GAMMA-RAYS BY COMPTON BACKSCATTERING IN A STORAGE RING, NEWSUBARU

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Abstract

Linearly polarized gamma rays have been produced via the Compton backscattering. The beam of 17.6 MeV gamma rays was obtained by backscattering 1064 nm laser photons from 1 GeV electrons circulating in a ring named NewSUBARU. Spectra of the backscattering photons have been measured with a NaI scintillation detector. The maximum energy and the energy spectra measured with the detector show agreements with simulation calculations. A detailed description of the gamma ray beam and the outlook for future improvements are presented.

1 INTRODUCTION

Backward Compton scattering of laser from a high-energy electron beam has been a promising method of producing useful yields of high energy polarized photons. The gamma ray beam will have properties, which open up many new possibilities for basic research and applications. The first real gamma ray beam for nuclear physics research was developed at the 1.5 GeV ADONE storage ring [1]. There are at present a number of facilities that produce polarized gamma-rays for nuclear physics studies. In order to carry the photonuclear experiments in the energy range of several MeV to tens of MeV, the Compton backscattering system has been installed at a storage ring, NewSUBARU[2] at Laboratory of Advanced Science and Technology for Industry (LASTI) in Himeji Institute of Technology. The method of the angle-energy correlation has been used in the system. In this paper, we will give some results obtained by the experiments

2 SETUP AND CALCULATIONS

A plan of the NewSUBARU facility is shown in Fig.1. The racetrack shaped ring can operate at energy 1.0 GeV to 1.5 GeV and has the ability to store an average current of 100 mA at injection energy of 1 GeV. A line (BL-1), which is 14 m straight line, was used for the experiment of the Compton backscattering. The experimental arrangement is schematically displayed in Fig.2.

Experiments have been made with the electron energy of 1.0 GeV and YAG laser (1,064nm, 1.168 eV). The stored electron current was 10 mA and YAG laser power was 0.36 W. The backscattered photon beam was collimated in 0.66 mrad. by a lead collimator with a length of 90 mm. The produced photon flux was monitored by a 3" × 3" NaI(Tl) scintillator. The NaI scintillation detector was placed on the gamma-ray beam axis approximately 20 m from the center collision point and at about 1 m behind the lead collimator. The response function of NaI detector was calculated by code EGS4[3].

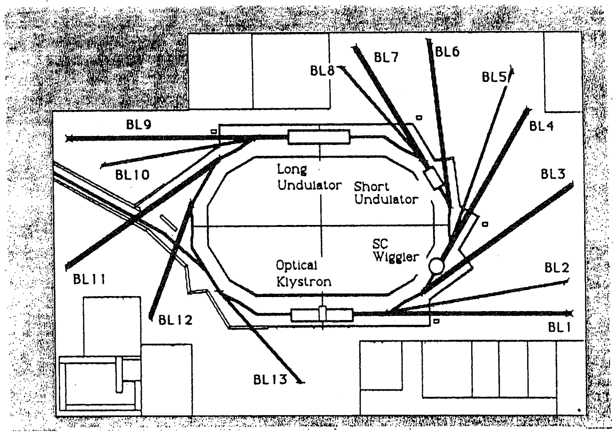

Figure 1: A plane view of NewSUBARU.

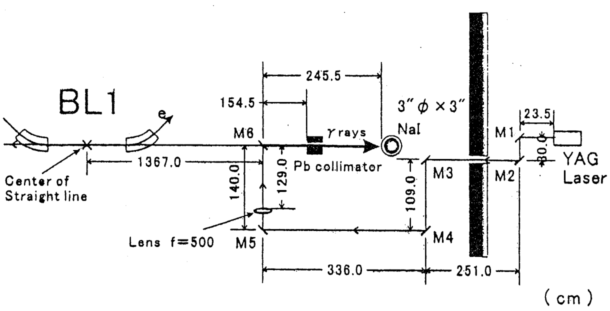

Figure 2: Schematic experimental arrangement.

We calculated the properties of the gamma rays expected from the facility by the simulated calculations. Figure 3 shows the calculated results.

3 EXPERIMENTAL RESULTS

First, we measured the room background for 3053 sec in the tunnel where the ring is installed. Figure 4 shows an energy spectrum of the room background in the tunnel. The spectrum consists of the 1.461 MeV gamma rays from the ^{40}K, of the 2.4 MeV gamma rays from ThC' and low energy gamma rays. We did not observe the gamma rays of higher energy than 2.5 MeV. The gamma ray energies were calibrated with the 1.461 MeV and the several standard gamma ray sources.

There are two potential background sources of photons, which are bremsstrahlung flux that originates from high-energy electrons interacting with residual atoms in the evacuated beam line and the synchrotron radiation. The synchrotron radiation energies are all less than keV. We measured bremsstrahlung flux of 1 GeV electrons and 10 mA electron current on the residual gas atoms in the BL-1 beam line using the NaI detector. The degree of the vacuum in the beam line was 1×10^{-7} Pa. A measured spectrum of the bremsstrahlung gamma rays is shown in Fig. 5.

The spectra of the backscattered photons were measured at the electron energy of 1 GeV. The produced maximum photon energy of 17.6 MeV at the wavelength of the primary laser photon of 1064 nm is expected for the head-on collision. Figure 5 shows a measured energy spectrum. The stored electron current was 10 mA and the laser power was 0.36 W. The spectrum subtracted the bremsstrahlung spectrum is the spectrum of the Compton backscattering and is also shown in Fig. 5. The maximum photon energy measured shows a good agreement with the calculated energy.

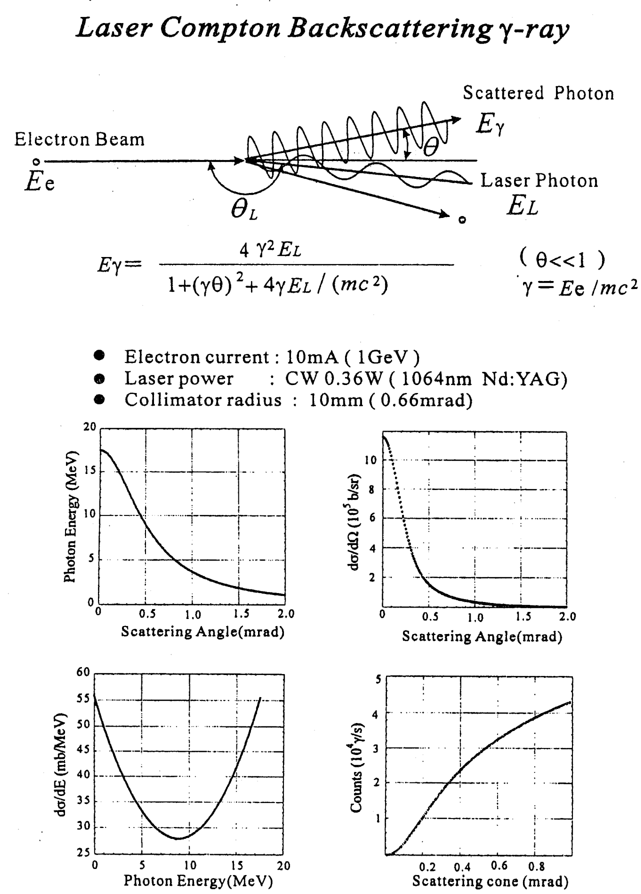

Figure 3: Calculations of the properties of the gamma rays.

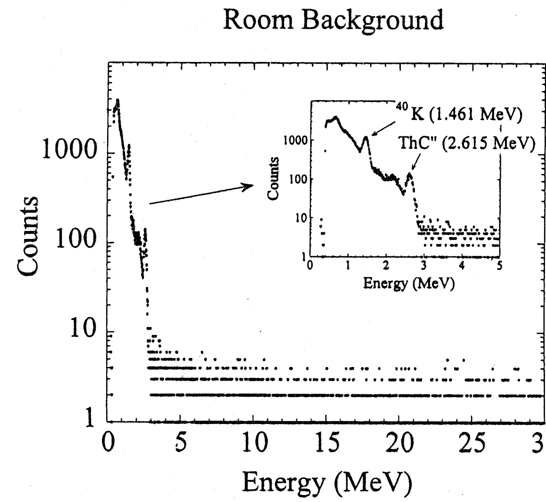

Figure 4: Energy spectrum of the room background.

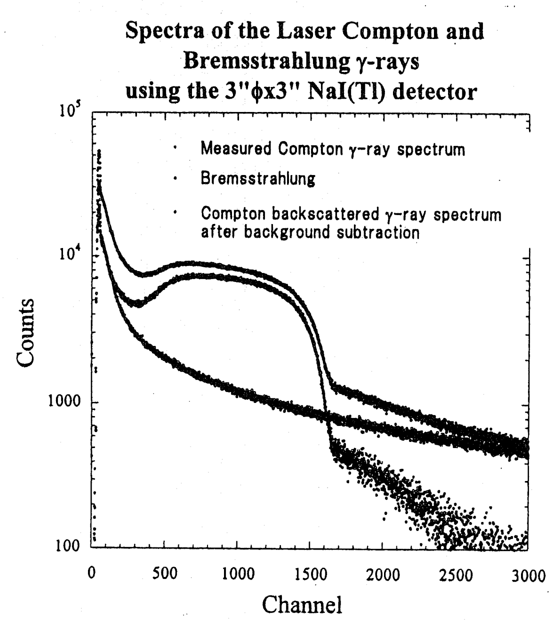

Figure 5: Energy spectra of Bremsstrahlung and Compton backscattering. Spectrum after subtraction of Bremsstrahlung spectrum is also shown.

The total yields of the backscattered photons were measured with the NaI detector. The geometry of the present system requires the gamma rays to penetrate several media between the interaction point and the detector. The produced gamma rays penetrate a silicon dioxide mirror for the injection of the laser photons and a koval window that separates the high vacuum from air pressure. The total yields of photons were estimated by taking account of the detector efficiency and the attenuation by the several media. We obtained the photons of about 3×10^4 photons/sec in the energy range of 7 MeV to 17.6 MeV. The difference between the experimental and calculated values is very small as seen in Fig. 3.

A more detailed calculation of the results was performed using the EGS4[3] code. The simulated spectrum was created by assuming an ideal energy spectrum at the collision point and by convoluting it with a simulated response function of NaI detector. The simulated and measured spectra are shown in Fig.6. The agreement of the shapes between calculation and experiment is good.

Comparison of Experimental and calculated Compton backscattered γ-ray spectra.

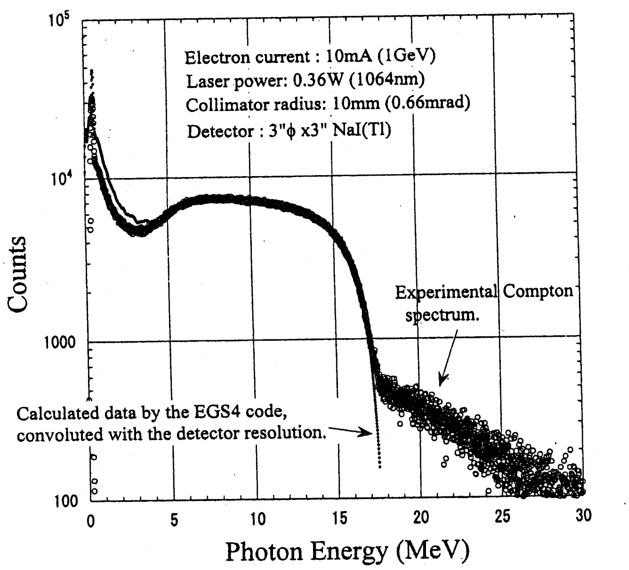

Figure 6: Comparison of the measured spectrum and the simulated gamma ray spectrum.

4 SUMMARY

In this paper, we demonstrated the Compton backscattering in NewSUBARU. The gamma ray yields were measured to be 50 photons $mA^{-1}W^{-1}sec^{-1}$. The fundamental characteristics well agree with the calculations. At present, a full program of the study is being developed. We are preparing a 4 W laser source to obtain more high flux of gamma rays and we are performing the Compton backscattering with the electron beam current of 100 mA.

5 REFERENCES

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