SPEAR 3

Quarterly Progress Report

Stanford Synchrotron Radiation Laboratory

July through **September**
2001

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A. SPEAR 3 PROJECT SUMMARY

1. Technical Progress

Summary - The SPEAR 3 project is near the 50% completion mark in terms of accomplishments, costs and overall progress. The major part of the conventional construction (mostly shielding modifications) has been accomplished on schedule during the CY 2000 and CY 2001 regular shutdown periods with completion scheduled for the CY 2002 regular shutdown. The main magnet fabrication will be complete and delivered near the end of this year with correction magnet completion by next summer. Vacuum chamber production has proved more difficult with the current completion goal toward the end of next summer. The assembly of magnets and vacuum chambers on new steel support rafts will be the major activity during the coming year. A prototype raft with magnets and vacuum system has been assembled. (See Section 1.1) The arrival of production support rafts will begin in December of this year. Another goal for the coming year will be the optimization and completion of the detailed schedules for the removal of SPEAR 2 and the installation of SPEAR 3 in FY 2003.

On July 24, 2001, the DOE Office of Science held the fifth semi-annual Status Review of the SPEAR 3 project. The agenda covered Accelerator Physics, Magnets, Vacuum RF System, Instrumentation and Controls, Installation Plans, ES&H and Cost/Schedule. The DOE Committee Summary report concluded, "The SPEAR 3 project is within costs (TEC is 58M$), on schedule (CD-4 is 2/22/04) and meets the Technical scope objective." The committee expressed strong interest in the final installation plans and schedule for FY 2003. They requested a complete and refined schedule at their next review and recommended that an independent technical and ES&H review of the installation plan be conducted.

Magnet System - The production of major magnets is nearing completion. Dipoles are 100%, quadrupoles 90%, and sextupoles 80% complete. The final shipment of these magnets is scheduled to arrive from IHEP near the end of this calendar year. The prototype unit for the Horizontal and Vertical Corrector magnet arrived in September and met specifications. Production of 74 units at IHEP was approved and final delivery of these units is scheduled for May 2002**.** A prototype support raft with production magnets (one dipole, two quadrupoles, one sextupole and a corrector magnet) was assembled to confirm design and assembly tolerances. The production rafts are now in fabrication.

Vacuum System - While the E-beam welding of 12 units of the QFC vacuum chamber has progressed, welding problems were found at a high stress point in the chambers which resulted in vacuum leaks. A detailed analysis indicated that deeper welds and thinner side plates for the copper chamber will help the problem. In addition, other information indicates that the copper undergoes structural changes at bake-out temperatures of 200º C. Future bakeouts of longer periods at ~150º will also be utilized.

RF System - While production of RF cavities remains on track and deliveries of the four cavities are scheduled for the beginning of CY 2002, problems have been encountered in the klystrons manufactured in Marconi. The tube delivered for SPEAR 3 in March 2001 has failed as well as several tubes manufactured for PEP-II. Marconi does not appear capable of repairs and appropriate actions are being taken. While some failed tubes are being repaired locally at CPI and at SLAC, a decision was made that SLAC will manufacture four tubes in the next two years. The SLAC tubes are more robust and should have longer lifetimes. Note that PEP-II requires in excess of eight tubes, while SPEAR 3 requires only one.

Power Supply - In the power supply area, a PEP-II chopper module supply was tested. The module performed well and the decision was made to proceed with fabrication of six modules for the SPEAR 3 dipole power units. A design package is being reviewed for six other large free-standing supplies that power four quadrupoles and two sextupole strings.

Instrumentation and Controls – For these systems, efforts were devoted to further detailed specifications of the Computer Control System and finalizing the plans for the BPM processing and Timing Signal Systems. Work is continuing on the design of the fast corrector magnet controllers and the overall Machine Protection System.

Cable Plant - Another important accomplishment of the SPEAR 2 shutdown period during this quarter was the fabrication and installation of new cable trays and associated supports that will carry power, control, and monitoring cables from building 118 across the ring to each straight section area. New supports were required to meet earthquake standards. New cable trays were also installed through building 118 to meet the needs of the new power supply systems that will be installed for SPEAR 3. As many cables as possible will be installed during the coming year.

Accelerator Physics - During this reporting period, the SPEAR 3 accelerator physics group concentrated on the analysis of magnetic measurement data, software application development, diagnostics and impedance studies. Studies of electron beam loss during injection are proceeding for the Radiation Physics Group. Documentation outlining the physics aspects of the synchrotron light monitor was also developed.

ES&H - In the ES& H activities, studies have continued to comprehensively address all design and shielding requirements. During this reporting period, the new WEST straight section area shielding was completed; ES&H issues were reviewed and monitored and properly addressed by the subcontractor.

2. Cost Reporting

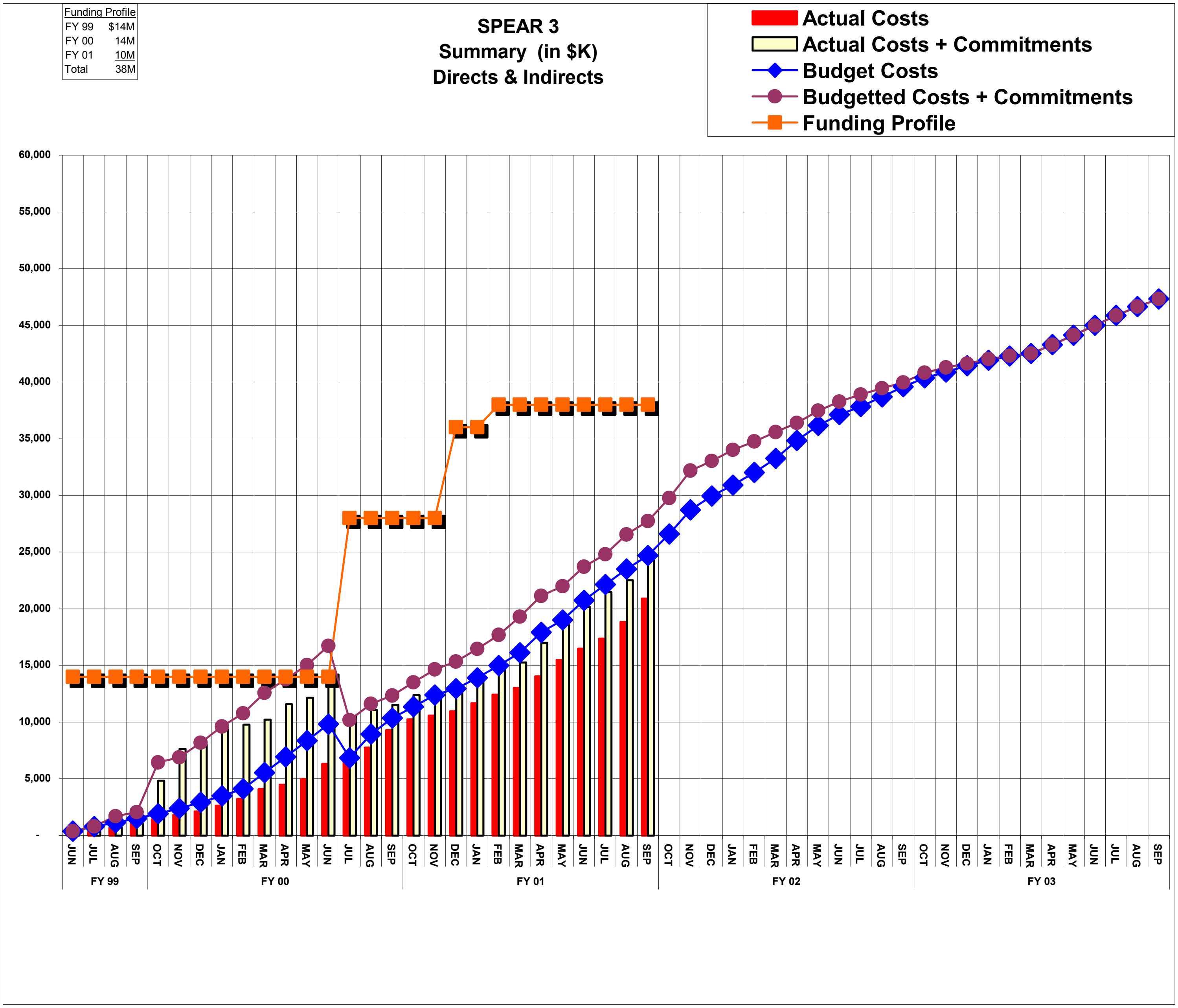
The total project costs and commitments through September of this quarter are provided in Table A1. The integrated costs and commitments per month are given in Fig. A1.

Table A1
Costs and Obligations
(Through September 2001)

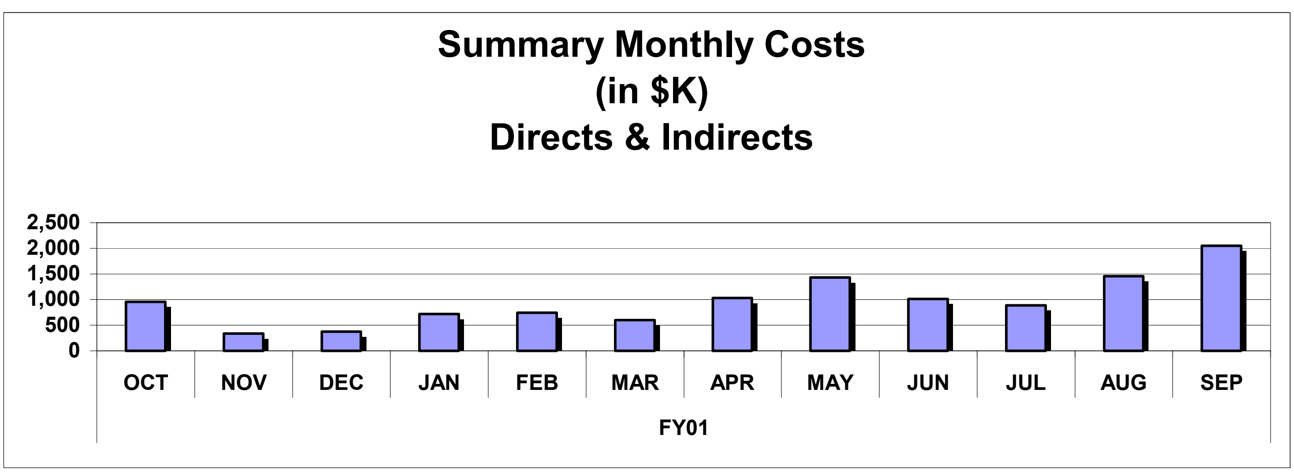
	K$	
	Direct	Direct & Indirect
Costs	18,375	20,889
Commitments	3,413	3,703
Total	21,788	24,592

Table A2 provides the project performance data with associated cost and schedule variances at WBS Level 2. Monthly plots of this data for FY 2001 are provided in Figure A2.

The project schedule, from which the schedule variances are determined in Table A2 has been under revision. The effort is largely complete for the WBS Level 2 areas of Magnets, Power Supplies, R.F. System, Instrumentation and Controls and Beam Lines. The work is still in progress for Vacuum, Cable Plant and Facilities.



Funding Profile
FY 99 $14M
FY 00 14M
FY 01 10M
Total 38M
SPEAR 3
Summary (in $K)
Directs & Indirects
Actual Costs
Actual Costs + Commitments
Budget Costs
Budgetted Costs + Commitments
Funding Profile
60,000
55,000
50,000
45,000
40,000
35,000
30,000
25,000
20,000
15,000
10,000
5,000
-
JUN JUL AUG SEP OCT NOV DEC JAN FEB MAR APR MAY JUN JUL AUG SEP OCT NOV DEC JAN FEB MAR APR MAY JUN JUL AUG SEP OCT NOV DEC JAN FEB MAR APR MAY JUN JUL AUG SEP OCT NOV DEC JAN FEB MAR APR MAY JUN JUL AUG SEP
FY 99
FY 00
FY 01
FY 02
FY 03



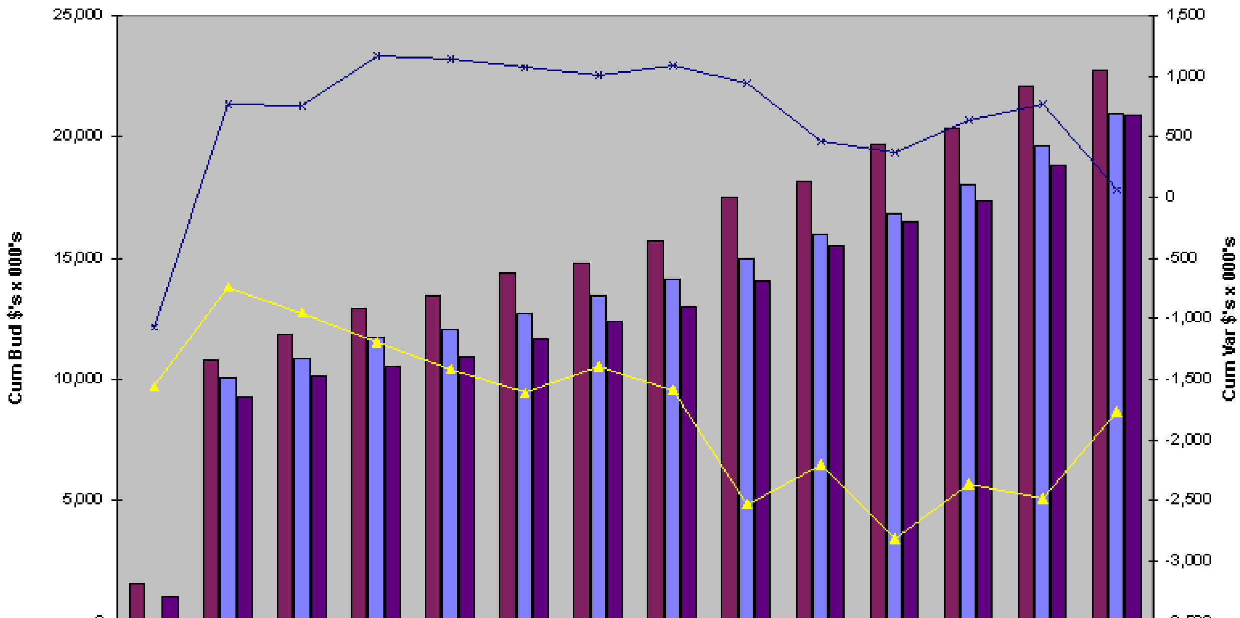
Summary Monthly Costs
(in $K)
Directs & Indirects
2,500
2,000
1,500
1,000
500
0
OCT NOV DEC JAN FEB MAR APR MAY JUN JUL AUG SEP
FY01

Fig. A1

Table A2

Cost/Schedule Status Report - DIRECTS, OH, ESC									
	Contract Type/No:		Project Name/No: SPEAR3 Rebaseline ($58M)		Report Period: 8/31/2001 9/30/2001		Signature: Title/Date: 11/9/2001		
(1) Original Contract Target Cost	(2) Negotiated Contract Changes		(3) Current Target Cost (1) + (2)		(4) Estimated Cost of Authorized Unpriced Work		(5) Contract Budget Base (3) + (4)		
					0		57,995		
Performance Data									
	Cumulative to Date					At Completion			
WBS[2]	Budgeted Cost		Actual Cost	Variance					
	Work Scheduled	Work Performed	Work Performed	Schedule	Cost	Budgeted	Latest Revised Estimate	Variance	
1.1 Magnets and Supports	5,335	5,344	4,932	9	411	8,873	8,873	0	
1.2 Vacuum System	4,720	4,154	4,509	-566	-355	10,926	10,926	0	
1.3 Power Supply System	812	736	446	-76	290	3,499	3,499	0	
1.4 RF System	2,435	2,401	2,296	-33	106	4,624	4,624	0	
1.5 Instruments Control & Protection	1,147	1,024	959	-123	64	3,633	3,633	0	
1.6 Cable Plant	1,328	639	657	-689	-18	2,354	2,354	0	
1.7 Beamline Front Ends	236	275	187	39	89	1,056	1,056	0	
1.8 Facilities	1,741	1,418	2,131	-323	-712	2,656	2,656	0	
1.9 Installation and Alignment	0	0	0	0	0	3,224	3,224	0	
1.0 Mgmt, Support, & Accelerator Pl	2,162	2,162	2,171	0	-9	4,037	4,037	0	
Gen. and Admin.	2,801	2,801	2,606	0	195	5,907	5,907	0	
Undist. Budget						0	0	0	
Sub Total	22,716	20,953	20,893	-1,763	61	50,788	50,788	0	
Management Resrv.						7,206	7,206	0	
Total	22,716	20,953	20,893	-1,763	61	57,995	57,995	0	

Figure A2



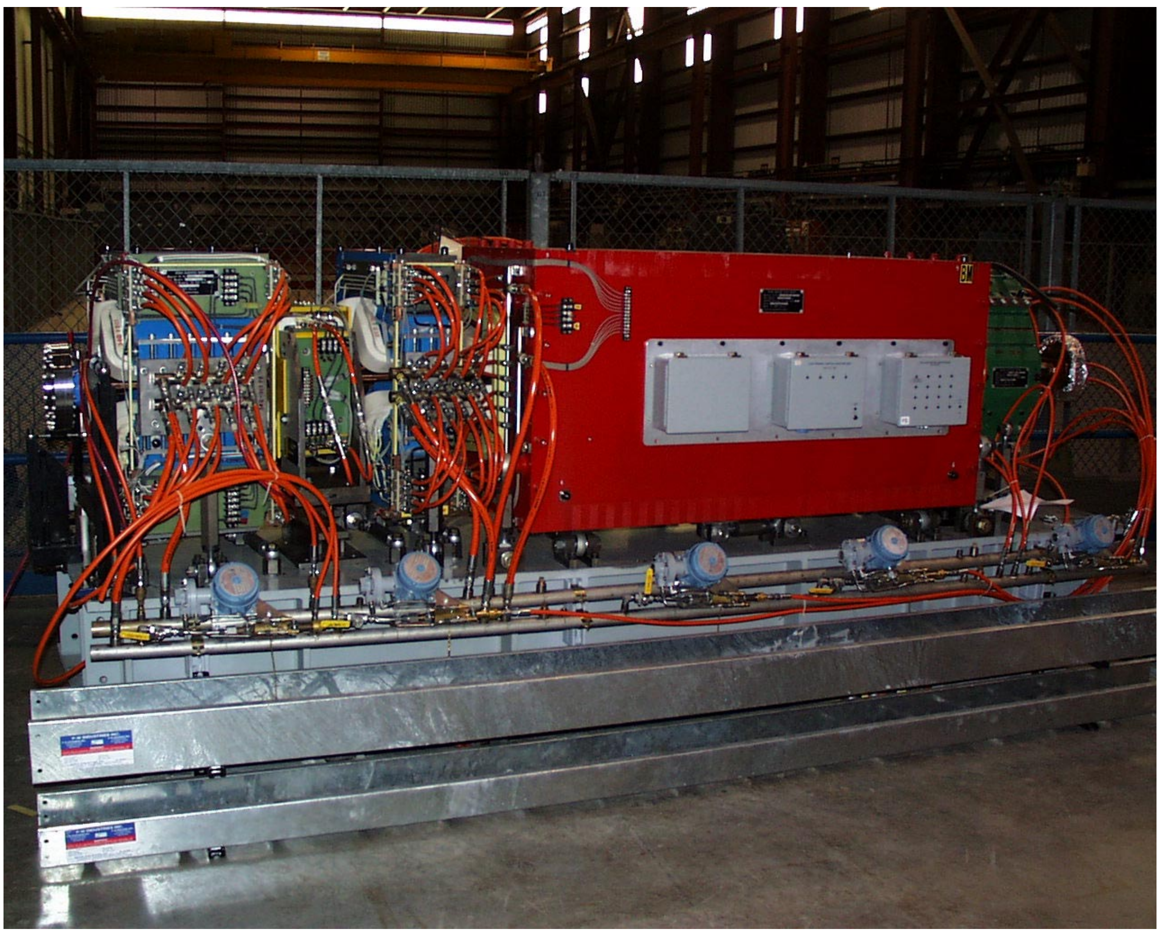
	FY99	FY00	OCT00	NOV00	DEC00	JAN01	FEB01	MAR01	APR01	MAY01	JUN01	JUL01	AUG01	SEP01
Bud	1,558	10,792	11,838	12,910	13,482	14,355	14,816	15,694	17,523	18,145	19,681	20,381	22,092	22,716
Per	0	10,056	10,890	11,720	12,068	12,744	13,424	14,107	14,994	15,942	16,865	18,022	19,611	20,953
Act	1,069	9,289	10,133	10,552	10,924	11,675	12,418	13,017	14,050	15,482	16,491	17,383	18,843	20,893
SV	-1,558	-736	-948	-1,190	-1,414	-1,611	-1,392	-1,587	-2,529	-2,203	-2,816	-2,359	-2,481	-1,763
CV	-1,069	767	757	1,168	1,144	1,069	1,006	1,090	944	460	374	639	768	61

B. Detailed Reports

1.1 Magnets and Supports

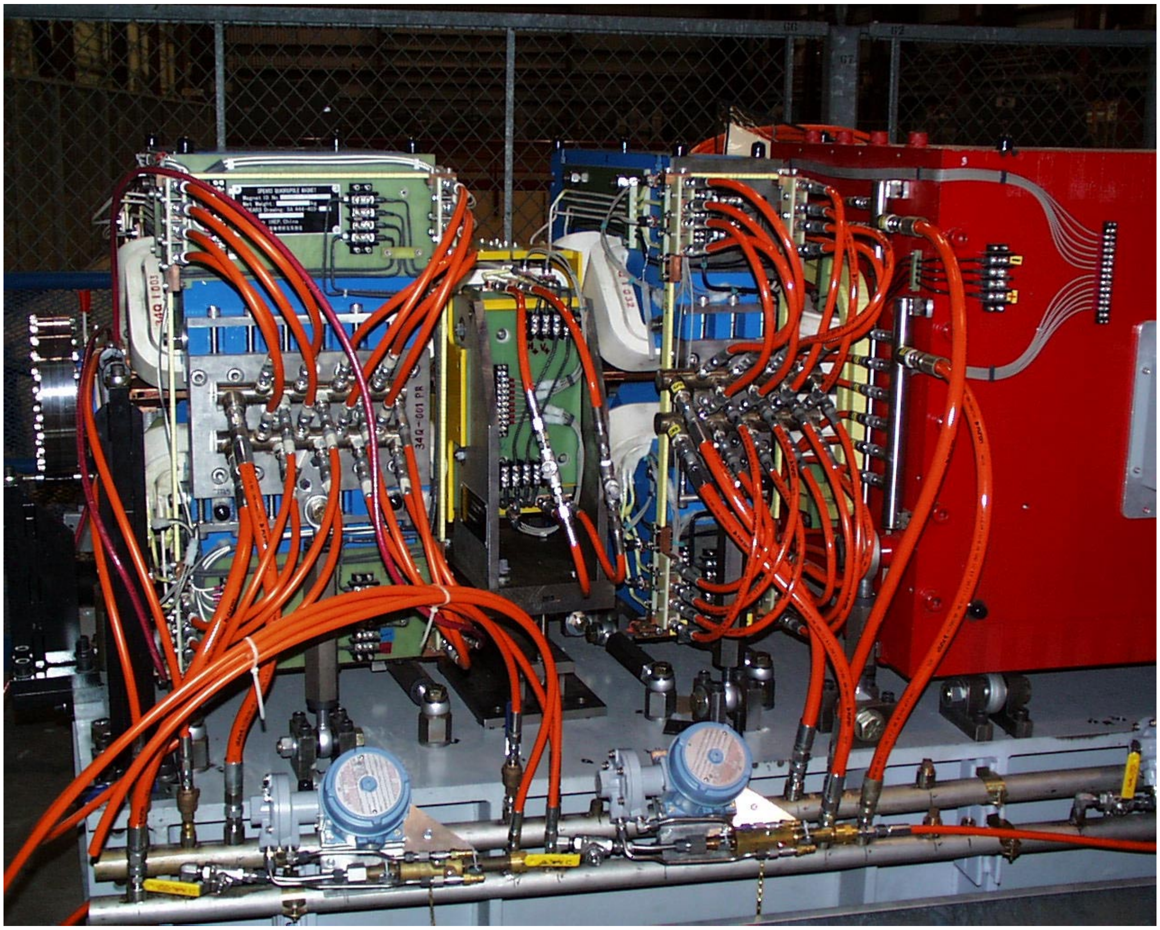
Support System

Work continues on the assembly of the SPEAR3 prototype raft with production magnets and vacuum chamber. Shown in the picture below are (L to R) the 34Q, H/V Corrector, 15Q, 145D, and 25S magnets installed and aligned onto the support raft. The assembled raft, weighing approximately 30,000 lbs, was removed and re-installed onto its supports and locating pins within .005" tolerance vertically. This was a major goal of the raft design and gives us confidence that we can install the complete aligned raft inside the SPEAR tunnel to a tolerance of +- .020".



Prototype Raft Assembly

All magnet support hardware has been ordered this quarter including struts, quadrupole mounting plates, support plates, and rafts. Mounting hardware (bolts, washers, etc.) will be ordered early next quarter. Shown in the picture below is the prototype Horizontal/Vertical Corrector magnet installed between its two adjacent quadrupoles. This is one of the tightest locations in the lattice and the Corrector fits as designed. The second location, after the sextupole, was also checked for fit and function. After mechanical checks of the prototype Corrector it was moved to magnetic measurements for qualification (see Corrector below). Other items completed are the LCW manifolds and flow switches. These items were developed on the prototype raft and finalized for production fabrication that will occur next quarter.



Assembly showing 34Q, Corrector, 15Q & 145D magnets with LCW manifold and flow switches

Magnet support rafts are underway in fabrication at Hogan manufacturing in the Sacramento valley. There are 46 rafts being constructed in this order with 8 Matching cell rafts to be ordered the next quarter. The delivery schedule is set for late November 2001 for the first set of rafts and it appears that the rafts may be delivered earlier, which gives additional time to assemble the first 50Q raft assembly. The pictures below show a few of the completed steel construction rafts. These rafts are box welded, annealed, surface ground, holes machined, uni-strut welded, painted, and then shipped to SLAC for assembly.

SSRL staff along side the 145D Type 1 Raft after completion in the welding sequence

50Q Rafts waiting shipment to the machining operation

Magnets

Richard Boyce and Nanyang Li visited IHEP in late September to review the magnet production. The magnets are in the final stages of completion as can be seen from the schedule below. The 60Q magnets have 100% of their hardware fabricated and assembly of the cores were just beginning during the visit. IHEP is preparing for shipment # eight which is scheduled to leave China in early October.

At this point in the magnet production, IHEP has the following magnet completion percentage:

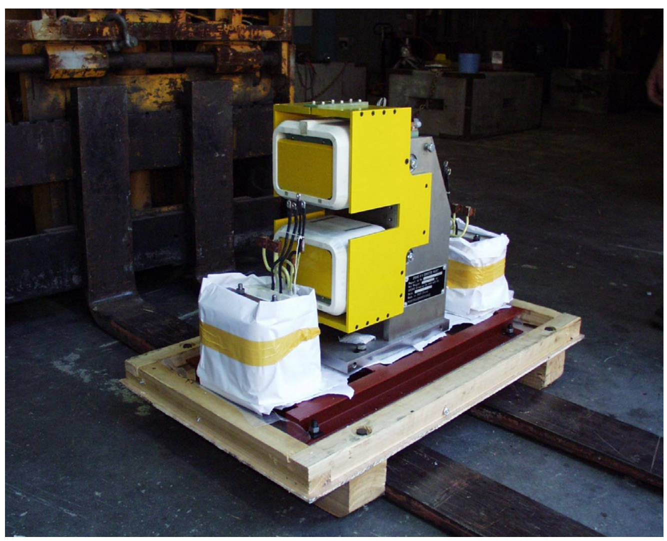
Magnet Type	Qty Required	Percent Complete
145D	30	100
109D	10	100
21S	46	65
25S	30	100
15Q	30	100
34Q	46	86
50Q	20	100
60Q	6	0
Corrector	74	0

Horizontal/Vertical Corrector Magnet

The H/V Corrector magnet production was released to IHEP on September 21st after completion of the prototype Corrector magnetic measurements at SLAC. The prototype Corrector was received at SLAC in early September, was mechanically checked, and magnetically qualified by the 21st of September.

During the visit to IHEP in September we observed the winding of the very complicated 192 turn coil and potting of two test coils. The complexity of the coil is due to the fact that the vertical steering field uniformity is dominated by the individual conductor placement. One of the test coils failed and was subsequently dissected showing the location and possible reason for the short in the winding. Additional coils are being fabricated to determine how best to process this complicated coil.

Horizontal/Vertical Corrector prototype at IHEP


H/V Corrector prototype magnet received at SLAC

Magnetic measurements

Measurements and fiducialization of the magnets are proceeding on schedule. Results of IHEP measurements have indicated that all magnets, received thus far, have met or exceeded the field quality and reproducibility requirements set forth in magnet specifications. Verification measurements at SLAC for the gradient magnets are proceeding. Verification measurements at SLAC for the quadrupoles and sextupoles are just beginning.

AC measurements of the prototype Corrector are just beginning. Since the corrector will be used in feedback mode to correct for vibrations in the synchrotron as seen on the photon lines, a fraction of the corrector field will operate at up to 100 Hz. We need to understand the attenuation characteristics due to eddy currents in the chamber on this time varying magnetic field. We also need to compare the measured results with results of MAFIA computer simulation runs made over a year ago.

1.2 Vacuum System

Work Summary

The engineering efforts and manufacturing milestones during the past quarter have been the following:

- Assembly, welding and vacuum processing the standard and matching QFC chambers.
- BM-1 chamber halves for all the standard cells received and inspected.
- Machining of the BM-2 chamber halves started.
- BM-1 production piece parts received.
- BM-2 piece part fabrication and procurement underway.
- Finalizing the design and producing prototype detail drawings of the septum chamber.
- Finalizing the design and analysis of the bellows modules.
- Finalizing the design of the primary vacuum chamber and aperture masking for the SLM.
- Completing the design and analysis of the cold finger and primary mirror for the SLM.
- Finalizing the overall optics, tunnel, and building layouts for the SLM
- Completed the HOM testing of the injection kicker prototype magnet/chamber.
- Fabricating the standard girder supports.
- Finalizing the design and analysis of the matching girder supports.

Standard Girder Chambers

<u>QFC Standard and Matching Chambers</u>

The production tooling modifications and weld programming were completed this quarter. The assembly/welding workflow was greatly improved and at peak production two chambers were completed in one week. This was above our plan of 1 to 1.5 chambers a week. Figure 1a and 1b show the QFC welding performed.

The first two completed chambers were successfully baked up to 200°C; however, the following two chambers opened up a leak at similar locations after raising the bake-out temperature from 150° to 200°C. The leaks were in the back wall weld. All the chambers were typically baked for 3 to 5 days at 150°C and raised to 200°C for 1 to 2 days. The bake-out procedure was based on the vacuum processing of the PEP-II copper chambers, and the project did not believe there was a need for further studies to determine if 200°C was an acceptable bake-out temperature for the SPEAR3 copper chambers.

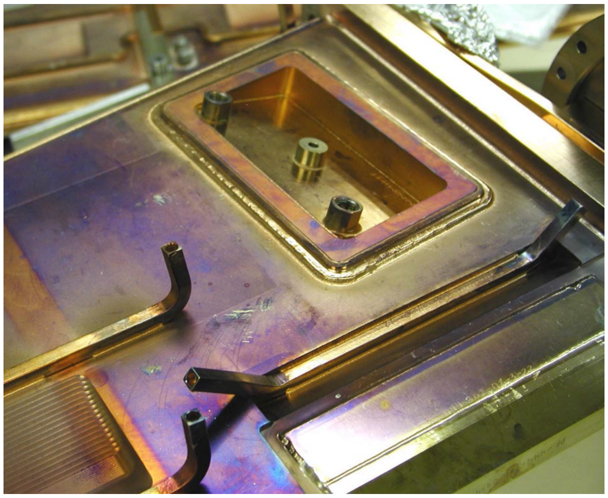
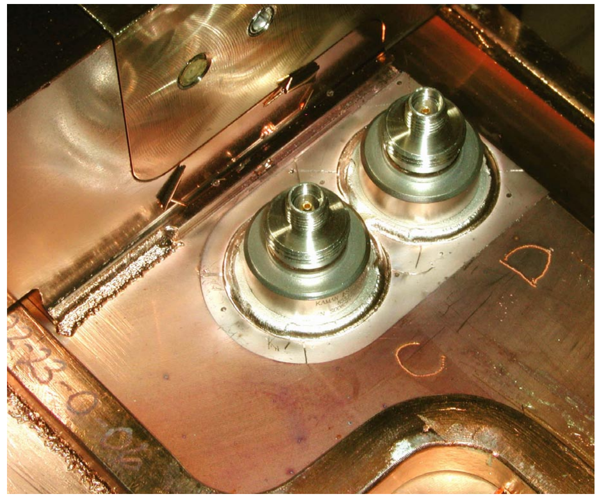



Figure 1a: QFC Chamber Absorber, Cooling Bar and Eddy Break Weld.
Figure 1b: QFC BPM Weld

The structural analysis indicated that the highest stress in the chamber was at the location of failure. Twelve of the fourteen standard QFC chambers were either fully welded or at the final weld step when the bake-out failure was discovered. Structural analyses using information from micrographs of the welds were used to study the chamber weld stresses. The micrographs showed that the weld penetration depth was less than the design value. The weld penetration depth was tested in the beginning of the fabrication, but the micrographs proved that the testing method was inaccurate. The calculated stresses using the actual depth of the weld were higher than the desirable levels. Several cases with varying parameters were analyzed to quantify and reduce the stresses in the welds. Any modification required would need to have minimal design impact, since all the parts and many of the chambers were completed. Also, the results from the analysis of the successful welds were used to qualify the acceptable stresses of the welds for a 200°C bake-out.

Literature research and material testing data was re-examined in an attempt to characterize the failure. The mechanical properties of annealed copper indicated decreased tensile strength of copper at elevated temperatures, as well as a steep drop in the percent elongation near 200°C. Depending on the grain size/condition of the material, the decrease in the mechanical properties of the material at elevated temperatures is magnified. For annealed copper with large grain sizes, the reduction in the tensile strength was found to be on the order of 50 percent. Further material testing on the copper weld joint continues and the chamber bake-out temperature will be optimized for mechanical reliability and outgassing rate. Current information indicates that the combination of high stress along with elevated temperature is creating the leaks. The condition of the weld and porosity of the welds are also probable contributors to mechanical failure. Continued studies will help validate the robustness of the design. It should be noted, that during operation these chambers do not nominally operate at high temperatures. Their average temperature will be 35°C and during some mis-steers the weld joint temperature would increase by less than 10°C.

From the material information and analysis, the current plan is to reduce the sidewall thickness, increase the weld penetration on the back wall reducing the stresses by about a factor of two, and reducing the bake-out temperature. The QFC prototype experience led the project to believe that the weld distortion could significantly reduce the slot height. Originally the weld penetration depth was kept to a minimum to reduce weld distortion, therefore the stresses at the welds did not allow for any design safety factor. However, the production tooling and weld sequencing nearly eliminated any weld distortion. The profile slot measurements of the twelve production QFC chambers indicated that increasing the weld depth would unlikely create large weld distortions. The thirteenth production QFC box was welded with the new weld parameters and alignment data showed minimal to no change in the slot profile before and after the box was welded. The existing twelve chambers will be re-welded to increase the depth of the welds at the back wall. The remaining seven QFC chambers for the standard and matching cells will have the back wall thickness reduced and greater weld penetration.

Figure 2: Completed QFC Chambers

The weld stress problem has delayed our production schedule by about one month. During this quarter we completed all the QFC cooling bar welds for the matching and standard cells. Originally the matching chambers were not scheduled to start until fall of 2002. End flanges need to be welded to complete the remaining boxes which should take approximately 1.5 weeks. However, re-welding and re-measuring the slot of the 12 existing chambers will delay our schedule by an additional 3 weeks. The alignment set-up for measuring the slot and fiducializing the chamber is shown in figures 3a and 3b. The tooling for re-welding was designed and built and the re-welding will start after re-calibration of the welder.

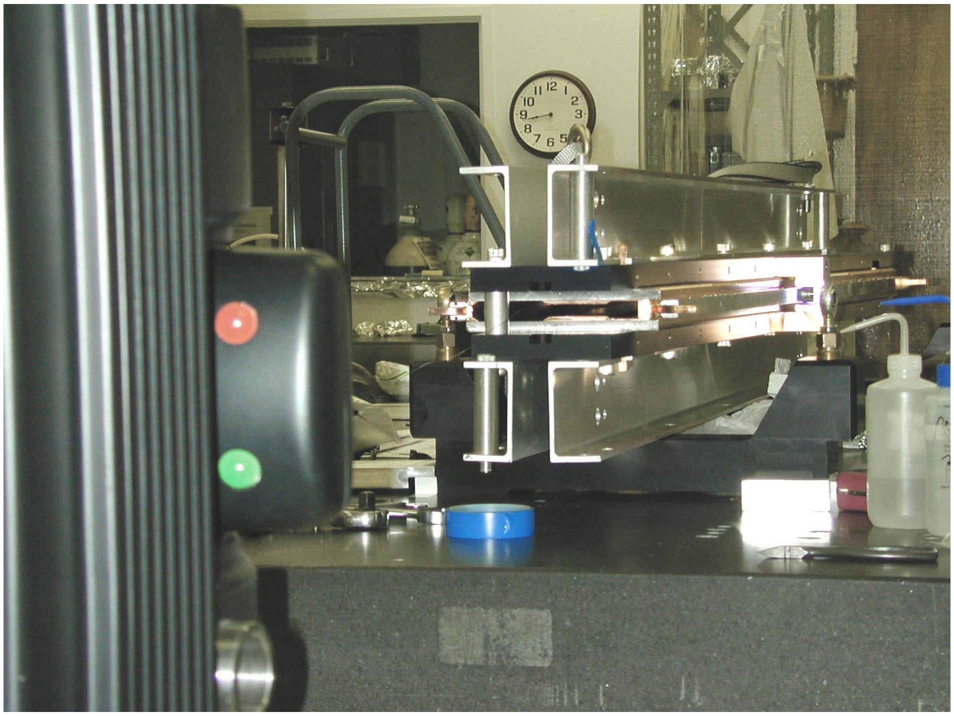


Figure 3a: Slot profile measurement of the QFC chamber in the box weld tooling.

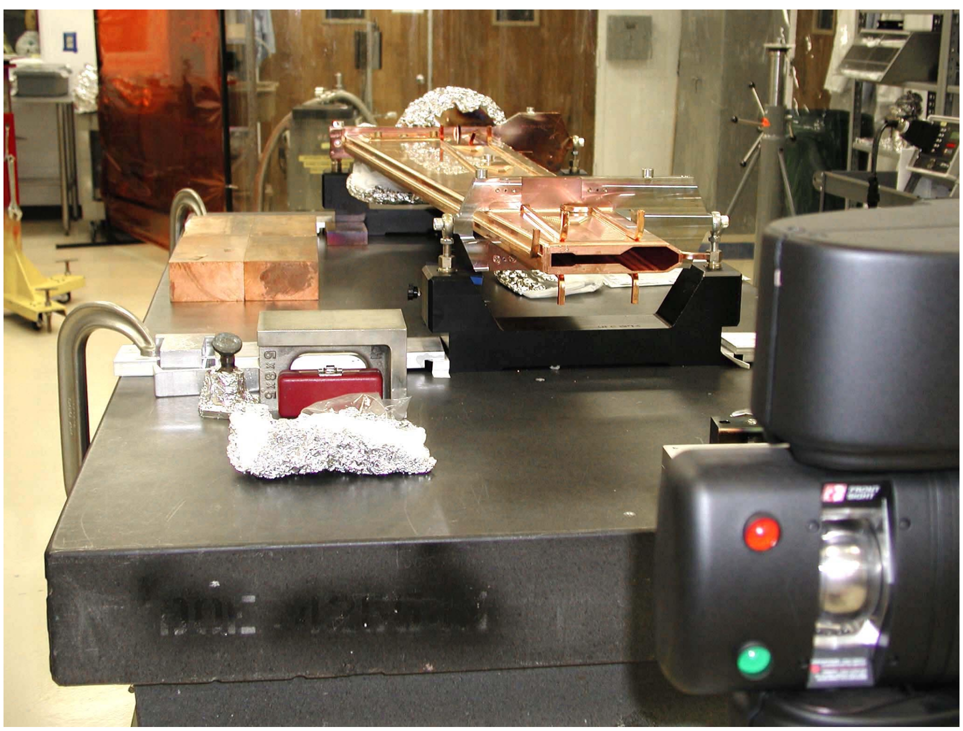


Figure 3b: Slot profile measurement and fiducializtion of the chamber after welding.

BM-1 Standard Chambers

Machining of the production BM-1 chamber halves was completed this quarter on schedule. All the piece parts excluding the eddy breaks have been received. The eddy breaks were delayed because the received cupronickel material did not meet the SLAC specification and had to be re-ordered from another vendor. The material was replaced within a week of determining that it was unsatisfactory for vacuum use and machining is underway. The production EB weld tooling was completed with modifications made from the first article experience. The BM-1 chamber was successfully assembled in the box weld tooling and the profile of the slot measured. The slot measurements indicated that the chamber was well within tolerance. The long BM-1 plates showed less distortion from machining than the short QFC plates and the slot profile was slightly better. The change in the material condition from a different plate rolling procedure, along with the experience in machining copper produced straighter plates.

The production EB weld programming for all the major welds was completed this quarter and the first BM-1 cooling bar welds are scheduled for completion by the end of October. Figure 4 shows the BM-1 cooling bars prior to being loaded onto the EB welder run-out table. The first three H3 absorbers for the BM-1 chamber were completed this quarter and the remainder should be complete by January.

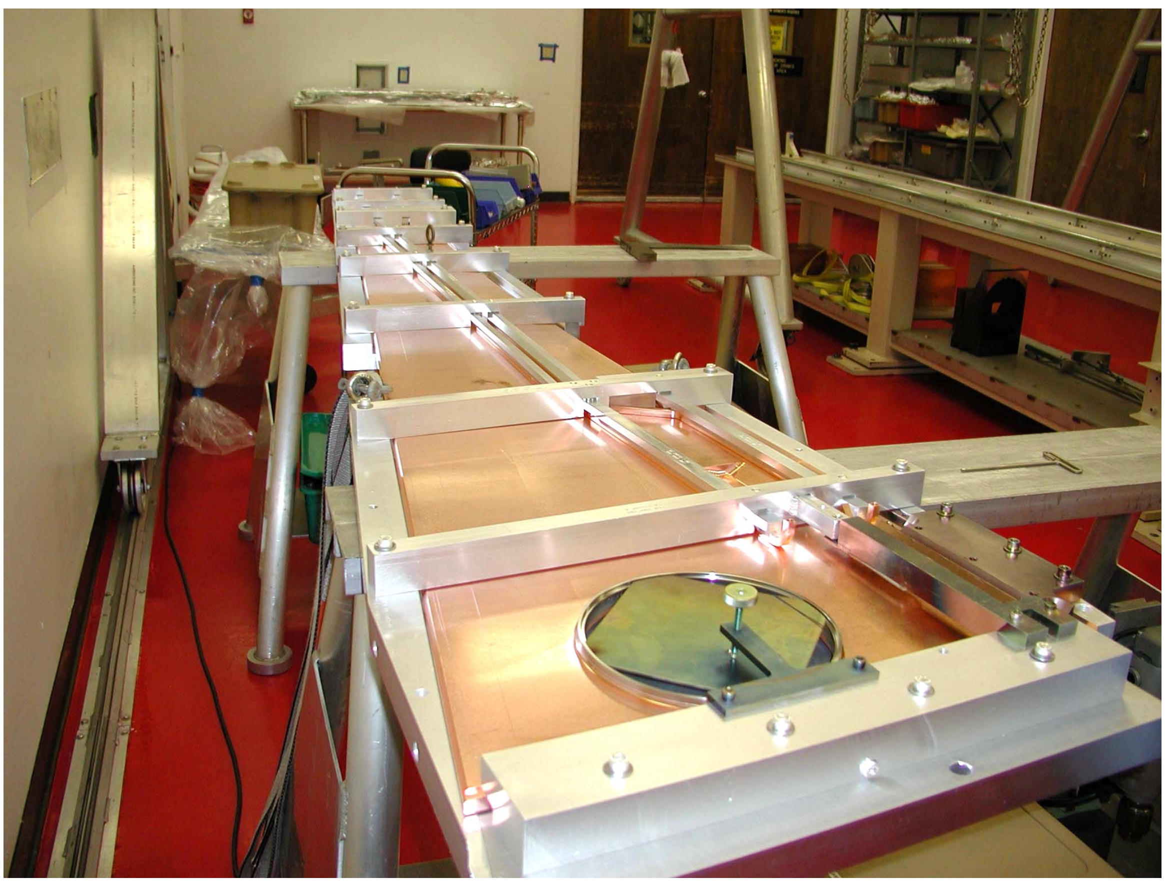


Figure 4: BM-1 Cooling Bar Weld Set-Up

BM-2 Standard Chambers

The machining for the BM-2 chamber halves started this quarter on schedule and the first shipment is due by the end of the year. Approximately half of the piece parts have been completed and inspected. The tooling modifications from the first article experience have been incorporated into the detail drawings. Production EB weld programming had already completed during the previous quarter.

Electron Beam Welding and Vacuum Facility

The calibration originally scheduled for this quarter was cancelled, but due to the continued technical problems, the calibration was rescheduled for this October. While the representative from Sciaky, the manufacturer of the welder is here calibrating, he will test and repair the overall welder system and install updated software. The machine has not been calibrated since it was delivered to SLAC in 1995.

A requisition to hire an additional welder was placed this quarter. This welder will provide us with another shift to help make up the schedule variance. Also, SLAC Machine Maintenance is planning on training their personnel on troubleshooting and repairing the welder to decrease downtime and the need to obtain repair people from out of the area.

Matching BM-1 and BM-2 Chambers

The matching cell A and matching cell B chamber designs are being finalized. Magnet-raft-support-vacuum clearances are being verified and the final waterline placement is underway. Structural, thermal and vacuum calculations are also being completed. The final review should be held by the end of the year.

Standard Girder Vacuum Supports

The standard girder vacuum supports are on schedule and the first shipment is due by the end of the year with the remaining shipment expected by the beginning of 2002. The support fabrication budget is within the original estimate.

Straight Section Drifts

Engineering work has restarted on the straight section drift chambers and the conceptual design should be complete by the end of next quarter. Fabrication of the RF straight components is still pending the HOM calculations.

Injection System

The higher-order-mode testing for the kicker chamber was completed this quarter. The electrical tests should be completed by the end of the year and if no significant changes are required, the production injection kickers will begin.

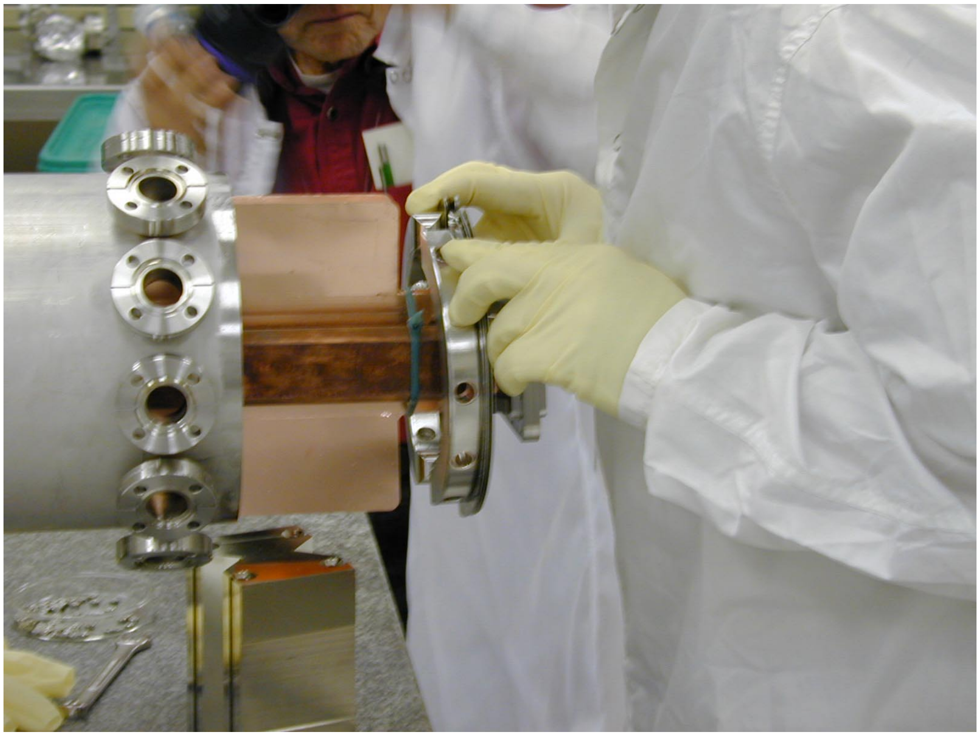


Figure 5: Injection Kicker Chamber/Magnet Prototype

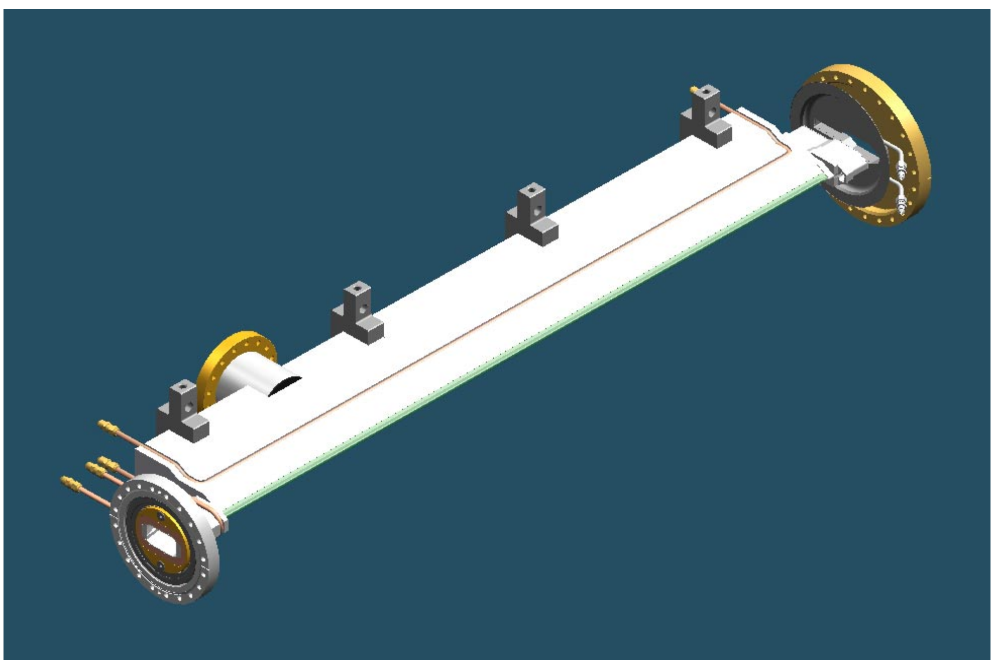


Figure 6: Septum Chamber

The preliminary prototype piece part drawings were completed this quarter and estimates are being made to build the prototype and production septum chamber. A prototype is desired to determine the fabrication tolerances and possibly improve the welding technique to reduce the weld distortion.

Bellows Module

The final design for the bellows module is near completion and a design review will be held in November. Detail drawings for a prototype bellows will be completed by the end of the year. Production bellows fabrication will not start until after the completion of the first lot of BM-1 chambers to verify the offset, pitch and yaw requirements for the bellows module.

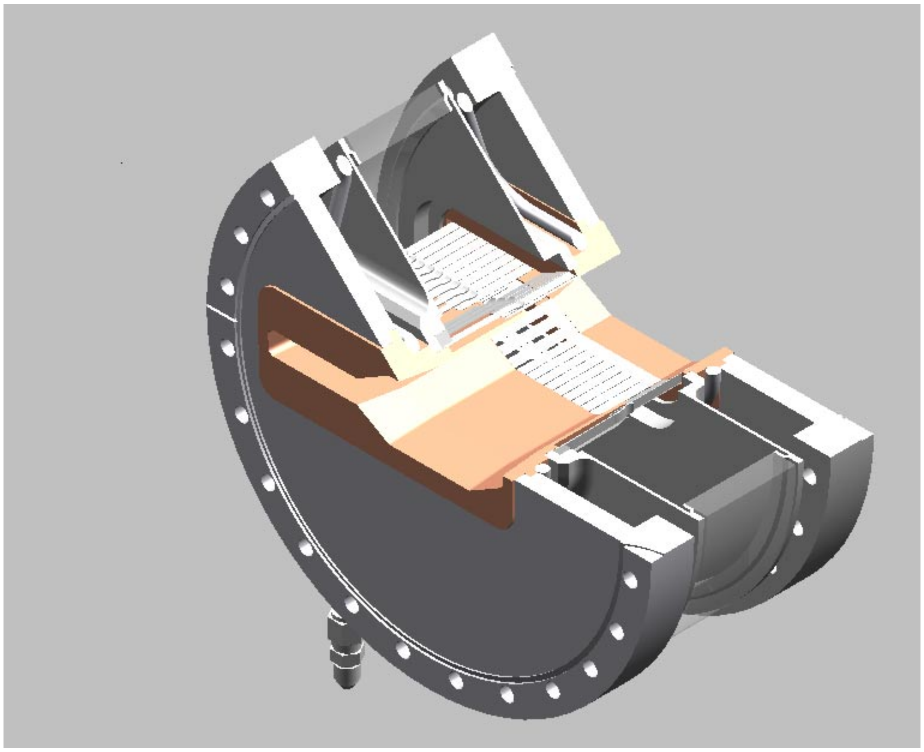


Figure 7: Bellows Module

Pumping System

All the production parts for the titanium sublimation pumps arrived this quarter except for the transitions. The first lot of transitions should be complete by November and the first lot of TSP pumps will be assembled by the end of the year.

1.3 Power Supplies

Unipolar Power Supplies

Dipole Power Supply

The PEP-II chopper module spare was brought over to the SPEAR Booster Building for testing under SPEAR 3 operating conditions. The SPEAR Bias Power Supply, which served as a bulk power source, was connected to the chopper module input. The chopper module output was connected to a string of White Circuit magnets to simulate a large, inductive load. The chopper module was run for 12 hours with 750 VDC input and with a module output of 600 V, 400 A. The module performed well. On the basis of this successful test, the decision was made to proceed with fabrication of 6 PEP-II style chopper modules for use in the SPEAR 3 dipole power supply.

The SLAC Power Conversion Department (PCD) has about 90% of the module electronic components on order for the chopper modules. The part ordering has gone smoothly, except for the availability of the 2 large, feed-through capacitors that are needed for each module. If the original source, or an alternate source is not found, then another solution will be considered. About 10% of the chopper module mechanical parts have also been ordered. At this time it appears that PCD night-shift personnel will build the chopper modules.

PCD has also received the chopper module controller printed circuit boards. The boards will be bench tested during the next reporting period. About 80% of the mechanical parts for 3 controller chassis are on order. The PCD fabrication shop in B24 is slated to build the 3 controllers.

Large Power Supplies

In addition to the Dipole Power Supply, there are 6 other large, freestanding power supplies needed for SPEAR 3. These power the QD, QF, QFC, QFC, SD and SF strings and have output ratings of 70 kW and 135 kW. IE Power is the designer/manufacturer. They have submitted a design package, which is currently undergoing review. If the design package is acceptable, the power supplies will be released for fabrication.

Intermediate Power Supplies

An RFP for 80 intermediate (rack-mounted) power supplies ranging in output from 2.5 kW to 15 kW was issued to industry. Proposals were received from 5 bidders. IE Power was selected to design and manufacture the power supplies based on technical responsiveness, lowest cost and acceptable schedule.

Titanium Sublimation Pump (TSP) Power System

An interdisciplinary design review of the TSP Power System that will power the 75 TSP pumps located around the SPEAR ring was held on August 22, 2001. The purpose of the review was to address the operational details of the TSP Power System and associated controls.

The TSP power system consists of 4 power supplies and a series of high-current switches. Four TSPs, one in each ring quadrant, will be powered simultaneously to sublimate the vacuum chamber.

IDOMs will be used to control the switching of the TSP power supplies to the appropriate TSP. The TSP power/control system will provide for fully automatic, unattended switching or manual (from a computer keyboard or touch screen) switching of the TSP power supplies. No local switching control will be provided and is unneeded, since vacuum chamber sublimation will occur during machine operation when the computer system is up and operational.

At this junction in time, the PCD fabrication shop is the most likely candidate to build the TSP switching chassis.

There are 4 TSPs per girder around the SPEAR ring. About 75% of the coding for the long-haul cables that will connect the TSPs to the power supplies in Building 118 has been completed.

One item that has been identified as long lead is the Amphenol connector that will mate with the connector on each TSP. However, it is expected that these will be received in time to support wiring of the rafts slated to start in December.

Bipolar Power Supplies

Corrector Power Supplies

Fabrication of a crate of 8 bipolar corrector power supplies has been complete since about mid-July. The 8 power supplies were tested for heat dissipation, noise and power supply cross talk. Although testing is still underway, no major problems have been uncovered.

Bira Systems, Incorporated has been contracted to fabricate and perform functional bench testing of 150 bipolar power supplies that will be needed to power the SPEAR 3 horizontal and vertical correctors, insertion device trims and the quadrupole modulation trims.

Quadrupole Modulation System (QMS)

The design effort has started. During the next reporting period a design review will be held to address:

- Equipment safety if a trim coil, or trim coil bus bar, should short to a main HV winding
- Suppression of the high voltages that can be induced in the trim coils if the currents in the main coils are chopped.
- Minimizing 10 Hz modulating current coupling into the quadrupole main windings.

Pulsed Power Supplies

Kicker Pulsers

The slow IGBT turn-on and turn-off times cited in the last report was solved by a redesign of the gate driver circuit and by reducing the output circuit inductance by a physical re-configuration of cable and connectors.

During prototype kicker pulser testing it was discovered that the high voltage cable has an impedance of 25 ohms. However, the pulser design is based on 22-ohm cable. The higher cable impedance unacceptably lowers the magnet current. Two initial solutions were eventually discarded as impractical. The first solution entailed an additional parallel cable. However, there would be an increased cost for the purchase and installation of additional cable and there are space constraints in the SPEAR ring. The second approach would have increased the charging voltage to compensate for the increased cable impedance, but this would compromise the IGBT rated to operating voltage safety margin.

It was decided to increase the charging voltage and to add one IGBT stack to compensate for this increased voltage. The result is that the IGBT voltage safety margin remains unchanged and the proper current can be applied to the magnets. The cost for the additional stacks is small.

A quote has been received from Westcode for the high voltage charging and freewheeling diodes. The PLC controller has been received and about 90% of the components for 3 kicker pulsers are on order.

BitBus Power Supply Controllers

The BitBus electronic components, printed circuit boards and sheet metal parts have been released for purchase. It is expected that all the electronic components and the boards will be on-hand in 2 or 3 months. The boards will then be sent to industry for stuffing.

Racks And Accessories

Racks

A successful design review for the power supply racks and rack internal accessories was held on August 15, 2001. The specification and drawings for the racks and rack accessories were revised to incorporate review commentary. An RFP was issued to industry and the rack bids are due in October.

Other Work

General

An update to the AC one-line diagram for the power supplies is in progress along with an update of the power supply layout in Building 118. The updates will be completed during the next reporting period.

The Power Supply design, purchase, installation and field-testing schedule, WBS 1.3 and 1.9.3 have been re-baselined in response to SPEAR management's request and also to reflect the latest project information.

Magnet Testing

Testing of the SPEAR 3 dipole, quadrupole and sextupole magnets is on going and occurs as the magnets are received from Beijing.

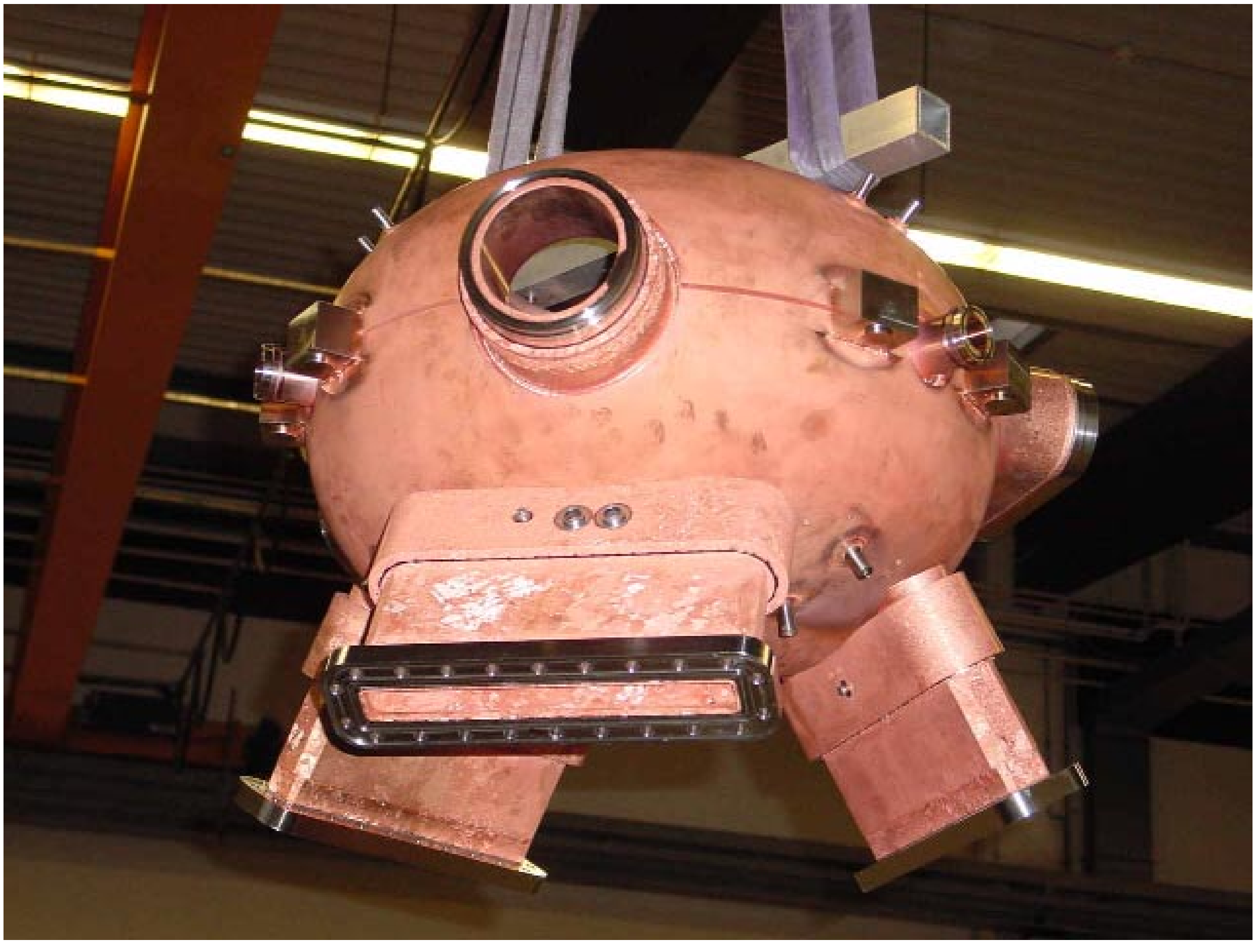
1.4 RF System

RF Project

A CCB (Change Control Board) document was prepared reflecting known cost increases and changes to the schedule of the RF Project.

Cavities

Cavities are being fabricated at Accel Instrumentation in Germany. A major milestone has been accomplished by welding all peripheral ports into the first cavity.



Remaining work includes final machining of cavity interior, frequency tuning and beam port welding. The first cavity is expected to be delivered in November 2001, (a three-month delay) but still early in the fabrication schedule for SPEAR3.

Cavity accessories

The cavity rafts have been ordered and are expected in October. All twelve high order mode loads are completed. A first successful ceramic window was fine-tuned and is now being coated. Other components like tuners and coupling network are close to completion.

Waveguide

The waveguide system specifications are being finalized in preparation for the waveguide procurement process.

Low-level RF

The Low-level RF System design modifications are in process at the new Electronics & Software Engineering Department at SLAC. New design engineers have been hired intensifying the design effort. A schedule for completion by the end of 2002 has been established.

High Voltage Power Supply

A power supply has been ordered from NWL with expected delivery in December 2001. The SLAC provided control circuits are being fabricated at SLAC.

1.5 Instrumentation and Control Systems

Computer Control System

SPEAR 3 control system software tasks were defined in further detail, including those for power supply Bitbus control and BPM data acquisition. The first EPICS IOC was created on a VME CPU; Control Net driver software is being implemented that will enable an EPICS interface to Allen-Bradley logic controllers used for machine protection. A design review for the complete computer control system plan is scheduled for November 2001.

SPEAR 3 component nomenclature was defined in further detail and entered into the web-based database. This information is being used to specify the cable plant.

The detailed design of the 8-Channel Power Supply Controller continued. A prototype controller is planned for completion by the end of CY 01.

Beam Monitoring Systems

The specification of the two-system Beam Position Monitor (BPM) processing system continued. Prototype versions of modified BPM Bergoz processors were received, tested, returned to Bergoz for a design revision, and will be tested again in October. The plan is to use these button-multiplexed processors for narrowband BPM processing with signals shared between the orbit monitoring and orbit interlock systems. A second set of wideband, un-multiplexed processors will be developed to electronics will be used for 1st-turn, turn-by-turn, and high resolution orbit acquisition using programmable digital IF receivers. Work continued on the data acquisition and digital processing system that will be used for the commercial switched-button BPM processors. A design review for the two-system approach will be held in the next quarter.

Cable harnesses that will connect BPM button assemblies to bulkhead panels on the accelerator support girders have been designed. These harnesses must be installed on the vacuum chamber prior to installation in the magnet raft assemblies, which begins at the end of CY 01.

Quadrupole Modulation System

The design of the Quadrupole Modulation System was assigned to an engineer within the SLAC Power Conversion Group. The preliminary design of this system will be reviewed in mid-July.

Timing System

The RF Signal Generator system has been specified and will be ordered in the next quarter. Work is underway to try a prototype version of the injection timing system using booster RF signal frequency shifting in the next months.

Protection Systems

Work is continuing on developing the Orbit Interlock Data Acquisition and Processing System proposal. The proposal will be reviewed in the next quarter.

The design of the SPEAR 3 vacuum and magnet cooling protection systems are in progress. The programmable logic controllers that will be used for these systems have been ordered. Full specification of the ion pump power supply system, ion gauge controllers, and temperature monitoring system should be completed in the next quarter.

1.6 Cable Plant

Work Summary

The first of three major milestones for the Cable Plant effort was accomplished this quarter. An installed cable tray system serving inside B118 and in front of B117 and B118 (see figure below), extending to the East and West pits, was completed according to the schedule. The installation included numerous structural supports, along with five 10' x 9' concrete footings for cable trays used by DC power and I&C cables. HV wireway for the Klystron was ducted via underground trench. This installation was accomplished without the need for change orders. We have also started the design and layout of cable trays in the West Pit and behind B118.

The fabrication of the cable tray supports for use inside and outside B118 were inspected at the Vendor's site prior to shipment. The inspection found the vendors work to be of very good quality with only one correction to a single support baseplate bolt pattern.

We began planning for the support of SPEAR 3 raft assembly in B750. Pre-wiring of rafts will begin before the end of the current year.

Review of the beam line components database has begun as a precursor to the CAPTAR database entry effort. We have started planning and scheduling for the second phase of cable tray installation coming in the summer of 2002. Plans also include assistance in the demolition of cable plant and existing utilities in preparation for the major SPEAR3 installation.

Installation of New Cable Tray System

1.7 Beam Line Front Ends

Work Summary

The preceding quarter has seen substantial progress on beam line front-end system design. The bend magnet beam line fixed/moveable mask design has been released as has the shortened injection stopper design required by the SPEAR3 exit port relocation relative to the SPEAR2 exit port location. Fabrication of these bend beam line front-end components will commence shortly. Designs for the remaining five high power moveable masks for the insertion device beam lines are in final checking prior to design release. Finite element analysis of the fixed mask design continues.

1.8 Facilities

Work Summary

The installation of the concrete roof shielding over the West straight section and new shielding walls in the transition areas to the straight section started on July 16th, 2001. The new concrete roof shielding was installed monolithically over the straight section in the West straight, while the new shielding walls outside the West Pit received new movable concrete panels. All concrete work was cast-in-place to facilitate project schedule. The work was completed on August 30th. A view of the completed West straight section area is shown below as well as the foundation pad for the new klystron building. The remaining cast-in-place concrete shielding wall in East Pit and the roof shielding will be installed in the summer 2002.

New Roof and Shielding for West Area

New Foundation for Klystron Enclosure

2.0 Accelerator Physics

Magnetic Field Perturbations

In collaboration with the magnet design and measurements group, accelerator physics staff investigated the effect of magnetic materials in the near region close to the circulation electron beam. In particular, high permeability Invar struts and rod ends that support the vacuum chamber are close to the beam at several locations in each cell. Simulations indicate the dipole fringe field perturbation is near the limit of tolerance for multiple field specifications. Direct measurements, however, indicate almost no effect. The difference is likely due assumptions made for the fringe field of the dipole magnet in the modeling procedure. A decision on whether to replace the struts and/or rod ends with non-magnetic material is pending.

Data from DC and AC field measurement for the prototype corrector magnet have analyzed and discussed. Overall, the corrector magnet performance meets specifications set forth in the SPEAR 3 Design Report and the go-ahead has been given to IHEP to proceed with the production run (74 magnets). A decision is pending on whether or not to use the iron shields with the corrector magnets. For AC applications, the shields tend to screen higher frequency drive signals, which could complicate feedback algorithms and data analysis. If the level of DC field perturbation is acceptable without the shields, the shields may be removed to improve AC performance.

Impedance Studies

New wiggler magnets and vacuum chambers will be installed at beam lines 4 and 7 during the main SPEAR 3 shutdown in year 2003. Based on calculations of resistive wall impedance, the +/-6mm SS chamber walls will contribute more impedance than the entire SPEAR 3 (~180 m) copper chamber. Calculations show that 0.002-0.003 inch thick copper strips deposited on the top and bottom ID chamber walls will reduce impedance by a factor of ~6. Hence, the small-gap SS chambers appears to the beam as small-gap copper chambers with less wall resistance. An internal accelerator physics memo covering relevant computations and an Engineering Note calling out thickness and width of the copper strip will be issued.

Additional calculations were made for impedance of the straight section segments of the vacuum chamber. Initially, it was thought that SS drift tubes could be used instead of Cu drift tubes to attenuate longitudally-propagating microwave power; however, electromagnetic calculations show that the effect is small. The recommendation to the vacuum engineering group is therefore to produce drift tubes of equivalent effective cross-section as in the copper raft chambers and to make the material selection based on cost, vacuum properties and ease of fabrication.

Application Programs

1. Orbit Program - During the summer of 2001 an undergraduate student was mentored to work on graphics for the orbit control application program. The program interface was re-structured for inter-platform compatibility and easier program use. Code documentation and algorithm streamlining were also enhanced. Based on experience with online tests at SPEAR 2 (year 2000 run period), the orbit program was modified to run in the simulation mode for SPEAR 3.

2. Quadrupole Shunting – Preliminary studies were made to develop an application program that will center the electron beam in quadrupole magnets. Once centered, adjacent electron BPMs can be calibrated for absolute positioning. The new program makes an advance in the field by utilizing all quadrupole 'shunt' measurements simultaneously in a matrix inversion procedure. Since the problem is inherently non-linear, several iterations are required but the calibration measurements can in principle be completed within 1 hr online. Modifications to the code are still needed to communicate with hardware modules, to make the code operationally robust and to improve the graphic interface.

3. Accelerator Modeling – Work was initiated to convert the FORTRAN program 'LOCO' to MATLAB format for improvements in speed and ease of use. Investigations are underway to study if the numerically intensive program can be run in a parallel process mode. Improvements have also been made to the closed-orbit calculation routines to increase computation speed.

Orbit Interlock Verification System

Using the MATLAB Accelerator Toolbox software developed at SSRL, work has begun on the orbit Interlock Verification System (IVS). In the simulation mode, the software can produce electron beam 'bumps' across beam line source points and monitor motion at adjacent BPMs. Algorithms for both dipole beam lines and insertion beam lines have been tested. For each beam line under investigation, the orbit motion is recorded to log files and flags are set to indicated if the beam was moved outside of the safe interlock zone. Since this software is a sensitive application program, particular care has been taken to develop robust code. Pending further tests on the core algorithms, attention will turn to interface development and communication with hardware via Channel Access.

Diagnostics

Documentation outlining physics aspects of the synchrotron light monitor (SLM) was produced. The vacuum group hired an additional designer to develop detail drawings for the monitor mirrors and supports. A decision was made to use permanent magnet(s) to deflect any charged particle radiation propagating through the SLM beamline on to a dedicated beam dump. Although the chance of electrons entering the beamline is remote, precautions will be taken to protect workers outside the main shielding vault. Discussions were held to determine if existing permanent magnets at SSRL are sufficient or if an additional permanent magnet must be fabricated.

Radiation Safety

The accelerator physics group is analyzing electron beam loss scenarios during injection for the Radiation Physics Group. If the electron beam is miss-steered to strike the vacuum chamber wall, the radiation dose outside the shielding area is dependent on strike angle. In addition, an Engineering Report is also in progress to describe and parameterize the fixed radiation dump at a high dispersion region.

Shanghai Symposium on Intermediate Energy Light Sources (SSILS). Sep 24-26 Presentations and Papers

SPEAR : Technology Investment Today for Science Tomorrow - J. Corbett
Electron Beam Stability in Light Sources – R. Hettel
Design and Fabrication of the SPEAR 3 Vacuum System – N. Kurita and J. Langton
Main Magnet Production for SPEAR 3 – J. Tanabe

2.1 ES&H

This year's summer shutdown saw the completion of the shielding in and around the West Pit area of the SPEAR ring, with major focus on the completion of the side walls and construction of a concrete roof. In general ES&H issue were well addressed by the sub-contractor, although one incident of possible dust exposure could have been either prevented or mitigated with better planning and job site review. Construction activities scheduled for next year on the East Pit should mirror this work and hazards should be of a similar nature.

Work continues on radiation physics objectives to comprehensively assess all shielding and design parameters, thus assuring that respective regulations and internal limits are met. The roof shielding and wall shielding parameters were finalized, as were the modifications to the West Pit. Present work focuses on radiation dose attributed to miss-steering conditions in the beamline front ends, discreet shielding for high/intentional beam loss areas and the effective use of ACM's and LION's both as a diagnostic and beam containment tool. We are still seeking to finish with all radiation physics issues by mid 2002 and presentation to the SLAC Radiation Safety Committee for their approval.

The environmental sampling for the remaining excavation activities has been completed. Results are similar to previous years, in as much that there is trace contamination of PCB's, lead and petroleum by-products in the asphalt and concrete, but the underlying dirt is relatively clean. As in the past, excavated material will be disposed off as hazardous waste through the proper SLAC channels.