RESPONSE to the Recommendations of the Experimental Readiness Review for the CPP and NPP Experiments

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We address the recommendations point by point.

Hall D E12-13-008/ E12-13-008A
Experiment Readiness Review
Jefferson Lab February 10, 2021 – remote

Report

Experiment Readiness Review for the Hall D experiments E12-13-008/E12-13-008A

February 23, 2021

Reviers:
Stepan Stepanyan (chair+muon detector)
Alexandre Camsonne (Trigger)
Brad Sawatzky (Tracking System -MWPC)
Chris Keith (Target)
Robin Wines (Installation)
Mikhail Kostin (RadCon)
Edy Nissen (Beamline)
Javier Gomez (Observer)
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The experiment readiness review for the Hall-D Charged (E12-13-008) and Neutral (E12-13=008A) Pion Polarizability experiments took place on February 10, 2021, in a remote setting over the *bluejeans*. The meeting agenda and presentations can be found on the review page: https://halldweb.jlab.org/wiki/index.php/CPP_and_NPP_Readiness_Review

The review committee thanks the CPP/NPP collaboration for preparing the presentations, providing ancillary information, and patiently answering our questions during the review. Below are our answers to the Review Charge questions with comments and recommendations.

Review Charge:

1. *What are the running conditions for the experiments? Please state clearly the target, detectors, beamline configurations and operation as well as the integration of the Muon Detector (for E12-13-008) in Hall D. Has the detectors ownership, maintenance and control during beam operations been defined?*

Findings:
The running conditions were defined but are not final. The collimator diameter and the beam current are still in question. Design and planning of the integration of the muon detector are underway. The ownership, maintenance, and control during the operations are defined.
Comments:
There are plans to do checks with the beam for the trigger during the 2021 Hall-D run. Collaboration should plan to test the smaller collimator and the stable running at low currents (~25 nA to 30 nA) at the same time.
Recommendation: None

2. *What is the status/performance requirements of the new installations required for these experiments? Specifically:*

- The Multi-wire proportional chambers –

Findings:
Presentations indicated that 8 MWPC are planned to be available at JLab by the end of Summer 2021. Of those, only 6 are needed for production. That leaves a healthy margin of 2 spares. As stated in the presentation, 5 planes are ready to go and are awaiting shipping from UMass. Three planes still need some modest work but should be ready and shipped in plenty of time to meet the projected schedule. Space has been allocated for delivery and testing of the chambers. In the hall, the CDC gas system will be utilized for the new wire chambers.
Comments:
Plans/procedures and equipment needed to support access to the top and side of muon detectors during the experimental program should be outlined in the relevant OSPs/documentation. Chris Cuevas (JLab Fast Electronics Group) should be consulted to ensure that the new muon detector systems conform to current JLab electrical requirements (may require some formal approval). Repurposing of the CDC gas system for new chambers should be reviewed by pressure system DA and documented.
Recommendations:

- Please provide a status summary of the as-built 8 MWPC planes. This summary should include the following information for each plane whether it is ready for Production or not.
  - If it is "Production-ready", then:
    - Include some plots with data supporting that assessment. This could include some combination of:
      - HV plateauing plots
      - ToF histograms from cosmic data
      - Plane/wire efficiencies extracted from cosmic data,
      - etc.
  - If a plane is not “Production-ready”, then:
    - Tabulate what still needs to be done, a timeline for completion, and who is assigned to the work
- Come up with a plan/procedure to measure the efficiency of MWPC since it will affect the physics results

RESPONSE:

- Regarding the testing of the MWPCs at JLab: We will get space in EEL 126 to test the wire chambers. We tested the FDC and CDC in that location, and have requested the room for the second half of this year. There is a small DAQ system in EEL 118 (electronics lab) that can easily be moved. The minimum requirement is two f125ADCs and external trigger input. In addition to the DAQ we will also need a gas supply as well as HV and LV supplies. There will also be time to finalize the design and installation of the air cooling system for the chambers. We plan to use two scintillator panels to set up a cosmic ray trigger (4 additional HV channels plus signal handling). There are three main goals for this cosmic test (operating gas Ar/CO2 [90%/10%] at 300 cc/min): (1) HV scan, to trace out the plateau curve, (2) characterize the timing response as a function of HV, and (3) determine optimal configuration parameters for the f125.
- We have prepared a document summarizing the fabrication, testing and plans for installation in Hall D. See GlueX-doc-XXX.

- *The downstream platform, support structure and iron absorbers –*

Findings:

The platform is designed, some parts are on hand, part of the drawings have been released. A concept has been developed for assembly, alignment, and installation of the chambers and iron absorbers. Chamber and absorber materials and alignment requirements are known. Design and analysis have been completed for the detector stand. Results indicate design is within acceptable safety margins. Drawings of the stand exist and are ready for procurement. A concept has been developed for the platform modifications to accommodate the installation of the detector. Rails and adjusters exist for the install and alignment of the detector.

Comments:

Platform modifications should be analyzed and documented to ensure planned and future needs are accommodated. Load limits and access routes on the platform should be noted with signs. Documentation on the Darkroom access would be beneficial to prevent safety issues after modification. Physics driven specification for iron absorbers from stating material, coating allowances, and air gap allowance between plates would be beneficial in fabrication. Detector assembly documentation should be completed before fabrication.

Recommendation: None

- *The Pb target –*

Findings:

Both experiments will utilize the 0.30 mm thick (5% RL), 25mm diameter 208Pb (99.1% enrichment) target from the Hall B PRIMEX experiment. The target sample's thickness was well-characterized by the PRIMEX collaboration, with an uncertainty of 0.4% at its center. Target In/Target out operations will be performed periodically, but the frequency is not so high as to require an automated process. It can be done manually by the user. The target should be placed in the beam with positional reliability of about 1 mm. The target will be placed about 64 cm upstream from the nominal GlueX target center. The target will be placed in the air, about 1

cm downstream from a 5 mil Kapton beam window. Target mounting mechanism design is to be completed by end of summer ’21.

Comments:

The design of the target mounting mechanism is in a “pre-conceptual” phase. A hand-drawing of a rotating design was shown, but it is not far enough along for a worthwhile review. While positional reliability of less than 1 mm should not be difficult to achieve, the collaboration should confirm that this is acceptable before proceeding with the final design. The 1 cm separation between the lead and Kapton beam window should be confirmed as well. Consider a simple in-beam contact (switch) that can be read into EPICS to display the target position.

Recommendation: None

RESPONSE:

- The target holder will consist of two frames, one with the ^{208}Pb target and the second with no target (empty). The circular target has a diameter of 2.5 cm and is held in a square frame 3x3 cm^2. We require that the target be aligned within 1 mm to the beamline. As the configuration is changed between full and empty targets, we require the reproducibility to be within 0.5 mm.
- The target will be located approximately 1 cm downstream of the vacuum window. The space between the target and the FDC will be filled with a He bag.
- The in-beam contact switch is a good one and we will consider incorporating it into the design.

- The new trigger configuration (for E12-13-008) -

Findings:

There is a plan for modifying the existing TOF trigger using a different grouping and coincidence between two planes. The timeline for development, implementation, and testing are reasonable. Trigger rates of 30 kHz have been quoted for CPP using a 40ns coincidence window. This rate was estimated from the measured rates with the nominal target and the collimator for Gluex after correcting for the target thickness and the collimator size. The calorimeter trigger rate for NPP is expected to be 10 kHz (FCAL/BCAL). The target position was not folded in the estimate of the neutral trigger. The Hall-D DAQ can handle 80 kHz.

Comments:

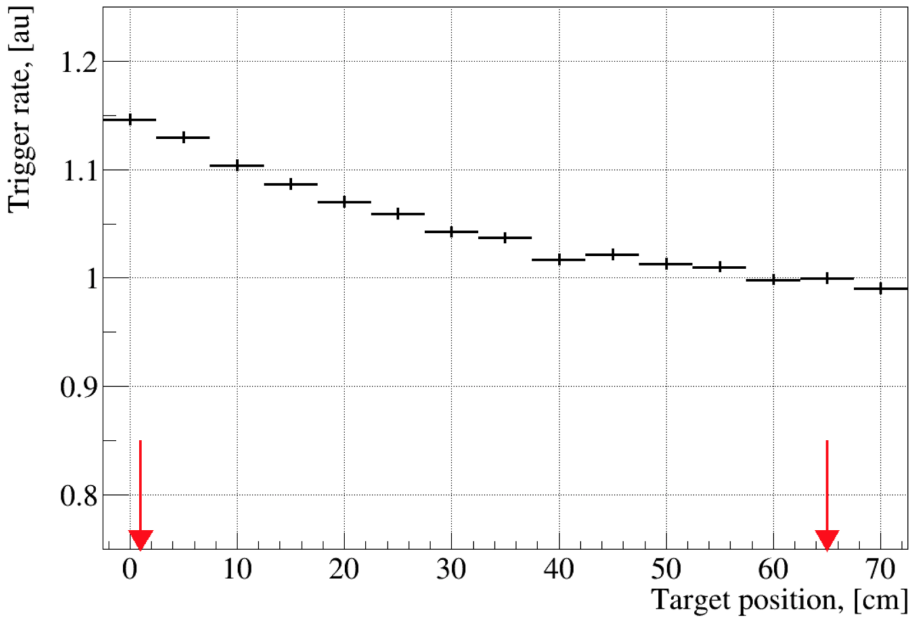
A plan for TOF gain matching should be clearly defined during the commissioning of the experiment. Some efficiency numbers were mentioned in the rate estimates document, but it was not clear how they were determined (thresholds, type of particle, logic to obtain the sample). It would be good to add to the existing document or spell it out in a separate document since the efficiency of the trigger is required for cross-section measurement. Some provision for a muon trigger could be useful to check the muon detector efficiency.

Recommendations:

Provide the real measured rates and the details of how the 30 kHz rate was estimated. The provided estimates (for CPP and NPP) were based on the measured rates with the target at the nominal position. How much rate increase is expected from having the target ~60 cm upstream, including the rate from additional air downstream of the target.

RESPONSE:

- The analysis of the beam tests and trigger rates are provided in GlueX-doc-4796 (https://halldweb.jlab.org/doc-private/DocDB/ShowDocument?docid=4796).
- The effect of having the target 64 cm upstream of the nominal GlueX target increases the rates by about 15%. The rates as a function of target position are shown in the following plot computed with our hdgeant3 simulation of the experiment. The arrows indicate the nominal GlueX target center (65 cm) and the proposed CPP target position (1 cm).



3. *If not completed, what are the completion/commissioning schedules, tasks and user commitment?*

Findings:
A high-level schedule for the hardware installation, trigger design, and commissioning has been presented and discussed.
Comments:
Make sure all tasks are discussed and resources identified, especially for the pre-run test of MWPC in ESB. The platform area will have limited space during the last phase of installation. Review installation schedule to ensure resources are available and not conflicting in the last phase of installation. Include items to be removed in the installation schedule.
Recommendations:
- The remaining tasks must have names assigned.
- Timeline for completion of simulation and reconstruction work must be provided.

RESPONSE:

- The coarse schedule for CPP-NPP tasks has been updated with these tasks (attached). We have also added a table of responsibilities for the remaining tasks.

4. *Are there any potential non-standard hazards or tasks, for example is there any temporary structure needed for the experiments that require access?*

Findings:
There are no non-standard hazards or tasks. The potential hazards are known and have been addressed. An additional staircase is being provided for additional access and egress of the platform.
Comments:
Make sure planned work for assembly, testing, and installation are included in DList, THA's done, and properly reviewed.
Recommendations: None

5. *What are the expected data rates for the experiments (both physics data rate and background rates)?*

Findings:
Only trigger rates have been discussed, no data rate was provided.
Comments:
The trigger rate is within the limits of the Gluex DAQ and one expects the data rate to be the same. Nevertheless, an estimate of the expected data rate will be useful since the inclusion of the ToF trigger for CPP may require lowering the thresholds on this detector and therefore increase the data rate.
Recommendation:
Provide rates per-plane for MWPC and the total expected data rate for the experiments.

RESPONSE:

- There are several contributions to the rates in the MWPCs. The rate due to particles traversing the MWPCs is expected to be relatively small. There are at least two contributions: The first comes from particles in the tail of showers that are not contained in the FCAL. This contribution has been calculated through simulation to be approximately 0.5 kHz. The second contribution comes from particles scattered in the beam aperture of the iron absorbers. This contribution has been estimated from our beamline simulation to be approximately 5-10 kHz.
- During our beam test in the spring of 2018, we placed a full-scale MWPC prototype in Hall D behind the forward carriage. It was essentially unshielded from the room background and the beam went through the center of the chamber. The raw rate was initially about 10 MHz, primarily due to ground oscillations in the electronics, something not observed at UMass or in the initial testing of the detector in the JLab EEL building. The ground oscillation seems to be something specific to the Hall D environment. Partial efforts to shield the electronics during the test with copper foil reduced the noise to less than 100 kHz, thereby reducing the amplitude of the oscillations, however not eliminating

the problem. Since the test run we have worked on ways to reduce possible sources of electronic noise in the chamber. First, the grounding has been significantly improved by adding ground wires from each preamp board to the chamber body every 10 inches. Second, we have enclosed the chamber electronics in an Al enclosure for electromagnetic shielding. We anticipate that these improvements will eliminate most, if not all, of the electronic noise hits during the experiment. The real rate of particles is easily manageable.

- The thresholds on the TOF PMTs are well-below the Landau Peak to ensure high efficiency. We do not expect that these will need to be reduced for the CPP trigger. The nominal data rate for GlueX I was about 600 MB/s. For CPP the trigger rate and event size will be similar, so we expect the data rate to be about the same.
- Baseline simulations of backgrounds with the updated HDgeant4 configuration will be done during the fall of 2021.

6. *Are the responsibilities for carrying out each job identified, and are the manpower and other resources necessary to complete them on time in place?*

Findings:
The responsibility for the design, fabrication, and installation of the platform, detectors, and the target in the hall resides on the Hall-D engineering and service group, responsibilities are defined. The schedule allows for 6-8 weeks of float.
Comments:
Integration of all activities would be beneficial to ensure resources and spaces are not dually allocated.
Recommendations:
The remaining tasks must have names assigned. Make sure this includes software tasks.

RESPONSE:

- See attached the coarse schedule and table of responsibilities

7. *Are the beam commissioning procedures and machine protection systems sufficiently defined for this stage?*

Findings:
The beam commissioning procedures and machine protection systems were not discussed. The beam delivery will use the same procedures as for the nominal GlueX runs.
Comments:
There might be some issues with the running at relatively low beam currents (~27 nA vs. 150 nA of GlueX) due to the bleedthrough or beam position stability. The stable running at the proposed beam current should be tested during the next Hall-D beam run.
Recommendations: None

8. *What is the simulation and data analysis software status for the experiment? Has readiness for expedient analysis of the data been demonstrated? What is the projected timeline for the first publication?*

Findings:

Work for the integration of the MWPC simulation and reconstruction has started but is not completed. No completion dates for the remaining software tasks have been set. The readiness for the expedient analysis of data and the first publication timeline were not given.
Comments:
Only one person was quoted for the software tasks who is not a member of Hall-D.
Recommendation:
The analysis plan and timeline for the first publication weren't addressed in the presentation, as well as the readiness of the software for muon-pion separation. These items, including how the efficiency of MWPC and the TOF trigger will affect the physics results should be submitted to the Committee.

RESPONSE: Timeline for first publication

- We have added time estimates for the projected software tasks to the coarse schedule (attached).
- We have added a new timeline with projections to a first publication (attached).
- The basis for some of the issues that drive the schedule are detailed next:

RESPONSE: Analysis Plan

- One of the first tasks is to update our GEANT3 simulation to GEANT4, which now defines the default GlueX Monte Carlo(MC). This process is ongoing and we expect the shell to be completed in April, 2021. The simulation will be used to develop all the low-level software objects for the MWPC. It will also be used to develop monitoring programs that will be used online and during offline monitoring and data validation.
- Simulated data from this MC will be used to generate events in the GlueX detector, including the new MWPC muon detector, that can be used for developing the track matching software between GlueX and the muon detector.
- We plan on running extensive MC runs in the fall of 2021 to provide samples for the optimization of our reconstruction algorithms and optimization of our machine learning algorithms for distinguishing $e/\mu/\pi$ events.

RESPONSE: Ready for expedient analysis and publication

- The muon-pion separation will be studied in detail using the updated simulation of HDgeant4. Essentially it builds on our present effort in electron-pion separation using neural-net techniques. We will modify the muon and pion neural nets presently under development to include the information from the MWPCs. The simulation data will be available at the end of this year (2021).
- Regarding how the efficiency of the TOF trigger will affect the physics results: our plan is to measure cross sections relative to Bethe-Heitler mu+ mu- production. Since the tracking and trigger efficiencies for pi+pi- and mu+mu- pairs are nearly identical, with the exception of a calculable correction due to particle decay, this should provide an accurate method to obtain relative cross sections. It will also be possible to measure the absolute TOF trigger efficiency by using FCAL to trigger on Bethe-Heitler e+e- pairs, and measuring the TOF

trigger efficiency relative to FCAL trigger efficiency, the latter being essentially 100% efficient.

- Regarding how the efficiency of the MWPC will affect the physics results: the MWPCs are used for providing information to the neural net for the decision if a track is pion or muon. In the training of the pion neutral net response actual CPP data will be used for training; these are gamma A -> pi+pi- events where the pions reconstruct to rho0 decay. Because the training data is actual CPP data, the pion neural net is self-calibrating and doesn't depend on knowledge of the MWPC efficiencies. Training the muon neural net response is handled somewhat differently. In this case we'll use a monte carlo simulation of Bethe-Heitler muon pair production as the training sample, since a pure sample of muon pairs cannot be obtained experimentally. In this case it will be necessary to measure the MWPC efficiency, preferably throughout data taking, and utilize that efficiency in the monte carlo simulation of the muon detector system.
- The timeline for calibration and reconstruction are shown schematically in the attached timeline. The calibration and reconstruction steps are based on the Hall D experience of analyzing the GlueX 2020 spring and fall data.
- The time for analysis and first publication will depend on specific analyzes for our two CPP and NPP experiments and the level of measured backgrounds. Many of the high-level Amplitude analyses have been developed and will be ready for deployment at the time of the experiment.

9. *What is the status of the specific documentation and procedures (COO, ESAD, RSAD, ERG, OSP's, operation manuals, etc.) to run the experiments?*

Findings:
The preliminary versions of the COO, ESAD, RSAD, ERG, and some of OSPs are in reasonably good shape.
Comments:
Two ESAD's were provided, one for the existing equipment in the hall and the second with added muon detector. Please clarify with DSO which one you need. Will need an OSP for the target, as well as OSPs for MWPC tests in ESB.
Recommendations: None