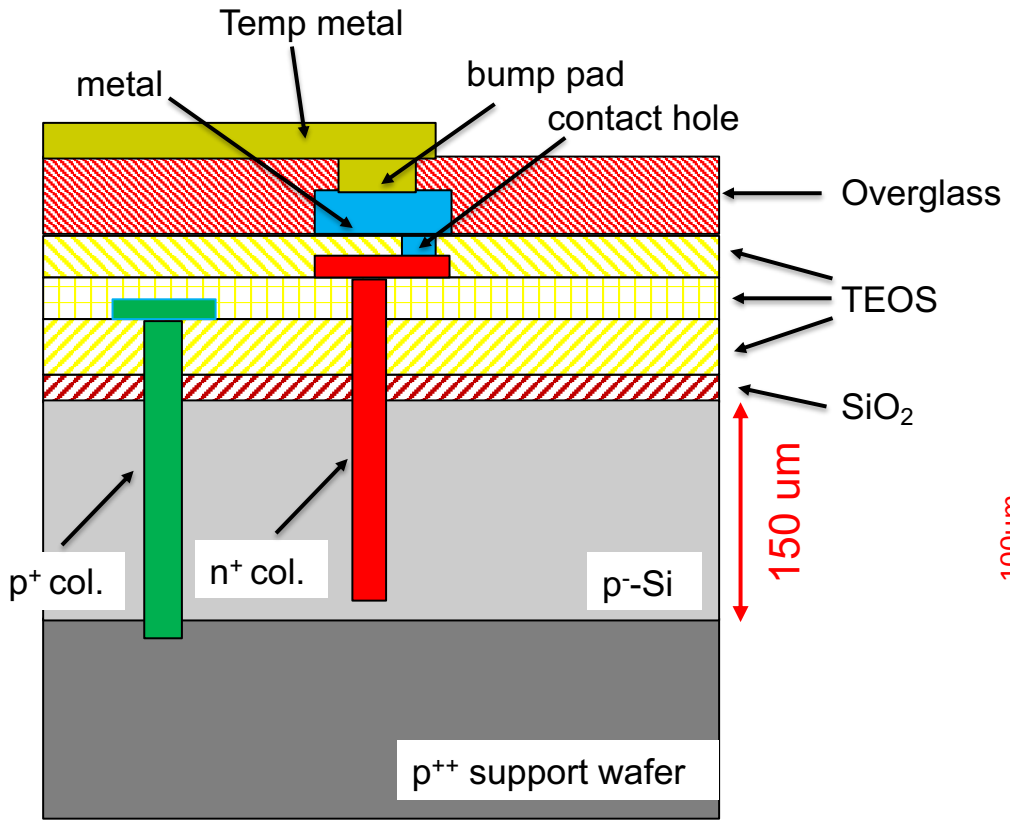
Trento Institute for
Fundamental Physics
and Applications

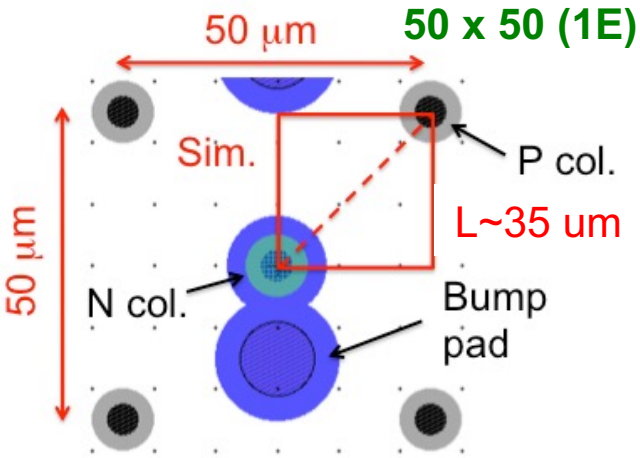
CSN1 Project
FASE2_ATLAS

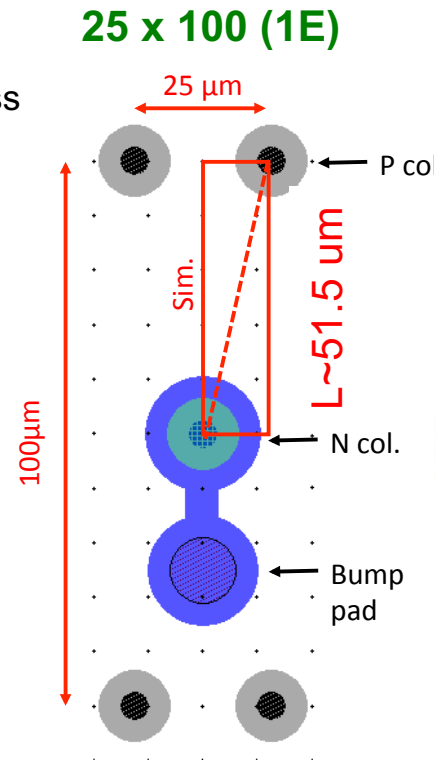
Gian-Franco Dalla Betta
DMS Sultan

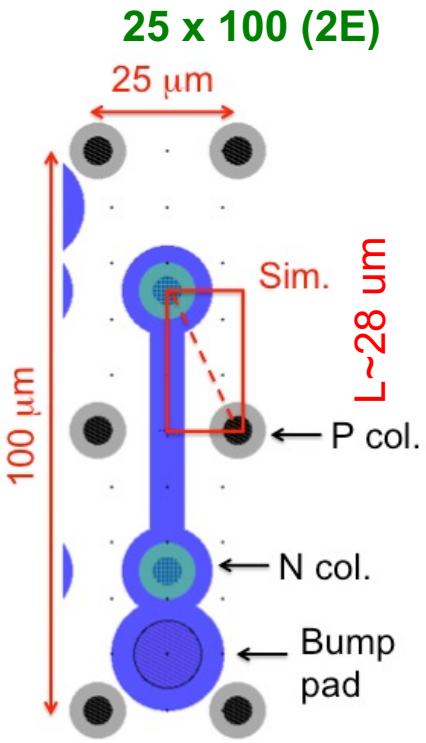
Small-pitch thin 3D pixels

- Joint ATLAS-CMS R&D with FBK started in 2014
- Now in production phase …

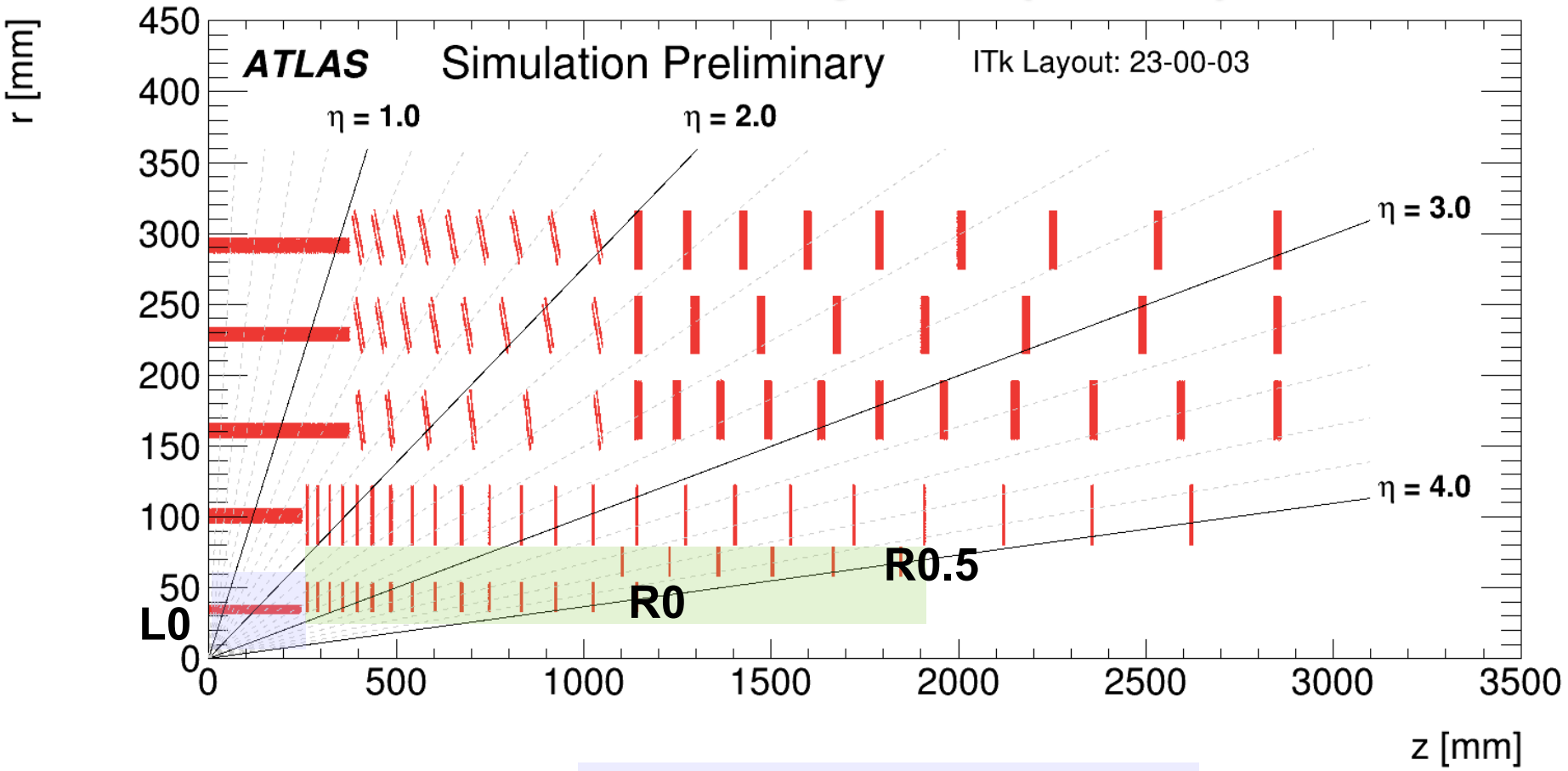








ATLAS ITk Layout (Pixel)



3D sensors

- Barrell (L0): 25x100 μm^2 (1E)
- Endcap (rings R0, R0.5): 50x50 μm^2

3D sensor production scheme

- Production of 3D sensors for the Barrel (25 x 100 μm^2 - 1E)
  → CNM on 4-inch wafers (~500 sensors)
- Production of 3D sensors for the Endcap (50 x 50 μm^2)
  → FBK and SINTEF on 6-inch wafers (50% each = 800 sensors)
- Status at all vendors:
  → FBK: successfully completed and delivered pre-production, started production
  → SINTEF: successfully completed and delivered pre-production
  → CNM: failed pre-production
- Back-up solution for 25 x 100 μm^2 pixels:
  → FBK qualified through a CMS batch (CROC), successfully completed and delivered pre-production

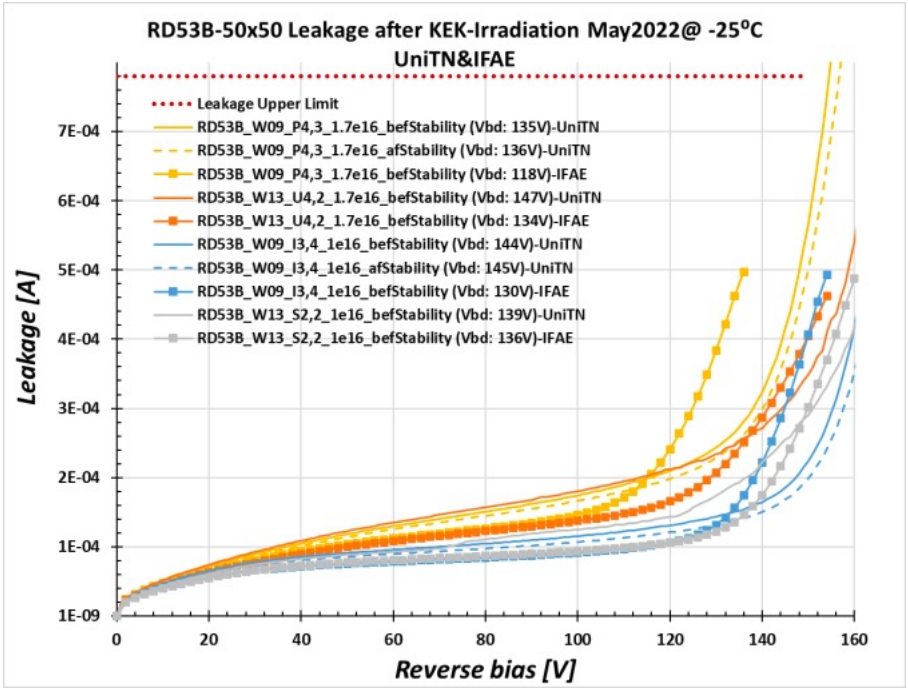
FASE 2_ATLAS: stato attività 2023

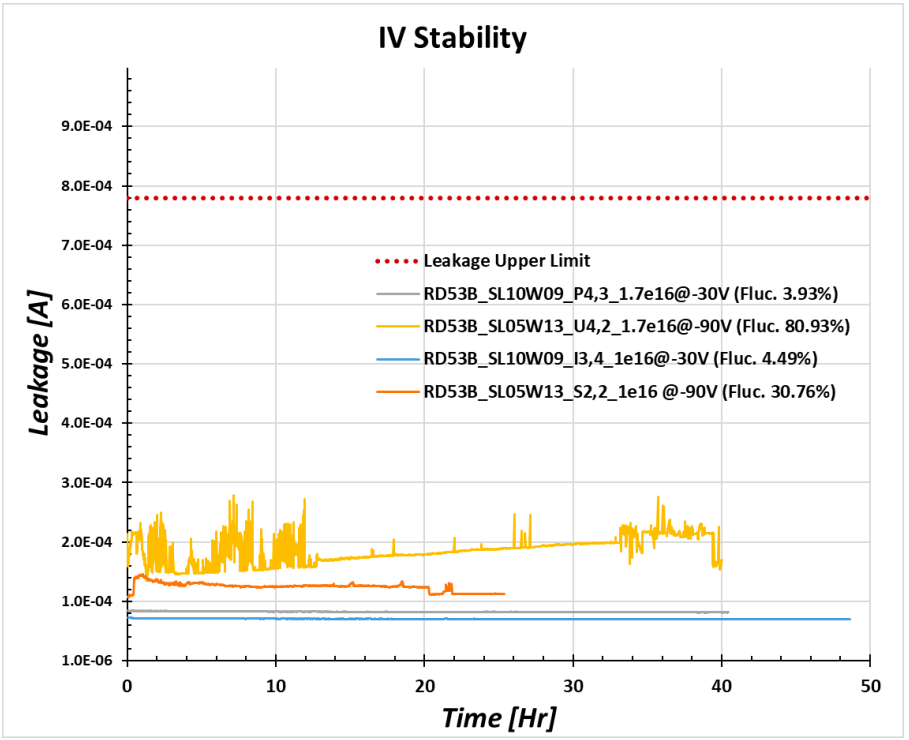
- Caratterizzazione elettrica e funzionale moduli 3D-ITkPix1 dal lotto di pre-produzione (pre- e post-irraggiamento) **OK**

- Allestimento setup e qualificazione sito per test sui moduli 3D **In corso**

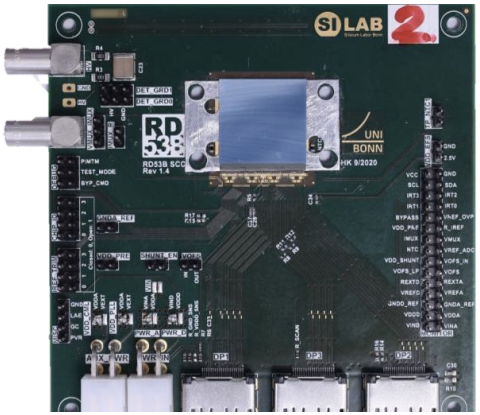
QC Irradiated Sensors

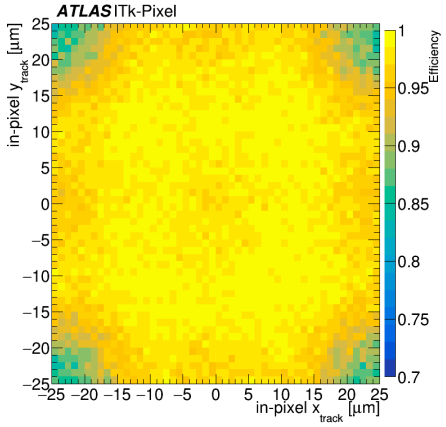
- Caratterizzazione elettrica in camera climatica sensori e strutture di test dopo irraggiamento con protoni da 70 MeV @CYRIC (@ DII, UniTN)
- Risultati confrontabili con IFAE



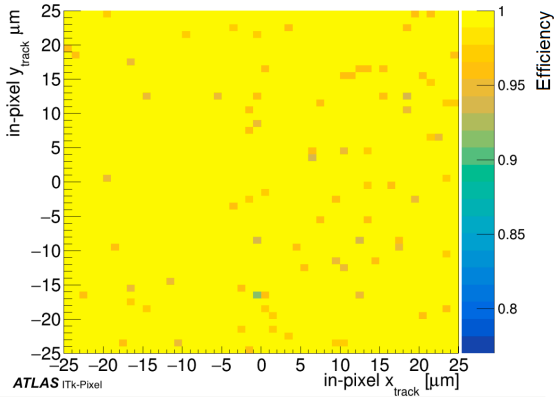


First ITkPixV1 modules after irradiation

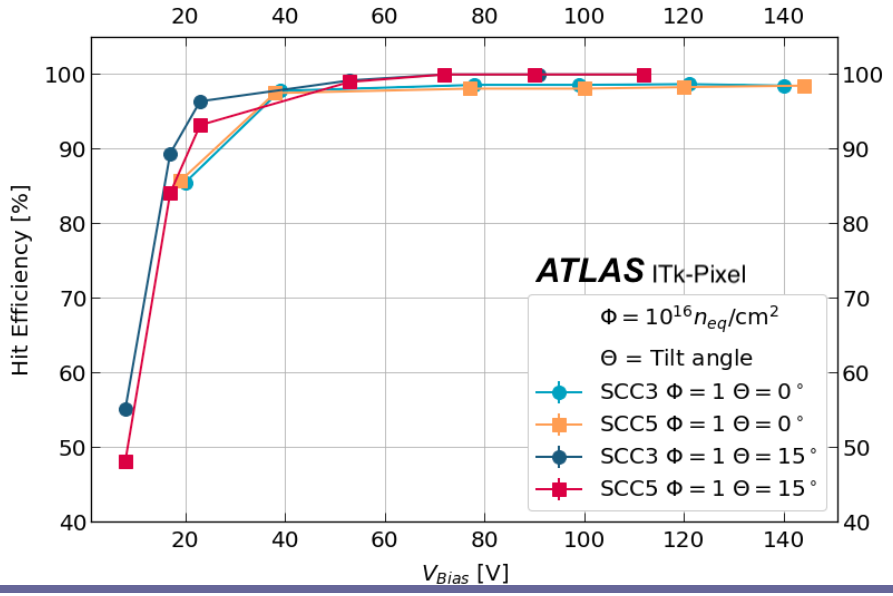


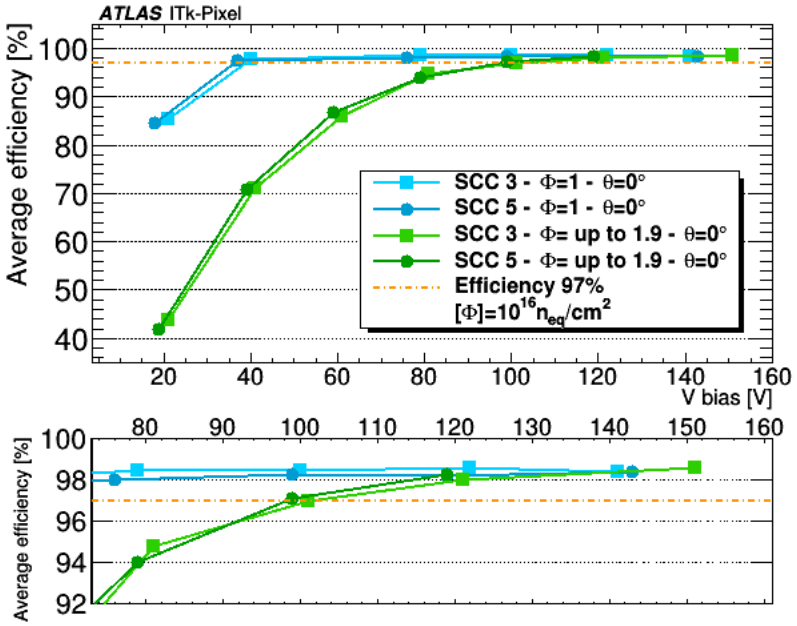


Perpendicular incidence



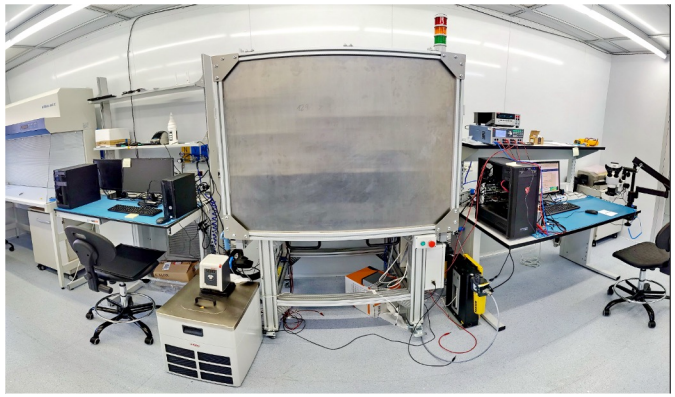
Tilt 15 degrees



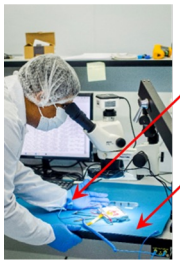


QA/QC setup for ITk Triplet Module Qualifications

Cleanroom Requirements (1)

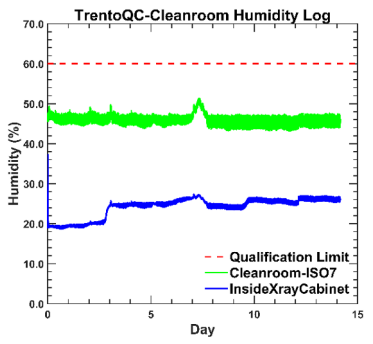


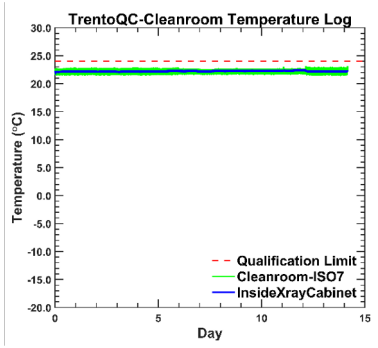
QC-Cabinet and test benches

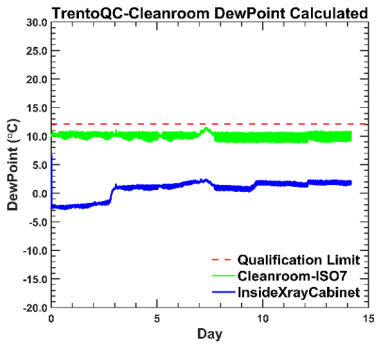


	Block	Sub-Block	Qualification released	EDMS link to process document
1	Lab infrastructure			AT2-IP-QA-0016 v.1
		Lab rooms + services	TRUE	AT2-IP-QA-0034 v.1
		ASIC Compliance & Handling	TRUE	AT2-IP-QA-0043
		Storage of Bare Module, Module PCB and assembled module	TRUE	AT2-IP-QA-0044 v.1
		Shipping	TRUE	AT2-IP-QA-0045 v.1
		Production Rate Planning	TRUE	AT2-IP-QA-0038 v.1

- **INFN-Trento as a ITk Triplet module QC has to pass through a wide set of qualification steps.**
- **ISO Class 7 grade cleanroom is mandatory.**
- **All required ESD safe grade facilities are met already.**
- **INFN-Trento has qualified for the first three blocks of infrastructure qualifications: 1, 2 & 3.**
- **Stable temperature and humidity have been thoroughly inspected for a continuous 14-days.**

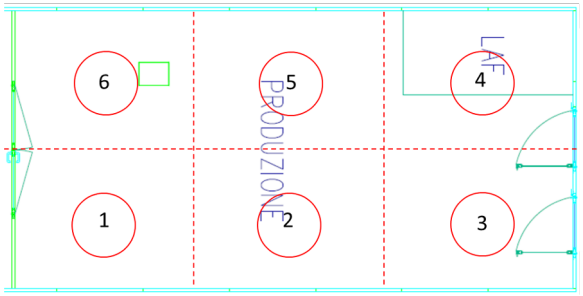






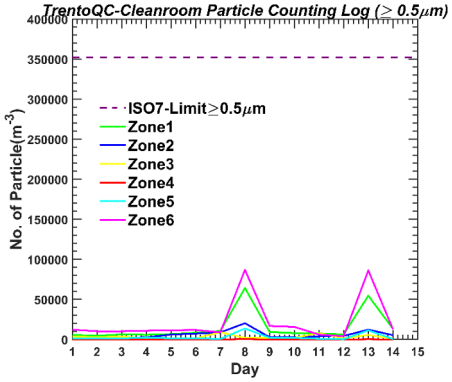
Dry-Cabinet

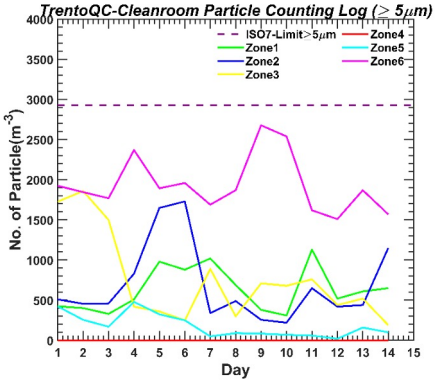
Cleanroom Requirements 2



Aerotrak 9350-2

- Aerotrak 9350-2 particle counter used to qualify particle conditions within the cleanroom. It meets ISO-7 standards.





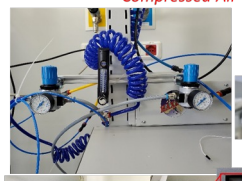
ISO Std.	Particle Size		
	0.5 μm	*1.0 μm*	*5.0 μm*
ISO7	352,000	83,200	2,930
ISO5	3,520	832	29

- Oil-free and ISO8573-1 (≤ Class 1) grade dry-air is required for QC activities. INFN-**T**rento meets these requirements.

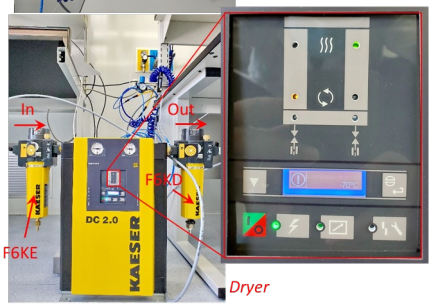
Povo-0 Oil & Solid filters

- INFN-**T**rento also installed an additional dryer and vacuum injector.
- The additional dryer ensures the dewpoint -70 ˚C.
- **Vacuum injector ensures regulated pressure up to -900 mbar.**

Compressed Air-Inlets



Vacuum Injector

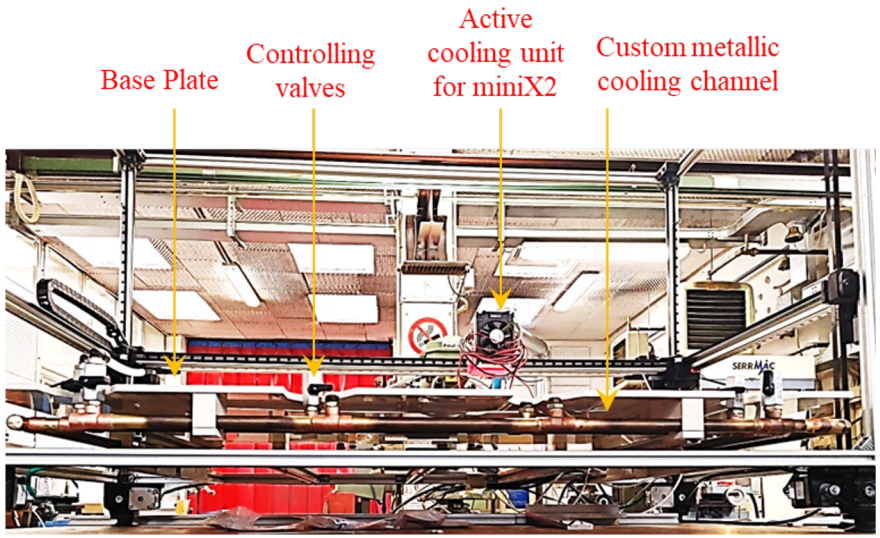


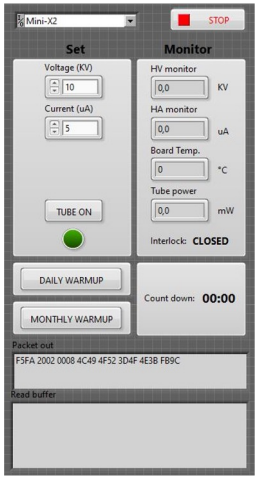
Dryer

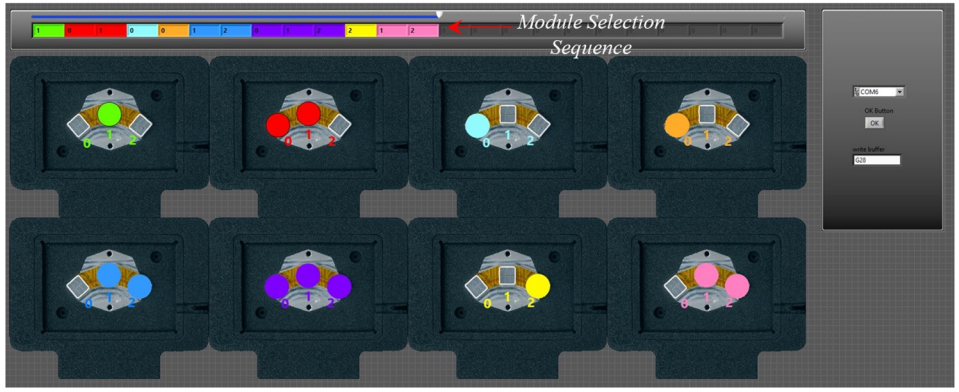
QC Test setup

10	Testing set-up			AT2-IP-QA-0024 v.1
	twiki overview	Cold testing setup	TRUE	AT2-IP-QA-0037 v.1
		Thermal cycling	TRUE	AT2-IP-QC-0019 v.1
		Interlocks	TRUE	AT2-IP-QA-0031 v.1
		DCS	TRUE	AT2-IP-QC-0017 v.1
		Testing Parallelization Setups	TRUE	AT2-IP-QC-0020 v.1
		Stability Test	TRUE	AT2-IP-QA-0054 v.1
		Source or x-ray test setup	TRUE	AT2-IP-QA-0052 v.1
		Room temperature test setup (Digital)	TRUE	AT2-IP-QA-0042 v.1

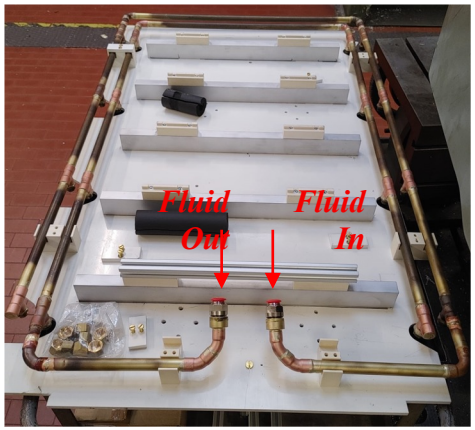
- **ITk Triplet module QC test setup requires several detailed qualifications.**
- **Source-scan within the XYZ moving stage has already been implemented and integrated with a LabView framework.**
- **Mini-X2 X-ray unit with active cooling and temperature sensing units is loaded.**
- **The required control and hard interlock of mini-X2 (in case the cabinet gets open) are also implemented in the LabView framework.**



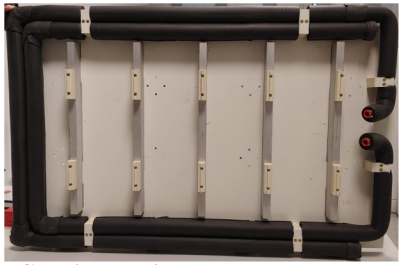




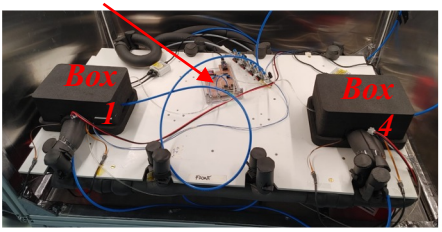
QC Test setup (parallel cooling circuits)



Insulated with 6mm thick Armaflex



Vacuum Sensing Unit



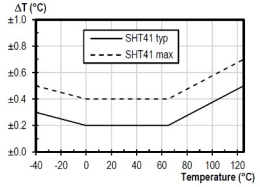
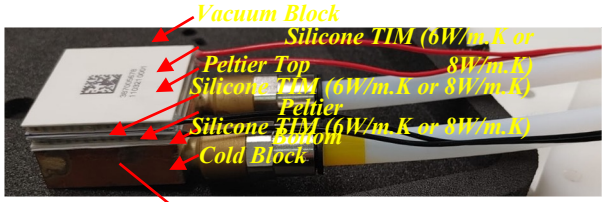
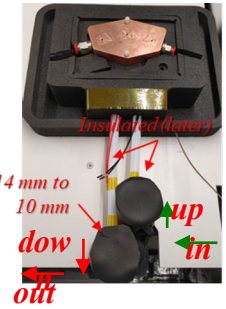
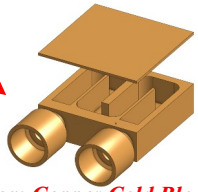


Figure 7: SHT41 typical and maximal temperature accuracy.



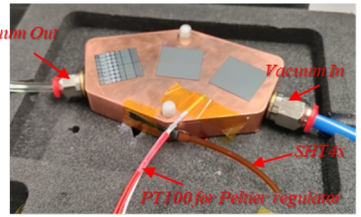
Stack up Details

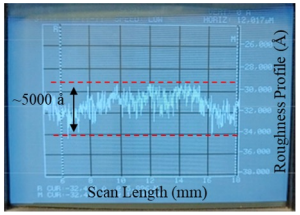




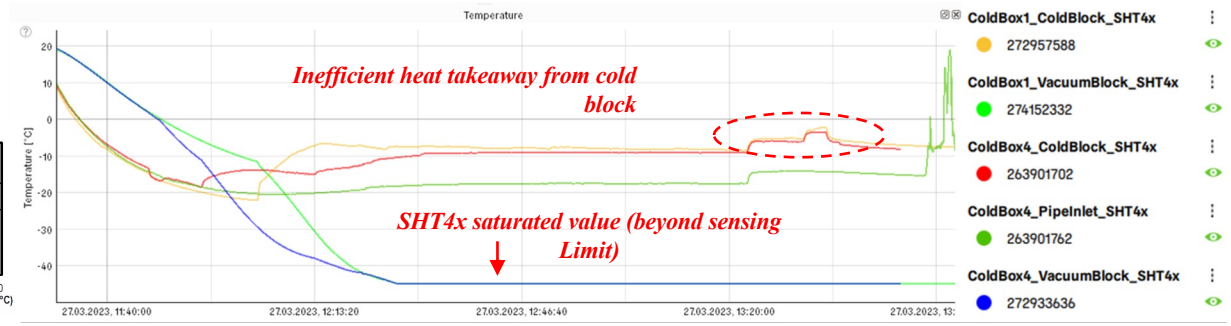
Custom Copper Cold Block

Temperature at coldbox4-vacuum (pt100)

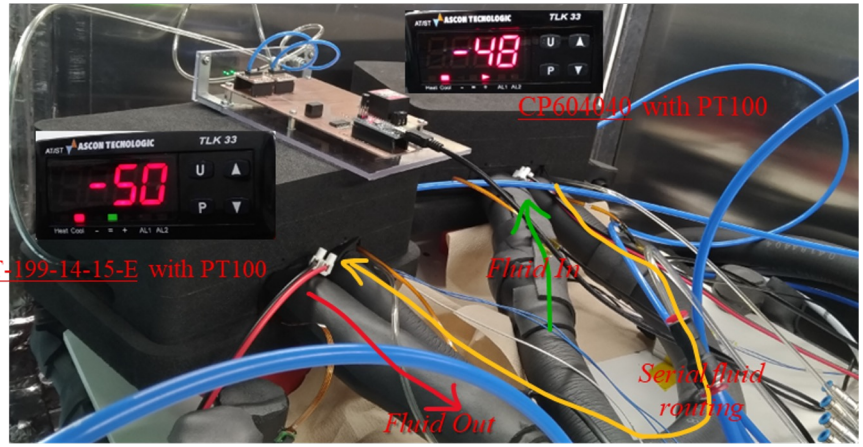




- Cu-based cold block and vacuum chuck prototypes designed for better heat transfer. The vacuum chuck meets surface roughness requirements (<600nm) and pressure integrity.
- A custom parallel cooling circuit was implemented and tested for multiple foam boxes. The least temperature at the vacuum chuck is ~ -42 ºC. (The low chiller-pressure and take-away heat power are the bottlenecks)

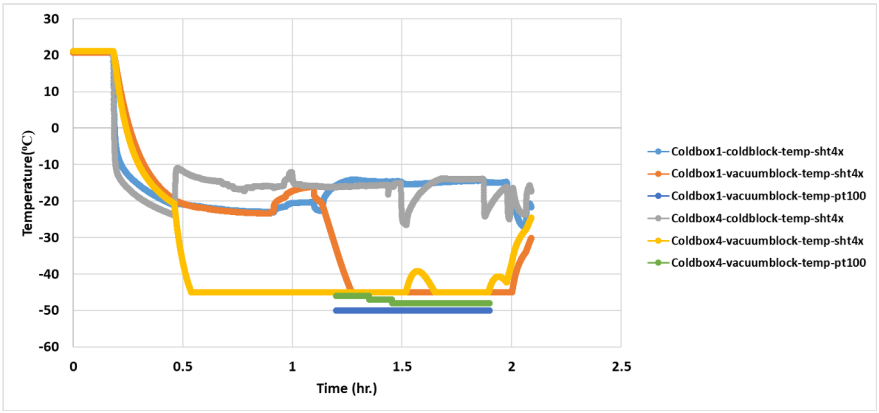


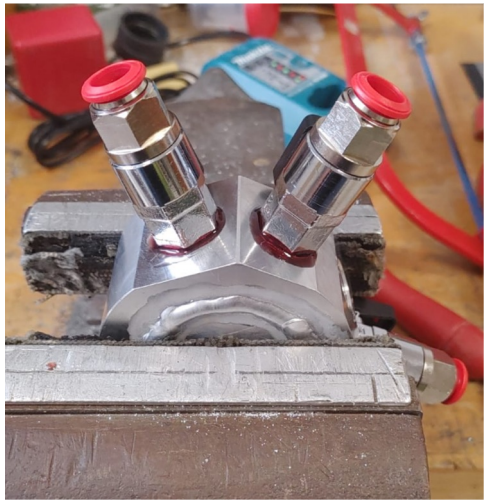
QC Test setup (Serial cooling circuits)



Serial Cooling Circuit

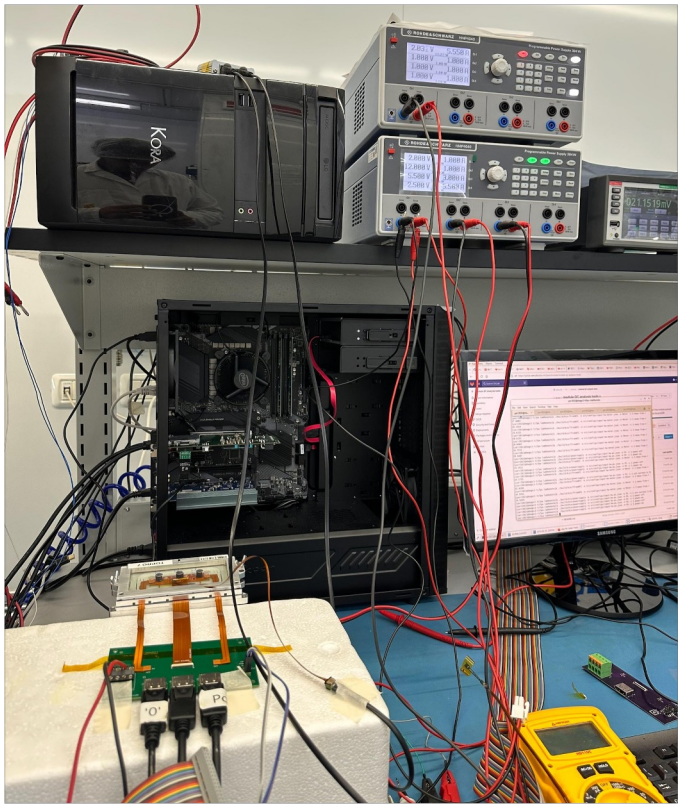
- An alternate serial cooling tested and found to work for two-foam-boxes (vacuum block reaches ~-50 ºC).
- Serial cooling circuit is recommended for multiple boxes as the heat from the 1st cold block aggregates to the following chain.
- A new yet simpler parallel distribution block was designed and is under investigations.





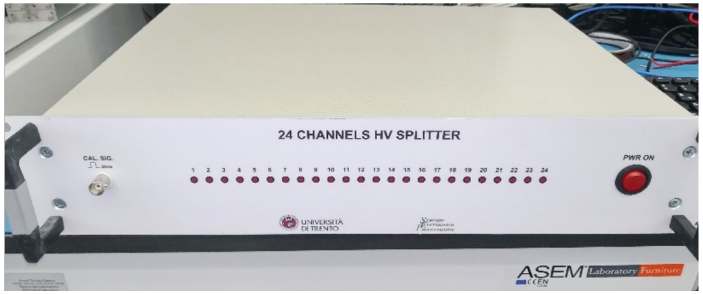
A new parallel chiller fluid distribution Unit

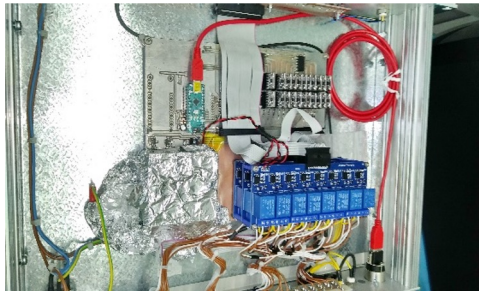
QC Test setup (associated hardware developments)



A module reception test setup at RT

- All necessary PCs, Programmable PS, and multimeter are procured and being used.
- A 1-to-24 parallel HV splitter is designed. It allows reverse biasing up to 300 V. Per channel, it can sense current (min. current resolution: 100 nA), and trip relay connection it a sensor draws current ≥1 mA. It is yet to be integrated in the LabView framework.
- An Arduino-based vacuum sensing unit designed and tested successfully (yet to be integrated in the LabView framework).
- An Arduino-based temperature and humidity unit fabricated (yet to be populated, tested, and integrated in the LabView framework).
- Trento received a prototype PCB from Bologna for hard-interlock relays. Detailed interlock-conditions will be implemented.





An interactive reverse HV splitter

QC Test setup: summary

- INFN-Trento is now a qualified QC institute when it concerns the adequate infrastructure.
- ITk Triplet module QC test setup has several strict challenges (more critical than quad-testing). The set requirements also change with the testing community experiences, and became bumpy for a steady setup developments.
- INFN Trento is already progressed significantly. The required XYZ stage of the mini-X2 stage and its associated control and hard interlock were successfully implemented.
- The parallel cooling circuit optimization is being investigated.
- The required commercial hardware: PC, PSs, Multimeter, and FPGAs are procured and are being used by incorporating the necessary custom DAQ software packages.
- Several custom hardware are developed, tested, and already met the required functional benchmark from the ITk testing community.
- The ambient sensor-based interlock-part is not yet ready.

Piano attività TN 2023-2024

- Test elettrici e funzionali su sensori e moduli ITKPix1 25x-100 irraggiati a fluenze di interesse ITk (~1.7×10^{16} n_{eq}/cm^2)
- Confronto tra simulazioni e risultati misure
- Qualificazione elettrica (a campione) su sensori 3D lotti di produzione
- Completamento dell'allestimento setup per la qualificazione dei moduli 3D e inizio del lavoro

Riassunto FTE 2024 (preliminare)

Nome e Cognome	Ruolo	ATLAS	FASE2_ATLAS
Gian-Franco Dalla Betta (R.L.)	PO	10%	30%
Giovanni Verzellesi	PO		50%
David Macii	PA		50%
Roberto Iuppa	PA	50%	
Giacomo Baldi	PA		40%
Francesco Follega	RTD-A	20%	
Ester Ricci	RTD-A	20%	
DMS Sultan	Asseg.		100%
Arif Samy (*)	Asseg.		50%
Andrea Di Luca	Asseg.	100%	
Greta Brianti	Dott.	100%	
Daniela Mascione	Dott.	100%	
Jixing Ye	Dott.		80%
Abderrezak Boughedda	Dott.		50%
Marco Cristoforetti	FBK	50%	
Maurizio Boscardin	FBK		20%
Nicola Zorzi	FBK		30%
Francesco Ficorella	FBK		10%
Sabina Ronchin	FBK		40%
Giovanni Paternoster	FBK		10%
Totale FTE		**10.1 + 1.5 (*) = 11.6**	

(*) + 1.5 FTE
su sigle sinergiche:

AIDAInnova
IGNITE

Riassunto richieste 2024 (preliminare)

Voce	Richiesta
Missioni	
▪ Metabolismo MI	11.5
▪ Metabolismo ME	44.0
▪ Irraggiamenti e test beam FASE2 (1 mese uomo)	4.0
▪ ESP per duties (3.87 FTE)	22.0
Consumabili:	
▪ Metabolismo consumo	17.5
▪ Consumo per QA/QC moduli	3.0
▪ “Gettone” consumo per clean room	2.0
Totale (k€)	**104.0**