

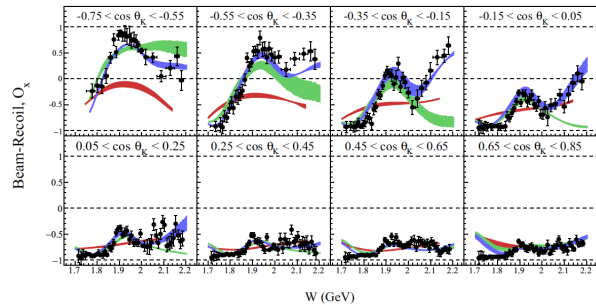
December 2016

## Dear CLAS and Hall B collaborators

In many ways 2016 has been a very successful year for Hall B. As we are about to enter a new year I like to take the opportunity to take a look back at some of the highlights of 2016. Before I do this I like to welcome all new members who have recently joined the CLAS collaboration or one of the other Hall B collaborations (HPS & PRad). Our reach in science has further broadened with results from the 6 GeV era still coming out unabated, while at the same time we have carried out high impact experiments searching for evidence of dark matter and trying to solve the proton radius puzzle. At the same time we have nearly completed the construction of CLAS12 and related hardware, and software tools have been developed for the new era of 12 GeV physics.

## The 6 GeV science program

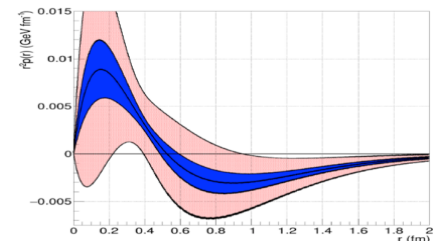
The CLAS collaboration continued the good harvest of papers published in refereed journals by exploiting the sensitivity of polarization observables in the search for new baryon states and in the study of the proton spin-structure in the nucleon resonance region. The graph shows the double polarization observable  $O_x$  in  $K^+\Lambda$  production using the linearly polarized photon beam and measuring the  $\Lambda$  recoil polarization. Another measure of the collaboration's productivity is seen in the number of conference talks given. A large number of over 170 talks on physics results were delivered by CLAS collaborators at major international conferences and workshops, nearly 80% of them invited. This is the 2<sup>nd</sup> highest number of any year. As education of young scientists is one of our missions, we can be proud that seven PhD students graduated this year and 35 PhD projects from CLAS data are currently in progress for a total of over 200 PhD's completed or in process. Two students graduated on HPS and several PhD projects are ongoing with HPS and PRad.



## The 12 GeV Upgrade

### PAC44 - Broadening of the science program

The first new CLAS12 run group RG-K “*Confinement & Strong QCD*” consisting of 3 experiments requiring less than 11 GeV beam energy, were approved with 100 additional beam days. It represents a significant broadening of the science program and bridges the search for hybrid baryons with probing the running quark mass and the first extraction of gravitational form factors in an attempt to determine the color confinement forces on the



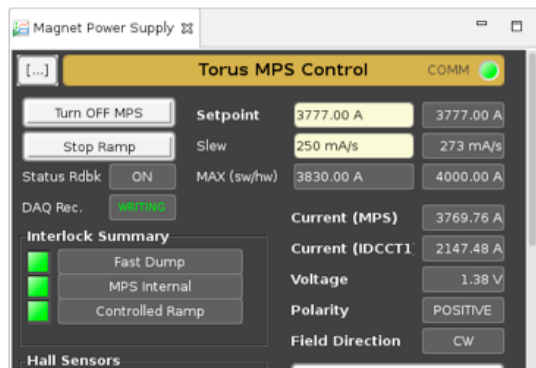
light quarks in protons. The graph shows calculation of the pressure on quarks versus the radial distance within the quark soliton model and from world data (red) and projected results (blue). Other run group proposals on radiative meson decays and on polarized neutron DVCS were also added to the experimental program.

## Base equipment



Much progress has been achieved with the CLAS12 detectors. All detectors have been constructed, tested and the EC, PCAL, FTOF1, FTOF2, LTCC, DC have been installed to complete the CLAS12 FD. The HTCC will be installed in January as the last component of the CLAS12 FD. The photo shows the status of CLAS12 as of December 19, after the forward carriage was moved into the final operating position. What is not visible in the photo though critical for the success of CLAS12 is the tremendous effort that went into the development and implementation of the entire data acquisition hardware and complex event selection programming software. The other baseline detectors, HTCC, SVT and CTOF will be placed on the Hall B beam line in January in preparation for the first beam run in February 2017.

## Superconducting magnets



The year 2016 also saw the completion, commissioning, and field mapping of the superconducting Torus magnet. A very large effort was needed, involving many groups across the Lab, to successfully complete the construction, to carry out the pump out and cool down, and to energize the magnet to full design current of 3770 A. This last step occurred on November 7, 2016 (left graph), and without a quench. The magnet was then field mapped showing excellent symmetry with maximum sector-to-sector variations of the main field

component of less than 0.5%.

The superconducting Solenoid magnet is in construction at ETI in Pennsylvania. The Solenoid has been making significant progress, albeit slower than we had hoped for, and it will be the last piece of CLAS12 equipment to arrive at JLab, now expected for the spring of 2017. The magnetic system containing the four main coils and the outer shield coil has been fully assembled including the heat shield. The next step is to mount the coil system into the cryostat and make all the final cryogenic and electrical connections. This should be happening in the beginning of 2017 and the



magnet is expected to arrive at JLab in March 2017, where the service tower will be attached and the cryogenic system will be connected with the cryogenic distribution can in Hall B. The photo above shows the fully assembled coil system with the polished highly reflective aluminum sheet attached to the coils outside surface as heat shield.

## Extending the CLAS12 science reach

Many CLAS12 experiments require additions to the base equipment, such as the central neutron detector (CND) for neutron detection at large angles, two different sets of micromesh gas detectors (Micromegas) to improve resolution and efficiency of charged particle tracking at forward and at large scattering angles, the forward tagger (FT) for quasi-real photoproduction experiments at very high rates, and the RICH detector for improved charged kaon identification. These systems are provided by collaboration institutions and have either been completed and are ready for installation (CND, FT, FMT) or are in advanced stages of development (BMT, RICH). The CND will be the first component of the CLAS12 Central Detector to be installed in the solenoid magnet once the magnet has been commissioned, and tested for operational performance at a maximum field of 5 Tesla. The final two layers of the BMT should also be ready for integration with the SVT this summer. Work on the RICH counter is also progressing well. The mechanical structure is expected to arrive at JLab in January, and assembly will be done in the EEL clean room. The photo shows the RICH mechanical structure pre-assembled at LNF Frascati.

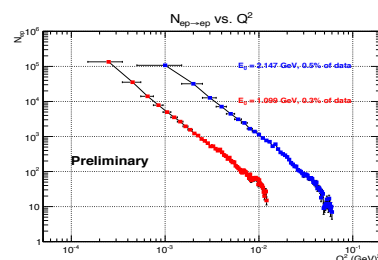


## Preparing for the first physics experiments with CLAS12

With the completion of the baseline detector construction work the focus is now on getting ready for the first physics experiment with CLAS12. This includes having the calibration software developed and tested, and make the offline software package robust and user friendly. Several “First experiment workshops” have been organized in connection with the CLAS collaboration meetings, specifically to involve the collaboration in the development of the calibration and analysis software. Following the pre-operation run in February, the engineering and commissioning run is scheduled for October/November 2017. This run will include the entire complement of both the baseline detectors as well as the ancillary detectors that are ready for installation.

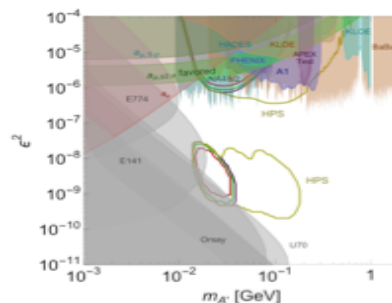
## High impact measurement early in the 12 GeV era

The PRad experiment aims at solving the proton radius puzzle by measuring elastic electron-proton scattering at very low  $Q^2$ . The experiment hopes for beam time in the spring of 2016. The measurement will employ a non-magnetic spectrometer based on the HyCal calorimeter previously used in the two PRIMEX experiments in Hall B. Graph shows online graphs of less than



0.5% of the statistics for the two energies.

The search for evidence of the  $A'$  boson as mediator of the interaction with dark matter with the HPS experiment entered its production phase in the spring of 2016 at 2.2 GeV beam energy. This allowed exploration of the extended parameter space for the hypothetical “dark photon” to higher masses and smaller coupling constants compared to the short run at 1.1 GeV in 2015 (graph).



## Looking forward to 2017 and beyond

By the fall of 2017 CLAS12 will be fully operational, with both magnets and the detection system fully instrumented including all the ancillary equipment and the beam line components, including the Moller polarimeter and the cryogenic target. The software development for the detector calibration and commissioning will continue to be at the forefront with a focused effort of having a complete suite of fully tested calibration and analysis tools available.

Besides preparing for the first CLAS12 data run, we have many exciting analysis projects of CLAS data ongoing that will continue in full strength and involve many students and senior researchers. In the coming years we may expect new publications in baryon spectroscopy, meson decays, nucleon structure studies, deeply virtual production and QCD processes in nuclei. Beyond the ongoing analyses, the data accumulated with CLAS are rich with unexplored physics and provide great opportunities for new analysis projects for years to come.

As we are leaving behind the year 2016 that saw excellent science emerging, and major progress towards the completion of CLAS12, we are looking forward towards the successful exploitation by the collaboration of the great potentials provided by the unique CLAS12 instrument. This is where the leadership, scientific curiosity, and energy of the collaboration members is needed to enter the new era of hadronic and nuclear science towards solving the most intricate problems of strong interaction physics.

To all a peaceful and successful year 2017

*Valw Bueh*