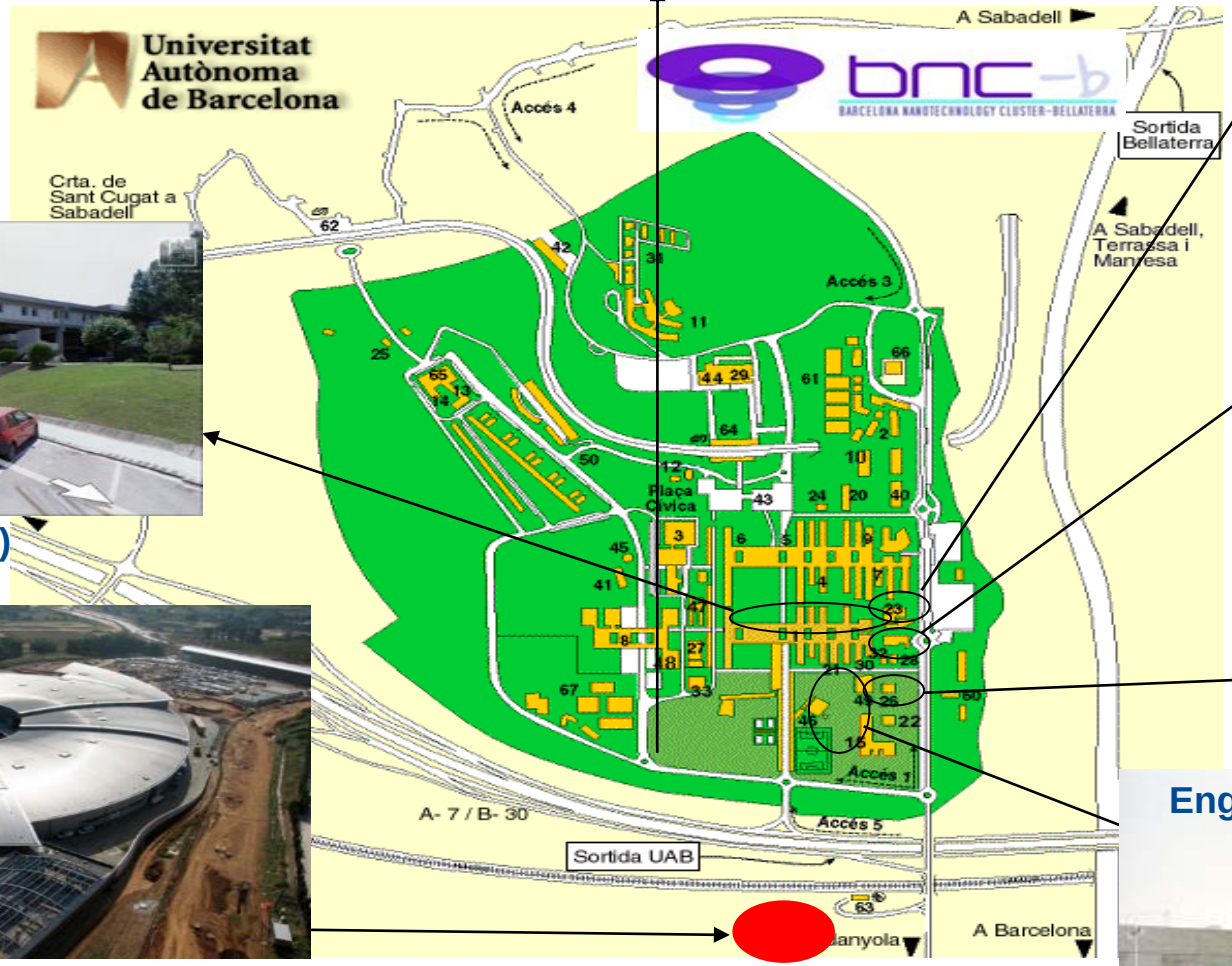
R&D Activities @ IMB-CNM for the DRD3

Giulio Pellegrini

On behalf of the RDG

Ecosystem

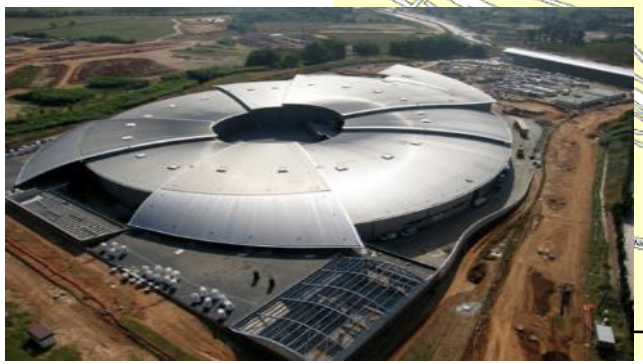
PRUAB
Spin-off Incubator



IMB-CNM(CSIC)

Sciences (UAB)

Materials Science Institute (CSIC)



Alba Synchrotron

ICN2

Engineering

Clean Room

Largest R&D Clean Room in Spain

1500 m²
total area

190
equipment units

3000
Wafers/year

550
Runs/year

40
staff

40
self service

2500
Hours self service

450
registered self service licenses

The main activities of IMB-CNM is basic and applied research and development, education and training in micro and nanotechnologies, components and systems.

Clean room virtual tour

Experience in production

SiC rectifiers for space

Bepi-Colombo & Solar orbiter missions
Main contractors EADS, Airbus, ALTER
400k€/year (2,800 k€ accumulated)

Chemical sensors ISFETs type

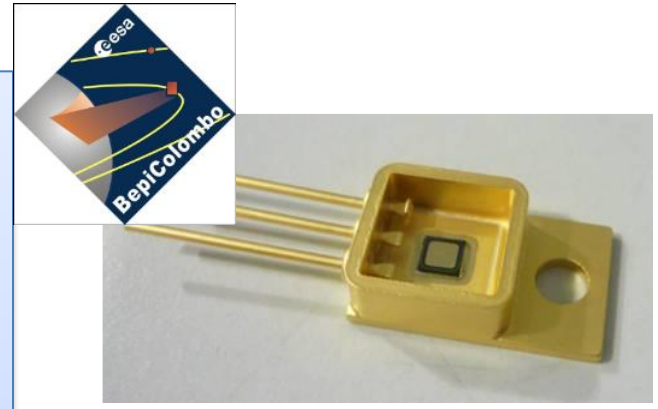
Main contractors: AlphaMOS & Devicare-global Health Home Devices
120k€/year.

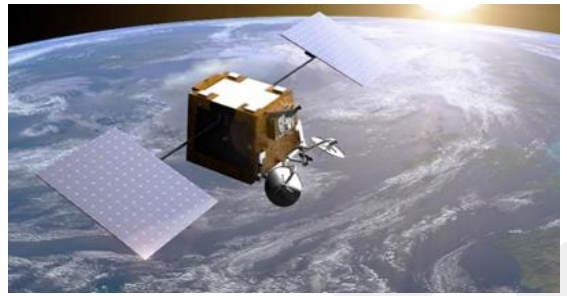
Radiation detectors and dummies.

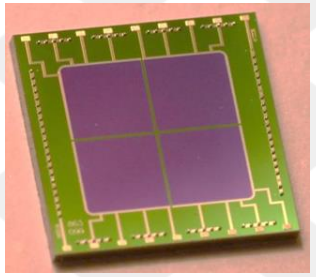
Main contractor CERN (ATLAS, CMS, RD50, TOTEM) for HEP.
Other contractors: Argonne, INFN, BNL, DESY, GSI, Xian University, Amsterdam scientific, for Nuclear Physics and other applications.

Four Quadrant diodes for space

OneWeb constellation. Airbus and SolarMems.
In orbit since February 2019, full contract 650 k€







Centro Nacional de Microelectrónica IMB

CSIC Consejo Superior de Investigaciones Científicas

Radiation Detector Group (RDG)

High internationalization, 36% foreigners.

Senior researchers

1. Giulio Pellegrini, Head of the group
2. Manuel Lozano Fantoba,
3. Miguel Ullan Comes,
4. Maria Celeste Fleta Corral,
5. Joan Marc Rafi Tatjer,
6. Enric Cabruja Casas,
7. Esteve Amat Bertran, *this year*
8. Consuelo Guardiola Salmeron, this year
9. Gianluigi Casse 2023

10. Salvador Hidalgo (PDS group)
11. David Flores (PDS group)
12. Angel Merlos (GTQ group)

Postdocs

1. Daniela Bassignana (D+T project manager)
2. Ivan Lopez Paz
3. Maria Manna
4. Neil Moffat,
5. Martín Pérez, Marie Curie Fell., 2023

Technician

1. Vainius Dauderys,
2. Francisco Javier Bravo Calvo,
3. Luis Figueras (2023)

Phd students

1. Eric Bach Marques,
2. Oscar David Ferrer Naval,
3. Marcio Alfonso Jimenez Venegas,
4. Carla Riera Llobet,
5. Milos Manojlovic,
6. Jairo Antonio Villegas Dominguez,
7. New FPI, 2023.

RDG Radiation Detectors Group

+ Erasmus, Master, grade students, visiting PhDs.

https://rdg.imb-cnm.csic.es/

Technological area in DRD3	Resources (FTE per year) [2024 to 2028]	
	Permanent [FTE/year]	**Temporary [FTE/year]**
• Monolithic CMOS sensors	**0**	**1**
• Sensors for tracking and calorimetry with space, time and/or energy resolution [4D, 3D, trench detectors, modelling, simulation, …]	**2**	**2**
• Radiation damage & ultrahigh fluences [Defect characterization, TCAD and other damage simulations, irradiation tests, …]	**0.5**	**2**
• New characterization techniques and facilities of common interest [Irradiation and test beam facilities, IBIC, laser testing, ..]	**0.5**	**0.5**
• Non-silicon semiconductor and other material studies [Diamond, SiC, GaN, WBG, ..]	**1.**	**1**
• Interconnect and device fabrication technologies [3D integration, TSV, reduction of pitches, wafer bonding technologies,..]	**0.5**	**1**
• Dissemination and outreach	**0.5**	**0**

National and EU projects related to DRD3

FPA

1. Detectores para las mejoras de atlas para el HL-LHC, PID2021-124660OB-C22.
2. Construcción de los sensores de strip del ITK de ATLAS y desarrollo de las tecnologías para los sensores de los futuros experimentos, PID2021-126327OB-C22.
3. Actividades del IMB-CNM para los “upgrades” de alta luminosidad del Inner Tracker y EndCap Timing Layer (CMSUPG) (PID2020-113705RB-C32).
4. Detectores de avalancha de baja ganancia de rayos-x blandos con pitch de 55um para aplicaciones de imagen empleando el ASIC TIMEPIX4, PID2020-118275RB-C22.

International

1. Development of particle detectors based on silicon-carbide devices, Contract with Austrian Academy of Sciences.
2. Advancement and Innovation for Detectors at Accelerators (AidaInnova), EU 101004761.
3. Different projects from RD50 common funding.

Proof of concept

1. Optimización y fabricación de sensores LGAD para el demostrador tecnológico de un tomógrafo de muones con resolución temporal (TOMULGAD) (PDC2021-121718-C32).
2. Micro detectores 3d para estúdio de terapia FLASH, PDC2022-133120-C21

Other funding (EU and national) related to DRD3

EU projects

1. Metrology for Advanced radiotherapy using particle beams with ultra-ligh pulse close rates (UHDpulse) EU18HLT04.
2. Future Oriented Renewable and Reliable Energy SIC Solutions, EU 101075672 (Coordination).
3. An interoperable multidomain CBRN system, EU 101018596.
4. THz Wave Accelerating Cavity for ultrafast science, EU TWAC (101046504).
5. Marie Curie Felloship > 2023

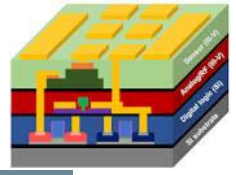
National

1. Technology developments of solid-state detectors for advanced dosimetry" (NEWDOSI) , PID2021-123484OB-I00 .
2. Detectores de neutrones ultra delgados para haces pulsados, SUBV-8 /2022.
3. Microdetectors for medical applications, 20225AT008
4. RDG financiado por la Generalitat de Cataluña, AGAUR, Generalitat de Cataluña. Grupo calidad 2023.
5. PIACeD: Planar All-Carbon electrode Diamond detector for radiotherapy (CNM internal project)
6. Un microchip muy grande, FCT-21-16975.

Collaborations

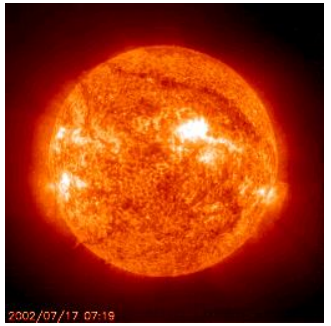
All CERN projects are coordinated with the main HEP institutes in Spain.

Soft X-ray imaging

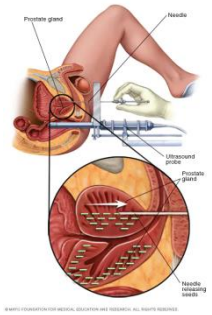


IFIC Instituto de Física Corpuscular

3D system integration



Fusion



Brachytherapy

Interconnection

IFAE Institut de Física d'Altes Energies

- DMAPS simulation
- Timing and 3D
- 2D materials

CNA Centro Nacional de Aceleradores

Infraestructuras Científicas y Técnicas Singulares

- WBG materials (SiC, GaN, Diamond)
- Irradiation studies

Centro Nacional de Microelectrónica IMB

Single Photon Detectors for Quantum Imaging

IFCA Instituto de Física de Cantabria

- Innovative LGAD technologies
- Ultra radiation hard silicon
- SiC testing.

IGFAE Instituto Galego de Física de Altas Enerxías

- Medipix 4 (LGADs and 3D)

Radiotherapy

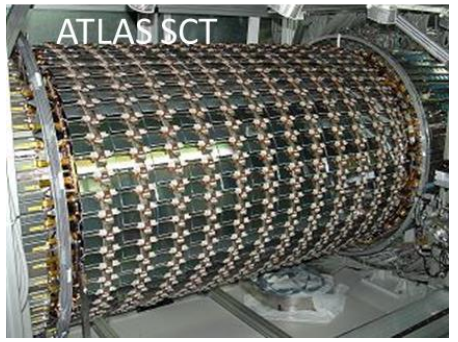
Technologies developed within the RD50 collaboration

Strong involvement since the start of the collaboration.

Main technological breakthrough in radiation detectors used in experiments.

IFIC Institut de Física Corpuscular — University of Liverpool

- P-type strip detectors
- Alibava systems
- 3D double sided
- LGAD technology

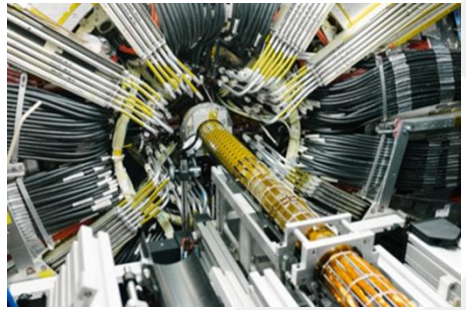


University of Liverpool — IFIC Institut de Física Corpuscular

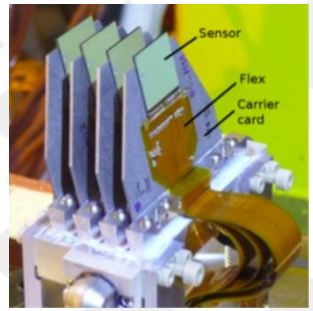
Supported the early development of this technology.

IFAE Institut de Física d'Altes Energies

Atlas IBL

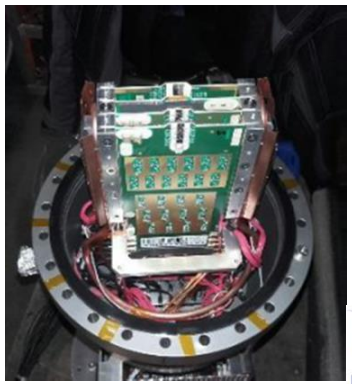


Atlas AFP



First DS3D at IMB-CNM

TOTEM CT-PPS is the first CERN experiment using LGAD proposed and fabricated at CNM!

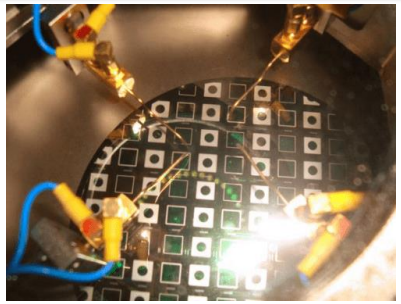


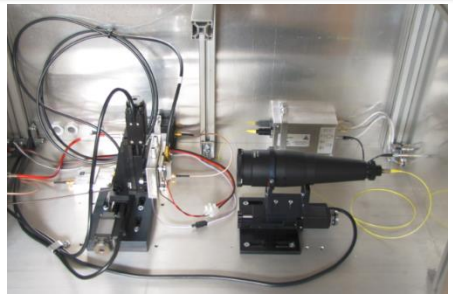
IFCA Instituto de Física de Cantabria

Infrastructures available at IMB-CNM

- **Clean room facility**
- **RDG Laboratory**

- **Steady-state electrical characterization setup**
- **Cascade probe station with thermal chuck (–70º to 210ºC)**
- **Transient Current Technique (TCT), UV, blue and infrared lasers.**
- **CCE setup for timing (mip particles).**
- **Alibava System: Portable readout system for radiation detectors**
- **X-ray tube for irradiation and imaging.**





Clean room

- class 100 to 10.000
- Technologies for Micro y Nano fabrication
- 3 Areas:
  - ✓ CMOS (high purity, no contaminants)
  - ✓ MNC (Noble Metals contaminants for Si)
  - ✓ Nanolithography
- Process size: 4'' and 6” wafers.
- Technologies: CMOS, MEMS/NEMS, power devices, radiation detectors
- Silicon + WBG (SiC, GaN, Diamond).
- Silicon Micromachining
- ISO9001 in progress (2023)

Microelectronic Packaging Area

- 200 m2, class 100
- Wafer cutting, wire-bonding, bump-bonding

Future Plans (involvement in the DRD3)

DMAPS

We are interested in working on the simulation of DMAPS in collaboration with other institutes within the DRD3 collaboration. The IMB-CNM group is expert in Sentaurus simulation toolkit and has a large experience in the technology of CMOS devices

4D tracking

Continue to develop, through simulation and fabrication, innovative solid state sensors with 4D-capabilities for tracking applications based on the different LGAD technologies (iLGAD, n-LGAD, AC-LGAD, etc..) and 3D detectors.

Radiation damage & ultrahigh fluence

Develop new detector in innovative materials (SiC, GaN, Diamond, 2D materials) to operate at extreme fluences and study the performance of combined TCAD-simulated electric fields with Geant4 (G4) simulations.

Interconnection

The development of advanced hybrid and 3D integration techniques at IMB-CNM. Improving the UBM layer deposition technology and the development of 3D stacking techniques like Through Silicon Vias (TSV), stitching, or bonding technologies.

Dissemination and outreach

We are interested to provide training events at our institutions on simulation and microelectronic fabrication in the framework of a Master program.

Centro Nacional de Microelectrónica IMB CSIC Consejo Superior de Investigaciones Científicas

Thank you for your attention

Campus Univ. Autónoma de Barcelona (UAB)
08193 Cerdanyola del Vallès (Bellaterra)
Barcelona · Spain

Giulio Pellegrini

@imb_cnm

www.imb-cnm.csic.es