**Secondary Ions Dynamics in the JLab GTS 300 keV Beam Line**

The Jefferson Lab (JLab) Gun Test Stand (GTS) consists of an inverted insulator geometry 300kV DC photogun and a 4-meter long diagnostic beamline. By means of a CsK2Sb photocathode grown in a preparation chamber connected to the photogun and using a DC laser operating at 532 nm, electron beam has been generated up the limit of the high voltage power supply at 4.5 mA to study photocathode lifetime. Sustained current at that level is limited to a few minutes due to arcing between the photocathode and the anode. However, operating with a solenoid magnet utilized in a separate experiment to generate magnetized beam, leads to sustain 4.5 mA DC for multiple hours without arcing. It is likely that secondary ions generated in the beamline and trapped by the electron beam migrate to the anode-cathode gap where eventually reach sufficiently high density to induce arcing. We present secondary ions dynamics simulation studies to interpret the experimental observations.

**Ion beam formation at the JLab electron beamline Gun Test Stand**

**Ion production at the JLab electron gun test stand and its impact on DC high voltage photogun operation**

The Gun Test Stand at Jefferson Lab consists of a bi-alkali antimonide photocathode deposition chamber, a compact 300kV DC high voltage photogun with inverted-insulator geometry, and a 4-meter long diagnostic beamline. Beam delivery at 4.5 mA using a DC laser at 532 nm was limited to just a few minutes due to arcing between the photocathode and the anode. However, when operating with a solenoid magnet located near the photogun anode and used to generate magnetized beam, beam delivery at 4.5 mA could be sustained for hours without arcing. To understand this behavior, beam dynamics simulations were performed that quantify ion production that results from ionization of residual gas within the cathode/anode gap and the adjoining beamline, ion transport to the photocathode, and secondary electron emission from the photocathode surface. Simulation results presented here suggest that when the gun solenoid is OFF, the density of ions within the cathode/anode gap of the photogun is sufficiently high to induce arcing. But when the gun solenoid is energized, the secondary electron emission from the photocathode surface does not strike the anode plate, which serves to improve the vacuum in the cathode/anode gap and limits subsequent ion production. In addition, ions from the beamline traveling toward the gun are repelled by the gun solenoid magnetic field. We speculate that the reduction in ion beam density within the cathode/anode gap when the gin solenoid is energized helps to minimize arcing and prolong photocathode operating lifetime.

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**Generation and Characterization of Magnetized Electron Beam from DC Photogun for JLEIC Cooler**

Magnetized electron beam is required for faster electron cooling of ion beams in the proposed JLEIC magnetized cooler, a critical part of the collider ring, to achieve high luminosity. Magnetized electron beam has been generated from a 300 kV DC high voltage photogun and beam magnetization is calculated from beam size and rotation measurements using slit and viewer image diagnostic tools as a function of magnetic field strength on bialkali antimonide photocathode. The lifetime of the magnetized beam is measured as a function of beam magnetization, beam currents (up to 4.5 mA), and DC gun high voltage. Results will be presented for different laser spot sizes and illumination positions on the photocathode for DC and RF pulsed laser.

**Production of Magnetized Electron Beam from a DC high voltage Photogun**

Bunched-beam electron cooling is a key feature of all proposed designs of the future electron-ion collider, and a requirement for achieving the highest promised collision luminosity. At the Jefferson Lab Electron Ion Collider (JLEIC), fast cooling of ion beams will be accomplished via so-called “magnetized cooling” implemented using a recirculator ring that employs an energy recovery linac. In this contribution, we describe the production of magnetized electron beam using a compact 300 kV DC high voltage photogun with an inverted insulator geometry, and using alkali-antimonide photocathodes. Beam magnetization was assessed using a modest diagnostic beamline that includes YAG viewscreens used to measure the rotation of the electron beamlet passing through a narrow upstream aperture. Magnetization results are presented for different gun bias voltages and for different laser spot sizes at the photocathode, using 532 nm lasers with DC and RF time structure. Photocathode lifetime was measured at currents up to 4.5 mA, with and without beam magnetization.

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**A Research in Inverted High Voltage DC Gun and CsK2Sb Photocathode**

A compact inverted high voltage DC gun was designed, built, conditioned, and has been operated reliably at 300kV. A thorough study of CsK2Sb photocathode was performed to characterize how the thickness of the Sb layer or roughness of the photocathode surface affects the electron beam emittance, and the life time and quantum efficiency of the photocathode. The performance of the electron gun and the findings of CsK2Sb photocathode studies will be presented.

**300 kV DC high voltage photogun with Inverted Insulator Geometry and CsxKySb Photocathode**

A compact DC high voltage photogun with inverted-insulator geometry was designed, built and operated reliably at 300 kV bias voltage using alkali-antimonide photocathodes. This presentation describes key electrostatic design features of the photogun with accompanying emittance measurements obtained across the entire photocathode surface that speak to field non-uniformity within the cathode/anode gap. A summary of initial photocathode lifetime measurements at beam currents up to 4.5 mA is also presented.

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**Simulation Study of Magnetized Electron Beam**

The proposed Jefferson Lab Electron Ion Collider (JLEIC) is required to obtain ultra-high collision luminosity. Small transverse emittance at the colliding position is one of the key requirements to achieve this goal. Emittance growth in collision is controlled by electron cooling and it can be further improved by using a magnetized electron beam, where the cooling process occurs inside a solenoid field. The radial fringe magnetic field at the entrance of the solenoid creates a large additional rotational motion which affects the cooling process. At the electron source, we have created the electron beam inside a similar field but rotating in the opposite direction to compensate this effect and measurements have being taken. Simultaneously, simulations have being developed using ASTRA and GPT software on beam size variations along the beamline, for different solenoid currents, with and without space charges, etc. and the comparison will be presented.

**Simulation Study of Magnetized Electron Beam**

The proposed Jefferson Lab Electron Ion Collider (JLEIC) must provide ultra-high collision luminosity to achieve promised physics goals. Small transverse emittance at the ion-electron collision point is one of the key requirements of the collider design. Emittance growth that results from electron-ion collisions will be controlled by electron cooling of the ion beam and cooling can be enhanced using a magnetized electron beam, where the cooling process occurs inside a solenoid field. The radial fringe magnetic field at the entrance of the solenoid creates a large additional rotational motion which adversely affects the cooling process. At the electron source, we create the electron beam inside a similar field but inducing rotational motion in the opposite direction to compensate this effect. Beam-based magnetization measurements have been performed and this presentation provides a comparison to predictions based on simulations using ASTRA and GPT software, as a function of beam size variations along the beamline, for different solenoid currents, with and without space charges, and other parameters.

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**A Non-destructive Magnetic Momentum Monitor Using a TE011 Cavity**

JLAB is developing a high current magnetized electron source for JLEIC ion ring’s bunched beam cooler. The non-destructive real time monitoring of the magnetic momentum is highly desired for this beam. The authors propose to use a passive copper RF cavity in TE011 mode as such a monitor. In this paper, we will show the mechanism and scaling law of this device, as well as the design and testing results of the prototype cavity.

**Non-invasive Magnetic Momentum Monitor Using a TE011 Cavity**

The Jefferson Lab electron-ion collider design relies on bunched-beam magnetized electron cooling of the ion beam using an electron accelerator complex that employs a recirculator ring, an energy recovery linac, and a long solenoid where the cooling takes place. A non-invasive real-time monitoring system is highly desired to quantify electron beam magnetization. The authors propose to use a passive copper RF cavity in TE011 mode as such a monitor. In this paper, we will show the mechanism and scaling law of this device, as well as the design and testing results of the prototype cavity.