

# Radiation Detector Group IMB-CNM, CSIC

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IMB-CNM, CSIC

1<sup>st</sup> Position Sensitive Germanium Detectors  
Workshop

Orsay, 3<sup>rd</sup>-4<sup>th</sup> Octobre 2016



Centro Nacional de Microelectrónica



IMB



**CSIC**

CONSEJO SUPERIOR DE INVESTIGACIONES CIENTÍFICAS

## IMB-CNM

- Instituto de Microelectrónica de Barcelona, Centro Nacional de Microelectrónica
- Public Research Organism, belongs to the Spanish Council for Scientific Research (CSIC)
- Located in Bellaterra, Barcelona (Spain)
- Devoted to Nano and Microelectronics
- Micro Nano Fabrication Facility (Clean Room)
- Departments:
  - Micro and Nano Systems
  - Systems Integration



## IMB-CNM facilities

- Clean Room
  - 1.500m<sup>2</sup>, class 100 to 10.000
  - Micro- and nano-fabrication technologies
  - Three areas:
    - Pure (CMOS)
    - Noble metals allowed
    - Nano-electronics
- Processes
  - 100mm complete
  - 150mm partial
- Available technologies:
  - CMOS, BiCMOS, MCM-D, MEMS/NEMS, power devices
  - Bump bonding packaging
- Silicon micromachining
- Packaging
  - 200m<sup>2</sup>, class 100
- Laboratories
  - Characterization and test
    - DC and RF (up to 8GHz)
    - Wafer testing
    - Thermography
    - Radiation testing
  - Reverse Engineering
  - Simulation
  - CAD
  - Mechanical Workshop
  - Chemical sensors
  - Bio-sensors
  - Radiation sensors
  - Optical sensors



# IMB-CNM clean room facility

## Principal Processes

### Thermal Processes and CVD

- Oxidation, annealing and RTP processes
- LPCVD, PECVD and ALD deposition

### Ion Implantation

- Medium current systems for B, P, As, N, Ar, Al, Si, Mg, O, He

### Photolithography

- Contact and double side mask aligners
- PR deposition and development robot
- G-line and i-line steppers

### Dry Etching

- Reactive ion etching (RIE)
- Deep reactive ion etching (DRIE)
- Plasma Ashing

### Microsystem and wet etching

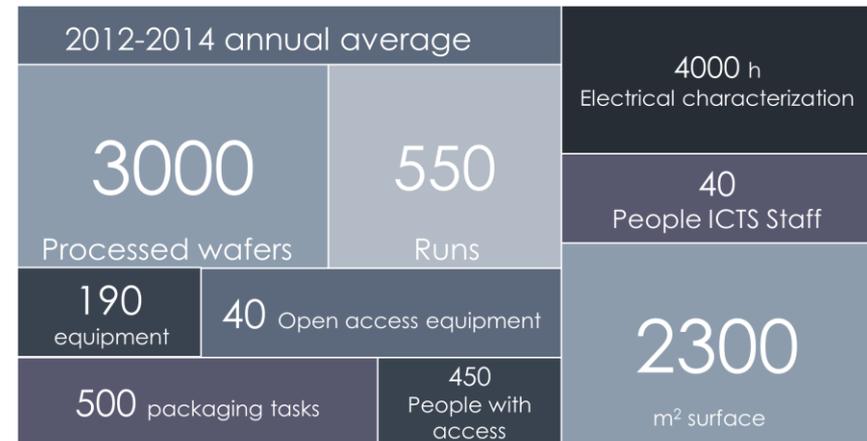
- Etching and cleaning (anisotropic, lift-off)
- Bulk and surface micro-machining (wafer bonding)
- Electrodeposition and electroplating

### Nanolithography

- Electro-beam (e-beam)/ Focus Ion Beam (FIB)
- Nanoimprint lithography (NIL)
- Atomic force microscopy (AFM)



**MICRO  
nano  
FABS**



# Radiation Detectors group

## IMB-CNM Radiation Detectors Group:

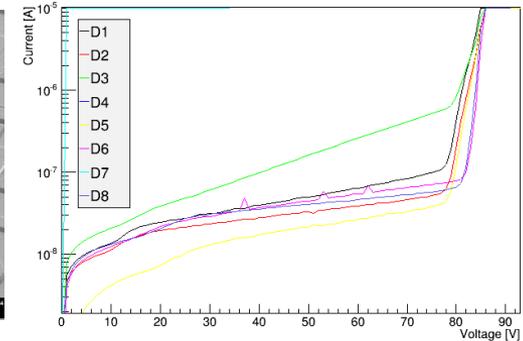
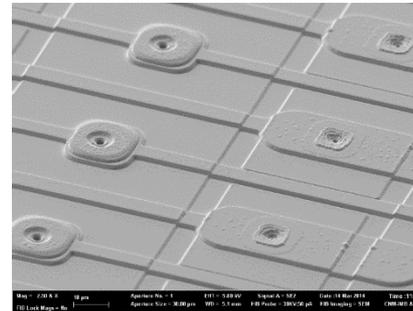
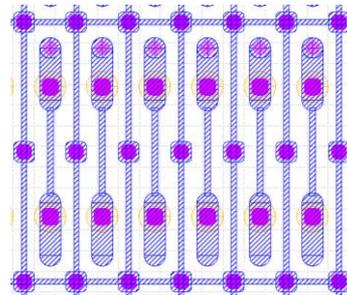
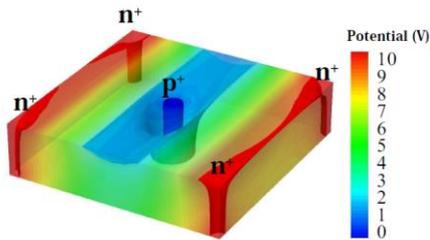
- |                        |                            |
|------------------------|----------------------------|
| ✓ <b>Manuel Lozano</b> | ✓ Daniela Bassignana       |
| ✓ Enric Cabruja        | ✓ Pablo Fernández Martínez |
| ✓ David Flores         | ✓ Rossella Zaffino         |
| ✓ Salvador Hidalgo     | ✓ Sergi Esteban            |
| ✓ Miguel Ullán         | ✓ Mar Carulla              |
| ✓ Joan Marc Rafi       | ✓ Xavier Fernández Tejero  |
| ✓ Giulio Pellegrini    | ✓ Maria Manna              |
| ✓ Angel Merlos         | ✓ David Quirion            |
| ✓ Celeste Fleta        | ✓ Carlos Jumilla           |
|                        | ✓ Javier Bravo Calvo       |

- People
  - 8 permanent doctors
  - 5 contracted doctors
  - 4 PhD students
  - 2 Engineers
- Activities started in 1996
- Experiments
  - Members of the RD50 CERN collaboration
  - ATLAS, CMS, LHCb
- Collaborations
  - IFAE, IFIC, IFCA (Spain)
  - BNL, SCIPP-Santa Cruz
  - INFN
  - Glasgow, Liverpool
  - DESY, Freiburg, Karlsruhe

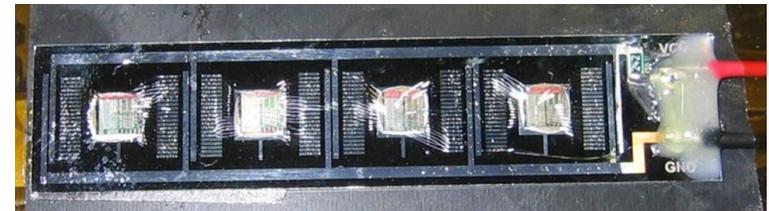
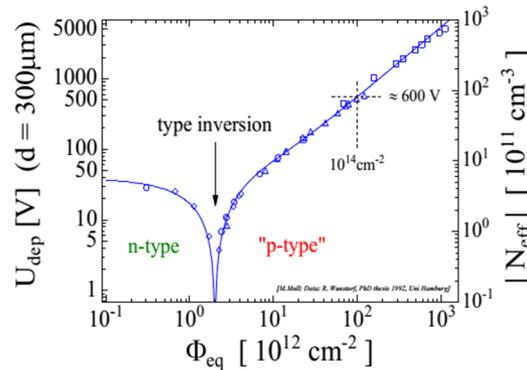
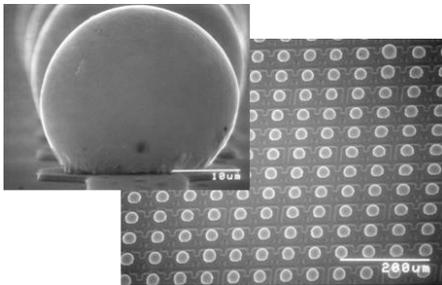


# Radiation Detector Group – full chain value

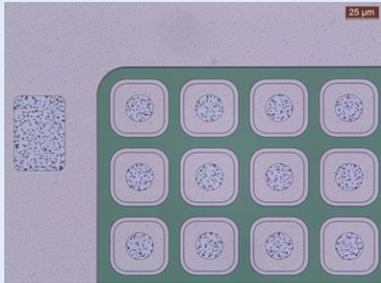
- Simulation, design, fabrication and characterization of silicon radiation detectors



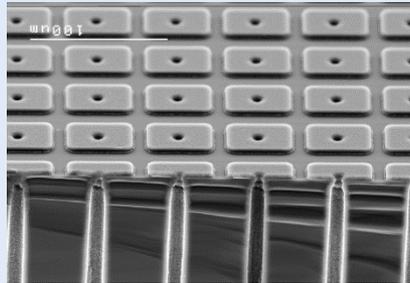
- + packaging capabilities (wire-bonding, flip-chip), irradiation studies...



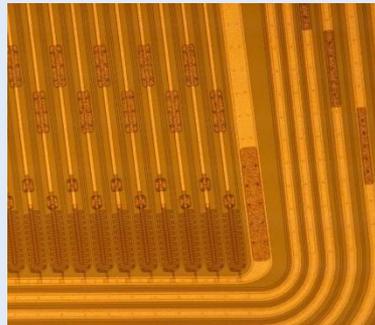
### Silicon radiation detectors



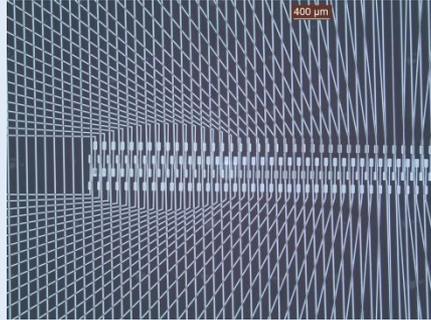
Pixels



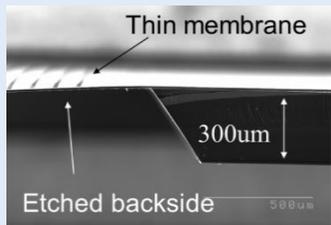
3D geometry



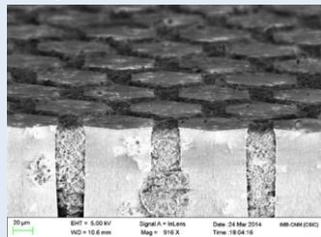
Microstrips



Embedded pitch adapter



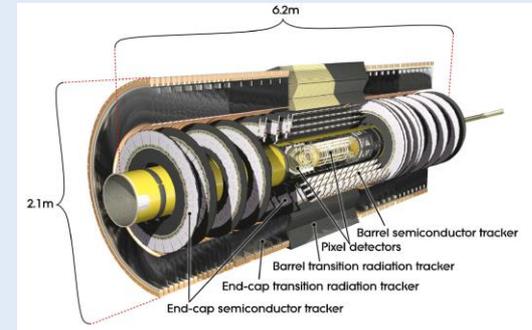
Ultra-thin



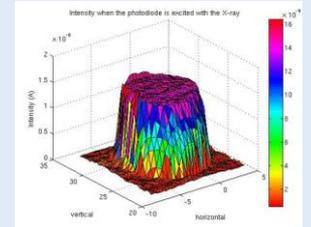
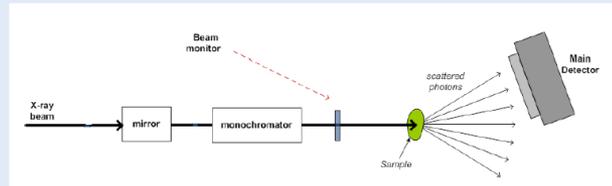
Neutron conversion

for:

### High Energy Physics



### Synchrotron



### Medical applications

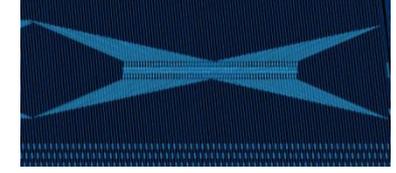
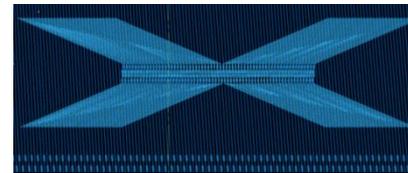
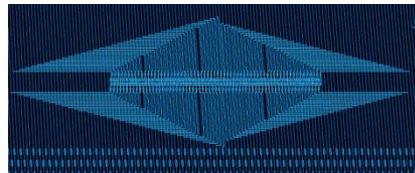
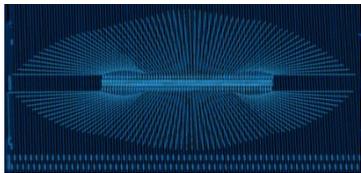
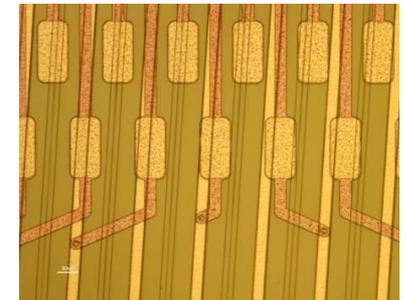
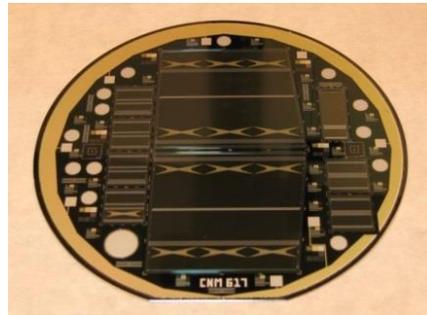
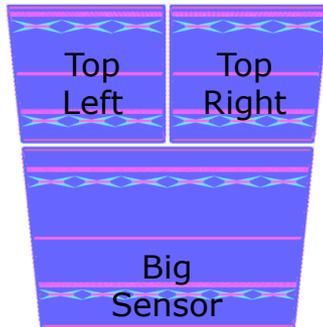
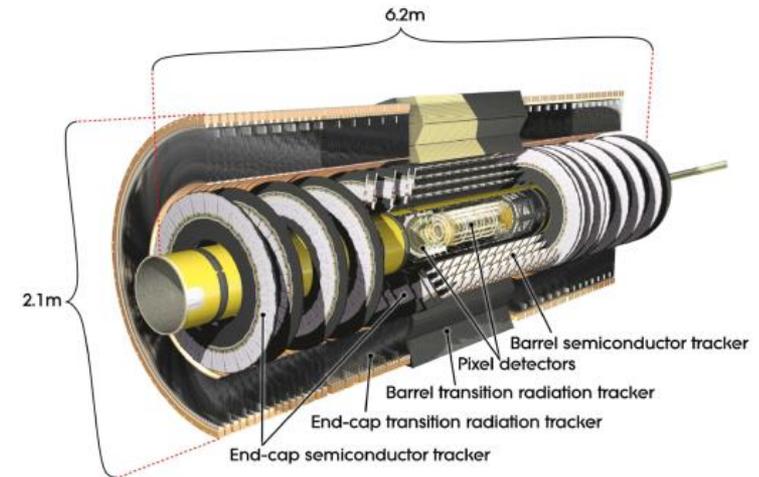


### Homeland Security



# ATLAS ITk End Cap detector prototype fabrication

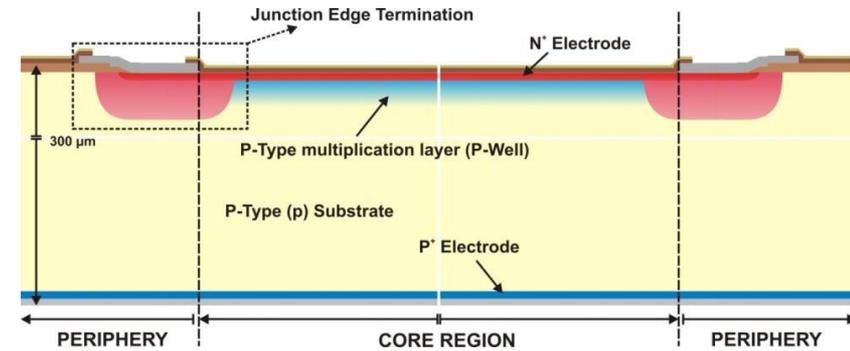
- ❑ Sensors for the module prototypes of the End-Cap Inner Tracker ("Petalet")
- ❑ Microstrips n-on-p technology
- ❑ Second metal to implement fan-ins built in the detector
  - Solution to large bonding angle without the drawbacks of external pitch adapters)
- ❑ Several design optimization tested



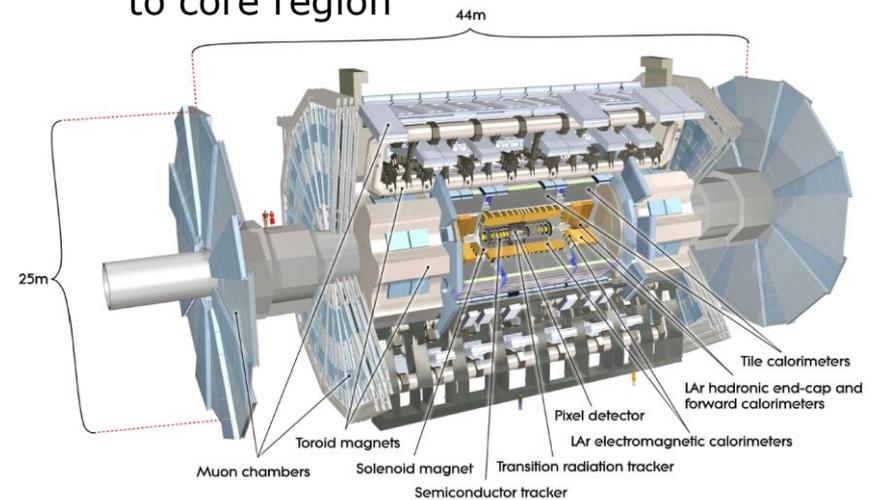
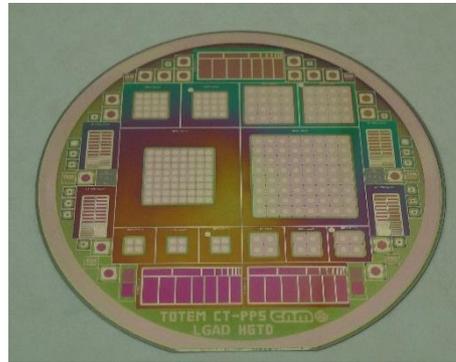
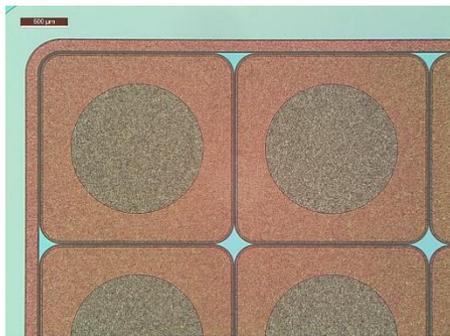
V. Benítez et al., Nucl. Instr. Meth. Phys. Res. A833 (2016) 226

# Low Gain Avalanche Detectors (LGAD)

- Revisited avalanche diodes (APD) suitable for fine segmentation pitches (microstrip or pixel devices)
- n-on-p technology
- Properties:
  - Proportional Response (linear mode operation)
  - Fast timing capability (down to 26ps)
- Application: High-Granularity Timing detector to replace ATLAS liquid-argon forward calorimeter (pile-up mitigation)



- Core region: uniform high electric field for impact ionization
- Termination: high electric field confined to core region

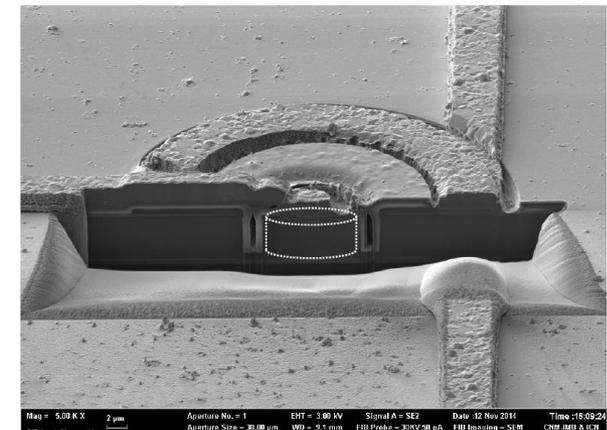
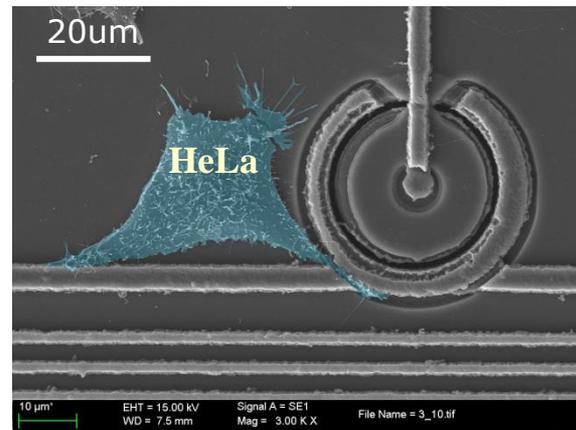
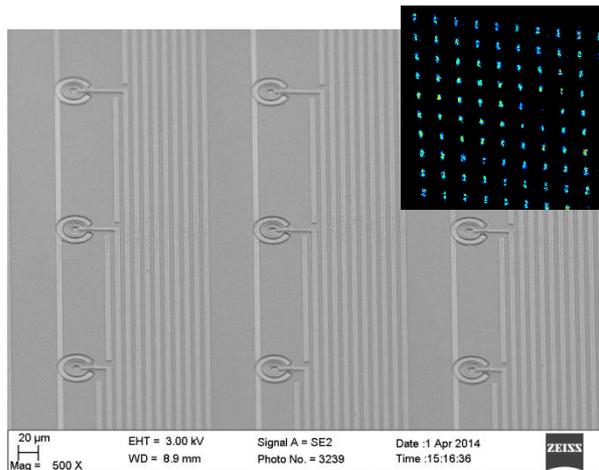
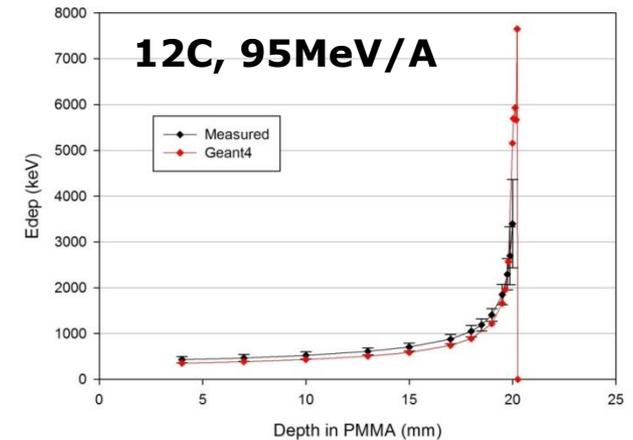


G. Pellegrini et al., *Nucl. Inst. Meth. Phys. Res.* 765 (2014) 12; N. Cartiglia et al., *arXiv:1608.08681* (2016)



# Silicon Micro-dosimeters for Hadron-therapy

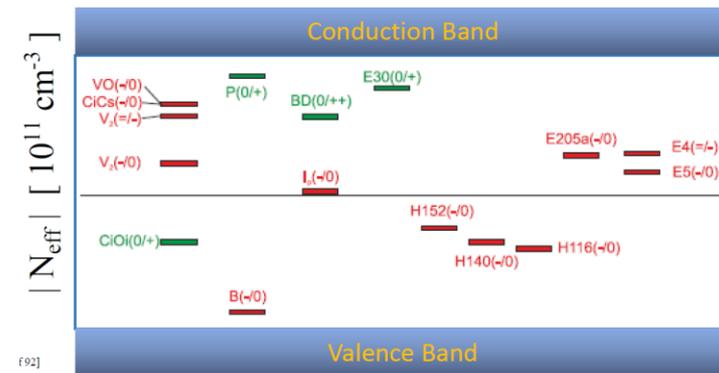
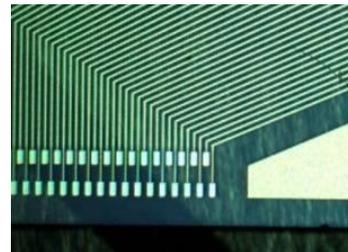
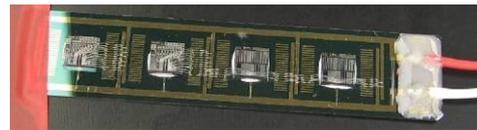
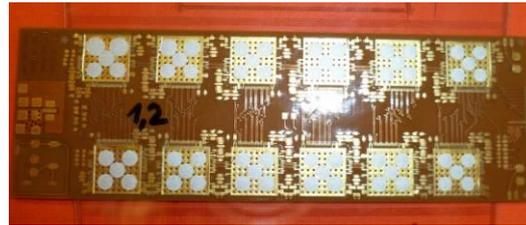
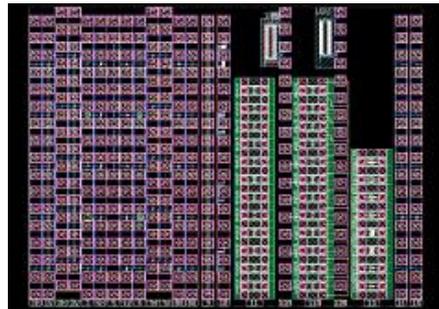
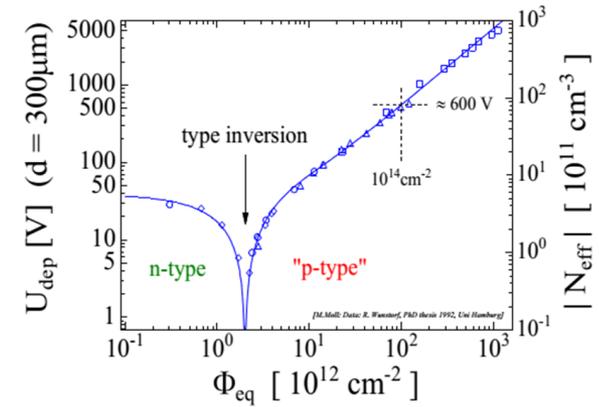
- Micrometric cylindrical silicon detectors with well-defined geometry
- Goal: to measure the deposited energy by radiation in microscopic volume ( $\sim$ cell)
  - Biological effect of radiation does not depend only on doses, but also on its distribution
- Applications: Treatment planning in hadron-therapy...



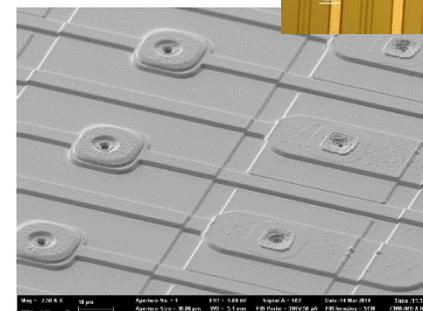
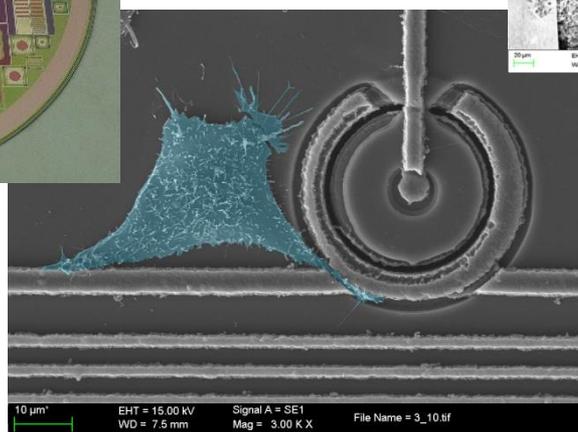
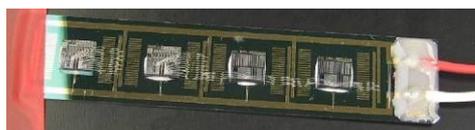
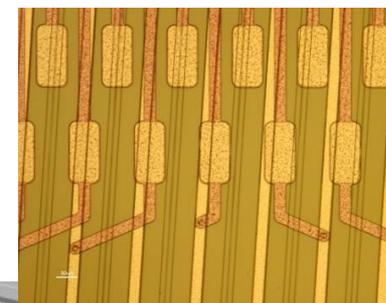
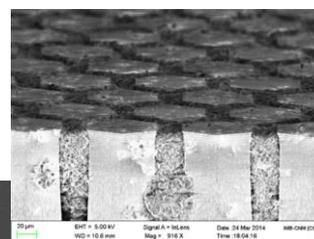
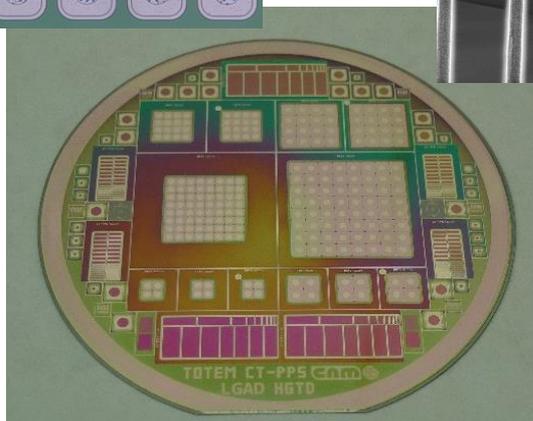
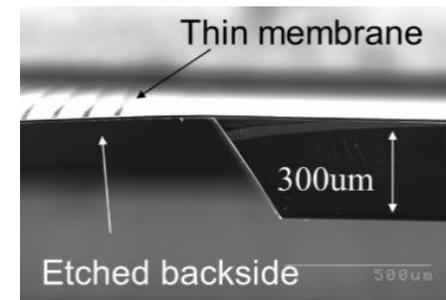
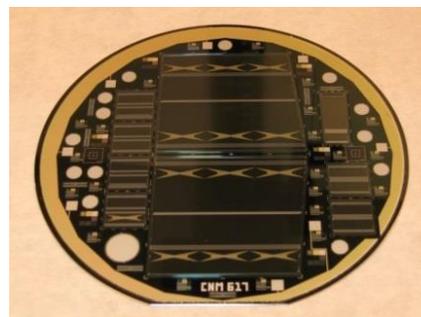
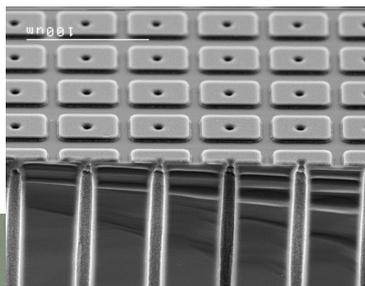
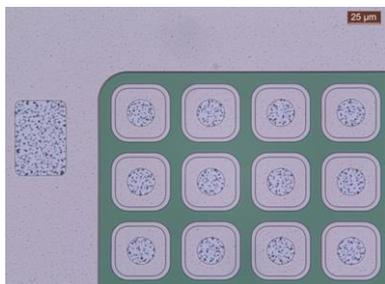
C. Guardiola et al. *Appl. Phys. Lett.* 107 (2015) 023505; C. Fleta et al., *J. Inst.* 10 (2015) P10001

## Investigation of radiation effects

- Member of RD50 CERN collaboration
  - Rad-hard detectors for LHC upgrade
- Radiation Assurance Test
  - Radiation Detectors
  - Microelectronic Technologies and Devices
    - TID
    - Displacement
    - SEE
  - Other materials



[92]



## THANK YOU FOR YOUR ATTENTION