Hall C Beamline and Moller Polarimetry

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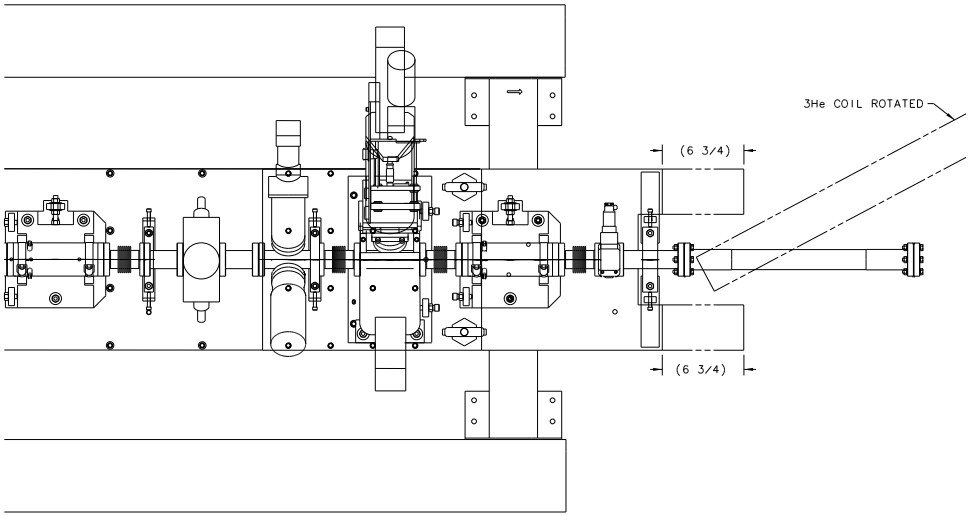
A1n/d2n Collaboration Meeting

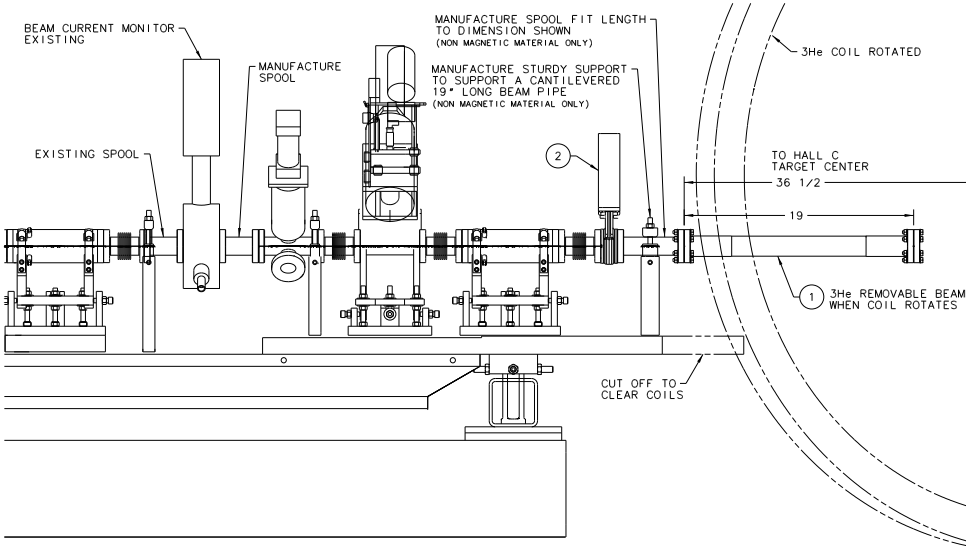
June 15, 2018

Outline

1. Beamline work
2. Møller Polarimeter

Beamline Modifications for Polarized ^{3}He





Coils for polarized ^{3}He will run into end of last girder when rotated to certain configurations

→ End of girder will need to be cut off
→ Requires relocation of MPS BCM

Originally, planned to accomplish both summer, 2018 as part of preparations for E12-16-007
→ Due to short summer down, limited ENG availability, will only move MPS BCM (install radiator)
→ Girder will be cut later

Beamline Modifications for Polarized ^{3}He

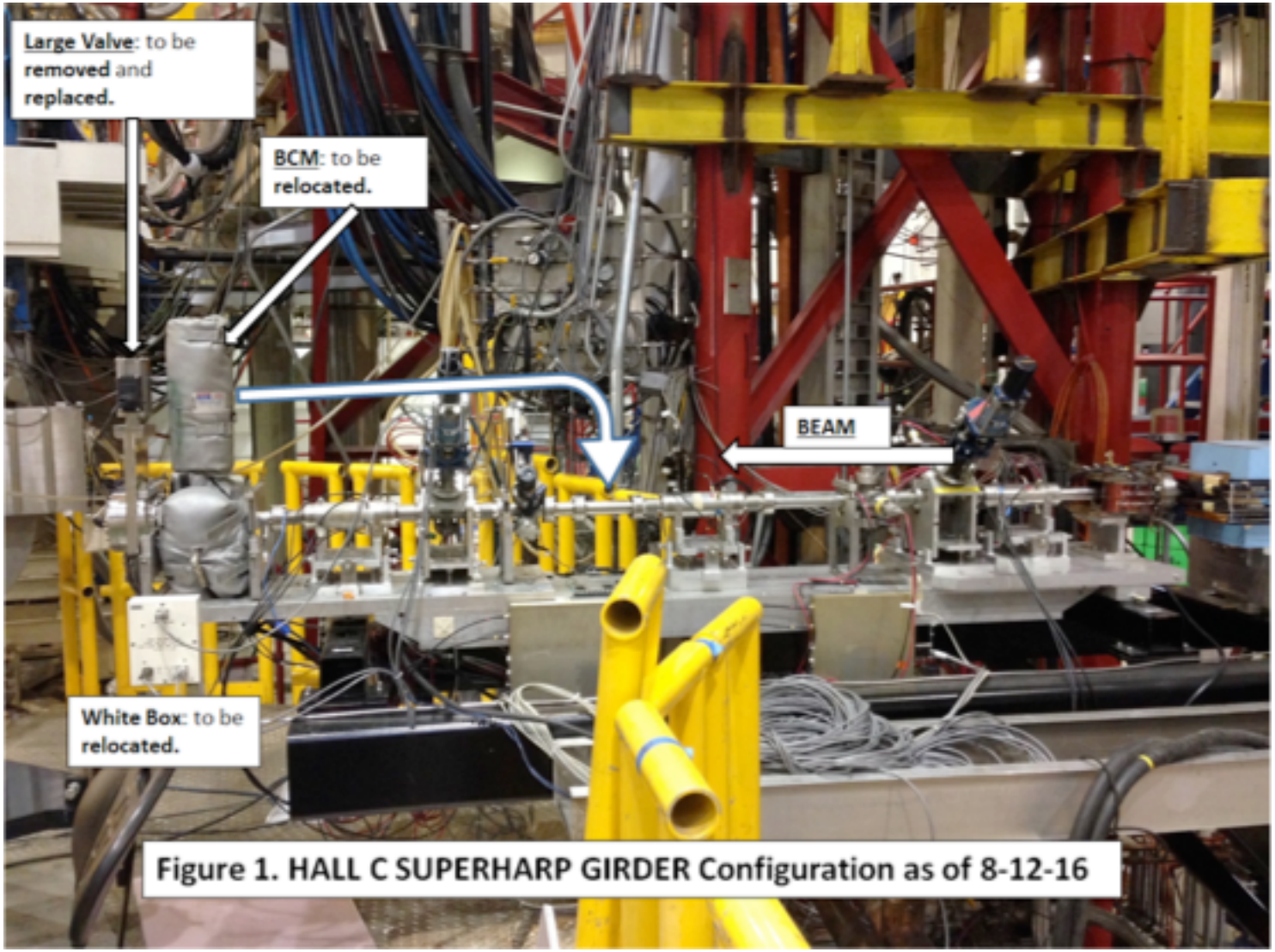


Figure courtesy Tim Michalski

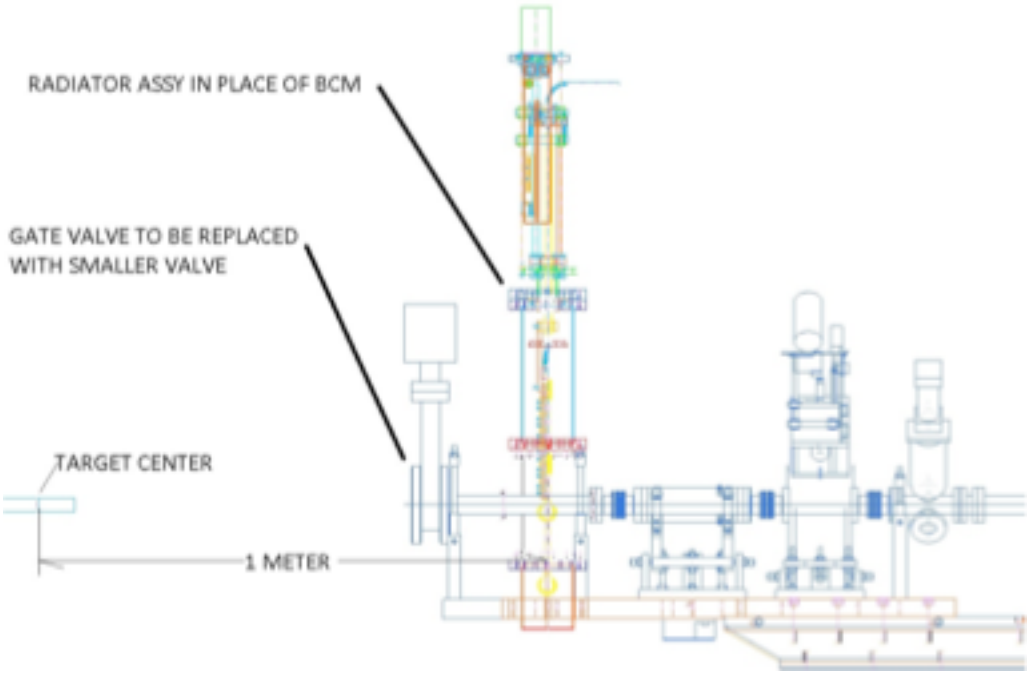
Beamline Modifications for Polarized ^{3}He

E12-16-007 will require use of a new radiator

→ Radiator will be installed as last element on Hall C diagnostic girder

→ MPS BCM will be relocated upstream

→ Cutting off end of diagnostic girder would have required other mods to accommodate radiator

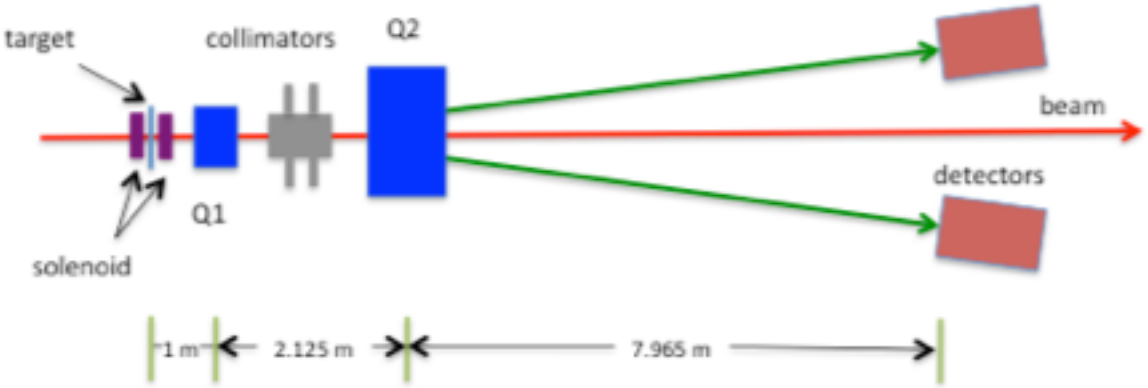


Engineering will relocate MPS BCM Summer 2018 (done)

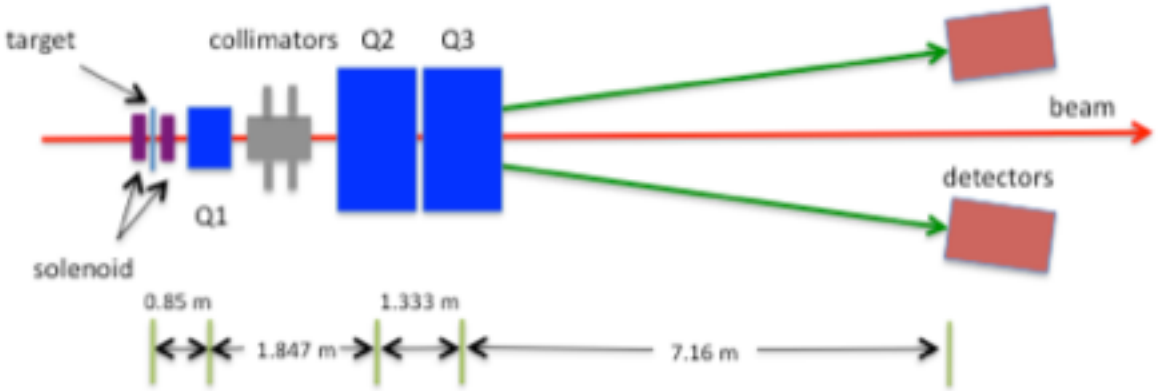
→ Remaining mods will be done as part of A1n/d2n installation

Møller Polarimeter – New layout

6 GeV



11 GeV

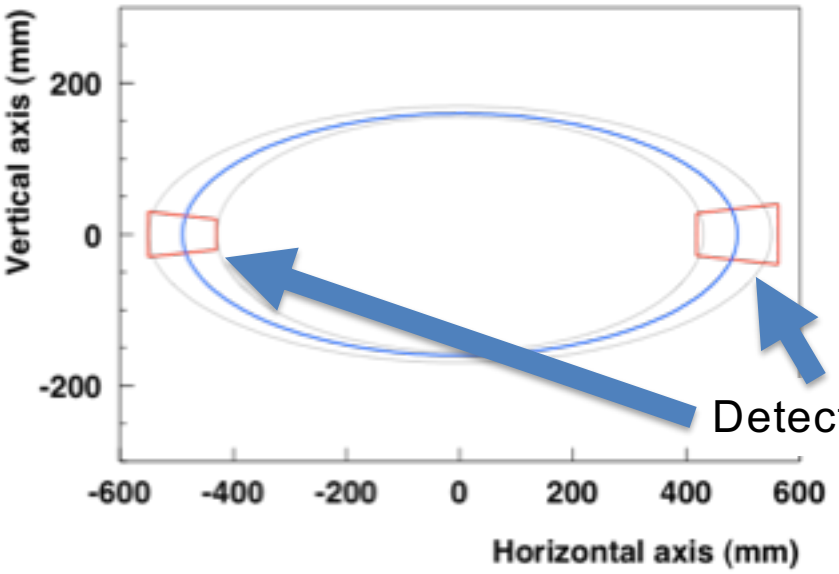


Additional large quad required to steer electrons to detectors

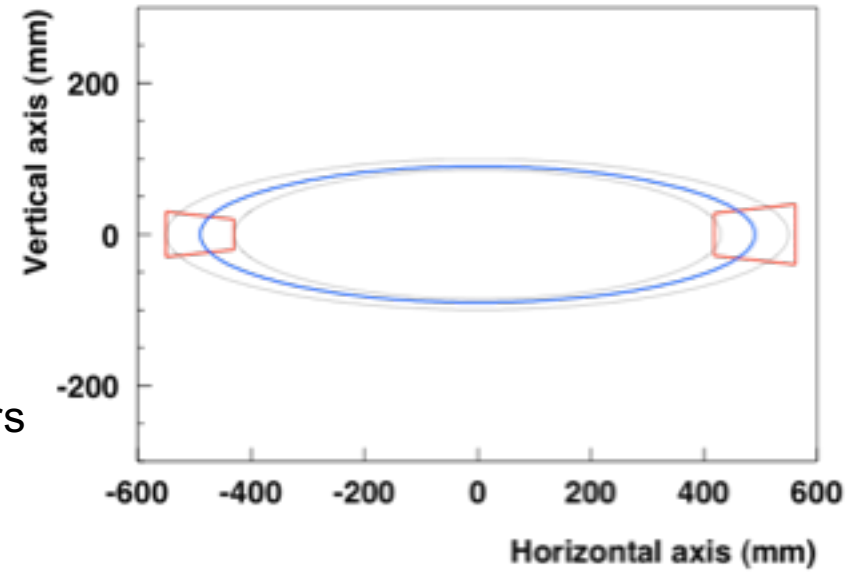
→ Even with new quad, some compromise had to be made with respect to polarimeter optics

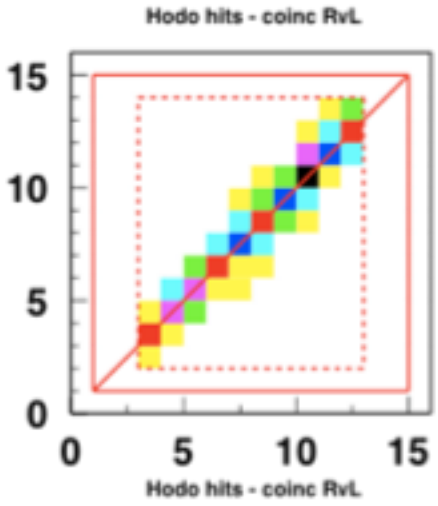
Møller Polarimeter – New optics

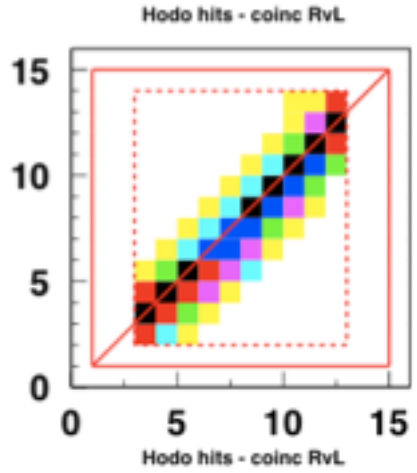
6 GeV



11 GeV





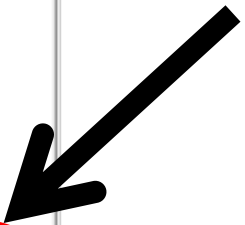


Expected Møller Performance at 11 GeV

Monte Carlo studies by Kamilah Walker – Phoebus High School

Source	Uncertainty	*dA/A (%)*		Average
Beam x position	0.5 mm	0.058	0.103	0.081
Beam y position	0.5 mm	0.000	0.045	0.023
Beam x angle	0.5mradians	-0.039	0.289	0.125
Beam y angle	0.5mradians	0.039	0.116	0.078
Q1 current	2.00%	0.077	0.129	0.103
Q3 (and Q2) current	2.50%	-0.019	0.411	0.196
Q1 position	1 mm	-0.008	-0.008	-0.008
Q3 position	1 mm	0.000	0.000	0.000
Multiple scattering	10.00%	0.064	0.064	0.064
Radiative corrections	10.00%	-0.022	-0.022	-0.022
Levchuk effect	10.00%	0.295	0.295	0.295
Collimator positions	0.5 mm	0.088	0.088	0.088
Solenoid focusing	100.00%	0.013	0.013	0.013
Solenoid position	0.5 mm	-0.006	-0.006	-0.006
Constant sources of unc.				
Target temperature	100.00%	0.14	0.14	0.14
B-field direction	2 deg.	0.14	0.14	0.14
B-field strength	5.00%	0.03	0.03	0.03
Spin polarization in iron		0.25	0.25	0.25
Electronic DT	100.00%	0.04	0.04	0.04
High current extrapolation		0.5	0.5	0.5
Monte Carlo statistics		0.12	0.12	0.12
Total		0.69	0.87	0.74

Total systematic error comparable to Q-Weak



Møller Polarimetry – Precision and Strategy

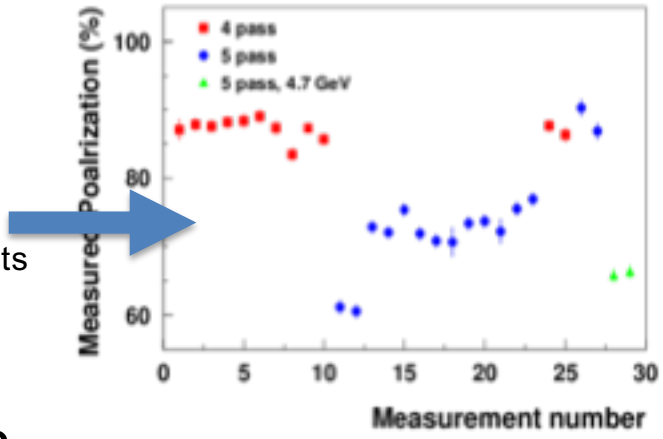
Precision of Møller measurements expected to be < 1%
→ Time dependence of beam polarization also needs to be tracked in between intermittent Møller measurements

Polarization changes mostly come from:
1. Changes at source → Spot at photocathode, heat-and-reactivation, quantum efficiency
2. Changes in beam energy → change spin precession and spin direction at hall

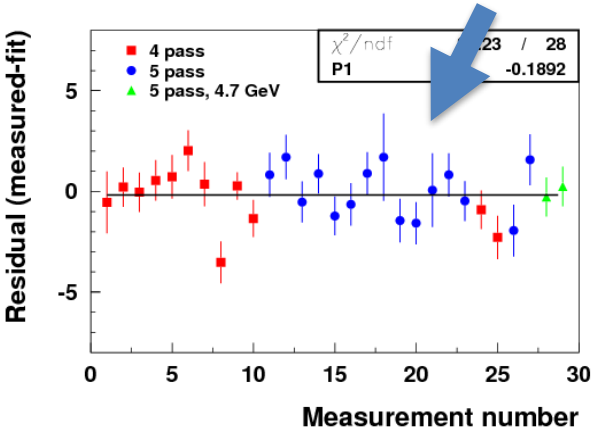
We can keep track of and correct for these effects

SANE

Møller measurements



Residuals from fit to Møller data



Møller Polarimetry - Spin Precession and Beam Energy

At higher energies, we are more sensitive to spin precession

→ If Wien angle set for maximum polarization in Hall C, a 10^{-4} change in beam energy results in <0.1% change in polarization

→ If Wien set for 90% of maximum polarization, then 10^{-4} energy change results in 1.6% change in polarization

Spin precession calculations from Joe Grames/Yves Roblin

Hall	Pass	Horizontal Bends	LINAC	Final Energy	Horizontal Precession	Modulo 360 deg	Within +/- 90	Wien Angle	Net Precession	Fraction of Polarization
		#	MeV	MeV	deg	deg	deg	deg	deg	#
A	1	68	1050	2218.36	666.09	306.09	-53.91	53.91	0.00	1.0000
			0.25%	2223.36	667.54	307.54	-52.46	52.46	0.00	1.0000
B	5	452	1050	10575.72	19705.81	265.81	85.81	53.91	139.72	-0.7629
			0.25%	10600.32	19751.48	311.48	-48.52	52.46	3.94	0.9976
C	5	460	1050	10573.25	18805.41	85.41	85.41	53.91	139.32	-0.7584
			0.25%	10597.82	18848.98	128.98	-51.02	52.46	1.44	0.9997

At "nominal" 10.6 GeV energy, Hall C receives ~76% of maximum when Wien optimized for Hall A

→ Increasing linac energy 0.25% results in ~100% for all halls

Møller Polarimeter Tasks

- Plan to use Møller for Fall 2018 run for Hall C SIDIS experiments
- Møller quadrupoles have already been used as part of Hall C beamline optics
- Tasks to get Møller ready
  - Test cooldown, verify cryo system controls; ~~Spring 2018~~ Fall 2018; *Hall C + Cryo*
  - Connect new power supply to upgraded AC distribution in hall; Summer 2018; *Hall C + Lab Electricians*
  - Check out detectors – repair if needed; Summer 2018; *Hall C*
  - Install shielding near beamline and detectors; Summer 2018; *Hall C*
  - Revive DAQ; Summer 2018; *Hall C*
- New Møller OSP has been reviewed and approved

Møller Analyzer

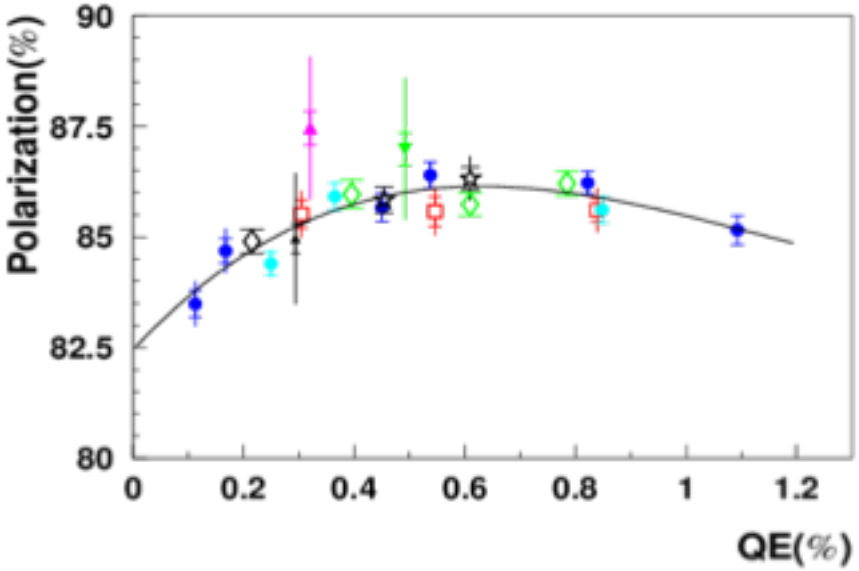
- Existing Møller analyzer has been in use since 1990's → FORTRAN/HBOOK based
- Some work was done in 2010 to try and port the analyzer to C++/Root
  - This was partially completed (could analyze scaler data, but not ADCs/TDCs), but never finished or used for production data
  - C++/Root port used Q-Weak analysis framework → lots of extra, unnecessary stuff comes along with that
- Would like an analyzer based on "modern" language, but minimizing dependence on other, large packages
- Michael Berkowitz (Grad student – Columbia) will start looking at this as time allows (low priority task)

Summary

- Hall C beamline modifications have begun, but last girder will still need work summer of 2019
- Møller polarimeter expected to provide measurements with <1% precision
  - Will need to track source configuration, beam energy to provide polarization between Møller measurements
- Increased sensitivity to beam energy means we can't be too far from optimum Wien angle for Hall C

EXTRA

Polarization Dependence on QE

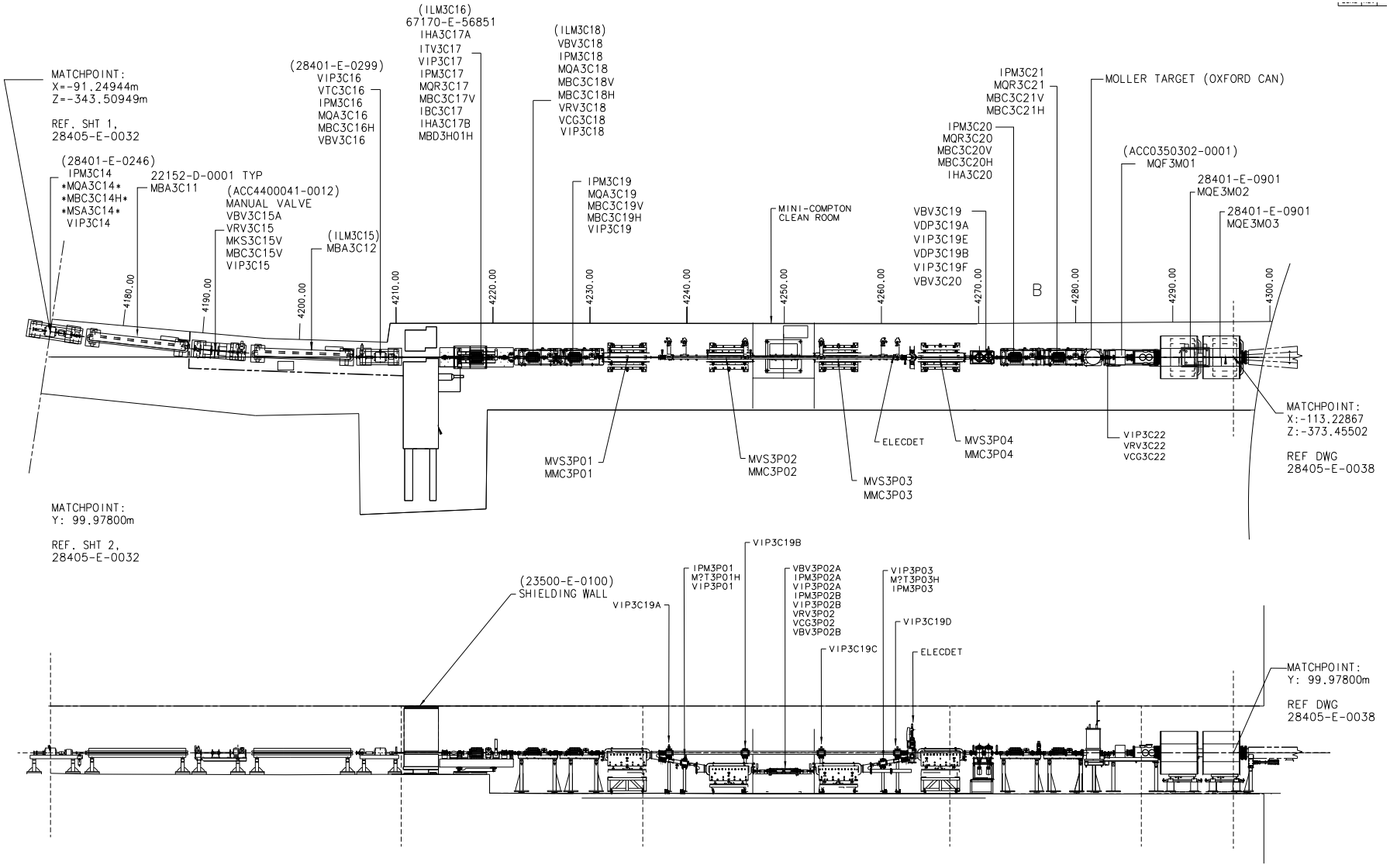


Measured QE dependence from GEp, GEp-2gamma

→ Similar QE dependence observed during Q-Weak, Run-1

→ Q-Weak, Run2: larger laser spot used at photocathode – no measurable QE dependence

Hall C Songsheet – Green wall to Hall



Hall C Songsheet - Hall