

Evaluation of LDRD Proposal 2018-LDRD-4: Geometry Tagging for Heavy Ions at JLEIC (Vasiliy Morozov)

1. *Is the project innovative and does it have high scientific and/or technical excellence in one or more of the forefront areas relevant to the DOE missions?*

The project, which would be in its second year if approved, aims to quantify the physics benefits of geometry tagging in JLEIC by using, and improving, event generators BeAGLE and Sartre and evaluating the result in the JLEIC simulation. The first year of the LDRD has fulfilled all of the mid-year milestones and are well on the way to fulfilling the final milestones for the first year. The project is innovative in that it seeks to investigate the trade-off between detection capabilities versus energy reach to access collective effects. Early results find that geometry tagging with JLEIC's excellent detection capabilities can increase the accessible parton saturation scale as effectively as an increase in beam energy by more than a factor of 3. Early results also illustrate the advantage of such excellent detection capability, beyond a zero-degree calorimeter, to reduce incoherent diffractive backgrounds obscuring coherent collective saturation effects. In this, the project is innovative and has high scientific excellence as critically relevant for the EIC. The project enhances the ability to pursue key scientific goals of the EIC and is therefore relevant to the DOE mission.

2. *Does the project align well with or enhance JLab's Strategic Goals?*

Yes, this project may be able to demonstrate a particular effectiveness of the JLEIC Interaction Region and Detector concepts in pursuing the physics of saturation and propagation of color in cold QCD medium. The project may, then, help in building the case for the JLEIC realization of the Electron-Ion Collider. Hence, this project is directly aligned with enhancing the science of a Jefferson Lab based EIC. It may also have, albeit still tenuous, some impact on the 12-GeV science program.

3. *Is there a clear high impact deliverable by the end of the funding period?*

At project end, there should be a detailed study of the physics impact of the JLEIC detector capabilities in the relevant physics studies. Also tuned event generators interfaced to the JLEIC detector and IR simulation should be available for further studies. In the best case, there should be a clear demonstration of the advantages of JLEIC Detector and IR design in pursuing these particular physics goals.

4. *Can the project's aim be completed within the timeline and budget limits (i.e. are the human, technical and financial resources adequate)?*

The LDRD has made very good progress in the first year and has reached interesting conclusions, such as the high enhancement factor for geometry tagging towards gluon saturation scales, and the comparison of simulations with the to-date mysterious E665 mu-Pb forward neutron multiplicities data. Judging from the progress in the first year of the LDRD, it appears to be very likely that the aims for year 2 can be completed within the proposed budget.

5. *Is there any aspect of the project that is not clear from the written material provided or any aspect that has high technical risk?*

There is a certain amount of emphasis on the Uranium beam studies in the proposal. While the deformation of the U nuclei is interesting, it is not clear if there are reasons to expect a significantly difference from the Au or Pb case beyond what one might do by a back-of-the-envelope calculation. Other goals, such as looking at incoherent vector meson production tagging, may be more promising. Most important remain the study and quantification of the advantages of the JLEIC detector and Interaction Region for geometry tagging towards the study of enhanced collective effects, e.g. by the planned studies of the suppression of background to coherent diffractive events.

6. *Is there a reasonable probability that timely “follow-on” funding will result from the project in the proposal?*

Even at this early stage, some interesting detector questions are coming up. For instance, what are the characteristics of the Zero-Degree Calorimeter that will be able to tag the number of neutrons effectively? There will doubtless be others similar questions that will come up. These can lead to effective detector R&D proposals. This will certainly be enhanced if the science potential for an EIC with appropriate high luminosity and intermediate energy range coupled to excellent detection capabilities, as inherent in the JLEIC design, is further quantified with this LDRD work.

Comments: In answer to the question raised on the emphasis on the Uranium beam studies in the proposal as compared to the quantification of the excellent detector capabilities of the JLEIC design for geometry tagging, for example in the suppression of backgrounds to coherent diffractive processes, the proponents confirmed the priority will remain on the latter. The goals for the second year of this LDRD proposal continuation are 1) the development of the eA event generator; 2) simulations of the relevant eA physics processes, both to science related to the onset of gluon collective effects and ultimately saturation and the medium effects on the struck partons; and 3) input to the detector design. This LDRD proposal has now even gathered more interest of outside participants. This further underlines the interest in this topic as relevant for a foreseen Electron Ion Collider.

The topic of geometry tagging builds heavily on the strengths of the Jefferson Lab EIC design to provide a truly full acceptance to detect reaction products. This was for example shown with results of last year’s efforts showing many events with no evaporated neutrons. This directly impacts prospective to constrain collective effects at any EIC. Simulations confirm the accessible path length through the nuclear medium of the parton struck in the electron-ion collision. The quantitative gain in reach of geometry tagging towards saturation effects enabled by excellent acceptance, as trade-off with energy reach, was found to be a factor of 3.2 and is impressive. This confirms the strategic relevance of this LDRD proposal.

Recommendation: The committee judged this to be an *Excellent* Proposal that should be funded if at all possible.