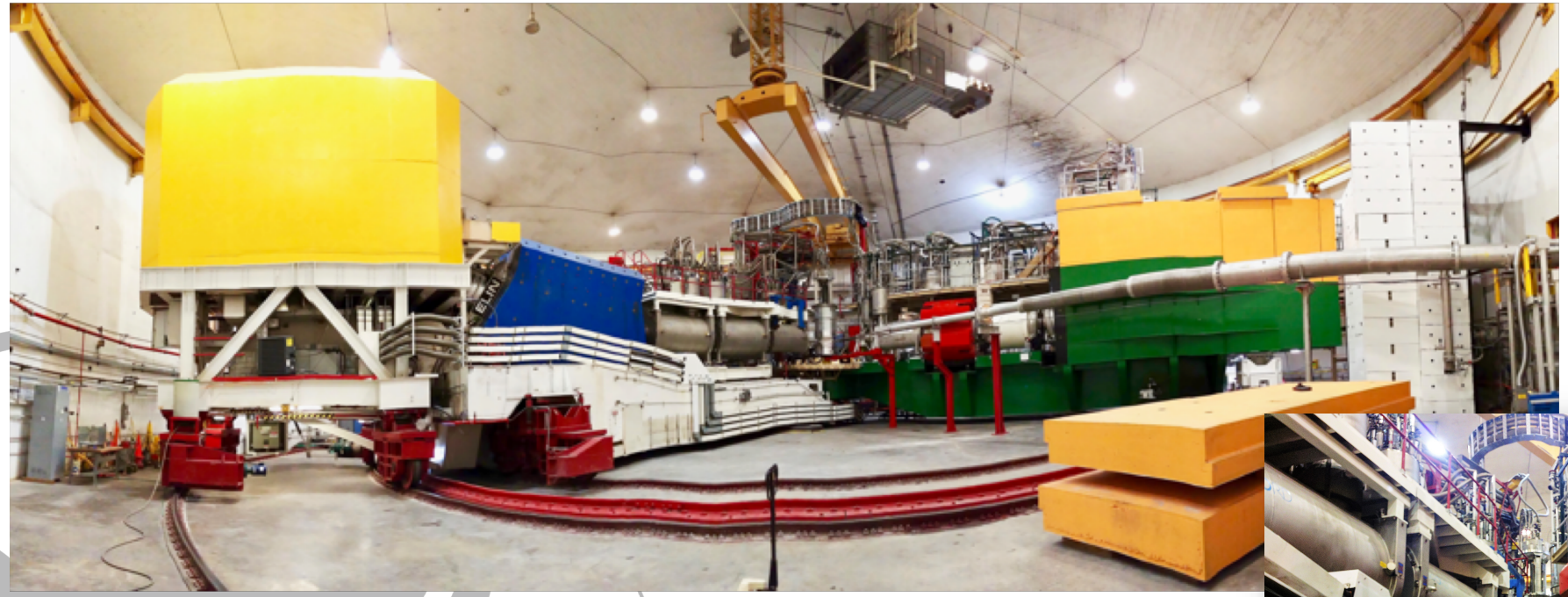
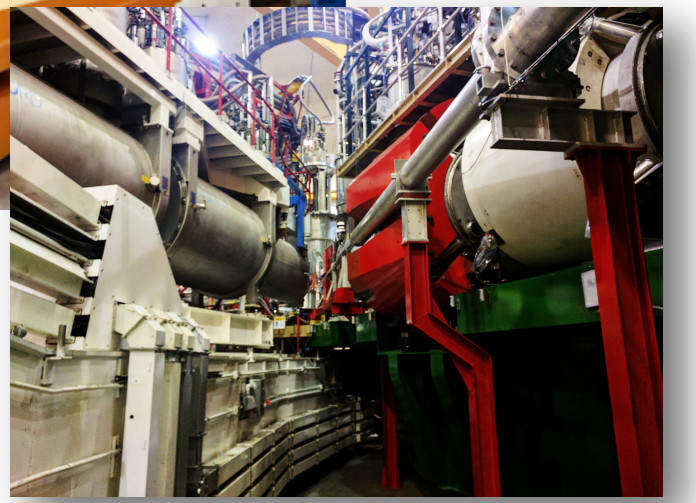
Update and Overview of the Hall C Optics (at high central momenta)





Holly Szumila-Vance

Hall C Winter Collaboration Meeting

Monday, Jan 28th 2019

Jefferson Lab

U.S. DEPARTMENT OF ENERGY | Office of Science

JSA

Overview

1. HMS:
    1. Document on setting magnets/changes: https://hallcweb.jlab.org/DocDB/0009/000998/002/hmsSat.pdf
    2. Hydrogen and carbon data
    3. Mis-pointing

2. SHMS:
    1. Document in progress
    2. History of setting SHMS
    3. Optimization
    4. Mis-pointing

3. Reminder, all field setting program changes are here: https://github.com/hszumila/field17

HMS

Hall C Collaboration • December 4, 2018

Commissioning the HMS optics in the 2017-18 run period

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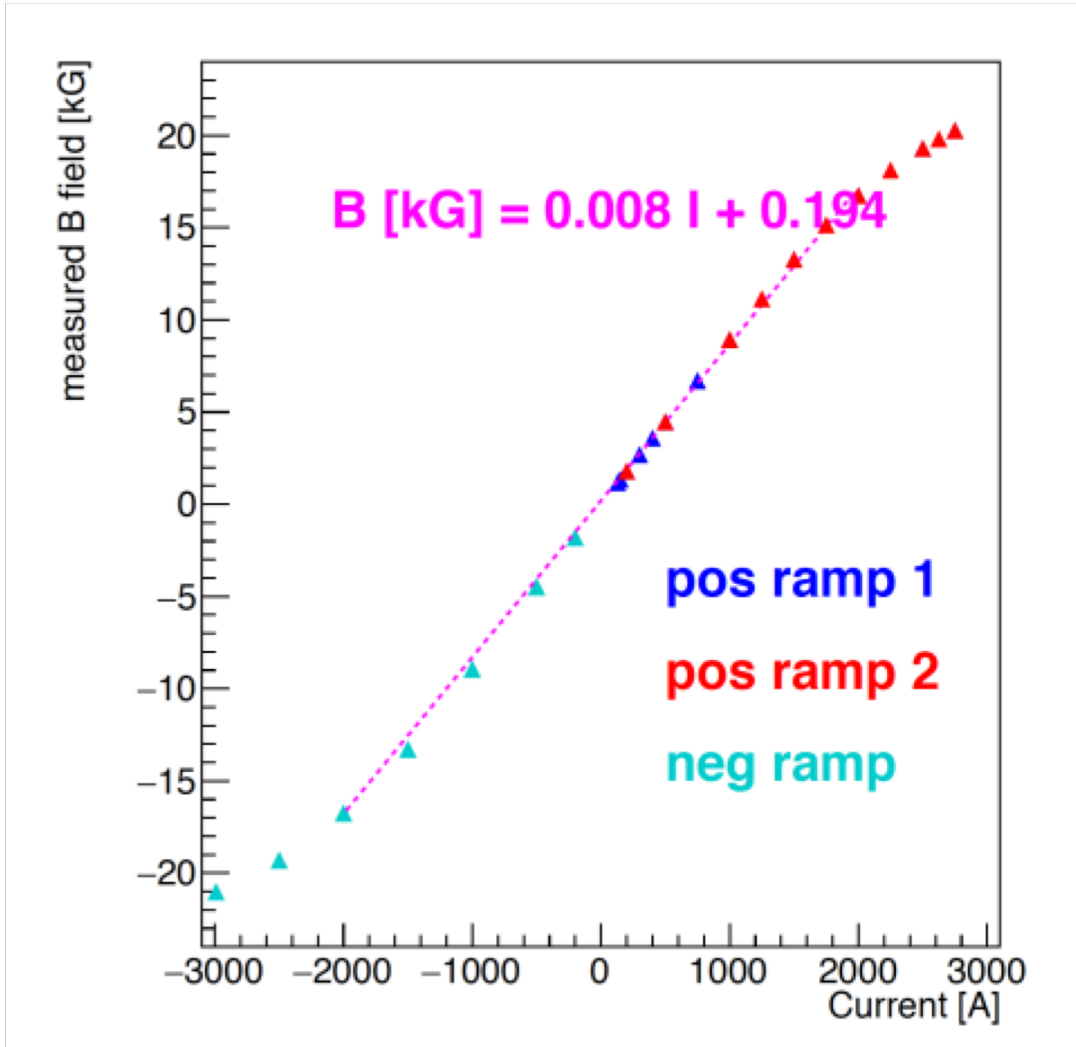
Abstract

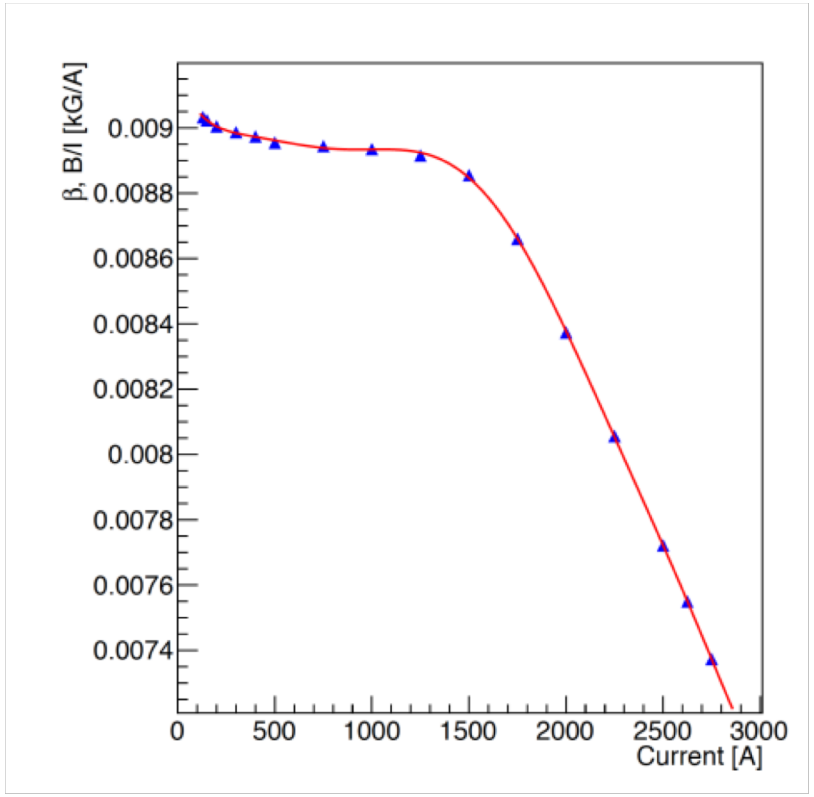
The purpose of this document is to record the procedures and studies that are established for setting the High Momentum Spectrometer (HMS) in the 12 GeV era. The NMR probe in the HMS magnet was moved and set to a new location since the 6 GeV era during the summer of 2017. Initial measurements were taken to precisely determine the central field values and the external NMR field measurements of the HMS dipole magnet with the corresponding current settings. The field setting programs and initial optimization of the HMS are discussed.

Document includes:

- relevant TOSCA models
- central field measurements with the NMR and B/I studies
- how we set the HMS dipole and quads (including the quad models)
- current mis-pointing survey information used during optimization

HMS: Models



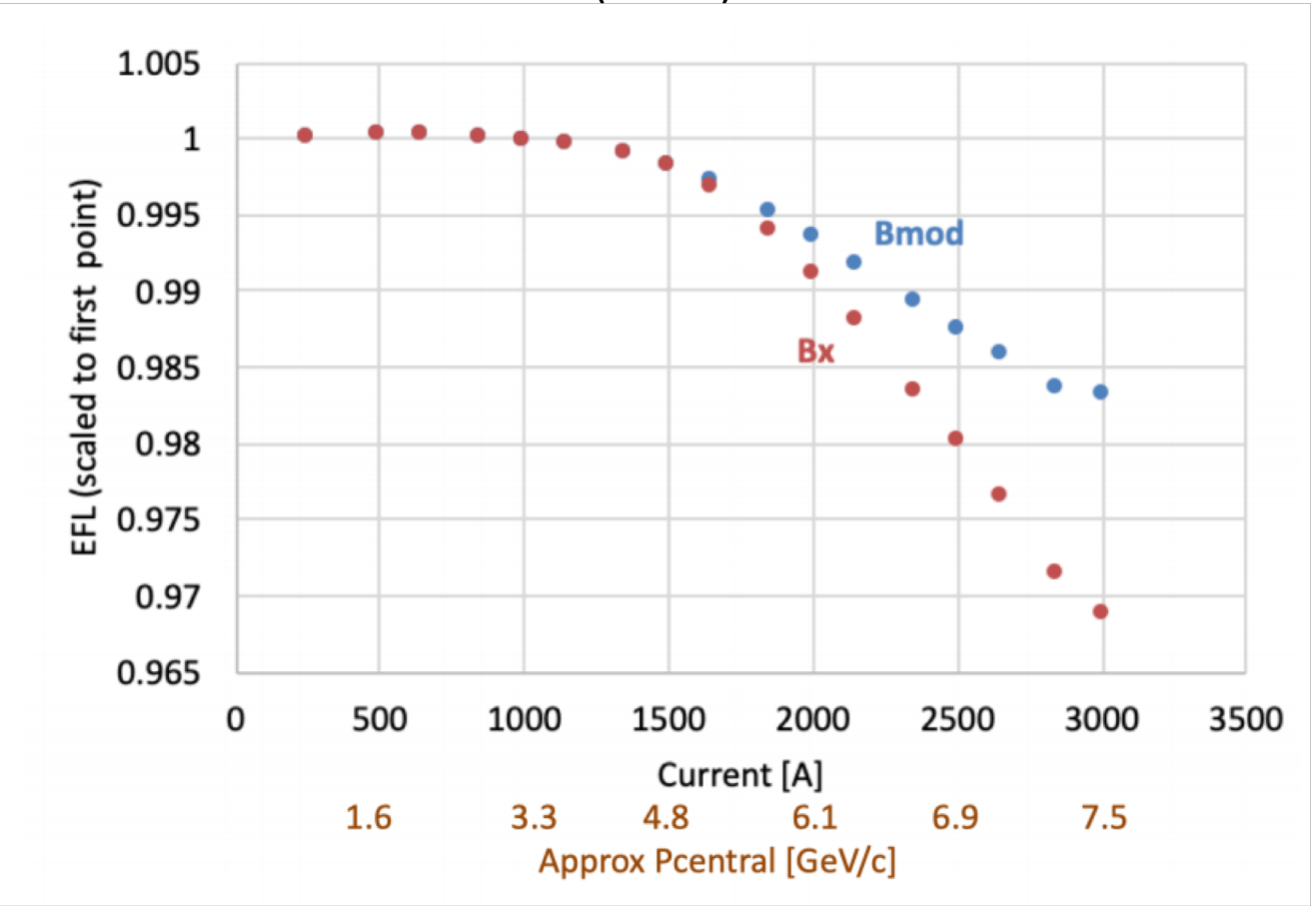


$$B/I_{set} = 7.76495 \times 10^{-29} I_{set}^{8} - 9.59365 \times 10^{-25} I_{set}^{7} + 4.80895 \times 10^{-21} I_{set}^{6} - 1.25206 \times 10^{-17} I_{set}^{5} + 1.81193 \times 10^{-14} I_{set}^{4} - 1.48202 \times 10^{-11} I_{set}^{3} + 6.77632 \times 10^{-9} I_{set}^{2} - 1.71809 \times 10^{-6} I_{set} + 0.00916971$$

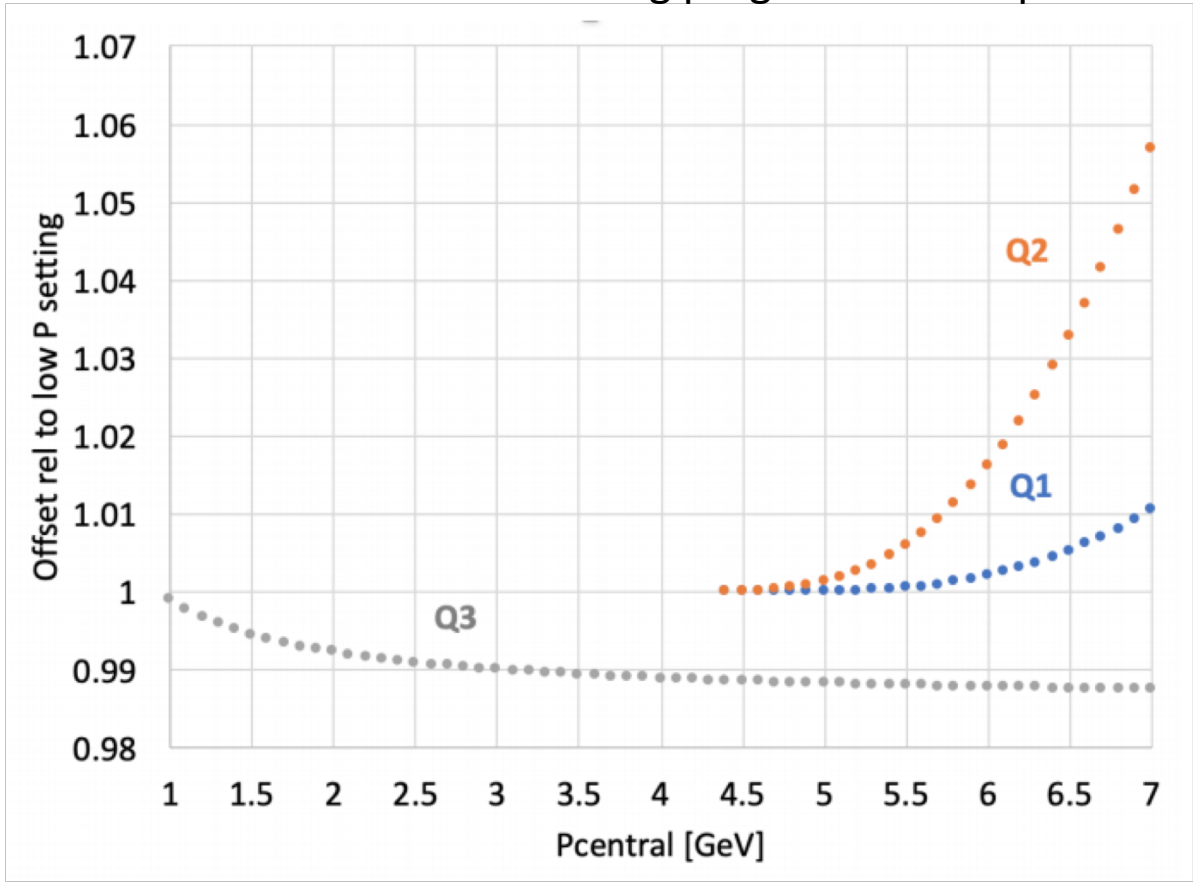
Measurements are here: https://github.com/hszumila/magnets

HMS: Models

Steve Lassiter's latest (Nov 1) TOSCA EFL calculation:



Field03 fortran field setting program for the quads:



Because we set by field, we eliminate the saturation effects from the non-linearity of the B/P ratio, but we don't account for the EFL.

The Q1 and Q2 saturation models above 6 GeV are scary (not studied previously for sure). I have not studied these magnets thoroughly.

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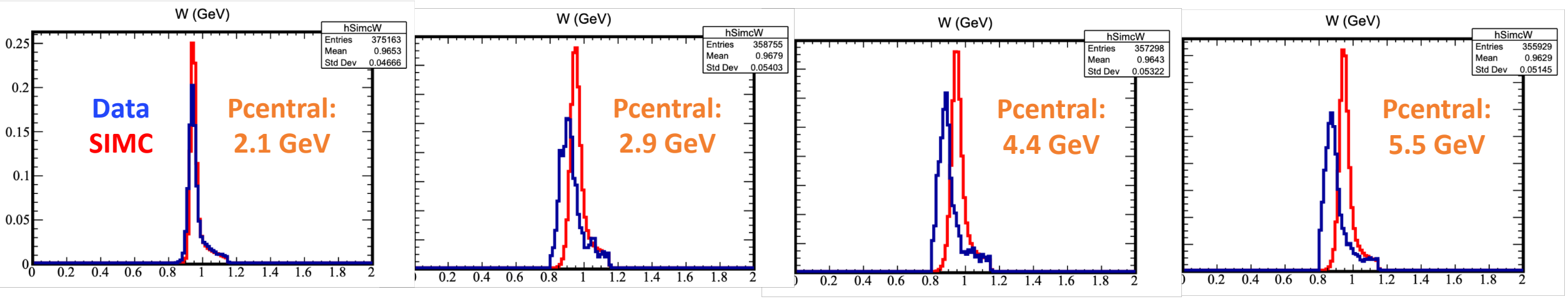
HMS: Hydrogen data from CT experiment



B/P nominal ratio = 0.273767 T/GeV
(no saturation models applied)

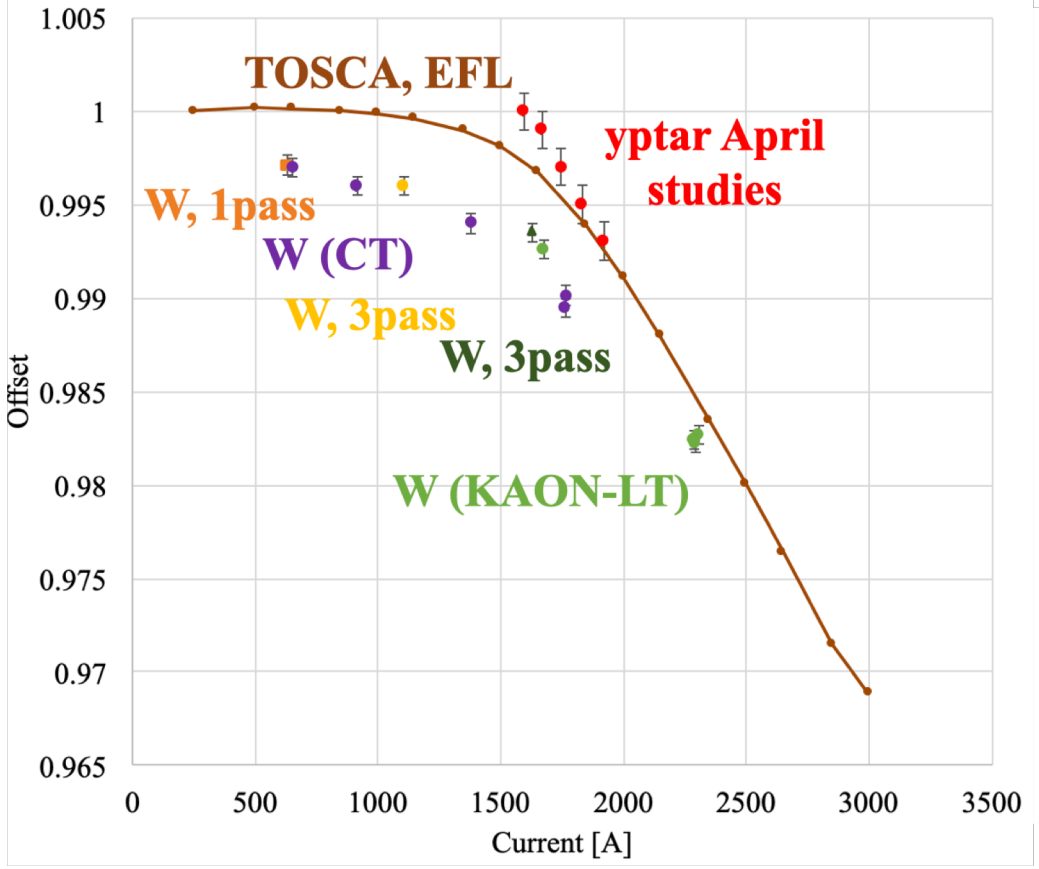
From the CT experiment, clearly had some changes happening to the expected W peak location as a function of (at least) the central momentum.

HMS: Hydrogen and Carbon data

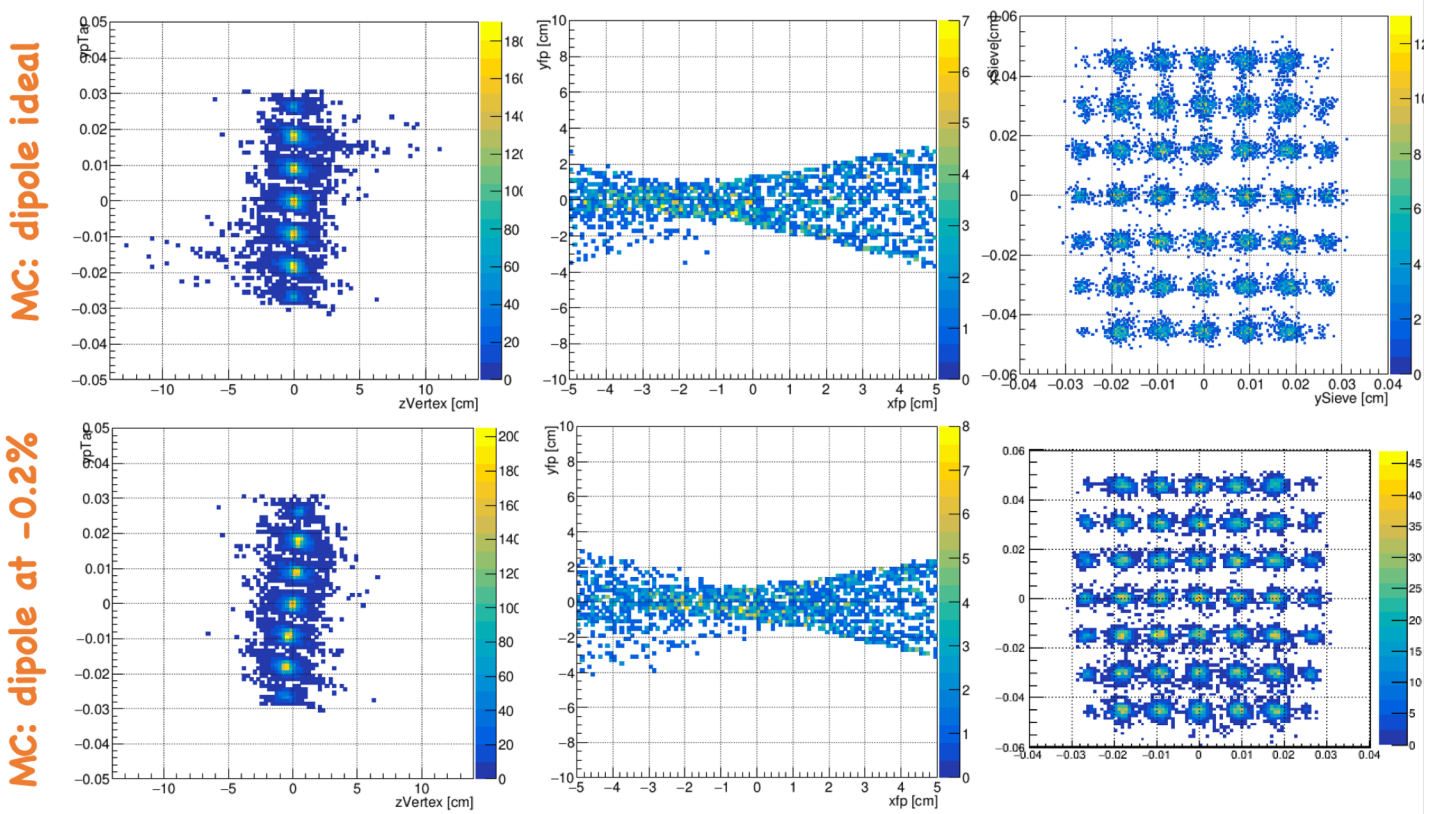
Later saturation factors applied in dipole setting program

- **Version 1** Applied on April 9, 2018 at 8:42 am starting with coincidence run 3368. The saturation factor applied to the field is $0.01P + 0.948$ at 5.3 GeV/c central momentum and above [9] [6].
- **Version 2** Applied on Sept. 26, 2018 at 7:04 pm starting with coincidence run 4701. The saturation factor applied to the field is $0.01P + 0.949$ at 5.1 GeV/c central momentum and above [7] [8].

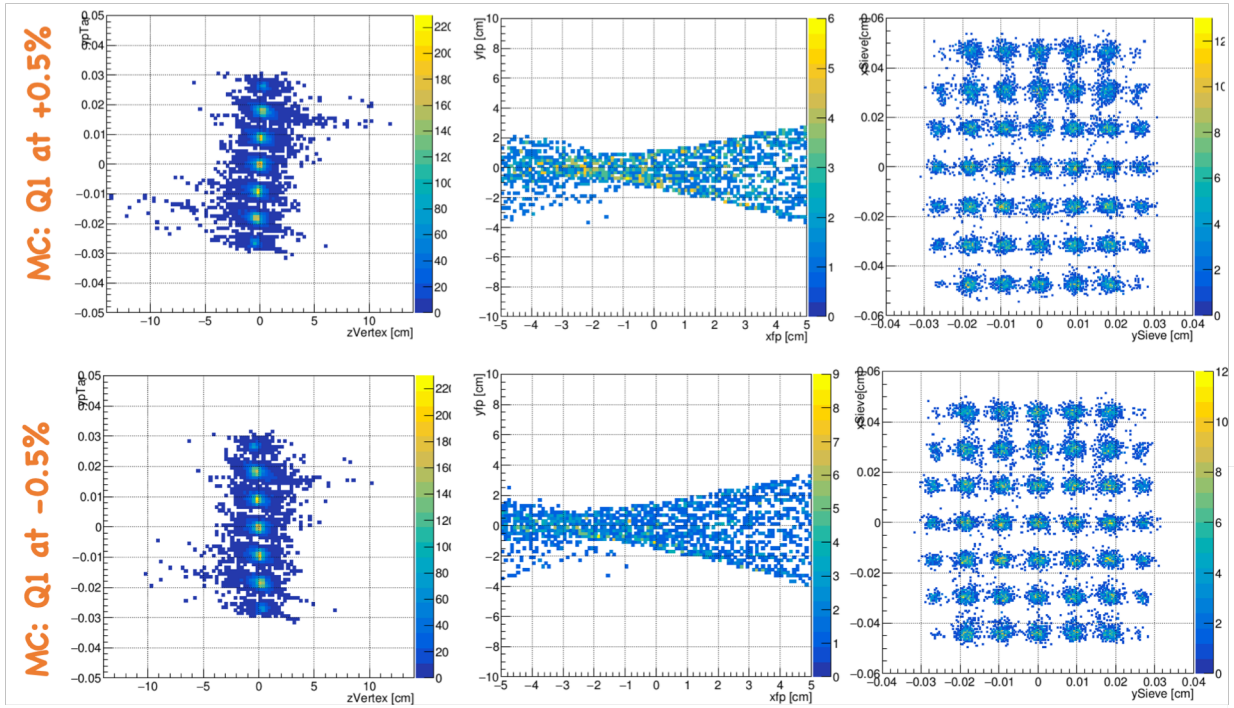
Offset w/r/t current



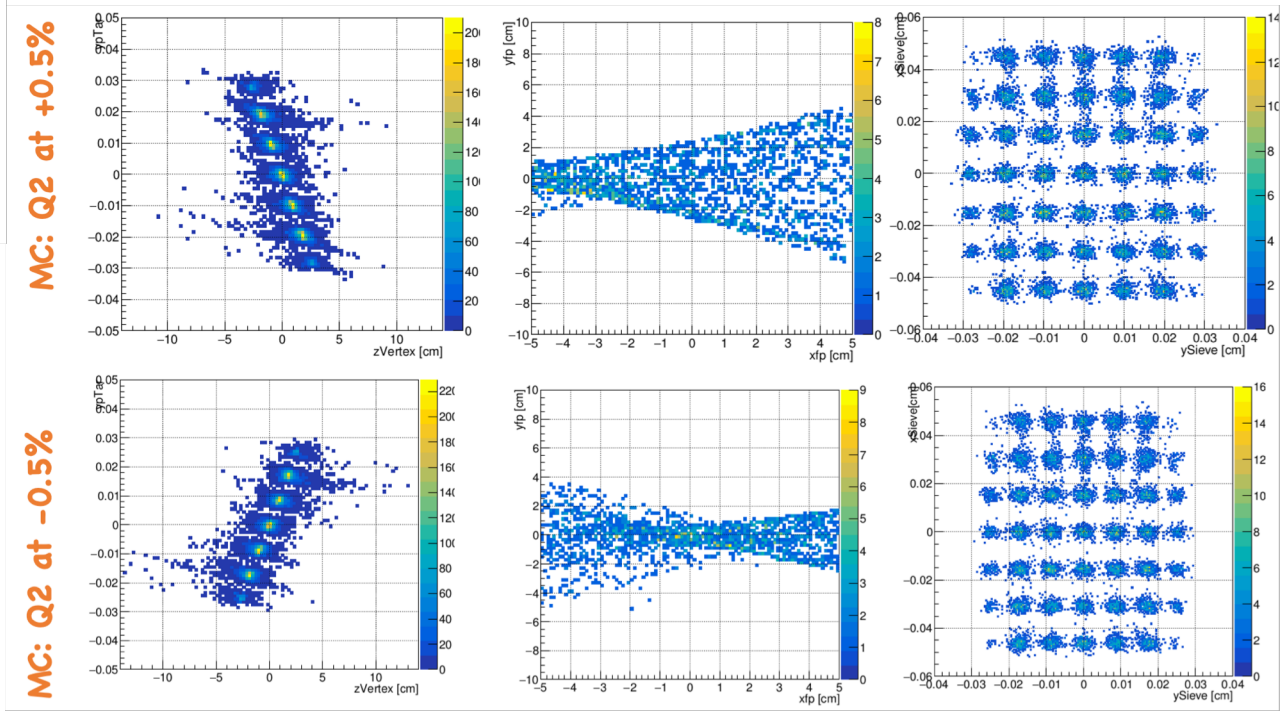
yptar studies: Carbon sieve data of yptar vs zvertex



HMS: Carbon data of yptar vs zvertex

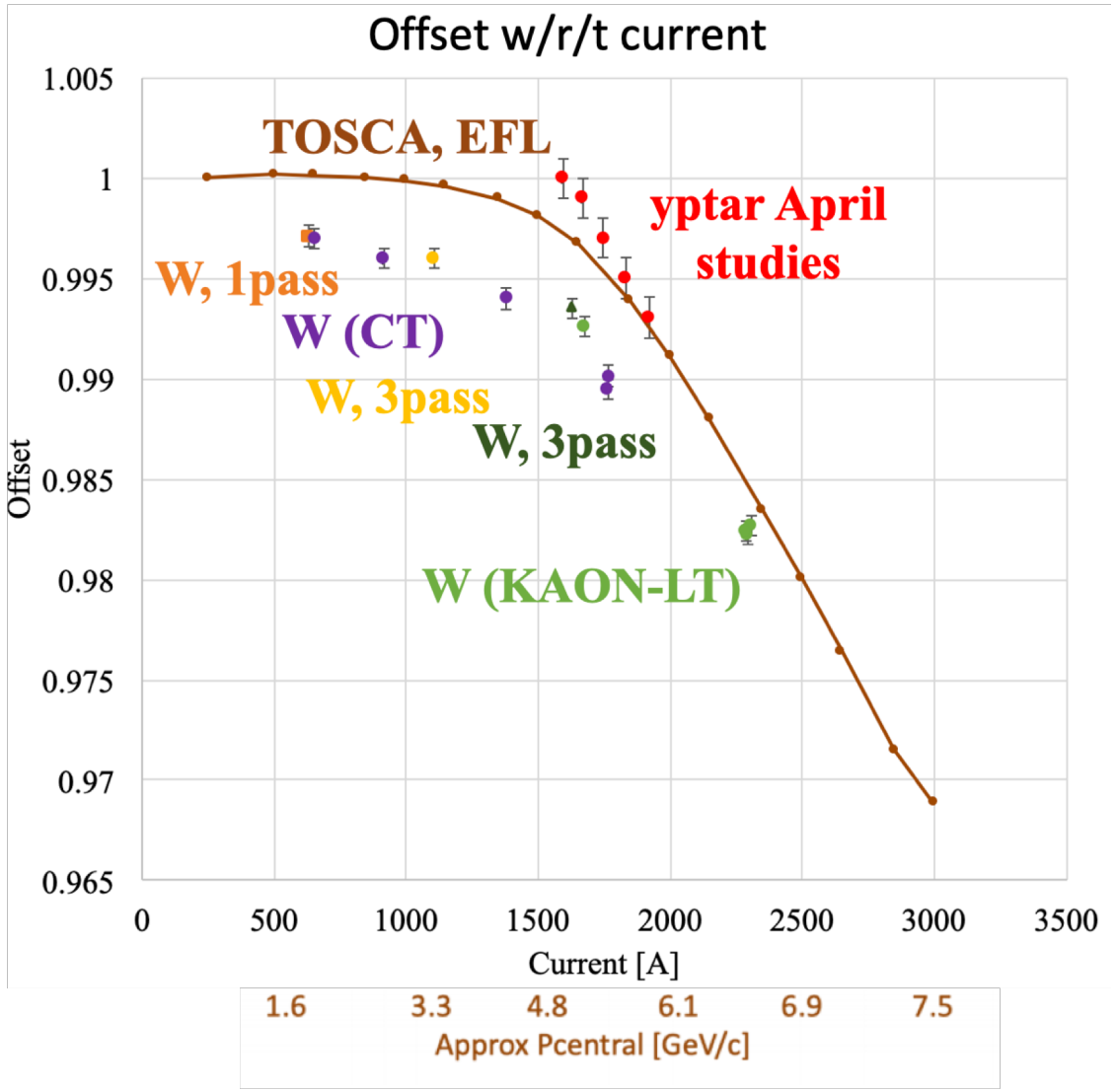


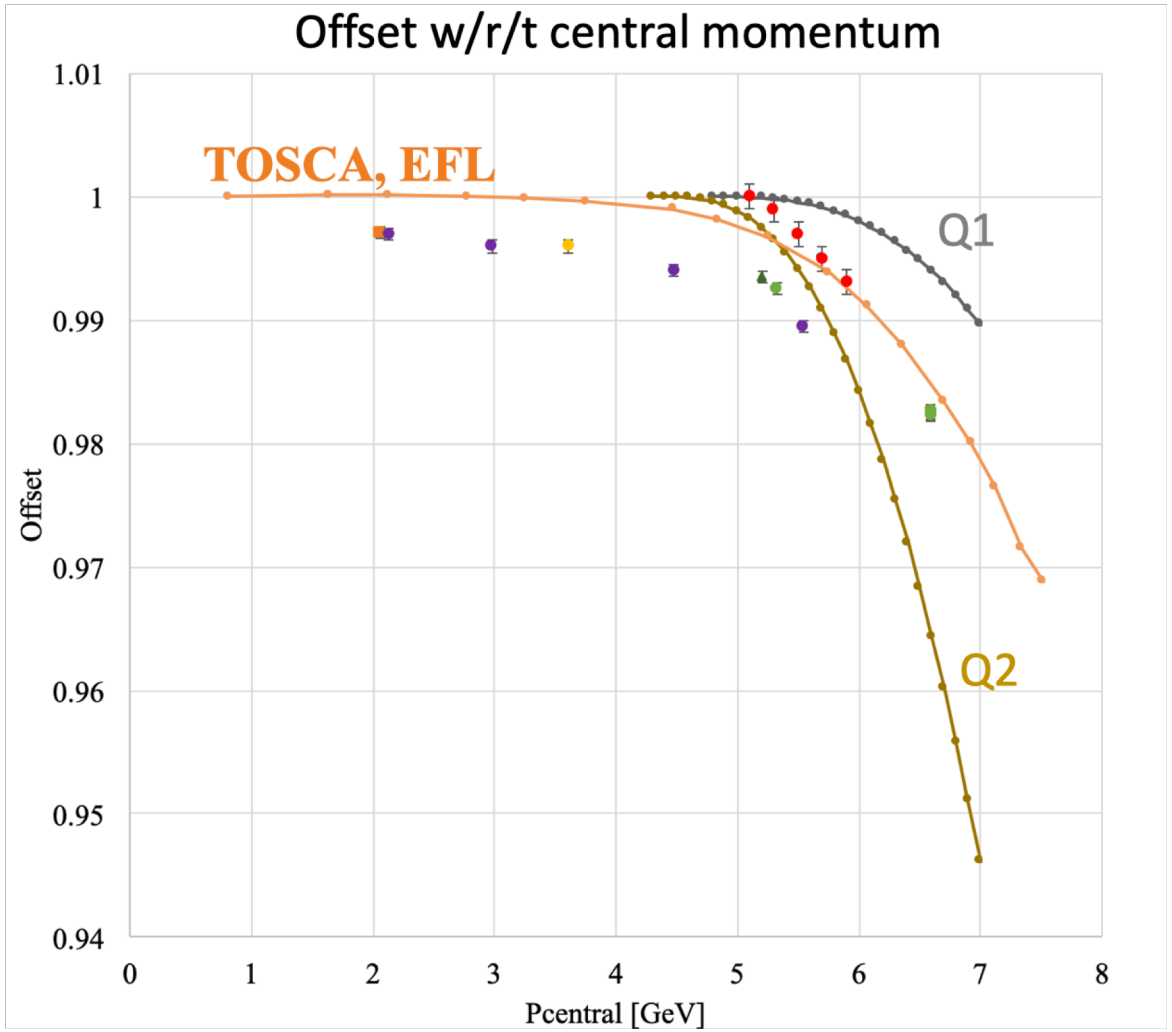
- The quads can induce similar distortions to the yptar vs zvertex dependency and can be (overall) difficult to dis-entangle.
- To fully understand the distortions, both hydrogen and carbon sieve data and provide details for the full picture.



- H(e,e'p) can show us true dipole offsets by comparing the W peak in data and simulation
- Carbon+sieve data can show optics distortions, used for re-optimization

HMS: Hydrogen and Carbon data





HMS: Lots of work to fully characterize!

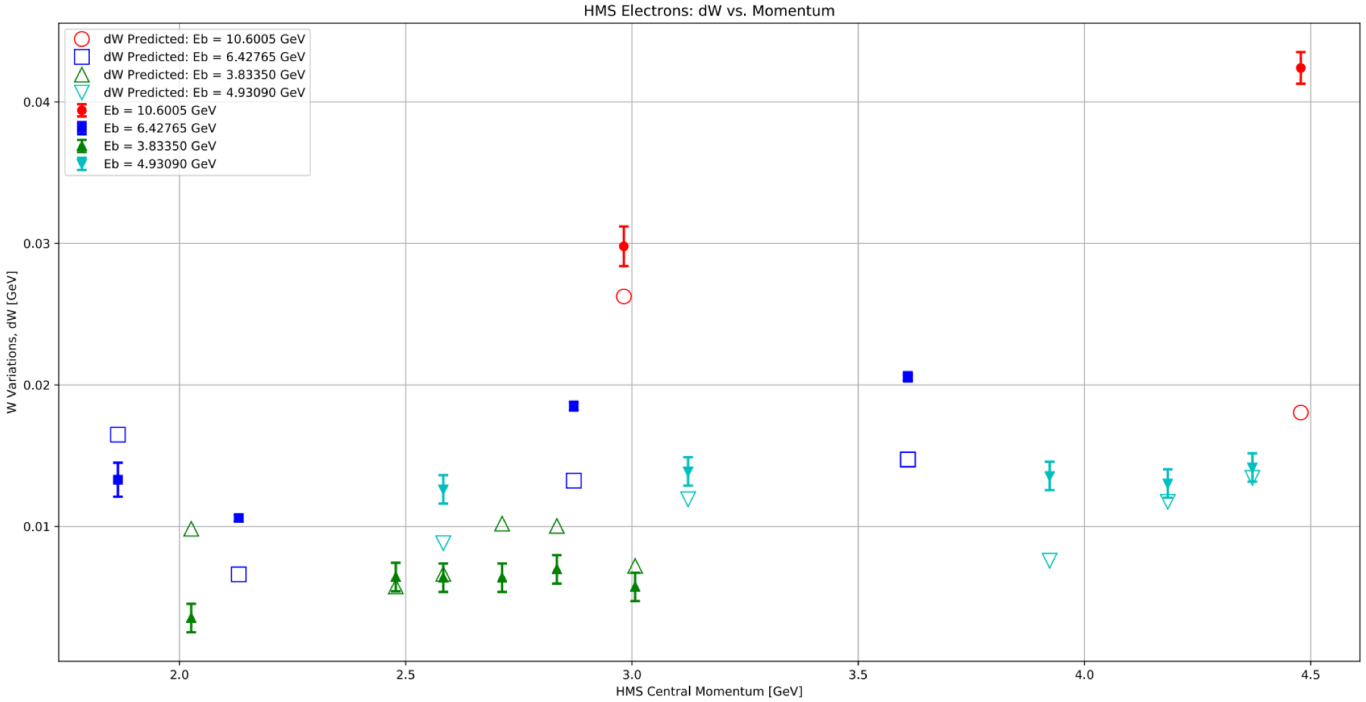
Carlos Yero, FIU graduate student: full analysis of H(e,e'p) runs at various angles, beam energies, and central momentum to extract offsets [<4.5 GeV central P]

Burcu Duran, Temple U. graduate student: optimizing the HMS at settings above 5 GeV from fall running [5.2 – 6.3 GeV central P]

Slide from Carlos Yero:

$$\frac{dE_b}{E_b} = 0.0008, \frac{dP}{P} = -0.0015, \delta\theta = -0.0005 \text{ rad}$$

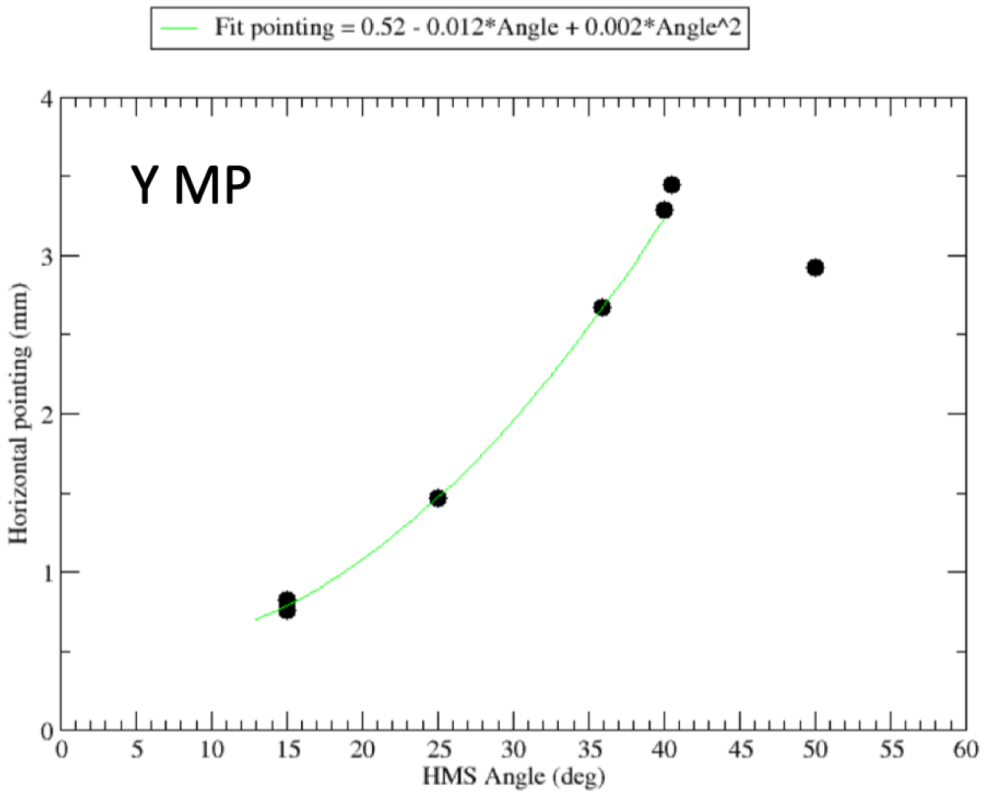
Min. Chi2 Param.

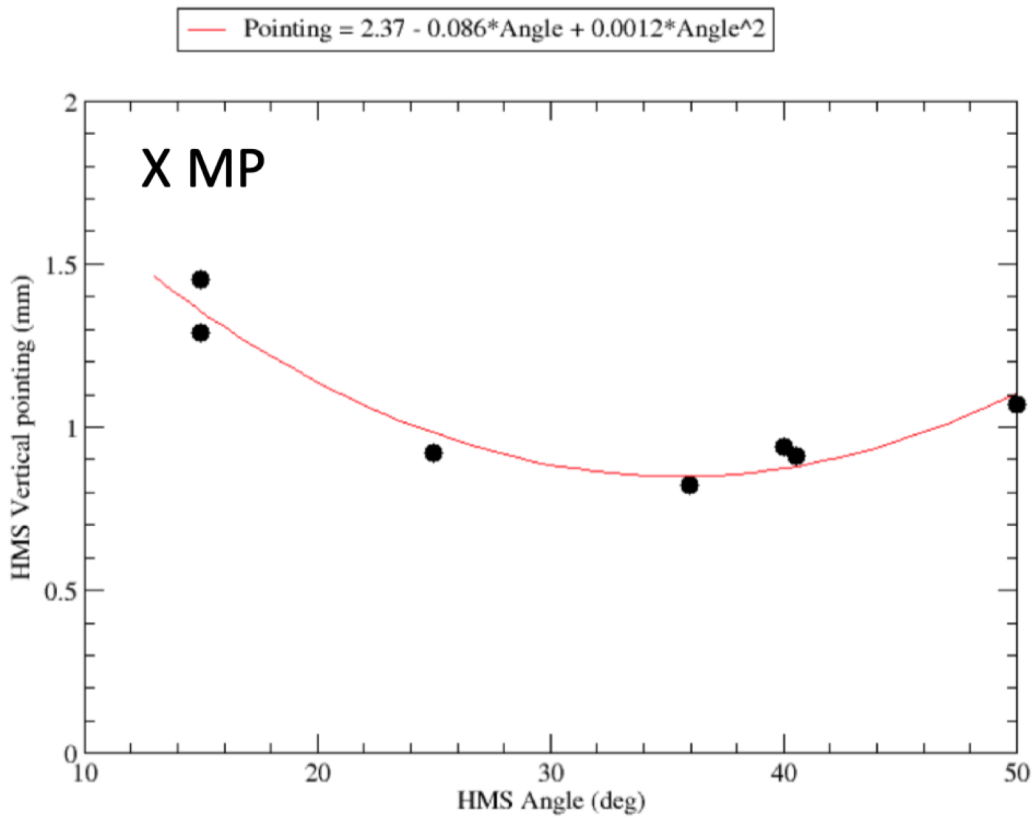


Carlos's latest work:
https://hallcweb.jlab.org/wiki/images/d/d2/Chi2Minimization.pdf

HMS: Mis-pointing

HMS surveys: HMS mis-pointing in X and Y as a function of HMS angle





Mark Jones maintains summary here:
https://hallcweb.jlab.org/elogs/Commissioning+Experiments+Analysis/180221_141950/survey-summary.pdf

SHMS: Models

Field setting code changes to the SHMS: https://github.com/hszumila/field17

- Version 1: Q1, Q2, Q3 at 1.05 (Dec 2017, https://logbooks.jlab.org/entry/3502390)
- Version 2: Q1, Q3 at 1.03, Q2 at 1.04 (Dec 2017, https://logbooks.jlab.org/entry/3506891)
- Version 3: Q1 and Q3 saturation models completely removed (April 2018, https://logbooks.jlab.org/entry/3555447)
- Version 4: HB, Q1, Q2, Q3 and dipole scaled up by 1/0.983 (August 2018, https://logbooks.jlab.org/entry/3587052)
- Version 5: Remove any model of SHMS dipole above 6 GeV (August 2018)
- Version 6: Q1 saturation model between 6-8 GeV from Kaon-LT commissioning (Sept 29 2018 studies, includes Q1 saturation model at 6-8 GeV central P)

Original matrix optimization at 3-pass (currently in repo):

- 2 GeV at 30 deg
- 3.2 GeV at 22 deg
- 4 GeV at 15 deg

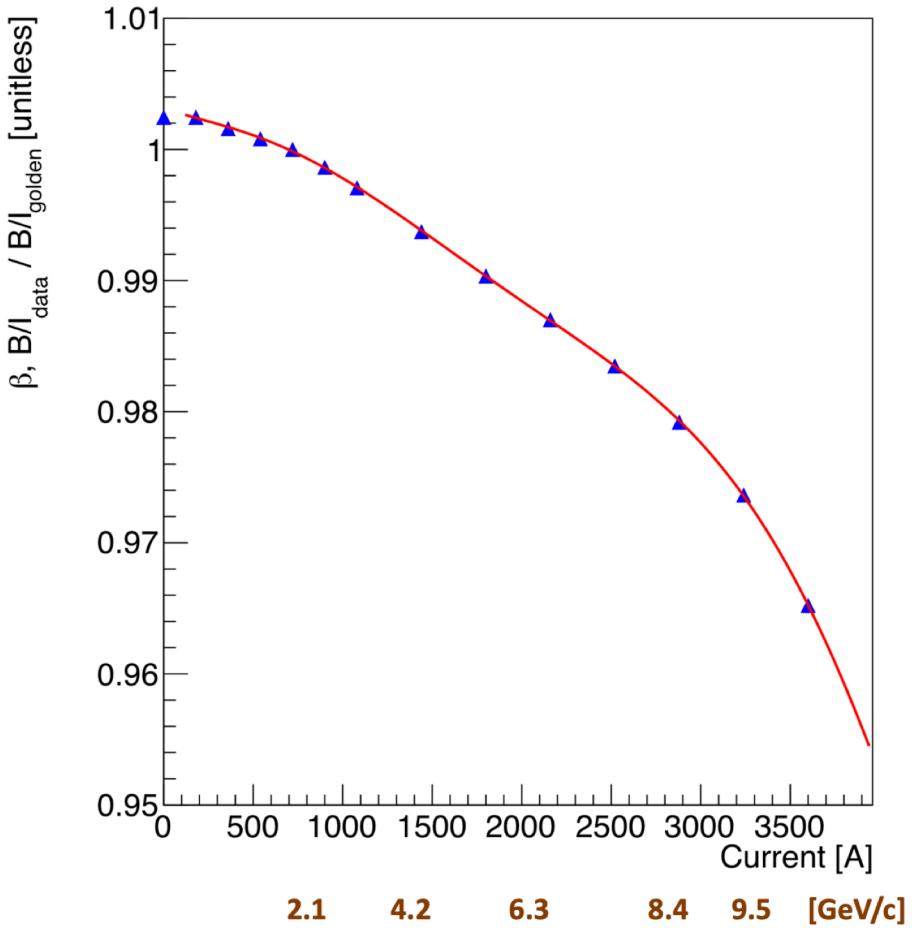
New matrix optimization (exclude effects from mis-set Q1 and Q3, soon to be in repo):

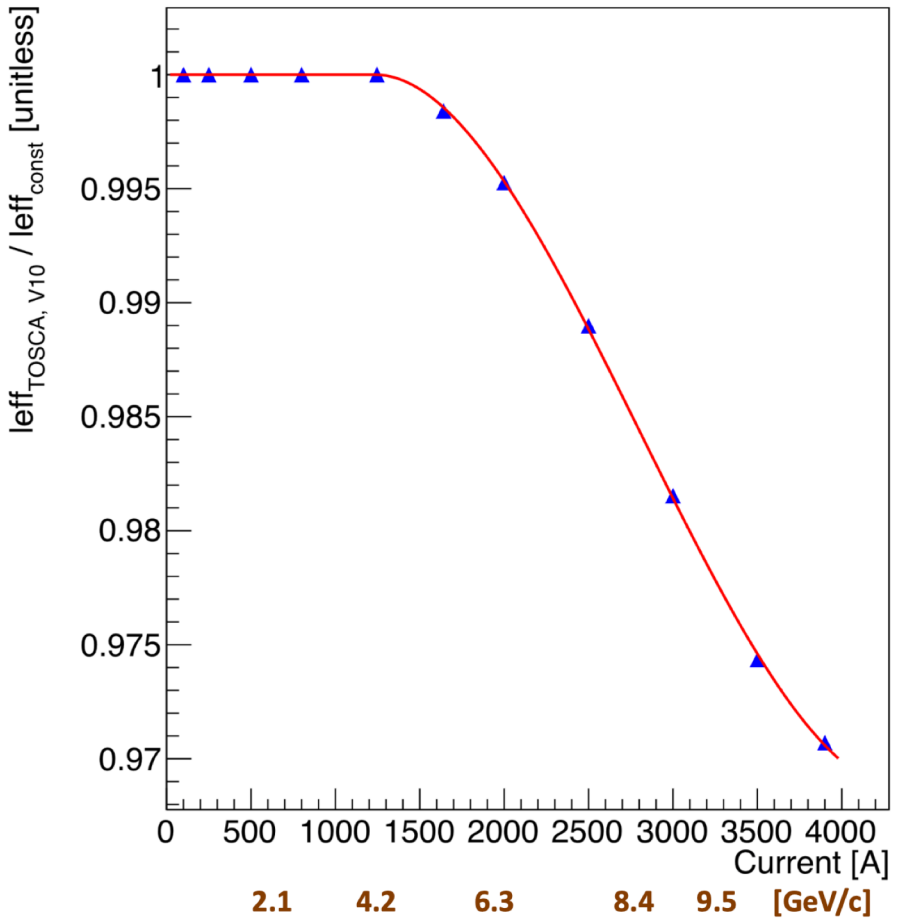
- 2 GeV at 30 deg
- 3.2 GeV at 22 deg
- 3 GeV (single foil) at 9.5 deg

Measurements are here: https://github.com/hszumila/magnets

SHMS: Horizontal Bender modeling

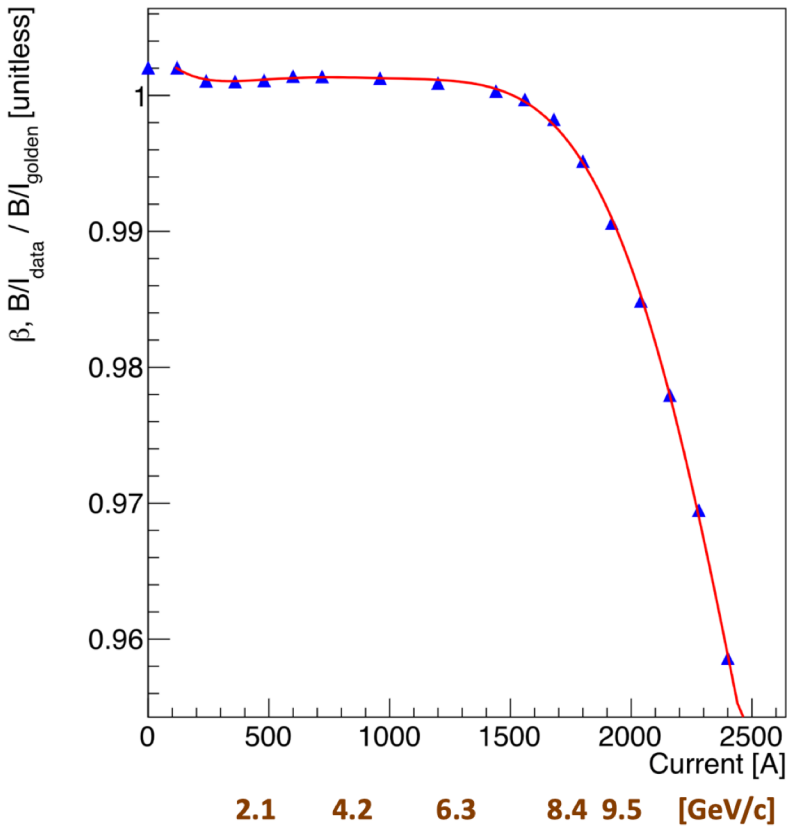
Horizontal Bender model:
Seems to work (based on data)

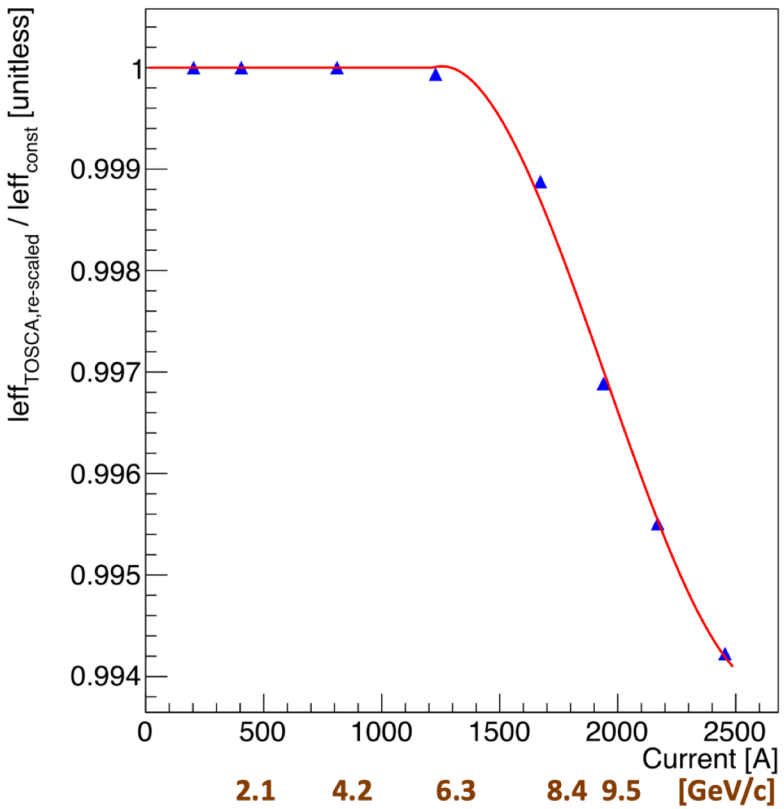




SHMS: Q1 modeling

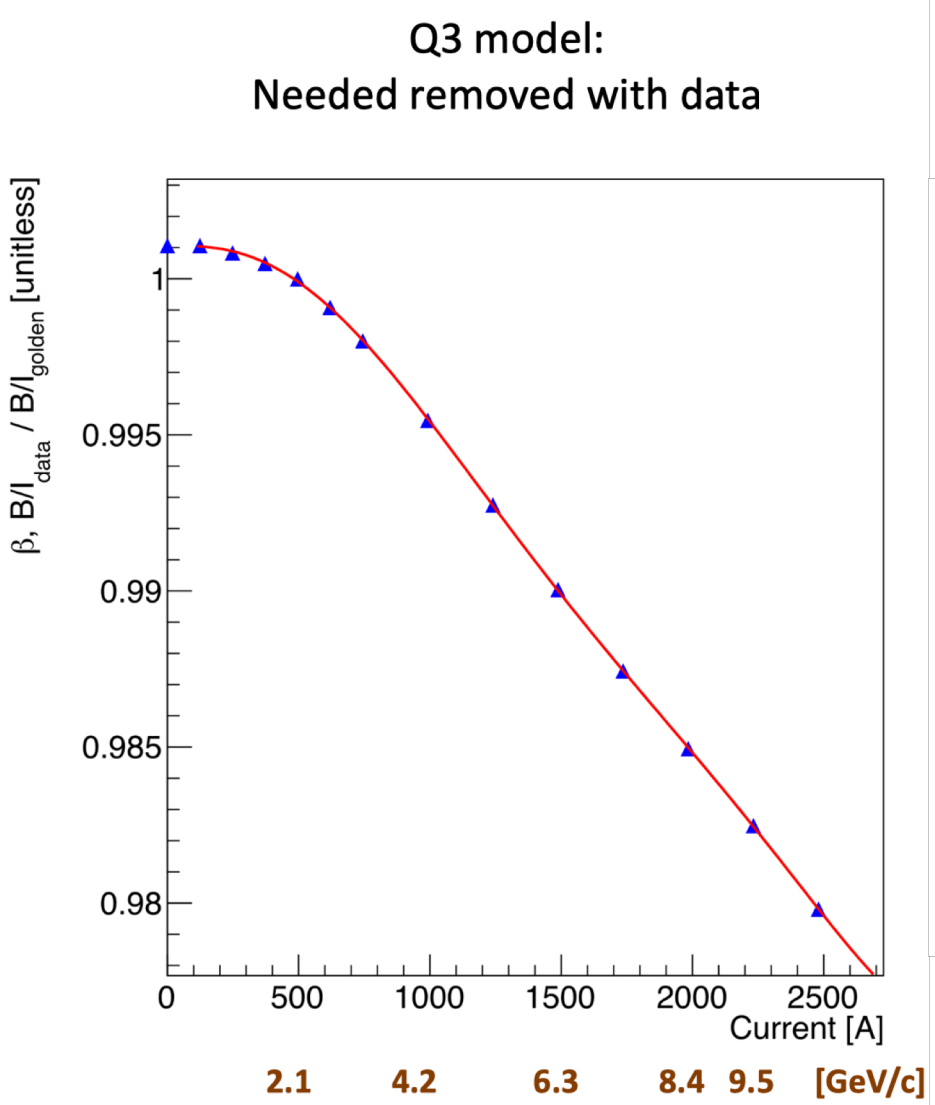
Q1 model:
Needed refining with data





- The model we put in place based on Kaon-LT data starts at 6 GeV. Seems roughly consistent with the TOSCA Leff model.
- Removed the B/P model entirely.

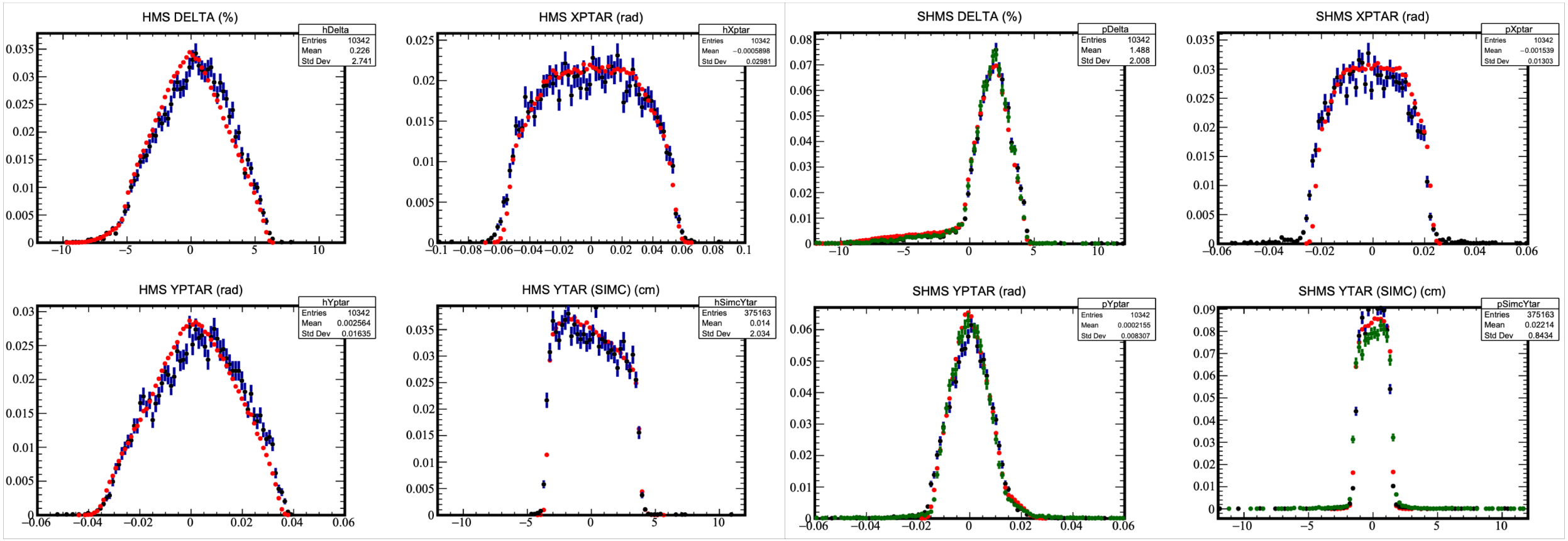
SHMS: Q3 modeling and effects



- This model was used in the spring 2018 running until deuteron experiment, April 2018.
- This model just doesn't match the beam data.
- Abishek took a preliminary look of the spring data at 9.8 GeV, the corrections I derived don't seem to fix much, and a great deal of work is required to clean up this data.

SHMS: Deriving corrections for CT data (driven by Q1, Q3 mis-sets)

CT running: electrons in HMS and protons in SHMS

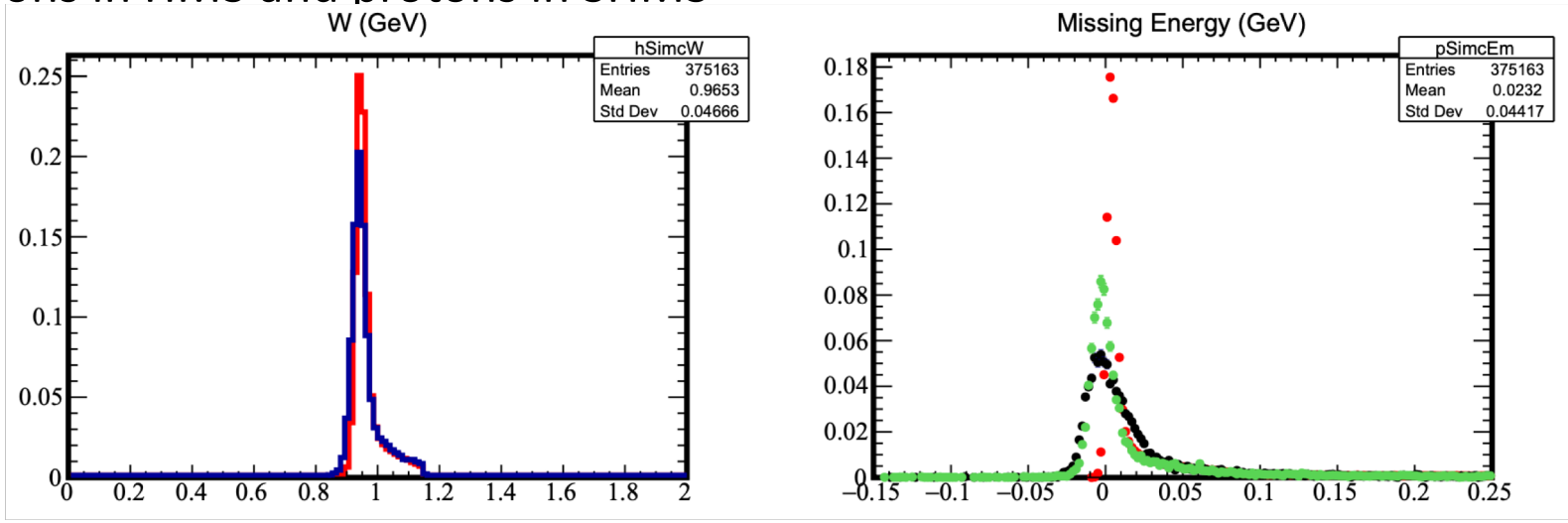


Q2 = 8, H(e,e'p)

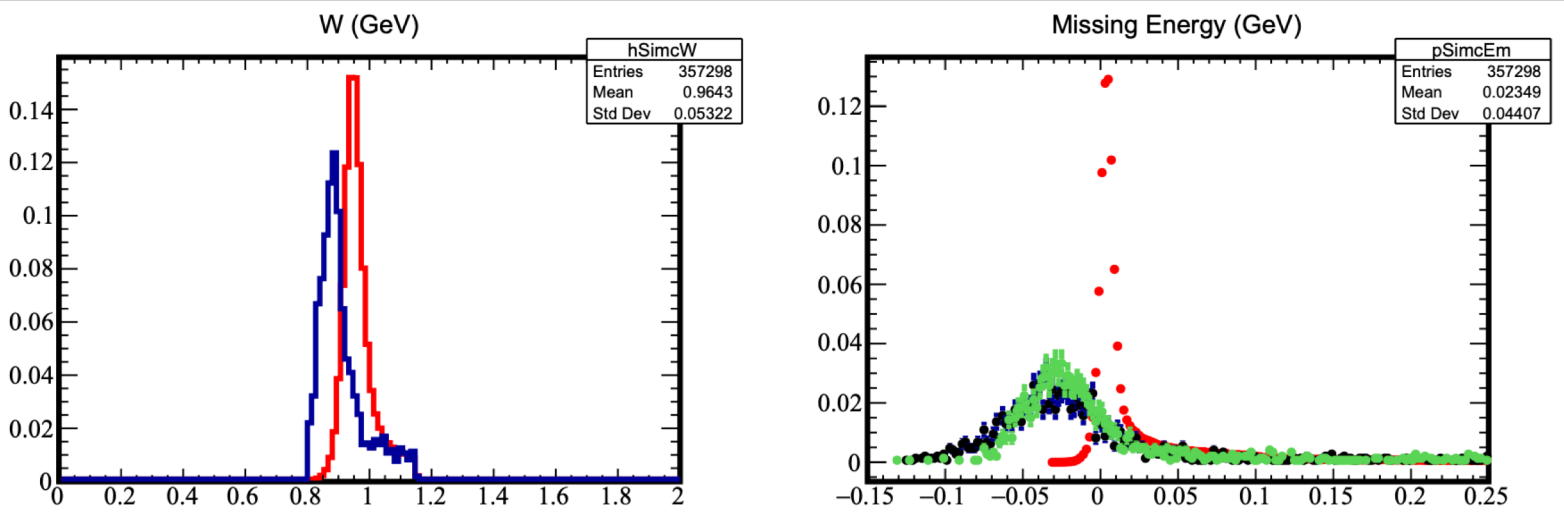
SHMS: Deriving corrections for CT data (driven by Q1, Q3 mis-sets)

CT running: electrons in HMS and protons in SHMS

Q2 = 8:
HMS at 2.1 GeV
SHMS at 5.1 GeV



Q2 = 11.5:
HMS at 4.5 GeV
SHMS at 7 GeV

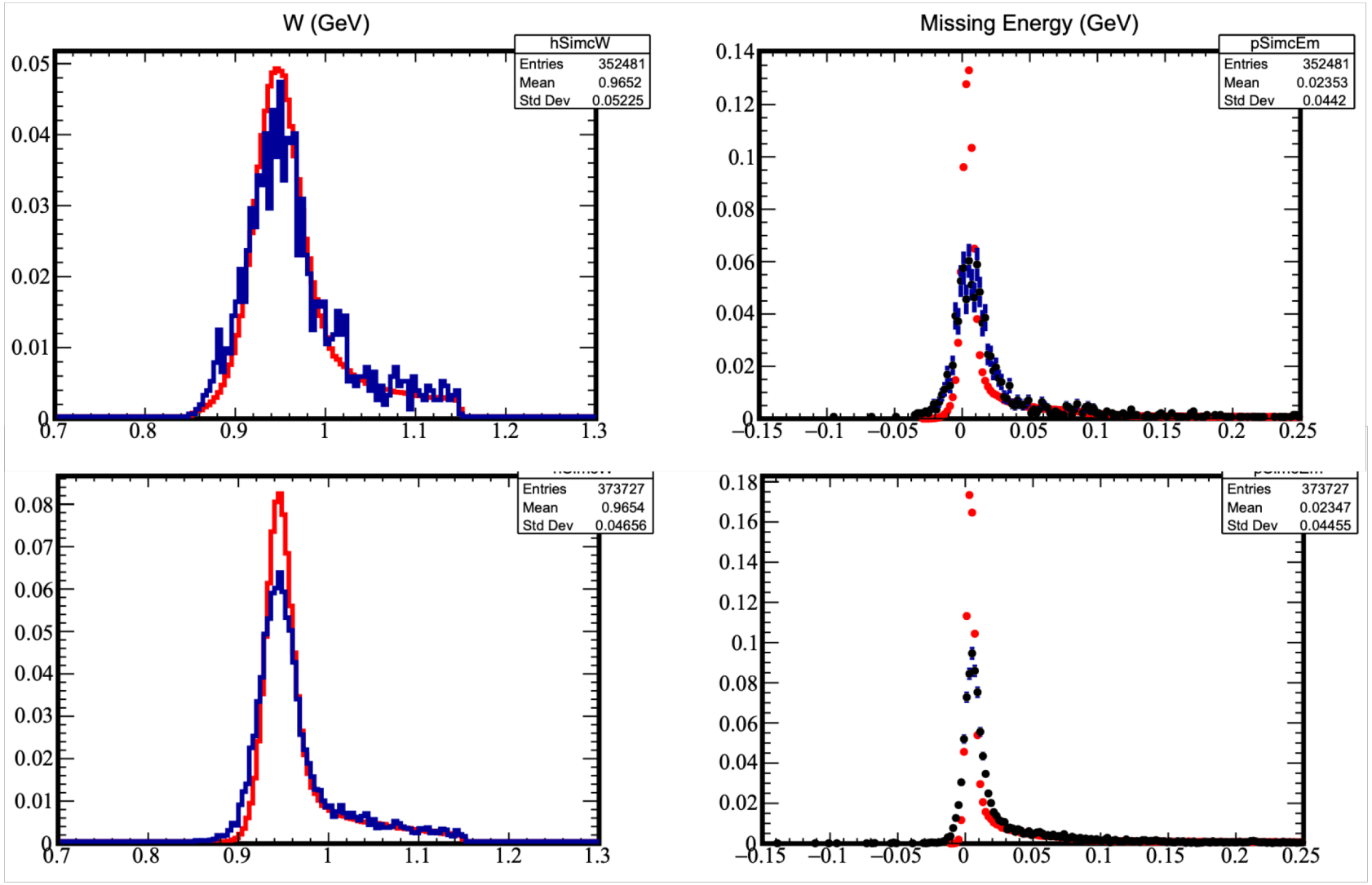


SHMS: Deriving corrections for CT data (driven by Q1, Q3 mis-sets)

- First correcting the HMS, use the HMS to correct the SHMS optics in the H(e,e'p) data.
- Verify corrections when applied to Carbon.

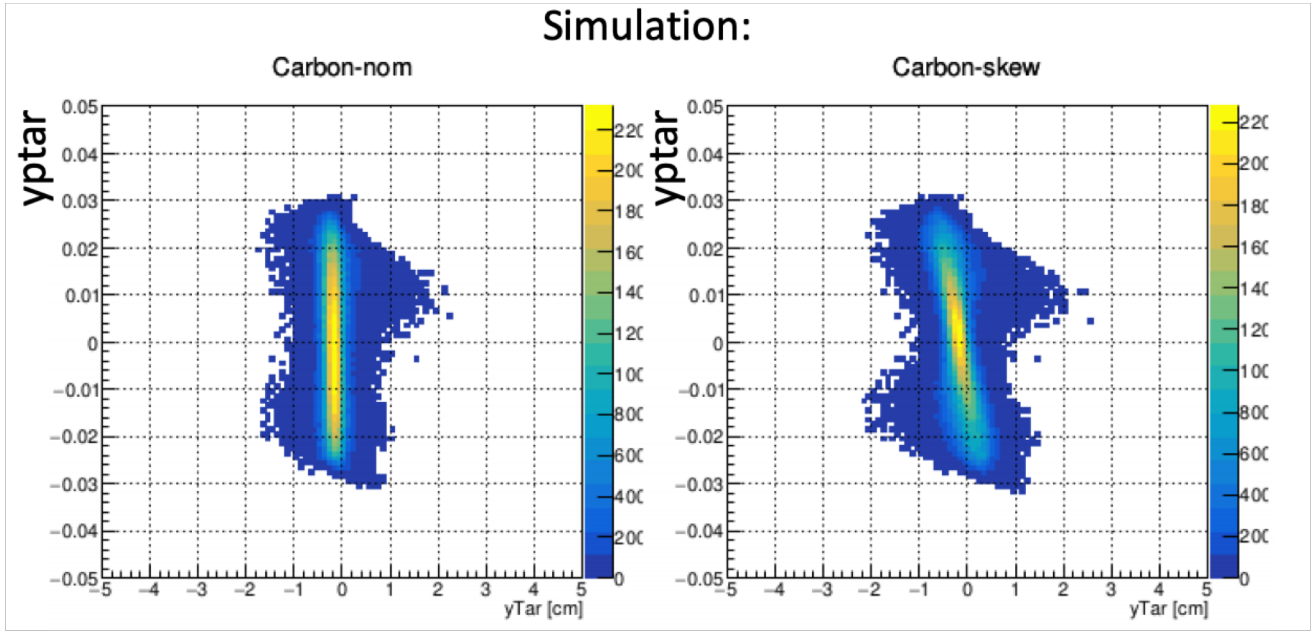
Q2 = 8:
HMS at 2.1 GeV
SHMS at 5.1 GeV

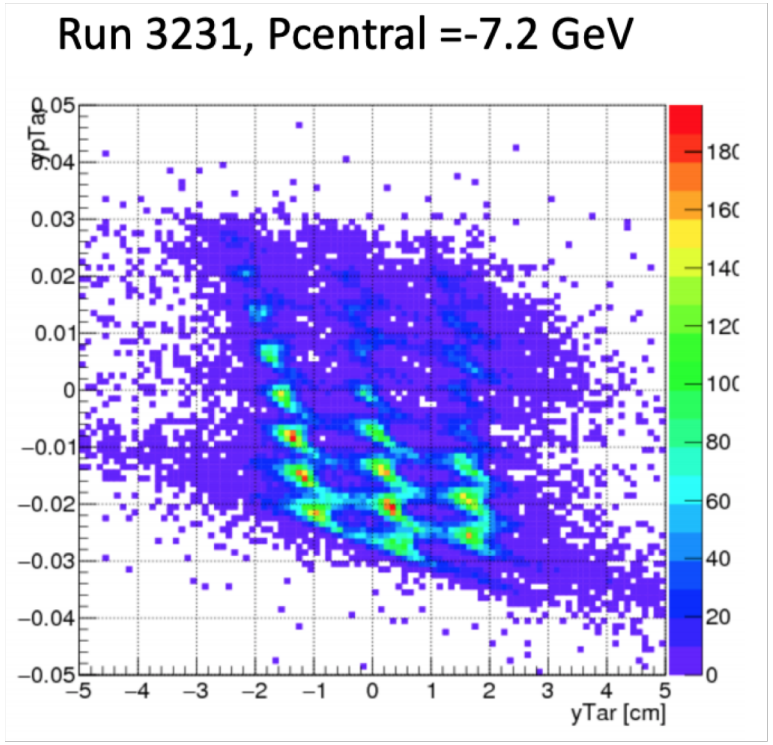
Q2 = 11.5:
HMS at 4.5 GeV
SHMS at 7 GeV



SHMS: Deriving corrections for CT data (driven by Q1, Q3 mis-sets)

- Generate SIMC with Q1 and Q3 offsets to determine the order of the correction
- Derive delta correction by correcting Emiss dependencies





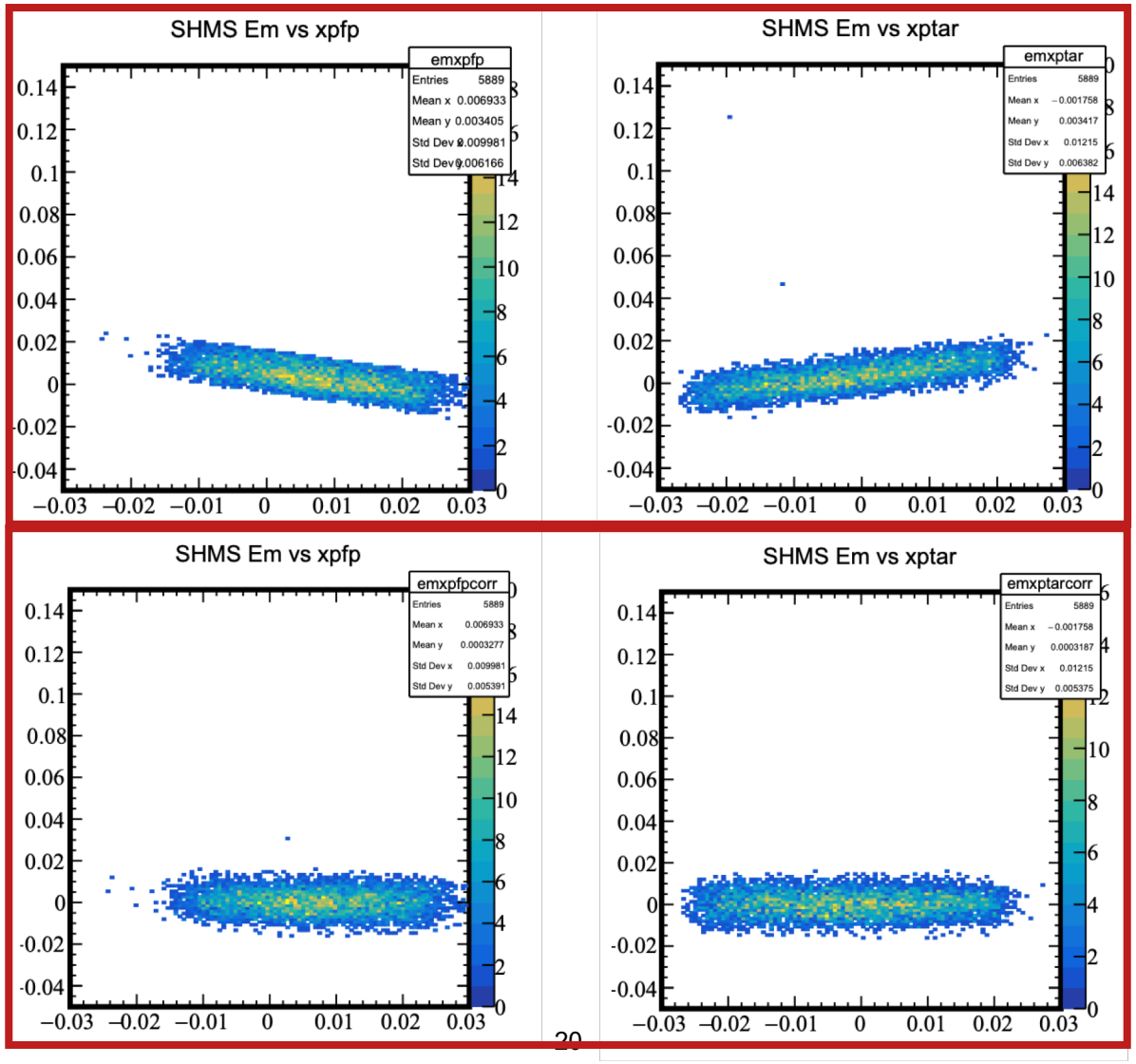
Difficult to dis-entangle all effects, but mostly dominated by a correction to first order optics (not sure I would trust anything of higher order from simulation studies and fits from data)

SHMS: Deriving corrections for CT data (driven by Q1, Q3 mis-sets)

- Generate SIMC with Q1 and Q3 offsets to determine the order of the correction
- Derive delta correction by correcting Emiss dependencies

Pre-correction

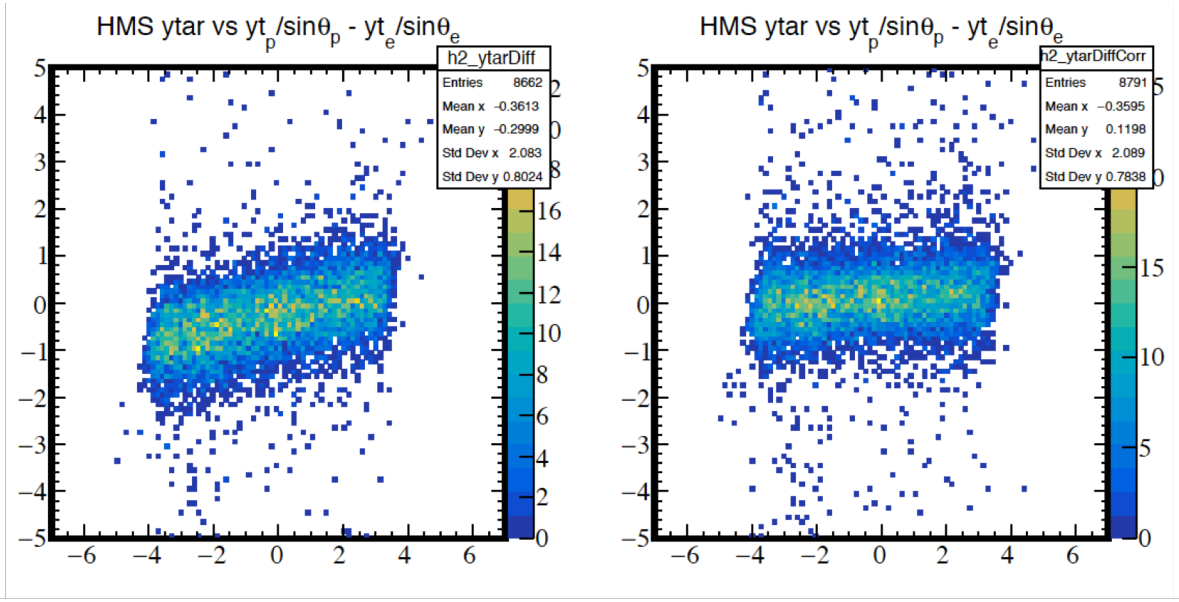
Post-correction



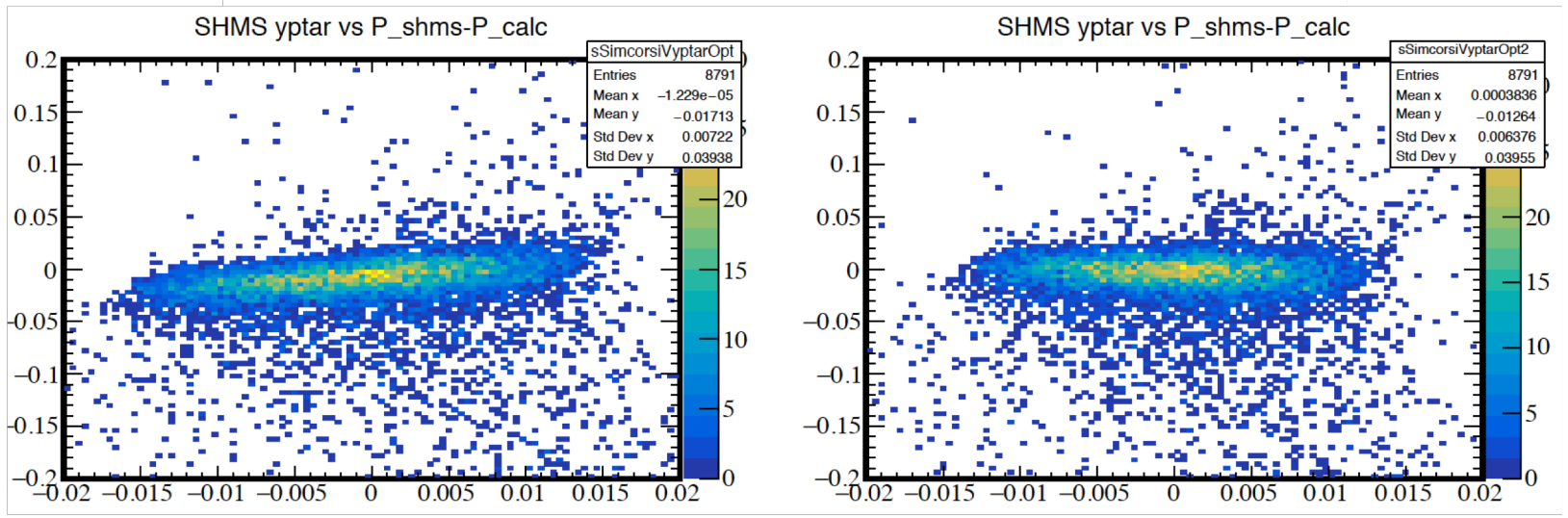
SHMS: Deriving corrections for CT data (driven by Q1, Q3 mis-sets)

- ypTar correction
- yTar correction

Pre-correction



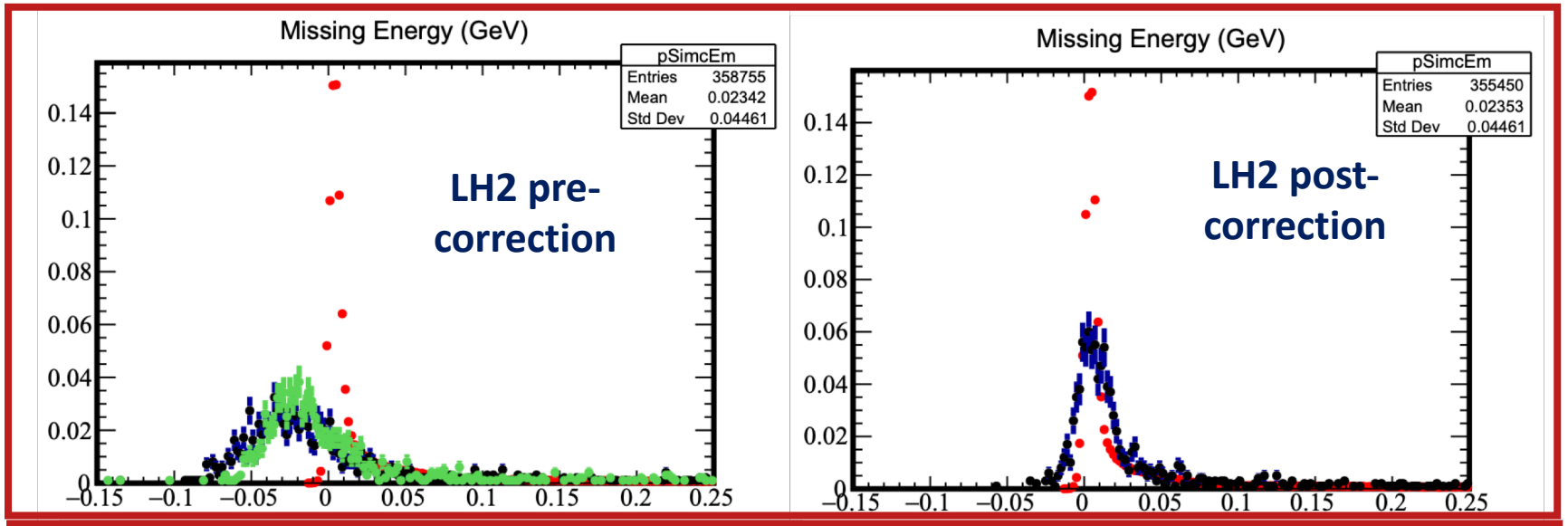
Post-correction

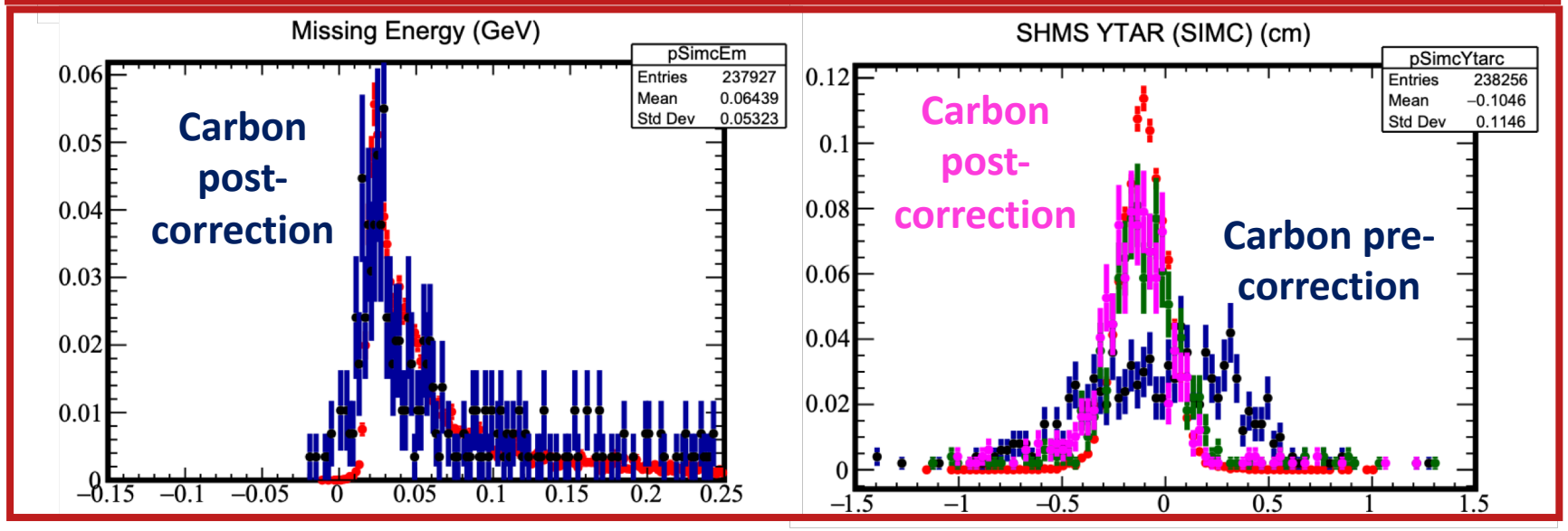


SHMS: Deriving corrections for CT data (driven by Q1, Q3 mis-sets)

Corrections sensitive also to having a good starting point.

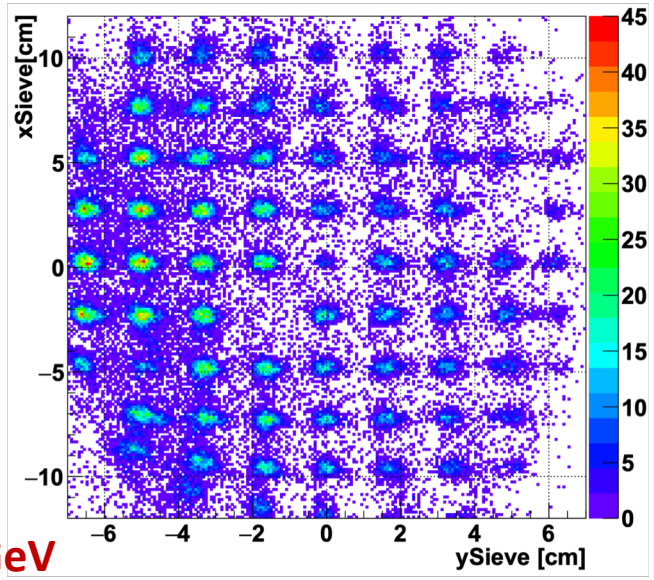
Q2=14.3:
SHMS at 8.5 GeV
HMS at 2.9 GeV

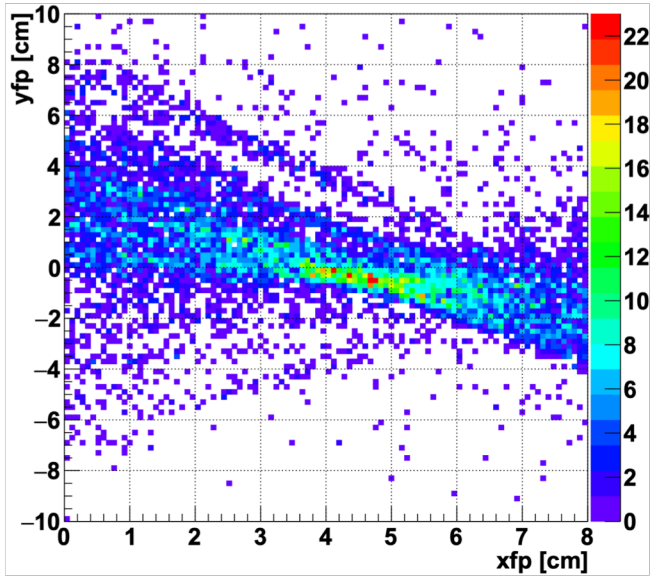




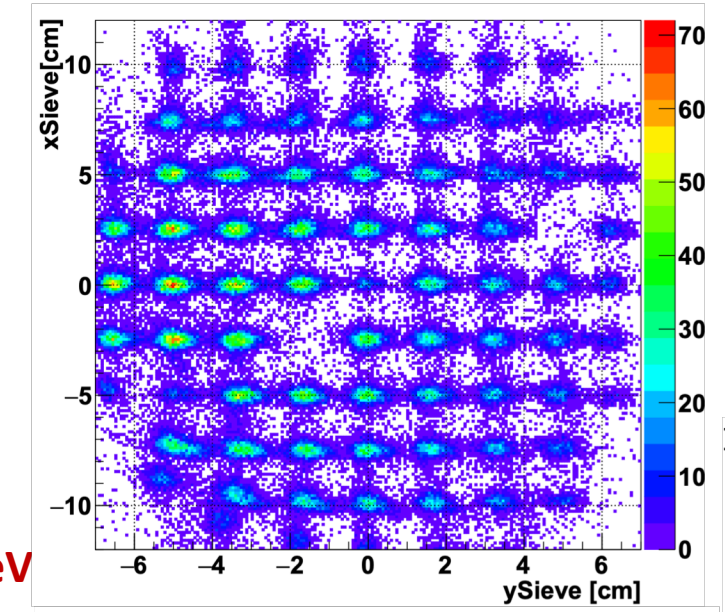
SHMS: sieve comparisons

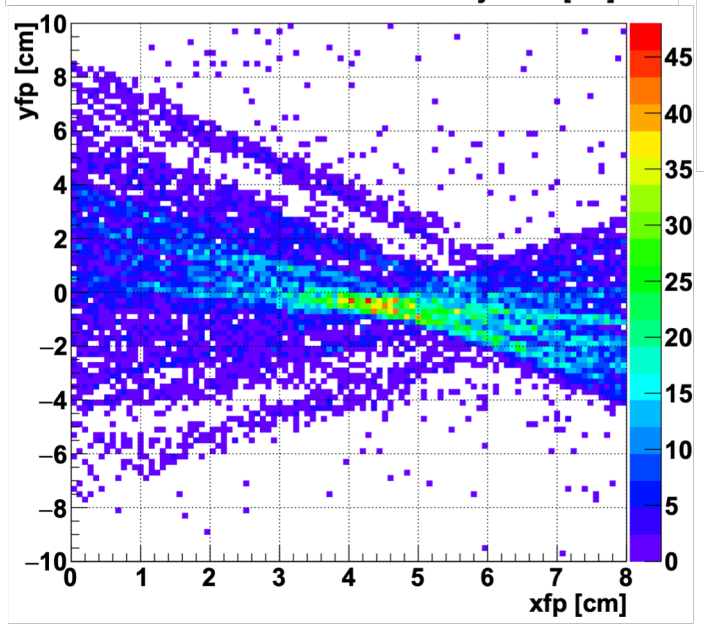
Run 4787:
9.5 deg, 6.3 GeV



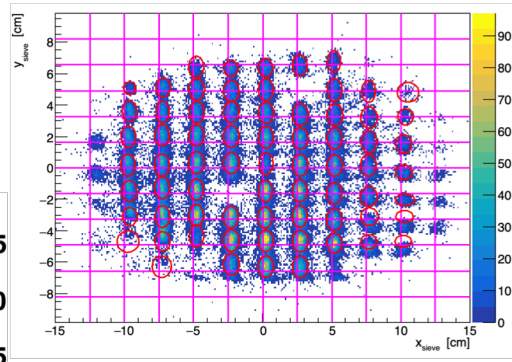


Run 6620:
9.5 deg, 3 GeV





Include 6620 in re-optimization



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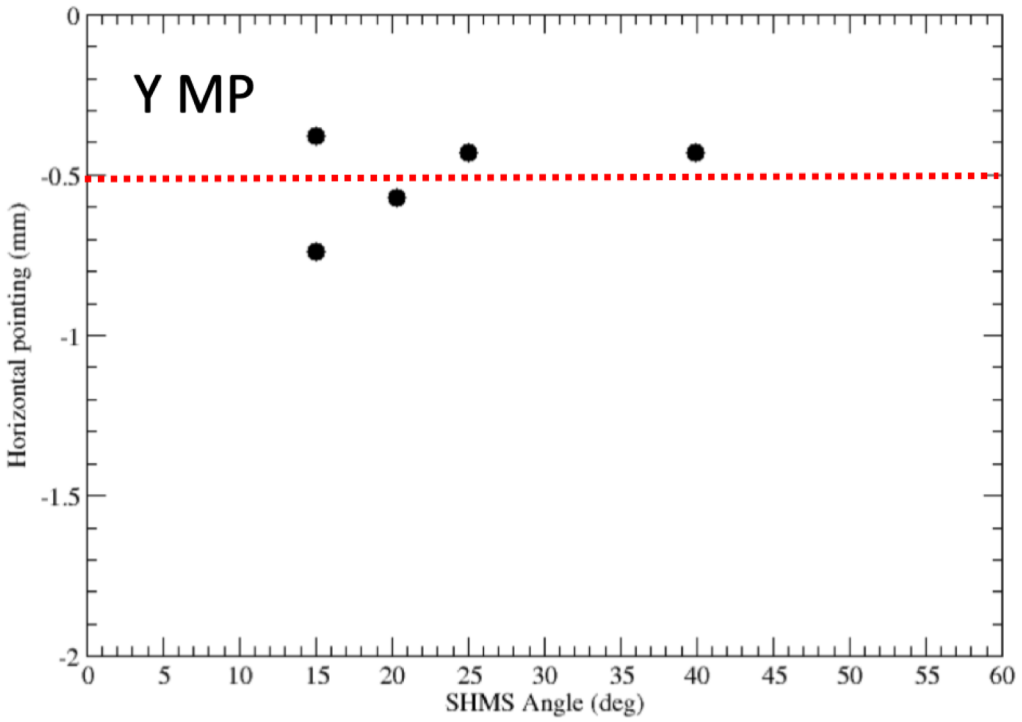
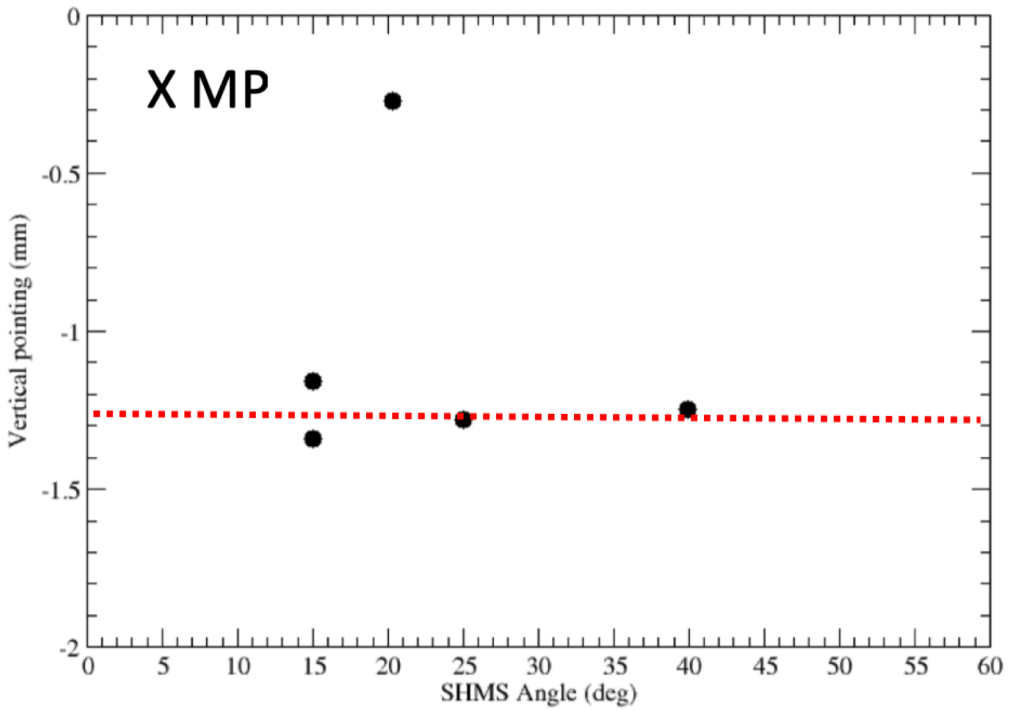
SHMS: Mis-pointing

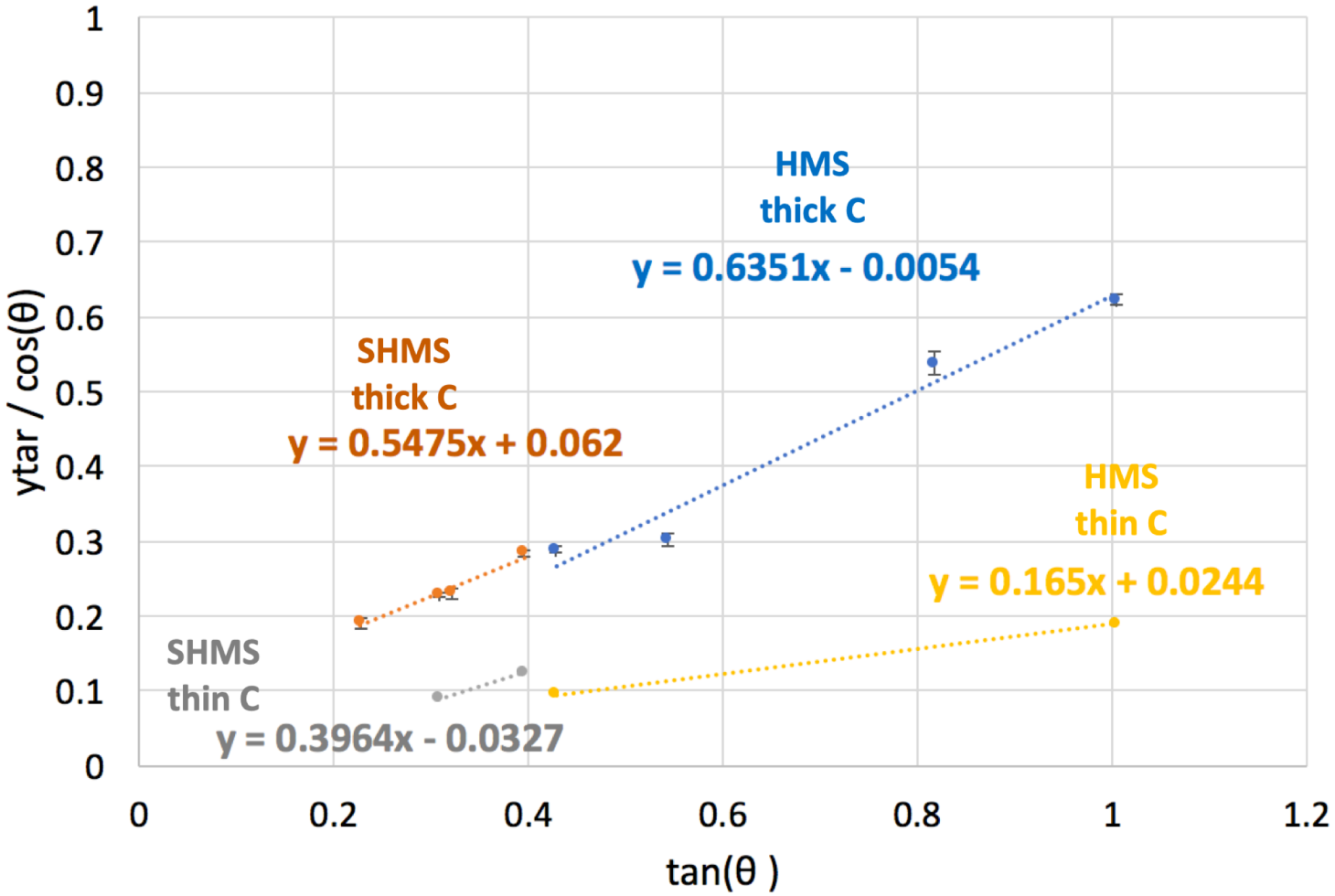
SHMS surveys: HMS mis-pointing in X and Y as a function of HMS angle





Mark Jones maintains summary here:
https://hallcweb.jlab.org/elogs/Commissioning+Experiments+Analysis/180221_141950/survey-summary.pdf

SHMS and HMS: beam and target information



$$\frac{\Delta y_{tar}}{\cos(\theta)} = \Delta x_{beam} + \Delta z_{tar} \cdot \tan(\theta)$$

- No x beam offset (consistent with BPM information)
- zTarget seems to have maybe 0.13 cm offset

Summary

- **HMS:**
  - General trend of the change in HMS optics with momentum. Not clear the cause (saturation of dipole and/or combination of quads).
  - Recommend taking carbon sieve and hydrogen data at settings >5 GeV/c central momentum.
  - Carlos off to great start studying H(e,e'p) runs below 4.5 GeV.
- **SHMS:**
  - Effects from mis-set quads during spring running (and optimization).
  - Re-optimization (in checks). Have a working point for the HB and Q1 saturation models in the data that seem right.
  - Parameterize CT corrections with momentum for other experiments? Does this work with 9.8 GeV data?
  - Further studies above 8 GeV for Q1 model desired.
- **Latest optics Matrix Elements always in the DATFILES/Readme**

Thank you to the Hall C Collaborators!