Electron Source Update

A. Brachmann, J. Sheppard, F. Zhou
-SLAC –

M. Poelker
- Jlab -

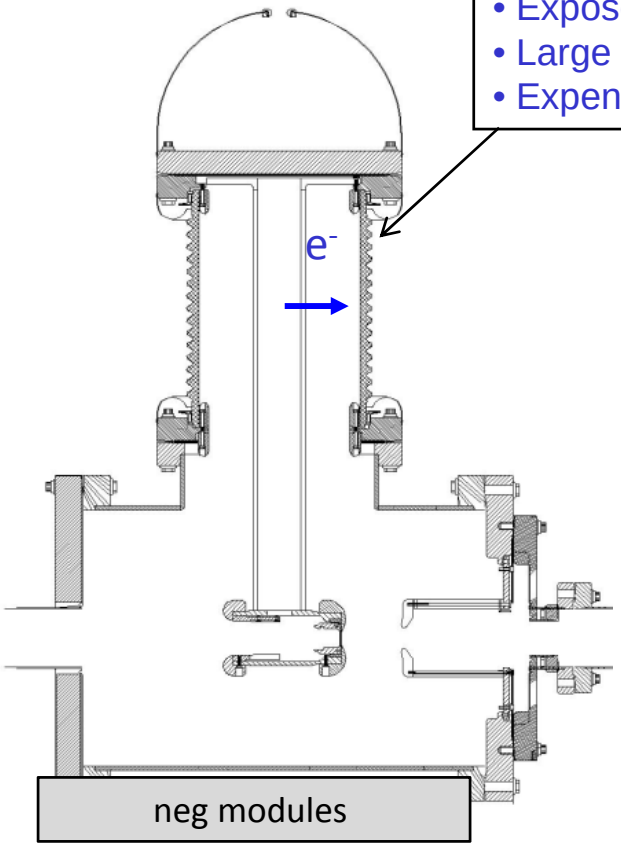
TILC, Tsukuba, April 2009

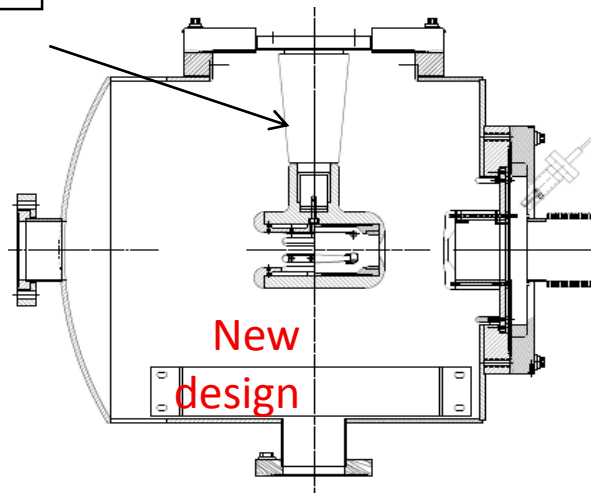
DC Gun Development at Jlab

Present Ceramic
- Exposed to field emission
- Large area
- Expensive (~$50k)

Medical x-ray technology

New Ceramic
- Compact
- ~$5k



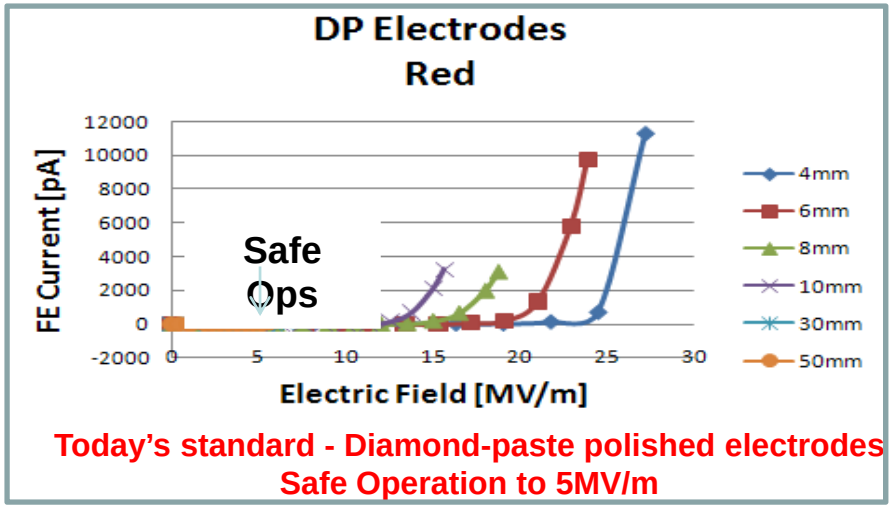


HV chamber ordered, electrode drawings to shop, should have gun under vacuum and attached to Test Cave beamline by May….

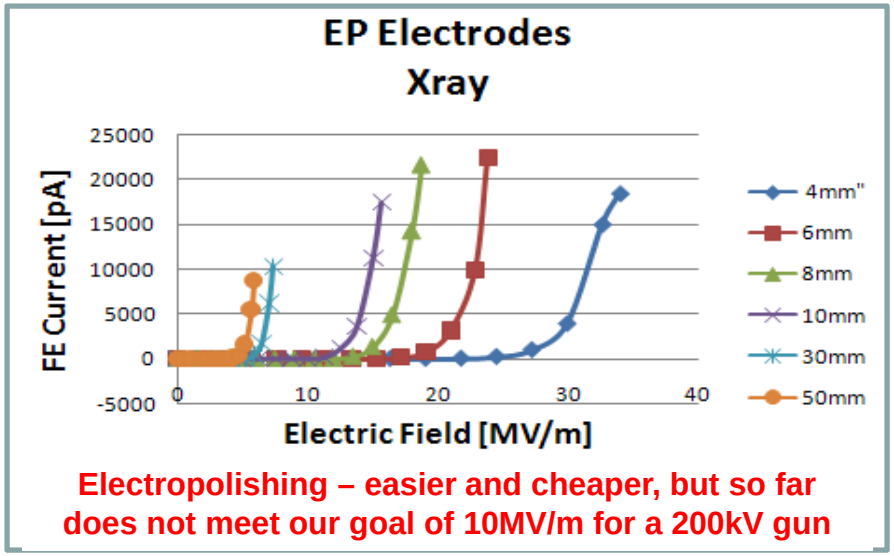
Field Emission Test Stand

- Flat electrodes and small gaps not very useful
- Want to keep gun dimensions about the same – suggests 200kV gun needs quiet electrodes to 10MV/m

Work of Ken Surles-Law, Jefferson Lab



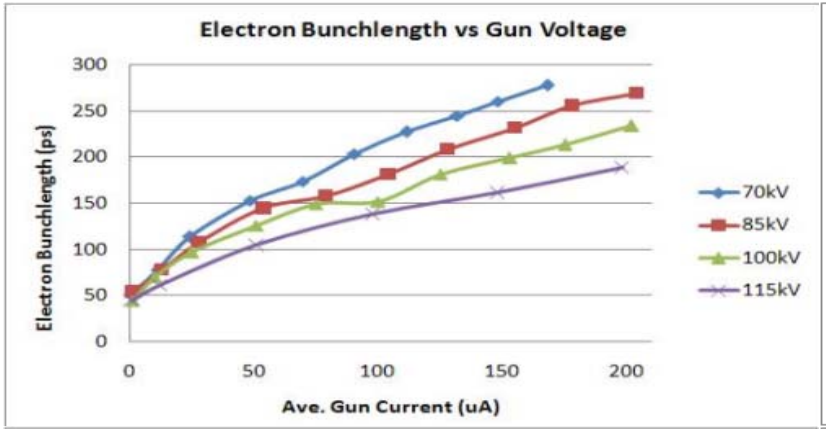
Today's standard - Diamond-paste polished electrodes
Safe Operation to 5MV/m

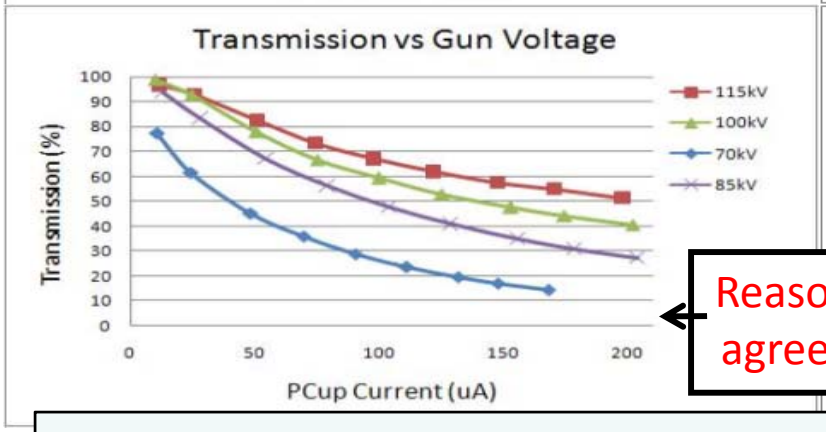


Electropolishing – easier and cheaper, but so far does not meet our goal of 10MV/m for a 200kV gun

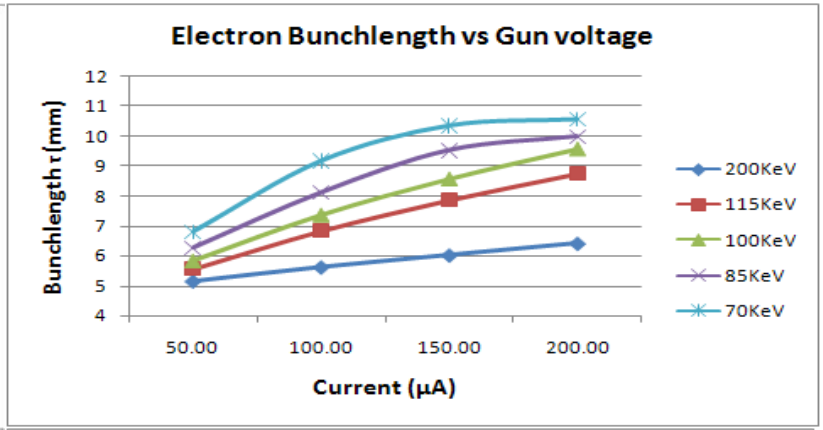
Benchmarking PARMELA Simulation Results Against Beam-Based Measurements at CEBAF/Jefferson Lab –

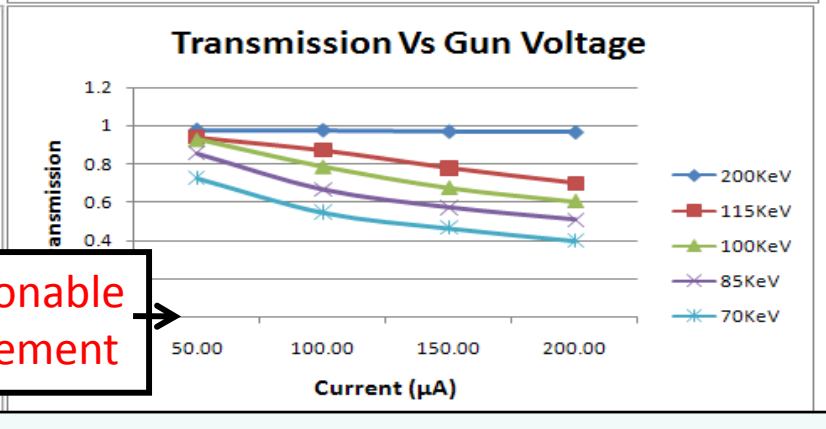
Measurements at CEBAF/JLab





PARMELA Simulation Results





Reasonable agreement

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

work of Ashwini Jayaprakash, JLab

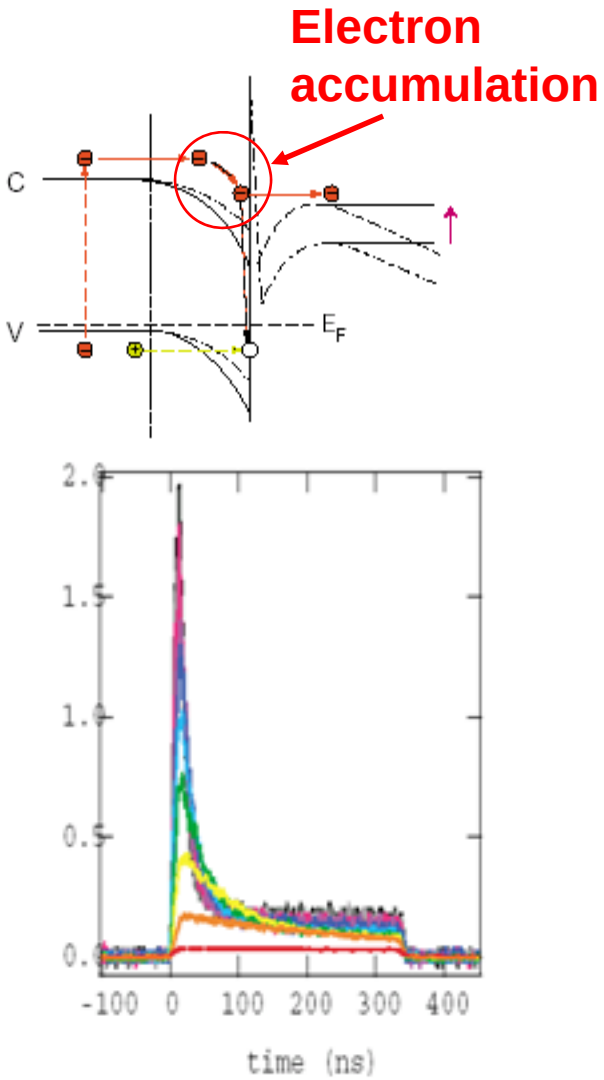
Current Cathode R&D at SLAC:

Currently using SLC source:

1. Measurements of ion back-bombardment effects on QE decay are being taken and analyzed:
   - vs average beam current
   - vs laser size on cathode
   - vs laser wavelength
   - CW vs pulsed beam
2. To apply new activation technique (Cs+Li) into GTF:
   - Expected to improve QE lifetime
3. Study gradient doping in cathode structure and gradient doping in the active layer:
   - Expected to improve both QE and polarization

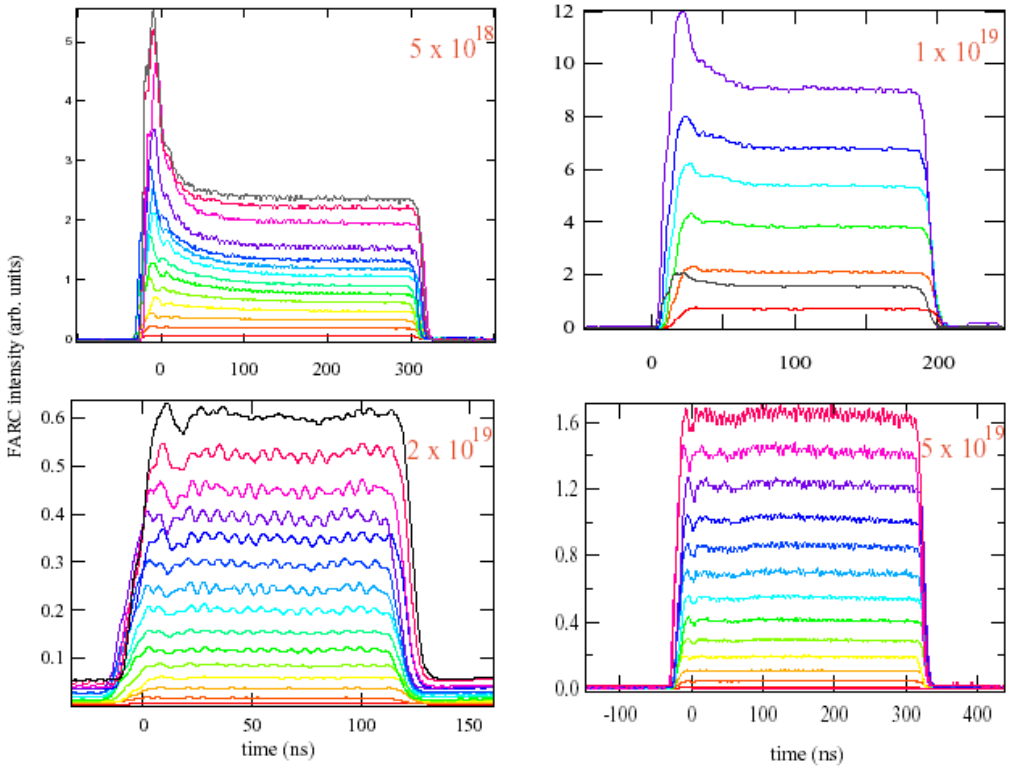
Most critical issue: Surface charge limit

- Photon absorption excites electrons to conduction band
- Electrons can be trapped near the surface; electron escape prob. < 20%
- Electrostatic potential from trapped electrons raises affinity
- Affinity recovers after electron recombination
- Increasing photon flux counterproductive at extremes



Adjustment of doping level mitigates SCL

Solution: adjustment of doping level
Caveat: negative effect on Polarization

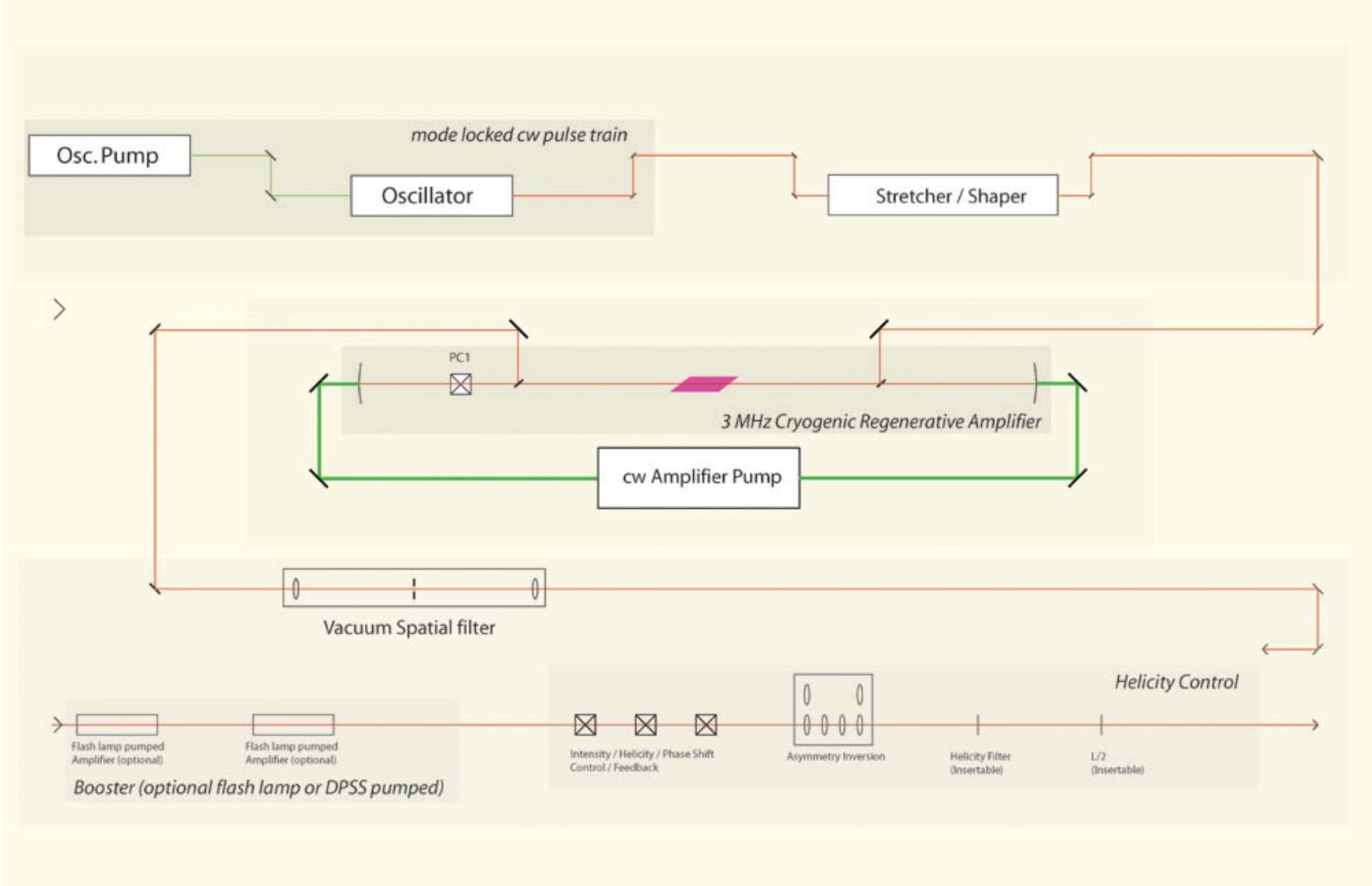


Four samples with different doping levels:

- 5×10^{18} cm^{-3}
- 1×10^{19} cm^{-3}
- 2×10^{19} cm^{-3}
- 5×10^{19} cm^{-3}

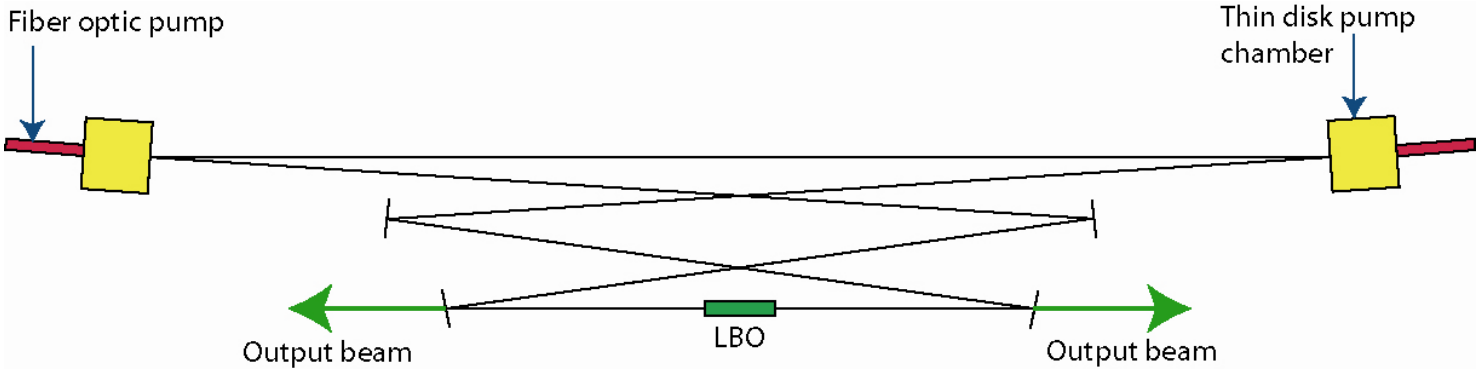
Demonstration for ILC conditions needed (need laser system)

Laser system overview

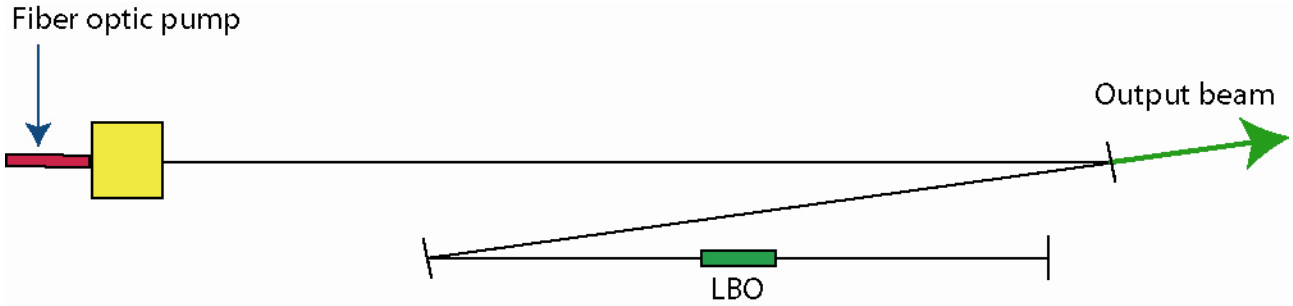


Re-design & engineering of pump laser for amplifier

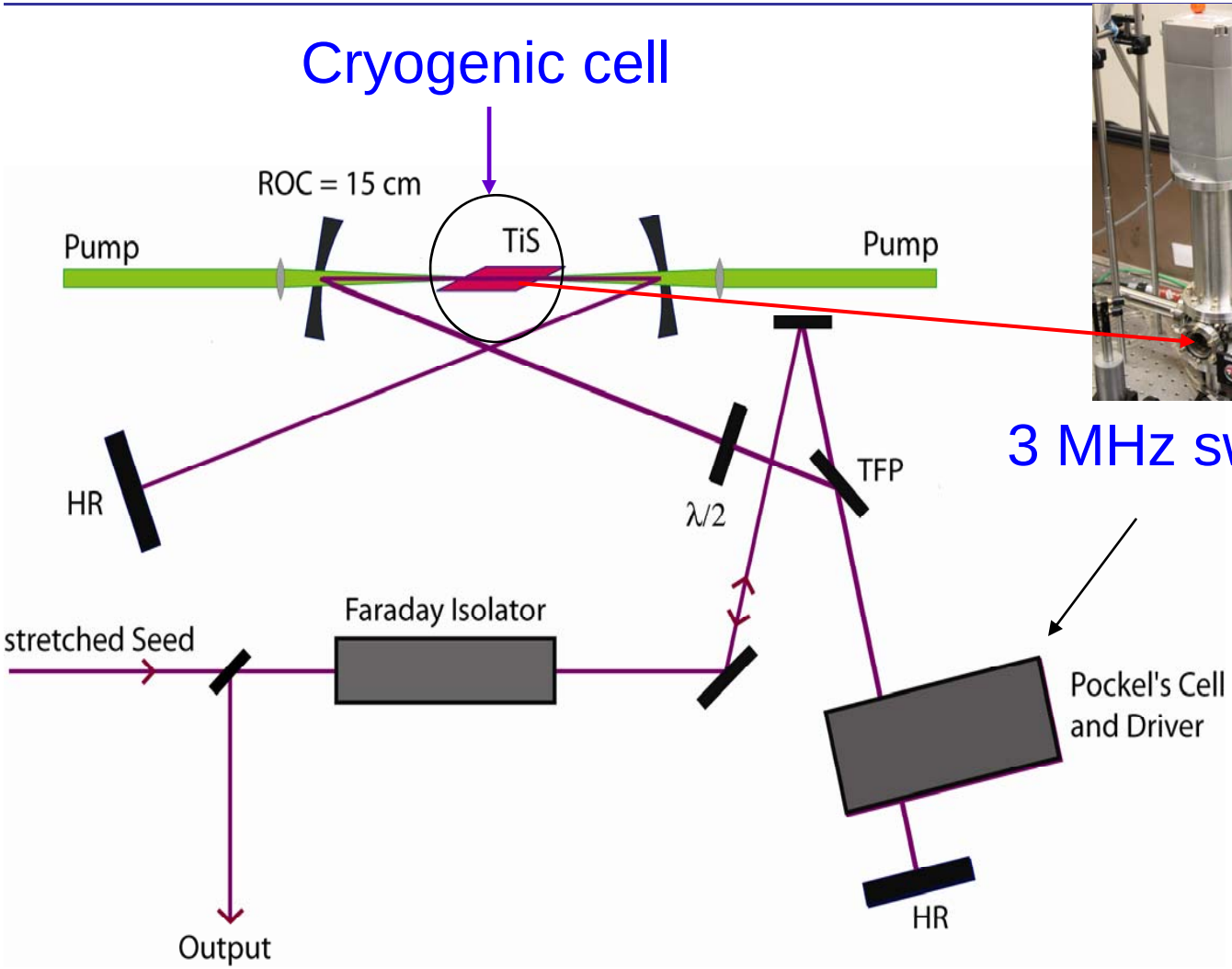
Current design: Ring cavity



Construct two single arm cavities:
Simplification of optical system
→ reduced losses, improved performance



Close-up of Regenerative Amplifier



Source laser development

- Work on Amplifier Pump laser
  - **Measurements of cavity performance (very lengthy process, ongoing since Chicago meeting)**
- Most likely outcome:
  - **1) Needs at least re-engineering and replacement of critical components**
  - **2) total replacement of pump laser maybe required**
  - **If M&S is considered only, option 2) is the more costly alternative (k$ 250) but maybe desirable to meet current milestones**
- Emerging plans to work on CLIC source laser system using SLAC's equipment
  - **Minor modification of existing laser system at SLAC**
  - **Informal agreement with L. Rinolfi**

Milestones

- Gun Development
  - **2009 - Reliable 200kV load locked gun**
  - **2010 - Progress towards ~ 350kV design**
  - **2011 - Reliable ~ 350kV load locked gun…**
- Laser Development
  - **Positive outcome of pump laser re-build:**
    - 2009 – working pump laser for amplifier
    - 2010 – complete source laser system
  - **If new pump laser is needed, program will be delayed by ~ 6 months**
    - Purchase of replacement laser will not be possible in FY09
- Photocathode R&D
  - **Investigation of surface charge limit depends on laser system**

  → earliest possible date is end of 2010

Summary

- DC-Gun development at Jlab with CEBAF synergy
  - **'Joint' project with ILC to develop a higher voltage DC gun**
  - **Inverted gun**
  - **Development of materials and techniques to supress field emission**
- Laser development
  - **Progress, but slowed by amplifier pump laser problems**
- Photocathode R&D
  - **Studies of surface charge limit QE and polarization optimization are ongoing**
  - **Needs laser system to demonstrate performance of ILC beam**