RCS Møller Polarimeter

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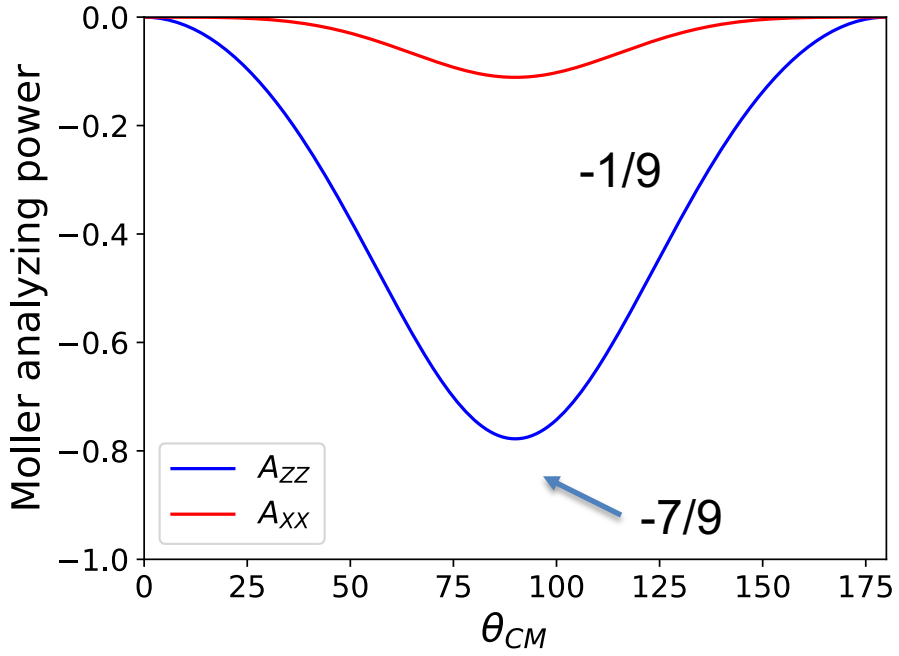
Polarimetry for RCS

Recap from EICUG meeting:

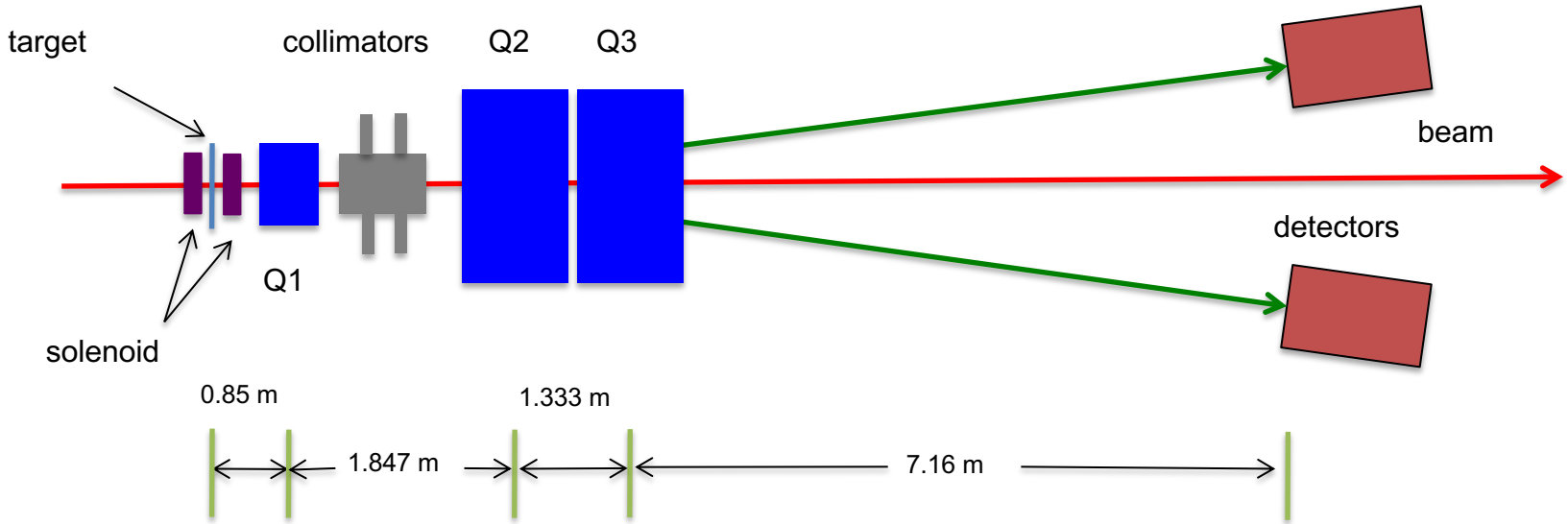
Polarimetry in RCS challenging
→ Beam energy increases from 400 MeV to 5,10,18 GeV
→ Bunch lifetime in RCS is short → 100 ms
→ Low average current: 28 nC bunches at 2 Hz

Møller polarimetry:
→Analyzing power independent of energy
→ Relatively fast measurement times
→ Can't be deployed in RCS since measurement is destructive (ferromagnetic foil targets)



Møller polarimeter could be deployed in transfer line between RCS and ESR

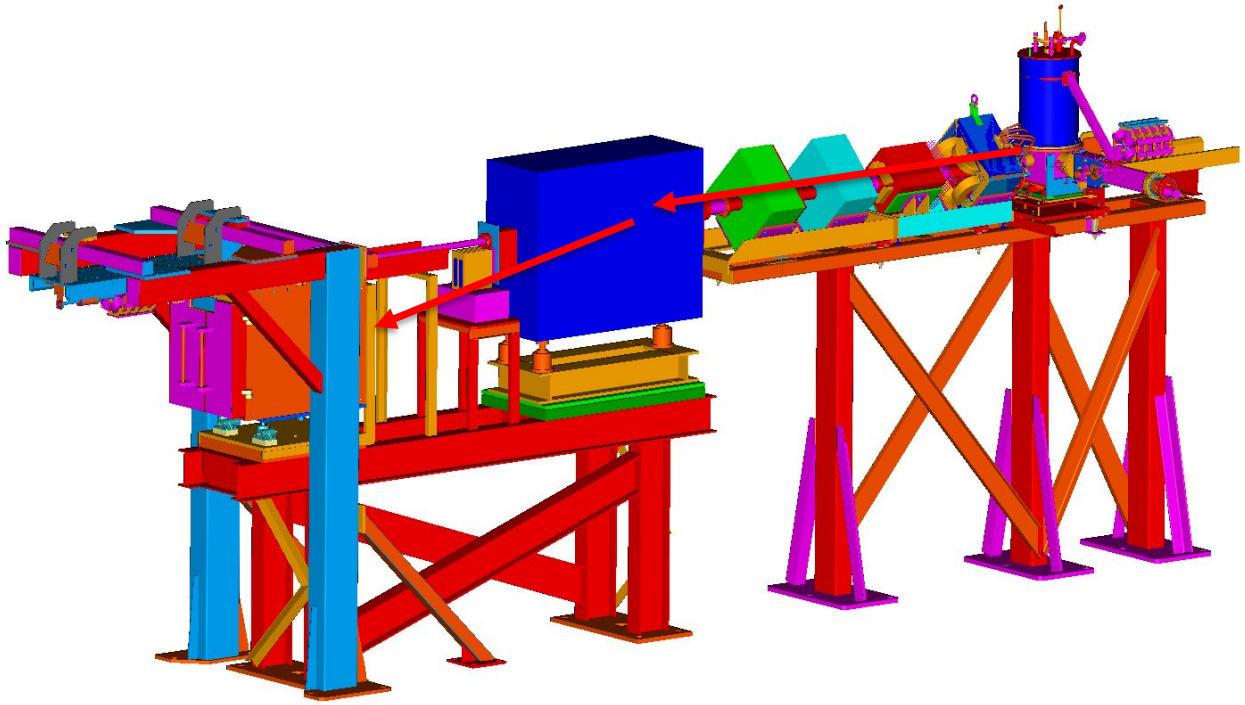
Møller Polarimeter Space Requirements



Hall C Møller Polarimeter uses “2-quadrupole” spectrometer that allows fixed optics/acceptance for full energy range

→ Length along beamline ~ 11 m, detectors at +/- 50 cm
→ Operates up to 11 GeV
→ Requires large bore (10 inch) quadrupoles
→ Some space can be recovered after large quads
→ Operation at 18 GeV would require either longer drift to detector, or smaller separation of detectors from beamline

Møller Polarimeter Space Requirements



Hall A Møller Polarimeter uses 4-quadrupole + dipole system

→ Flexible system that allows multiple optics solutions at each energy

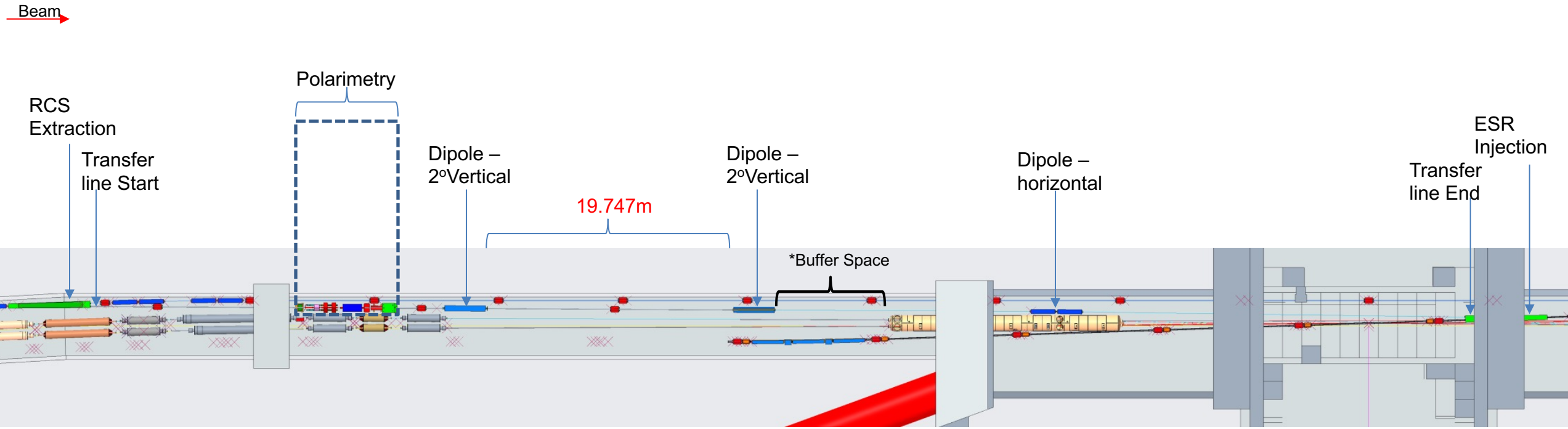
→ Acceptance not defined at a single point

→ More compact than Hall C Møller, ~ 7 m long. Detectors below beamline

→ Like Hall C system, operation at higher energy would likely require more space

Hall A Møller in Transfer Line

First look at integrating Møller polarimeter starting with Hall A design
RCS extraction region very crowded
→ Extraction beam line shares tunnel with several beam lines
→ RCS starts at lower height, beam is kicked up to same elevation as ESR in the extraction line
→ Would like to avoid placing the polarimeter between height-adjusting dipoles (spin precession)
Looking at placing the polarimeter before first dipole, or after last dipole



Polarimeter before vertical bend

Picture courtesy Bijan Bhandari

Hall A Møller in Transfer Line

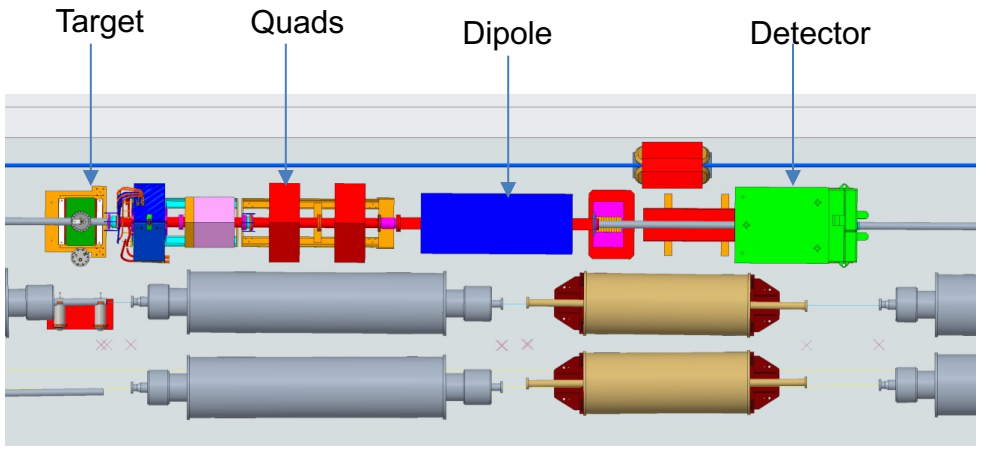
Issues/challenges:

→ Access to components difficult once installed – little clearance between between beamline elements

→ Target magnet and spectrometer magnets need to be more compact

→ Dipole bend must be up to avoid detector conflict with floor of tunnel

→ Hall A polarimeter functions up to 11 GeV – modifications needed for 18 GeV operation. More space along beamline almost certainly required



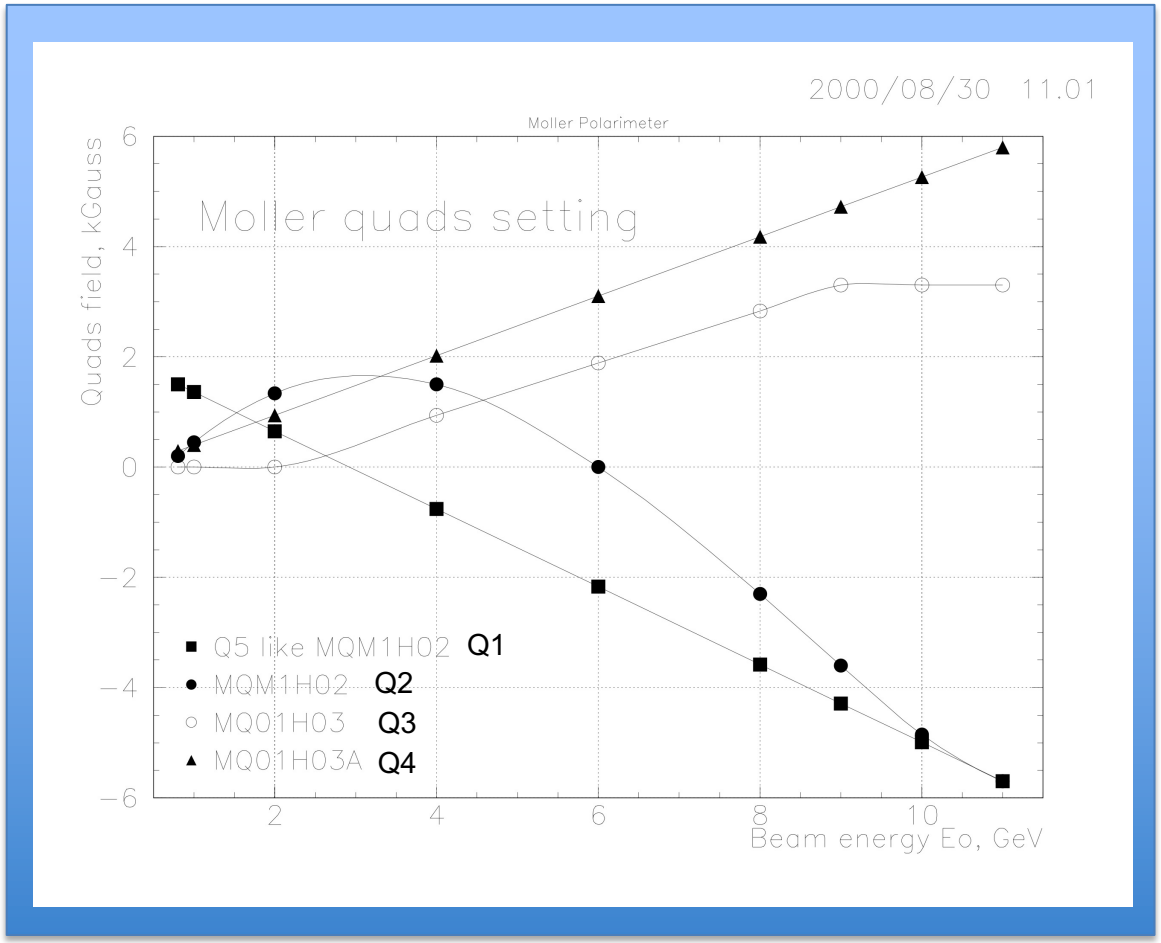
Picture courtesy Bijan Bhandari

Hall A Møller Polarimeter Optics

	Q1	Q2	Q3	Q4
1.1GeV	1.35	0.47	0	0.4
2.2 GeV	0.5	1.5	0	1.05
4.4 GeV	-1.7	0.64	1.5	2.7
6.6 GeV	-2.2	0.75	2.2	3.5
8.8 GeV	-4.1	-3.3	3.2	4.6
11.0 GeV	-5.7	-5.7	3.3	5.8
Field Values in kG				
Max. field	**5.8**	**6.0**	**6.1**	**5.8**

Dipole bend = 7.3 degrees (maximum accessible at 11 GeV)

Several magnets at their limits at 11 GeV



Hall A Møller at Higher Energy

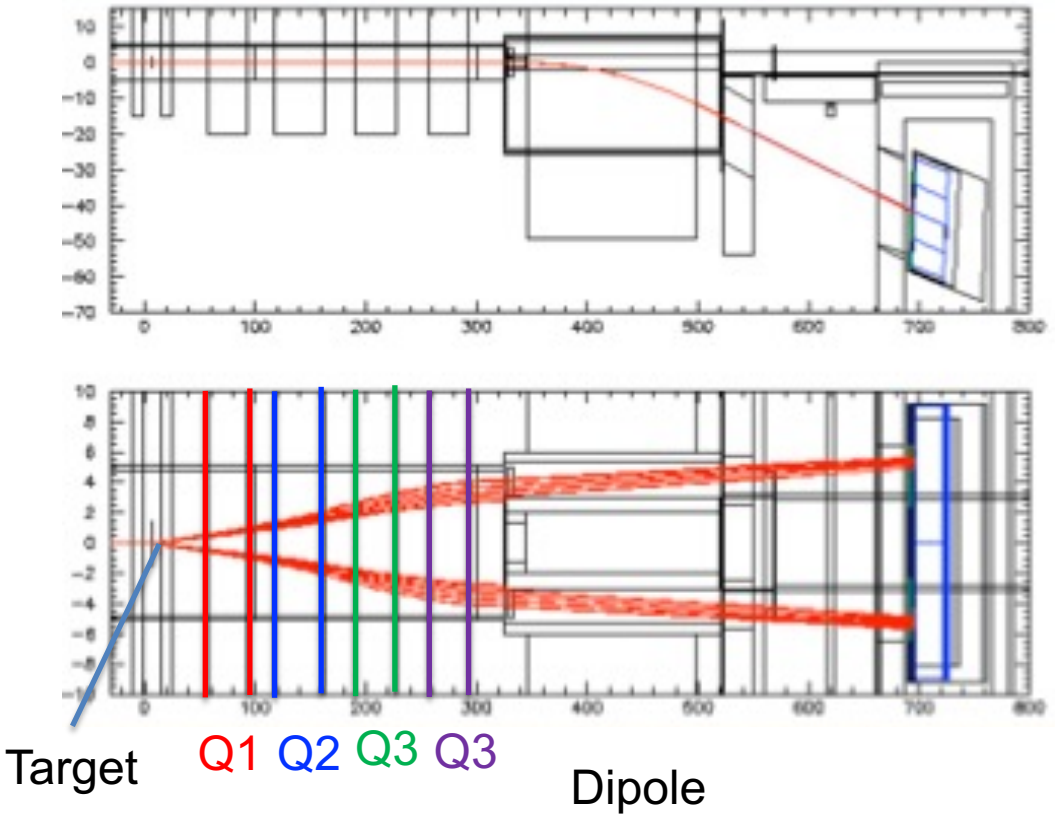
Dipole:

→Operation at 18 GeV, requires reducing bend from 7.3 to 4.5 degrees

→Keeping detectors at same vertical distance from beam would require increasing the drift from by a factor of 1.6 (1.8 m to 2.9 m)

→Could also explore placing detectors closer to beam

11 GeV



Hall A Møller at Higher Energy

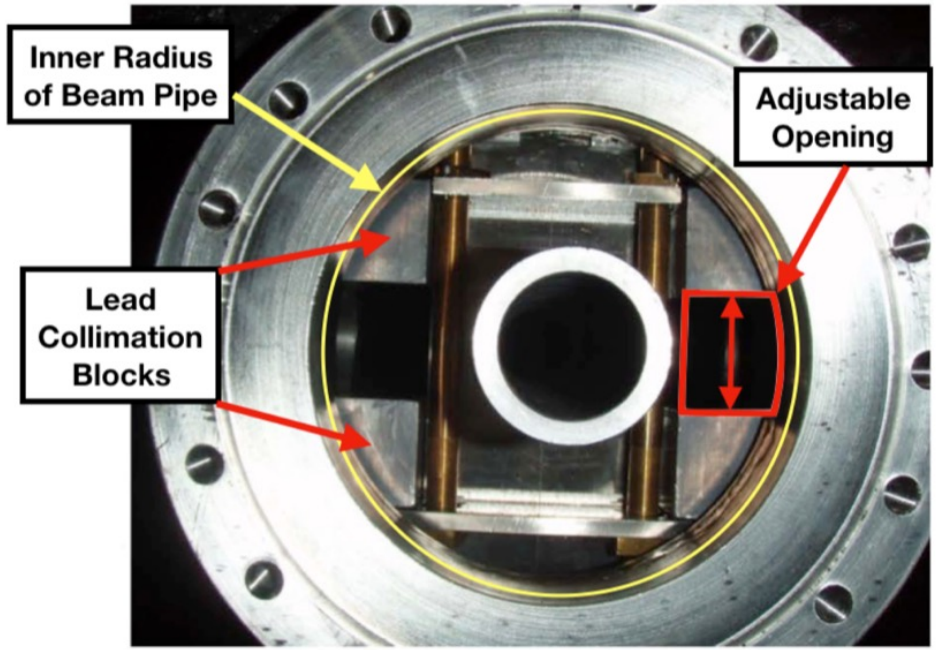
Quads:

→ Quads set to put Møller events +/- 4 cm from nominal beam path at dipole entrance

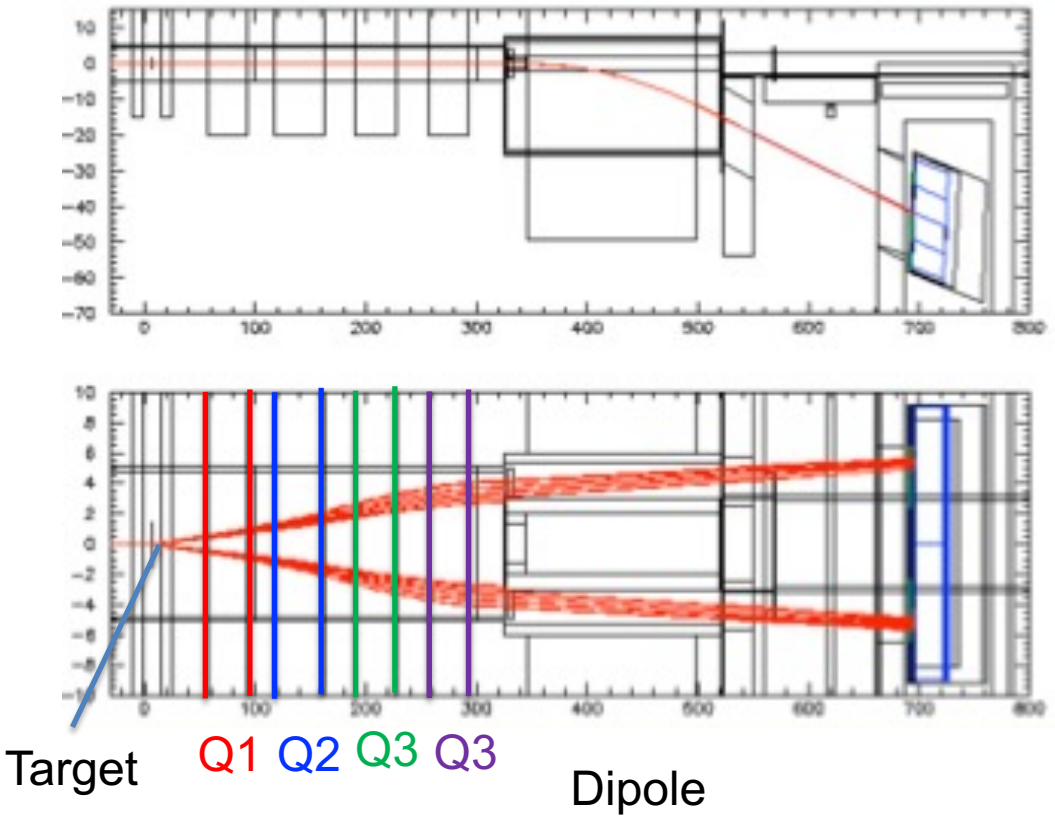
→ Tune optimized to maximize rate while minimizing systematic uncertainties

→ Need to explore alternate solutions, relaxing optimization constraints

→ Moving target further upstream might help



11 GeV

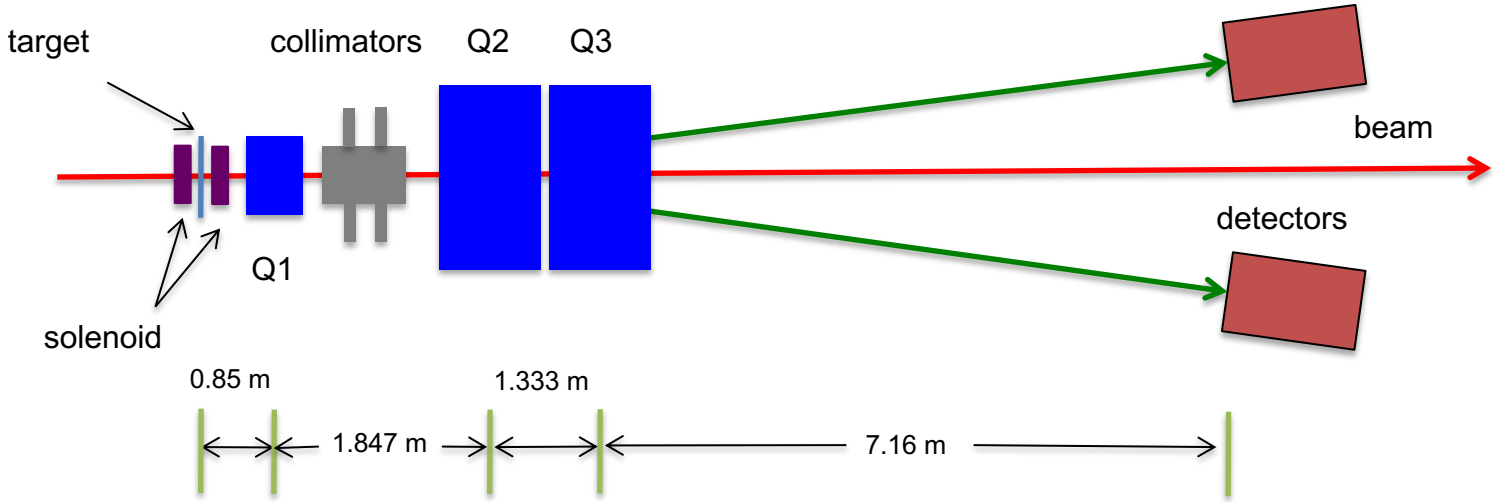


Summary

- JLab Hall A and Hall C Møller polarimeters provide useful basis/prototype for variable-energy polarimeter at RCS extraction line
- Initial design layouts suggest that horizontal spacing might be issue
  - Space along beamline perhaps ok
- More space likely needed for operation at 18 GeV
  - On the order of 1 m extra needed due to dipole limitations
  - Might need more drift before/between quads as well
- Exploration of possible Møller optics solutions the next task

EXTRA

Møller Measurement Time



Time estimates scaled from experience in Hall C @11 GeV
→ 15 minutes for 1% measurement of P_L at 1 μA, 4 μm iron target

RCS: average (extracted) current ~ 56 nA (28 nC bunch at 2 Hz)
→ Transverse analyzing power smaller by factor of 7, ***figure of merit worse by factor of 49***
→ Time estimate for 1% measurement of beam from RCS: 15 min * (1/0.056) * 49 = too long
→ ***Thicker foil (30 μm), reduced precision (10%): Measurement time = 17.5 minutes***

Some discussion of running at larger bunch charge for these measurements