Qweak "Halo" Experience and Injector Studies

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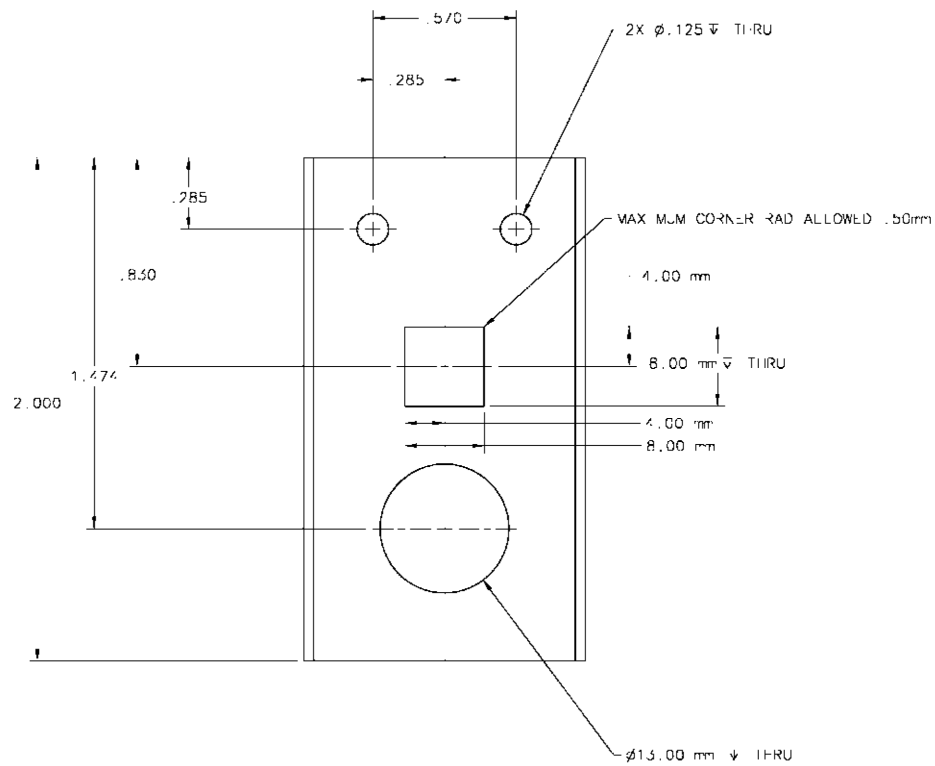
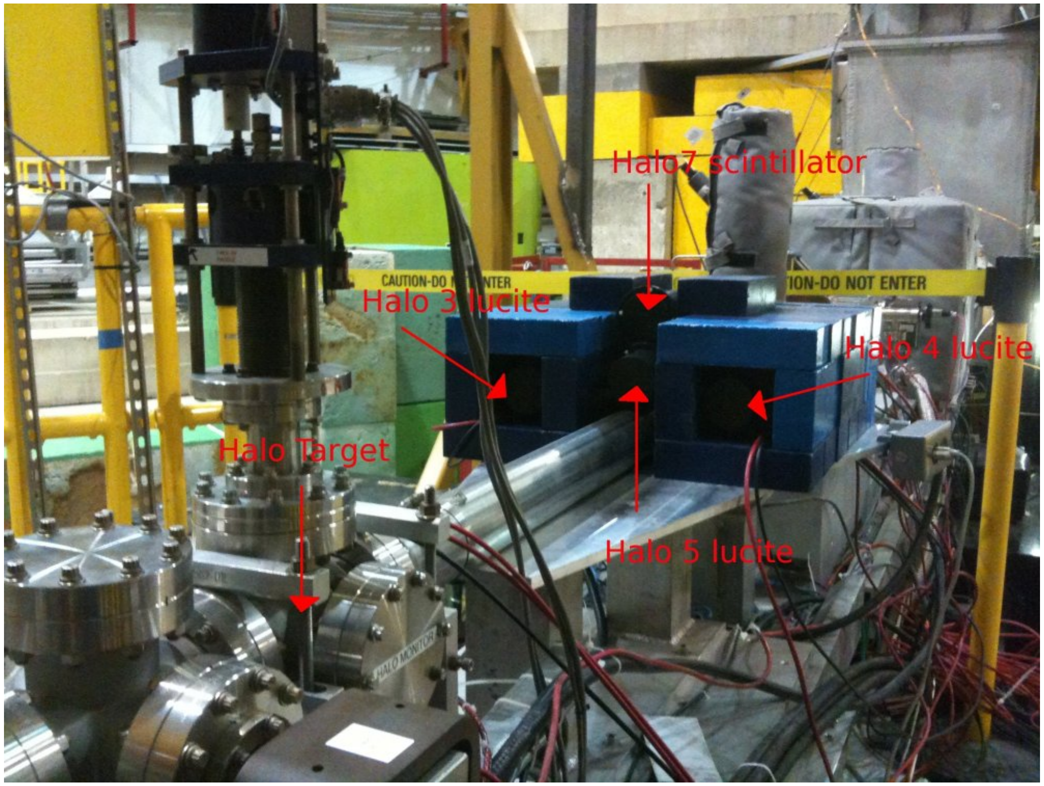
March 5, 2015

- Qweak Beam Halo Measurement System
- Qweak Beam "Halo" Experience
- Relevant Injector studies

Qweak Beam Halo Measurement System





Halo target: thin aluminum with two holes, mounted near usual Hall C pivot on superharp linear drive mechanism

•8 x 8 mm square hole (for invasive check on beam halo "specs")

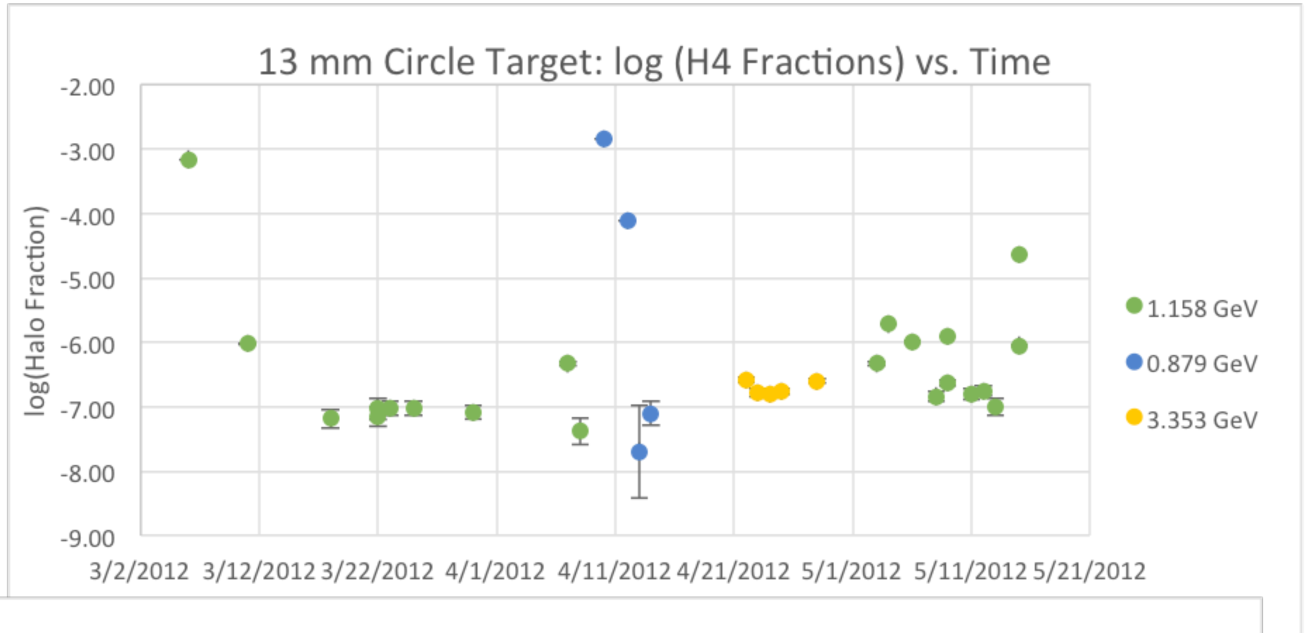
•13 mm diameter hole; to put in place during routine production running

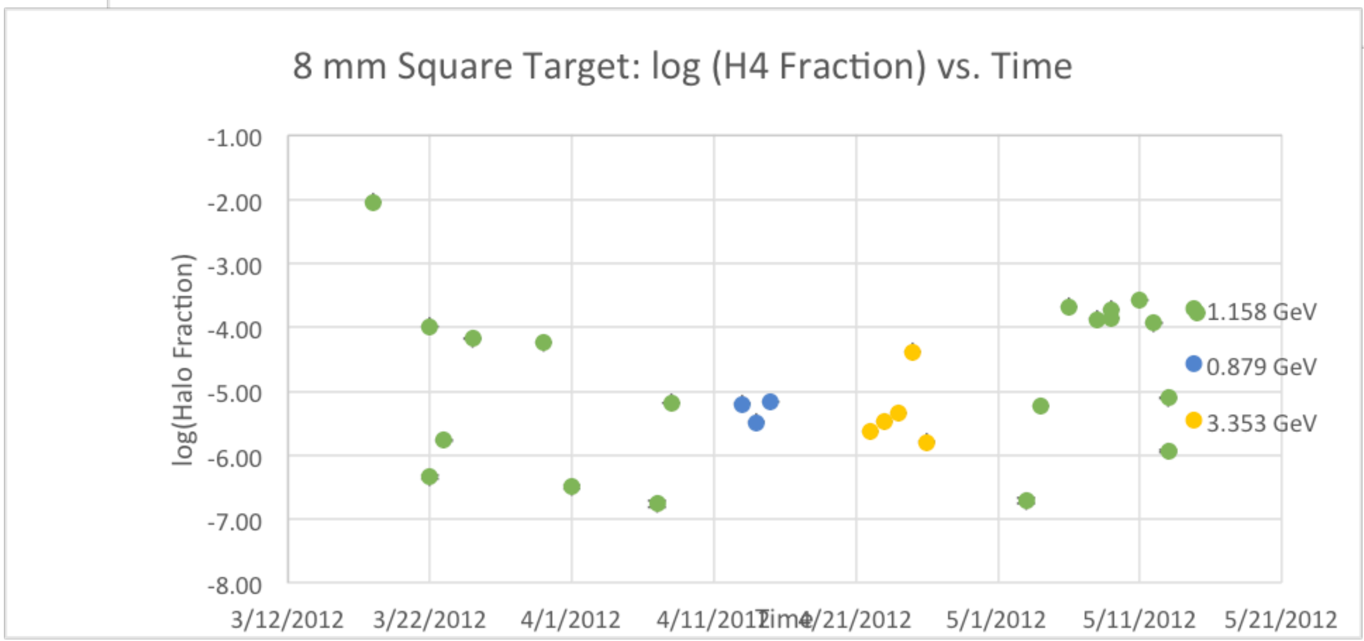
→ size of the smallest aperture in the experiment – tungsten beam collimator

Monitored with lead shielded lucite+ 2 inch PMT "halo monitors"

Calibrated by putting 1 nA of beam directly into halo target frame

Typical Qweak Halo Characterization Results





13 mm Halo “Circle” Target: Typical: $10^{-7} – 10^{-6}$ but as large as 10^{-3} observed

8 mm “Square” Target: Typical: $10^{-7} – 10^{-4}$ but as large as 10^{-2} observed

Qweak Beamline Background Experience

- During Qweak there appeared to be a component of the beam (“halo”) that could develop a large helicity-correlated charge asymmetry.

- We referred to it as “beamline background” because the signal that came from this component that got into our primary detectors appeared (based on “tungsten blocker” studies) to originate from secondary scattered events in the “tungsten beam collimator” (our limiting aperture) and the beamline just downstream of it.

- Set the scale: This component could typically have ~ 5000 ppb charge asymmetry but only contributed 0.19% to our main signal.

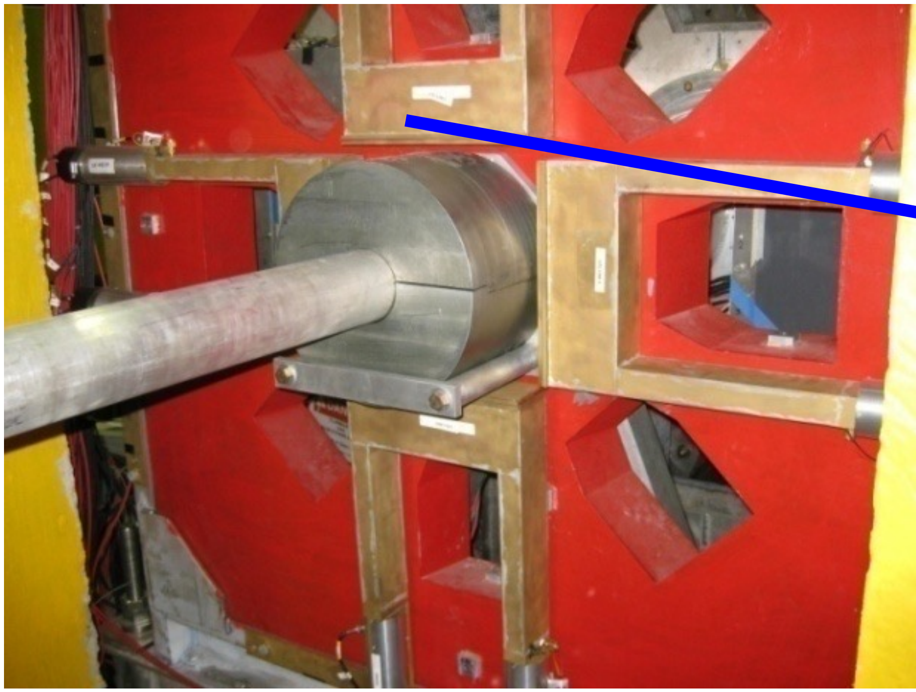
  False asymmetry ~ (.0019) * (5000 ppb) = 10 ppb

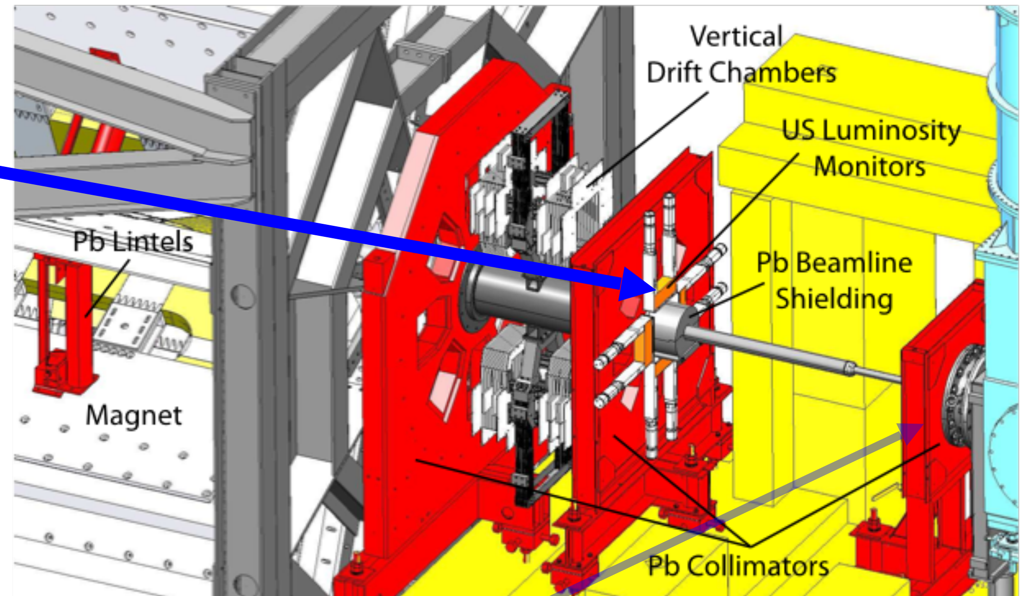
(Compare to Qweak asymmetry ~ 200 pbb, MOLLER asymmetry ~ 30 ppb!)

- Symptoms:
    - otherwise unexplained “false” asymmetries in main detector
    - asymmetries in ancillary detectors (esp. “Upstream Lumi”)
    - additional noise in upstream lumi

Upstream Luminosity Monitors

Four symmetrically placed quartz blocks (read out with 2 lightguides each) placed on the primary, defining collimator (Collimator #2)





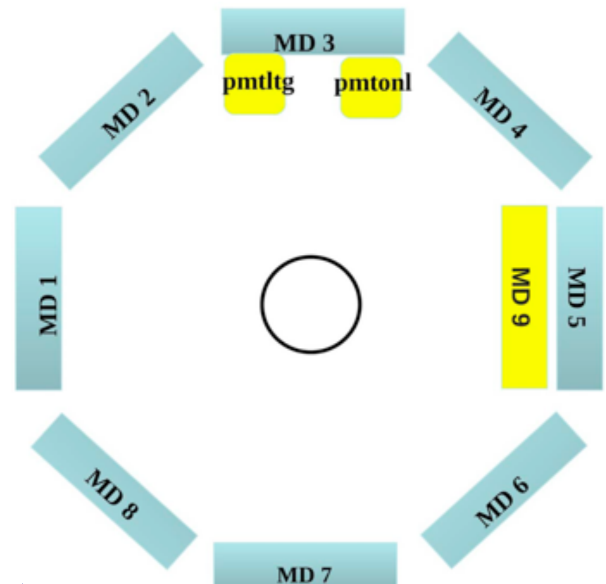
Designed to primarily detect ~ 50 MeV Moller electrons (~ 100 GHZ rate@ 180 uA) but (from octant blocker studies) ~ 50% of their signal remained when their own octant was blocked – presumably the bulk of this comes from incompletely contained showers in the "tungsten plug"

Summary of situation for PRL result from Mark Dalton 2012 DNP talk

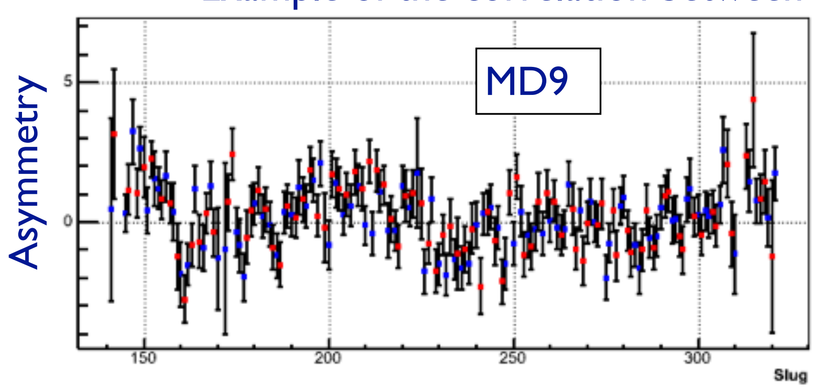
Beamline Background Asymmetry

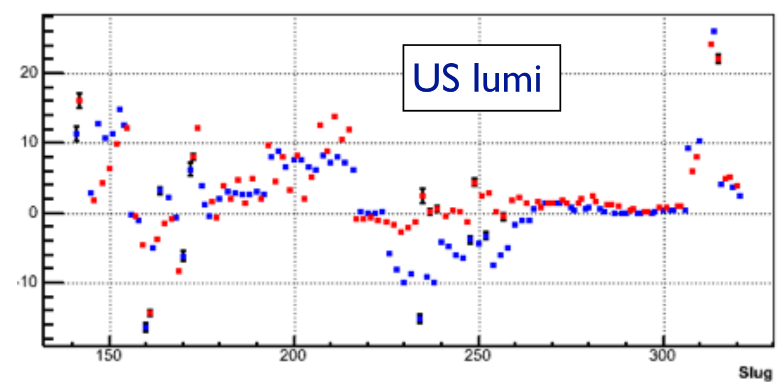
$$C_{\text{beamline}} = -10.2 \pm 23.5 \text{ ppb}$$

- Various "background" detectors observed highly correlated non-zero asymmetries
- Asymmetries were primarily from beamline background (hypothesis: asymmetric "beam halo" events interacting in Tungsten beam collimator and beamline)
- Beamline background contributes only ~0.19% to the signal of the main detectors.
- Background detectors provided continuous monitoring of any asymmetry associated with this background
- Correction is determined from the upstream lumis.
- Relationship to main detector determined using a variety of methods (including direct blocking of primary events), appears to be well understood.



Example of the correlation between background detectors.

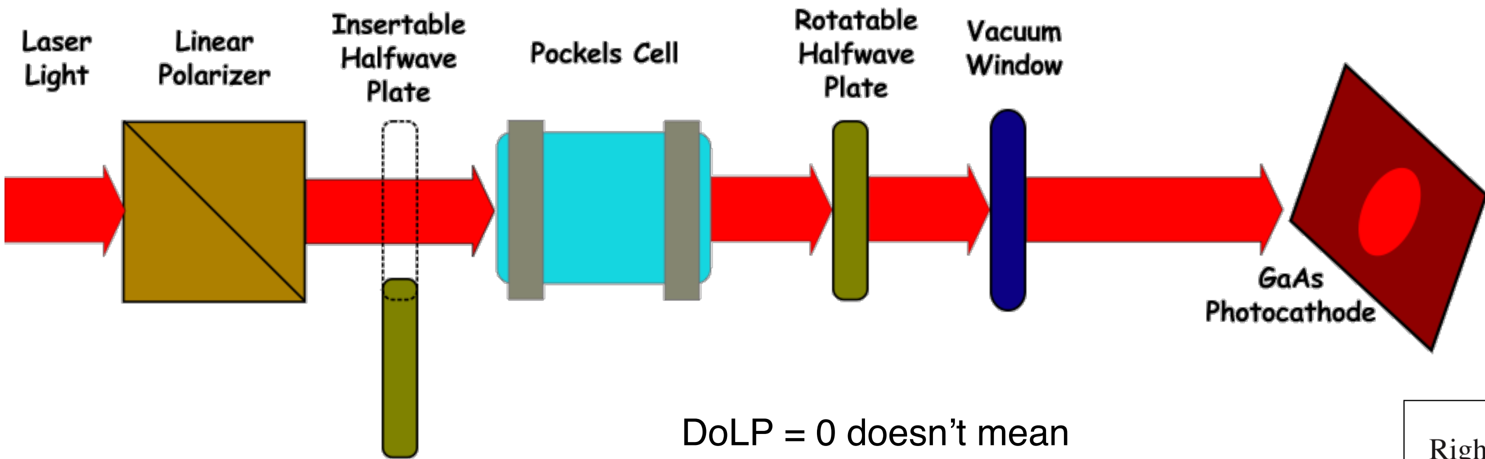




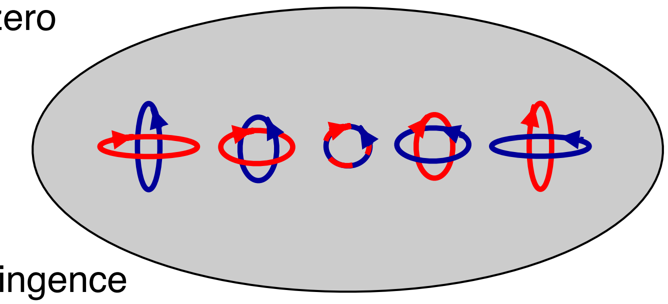
Possible connections to injector?

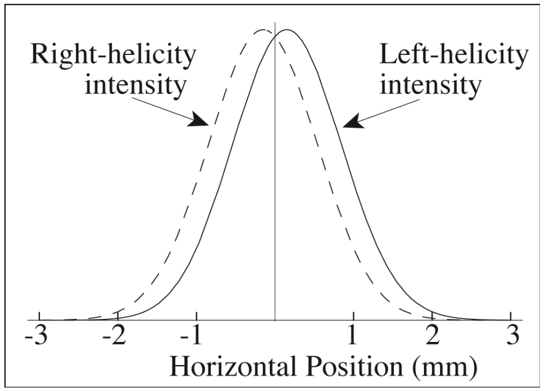
- Fringe, halo, tail… at injector apertures?
- Machine tuning vs “halo”
- laser phase vs. “halo”
- longitudinal structure in helicity asymmetry?

Laser, Cathode, Injector

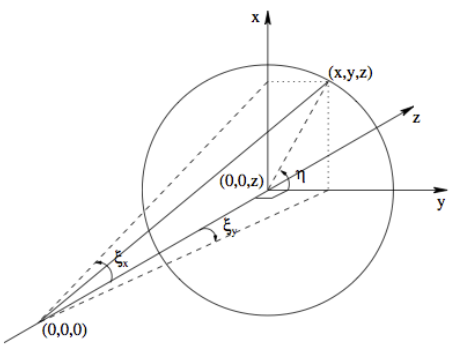


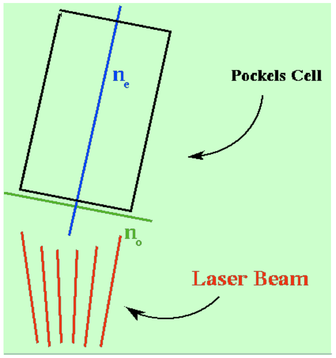
DoLP = 0 doesn't mean the spatial variation of LP is zero



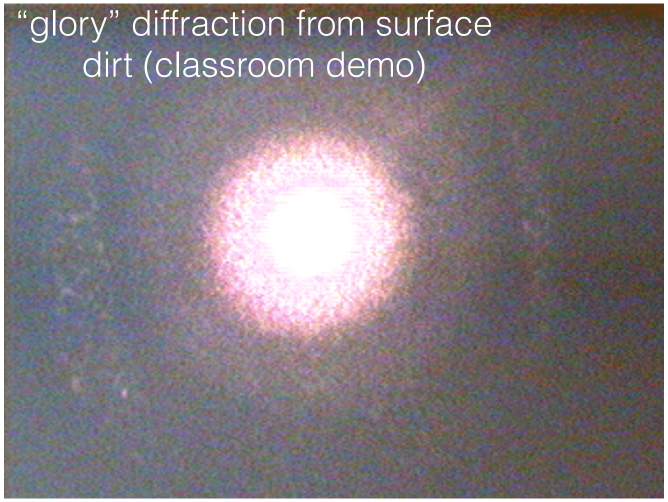


Angle is critical: larger angle = much larger birefringence

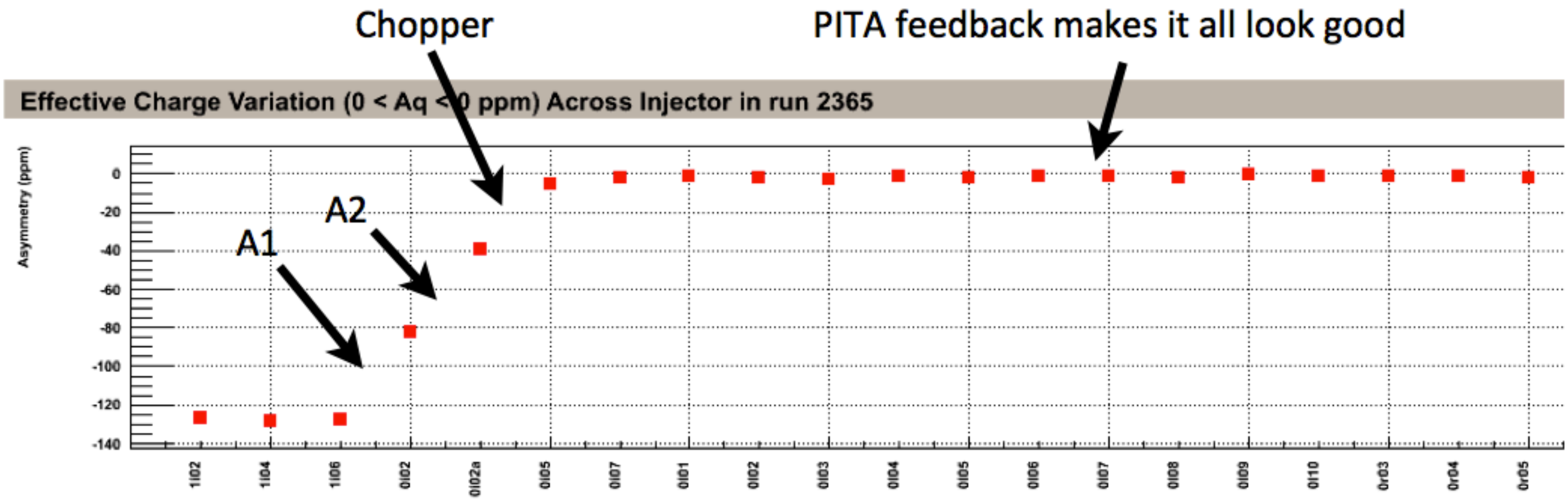




How do off-peak electrons get collected?
Longitudinal, transverse differences possible?



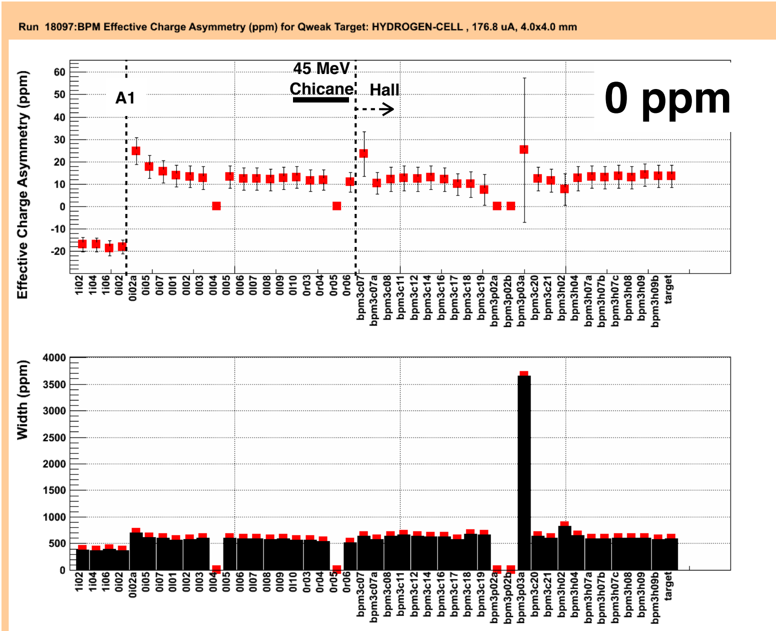
Injector Apertures

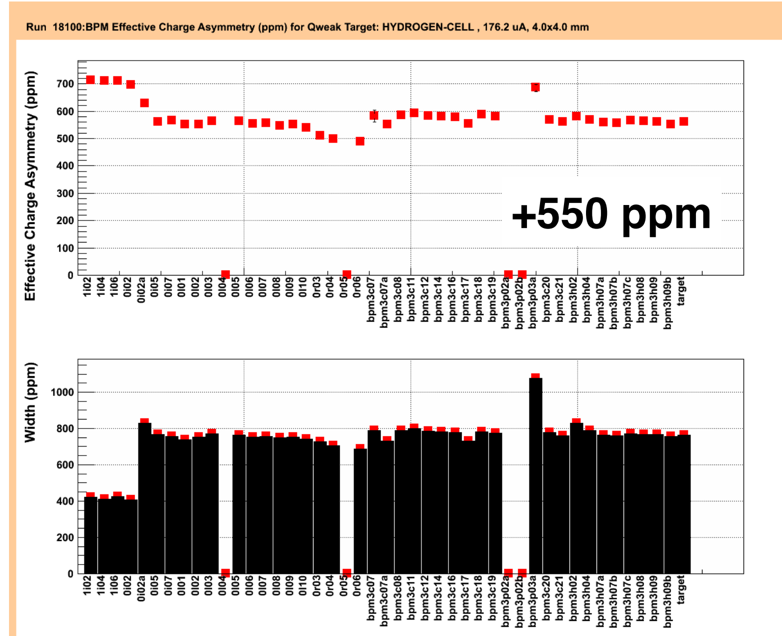


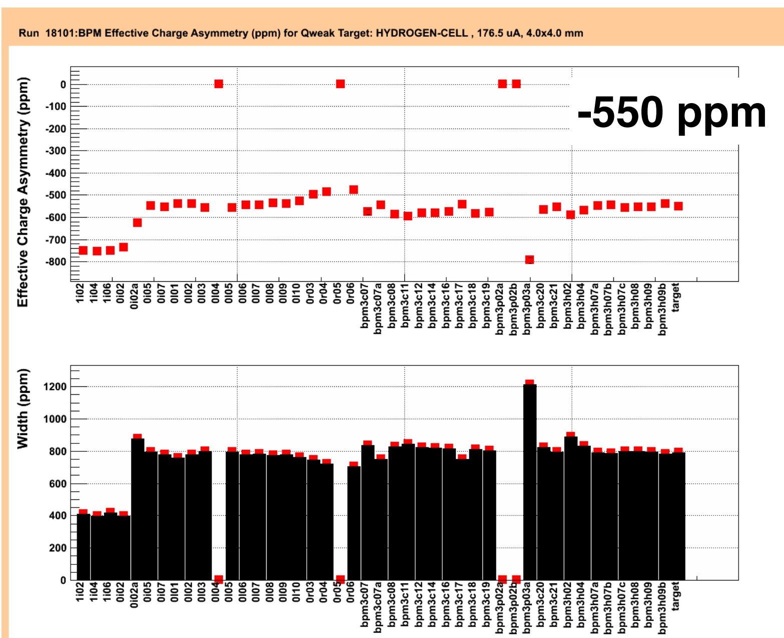
Is clipping in injector related to beam tail?

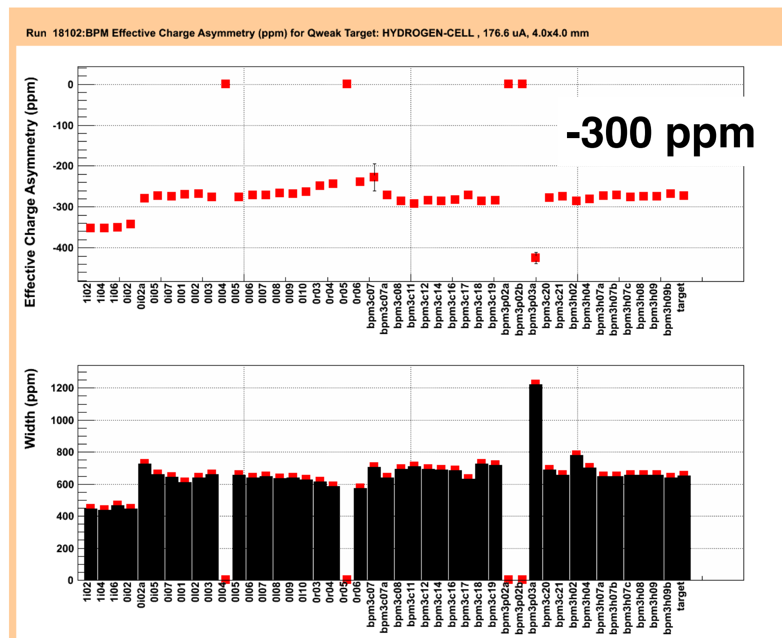
Asymmetry-dependent clipping in the injector

As noted in hclog:269308





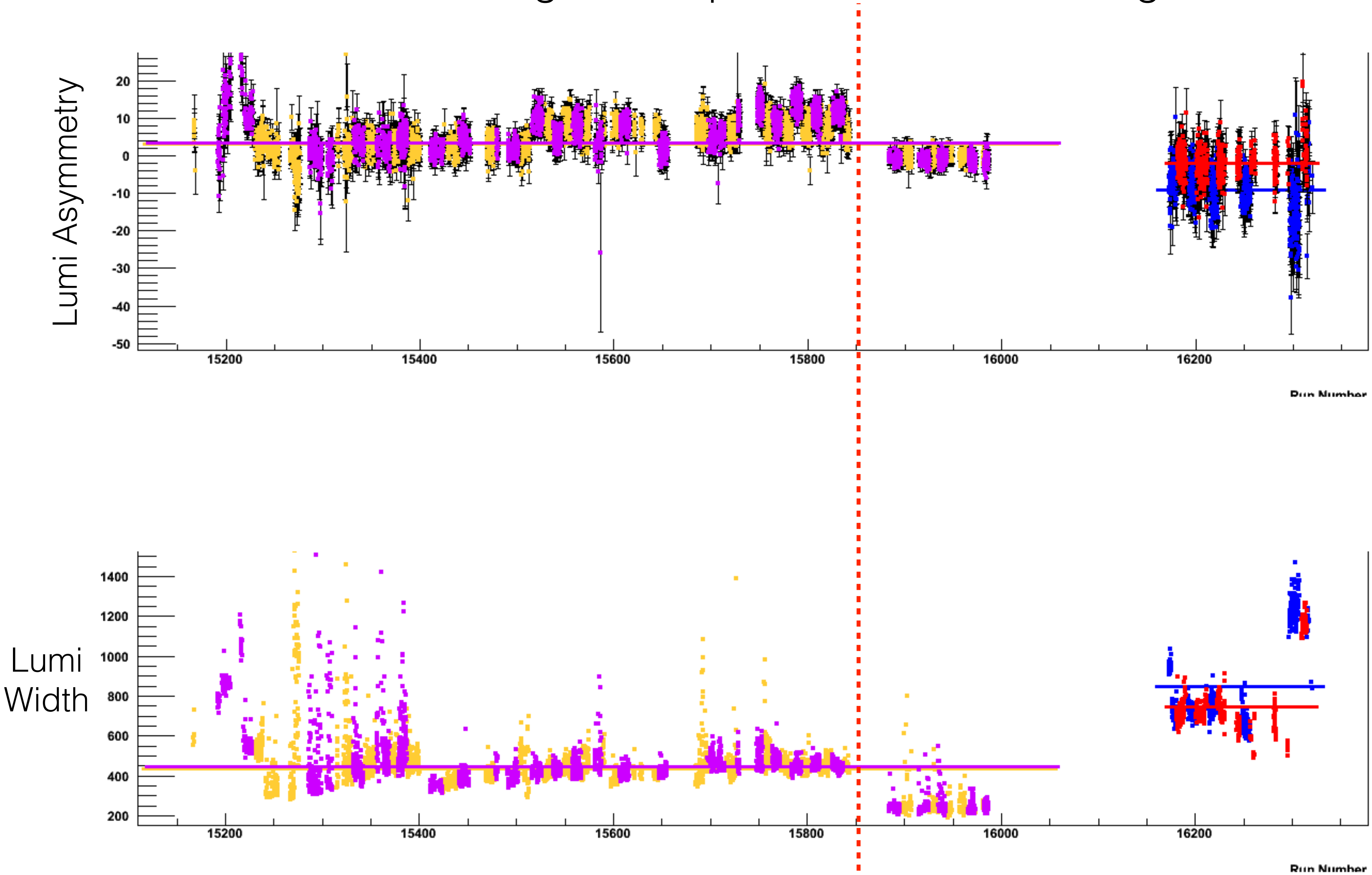




May 10, 2012. HCLOG:269308 https://hallcweb.jlab.org/hclog/1205_archive/120510155309.html

“M56” retune

“halo” signals respond to machine tuning



“M56” retune

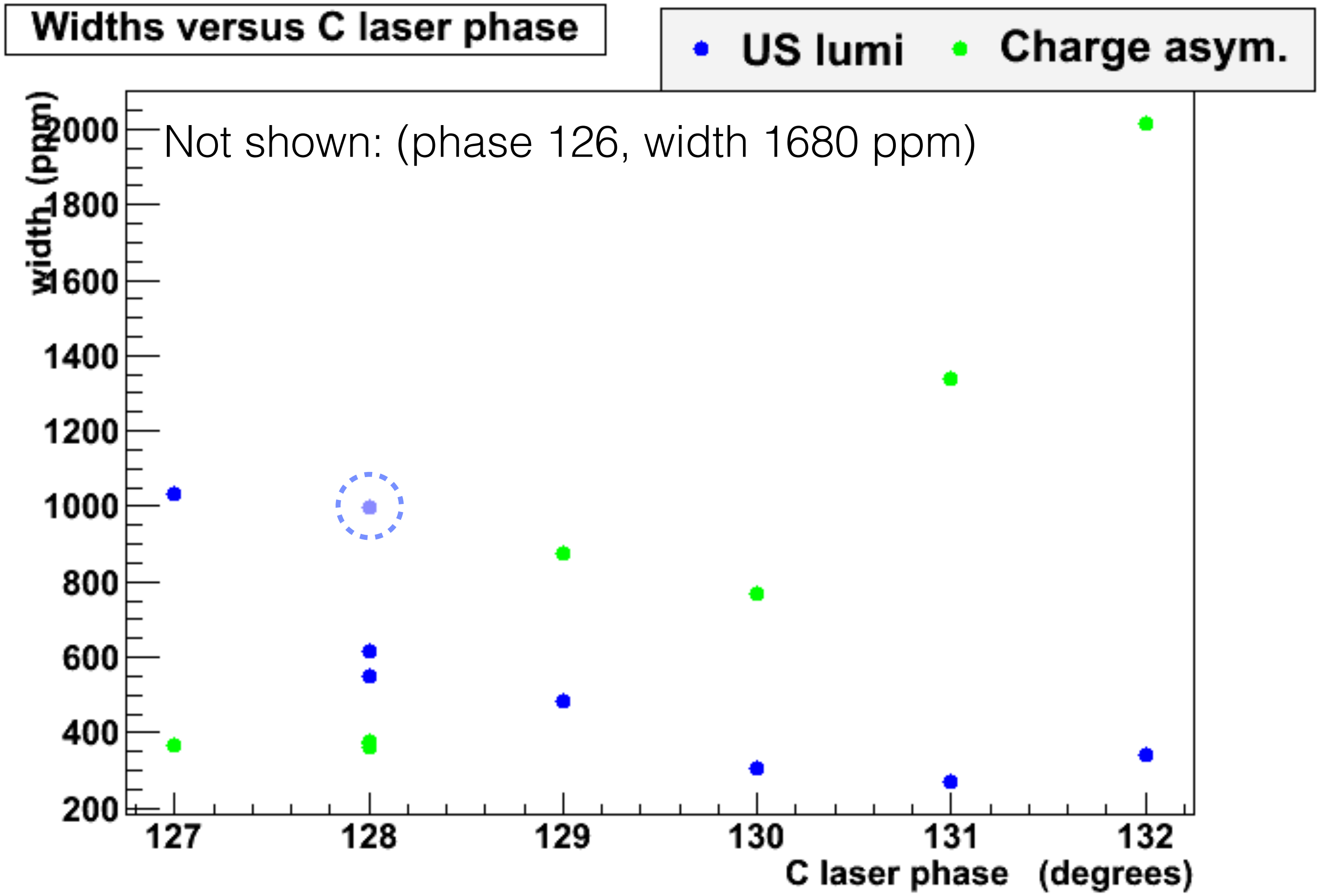
Pitt, Feb 26, 2012. HCLOG:255716

https://hallcweb.jlab.org/hclog/1202_archive/120226131809.html

Laser Phase Study

Run#'s around 16359-16364, Wien 9, Feb 27

Raw Width



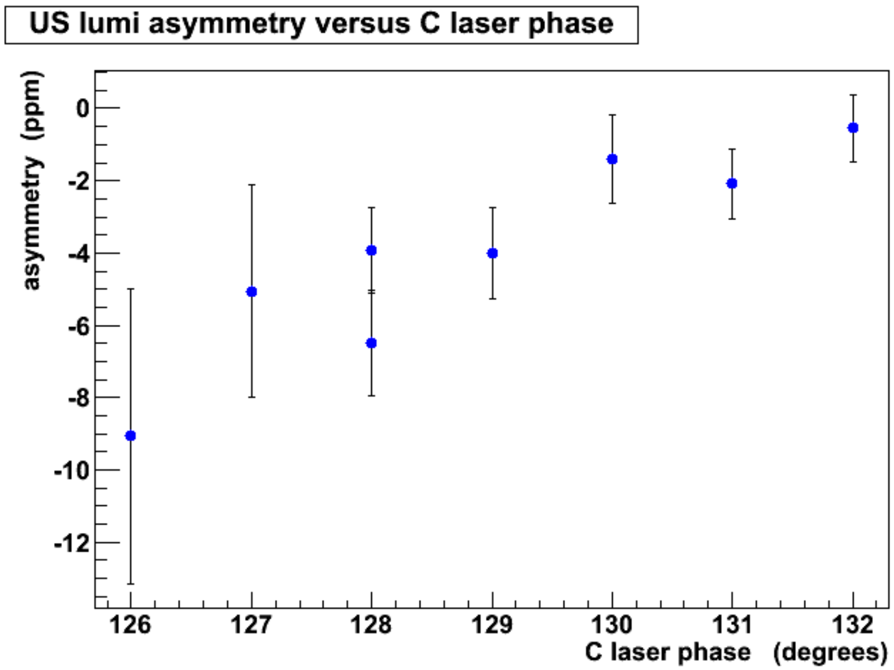
Point in dotted circle: can't find it in nearby logbook entries, don't know what it is.

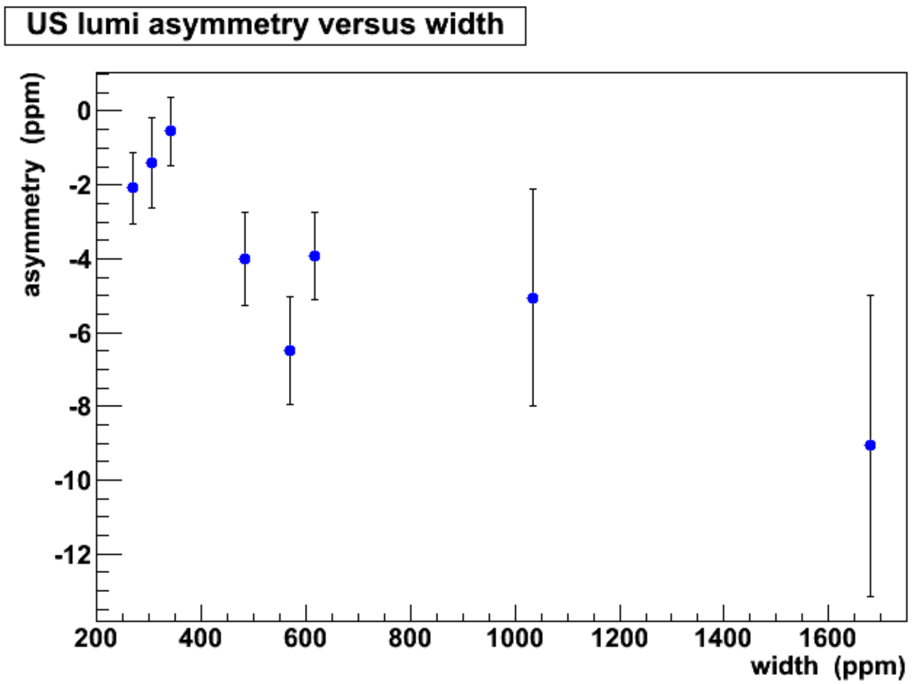
20-50 μA interception on A2

(implied in hclog:256336)

Dalton, Feb 27, 2012. HCLOG:255979
https://hallcweb.jlab.org/hclog/1202_archive/120227182021.html

Laser Phase Study



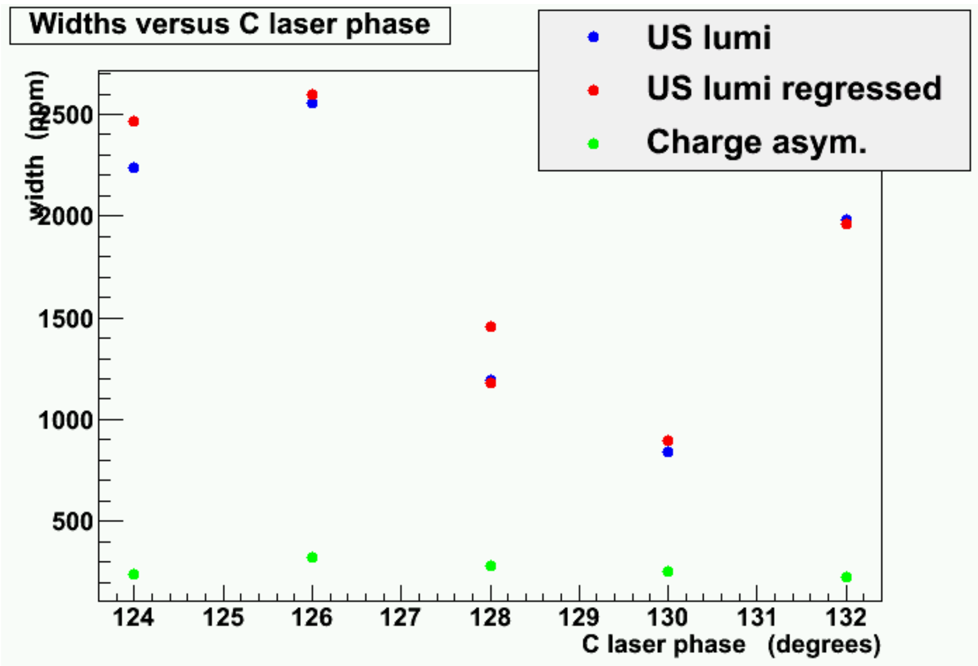


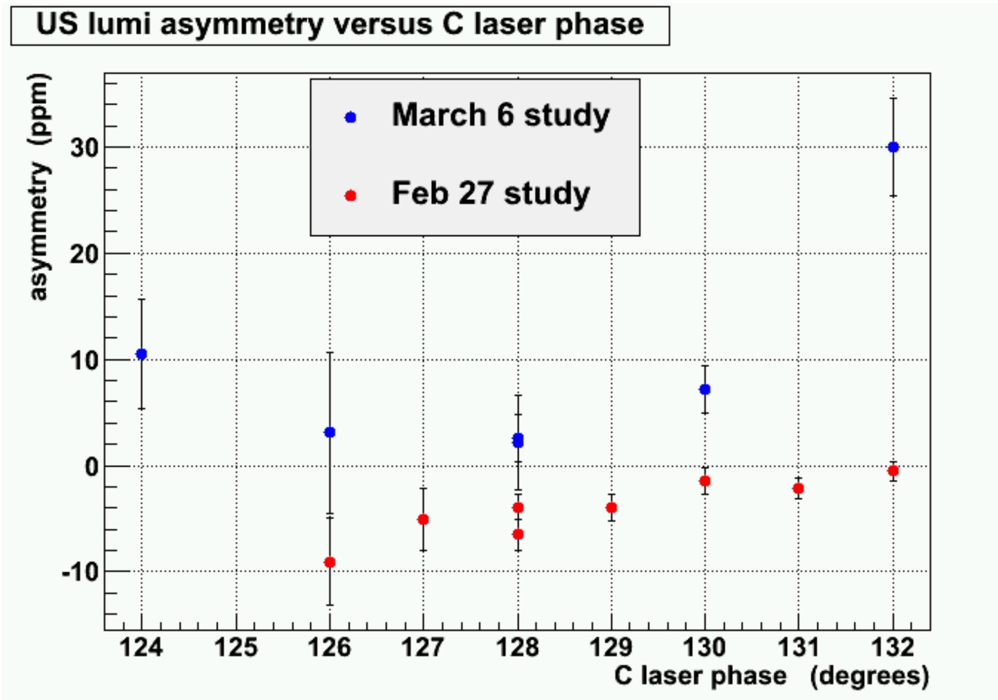
Dalton, Feb 28, 2012. HCLOG:256081
https://hallcweb.jlab.org/hclog/1202_archive/120228113920.html

Second Laser Phase Study

Injector Tuned to Avoid A2 Interception

Run#'s around 16547-552, Wien 9, March 6





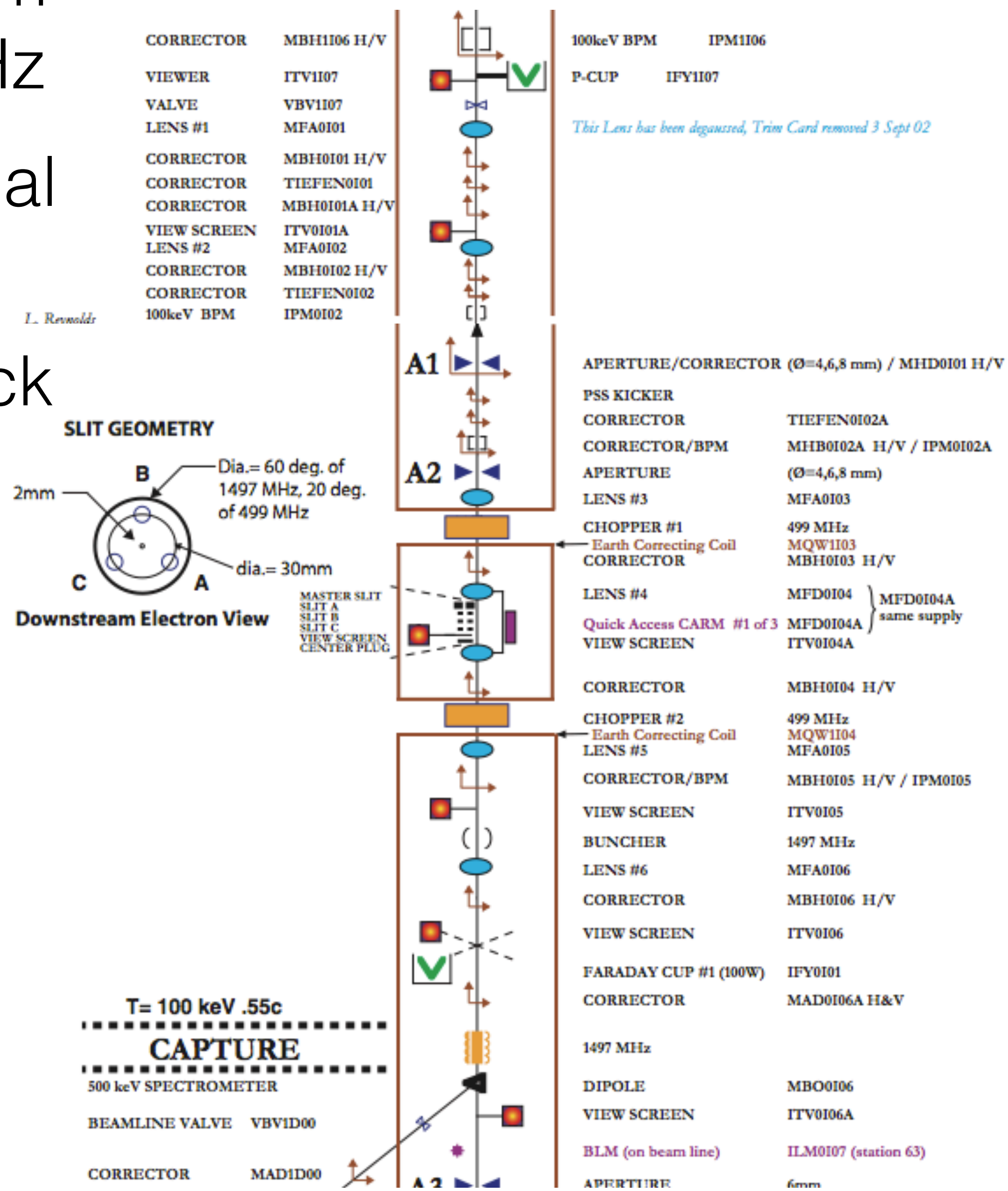
Data: Armstrong, Mar 6, 2012. HCLOG:257352
https://hallcweb.jlab.org/hclog/1203_archive/120306120839.html

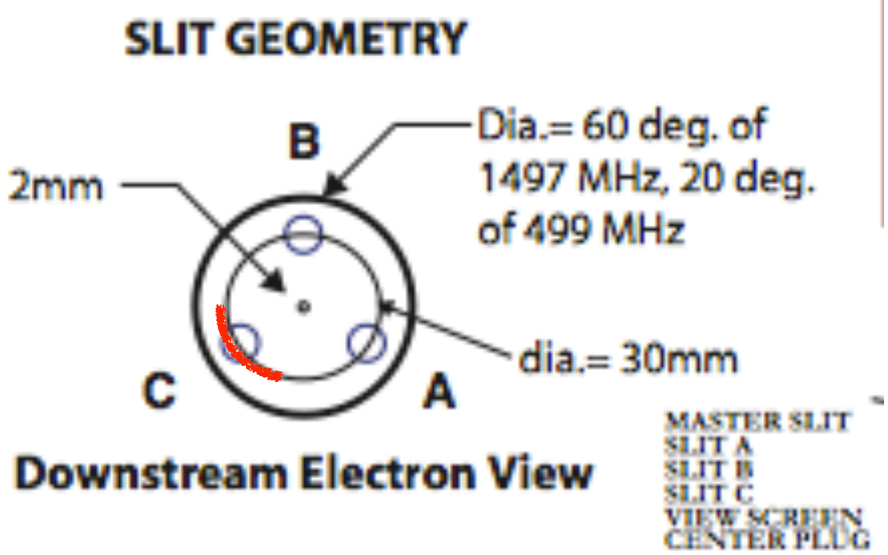
Results: Dalton, Mar 7, 2012. HCLOG:257521
https://hallcweb.jlab.org/hclog/1203_archive/120307095852.html

RF “chopper” sweeps beam around 360º arc at 499 MHz

Aperture cuts on longitudinal position in beam bunch

2nd RF chopper puts it back





Asymmetry vs. bunch position

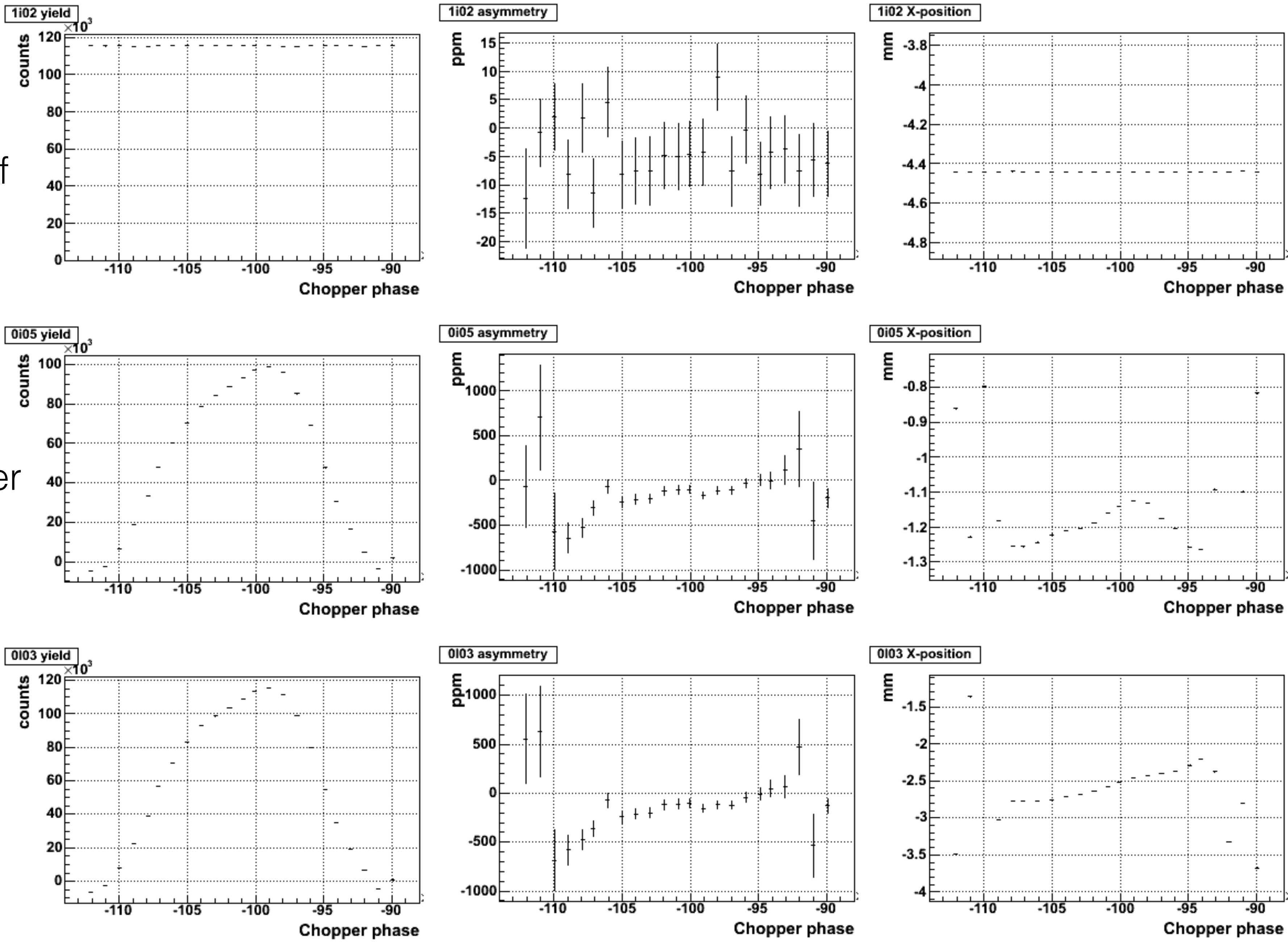
Narrow slit, scanning chopper phase to measure portions of each bunch

ELOG:Beam:259 [Manolis]

Upstream of chopper

After chopper

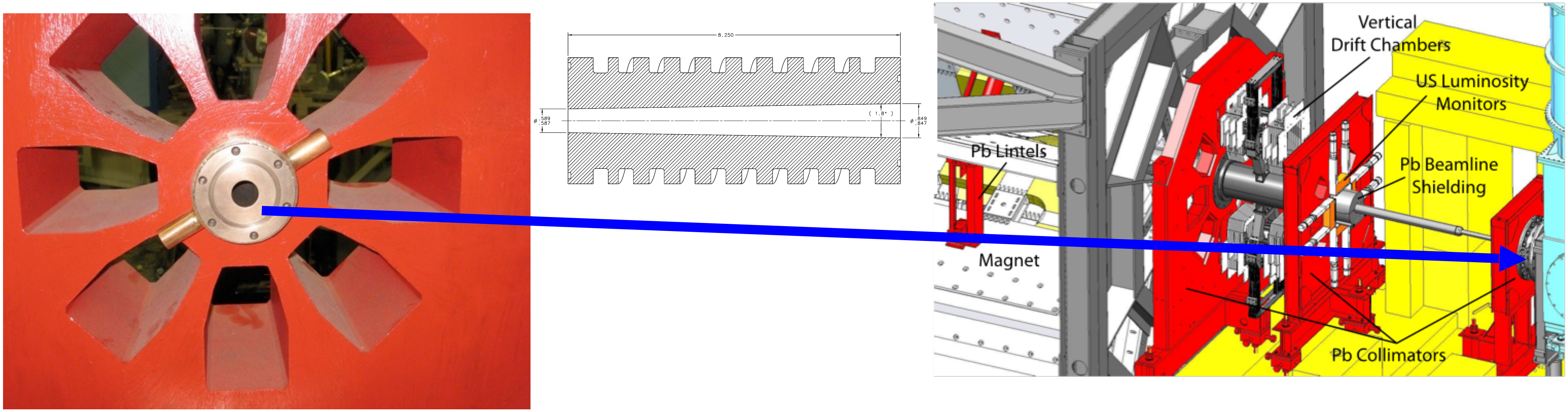
0L05 (5MeV)



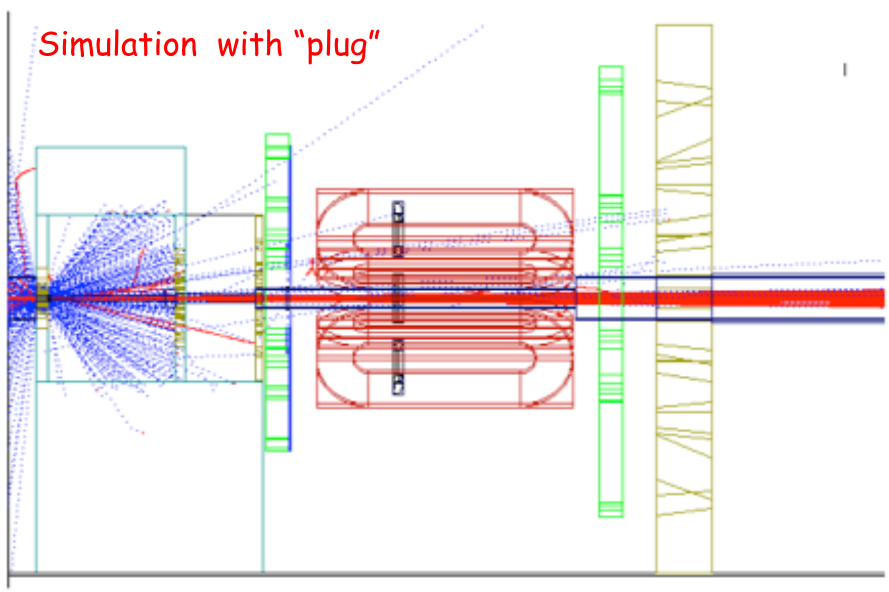
http://qweak.jlab.org/elog/Beam/259

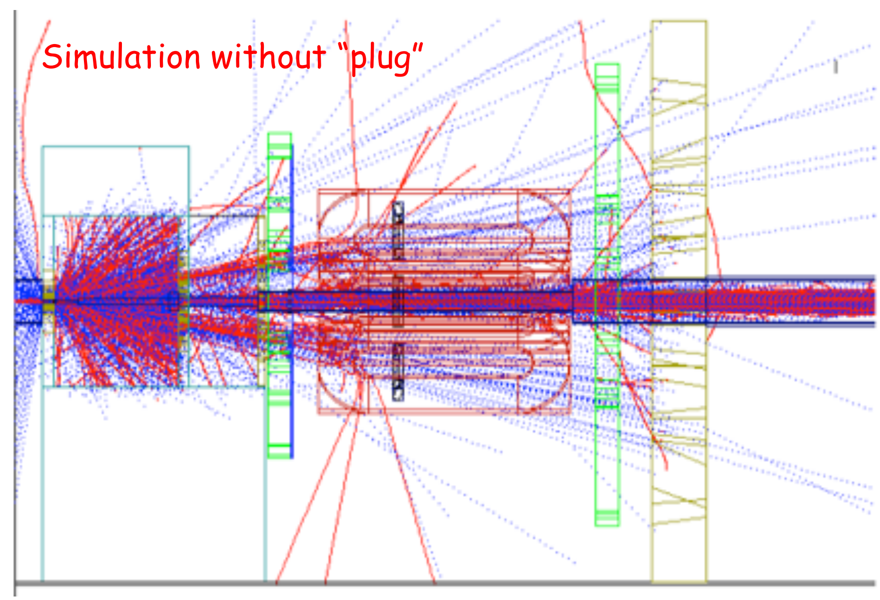
backup

Qweak Tungsten Beamline Collimator



Small aperture tungsten-copper collimator placed in center of collimator 1 to block small angle scattered particles from interacting with the downstream beampipe (~ 1.6 kW power deposit expected and measured)

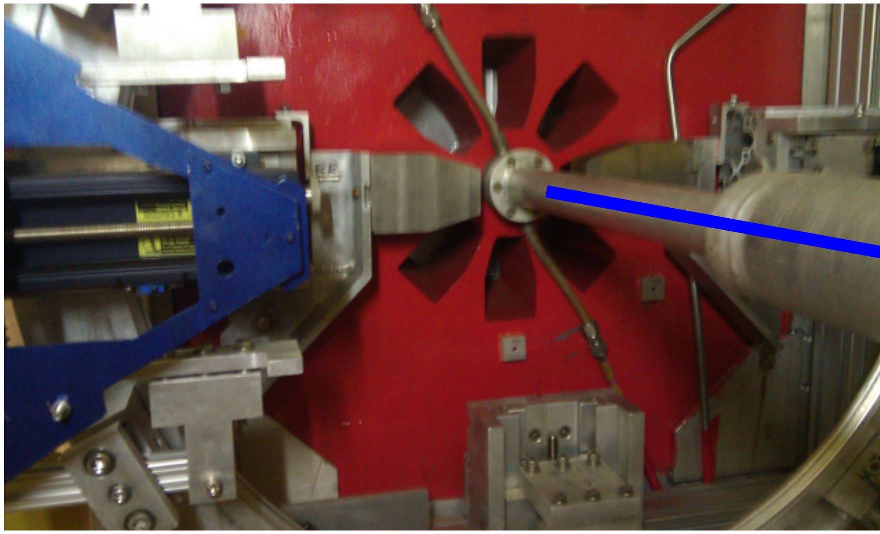


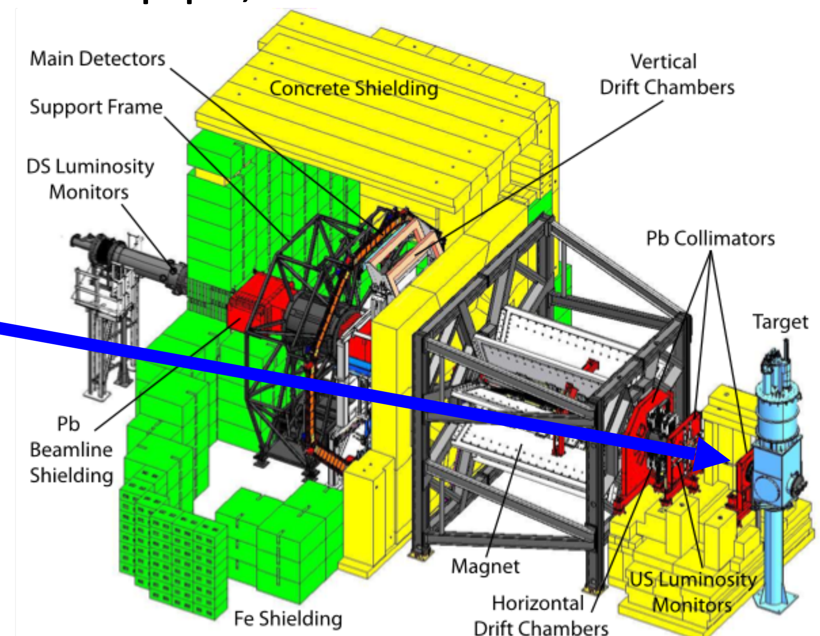


Simulation indicated the "plug" keeps scattered beam from interacting in downstream beampipe.

Qweak Tungsten Octant Blocker

Two 5.1 cm thick tungsten blocks could be inserted manually into the Octant 1 and 5 holes of Collimator 1: eliminates direct scattered events from the target and measures scattering flux from tungsten collimator, beampipe, etc.





Diffuse backgrounds directly demonstrated with measurements

•Fraction of signal left in a main detector when blocked with tungsten blocker
~ 0.19 ±0.06% (it is believed that the is mostly neutrals)

→ Beamline background contribution to main signal was very small;
the problem for Qweak was that this small component had a large asymmetry

Qweak Beamline Background, PRL Result

- Corrected for beamline background asymmetry using continuously measured upstream luminosity monitor asymmetry
- Relation between main detector and USLUMI asymmetries determined through variety of techniques

$$A_{\text{MD correction}} = 0.0046 A_{\text{US Lumi}}$$

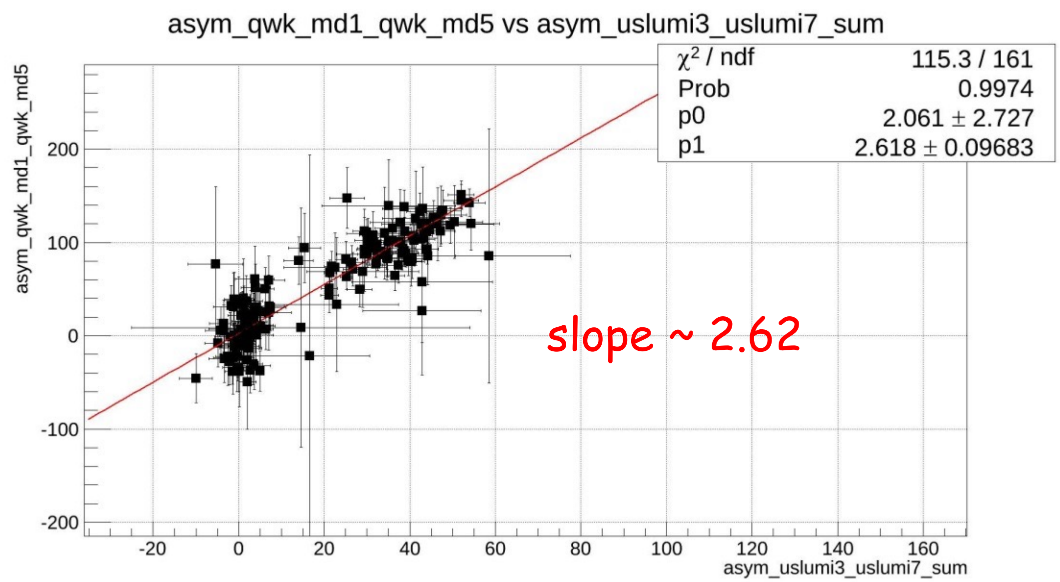
One way to get this relation is from measurements with "tungsten blocker":

•Blocked octant to upstream lumi asymmetry correlation ~ 2.62

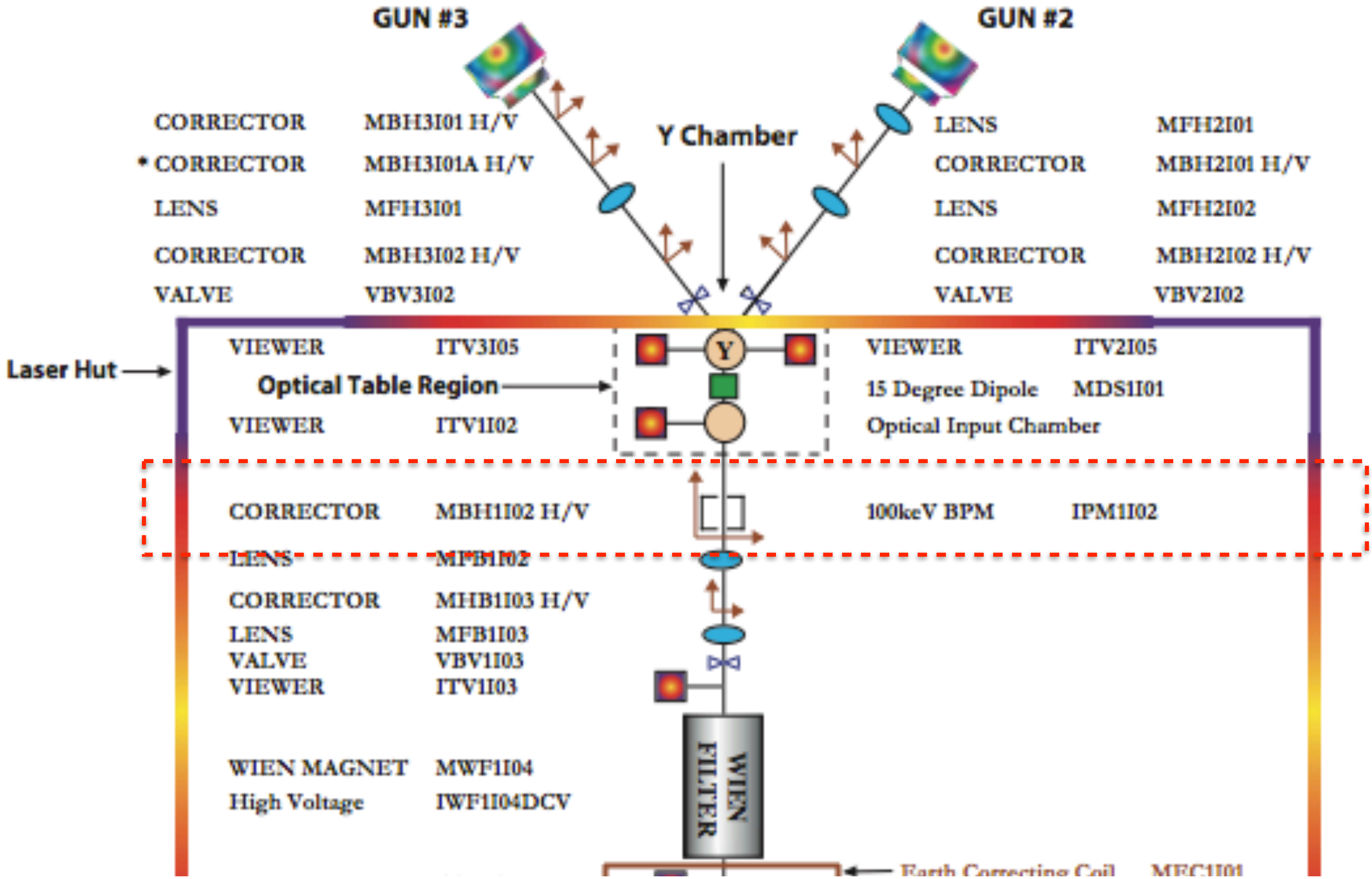
•MD Beamline background dilution factor ~ 0.0019

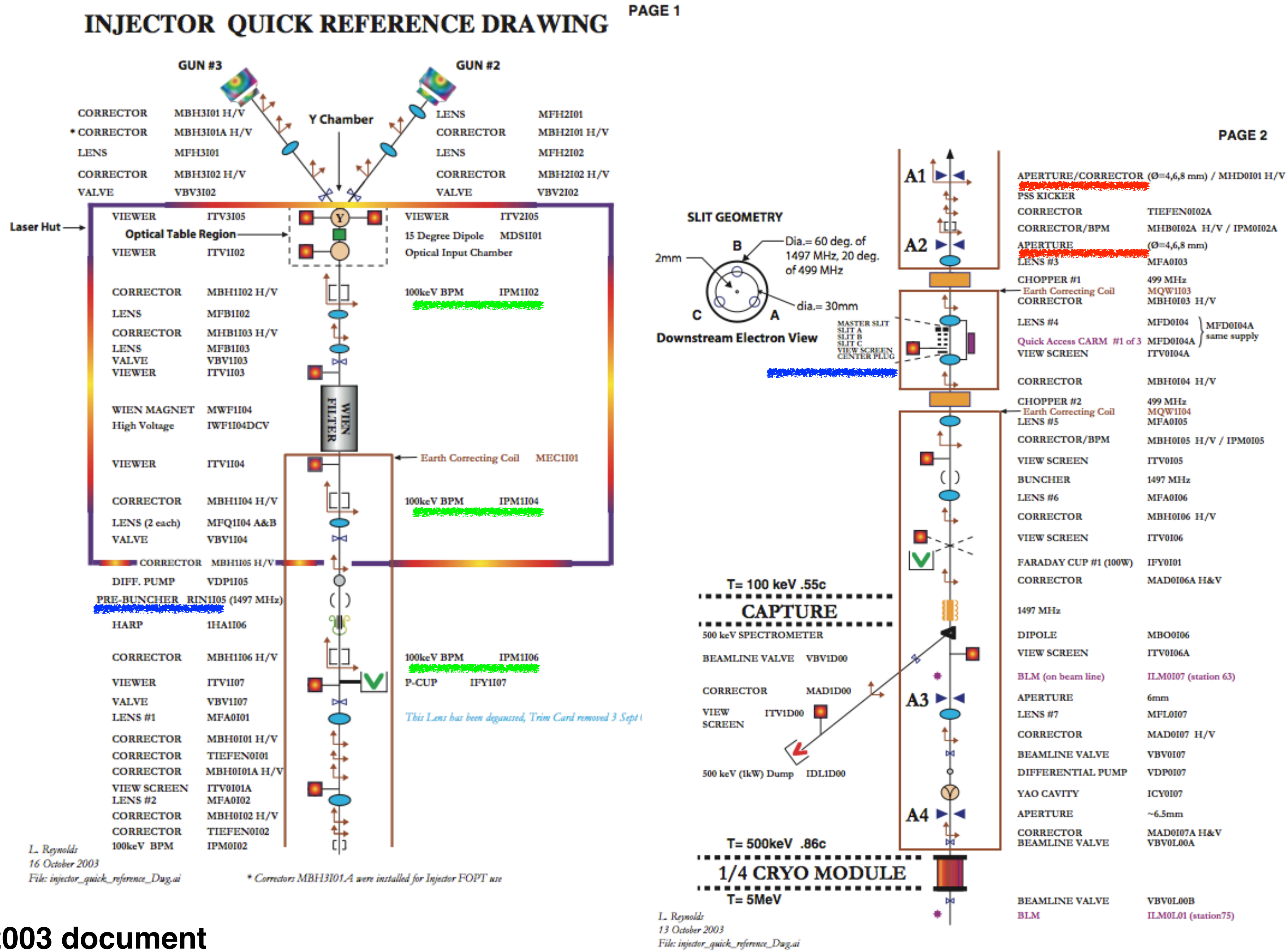
relation = (0.0019) * (2.62) ~ 0.0050

Blocked MD Asymmetry (ppm) vs. USLUMI Asymmetry (ppm)



INJECTOR QUICK REFERENCE DRAWING

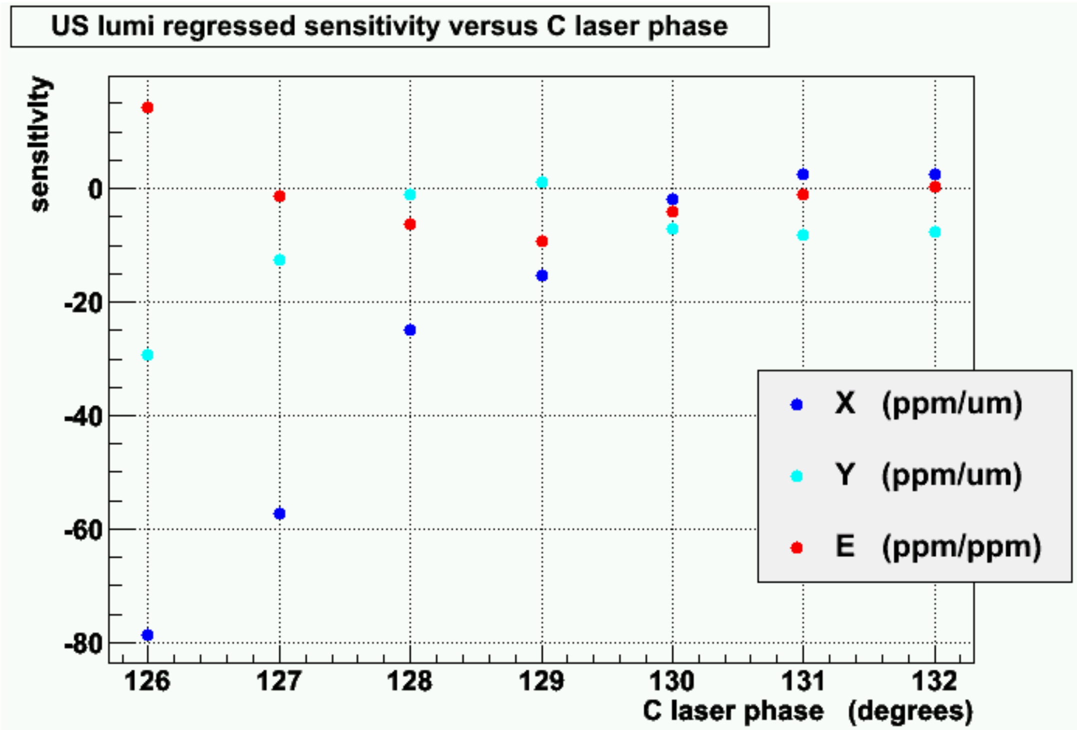


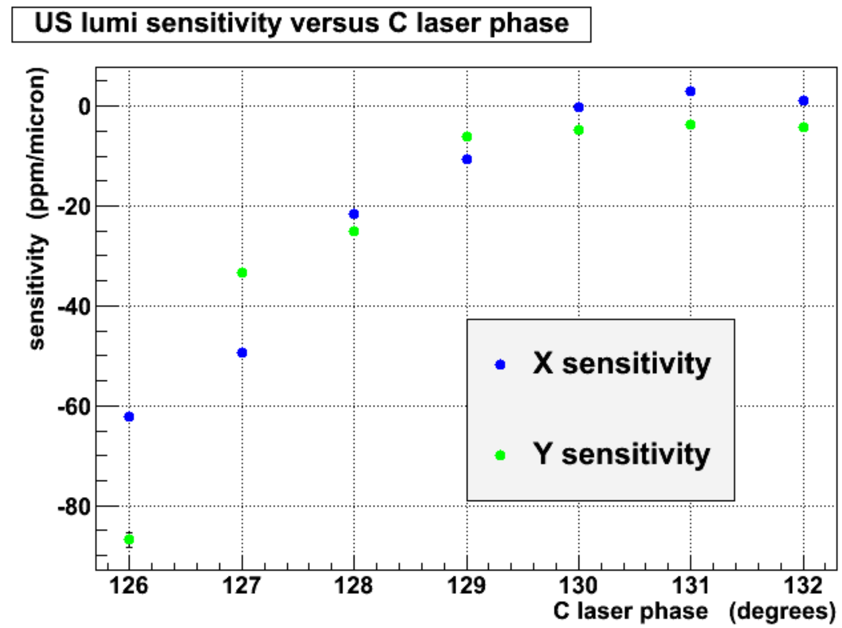


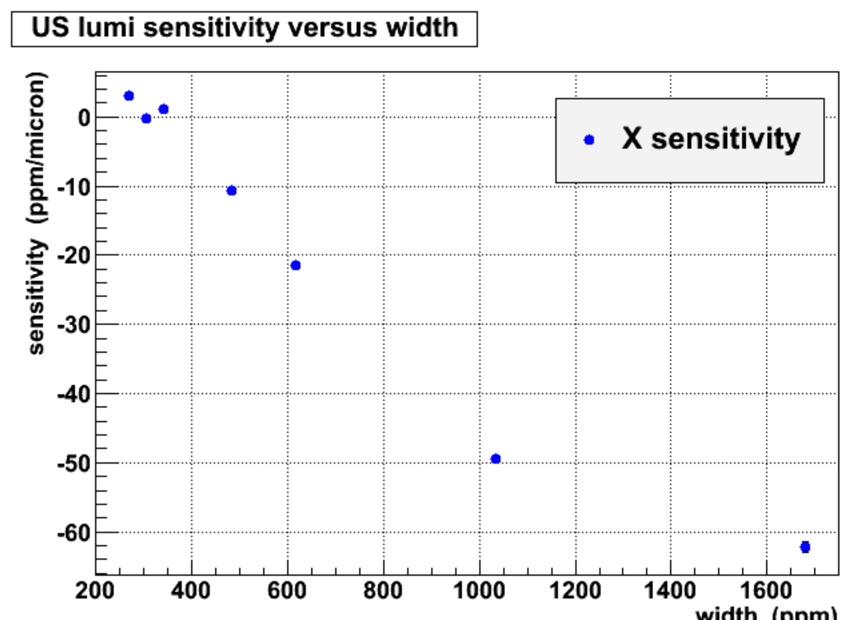
2003 document

Laser Phase Study - Beam Sensitivities

(online 1-parameter correlation slopes)







Large changes in Left/Right cancellation of x slope

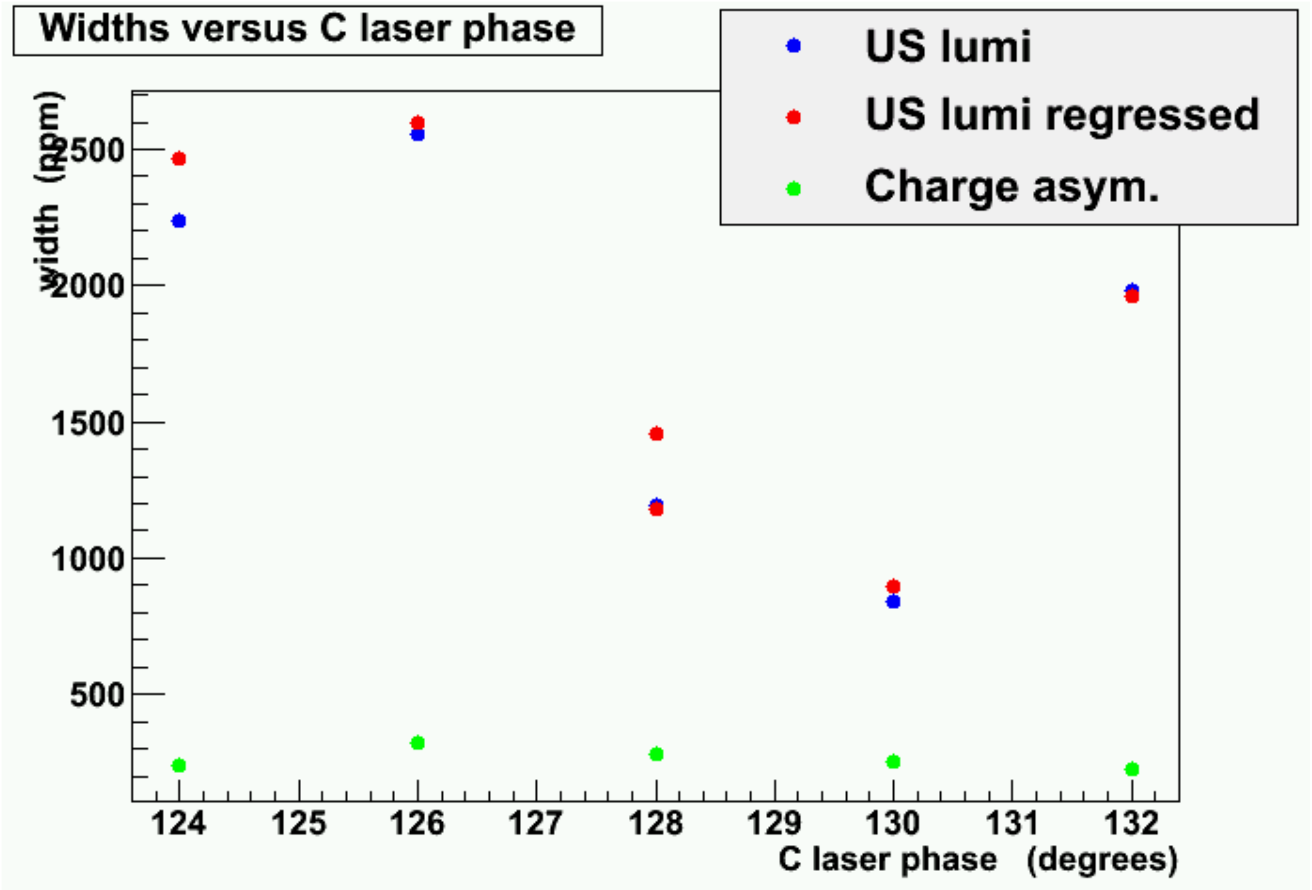
Dalton, Feb 29, 2012. HCLOG:256190
https://hallcweb.jlab.org/hclog/1202_archive/120229172720.html

Dalton, Mar 1, 2012. HCLOG:256336
https://hallcweb.jlab.org/hclog/1203_archive/120301110120.html

Second Laser Phase Study

Injector Tuned to Avoid A2 Interception

Run#'s around 16547-552, Wien 9, March 6



Data: Armstrong, Mar 6, 2012. HCLOG:257352
https://hallcweb.jlab.org/hclog/1203_archive/120306120839.html

Results: Dalton, Mar 7, 2012. HCLOG:257521
https://hallcweb.jlab.org/hclog/1203_archive/120307095852.html

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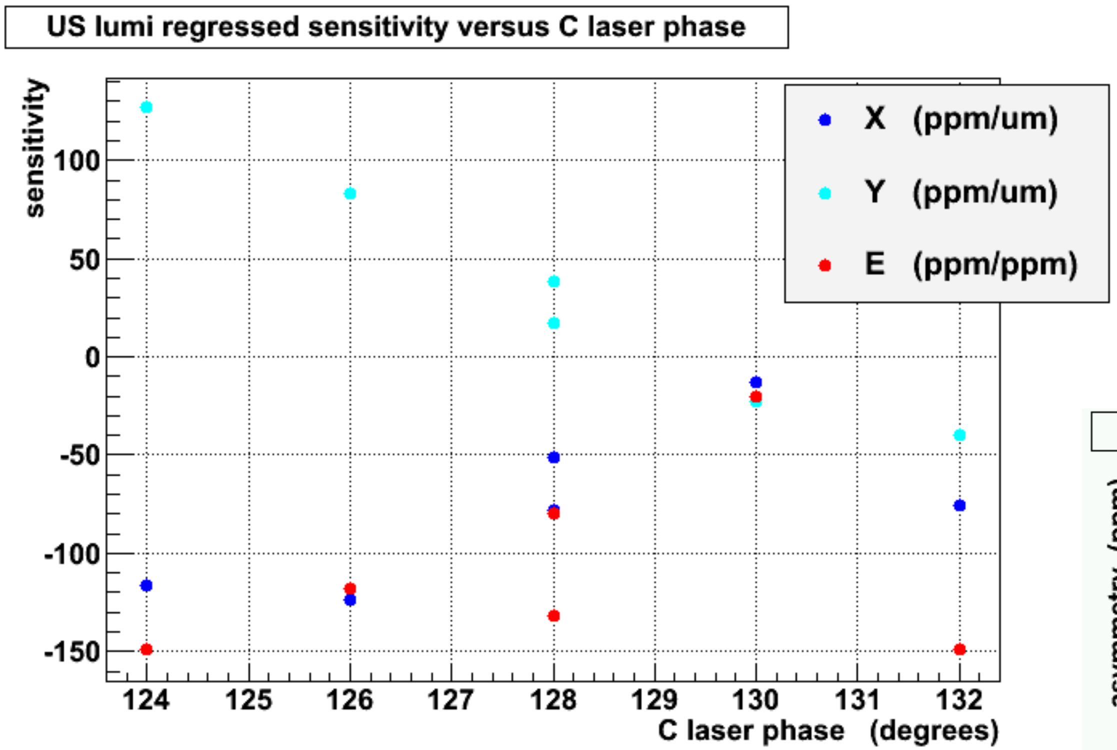

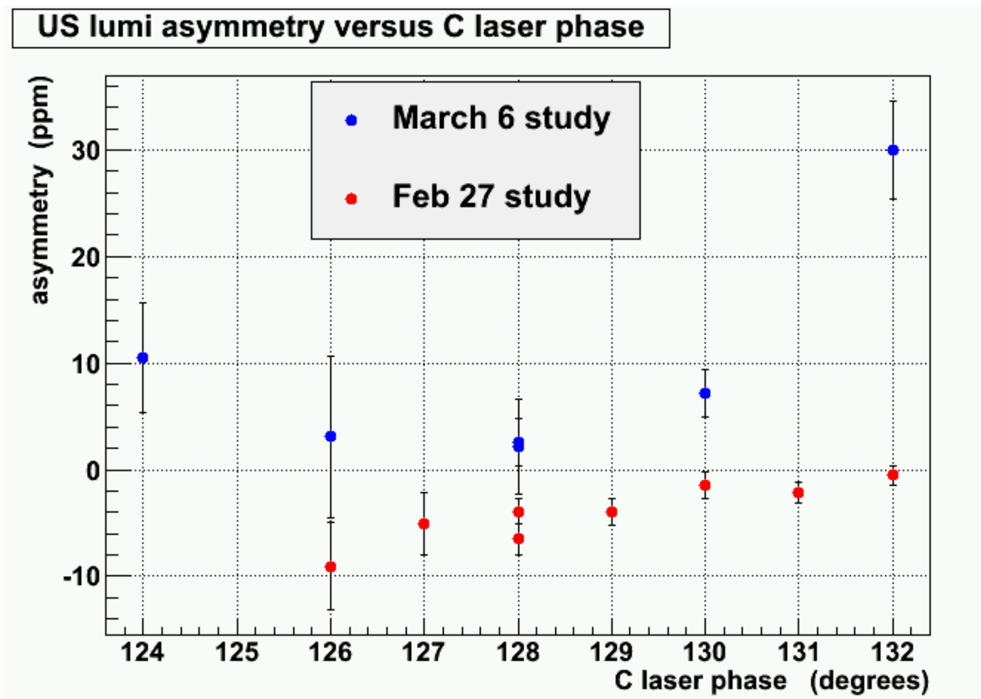

Results: Dalton, Mar 7, 2012. HCLOG:257521
https://hallcweb.jlab.org/hclog/1203_archive/120307095852.html