



Irradiation Studies of GaAs Sensors in a High Intensity Electron Beam

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Overview

➤ Testbeam

- ✦ motivation and goals
- ✦ where and what
- ✦ equipment and measurements

➤ GaAs:Cr material

➤ GaAs:Cr results

Testbeam

Motivation and goals

The colliders of the next generation require radiation hard sensors

- LHC beam condition monitoring
- forward calorimetry for the ILC
- ...

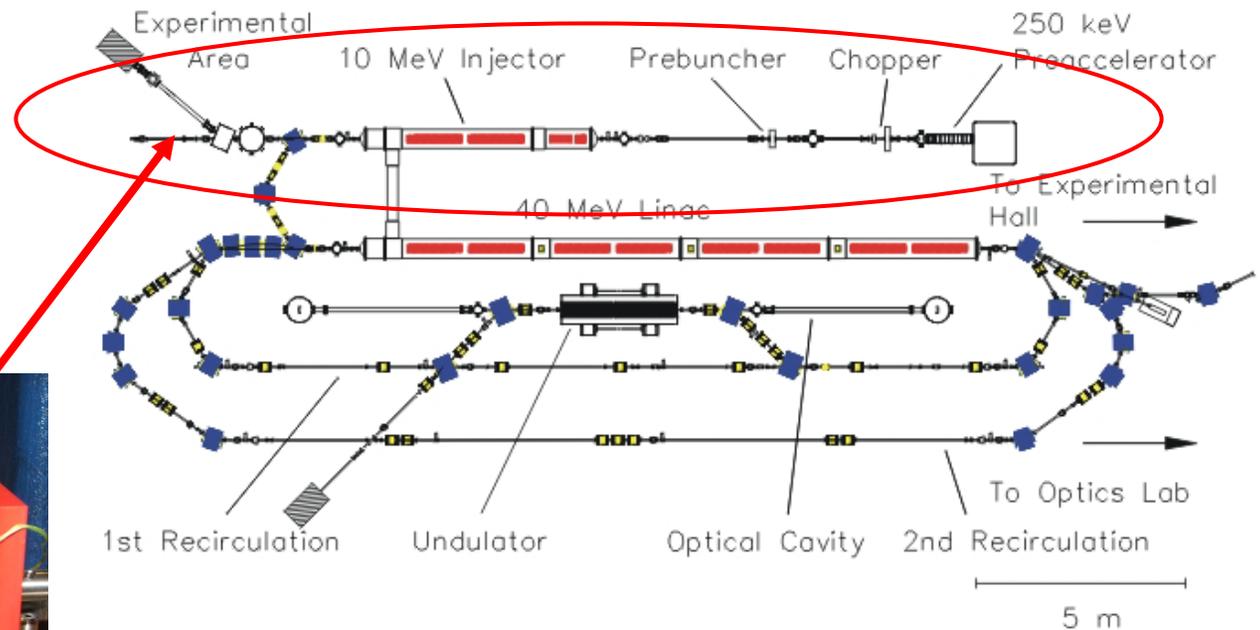
The sensor characteristics (CCE, I-V) had been measured before the irradiation

Irradiation done in the steps, with the CCE measurements in between

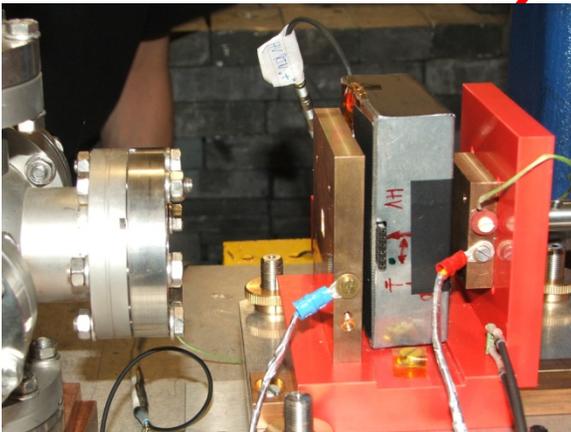
Sensor characteristics measurement after the irradiation

What and where

Superconducting Darmstadt Linear Accelerator, Technical University Darmstadt



Testbeam Setup



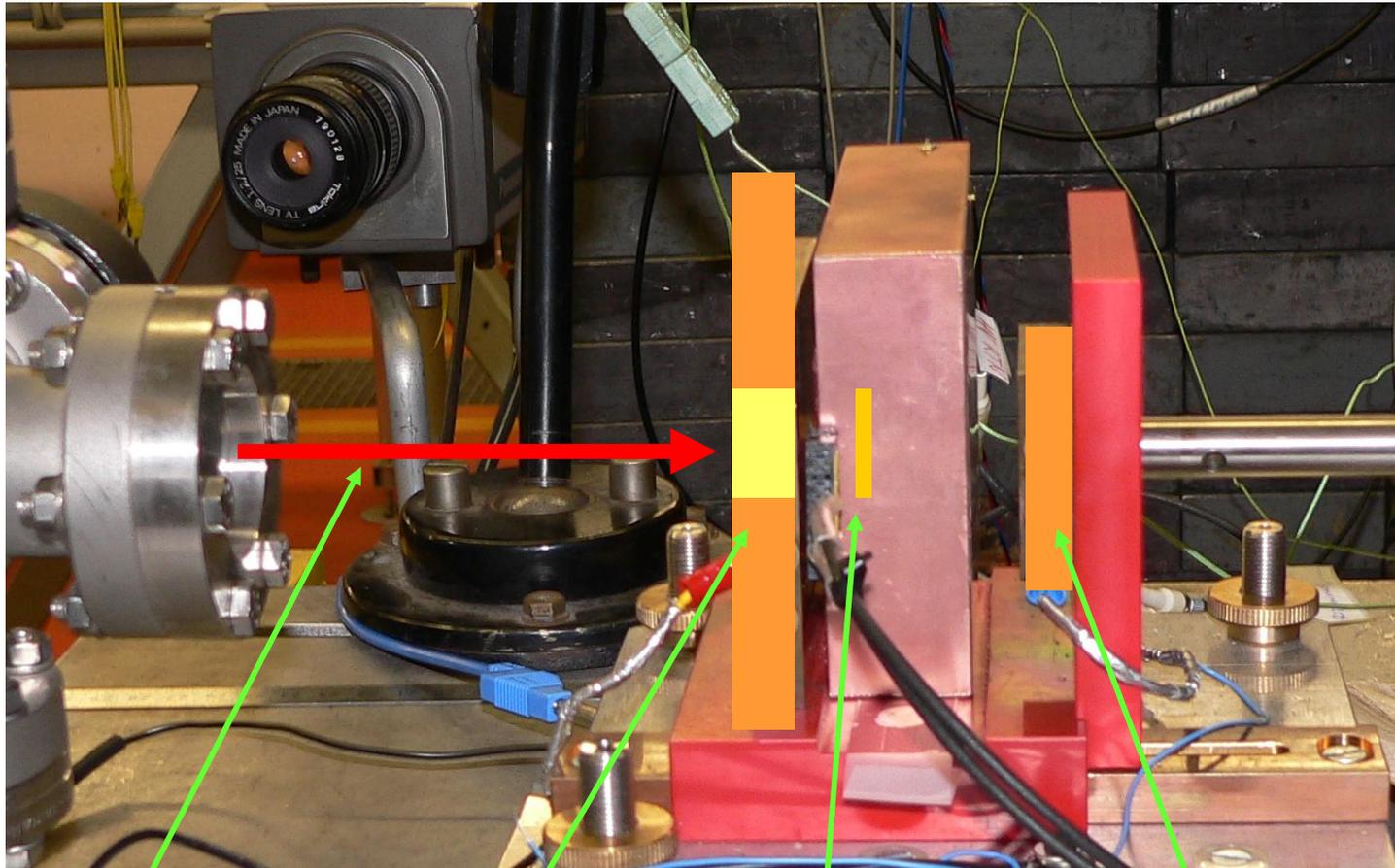
8.5 MeV electron beam

Beam currents 10 nA, 20 nA, 50 nA

10 nA \leftrightarrow \sim 80 kGy/h

Equipment

Beam setup



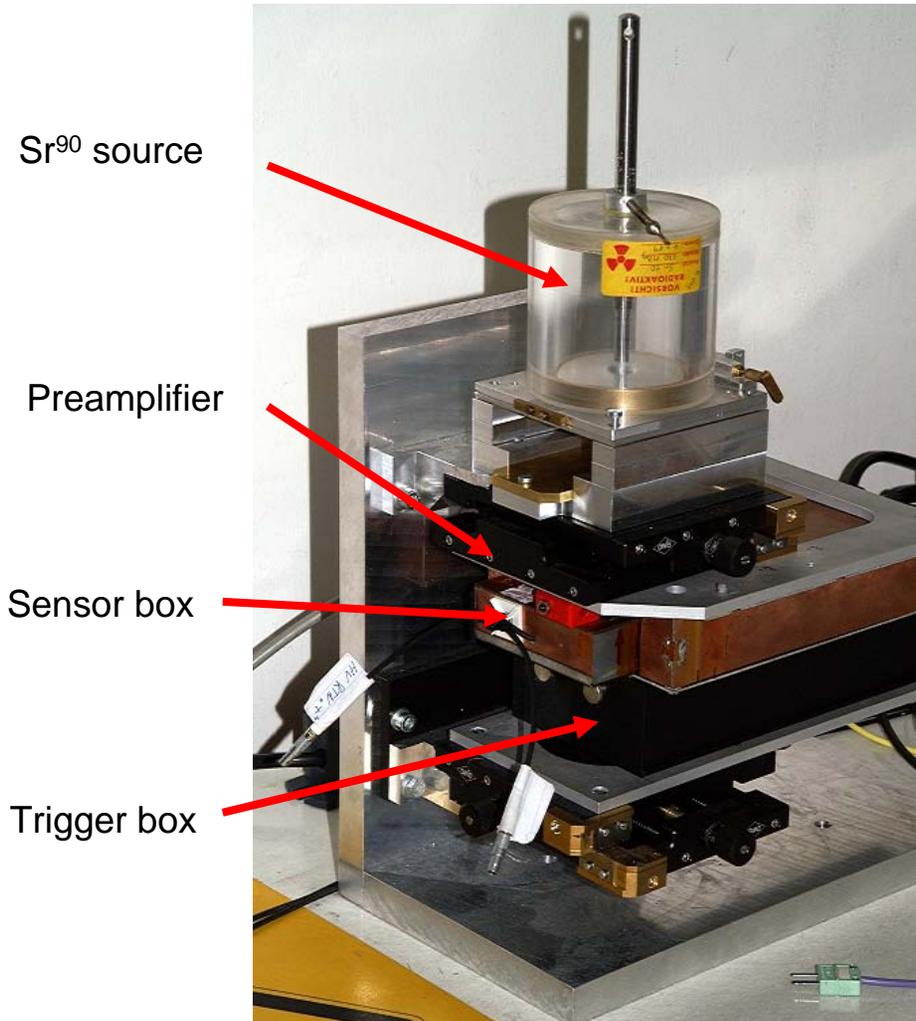
Beam

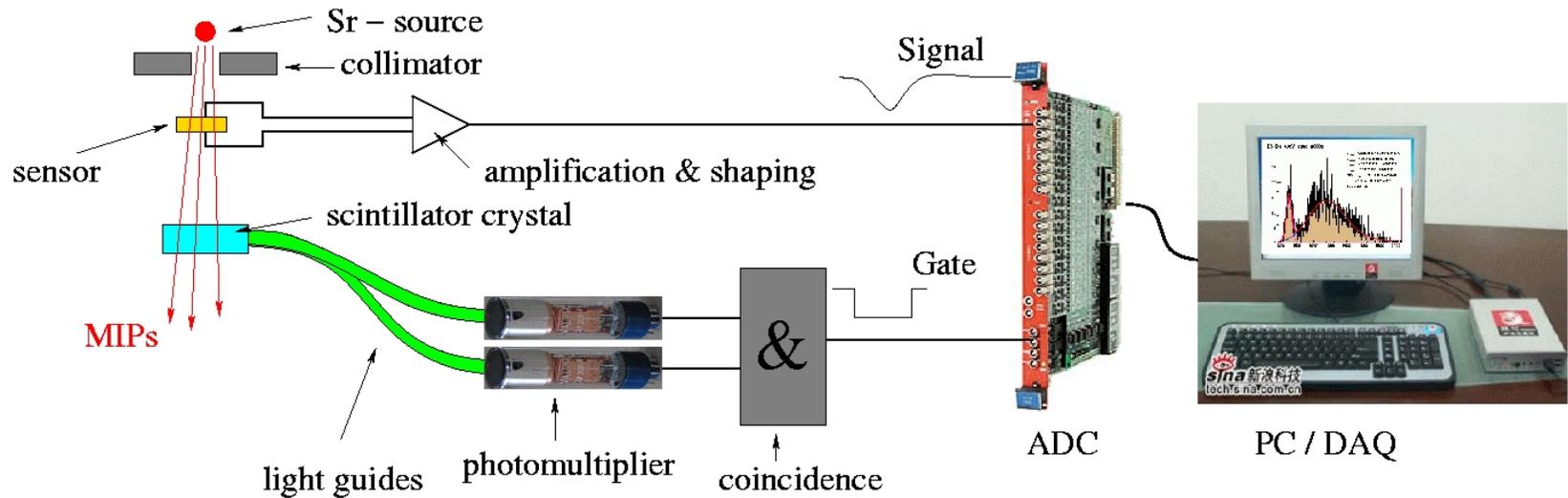
Collimator

Sensor

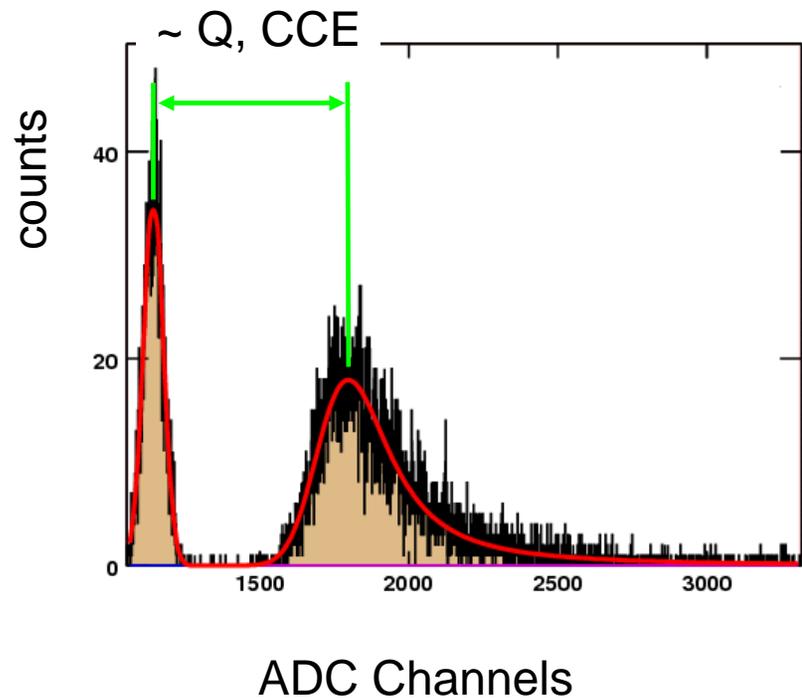
Faraday cup

CCE setup





$$\text{CCE} = \frac{(\text{MPV}_S - \text{Mean}_P) \times k}{N_{e-h} \times d} \times 100\%$$



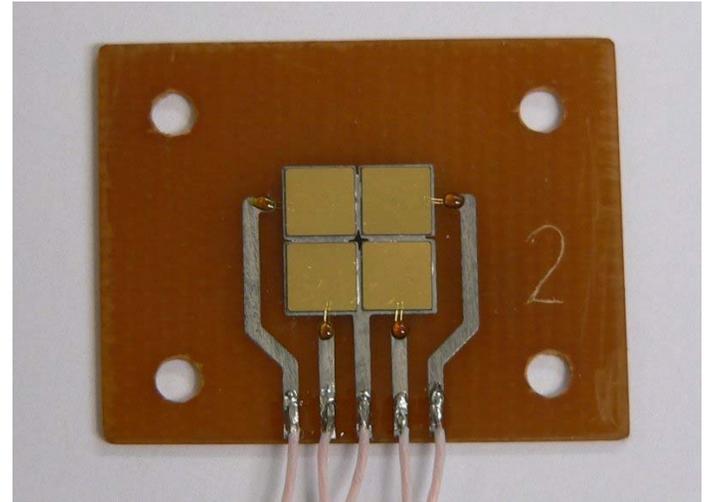
GaAs:Cr material

- n-type (Sn -shallow donor) GaAs grown by Liquid Encapsulated Czochralski (LEC) method in Siberian Institute of Physics and Technology (Tomsk, Russia)
 - low-ohmic material, filling the electron trapping centers EL2+
- Cr (deep acceptor) ion implantation
 - high-ohmic

Thicknesses 150 – 200 μm

Metallization:

V (30 nm) + Au (1 μm) from both sides



3 batches with different Cr concentration:

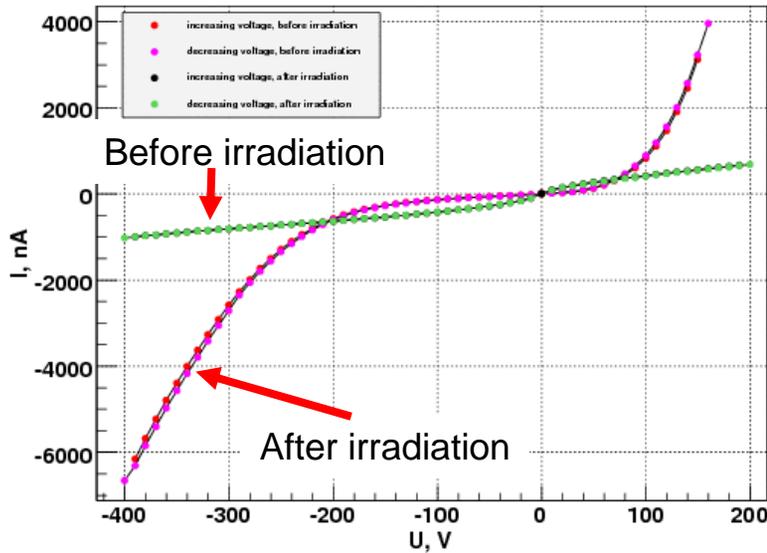
Batch #	Cr concentration, cm ⁻³	Notes
1	(1-1.5)*10 ¹⁷	non uniform over the thickness
2	(5-6)*10 ¹⁶	uniform ?
3	(1-3)*10 ¹⁶	uniform

The higher Cr concentration, the higher the radiation tolerance (?)

GaAs:Cr results

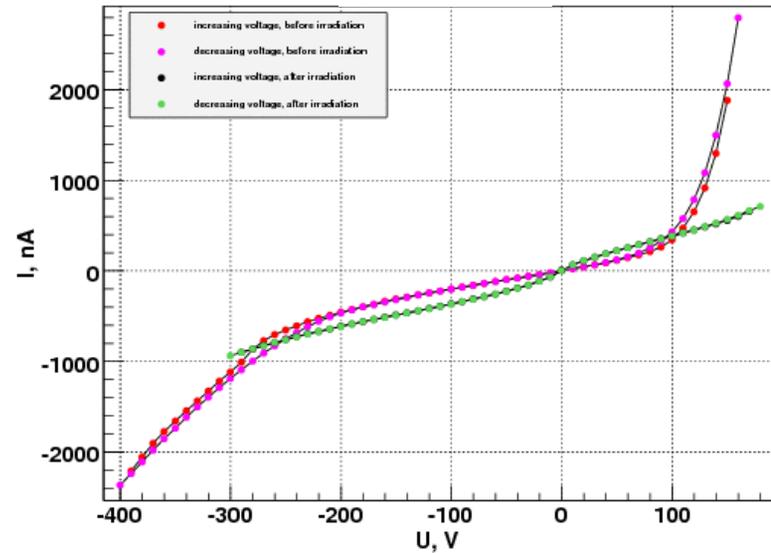
I-V B11 pad4 23C

Batch#1



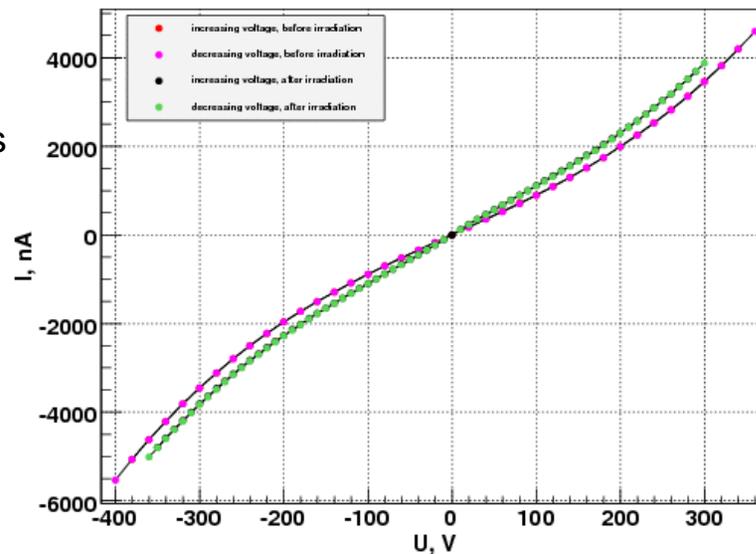
I-V B7 pad2 23C

Batch#2



I-V B2 pad1 24C

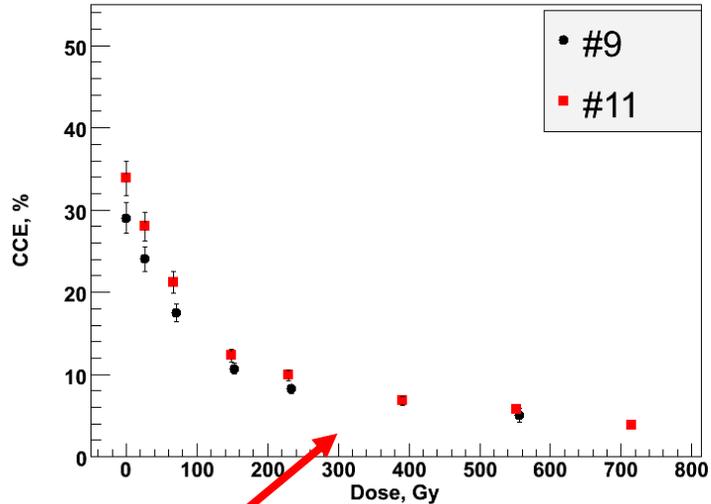
Batch#3



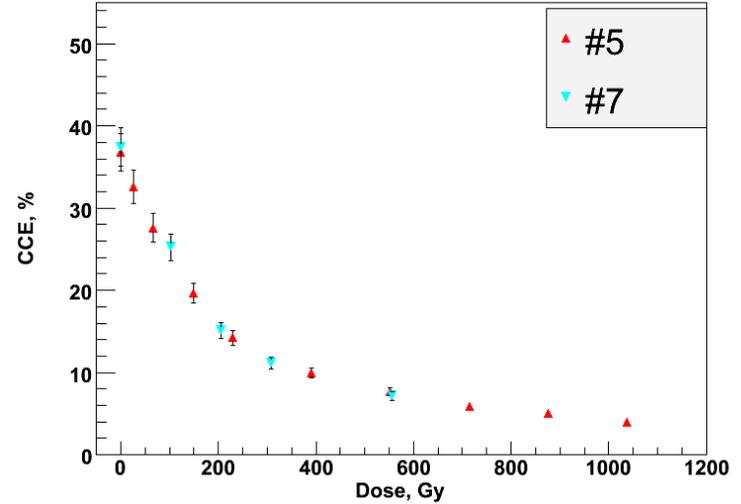
Nitrogen flow
Voltage applied in 50 V steps

CCE measurements

GaAs:Cr CCE vs dose (batch #1) (preliminary)

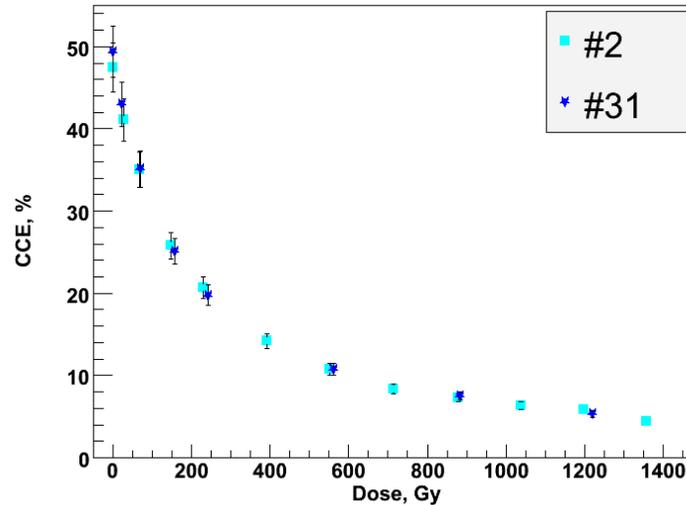


GaAs:Cr CCE vs dose (batch #2) (preliminary)



The highest Cr concentration

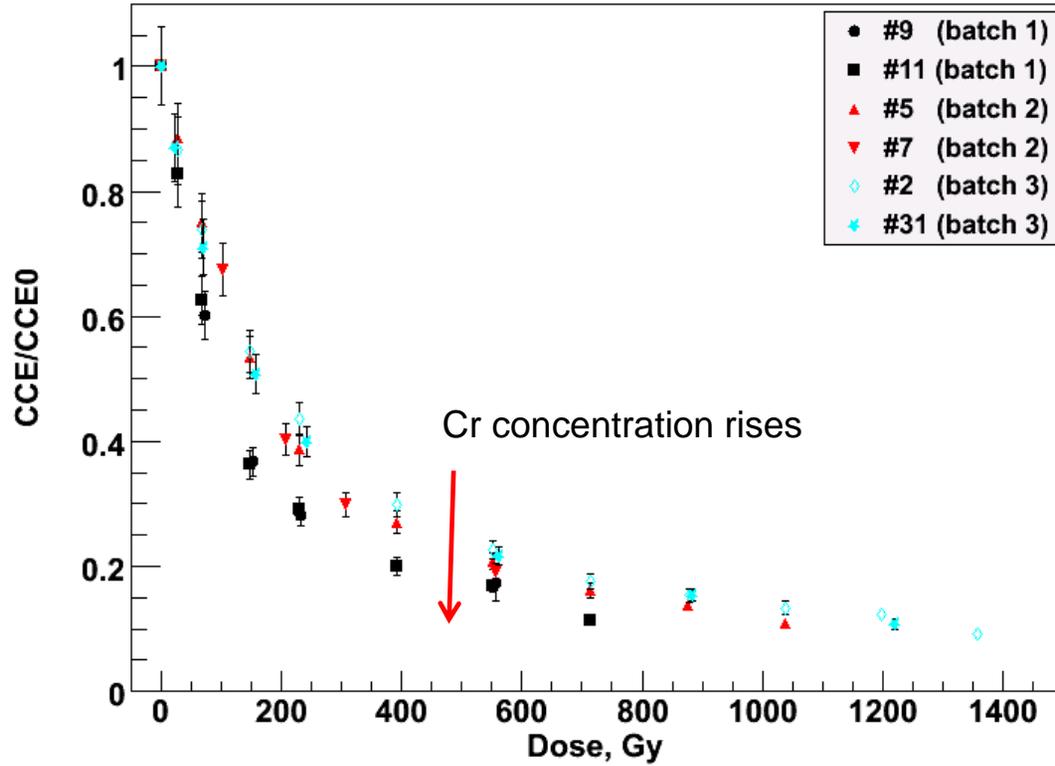
GaAs:Cr CCE vs dose (batch #3) (preliminary)



The lowest Cr concentration

Normalized CCE vs dose

GaAs:Cr CCE vs dose (preliminary)



Summary

1. 6 sensors of GaAs:Cr with different Cr concentration have been irradiated with electrons up to high doses of 1.4 MGy
2. All sensors withstood doses up 500 kGy , the signal of a MIP was still observed
3. The assumption that the higher Cr concentration the higher radiation hardness was not confirmed