独立行政法人理化学研究所　仁科加速器研究センター
第１１１回RIBF核物理セミナー
RIKEN Nishina Center for Accelerator Based Science
The 111th RIBF Nuclear Physics Seminar

Direct photons from Au+Au collisions and initial temperature of the Quark Gluon Plasma at RHIC

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Experimental results of RHIC in its first decade firmly established that dense partonic matter, a quark gluon plasma (QGP), is formed in heavy ion collisions at RHIC. Unlike some early expectation, the QGP formed at RHIC is not a weakly coupled gas of quark and gluons, but instead appears to be a strongly-coupled liquid with very low viscosity. RHIC is now moving into an exciting phase of quantitatively characterizing the properties of the ″strongly-coupled″ QGP.

Electromagnetic probes, i.e. lepton pairs and direct photons, are ideal probes of the QGP formed at RHIC. Since the mean free path of photons is much larger than typical nuclear scales they leave the medium without final state interactions, carrying the information of deep inside the matter.

A hot QGP should emit thermal photons. Theoretical calculations predict that the QGP phase is the dominant source of direct photons with $1 < p_T < 3$ GeV/c in Au+Au collisions at RHIC. The observation of thermal photons provides direct evidence that a hot QGP is formed, and its initial temperature can be determined from the yield and the spectrum of thermal photons.

The measurement of real direct photons in such a low p_T range is, however, very difficult due to a large background of photons from hadron decays. To overcome this problem, PHENIX experiment at RHIC instead measured low-mass high-p_T electron pairs, i.e. quasi-real virtual photons. By measuring the electron pairs just above the π^0 mass, the background contribution from π^0 decays is removed, and the background is reduced by a factor of five.

The production of e^+e^- pairs for $m_{ee} < 0.3$ GeV/c^2 and $1 < p_T < 5$ GeV/c is measured in p + p and Au + Au collisions at sqrt(s_{NN})=200 GeV. An enhanced yield above hadronic sources is observed. Treating the excess as photon internal conversions, the invariant yield of direct photons is deduced. In central Au + Au collisions, the excess of the direct photon yield over p + p is exponential in transverse momentum, with an inverse slope T = 221 ± 19(stat) ± 19 (syst) MeV. If the enhanced direct photons in Au+Au collisions are thermal photons, the inverse slope T is related to the initial temperature T_{init} of the matter. T_{init} is 1.5 to 3 times T due to space-time evolution. Hydrodynamical models with initial temperatures ranging from T_{init} = 300-600 MeV at times of 0.6-0.15 fm/c after the collision are in qualitative agreement with the data. Lattice QCD predicts a phase transition to quark gluon plasma at 170 MeV.

The seminar will be given in English.

Jan. 24 (Mon), 2011　15:00-
Nishina Hall, RIKEN

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