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</tr>
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New GeV-$\gamma$ Beam Line

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A new $\gamma$ beam line has been constructed at Laboratory of Nuclear Science, to deliver a tagged photon beam to GeV-$\gamma$ Experimental Hall built in the summer of 2002. The photon beam is produced by means of Bremsstrahlung of electrons stored in the 1.2 GeV STB ring. A thin carbon fiber of 11 $\mu$m in diameter is employed as an internal radiator which is movable toward the center of the circulating electrons. The beam line starts from the internal radiator placed 303 mm upstream of the entrance of the bending magnet BM5 in the STB ring and ends at the beam dump in GeV-$\gamma$ Experimental Hall as shown in Fig.1. The total length of the beam line is 23 m from the internal radiator to the beam dump. The energy of Bremsstrahlung photons is tagged with a new tagging system recently installed in the inner vacant space of the C-type BM5 return yoke. The geometry of the beam line is depicted in Fig.2. Two lead collimators are placed on the beam line at the distance of 4.15 m and 12.22 m, respectively, from the internal radiator. The thickness of the first collimator located in Experimental Hall 2 is 200

![Plan view of the STB ring and GeV-$\gamma$ Experimental Hall.](image-url)
mm, and that of the second one placed in GeV-$\gamma$ Experimental Hall measures 100 mm. The distance from the radiator to the target is 17.02 m.

The $\gamma$ beam produced with the internal radiator goes straight through the BM5 magnet and comes out of a 2 mm thick Al window on the end flange of the vacuum duct. Then the $\gamma$ beam runs 10.3 m in the air from the exit of the vacuum duct of BM5 to the second collimator located at the entrance of GeV-$\gamma$ Experimental Hall. Just after the second collimator, there is a charge sweeping magnet equipped with a vacuum chamber having a 50 $\mu$m thick Mylar window for the $\gamma$ beam passing through. A vacuum pipe connects the vacuum chamber of the sweeping magnet and the target chamber placed downstream. Therefore the collimated beam runs in a vacuum up to the target. This configuration has been working very well in reducing background events due to the beam itself.

The charge sweeping magnet came from the storeroom at Cyclotron and Radioisotope Center and used to be a switching magnet over there. The size of the return yoke is 1265 mm wide, 760 mm high, and 635 mm long along the beam. The gap of the pole tips has been changed from 40 mm to 60 mm to make things simple at the first stage in the construction of the new beamline. The field strength of the charge sweeping magnet under the present configuration is represented by

$$\int Bdl = 0.52 \text{ [tesla} \cdot \text{m]}, \quad (1)$$

which corresponds to the bending power

$$\Delta \theta = \frac{0.16}{p} \text{ [rad]} \quad (2)$$

for a charged particle with momentum $p$ (GeV/c).

The intensity of circulating electrons in the STB ring is going down when the internal radiator
starts operation. This happens because the circulating electrons are disturbed by the radiator moving close to the center of the electron orbit. The number of electrons lost by Bremsstrahlung coming about at the radiator is small compared to the case by other disturbance due to the radiator. Most of scattered electrons by the radiator of the thin carbon fiber fade out from the center orbit and sometimes hit the radiator frame, which then becomes another thick radiator for Bremsstrahlung at a wrong place. Therefore the frame of the radiator should be kept far away from the electron orbit as much as possible

![Diagram of a radiator frame.](image)

Fig.3. Radiator frame.

and also be made of some light material. Taking this situation into consideration, the radiator frame is designed by improving previously used one at the first tagging station [1]. The carbon fiber of the internal radiator is mounted on the new light Al frame with small tension. The size of the radiator frame is indicated in Fig. 3. The frame itself is drawn in the lower part of the figure. The upper part shows a position of the radiator where Bremsstrahlung takes place, together with the vacuum duct. The internal radiator starts moving just after the electrons are boosted up to the flat top energy, 1.2 GeV, and the moving speed is controlled so as to provide a uniform intensity of the $\gamma$ beam. This method has been developed at LNS [2].

The transmission rate of the tagged $\gamma$ beam has been measured with a lead glass counter placed at the beam dump in GeV-$\gamma$ Experimental Hall. The size of the lead glass is $150 \times 150 \times 300$ mm$^3$ corresponding to 11.8 radiation lengths along the beam direction. A 5-inch photomultiplier tube, HAMAMATSU R1250, is employed to detect Cherenkov lights due to the electromagnetic showers originated by an incident photon on the lead glass. The beam intensity is reduced in this measurement so that the counting rate of the lead glass counter becomes about 60 kHz with $V_{\text{th}} = -30$ mV. The transmission rate $T$ is defined as
\[ T = \frac{N_L \otimes N_L}{N_T} \]  

where \( N_L \) and \( N_T \) are the number of photons detected with the lead glass at the beam dump and that of
tagged photons, respectively. The background events without the radiator are measured independently
and are taken into account for \( N_L \) and \( N_T \). Intensive work has been made by the accelerator group of
LNS to get a beam of good quality and a higher transmission rate [3]. The overall average value of 80 %
is obtained for the transmission rate without any collimators, after the function of the STB accelerator
has been improved for this purpose. The new GeV-\( \gamma \) beam line is now ready for experiments.

References

Linear Accelerator Meeting in Japan", August 4-6, 2004, Funabashi, Japan, p206-208.