First Unambiguous Measurement of Jet Fragmentation and Energy Loss in the Quark-Gluon Plasma Proj.No.20090303ER – ADDENDUM

The physics topic of this ER proposal is the measurement of jets in heavy ion collisions at the Large Hadron Collider (LHC). The jets of interest are to be tagged via a unique signature, a muon pair from a Z^0 decay. In the following we will demonstrate that detecting the muon pair at the trigger level not only enables the measurement, but also satisfies the requirement for service work in the CMS collaboration at the LHC, a necessary step to join CMS. This proposal puts a strong emphasis on the broad expertise available in the Physics, ISR and Theory divisions at LANL, ensuring a large institutional involvement at the LHC.

After the LDRD office indicated that reserve funds are available to increase the scope of the approved ER project, with the goal of LANL gaining full collaboration member status at CMS, we have held extensive discussions with the CMS project manager and the Princeton-Rutgers Pixel Luminosity Telescope (PLT) collaboration on how to define a significant role for LANL at CMS. The conclusion from these discussions is that the available funds would not allow us to take a lead role in the PLT project. Instead, we have determined that by adding experts from the ISR division, we can expand the original scope of the ER proposal to provide a critical new contribution to the CMS trigger project. Specifically, we will add now the capability to trigger on the combined data from the Calorimeter and the Muon Tracker, which is essential for our proposed measurement. This will allow us to directly and cleanly select events with muons. This trigger development would also serve as a prototype for the next generation of trigger hardware needed for the near future. The US-CMS project manager has specifically encouraged our involvement in the trigger work, due to our unique capabilities. We have, therefore, developed a timetable for joining the CMS collaboration within the first six months of this ER project.

We propose to expand the experimental section of our ER project by adding a nuclear physicist, Andi Klein (P-23/ISR-1), who is a specialist in data acquisition and computational physics (20%), and a full-time technically oriented post-doc for three years. Together with electrical engineer Matthew Stettler (ISR-3), who is directly supported by CMS, we will be able to address all aspects of this important muon trigger work. This includes board development, installation into CMS, integration into the trigger databases, and development of software algorithms needed to trigger on muon-tagged jets. The additional manpower will help to fulfill the service work requirements as well as to perform the first physics analysis starting in the fall. The analysis remains as outlined in the original ER proposal.

Matt Stettler has worked for several years on the CMS trigger electronics without being a member of CMS, an unsatisfactory situation for him and LANL. He has established an excellent reputation within CMS, which makes his expertise highly sought after. His design of the next generation trigger has been accepted by the CMS collaboration. We propose that some of the funds available this year be used to prototype and produce this board as a LANL project, leading to higher visibility for LANL within CMS. The production version of this trigger board will complete the necessary trigger system for our ER project. So that much of the trigger development can be done locally and the expertise spread among our staff members, we propose to build up a trigger testing and processing infrastructure at LANL.

Investing in the appropriate technology now will preserve LANL's place as a prime contributor to this important CMS detector system.

With the suggested allocation for funds to be spent this fiscal year, we propose the purchase of the following items:

1. The following are required for the immediate construction and test of the prototype boards necessary to combine the CMS Calorimeter and Muon trigger data.

a) Fabrication of the processing module circuit boards	$13470
b) Assembly of the processing module circuit boards	$10000 (estimate)
c) LANL Tech labor to support construction	$5769
d) LANL Staff labor to support construction	$2116

2. Test crates and software are needed to allow us to locally test the prototypes as opposed to shipping them to CERN.

a) Two micro TCA test crates to facilitate module test	$4000
b) Software IDE to facilitate uTCA compatibilty	$9519
c) Xilinx software suite for Virtex-V	$2500

3. The following components are required for the full production of the trigger system boards:

a) Xilinx V5FX70T FPGA devices	$8440
b) Mindspeed M21141 72x crosspoint switches	$8000

4. We consider the following systems vital for the development of appropriate technology for meeting the requirements of a future SLHC trigger.

a) Tilera array processing system (PC development environment)	$20913
b) NVIDIA Tesla D870 coprocessing system (PC environment)	$10347

The total of the above items is : $95074

There are other useful long lead-time items that cannot be purchased by September 15th.

In summary, we propose in this addendum a focused trigger effort that applies the unique resources of LANL to make an important impact on CMS and set the stage for formal membership in the collaboration.

We envision a long-term role for LANL at CMS once this ER project is completed. The approved future luminosity upgrade at the LHC, known as Super LHC, will require a new approach to detector instrumentation and triggering in the central region. The expected luminosities will be so high that the existing silicon tracker must be replaced and its data acquisition system upgraded and included in the trigger, which it currently is not. The LANL heavy ion experimental team's strength lies in silicon tracking and high-speed data acquisition. Our current $5M FVTX silicon detector project at RHIC, funded by DOE, was based in part on our successful existing LDRD DR project. It would be a role well suited for this National Laboratory to engage in the silicon upgrade at CMS in the future and to possibly bring another large construction project to LANL.