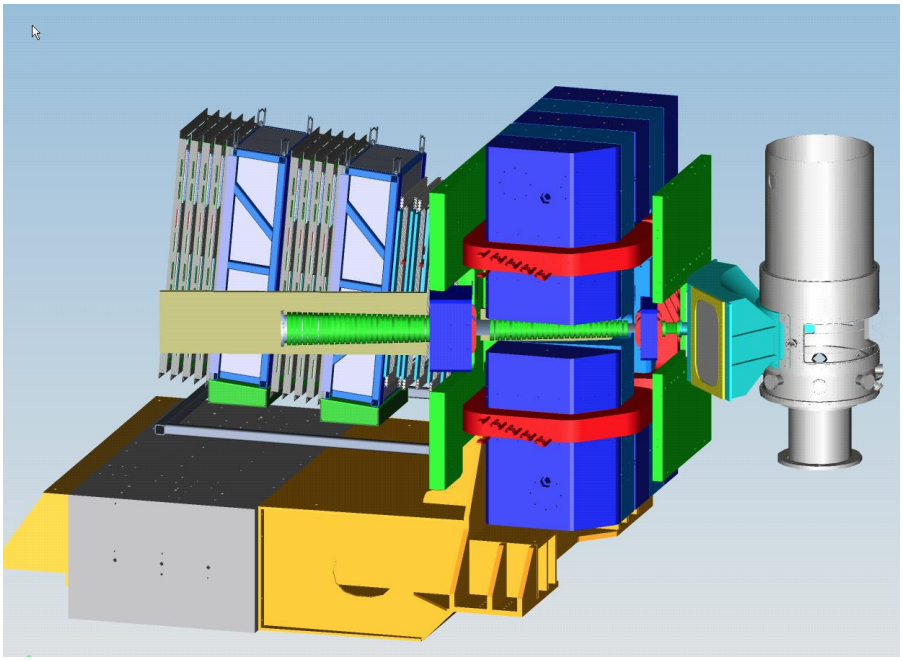
Jefferson Lab
Thomas Jefferson National Accelerator Facility

Super-Bigbite-Spectrometer (SBS)

Monthly Progress Report

September 15, 2016



Introduction:

The SBS Program consists of three separate, but interrelated Projects.

- The first Project, **SBS Basic (WBS 1)**, involves the acquisition of an existing magnet and the associated work of preparing it for use during the SBS research program. The effort includes modifications to the magnet, including machining a slot in the yoke for beam passage, field clamps, and a solenoid to reduce the transverse magnetic field on the beam line, the design and development of the infrastructure needed to run the magnet, and the construction of the platform on which it will stand.
- The second Project, **Neutron Form Factor (WBS 2)**, involves the construction of The PMT-based Coordinate Detector (CDet), trigger electronics for the Hadron Calorimeter (HCal) to meet the requirements of the approved neutron form factor measurements.
- The third and final Project, **Proton Form Factor (WBS 3)**, involves the construction of forty GEM detector modules with associated front-end and DAQ modules to meet the requirements of the approved proton form factor measurement.

Project Management Highlights:

This is the 45th Monthly Progress Report for the SBS Program.
The SBS Basic (WBS 1) project started in FY13 and was completed in January 2016. The SBS Neutron Form Factor (WBS 2) started at the beginning of FY14. The SBS Proton Form Factor (WBS 3) started on October 1, 2012.

- The level 2 milestone for the WBS 2.01 Coordinate Detector of " Coordinate Detector Assembled" was completed on Aug 31st.
- The polarized target dependency completed the milestone of "Start bench test of 3 liter glass convection target" in August. The initial test was not a success. Details in dependency section of report.

WBS 1: SBS Basic

WBS 1	**SBS Basic: (Hall A Infrastructure)**	**WBS 1.01**	Milestones
		WBS 1.02	Project Oversight
		WBS 1.1	Magnet, power and construction
		WBS 1.2	Magnet/detector platforms
		WBS 1.3	Beam line

WBS1 Project was completed on January 22nd, 2016.

WBS 1 Costs:

- The budget for this WBS for FY15 is $212K.
- The incremental budget (FY13+FY14+FY15) is $1,694K.
- At project completion, costed and obligated: $1738K (103%).

WBS 1.01 Milestones: (see Appendix 1 for graphic view of milestones)

Level (ID#)	Milestone	Scheduled Date	Expected Date N/A	Expected Date N/A	Comment
1 (1.1-01M)	Project start	10/1/2012			**Completed 10/1/2012**
2 (2-01M)	Magnet delivered to JLab	4/30/2013			**Completed 8/21/2013**
3	Power supply received	1/4/2014			**Completed 10/17/2014**
3	Magnet yoke modifications Completed	4/1/2014			**Completed 5/22/2014**
2 (1.2-10M)	Platform parts received	6/27/2014			**Completed 3/24/2015**
3	Assemble magnet in Testlab	7/1/2014			**Completed 9/4/2014**
3	Commissioning test of magnet in Testlab completed	10/1/2014			**Completed 10/29/2014**
3	Beampipe solenoid correctors received	1/5/2015			**Completed 12/11/2015**
3	Detector supports completed	4/1/2015			**Completed 3/24/2015**
2 (1.2-30M)	Beam-line parts received	9/24/2015			**Completed 11/30/2015**
1 (1.1-10M)	Project completion	1/29/2016			**Completed 1/22/2016**

WBS 2: Neutron Form Factor

WBS 2	**Neutron Form Factor**	**WBS 2.01**	Milestones
		WBS 2.02	Project oversight
		WBS 2.1	Coordinate Detector (ISU)
		WBS 2.2	Electronics Hut, Lead Shielding, Lead platform, and Detector Frames (JLab)
		WBS 2.3	Pole Shims and field clamp (JLab)
		WBS 2.4	Trigger (RU)

WBS 2.02 Project Oversight:

- SBS weekly meetings, via tele and video conference, were held on Aug 17, 24 and 31st. Participants included Jefferson Lab, University of Virginia, Carnegie-Mellon University, William and Mary, Norfolk State University, University of Connecticut, University of Glasgow, Saint Mary's University, Idaho State University, Christopher Newport University and INFN Rome.
- Project is staffed appropriately for this stage, and includes Jefferson Lab (manager, scientist) and Idaho State University (one scientist).

WBS 2.1 Coordinate Detector (ISU):.

- The Level 2 milestone of "Coordinate Detector assembled" was completed with the assembly of modules 4, 5 and 6 by Aug 31st.
- The QA tests for the 14-scintillator groups for module 6 were complete in early August.
- The CDET frame to hold all modules will be delivered to JLab on Sept 15th.
- The procedures and results of the CDET QA are being archived in the SBS document database.

WBS 2.2 Electronics Hut, Lead Shielding & platform, and Detector Frames:

- The beam-line corrector magnet stands sent to procurement in early August. The contract was awarded at the end of August with completion expected by end of October. Beamline shielding assembly hardware drawings were completed and sent to procurement in the 3rd week of August. The hardware is expected at JLab in middle of October.
- The detailed design work for SBS detector support for the GEM frames was completed and sent to procurement at the end of August. The completion date of the contract is middle of November.
- The drawings for the UVa GEM frames were sent to UVa in the beginning of August. The UVa shop is building one frame and modules will be test fit into the frame. The test fit will be completed by the first week of September, then the frames will be ordered.

WBS 2.3 Pole Shims and field clamp

- Completed.

WBS 2.4 Trigger:

- Completed.

WBS 2 Costs:

- Budget for this WBS for FY16 is $77K.
- The incremental budget for FY14+FY15+FY16 is $1,361K.
- Costed and obligated as of 9/1/2016: $1233K (91%).

WBS 2.01 Milestones: See Appendix 1 for a graphic view of the milestones .

Level	Milestone	Scheduled Date	Expected date 9/1/2016	Expected date 10/1/2016	Comment
1	Project start	10/1/2013			**Completed 10/1/2013**
3	Finish testing of module prototype	8/30/2014			**Completed 8/30/2014**
3	Scintillator ordered	9/30/2014			**Completed 9/15/2014**
2	CDET module design completed	11/30/2014			**Completed 11/30/2014**
3	Wavelength Shifting Fibers ordered	1/15/2015			**Completed 1/20/2015**
3	Scintillator shipped for machining	4/30/2015			**Completed 4/10/2015**
2	JLab receives exit field clamp	6/2/2015			**Completed 11/18/2015**
3	Begin preparation of WLS fibers	6/15/2015			**Completed 7/6/2015**
3	Begin construction of CDET modules	9/1/2015			**Completed 9/24/2015**
3	Assembled one CDET module	10/1/2015			**Completed 11/15/2015**
2	Electronics hut parts received	10/2/2015			**Completed 3/30/2016**
2	Trigger completed	10/4/2015			**Completed 3/15/2016**
3	Assembled one CDET plane	12/1/2015			**Completed 7/15/2016**
2	Coordinate Detector assembled	6/30/2016	8/30/2016		**Completed 8/31/2016**
1	Project completion	1/29/2017	1/29/2017	1/29/2017	

WBS 3: Proton Form Factor

WBS 3	**Proton Form Factor**	**WBS 3.01**	Milestones
		WBS 3.02	Project Oversight
		WBS 3.1	GEM's (UVa)
		WBS 3.2	GEM electronics (UVa)

WBS 3.02 Project Oversight:

- SBS weekly meetings, via tele and video conference, were held on Aug 17,24 and 31st. Participants included Jefferson Lab, University of Virginia, Carnegie-Mellon University, William and Mary, Norfolk State University, University of Connecticut, University of Glasgow, Saint Mary's University, Idaho State University, Christopher Newport University and INFN Rome.
- Project is staffed appropriately and includes Jefferson Lab (manager, scientist) and UVa (two scientists).

WBS 3.1 GEMs

- Present status for completion of 40 GEM modules:

GEM module #	Status
35	Under construction, 3 GEM foils and 1 RO board at UVa and passed QA tests
36	3 GEM foils and 1 RO board at UVa and passed QA tests
37	2 GEM foils at UVa and passed QA tests 1 GEM foil and 1 RO board shipped in Sept
38	3 GEM foils and 1 RO board shipped in Sept
39	1 GEM foil shipped in Sept 2 GEM foils and 1 RO board shipped in Oct
40	3 GEM foils and 1 RO board shipped in Oct

- The three new readout boards arrived from CERN in August were tested. One of the three has some issues and will be return to CERN for repair. The other two will be used for modules 35 and 36.
- In August, nine GEM foils were returned as certified fixed by CERN (Five GEM foils are still at CERN being fixed and will be shipped in the first week of September). All were retested at UVa. Four foils are good and will be used for the next modules. The five bad foils will be shipped back to CERN. Additional GEM foils will be shipped in October.
- A shipment of two readout foils is due in the middle of September and other two readout foils will be shipped in October. A shipment of readout planes for eight spare modules will be in November and December.
- During preparations for frame varnishing for module #35, it was discovered that the hardener of the two-part varnish used for the frames had congealed. This varnish is a special formulation extensively tested for chamber aging at CERN and selected as the best candidate to be used in GEM chambers. The varnish can only be purchased from a company in Switzerland and the process takes about 4 weeks. The process for ordering a new batch was initiated on August 25.
- During the wait for varnish, the other chamber components will be prepared for the next few modules. It is expected that the module production could proceed faster when the varnish arrives and UVa expects to complete 40 modules by the end of November. The plan is to finish module 35 by end of September. Modules 36, 37 and 38 will be completed in October. Modules 39 and 40 will be completed in November.
- Nine GEM foils were returned as certified fixed by CERN (Five GEM foils are still at CERN being fixed). All were retested at UVa. Three foils are good and will be used for the next modules. Six of the returned foils still exhibited the original problem UVa had noticed of small positive sparks (of the order 100 nA or more) during high voltage testing. These sparks are different from the normal sparks in GEM foils, which are negative sparks (with the electron current running from the top side of the GEM to the bottom across a GEM hole). UVa suspects that since these foils do not show negative sparks they passed all acceptance tests at CERN. However, during extensive testing, UVa discovered that the positive sparks are associated with

small corona discharges from the top side of the GEM foil. It is likely that inaccurate chemical etching of one batch of foils caused sharp pointy features on the GEM conductor causing these discharges. Given that these could completely handicap the operation of a GEM at high rate, these foils were returned to CERN again for replacement.

- Module #34 is being prepared for x-ray testing.
- A set of 3 early chambers, #1, #2 and #4 , which were in storage for about two years, were re-tested using cosmic; all sectors work well as expected. .

WBS 3.2 GEM electronics

- The 32 of the 57 MPD modules were successfully tested. The rest will be tested in September. Procedures for QA for testing the APV cards and backplanes are being written.
- The remaining APV cards and backplanes will be shipped by EES to UVa in September.

WBS 3 Costs:

- Budget for this WBS for FY16 is $309K.
- The incremental budget of FY13+FY14+FY15+FY16 is $1739K.
- Costed and obligated as of 9/1/2016: $1671K (96%).

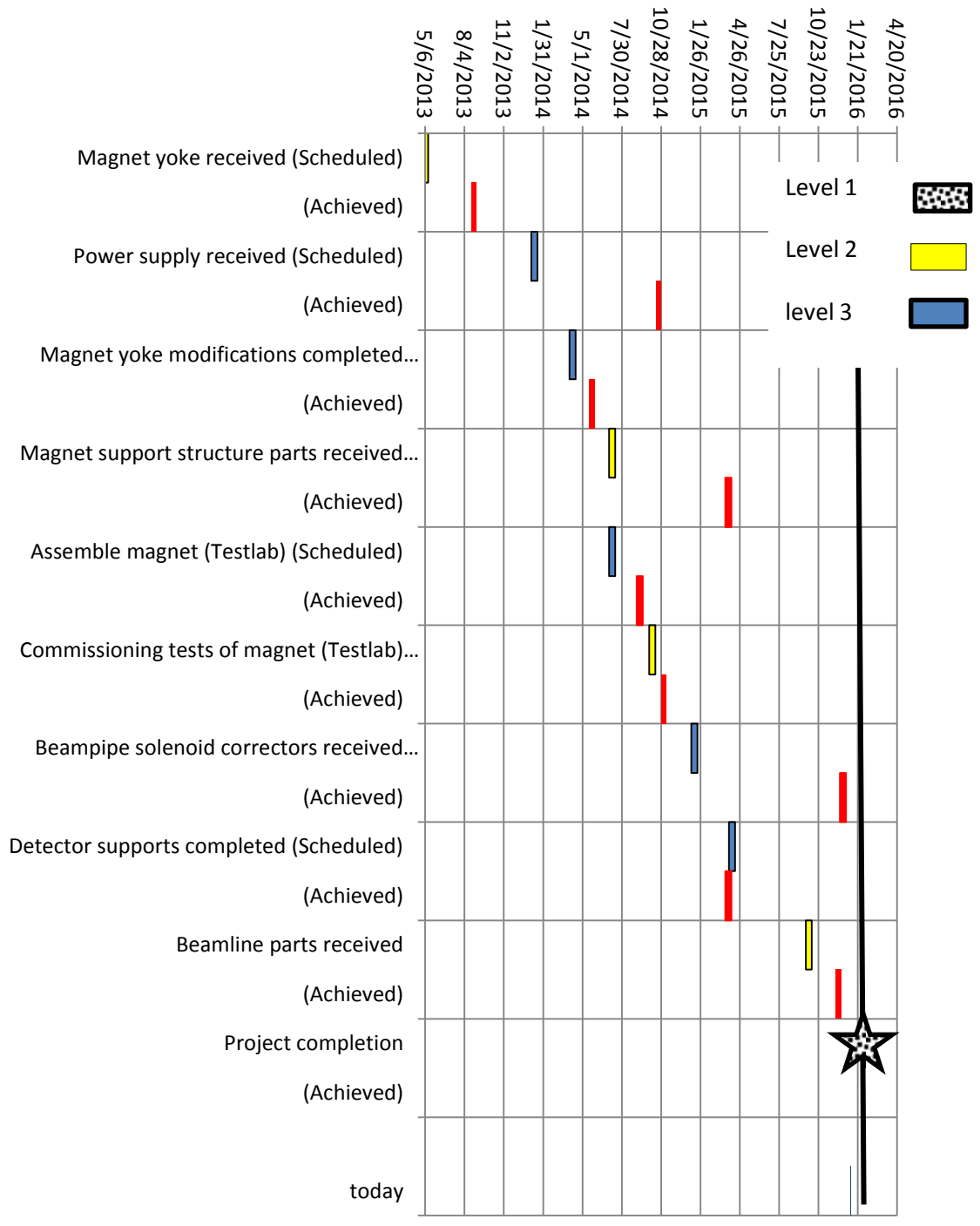
WBS 3.01 Milestones: (see Appendix 1 for a graphic view of the milestones)

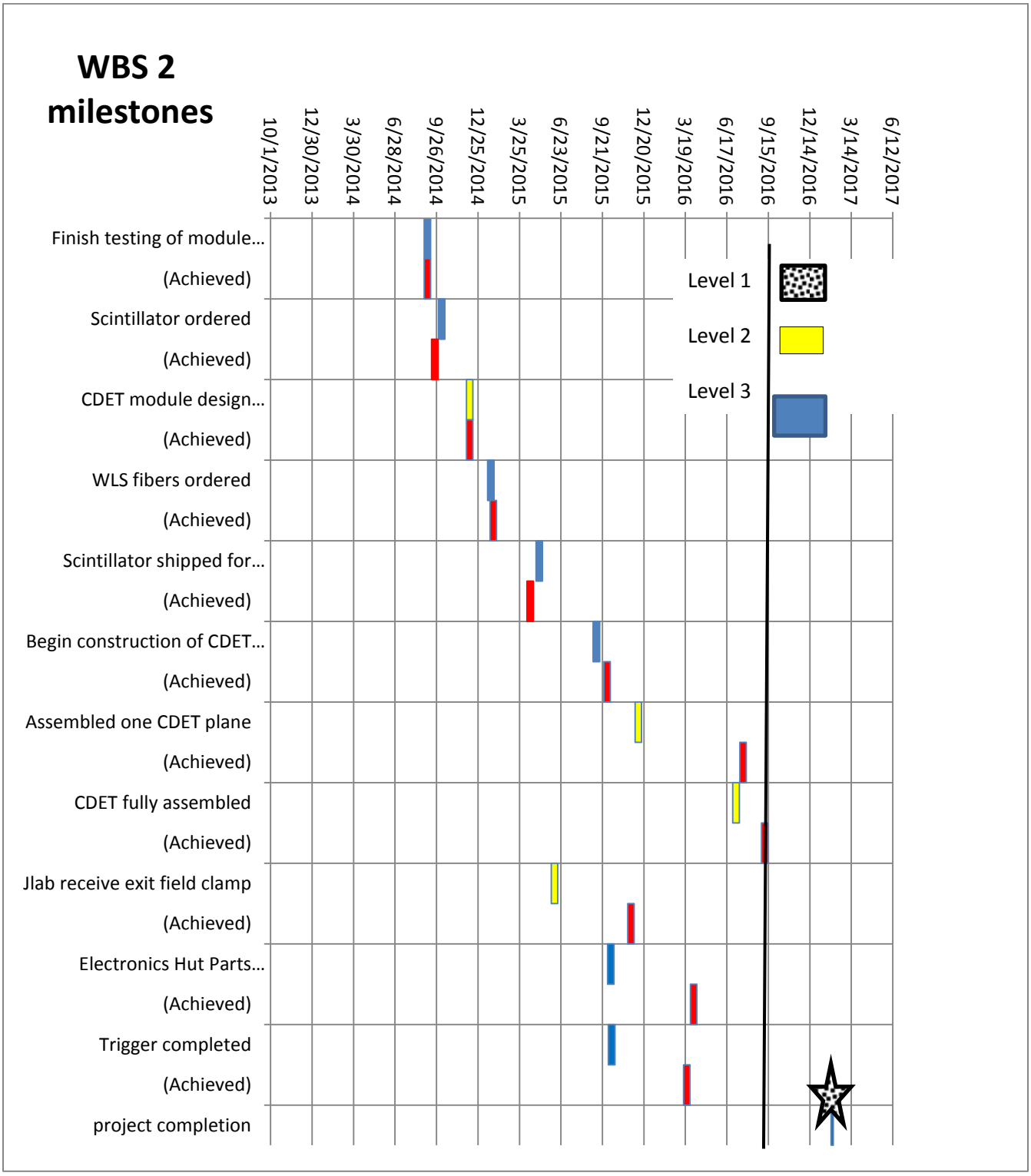
Level (ID#)	Milestone	Scheduled Date	Expected date 9/1/2016	Expected date 10/1/2016	Comment
1 (3.1-01M)	Project start	10/1/2012			**Completed 10/1/2012**
3	Order GEM Parts	10/1/2013			**Completed 10/18/2013**
3	UVa receives GEM parts	2/3/2014			**Completed 4/23/2014**
2 (3.2-01M)	First module assembled and tested	3/3/2014			**Completed 5/15/2014**
2 (3.2-10M)	UVa 5 GEM modules assembled and tested	6/2/2014			**Completed 12/23/2014**
2 (3.2-20M)	UVa 6-16 GEM modules assembled and tested	9/30/2014			**Completed 7/28/2015**
2 (3.2-30M)	UVa 17-29 GEM modules assembled and tested	3/2/2015			**Completed 3/30/2016**
2 (3.2-40M)	UVa 30-40 GEM modules assembled and tested	7/15/2015	10/30/2016	11/30/2016	
2 (3.2-50M)	1st order of Front End Electronics	10/1/2014			**Completed 3/5/2015**
2 (3.2-60M)	2nd order of Front End Electronics	10/1/2015			**Completed 3/5/2015**
1 (3.1-10M)	Project completion	2/1/2017	2/1/2017	2/1/2017	

Appendix I

The following are graphical representations of the milestones for SBS Basic (WBS 1), Neutron Form Factor (WBS 2,) and Proton Form Factor (WBS 3), updated on December 1, 2013. Black represents level 1 milestones as specified in the PMP. Yellow represents level 2 milestones from the PMP. Blue represents the new level 3 milestones to allow better quarterly tracking. The black vertical line indicates the day the chart was made. The red bar indicates when the milestone was achieved (e.g. Magnet yoke received.

WBS 1 Milestones




WBS 2 milestones
10/1/2013
12/30/2013
3/30/2014
6/28/2014
9/26/2014
12/25/2014
3/25/2015
6/23/2015
9/21/2015
12/20/2015
3/19/2016
6/17/2016
9/15/2016
12/14/2016
3/14/2017
6/12/2017
Finish testing of module…
(Achieved)
Scintillator ordered
(Achieved)
CDET module design…
(Achieved)
WLS fibers ordered
(Achieved)
Scintillator shipped for…
(Achieved)
Begin construction of CDET…
(Achieved)
Assembled one CDET plane
(Achieved)
CDET fully assembled
(Achieved)
Jlab receive exit field clamp
(Achieved)
Electronics Hut Parts…
(Achieved)
Trigger completed
(Achieved)
project completion
Level 1
Level 2
Level 3


WBS 3 milestones
8/14/2013
11/12/2013
2/10/2014
5/11/2014
8/9/2014
11/7/2014
2/5/2015
5/6/2015
8/4/2015
11/2/2015
1/31/2016
4/30/2016
7/29/2016
10/27/2016
1/25/2017
4/25/2017
Order GEM parts
(Achieved)
receive GEM parts
(Achieved)
assemble and test 1st module
(Achieved)
assemble, test, and deliver 5 modules
(Achieved)
modules 6-16
(Achieved)
modules 17-29
(Achieved)
modules 30-40
(Achieved)
1st order Front end electronics
(Achieved)
2nd order Front end electronics
(Achieved)
Project completion
(Achieved)
Today
Level 1
Level 2
level 3

Appendix II

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	Received by JLab in Aug 2015. Testing complete by Dec 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 Dec 2016
Vessel completely assembled	Mar 15, 2016	Expected Sept 2016
GRINCH ready for installation	Jun 15, 2016	Expected Jan 2017
Final analysis software complete	Jun 15, 2016	Expected Mar 2017

Status update:

- The vessel assembly is complete at the 80% level. The remaining item is mounting the mirror frame and alignment.
- The Photon Detector Array has been successfully test fit to the vessel. The 500 PMT and bases need to be mounted and this will be complete by December 2016. Following this, the GRINCH can be installed on the BigBite detector stand.
- The workforce for the GRINCH is focused on construction and DAQ. After this work is complete in December 2016, then the workforce will be moved software. The software work will be completed by March 2017. The delay in software has no effect on scheduling of the experiments.

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 Oct 2016, delay due to manufacturing of carbon frame
GEM chambers 5 and 6 completed	Dec 2016	Expect in March 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 Feb 2017

Status update:

- Module production is ongoing. Have produced 184 modules (169 modules at JLab) of the total of 288 modules in HCAL.
- The CMU technician was needed for other JLab related work, so no new modules were assembled in August.
- All the parts needed to assemble the remaining modules have been fabricated and the parts just have to be assembled into the modules. In the past, CMU has assembled two modules per day so the remaining modules could be assembled by middle of November. Since there is no schedule pressure to complete the modules by middle of November and CMU has other commitments, the decision is to assemble at a rate of one module per day. Given this rate of assembly, the projected completion is February 2017. This has no effect on other parts of the schedule.
- In November, the plan is to start stacking the modules into their sub assembly frames at JLab.

ECal from JLab/SBU/JMU (for GEP)

Milestone	Completion date	Comment
Develop concept of annealing	July 2014	**Completed July 2014**
Test of annealing with prototype	Nov 2015	**Completed May 2015**
Fabrication of C200 frame started	Sept 15 2015	**Completed Sept 2015**
Design of ECAL platform modification started	Dec 1 2015	Delay until Jan 2016
C200 assembly completed and testing begins	Jan 15 2016	**Completed Jan 2016**
C200 report results, recommendations completed	June 1 2016	Sept 2016
Design of ECAL frame/oven started	July 1 2016	Delay until Aug 2016
ECAL platform in testlab .	Nov 1 2016	Delay until Dec 2016
Installation of lead glass started	Jan 15 2017	
Lead glass installation compete and cabling started	July 15 2017	
Cabling completed and cosmic tests started	Nov 1 2017	
Finished cosmic tests and ECAL is ready to install	Jan 15 2018	

Status update:

- Three reviewers from the DOE review panel (Ricardo Alarcon, Hank Crawford and Will Jacobs) reviewed the report that compares the three options for ECal. Their comments were incorporated into a response to the Nov 2015 review recommendation that was sent to DOE on September 1st.
- Summary of the C200 studies:
    - From Aug 2015 to Jan 2016, COMSOL simulation for C16 and C200 was created. COMSOL simulation of the C16 was developed and compared to the measured temperature profile. A COMSOL simulation was developed for the C200 to guide requirements for cooling and heating configurations.
    - From Oct 2015-Jan 2016, the insulated, liftable oven support structure was fabricated by the Stony Brook machine shop. The oven design serves as the enclosure for controlled heating and can hold about 1 m^2 of blocks and filler material. The final version of the oven will be about 4.5 m^2.
    - In November 2015, the C16 prototype and associated equipment was moved from Jefferson Lab to Stony Brook by rental truck.
    - In Feb 2016, the FOAMGLAS insulation material was procured and installed in the external oven paneling. The material will be used in the final version.
    - In Feb-Mar 2016, 200 lead-glass blocks were shipped by freight to Stony Brook.
    - From Jan-Jun 2016, work on the heating control and monitoring system was done. The components were purchased and installed into a rack mounted tray. Wiring power

through solid state relays and resistive heaters done and tested. The monitoring is done by an array of calibrated thermocouples. The software for controlling the system and monitoring temperatures by computer through RS-232 was developed in Labview and tested. This same system will be used for the final version.

- From Jan-July 2016, work on design of attachment of PMTs under uneven thermal expansion was done. The design of a supermodule to hold nine blocks was developed. In July, one supermodule was tested in the C16 enclosure and demonstrated that after heating and cooling over several cycles the PMTs and light guides were mechanically fine.
- From Jul-Aug 2016, 10 supermodules were constructed by the Stony Brook machine shop and 10 from an external vendor. All 20 are now at Stony Brook.
- From Jan-September 2016, work on the air cooling design was researched. The PMTs need to be held at $\sim 38^{o}$C while keeping the nearby back area of the lead glass at $\sim 180^{o}$C. A design was made for a polymide barrier over the light guides between the heated blocks and PMTs to isolate the two regions from convection. The concept of using a flexible silicon tubing manifold capable of sustaining high temperatures was developed to provide uniform distributed cooling air flow over the lightguides. The design will be implemented and tested in the C200. The design is scalable to the final version.
- From Jan-August 2016, work on the resistive heating system was done. The final heating system is designed to use kapton heating tape to provide heat on the order of kWs to the front, outer side surfaces, and back of the lead glass. The design is scalable to the final version.
- For Sept 2016, testing of ceramic filler material will be done. The lead glass is stacked in a ”C” shape to match the phase space of proton and does not fill the entire oven. Filler material is being researched and tested in C200 with the intent on being used in the final version.

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	Expect by Sept
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	
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	

Status update:

- The 3 liter glass convection cell arrived at UVa in August. Unfortunately, the cell ruptured while it was being pumped up in the oven. The cause is still being investigated, the rupture seems to be in the pumping cell. The preliminary reason is a slight overpressure and slightly thinner walls then had been done in the past. This is part of the training process.
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