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LOW-ENERGY PHOTON TRANSPORT ALONG THE TRISTAN ACCESS TUNNEL

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Abstract

TRISTAN, the high-energy electron positron storage ring in KEK, was constructed underground. Access tunnels to the ring are about 60 m long to prevent intense synchrotron radiation from spreading to the earth surface. In this work, low-energy photons were measured using thermoluminescent dosimeters and ionization chambers in the access tunnel. Photon transport calculations ware performed using electromagnetic cascade Monte Carlo code and single-scatter code.

INTRODUCTION

There are many studies about photon transport in ducts and mazes but usually they are less than 10 m long. In this case, the access tunnel is too long to extrapolate some published results. Moreover there are few studies about low energy photons transport, mainly below 200 keV.

Energy of electrons stored in TRISTAN was between 24.5 and 26 GeV. Very intense synchrotron radiations were emitted from bending magnets and scattered into access tunnel. Measurements were done at the access tunnel (12-C), which is rectangular 2nd-legged and 60 m long.

Absorbed dose of air was measured using thermoluminescent dosimeters in the 1st leg and ionization chambers in the 2nd leg. Photon energy spectrum at the end of the 2nd leg was measured using HP-Ge detector.

Open area of C-type bending magnets was shielded by 1-cm-thick Pb. Leakage photon fluxes from them were calculated using electromagnetic cascade Monte Carlo code EGS4[1]. Next photon flux distribution in the access tunnel was calculated by single-scatter kernel integration code G33-GP[2].

MEASUREMENT

The access tunnel (12-C) is placed inside the storage ring and is made of concrete. Plane view of its 1st leg is shown in Fig.1. Bending magnets (B19, B20 etc. in Fig.1) are lined in the storage ring and they are seen from the end of the 1st leg. The cross sectional area of the leg is 3 m wide and 4 m high. The electron beam level is 1.2 m high from the floor. Measurement was done at 24.5 GeV operation of TRISTAN. Thermoluminescent dosimeters were placed in the leg. They are made of BeO (Matsusita UD-170L).

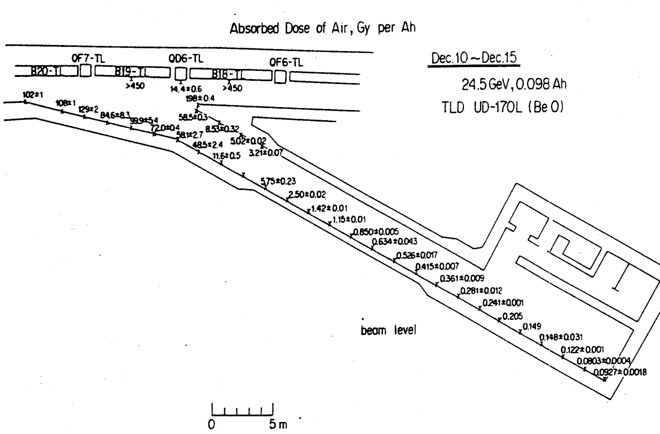

Fig. 1 Plane View of TRISTAN Access Tunnel 12-C.

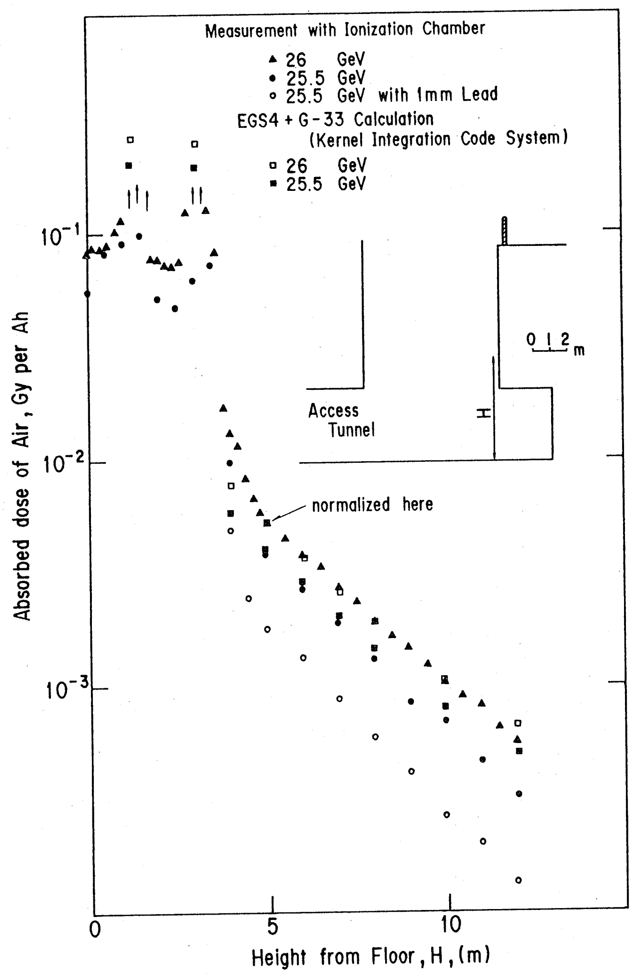

Fig. 2 Side View of the Vertical 2nd Leg of 12-C and Absorbed Dose of Air.

The 2nd leg of 12-C turns upward rectangularly to the earth's surface. Its side view is shown in Fig.2.

The central axis of the 2nd leg is 40 m distant from bending magnets. The cross sectional area is 7.4x4.6 m^2. Measurements were done at 25.5 and 26 GeV operations. Absorbed dose of air was measured using ionization chambers (Applied Engineering AE-133) along the backward side wall as shown in Fig.2.

Photon energy spectrum on the earth's surface, 12 m different from the floor, was measured using HP-Ge detector (ORTEC GAMMA-X). the detector head was turned down to see the floor.

CALCULATION

Synchrotron radiation hits the inside wall of vacuum chambers made of aluminum. Some portion of photons are scattered backward and penetrate through vacuum chambers and 1-cm-thick Pb shields. Photon energy spectra outside Pb were calculated using EGS4[1]. They were used as the source of the next step.

To calculate photon fluxes in the access tunnel, leakage radiation from Pb was assumed as a point isotropic source and placed in the tunnel. Single-scatter calculations were done using G33-GP[2], which also includes a correction for multiple-scattering by applying a buildup factor for the pass between side walls and detector points.

RESULTS AND DISCUSSIONS

Measured values of absorbed dose of air in the 2nd leg are shown in Fig.2. On the earth's surface, 12 m high from the floor, dose becomes less than 1 percent that at the entrance of the 2nd leg. When the ionization chamber was covered with 1-mm-thick Pb, dose becomes less than half.

It is difficult to determine the absolute photon intensity of the source. So calculated results were normalized to measured ones at the point 5-m-high from the floor in case of 26 GeV operation and absolute source intensity was determined. For 25.5 GeV operation, the same normalization factor was used. Results are shown in Fig.2. Agreement between Measured and calculated results are good.

Both measured and calculated results of absorbed dose of air in the 1st leg are shown in Fig.3. The same normalization factor, mentioned above, was used. Near the entrance of the leg, calculated results are too small because many bending magnets can be seen there as shown in Fig.1. At the end of the leg, both results are in agreement within 60%.

Measured photon energy spectrum on the earth's surface at the end of the 2nd leg is shown in Fig.4. There is a broad peak at 70-100 keV.

CONCLUSION

On the earth's surface, absorbed dose is less than 1 percent of that at the tunnel floor. When energy of electron increased from 25.5 to 26 GeV, dose became 60-90 % higher.

Calculations were done using Monte Carlo code and sigle-scatter code. They represent well the attenuation of dose in the tunnel and dependence on electron energy. Single-scatter calculation is useful for such a long tunnel. But it is difficult to know the absolute value of dose because calculated leakage photons from magnets using Monte Carlo code must be converted to a point isotropic source.

REFERENCES

1) W.R.Nelson, H.Hirayama and D.W.O.Rogers, The EGS4 Code System, SLAC-265 (1985)
2) RSIC, G33-GP, Oak Ridge National Laboratory, CCC-494 (1986)

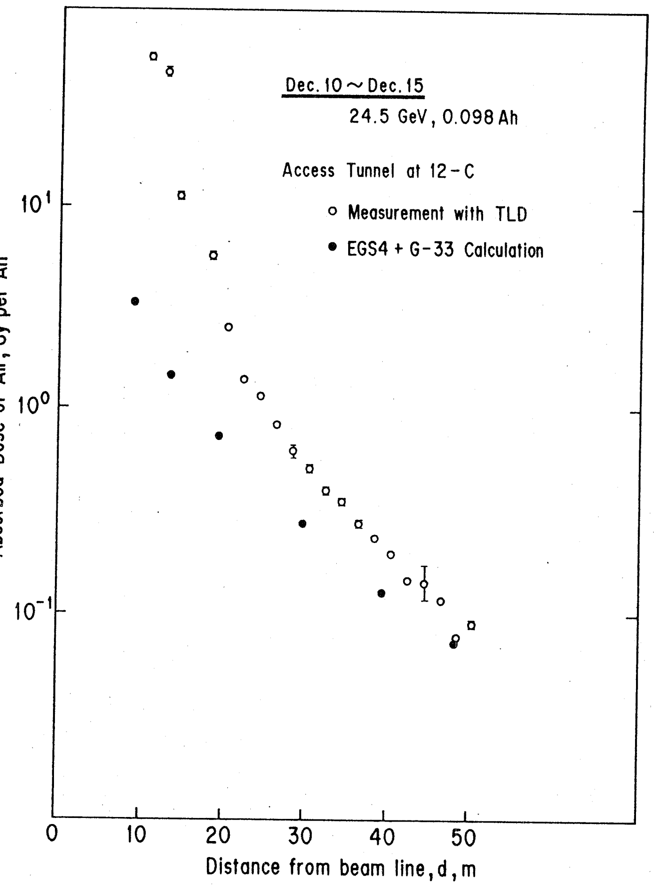

Fig. 3 Absorbed Dose of Air in the 1st Leg. Calculated results were normalized as the same as in Fig.2

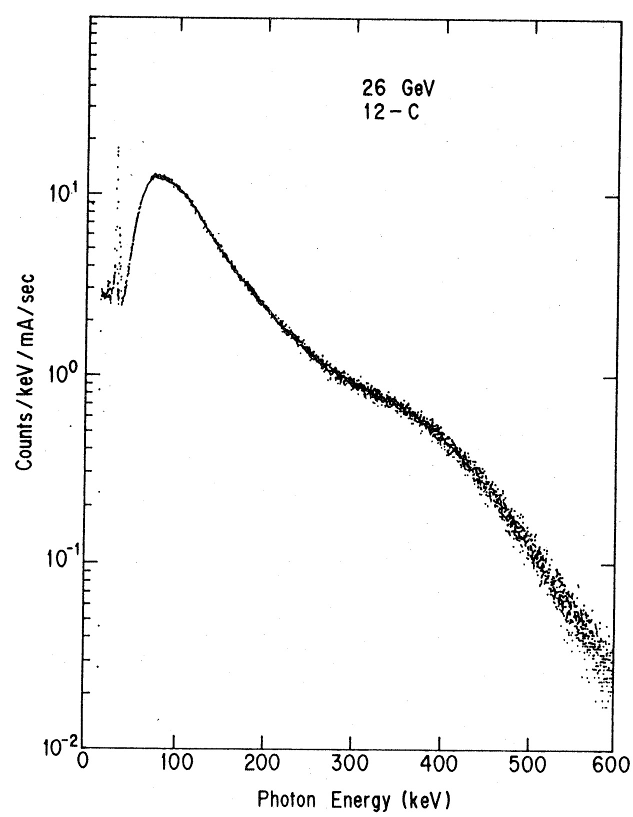

Fig. 4 Photon Energy Spectrum on the Earth's Surface Measured using HP-Ge Detector.