

Hall A 12 GeV Compton Polarimeter

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SoLID Collaboration Meeting
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Hall A “12 GeV” Upgrades

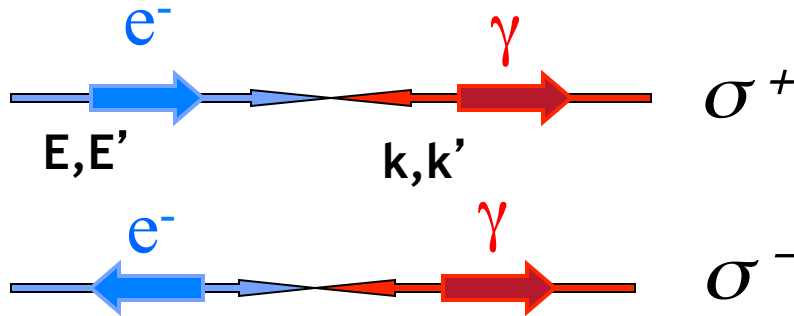
Upgrade beam-line instrumentation to measure beam polarization and energy up to 11 GeV

System	Present “6 GeV” Capability	11 GeV Requirements
Møller Polarimeter	$\pm 3\%^1$	$\pm 3\%$
Compton Polarimeter	$\pm 3\%^1$	$\pm 3\%$
ARC Energy Measurement System	$\pm 2 \times 10^{-4}$	$\pm 5 \times 10^{-4}$

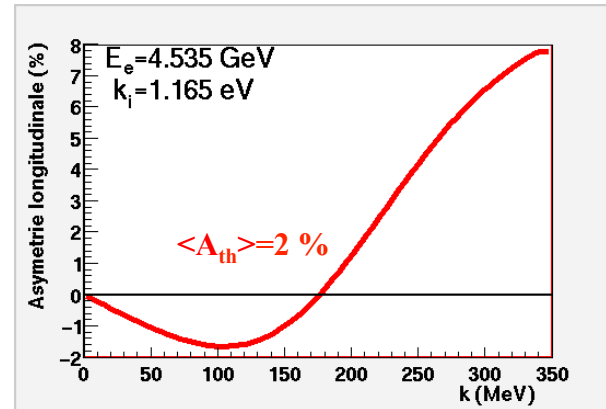
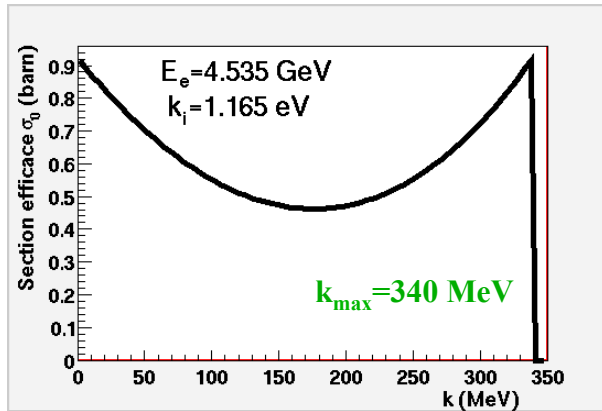
¹With ongoing improvements of 6 GeV capability, driven by the parity program, expect to achieve $\pm 1\%$



Compton Polarimetry



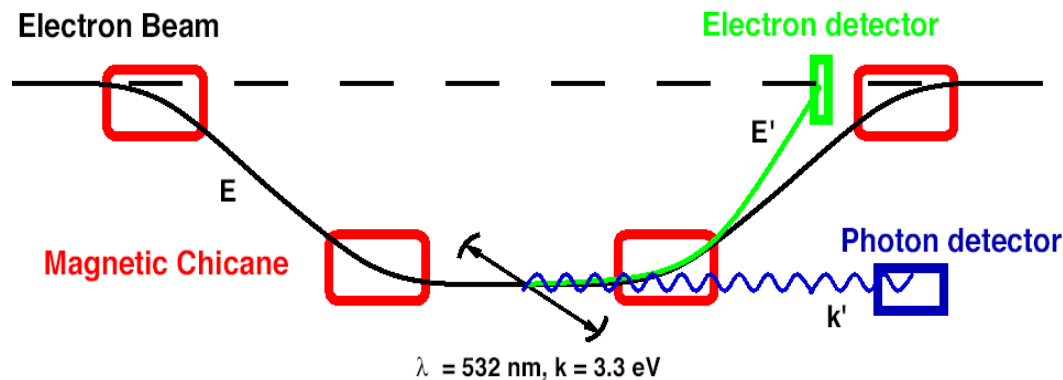
$$A_{\text{exp}} = \frac{n^+ - n^-}{n^+ + n^-} = P_\gamma \times P_e \times \langle A_{th} \rangle$$



- Non-Intrusive measurement
- Accuracy improves with higher beam and photon energies
 - Figure-of-Merit $\sim \sigma \times A^2 \sim k^2 \times E^2$

Hall A Compton Polarimeter

Provide precise electron beam polarimetry from 1 to 11 GeV.
Hall A Parity violating experiments (PREX, MOLLER, SoLID...) are primary beneficiaries



Electron Detector

- High resolution silicon micro-strips
- Movable in dispersive plane for wide energy dynamic range

Photon Calorimeter

- Single crystal GSO detector
- Counting and integrating capabilities

High Power Green Fabry-Perot Cavity

Twice the Analyzing power of IR cavity

➔ Increased Figure-of-Merit

12 GeV Design

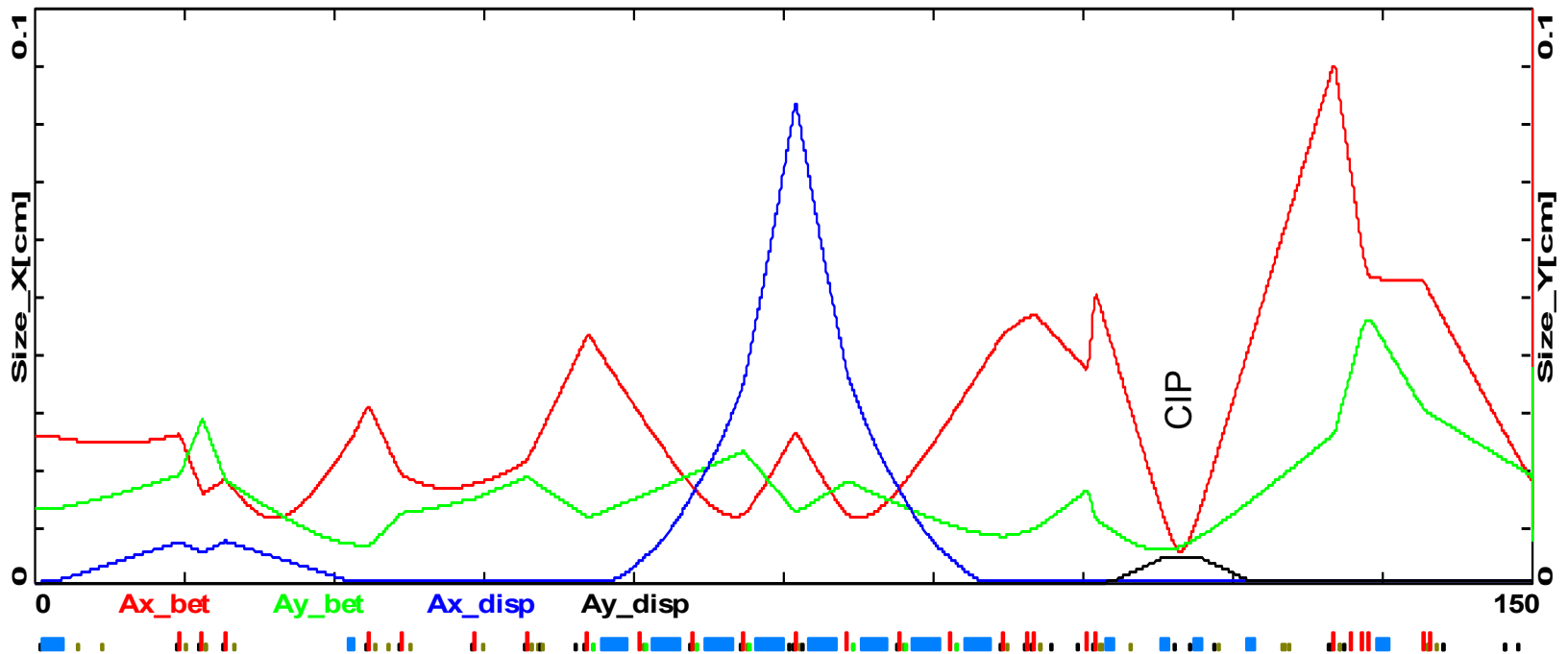
- **Present Magnetic Chicane**
 - Four dipole design with 300 mm displacement
 - 1.5Tm dipoles will go to 8 GeV
- **Design choices**
 - Keep present 300 mm geometry, and overall length
 - => Higher strength dipoles => \$\$\$
 - Reduce displacement to 218 mm
 - Keep present dipoles
 - New beamline geometry => \$\$

Decision to go with 218 mm chicane adopted in 2005



Hall A 12GeV Beamline Optics

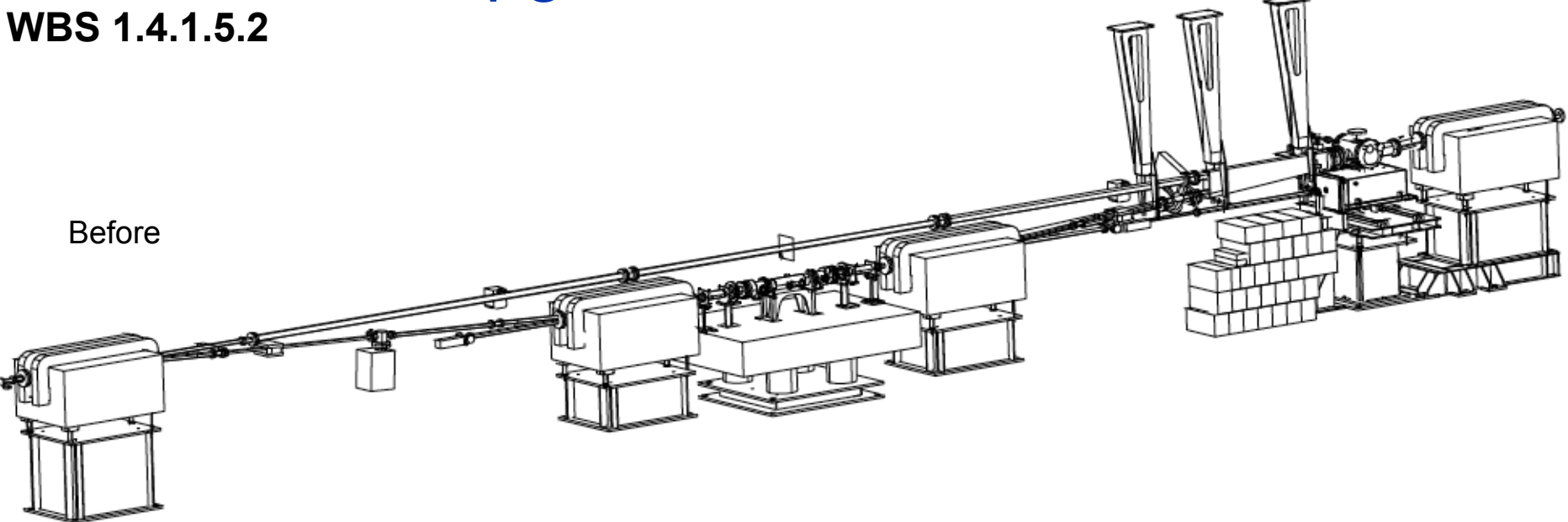
Thu Oct 01 13:25:04 2009 OptiM - MAIN: - O:\optim\jfbwork\myopt\New_baseline\hallA\halla_5_11gev_22cmComp



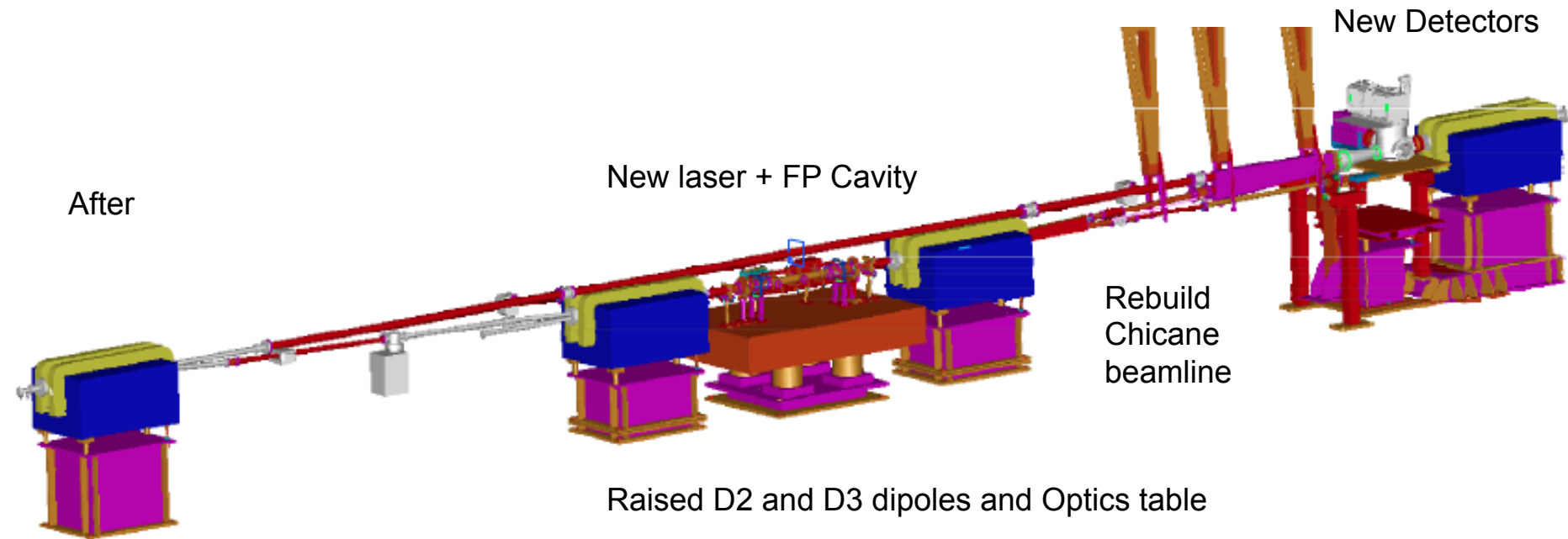
J. Benesch



Before



After



New laser + FP Cavity

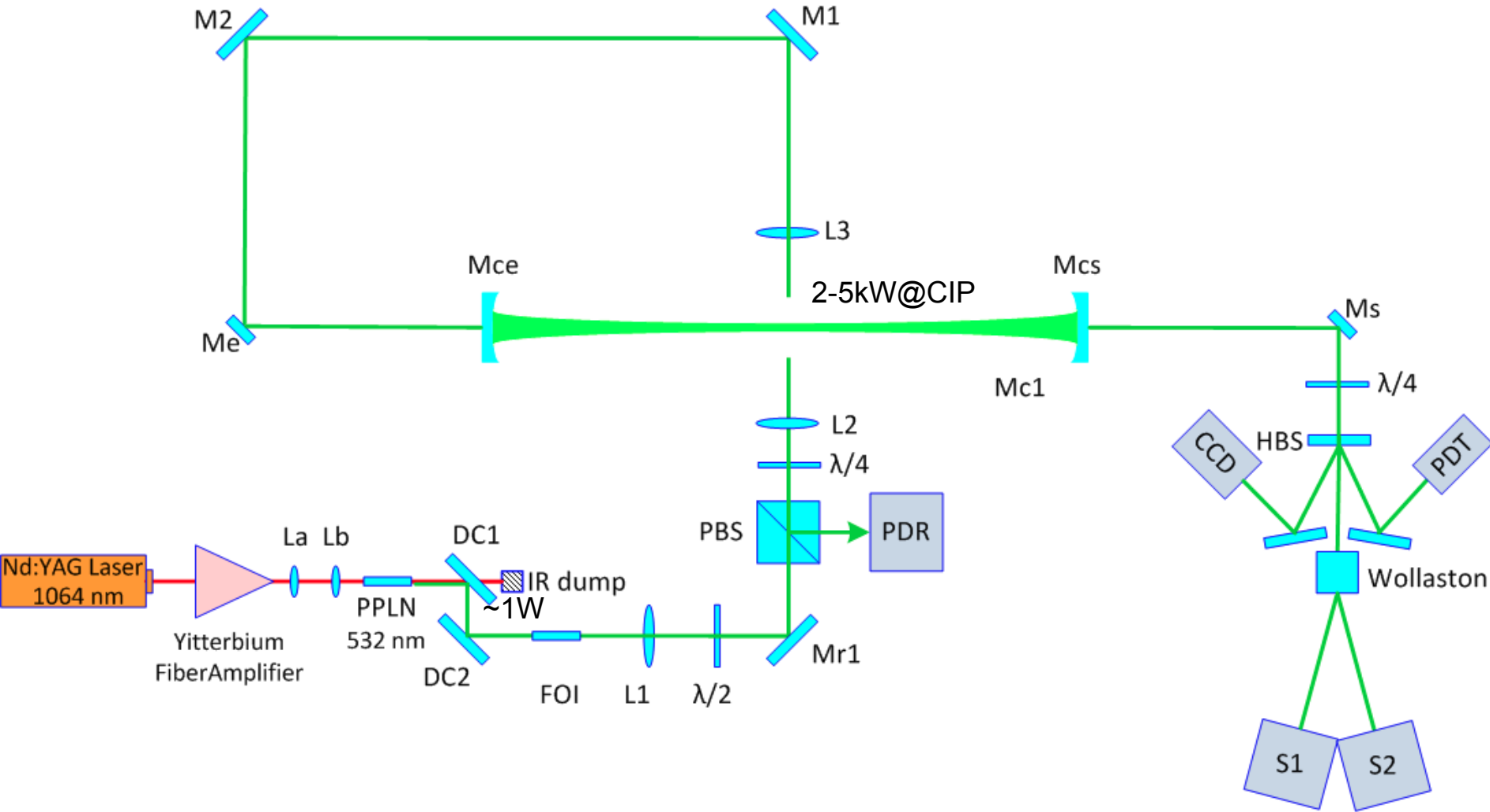
New Detectors

Rebuild Chicane beamline

Raised D2 and D3 dipoles and Optics table



Compton Optical setup



MS Visio Drawing by A. Rakhtman

Fabry-Perot Cavity

- **Design**

- Intra-cavity power 3 kW
- Wavelength 532 nm
- Mode CW/ TEM₀₀

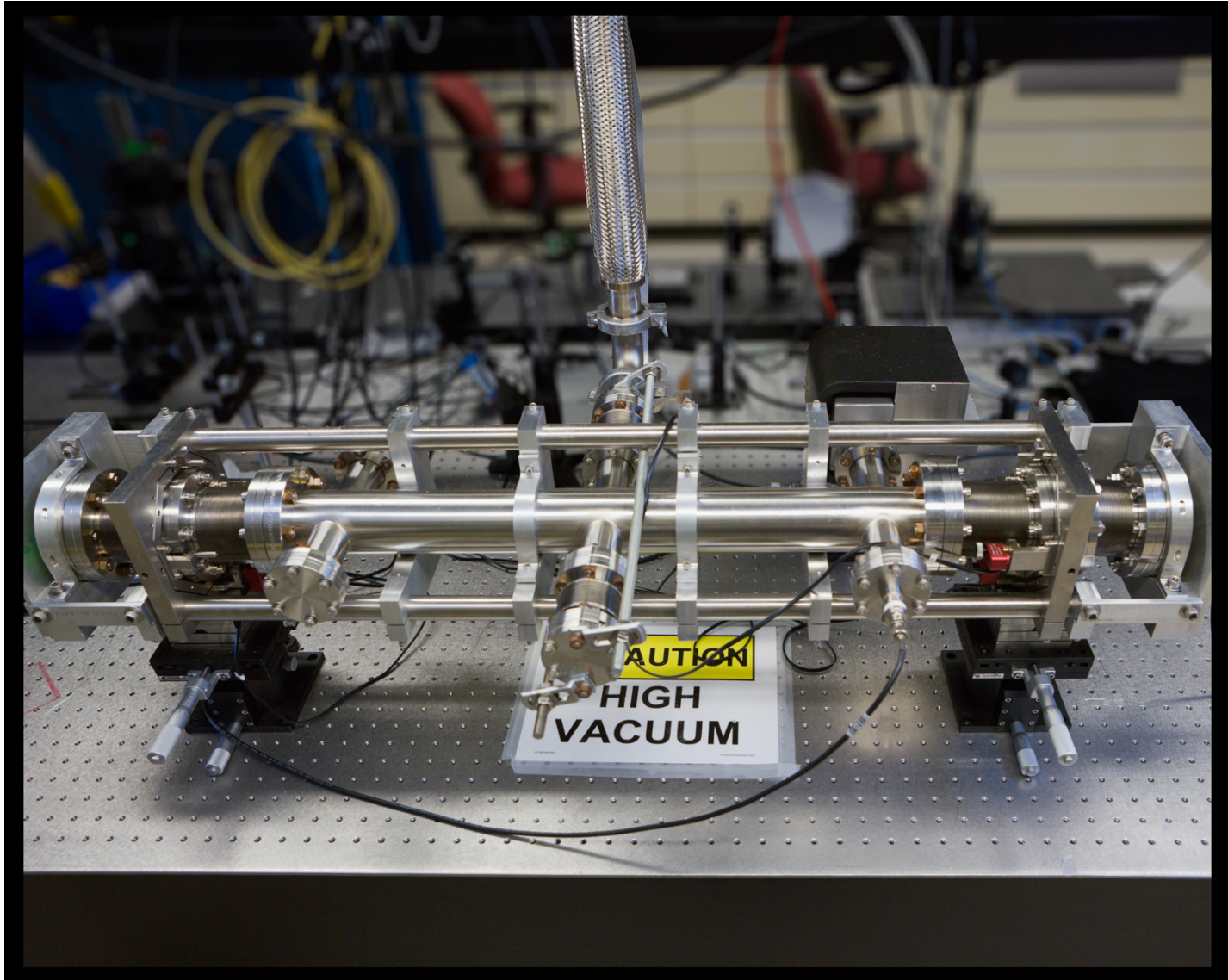
- **Solution**

- Nd:Yag seed laser + Ytterbium Fiber Amplifier + PPLN Second Harmonic Generator
 - > High Finesse FP Cavity
- Pound-Drever-Hall cavity lock electronics

- **Achievement**

- Successfully acquired lock at > 5 kW in test bench Oct-Nov '09
- Core technology on hand to build high gain FP cavities!

Cavity in ARC Compton Lab



Photograph: Alan Gavalya

Thomas Jefferson National Accelerator Facility

S. Nanda, January 28, 2011 10



Electron Detector

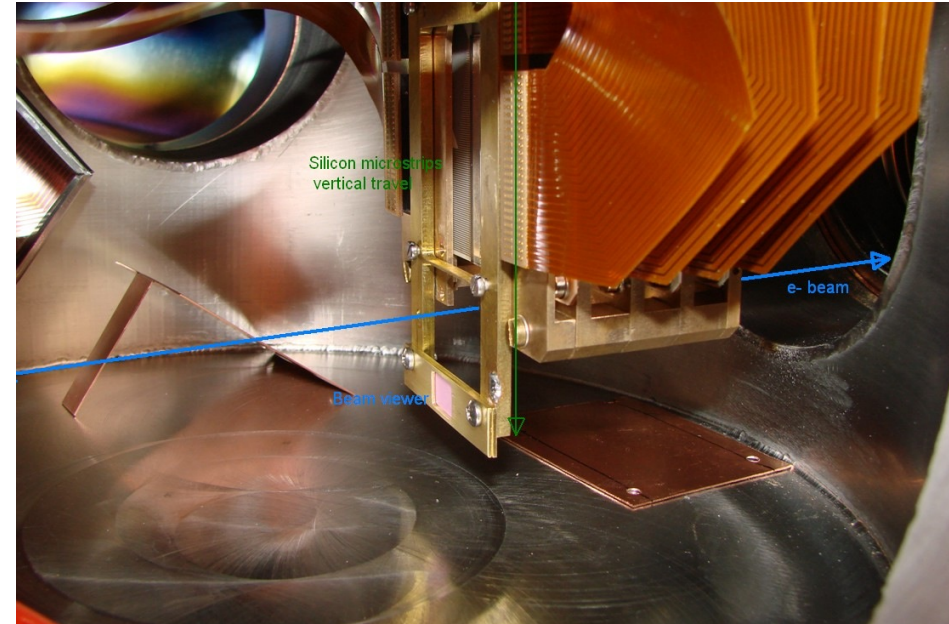
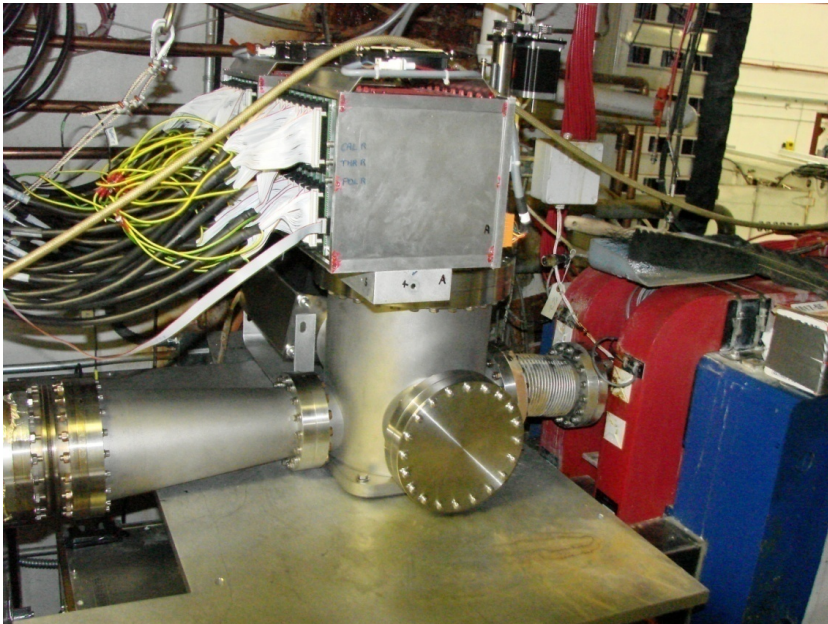
LPC Clermont-Ferrand

- **Goal**

- Stand-alone Asymmetry measurement with improved tracking resolution
- Provide absolute energy calibration for photon detector

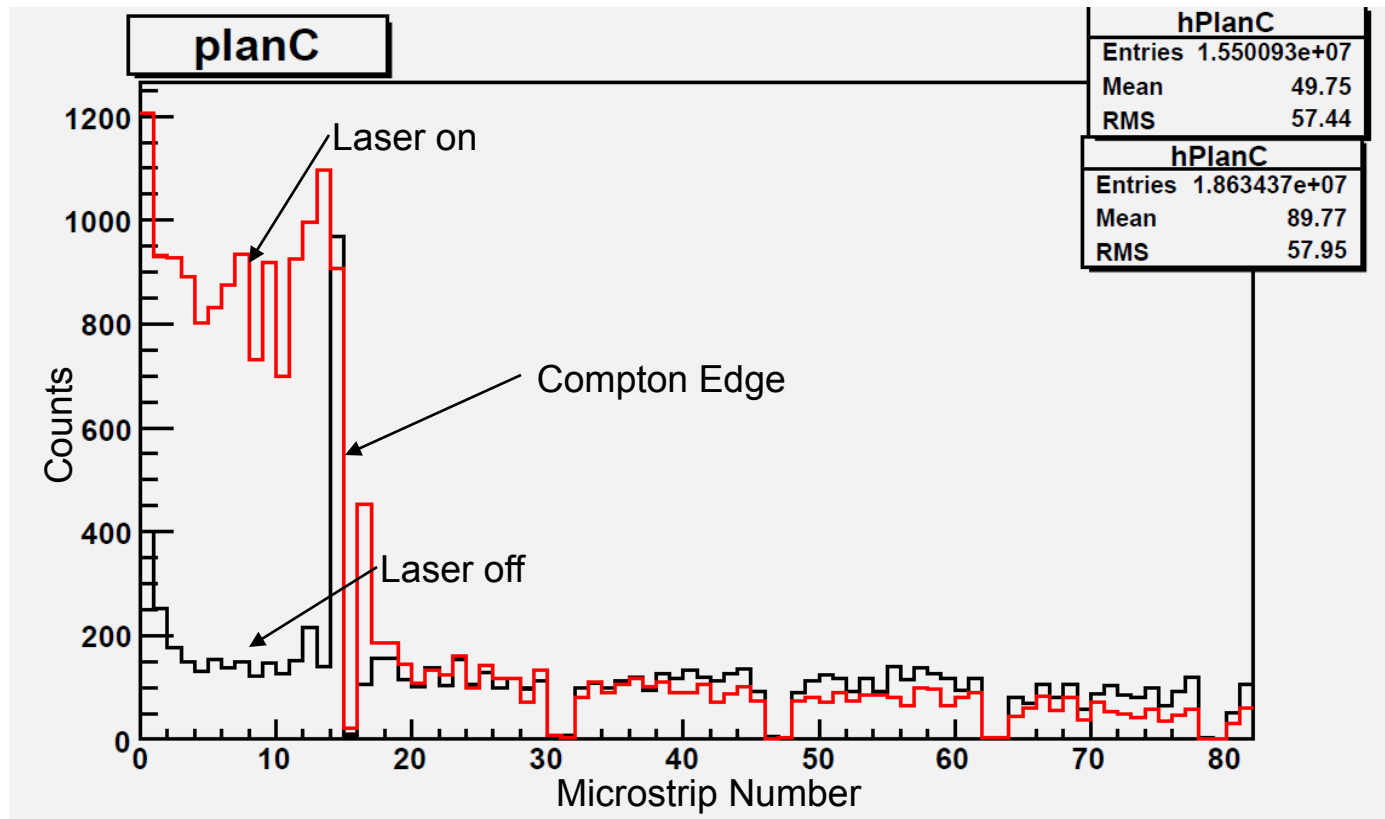
- **Scope**

- 768 ch 240 μm pitch silicon μstrips
- 4 Planes, 192 strips/plane, 1 cm spacing between planes
- 120 mm Vertical motion to allow coverage of Compton edge from 0.8-11 GeV



Compton Electron Spectrum

- **First Compton Scattered electron spectrum obtained in the new silicon microstrip e-detector in April 2009**
 - Singles spectrum with 3GeV electron beam
 - However, detector plagued with low efficiency
 - Being sent back to Clermont-Ferrand for troubleshooting

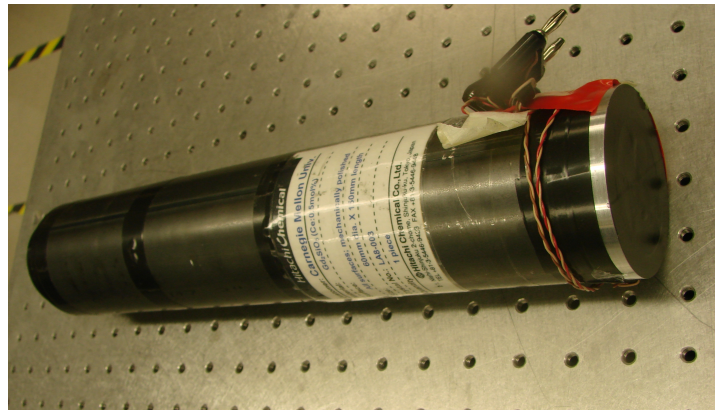


Photon Detector

Carnegie-Mellon University

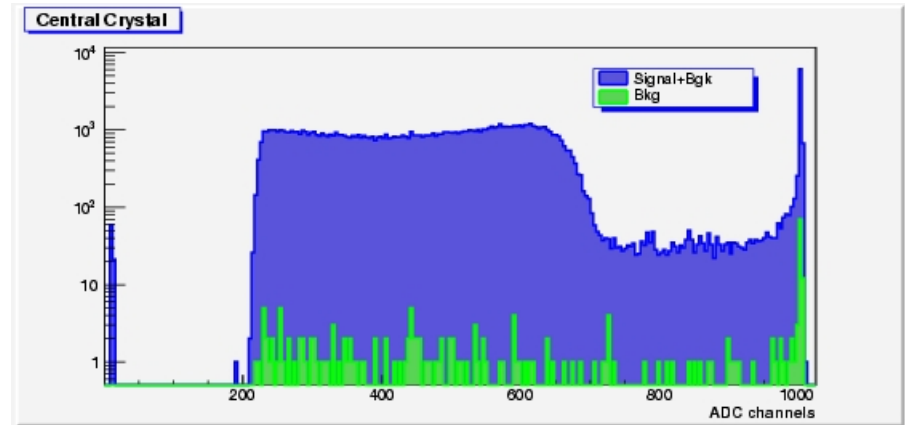
- Calorimeter

- Single crystal GSO, 6 ϕ x15 cm cylinder supplied by Hitachi Chemicals
 - High light output, fast decay time (less than 60 ns)
 - Triggered counting as well as continuous integration.
-
- Performance of the GSO calorimeter has been outstanding!

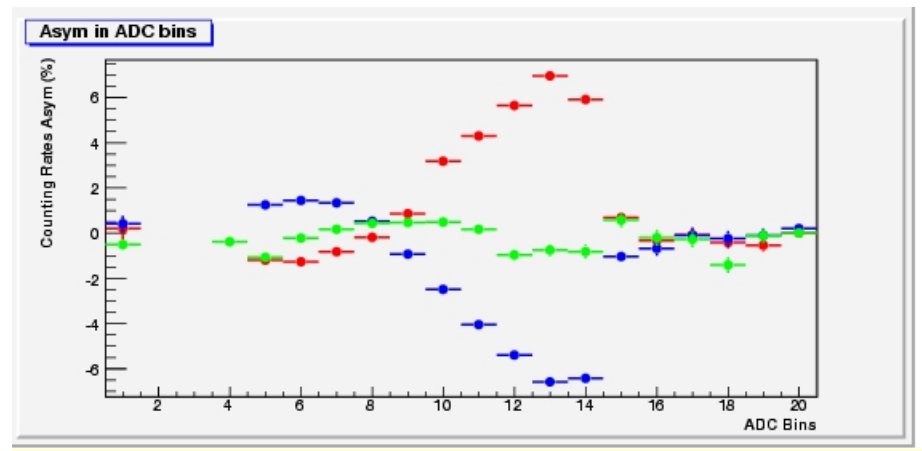


GSO Calorimeter Performance

- First photon Spectrum and Asymmetry with counting DAQ obtained October 2008



- $E_e = 5.9 \text{ GeV}$
- $E_\gamma = 0.2 - 0.8 \text{ GeV}$
- $P_{\text{cav}} = 450 \text{ W@1064 nm}$



Schedule

- **Design:**
 - Completed 2010
- **Fabrication:**
 - Begins Fall 2011
- **Installation:**
 - During 12MSD (May 2012 – Apr 2013)
- **Project completion:**
 - October 2013 deliver 3-pass >6 GeV beam to Hall A. Compton Polarimeter ready to take beam in the chicane with 3-pass ≥ 6 GeV beam, ≥ 2 nA



“12 GeV Compton” Issues

The 11 GeV beam will produce more background in the Compton detectors from increased beam halo as well as higher levels of synchrotron radiation

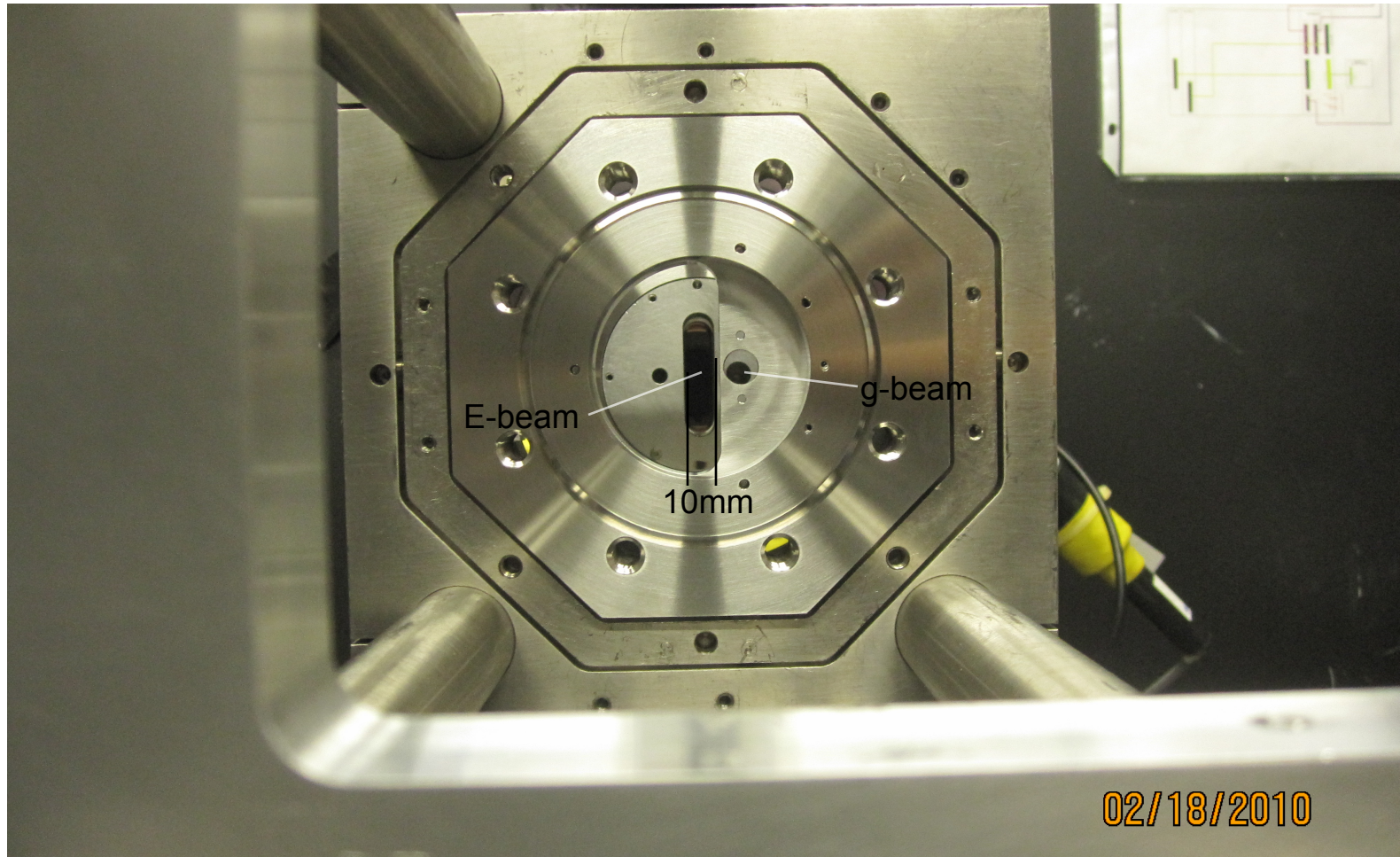
- **Simulation**

- Accurate simulation model to estimate and mitigate backgrounds is highly desirable. Volunteers?
- Synchrotron radiation shielding to be designed and implemented

- **Crossing angle**

- The present 24 mr crossing angle between electrons and photons results in an e-beam aperture that is tight at 10 mm
- “Unacceptable Compton tune” is often blamed on this tight aperture.
- Increasing crossing angle to 36 mr (20 mm aperture) should be investigated. The hit on polarimetry figure-of-merit is small.
- Requires major changes to cavity and optics –
- Beyond the present 12 GeV upgrade WBS scope.

Present FP Cavity aperture



Increasing the present 10mm horizontal aperture to 20mm is desirable!

More Issues...

- **Photon power**

- Higher photon power ($\sim 10\text{kW}$) will be necessary to maintain acceptable S/N.
- 5kW cavity power at 532nm has been demonstrated, more development is necessary to boost it further
- 10-20kW in the IR (1064nm) is easier to achieve than in green. At High beam energies, IR has plenty of figure-of-merit.
- Dual band optics to afford 1064/532 nm photons on demand desirable

- **High rate DAQ**

- With 10kW photon power, Compton counting rate with 100 uA beam is about 1MHz
- High speed detectors and DAQ are needed for counting method

Conclusion

- The 12 GeV upgrade of the Compton polarimeter builds on the success of the 6 GeV green upgrade.
- On track for 2013 Completion to provide 3% polarimetry

