Generation and Characterization of Magnetized Bunched Electron Beam from DC High Voltage Photogun for JLEIC Cooler

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September 29, 2016

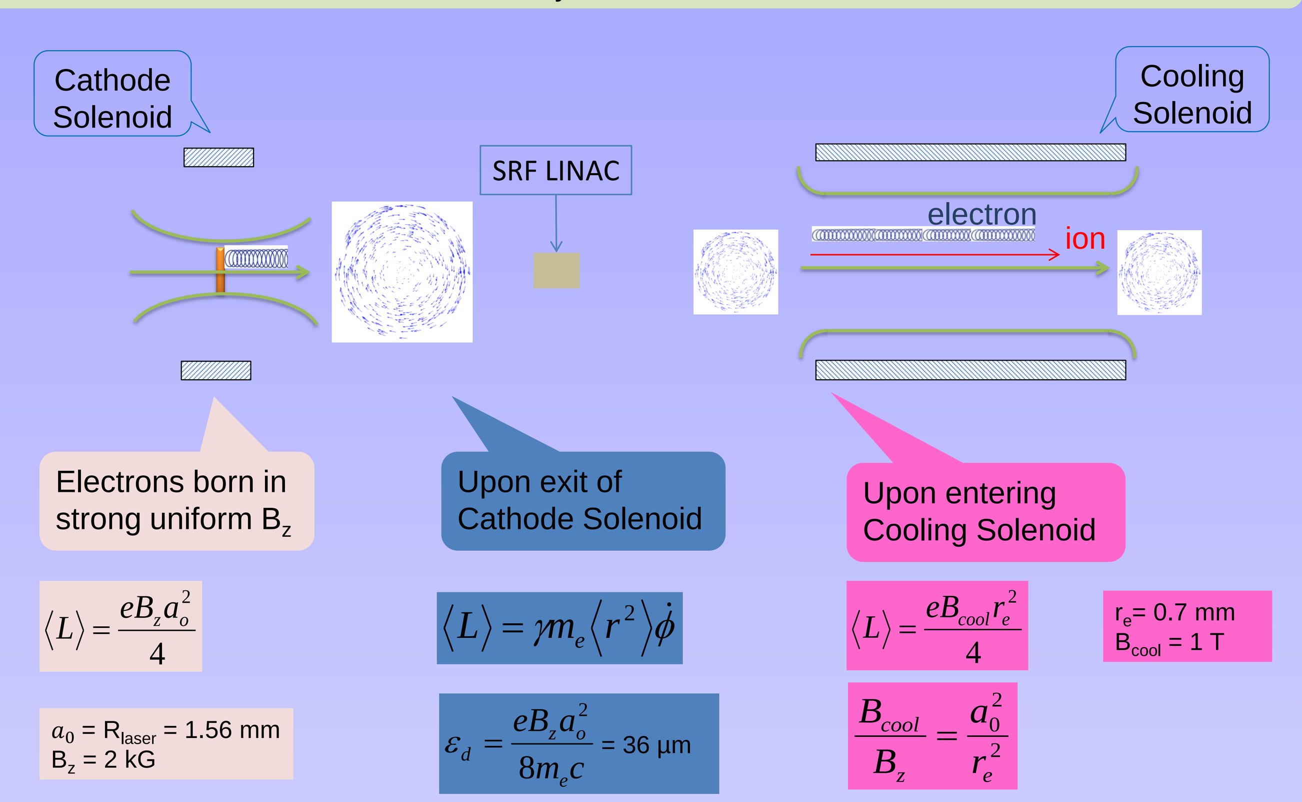
Motivation

Jefferson Lab Electron Ion Collider (JLEIC) bunched magnetized electron cooler is part of Collider Ring and aims to counteract emittance degradation induced by intra-beam scattering, to maintain ion beam emittance during collisions and extend luminosity lifetime

Magnetized Cooling

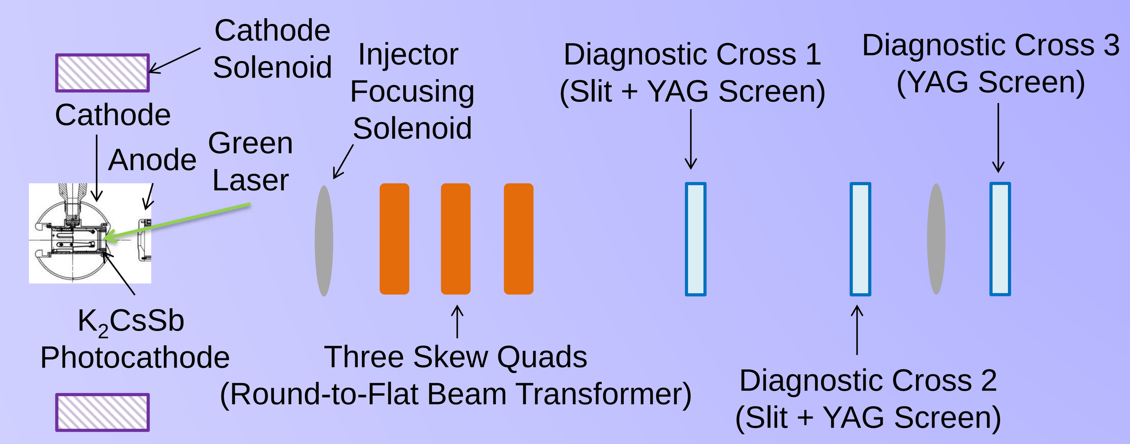
- Electrons helical motion in strong magnetic field increases electron-ion interaction time, thereby significantly improving cooling efficiency. Electron-ion collisions that occur over many cyclotron oscillations and at distances larger than cyclotron radius are insensitive to electrons transverse velocity.
- Cooling rates are determined by electron longitudinal energy spread rather than electron beam transverse emittance as transverse motion of electrons is quenched by magnetic field.
- This cyclotron motion also provides suppression of electron-ion recombination.

Electron beam is being used inside cooling solenoid where it suffers an azimuthal kick when it enters. This kick is cancelled by an earlier kick at exit of cathode solenoid

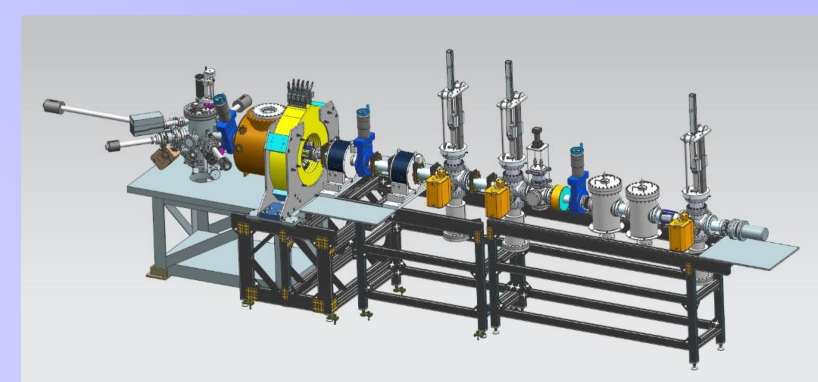


Bunch length	60 ps (2 cm)
Repetition rate	476.3 MHz
Bunch charge	420 pC
Peak current	7.0 A
Average current	200 mA
Transverse normalized emittance	10s mm mrad
Cathode spot radius – Flat-top (a_0)	1.56 mm
Solenoid field at cathode (B_z)	2 kG

Experimental Overview



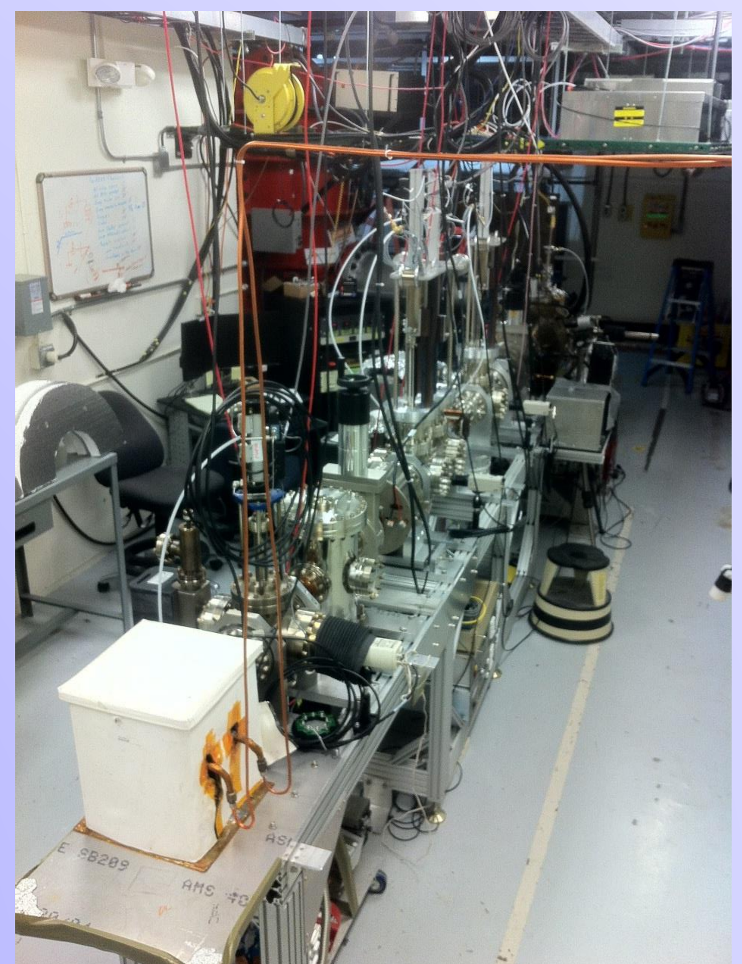
➢ Generate magnetized beam:
- a_0 = 1 – 5 mm, B_z = 0 – 2 kG
- Bunch charge: 1 – 500 pC
- Frequency: 15 Hz – 476.3 MHz
- Bunch length: 10 – 100 ps
- Average currents up to 32 mA
- Gun high voltage: 200 – 350 kV



1. Measure mechanical angular momentum
2. Measure photocathode lifetime versus solenoid field at high currents (up to 32 mA) and high voltages (200 – 350 kV) limited by in-house HV supplies
3. Study beam halo and beam loss versus magnetization
4. Use skew quads – Round-to-Flat Beam (RTFB) Transformer – to generate flat beam and measure horizontal and vertical emittances using slit method
5. Generate very high currents magnetized beam and study beam transport and RTFB versus electron bunch charge

Beamline

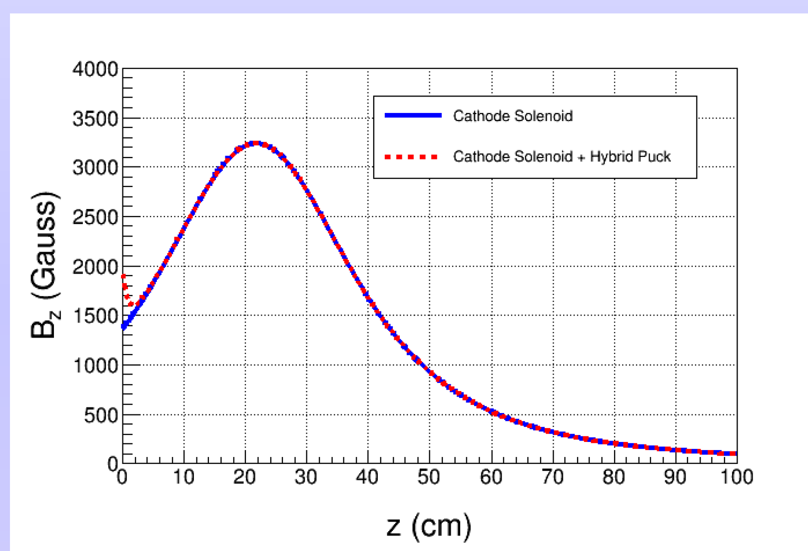
- K_2CsSb Photocathode Preparation Chamber, Gun and Beamline: delivered 1 mA to dump (non-magnetized)
- Simulation (Fay Hannon):
  - Used ASTRA and GPT simulation to design beamline and to locate magnets and diagnostics at optimum positions
  - Simulated magnetized electron beam properties along beamline for various starting conditions
  - Simulated a round to flat transformer

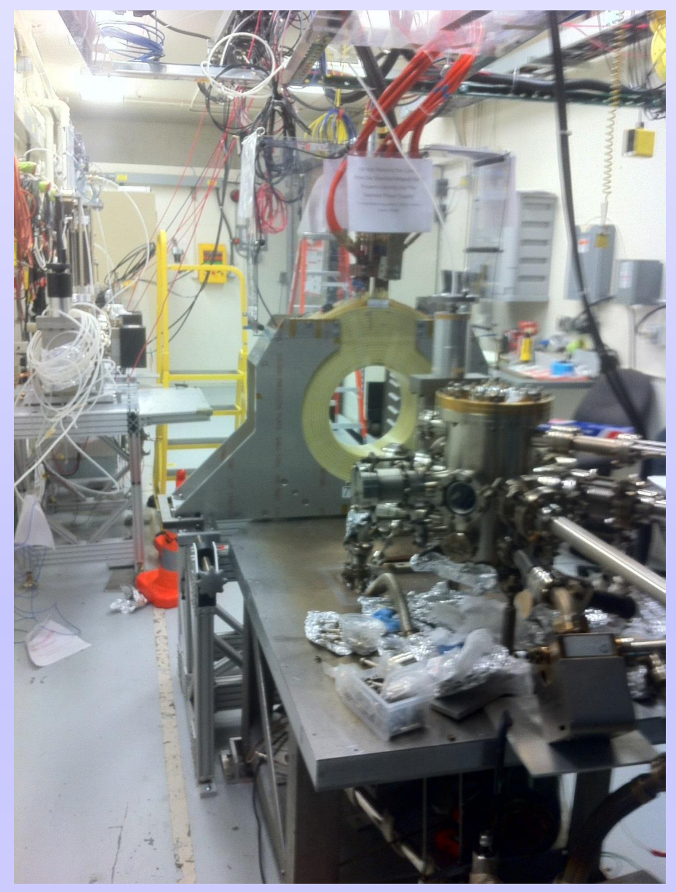


Cathode Solenoid

Cathode Solenoid Magnet

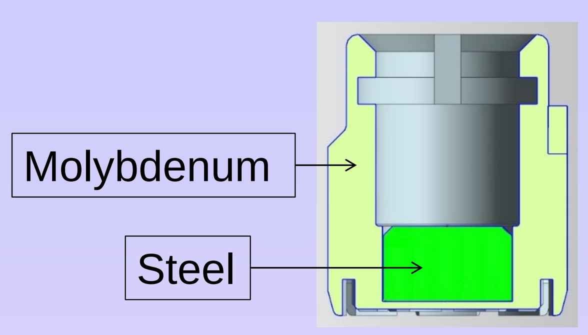
- Mapped and installed at GTS





New Pucks

- Enhance magnetic field at cathode to 2.0 kG



Plans and Summary

- Generate magnetized electron beam and measure its properties starting fall 2016
- Explore impact of cathode solenoid on photogun operation
- Simulations and measurements will provide insights on ways to optimize JLEIC electron cooler and help design appropriate source
- Jefferson Lab will have direct experience magnetizing high current electron beam

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Acknowledgement: This work is supported by the Department of Energy, Laboratory Directed Research and Development funding, under contract DE-AC05-06OR23177

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