# Synergies with LHC

# Detectors


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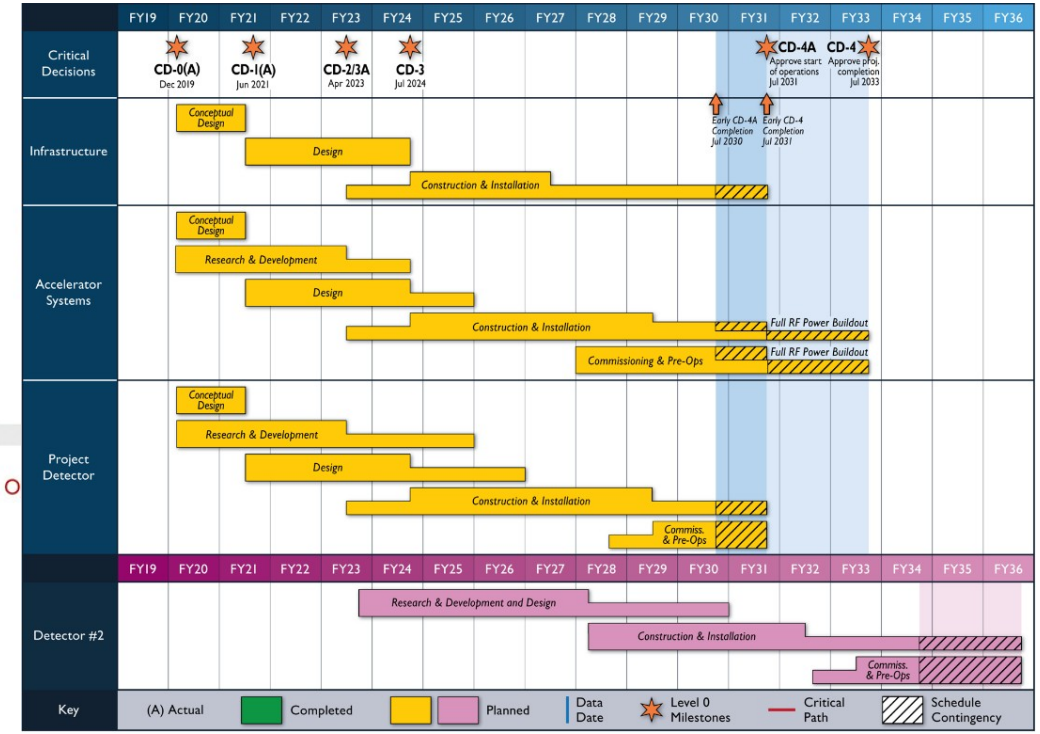
# Timelines

Are they common R&D to projects with timelines so different?

Cerncourier 09/2023


Jana Bielcikova (2022)



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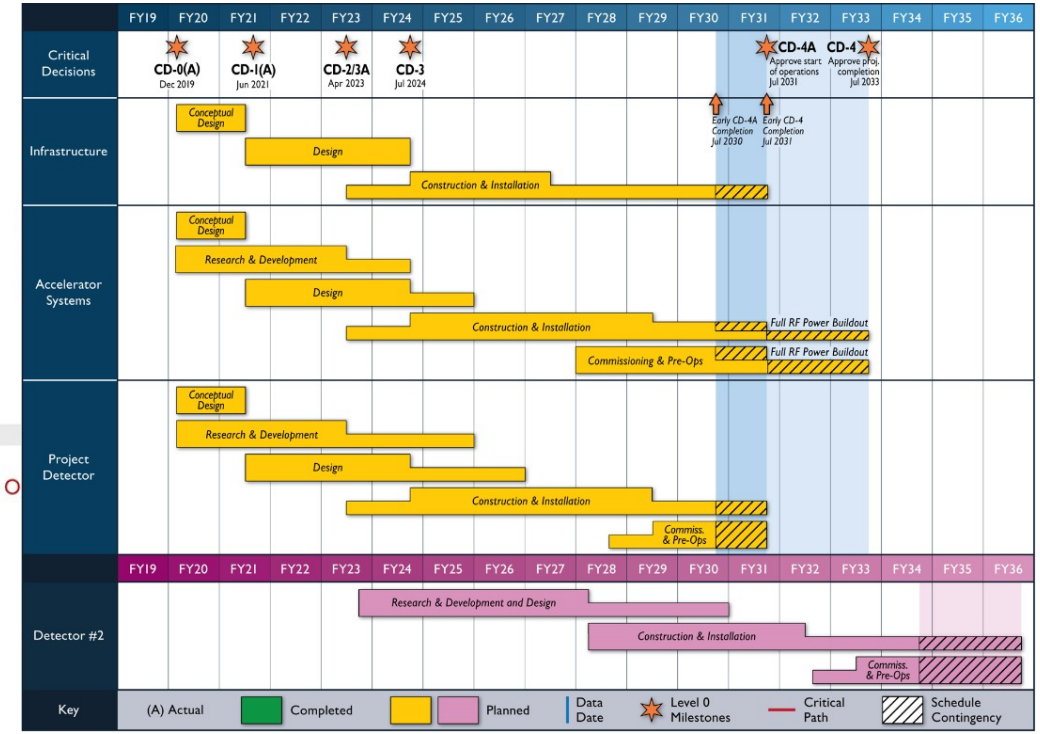


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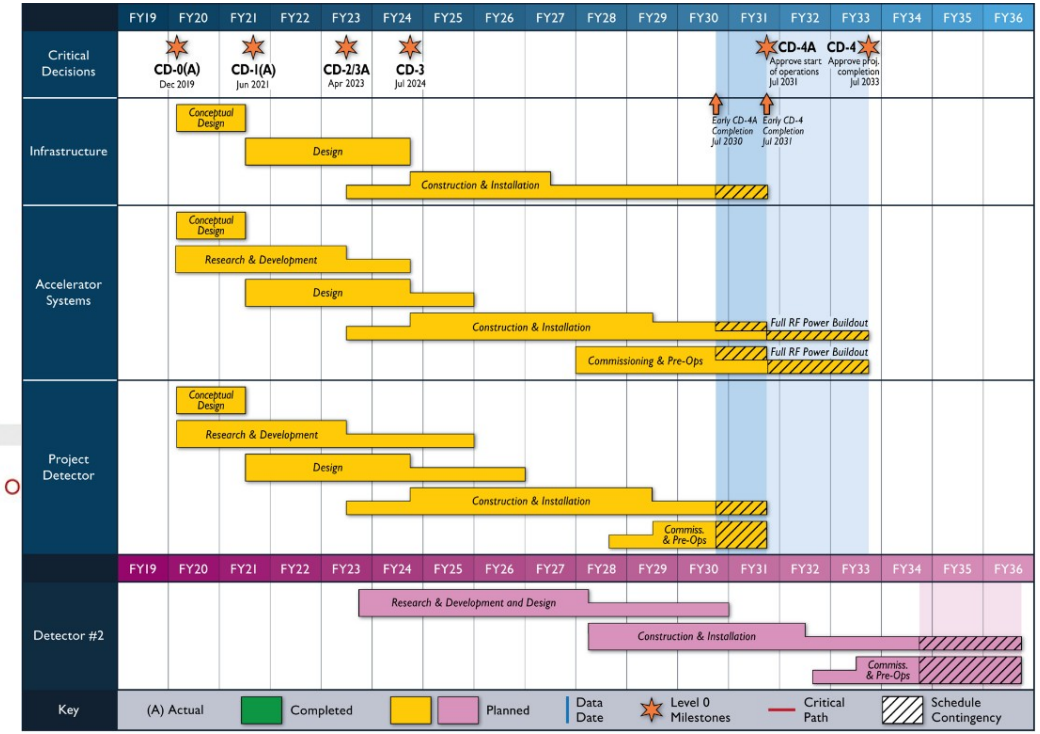


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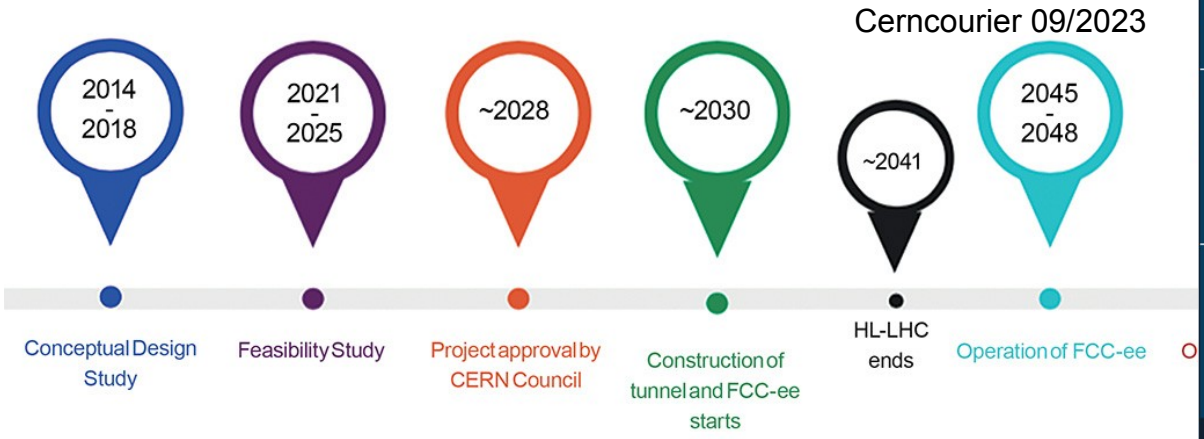


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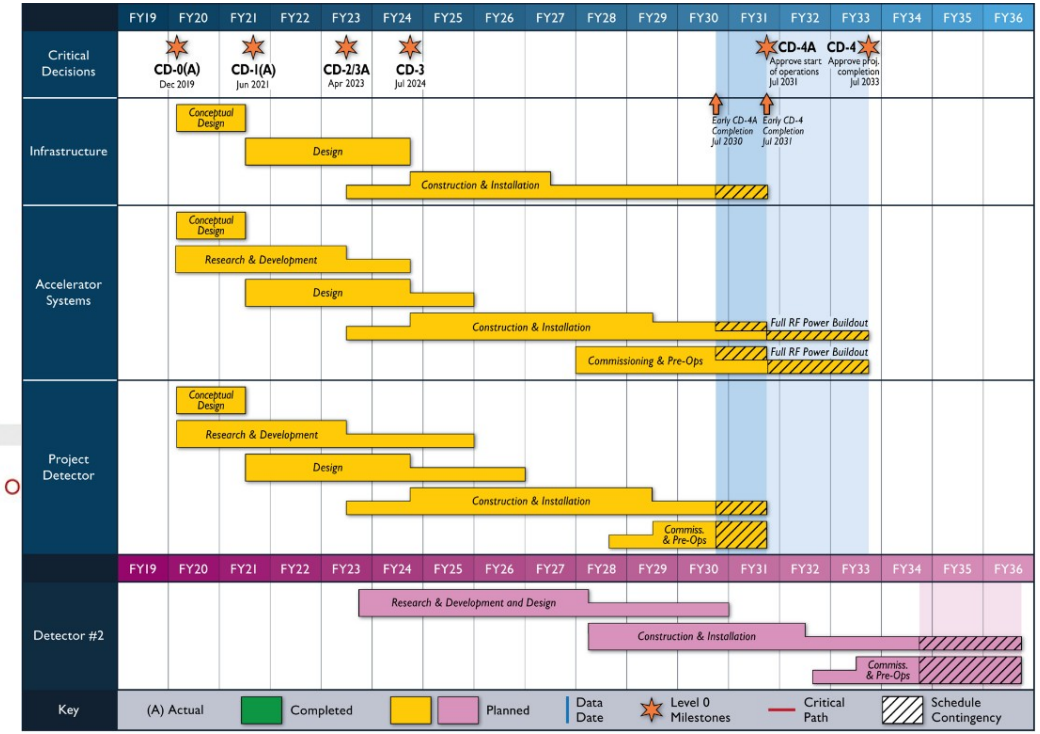


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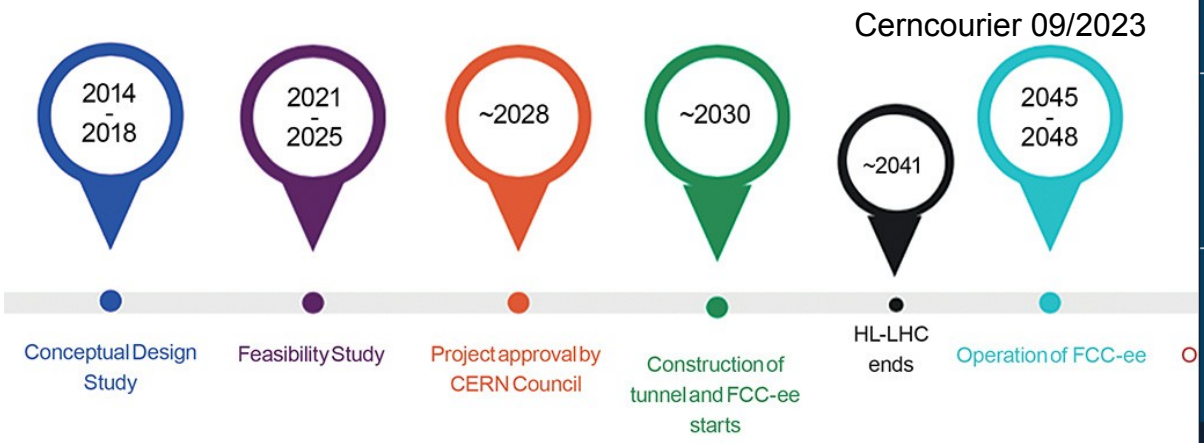


- It’s a step by step work

- Other experiments

- Aspects can be pushed all together with ressources

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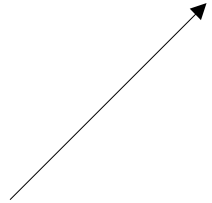
- I do believe sometimes the people that wrote the ERD are already implied in the DRD

It’s just going to be a list from now on

**GEIC - DRD5** (DRD4)



Where it can be found

**GEIC - DRD5** (DRD4)

- A cooled superconducting nanowire can detect single photons with high efficiency, low dark count and low timing jitter

Black square is for random details

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- **DRD5 WP3 Cryogenic materials, devices and systems**

Some of the most important ones are the Transition edge sensors (TES), Kinetic Inductance Detector (KID), Superconductor-Insulator-Superconductor (SIS) mixer, Hot Electron and Cold Electron Bolometer (HEB and CEB), Superconducting Nanowire Single Photon Detector (SNSPD), Superconducting Parametric Amplifiers (SPA), Superconducting Quantum Interference Device (SQUID) and the Magnetic Microcalorimeter (MMC)

Bronze square as it appears in a DRD

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- WP-4 Scaling up "quantum"

WP-4b a: Scintillators (SNSPD mentionned)
WP 4b b: Ensembles of heterostructures (SNSPD mentionned)

Silver as it appears in a work package

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WP-4 Scaling up "quantum"

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Gold when it appears in a task or deliverable

## ERD101, ERD102 - DRD4

- ERD101 not selected for ePIC but synergies are the same anyway. Find new aerogel is probably the main point of synergy. Quality assessment is also probably.

- **DRD4 WP4.3 Task 4.3.1**

New Materials Radiators and Components
• Study of radiator gas alternatives to per-fluorocarbons
• New aerogel optimisation and characterisation
• Exploration of meta-materials as Cherenkov radiators.
• Development of advanced instrumentation and techniques for Cherenkov radiators characterisation, quality assessment and monitoring.

- **DRD4 WP4.1** focus on the further improvement of the SiPM technology.

- Task 4.1.1 - SSPD with new configurations and modes
- Task 4.1.2 - Fast radiation hard SiPMs

**ERD110/114-DRD4**

- W.G 4.3 study integrated electronics for the fast low-noise full readout chain of PMT/MCP/SiPM, targeting single-photon counters.
  Task 4.2.3 read-out electronics capable to reach 10 ps timing resolution
- Task 4.2.1:
  1. Develop new materials and techniques to prolong the lifetime of a MCP-PMT tube, improving at the same its time rate capabilities
  2. Use new techniques with new materials to achieve high aspect ratio with small diameter, to have better gain, time, and spatial resolution

- Task 4.2.2, focuses on new photocathode materials

- Deliverable 4.3.5 - Software and Performance.
  Establish, develop and make available a common framework for (fast) tracing of Cherenkov optical photons; develop and make available a test-bench/framework for a detector-agnostic software for fast reconstruction in RICH detectors; definition and report on software and performance evaluation benchmarks for future RICH detectors; mapping and evaluation of the dedicated external software tools used by the community

# DIRC/GEIC Z-Tagging Mini DIRC

## ERD103, GEIC - DRD4

■ ERD101 not selected for ePIC but synergies are the same anyway. Find new aerogel is probably the main point of synergy. Quality assessment is also probably.

■ **DRD4 WP4.4**

- Task 4.4.3 - Develop lightweight mechanical supports for DIRC-type TOF detectors specificaly for quartz radiators
- Task 4.4.4 Develop techniques for measuring the optical properties of optical components for TOF detectors specifically for quartz radiators
- Deliverable: D4.4.4 Completion of commissioning of an optical laboratory for characterizing the performance of a DIRC-style **quartz** radiator plate (M36).

**ERD104/111/113-DRD4/DRD7**

- The contact person for ERD104 uses a CERN email. Treat the 3 proposals together has a SVT consortium exists.

- **ERD104:** Service reduction:
  M4.1.3 – Demonstration of High-Performance Readout Electronics for SiPMs
  Milestone M4.3.5 – Demonstration of Low-Power Consumption Readout Electronics
  DRD7 → Milestone M7.2.3 – Testing and Validation of Optical Data Transmission Systems
  **ERD111:** Modules, mechanics, cooling and integration
  Task 4.3.3 – Thermo-Mechanical Design and Cooling
  **ERD113:** sensor development, I could add reference here, but according to the document, the work is already carried on in collaboration with ALICE teams. Agreements between CERN and BNL are planned.

## ERD105/106/115/GEIC-DRD4

- ERD105 is now in GEIC. For ERD106 as far as I understand the material for the fibers is selected, the ERD do not mention R&D steps. What follows is similar activities found in DRD4.

- M4.5.1.1 Pre-Selection of suitable scintillators or cladding modification
  M4.5.1.2 Radiation hardness qualification of materials
  M4.5.1.3 Production of prototype fibre(s)
  M4.5.1.4 Testing and qualification of prototype(s)

Maybe a way to characterize your detectors but it seems that all is ready.

Nothing on SiPM connection with light guides

## ERD107

- From ERD107: “using the same base material and scintillator dopant chemistry as is used for the CMS HGCal tiles“. R&D at CERN seems to focus on new material for long scale as well as smaller tiles while the R&D to carry out for ERD107 focuses on building largers tiles and check its properties.

# R&D efforts for electronics and ASICs

**ERD109-DRD7**

- ERD109 includes search for different electronics ALCOR for dRICH readout by SiPM and SALSA for MPGD
- DRD7.4.a The project will focus on cryogenic device modelling from selected CMOS technology nodes (already working together I believe)

SALSA for MPGD (SALSA specifically developped for ePIC)

# LGAD for different detectors

**ERD112-DRD3**

- Part of DRD3 is to focus on LGAD with 30 ps time resolution but spatial resolution <10µm. Depend on where there are, it might be interesting to follow or not if the development is only focusing on small detectors for now.

- Though, RG2.4 focuses on LGAD for ToF (Large area, >30 µm et < 30 ps) 2024-2026: Production of LGAD sensors with large size for Tracking/Time-of-Flight applications to demonstrate yield and doping homogeneity. Study of spatial and temporal resolutions as a function of the pixel size.

# LGAD for different detectors

**GEIC-DRD6/DRD7**

- sandwich calorimeter with scintillator tiles and SiPM, also wish to study 5D reconstruction which is time, energy and transverse distribution, the authors seem well aware of the development on going in the CALICE collaboration. Are they following the new DRD6 collaboration? From DRD6 “SiPM-on-Tile is relatively mature, shifting the main focus of the R&D to system aspects.“

- See WP4 of calorimetry for the electronics where a search for lower power dissipation, might be usefull
  Task 1.1 highly pixelised electromagnetic section SiW-ECAL uses silicon pad sensors with analogue readout embedded between tungsten (W) absorber layers
  Task 1.2 for hadronic section with optical tiles: improve cell-by-cell time resolution, alternative scintillator-integration

- About 5D: Work Package 7.3: 4D and 5D techniques

# Towards a Few-Degree Calorimeter

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# Glass scintillators



- Includes two GEIC: Feasibility of Organic Glass Scintillators for EIC ZDC, Generic glass scintillators for EIC Calorimeters and EIC KLM.

- Task 1.2 Hadronic section with optical tiles M1.9
  ScintGlassHCAL -> study new glass material, see also subtask 3.4.1 ScintCal: "identify the key R&D activities necessary to be carried out on various scintillators and wavelength shifters"
  D3.16 samples of most promising glasses produced and characterised

# Gaseous detectors

**GEIC-DRD1**

- **Development of Double-sided Thin-Gap GEM-µRWELL for Tracking at the EIC**
  See the work done on double-sided RPC but not the same and not sure something is done
- **Development of High Precision and Eco-friendly MRPC TOF Detector for EIC**
  WG4 D4.6.1
- **Development of Thin Gap MPGDs for EIC Trackers**
  Thin gap MPGD's are mentionned but it does not seem that any group is actually working on it
- **Performance of GridPIX Detector in Magnetic Field with low mass and high efficiency $CO_2$ cooling**
  Only a few mention of GridPix in DRD1 and never in Task, no mention of $CO_2$ cooling

# Silicon based detectors 1/2



- **Simplified LGAD structure with fine pixelation/Slim edge for LGADs**
  Task 2.2, Mile stone 2.4/Deliverable 2.3 Improve position resolution in LGAD toward about 10 micron maintaining a 30 ps temporal resolution (for 2025)
  While the aim of this GEIC is to develop a simple novel way to build LGAD with a smaller pitch for 4D tracking

- **Silicon Tracking and Vertexing Consortium, Section 1: Embedded/A Fast Timing MAPS**
  Detector for the EIC (this last one already working with CERN)
  Monolithic Active Pixel Sensor R&D/
  WP1, Detector R&D theme 3.1 WG1 focuses on monolithic CMOS sensors for future tracking, aiming for spatial resolution below 3 µm and time resolution towards 20 ps, will test many designs at different foundries

- **Silicon Tracking and Vertexing Consortium, Section 2: Aluminum Flexible Circuit Manufacturing Capability**
  Specific to US as it is a search for North American manufacturer

- **Slim Edge for LGADs** could not find a match here

# Silicon based detectors 2/2



- **Photonics-Based Readout and Power Delivery by Light for Large-Area Monolithic Active Pixel Sensors**
- DRD3 WP1, Task 1.3 MS1.3 focuses on low power tracker with silicon detectors (note that one the option of the collaboration is to use ALICE-ITS3 sensors or improved MAPS)
- Maybe WP7.1 Data density and power efficiency with for example
  Project 7.1 develop power distribution schemes and their voltage/current regulators and converters for use in a wide range of future particle physics applications, from low-temperature neutrino detectors to high-radiation environment HL-HLC pixel detectors and beyond

- **Large-Area Monolithic Active Pixel Sensors Combining High Spatial and Temporal Resolution** optimization of the ITS3 MAPS to achieve better time resolution, likely already in agreement with groups at CERN, not sure though as DRD seem to be focusing on finding new foundries

# Electronics



- **R&D of 4D Detectors with EICROC and AC-LGAD at EIC consolidating a US-Japan Consortium**
  - Aim is in the title of the GEIC and also test different AC-LGAD with EICROC
    This is wide, not really R&D but see WG2 of DRD3

- **Design, Fabrication and testing of a multi-channel System on a chip for Low-Power High-Density High Timing Precision Readout ASIC forAC-LGADs (HPSoCv3)**
  - In DRD3 one can find:
    RG 2.2: 3D sensors with a temporal resolution better than 50 ps.
    – 2024-2025: Production of a small matrix with pitch equal to or less than $55 \times 55\ \mu m^2$ to be connected with existing read-out ASICS
    – 2026-2028: Production of large-size sensors (using the selected geometry from the R&D runs) and interconnection with custom-made read-out ASIC