SBS Integration Plan

Overview

The three main Super BigBite Spectrometer (SBS) experiments are the measurement of the neutron magnetic form factor (GMn), the neutron electric form factor (GEn) and the proton electric form factor (GEp). The SBS experiments use a variety of hardware that either has been used in previous experiments or is newly constructed. The SBS Program Management Plan (PMP) and Research Management Plan (RMP) document the goals and milestones for the construction of the individual hardware components and are discussed in the Management Plans section. Oversight of the construction and integration of components into the final detector package is discussed in the Integration Oversight section. Tracking and reporting on this oversight is described in the Integration Tracking section. Installation in the hall and scheduling of the experiments will follow the standard Jefferson Lab process described in the Review Process section. The final section overviews the equipment used in each of the SBS experiments.

Management Plans

The SBS Program Management Plan (PMP) documents the budget, goals and milestones for three major projects. The SBS Basic (WBS1) project covers the acquisition and updating of the Brookhaven Labs 48D48 magnet along with the necessary infrastructure which includes power, water and support platform. In addition, WBS1 covers the new beam line corrector magnets, field clamps and passive magnetic shielding needed for the experiments. The SBS Neutron Form Factor (WBS2) project covers the construction of the photo-multiplier based Coordinate Detector (CDET), the acquisition of DAQ hardware for the Hadron Calorimeter (HCAL), the construction of the SBS detector frames and the lead beam line shielding. The SBS Proton Form Factor (WBS3) project covers the construction of forty GEM detector modules and the associated front end DAQ electronics used as the rear tracker for the polarimeter used in the GEp experiment. Table 1 lists the managers for the major SBS subsystem.

Subsystem	Institution	Manager
Magnet/Infrastructure and Installation	Jefferson Lab	Robin Wines
Rear Tracker GEMs and electronics	University of Virginia	Nilanga Liyanage
Coordinate Detector	Idaho State University	Mahbub Khandaker

Table 1 SBS subsystem managers

The PMP includes a list of the components (external dependencies) that are not included in the SBS projects and are being constructed by either US universities , international groups or Hall A staff. These dependencies are listed in Table 2 with the associated institution and contact.

Dependency (Apparatus)	Institution	Contact	JLab Contact
Polarized 3He target	University of Virginia	Gordon Cates	J. P. Chen
Gas Cherenkov detector	College of William and Mary	Todd Averett	
Front tracker GEMs	INFN-Rome	Evaristo Cisbani	Alexandre Camsonne
Hadron calorimeter	Carnegie Mellon University and INFN-Catania	Gregg Franklin	Mark Jones
GEp Electron calorimeter	Jefferson Lab	Bogdan Wojtsekhowski	

Table 2 External dependencies of the SBS program

The Research Management Plan (RMP) was updated in February 2014 to include a discussion of dependencies and each institution's involvement. The milestones for the dependencies are listed in the RMP and, since February 2014, the list of milestones has been included as an appendix in the SBS monthly reports sent to the DOE. The RMP has a table which details the institutional responsibilities for components that are dependencies or part of the SBS Projects. The PMP and RMP cover milestones for construction of the apparatus and delivery to JLab. Once the apparatus is at JLab, the standard Jlab process described in the next section will be followed to insure operational readiness and safety of the apparatus.

Jefferson Lab Experimental Readiness Review Process

The Jefferson Lab Physics Division has developed a process that transitions an experiment from a proposal to a running experiment as shown in the flow chart presented in Fig. 1. The text that describes each phase is available on the web at http://www.jlab.org/user_resources/PFX/NP-PFX/text.html .

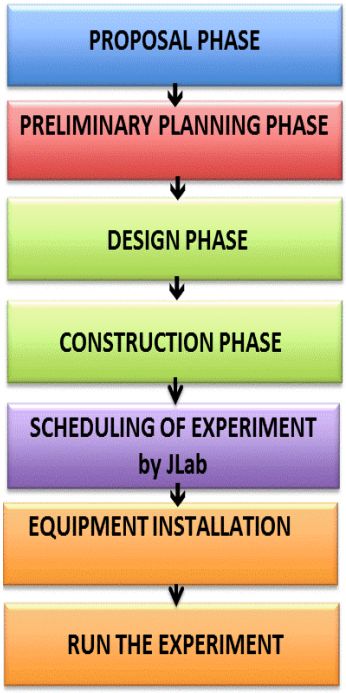

Figure 1 : Flow chart of Jefferson Lab Experimental Readiness Review process

The SBS experiments are at the Construction Phase in the flow chart. Most of the SBS apparatus are at the beginning of construction at their institution. Once the apparatus is ready to be shipped to JLab, available space has been arranged in the JLab TestLab. This is coordinated by Walt Akers, the Physics Division Technical Interface. After the apparatus is moved to JLab, a Work Control Document, in the form of a Temporary Operational Operating Procedure, needs to be written before the apparatus can be operated in the TestLab. Complete cabling of readout and high voltage will be done in the TestLab along with test of the data acquisition. The apparatus will have to be documented and have a written operational procedure for commissioning and use in the experiment.

Once the construction of apparatus is completed or near completion and before requesting scheduling, the experiment has to complete:

- Calculate and document an Experiment Operating Envelope and request a formal Radiation Safety Assessment Document from RadCon.
- Complete a final safety analysis of the equipment and write a preliminary Experiment Safety Assessment Document.
- A review by the Jefferson Lab Review Committee with additional subject matter experts that includes the experiment installation plan, timeline and resource requirements.

After the experiment has been scheduled, then standard procedures for installation and running of the experiment will be followed.

Integration Oversight

Weekly meetings are held between the Hall A Leader (Cynthia Keppel), Program Manager (Mark Jones), Program Scientist (Bogdan Wojtsekhowski) and Hall A Lead Engineer (Robin Wines) to discuss the status of the SBS projects and dependencies. A crucial input to this meeting comes from the weekly meeting of SBS users that is coordinated by the chairman of the SBS Coordinating Committee (presently Brian Quinn of CMU). This weekly user meeting is attended by the Hall A Leader, the Program Manager and JLab Program Scientist. Presentations, which are posted on the web at http://hallaweb.jlab.org/12GeV/SuperBigBite/SBS-minutes/, rotate between the various SBS projects and dependencies.

The Hall A Lead Engineer (Robin Wines) holds weekly meetings with the Hall A Work Coordinator (Ed Folts), Jack Segal, Hall A designers and engineers to discuss progress on the SBS work. The Hall A designers maintain a detailed 3-dimensional model of the hall. Robin Wines makes regular presentations at the weekly user's meeting to update the users on progress and plans. Users consult and have their plans reviewed by the Hall A designers and engineers to insure that the apparatus will integrate with other equipment and the rest of the hall infrastructure. The design reviews of the apparatus are a formal part of the milestones for most of the SBS apparatus.

Figure 2 charts the timeline for production at the home institution (labeled "production") and work at the Jefferson Lab (labeled "JLab") for the SBS projects and dependencies. The Electron Calorimeter and the Coordinate Detector will be assembled at Jefferson Lab, so only a timelines for "JLab" are shown for those two apparatus. The float for each activity is plotted as a blue bar.

Integration Tracking

To track progress on the SBS projects and dependencies, monthly meetings are held between Associate Director of Experimental Physics (Rolf Ent), the Hall A Leader (Cynthia Keppel), Program Manager (Mark Jones), Program Scientist (Bogdan Wojtsekhowski). These meetings review the progress for the SBS projects and dependencies relative to the milestones in the PMP and RMP. Expected dates to meet milestones are updated. If the expected date for a milestone slips, then a critical evaluation of the effect on the milestone's float and on other SBS components is made. Progress and updates are reported to the DOE in a monthly report and quarterly phone conferences are held to review the reports.

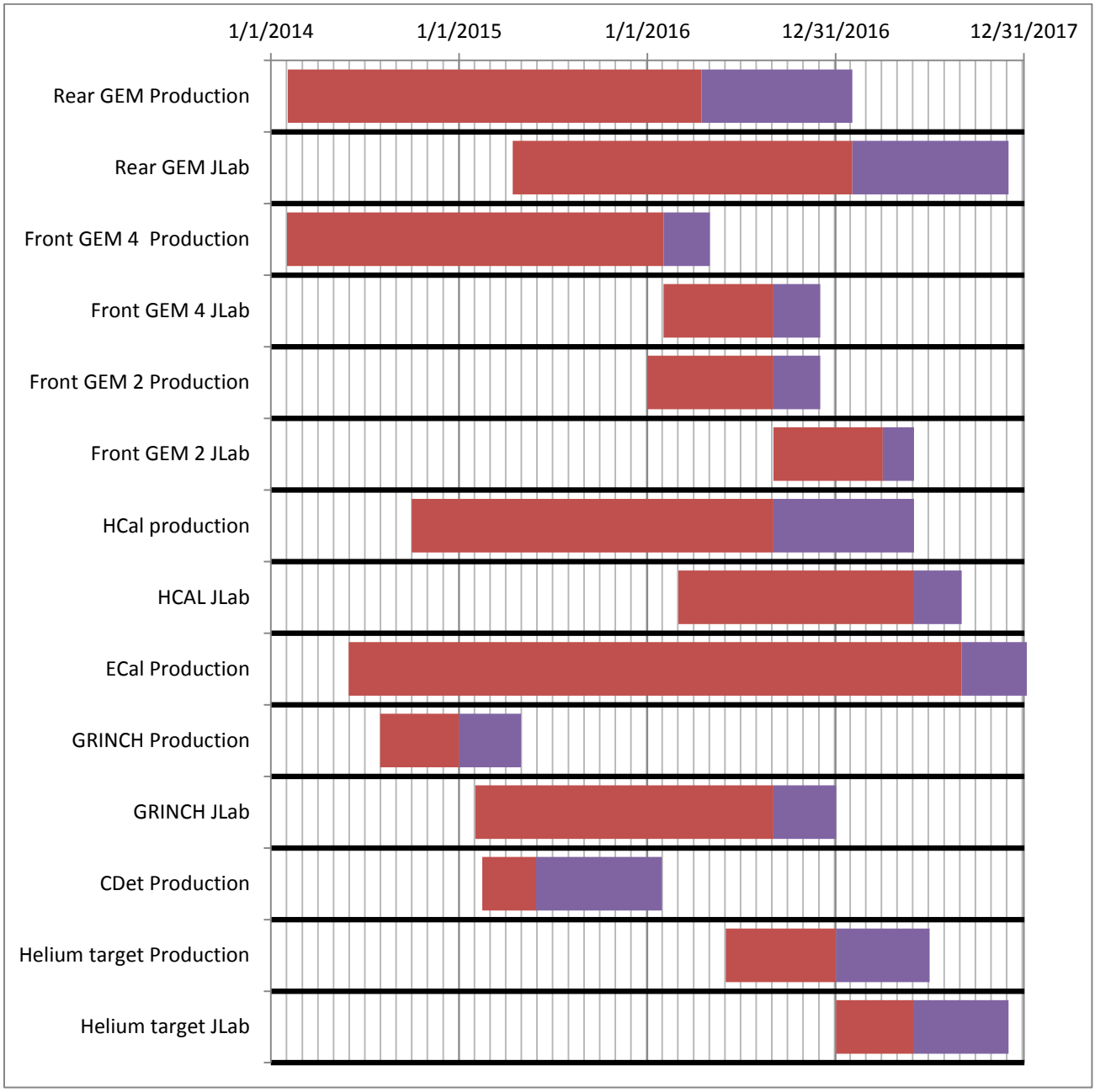

Figure 2 Timeline for the SBS projects and dependencies. The red bar is length of the activity and the blue bar is the float. The "Front GEM 4" means the first 4 GEM chambers (12 GEM modules with 40x50cm^2 area) needed for the neutron form factor experiments and "Front GEM 2" means the last 2 GEM chambers (6 GEM modules with 40x50cm^2 area) needed for the GEp experiment.

Experiment equipment description

This section gives an overview of the experimental apparatus for the SBS experiments. Technical reports are available which give details on each of the apparatus. Details on the data acquisition integration are given in a separate document. In Table 3 is a list of apparatus showing which experiment they are used on and whether they are in the electron or hadron arm. The following paragraphs give an overview of how the apparatus is used in the experiment.

Table 3 List of apparatus showing which experiment they are used on and whether they are in the electron or hadron arm.

Apparatus	Status	GMn	GEn	GEp
BigBite Magnet and Platform	exists	Electron	Electron	
Front Tracker GEMS	SBS dependency	Electron	Electron	Hadron
Gas Cherenkov	SBS dependency	Electron	Electron	
BigBite Scintillator Array	exists	Electron	Electron	
BigBite PreShower and Shower calorimeter	exists	Electron	Electron	
48D48 Magnet and platform	SBS WBS 1 & 2	Hadron	Hadron	Hadron
Beamline upgrades	SBS WBS 1 & 2	Hadron	Hadron	Hadron
Coordinate Detector	SBS WBS 2	Hadron	Hadron	Electron
Hadron Calorimeter	SBS dependency	Hadron	Hadron	Hadron
Rear GEM tracker	SBS WBS 3			Hadron
GEp Electron calorimeter	SBS dependency			Electron
LD2 target	exists	x		
LH2 target	exists			x
Polarized 3He target	SBS dependency		x	

The neutron form factor experiments detect the quasi-elastic coincidence reaction by using the existing BigBite magnet with an updated detector package to detect electrons and the new Super BigBite Magnet with the new Coordinate Detector and new Hadron Calorimeter to detect protons and neutrons. The GMn experiment measures the ratio of d(e,e'n)/d(e,e'p) cross sections to extract the neutron magnet form factor and therefore uses a liquid deuteron target which is standard for Hall A experiments. The GEn experiment measures the asymmetry in the ^{3}He(e,e'n) reaction using a polarized ^{3}He target. A new ^{3}He target design is needed to achieve the high luminosity and polarization needed for the experiment. The BigBite magnet and platform are standard Hall A equipment and will be used unmodified. The standard BigBite electron detector package will be used, except for replacement of the wire chambers and the gas Cherenkov. The INFN group is constructing four GEM chambers (each consisting of 3 GEM

modules) will be used for tracking at the magnet exit. A new highly segmented Gas Cherenkov detector is being constructed by a group led by the College of William & Mary. For the hadron arm, the Coordinate Detector is used as a charged particle veto for GEn and a proton particle identification in GMn. The Coordinate Detector is two planes of scintillator bars, each covering 1x3m2, and the planes will be placed side by side for GEn and GMn. The hadron calorimeter is directly behind the Coordinate Detector and will be used in the trigger and in particle identification through time-of-flight

The proton form factor experiment (GEp) detects the elastic electron-proton reaction. A standard Hall A liquid hydrogen target will be used. The electrons are detected in the electron arm apparatus which consist of the Coordinate Detector and the lead glass calorimeter (ECAL). ECAL is built from hardware used in a previous JLab experiments. The ECAL needs to be refurbished to use heating as the method of annealing the glass from radiation damage. The Coordinate Detector will be the same as used in the neutron form factor experiments, but it is arranged so that the two planes are back to back and in front of the lead glass calorimeter. Protons will be detected using the Super BigBite magnet with polarimeter followed by the Hadron Calorimeter. The Super BigBite magnet needs to have field integral of 2.5Tm, so pole shims will be placed inside the gap to increase the field strength. Details on the Super BigBite magnet are given in a technical document. The polarimeter measures the spin of the recoiling proton. The polarimeter consists of a front tracker followed by two analyzers and rear tracker GEMs. The front tracker is a set of 6 GEM chambers (each chamber consist of 3 GEM modules which each cover 40x50cm^2) which will reuse the 4 GEM chambers from BigBite spectrometer along with 2 additional identical GEM chambers. The front tracker is used to measure the track of the proton after passing through the Super BigBite magnet. This gives the momentum and angle of the scattered proton and the incident track into the first analyzer (50cm thick block of plastic). Five GEM chambers, each built from four 60x50cm^2 modules, measure the track of the proton after the analyzer. To increase the efficiency of scattering the proton, a second combination of analyzer block and five GEM chambers follows the first. Behind it all is the hadron calorimeter in the same configuration as for the neutron form factor experiments.