Status of the 5 MeV Mott at MESA

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Outline

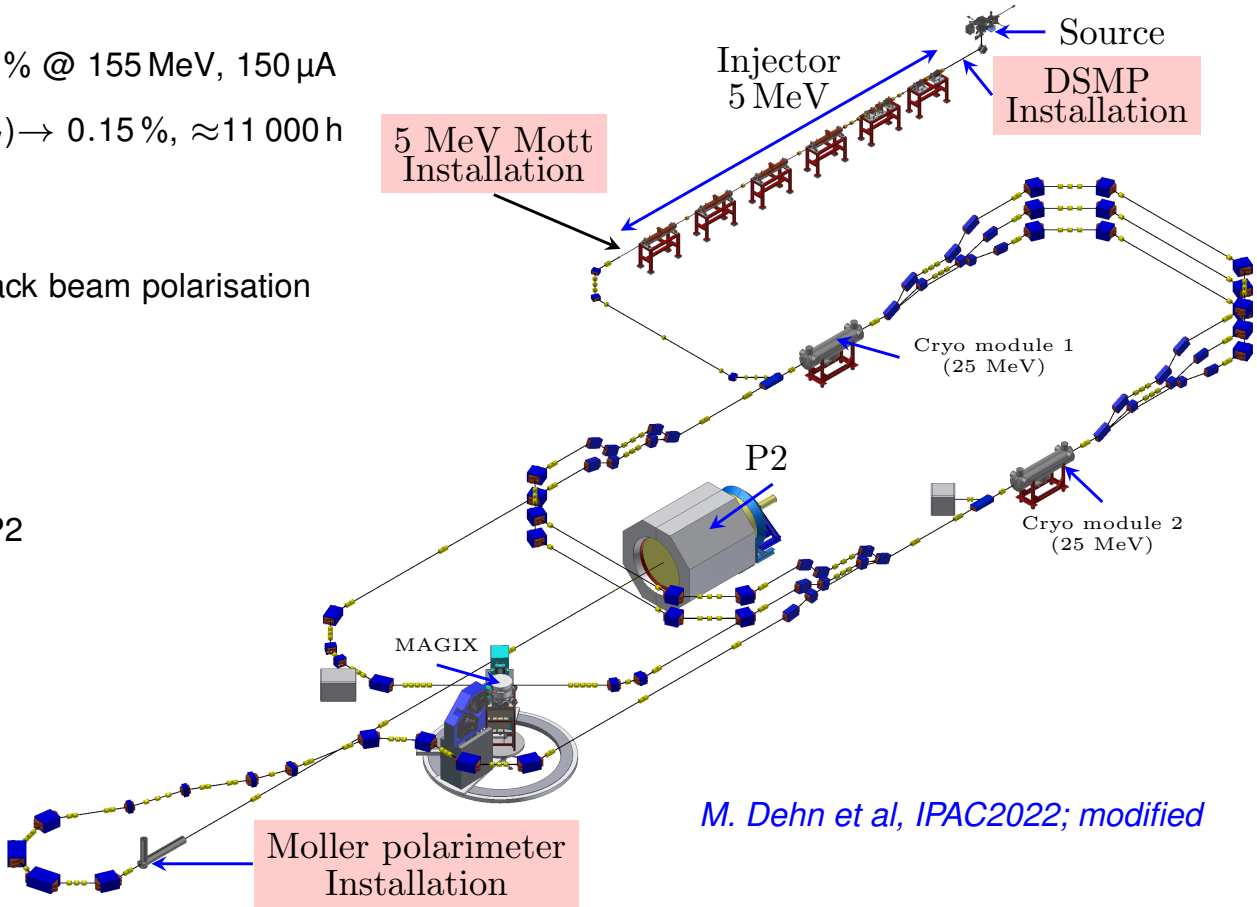
Introduction and motivation

P2 experiment:

- Polarised beam P $>$ 85 % @ 155 MeV, 150 µA
- Weinberg angle $(\sin^2\theta_W) \rightarrow$ 0.15 %, $\approx$11 000 h
- Requires $\frac{\Delta P}{P} \leq 1\,\%$
- Polarimeters chain to track beam polarisation

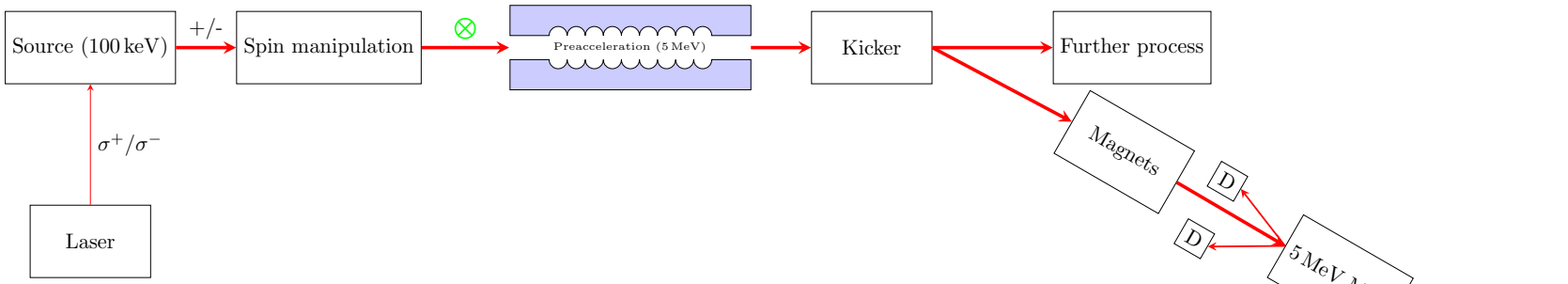
Project objective:

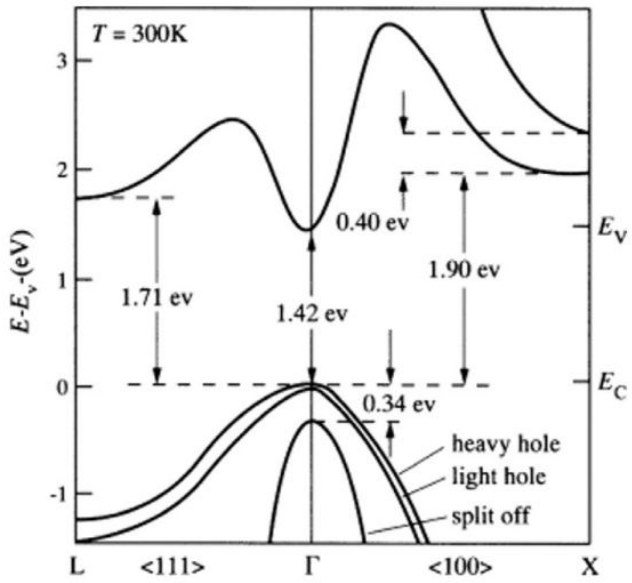
- 5 MeV mott installation
- Beam current $\approx$150 µA
- Deliver $\frac{\Delta P}{P} \leq 1\,\%$ to P2



M. Dehn et al, IPAC2022; modified

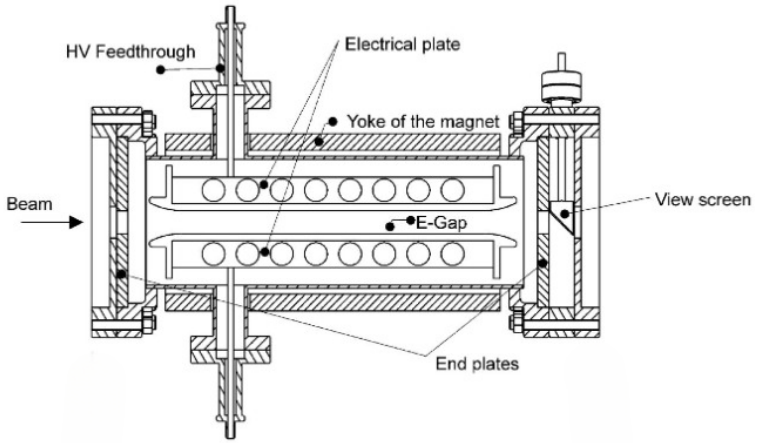
Overview of spin analyzing process





Energy level diagram of bulk GaAs.

J.S. Blakemore et al.,1982



Wienfilter

V. Tikouine et al.,2006

Mott scattering

Mott cross section

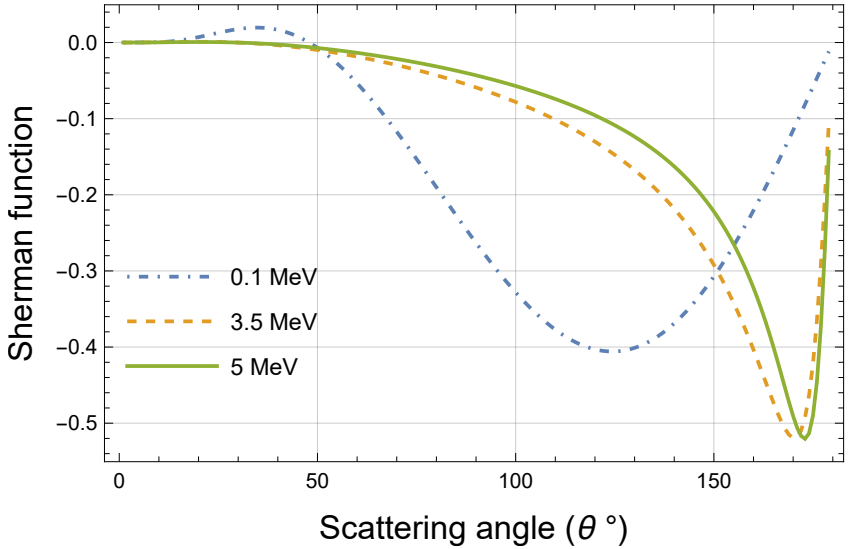
$$\sigma(\theta) = I(\theta)[1 + S(\theta)\vec{P} \cdot \hat{n}]$$

$S(\theta)$ = Sherman function/analysing power
$I(\theta)$ = unpolarised cross-section

- Asymmetric elastic scattering of spin polarised electrons in coulomb field

Theoretical corrections to Sherman function:

- Screening by atomic electrons
- Finite size correction
- Radiative corrections



Sherman function calculation for point nucleus of Au.

Sherman function values will be taken from the existing precise theoretical calculations published.

Mott polarimetry

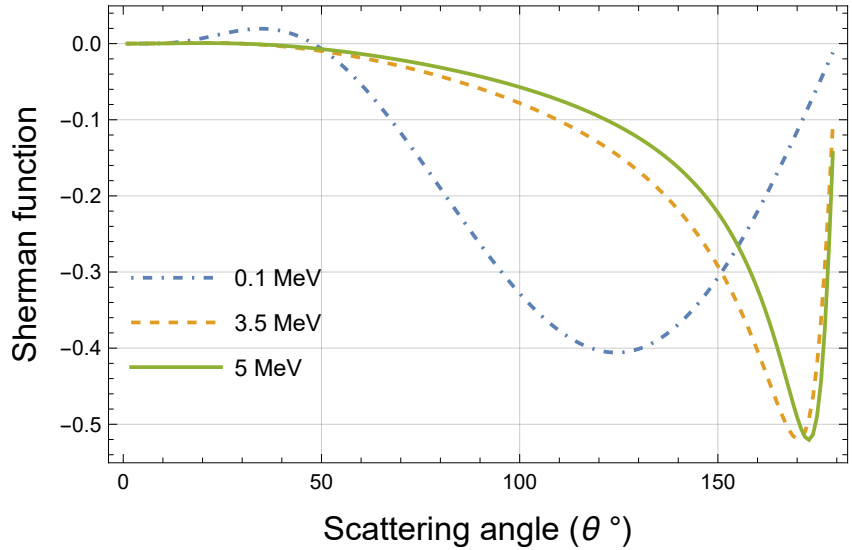
- keV Mott polarimeters are commonly used for source optimisation.
- Two existing Mott polarimeters operating at 3.5 MeV MAMI and 5 MeV JLAB
- Existing MeV mott polarimeters can be used for precision polarisation measurements.

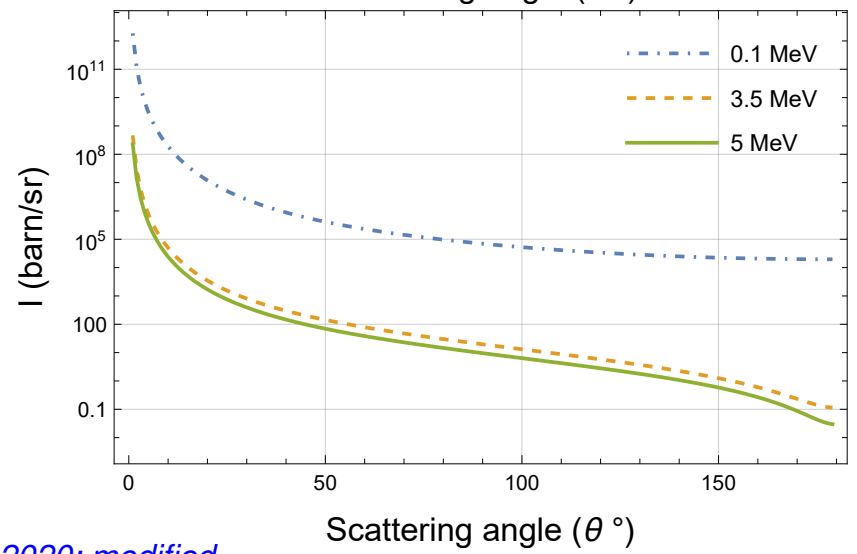
MeV energy mott benefits

- Larger analysing power
- Smaller cross section
- Free standing target

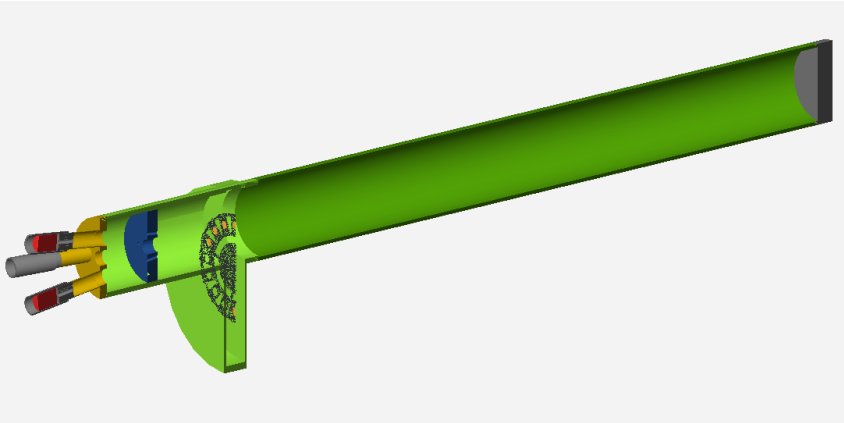
Contribution to the total uncertainty	Value
Theoretical Sherman function	0.50%
Target thickness extrapolation	0.25%
Systematic uncertainties	0.24%
Energy cut (0.10%)	
Laser polarization (0.10%)	
Scattering angle and beam energy (0.20%)	
Total	0.61%

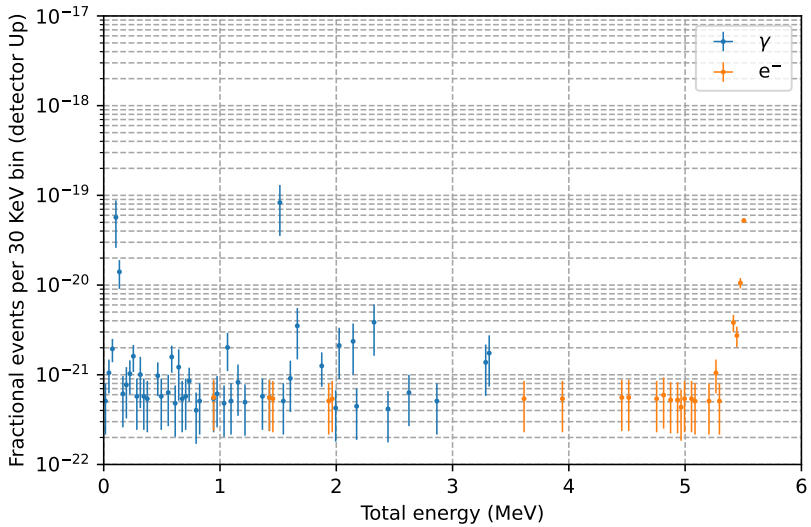
Uncertainity budget of JLab 5 MeV polarimeter.*J. Grames et al., 2020; modified*



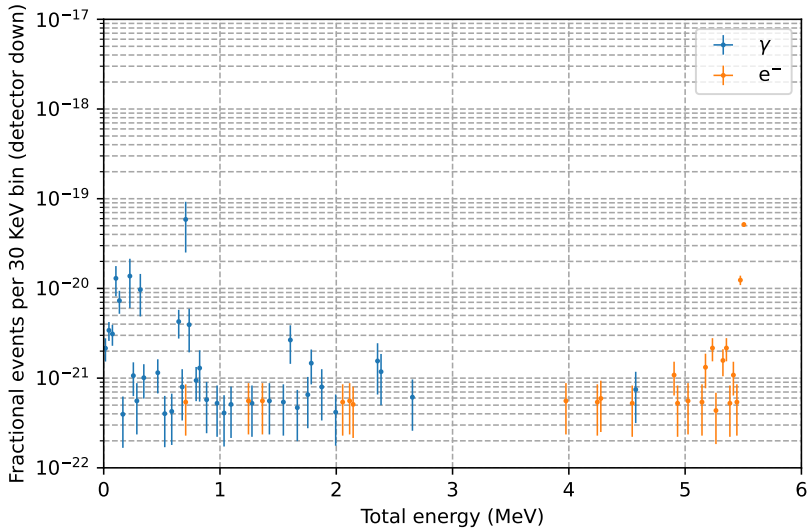


Simulation of the Mott geometry





- Both MAMI and JLab geometry were studied.
- Geometry with targets in the line of sight is chosen.
- Background comes from low energy photons and electrons events.
- Background can be controlled implementing low Z material, shielding and collimation.



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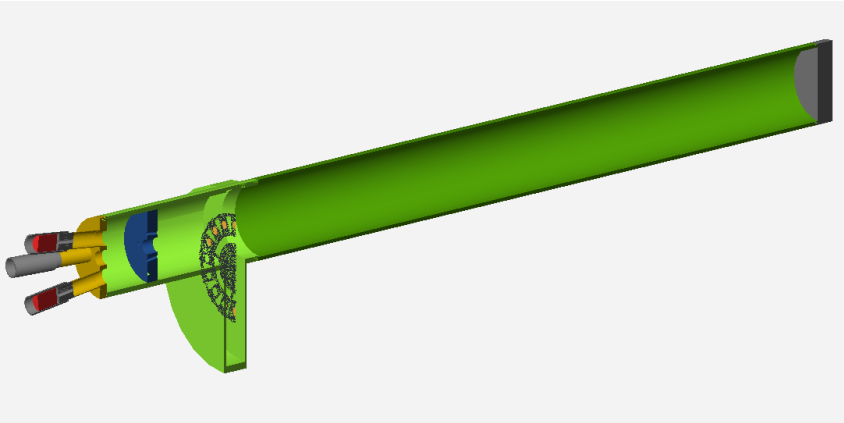

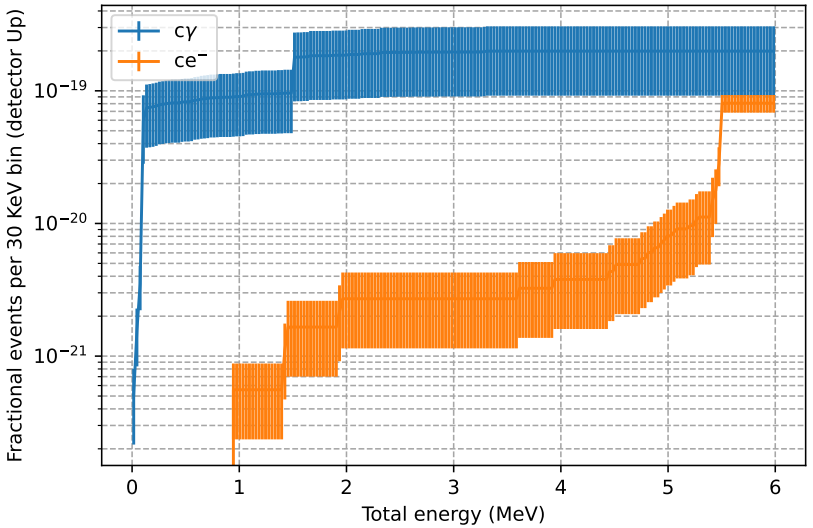

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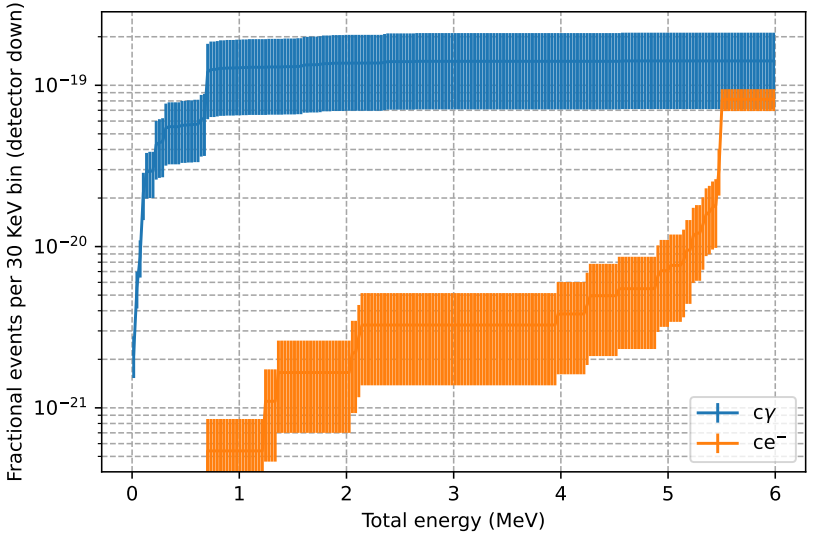
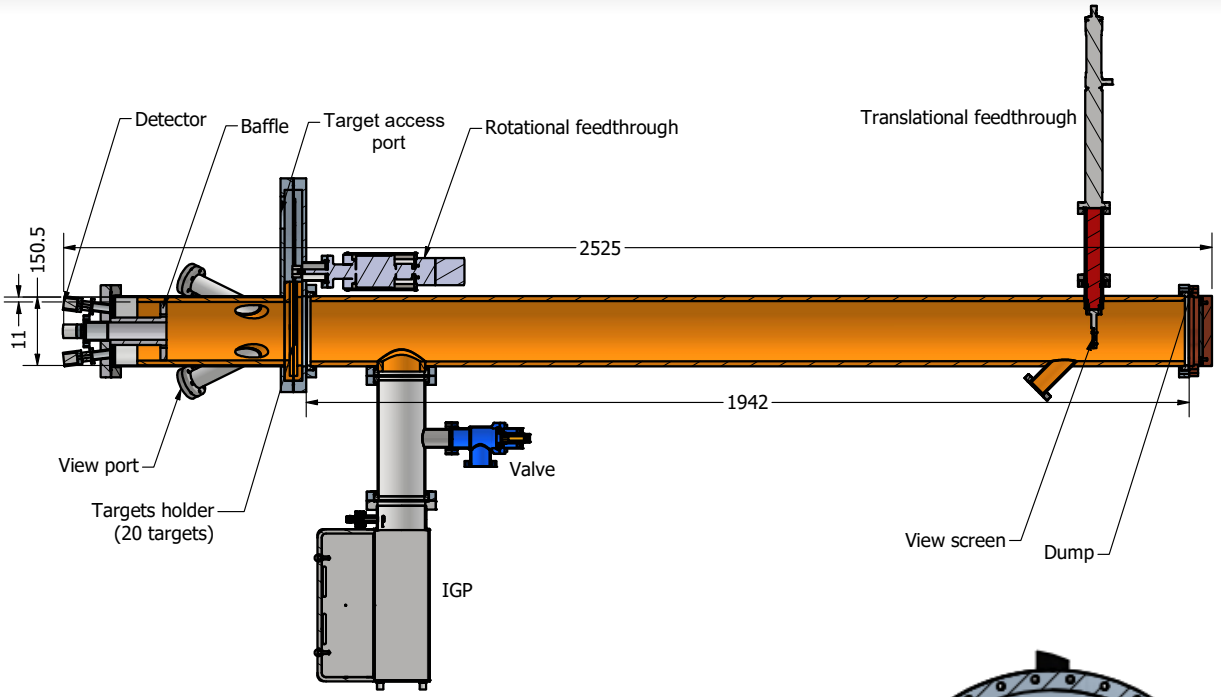
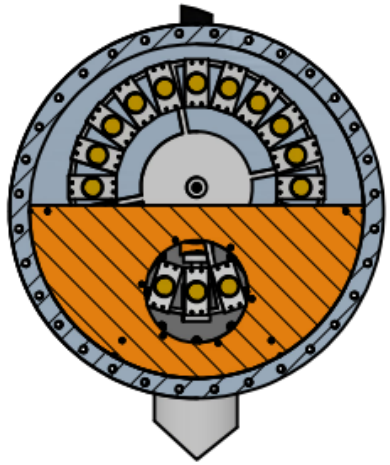


Design of the 5 MeV polarimeter set-up

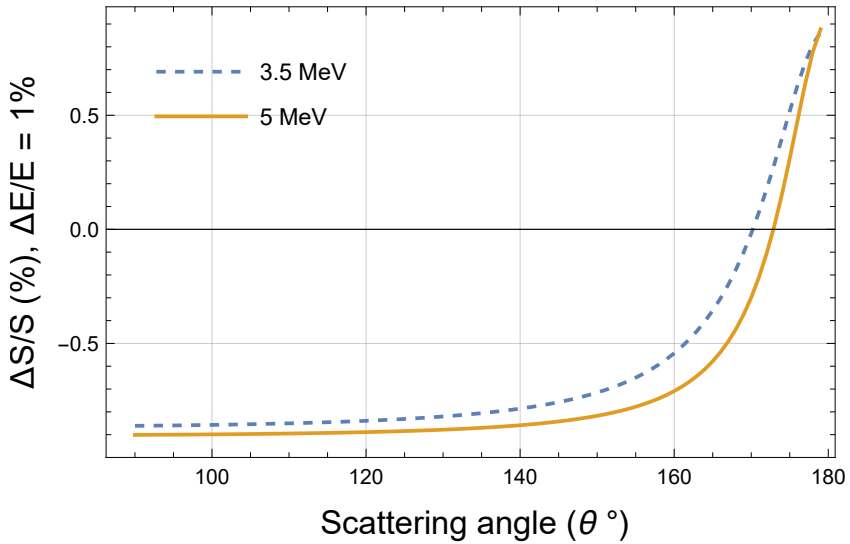


- Beryllium disc to minimize the electron backscattering from the dump.
- Aluminium liner inside the scattering chamber and aluminium dump extension pipe to reduce the backscattering.
- Can hold large number of targets .



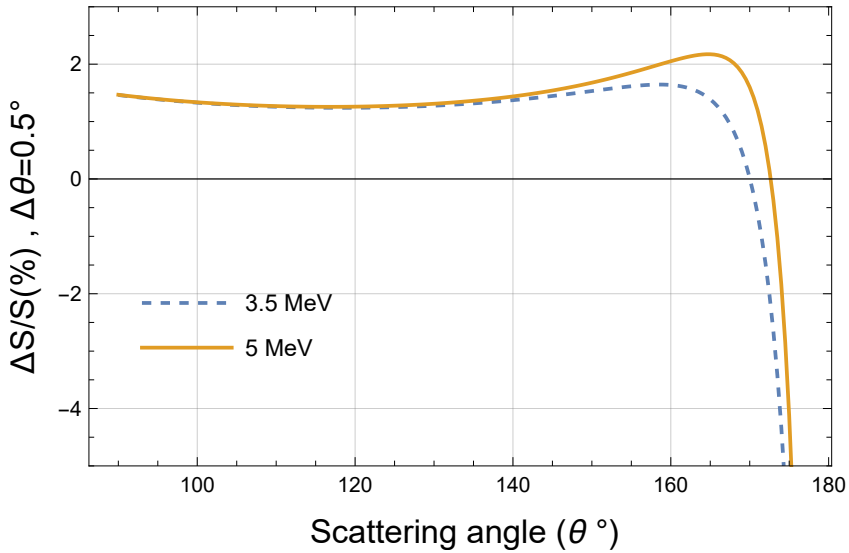
Section view of target system.

Set-up accuracy



Sensitivity of Sherman function to energy.

- For E = 5 MeV and $\Delta E/E = 1\,\%$, sherman function changes by 0.02 % at maximum.
- Energy spread can be measured using Dipole magnet.

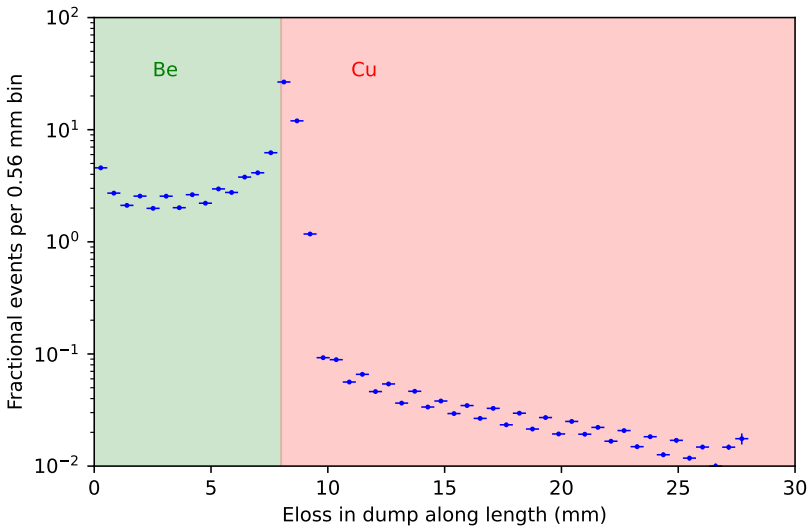


Sensitivity of Sherman function to angle.

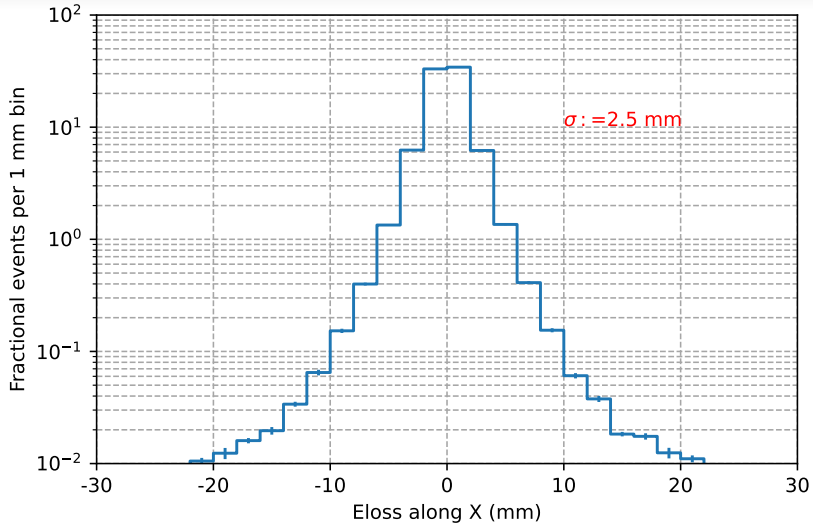
- At 172.5° Sherman function changes by 0.25 %
- At 173.5° Sherman function changes by 1 %

Simulation of 1 kW Dump

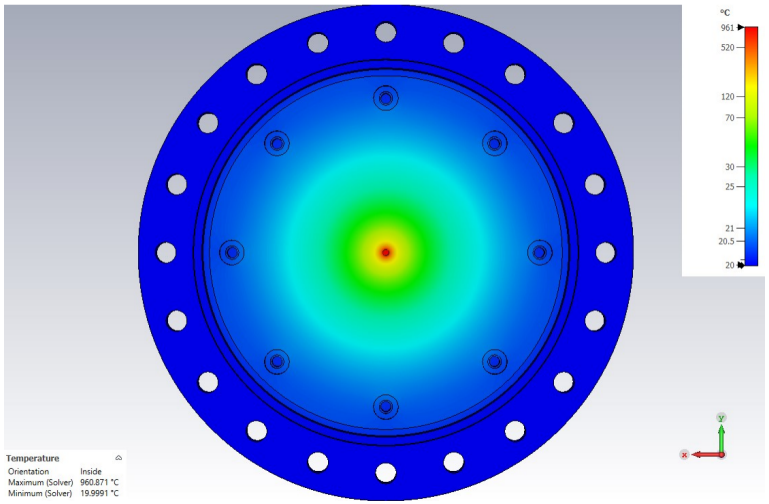
- Bdsim simulation with Pencil beam.
- $\approx$ 2.5 MeV energy stopped in 8 mm Be.
- Maximum energy stopped in first $\approx$ 2 mm Cu.
- CST simulation: 2.5 mm source, background air



Bdsim simulation for Eloss along Z.

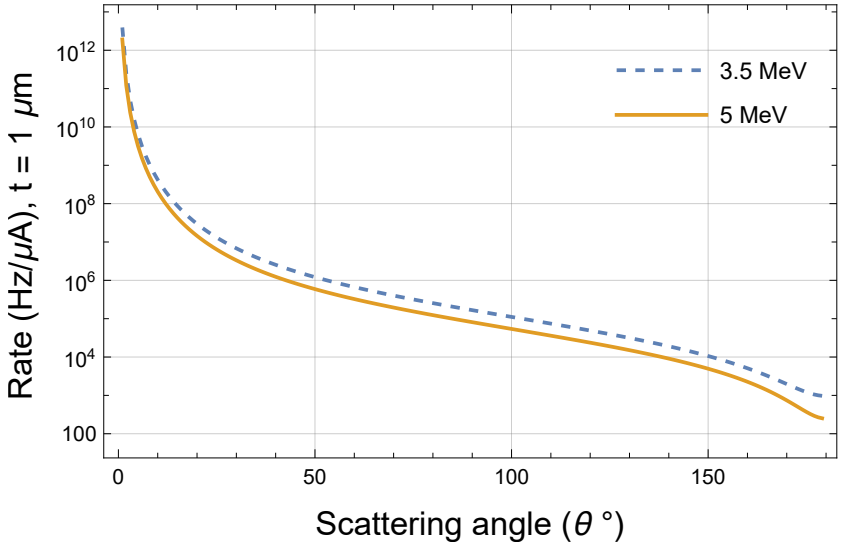


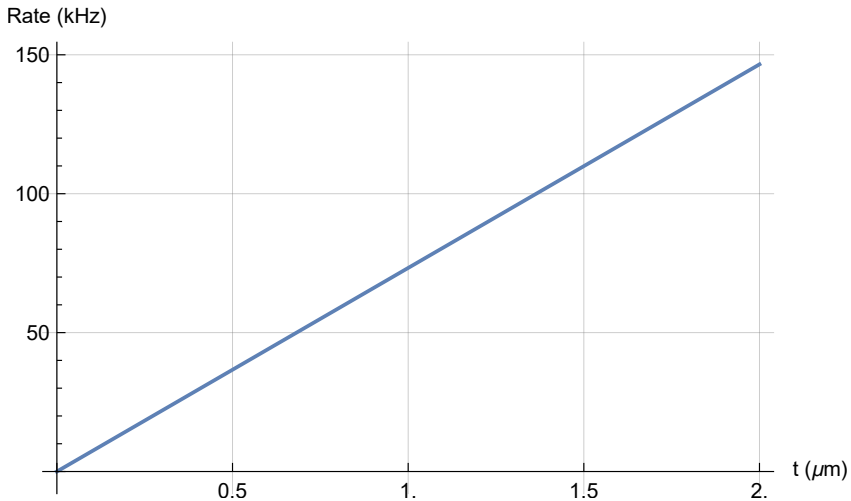
Bdsim simulation for Eloss along X.



Thermal simulation with 1 kW source.

Detector set-up





Total scattering rate for 150 µA beam current, $\Delta\Omega$ = 0.23 mSr

- To further eliminate the background, coincidence and time of flight method can be implemented.
- 8 different thickness targets are used for extrapolation which will be fabricated by GSI Darmstadt.
- Appropriate DAC is planned to be adapted from existing system (Sebastian Stengel PhD work on MAGIX trigger veto system).

Outlook and summary

Outlook

- Implement 5 MeV mott
- set up appropriate detector system
- Calibration of polarimeter

Summary

- Mott scattering experiment to analyze polarization.
- Design of the 5 MeV Mott set-up at its final stage.
- Experiment requires $\frac{\Delta P}{P} \leq 1\,\%$
- Next step is to implement the design.

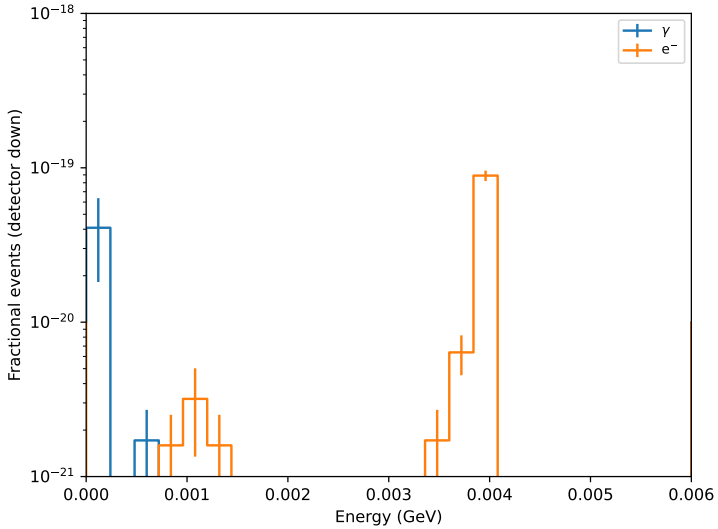
Thank you!

Acknowledgements

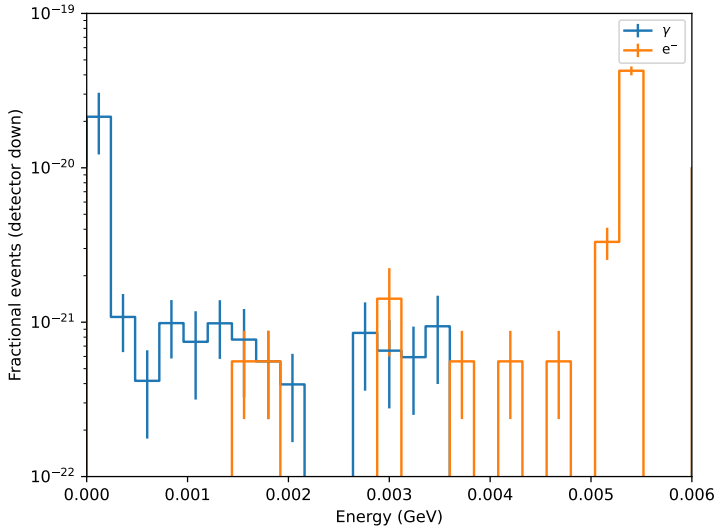
I want to thank B. Ledroit and BDSIM developers, especially L.J. Nevay and S.T. Boogert for the bdsim simulation comments and guidance. The bdsim simulations are done at the MOGON II cluster using himster 2 experimental partition.
I am thankful to Mr. Thorsten Feldmann, Dr. Valery Tioukine, and Prof. Kurt Aulenbacher for the consistent support during Mott design.

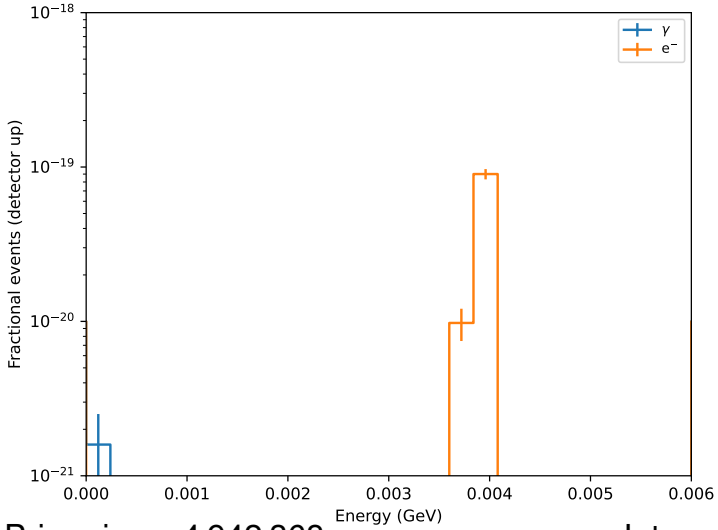
Back up

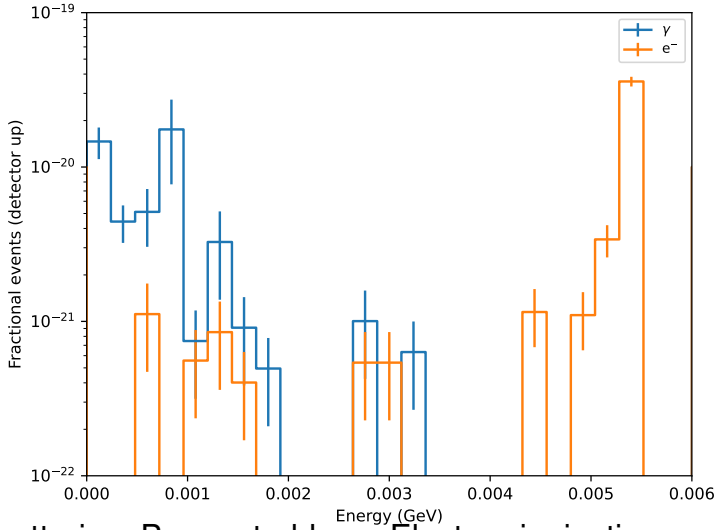
MAMI 3.5 MeV Mott



JLab 5 MeV Mott







Primaries = 4 942 368

Interactions: Coulomb scattering, Bremsstrahlung, Electron ionisation

Simulated model dimension