Hall A Compton Polarimeter

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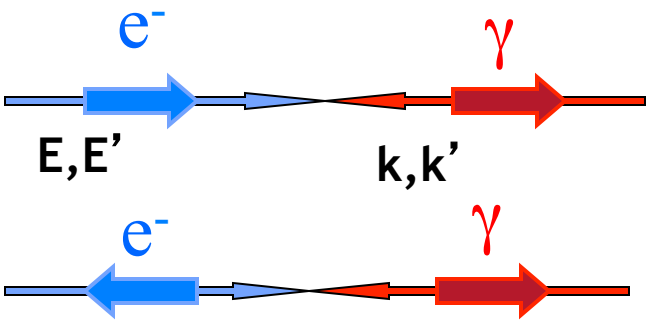
Jefferson Lab

Hall A Collaboration Meeting
June 13, 2013

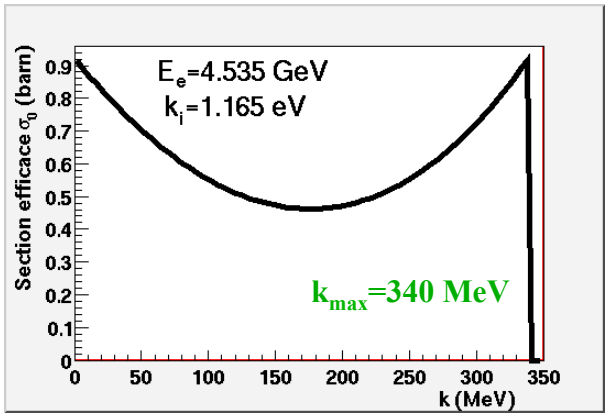
Compton Polarimetry Basics

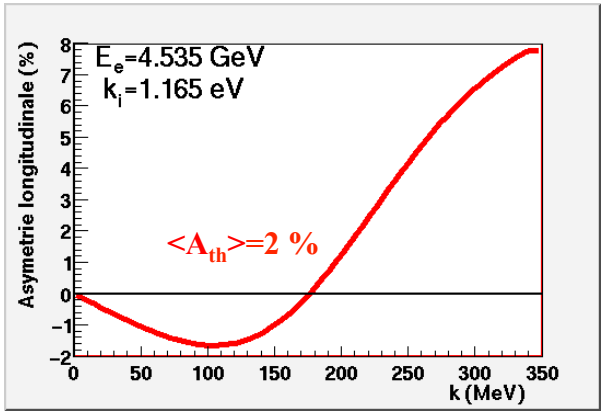


σ^+

σ^-

$$A_{\exp} = \frac{n^+ - n^-}{n^+ + n^-} = P_\gamma \times P_e \times < A_{th} >$$



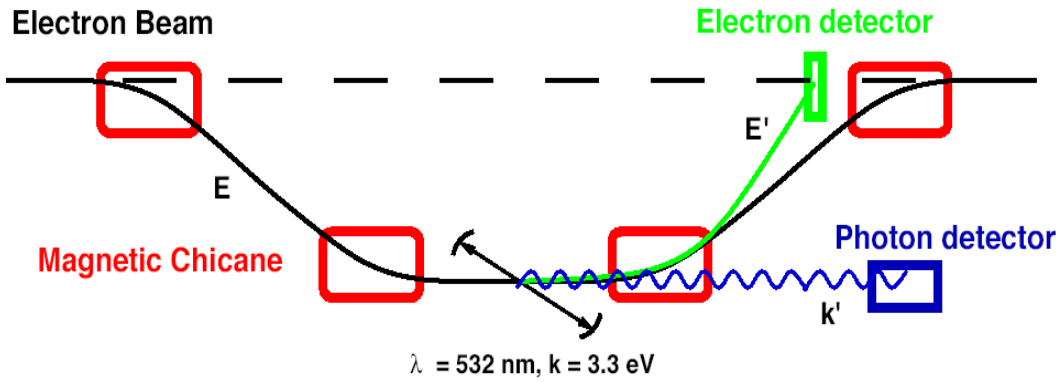


- **High precision, non-intrusive, real-time electron beam polarimetry**

-> Accuracy improves with higher electron and photon energies

- Figure-of-Merit ~ $\sigma \times A^2$ ~ $k^2 \times E^2$

Hall A Compton Polarimeter



Electron Detector

- High resolution silicon micro-strips
- 240 μm pitch/768 chan/4 planes
- Movable in vertical plane

Photon Detector

- GSO detector for low energy
- PbWO for higher energies
- Counting and integrating capabilities

High Power Fabry-Perot Cavity

Green: Twice the Analyzing power of IR cavity
➲**Increased Figure-of-Merit**

Infrared: Offers higher power than Green
➲**Better suited for higher energies/poor beam background**

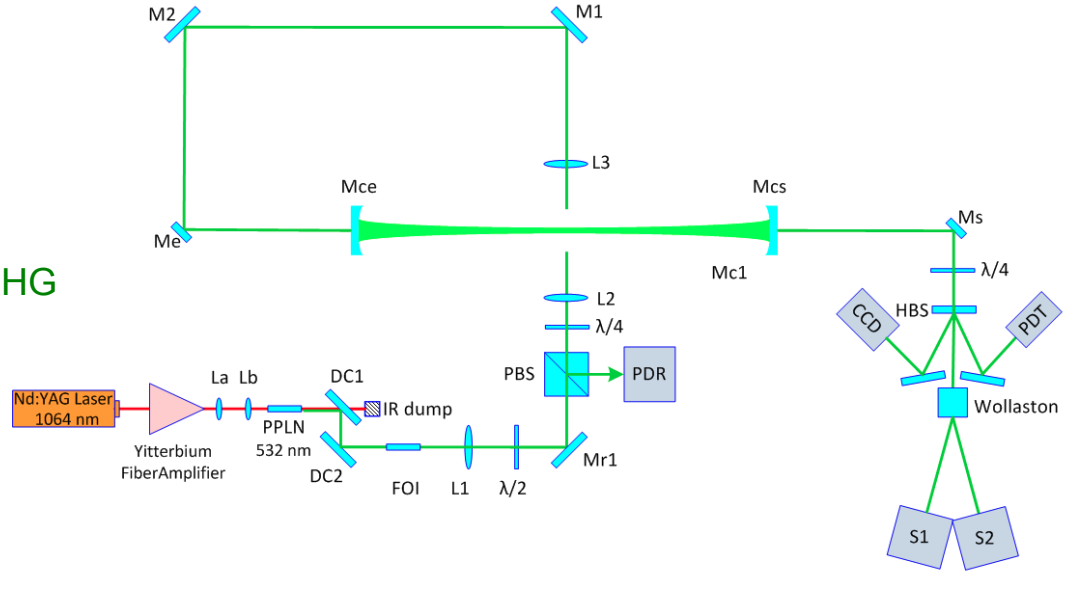
Data Acquisition

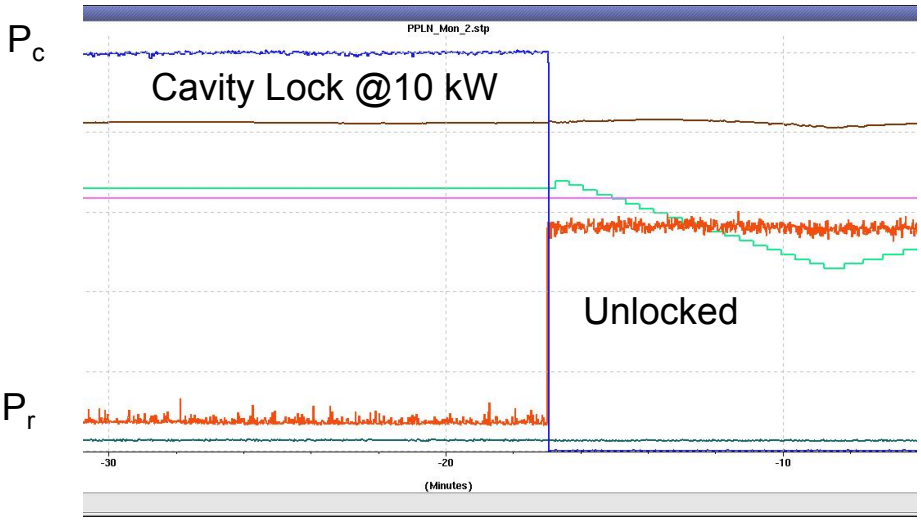
- Integrating photon DAQ operational
- High speed counting (1 MHz@1kHz spin-flip) DAQ in development

Participating Institutions: **Clermont-Ferrand, CMU, Syracuse, UVA, Duke, Manitoba, MSU, and Jlab**

Photon Source

- **Fabry-Perot Cavity**
  - 532 nm CW
  - Invar resonator, *adjustable* mirrors
  - Nd:Yag 1064nm ➔ YDFA ➔ PPLN SHG
    ➔ High Finesse FP Cavity
  - Pound-Drever-Hall locking scheme
    Home made electronics



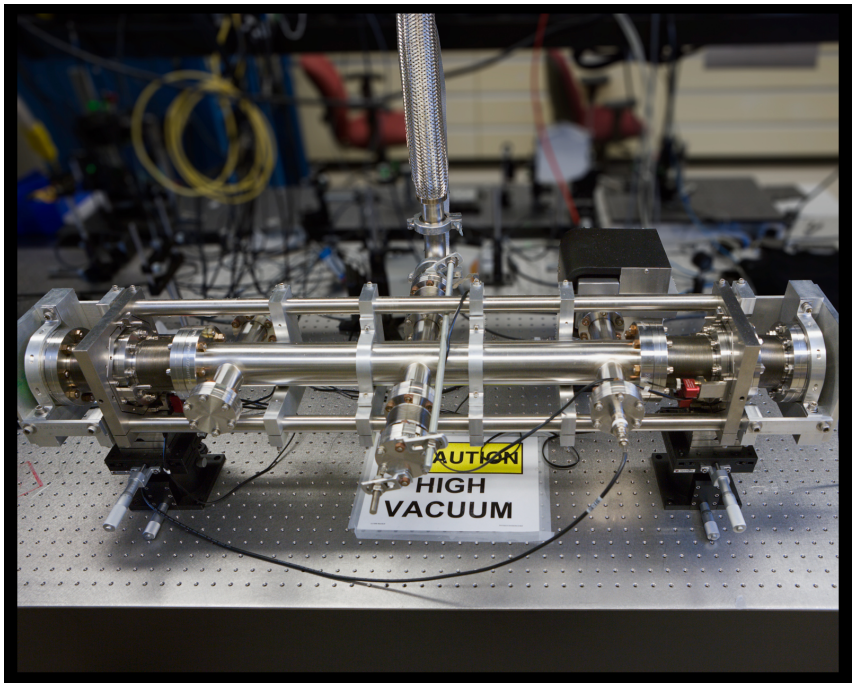


Present Status:
Infrared pump: 4 W
Green laser power: 1 W
Incident on cavity: 0.8 W

Power in cavity: 10kW
Mirror finesse: 26,825
Cavity Gain: ~ 12,000

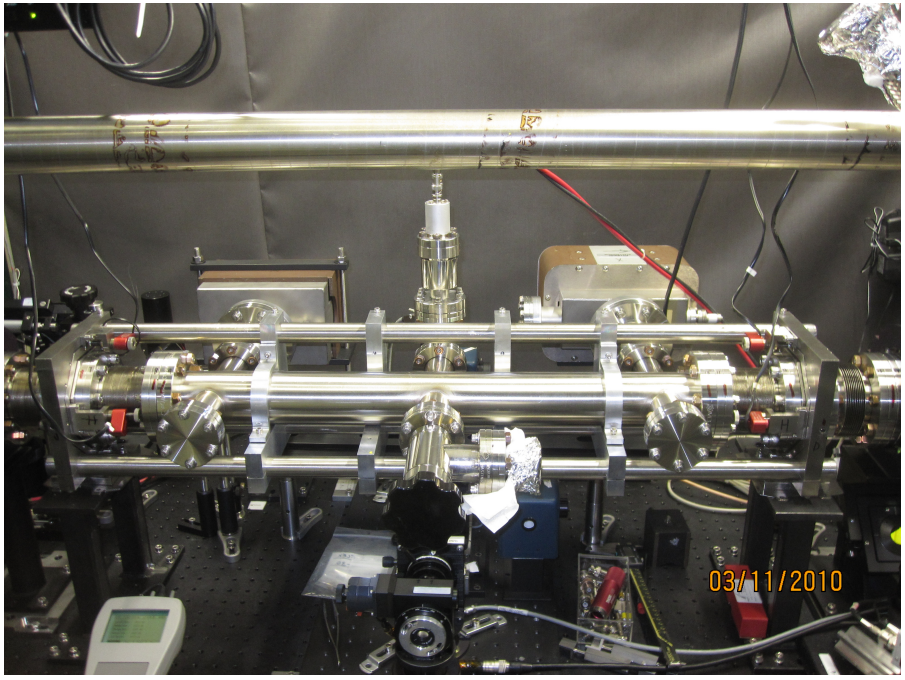
Striving to achieve >10kW in Compton laser lab test setup☺

Green Fabry-Perot Cavity



Under tests in Compton Lab

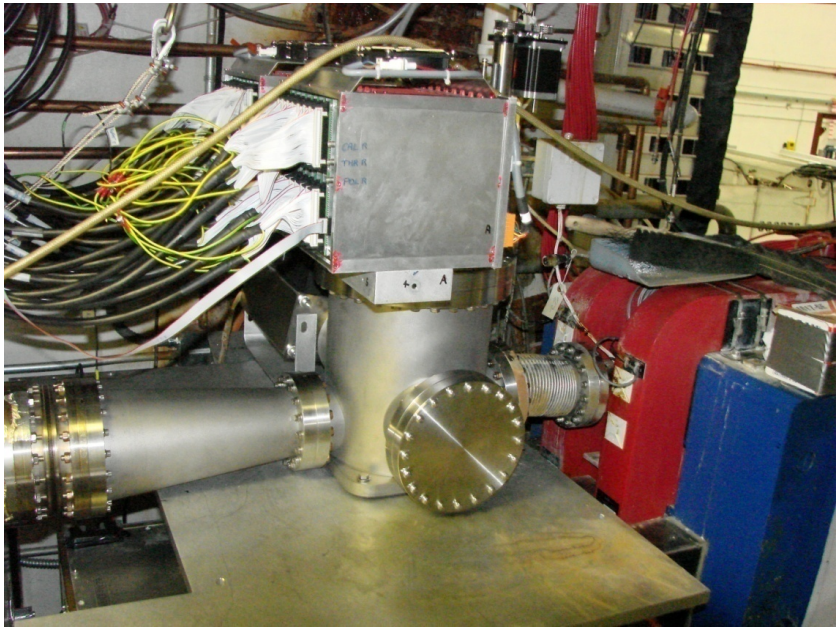
Installed in Hall A



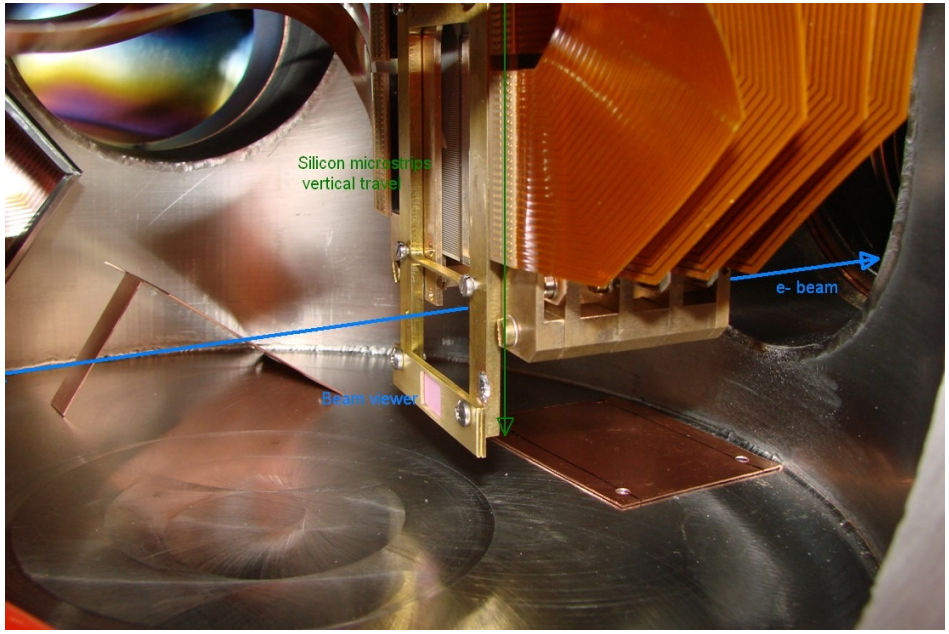
Electron Detector

Clermont-Ferrand, Manitoba, MSU

- **Scope**
  - 768 ch 240 μm pitch, 0.5mm thick silicon μstrips
  - 4 Planes, 192 strips/plane, 1 cm spacing between planes
  - 120 mm vertical motion allows coverage of Compton edge from 0.8-11 GeV



Installed in Hall A

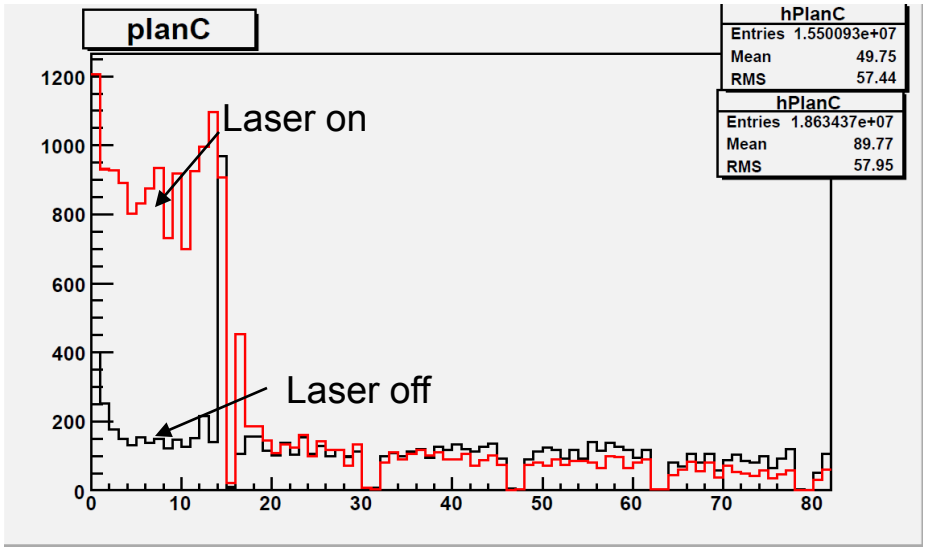


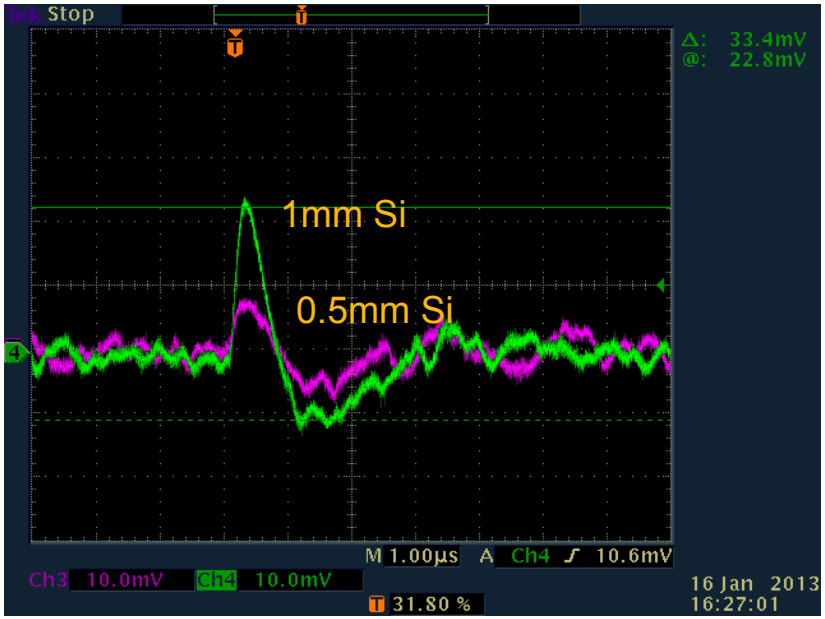
Inside view

E-detector Status

Compton spectrum obtained at 3 GeV in Hall A☺

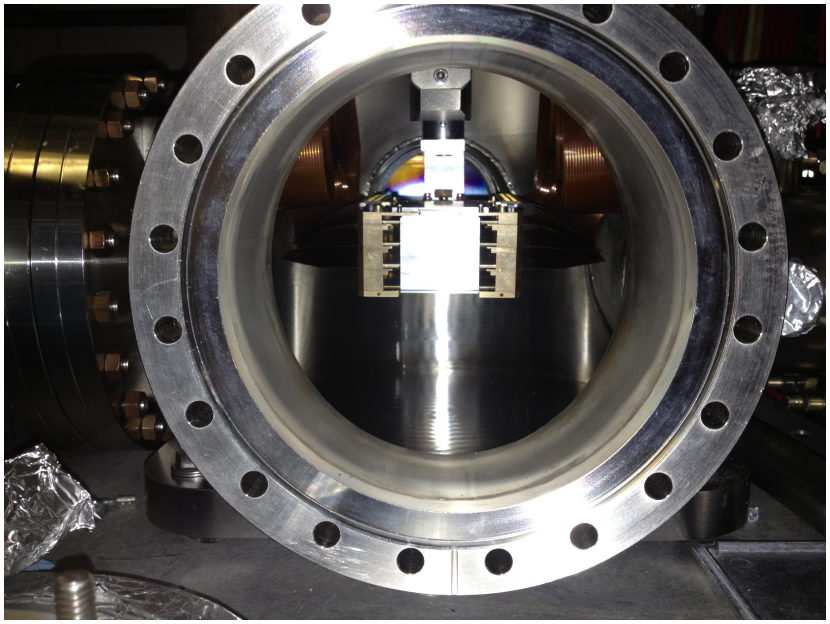
- But, poor signal-to-noise ratio => low detection efficiency
- Thicker silicon strips to improve signal under study, cosmic ray studies in progress in Hall A following Clermont-Ferrand tests
- Test setup in preparation at Manitoba to improve electronics





Si strip signal with radioactive source

Vertical mount for cosmic studies



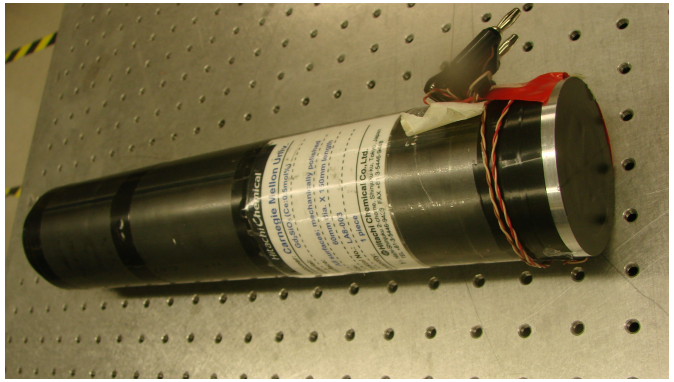
Ready for commissioning with beam in Spring 2014

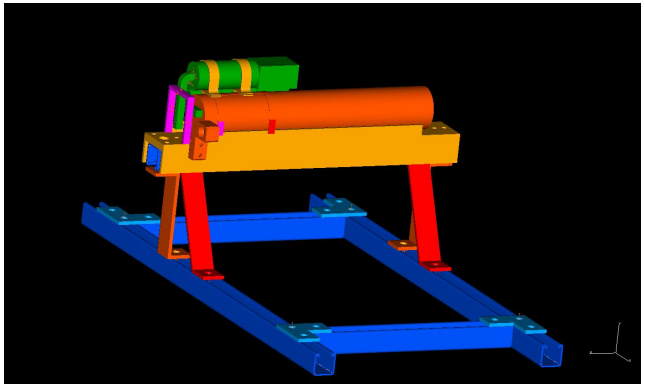
Photon Detector

Carnegie-Mellon University

- Calorimeter
  - Single crystal GSO, 6ϕx15 cm cylinder supplied by Hitachi Chemicals
  - High light output, fast decay time (less than 60 ns)
  - Triggered counting as well as continuous integration.
  - Operational in Hall A since 2009

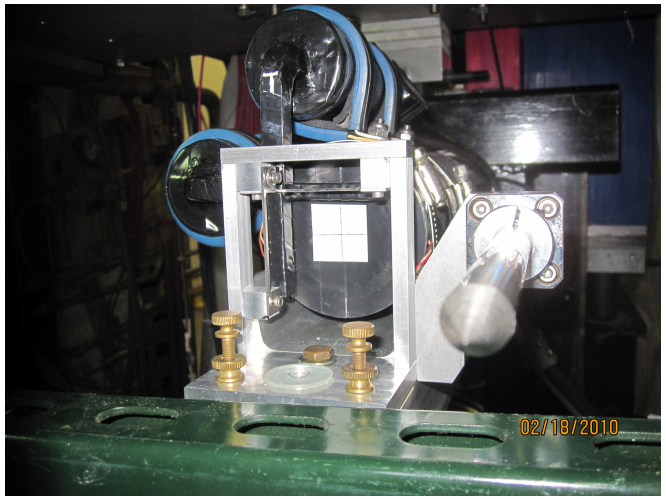
  - PbWO4 calorimeter for 11 GeV in development



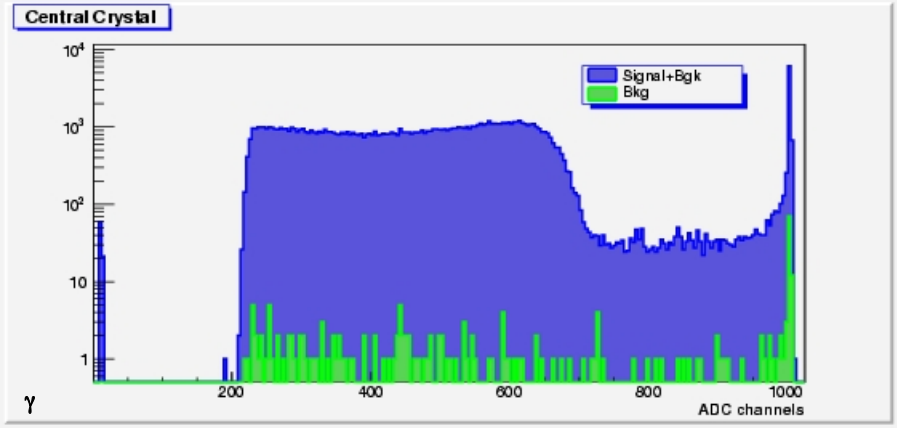


GSO Calorimeter High Energy Performance

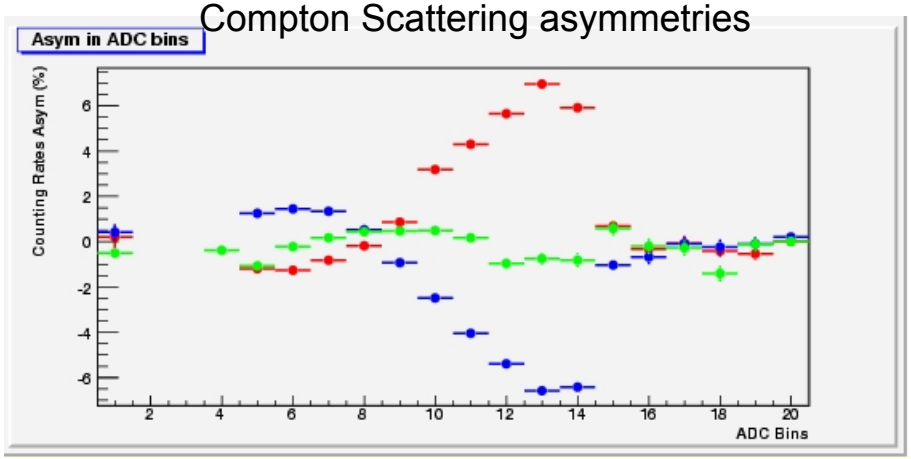
- **GSO calorimeter has been tested up to 6 GeV**



Compton Scattering cross-section



Compton Scattering asymmetries



- E_e = 5.9 GeV
- E_γ = 0.2 - 0.8 GeV
- P_γ = 450 W@1064 nm

Ready for commissioning with beam in Spring 2014

Compton DAQ Upgrade

Bob Michaels, Kalyan Allada, Alexandre Camsonne, and DAQ Group

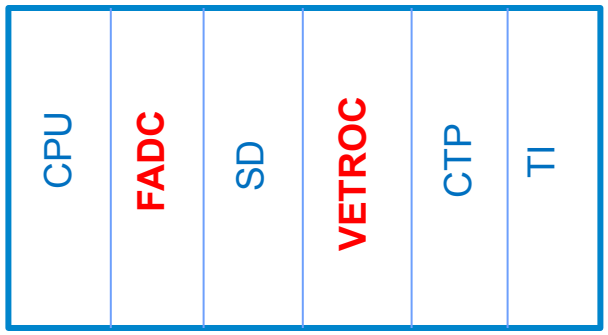
VXS-based Pipelining CODA3 **DAQ for high-rate counting**

FADC for **Photon Detector***

Ready by Feb 2014

VETROC for **Electron Detector****

Prototype in ~1 year, final product in 3 yrs



Event Builder

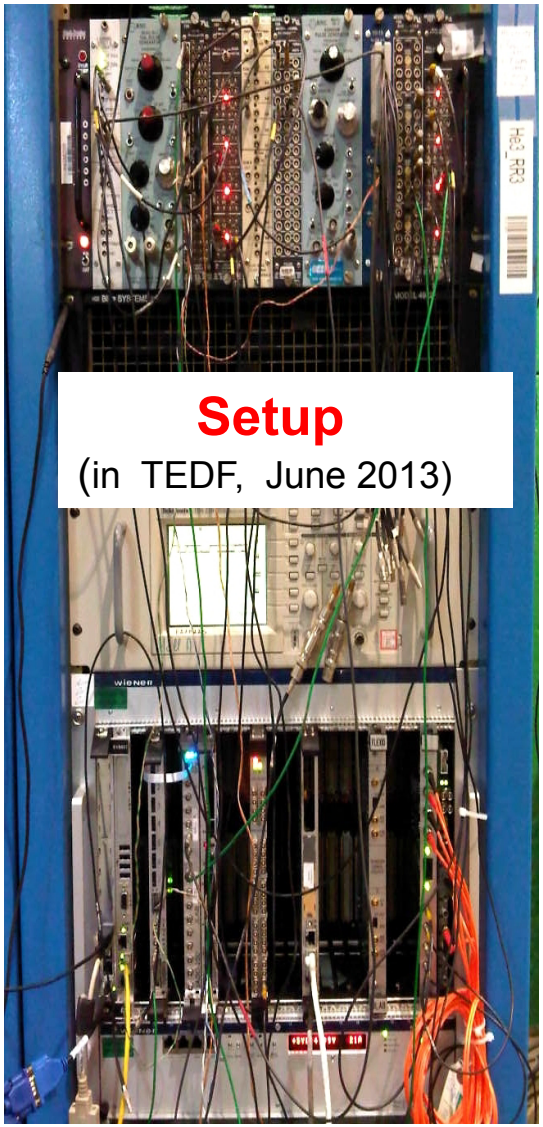
Slow (helicity-based) **DAQ**

BPM, BCM, Laser state,
Integrating FADC, scalers

hallaweb.jlab.org/equipment/daq/compton_coda3.pdf *

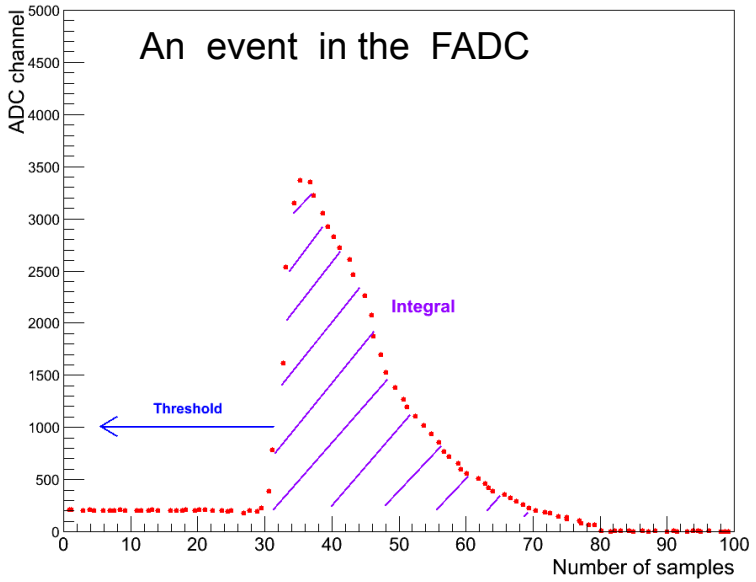
/compton_vetroc.pdf **

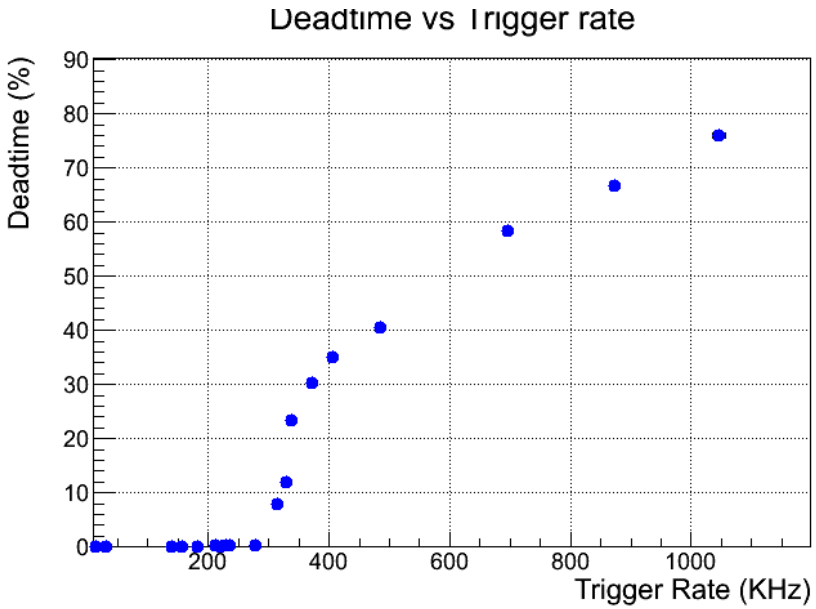
DAQ Test Stand – Photon Counting



Setup

(in TEDF, June 2013)

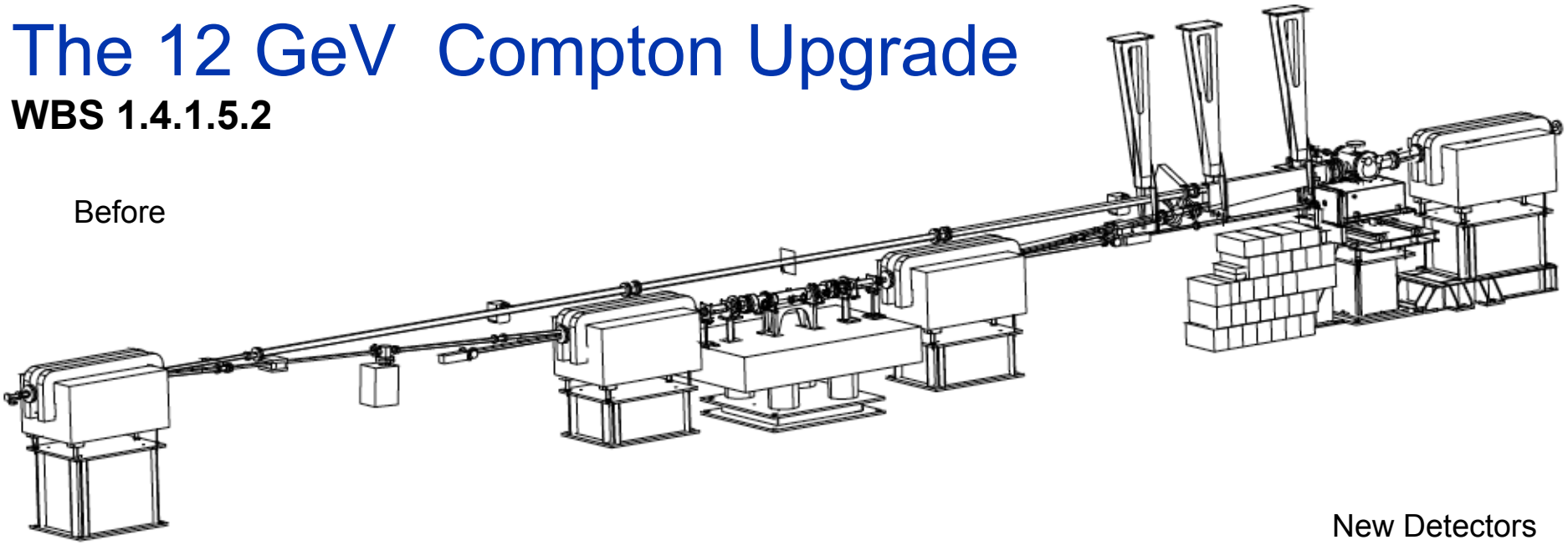




The 12 GeV Compton Upgrade

WBS 1.4.1.5.2

Before



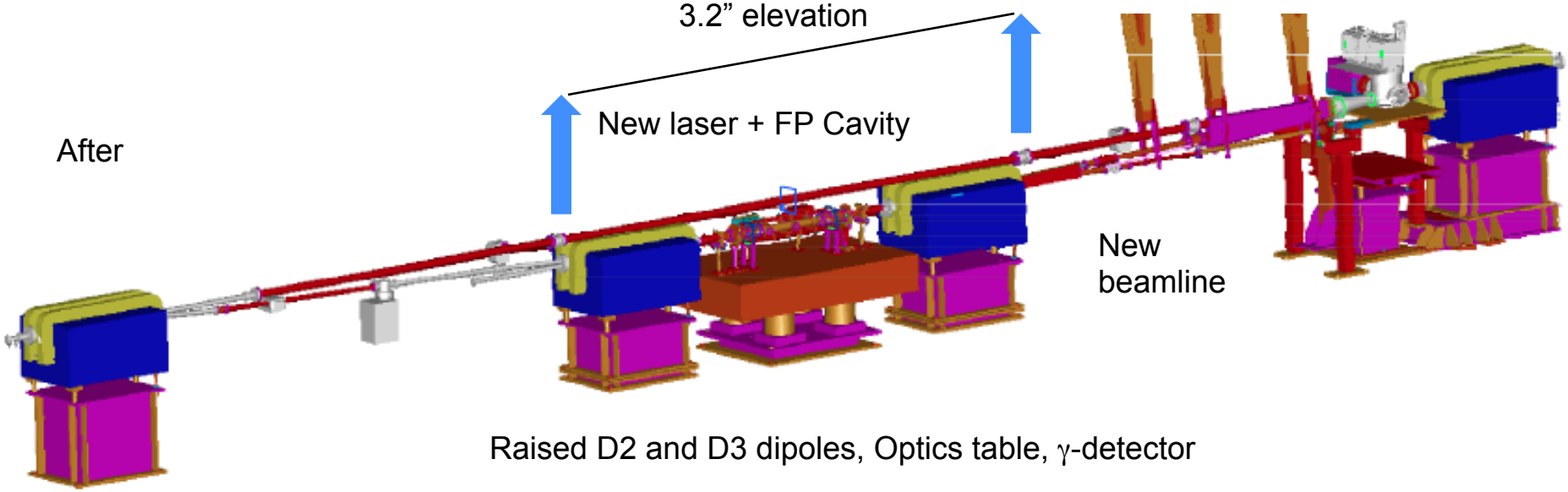
After

New Detectors

3.2” elevation

New laser + FP Cavity

New beamline



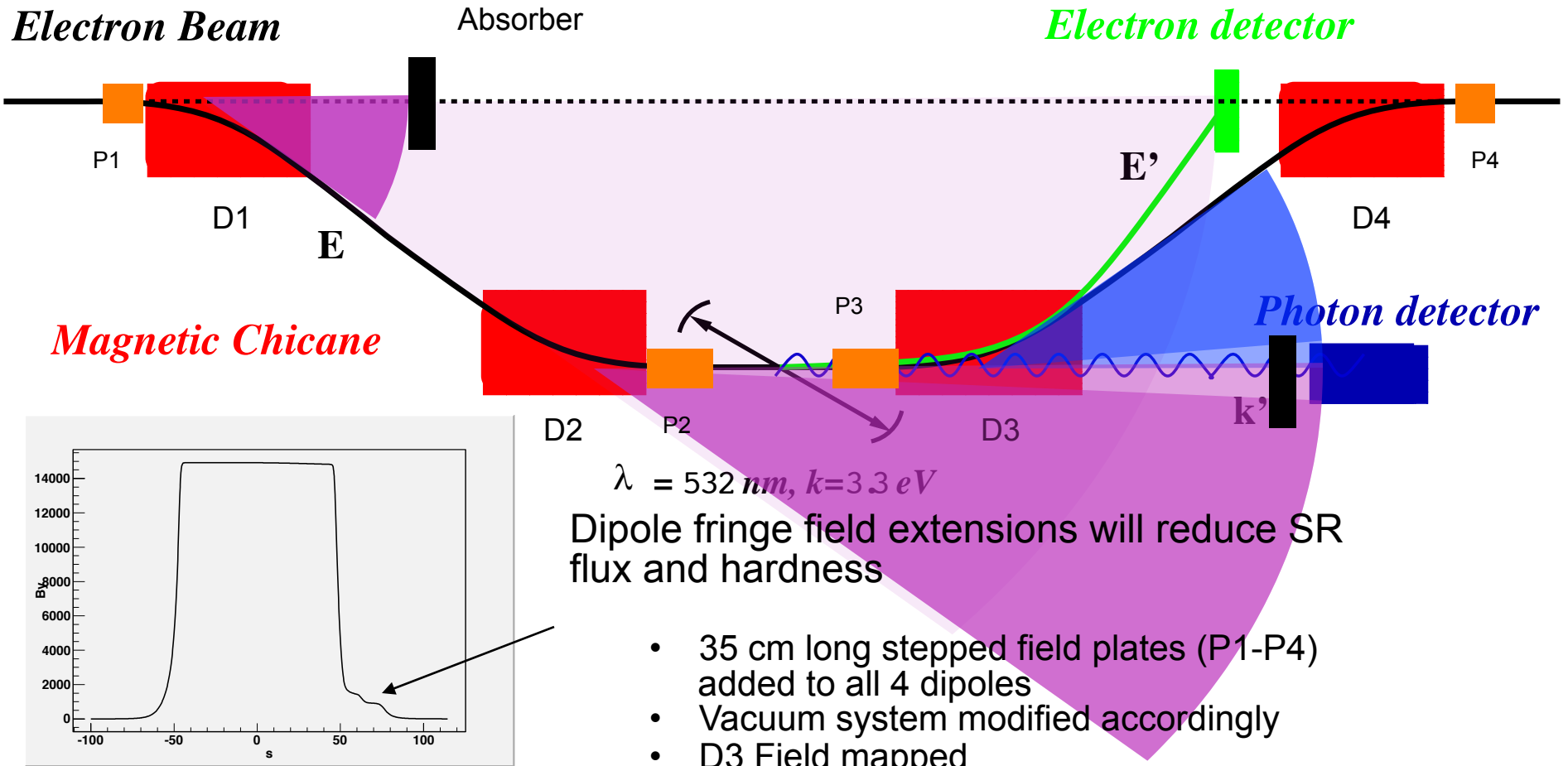
Raised D2 and D3 dipoles, Optics table, γ-detector

Synchrotron Radiation Background

Quinn et al…

At 11 GeV synchrotron radiation background overwhelms the photon calorimeter

But, it can be suppressed with simple fringe field modifications☺



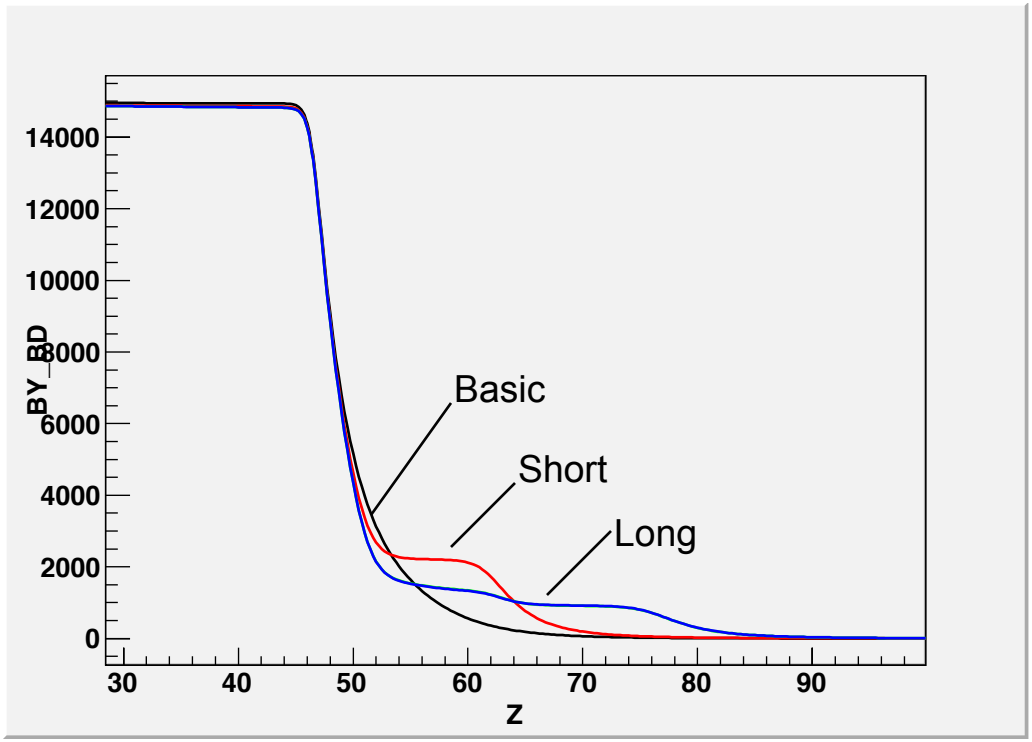
Dipole fringe field extensions will reduce SR flux and hardness

- 35 cm long stepped field plates (P1-P4) added to all 4 dipoles
- Vacuum system modified accordingly
- D3 Field mapped

Fringe field extension plates

Long field plates

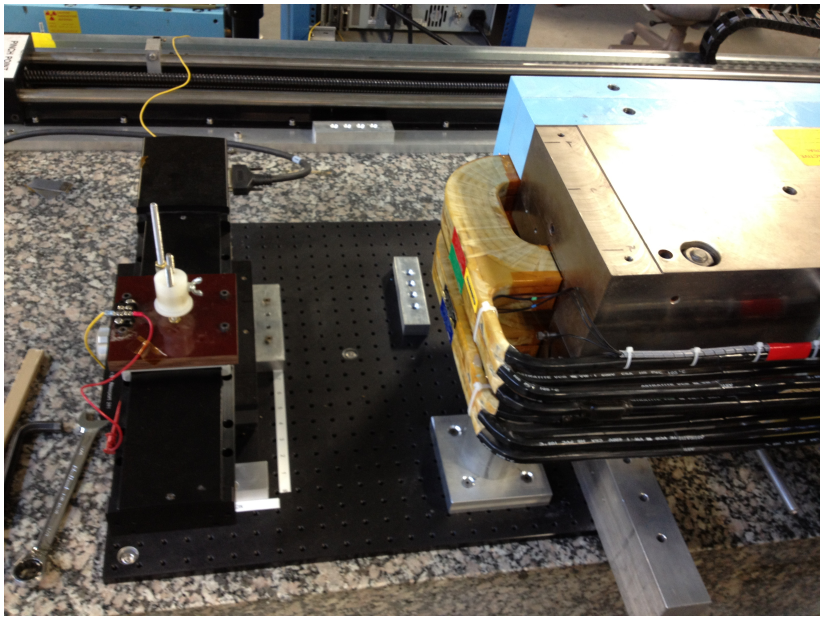
TOSCA computations (J. Benesch)



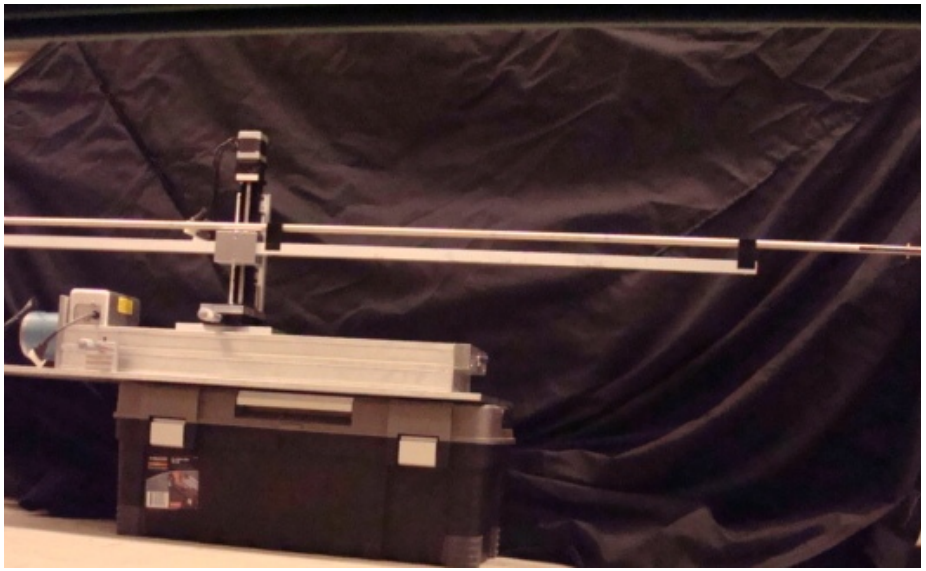
Long plates installed on all four dipole magnets

Magnetic Field Measurements

Goal: - Map only D3, Both integral and differential
- Verify field plate design for beam transport
- 3D map of D3 to improve e-arm analysis
- 3 Maps: Basic dipole, +P1, and +P2



- **Integral (Bagget, Pena, Meyers)**
  - Stretched wire technique
  - 2 m coverage (1 m EFL)
  - 0-400-0 A, 25A step loop, 1.5T Max
  - ~0.5×10^{-4} accuracy for integral



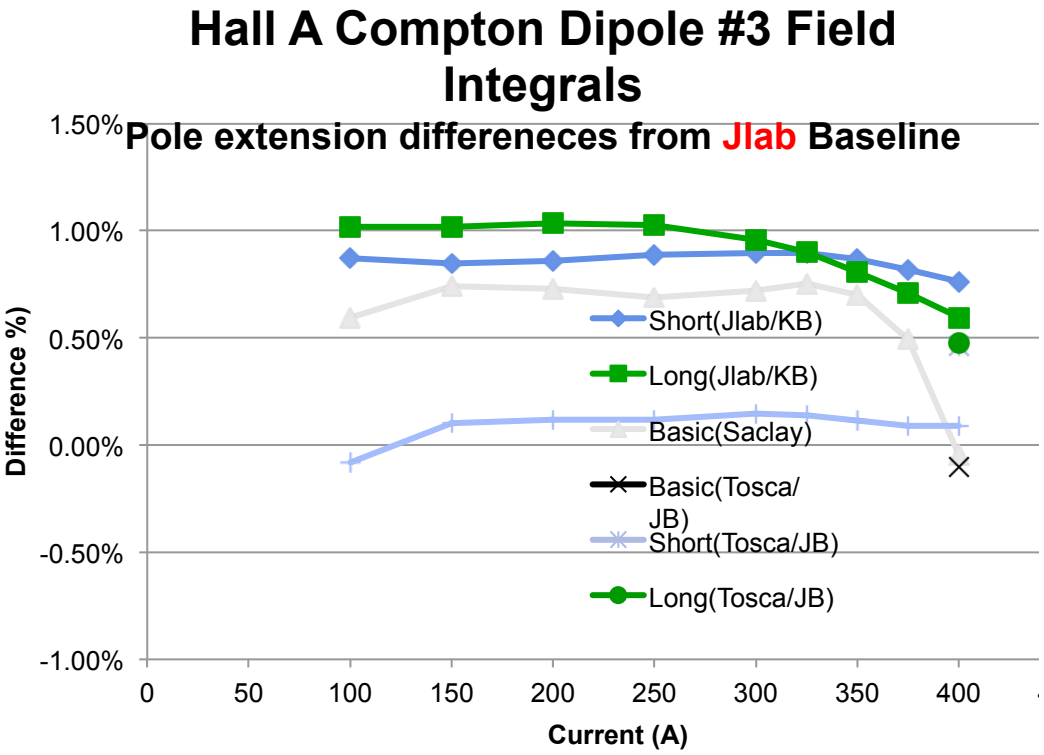
- **Differential 3D (Jones, Paschke, Zhang)**
  - Hall Probe with NMR Cross calibration
  - 2x4x80 cm coverage
  - 0-400-0 A, 100A step loop
  - ~10^{-3} accuracy per point

Both mapping results are in excellent agreement with Tosca simulations

Dipole #3 Field Map Staging

- D3 rolled downstream on temporary support (Folts)
- Field plates installed, ready for field measurements

∫ Bdl Measurements



Integral field measurements with stretched wire technique

- Agree well with previous Saclay measurements
- Validate Tosca calculations at 10^{-3} level

New Compton Laser Lab

Packing up Old Lab L310

On the move…

New Lab L213

Thanks to:
Walt Akers, Jack Segal, Ed Folts and many others

We have a new Laser Lab
Expected to be operational in July

Compton Upgrade Status

- Engineering
  - Designs done
  - All major components fabricated, delivered to Hall A
- Installation
  - D2, D3, Optics table raised
  - Magnet power/LCW restored
  - Field measurements completed
  - Beam line installation in progress
- Optics
  - Optics table 'boxed up' to facilitate beamline work (Hafez)
  - New Compton Laser Lab coming online soon
  - Optics restoration to commence thereafter: *Collaboration help needed!*
- Detectors
  - Photon and electron detectors installed, checkout in progress
  - DAQ in development

Ready for commissioning with beam in Spring 2014