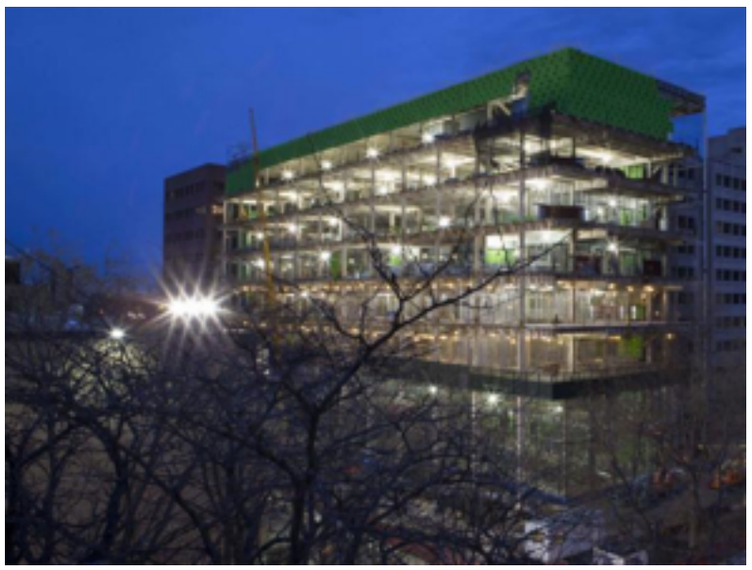
High Field Møller Polarimetry

Status, Progress, and Plans

Jim Napolitano, Temple University
with Ted Berger, Ben LeRose, Paul Stoler, James Wilhelmi and JJL Magnet Optics, LLC

PREX & CREX Collaboration Meeting
Jefferson Lab 11-12 April 2014

TEMPLE UNIVERSITY



Outline for Today

Our goal is a <1% uncertainty in the beam polarization using the existing (essentially) "High Field" Møller Polarimeter apparatus.

There are several challenges. Right now, we are focussing on two of them.

1) Foil orientation tolerance (better than 1°)

2) Average analyzing power uncertainty

Other Challenges to 1%

Save these for another time

- Demagnetization due to target heating
- Levchuk effect
- Radiative corrections to the asymmetry
- Statistical precision (including confirmation of systematic uncertainties)

Target Foil Apparatus

Why use a "High Field" Target Foil?

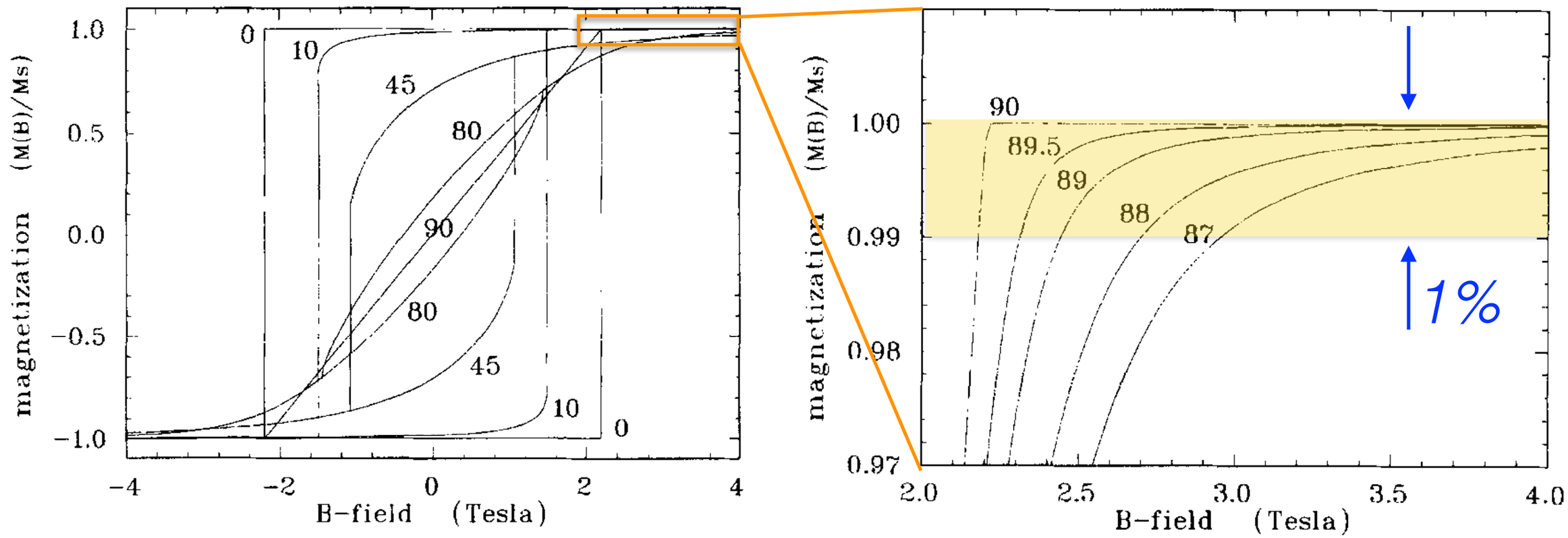
Nuclear Instruments and Methods in Physics Research A 400 (1997) 379–386

A target for precise Møller polarimetry

L.V. de Bever*, J. Jourdan, M. Loppacher, S. Robinson, I. Sick, J. Zhao

Bottom Line: "Tilted, low field" target foils are limited in precision because of our knowledge of magnetization in ferromagnetic alloy foils from external fields, and a fundamental limitation in knowing g' for alloys used.

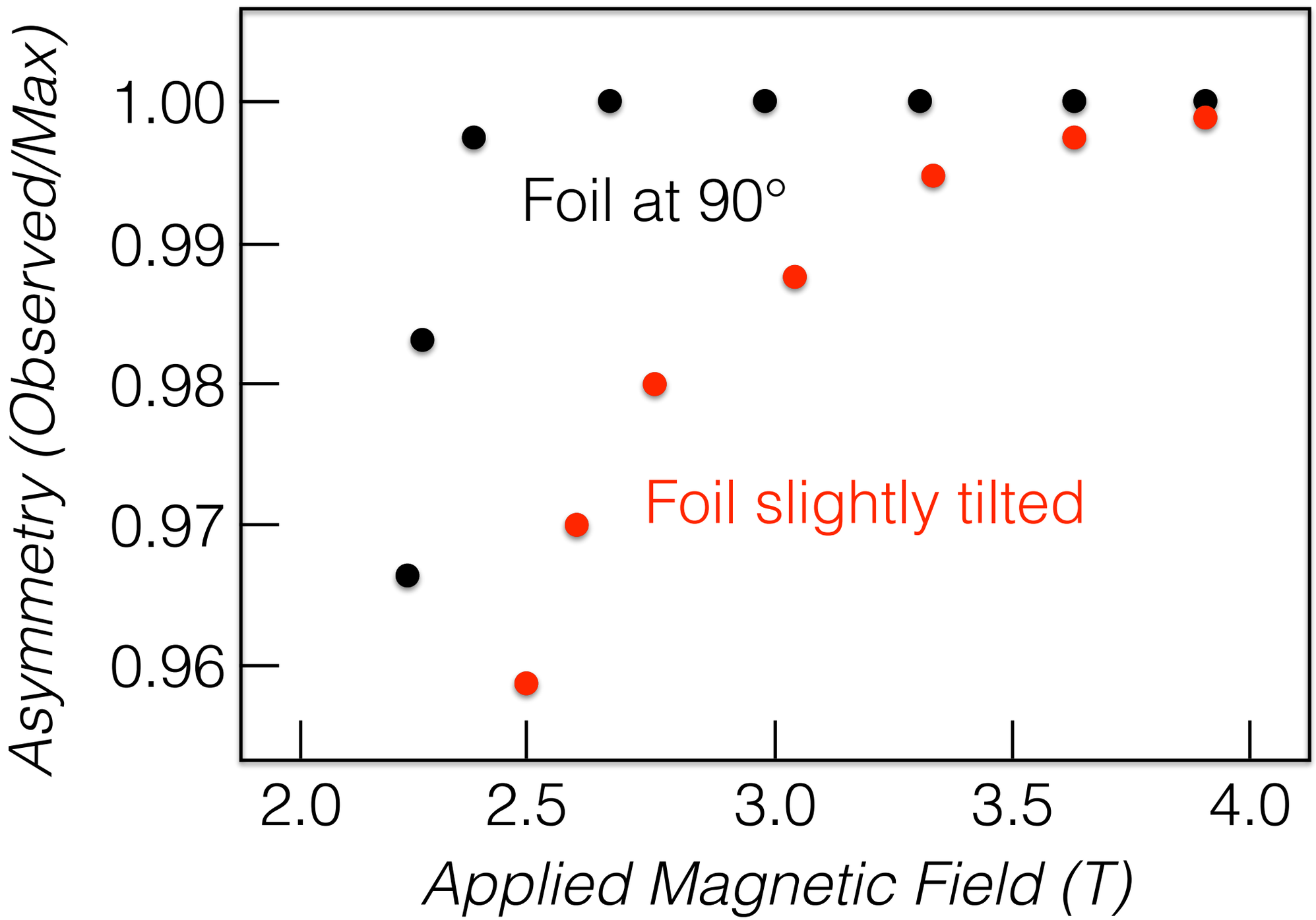
Solution: Fe Foils at 90°



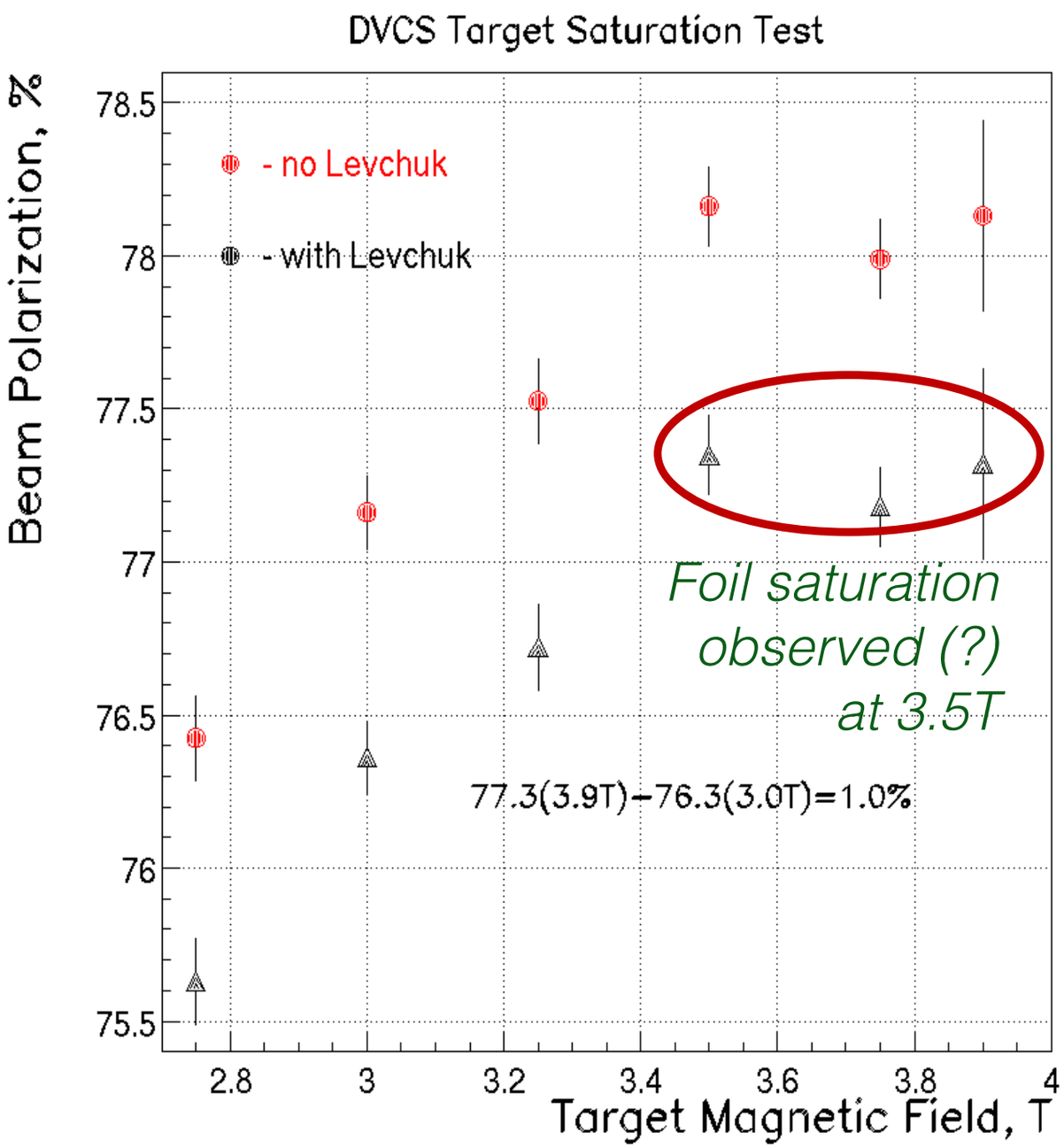
➜ We take the tolerance on the foil angle to be 1°

Note: These curves are from a ferromagnetic model calculation by Stoner & Wohlfarth, Trans. Royal Society of London, Series A, 240(1948)599

Ultimate Demonstration



Existing results (ca 2010?)



http://hallaweb.jlab.org/equipment/moller/talks.html

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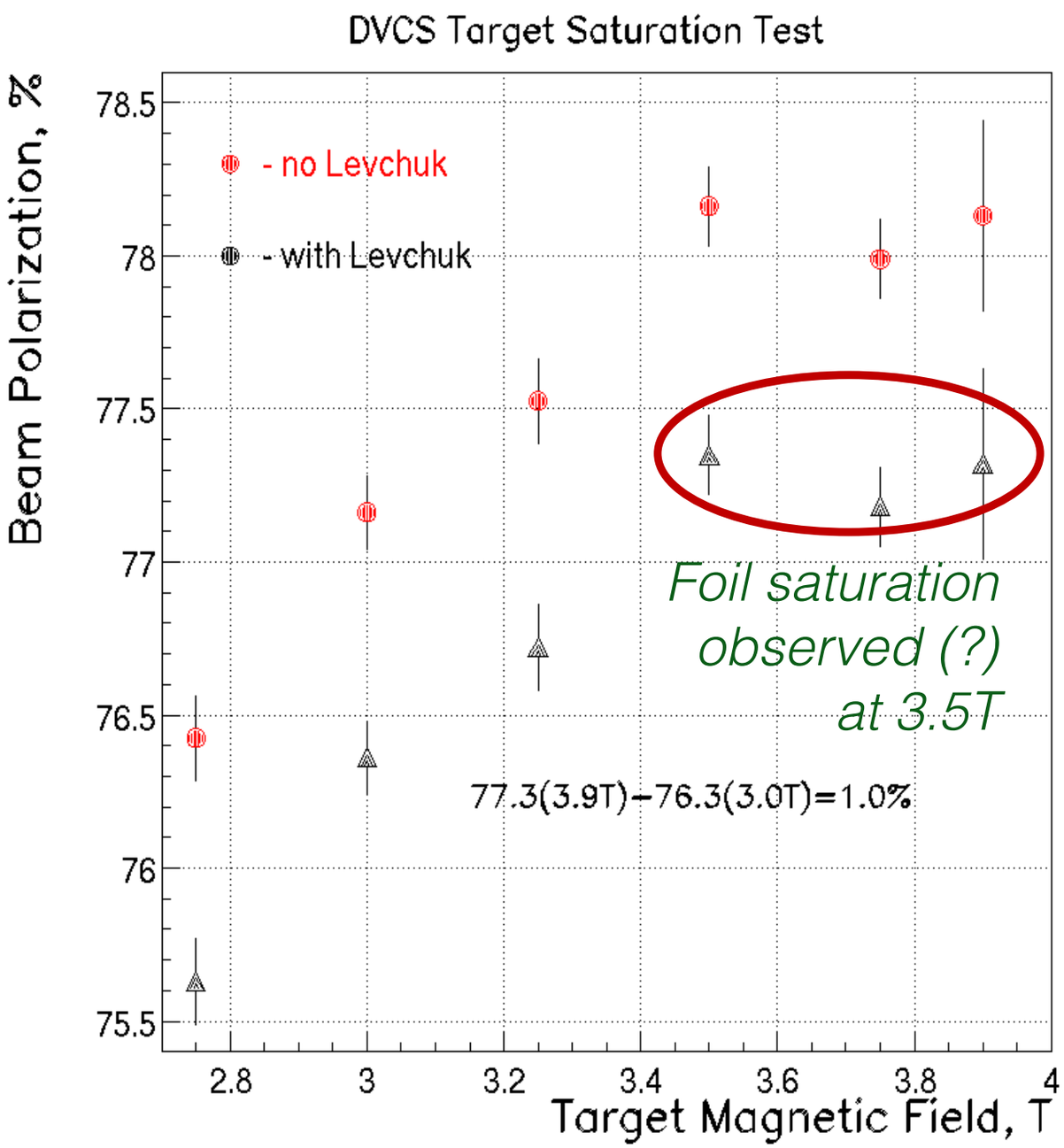
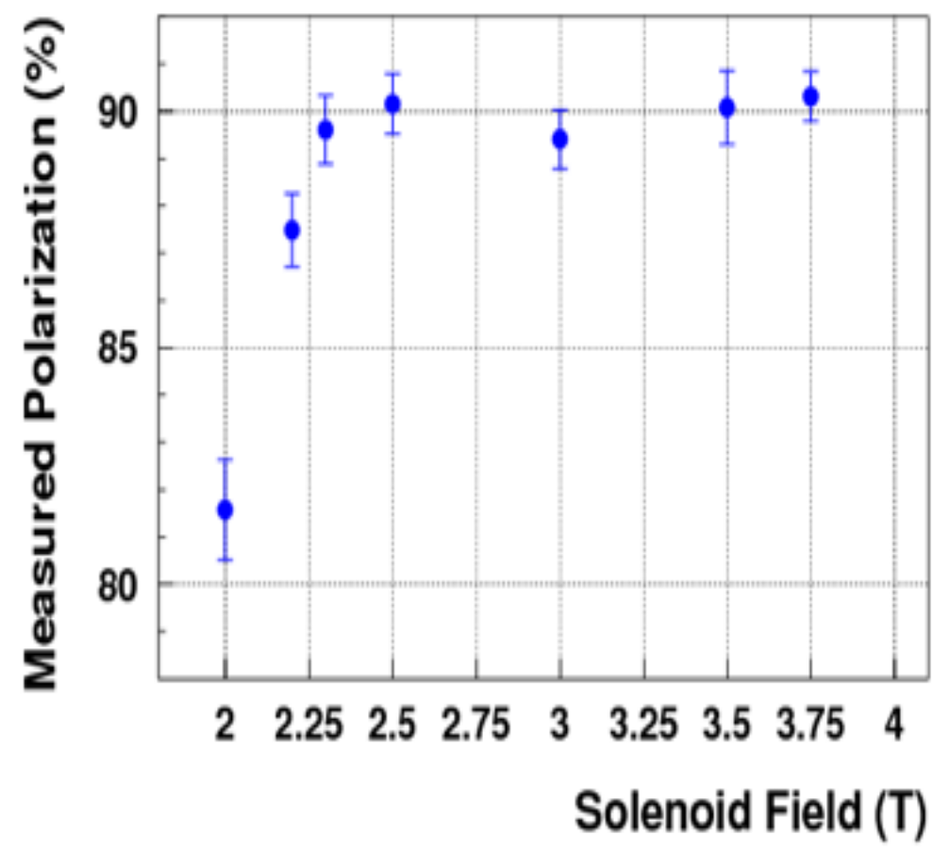


Note: Hall C results are closer to model calculation



http://hallaweb.jlab.org/equipment/moller/talks.html

Old “High Field” Target Chamber

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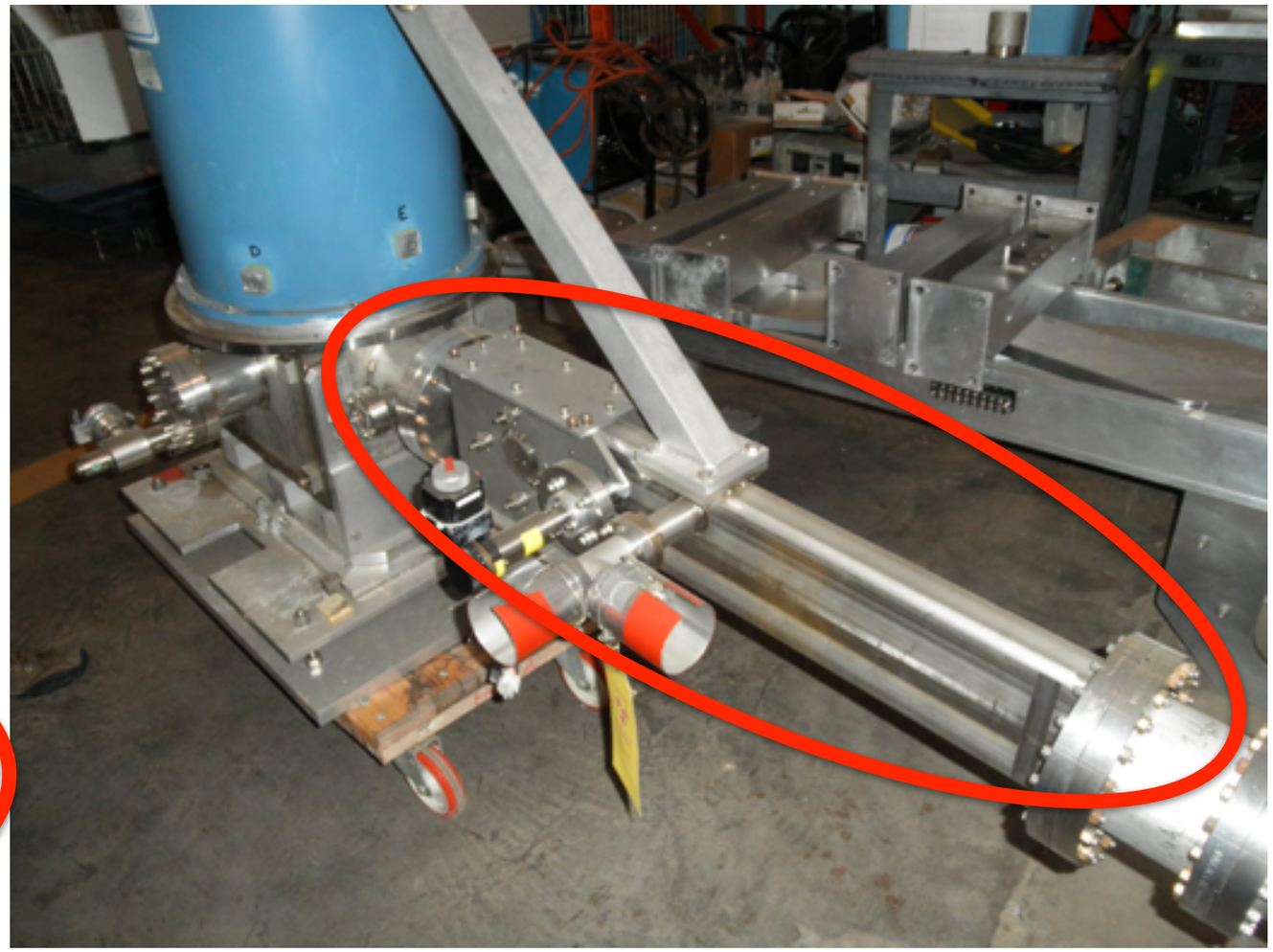
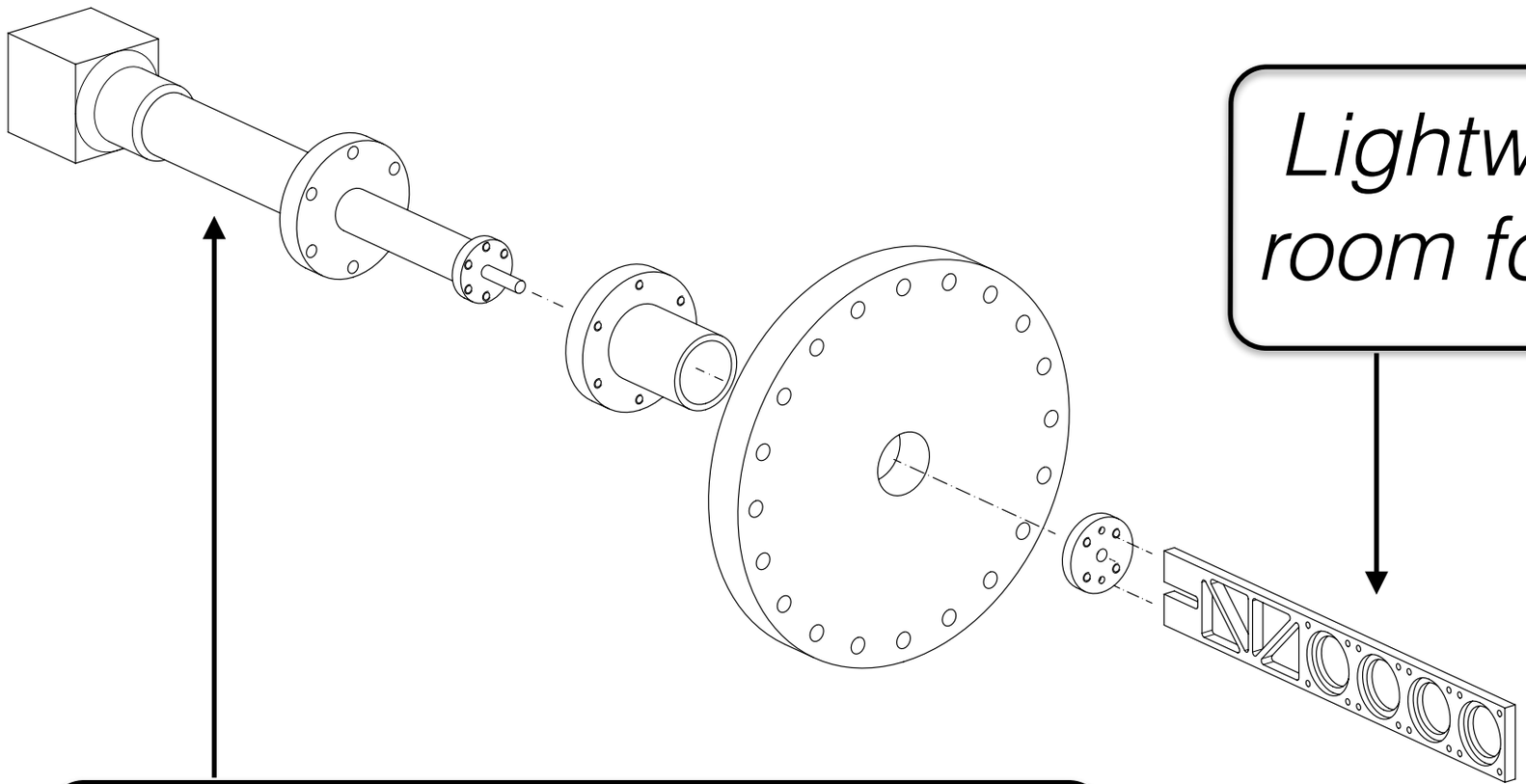


Ambitious apparatus with ability to orient target in all six degrees of freedom.

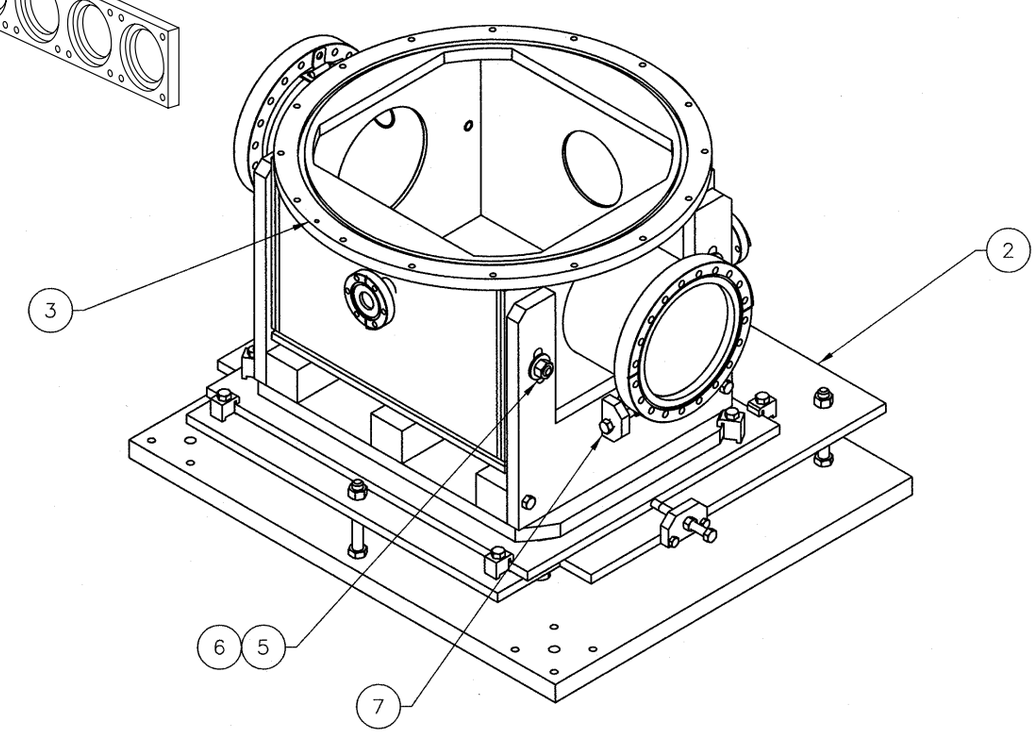
New Target Motion Apparatus

Inspired by Hall C Møller Target



Lightweight ladder with room for <u>four</u> target foils.

Existing target chamber
(Not to scale!)



Actuator for target ladder insertion and rotation (Two degrees of freedom)

Photos

Flange Assembly

Test Stand

Alignment Issues

Remember: We have 1° tolerances

- Good News: Machining tolerances and actuator and stepper motor should met easily for orienting the target ladder assembly to the target chamber

- How well is the magnetic field aligned to the axis of the target chamber? Probably will need to remap the magnet on the beam line because of probable interference with quadrupole magnet iron.

- How well is the electron beam aligned to the axis of the target chamber/magnetic field?

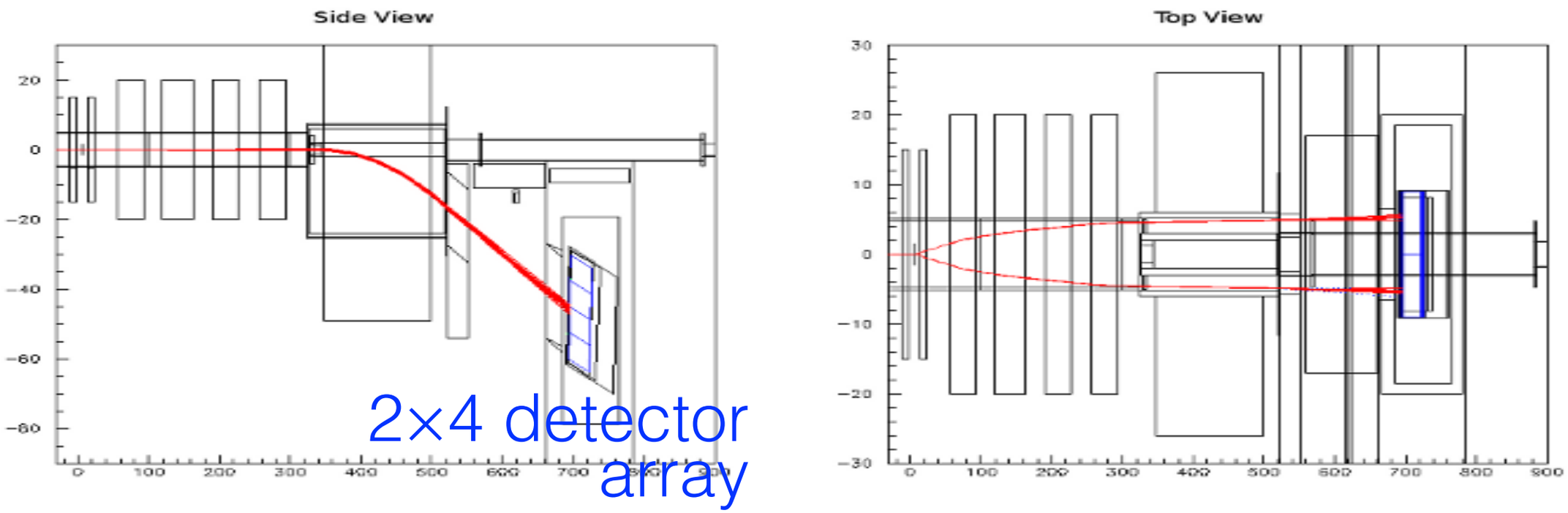
Progress & Schedule

- Vacuum parts have arrived. Actuator shipped. Stepper motor options are under consideration.
- Ladder parts in machine shop at RPI, done soon.
- Stand for preliminary assembly almost completed.
- Ladder, actuator, motor assembled and ready for testing in three weeks. Move to Temple in Summer.
- Preparations underway for target chamber move to Temple this Summer. (Waiting on MOU from JLab.)
- Ready to deliver to JLab by Spring 2015.

(Some uncertainty re availability of SERC@Temple)

Spectrometer Studies

Remember: Fourth Quad added for 11 GeV Beam



Beam energy is 1.063 GeV. (Same for PREX & CREX?)

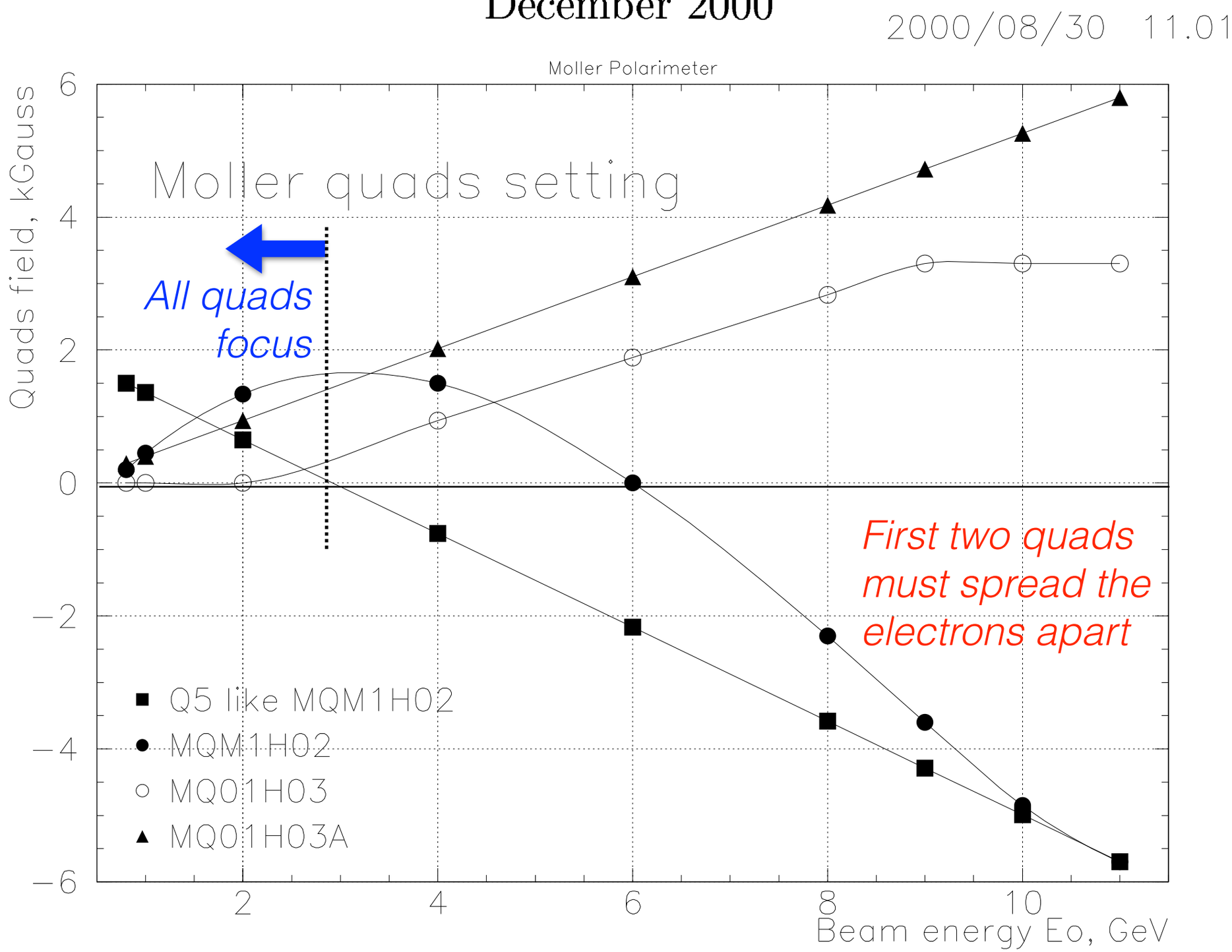
Magnets set to Dec 2000 note from Sasha and Eugene.

Investigate (*This Week!)* settings with JJL Magnet Optics.

Hall A Møller Polarimeter Upgrade for 11 GeV

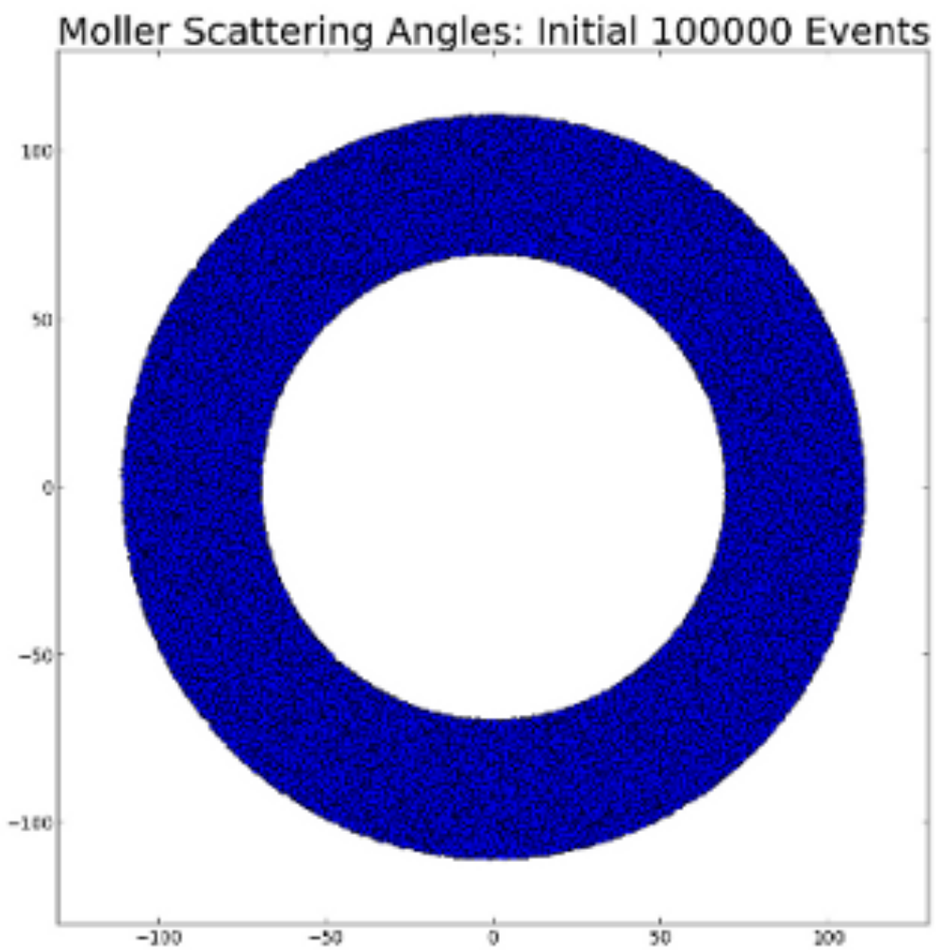
A. Glamazdin and E. Chudakov

December 2000

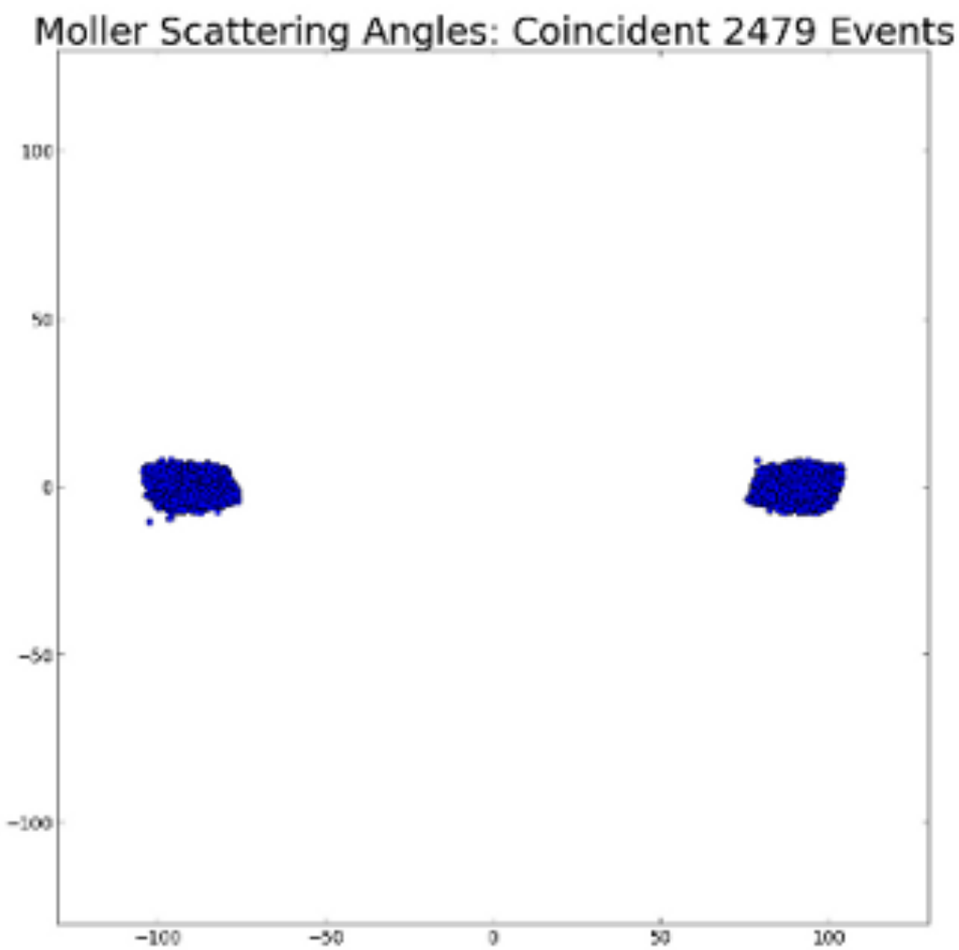


Default GEANT Settings

Generated

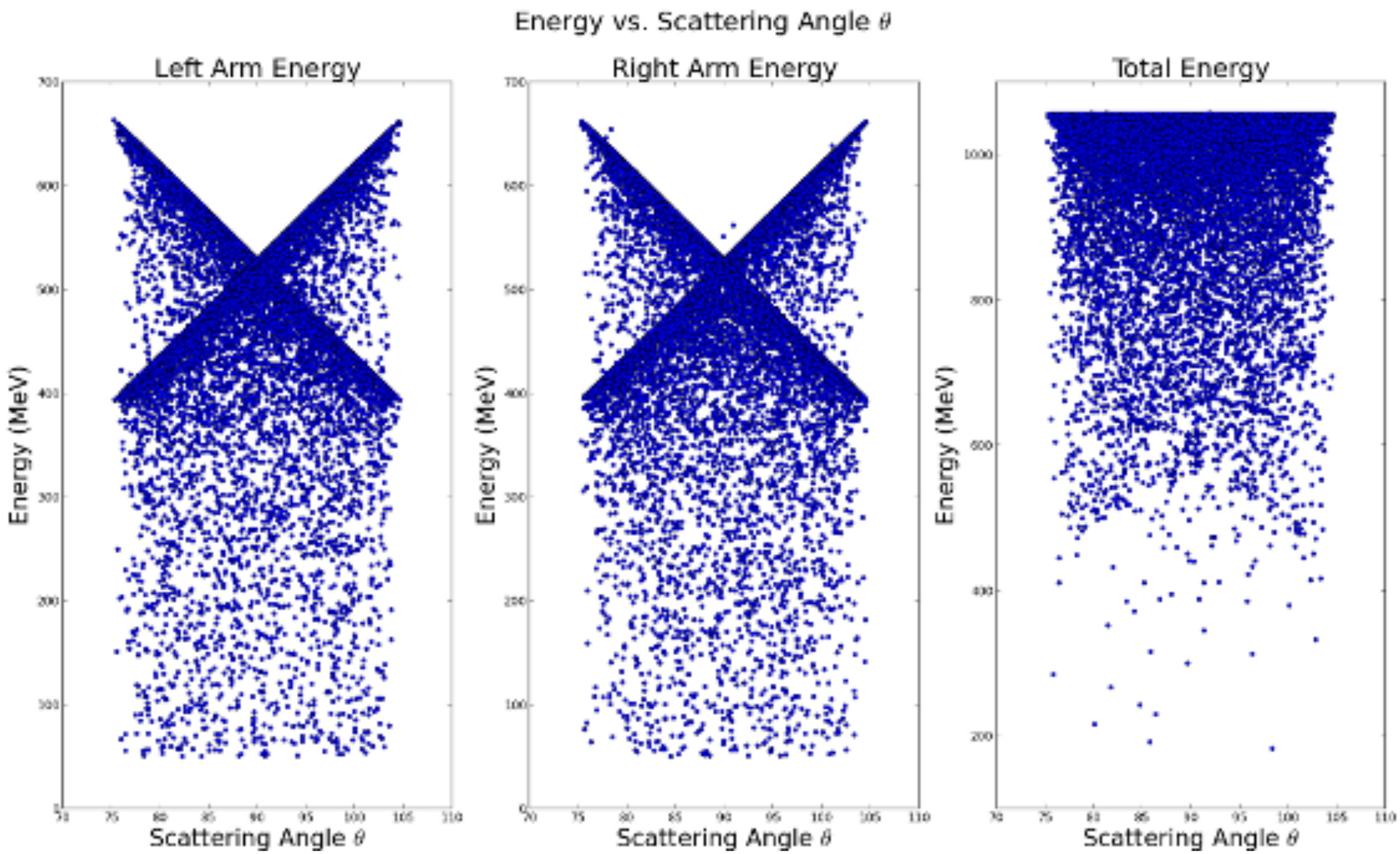


Detected (Coincidence)



What is determining the aperture?

Simple Check: Energy



This looks about right, but what's causing the energy loss?

Analyzing Power

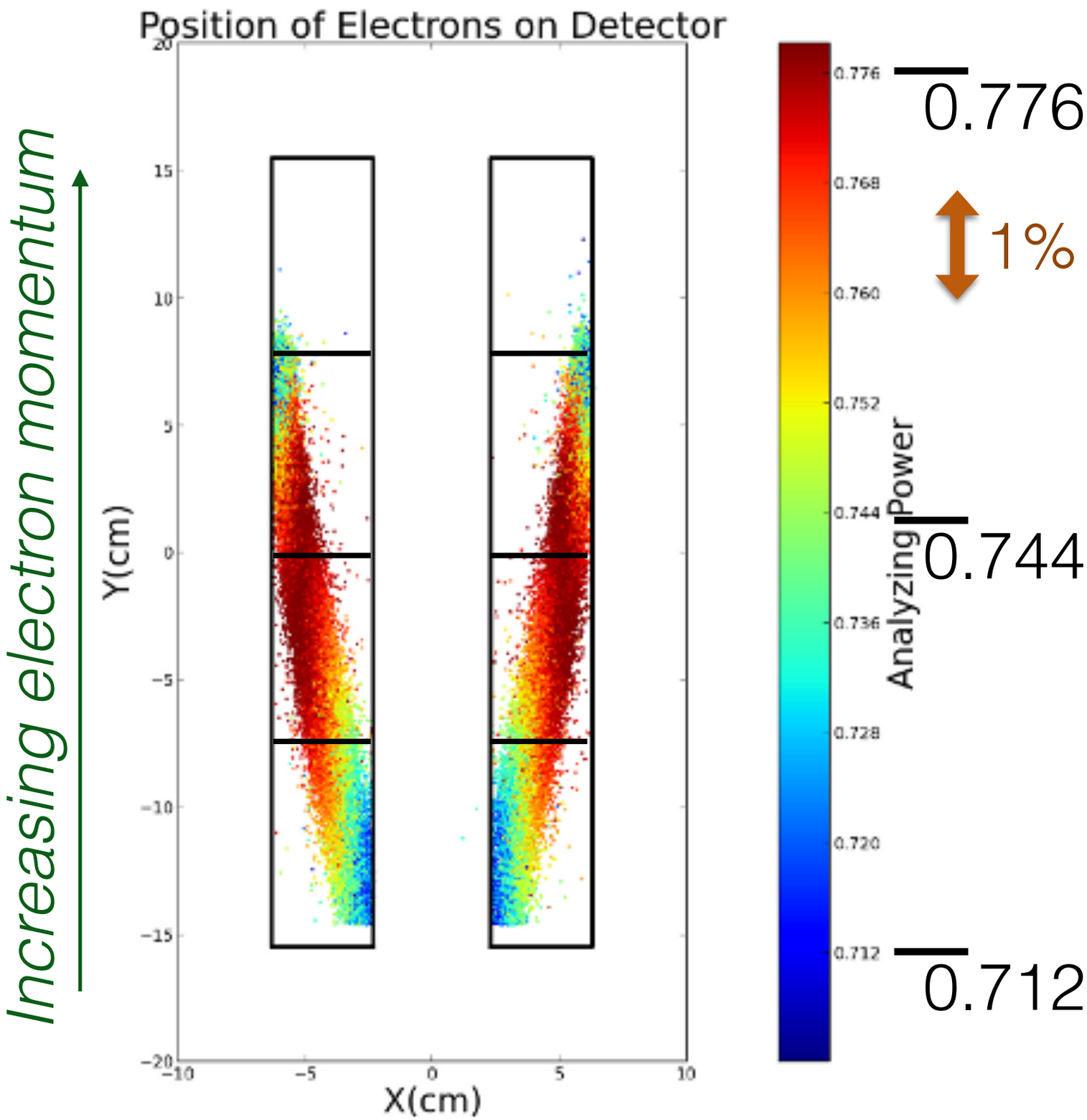
$$A_{\text{long}}(\theta) = \frac{(7 + \cos^2\theta)\sin^2\theta}{(3 + \cos^2\theta)^2}$$

Depends on CM Scattering angle, not energy.

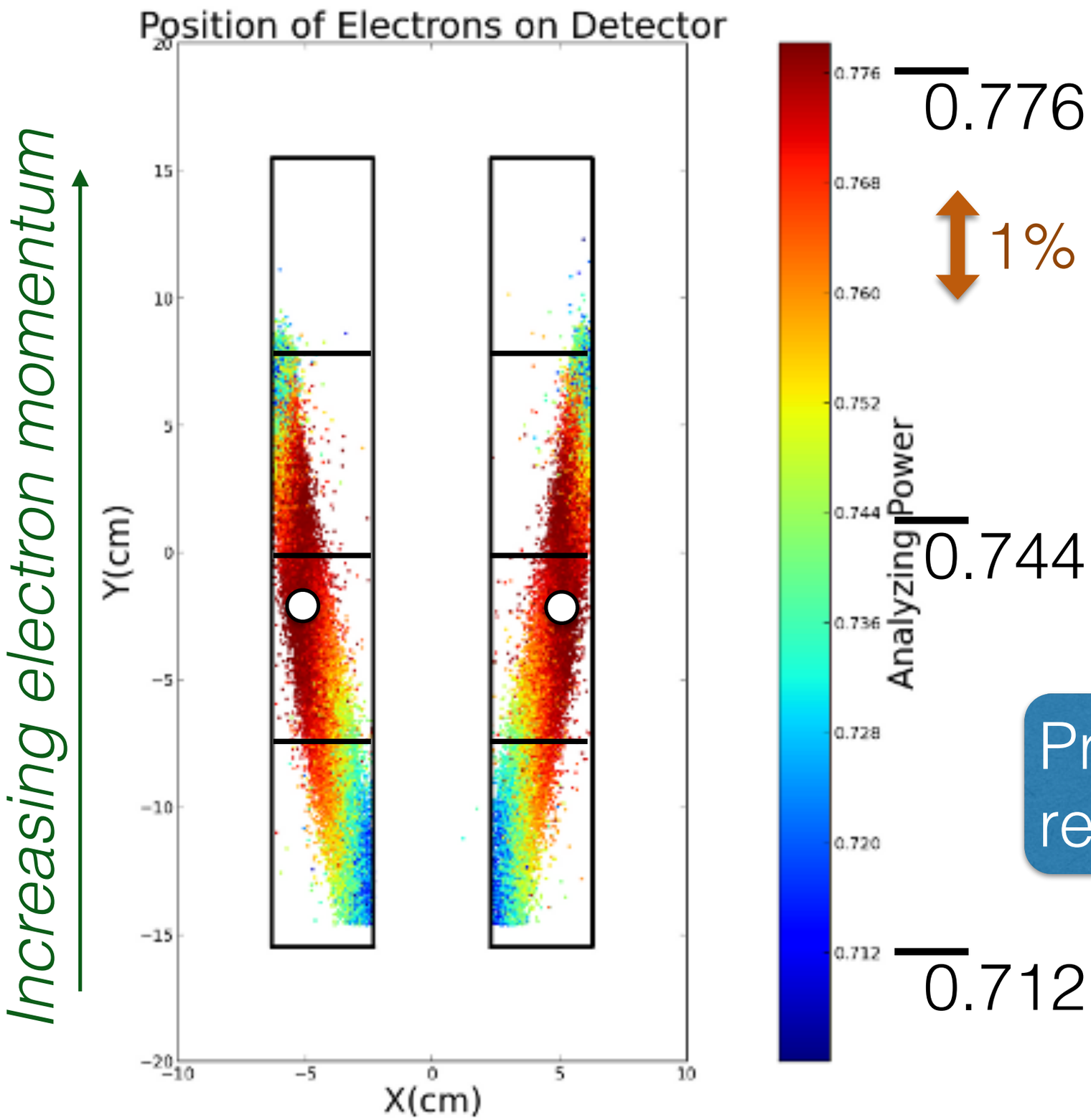
However, acceptance is in lab angle, not cm angle.

Therefore, the accepted analyzing power will depend on the beam energy.

➜ *More severe systematic uncertainty at low energy.*



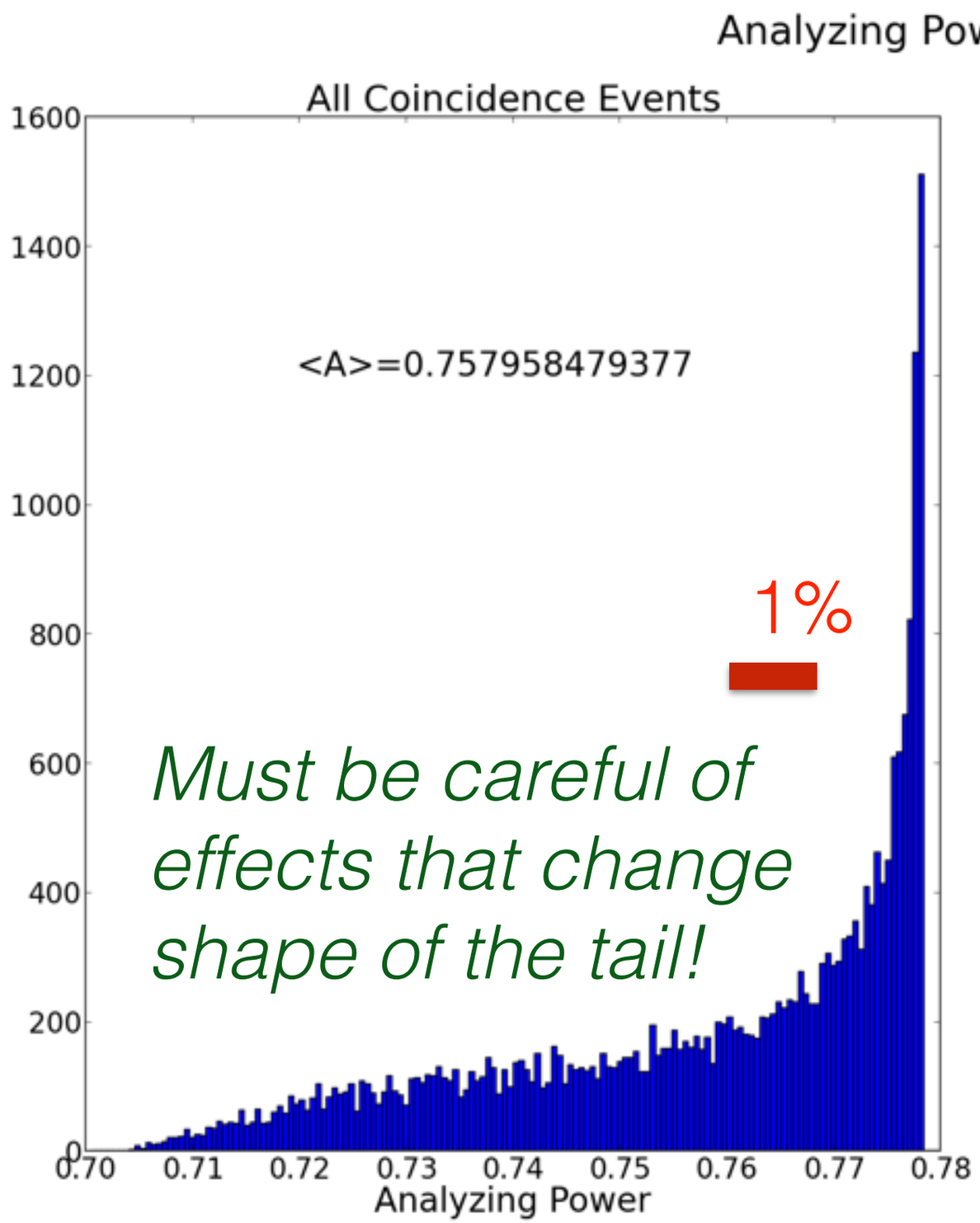
Analyzing power correlates with hit position on detector array.

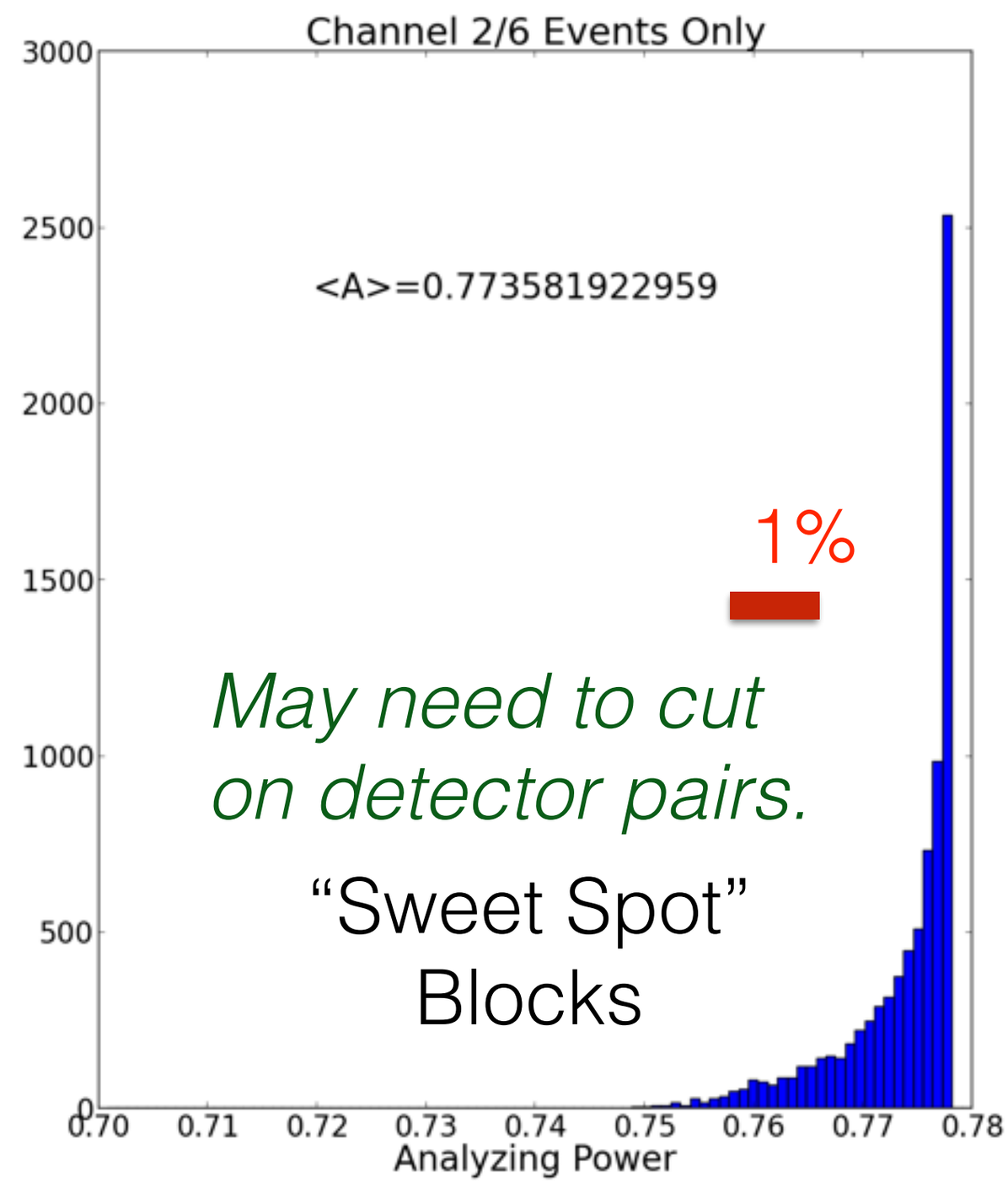


Analyzing power correlates with hit position on detector array.

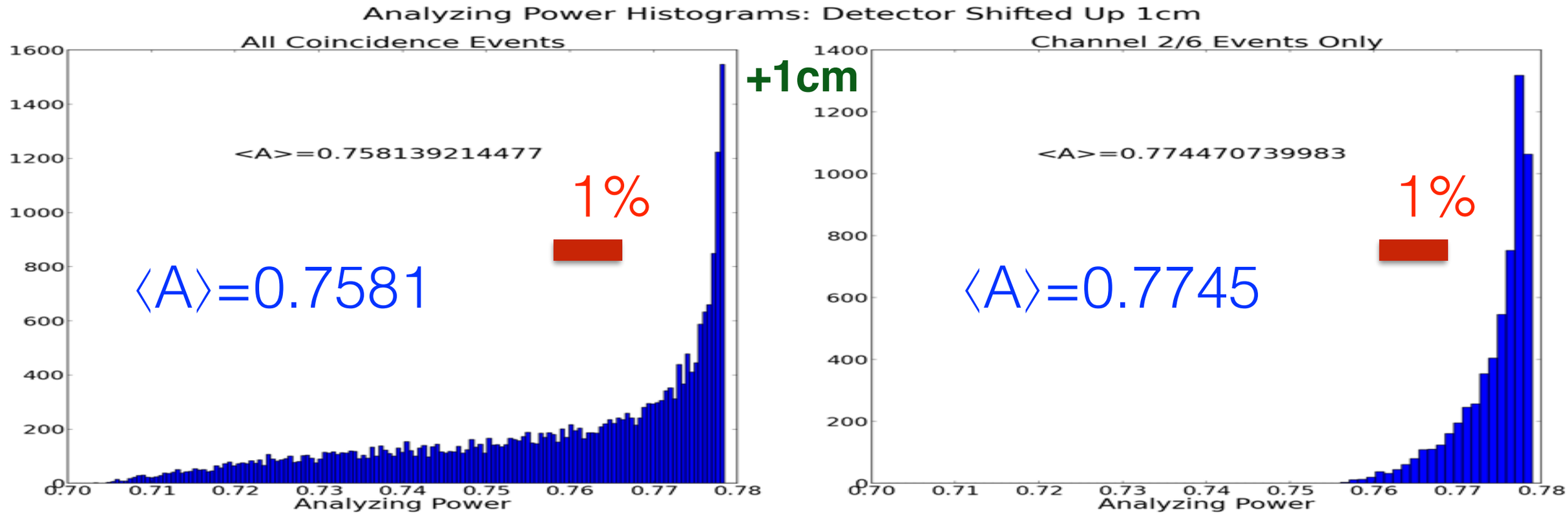
Probably want to readjust “sweet spot”

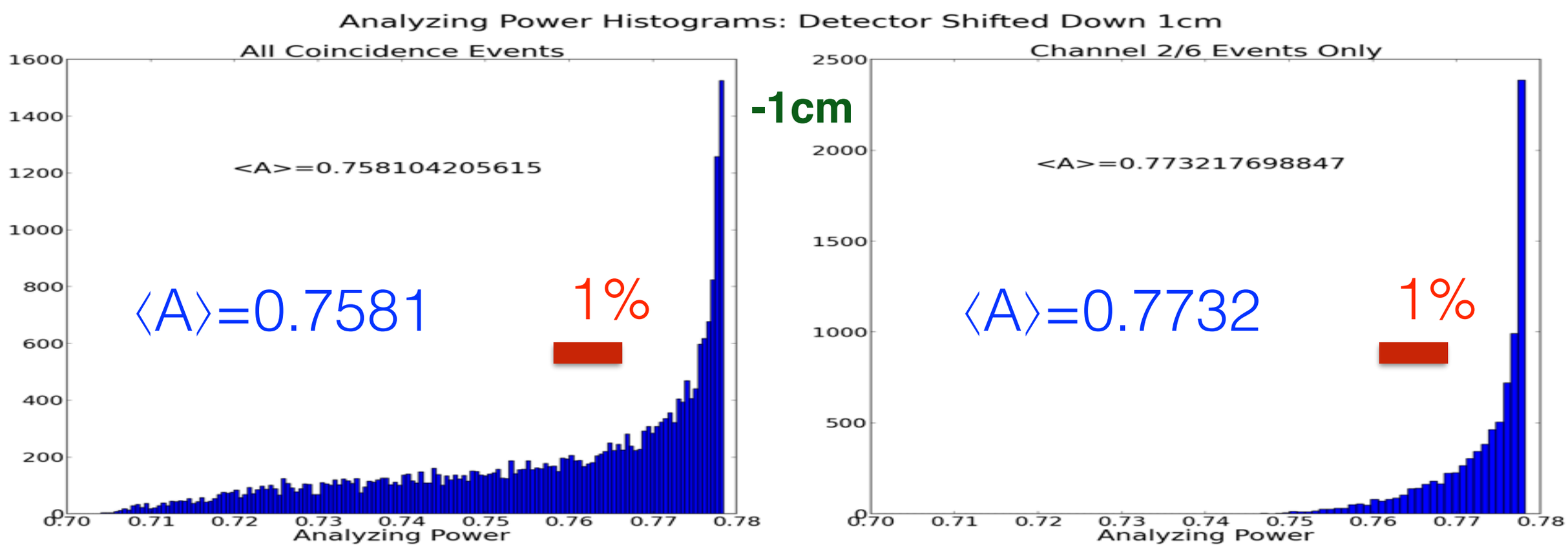
Initial Systematic Checks



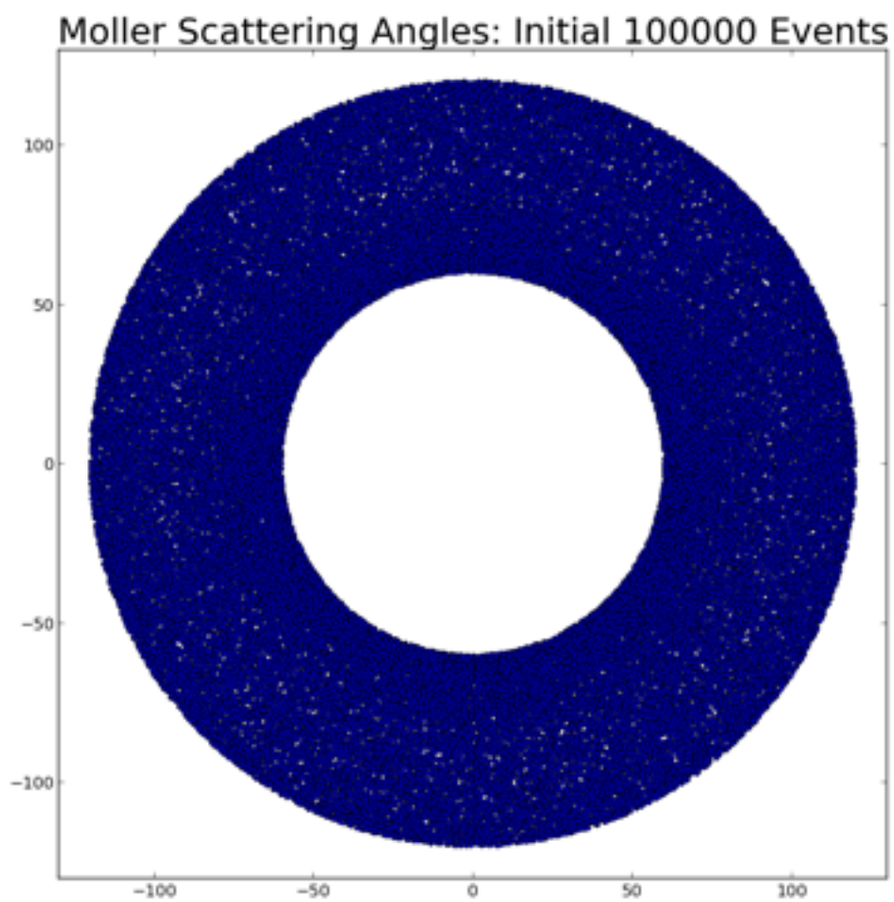


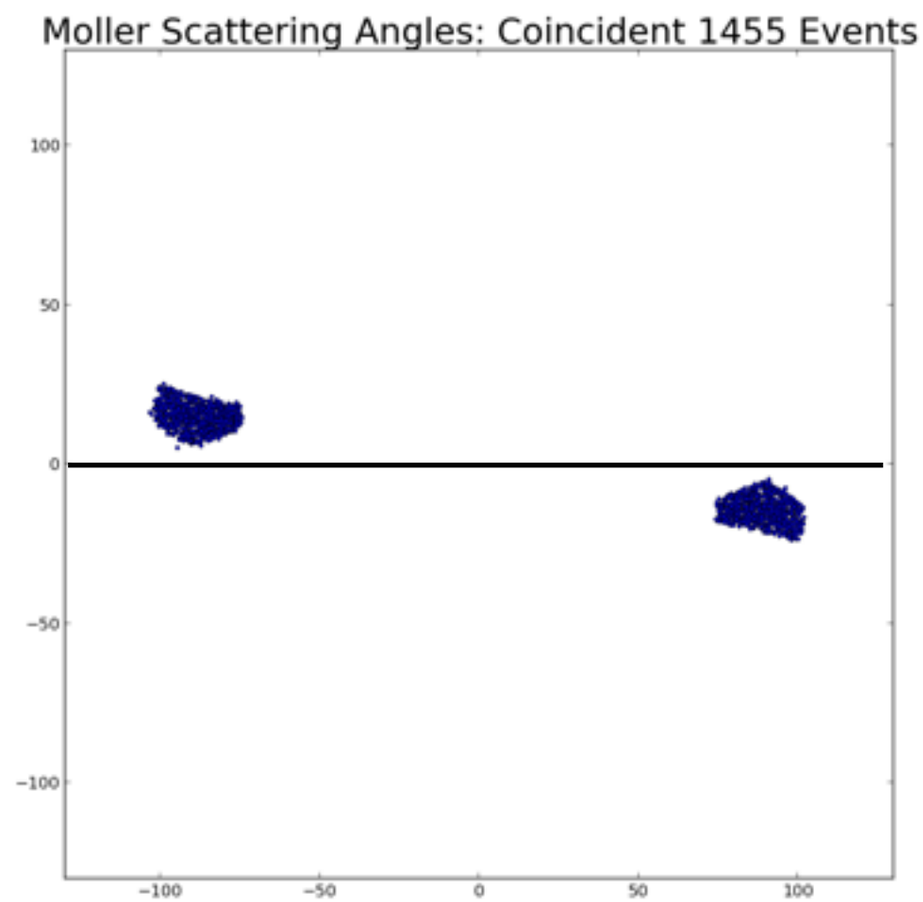
First Thing Tried: Effect of Moving Detectors Up or Down





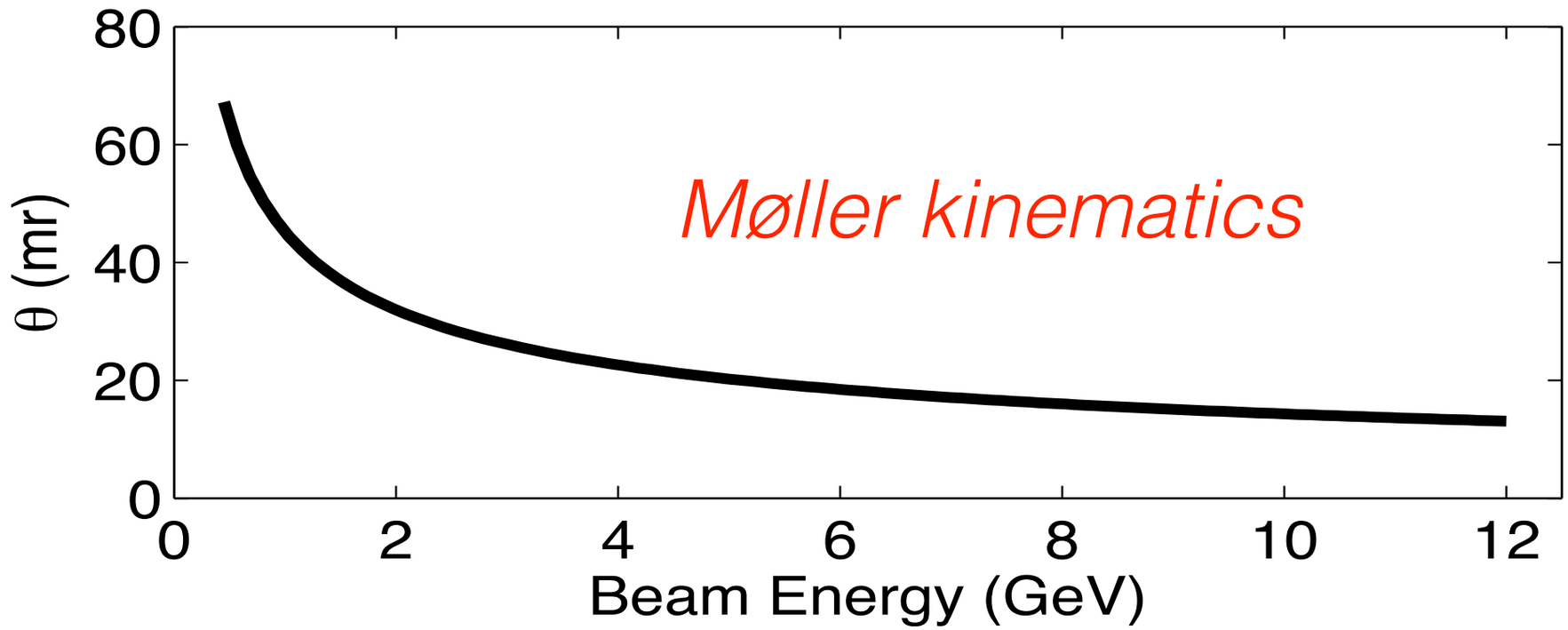
With 4T Holding Field

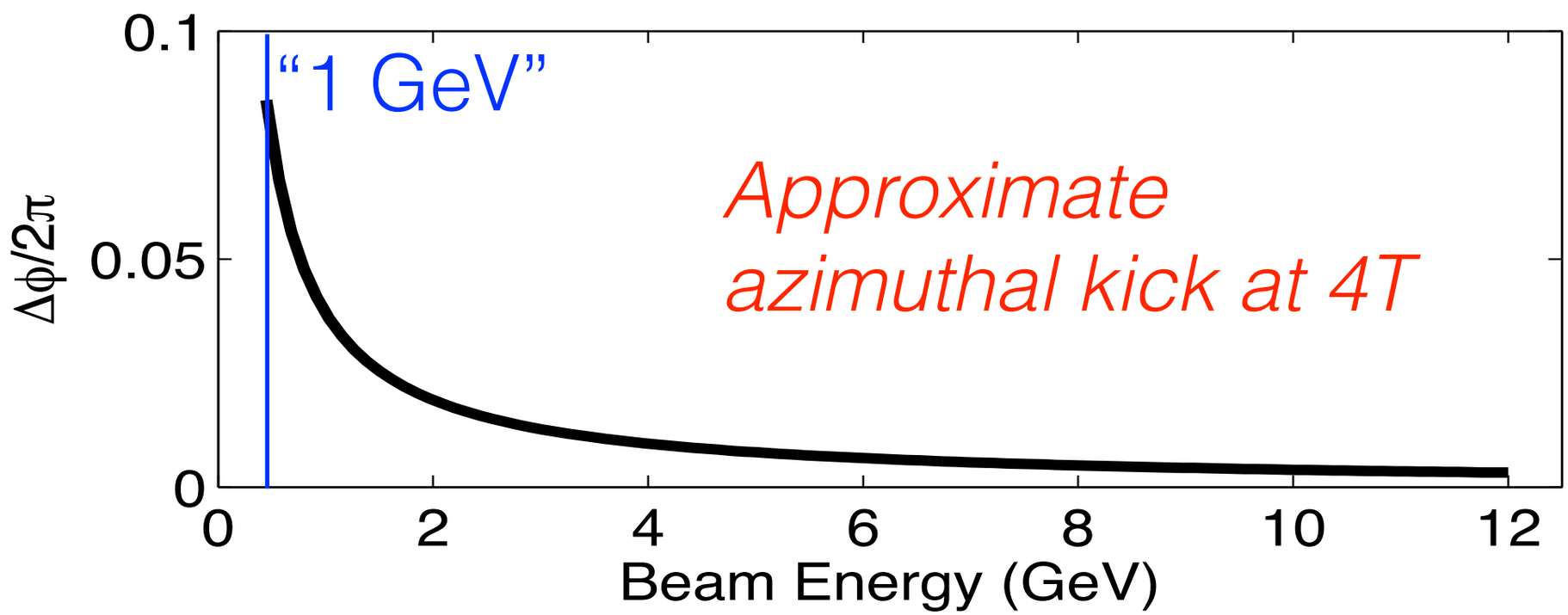




Big effect! We are just starting to look at how this affects the acceptance function and analyzing power.

Such a big effect?





Conclusions

- Biggest change (new target insertion) making good progress, will be ready in Spring 2015
- Alignment issues: Big question mark for now, including likely need to remap target holding field
- Spectrometer optics under study, will need to be careful that we know analyzing power to 0.1%
- Other effects (Levchuk, radiative corrections, target heating) need work, but should be easy enough