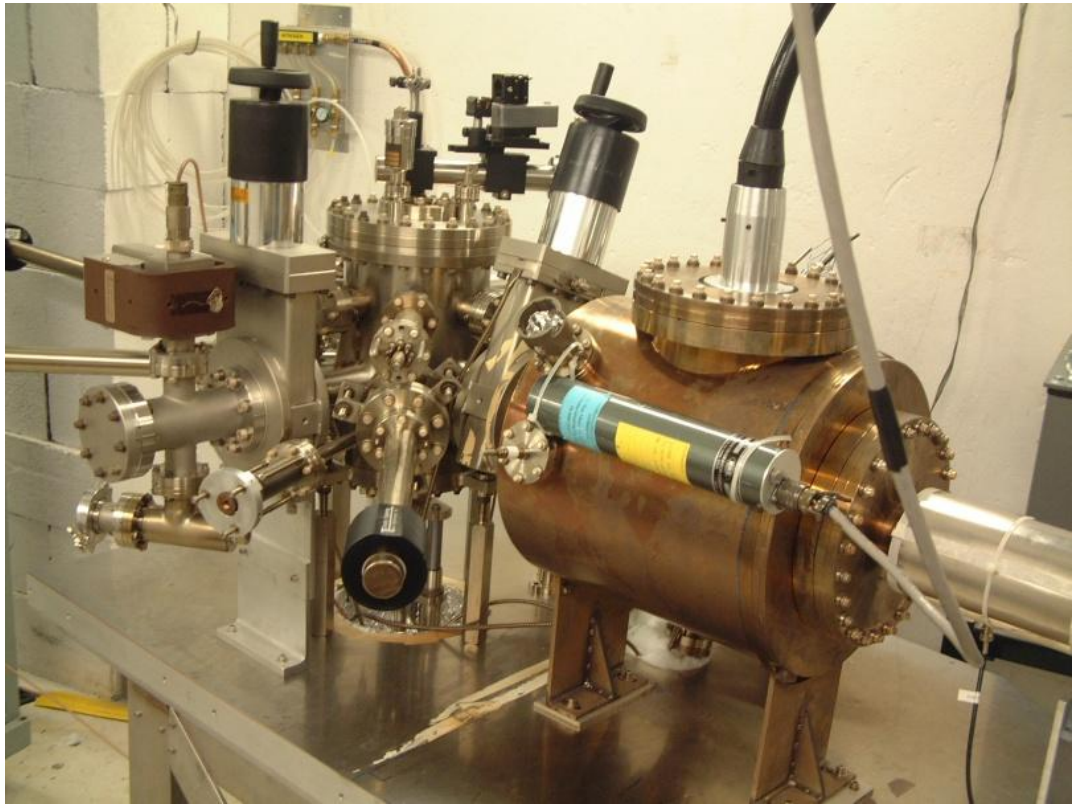
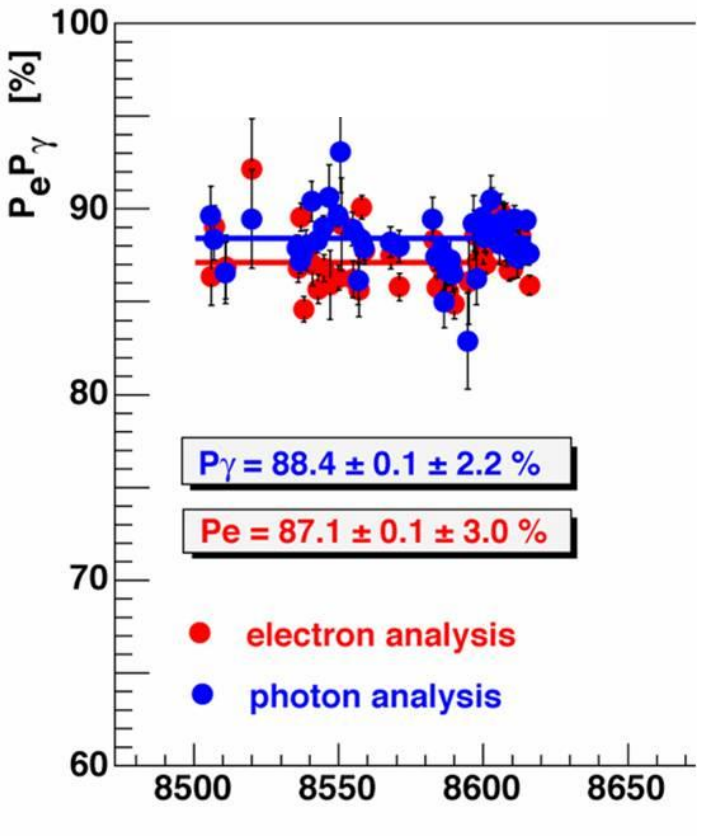
The CEBAF 200kV Inverted Gun





P. Adderley, M. BastaniNejad, J. Clark, J. Grames, J. Hansknecht, J. McCarter, M. Poelker, M. Stutzman, R. Suleiman, K. Surles-Law

Benefit of Higher Gun Bias Voltage

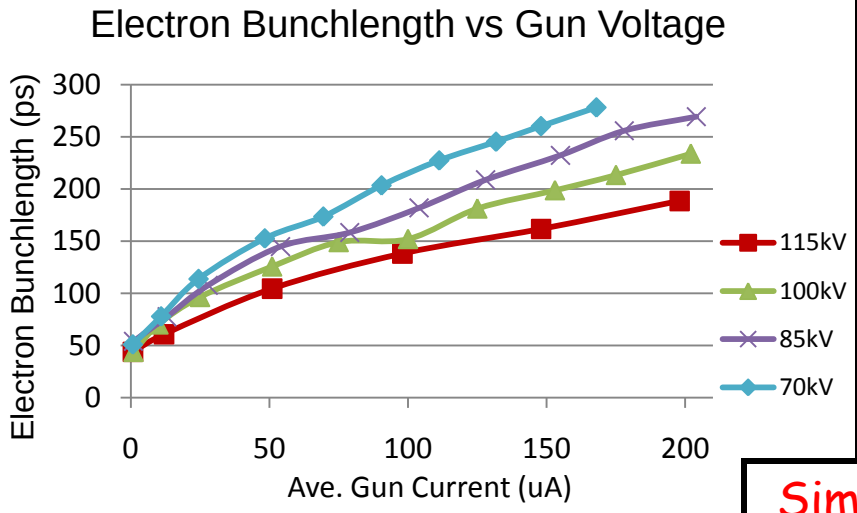
- Reduce space-charge-induced emittance growth, maintain small transverse beam profile and short bunchlength
  - In other words, make a "stiff" beam right from the gun
  - Particularly important for high bunch charge beam

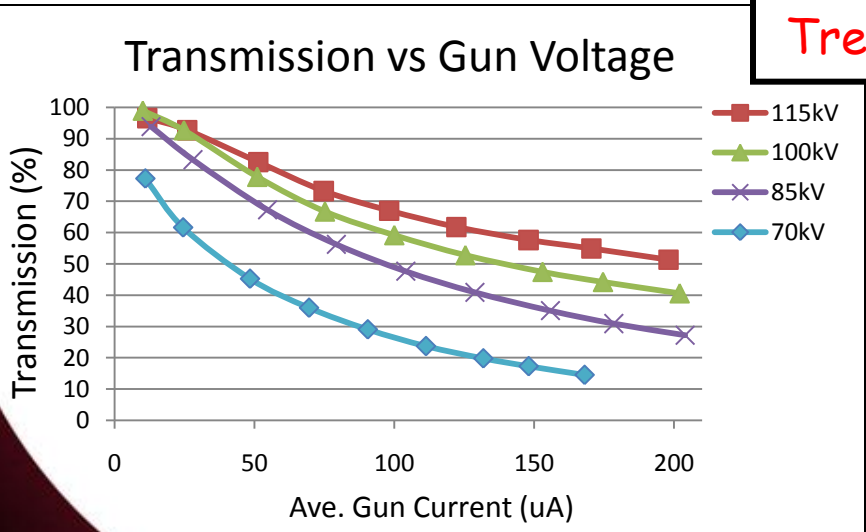
- CEBAF guns have always operated at 100kV (β = 0.55)
- Expect better transmission for Qweak at 140kV (and ILC Baseline design) (β = 0.62)
- Later, we envision an improved CEBAF photoinjector with a 200kV gun and SRF capture section (β = 0.69)
- Indentify what it takes to reach 350kV bias voltage or higher (β= 0.8+). For ILC, CLIC, EIC, etc.

Biggest obstacle: Field emission and HV breakdown… which lead to Photocathode Death

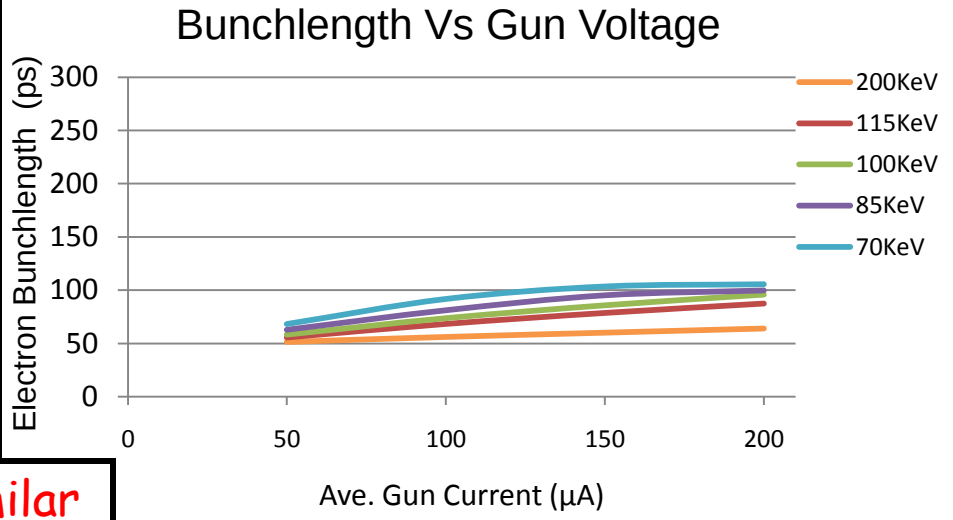
Benchmarking PARMELA Simulation Results Against Beam-Based Measurements at CEBAF/Jefferson Lab – work of Ashwini Jayaprakash, JLab

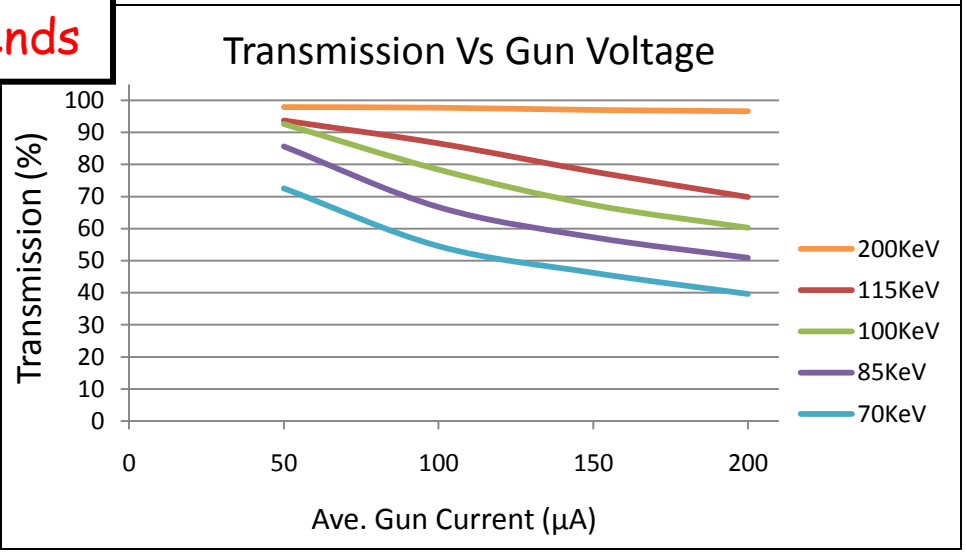
Measurements at CEBAF/JLab





PARMELA Simulation Results



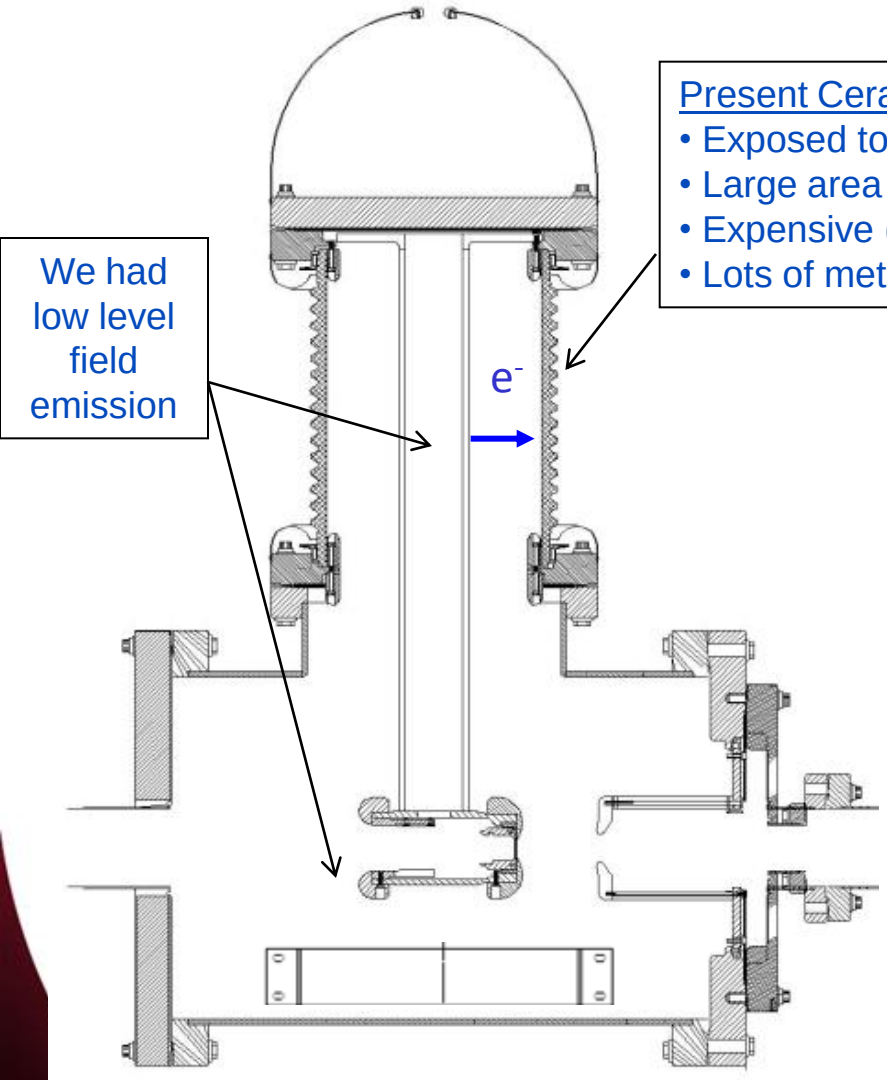


Similar Trends

Message: Beam quality, including transmission, improves at higher gun voltage

Old Gun Design

New "Inverted" Design

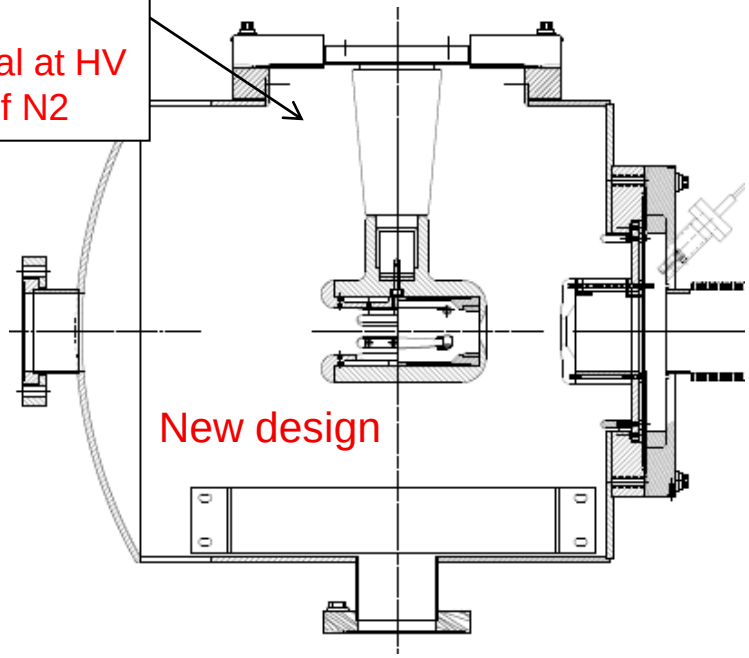


Present Ceramic
- Exposed to field emission
- Large area
- Expensive (~$50k)
- Lots of metal at HV

We had low level field emission

Medical x-ray technology

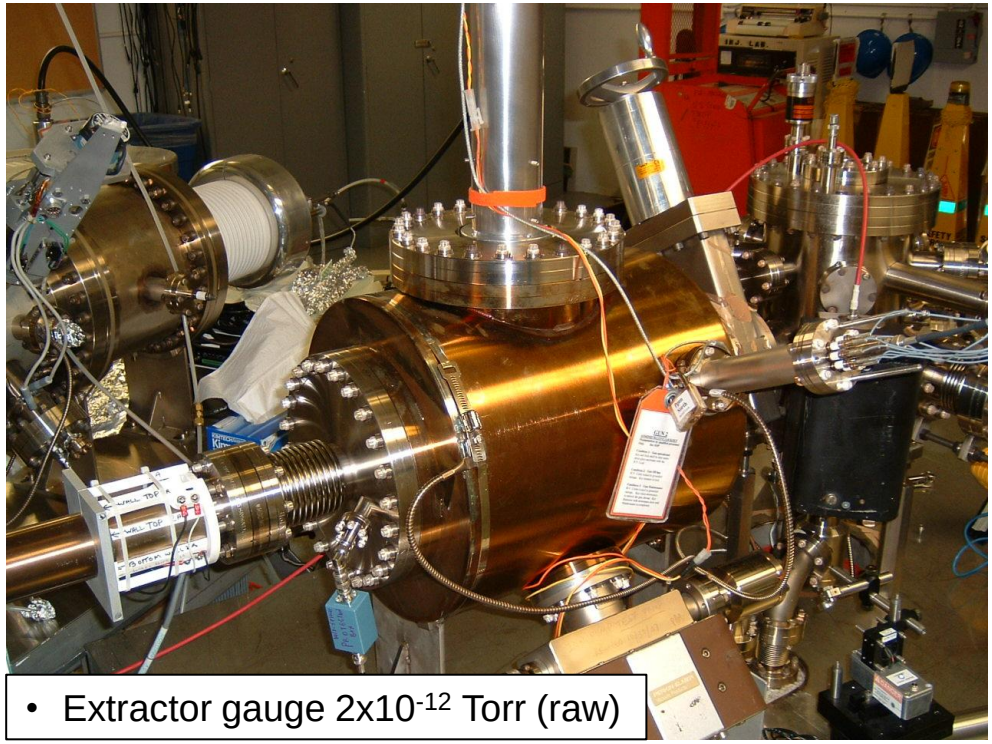
New Ceramic
- Compact
- ~$5k
- Less metal at HV
- No SF6 of N2



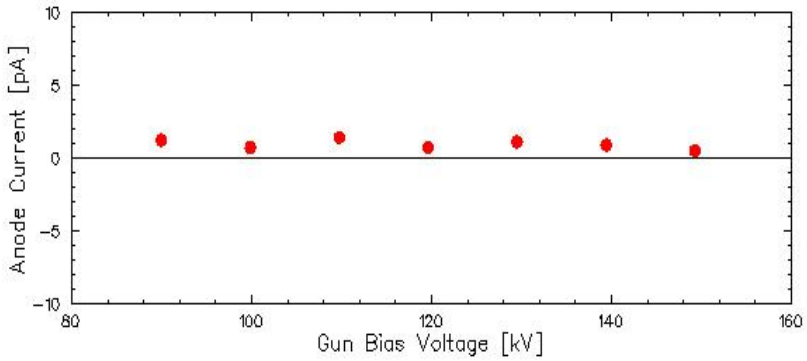
Move away from "conventional" insulator used on most GaAs photoguns today – expensive, months to build, prone to damage from field emission.
High gradient locations not related to beam optics, lots of metal to polish

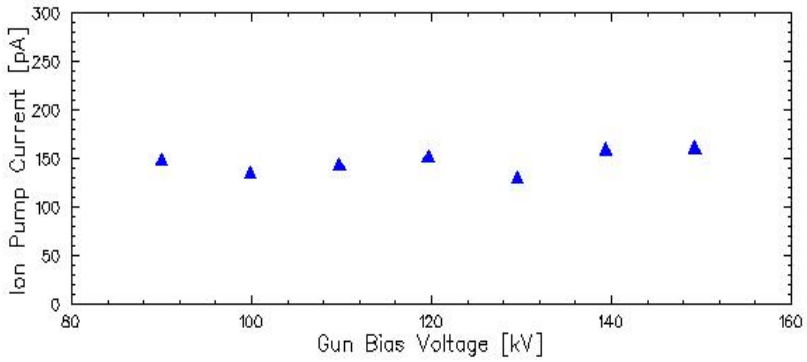
First Inverted Gun @ CEBAF

ILC-funded Project



- Extractor gauge 2x10^{-12} Torr (raw)

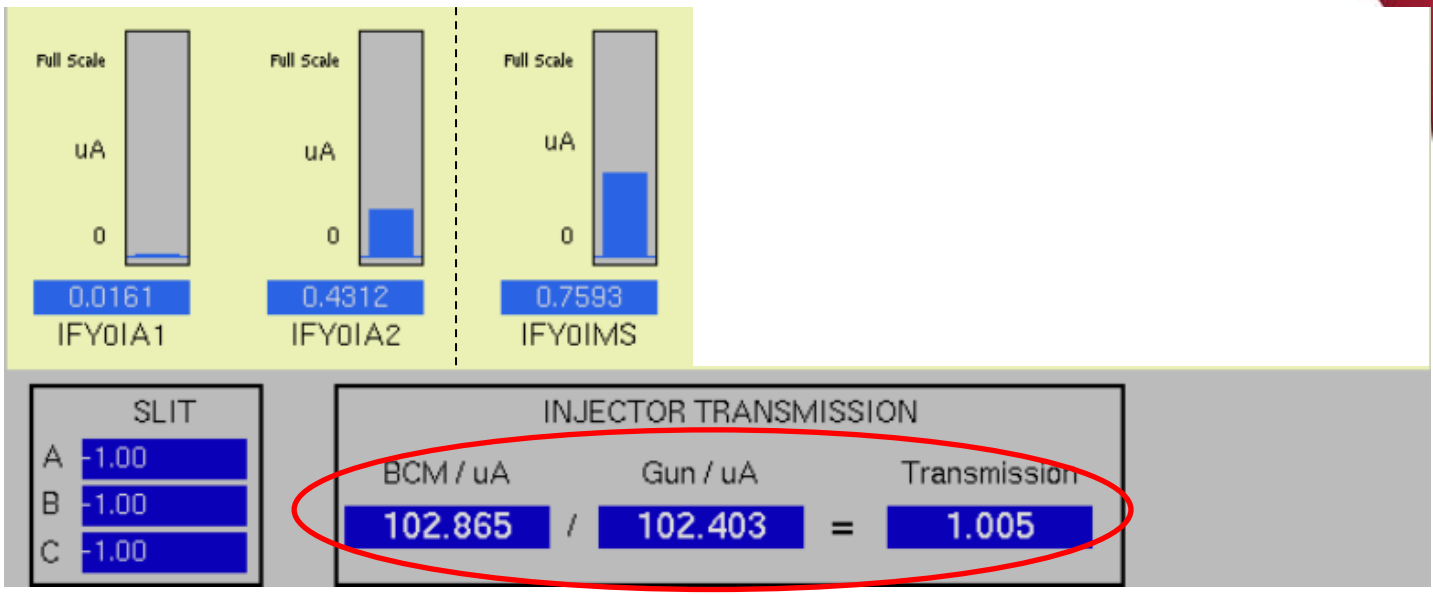




- Spring, 2009 – Built our first inverted gun (stainless steel electrode)
- July, 2009 – Installed at CEBAF
- Ran CEBAF program @ 100kV
- September, 2010 – Conditioned to 150kV successfully
- Since – Operating at 130kV (limited by present injector design)

CEBAF Benefiting @ 130kV

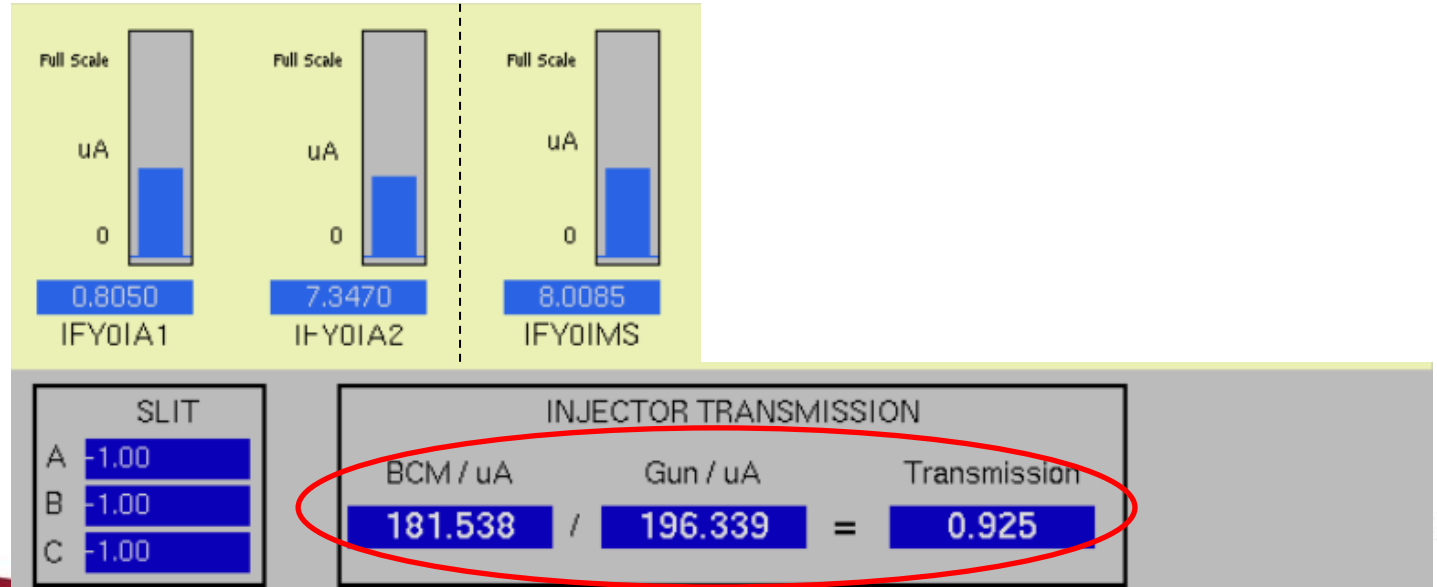
100% transmission
at ~100 μA



Transverse
Emittance Filter

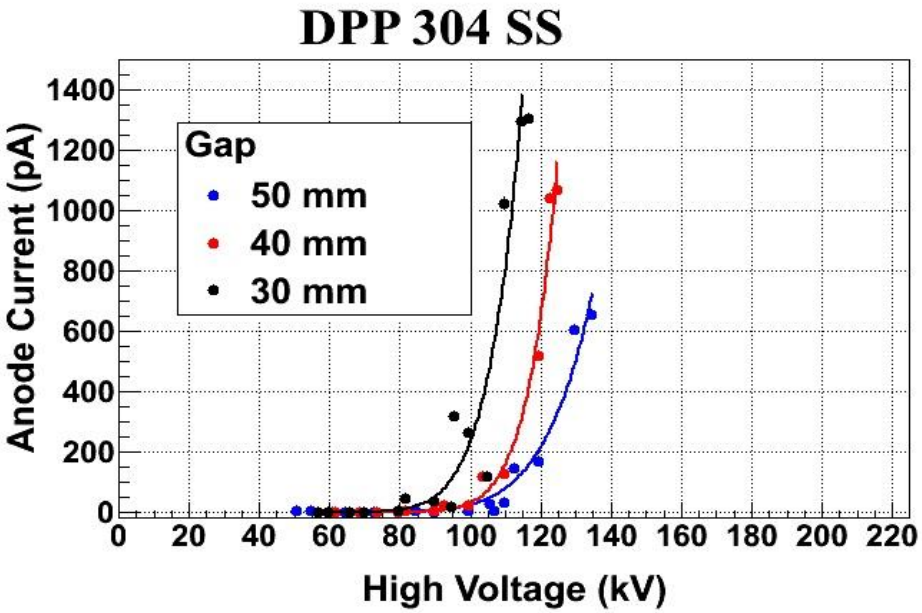
Longitudinal
Emittance Filter

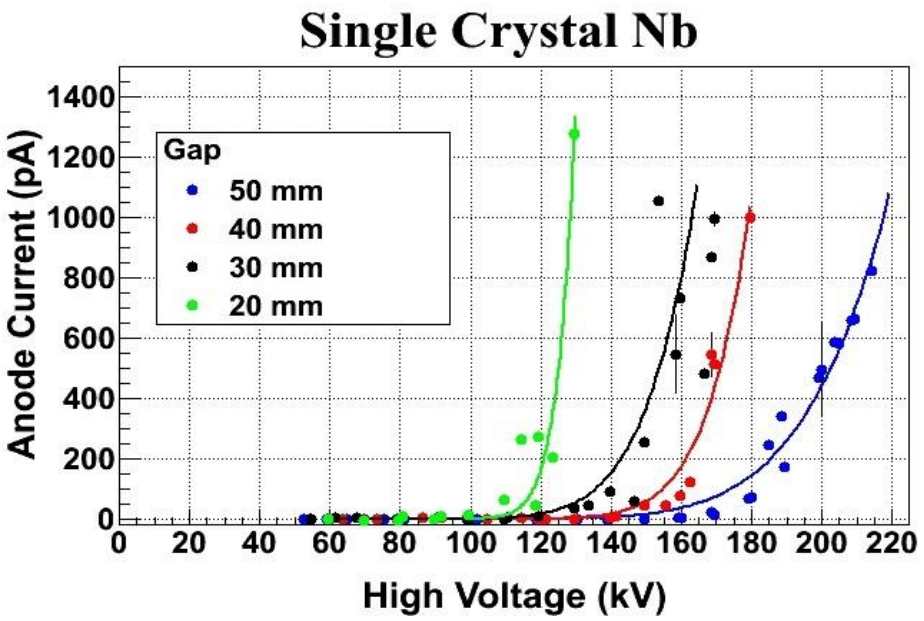
92% transmission
at ~200 μA

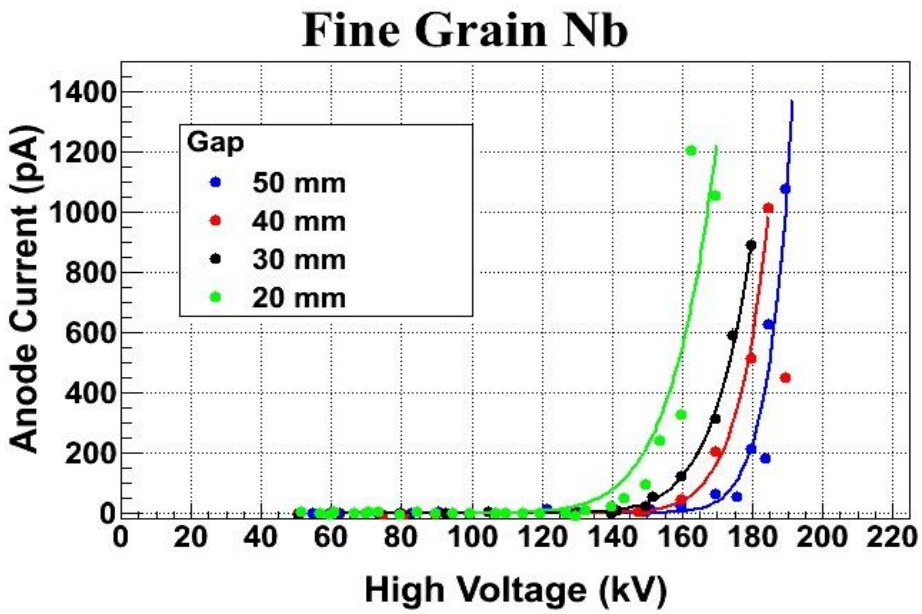


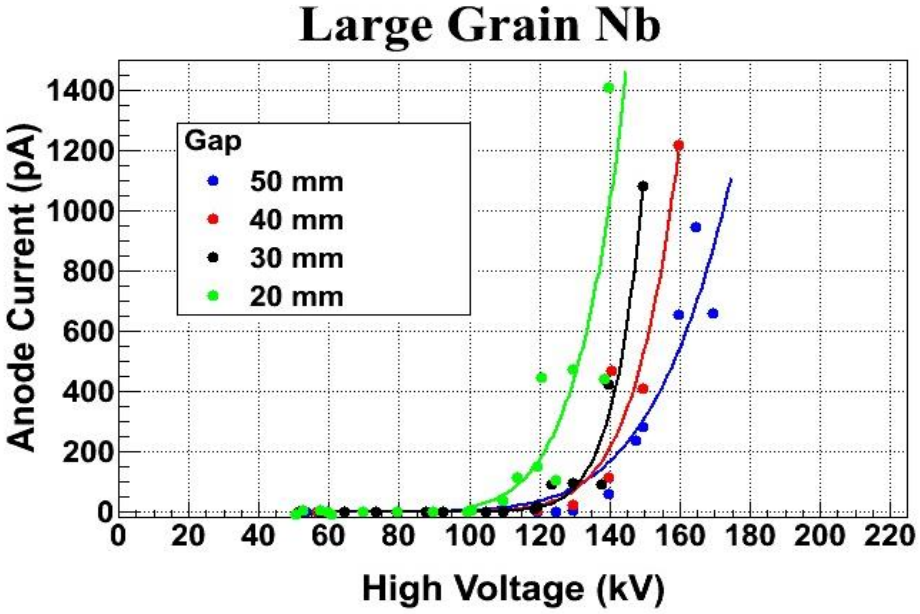
Synergy with JLAB SRF Institute

See WEP287 M. BastaniNejad et al.



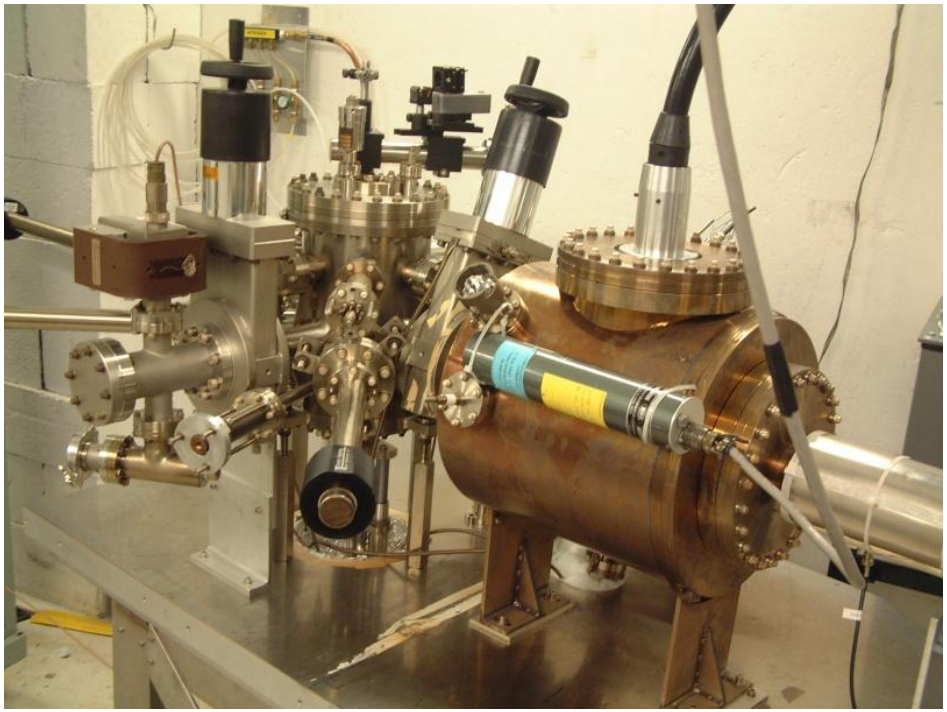


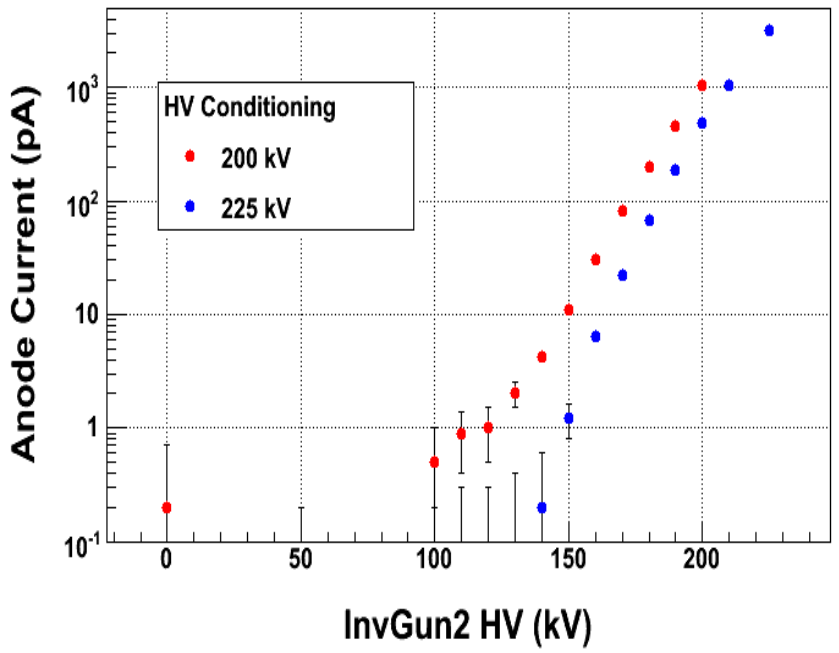




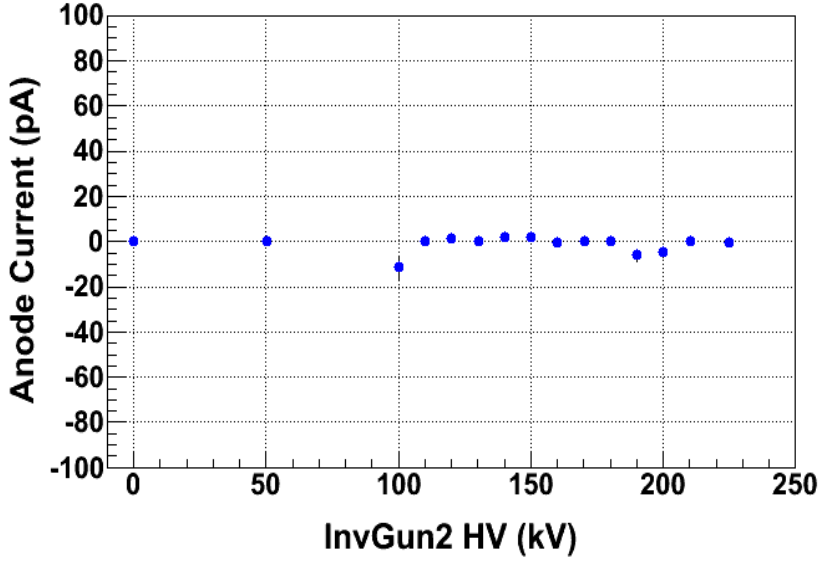
Second Inverted Gun @ Injector Test Facility

ILC-funded Project

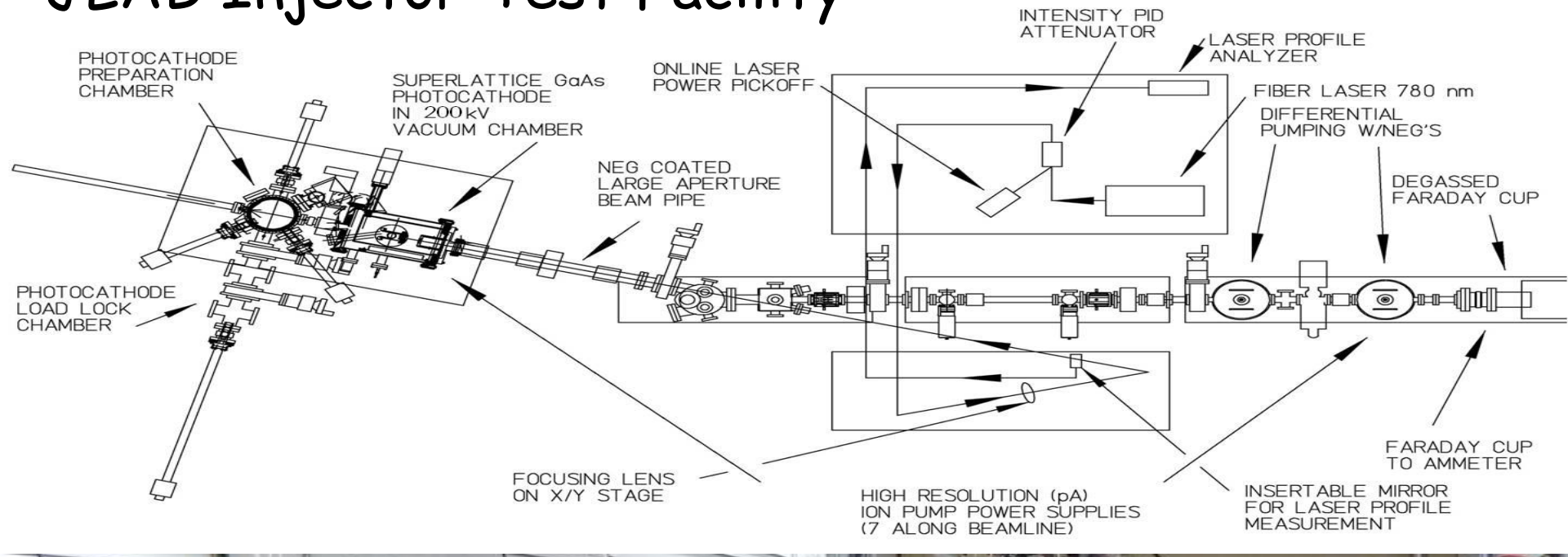


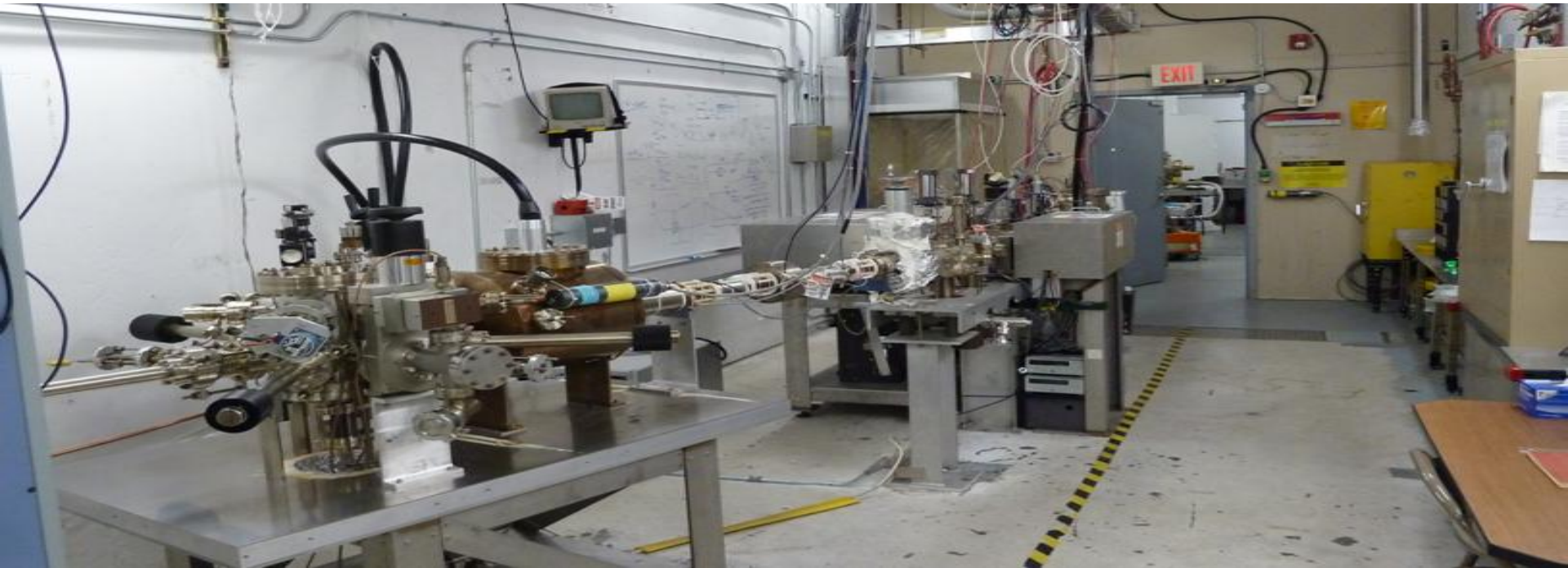


- 2nd inverted gun: large grain Nb electrode
- Problematic field emission at 200kV
- Conditioned to 225kV helpful (limited HVPS)
- Longer buffer chemical polish successful
- No field emission up to 225kV



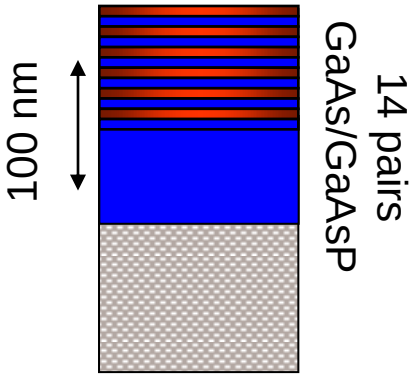
JLAB Injector Test Facility

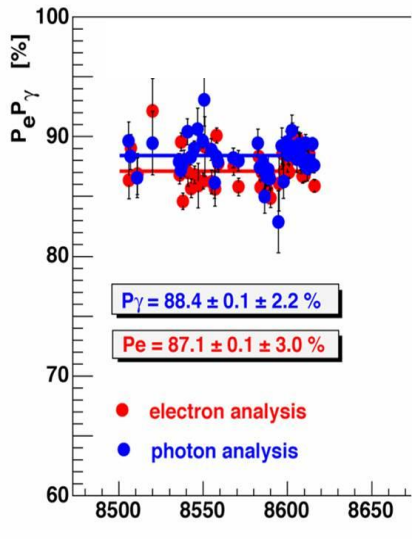




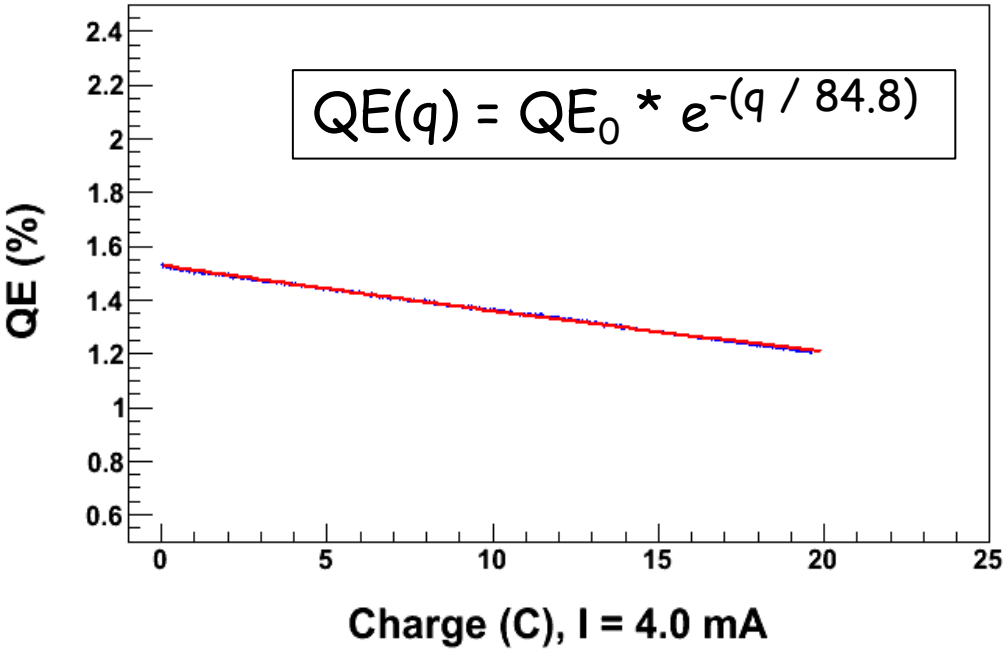
High Polarization SSL @ 4 milliAmp's

Parameter	Value
Laser Rep Rate	1500 MHz
Laser Pulselength	50 ps
Laser Wavelength	780 nm
Laser Spot Size	350 μm FWHM
Photocathode	GaAs/GaAsP
Current	4 mA
Duration	1.4 hr
Charge	20 C
Lifetime	85 C

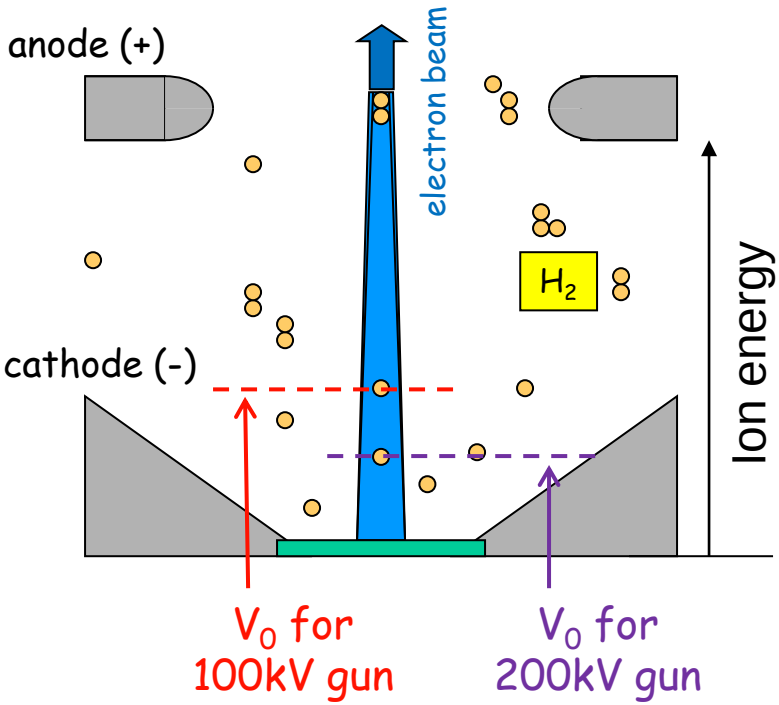


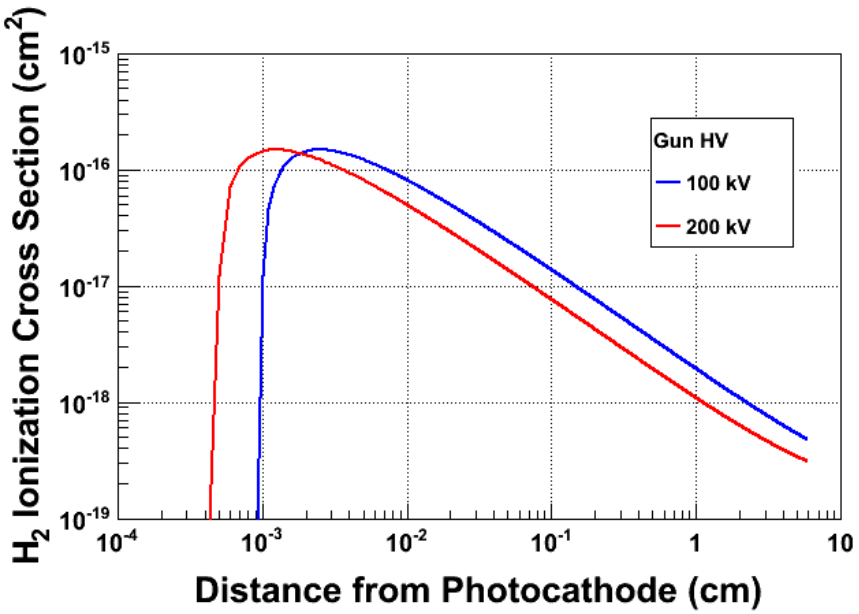


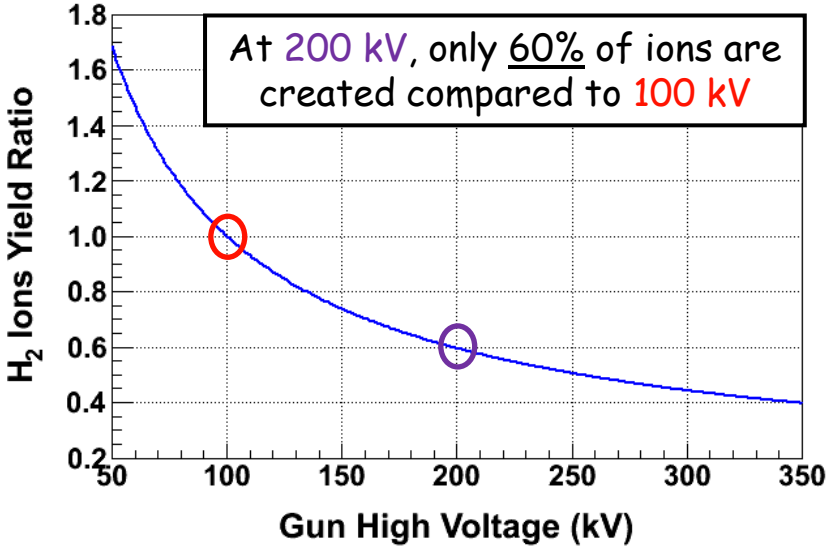
- High initial QE ~ 1.5%
- Higher 200kV voltage => superceding 1mA demo (PAC'07)
- Push technology in support of Electron Ion Colliders > 50 mA



Will higher bias voltage improve lifetime?







Experimental Charge Lifetime
(2mA from photocathode center)

- 100 kV = 11.1 C
- 200 kV = 19.4 C

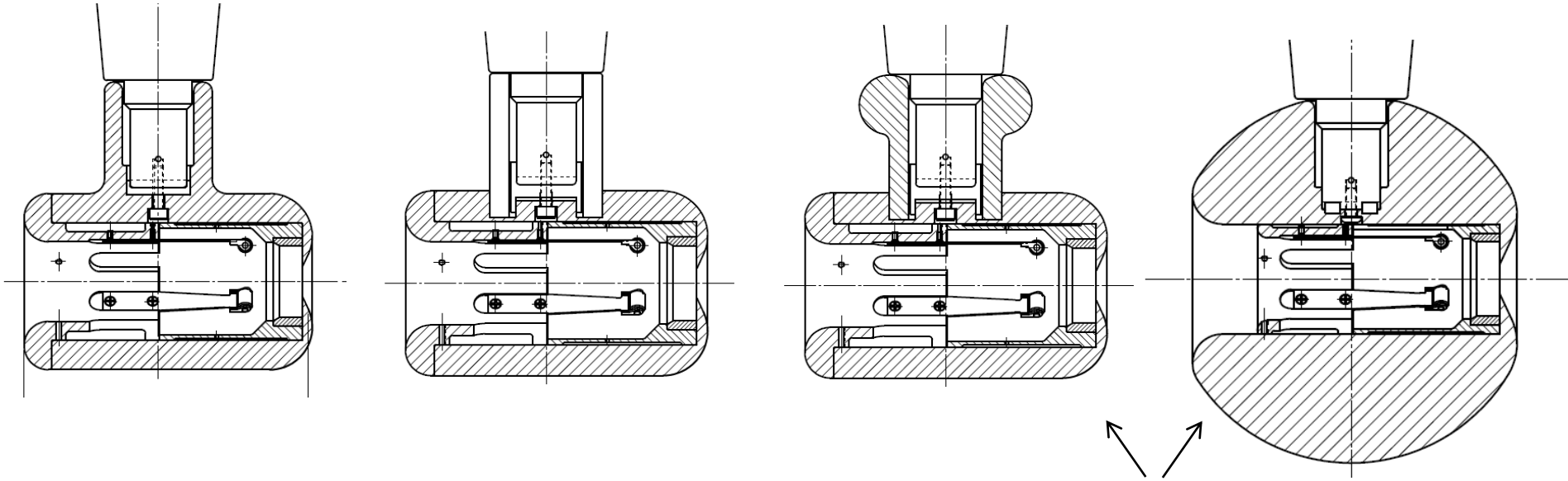
Lifetime improved by 57%

Summary

- Inverted Gun #1 – Stainless steel electrode operating at 130kV (conditioned to 150kV) at CEBAF for precision parity violation experiments requiring high beam current (~180 μA)

- Inverted Gun #2 – Large grain niobium electrode operating at 200kV (conditioned to 225kV) at Injector Test Facility for studies of high polarization photocathode operating at milliampere current

- R&D for new electrode designs and higher voltage 350kV HVPS under way…



Design from Muons, Inc.