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Electron/Positron Test Beamline

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An electron/positron beamline for testing detectors has been constructed by utilizing a charge sweeping magnet $\mathcal{R}$TAGX, which can analyze the momentum of electrons and positrons at a fixed bending angle. The measured energy, profile, and intensity of the beam are reported together with a simulation result.

§1. Electron/Positron Beamline for Testing Detectors

A dipole electromagnet $\mathcal{R}$TAGX was installed two years ago [1] in the GeV-γ experimental hall, where meson production experiments have been conducted with an incident γ beam [2]. Besides sweeping out undesirable charged particles in the γ beam, the $\mathcal{R}$TAGX can provide momentum-analyzed electrons or positrons at a fixed bending angle. We have desired a beamline where performance tests can be made for many kinds of detectors. Thus an electron/positron beamline has been constructed in the GeV-γ experimental hall for testing detectors. The beamline consists of a converter, the $\mathcal{R}$TAGX magnet, and lead apertures as depicted in Fig.1. A Au foil, one of the converters, with a thickness of 20 μm is

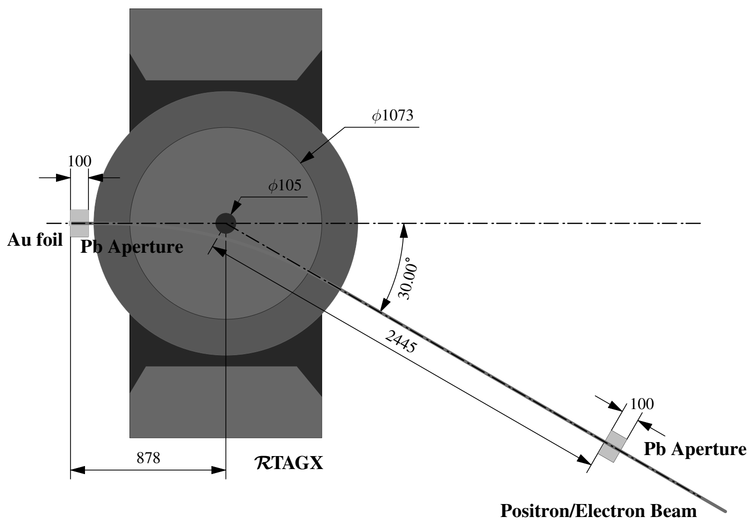

Fig.1. Schematic view of the electron/positron beamline for detector test. The beamline comprises a converter, a dipole electromagnet $\mathcal{R}$TAGX, and entrance and exit lead apertures. Electrons/positrons passing through the lead apertures are used as a beam.

placed 878 mm upstream of the pole center of the $\mathcal{R}$TAGX. There is a 100 mm thick lead aperture just behind the converter. Another 100 mm thick lead aperture with a diameter of 20 mm is placed 2445 mm downstream at -30° with respect to the axis of the incident γ beam. A vacuum chamber and a vacuum pipe were installed between two lead apertures on 23rd Apr. in 2007.

The incident γ beam coming into the GeV-γ experimental hall irradiates the converter in front of the $\mathcal{R}$TAGX. Some photons in the beam are converted into electron-positron pairs. The generated electrons and positrons are bent by the $\mathcal{R}$TAGX according to their momenta. Then semi-monochromatic electrons or positrons passing through the lead apertures are used as a beam.

§2. Estimated Energy and Resolution

The energy and resolution of the beam for a given $\mathcal{R}$TAGX current are estimated by a simulation code based on GEANT3 with a corresponding magnetic field map [1, 3]. Figure 2 shows the estimated beam energy as a function of the $\mathcal{R}$TAGX current and the energy resolution versus the beam energy.

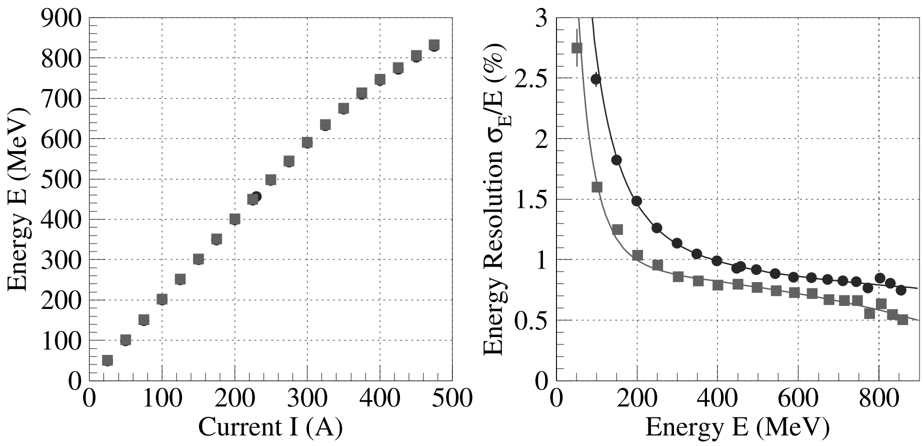

Fig.2. Estimated energy and resolution of the electron/positron beam with a simulation based on GEANT3. The left panel shows the mean energy as a function of $\mathcal{R}$TAGX current. The right panel shows the energy resolution as a function of the beam energy. The circle and square markers show the data points when the beam travels in the air and in the vacuum, respectively. Data points are fitted with the form $\sqrt{P_1E^{-2} + P_2E^{-1} + P_3 + P_4E}$.

The electron/positron beam energy is almost proportional to the $\mathcal{R}$TAGX current. The value of the energy in MeV corresponds roughly to twice of that of the current in ampere. The energy resolution as a function of the energy is described as

$$\frac{\sigma_E}{E}(E) = \sqrt{\frac{(7.49 \pm 0.26) \times 10^5}{E^2} - \frac{(125.9 \pm 13.5)}{E} + (0.977 \pm 0.028) - (3.9 \pm 0.2) \times 10^{-4}E} \quad (1)$$

when electrons or positrons travel in the air, while that is described as

$$\frac{\sigma_E}{E}(E) = \sqrt{\frac{(1.08 \pm 0.15) \times 10^5}{E^2} - \frac{(8.6 \pm 78.1)}{E} + (0.695 \pm 0.149) - (2.1 \pm 1.1) \times 10^{-4}E} \quad (2)$$

when they travel in the vacuum. The numerical data are given in Ref. [4].

§3. Measured Beam Energy and Intensity

The beam energy was measured with a lead glass Čerenkov counter. The beam profile was also measured with a beam profile monitor (BPM). The BPM consists of two layers of scintillating fiber (SciFi) hodoscopes, each of which is made up with 16 SciFi modules. The fiber measures 3×3 mm^2 in cross section. The upstream and downstream layers determine x and y positions from responded fibers, respectively.

Figure 3 shows the measured energy distributions, and the beam profile for the $\mathcal{R}$TAGX current of 230 A. The measured energy is consistent with an estimated one, although the energy spread of the beam is not detectable because of poor energy-resolution of the lead glass counter. The size of the beam spot is about 50 mm in diameter at the place about 7 m from the center of the $\mathcal{R}$TAGX.

Figure 4 shows the beam intensity as a function of the $\mathcal{R}$TAGX current.

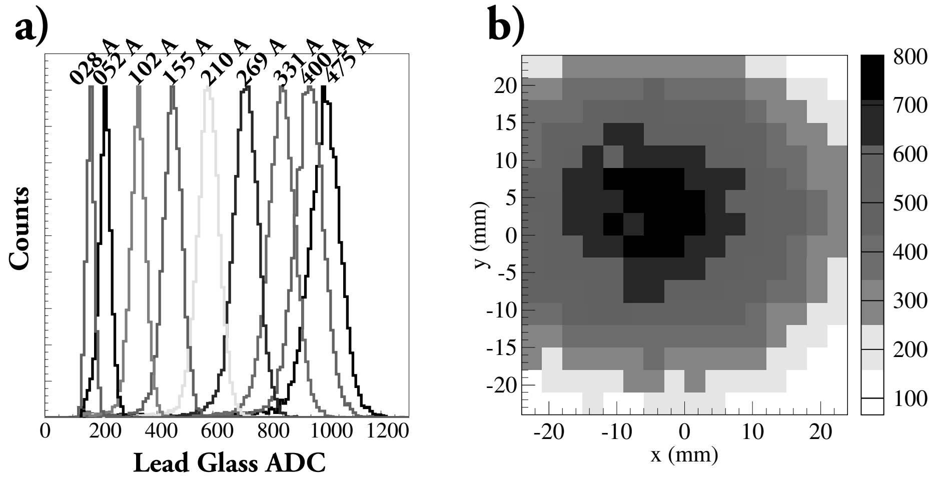

Fig.3. a) Measured beam energy distribution for several $\mathcal{R}$TAGX currents. The unit of energy is arbitrary (ADC channel). b) Measured beam profile for the $\mathcal{R}$TAGX current of 230 A. Both data were measured before the vacuum chamber had been installed.

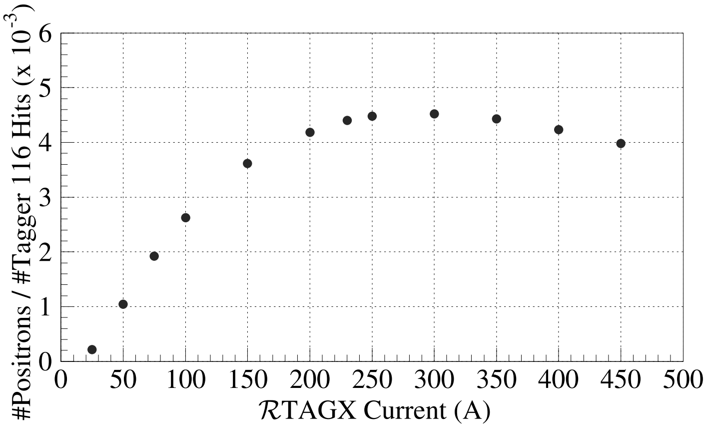

Fig.4. Intensity of the positron beam as a function of the $\mathcal{R}$TAGX current with a converter of 20 μm thick Au foil. The intensity is normalized by the counting rate of the 116th channel of the STB-Tagger II.

Since the beam intensity depends on the circulating electron current in the STretcher Booster ring, it is normalized by the counting rate of the 116th channel of the STB-Tagger II [5]. More intense beam can be obtained with a thicker converter. So far, the maximum intensity of the positron beam is about 700 kcps with an 8 mm thick Cu converter.

References

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