SBS Newsletter #4

April 4th, 2011

Note from the Editor

The newsletter is a forum for progress reports to update the collaboration. The latest version of the response to the Technical Review's report. A summary of the MIE proposal is included in the newsletter.

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News from University of Glasgow. (J. Annand)

1)We now have the plastic scintillator (EJ200 from Eljen Technology) for:

a) An upgrade to the BigBite timing plane. The increased segmentation is for higher luminosity with 90 elements covering 25x25x600mm. Construction to start this year.

b) A prototype of the neutron analyzer array. We have 100 elements 40x40x250 mm. Construction has started.

2) Arrangements have been made to dismount and send to JLab, 3000 PMTs used on the DIRC system of the BaBar spectrometer at SLAC. This is due to take place end of March.

Update on GEMs (E. Cisbani)

GEM prototyping:
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1. First 40x50 cm2 GEM prototype has been assembled last October 2010
2. Beam test done at DESY in late November together with the latest version of the APV25 electronics. Results are encouraging. Beam profile is clearly seen. Main issue is the suppression of the noise level.
3. A 40x50 cm2 module now under cosmic and Sr90 source test in Rome.
4. A few mechanical bugs and improvements are under implementation on the frames and GEM foils.
5. Catania Group has almost completed the set up of the clean room (class 100!) for GEM pre-production
6. Pre-production of 3 full scale modules will start soon (few weeks), as soon as the drawing (by Francesco Noto) are ready and checked.

APV Electronics:
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1. Paolo Musico is working on the firmware of the VME module (named: MPD = Multi Purpose Digitizer); in particular he is working on the SDRAM trying to buffer the data for optimal transfer rate
2. Had a short meeting with Geoff Hall (responsible of the APV25 chips in CMS): he said that there is a large amount of APV25 still available at same price as before: 28 CHF for each APV die. We intend to buy a few 100 in the next months as soon as we gets some money.

SBS/GEM Montecarlo:
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1. Slowly improving the second version of the SBS-MC; first version is under production for reconstruction study by Ole et al.

GEM tests at JLab (M Jones)

In the Fall of 2010, James Coutry and Craig Plazony (students from Christopher Newport University) set up a test stand in the EEL building for the 10x10 GEM detectors. The GEMs were from INFN and the University of Virginia. Presently, GEMs from UVa are being prepared for a test in Hall A during late April.

GEM Simulations & Tracking (O Hansen)

Over the past several months, the simulation and track reconstruction software for the SBS front trackers for the GEp(5) experiment has made significant progress and is approaching completeness. Specifically, we have achieved the following milestones

1. The GEANT4 Monte Carlo developed at INFN fully simulates the target, magnet, and GEM front tracker systems. Several production runs have been completed, both for the originally-proposed SBS angle for GEp(5) and the new angle suggested by the PAC (16.9^o). The photon and electron backgrounds in these data sets are still based on the original estimates from L. Pentchev made in 2009.
2. The digitization of the GEM detector response is fully implemented. Digitization parameters have been tuned based on the published data from COMPASS. Digitized data sets are available for both the originally proposed u/v-x/y orientation of readout planes and chambers with only x/y readouts.
3. The track reconstruction code based on the TreeSearch algorithm is fully working. The code can perform projection matching both geometrically (if 3 or more projections are available, e.g., x, y, and u) or by correlating hit amplitudes between the two coordinates of a shared readout plane (e.g. x/y).
4. Noise suppression has been implemented in the analysis of the raw data from the APV25s. We assume that we will read out 3 amplitude samples from each GEM strip. Analyzing the amplitude ratios of these three samples yields an estimate of the peak position of the pulse in time with better than 10 ns FWHM resolution. A time cut can then be used to reject noise quite effectively. This is a good example of how a pipelined ADC can simultaneously function as a low-resolution TDC.
5. After careful optimization of parameters, we can reconstruct tracks with 92-97% efficiency for Monte Carlo data with zero background. For comparison, due to 3σ cuts used to select "good" tracks, the theoretical maximum tracking efficiency in this analysis is at most 98.9%. Residuals of reconstructed tracks are very small, with a σ on the order of 25 µm for reconstructed position and 160 µrad for angles (see Figures 1 and 2). These numbers repre-

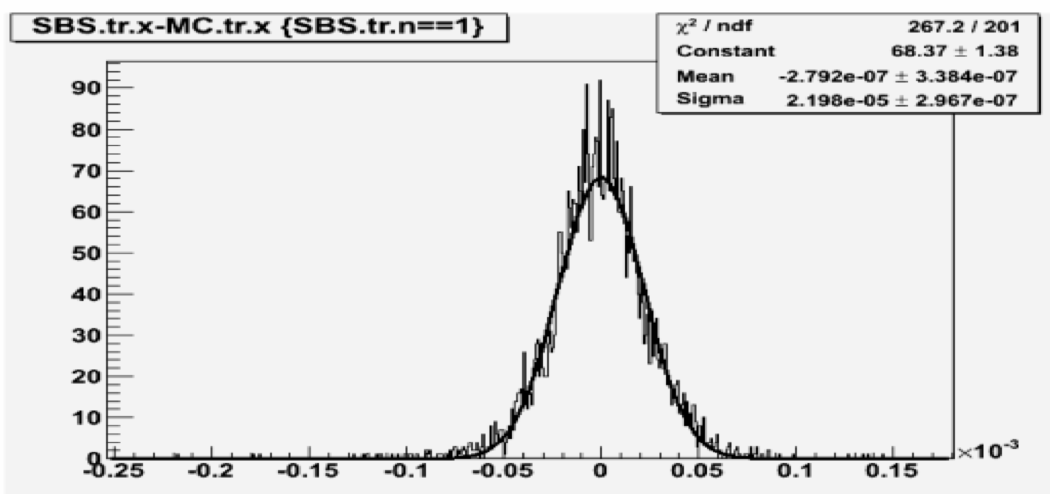

Figure 1: Residuals of reconstructed track x-coordinate for the "g17" production (16.9° SBS angle, no magnet field) and zero background.

sent the baseline for evaluating the track reconstruction performance.

6. The tracking efficiency for the case of **full** background at 16.9° SBS angle is at least 50% with noise suppression enabled. Optimization is still in progress.

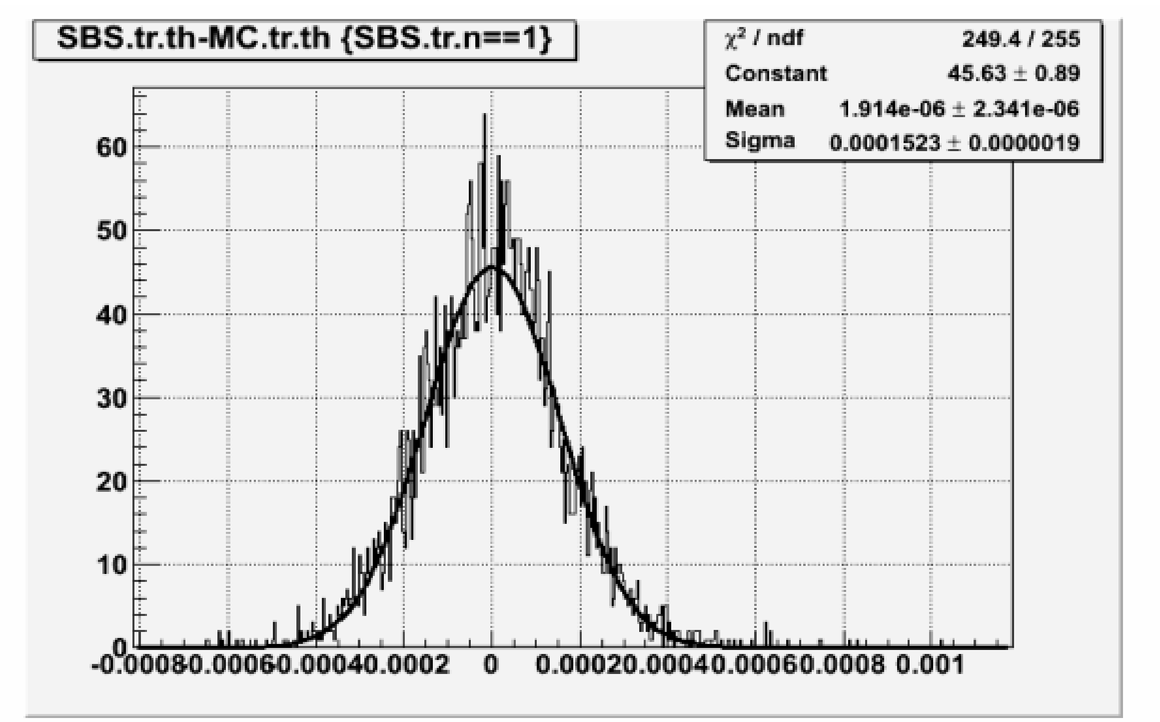

Figure 2: Residuals of reconstructed track θ-angle. Other parameters as in Fig. 1

Currently, we are investigating a number of ideas to improve the tracking efficiency under full background conditions. Since tracking performs very well with clean input data, as we have shown, the main objective is to improve the quality of the noise suppression and hit amplitude distortion due to pileup.

Other tasks still left to do include

1. Complete simulation of the background within GEANT4 instead of using pre-computed distributions.
2. Systematic study of tracking performance as a function of various parameters, such as numbers of planes, minimum cluster amplitude, etc.
3. Comparison of x/y-only plane configuration to u/v-x/y arrangement.
4. Write-up of results.

The Nucleon Electromagnetic Form Factor Measurements in Hall A TJNAF using the 12-GeV CEBAF

An MIE proposal to the United States Department of Energy

The physics program to be funded by this MIE proposal includes three measurements of the ground-state elastic nucleon electromagnetic form factors. Each of the measurements was approved by JLab PAC35 and will use the electron beam from the upgraded 12-GeV CEBAF accelerator. The three experiments include:

- A measurement of G_E^n (E12-09-016) up to $10\,\mathrm{GeV}^2$ using the double polarization beam-target technique that was first approved by the JLab Program Advisory Committee (PAC) in January of 2009.
- A measurement of G_E^p (E12-07-109) up to $12\,\mathrm{GeV}^2$ using the double polarization beam-recoil-polarimeter technique that was first approved by the JLab PAC in August of 2007.
- A measurement of G_M^n (E12-09-019) up to $13.5\,\mathrm{GeV}^2$ by determining the cross-section ratio for the two reactions $d(e,e'n)$ and $d(e,e'p)$ that was first approved by the JLab PAC in January of 2009 (a request for an extension to $18\,\mathrm{GeV}^2$ is planned).

These three experiments will probe a range of Q^2 that is of great interest ever since the surprising results were seen for the Q^2 dependence of G_E^p/G_M^p. Taken together with E12-07-108 (not part of the Super Bigbite program) that will provide information on G_M^p, these experiments will determine all four ground-state elastic electromagnetic nucleon form factors, as well as making possible a flavor separation.

Because all the the elastic form factors drop off so quickly at high values of Q^2, the three above-mentioned experiments will all depend critically on both high luminosity as well as relatively large acceptance. The Super Bigbite answers these requirements by providing very high rate-handling capability, and large solid angle acceptance. The exact configuration for each experiment is somewhat different, but all draw on a common set of equipment that we will refer to collectively as the Super Bigbite Apparatus (SBA). The large rate-handling capability will be accomplished through the use of detector packages that utilize state-of-the-art GEM-based trackers. The large-acceptance detection will be facilitated by using open-geometry spectrometers based on a single 100 ton dipole magnet, a 48D48, that will be appropriately modified for the project. The Super Bigbite Project will also use, in two of the experiments, the existing Hall A BigBite Spectrometer but with upgraded GEM-based tracking systems.

This approach behind the Super Bigbite Apparatus would have seemed quite risky only a few years ago. With the success of the Hall A BigBite Spectrometer, however, the strategy has proven to be extremely effective. Notable BigBite experiments include the measurement of short-range correlations (recently published in *Science* in 2008) and measurements of G_E^n up to $Q^2 = 3.4\ \mathrm{GeV}^2$(published in Physical Review Letters in 2010). Indeed, BigBite provided an order-of-magnitude increase in the Figure-of-Merit over previous techniques in experiments where only modest momentum resolution was required. To push this approach further, however, it was necessary to have tracking systems capable of handling significantly higher rates, which is why we went to the GEM technology. Also, the 48D48 magnet is larger, has higher field capability than does the BigBite magnet, and incorporates in the yoke a wide Lambertson-type path for the electron beam, making detection at forward angles possible.

Funding Profile

A revised funding profile for the Super Bigbite Apparatus MIE is presented in Table 1. The cost shown is in actual year dollars (escalated by 3.5% per year from FY11 when the quotations were obtained). The construction of the hadron calorimeter ($331k, Carnegie-Mellon University) has been moved out of the SBA MIE because it will be used in several non-MIE experiments, including the measurement of G_E^p in

Hall C with a polarized target. As such it will be funded by Jlab's ongoing capital equipment budget. The SBA MIE profile starts with "off project" R&D in FY2011 with $100k to allow us to retain existing students at UVa and to start engineering at JLab. FY12 continues off project" R&D with prototype GEM chamber construction at UVa and the SBA engineering work at JLab. This profile will allow us to complete preparation for the neutron form factor measurements by end of FY15 - beginning of FY16, complete the entire SBA construction process by early FY17, and the GEp(5) configuration at the end of FY17.

Table 1: Experimental equipment budget (in $1000) broken down by institute (project) and fiscal year. The overhead is included. The 3.5% per year inflation and the contingency are included.

Institute	FY2011	FY2012	FY2013	FY2014	FY2015	FY2016	FY2017	Total
JLab	55	183	386	628	510	260	82	2124
UVA	45	213	338	349	438	233		1616
W&M					86			86
NSU				283	196			479
Rutgers					22	179		201
year total	100	356	724	1260	1253	673	82	4447
MIE total	0	0	724	1260	1253	673	82	3991

Collaborating institutions

The core of the collaboration has considerable experience, having recently completed JLab experiments E04-108 (GEp(3)) and E02-013 (GEn(1)). Included in this core are JLab, UVa, Carnegie Mellon, William and Mary, the University of Glasgow (Scotland), Norfolk State University, Rutgers, INFN (Italy).

Hall A sub-group: The Hall A group will take on the design of the apparatus layout, the modification of the 48D48 magnet and the beam-line vacuum pipe. The group will be responsible for the installation and commissioning of the upgraded infrastructure required for the magnet, the targets, and the beam line.

College W&M sub-group: The College of William and Mary sub-group will take responsibility for assembling and testing the coordinate detector, which will be used in the electron arm of the GEp(5) experiment. It will require design and construction of a large mechanical frame for the two-plane detector with a one-dimensional readout. This detector will have a simplified version of the polarimeter GEM chambers.

NSU sub-group: The Norfolk State University sub-group, in collaboration with the INFN-Rome group, will fabricate, test, and commission the Front-End-Electronics and Data Acquisition electronics for all GEM-based trackers in this proposal. The total number of analog channels is about 40 thousand.

Rutgers University & UNH sub-group: The Rutgers University & University of New Hampshire group, in collaboration with Jefferson Laboratory, will take responsibility for developing, assembling and testing the trigger electronics for the EMFF experiments. As part of this work Rutgers and UNH will write specialized code for the programmable modules used for identifying coincidences.

UVa sub-group: The University of Virginia group, in collaboration with the College of William and Mary and Jefferson Laboratory, will develop and fabricate the GEM-based units with active area $40{\times}50$ cm^2 that will be used for two of the polarimeter trackers and the coordinate detector. The UVa clean room will be increased by the addition of a new class 10,000 level $6{\times}4$ m^2 clean room adjacent to the original clean room, and will be specially equipped for the construction of the GEM chambers.

The impact on the plan developed in against the possibility that DOE would not provide MIE funds until FY14. That could be done as ”off project R&D and some mini-projects.

The goal of both of these exercises is to be ready to run GEn early in the Hall A program (nominally late FY15 to early FY16 install), and to keep the collaboration whole.

If the MIE funding start will be shifted to FY14 there are following projects which progress will allow us to advance in “pre-production” of the SBA components:

- Construction of two pilot GEM chambers at UVa. Test and improve the construction technology. Estimated cost is of $200k.
- Constrution of the test lab in NSU and test of the electronics evaluation process using actual front-end-cards. Estimated cost is of $150k.
- Preparing production drawings for the SBS magnet and the beam line in Hall A. Estimated cost is of $150k.

Advances in these items will reduce delay of the project in case of late start of the MIE funding.