Report of the Review Committee for the SoLID Director's Review

Jefferson Laboratory
23-24 February 2015

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Executive Summary

The Director's Review for the proposed SoLID detector and its experimental program was held at Jefferson Lab on February 23 and 24, 2015. The reviewers had access to the SoLID pCDR, copies of the proposals for the approved experiments utilizing SoLID as well as copies of presentations. During the review, additional information was provided by the collaboration. This information included additional details on manpower, installation schedule, the report from a Dry-run Review carried out in 2012, as well as anticipated physics comparisons with other 12-GeV experiments. The review was organized around a series of overview talks covering most aspects of the experimental program, the detector and the management and costs. Breakout sessions focused in more details on detectors, engineering, costs, software and data acquisition.

The Preliminary CDR (July 21, 2014) is well developed for this phase of experimental planning. Of particular note is Appendix B, which contains details on each major system such as duration, needed JLab support, and anything unique to the system that drives the project. The SoLID detector, as proposed, together with its suite of highly-rated experiments make this program at least as large as both the GlueX program in Hall D and the CLAS-12 program in Hall B.

Overall the Committee members were very impressed with the quality of the material presented and the state of SoLID as presented. They were also very impressed with the high level of international contributions to SoLID. The collaboration should be commended on the international nature of their effort. The Committee felt that SoLID was in a good state to move forward, but also identified a number of areas where additional work will be needed, as well as a number of items that are either not included, or underestimated in current planning. The recommendations from this report, together with the excellent comments in the Dry-run review report from 2012, can provide guidance on moving SoLID towards its ultimate realization.

1. Physics Relevance and Risks

1a. The completeness and credibility of the discussion of the experimental reach, including statistical, systematic and theoretical uncertainties.

Observations

- The proposed SoLID detector and suite of experiments will be at the same scale, or larger, than both the CLAS-12 and GlueX experiments.
- The core of the physics program with SoLID was presented to consist of five JLab PAC approved and highly rated experiments, namely three SIDIS, one PVDIS, and one threshold J/ψ production measurements.
- Luminosity and acceptance requirements were presented for each of the five core experiments.
- Systematic effects and uncertainties were presented for each of the core measurements.

Findings

- The physics requirements were not well translated into quantitative experiment and subsystem specifications.
- End-to-end physics simulations for the core measurements are lacking.
- It is plausible that the PVDIS requirement to measure absolute beam polarization to 0.4% can be met, although this has not been demonstrated at this time.

Recommendations

- End-to-end simulations with realistic subsystem responses and material budgets, and complete track finding and reconstruction should be developed.
- Acceptances, efficiencies, and systematic uncertainties should be simulated for each of the core measurements.
- For the PVDIS measurements, the viability of the elastic scattering calibration procedure, to determine absolute Q^2 should be demonstrated by simulations for similar scattering angles to those probed in DIS, and with realistic misalignments.
- Bin migration effects should be simulated for the measurements of the sharply rising J/ψ production cross section near threshold.

1b. Ability to handle the desired luminosities and backgrounds including impacts on both the apparatus and the beam line downstream of the target.

Observations

- Simulated signal and background particle fluxes were presented for the PVDIS and SIDIS measurements.
- The corresponding trigger rates and DAQ requirements were derived.
- Simplified track reconstruction algorithms have been used to make initial estimates of tracking efficiencies and ghost rates.

Findings

- The requirements on magnetic field and resolution can be met.
- The displacements for beam momentum particles in the forward direction are feasible.
- The SoLID simulation framework is in the beginning stages of development.
- The results from the present, simplified track reconstruction effort do not reveal evident showstoppers, but also do not demonstrate measurement capability.

Recommendations

- The signal and background trigger rates should be simulated for the J/ψ measurements.
- The dead-time(s) in the DAQ chain should be modeled.
- The development of a simulation framework with realistic reconstruction and analysis should be pursued with high priority and increased resources.

1c. The implications for the relevance of the physics results in the context of possibly competing experiments at both Jefferson Lab and internationally.

Observations

- The five core measurements of the program with SoLID have been highly rated and approved by the JLab PAC.
- The expected results from the SIDIS program were compared to results of completed experiments.

Findings

- The PVDIS program with SoLID at JLab presents unique opportunities to carry out a broad program of ~10^{-4} parity-violating asymmetry measurements in the DIS regime through a combination of high luminosity, large acceptance, high-rate capability, and systematic controls.
- The PVDIS measurements will, at the proposed accuracy, form a very significant new measurement of the difference of the couplings, $C_{2u} - C_{2d}$, of the Standard Model coupling of electron vector and quark axial currents in parity violating lepton-nucleon scattering.
- The complementarity of the SoLID PVDIS search for the existence of non-SM physics with LHC direct searches was illustrated with the selected case of a lepto-phobic Z'; a broader treatment, including complementarity with the Møller and MESA efforts, would be beneficial.
- The expected results from the SIDIS program are expected to provide a significant improvement in reach and precision beyond competing experiments, such as the SBS program and CLAS12.
- The J/ψ electroproduction cross-section near threshold, if it is large, could conceivably be observed as part of the program with CLAS-12; similarly photoproduction could be observed first by GLUEX.
- Intensified effort with the theory and lattice QCD community may make it possible to assess the impact of the proposed J/ψ threshold measurements on the conformal anomaly of QCD and its contribution to the proton mass.

Recommendations

- Better comparisons with the expected results on programs such as SBS and particularly CLAS12 are needed to clarify the need for the SoLID SIDIS program. Crisp demonstrations of the improvements possible with SoLID should be developed.
- The SoLID Collaboration should investigate the possibility of kaon identification, especially given their high luminosity.
- The SoLID collaboration should investigate the feasibility of carrying out a competitive GPD program. Such a program would seem particularly well suited to their open geometry and high luminosity. If SoLID's luminosity is sufficiently high to permit a program of precise Double Deeply Virtual Compton Scattering (DDVCS) measurements, it would make a groundbreaking contribution to GPD studies.

2. Viability of Approach and The Experimental Technique

2a. Any R&D required to meet the technical challenges of the experiment.

Observations

- Individual sub-detectors presented a timeline for their R&D.
- The reference designs of the Cherenkov detectors were presented.
- Magnetic field tests of PMTs for the gas Cherenkov detectors have been carried out.
- A heavy gas Cherenkov prototype will be built and tested in the near future.
- Prototyping for the pre-shower detector has started.
- A good baseline design for the electromagnetic calorimeter was presented.
- Simulations were presented for the EM calorimeter for physics and trigger performance.
- Other experiments have extensive expertise with scintillating fibers and SiPMs in harsh radiation environments, like LHCb.
- A design for the Scintillating Pad Detectors (SPDs) was presented.
- The FASPDs are read out using wavelength shifting fibers and MA-PMT; the LASPD is readout directly with fine-mesh PMTs.
- The full cost for the GEM foils has been put in the base cost for the detector. A US company (Tech-Etch) is a possible commercial vendor for GEM foils. A backup solution is procuring GEM foils from CERN.
- The low-conductivity glass allows for an MRPC system that can handle the expected rates.

Findings

- The specifications for each detector were not well motivated by a corresponding physics goal.
- The choice of fiber for the EM calorimeter seems well motivated with respect to radiation damage.
- The plan to rely on an outside international laboratory to produce EM calorimeter modules seems risky, considering difficulties with communication observed so far.
- The simulations do not seem to include the support structures and inactive material.
- The choice of GEMs as a tracking detector in a high-rate environment seems very well motivated.
- The US groups have good experience in designing and building GEM chambers.
- The GEM foil technology has not yet been transferred to a commercial company in China.
- The results shown indicate that the conductivity of the MRPC glass may not be as stable over time as required.

Recommendations

- Develop an overall R&D plan for the project with a timeline
- Close interaction between the US and Chinese groups in the development of GEM foils to assure good quality control is highly recommended.

- Investigate the schedule risk when GEM foils are not produced in a timely way and continue to pursue Tech-Etch as a potential supplier for the foils.
- The calorimeter group is encouraged to contact other groups (ALICE, LHCb and possibly CMS) to understand the detector design choices these groups have made and resources needed for construction.
- The stability tests of the conductivity of the glass for the MRPCs should be extended for a much longer period and the risk associated with the R&D needs to be identified.
- The collaboration is strongly encouraged to develop an end-to-end realistic simulation and reconstruction to further optimize cost and physics reach and derive clear performance requirements for the individual subdetectors.
- The collaboration is encouraged to explore the power of extended kaon identification (through Cherenkov or TOF).

2b. Proposed magnet concept and choice, including magnet configuration modifications (if any), magnet cool down and infrastructure requirements.

Observations

- The choice of the CLEO magnet is well motivated by the physics demands of the experiment, and plans are in place to transfer the magnet to Jefferson Lab by 2017.
- Costs for this move are captured in operations.
- SoLID plans include reusing the existing CLEO magnet power supply.
- The CLEO magnet has not been used since 2008.
- The CLEO magnet will be difficult to work on in Hall A.

Findings

- Appropriate testing, both when the magnet arrives at Jefferson Lab, and prior to installation need to be included in the budget.
- No plans or costs for mapping the magnet have been included in the schedule.
- The cost and schedule impact to the project could be significant if the CLEOII magnet does not operate as expected.
- The magnet power supply from Cornell will likely be 25 years old when SoLID runs.

Recommendations

- The Committee strongly recommends testing the CLEO magnet coils (cold test), power supply and controls, before installation in Hall A.
- A new magnet power supply should be included in the total cost of SoLID.
- Evaluate the schedule impact of mapping the magnetic field in situ in Hall A.

2c. Proposed detector concept and associated electronics and data acquisition.

Observations

- SoLID plans to use much of the current 12-GeV electronics from Jefferson Lab.
- Plans for using the APV25 chip for GEM readout were presented.
- The Level 3 trigger was not described and no costs were included.
- The slow control needs of the experiment were not presented and no costs were included.
- The SoLID collaboration currently has some simulation and limited reconstruction.
- The manpower currently associated with software for SoLID is estimated to be 6 FTE-years. Numbers from both Hall-B/CLAS-12 and Hall-D/GlueX are in the range of 30 to 50 FTE-years.
- The data scale expected from SoLID is similar to that anticipated in Halls B and D, while that in the early Hall-A experiments have a much smaller data footprint.
- No plan for data handling was presented.
- Data storage needs for Monte Carlo simulations were not included.

Findings

- Consultation with appropriate people from the other halls would be useful to get a more accurate estimate of software needs, including manpower.
- Early exploration of the tools available at Jefferson Lab that can handle the data at the expected scale of SoLID will be crucial in minimizing the false starts in software development

Recommendations

- The plans for the High Level Trigger and the needs for slow control need to be worked out in detail and the implications for resources need to be evaluated.
- The implications of the need for these resources in the context of availability of resources at the laboratory need to be understood.
- Closer communication with the other JLab experiments and the JLab computing center is strongly encouraged.
- Having a functional simulation and reconstruction routines as soon as possible should be a high priority in the software effort. Such software will pay off many times over in experimental design and avoiding pitfalls.

2d. Beam line design, including collimation and shielding.

Observations

- The most intense radiation comes from the PVDIS configuration.
- Radiation estimates have been made with three models, which are in reasonable agreement.

- Borated shielding inside the solenoid is effective in reducing neutrons.
- Radiation levels are an order of magnitude below that which would damage the APV25 chips.
- Radiation levels are well below that which would damage the superconducting material in the coil.
- Activation of the nose may be an issue for access to detector repair and switching between configurations and the eventual disassembly.
- The baffle was presented as lead.
- Very good initial radiation studies have been completed using FLUKA and Geant4.

Findings

- While the radiation levels to damage electronics appear not to have been reached, the levels may still be high enough to disrupt data taking electronics. Experts should be consulted to understand at what level this becomes apparent.
- The effects of radiation on the front-end electronics have been examined, but the radiation effects on subsequent electronics, that may not be in the shielded hut, appears to be an open question.
- Calculations of absorbed dose to various electronics under various realistic running scenarios and other potentially radiation sensitive components need to be completed and compared to component lifetimes and failure modes. For particularly sensitive electronics, beam tests might be appropriate if data are not available from other experiments.
- The effect of radiation backgrounds on heating of the cryogens in the solenoid have not been investigated
- Detector designs should also consider the impact of activation and the ultimate disposal of radioactive material with the goal of making it possible to easily separate and dispose of the most active material.
- Choice of material in the baffle appears not to have been optimized. A study of the effects of different material choices that incorporate physics signals, background levels and activation of the material could provide useful information. (Lead is a hazardous material, activated lead is expensive to dispose of and lead may have other unintended consequences due to impurities in it.)
- Significant radiation studies need to be completed, including a list of the main components and their activation levels based on several realistic running scenarios. These calculations will likely impact the design of support structures and how components are removed for the next experiment.

Recommendations

- Complete radiation calculations to determine activation and absorbed dose on components of concern and mitigate as appropriate.
- It should be confirmed that the baffle design, including the support structure, is optimized for background rejection and signal acceptance. Furthermore the baffle design should minimize generation of secondary backgrounds.

2e. Cryogenic and polarized target system concepts and integration.

Observations

- Several target designs were presented with different polarizations and cooling requirements.
- The R&D and development of at least two targets was off-project.
- The D2 target for the PVDIS experiment is expected to develop some small polarization due to the solenoidal magnetic field.

Findings

- The plans and R&D necessary to deal with the small polarization of the D2 target need to be fully developed.

2f. Beam polarimetry requirements.

Observations

- A program at Jefferson lab was presented that will develop the required polarimetry that would be required to run SoLID.

Findings

- These developments need to be monitored to ensure that the capability is in place when needed by SoLID.

3. Understanding, Completeness, and Credibility of The Resources Needed for The SoLID Project.

3a. Experience, expertise and quantity of the scientific and technical manpower for the project.

Observations

- The Solid collaboration presented a four-year plan for construction and installation of the baseline detector in Hall A.
- The project is well organized, is enthusiastic and has a good structure of video conferences and meetings in place. This will serve them well during construction, installation and beyond.
- The success of the collaboration in engaging international collaborators and the high level of interest and contributions from the Chinese part of the collaboration is highly commended.
- The project presented a rollup of FTEs and procurement dollars per area and summed, including overhead and contingency in FY2014 dollars. The total cost was $59.1M with $11.3M being contributed from other sources and $47.7M from the MIE. This was based on 139.4 FTE-years with 83.1 of those FTE-years from JLab. For the FTE-year rate a single average JLab value was used of $125K unburdened.
- The duration of the project was assumed to be 4 years, including 1.5 years of installation.
- An initial breakdown of resources by types of people (engineers, technicians, etc.) was provided by area and rolled up.
- Project management was listed as 6 FTE-years and offline software as 6 FTE-years total. In addition, the project listed an average of 1.6 postdocs per year during construction and installation.
- Costs for a portable crane, full field measurements of the magnet (including the procurement of materials to do this), cooling system, slow controls and the cost of the level-3 trigger were not included in the estimate.

Findings

- Based on experience of other major installations at Jefferson Lab the four-year plan for construction and installation is seen as aggressive. A more realistic plan in line with the Halls B and D experience should be developed.
- Adopting project management tools early in the project will go far in identifying and alleviating bottlenecks. It will also help make optimal use of manpower and resources and make plans to smooth out bumps.
- The present management structure may not be optimal for the construction stage of the project.
- It is very early on in the project and the committee recognizes that real resource planning is just starting. That said, some areas appear considerably underestimated when compared to other projects of similar size. In particular the committee noted project management and software.

- Detailed installation plans for both the SIDIS and PVDIS configurations, as well as plans for moving from one to the other need to be developed. To the extent possible, these should include not only manpower needs, but also the impact of activation of material in the plans.
- There are many comments from the 2012 internal review report that should be addressed.
- The efficacy of future reviews can be improved significantly by providing previous review reports and responses to those reports to future review committees in advance of their review.
- Using one average JLab rate for all FTEs could lead to some significant cost differences versus an average for each resource type.
- Agreeing on a standard format for all mechanical drawings and setting up an official repository for these drawings at Jefferson Lab should happen sooner rather than later.

Recommendations

- Compare the resource levels you have assumed in some key areas (particularly in software, data acquisition and project management) to make sure the estimates align with other similar projects or there is a good reason they do not.
- Redo the cost estimate using an average cost per type of resource.
- Create a high level resource loaded schedule to get a more realistic schedule, funding and resource profile. This will also allow JLab to better determine their ability to support the FTE needs.
- Revisit the comments of the 2012 Internal Review Report in conjunction with the recommendations from this report.

3b. Utilities (power, cabling, LCW, cryogenics) requirements for the project.

Observations

- The project is to be commended for reusing some existing infrastructure and the CLEOII magnet and other components.
- Power and cryogenic needs were presented and appear supported by the present infrastructure. Some cabling will be reused.
- Preliminary plans for mounting the detectors, cooling, cable routing and ease of installation and access for repairs are notional.

Findings

- A project of this size should have a dedicated effort associated with integration, space management, installation, reconfiguration between experiments, maintenance, cables etc.

Recommendations

- A cost benefit analysis for any systems being reused should be carried out, including the magnet power supply.

- Appoint a small team to facilitate the integration planning for SoLID.

3c. Requirements from Jefferson Lab on, for instance, engineering needs, electron beam, polarized source and cryogenic target requirements.

Observations

- Overall engineering needs for the project are significant.
- Dependencies for the project, which are not on the project, are also significant, and will need to be supported by JLab.
- Estimates of these dependencies are not as well developed as those of other efforts on the project. These include moving and initial testing and refurbishment of the magnet, the PVDIS custom high power cryotarget, the SIDIS transversely polarized NH_3 target and the forces with the magnet.

Findings

- It will be a challenge for JLab to support the engineering needs of the project and the dependencies.
- Supporting the engineering effort with physics division personnel appears a solvable management challenge.
- In order to ensure the ability to complete the SoLID program, including dependencies, dependency items should be treated with nearly the same rigor as those on the project. This makes clear what needs to be provided by other sources. Appendix B of the pCDR lists much of this information.
- An Assumptions Document that outlines what is provided by who would be useful.

Recommendations

- We strongly recommend tests at JLab of the CLEOII magnet coils (cold test), ideally with the new power supply and controls, before installation into the hall.
- An effort should be made to clearly specify resources required from JLab that are not explicitly in the project (effort, non-effort, equipment, building space, etc.).

3d. General experiment installation and alignment issues, including potential interaction with other Hall A programs and operations.

Observations

- Plans for running in Hall A were presented up to the start of the SBS program.
- The project did not present a plan of how one would change from one SoLID configuration to the other.
- A preliminary installation spread sheet was presented to the committee.

Findings

- Strawman programs for experiments beyond SBS in halls A and C need to be developed.
- As many SoLID components as possible should be tested before installation in order to minimize the impact on other Hall A programs.

Recommendations

- The project should develop a preliminary resource loaded schedule for the installation and the corresponding space-management plan for the hall floor.
- The project should start planning the process of how to change from one SoLID configuration to another in order to better understand the time and effort involved and if there are any potential issues such as radiation levels.

Appendix A – Agenda

Monday 23 February 2015

Executive Session - F113 (08:30-09:00)

Charge and Comments - (09:00-09:15)
MONTGOMERY, Hugh; MCKEOWN, Robert; ENT, Rolf
Discussion - (09:15-09:20)

Physics Overview - (09:20-09:50)
GAO, Haiyan
Discussion - (09:50-10:00)

Hall A and SoLID - (10:00-10:30)
KEPPEL, Cynthia
Discussion - (10:30-10:40)

BREAK - (10:40-11:00)

SoLID Overview: Layout, Dependencies, Cost, Project Management - (11:00-12:00)
CHEN, Jian-ping
Discussion - (12:00-12:10)

Working Lunch (Executive Session) - F113 (12:10-13:30)

Experimental Requirements - (13:30-14:00)
SOUDER, Paul
Discussion - (14:00-14:10)

Radiation and Activation with SoLID - (14:10-14:40)
ZANA, Lorenzo
Discussion - (14:40-14:50)

BREAK - (14:50-15:10)

Breakout Session I: Detectors – F113 (15:10- 17:00)
Committee Members: Richard Majka, Marcel Demarteau, David Mack, Ernst Sichtermann and Bolek Wyslouch

EM Calorimeter - (15:10-15:40)
Prof. ZHENG, Xiaochao
Discussion - (15:40-15:50)

Light Gas Cherenkov - (15:50-16:20)

PAOLONE, Michael
Discussion – (16:20-16:30)

Heavy Gas Cerenkov - (16:30-16:50)
MEZIANE, Mehdi
Discussion – (16:50-17:00)

Breakout Session II: Magnet, Management & Costs – L102 (15:10-17:00)
Committee Members: Paul Brindza, Nancy Grossman, Naomi Makins, Curtis Meyer and William Wisniewski

Magnet, Utilities and Supports: Engineering and Cost - (15:10-15:40)
WINES, Robin
Discussion - (15:40-15:50)

Magnet, Utilities and Supports: Support and Infrastructure - (15:50-16:20)
SEAY, Whit
Discussion - (16:20-16:30)

Project Management & Cost - (16:30-16:50)
CHEN, Jian-ping
Discussion - (16:50-17:00)

Executive Session - F113 (17:00-18:00)

Reception - Atrium (18:00-19:00)

Tuesday 24 February 2015

Executive Session - F113 (08:30-09:00)

Breakout Session III: Detectors – F113 (9:00-12:00)
Committee Members: Paul Brindza, Marcel Demarteau, Nancy Grossman, Richard Majka and David Mack

MRPC - (09:00-09:30)
WANG, Yi
Discussion - (09:30-09:40)

GEM-US - (09:40-10:10)
LIYANAGE, Nilanga
Discussion - F113 (10:10-10:20)

GEM-China - (10:20-10:50)
LIU, Jianbel

Discussion - (10:50-11:00)

<u>**Breakout Session IV: Trigger, Simulation and Reconstruction – L102 (09:00-12:00)**</u>
Committee Members: Naomi Makins, Curtis Meyer, Ernst Sichtermann, William Wisniewski and Bolek Wyslouch

Study for Baffle, Background, Trigger Rate - (09:00-09:30)
ZHAO, Zhiwen
Discussion - (09:30-09:40)

SoLID Software and Simulation - (09:40-10:10)
RIORDAN, Seamus
Discussion - (10:10-10:20)

Software/Tracking - (10:20-10:50)
HANSEN, Ole
Discussion - (10:50-11:00)

BREAK - (11:00-11:20)

DAQ/Trigger - (11:20-11:50)
Dr. CAMSONNE, Alexandre
Discussion - (11:50-12:00)

Working Lunch (Executive Session) - F113 (12:00-13:30)

Questions and Answers - F113 (13:30-14:30)

Executive Session - (14:30-15:30)

BREAK - (15:30-15:50)

Executive Session - Draft Report - (15:50-17:00)

Close Out - (17:00-18:00)

Appendix B – Committee Charge

SoLID Director's Review --- Charge to the Review committee

Introduction

The first Hall A SoLID experiment (E12-10-007) was approved at the 35th meeting of the Jefferson Lab Program Advisory committee in January, 2010. As there are now 4 additional highly rated experiments approved for SoLID along with 2 run group additions, it is projected as a major new thrust of the scientific program at Jefferson Lab.
The experimental apparatus and the scope of the program is of a scale similar to a complete hall program such as those in Hall B (CLAS12) and Hall D (GlueX). In embarking on this program and as a precursor to discussing CD0 for the project, we need to scrutinize all aspects of the experiment. . In particular interactions with DOE in analogous discussions about other experiments have emphasized the need to understand the necessary R&D phase. The project has been asked to prepare material, which should include a Technical Proposal and presentations that will enable the review committee to address the charge outlined below.

Charge

1. For each proposed configuration of SoLID, review the relevance of the physics program and the potential risks to the physics case. This should include:

   a. The completeness and credibility of the discussion of the experimental reach, including statistical, systematic and theoretical uncertainties.
   b. Ability to handle the desired luminosities and backgrounds including impacts on both the apparatus and beam line downstream of the target.
   c. The implications for the relevance of the physics results in the context of possibly competing experiments at both JLab and internationally.

2. Review the viability of the approach used in the project with respect to the general experimental technique proposed for the approved physics program. This should include the evaluation of the credible plans for:

   a. Any R&D required to meet the technical challenges of the experiment.
   b. Proposed magnet concept and choice, including magnet configuration modifications (if any), magnet cool down and infrastructure requirements.
   c. Proposed detector concept and associated electronics and data acquisition.
   d. Beam line design, including collimation and shielding.
   e. Cryogenic and polarized target system concepts.
   f. Beam polarimetry requirements.

3. Review the understanding, completeness, and credibility of the resources estimated in both manpower and cost. In addition to the apparatus, this should include:

a. Experience, expertise and quantity of the scientific and technical manpower for the project.
b. Utilities (power, cabling, LCW, cryogenics) requirements for the project.
c. Requirements from Jefferson Lab on for instance engineering needs, electron beam, polarized source, and cryogenic target requirements.
d. General experiment installation and alignment issues, including potential interaction with other Hall A programs and operations.