Fermilab

Managed by Fermi Research Alliance, LLC for the U.S. Department of Energy Office of Science

H^- Ion Source Development at FNAL

Alejandro Garcia Sosa

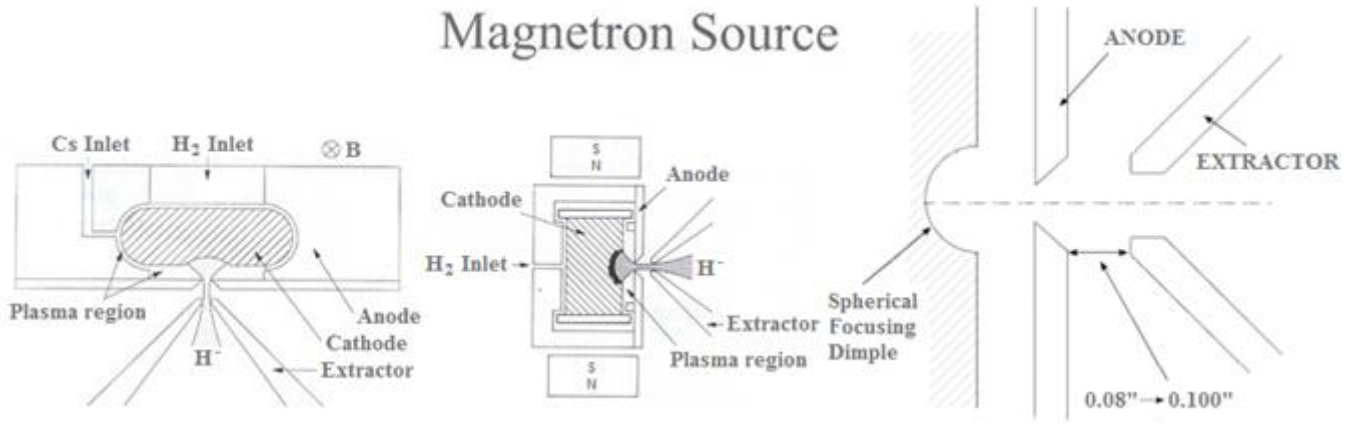
Proton Accelerators for Science and Innovation Workshop

Nov 11-13 2015

Outline

- Magnetron Source
- Work done on operational sources
  - Beam Neutralization
  - Fiber Optics Chassis
  - Electron Microscope Studies
- Experiments on the test stand
  - Solenoid Valve
  - Gas Mixing Experiment
  - Tungsten Dimple Cathode
  - Cs delivery system
- A look into the future: PIP-II Linac
- Conclusions

FNAL H- Ion Source



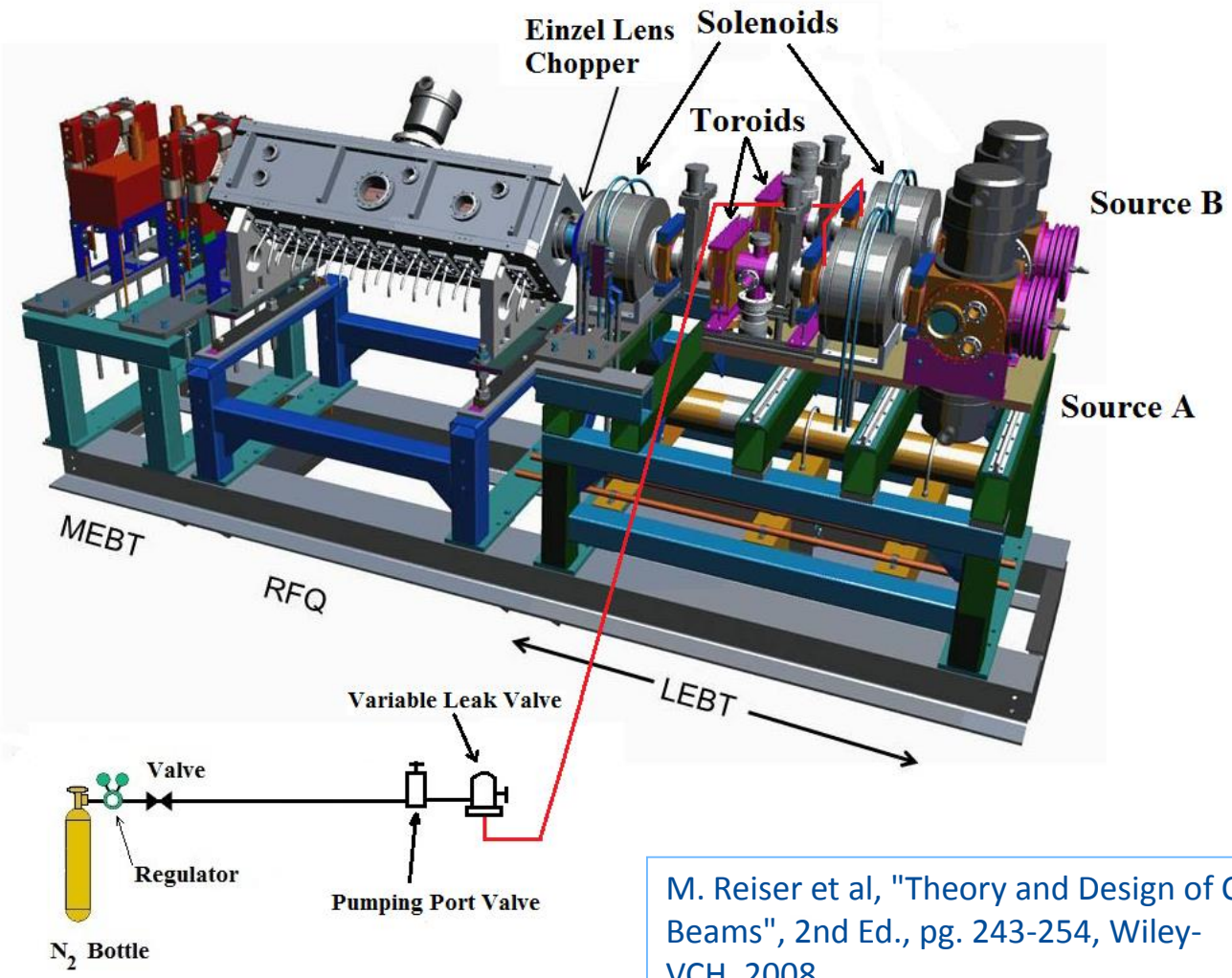
Current FNAL H^- Source parameters

Parameter	Value	Units
Arc Current	15	A
Arc Voltage	180	V
Extractor Voltage	35	kV
Beam Current	80	mA
Power Efficiency	48	mA/kW
Rep Rate	15	Hz
Arc Pulse Width	250	μs
Extracted Beam Pulse Width	80	μs
Duty Factor	0.375	%
Cathode Temperature	380	°C
Cs Boiler Temperature	130	°C
Emittance $\varepsilon_x/\varepsilon_y$ (norm., 95%)	0.17/0.28	π mm mrad
Extraction Gap	4.67	mm
Lifetime	9	months

9 months of continuous operation!

Fermilab

Beam Neutralization



M. Reiser et al, "Theory and Design of Charged Particle Beams", 2nd Ed., pg. 243-254, Wiley-VCH, 2008.

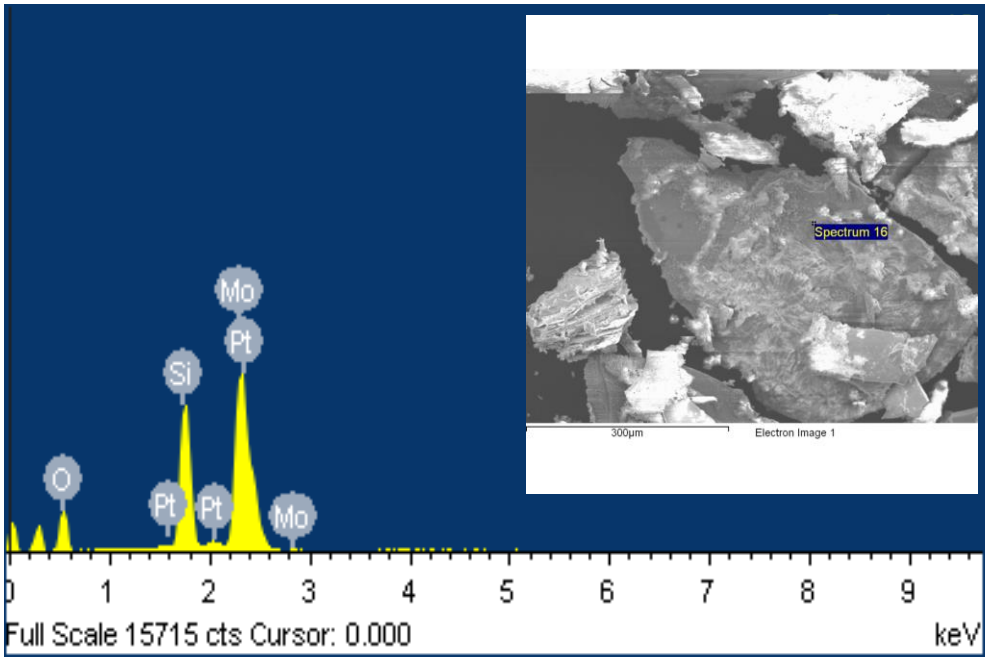
Fermilab

Fiber Optics Chassis

- Removed HRM from the HV rack
- Replaced by fiber optics communications link
- Reduced overall spark rate due to asynchronous rebooting of HRM
- Standardization of operational sources
- More stable operations

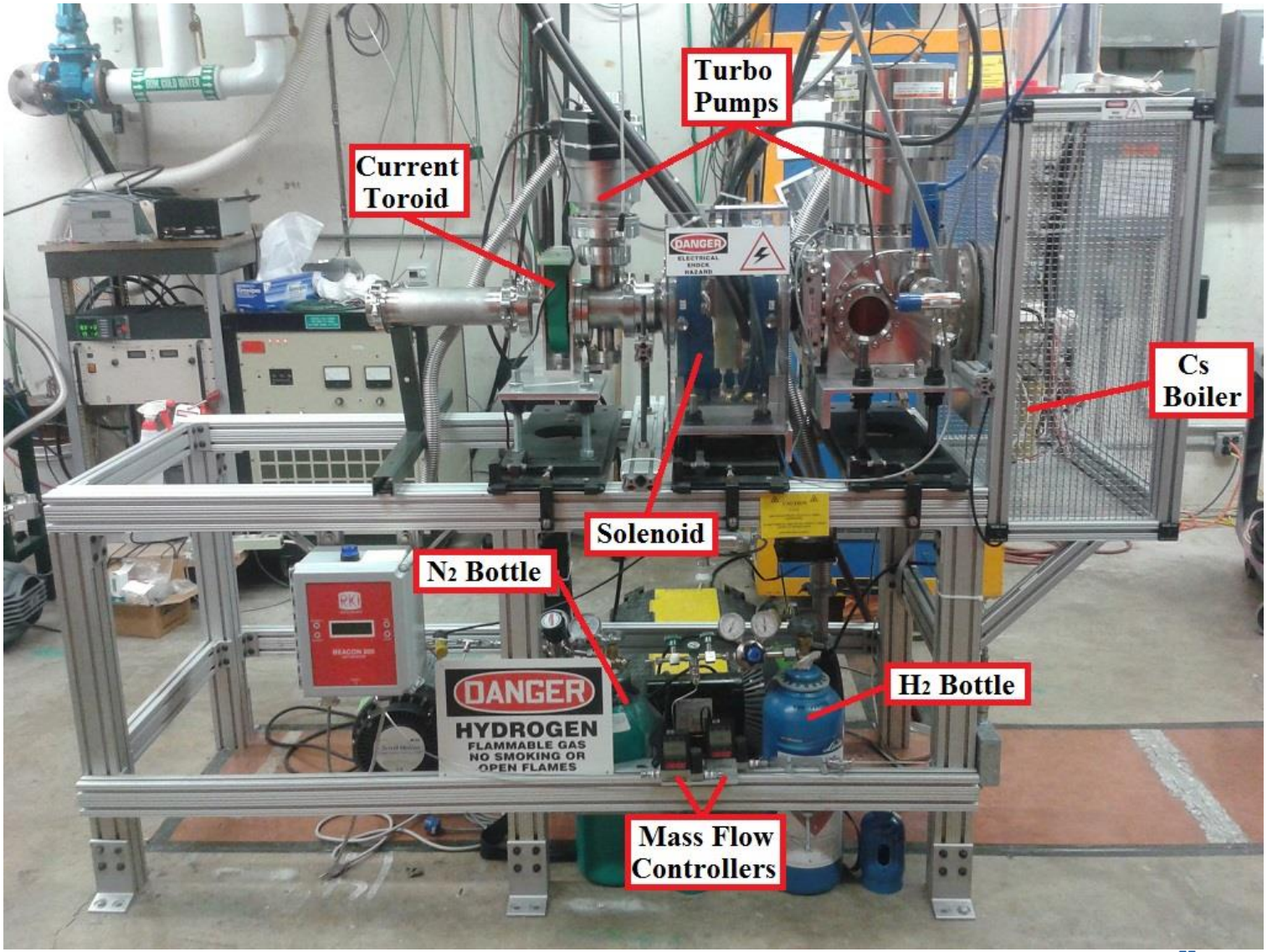
Electron Microscope Studies

- Aim: Analysis of black residue in source B components (9 month run)
- Silicon, Oxygen and Molybdenum identified
- Cathode material is Mo
- Insulators are Macor -> Silica SiO_2



Fermilab

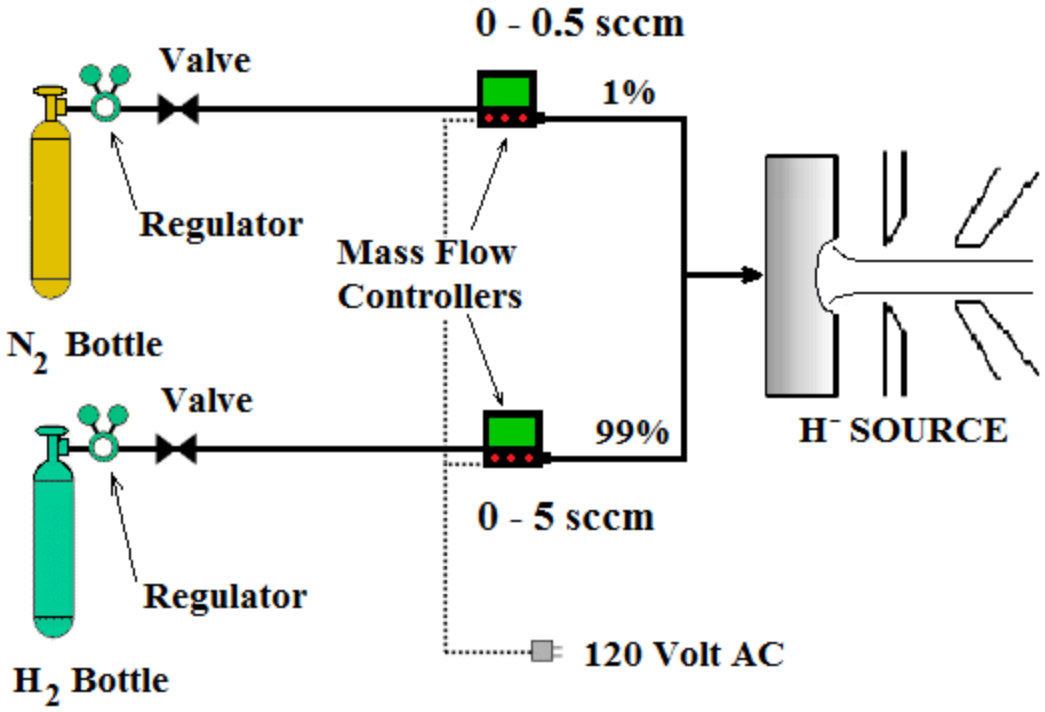
Test Stand



Fermilab

Gas Mixing Experiment

- Aim: Study effect on beam current noise
- Active mixing: gas mixture can be dynamically adjusted
- Mass Flow Controllers make use of pressure drop in a laminar flow (10 - 15 psi)

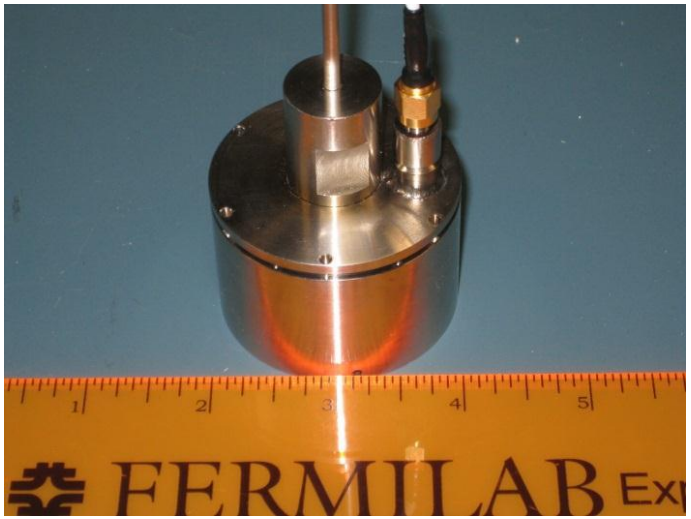


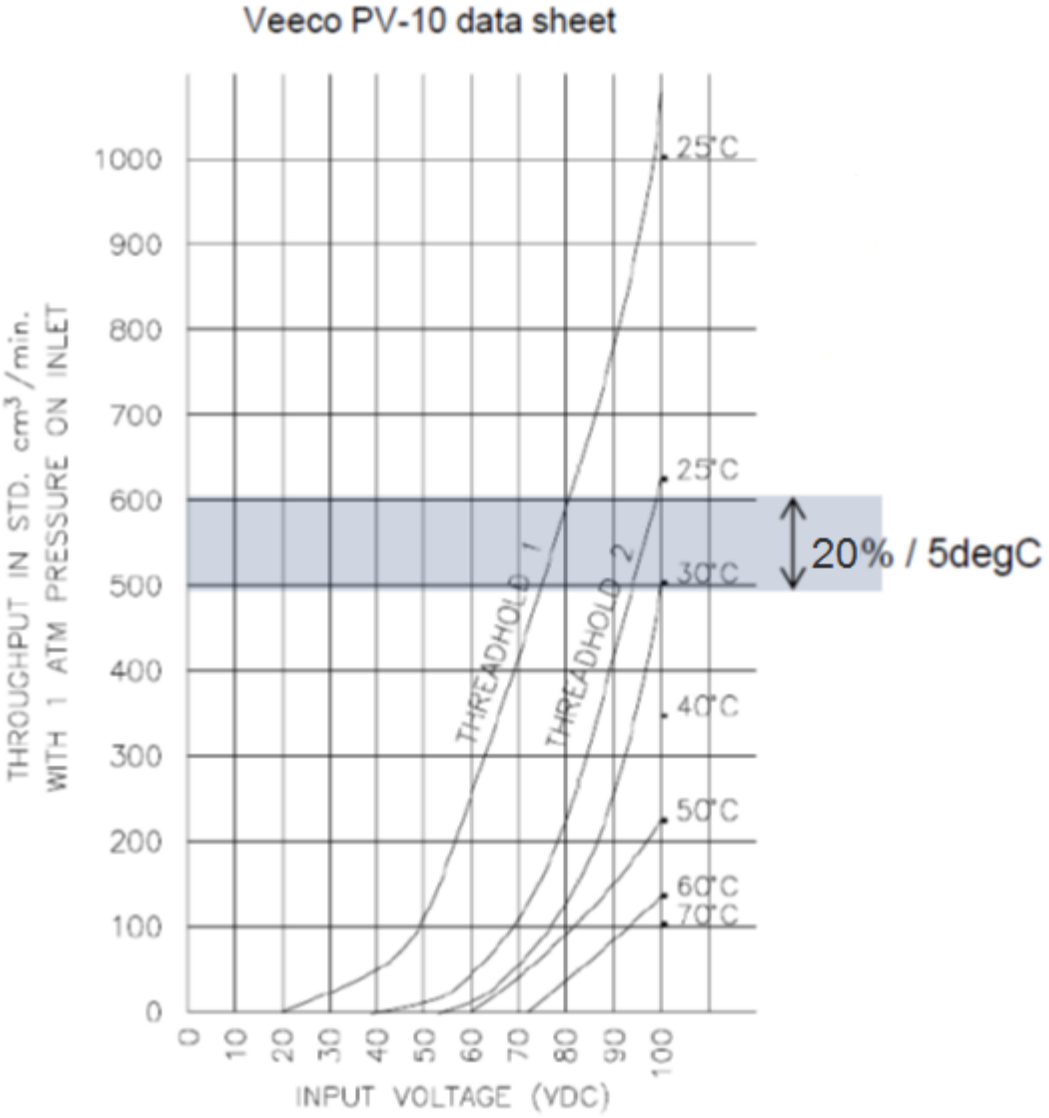
Chaco, E., Moehs, D., & Schmidt, C. W. The Effects of Nitrogen Gas on the Production of Negative Hydrogen Ions. *Fermilab SIST Program*.

Fermilab

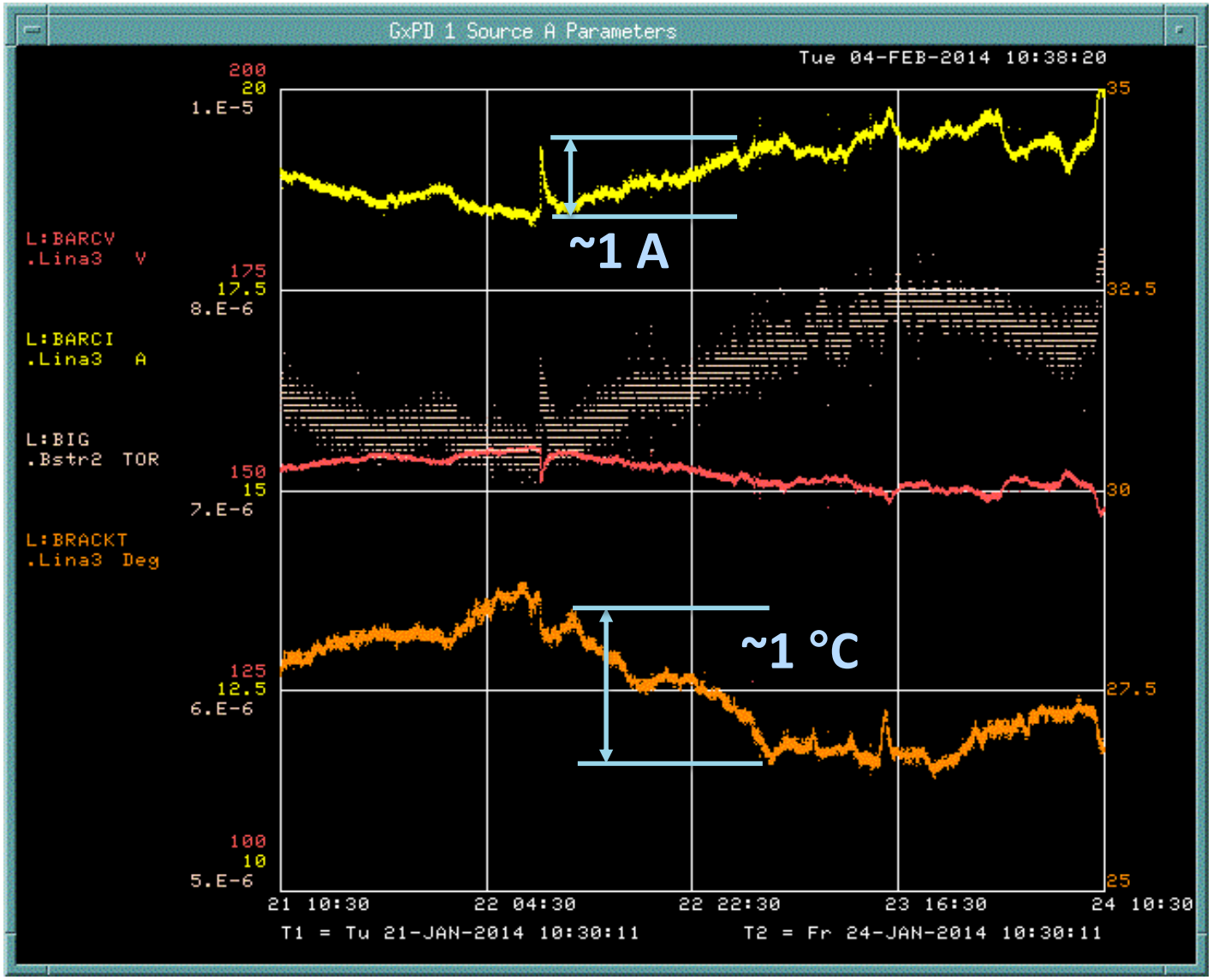
Problems with Piezoelectric Valves

- Veeco PV-10 piezoelectric valves
- Very sensitive to temperature changes
- Affects the arc current and vacuum pressure





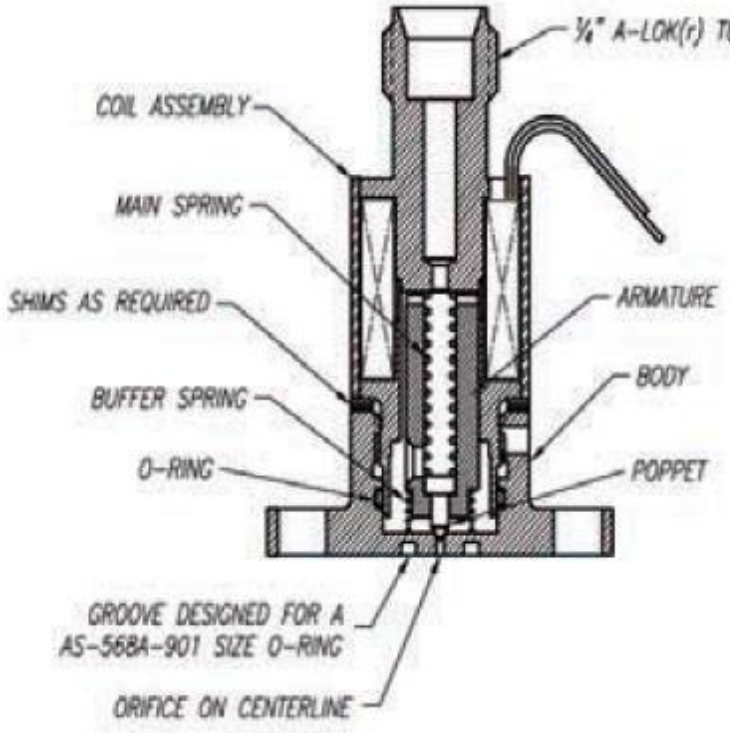
Problems with Piezoelectric Valves



Fermilab

Solenoid Gas Valve

- Aim: Study feasibility of using these valves to tune the source
- Less sensitive to temperature changes



Fermilab

Tungsten Dimple in Source Cathode

- Aim: Analyze the performance of the source running with a W dimpled inserted in the Mo cathode
- W provides a broader H^- production peak than Mo
- If source runs successfully: Production of a full W cathode

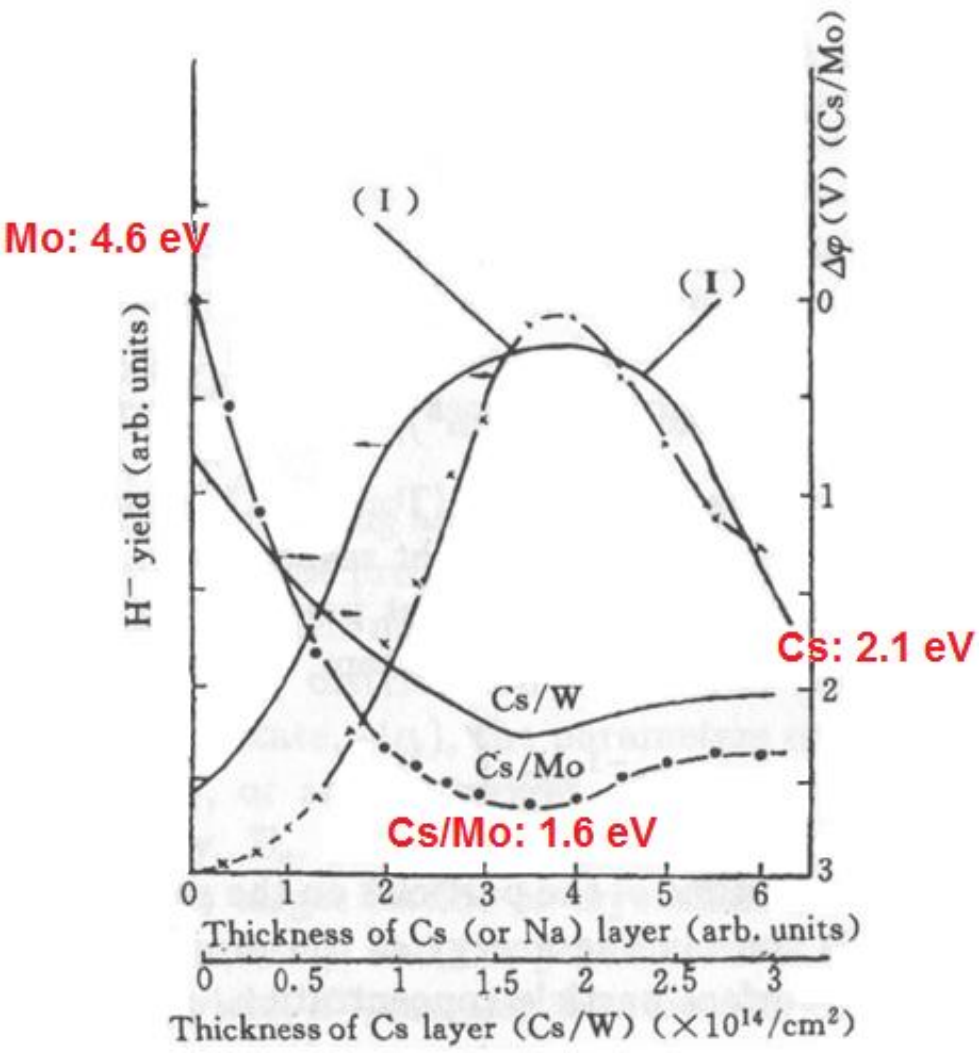


Figure from ZHANG Ion Sources

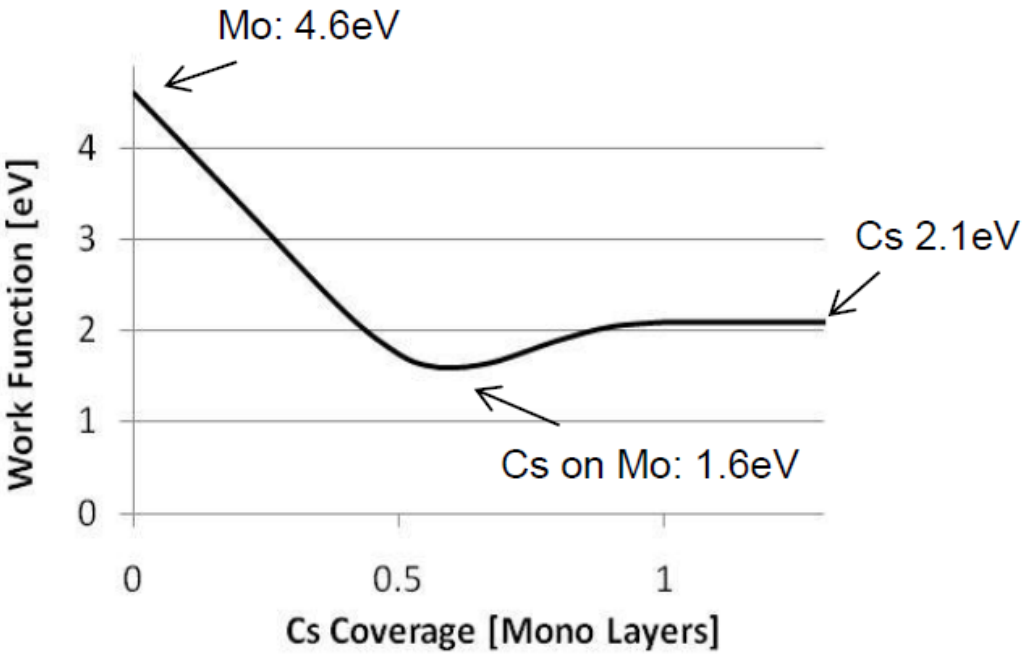
Tungsten Dimple in Source Cathode

Fermilab

Cs delivery system

If Cs layer is too thick/thin:

- Work function increases
- Decreased H- production
- Increased number of free electrons

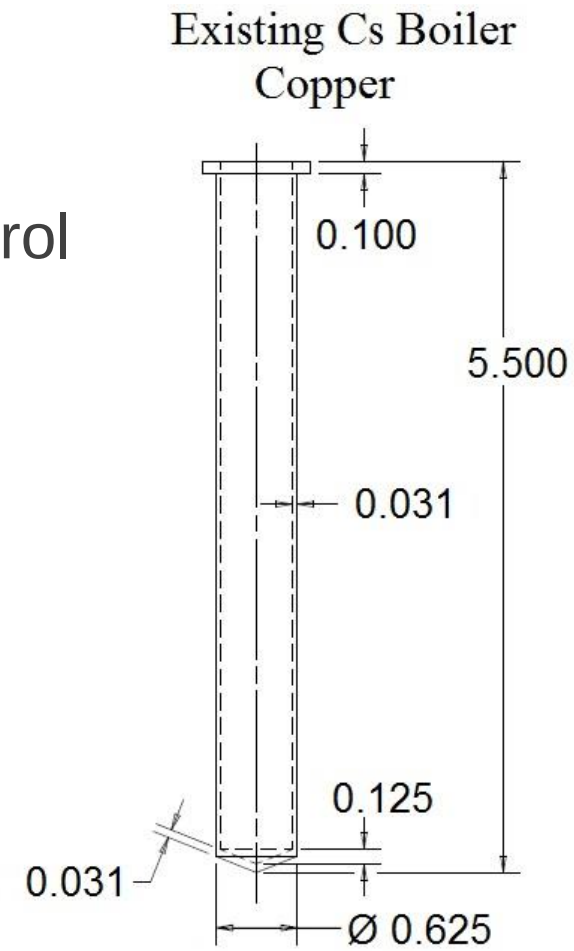


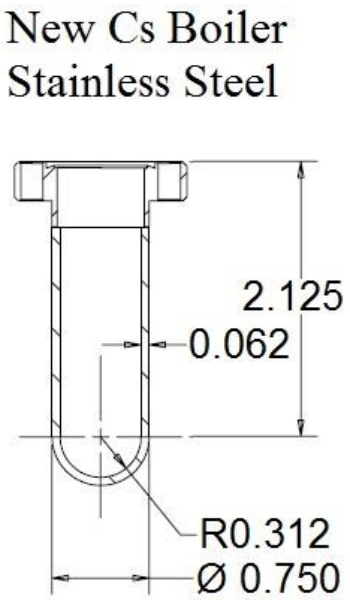
Cs delivery system

- We currently use 5 g Cs glass ampoules
- Cs is often trapped in the glass shards

Cs delivery system

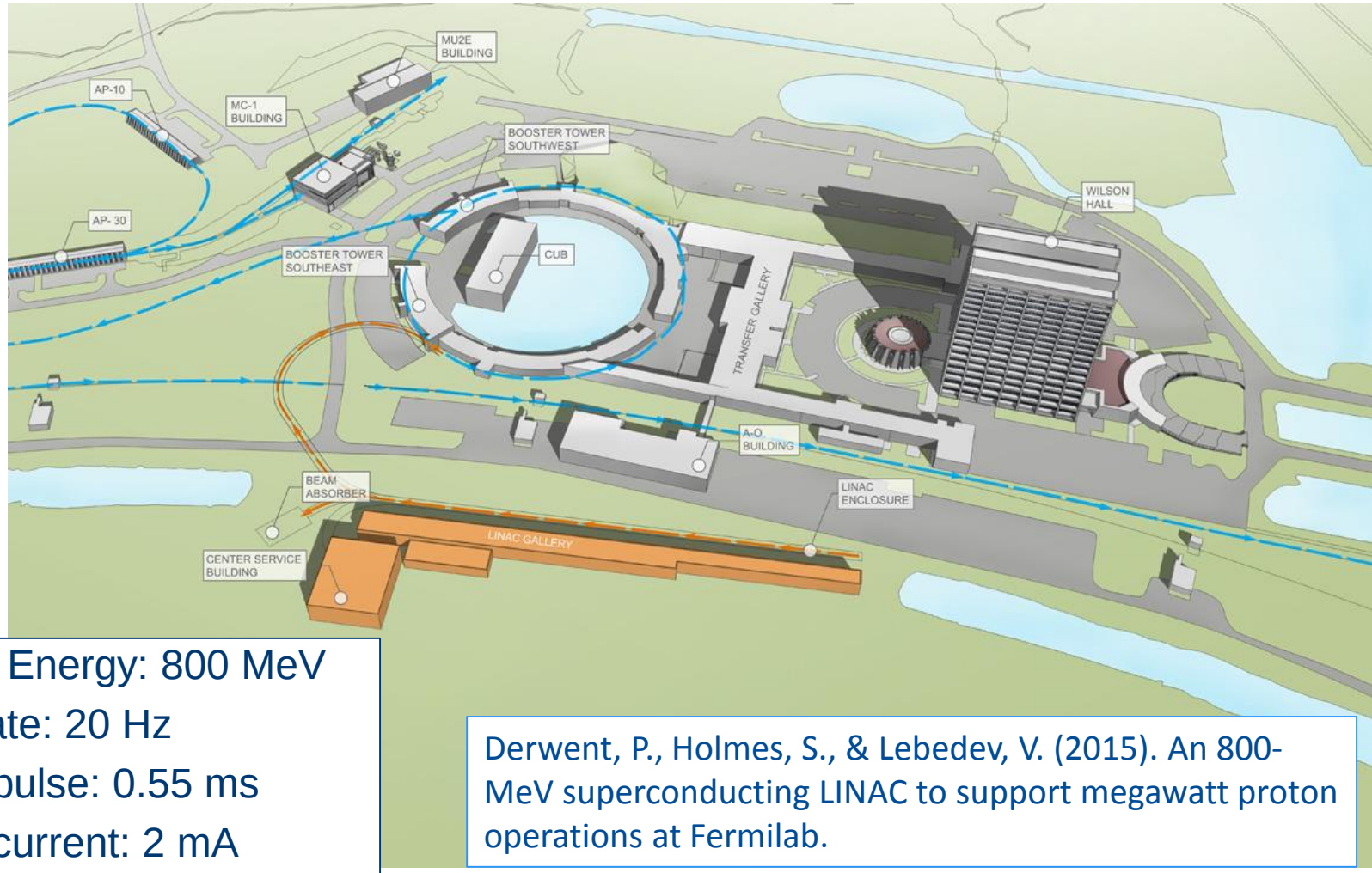
- Better temperature control
- No-ampoule boiler





Fermilab

A look into the future: PIP-II Linac



- Output Energy: 800 MeV
- Rep. rate: 20 Hz
- Beam pulse: 0.55 ms
- Beam current: 2 mA
- Able to run CW

Derwent, P., Holmes, S., & Lebedev, V. (2015). An 800-MeV superconducting LINAC to support megawatt proton operations at Fermilab.

Fermilab

Conclusions

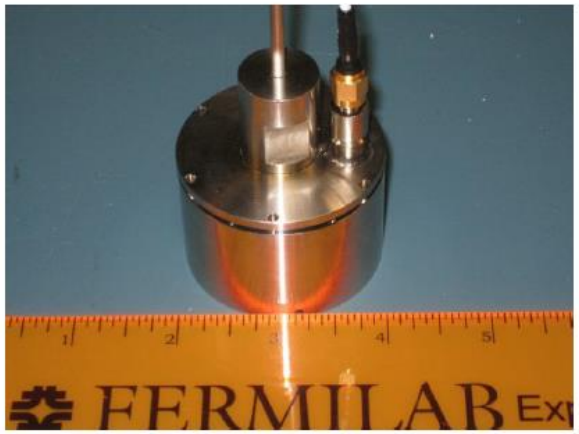
- 9 month run is a big achievement
- Continue improving the sources (stability/reliability/performance)
- Test stand up and running

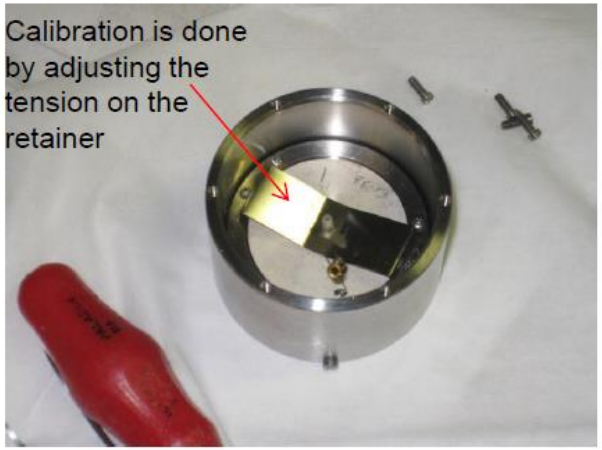
Thank you!

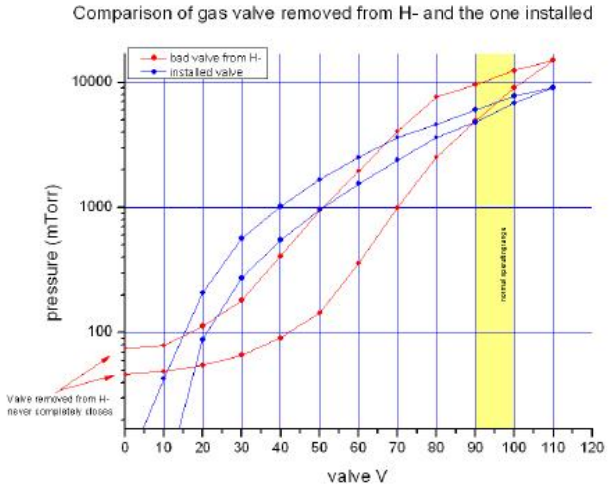
Backup Slides

Piezoelectric Valves

The current gas valves are Veco PV-10 piezoelectric valves. They are fast and reliable for the most part and have been in use since day one.







End up with a hysteresis curve like these. The valves start to open around 20V and are fully open by 100V