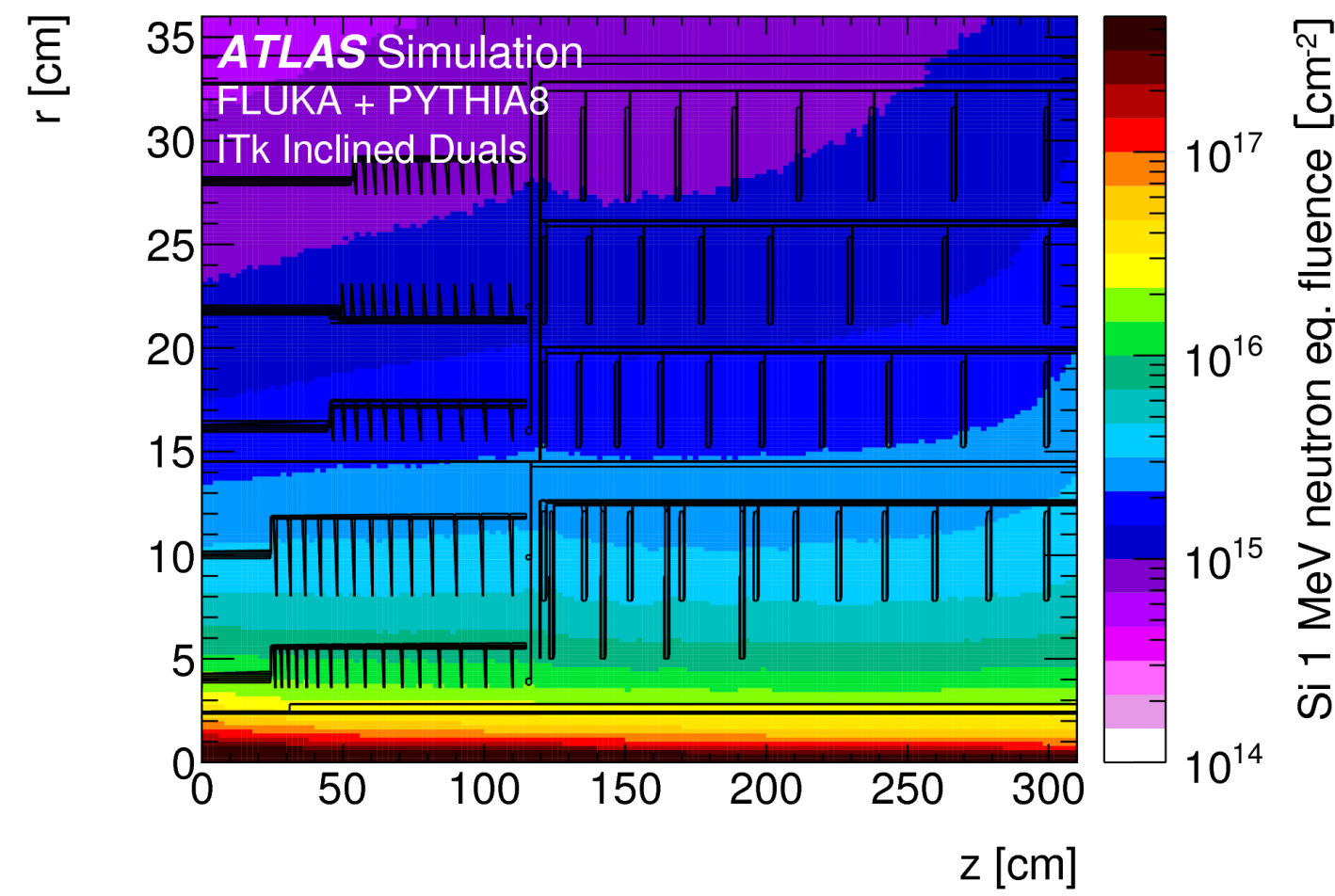


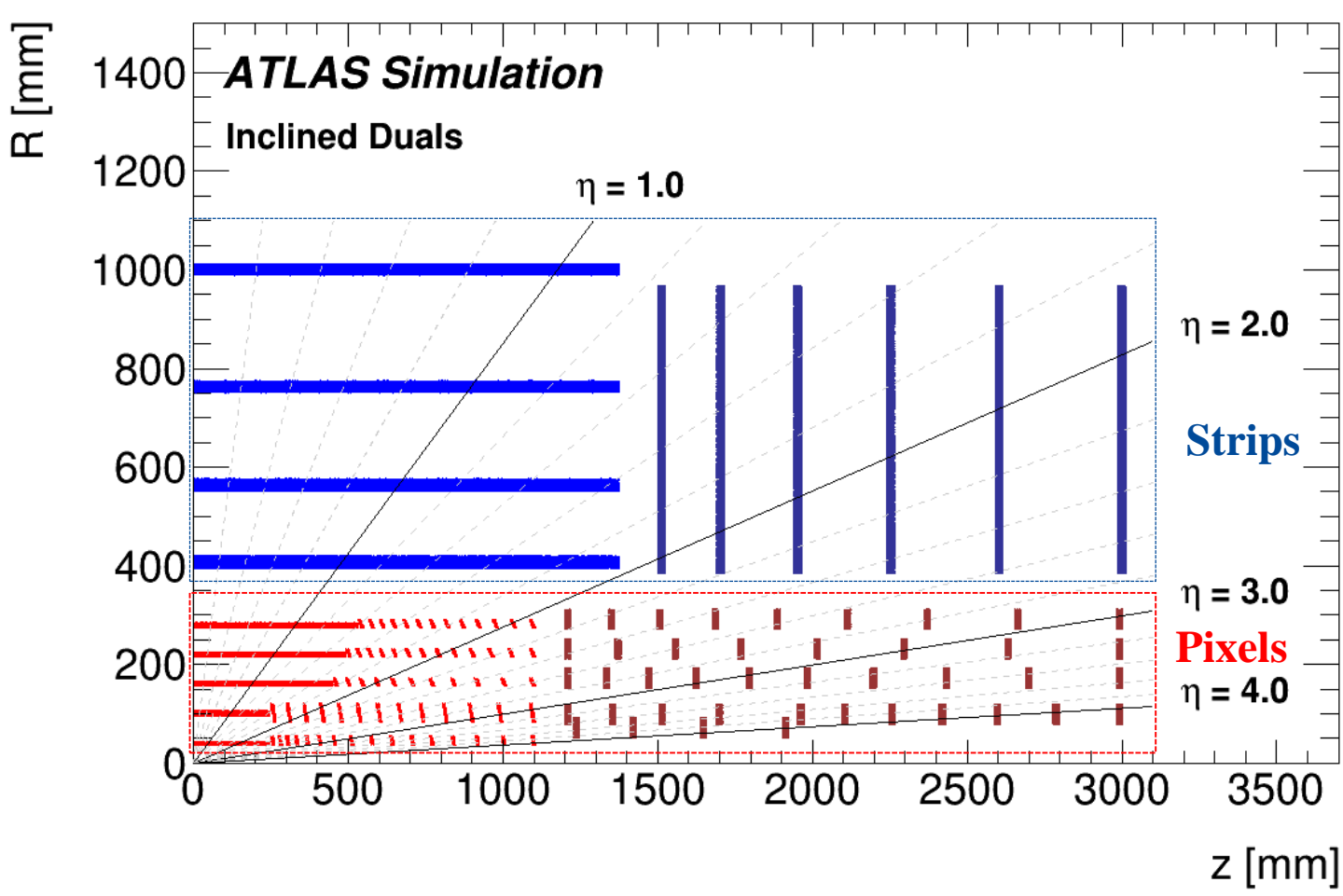
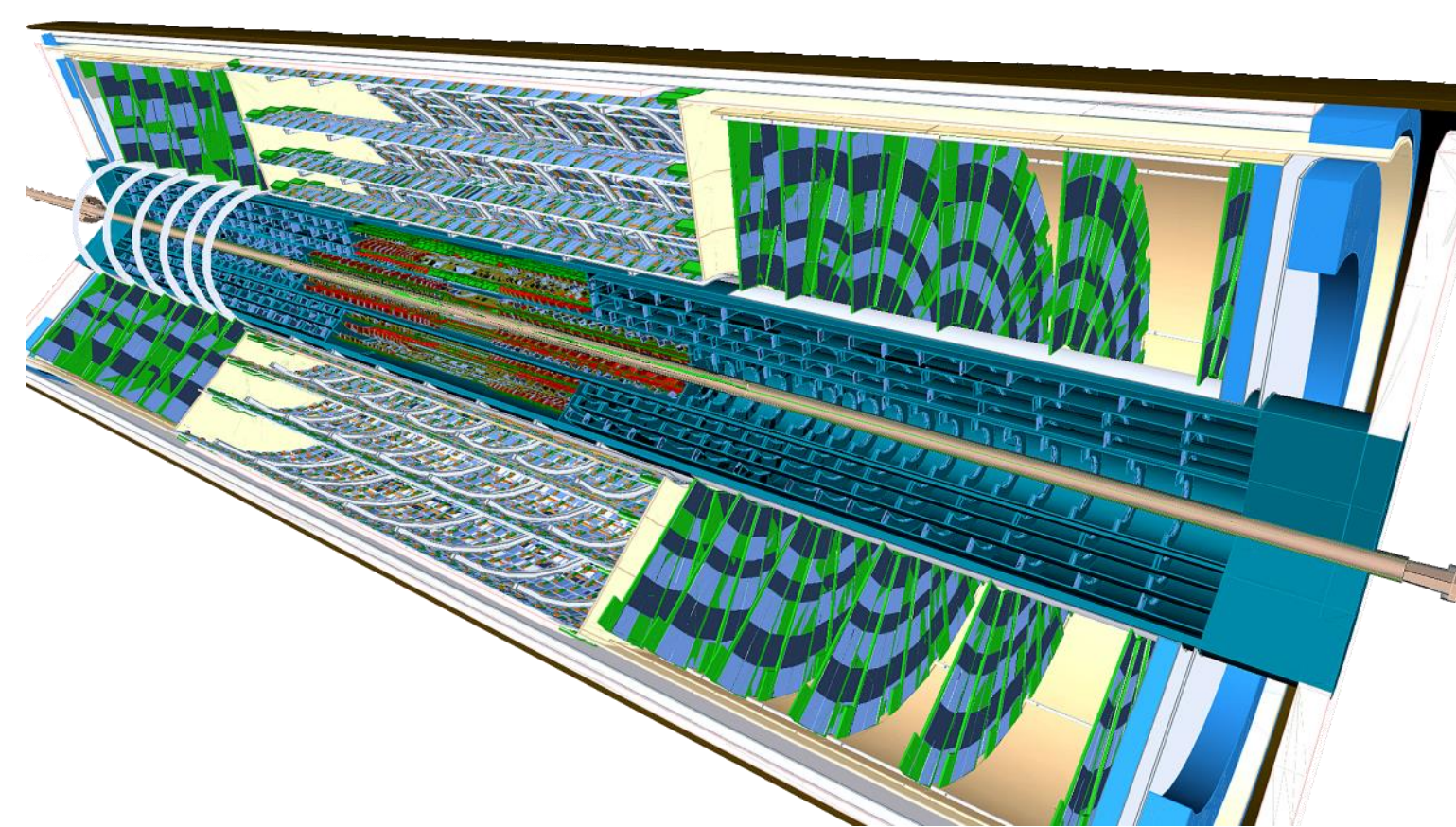
ATLAS Inner Tracker for HL-LHC (ITk)

At the HL-LHC the ITk detector will face:

- Radiation Damage**
 - HL-LHC should deliver $\sim 4000 \text{ fb}^{-1}$ (current inner detector for IBL $\sim 850 \text{ fb}^{-1}$)
 - New sensor design requires **increased radiation hardness**
- Pileup ~ 200**
 - Keep current inner detector occupancy **granularity increased by $\sim 10\times$**



- All silicon design
- Higher granularity
- Minimum material
- η coverage increased to 4 (currently ~ 2.5)
- CO₂ cooling



ITk Pixel Detector:

- 5 barrel layers: short barrel + inclined modules ($|\eta| < 1.4$) + endcap rings ($|\eta| < 4$)

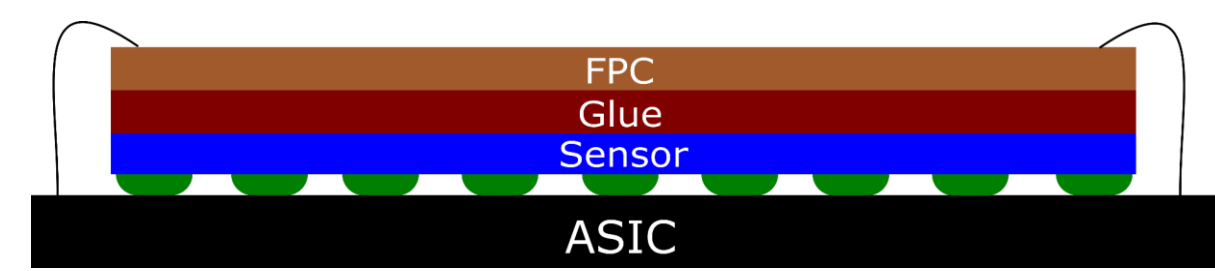
ITk Strip Detector:

- 4 barrel layers + 2x6 endcap wheels ($|\eta| < 2.7$)

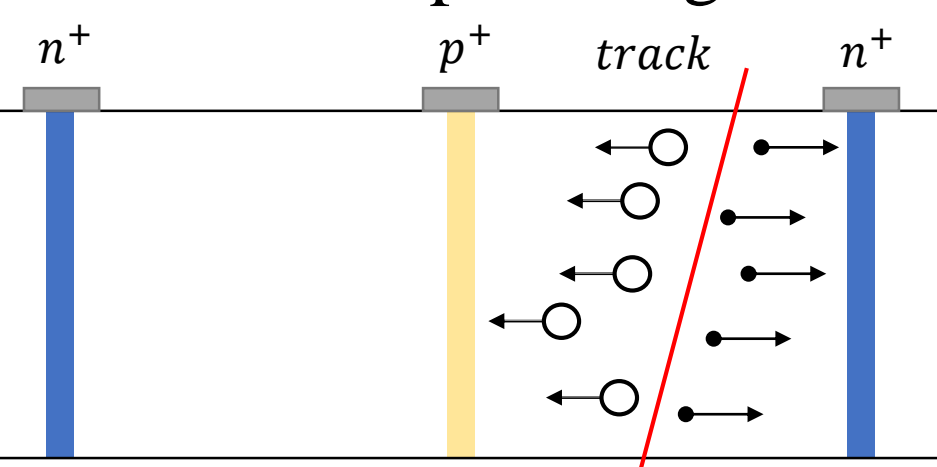
ITk Pixel Detector

Pixel Module development:

- Si n-in-p technology, small pixel size
- FE chip: Gbps readout capability
- Flip-chip using bump bonding
- Serial powering scheme

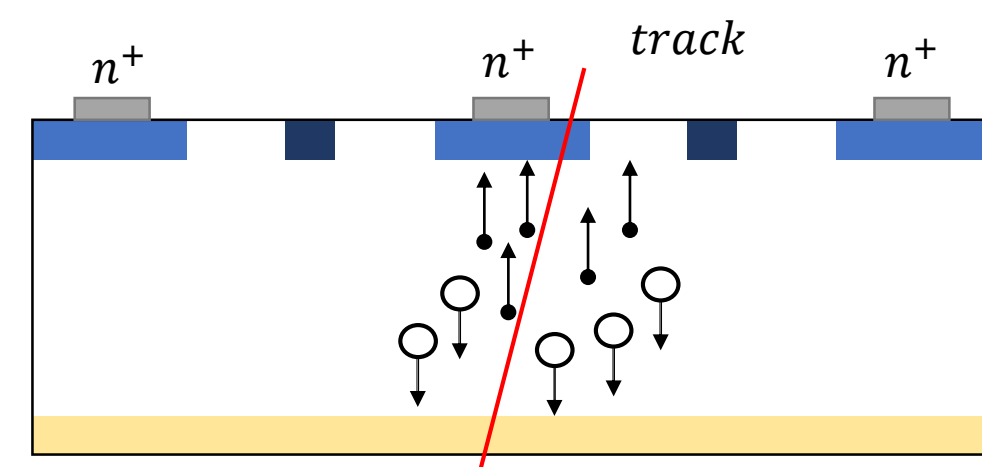


- Sequence development on going:
 - Attachment, wire bonding, encapsulation



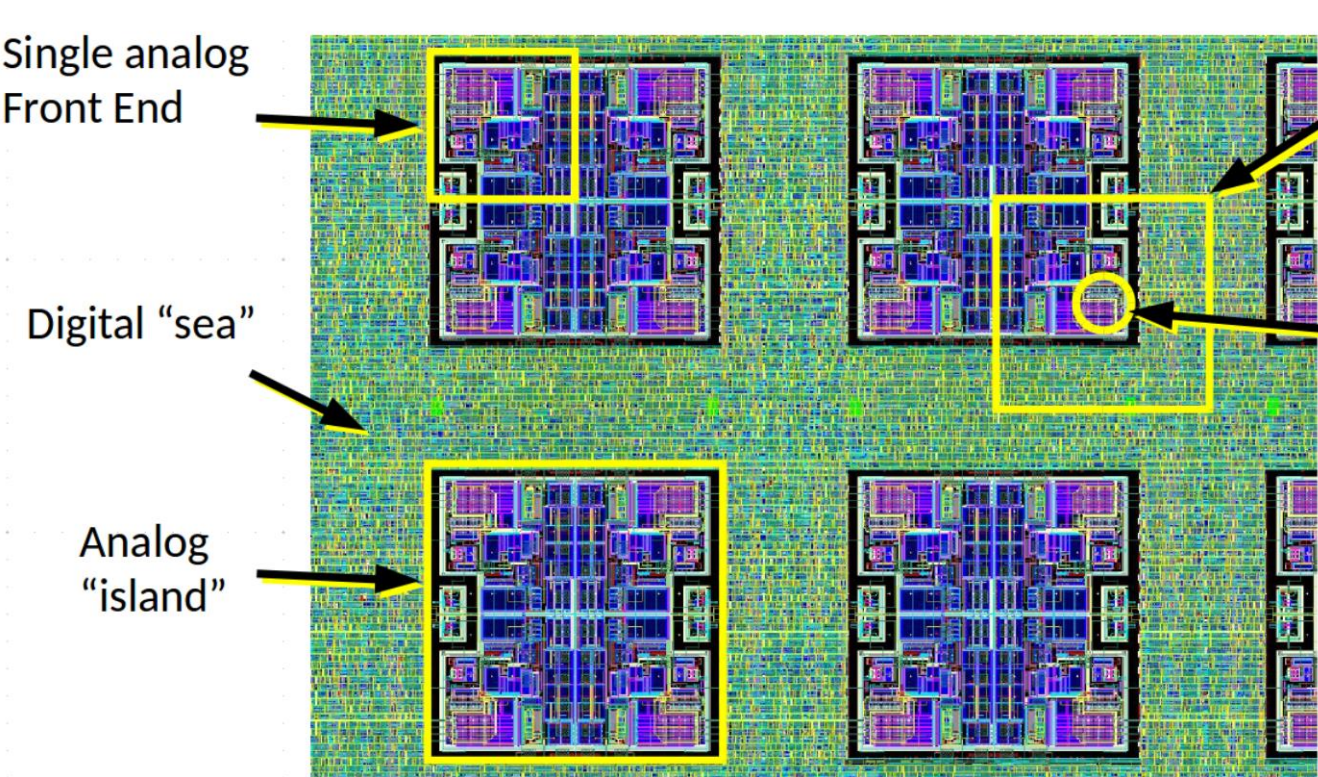
Pixel size: $50 \times 50 \mu\text{m}^2$ or $25 \times 100 \mu\text{m}^2$

Considering CMOS for outermost layer



- Planar n-in-p type other layers
- Thinned to $\sim 150 \mu\text{m}$

ASIC rad hard 65nm CMOS: Joint ATLAS & CMS project within RD53 collaboration

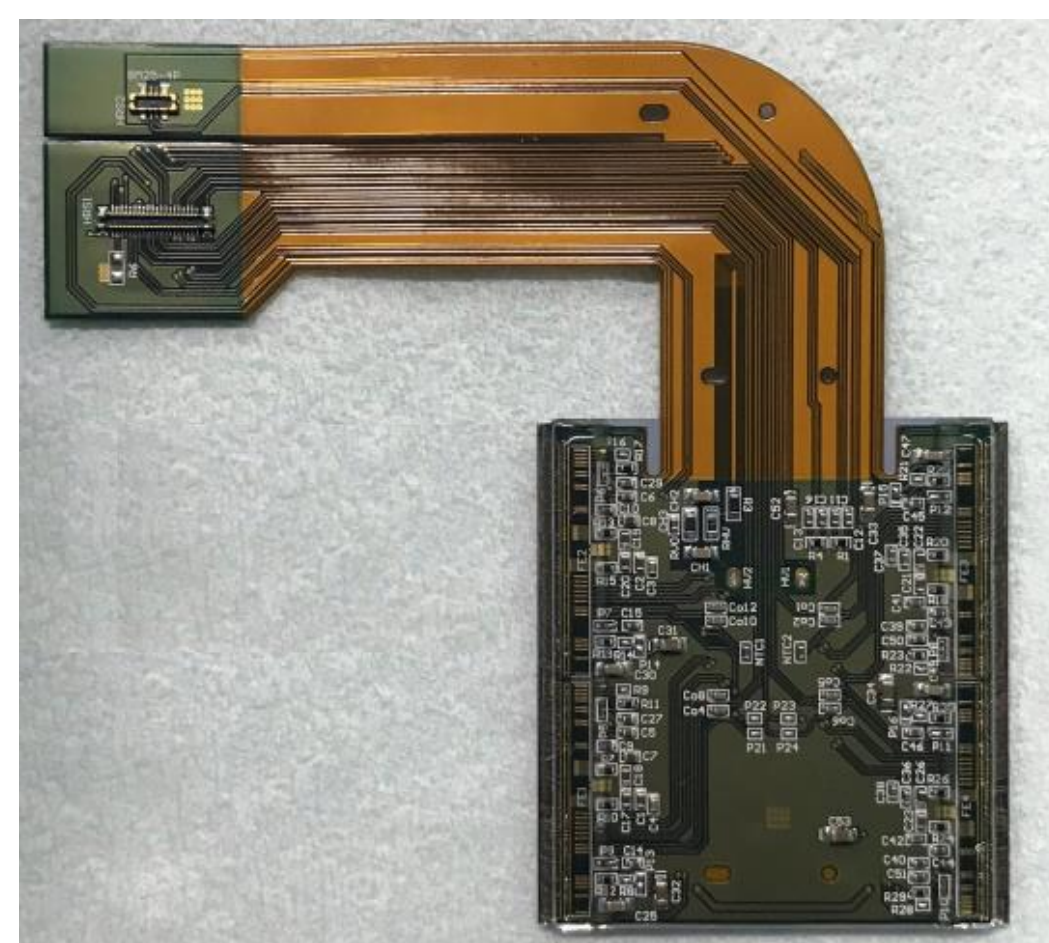


Example of square pixel on sensor above

Bump bond location

- Data rate $\sim 1.28 \text{ Gbps}$
- Noise rate ($< 10^{-6}$, $600 e^-$)
- RD53A first prototype of the final readout ASIC

<http://rd53.web.cern.ch/rd53/>



Quad barrel module



Quad module for outer endcaps



Loading tests with modules on Endcap ring local support

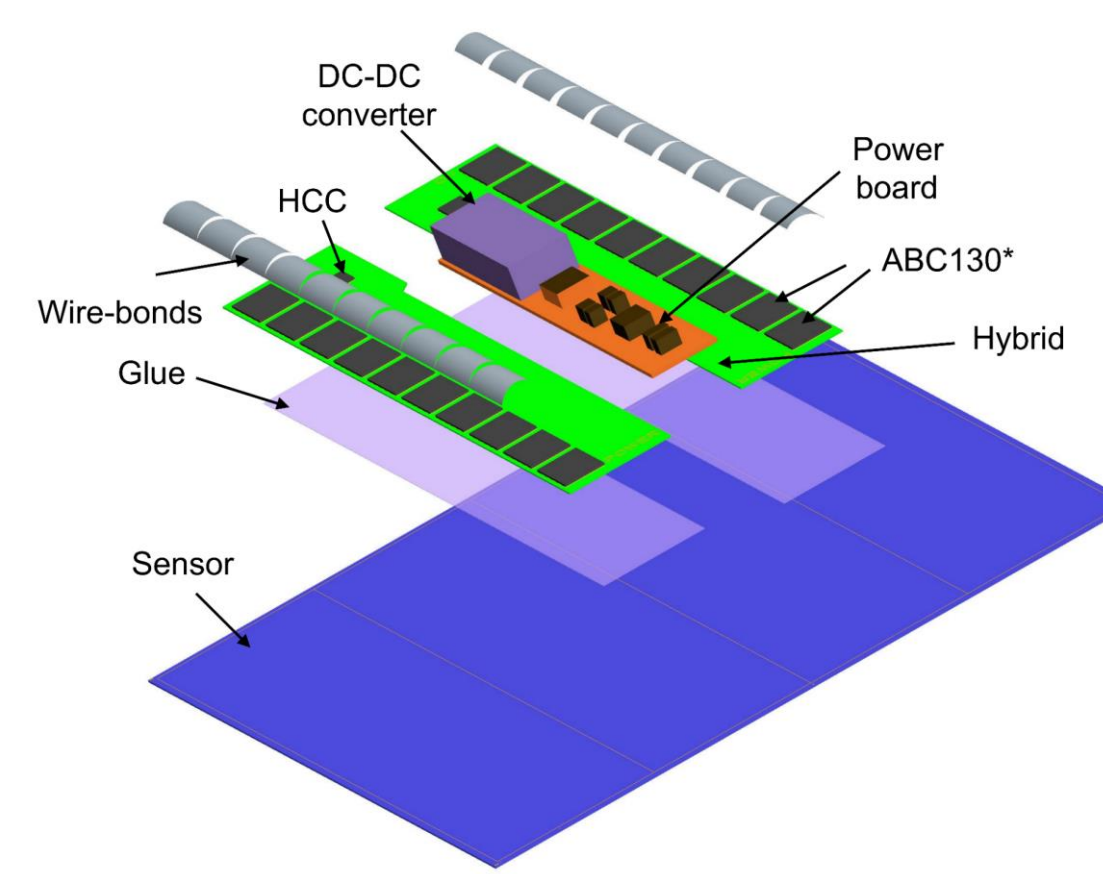


7 loaded FE-14 quad modules on outer barrel stave prototype

ITk Strip Detector

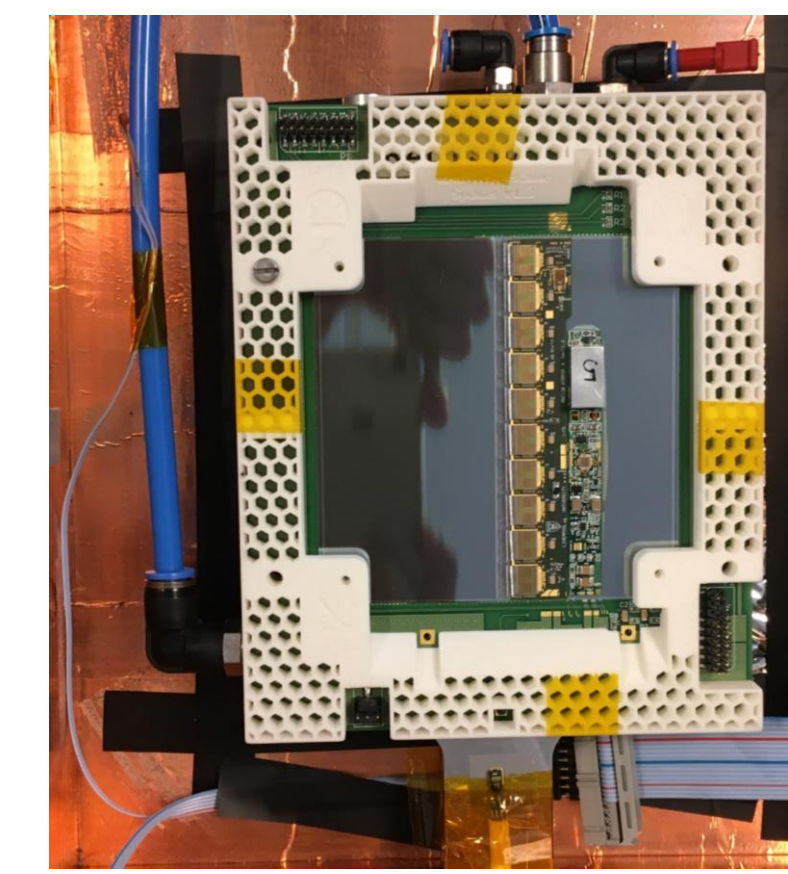
ITk Strip Module:

- One sensor
 - Planar Si n-in-p
- Low mass PCBs (hybrids)
- Power board with DC-DC
- ASICs ABC 130 nm CMOS



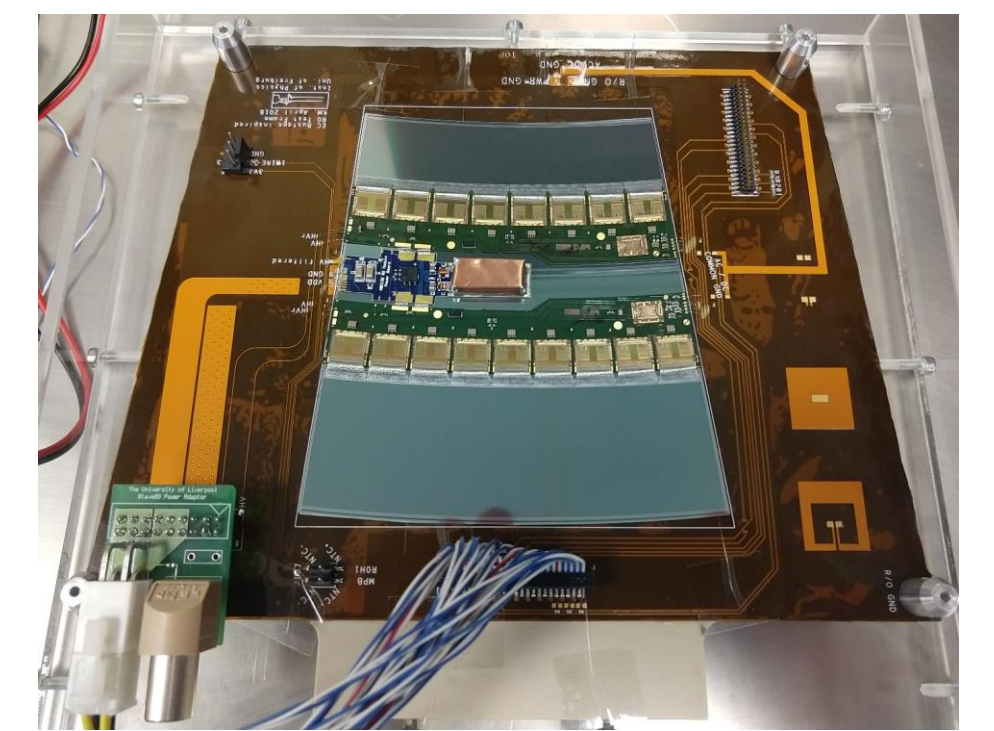
Barrel Module:

- Rectangular geometry
- Strip length 2.4 – 4.8 cm
- Pitch 75.5 μm
- Stereo angle 52 mrad
- 2 different modules



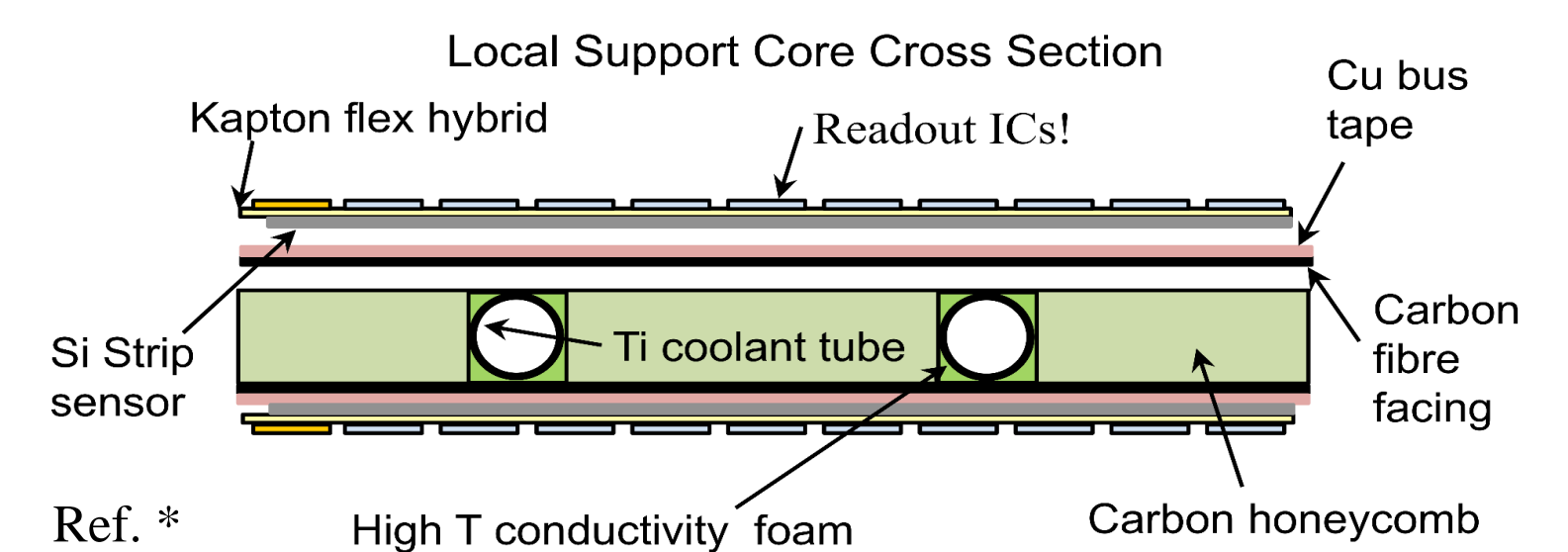
Endcap Module:

- Radial geometry
- Strip length 1.9 – 6 cm
- Pitch 69.9 – 80.7 μm
- Stereo angle 40 mrad
- 6 different modules



Local Support:

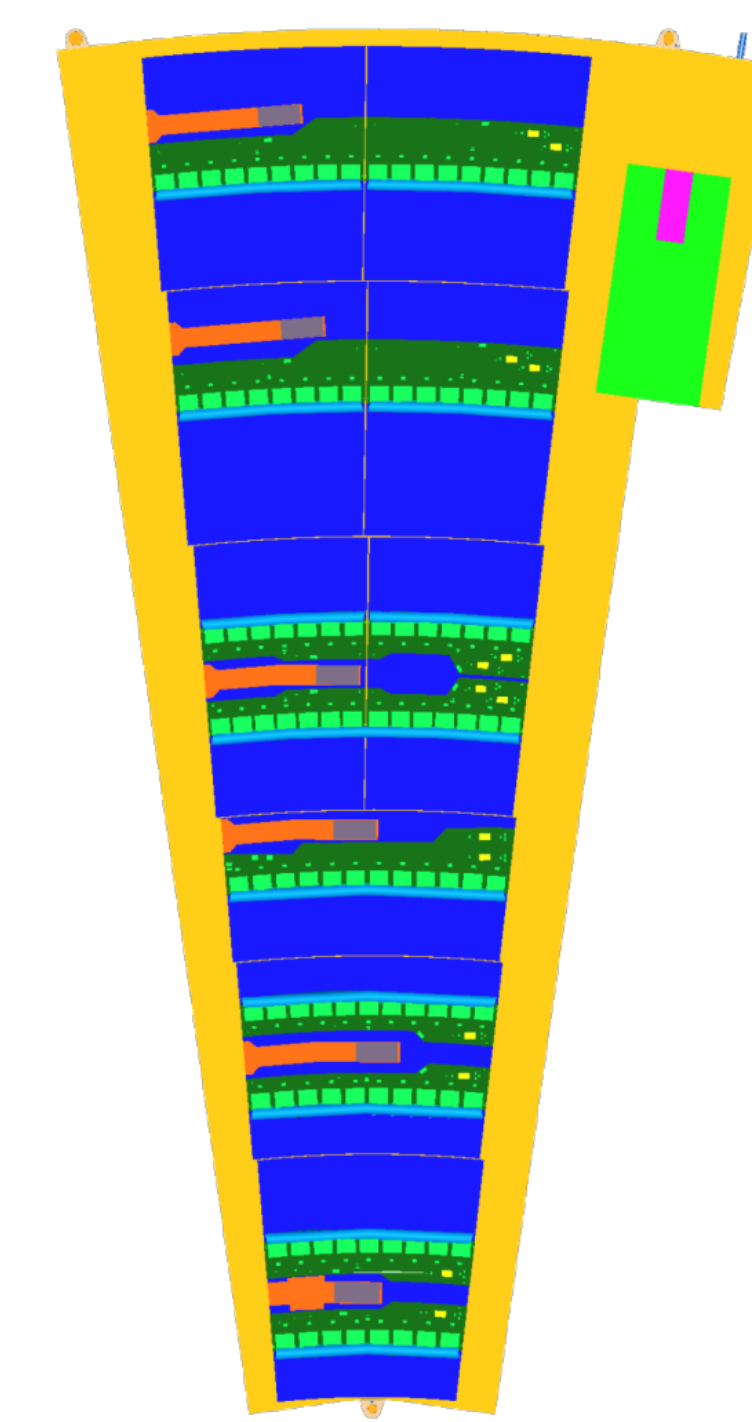
- Mechanical stability requirement: Barrel and endcap z , R ($20 \mu\text{m}$), ϕ ($2 \mu\text{m}$)
- Titanium cooling pipes
- Electrical services



Basic building units



Barrel staves



R5

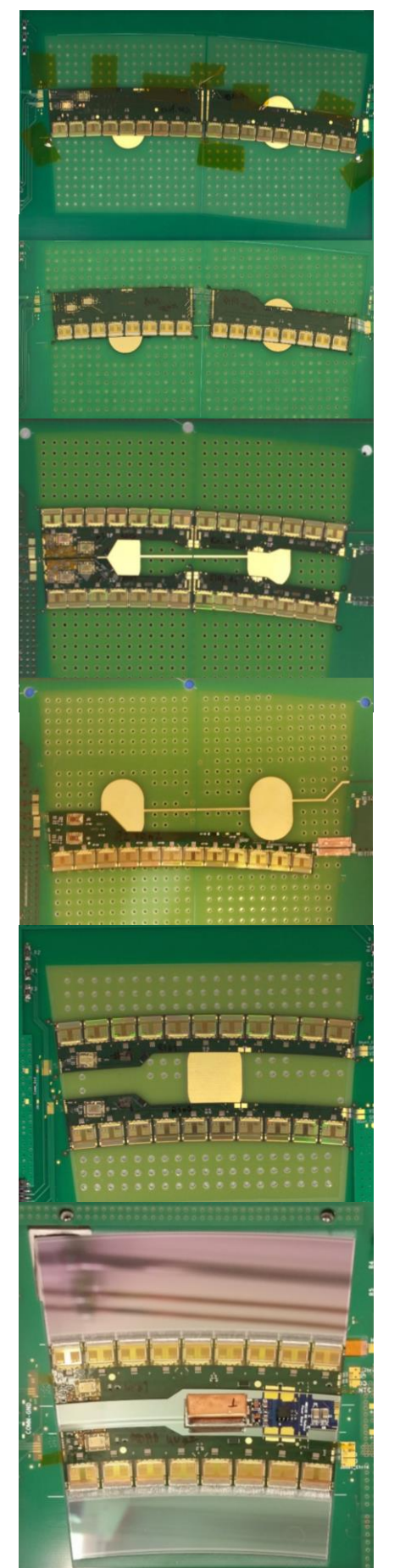
R4

R3

R2

R1

R0



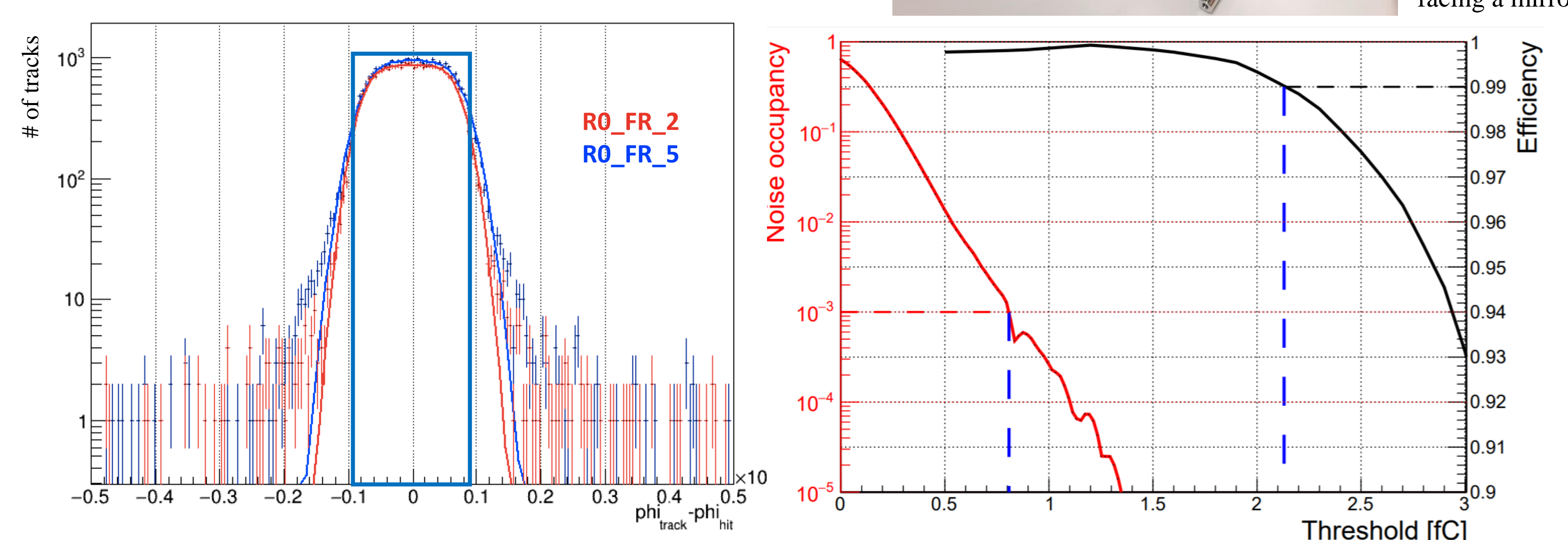
Endcap petals

Double-Sided R0 strip module

- Single-sided modules on both sides of a core
- Unirradiated sensors
- Petalet core including coolant tubes
- Readout independently from both sides, using a Nexys board
- Successfully tested in:
 - Freiburg clean room
 - Beam Test at DESY



DS R0 module facing a mirror



Residual distributions of hits with respect to tracks for either side of the double-side with blue box indicating strip pitch (left). Noise occupancy and efficiency as a function of applied threshold in fC (right). Defining operation requirements as efficiency $> 99\%$ and noise occupancy $< 10^{-3}$. The module can be operated using a threshold between 0.8 – 2.1 fC