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Readiness Review Report

Project : Experiment E07-003 (SANE) in Hall C

Committee : Eugene Chudakov (chair), John Domingo, Michael Epps, Charles Hightower, Walter Kellner, Dave Mack, Lubomir Pentchev, Mikell Seely

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To : S. Wood, S. Choi, Z.–E. Meziani, O. Rondon-Aramayo

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1 Introduction

A readiness review of experiment E07-003 (Spin Asymmetries on the Nucleon Experiment, SANE) in Hall C, was held on July 2, 2007 at JLab. Additionally, three other experiments which may be scheduled to run immediately after SANE, namely E04-113 (Semi-Inclusive Asymmetries on the Nucleon), E05-101 (Helicity Correlations in Wide-Angle Compton Scattering), and E07-011 (High Precision Measurement of g1d/F1d) have been briefly discussed. The committee was able to review the written material prior to the meeting. During the meeting, the general features of the experiment have been discussed as well as details on the present status of the preparations, the schedule for completion and installation of the experimental equipment.

SANE's installation and running will take 4 months, which makes it a considerable beam-time investment and requires a thorough planning. SANE also requires a major installation work. It will benefit from running just after experiment $\mathrm{G_Ep} - \mathrm{III}$, which is also using a big lead glass calorimeter BigCal. The milestones of the provisional schedule are:

- installation: May 19 – July 10, 2008;
- survey and alignment: July 10 – 14, 2008;
- commissioning July 14 – 25, 2008.
- data taking July 26 – September 22, 2008.

The committee has not identified any serious showstopper. However, it recommends that several potential problems will have been solved somewhat in advance of the installation start. These recommendations are emphasized in the text by black bullets. A number of other recommendations, perhaps less critical, have been also given.

2 Physics Goals

SANE is going to measure the polarized structure functions in a wide kinematic range, including large x_{Bj}. The electron energy is measured with a calorimeter, with a relatively poor accuracy. It is not clear what would be the contamination of the large x_{Bj} sample with lower x_{Bj} events (bin migration), for the expected calorimeter performance. Additional effects which may introduce systematic error are the event pileup (mimicking a higher particle energy) and the mis-calibrations of various kinds.

This effect may put additional requirements on the calorimeter calibration and performance.

2.1 Recommendations

- It should be demonstrated that the expected calorimeter resolution, as well as the calibration and monitoring procedures, are good enough to reach the physics goals of the experiment.

3 Beam Line

3.1 Beam Energy

SANE will run at several energies, the higher energy can be selected in a range 5.7–6 GeV. Since the other two halls also suppose to use beam polarization at the same time, an energy that provides high polarizations in all three halls should be selected. A calculation for 5.917 GeV at 5 passes has been done, however it is likely that this energy will be too high to reach in 2008. It is unclear what would be the implications of of lower energy in means of the interference with the other halls.

3.2 Beam Diagnostics

The beam tunning for SANE will be a challenge. The experiment will use a much lower beam current ($\sim$ 50 nA) than usual in Hall C. Additionally, it has to pass through a chicane. The exit pipe is replaced by a helium bag. A portable beam dump will be used. The beam position will be measured with the Secondary Emission Monitor (SEM). Most of these elements have been already tested and used in Hall C in the past. A similar scheme was used in experiment $G_E n$ at low currents, with a chicane, a helium bag and a portable dump.

The SEM system has been modified to allow the electronics to be better shielded from radiation. This requires that the SEM head be connected to the electronics by a cable, which might pick up electronic noise.

3.3 Recommendations

• There should be a low current (nA) diagnostics package of some kind to verify beam position from the target to the dump.

• The read backs from the Secondary Emission Monitor (SEM) should be made available to the MCC through EPICS.

• Additional FSD protection for the total beam current, the BE and BZ magnets, rasters, and beamline components between the target and the dump.

• TOSP for hall access including the Hodoscope platform and 5T magnet area.

○ The new SEM system should be checked in the noisy environment of the hall as soon as possible so that additional cable shielding can be provided if required.

○ The value for the highest running energy depends on the progress with the accelerator and is still unclear. The collaboration should provide a set of energy points in a range of 5.6-6.0 GeV, optimal for maximizing the beam polarizations in all three halls.

4 Radiation Shielding

The open-floor geometry of the BETA detector package requires an elaborate shielding. The Monte-Carlo code of P. Degtiarenko, used for the background simulation, has been used in various JLab open-floor experiments, as RCS and $G_E n$ in Hall A. The GEANT3-based simulations typically underestimate the low energy backgrounds, which affect the wire chamber performance, by a factor of 2-3. Plastic Cherenkov and scintillator counter rates were also typically higher than anticipated from simulation. SANE collaboration should design the shielding assuming a factor 2-3 higher background than calculated. The background with the perpendicular field in the target magnet is considerably larger than the background in the parallel field configuration. The background in BETA comes mainly from the target.

The shielding consists of several elements:

- a lead wall between a BETA side and the beam;
- a lead block at the opposite side, to shield the PMTs;
- cast iron blocks along the downstream pipe, in order to shield the background generated in the beam dump;
- 6 mm of iron in front of the BigCal will be used in order to reduce magnetic fields.

The lead shields will require well designed support platforms. A working platform around the Cherenkov counter to facilitate adjustments of the mirrors and photomultipliers was also requested.

The shields in front of the detectors affect strongly the detector performance. Changing these shields during the experiment would affect the calorimeter calibration.

4.1 Recommendations

- The lead shields need cassettes to pack in lead bricks, as well as special supports or platforms. These platforms need to be carefully designed in order to avoid interference with other objects and to safely support the weight of the shields. The position and size of these supports should be communicated to the Hall C designers so that their construction can be started. The safety issues must be elaborated.

◦ The shields in front of the detectors should be optimized before the calorimeter calibration.

5 Target

The polarized NH_3 target is kept in a 5 T magnetic field. The target elements, as the material, the magnet, the micro-wave system etc, are inherited from other experiments. A new vacuum chamber window is being manufactured.

The use of Torlon target cups was suggested. This will require an additional TE measurement (empty cup) for proton targets and will increase the systematic error in the NMR polarization measurement.

5.1 Recommendations

- The collaboration indicates that 9 additional target operators will be needed to staff this experiment. Those individuals should be identified and plans for their training should be specified. This is likely be be a difficult requirement to fulfill.

◦ It is suggested that the target cups be made easily replaceable to allow the use of hydrogen free plastics.

6 Electromagnetic Calorimeter

The electromagnetic calorimeter (BigCal) is the main detector in this experiment. SANE inherits it from experiment $\mathrm{G_Ep-III}$. Before SANE starts the BigCal will have been checked-out. A part of this calorimeter has been used in experiment RCS in Hall A. From this experience one should expect a strong radiation damage of the frontal part of the lead glass blocks at the end of the $\mathrm{G_Ep-III}$ running.

6.1 Annealing

The collaboration plans to anneal the blocks in situ, using a powerful UV lamp, during the SANE installation time. This will include: removing the PMT bases and the PMTs with cookies, mounting the UV source probably at four positions, making new cookies, putting back the PMTs with cookies and the bases and testing everything inside the calorimeter. The committee's estimated the manpower needed as 4 weeks for 4 people, two of them experts. Since large resources must be allocated to this procedure, it would be helpful to provide its quantitative justification, comparing the calorimeter resolutions with and without the annealing. It was mentioned that there might be a way to anneal the glass with a less powerful light source, which would not require the PMTs removal. The collaboration should compare these options.

6.2 Calibration and Monitoring

The initial calorimeter calibration will be done with $\mathrm{e^-p}$ elastic scattering with the help from the HMS. Several settings for the target magnet will be used to irradiate various areas of the calorimeter surface. This calibration will be done at the beginning of the experiment, at ~ 2.4 GeV. Still, some part of the detector will not be covered by this calibration.

On a short time scale, the gains will be monitored using stable light flashes, distributed to the frontal faces of the glass modules. This monitoring system is under construction for the Gep experiment. However, there it will be used mostly for testing purposes without paying attention to its stability. The SANE collaboration should provide a control of the light stability in order to use the system for gain monitoring. Since the radiation damage occurs mostly in the frontal 3 cm layer of the glass, the monitoring light is absorbed stronger than the light from a shower, which peaks at 10-15 cm inside. Therefore, the "flasher" provides a poor monitoring of the detector response in case of the growing radiation damage. The radiation dose on the lead glass during the SANE running is expected to be much lower than the dose in the high luminosity experiments as the RCS or the $\mathrm{G_Ep-III}$, still it is not clear how accurate the monitoring will be. The monitoring must help detecting quick changes in the detector response, for example ones caused by the magnetic field rotations.

During the experiment, the plan is to use $\pi^\circ \rightarrow \gamma\gamma$ or $\pi^\circ \rightarrow \gamma e^+e^-$ decays for readjusting the calibration factors. The latter process rate is about 1% of the former one, but it might be accepted by the regular trigger. It has not been demonstrated that the calorimeter thresholds used for the regular trigger are low enough for this. Since two or three particles are involved, this calibration procedure converges slowly and requires a large statistics of detected π°. The collaboration should provide quantitative estimates for the rates and the time needed to obtain the accuracy required. This must include the realistic trigger requirements and the calorimeter acceptance effects. The electrons and photons may have have different incidence angle and different effective shower depths, affecting the relative detector responses. These effects need to be understood.

A considerable amount of material (about 0.5 r.l.) will be placed in front of the calorimeter, including areas with a strong magnetic field, which will affect the energy resolution. This influence should be evaluated.

6.3 Magnetic Field

The target magnet will provide, accordingly to calculations, a magnetic field of about 9 Gs in the area of the photomultiplier tubes. The tubes have magnetic shields, made of μ-metal. The plan is to put the whole detector in a steel box about 6 mm thick. The magnetic shielding is critical for the detector performance, since one has to compare the results obtained with different target field orientations. A small change of the gain caused by the magnetic field may introduce a systematic error.

6.4 Recommendations

- The annealing action should be quantitatively justified. If it is indeed needed, a manpower estimate should be done, taking into account other activities during the installation period. If a less intrusive way of annealing (without PMTs removal) exists, it should be investigated.

- The magnetic shielding should be carefully calculated and the detector response should be measured for different residual field values and orientations.

◦ The continuous calibration using π° decays could be a powerful tool to minimize the systematic errors associated with the calorimeter response. The time scale for this calibration (the data taking time and the data analysis time) should be estimated and, if needed, a special trigger should be organized in advance.

7 Gas Cherenkov Detector

The gas Cherenkov detector is a critical element for the pion background suppression, particularly on the trigger level. Testing, final design, and fabrication appear to be on track. Tests were done in the hall with a different Cherenkov detector design to check backgrounds. Photon transport was thoroughly simulated. Photocathodes of 3" diameter were chosen to minimize backgrounds and make magnetic shielding easier. Background simulations were made to guide the design of local shielding to protect the PMTs and keep stray electrons out of the radiator volume. The mirror glass has been slumped, aluminized, MgF coated, and had its reflectivity measured. Mounting solutions for the mirrors and PMTs were found, and have been fabricated. A scheme for aligning the mirrors and PMTs exists. The gas system requirements have been defined. The radius of the mirrors still needs to be checked.

Critical tests of a section of a production detector have not yet been made, but are planned for this fall. Some plans for the tests do not seem realistic. For example, building a lead wall is impossible since it will interfere with the $\mathrm{G_Ep-III}$ experiment. It will need at least a platform not yet designed.

7.1 Recommendations

- The 2007 tests need to be better coordinated with the $\mathrm{G_Ep-III}$ collaboration in order to make realistic planning.

8 Hodoscopes

There are two tracking hodoscopes being built - a thick (3.5 cm) Lucite Cherenkov hodoscope and a scintillating fiber front tracking hodoscope. The Lucite hodoscope provide about 10 p.e. from MIPS, while the fiber hodoscope provides 3–4 p.e. per fiber. A WLS fiber is glued parallel to the 3×3 mm^2 scintillating bar. The WLS fibers are collected on 64-channels PMTs.

The PMTs, in particular those of the Lucite hodoscope, are located in a strong field. Magnetic shielding is foreseen.

8.1 Recommendations

- The effectiveness of the magnetic shielding should be demonstrated in a more convincing way, either by calculations or by measurements.

9 Software

The simulations have been helpful in guiding detector design but are not reaching the high level of sophistication one would hope for this difficult first-of-a-kind measurement. The collaboration is just beginning to incorporate the hodoscopes into the simulation and develop the tracking software.

Significant advances in the simulations since the original proposal include photon transport to help design the Gas Cherenkov Detector, distinguishing low energy electrons and positrons with the fiber hodoscope, and overall optimization of the running time between beam energies, anneals, etc.

It seems that the collaboration has not developed so far the calibration and data analysis software.

9.1 Recommendations

- It will be crucial to have working software for BigCal e^-p and π° calibration before the experiment starts.

10 Detector infrastructure

It has been already mentioned that the detector platforms have yet to be designed. The platform for the gas Cherenkov detector should provide space to service some elements, like the phototubes.

Other infrastructure issues have not been discussed, namely the locations of the cable runs, the cable delay lines and the trigger timing, in particular coincidences with the HMS.

10.1 Recommendations

- The proper timing of various elements including the ADC gate should be demonstrated.

11 Installation

Installing this experiment in 8 weeks will be a challenge given the number of different activities that must take place (target, beam line, BETA and HMS) and the overlap in resources and personnel. Careful planning and coordination will be needed. The existing plan includes scheduling for all the subsystems. It has to be elaborated taking into account scheduling the crane, waiting for activation from the GepIII experiment to die down, identification of tasks that must take place sequentially because they cannot safely take place in parallel, etc. For example, work by the polarized target group and by the BETA PID detector groups will have to be coordinated.

11.1 Recommendations

- A detailed installation plan needs to be developed before one can answer the question of whether 8 weeks is sufficient for installation.

12 General Organization

This is a complex experiment in which a number of institutions must collaborate to bring together a number of devices. A clear definition of responsibilities within the collaboration is needed. The appointment of a Jefferson Laboratory staff member to serve as project coordinator (or physics liaison) would be helpful at this time. The project coordinator would serve as the point of contact between the collaboration and the laboratory and would be responsible for insuring that the required laboratory resources are available.

12.1 Recommendations

◦ The role of the physics liaison, or the project coordinator is particularly important for this experiment, and someone has to assume these responsibilities ASAP.

13 Manpower

On the installation stage, the same people are responsible for various parts of the project. With a careful planning, the manpower might be adequate.

Shift manpower also appeared to be adequate. However, a relatively large number of target operators (9) still need to be trained. Postdocs seem to be playing less of a role in SANE than in other large installation experiments. If more postdocs could be recruited, there are many important software tasks awaiting them.

14 Other Experiments

Short presentations on three other experiments were given. Some of these experiments (g1D/F1D) are similar to SANE and might have been straightforward to evaluate, but no information was provided about manpower, possibly due to the limited time available to presenters. The committee had little time to consider the details of these projects and can give only a few comments:

– Each of these collaborations needs to demonstrate that it has sufficient manpower, and that this manpower will be available after months of running all the polarized target experiments in front of it. Obviously, this is not something that can be addressed without a couple of straw-man schedules.

– Given SANE's lack of software manpower, one would have hoped the semiSANE collaboration would have brought new manpower to BETA as well as new demands.

– SemiSANE and WACS plan to replace the Helium bag with a small angle and standard beam pipe, respectively, to allow the HMS to detect hadrons at small angles. The target field would be longitudinal so there is no issue of sweeping degraded primary beam into the pipe. However, Pawel Degtiarenko's previous simulations have shown that the small angle beam pipe typically dominates the site boundary dose for even relatively thin 4 cm LH2 targets. The beampipe can therefore expected to be a major source of background for exposed detectors. As proposed, the semiSANE and WACS experiments would exacerbate backgrounds due to the 2 cm diameter raster, longitudinal focusing of the Moeller electrons, the thick (7%) polarized target, and use of a radiator (in the case of WACS). Removing the beampipe would probably reduce backgrounds, but the illuminated portion of HMS Q1 could still be a major background source. Of the two experiments, the backgrounds are perhaps of greater concern in semiSANE.

In summary, all the experiments have to demonstrate the adequate manpower behind them. SemiSANE and WACS appear to have the beam pipe issues to solve, which would require independent reviews.

15 Summary

The committee has reviewed the preparations for the installation of experiment SANE. The collaboration is making significant progress in making the components of the experiment ready to be installed in May 2008. The readiness review committee has not found any obvious problem that would jeopardize the installation and running of the experiment.

The installation schedule is a matter of concern. A detailed installation plan should be provided in order to answer the question of whether 8 weeks is sufficient for installation.

The committee has emphasized certain aspects of the preparations and gave recommendations. Some of these points are: the design of the magnetic shielding, in particular for the BigCal; the installation planning; the manpower for target operations, etc.

Due to a lack of time, some items have not been discussed in details, as, for example, the preparations of the EH&S documentation.