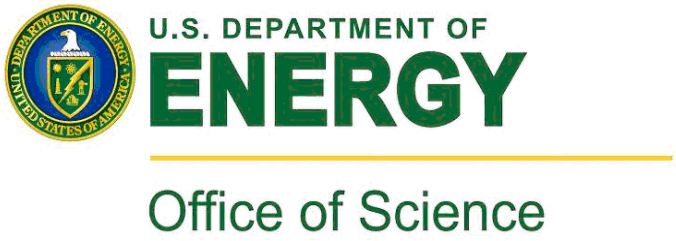


# *Department of Energy*
# *Office of Nuclear Physics Reviewer Excerpts*

on the

Annual Progress Review

of the

# Super Bigbite Spectrometer (SBS)

November 4-5, 2013

## EXCERPTS FROM PANEL MEMBER REPORTS

The Annual Progress Review of the proposed Super BigBite Spectrometer (SBS) project was held at Thomas Jefferson National Accelerator Facility (TJNAF) on November 4-5, 2013. 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.

**The significance and merit of the project's scientific goals:**

**Reviewer:**
"The scientific program of the proposed Super BigBite Spectrometer (SBS) is focused mainly on two measurement techniques of the nucleon electromagnetic form factors up to momentum transfers $Q^2 \approx 10$ GeV$^2$. They are possible due to the new 12 GeV capabilities promptly available at Jefferson Lab. Results from these measurements are likely to have a lasting impact on the nuclear physics field. The form factor measurements 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."

**Reviewer:**
"Measuring the structure functions to higher $Q^2$ is a goal for the whole community and will help understand the evidence for orbital motion in a nucleon. I rate these goals as excellent. The ratios on which the firmest conclusions are based require measurements by other groups in Hall A, but these appear to be well considered."

**Reviewer:**
"The proposed suite of measurements takes excellent advantage of the 12 GeV upgrade to make precise measurements to high $Q^2$. The data should provide new insight into the basic structure of the nucleon. The measurements are of high significance."

**Reviewer:**
"The Super BigBite Spectrometer (SBS) program concerns making high-accuracy measurements of 3 of the 4 elastic nucleon form factors (GE(n), GM(n), GE(p), with the 4th (GM(p)) being measured very accurately in another Hall A program. Measurements of the ratio of the neutron electric to magnetic form factors would be extended to $Q^2$=10 GeV$^2$. Measurement of the ratio of the proton electric to magnetic form factors would be extended to $Q^2$=12 GeV$^2$. The ratio of the neutron to proton magnetic form factors would be extended to $Q^2$=13.5 GeV$^2$. I am very impressed with the high significance and substantial merit of the experiment. This interest depends critically upon successful completion of the experiments. Thus the researchers (as usual) carry a lot of responsibility

"Nucleon form factors are important quantities, and successfully obtained results would immediately be incorporated in textbooks. The separate measurements of neutron and proton form factors would yield unprecedented knowledge of the structure of the nucleon

by obtaining the separate up and down quark contributions. I am very excited about the prospect of having this kind of information available. I speculate that the measurements could even say something about the strange quark content of the nucleon.

"Interest in the nucleon electromagnetic form factors, in terms of basic phenomenology, QCD lattice calculations, and models remains high and can be expected to remain high. The experiment will challenge and stimulate future lattice QCD calculations for many years to come. Various models and ideas regarding nucleon structure, including quark-diquark models would be tested.

"The results of the experiments would enable measurements of transverse charge and magnetization densities at very small transverse sizes. Determining the values of $F_1^n$ at large values of $Q^2$ could change the current result that the central transverse charge density of the neutron is negative.

The program includes a semi-inclusive deep inelastic scattering SIDIS experiment aimed at measuring transverse momentum distributions TMDs of the neutron with broad kinematic coverage that would vastly extend existing knowledge. It would be great if the pretzelocity TMD $h_{1T}^{perp}$ could also be measured. The measurements of $A_1^n$ would be extended to large values of x. The SIDIS and $A_1^n$ measurement would uniquely supply important information regarding neutron structure."

**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:**

**Reviewer:**
"In practice the proposed SBS spectrometer with its associated infrastructure (targets and auxiliary detection systems) are well matched to the capabilities of the laboratory in terms of the needed luminosity, beam polarization, and scientific and technical personnel. In addition, the SBS collaboration has a strong record of doing these types of measurements and on the use of the proposed polarization techniques as well as on 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 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 new proposed position-sensitive scintillation coordinate detector (CD) 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 CD detector acts as a charge particle veto of 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 CD detector 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 significant. The magnet is at JLab and the Laboratory handles this part of the project. The SBS detector responsibilities all 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 first of 29 GEMs. If the CD goes ahead then only 11 more GEMs are needed for the entire project (prior to the CD the project needed 64 GEMs for both experimental configurations). The hadron calorimeter, not included in the project WBS) is in the hands of the Carnegie Mellon University (CMU) group, a final construction plan is in place and no hurdles are foreseen except the enormity of the tasks (24,000 scintillator channels). Other off-project detector tasks include the construction of a Front Tracker GEM system from the INFN group and the refurbishing of auxiliary detection systems (Gas Cherenkov, Calorimeters) from various outside expert groups. The recent proposed CD detector is the main responsibility of Saint Mary's University, the detector adds significant technical capabilities to the proposed measurements but it requires a significant effort in terms of coordination and oversight."

**Reviewer:**
"There was no formal discussion of electronics, trigger, or daq during this review. However, based on previous knowledge we were able to investigate aspects of these items relevant to the current situation. As before, I find no particular issues with the approach, although I would recommend replacing the Fastbus units with the JLab FADC system if possible. This only reflects the superiority of the newer electronics and would significantly reduce the manpower required to implement a trigger/daq system based on three separate electronics standards. Either way, it is useful to encourage development of written interface documents describing connection between the APV (GEM) system, the FADC (HCal) system, and the Fastbus (ECal) systems with trigger and daq.

"The basic signature of the elastic scattering process is based on geometry, and the detector set proposed appears to be more than adequate to the task. The trigger will employ both energy cuts in the hadronic and electromagnetic calorimeters as well as geometry cuts based on cell locations. Offline analysis will benefit from greatly improved spatial resolution based on GEMs and the scintillator CDet detectors. My summary from the review in 2011 gives more details if needed.

"The expected event rate of a few kHz is throttled from individual rates of a few MHz using energy cuts first and then coincidence geometry cuts to stay well below the limits imposed by the JLab daq system. I believe the common daq approach is a fine way to share effort and resources at the lab. We were told that the "real" event rate, the elastic scattering signature, occurs at a rate of only ~0.1 Hz, so the vast majority of the events is actually background. I would have liked to see an analysis of the signal rate as a function of the thresholds applied at both the energy and the track cut levels, but I have no doubt that these can be tuned to deliver the signal sought."

**Reviewer:**
"The design of the detector appears well matched to the requirements of the environment and the physics measurements. The collaboration is making good use of existing equipment and contributed resources where possible."

**Reviewer:**
"Work is being done on the coils for the SBS magnet. A combination of racetrack coils and existing saddle coils from Brookhaven National Laboratory would be used. The use of the BNL coil would reduce the acceptance of the proton measurement by 10 %, but not impact the significance of the ultimate experimental data. I hope that there are not too many other such limitations."

**The feasibility and completeness of the budget and schedule, including workforce availability:**

**Reviewer:**
"The project has been divided in three main WBS: WBS1 concerns magnet and infrastructure, WBS2 deals with the detector systems needed for the neutron form factor measurements, and WBS3 deals with the detector systems for the proton form factor measurements. The budget and schedule for WBS1 appears on track although no significant resources have been allocated yet, and the workforce comes mainly from JLab manpower. The division of WBS2 and WBS3 is somewhat arbitrary and the new proposed CD detector implies significant overlap with not so clear distinctions respect to budget, schedule, and manpower. The subcontract awarded to UVa is significant and can cover most of the GEMs needed for WBS2 and WBS3. The corresponding schedule depends largely on the timely delivery of GEM foils from CERN. UVa seems to have the right infrastructure for a timely construction of the GEM detectors. The other detector systems are at too early stages to make significant comments regarding schedule. Budgets on the other hand seem adequate."

**Reviewer:**
"This is made problematical by the fact that a number of apparently essential components are "off-project." I believe that the schedule and costs presented indicated that those components of the SBS that are "on-project" are in good shape. The approach chosen to save money and improve the timing resolution for the Fe-scint HCal reflects the resourcefulness and tenacity of the principals. The improvements offered by the scintillator CDet show a clever use of "donated" equipment coupled to an ingenious array design to improve overall position resolution and hence signal to noise. The GEM developments indicate a well-organized effort with good management and sufficient manpower: the change from GEM to CDet makes this part of the project fit the schedule more readily. I note that while the INFN electronics appear to have been reviewed by JLab safety personnel, the SRS system from CERN has not yet been scrutinized."

**Reviewer:**
"The budget seems in line with the proposed construction although it needs to be updated for changes in the scope. In particular if the scintillator approach for the Coordinate Detector is used the budget, profile and schedule need to be updated to reflect this.

"The schedule to produce 35 GEM chambers under WBS 3 looks aggressive. Using the scintillator Coordinate Detector will greatly help the GEM schedule as well as bringing other collaboration resources into the project."

**Reviewer:**
"I am impressed with the ability of the researchers to garner University support for this project."

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

**Reviewer:**
"JLab does the project management and at present there are weekly meetings involving the project management team and the collaboration whose leadership is comprised in a Coordinating Committee. The communication channels are working well and the real challenges lie ahead as the project now is entering the exciting construction phase with allocated resources."

**Reviewer:**
"It appears that JLab management is paying attention to the details of the project and the concerns of ES&H. I think the project would benefit from a more global view of milestones and I encourage the management to develop a schedule that includes all essential portions of the experimental program. I think the organization of the SBS group is very effective, with strong leadership and effective cooperation in heading toward their goals. The fact that each "subsystem" is represented on the collaboration council is very important is keeping information flowing and all parties committed. I really like their bi-weekly meetings open to the whole collaboration for sharing progress and problems. I did not see this as in conflict with any management structure."

**Reviewer:**
"The management structure has been working well so far however as noted in the closeout it would benefit from added support to allow timely response to changes in scope and to keep the project documents current. Preparation of requirements documents for all detectors as well as an integration and installation plan need to be done as soon as possible so as to identify and address potential problems early in the project."

**Other issues relating to the SBS project:**

**Reviewer:**
"In summary, 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:**
"In a future review, I'd suggest including a talk on electronics, trigger and daq, not just because it is my area of expertise, but you can't really judge whether an experiment will succeed if you don't look at this area. Offline discussions with the SBS experts clarified the situation greatly for me. I don't have any major concerns about whether they will successfully stage the SBS."

**Reviewer:**
"As noted in the closeout report the collaboration should be careful to not underestimate the effort required to integrate the many efforts and detector systems. Coordinating a large multi-institution and multi-national effort to meet the design goals and schedule will require significant management effort. It would be good to see an integrated plan by the time of the next review."