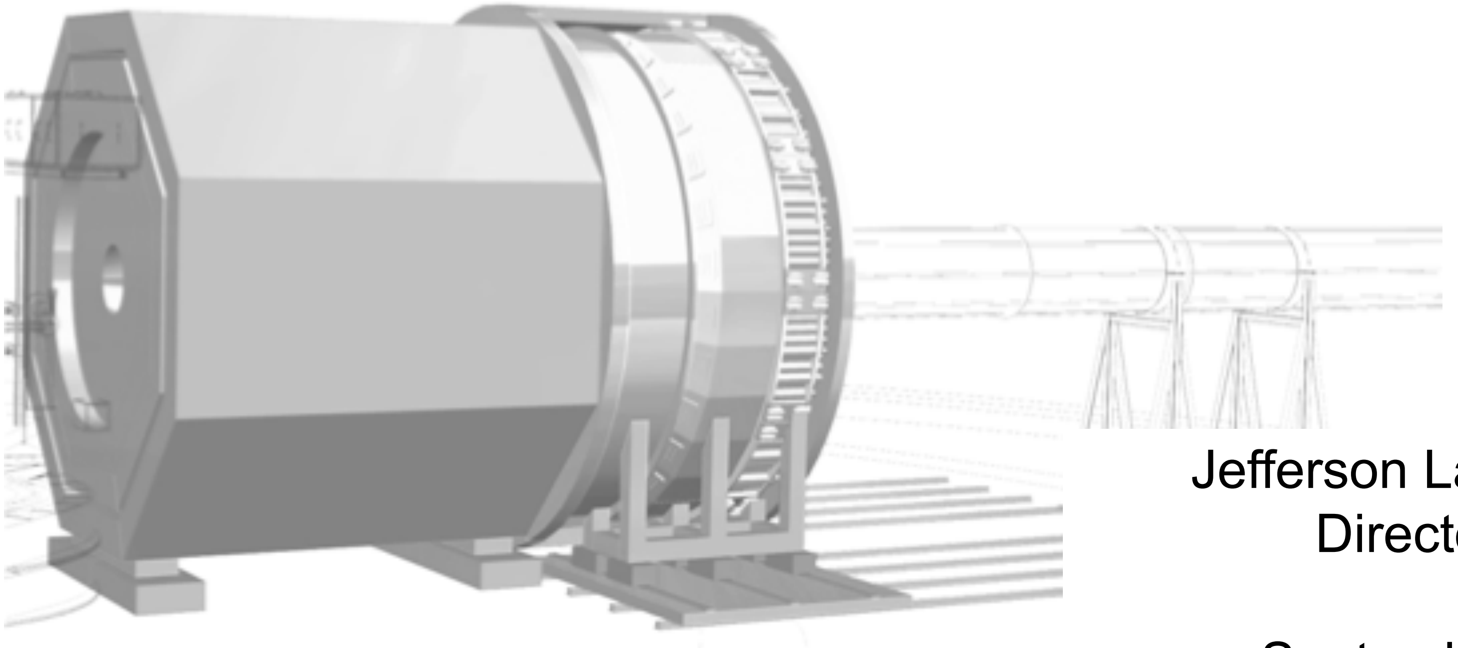
Dependencies



Jefferson Lab SoLID Project
Director's Review

September 9-11, 2019

Thia Keppel
Jefferson Lab

Two Types of Dependencies

1. Dependencies to Base Equipment
2. Experiment-Specific Dependencies

Note: Not to be confused with Enhancements to Baseline Configuration

Dependencies to Base Equipment

1. ***DAQ electronics:*** JLab intends to have an electronics pool to share basic DAQ electronics among the four experimental halls. Some of these electronics, mainly 188 FADCs will be borrowed by SoLID. The cost estimates assumes reuse of SuperBigbite equipment (2K channels of HV, and 100K channels of GEM readout system based on APV25 chips), along with network upgrade up to 1GB/s. It was also assumed that the mass storage silo will be able to handle 3 GB/s by the time the first SoLID experiment runs.
2. ***Magnet:*** JLab formally requested the CLEO-II magnet and received a positive response from Cornell University. JLab, in coordination with Cornell, had the magnet coils, coil collars and cryostat transported to JLab in the fall of 2016. The CLEO-II magnet iron pieces arrived at JLab in August 2019.

3. ***Beamline:*** The Hall A beamline with standard instrumentation is assumed to be in operational condition and is not included in the SoLID base equipment.

Base Equipment 1. DAQ Electronics

The Halls and Physics Division have been steadily purchasing fADCs for shared use. Currently own: 169 Division, 41 Hall A with SBS user contributions, and 49 Hall C (may not be all available, schedule depending) = 259 of which SoLID plans to utilize 188.

All SBS components are expected to be fully available for Hall A continued use after ~2024 (SBS installation scheduled for 2020), and those needed for SoLID will be earmarked and stored for this purpose.

GlueX *currently* sends 1.5GB/s to the silo while the other halls are running. Supporting 3 to 6 GB/second in a few years is not anticipated to be a problem by JLab Data Acquisition Group, as long as the requirements are communicated in advance.

Base Equipment 2. Magnet

CLEO-II magnet coils, coil collars and cryostat were transported to JLab 2016, with remaining steel arriving last month.

A phased plan has been developed for testing, in advance of the project start, to reduce schedule risk (a review recommendation).

Capital Equipment project in place (Phase I) for the laboratory to have a superconducting solenoid compatible with the lab's other magnets, CLEO-II testing and refurbishment

- Work to static test
- Instrumentation and controls to reduce highest schedule risk
- Cryo reservoir

Operations to incrementally achieve low field testing (Phase II)

- Re-use either one of the existing HMS quad power supplies when newly procured ones arrive, or one of the HRS-R supplies
- Some procurements necessary to enable running the power supplies outside of the Hall
- Requisite resource availability expected in the next year-to-year-after time frame

Base Equipment 2. Magnet

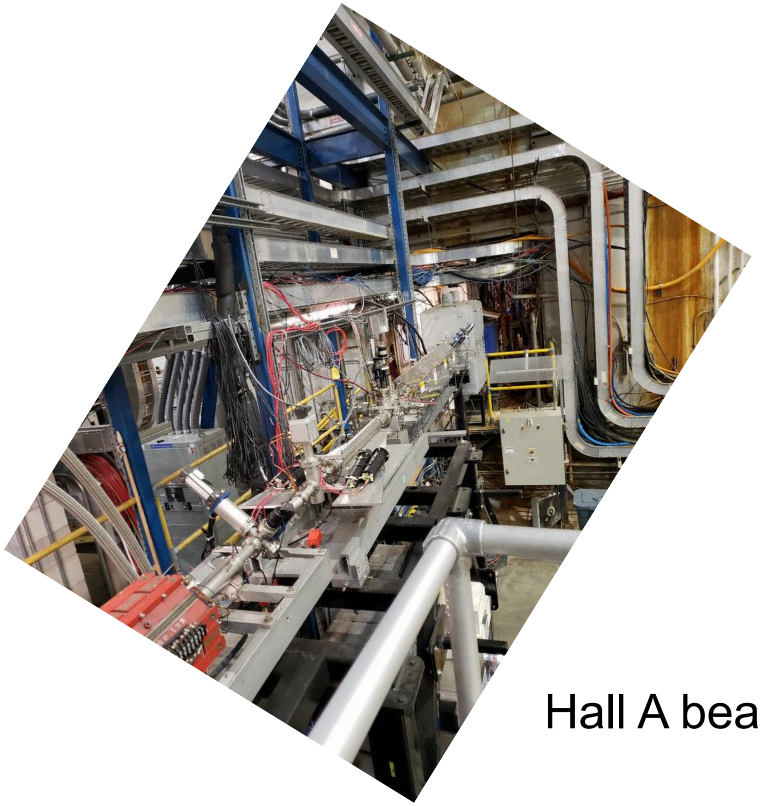
Cryostat and yoke steel stored in Jefferson Lab test lab high bay

Final 37 pieces of steel arrived at Jefferson Lab Summer 2019

Base Equipment 3. Beamline

The Hall A beamline is equipped with sufficient charge and position monitoring, raster magnets, polarimetry, focusing and steering magnets, parity instrumentation, to accommodate SoLID.

SoLID beamline optics, assuming use of existing Hall A components, have been studied by Jefferson Lab accelerator experts.



Hall A beamline in (current) PREX2 era

Experiment-specific Dependencies

1. ***For SIDIS with a polarized ^3He target:*** The existing polarized ^3He target with performance already achieved from the 6 GeV transversity (E06-010) experiment is required. However, modifications to the stand, supports, and service may be required to accommodate integration into SoLID.
2. ***For J/Ψ the standard cryogenic LH2 target system is assumed.*** This is standard Hall A equipment, however the SoLID SIDIS configuration will require re-arrangement of the detector system for the target and there may be significant modifications required for both to accommodate integration into SoLID.
3. ***For PVDIS: A Compton polarimeter and a super-conducting Moller polarimeter*** (both also required by the MOLLER project and to be employed for PREX-II also) are assumed to be available.
4. ***For PVDIS: modifications to a custom, high-power cryotarget*** beyond what is required for the SBS GEp and MOLLER experiments. The scope will be folded into JLab's planning. ESR2 is assumed to be available as required by the MOLLER project.
5. ***For SIDIS with transversely polarized proton: a transversely polarized proton target needs to be developed.*** The development of such a dynamic nuclear polarized target is required for other approved experiments in the JLab science program. An initial study has been performed by Oxford which concluded that such a target is feasible.

Experiment-specific Dependency 1. polarized ^{3}He target

Currently installing in Hall C for 2019 run

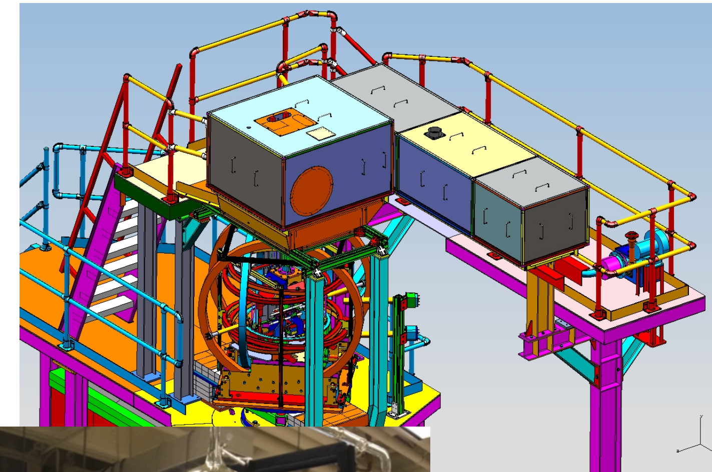
- Goals:

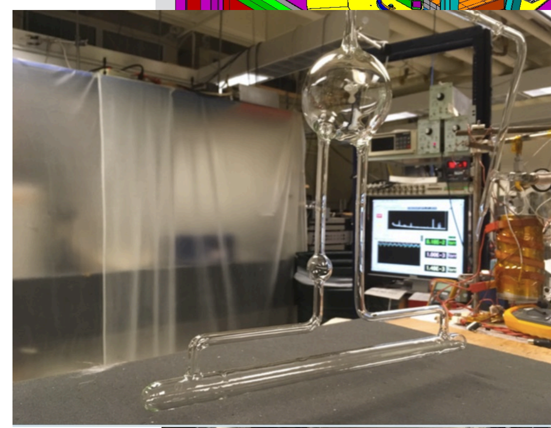
30 uA on 40 cm , ~10 atm, $\mathcal{L}$ ~ 2.2x10^{36} cm^{-2}s^{-1}

In-beam polarization ~ 55-60%,

Polarization measurement precision ~ 3%

Adequate for SoLID science





- Design and fabrication complete.
- Lasers and fibers in hand.
- Instrumentation working.
- EPR and Pulse NMR (new) polarization measurements working.

Target cell production is underway:

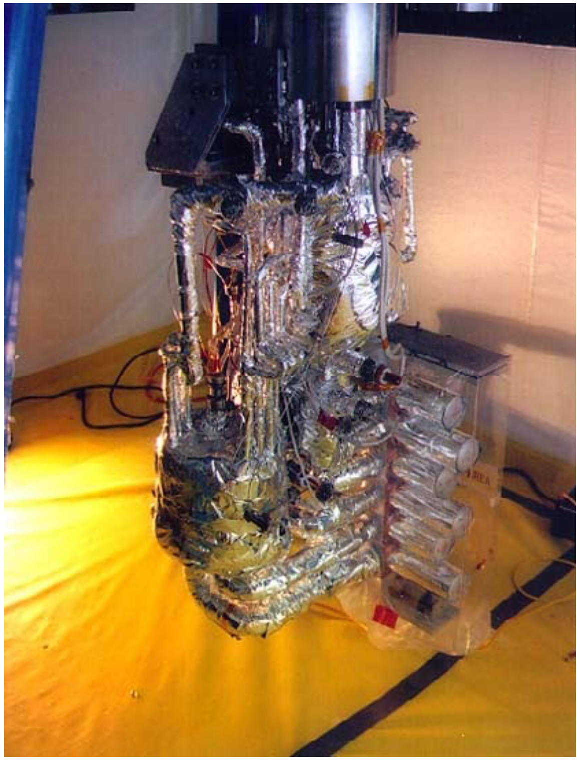
- Production/filling at W&M and UVA
- Testing/characterization at (JLab and) UVA.
- 2-3 usable cells in hand.

Planned upgrade for Hall A SBS G_e^n experiment

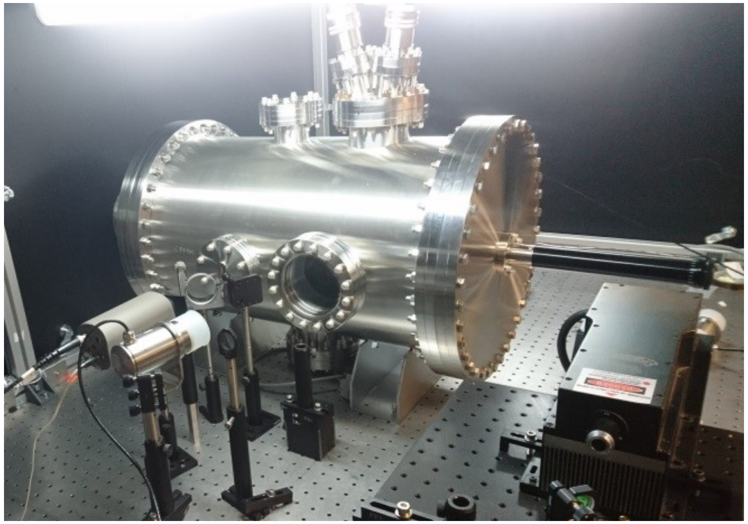
Experiment-specific Dependency 2. standard cryogenic LH2 target

- Design modifications, different chambers, stands, supports, custom cell designs and the like are routine Hall and JLab target group operations.
- Integration into SoLID will require such effort.

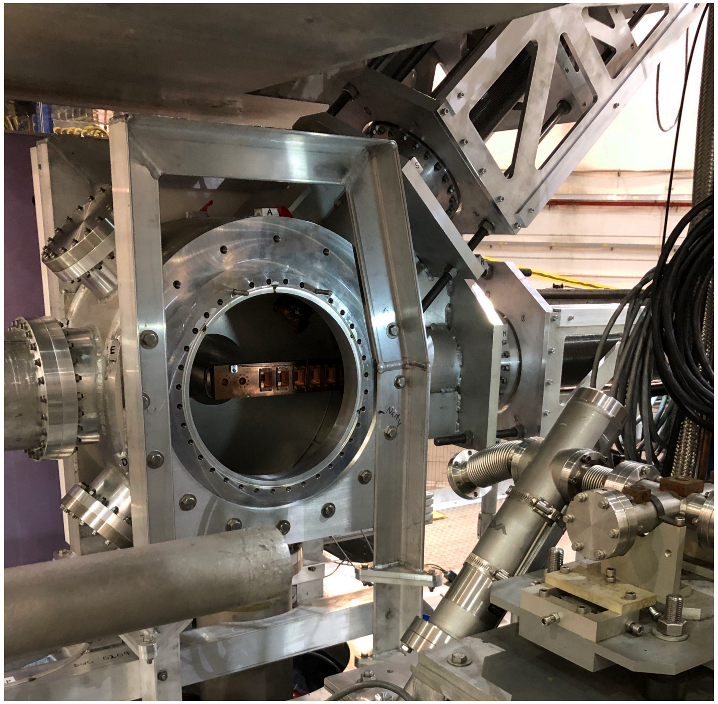
Standard cryotarget ladder



APEX (2019 run) target heat load testing



PREX2/CREX target currently installed in Hall A

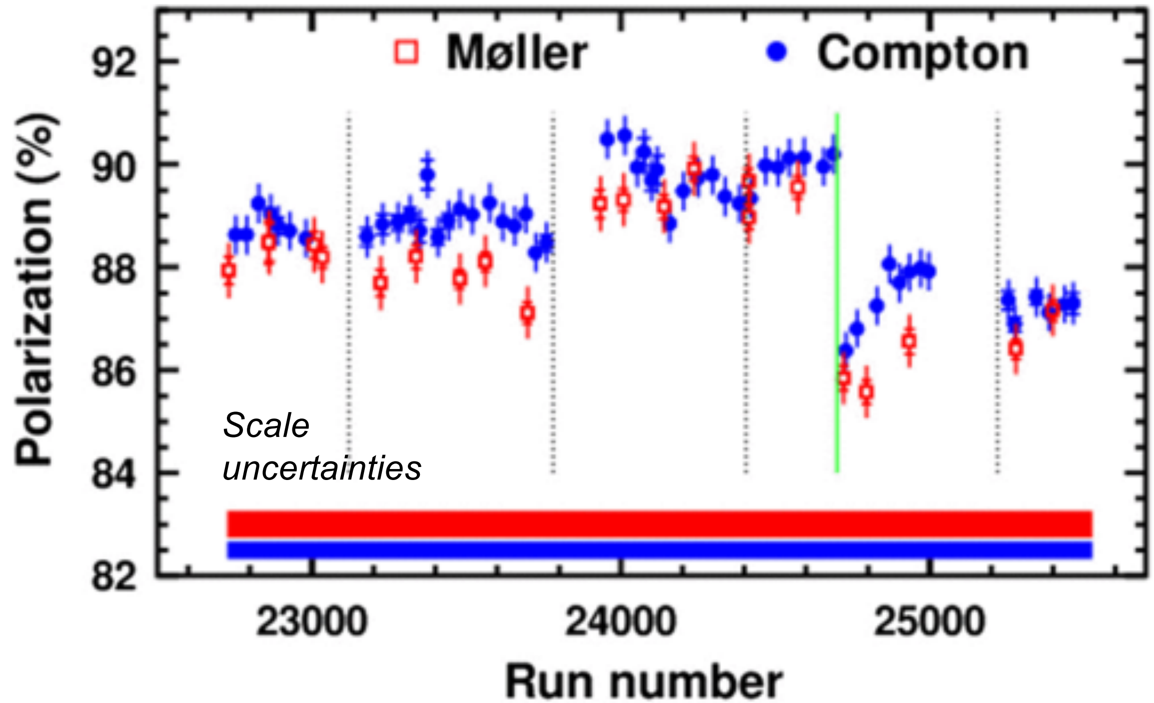


Experiment-specific Dependency 3. polarimetry

Beam polarization for SOLID will be measured in Hall A using existing Compton and Møller polarimeters

Polarimetry in 6 GeV era:
HAPPEX 3 (2009): 1% at 3 GeV
PREX (2010): 1% at 1 GeV
QWEAK (2012): 0.6% at 1 GeV
Compton→ dP/P = 0.59%
Møller → dP/P = 0.85%

Hall C: Q-Weak, Run 2



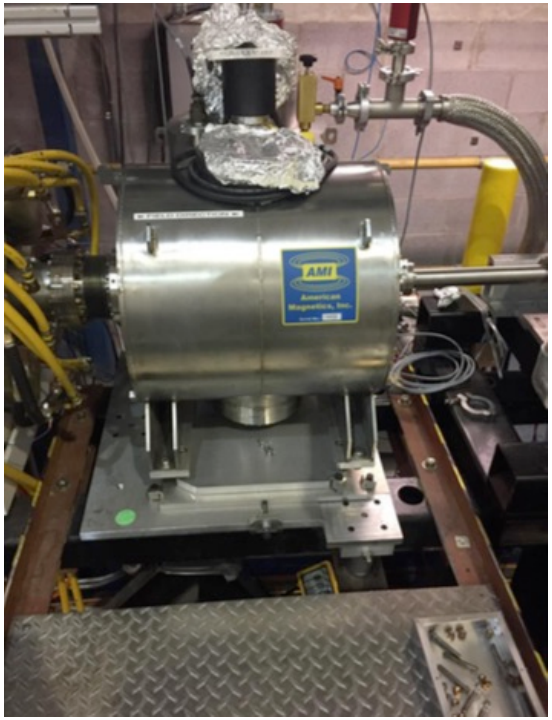
Precision achieved during Q-Weak (Hall C) approaches that needed for SOLID
→ *Similarities between Hall A and C systems allow lessons from Q-Weak to be easily applied in Hall A*

Precision Polarimetry for SoLID

- Near-term goal is to achieve similar capabilities for Hall A and C polarimetry to fully leverage available beam-based opportunities for development

- Global Hall A/C polarimetry improvement plans via Capital project
  - Laser system for Hall C (low gain cavity → high gain cavity)
  - Upgrade Compton electron detector DAQ for Hall C (new VTROC system already planned for Hall A)
  - Electron detectors for Halls A and C
    - Existing Hall C detector size marginal for 11 GeV
    - Existing Hall A detector suffers from poor performance
  - Operations support
    - New target magnet for Hall C (operations)
    - New target ladders, single design, for Halls A and C

- Further Polarimetry improvements as part of MOLLER project
  - Hall A Møller polarimeter
    - Tracking detector (GEM)
    - Improved collimation system



Polarimetry Plan – Electron Detector

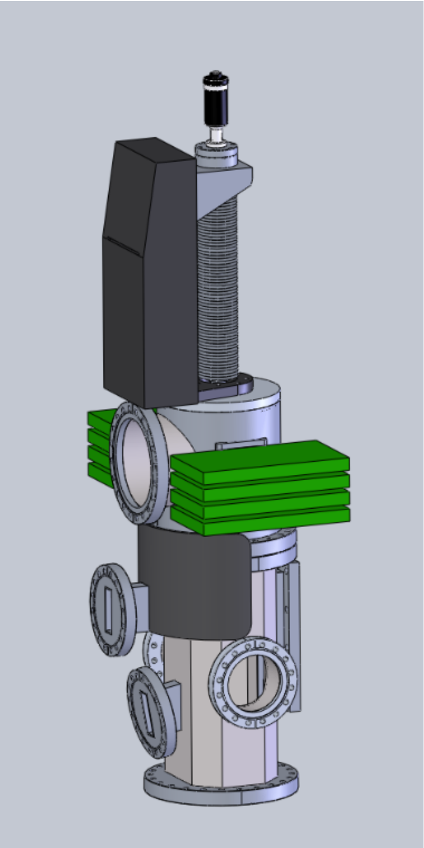
As part of Capital project, will build and install improved electron detector system in Hall A

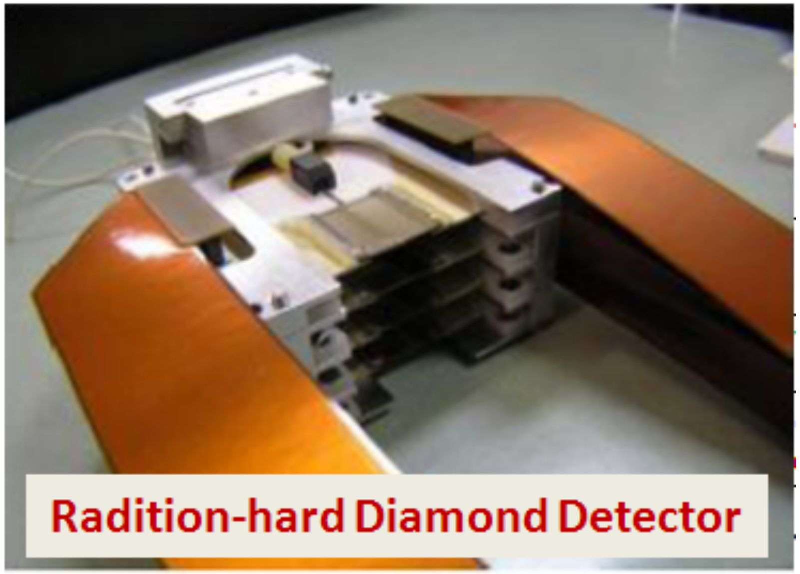
→ Default system will be modeled on successful Hall C diamond strip electron detector

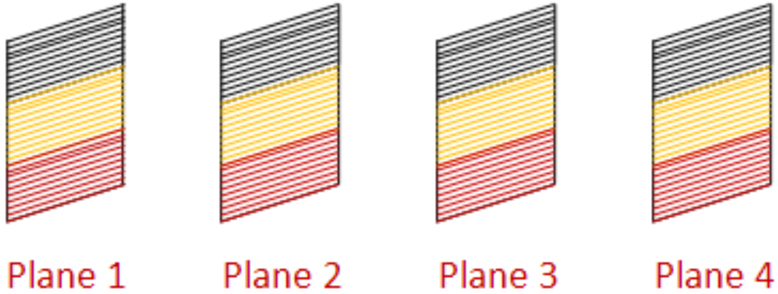
→ Alternate solutions may be implemented depending on outcome of upcoming tests

Components:

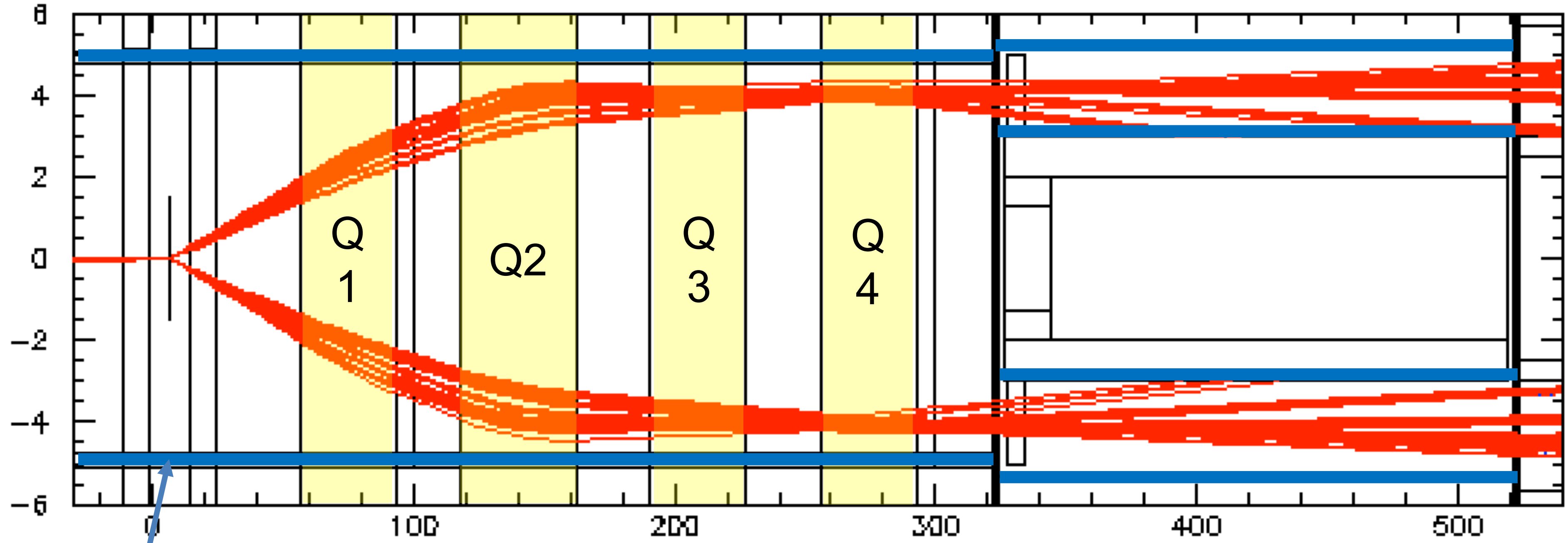
1. Diamond detector
2. Amplifier-discriminator cards
3. Vacuum can (w/appropriate feedthroughs)
4. Motion mechanism







Polarimetry Plan – Møller Polarimeter



Magnet aperture/beampipe

Q1=1kG Q2=1kG Q4=0.2kG

Acceptance not determined at any single point in polarimeter system

→ Install additional collimator to better define detector acceptance – constrain analyzing power

→ Additional tracking detector (GEM) in front of calorimeter to improve understanding of polarimeter optics

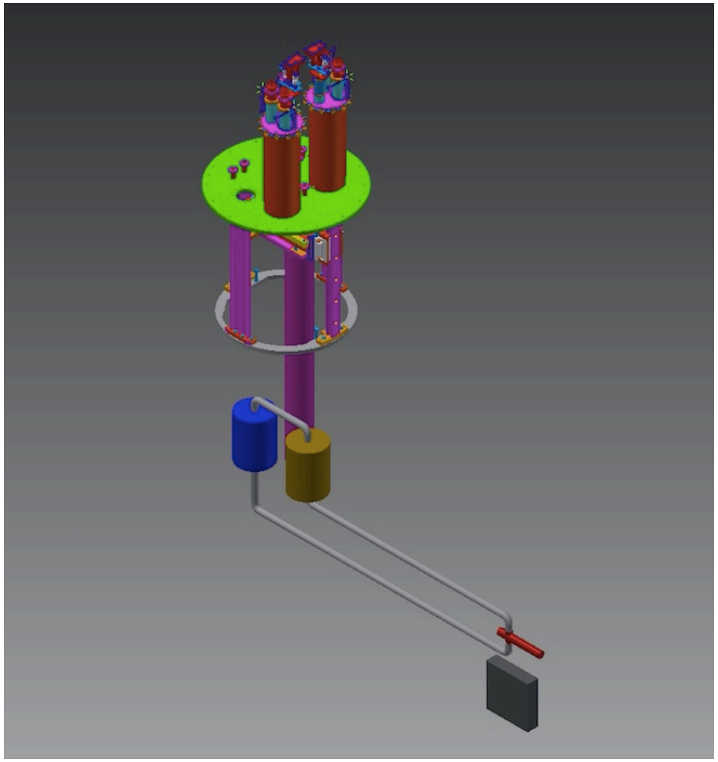
Experiment-specific Dependency 4. high power cryotarget

- *Initial* conceptual design document exists, defines necessary parameters and requisite components

- Requirements of the SoLID target regarding density fluctuations are less stringent than the G0, Qweak, or MOLLER targets.

- Analysis of the cell design using computational fluid dynamics (CFD) will be employed to ensure an acceptable cell design.

- Will require a custom, L-shaped system.

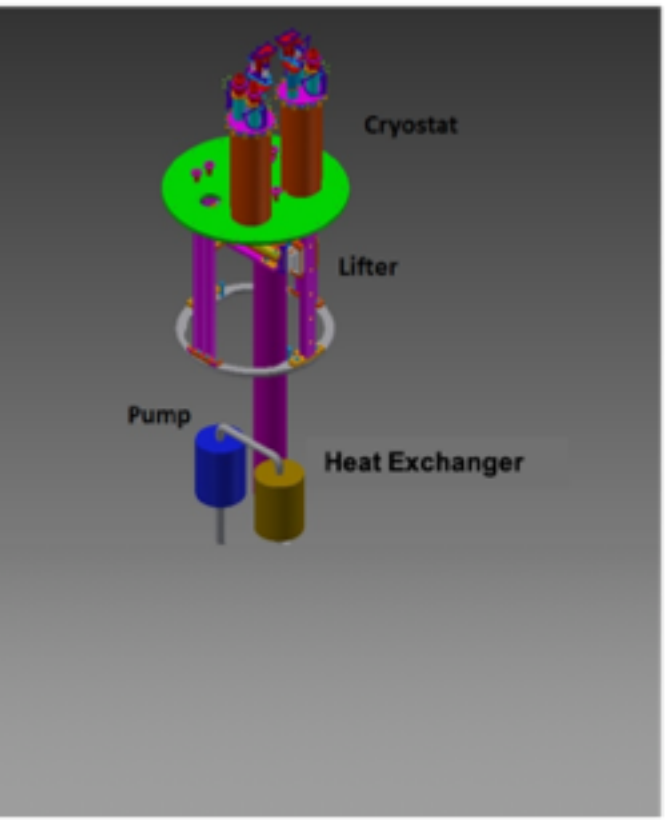


Experiment-specific Dependency 4. high power cryotarget

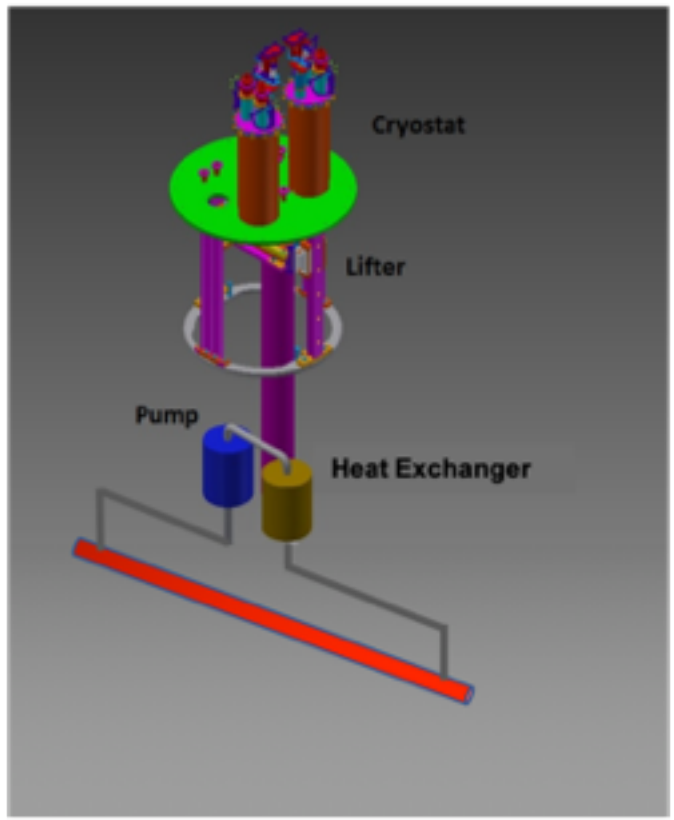
Since the MOLLER experiment target is still in the conceptual design phase, it might be easier to adapt this for SoLID than the existing 3-loop cryotargets

- design with compatibility in mind

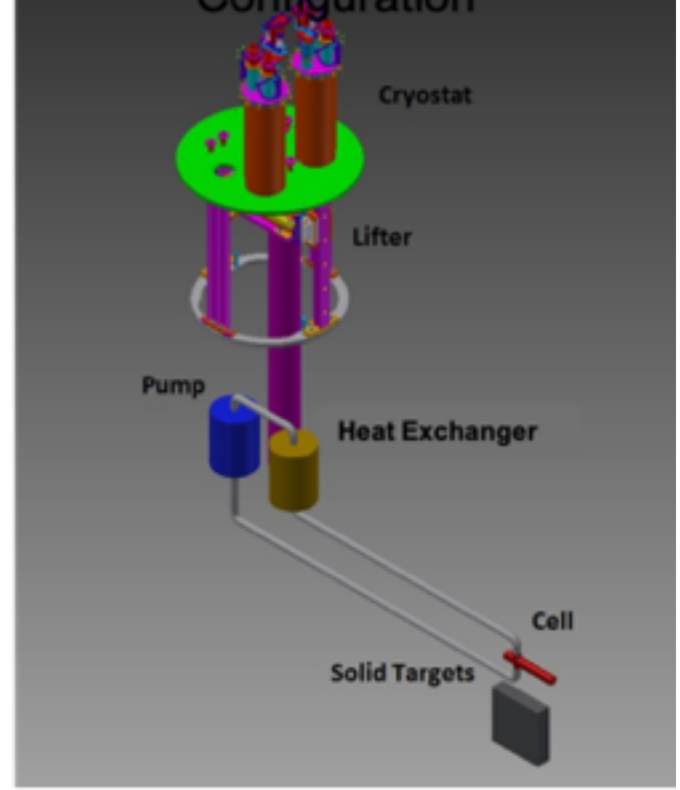
High Power Cryotarget



Moller Configuration



SoLID PVDIS Configuration



ESR-2: Project Overview Budget and Schedule

- ESR 2 building was Completed in December 2010
- Project funds of 9.9M$ awarded – April 2018
- Project funds rescinded in June 2018
- Funds may be re-awarded in FY2019 or FY2020
- PEP (Project Execution Plan being written)
- Received some internal funding to start design work

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Experiment-specific Dependency 5. polarized proton target

Needs development

Existing JLab targets are optimized for longitudinal running

Magnet opening angle parallel to field: $\pm 55^{o}$

Opening angle perpendicular to field: $\pm 19^{o}$

SoLID experiments focus on transverse polarization and require opening angle $\geq \pm 25^{o}$

Target group recommendation:

Design new 5T magnet with a larger opening angle for transverse experiments and integrate into existing JLab system

- Hopefully could be designed as a drop-in replacement for the current 5 T magnet, which would continue to serve in longitudinal experiments. The rest of the system would remain (mostly) unchanged.
- Other system components would, however, need upgrades.
- Will need a beamline chicane.
- The laboratory is currently discussing an updated system for a transverse polarized target for the CPS in Hall C.

SoLID Polarized Proton Target

- Oxford Instruments Design Study (Nov. 2012):
  - Initiated by Don Crabb, UVa
  - Describes a high homogeneity, 5 tesla magnet w/ ± 25^{o} split
  - Helmholtz configuration of 14 superconducting coils in series
  - Operating current for 5 Tesla is 106 amps
  - Design, dimensions, and current are similar to Hall B & C polarized target magnets
  - Detailed ANSYS study was performed of forces acting on the coils

Conclusion

"Analysis indicates that 5 tesla with ±25 split access is realizable…"

Design Report rfq 13241, Oxford Instruments Nanotechnology Tools LTD, Nov.12, 2012

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