



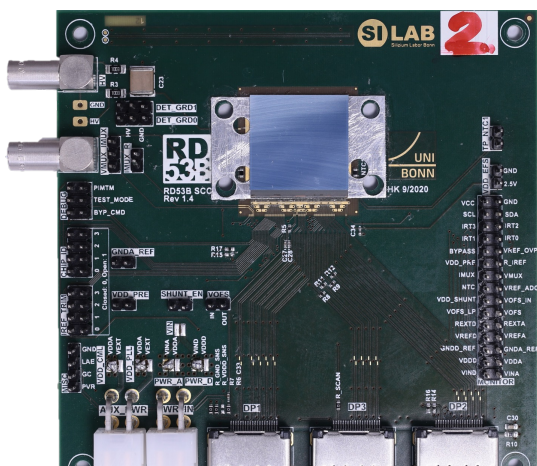
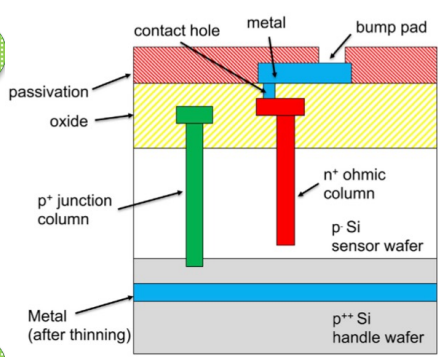
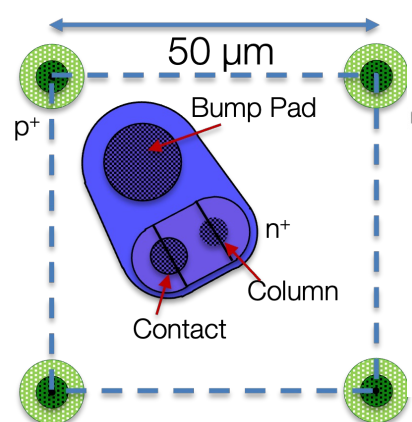
Characterization of pre-production 3D FBK sensors for the ATLAS ITk Pixel Detector Upgrade

LHCC Poster Session – 29.11.2022

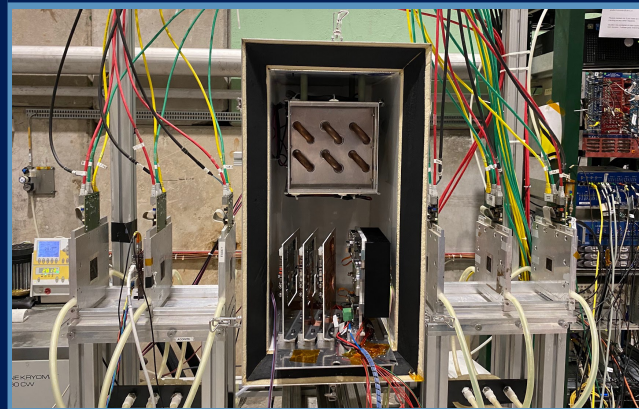
1. ITkPixVI.1 3D Pixel Modules

- ITkPixVI.1 are the latest prototype of ATLAS readout chip.
- Designed by the RD53 collaboration in 65 nm technology.

- With 50x50 μm shape sensors were produced by FBK in Trento, in Genova were assembled the first 8 pre-production modules with ITkPixVI.1 chips, on Single Chip Card (SCC).

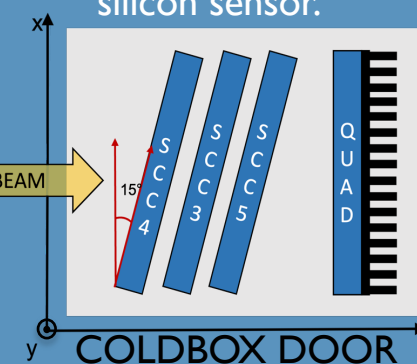


2. Beam Test Setup at CERN Facilities



- PS and SPS facility deliver 12GeV proton beam and 120GeV pion beam respectively.
- In both cases, a EUDAQ telescope was used: two arms with three planes of MIMOSA26 monolithic silicon sensor.

- The DUTs are placed in a coldbox in the middle of the telescope. DUTs configuration can be perpendicularly or tilted by 15° with respect to the particles beam.
- The data acquisition system is YARR and EUDAQ based.



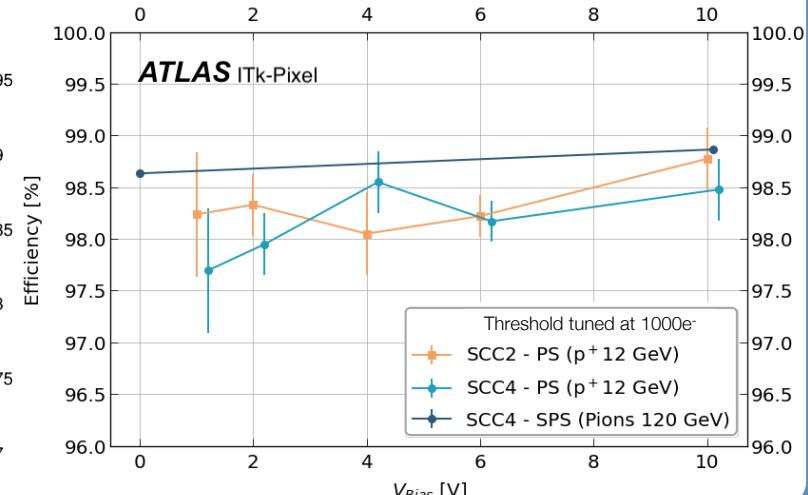
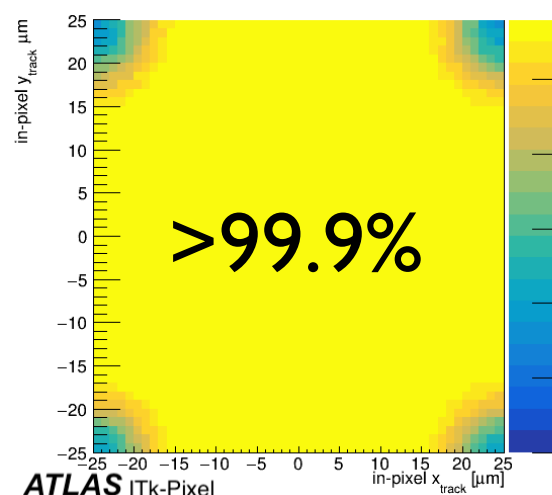
3. Unirradiated: 3D+ITkPixVI TB at PS and SPS - Perpendicular Configuration

PS facility:

- 1, 2, 4, 6 and 10 V_{bias} : Mean efficiency > 97.5 %.
- Large errors from alignment and timing instability.
- Several runs for each voltage setting \rightarrow Mean and st.dev of the run distributions used as mean and uncertainty.

SPS facility:

- Mean efficiency = 98.87 ± 0.06 at 10 V_{bias} .
- Central area efficiency higher than 99.9% at 10 V_{bias} .
- Lower efficiency is visible in corners (75% – 99%): 10 μm radius (4 μm radius p^+ col.).



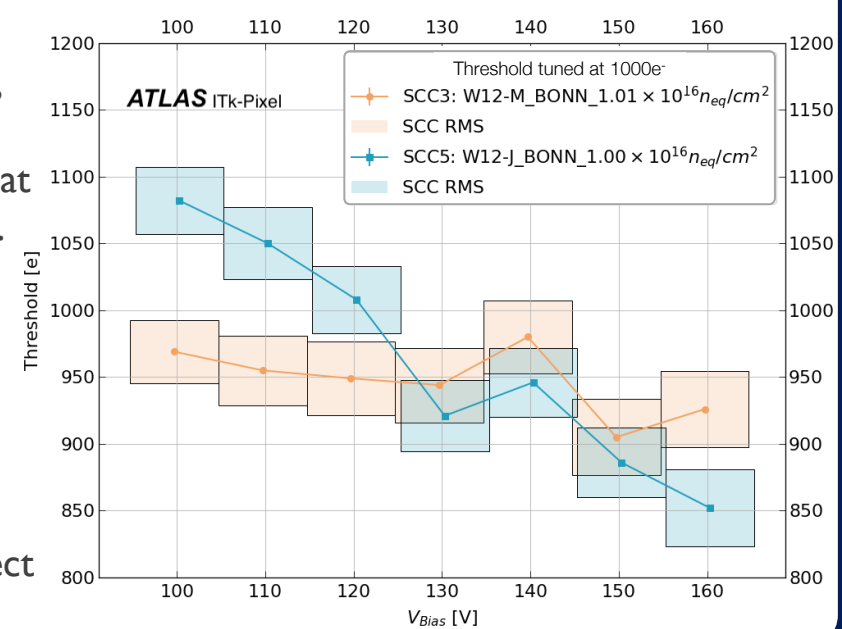
4. Bonn Modules Irradiation

- SCC3 and SCC5 modules were sent to Bonn for irradiation to fluence $1 \times 10^{16} n_{\text{eq}}/\text{cm}^2$.
- Irradiation with 15 MeV proton beam:
 - Almost uniform irradiation of the sensor surface (20x20 mm^2) with protons: only 1% variation.
 - n_{eq} fluence uncertainty $\sim 15\%$, while uncertainty proton fluence < 5%.

SCC	$n_{\text{eq}}/\text{cm}^2$	p/cm^2	Dose [Grad]
SCC 3	1.01×10^{16}	2.45×10^{15}	1.13
SCC 5	1.00×10^{16}	2.45×10^{15}	1.13

5. Irradiated 3D+ITkPixVI TB at SPS

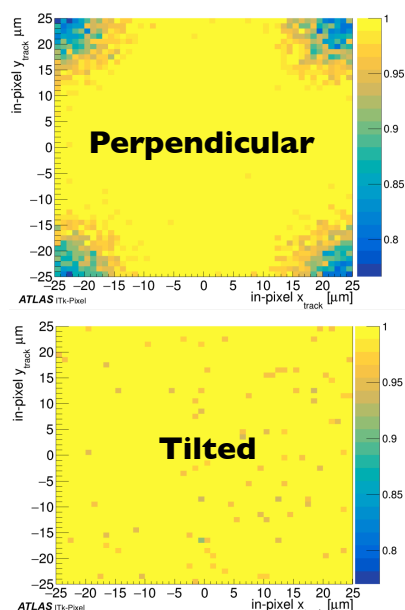
- SCC3 and SCC5 tested irradiated at CERN SPS with SCC4 (unirradiated) as reference plane.
- SCCs threshold tuned at 1000e, at -34 $^{\circ}\text{C}$ and 100 V_{bias} :
 - Threshold scan performed at several V_{bias} to verify tuning.
 - Same tuning used over all V_{bias} applied.
 - Tuning mean error < 1%.
- Two batches of data:
 - SCCs perpendicular to the beam.
 - SCCs tilted by 15° with respect to the beam.



6. Irradiated Modules Results: The Efficiency – Perpendicular and Tilted Configuration

- In table are show the most relevant efficiency values at different voltage with SCC3 and SCC5 in titled and not tilted configuration.
- The plots on the right are the SCC5 pixel cell efficiency in perpendicular (top) and tilted (bottom) configuration.

	ϵ @ 20V		ϵ @ 40V		ϵ @ 80V	
θ Tilt	0°	15°	0°	15°	0°	15°
SCC 3	85.4%	96.3%	97.7%	99.1%	98.5%	99.9%
SCC 5	85.6%	93.1%	97.4%	98.9%	98.0%	99.9%



SCC3 and SCC5 Hit Efficiency in both configuration

