【Grant-in-Aid for Scientific Research (S)】

Science and Engineering (Mathematical and Physical Sciences)

Title of Project : Photon Physics Revealing Hidden Properties of Quark Matter in the ALICE Experiment

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Research Area : Particle Physics, Nuclear Physics, Cosmic-ray, Astrophysics
Keyword : Quark matter, Photon physics, ALICE experiment, Quark-gluon plasma, QGP

【Purpose and Background of the Research】

A head-on collision of heavy nuclei accelerated at a high energy pours a huge amount of its energy into a tiny space in the vacuum. The vacuum is abruptly heated up, boiled and the space is filled with a large number of quark-anti-quark-pairs and gluons created in the vacuum. It is a reproduction of the little Big Bang. Our primordial Universe has been filled with such quarks and gluons until the QCD phase transition occurred at around 10 μs after the Big Bang. Although QCD theory has been established today, it is not yet feasible to predict properties of such quark matter due to its non-perturbative characteristics. Our discovery of the perfect liquid at RHIC was totally beyond theoretical expectations. Recently, one realized that the collective behavior of the quark matter is similar to that of ultra-cold trapped atomic systems. Interconnection between these frontiers will be more important along with developments of AdS/CFT theories. In this research project led by Japanese universities, we promote unique photon physics in the ALICE experiment during the RUN-2 period at the CERN LHC.

【Research Methods】

We explore collective properties of quarks in a new domain at the LHC, using the high performance photon spectrometer, PHOS, and the new di-jet calorimeter, DCAL, which have been constructed by ourselves for the ALICE experiment (Fig.1). We will upgrade the PHOS readout system before the RUN-2 starts in 2015, and also take part in a few detector R&D programs. With di-jet angular correlation measurements between DCAL and another detector, EMCAL, in opposite sectors, we study how much energy is lost by leading partons when passing through the matter, and figure out where the energies are distributed to. PHOS is a unique and precise photon spectrometer at GeV energies. With its outstanding performances of precise granularity and high energy resolution, we identify direct photons and observe the energy spectrum of the thermal photon ingredient to figure out thermal characteristics of the hot quantum object.

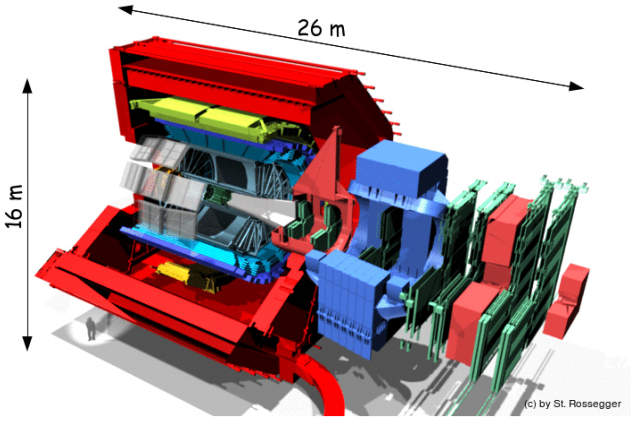

Figure 1. The ALICE apparatus

【Expected Research Achievements and Scientific Significance】

The di-jet angular correlation and thermal photon measurements in this coming RUN-2 shall provide novel information to understand the hot quantum object. A forward photon detector, FOCAL, may open a door to attack an unknown small x domain where fruitful physics played by low p_T partons might be involved. This research program exploring hidden properties of pure quark matter is not simply to study non-perturbative features of QCD phenomena, but to develop a new discipline along with progress of fundamental theories. In the near future, a new forefront "strongly interacting quantum objects" might be created.

【Publications Relevant to the Project】

- ALICE collaboration, "The ALICE experiment at the CERN LHC", Journal of Instrumentation 3, S08002 (2008).
- ALICE collaboration, "Neutral pion and eta meson production in proton-proton collisions at $\sqrt{s}$ = 0.9 TeV and $\sqrt{s}$ = 7 TeV", Physics Letters B717, 162-172 (2012).

【Term of Project】 FY2014-2018

【Budget Allocation】 141,200 Thousand Yen

【Homepage Address and Other Contact Information】

http://www.hepl.hiroshima-u.ac.jp