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Radiation damage test of MPPC by a 290 MeV/u C beam at HIMAC

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We present the damage of MPPC by a 290MeV/u C^{6+} ion beam generated by the HIMAC accelerator. We used two types of MPPC, S10362-11-050C(400pixel) and S10362-11-100C(100pixel) manufactured by HAMAMATSU Photonics K.K. We irradiated MPPCs with C^{6+} beam ,which intensity was changed from 10 to 10^7 (particle/mm^2/s). We measured output charge from the MPPCs at each dose using stationary Xe light source.
Finally 1.2×10^{10} particles are irradiated to MPPCs, which correspond to 16kGy. We observed the output charge decreased by half after 1Gy irradiation corresponding to 7.5×10^5 C^{6+} exposure. Leak current was measured 70 days after the irradiation. In this measurement, leak current was about 10 times higher than that of same type of MPPC without irradiation.

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1. Introduction

Recently, a Multi Pixel Photo Counter(MPPC) has been developed for many application elsewhere. However it's radiation tolerance has not been well studied. Especially the damage by high-intensity ion beam such as C^{6+} beam have never studied. This time, we used carbon 6+ ion beam from the HIMAC(Heavy Ion Medical Accelerator in Chiba) accelerator to study the radiation damage of MPPC by a heavy ion beam. The energy of this ion beam is 290MeV/nucleon.

Two types of MPPC made by Hamamatsu Photonics K.K., S10362-11-050C (50C) having 400 pixels, and S10362-11-100C (100C) having 100 pixels, were irradiated. We irradiated two samples for each type(50C_1, 50C_2, 100C_1, 100C_2) at the same time.

2. Method and Result

Fig. 1 is a schematic view of this experiment. Four MPPCs placed along the beam line were exposed at the same time. The beam intensity was changed from 10 to 10^7 (particle/mm^2/s),corresponding to 0.05Gy/h - 50kGy/h for dose rate at MPPCs. Irradiation was done at low beam intensity, and later at gradually higher intensity. Finally 1.2×10^{10} particles(corresponding to 16kGy) were exposed to MPPCs.

Beam intensity was monitored by an ion chamber calibrated by scintillator and scintillation fibers at low intensity. The output charge from MPPCs was read by a read out circuit shown as Fig. 2 then was recorded by ADC(CAMAC 2249W) at each dose by flashing Xe lamp with several tens of photons through optical fibers. Temperature in the black box which MPPCs were located was kept 25.1 ± 0.2 degrees Celsius during the exposure.

The result is shown in the Fig. 3. In this figure, we can see the output charge from MPPCs decreased as amount of beam exposure increased. In all samples, counts of ADC decreased by half after 1Gy irradiation, which corresponds to exposure of 7.5×10^6 C^{6+} ions . After 100 Gy irradiataion, signals from all 4 samples were not detected anymore.

We checked these 4 samples 70 days after the 16kGy irradiation again. Still no signal was observed from all the samples. The I-V curves were also measured at the same time as shown in the Fig. 4. At this measurement, temperature was kept 21.1 ± 0.2 degrees Celsius. We found leak current of irradiated MPPCs are about 10 times bigger than those of not irradiated at the same voltage. This result indicates that break down voltage is shifted lower by the C^{6+} irradiation (shown as table 1) and MPPCs are seriously damaged by irradiation of heavy ion beam comparing with the result of gamma ray irradiation[1].

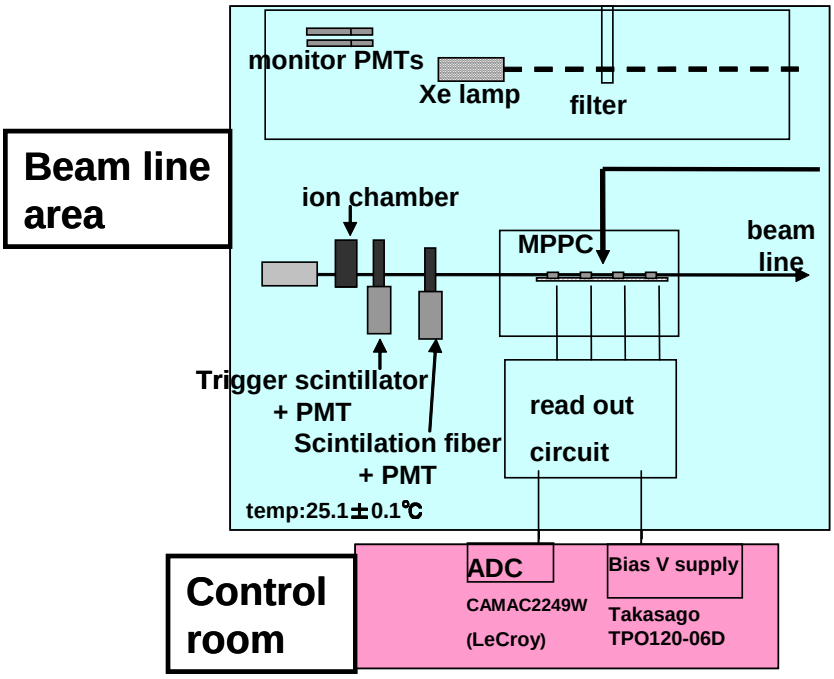

Figure 1: Schematic view of this experiment. Blue region shows the beam line area. Pink region shows the control room.

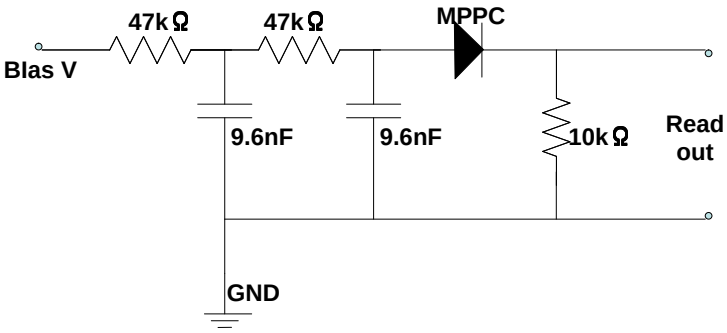

Figure 2: Diagram of the read out circuit.

	before irradiation		70 days after 16kGy irradiation
	V break(V)	operated(V)	V break(V)
50C_1	70.59	72.00	69.5
50C_2	69.55	72.00	68.3
100C_1	69.59	70.00	68.5
100C_2	69.48	70.00	68.3
50C not irradiated	69.90	-	-
100C not irradiated	69.57	-	-

Table 1: Summary of break down voltage and operated voltage during the exposure for 4 samples(before irradiation and after)

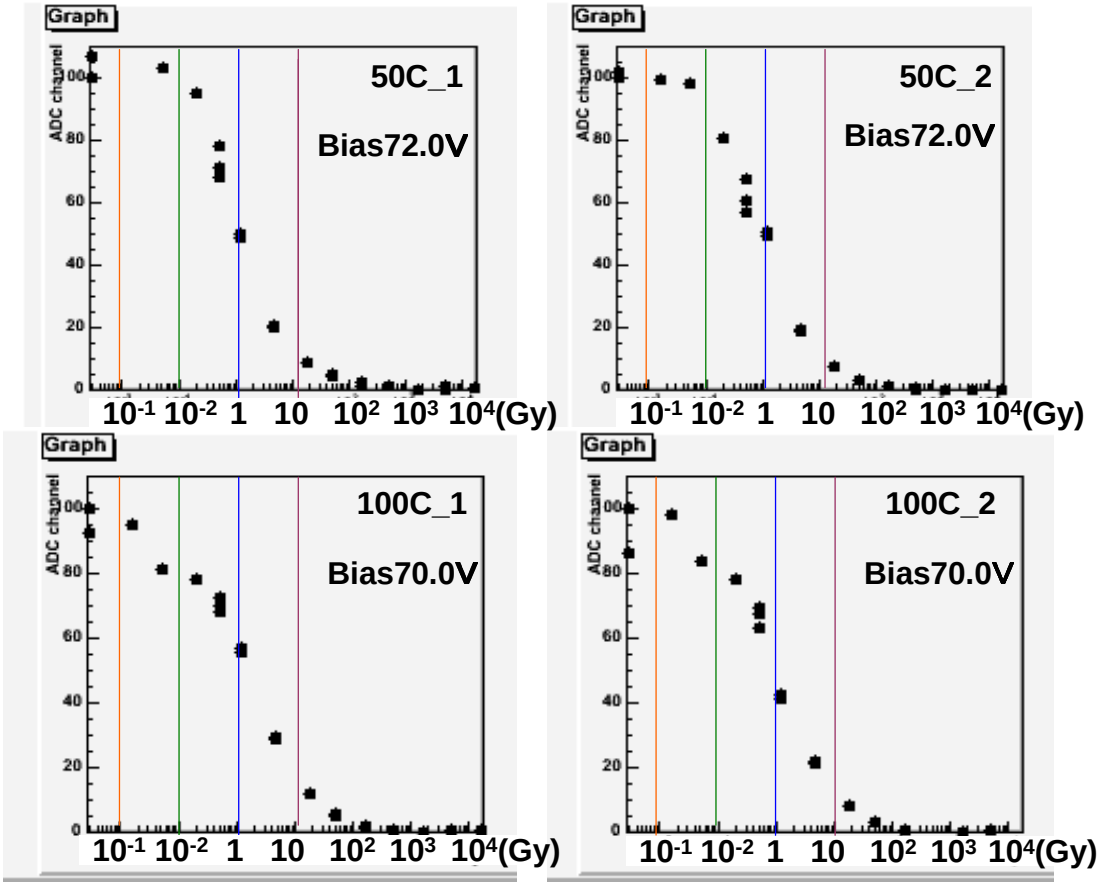

Figure 3: Radiation damage of 4 MPPC samples. Upper 2 figures show the damage for 2 samples of S10362-11-050C(50C_1, 50C_2). Lower 2 figures show the damage for 2samples of S10362-11-100C(100C_1, 100C_2).

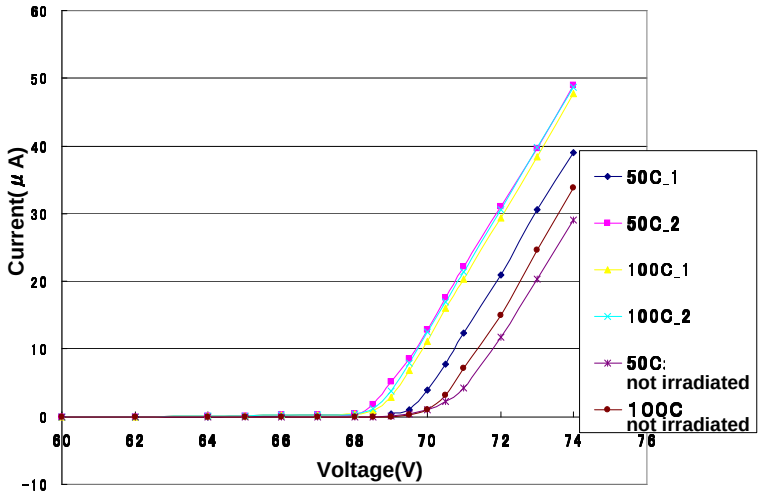

Figure 4: I-V curve for leak current measurement. Comparing irradiated samples and not irradiated samples.

3. Summary

We checked radiation damage of 4MPPCs of two different types(S10362-11-050C,S10362-11-100C) irradiated by 290MeV/u C^{6+} beam at HIMAC, up to 16kGy(1.2×10^{10} C^{6+} ions).

We found output charge from all the MPPCs illuminated by a Xe lamp, decreased by a half after 1Gy irradiation (7.5×10^{6} C^{6+} ions). After 100Gy irradiation (7.5×10^{8} C^{6+} ions), no signal was observed from all samples. Leak current measured 70 days after 16kGy irradiation became about 10 times higher at the same bias voltage or break down voltage shifted lower. For the further study, we are planning to irradiate Carbon beam again with measuring one photon distribution, noise rate and so on, and going to understand what kind of effect damage to MPPCs.

References

[1] T.Matsubara, *Radiation damage of MPPC by gamma-ray irradiation with Co 60*, in proceedings of *International Workshop on new Photon-Detectors*, PoS(PD07)032.