1.0 Generation and Characterization of Magnetized Bunched Electron Beam from a DC Photogun for MEIC Cooler

Principal Investigators: Riad Suleiman and Matt Poelker

Project Status

Project work started with the focus to be ready to generate non-magnetized beam in the second half of FY16 and with the preparation to generate magnetized beam on Oct 1, 2016. Accomplishments of the past 6 months include:

- ✓ Started with an empty room at LERF Gun Test Stand (GTS) and built a photogun, an alkali-antimonide photocathode preparation chamber and diagnostic beamline. All vacuum chambers were painstakingly baked to achieve the desired pressure.*
- ✓ Engineering staff now providing support to develop the required instrumentation and controls, including viewers, ion pumps, current monitoring and control of beamline magnets.*
- ✓ Operations Software developing suitable EPICS control software for items mentioned above.*
- ✓ Finished HV conditioning the gun and ready to make beam at 325 kV.*
- ✓ CEBAF Operations staff member and ODU graduate student Yan Wang has optimized the cathode electrode and triple point shield geometry using POISSON. Fay Hannon using a more sophisticated 3-D field solver program validated his electrode shapes. Electrodes and triple point shields were manufactured and polished and await installation at the next sensible opportunity. These optimized electrodes will allow gun operation at higher voltage, with goal being 350 kV, which will help us extract higher bunch charge beams.*
- ✓ Don Bullard developed a method to polish gun electrodes using a barrel-polishing device owned by the SRF institute. Results are impressive – electrodes can be polished in just two hours, achieving a surface finish comparable to diamond-paste polishing which can require many weeks of painstaking labor.*
- ✓ Graduate student Md. Abduhlah Mamun is now commissioning the alkali-antimonide preparation chamber, which looks very similar to a functioning test stand in Test Lab. Mamun's focus today relates to applying his photocathode recipe to substrates mounted to pucks that can be inserted into the gun electrode versus substrates attached to long stalks used on his Test Lab chamber. We successfully made our first photocathode at the GTS on April 25, 2016.*
- ✓ Shukui Zhang has installed a 10 W DC green laser inside the GTS Laser Hutch. We will commission the beamline using this laser. Later, we can make rf-pulsed beam using the existing Nd:YLF mode-locked laser. The laser LOSP has been approved. Turning mirrors

are now being mounted to the ceiling, and soon we expect to deliver low power laser light to the photocathode. Shukui and John Hansknecht will install a tune-mode generator to create machine safe beam modes with low duty factor, ideal for initial beam steer up.*

- ✓ GTS OSP is approved for only 10 nA – now working with Radiation Control Group for approval at high currents (32 mA). We believe RadCon will approve operation at the desired high current via judicious placement of local shielding along the beamline and beam dump.*
- ✓ Designed the cathode solenoid magnet and finished procurement on March 31. Magnet will be on site by July 8, 2016. The magnet will provide 1.4 kG at cathode with a standard molybdenum puck.
- ✓ Designed a molybdenum and carbon steel hybrid puck to enhance field at cathode to 2.0 kG.
- ✓ Designed emittance slit measurement system.
- ✓ Identified the power supply for cathode solenoid magnet as the new CEBAF spare Dogleg magnet power supply (500A, 80V) and got permission to use it at GTS. EES and the installation group are now installing this supply above the GTS beamline.
- ✓ Used ASTRA and GPT simulation to design beamline and to locate magnets and diagnostics at optimum positions.
- ✓ Simulated magnetized electron beam properties along the beamline for various starting conditions.
- ✓ Simulated a round to flat transformer.
- ✓ Recruited a Ph.D. student to work on this project (Gabriel Palacios – Supervisor: Prof Geoff Krafft, ODU). The student is supported by ODU/JLab and will work on this project during this summer and start full time in fall 2017.
- ✓ Working to hire a postdoc - Dr. Mamun Md Abdullah – who recently graduated from ODU. A postdoc position will be posted once he has received his work visa, expected late May, early June. Initially, his position will be funded via soft-money related to an SBIR partnership (i.e., we have budget to hire him). Later, he will be funded by this LDRD starting Oct 1st, 2016.

Project Plan

Work in the remainder of FY16 will focus on generating non-magnetized beam (May – July) and to be ready to generate magnetized beam on Oct 1, 2016. This includes:

1. Generate non-magnetized beam and commission the exiting beamline.*
2. Work with Radiation Control Group for approval at high currents.*

3. Measure thermal beam emittance using the solenoid-viewer method. Correlate thermal emittance values to different alkali-antimonide photocathode recipes, which can produce widely varying photocathode surface morphologies.*
4. Measure photocathode lifetime up to 5 mA (not magnetized).*
5. Procure slits for beam emittance and magnetization measurements.
6. Relocate the new CEBAF spare Dogleg power supply to the GTS.
7. Procure the hybrid molybdenum and carbon steel puck.
8. Map the field of cathode solenoid magnet with and without the hybrid molybdenum and carbon steel puck.
9. Design and install the support structure for the cathode solenoid magnet.
10. Design and procure the three skew quadrupoles.
11. Install slits, insertable Faraday cup and cathode solenoid. We will use this opportunity to replace a leaky valve, replace the HV ceramic insulator with a version that possesses a very mild conductivity and the optimized HV triple point shield, and add more pumping to gun chamber. These planned changes will enable us to reach 350 kV with minimal HV conditioning. For the preparation chamber, the plan includes adding moly and carbon steel hybrid pucks and modifying the tip of the long manipulator. All this is planned in the first half of August. The bake of preparation chamber, gun and beamline is scheduled in the second half of August.
12. HV conditioning is planned in September.
13. Mark the magnet 5 G field region and establish procedures to operate the magnet safely.
14. Be ready to generate magnetized beam on Oct 1, 2016.

* Only partially funded by this LDRD. Nevertheless, part of the milestones and pre-requisite to LDRD work.

Budget

We worked with the budget analyst to move $50k from “Materials and Supplies” to “Labor”. Last year when we budgeted $60k for solenoid magnet, we put all the cost as Materials and Supplies. However, part of the cost is Labor, so we fixed this. Actually, we have already procured the magnet for $20k, hence we moved the remaining $40k to Labor to map and install the magnet and its power supply. In addition, we initially budgeted $20k for beamline components, and again there is Labor so we moved $10k to Labor.

Publications

N/A

Workshops/Conferences

R. Suleiman, M. Poelker, J. Benesch, F. Hannon, C. Hernandez-Garcia and Y. Wang, *Generation and Characterization of Magnetized Bunched Electron Beam from a DC High Voltage Photogun*, APS April Meeting, Salt Lake City, Utah, April 16–19, 2016.

http://meetings.aps.org/Meeting/APR16/Session/D1.37