

# HV-CMOS Pixel Detector Demonstrator with Serial Powering and Innovative Interconnections

Group meeting, Zoom, 5 January 2026

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**CCF Project Proposal by**

Birmingham, Bristol, Edinburgh, FBK, Heidelberg, Hochschule RheinMain, IHEP,  
KIT, Lancaster, Milano, *Oxford*, Pisa, *Syracuse*, Torino, Trento



UNIVERSITÀ DEGLI STUDI DI MILANO  
DIPARTIMENTO DI FISICA

# Project proposal

- This proposal aims to develop a **large area HV-CMOS pixel detector demonstrator** for large-scale production in **future Higgs factory** experiments, based on **multi-chip modules** with **data aggregation** and **serial powering**.
- These multi-chip modules, including **low-mass multilayer flexible PCBs**, will then be integrated in staves, where modules will be powered in serial mode utilising the on-chip Shunt Low Drop Out (SDLO) regulators. Together with data aggregation, this will substantially **reduce the number of stave data and power connections**.
- **Low-mass aluminium flex productions**, innovative connection methods (e.g. single-point Tape Automated Bonding), **low-mass mechanical support**, and **efficient cooling technologies** will be explored for overall system optimization in power and material budget.
- *The expertise gained by the participating institutes will be beneficial for the integration of future full-size devices that will be developed by the strategic DRD3 projects in the next few years*

Available in DRD3 CDS Repository: [CERN-DRD3-PROJECT-2025-014](#)

# Institutes and Contact Persons

| Institute                       | DRD3      | RD50     | Project contact                     |
|---------------------------------|-----------|----------|-------------------------------------|
| University of Birmingham        | x         | x        | <a href="#">James Glover</a>        |
| University of Bristol           | x         |          | <a href="#">Jaap Velthuis</a>       |
| University of Edinburgh         | x         |          | <a href="#">Yanyan Gao</a>          |
| University of Heidelberg        | x         |          | <a href="#">Heiko Augustin</a>      |
| Hochschule RheinMain            | x         |          | <a href="#">Daniel Muenstermann</a> |
| IHEP                            | x         | x        | <a href="#">Yiming Li</a>           |
| INFN and University of Milano   | x         |          | <a href="#">Attilio Andreazza</a>   |
| KIT                             | x         |          | <a href="#">Ivan Peric</a>          |
| University of Lancaster         | x         | x        | <a href="#">Harald Fox</a>          |
| INFN Pisa                       | x         | x        | <a href="#">Fabrizio Palla</a>      |
| FBK Trento                      | x         | x        | <a href="#">David Novel</a>         |
| TIFPA and University of Trento  | x         |          | <a href="#">Roberto Iuppa</a>       |
| INFN Torino                     | x         | x        | <a href="#">Stefania Beolè</a>      |
| <b>Participating institutes</b> | <b>13</b> | <b>6</b> |                                     |

In addition also Oxford and Syracuse

## 1. Demonstrate the operation of a CMOS based multi-chip module SP chain in realistic environment

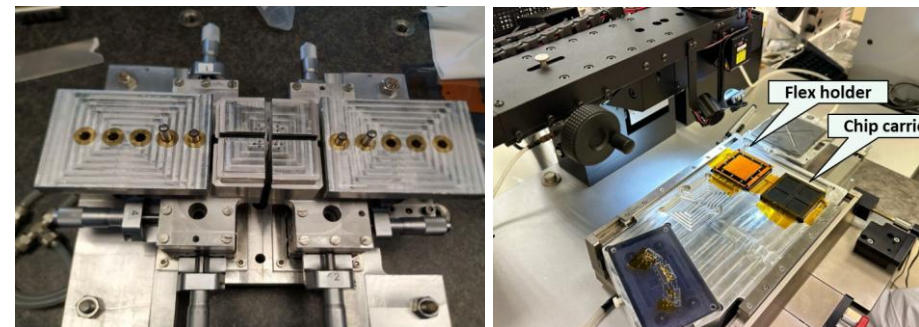
- verifying the chip SLDO performance in multi-chip/module setups, establishing multi-module SP chain DAQ systems
- assessing the feasibility of power bus based on Aluminum conductor
- producing low mass cooling and mechanical supports.
- *Many components for this stage are either existing or in advanced R&D stage from previous projects, such as ATLASPix3.1 based quad-chip modules with  $150\mu\text{m}$  thickness being assembled by Edinburgh and Milano, a long mechanical support stave from FCC-ee R&D from Pisa,  $50\mu\text{m}$  thick ATLASPIX3.1 sensors in Heidelberg.*

## 2. Increase the level of integration above the ATLASPix3.1: Explore high density aluminum flex PCB production and innovative interconnections

- This stage will exploit new sensors to be submitted in LF 150 nm technology around September- December 2025 (led by KIT)
- DAQ systems of the participant institutes will also be upgraded accordingly.

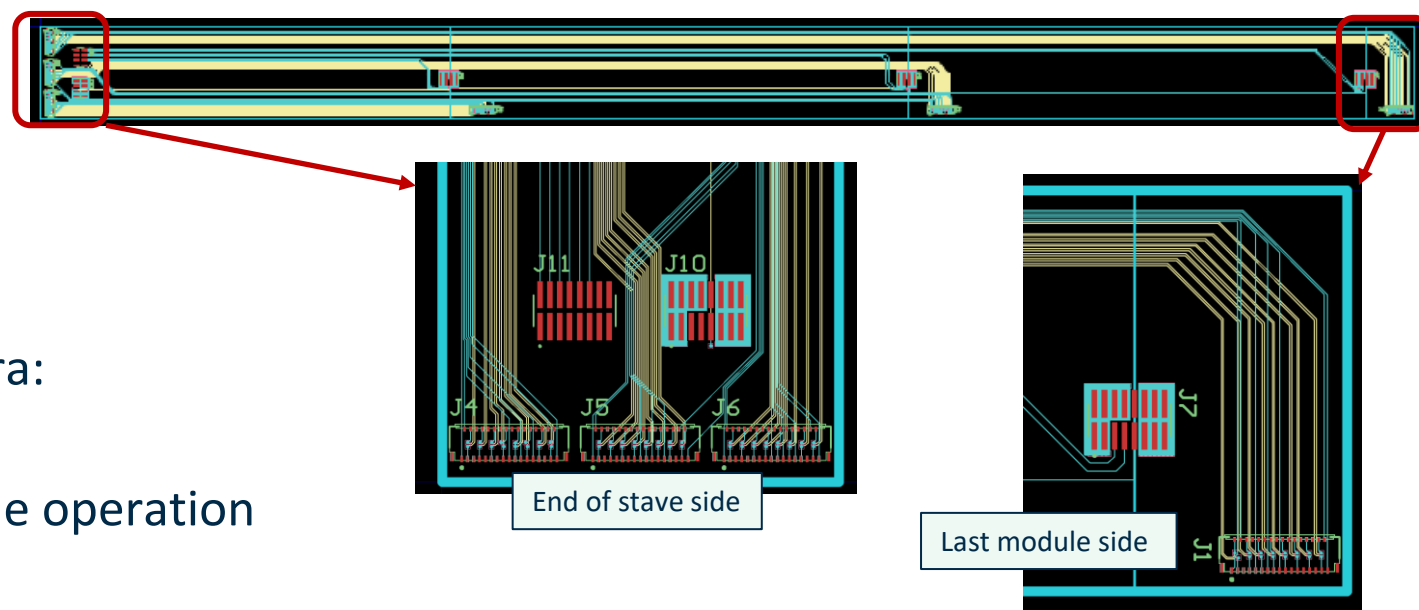
# Stage 1 Completion

- Assembly modules with remaining ATLASPIX3.1 chips
  - ~6 modules with 150  $\mu\text{m}$  sensors probed by Milano/Edinburgh
  - 50  $\mu\text{m}$  sensors available from Heidelberg
  - Either pick-and-place or dedicated jig



- Designed a power bus to test a multi-module serial power chain

- Aluminium conductor to reduce thickness in radiation lengths
- Connecting to modules by pigtails
- 4 cm  $\times$  60 cm size to match CERN Microfabrication Lab capability
- Received quotation from Rui De Oliveira: 14,200 CHF for a panel (5-8 pieces)
- Ready to start production, since module operation issues are solved



- Loading of cold plate (half stave with 3 modules + heaters)
  - Need tooling for loading and instrumentation for assessing thermal performance

1. **Submission and production of LF generic R&D chips**
2. **Thinning of sensors to samples of 150 and 50  $\mu\text{m}$  thickness**
3. **Design and production of multi-chip module PCB for LF sensors:**

Requires sequential steps in understanding and verification of chip behaviour:

  1. Test of chips on single-chip-carriers, to define the operating point, minimal amount of signal, wire bonding and register configuration
  2. Copper based version, standard wire bonding, to verify the schematics and operation of the multi-chip modules
  3. Low-mass Aluminum based using FBK technology, implementing tab bonding
4. **Assembly and operation of SP chain with multi-chip modules**
  - Daisy chaining of modules through adapter cards
  - Interface to DAQ system
5. **Realization of an integrated power bus and multi-chip module PCB**
  - Major step with respect to the separate structure with power bus and module PCB as separate pieces, connected by pigtailed
  - **May test some of the chip-to-flex attach technologies being developed in WG7**

# Deliverables and timelines

| Deliverable   | Original Timeline   | Current Guesstimate |
|---|---------------------|---------------------|
| Multi-chip module construction and readout (ATLASPix3.1)            | 06/2025             | 03/2026             |
| AI-flex production for ATLASPix3.1 power bus                        | 09/2025             | 02/2026             |
| ATLASPix-based SP chain prototype construction and characterisation | 03/2026             | 06/2026             |
| Submission and production of new CMOS sensors (LF)                  | 07/2025-<br>03/2026 | 06/2026             |
| Multi-chip readout flex submission for the LF CMOS sensors          | 12/2026             | 06/2027             |
| Multi-chip LF module construction and readout                       | 03/2027             | 12/2027             |
| AI-flex production for the LF CMOS sensors                          | 09/2027             | 06/2028             |
| LF sensors based SP chain prototype construction                    | 01/2028             | 09/2028             |
| LF sensors based SP chain prototype evaluation                      | 03/2028             | 12/2028             |

| Procurements  | Cost (CHF)     |
|---|----------------|
| Al Serial Power Bus for ATLASPIX 3.1 (CERN)                 | 15,000         |
| Cu Multi Chip Module Flex LF sensors (design verification)  | 5,000          |
| Al Multi Chip Module Flex LF sensors (FBK)                  | 15,000         |
| Al Serial Power Bus for LF sensors (CERN)                   | 15,000         |
| DAQ Upgrades (FPGA, chip carriers and readout boards)       | 15,000         |
| Chip-to-Module assembly jigs                                | 2,000          |
| Stave loading and test equipment                            | 10,000         |
| CMOS Wafers production and processing (thinning and dicing) | 20,000         |
| <b>Total project cost:</b>                                  | <b>107,000</b> |

- Total project cost:** **107,000 CHF**
  - DRD3 CCF contribution (13 institutes × 2650 CHF) 34,450 CHF
  - RD50 CCF contribution (6 institutes × 2650 CHF) 15,900 CHF
  - Funding from participating institutions 56,650 CHF

# Institutes' Contribution

| Procurements  | Institute                   | Institute contribution | DRD3/RD50 Contribution | CCF Project totals | Additional contribution |
|---|-----------------------------|------------------------|------------------------|--------------------|-------------------------|
| Al Serial Power Bus for ATLASPIX 3.1 (CERN)                 | Milano (in-kind)            | 15,000                 |                        | 15,000             |                         |
| Cu Multi Chip Module Flex LF sensors (design verification)  | IHEP                        | 5,000                  |                        | 5,000              |                         |
| Al Multi Chip Module Flex LF sensors (FBK)                  | INFN                        | 5,000                  | 10,000                 | 15,000             |                         |
| Al Serial Power Bus for LF sensors (CERN)                   | Edinburgh                   | 5,000                  | 10,000                 | 15,000             |                         |
| DAQ Upgrades (FPGA, chip carriers and readout boards)       | Spread across testing sites | 7,000                  | 8,000                  | 15,000             |                         |
| Chip-to-Module assembly jigs                                | Milano (?)                  | 2,000                  |                        | 2,000              |                         |
| Stave loading and test equipment                            | Pisa (in kind)              | 10,000                 | 10,000                 | 20,000             |                         |
| CMOS Wafers production and processing (thinning and dicing) | Lancaster+Edinburgh         | 10,000                 | 10,000                 | 20,000             |                         |
| <b>Total project cost:</b>                                  |                             | <b>56,650</b>          | <b>50,350</b>          | <b>107,000</b>     |                         |

Original table in google doc: sum of contribution higher than required, but for some item cost underestimated

# Institutes' Contribution

| Procurements  | Institute        | Institute contribution | DRD3/RD50 Contribution | CCF Project totals | Additional contribution |
|---|------------------|------------------------|------------------------|--------------------|-------------------------|
| Al Serial Power Bus for ATLASPIX 3.1 (CERN)                 | Milano (in-kind) | <b>15,000</b>          |                        | <b>15,000</b>      |                         |
| Cu Multi Chip Module Flex LF sensors (design verification)  |                  |                        |                        | 5,000              |                         |
| Al Multi Chip Module Flex LF sensors (FBK)                  |                  |                        |                        | 15,000             |                         |
| Al Serial Power Bus for LF sensors (CERN)                   |                  |                        |                        | 15,000             |                         |
| DAQ Upgrades (FPGA, chip carriers and readout boards)       |                  |                        |                        | 15,000             |                         |
| Chip-to-Module assembly jigs                                |                  |                        |                        | 2,000              |                         |
| Stave loading and test equipment                            | Pisa (in kind)   | <b>10,000</b>          |                        | 20,000             |                         |
| CMOS Wafers production and processing (thinning and dicing) |                  |                        | <b>20,000</b>          | <b>20,000</b>      | <b>KIT 36,000</b>       |
| <b>Total project cost:</b>                                  |                  | <b>56,650</b>          | <b>50,350</b>          | <b>107,000</b>     |                         |


In bold: money already assigned/spent

- Since yesterday afternoon dedicated category in Indico:
- e-groups:
  - [drd3-ccf-hvcmos-lad-contacts@cern.ch](mailto:drd3-ccf-hvcmos-lad-contacts@cern.ch)
  - [drd3-ccf-hvcmos-lad@cern.ch](mailto:drd3-ccf-hvcmos-lad@cern.ch)
- Presentations:
  - FCC Vertex Workshop (30-31/10/2025)
  - Mighty Tracker SP workshop (10-11/2/2026)
  - Report at DRD3 week (Bucharest 29/06-03/07/2026)
- Follow up topical meetings:
  - HVPix submission and features (second half of February)
  - Define workflow with FBK (first half of March)
  - Planning of Serial powering tests on CEPC stave (second half of March)

DRD3 - Projects



Create event ▾

 Navigate

 Parent category

|   |           |      |
|---|-----------|------|
| CMOS Pixel Detector Demonstrator with Serial Powering and Innovative Interconnections | empty     | →    |
| LGAD based timing tracker development for future colliders                            | 3 events  | →    |
| Novel silicon 3-D trench pixel detectors on 8inch CMOS process                        | 7 events  | 🛡️ → |
| Project Cactus  | 5 events  | 🛡️ → |
| Project CASSIA  | 8 events  | 🛡️ → |
| Project OCTOPUS   | 74 events | 🛡️ → |
| Project TH-LGAD   | 3 events  | →    |
| Project: Serial Powering  | empty     | 🛡️ → |
| Project: Shared Submission in LF15A Technology  | empty     | 🛡️ → |
| Versatile MAPS  | 31 events | →    |

# BACKUP



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