Hall-C NPS ERR Report

Review data: May 15, 2019
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Charge and presentations:
https://wiki.jlab.org/cuawiki/index.php/NPS_ERR#Documentation_Drafts

First, the committee would like to thank the Neutral Particle Spectrometer (NPS) collaboration for the clear and concise presentations as well as for their thorough discussion of the charge elements.

The scientific program of the NPS collaboration includes five experiments, four approved, one conditionally approved. From five approved experiments, the four as described in the charge item #1 has been presented for Experimental Readiness Review (ERR). The four experiments are grouped into two run groups, an electron run group with E12-13-007 and E12-13-010, and a photon run group with E12-14-003 and E12-14-002. The main distinctions between these two groups from the point of view of ERR were their requirements for NPS and radiation levels generated on the experimental equipment.

Bellow, we answer the questions posed in the ERR charge point by point, providing general feedback in the form of findings, comments, and recommendations.

Committee response

1. **What are the running conditions for E12-13-010, E12-13-007, E12-14-003, E12-14-005 experiments?**

Findings:

The running conditions of each experiment, combined into two run groups, have been presented and discussed. Tables with experimental requirements for NPS energy-angle resolutions, photon detection energy range, run luminosity, beam currents, and targets, as well as kinematic settings (arrangement of NPS and HMS) have been presented. For the electron run, group total of 8 settings are planned all with NPS mounted on one side of the SHMS (right side, close to the beamline). For the photon run group number of kinematic settings are 10 with NPS being installed in both sides of the SHMS. Note, some of the settings from the original proposals have been discarded.

Comments:

- Number of settings presented in the first talk were different from the number of settings shown in the radiation budget tables presented in the second talk.

- It was not clear how the quoted luminosities of 10E38 cm^{-2} sec^{-1} for electron runs and 1.5x10E38 cm^{-2} sec^{-1} for photon run group experiments were calculated. Neither number can be confirmed from the numbers (beam current and target thicknesses) presented in the radiation budget tables.

Recommendations:

- While based on the presented NPS construction schedule and presumed time for installation it is not likely that any of the NPS run groups will be scheduled to run before the fall of 2021, it is recommended to draft a run plan for individual run groups. The order of running of different settings will matter from a radiation point of view as activation of detector components will define the time needed for switching from one setting to another (see also recommendation for Charge 7). This will directly affect beam time scheduling, floor time vs. beam run time. Priorities between the settings of individual experiments must be defined, as possibly longer changeover between settings may not allow running of every setting.

2. What is the status of the Neutral Particle Spectrometer. Precisely:

a. magnet: design, assembly, testing
b. Calorimeter: crystals and PMTs procurement and characterization
c. Mechanical Structures: Frame and Platforms realization
d. Electronics: FE and Readout boards procurement and characterization
e. Infrastructure: cables, HV, crates procurement
f. trigger, DAQ, Slow Control: integration in the Hall C system

If the above elements are not already completed, what are the completion/commissioning schedules, tasks and user commitment?

Findings:

The magnet is ready, in the test lab. Preparations for the test are ongoing. Procurement of crystals is complete, part of PMTs are on hand (340), rest have been ordered. The 80% of dividers are commissioned, expected to have all of them ready in summer 2019. The design of the platforms, enforcements to SHMS, and cable trays are complete, ready to produce drawings for fabrication. Installation schedule for NPS has been developed. Similarly, cables, modules for FE and readout boards, HV and trigger modules either are available, in procurement or requests have been submitted for procurement. Calorimeter enclosure and crystal support system design is in advance stage. Prototypes have been built and tested.

Comments:

- for 2a – Although there are power supplies that can be used for both coils of the magnet, it is advised to identify exactly which power supplies will be used early on. Some of existing (mentioned) power supplies have been reserved for other magnets/experiments.

Recommendations:

- *for 2a* – The test of the magnet in the hall to full current must be scheduled. It will require resources for installation, connecting to the power and LCW. As was discussed at the review it will be a month or more to complete this work. Therefore, it must be scheduled beforehand as with installations and running of the ongoing experiments such test will become challenging.

- *for 2a* – Question of the high pressure LCW in the hall was not clear, operating parameters of the magnet must be provided as regulation of the LCW pressure for the magnet will be needed.
- *for 2b* – Collaboration has to perform radiation hardness test of dividers and LED, perhaps can be done together with radiation hardness tests of crystals.

3. What are the controls in place to assess the operational performance of the Neutral Particle Spectrometer. For example:
   a. PMTs gain
   b. crystals light output

Findings:

Testing of PMTs and dividers has started. Crystals on hand have been fully characterized, some have been rejected due unacceptable performance. Irradiation and curing tests started based on which plans will be made for curing crystals during the run as needed. The PMT stability during the operations will be monitor using the LED system in pulsed mode.

Comments:

- No clear proof to include amplifier with low gain as an active element of the divider was presented.
- Calorimeter has to cover a wide energy range from 0.5 GeV to 7.6 GeV, but the linearity and resolution have been studied only for energies >3 GeV. Studies of performance must be extended to the full energy range.

Recommendations:

- Clarify what the threshold energy for individual modules should be for required energy resolution and what the rates of each channel is expected with that thresholds.
- Develop a commissioning plan for the calorimeter.

4. Has the entire beam line, spectrometers, detector configuration been defined, including ownership, maintenance and control during beam operations?

Findings:

The beamline and detector configurations for different run groups are defined. Standard Hall-C beamline will be used for the experiments with existing raster system and controls.

Comments:

- The electron experiments will require a polarized beam. It was not clear what will be used to measure the beam polarization, how often. From current run experience, Wein angle setting using presumed value for the beam energy is often incorrect. Depending on the degree of polarization needed, some kind of "spin dance" may be needed to set the Wein angle correct for the optimum polarization transfer.

Recommendations:

- Ownership and the controls of the sweeper magnet and the corrector coil are not clearly defined. Procedures, and who and how will control the magnet for safe operations must be provided.

5. 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:

Responsible groups/individuals are identified for all mission critical jobs. Manpower is adequate, most resources are defined for completion of the project.

Comments:

- While software tasks for integration of the NPS into Hall-C offline analysis software framework are few and should not take too long to complete, identifying people who will work on these tasks must be done soon.

Recommendations: None.

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

Findings:

Beam commissioning procedures are similar to other Hall-C experiments. The FSD system has enough inputs available to accommodate NPS needs. Procedures and machine protection systems are sufficiently defined for this stage.

Comments: None

Recommendations: None.

7. Are the radiation levels expected to be generated in the hall acceptable? Is any local shielding required to minimize the effects of radiation in the hall equipment?

Findings:

Preliminary estimates of site boundary dose have been made and they appear acceptable. Activation and prompt radiation levels in the hall should be evaluated to address several issues.

Comments:

- RadCon department assistance will probably be needed to conduct/review some of the simulations. This should be coordinated with RCD as soon as possible.
- Final boundary dose estimates should be calculated taking the radiator into account.

Recommendations:

- Activation levels should be modeled to evaluate residual dose rate fields. Results of this simulation will help with:
  - decisions on the sequencing of the different configurations.
  - final design of sweeping magnet support hardware; if the magnet is in a high radiation area, effort should be given to enhancing the hardware to reduce the amount of hands-on manipulation needed.
  - decisions to apply local shielding at the radiator or elsewhere for ALARA.
- Simulation was done and estimates were calculated for the integrated dose on the crystals. Specific simulations to evaluate the radiation dose to the calorimeter electronics should be conducted.

8. What is the simulation and data analysis software status? Has readiness for expedient analysis of the data been demonstrated? What is the projected timeline for the first publication? Please provide a documented track record from previous experiments.

Findings:

The collaboration plans to leverage on existing software tools from the 6 GeV era or from tools developed for previous 12 GeV experiment to support the events simulation, reconstruction and analysis of the NPS-based experiments. The tools include the simC package used to describe acceptance and resolution of the charge particle spectrometers, a GEANT4-based simulation of the NPS spectrometer, event reconstruction and analysis libraries in the hcana package, and the DCVS library developed for the Hall A experiment.

Simulations of the experimental setup will be based on the integrated used of simC and the NPS calorimeter geant4 package. Event reconstruction and analysis will be based on the hcana package, updated by linking the existing DCVS libraries. This includes tools for low-level analysis of the calorimeter signals, such as pulse fitting, and clustering algorithm based on cellular automaton algorithm. These algorithms have been applied to the reconstruction of the PbF2 calorimeter used for the Hall A DVCS experiment and are expected to be applicable to the NPS case.

Given the modest data volume the experiments will accumulate and relatively low complexity of the event reconstruction and data analysis, the proposed approach and tools seem to be adequate for the purpose. The development needed to finalize the simulation and reconstruction/analysis is relatively modest and can be presumably completed in a time frame of few months even if no detailed plans were presented.

A novelty for the experiments under review compared to previous ones is represented by the FPGA-based trigger that will be adopted for the readout of the NPS calorimeter. While this trigger is conceptually simple, validation and efficiency evaluation would require implementation of the trigger algorithm in the detector simulation which is currently not planned.

The history of publication records for similar experiments in Hall A and C shows the the first article was published about 2 years after the data taking while the most complex analysis involving high precision cross section measurements can take a few years. Being the level of complexity of the data analysis for the four experiments under review similar to previously completed analyses, it is reasonable to presume the first publication may be in about two years from data taking, with the most sophisticated analyses being published on a longer time scale..

Comments:

- As NPS will remain in the Hall C equipment portfolio and may be used by other experiments in the future, it would be advisable to have well defined procedures and prescriptions for performing simulations of charged and neutral particles with the integrated use of simC and of the GEANT4 simulation of the NPS calorimeter.
- Even though the work involved is relatively limited, it is advisable to assign task for the remaining software development tasks and define a timeline to have the work completed by early next year and have sufficient time for tests and possible upgrades before the tools will be needed.
- The GEANT4 simulation of the calorimeter will be crucial to tune the reconstruction algorithms for neutral particles, determine acceptance and efficiency. Any remaining work to tune the simulations make this tool accessible to users should be completed as soon as possible. This will also be crucial to simulate the trigger used in the detector

readout: at this end, full simulation of the pulse shape, fADC sampling and FPGA algorithm will be necessary.

Recommendations:

- Define/present a plan for developing software for simulation of the NPS trigger and complete its validation during the NPS calorimeter commissioning

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:

Overall not much has to be added to the existing Hall-C documentation for the NPS run. Collaboration is aware of it (has a list of missing documents and parts) and is working to complete the full documentation.

Comments:

- NPS part is missing from ESAD (just started to implement).
- No RSAD ready yet, but preliminary boundary dose calculations are complete.
- A list of new OSPs has been presented, most are in motion but not complete yet. Having OSPs approved in advance will ensure that no safety issues with running the detector and or performing the task.

Recommendations: None.