Nuclear Physics

LEPS and LEPS2 Beamlines Overview

The linearly polarized photon beam produced by laser-induced backward Compton scattering from 8 GeV electrons has been used to study the quark-nuclear physics via the photoproduction of hadrons at BL33LEP (LEPS). This photon beam has a large polarization, nearly 100% at the maximum energy, which is a great advantage to elucidate the photoproduction mechanism. The photon energies above 1.5 GeV are tagged by detecting recoiled electrons.

The LEPS beamline has been upgraded in parallel to the experiments. An all-solid UV laser with a 355-nm wavelength (Paladin) was introduced instead of the previous Ar laser, and thanks to the low power consumption, we performed the simultaneous injection of two UV lasers. The gain of beam intensity was accomplished by a factor of 1.6. The maximum energy has also been extended up to 2.9 GeV by introducing 266-nm deep UV lasers (Frequad-HP). The photon intensities have reached 2.5×10^{6} s^{-1} for the 2.4-GeV beam and 2.0×10^{-5} s^{-1} for the 2.9-GeV beam, respectively.

The upgraded high intensity beam has been utilized for the high-statistics experiments. The article by Tokiyasu *et al*. reports the results of the search for the $K^{-}pp$ bound state through the $\gamma d \to K^{+}\pi^{-}X$ reaction. The kaonic nuclei like a $K^{-}pp$ state are very exotic because they contain a real kaon as a nuclear component. The confirmation of the existence of such nuclei is one of the recent hot subjects in hadron physics and this is the first try using the photoproduction. The obtained missing mass spectrum has shown no peak structure corresponding to the $K^{-}pp$ bound state in the expected mass region. The upper limit of the production cross section has been estimated.

The construction of a new laser-electron photon beamline, LEPS2, has started at **BL31LEP** in 2010. Based on the experience in the LEPS experiments, the LEPS2 project aims to improve the beam intensity one order of magnitude and to enable the installation of the large acceptance detector with high resolution. A new LEPS2 experimental building was constructed outside the experimental hall of the storage ring. Figure 1 shows the ribbon-cutting scene of the inauguration ceremony of LEPS2 performed in front

Fig. 1. Photograph of the inauguration ceremony of the laser-electron photon beamline LEPS2 (BL31LEP) held on February 21, 2013.

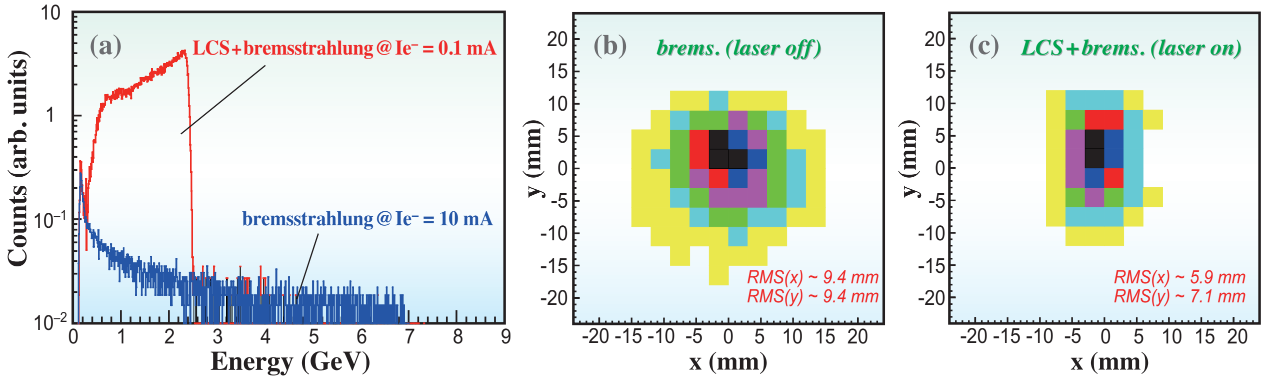

Fig. 2. **(a)** Energy spectra of the photon beam in the case of laser ON and OFF, respectively. The vertical scale is normalized by the electron beam current. **(b)** Beam profile for the Bremsstrahlung photon only (laser OFF). **(c)** Beam profile in the case of laser ON.

of the experimental building. By using one of four special beamlines with 30-m straight sections, which have the smallest beam divergence, the photon beam does not spread out even at the target position (135-m downstream of the collision point).

The LEPS2 project reached a milestone in 2013. On January 27, the first photon beam at BL31LEP was successfully observed in the measurements of energy spectrum, beam profile and beam intensity. In the beam commissioning, two 16-W lasers and a 24-W laser with the wave length of 355 nm were used and injected simultaneously. The energy spectrum measured with a BGO crystal calorimeter and beam profile measured by a position counter with scintillating fibers are shown in Fig. 2. The Compton edge of 2.4 GeV is clearly identified for the laser-Compton scattering (LCS) gamma rays and the small beam size (< 10 mm in RMS) was confirmed as expected. The Compton scattering rate was estimated to be about 7×10^6 s^{-1} for the 100-mA storage electron current.

In the LEPS2 experimental building, we have been preparing two detector systems. One is a large acceptance charged particle spectrometer using a large 1-T solenoid magnet transported from the Brookhaven National Laboratory (BNL) in U.S. Several chambers and counters which will be placed inside the solenoid are still under the construction. Another detector is an electromagnetic calorimeter, BGOegg, consisting of 1320 BGO crystals, which has been developed by the ELPH group in Tohoku University, and is now placed upstream of the solenoid magnet. A photograph of the inside of the LEPS2 experimental building is shown in Fig. 3. After many efforts for the setup of detectors and for the preparation of the data acquisition system, the commissioning run has just started with the BGOegg. The full-scale BGOegg experiment will be performed in 2014 to investigate the η' meson physics, etc.

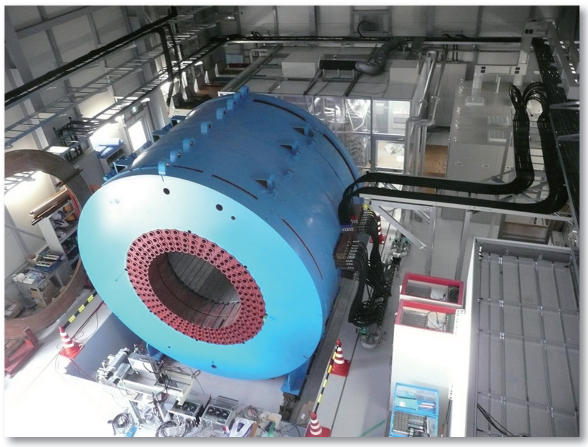

Fig. 3. Photograph of the inside of the LEPS2 experimental building. The BNL/E949 solenoid magnet is installed around the center of the room and the BGOegg is placed in the clean booth upstream of the magnet. The diameter of the magnet yoke is 5 m.

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