g8b Report to the CLAS Collaboration

Data taking:
June 20 – September 1, 2005

Jefferson Lab
Thomas Jefferson National Accelerator Facility

Philip Cole for g8b Group

Idaho State University
3 November 2005

Physics Motivations

- Model calculations and coupled-channel analyses show that spin observables are very sensitive to contributions from resonant coupling (even at the few percent level).

- Measuring such parameters over a large energy range with full angular coverage are crucial for disentangling N*s.

Need a high-quality beam of linearly-polarized photons with a 4π Detector: **Coherent Bremsstrahlung Facility + CLAS**

Motivations for g8

$\vec{\gamma}p \rightarrow VN$ here, V = (ρ, ω, ϕ).

for example $\omega \rightarrow \pi^+\pi^-\pi^0$

Idea: The angular distribution of the daughter (spin-0) pions will reflect the polarization state of the parent (spin-1) ω mesons.

If we can set a unique direction in space, we can uniquely measure the angular distributions of the decay pions.

Linearly Polarized Photons provide that unique direction in space

Motivations for g8

POLARIZATION OBSERVABLES afforded by linearly-polarized photon provide:

- a parity filter on *natural* vs *unnatural* exchange in the *t* channel
- Constraints on the bilinear combinations of the helicity amplitudes, i.e. the density matrix elements
- Information on the *s* and *t* evolution of the density matrix elements; this being necessary towards disentangling the broadly overlapping baryon resonances.
- 6 of the 8 total observables for hyperon production.

Hence the need for

A TAGGED, COLLIMATED BEAM OF LINEARLY-POLARIZED PHOTONS IN

Experiments comprising g8a

- ρ^0 **production** (density matrix elements)
  (Glasgow University and Idaho State University)
- ϕ **production** (density matrix elements)
- ω **production** (beam-VM double polar.)
  (Catholic University of America)
- $K\Lambda$, $K\Sigma$ **production** (beam-recoil double polar.)
  (Glasgow University and Idaho State University)
- η **production** (beam asymmetry)
  (Arizona State University)
- others … (e.g. π & Δ production)

ASU Arizona State University

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ISU

Photoproduction of Vector Mesons and Hyperons with a Beam of Linearly-Polarized Photons

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- Lu Cheng
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- Julian Salamanca and Davit Abrahamyan
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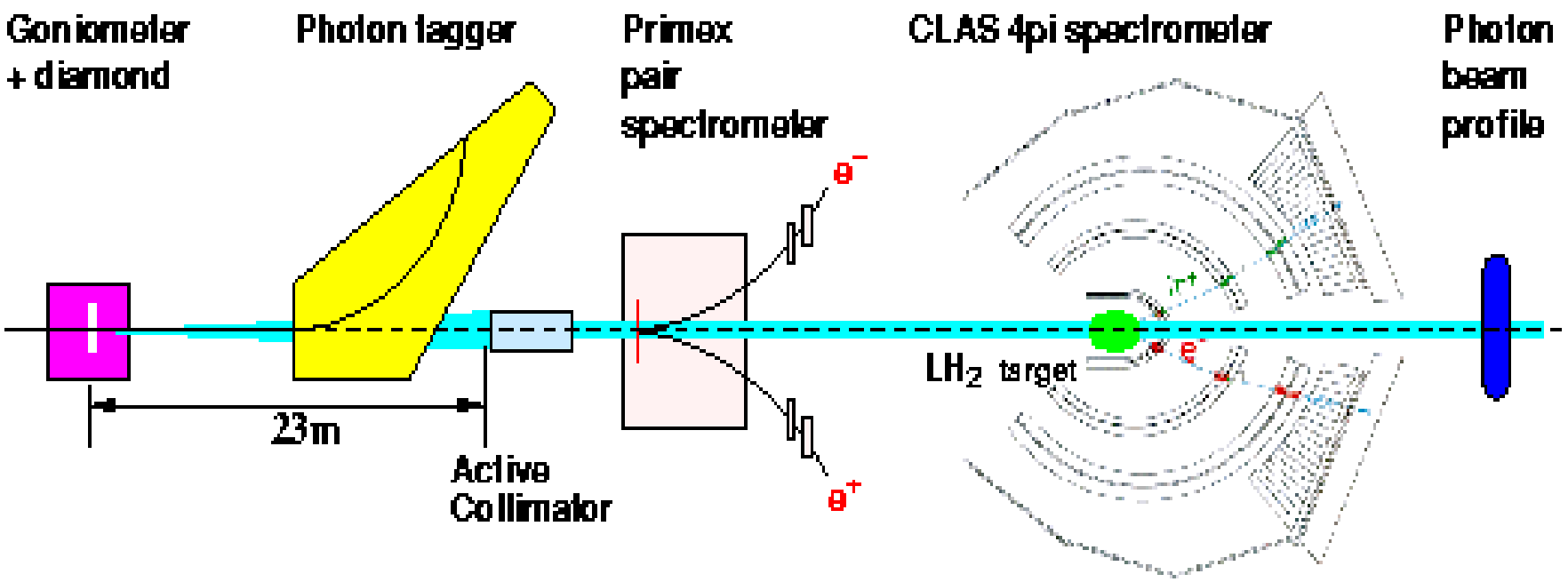
Coherent Bremsstrahlung Facility Beamline

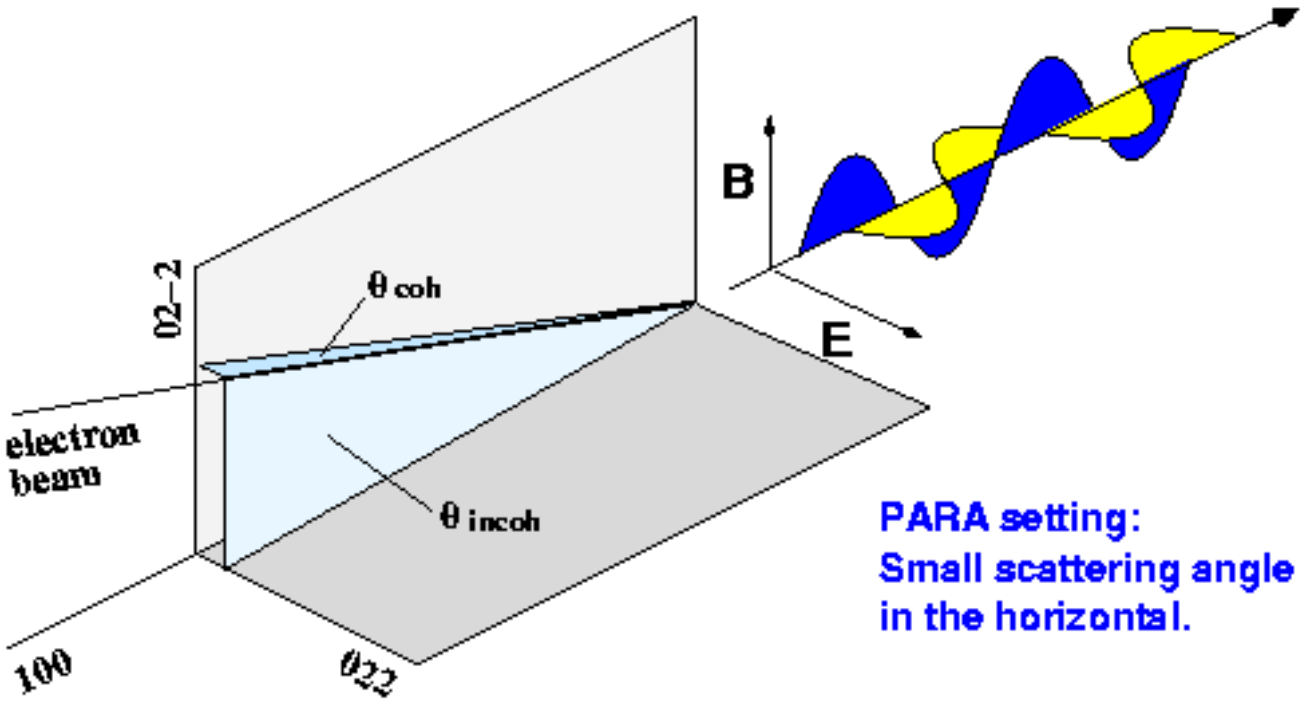


How to make polarized photons
First buy a goniometer….

Align crytal in terms of angles between beam and 022, 02–2 planes

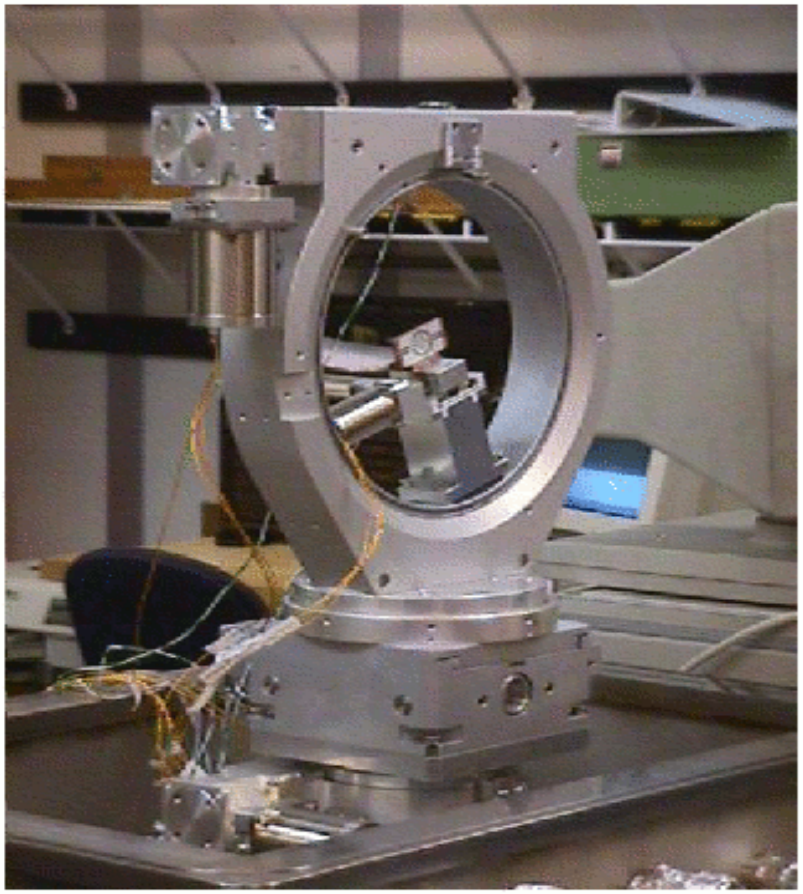
θ_{coh} sets the position of the coherent peak in photon energy spectrum

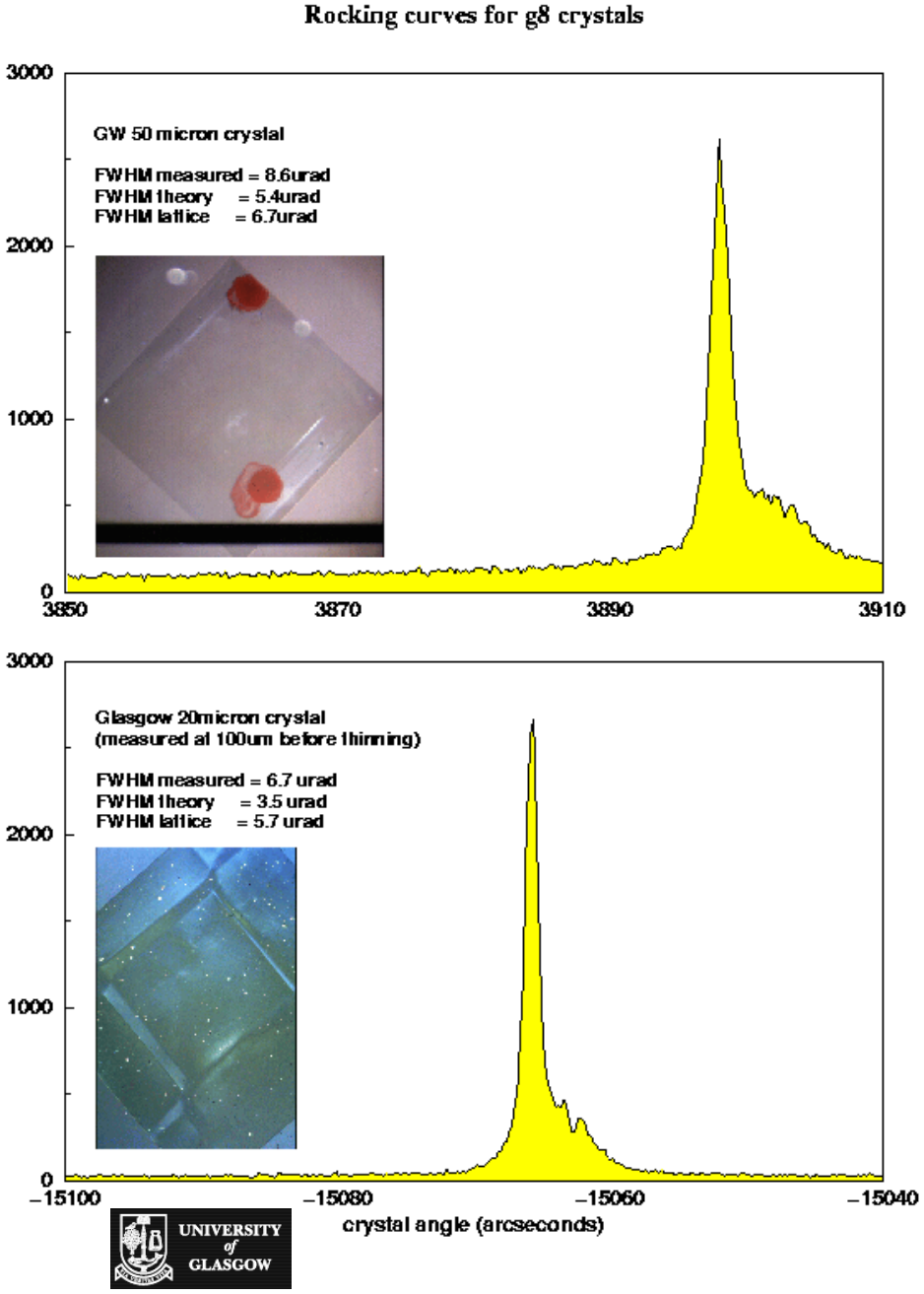
θ_{incoh} set large to remove coherent components from orthogonal planes



PARA setting:
Small scattering angle
in the horizontal.

Goniometer and Diamonds





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WASHINGTON DC

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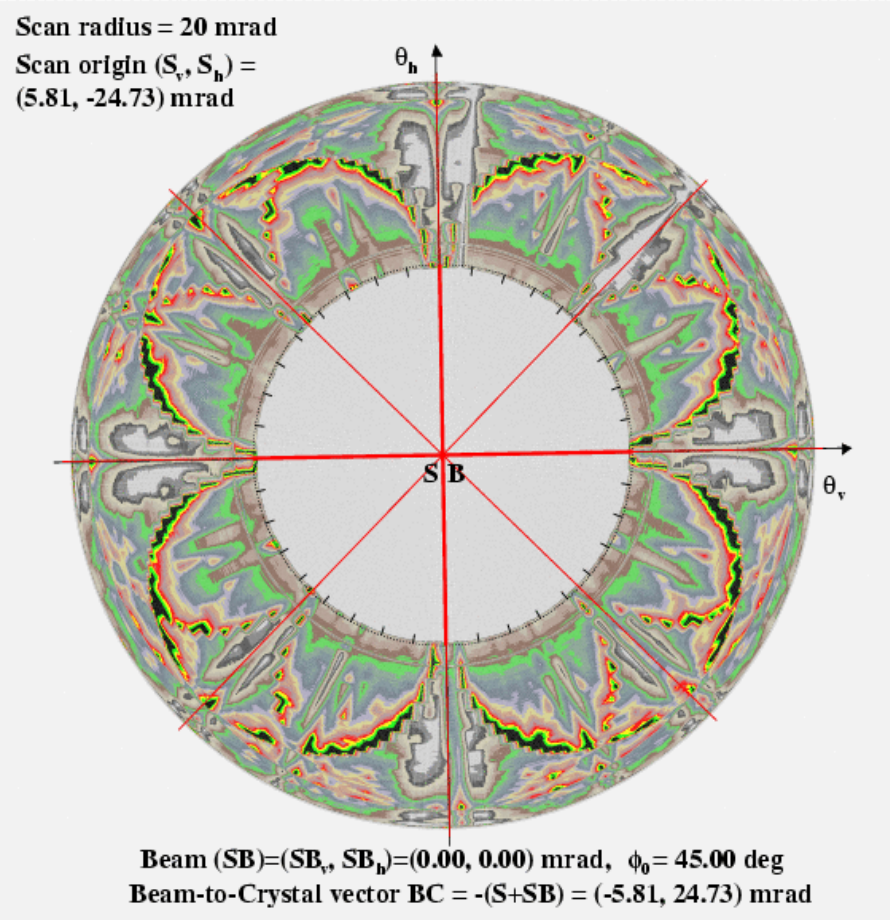
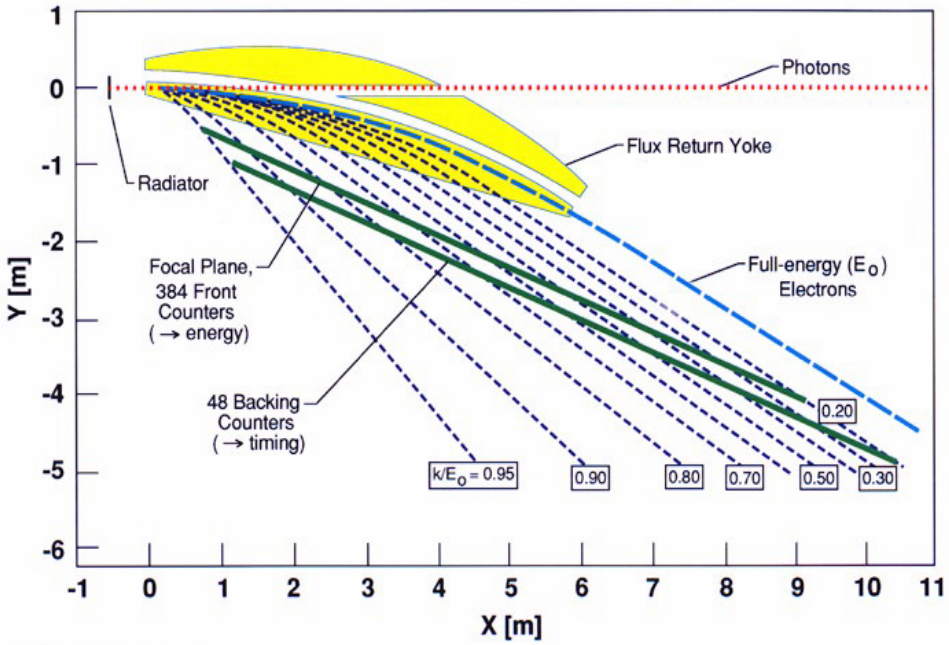
Crystal Calibration

A well-behaved tagger is key for aligning the crystal.





Tagged and Collimated $\vec{\gamma}$ beam on target

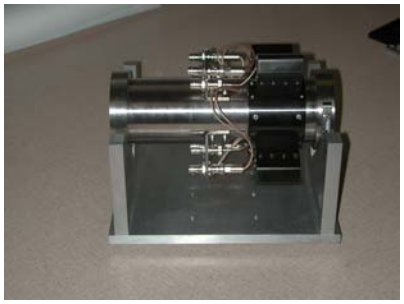
Photon Polarization

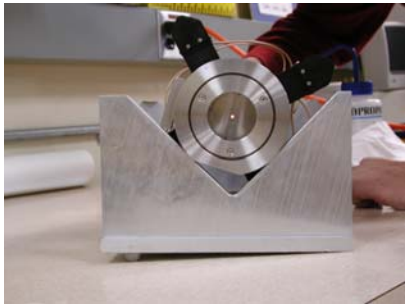
exceeds 90% in the peak

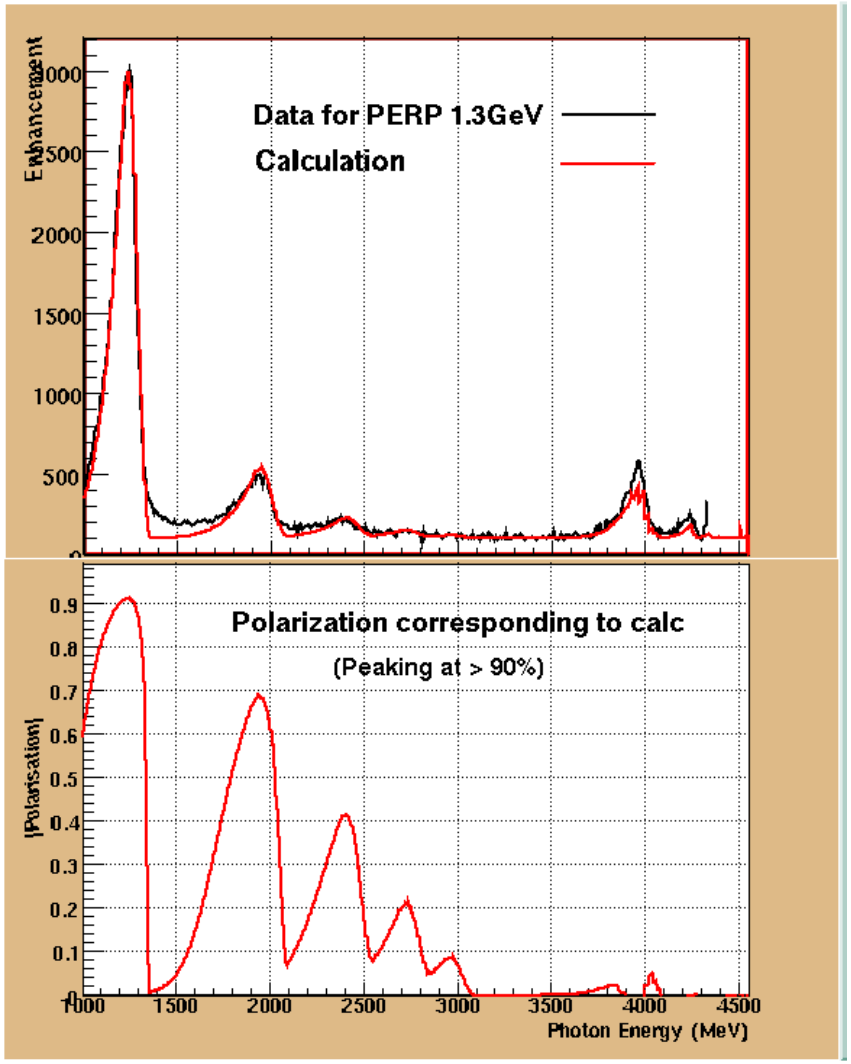
Tightly and Actively Collimated:

~½ of a characteristic angle

(Collimator subtends 44 μradians)







g8b Data Statistics

- The approximate good events, i.e. an event with at least one track at these energy settings is:

  - **1.3 GeV** (1.4 Billion)
  - **1.5 GeV** (2.0 Billion)
  - **1.7 GeV** (1.8 Billion)
  - **1.9 GeV** (1.2 Billion)
  - **2.1 GeV** (0.9 Billion)
  - **Amorphous** (1.8 Billion)

- We extended the the energy reach of g8b to overlap with the energy range spanned by g8a (1.8 to 2.2 GeV).

N.B. in this range of 1.9 to 2.1 GeV, we collected 2.1 Billion (≥ single-track events) for g8b; this number should be compared to the 1.8 Billion triggers (1.3 Billion good events) for g8a.

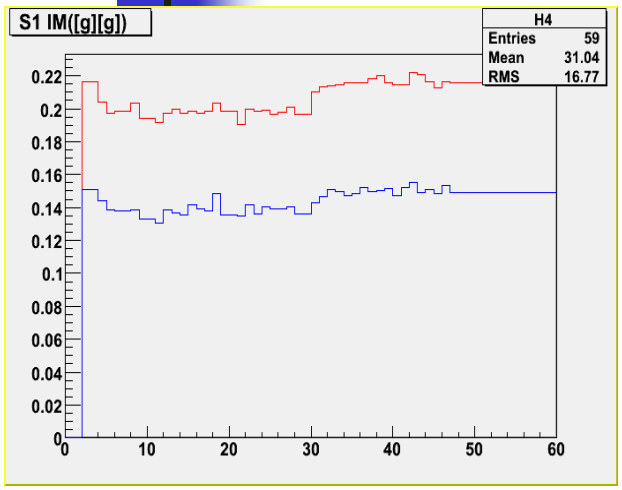
Cooking

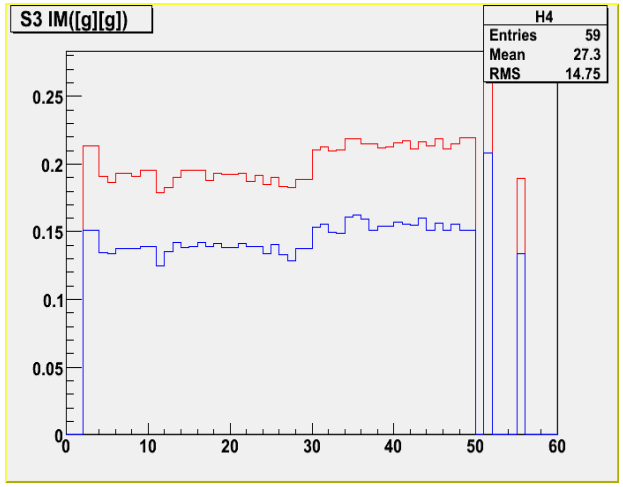
- Pass0 (snapshot) done by Nov. 5
  * studies for *'calibration drift'* i.e. How robust?
  * files: 2nd & 11th (A0 + A10) sampled.

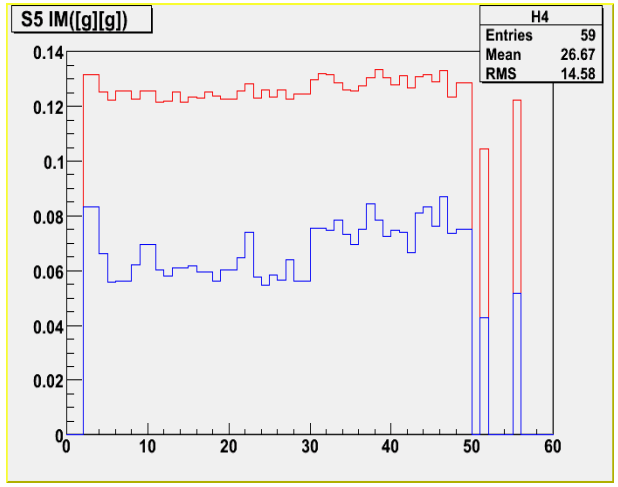
- Cooking about 120 files a day
  * Recsis
  * J. Langheinrich's version of the start counter code
  * CLAS cooking database to monitor output

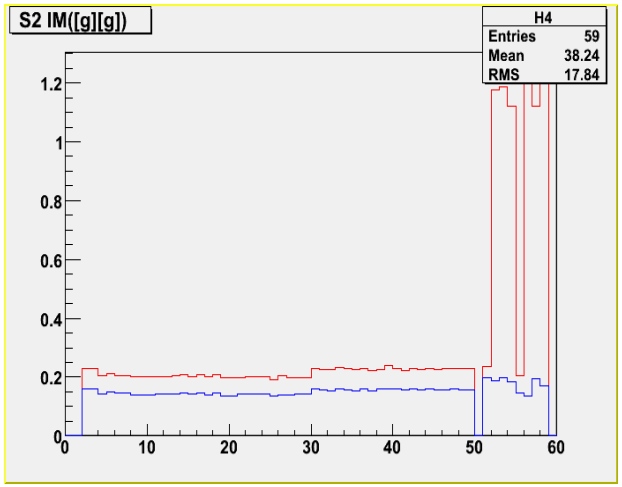
- ASU and Glasgow are taking charge of the Cooking.

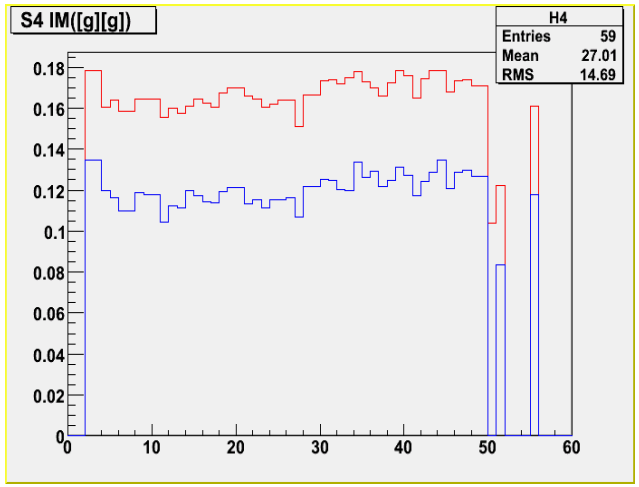
Monitoring: Timeline of π^0 over 60 files (mean and sigma)

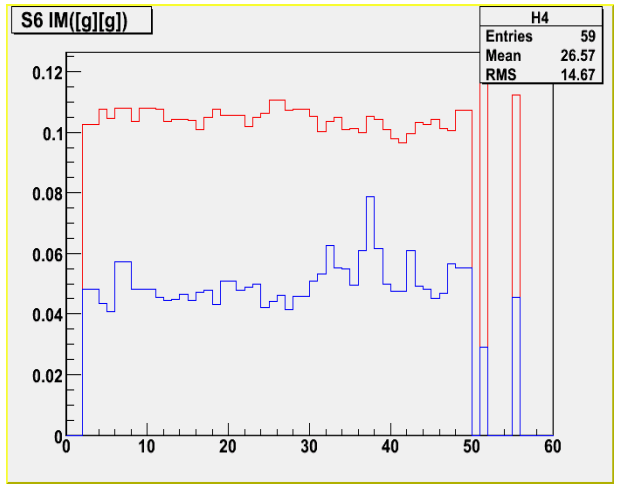








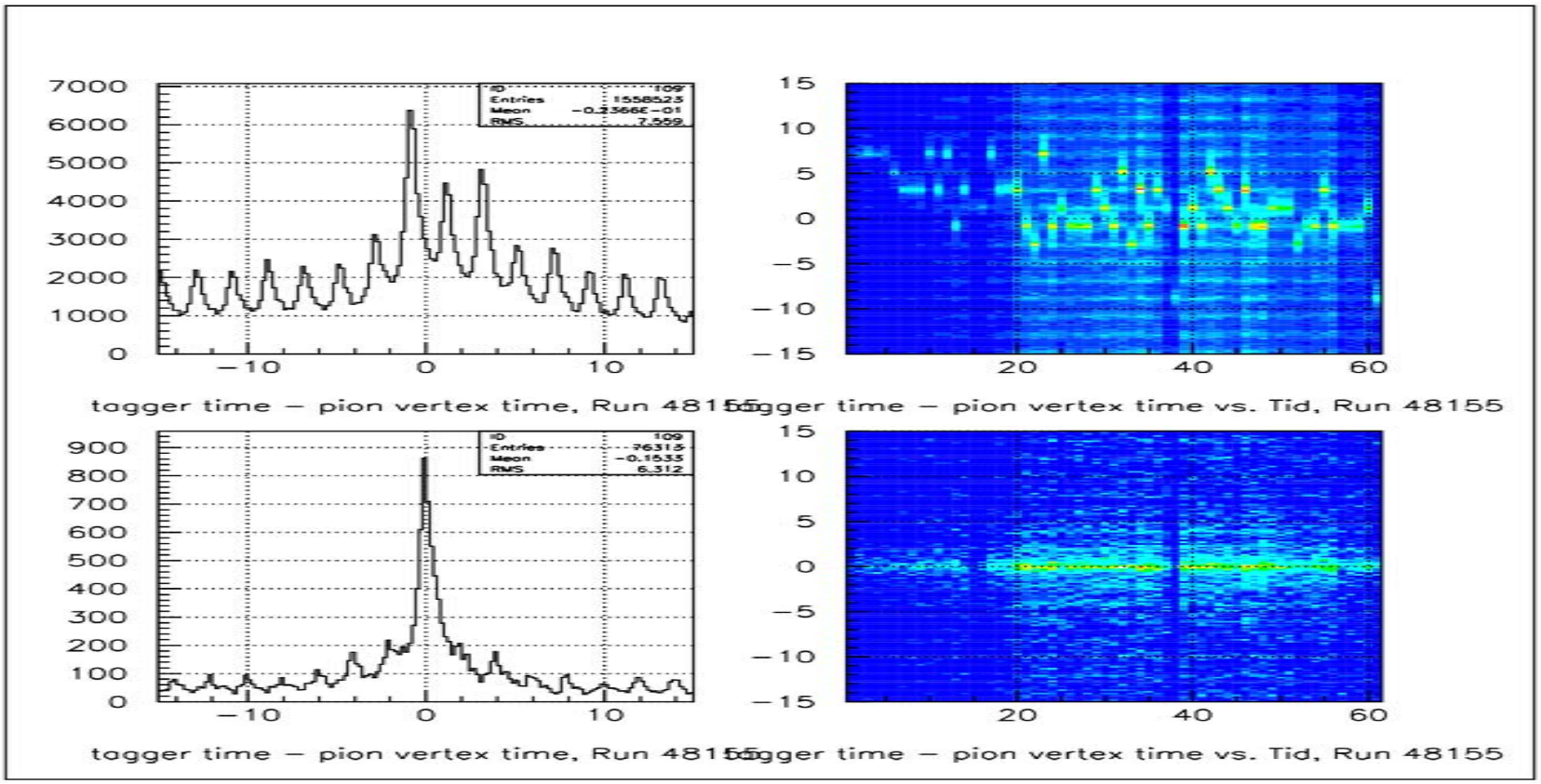




Calibrations

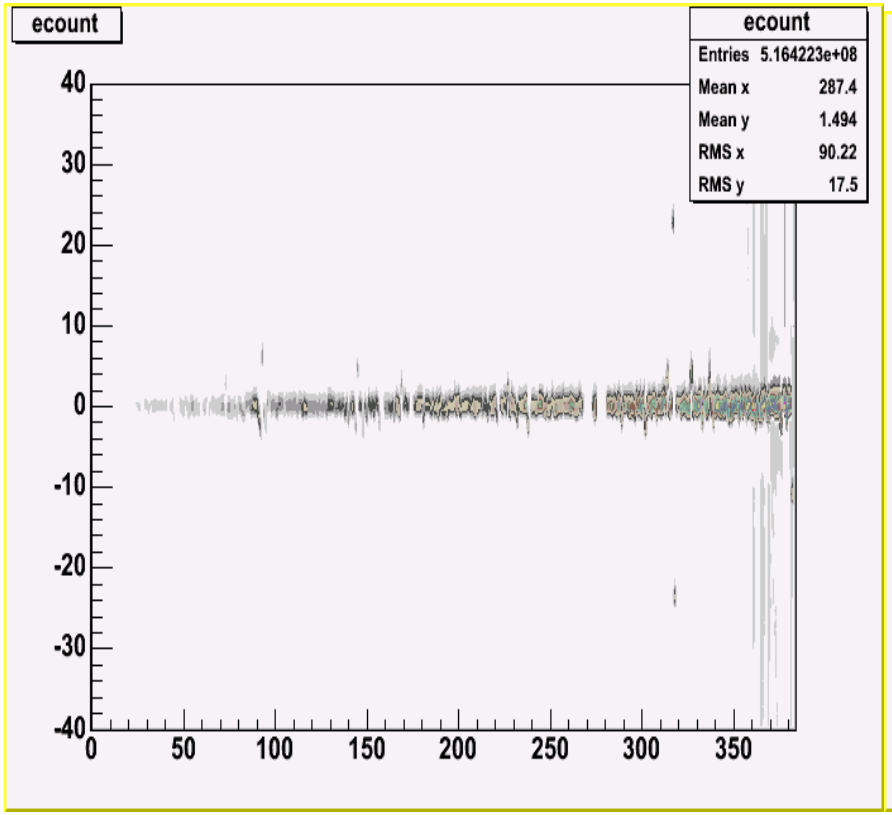
- DC -- CUA
- Start Counter -- ISU
- ToF -- CUA
- Tagger – ASU and Glasgow

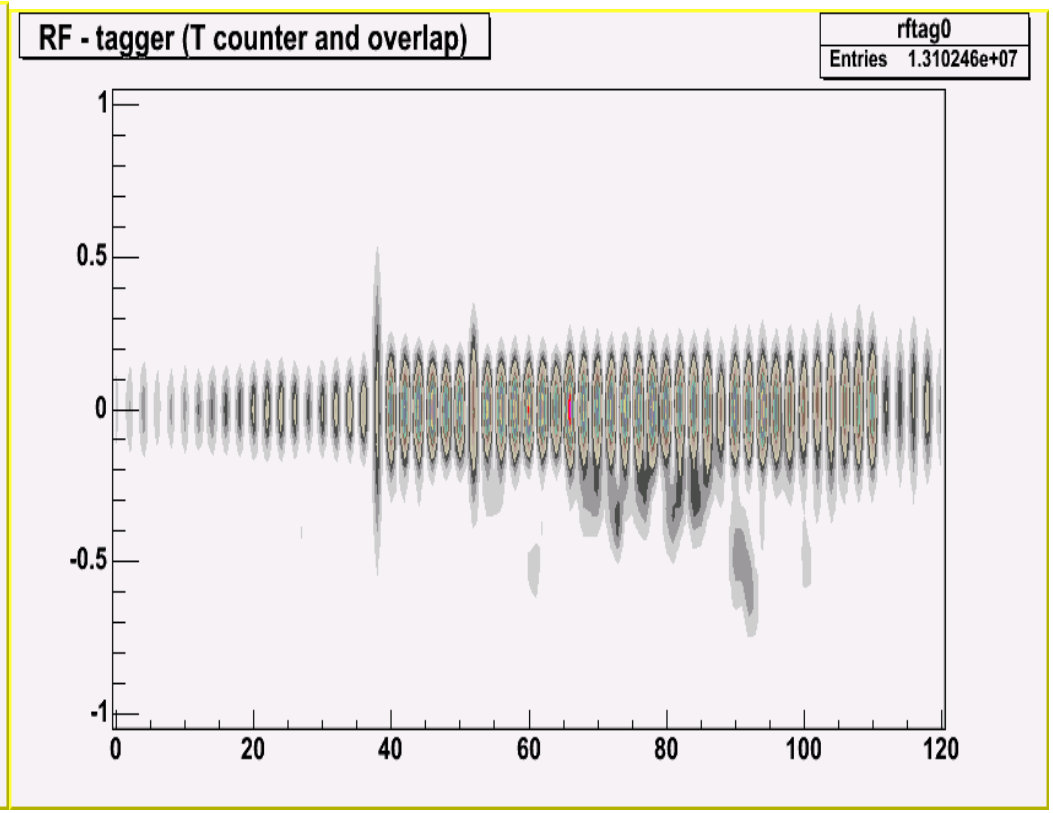
Tagger Calibration: (Before and After)



E-Counter and T-Counter Calibration

Tagger calibration is coming along. Unfortunately, we have evidence of "drifting behavior."





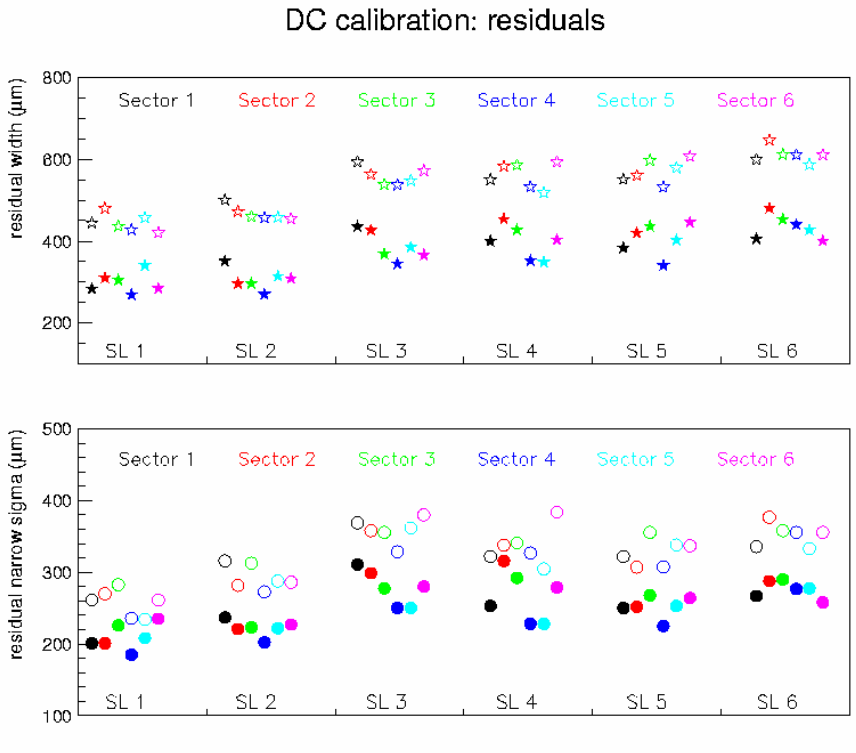
Drift Chamber Calibrations for run 48506

- **Residuals:**

  * Open symbols (before T0 correction)

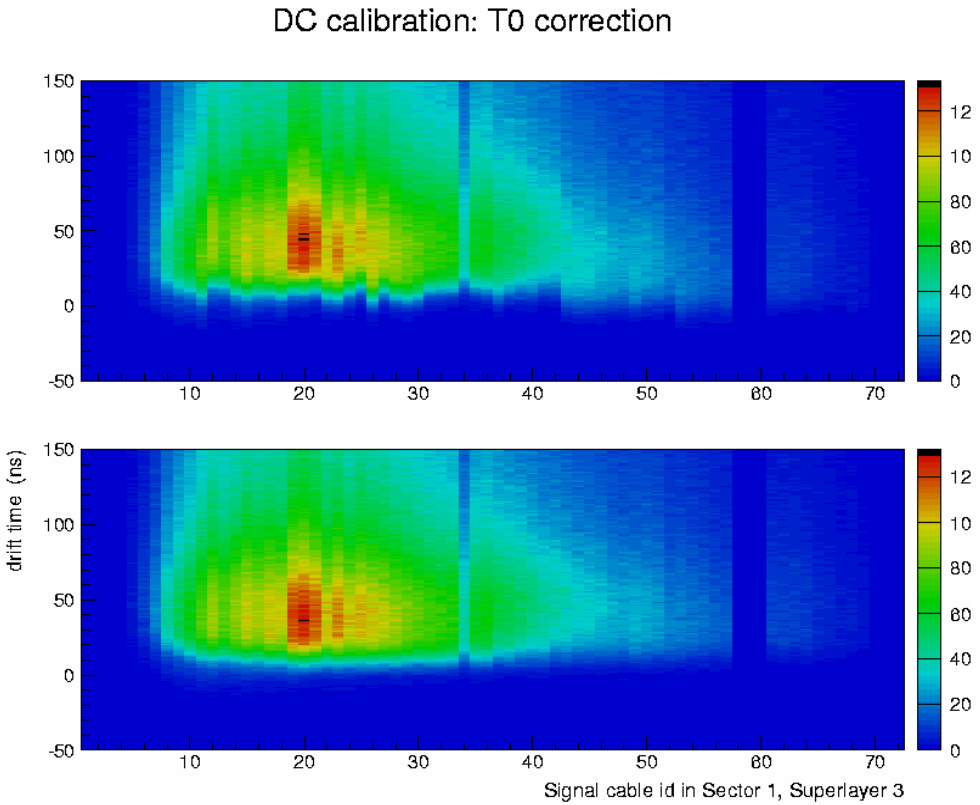
  * Filled symbols (after T0 correction)

- *width* is the weighted average of the narrow and wide sigma of the fit
- *narrow sigma* is a double gaussian fit to the DC residuals per superlayer



Drift Chamber Calibrations for run 48506

- T0=common stop offset is usually accounted for in units of layer number.
- However, T0 varies for each electronic group through which the sense wire signals travel (preamplifier-chip, signal cable, multiplexer-chip, TDC-chip).
- Most obvious are variation for groups of 16 wires belonging to a signal cable (wires are from different layers within a superlayer).



Contributions to the success of g8b

- High beam quality, especially the position stability.
- Hall-B **tagger performance notably better** than before its upgrade in 2002/3.
- Of note is the **DAQ upgrade** with the **pipeline TDCs**.
- The **beamline instrumentation** was **much better** for g8b than for g8a and allowed us to **commission the run** within **six days!**
- Once we set the beam tune parameters on **26 June 2005**, they did not change for the **remaining nine weeks of the production run**.
- The **tagger** was key for aligning the crystal and it **behaved exceptionally well.**

Highlights

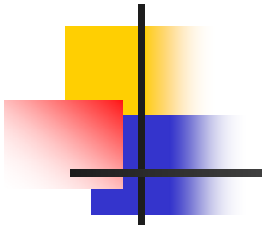
- The PrimeX P.S. was an important tool for monitoring the beam online and for making sure the central core of the coherent peak made it through the Active Collimator.

  It provides additional information over the Active Collimator Instrumentation

- The Active Collimator was sensitive to beam position shifts of ~25μm and the PS count rate for (Ecoh peak) : Amorphous was 6:1

- Thus with a fully operational tagger + goniometer and with the 50-μm diamond wafer, coupled with tagged and tight collimation led to very high polarizations.

- We achieved over 90% polarization in the coherent peak for the 1.3 GeV energy setting. This is a **breakthrough** - the world's highest polarization for coherent bremsstrahlung.



DATA ACQUISITION

- The data acquisition event rate topped out at 5.5kHz (Level 1 trigger) which is nearly double that of g8a.

- It is the tagger -- not the DAQ -- which now limits the rate.
  The tagger cannot exceed a total of integrated rate of 50 MHz and/or a count rate of 5 MHz per T-Counter (e.g. in the coherent peak).

- We further implemented a second-level trigger, which required a drift-chamber track within the region defined by the sector-based trigger.
  This brought the event rate to 3.0 kHz for a livetime of 90%.

- The g8b data sample is therefore very rich (at least one track per trigger) and exceptionally clean.
  What we did not require, however, was a coincidence with the tagger, since at these high rates it buys us very little.

Hardware improvements (over g8a)

- Focusing and steering quadrupoles upstream of the goniometer.

- A rewired and fully-tested and calibrated goniometer.

  This allows for flipping orientations of the diamond radiator from perpendicular to parallel settings, i.e. swapping the polarization axis by 90 degrees.

  This will clearly improve our understanding of the systematics for track reconstruction in the CLAS in extracting the polarization observables.

- Well-behaved Tagger + new VME electronics for the E-Counters and pipeline TDCs for the T-Counters.

  All 384 E-Counter channels are read out independently and are very robust, i.e. they do not spark and interfere destructively with their neighbors as was the problem during the month-long commissioning phase of g8a.

- Sweeper magnet after the collimator.

Further Hardware improvements

- e^+e^- pair polarimeter
- Fully commissioned and instrumented PS (PrimEx).
  The *fore/aft--left/right* arrangement of the PrimEx pair spectrometer telescopes afforded a nice (*and independent)* way of monitoring the flux in the coherent peak.
- Photon harp scanner
- Beam offset monitor
- Longer target
  (400 mm vs the 180-mm one for g8a)
- Highly-segmented start counter
  (24 paddles vs the 3-paddle segmentation for g8a)
- gamma profilers (*x* & *y*)
- new Total Absorbtion Counter

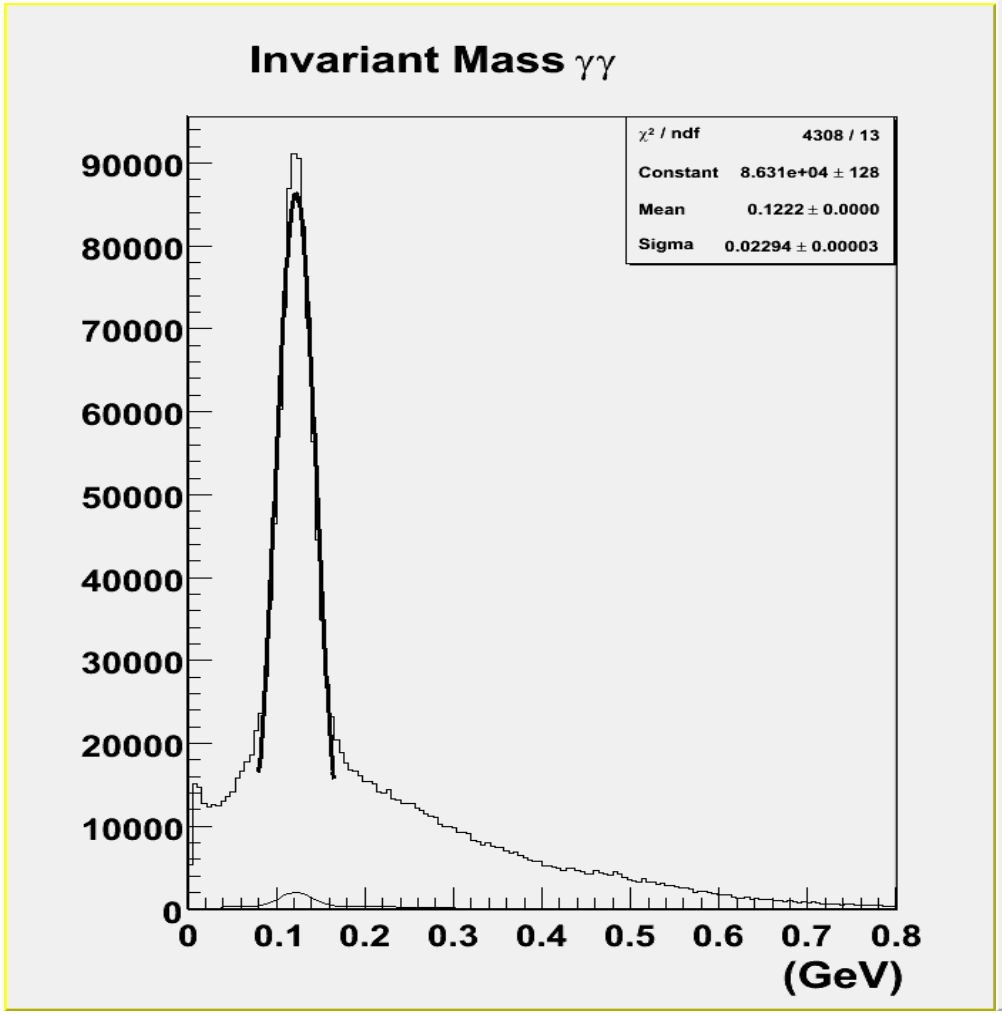
Things that need improvement for the Coherent Bremsstrahlung Facility

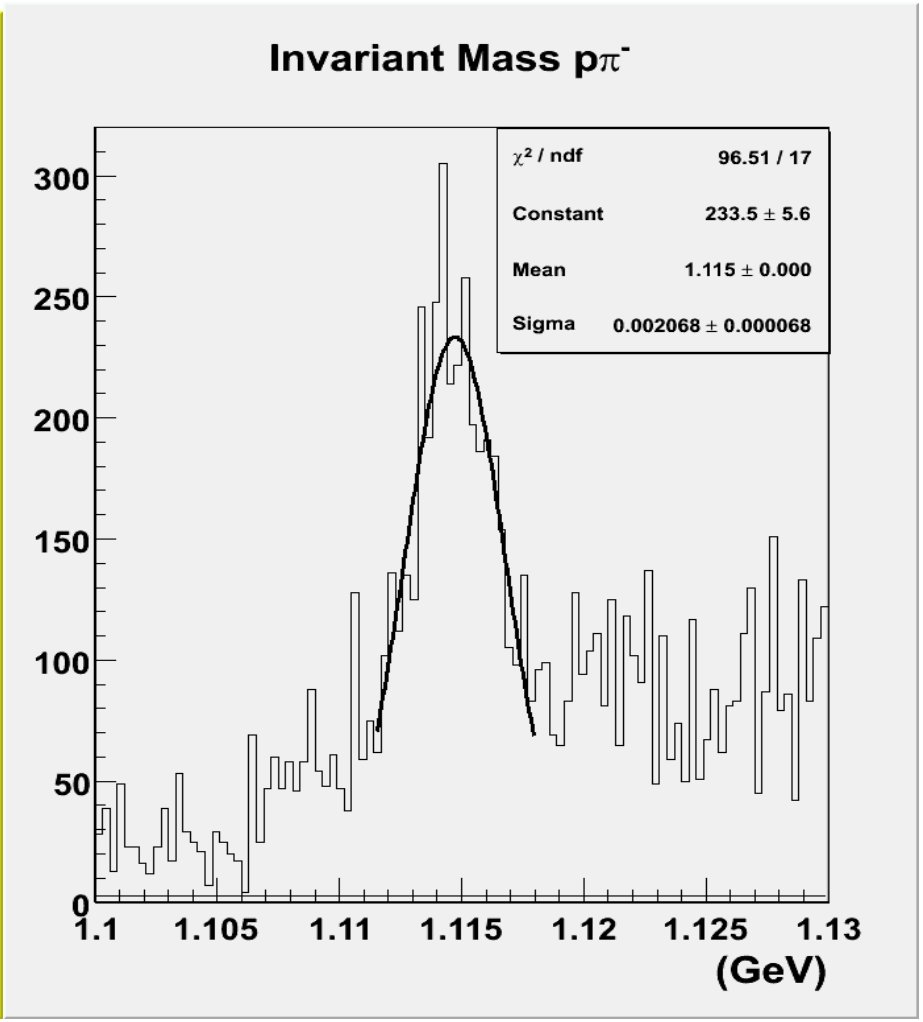
- Need a platform to raise and lower the collimator

  so that we may move the collimator to the beam. Steering the beam to the aperture of the collimator is NOT GOOD; it messes up the beam optics and it takes at least an EXTRA DAY of commissioning time to find the "sweet spot."

- Polarimeter

Invariant Mass Distributions: Λ and π^0

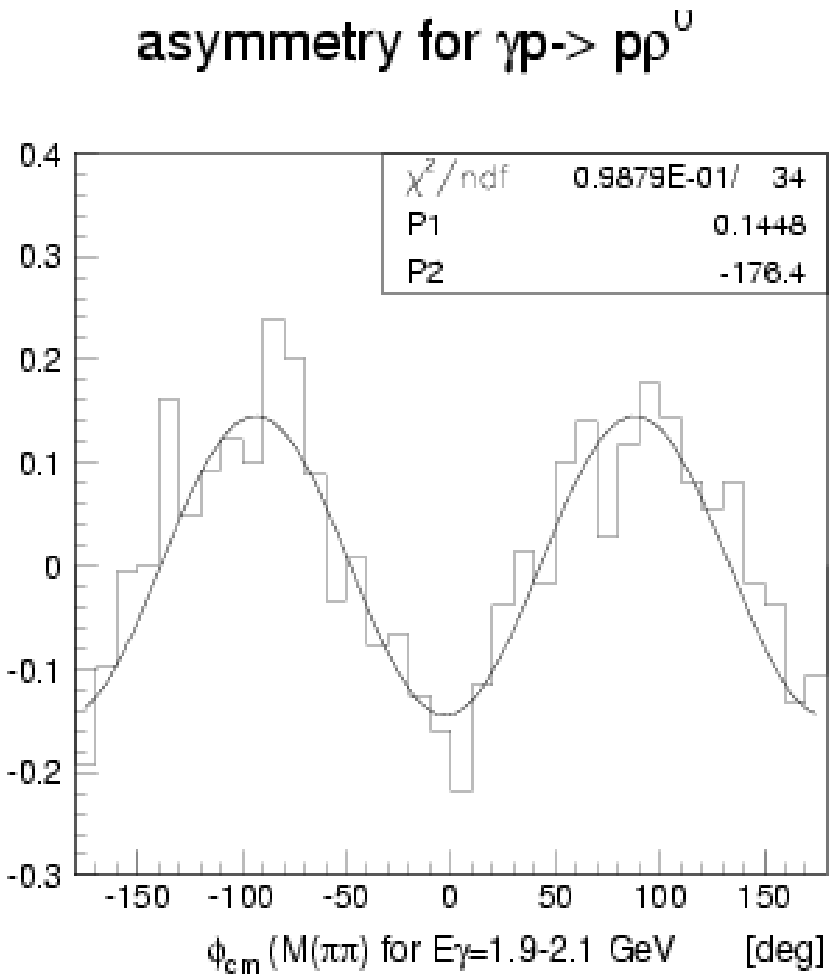


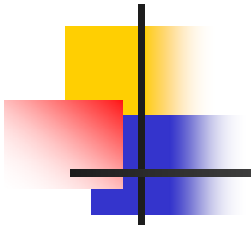


Asymmetry Analysis

Preliminary analysis for ρ^0
at low $|t|$ (< 0.30 GeV^2)
coherent edge at 2.1 GeV
(4 PERP-runs normalized)

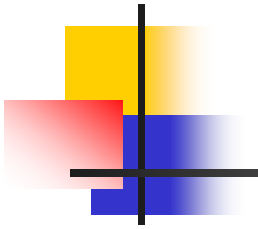
30,000 events





Time estimates

- Calibration and cooking (data summary tapes): 9 months
- MC studies and efficiency calculations: 12 months
- Analysis for channels $\rho^0\pi$, ωp, πp, KΛ/Y, ηp. 12 months.



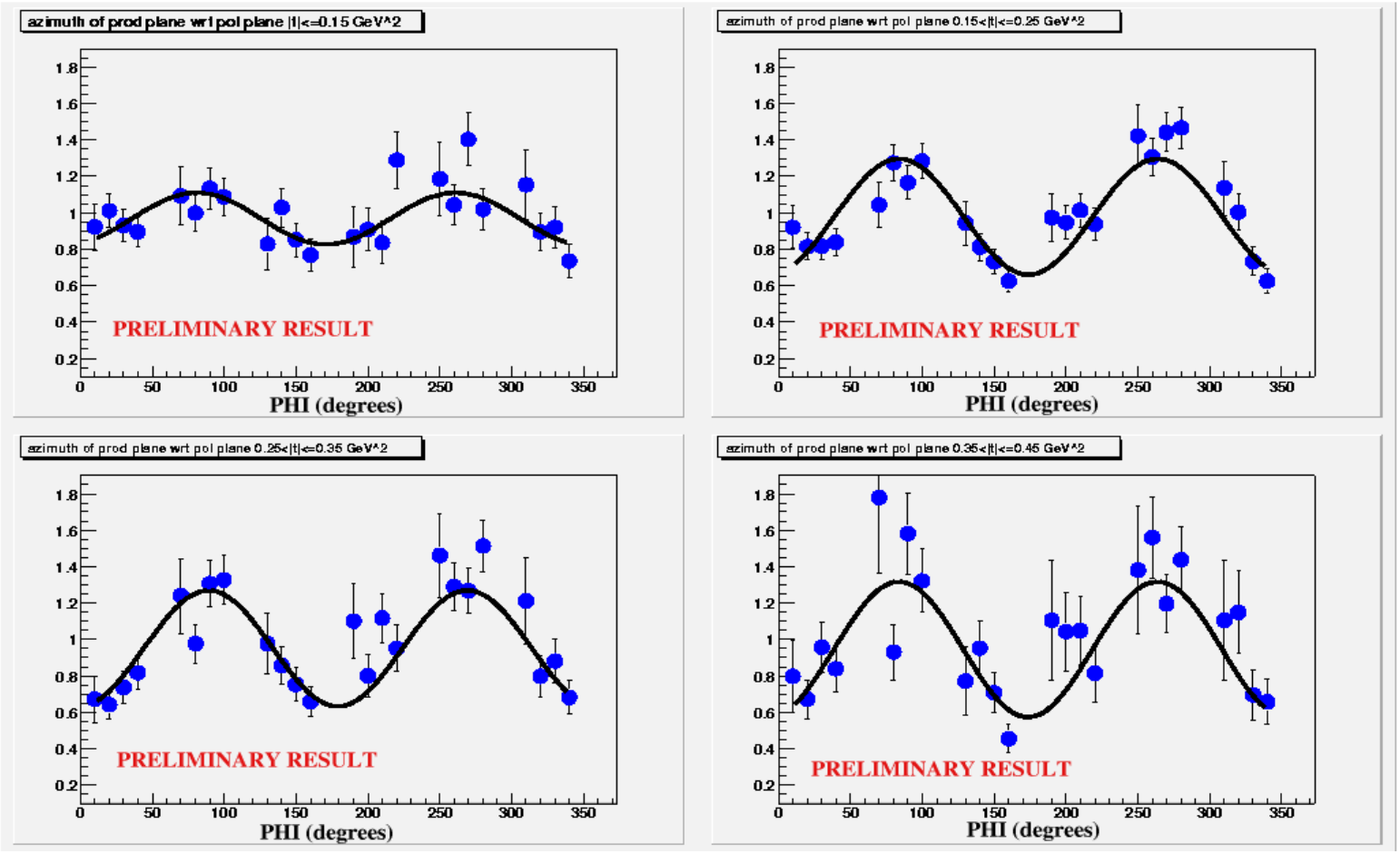
The g8b Group extends its thanks to

- The MCC folk
- The survey group
- Dave Kashy's crew
- Collaborators…

- EXTRA STUFF...

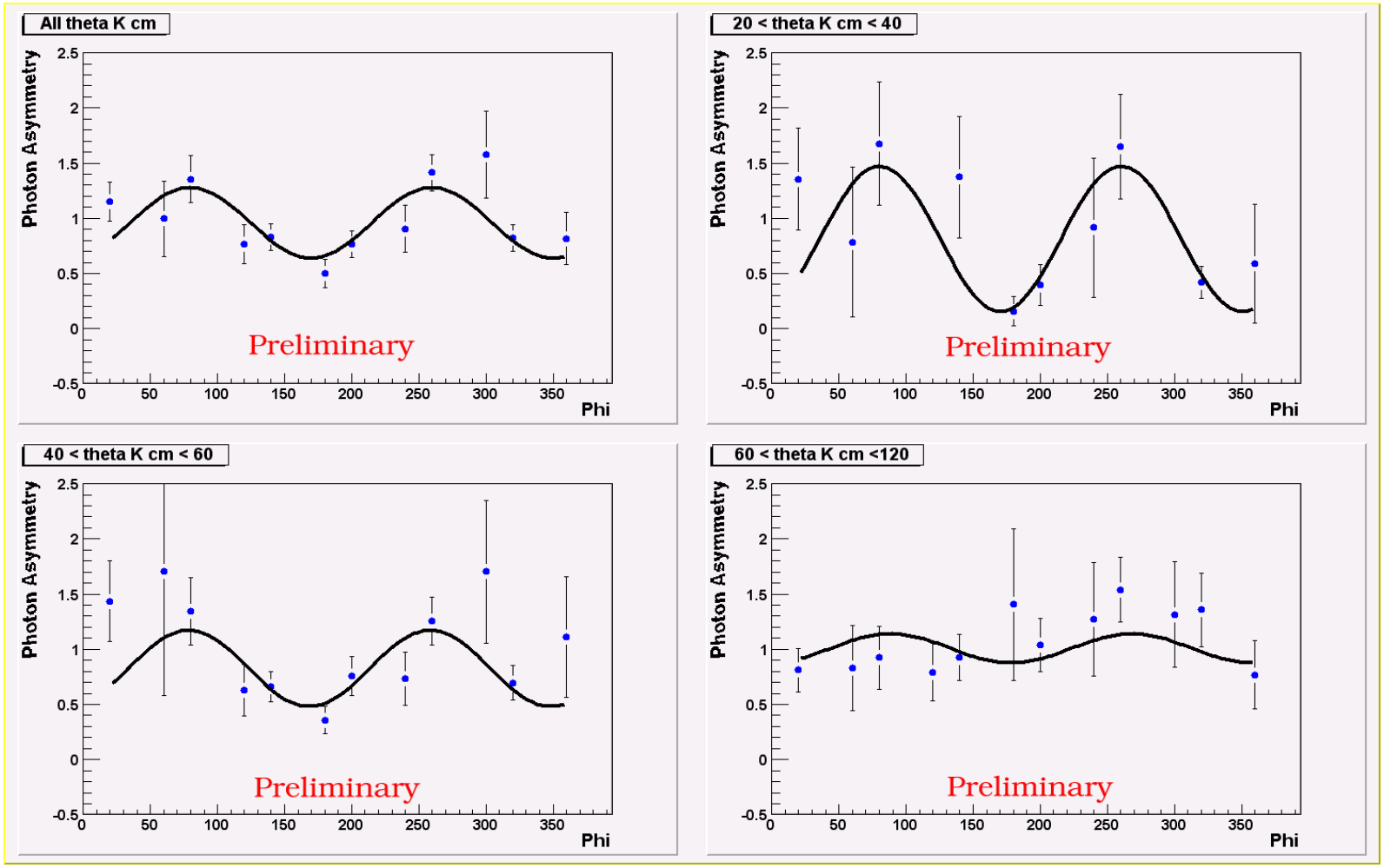
g8a (2001) results
(Chris Gordon – Glasgow University)

ρ^0 production at 2.0 - 2.2 GeV



g8a (2001) results
(Joseph Melone – Glasgow University)

$K\Lambda$ production at 2.0-2.2 GeV

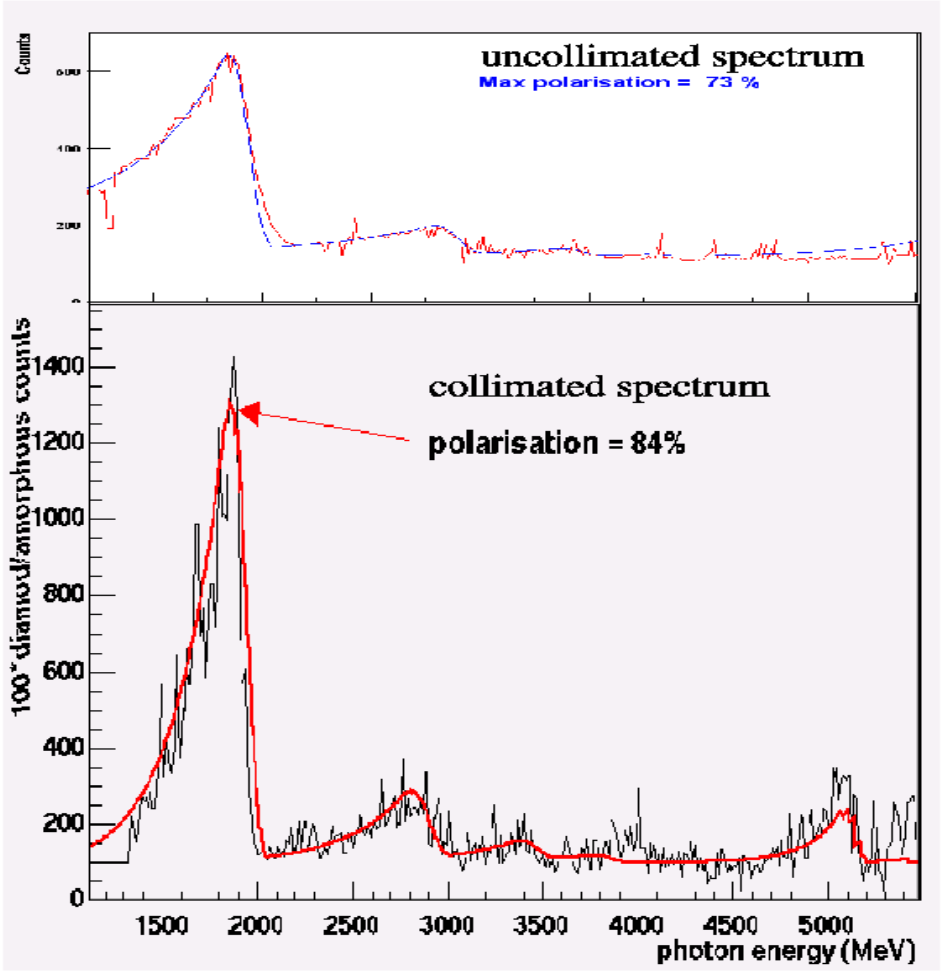


g8a (2001) results

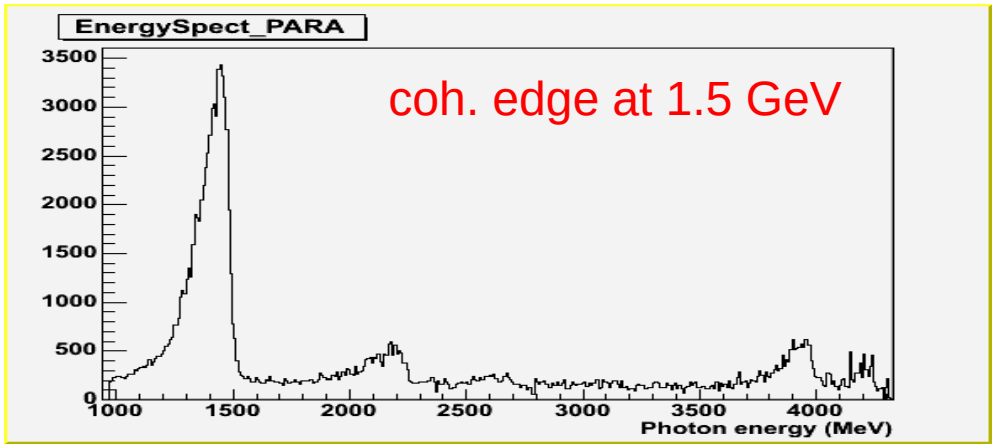
Photon Polarization

Before and after collimation

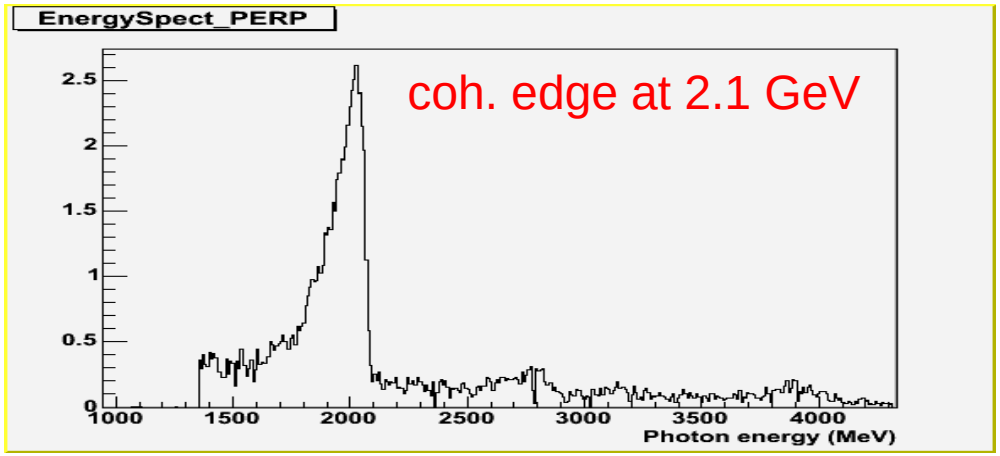
Tightly and Actively Collimated:
~½ of a characteristic angle
(Collimator subtends 44 μradians)

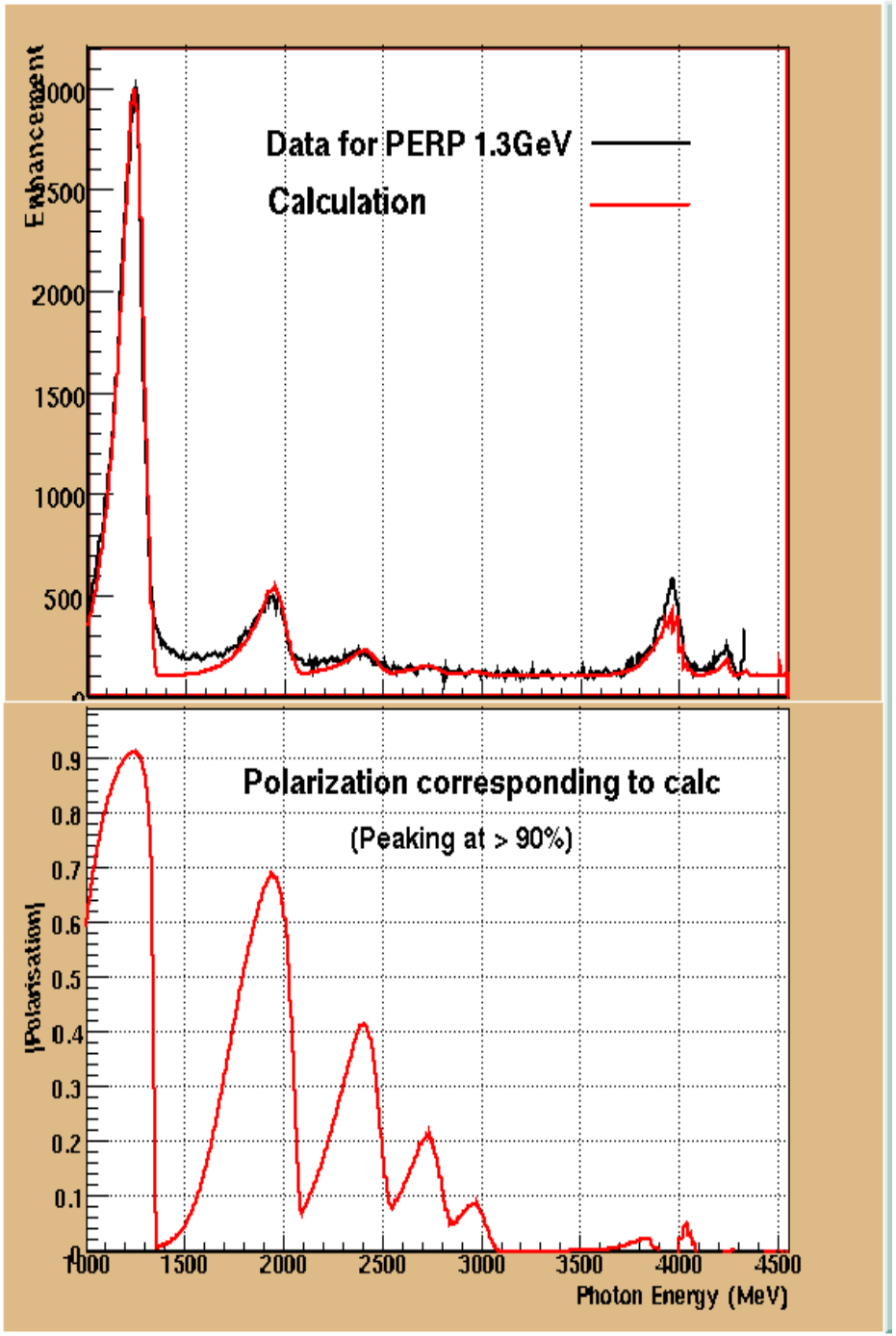


Photon Polarization for g8b



x1000





Problems ????

- **Polarized photon beam produced via coherent bremsstrahlung on a 50-μm thin diamond.**
  However, the diamond didn't provide equal degrees of polarization for parallel and perpendicular orientation when we were in automated flip mode.

- **Ken Livingston did solve the problem in late July by using a full rotation of 90 degrees.**
  It took 20 min to switch to the new position.