Bergen ITk Status June 2024

Simen Hellesund, Simon Huiberts, Sohaib Hassan
On behalf of the Bergen group

June 2024 – Norway

Personnel

Bjarne Stugu: Professor

Attiq Ur Rehman: Senior engineer

Thomas Poulianitis: Chief engineer

Simen Hellesund: Postdoc

Simon Huiberts: PhD

Sohaib Hassan: PhD

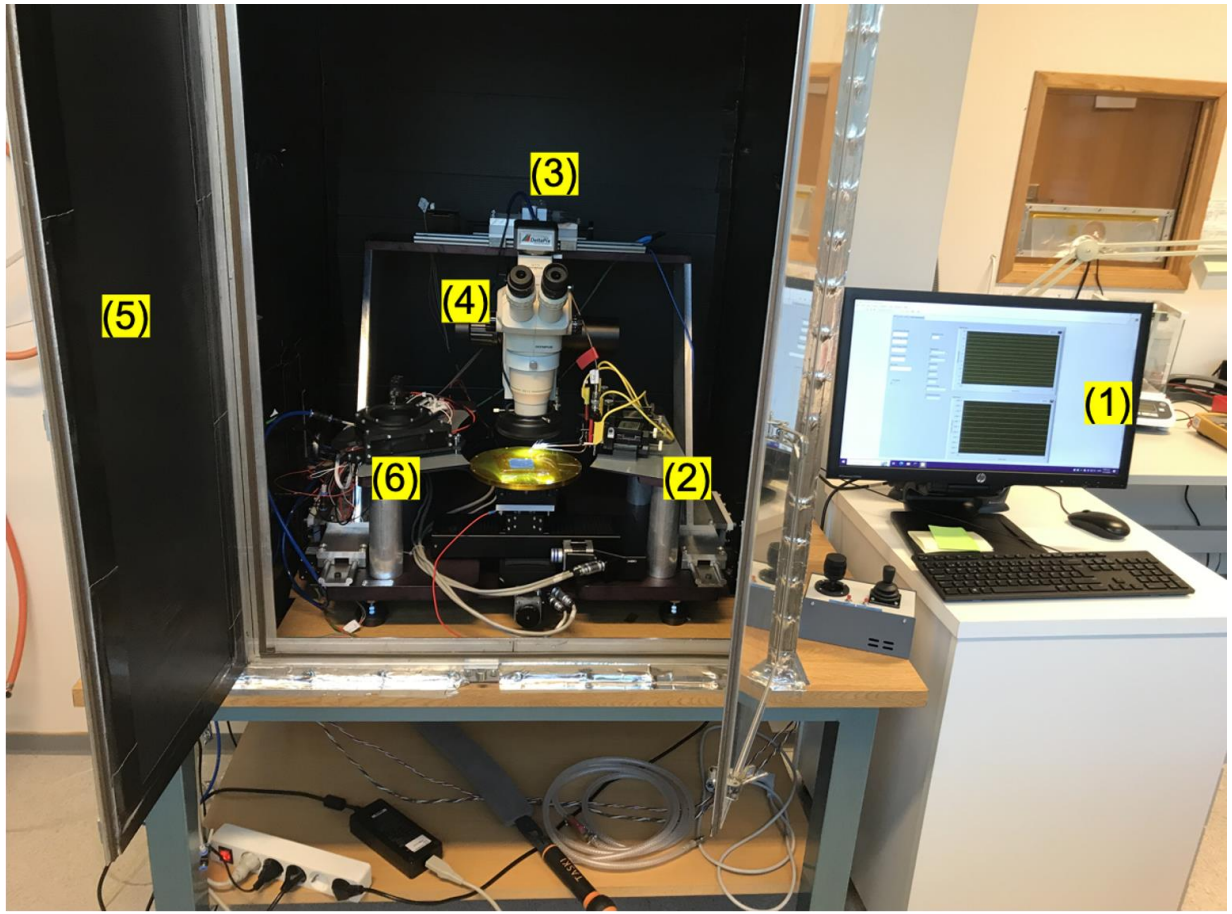
Facilities and Equipment

- Clean Room
  - ISO 7 Standard. Manual particle counter. Environment monitor with automatic email notification system.
  - Microscope probe station
  - Smart Scope metrology station with custom vacuum chuck.
  - KERN digital scales for precision mass measurements.

- Detector Lab
  - ISO 9 standard (Not certified, but confirmed over a 2 week particle counting campaign summer 2023).
  - Temperature, humidity and particle count monitored 24/7 by a canary board, logging to an influx server.
  - Flex cleaning/drying and storage.
  - Visual inspection microscope
  - Vacuum sealer.
  - Climate chamber.
  - Module cold test setup.

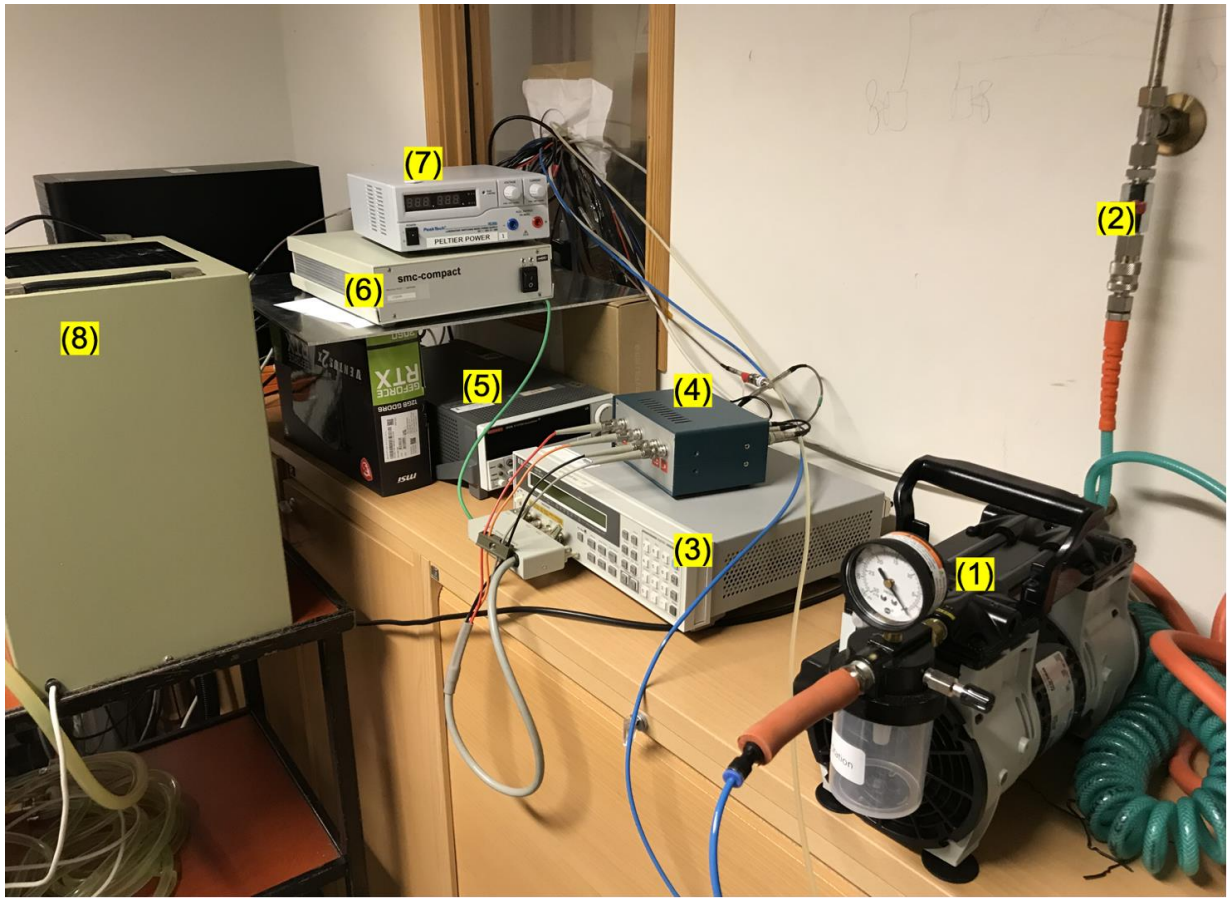
Facilities and Equipment – Clean Room

Probe Station - inside cleanroom



1)- PC with control and data acquisition software
2)- Platform with probe station needles
3)- Deltapix camera (usually used setting: 1.6M, 1536 × 1024)
4)- Microscope (Olympus SZ-CTV stereo c-mount)
5)- Dark (light-tight) box and a light source
6)- Cold chuck (under development)

Probe Station - outside cleanroom



1)- Dry vacuum pump for the chuck
2)- Dry nitrogen line for the cold chuck
3)- LCR 4263b for C-V measurements
4)- Decoupling box to protect LCR
5)- Keithley 2635A for I-V measurements
6)- Motor controller to move the chuck and microscope
7)- Power unit for the Peltier element of the cold chuck
8)- Chiller for the cold chuck

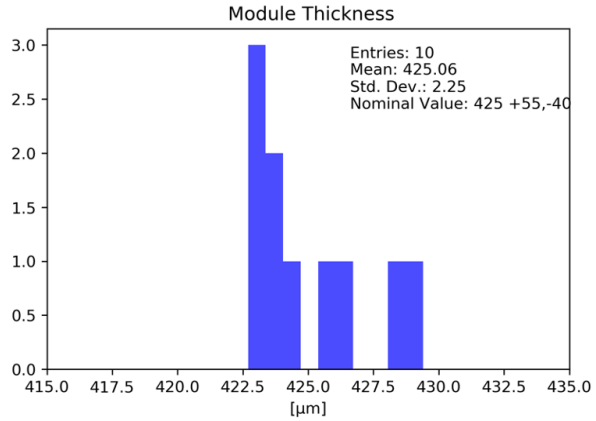
Facilities and Equipment – Clean Room

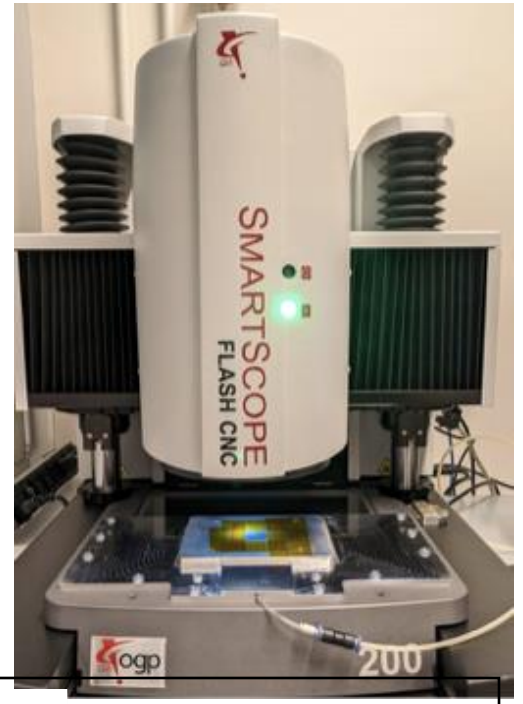
Smartscope - Metrology

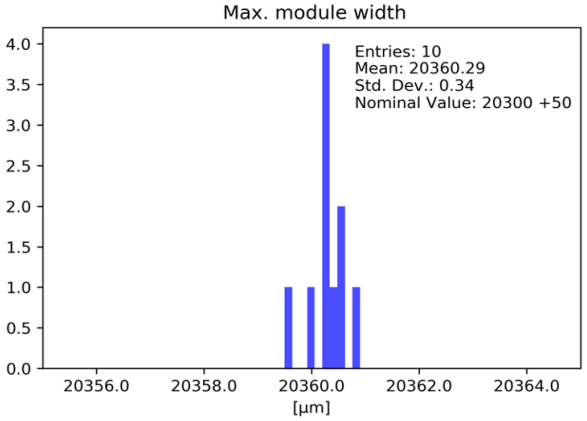
- Ø Manufacturer's description: Smart Scope Flash CNC 200/ CERN Box copy
- Ø XYZ Travel: 200 × 200 × 150 mm
- Ø XY Area Accuracy: E2 = (2.0 + 6L/1000) µm, Z Linear Accuracy: E1 = (3.5 + 6L/1000) µm
- Ø Scale resolution: 0.5 µm
- Ø Fitted with grid projector for enhanced focusing on specular surfaces
- Ø Custom-made vacuum chuck for metrology
- Ø Equipped with ZONE3® metrology software

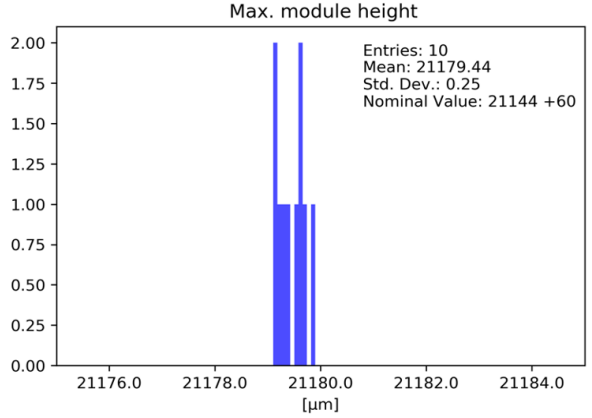
Smartscope - Imaging

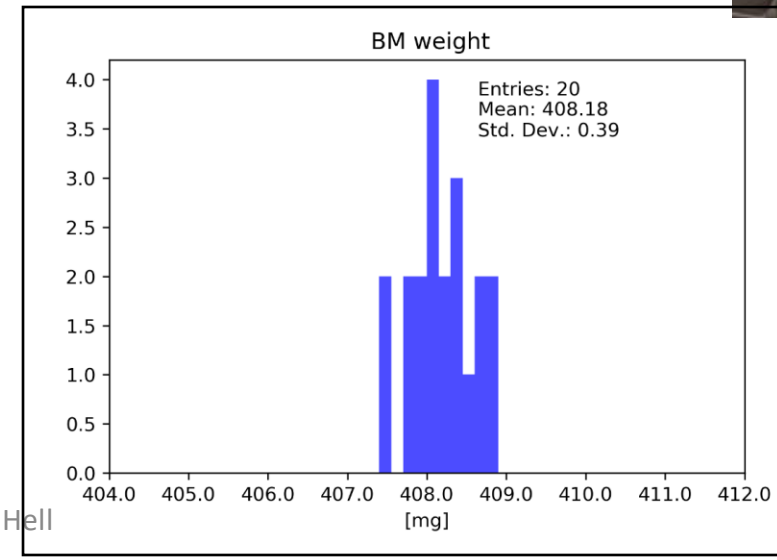
- Ø Field of view from 0.905 mm × 0.679 mm (7.00x) to 7.961 mm × 5.974 mm (0.80x)
- Ø Standard definition (640 × 480) 0.92 Mega pixel resolution
- Ø Ring, coaxial and backlight
- Ø ZONE3® metrology software for clicking images

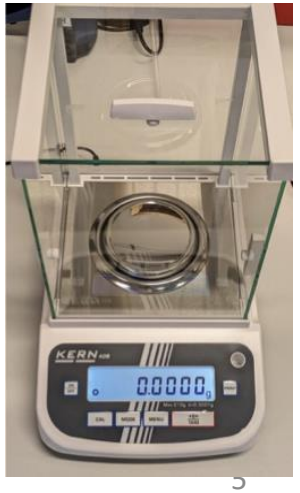




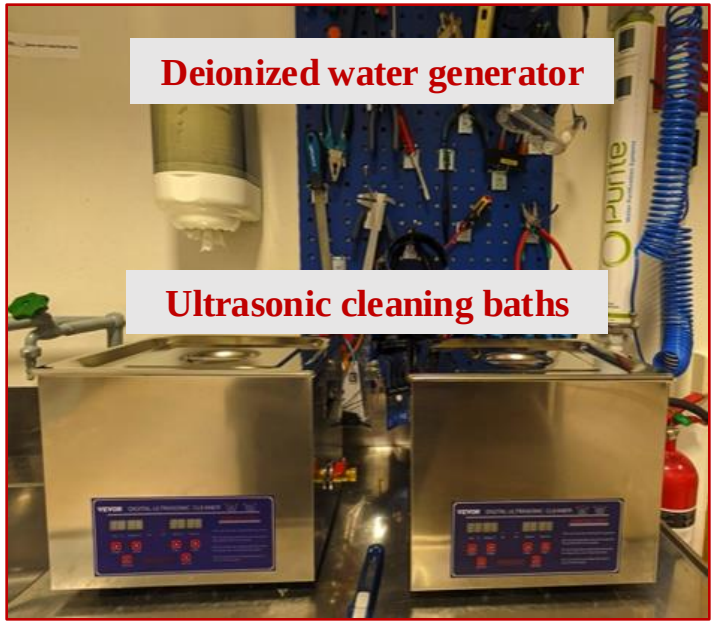


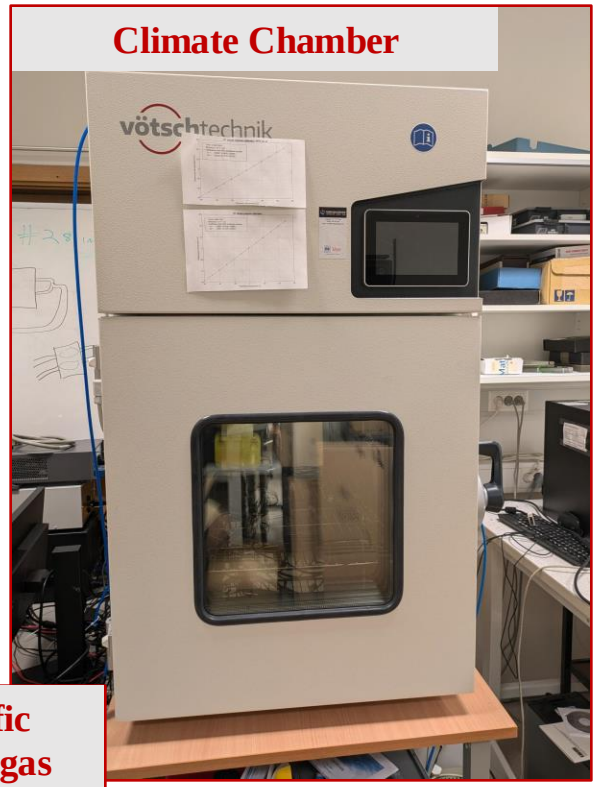




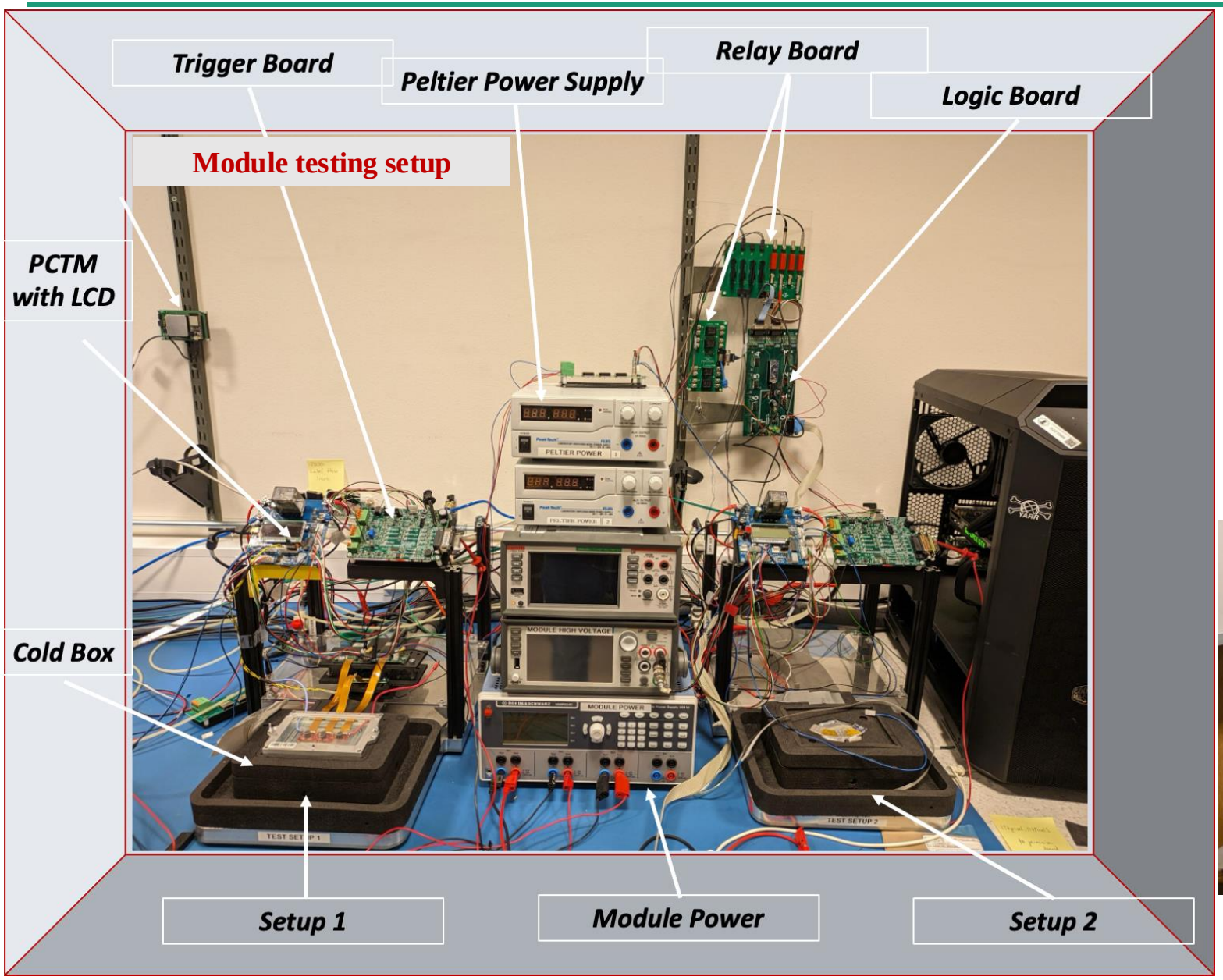


Facilities and Equipment - Detector Lab

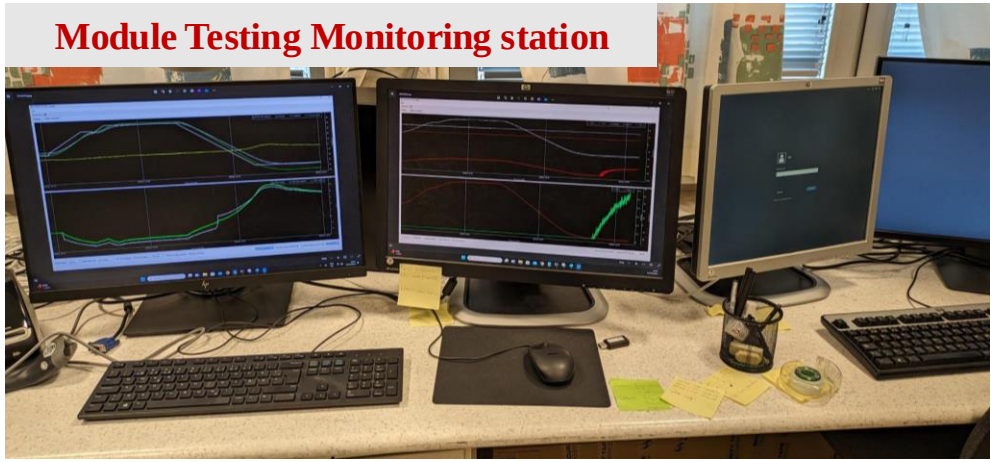




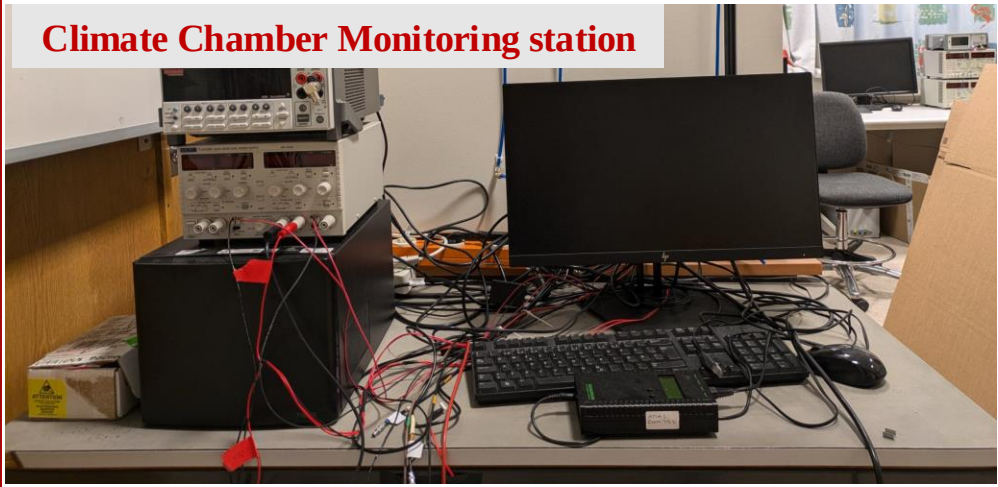
Facilities and Equipment – Detector Lab



Module Testing Monitoring station

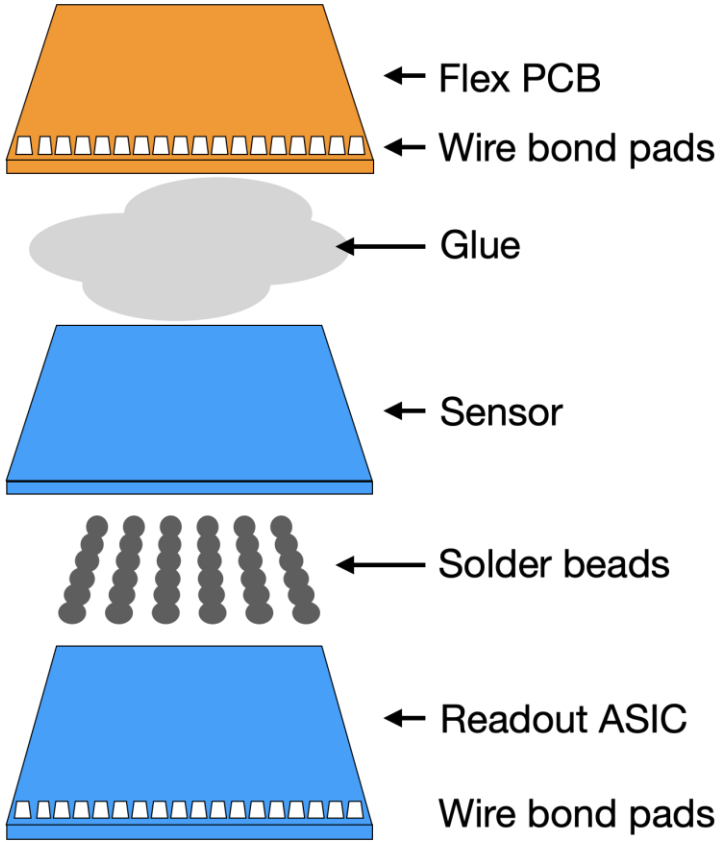


Climate Chamber Monitoring station

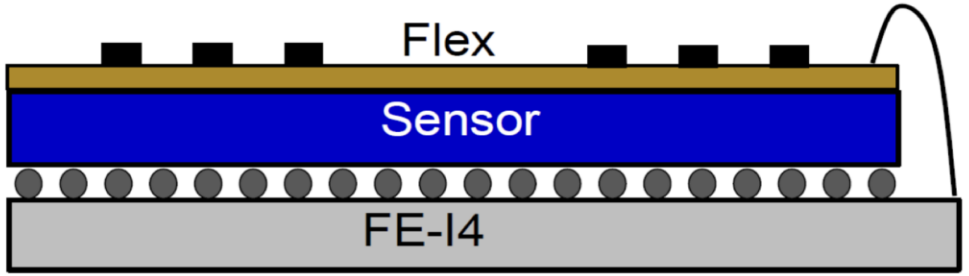


Bergen ITk Commitments and Activities

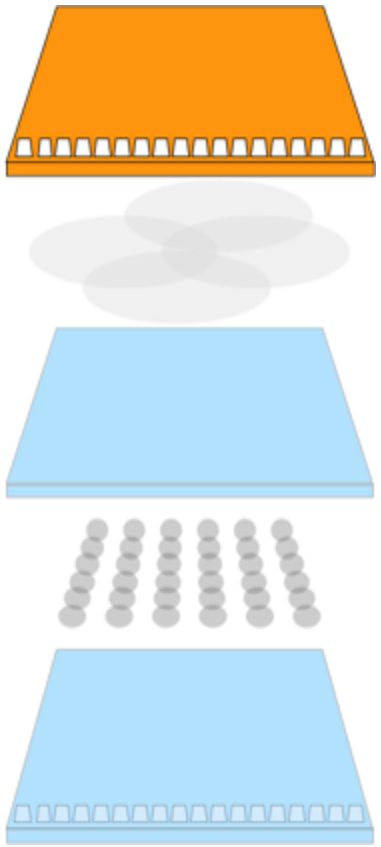
Exploded stylised view of an ITk module



Styliesed side-on view of an ITk module

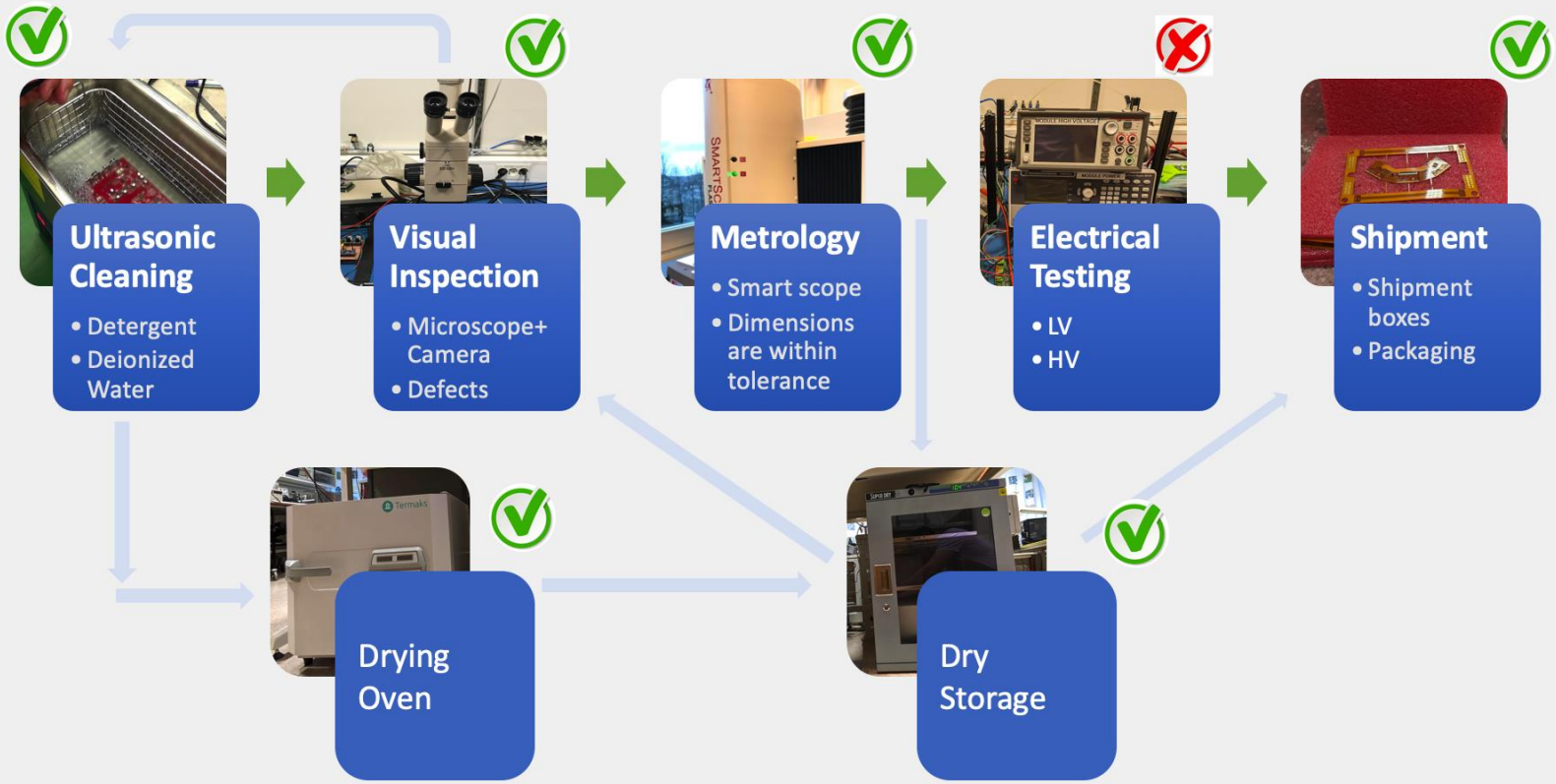


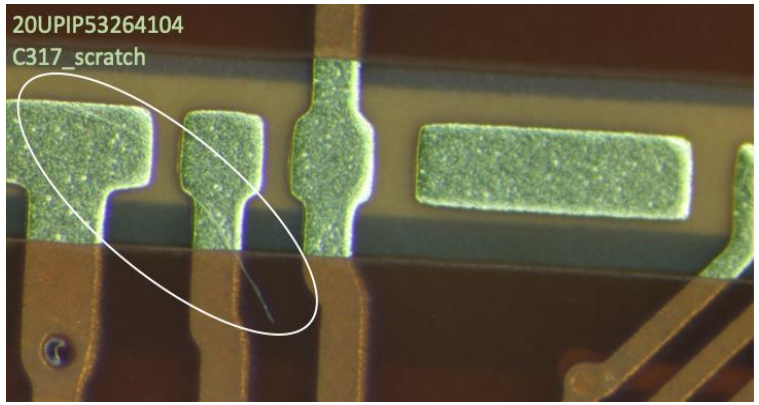
Bergen ITk Commitments and Activities - Loaded Flex Reception

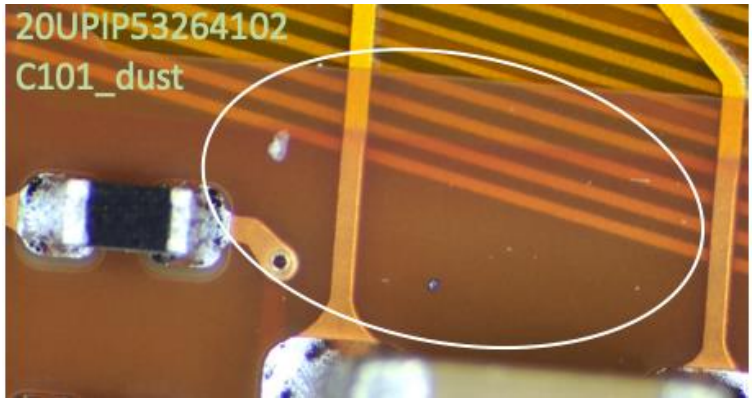


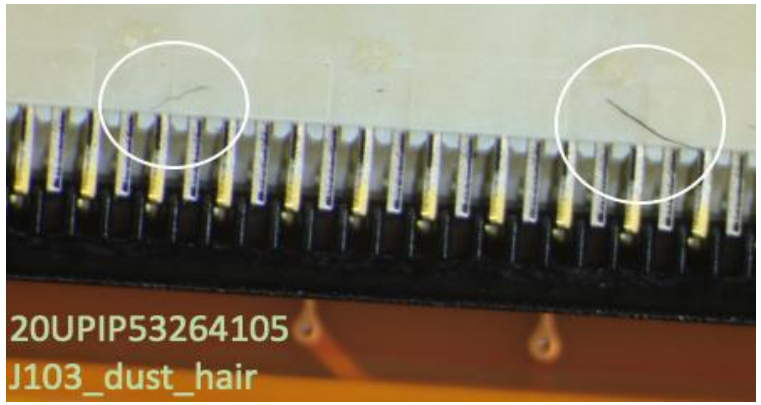
- Flex PCBs for all triplet module flavours designed by the Oslo group.
- We are qualifying for reception test of loaded flexes.
  - Cleaning
  - Visual inspection
  - Metrology
  - Electrical tests
  - Registration in the production database

Flex QA/QC







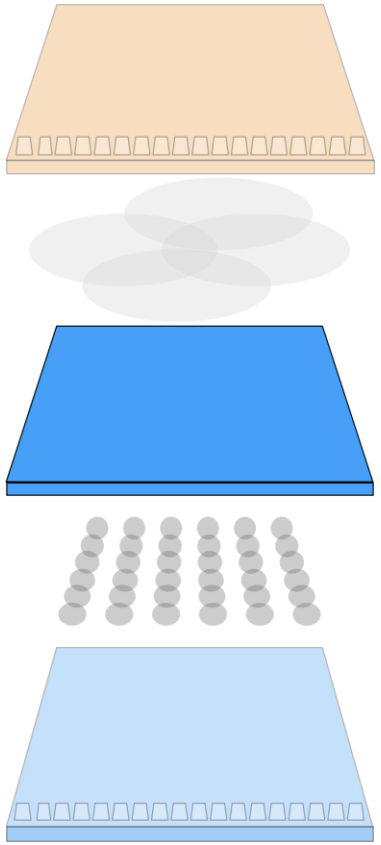


- **Received:** 20 linear + 20 Ring 0.5 (pre-prod)
- **In Stock:** 15 linear + 15 Ring 0.5
- **Shipped:** 5 linear + 5 Ring 0.5 (to oslo)

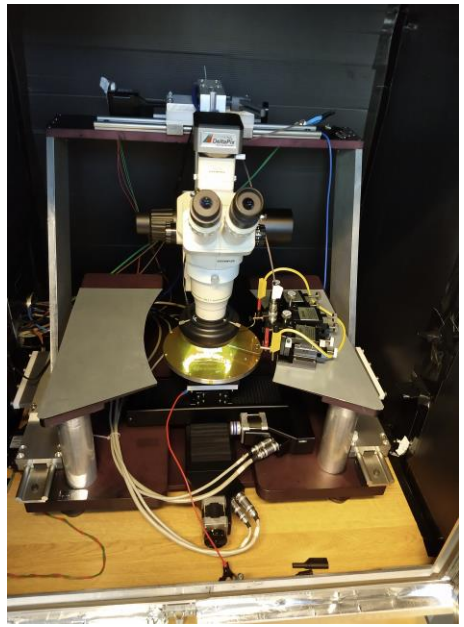
- All instock flexes have been visually inspected, waiting for metrology.
- No electrical testing setup so far.

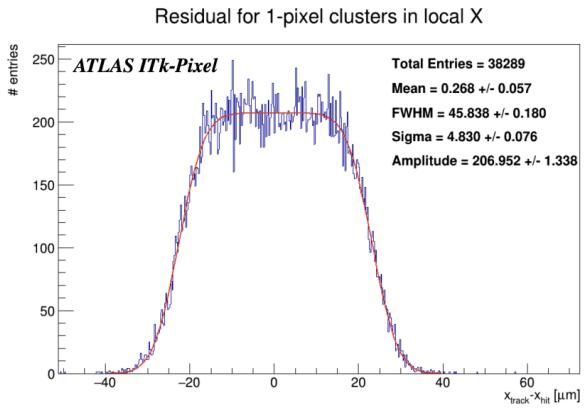
Simen Hellesund

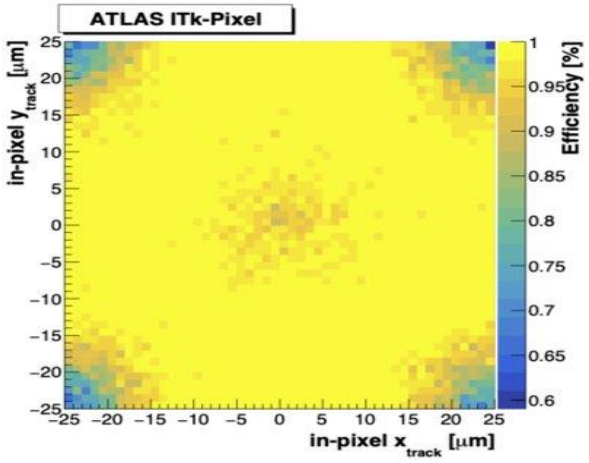
Bergen ITk Commitments and Activities - Sensors

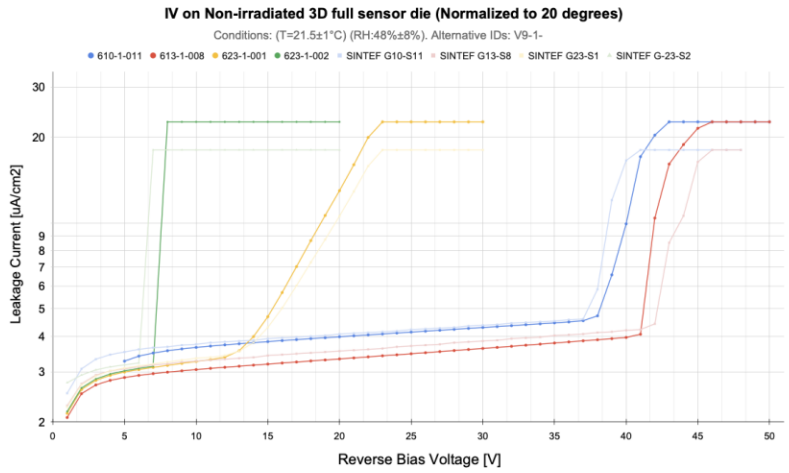


- The Bergen group are contributing to the testing of SINTEF 3D pixel sensors
- We can do sensor IV and CV measurements with our probe station setup.
- We are involved in ITk test beams. (poster with test beam results from 2023)
- Currently contributing to a paper on the latest production run of SINTEF sensors.

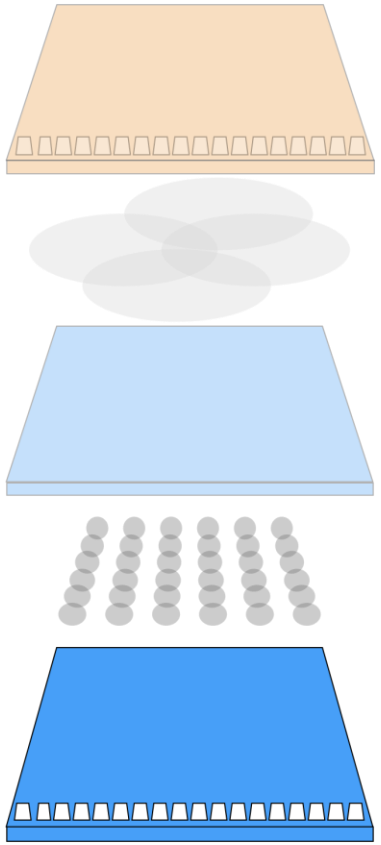




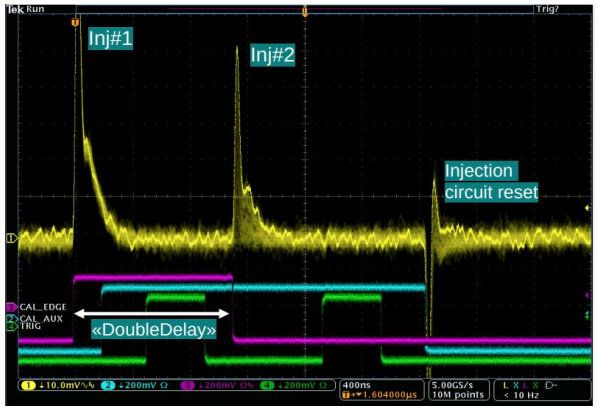


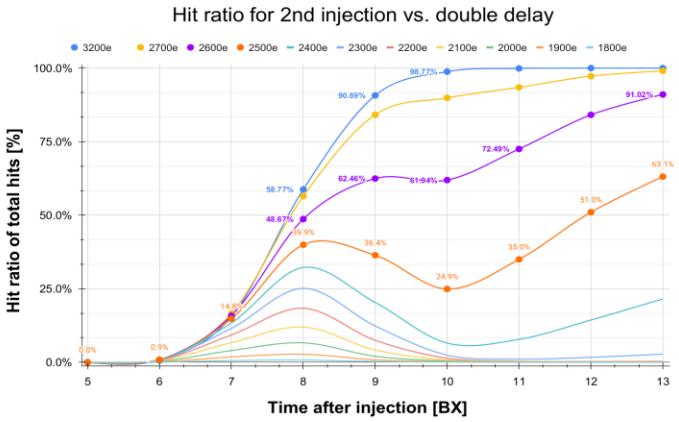


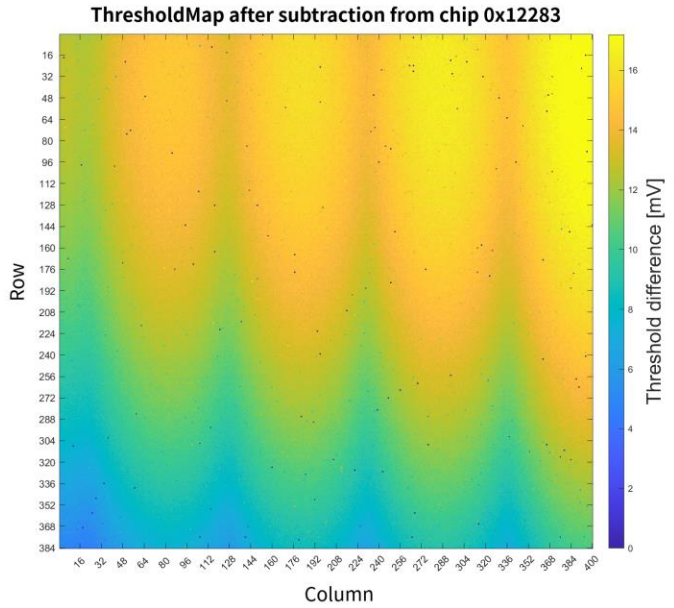
Bergen ITk Commitments and Activities - Readout Electronics



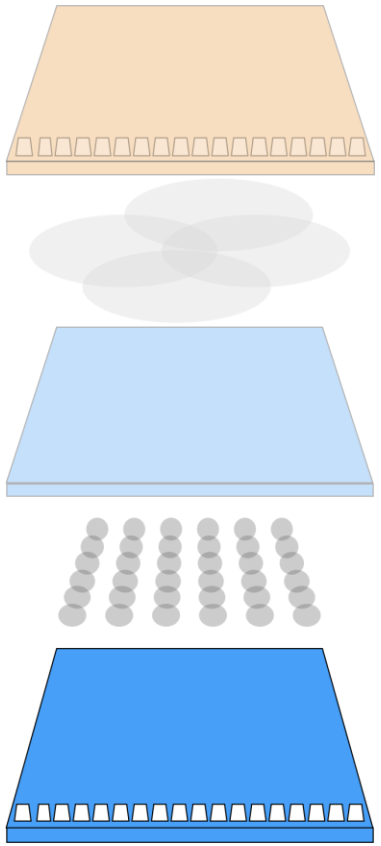
- Our engineer Attiq has contributed to simulations and performance verification of the RD53 chip and of calculation of the data read-out rates of the ITk Pixel detector (link).
- Simon has studied the efficiency of consecutive hits with small separation in time.
  - Also mapped local ground variation in the chip.



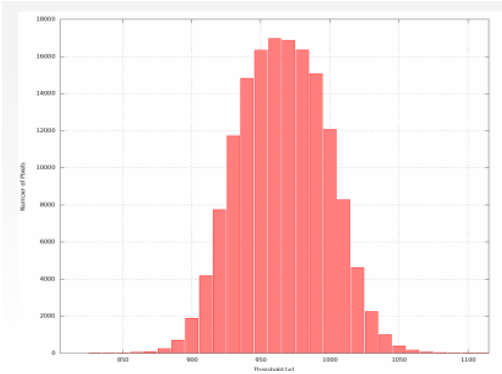


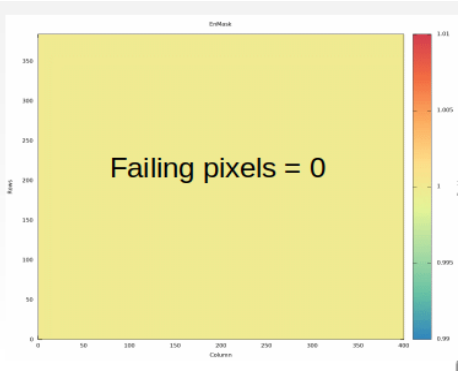


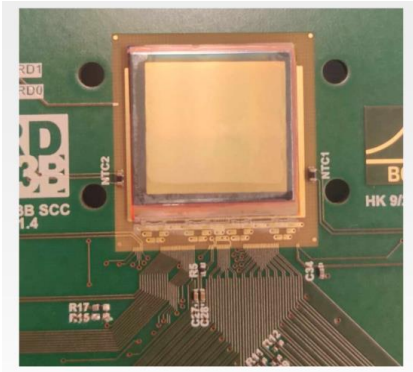
Bergen ITk Commitments and Activities - Readout Electronics



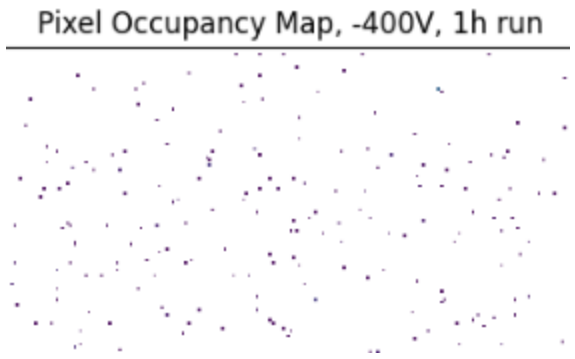
- Simon recently came back from a research stay at Berkeley.
- He worked on how to improve ITkPix chip tuning to reduce the number of dead pixels.
- He also studied the possibility of making a pixel detector by coating an ITkPix readout chip with a thin film of selenium.



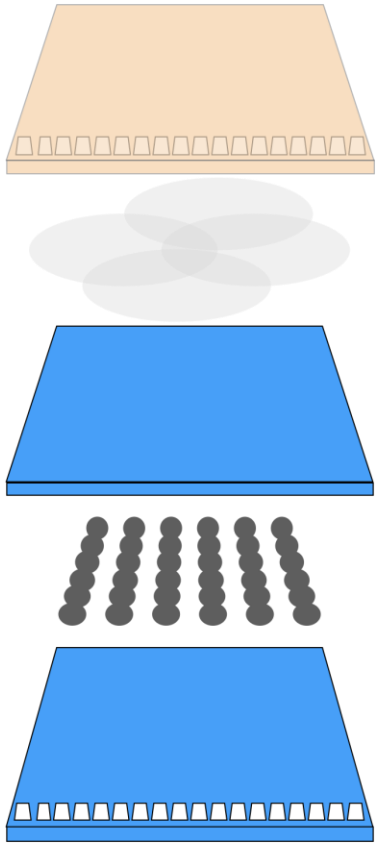




Selenium-coated ITkPixV1



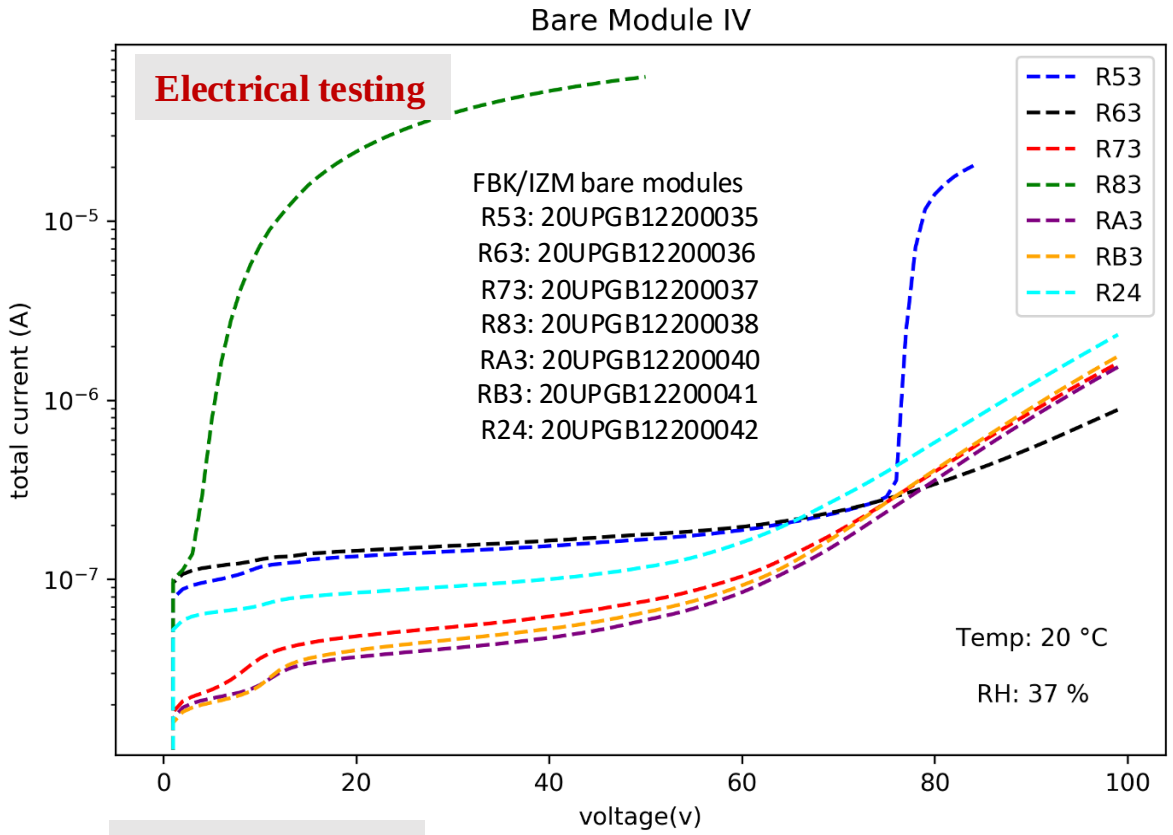
Bergen ITk Commitments and Activities - Bare Modules



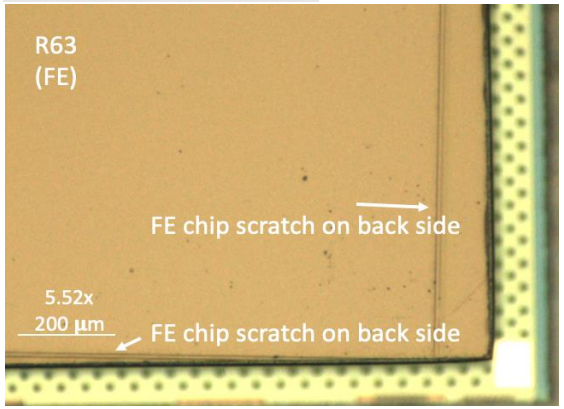
- For his qualification tast, Sohaib developed fast feedback test procedure for bare modules.
- Bergen is qualified for bare module reception.
  - Can receive bare modules here for testing before shipping to Oslo for assembly.

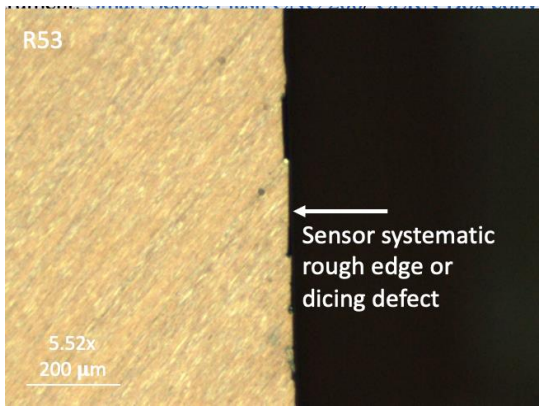
Bare Modules QA/QC

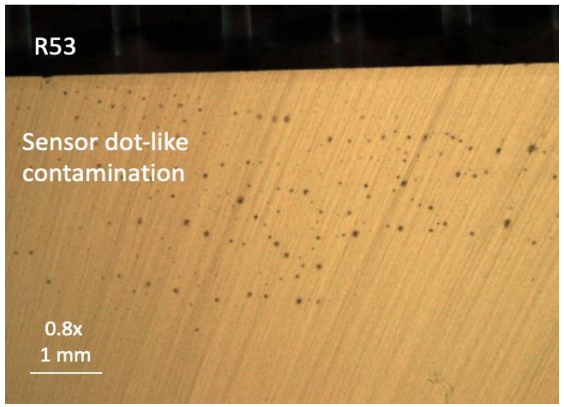
Electrical testing

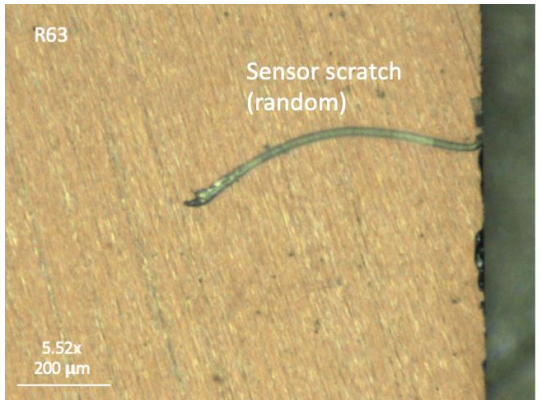


Visual inspection





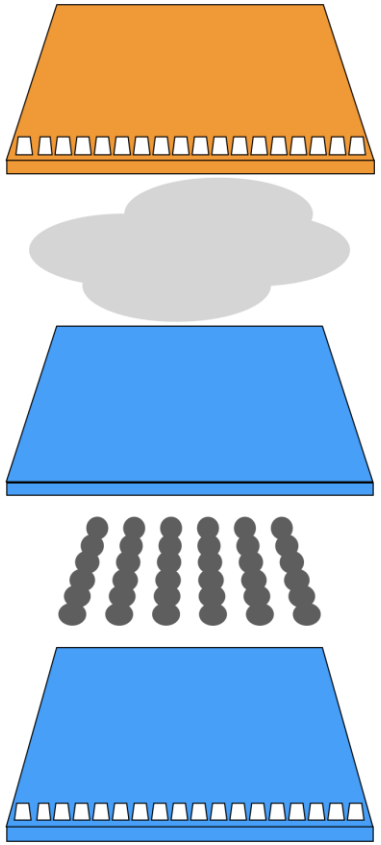




Metrology

BM Sr. No	Sensor Width Max (1a, 1b) [mm]	Sensor Height Max (2a, 2b) [mm]	BM Height Max (3a, 3b) [mm]	FM to FE Edge 4a/4b [mm]	FM to Sens. Edge 5a/5b [mm]	Avg. BM Thickness (std.) [mm]	Avg. FE Thickness (std.) [mm]
R53: 20UPGB12200035	20.3616	19.5593	21.1829	0.1079/0.1079	0.1149/0.1314	0.4225 (0.0033)	0.1564 (0.0007)
R63: 20UPGB12200036	20.3624	19.5587	21.1818	0.1083/0.1113	0.1158/0.1273	0.4266 (0.0058)	0.1633 (0.0064)

Bergen ITk Commitments and Activities - Module QC

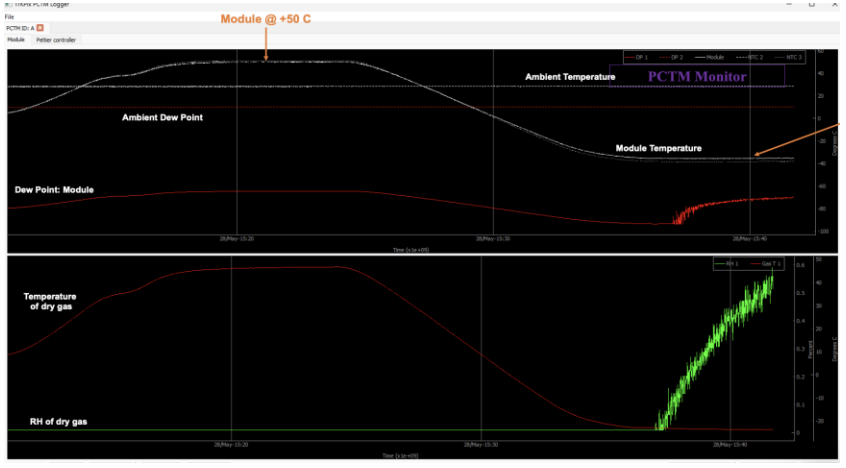


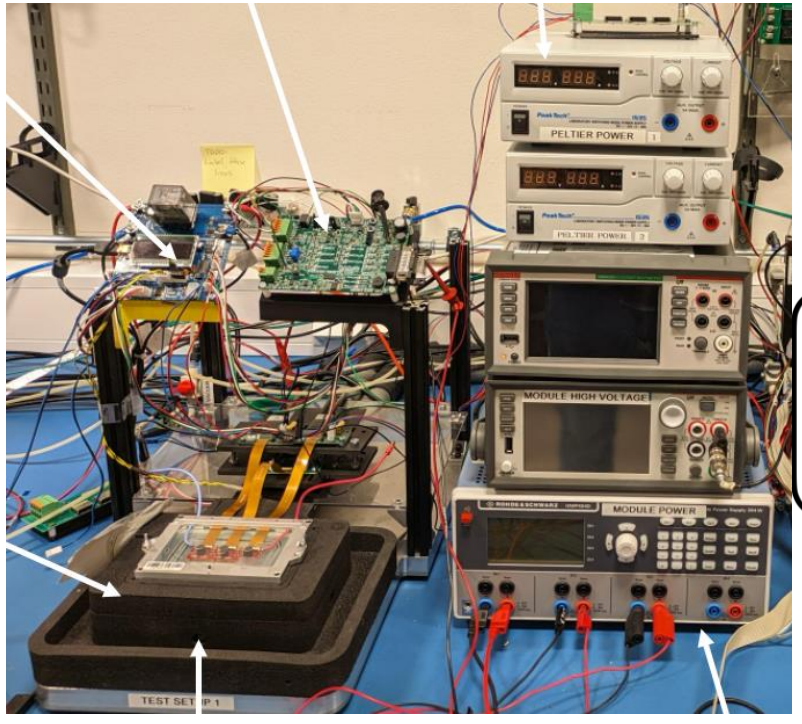
- One of the main Bergen contributions to the ITk is in the form of module QC.
- Oslo will assemble Ring 0 triplet modules and ship them to Bergen to undergo full QC:
  - Thermal cycling
  - Electrical tests
  - Source testing
  - Stability test

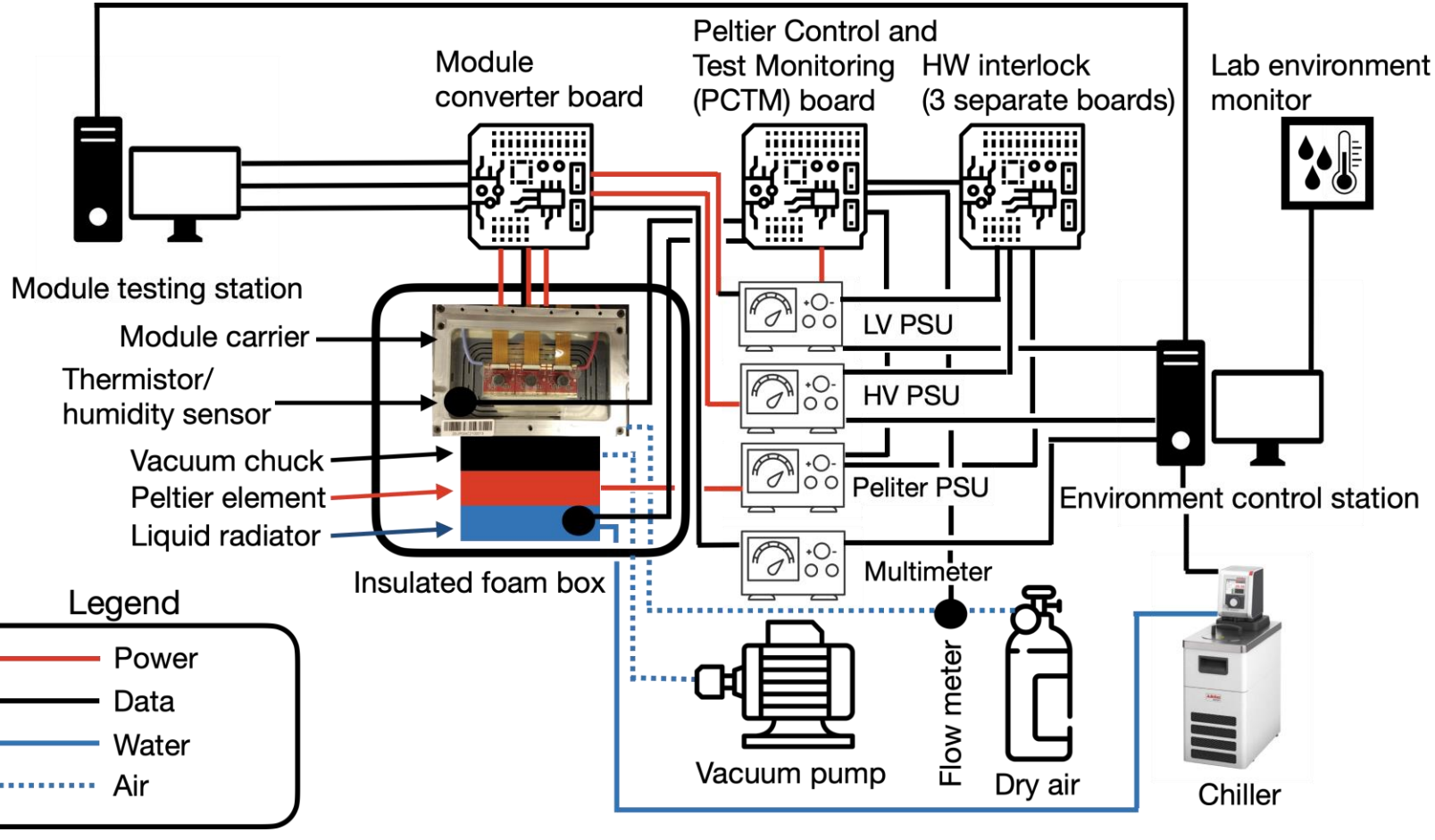
- We have two test beds for cold tests, thermal cycling and source testing, one working (but currently set up for linear triplets) and one under construction for Ring 0 modules.
  - Thermoelectric/liquid cooling.
  - Monitor module and air temperature and humidity, dry air flow, and vacuum pressure (in progress).
  - Software and hardware (in progress) interlock to shut down power supply and peliter power when temperature or humidity falls outside of allowed range.
  - First qualification of the setup has been submitted (step 10.1), working hard on the rest.

- If one module takes 2 day to fully test, then with two test beds we will have a testing capacity of 5 modules per working week.

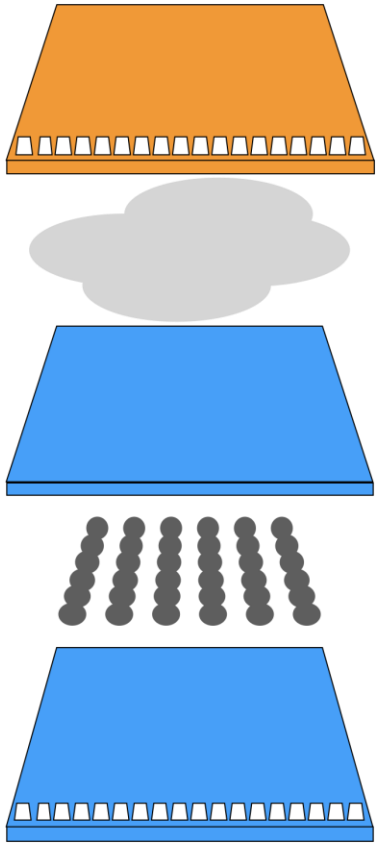
Bergen ITk Commitments and Activities - Module QC







Bergen ITk Commitments and Activities - Module Shipment

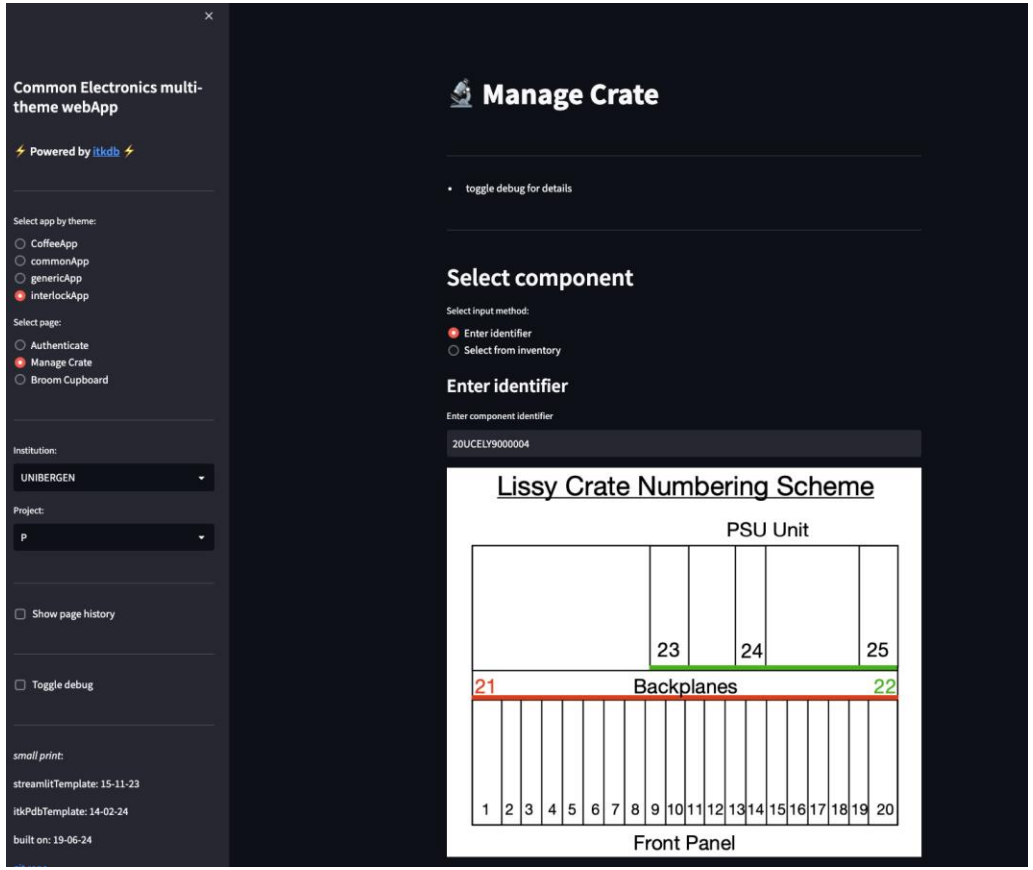


- We have developed and qualified a shipping solution for triplet modules.
- Joint order for triplet shipping insert foam. Has been distributed to triplet sites.
- Crates will be reused.
  - Tracked in the production database

Bergen ITk Commitments and Activities - Production Database

- Involved in the development and maintenance of the ITk production database.
- Define database objects for ITk interlock crates.
- Create a webapp for the common electronics project, based on the pixel and strips webapps developed by Kenny Wraight.

Name	Interlock Module
Code	INTERLOCKMODULE
Description	A database object for modules of the Lissy and MIC crates of the ITk interlock.
Id	6628d12d2ab1c10035cd99a3
Category	Assembly
Project	Common electronics
Subproject	
State	ACTIVE
ATLAS Serial Number	Automatic
SN Assigned Later	No
SN Component Identifier	LM
Child registration	No



Qualification Progress

block	sub-block name	Sub-block number	Database Code	Qualification documer	Bergen Statu	Comment
1 Lab Infrastructure						
	1.1	Lab rooms + services	LAB_ROOM		Done	
	1.2	ASIC Compliance & Handling	LAB_ASIC		Done	
	1.3	Storage of Bare Module, Module PCB and assemble	LAB_STORAGE		Done	
	1.4	Shipping	LAB_SHIP		Done	
	1.5	Production Rate Planning	LAB_PRO		Done	?
2 Database						
	2.1	ITkPD account and necessary privileges	DB_ACC		Done	
	2.2	Setting up InfluxDB+Grafana and Local Database+it	DB_SETUP		Done	
	2.3	Setting up QC Helper/WebApps for non-DAQ data	DB_HELP		Done	
	2.4	Input format validation for non-DAQ data	DB_NON		Done	
3 Flex						
	3.3	Metrology	FLEX_MET			OBS!
	3.4	Visual inspection on populated flexes	FLEX_VIPOP			OBS!
	3.5	LV/HV test	FLEX_LVHV	AT2-IP-AP-0018 v.1		
8 Reception of Triplet components						
	8.1	Instruments for metrology and reception	TREC_INST		Done	
	8.6	Metrology & mass of bare module	TREC_BMMM		Done	
	8.7	Visual inspection of bare module	TREC_BMVI		Done	
	8.8	Bare module Electrical test	TREC_BMET		Done	
10 Testing Setup				AT2-IP-QA-0024		
	10.1	Cold testing setup	TEST_COLD	AT2-IP-QA-0037 v.1	Submitted	
	10.2	Thermal cycling	TEST_TC	AT2-IP-QC-0019 v.1		
	10.3	Interlocks	TEST_INT	AT2-IP-QA-0031 v.1		
	10.4	DCS	TEST_DCS	AT2-IP-QC-0017 v.1		
	10.5	Testing Parallelization Setups	TEST_PAR	AT2-IP-QC-0020 v.1		
	10.6	Stability Test	TEST_STAB	AT2-IP-QA-0054 v.1		
	10.7	Source or x-ray test setup	TEST_XRAY	AT2-IP-QA-0052 v.1		
	10.8	Room temperature test setup (Digital)	TEST_RT	AT2-IP-QA-0042 v.1		
	10.9	Quad & Triplet Complementary stage	TEST_TQ			?
11 Digital Module tests						
	11.1	First power-up	DIG_1PU	AT2-IP-QA-0025 v.1	Done	
	11.2	Minimal tests	DIG_MIN		Done	
	11.3	Simple scans	DIG_SIMP		Done	
	11.4	Advanced scans	DIG_ADV		Done	
	11.6	Quad & Triplet Complementary stage	DIG_TQ			?
12 Full QC						
	12	Reception test for testing sites	FULL_RREC			
	12.1	Temperature controlled testing	FULL_TCT			
	12.2	Disconnected bump tests (source, crosstalk, no-bias	FULL_DIS			
	12.3	Thermal cycling	FULL_TC			
	12.4	Long-term stability test	FULL_LONG			
	12.5	Full QC on 1 module	FULL_QC1			
	12.6	Full QC on 5 quads/3 triplets in total	FULL_QC5			
	12.7	Full QC data merging	FULL_QCP			
	12.8	Quad & Triplet Complementary stage	FULL_TQ			?
	12.9	Swapping module	DIG_SWAP			

- Qualification material collected here: https://cernbox.cern.ch/s/mIvdGm0FLX11Dai

Summary

- The Bergen group is, or has been, involved, at some level, at almost every stage of module production, from sensor die to assembled modules.
- Main contribution as a testing site for (Ring 0) triplet modules, but also contribute to flex and bare module reception, test beams, database work, etc.
- Many qualification steps have been completed. Working hard on the qualification of our test setup and of full module QC.