Accelerator Systems Division Highlights for the Week Ending November 8, 2002

ASD/LANL: Warm Linac

HIGH-POWER RF (WBS 1.4.1.1)
Accomplishments this week: (1) Finished site acceptance test of 3rd CPI 550-kW SRF linac klystron (S/N 4); (2) began factory acceptance tests of CPI klystron S/N 6; (3) received and reviewed test plan for SC linac klystron transmitter and returned comments to Titan in preparation of the test plan review next week; (4) completed high power testing of two 550 kW loads.
Concerns & actions: (1) SNS arc detector system warranty could be jeopardized due to installation personnel cutting and reterminating fiber optic cables – we communicated to ASD the vendor's (AFTs) position that their personnel must be involved with these field changes to maintain a valid warranty; (2) disclosure of vendor proprietary information – we formally advised ASD not to disclose background intellectual property from one vendor to their competitor without a license agreement. We also recommended straightforward alternatives to a negotiated agreement such as generic specifications to mating hardware.

HIGH-VOLTAGE POWER CONDITIONING (WBS 1.4.1.2)
Accomplishments: (1) Sent team of three to ORNL to assist in operation of the of the RFQ high-voltage converter modulator (HVCM) – 120-kV, 8 MW low-duty operation achieved, and crowbar wire tests successful. LANL director John Browne visited the SNS site (Fig. 1) and met with the team during these tests.

Fig. 1: LANL Director John Browne (center) at the RFQ HVCM in the SNS klystron gallery.

LOW-LEVEL RF CONTROLS (WBS 1.4.1.3)
Accomplishments: (1) Held an FMEA (Failure Modes and Effects Analysis) on the HPM (high-power protect module) design and identified areas to improve system reliability with minor board changes to the REV E release; consequently, decided to hold the REV-E board until we can review these changes and implement them. We also identified a few areas where a system-level FMEA would be appropriate, as there are some failure modes where the HPM continues to function normally but, because of undetected system-level problems, the system may be at risk (FMEA results attached). (2) Work continues on building two HPM test stands. They should be ready by the end of next week. (3) Worked on klystron control (ripple compensation) by developing a disturbance estimator based klystron control. This is the same approach used for the PEP-II LLRF system at SLAC. The model's closed loop system bandwidth is 15 kHz, which is constrained by the loop time delay. The modeled ripple is 60 Hz harmonics plus the recently reported 20 kHz effect. The closed loop system minimizes the effect of the low harmonics of 60 Hz but cannot compensate for 20 kHz ripple. The low frequency ripple compensation was reported by SLAC. In order to avoid using a high order disturbance estimator, we used the same kind of disturbance observer that is expected to be implemented for the Lorenz force detuning estimator. This work will be published in *IEEE Trans. Nuclear Science* in

February. (4) A subset of the MATLAB models was sent to LBNL for evaluation. The whole set of models and control simulations will be placed in CVS within the next week. (5) We developed a draft high-level architecture for the ultimate LLRF system. The proposal highly leverages the digital front end and the analog front end as built by Bergoz for the SNS diagnostics system. (6) We held a full day architecture discussion meeting with participants from LANL, LBNL and Ztec Corp. Participants were provided a list of specifications and design guidelines that emphasized utilization of tested technologies, incorporating minimum-risk designs, and allowing for future upgrade of system capabilities. The team arrived at an architecture which we believe will meet requirements and upon which we can develop a detailed design for the ultimate system. (7) We held an architecture review meeting of the proposed design with participants from LANL, LBNL, and ORNL. The three labs accepted the draft block diagram (Fig. 2) with some recommendations to consider further simplifying the design (replacing a family of chips with PLD code). The high-level architecture will be refined with all raised questions and concerned answered during the next three weeks. We will have a formal architecture review the first week of December. The exact date, the list of reviewers and the location will be determined within the next few days. To expedite prototype development, our ECAD group is building a library of the proposed parts in preparation for producing the first schematic.

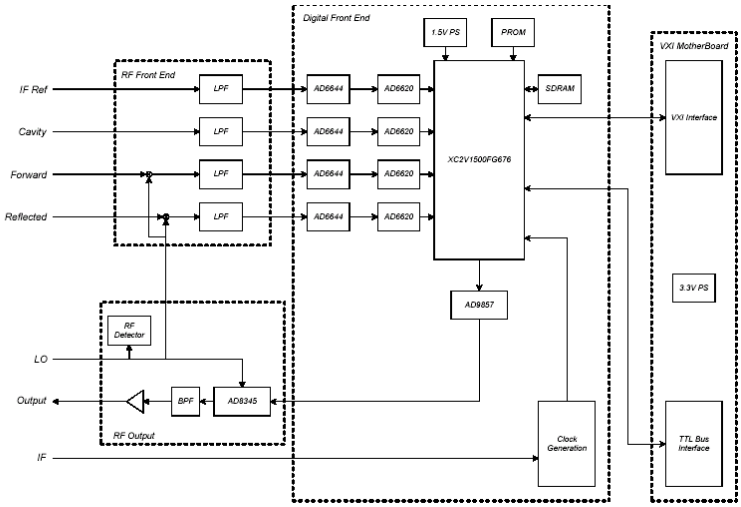


Fig. 2: SNS RF Control System Hardware Block Diagram.

Concerns & actions: Staff availability - we are assigning names to individual tasks on the development schedule. The digital portion of the platform development is staffed. Analog part depends on the expertise of the SNS Diagnostic Team and their suppliers, who must also deliver on the BPMs, D-plate electronics, *etc.* We will begin discussions with Diagnostic Team immediately to develop solutions meeting both teams' interests. We are also need skilled VHDL expertise. This includes all of the applications which comprise the heart of the LLRF controls and which has seen least amount of testing. We need to identify a candidate quickly, perhaps from industry.

DRIFT-TUBE LINAC (WBS 1.4.1.2)

Accomplishments: (1) Investigation of repair techniques for Tank 3 drift tubes continued at ISYS using coupons emulating rings of increased height and special cross-section to ensure adequate weld puddle material and placement for subsequent surface clean-up. These trials appear successful but final verification will require reprofiling of welded surface. (2) Weld repair of Tank 1 drift tubes also continued at ISYS. All repairable drift tubes have been rewelded and have passed a post welding vacuum leak check. We recognize and appreciate significant contributions from ASD's John Crandall during these tests. (3) A preliminary statement of work for E-beam welding of PMQ and empty drift tubes for tanks four, five and six has been generated and transmitted for Hanford for their consideration. Discussions with Lawrence Livermore Lab regarding the electron beam welding of the EMD drift tubes continued; we are about to establish an agreement with them for the development and qualification of SNS EMD DT electron beam welding processes. (4) Process drawings for the first stage of remanufacturing 40 tank 1 drift tubes have been produced (120 sheets), the first stage process drawings for the first group of 10 drift tubes has been transmitted using PDF format to Coronado Machine (CMI). Negotiations with CMI for the first stage of machining are underway; it is expected actual machining will commence 11/12/02. The balance of the processing drawing PDF files will be transmitted on the 11/12 along with delivery of paper drawing copies. (5) Initial sectioning of several tank-1 drift

tubes slated for rebuilding was completed. These units will be further sectioned and examined to evaluate the adequacy of the diverter braze joint.
Concerns & actions: The bore tube E-beam welds of the aforementioned sectioned tank 1 drift tubes were examined. These welds exhibited the expected burn through, and also significant weld location error due to a probable combination of PMQ beam steering and focusing. This weld location error (the weld path may have moved completely out of material and into the bore itself) may require scrapping or additional repair of tank-1 drift tubes presently undergoing repair by rewelding and reprofling. Bore tube welding trials using bore tube "mockups" complete with a PMQ and simple bore magnetic field shunts were started; these trials did not produce good results indicating that more effective shunts of more elaborate design will likely be required. Materials and concepts for these better shunts are available and will be tested in the near future

ASD/JLAB: Cold Linac

The first two sections of the liquid nitrogen transfer line have been completed and are being purged with nitrogen.

The klystron from the 1 MW RF test stand has been delivered to LANL. The replacement tube is expected at JLab at the end of next week, with installation and commissioning to take place the following week.

The prototype cryomodule has been removed from the test cave. Since its performance was good enough to qualify for service as a spare, some time will now be taken to correct some of the deviations between the prototype, as built, and the production units, as designed. It will then be shipped to ORNL.

HOM coupler cans for high-β cavities have been received from the vendor and heat-treated to improve their mechanical properties for tuning.

All three cavities for medium-β production cryomodule #1 have been qualified for addition of helium vessels. All helium vessels have been welded in place.

ASD/BNL: Ring

Breakout talks for WBS 1.5 Ring Systems were submitted to ASD for the DOE Review.

BNL's Mike Hemmer sent a revised edition of the Ring lattice drawing to ASD this week.

Lead tech, Robert Sikora, returned from SNS/OR where he spent time assisting ASD with repairs of MEBT wire scanners.

The design of the 12cm HEBT quad vacuum chamber-welding fixture continues. Assembly and welding of all 21cm quad chambers has been completed.

Ring half-cell #1 was shipped this week to SNS/OR (ahead of schedule) for the upcoming DOE Review.

The Ring ion pump assembly was successfully test-fitted to the #1 half-cell.

Vacuum pipes for RF cavities #2 and #3 have been TiN coated and delivered to the RF Group.

Danfysik shipped the last five (5) 12Q45 quads to SNS/OR.

Danfysik reported that fifty (50) low field power supplies are en route to SNS/OR.

Tesla reported that they would ship their last HEBT dipole to SNS/OR later today.

Controls

With the completion of the Personnel Protection System (PPS) for the Ion Source (phase 0.0a), attention has moved to completing the PPS interfaces to the SCR controller and RF transmitter for the RFQ. These devices, along with the MEBT RF interface equipment that arrived this week, will be required for phase 0.0 (Front End). After this phase is completed, no further work is anticipated for phase 0 until the DTL tank 1 is installed.

The production Chipmunk vendor is one week behind schedule with the first delivery. Because we are using Chipmunks loaned from Brookhaven, we should have plenty of time to test production units prior to placing them into operation.

There was a problem with a control system server (ics-srv2) at 701 Scarboro that resulted in a several hour server shutdown that affected the work of several developers. After hours of diagnostics and consultation with vendors (making use of our maintenance plans) the problem turned out to be a Red Hat Linux file system error. The error has been corrected through the heroic efforts of Ernest Williams and Greg Lawson, who worked until 1:00AM Friday morning, and were back at it at 5:00AM - four hours later.

There have been many developments at the site in support of initial operations. A Conventional Facilities Operator Interface has been set-up in the Klystron building to support Sverdrup installation and checkout. Three laptops were set-up with Windows 2000 and Linux to support Control System commissioning and checkout. The Front End Emittance IOC has been integrated with EPICS server and is now back online. Improvements were made to the Archiver Retrieval tool, which now supports long names. Front End screens were switched over from the display tool used at Berkeley (DM2K) to the standard SNS display tool (EDM). The new screens are being used by operations, notwithstanding a small (and diminishing) number of remaining problems.

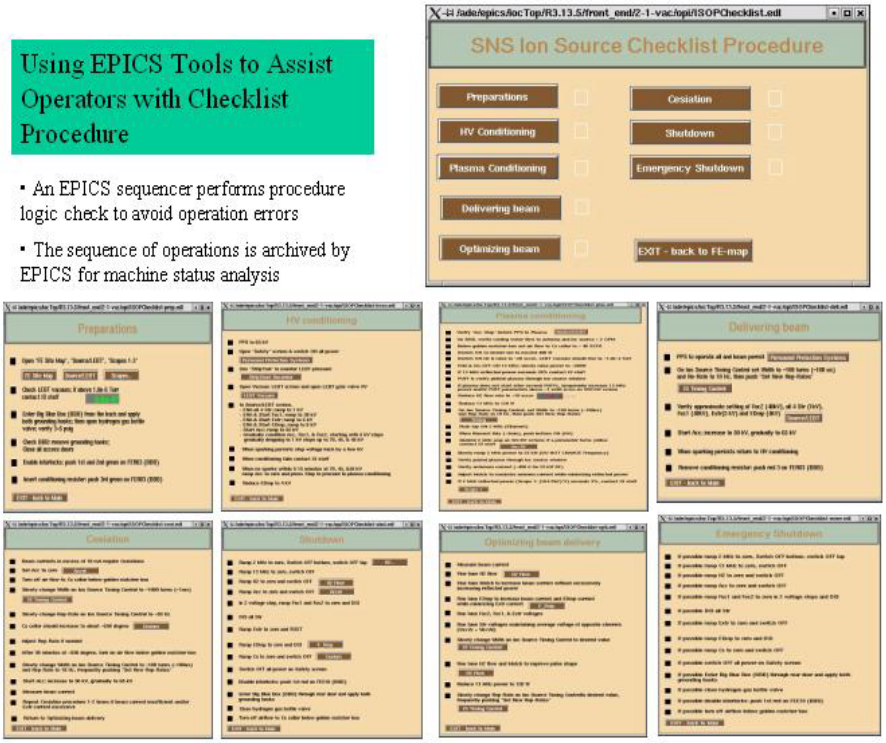
At BNL, the Beam Current Monitor (BCM) Labview code was enhanced to support automatic calibration using a calibration pulse. As of now, all known BCM issues relating to MEBT commissioning have been addressed. BNL Diagnostic (and probably Controls) personnel will go to ORNL in the next couple weeks to finish commissioning the of the BCM system in place.

At LANL, a final decision was made to use Beckhoff I/O modules for the superconducting vacuum system. The same system will be used for DC bias supplies and for CCL shunt control. The equipment has been ordered, and a driver is being developed. Signal list documentation for the superconducting linac cavity tuners, the Quadrupole cooling system and the D-Plate continued. Documents on the RF and Vacuum systems have been submitted to the LANL documentation system. Software developments include making the simulation engine independent of XAL, modifying the channel history plot, completing the warm window portion of the RF Vacuum software and reviewing the new database configuration tool (VDCT) for functional compatibility with the old (CapFast).

The four Resonance Control Cooling System (RCCS) racks for the CCL section are complete. All of these racks now have a power panel installed in them, as well as RTD input modules which were installed before being shipped to the RATS building. Processors have been "flashed" and loaded with some older LANL ladder logic for testing. All checkouts for these racks were good. The CCL RCCS racks will be installed at the site shortly.

On the weekend of December, LANL control staff will be at ORNL to install and test DTL vacuum control software. A DTL test stand has been setup at RATS to support this activity. (See photo below.)

A semi-automated Ion Source Operation Checklist Procedure has been integrated into the Front End control system. Sequences derived from Ion Source operating instructions (see screen shots below) can be activated from EPICS screens, while the relevant system status is reported on the same screens.



Instrumentation and control cable required for the signals in the CHL building and the Medium Beta cryomodules was ordered. Several spools of cable have been received. One of the CHL Control Room Operator Interface Workstations, including the 3 monitors, and the PLC development computer was also received.

The contract for the fabrication of the Medium Beta Cryomodule Marshalling panel racks (3 total) was awarded to DCS. Each of these 6' wide enclosures will be installed on the North wall of the Klystron building. Each contains the PLC interface modules and devices for the 4 MB cryomodules.

The directory structure for the Cryogenic Control System was updated to facilitate configuration control, development, checkout, and maintenance. Folders were added to provide a control system software structure that is consistent with the cryogenic system checkout and commissioning activities. Proper operation of the EPICS OPI screens and IOC algorithms was verified after the programs and configuration files were installed in the new directory structure.

Installation

Accelerator Physics

FE commissioning started this week. Regular shifts started Tuesday this week. Due to delay with high power RF for RFQ our activity is devoted to Ion Source commissioning. After great efforts from IS group people stable operation of the ion source is established. Maximum H- current of 30mA in 1ms pulse is achieved after cesiation. Stable plasma production at full duty cycle of 6% and 20kW RF power is established. Beam extraction at this duty cycle is prohibited by power dissipation in the collector. Seven hours of uninterrupted extraction of 22 mA beam current is demonstrated on Friday without single spark or reset. This is remarkable achievement in terms of the system stability. Safe operational envelope is established for operator's training.

Operations Group

Following Last week's ARR Closeout we obtained DOE permission to start commissioning

Conducted intensive training to certify personnel as Chief Accelerator Operators

Assisted with the final certification of the PPS

Commissioning the Ion Source with limited rotating source coverage

Participated in the DOE Dry Runs

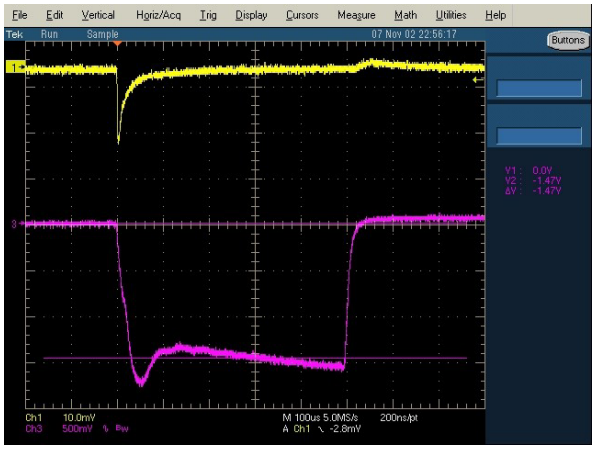
Started a series of ARR "Lessons Learned" meetings

Participated in the CLO Space planning exercise

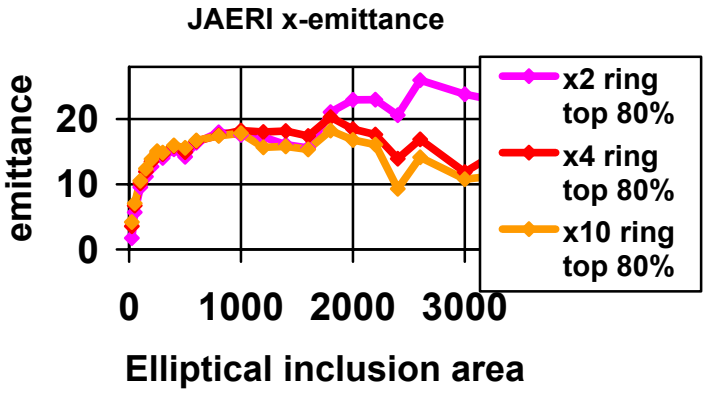
Ion Source Group

The ion source procedure checklists were finalized and made available on the EPICS screen to assist operators in safe operations.

The ion-source-commissioning plan was adjusted to enhance ion source operation and to improve operator training while the RFQ is readied. Monday afternoon a flag was installed on the ground electrode, which blocks the beam from entering focus 2, but allows a direct current measurement. A series of problems was encountered during the week, but all got satisfactorily resolved. The source is currently producing up to 30 mA with up to 1 ms pulse length at a low duty cycle to avoid problems with the un-cooled flag and ground electrode. A 20 mA beam requires about 20 kW RF. The figure shows 0.5 ms, 29 mA beam pulse together with the extractor current on top.



Martin Stockli presented the lecture on ion sources at the US-CERN-Japan-Russia Joint Accelerator School. In addition he presented the SNS seminar for Norbert Holtkamp who was unable to attend. Both presentations triggered multiple requests for electronic copies of the presentation.



Mechanical Group

Water: (From Ray Savino)
- RCCS skids to DTL #1 & 2 hooked up in klystron gallery.
- Front-end water complete.
- RFQ klystron and water load hooked up to skid.
- Beam stick hooked up and running.

Design:
- Laser profile monitor design and details finished, out to bid next week.
- Laser profile monitor test rig for MEBT same as above.
- BNL wire scanner re-design finished, implemented and installed.
- DTL o'rings design modifications finished and implemented.

Vacuum:
- DTL #3 under vacuum ready for DOE.
- Other tank sections having o'ring modifications machined at ORT-E.

Magnets:
- First 1/2 cell assembly arrived. Mounting base bolted to floor and surveyed.
-Magnet assembly to be lifted onto base Monday ready for DOE.

The first DTL tank o-ring groove has been enlarged at Oak Ridge Tool. A lathe was used and a finish of ~16 micro-inches was achieved. Additional grooves will be cut using the same procedure. Twenty-five percent o-ring compression can be achieved with this enlarged groove.

DTL Tank on Lathe

Magnet Systems

The first Ring Half Cell arrived and is setting in RATS. We are installing a Half Cell base and then will mount the Half Cell onto the base. This operation has gone very smoothly.

HEBT Dipole #7 has been measured and accepted. #8 Dipole is now on the measurement stand.

Vacuum Systems

Linac HPRF

Installed Klystron diode (Beam-Stick (BS)) on HV Tank and substituted it for the resistive load in DTL2 position used by HVCM-1. BS collector water was run (~70 gpm) from DTL1 water cart. Ran DTL1 water cart under control of DTL2 transmitter. Found the beam-stick did not conduct, although vacuum and filament readings were good. Diagnostic efforts are underway. Permanent lead shielding for the beam-stick from the ORNL Lead Shop should be ready by 11-12-02.

Ran this Monday p.m. with the beam stick at up to 30 Hz, 110 kV, for several minutes. SCR was open loop for duration of run. Attached is waveform showing voltage (blue, 10,000:1), modulator current (cyan, calibration 20 A/V, we thought), and transmitter current (magenta, I forget cal factor (20mV/A)). Perveance (0.77E-6) of diode indicates we should see about 24 A of beam current, so we may need to recalibrate the HVCM current diagnostics. Radiation measurements were taken at this level, with 240 mrem/hr on contact with the collector and 80 mrem/hr 1 ft. away. HVCM crowbared after several minutes due to vacuum overcurrent first fault (internal beamstick arc?) and SCR overcurrent first fault on modulator. Tried to bring back open loop, but kept getting current limit faults. Installed regulator card in SCR, and unit came back online at 20 Hz, but no regulation and severe overshoot of voltage. We will modify the SCR regulator card in the a.m. and try again tomorrow. Current limit trip may be due to "hard" turn on in open loop condition, which seems consistent with what we saw after the trip. Hopefully, we can run 60 Hz tomorrow for a few minutes. Unfortunately, replacement oil pump did not leave Burlington last week, and will not arrive until Wednesday this week.

Received two more klystrons and sundry RF components from LANL (see LANL report). Both klystrons are under vacuum. We now have two 402 MHz and two 805 MHz klystrons with supporting equipment in RATS.

Linac LLRF

Electrical Systems Group

Completed all front-end power supply checkouts. Problems with a quad power supply were due to a faulty circuit breaker. Front-end power supplies sent to manufacturer for repair have been repaired and returned and check out ok.

Rack row 7 in klystron gallery under construction. Rack rows 1 and 2 in klystron gallery have completed their safety check out and have permanent ac power.

The base for CCL Row One will be permanently commence next week, as we will be finished up with DTL 7, The last row in the DTL!

Vacuum Racks for the CCL are being stuffed in RATS, one next week, or the week after.

All components Equipment for CCL Vacuum Racks (8 in all) will be stuffed and wired, for these vacuum racks by Skilled Labor/ Davis Bacon @ RATS One. Magnet Power supply Racks for the CCL, are being fabricated in Rats 2 too. This week. (14 of them) No equipment yet, but they'll be here again at the end of the month.

Survey and Alignment Group

Magnet fiducialization has continued in RATS.

Laid out the area that is to receive the Medium Beta Test Unit next week.

Continued with site plans to extend our global control network through the ring.

Survey Engineers were at Argonne discussing alignment concerns with Instrument Group.

Survey Engineer was out J-Lab this week to witness the alignment process on the first beta unit that is due to be shipped to SNS next week.

Cryogenics Group

CHL: Field assembly of the 4.5K cold box continued this week. Monday we will begin setting the warm gas tanks, the oil separation equipment, vaporizers, the instrument air tank, (if it arrives on time), the nitrogen Dewar and the control room cabinets.

Tunnel: The 3.5-inch shield supply lines on the east end have been leak checked and wrapping of superinsulation has started. The 6" clamshells have been cut and welding will commence when the superinsulation is finished. The west and east supply end boxes and 2 return modules were received and set in the appropriate stands

The two supply end boxes and 2 return modules were shipped to the tunnel. Work has started on the CHL supply expansion can tooling. The next two return modules are being assembled, one is 35% completed and the other is 65% completed.

Beam Diagnostics

BNL beam diagnostics report:

General: Preparations for the DOE review were completed.

1.5.7.1 BPM: Work on the remainder of the 26cm BPM PUEs continues. Work on AFE continues.

1.5.7.2 IPM: Detailed design of electromagnets continues. There is come concern that the Project Office will not approve PCR for electromagnets; design effort will shift to detector and vacuum chamber until the electromagnet situation is clarified. Work continues on the control system for the IPM/luminescence profile monitor gas system. Development plan for luminescence monitor is in place. The short range (multi-channel PMT with gas puffer) and long range (supersonic gas sheet with camera imaging the actual profile rather than the projections) plans are proceeding in parallel. First testing will be accomplished at the tandem. This effort is driven by RHIC needs, with SNS as the beneficiary.
Five Argonne-style detectors have been assembled for installation in RHIC, where there is a serious electron cloud problem. SNS electron detector activity is parasitic to the RHIC efforts (which utilize CERN-style detectors) and will permit cross-calibration with RHIC and CERN data (as well as with the RHIC IPM).

1.5.7.3 BLM: Design and fabrication continues on AFE module and back plane, MPS comparator module, and detector PCB. PCR effort continues.

1.5.7.4 BCM: Work is proceeding on evaluating software changes. Welded the end caps onto the beam pipe of the prototype HEBT BCM. The unit is ready for the assembly.

1.5.7.6a Carbon Wire Scanner: Continue to fabricate and ship parts in support of the MEBT carbon wire scanners. A group member spent the week at ORNL in support of the wire scanners. Received a quotation from a vendor on the special beam box design to accommodate the LANL request for space for a larger fork assembly. The unit cost of the cross will be doubled, compared with that of the standard 6-way cross, resulting in a total cost increase of about $40K for the 21 vacuum chambers. Communicated with LANL to finalize the design parameters of the special beam box.

1.5.7.6b Laser Wire Scanner: Preparations for testing at 750KeV continue

LANL beam diagnostics report:

BPM pickups: All the CCL pickups have been fully tested and are ready to be turned over to Nathan Bultman for welding into the CCL spool pieces. The D-plate DTL-style BPM has been tested and mapped and by the end of this week it should be welded to the D-plate spool piece.

BPM electronics: ECAD work has begun on the PCI motherboard modifications (clock circuit layout, power supply regulation, and power supply isolation). Work on the BPM electronics has slowed down due to more manpower shifts to low-level RF.

CM: Work to add potting epoxy to a DTL CM transformer, to solve an excessive out-gassing problem, has been successful. We now have a CM to use for the D-plate. We will add epoxy to the rest of the CM transformers.

WS actuators: Work continues to correct the wiring on our Huntington actuators, to mount the wire scanner forks, to modify the limit switch mounting brackets (to ensure the MPS switches are closed first on the way to the out limit), and to test the positioning accuracy. Work continues at BNL to investigate the possibility of using a larger beam box for the HEBT that will allow the tines of the wire scanner fork to stay out of the beam pipe aperture.

WS electronics: The prototype linear driver circuit is almost ready to test.

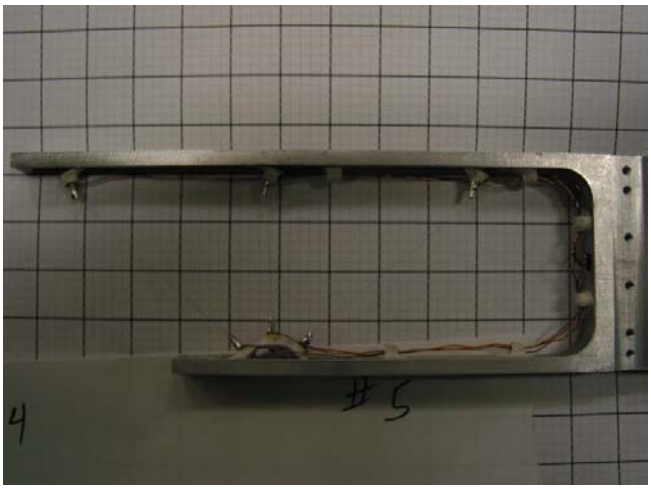
D-plate: The hydrostatic beam stop acceptance test is now scheduled for 1:00 Friday (8/Nov) in Albuquerque. Further tests with pressurized helium will be performed at LANL. A water leak was discovered in a valve on the first water manifold during vendor acceptance tests. A valve seal kit has been ordered to repair the valve. The ED/FC for the D-plate is complete except for the graphite energy degrader, promised from the vendor to arrive later this week (by 8/Nov).

Misc: Four members of the beam diagnostics team are preparing to travel to ORNL the weeks of Nov. 12.

ORNL beam diagnostics report:

Laser profile monitor design is progressing very well. The initial results of vibration measurements made by Dan Stout and James Kelly show very little vibration at the entrance of the laser mirror box on HEBT ceiling. Dan reports the following preliminary analysis:
For frequencies below 10 Hz, the peak of 2.4 micrometer [RMS] is observed at 1 Hz. For frequencies above 10 Hz, the RMS vibration drops to less than 2E-7. This is certainly good news. The optics box design is complete. The vacuum box design is complete. The mechanical group has asked Max Cronin (ORNL liaison) to put the drawings for bid. We would like to have one system ready for the MEBT testing by the end of this year.

All wire scanners were repaired and installed on the MEBT, 5 days ahead of schedule. The ORNL-SNS Mechanical group led the effort with support from Bob Sikora (BNL), Andy Webster (ORNL) and the diagnostic collaboration (LANL, BNL and ORNL).



The ends of the new 32-micron carbon fibers are copper plated prior to installation.

Craig Deibele has rematched all BPM cables. This is necessary for the phase measurements. He is also working with Jim Pogge on the 2.5 MHz TTL distribution box. Jim has also designed a circuit that could provide all RF references for the BPM system. The schematic and board layout have been reviewed internally and a prototype will be fabricated. The LANL diagnostic experts are due to come to ORNL on November-13-02.

The first report of the LLRF advisory board has been distributed to SNS management and laboratory directors. Following this, the board members have had several conversations with team members. They have also reviewed the preliminary block diagram and key component choices.

All key functions of the embedded timing circuit have been tested. There is still some development required to add enhanced functionality and to refine the driver. This work will be done in parallel with the development of the CardBus version.

The FY03 work packages for diagnostics groups at ORNL, LANL, and BNL have been reviewed. The impact of the final ORNL work package is being assessed. Tom Shea and Mike Plum discussed developments in RF reference circuitry for the BPM system and possible collaboration by ORNL and LANL in this effort. A requisition was prepared for contract labor from TechSource. This will support initial production of the loss monitor system in FY03.