Jornadas de colaboración de la Universidad de Sevilla con el CERN

Research activities at the 3 MV Tandem accelerator of the CNA

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Unión Europea
Fondo Europeo de Desarrollo Regional
"Una manera de hacer Europa"

MINISTERIO DE ECONOMÍA Y COMPETITIVIDAD

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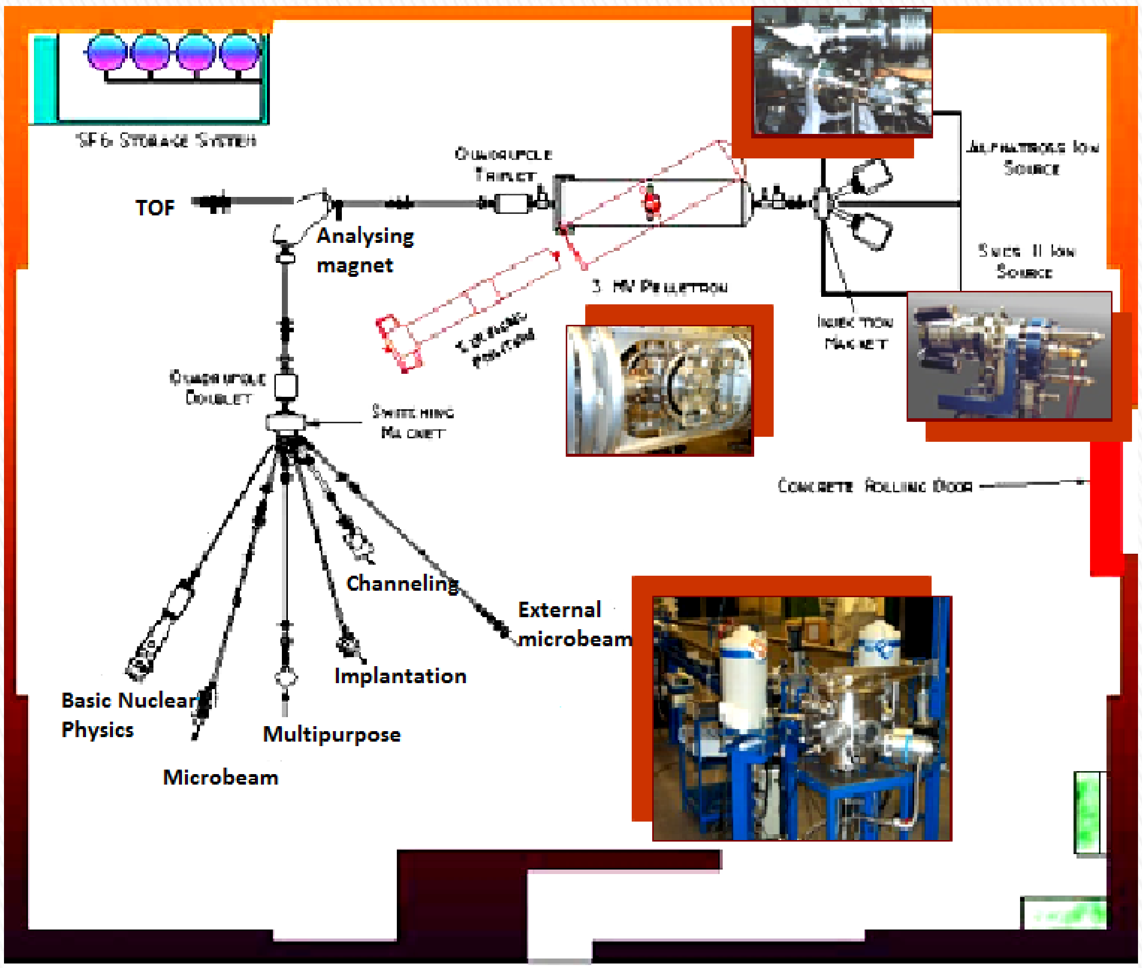
PROYECTO COFINANCIADO POR LOS FONDOS FEDER

25 May 2017, Sevilla

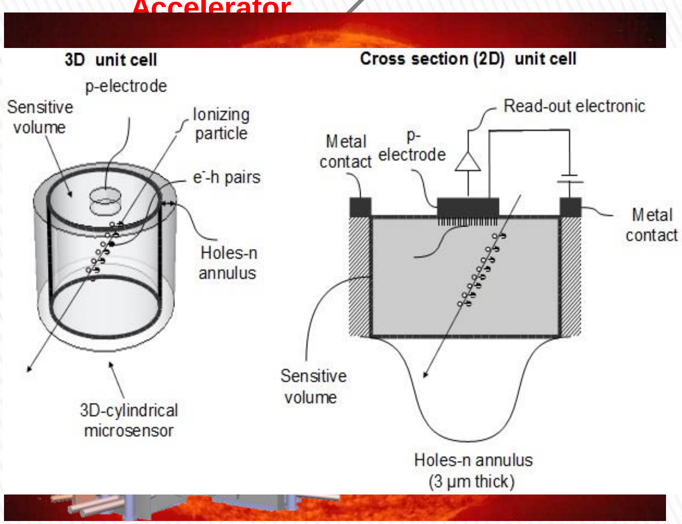
3 MV Tandem accelerator

- All stable ions available: H – Au
- Energy range: 600 keV – few MeV
- Beam currents: µA – pA
- Continuous and pulsed beams

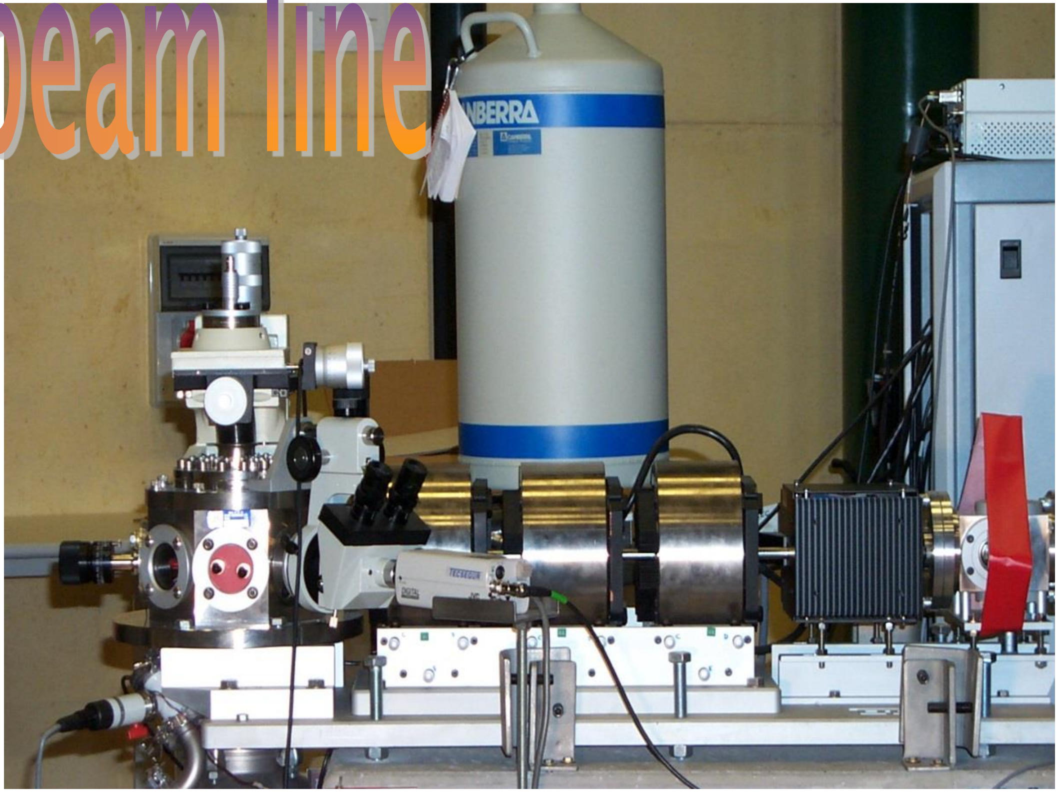
* Analysis of materials (RBS, PIXE, NRA, IL, etc)
* Materials Modification
* Irradiation Damage (also Cyclotron)
* Neutron Physics
* Radiation detectors



Scintillator detectors
Tracking detectors
Characterization of ion detectors for fusion
Semiconductor detectors



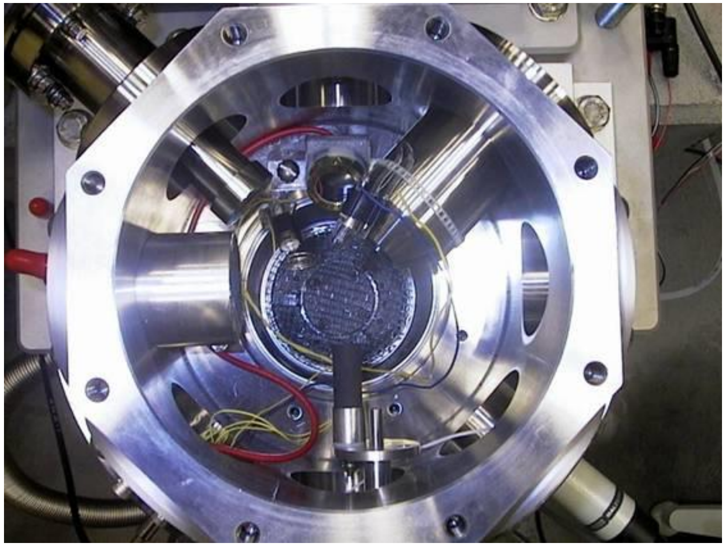
Vacuum micro beam line



- Particle detectors (PIPS)

- X-ray detector (SiLi)

-Microscope



- Ion beam size ~ 4x4 µm²

- Beam current: nA to few pps (micrometric slits)

- Scanning system: few mm²

-Synchronous signal acquisition system with scanning: mappings

Cyclotron 18 MeV H^+/ 9 MeV D^+

-Radioisotope production for PET
-Irradiation of materials, high energy PIXE

Pulsed beam (2.4 ns pulse every 24 ns)

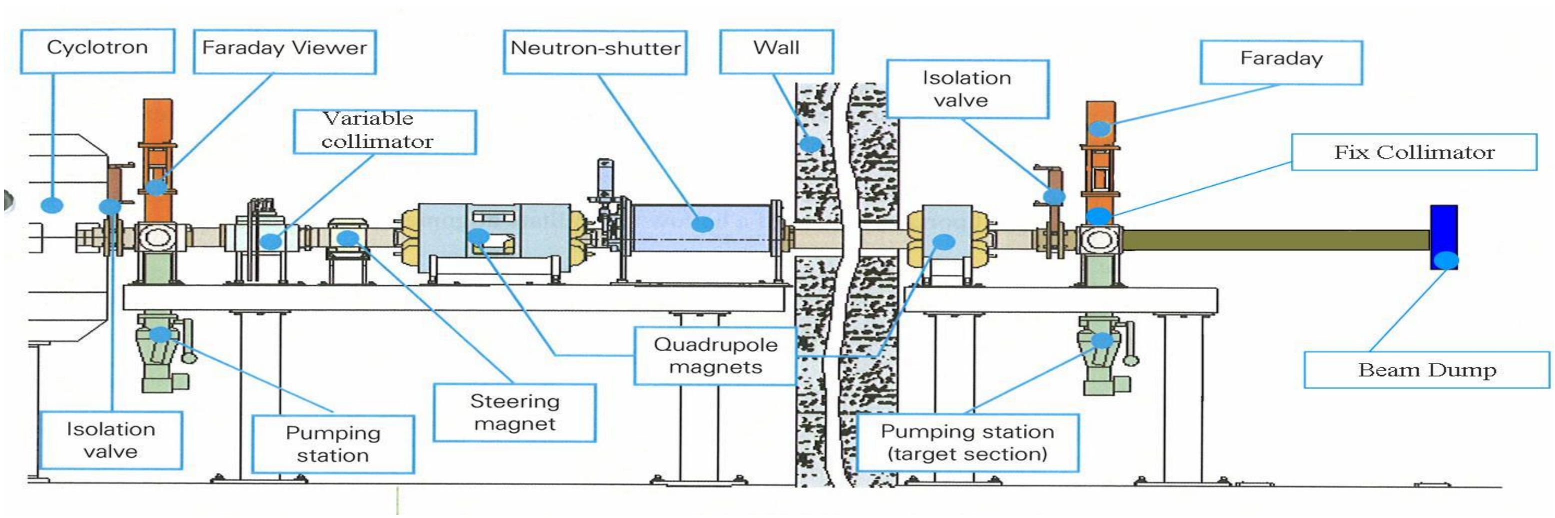
FWHM 200 KeV (1.1%)

Maximum currents ~ tens of µA

Remote control variable collimator & FC
(beam current can be drastically reduced)

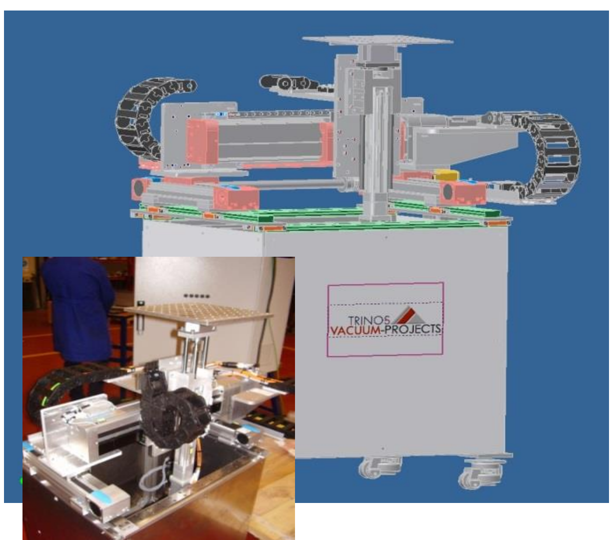
Q-poles & XY steerers

Cyclotron External Beam Line



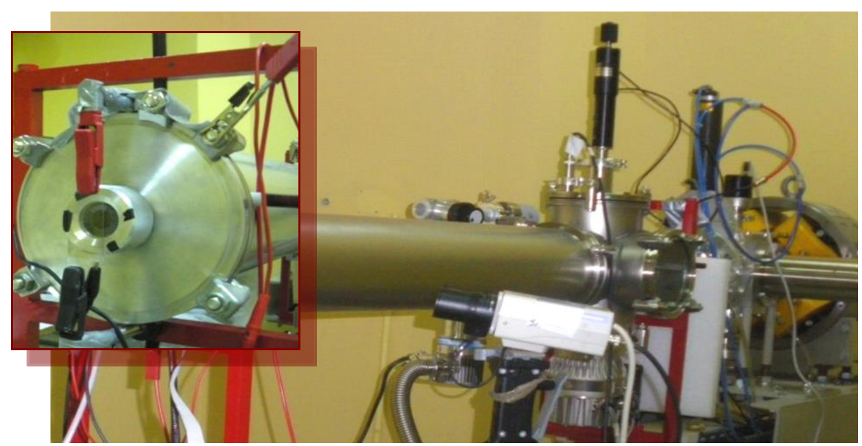
SAMPLE HOLDER

Remote control (step 0.06 mm)
X 200 mm; Y 200 mm; Z 100 mm
Manual movable structure



EXIT FLANGE

Various sizes available
Internally covered with a 5 mm carbon film to avoid the activation.
Different graphite collimators with several hole diameters
Several windows



Strain response of proton-irradiated optical fiber sensors to be used at Large Hadron Collider – CERN

Instituto de Física de Cantabria (IEEE TNS 59, N. 4 (2012) 937)

Radiation sensitivity of Fiber Bragg Gratings – Suitable deformation monitors

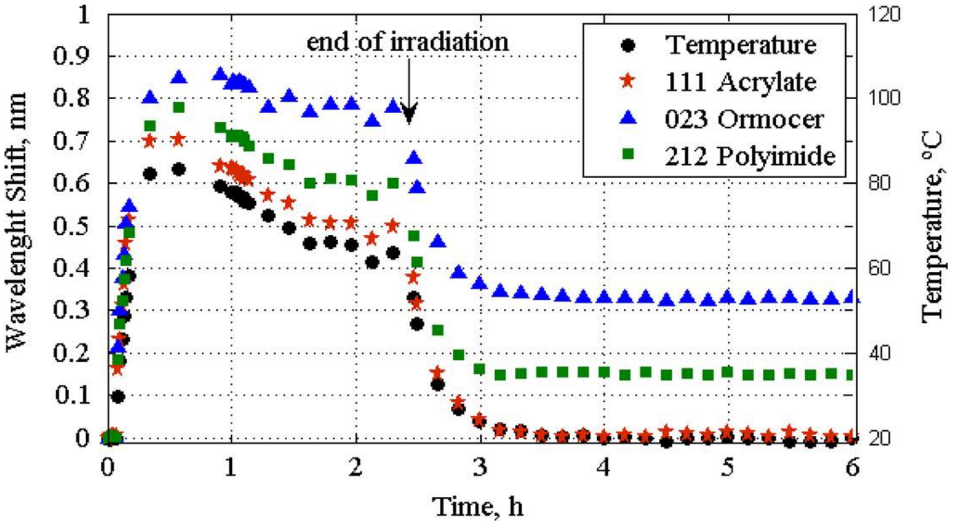
Temperature monitoring on line

Protons 13.5 MeV

Flux $3x10^{11}$ p/cm^{2}s

Fluence up to $3.3x10^{15}$ p/cm^2

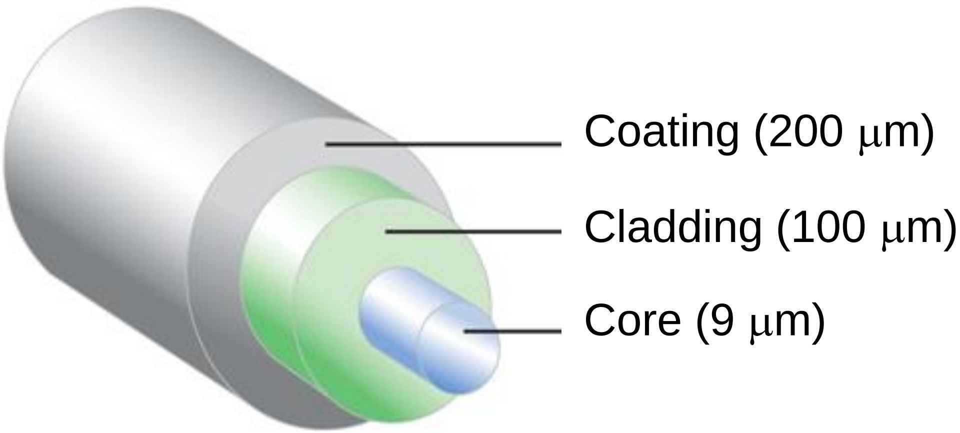
(absorbed dose 15 MGy(SiO_2))



Sensitivity depends on the type of coating

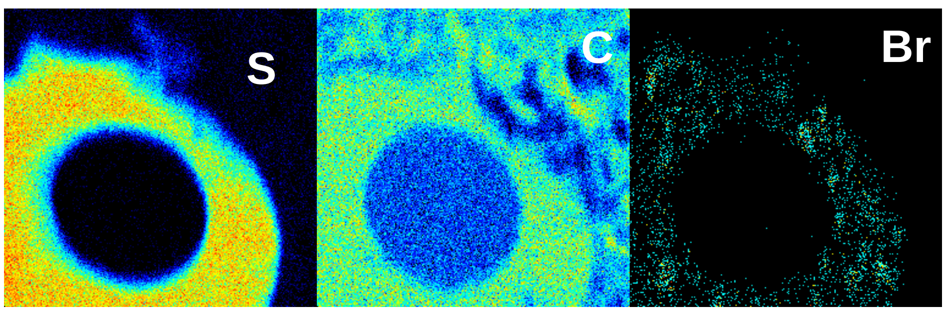
Dependence on fiber composition?

Compositional study of Optical Fibers (microbeam)



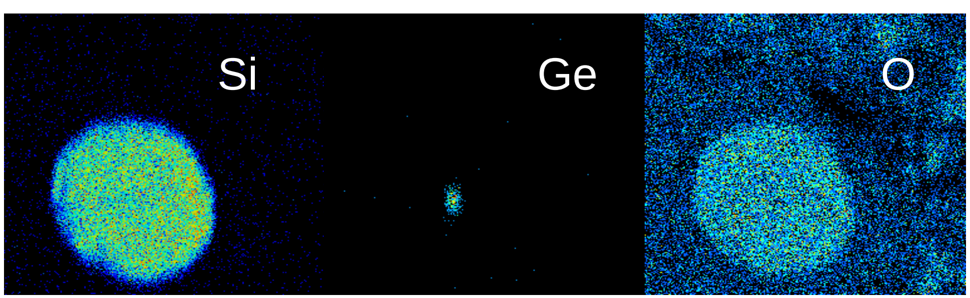
Ion beam analytical techniques (PIXE, RBS, NRA) allows quantification and lateral distribution of elements

Coating



200x200 μm^2 maps

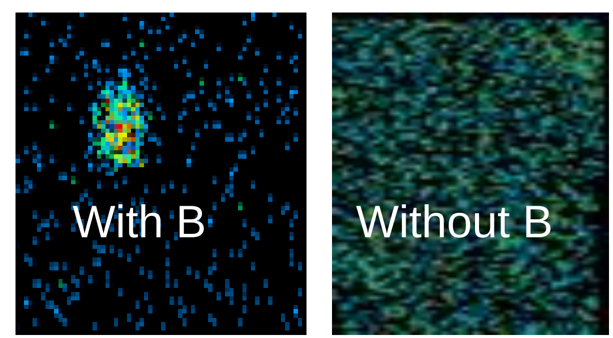
Cladding + core



Boron enriched core (1% at)

$^{11}B(p, \alpha)2\alpha$

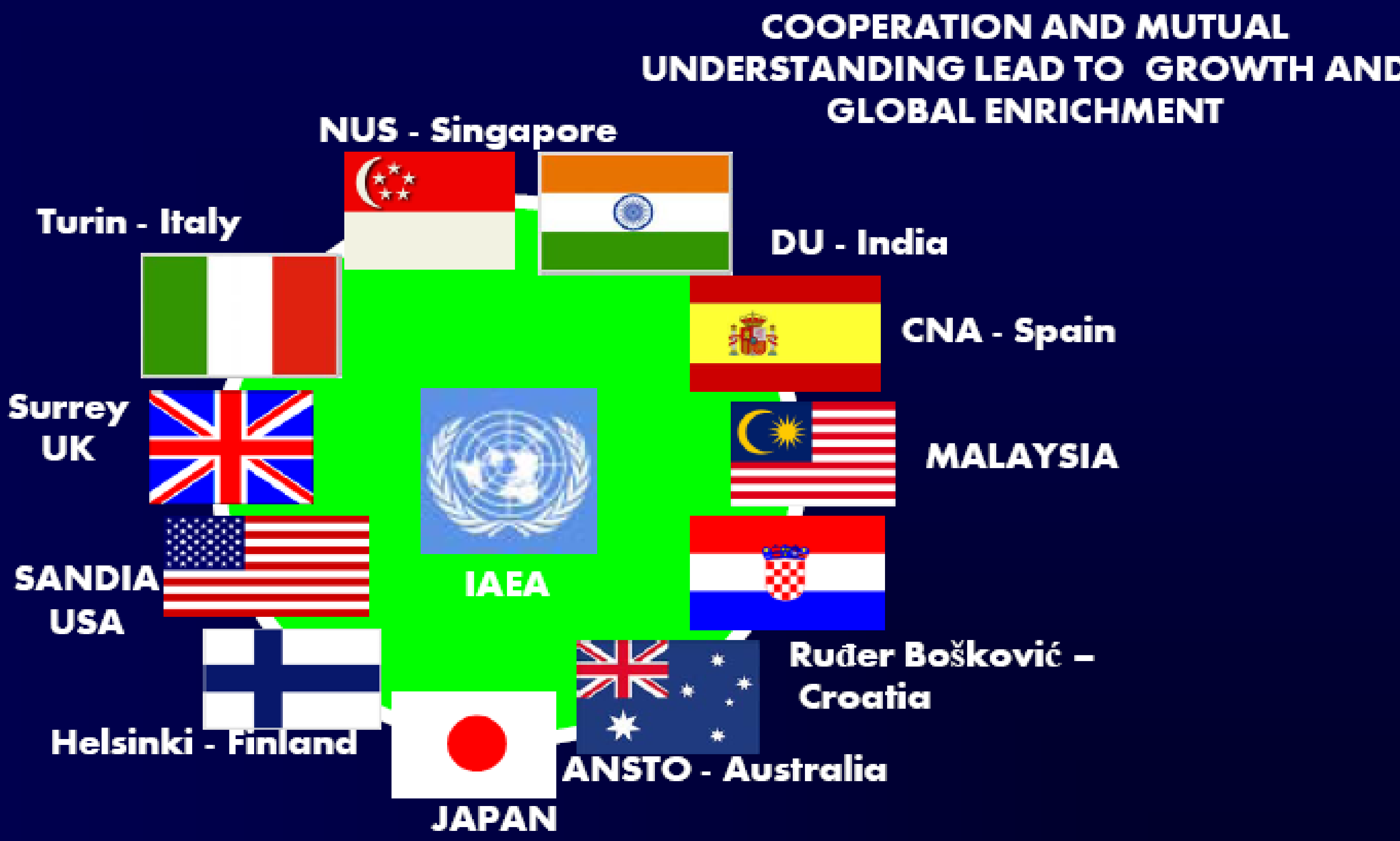
50x50 μm^2 maps



Characterization of SC detectors

IAEA Coordinate Research Programme (CRP) F11016 (2011-2015)

"Utilization of ion accelerators for studying and modeling of radiation induced defects in semiconductors and insulators"



RD50 Collaboration

RD50-Radiation hard semiconductor devices for very high luminosity colliders.

1. Formed in 2001, approved by CERN in 2002.
2. The main objective is:

Development of radiation hard semiconductor detectors for the luminosity upgrade of the LHC to $7.5 \cdot 10^{34} cm^{-2} s^{-1}$.

3. One of the most important challenges is to achieve **radiation hardness up to $10^{16} cm^{-2}$**
4. The current activities of RD50 include:

a)Identifying the defects through dedicated measurement techniques (DLTS, TSC, TCT) or monitoring the macroscopic changes in HEP experiments.

b) Work out how to get rid of damage (or avoid it) –new technologies, new structures (3D sensors, HV CMOS, LGAD, simulation (FLUKA, GEANT4, TCAD…).

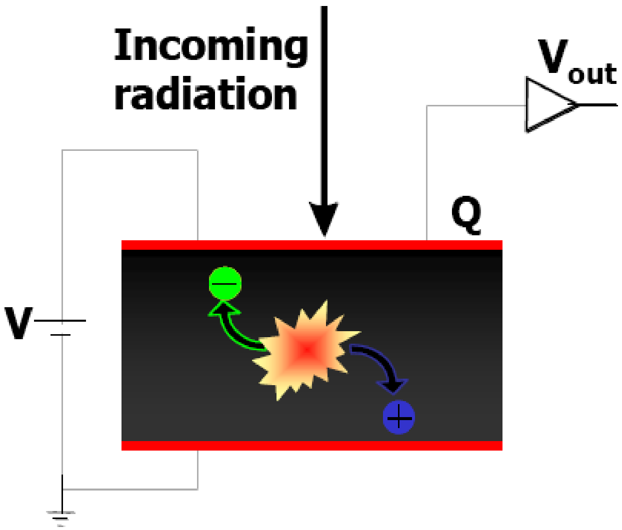
c) test the solution:

- neutron exposition in nuclear reactor,
- proton irradiation at cyclotrons and synchrotrons,
- new dedicated irradiation center @ CERN.

d) Incorporate the feedback from experiments.

Source:
Agnieszka Obłąkowska-Mucha

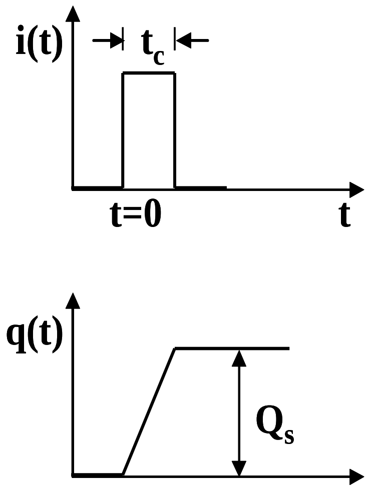
Charge collection efficiency



***Shockley –Ramo theory**: induced current in the external circuit is due to charge carriers moving under influence of electric field in the sensitive volume of SC device*

Charge Collection Efficiency (CCE)

$$CCE = \frac{\text{Induced charge due to motion of the carriers}}{\text{Charge created by the ionizing event}} \leq 1$$



$$\rightarrow \quad V_{out} \propto Q_s$$

- Deposited energy
- Transport of free carriers (E, defects, …)

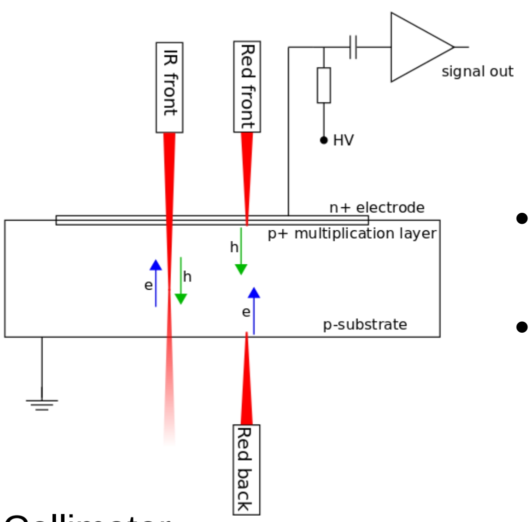
Charge Collection Efficiency of radiation detectors
How to measure it?

RD 50 recommendations for MIP CCE measurements (A. Chilingarov; TN RD50-2004-01)

Pulsed laser

675 nm → Absorption lenght 4 μm

830 nm → Absorption lenght 13 μm

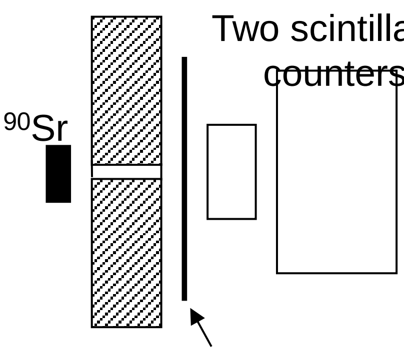


- Lateral resolution ~ 5 μm
- Needs opening in metal

^{90}Sr e^- source

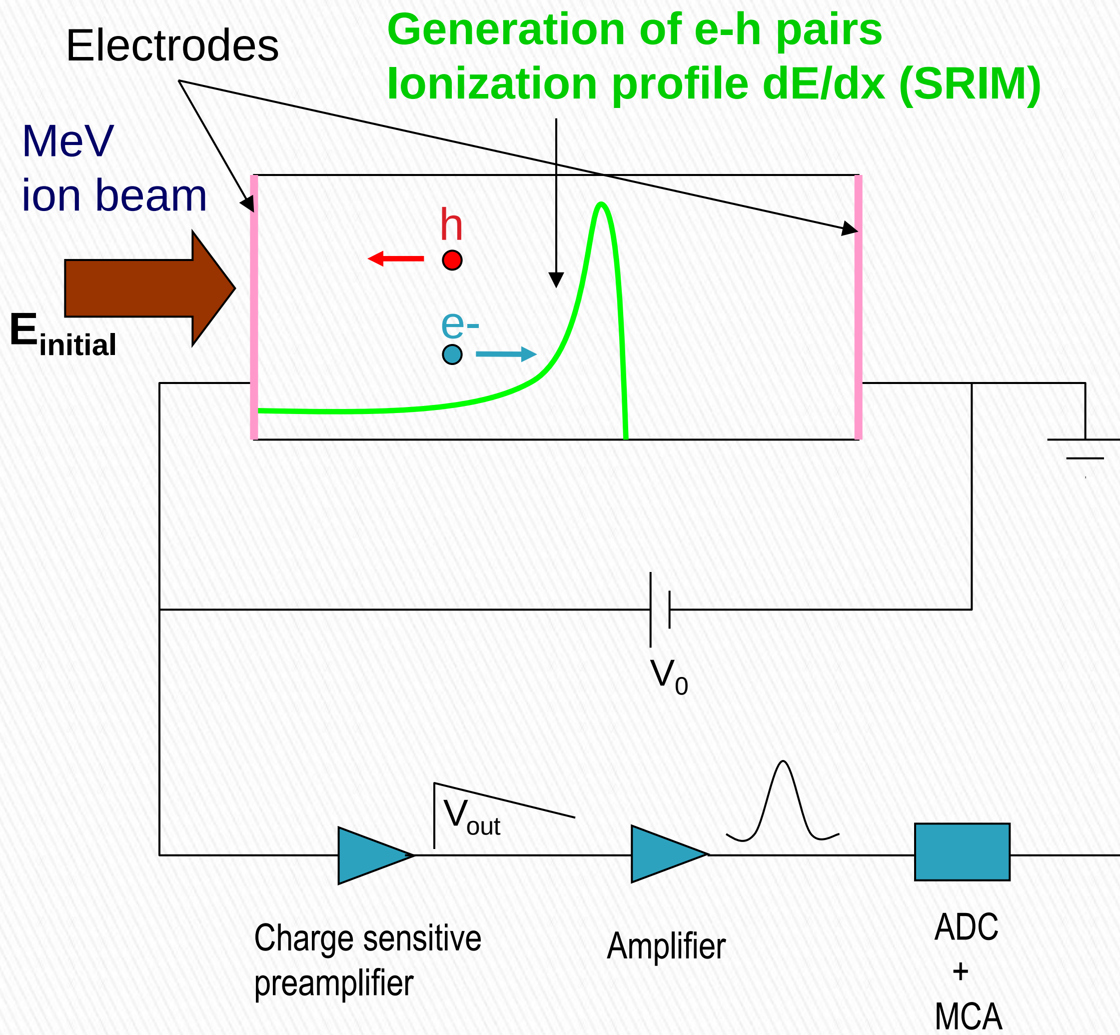
0.55 MeV → Range 1 mm

2.28 MeV → Range 4 mm



- Lateral resolution defined by the collimator
- Low S/N for thin sensors
- Trigger to separate low and high energy β

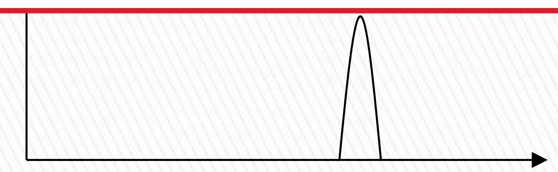
Ion Beam Induced Charge (IBIC)



$$CCE = \frac{E_{Deposited}}{E_{Measured}}$$

- Lateral resolution ~ 4 μm
- Can explore depletion regions through thick metallic and passivation layers
- Use of different ions/energies to explore various depths

Range (H, 4 MeV) ≈ 150 μm
Range (He, 1 MeV) ≈ 15 μm

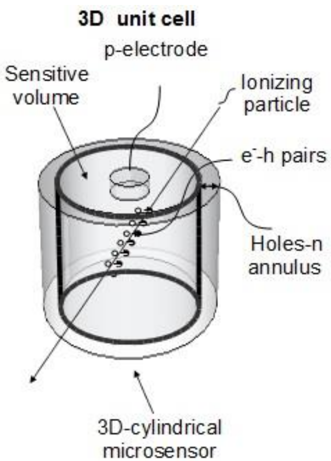


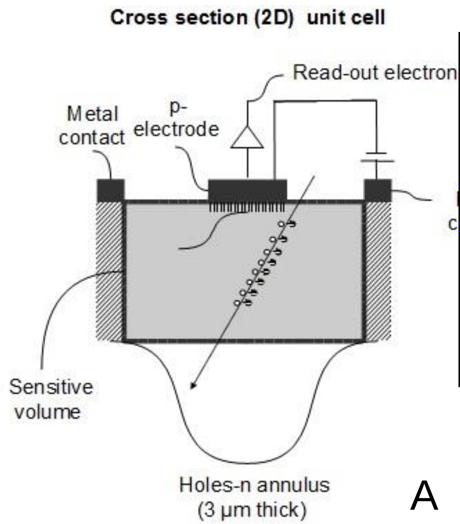
Same electronic chain as used in nuclear spectroscopy

3D Si Detector Characterization by IBIC

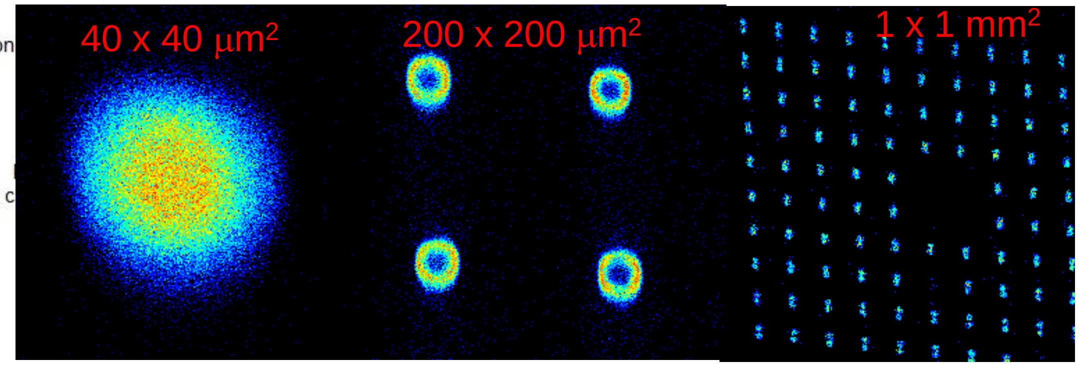
Centre Nacional de Microelectrònica IMB

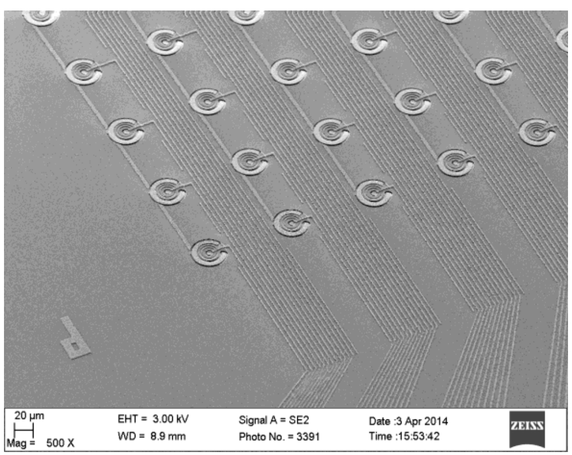
JINST 10 (2015) P10001





IBIC maps -5 MeV He^{2+} in microdosimeters

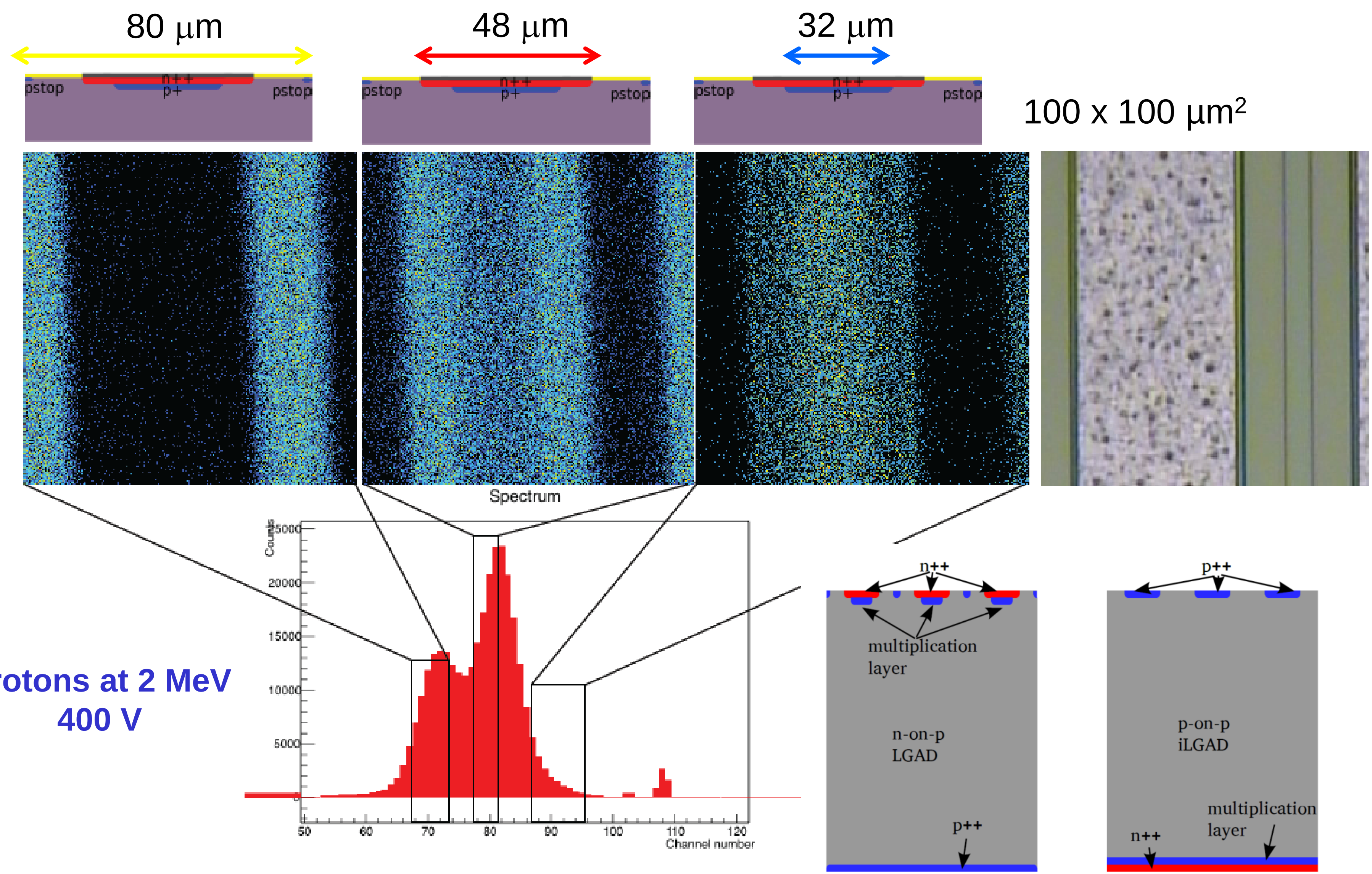




A charge collection study with the ion beam-induced charge collection technique, with microbeams of He^{2+} and H^{+}, has **shown full collection efficiency in the active area of the microsensors at voltages as low as 3 V**, with the **effective radius reduced by 2.5 μm due to the highly doped regions near the cylindrical electrode**.

The IBIC maps also show a 100% yield of active cells in a microdosimeter array, with each microsensor acting as an independent active site.

Multiplication factor in LGAD developed at CNM/IMB



Protons at 2 MeV
400 V

New configuration proposed

CNA collaborations for SC characterization

- **International Atomic Energy Agency (CRP)**

- **CERN (RD50 Collaboration)**

- **Helsinki Institute of Physics**
- **Centro Nacional de Microelectronica- IMB**
- **Japanese Atomic Energy Agency (SiC detectors)**
- **Università Milano-Bicocca &**
  Rutherford Appleton Lab. (Diamond detectors)

Thanks for your attention !!!

CNA

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