Optics Group Update

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Outline

1. Overview of the optics projects
2. Current progress
3. Following plans

Optics study projects

1. Direct impact on the weak charge extraction:

$$< A_{PV} > = \frac{\int A_{PV}\sigma(\theta)\epsilon}{\int \sigma(\theta)\epsilon} \qquad A_{PV} = \frac{N_+ - N_-}{N_+ + N_-} = mE\frac{G_F}{\sqrt{2}\pi\alpha}\frac{4\sin^2\theta}{(3+\cos^2\theta)^2}Q_W^e$$

Kinematic factor (θ or E'), accuracy <0.5%

- Acceptance function
- Kinematic factor

Determined from MC

Experience from the PREX/CREX experiments:

Tweak the MC so that the MC distribution matches the data distribution (ideally both at the main detector/tracking detector and at the target)

- Need an optics map for data projection from the tracking detector to target
  - Sieve collimator
  - multi foil carbon targets
  - Multiple beam energies

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- Design a sieve pattern
- Target foil position
- Beam energies

Optics study projects

2. Systematic measurements and check

1). e-p elastic background
2). Moller double counting events percentage

direct counting mode measurement using the production hydrogen target with 11 GeV beam

- e-p elastic background estimation vs. current
- Moller double counting events vs. current
- A proper beam current to perform the measurement

3). Edge scattering, detectors alignment, other backgrounds

- Insert a blocker in front of collimator 1 and 2 to check

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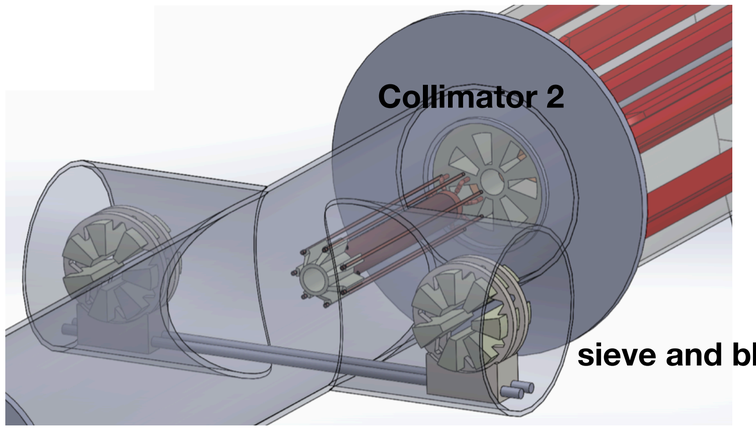
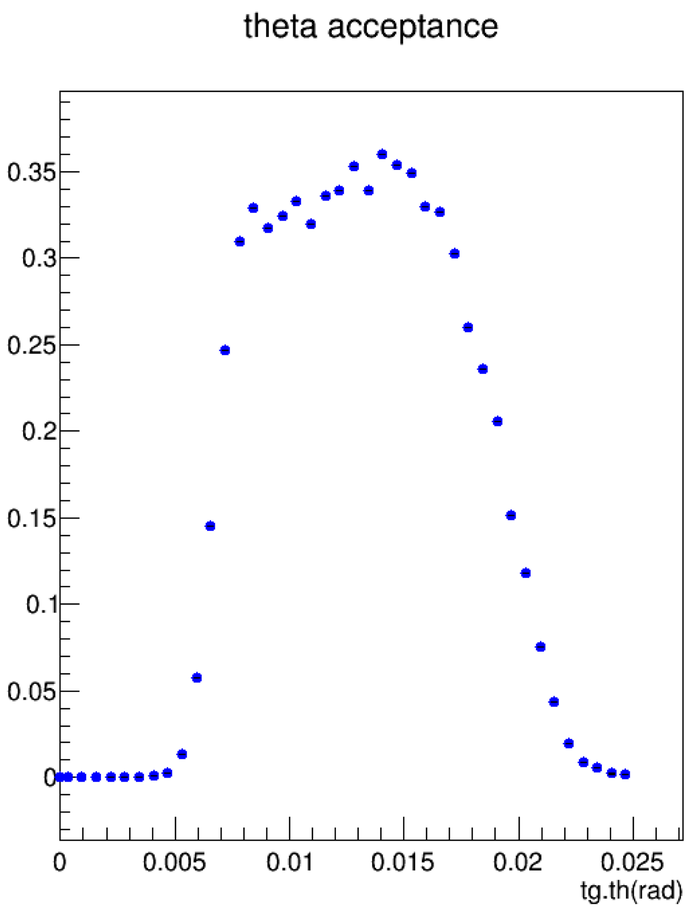
- Blocker thickness
- Blocker inner radius

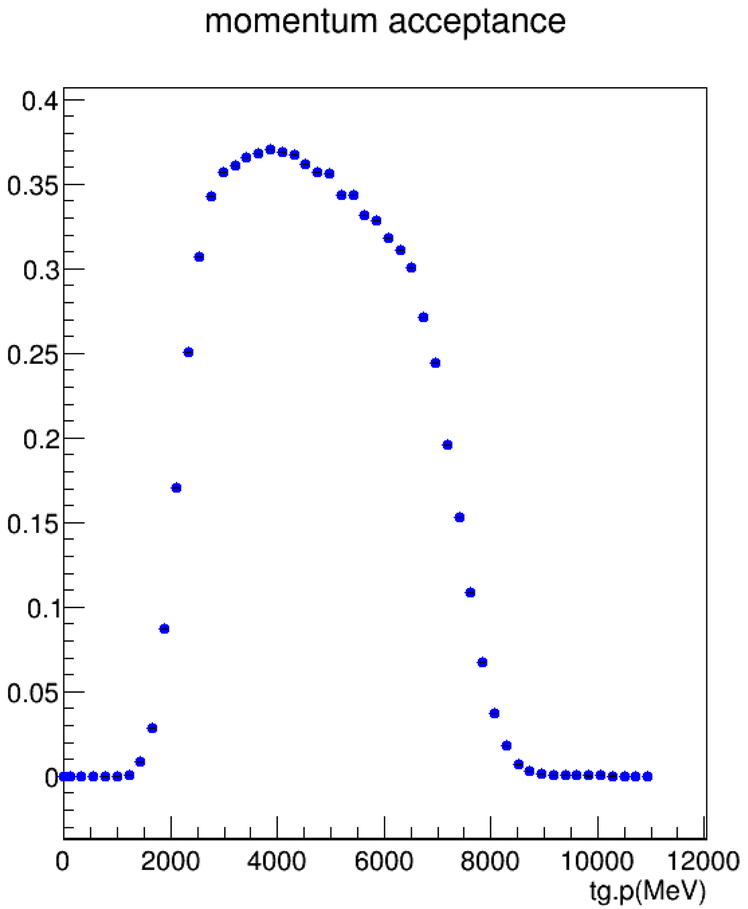


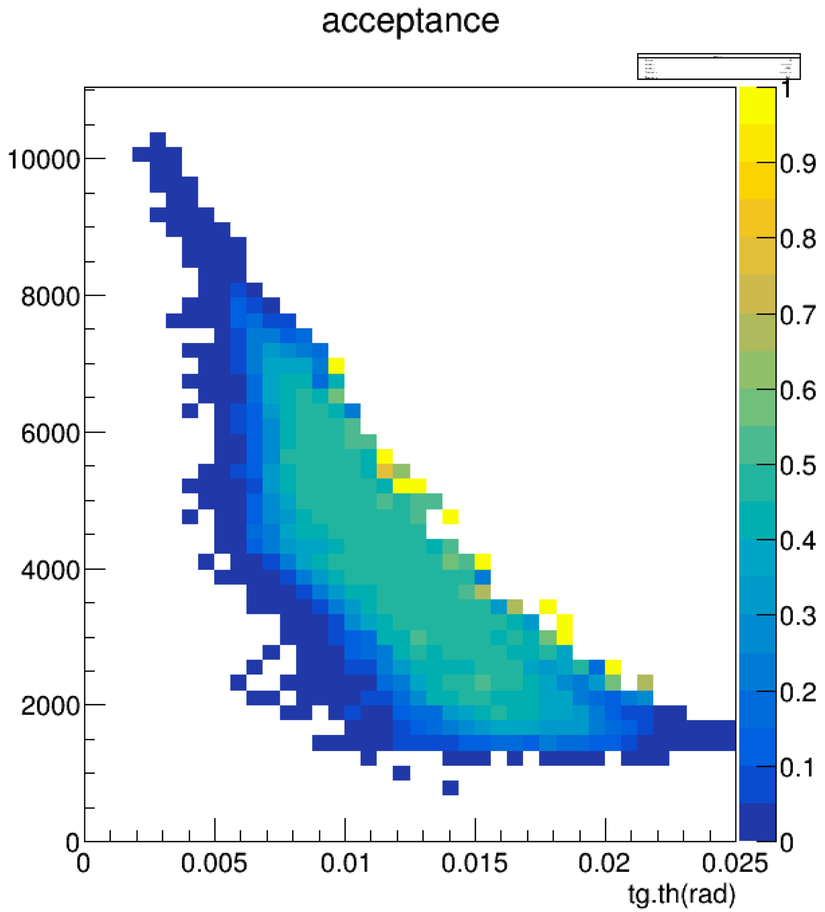
sieve and blocker (remotely insertable)

Acceptance functions (MC)

- Total acceptance at target

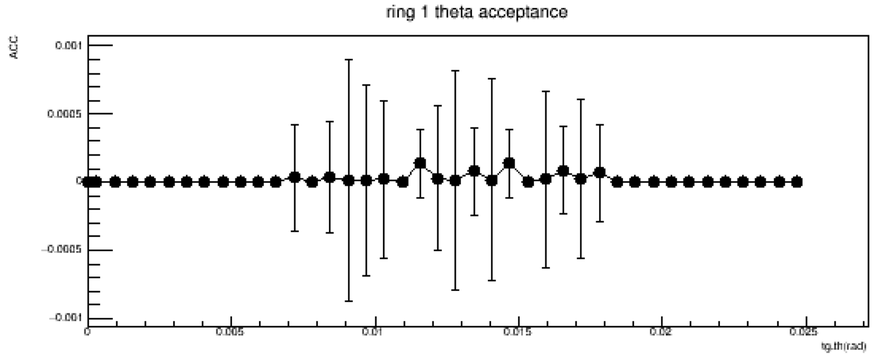


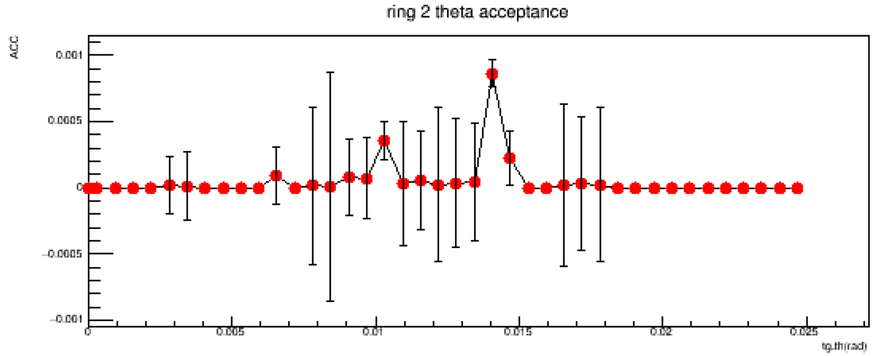


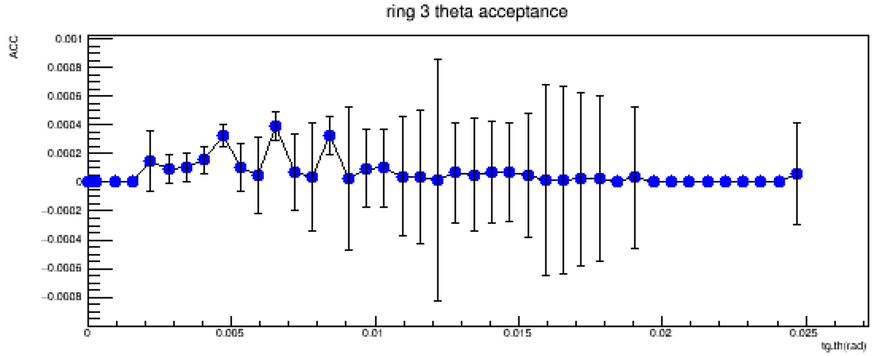


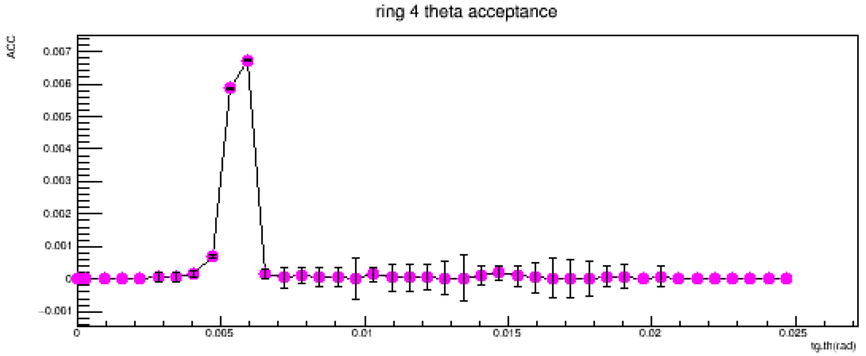
Acceptance functions (MC)

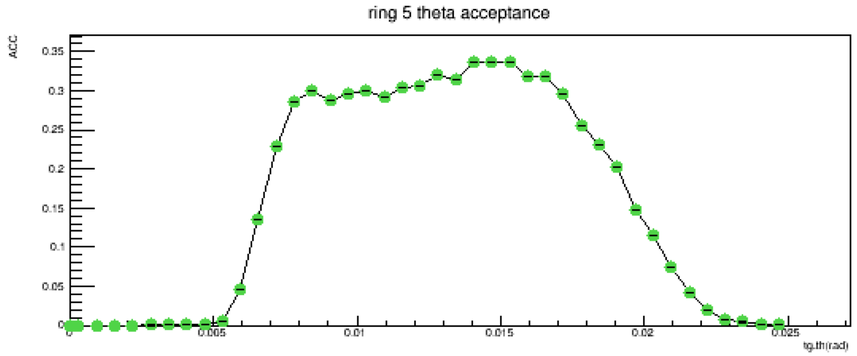
- Theta acceptance for each ring

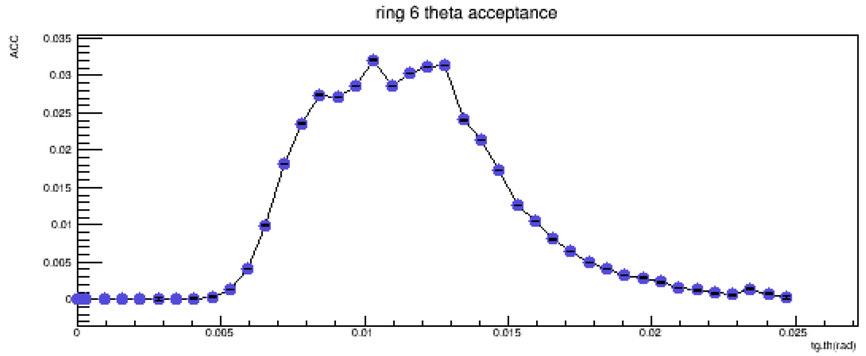






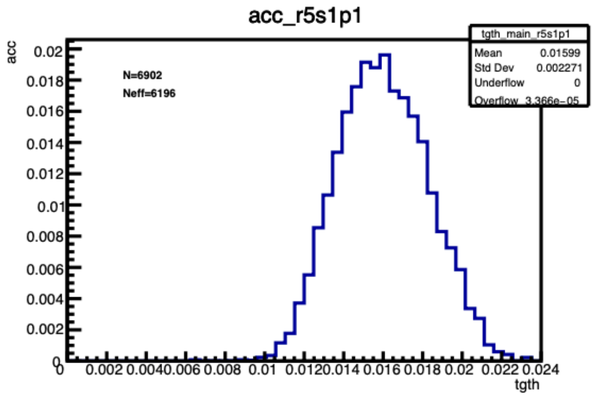




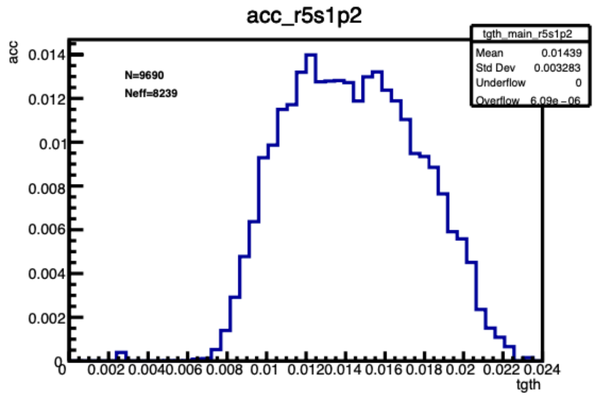


Acceptance functions (MC)

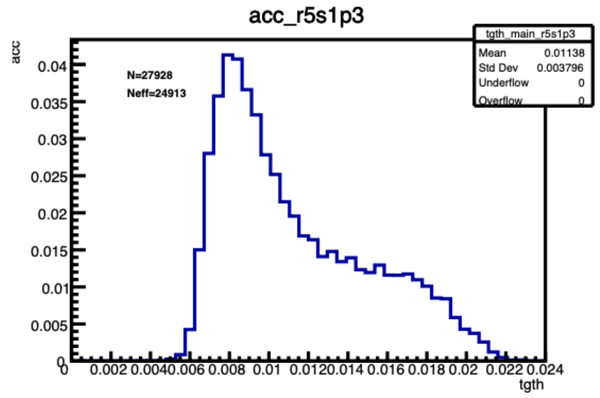
- Theta acceptance for each sector at ring 5



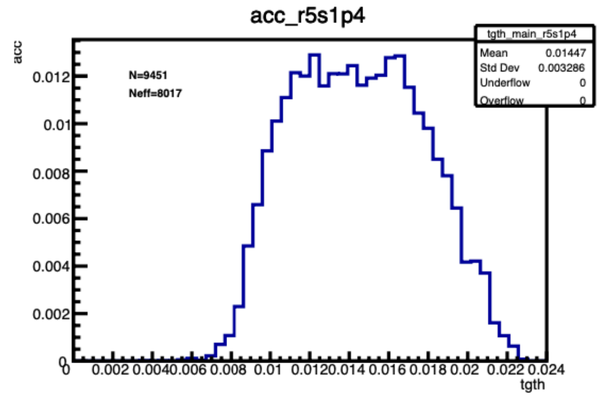
Close



Transition



Open



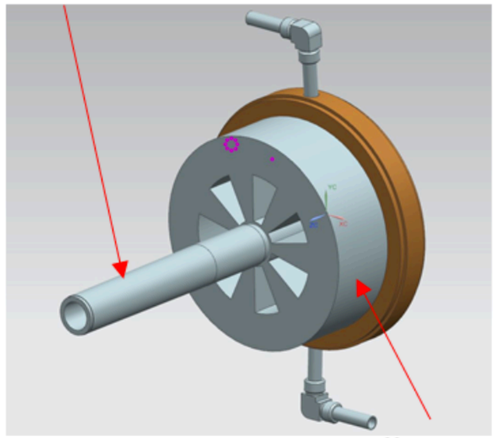
Transition

Things learned:

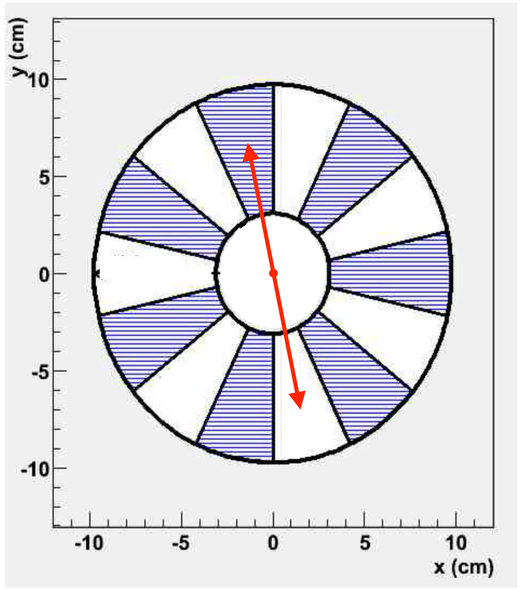
1. Two dimensional acceptance functions (or even 3D when considering ϕ)
2. Difference rings have different acceptance functions
3. Difference segments have different acceptance functions

Moller double counting

Collimator #1

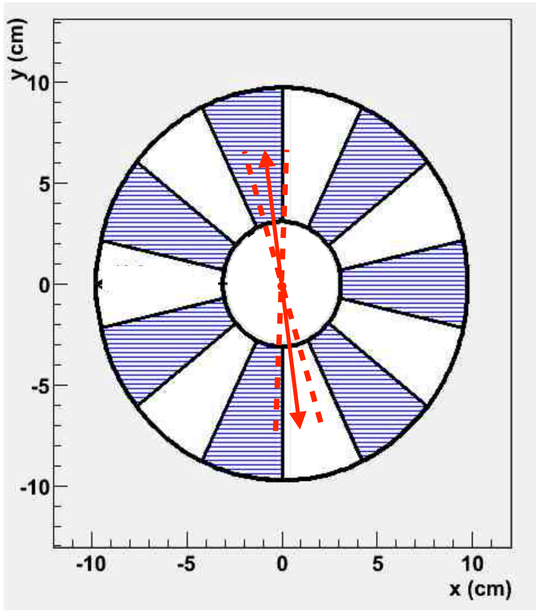


Collimator #2

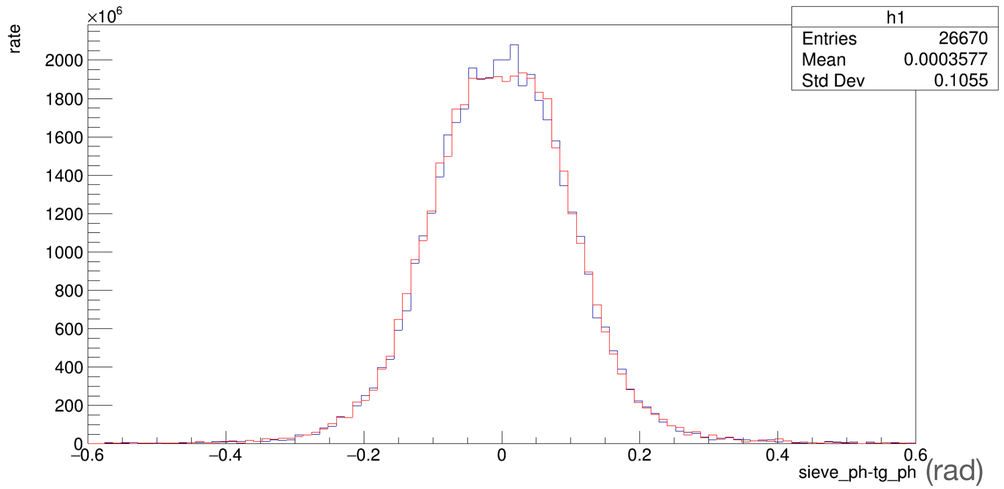


Ideally, moller electrons should be back to back

radiations change ϕ

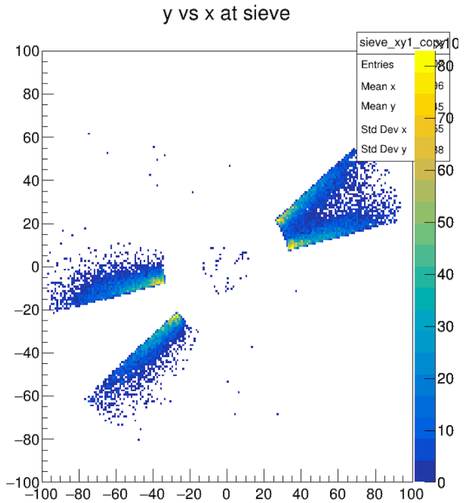


Sometime, both moller electrons can reach the main detector

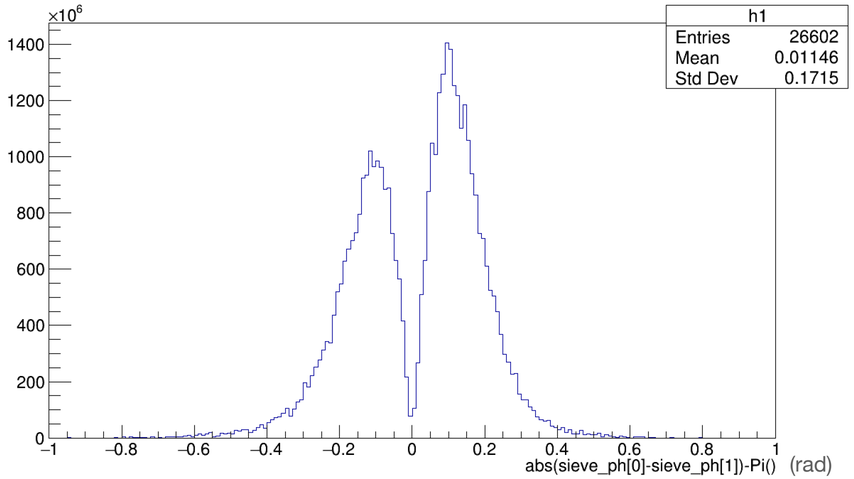


Moller double counting

1. Simulation estimate about 7% of moller events are double counted

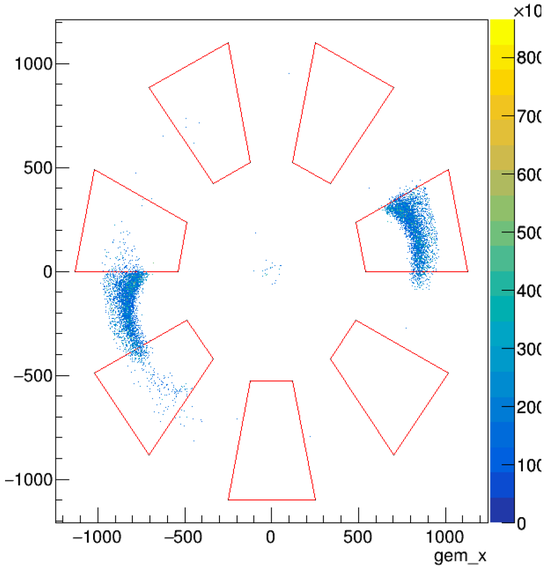


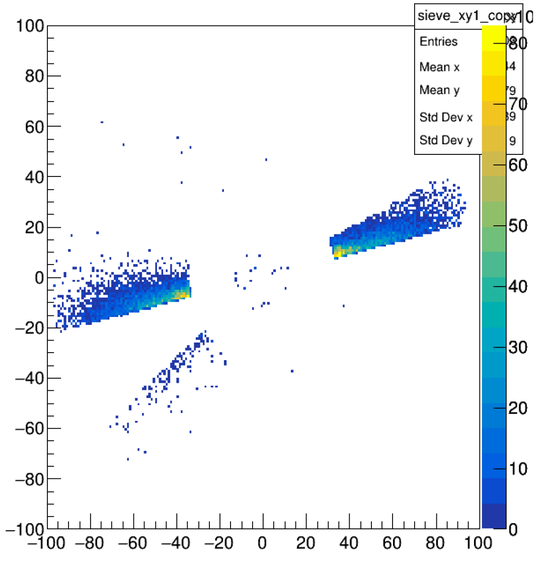
both moller electrons pass through the collimator 2



smear of the back to back angle from π

If all GEMs rotate together, only able to measure some of the double moller electrons at the GEMs





Moller double counting

Impact of double counting events

1. Shouldn't affect the central value of the asymmetry, but will change the statistical uncertainty:

measured event counts: $N_m = N_r + N_{2trk}$ ——————— $\delta_s^m = 1/\sqrt{N_m}$

real one track event counts: N_r ——————— $\delta_s^r = 1/\sqrt{N_r}$

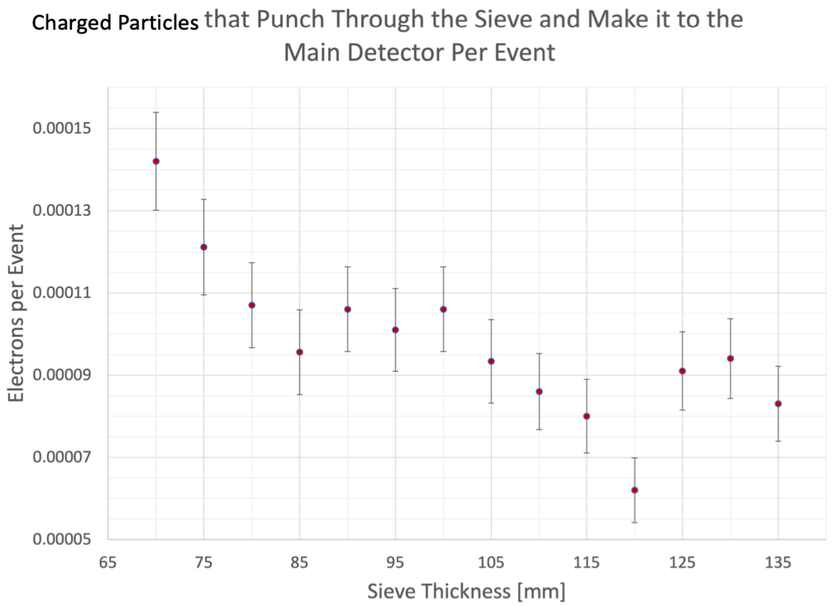
$$\delta_s^r/\delta_s^m = \sqrt{\frac{N_m}{N_r}} = \sqrt{\frac{N_r + N_{2trk}}{N_r}} = \sqrt{1 + N_{2trk}/N_r} \sim 1.03 \text{ if } N_{2trk}/N_r = 7\,\%$$

So,

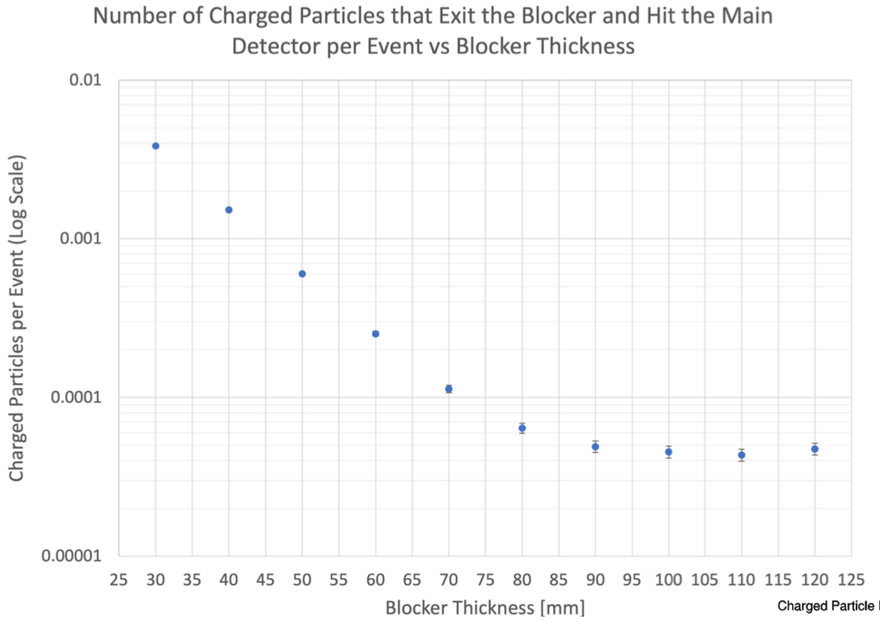
Need to confirm the percentage of double counting events in counting mode runs.

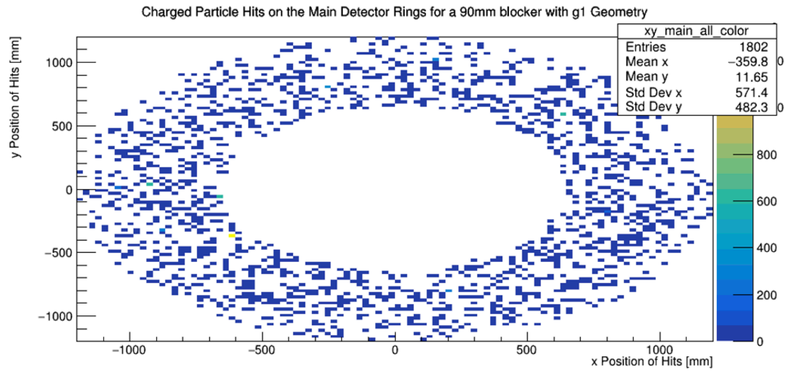
Sieve and Blocker geometry

- Sieve: optics map
- Blocker: edge scattering and other backgrounds



Credit to Kate Evans
(carbon target, 11 GeV beam, pure Tungsten)





no hot spot observed

- Thickness between 90-100 mm should be good
- Taper is not needed for blocker central bore
- Sieve holes don’t need to be tapered or “titled”

Ongoing projects

1. Prepare a software for optics map fitting and get a preliminary optics map from simulation
2. This tool will also help the sieve pattern design and determine the optics kinematics
3. Blocker inner radius study: fulfill the blocker function while minimizing the total power deposited
4. Determine positioning tolerances on the Blocker and Sieve

Check the validity of the two track events

1. Angle smearing of the multi-scattering from the target thickness ~ 0.4 mrad

$$\theta_0 = \frac{13.6\ \text{MeV}}{\beta c p}\, z\, \sqrt{x/X_0}\left[1 + 0.038 \ln(x/X_0)\right]$$

2. "Cut flow" in remoll:

- carbon, moller, 5*5 raster ——— 2.4%
- LH2, moller, 0*0 raster, no generator msc, no geant4 msc ——— 2.3%

(no generator msc: set "fApplyMultScatt = false" in "remollGenMoller.cc")
(no geant4 msc: "/process/inactivate msc" to the macro)

- LH2, moller, 5*5 raster, no generator msc, no geant4 msc ——— 4.1%
- LH2, moller, 5*5 raster, no geant4 msc ——— 4.8%
- LH2, moller, 5*5 raster ——— 6.9%
- LH2, moller, 0*0 raster, no generator msc, no geant4 msc, eIoni, eBrem, compt——— 1e-4

————> having 6% two tracks events seem real