100MeV Proton Irradiation

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Introduction:

Review

➢Status quo

- LGAD sensor has good time resolution without irradiation
- Irradiation can degrade the performance of the sensor

➢Irradiation particle:

- π,proton,neutron,e

➢Motivation:

- Research the effect of different irradiation fluences
- Contrast proton irradiation and neutron irradiation

Three Problems:

Review

- Uniform:
  - Beam uniformity: about 1%
  - Position uniformity is accordance with Gaussian distribution, but it is difficult to determine the specific fluences
- Irradiation attenuation (through 5 layers)
  - The proton energy and quantity of each layer may be different
  - We are doing simulation calculations
- Low Temperature:
  - Now: Compressed air blowing can't lower the temperature to below 0℃
  - Plan: Replace compressed air with liquid nitrogen

Irradiation Fluence:

Fluence (Neq)	Conversion factor (100 MeV)	Proton	Beam Current (nA)	Beam intensity (1E11 p/cm^2 s)	Time (s)	Time(m)	Time(h)	Core Sensor (NDL)	Core (HPK)	Core (CNM)	NDL	HPK
7.00E+14	1.276	5.49E+14	100	1.00E+11	5.49E+03	91.43	1.52E+00	BV170(5)	W8-SE5	W3_G09	9#(3), BV60(2)	W17(SE3)
1.00E+15	1.276	7.84E+14	100	1.00E+11	7.84E+03	130.62	2.18E+00	10#(2), BV170(5)	W8(SE3,SE5) W18(SE3, SE5)	W3_B17	9#(3), BV60(2)	W17(SE5)
2.00E+15	1.276	1.57E+15	100	1.00E+11	1.57E+04	261.23	4.35E+00	BV170(5)	W18(SE5), W8(SE5)	W3_E06	9#(3), BV60(2)	W17(SE5)
3.00E+15	1.276	2.35E+15	100	1.00E+11	2.35E+04	391.85	6.53E+00	10#(2), BV170(5)	W8(SE3,SE5) W18(SE3, SE5)	W3_J02	9#(2), BV60(2)	W17(SE5)
4.50E+15	1.276	3.53E+15	100	1.00E+11	3.53E+04	587.77	9.80E+00	10#(2), BV170(5)	W8 SE2, W18 SE2		9#(3), BV60(2)	W17(SE5)

Fluence(Neq)->proton fluence: $100\ MeV\ proton\ dose = \frac{1\ MeV\ neutron\ dose}{100\ MeV\ proton\ radiation\ hardness}$

Fluence calculation:

100MeV radiation hardness factor 1.276, 100nA 100MeV proton, Beam area 2.5cm*2.5cm

$$beam\ current = 100\ nA = 10^{-7}\ C/s = \frac{10^{-7}\ C/s}{1.602 \times 10^{-19}\ C/proton} = 6.242 \times 10^{11}\ proton/s$$

$$fluence = \frac{beam\ current}{area} = \frac{6.242 \times 10^{11}\ proton/s}{2.5 \times 2.5\ cm^{-2}} = 0.9987 \times 10^{11} proton \cdot cm^{-2} \cdot s^{-1}$$

$$\cong 10^{11} proton \cdot cm^{-2} \cdot s^{-1}$$

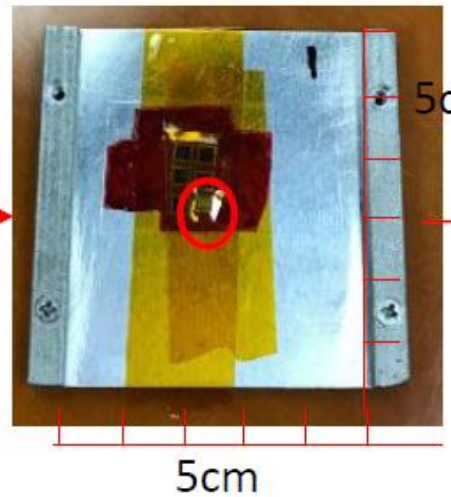
$$total\ beam\ time = \frac{maximum\ proton\ dose}{fluence} = \frac{3.53 \times 10^{15}\ proton/cm^{-2}}{10^{11} proton \cdot cm^{-2} \cdot s^{-1}} = 35266.5s$$

$$= 587.87min = 9\ hour\ 48\ minute$$

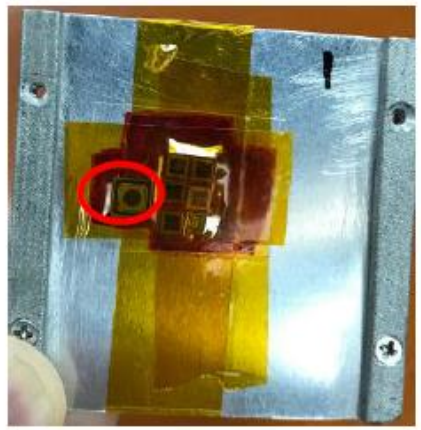
- Next, we may use the irradiated aluminum sheet for irradiation fluence calibration --detail in backup

Fixed sensor process (7E14): W8-SE5

BV170: 5

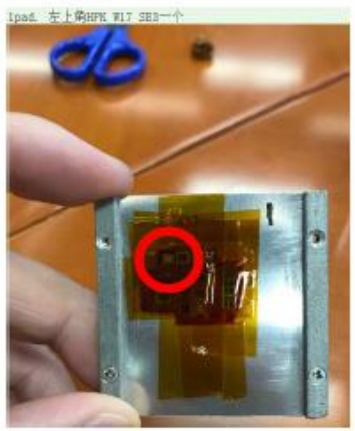


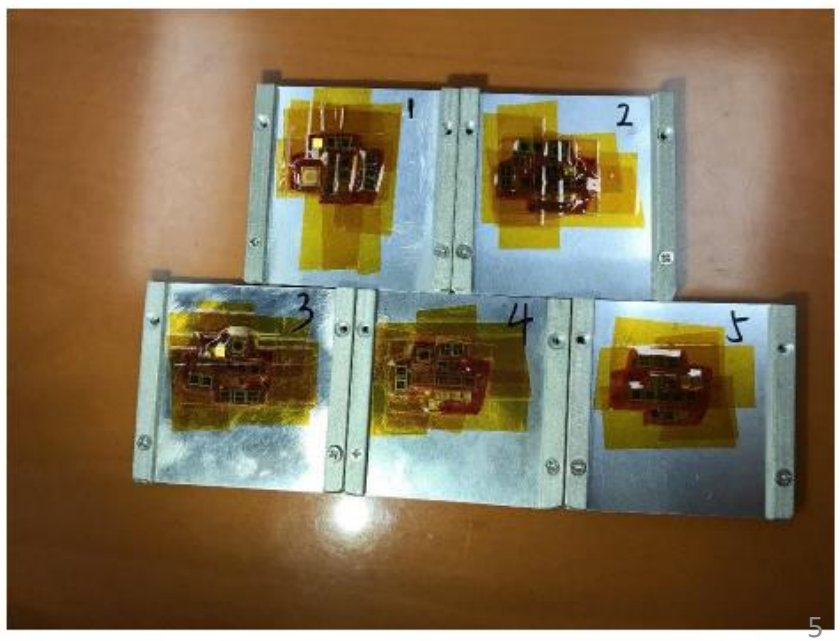
CNM RUN 11486 W3-GO9



1pad NDL 9#right:3 . BV60 up: 2

W17-SE3





The details of selecting sensor:

NDL sensors

NDL \ Fluence	7E14	1E15	2E15	3E15	4.5E15
10#	0	2	0	2	2
9#	3	3	3	2	3
5#	0	0	0	0	0
BV170	5	5	5	5	5
BV60	2	2	2	2	2
Total	10	12	10	11	12

HPK sensors

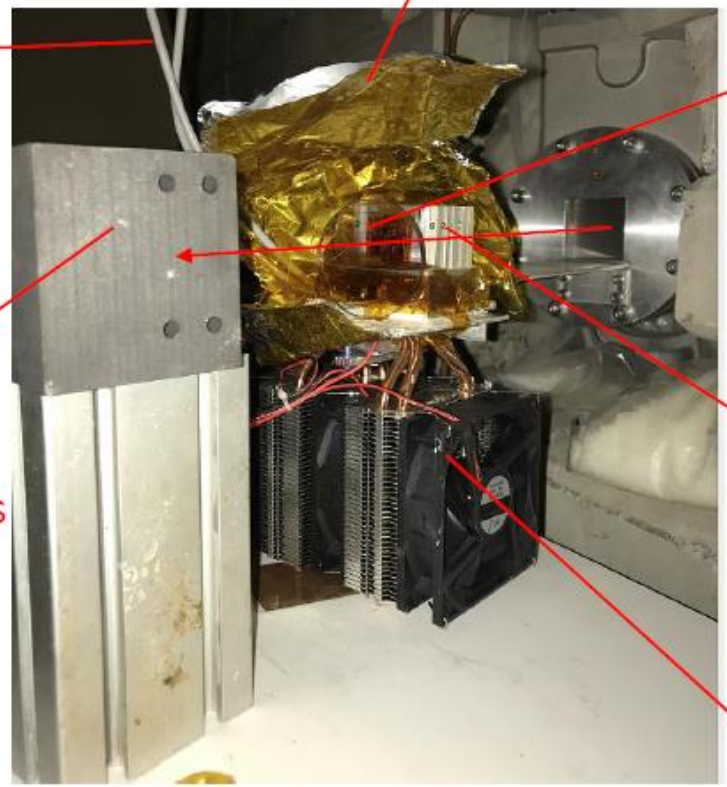
HPK \ Fluence	7E14	1E15	2E15	3E15	4.5E15
W8	SE5	SE3,SE5	SE5	SE3,SE5	SE2
W17	SE3	SE5	SE5	SE5	SE5
W18		SE3,SE5	SE5	SE3,SE5	SE2

Experiment device:

Al foil: keep the temperature

Test beam status:
exist or not

Thermocouple:
temperature measurement



Beam direction

Graphite:absorbing protons

Sensor

Refrigeration device: keep the sensor
below 0C

Temperature test: the surface is frost, and the temperature up to 2C throughout the test

The details of proton irradiation:

- Temperature: most of time below 0C, maximum 2C->prevent annealing
- Beam current: 100nA error:1%-2%
- Experimental time: about 21 hours
- After irradiation, there is still a high radioactivity on the sample
- After 6 days, the radioactivity of total only 0.5μsv/h
- We have taken sensors back , and start adjusting the temperature system.
  We may measure some sensors this week, if the temperature can reach -30C.

Next Plan

- Cryogenic system update –reach -30C
  - Now, we only borrow a big liquid nitrogen tank to measure firstly.
- Measure 1e15 HPK sensor for calibration
- Measure NDL sensor: I-V,C-V, collection charge, time resolution and so on