Opportunity for China to Build a World Class QCD Machine in the Next Decade

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1 Motivation

China is building up a strong community of physicists working in QCD. There are excellent laboratories which accelerate ions to multi-Gev energies. The fourth generation High Energy Photon Source (HEPS) is under construction in Beijing. It is a storage ring with energy 6 GeV and circulating current of 200 mA. There are many Chinese physicists in leadership positions in QCD physics in the United States. There is a vision to realize an electron-ion collider in China in the longer-term. As a step on the way to build the necessary technology for EIC-China and to put in place a world class QCD machine in the nearer term, **I propose that China consider to build a 10 GeV polarized electron/positron ring with polarized internal gas targets and a modern spectrometer to detect scattered lepton and final-state particles.**

The scientific goal is to study QCD with electron and positron scattering from both longitudinally and transversely polarized targets in the valence quark regime. There is substantial international interest in measurements with positrons at 10 GeV energy [1]. We know from Jefferson Lab that the quark parton model works well in describing the valence quark regime at an incident energy of 10 GeV. The HERMES experiment at DESY (1995-2007) [2] scattered polarized electrons and positrons of energy 27.5 GeV from undiluted internal polarized gas targets of hydrogen, deuterium [3] and helium-3 [4]. The facility proposed here would aim for an order of magnitude more luminosity than HERMES. Further, a program of spin-dependent electron scattering at

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850 MeV from polarized hydrogen and deuterium was carried out in 2002-2005 at the MIT-Bates South Hall Ring by the BLAST collaboration [5]. Finally, a precision determination of the ratio of positron-proton to electron-proton elastic scattering was carried out by the OLYMPUS collaboration at the DORIS storage ring at DESY, Hamburg, Germany [6].

While Jefferson Lab is a world leading center to study electron scattering at 11 GeV, its polarized targets have large amounts of extraneous material and transverse polarization is technically challenging. Further, Jefferson Lab has not produced positron beams due to their technical challenges. It does have a scheme to produce positron beams only for several years in the later 2030s.

Some scientific highlights of such a facility would include:

- measurement of TMDs using transversely polarized hydrogen, deuterium and ^{3}He;
- DVCS measurements on proton and neutron using full polarization of beam and target as well as beam charge asymmetry;
- precision comparison of positron-proton and electron-proton elastic scattering to determine contributions beyond single photon exchange in QED expansion for elastic lepton-proton scattering.

2 Realization

2.1 Electron/Positron Storage Ring

The electron/positron ring should have an energy of 10 GeV and a stored current of 200 mA. The emittance of a stored electron/positron beam is determined by synchrotron radiation damping and is quite insensitive to the method or efficiency of injection. The experiment needs to be located in a low-β region where extensive differential pumping can be installed to accommodate the gas targets.

2.2 Polarized Electrons/Positrons

The electrons/positrons can be self-polarized transversely by the Sokolov-Ternov effect, as in HERA [7]. Spin-rotators around the experiment rotate the spin into the longitudinal direction, required for QCD experiments. The polarization of the stored electrons/positrons can be measured by laser backscattering polarimeters, as was done at HERA.

2.3 Positron Source

Positrons are produced at low energies by electroproduction in a thick target and capture to form in a secondary beam. IHEP has the technology to produce positrons.

2.4 Targets

The targets are gaseous and internal to the ring. The polarized targets consist of a polarized source (atomic beam source for hydrogen/deuterium, laser pumped source for He-3 and Li-6/7) that directs atoms into a windowless storage cell through which the beam passes. In addition, unpolarized gases of light and medium mass nuclei can be used.

2.5 Spectrometer

The spectrometer should be instrumented to detect the scattered electron and coincident hadrons produced in both deep inelastic scattering and deeply virtual exclusive processes. It should have large acceptance and good particle identification. The HERMES spectrometer [8] had a dipole field which required an iron shielding plate through which the electron/positron beam passed. This resulted in a symmetric detector. The CLAS12 detector [9] would be a good template to consider.

3 Summary

A 10 GeV electron/positron storage ring with polarized beams, polarized internal targets and a modern spectrometer would enable a world class QCD program. Utilization of an existing storage ring should be considered. It would require a scientific collaboration of order 200 physicists and an organized program to develop the necessary technologies. It would be complementary to Jefferson Lab and would put in place expertise and technology essential for a future EIC-China facility.

References

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