2014 JSA Sabbatical report
Submitted by
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Summary
I was on Research leave from Ohio University during the 2014 calendar year. JSA provided support for my stay at Jefferson Lab during that time. I focused my sabbatical activities on the preparation, installation and initial data taking for experiment E12-06-114. As one of the four spokespersons of the experiment I represented the collaboration in interactions with lab management, coordinated and oversaw the installation and data acquisition period. I mentored two Ohio University graduate students and two summer undergraduate interns. I presented two invited talks. My synergistic activities ranged from serving as chair of the Hall A collaboration to contributing to the "Adopt a physicist ” program.

The project
Generalized Parton Distributions (GPDs) provide an unprecedented way to describe nucleon structure and thus help understand the transition between perturbative and non-perturbative QCD. Experimentally, GPDs can be accessed through hard exclusive processes, provided that the kinematics of the reaction is such that the main mechanism of the reaction is well described by its leading twist contribution. Physically, this corresponds to the limit where the virtual photon interacts with one single parton inside the nucleon. The GPDs program is at the heart of the scientific motivation of the upgrade of JLab to 12 GeV[1]. I am the co-spokesperson of three experiments dedicated to the study of GPDs in Hall A at JLab: experiment E07-007[2] took data in the fall of 2010, experiment E12-06-114[3] started taking data in the Fall of 2014 and experiment E12-13-010[4] yet to be scheduled. E12-06-114 was rated with the highest scientific rating by the JLab Program Advisory Committee (PAC38). The data taking for E12-06-114 was the main objective of my research leave. Both E07-007 and E1206-114 extend successful previous measurements [5] of absolute cross sections of electro-production of photons which provide access to the GPDs through the measurement of Deeply Virtual Compton Scattering (DVCS). In these experiments, the collaboration measures absolute helicity-correlated and helicity-independent cross-sections using a really simple apparatus in which the solid angle is easily evaluated. Indeed the scattered electron is detected in the standard Hall A left HRS while the produced photon is detected in a simple rectangular, segmented lead calorimeter. Electron-production of photon events are detected through missing mass technique. Typically the absolute cross-sections are extracted with a 5% relative precision and GPDs related information are extracted from the azimuthal variation of the cross-sections. Experiment E12-06-114 is the third generation of experiments of its kind. The first genera-
Figure 1: Projected kinematics for the E12-06-114 DVCS Hall A experiment. With polarized 6.6, 8.8 and 11 GeV electron beam, the experiment covers almost the entire kinematic range accessible at the facility. The 5.57 GeV data already exist [5].

...tion demonstrated the feasibility of the experiments and the reliability of the experimental methodology used to extract the results with DVCS data on the proton[5] , the neutron[6] and on exclusive pion production[7]. The results of this first experiment provided backing to the original theoretical predictions that DVCS scaling is based on the same foundation as DIS scaling. But the 6 GeV beam available at the time of the data taking provided a limited lever-arm in $Q^2$ such that strong scaling tests of the DVCS amplitude were unfeasible. The second generation, which is currently under analysis, used an expanded apparatus to further the understanding of the DVCS and Deeply Virtual Meson Production for GPDs measurements. For example, in the DVCS case, the aim of E07-007 is to separate (at twist-2 order) all of the terms making up the unpolarized cross section. The third generation of experiment (which was the focus of my research leave) uses largely the same hardware as E07-007 but will take advantage of the newly upgraded electron beam at JLab to extend the kinematic reach of the measurement (see Figure 1).

Research activities

The E12-06-114 equipment was installed on the floor of Hall A in August 2014. In the first part of 2014, myself focused on the testing of the trigger module developed for E12-06-114. For this part of the work, I worked closely an OU graduate student and JLab staff scientist A. Camsonne. The FPGA based trigger module establishes the coincidence between an electron signal detected in the LHRS and a photon signal detected in the EM calorimeter. The trigger module had been developed by an electronic engineer in France and delivered at JLab in September 2013. The module was tested in France using Labview but not fully
tested using the much faster VME protocol used by CODA, the DAQ software used at JLab. With much help from JLab scientist B. Raydo, the module was made to function properly by May 2014. Later on, the inclusion of the trigger module with the standard Hall A DAQ system was lead by my OU colleague P. King whom I assisted. I especially focused on software development to support the trigger module as well as the dedicated flash ADC used by our collaboration.

The 12 GeV era new beam was received for the first time in Hall A in April 2014. Beam was again delivered in the Fall of 2014. The primary objective of the Spring run was to commission the standard instruments (beamline and refurbished HRS) while the objective of the Fall run was to start the E12-06-114 data taking. As a spokesperson of the experiment, I contributed to all aspects: advocating on behalf of the collaboration, putting together run plans, managing the data collection, analyzing and interpreting data. I also trained two OU graduate students in the data taking and analysis of the experiment. As a result of our work, we were acquire data for one of our proposed kinematic points shown on figure 1 ($x_{Bj}=0.36$ and $Q^2=3$ GeV$^2$). Data taking is scheduled to continue up to spring 2016.

**Student mentoring**

During CY 2014, I worked with graduate students M. Dlamini and N. Israel. Both Norman and Mongi worked on the DVCS program. They both were based at JLab. Norman focused on data acquisition and especially on the implementation of the trigger which is the one new piece of hardware we used in 2014. Norman successfully defended his Master in August and left the program at the end of 2014. Mongi first focused on simulation for a new DVCS experiment on the neutron (He3) to be potentially proposed in Hall C as part of the NPS project. Once he was done with this project, he focused on the commissioning of detectors used in the experiment and on the data taking.

I also took two OU undergraduate students as summer interns. R. Radloff worked for 8 weeks on the JLab campus studying the possibility to by-pass the dedicated DVCS trigger system (as a back-up solution). K. Holmes worked for 4 weeks also on the JLab campus trying to simulate pion signals as an input to a possible extension of the calorimeter trigger. Out of these 4 students, three are from underrepresented groups and three are first generation students.

**Publications and presentations**

The following CY 2014 publications are the results of previous work (not on the DVCS program):


- D. Wang et al. [PVDIS Collaboration], Nature 506, no. 7486, 67 (2014).

Between January and December 2014, I presented the following talks:


- Future precision studies of the DVCS process at JLab, PANIC 2014, Hamburg Germany, September 2014.

During the same period, the students I mentored presented the following talks and posters:


- Commissioning of the Trigger module for the 12 GeV era experiment E12-06-114 at JLab, N. Israel, Ohio University master defense, August 2014.


**Synergistic activities**

- Chair of the Hall A coordinating committee. The main activity was to organize the Hall A summer meeting jointly with Hall C users. Over 70 international participants took part to the meeting.

- Blogger for the ”Adopt a physicist”, a program that connects high schoolers to physics graduates. My 2014 forum contained 160 posts about half authored by me.

- Member at large of the JSA graduate fellowship committee. Evaluated and ranked 18 applications.

- Interviewee for the JLab 12 GeV Science Magazine by A. Cho.
Looking ahead

Beyond the participation in the immediate E12-06-114 data taking, I have been working actively on other aspects of the "DVCS/Hall A" program, namely: the analysis of E07-007 and the construction of a neutral particle spectrometer in Hall C. We are in the final stage of the analysis of E07-007 and we have submitted a NSF/MRI proposal in January 2015. I am also continuing my involvement with the parity violation program namely the QWEAK program and on a longer term the MOLLER program.

Acknowledgement

I am very grateful for the support JSA has provided me during the calendar year 2014. Being able to relocate to JLab has allowed me to have a very productive research leave. Thank you.
References


[2] The proposal of experiment E07-007 titled “Complete separation of Deeply Virtual Photon and $\pi^0$ electro-production observables of unpolarized protons” can be found at: http://hallaweb.jlab.org/experiment/DVCS/documents/phys_prog/E07007_proposal.pdf


