LEPS2: the new high-intensity GeV photon beamline BL31LEP

The GeV photon beamline at SPring-8 (LEPS) started the experiments to investigate the sub-atomic and sub-nuclear physics in 2000. The photon beam was produced by means of laser-induced backward Compton scattering from 8 GeV electrons, which was called laser-electron photon (LEP). The photon energies above 1.5 GeV are tagged by detecting recoiled electrons. The beam polarization of LEP is high and nearly 100% at the maximum energy. Polarization observables play an important role to elucidate the photoproduction mechanism. The LEPS experiments have been carried out, mainly using the forward charged-particle spectrometer, and various interesting data on hadron photoproductions, like the pentaquark Θ^+ [1], have been reported. However, the low beam intensity (~10^6/sec) and limited acceptance of the spectrometer have restricted the further investigation, especially for concluding the Θ^+ existence and determining its spin and parity. We need to measure precisely both the photoproduction process and decay process simultaneously.

The construction of a new laser-electron photon beamline, LEPS2, has started at **BL31LEP** in 2010 [2]. Based on the LEPS experience, LEPS2 aims to improve the intensity of the photon beam and to expand the detector acceptance, which requires a much larger space to place the whole detector system. A new LEPS2 experimental building has been constructed outside the experimental hall of the storage ring. By using one of four special beamlines with 30-m straight sections, which have the smallest beam divergence, the LEP beam size will be small within a few cm at the target (150-m downstream of the collision point). A schematic view of the LEPS2 facility is illustrated in Fig. 1 and a picture of the LEPS2 experimental building is shown in Fig. 2.

The high intensity beam enables data collections with high statistics and is the key of the LEPS2 project. Two methods of the laser injection are planned to produce the higher intensity beam. One of the methods is the simultaneous injection of multi-number of lasers into the 8 GeV electron storage ring. In this case the beam intensity is nearly proportional to the number of lasers. We have already tested two-laser injection at the LEPS beamline and successfully used. In LEPS2, we will employ a four-laser injection system, as illustrated in Fig. 3. The new BL31LEP vacuum chambers in the storage ring are designed to expand their apertures for the four-laser injection and the standard vacuum chambers will be replaced with them. A technique of the laser beam shaping is another method. Since the electron beam profile at the collision point is very flat, i.e., horizontally wide, the efficiency of the backward Compton scattering will be increased by an elliptical laser beam. The test of the laser-beam shaping by using a cylindrical lens was succeeded for the visible laser. Twice intensities are expected by the elliptical beam shaping with the optimized design of the optical system. We expect the beam intensity around 10^7/sec for the 355-nm lasers (the maximum LEP energy is 2.4 GeV) and 2×10^6/sec for the 266-nm lasers (the maximum LEP energy is 2.9 GeV), respectively.

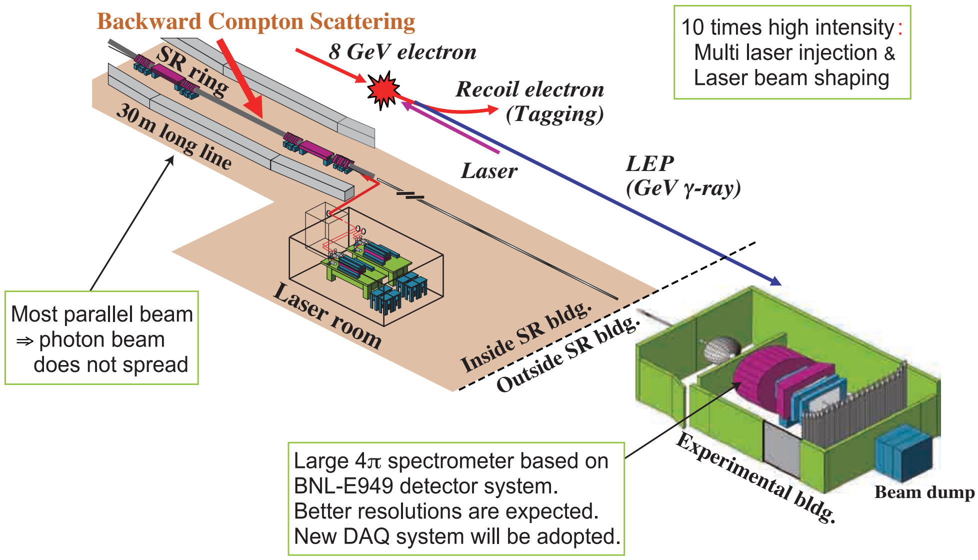

Fig. 1. Schematic view of the LEPS2 facility.

Fig. 2. Photograph of the LEPS2 experimental building. This building was constructed by the support of the RIKEN Nishina Center. A cooling system for the magnet coil is also seen in front of the LEPS2 building.

In order to measure precisely both the photoproduction process and the decay process simultaneously is one of the most important requirements for the LEP2 detector system. Unfortunately, the photoproduction cross section is small and the photon-beam experiment needs much longer beam time than that using hadron beams. Thus, the general-purpose detector with a large solid angle to detect not only charged particles but also neutral particles like photons is desirable. Such a detector, in general, needs a large cost and a long construction time. We have taken a choice to utilize the E949 detector of the Brookhaven National Laboratory (BNL) in the U.S. as such a large solid-angle detector, which was used in the kaon rare-decay experiment. In the E949 experiment, measurements of charged decay products were made in a 1-T magnetic field using an active target, a low-mass central drift chamber and a cylindrical range stack (RS) of scintillating detectors. Photons were detected in a calorimeter consisting of a lead/scintillator sandwich barrel detector surrounding the RS. Although tracking chambers should be modified for the photon-beam experiment, the inner bore size (3-m diameter and 2.2-m length) of the solenoid magnet is sufficiently large for the further optimization of the detector system. According to the simulation results for the LEPS2 experiments using the new detector system consisting of double-sided silicon strip detectors, forward drift chambers, a time projection chambers, and high-resolution time-of-flight counters, etc., we can obtain an invariant mass of Θ^+ with a 3.5 MeV resolution. The E949 magnet and detectors were disassembled and has been transported from BNL to SPring-8. The magnet has just been installed in the LEPS2 experimental building (Fig. 4). The development of detector system is still underway. After the beam commissioning, the physics data-taking will start from 2013.

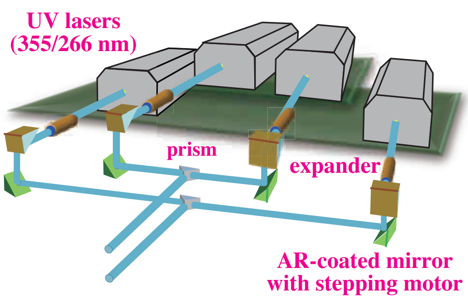

Fig. 3. Setup of the simultaneous injection of four UV Lasers. Each laser output from the beam expander is reflected at the upper mirror and the lower mirror, and then two laser beams with the same height are merged at the prism toward the injection line.

Fig. 4. Photograph of the E949 solenoid magnet installed in the LEPS2 experimental building. The diameter of the magnet yoke is 5 m and the length is 3.5 m. It is placed in the pit with the depth of 1.5 m.

Masaru Yosoi for the LEPS2 Collaboration

Research Center for Nuclear Physics (RCNP),
Osaka University

E-mail: yosoi@rcnp.osaka-u.ac.jp

References

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[2] *M. Yosoi (the LEPS2 Collaboration): AIP Conf. Proc.* ***1388*** *(2011) 163.*