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

Laboratory Directed Research and Development (LDRD) Proposal

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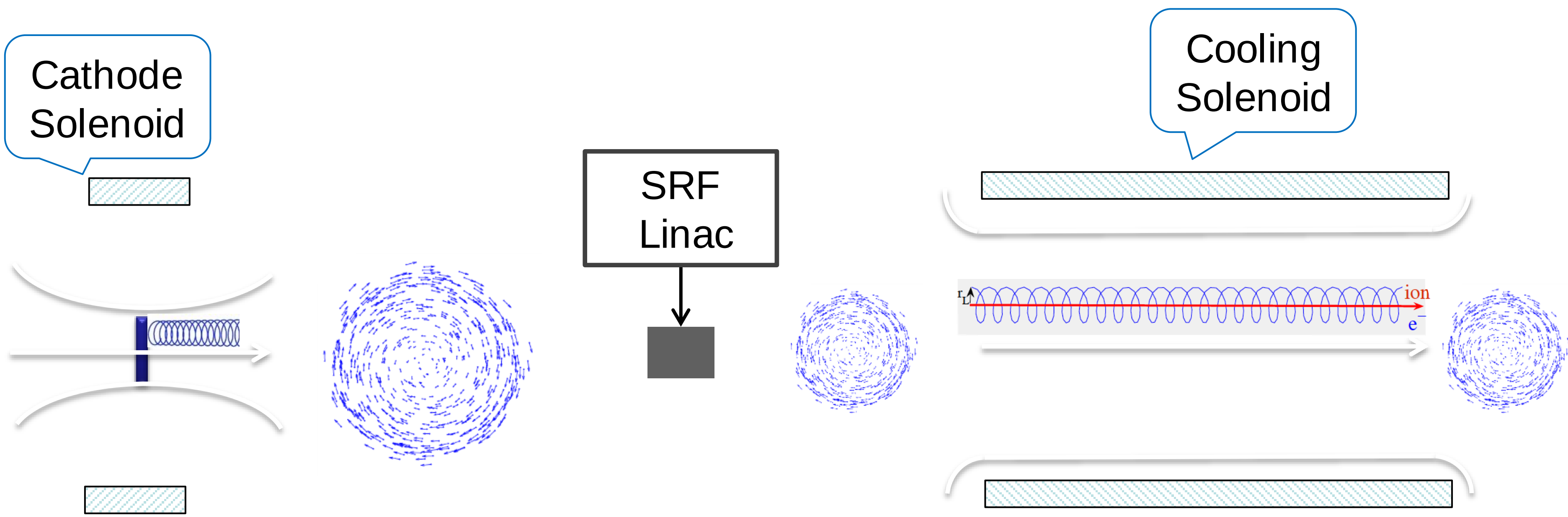
Magnetized Cooling

I. MEIC magnetized electron cooler is part of Collider Ring

II. Goal: maintain ion beam emittance and extend luminosity lifetime

III. Requires magnetized bunched electron beam



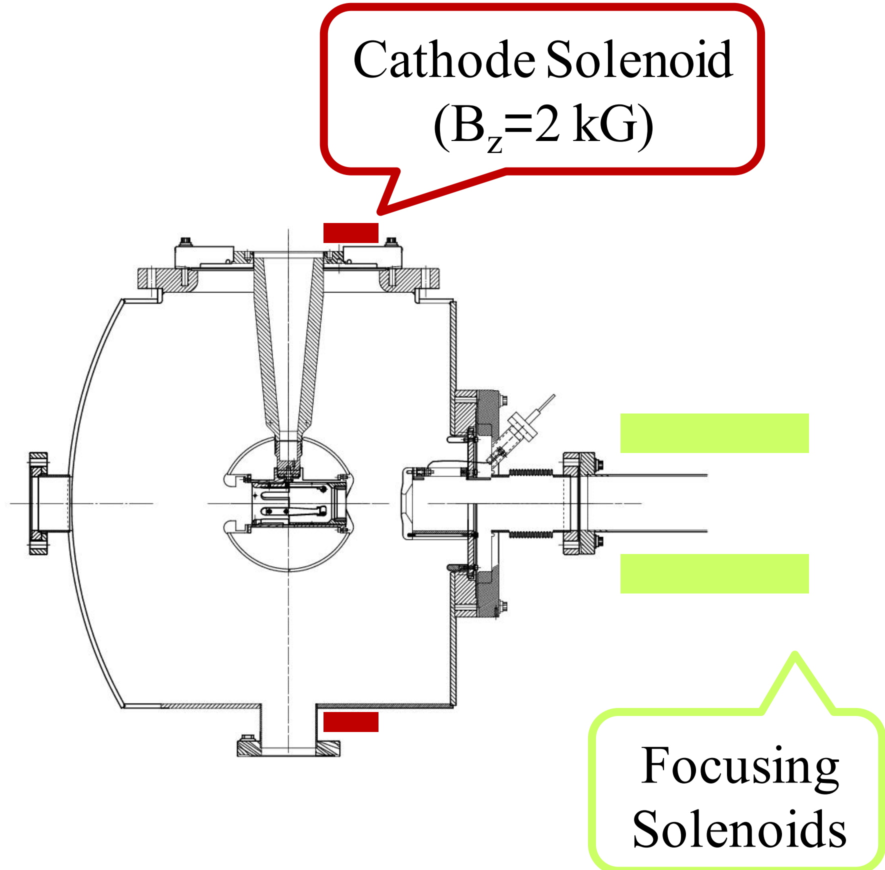
Magnetized Bunched Electron Beam Requirements

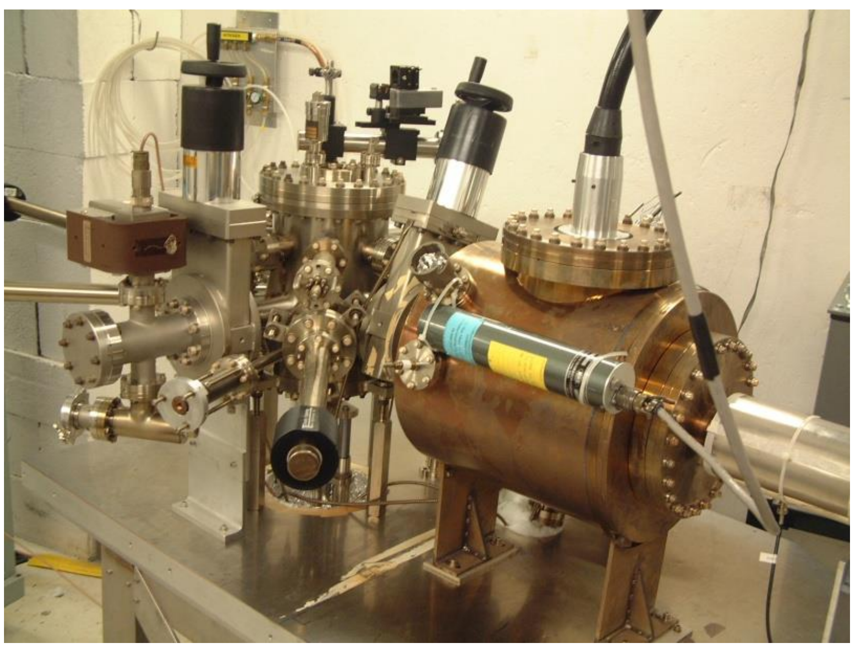
Bunch length	100 ps (3 cm)
Repetition rate	476 MHz
Bunch charge	420 pC
Peak current	4.2 A
Average current	200 mA
Transverse normalized emittance	10s microns
Emitting radius (a_0)	3 mm
Solenoid field at cathode (B_z)	2 kG

Generation of Magnetized Beam

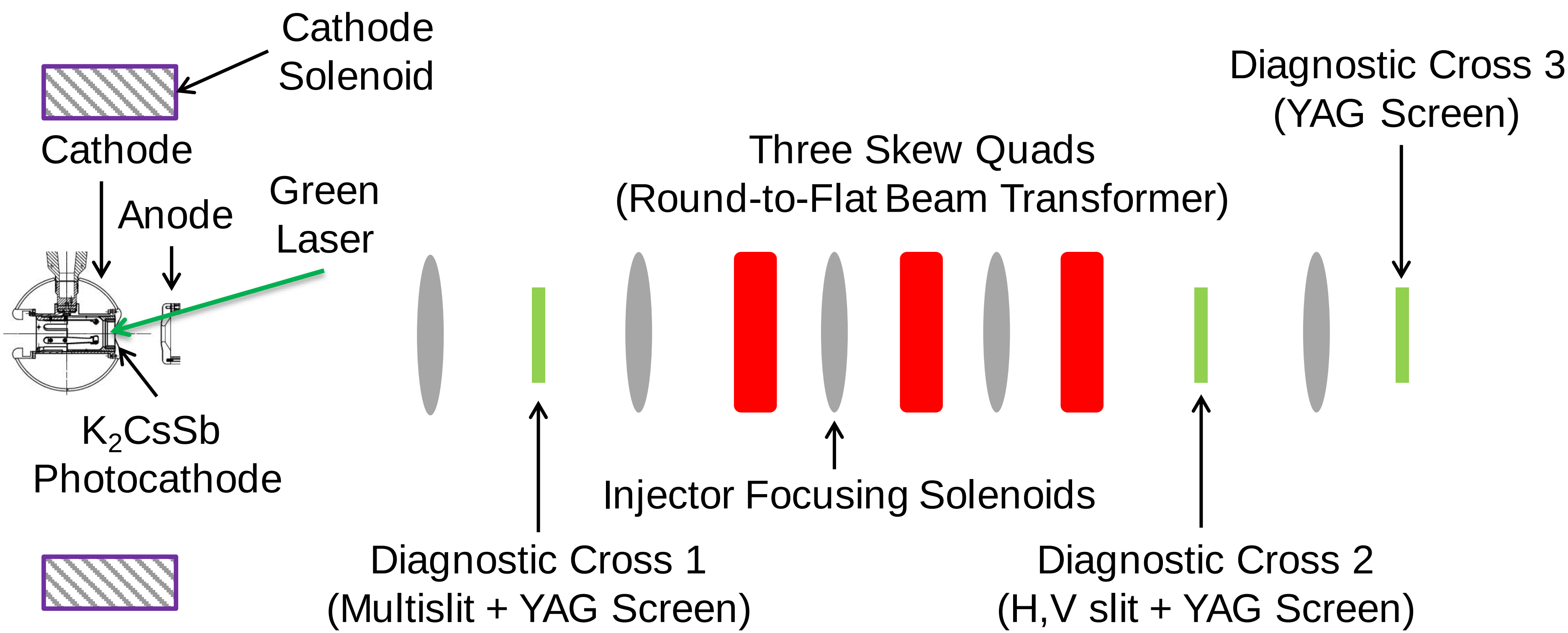
I. Cathode Solenoid:
- ➢ To produce magnetized beam

II. Injector Focusing Solenoids:
- ➢ For magnetized beam transport
- ➢ To compensate space-charge emittance growth





Experimental Overview



- Generate magnetized beam:
  - a_0 = 0.1 – 3 mm, B_z = 0 – 2 kG
  - Bunch charge: 1 – 500 pC
  - Bunch length: 50 – 150 ps
  - Average beam currents up to 32 mA
  - Gun high voltage: 200 – 350 kV

Simulation Plan

1. Beamline design to locate magnets and diagnostics at optimum positions

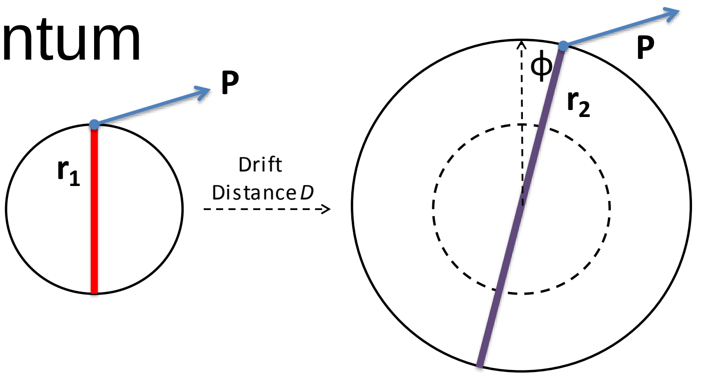
2. Simulation of different operating scenarios of bunch charge, magnetization, bunch shape etc. will be benchmarked against measurements of emittance and other beam parameters

3. As beams will be space charge dominated, there will be some limit to aspect ratio that can be achieved with RTFB transform – simulation will allow us to quantify how good or complete this can be made for different settings

- These results will guide injector design for MEIC magnetized electron cooler

Measurement Plan

1. Measure mechanical angular momentum (skew quads off)

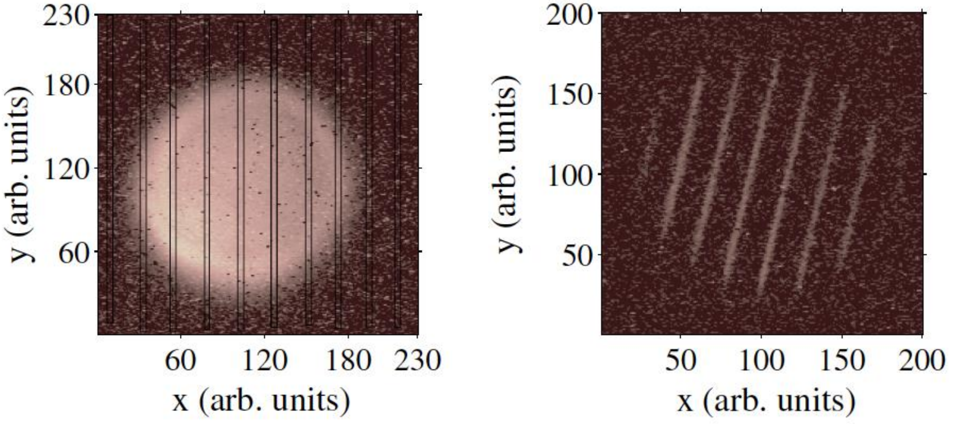


σ_1 beam radius measured at Diagnostic Cross 1
σ_2 beam radius measured at Diagnostic Cross 2
D drift between two crosses
p_z beam longitudinal momentum

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

- Angular rotation ϕ is measured from beam image at Cross 2 when multislit is inserted at Cross 1

Example of mechanical measurement at Fermilab (Piot et al.)



2. Use three skew quads – RTFB Transformer – to generate a flat beam with transverse emittance ratios of:

$$\frac{\varepsilon_x^n}{\varepsilon_y^n} >> 1$$

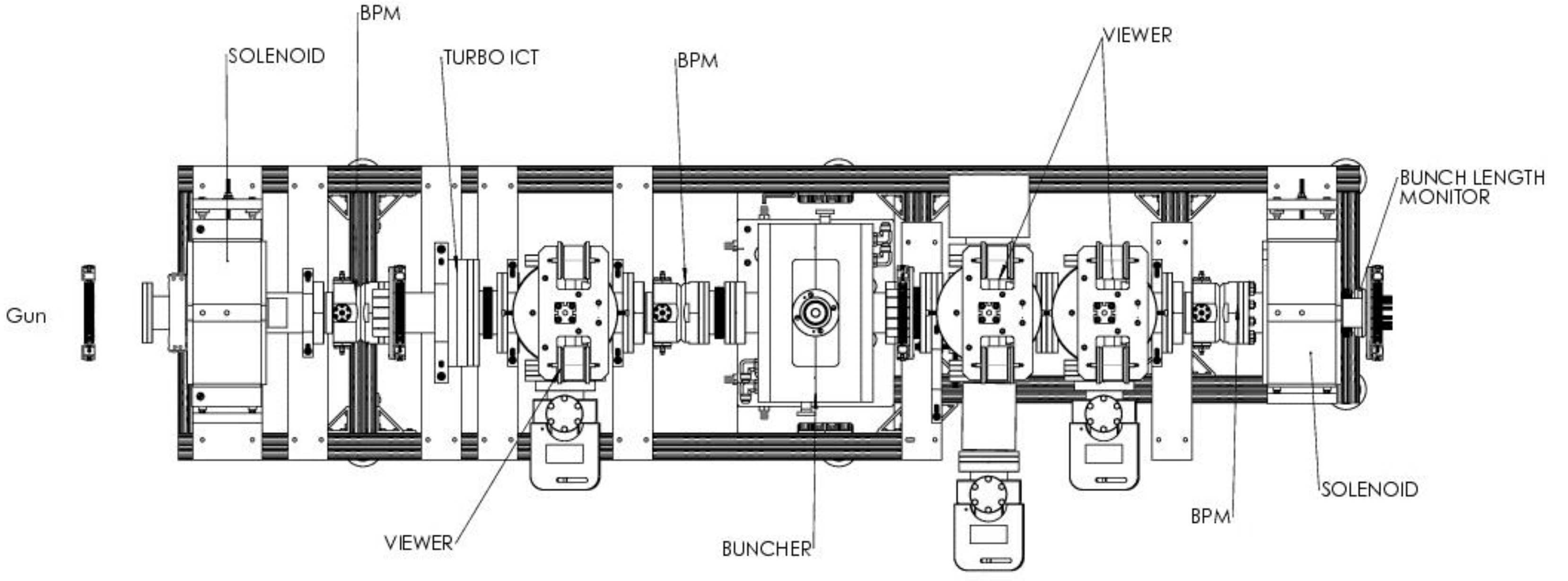
   Measure horizontal and vertical emittances using slit method

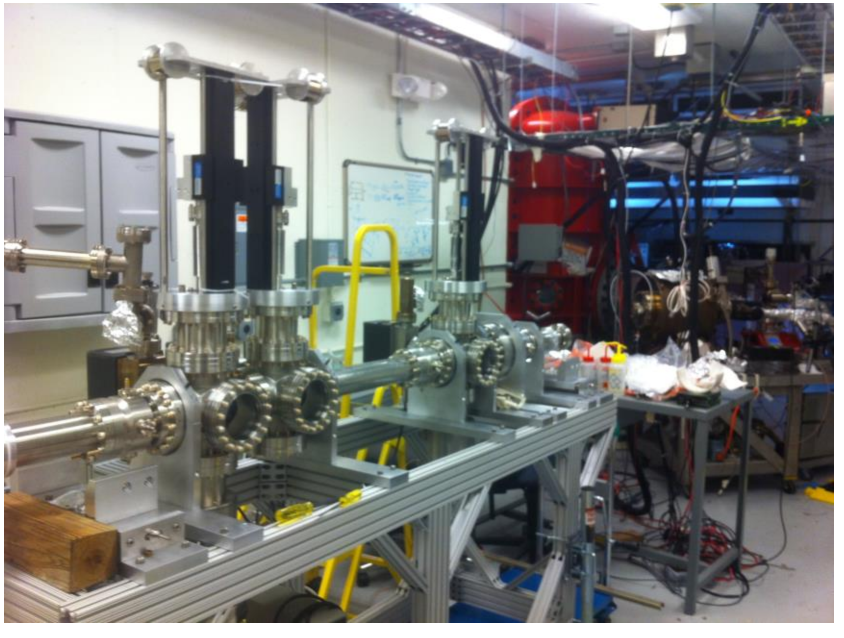
3. Generate very high currents magnetized beam and study beam transport and RTFB transformation versus electron bunch charge

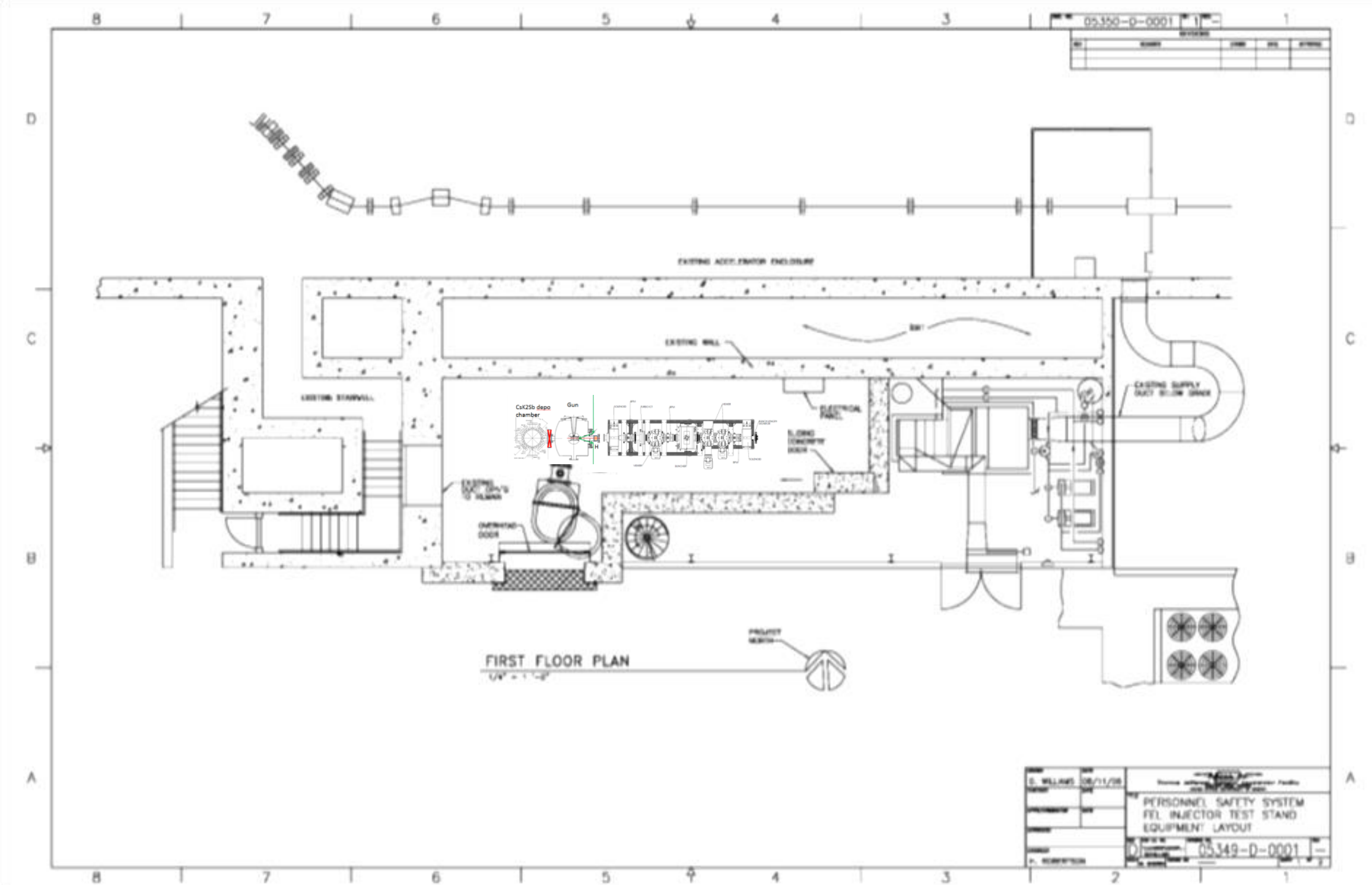
4. Measure photocathode lifetime versus solenoid field at high currents (up to 32 mA) and high voltages (200 – 350 kV) limited by in-house HV supplies

5. Study beam halo and beam loss versus magnetization

Location of Work: FEL Gun Test Stand







05350-D-0001
EXISTING ACCELERATOR ENCLOSURE
EXISTING WALL
EXISTING STAIRWELL
CsK2Sb depo chamber
Gun
ELECTRICAL PANEL
SLIDING CONCRETE DOOR
EXISTING SUPPLY DUCT BELOW GRADE
OVERHEAD DOOR
FIRST FLOOR PLAN
PROJECT NORTH
D. WILLIAMS
08/11/08
PERSONNEL SAFETY SYSTEM
FEL INJECTOR TEST STAND
EQUIPMENT LAYOUT
05349-D-0001

Budget

Materials and Supplies:

1. Solenoid magnet, or Helmholtz coil-pair
2. Three skew quadrupoles
3. Components for three diagnostics crosses

FY16	$339,211
FY17	$265,850
FY18	$212,025
Total	**$817,086**

Labor:

1. Gun magnet design and installation
2. Relocate old CEBAF arc dipole power supply
3. Mechanical designer for skew quad magnets and slits
4. ASTRA and GPT modeling
5. Postdoc – years 2 and 3 (first year funded by another project to finish developing K_2CsSb photocathode)

In response to questions from Review Committee about timeline and budget: we extended this LDRD to a third year