**Summary Comments Report**
5/21/2012

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**Review:** 2012 Early Career Research Program NP, SC-FOA-0000572
**Proposal Number:** 121045
**Proposal Title:** Experimental Study of the Strongly-coupled Quark Gluon Plasma via Heavy Quark Production at RHIC
**Investigator:** Dong, Xin (Lawrence Berkeley National Laboratory)
**Panel:** NP Early Career Review Laboratory Panel
**Proposal Mean:** 4.25 - Encourage Funding

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**Please evaluate each proposal against the following six review criteria.**

**1. Scientific and/or Technical Merit of the Project**
What is the scientific innovation of proposed research? What is the likelihood of achieving valuable results? How might the results of the proposed research impact the direction, progress, and thinking in relevant scientific fields of research? How does the proposed research compare with other research in its field, both in terms of scientific and/or technical merit and originality?

Reviewer 34:
The scientific merit of the proposed project is very high. The ability to separate open heavy flavor from charm and bottom is key to understanding how heavy quarks lose energy in the medium. This is one of the most important open questions in the field. The physics merit of this led to the funding of displaced vertex detectors for both PHENIX and STAR. This proposal outlines some measurements that would cleanly obtain the nuclear modification (related to the energy loss) and elliptic flow of charm quarks in the medium created in Au+Au collisions, a measurement that is eagerly awaited by theorists.

Reviewer 47:
Since I am a theorist outside the heavy ion physics community, I urge the selection committee to not weight my evaluation very heavily, since I do not have sufficient familiarity of the STAR collaboration to adequately judge Dong's role, and it is difficult to assess that role from the document provided.

The proposal to complete construction of the HFT and proceed to take measurements with it is very sound: it has been long known that heavy quarks can provide a unique probe of the QGP, and by allowing detailed study of in-medium properties of heavy quarks, the HFT will open a new window onto the nature of the QGP. The measurements being proposed -- to measure charmed hadron production in both p+p and Au+Au, whether charm quarks are affected by collective flow, and heavy quark correlations all sound very interesting, as do looking for correlations with jets and leptons.

Reviewer 72:
The proposed research effort addresses heavy flavor production and energy loss in Au-Au collisions at STAR at RHIC using the new, Heavy Flavor Tracker (HFT) detector upgrade which enables the secondary decay vertices for B- and D-mesons to be separated from the primary vertex. This new detector enables significant improvement over present methods for measuring heavy flavor production which rely on semi-leptonic decay leptons (mainly electrons and positrons) to serve as proxies for the heavy flavor hadrons.

In the first two years the effort will mainly focus on HFT support followed by physics analysis. The latter includes measurements of c,b quark production yields and cross sections in p-p, d-Au, and Au-Au, attenuation of yield per binary collision (R_AA), D-meson v2, D-Dbar correlations, D-meson correlations with hadrons and jets, and identification and reconstruction of b- and c-quark jets. In addition, the explicit measurement of D-meson yields can be used to constrain the corresponding contribution to the dilepton spectrum.

Most of the proposed charm physics research is similar to ongoing effort within the STAR heavy flavor physics working group and that in the STAR HFT proposal and will therefore also be carried out by several groups within the STAR collaboration. The proposed study of possible medium effects on correlated, back-to-back production of D- and Dbar-mesons via pQCD 2 -> 2 processes is novel and interesting and may lead to new insights into higher-order (NLO) pQCD processes in the dense, energetic system when massive quark flavors are involved. Explicit identification of heavy flavor jets, and possible medium modifications to those jets is also novel and offers interesting possibilities to learn something new about fast parton fragmentation in dense systems when the primary parton is a heavy b or c quark. Given the surprisingly large energy loss of heavy flavor mesons in central Au-Au collisions it is worthwhile to invest effort in this area.

The proposal emphasizes the study of the charm sector rather than a comprehensive approach to both c- and b-quark physics, in part, because of the practical necessity of determining the b-quark yields by subtracting the c-quark contribution from the combined heavy flavor yields. However, the apparent lack of attention in the proposal to the bottom flavor is strange.

Reviewer 82:
The proposed project is to initially support the Heavy Flavor Tracker (HFT) project in STAR through the commission phase and later to carry out a physics program on heavy flavor physics based on data from the HFT.

Studying the properties of the strongly-coupled QGP (sQGP) through observations of the propagation of heavy flavor quarks through this medium has become increasingly important as the RHIC program has progressed. The STAR HFT project has very high scientific merit and the results from this upgrade are eagerly awaited. The proposal contains a clear and exciting description of all the opportunities ranging from the

mundane initial charm cross-section measurements to the exciting prospects of doing heavy quark correlation studies.

The PI very prudently proposes to first do a set of more service oriented tasks related to the HFT, like integrating the HFT readout with the STAR DAQ and performing alignment calibrations. During the last three years the proposal will then focus on data analysis tasks of high scientific merit. In particular, the heavy quark correlation studies have great potential for giving valuable information on heavy quark propagation parameters that can then be related to properties of the sQGP, like *h/s* and gluon densities. The correlation studies are not going to be easy and maybe they will not be finalized within the proposal period, but at least the proposed research will bring STAR close to that stage.

One can question if it is realistic for the PI and his two proposed post-docs to do all the analysis tasks outlined on page 11-15. It sounds a bit more like a list of most of the issues that can be addressed by the HFT and it is doubtful, if it can all be done within this proposal even with 2.5 FTEs.

The proposal is well aligned with a high priority project and has a substantial potential for providing scientific information of high value.

**2. Appropriateness of the Proposed Method or Approach**
How logical and feasible are the research approaches? Does the proposed research employ innovative concepts or methods? Are the conceptual framework, methods, and analyses well justified, adequately developed, and likely to lead to scientifically valid conclusions? Does the applicant recognize significant potential problems and consider alternative strategies?

Reviewer 34:
The proposed research approach is reasonable.

First, it involves a sequence of measurements of reconstructed charm hadrons in p+p and Au+Au collisions that makes use of the secondary decay vertex reconstruction using the HFT, to reduce combinatorial backgrounds, and the large acceptance of STAR. The goal is to measure the charm hadron R_AA over a wide pT range, and elliptic flow. It is not demonstrated in this proposal, but it is stated that from simulations the signal significance is good to low pT in Au+Au. The proposal has a discussion of the difficulties that will need to be overcome in understanding the trigger efficiency when making high pT measurements of charm hadrons. These high pT measurements are quite important for understanding the energy loss mechanism. The proposed measurements seem to be feasible and likely to produce the desired results.

Second, it is proposed to study correlations of heavy quark pairs in several ways. The cleanest in principle, but challenging in yield, is DD_bar correlations. Correlations using semileptonic decay leptons in coincidence with D mesons, hadron or other semileptonic decay leptons are also proposed. Finally, correlations of fully reconstructed heavy quark

jets with charm hadrons are to be studied. These are ideal for studying the medium response, but are very difficult because of trigger bias. They will be studied in p+p, with a view to seeing if they can be done in heavy ions.

This proposal presents a realistic discussion of the difficulties expected for each of these measurements. I think it is clear that very important results will come out of the proposed research, even if some of the more difficult attempted analyses do not work out.

Reviewer 47:
I am unable to judge the soundness of the proposed hardware an experimental methods since the devil is in the details; but I trust that they are sound, given the long successful track record of the STAR collaboration, and the responsible positions Dong has assumed within that collaboration.

Reviewer 72:
Previous proof-of-principle analysis of D-meson - hadron and D-meson - jet correlations using non-photonic electron proxies have been done by the STAR collaboration. These previous studies provide important experience for the proposed, more ambitious analysis discussed here. The proposed time-line for the detector support and data analysis is well matched to the planned HFT construction, installation and commissioning.

There are however a few concerns about the practicality for the P.I. to carry out the proposed analysis program:
The first involves the P.I.'s present, major commitment to the STAR collaboration -- that of Physics Analysis Coordinator (PAC). This position is extremely time consuming based on recent experiences of previous STAR PACs. This position can easily be a full-time job. During the first two years the P.I. proposes to conduct major commissioning, calibration and QA support for the HFT, carry out major simulation and charm production analysis for the proto-type and final pixel detectors, while maintaining his role as the STAR PAC. Even with two post-docs it will be a considerable challenge for the P.I. to adequately manage all these tasks, not to mention being a mentor to the part-time graduate student. Being aggressive is a good thing in general, but one needs to be realistic.

A key part of the new physics capability which the HFT provides is the identification of secondary vertices of order 100 microns away from the primary collision vertex. While I am confident this performance bench-mark can eventually be achieved it is likely going to be more challenging than suggested by the Geant simulation studies cited in the proposal and will require considerable effort, very likely in the form of further development of the STAR tracking codes which lie beyond the control of the P.I. The proposed analysis program could easily be delayed while these improvements are being made.

An important component of the proposal involves the correlation of D-mesons with jets as well as the identification and reconstruction of c- and b-jets. Jet reconstruction in Au-Au collisions is itself a challenging research project and has by no means matured to the

point where jet finding codes for the Au-Au environment can be readily used by non-experts. This proposal does not address the highly complex problem of jet reconstruction in Au-Au collisions. The risk is that by assuming that jet finding and reconstruction in the Au-Au collision environment is a "turn-key" operation they may inadvertently generate erroneous D-meson -- "jet" correlations and will disseminate spurious results to the community.

Reviewer 82:
The first part of the proposal related to infrastructure work during the commissioning phase of the HFT has to be done and the approach as described seems reasonable. I get the impression that the PI is reasonable familiar with this aspect of the work and there are no reasons to assume that he and his colleagues will not be successful. For the data analysis part the PI describes this in somewhat more detail and demonstrates that he is very familiar with the problems he will encounter, like understanding the trigger bias for charm hadronic decay studies. It is going to be a challenging analysis, but the HFT combined with the other STAR detectors should be up to the task even if it will take substantial time to understand the systematic errors.

**3. Competency of Applicant's Personnel and Adequacy of Proposed Resources**
What are the past performance and potential of the Principal Investigator (PI)? How well qualified is the research team to carry out the proposed research? Are the research environment and facilities adequate for performing the research? Does the proposed work take advantage of unique facilities and capabilities?

Reviewer 34:
The PI seems to be well qualified and capable of leading this effort, which is an important component of the STAR physics program.

Reviewer 47:
I find it impossible to evaluate this question from the information provided in the proposal. When the PI writes ``We will carry out precision measurements of various charm hadrons in p+p and Au+Au collisions" I have to assume that "We" refers not just to the PI and his post-docs and students, but that a significantly larger part of the STAR collaboration will be part of this project; in which case it would be useful to know what part of this project will be the PI's sole responsibility. Similarly, should I assume that when he says "we will carry out heavy quark azimuthal angular correlation analyses"he is still referring to the larger collaboration, or just to his small group? If the latter, he should give some estimate of the person-hours this will take, or else how can one assess whether he has adequate resources? Perhaps these are things all experimentalist reviewers will know and understand and can assess without it being spelled out in the proposal, but I cannot.

As for the competency of the personnel, I infer that since Dong was the co-convener of the Heavy Flavor Working Group 2009-2011 and is currently the Physics Analysis Coordinator for the STAR collaboration, he must be deemed quite competent by his

collaborators.

Reviewer 72:
The P.I.'s competence as far as detector and software support is well proven based on previous leadership and development work with the STAR Time-of-Flight project. He has also demonstrated ample experience working in heavy flavor physics analysis and presenting results on behalf of the STAR heavy flavor physics working group over the past couple of years.

However, I am concerned that his scientific objectivity may be clouded. For example, the proposal wording suggests a failure to distinguish between experimental observations which would require specific physical characteristics of the heavy-ion collision system as opposed to observations which are merely consistent with a specific model but do not necessarily require that model (e.g. models assuming rapid equilibration and opacity). The P.I. does not display healthy scientific skepticism regarding the often made claims for rapid equilibration in heavy-ion collisions. For example, the P.I. is all too ready to (naively) use the planned D-meson v2 measurements to infer a viscosity parameter for the system, without acknowledging the extreme model dependence of such inferences. Again, the risk is that the P.I.'s apparent lack of scientific skepticism may result in the publication of spurious results.

Reviewer 82:
Dr. Dong has in a relatively short time developed into an authority on heavy flavor physics. I am not personally very familiar with him, but based on my observations at conferences etc. combined with the well written proposal, I have no doubt that he has the needed competency for the proposed research.

With two post-docs there the resources are adequate, since the proposal does not require any hardware resource (just manpower). However, as stated earlier, I doubt they will have time to do all what they propose to do.

**4. Reasonableness and Appropriateness of the Proposed Budget**
Are the proposed budget and staffing levels adequate to carry out the proposed research? Is the budget reasonable and appropriate for the scope?

Reviewer 34:
The budget seems OK to me. The proposed level of support of HFT commissioning and software development will need significant manpower, and 2 postdocs and a graduate student does not seem to be too much manpower by any means.

Reviewer 47:
As I found it difficult above to say whether the staffing level requested in this proposal is adequate to the job, I must of course say that I cannot tell whether the budget is appropriate.

As is usual with Career Awards to scientists at national labs, I find it very odd that the proposal requests 50% - 80% of the PI's salary, since that will just mean that the lab pockets the money and redirects their salary savings to projects unrelated to the one in the proposal. Why should the Early Career funds subsidize lab projects unrelated to the review process? If a case can be made that the lab would require Dong to work on something completely different if this proposal wasn't funded, there might be a case, but I find that hard to believe. Funding post-docs and students makes sense to me, since they will be working directly on this project, and presumably would not be without this grant being funded.

Reviewer 72:
Developing the software and calibrations to fully exploit the HFT capabilities will be a lot of work, as will the proposed analysis. 2.5 to 2.8 FTEs seems about right. Including part-time graduate student support (two 6 mo appointments during the first two years) can be highly worthwhile to the graduate student's experience. Previous STAR graduate students have participated in these extended research visits to LBNL with good results.

Reviewer 82:
The proposal follows the normal level of Early Career Research proposals. If all the research proposed is really going to be carried out within this proposal, it is appropriate to request two post-docs. However, I am sure the analysis will be done by other groups, even if this proposal only has one post-doc, so one can raise a question mark with the level of post-doc support.

**5. Relevance to the mission of the Office of Advanced Scientific Computing Research (ASCR) program (n.b. This should have referred to Nuclear Physics.)**
How does the proposed research contribute to the mission of the program in which the application is being evaluated?

Reviewer 34:
The proposed support of the HFT commissioning and software development is critical to a major portion of the STAR physics program, which is also widely recognized in the field as addressing an important physics goal, and thus to the DOE.

Reviewer 47:
The STAR heavy ion physics program is one of jewels of the Office of Nuclear Physics, and this proposal is completely in the service of that program.

I see no relevance to ASCR, but I assume that the question is a mistake.

Reviewer 72:
The analysis is aimed at obtaining precision heavy flavor yield and correlation measurements which will help further constrain model descriptions of the dense, energetic system produced at RHIC. It is therefore within the main focus of the DoE's Office of Science nuclear physics mission. However, I am concerned about the eventual, uncritical interpretation of the data which would not serve DoE's mission.

Reviewer 82:
The proposal is highly relevant to the Office of Science Program Mission, Nuclear Physics. It fits into the scope of Office-of-Science-funded research programs at the Lawrence Berkeley National Laboratory.

**6. Potential for leadership within the scientific community**
What has the Principal Investigator (PI) done to serve others in the scientific community outside of direct research contributions? How has the PI demonstrated the potential for scientific leadership and vision?

Reviewer 34:
The PI was a co-convener of the STAR Heavy Flavor Physics Working Group for two years, until August of last year. At that point he became the Physics Analysis Coordinator of the STAR Collaboration. These positions are indicative that he is held in high regard within the STAR collaboration, and also that he is willing and able to perform challenging leadership jobs. He is also STAR group leader at LBNL. These are all signs of strong leadership abilities.

Reviewer 47:
Dong seems to have a high profile within the collaboration, as Physics Analysis Coordinator, as well as STAR group leader at LBNL. These two positions suggest he is very much a leader. Furthermore, he has co-organized two workshops. However, it is striking though that he does not list a single talk given, not a seminar, not a conference talk, not a colloquium --- which means that outside his collaboration he is apparently unknown. I do not think that having a significant role within the collaboration is quite enough to count as "playing a leadership role in the scientific community".

I tried to discover from the HFT documents listed as [30] and [31] in the proposal's references whether Dong played any role in the design of the HFT. I found that [31] was not accessible to people outside the STAR collaboration (which means it is useless as a reference); ref [30], written in 2007, lists Dong as one of over 50 co-authors, but does not allow on to deduce what role he played in the design of the HFT --- and Dong does not mention any role in his proposal.

For what it is worth, I am rating this proposal "3" because I find that the proposal does not provide enough evidence that Dong has any visible profile outside of the STAR collaboration, and because I find the proposal far too general to assess exactly what his role has been in the development of the HFT, and what part of all the future projects he lists will be the sole responsibility of his group. I think the physics described in this proposal is very interesting, and if other reviewers are confident that Dong has played a leading role in developing the heavy flavor program, and that he will be playing a high profile role in carrying it out, then their verdict should carry more weight.

Reviewer 72:
The P.I. has just begun serving as the STAR Physics Analysis Coordinator. He was previously a co-convener of the STAR Heavy Flavor Physics Working Group. Before/during that period he served as the STAR time-of-flight software leader. He has previous workshop organization experience as well. Overall, the P.I. aggressively seeks organizational leadership positions. What is not yet evident is a physics niche that would define his early career contributions to nuclear physics. The proposed study of open charm correlations may suffice provided his service as the STAR PAC, his hardware and software work on the HFT, and his lack of scientific skepticism do not get in the way.

Reviewer 82:
Dr. Dong is definitely on a trajectory to become one of the future leaders of our field. He has had several important publications outside of the STAR collaboration, and he has assumed a couple of important positions like STAR group leader at LBNL and Physics Analysis Coordinator in STAR.

This is a good proposal. The research topic it is addressing, heavy quark propagation in the sQGP and the extraction of intrinsic properties of the sQGP, is of high scientific merit and the PI is well qualified to do them. Maybe the proposal promises too much, but it would be great to be proven wrong! It definitely deserves to be funded and I will therefore give it a grade of 5 (Strongly Encourage Funding).

**7. Please choose one of the ratings below:**

Strongly Encourage Funding (5-6)
Encourage Funding (3-4)
Discourage Funding (1-2)

Reviewer 34:
Rating: 6.00 - Strongly Encourage Funding

Reviewer 47:
Rating: 3.00 - Encourage Funding

Reviewer 72:
Rating: 3.00 - Encourage Funding

Reviewer 82:
Rating: 5.00 - Strongly Encourage Funding