1st ADAMAS Workshop
16-18 December 2012, GSI

Radiation hardness tests on thin diamond detectors

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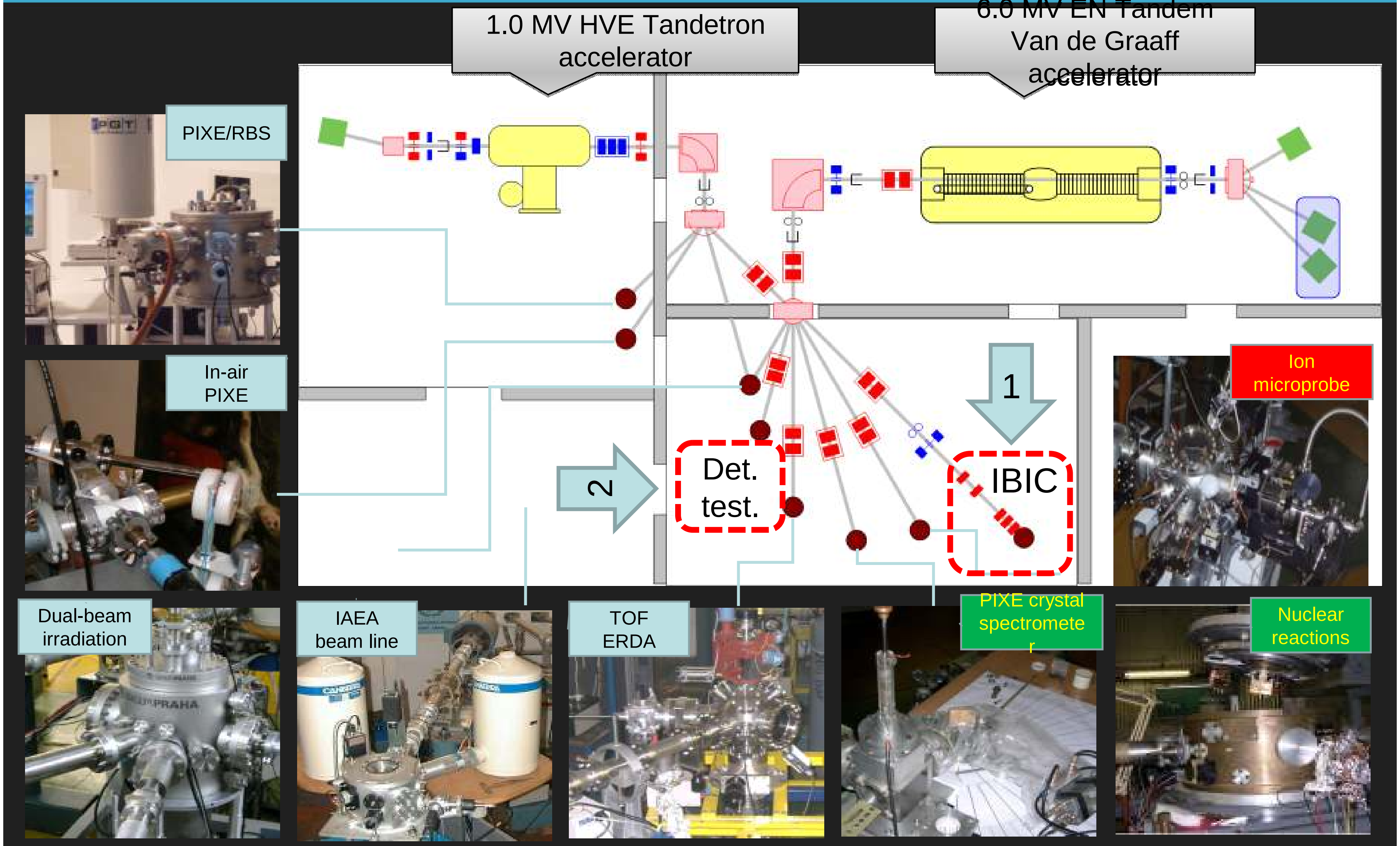
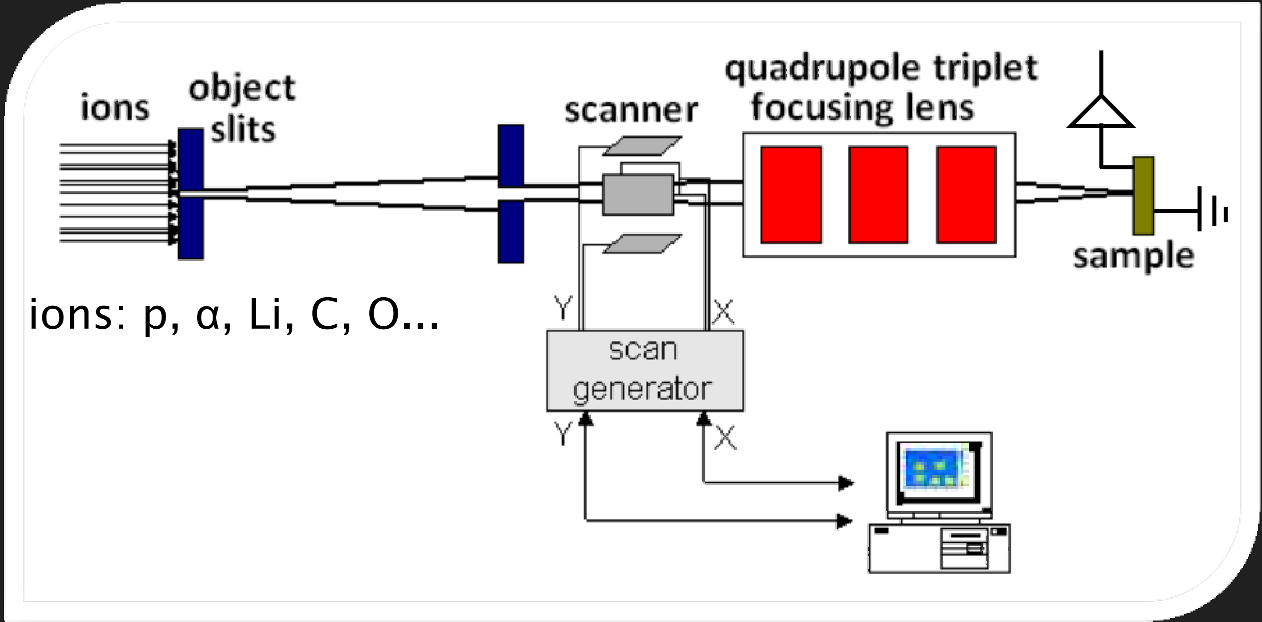
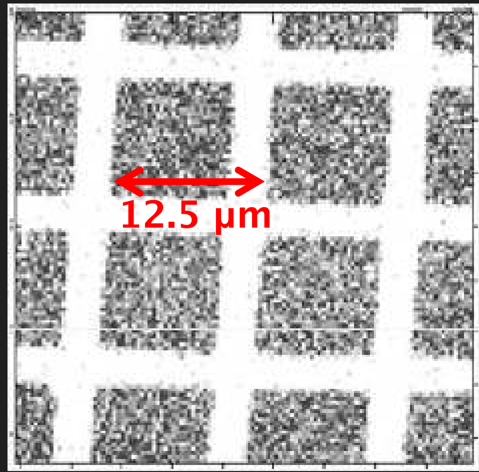
Detector testing at RBI

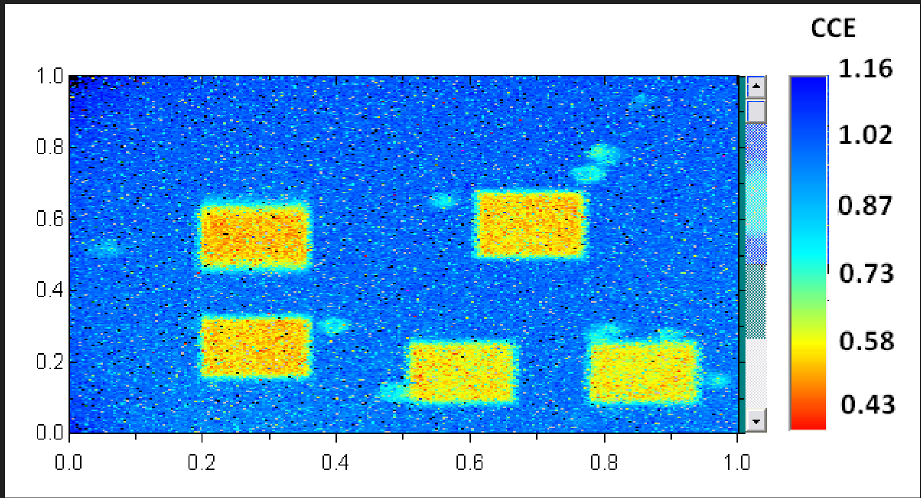


Detector irradiation on microprobe line



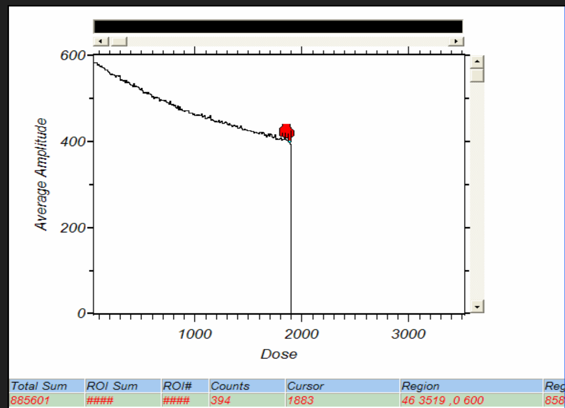
lateral beam resolution ~ 1μm



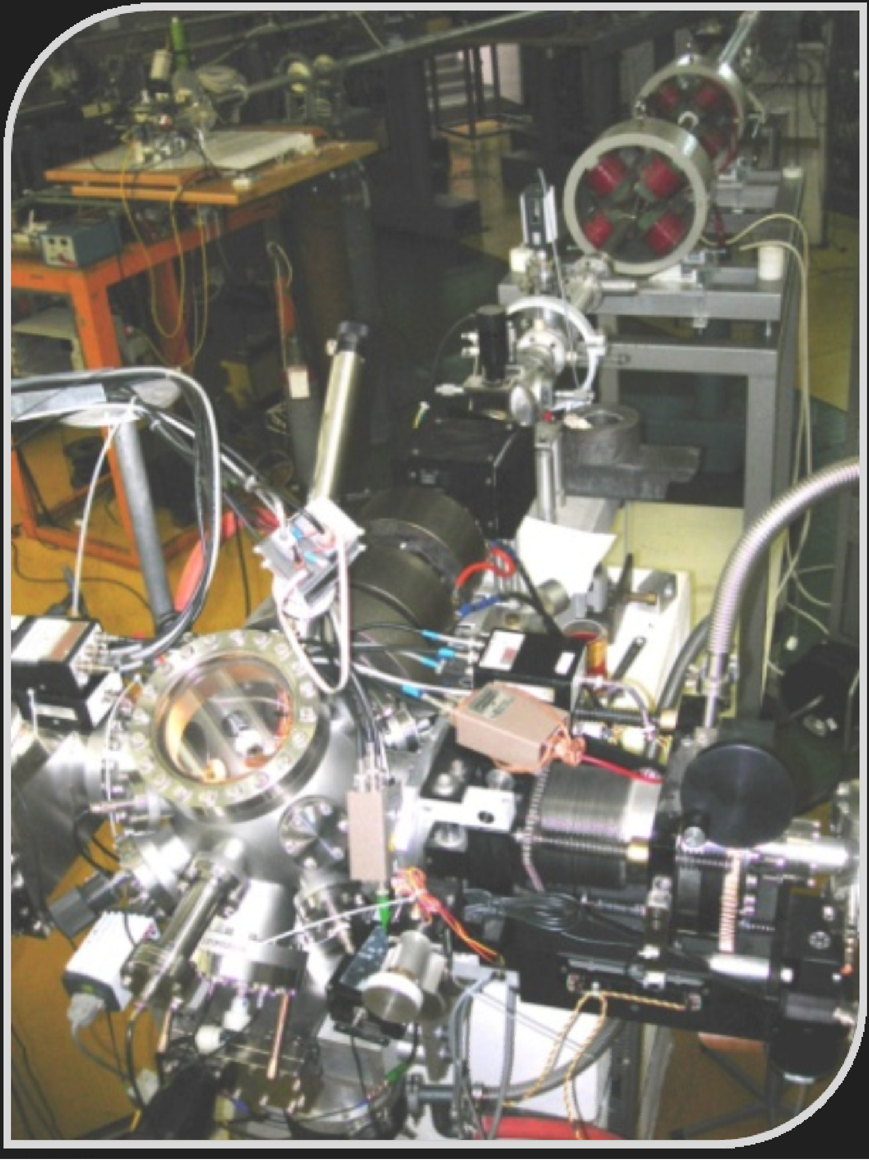


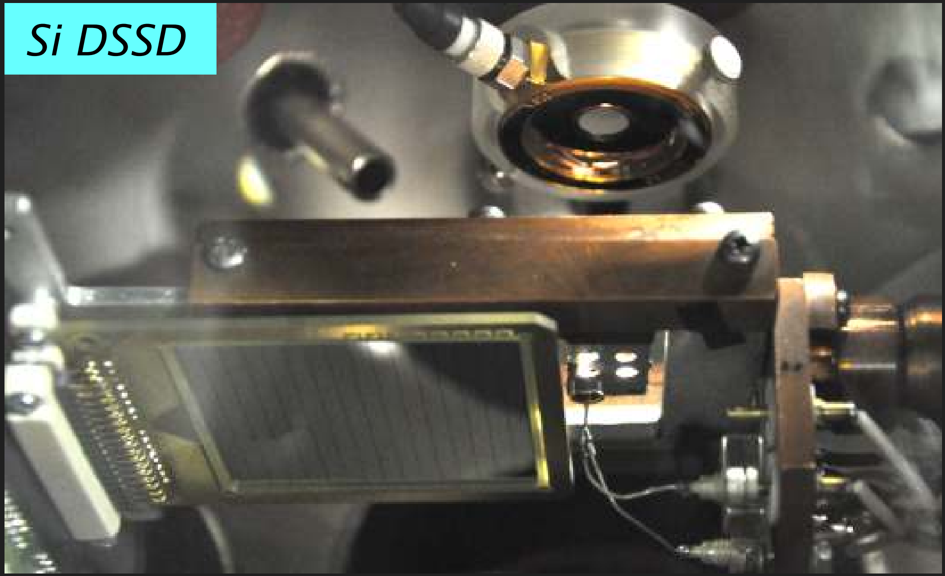
selective damage introduction

on-line monitoring

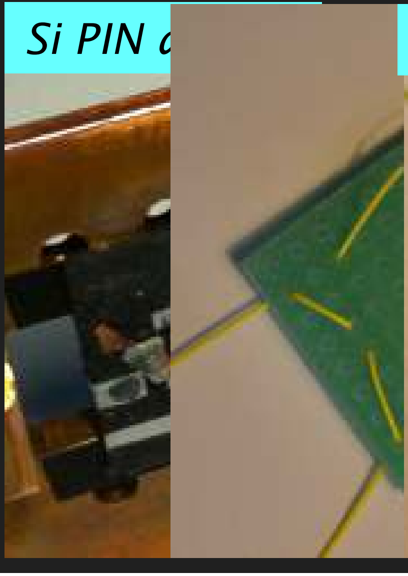


Detector irradiation on microprobe line





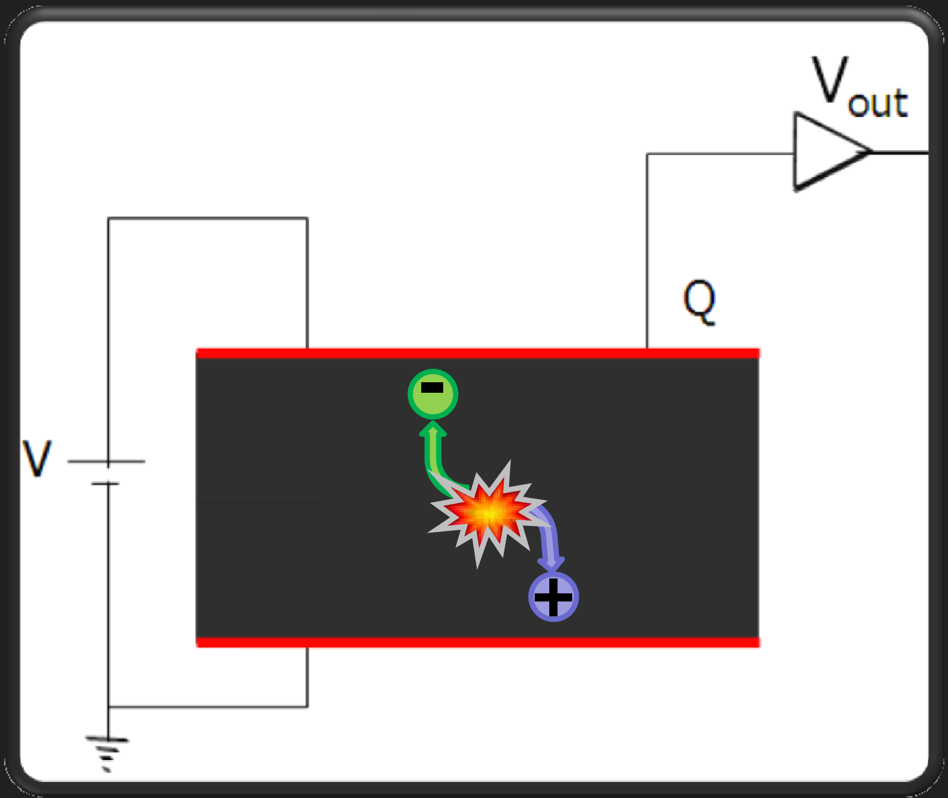
Si DSSD



Si PIN d

CVD diamond

Ion Beam Induced Charge



$$Q_{induced} = q\left(\left.\frac{\partial \psi}{\partial V_i}\right|_{final} - \left.\frac{\partial \psi}{\partial V_i}\right|_{start} \right)$$

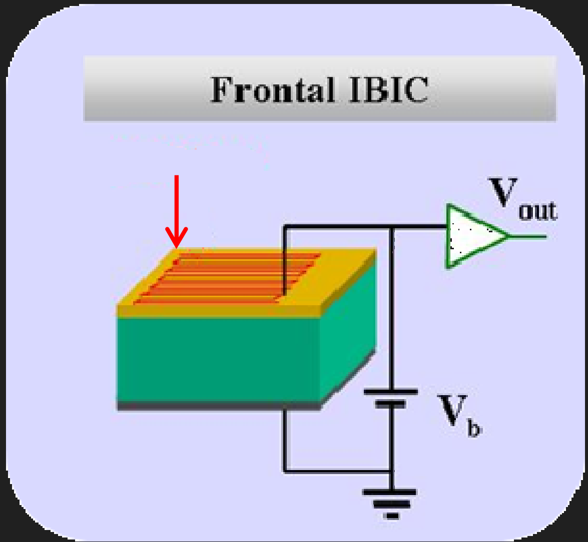
Free charge genetration and transport

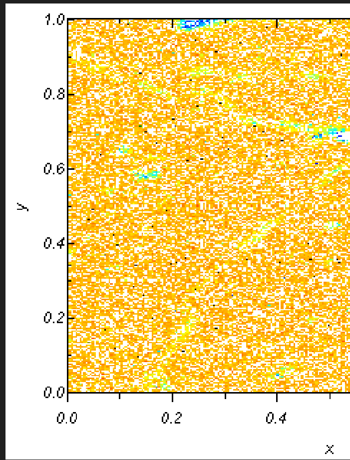
Ouput signal V_{out}

opservable: $CCE = Q/Q_0$

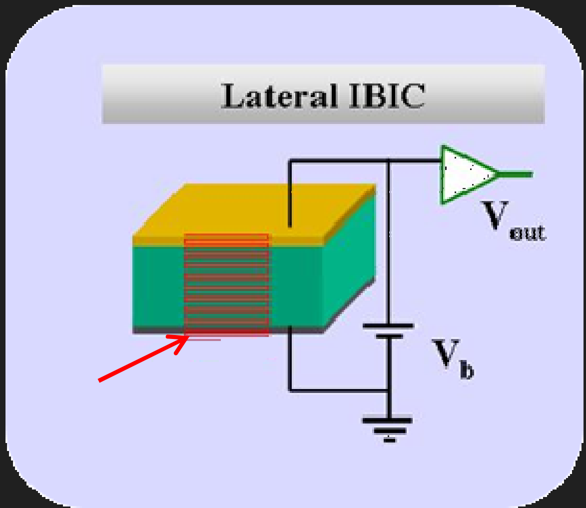
V_{out} = F (deposited energy, free carrier transport)

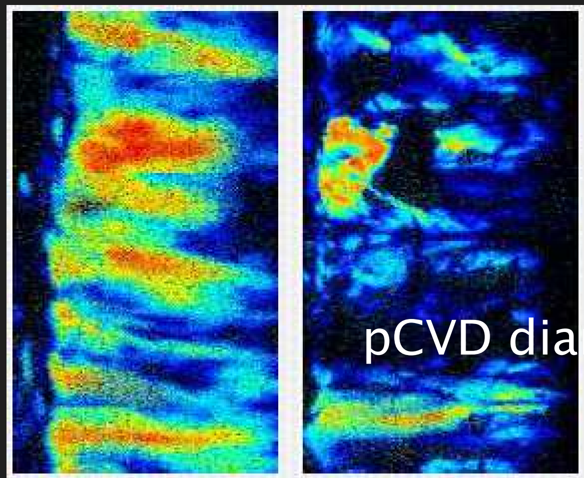
Ion Beam Induced Charge – imaging





scCVD diamond

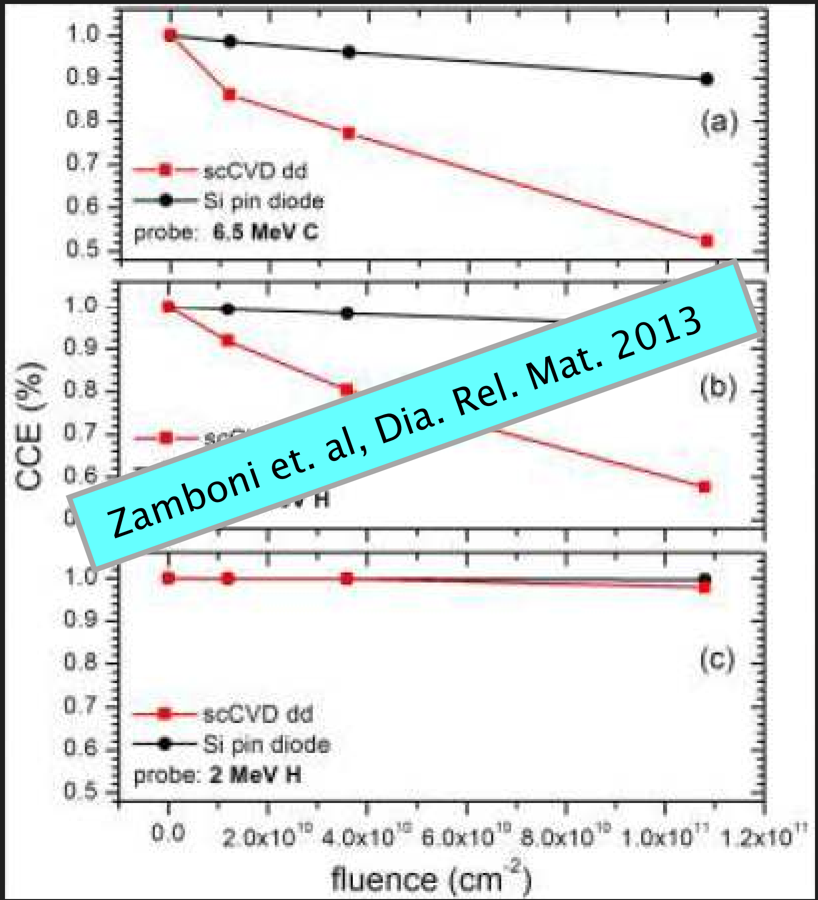




pCVD diamond

Motivation

Last year:



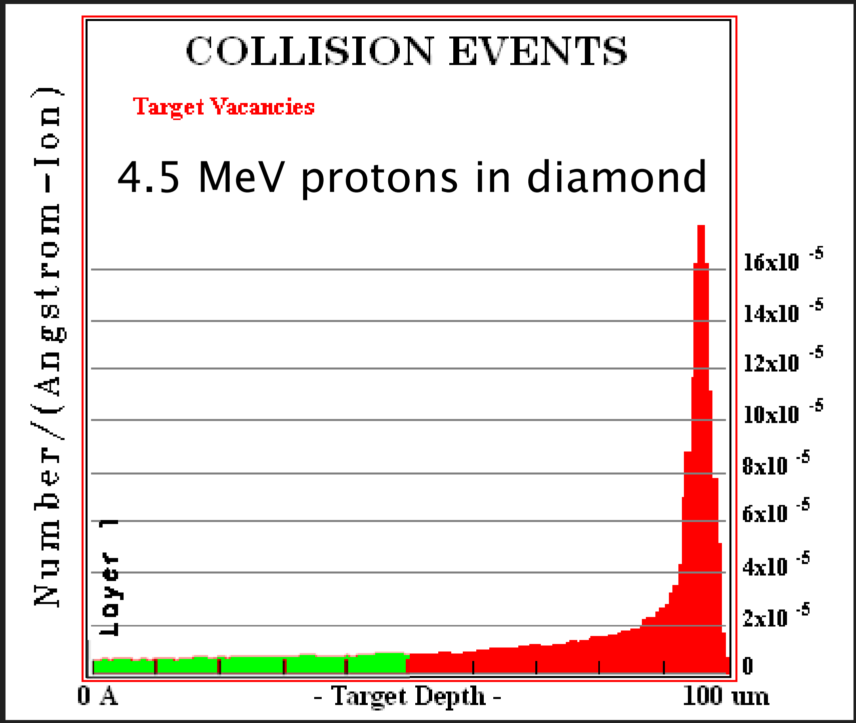
Possible problems:

- ➢ surface effects (contacts)
- ➢ polarization

This year:

- ➢ homogeneous distribution of radiation induced defects

MeV proton irradiation of thin detectors



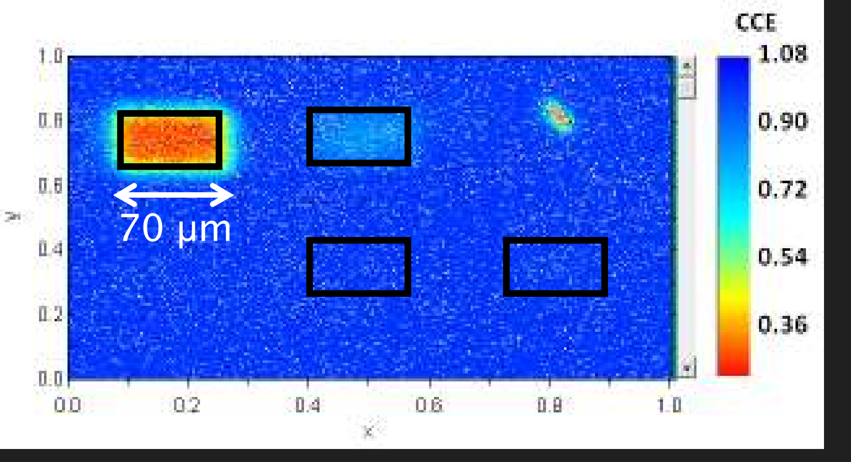
SRIM 2008.04

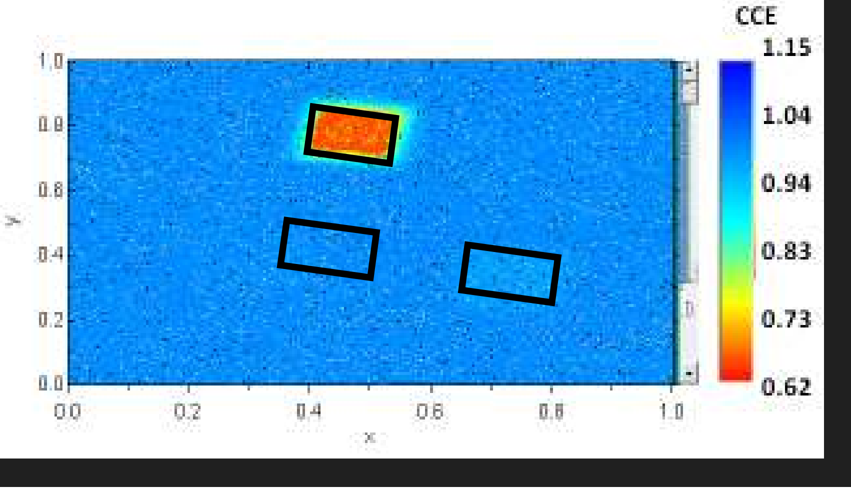
Samples and irradiation conditions

- 50 µm thick scCVD diamond detector from Diamond Detectors Ltd.

- 50 µm thick SSB detector from ORTEC

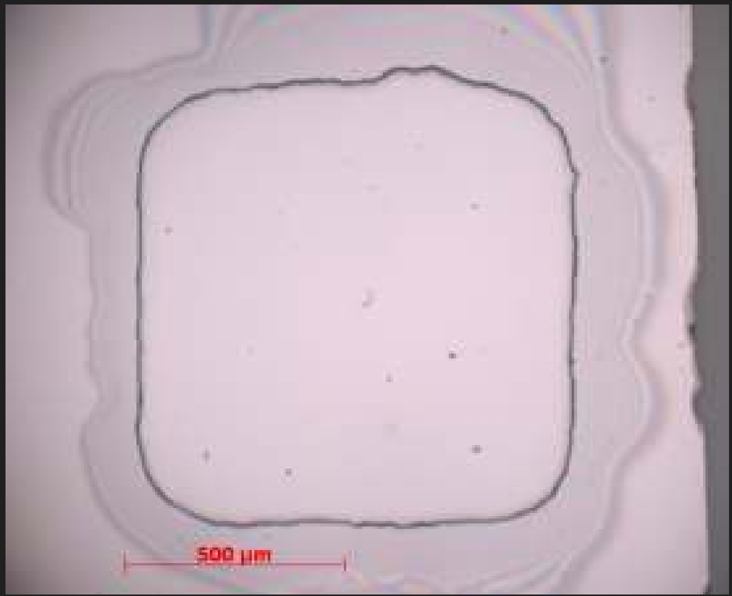
- irradiation: 4.5 MeV protons
  beam current ~ 1pA
  beam resolution ~ 1µm

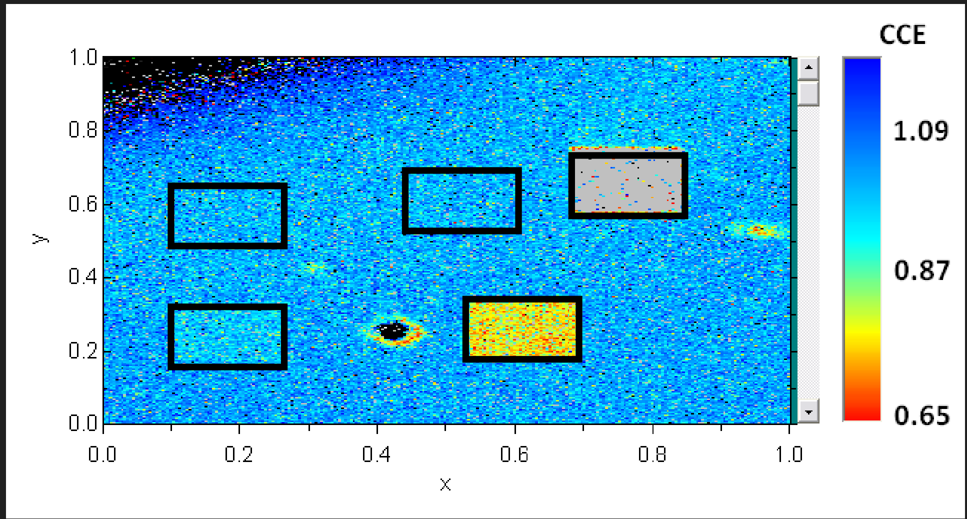




Samples and irradiation conditions

- 6 µm thick diamond membrane (optical grade) from Michal Pomorski Ltd. ☺



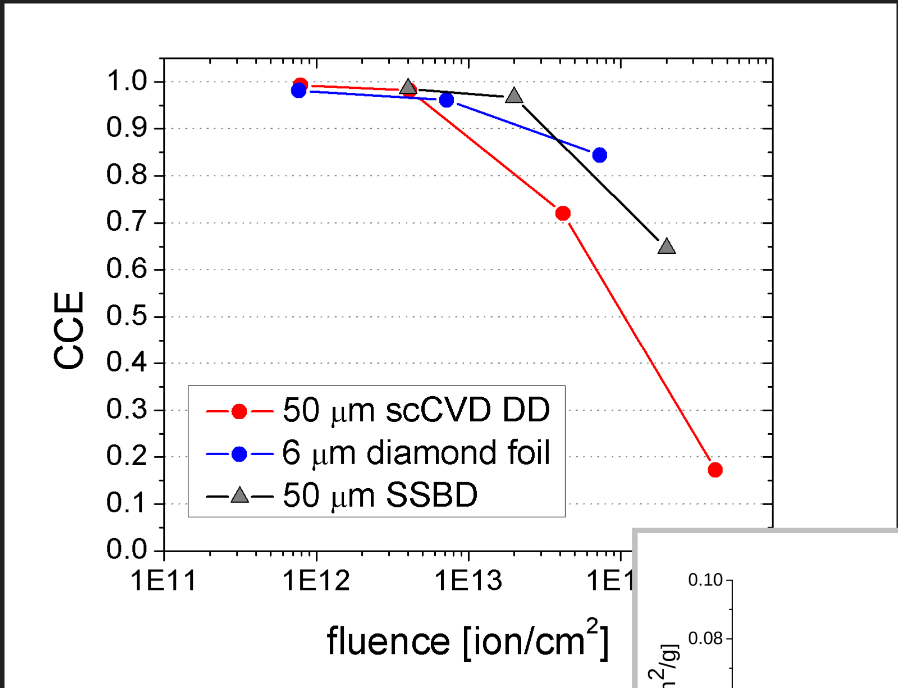


- irradiation: 2 MeV protons
  beam current ~ 1pA
  beam resolution ~ 1µm

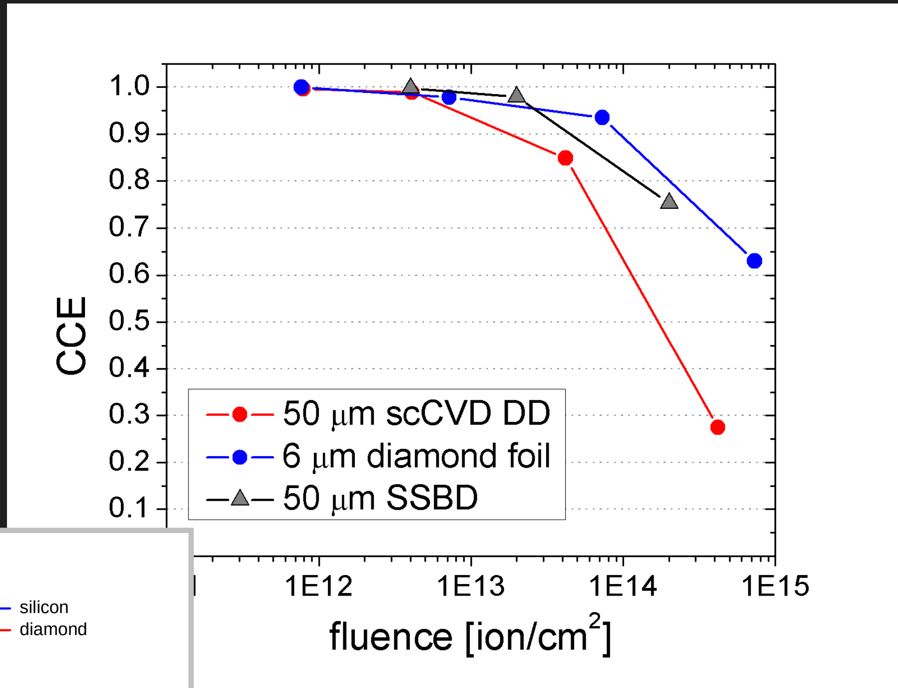
Radiation hardness results

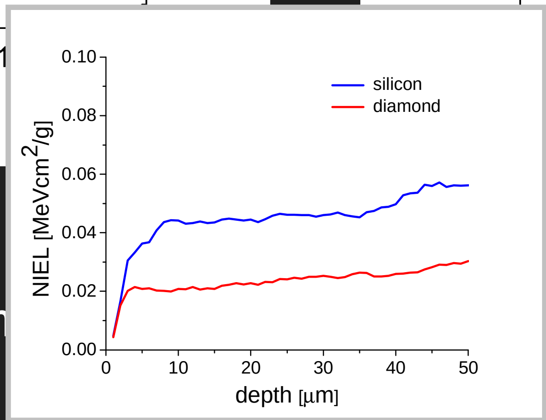
- IBIC done with transmitting ions:

1 V/μm



2 V/μm

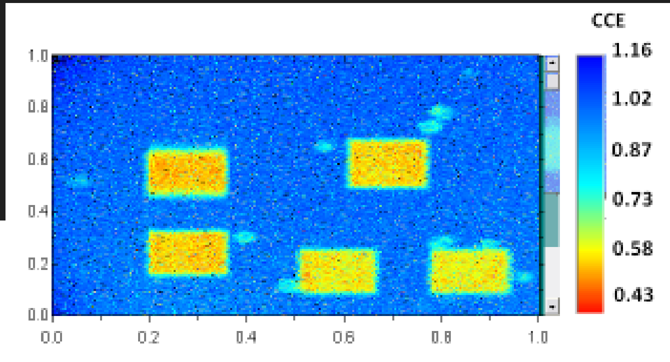


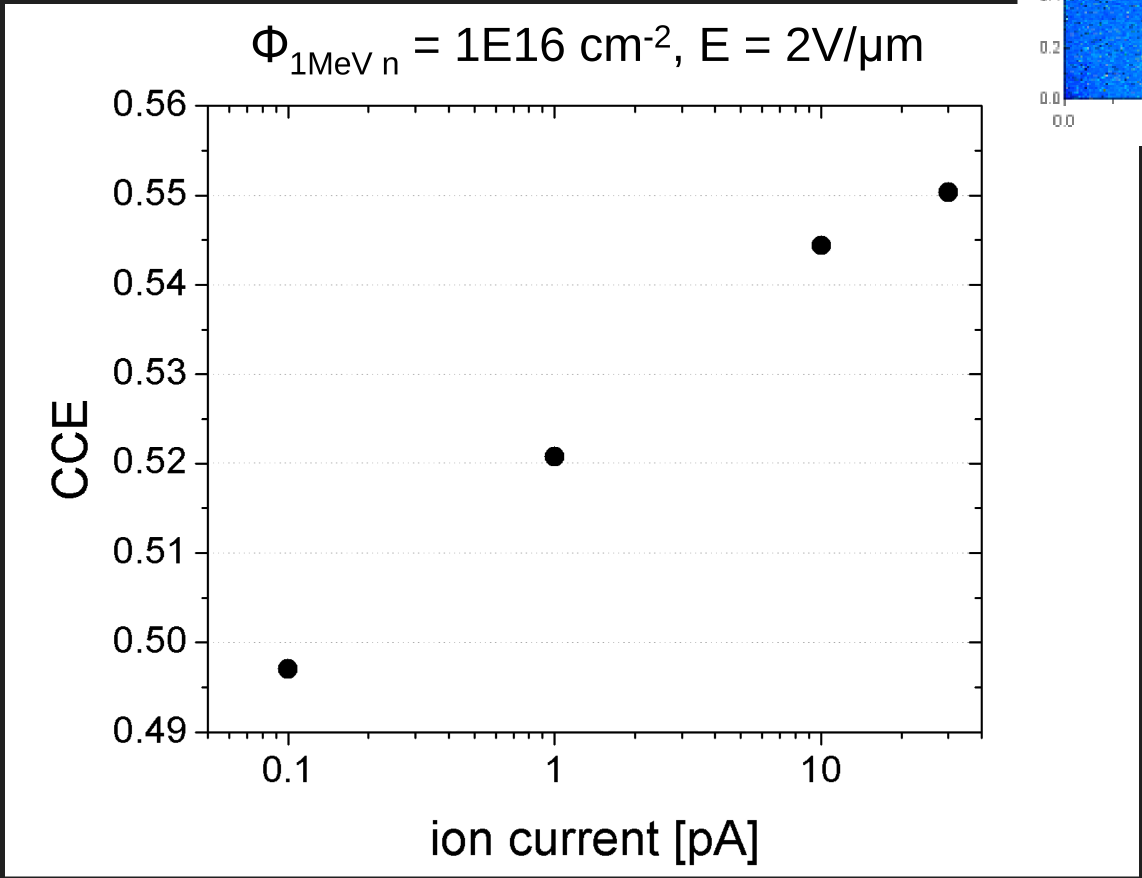


– possible explanation ... g dominates, annealing

Dose rate influence

- same fluence, different ion current:

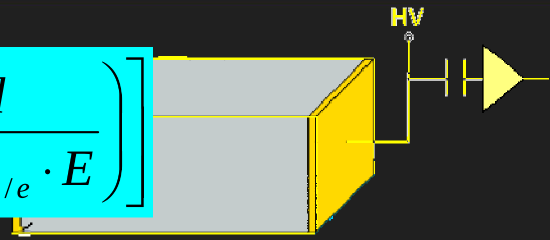


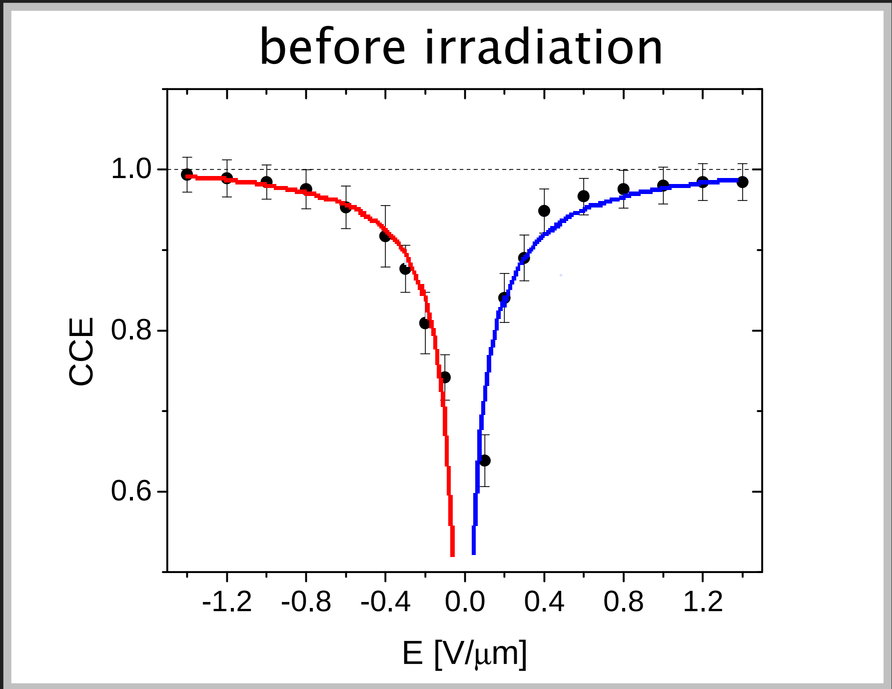


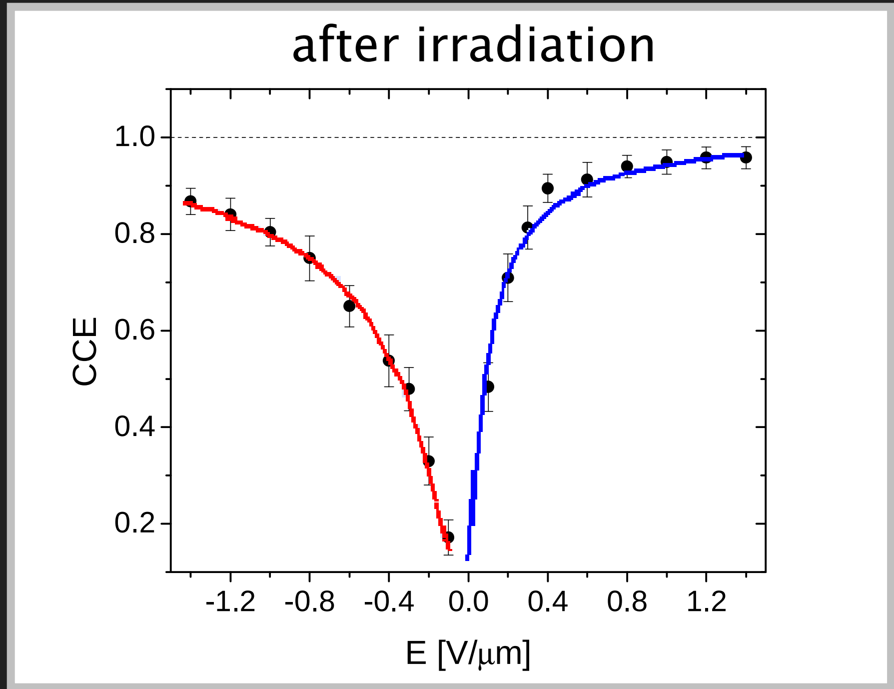
Short-range IBIC probe

- sample: 50 μm thi
- probe: 500 keV p
  range in

$$CCE = \frac{(\mu\tau)_{h/e} \cdot E}{d} \cdot \left[1 - \exp\left(- \frac{d}{(\mu\tau)_{h/e} \cdot E} \right) \right]$$







$(\mu\tau)_e = (6.2 \pm 0.2) \times 10^{-5} cm^2/V$

$(\mu\tau)_h = (5.4 \pm 0.2) \times 10^{-5} cm^2/V$

$(\mu\tau)_e = (8.9 \pm 0.2) \times 10^{-6} cm^2/V$

$(\mu\tau)_h = (3.0 \pm 0.2) \times 10^{-5} cm^2/V$

To conclude...

- microprobe + IBIC = powerful technique for irradiation of selected detector regions and characterization of electrically active defects produced
- radiation hardness of diamond decreases when switching from GeV to MeV energy range of impinging ions
- shortening of charge carrier transport time is effectively increasing detector resistivity to radiation
- produced defects can have different influence on electrons and holes
- concentration of defects remaining after the irradiation is dose dependant

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Michal Pomorski, CEA

Tomihiro Kamiya, Wataru Kada, JAEA

Thank you for attention!