1 Overview

Heavy ion collisions at the Large Hadron Collider (LHC) provide an opportunity for an unprecedented expansion of the study of Quantum Chromodynamics (QCD) in systems with extremely high energy density.

Data collected by the four experiments at the Relativistic Heavy Ion Collider provide insight into what can be expected at the LHC. The results suggest that in heavy ion collisions at XXXX 200 GeV an equilibrated, strongly-coupled partonic system is formed. There is strong evidence that this dense partonic medium is highly interactive, perhaps best described as a quark-gluon fluid, and is also almost opaque to fast partons. In addition, many surprisingly simple empirical relationships describing the global characteristics of particle production have been found. An extrapolation to LHC energies suggests that the heavy ion program has significant potential for major discoveries. Similar to the expectations for high energy physics, heavy ion studies at the LHC will either confirm and extend the theoretical picture emerging from lower beam energies or challenge and redirect our understanding of strongly interacting matter at extreme densities. This will be accomplished both by extending existing studies over a dramatic increase in energy and also by bringing to bear a broad range of novel probes (such as high X jets and photons, X bosons, the X states, X and X mesons, and high-mass dileptons) which are accessible only at LHC energies.

In this proposal, we will show that the Compact Muon Solenoid (CMS) detector provides unique capabilities for focused measurements that exploit the new opportunities at the LHC. These measurements will directly address the fundamental science questions in the field of high density QCD. This potential was recognized by the CMS collaboration which has included a heavy ion group since its inception. The US component of that group played a key role in expanding and developing the physics program and now leads the overall effort. The apparatus provides unprecedented coverage for tracking and both electromagnetic and hadronic calorimetry combined with high precision muon identification. The detector is read out by a very fast data aquisition system and allows for sophisticated triggering.

In Section 2 we will describe the science case for heavy ion physics at LHC. Based on the knowledge gained in the first five years of RHIC running, and our current theoretical understanding, we provide examples of measurements that will address the fundamental science questions in this field. A description of the CMS detector (Section 3) and studies of its performance in the high multiplicity heavy ion environment (Section 4) illustrate that it excels in exactly those categories which the experience at RHIC indicates will be most critical.

The key component in exploiting the CMS capabilities in heavy ion collisions is the trigger system, which is crucial in accessing the rare probes expected to yield the most direct insights into the properties of high density strongly interacting matter. The general trigger strategy and overall structure of the trigger hardware are introduced in Sections 5 and 6. More details of the Level-1 and Higher Level Triggers are given in Sections 7 and 8. Our studies have led to a unique trigger strategy for CMS Pb+Pb running, where the event selection will be performed in a very large online CPU farm running offline reconstruction algorithms. The implementation of this strategy forms the core of the proposed US contribution to CMS heavy-ion operations.

Finally, the requested funding and the proposed schedule and management plan are described in Sections 9 and 10. This proposal asks for a total of 2 M$ for FY2007 through FY2010. The bulk of this funding will be used to purchase computer hardware for use in the CMS trigger, with small amounts needed for establishing a trigger development facility in the US. It should be noted that this contribution represents about 10% of the overall cost of the full DAQ system and 0.4% of the total cost of the CMS experiment.

With the exception of 0.25 FTE technician in FY2007 for the initial setup of the trigger facility, no personnel are supported under this proposal. Instead all of the US CMS heavy ion physicists (profiled in Appendix A) will be funded by their individual group budgets. Additional operating costs to cover collaboration fees as well as the anticipated impact of this project on the groups' travel expenses are discussed in Appendix B. The capital cost of off-line computing to support CMS heavy ion physics at US institutions is discussed in Appendix C. Additional hardware projects to construct the ZDC (see Appendix D) and CASTOR detectors are also part of the US CMS heavy ion effort but are funded through other sources.

In summary, The US CMS heavy ion group is actively engaged in preparing to exploit the unique physics potential using CMS to study heavy ion collisions at the LHC. Group members have extensive experience in the relevant topics from several of the detectors at RHIC as well as experiments at other facilities. Consultation and cooperation