Hall C Beamline and Møller Polarimetry

Dave Gaskell

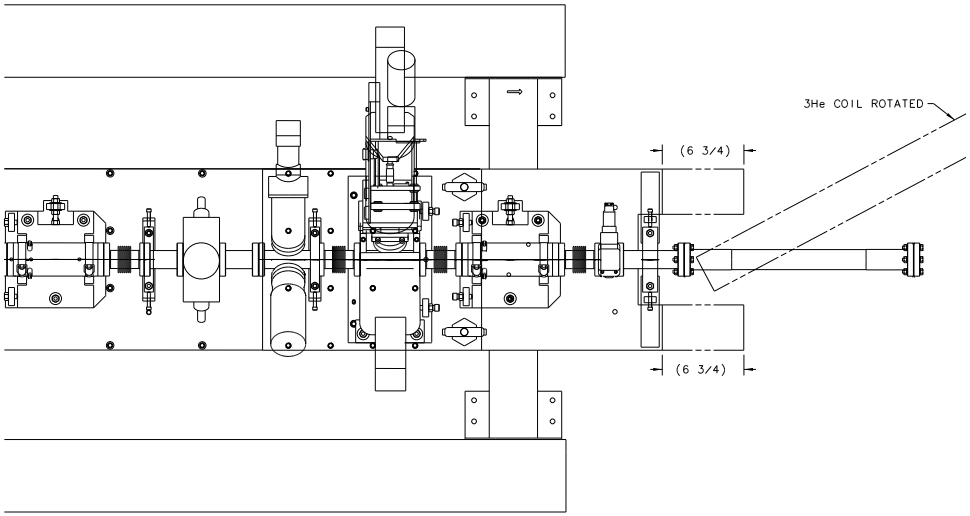
A1n/d2n Collaboration Meeting

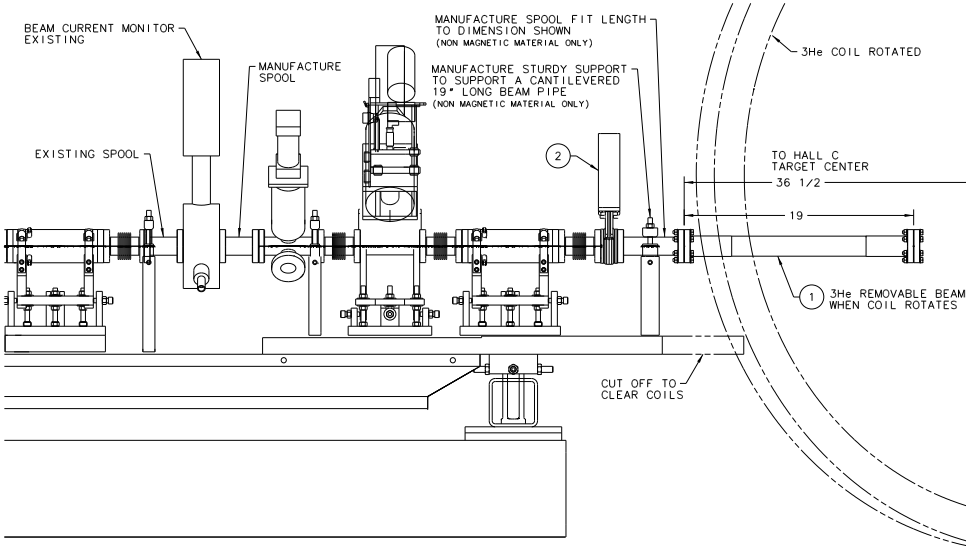
July 24, 2019

Outline

1. Beamline
2. Møller Polarimeter

Beamline Modifications for Polarized ^{3}He



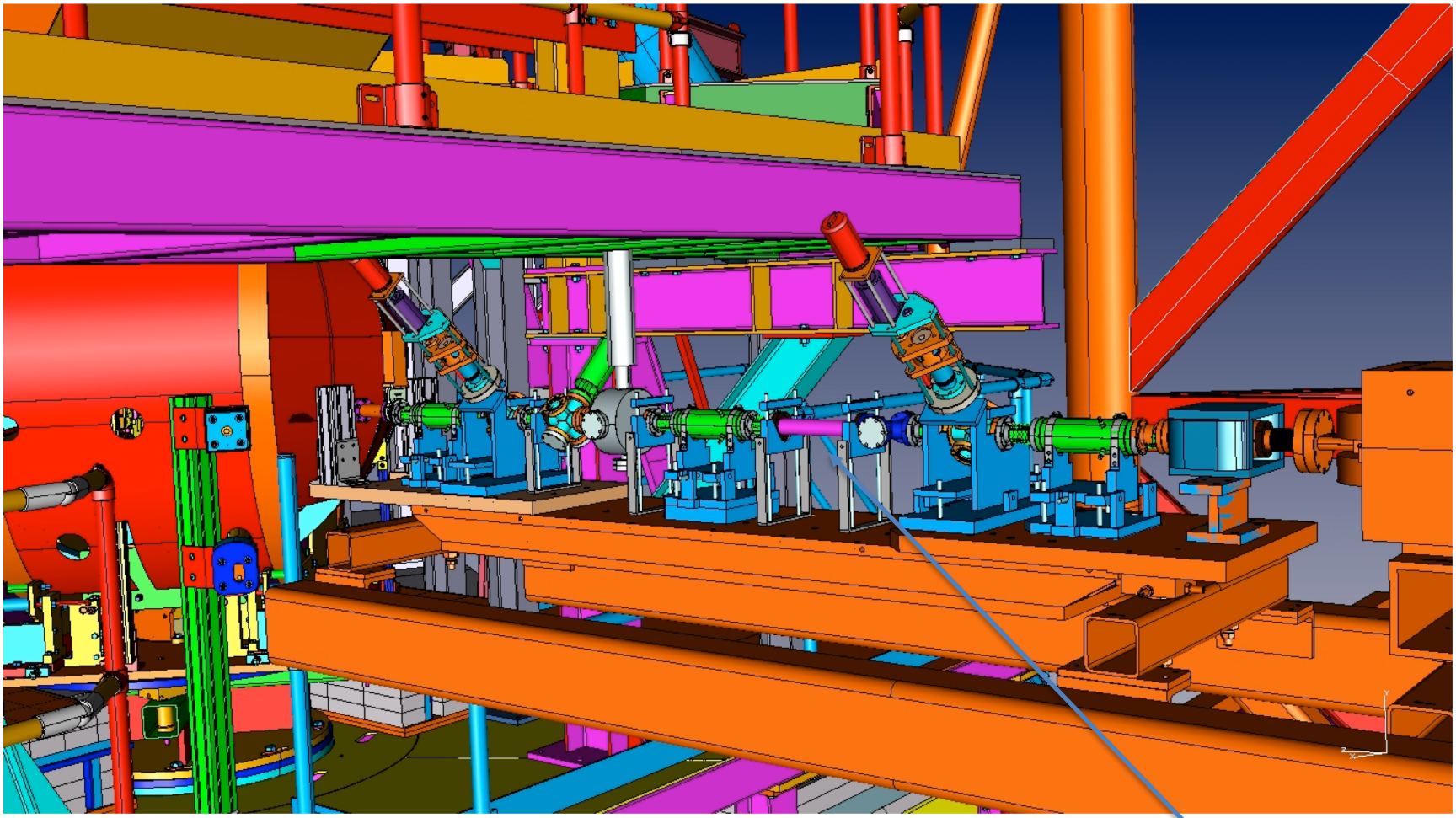


Coils for polarized ^{3}He will run into end of last girder when rotated to certain configurations

→ End of girder will need to be cut off – TO-DO
→ Requires relocation of MPS BCM - DONE
→ Radiator will need to be removed

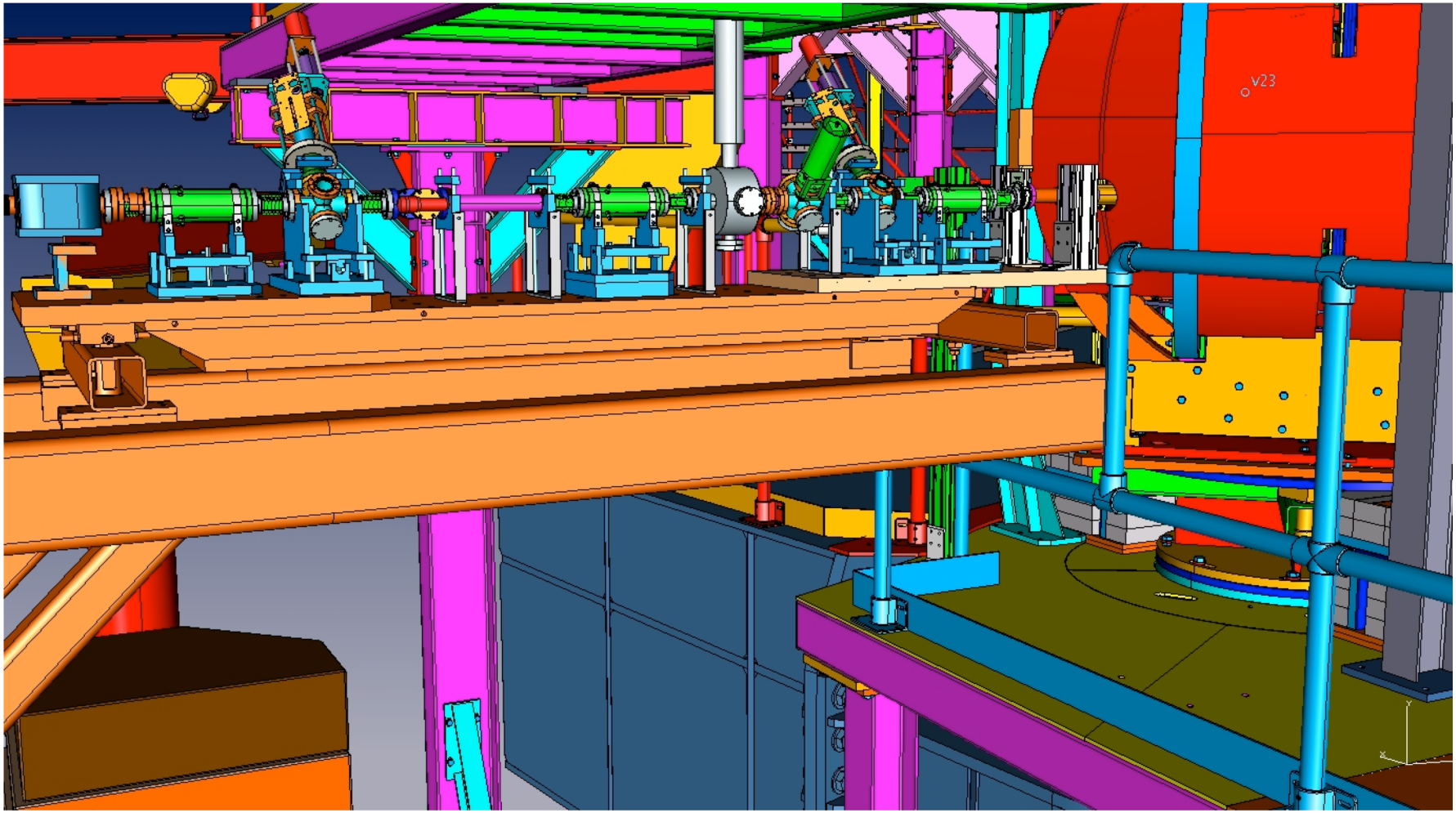
→ Detailed drawings for beamline 100% complete – parts 98% complete
→ Target group will remove radiator
→ Engineering will modify beamline – work can be done in place (not yet scheduled)

Beamline Pictures

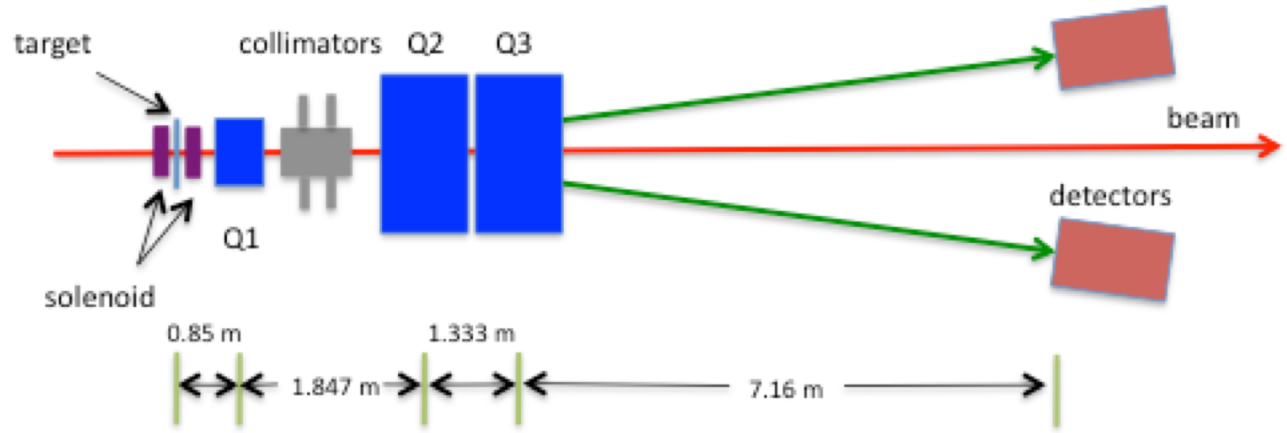


Bert Metzger

Beamline Pictures



Møller Polarimeter – Layout



Additional large quad added for operation at higher energy
→ Both quads wired in series, operated by one power supply

For operation at low energy (1 pass), need to use Q3 only
→ Will require slight reconfiguration of quad power cables
→ If prepared ahead of time, should only take 1-2 hours
→ May cause some confusion for OPS since these quads are also used for beamline optics

Møller Polarimeter Tasks

- Test Møller at end of summer run. Not highest energy → 4.6 GeV
- Tasks to get Møller ready
  - Test cooldown, verify cryo system controls; January 2019; *Hall C + Cryo* → **Complete**
  - Connect new power supply to upgraded AC distribution in hall; Summer 2018; *Hall C + Lab Electricians* → **Complete**
  - Check out detectors – repair if needed; Summer 2018; *Hall C* → **Complete**
  - Install shielding near beamline and detectors; Summer 2018; *Hall C* → **Complete**
  - Revive DAQ; Summer 2018; *Hall C* → **Complete**
- New Møller OSP has been reviewed and approved
- Run preparation tasks
  - Update OPS Møller Procedure (very few changes needed)
  - Update Monte Carlo with new magnet maps → **Complete**
  - Generate nominal settings for upcoming run

Test Cooldown and Ramp

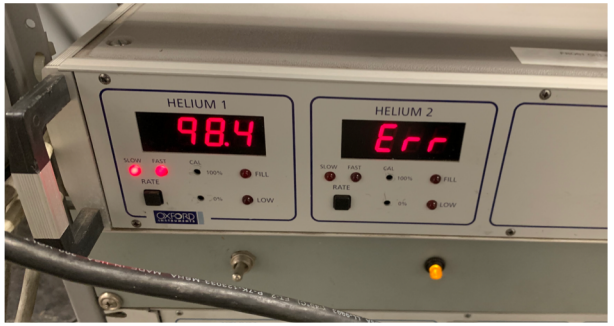
January 24, performed a test cooldown of the Møller solenoid

→ Solenoid has not been cooled or turned on since 2012

→ Cryo configuration during Q-Weak was unusual
– Wanted to test after return to normal configuration

Solenoid cooled down successfully – ramped to 3 T

Solenoid at 3 T



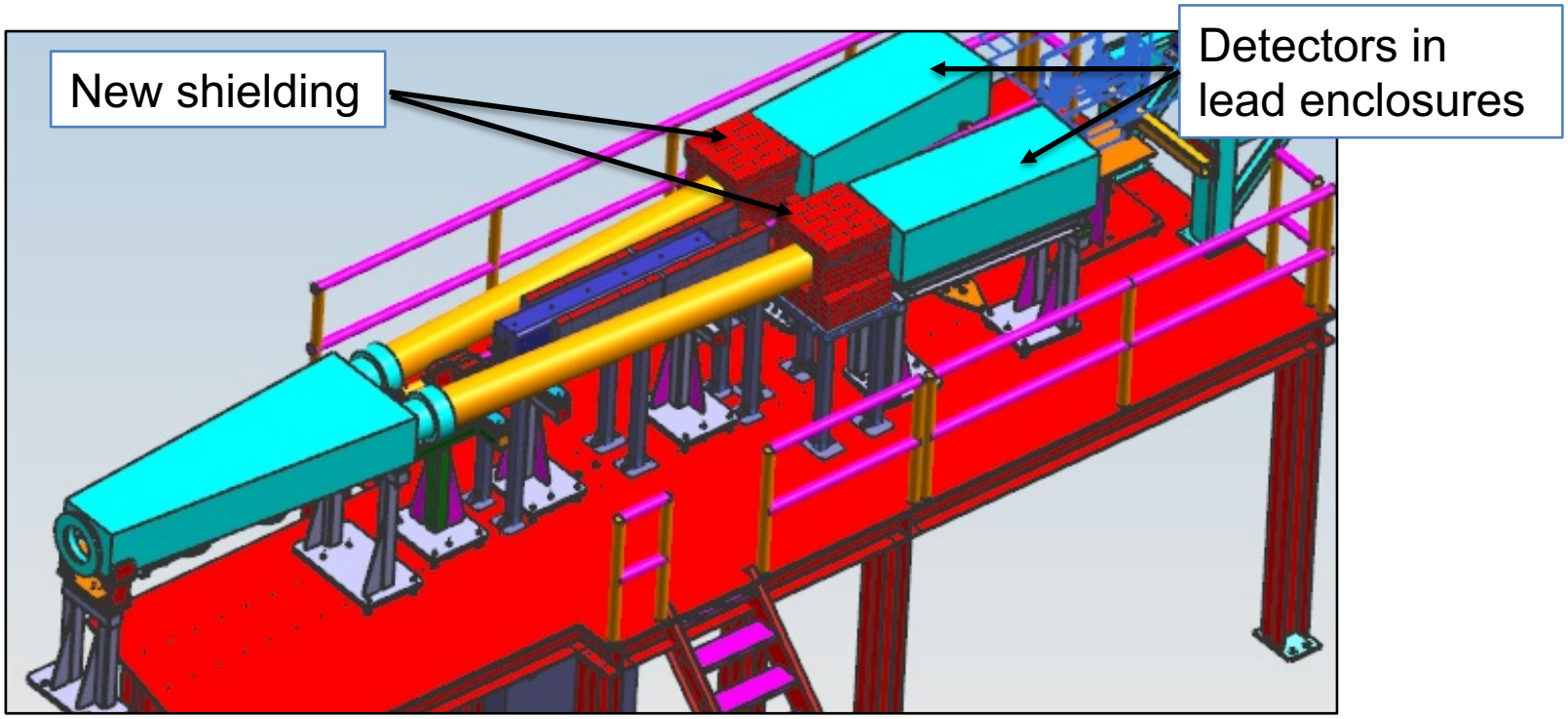
Møller Solenoid/Cryo Issues

During cooldown – discovered some issues to be resolved

1. LHe/LN2 level meter was not working → Chris Keith found a spare marked ”Hall C”
2. Some supply instrumentation not reading out (T and P sensors)
3. (Software) readback of solenoid field not correct → solved by Sue Witherspoon
4. Cooldown valve, warm return bypass valves not acting correctly → still to be resolved

Remaining issues will be resolved during next down

Møller Shielding



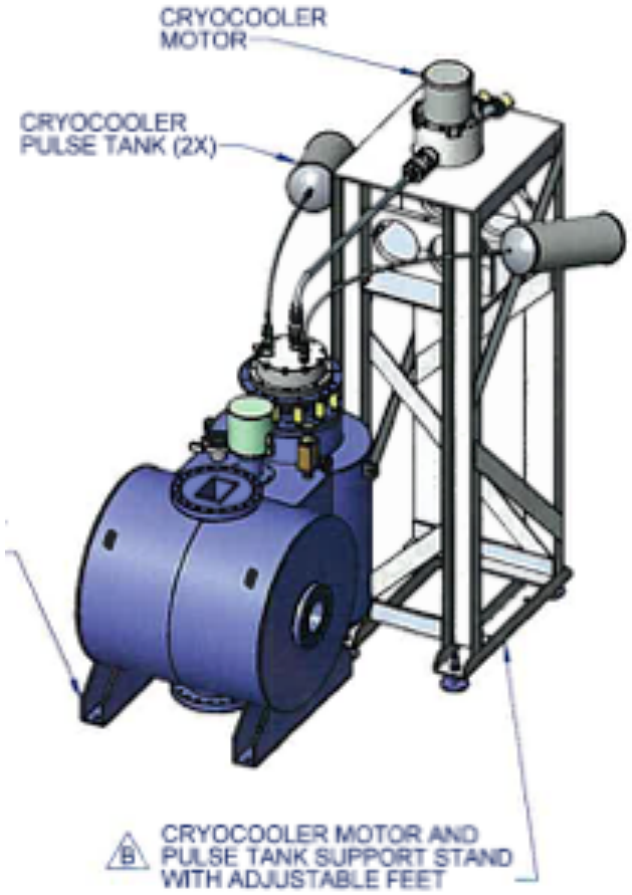
Extra detector shielding added as part of 12 GeV beamline design (Q-Weak saw higher backgrounds) → part of this extra shielding installed during summer 2018 SAD

→ Test run will help judge whether more shielding is required – can be installed during summer down

New Møller Solenoid

Existing target solenoid will be replaced with conduction-cooled (cryogen free) magnet → In use in Hall A starting 2014

Contract awarded to American Magnetics – system won't be delivered until January-February of 2020, so can't/won't be used for A1n/d2n



Møller Polarimetry – Precision and Strategy

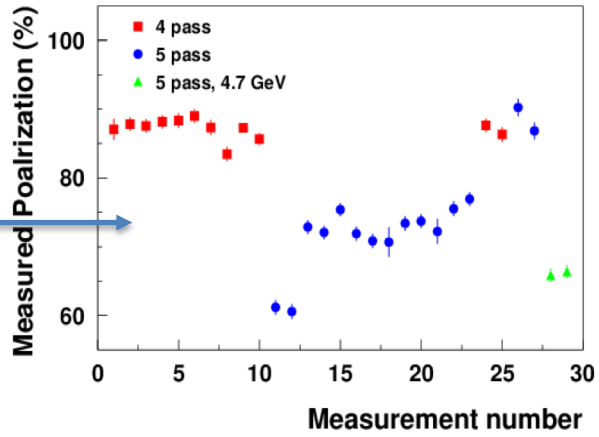
Precision of Møller measurements expected to be < 1%
→ Time dependence of beam polarization also needs to be tracked in between intermittent Møller measurements

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

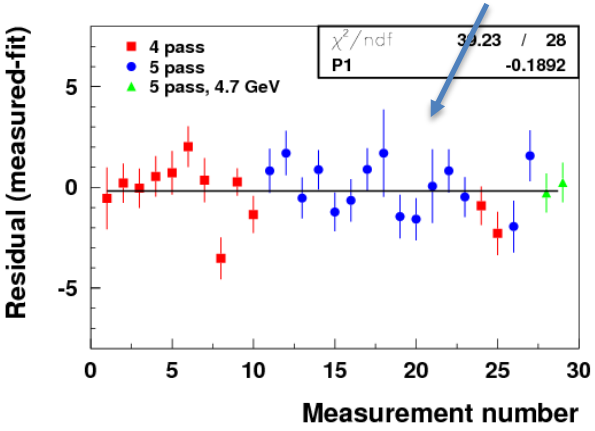
We can keep track of and correct for these effects

SANE

Møller measurements



Residuals from fit to Møller data



Møller Measurements, Polarization Tracking During Experiment

- Møller measurements should be done by a small group of people → a written procedure exists, but measurements go better with experienced/trained group
- During Q-Weak, had a team of 3-5 people for 2-3 measurements/week – for A1n/d2n need at least 2
- Final polarization values generally generated by collaborator/student → compares systematic checks against Monte Carlo, etc.
- Should also have someone dedicated to tracking the time dependence of the polarization
  - Monitor QE, beam energy, etc.
  - Help decide when "extra" measurements might be needed

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
- Would like an analyzer based on "modern" language, but minimizing dependence on other, large packages

GEANT4 Simulation

Existing/6 GeV Møller simulation is a FORTRAN, aperture-checking Monte-Carlo

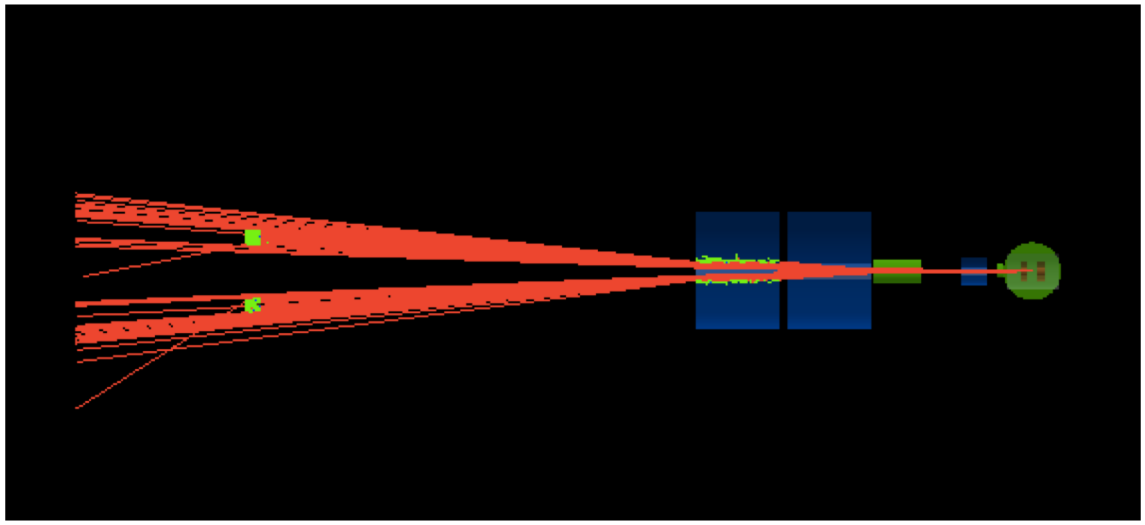
→ Based on simulation from SLAC SLC-linac Møller polarimeter

[M . Swartz et al, NIMA 363 (1995) 526-537]

GEANT4 MC has been under development in Hall A

→ Summer 2018, this simulation was ported for Hall C setup (Alyssa Petroski, Holly Szumila-Vance)

→ Major components in place – a few detailed geometry issues to be resolved



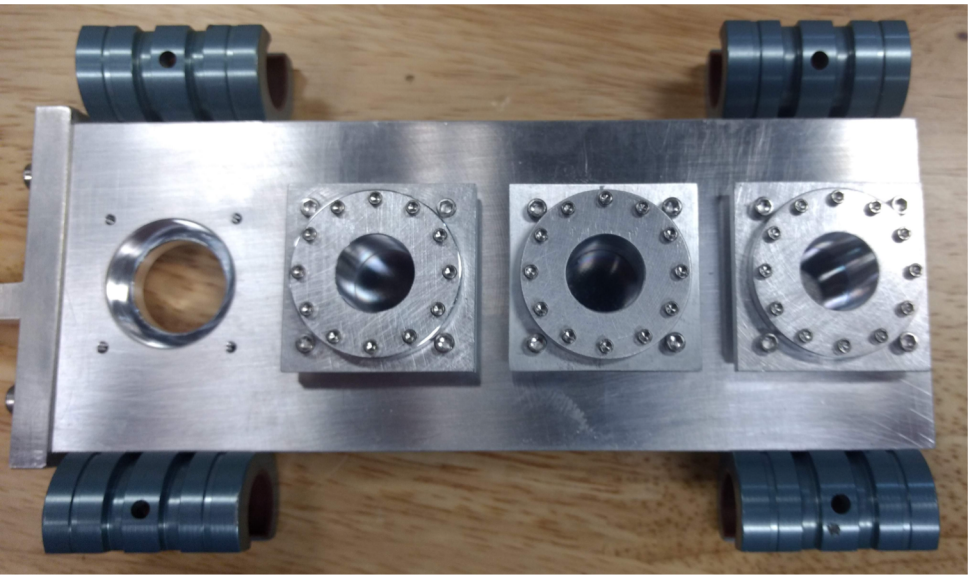
https://github.com/JeffersonLab/hallc-moller-polarimeter

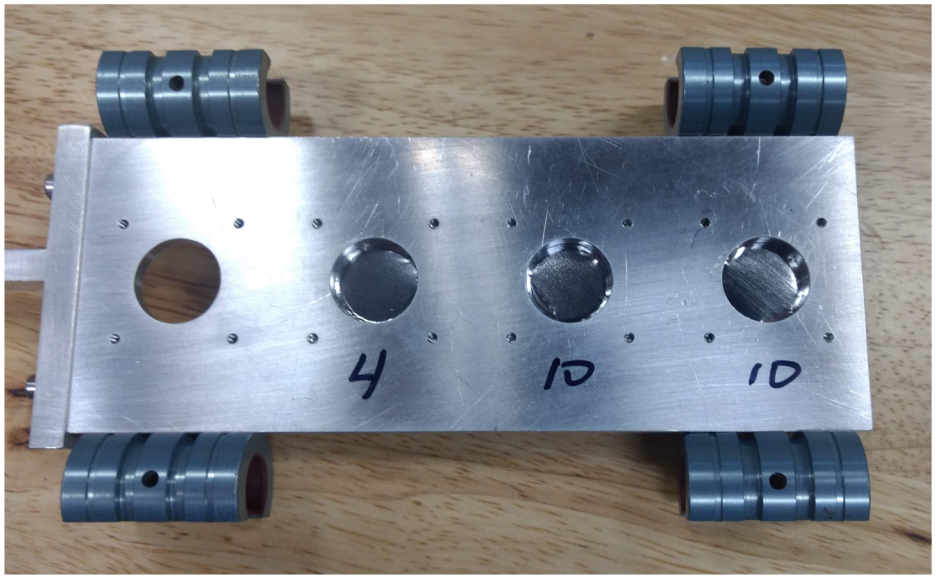
Summary

- Modest amount of work remaining for Hall C beamline
  - Remove radiator, cut girder
  - Install narrow “collimator” pipe, install downstream pipe with Be window
- Møller polarimeter mostly ready
  - DAQ, detectors, target ready, test cooldown complete
  - Initial commissioning at end of summer run
  - Need to start planning for measurements and analysis

EXTRA

New Møller Target Foils and Ladder





During Summer 2018, Dave Meekins designed new target ladder → smaller foil aperture, easier to get thick foils “flat”
→ New iron foils installed (4 μm, 10 μm, 10 μm)

Expected Møller Performance at 11 GeV

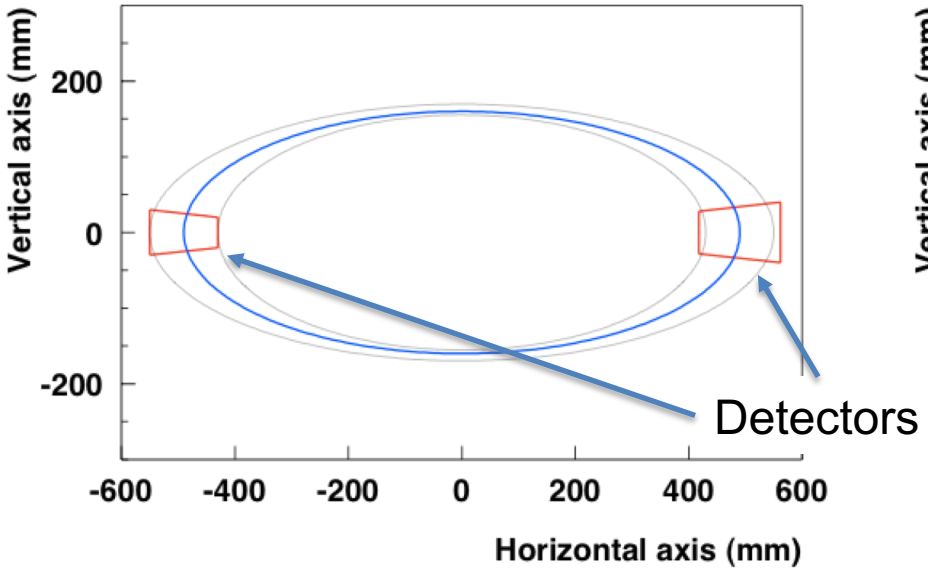
Monte Carlo studies by Kamilah Walker – Phoebus High School

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

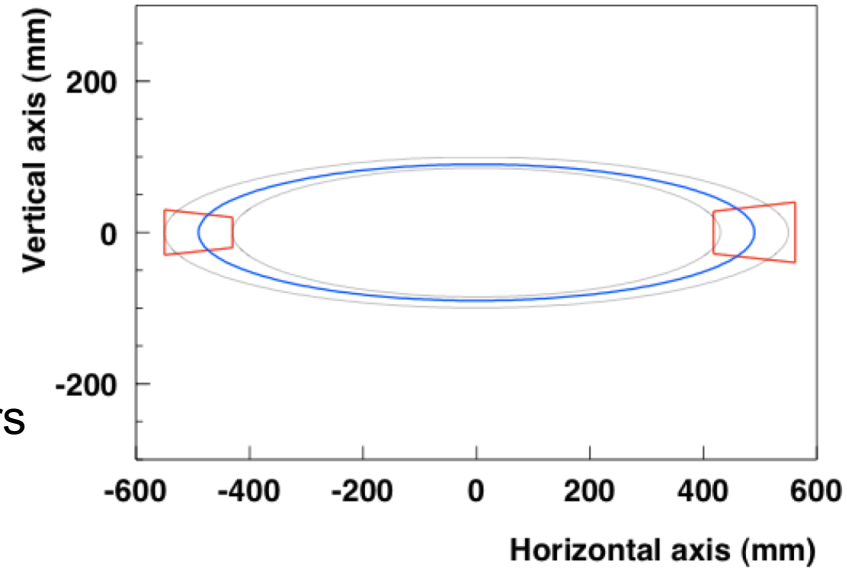
Total systematic error comparable to Q-Weak

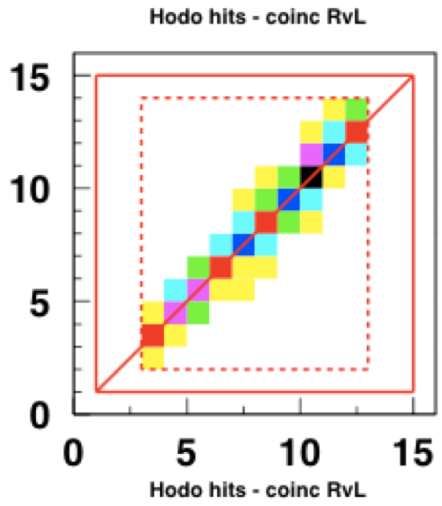
Møller Polarimeter – New optics

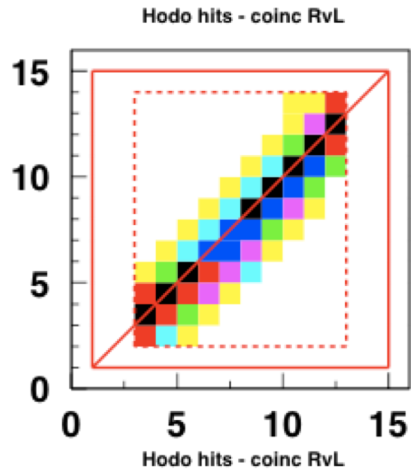
6 GeV



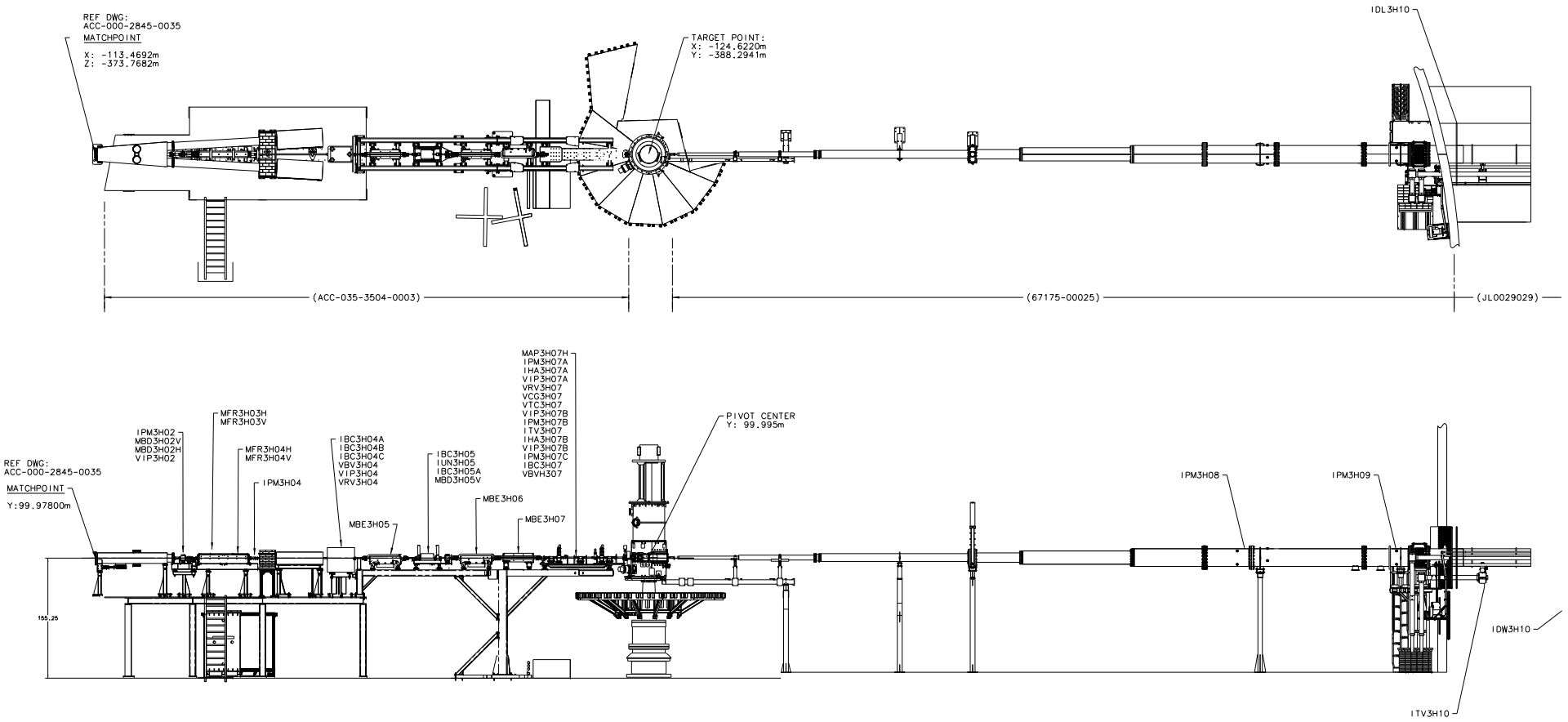
11 GeV







Hall C Songsheet - Hall



Hall C Songsheet – Green wall to Hall