

GA-C19570(1/89)  
(1/20/89)

# **PROGRAM STATUS 1st QUARTER – FY 1989**

## **CONFINEMENT SYSTEMS PROGRAMS**

- DIII-D RESEARCH OPERATIONS
- INTERNATIONAL COOPERATION
- CIT PHYSICS

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**Contract No. DE-AC03-89ER51114  
General Atomics Projects 3466/3467/3470**

This Quarterly Report Under  
DOE Contract DE-AC03-89ER51114  
is Submitted in Compliance with Sections A and B  
of the REPORTING REQUIREMENTS CHECK LIST

**JANUARY 20, 1989**

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**PROGRAM STATUS**  
**1<sup>ST</sup> QUARTER – FY 1989**  
**DIII-D RESEARCH OPERATIONS**

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**DIII-D PROGRAM**  
**COMING ATTRACTIONS**  
**2<sup>ND</sup> QUARTER – FY 1989**

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- Plasma operations scheduled for four weeks in February and March.
- A vent is planned in March to repair inside launch ECH components, replace Faraday shield, and install tiles for erosion measurements.
- Construction of shield wall will be carried out in parallel with plasma operations.
- Received repaired 60 GHz ECH gyrotron #105 from Varian (January).

# PROGRAM STATUS

## 1<sup>ST</sup> QUARTER - FY 1989

**TASK:** DIII-D RESEARCH OPERATIONS

### OPERATING

**B/R NOs:** AT101014D (Operating)  
35AT1002 (Capital)

**FY89 FUNDING:** \$27,600 K  
**FY89 PLAN:** \$27,600 K

**CONTRACT NO:** DE-AC03-89ER51114

### CAPITAL

**GA PRINCIPAL INVESTIGATOR:** T. SIMONEN

**FY89 FUNDING:** \$ 1,700 K

**SAN PROJECT MANAGER:** C. BEIGHLEY

**FY89 PLAN:** \$ 1,700 K

**OFE PROGRAM MANAGER:** E. OKTAY

MILESTONE	LEVEL	APPROVED DATE	TARGET DATE	COMPLETION DATE
50. Initiate ICH IBW experiments	I	10/88		10/88
39. Assessment of energy confinement in DIII-D	I	11/88		11/88 <sup>(1)</sup>
53. Report on the physical mechanism of the $\beta$ limit	I	11/88		10/88
47. Compare ECH inside and outside launch heating	I	12/88	6/89 <sup>(2)</sup>	
57. Report on a preliminary assessment of ECH profile control	I	1/89		
54. Assess stability and confinement in NBI current driven discharges	I	3/89		
52. Complete radiation shielding walls	I	4/89		
48. Evaluate ECH current drive (with LLNL)	I	5/89		
49. Evaluate $\beta$ limit of a double null divertor	I	6/89		
58. Extend current scaling, power scaling and isotope studies to 2.5 MA and 10 MW D $\rightarrow$ D	I	7/89		
55. Assess optimization of plasma configuration for maximum $\beta_T$	I	9/89		

### REMARKS:

(1) Milestone completion awaiting DOE approval.

(2) Date revised due to initial experiments damaging inside launch waveguides. New hardware being installed in March. Approved date change awaiting DOE approval.

# CONTRACT MANAGEMENT SUMMARY REPORT

TITLE: OPERATION OF DIII-D FACILITIES & RELATED RESEARCH

CONTRACT NO.: DE-AC03-89ER51114

CONTRACTOR: GENERAL ATOMICS

P.O. BOX 85608

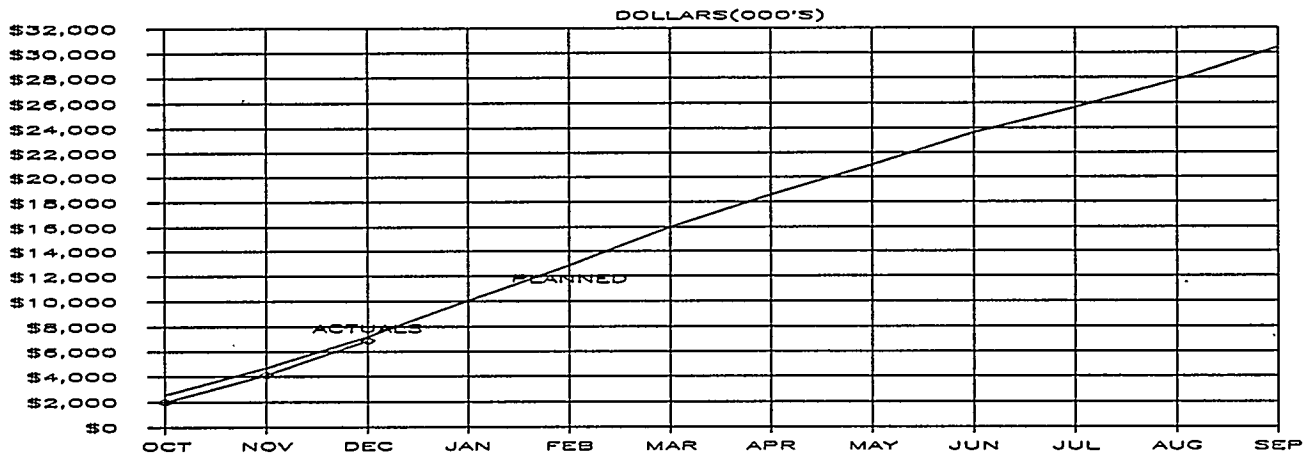
SAN DIEGO, CA. 92138

COST & LABOR PLAN DATE:

JAN 12, 1989

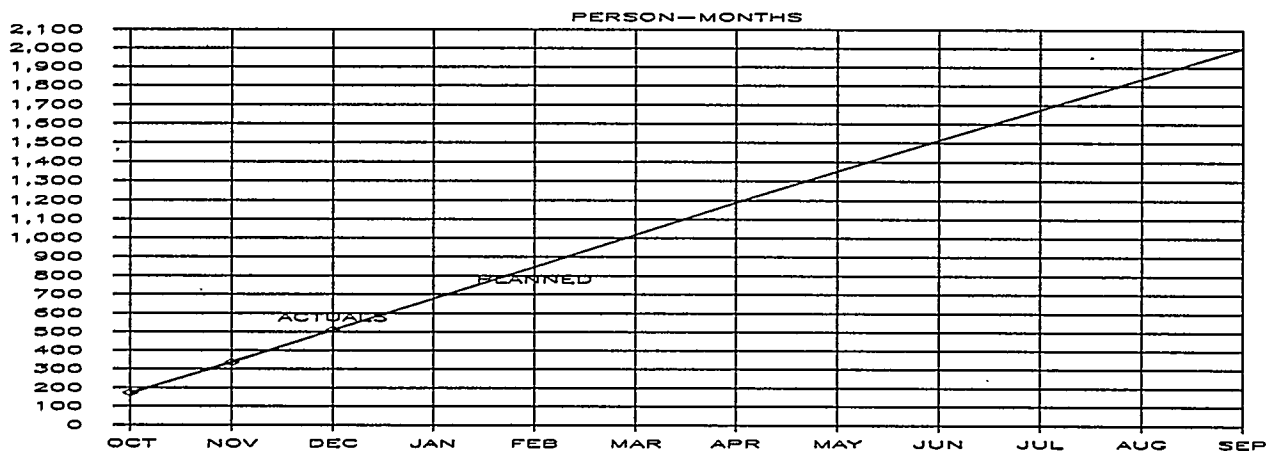
START DATE: SEPTEMBER 30, 1988

COMPLETION DATE: SEPTEMBER 30, 1989



TOTAL

PLANNED	\$2,564	\$2,157	\$2,493	\$2,851	\$2,808	\$3,110	\$2,608	\$2,404	\$2,607	\$2,069	\$2,145	\$2,604	\$30,420
ACTUAL	\$2,012	\$2,126	\$2,736										\$6,874
VARIANCE	\$552	\$31	(\$243)										
CUM VAR	\$552	\$583	\$340										



PLANNED	168.9	170.7	170.7	168.6	169.4	170.5	167.9	164.3	163.5	162.3	162.2	162.1	2,001
ACTUAL	173.4	162.6	175.5										512
VARIANCE	-4.5	8.1	-4.8										
CUM VAR	-4.5	3.6	-1.2										

SIGNATURE OF PARTICIPANT'S PROJECT MANAGER & DATE:

# PROGRAM STATUS

## 1<sup>ST</sup> QUARTER – FY 1989

### DIII-D RESEARCH OPERATIONS

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#### HIGHLIGHTS:

- Four papers on DIII-D experimental results were presented at the IAEA meeting. These papers were extremely well received.
- 39 DIII-D papers were presented at the APS meeting including 3 invited papers (including LLNL).
- Modeling of high beta disruptions supports the hypothesis that the maximum beta in DIII-D H-mode discharges is limited by the  $n=1$  ideal external kink mode, triggered by a sawtooth fall.
- H-mode was achieved in discharges limited on the inside wall, with energy confinement comparable to single null divertor discharges having similar parameters.
- Plasmas with elongations up to 2.5 were produced in an up-down symmetric limiter configuration for short durations.
- Longest plasma shot in DIII-D obtained (7 sec).
- Long pulse H-mode discharge maintained for 4.8 sec – much longer than the plasma characteristic time scales.
- Additional H-mode regimes have been found where confinement exceeds both the ohmic confinement time and the value predicted by Shimomura scaling.
- ECH heating at the fundamental has been used to achieve H-mode.
- Two long-term (2 mo.) Russian visitors have returned home after participating in ECH experiments.
- Testing supports a model for the failure of the inside launch ECH components. The prototype tests of the new components indicate these problems have been overcome. Construction of new parts is underway.
- Current understanding of the inability of IBW to heat is that the Faraday shield may introduce high  $k_{\parallel}$  components which are then Landau-damped near the edge. A new shield is being fabricated in an attempt to overcome this problem.
- Meeting of outside collaborators (LLNL, ORNL, SNLL, SNLA, UCLA) in the advanced divertor program was held to finalize agreement on roles.

- The U.S. Department of Justice made final preparations in December to file a lawsuit disputing the legality of sales and possessory interest taxes on the DIII-D program.
  - Plans are underway to measure erosion/redeposition in the divertor region (with SNL).
  - Received MFTF Power Supply from LLNL for conversion to use with ECH (with LLNL).
  - The shielding roof was in place for the first time during plasma operation. The measured shielding factor of two for the roof alone is in agreement with our predictions.
  - Construction has begun on the shield walls.
  - J. Luxon attended the ASDEX and TORE SUPRA steering committee meetings.
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## INTRODUCTION AND SUMMARY

The high point of this quarter and the year was the presentation of four papers on DIII-D at the IAEA meeting in Nice, France and 39 papers including 3 invited papers (one by D. Hill of LLNL) at the APS meeting. Response to these papers was enthusiastic. The DIII-D program is identified as one of the most productive in the world, and the key to providing the necessary inputs to build CIT and ITER and understand tokamak confinement.

DIII-D made detailed presentations at a DOE meeting in Washington on potential contributions to CIT, ITER, and the Transport Task Force. The contributions DIII-D can make to each of these efforts is substantial with DIII-D continuing to make decision-guiding inputs in many areas. DIII-D was identified as the most comprehensive and prolific contributor and requests for yet further contributions were made. Additional discussions are being held on balancing contributions and resources.

Regimes in which good confinement can be obtained continue to be identified. NBI-heated H-mode has been achieved in discharges limited on the inside wall. In divertor discharges, additional NBI-heated H-mode regimes have been identified with the confinement time exceeding both ohmic confinement and Shimomura scaling. H-mode has been achieved with ECH power at the fundamental in addition to the previous result at the second harmonic.

Considerable progress has been made in understanding the recent poor heating results with both ECH inside launch and IBW heating. The melting in the inside launch waveguides is thought to be due to localized heating from small losses in the mode convertor. Bench tests, *in situ* tests, analysis and tests with a prototype mode convertor support this model. Replacement parts are currently under fabrication.

The poor coupling of IBW power to the plasma is thought to be due to the presence of a high  $k_{\parallel}$  mode which produces heating at the edge although no direct evidence exists. A new Faraday shield designed to suppress these modes is being designed, prototyped, and fabricated.

A collaborative program on the advanced divertor is being actively developed. This program will combine the resources of a number of laboratories and institutions to carry out comprehensive studies of the divertor and develop enhancements to further optimize the configuration. A meeting was held with the outside participants (including LLNL, ORNL, SNLL, SNLA, and UCLA) to finalize roles and resulted in a working understanding. A design effort is underway at GA to develop the configuration.

A vent of the machine is now scheduled for mid-March. This vent will allow replacement of ECH inside launch component and the IBW Faraday shield and will allow other in-vessel tasks to be carried out.

Work on the DIII-D facility radiation shield continues to progress. The translating radiation shield roof has been used in conjunction with DIII-D experiments, and can readily move from one end of the building to the other. Work continues to improve the mechanical systems (drive motors and seismic pin actuators). This is expected to be completed during the second quarter.

General Atomics decided to act as contractor in construction of the shield wall work after competitive bidding identified no vendor at reasonable cost and schedule, and recognizing that a formidable amount of task integration was going to be needed in any case to properly integrate the work with the ongoing experimental schedule. Construction began in early December and is on schedule.

Assessment of the shielding needs of individual diagnostics has begun and preliminary indications are that substantial work will be needed in some cases (*e.g.*, Thomson scattering).

A document has been developed reporting all shielding related issues and the results of the analysis for the shield. This document indicates that a shielding factor of 300 can be obtained.



## RESEARCH PROGRAM

### Beta and Stability

Modeling of high beta disruptions supports the hypothesis that the maximum beta in DIII-D H-mode discharges is limited by the  $n = 1$  ideal external kink mode. These very fast disruptions ( $\tau_{\text{growth}} \sim 20\text{-}100 \mu\text{sec}$ ) tend to occur immediately after a combined sawtooth plus ELM event. The effect of such an event on the stability of the discharge is simulated by modifying a measured pre-sawtooth pressure profile to reduce the central pressure and the edge pressure gradient, while broadening the current profile slightly, all consistent with magnetic and soft x-ray data. The resulting equilibrium has a beta threshold for the  $n = 1$  ideal external kink instability which is significantly lower than in the pre-sawtooth case, and which is in reasonable agreement with the observed beta limit. This implies that the pressure and current profile redistribution resulting from the sawtooth fall could trigger the external kink instability.

H-mode was achieved in discharges limited on the inside wall, with safety factor  $q$  between 2 and 3. The energy confinement was comparable to single null divertor discharges with similar parameters, although the power threshold for the H-mode transition was about twice as great for the limiter discharges. While there was no explicit attempt to reach high beta, the normalized beta ( $\beta a B / I$ ) of 2.6 was as high as in the best divertor discharges at similar parameters. As in divertor discharges, at the H-mode transition a dramatic decrease in the level of broad-band magnetic fluctuations was observed on the magnetic probes. In the present case the fluctuations are best observed on the inner wall probes. The close proximity of the plasma to these probes, without the complicating presence of an x-point, may make such discharges a superior medium for the study of these fluctuations.

Use of kinetic profile data in the MHD equilibrium analysis is found to provide a significant constraint on the value of  $q(0)$ , the safety factor on axis, as compared to the result from analysis using magnetic data alone. For a case with  $q_{95} = 3.1$ ,  $\beta = 6\%$ , the best fit gives  $q(0) = 0.95 \pm 0.15$ .

Plasmas with elongations up to 2.5 were produced in an up-down symmetric limiter configuration. The discharges with highest elongation were transient, owing to the need for a current ramp to obtain the broad current profile required for discharge shaping and stability. The new vertical stability control system worked well, maintaining stability up to the theoretical limit for the particular discharge shape and current profile. These encouraging results suggest that, given cleaner vessel conditions and broader current profiles, higher elongations should be possible.

Single null divertor discharges of 7 sec duration were achieved after appropriate modifications of the power supplies and feedback system. These discharges had a 5 sec long flat-top at 1.25 MA, with no disruption until the current had ramped down to 100 kA.

### Confinement

We continue to find H-mode shots where  $\tau_E$  exceeds the ohmic confinement time and the value predicted by saturated Shimomura scaling. At 1.25 MA,  $q = 4.4$ , and 4.4 MW of  $D^0 \rightarrow D^+$ , a 500 msec ELM free period resulted in  $\tau_E$  of 230 msec compared with 135 msec for the ohmic confinement time and 165 msec for saturated Shimomura scaling. The power threshold for the L to H transition depends on the product  $\bar{n}_e B_T$ . The threshold condition at the plasma edge appears to depend on  $T_e(\text{edge})/B_T$  rather than  $T_e(\text{edge})$  alone. Limiter H-modes with  $\tau_E$  comparable to ohmic values were obtained at  $I_p=1.25$  MA,  $B_T=1.0$  T, and  $q < 3$  with  $d_{sep} < -3$  cm.

Analysis of counter NBI discharges indicate only a slight peaking of the density profile ( $n_o/\langle n \rangle \leq 1.4$ ) over the co-NBI case ( $n_o/\langle n \rangle \leq 1.2$ ). No significant improvement in confinement was observed. However, counter NBI did result in peaking the toroidal rotation velocity profile. Analysis indicates the momentum confinement and diffusivity are approximately equal to the energy confinement and diffusivity respectively. In the analysis, enhancement of the total momentum diffusivity due to the inclusion of radially sheared toroidal rotation speeds was found to be insignificant. The stored rotation energy is less than 5% of the total plasma energy.

With the help of a Fokker-Planck code from PPPL, analysis of fast-ion profiles at high  $\beta$  suggests that shear Alfvén instabilities may be responsible for the observed fast-ion losses.

No evidence of ion heating was observed with the charge exchange system during application of IBW power.

Work has begun on the addition of profile and transport quantities to the YOKA database. This will allow storage of ENERGY code profile fits and ONETWO transport output for general use. In addition, a team of five people was formed to begin work of the new multipulse Thomson scattering system.

### Boundary Physics

Further progress was made in the development of long pulse H-mode plasmas. We have demonstrated that H-mode confinement can be sustained without impurity accumulation or confinement deterioration for times much longer than all the plasma characteristic time scales.

Several innovative ideas for improving the performance of diverted plasmas have been incorporated into the so called DIII-D advanced divertor program. The program includes several concepts for particle control, plasma stabilization confinement improvement, and DC current drive. We have invited outside participation on this program. Several groups from ORNL, SNLA, SNLL, LLNL and UCLA are enthusiastically seeking to participate in this program. A document describing the proposed DIII-D collaborative advanced divertor program was written, and draft copies were distributed among the prospective participants in the program. A meeting was held at GA in December to finalized the roles of the various parties.

Work is underway to measure the graphite erosion/redeposition from the divertor region of DIII-D. The ITER team has identified divertor target heating and erosion as the number one issue for the design team. Detailed profile measurements of the tiles ( $4\mu\text{m}$  accuracy) before and after exposure to plasma discharges will give some indication of whether the erosion rate is close to the predicted values. It is anticipated that the experiments will be carried out over as many as 3000 discharges. This will constitute the first step in a continuing program whose ultimate goal will be to measure time-resolved erosion/deposition rates and correlate them with measured divertor plasma parameters.

### Electron Cyclotron Heating

Electron Cyclotron Heating results from last Quarter were analyzed and presented at the IAEA and APS meetings. The results included the following:

- A comparison was made of the principal modes of ECH (fundamental outside launch of the ordinary mode; second harmonic outside launch of the extraordinary mode; and fundamental inside launch of the extraordinary mode). The results are qualitatively consistent with ray-tracing theory, with inside launch heating extending to the highest density. Heating efficiency was as high as expected.
- The increase in central electron temperature was highest at low density, with  $T_e(0)$  reaching 5 keV at  $1 \times 10^{19} \text{ m}^{-3}$ .
- Calculations of the electron and ion heat transport coefficients from the experimental data showed that when the ECH H-mode is attained the electron heat transport coefficient decreases by a factor of 2.

- Suppression of Edge Localized Modes by ECH results in an increase in the global energy confinement time of 70% compared to the H-mode when ELMs are present. In the best case, with 1.25 MW of neutral deuterium injection and 0.9 MW of ECH power at a plasma current of 0.6 MA of plasma current, the confinement reaches 330 msec/MA. The improvement in confinement when ELMs are suppressed extends to both the particle and the electron heat confinement.

During the 1st Quarter of FY89, new data were taken using ECH alone to generate the H-mode. Unlike previous experiments using second harmonic ECH, these H-mode discharges were obtained using fundamental mode heating (ordinary mode, outside launch). This experiment is more difficult, since the power threshold for the H-mode is proportional to the toroidal field, which doubles for the fundamental heating. Nevertheless, the H-mode was obtained over a wide range of conditions at ECH power in the range of 1.2 to 1.4 MW.

The Soviet visitors (S. Kalmykov and V. Ilin, at GA as part of a US/USSR exchange) participated in the performance and analysis of the experiments.

### **Ion Bernstein Wave Heating**

High power Ion Bernstein Wave experiments were begun during this Quarter. The heating results at the 500 kW level have so far been disappointing. Under none of the conditions tested has central heating been observed either in the ion channel or the electron channel. Most experiments have been performed with the two antenna loops in phase, which was the configuration used in earlier experiments on PLT. However, experiments with the loops out of phase also did not show heating. The parameters which were varied included the toroidal field, which determines the location of the resonance; the plasma density and the antenna/plasma separation distance which affect wave coupling; the mixture of hydrogen, deuterium, or helium used as the working gas; antenna loop phasing; and the antenna and Faraday shield cleaning procedures. Both divertor and limiter configurations were tested. The antenna loading resistance was observed to depend strongly on the antenna phasing.

One concern is that the present Faraday shield may introduce a high  $k_{||}$  component which may enhance Landau damping by electrons or absorption at high harmonics by carbon ions at the plasma edge. Another possibility is that the open Faraday shield may not provide adequate screening of unwanted field components leading to surface wave excitation rather than excitation of the Bernstein wave. A project is underway to replace the Faraday shield, which is constructed in a manner very similar to that of the Oak Ridge fast wave antenna which was previously installed in DIII-D, with a double-tier, one more similar to that of the PLT or Alcator C experiments. The new Faraday shield will be installed during the March vent.

Dr. Masayuki Ono of Princeton and Dr. Miklos Porkolab of MIT participated extensively in the IBW experiments. These consultants were centrally involved in the previous IBW experiments on PLT and Alcator C, respectively.

### Current Drive

Two days of DIII-D experimental time in October 1988 were devoted to current drive experiments, one day each to neutral beam current drive (NBCD) and oscillating fluxes current drive (OFCD). Data analysis and modeling work continued. Theoretical analysis of DC helicity injection (DCHI) current drive began for the DCHI experiments planned for the advanced divertor program.

The October NBCD experiments differed from previous ones in DIII-D in two main ways. (1) The plasma position and shape control system voltage made fast enough to maintain control of the plasma at all times; this successfully avoided plasma cooling and contamination that plagued the August experiments. (2) ECH was used to heat the target plasma at low density prior to beam injection, because hot, low density plasma is favorable for NBCD. The October and August results were similar, excluding plasmas with poor control. An initial flattop period, where current is sustained, was eventually followed by a slow current decay. Any effects from the ECH were washed out by the large H-mode density rise that accompanied the beams. Correspondence between theoretical calculations and experimental data is good in both the flattop and slow decay phases. In particular, both theory and experiment support a linear proportionality between the current drive efficiency,  $\Gamma = nIR_0/P_{NB}$ , and energy confinement time,  $\tau_E$ , in these diverted H-mode shots. The slow decay of current drive is linked to a slow decrease of  $\tau_E$ . Long term current sustainment depends on avoiding this decrease. Finally, a time dependent transport simulation by the ONETWO code of one shot, where the current profiles did not change much between ohmic and beam driven phases, showed a reduction of the internal toroidal electric field to its new, nearly uniform value in about 200 ms. This is much shorter than the classical time scale because the electric field gets rapidly *replaced* by the NBCD. Therefore, extremely long flattop periods might not always be necessary to verify NBCD.

The October OFCD experiments achieved conditions suitable for unambiguous observation of OFCD drive and antidrive. The measured result was much lower than the prediction from simple helicity theory. In particular, the oscillating fluxes should have changed the toroidal loop voltage by about 0.3 volt, out of 0.6 ~ 0.7 volt loop voltage. However, only about 0.1 volt changes were measured. Some suggested explanations are: (1) There was no OFCD at all, and the result was just a temperature profile change. (2) OFCD saturates for some reason at 0.1 volt. (3) OFCD works at considerably less

than 100% of theoretical efficiency. (4) OFCD works at the edge, but it does not penetrate well to the plasma interior. The actual reason is not yet known.

Parameters for DCHI experiments in DIII-D were estimated using helicity injection and transport theory. Drive of 1 MA or more should be possible with the initially planned advanced divertor hardware and power system. Theory and some experimental data argue that the plasma current profile will be nearly flat (actually slightly hollow). Such plasmas are much more easily elongated than the usual peaked-current ones. At the expected elongation ( $\kappa \approx 1.8$ ), the  $q$ -profiles of model equilibria are monotonic and have shear similar to many conventional circular tokamak plasmas. Conditions are qualitatively good for stability, but quantitative stability tests need to be done.

## OPERATIONS

### Tokamak Operations

The neutron shielding roof was moved over the pit for the December operation, in order to take advantage of the shielding effect and to measure the shielding effect of the roof. The radiation at the site boundary normalized to the plasma neutron production was measured to be a factor  $2.0 \pm 18\%$  lower than without the roof in place. At the same time the x-ray radiation at the site boundary was measured to be about 4% of the neutron radiation dose, which is equivalent to previous measurements (*i.e.*, gamma radiation from neutron capture in the roof is almost undetectable at this time).

Two fission detectors have been installed in the machine pit. The detectors still need to be calibrated, but will eventually give information of the number of neutrons produced in the plasma, as the current  $\text{BF}_3$  counter are doing. The  $\text{BF}_3$  counters however saturate at a level too low for future operation, while the fission detector is operational in the higher neutron flux region.

The machine was vented twice during the quarter. The first vent was to remove a carbon tile that had broken off the DIII-D limiter and repair a damaged shutter on the bolometer array. At the same time an instrumented ECH inside launch window assembly was installed. The second vent was to install another window with modifications to the mode convertor. The second vent was very short ( $\sim 15$  min), and was performed during a maintenance week, and led to no lost operating time.

Operations during December was plagued by several independent problems from the power supplies, computers, and the gas puff system. There was a small fire in the SXR array cooling system. The fire was readily extinguished, but the cleanup took one day. The gluey insulation material used at the cooling system joints and over fittings had caught on fire, where it had come in contact with a heater jacket power cord. The heat of the fire caused the insulation to melt, spreading the fire to parts of the machine below the SXR array. The damage was largely cosmetic, but the spread of the fire to multiple areas led to a more extensive cleanup. After investigating this incident the use of this gluey material in the machine pit has been banned and existing material will be replaced prior to the next operating period. Improvements in the adherence to machine operating policy were also implemented.

The 180° 5000 1/sec Balzers pump was reinstalled on the machine toward the end of the quarter, and the pump was used on the machine in the beginning of January. The 180° 5000 1/sec Balzers pump started to have bearing problems in June. Difficulties were encountered in obtaining replacement parts. When the bearings were received, we installed the new bearings ourselves. The pump is now operational.

A highlight of the quarter was that we obtained the longest plasma (7 sec) and the longest H-mode period in a plasma (4.8 sec) ever achieved at DIII-D.

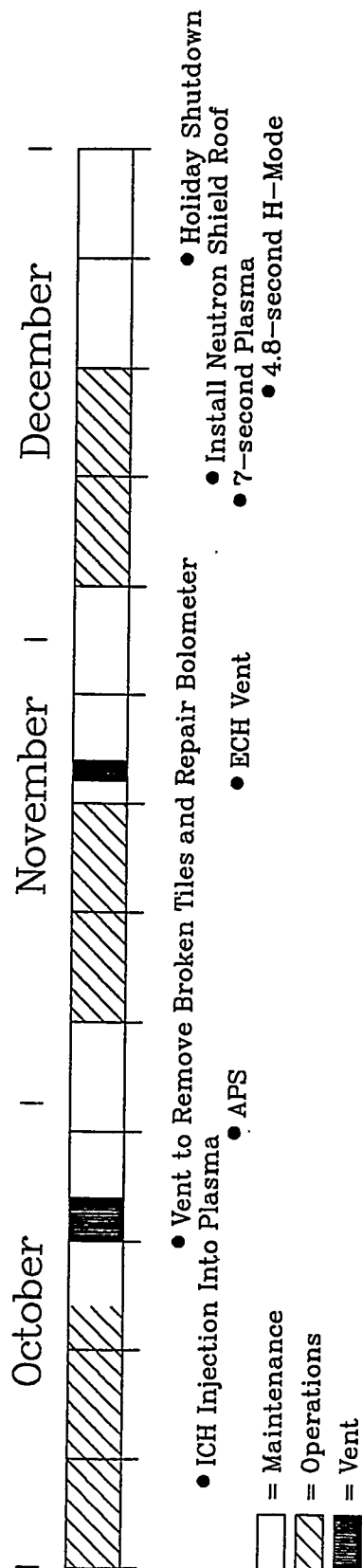
During the first quarter of FY89 6.5 weeks of operations were achieved with an availability of 76.5%.

### Neutral Beam Operations

The primary emphasis of plasma heating operations during this past quarter has been to test out various ion cyclotron heating schemes and thus demands for beam operation were less than normal. This is reflected in the beam system availability chart (shown below) where there is a large amount of unscheduled time. Much beam operation has been to supply short pulse power from the 330° and 150° sources for various diagnostic devices. Long pulse operation of the beams was used to successfully produce 4.8 sec H-mode plasmas. Limited high power deuterium operation using all eight sources was scheduled for high beta studies and testing the neutron shielding capability of the new pit roof.

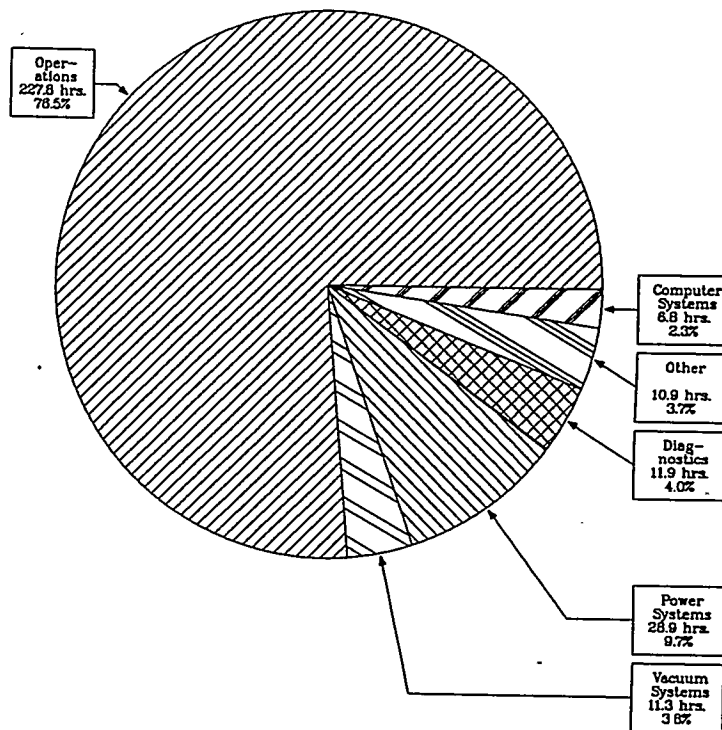
The UVC #7 power system was converted from ECH to Neutral Beam operation. With this supply, the 30° right source reached 75 keV on the first day without any operational difficulties. (This source has been out of operation for approximately 6 months).

## DIII—D FY89 First Quarter Operations

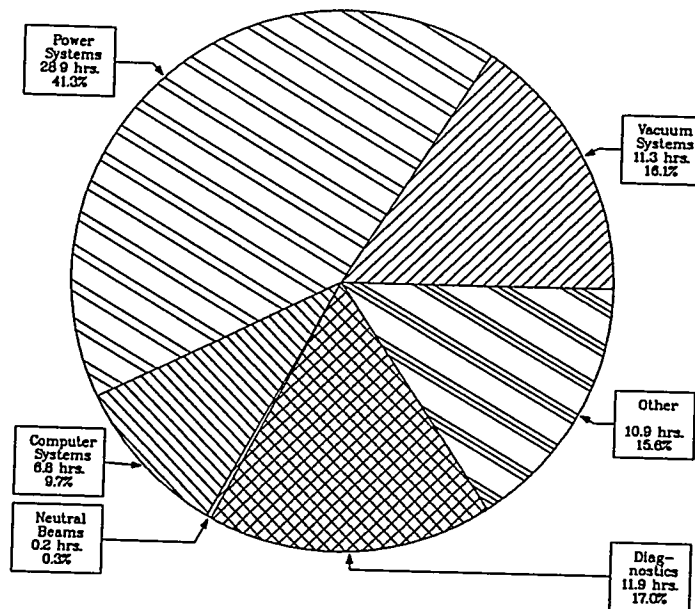




**PERCENTAGES OF MACHINE TIME**  
(October 1988 through December 1988)



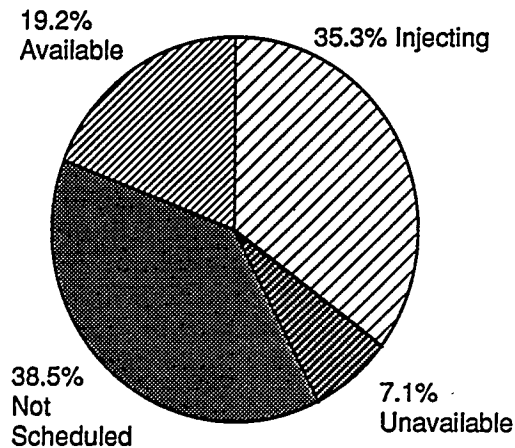
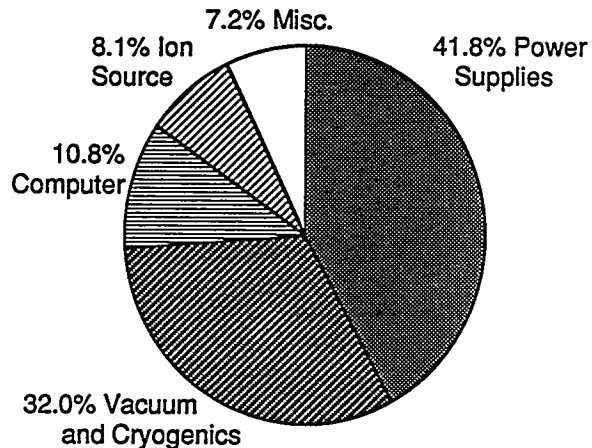
**PERCENTAGES OF TOTAL DOWN-TIME**  
(October 1988 through December 1988)



**NEUTRAL BEAM AVAILABILITY**

October, November, December 1988

number of DIII-D shots times eight sources

**System Availability****Breakdown of "Unavailable"**

The arc regulation experiments to enable an ion source to operate very stably and deliver a high perveance beam have been a great success. Modifications and improvements to the circuitry to allow remote adjustment of the regulator from the control room are now in hand, and the first system has been installed on the 330° beamline. Frequency response and stability tests of the circuitry were made immediately prior to the Christmas shutdown. Data analysis is currently underway.

The experiments on replacing the obsolete HP2626 terminals have also been extremely successful. A Macintosh computer (Mac II) now performs all the functions of the split screen HP unit on the 210° beamline. In addition, it directs the operation of the other five video displays on the console, schedules the waveforms to be sent to the laser printer and maintains the operators shot log. It is also being programmed to replace the very troublesome LBL-fabricated touch-screens that are used to change the beam shot timing.

During maintenance inspections of the high voltage transformer-rectifier sets in October it was found that several of the coil shims in the UVC #8 T-R set had come loose and fallen out. Because of the stresses on the coils which can be imposed during long-pulse, high power shots scheduled in the December operating period, it was decided to un-tank this T-R set and to replace the missing shims. This system was out of operation for the month of November.

The 210° left source arc chamber exhibited an unstable discharge (thought to be due to thermal cycle effects), and was removed from the beamline to be examined during the November maintenance period. Our spare arc chamber was installed on the 210° left source. This arc chamber also initially operated erratically. Its problem was traced to mis-wiring in the signal collection box on the back of the arc chamber.

The LN<sub>2</sub> supply to the 150° beamline experienced three blockages in a six-week period. It is believed that these were due to some condensable contaminant in the supply. Several days were lost on each occasion while the beamline was warmed up and the line purged. The entire LN<sub>2</sub> storage system is to be drained in January and new vendor has been contracted to deliver LN<sub>2</sub> in the future. We hope that this will cure this periodic blockage problem.

A computerized program for neutral beam system maintenance and trouble reporting has been devised and is currently under review.

Plans for 2<sup>nd</sup> Q FY89 include:

- Continue the replacement of obsolete control system equipment on the 210° console.
- Implement arc regulation on additional systems.
- Re-convert UVC #7 to ECH operation following high power D-D injection experiments.
- Implement the computerized maintenance and trouble reporting system.
- Investigate the use of a distributed, relational database to maintain all NB data and journal entries for the entire system.

### ECH Operations

There were six days of plasma operations with ECH (as scheduled) in this quarter. Eight of nine available gyrotron systems were used in outside launch experiments. RF power levels up to 1.4 MW with 150 ms duration were achieved during these operations, with a total system availability of 84%.

The superconducting magnet which developed a nitrogen-vessel leak during the last quarter of FY88 was repaired and is ready for test. The magnet will be tested together with S/N 105 gyrotron presently being repaired at Varian (arrived in January). Improvements have been made to the cooling and protection system for the leads to the superconducting magnets.

Testing of two inside launch systems was conducted to help identify the cause of overheating in inside launch waveguide components. A long pulse dummy load is being installed to facilitate conditioning of the gyrotrons out to longer pulse durations independent of the DIII-D operations.

Experiments with pressurization of waveguides have shown a significant reduction in the incidence of waveguide arcs at higher rf output power levels. A pressurization system is now being installed for all the waveguides.

Stainless steel water supply and return hoses have been installed in the gyrotron systems to reduce problems with water hose failures.

### ICH Operations

A new final power amplifier (EPA) tube (X2242) was received from Varian, and conditioned up to a power level of 1.3 MW and 1 sec pulse width at 38 MHz into a dummy load.

There were 6 days of vacuum conditioning of the antenna, and 12 days of plasma operations with IBW in this quarter. A system availability of 95% was achieved with typical shots in the range of 500 to 600 kW of 1 sec duration, with peak power level shots of 800 kW.

Output power regulation circuitry was developed and installed permitting rapid power control under varying load conditions.

Some rf interference problems with other equipment were corrected during this period, and additional interference problems are being investigated.

### Calibration Laboratory

Substantial progress on developing a Calibration Laboratory to monitor and carry out the calibration of electronic equipment at DIII-D is being initiated. A complete inventory of equipment has been developed and computerized. All repair and calibration must be carried out through this facility (January) and a routine calibration schedule is anticipated this quarter.

Computer Data Systems

Software for the SUMMUS 8 mm tape was completed and put in place. Currently, 2400 foot reels are being used to store compressed data. All data, both uncompressed and compressed is being archived to the 8 mm unit. The average shots have produced 24 or 25 megabytes of data, and 70 uncompressed shots will fit on one 8 mm tape, while 220 compressed shots are stored. Only 6 uncompressed shots fit on a 2400 foot tape, so the storage improvement is dramatic. The use of the 8 mm tape has made daily operation much easier, and storage and handling of tapes is much better. A second unit was ordered and has been received by the User Service Center. Software development has started so that shot restoration from the 8 mm tapes will be handled automatically at the USC. The scheduled completion of this task is Q3FY89.

A disk drive unit which incorporates 2 sealed Winchester disk units and a tape cartridge was evaluated on the MODCOMP computers. These drives are more reliable, faster, and provide more storage space. The evaluation was fairly comprehensive and it was decided to purchase the units (total of 6). They arrived at the end of the quarter, and it is hoped to complete installation during January.

The neutral beam system to save parameters into a historical file was greatly improved and expanded during the quarter. The number of parameters was tripled, and all interface codes were changed to use the new data and format. Many new parameters, such as thermocouples, were added. Display and update programs on the MODCOMP beam acquisition system were changed to be compatible. Codes which transfer the data through several computers and ultimately to the VAX data base were changed. This new data base will be useful in evaluating all performance aspects of the neutral beam sources over a long period of time.

Specifications were developed and programming began on a project to save the actual power supply control waveforms into a database on the MODCOMP computers. Up to 1000 shots of data will be stored in the database, and any of these old shots can be reloaded. This facility will be of great use to the physicist who is in charge of a particular experimental day. Work should be completed in the second quarter.

The second issue of *Fusion Bits & Bytes* was published.

During the quarter, 24.2 gigabytes of data was collected. One hundred thirty seven 2400 foot reels of tape were written, and 14 8 mm tapes. The largest single shot file remained at 30.0 Megabytes. The size of the defined data base is approximately 33 megabytes, but all data has not been collected during one shot.

Testing of the GA ESnet system was rescheduled for the 2nd Quarter FY89.

The USC completed its move from Bldg. 13 to GA's main computer facility in Bldg. 15 the weekend of November 19th. Other than a few terminal and printer lines, the computer center was available to the users Monday morning, November 21st.

The USC VAX cluster was available for processing 96% of the time during this quarter. This includes all the downtime connected with the move.

## PROGRAM DEVELOPMENT

### Experimental Planning

The experimental schedule for the second quarter was updated and streamlined to allow for more efficient tokamak operations and allow construction of the radiation shield enclosure in parallel. The vent of the machine has been scheduled in March to allow completion of a more comprehensive set of modifications to the ECH and IBW in-vessel components and additional machine operations while minimizing the total number of machine vents.

Earlier plans called for December, February, and March vents along with a potential May vent. Now the work is condensed into a single March vent with a potential May vent. This was in part motivated by a recognition that frequent venting of the tokamak was impacting productivity in that it was causing the corners of our operating space where significant new work was being done to be temporarily lost. Machine operations will be carried out for a total of four weeks in late January and February followed by the dirty vent in March.

Much of December and January (including the GA plant shutdown period) was used to begin shield wall construction. This has been progressing on a very aggressive 6 day/week basis and is on schedule at this time. Once operations begin again, the shield wall work will proceed on a second shift basis while operations will occur on a modified 7 A.M. to 5 P.M. schedule. Since a 7 A.M. start requires considerable earlier preparation, substantial flexibility is being expected from the staff. Carrying on construction and other work in parallel is requiring considerable planning interfacing and accommodation by everyone involved. Anticipated completion of the shield is in advance of the April 31 milestone.

Present plans for the ECH system include replacing the necessary in-vessel inside launch components to make all ten of these systems available. Eight of these will be set for 15° launch while the remaining two will be set for 30° launch. Testing of these systems followed by plasma operations will begin immediately after the vent. If the 30° launch proves superior to 15° in operation, plans will be considered to change all systems during a vent in May or later.

The plans for IBW are focused on replacement of the Faraday shield with a titanium carbide coated double layer shield to better control the boundary layer in front of the antenna. This is thought to be the best approach to improve the present poor coupling. Tests of the new antenna will begin shortly after the vent.

Following the vent, operations are anticipated on a two weeks out of three basis for much of the remainder of the year in order to meet program commitments. This requires careful planning to ensure that required testing and maintenance is also carried out.

## HARDWARE DEVELOPMENT

### ICH 2 MW System

The hardware development of the 2 MW ICH system has been completed, and the system is operational.

### Shielding

**Roof System.** The crane rail supported translating roof system has been used successfully for shielding even though the final acceptance isn't complete. The roof was positioned over the DIII-D machine for shield testing during the first two weeks of December. Radiation monitoring at the site boundary confirmed the expected reduction of a factor of 2 for the roof system only. This reduction is logical since the roof added effective shielding to about 50% of the area of the original unshielded system. The other 50% area coverage will be produced by the walls which in conjunction with the roof should produce a radiation reduction factor of 300 at the site boundary.

The roof drive system was upgraded by replacement of the four drive motors with modified, higher power motors. This improved roof movement but the motors still overheat before the roof has moved the required 250 feet. Bisco, the roof contractor, has ordered two additional drive motor systems for installation in late January. It is expected that this six-motor system will provide adequate operation based on extrapolation of existing test data. In the interim, the roof can be moved but requires periodic stopping to allow motor cooling.

The seismic restraint locking system has been improved but needs additional work. The main difficulty is the repeatable alignment of the 12 seismic pins simultaneously with their 12 targets which are mounted on the crane girders which are spaced 60 feet apart. The 12 target receptacles exist in three parking locations. The roof and crane rail system didn't provide the necessary repeatability within the 0.06 inch positioning accuracy as intended in the design. The design has been changed by the addition of a hard rubber receptacle which deflects to accommodate pin misalignment in excess of 0.06 inches. This has reduced the number of inoperative pins but there are still 3 pins with alignment problems for the south parking position. Additional modifications are being considered.

The fire sprinkler system on the moving roof is operational.

**Wall System.** GA received only one technically acceptable response to the RFQ for the wall installation. After evaluation of the quoted cost and schedule for the project and significant negotiations with the bidder, Bisco, it was decided that GA could do a lower cost job within the schedule and with better schedule control and thus would act as the general contractor and use subcontractors for the construction labor.

Design work for the shield walls had been started during the 4<sup>th</sup> quarter of FY88. On-site installation of structural steel started in early December and continued through the holiday period. By the end of the year the wall structural steel was nearly complete for 2 of the 4 walls and it appears that we are on schedule for wall completion in late March 1989 and door installation during April 1989. This task has used about 15 construction workers working 60-hour weeks since operation of DIII-D was stopped in mid-December. The scheduling of construction work has been carefully worked out to maximize construction access on an off-shift basis once machine operation starts up in late January.

**Shielding Analysis.** The analysis of the shielding configuration has been wrapped up and a document summarized radiation issues and analysis is in review. Shielding analysis indicates that a shielding factor of 300 for the total radiation including neutrons and gamma radiation is anticipated.

Recent measurements and model calculations are in good agreement. Measurements and calculation of the *in situ* shielding factor of the existing concrete wall material were in good agreement. The measured shielding factor was 260 while the calculated value was 280.

A direct comparison was also made between the measured and modeled values for the shielding produced by the recently completed roof alone without the walls. The measured value was  $2.0 \pm 0.36$  while the model predicted 1.8.



### ECH Hardware

An analysis was made of the problems associated with the ECH inside launch installation. It was determined that the problems, which included melting of parts of the waveguides in the DIII-D vacuum vessel, were due primarily to the conversion of about 1% of the forward rf power to highly lossy surface waves. A new mode converter, for which a patent disclosure has been submitted to the DOE, was developed which converts directly from the  $TE_{0,1}$  mode to the  $HE_{1,1}$  mode without having a transition mode like  $TE_{1,1}$ , which is rather lossy. This converter was tested in DIII-D with thermocouples to determine the heat distribution, and it was found to run much cooler than the previous mode converter. We plan to install new mode converter assemblies on all ten waveguide assemblies during the vent of DIII-D scheduled for March, 1989. At that time, two inside launch antennas will also be rotated from 15° from radial to 30° to test the dependence of wave damping on launch angle.

### ECH Power Supply

An MFTF neutral beam power supply (80 kV, 80 A) has been removed by LLNL and shipped to GA for conversion to use with the ECH system. This supply will provide more ready availability of power for ECH operations and development, and will alleviate the present conflict between ECH and NBI use.

The conversion is a joint effort between GA and LLNL. LLNL removed the supply and converted the polarity of the rectifiers. They will also support on-site installation. LLNL has provided documentation and considerable consultation on the design.

### OPERATIONS SUPPORT

Services including storekeeping, materials handling, quality assurance, plant engineering, inspection, safety monitoring and control, scheduling, cost control, procurement control, status reporting, and engineering services such as document control, design integration, space allocation and CAD support were provided to DIII-D under "Operations Support." DIII-D authorized tasks and budgets for FY89 have been established at the funding level of \$27,600K Operating and \$1700K Capital. An initial possessory interest tax payment of \$187K was made in November 1988 prior to the filing of the lawsuit disputing the legality of such taxes by the U.S. Department of Justice. No further tax payments are anticipated this year due to this action. (See separate discussion in this report on tax status.)

## COLLABORATIVE EFFORTS

**LLNL** — During the first quarter of FY89, Livermore personnel remained active in several areas of the DIII-D program: divertor physics (experiments and modeling), analysis of non-inductive current drive experiments, and the physics of ECRF and NBI heating. In December Marv Rensink returned to Livermore where he will continue his work with the 2-D Braams code; this will facilitate coupling his DIII-D results to the ITER studies there. As of the end of the quarter, six LLNL personnel live in San Diego and three commute.

This quarter we have participated in another series of ECH experiments. With the O-mode outside launch, an ECH sustained H-mode was obtained that was relatively insensitive to the location of the resonance layer. ECRF central heating of a beam-sustained H-mode plasma showed evidence for the ECRF lowering the frequency of ELMs, however, more analysis is required.

In order to better diagnose the ECRF heating and current drive results, work was begun (with participation from the ECE group at JET) on a new code to simulate the expected ECE (electron cyclotron emission) signals. This code will include the effects of non-thermal emission and the imperfect collimation of real instruments. In parallel, the present U. Maryland Michelsen interferometer is being modified to include a horizontal line-of-sight to provide further information on non-thermal emissions.

We have also started construction of the ZEP (Zeeman Effect Polarimeter) which will be used to measure the internal poloidal magnetic field. Data from this diagnostic will be incorporated into the EFITD MHD code to better define the central  $q$  during NBCD.

In the area of divertor physics, we presented the results of our study of particle confinement with an invited talk at the November APS meeting. We found that the particle confinement time doubled following the H-mode transition, and that a large inward pinch localized at the edge was required to simulate the observed density buildup. This quarter we also worked with General Atomics and several other institutions in developing the concept of an Advanced Divertor Program for DIII-D. LLNL personnel began the work of upgrading the IR camera data acquisition system so that, using GA's new hardware, we can routinely look at heat flow to the upper and lower divertor targets as well as the entire centerpost.

**JAERI** — A total of four scientists were on site from JAERI during the first quarter. Michiya Shimada worked with divertor physics relating H-mode, Takashi Okazaki did analysis of ECH heating and simulation of ECH current drive, and Yuzuru Neyatani analyzed magnetic fluctuation. Hiroshi Matsumoto is in charge of H-mode physics and started fluctuation studies in DIII-D.

JOHNS HOPKINS — Mark Perry worked on putting ASDEX impurity code on DIII-D VAX computer. He successfully defended his Ph.D. thesis.

UCLA — Tom LaHecka analyzed data with the microwave reflectometer which was presented at the IAEA meeting. Ralph Phillipono completed the installation of the FIR scattering system and began checkout.

MARYLAND — Scott Janz analyzed VECE signals from high-temperature (5 keV) ECH-heated plasmas.

LAUSANNE and ORNL — Ed Lazarus lead experiments in controlling very elongated plasmas. Together with Joe Lister he has been preparing a journal article.

IPP GARCHING — Uli Stroth presented a paper at the APS meeting on momentum confinement analysis. Gunther Haas worked on the bolometer system. Gunther Janeschitz wrote analysis software for the LLNL SPRED and modeled impurity content of long pulse H-mode.

ILLINOIS — Glen Sager presented analysis of counter injection plasmas at the APS meeting.

MIT — Steve Wolfe completed transport analysis of a current scan that was presented at the APS meeting.

JET — Alan Costley developed a number of suggestions for ECE diagnostics.

DIII-D PROPERTY AND SALES TAX ACTIVITY - 4<sup>th</sup> QUARTER 1988PROPERTY TAX

The 1982-1985 D-III tax assessments were enrolled in the last quarter of 1988. The details are provided below:

	Year	Amount	Due Date
Received 12/2/89	1982	53,507.79	1/3/89
Received 12/22/89	1983	139,473.09	1/31/89
Received 12/22/89	1984	87,474.13	1/31/89
Received 12/22/89	1985	247,056.64	1/31/89
Received 12/22/89	1986	N/A	N/A

A 10 % penalty accrues if the tax is not paid by the due date listed above. DOE/SAN instructed GA not to pay the bill due on 1-3-89 because the Department of Justice lawsuit was about to be filed. (The lawsuit had not been filed as of 1-13-89. It may have been filed on 1-17-89 or later, but GA has not been notified.)

SALES TAX

General Atomics (GA) received the State Board of Equalization's hearing officer's report on December 20, 1988. Basically, the hearing officer found that the vessel chamber and any property purchased which became a component part of the vessel chamber or an accessory attached thereto, was machinery and equipment rather than real property. Provided that title, risk of loss and control to the property passed to DOE before GA's use of the property, those items are non-taxable.

The hearing officer also ruled that property that became a part of property needed to operate the vessel chamber, but not actually becoming a component of the vessel chamber or an accessory attached thereto, was taxable real property. Examples given in the hearing officer's report are "wiring, piping used as a source of power, water and gas requirements of the vessel, and other affixed supporting properties". Those items would be taxable in instances where they were shipped from "in-state" to GA.

Thirdly, the hearing officer found that property that would otherwise be taxable would not be taxable if it was purchased outside California and title, risk of loss and control passed to DOE outside California.

There is some ambiguity in the hearing officer's recommendations as to the types of items that are taxable. For example, the hearing officer refers to piping used as a source of power, but does not refer to the power supplies themselves. GA's view is that the motor generators were constantly being reconfigured as the power requirements of the Doublet III project varied, and that to a large extent the power supplies were also more like experimental property. If pressed on this point, however, I would expect the State Board to take the position that if piping used as a source of power is taxable, that the power supply itself is taxable.

A reaudit will be performed to determine a tax liability based on the above recommendations. That audit will probably be performed within the first half of 1989. If GA disagrees with the reaudit adjustments a full State Board hearing will be requested. GA has estimated the final liability will be reduced from over \$2.0 to around \$1.2 million, including interest, for the period 1/1/81-6/30/84. From that point to 9/88, which is currently being audited, we expect an additional liability for power supplies. That liability is also expected to be around \$1.2 million.

**DIII-D RESEARCH OPERATIONS  
– OPERATING –**

	FY89 BUDGET		FY89 ACTUALS	
	FTE's	TOTAL \$000	FTE's	TOTAL \$000
BASE OPERATIONS	46.5	8359	50.1	2097
DATA SYSTEMS	10.1	1686	10.3	400
DIAGNOSTICS	44.3	6782	40.8	1323
HEATING	32.6	5009	30.1	991
OPERATIONS SUPPORT	23.9	3607	27.8	1050
SHIELDING	3.8	1932	7.0	490
TAXES	0.0	225	0.0	187
<b>Total</b>	<b>161.2</b>	<b>27600</b>	<b>166.1</b>	<b>6538</b>

**DIII-D RESEARCH OPERATIONS  
– CAPITAL –**

	FY89 BUDGET		FY89 ACTUALS	
	FTE's	TOTAL \$000	FTE's	TOTAL \$000
BASE OPERATIONS	–	653	–	–
DATA SYSTEMS	–	264	–	147
DIAGNOSTICS	–	202	–	34
HEATING	–	461	–	–
OPERATING SUPPORT	–	120	–	–
<b>Total</b>	<b>0.0</b>	<b>1700</b>	<b>–</b>	<b>181</b>

# CONTRACT MANAGEMENT SUMMARY REPORT

TITLE: DIII-D RESEARCH OPERATIONS - B&R #AT1010114D

CONTRACT NO.: DE-AC03-89ER51114

CONTRACTOR: GENERAL ATOMICS

P.O. BOX 85608

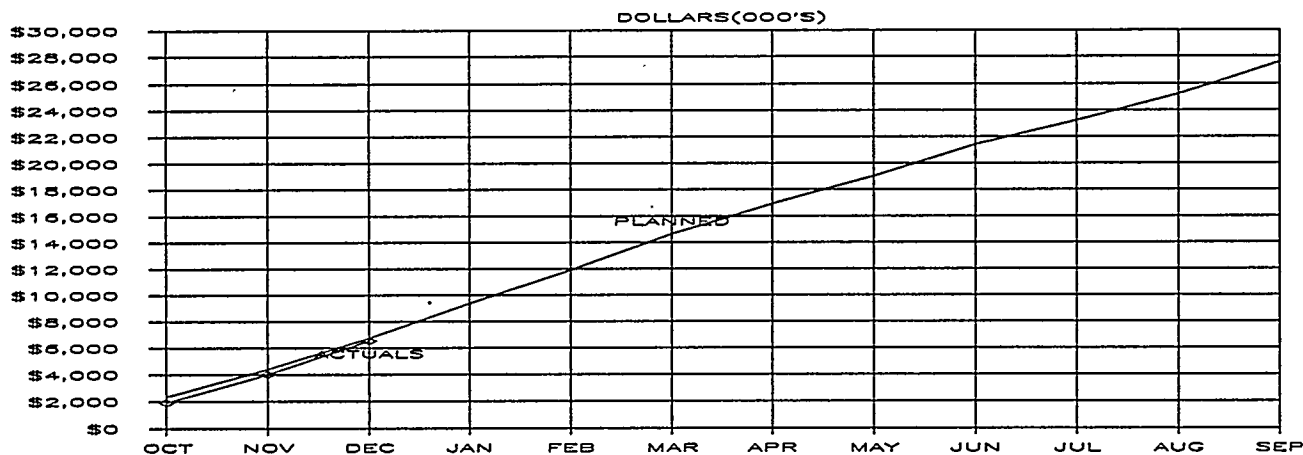
SAN DIEGO, CA. 92138

COST & LABOR PLAN DATE:

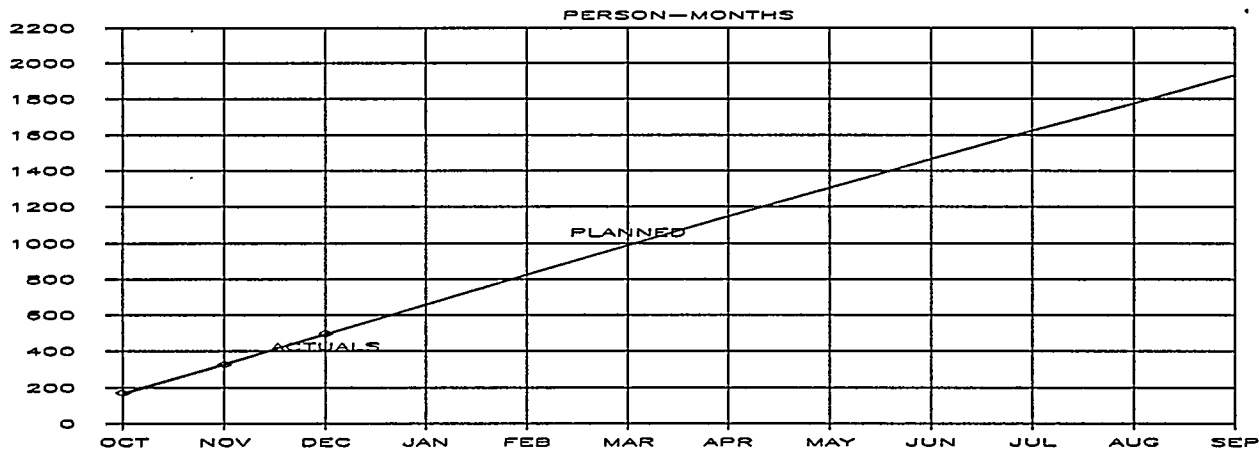
JAN 12, 1989

START DATE: SEPTEMBER 30, 1988

COMPLETION DATE: SEPTEMBER 30, 1989



PLANNED	\$2,389	\$2,037	\$2,318	\$2,628	\$2,566	\$2,712	\$2,279	\$2,108	\$2,352	\$1,837	\$1,976	\$2,398	\$27,600
ACTUAL	\$1,942	\$2,087	\$2,509										\$6,538
VARIANCE	\$447	(\$50)	(\$191)										
CUM VAR	\$447	\$397	\$206										



PLANNED	163.9	165.7	165.7	163.6	163.6	164.7	162.1	158.5	157.7	156.5	156.4	156.3	1934.7
ACTUAL	169.8	158.7	169.1										497.6
VARIANCE	-5.9	7.0	-3.4										
CUM VAR	-5.9	1.1	-2.3										

SIGNATURE OF PARTICIPANT'S PROJECT MANAGER & DATE: .

# CONTRACT MANAGEMENT SUMMARY REPORT

TITLE: D III-D CAPITAL EQUIPMENT-B&R # 35AT10020

CONTRACT NO.: DE-AC03-89ER51114

CONTRACTOR: GENERAL ATOMICS

COST & LABOR PLAN DATE:

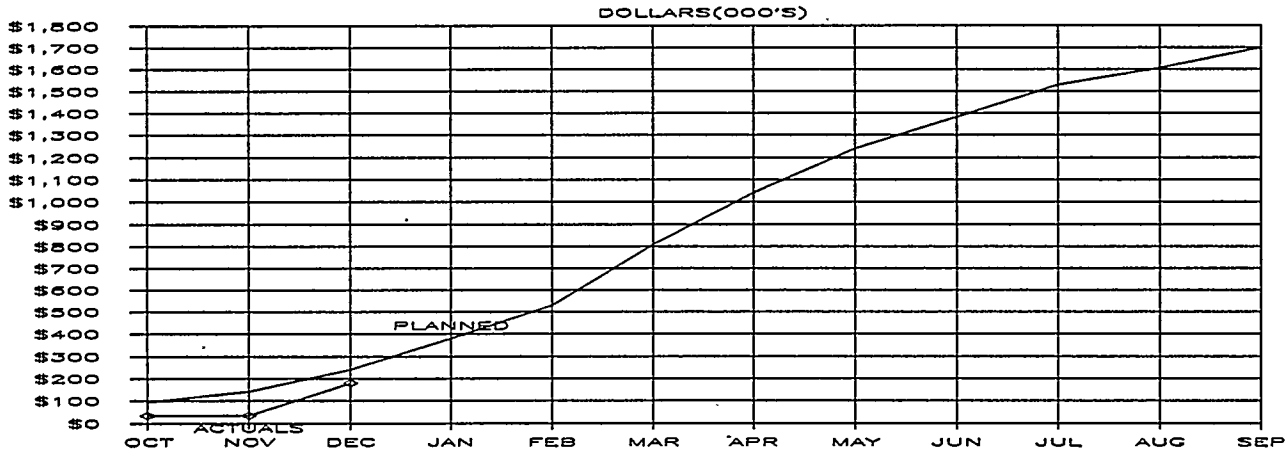
START DATE: SEPTEMBER 30, 1988

P.O. BOX 85608

JANUARY 12, 1989

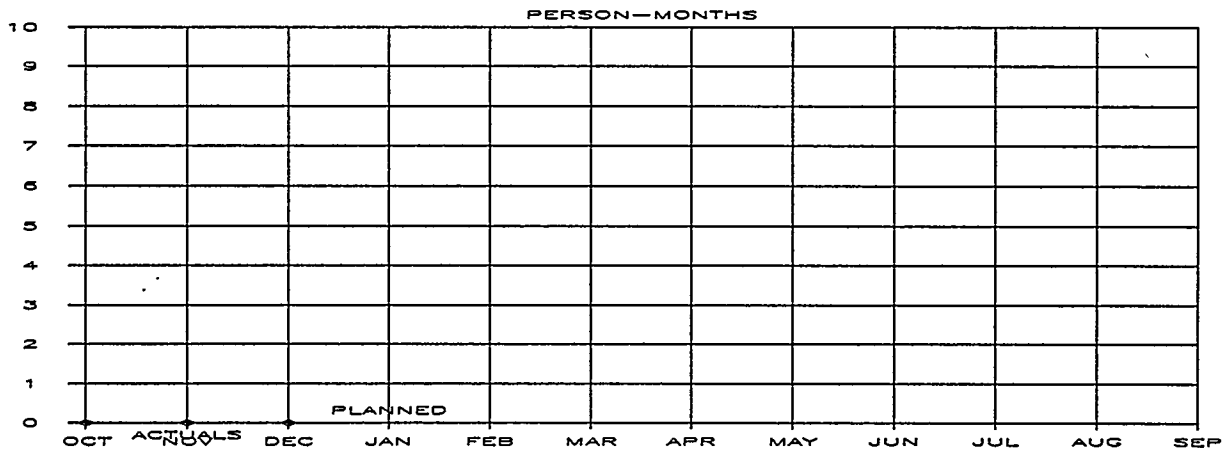
COMPLETION DATE: SEPTEMBER 30, 1989

SAN DIEGO, CA. 92138



TOTAL

PLANNED	\$95	\$47	\$100	\$141	\$147	\$277	\$235	\$199	\$144	\$145	\$77	\$93	\$1,700
ACTUAL	\$34	\$1	\$146										\$181
VARIANCE	\$61	\$46	(\$46)										
CUM VAR	\$61	\$107	\$61										



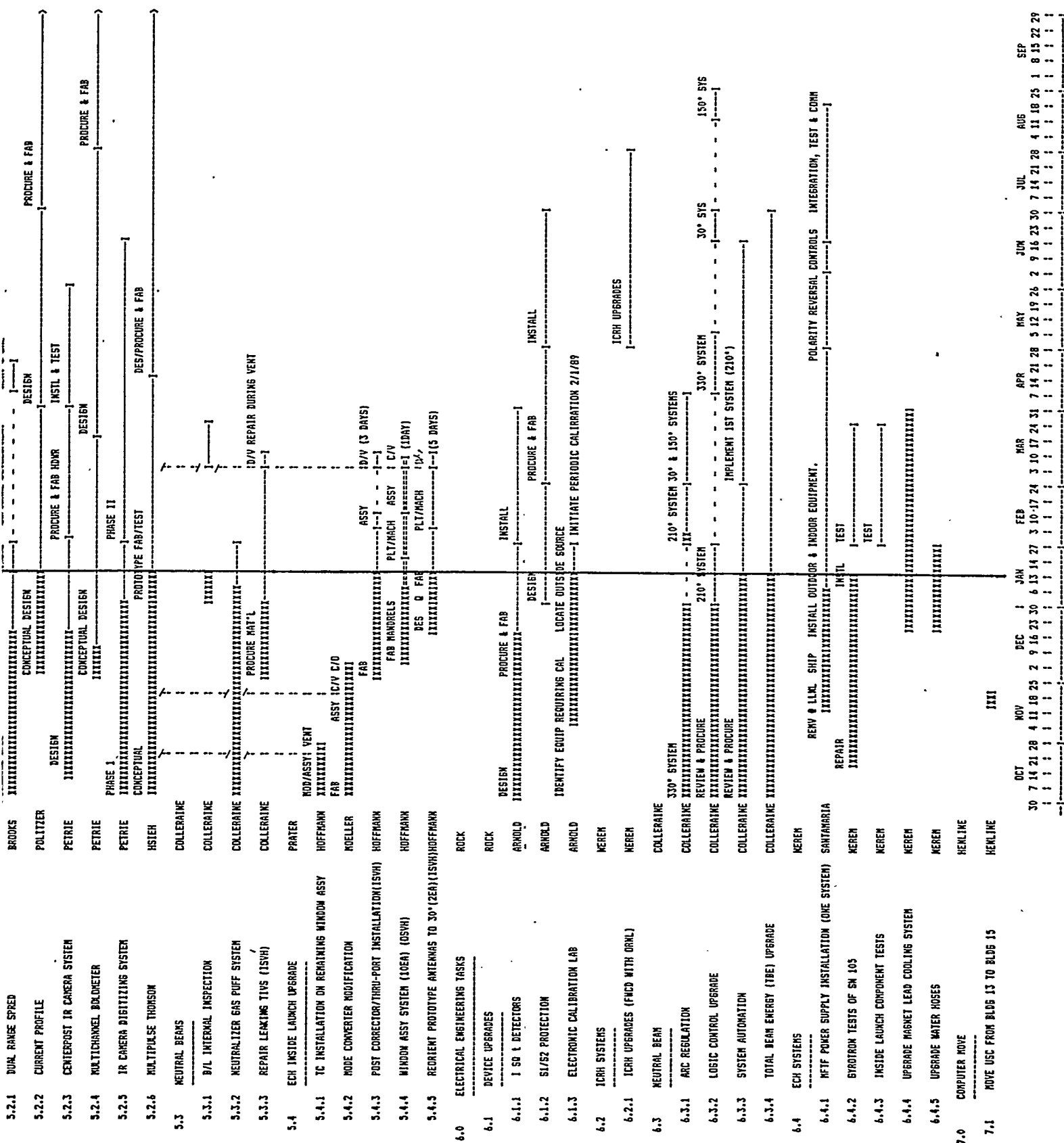
PLANNED	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
ACTUAL	0.0	0.0	0.0										0.0
VARIANCE	0.0	0.0	0.0										
CUM VAR	0.0	0.0	0.0										

SIGNATURE OF PARTICIPANT'S PROJECT MANAGER & DATE:

4-107-89

[illegible]





5.2.1	DUAL RANGE SPREAD	BROOKS	CONCEPTUAL DESIGN	DESIGN	PROCURE & FAB
5.2.2	CURRENT PROFILE	POLITZER	CONCEPTUAL DESIGN	DESIGN	PROCURE & FAB
5.2.3	CENTERPOST IR CAMERA SYSTEM	PETRIE	CONCEPTUAL DESIGN	DESIGN	PROCURE & FAB
5.2.4	MULTICHANNEL BOLMETER	PETRIE	CONCEPTUAL DESIGN	DESIGN	PROCURE & FAB
5.2.5	IR CAMERA DIGITIZING SYSTEM	PETRIE	CONCEPTUAL DESIGN	DESIGN	PROCURE & FAB
5.2.6	MULTIPULSE THOMSON	HSIEN	CONCEPTUAL DESIGN	DESIGN	PROCURE & FAB
5.3	NEUTRAL BEAMS	COLLAIRNE	CONCEPTUAL DESIGN	DESIGN	PROCURE & FAB
5.3.1	B/L INTERNAL INSPECTION	COLLAIRNE	CONCEPTUAL DESIGN	DESIGN	PROCURE & FAB
5.3.2	NEUTRALIZER GAS PUFF SYSTEM	COLLAIRNE	CONCEPTUAL DESIGN	DESIGN	PROCURE & FAB
5.3.3	REPAIR LENSING TIPS (TSVH)	COLLAIRNE	CONCEPTUAL DESIGN	DESIGN	PROCURE & FAB
5.4	ECH INSIDE LAUNCH UPGRADE	PRATER	CONCEPTUAL DESIGN	DESIGN	PROCURE & FAB
5.4.1	TC INSTALLATION ON REMAINING WINDOW ASSY	HOFFMANN	CONCEPTUAL DESIGN	DESIGN	PROCURE & FAB
5.4.2	MODE CONVERTER MODIFICATION	NOELLER	CONCEPTUAL DESIGN	DESIGN	PROCURE & FAB
5.4.3	POST CORRECTOR/THRU-PORT INSTALLATION(TSVH)	HOFFMANN	CONCEPTUAL DESIGN	DESIGN	PROCURE & FAB
5.4.4	WINDOW ASSY SYSTEM (10EA) (OSVH)	HOFFMANN	CONCEPTUAL DESIGN	DESIGN	PROCURE & FAB
5.4.5	REDIRECT PROTOTYPE ANTENNAS TO 30°(2EA)(TSVH)HOFFMANN	HOFFMANN	CONCEPTUAL DESIGN	DESIGN	PROCURE & FAB
6.0	ELECTRICAL ENGINEERING TASKS	ROCK	CONCEPTUAL DESIGN	DESIGN	PROCURE & FAB
6.1	DEVICE UPGRADES	ROCK	CONCEPTUAL DESIGN	DESIGN	PROCURE & FAB
6.1.1	1 SO 1 DETECTORS	ARNOLD	CONCEPTUAL DESIGN	DESIGN	PROCURE & FAB
6.1.2	SI/82 PROTECTION	ARNOLD	CONCEPTUAL DESIGN	DESIGN	PROCURE & FAB
6.1.3	ELECTRONIC CALIBRATION LAB	ARNOLD	CONCEPTUAL DESIGN	DESIGN	PROCURE & FAB
6.2	ICRH SYSTEMS	KEREN	CONCEPTUAL DESIGN	DESIGN	PROCURE & FAB
6.2.1	ICRH UPGRADES (FUCD WITH ORNL)	KEREN	CONCEPTUAL DESIGN	DESIGN	PROCURE & FAB
6.3	NEUTRAL BEAM	COLLAIRNE	CONCEPTUAL DESIGN	DESIGN	PROCURE & FAB
6.3.1	ARC REGULATION	COLLAIRNE	CONCEPTUAL DESIGN	DESIGN	PROCURE & FAB
6.3.2	LOGIC CONTROL UPGRADE	COLLAIRNE	CONCEPTUAL DESIGN	DESIGN	PROCURE & FAB
6.3.3	SYSTEM AUTOMATION	COLLAIRNE	CONCEPTUAL DESIGN	DESIGN	PROCURE & FAB
6.3.4	TOTAL BEAM ENERGY (TBE) UPGRADE	COLLAIRNE	CONCEPTUAL DESIGN	DESIGN	PROCURE & FAB
6.4	ECH SYSTEMS	KEREN	CONCEPTUAL DESIGN	DESIGN	PROCURE & FAB
6.4.1	RF POWER SUPPLY INSTALLATION (ONE SYSTEM)	SANTAMARIA	CONCEPTUAL DESIGN	DESIGN	PROCURE & FAB
6.4.2	GYROTRON TESTS OF SN 105	KEREN	CONCEPTUAL DESIGN	DESIGN	PROCURE & FAB
6.4.3	INSIDE LAUNCH COMPONENT TESTS	KEREN	CONCEPTUAL DESIGN	DESIGN	PROCURE & FAB
6.4.4	UPGRADE MAGNET LEAD COOLING SYSTEM	KEREN	CONCEPTUAL DESIGN	DESIGN	PROCURE & FAB
6.4.5	UPGRADE WATER HOSES	KEREN	CONCEPTUAL DESIGN	DESIGN	PROCURE & FAB
7.0	COMPUTER MOVE	HEWLINE	CONCEPTUAL DESIGN	DESIGN	PROCURE & FAB
7.1	MOVE USC FROM BLDG 13 TO BLDG 15	HEWLINE	CONCEPTUAL DESIGN	DESIGN	PROCURE & FAB

# **PROGRAM STATUS**

## **1<sup>ST</sup> QUARTER – FY 1989**

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**TASK:** INTERNATIONAL COOPERATION

**FY89 FUNDING:** \$ 1000 K

**B/R NO:** AT101014Z

**FY89 PLAN:** \$ 1000 K

**CONTRACT NO:** DE-AC03-89ER51114

**GA PRINCIPAL INVESTIGATOR:** R. STAMBAUGH/D. BAKER/ J. LUXON

**SAN PROJECT MANAGER:** C. BEIGHLEY

**OFE PROGRAM MANAGER:** E. OKTAY

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### **TORE SUPRA**

The machine has been difficult to start after the one month vent. There have been problems with timing because of the pulse required for TF coil number 17. The pulsed coil technique works relatively well from all other points of view (except that a 30-minute cooldown cycle is required between pulses). A 2.0 tesla field is produced for 2 to 3 minutes but the coil current ramp up-time must be controlled very precisely to prevent excessive coolant heating and expansion.

They have achieved 600 kA for 1 sec. There have been having many disruptions. They suspect problems with coil ripple, dirt in the machine, position control, and a faulty discharge cleaning system. EML experiments still have priority for near term experiments.

The spectra and resulting radial field line excursions and islands, due to the toroidal field coil with the full eighteen turns, as well as for reduced number of turns, have been numerically calculated. The effect of finite collisional mean free path on diffusion of field lines has also been investigated numerically.

J. Luxon and T. Evans attended the TORE SUPRA Steering Committee Meeting in October. The program plan for the next year, the role of U.S. and General Atomics experiments, and the need for a participative planning process were topics of discussion.

## HIDEX – Nagoya Tokamak Experiment

During the first week of November we attended the American Physical Society, Plasma Physics Division Conference in Hollywood, Florida, and presented posters on some of our HIDEX results.

Since then we have continued to work on the analysis of the data, in order to be able to write a paper summarizing the experiment. A. Howald has been concentrating on the question of particle collection in the pump limiter, since he thinks this is still the least well understood aspect of our experiment in Nagoya. T. Leonard has been looking at heat transport in conjunction with HIDEX, while L. Peranich has been studying the correlation of MHD activity with HIDEX.

We have found a strong relationship between the collection efficiency and the heat flux incident on the limiter. The heat flux appears to be proportional to the collection efficiency. The heat flux factor appears to be somewhat smaller for operation in the island o-point, but the effect is small.

## ASDEX

The ASDEX/U.S. DOE Steering Committee Meeting was held in Nice in October. T. Simonen and J. Luxon attended. Work from the past year was summarized and plans for the next year were presented and approved.

Dan and Mary Thomas returned from ASDEX after a two-month stay preparing the Li beam upgrade diagnostic for current density measurements during LHCD experiments. The ion source hookups were completed and the beamline operated successfully at ion currents from 10 to 20 mA (the power supply limit). The beam could be operated either in continuous or pulsed mode, however for quasi CW operation, a thermal instability results in runaway currents. This will be rectified in the future by feedback controlling the filament heating power supply based on the emission current density. Ion beam quality was very good – based on rough profile measurements in the neutralizer section, beam diameter of  $\sim 1$  cm was achievable for all current levels. The extraction voltage was found to be a sensitive parameter for minimizing the beam waist. Beam energies were power supply

limited to below 65 keV. Initial alignment of the neutralizer was performed, however filament power supply problems prevented neutralization efficiency measurements before our return home. These will be performed by McCormick after the HV supplies are repaired – probably in a couple of weeks.

The edge density profile data analysis code was installed on the ASDEX Cray computer. It is compiled and running but some bugs remain.

## JET

Tim Luce has made preparation to visit JET during the second quarter.

## JFT-2M

Initial discussions were held with Dr. Maeda in FY88. We are continuing to analyze experimental program possibilities.

## CHS

Initial plans for the CHS Cooperation have been made including ORNL and Nagoya.

## JT-60

No activity.

## INTERNATIONAL COOPERATION

	FY89 BUDGET		FY89 ACTUALS	
	FTE's	TOTAL \$000	FTE's	TOTAL \$000
TORE SUPRA	1.3	200	1.6	44
ASDEX	0.9	200	0.3	27
JET	0.7	175	0.0	0
CULHAM	0.1	25	0.0	0
HIDEX	0.6	100	2.7	84
CHS	0.5	100	0.0	0
JFT-2M	0.7	165	0.0	0
JT-60	0.2	35	0.0	0
Total	4.8	1000	4.6	155

# CONTRACT MANAGEMENT SUMMARY REPORT

TITLE: INTERNATIONAL COOPERATION B\R NO: AT101014Z

CONTRACT NO.: DE-AC03-89ER51114

CONTRACTOR: GENERAL ATOMICS

P.O. BOX 85608

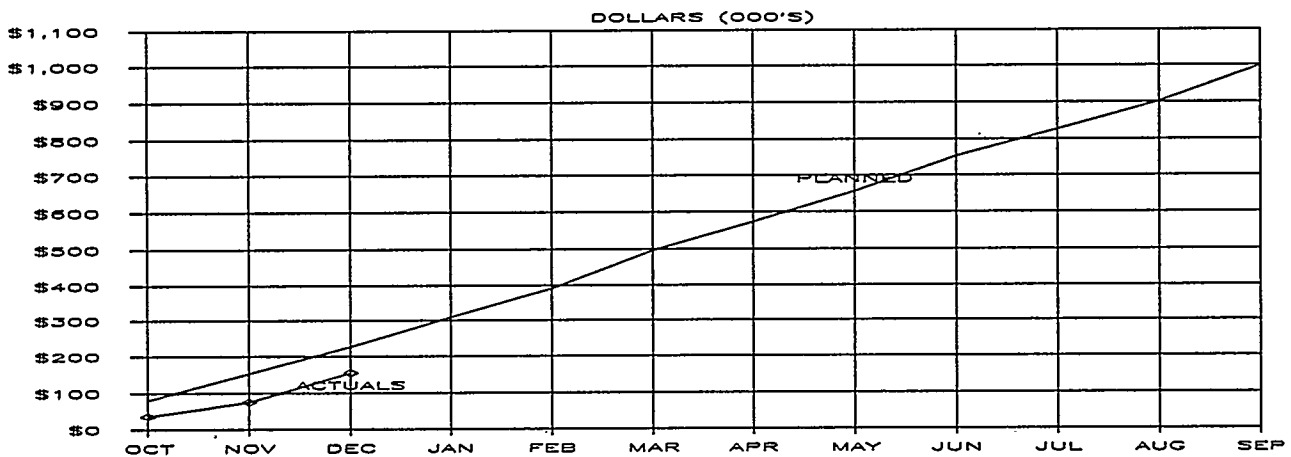
SAN DIEGO, CA. 92138

COST & LABOR PLAN DATE:

JANUARY 12, 1989

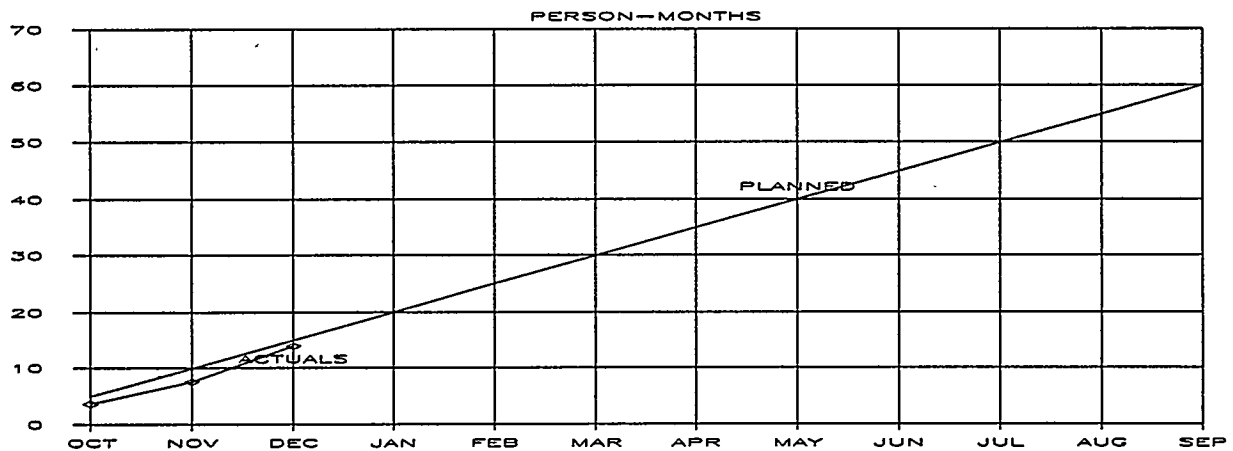
START DATE: SEPTEMBER 30, 1988

COMPLETION DATE: SEPTEMBER 30, 1989



TOTAL

PLANNED	\$80	\$73	\$75	\$82	\$81	\$104	\$80	\$82	\$95	\$74	\$78	\$96	\$1,000
ACTUAL	\$36	\$38	\$81										\$155
VARIANCE	\$44	\$35	(\$6)										
CUM VAR	\$44	\$79	\$73										



PLANNED	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	60.0
ACTUAL	3.6	3.9	6.4										13.9
VARIANCE	1.4	1.1	-1.4										
CUM VAR	1.4	2.5	1.1										

SIGNATURE OF PARTICIPANT'S PROJECT MANAGER & DATE:

**PROGRAM STATUS**  
**1<sup>ST</sup> QUARTER - FY 1989**

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**TASK:** CIT PHYSICS

**B/R NO:** AT101018B

**CONTRACT NO:** DE-AC03-89ER51114

**FY89 FUNDING:** \$ 120 K

**FY89 PLAN:** \$ 120 K

**GA PRINCIPAL INVESTIGATOR:** J. LUXON

**SAN PROJECT MANAGER:** C. BEIGHLEY

**OFE PROGRAM MANAGER:** T. JAMES

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MILESTONE	LEVEL	APPROVED DATE	TARGET DATE	COMPLETION DATE
1. Complete time dependent code			4-89	
2. Complete application to CIT			9-89	

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**REMARKS:**

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## VACUUM CHAMBER FORCES RESULTING FROM FAILURE OF THE VERTICAL POSITION CONTROL SYSTEM

### INTRODUCTION

A model for the forces on the vacuum chamber resulting from a failure of the vertical position control system is given in GA-A19277 (by Jensen and Chu, submitted to *Physics of Fluids*). The model consists of two parts, a static part dealing with the equilibrium and a dynamic part which determines the evolution of the equilibrium.

In order to determine the relevance of the model to real events a comparison of model predictions to experimental observations from DIII-D is made. The simplest piece of the comparison concerns the static part. An expanded version of the DIII-D equilibrium fitting code, which allows for toroidal as well as poloidal currents in the vacuum chamber wall, was used. For the cases studied, it was possible during the vertical displacement episode to obtain good fits to experimental data only when both toroidal and poloidal vessel currents were included. This provides strong support for the model. A portion of this material was presented as a poster at the APS meeting in Florida\*. A paper on this subject is planned.

### Status

Work on the more difficult portion, namely comparing predictions from the dynamics part of the model to experimental observations has started. It is the plan to construct a simulation code corresponding to the model. The most difficult part of this simulation code concerns the evolution of the function  $f(\psi)$  [ $B_T(\psi) - R$ ]; it is assumed that this function can be expanded in a Taylor series and expressions for the time derivatives of the expansion coefficients have been found. Initially the code will be used for a study of sensitivity to various input parameters. Most important may be the study of sensitivity to the assumptions on the plasma resistivity. It would be fortunate if plasma resistivity could be neglected so that the dynamics is determined mainly by the resistance of the vacuum chamber wall to toroidal and poloidal currents.

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\* "Vertical Forces on Vacuum Chambers of Elongated Tokamaks After Control System Failure," by T.H. Jensen, L.L. Lao and M.S. Chu, *Bull. Am. Phys. Soc.*, **33** 1975 (1988).



# CONTRACT MANAGEMENT SUMMARY REPORT

TITLE: CIT PHYSICS B/R NO:AT101014Z

CONTRACT NO.: DE-AC03-89ER51114

CONTRACTOR: GENERAL ATOMICS

P.O. BOX 85608

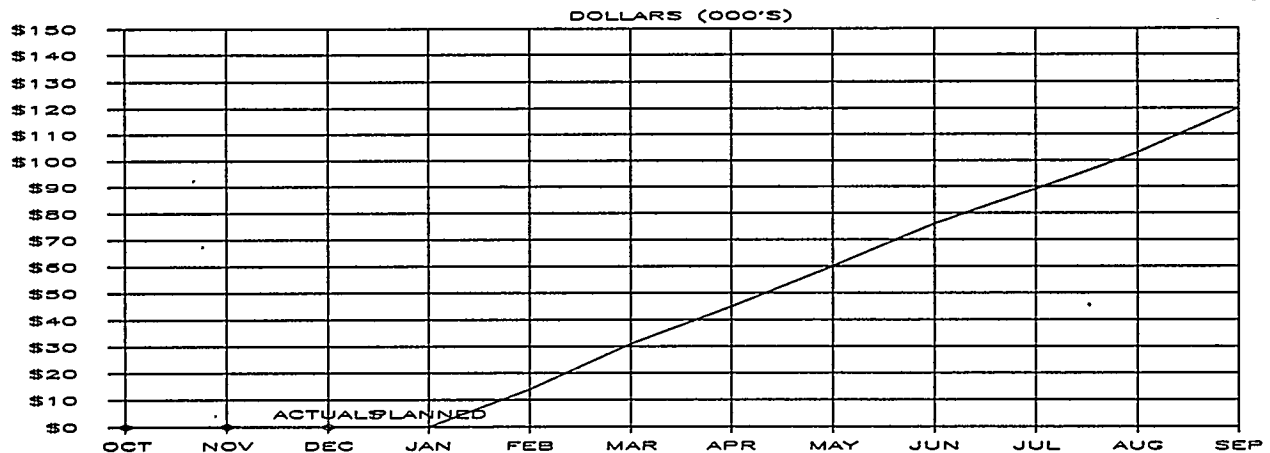
SAN DIEGO, CA. 92138

COST & LABOR PLAN DATE:

JAN 12, 1989

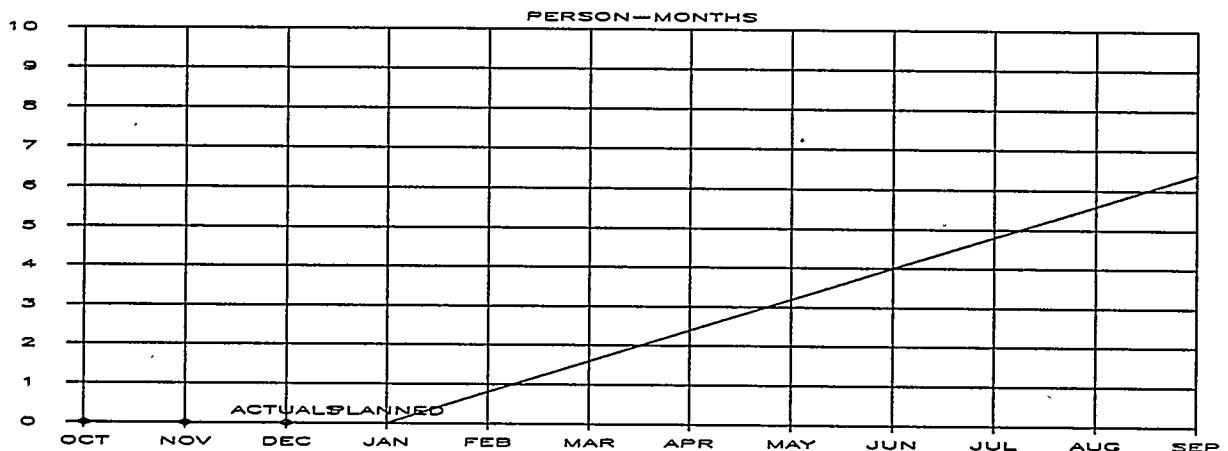
START DATE: SEPTEMBER 30, 1988

COMPLETION DATE: SEPTEMBER 30, 1989



TOTAL

PLANNED	\$0	\$0	\$0	\$0	\$14	\$17	\$14	\$15	\$16	\$13	\$14	\$17	\$120
ACTUAL	\$0	\$0	\$0										\$0
VARIANCE	\$0	\$0	\$0										
CUM VAR	\$0	\$0	\$0										



PLANNED	0.0	0.0	0.0	0.0	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	6.4
ACTUAL	0.0	0.0	0.0										0.0
VARIANCE	0.0	0.0	0.0										
CUM VAR	0.0	0.0	0.0										

SIGNATURE OF PARTICIPANT'S PROJECT MANAGER & DATE: