

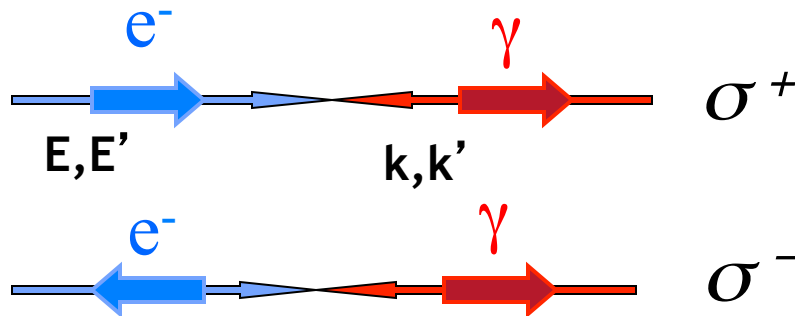
# Hall A Compton Polarimeter

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*Jefferson Laboratory*

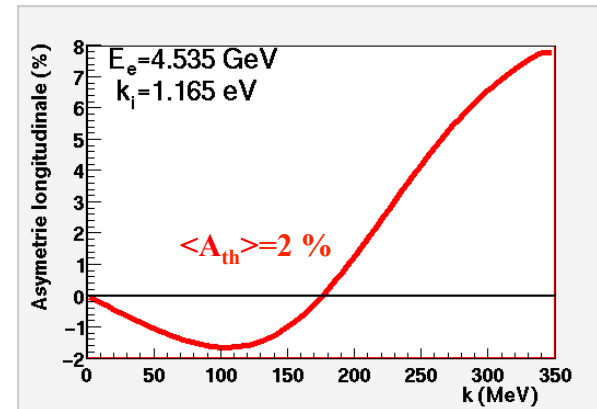
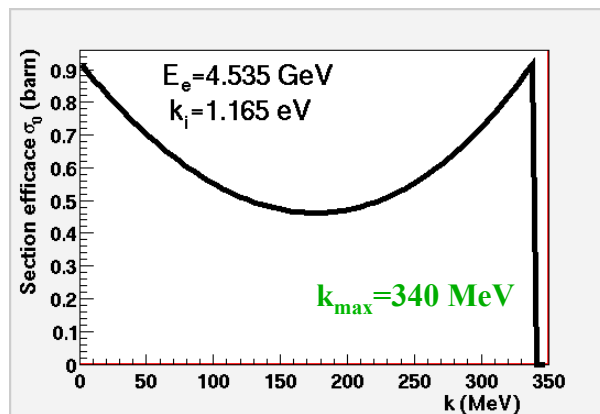
Hall A Collaboration Meeting  
June 9-10, 2011



# Compton Polarimetry Basics



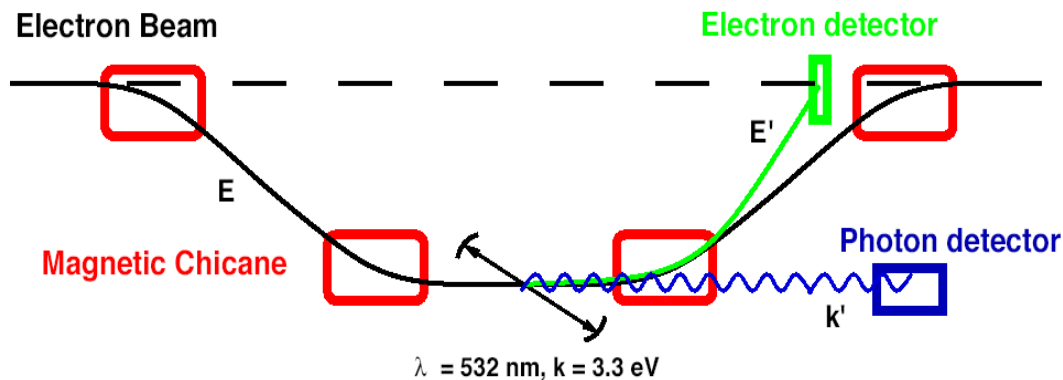
$$A_{\text{exp}} = \frac{n^+ - n^-}{n^+ + n^-} = P_\gamma \times P_e \times \langle A_{th} \rangle$$



- 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 Upgrade

- Upgrades the Infra-red Compton Polarimeter to green to provide accurate electron beam polarimetry from 1 to 11 GeV.
- Precision experiments - PReX, MOLLER, SoLID, DVCS,  $^3\text{He}$  experiments are a few beneficiaries
- With planned cavity power boost, extend dynamic range down to  $1 \mu\text{A}$  beam current



## *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

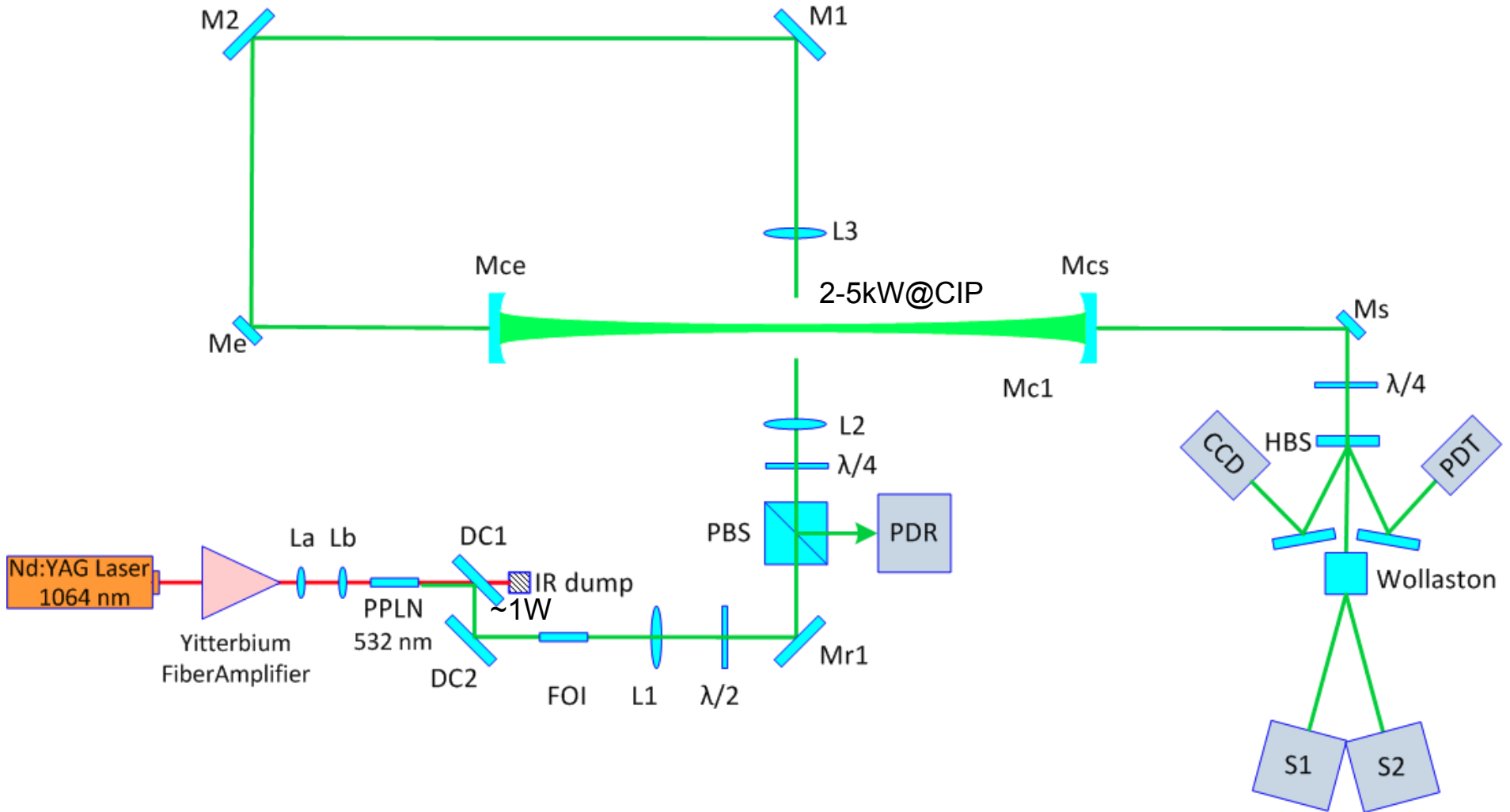
## *High Power Green Fabry-Perot Cavity*

Twice the Analyzing power of IR cavity

➔ Increased Figure-of-Merit



# Compton Photon Target



MS Visio Drawing by A. Rakhman



# PREX Fabry-Perot Cavity

- **Design**

- Intra-cavity power      3 kW
- Wavelength              532 nm
- Mode                      CW/ TEM<sub>00</sub>

- **Solution**

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

- **People**

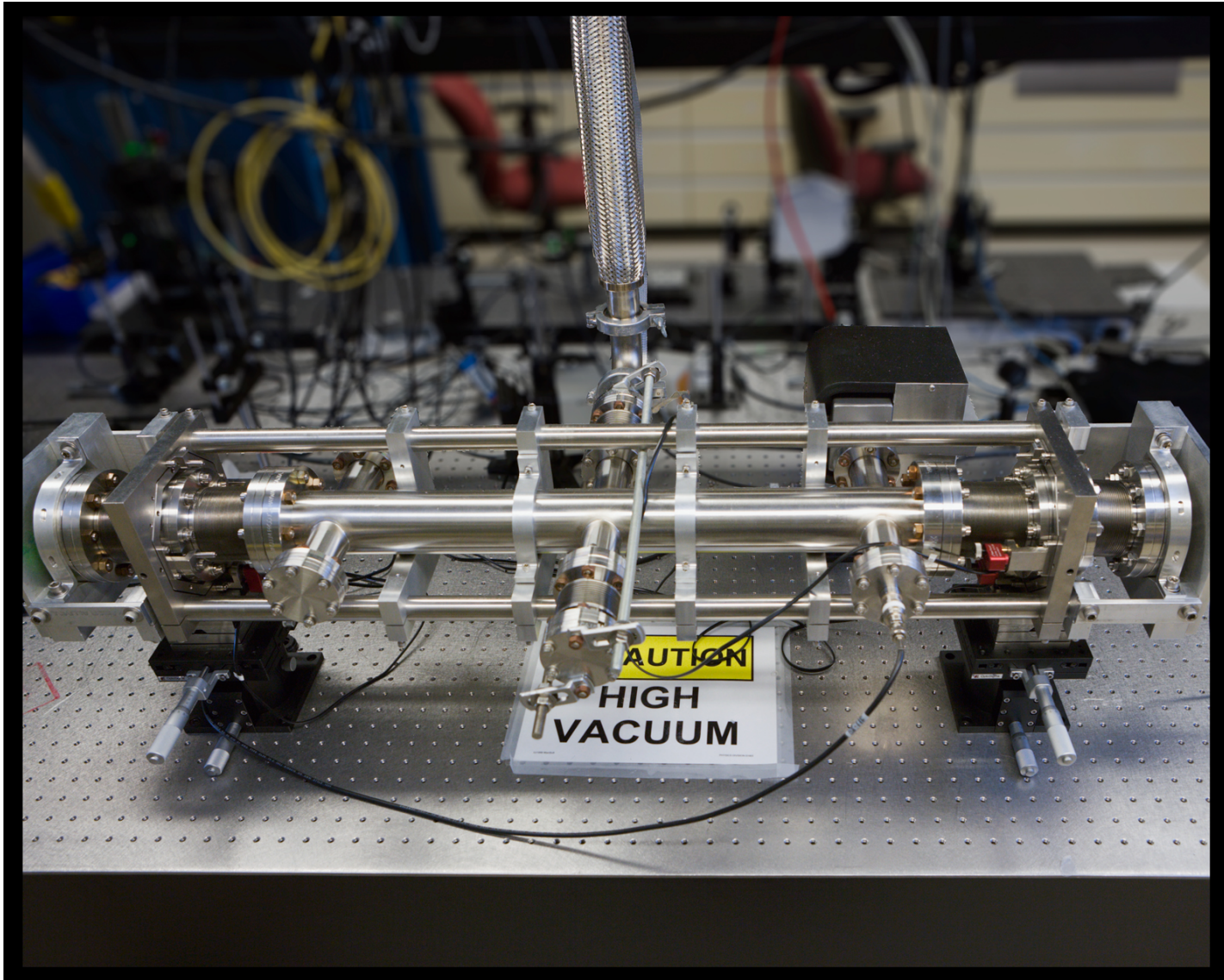
- A. Rakhman, M. Hafez, A. Tobias *et.al* - *lasers and FP cavity*
- M. Friend, A. Camsonne - *Detectors and DAQ*

- **Result**

- **The Good**
  - Successfully Installed and commissioned for PREX with designed power
  - Production polarimetry runs with integrating GSO detector
- **The Bad**
  - Some radiation damage to cavity mirrors from high backgrounds
  - Mechanical instability of cavity under vacuum load



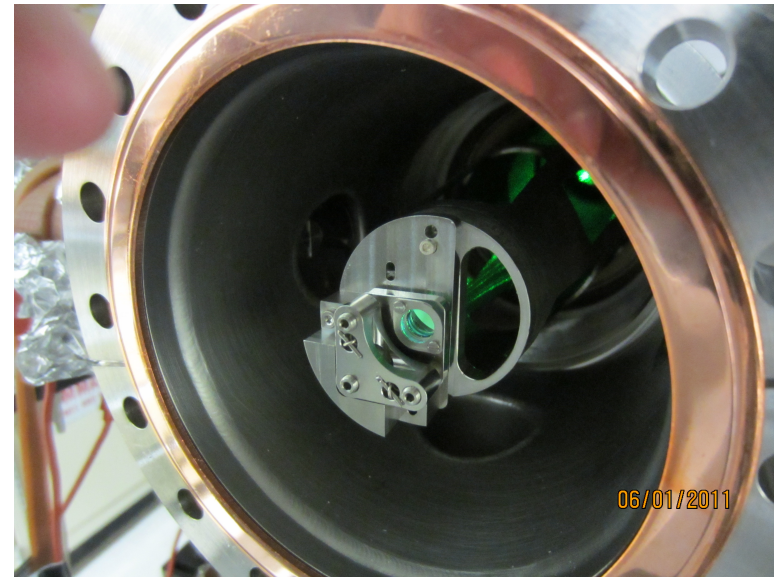
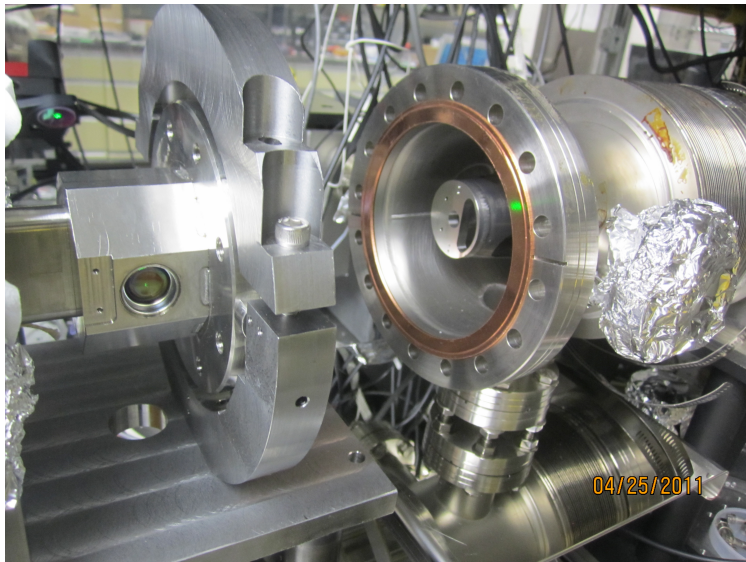
# Green Cavity in Compton Lab



Photograph: Alan Gavalya

# Test Setup in Compton Lab

- The old Saclay cavity resurrected as a test cavity
- Replace fixed 10mm mirror mount with adjustable 7.75 mm mount
  - Mirrors can be aligned before pulling vacuum
  - Vacuum load expected to be small – *to be tested*
- Work in progress on Higher power Fiber Amp PPLN green laser



# G2p Plans

- **Boost Cavity Power**
  - Change Cavity mirrors to higher finesse
    - *Remove  $T=240$  ppm mirrors, install  $T=80$  ppm (ATF80) mirrors*
  - Expected cavity power > 5kW
- **Schedule**
  - Mirrors on hand
  - Successfully locked at 5kW in the Compton Lab
  - Installation in Hall A in July
- **Run Plan**
  - A few dedicated Compton runs with 1uA straight thru beam
  - GSO detector in counting mode for 3% polarimetry
  - Continued commissioning of the e-detector





# Electron Detector

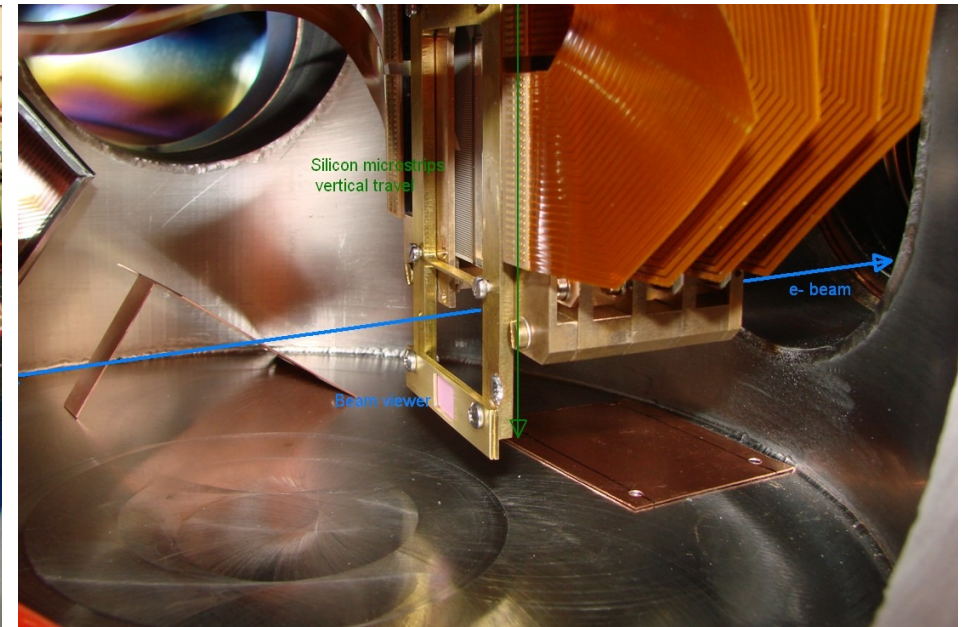
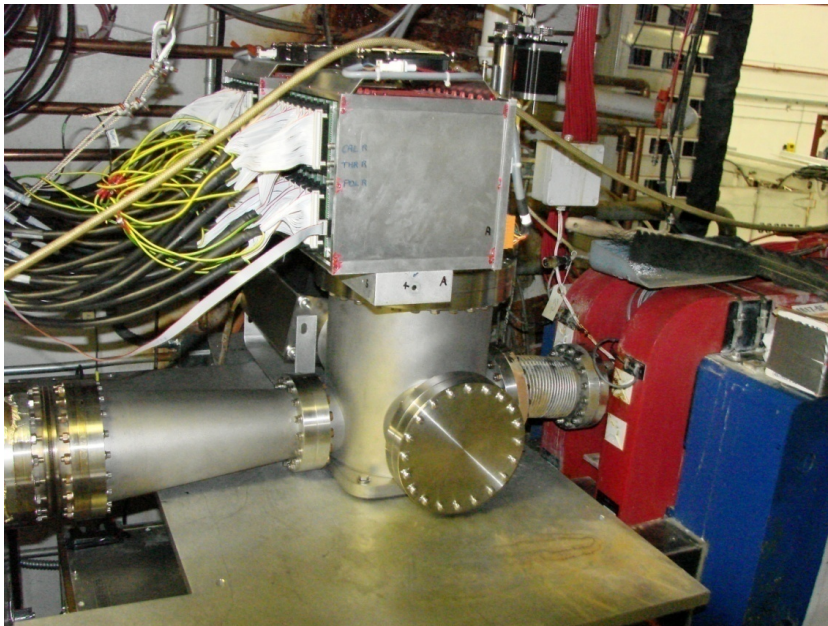
LPC Clermont-Ferrand

- **Goal**

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

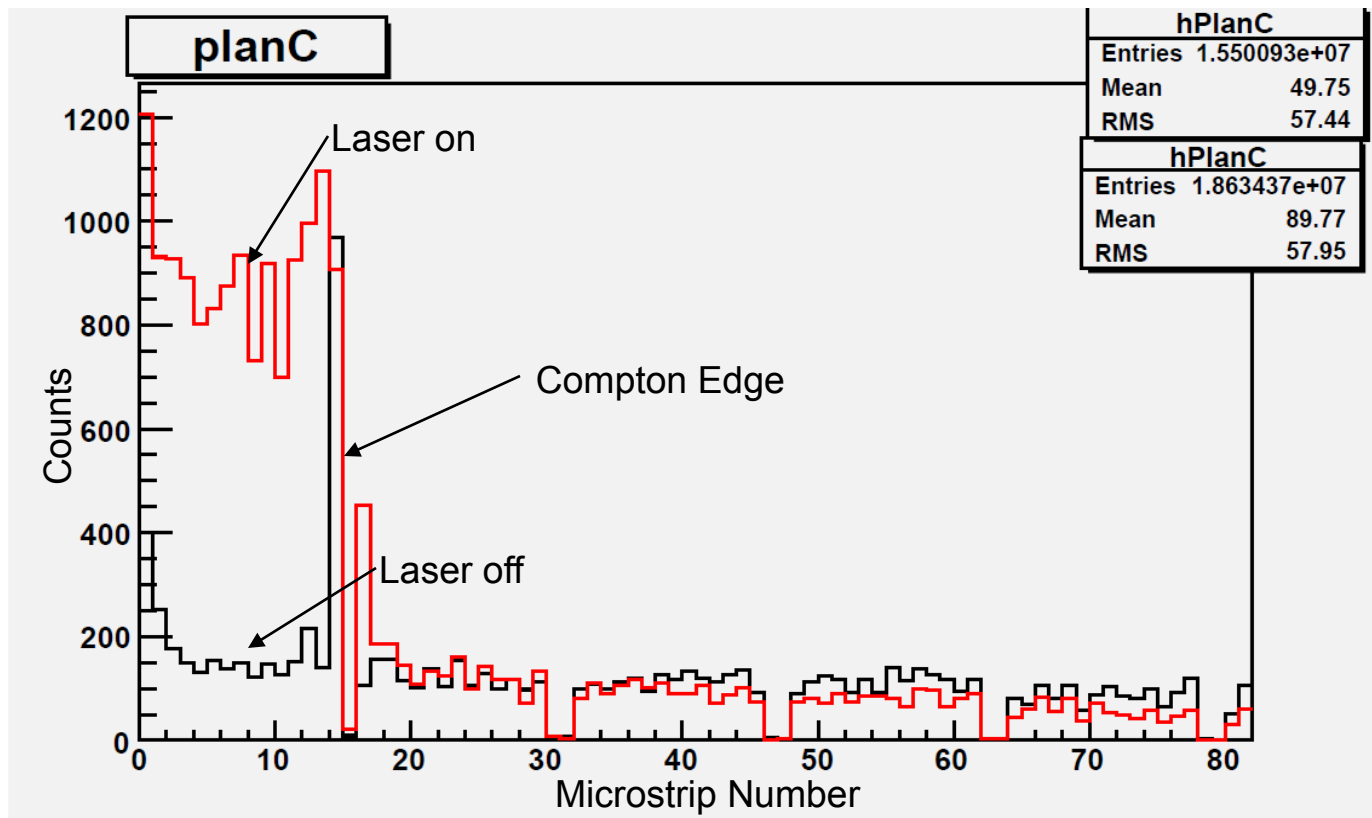
- **Scope**

- 768 ch 240  $\mu\text{m}$  pitch silicon  $\mu\text{strips}$
- 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

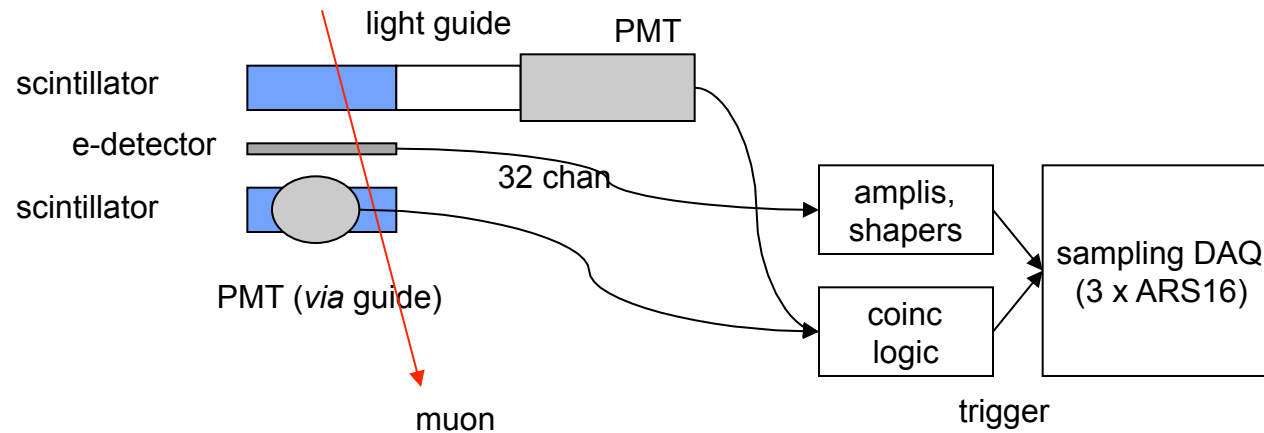
- **First Compton Scattered electron spectrum obtained in the new silicon microstrip e-detector in April 2009**
  - Singles spectrum with 3GeV electron beam
  - However, detector plagued with low efficiency
  - Sent back to Clermont-Ferrand for troubleshooting Jan '11



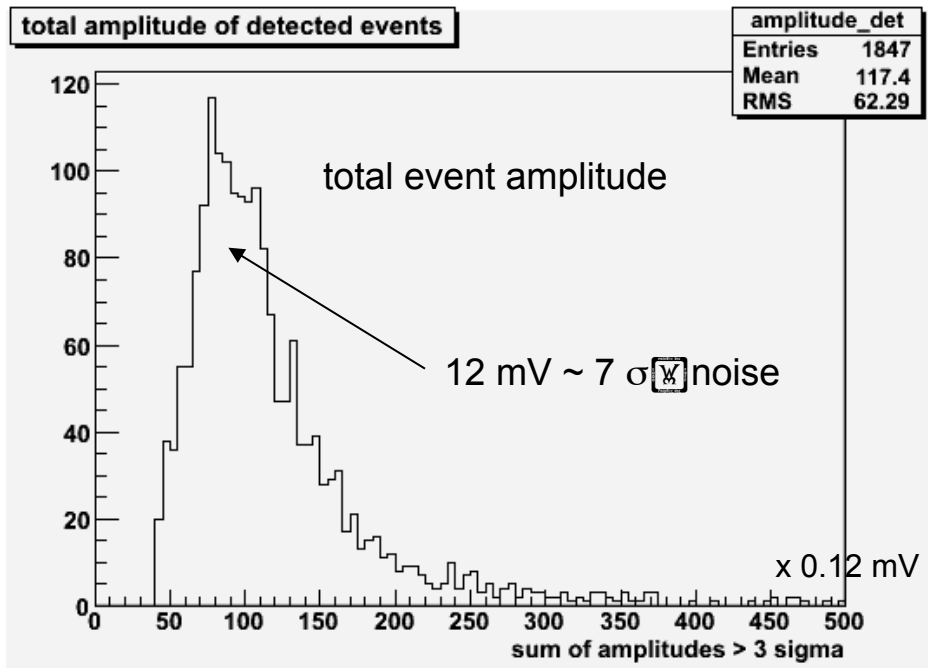
# Tests at Clermont-Ferrand

B. Joly, M. Brossard, M. Crouau, M. Magne, G. Savinel, C. Munos Camacho, P. Bertin

- 32 Si  $\mu$ strips( 0.5mm thickness) cosmic tests
- Evaluate 1mm thick Si  $\mu$ strips with the same setup
- Improved electronic noise shielding



# Preliminary results



- peak amplitude for *m.i.p* is well above noise
- 90 % detection efficiency
- Perspective: testing a stacked detector with a trigger logic

PMT thresh. (mV)	selected events (PMT > thresh.)	"detected" events (at least 1 chan > 3 sigma)	efficiency
90	2411	2072	86%
121	2037	1847	91%
151	1782	1635	92%
181	1577	1455	92%

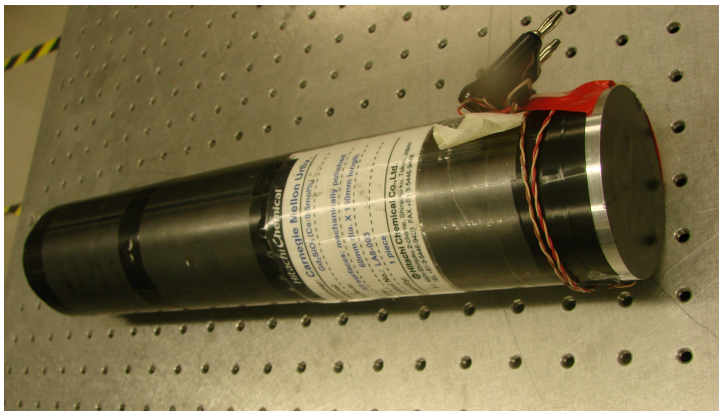


# Photon Detector

Carnegie-Mellon University

- Calorimeter

- Single crystal GSO, 6 $\phi$ 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!
  - Successful polarimetry production data for PREX with integrating DAQ



# Hall A 12 GeV Scope

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

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



# 12 GeV Compton Beamline

- **Present Magnetic Chicane**

- Four dipole design with 300 mm displacement
- 1.5Tm dipoles will go to 8 GeV

- **Design choices**

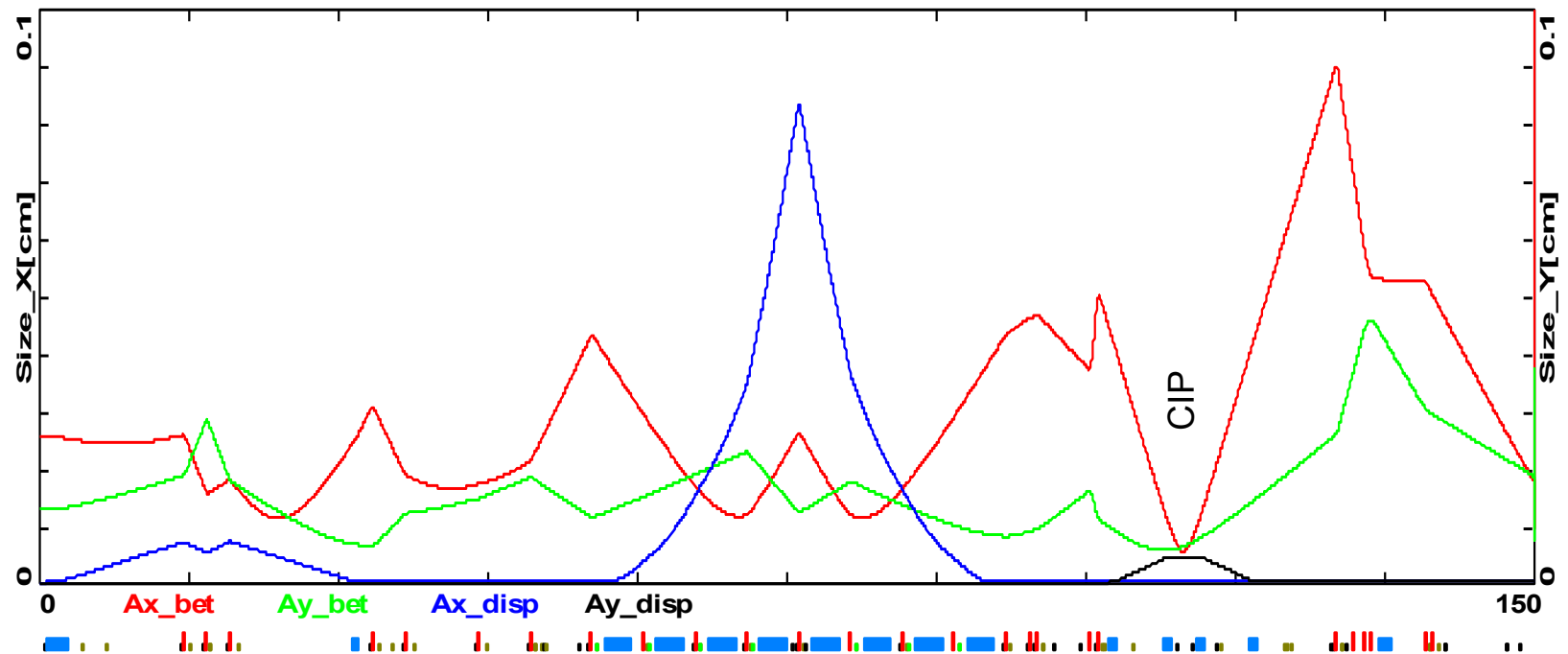
- Keep present 300 mm geometry, and overall length
  - => Higher strength dipoles => \$\$\$
- Reduce displacement to 218 mm
  - Keep present dipoles
  - New beamline geometry => \$\$

**Decision to go with 218 mm chicane adopted in 2005**



# Hall A 12GeV Beam line Optics

Thu Oct 01 13:25:04 2009 OptiM - MAIN: - O:\optim\jfbwork\myopt\New\_baseline\hallA\halla\_5\_11gev\_22cmComp

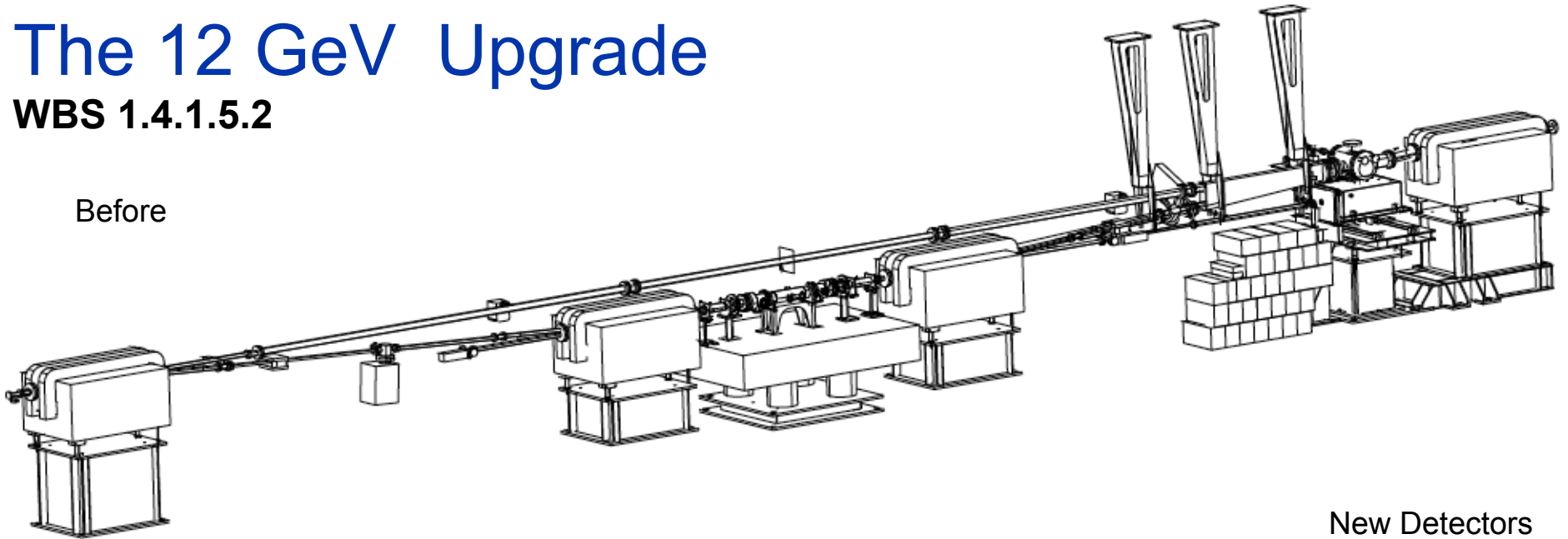




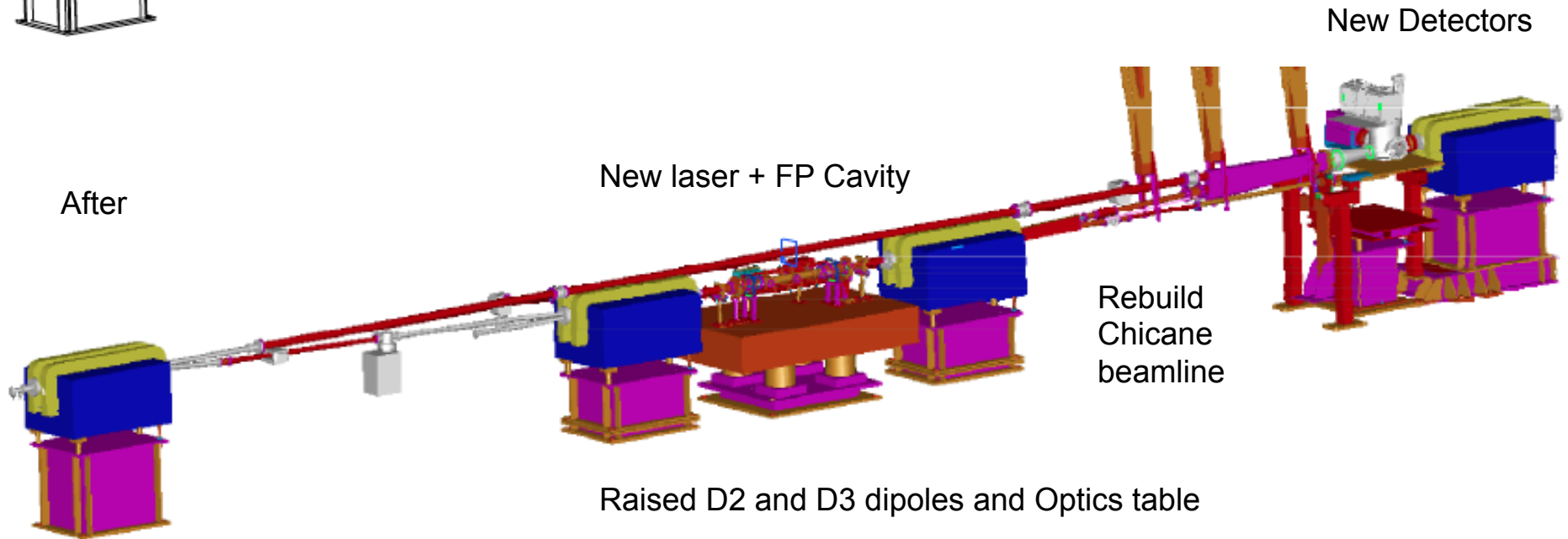
# The 12 GeV Upgrade

WBS 1.4.1.5.2

Before



After



# Schedule

- **Design:**
  - Completed 2010
- **Fabrication:**
  - Begins Fall this year
- **Installation:**
  - During 12MSD (May 2012 – Apr 2013)
- **Project Completion Milestone:**
  - October 2013 accelerator to deliver 3-pass >6 GeV beam to Hall A.
  - Compton Polarimeter ready for commissioning.



# Conclusion

- Boost cavity power to  $>5\text{kW}$  for g2p
  - Provide 3% beam polarimetry at  $1\mu\text{A}$
- E-detector being reworked and bench tested at Clermont
  - Beam tests planned during g2p runs
- 12 GeV Compton upgrade approaching construction phase.
  - On track for 2013 Completion

