**Proposal Number:** LOI 12-20-003 **Hall:** A

**Title:** Sub- and Near-threshold Production of J/ψ Mesons from a Deuterium Target at SoLID

**Contact person:** Haiyan Gao (hgao@duke.edu)

**Beam time request:**

Days requested for approval: 47 days production and 3 days aluminum dummy and detector studies (if following E12-12-006)

Time needed including energy changes: 50 days

Tune up included in beam time request: yes

**Beam characteristics:**

Energy: 8.5 GeV

Current: 1.25 A

Polarization: No

**Targets:**

Nuclei: LD2 (15 cm)

E12-12-006 will use the same target type with H2 prior to this experiment.

Rastering: ???

Polarized: No

**Spectrometers:**

HRS-L No

HRS-R No

Other SoLID

**Special requirements/requests:**

None

**General Comments:**

1. This LOI proposes to study sub- and near-threshold electro- and photo-production of J/ψ mesons from a 15-cm liquid deuterium target using the proposed SoLID apparatus in Hall A. The experiment would measure the J/ψ − N interaction and test lattice QCD predictions with the goal of shedding light on nucleon-nucleon short range correlations.

**Technical Comments:**

1. This LOI proposes to use an identical experimental configuration as the already approved experiment E12-12-006, which plans to study J/ψ production from the proton using the SoLID detector. As such no modifications or configuration changes, except filling the target with deuterium instead of hydrogen, will be required for the SoLID detectors or the experimental hall beyond those already planned for the approved SoLID program.
2. This LOI proposes to run directly after experiment E12-12-006 and use the detector studies of E12-12-006 to save run time. The LOI allocates 3 days for aluminum dummy runs and detector studies. If this experiment does not directly follow E12-12-006 it will likely need to allocate more run time to detector studies.
3. The LOI states, “The production cross-section from the proton near the threshold from E12-12-006 will be used as an important input to the theoretical calculation of the sub-threshold and near threshold production from the deuteron.” If for some reason the cross section E12-12-006 proposes to measure is not available will this experiment face complications?
4. The caption for figure 3 is the same as the caption for figure 2 and does not match the description in the text.
5. In figure 5 the J/ψ-N rescattering contribution to the three-fold differential cross section exceeds the total line in the region around 50 MeV.
6. The signal rates calculated in the LOI are calculated from a Pomeron-exchange model. A more advanced Pomeron-LQCD model based on vector meson dominance and extended to include the two-gluon exchange amplitude has recently been more successful at reproducing Hall D J/ψ photoproduction cross sections. The new model predicts near threshold total photoproduction cross sections from the nucleon more than an order of magnitude larger than the Pomeron-exchange model. The previous Pomeron-exchange model, however, fits the cross section data from references 50-53 better. The authors state that if the Hall D data are confirmed the Pomeron-LQCD model will be used for signal estimates in the full proposal. This would drastically increase the predicted rates and could shorten the run time required. Improved theory calculations for J/ψ near threshold production would increase confidence in the beam time request in the full proposal.
7. The LOI calls for a beam energy of 8.5 GeV (300 MeV above the J/ψ production threshold). Recent accelerator energies have been on the order of 2.062 GeV per pass and above (4-pass ~8.248+ GeV). The upcoming planned accelerator shutdown hopes to improve the energy per pass of the accelerator beyond its current limitations. This experiment should evaluate whether it can successfully meet its physics goals with beam energies in the region of 2-2.2 GeV/pass, and if not it may need to request a non-standard beam energy.
8. Detecting the proton as well as the J/ψ decay electron and positron is necessary to reconstruct the interaction energy. In the case of electroproduction a second electron is sometimes seen in the detectors. How is this second electron distinguished from the J/ψ decay electron? Is there a timing difference between the electrons? Is the energy of the electron matched to the positron energy or is the angle between the J/ψ decay products used?
9. Enumerated uncertainties would be helpful to understand the signal rates. The LOI states that events below the J/ψ production threshold are most relevant to the J/ψ-N SRC this proposal is interested in studying. It predicts a total of 1262 J/ψ events and 925 Bethe-Heitler background events will be collected throughout the run (based on the Pomeron-exchange model). Subtracting the BH background here would give a statistical uncertainty of ~2.4% on the number of J/ψ events. If the Pomeron-LQCD prediction of an order of magnitude more J/ψ events is accurate the uncertainty on the J/ψ events would fall to ~0.24%. Explicit uncertainty estimates would provide a better understanding of the precision of the proposed measurement and what the major uncertainties are, as well as illustrate possible statistical gains from the Pomeron-LQCD predictions.
10. The LOI asserts that events below the J/ψ production threshold are most relevant to studying SRC. Are the above threshold J/ψ events, of which there will be more, useful for studying SRC as well? Or are the above threshold events used more as a test of LQCD predictions? Some discussion of what can be learned from the above vs. below threshold J/ψ events would be useful in the full proposal.
11. The LOI states that the Bethe-Heitler process cannot be distinguished from the J/ψ production since the electron-positron pair can have the same invariant mass. Is there not another way to distinguish between the BH electron-positron pair and the J/ψ electron-positron decay pair, such as the angle between the electron and positron or the relative timing between the proton detection and the detection of the electron-positron pair? Simulations should reveal if these events can be distinguished with data analysis.
12. The LOI does not address whether the beam on the target is planned to be rastered. This should be addressed in the full proposal.