Switzerland interests in FCC

- Detectors and systems:
  - Tracker, Vertex, TDAQ
- Groups interested in vertex detectors for FCC-ee:
  - Bern, ETH, PSI, UZH
- Funding in the past 5 years:
  - One SNF grant for a postdoc (UZH) and 2 PhD students (UZH/VUB)
- Funding 2025-2029:
  - CHEF: Swiss High Energy Physics for the FCC
  - Partly (1/2) supported by the Science, Education, Research, Innovation ministry (SERI)
  - Consortium of Institutions: Basel, Bern, ETHZ, EPFL, Geneva, PSI, Zurich
  - About 20 PhD students + 10 postdocs
    - Mostly for detectors
    - Computing, Theory, Physics studies also covered

UZH

Experiment HEP groups (Canelli and Kilminster)

- Groups currently consists of
  - 2.5 senior scientists
  - 7 postdocs
  - 13 PhD students (+3 PSI +1 CERN)
- Department funds our access to:
  - Well-equipped mechanics shop (9 staff & apprentices)
  - Electronics shop (4 engineers)

HEP group within laboratory of particle physics (LTP) at PSI

- Group currently consists of
  - 6 senior scientists
  - 5 postdocs
  - 4 PhD students (1 ETHZ + 3 UZH)
  - 3 technicians and engineers

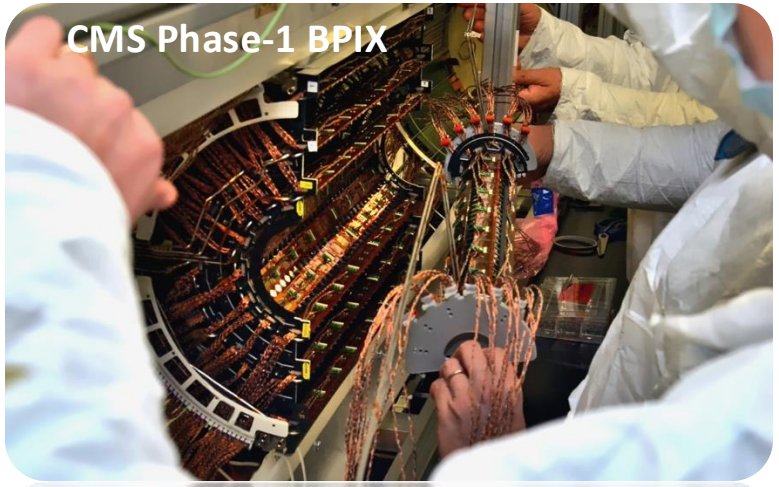
UZH

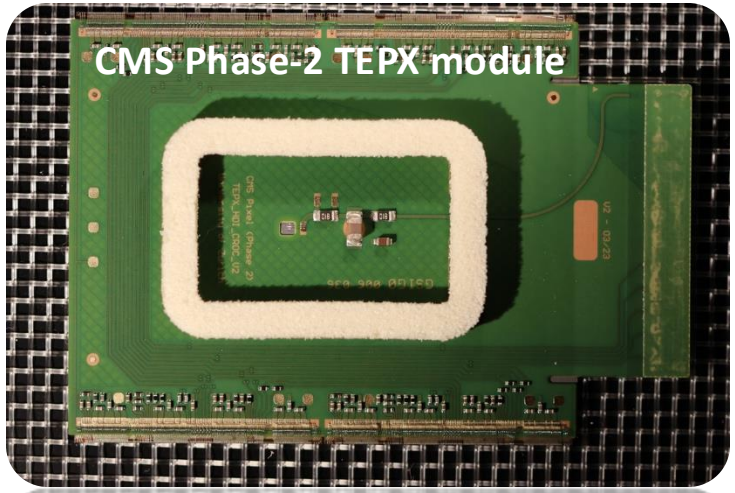
PSI

- Main focus of these groups: CMS experiment
  - Physics analysis
  - Pixel detector operation and upgrade

- CH consortium (PSI, ETH, UZH) led design, construction, integration and commissioning of original and Phase-1 CMS barrel pixel detector

- UZH/PSI currently constructing TEPX Phase-2 upgrade

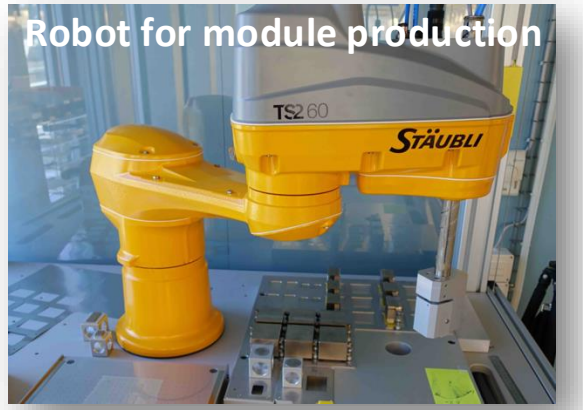




Competences & Infrastructrure

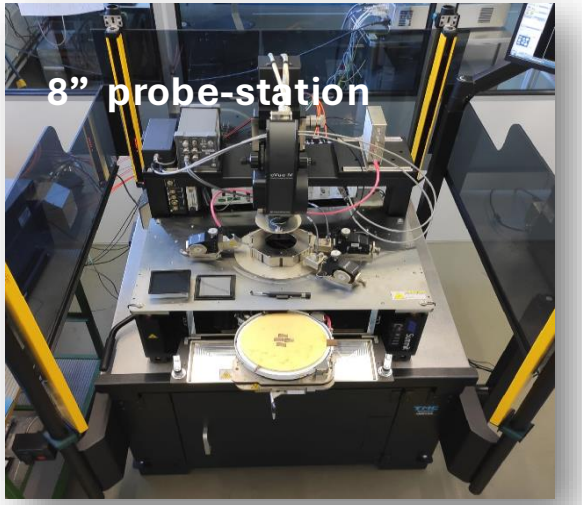
Key competences for pixel detector development at UZH and PSI

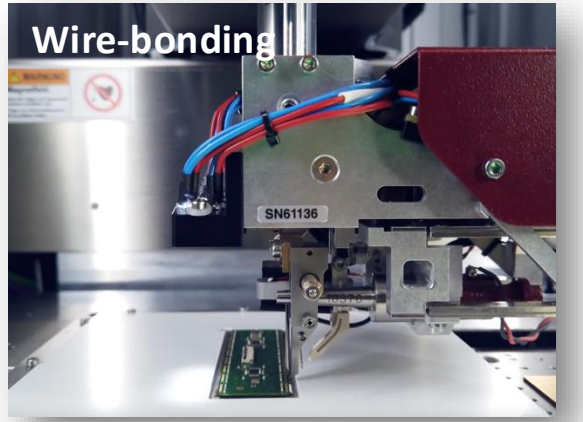
- Design of planar silicon sensors
- Hybrid pixel detector module design
- System conception of pixel detector control and readout
- Design and construction of lightweight mechanical structures
- Design of readout ASICs and planar silicon sensors (PSI)



Available infrastructure

- UZH DEMETER center for silicon detectors R&D
  - Clean room facility
  - 8” wafer probe-station
  - Semi-automatic wire bonder
  - Two Photon Absorption system to be acquired in 2026
  - MARTA and Lucasz CO2 cooling systems
- PSI
  - In-house bump-bonding and wire-bonding
  - Wafer-level testing of ASICs and sensors
  - Module assembly lines (manual and robotic)
  - Clean room facilities





UZH - R&D for future detectors

R&D in view of future upgrades of CMS and FCC-ee detectors:

- **Vertex and silicon wrapper simulation:** development of versatile tracking detector constructor algorithms in DD4hep, enabling detailed performance evaluation (slide 9 – see A. Ilg's talk)
- **OCTOPUS and its predecessors:** characterization of APTS and CE-65 structures in 65 nm CMOS by doing calibrations with radioactive source and test beam studies (slide 10 – in IPHC's talk)
- **Silicon Wrapper Timing Layer:** Feasibility study of pixelated LGAD sensors for time-of-flight detectors, aiming at a spatial resolution of ≈10 μm and a timing resolution of ≈30 ps for use as a silicon wrapper – and also study of possible alternative: monolithic CASSIA timing MAPs, also an option for the final vertex layer (slide 11)
- **Quantum sensors:** validation of superconducting nanowire particle detectors (SNSPDs) of different material and geometries for detecting charged particles (slide 12 – a different workshop)
- **Wireless communication:** prototyping implementation of wireless data transmission for vertex detector using 60 GHz transmission (slide 12 – A. Macchiolo's talk)

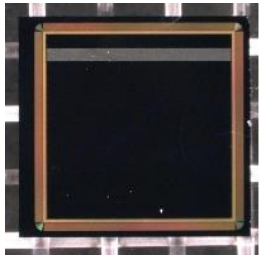
PSI - R&D for future detectors

R&D in view of future upgrades of CMS, FCC-ee detectors, and low-energy experiments at PSI

Two main R&D lines:

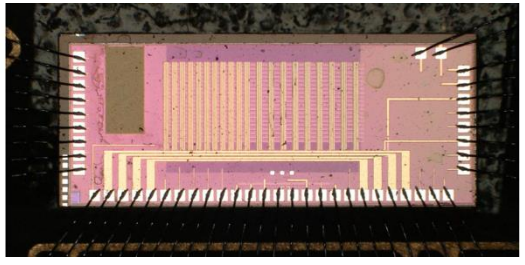
1) Development of depleted monolithic active pixel sensors (DMAPS) with timing capabilities (currently targeting O(100ps)) (with ETHZ)

MOTIC (LF 110 ARCADIA, 2022)
A. Ebrahimi et al.
Proceedings VERTEX2023



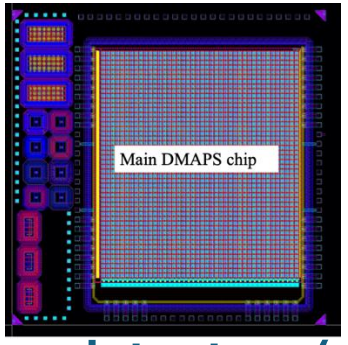
80x64 pixels
50x50μm²

MAPSI (TSI 180nm, 2023)
T. Rohe et al.
43rd RD50 meeting



20x20 pixels
50x150μm²

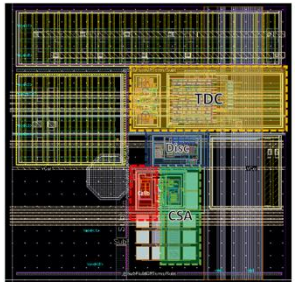
PANTHER (LF150, 2025)
Currently under test



PANTHERv2 (LF150, 2025)
Submission early 2026
shared within DRD3

2) Development of readout electronics for fast silicon timing detectors (with resolution <30ps) (with UZH)

- Started from test structures of TDCs in 110nm to fit in pixels of 100x100μm²
- Demonstrated that O(10ps) can be achieved
  M. Senger et al. https://arxiv.org/pdf/2302.06711



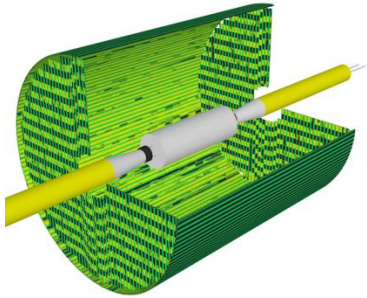
LIGHT (28nm CMOS, 2025)

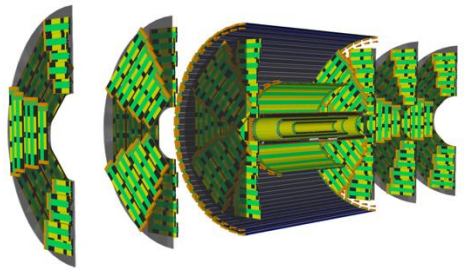
- First small-scale chip
- 8x8 pixels of 100x100μm²
- For TI-LGAD sensors
- submitted yesterday

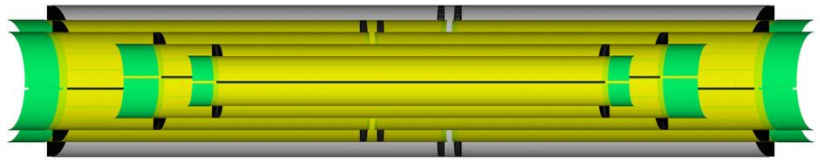
Backup

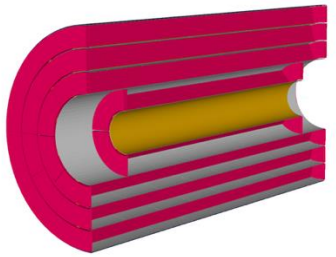
Vertex and silicon wrapper simulation

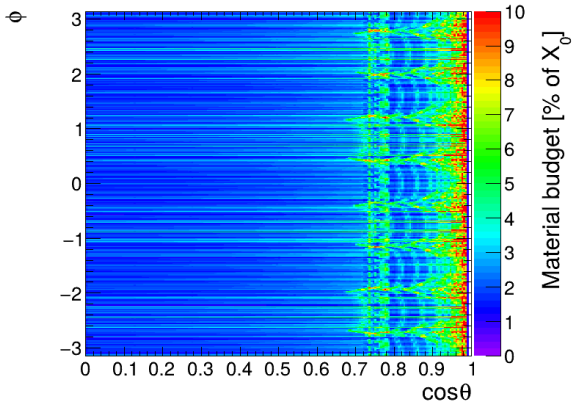
Development of versatile tracking detector constructor algorithms in DD4hep, enabling detailed performance evaluation



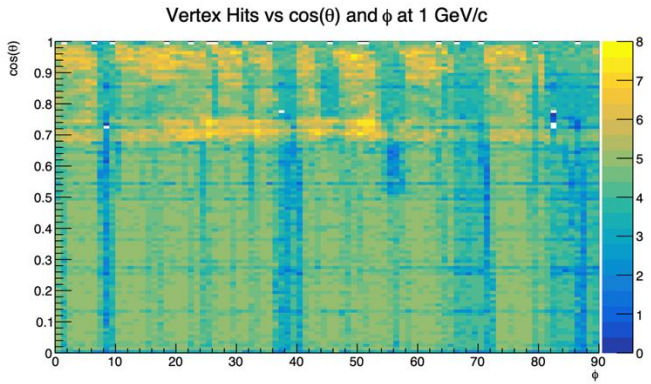




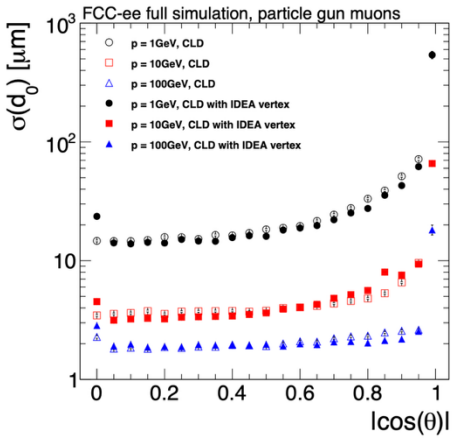




IDEA classic mat. Budget distribution



Number of hits in ultra-light concept



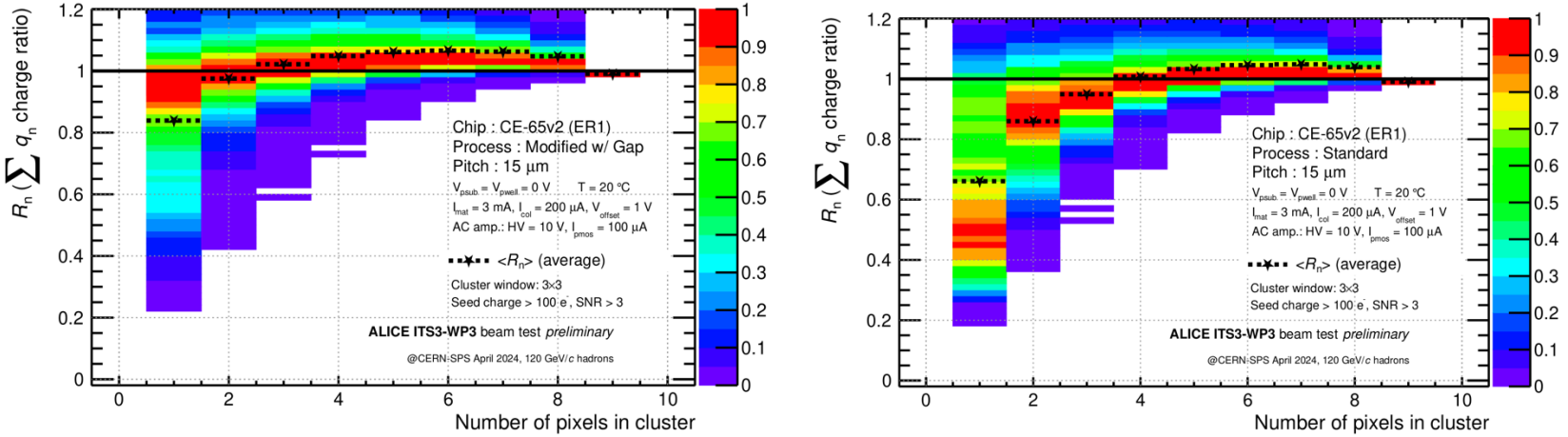
IDEA vertex detector perf.

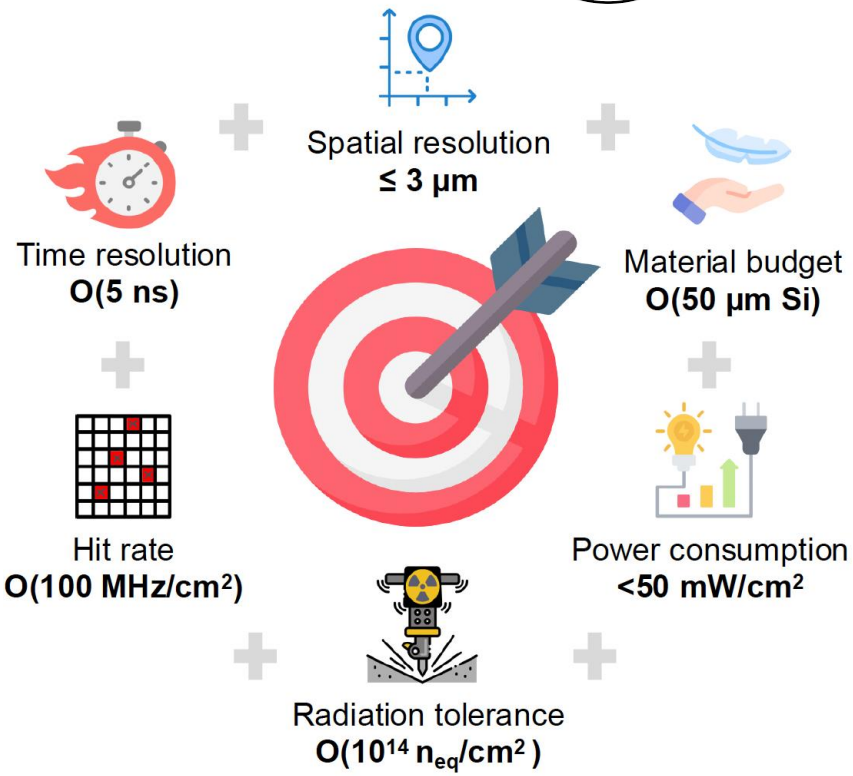
- Plans for the future:
  - Optimise VXD layouts in DD4hep
  - Compare IPC hit rates in different sensor designs technologies (high vs. low charge sharing)
  - Reassess vertexing performance using track reconstruction chain of VTXD + gas tracker + SiWr
  - $B^0 \rightarrow K^{*0}\tau^+\tau^-$ full simulation study

OCTOPUS and its predecessors

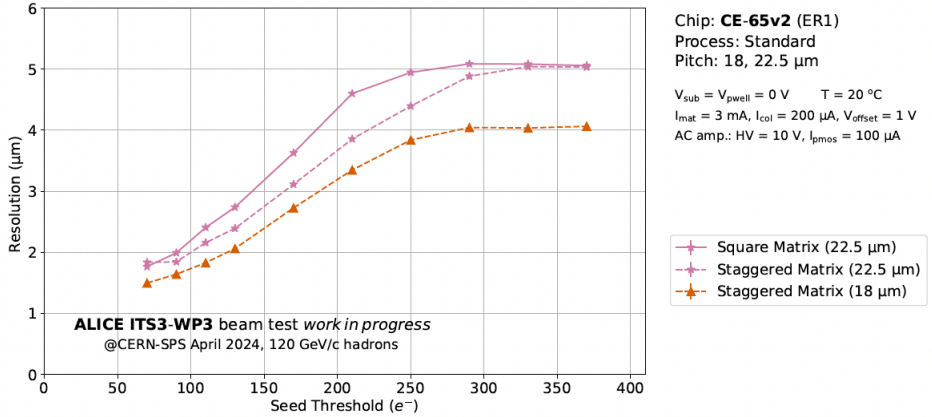
- In-depth characterization of APTS and CE-65 structures in 65 nm CMOS
  - Calibrations with radioactive source and test beam studies

CE-65 : Study of charge sharing in the Modiofied with Gap and Standard Proces





CE-65 : Study of spatial resolution as a function of the process and pixel size (see Eduardo‘s talk)



- Plans for the future:
  - Participate to the characterization of the SPARC prototype chip and of Wolfi
  - Simulation of the detector response: digitization
  - Development of DAQ SW for the Caribou board

4D Tracking for the Silicon Wrapper

- **LGADs for 4D tracking and ToF within DRD3 WG2**

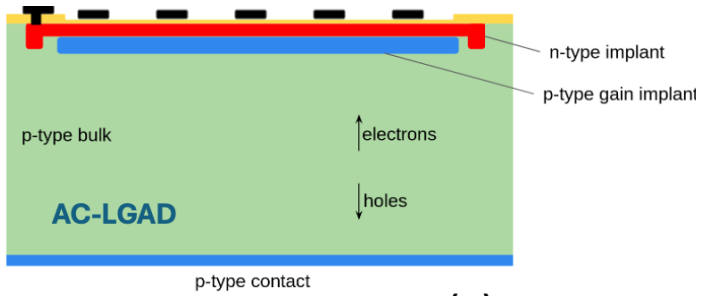
WG2 research goals <2027	
	Description
RG 2.3	LGAD for 4D tracking < 10 μm, < 30 ps, wafer 6" and 8"
RG 2.4	LGAD for ToF (Large area, < 30 μm, < 30 ps)

- Goal: demonstration of the feasibility of producing pixelated LGAD sensors to achieve a position resolution around 10 µm, with a timing resolution of the order of 30 ps before irradiation.
- Plans: characterize full modules (PSI chip LIGHT, INFN IGNITE in 28 nm CMOS) and study system aspect (power dissipation and cooling)

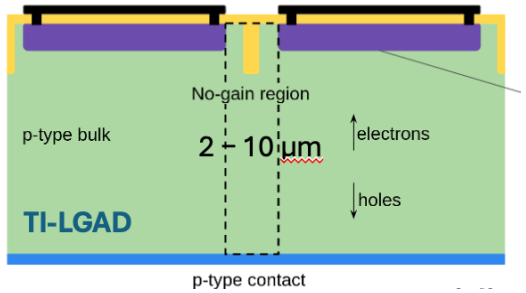
- **CASSIA timing MAPs within DRD3 WG1**

Goal:

- Validation of the technology
- Study the feasibility and the physics case of implementing monolithic timing sensors as last Vertex layer before the drift chamber

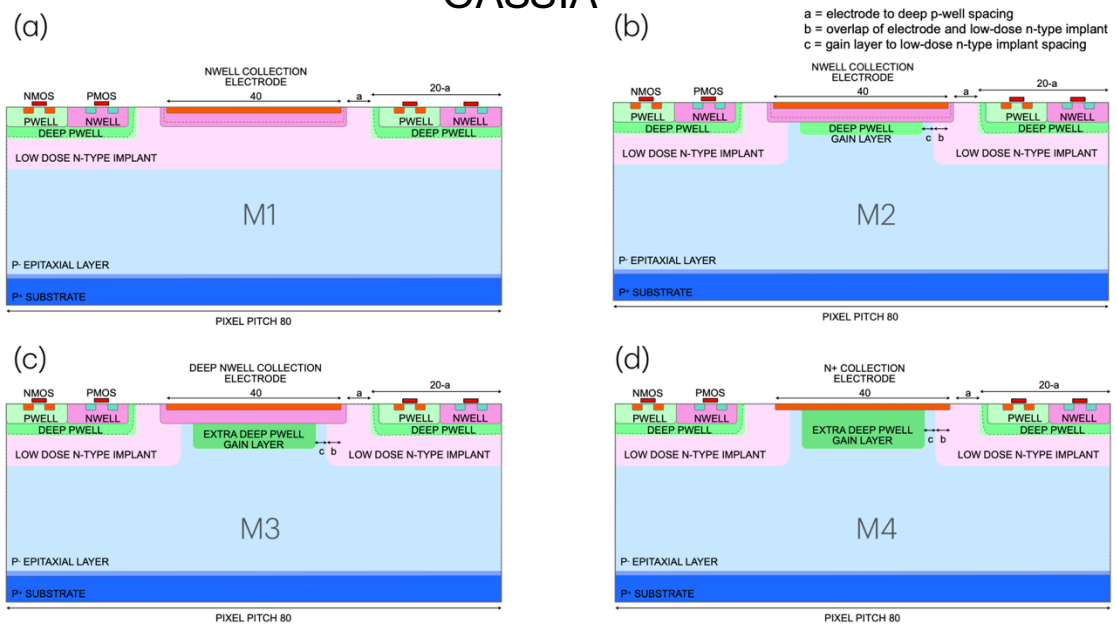


Collaboration with BNL/Brown



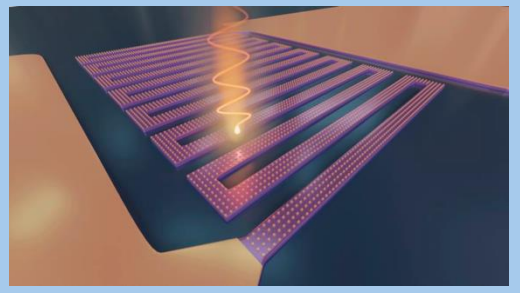
UZH coordination of DRD3 project

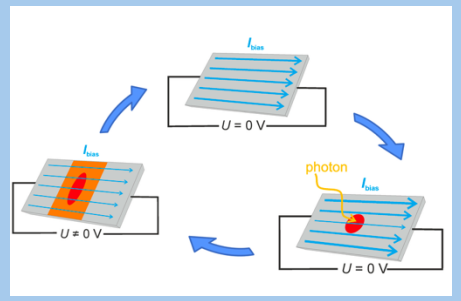
CASSIA

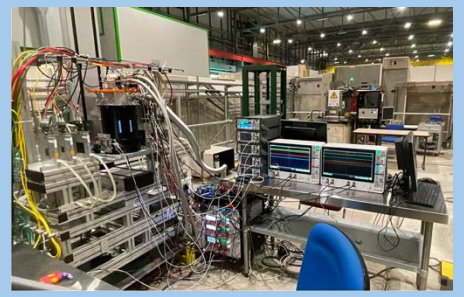


Quantum sensors and wireless communication

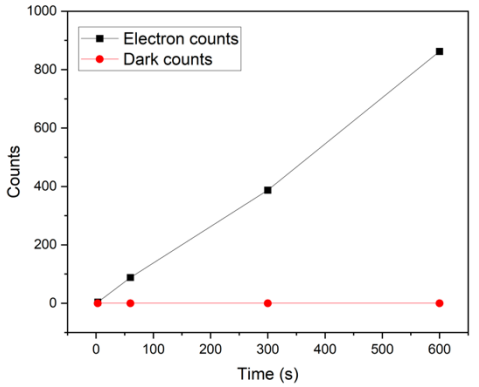
- NSSPD: validation of superconducting nanowires SPDs of different material and geometries for detecting charged particles
  - Study of hit efficiency and timing properties in comparison to silicon sensors
- Investigation of the feasibility of applying the technology to FCC luminometers
  - *Understanding MDI constraints for detector concept & providing cryogenics*
  - *Study possible improvements in the determination of the fiducial region thanks to 100 nm wire size and in the background rejection by using correlated timing measurements*







Measurements with a ^{90}Sr



- Wireless communication: *prototype implementation of wireless channels using commercial 60 GHz integrated circuits*
  - *Antenna design and link optimization*
  - *Study interference between links in the FCC environment topology, test in a mock-up*
  - *Study interlayer intelligence for a fast-track trigger*