ALICE Sensor Characterisation

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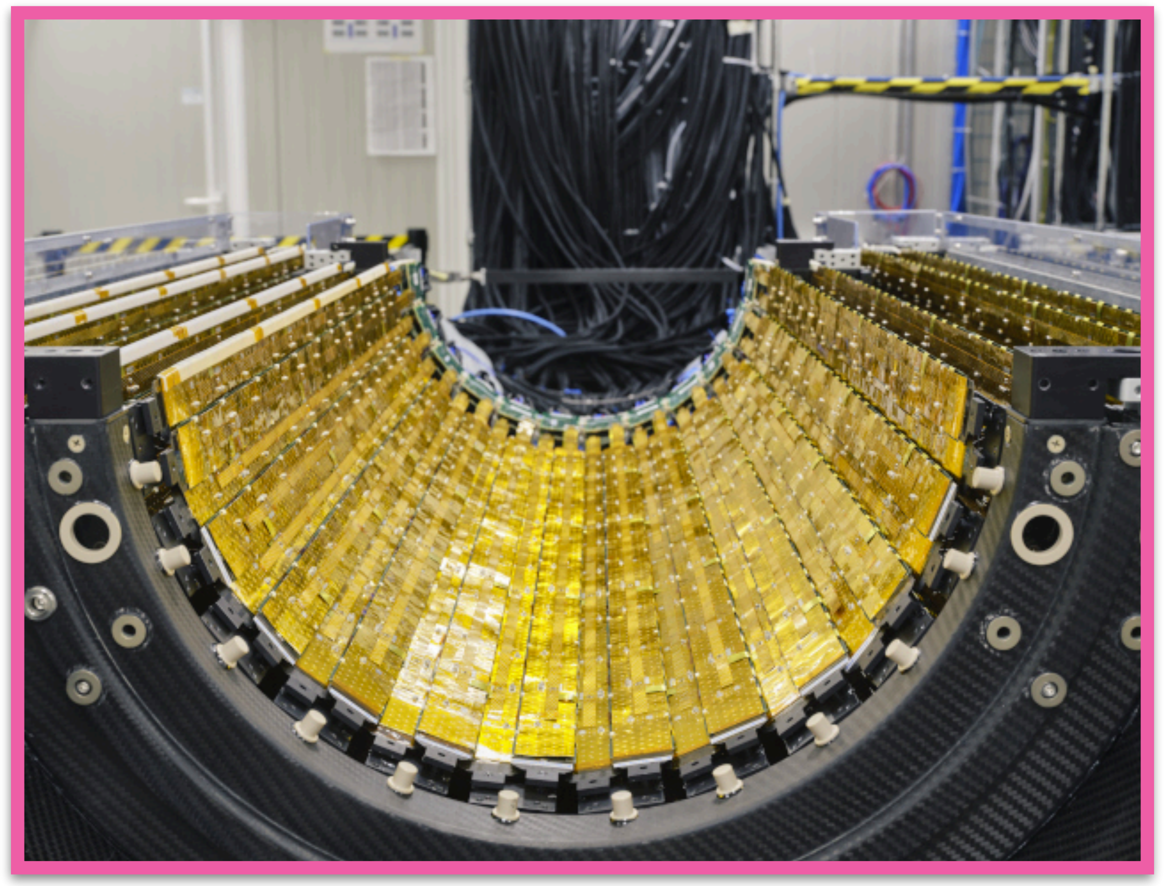
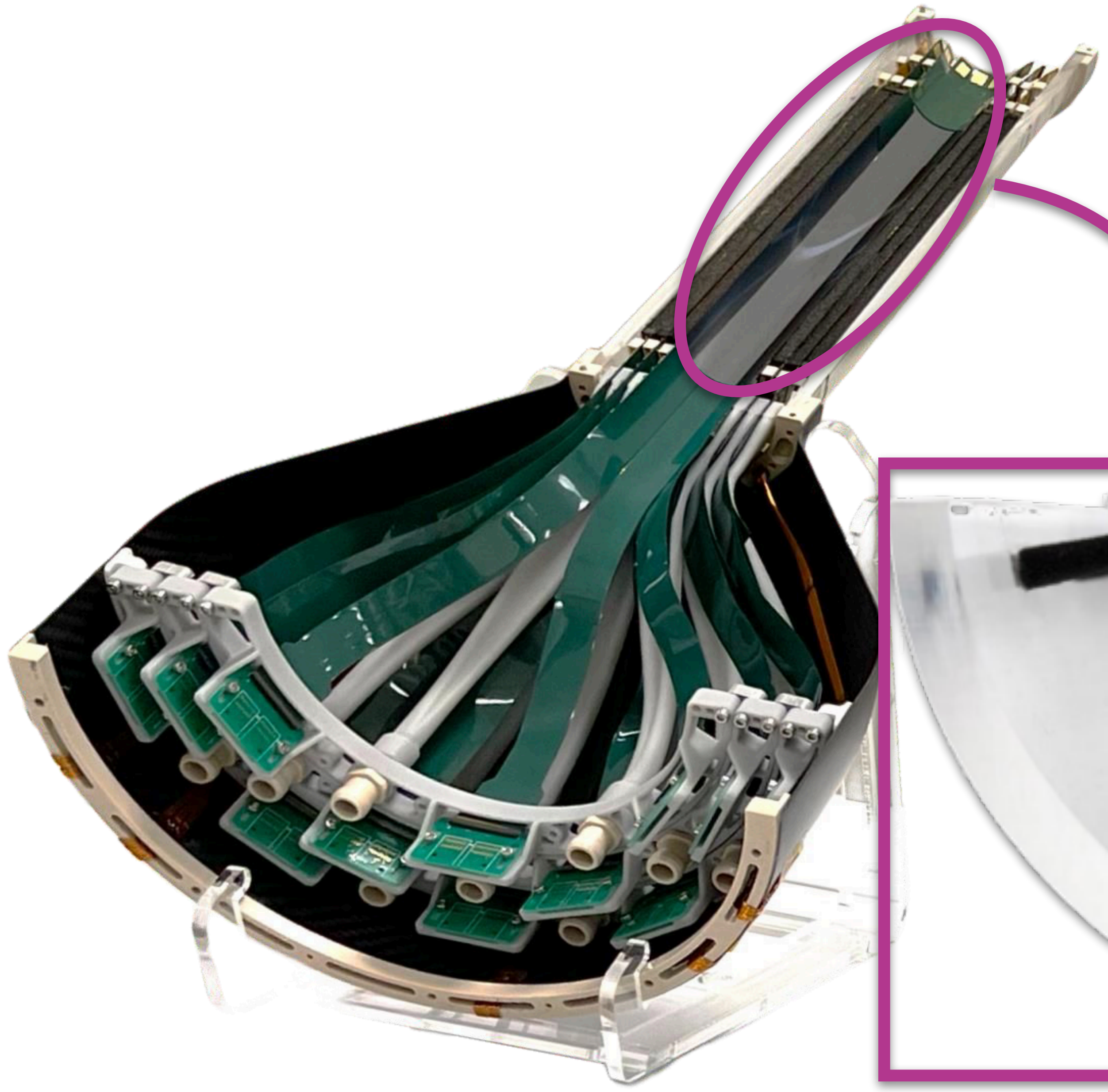
Nikhef Jamboree 2026
12/05/2026

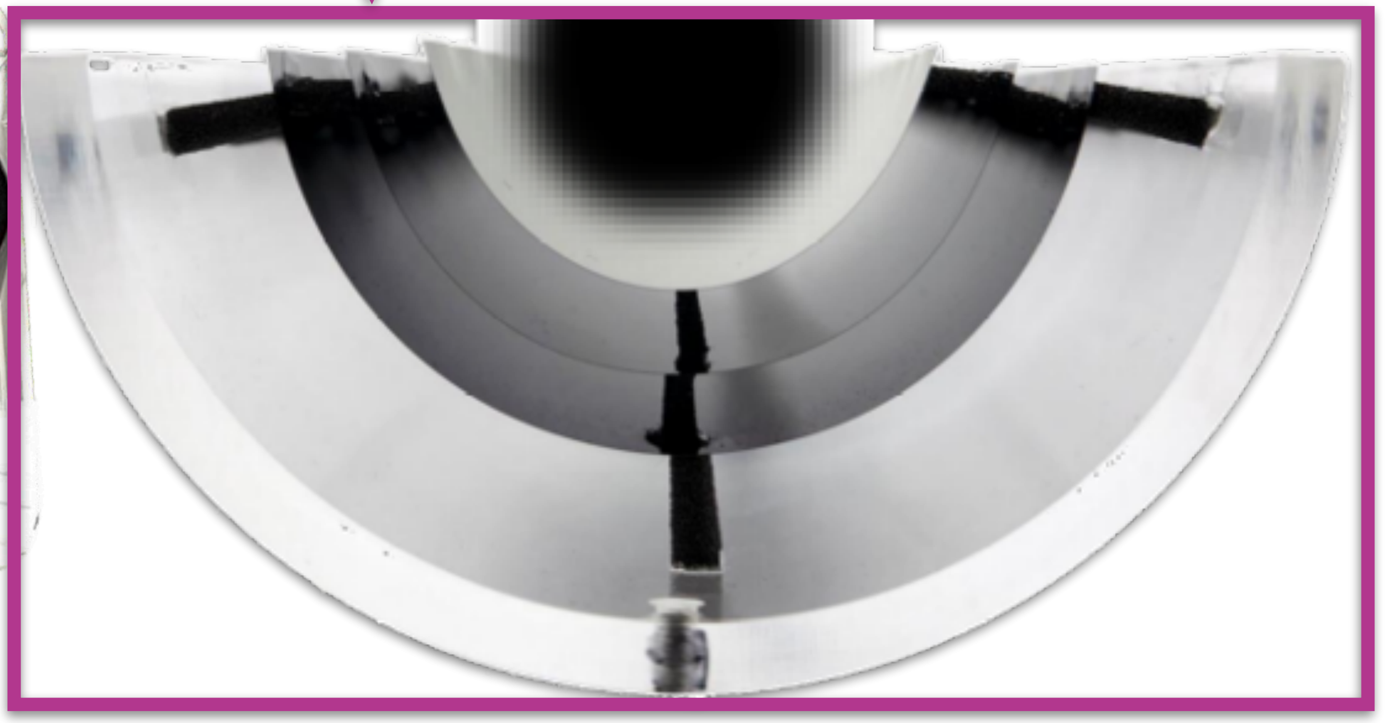
ALICE tracker over time

ITS2
~6 m^2 MAPS (ALPIDE) detector





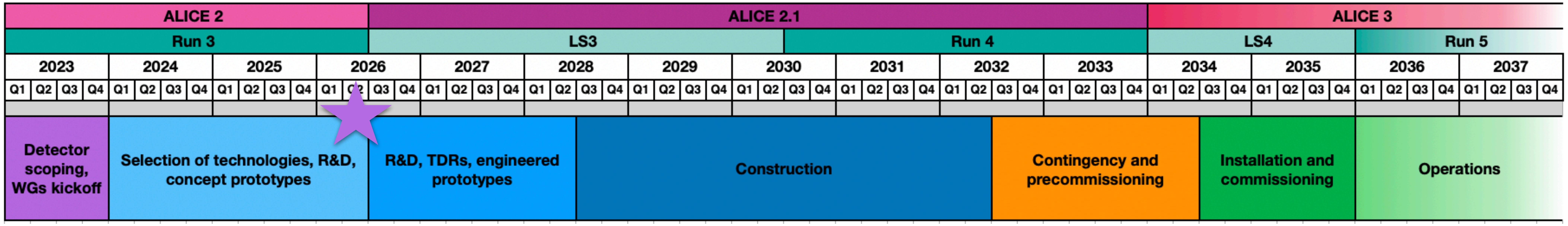
ITS3
3 innermost layers replaced with ultra-thin, wafer-sized, bent sensors



ALICE 3 tracker

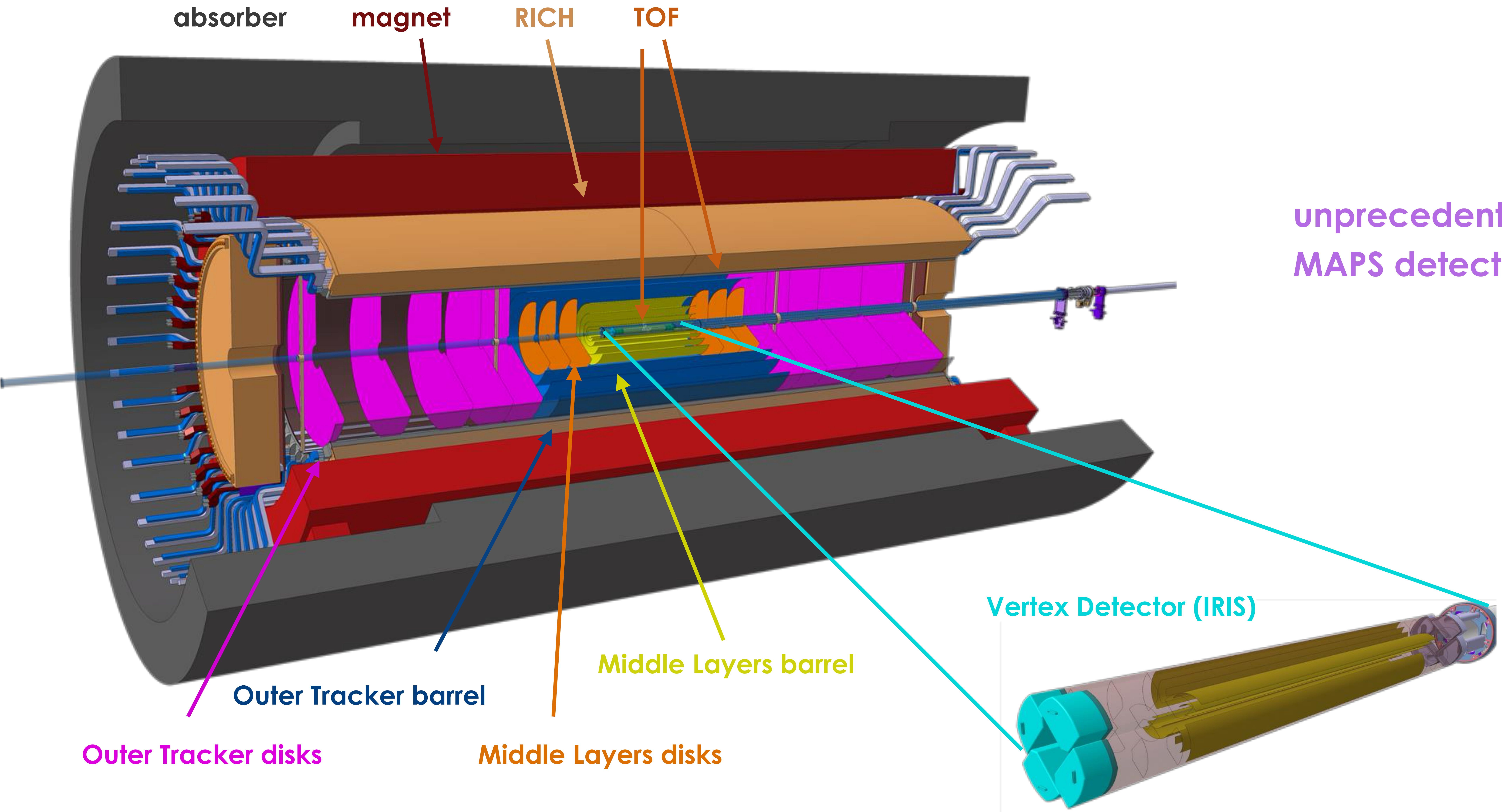
?

ALICE 3 timeline



now in the R&D phase towards Technical Design Reports (TDR)

ALICE 3 tracker



unprecedented 60 m² of MAPS detector!

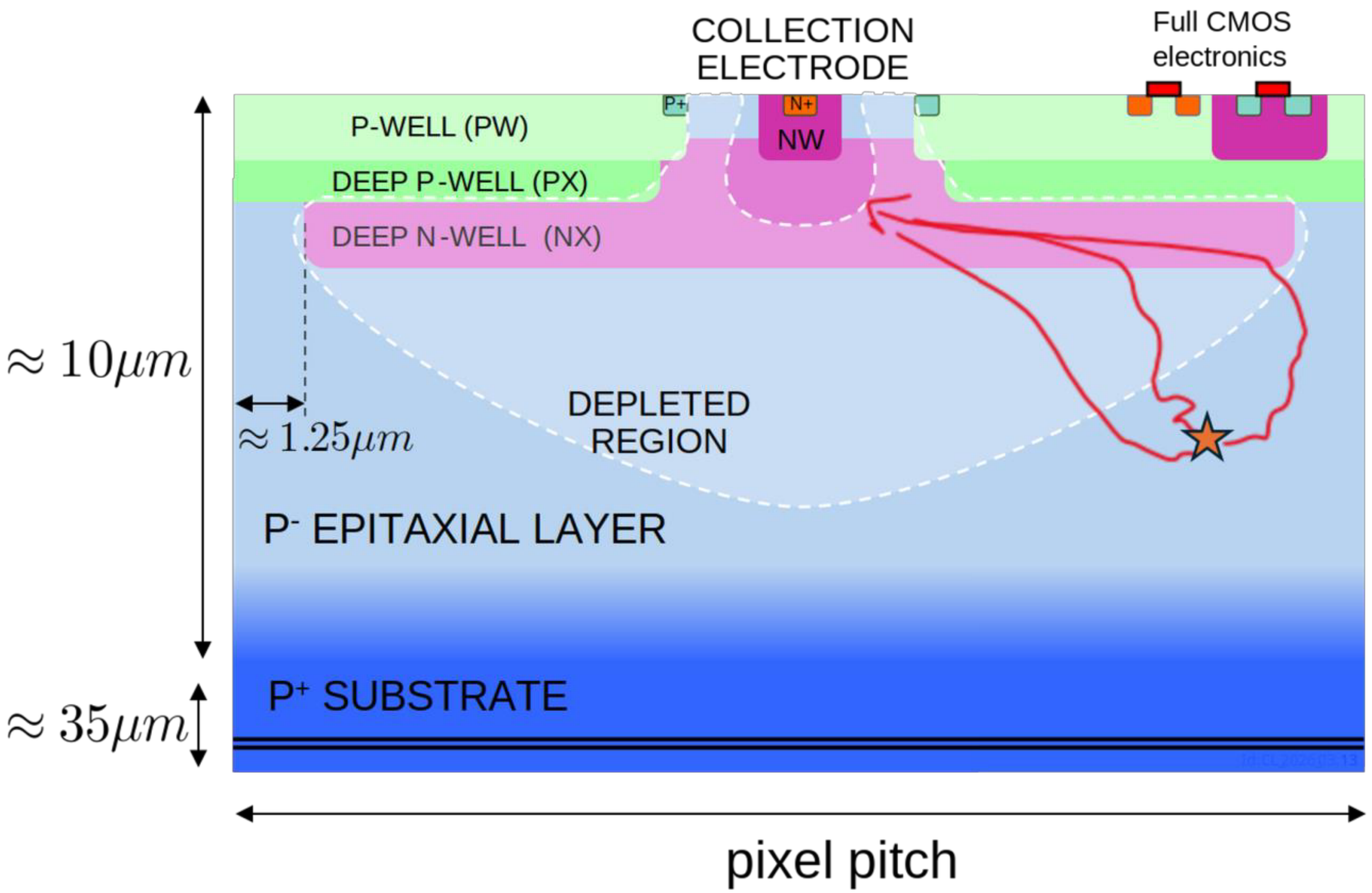
The technology

- MAPS sensors in 65 nm CMOS imaging process
- 2 different ASICs for VD and ML/OL but…
- …based on a common development:
  - pixel layout, front-end circuit, matrix readout and control logic identical
  - two pixel pitch variants: 10 um (VD), >= 20 um (ML/OL)

target performance

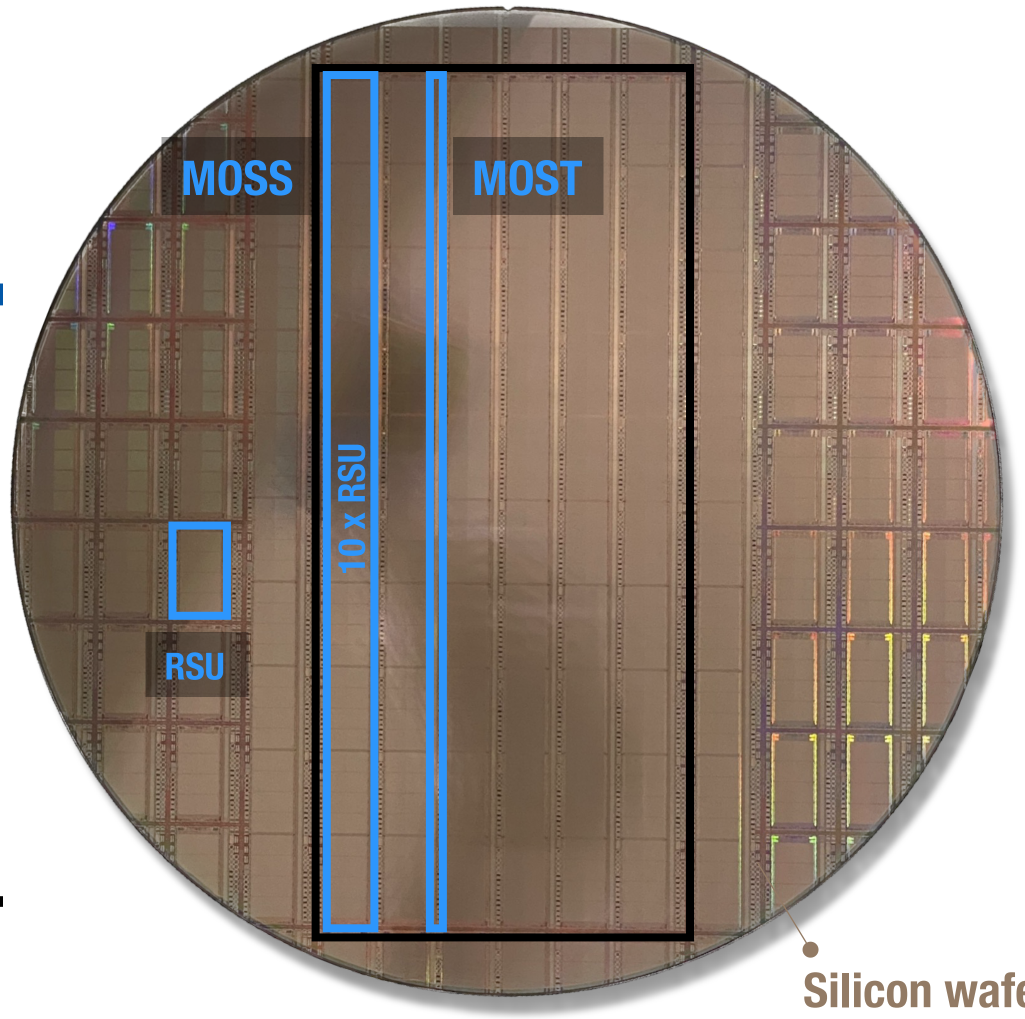
	VD	ML/OL
spatial resolution	2.5 um	~10 um
power density	~70 mW/cm²	20-30 mW/cm²
radiation tolerance	>10^{15} MeV n_{eq} cm^{-2} (beyond ITS3 design)	~6x10^{13} MeV n_{eq} cm^{-2}

cross-section of 1 pixel



Sensor design evolution

Engineering Run 1 (ER1)
tape out Nov 2022
First stitched MAPS



Silicon wafer, 300 mm (12")

MLR1 (Multy-Layer Reticle)
tape out Dec 2020

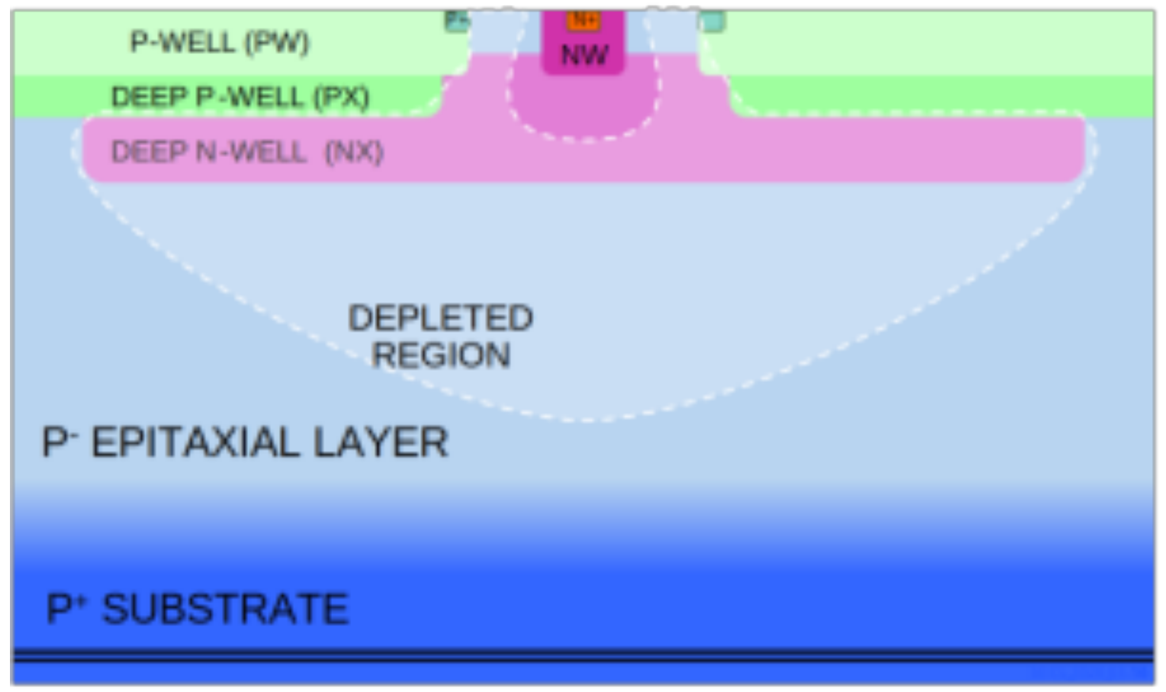
First MAPS in TPSCo 65 nm

- 55 (small scale) chip prototypes, 2 doping variants
- technology qualified
- explored beyond ITS3 requirements: degradation of performance from 1e15 MeV n_{eq} cm^{-2}

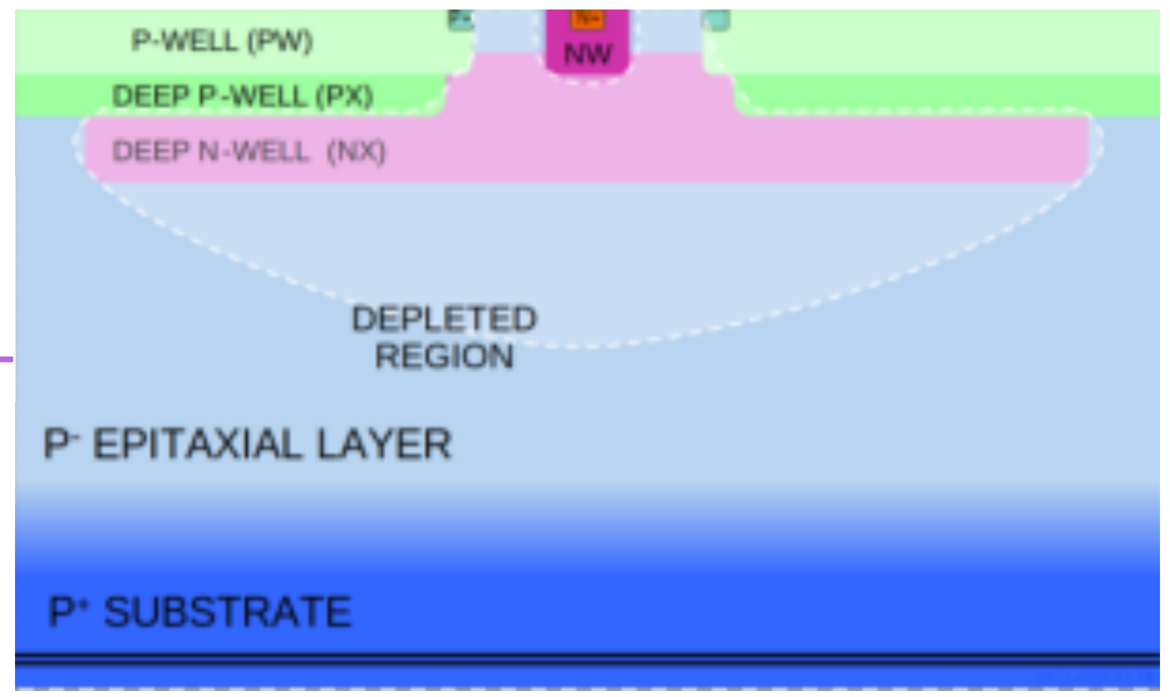
ER2 tape out Aug 2025

- full scale size prototypes for ITS3 (MOSAIX)
- new doping variants (splits)
  - split 4-6: for -1.2 V and 20 μm pitch optimized for ITS3 and ALICE 3 ML/OT
  - split 7: for – 4 V and 10 μm pitch optimised for ALICE 3 VD

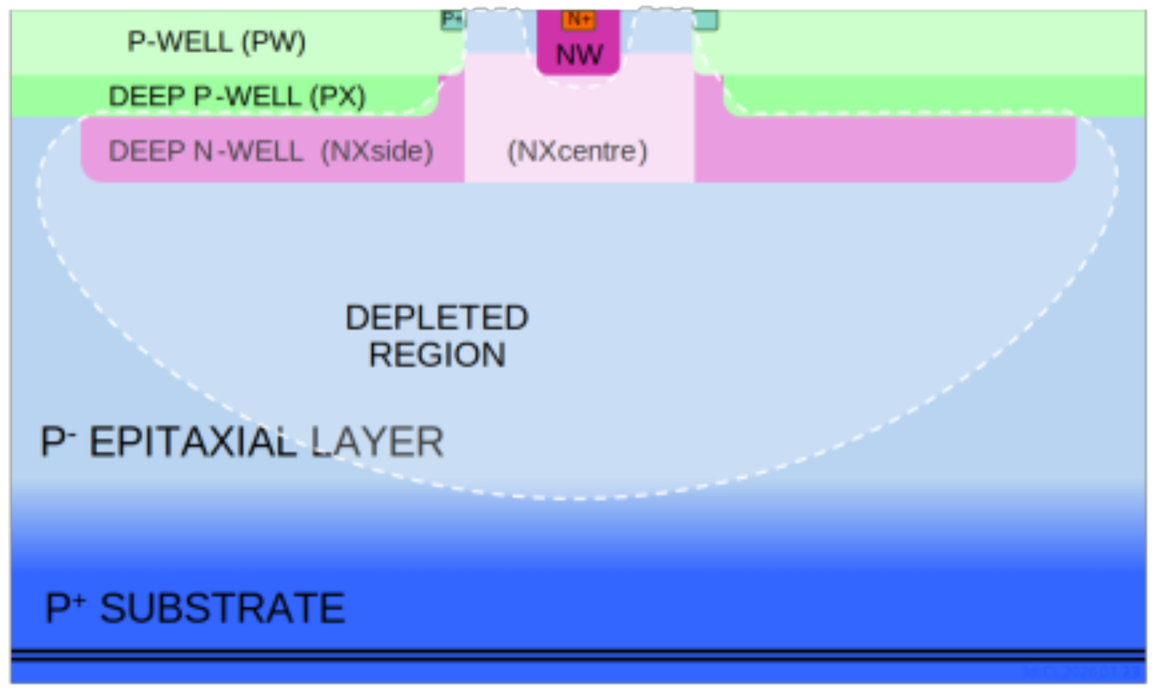
split 1



split 4



split 5,6,7



received first chiplets, now under test!

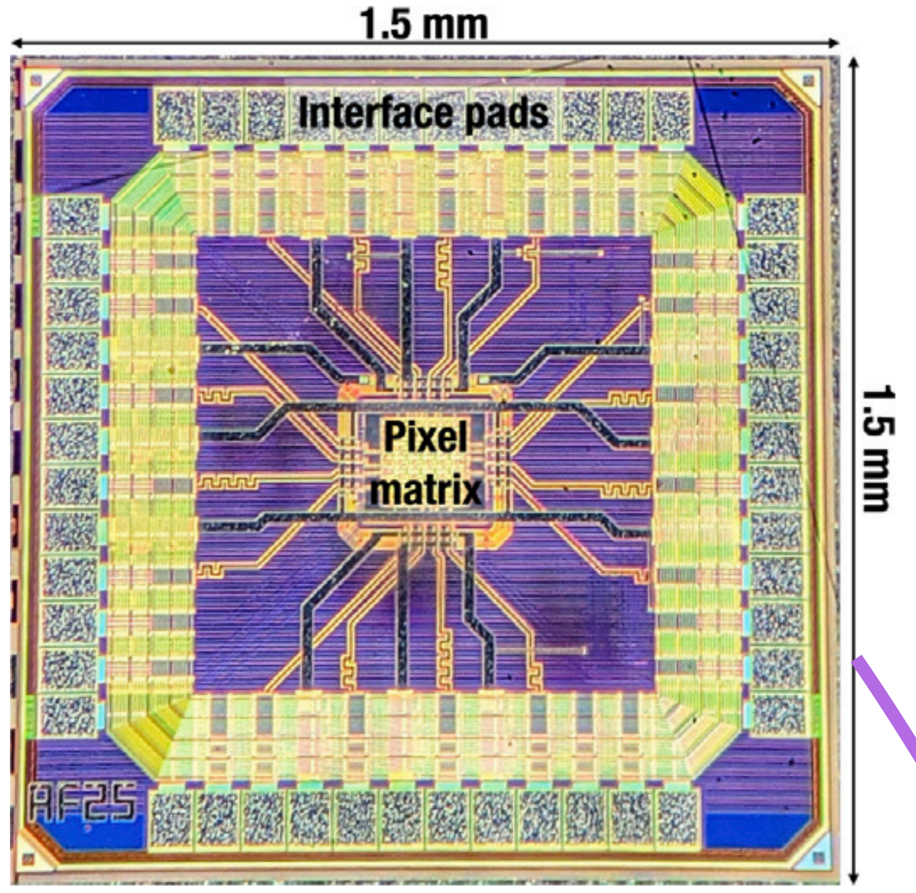
Lab Setup

Analog Pixel Test Structures (APTS)

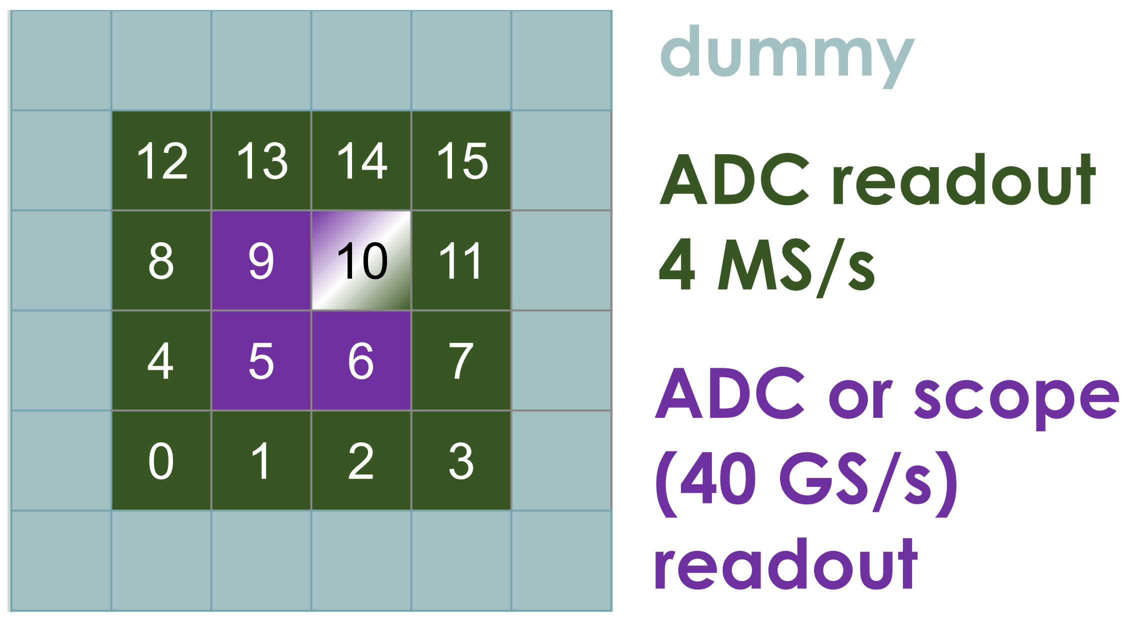
2 flavours:

- APTS-SourceFollower for performance comparison between process variants and pitches in terms of capacitance, detection efficiency, resolution…
- APTS-OpAmp for detailed studies on timing and charge collection

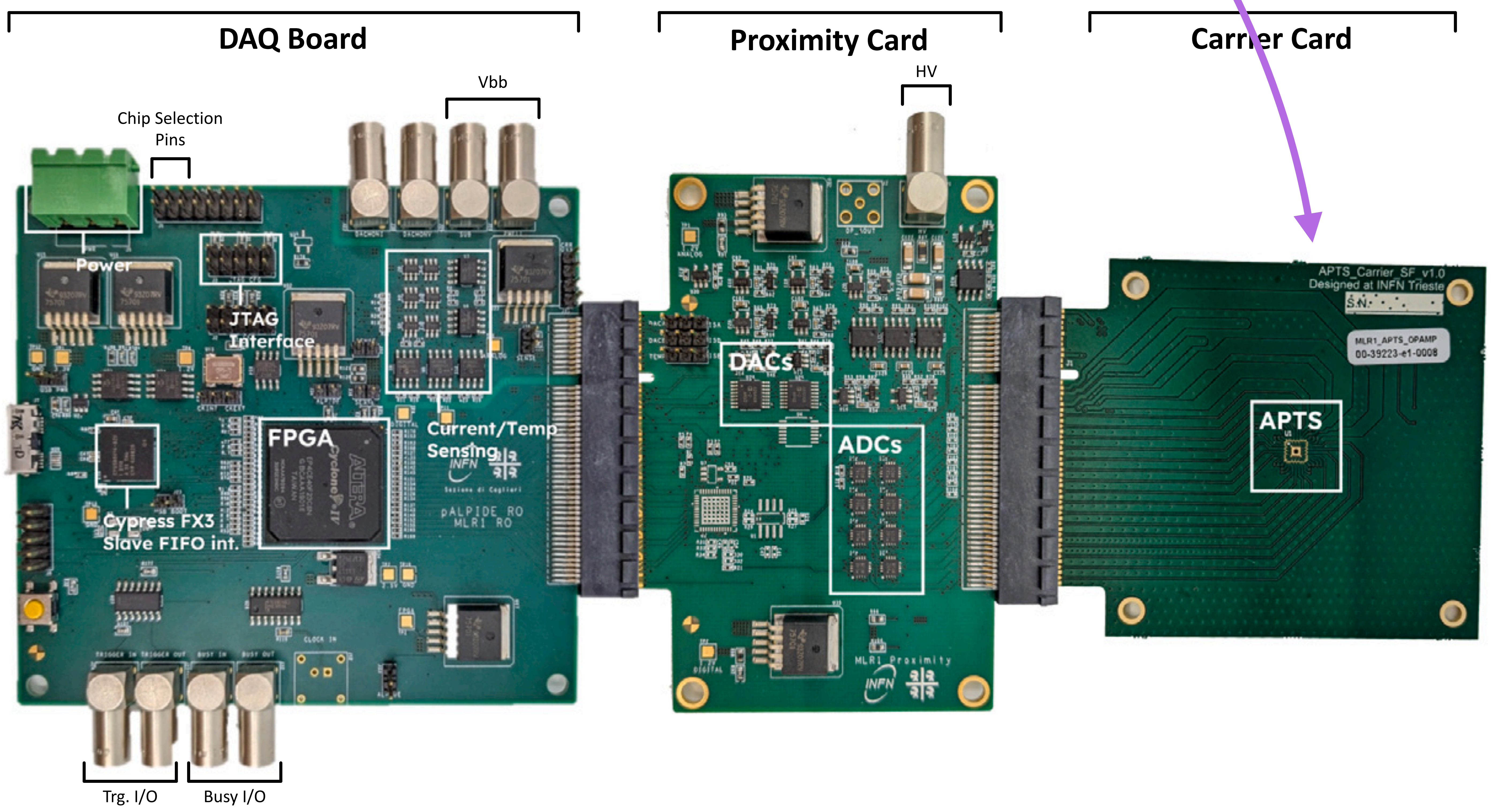
APTS



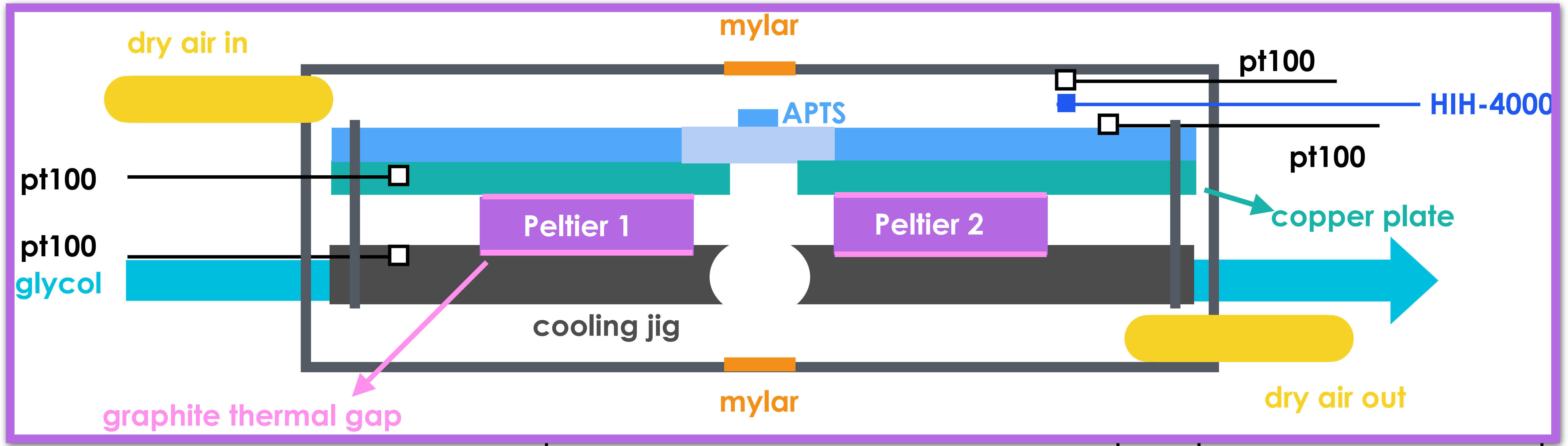
pixel matrix

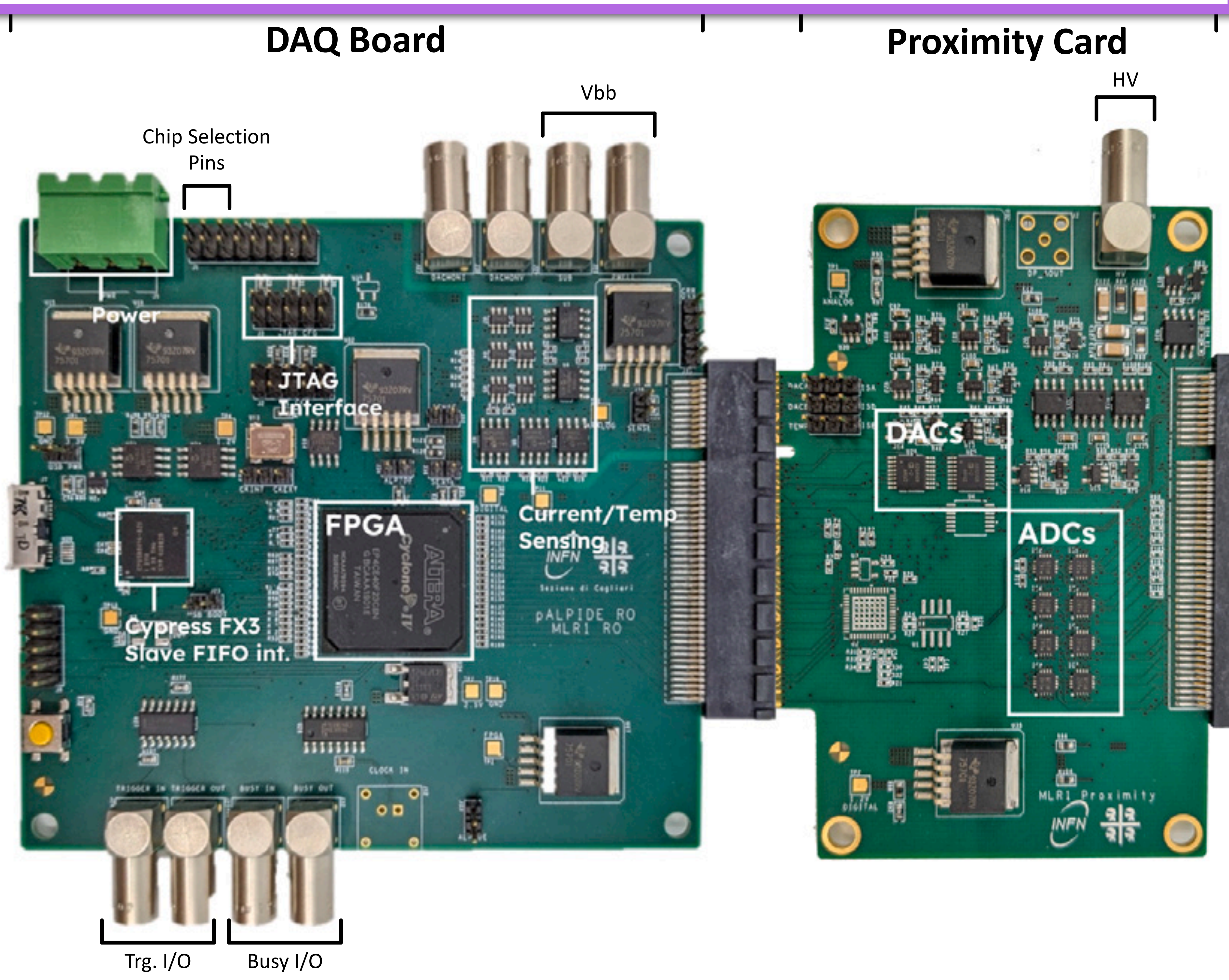


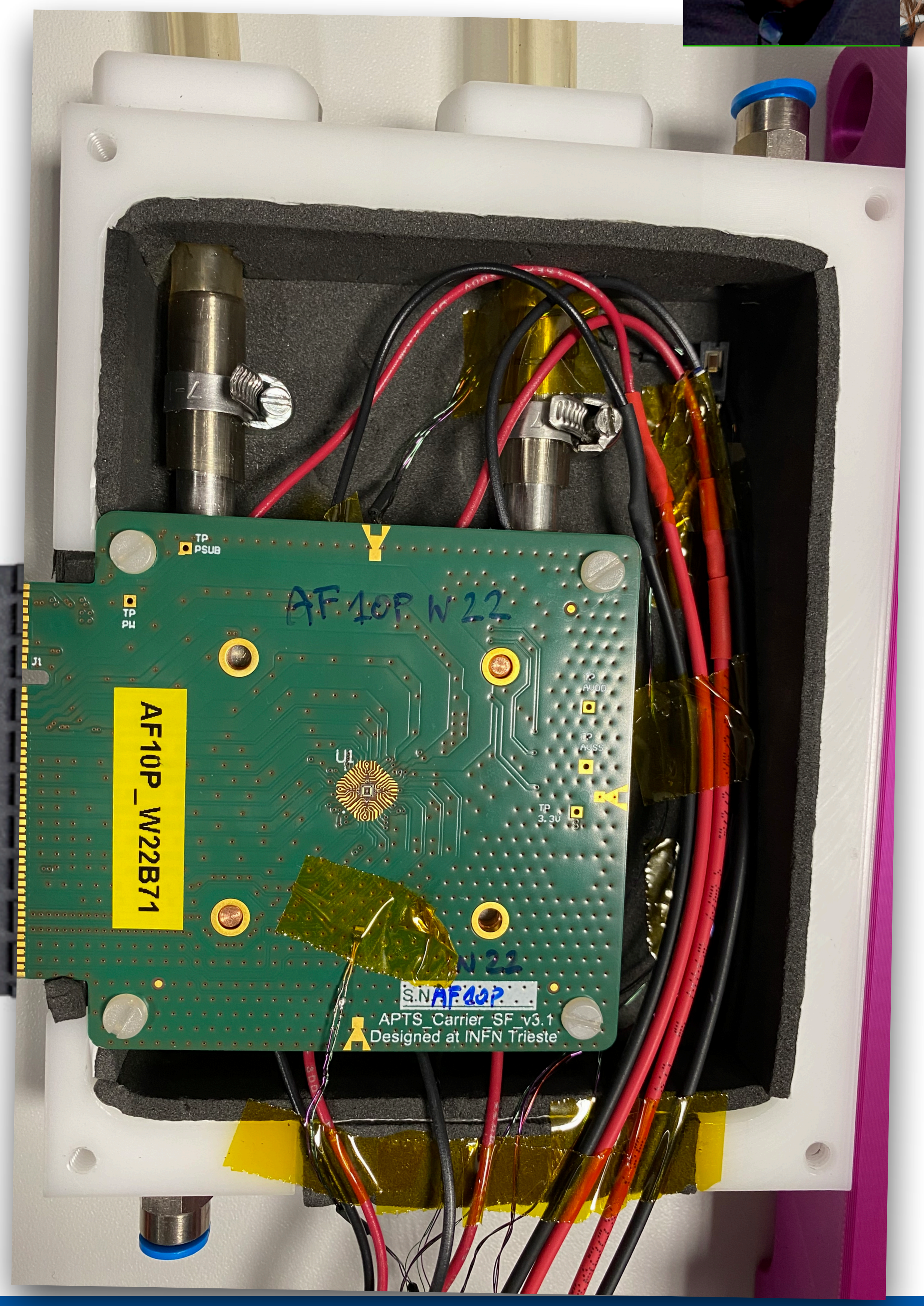
Test system



Lab Setup







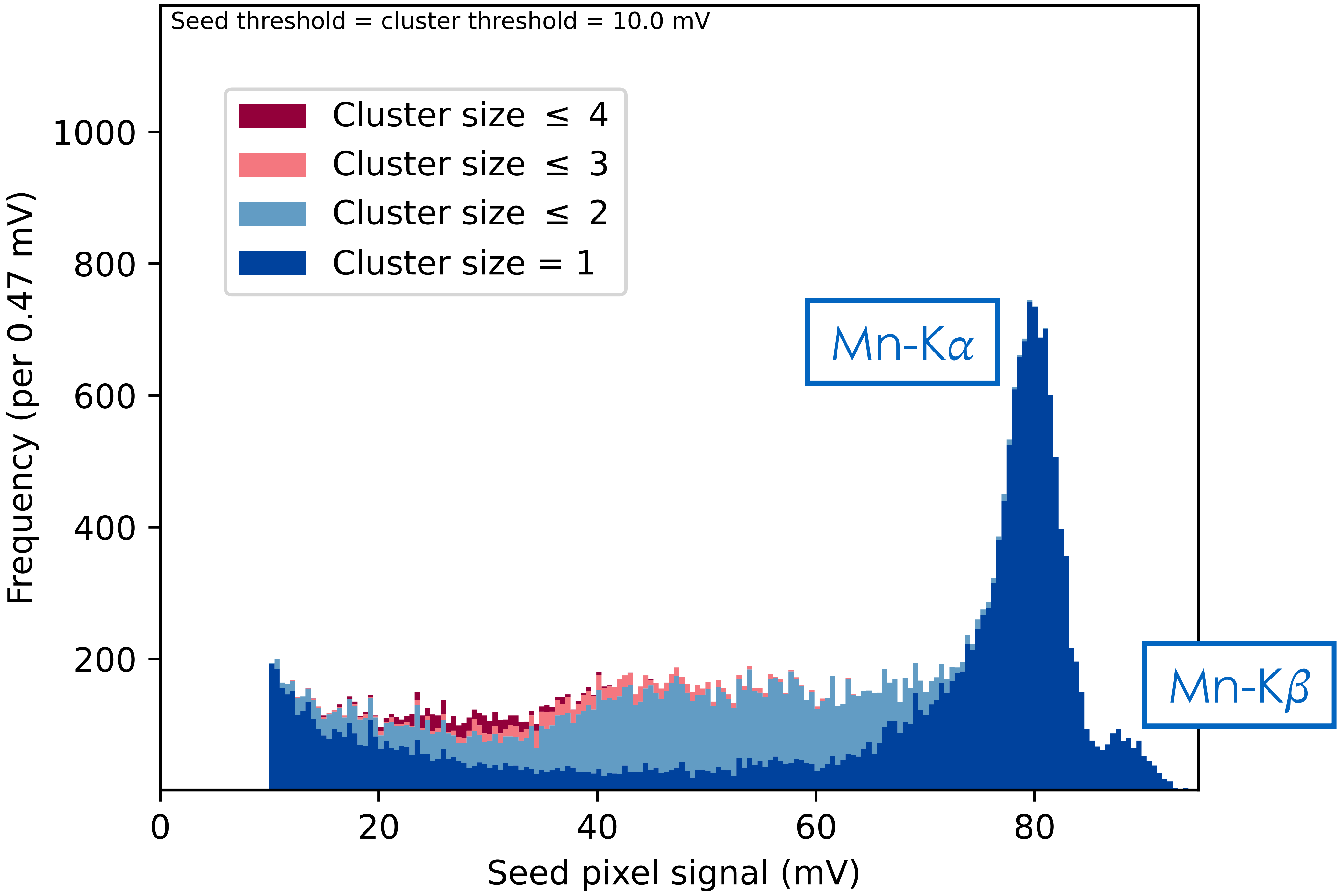
Test system

developed a cold setup to characterise the APTS at low temperatures

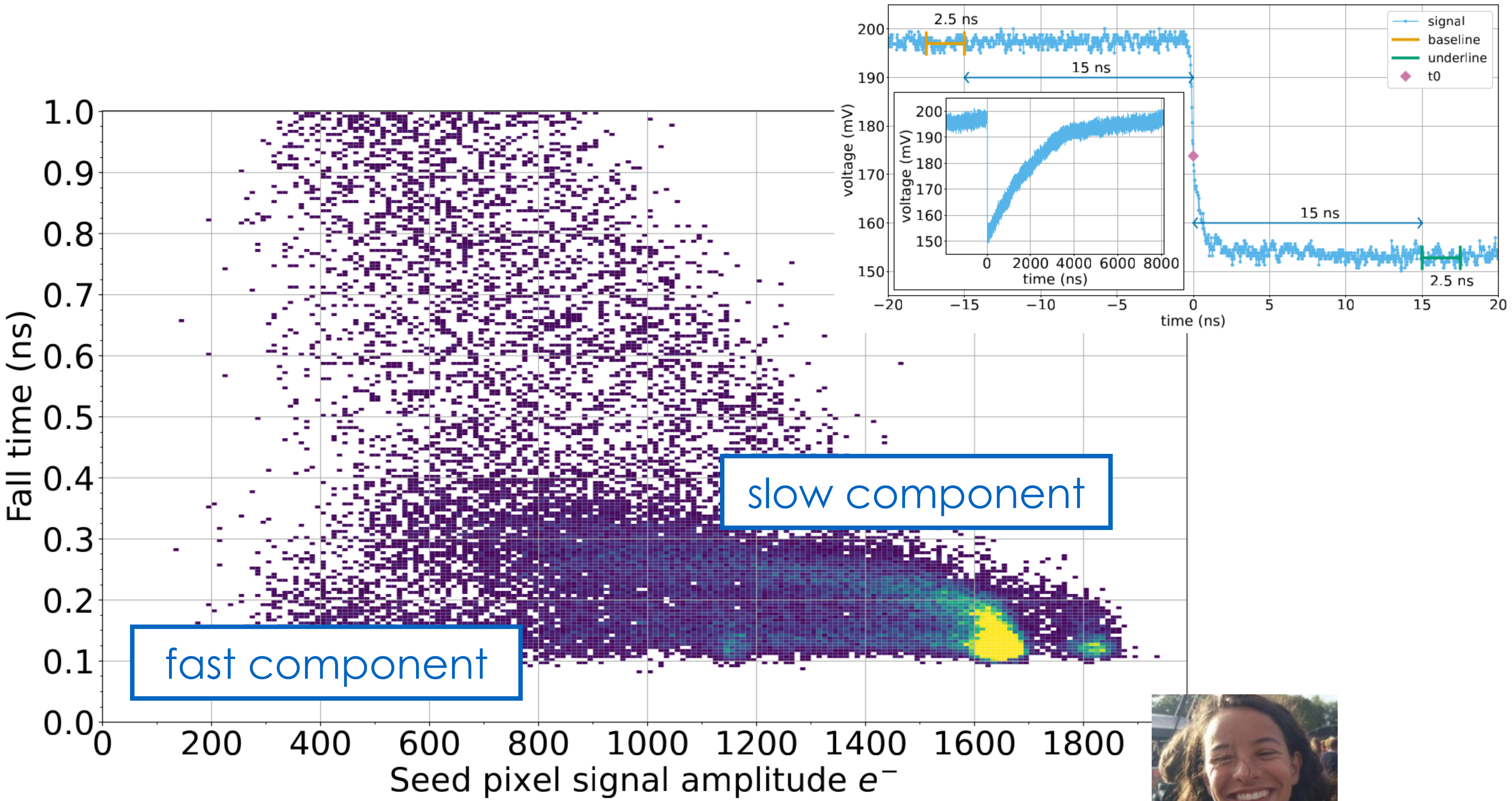
- small box flushed with dry air
- combination of Peltier elements and liquid cooling
- achieved -30 deg on the chip

Typical lab tests

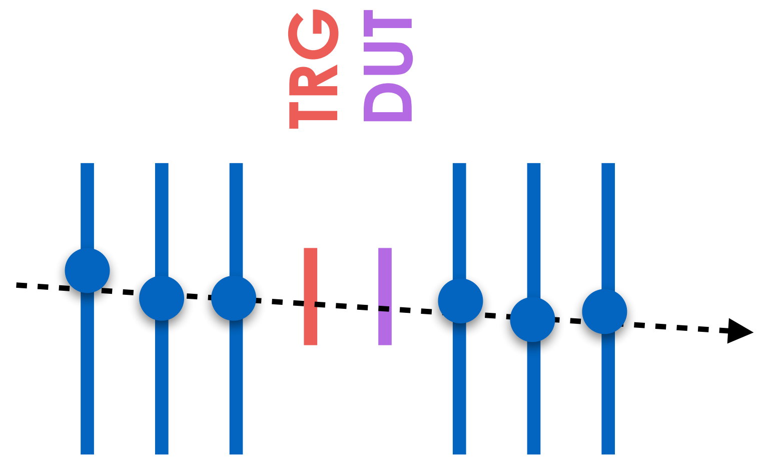
Fe55 spectra



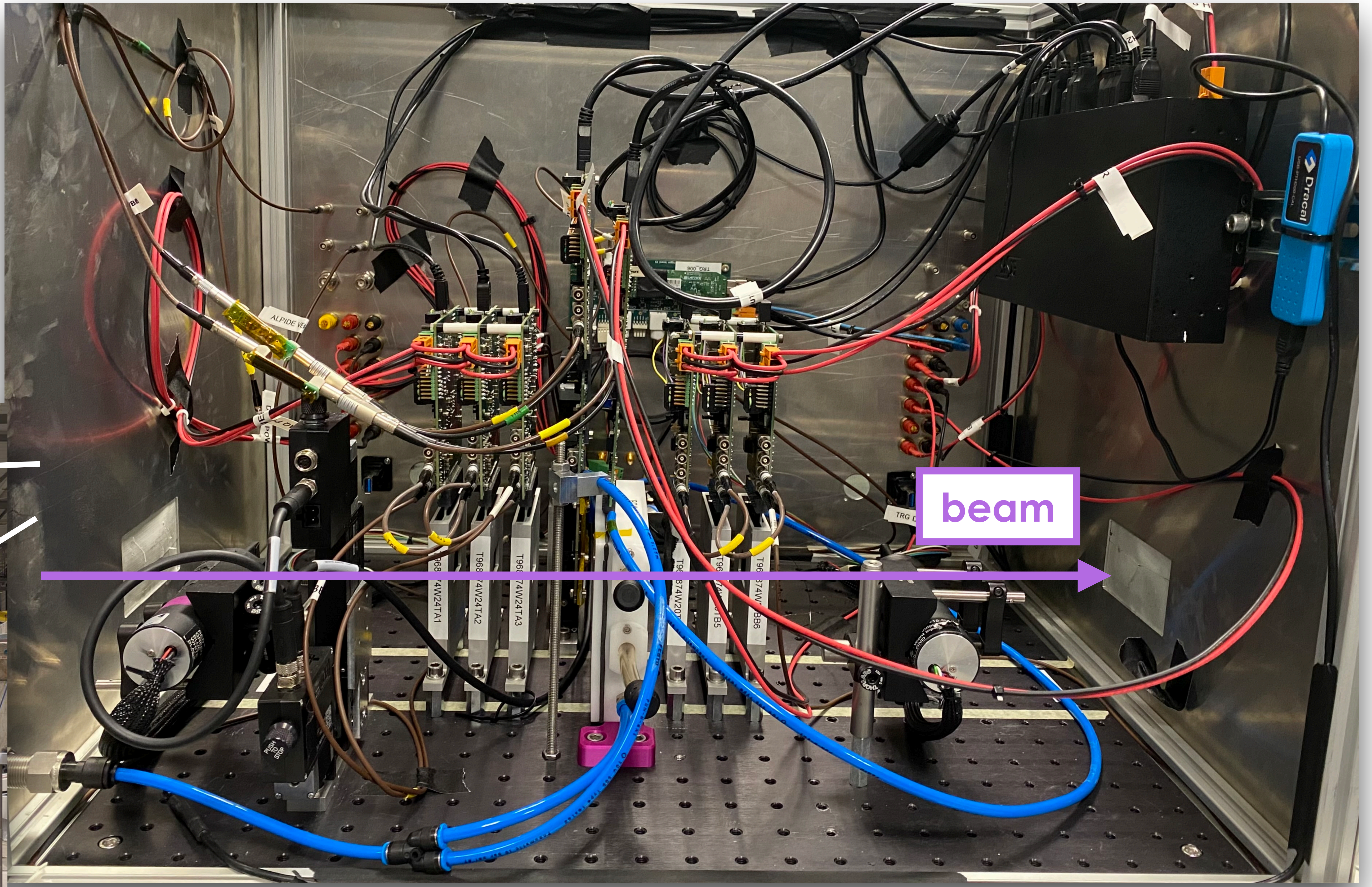
Charge collection time



Telescope

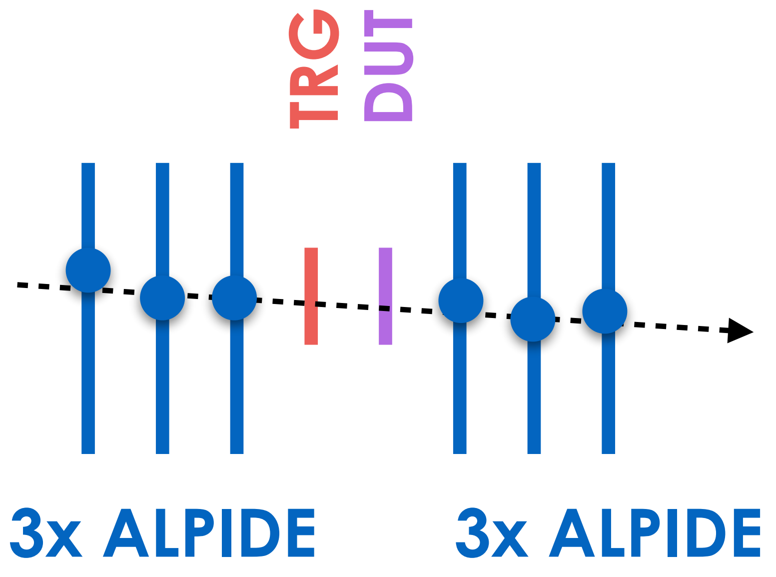


beam telescope

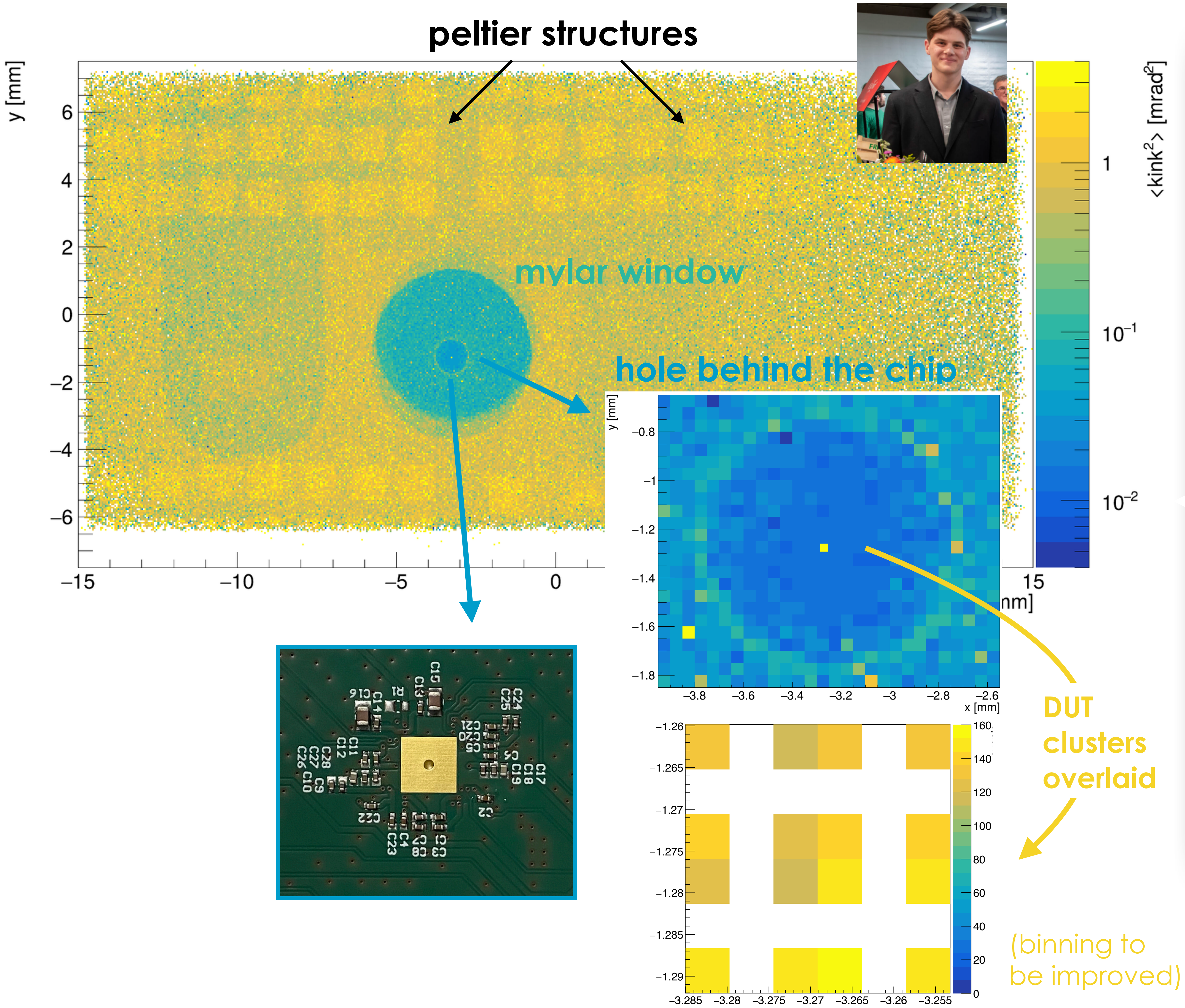


installation
at SPS

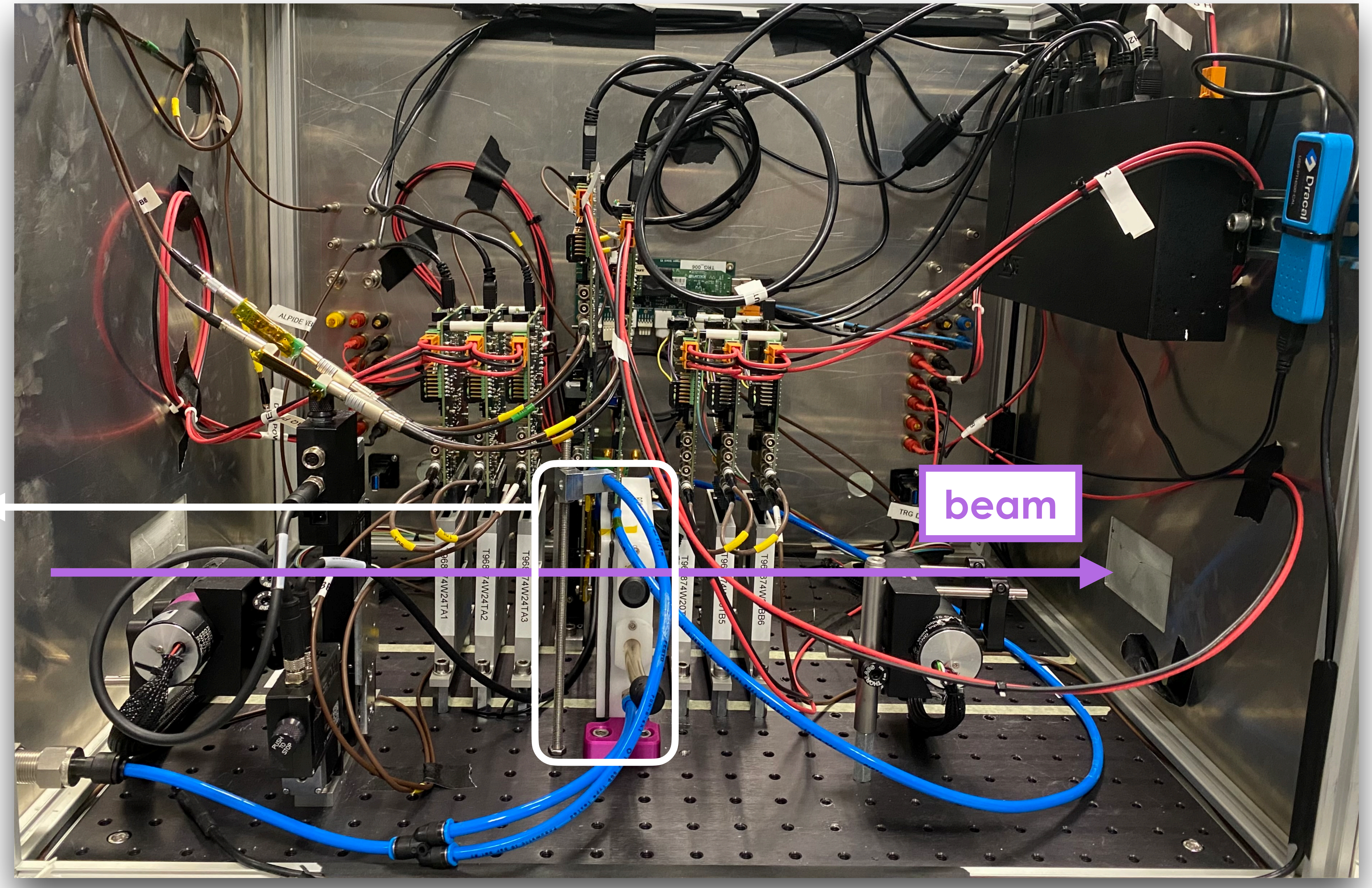
Telescope



scattering due to material at DUT plane



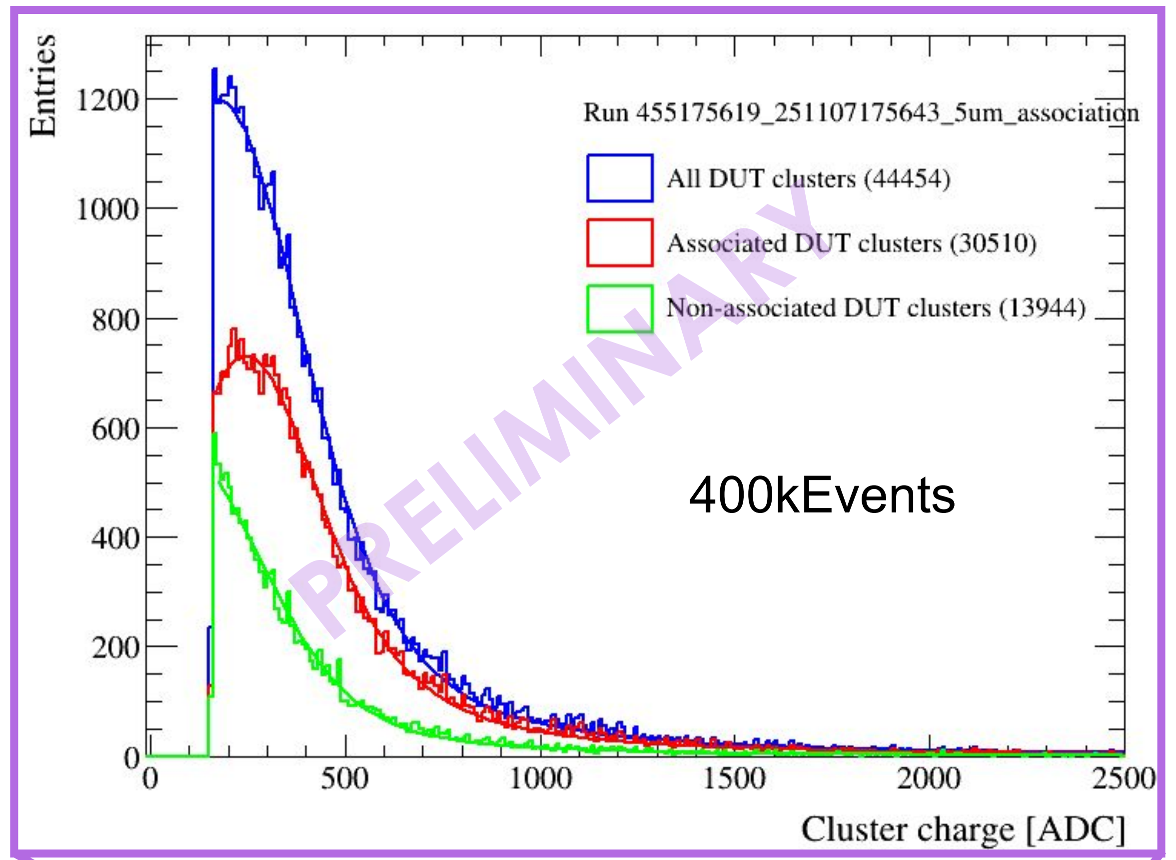
beam telescope



Testbeam results

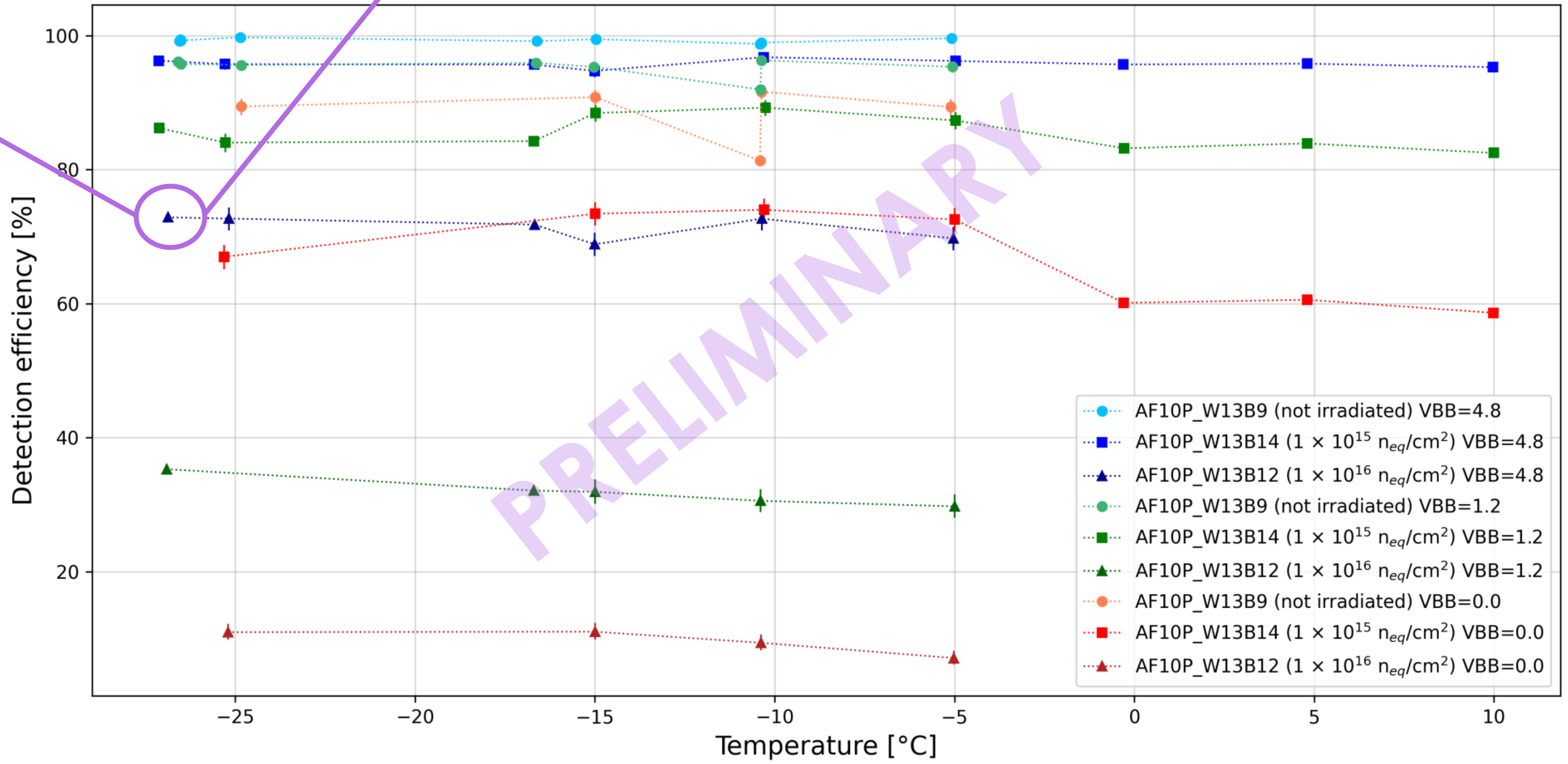
arXiv 2512.13339v2

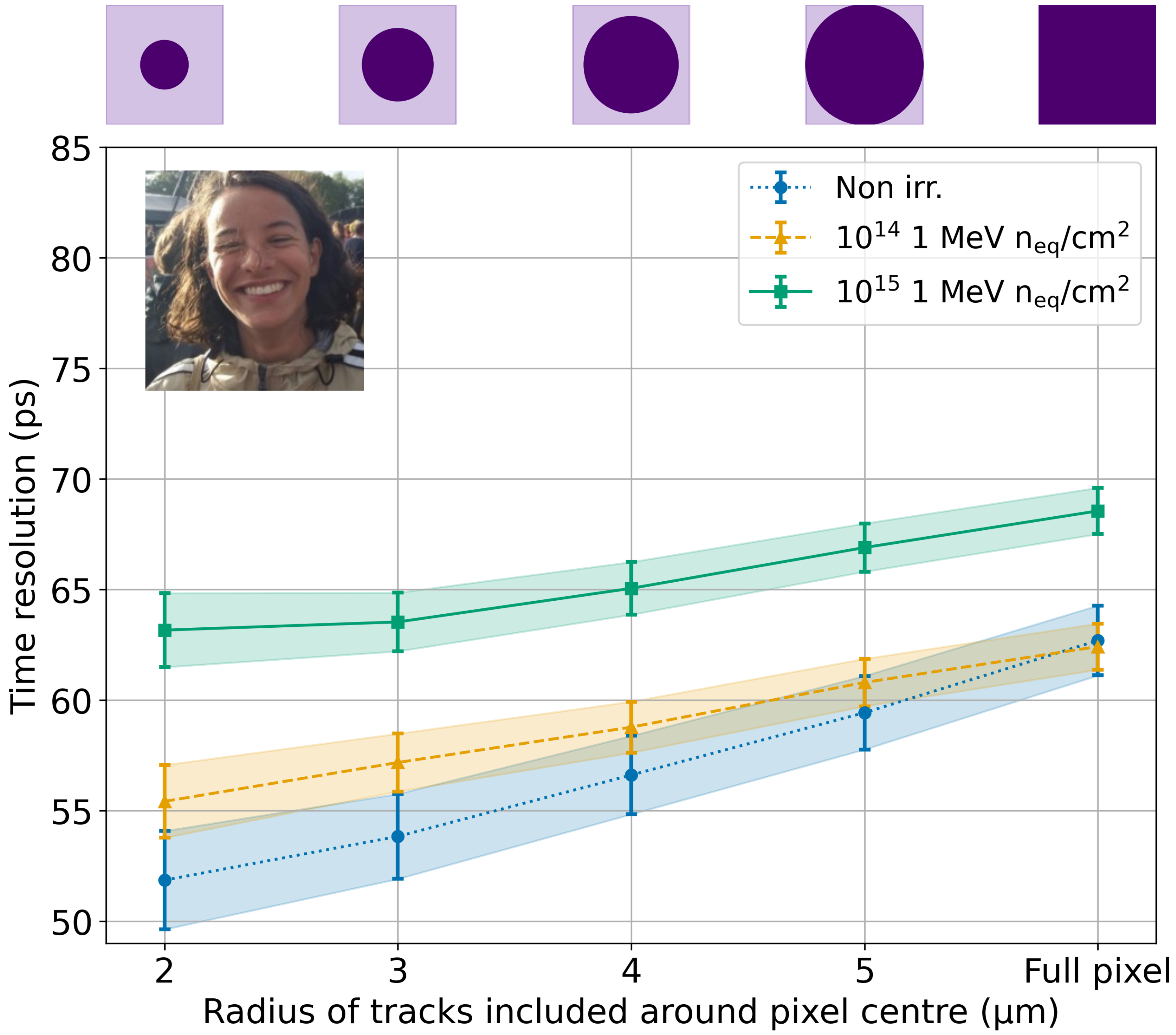
towards radiation hardness



detection efficiency and charge collection

MLR1, split 1, 10 um, IReset 200 pA





time resolution

Looking ahead

- broad Nikhef involvement in MAPS development on many fronts with a leading role in characterisation of the sensors
  - commissioning of the cold setup at Nikhef ongoing
  - coordination and participation of several people to testbeam campaigns
- we are just at the very start of a massive campaign aiming at testing hundreds of sensor variants

looking forward to the ER2 sensor to be delivered!