Low-energy RHIC electron Cooler (LEReC) progress updates

October 17, 2016:

Physics Support:

- Optics for extraction beam line was updated and reviewed.
- Optics for RF instrumentation line has been finalized.
- The Exempt Accelerator Safety Analysis for the Low Energy RHIC Electron Cooling DC Gun Test has been finalized. The analysis has been presented for review to Lab LESHC committee.
- Cooling Section Shielding Test Bench: Performed tests with the junctures between shielding cylinders shielded by several layers of high-mu foil. The tests were performed for one layer of shielding. The tests show that shielding joints with foil does work. Tests with two layers of shielding require rebuilding additional spacers. The work is in progress. The shields manufacturer can produce the re-annealed cylinders of up to 42" length. This results in 2 joints per drift between solenoids.
- Working on building the actual Machine Protection System for the winter gun test run.
- Work continues on the on-line model and respective high level application that can be used for LEReC commissioning
- The algorithm of e-beam trajectory alignment in the cooling section was presented to and approved by the LEReC accelerator physics group. It was decided to procure the individual power supplies for the CS solenoidal modules.

DC gun and cathode system:

- With help from BNL Cornell completed gun and PS assembly. Several vacuum leaks were fixed. Power Supply was tested to 600kV. Pre-processing of the Gun at Cornell was very successful. After 44 hours of processing, the final peak voltage of 440kV was achieved. DC gun delivery to BNL October 18, 2016.
- With help from Cornell the following documentation was revived or developed: HVPS documentation; Two matlab scripts for auto HV conditioning; A procedure for helium gas processing; document about HV conditioning (original from Jlab); Developed a preliminary SF6 gas filling procedure; Beam alignment procedure for Cornell accelerator (including laser centering, solenoid alignment, SRF alignment);
- Transport system vacuum components in shops, insertion system vacuum components in shops; transfer manipulators ordered/on hand; transport cart ordered; windows, pumps gauges ordered/in hand.

Cathodes:

- Successfully tested the tube furnace that will keep the alkali metals from clogging the effusion cell. The highest melting point is for Na at ~ 98 deg. C. Were able to heat it up to ~ 300 C, well above the required temperature.
- Mounted the puck on our heater platen. Found that the fork that transfers the puck to the deposition chamber was too large and is now being modified.
- All the ion pumps are wired and a few of them have been tested. With these pumps, the chambers have been pumped down to 9 scale vacuum even without baking, a good sign. One of the ion pumps had to be reoriented to make room for the transport section.

Laser:

- Laser trailer: The trailer was re-installed at its nominal location now atop a solid 50-ton steel base. The laser trailer floor was modified to allow the optical table's support legs to connect directly to this stable base (to decouple the optical table from the floor of the laser trailer). A new optical table has been relocated in the trailer. Design work is underway for rack layouts and additional shelving.

- Laser transport: The overall layout was finalized. Engineering designs for the in-vacuum transport and custom mirror supports were completed. The bore through the RHIC shield wall is underway. The concrete supports and shield blocks for the relay and gun tables are on hand and await surveying of the end-to-end optical path. These tables have been received.

- Laser development in laser R&D lab: The renovation to the bldg. 912 laser room was completed. The laser oscillator, amplifier and frequency doubling were reestablished on the newly installed 5' by 13' by 2' optical table (property transfer from the BNL SDL lab). Beam pointing instability measurements were completed (~ 5 microns over ~ 20 minutes for both 100 W and 180 W in the infrared). Design IR (160 W) and green (120 W) were demonstrated. Efforts are underway to coordinate a conduit from Industrial Laser Systems (Germany) to allow adjustment in the laser amplifier temperature setpoint to allow higher power operation for determination of performance limits.

- Laser transport development: A temporary test area, located in the clean room near the laser R&D lab, with borrowed optical table and newly installed networking infrastructure was realized. A cross-correlator was designed, set up and aligned. Testing of motion controllers for translation of optical devices was completed and decisions reached on types of controllers to implement for high reliability operation. A mock-up of the optical transport from the gun table to cathode to laser exit port was established. Two axes of mirror motion control (for mapping of the cathode quantum efficiency) were successfully tested using the RHIC controls system environment. Images of the spatially shaped laser beam were acquired over the intended range of spot sizes at the cathode (2-6mm diameter).

RF cavities:

- **2.1 GHz Warm RF Cavity**
  - Cavity has been delivered
  - The custom copper vacuum waveguide delivery has been delayed by vendor and is scheduled to be delivered by the mid-October.
  - Tuner actuator has been delivered, leak checked and tested. It's ready for installation.
  - Tuner plunger has been delivered, passed leak checked but needed some work to make things fit together.
  - Most of the waveguide components that were ordered are in house. All waveguide components necessary of installation have been ordered.
  - The custom waveguide transition from JLab C100 dimension to WR430 has been delivered and passed RF test.
  - Design of the cavity support is completed. Fabrication of the stand is done and the mounting plates are in the shop.
  - All hardware necessary for installation have been ordered.
  - 2.1 GHz and tuner components are being pre-surveyed in preparation for assembly and installation.
  - All the components for the high power test of the RF window are in house except for the amplifier.
  - Custom Stainless steel window flange adaptor to waveguide is done, tested and ready for installation. This will also be used for the window test.
  - We are still troubleshooting a malfunctioning humidity sensor and error with the LabVIEW code so that we can do a low power test until the amplifier arrives.

- **704 MHz Warm RF Cavity:**
  - The design of the 704 MHz is completed. Fabrication is underway. Due to some OTHER issues during fabrication (EB weld) the RF test has been delayed to the end of October and the delivery has been delayed to mid/end of November.
  - The tuner actuator PO has been placed and awarded/ delivery not confirmed yet because of delayed with parts that are outsourced.
  - Tuner plunger PO has been placed and awarded/ delivery TBD.
  - Design of manual tuner for RF test at RI is completed. Fabrication is underway.
  - Design of coupling flange adaptor for RF test at RI is completed. Fabrication is underway.
  - Design of the vacuum FPC waveguide adapter is completed and PO has been placed and awarded/ delivery TBD.
  - Design of the cavity support is underway.
  - Coax layout is completed/ PO submitted for all components necessary for installation.
  - PO for custom vacuum cross for tuner has been placed and awarded / delivery TBD
  - PO for custom shield RF elbow has been placed and awarded / delivery TBD

- **704 MHz Deflecting Cavity**
  - Design of the tuner is underway

- Awaiting final design review
- Drawings for the bid package are being checked.
- Completed SOW and specs / waiting for final design review and signatures.
- Plan is to send the bid package by November.

- **SRF Booster cavity**
  - The cavity modifications performed by Roark under contract to ANL don't appear to have caused any negative impact.

  The cavity reprocessing (BCP + HPR) at ANL appear to have removed the 1.6MV (thermal) quench limit observed during the end of ERL testing.

  The cavity low field Q0 is lower than observed during the original vertical testing at J-Lab N years ago. This needs more careful analysis for sources of measurement error, etc.

  The cavity likely has particulate contamination, evidenced by early onset of field emission. We discussed results with J-Lab and elected to perform another round of HPR at J-Lab. One change will be that J-Lab will use the BNL custom designed HPR nozzle. Following Round 2 of HPR, J-Lab will perform another vertical test. We'll again be present for the VT.

Magnets:

- Remaining DC gun test beamline correctors are under construction.
- DC gun area solenoids received and magnetic measurements is being prepared.

Vacuum elements:

- Vacuum elements are being prepared for the DC gun test beamline installation.
- Vacuum chamber for 45 deg. magnet is being fabricated.

Power Supplies:

- All of the power supplies have been installed for the DC gun test. Nothing is connected to any of the power supplies yet.
- DC cables have arrived for the gun injection test.
- Building an MPS current sensor chassis for the gun injection test.
- The 180 degree magnet ps is still undergoing stability testing and the temperature controller needs to still be tested under varying external temperatures. The loop has been

modeled up so we can come up with the proper compensation for the magnet when it is ready.
- The Spellman ps for the anode high voltage bias is due to be delivered on 10/18/16

Beam Instrumentation:

- **Profile Monitors:** Parts on order for 2 of 3 PM's – 1 PM complete. Optics testing underway.
- **Emittance Slit:** Parts on order, but ferrite order is delayed.
- **BPMs:** all chambers & buttons in-house, buttons & chambers for gun test line being prepared for installation. Electronics under test.
- **Current Transformers:** FCTs on order to be installed in December.
- **Faraday Cup** electronics chassis construction underway.
- **NMR probe** under construction, delivery planned by end of October.
- **Radiation detectors** materials in-house, construction to begin next week.
- **Halo Monitors** extracted from ERL and new chamber on order for installation in November.
- **Motion control** chassis design complete for gun commissioning tests, construction underway
- Upgrade of **PMT loss monitors** from ERL with scintillating fibers under development – detector tests planned in November.

Controls:

- The initial version of the remote interface for the AMP motion controller that will be used with the laser beam alignment systems has been developed, and has been validated through field testing by laser experts.
- Software associated with the subset of power supplies that utilize an ethernet interface has been fully configured, and a LEReC control page has been developed for these supplies.
- Initial software development for the Machine Protection System user interface has begun.
- Remote interface software has been developed for the Agilent hot cathode vacuum gauge controller that will be required for DC Gun conditioning, though we have not had the hardware available yet to test with.
- Code has been developed for the DC Gun remote interface, and a member of our group visited Cornell to see their version of the interface in action. Information learned during this exchange will be implemented directly in our own version of the software in order to streamline the conditioning process.
- Workstations and communications support equipment required for DC Gun conditioning is expected to be fully installed during October.

Commissioning:

- Plan and procedures are in preparation.

Installation and other Design work summary:

- IR2 is being prepared for DC gun installation. Power is being installed; water connections; Cables are being pulled.
- Stands are being fabricated.
- 1002D power and cable tray installation underway.
- Tunnel penetration for laser transport and RF is underway.
- Laser building is back in place. Electric work is underway.