U.S. DEPARTMENT OF ENERGY

Office of Science

Department of Energy
Office of Nuclear Physics Reviewer Excerpts

on the

Annual Progress Review

of the

Super BigBite Spectrometer (SBS)

November 16-17, 2015

EXCERPTS FROM PANEL MEMBER REPORTS

The Annual Progress Review of the Super BigBite Spectrometer (SBS) project was held at Thomas Jefferson National Accelerator Facility (TJNAF) on November 16-17, 2015. Provided below are excerpts from the reports of the review panel members regarding their findings in response to the review criteria they were asked to address.

<u>The significance and merit of the project's scientific goals:</u>

Reviewer:
"The scientific program of the proposed Super BigBite Spectrometer (SBS) focus mainly on measurements of the nucleon electromagnetic form factors up to momentum transfers $Q^2 \approx 10$ GeV^2. These measurements take advantage of the new 12 GeV capabilities available at Jefferson Lab and successful results from these measurements are likely to have a lasting impact on the nuclear physics field. The form factor determinations have a direct connection with the structure of the nucleon and the proposed program will probe this structure at scales not attempted before, which would lead the way to evaluations of theoretical models in a region where the data are expected to be sensitive mainly to the three-quark core.

"Critical to this endeavor is the development of the simulation and analysis framework needed to properly extract the form factors from the data while minimizing systematic uncertainties. The experimental setup can be augmented to address other important physics topics such as measurements of the Collins and Sivers asymmetries in semi-inclusive deep inelastic scattering (SIDIS) and measurements of the pion parton distribution function (PDF)."

Reviewer:
"The conclusions previous reviews that the proposed suite of measurements takes excellent advantage of the 12 GeV upgrade to make measurements to high Q^2 and improved precision measurements at lower Q^2 are reaffirmed. It is encouraging to see that additional experiments building on the SBS equipment have been proposed and evaluated with a high rating. It would be helpful to see a clear plan to extract the physics quantities from the data with particular attention to radiative corrections."

Reviewer:
"The scientific goals of this project are compelling - to probe the interior structure of protons and neutrons. They are already thinking beyond the core experiments to exploit the SBS/BB capabilities to probe pion clouds and low-x correlations. The SBS detectors can be augmented with some interesting new detectors including a radial TPC using a cylindircal GEM readout enabled by the R&D for the core program. The flexibility of the JLab trigger/Daq electronics approach enables this program."

<u>The feasibility and merit of the technical approach for delivering the science, and the technical status of the project, including completeness of scope and fabrication progress:</u>

Reviewer:
"In practice the proposed SBS spectrometer with its associated infrastructure (targets and auxiliary detection systems) are reasonably well matched to the capabilities of the laboratory in terms of the needed luminosity for the extraction of the form factors. In addition, the SBS collaboration has a strong record of doing these types of measurements and in the use of the proposed polarization techniques as well as in the design, construction, and operation of open, large solid angle spectrometers like the proposed SBS.

"The SBS project encompasses two main distinct experimental configurations: one in which the SBS is used as proton polarimeter (PP) and another in which it is used as a neutron detector (ND). As a PP the SBS consists of the magnet followed by an array of GEMs and analyzers for tracking proton polarization and a position-sensitive scintillation coordinate detector (CDet) as the front face of a hadron calorimeter (HCAL) for proton full identification. In the ND configuration the GEMs and analyzers are not needed and the CDet acts as a charge particle veto for the hadron calorimeter.

"The electron arm in each case is also quite distinct of one another. A *non-magnetic*, large solid angle detector consisting of the CDet followed by an existing calorimeter achieves the electron detection when the SBS is used in the PP configuration. On the other hand, for the neutron form factor measurements an existing *magnetic* spectrometer is used as the electron arm as a way of improving the accuracy of the scattered electron kinematical information. The two experimental configurations use their unique targets: an unpolarized liquid hydrogen target for the proton and a polarized ^{3}He gas target for the neutron form factor measurements, respectively.

"The overall complexity of the SBS program is quite significant with responsibilities spread out between JLab and a number of outside university groups. The 48D48 magnet is at JLab and the yoke pieces have been modified for use as the SBS magnet. The Laboratory handles this part of the project and progress up to now has been substantial. It is quite likely that the remaining tasks will meet their deadlines by January 2016. The responsibilities for the construction of all SBS detector elements reside with outside universities.

"The GEMs fabrication project is in the hands of the University of Virginia (UVa) group and a subcontract has been awarded to UVa for the construction of the GEMs. Production of the GEMs is steady with half the modules already built. The group has done an extremely professional job in establishing a production line of high quality GEMs. They have established a strong connection with the foils production site at CERN and implemented a rigorous testing procedure that gives high confidence in the quality of the final detector.

“The CDet adds significant technical capabilities to all proposed measurements but it requires a significant effort in terms of coordination and oversight. The CDet has made significant progress and it is on schedule to deliver the detector by August 2016.

“The HCAL, which is not included in the project WBS’s, is in the hands of the Carnegie Mellon University (CMU) group. A final construction plan is being carried out and no hurdles are foreseen except for the enormity of the tasks (24,000 scintillator channels). The HCAL consists of 288 total modules and final production of half of these modules is expected by March 2016. There are no known or projected issues to prevent HCAL detector completion as anticipated.

“The measurements of the proton form factors required detection of the scattered electrons in coincidence with the detection of the polarized recoil protons that is achieved with the instruments already discussed (GEMs, CDet, HCAL). A non-magnetic solid angle detector consisting of the CDet followed by an electron calorimeter (ECAL) has been proposed for the detection of the scattered electrons. The ECAL design has changed from the original proposal and significant hurdles to implementation remain requiring special attention from the collaboration and JLab.

“The ECAL consists now of a large array of available lead glass blocks that requires continuing annealing for operation in the radiation environment. The design and fabrication of a prototype consisting of 200 lead glass blocks (C200, 10% of the final array) is underway at Stony Brook. The C200 is being modeled with COMSOL to understand and evaluate the heating and mechanical challenges of the final design.

“The measurements of the neutron form factors require that the scattered electron detection be carried out with a magnetic spectrometer. The latter consists of an existing magnet (BigBite) followed by a focal plane detection system that has changed from the original proposal. The focal plane now consists of the front tracker GEMs under construction and on schedule, a gas Cherenkov being developed by several groups and projected to be ready for installation during the second half of 2016, and existing pre-shower and shower calorimeters and scintillator array.”

Reviewer:

“Good progress has been made across the project. It is encouraging to see that important aspects of WBS1 are completed or nearing completion.

“The on-project detector systems appear to be in good shape. The team has reacted well to input from last year’s review. The CDET mounting and alignment scheme has been streamlined and a first group of scintillators assembled. The GEM detector production is over half complete with the target production rate of 2 chambers per month being met and sustained over many months. Design and production problems uncovered with prototype chambers have all been addressed and corrected. Other on-project detector production also appears to be in good shape.

“All committee members noted significant issues with off-project dependencies. In particular ECAL and the ^{3}He target have or are likely to have significant impact on the schedule. The ECAL system has taken on a significant R&D component that likely will have a schedule and budget impact. It will be useful to understand the full impact of the added R&D by scheduling a project review, including plan, budget and schedule as soon as possible.

“The ^{3}He target schedule as presented leads to significant delay resulting in delays in scheduling the SBS physics program. It appears that this can be at least partially mitigated by allocating sufficient engineering and design resources. I encourage the experimenters and the laboratory to work together to find a solution to allow timely scheduling of the SBS physics program.”

Reviewer:
“The Coordinate detector essential as a preshower for ECal and for providing electron positions is in good shape. The HCal is proceeding well. The GRINCH had a problem with its readout chip (NINO) that appears to have been solved and is also in good shape. The magnet fabrication issues have been solved.

“The ECal is a radiation damage issue that does not yet have a proven solution. The innovative heat-annealing solution has been tested on a small set of cells but the approach used does not have an obvious solution for the full detector. Problems here include temperature uniformity and keeping the PMTs much cooler than the glass. They have a model of the radiation damage that appears to work well. They have shown that multiple cycles of damage and heat-annealing can leave the detector in a pristine state, unlike tests using UV annealing. Note that this problem affects only the GE(p) measurement since the GE(n) and GM(n) use different calorimeters at much reduced luminosities in better shielded positinos.

“The trigger/daq system employs multiple Fastbus systems to achieve the required readout rates and this has been tested, achieving the required 5kHz rates at 7% deadtime. A full DAQ test is scheduled for early 2016 to couple this Fastbus readout with the MPD and VME parts. No insurmountable problems are foreseen. Each readout has worked independently and a synchronized clock can be used to sew them together. Trigger algoritms look for the recoil electron in coincidence with a hadron (p or n) that uses a walking boundary to locate hadronic showers. This is an efficient approach. GEM readout at the 5kHz rate is proceeding in a collaboration between JLab and INFN. There is not yet a document describing the trigger/daq system in any detail. This is definitely needed soon, including detailed timing diagrams for each detector.

“There has been good progress on the simulations and they now can use Pythia to generate event inputs into GEANT. Using the GEM radiation sources to test models of detector response is a great idea. Open issues here include how to calculate and measure trigger efficiency essential to interpretation of the data. A clear path from raw data to interpreted GE and GM would be very helpful.

<u>The feasibility and completeness of the budget and schedule, including workforce availability:</u>

Reviewer:

"The project has been divided in three main WBSs: WBS1 concerns magnet and infrastructure, WBS2 deals with the detector systems needed for the neutron form factor measurements (CDet, HCAL trigger, and other detector infrastructure), and WBS3 deals with the detector systems for the proton form factor measurements (GEM tracker). Key dependencies not included in the WBSs are HCAL and ECAL, and the polarized ^{3}He target needed for the neutron electric form factor measurements. These external dependencies have added significant delay to the timeline for running the experiments.

"The budget and schedule for WBS1 is on track, a completion date is expected by January 2016 with all expenditures on budget. The WBS2 has a new completion date of January 31, 2017. The WBS2 expenditures (including open commitments) are at 68% of the total budget and about 28% of the contingency remains. The WBS3 completion date is February 1, 2017, and at present 20% of the budget remains to be committed and about 50% of the contingency is available which could be used for spare chambers.

"The workforce availability for the individual WBS elements seems adequate to complete the project. Management has considered an overall workforce plan and the anticipated availability seems adequate to complete the SBS project."

Reviewer:

"The schedule and budget for on-project activities appears to be in good shape."

Reviewer:

"There remain two problem areas - the polarized 3He target and the electromagnetic calorimeter (ECal). Their core program requires both of these to work, the LHe for the GE(n) measurements, and the ECal for the GE(p) measurements. The target appears to be more of a management problem than a technical problem. However, the JLab philosophy of multiple programs at HallA leads to an overall slowdown in SBS physics production because none will be staged until all are ready.

"Overall I believe the project is in good shape with caveats concerning the two areas noted above. The budget also appears in good shape, assuming the ECal problem does not expand. The management structure is sound, with excellent inter-group communication and a strong, well informed, project manager. No ES&H issues were uncovered."

The effectiveness of the management structure and the approach to ES&H:

Reviewer:
"JLab does the project management and the new Project Manager (PM) appointed early in 2014 has reinforced the confidence in the likely success of this project. He is clearly in touch with all aspects of the program, from the physics, through the infrastructure and detectors, and to the analysis of results.

"In order to keep track of the project the PM works closely with Hall A management and the collaboration through regular meetings. The Project Management Plan has been updated to reflect the recommendations of the last review. At present, no contracts to universities remain to be awarded and all project activities adhere to the protocols in the JLab EH&S manual."

Reviewer:
"The new project manager is doing an excellent job. Monitoring of project progress and work on integration and installation are going well."

Other issues relating to the SBS project:

Reviewer:
"This is an exciting users-driven project that goes after the most basic nucleon structure information in an unexplored energy region. University groups, all with solid records in the proposed experimental technique and significant expertise in detector construction, are responsible for most of the components of the detector project apparatus. JLab plays a key role in fostering an environment in which experimental ideas as this can emerge."

Reviewer:
"As noted above the off-project dependencies, HCAL and the ^{3}He target are now driving the schedule and introducing delay. I reiterate that the experimenters and laboratory should work together to develop a plan to minimize the delay."