Accelerator Physics activities at Jefferson Lab

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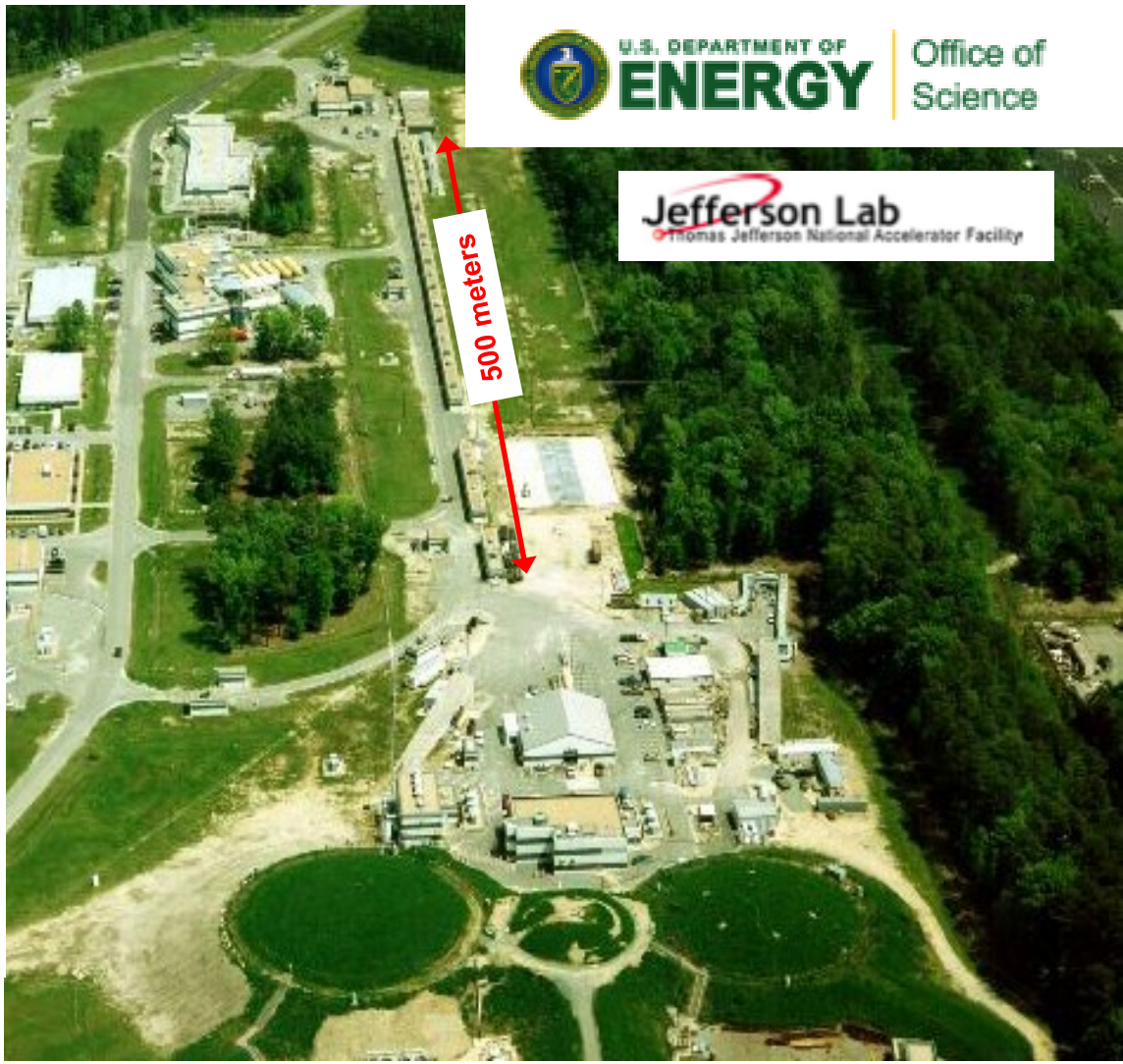
Thomas Jefferson Lab has a Continuous Electron Beam Accelerator Facility dedicated to high energy nuclear physics

QUICK FACTS

- Located in Newport News, Virginia USA
- 83 buildings
- 760 full time employees
- 43 graduate students
- 1,385 facility users

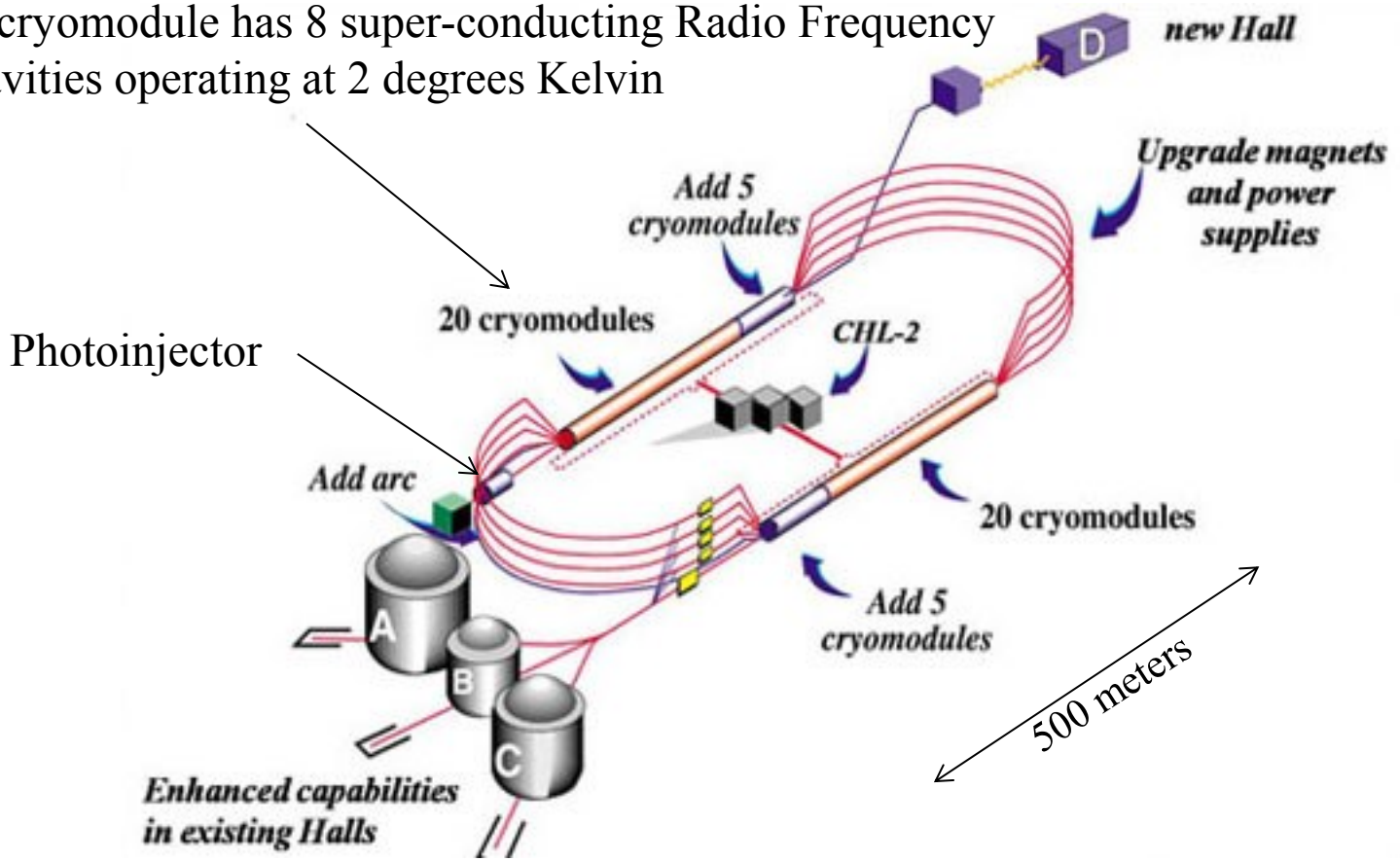
CORE CAPABILITIES

- 12 GeV accelerator for high energy nuclear physics
- 150 MeV accelerator for Free Electron Laser
- Fundamental research and technology development in
  - accelerators and
  - detectors

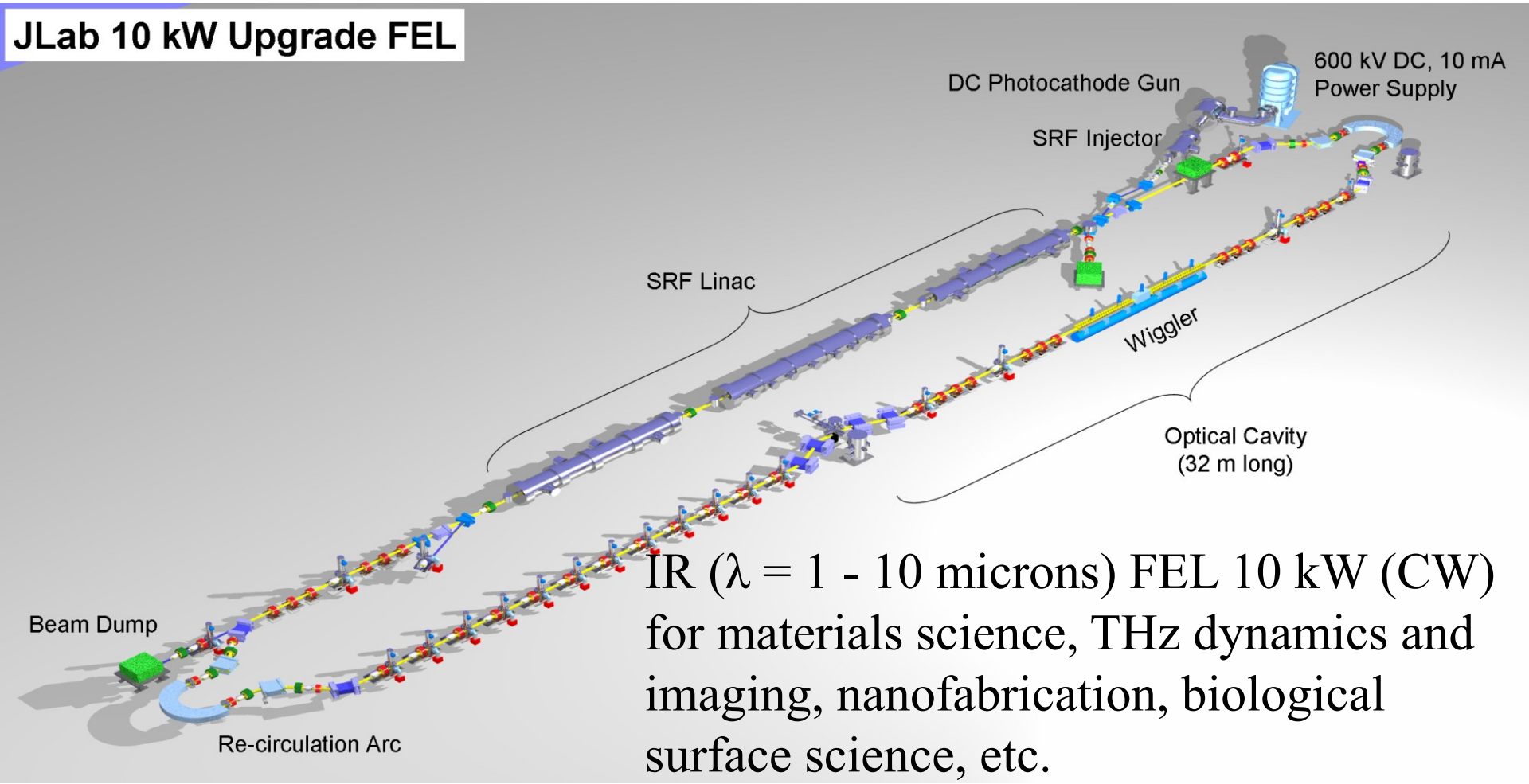


The principal linear accelerator provides polarized electron beams at 12 GeV CW (75 MHz, Q_{bunch} 0.01 – 1 pC) to the experimental target areas

Each cryomodule has 8 super-conducting Radio Frequency Nb cavities operating at 2 degrees Kelvin



The second linear accelerator provides unpolarized electron beams at 150 MeV CW (75 MHz @ Q_{bunch} 135 pC = 10 mA) for the IR Free Electron Laser



IR (λ = 1 - 10 microns) FEL 10 kW (CW) for materials science, THz dynamics and imaging, nanofabrication, biological surface science, etc.

Jefferson Lab has the following research areas

1. Radiation detectors and imaging for high energy nuclear physics

1. Theory Center for theoretical and computational physics

1. Super Conducting Radio Frequency Institute

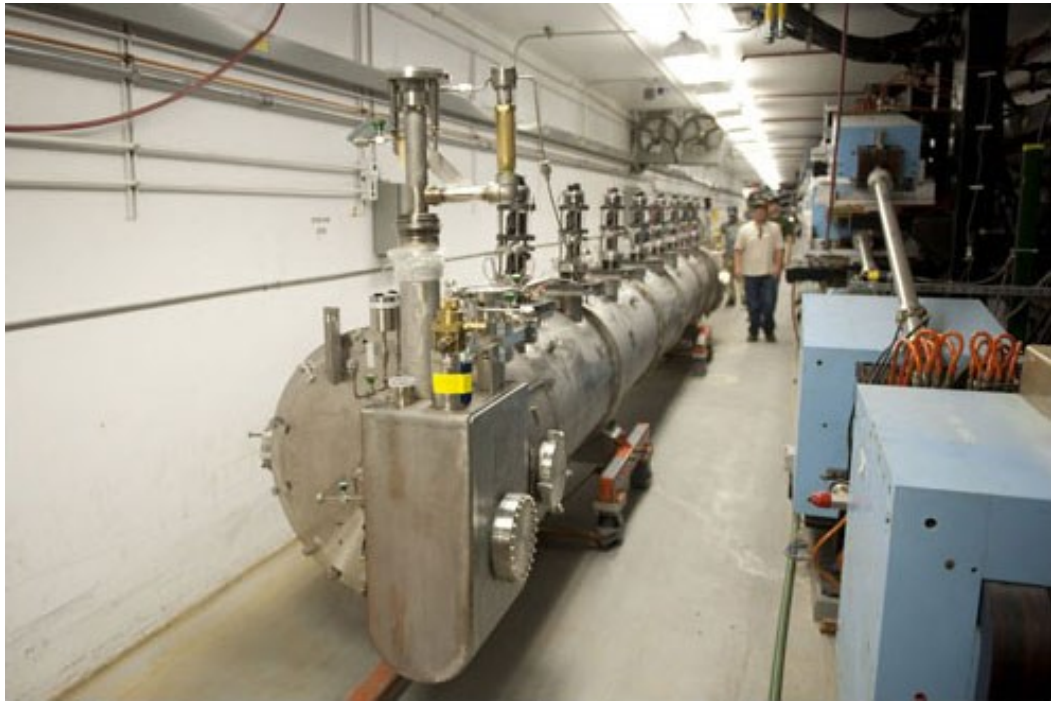
1. Center for Advanced Studies of Accelerators

1. Center for Injectors and Sources

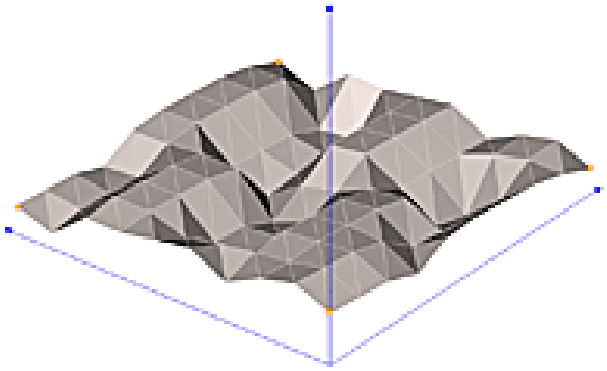
I will focus on the last three because are closely related to accelerator activities

The Superconducting Radio Frequency Institute is dedicated to:

The design (physics and engineering), fabrication, production assembly and conditioning of linear accelerators based on cryogenically cooled (2 Kelvin) Nb cavities.



Additionally the Superconducting Radio Frequency Institute has a strong program with local universities on Nb surface and material science for developing techniques to achieve higher gradients and higher Qs in production SRF cavities.



The Center for Advanced Studies in Accelerators is dedicated to

1. Design and operation of superconducting accelerators

2. Design and operation of recirculated and energy recovered electron accelerators

3. Design and operation of high average power photon sources, particularly those that generate ultrashort pulses over a wide variety of wavelengths (Free Electron Lasers)

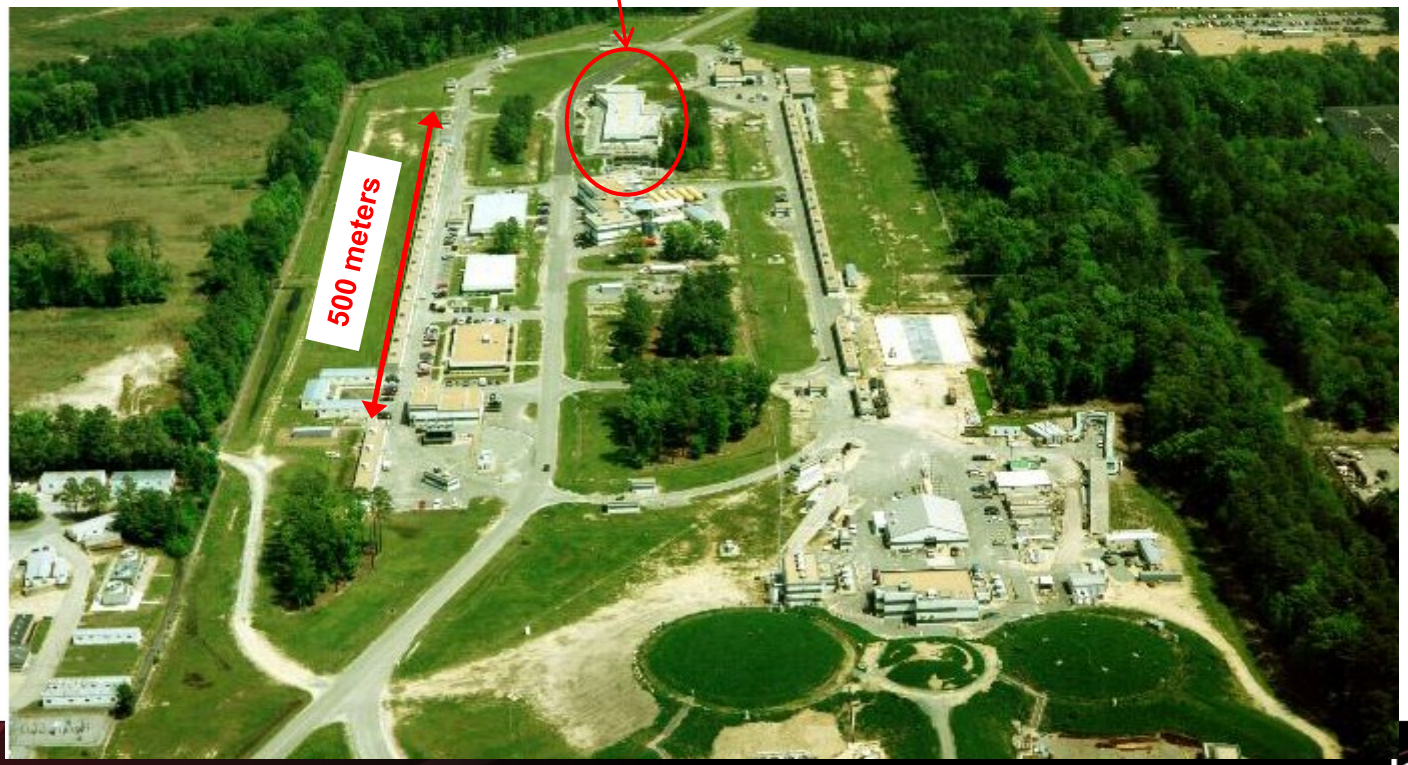
4. Development of advanced electron beam diagnostic devices, and advanced methods of controlling accelerators by computerized feedback systems

5. Development of advanced theoretical calculations for predicting beam behavior for a wide variety of physical arrangements

6. Development of advanced accelerator designs for a wide variety of applications based on RF superconductivity and beam recirculation

The Center for Injectors and Sources develops and maintains high performance electron photo-injectors for the accelerators at Jefferson Lab.

1. The primary responsibility is the operation of a highly spin-polarized (>85%) electron photo-injector for the Continuous Electron Beam Accelerator Facility (CEBAF) and the operation of the high current (10 mA CW) unpolarized photo-injector for the Free Electron Laser.



Additionally the Center for Injectors and Sources is focused on

1. Research, design, construction, characterization and operation of very high voltage DC guns (130 kV for CEBAF, 350kV for FEL. Higher voltage implementation presently being studied)

1. Development of novel photocathode materials

2. Fundamental research on extreme high vacuum ($1x10^{-12}$ mbar) for implementation in DC guns to improve photocathode lifetime

1. Development of high power RF synchronized (with accelerator) lasers as drivers for the photocathode

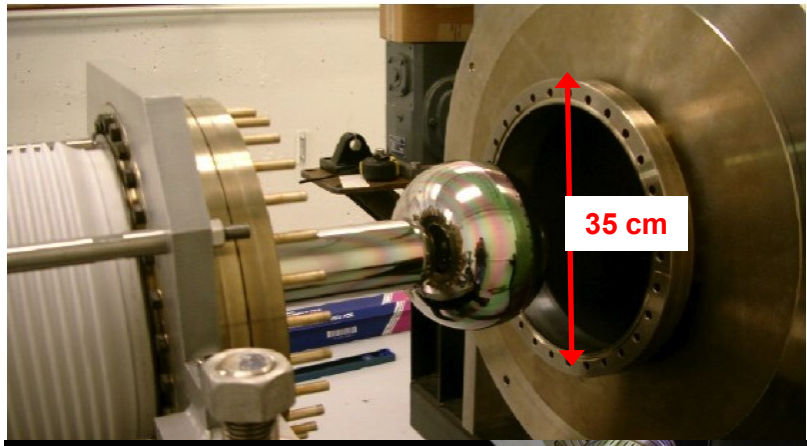
2. Design, development and operation of precision electron beam polarimetry systems

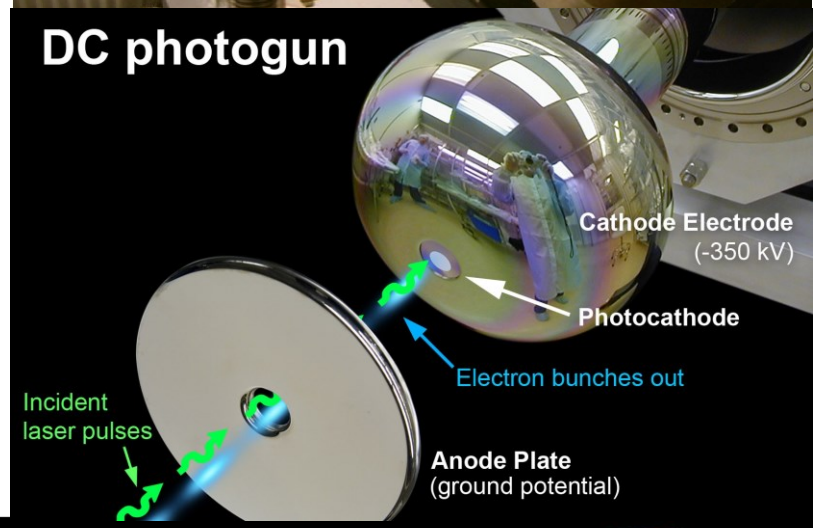
3. Development and operation of photo-injector test facilities within Jefferson Lab

The Center for Injectors and Sources develops and maintains two types of DC electron gun:

CEBAF, 130kV DC, 0.1 mA
Inverted insulator, cable connector

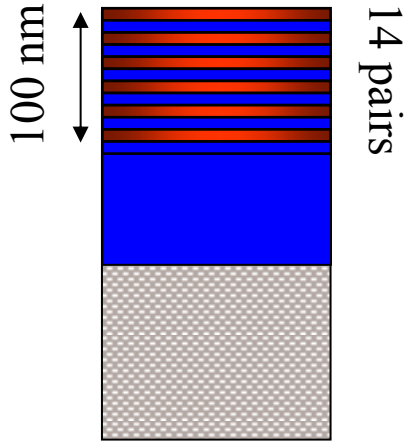
FEL, 350kV DC, 10 mA
Cylindrical insulator,
SF6 tank connector





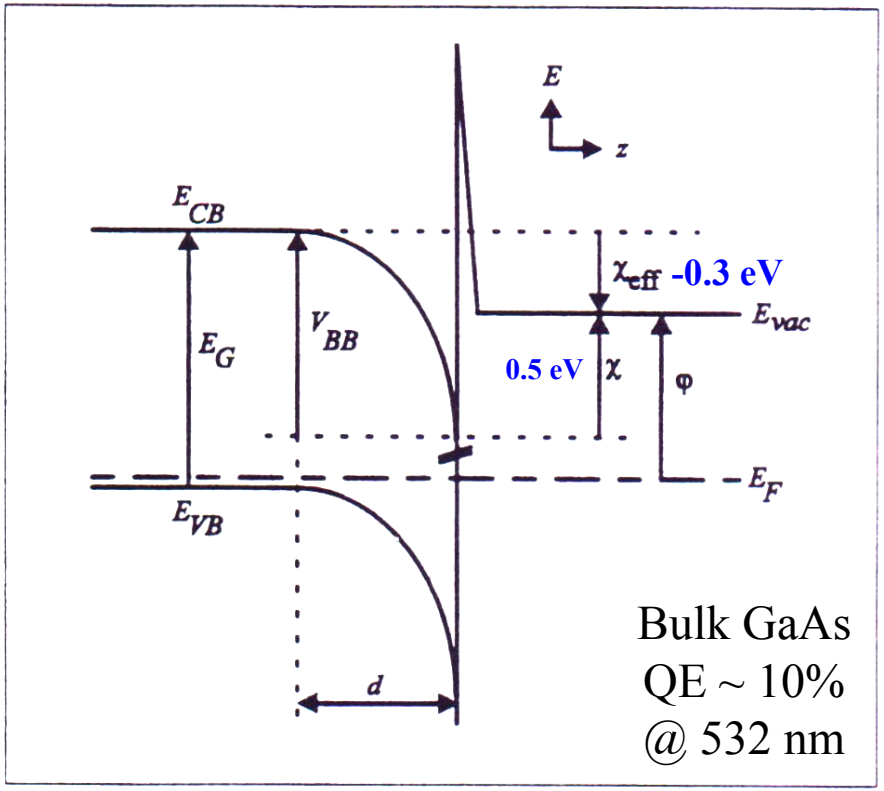
The CEBAF gun generates polarized electron beam with strained super-lattice Cs:GaAs photocathode, while the FEL gun generates unpolarized electron beam with bulk Cs:GaAs.

Superlattice GaAs: Layers of GaAs on GaAsP



QE ~ 0.8%
Pol ~ 85%
@ 780 nm

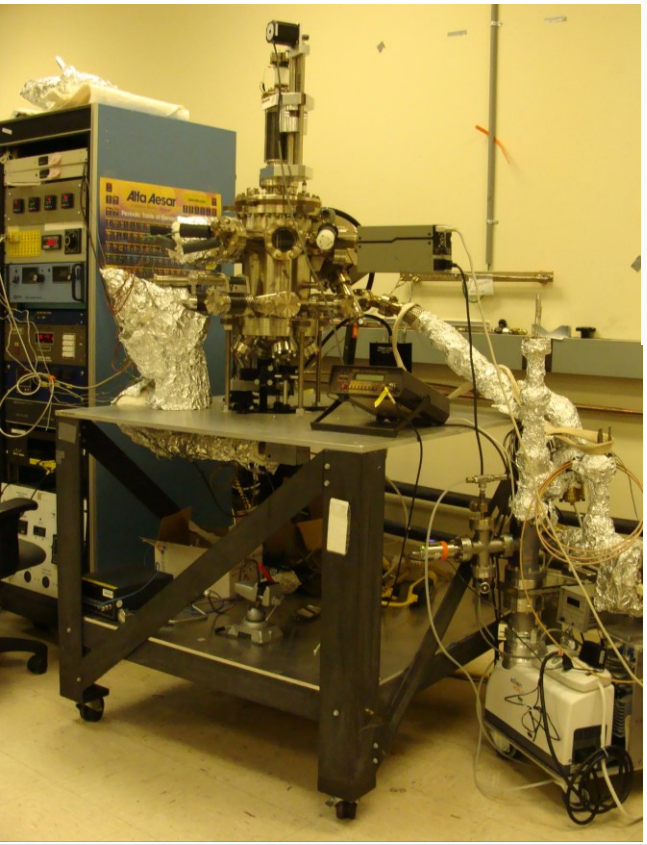
GaAs becomes a Negative Electron Affinity (X_{eff}) photocathode with the application of Cs and O_2

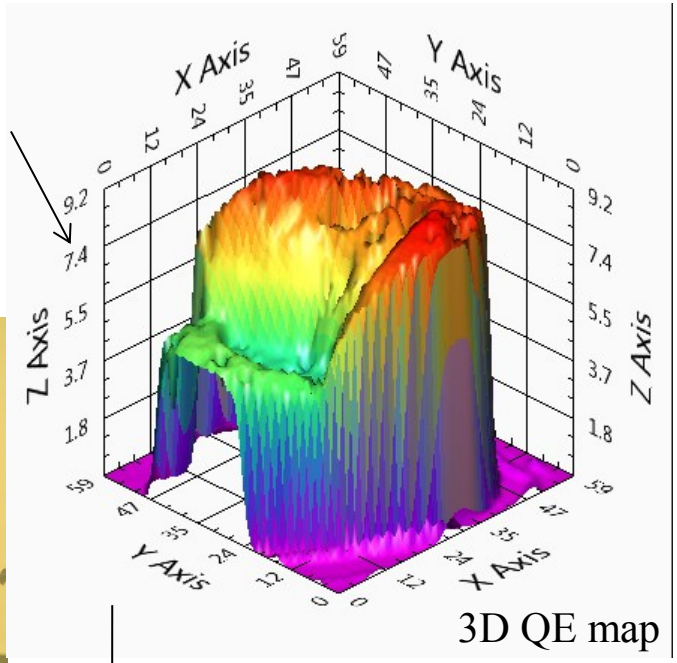


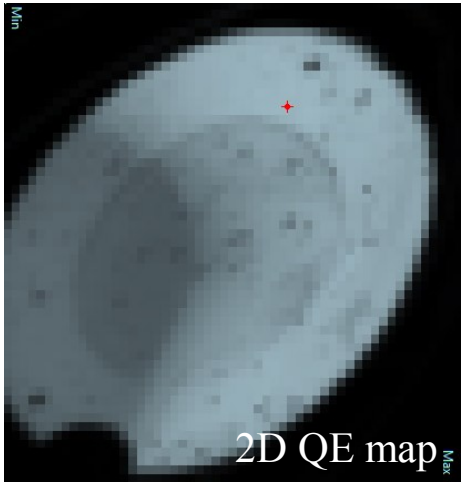
Bulk GaAs
QE ~ 10%
@ 532 nm

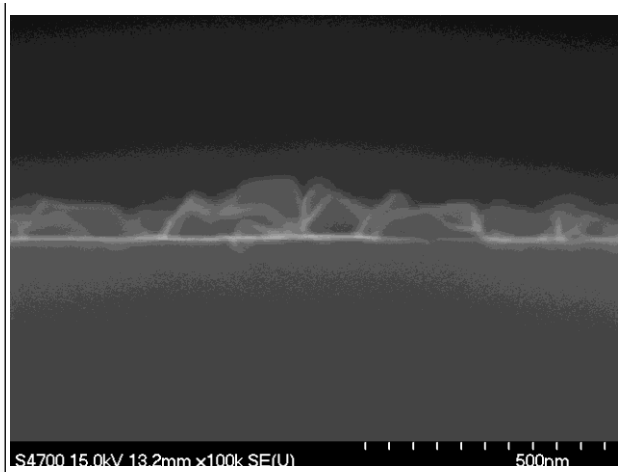
Research and development of super-lattice and of multialkali photocathodes has been implemented in the last year.

Several CsK_2Sb photocathodes with ~7% QE have been fabricated at JLab

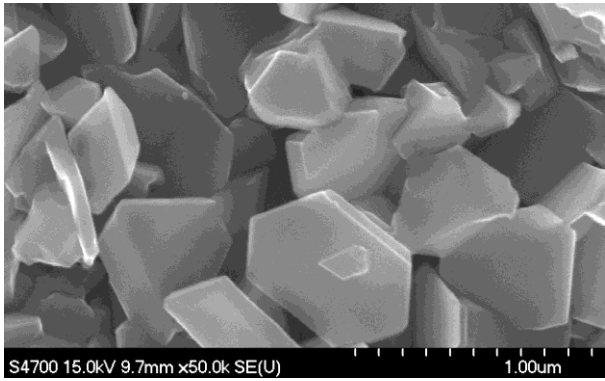




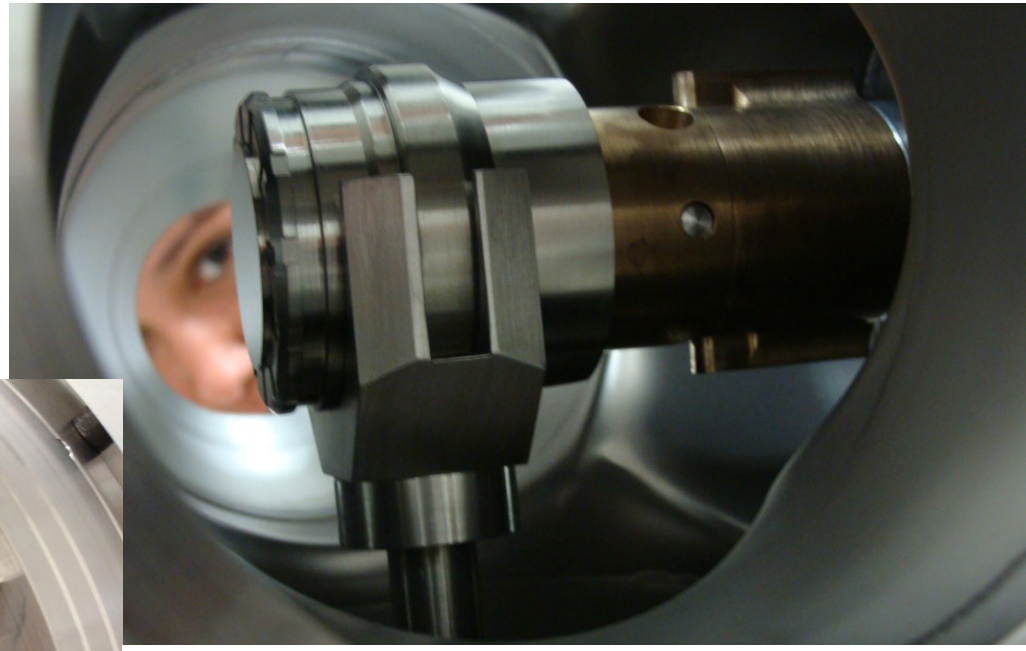


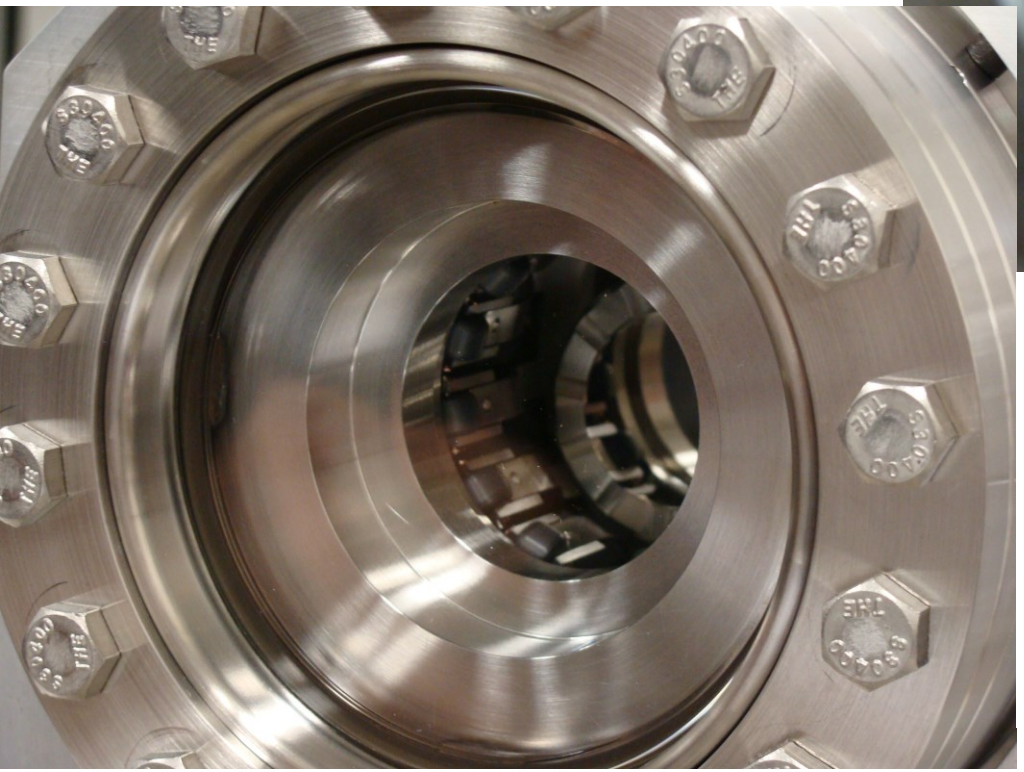


Electron microscopy shows formation of ~10 nm uniform Sb layer followed by amorphous micron-size crystal structures



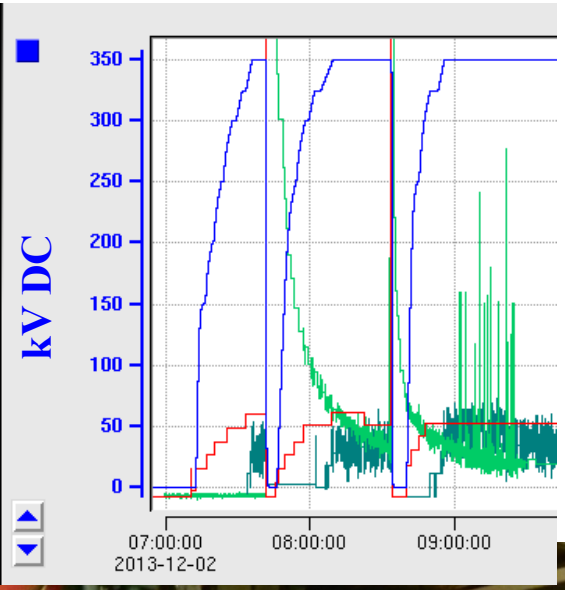
Additionally, photocathode load-lock systems are under continuous improvement and development

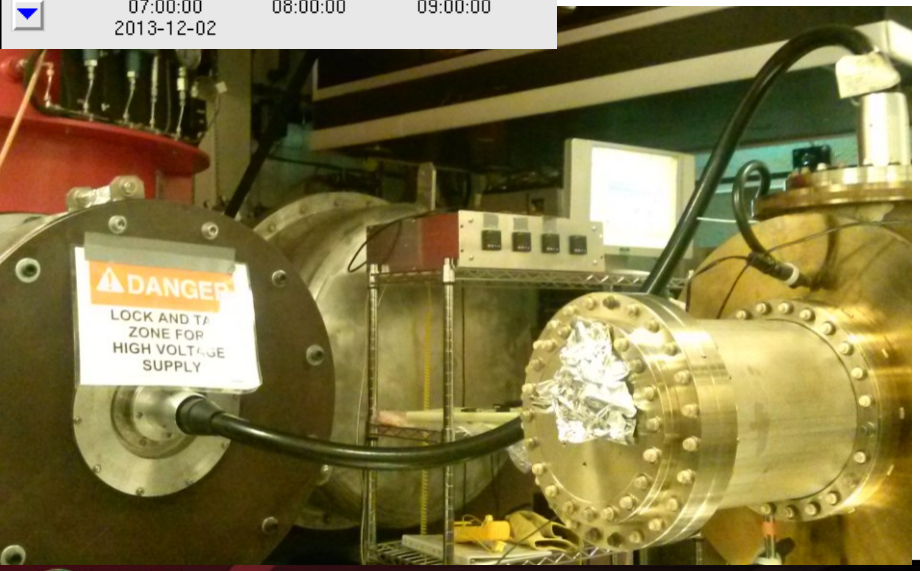


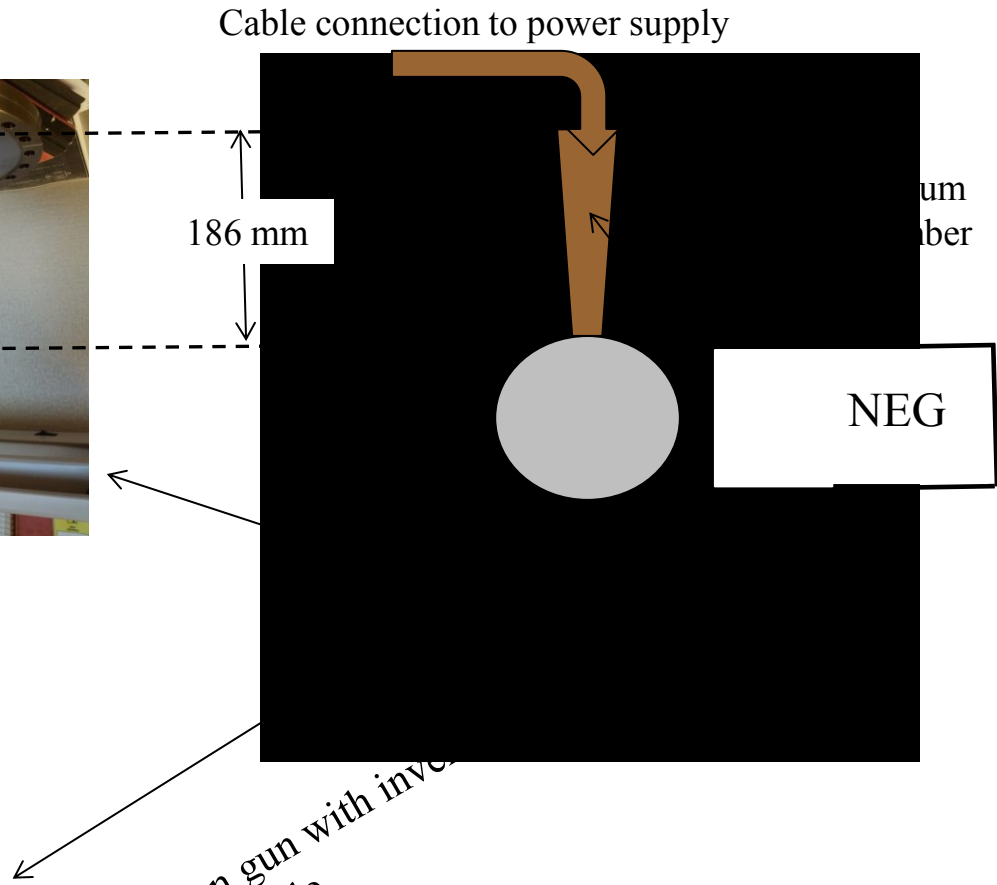


This is the prototype FEL Mo puck with 30 mm diameter GaAs wafer shown in the transfer chamber (above) and being inserted into the capture mechanism inside the gun electrode (left)

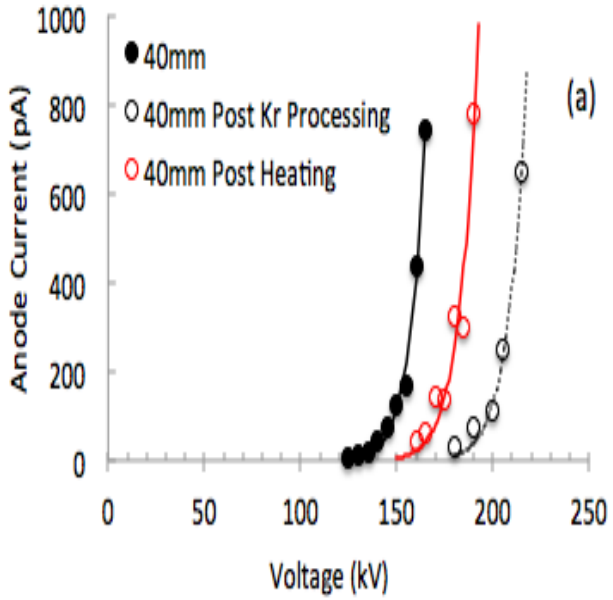
Research and development for reliable operation of prototype inverted geometry ceramic insulator to 350kV DC has been an activity for the past two years







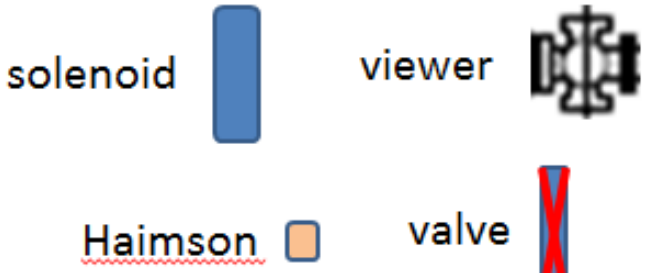
Research for minimizing field emission to achieve reliable operation >350kV DC is in continuous development



M. BastaniNejad, et al., Nucl. Instr. Meth A. In print.

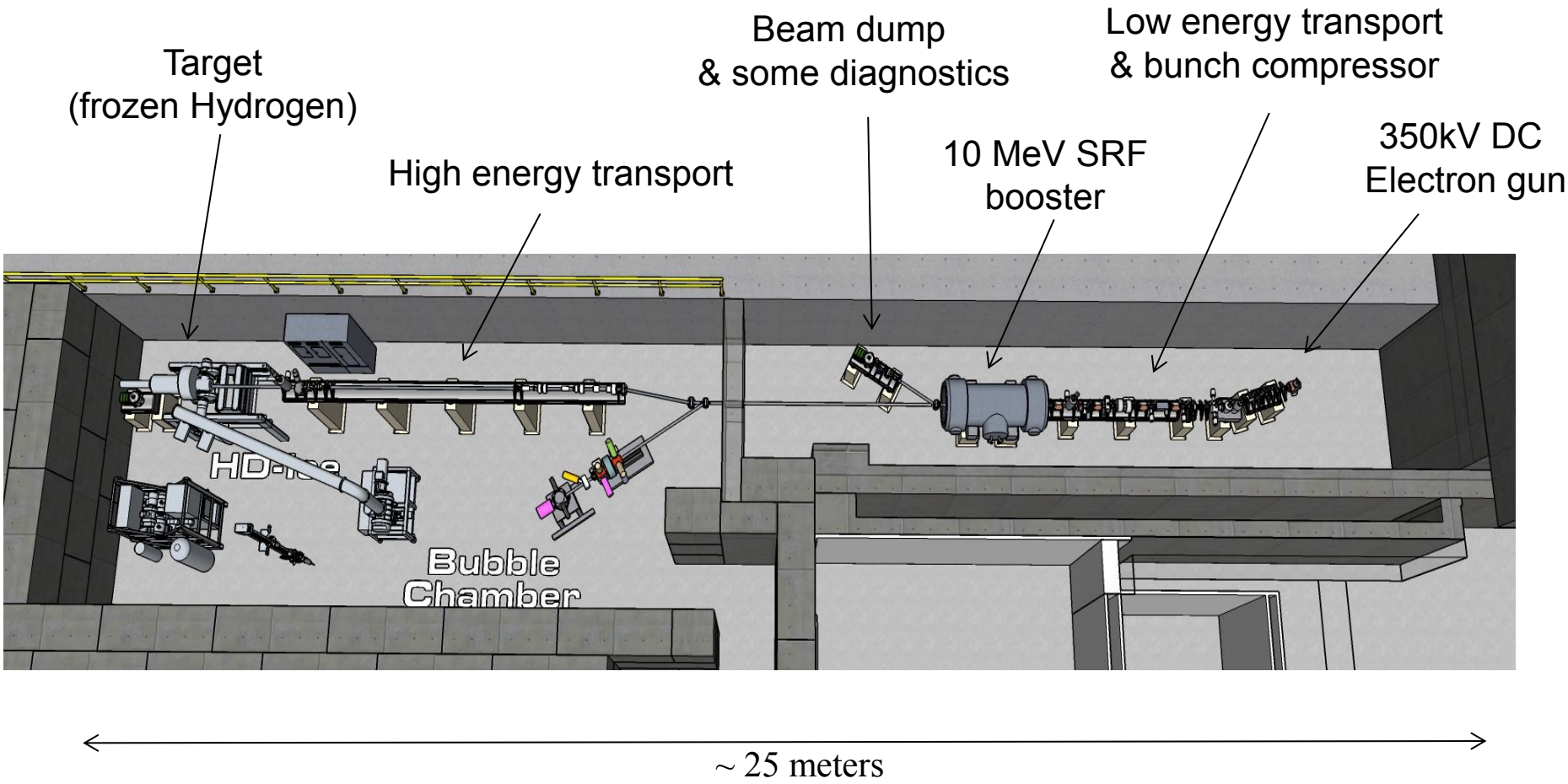
15 cm diameter test electrode after barrel polishing

Other activities include physics designs (beam dynamics simulations) and diagnostics development & implementation



A new beam line for characterizing the 350keV, 1nC bunch charge beam generated with multialkali photocathodes is under development

The latest project is the design and construction of a 10 MeV (10 nA CW) photo-injector designated to conduct nuclear physics experiments in late 2015



Thank you very much for your attention

Let me know if you have interest in specific areas.

I'll be happy to discuss it or direct you to the corresponding person in Jefferson Lab