



Radiation Hardness of Sensor Materials for BeamCal

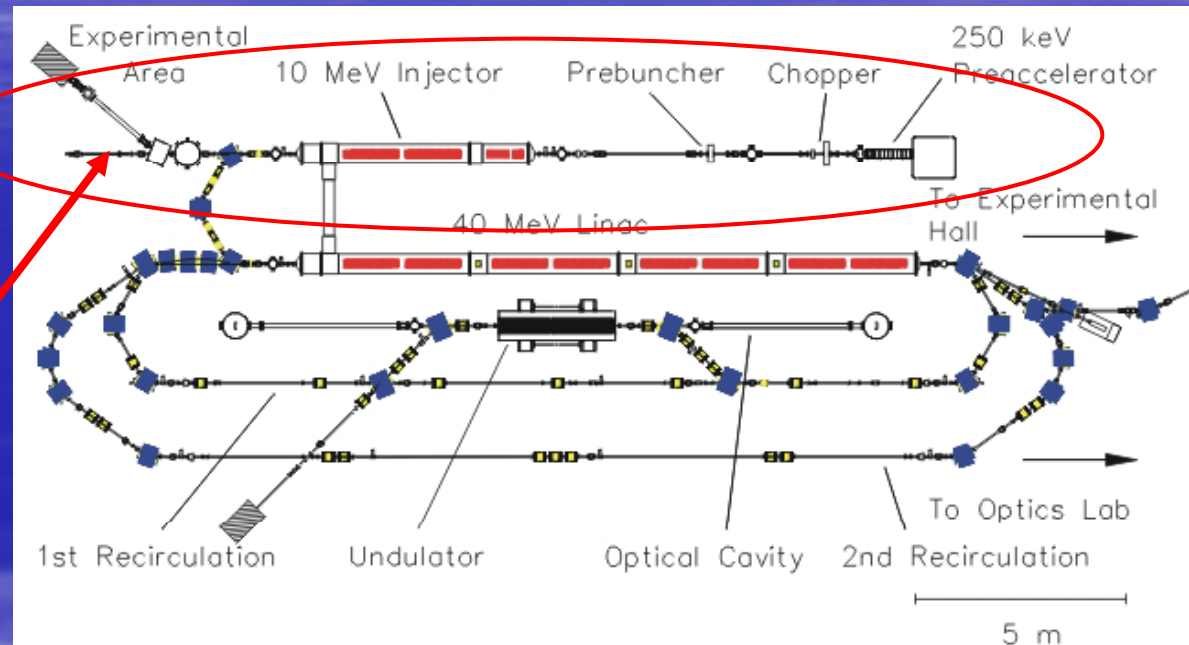
Alexandr Ignatenko

Hamburg-Zeuthen Meeting, Hamburg
October 2, 2007

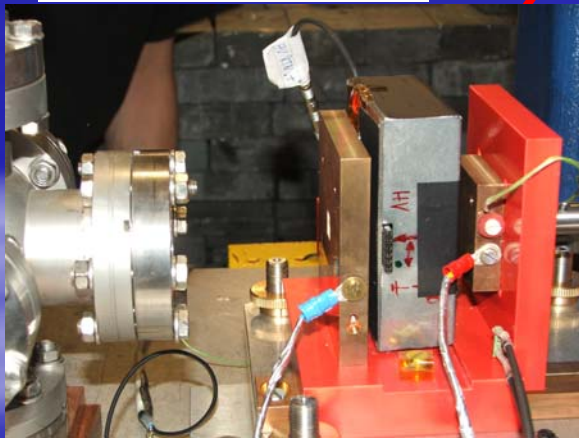
Overview

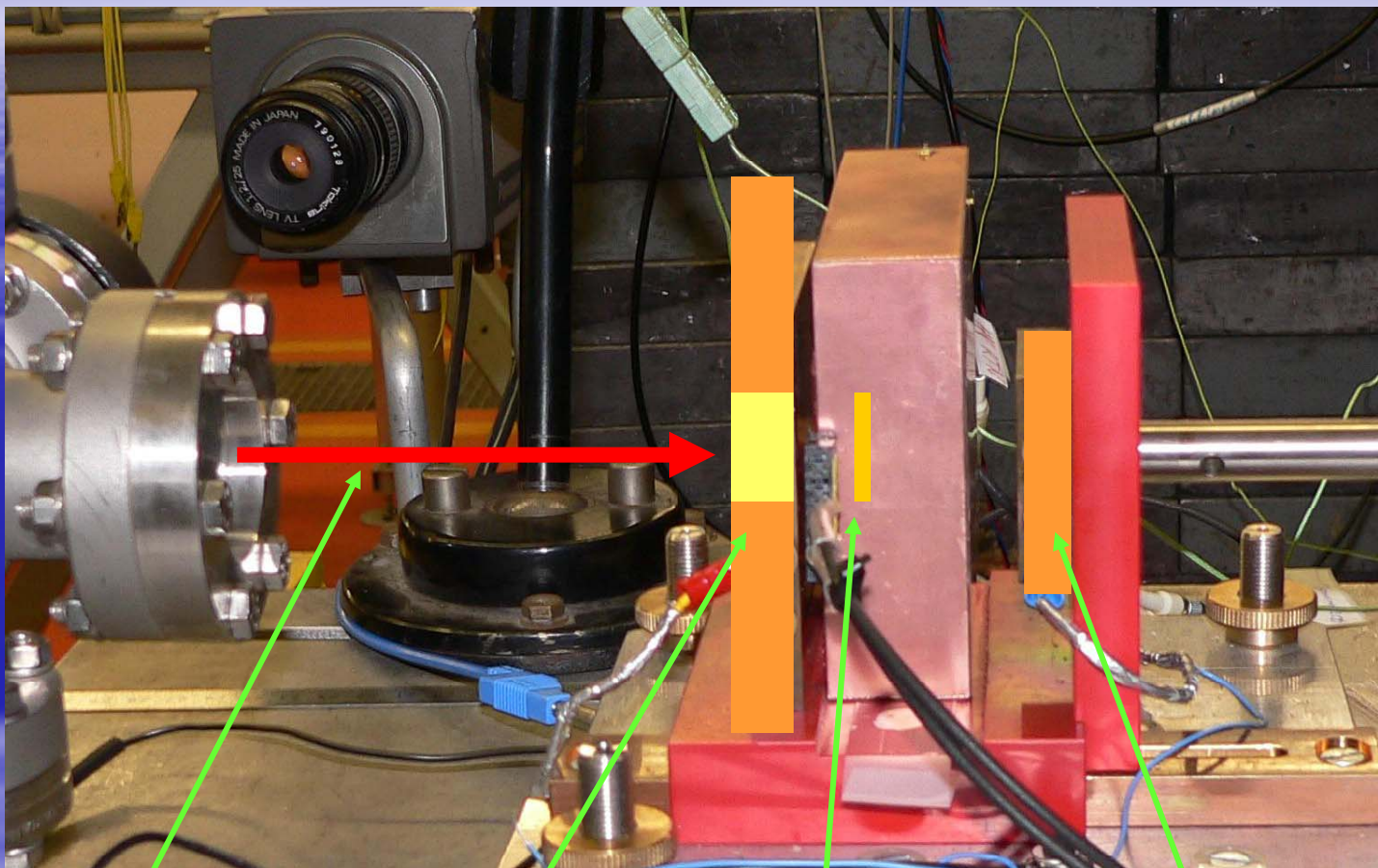
- Testbeam
- CVD diamond samples
 - ✦ pCVD diamonds investigation
 - Results from testbeam'06
 - Results from testbeam'07
 - ✦ scCVD diamond investigation
- GaAs
- Radiation hard silicon
- Summary

Testbeam



Testbeam Setup





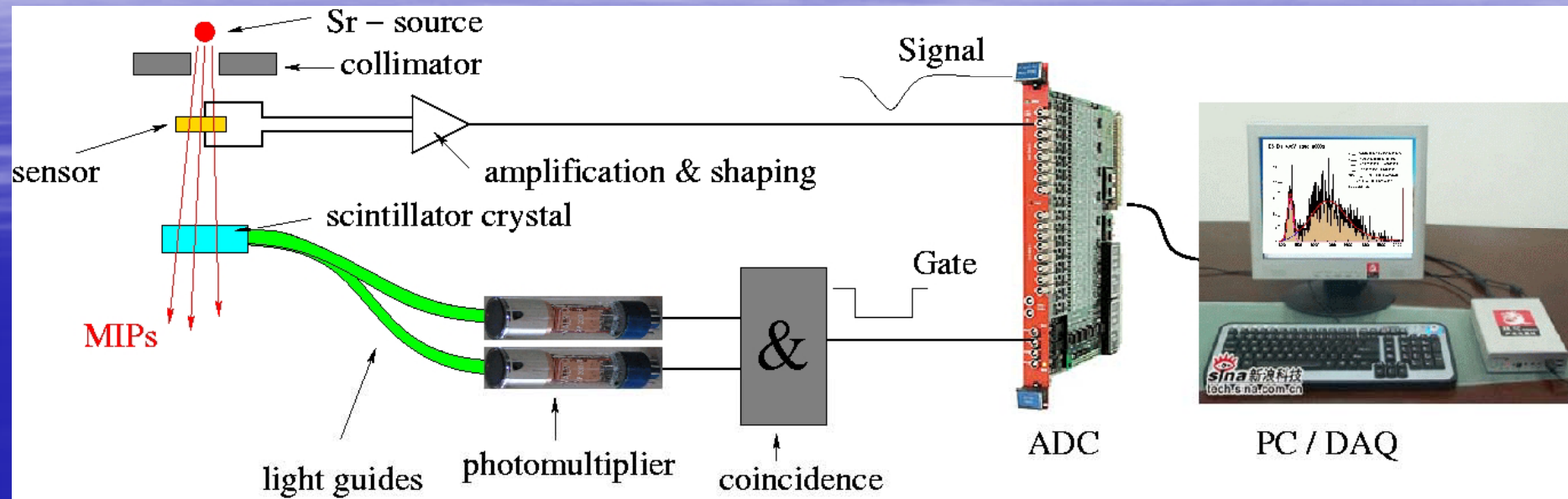
Beam

Collimator

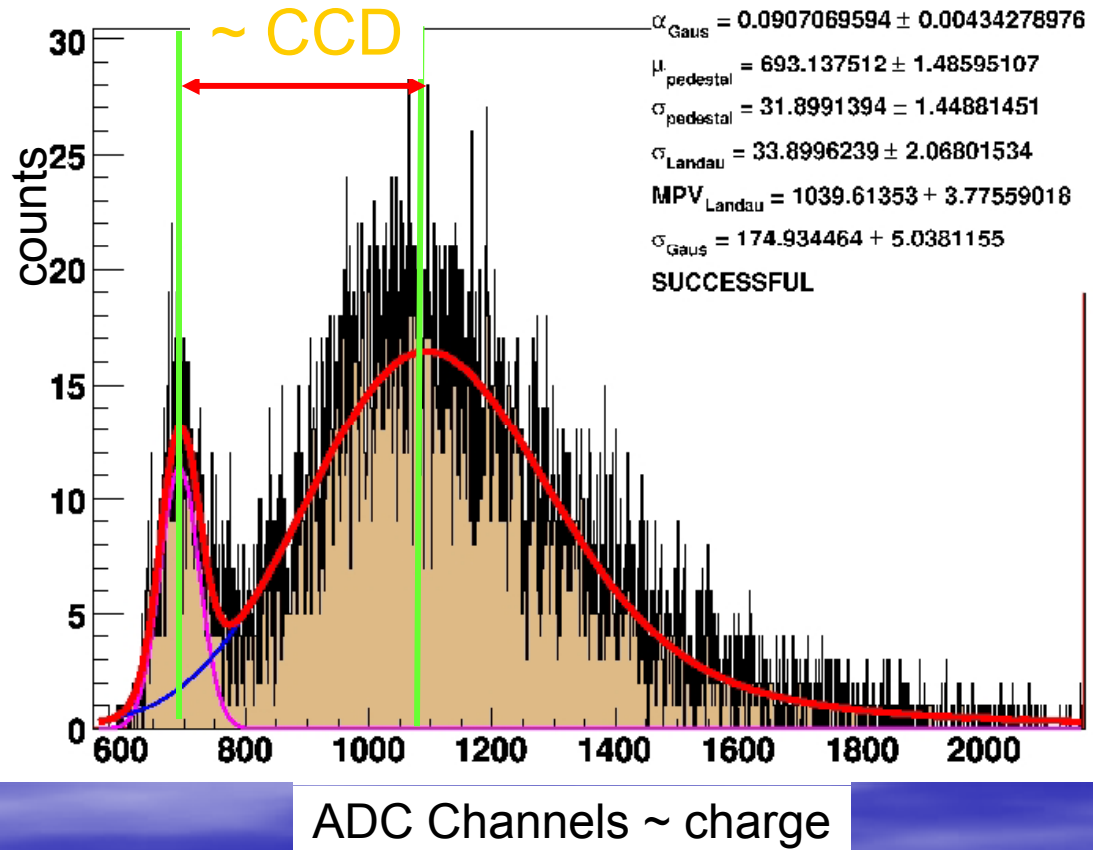
Sensor

Faraday cup

CCD setup



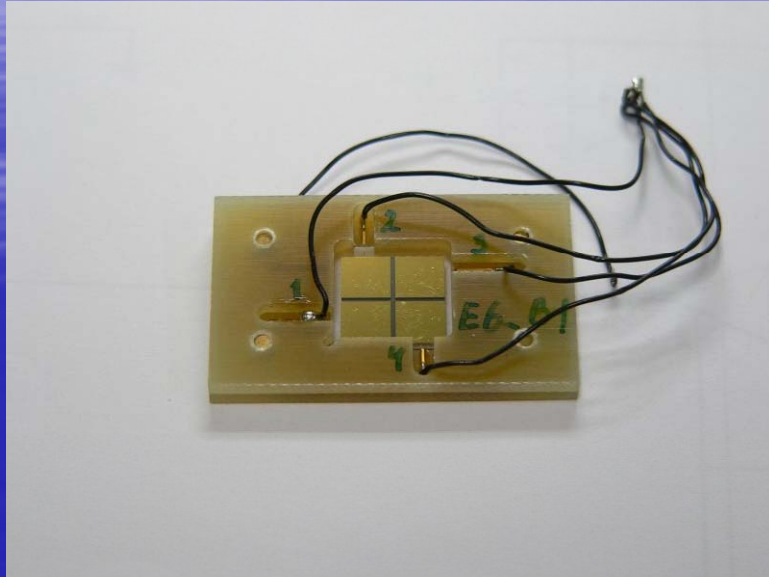
E6_B1_400V spec 00009



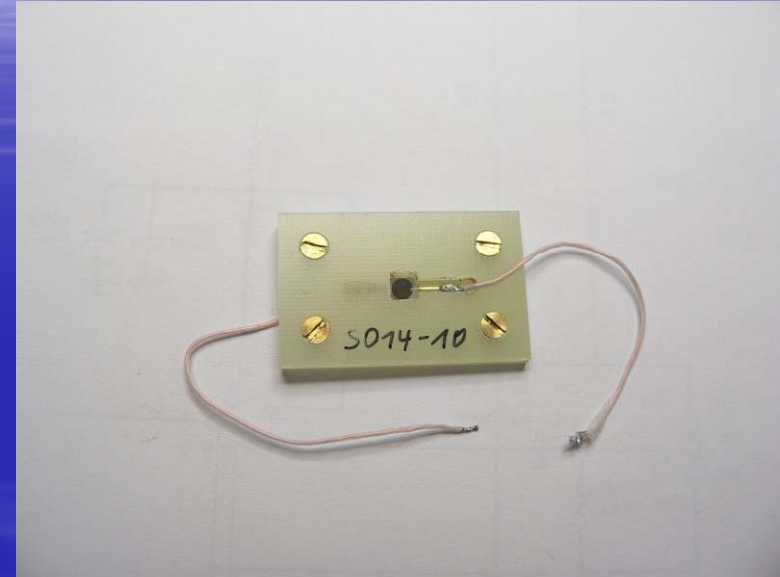
Plan for testbeam'07

- pCVD diamond (Element 6)
up to 5.5 MGy
- sCVD diamond (GSI DA)
up to 2.5 MGy
- Radiation-hard Silicon (BNL)
up to 90 kGy
- GaAs (JINR)
up to 0.9 MGy

CVD diamond samples

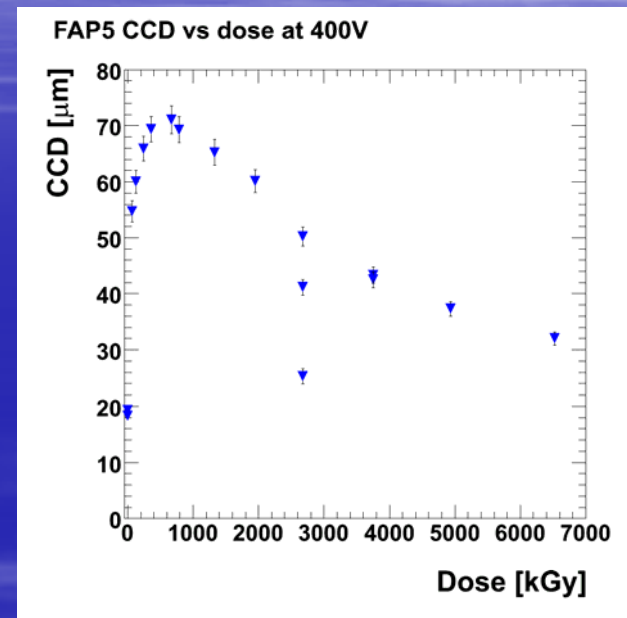
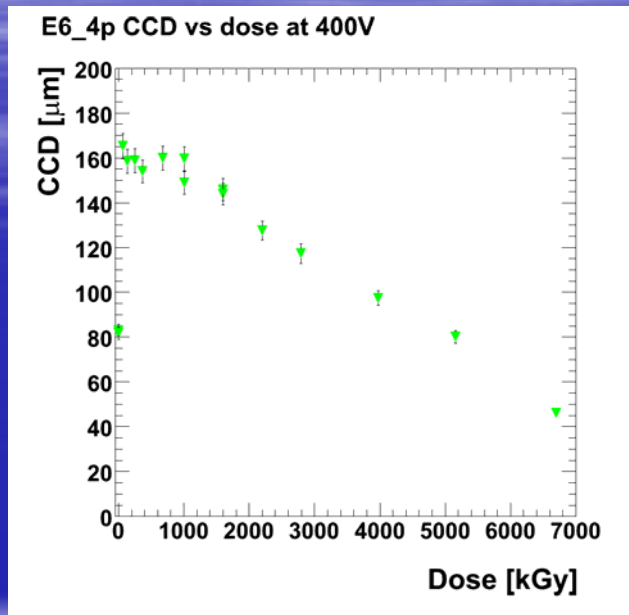


pCVD diamonds
active area 10x10 mm²,
thickness 500 μm
Ti-Pt-Au metallization



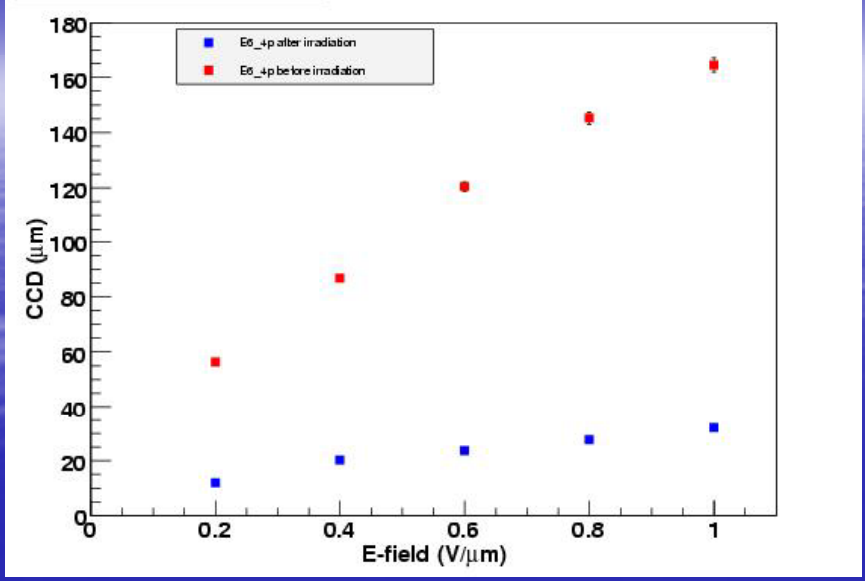
scCVD diamond
area 5x5 mm², thickness 320 μm,
metallization Ø3mm

pCR Results from test beam '06



Rather similar behavior: first pumping, then CCD decrease

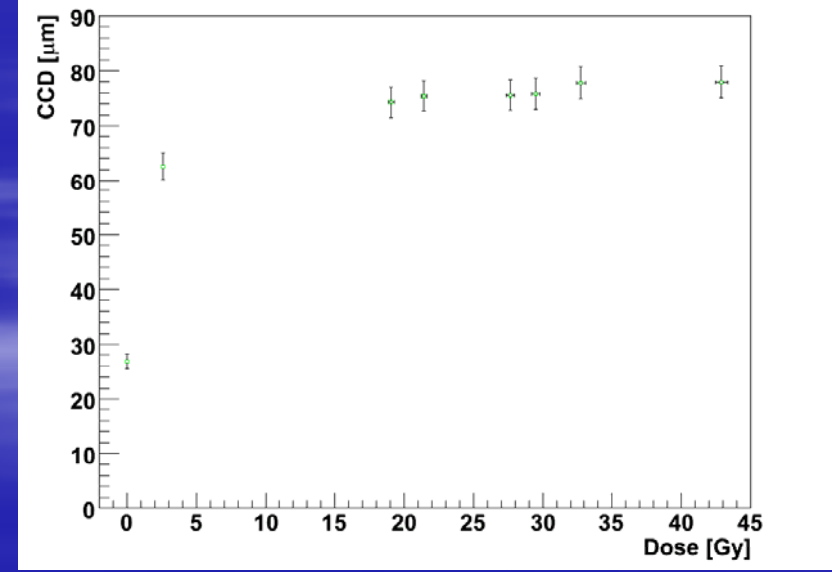
E6_4p CCD vs E-field

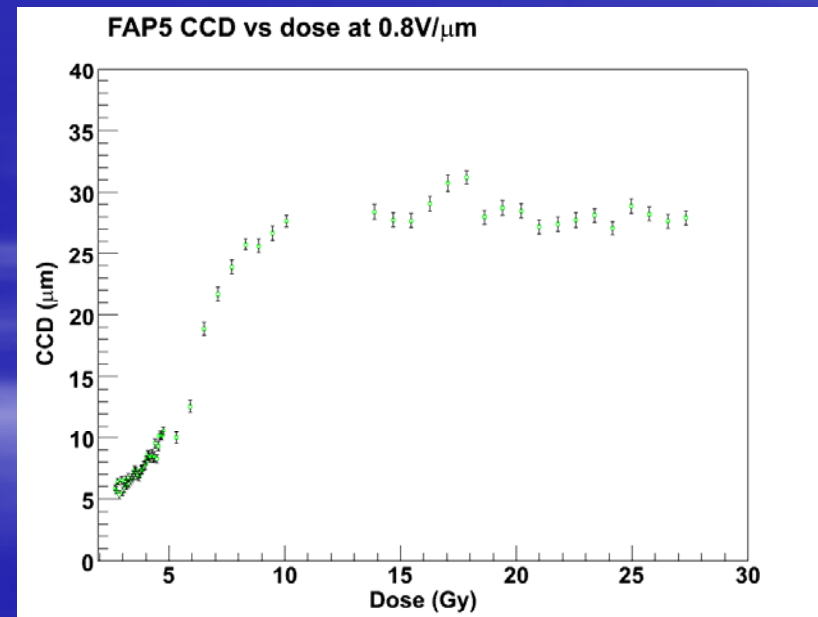
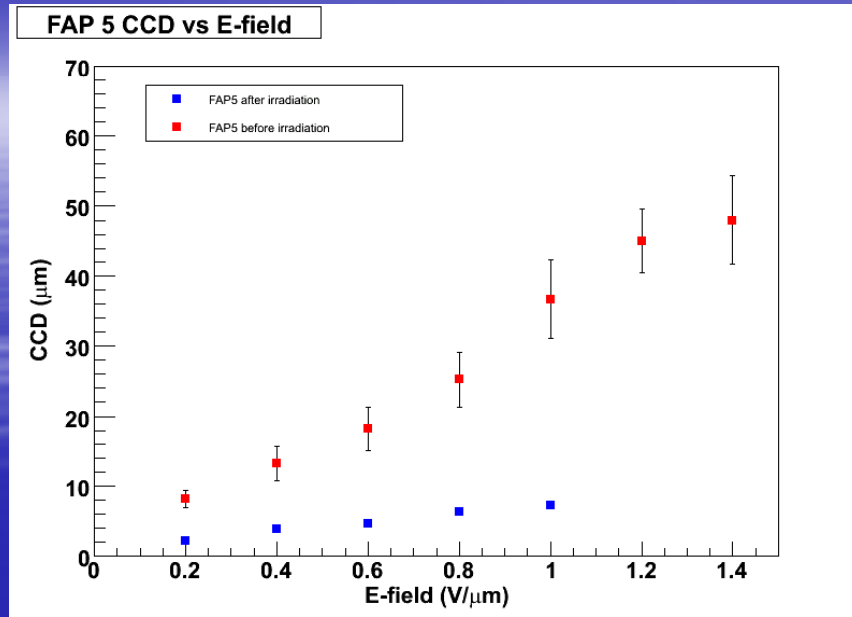


← The CCD decreased after the irradiation

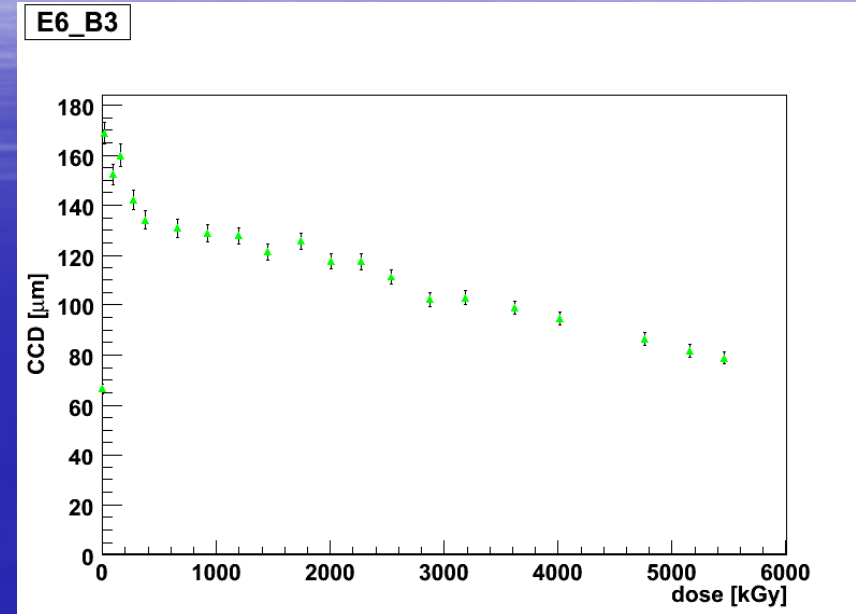
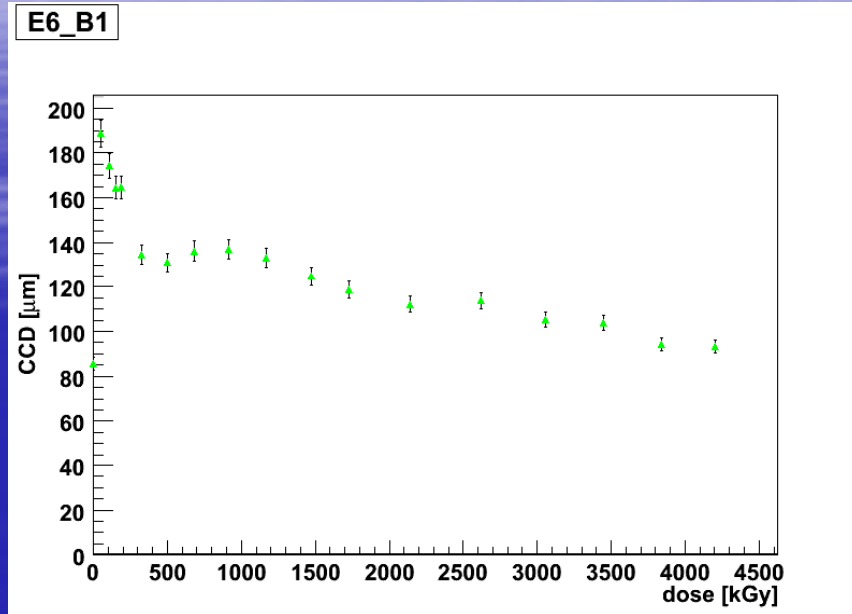
An attempt to recover at small doserates →

E6_4p CCD vs dose at 400V (0.8 $V/\mu m$)



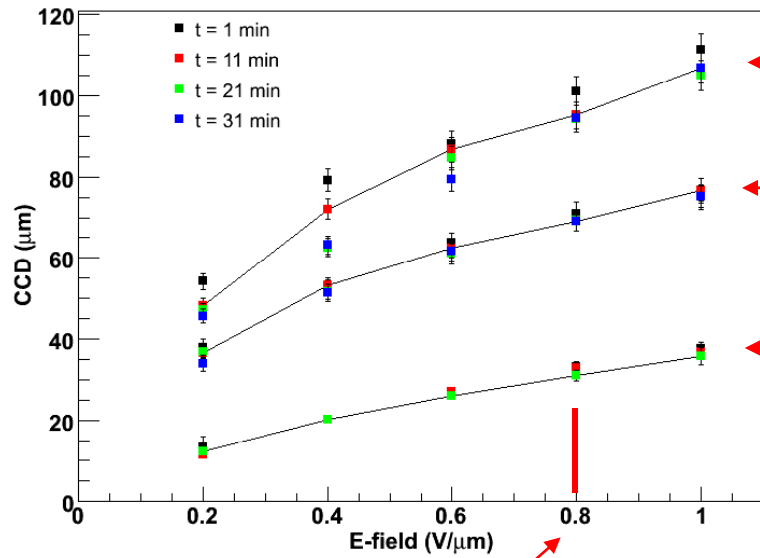


Results from testbeam'07



Similar behavior: first pumping, then the CCD decreases

E6_B1 CCD vs E-field



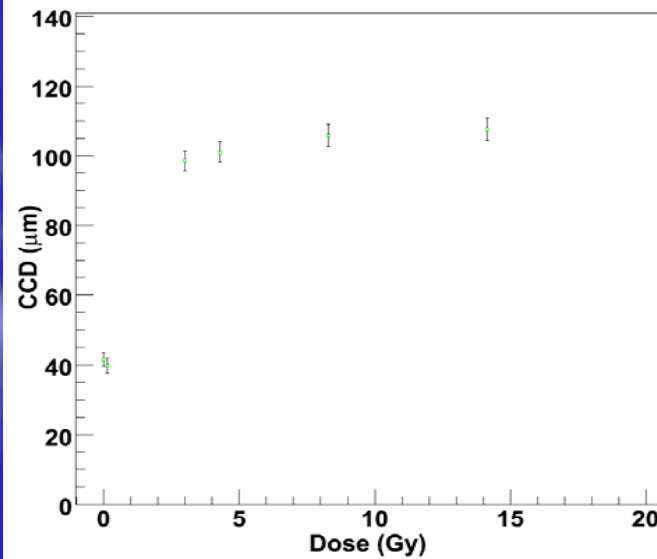
Before irradiation

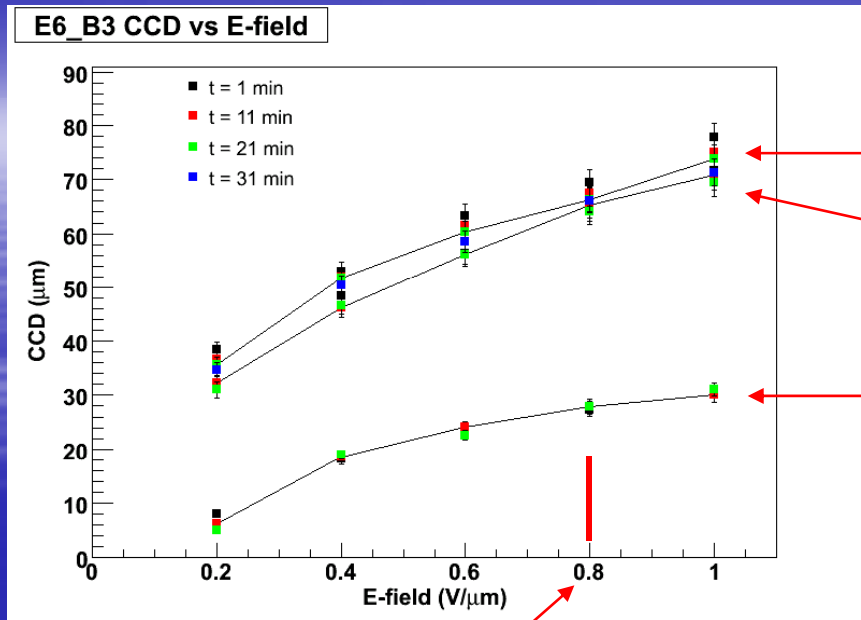
After irradiation before UV illumination

After irradiation, UV illuminated

Value used at testbeam

E6_B1 CCD vs dose at $0.8 V/\mu m$





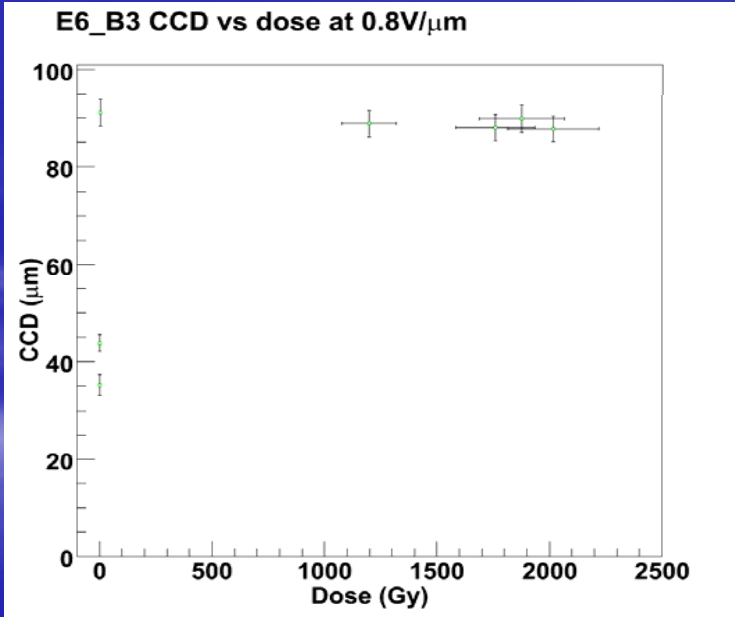
Before irradiation

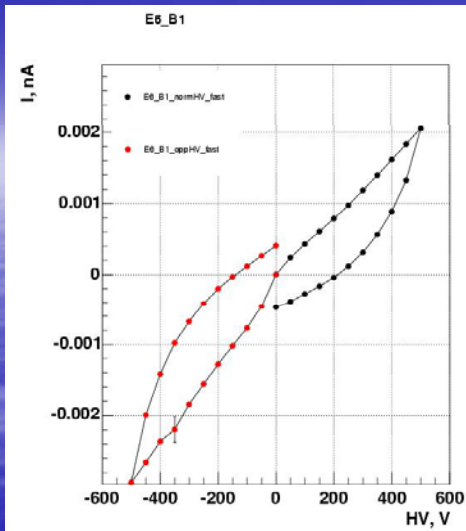
After irradiation before UV illumination

After irradiation, UV illuminated

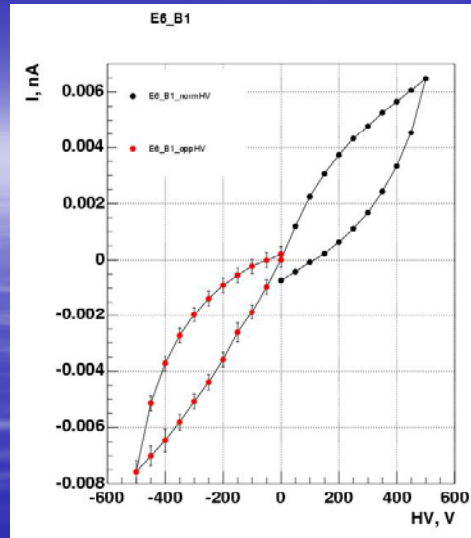
Value used at testbeam

Revealed the CCD larger than that before irradiation

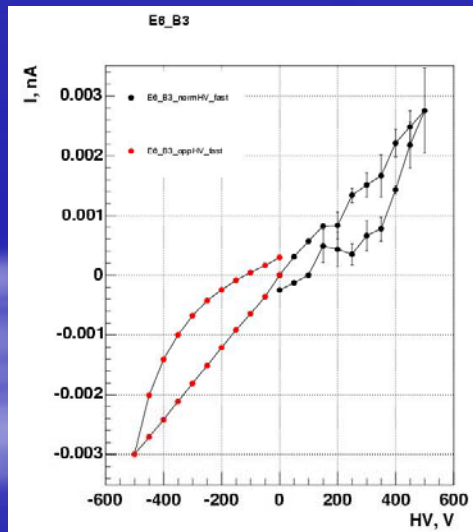




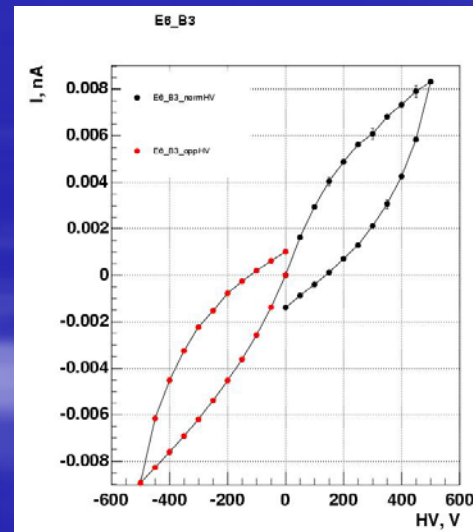
Before



After



Before

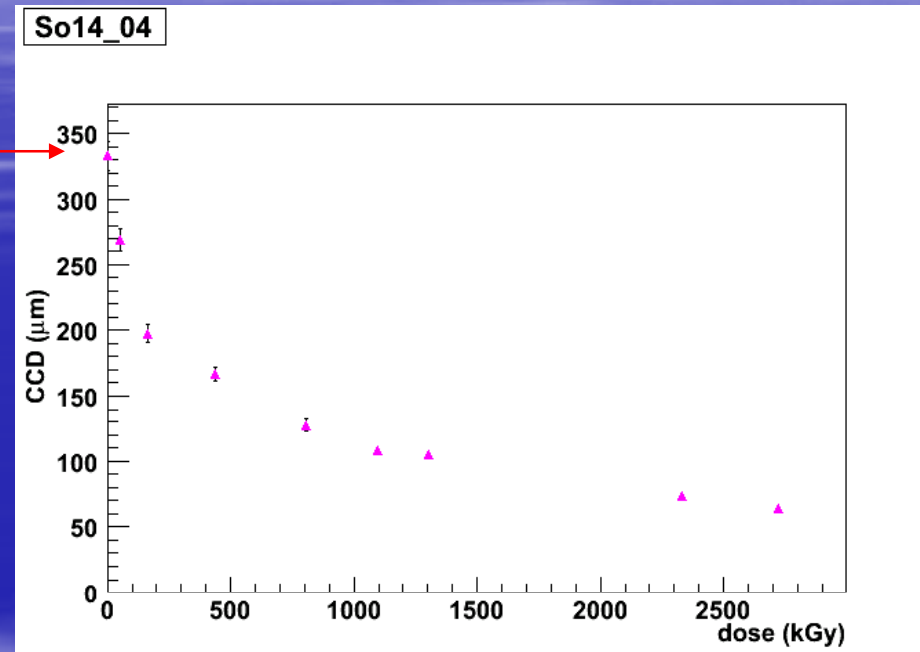


After

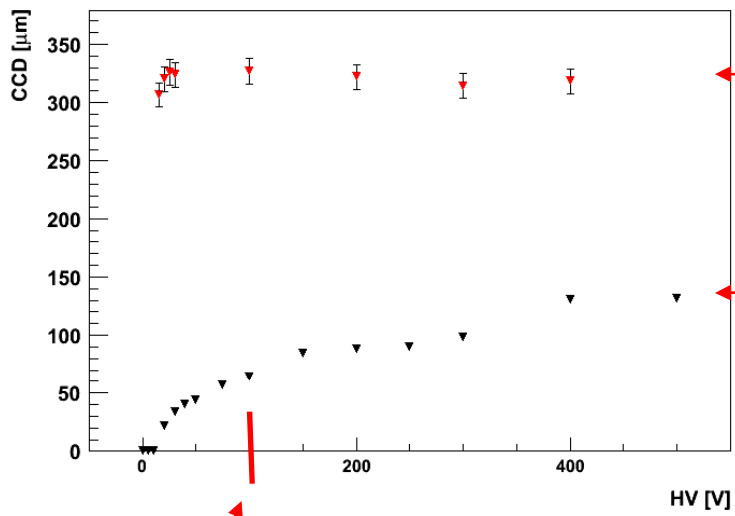
I-V characteristics

Results from test beam'07

100% efficient



So14_04 CCD vs HV

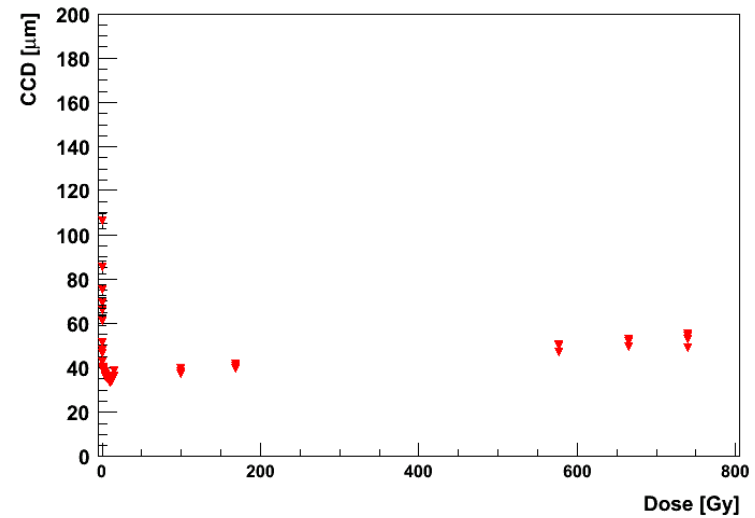


Before irradiation

After irradiation

Value used at testbeam

So14_04 CCD vs Dose

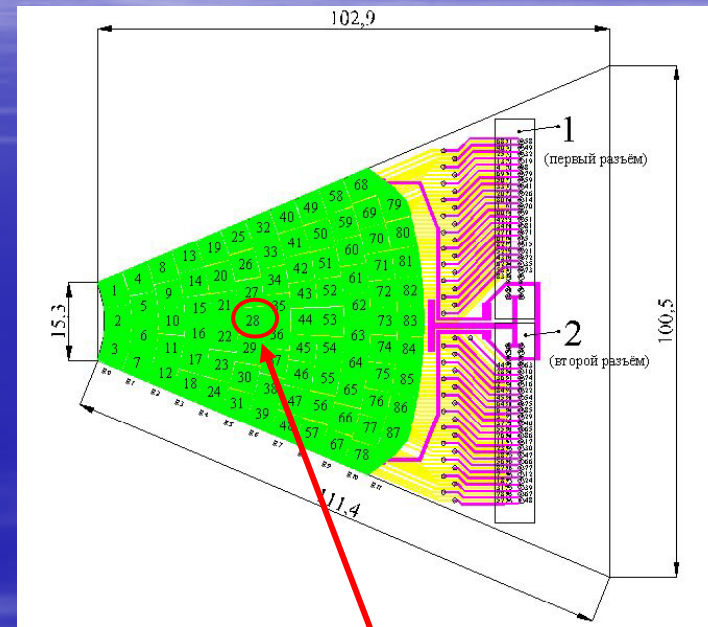


GaAs

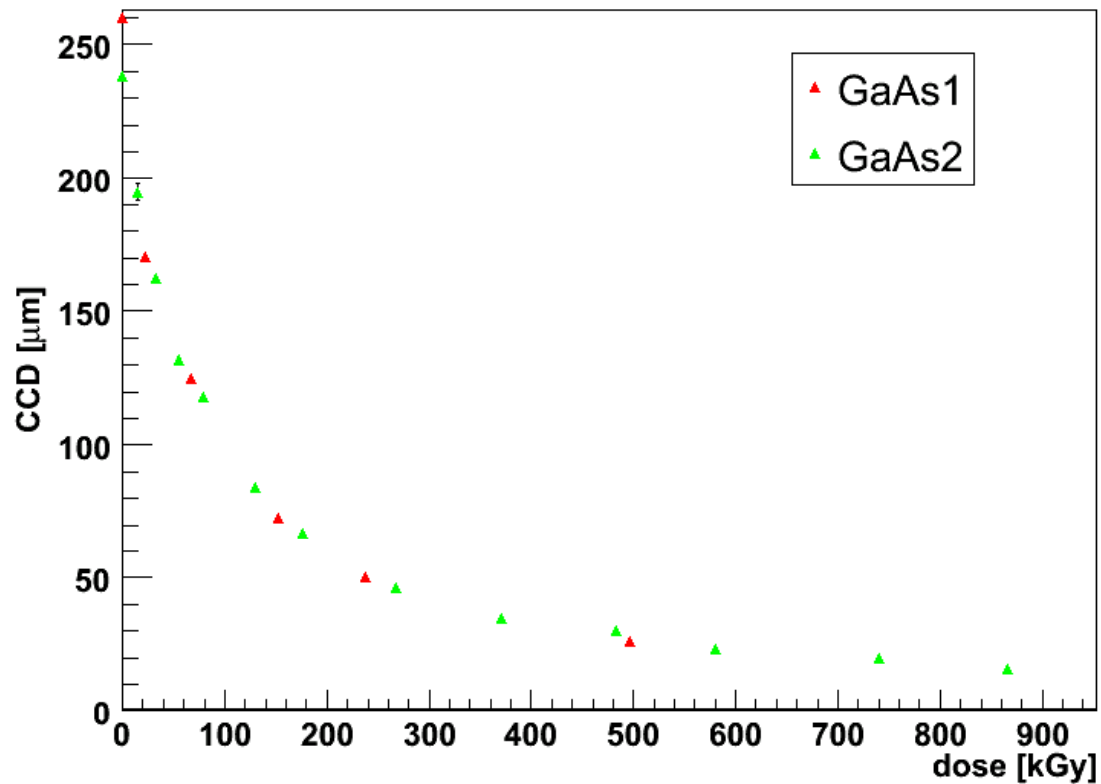
Supplied by FCAL group at JINR
Produced by Siberian Institute of
Technology, Tomsk
Two samples

semi-insulating GaAs doped by Sn
(shallow donor)
compensated by Cr (deep acceptor)

500 μm thick detector is divided into 87
5x5 mm pads
mounted on a 0.5 mm PCB with fanout



Irradiated pad



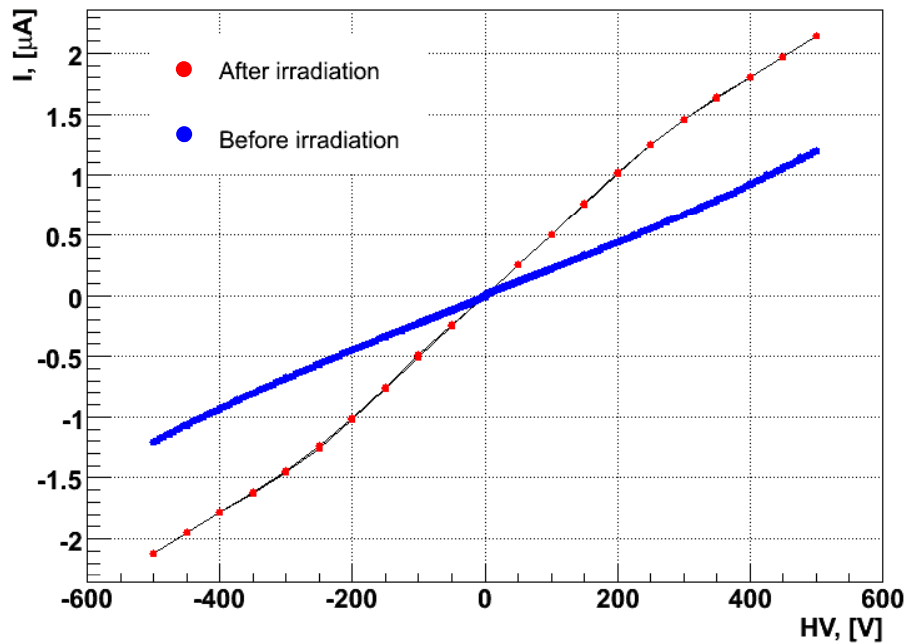
- No pumping as for pCVD diamond

Before irradiation

CCD = 50% of sensor thickness

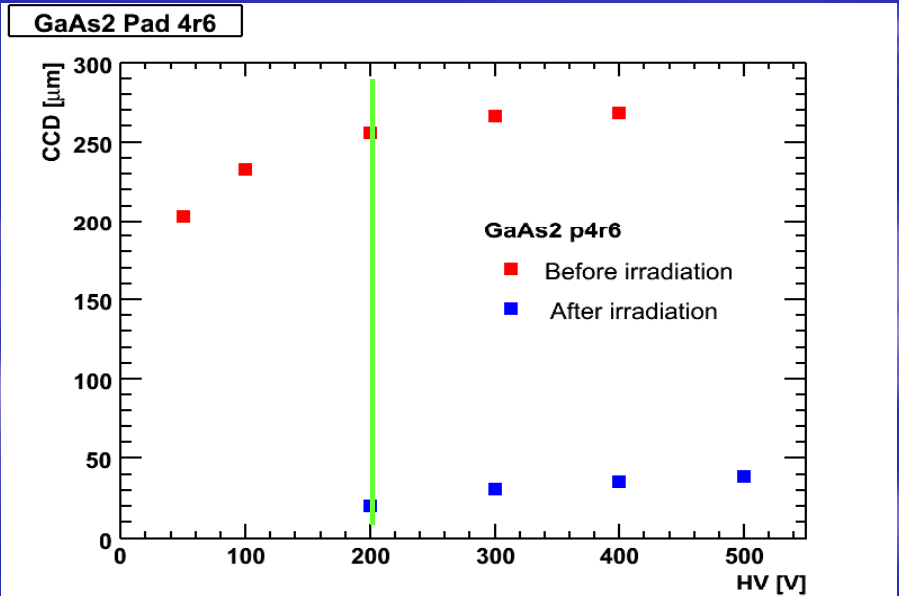
After irradiation (about 1 MGy)

CCD = 3% of sensor thickness

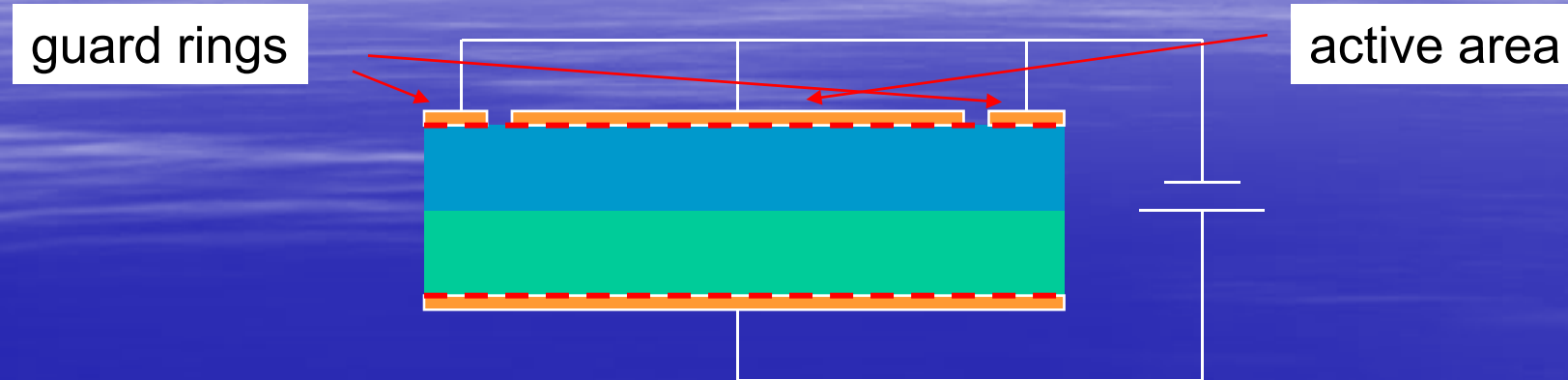


I-V characteristic

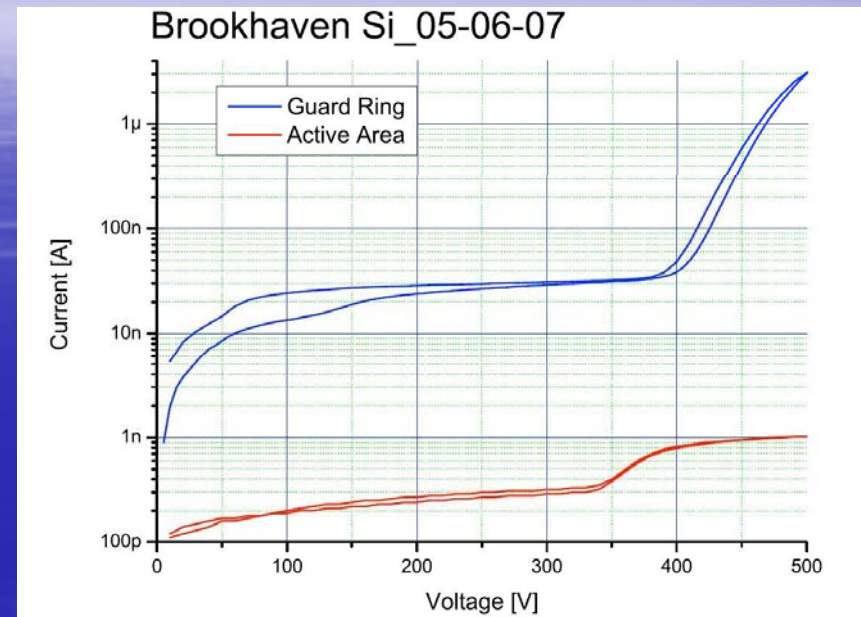
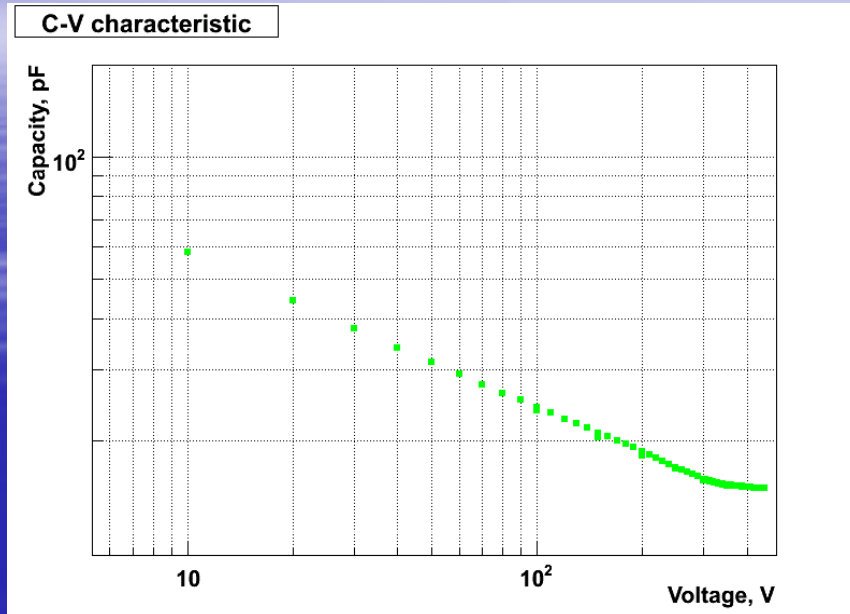
CCD vs bias voltage



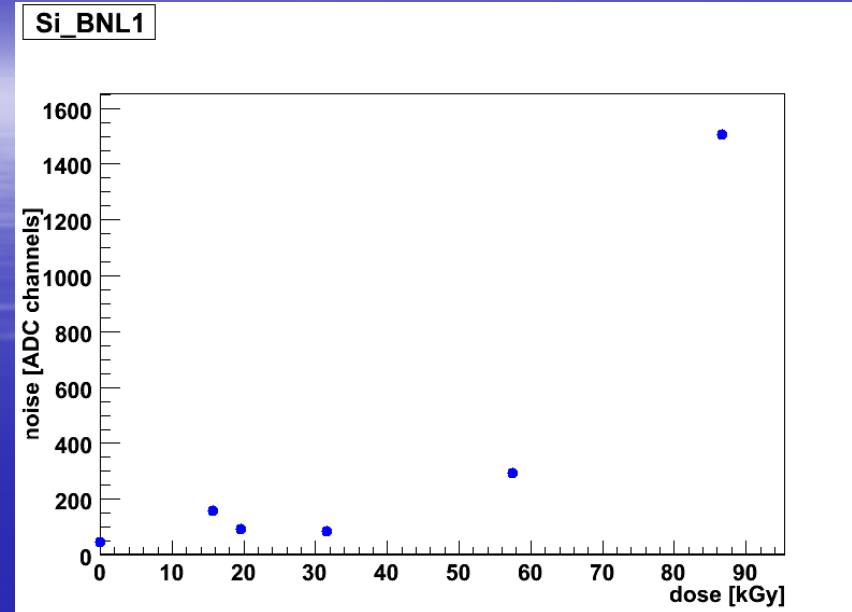
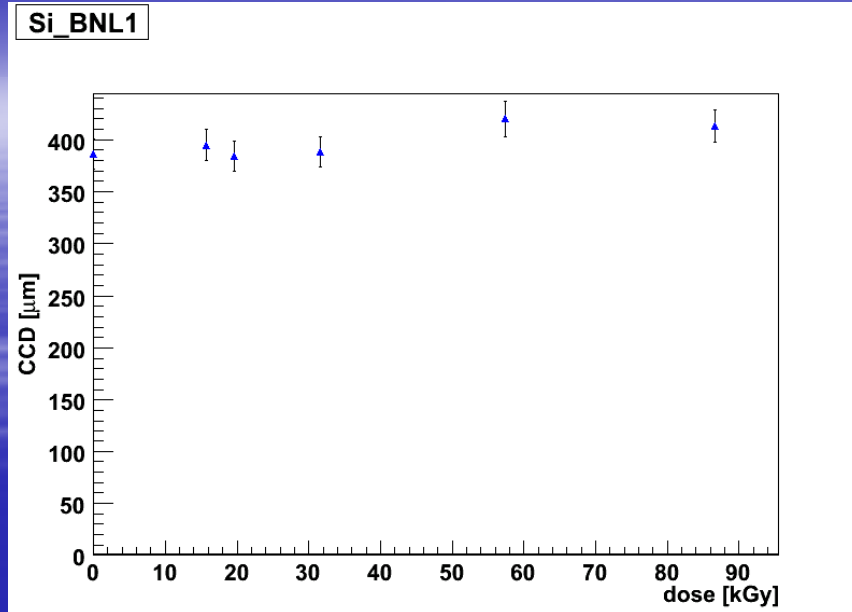
Radiation hard silicon



- supplied by **BNL** (Zheng Li)
radiation hard, thickness 380 μm , 5x5 mm^2
- guard rings structure



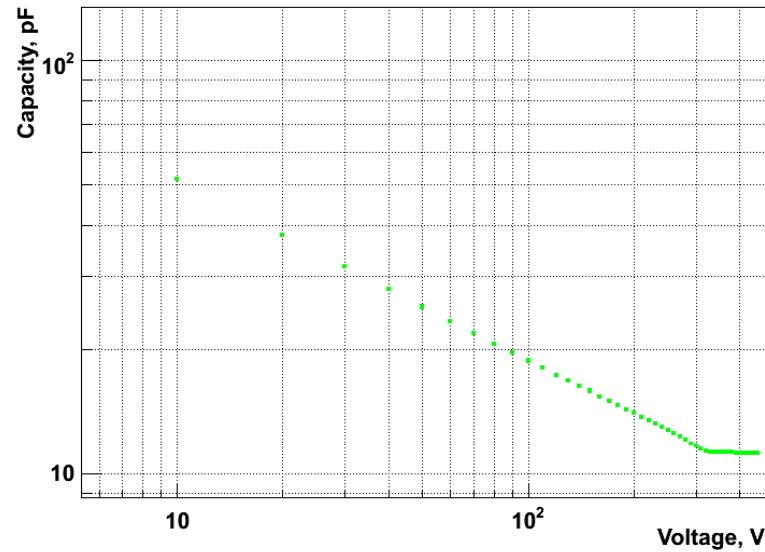
Before irradiation



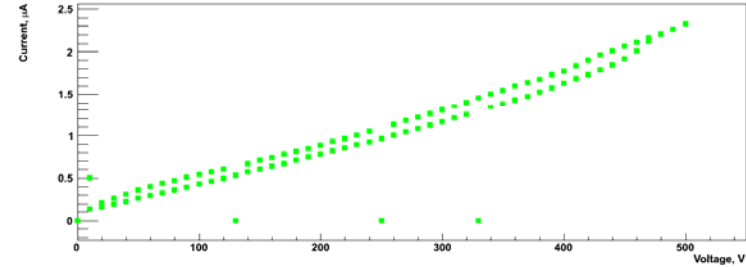
Irradiation

- CCD remained constant
- Noise increased strongly

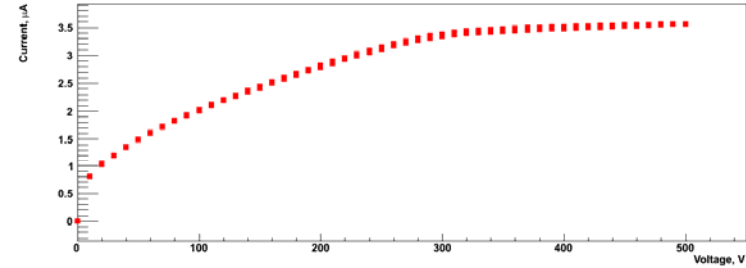
C-V characteristic



Guard ring current

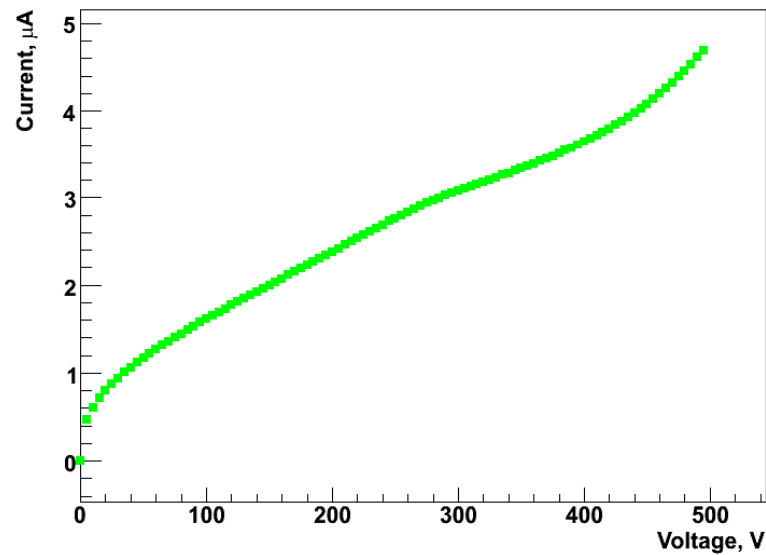


Active area current



no CCD measurement possible due to noise

Active area current



After irradiation

Summary

1. Both poly- and single crystalline CVD diamond sensors stood the absorbed doses of several MGy and still were able to operate properly.
2. GaAs sensors were operational after 500 kGy.
3. Radiation hard silicon did not loose performance after 90 kGy, but revealed high noise.

To be done:

1. Understand the mechanism of damage.
2. Clarify the dependence of CCD on dose, doserate and other factors.
3. Discuss with manufacturers the possibility to cure the problem and to provide more radiation hard samples in future.

