# Low-energy RHIC electron Cooler (LEReC) progress updates

## December 7, 2016:

**Physics Support**:

- Preparation for DC gun tests with beam is underway.
- Detailed plan for DC gun tests with goals and priorities is being prepared.
- DC gun HV processing started on 11/30/16. As of 12/7/16, 421kV achieved.
- Laser jitter simulation studies.
- Analytic estimates of the requirements to the RF phase stability and the Laser time jitter, and comparison with tolerance studies from simulations.
- The status of the MPS for the gun test:
    - Working on the system documentation and test procedures.
    - The logic is finalized and has being reviewed by the system engineer and MPS coordinator. It remains to be reviewed by the rest of the MPS group before the actual coding starts.
    - Working on finalizing the FCT processing scheme.
    - The general MPS design was reviewed by the DOE committee.

**DC gun and cathode insertion system:**

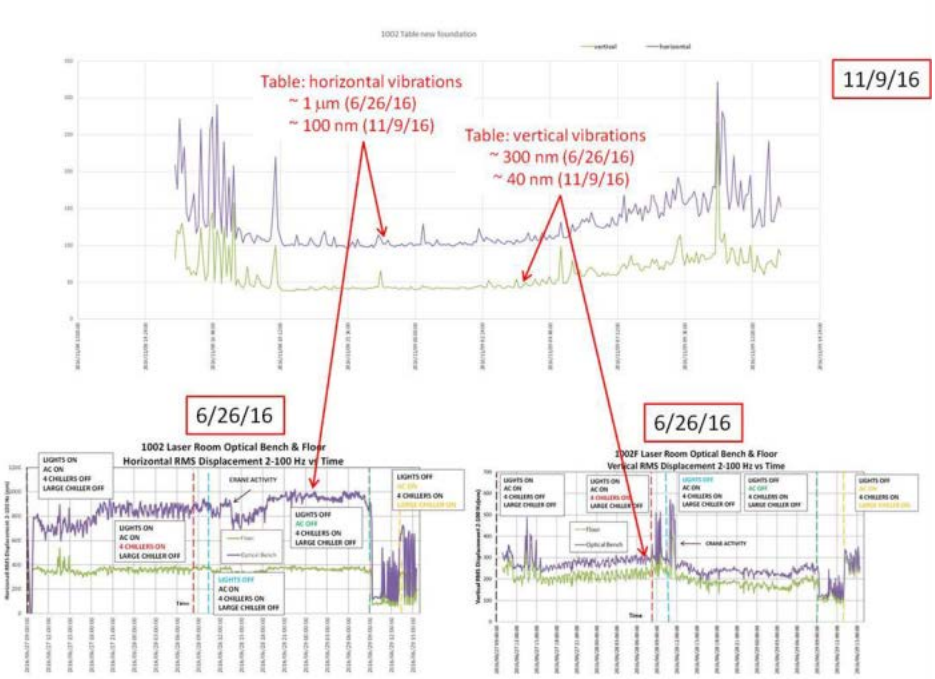
- Completed the installation of the pressure chambers above the gun chamber assembly.
- Finished the final survey of the gun assembly at 1002.
- Finished a pneumatic pressure test on the HV ceramic break and on the feedthroughs, which are attached to the pressure chambers, at a pressure of 110% operating pressure in 1002. The test was successful.
- Successfully filling/evacuating SF6 gas into/ out-of the gun pressure chambers, using a DILO SF6 gas service cart.
- Finishing up the remaining fabrication jobs in the Central Shop.
- Continue cleaning and firing vacuum components of the cathode puck insertion system and prepare for assembling the system in a clean room.
- Re-ordering silver plated hardware for the cathode puck insertion system use, which are compatible with the clean room environment.

**Cathodes:**

- The cathode fabrication chamber has been pumped and baked for 10 days and has reached very good vacuum: depo. section 2*10^-11, manipulator arm 7*10^-11 and load lock section: 1*10^-10.

**Laser:**

- Laser trailer: Vibration measurements were completed (T. Tallerico, S.V. Badea) showing significant improvement




- Laser trailer, continued: Trailer was re-keyed; the through-port for the optical transport line was completed; the move of laser from Bldg. 912 R&D area started

- Laser transport:

  - The optical table just inside the RHIC tunnel (relay table) has been installed and grouted
  - The optical table near the electron gun (gun table) has been pre-positioned atop its concrete support
  - The design for cathode imaging (exit table) was completed
  - The laser transport pipes have been cleaned and cut (Vacuum Group) and sent to Central Shops for welding; the in-tunnel optical table enclosures have been designed

- Laser integration: reviewed remote control diagnostics requirements, continued coordination with Controls Group on implementation specifics (signal types, frequencies,

levels, etc.); continued coordination on laser-related aspects to Machine Protection System

- The Laser System Development presented at the DOE review in Germantown (16-17 Nov, 2016)

**RF cavities:**

- **2.1 GHz Warm RF Cavity**
  - Cavity has been delivered and all components have been test fitted. Cavity components have been transferred to vacuum group for particulate free assembly.
  - Custom copper vacuum waveguide has been delivered. Transferred to vacuum group from leak check and bake out for particulate free assembly.
  - Tuner actuator has been delivered, leak checked and tested. Spacer was needed for limit switch. It's ready for installation. Transferred to vacuum group from leak check and bake out for particulate free assembly.
  - Repair of tuner plunger has been completed. New thermal analysis was done and shows a 50C rise in temp from original design (new max temp 155C). Pending discussion to determine if we need to build a new one during the run.
  - Fabrication of the stand and all the mounting plates to support vacuum waveguide is done.
  - All hardware necessary for installation have been delivered.
  - 2.1 GHz and tuner components have been pre-surveyed in preparation for assembly and installation.
  - Still waiting on amplifier for the high power test of the RF window.

- **704 MHz Warm RF Cavity:**
  - Fabrication is still underway. RF test was performed week Nov $8^{th}$-$13^{th}$. Cavity frequency and Q was good. After repair that was done to fix vacuum leak, there was an increase in cavity frequency and significant decrease in Q.
  - Possible solution to bring Q and frequency back to acceptable values have been discussed with vendor. Pending new RF results.
  - Delivery has been delayed to end of December.
  - The tuner actuator PO has been placed and awarded. Delivery estimated for mid-December.
  - Tuner plunger PO has been placed and awarded/ delivery in January 2017.
  - Design of the vacuum FPC waveguide adapter is completed and PO has been placed and awarded/ delivery end of December.
  - Fabrication of the stand is completed. Design of the cavity support plates is completed. Fabrication is underway.
  - Coax layout is completed/ PO submitted for all components necessary for installation/ Delivery delayed to mid-December.
  - Custom vacuum cross for tuner has been delivered..
  - Custom shield RF adaptor has been delivered.
  - Custom elbow delivery early December.
  - Penetration for coax in 1002 is completed.

- Installation of circulator at 1002 is completed. Waiting for amplifier.
- Design of custom coax to window transition is completed. Design verified by Binping. Drawings underway for fabrication.

- **704 MHz Deflecting Cavity**
  - PO has been placed. Kickoff meeting was done on Dec 2nd for RFP. Plan is to release PO first week of January.
  - Design of the tuner is underway.
  - Completed SOW and specs

- **SRF Booster cavity**
  - Final vertical test at J-Lab scheduled for 11-18-2016 was delayed to: cleaning around Thu 12/08 and HPR Tue 12/13

**Magnets:**

- Remaining DC gun test beamline correctors constructed and are under measurements.

**Vacuum elements:**

- The gun vacuum system was baked at 200C achieving a pressure of high 8e-11 torr. The RGA scan indicates over 90% hydrogen which is good.
- The remote He conditioning system was temporarily installed with a portable turbo station used for HV conditioning. The system has remote control through PET. The He lines used in conjunction with the leak valve were baked to minimize contaminating the gun chamber with water vapor
- The Rf shielded and unshielded bellows were received
- The pump tees were received
- All gate valves and roughing valves were received
- The laser transport tubes were cut waiting for welding
- All vacuum controls for the gun are remoted to the trailer and interfaced with PET
- Vacuum components for both the transport and cathode injection system were being vacuum fired

**Power Supplies:**

DC gun PS:

- Prepared DC gun PS for tests
- Multiplier was successfully tested to 600kV at IP2
- DC gun HV processing started

## Beam Instrumentation:

- **Cathode Imaging:** design complete and parts ordered
- **Profile Monitors:** Parts on order for 2 of 4 PM's – 2 PM ready to install. Optics testing underway.
- **Emittance Slit:** Parts on order.
- **BPMs:** Ready to install. Electronics under test.
- **Current Transformers:** FCTs on order (expected mid Dec); ICT, DCCT ready to install; electronics chassis under construction
- **Faraday Cup** electronics chassis ready to install.
- **NMR probe** cable procurement delays delivery to January.
- **Radiation detectors** Canberra GMTs installed and operating.
- **Halo Monitors** ready to install
- **Motion control** ready to install
- Upgrade of **PMT loss monitors** from ERL with scintillating fibers under development

## Controls:

- Timing System - expect to have commissioning implementation ready for start of run
  - HW configuration
    - Beamsync system ("slow timing") configured and installed in 1002d
  - application interface - compiling info for software changes to existing diagnostic interface, EventLinkDisplay
  - timing control manager - need a meeting later this week to review desired user interface and related knobs in Fast/Slow/RF systems
- Magnet Manager - expect to have commissioning implementation ready for start of run
  - manager software development - we plan on adapting CeC manager for LEReC role, though we'll be looking to learn the custom specs for LEReC next week
- QE Scan tool - expect to have commissioning implementation ready for start of run
  - software UI - we are currently discussing using the existing generic "scanner" application, though some changes will be needed to support the QE scan (ex. display of data)
  - manager interface - if needed, we can adapt ERL implementation to work with the LEReC mirror motion controller software interface
  - mirror motion interface - a basic interface has been developed and tested by Laser system experts

- Beam position - expect to have commissioning implementation ready for start of run
  - orbitDisplayApp - working to update to support LEReC configuration
  - manager middleware - we developed an initial version that requires integration testing with orbitDisplayApp

- Profile monitor - expect to have commissioning implementation ready for start of run
  - cameraViewer - application is available from CeC development, does not include color imaging support yet
  - manager software - currently working on adding support for color imaging (driven by CeC cathode spec)

- Scope remote display - expect to have implementation ready for start of run
  - RemoteScope - application will require minor adaptation for use with the LEReC diagnostic scope

- BLM display - development schedule for revised hardware/software needs to be discussed with Instrumentation Group and LEReC experts
  - software UI - existing implementation available using Gpm/LogView, new application development is waiting on development plan update
  - manager middleware - new development is waiting on plan update
  - PMT BLM software - development is waiting on plan update, existing version used at CeC is available
  - PMT BLM hardware - potential firmware changes to VME board are waiting on plan update

- Physics scan tool - schedule TBD
  - software UI - the software implementation is under discussion

- MPS interface - expect to have commissioning implementation ready for start of run
  - manager interface - collecting the final specifications from the experts, implementation will be a variation of ERL/CeC versions

- Synoptic displays - expect to have commissioning implementation ready for start of run
  - Syndi pages - developed a display for the DC Gun already, master LEReC and RF displays are pending

- Model server integration with Controls - schedule TBD
  - adaptation of existing/new managers - to support model server interaction and perhaps scanning tool or tape application interaction, for BPM/camera/magnet systems

- Solenoid 4D motion controls - schedule TBD
  - motion controller software - need to review status of hardware plan with Instrumentation Group first
  - manager middleware - a plan to handle the special circumstances here has yet to be developed
  - software UI - will depend on the establishment of the manager development plans

- ICT/FC sampling and machine protection - expected delivery by start of RHIC run (likely after any Dry Run)
  - hardware - working on porting the Zynq VHDL design from the CeC setup

## Cryogenics:

**Cryogenics:**
Mechanical hardware
• Cryogenic transfer line system for Booster cavity cryostat: Design review scheduled week Dec 12 at Vendor
• 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 updated for December
•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: Shipping scheduled for Dec 2
• Pressure transducers partial shipment received.
• Misc Rack parts ordered, I/O cards, Cables tunnel to racks ordered

## Installation and other Design work summary:

**DC gun and cathode system:**
• After reassembly, the DC gun was shipped to the RHIC 02:00 and placed in the LEReC operating position. A temporary cleanroom was installed and final alignment of the cathode was completed. The gun was vacuum baked for 4 days at 200C and then the power supply was assembled in place. The power supply was tested to 600 kV. The last day of November, was the first day of DC gun conditioning. After the first 6 hours of conditioning, the DC gun reached 213 kV.


DC Gun Power Supply Assembly

• Fabricated and procured parts for the cathode system were delivered during the month. The cathode insertion drive system was assembled and tested. The stands for the system have been assembled. The vacuum chambers were received, baked, and fired. Set-up and assembly of the puck removal tool was completed and successfully tested. Next step is UHV preparation and final assembly welding.
• All 36 molybdenum cathode pucks have been fabricated. The requisition for polishing these pucks has been released. In addition, there are 2 1$^{st}$ production units in hand that are being used in the cathode deposition facility and for laser imaging. One of the units was found to be oxidized and is being repolished. Pucks will be stored in dry gN2 or in vacuum in the future.

**Transport Beam Line Assembly:**
• Fabricated and procured parts for the DC Gun to Booster section of the transport beam were delivered during the month. The beam line stands and hardware were delivered. The solenoid magnets have been magnetically measured; the special correctors for this section of the beamline are complete and being measured. The solenoid magnet mounting system with remote positioning drives has been assembled and is being tested. The three custom vacuum chambers for this system of the beamline are a month late from the vendor. The first chamber was delivered near the end of the month, it has been leak checked and is being vacuum fired. The other 2 chambers are expected the week of December 5. BPM buttons are in hand. Profile monitor parts are being fabricated in BNL shops and are expected the week of December 5. The laser mirrors have been fabricated and positioning hardware is in hand being vacuum fired. The mirrors are being polished and silver plated by a vendor.
• The rest of the DC Gun transport line stands were assembled during the month. 5 of the 6 stands were surveyed into position and installed in the tunnel. One stand is being built up in the technical shop with components to free up space in the tunnel for staging other equipment. One stand was modified after installation because of a late decision to add another profile monitor in the beam line. It is located at the smallest aperture that will be in the SRF booster cavity when it is installed. The beam line solenoid magnets are installed and surveyed in the tunnel. The 45$^{o}$ dipole magnet with vacuum chamber has been installed on the stand in the technical shop. The quadrupole magnets have also been installed on the stand.

**Schedule – 2016 shutdown installation:**
There was some schedule slip during the month. The DC gun took longer to install and get operational than scheduled because the installation and survey of the power supply tanks was more difficult than anticipated and there were multiple trips of the water system which were traced to the DC gun power supply EMI affecting an electronic circuit breaker in the system. Also affecting schedule was an upgrade to the C-AD cleanroom that will allow High Pressure Rinse of RF cavities taking longer than anticipated by 2 weeks. That work has been completed and staff are working overtime in the cleanroom to catch up with component preparation. For the DC gun conditioning, additional staff is being trained (1$^{st}$ week of December) to add a midnight shift to the conditioning schedule. The goal is to allow conditioning to be completed earlier. This will allow shielding to be removed that will speed access to the tunnel for people and equipment and to allow evening overtime installation work in the tunnel to get back on schedule.