Low-energy RHIC electron Cooler (LEReC) progress updates

November 10, 2016:

Physics Support:

- Approval for DC Gun conditioning and beam tests was received from DOE field office.
- ACCRC and RSC check-off lists for DC Gun conditioning are in the process of being signed.
- Optics for extraction beam line was updated. Optics for the merger beam line was updated.
- Refined the final CS shielding design to accommodate the actual BPM connectors and to improve the shielding of the joints between the shielding cylinders.
- Additional tolerance study simulations were performed.
- Estimated the kick of the ion beam on the e-beam trajectory in the cooling section in case the centers of the beams are displaced with respect to each other. While the tolerance on the allowed beam displacement is easily achievable (~0.5 mm), this beam-beam kick prohibits us from using the Fermilab-established technique of displacing the centers of the beams to fight the overcooling of the ion beam core.

DC gun and cathode system:

- Received all the gun components from Cornell.
- Successfully re-installed the gun assembly and the HV power supply assembly at 912 and at 922 respectively, with some help from Cornell. Safely transported the gun assembly from 912 to RHIC 2 o'clock area. Installed the gun assembly at 1002.
- Bake-out was completed (5E-10 Torr).
- Assembled the pressure chamber support frame around the gun chamber inside the RHIC tunnel.
- Finished a HV power supply water piping pressure test (up to 1.5 times of the operating pressure) at 922.
- Received a mobile lift table (for the transportation of the cathode puck suitcase inside the tunnel) and a spreader beam (for the gun pressure chambers lifting).
- Preparing the SF6 handling system for the DC gun operation.
- Continue working on the cathode puck suitcase transport design.
- Continue fabricating parts for the cathode puck insertion system in the Central shop.

Cathodes:

- Puck has been successfully transferred back and forth between two sections both in air and in vacuum.
- The platen holding the puck has been heated, temperature of the puck calibrated against the platen thermocouple, operating parameters for reaching evaporation temperatures of the puck established
- Gate valve tested successfully when the pressure differential between its two sides was equal to an atmosphere
- Effusion cells have been heated successfully with tube furnace

Laser:

- Laser trailer: The electrical power circuits and outlets both on the new optical table and in the anteroom for the relocated chillers were installed. The trailer was thoroughly cleaned in preparation for the laser relocation to this trailer. Vibration measurements are underway.

- Laser transport: The bore through the RHIC shield wall was completed. The optical table near the electron gun has been pre-positioned atop its concrete support in the tunnel.

- Laser development: Measurements of laser properties in the R&D lab were completed:

    - Laser power IR: 160 W design, 270 W achieved
    - Laser power green: 120 W design, 180 W achieved
    - RMS time jitter: <500 fs design, ~ 240 fs (between 1 Hz and 1 MHz) achieved
    - Spatial profile: M^2<1.2 design, 1.09 achieved
    - Pointing instability: 10 μm rms design, < 10 μm rms at 180 W (IR),
    - RMS laser power stability: 0.12% (IR, 180 W), 0.5% (green, 100W)

- The laser will be moved from the R&D lab to the laser trailer (1002F) starting this week.

- Laser integration: Laser state tables for the LEReC Gun Test machine protection system were defined. The Standard Operating Procedure (SOP) for the LEReC (and CeC) lasers was updated and reviewed by safety experts (A. Etkins, C-AD ES&H Coordinator and C. Weilandics, BNL laser safety officer); a few installation-specific details will be incorporated into the document as that information becomes available. Laser failure possibilities and their impact are being evaluated.

RF cavities:

- **2.1 GHz Warm RF Cavity**
  - Cavity has been delivered
  - Fabrication of custom copper vacuum waveguide is done. To be inspected during our trip to RI this week Nov 8th-13th. RI will ship waveguide to BNL after inspection.
  - Tuner actuator has been delivered, leak checked and tested. It's ready for installation.
  - Tuner plunger has been delivered, passed leak checked but realized that overall length of tuner does not meet drawing specs. Pending discussion with vendor.
  - Fabrication of the stand is done and the mounting plates to support vacuum waveguide are in the shop.
  - All hardware necessary for installation have been ordered.
  - 2.1 GHz and tuner components have been 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.
  - Low power test on the windows was successful. Waiting on amplifier to do high power test.

- **704 MHz Warm RF Cavity:**
  - The design of the 704 MHz is completed. Fabrication is underway. RF test will be performed at RI this week Nov 8th-13th . Delivery has been delayed to end of November early December.
  - The tuner actuator PO has been placed and awarded/. Delivery estimated for mid-December.
  - Tuner plunger PO has been placed and awarded/ delivery end of December.
  - Design of manual tuner for RF test at RI is completed. Fabrication is completed and shipped to RI for RF test.
  - 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 completed. Fabrication will start soon.
  - Coax layout is completed/ PO submitted for all components necessary for installation/ Delivery end of November.
  - Custom vacuum cross for tuner has been delivered. Pending inspection.
  - Custom shield RF adaptor has been delivered/ Pending inspection.
  - PO for custom elbow has been placed/ Delivery end of November.
  - Penetration for coax in 1002 is completed.
  - Installation of circulator at 1002 is underway

- **704 MHz Deflecting Cavity**
  - Design of the tuner is underway
  - Final design review was done and RF geometry confirmed by Tianmu.
  - Drawings for the bid package are being checked.

- Completed SOW and specs
- PO has been placed. Waiting for official drawing in order to pin the PO.
- Plan is to send the bid package by mid-November.

- **SRF Booster cavity**
  -Modifications to Booster Cavity and cavity reprocessing are complete.
  -Vertical testing has shown very good performance.
  -Final vertical test at J-Lab 11-18-2016.
  -On schedule for cryomodule reassembly, horizontal test and installation in 2IR.

Magnets:

- Remaining DC gun test beamline correctors are under construction.
- First DC gun area solenoid was measured.

Vacuum elements:

- Vacuum elements are being prepared for the DC gun test beamline installation.

Power Supplies:

- All dc supplies from ERL have been extracted and installed in 1002D.
- The gun injection supplies for LEReC are all installed in 1002D.
- The ac cables are installed and connected to the power supplies and circuit breaker panel for the gun injection ps's.
- DC cable is on site for the gun injection power supplies
- Once cable tray and magnets are installed the dc cables can be pulled along with the magnet interlock cables and connected at the ps and magnet.
- Magnet interlock interface boxes are being built.
- MPS current sensor boxes are built and now being tested
- DC cable and magnet interlock cable pulling list ready for gun injection
- IP addresses assigned by controls for gun injection power supplies

DC gun PS:

- Multiplier assembled in building 922 and connected to inverter rack
- Multiplier was run up to 25kV in air in 922
- Inverter rack parts list made so we can build a duplicate and then the inverter and control chassis will be moved over to the new rack. Old rack wiring is not very neat. New rack wiring will be neater and then we will have a spare rack.
- Pressure Test of multiplier heat exchanger will be done in 922.
- Waiting to be moved to tunnel

180 deg. magnet:

- Power Supply is operational.
- Stability tests have been completed, but not under wide temperature variations yet.
- Temperature variations limits still need to be determined for the thermoelectric cooler.

- An interlock is being installed to prevent damage to the PS and regulator in case the thermoelectric unit fails.

The loop has been modeled up in a circuit program so that we can now determine the proper compensation for testing the magnet in 902A or the tunnel

Beam Instrumentation:

- **Profile Monitors:** Parts on order for 2 of 4 PM's – 2 PM's complete. Optics testing underway.
- **Emittance Slit:** Majority of parts received, but ferrite order is delayed.
- **BPMs:** Buttons & chambers for gun test line are ready for installation. Electronics testing in progress.
- **Current Transformers:** Two of four FCTs on order with December installation planned.
- **Faraday Cup** electronics chassis construction underway.
- **NMR probe** under construction, delivery planned for this month.
- **Radiation detectors** cables being pulled and detector will be installed by Nov 14.
- **Halo Monitors** All four are ready for installation when new vacuum chamber arrives.
- **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.
- **Instrumentation Rack** electronics installation in progress.

Controls:

- Workstation installation in the 1002D trailer has been postponed till early November while infrastructure preparations in the area are completed.
- The software interface to the DC Gun power supply has been tested successfully at building 922 for all available modes of operation. A full exercise of the controls won't be possible until the equipment is installed in IR2. The last critical piece of the hot cathode vacuum gauge controller software remote interface needs lab testing prior to DC Gun operations, involving relay interlock control. A script has been adapted from the software used at Cornell (MatLab->Python) that will automate the conditioning process. More offline testing will be performed prior to the start of conditioning. Modifications where made to the Canberra X-ray detector interface software to support reading back up to three sets of probe dose rates. We anticipate using a setup with two probes during DC Gun conditioning.
- Work has begun on the remote interface for the Spellman power supply that will be used with the Gun Anode Bias. The hardware was recently delivered to BNL.
- Discussions were held on developing the specifications for the interface between the future LEReC model server software and the controls for related instrumentation and power supplies.
- A software interface for laser shutter control and status readbacks was developed. Work continued on the remote interface software that will be used with laser power meter equipment.

- Support for lens iris controls were added to the ebicman interface for GigE cameras.

DC Gun Items:

- Controls cable pull requirements were finalized
- Bench testing of Floating Ammeter module and its Power-over-fiber setup completed
- Multiple rounds of testing Gun HVPS manager software connected to the supply (without HV)
- Serial data converter for HVPS was procured and tested

Other:

- Simple prototyping PC board for fast timing system elements designed and built
- Simple network throughput test for fast timing platform

MPS:

- The hardware was ordered and arrived .

Working on the logic flowchart.

Cryogenics:

Mechanical hardware

- Cryogenic transfer line system for Booster cavity cryostat: Vendor selected and contract awarded. Project kickoff meeting week Nov 1-4.
- 5 x Return heaters for the 5K intercepts cooling circuits: Requisition to be issued.
- 5K circuit heaters jacketed assembly drawings to be completed to go out for quotation.
- Large return heater for 4.5K subcooler vapor return: Fabrication completed. Delivery week of Nov 7-11
- Warm piping system valves: ordered

- Controls and Instrumentation
- UL listed Heater 5 zone control panel for the 5K circuit return heaters and Large heater Control Panel on order: Delivery in December
- Pressure transducers and temperature sensors ordered.
- Misc Rack parts ordered.
- Additional I/O cards ordered
- Cables tunnel to racks: ordered
- I/O list completed
- Control logic engineering doc completed.
- Cryogenic transfer line system for Booster cavity cryostat:
  Procurement department has issued the RFQ to vendors and is out for bid.