E. Piasetzky

Research Plan 2005-2010

The Continuous Electron Beam Accelerator Facility (CEBAF) is a unique super-conducting high current (200 μA), high duty factor electron accelerator with a maximum beam energy of about 6 GeV. In this facility, three beams that can be accelerated simultaneously are fed into three experimental halls, A, B and C. Since its commission, Hall A has two High-Resolution Spectrometers (HRS) and in the last year we added to the hall a third, large angular and momentum acceptance spectrometer, aptly named "BigBite". In the last 5 years the experimental group at Tel Aviv University was involved in the design and commission of BigBite. The experimental program for the next 5 years is based on approved experiments to be performed in Hall A, and the analysis of the data to be performed in Israel. The plan is to get involved also in future hardware design and construction for future experiments.

E01-015: Studying close proximity nucleons in nuclei via triple-coincidence measurement of the (e,e'pN) reactions.
Spokespersons: W. Bertozzi, E. Piasetzky, J. Watson, S. Wood

To a few percent approximation, the nucleus can be viewed as a system of independent nucleons (neutrons and protons, denoted as N) bound by an average potential dominated by the long-range part of the NN force and the Pauli Exclusion principle. This is covered well by the nuclear shell model with corrections due to long-range correlations between the nucleons. However, the shell model is not the full description of nucleons in nuclei. It can not explain the low occupancy (0.65 ± 0.1) of single-particle states in nuclei with $A \geq 4$ – about 35% of the nuclear wave-function is not described by an independent-particle model.

The biggest deficiency of this description is in ignoring correlated pairs of nucleons whose constituents are at short distances and large relative momenta . These configurations are dominated by the highly-repulsive, short-range part of the NN interaction. We will refer to this state of matter as 2N-short-range correlations (2N-SRC). The exploration of 2N-SRC is important not only for better understanding of the short distance properties of nuclear wave functions, but also because theses pairs are a cold, super-dense phase of nuclear matter. The distance and relative momentum between the nucleons in the pair are comparable to those expected in neutron stars (5-10 times the central nuclear density). Studying the properties of such super-dense nuclear matter, as well as modifications of its constituent nucleons, is one of the main challenges of high energy nuclear physics.

Probing 2N-SRC has proven to be difficult experimentally due to competing mechanisms, which can produce the same final state as one would expect from correlations. A quantitative. though preliminary understanding is beginning to emerge from a new set of measurements using high energy probes and large momentum transfer reactions. Following measurements at BNL using 6 GeV/c proton beams and the EVA detector we performed recently a measurement at Jlab, using the new BigBite spectrometer and a n-array. We measured the $^{12}C(e,e'p)$ and $^{12}C(e,e'pN)$ reactions under conditions sought to minimize the effects of competing mechanisms by going to high momentum transfers and large Bjorken x. The experiment was the first (commission) experiment for BigBite and collected data during Jan-Apr 2005. The results will be analyzed during the next 2-3 years by three Ph.D. students at MIT, KSU and TAU. The activities, which stats in 1997 were funded by both the ISF and the BSF. These activities included the preparation of the proposal, obtaining approval to perform the experiment, conducting necessary tests, with and without the beam, and the construction of the specific equipment. A new proposal was submitted this year to the BSF to continue this research. The proposal is now in a refereeing procedure.

A. Malki et al. "Backward Emitted High-Energy Neutrons in Hard Reactions of p and π^+ on Carbon" Phys. Rev. C65, 015207 (2002).

A. Tang,et al.. "n-p Short-Range Correlations from (p, 2p+n) Measurements" Phys. Rev. Lett. 90, 042301 (2003).

E. Piasetzky "Looking at Close Nucleons in Nuclei with High-Energy Probes" Fiska B8, 1, 41-50 (1999).

E03-101: Hard photodisintegration of a proton pair.

Spokespersons: E. Piasetzky, R.Gilman

Several highly-rated experiments measured the high-energy, hard photodisintegration of the deuteron. This new experiment extends that program to hard photodisintegration of a pp pair in the ^{3}He nucleus. Nonperturbative QCD calculations predict that, at the energies proposed for this experiment, the pp breakup cross section is comparable or larger than the one for pn break up. This is in contrast with low-energy observations and would be a clear indication of quark-gluon dynamics. In some models, the energy-dependent oscillations observed for pp scattering are predicted to appear also in the $\gamma^3He \to pp + n$ reaction. They also claim that the measurement of the light-cone momentum distribution of the recoil neutron probes the underlying dynamics.

We plan to measure the energy dependence at $\theta_{C.M.} = 90^0$, the angular distribution near 90^0 C.M., and the polarization for the hard photodisintegration of a pp pair in ^{3}He. The experiment was approved by the program advisory committee of JLab. (PAC24). We expect the measurement to be scheduled in 2006 or 2007. The research program is funded by an ISR grant of about $55,000/year for 4 years starting in 2005.

E. Piasetzky, R. Gilman (spokespersons). "Hard Photodisintegration of a Proton Pair", Proposal to Jefferson Lab. 2003 (unpublished).

S.J. Brodsky, L. Frankfurt, R. Gilman, J.R. Hiller, G.A. Miller, E. Piesetzky, M. Sangsian, M. Strickman. "Hard pholodisintegration of a proton pair in the 3He" , Phys. Lett B 578 (2004) 69-77.

E05-009: High Resolution Study of the Θ^+ Resonance in the nK^+ System.

Spokespersons: G.Gate, V.Neyubin, P.Reimer

Several experiments have claimed to observe an exotic S=1 baryon resonance with a mass in the range of 1525-1555 MeV and a very narrow width consistent with the experimental resolution. A baryon with a positive strangeness cannot be a 3 quark state. This resonance, named Θ^+, must have a minimal quark content of uudd$\bar{s}$ (pentaquark). However, at the present time, the existence of the Θ^+ has not been established with sufficient certainty. The evidences from the experiments that found the Θ^+ are marginal and there are about the same number of experiment who searched, but did not observe the Θ^+.

The proposed experiment is to search for an exotic baryonic state in the reaction Be(e,nK^+,K^-) in the mass range from 1500 to 1600 MeV. If the Θ^+ exist with a width of at least 1 MeV it will be observed unambiguously in this measurement. A failure to find a significant signal means that the previous measurements did not observe the Θ^+ as claimed.

One of the most striking aspects of the Θ^+ is its narrow width. If the Θ^+ exists this measurement will allow to determine its width with an accuracy of about 1 MeV. The precise determination of the width will lead to a better understanding of the pentaquark structure and the processes involved in its decay. The experiment uses a 5 GeV electron beam in Hall A , one of the HRSs , the BigBite spectrometer as a kaon detector, and a n-array. My level of commitment in this project depends strongly on the information from other experiments. The funding for this project was requested this year from the BSF. The proposal is in the refereeing process.

G.Gate, V.Neyubin, P.Reimer, spokespersons, "High Resolution Study of the Θ^+ Resonance in the nK+ System" , JLAB proposal PR05-009, unpublished (2004).

E. Piasetzky, S. Wood, R. Gilman, spokespersons, "Photoproduction of Θ^+ via the $\gamma d \rightarrow \Lambda\Theta^+$ reaction" JLAB proposal PR04-011, unpublished (2004).