Cooler e-source

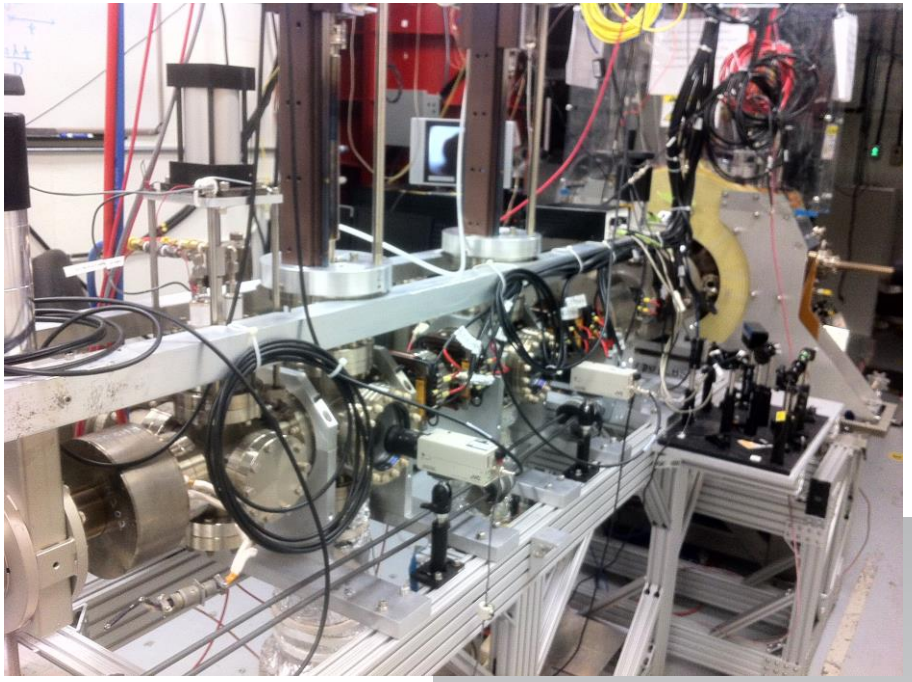
Magnetized Beam LDRD Progress Report

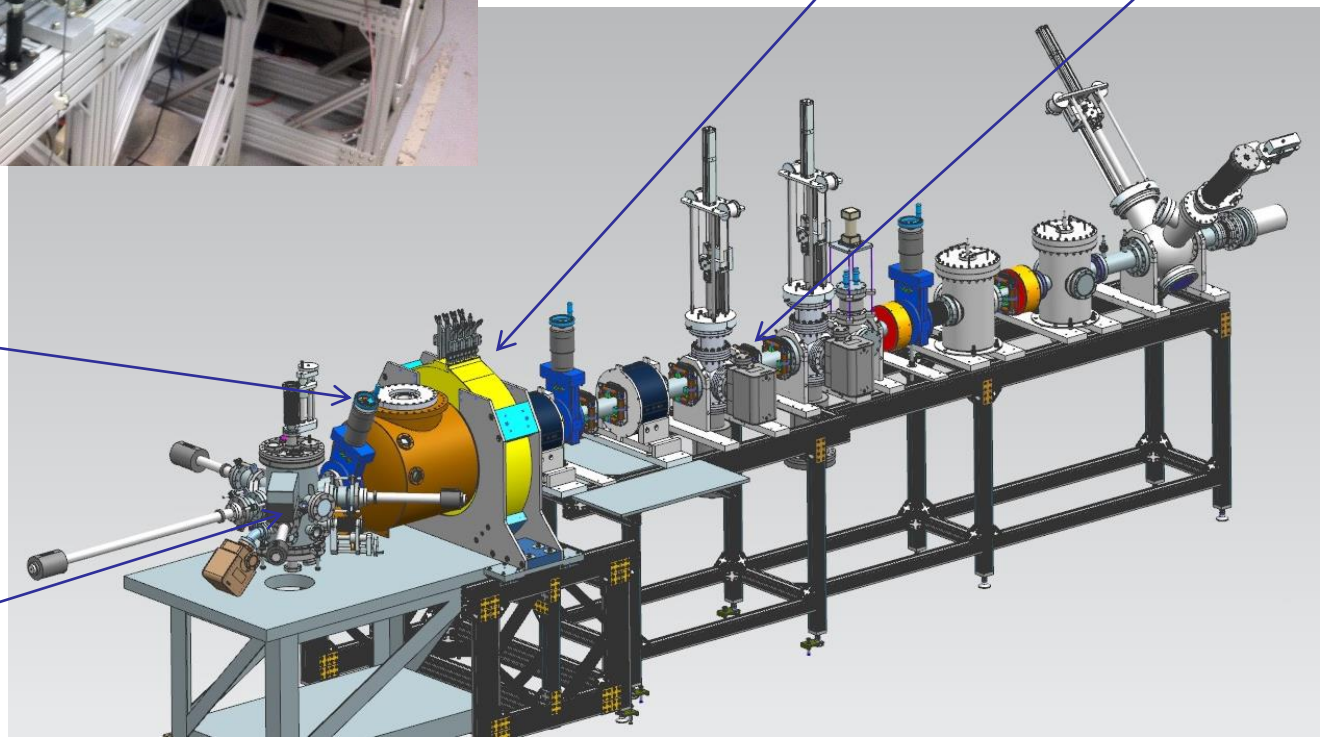
March 9, 2017

Magnetized Beam at GTS

- K_2CsSb photocathode was made – QE ~ 4%
- Gun HV operating at 300 kV with magnet at 400 A (B_z=1.4 kG with standard molybdenum photocathode holder and B_z=2.0 kG with steel holder)
- Beamline under vacuum with slits installed
- Generated magnetized beam on March 8
- Sajini Wijethunga, student from ODU (advisor: Jean Delayen, funded by 75% JLab + 25% ODU) started her Ph.D. thesis on magnetized beam
- **Plan to submit LDRD proposal for 3rd year funding**

Magnetized Electron Source at GTS





0 A


640x480 pixels: 8-bit: 300K
ITVGT01A
GTS2
x=28, y=22, value=51
ITVGT01A
2017-03-08
15:57:45-22

50 A


x480 pixels: 8-bit: 300K
GTS2
x=27, y=25, value=51
2017-03-08
15:54:19-17

100 A


540x480 pixels: 8-bit: 300K
ITVGT01A
GTS2
x=1, y=22, value=49
ITVGT01A
2017-03-08
15:55:17-28

150 A

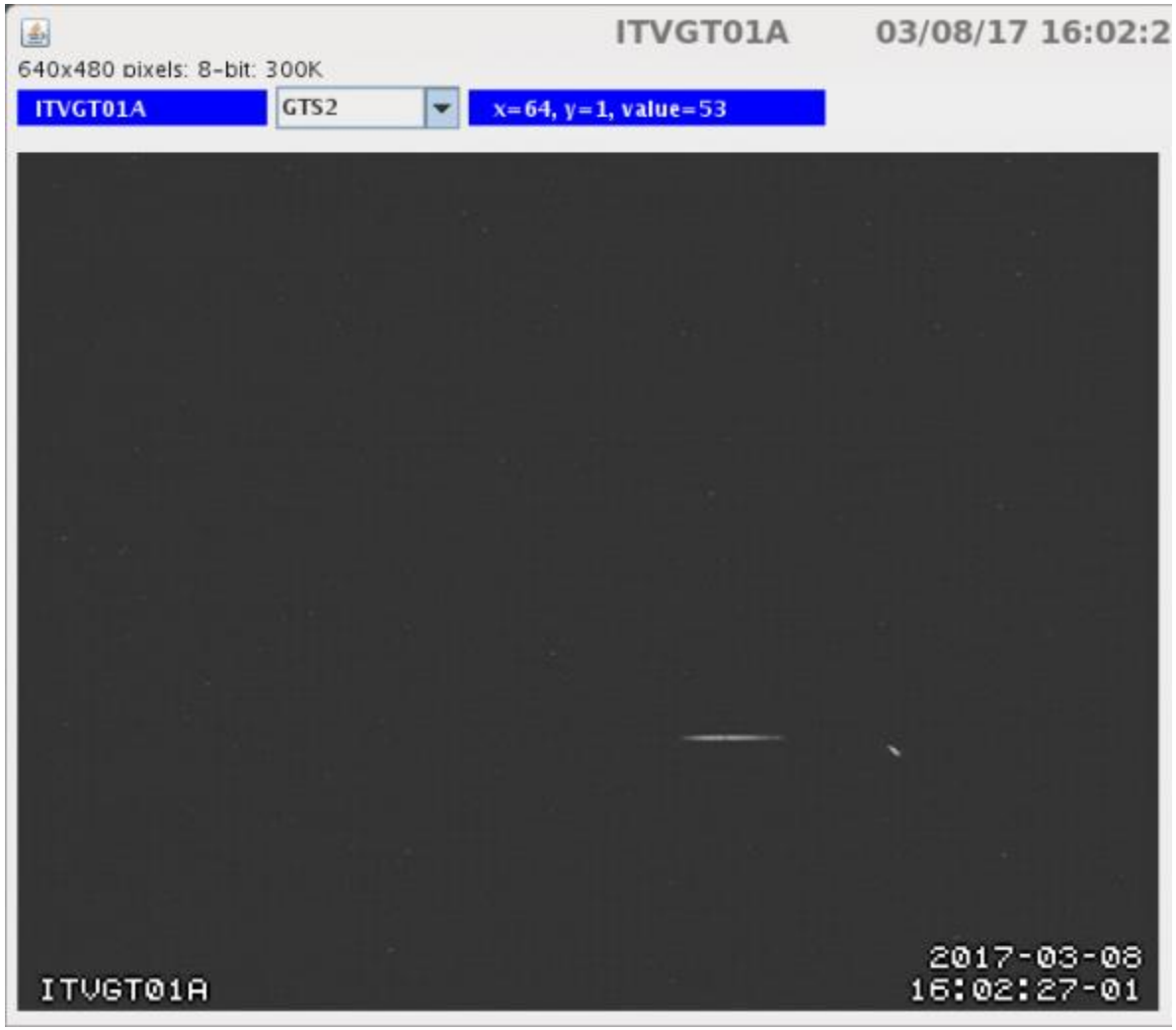

540x480 pixels: 8-bit: 300K
ITVGT01A
GTS2
x=13, y=25, value=53
ITVGT01A
2017-03-08
15:56:44-05

200 A

250 A


40x480 pixels: 8-bit: 300K
ITVGT01A
GTS2
x=148, y=6, value=51
ITVGT01A
2017-03-08
16:01:15-18

300 A


ITVGT01A 03/08/17 16:02:2
640x480 pixels: 8-bit: 300K
ITVGT01A
GTS2
x=64, y=1, value=53
ITVGT01A
2017-03-08
16:02:27-01

350 A


640x480 pixels: 8-bit: 300K
ITVGT01A
GTS2
x=42, y=1, value=51
ITVGT01A
2017-03-08
16:09:51-08

400 A

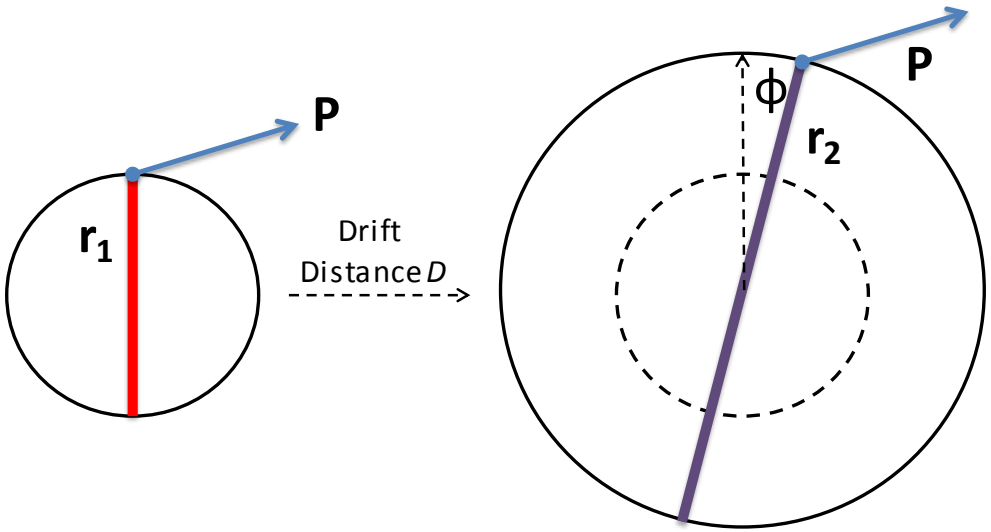

ITVGT01A
GTS2
x=30, y=176, value=51
ITVGT01A
2017-03-08
16:13:28-11

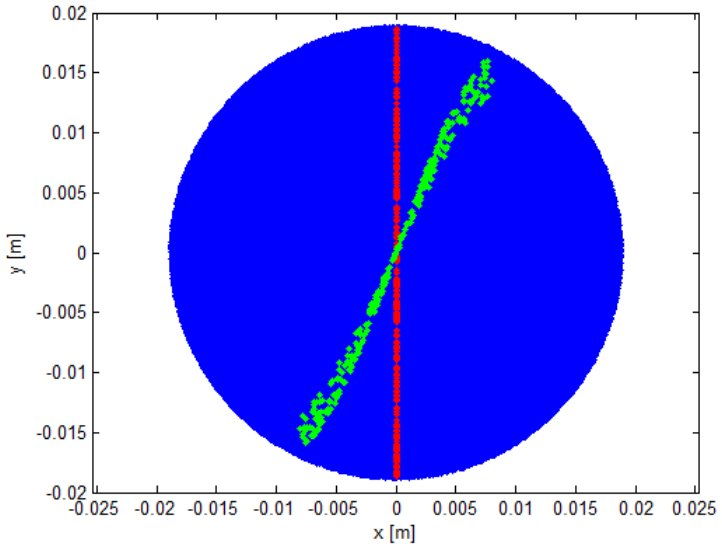
- Thanks to hard work of: Yan, Mamun, Bubba, Phil, John, Carlos, Fay, Shukui, Geoff, Sajini

Measuring Magnetization with RF Cavity

Measuring Magnetized Beam – I

- Use slit and viewscreens to measure mechanical angular momentum:





$$\langle L \rangle = 2 p_z \frac{\sigma_1 \sigma_2 \sin\phi}{D} = e B_z a_o^2$$

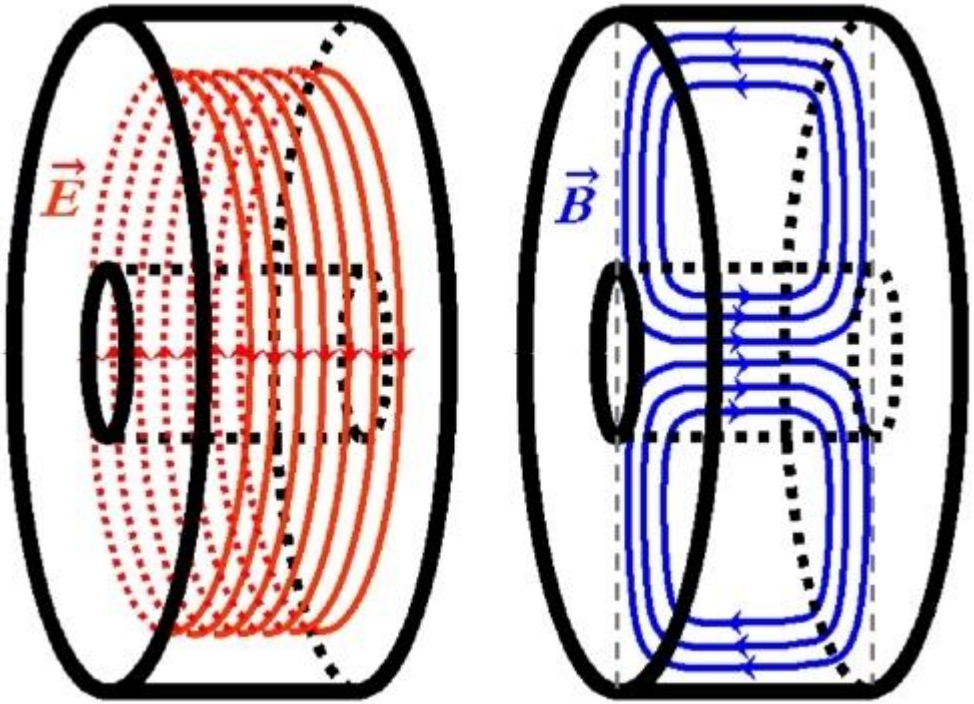
Measuring Magnetized Beam – II

- Having a non-invasive technique to measure beam magnetization is very critical for JLEIC e-cooler. An RF cavity could be right device. Cavities distributed around e-cooler will monitor magnetization and others installed inside cooling solenoid will ensure magnetization is completely removed during cooling process. Once beam exists solenoid, cavities will measure whether magnetization is fully restored.

- RF field will be excited by rotating bunched beam producing an easily detectable signal – beam will deposit energy into cavity, but not angular momentum

- Coupling to both electric and magnetic fields – expect main contribution to signal from electric field

TE011 Mode in Pill-box Cavity



$$E_r = 0$$

$$E_\varphi = \frac{i\omega\mu}{k_c} A J_0'(k_c r) e^{-ik_z z}$$

$$E_z = 0$$

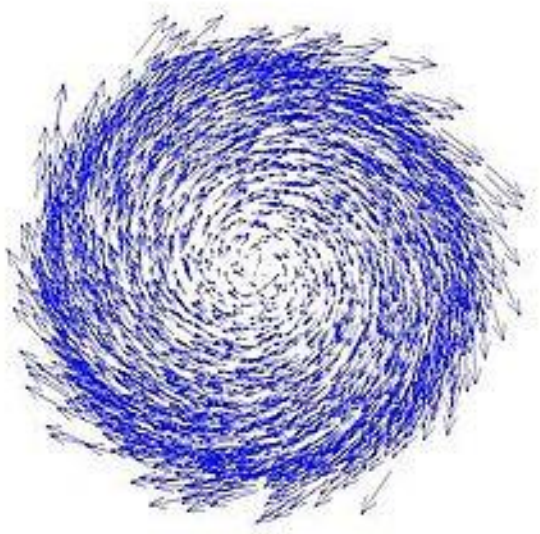
$$H_r = \frac{i\omega\epsilon}{k_c} A J_0'(k_c r) e^{-ik_z z}$$

$$H_\varphi = 0$$

$$H_z = A J_0(k_c r) e^{-ik_z z}$$

Magnetic Moment of Magnetized Beam

- Magnetic moment along beam axis:



$$\mathrm{M} = \frac{e}{2mc} L$$

$$\mathrm{L} = \frac{1}{2} B_z r^2$$

at photocathode

$$\mathrm{L} = \gamma m r^2 \dot{\varphi}$$

at cavity

For cylindrically symmetric Gaussian beam with sigma of a_0,$\langle r^2 \rangle = 2a_0^2$ and average canonical angular momentum for electron beam is $\langle L \rangle = eB_z a_0^2$ = 200 (neV s) at the photocathode and $\langle L \rangle = 2\gamma m_e a_0^2 \dot{\varphi}$ = 200 (neV s) = 3x10^8 ħ after existing solenoid

Can We Generate Magnetized Beam with TE011 Cavity?

- Axially-symmetric electric field mode **cannot** create angular momentum for a passing e-beam – one must take into account presence of associated RF magnetic field – due to *conservation of canonical angular momentum* before and after cavity

- Plan to build and install a cavity at GTS to measure beam magnetization in collaboration with Brock and SRF Institute – good project for a student