Fluences and Leakage Currents from the Irradiation in the LBL 88"" Cyclotron during Dec 18-24 1994

T. Dubbs, S. Kashigin, Hartmut F.-W. Sadrozinski
Santa Cruz Institute for Particle Physics (SCIPP)
University of California at Santa Cruz
Santa Cruz, CA 95064

During the December 1994 irradiation run, we exposed a silicon microstrip detector to 50MeV protons. Fig. 1 shows the relative position of the detector and rings of an ion chamber set-up used to determine the fluence and profile of the beam. Also depicted is the location and relative fluence for three photo diodes.

In Table 1, we present the total number of counts in each ring of the ion chamber after exposure to a nominal fluence of 10^{13} protons/cm^2 , the last of three equal steps.

Table 1. Ion chamber ring counts after a nominal fluence of 10^{13}/cm^2:

Ring 1	2 overflows + 16627583 =	5.02 10^7
Ring 2	8 overflows + 13470939 =	1.48 10^8
Ring 3	15 overflows + 8444399 =	2.60 10^8
Ring 4*	5 overflows +13678517 =	9.76 10^7
Ring 5*	1 overflow + 8336882 =	2.51 10^7

(overflow = 2^{24} = 1.68 10^7)

Care had to be taken of the overflows. The three exposures were equal to 10^{13} protons/cm^2 each within 2%.

Each ring has a different area as shown in Table 2 and we can calculate the number of counts per area, C, and thus the relative fluence in each ring F_r, taking the innermost ring 1 as 100%. The beam profile agrees quite well with numbers derived by others during the run.

Table 2. Ion Chamber counts/cm^2 C and relative fluence F_r after a nominal fluence of 10^{13}/cm^2:

	Radius (cm)	Area (cm^2)	C [cm^{-2}]	F_r
ring 1	0.5	0.78	6.44 10^7	100%
ring 2	1.0	2.36	6.27 10^7	97%
ring 3	2.0	9.42	2.76 10^7	42%
ring 4*	3.0	~14.0	7.0 10^6	11%
ring 5*	4.0	~13.0	1.9 10^6	3%

* Rings 4 and 5 extend outside the beam apperature as depicted by the dotted line in the figure. I have assumed 90% active area for ring 4, and 60% for 5.

In order to calculate the leakage current in the detector, we determine the expected current i(n) in the detector area covered by ion chamber ring n. Using the well known formula for the leakage current i as function of fluence F:

$$i = \alpha * Vol * F,$$

we get for the current i(n) covered by ring n if the fluence in the center was $3*10^{13}$:

$$i(n) = \alpha * Vol * 3 * 10^{13} * A_r(n) * F_r(n),$$

with Vol equaling the total detector volume of $0.61 cm^3$ and using the relative fluences $F_r(n)$ and fractions of detector areas $A_r(n)$ from Table 3. Where $A_r(n)$ is obtained from the relative fraction of the ring, R_f, which intersects the detector. The leakage current constant α is taken as $\alpha = 8.0*10^{-17}$A/cm. This is a factor 4 larger than the constant usually used: a factor 2 takes into account the increased NEL of 50 MeV protons when compared to high energy protons, another factor of 2 accounts for the insufficient annealing of the damage shortly after exposure. In Table 3 we show the expected leakage current increase for each of the four areas of the detectors covered by a different ion chamber ring.

Table 3. Expected leakage current i(n) in the KEK detector area covered by ion chamber ring n after $F=3*10^{13} cm^{-2}$

Ring	Rel. Fluence	Ring Frac.	Detector Area	Expected Current
n	F_r	R_f	A_r	i(n)[µA]
1	100%	100%	4%	58
2	97%	90%	10%	142
3	42%	60%	28%	173
4	11%	45%	35%	56
5	3 %	15%	16 %	7
Total			93%	436

The total predicted current for the detector is 436µA, to which we add the pre-rad current of 80µA to give 518µA. Shortly after exposure, we measured a leakage current of 610µA. Figure 1b shows measurements of the leakage current for a sample of individual strips across the detector face. The centers of the concentric rings have been adjusted to be consistent with the observed current measurements. The relative fluxes as measured by the photo diodes shown in figure 1a are also consistent with this description of the beam profile. We conclude that we can account for most of the observed currents and have a reasonable model for the distribution of fluences over the detector

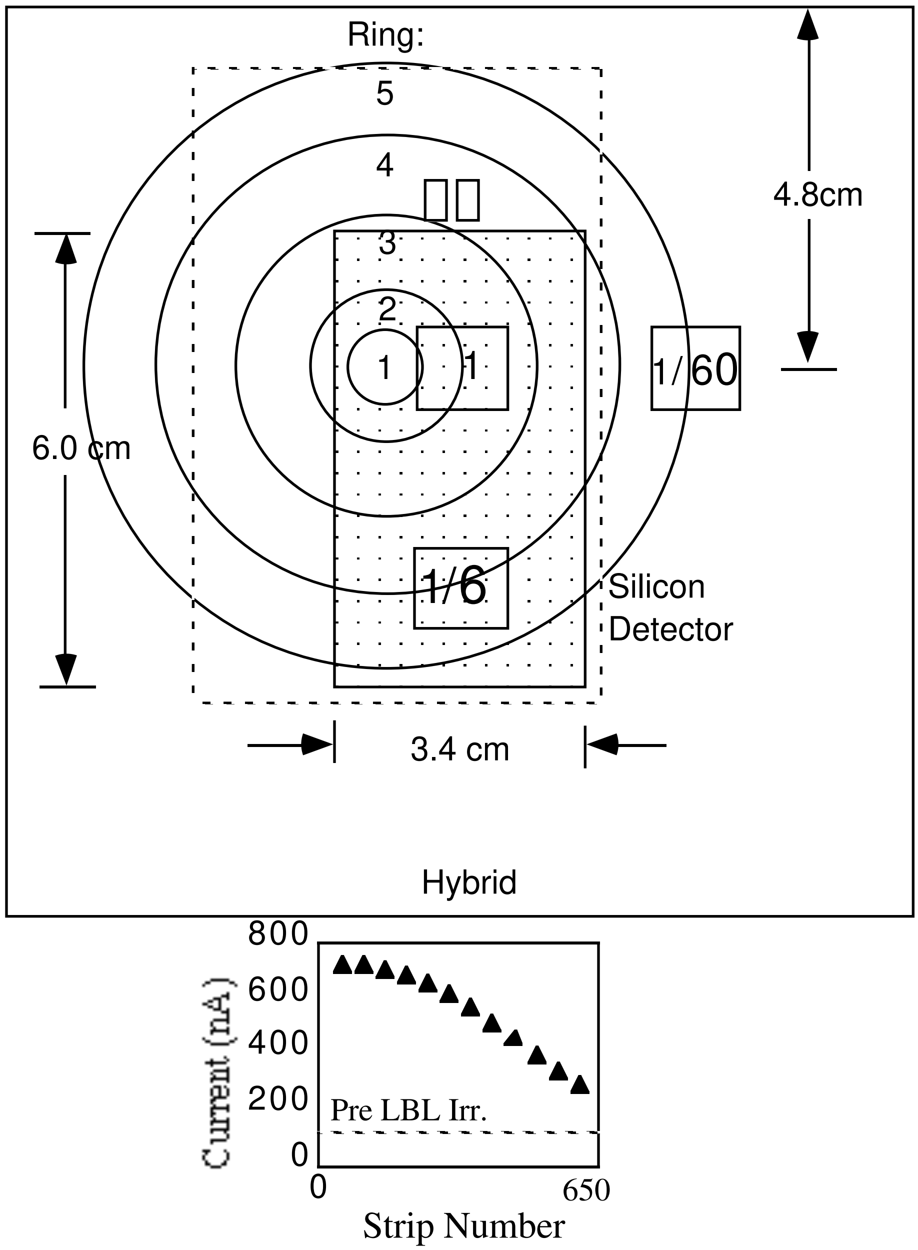

Fig.1 Approximate configuration of the KEK detector, ion chamber rings and photo diodes. Shown below is a measurement of the leakage current across the detector.