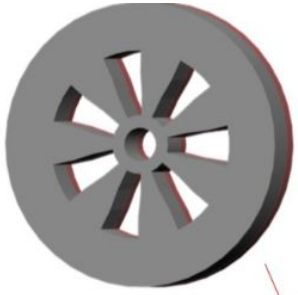
Counting Mode Calibration Studies

Chandan Ghosh (on behalf o f the MOLLER collaboration)

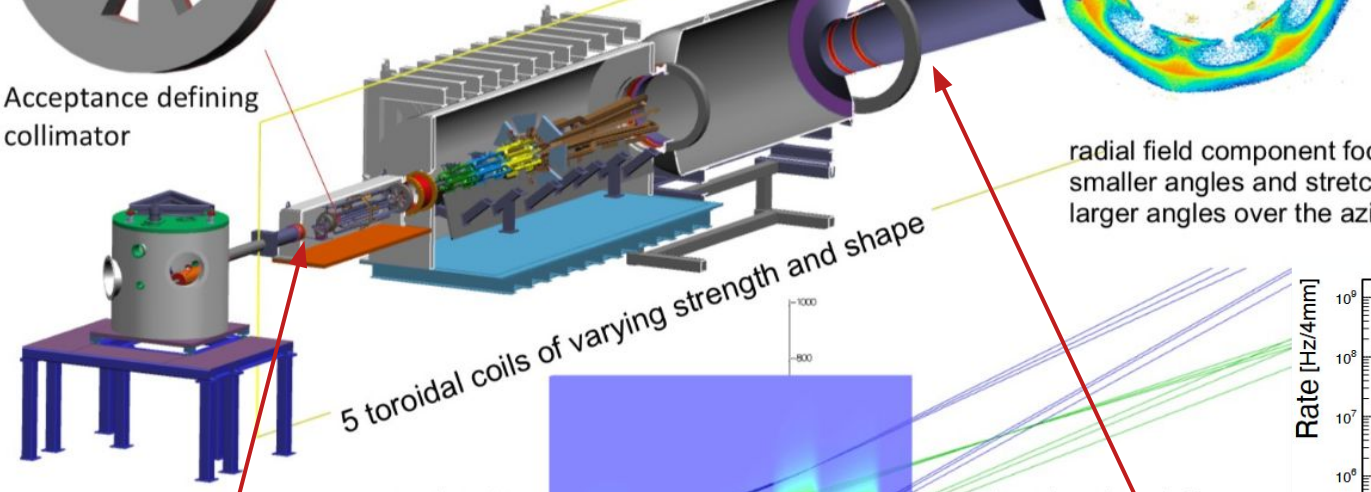
Hall A winter Collaboration Meeting

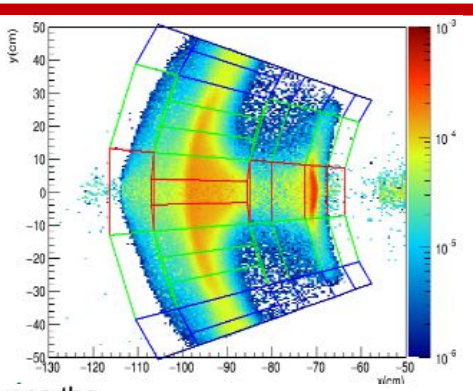
MOLLER: low-current calibration systems



Acceptance defining collimator

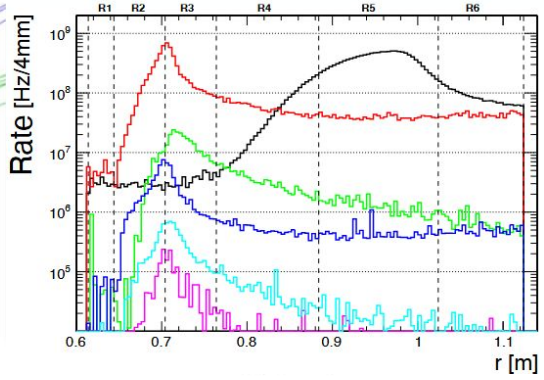
Full azimuthal acceptance for Møller scatters from $6 < \theta_{lab} < 20$ mrad



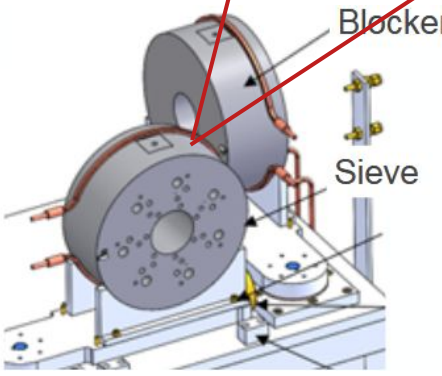


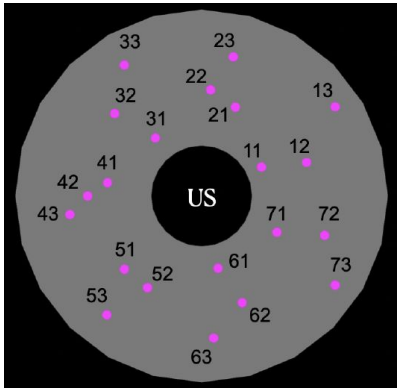
radial field component focuses the smaller angles and stretches the larger angles over the azimuth

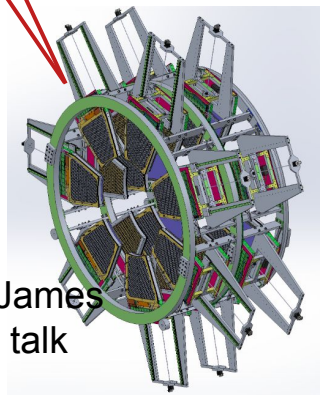
5 toroidal coils of varying strength and shape



map E-θ correlation for ee scattering to detector







Black: e-e scattering
Red: elastic e-p scattering
Green: inelastic e-p scattering
Dark blue: elastic e-Al scattering
Light blue: inelastic e-Al scattering
Magenta: Al quasi-elastic scattering

GEM: James Shirk's talk

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Kinematic Factor

$$A_{PV} = \frac{\sigma_R - \sigma_L}{\sigma_R + \sigma_L} = mE \frac{G_F}{\sqrt{2}\pi\alpha} \frac{4sin^2\theta}{(3+cos^2\theta)^2} Q_W^e$$

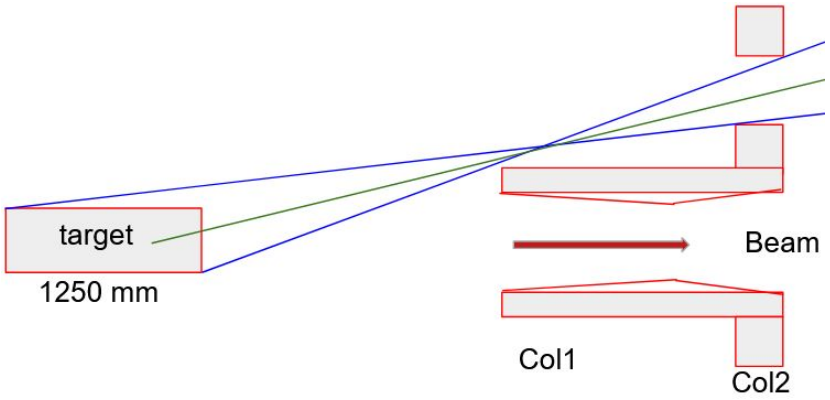
Electron Weak charge (2.4%)

Observables

Kinematic factor : $\mathcal{A}$ (Θ/E^l) (precision <0.5%)

- Beam energy E: $\delta E/E$ ~ 10^{-3} (routine to JLab)
- Θ - precision acceptance-defining collimator
  - Machining tolerance (200 micron) → $\delta\mathcal{A}/\mathcal{A}$ ~ 0.1%
  - Collimator positioning → $\delta\mathcal{A}/\mathcal{A}$ ~ 0.1%

- However, ***Challenges*** ⇒ ***Methods to handle them***
  - The non-uniformity in acceptance, energy-loss (~100 MeV) → Need to know the flux distribution (Optics)
  - Radiation and multiple scattering in our thick target (14.6% X_0) → Different target thickness
  - Elastic and inelastic ep scattering from hydrogen target → Measurement from different rings
  - Background from Al target window → Dedicated measurements with Al-targets
  - Pion-dilution → Dedicated measurements using pion detector (Andrew Gunsch's talk)



SIMULATION IS USED TO GENERATE THE ACCEPTANCE-AVERAGED VALUE OF THE KINEMATIC FACTOR

Simulation must be benchmarked and checked by the calibration measurements

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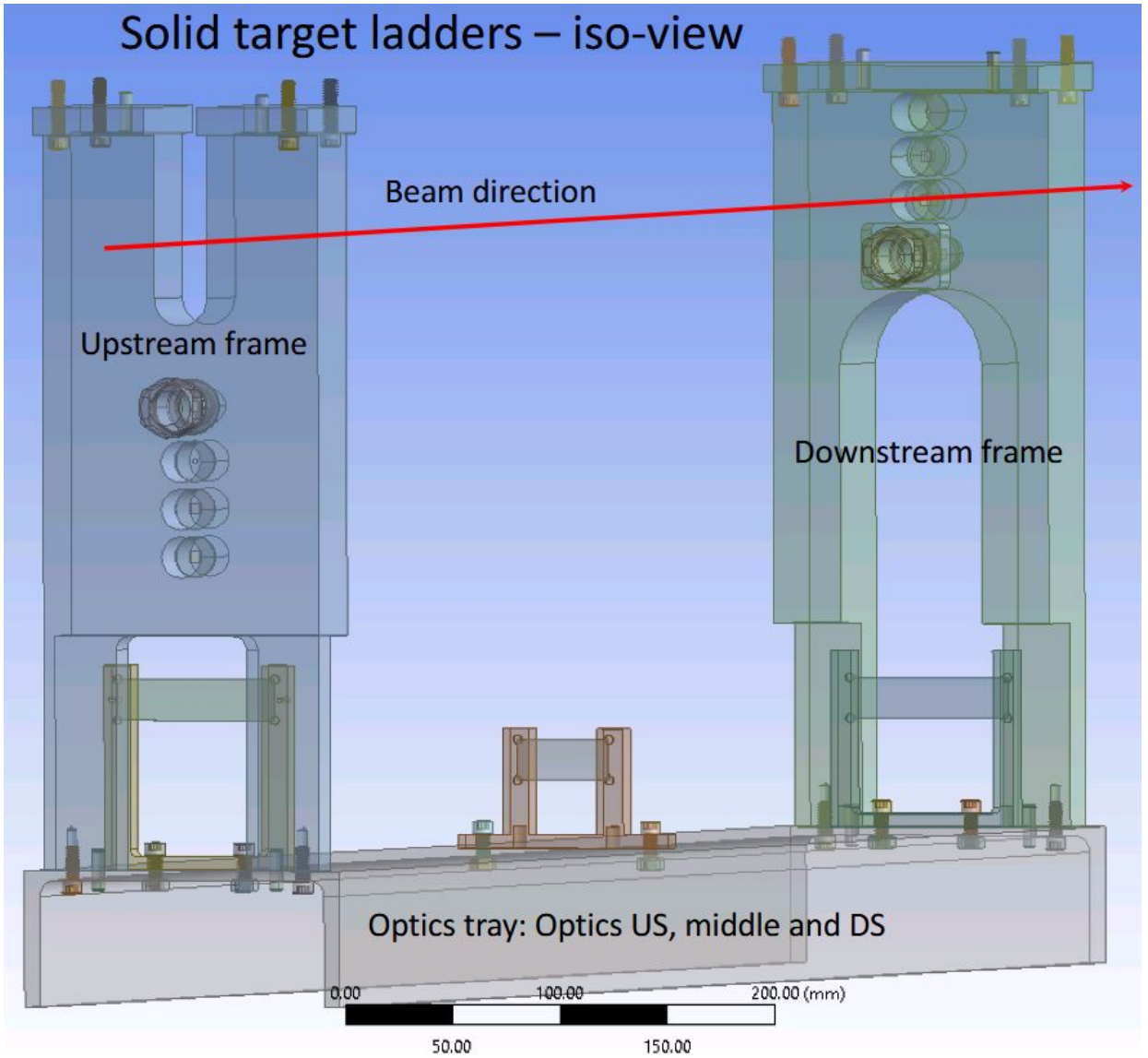
Tools: Targets for Calibration Runs

Considerations:

- To understand the optics of the spectrometer
- To cover the entire LH2 target length
- Evaluation of background from the Al-windows
- To evaluate and benchmark radiative loss in targets with different thicknesses

Targets for Calibration runs:

- C12 - 2 (US), 40 (DS) mm
- Al: 1, 2 (US), 6, 12.5 (DS) mm
- Hole: 2 mm (US &DS)
- Three optics targets located at the upstream end, middle and the downstream end of the LH2 target



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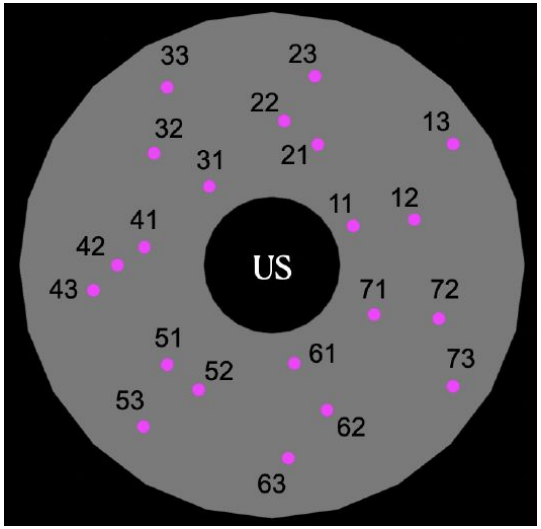
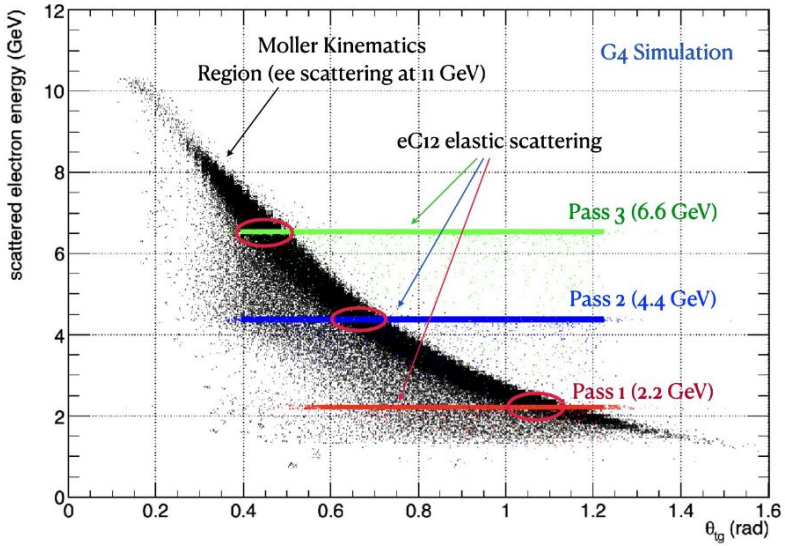
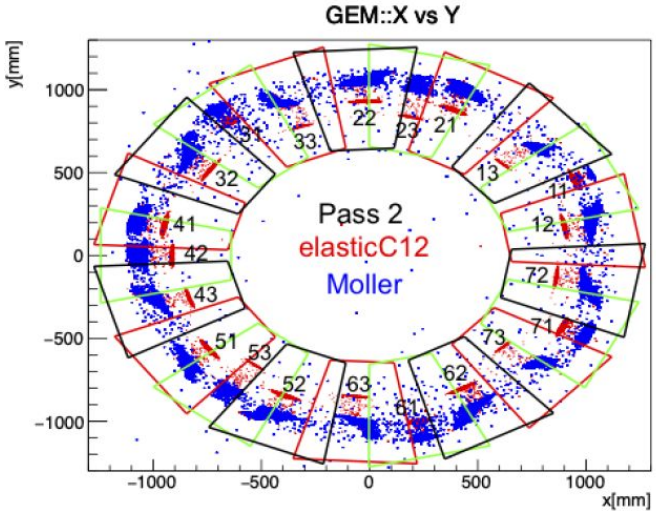
Optics studies with lower pass beams



- Consideration:
  - Complete coverage for Θ_{lab}, ϕ_{lab} acceptance
  - Least slit scattering and punch through
  - Redundancy of holes
  - Machining



Calibration studies will be performed at 2.2, 4.4 and 6.6 GeV beams to cover moller-acceptance using e-nuclear scattered events



- Measured (using tracking system):
  - position (r), angle (ϕ) and direction r' = dr/dz , ϕ' = dϕ/dz
- Geant:
  - Θ_{lab}, p, ϕ_{lab}, z-vertex (V_z)
- Required Mapping:
  - $(\Theta_{lab}, p, \phi_{lab}, V_z) \rightarrow \mathcal{M}(r, r', \phi, \phi')$
- Constraints:
  - Sieve hole: Θ_{lab}, ϕ_{lab}
  - Thin target: z-vertex

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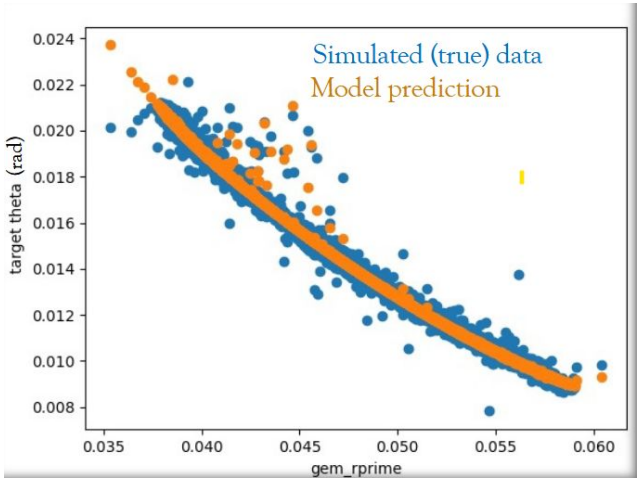
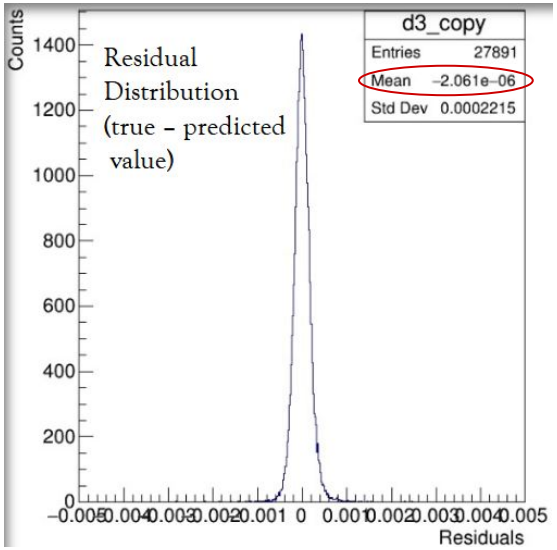
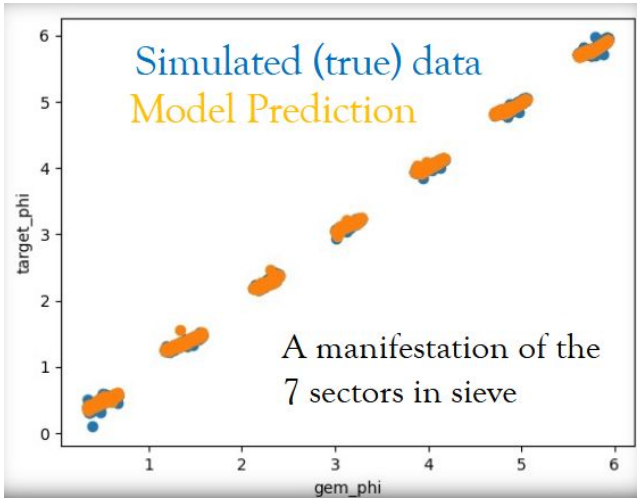
Reconstruction model: Θ_{lab}, ϕ_{lab}

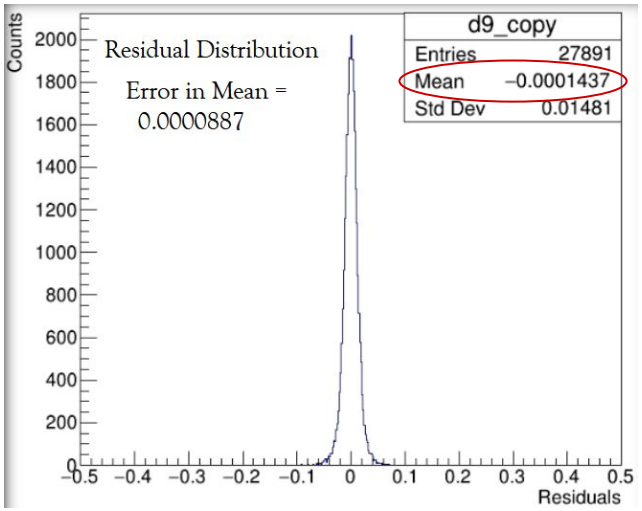


Θ_{lab}





ϕ_{lab}



Summary

- Low current calibration studies aim to
  - Extract the kinematic weighting in asymmetry interpretation
  - Verification of spectrometer optics
  - Background estimation
- The experiment is designed with tools to achieve its goal:
  - Dedicated calibration targets
  - Sieve and blocker collimators
  - Tracking detector system
- Optics model successfully reconstructed the vertex variables
- On-going active discussion making plans to execute the low-current calibration runs