February 11, 2003

READINESS REVIEW OF HALL A EXPERIMENT E00-110

(Deeply Virtual Compton Scattering at 6 GeV)

A readiness review of the Hall A experiment E00-110 (Deeply Virtual Compton Scattering at 6 GeV) was held on Thursday, February 6, 2003 at JLab. The members of the review committee were:

Hari Areti
John Domingo
Howard Fenker
Ed Folts
Bert Manzlak
Bernhard Mecking (chair)
Elton Smith

The committee reviewed the written material prior to the meeting and heard a detailed discussion of the requirements for the experiment, the present status of the preparations, and the schedule for completion and installation of the equipment. Note that the experiment had been reviewed on March 9, 2001 by (essentially) the same committee.

The DVCS experiment has been conditionally approved by PAC18 with the condition that 'adequate rate performance of the detectors in question be demonstrated to the JLab management'. The experiment is presently expected to be installed in March of 2004, after the completion of the next G0 run in Hall C.

As already noted by PAC18, the main problem of the experiment is the high rate in the detectors. The predicted rates drive the layout of the detectors, especially the segmentation and the readout technique. The committee was pleased to find that significant progress has been made towards the realization of this challenging experiment. In particular, an experimental test has been carried out demonstrating that the real rates are very close to expectations, and that the details of the rate composition are understood on the basis of a Monte Carlo simulation.

Based on the rate tests there is no longer any doubt that the proposed technical solutions will work. Therefore, the committee makes the following recommendation:

The committee recommends to JLab management that the condition be removed, and that the experiment E00-110 be elevated to the status of a fully approved experiment.

The committee did not come up with any issues that could jeopardize the successful running of experiment E00-110. The following sections contain comments, concerns, and recommendations regarding the planned detector setup and its implementation in Hall A.

1. DVCS Proton Array

The recoil proton detector is a C-shaped ring of 100 scintillators surrounding the nominal direction of the virtual photon. The scintillators are located approximately 70 cm away from the target, and are typically 6x10x30 cm^3. The function of the detector is to guarantee that the detected $e'\gamma$-events come from the exclusive $e\,p \rightarrow e'\,p\gamma$ process. The experiment counts on a factor of five suppression of unwanted events due to the detection of a matching proton.

The DVCS experiment requires a luminosity of $10^{37} cm^{-2} s^{-1}$ to achieve the desired statistical precision. The beam tests extrapolated to this luminosity give a maximum rate of 10 MHz per detector element at a threshold setting of 20 MeV (for the detector elements closest to the beam). In addition, there is a high level of small pulse height background resulting in a DC level shift. The strategy for dealing with these high rates includes adding passive material (3/8" Al) in front of the scintillators as well as using a transient digitizer for identifying and rejecting pile-up effects. The high background leads to a large anode current in the PMT. In order to preserve the life time of the PMT the group intends to run the PMT at very low gain and to use an electronic pre-amplifier. In addition, an iris in front of the PMT will be used to decrease the amount of light seen by the PMT

The design of the proton array has been completed, components have been procured, and the assembly of the detectors has been started. Decisions have been made on the mechanical assembly of the detectors and their support structure. Shielding is incorporated into the design in the front of the detectors and on the inside of the ring.

Concerns:

a) The PMT is not ideally matched to the run conditions. In particular, reducing the signal by discarding primary photons will lead to corresponding reductions in timing and energy resolution.

b) Potential radiation damage of the front part of the detector cannot be monitored by artificial light sources, and may go unnoticed

c) No provision has been made for shielding the outside of the detectors.

2. DVCS Calorimeter

The calorimeter has gone through major changes since the last review. Instead of using the RCS calorimeter, the group has decided to build a new calorimeter based on a 11x12 array of 28x28mm^2 PbF_2 crystals. The new design is much more compact, allowing the calorimeter and the proton recoil detector to be integrated into a single mechanical support structure. A 3x3 prototype has been tested (although not with the final components) and has performed well.

The design of the calorimeter and its gain monitoring system has been completed, components have been procured, and the assembly of the detectors has been started.

Concern:

There are significant differences between the test setup and the final calorimeter; a beam test should be conducted using the same components as used in the final calorimeter to check on the overall system performance.

3. Electronics

A fast Level-II trigger is required to reduce the event rate to a level that can be handled by the data acquisition system. This will be accomplished by sending the signals from every calorimeter crystal to a Flash-ADC, and adding the digitized signals from any cluster of 2x2 calorimeter crystals in a FPGA chip.

The DVCS group plans on making use of a custom-designed analog capacitor switch array running at 1 GHz clock frequency to serve as a waveform analyzer for the calorimeter and the proton detector. First modules have been used during the beam tests and have worked well.

The committee is impressed by the progress that was presented. Both trigger and transient digitizer are very interesting developments which may benefit all JLab experiments that need to operate in a high rate environment.

The problem of the radiation hardness of the electronics that was an issue at the last review has been solved by putting the electronics into the electron spectrometer hut. Access space to the hut is limited and requires careful layout of cables and patch panels.

Recommendation:

The mix of high quality delay cables and low quality cables for the patch panels may lead to unwanted signal degradation. A complete cable plan should be developed, and the signal propagation should be tested (or simulated).

4. Target

The target design has been simplified significantly since the last review. The present plan is to use an existing 15 cm long LH target in a new custom spherical scattering chamber. The 3/8" thickness of the Al wall presents no structural problems, and is well matched to the absorber thickness required to shield the proton detectors.

The committee was not presented with the optimization process that led to choosing an existing 15 cm long target cell as the best solution. While a long target cell minimizes the contributions from beam halo and target entrance and exit foils, it also increases the importance of double processes and radiative effects, and complicates acceptance calculations.

Recommendation:

In case this has not yet been done, the DVCS group should look into the target length optimization.

5. Installation

The DVCS installation will require changing the scattering chamber, adding the calorimeter and proton detector arrays, and cabling everything up. Some of these activities may interfere, e.g. in order to rig the scattering chambers out and in at the pivot, both HRS spectrometers must be placed at angles near 20 degrees. Thus, no rigging in the area planned for placement of the calorimeter or the proton detector will be possible as long as crane access to the target area is required. This makes parallel installation of the target and detectors impossible.

Recommendation:

The DVCS group should develop - in coordination with the Hall A contact person and the Hall A technical staff - a detailed plan for the installation of the detector and its integration into Hall A.

6. EH&S Review

Any major installation such as this one needs a safety review. The committee recommends that a plan for a safety review be developed in collaboration with the Hall A staff and the Physics Division EH&S professionals.

7. Summary

The DVCS group has made significant progress since the last review. This leads the committee to recommend full approval of the experiment. The committee did not find any issues that could jeopardize the successful running of experiment E00-110. The committee is confident that the remaining technical questions can be solved in collaboration with the Hall A staff, and that the experiment can be ready for installation by March 1, 2004. In addition, the committee is convinced that monitoring of the technical progress by the Hall A management will be sufficient and sees no reason for a follow-up readiness review.