Hall C Beamline and Møller Polarimetry

Dave Gaskell

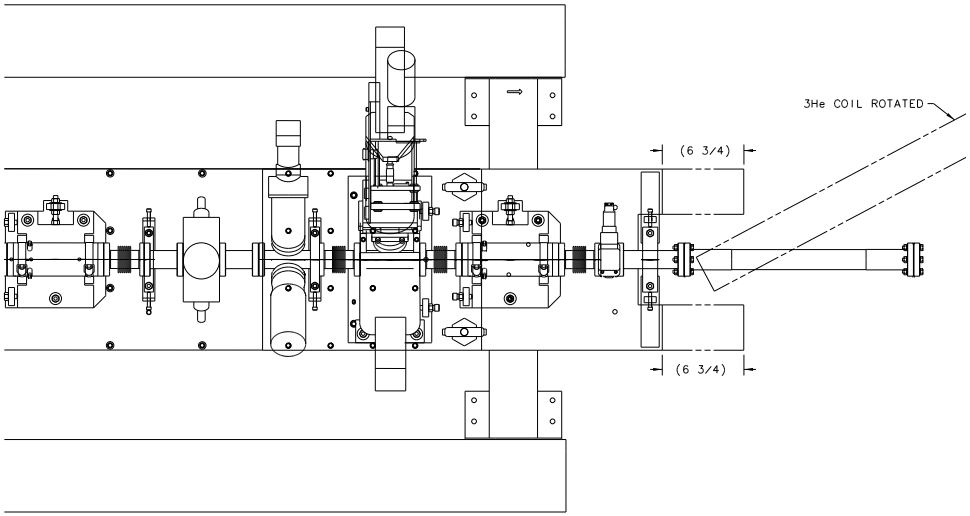
A1n/d2n Collaboration Meeting

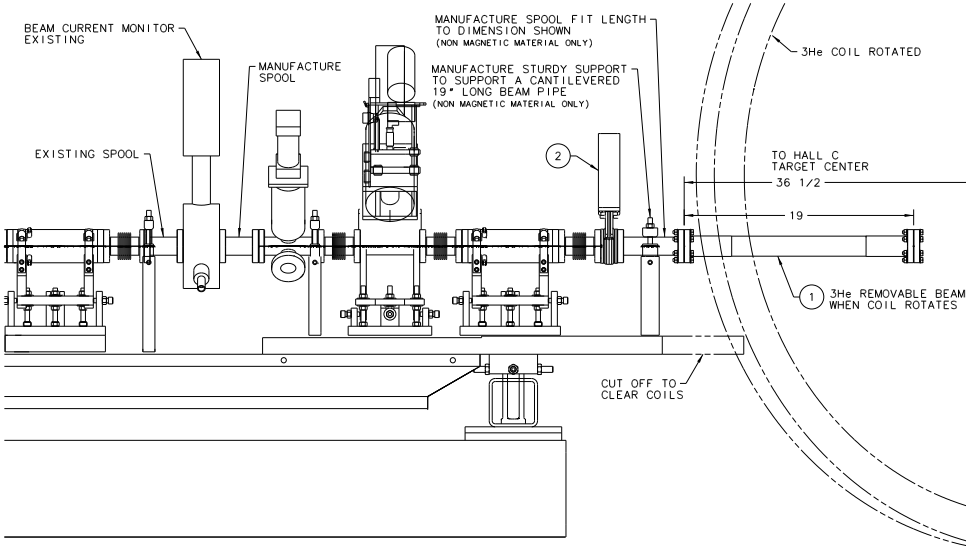
December 10, 2018

Outline

1. Beamline work
2. Møller Polarimeter

Beamline Modifications for Polarized ^{3}He





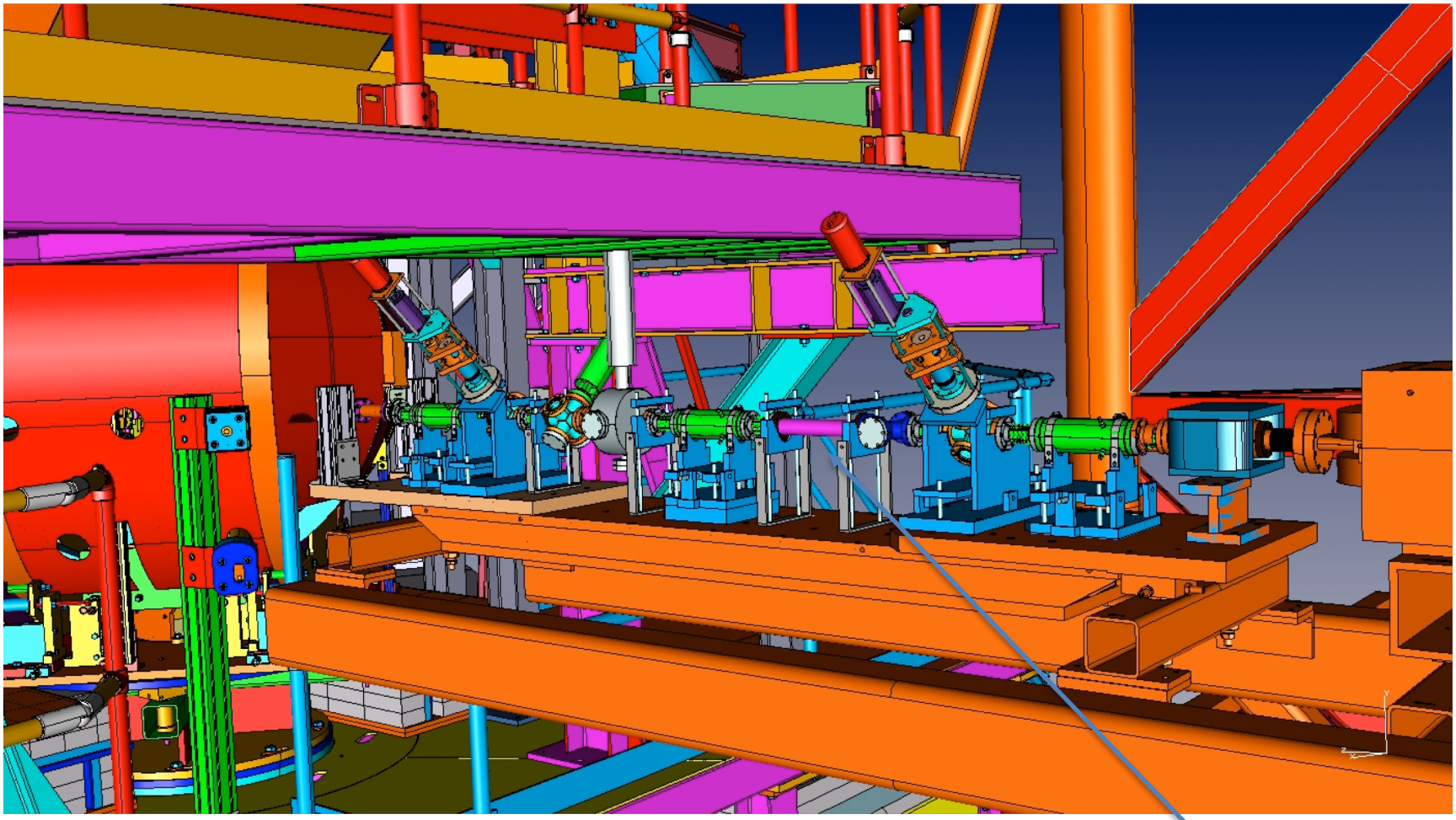
Coils for polarized ^{3}He will run into end of last girder when rotated to certain configurations

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

Originally, planned to accomplish both summer, 2018 as part of preparations for E12-16-007

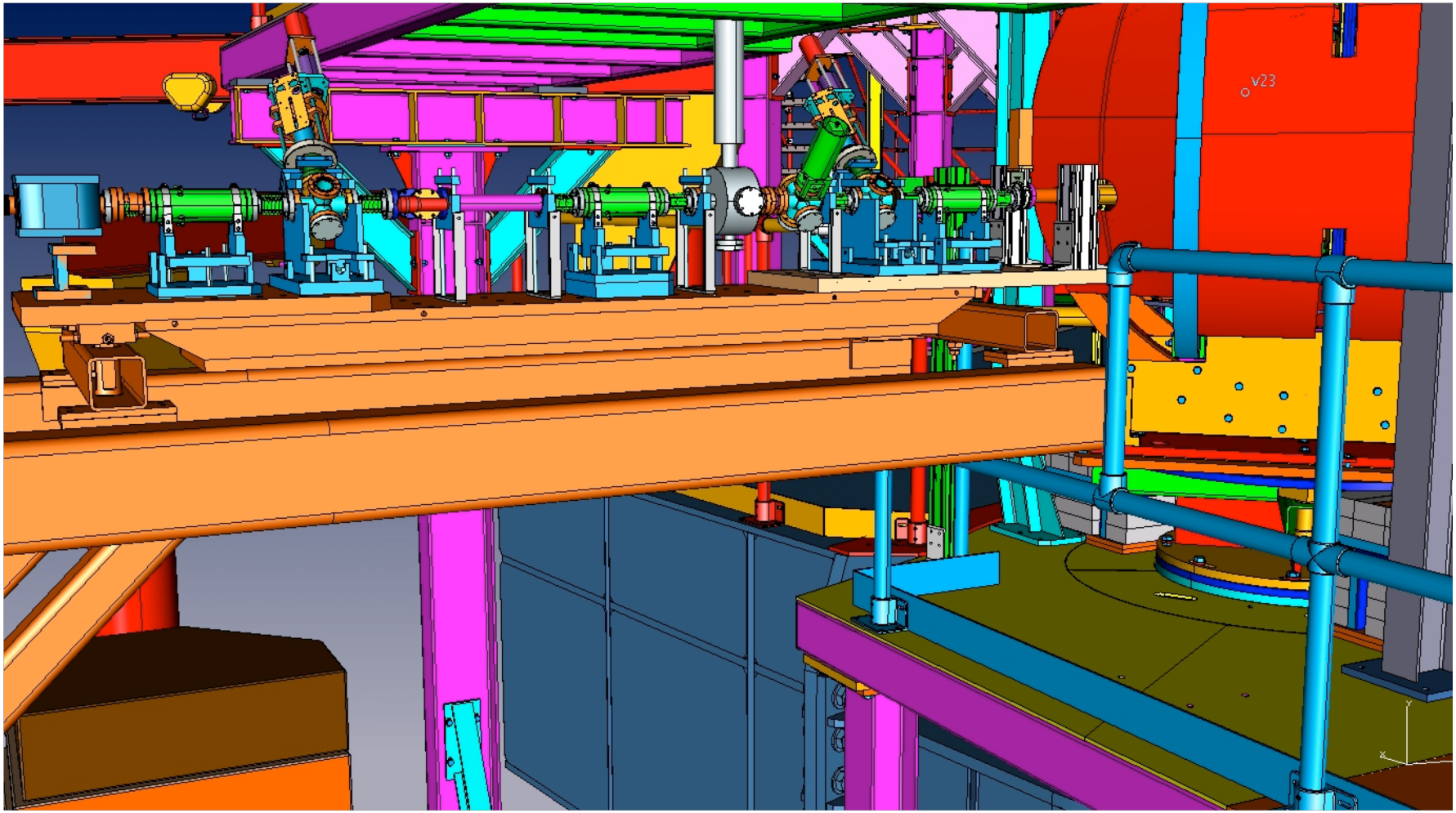
→ Due to short summer down, limited ENG availability, only moved MPS BCM (install radiator)
→ Girder will be cut during summer 2019 SAD

Beamline Pictures

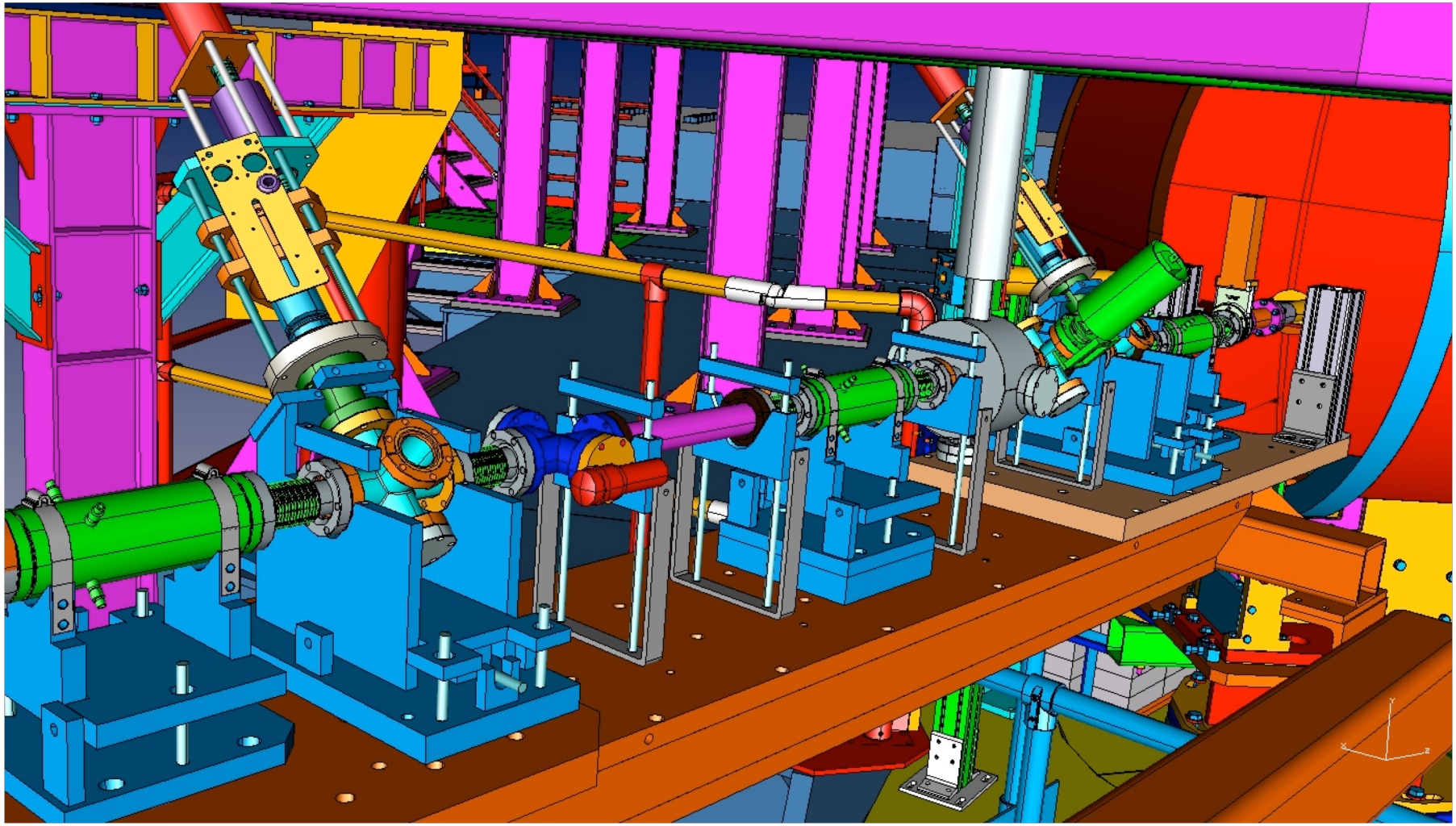


Bert Metzger

Beamline Pictures



Beamline Pictures



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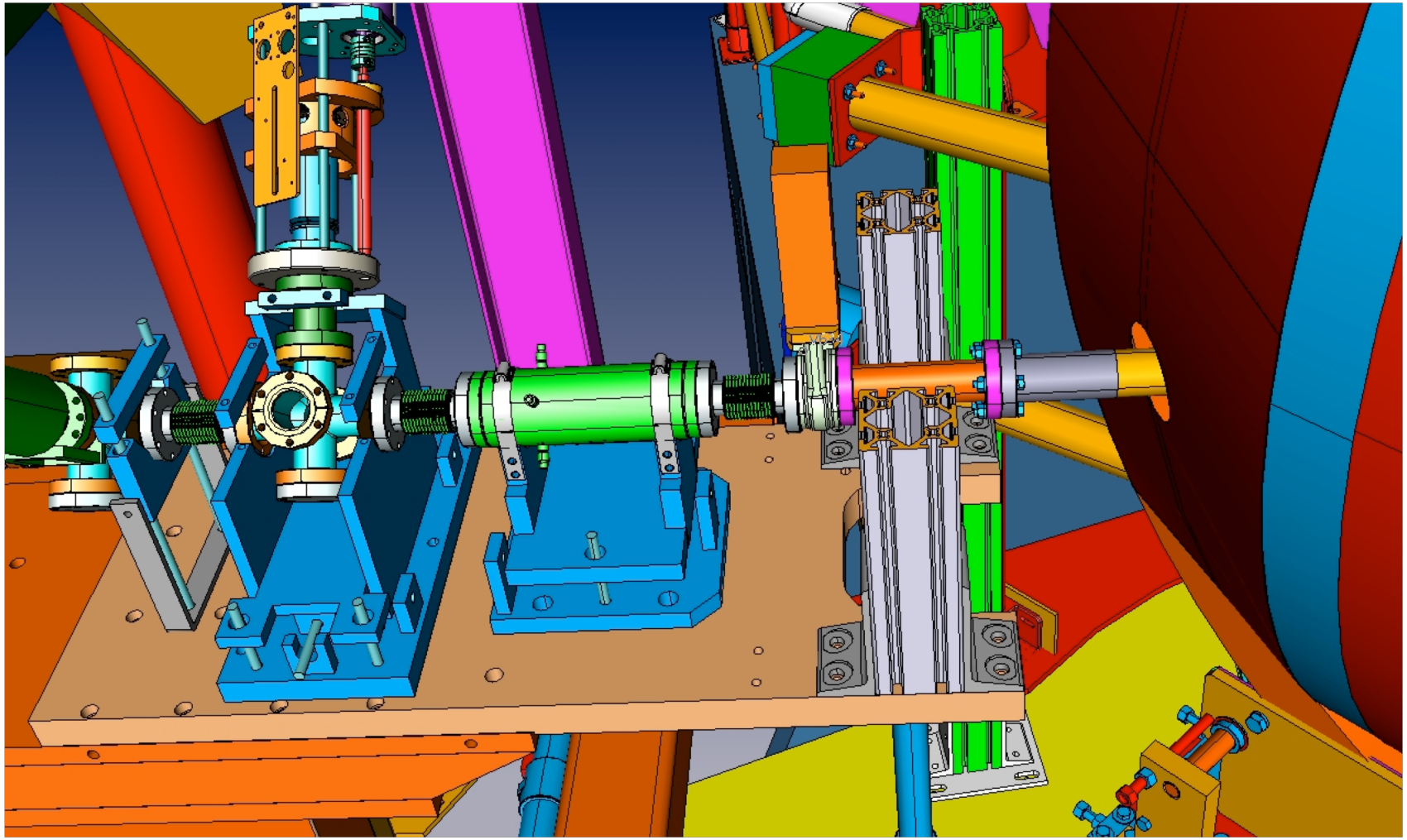
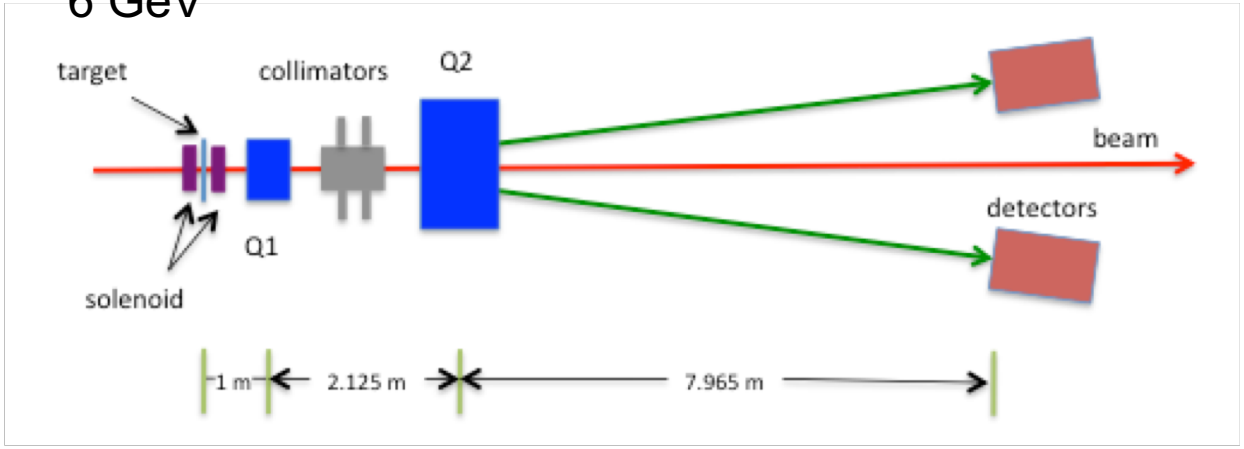
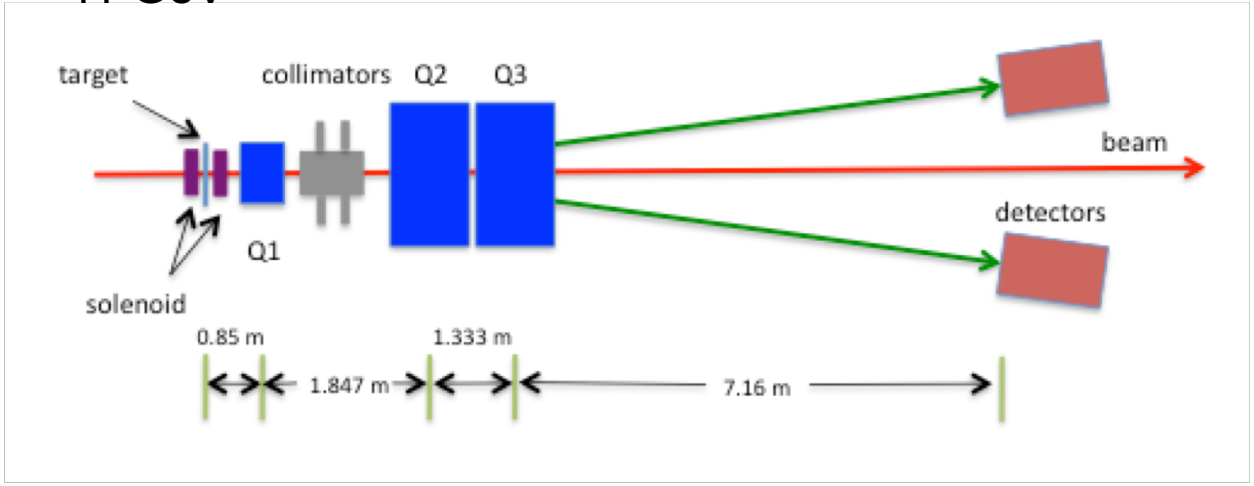


Møller Polarimeter – New layout

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 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

From last meeting

Møller Polarimeter Tasks

- ~~Plan to use Møller for Fall 2018 run for Hall C SIDIS experiments~~
  - This was deferred after we lost ~5 weeks of running this fall
  - Next opportunity to test Møller will be after June Hall C experiments. Not highest energy → 4.6 GeV
- Tasks to get Møller ready
  - Test cooldown, verify cryo system controls; ~~Spring 2018~~ ~~Fall 2018~~ January 2019; *Hall C + Cryo*
  - 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**
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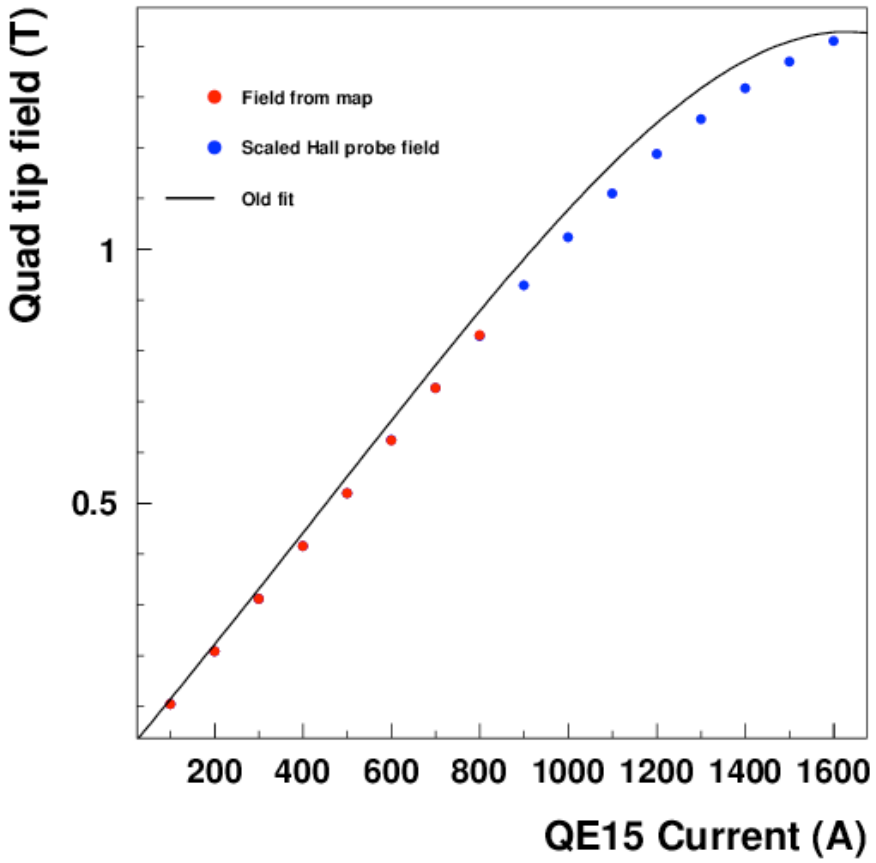
Large Quad – Full Current Test

Large Møller quads refurbished before 12 GeV operation → new coils

JLab Magnet Test group only able to check quad strength up to 800 A in their lab

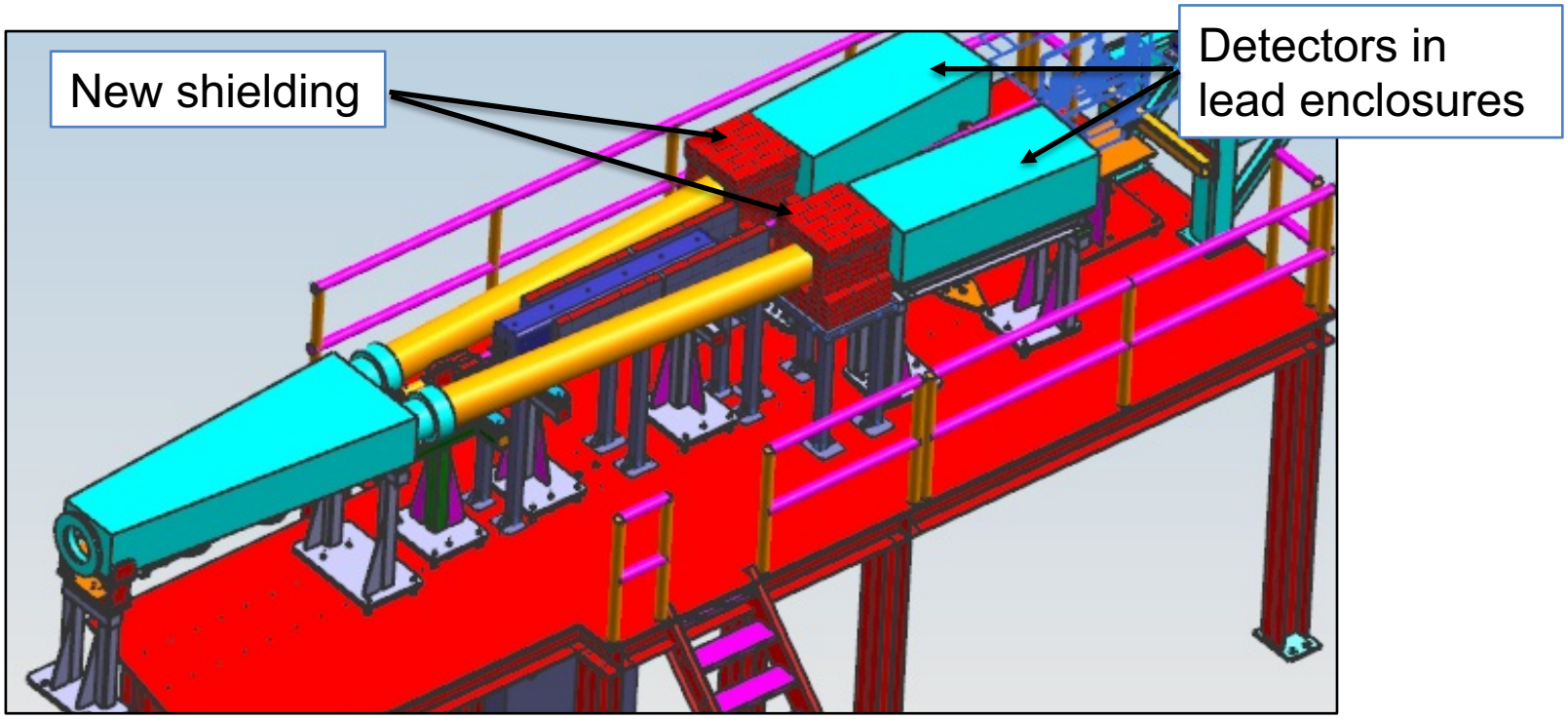
New Hall C power supply required for ~1600 A operation → Summer 2018 tested magnet and extended field measurements to full field

Measured field not totally consistent with old, 6 GeV era expectation



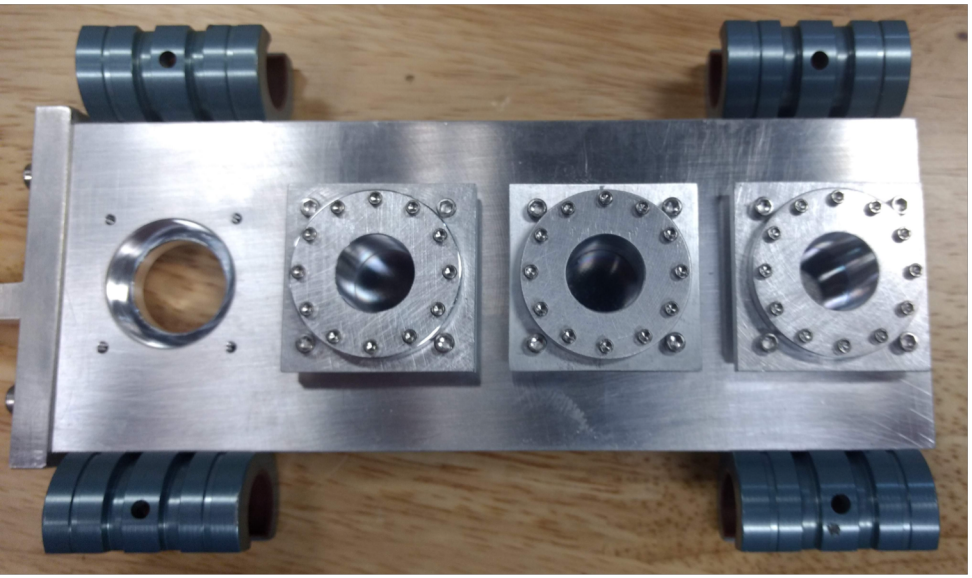
Refurbished quads capable of fields needed for 11 GeV operation

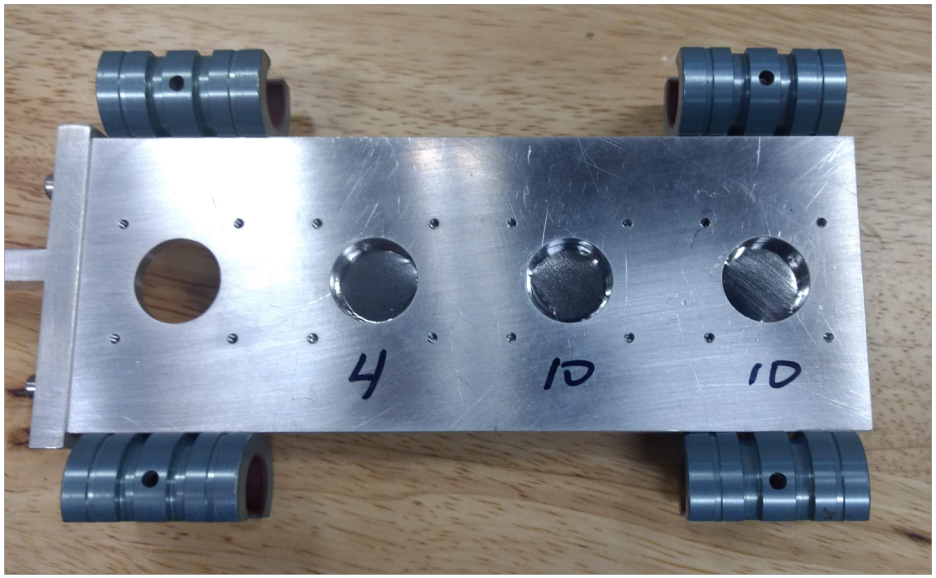
Møller Shielding



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

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)

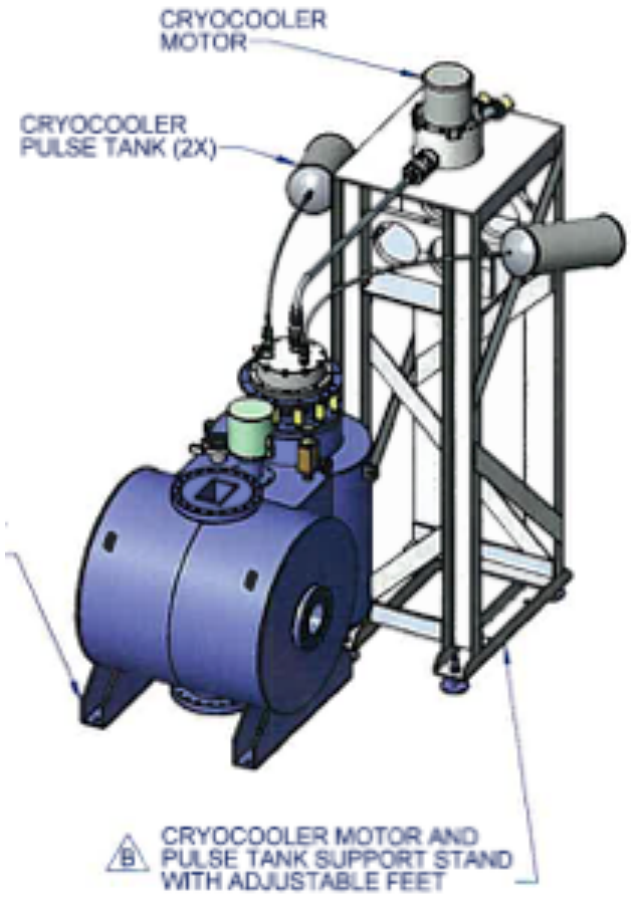
Possible New Møller Solenoid

Looking into replacing existing target solenoid with conduction-cooled (cryogen free) magnet → In use in Hall A starting 2014

Assessing whether Hall A-style magnet compatible with space in Hall C beamline

→ May require changes to target ladder, beamline stand, etc., but so far looks relatively straightforward

→ Depending on quote/delivery time, may be available in time for A1n/d2n, but would require additional installation work



Møller Polarimetry – Precision and Strategy

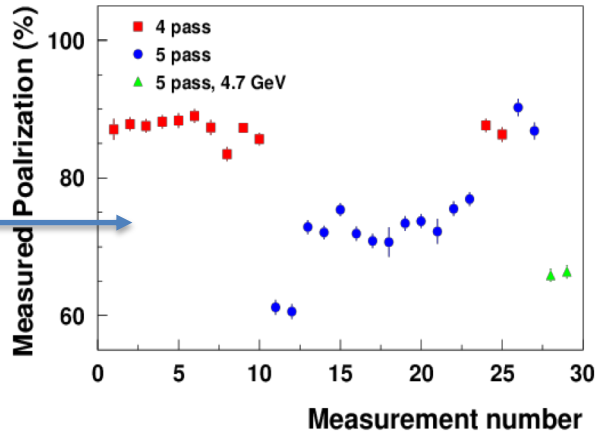
Precision of Møller measurements expected to be < 1%
→ Time dependence of beam polarization also needs to be tracked in between intermittent Møller measurements

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

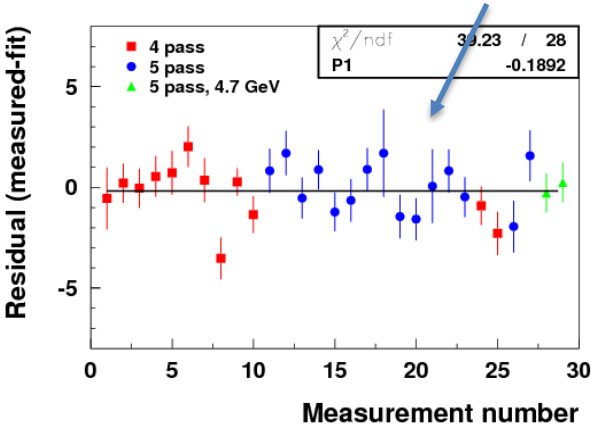
We can keep track of and correct for these effects

SANE

Møller measurements

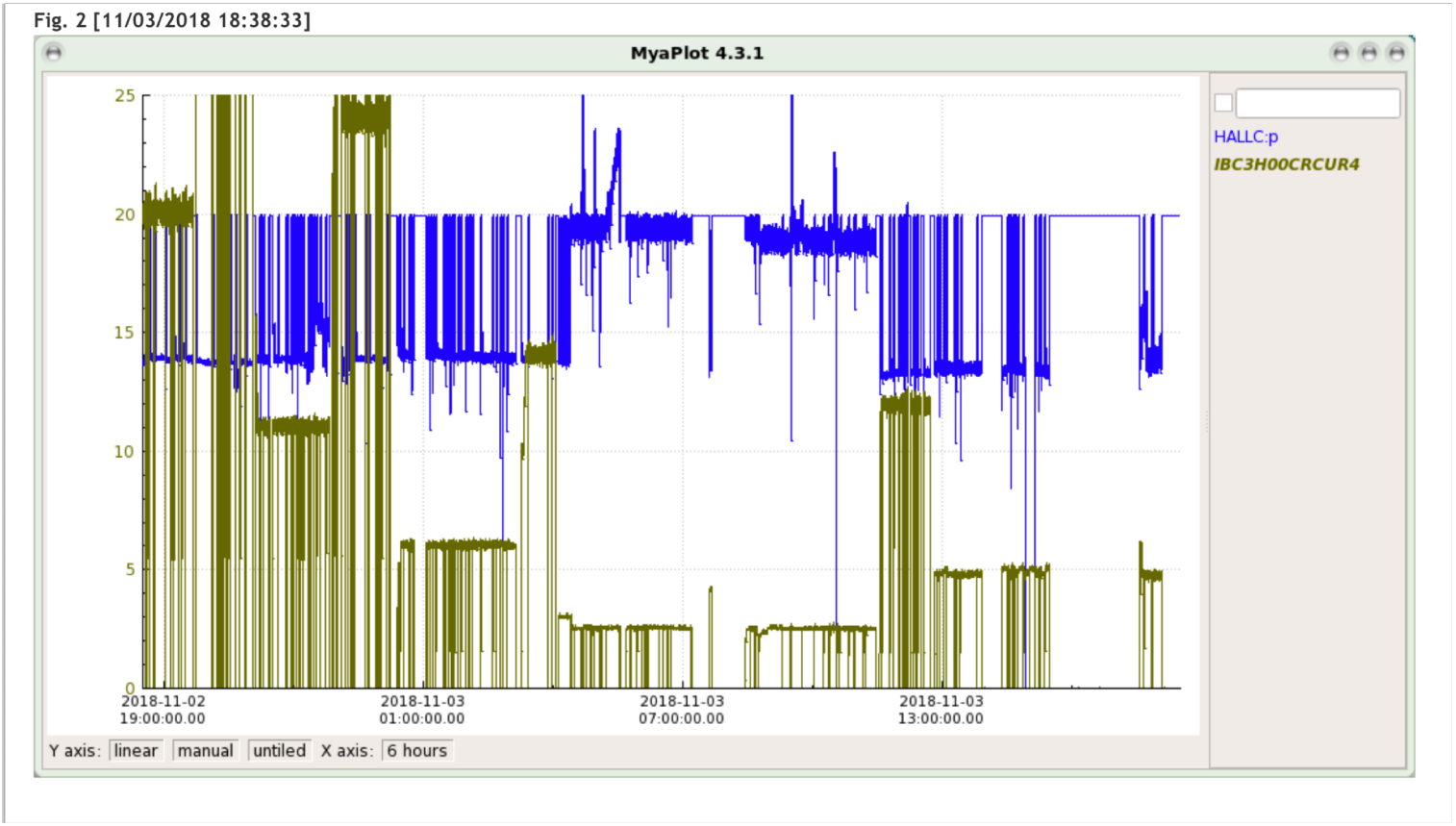


Residuals from fit to Møller data



Energy Monitoring in 2018

https://logbooks.jlab.org/entry/3620478



During SIDIS running in Hall C, Mike Tiefenback and Jay Benesch noticed HALLC:p wasn't accurate at low current → BPMs accidentally had autogain switched off

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 still needed
  - Commissioning in June?
  - There may be an option to install new solenoid

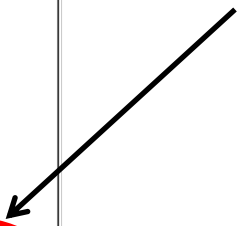
EXTRA

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 - 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

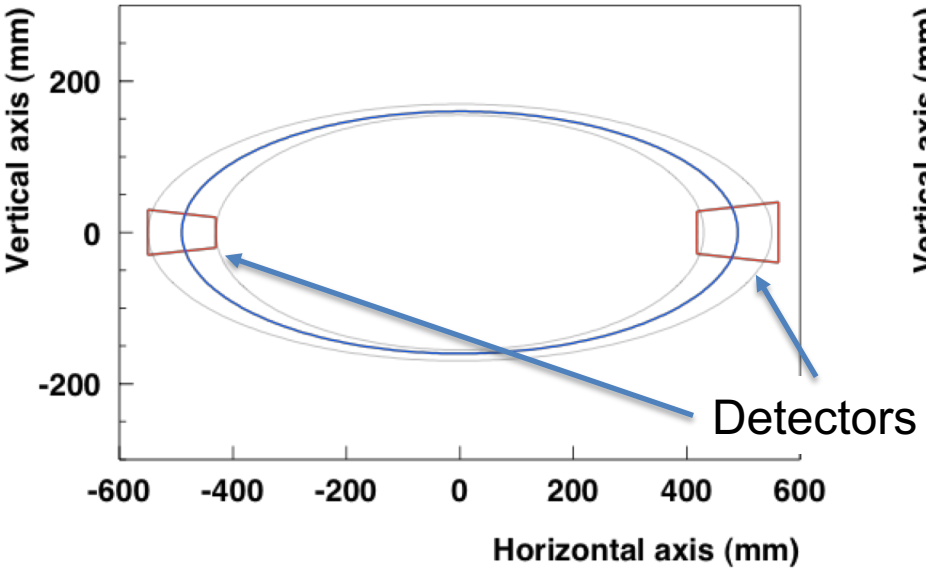
Hall	Pass	Horizontal Bends	LINAC	Final Energy	Horizontal Precession	Modulo 360 deg	Within +/- 90	Wien Angle	Net Precession	Fraction of Polarization
		#	MeV	MeV	deg	deg	deg	deg	deg	#
A	1	68	1050	2218.36	666.09	306.09	-53.91	53.91	0.00	1.0000
			0.25%	2223.36	667.54	307.54	-52.46	52.46	0.00	1.0000
B	5	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

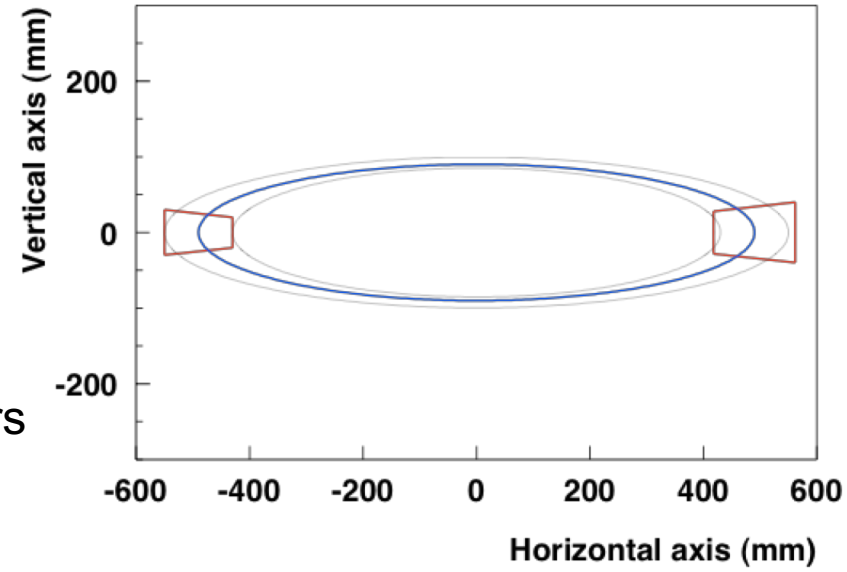
→ Increasing linac energy 0.25% results in ~100% for all halls

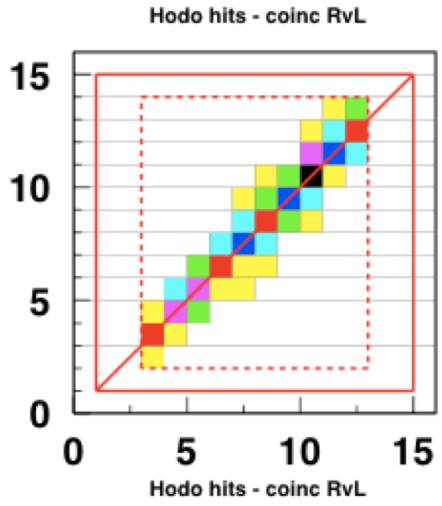
Møller Polarimeter – New optics

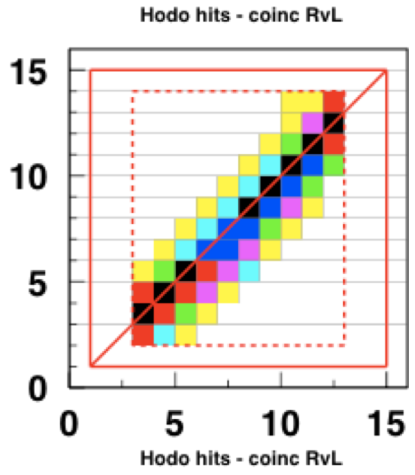
6 GeV



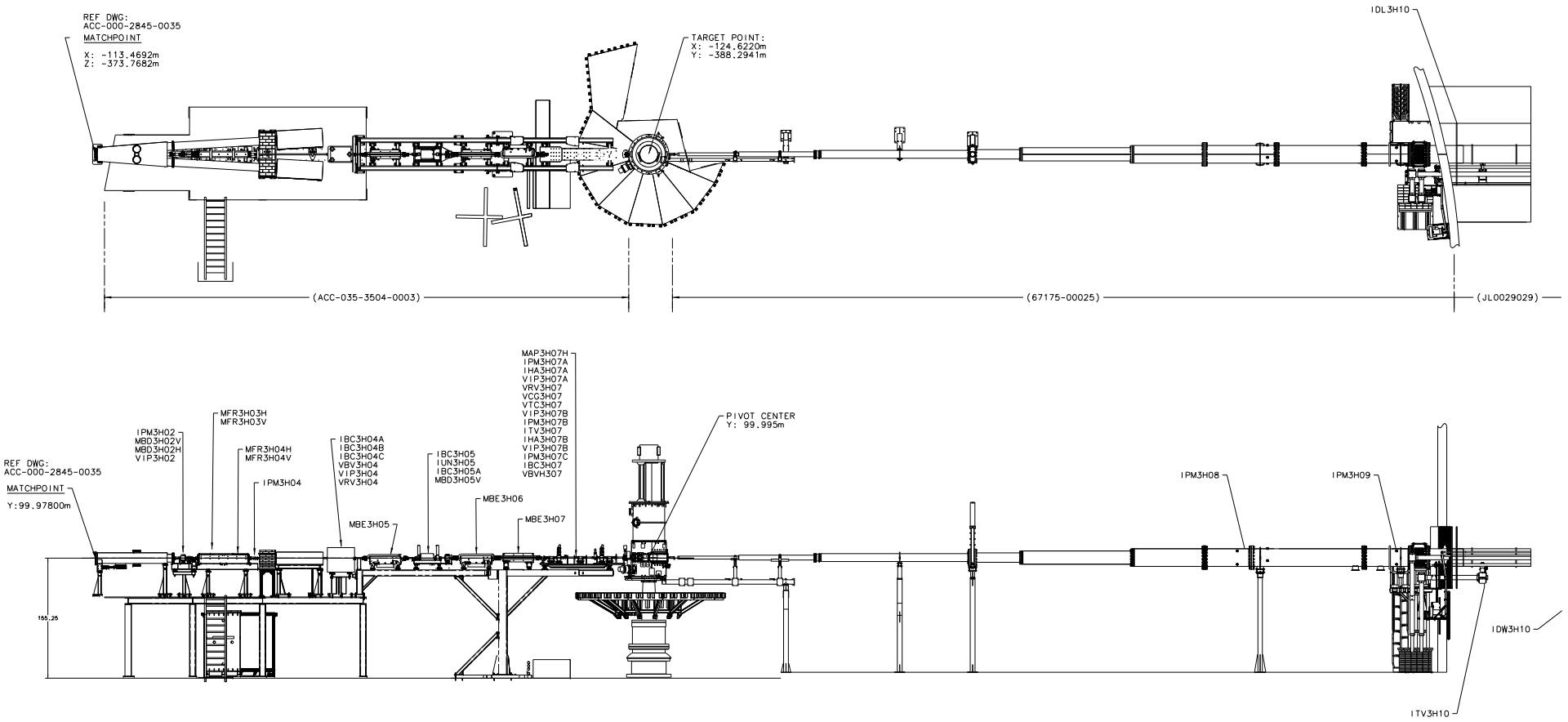
11 GeV







Hall C Songsheet - Hall



Hall C Songsheet – Green wall to Hall