【Grant-in-Aid for Scientific Research(S)】
Science and Engineering (Mathematical and physical sciences)

Title of Project : Search for New Physics Beyond the Standard Model with Rare Neutral Kaon Decays

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Research Area : Physics
Keyword : Experimental Particle Physics, Neutral Kaons, CP violation

【Purpose and Background of the Research】

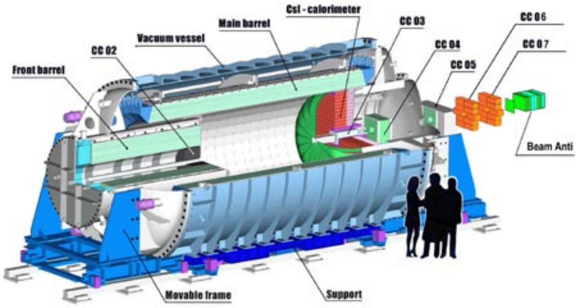
At the beginning of the universe, there were the same number of particles and antiparticles; but today, there are almost no antiparticles left. This is because particles and antiparticles behave slightly differently. This is called CP violation. In laboratories, CP violation was discovered in Kaons and B-mesons, and its mechanism was theoretically explained by Kobayashi and Maskawa. However, the CP violation mechanism in the standard model is still too small to explain why the antiparticles disappeared from the universe. This imbalance in the universe must have been produced by a CP-violating mechanism in a new physics beyond the standard model.

The purpose of this research is to search for new physics beyond the standard model that violates the CP symmetry.

【Research Methods】

We will search for CP violation caused by new physics in a neutral kaon decay mode, K_L decaying into a neutral pion and neutrino pairs. The standard model predicts it branching ratio to be small, $3x10^{-11}$, and its theoretical uncertainty is only a couple of %. If a particle of new physics, such as super symmetric (SUSY) particle or a 4th generation quark contribute to this decay mode, the branching ratio can be largely enhanced. Thus we will search for the decay down to the level predicted by the standard model, and measure its branching ratio.

To observe this rare decay, we will produce a large number of neutral kaons by hitting a target by protons accelerated by the J-PARC high intensity proton accelerator located in Ibaraki, Japan. The signature of the decay is that there are only two photons coming out from the decay. Other decay modes have charged particles or more than three photons in the final states. As shown in the next figure, an electromagnetic calorimeter is located downstream of the decay region to measure the energy and hit positions of the two photons. The decay region is surrounded by charged and photon veto detectors to reject all other decay modes which have extra particles.



Detector Setup

【Expected Research Achievements and Scientific Significance】

If we measure a branching ratio larger than the standard model prediction, it signifies the existence of a new physics, and gives the size of its effect. Even if we do not find the decay, we can still place constraints on new physics models and their parameters. In addition, by combining with results expected from a charged kaon decay experiment at CERN and B-meson results from new B-factory at KEK, both under construction, we can apply further constraints. If the proton-proton collider experiments at CERN LHC finds SUSY particles, we can give information on flavor structure of SUSY particles.

【Publications Relevant to the Project】

1. "Experimental Study of the Decay $K_L \to \pi^0 \nu \nu$", J.K. Ahn *et al.*, Phys. Rev. D **81**, 072004 (2010).
2. "Testing the CKM Model with Kaon Experiments", E. Blucher, B. Winstein and T. Yamanaka, Prog. Theo. Phys. **122**, 81 (2009).

【Term of Project】 FY2011-2015

【Budget Allocation】 171,500 Thousand Yen

【Homepage Address and Other Contact Information】

http://koto.kek.jp/