BROOKHAVEN NATIONAL LABORATORY
Instrumentation Division Ultrafast Laser Laboratory

Instrumentation Division Ultrafast Laser Laboratory

Lasers and Optics for Accelerator Applications

Triveni Rao, Thomas Tsang, John Smedley
William Smith, John Walsh

Photocathodes

- Multi-Alkali (K_2CsSb)
- Superconducting (Pb, Nb, etc)
- Metals (Cu, Mg, etc)
- Polarized Electron (Cs: GaAs)

Novel Electron Sources

- Diamond Amplified Photocathode

Particle Beam Imaging

- Electro-optic Measurement of Electron Bunch Length
- Hydrogen Jet Imaging of RHIC Beams

Custom optical systems

- Mercury Jet Imaging

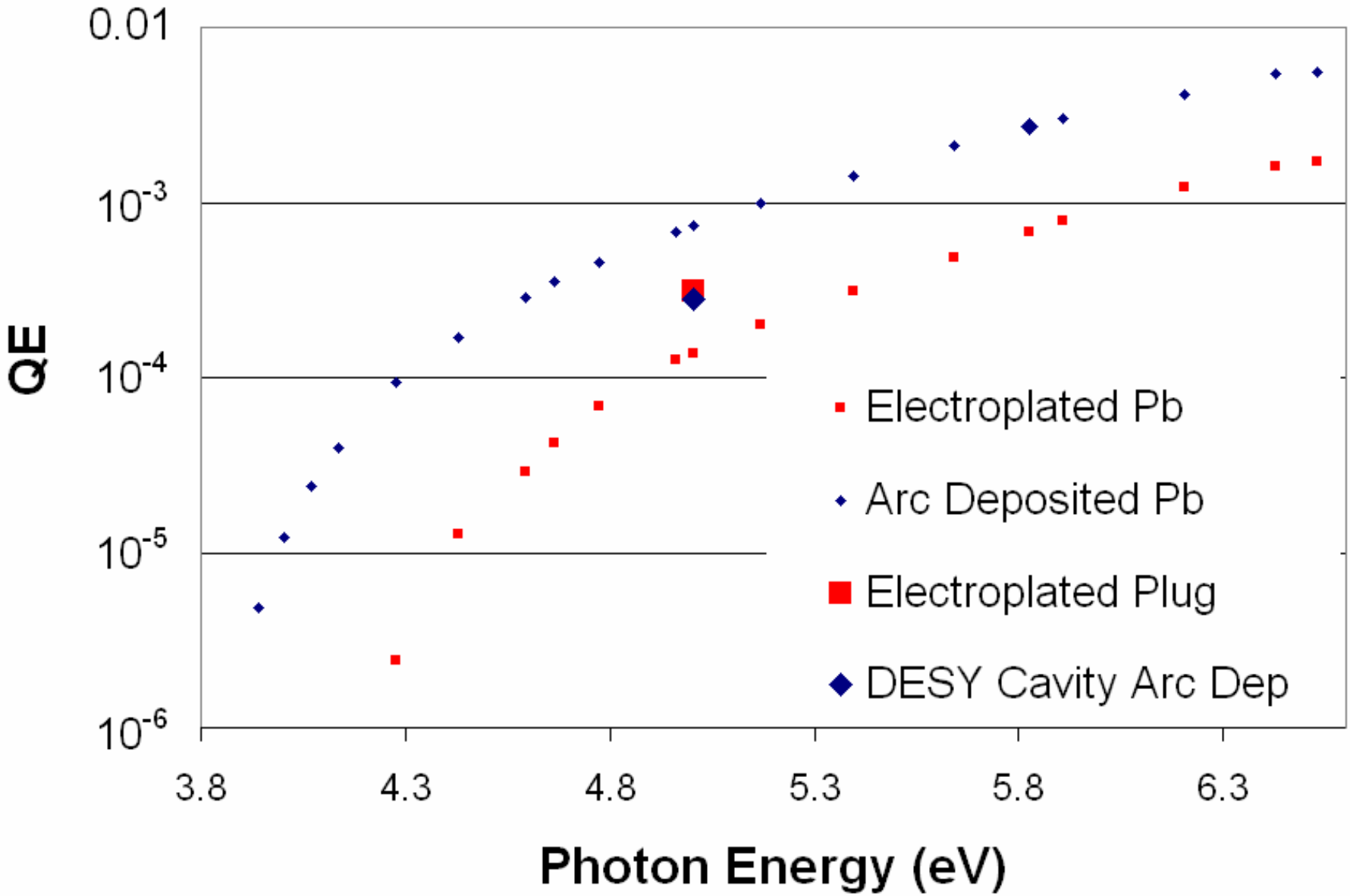
Photocathodes

The group has been involved in cathode development for every major BNL photoinjector, including ATF, SDL, and LEAF, as well as for SLAC/LCLS and UCLA.

- CAD Energy Recovery Linac/RHIC II
  - **Multi-alkali photocathode for high average current**
  - **Transparent photocathode**
  - **Objective: 50mA average current, 5nC/bunch**
- Superconducting cathode development
  - **Superconducting materials: Pb, Nb, etc.**
  - **Objective: 1mA average current, 1nC/bunch**
- Polarized electron source for e-RHIC/ILC
  - **Cs:GaAs in RF cavity**
  - **Objective: 260mA, 20nC/bunch, 70% polarization**

Collaboration with Jefferson Laboratory, Advanced Energy Systems, DESY, SUNYSB, INS-Świerk, FNAL and SLAC

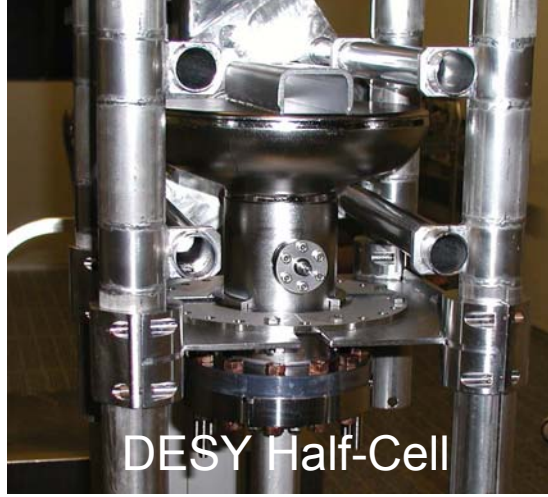
Superconducting Photocathodes

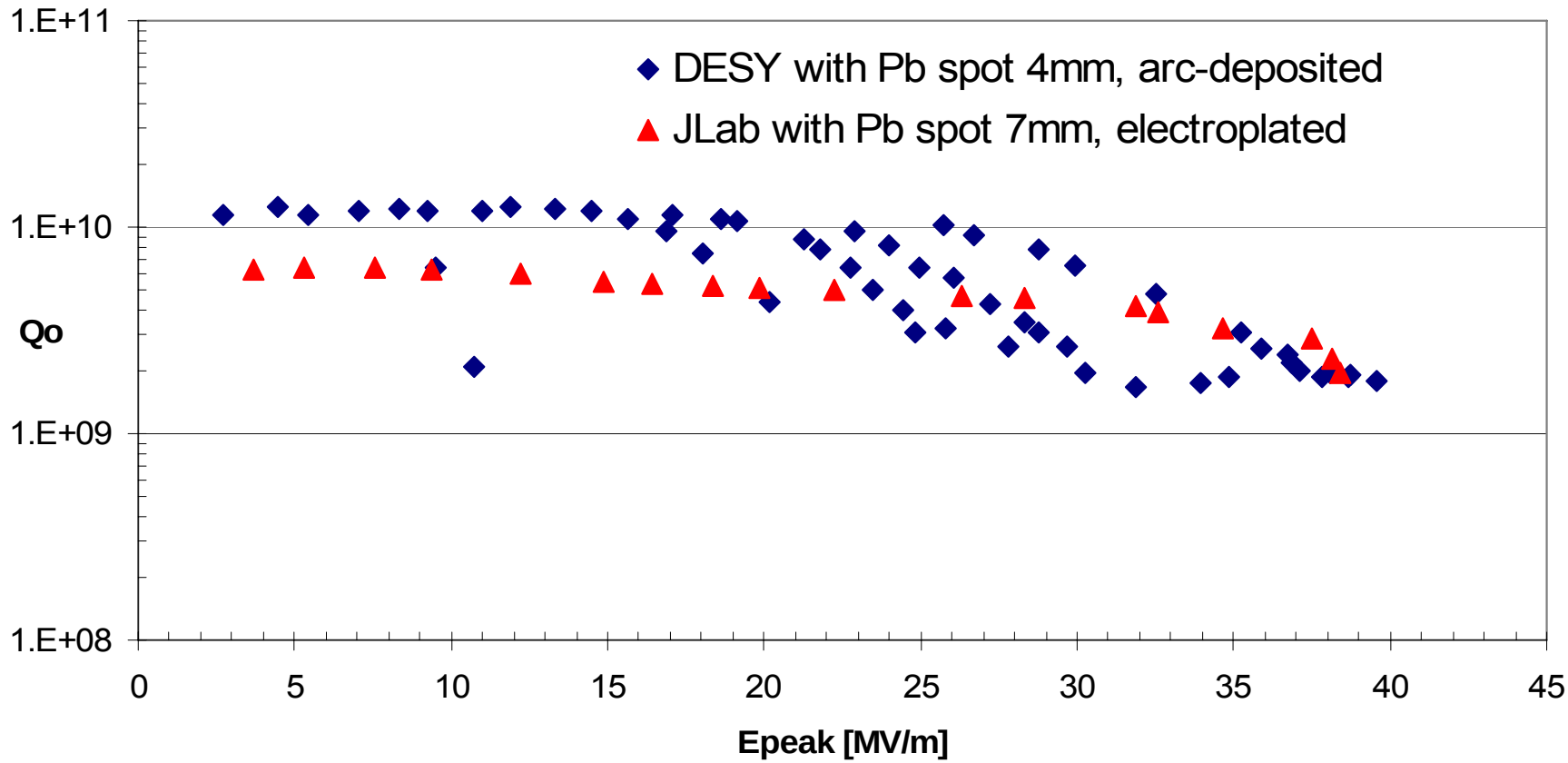


Cavity Tests

Nb-Pb Half-cells

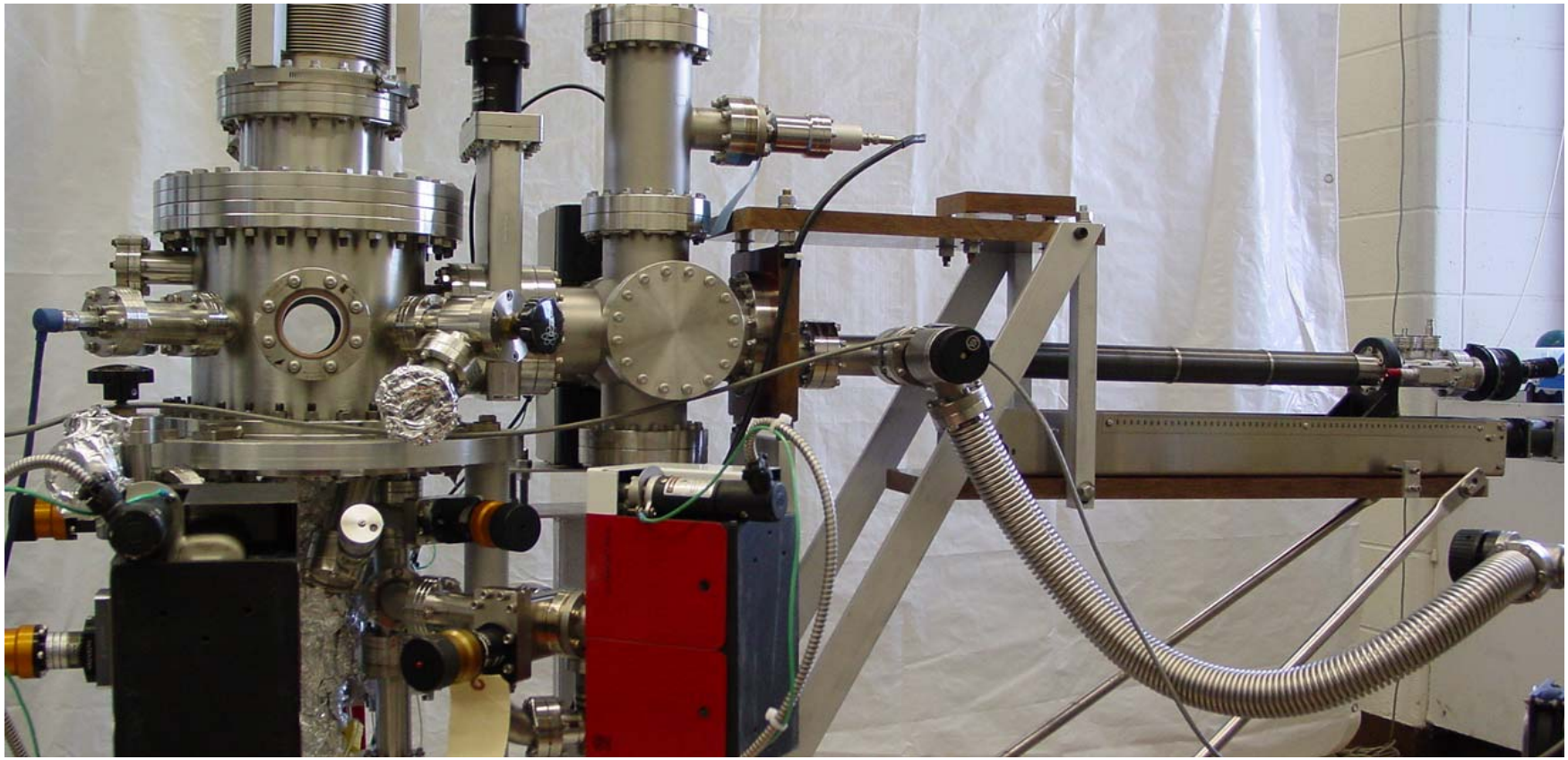
Status March 07





Cavity does not quench with 0.7 W of laser power

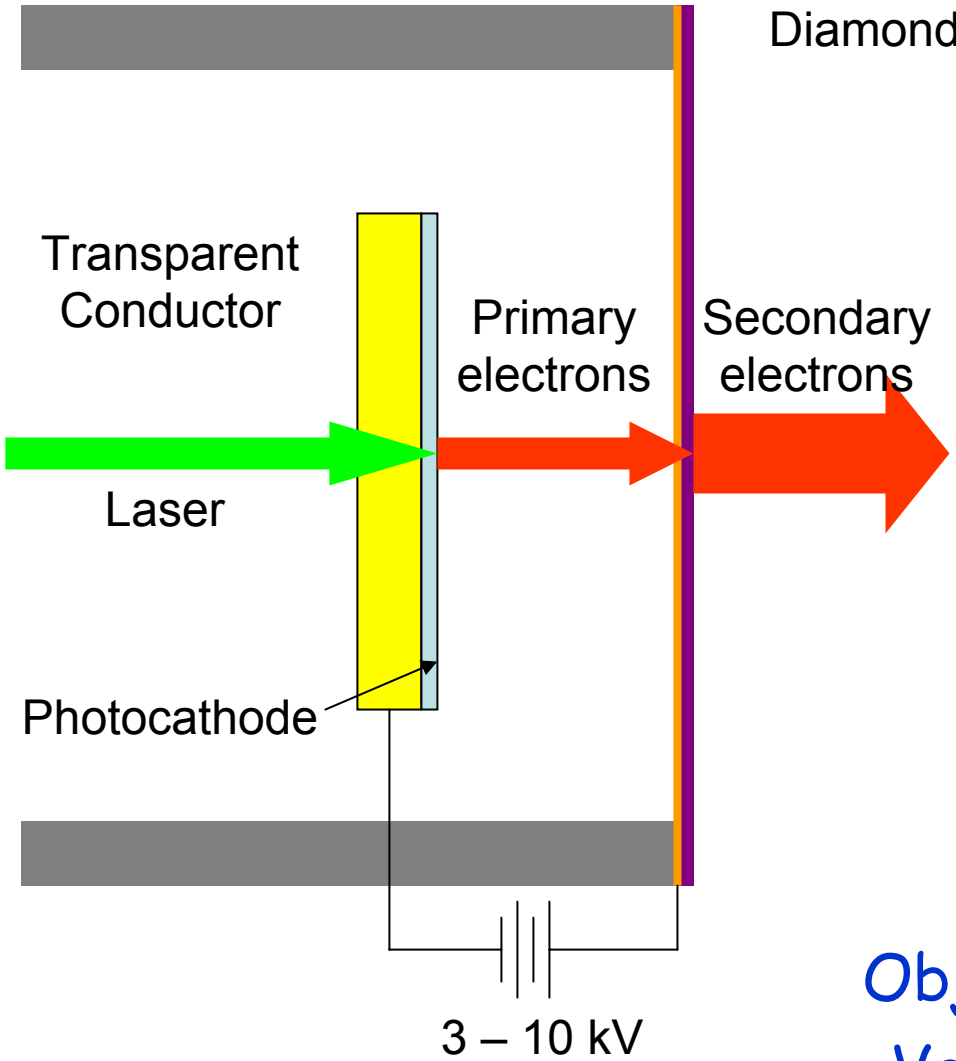
Multi-Alkali Deposition System

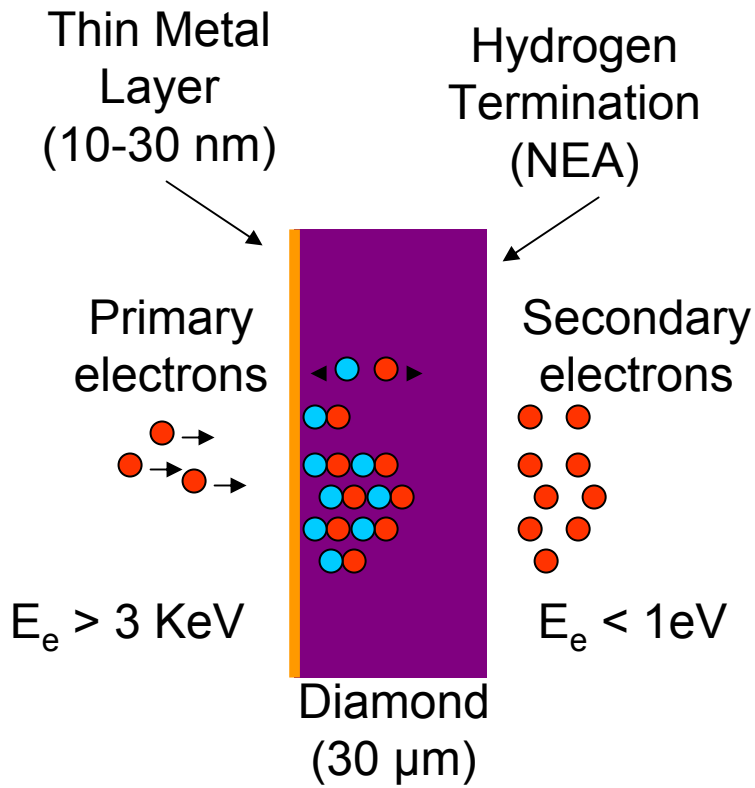


K_2CsSb deposition system:
- Vacuum under 0.1 nTorr
- In-Situ thickness monitor
- Sealed, inert sources

QE measurements:
- During deposition
- Transmission mode
- Reflection mode
- Multiple wavelengths

Diamond Amplified Photocathode





Amplify Photocurrent

Objective: ~1A average current

Vacuum Isolation for Cathode

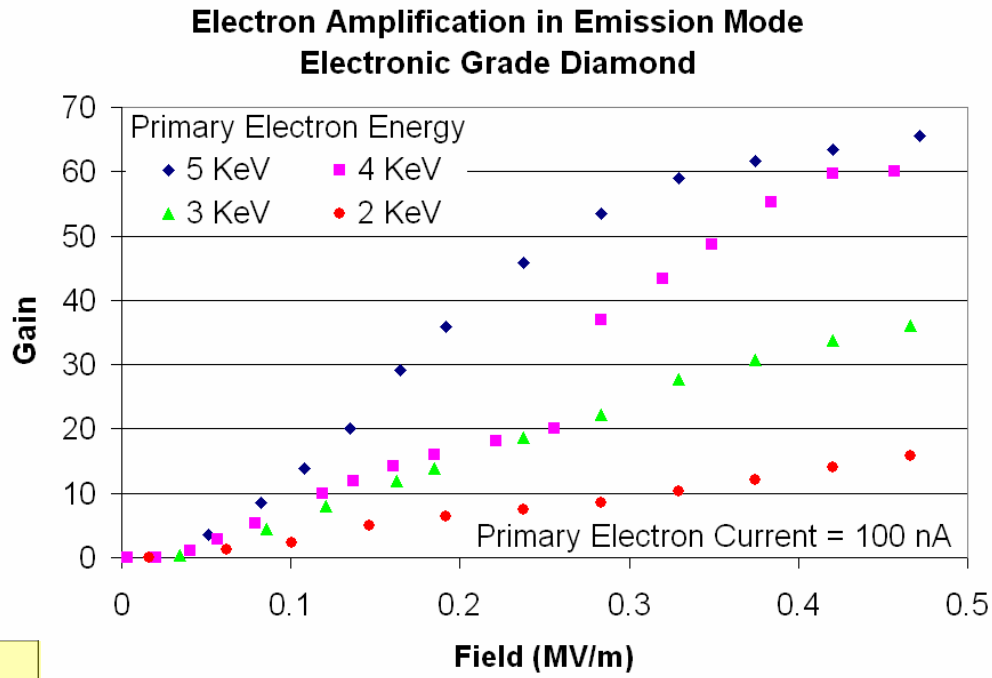
Diamond Amplified Photocathode

Electron Gain

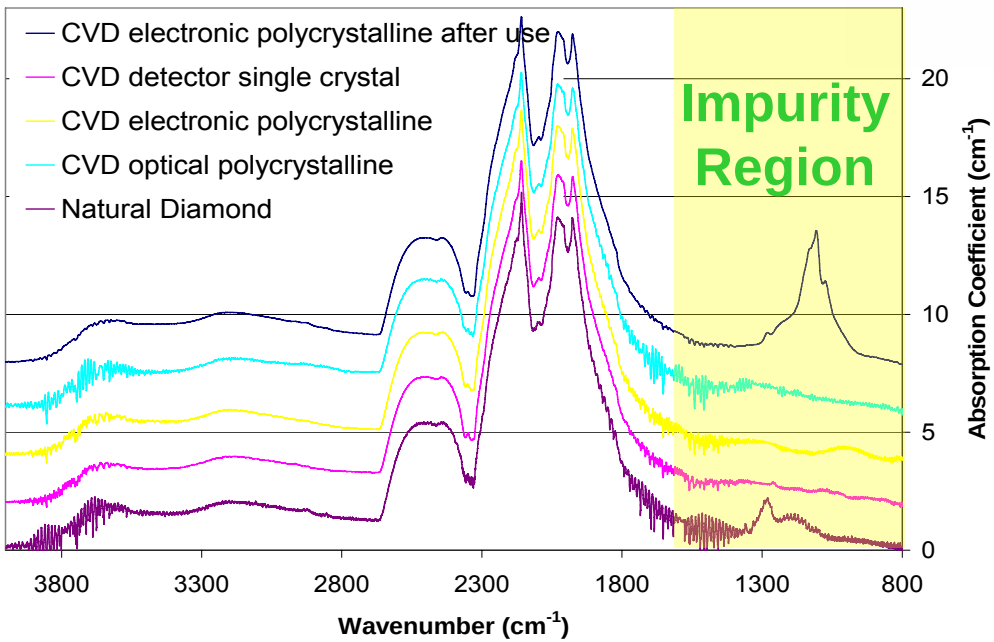
- Synthetic and Natural diamonds
- Emission and Transmission
- Short e^- bunch studies underway

Thinning of Diamond

- Laser Ablation
- Reactive Ion Etching



IR Spectroscopy (FTIR)

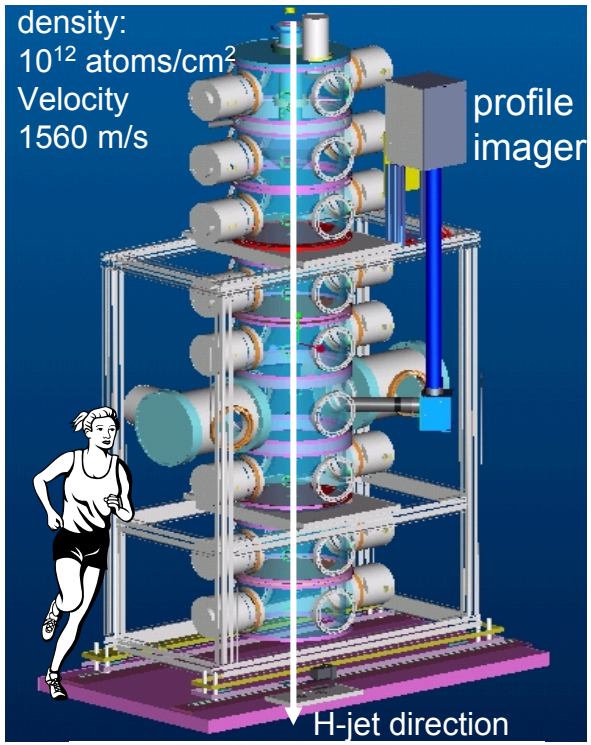


Characterization of Diamond

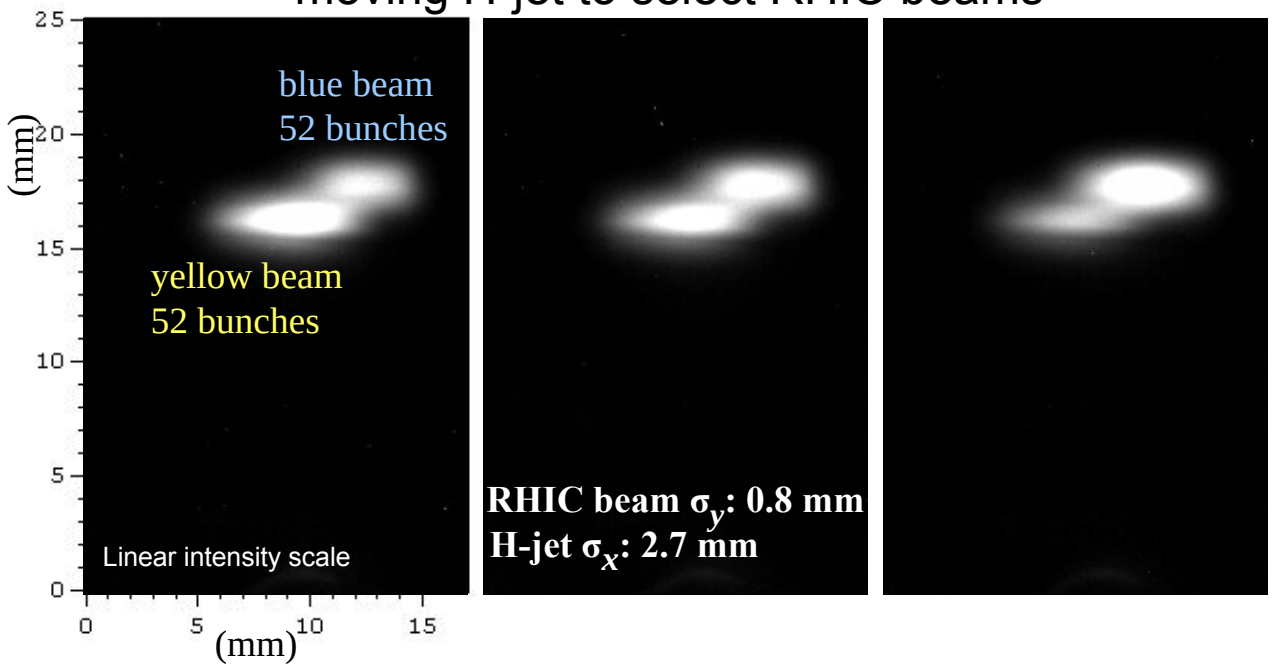
- FTIR
- Crystallography
- Raman
- Photoluminescence
- NEXAFS

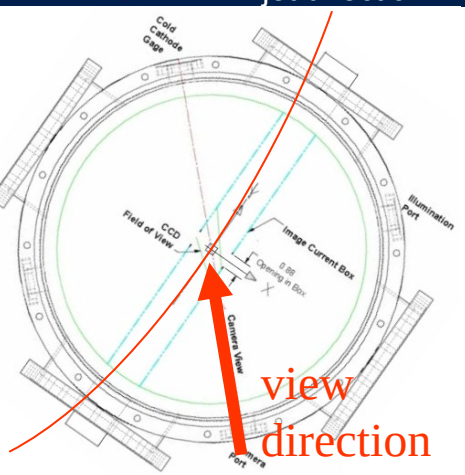
Beam Profile Measurement at RHIC

Observe H-α Balmer line emission due to beam excitation of hydrogen jet



moving H-jet to select RHIC beams

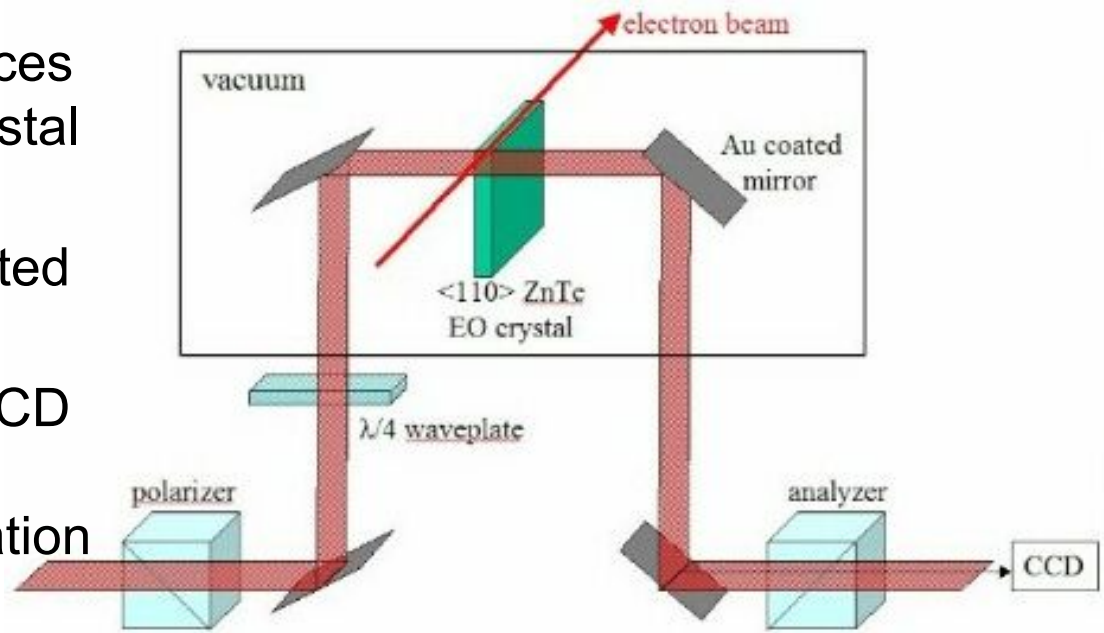


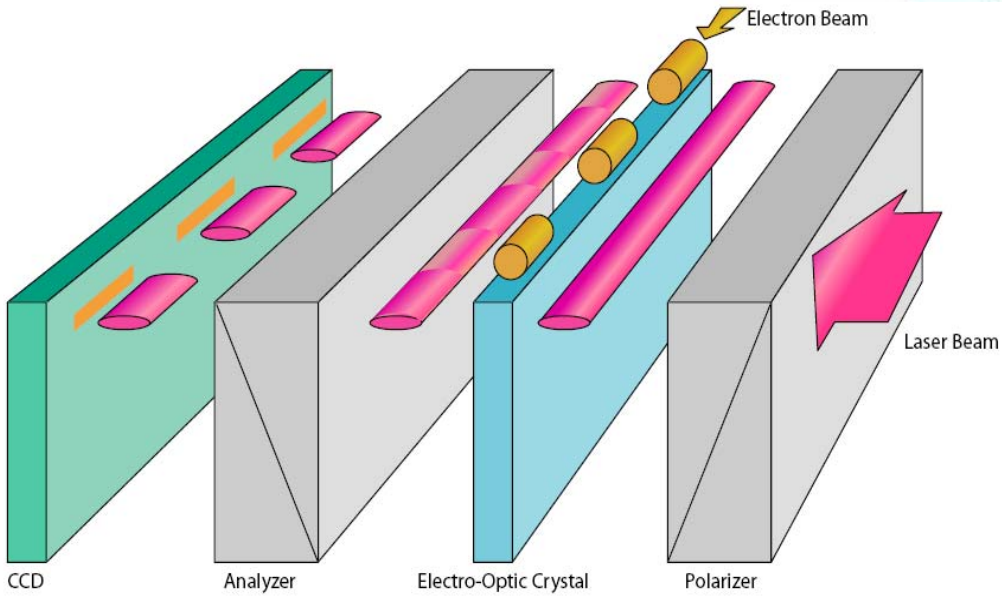


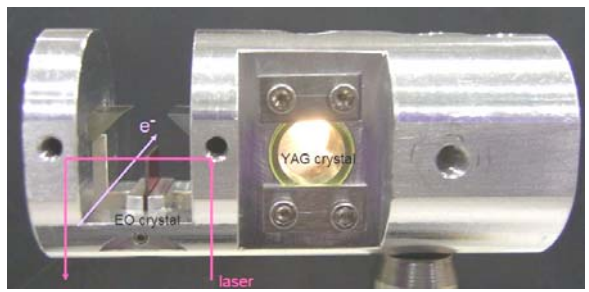
blue beam in motion

Electro-optic Bunch Length Measurement

- Electric field of the bunch induces polarization rotation in E-O crystal
- Diagnostic laser polarization is chosen so that light is transmitted only where e^- beam is present
- Laser beam is measured on CCD camera, converting temporal information into spatial information







Installed @ SDL

Installed @ ATF

Mercury Jet Imaging for Muon Source

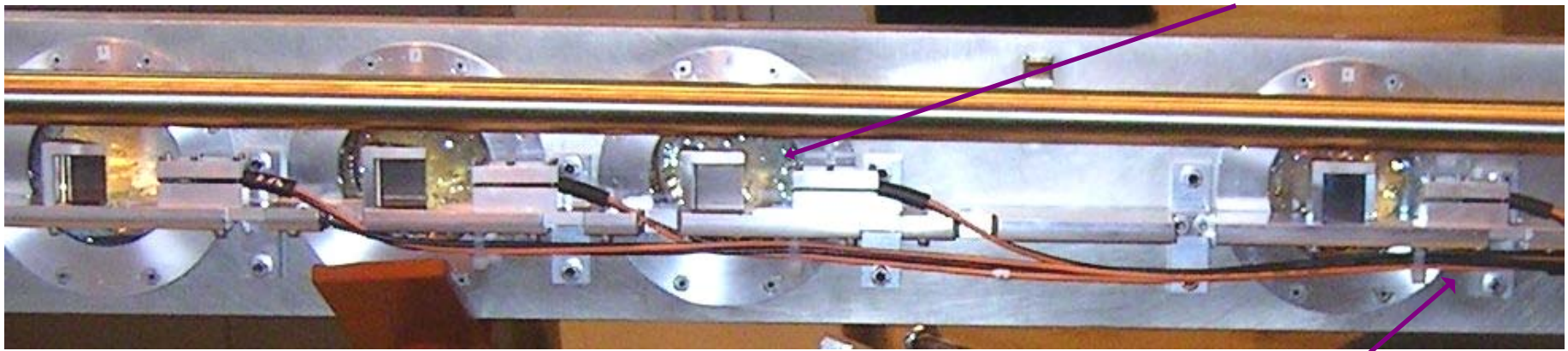
A proof-of-principle test of a target station suitable for a Neutrino Factory or Muon Collider. A 24-GeV proton beam is incident on a mercury jet inside a 15-T solenoid magnet. The goal is to capture low energy pions which subsequently decay to produce muons. The principle diagnostic is a high-speed optical camera.

Design and construct a high-speed optical camera system, perform image collection and data analysis

Back illuminated pulsed laser shadow photography

4 channels of imaging optics

Windows with focusing mirrors



Passive components inside magnet

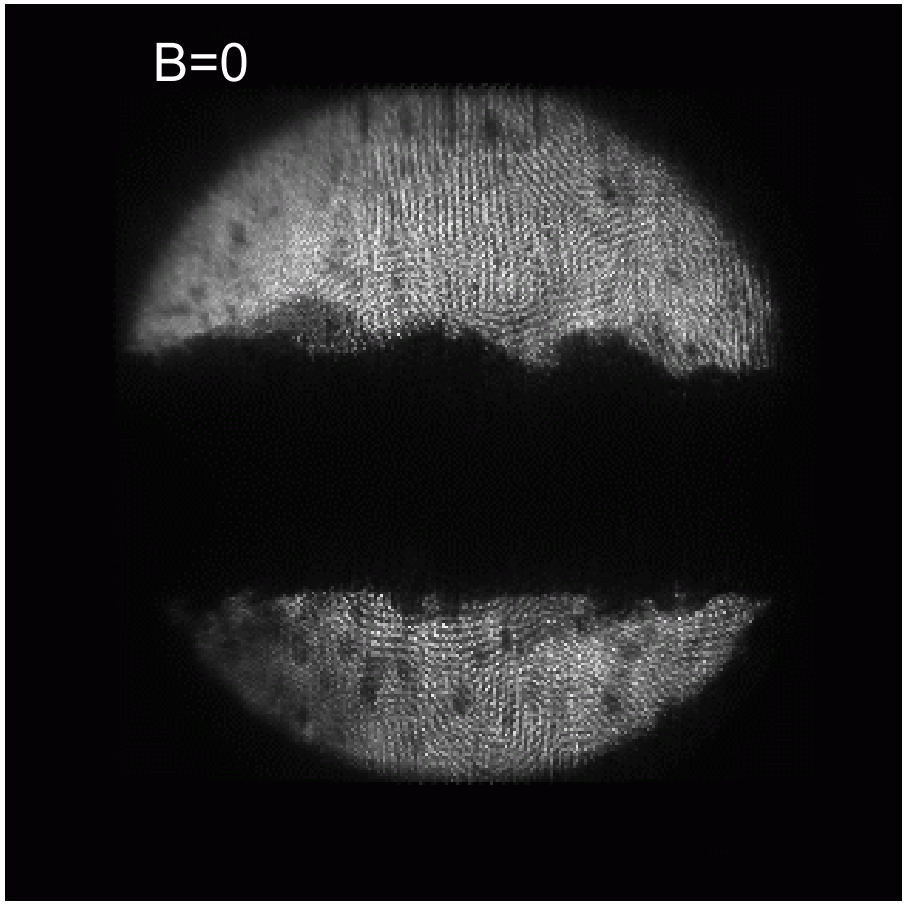
Fiber-optic optical transport

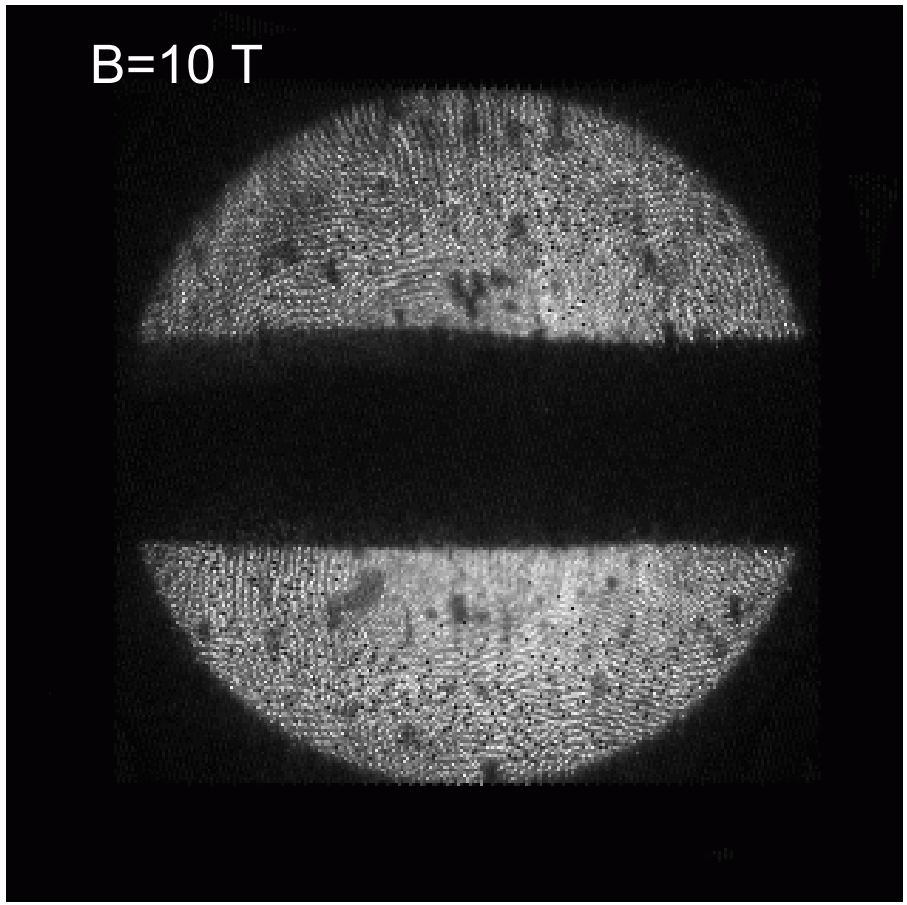
Mercury jet and proton beam co-propagate

Princeton, ORNL, MIT, CERN, and BNL

1st Hg jet run
Feb 14, 2007 @ ORNL

1st Hg jet run with pulsed solenoid
March 3, 2007 @ MIT





Hg jet is stabilized by magnetic field
System in now at CERN - proton beam interaction this summer

Summary

Facilities

Class IV laser facility, with 9 lasers spanning IR-UV, pulse duration from 12 fs to CW

Deposition systems for cathode fabrication

Diagnostic systems: Charge, Current, Laser spatial and temporal profile

R&D Program

Photocathode development, electro-optic beam diagnostics, diamond amplifier, and laser beam shaping

Laser and optics support for numerous projects, including several for RHIC and its upgrades

Involved in several collaborations: internal, national and international