Études de collection de charges sur la plateforme AIFIRA

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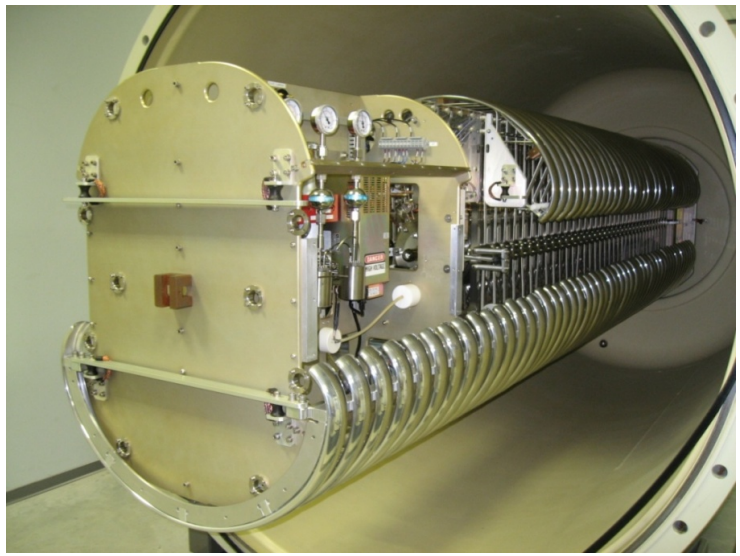
1. AIFIRA

2. Examples of detector characterization

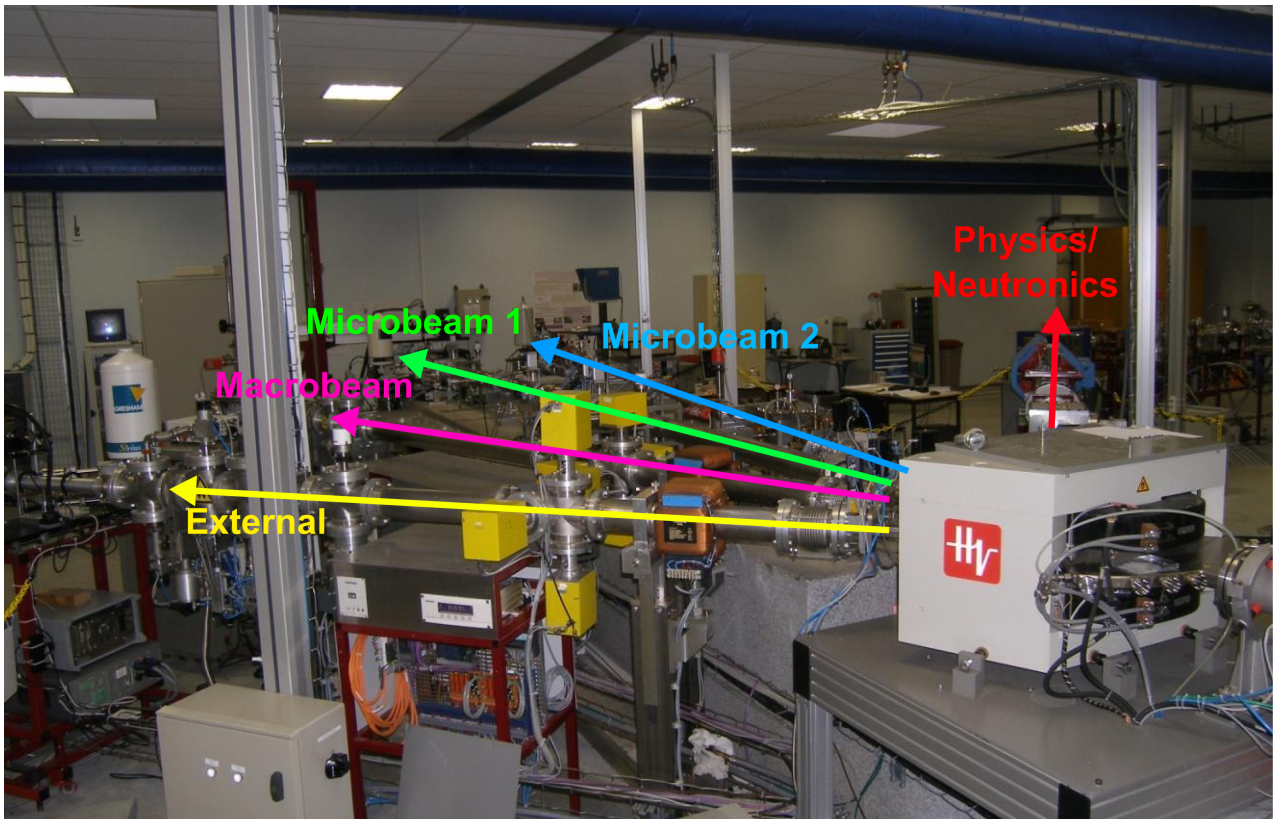
AIFIRA facility

Applications Interdisciplinaires des Faisceaux d'Ions en Région Aquitaine

- Single stage accelerator $\rightarrow$ Singletron 3.5 MV (HVEE)
- RF ion source $\rightarrow$ H^+ , D^+ , He^+ beams



5 Beamlines



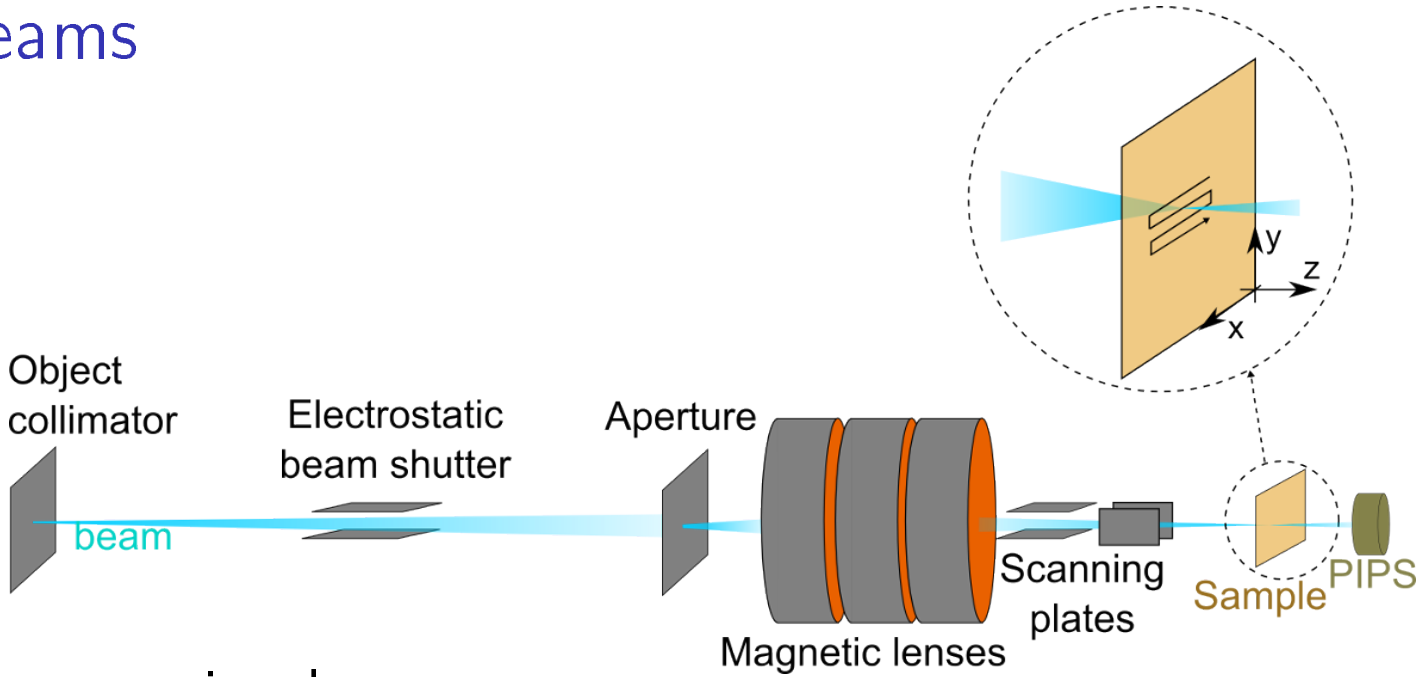
- Primary Particles
  - protons, deuterons and helium 0.5 to 3.5 MeV
  - High beam brightness and energy stability
- Secondary particles
  - neutrons $\rightarrow$ 0.1 to 2 MeV and 4 to 6 MeV
  - $\gamma \rightarrow$ 6.1 MeV from $^{19}F(p,\alpha\gamma)O^{16}$

Microbeams

AIFIRA is equiped with 2 microbeam lines :

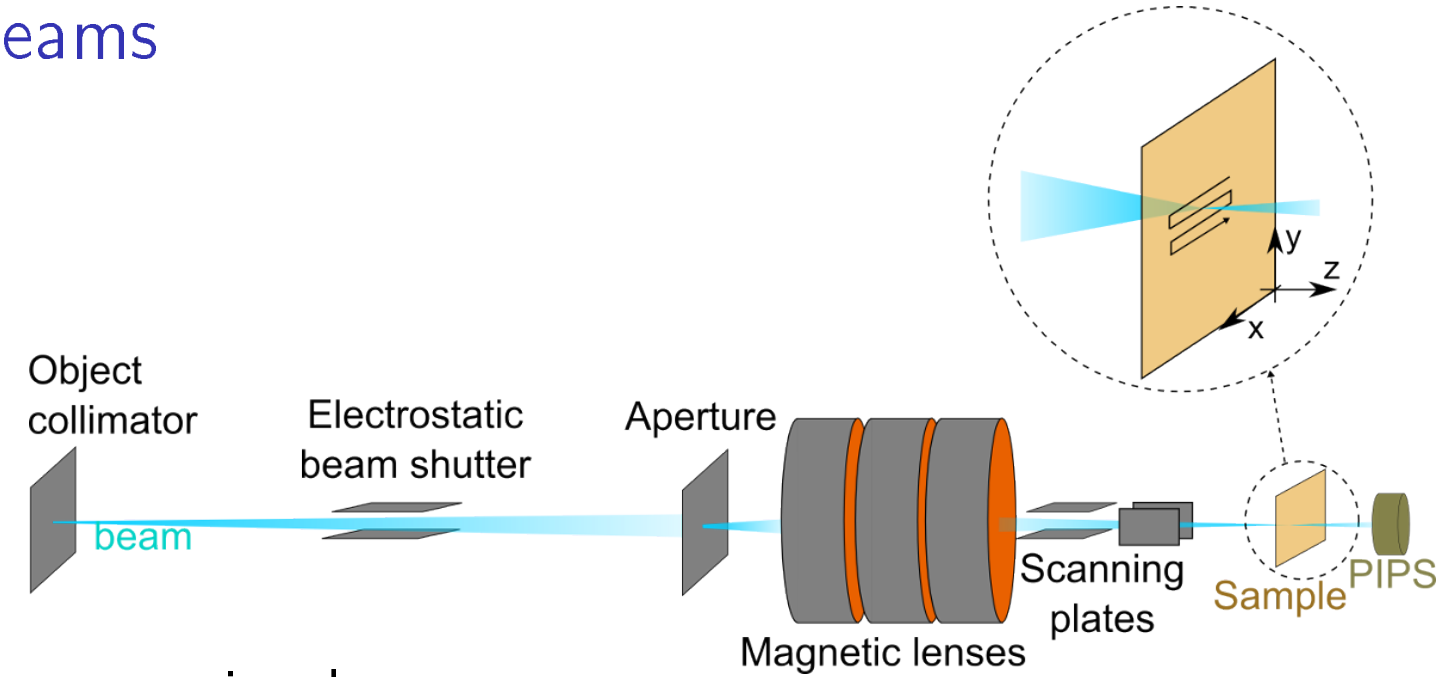
- Micro-irradiation of biological samples
- Ion beam microanalysis :
  - Particle-Induced X-Ray Emission (PIXE)
  - Rutherford Backscattering spectrometry (RBS)
  - **Scanning Transmission Ion Microscopy (STIM)**
  - **Ion Beam Induced Charge (IBIC)**
  - Secondary electrons microscopy (SEM)

Microbeams



- Beam spot size down to
  - 300 nm,low intensity (kHz)
  - 1 μm, intensity = pA to nA
- Electrostatic scanning (sub-millimeter frames)
- Motorized sample holder (cm motion)
- Acquisition system with 2D mapping capabilities (MPA-3 FastCom Tech)

Microbeams



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$\Rightarrow$ Useful tool to study charge collection in semi-conductors at μm scale

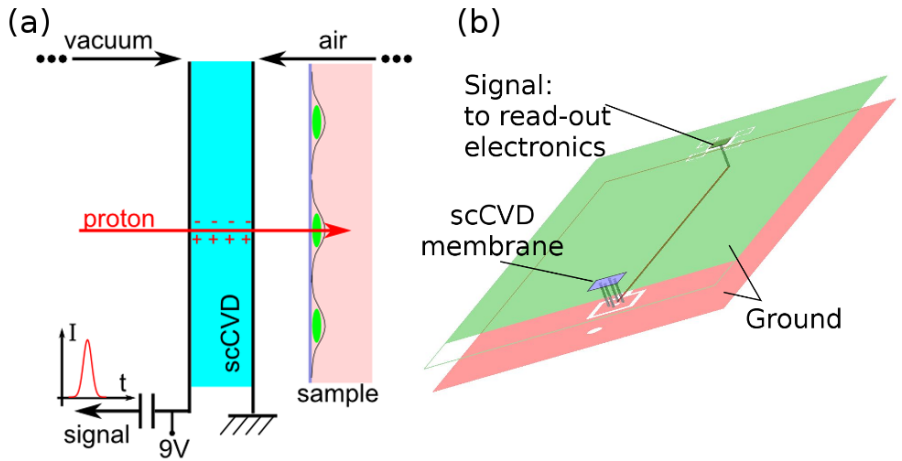
1. AIFIRA

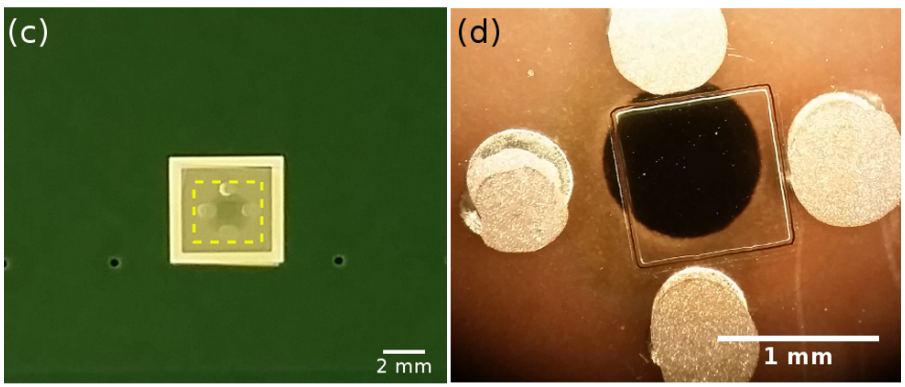
2. Examples of detector characterization

characterization of thin diamond membranes

Context: development of thin transmission detectors for radiobiology experiments @ microbeams.

Idea: developping thin scCVD diamond membranes for the detection of 3 MeV protons

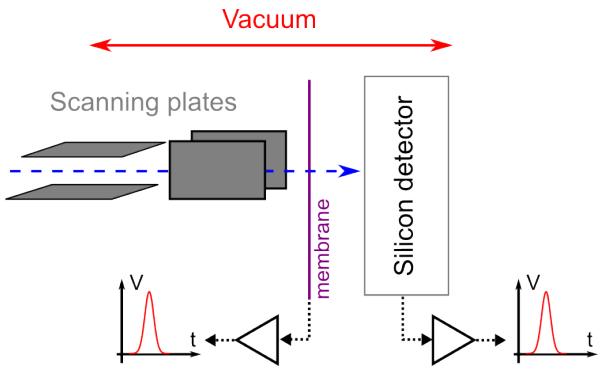


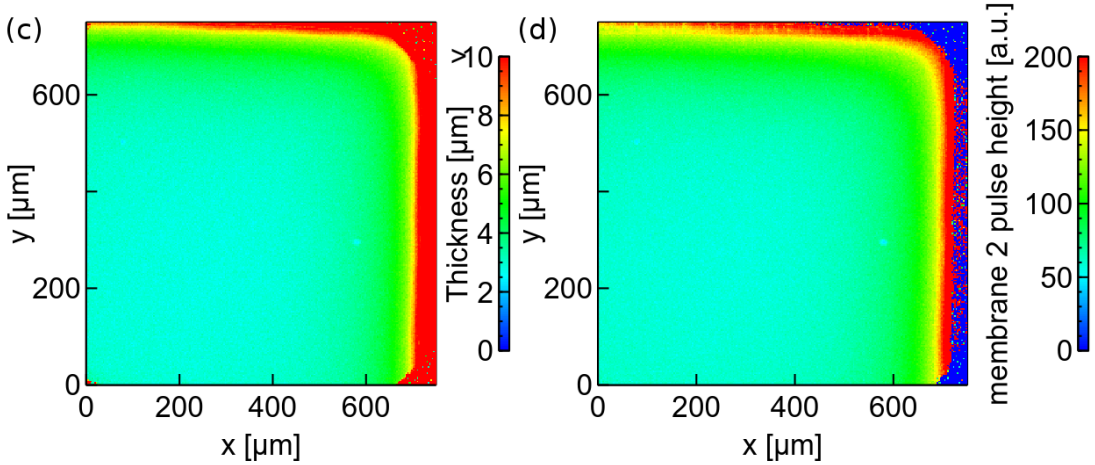


Questions:

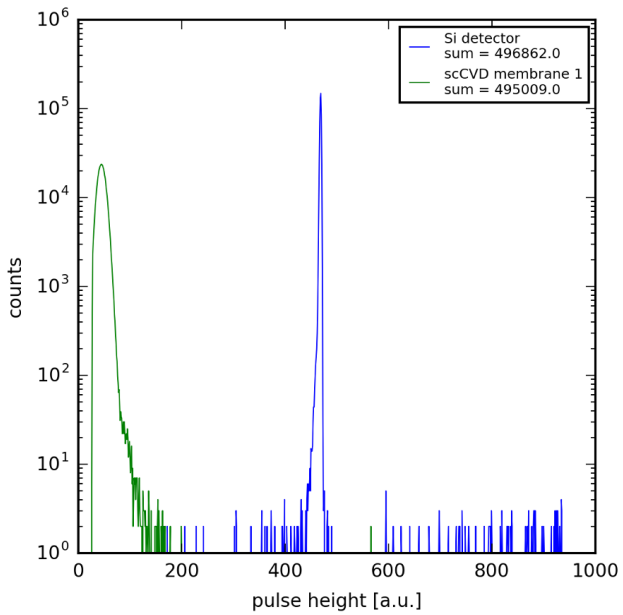
- thickness and energy loss ?
- detector homogeneous over 1 mm^2 ?
- 100 % efficient ?
- radiation damage ?

characterization of thin diamond membranes





thickness and signal mapping

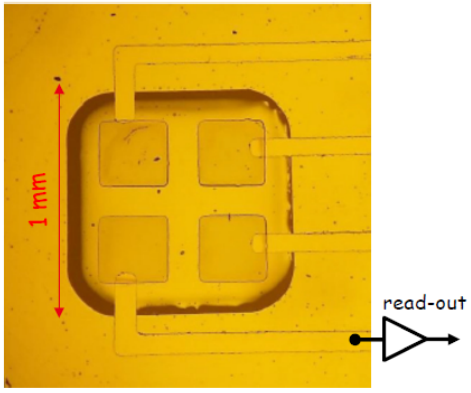


Coincidence measurement

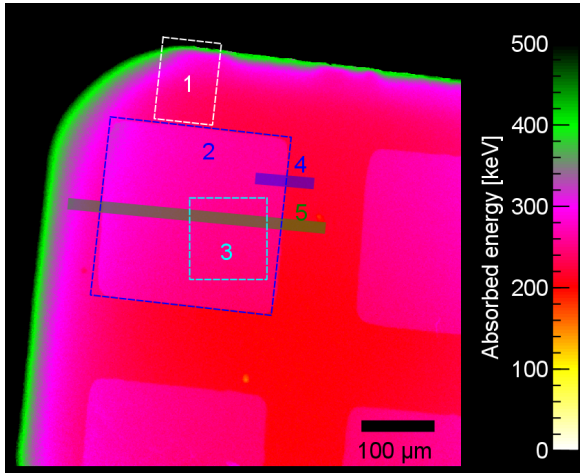
$\Rightarrow$ efficiency

Barberet et al., Applied Physics Letters 111(24), 2017

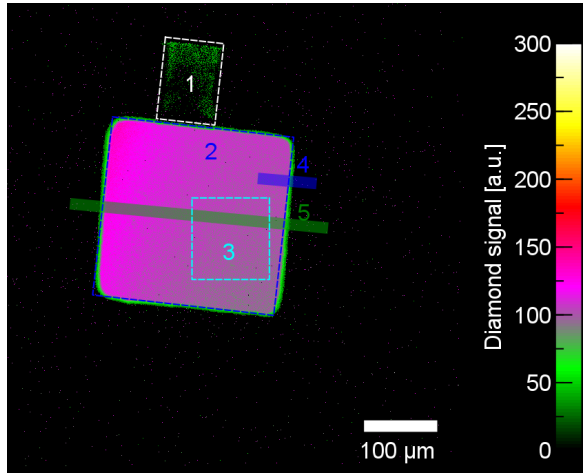
scCVD diamond microdosimeter for hadron therapy



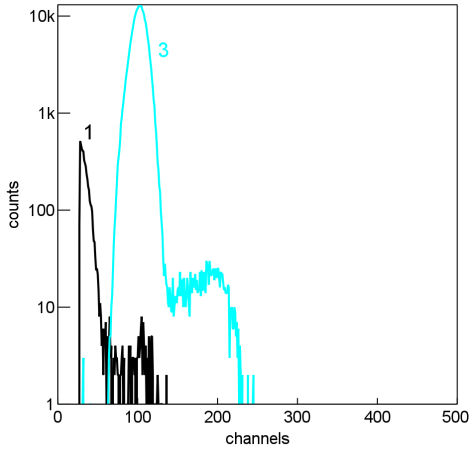
300 μm pixels (SV),
6 μm thick scCVD diamond membrane

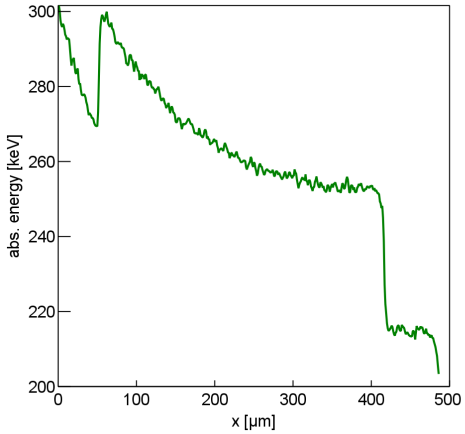


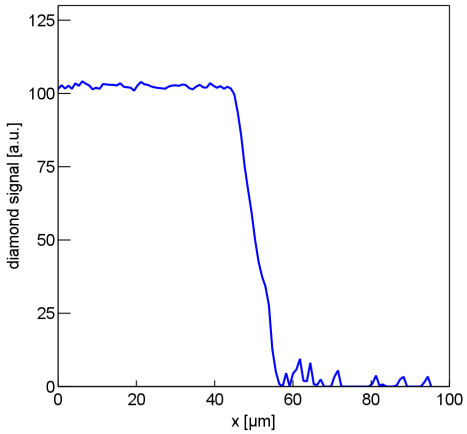
Absorbed energy map



signal map



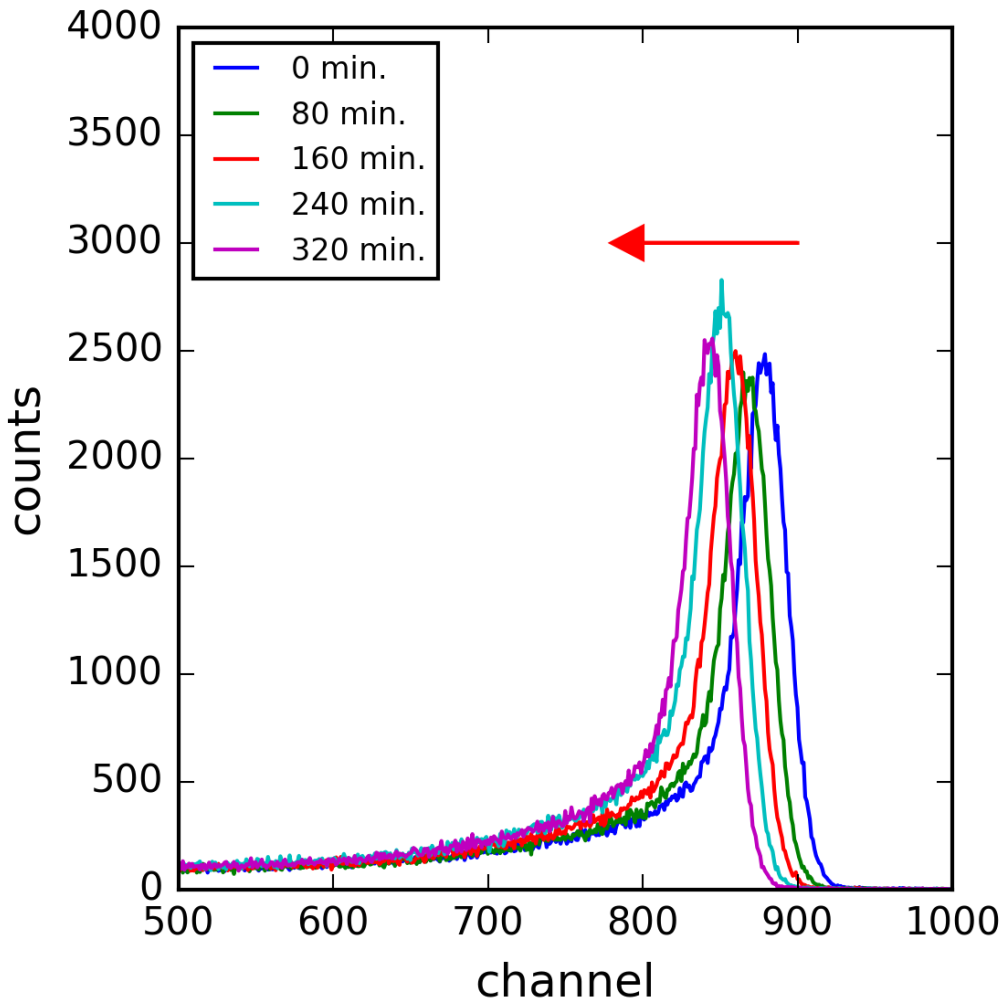




Preliminary data → See talk I. Zahradnik & M. Pomorski tomorrow

radiation damage

Possibilities of "time-lapse" acquisition at various irradiation times (*i.e.* fluences)



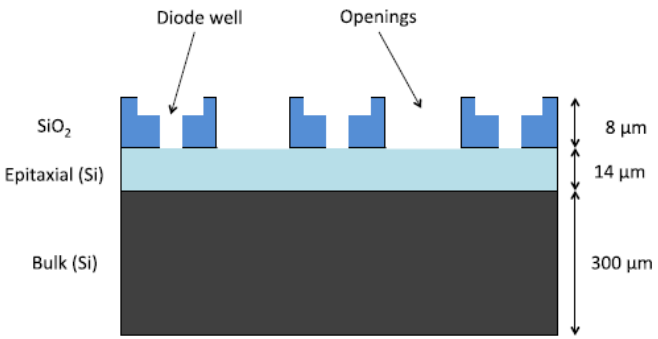
Evolution of one sensitive volume under irradiation

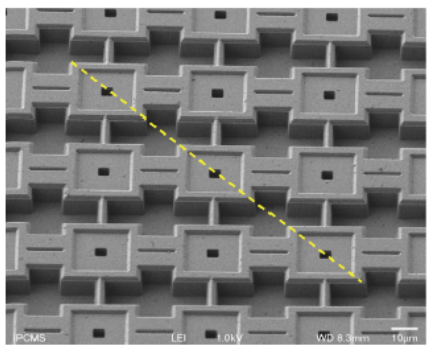
3 MeV α-particles
2500 cps delivered on
$100 \times 100 \mu m^2$

Micro-scale characterization of a CMOS-based neutron detector

Context: Development of a neutron dosimeter in-phantom measurements in radiation therapy $\rightarrow$ AlphaRad Sensor

- realtime monitoring
- high transparency to γ-rays
- accurate fast/thermal neutrons separation
  - thermal n from ^{10}B converter
  - fast n : recoil proton from converter (polymer or phantom)



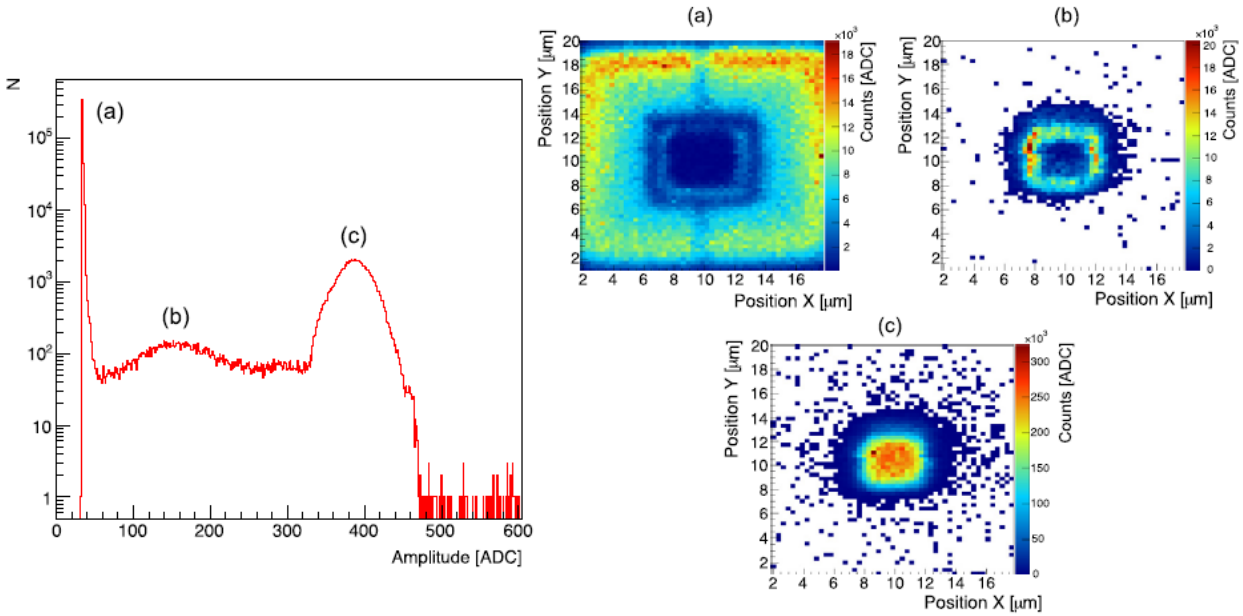


Aim:

- precise calibration of the signal amplitude
- charge collection in the different parts of the sensor ?

DeSIs group @ IPHC, Strasbourg : *Arbor et al., NIM A 888 (2018) 103–109*

Micro-scale characterization of a CMOS-based neutron detector



Maps of the charge collection in the different parts of the sensor (2.2 MeV α-particles)

- correlation between the signal amplitude and the main geometrical features
- energy-amplitude relation $\rightarrow$ selection of the particles $\rightarrow$ separation of fast and thermal neutrons

Arbor et al., NIM A 888 (2018) 103–109

Conclusion

Charged-particle microbeam are useful to characterize "small" detectors (pixel, membranes ...):

- Charge collection 2D mapping
- Correlation CCE vs detector geometry
- Thickness measurements using STIM (if < 100 μm)
- Radiation damage studies

Successful for characterization of diamond membranes and AlphaRad sensor

Characterization of diamond microdosimeters in progress ...

Beam time opened to external users

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