Aluminum contribution from the DS window to the tiles

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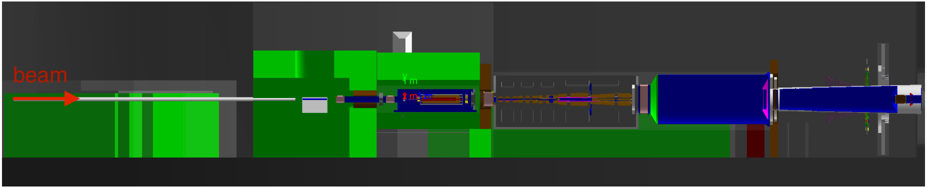
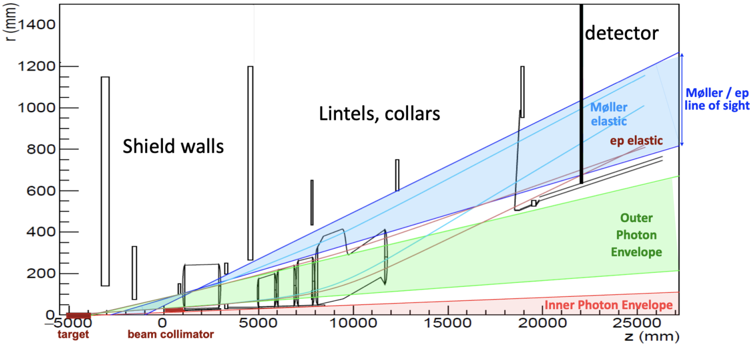
MOLLER Experiment



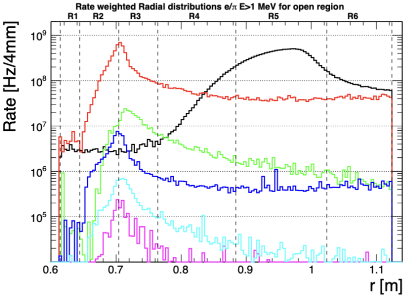
- Measures tiny differences in electron-electron scatering depending on electron spin direction (parity violating asymmetry). High precision (33 ppb)
- Backgrounds: Aluminum windows contribute to irreducible electron backgrounds.
- Accurate quantification of the aluminum contribution is crucial for the experiment. MOLLER expects significantly smaller Al corrections (1.5%).
- The goal of this study is to quantify the aluminum contribution from the downstream Al window to the quartz tiles.

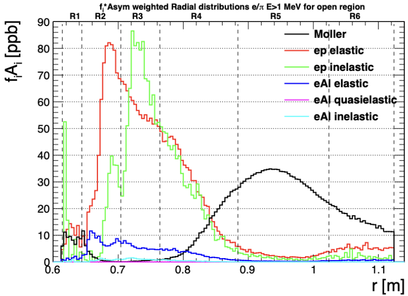
Backgrounds

- Irreducible backgrounds arise from scattering off the target material that will pass through the spectrometer and arrive at the detector plane.
- The principal irreducible background under the Møller “peak” is radiative elastic ep scattering.



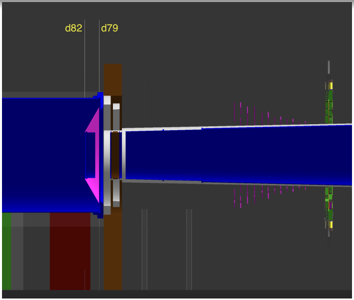
Background Deconvolution





- Deconvolute the signal from the background using the segmented detector plane.
- Elastic ep: 10% of the signal, asymmetry is well known.
- Inelastic ep: $< 0.3\%$ of the signal but asymmetry is $20x$ larger, not well known.
- The inelastic contribution is prominent in Rings 2 and 3, will be measured there.

Analysis Method



- In the first simulation, we ran Moller and ep elastic event generators. Selected e-/e+ hits on the virtual detector plane (d82), which is placed in front of the DS window ($520.954 \leq r \leq 1068.578$). Then, we checked whether the hits made it to the Ring5 tiles.
- In the second simulation, particle hits are generated in front of the d82 plane. During the analysis step, we first analyze the hits recorded in the Ring 5 tiles. Subsequently, we verify whether these hits are also recorded at the d82 plane. In the next step, we analyze all the hits recorded by the d79 plane, ensuring that the hits recorded at d79 are also present in the d82.

Analysis Method

- **Simulation:** For each event, we found the kinematic variables between d82 and d79.
- **Process-Dependent Calculations:** The effective x–section for Al scattering is computed separately for elastic, inelastic, and quasi–elastic processes. In each θ bin, the **weighted x–section** is obtained as:

$$\langle \sigma \rangle = \frac{\sum(\sigma \times \text{rate})}{\sum(\text{rate})}.$$

- **Average Asymmetry:** For each process in each θ bin, the **average asymmetry** is calculated by dividing the *rate×asymmetry×x–section* histogram by the *rate×x–section* histogram:

$$\langle A \rangle = \frac{\sum(A \times \sigma \times \text{rate})}{\sum(\sigma \times \text{rate})}.$$

- **Combined Asymmetry:** For both hit and missed events, the individual process asymmetries are combined using the corresponding x–section weights:

$$\langle A \rangle_{\text{combined}} = \frac{X_{\text{el}}\, A_{\text{el}} + X_{\text{inel}}\, A_{\text{inel}} + X_{\text{qel}}\, A_{\text{qel}}}{X_{\text{el}} + X_{\text{inel}} + X_{\text{qel}}}.$$

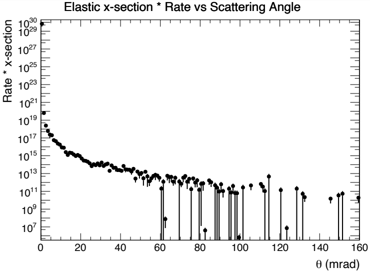
- **Missing Fraction and Final Product:** The fraction of missed events in each θ bin is given by:

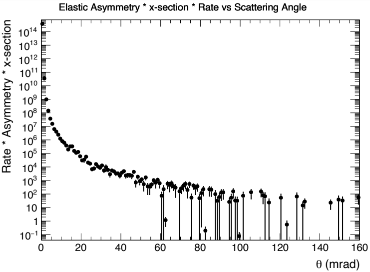
$$f_{\text{miss}} = \frac{X_{\text{miss, total}}}{X_{\text{hit, total}} + X_{\text{miss, total}}},$$

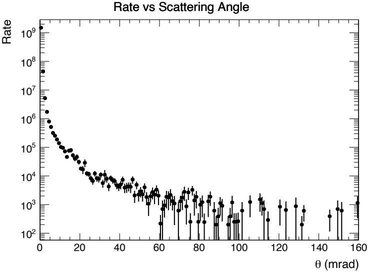
  where X represents the effective x–section.
- The final missed contribution is:

$$P_{\text{miss}} = \langle A \rangle_{\text{miss, combined}} \times f_{\text{miss}}$$

Effective Cross-Section and average asymmetry vs. θ, [Elastic], Hits R5

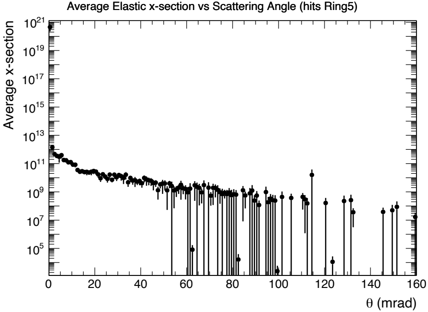


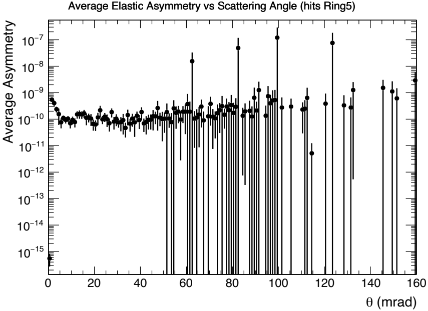




Top-Left: The rate weighted elastic cross-section as a function scattering angle.
Top-right: rate*asymmetry weighted cross-section distribution as a function scattering angle.
Bottom: Rate distribution as a function of scattering angle.

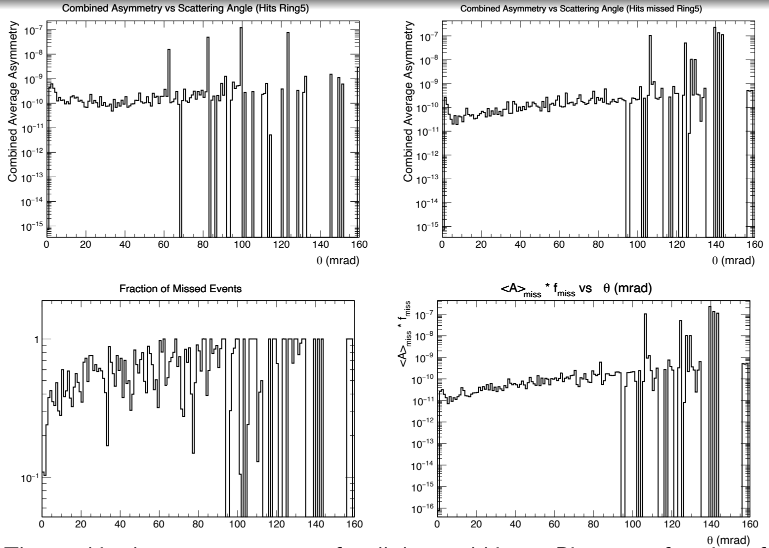
Average Cross-Section and Asymmetry vs. θ, [Elastic], Hits R5





Left: The average elastic cross-section as a function scattering angle.
Right: The average asymmetry as a function scattering angle.

Combined Asymmetry, Missing Fraction, and Missed Contribution Factor



Top-left: The combined average asymmetry for all detected hits on Ring5 as a function of scattering angle. Top-right: the combined average asymmetry from electrons that did not hit Ring5. Bottom-left: The fraction of missed hits. Bottom-right: The product of the average asymmetry from missed hits and the the fraction of missed hits.

- Identified events hitting or missing Ring5.
- Calculated cross-sections and asymmetries for Al-elastic, in-elastic and quasielestic processes.
- Evaluated the combined asymmetry for hits and missed events.
- The average asymmetry by fraction of events missing Ring5 is found to be smaller than 10^{-10}.
- This confirm negligible contamination from events missing Ring5.