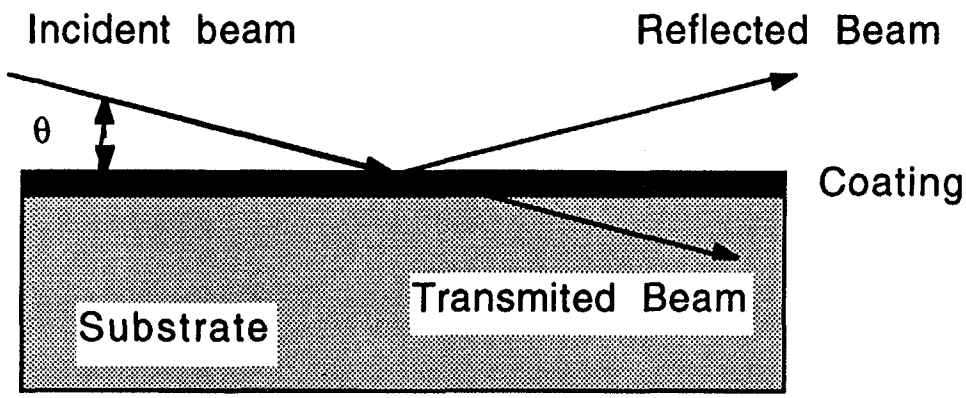
APS Sixth User's Meeting

W. Yun

- Undulator A Power Spectrum
- Advantages of Using Mirror as the First Optic
- High Heat Load Mirror Development at the APS
- Design Considerations

Contributors: ID Group: A. Khounsary, K. Randall, B. Lai, I. McNulty, E. Gluskin
E & C Group: D. Shu, V. Tcheskidov, J. Barraza

X-ray Mirror



Important Mirror Parameters

- Surface roughness
- Slope errors (tangential and sagittal)
- Critical energy for total reflection (high energy cut-off), dependent of the incidence angle and the coating material

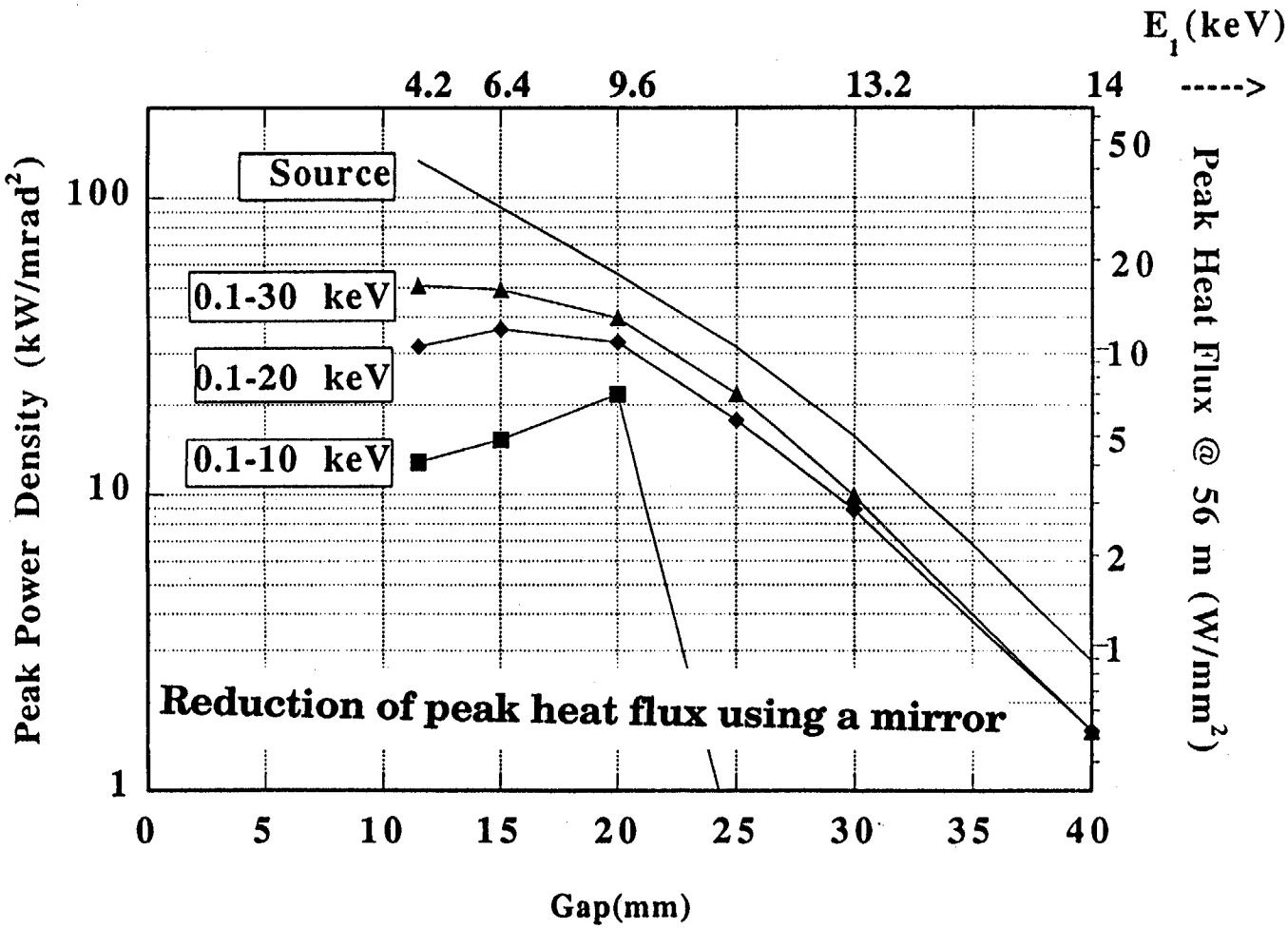


Fig. 2 Calculated peak power densities and peak normal incidence heat fluxes at 56 meters from the source for the entire Undulator A spectrum and for the three energy bands indicated in the figure.

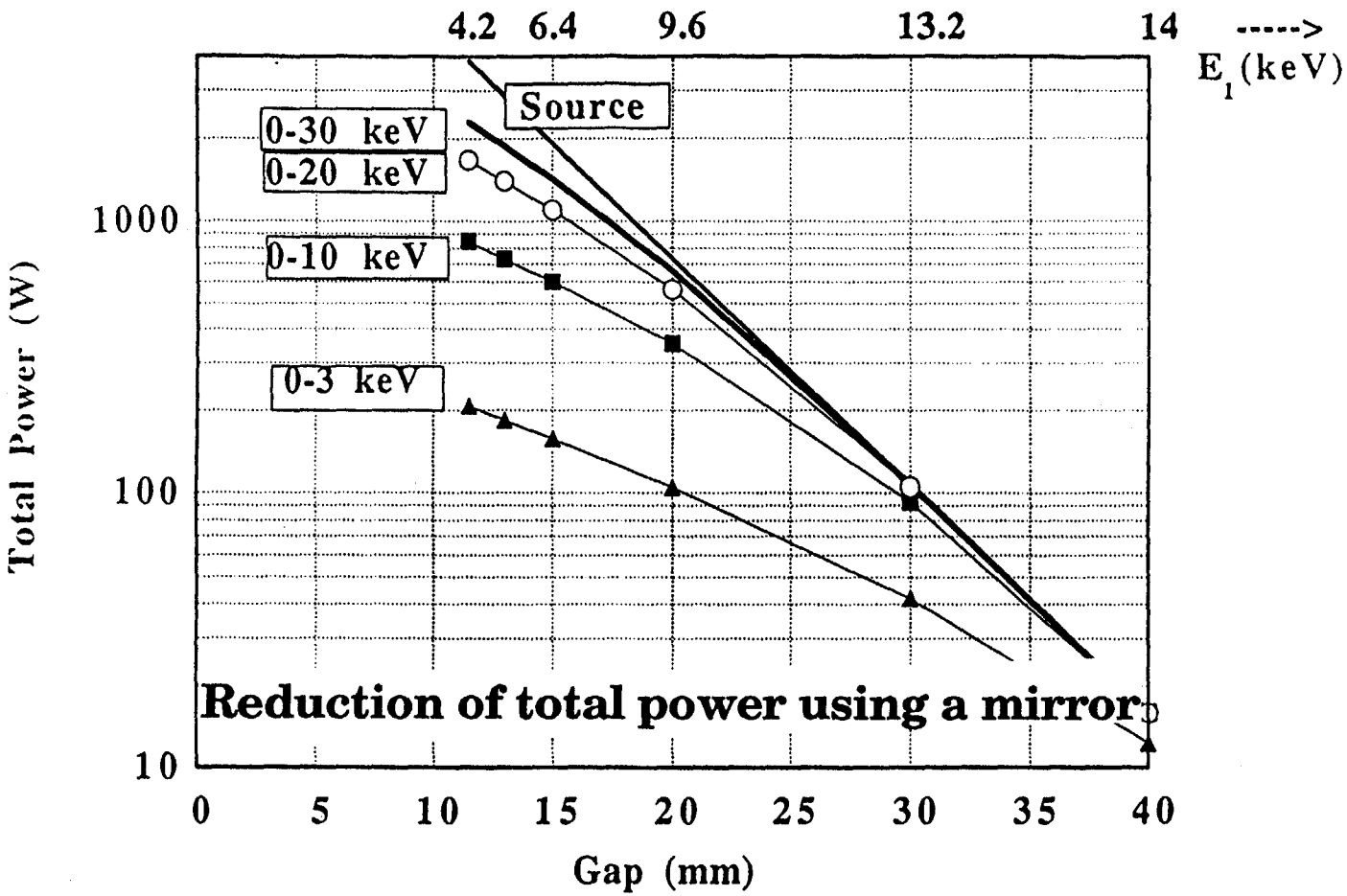


Fig. 3 Calculated total power of the entire Undulator A spectrum and the total powers integrated over the four energy bands that are indicated in the figure.

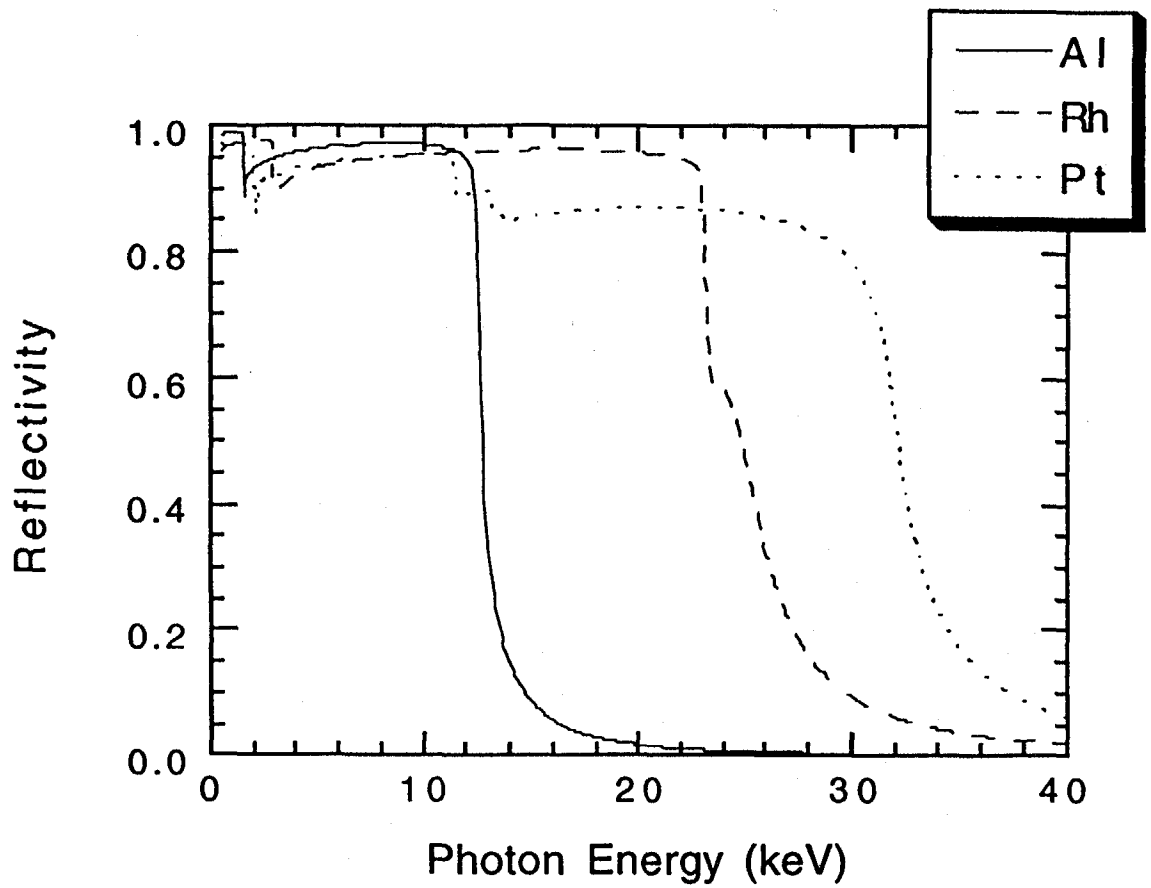


Fig. II-11 X-ray reflectivity as a function of x-ray energy for Al, Rh and Pt mirrors at 0.15 degree of incidence angle. Note the cut-off energy for Pt mirror is about 30 keV.

A Mirror as the First Optic

Advantages:

- Reduced thermal loading (especially the peak heat flux) on downstream optical components. Therefore, simple thermal cooling design can be used, e.g.,
  1) water-cooled noninclined crystal monchromator
  2) water-cooled mirrors for beamlline branching

- Separation of gas bremsstrahlung radiation from synchrotron beam
  1) The radiation shielding requirements for mirror-reflected undulator spectrum are similar to that for monochromatic beamline without a mirror
  2) Reduction in the peak heat flux on the monochromator by placing it at a large distance from the source
  3) Small off-set monochromator for quick energy scan with small beam displacement

A Mirror as the First Optic

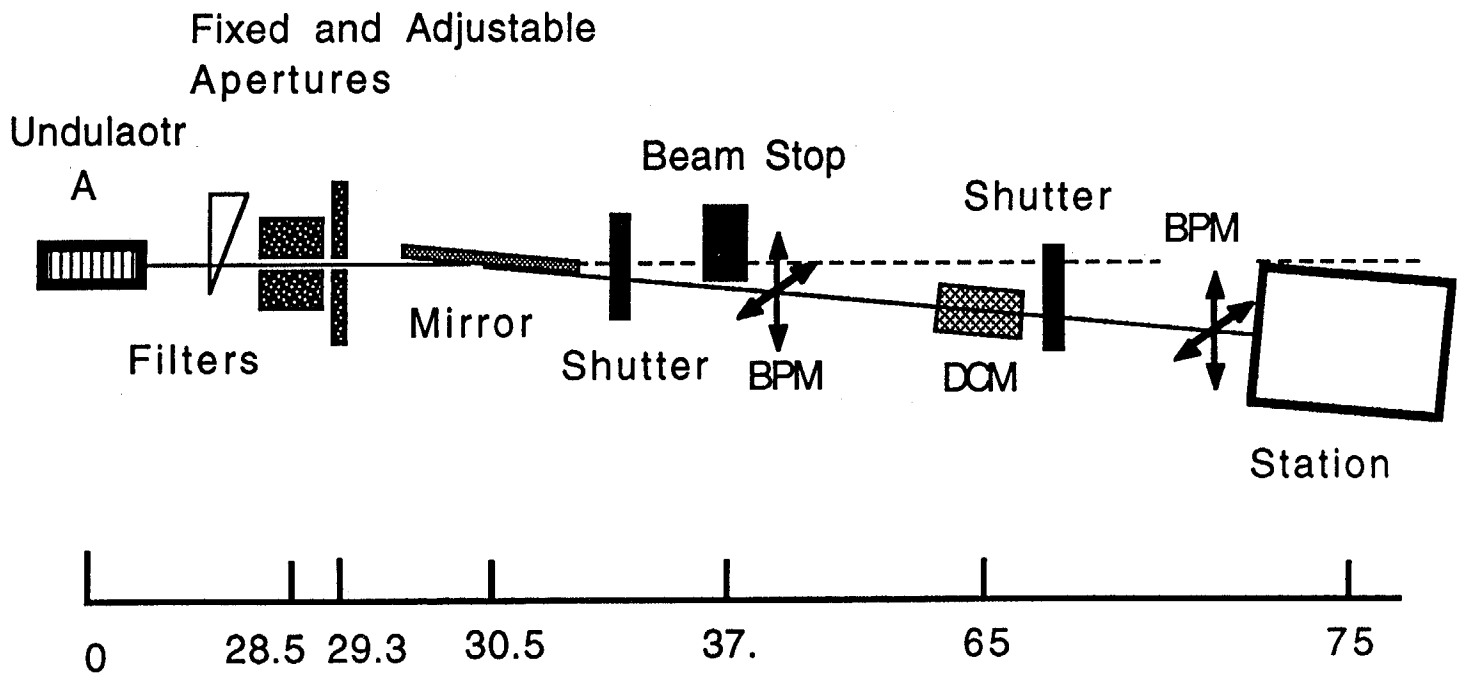
Advantages (continued):

- Lower heat flux on mirror surface and therefore thermal loading problem may be easy to deal with
- High order harmonic suppression
- Wide choice of substrate materials and material properties

Disadvantages:

- Large optics
- High energy cut-off
- Surface sensitive (UHV condition required)

Schematic Layout of 2-ID-E Branchline of Sector II, SRI CAT



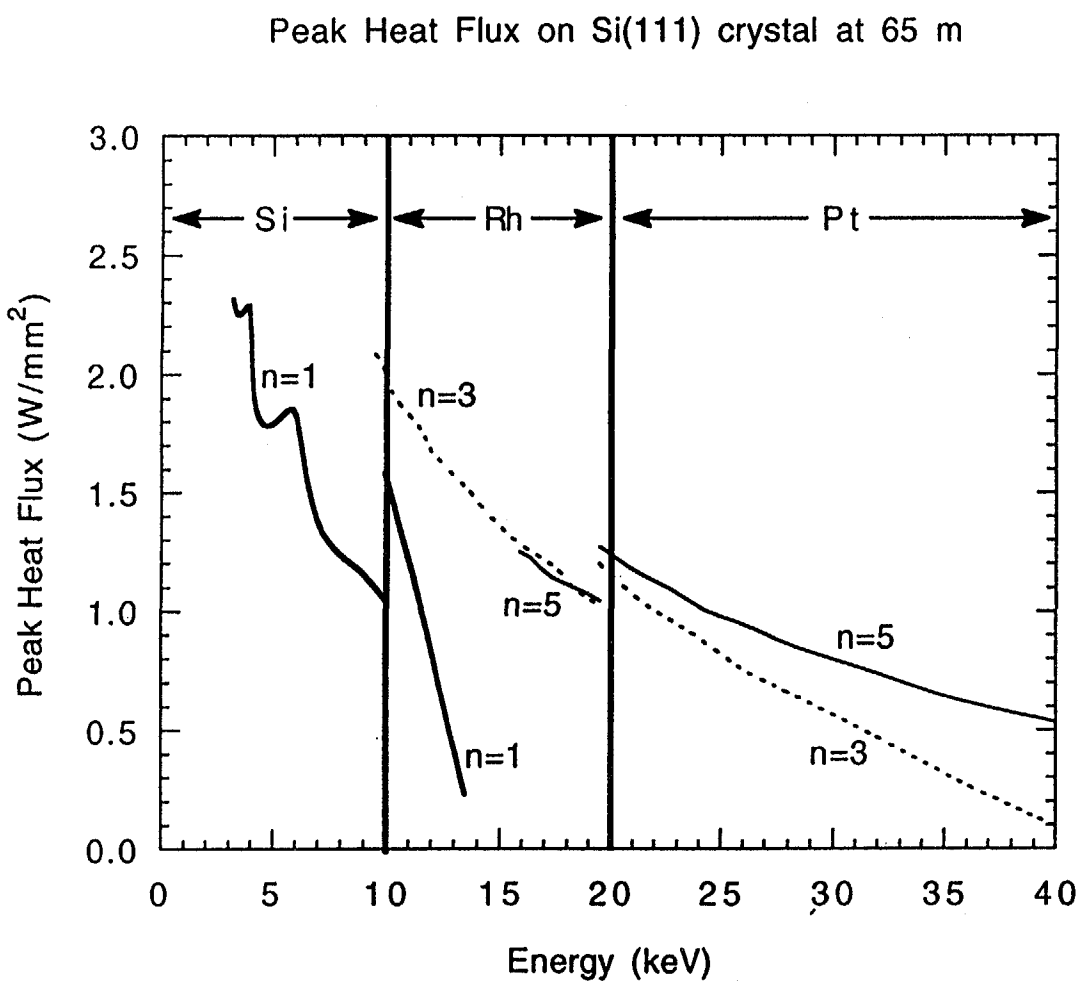
Distance of Key Optical Components from Undulator Source (m)

Maximum Power Loading on Optics at 2-ID-E

	Total Power	Peak Power Density
Undulator A	3.8 kW	133 kW/mrad^2
After Fixed Aperture	1.8 kW	133 kW/mrad^2
Incident on HDM-1	1.26 kW	0.32 W/mm^2 @ 0.15°
Reflected from HDM-1*:		
Si-coated	255 W (78W)	23 kW/mrad^2
Rh-coated	540 W (163W)	47 kW/mrad^2
Pt-coated	627 W (190W)	55 kW/mrad^2

* The number in parenthesis in the total power column was calculated for a central cone containing 4 σ in both the horizontal and vertical directions.

Advanced Photon Source



Separation of Gas Bremsstrahlung Radiation (BR) from the Synchrotron Beam

- **Parameters of interest:**

Distance between mirror and beam stop *L*

Effective BR collimation by APS ID front end α_1

(α_1 = 1.4 mrad in vertical direction
= 3.3 mrad in horizontal direction, inboard)
= 13.2 mrad in horizontal direction, outboard)

Minimum incidence angle α_2 required for obtaining the desired high energy cut-off in the reflected beam

Minimum separation between the reflected beam and the incident beam at the FOE back wall *H*

Separation of Gas Bremsstrahlung Radiation (BR) from Synchrotron Beam

- **The minimum mirror incidence angle is set by the following two conditions**

  $0.5\ \alpha_1 < \alpha$ (1)

  $2\ \alpha L > H$ (2)

  For H = 2.5 cm, L = 6.5 m

  Eq. (2) yields α > 1.92 mrad

  1.92 mrad > 0.5 α_1 except for deflection in the outboard horizontal direction

- **The maximum mirror incidence angle for a 34 keV high energy cut-off with a Pt mirror is α = 2.6 mrad**

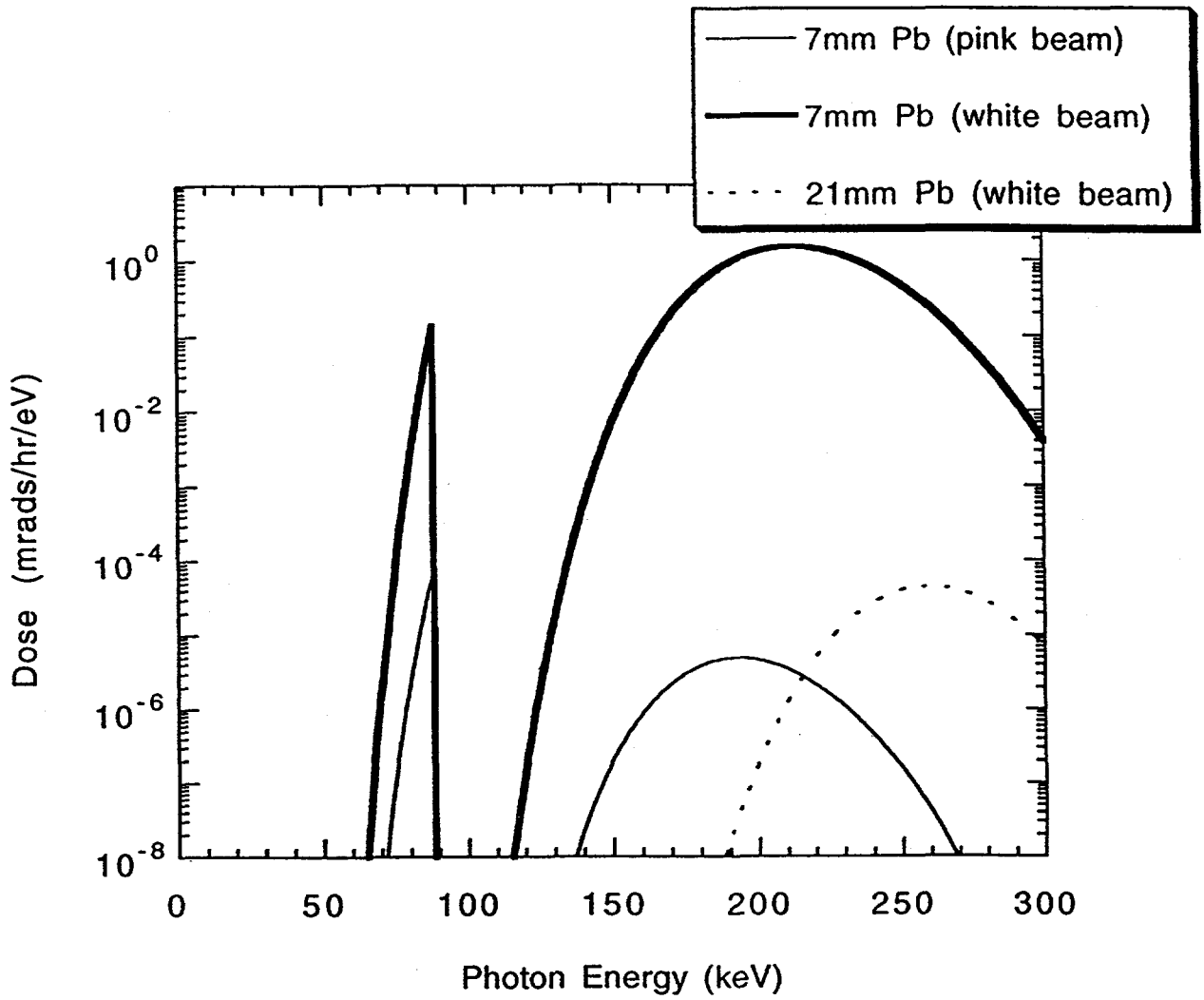


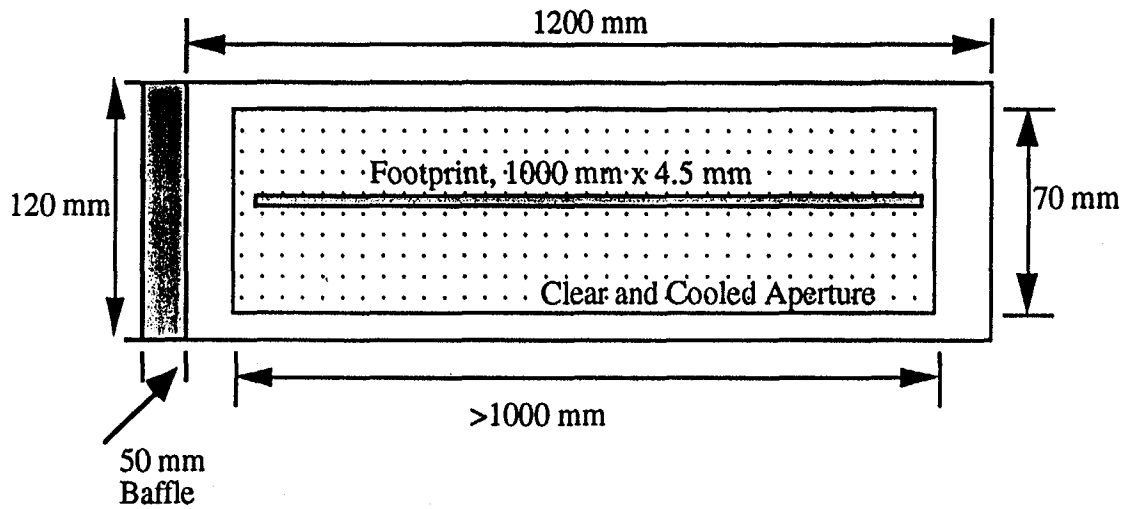
Fig. 2 Surface dose received on human tissues for different thicknesses of Pb on the beam transport. The Pb is located 2 inches away from the 30 cm Cu scatterer, at 90^0 to the x-ray beam. The x-ray beam can be directly from the Wiggler A source (white beam), or after reflecting off a Pt mirror at $\theta = 0.15^0$ (pink beam).

Specifications for the Horizontally Deflecting Mirror

Grazing incidence angle	0.15^{o}
Incident beam power	1200 W
Peak heat flux	0.36 W/mm^2
Surface roughness	< 4Å
RMS slope errors (excluding thermal effects):	
Tangential (along the mirror length)	≤2 μrad
Sagittal (along the mirror width)	≤ 2 μrad
RMS slope errors (including thermal effects):	
Tangential (along the mirror length)	≤4 μrad
Sagittal (along the mirror width)	≤ 20 μrad
Mirror length	1500 mm
Maximum mirror width	150 mm
Substrate	Si
Surface coating	Rh, Pt

1.2 m spec/5-22-94/AMK

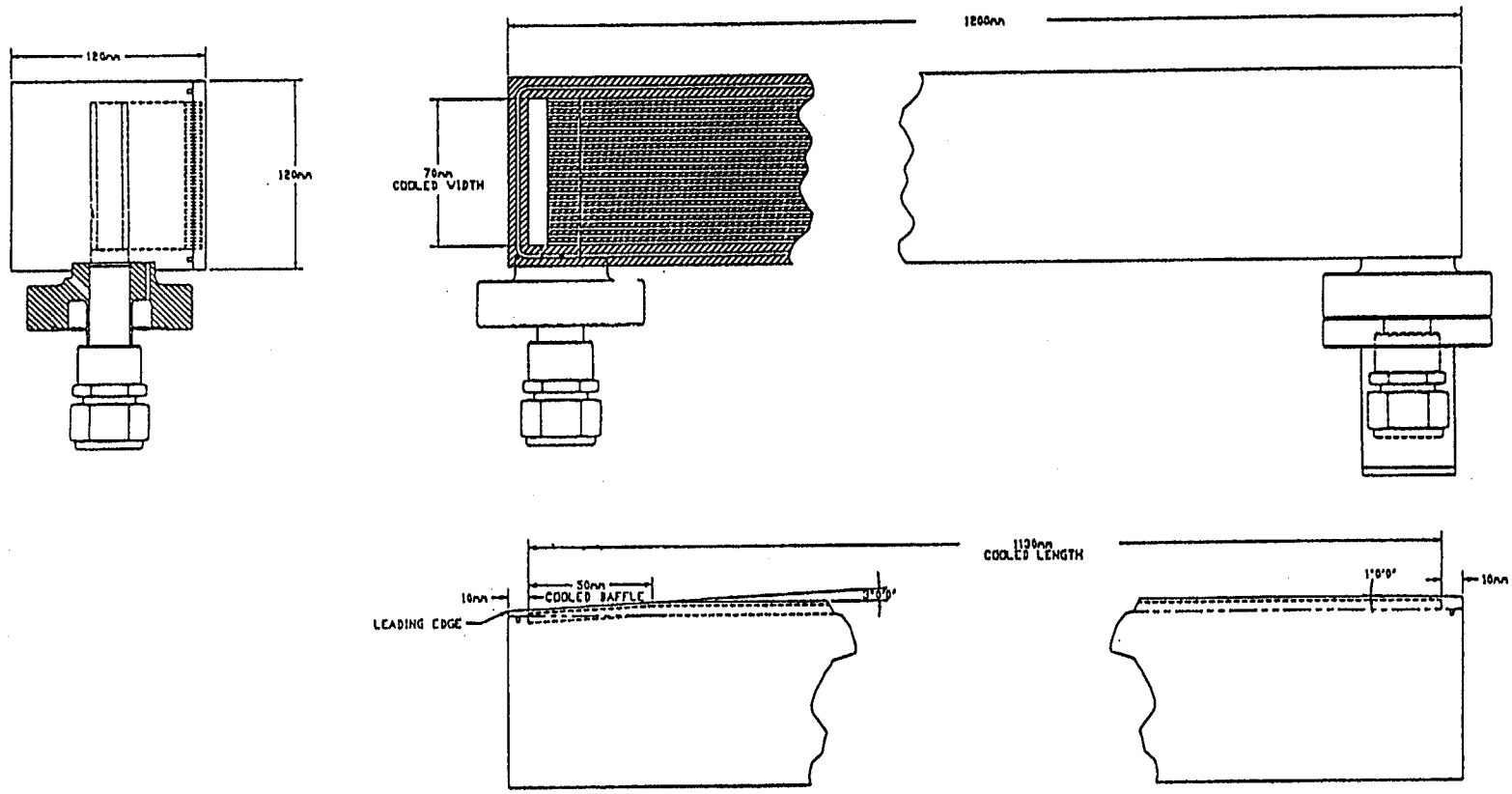
1.2-m Mirror



1.2 m mirror 5-22-94/AMK

Advanced Photon Source

Preliminary design of a 1.2-m high-heat-load mirror (mm-channels)

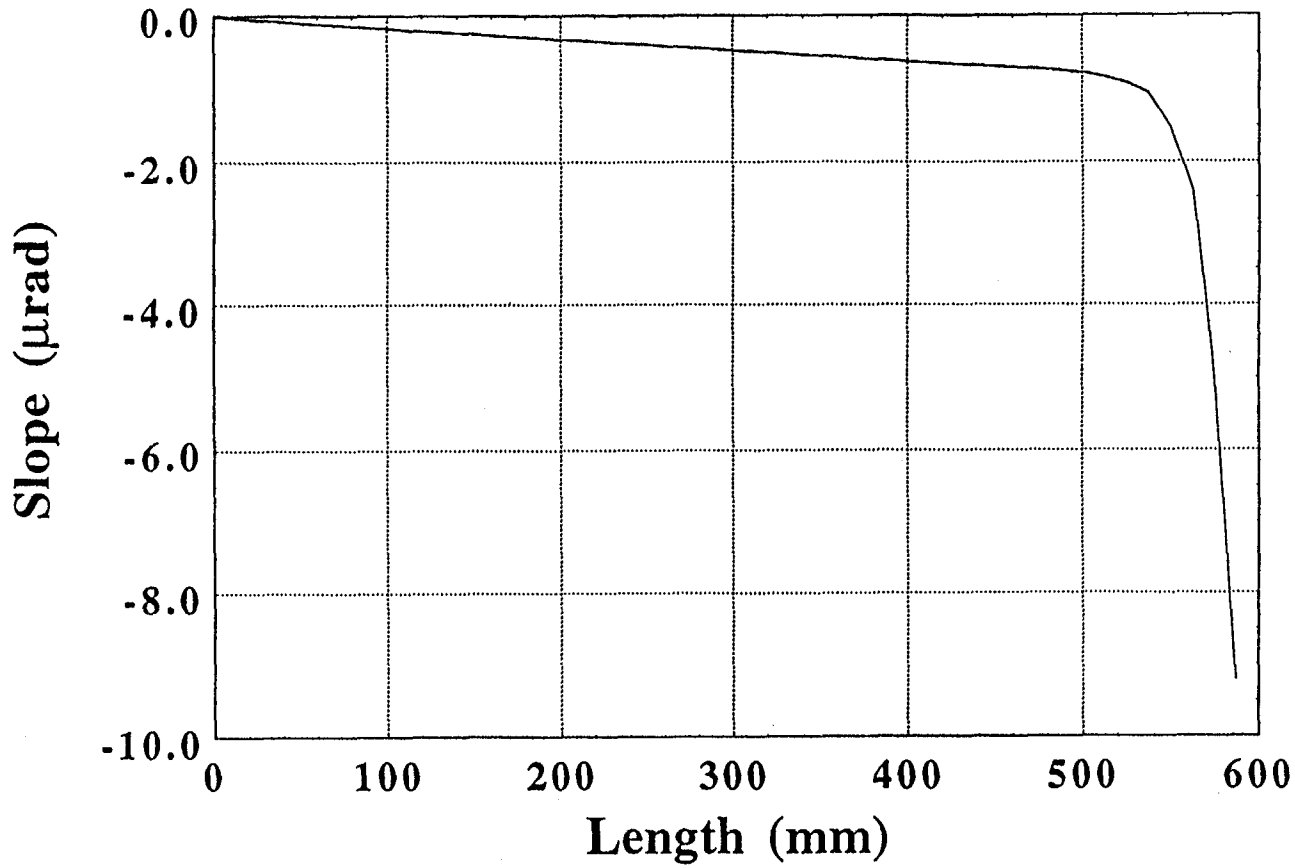


1.2 m mirror, 5-22-94/AMK

Advanced Photon Source

Tangential Slope Error of a Contact-Cooled, High-Heat-Load Mirror

(P = 2.0 kW, F = 0.36 W/mm^2, Footprint = 1200 mm x 4.5 mm)



tang slope 5-22-94/AMK

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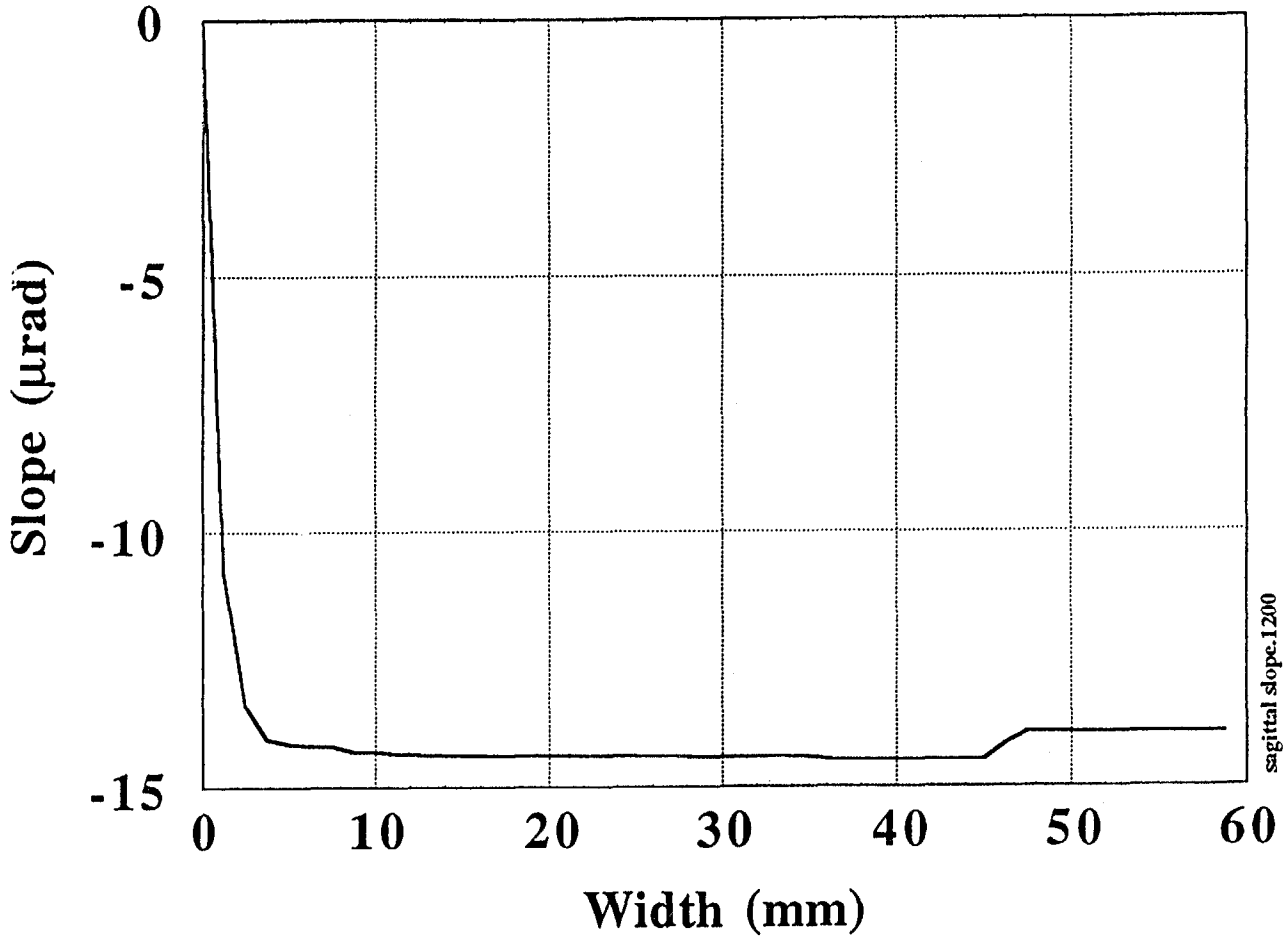
Sagittal Slope Error of a Contact-Cooled, High-Heat-Load Mirror

(P = 2.0 kW, F = 0.36 W/mm^2, Footprint = 1200 mm x 4.5 mm)



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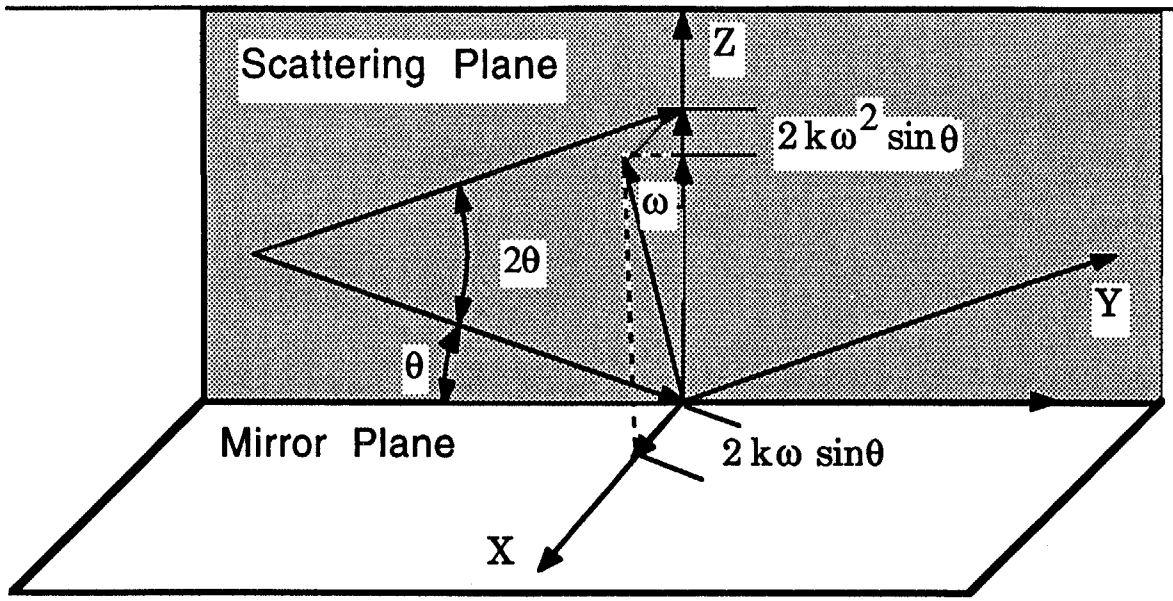
Beam divergence increase due to sagittal slope error



Beam divergence increase $= \omega \sin\theta$ **sagittal direction**

$= \omega^2 \sin\theta$ **tangetial direction**

For $\theta = 2.6$ **mrad (0.15°),** $\omega = 30$ **μrad**

$\omega \sin\theta \ll 1$ **μrad and** $\omega^2 \sin\theta \ll 1$ **μrad**

Horizontal vs Vertical Deflection

- **Horizontal Deflection**

  Pros: Less strigent requirement in slope error for brilliance preservation, especially for coherence preservation in the vertical direction

  Gravitational force parallel to mirror surface

  No change in beam height

  Cons: Long mirror

- **Vertical Deflection Mirror**

  Pros and cons are almost opposite those for horizontal deflection

Progress on High Heat Load Mirrors

- **Design and fabrication of an internally cooled <u>high heat flux</u> mirror**

  Total Power = 2 kW Heat Flux = 3.5 W/mm^2
  Slope Errors: tangentially < 2 μr; sagittally < 4 μr
  Mirror will be tested at TDTF this summer.

- **Long, channel cooled <u>high heat load</u> mirror:**

  Preliminary design complete; delivery in 6 months
  Total Power = 1.2 kW Heat Flux =0.36 W/mm^2
  Slope error target: tangentially < 2 μr

- **We are working on the Optimized Contact Cooling concept:**

Preliminary results: for preceding case, slope < 1 μrad

Progress on High Heat Load Mirrors (Cont.)

- **We are investigating mirror reliability issues including:**

  Water quality for internally cooled optics
  Understanding of failure modes ⇒ design improvements

- **We have worked with vendors on:**

  Developing specifications and acceptance criteria for single crystal silicon boules
  Producing long single crystal silicon boules
  Achieving reasonable cost and delivery times for silicon boules
  Examining alternate silicon materials and SiC

- **We are developing a working knowledge of materials, designs, polishing, fabrication, cost and vendor capabilities for high heat load mirrors**

Optimized Contact Cooling Technique for X-ray Mirrors

- An Optimized Contact Cooling concept has been developed.
- It relies on an optimal selection of cooling strip and mirror geometry.
- Cooling is through cooled copper strips sandwiching mirror (Indium interface).
- Inverse thermal moment provides low tangential slope errors.
- Because of the "forgiveness factor," large sagittal errors are tolerated.
- Method appropriate for grazing incidence high heat load optics (not laser optics).
- Preliminary results indicate all Sector mirrors can be so designed.
- Tangential slope errors in all cases studied (using Si) are < 1 μrad.

why contact cooling 5-22-94/AMK

Advanced Photon Source

Optimized Contact Cooling Technique for X-ray Mirrors

- **Advantages:**

  (1) Reliability

  no coolant to vacuum joints
  no air guard needed
  no rigid bonding
  proven materials and techniques
  complete UHV compatibility

  (2) Simplicity of design

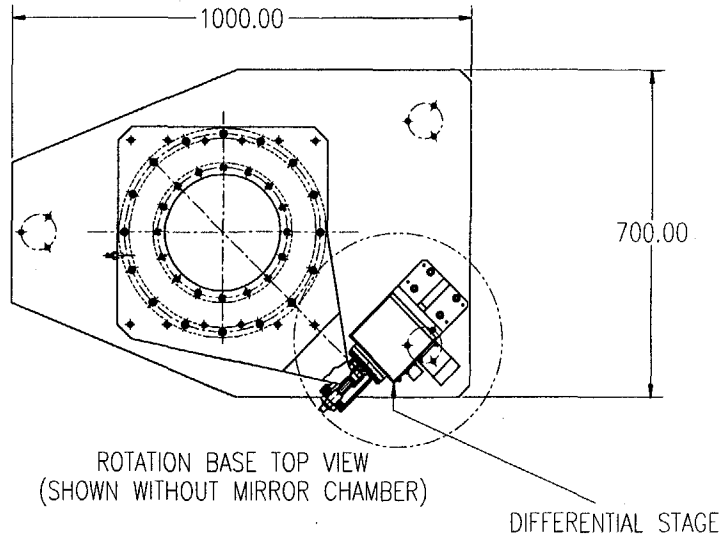
  (3) Modularity

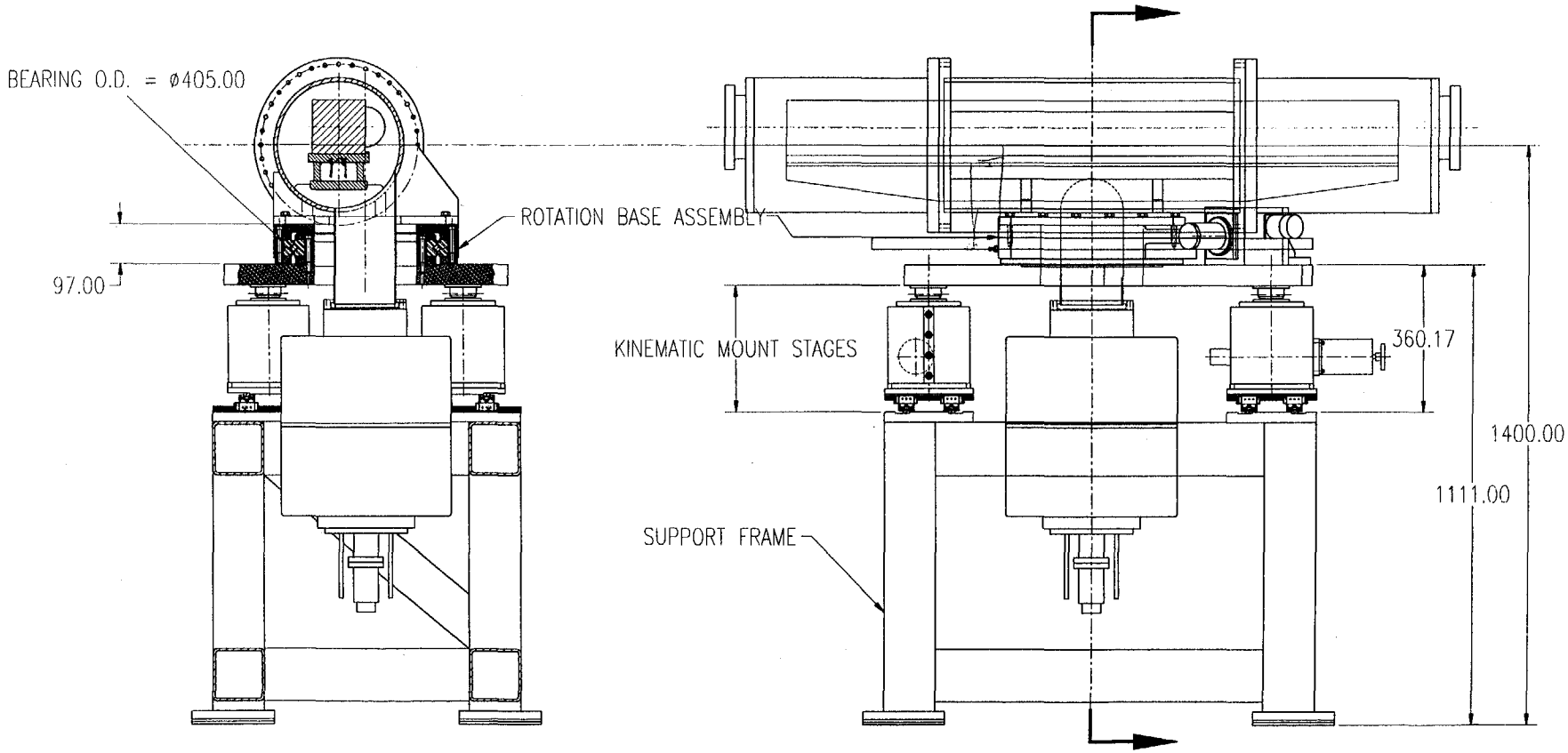
  (3) Lower costs

- **On-going work:**

  Optimization
  Time constant
  Indium, etc. interface
  End conditions, etc.

ADVANCED PHOTON SOURCE





2-ID HORIZONTAL DEFLECTING MIRROR ASSEMBLY

Useful Guidelines

- Plan ahead (long lead time)
- Work with vendors
- Coordinate mirror and vacuum-mechanical designs
- Reduce cost

Other Applications

- **Focusing**
- **Collimation** (12 μrad in horizontal direction, 3 μrad in vertical direction)
- **Beamline Branchling**
- **Tuned two- mirror system**

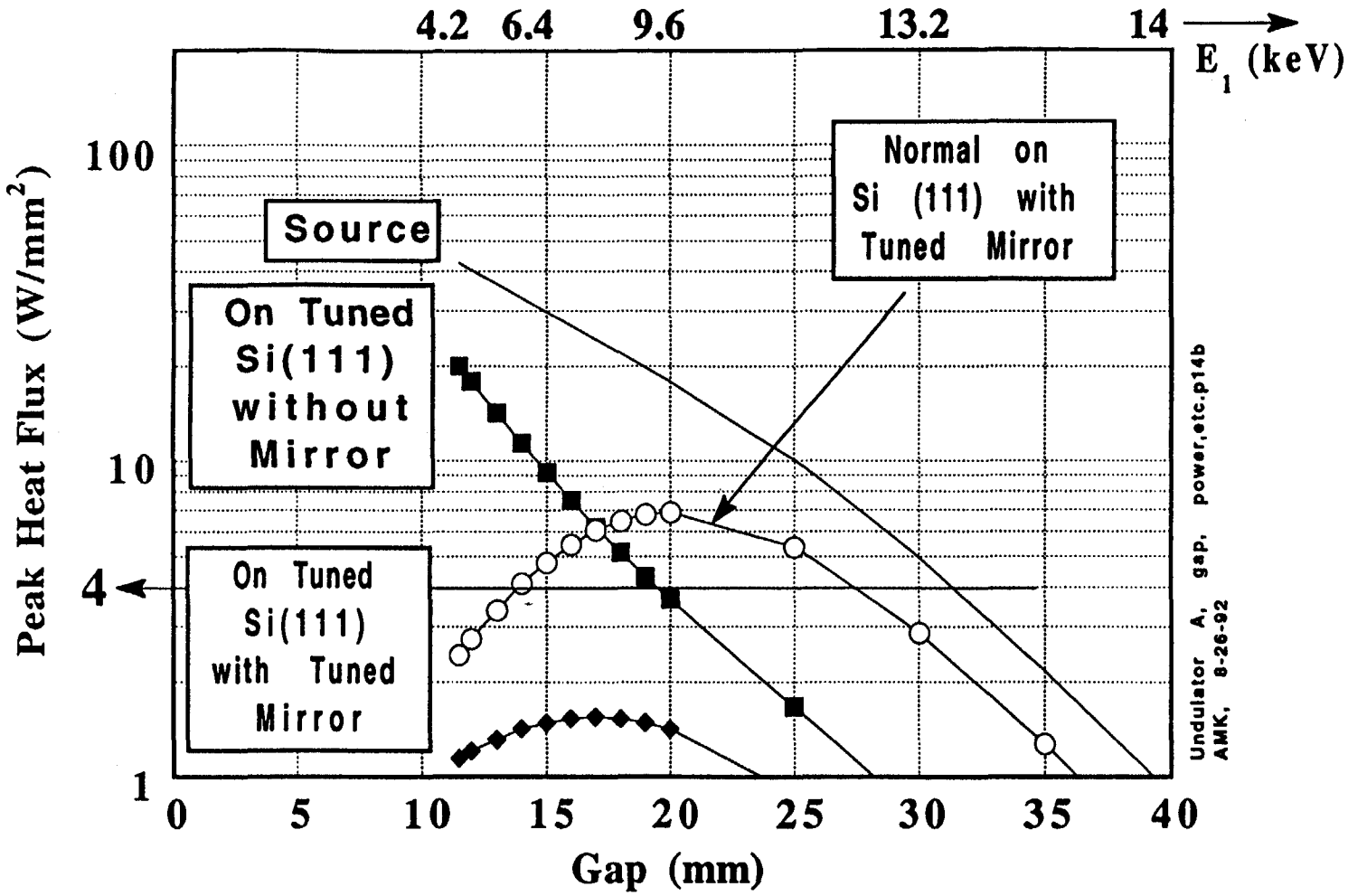


Fig. 7 Calculated normal-incidence heat fluxes at 56 meters from the source as a function of undulator gap for the spectrum reflected by the mirror pair, as well as the gap-dependent heat fluxes for the entire Undulator A spectrum at normal incidence and at the surface of a Si(111) crystal tuned to diffract the first harmonic radiation. Also shown in the figure are the peak heat fluxes on the surface of a Si(111) when both the mirror pair and the Si(111) crystal are tuned.

Rationale for Using a First Mirror

- Power Filtering **A mirror can substantially reduce the heat load on downstream optical components resulting in simpler designs. For example, one of the branchlines uses a conventional double crystal monochromator downstream of a first mirror.**

- Radiation Shielding **By substantially suppressing higher harmonics, the reflected wide band-width synchrotron beam requires a reduced shielding.**

- Polarization Preservation **At grazing angles of incident the source polarization is preserved.**

- Branching and Focusing **A first mirror may simultaneously be used for branching and/or focusing the synchrotron beam**

- Heat Flux Reduction **Because of the small grazing incidence angles, the heat flux on a mirror is correspondingly smaller than on a diffracting element.**

- Variable Band-Pass Filter **With an appropriate choice of coating materials and/or grazing angles, a low-band-pass filter with variable cut-off energy can be constructed.**

- Multi-Layer Capability **With multi-layer coatings, the spectral range of a mirror can be increased, although shielding requirements may also increase.**

- Choice of Substrates **A wider choice of substrate materials is available for high heat load first mirrors than for double crystal monochromators. Also, crystalline deformation in the fabrication process (e.g., bonding/brazing) of complex cooling structures necessary for high heat load optics.**

But

- Increased Optics Size **Because of the small angles of incidence in mirrors, the optics size can be large.**

- Tight Tolerances **Roughness and (fabrication & thermal) slope error tolerances for grazing incident optics are very tight.**

Overview of the APS User Access and Orientation Process

Susan H. Barr

Sixth Users Meeting
for the Advanced Photon Source
May 26, 1994

User Orientation Planning Group:

Liz Stefanski (XFD, Asst. Dir. Policy/Planning), Chair

Tony Rauchas (XFD Assoc. Dir. Operations Planning)

Bruce Stockmeier (XFD ES&H Coordinator)

Steve Davey (APS User Technical Interface)

Susan Barr (APS User Program Administrator)

Objectives:

Our objective was to develop an orientation/access system that provides:

- Sufficient training to ensure that APS users have the knowledge they need to work safely and productively
- A structure that enables APS users to use their time most efficiently once they arrive
- Compliance with DOE/ANL policies and procedures

Constraints:

- ANL requires a photo badge or gate pass for Laboratory access
- Unescorted APS site access requires training and a gate access card
- Unescorted access to the APS experiment hall requires General Employee Radiation Training (GERT)

Requirements:

- Information **from** the user **to** APS (for badging, etc.)
- Information **to** the user **from** APS
  - How to get here; how to get in; where to go on site
  - ANL/APS policies and procedures
  - General safety issues
  - Specific safety issues

Solution:

- A user registration form to be completed and returned in advance of a user's arrival
- *APS User Guide: What you need to know to work at the APS* - to be read in advance

ARGONNE NATIONAL LABORATORY

9700 South Cass Avenue, Argonne, Illinois 60439

Advanced Photon Source

Date of Initial Visit _____

(Call 708/252-9090 to schedule an appointment)

Temporary User Number _____
(to be assigned)

Permanent User Number _____
(to be assigned)

Name: _____ **Gender (M/F):** _____
Title First Middle Initial Last

CAT Affiliation: _____

Institutional Affiliation: _____
Department

Address: _____
Street Address or P.O. Box Room or Mail Stop

_____
city State Zip country

_____
Office Telephone Fax E-Mail

Employee or student: _____

If a student, academic institution: _____

Home Address: _____
Telephone

Social Security Number: _____ _____
Birth Date

Emergency Contact: _____

_____
Address Telephone

Private Vehicle Information: _____
Year, Make and Model State and License Plate Number

If NOT a United States citizen, please complete the following:

Citizenship: _____
Type of Visa Visa Expiration Date Passport No. Expiration Date

City and Country of Birth: _____

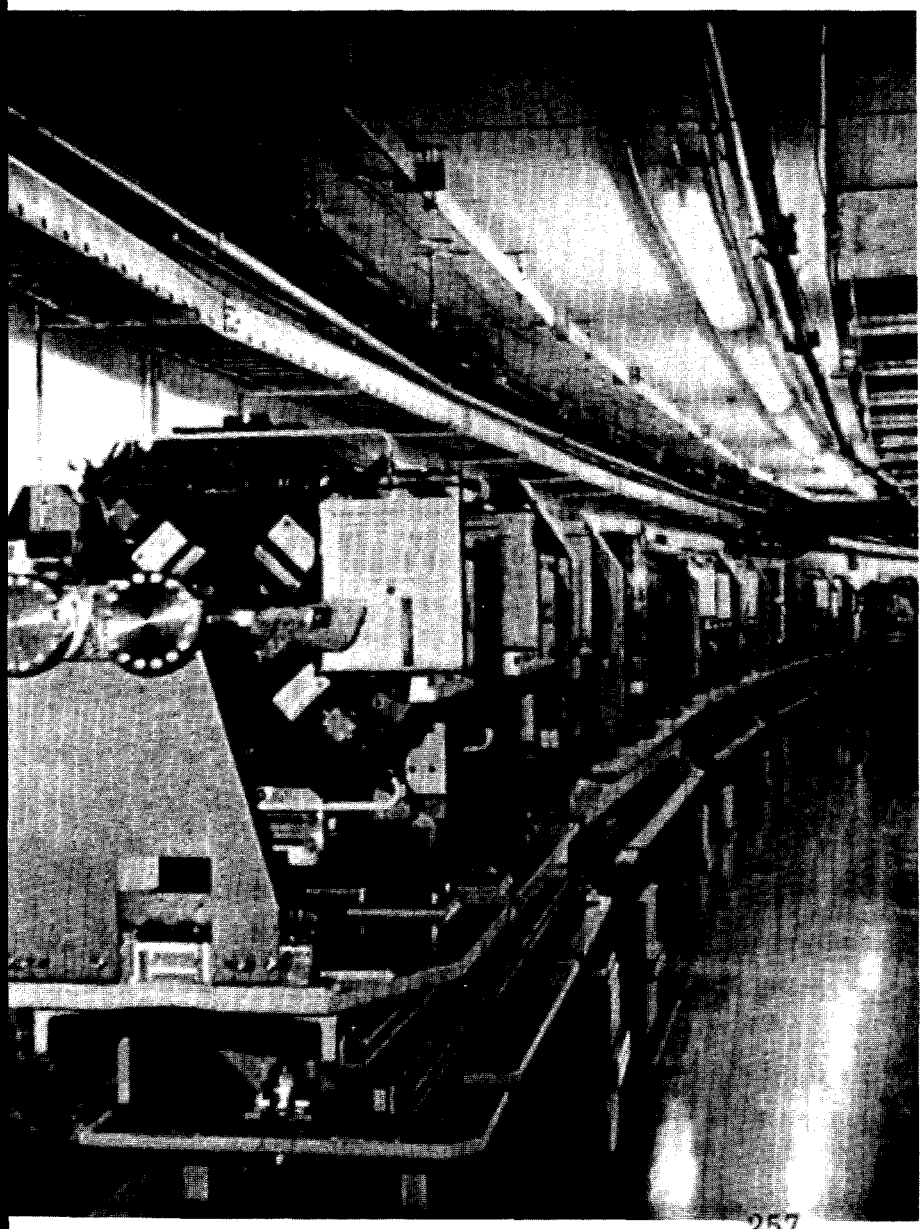
DOE General Employee Radiation Training (GERT) (yes or no): _____

If yes, where taken: _____
Training Date

USR 01

ANL/APS/TB-15

APS User Guide:
What you need to know to work at the APS



Advanced
Photon Source

Argonne National
Laboratory

May 1994
Version 1.0

How does a user obtain these items?

- By contacting the APS User Office (phone, fax, E-mail) *as far in advance as possible*
- By accessing the World Wide Web (APS Home Page) and downloading the registration form and Guide
- By picking up the Guide and registration form at the Sixth Users Meeting for the APS

BUSINESS MEETING OF THE ADVANCED PHOTON SOURCE USERS ORGANIZATION

Alan Goldman called the business meeting of the APSUO to order on May 26, 1994. He thanked Roy Clarke, outgoing Chairman of the APSUO Steering Committee, on a job done well for the past 18 months. He pointed out that Roy had set a fine example to follow. In brief remarks, Alan indicated that the APS is a unique facility for a lot of reasons, and one of the reasons is that it is strongly user driven. That is, users, their opinions and their input, make a very large difference at the APS.

The main purpose of the business meeting was to elect seven new members of the APSUO Steering Committee. Nine candidates had been slated in advance by the Nominating Committee. No one was nominated from the floor. Users voted for the new members by ranking them in order of preference. The winning candidates — Steven Ealick, Richard Harlow, Gabrielle Long, Ronald Pindak, John Quintana, Larry Sorensen, and D. Mark Sutton — assumed office immediately after the end of the Business Meeting.

Following the annoucement of the election results, Alan Goldman closed the APSUO Business Meeting.

APSUO STEERING COMMITTEE

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Program

SIXTH USERS MEETING
for the
Advanced Photon Source

May 25-26, 1994
Argonne National Laboratory
Argonne, Illinois 60439
Bldg. 362 Auditorium
(Overflow Location: Bldg. 360, Room L-119)

Tuesday, May 24, 1994

6:00-8:00 p.m. **Registration - Holiday Inn of Willowbrook**

Wednesday, May 25, 1994

7:30-8:30 a.m. **Registration - Bldg. 362 Lobby**

Morning Session; Roy Clarke, Chair

8:30 *Welcoming Remarks*
Alan Schriesheim, Director, Argonne National Laboratory

8:45 *Advanced Photon Source Project Overview*
David Moncton, Associate Laboratory Director for the APS

9:45 *The Possible Simplicity of Undulator Beam Research*
Jens Als-Nielsen, European Synchrotron Radiation Facility

10:30 **Break**

11:00 *The Study of Disorder in Materials Using Coherent X-ray Scattering*
Ronald Pindak, AT&T Bell Laboratories

11:30 *X-ray Science with Polarized Radiation*
Kenneth Finkelstein, CHESS, Cornell University

Noon **Picnic Lunch on Building 362 Lawn**
Displays, Demos, Exhibits, and CAT Meetings

Afternoon Session; Roy Clarke, Chair

2:00	*X-ray Microbeams: Creation Methods and Experimental Applications* Stephen Hoffman, Northwestern University
2:30	*Are We MAD? Can Anomalous Diffraction Solve the Phase Problem?* Robert Sweet, Biology Dept., Brookhaven National Laboratory
3:00 - 5:20	**APS Tour** Bldg. 400, APS Site
3:00 - 5:20	**Poster Session and Demos** Bldg. 400, Sectors 3 and 4
4:30 - 5:20	**Reception** Bldg 400, Sector 3
5:40	**Buses Leave from Bldg. 362 for Comiskey Park**
7:00 - 11:30	**Evening (Buffet and White Sox-Minnesota Twins baseball game) at Comiskey Park**

Thursday, May 26, 1994

Morning Session; Alan Goldman, Chair

8:30 a.m.	*Installation and Commissioning Plans for the Insertion Devices, Front Ends, and Beamlines* Gopal Shenoy, APS
9:10	*APS Undulator A Performance Enhancements* Efim Gluskin, APS
9:30	*First Optics Monochromator Performance* Dennis Mills, APS
10:00	*Personnel Safety and Equipment Protection Systems* Richard Parry, APS
10:20	**APSUO Business Meeting and APSUO Steering Committee Elections**
10:40	**Break**

11:10	*How to Design a Beamline: Tools and Techniques* Deming Shu, APS
11:40	*Mirrors as First Optics at the APS* Wenbing Yun, APS
12:10 p.m.	*Overview of the APS User Access and Orientation Process* Susan Barr, APS
12:20	**APSUO Election Results and Concluding Remarks**
12:30	**Adjourn**

* *

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Sixth Users Meeting for the Advanced Photon Source

Graduate Student/Postdoc. Poster Session

Wednesday, May 25, 1994; 3:00-5:30 p.m., Building 400

Posters

1. *Non-resonant Magnetic Diffraction Using an ESRF Bending Magnet*
   R. Bateson (ESRF) and S. Bramwell (ILL)

2. *Symmetry Properties of Tapered Undulator Radiation*
   B. I. Boyanov, G. Bunker, J. M. Lee, and T. I. Morrison (Illinois Institute of Technology)

3. *Mn Catalase - The First L-edge Studies in Mn Proteins*
   J. Chen, M. M. Grush (Univ. of California, Davis), T. L. Stemmler, S. J. George , J. E. Penner-Hahn (Univ. of Michigan), G. Christon (Indiana Univ.), Y. Ma (Univ. of Washington, Seattle), and S. P. Cramer (LBL)

4. *Kinetics of the Pressure Oscillation-Induced Lamellar Gel/Lamellar Liquid Crystalline Transition in Hydrated DMPC Using Time-Resolved X-ray Diffraction*
   A. Cheng and M. Caffrey (Ohio State Univ.)

5. *EXAFS of Radioactive Species in Hanford Waste Materials*
   J. C. Hutton, M. M. Lamoureux, D. L. Styris, R. L. Gordon, N. J. Hess, D. L. Blanchard (PNL), and S. D. Conradson (LANL)

6. *Sagital Focusing Design of Second Monochromator Crystal*
   I. N. Ivanov, H. Cease, P. Jemian, and T. I. Morrison (Illinois Institute of Technology)

7. *Observation of Synchrotron Radiation-Excited Nuclear Forward-Scattering from the 9.4 keV Transition in ^{83}Kr*
   D. E. Johnson (Old Dominion Univ.), D. P. Siddons, J. Z. Larese, and J. B. Hastings (BNL)

8. *Dynamical X-ray Diffraction from Quasi-Crystals*
   S. W. Kycia, A. I. Goldman, T. A. Lograsso, D. W. Delaney (Ames Lab. and Iowa State Univ.), D. Black (NIST), M. Sutton, E. Dufresne, R. Brüning (McGill Univ.), and B. Rodricks (ANL)

9. *Continuous Energy Diffraction Spectroscopy (CEDS): A New D-Space Matching Techniques for Energy Dispersive Synchrotron Radiation Diffraction*
   P. L. Lee, M. A. Beno, G. S. Knapp, and G. Jennings (ANL)

10. *Structure and Substrate Relaxation of the Sb/Si(100)-(2x1) Surface*
P. F. Lyman (Northwestern Univ.), Y. Qian, and M. J. Bedzyk (Northwestern Univ. and ANL)

11. *Determination of Short-range Order in Sol-Gel-Derived Amorphous Lead Zirconate Titanate by EXAFS*
L. Ma and S. Sengupta (Univ. of Illinois at Urbana-Champaign)

12. *Photoemission Extended X-ray Absorption Fine Structure: A New Approach to Probe Surface and Interface Atomic Geometry*
P. S. Mangat and P. Soukiassian (Northern Illinois Univ.)

13. *Synchrotron X-ray Fluorescence Analysis of Fluid Inclusions*
J. Mavrogenes, R. Bodnar (Virginia Tech.), A. Anderson (St. Francis Xavier Univ.), S. Bajt, M. Rivers, and S. Sutton (The Univ. of Chicago)

14. *Low-Pressure Multistep Gaseous Primary Ion Counting*
J. C. Milne, E. D. Johnson, and G. C. Smith (BNL)

15. *Anomalous Diffraction Methods: Structure Determination of the MoFe Protein of Nitrogenase*
S. W. Muchmore (Purdue Univ.), N. Campobasso (The Univ. of Chicago), W. Minor, and J. T. Bolen (Purdue Univ.)

16. *X-ray Standing Wave and SEXAFS Study of Structural Phase Transitions in Ag on Si(111) at Sub-monolayer Coverages*
G. Navroski (Cornell Univ.)

17. *X-ray Standing Wave Investigation of the Si(100) 2x2:Ga Surface*
Y. Qian, M. J. Bedzyk, (ANL and Northwestern), and G. E. Franklin (Harvard Univ.)

18. *Valence Determination and Hybridization Effects of Tb Doping in High T_c Superconductors From Type $RBa_2Cu_3O_x$ and $TbBa_2RCu_3O_8$*
U. Staub, M. R. Antonio, L. Soderholm, J. S. Xue (ANL), M. Guillaume, W. Hänggeler, and A. Furrer (ETH Zurich)

19. *XRAP - A Software Package for X-ray Absorptions in X-ray Optics and their Thermal and Stress Analysis*
Z. Wang, R. Dejus, and T. Kuzay (ANL)

20. *Magnetic Compton Scattering Studies of the Invar Effect in Fe_3Pt*
C. J. Yahnke, G. Srajer, D. Mills, D. Haeffner, and L. Assoufid (ANL)

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