Silicon Sensors Development: the INFN-FBK Collaboration

Matteo Centis Vignali
Maurizio Boscardin

mcentisvignali@fbk.eu
boscardi@fbk.eu

FONDAZIONE BRUNO KESSLER

FBK Microfabrication Facilities

Detector Clean Room (6 inch)
- Projection lithography CD 2 µm
- Stepping lithography CD 350 nm
- Dry/wet oxidation, diffusion
- Ion implantation
- LPCVD
- PECVD
- Dry/wet etching
- Metal sputtering
- Double sided process

MEMS Clean Room (6 inch)
- Projection lithography CD 2 µm
- Maskless lithography CD 300 nm
- Oxidation, diffusion
- Metal sputtering, evaporation
- Wet etching
- Focused ion beam

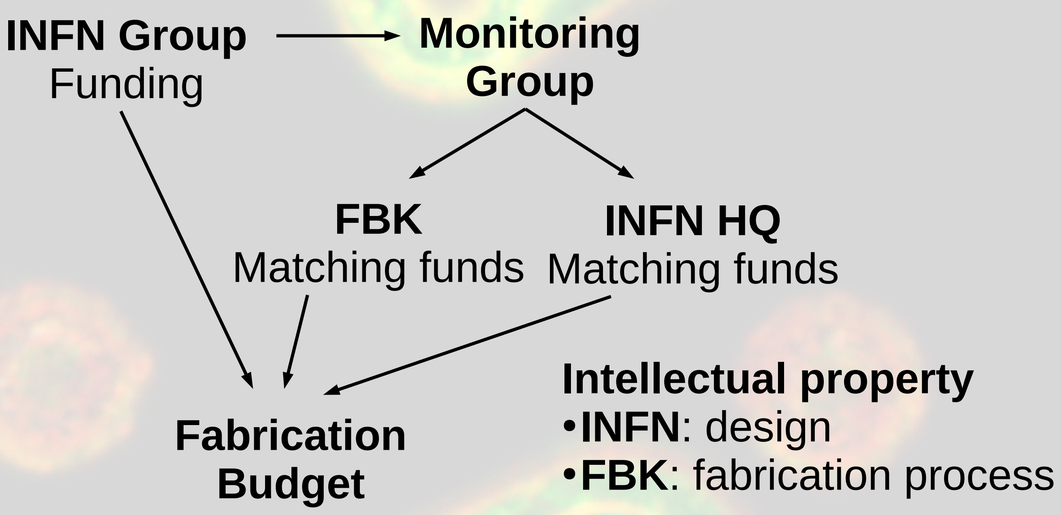
3D Integration Clean Room (6, 8 inch)
- Wafer bonding and de-bonding
- Metal and fusion direct bonding
- Grinding and polishing
- Metrology for 3D stacked wafers
- Atomic layer deposition

Packaging Clean Room (single dies)
- Wirebonding
- Pick and place
- Balling
- Coming soon: bump bonding

Coming next:
- **SiC clean room**
- **MEMS upgrade**

Collaboration Structure

- Device development
- Monitoring group to approve fabrication activities
- Matching funds from FBK and INFN head quarters

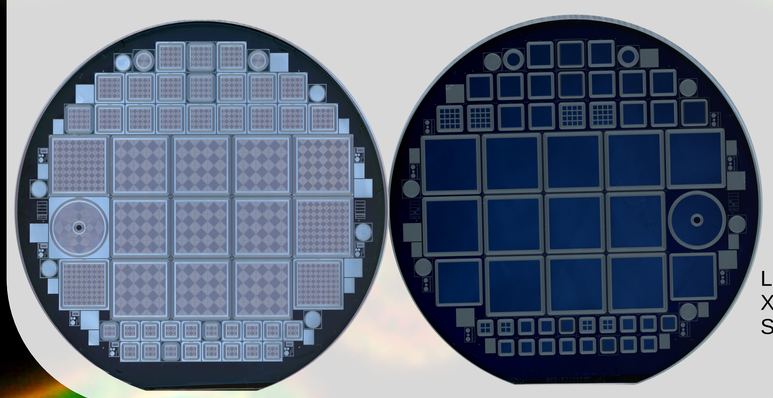


Intellectual property
- **INFN**: design
- **FBK**: fabrication process

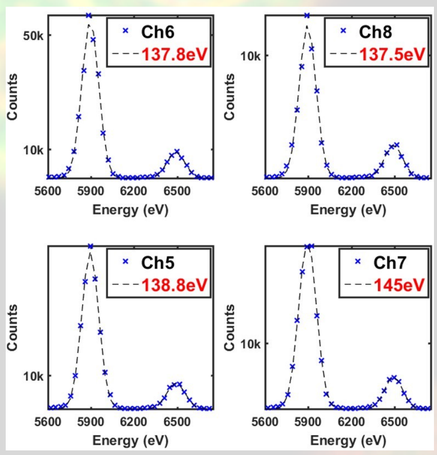
Silicon Drift Detectors

X-ray spectroscopy, particle and light detection

- Double-sided process
- Optimized entrance window for low energy x-rays
- Low input capacitance for electronics



FWHM Fe^{55}

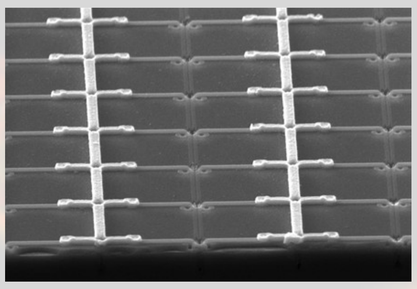


L.G. Toscano et al. “Development of high-efficiency X-ray detectors based on 1 mm thick monolithic SDD arrays” JINST 19 P07039 2024

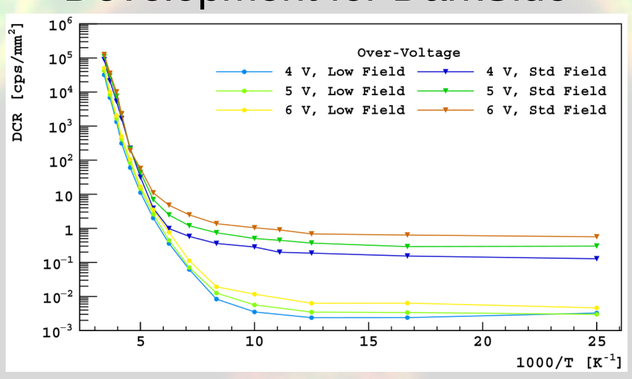
Silicon Photomultipliers

Single photon detection

- Red sensitivity
- UV sensitivity
- Low noise
- High dynamic range
- Cryogenic operation
- Radiation hardness



Development for DarkSide



F. Acerbi et al. “Cryogenic Characterization of FBK HD Near-UV Sensitive SiPMs” IEEE TED VOL. 64, NO. 2, 2017

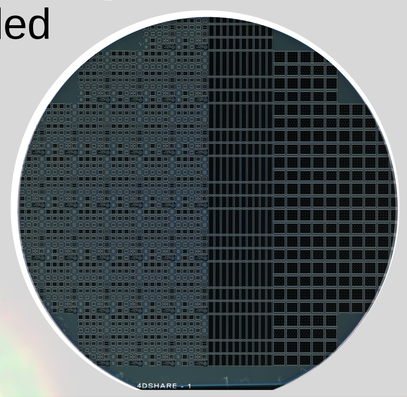
Latest development: backside illuminated SiPM

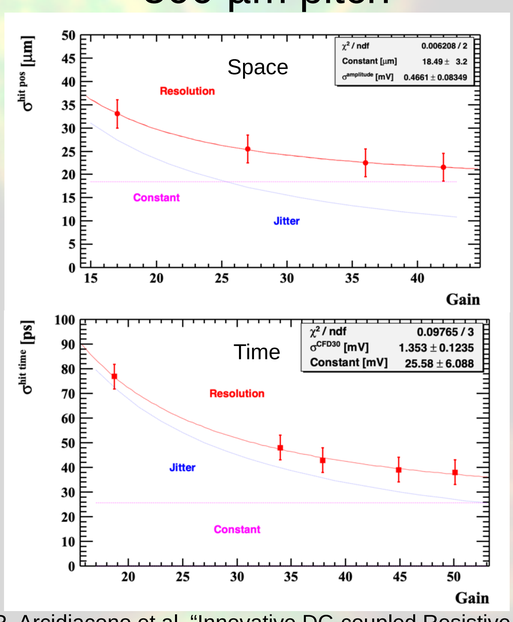
Low Gain Avalanche Diodes

Particle and x-ray detection

500 µm pitch

- Standard
- Radiation hard
- Double-sided (inverted)
- Trench isolated
- Resistive charge share
- AC-coupled
- N-type



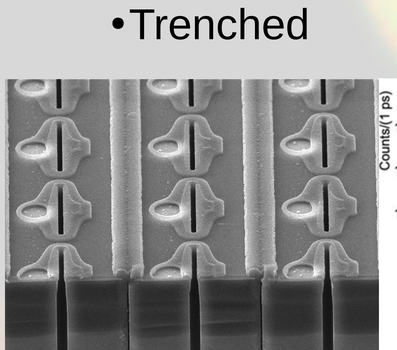


R. Arcidiacono et al. “Innovative DC-coupled Resistive Silicon Detectors for 4D tracking” VCI 2025

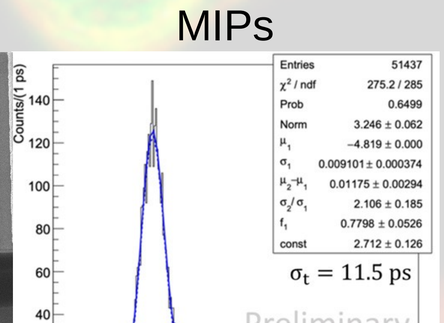
3D Sensors

Radiation hard tracking and timing

- Columnar
- Trenched



MIPs

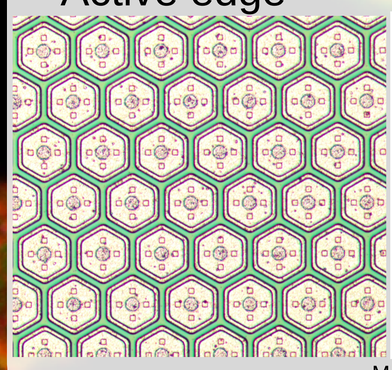


A. Lampis et al. “10 ps timing with highly irradiated 3D trench silicon pixel sensors” JINST 18 C01051 2023

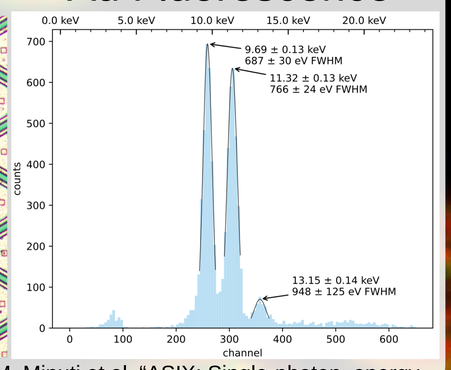
Planar Sensors

Particle and x-ray detection

- Pixels
- Strips (AC or DC-coupled)
- Double-sided
- Active edge



Au Fluorescence



M. Minuti et al. “ASIX: Single-photon, energy resolved X-ray imaging with 50 µm hexagonal hybrid pixel” Front. Sens. Sec. Sensor Devices Vol. 6 2025

Other Technologies

FBK is able to advance specialized technologies leveraging its expertise in Sensors, MEMS, Quantum technologies, and Photonics

Examples:
- Gas electron multipliers
- Flex connector cables
- Microchannel cooling
- Switchable mirrors
- Quantum devices
- Integrated photonics
- …