SBS Transition from Project to Operations

Experiment Readiness

1) Dependencies

- The table list the dependencies for the neutron magnetic form factor experiment (GMn), the neutron electric form factor experiment (GEn) and the proton electric form factor experiment (GEp).

Dependency	GMn	GEn	GEp
Front tracker	X	X	X
Hadron Calorimeter	X	X	X
Gas Cerenkov (GRINCH)	X	X	
Polarized Target		X	
Electron Calorimeter			X

- Progress on the dependencies will be tracked by milestones and monitored by the SBS management team (the SBS manager, the Hall A/C Group Leader, the SBS Principal Scientist and the Associate Director of Physics). Weekly meetings are held by the SBS Collaboration to monitor work by collaborators. An annual meeting of SBS Collaboration is held in the summer each year. The SBS Collaboration Coordinating Committee (CC) has biweekly meetings. The SBS manager, the SBS Principal Scientist and the Hall A/C Group Leader are members of the CC. The SBS manager, the Hall A/C Group Leader, Hall A Lead Engineer and the SBS Principal Scientist will meet monthly.
- The SBS manager, the Hall A/C Group Leader and the SBS Principal Scientist will meet quarterly with the Associate Director of Physics Rolf Ent. The SBS management team will provide a quarterly report and status update to the DOE SC Office of Nuclear Physics via e-mail.

The dependencies for each experiment will be tracked with milestones. Milestones for the dependencies (as shown in the final SBS monthly report) are given on the following pages.

GRINCH from W&M/NCCU/JMU (for GMN and GEN)

Milestone	Scheduled date	Comment
Design and drawings for vessel are complete	Feb 1, 2015	**Completed Feb 2015**
Photon Detector Array assembled and tested	Aug 1 , 2015	**Completed Nov 2016**
NINO chip front end cards system shipped to JLab	Jul 1, 2015	**Completed Oct 2015**
Purchase order issued for vessel	Oct 15, 2015	**Completed Aug 2015**
Full DAQ system ready	Dec 1, 2015	Expected June 2017
Vessel completely assembled	Mar 15, 2016	**Completed Sept 2016**
GRINCH ready for installation	Jun 15, 2016	Expected June 2017
Final analysis software complete	Jun 15, 2016	Expected Sept 2017

HCal-J from CMU/INFN-Catania (for GMN, GEN and GEP)

Milestone	Completion date	Comment
Detailed design completed	June 2014	**Completed July 2014**
Design review	Sept 2014	**Completed Dec 2014**
Module construction initiated	Mar 2015	**Completed Mar 2015**
Module assembly 25% complete	Sept 2015	**Completed Sept 2015**
Module assembly 50% complete	Mar 2016	**Completed April 2016**
Module assembly completed	Sept 2016	Expected in April 2017

Front Tracker from INFN (for GMN, GEN and GEP)

Milestone	Completion date	Comment
Electronics in production	Sept 2014	**Completed Sept 2014**
GEM chambers 1 and 2 completed	Sept 2015	**Completed Dec 2015**
Initial Electronics QA completed	Dec 2015	**Completed Dec 2015**
GEM chambers 3 and 4 completed	May 2016	Expect delivery in March 2017
GEM chambers 5 and 6 completed	Dec 2016	Expect in June 2017

ECal from JLab/NCCU/SBU/JMU (for GEP)

Milestone	**Completion date**	**Comment**
Light guide procurement	Jan 2017	**Jan 2017**
Mechanical design for main frame	Feb 2017	
Start gluing of light guides to leadglass blocks	Mar 2017	
Super module procurement	Apr 2017	
Main frame procurement	June 2017	
Detector assembly in main frame starts	Sept 2017	
Detector testing in the main frame starts	Oct 2017	**Critical decision**
Connection of Signal and HV cables	Dec 2017	
Finished first pass cosmic tests	Apr 2018	

Polarized ^{3}He target from UVa (for GEN)

Milestone	**Completion date**	**Comment**
Selection of target-cell design for high luminosity	Nov 2014	**Completed Oct 2014**
Conceptual design document complete	Jan 2016	**Completed Mar 2016**
Conceptual design review	Mar 2016	**Completed Mar 2016**
Start bench test of 3 liter glass convection target	April 2016	**Completed Aug 2016**
Conceptual design frozen	June 2016	**Completed Oct 2016**
Test of glass/metal technology complete	June 2016	**Completed July 2016**
Begin engineering and design	July 2016	**Completed May 2016**
Bench test of 3 liter glass/metal target	Jan 2017	Expect April 2017
Simulated beam test on the bench for full scale 6 liter cell	Sept 2017	
Begin production of full-scale cells	Nov 2017	
Engineering complete	Jan 2018	
Design of target hardware and instrumentation complete	June 2018	After CDR review updated to July 2018
Target is ready for installation	Jan 2019	

2) Experimental Readiness Reviews

- Each experiment will have a Jefferson Lab Experimental Readiness Review (ERR). The website, http://www.jlab.org/user_resources/PFX/NP-PFX/, explains the ERR process in detail. The ERR ensures that the SBS equipment is capable of achieving the scientific goals of the experiment. After the experiment passes the ERR, then the experiment can request to be scheduled for beam time. The first ERR is scheduled for June 15 and 16th, 2017 for the neutron magnetic form factor (GMn) experiment. This review will consider the SBS base equipment: magnet, beamline, BigBite Spectrometer and hadron calorimeter. The INFN GEMs will be reviewed as part of the BigBite Spectrometer. This review will cover the installation, assembly and testing of the magnet and other base equipment in the hall. This is the same base equipment needed for the neutron electric form factor experiment. There will be a separate ERR for the polarized helium target used in Hall A and C. The review of the neutron electric form factor (GEn) experiment will take advantage of the previous reviews and focus on the beamline configurations and EH&S documents for the polarized helium target for that experiment. The proton form factor (GEp) experiment will be the last ERR. In this ERR, the electron calorimeter, the operation of all GEMs, the beamline configurations and high powered cryotarget will be reviewed.

3) GEM Module Readiness

- The UVa GEM modules will be transported to JLab and stored in a dedicated clean area at JLab. The modules will be periodically tested in a cosmic ray test stand to monitor their sustained performance.

Key Performance Parameters (KPP) and Ultimate Performance Parameters (UPP)

- WBS 1
  - KPP in Program Management Plan.
    1. The modified 48D48 Magnet (yoke cut, new coils, beam-line field compensating coil, and entrance field clamp) must be on the platform and be energized.
  - Demonstration of KPP:
    1. The modified 48D48 Magnet has been placed on its platform. Separately it was energized to 200A (which is about 10% of the maximum current) with the magnet field measured (Fig. 1a shows the magnet with coils and Fig 1b is a copy of the table of the field measurements.). The 200A test is sufficient to demonstrate that the modified 48D48 Magnet performance is acceptable for SBS experiments.

Figure 1a SBS Magnet when being tested at 200A

	Current (A)	Probe 1 (Tesla)	Probe 2 (Tesla)	Probe 3 (Tesla)
62.5%	200	84.31mT / 843G	79.94mT / 799G	82.15mT / 821G
46.875%	150	63.23mT / 632G	59.97mT / 599G	61.62mT / 616G
31.25%	100	42.25mT / 422G	40.02mT / 400G	41.09mT / 410G

Figure 1b Table of field measurements at different locations in the SBS magnet opening at currents of 100, 150 and 200 A.

  - Ultimate Performance Parameters (UPP) focus on the GMn experiment.
    1. The GMn experiment will pass an Experimental Readiness Review (ERR).
    2. The hadron calorimeter will have a time resolution < 1ns.
    3. The Italian (INFN) GEM modules will have tracking efficiency > 95% using cosmic tests.
- WBS 2
  - KPPs in Program Management Plan.
    1. The main performance parameters of the CDET are:
       I. Coordinate resolution < 3.0 mm

II. Time resolution < 2.0 ns

III. Rate capability of 500 kHz per bar with deadtime < 10%

IV. Efficiency > 95% per plane

2. The pole shims must be in hand with dimensions verified.
3. Exit field clamp pieces must be in hand with dimensions verified.
4. The final trigger configuration will be a ready to use integrated hardware and software package. It will be considered complete when it has been successfully tested with pulsers and cosmic rays.

- Demonstration of the KPPs:
  1. The main performance parameters of the CDET:

     I. A detector thickness of 5 mm was achieved which projects to a coordinate resolution of 1.5 mm.

     II. Timing resolution of 1.25 ns was achieved (see Fig. 2a).

     III. Deadtime of 2.5% is given, since timing pulses for the amp/discriminator cards are less than 50ns wide. The PMTs are capable of handling rates up to 1MHz.

     IV. In cosmic tests, efficiency > 99% was achieved (see Fig. 2b).

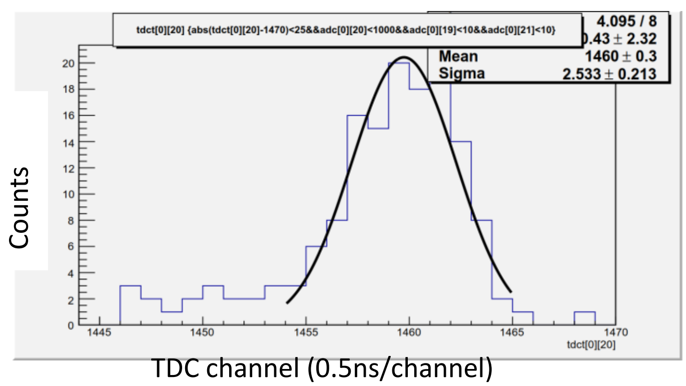

Figure 2a) Timing resolution of the CDet. The sigma is 1.25ns.

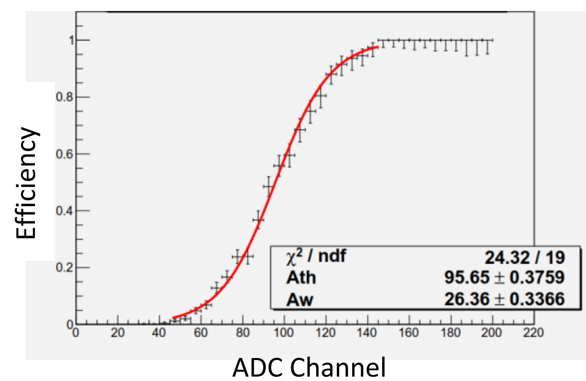

Figure 2b) Efficiency of TDC timing cut versus ADC threshold. The efficiency reaches > 99% at ADC channel=140. The minimum ionizing particles deposit a mean energy of ADC channel=300.

  2. Verification of pole shim dimensions was done by JLab Hall A engineers as standard part of Quality Assurance.
  3. Verification of exit field clamp dimensions was done by JLab Hall A engineers as standard part of Quality Assurance.
  4. The electronics for the trigger have been purchased and undergone acceptance tests.

- Ultimate Performance Parameters (UPPs) focus on the GEn experiment.
  1. The Coordinate Detector UPPs are the same as the KPPs.

2. The polarized helium target will pass an ERR.
3. The GEn experiment will pass an ERR.

- WBS 3
  - KPPs in Program Management Plan.
    1. All GEM modules must be constructed such that:
       I. all foils have an average dark current of less than 5 nA per 20 x 5 cm2 section at 4100 V on the full module
       II. they have a gain of at least 5000 at the operational voltage of 4000 V in a gas mixture of 70% Argon and 30% CO_2
       III. they have a track efficiency of at least 95%, averaged over the module, in cosmic tests
    2. All GEM modules with their attendant electronics must be assembled in their frames and tested with cosmics. GEM electronics and DAQ must be attached to the above GEMs and functional in an integrated data-acquisition system.
    3. The APV25 front-end read-out boards must be tested for low noise level performance and the equivalent noise charge must be less than 3500 e (RMS), averaged over the module.
  - Demonstration of the KPPs:
    1. All GEM modules are constructed:
       (*Note: The voltage of 4250V is used instead of the high voltage in the original KPP, because of the decision to used GEM foils produced by single mask compared to double mask which was an older technique. The decision was approved by the Associate Director of Physics Rolf Ent.)*
       I. As shown in Fig. 3a, all foils have average dark current of less than 5 nA per 20 x 5 cm2 section at 4250 V on the full module.
       II. As shown in Fig. 3b, modules have a gain of at least 5000 at the operational voltage of 4250 V in a gas mixture of 70% Argon and 30% CO_2.
       III. As shown in Fig. 3c, modules have a track efficiency of at least 95%, averaged over the module, in cosmic tests.
    2. As part of the track efficiency study with cosmics, each GEM module is assembled with its attendant electronics.
    3. The noise level for each APV25 front-end read-out board is less than 3500 e- (RMS), averaged over the module. As shown in Fig. 3d, the average noise level is 2280 e-.

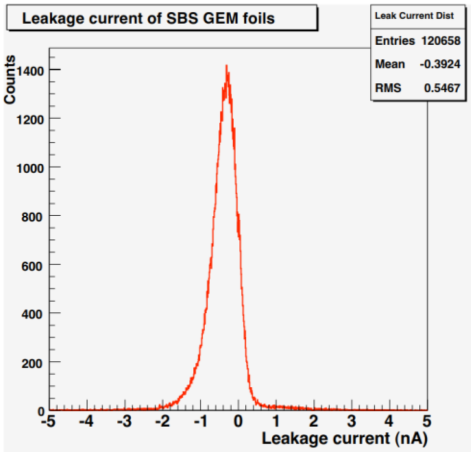

Figure 3a) The leakage current for all sectors of one module at 4250V.

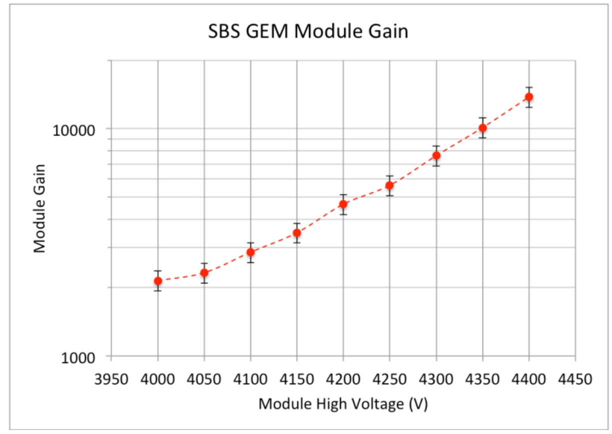

Figure 3b) Module gain versus high voltage. Reach gain of 5000 at 4250V.

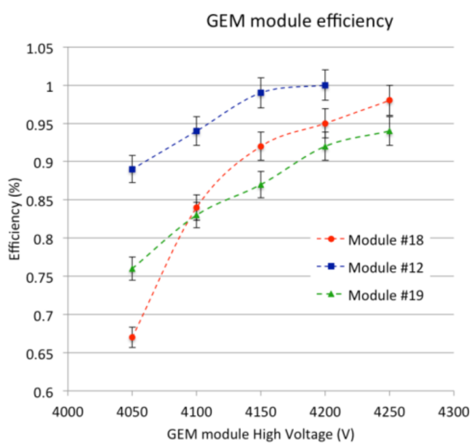

Figure 3c) Tracking Efficiency versus GEM high voltage for cosmic ray tests for three modules. The modules reach >95% at 4250V.

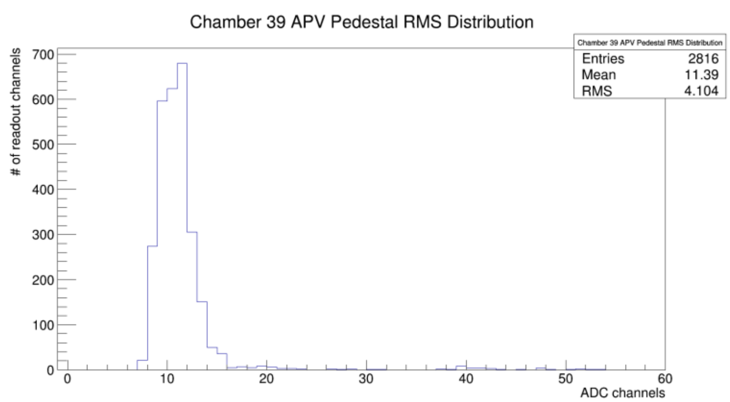

Figure 3d) The pedestal RMS for all readout strips in one module. An ADC channel is 200 e-, so the mean of the pedestal RMS is 2280 e-.

- Ultimate Performance Parameters (UPP) focus on the GEp experiment.
  1. The UVa GEM UPPs are the same as the KPPs.
  2. The GEp experiment will pass an ERR.