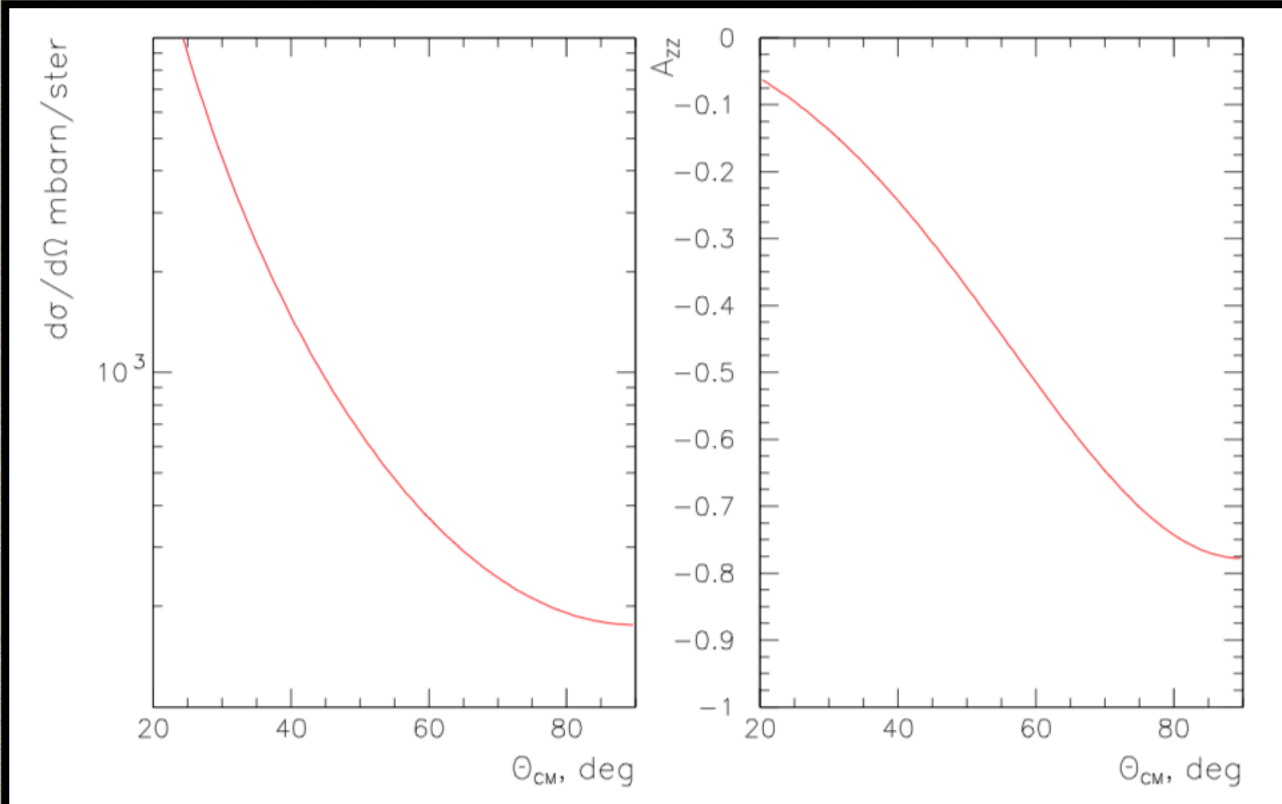
HALL C
MØLLER POLARIMETER
STATUS

MØLLER POLARIMETRY

Møller Scattering

Differential Cross Section | Analyzing Power (Azz) | Scattering Angle



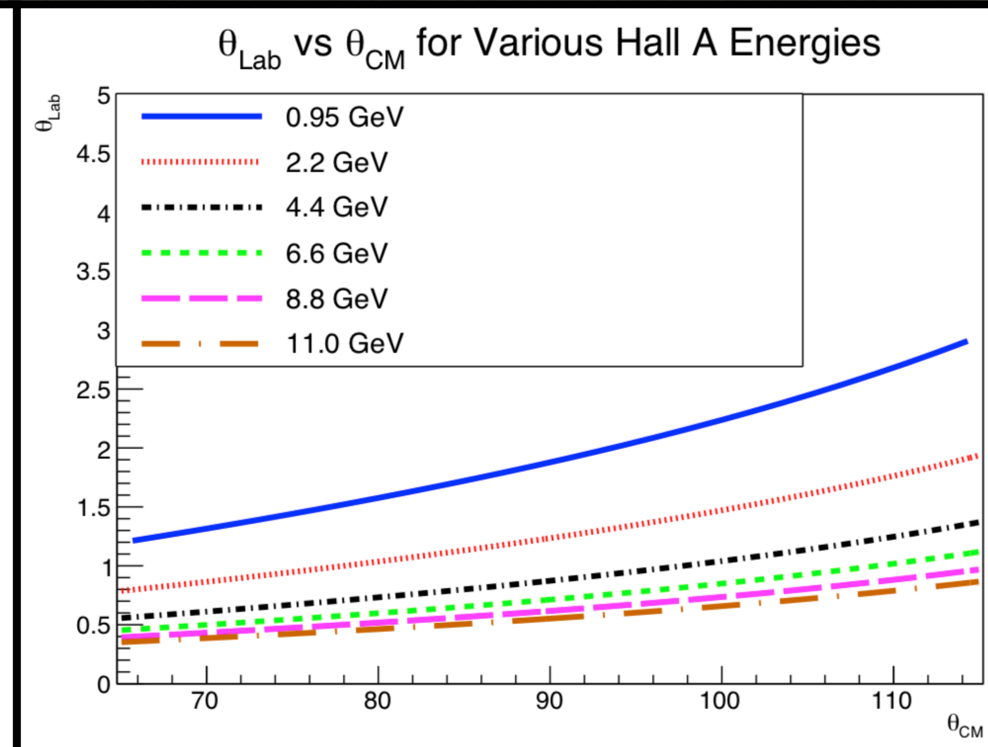


Figure 3.2: The Møller scattering angle in the lab frame vs CM frame

Large at 90°CM = -7/9

$$\mathcal{A}_{beam} = \frac{N_{\uparrow\uparrow} - N_{\uparrow\downarrow}}{N_{\uparrow\uparrow} + N_{\uparrow\downarrow}} = \mathcal{A}_{zz}(\theta_{CM})\mathcal{P}_z^{Beam}\mathcal{P}^{Foil}$$

$$\mathcal{A}_{zz}(\theta_{CM}) = \frac{-\sin^2\theta_{CM}(8 - \sin^2\theta_{CM})}{(4 - \sin^2\theta_{CM})^2}$$

MØLLER POLARIMETRY

Beam Polarization

Measured Asymmetry

$$\mathcal{P}_z^{beam} = \frac{A_{beam}}{\mathcal{P}^{Foil}\,\langle A_{zz} \rangle}$$

Target Polarization from **Theory**

Average analyzing power from **Simulation**

MØLLER POLARIMETERS

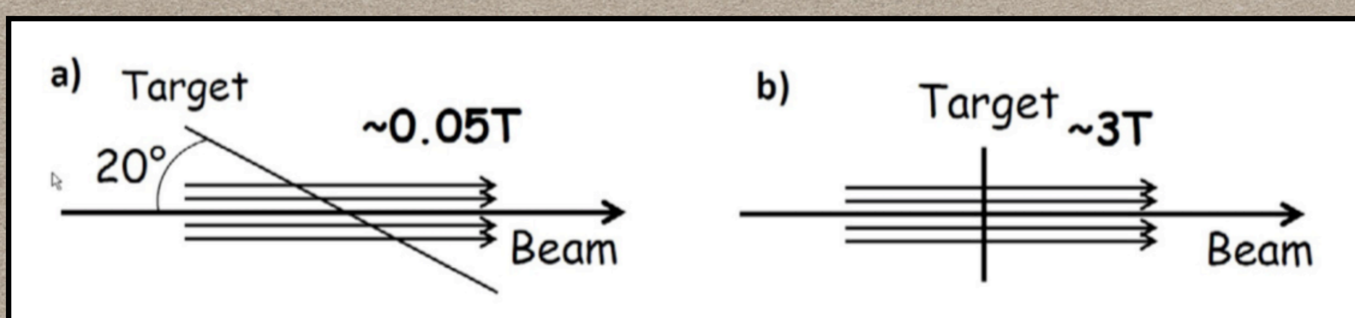
Table 2.1: Møller Polarimeters at various laboratories and their associated errors

Polarimeter	Beam energy (GeV)	Arms	Optics	$(\delta P/P)_{syst}$ Target	Full
SLAC[50]	48	1	D	1.7%	2.7%
SLAC[51]	16, 29	2	D	2.3%	2.4%
MAMI[47]	0.85	2	Q	2.0%	9.0%
MAMI[52]	0.85-1.5	2	D	0.6%	1.6%
Bates[48]	0.25, 0.57	1	Q	1.25%	6.0%
Bates[49]	0.87	2	Q	1.5%	2.9%
ELSA[53]	1.0 - 3.3	2	D	1.9%	2.0%
JLab, Hall A[9]	0.85 - 6	2	QQQD	1.5%	1.7%
JLab, Hall A[9]	0.85 - 6	2	QQQD	0.35%	0.9%
JLab, Hall B[54]	0.85 - 6	2	QQ	1.4%	3.0%
JLab, Hall C[41] (ideal)	0.85 - 6	2	QQ	0.3%	0.5%
JLab, Hall C[40] (Q-Weak)	0.85 - 6	2	QQ	0.3%	0.8%
JLab, Hall A	0.85 - 11	2	QQQQD	0.3%	1.0%

https://www.osti.gov/biblio/1574104

HALL C MØLLER TARGET

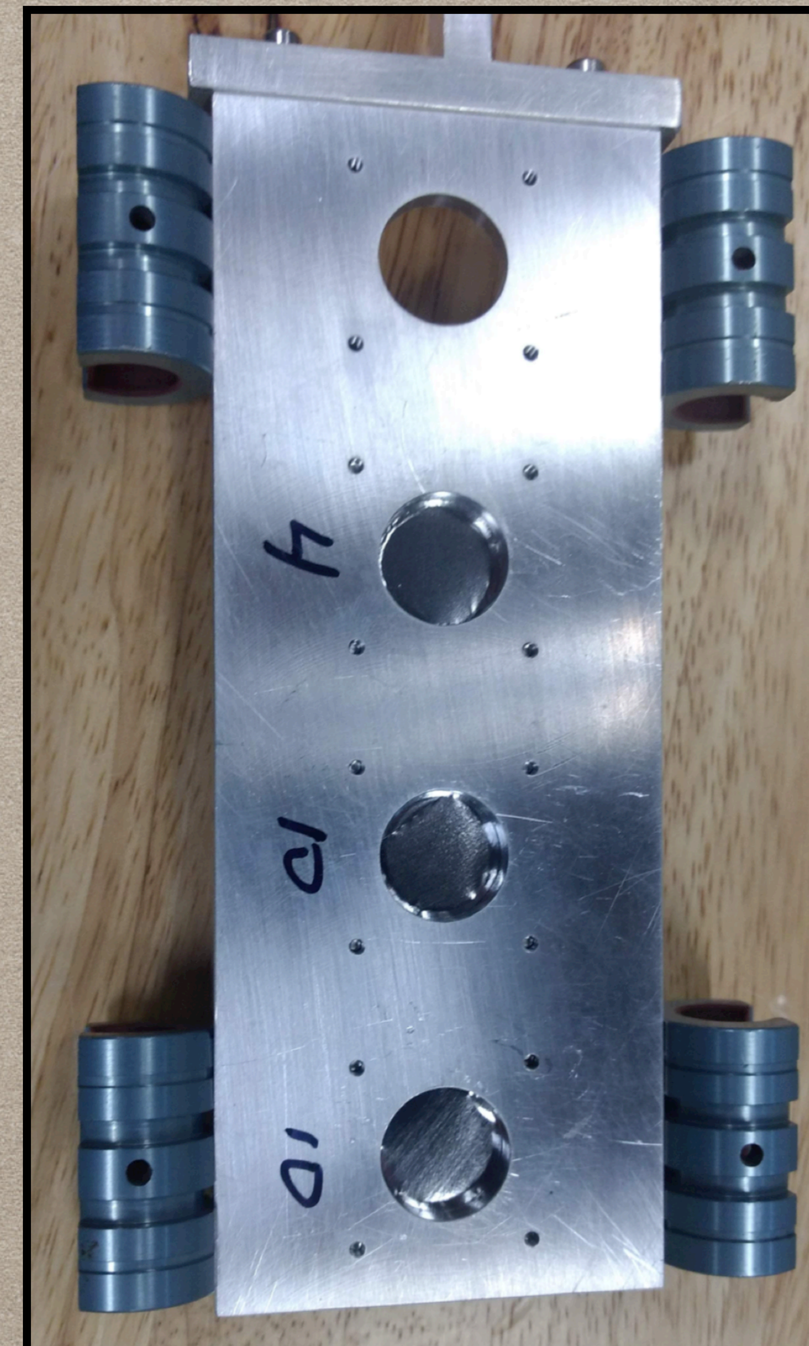
- Fe target polarized out of plane (Brute force)
- Target polarization is often the largest systematic error
- Target polarization 8.014% +/- 0.022%
- ΔP/P ~ 0.30% with beam heating



Møller (iron foils) existing techniques

O. Glamazdin

National Science Center Kharkov Institute of Physics and Technology
Kharkov 61108, Ukraine



HALL C MØLLER TARGET

- Fe target polarized out of plane (Brute force)
- Target polarization is often the largest systematic error
- Most recent value based on a compilation of world data (Don Jones)
- Target polarization 8.014% +/- 0.022%
- ΔP/P ~ 0.30% with beam heating

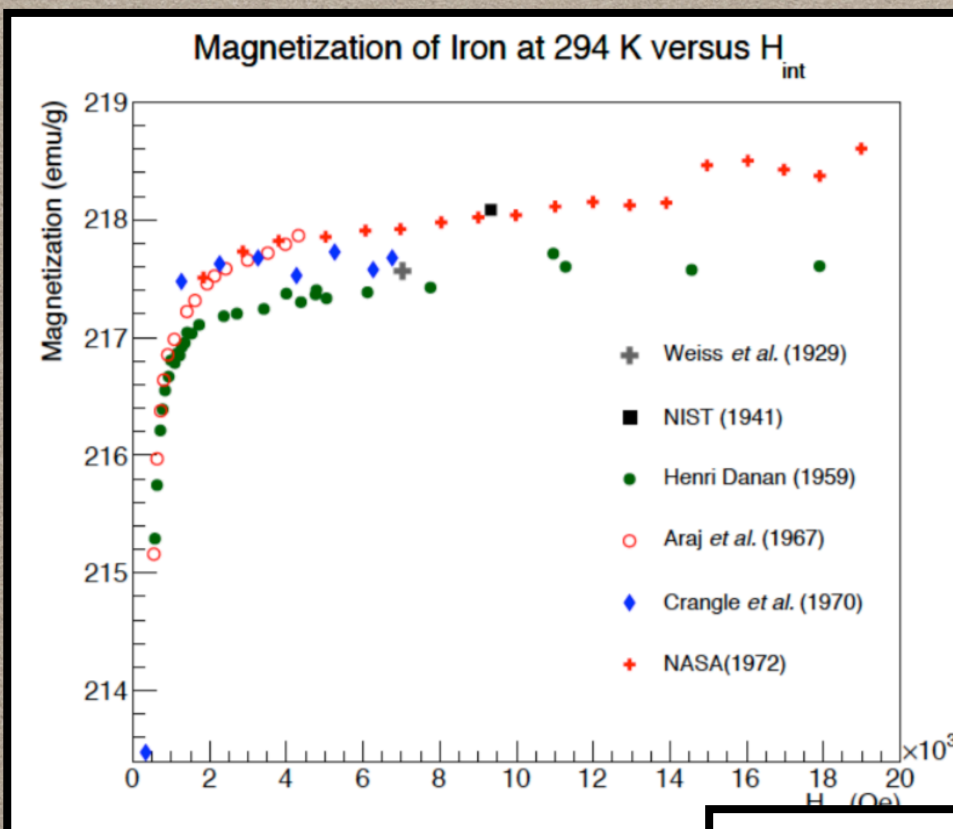
A target for precise Møller polarimetry

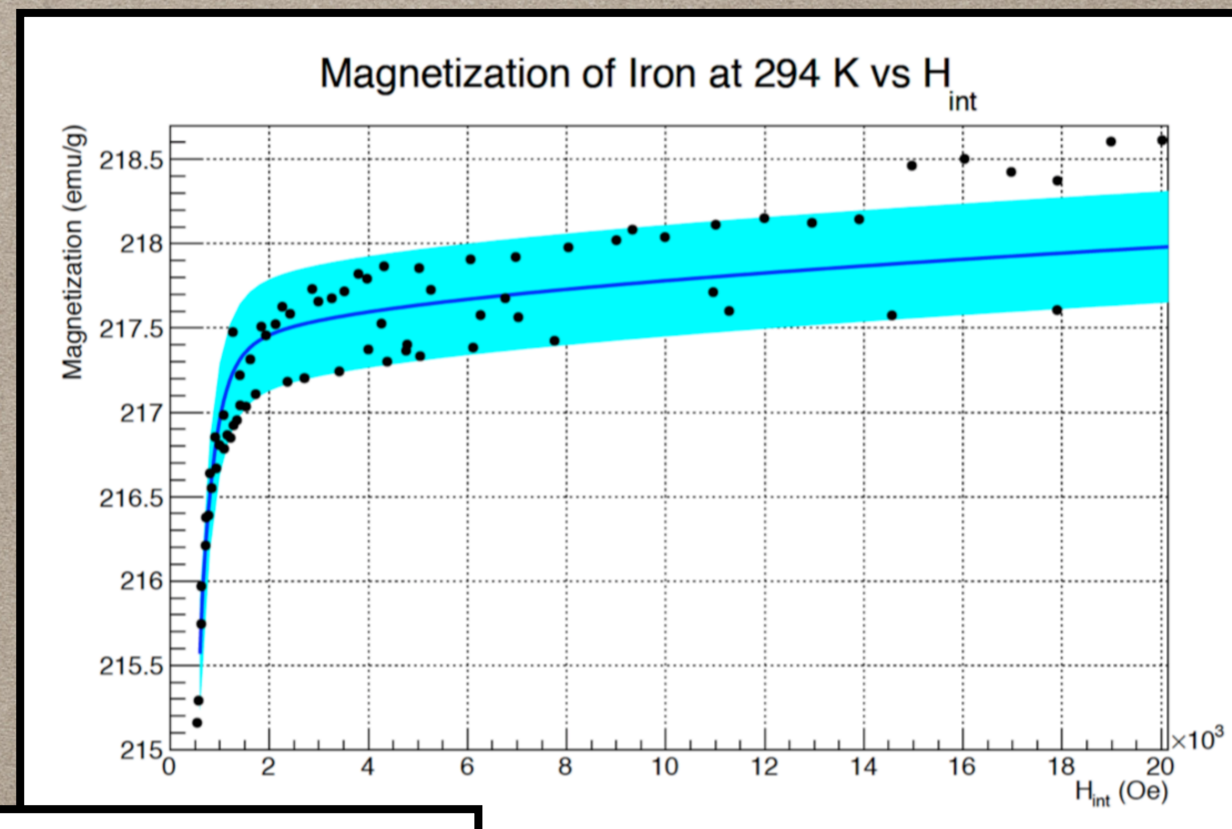
L.V. de Bever*, J. Jourdan, M. Loppacher, S. Robinson, I. Sick, J. Zhao

Dept. für Physik und Astronomie, Universität Basel, CH-4056 Basel, Switzerland

Received 29 January 1997

Effect	M_s [μ_B]	Error
Saturation magnetization ($T \to 0$ K, $B \to 0$ T)	2.2160	±0.0008
Saturation magnetization ($T = 294$ K, $B = 1$ T)	2.177	±0.002
Corrections for $B = 1$–4 T	0.0059	±0.0002
Total magnetization	2.183	±0.002
Magnetization from orbital motion	0.0918	±0.0033
Remaining magnetization from spin	2.0911	±0.004
Target electron polarization ($T = 294$ K, $B = 4$ T)	0.08043	±0.00015





Target Foil Polarization for Møller Polarimetry in Hall A

Donald Jones
Temple University

September 20, 2017

MØLLER DURING QWEAK

QWEAK

- Beam Energy: 1.16 GeV
- Systematics ΔP/P = < 0.8%

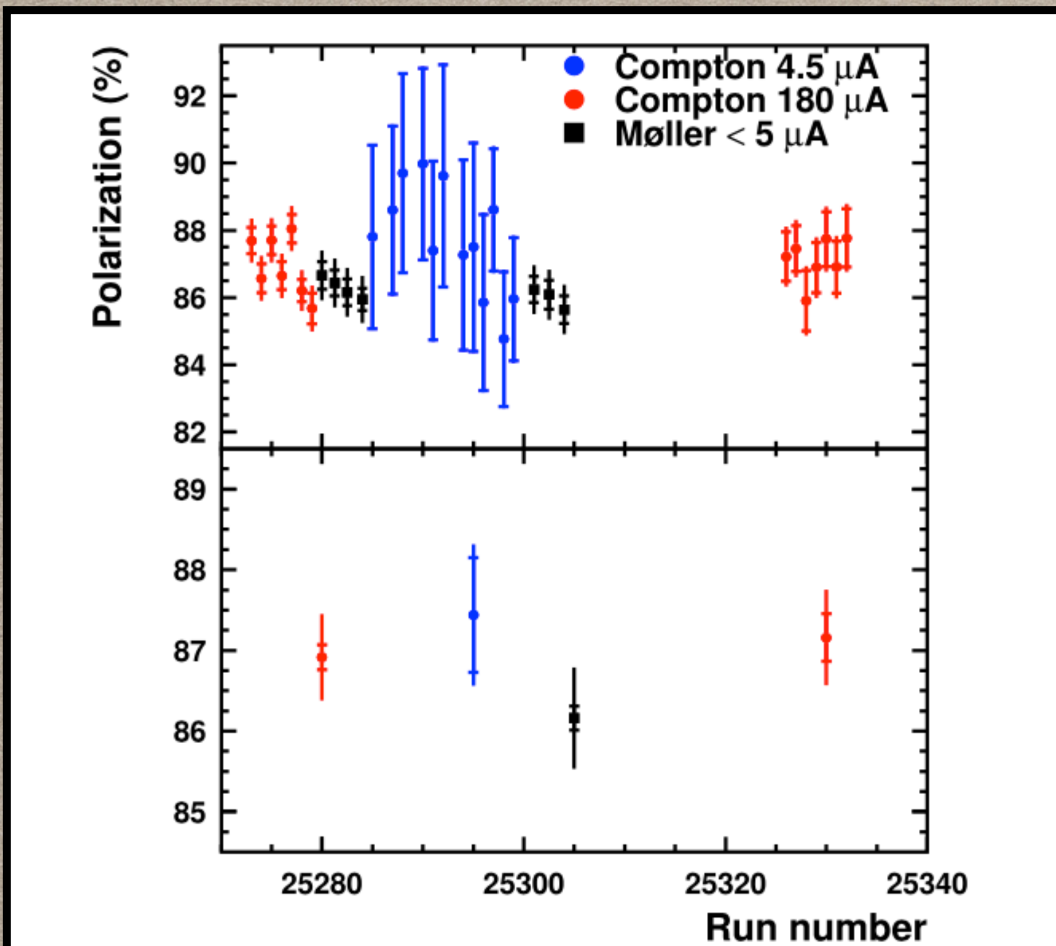


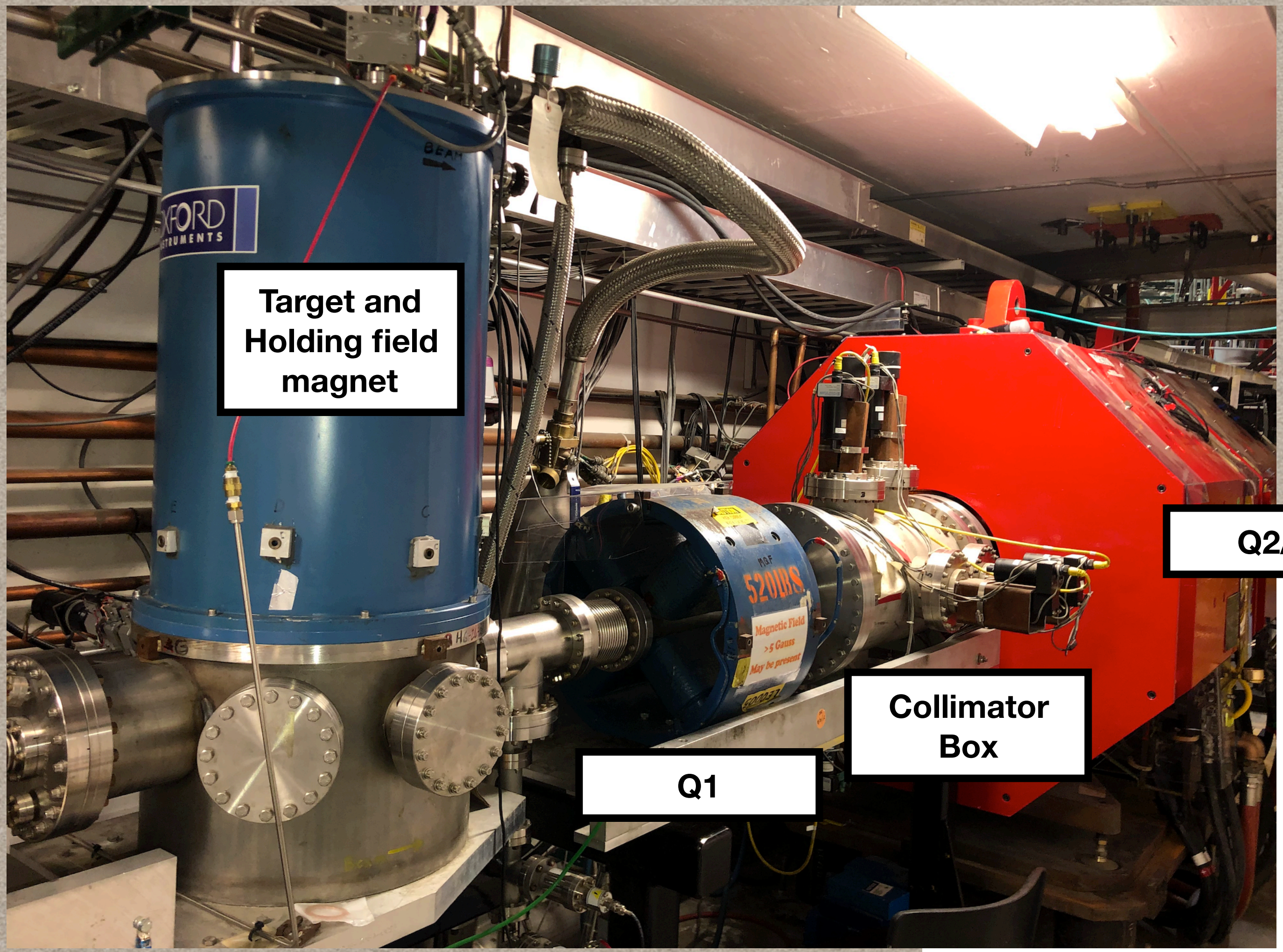
Table 1
Systematic uncertainties of the Møller polarimeter.

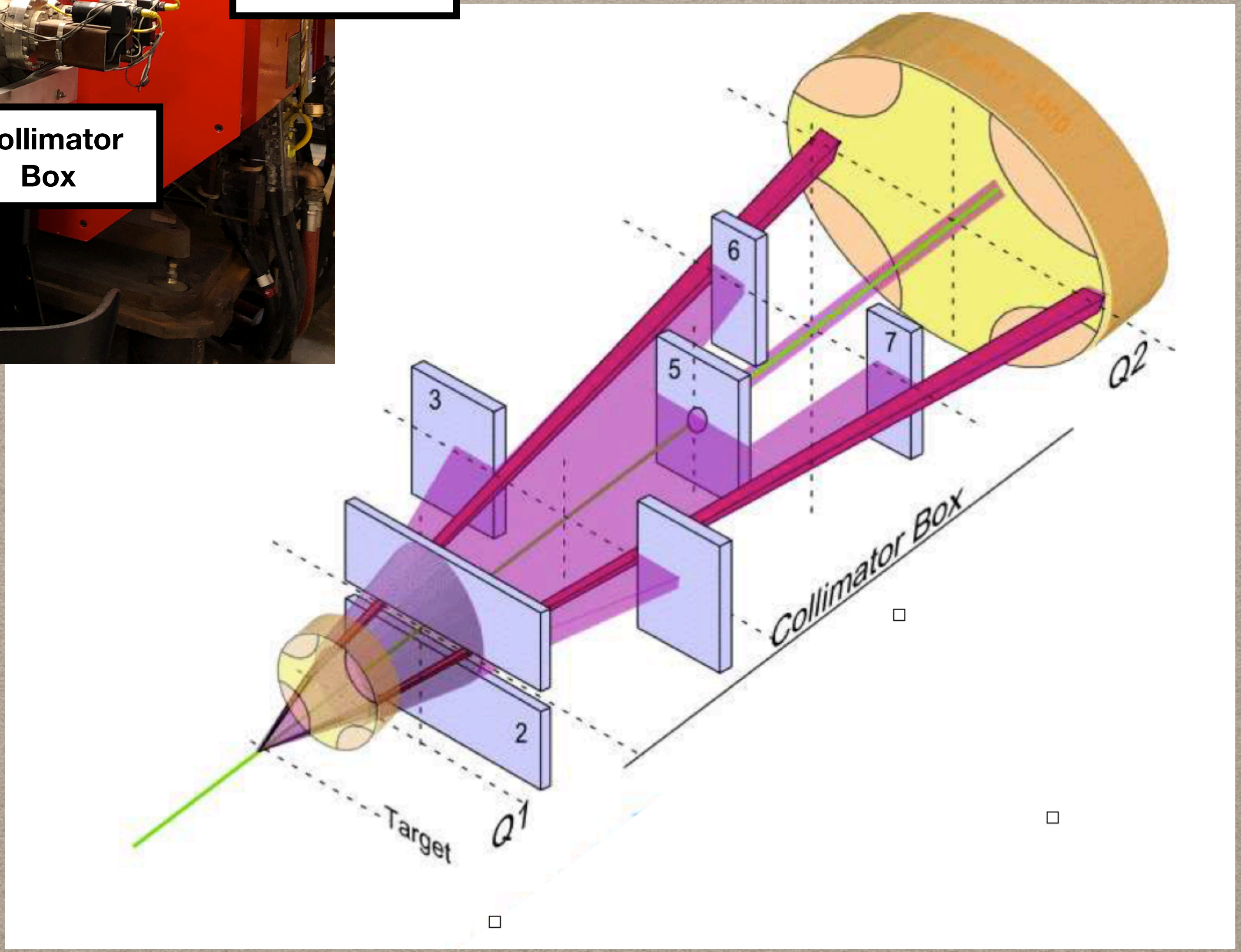
Source	Uncertainty	$\Delta P/P\%$
Beam position X	0.2 mm	0.14
Beam position Y	0.2 mm	0.28
Beam angle X	0.5 mrad	0.10
Beam angle Y	0.5 mrad	0.10
Q1 current	2%	0.07
Q3 current	2%	0.05
Q3 position	1 mm	0.10
Multiple scattering	10%	0.01
Levchuk effect	10%	0.33
Fixed collimator positions	0.5 mm	0.03
Beam heating of target	30%	0.24
B-field direction	2 degrees	0.14
B-field strength	5%	0.03
Spin polarization in Fe	–	0.25
Electronic D.T.	100%	0.045
Solenoid focusing	100%	0.21
Solenoid position (x, y)	0.5 mm	0.23
Monte Carlo statistics	–	0.14
Total		**0.71**

A novel comparison of Møller and Compton electron-beam polarimeters

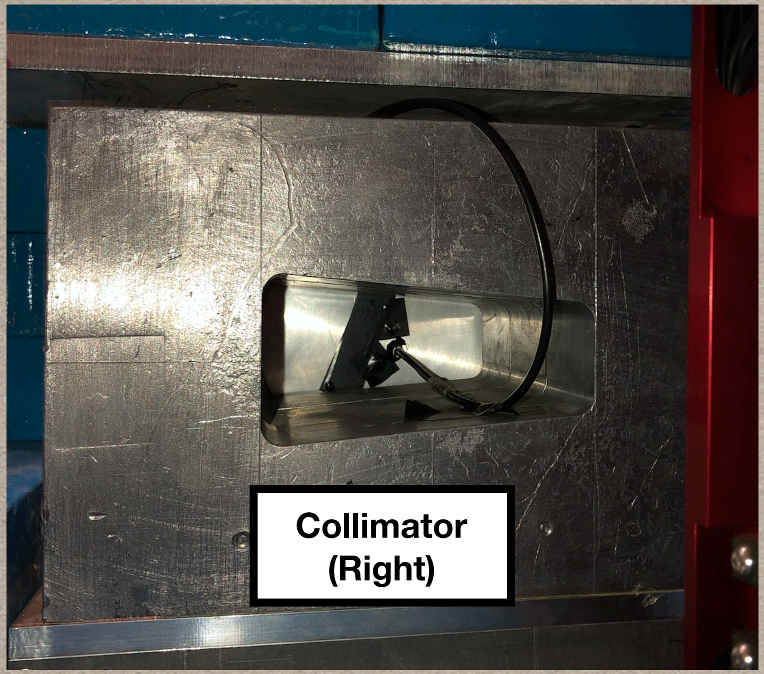
J.A. Magee [a], A. Narayan [b], D. Jones [c], R. Beminiwattha [d], J.C. Cornejo [a], M.M. Dalton [c,e]
W. Deconinck [a], D. Dutta [b], D. Gaskell [e,*], J.W. Martin [f], K.D. Paschke [c], V. Tvaskis [f,g],
A. Asaturyan [h], J. Benesch [e], G. Cates [c], B.S. Cavness [i], L. .A. Dillon-Townes [e], G. Hays [e],
J. Hoskins [a], E. Ihloff [j], R. Jones [k], P.M. King [d], S. Kowalski [l], L. Kurchaninov [m], L. Lee [m],
A. McCreary [n], M. McDonald [f], A. Micherdzinska [f], A. Mkrtchyan [h], H. Mkrtchyan [h],
V. Nelyubin [c], S. Page [g], W.D. Ramsay [m], P. Solvignon [e,1], D. Storey [f], W.A. Tobias [c],
E. Urban [o], C. Vidal [j], B. Waidyawansa [d], P. Wang [g], S. Zhamkotchyan [h]

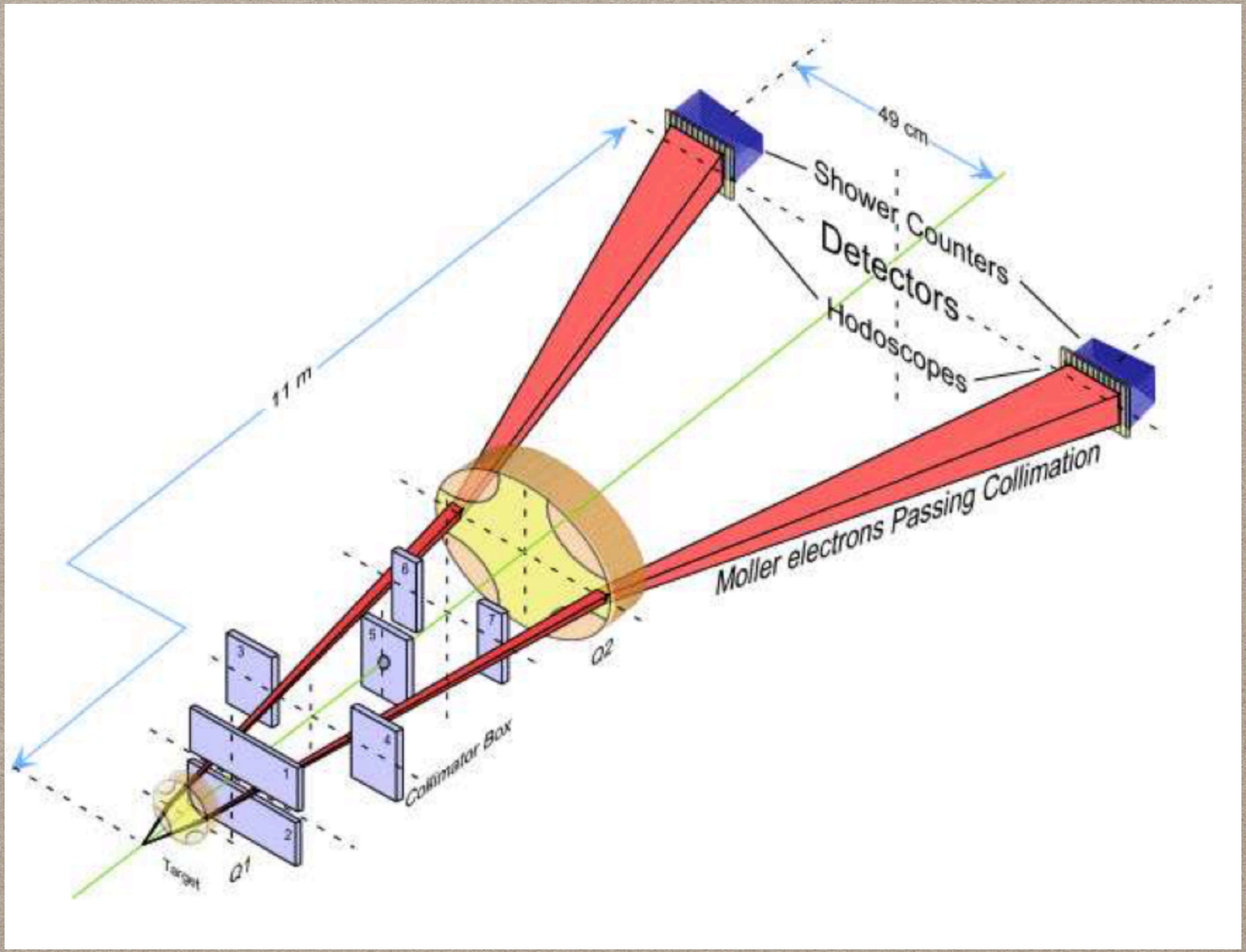
HALL C APPARATUS





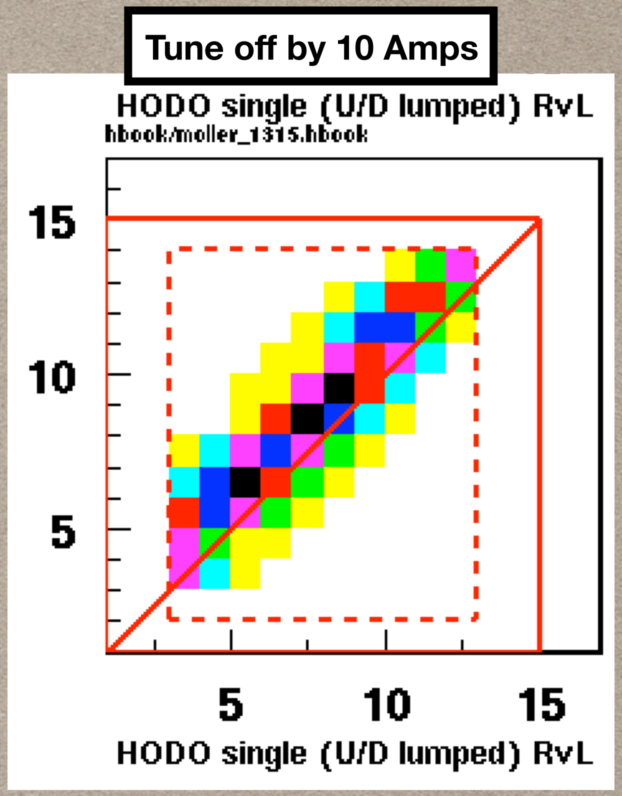
HALL C APPARATUS

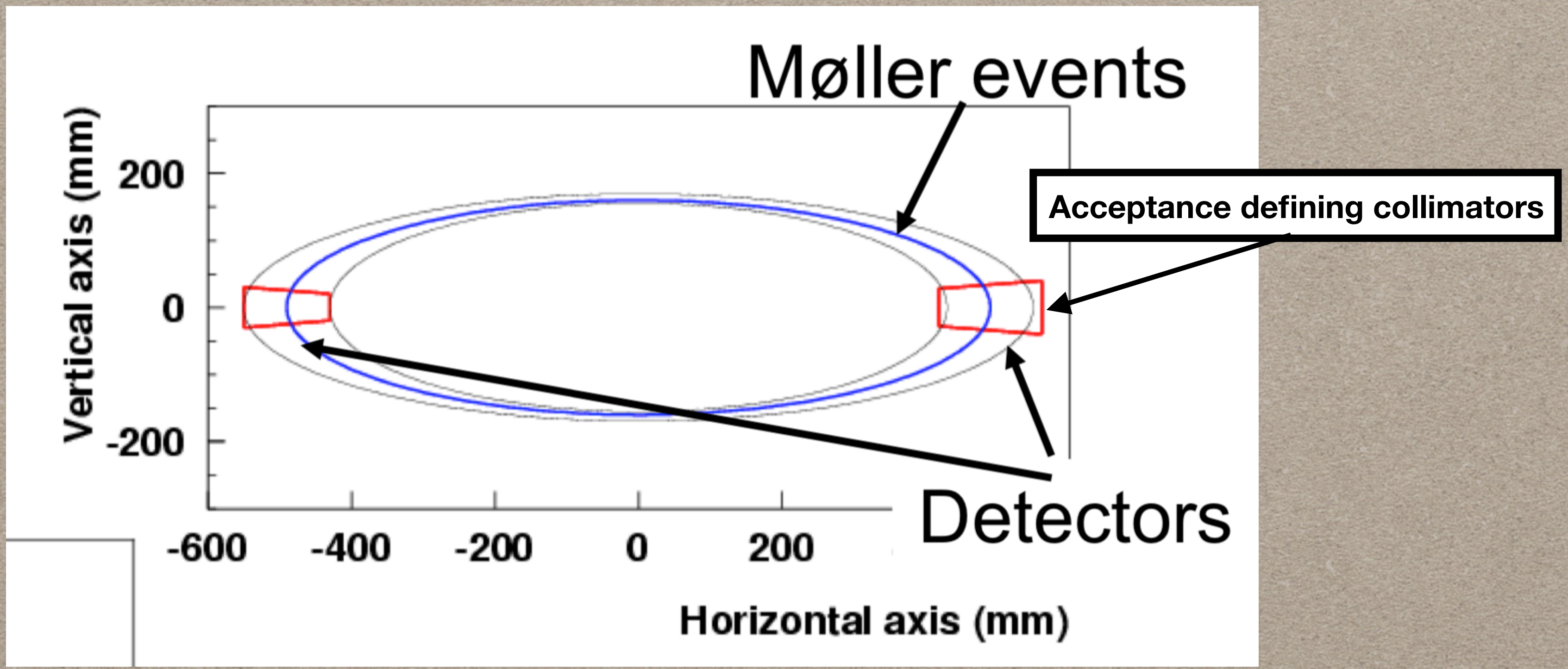


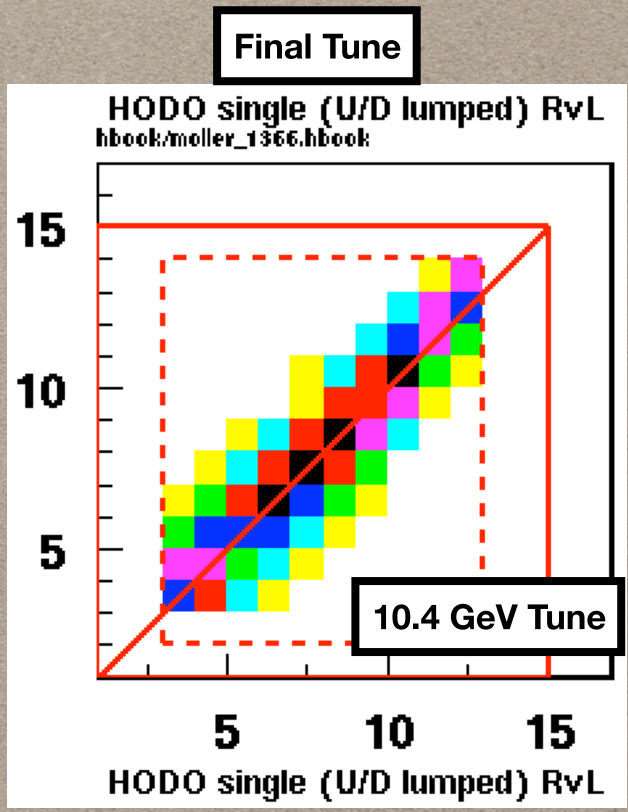


HALL C SETUP: QUADRUPOLES

- Simulation is used to determine initial quadrupole settings
- Special runs are taken to check the tune
- Q2/Q3 are adjusted to get an acceptable tune
- Tune is checked for each Møller measurement





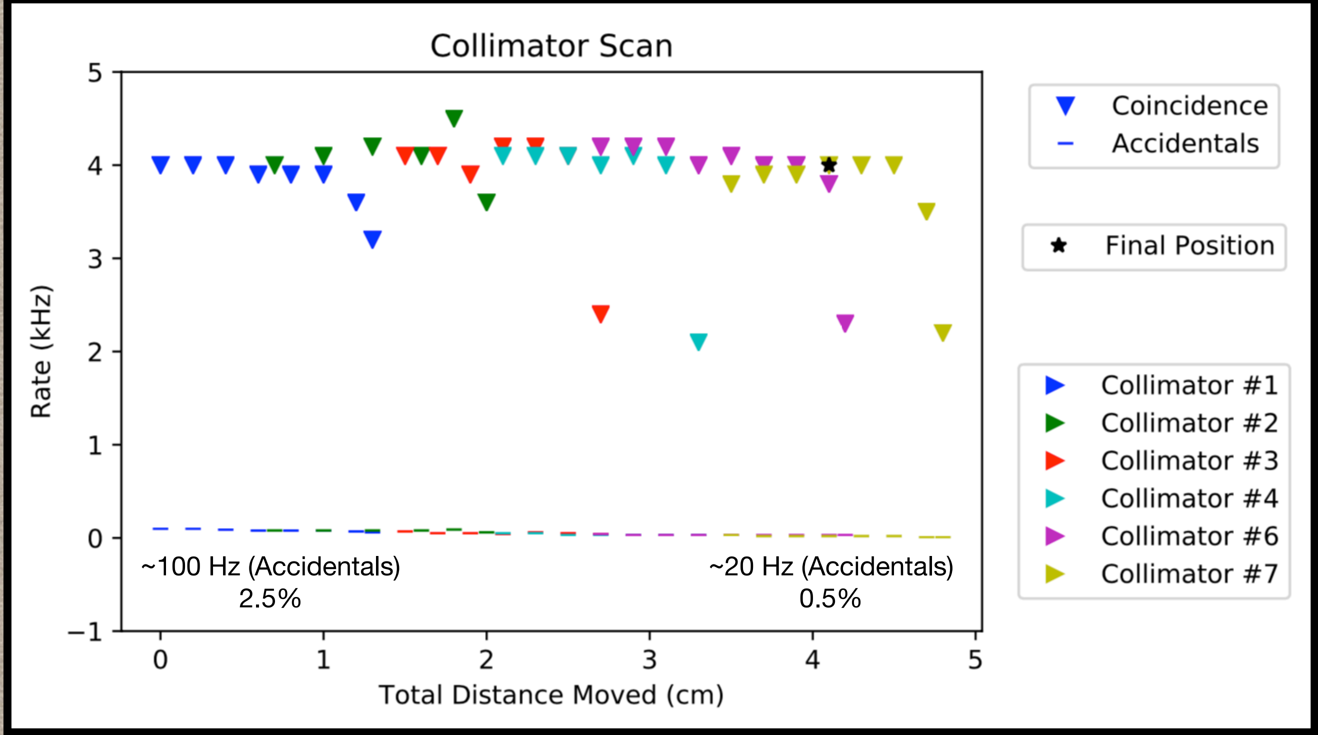


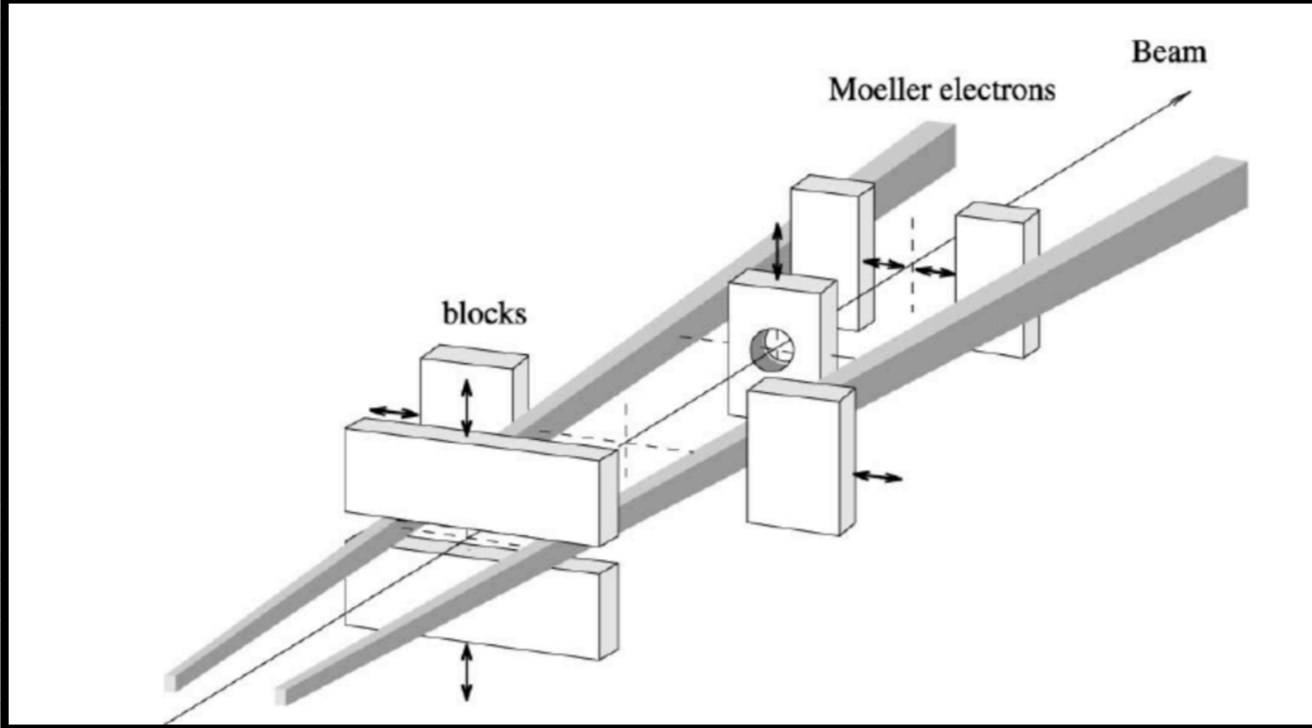
January 27th, 2019

HALL C SETUP

- 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

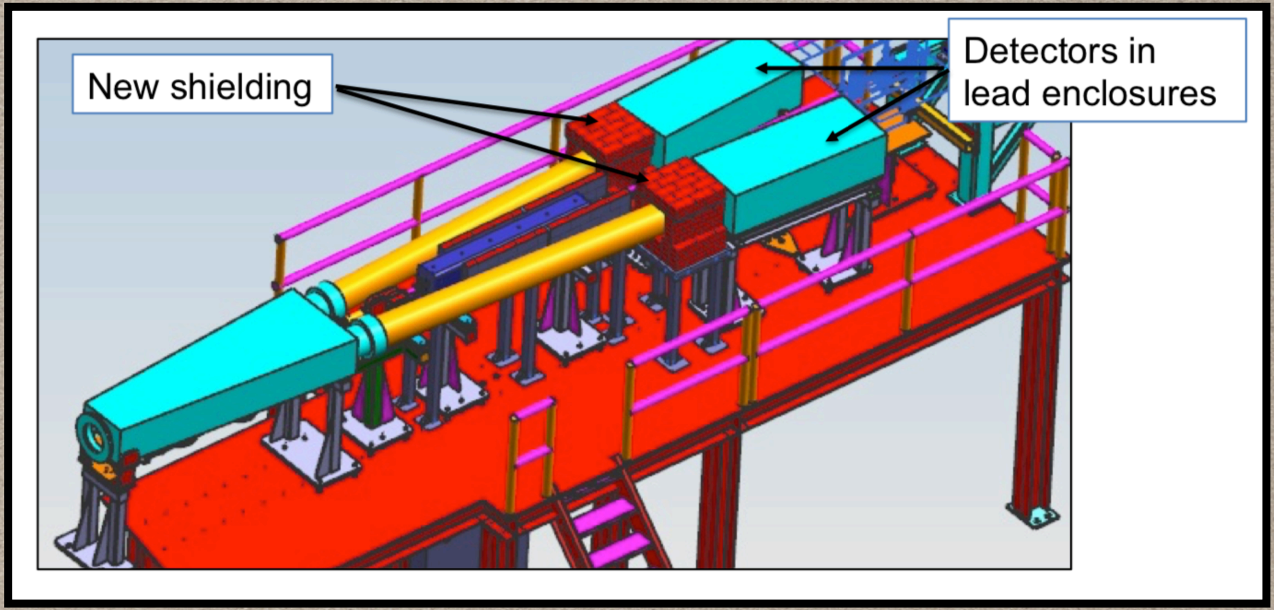
4.5 GeV Commisioning August 2019

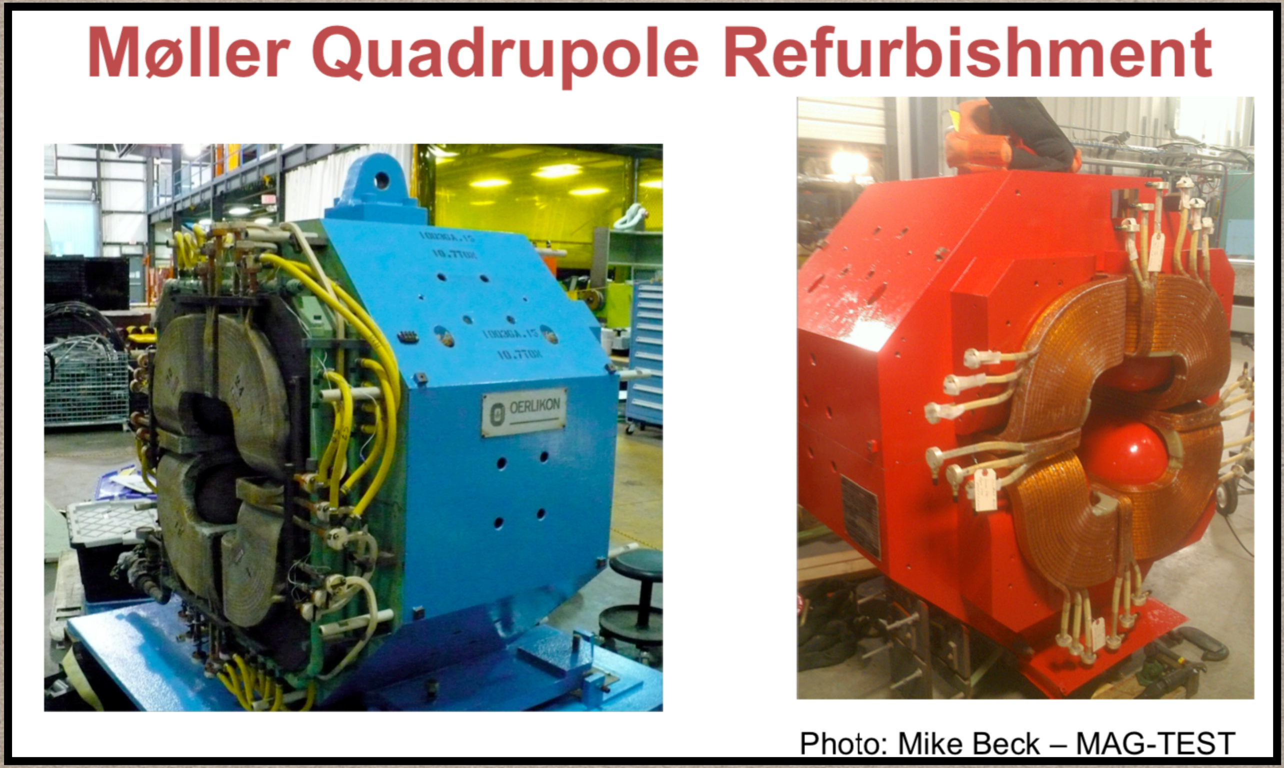


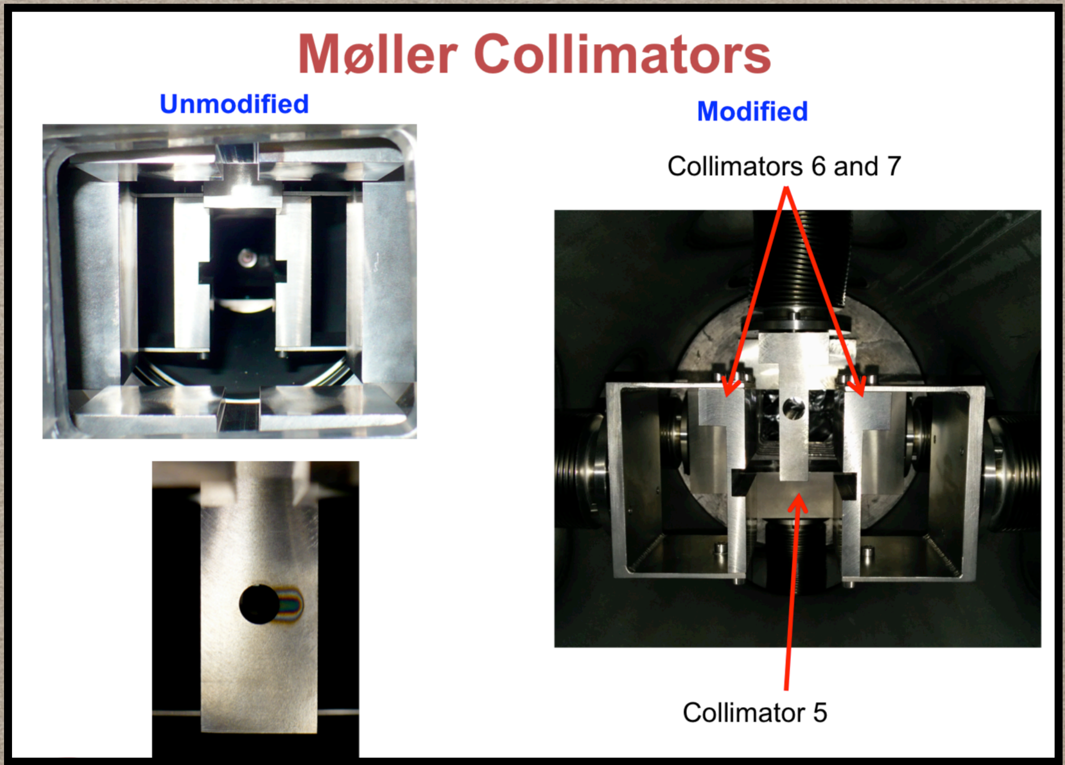


QUICK REVIEW OF STATUS FROM LAST YEAR

See Dave's talk from last year:
https://www.jlab.org/indico/event/296/session/11/contribution/10/material/slides/0.pdf







RECENT WORK

Summer 2019

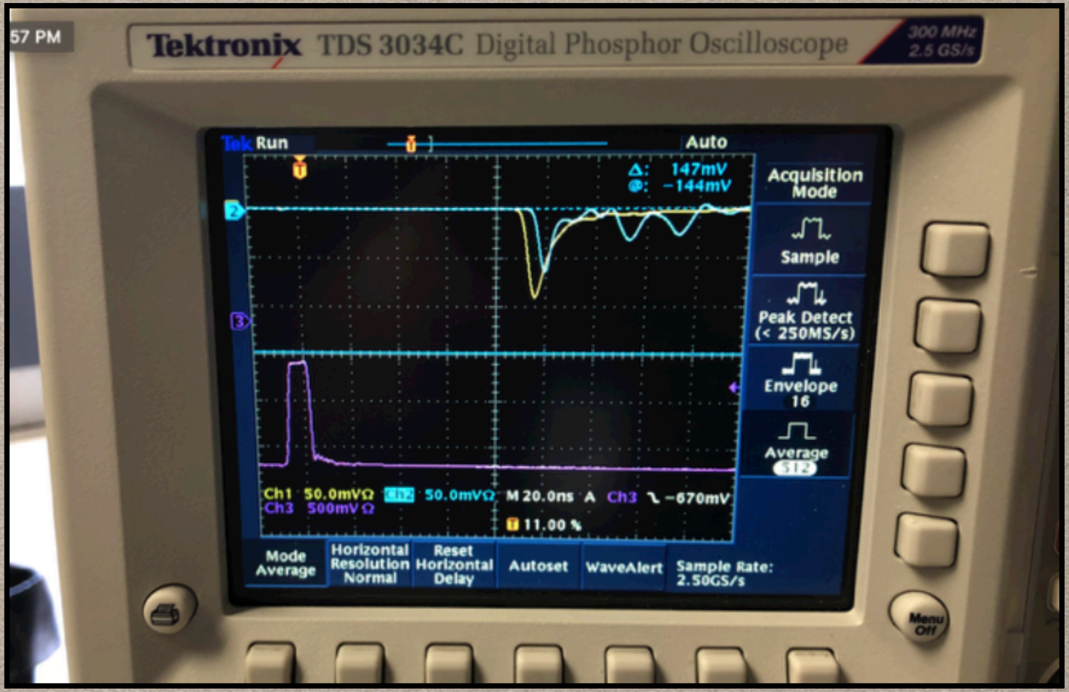
- Moller exercised for the first time since 2012
- Gain matched PMT HVs
- Noisy Cable Replaced
- Updated documentation
- Replaced card in HV crate
- Various small updates to analysis code

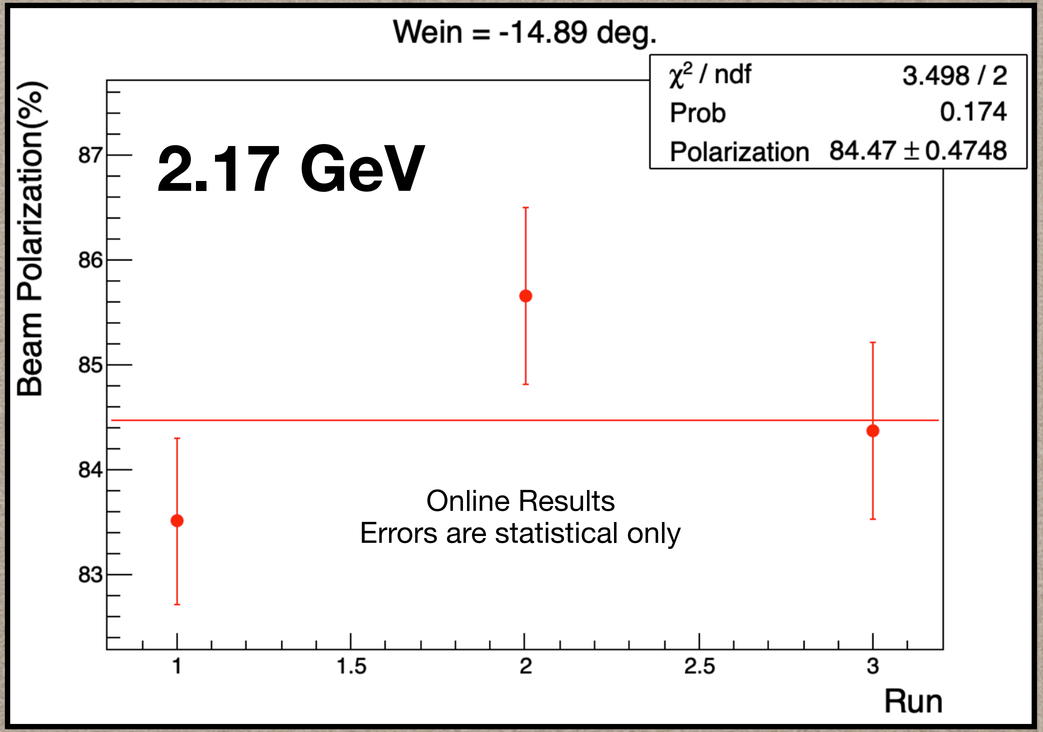
December 2019

- Solenoid CRYO work (valves and leak fixed)
- Dec 12th: 5-pass commissioning. (High accidentals rate)
- Dec 19th: 2-pass measurement. (Coincidence timing could be better)
- Break: Additional Shielding Added

January 2020

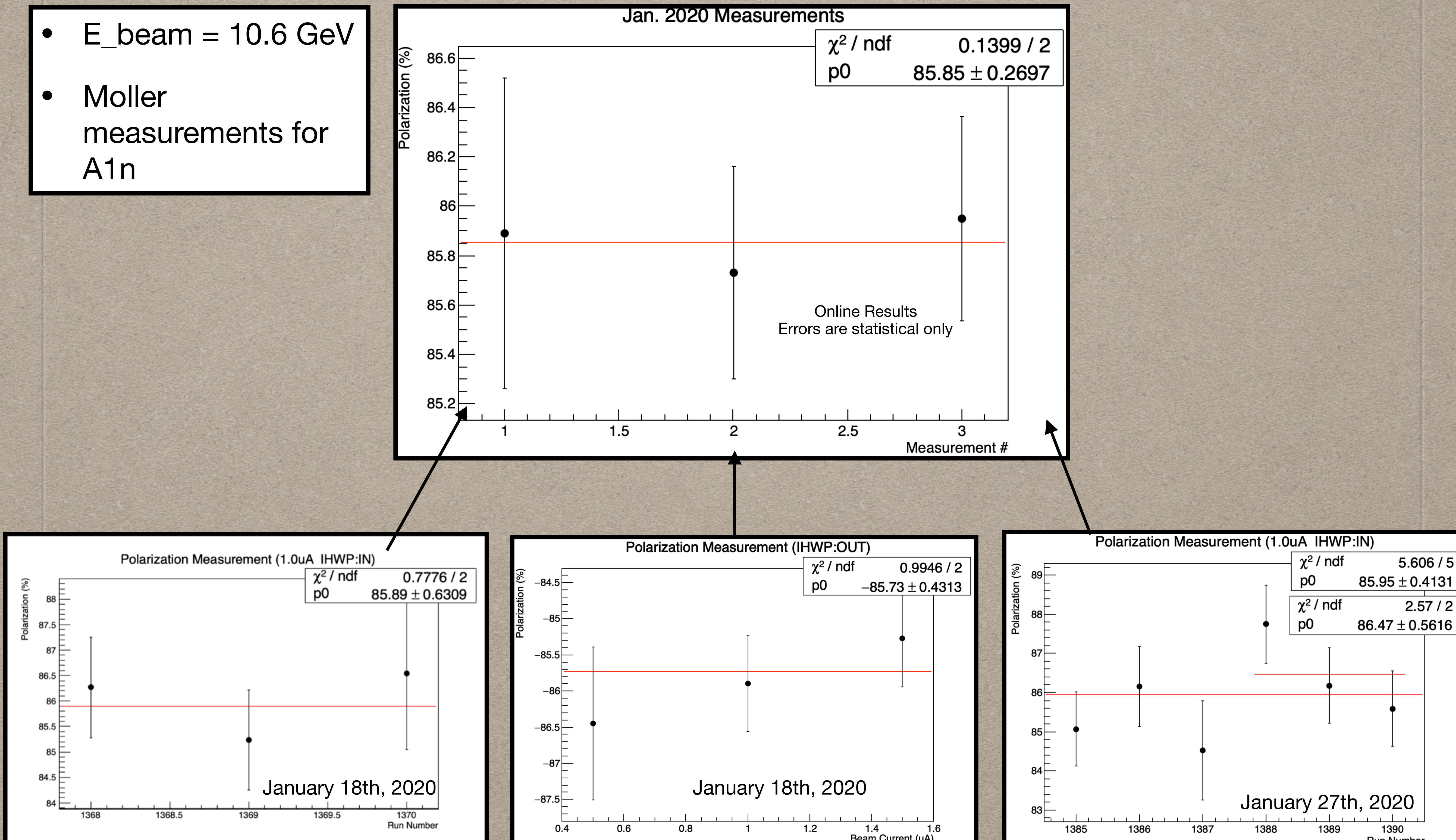
- Timing fixed and accidentals reduced
- Jan. 18th and Jan. 27th: 5-pass measurements





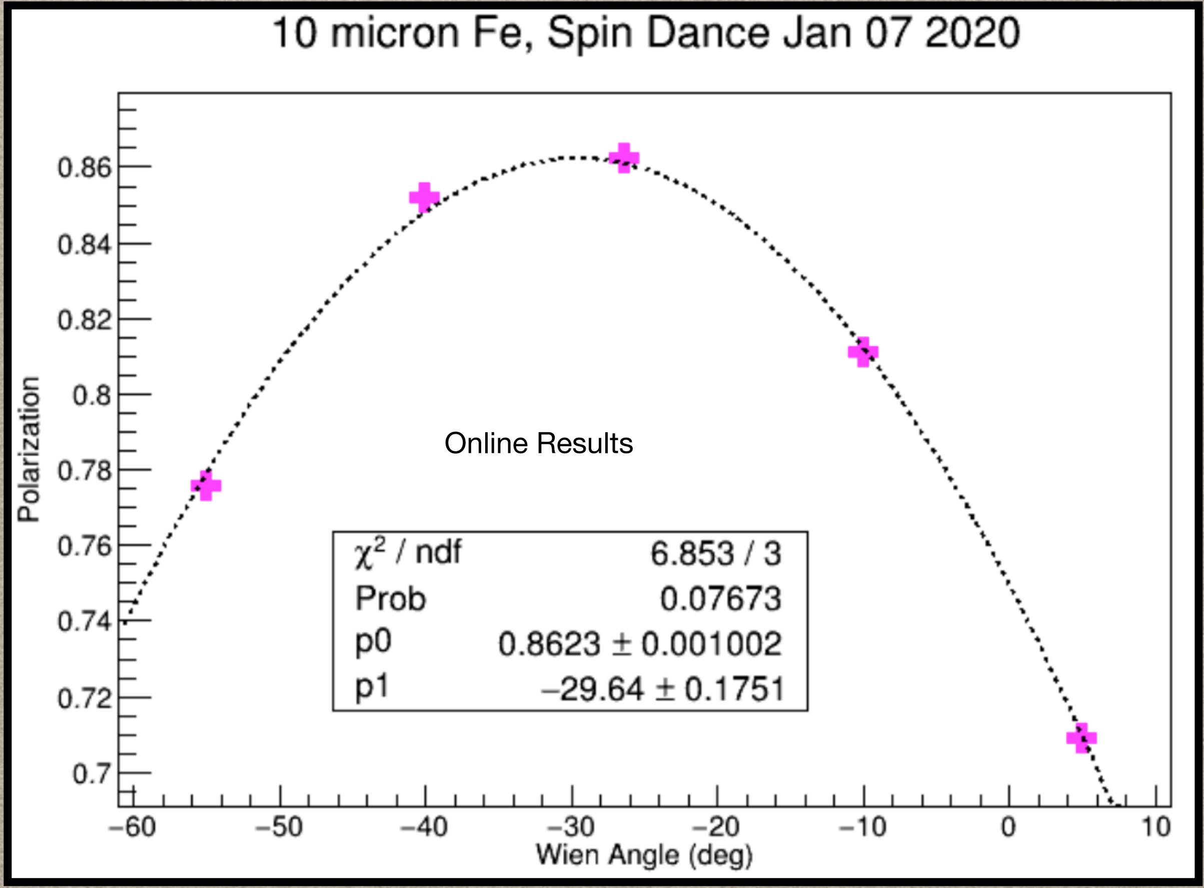
LATEST RESULTS

- E_beam = 10.6 GeV
- Moller measurements for A1n



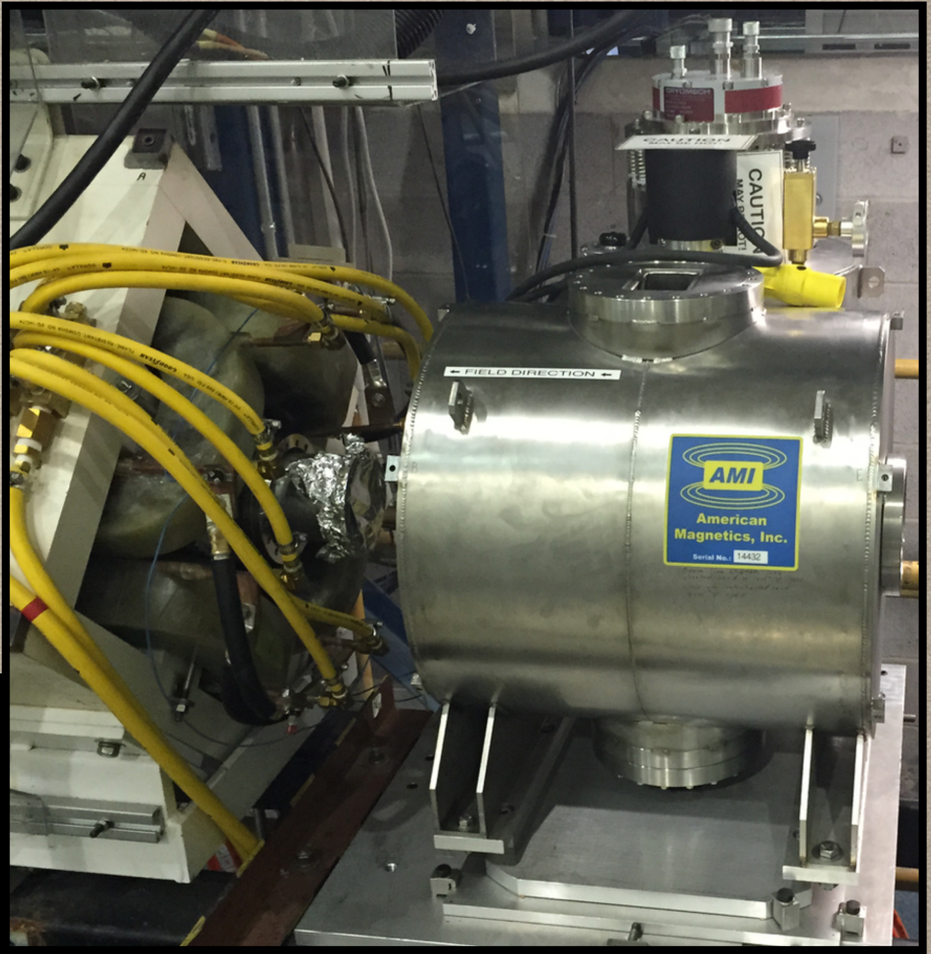
FUTURE WORK
SYSTEMATICS FOR A1N/D2N

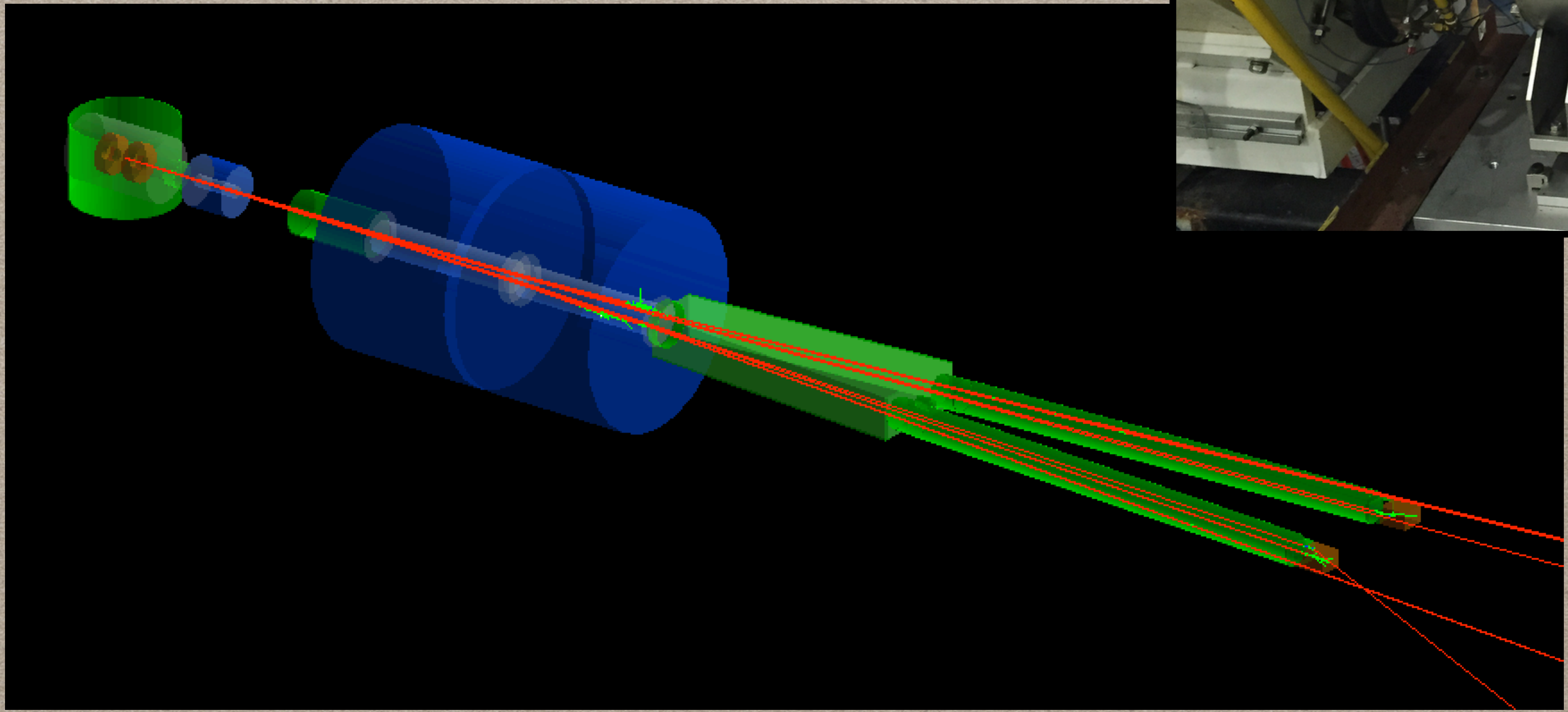
- A1n and D2n requires 2.0% - 3.0% precision. Will require limited systematic studies (mini spin dance, collimator positions, quad fields, etc….)
- Remember: This is the first time the Moller has been operated at 11 GeV and there is no currently no Compton polarimeter.
- Finishing the Geant4 simulation will be an important tool for systematics



FUTURE IMPROVEMENTS

- New superconducting split coil magnet is on site and will be installed for 2021
- DAQ and analysis software need to be updated
- Geant4 simulation is a work in progress

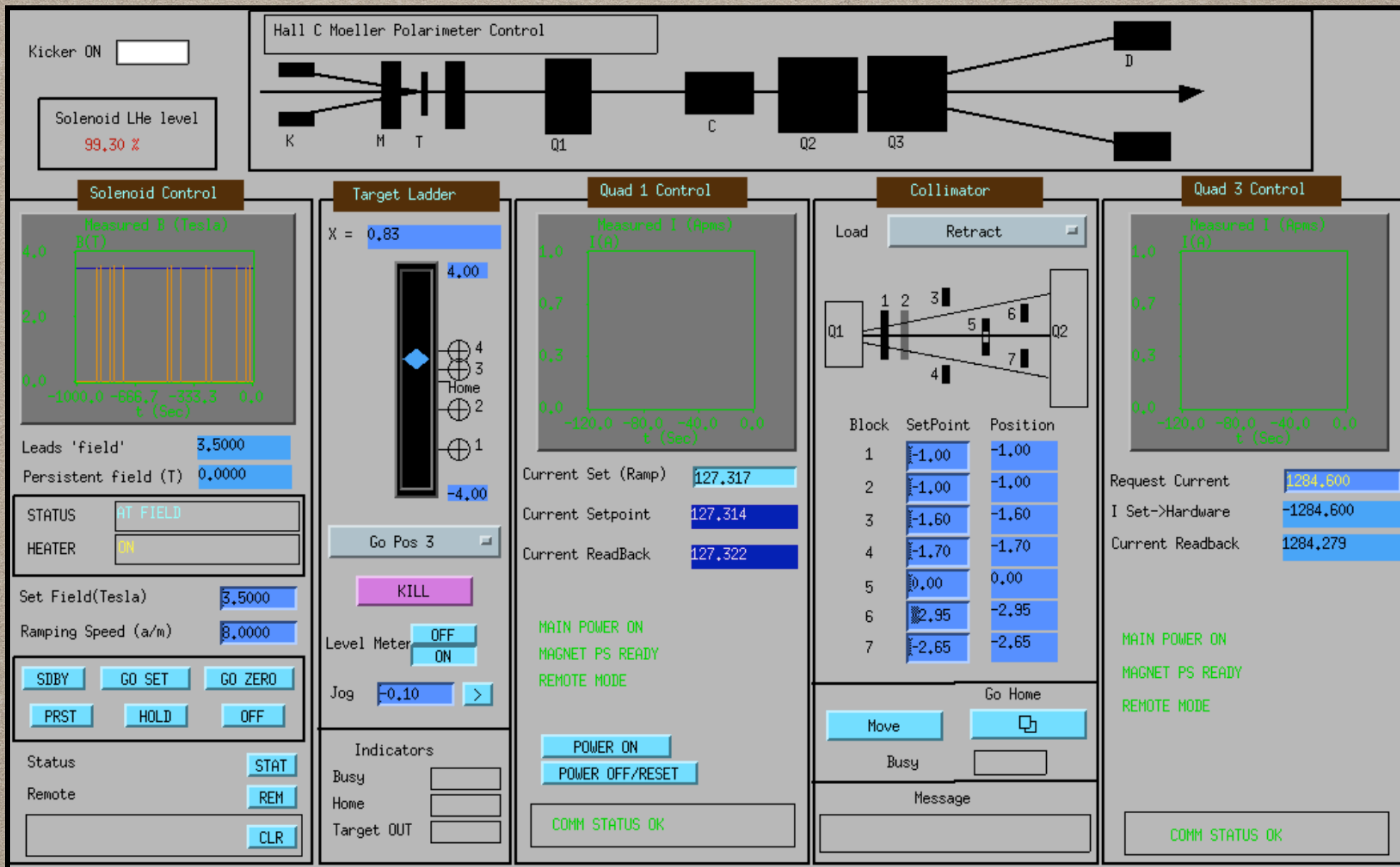




SUMMARY

- The Møller Polarimeter has been resurrected after a 7 year nap
- Commissioning was accomplished at the end of 2019
- Møller measurements are essential to the success of A1n and d2n. Precision measurements at the 2-3% level should be straightforward but this is the first time the polarimeter has run at 11 GeV.
- The new target magnet is on site and will be installed during the long shutdown

HALL C SETUP


Kicker ON
Solenoid LHe level
99.30 %
Hall C Moeller Polarimeter Control
K
M
T
Q1
C
Q2
Q3
D
Solenoid Control
Leads 'field'
3.5000
Persistent field (T)
0.0000
STATUS
AT FIELD
HEATER
ON
Set Field(Tesla)
3.5000
Ramping Speed (a/m)
8.0000
SDBY
GO SET
GO ZERO
PRST
HOLD
OFF
Status
STAT
Remote
REM
CLR
Target Ladder
X = 0.83
4.00
-4.00
4
3
Home
2
1
Go Pos 3
KILL
Level Meter
OFF
ON
Jog
-0.10
Indicators
Busy
Home
Target OUT
Quad 1 Control
Current Set (Ramp)
127.317
Current Setpoint
127.314
Current ReadBack
127.322
MAIN POWER ON
MAGNET PS READY
REMOTE MODE
POWER ON
POWER OFF/RESET
COMM STATUS OK
Collimator
Load
Retract
Block
SetPoint
Position
1 -1.00 -1.00
2 -1.00 -1.00
3 -1.60 -1.60
4 -1.70 -1.70
5 0.00 0.00
6 2.95 -2.95
7 -2.65 -2.65
Go Home
Move
Busy
Message
Quad 3 Control
Request Current
1284.600
I Set->Hardware
-1284.600
Current Readback
1284.279
MAIN POWER ON
MAGNET PS READY
REMOTE MODE
COMM STATUS OK