Møller Polarimetry Status

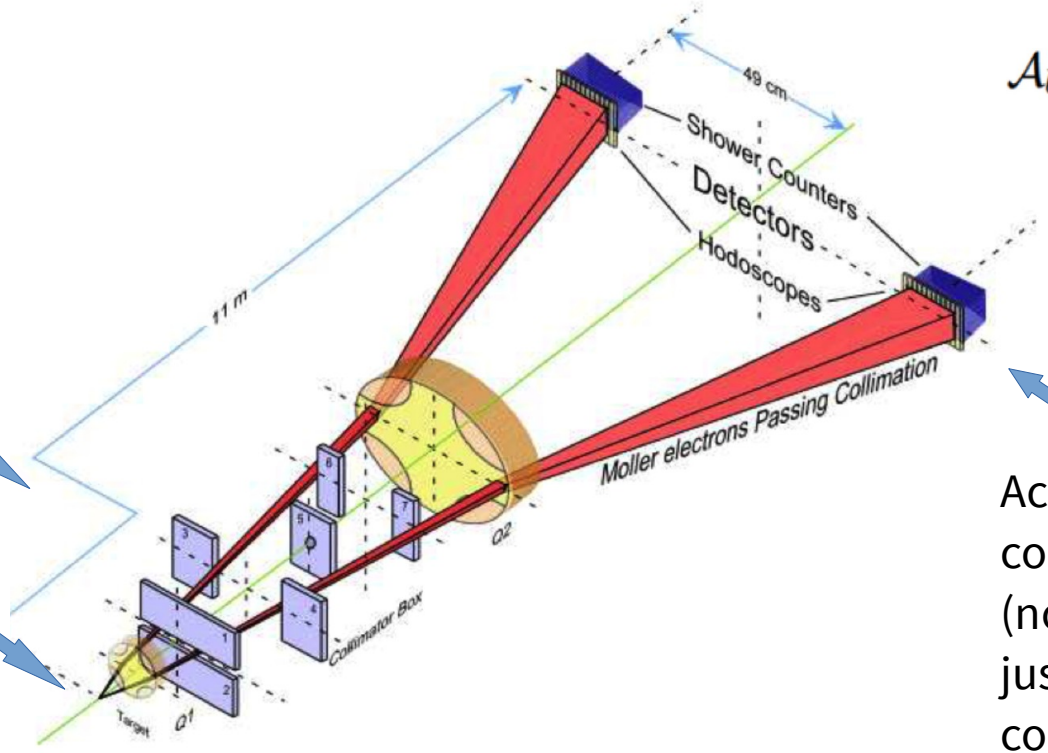
A1n d2n Collaboration Meeting
March 25th, 2021
Bill Henry (Jefferson Lab)

Møller Polarimeter Apparatus

$$\mathcal{A}_{beam} = \frac{N_{\uparrow\uparrow} - N_{\uparrow\downarrow}}{N_{\uparrow\uparrow} + N_{\uparrow\downarrow}}$$

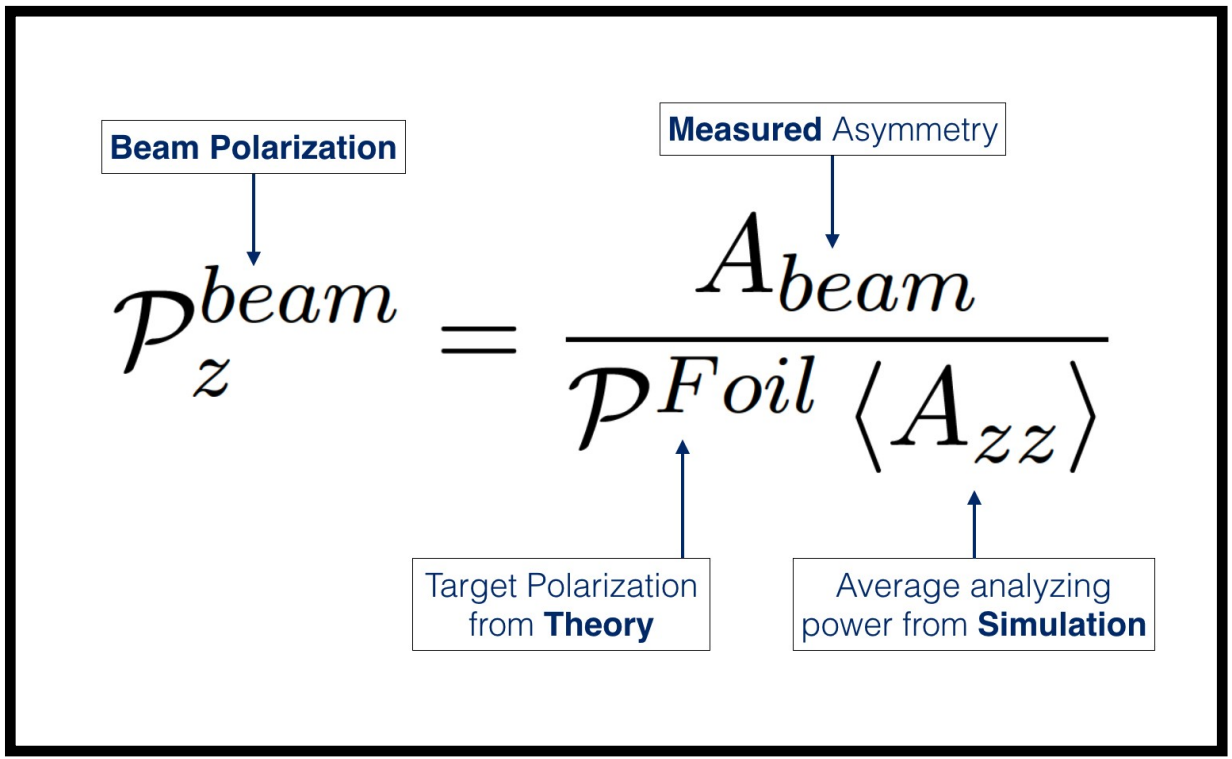
Collimators to reduce accidental backgrounds

Polarized Iron Foil (3.5 T)



Acceptance defining collimators (not shown). Located just before shower counters

Møller Polarimetry

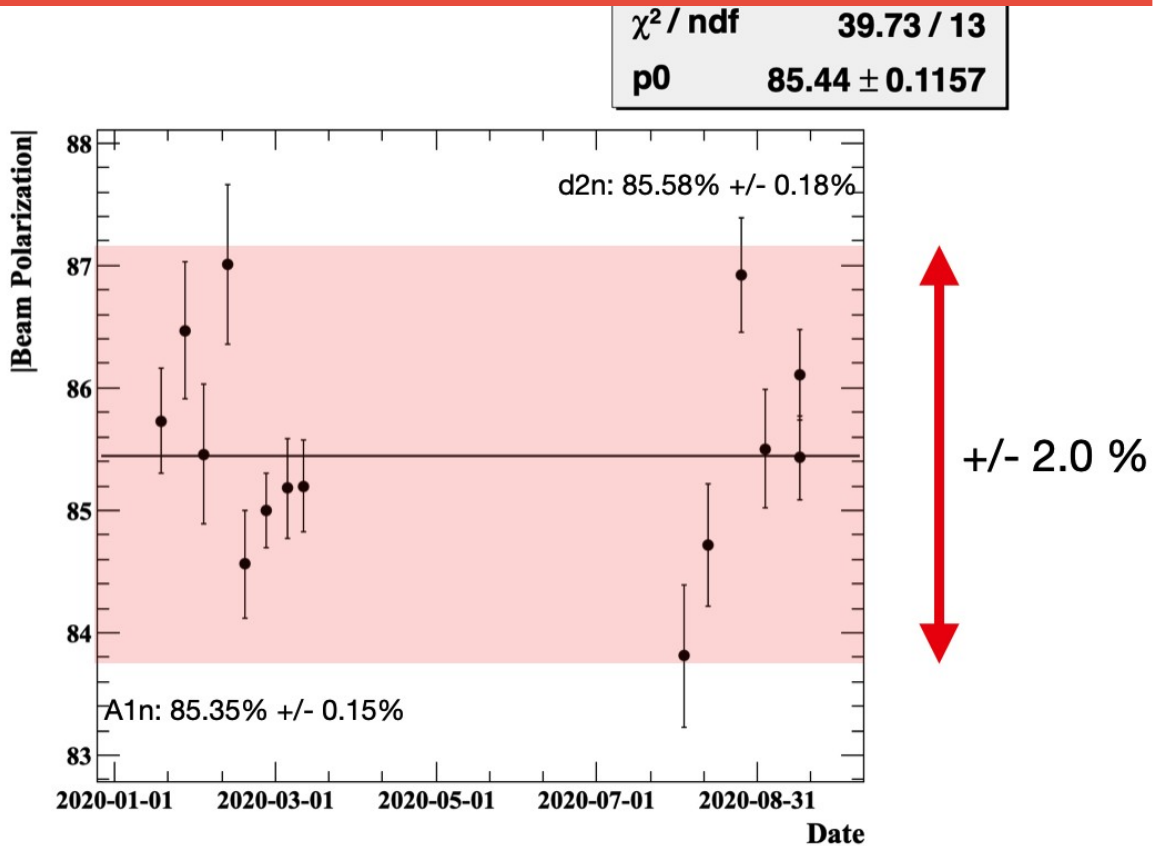


Beam Polarization: Current Status

Corrected for bleed-thru, deadtime, and charge asymmetry

Assumes nominal Analyzing Power

Minimal amount of work needed to finalize a 2% - 3% result.



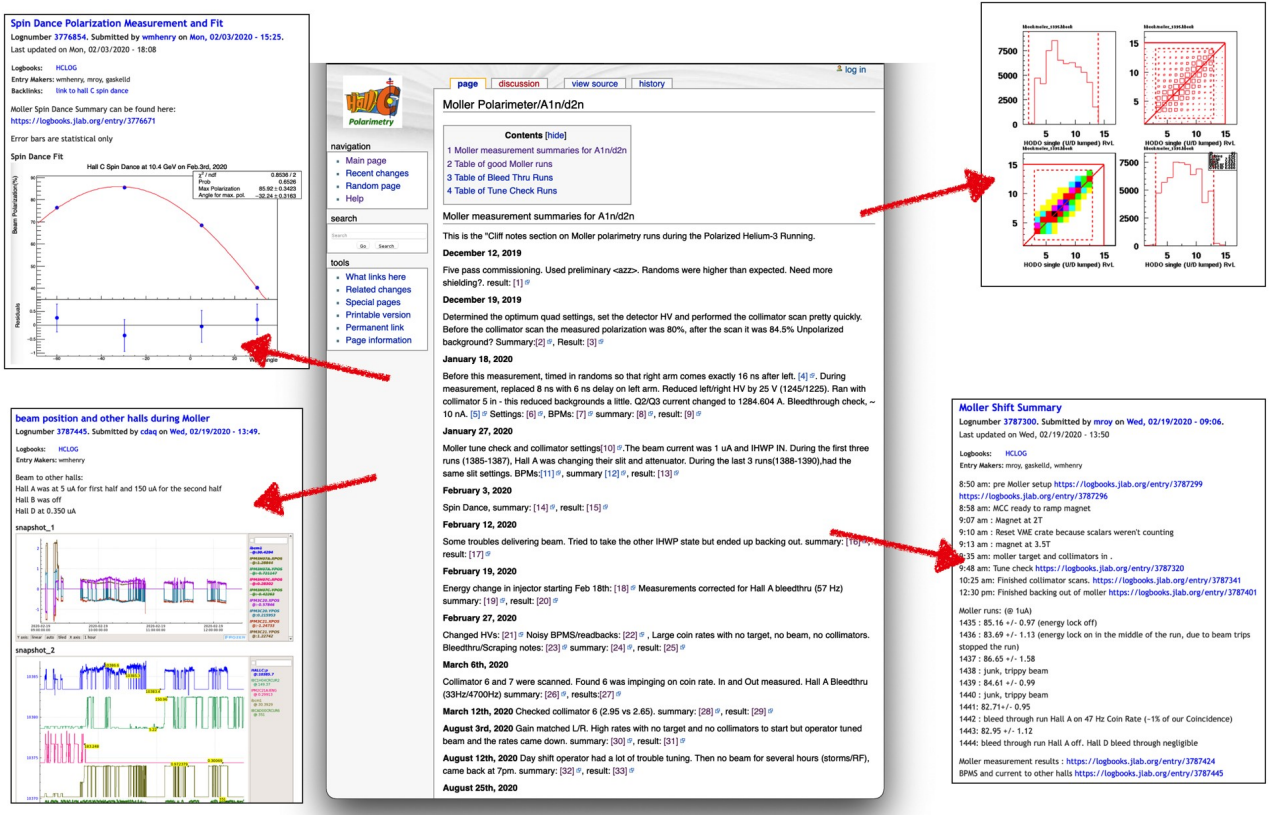
Required items to finalize 2.0 % - 3.0 % result

1) Document Measurements. (70 % complete)
2) Double check bleed thru corrections (80% complete)
3) Extract Beam positions (80 % complete)
4) Simulate collimator scans (to-do)
5) Verify analyzing power (to-do)
6) Assign Systematics (to-do)

Required items to finalize 2.0 % - 3.0 % result

Wiki Page includes:

- Shift Summaries
- Daily Results
- Useful Log entries
- Production Run List
- Bleed thru Run List



Required items to finalize 2.0 % - 3.0 % result

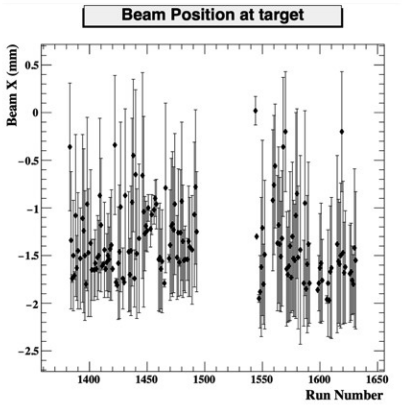
Changes in beam position will change the average analyzing power, <Azz>.

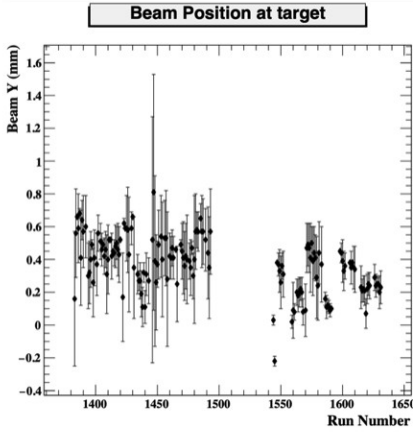
Beam position and angles have been extracted run by run (need to double check offsets).

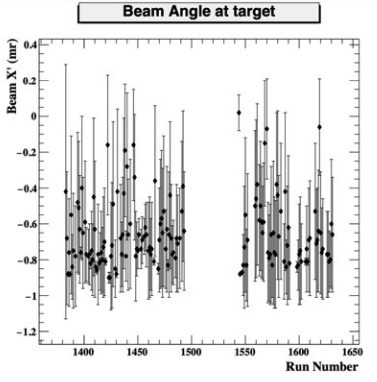
Next step is to add the beam position to simulation, check <Azz> and determine systematic.

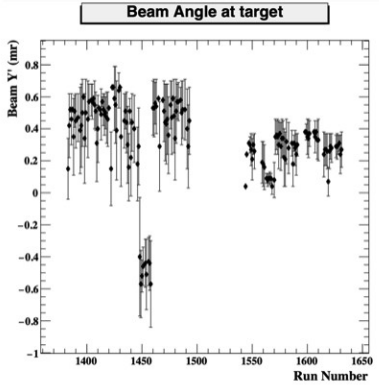
QWeak Systematics (1.16 GeV)

Source	Uncertainty	$\Delta P/P\%$
Beam position X	0.2 mm	0.14
Beam position Y	0.2 mm	0.28
Beam angle X	0.5 mrad	0.10
Beam angle Y	0.5 mrad	0.10



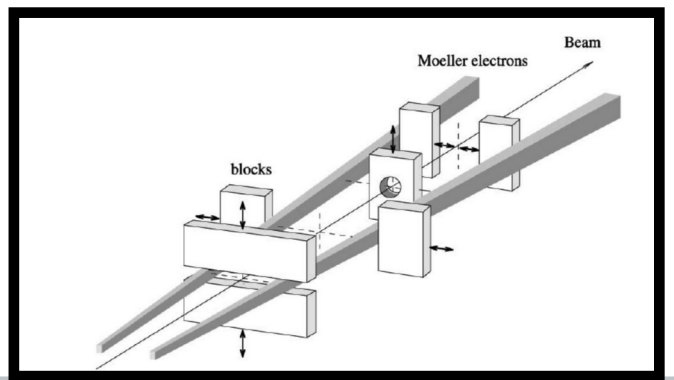


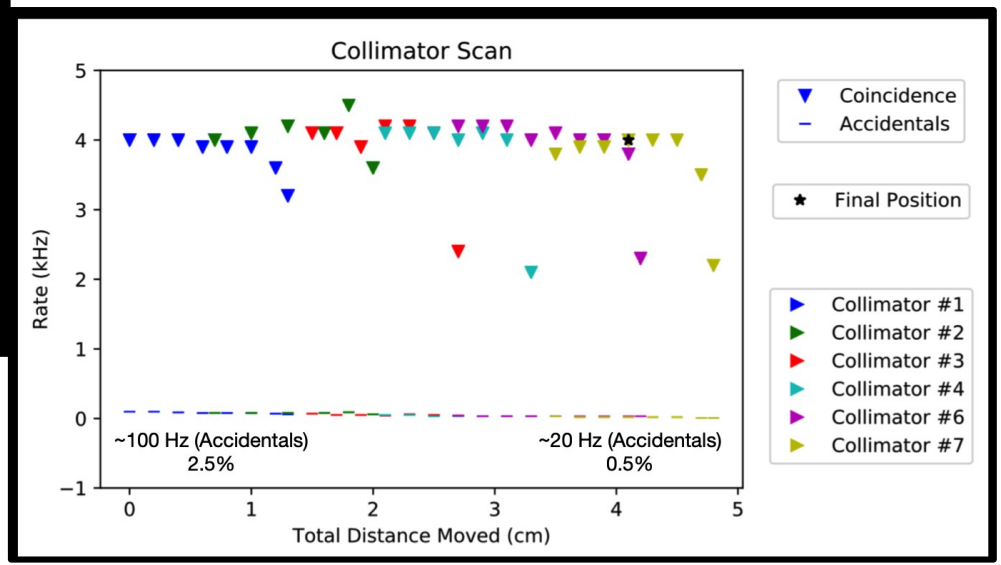




Required items to finalize 2.0 % - 3.0 % result

- Movable collimators are tuned for each beam energy
- First area of collimation in Møller polarimeter
- Used to reduce singles rates and accidental coincidences but not real Møller coincidences.
- Modified slightly as part of 12 GeV upgrade

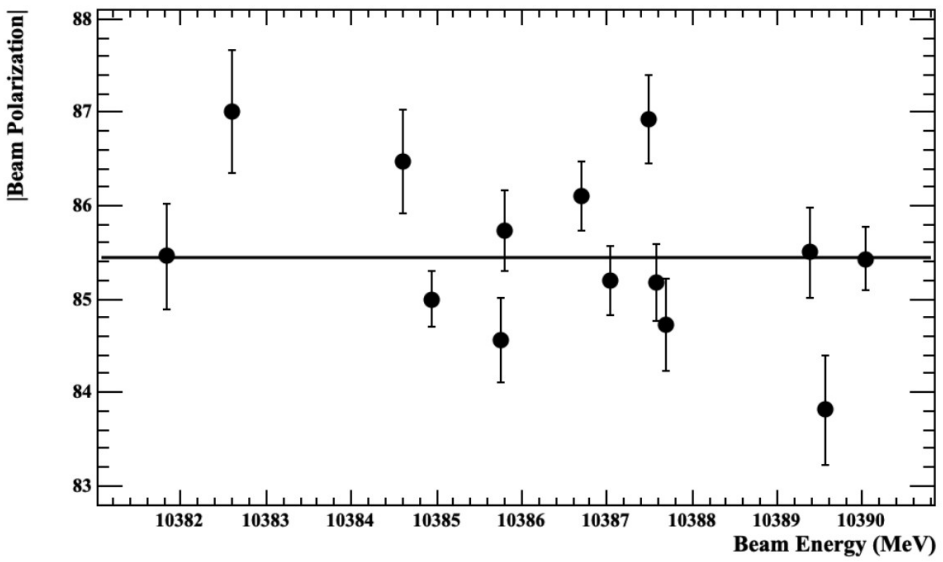


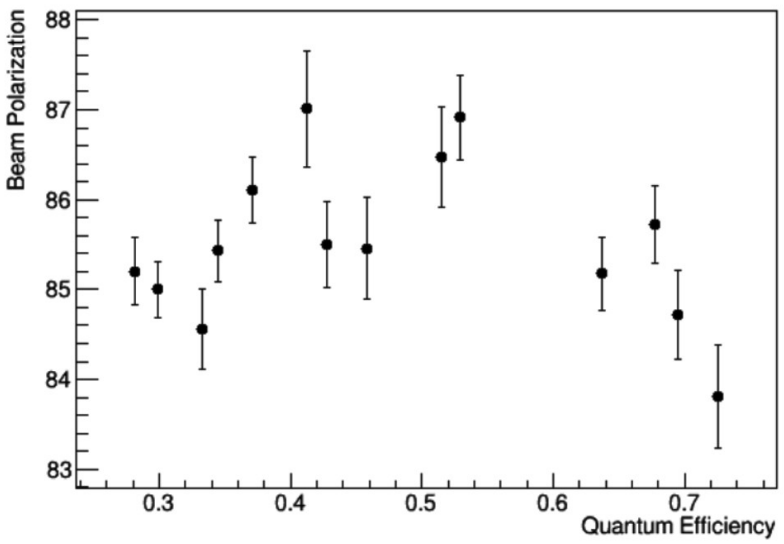


To-do: Simulate Collimator Scan

Improving the precision beyond the required 2.0% - 3.0%

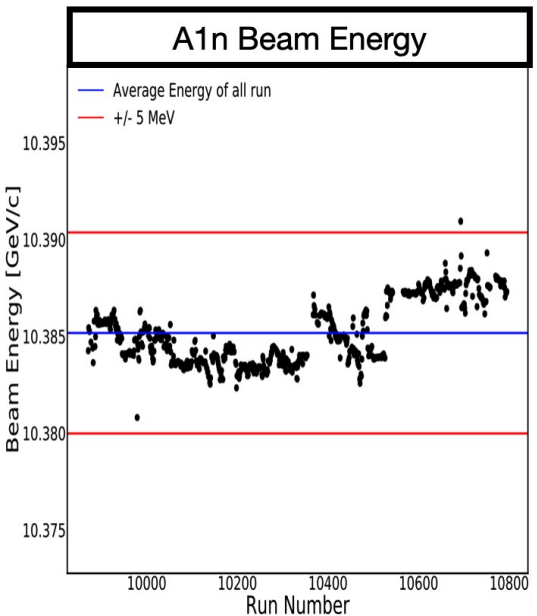
- By incorporating the accelerator energies and possibly the quantum efficiency of the photocathode cathode, it would be possible to calculate the beam polarization run by run.
- This is not a straightforward exercise but possible <u>if required</u>

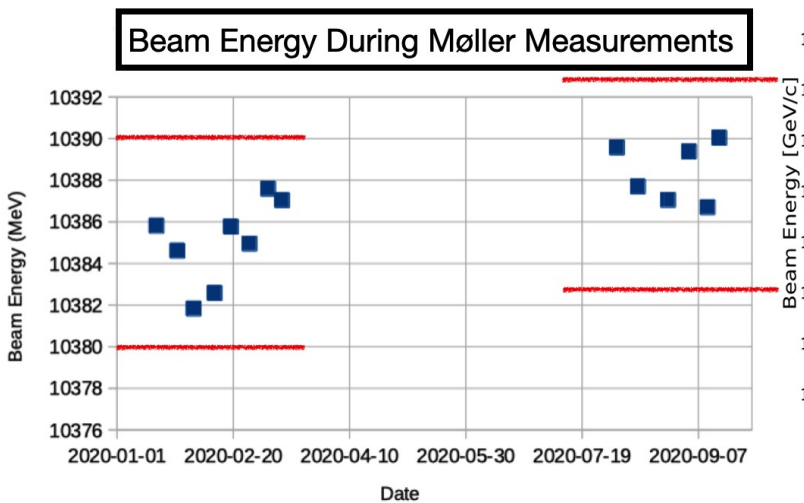


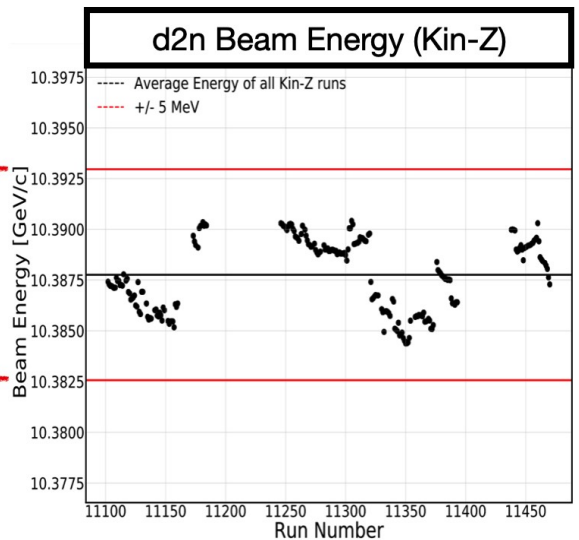


Beam Energy Dependence

- Beam polarization varies with beam energy due to spin precession
- Møller measurements were taken over the same energy range as production data







Production plots from Mike Nycz

Beam Energy Dependence

- A complete model of the energy dependence would require knowledge of the injector energy, linac imbalance, and the Hall C beam energy
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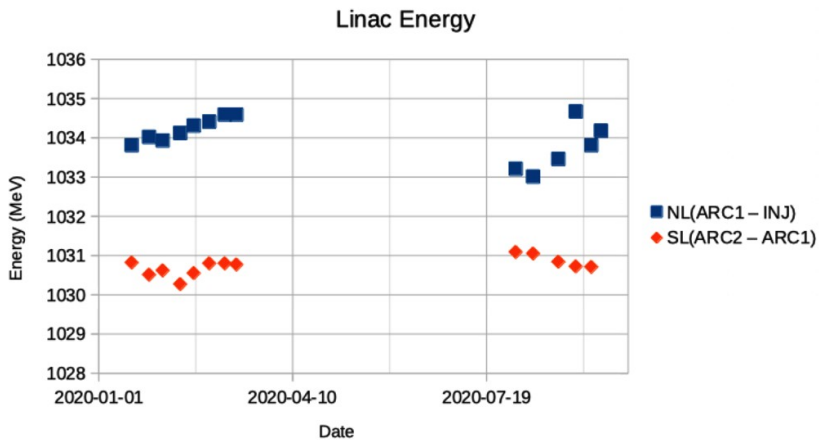
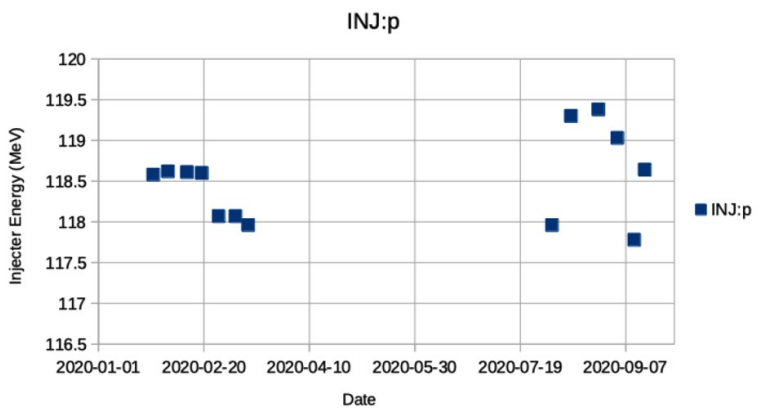
- Adding EPICS variables to data replay would be required. (HALLC:p, ARC1:p, ARC2:p, INJ:p, qe_hallc)





QE dependence

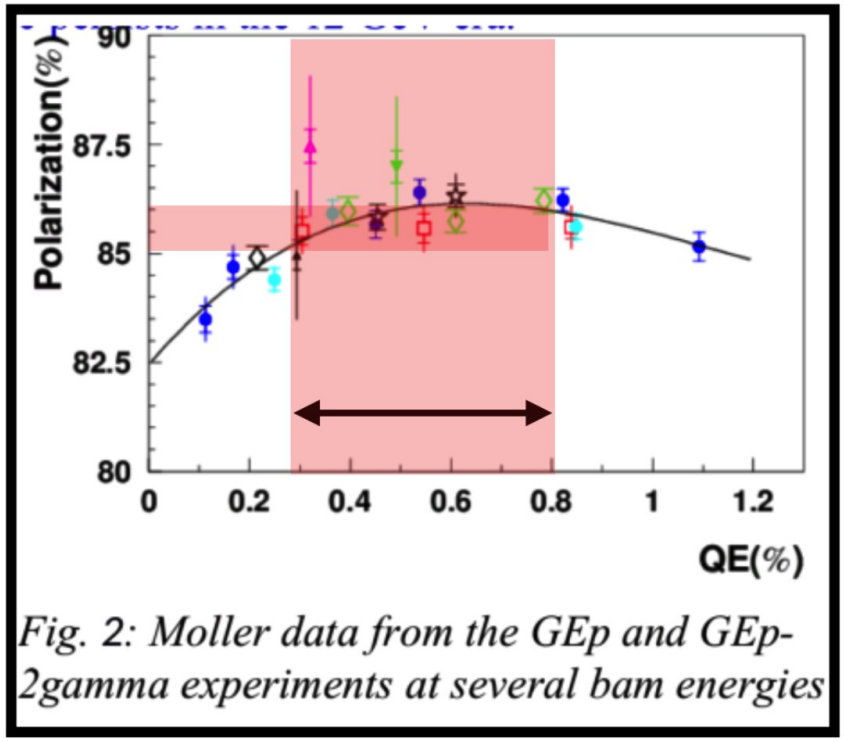


Fig. 2: Moller data from the GEp and GEp-2gamma experiments at several bam energies

QE ranged from 0.28 % to 0.80 % during A1n/d2n production running

From earlier studies the polarization off the photocathode would change by +/- 0.6 % over this QE range

Preliminary analysis shows no QE dependence during d2n running

A detailed analysis would require precessing the measured Hall C polarization back to the injector to determine QE dependence, if any.

Summary

- The Møller polarimeter successfully provided beam polarization measurements for the polarized He3 experiments.
- Providing the required 2.0 % – 3.0 % precision should be relatively straightforward.
- To-do list ：
  - Finishing documenting results
  - Simulate collimator scans and verify <Azz> including beam positions
  - Double check bleed thru corrections
  - Assign Systematic Errors
  - Evaluate precision of final result. Do we need better??

BACK UP SLIDES

Møller Measurement Procedure: Bleed thru

- Bleed thru from the other Halls proved to be challenging during measurements. (HV trips when moving collimators, high rates when beam was off in C, coincidence rates with target retracted etc).
- Special procedures were added to deal with and measure the bleed thru.
- Since we had to share our slit with Hall D, closing it was not an option. In the future running with our own dedicated slit is highly recommended.
- The bleed thru was measured, treated as a dilution and corrected online. Corrections ranged from 0.0 % to 1.0 %.

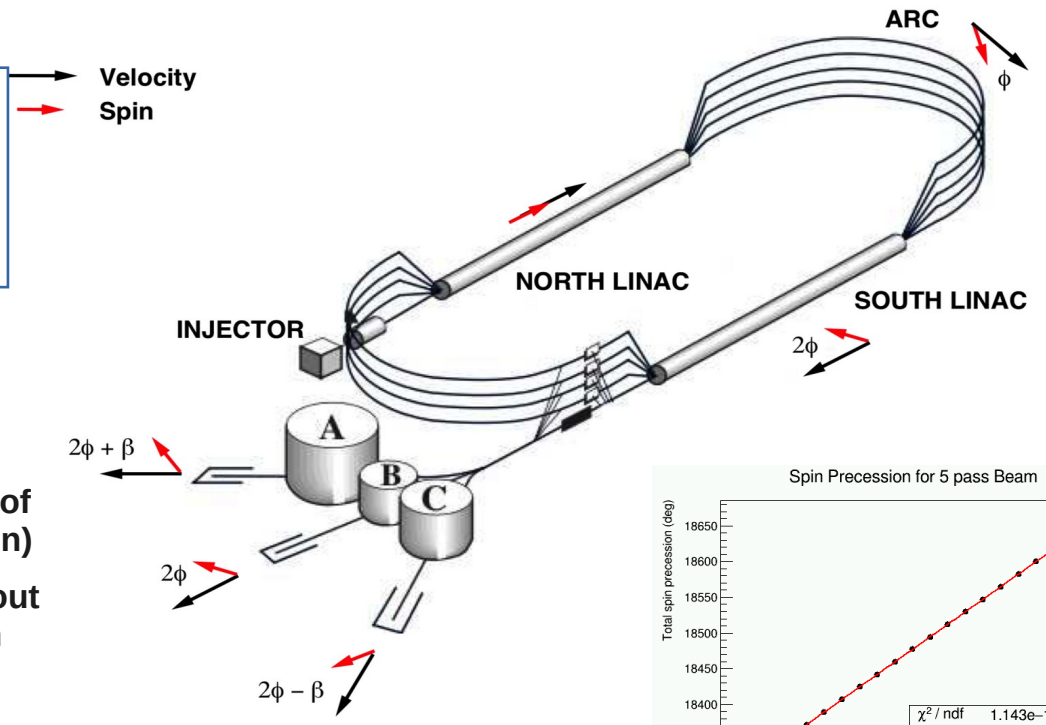
What's a spin dance?

SPIN PRECESSION

In general, the spin precession, $\Delta\phi$, of an electron of fixed energy as it bends through a series of dipole magnets is given by:

$$\Delta\phi = \frac{E}{440.65\text{MeV}} \times \Delta\theta \qquad (1)$$

https://arxiv.org/pdf/0901.4484.pdf



- **At 10.4 GeV, the electron's spin precesses over 18,000 degrees before reaching hall C !!**
- **A 1 MeV increase in beam energy equals 1.75 degrees of additional precession (neglecting synchrotron radiation)**
- **By varying the Wien angle at the injector we can map out the polarization dependence and find the optimal Wien setting.**

Hall C Spin Dance

- Polarization measurements were taken at four different Wien angles.
- Hall C ran at ~2.6 degrees from the optimal setting. The Wien angle was maximized for Hall A.
- Results show maximum possible polarization was 85.9% +/- 0.3%.
- The Wien angle was maximized for Hall A. Their spin dance was performed Jan. 7th found max. polarization of 86.2 % +/- 0.1 %. (online result)
- There is still a mystery that our relative optimal Wien angle seems to be inconsistent with the Hall A result. One explanation could be a 3° offset in the Wien filter.