LEPS II GeV photons at SPring-8

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The construction of a new GeV photon beam line, LEPS II, has started at SPring-8 in Japan. The photon beam of LEPS II is produced by backward Compton scattering of laser photons on 8 GeV electrons. The beam intensity will be improved one order of magnitude compared to the current LEPS. The development of a full-acceptance detector which can detect both photons and charged particles is underway. The design and current status of the development of the beam line and the detector system is presented.

1 Introduction

The GeV photon beam line at SPring-8 (LEPS) started physics data taking in 2000. The photon beam of LEPS is produced by backward Compton scattering (BCS) of laser photons on 8 GeV electrons of SPring-8. The LEPS detector is optimized to detect particles produced at the forward angles, and the acceptance in the large scattering angle region is limited. The LEPS has reported various interesting data on the hadron photoproduction measured in the forward region [1]. However, a large-acceptance detector is indispensable to measure the production reaction in wide kinematical region, and to detect particles produced both in the primary reaction and the decay of a resonance state, simultaneously.

In the year 2010, the construction of a new GeV photon beam line, LEPS II, has started. At the LEPS II, the beam intensity will be ten times higher, and a full-acceptance detector system which can detect both charged and neutral particles will be constructed. One of the features of the BCS photon is the high polarization degree more than 90 %. The design and the current status of the development of LEPS II are described in following sections.

2 LEPS II beam line

SPring-8 is a third generation synchrotron radiation facility with 61 beam lines in Japan. Figure 1 shows a top view of the LEPS II beam line. The laser photons are injected from the

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laser hutch toward the straight section where backward Compton scattering takes place. The scattered photon beam is irradiated to the target at 150 m downstream from the BCS collision point. We use one of four long straight section of SPring-8, BL31LEP, for our new experiment, LEPS II. This beam line has a 30 m-long straight section between the bending magnets. The major contribution to the angular divergence of BCS photon beam is the angular divergence of the electron beam which collide with the laser beam. Thanks to the small angular divergence of the electron beam in the long straight section, a very narrow BCS photon beam is formed at LEPS II. The beam spot size at the target is about a few millimeters in RMS.

The maximum energy of BCS photons is 3 GeV when a 266-nm laser is used. In order to increase the intensity of BCS photon beam, photons from four laser modules are injected simultaneously. The long straight section of BL31LEP is advantageous to avoid the interference of lasers by changing the focus points of lasers along with the electron beam. In addition, further improvement of the luminosity of BCS photon beam is achieved by increasing the collision probability of a laser photon with a 8 GeV electron. The electron beam has ellipsoidal cross section due to the bending magnets of SPring-8 storage ring. The cylindrical lenses are used to shape the cross section of the laser beam to be ellipse, and to gain collision rate between a laser photon and a electron. Thus, the BCS photon intensity increases twice. The beam intensity is 10^6 cps for 1.5-3.0 GeV with the 266-nm Ar laser and 10^7 cps for 1.5-2.4 GeV with the 351-nm solid state laser, respectively. These are ten times higher than those of the LEPS I. The energy of a BCS photon is obtained by measuring the momentum of the recoiled electron. The scattered electron are bended in the bending magnet of the storage ring more strongly than circulating 8-GeV electrons. Thus, the momentum of the scattered electron is measured from the position of the electron after the magnet, from which the energy of the corresponding BCS photon is obtained.

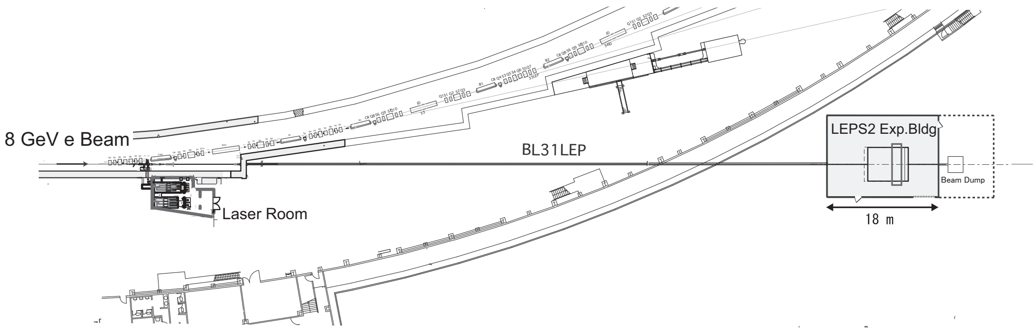

Figure 1: Top view of the LEPS II beam line.

3 LEPS II detector

Figure 2 shows a schematic view of the LEPS II detector. The LEPS II detector is designed to detect both of charged particles and photons. A solenoid magnet is shipped from USA to Japan in 2011, which was used for the kaon rare-decay experiment at BNL-AGS, E787/E949 [2]. The inner volume is 2.22-m long and 2.96-m in diameter. The LEPS II detector will be immersed in the solenoidal magnetic field of 1 T, which consists of double-sided silicon strip detectors (DSSD), forward drift chambers (FDC), a time projection chamber (TPC), time of propagation counter (TOP), range stack counter, resistive plate chamber (RPC-TOF), barrel electromagnetic calorimeter (EMCAL), and aerogel Čerenkov counter (AC). Charged particles are momentum-analyzed by the magnetic field of 1 T, and their trajectories are reconstructed by the DSSD, FDCs and TPC. The charged particles scattered at forward angles are detected by the DSSD and FDCs. On the other hand, the TPC measures the momentum in the large angle region. The momentum resolution of $\sim$1 % is achieved for 1 GeV kaons in the range of polar angle $\theta > 10^\circ$. The energy and direction of photons are measured with EMCAL, which is moved from BNL-AGS E949. The EMCAL is a sampling lead/plastic scintillator calorimeter with the total radiation length of $14.3X_0$ [2]. The polar angle coverage of the EMCAL is from 30° to 110°. The range stack counter can be used to detect neutrons with the detection efficiency up to 20 %.

The identification of momentum analyzed particles is performed by measuring a time of flight (TOF) from the target to the RPC-TOF in the low momentum region. A start signal for the TOF measurement is provided by the RF signal from the SPring-8 storage ring, which has a time resolution of 12 ps. Since the speeds of a laser photon and a 8 GeV electron are same, the arrival time of the BCS photon at the target is synchronized with the RF signal. A stop signal is provided by the RPC-TOF counters located at the barrel part where the radial distance is about 1 m. On the other hand, in the momentum region more than 1.2 GeV/c, Čerenkov counters are employed to distinguish kaons from pions. The high momentum particles up to 3 GeV/c are scattered at the forward region. The TOP counters are used to separate kaons from pions with 3σ in the end-cap region. The TOP counter is made of a quartz bar, which reconstruct the Čerenkov angle using the timing and position information of the Čerenkov photons traveling in the quartz bar [3]. In addition, the AC's are used at the barrel part for the K/π separation. The e^+e^- pair production is vetoed at the trigger level using the ultra low index AC with $n = 1.008$. The trigger rate of hadron production is estimated to be $\sim$5 kcps. A high rate dead-timeless readout system will be used for the data acquisition.

4 Summary

The construction of a new GeV photon beam line at SPring-8, LEPS II, has started in 2010. The beam intensity will be improved one order of magnitude compared to the current LEPS.

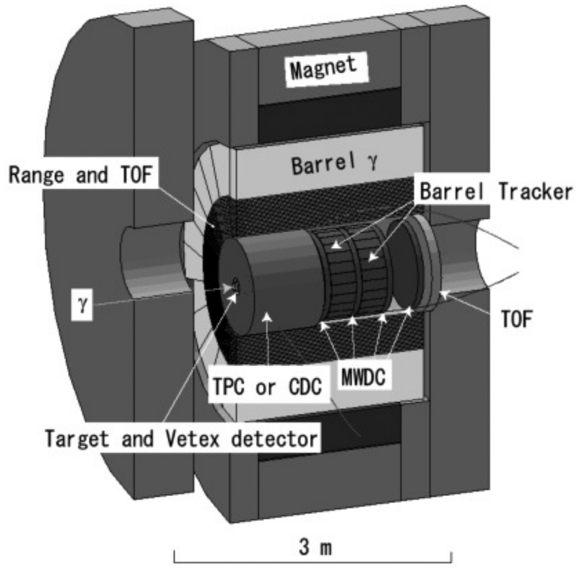

Figure 2: Schematic view of the LEPS II detector.

The development of a 4π detector which can detect both photons and charged particles is underway. The beam commissioning is planned to start in this year, and the physics data taking will start from 2013.

References

[1] T. Mibe *et al.*, Phys. Rev. Lett. **95**, 182001 (2005)
M. Niiyama *et al.*, Phys. Rev. C **78**, 035202 (2008)
T. Nakano *et al.*, Phys. Rev. C **79**, 025210 (2009)
M. Sumihama *et al.*, Phys. Rev. C **80**, 052201 (2009).

[2] M. S. Atiya *et al.*, Nucl. Instrum. Meth. A **321**, 129 (1992).

[3] M. Akatsu *et al.*, Nucl. Instrum. Meth. A **440**, 124 (2000).