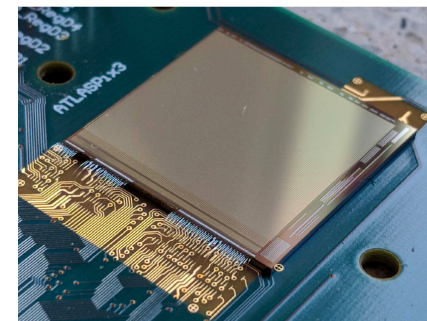




# Pixel Detector Modules

a tale of sandwich and pie

- chips, and maybe Christmas lights

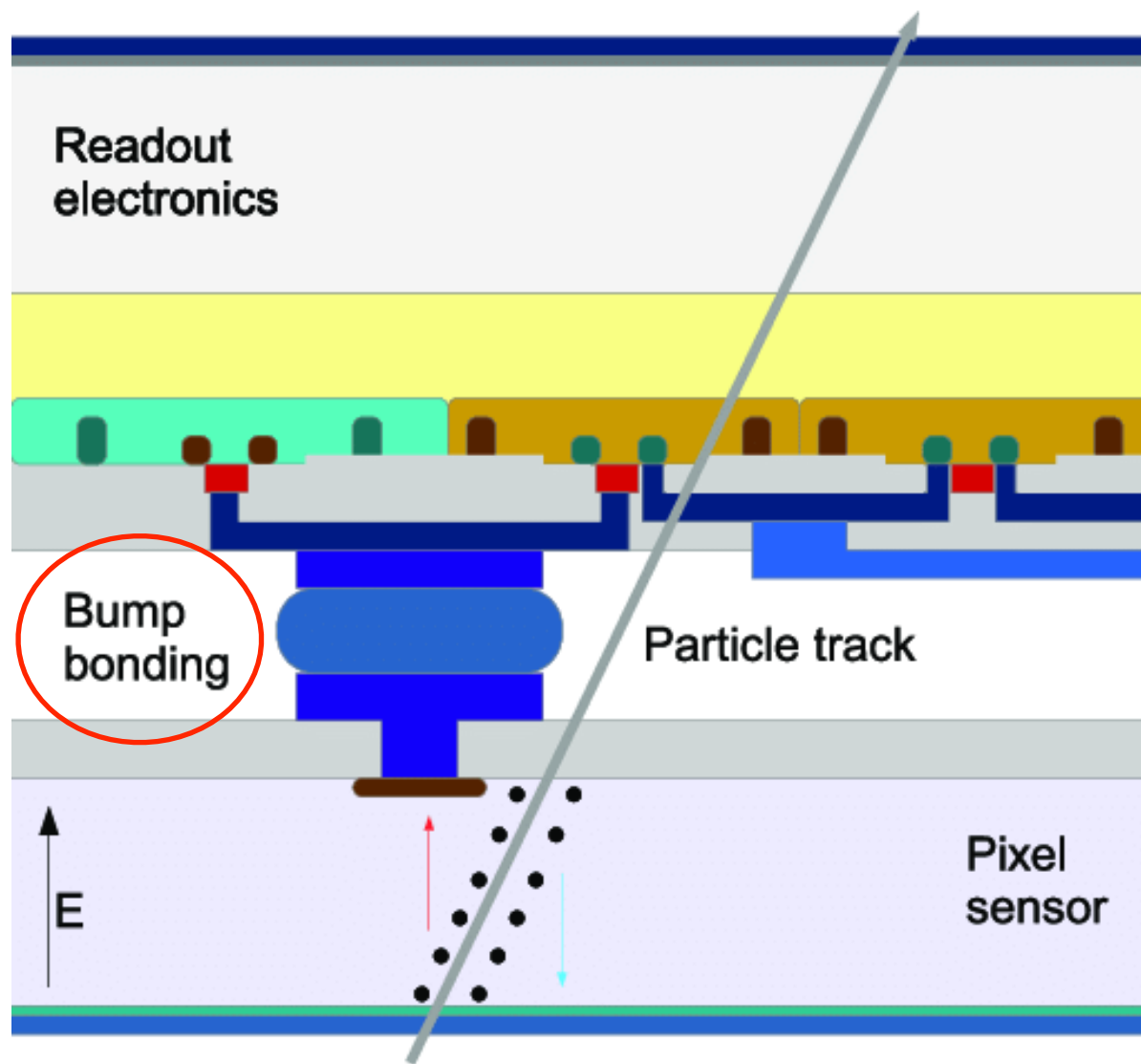
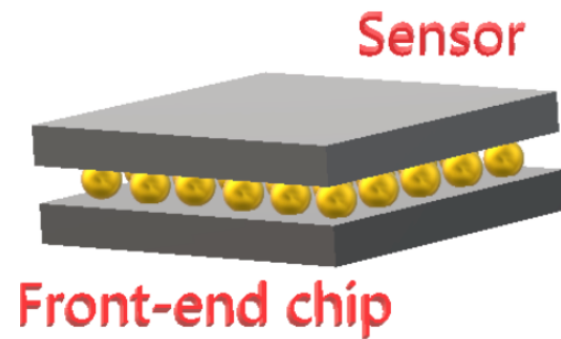


Yanyan Gao

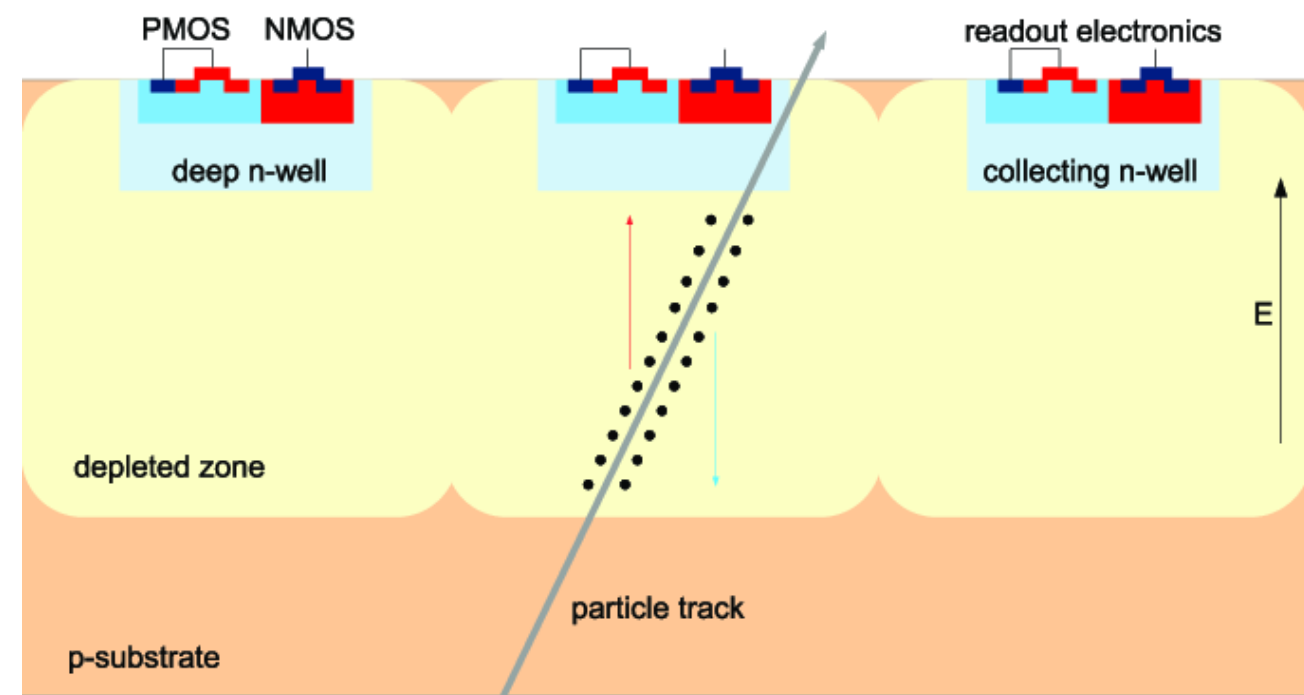
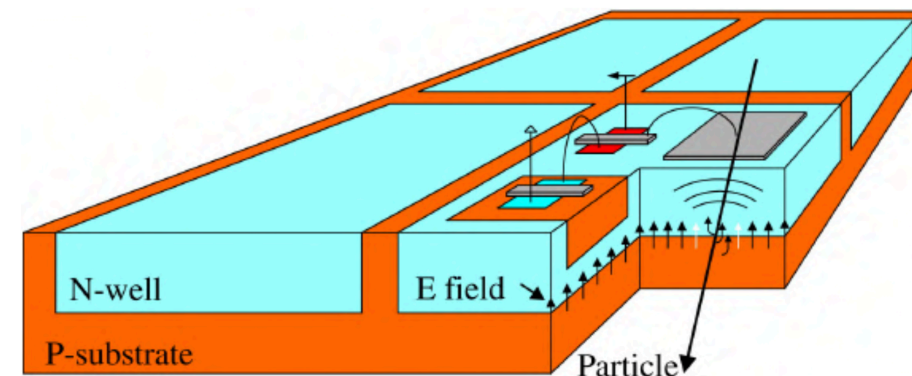


Edinburgh PPE Annual Christmas Gathering 2025

# Pixel Detector: Hybrid vs Monolithic concepts



Hybrid planar sensor

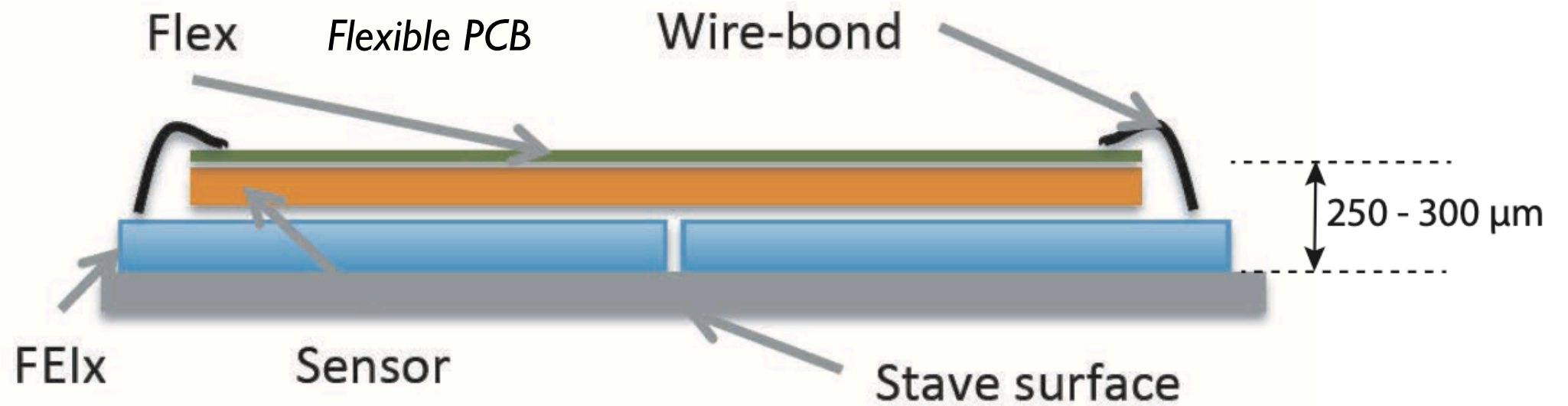


Monolithic Active Pixel Sensor (CMOS process)

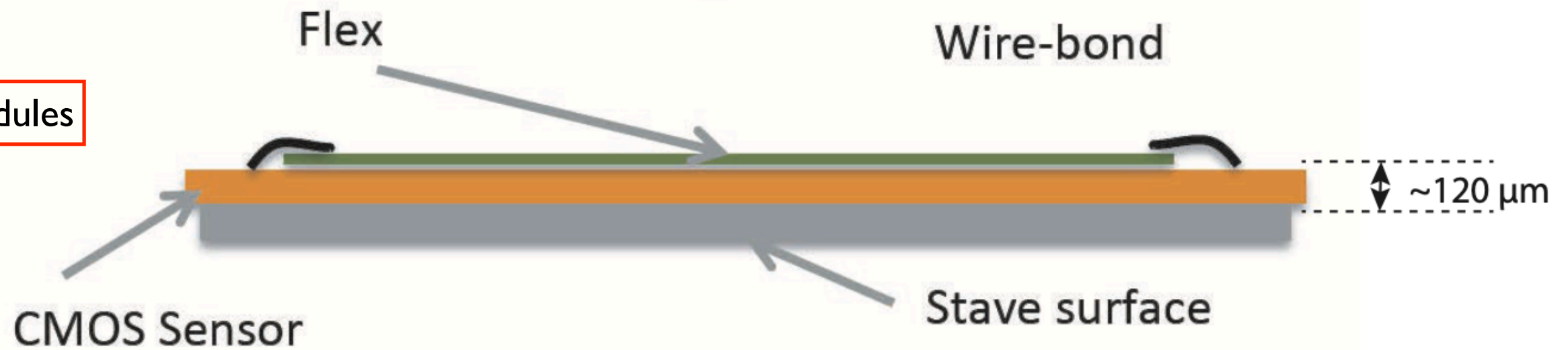


# Chip(s) to Modules

Hybrid modules

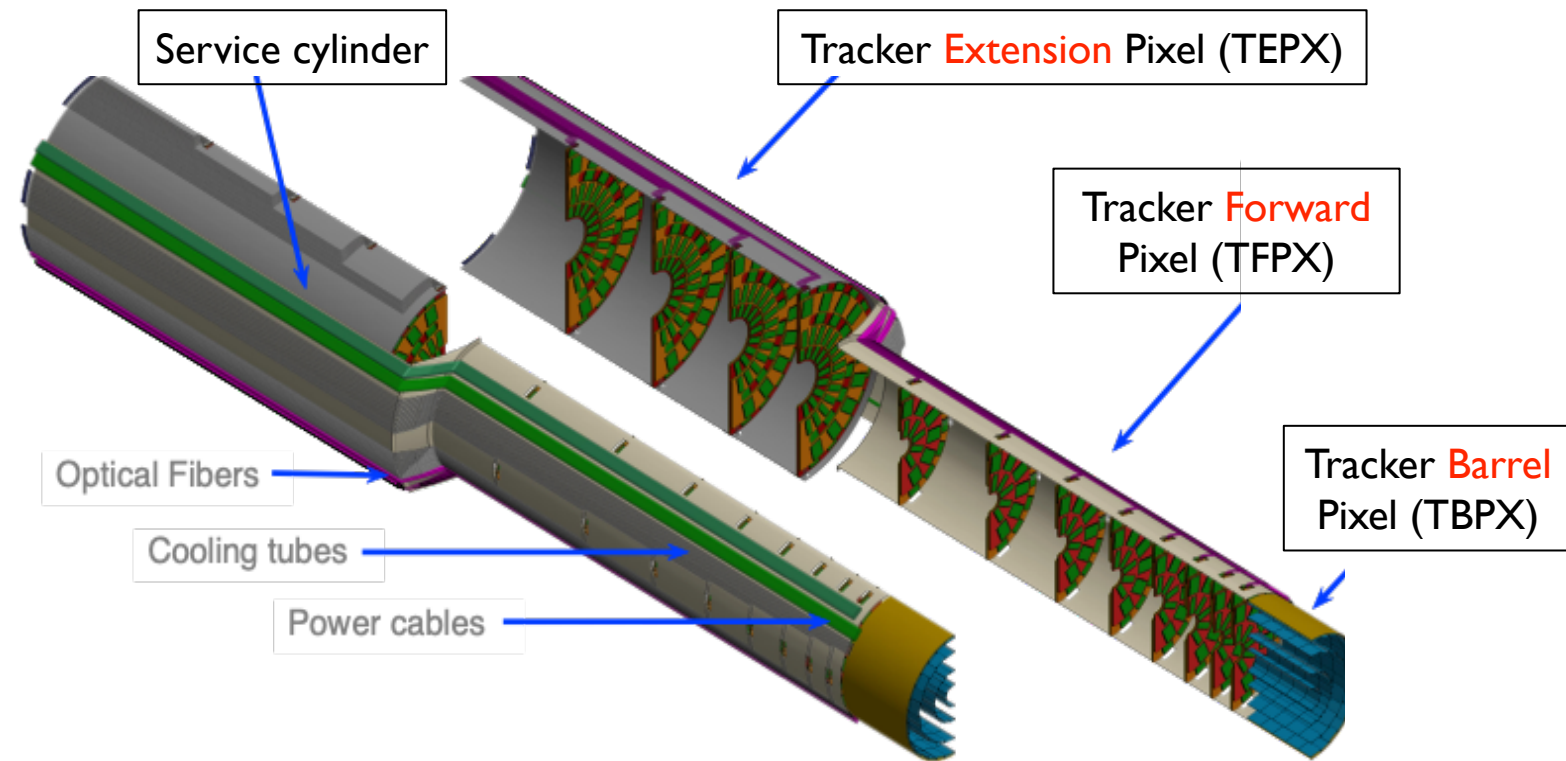
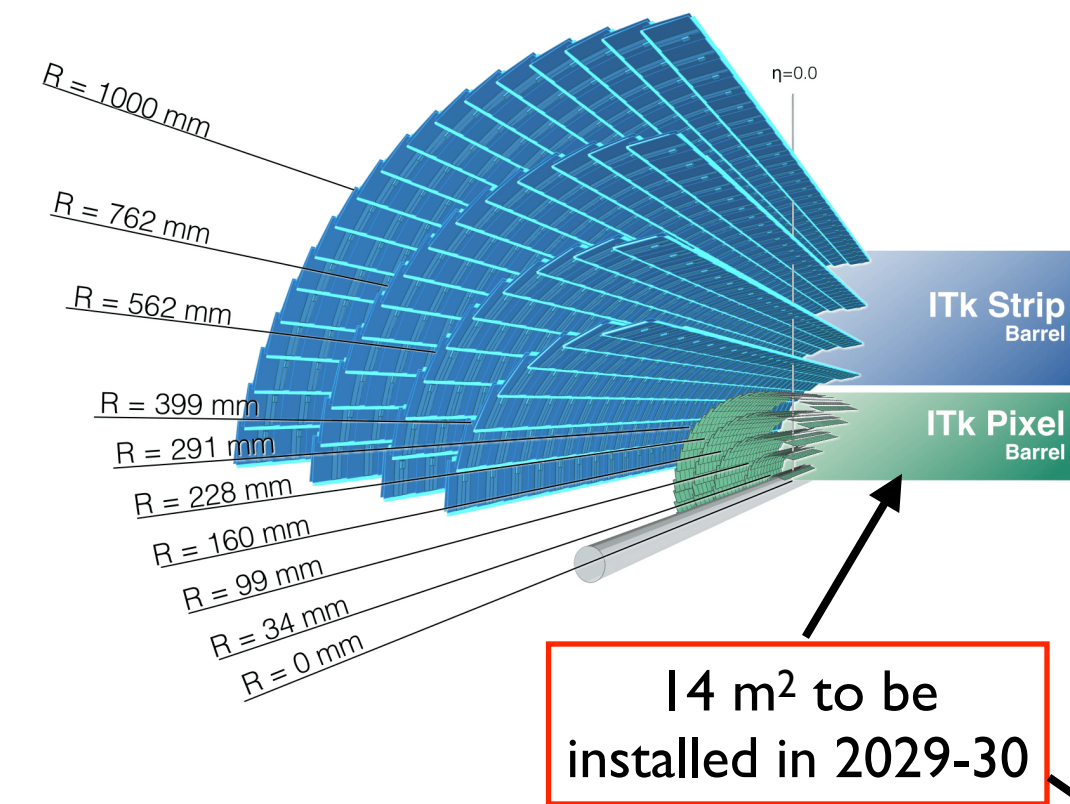


CMOS modules



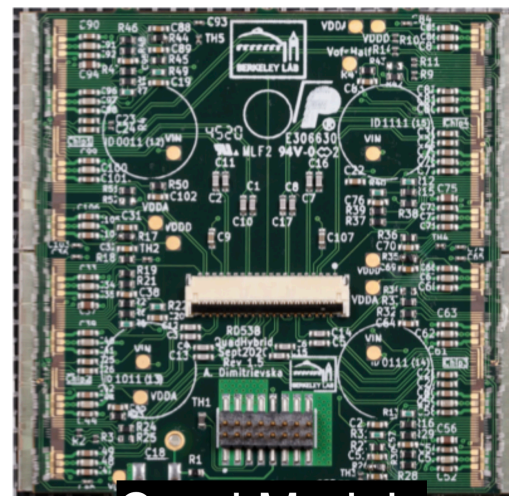
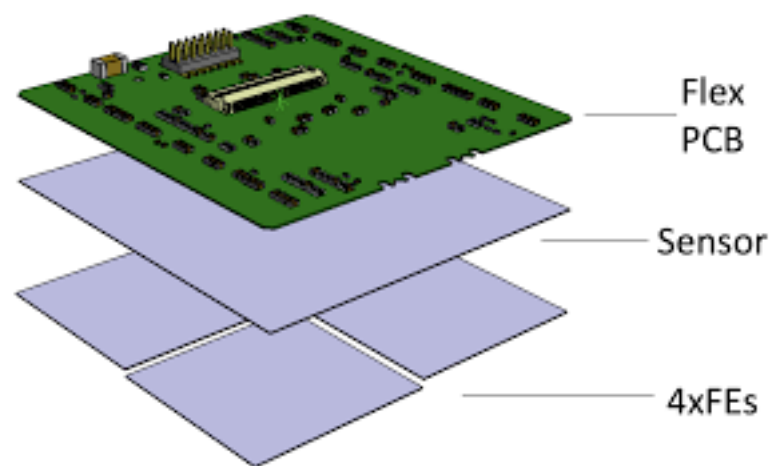
# ATLAS Inner Tracker (ITk) Upgrade

UK deliverable: Pixel Outer Endcap 1.3m<sup>2</sup>



We are in production

~9000 quad-modules



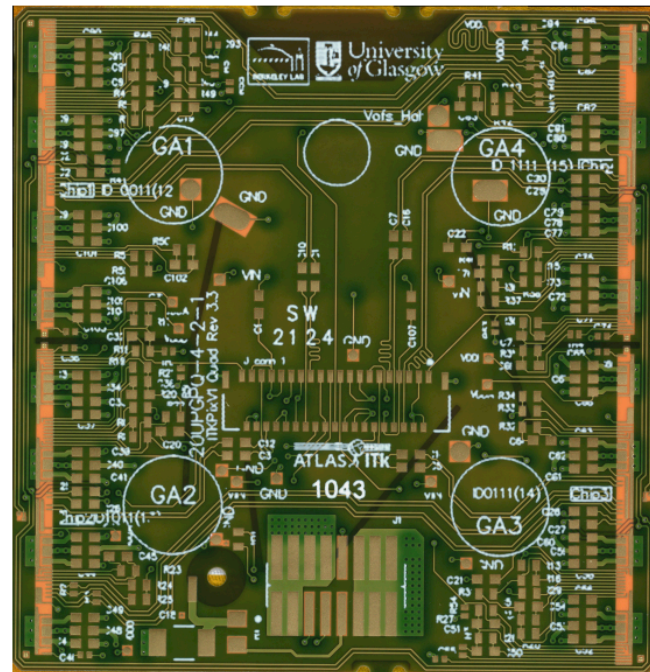


# ITk Pixel Quad-Module Flex PCB QC

Afroditi in ITk week



## Flex PCBs

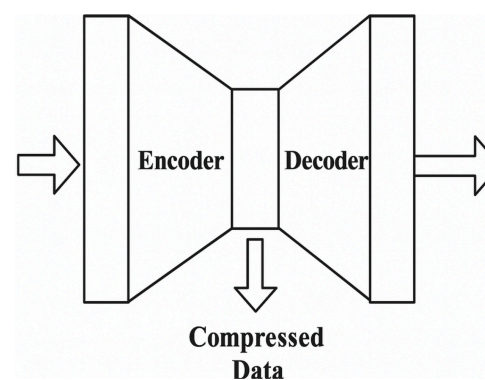
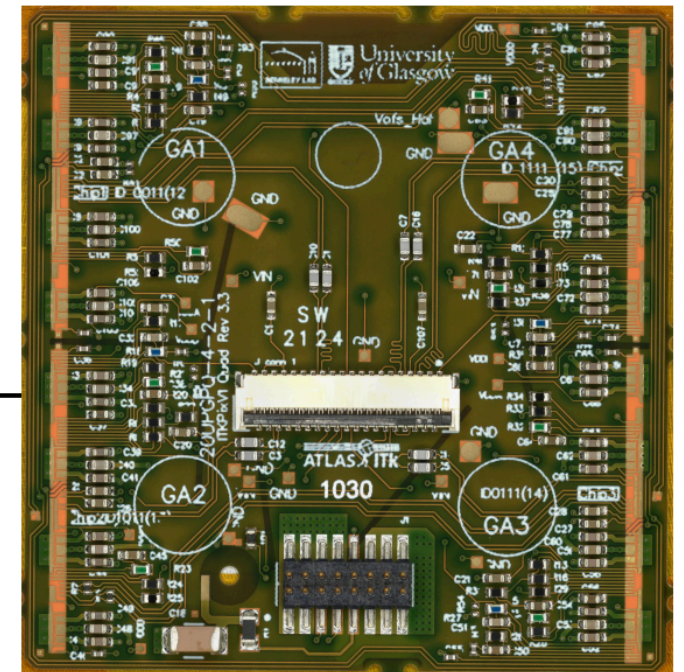


### Bare PCB

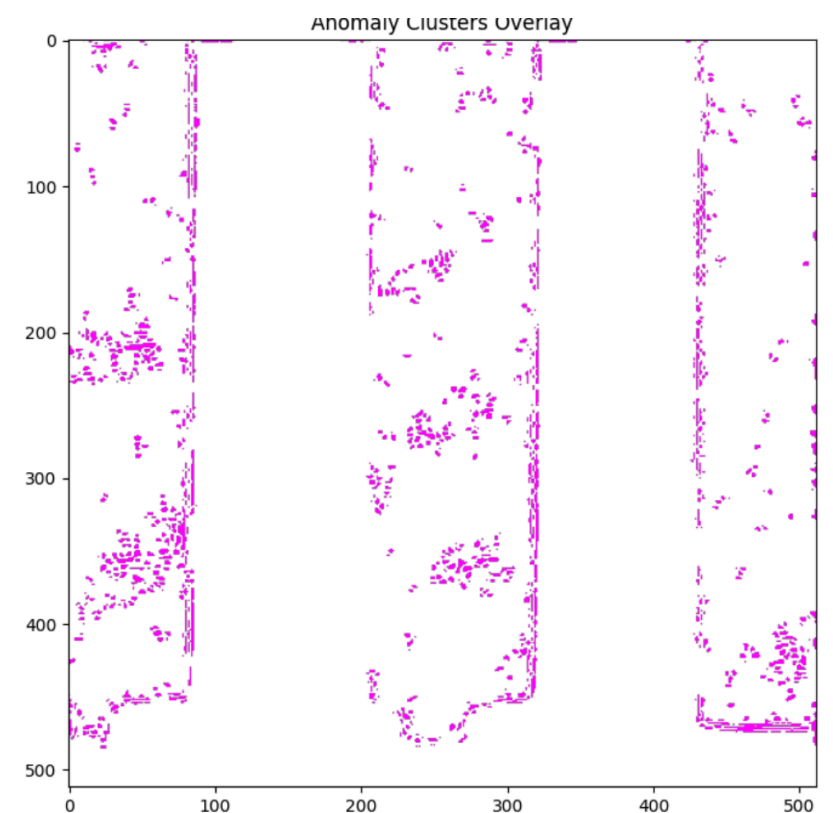
For bare flexes, the QC workflow includes tests such as Layer thickness measurements and Visual Inspection (VI) to identify fabrication defects.

### Populated PCB

After population, further checks are performed, including VI of the assembled boards and High-Voltage/Low-Voltage (HV/LV) tests to verify electrical integrity.

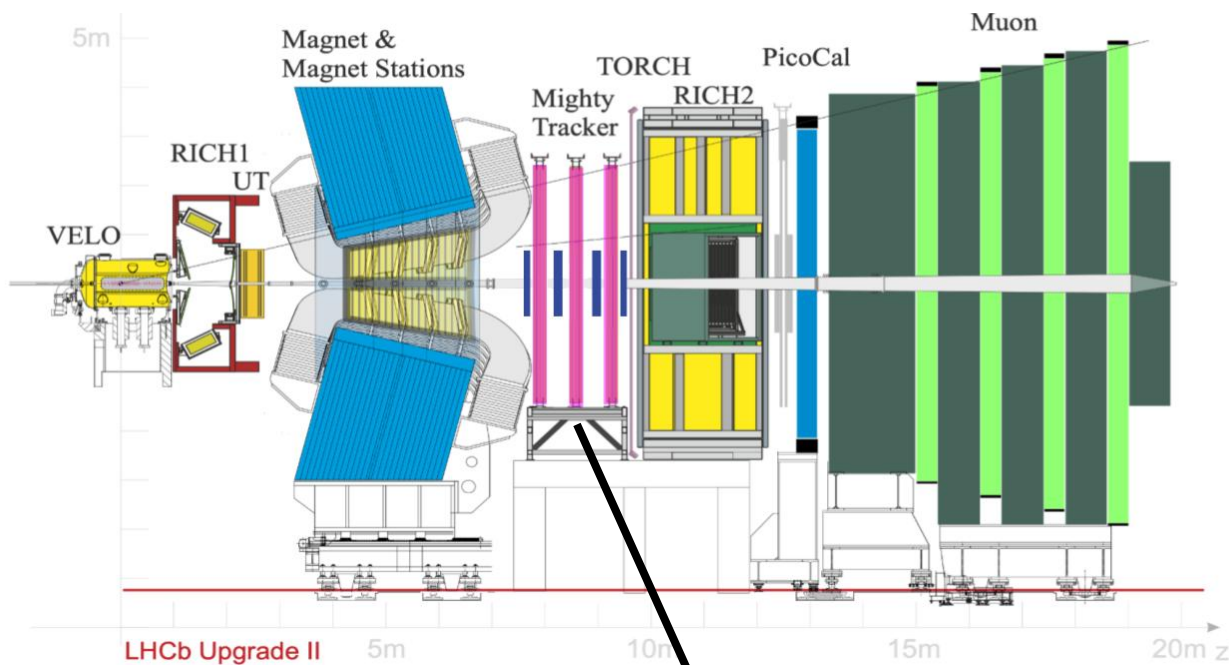


5

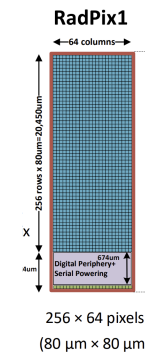




# The LHCb Mighty Tracker

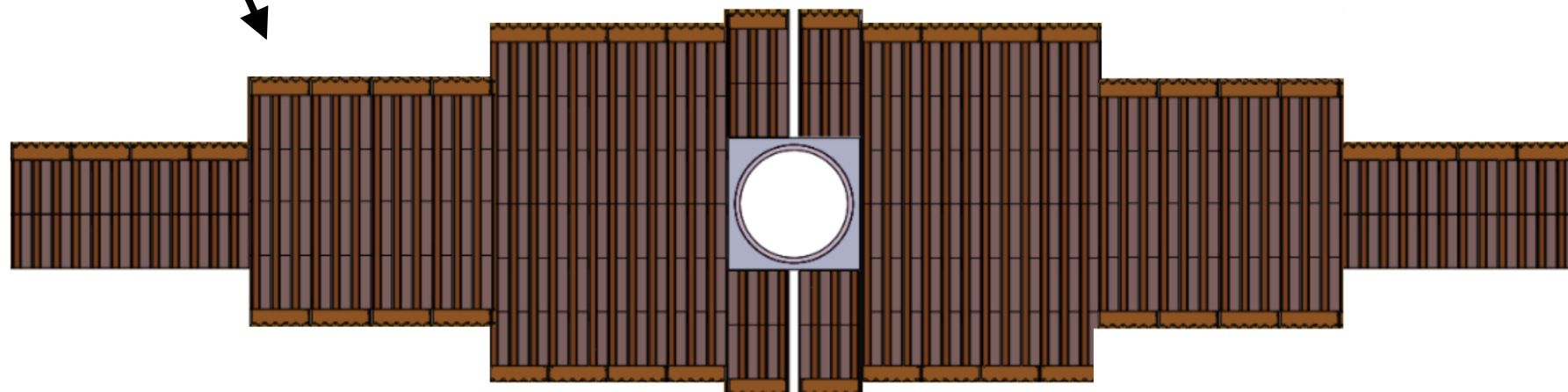
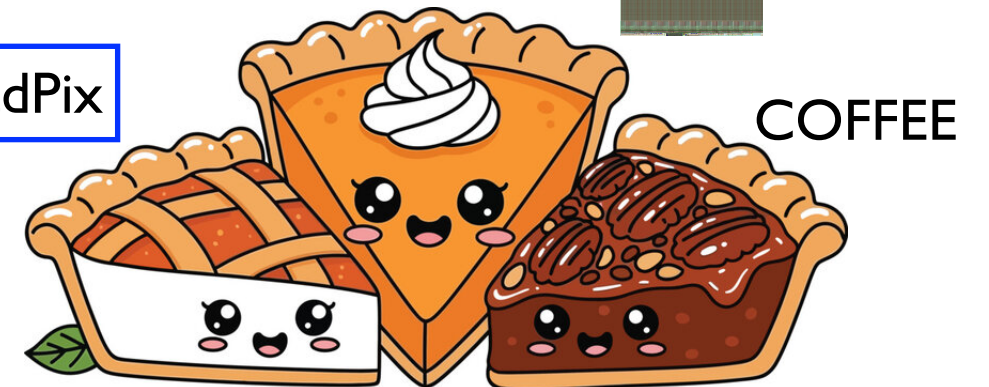


8 m<sup>2</sup> HV-CMOS pixel detector, to be installed ~2034

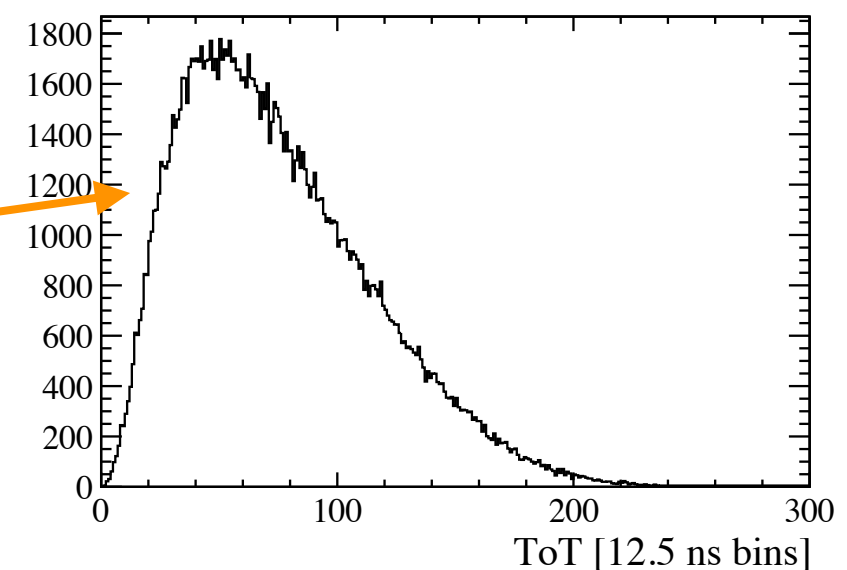
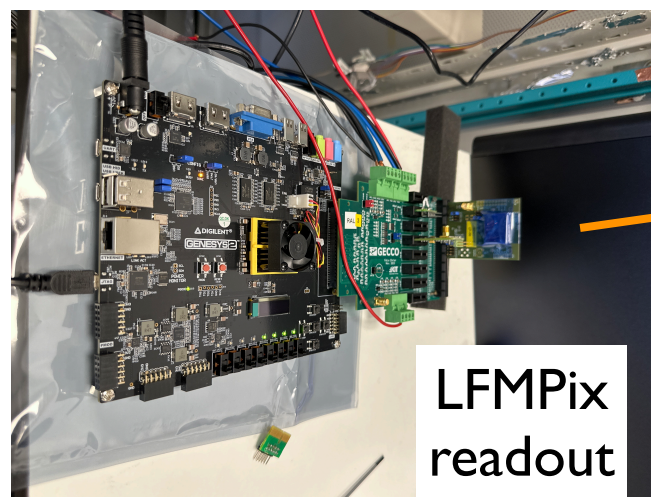
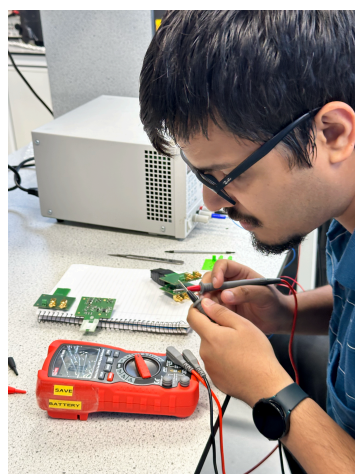
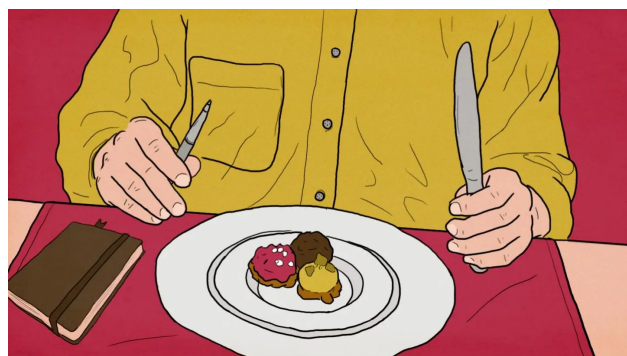


RadPix

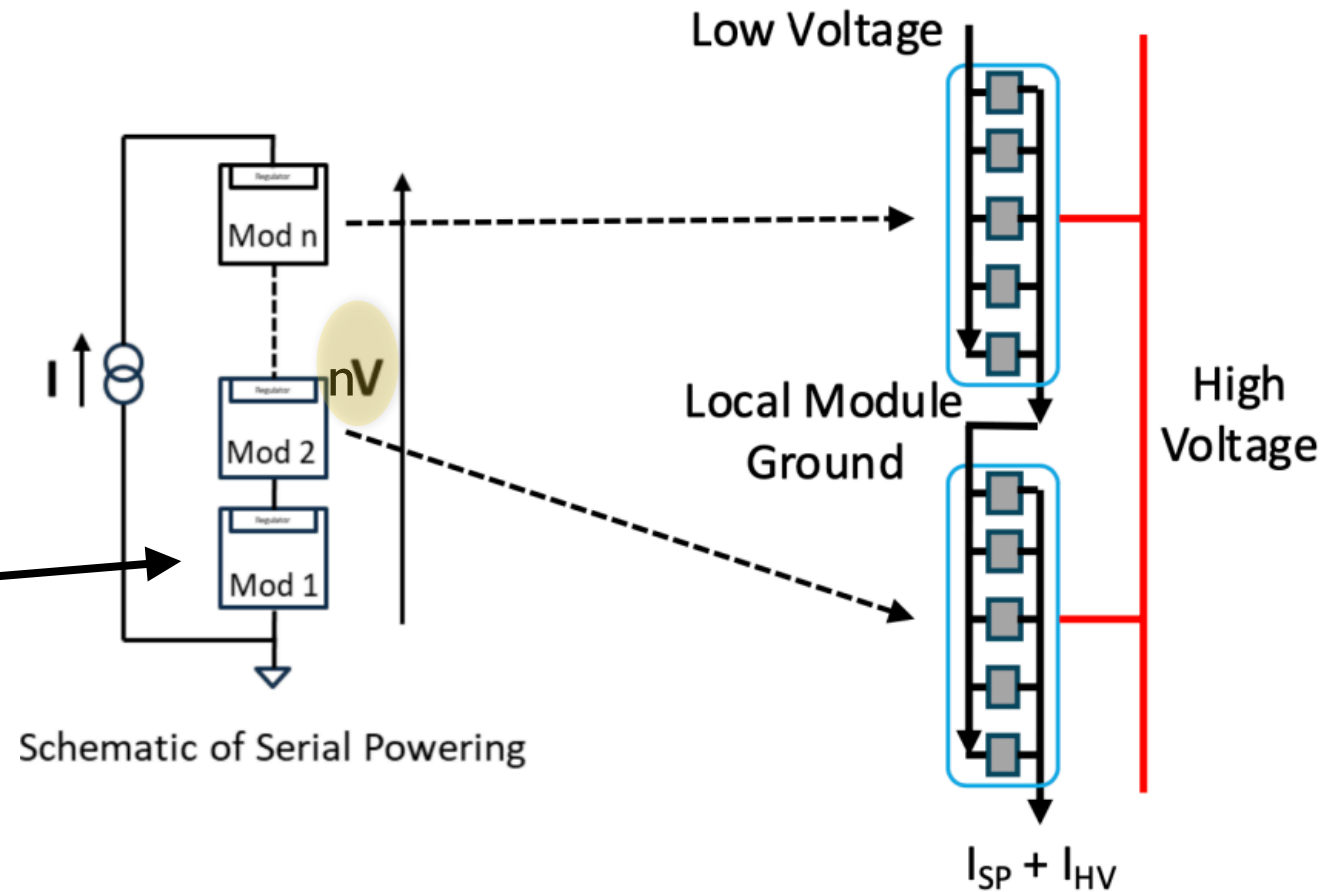
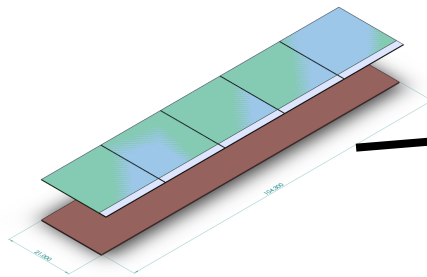
MightyPix



Edinburgh MT team

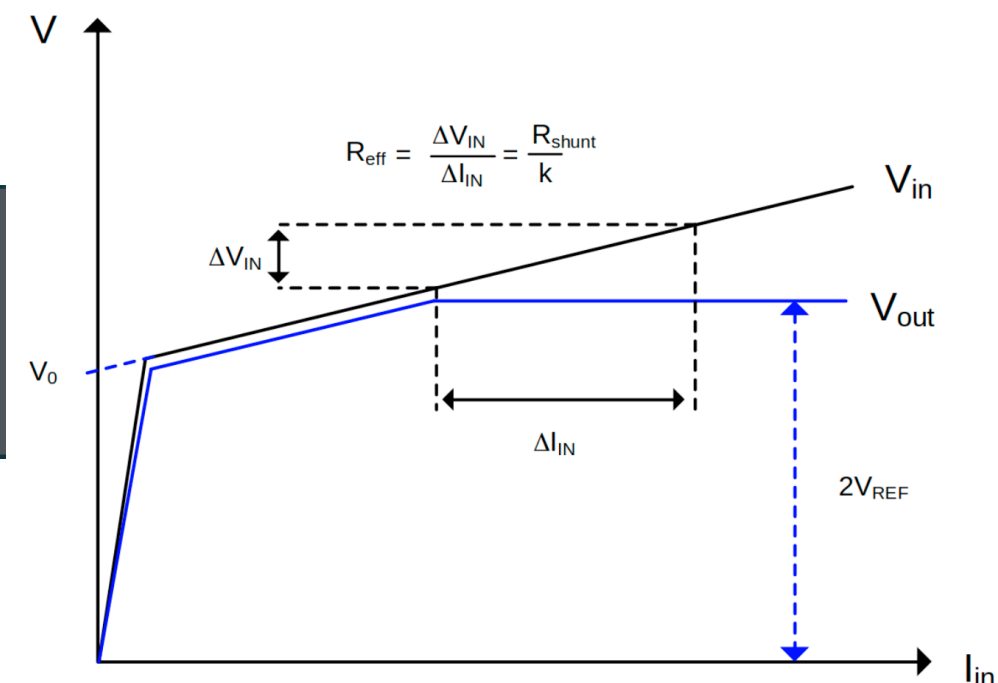
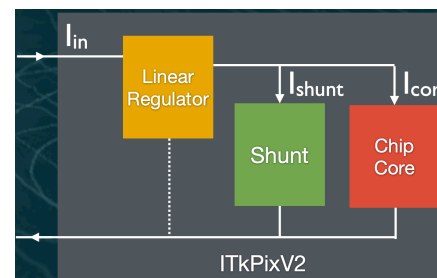


# Multi-chip modules and Serial Powering Chain



- $n$  modules ( $m$  sensors each powered in parallel) are powered in series
- This is to power the **readout electronics powering** ( $\sim$  a few V)
- LHCb MT: 9 penta-modules (5 sensor each) in a chain
- Main advantage: service material reduction and power consumption
- Cable volume/power loss reduce by  $n$

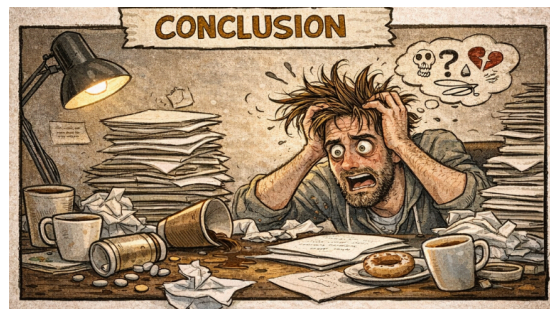
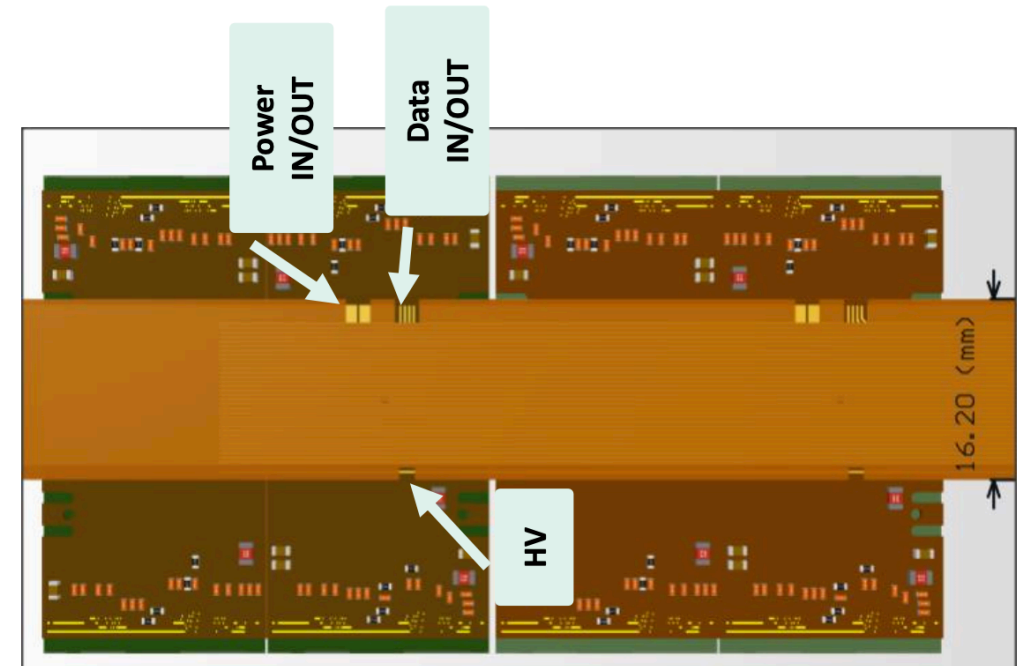
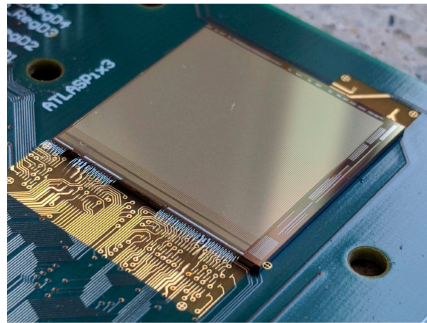
On-chip **Shunt Low Drop Out** regulators: convert current to constant chip supply voltage **VDD**





# “Large” HV-CMOS Pixel Detector Demonstrator

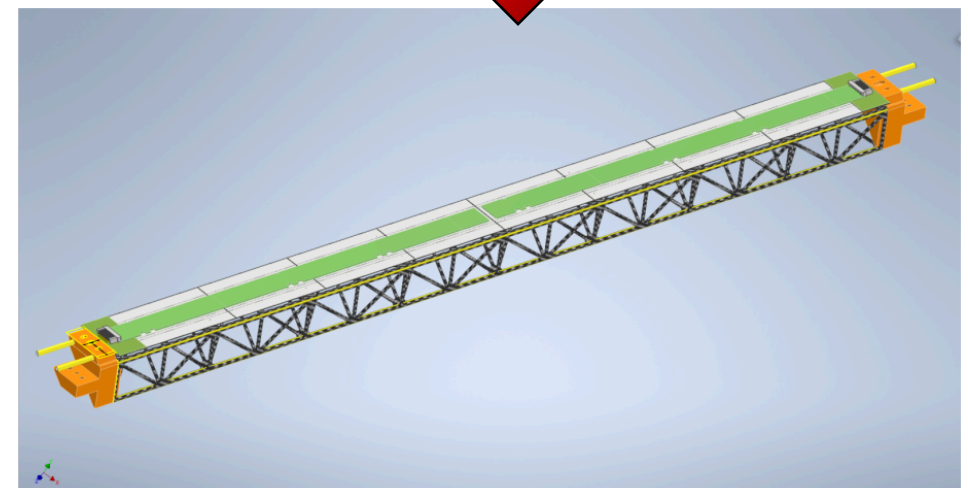
- A system prototyping project in LHCb MT/DRD3 (CERN-DRD3-PROJECT-2025-014)



Pixel Detector Development for Future Collider-Based Particle Physics Experiments

Fuat Ustuner

A long (4 cm×60 cm) aluminium flex is in production at CERN Microfabrication Lab



- Optimised **power and data signal routing** along the stave
- **Readout Unit Design**
  - **Multi-chip modules** (e.g., 2×2 quad modules)
  - **Serial Powering Architecture**:
    - Internal bias generation via **shunt-LDO regulators**
  - **Chip-to-chip data transfer** for local aggregation

Long stave (~1.3m) mechanical structure (fabricated in Pisa)