



ITk pixel module assembly and testing experience



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1. ITk pixel detector

- The pixel detector plays a central role in event reconstruction and momentum measurement in the ATLAS experiment
- New silicon modules to improve tracking, cope with high multiplicity and work in high luminosity environment provided by HL-LHC
- Five barrel and five end-cup layers
- 10.000 modules, approx. 13 m² of pixel detectors
- $|\eta|$ coverage increased from 2.5 to 4
- <https://cds.cern.ch/record/2776651>

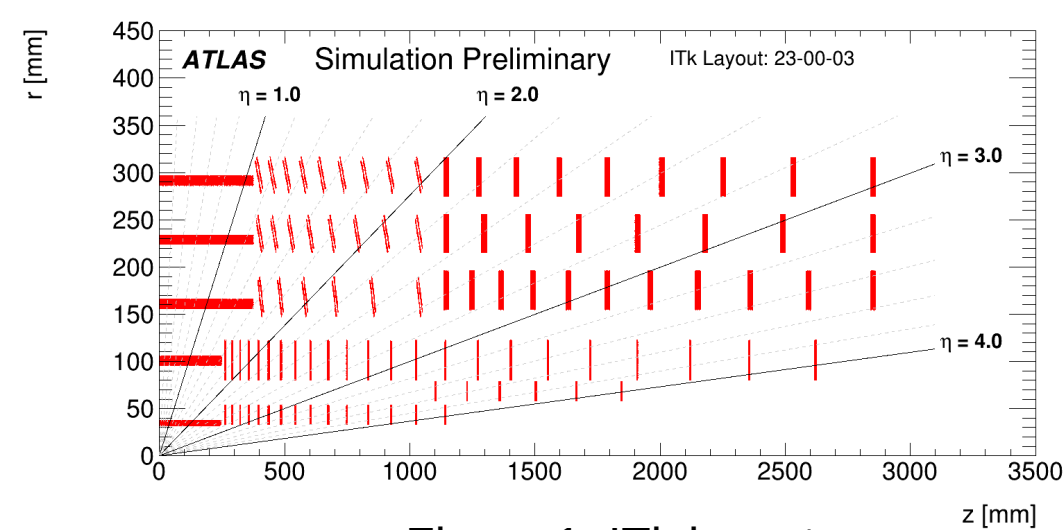


Figure 1: ITk layout

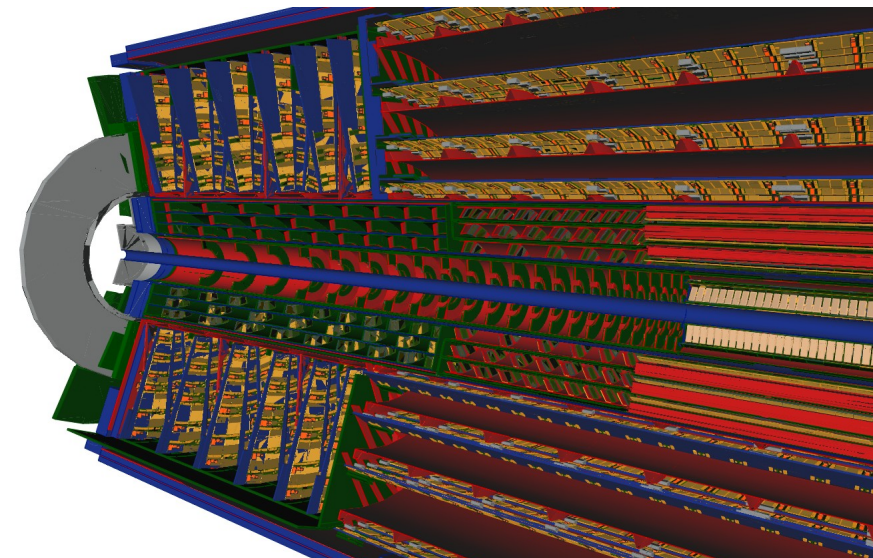


Figure 2: ITk layout, 3D view

2. Pixel module concept

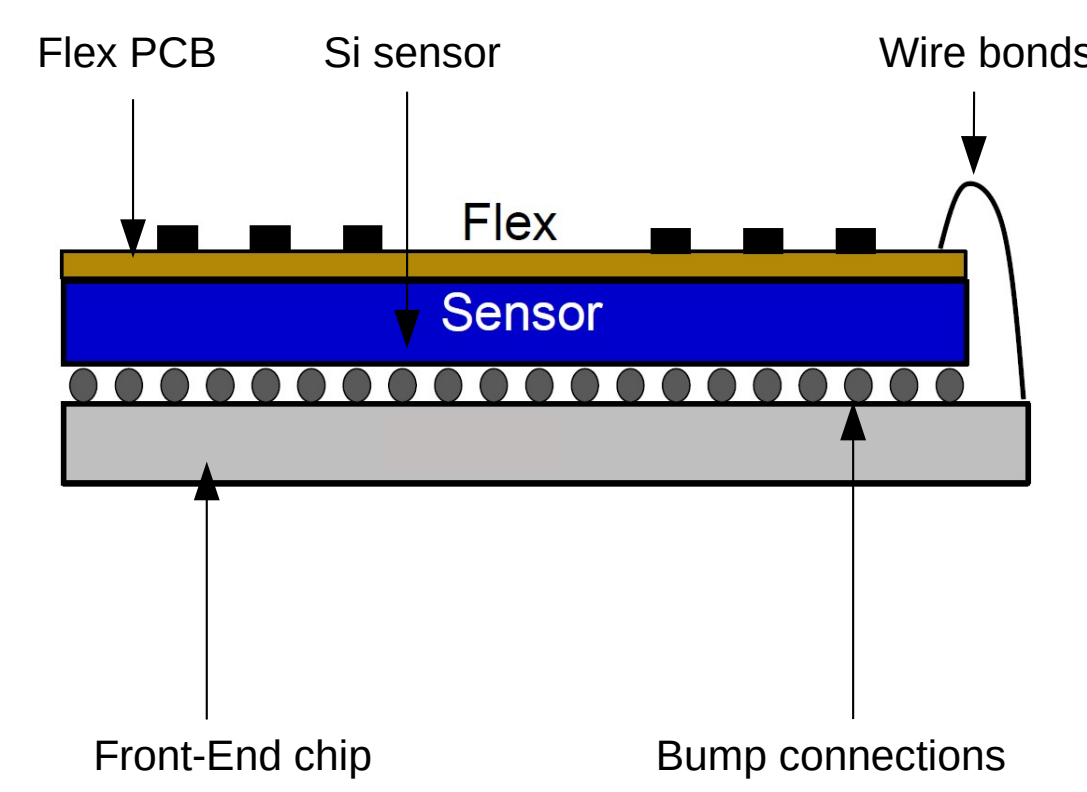


Figure 3: Pixel module illustration

- Basic idea:** common standardized detector modules for all regions of ITk, use specific detachable pigtails in different regions to connect common hybrid and further services
- 0.2 mm flex PCB, three 20 μ m copper layers, 40x40 mm² (rectangular part), routes signal and power lines, provides sensor bias Voltage
- 4 FE chips to record signal
- Small amount of passive components
- High radiation tolerance and reliability
- Cope with high hit rate

3. How to build pixel modules

Module production steps

- Bare module design and production (not in Siegen)
- Flex PCB design
- Flex production in industry
- Soldering of passive components
- Cleaning of the flexes
- Flex attach to the bare module
- Wire bonding of FE chips and flex
- Parylene coating and covering of the wire bonding area
- Readout tests

How to get to module production

- Prove the concept with RD53A modules
- Use the Outer Barrel demonstrator for the serial powering scheme
- Exchange to RD53B modules
- Use the final ITkPix modules for pre-production/production
- <http://rd53.web.cern.ch/>



Figure 4: VI setup



Figure 5: Photo setup

4. Technical details of the module building

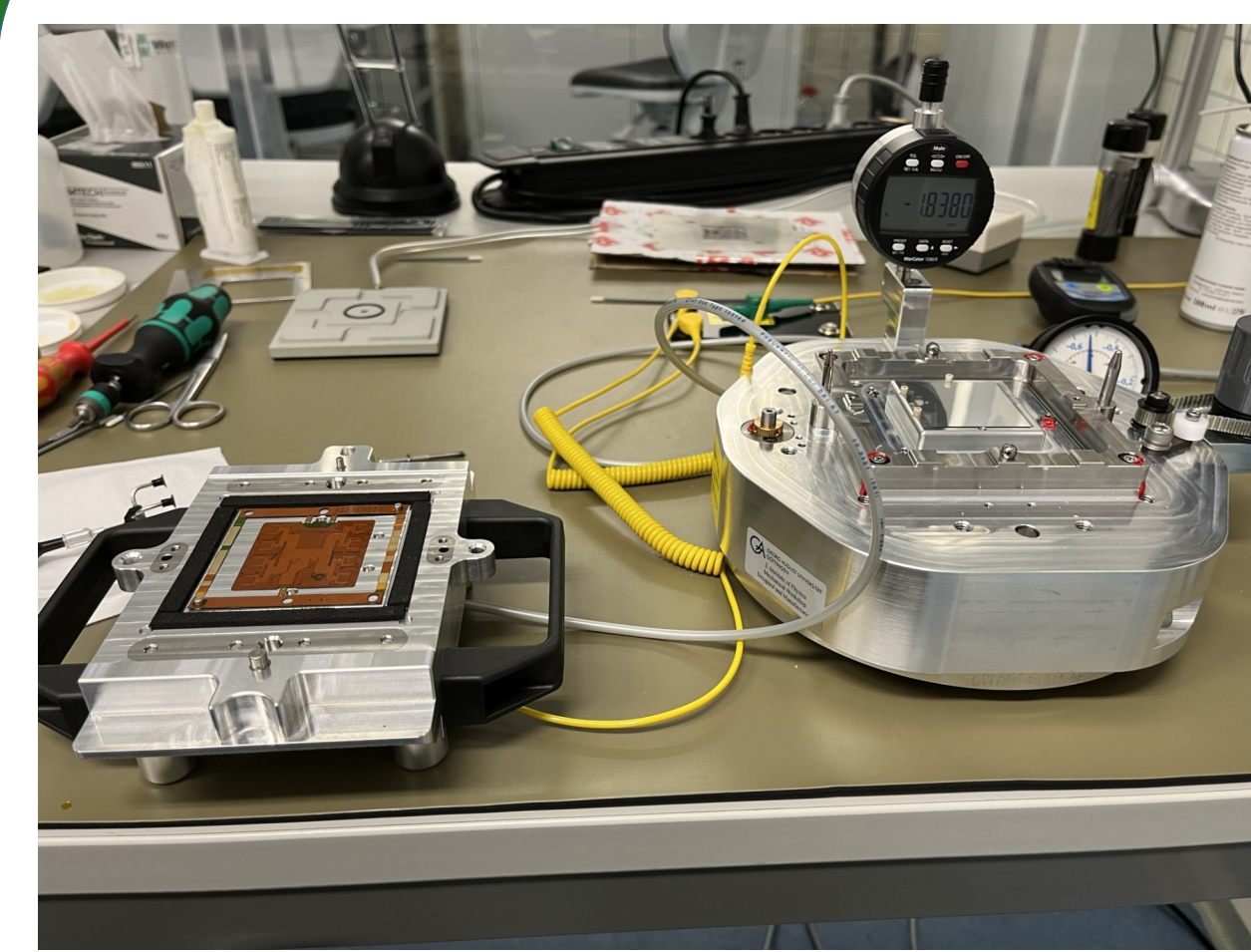


Figure 6: Tooling for RD53B module assembly

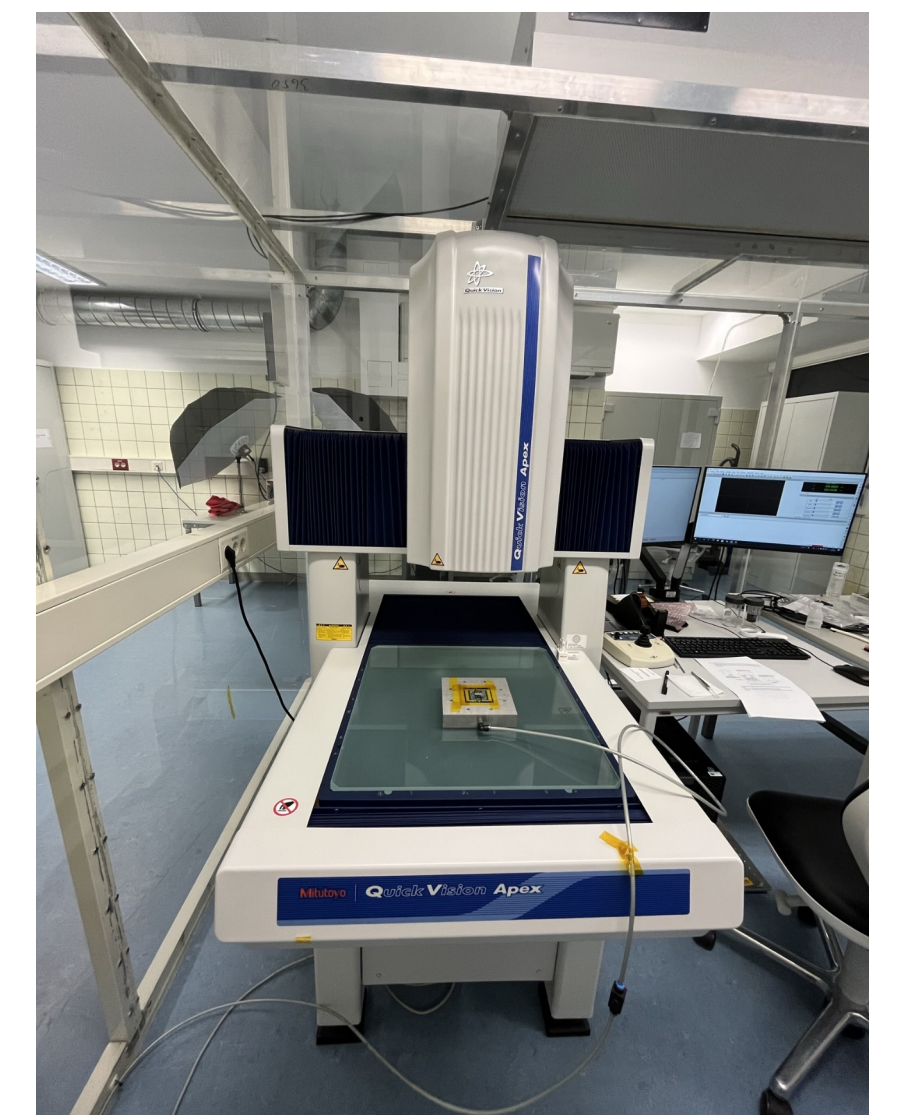


Figure 7: CMM for module metrology

5. Wire bonding of the hybrid

- Automatic wire bonding machine Bondtec 56i with 10 KHz ultrasonic generator
- Manual pull tester LT101 for precise pull test force
- About 800 wire bonds programmed for each module
- 24 wires pulled for testing

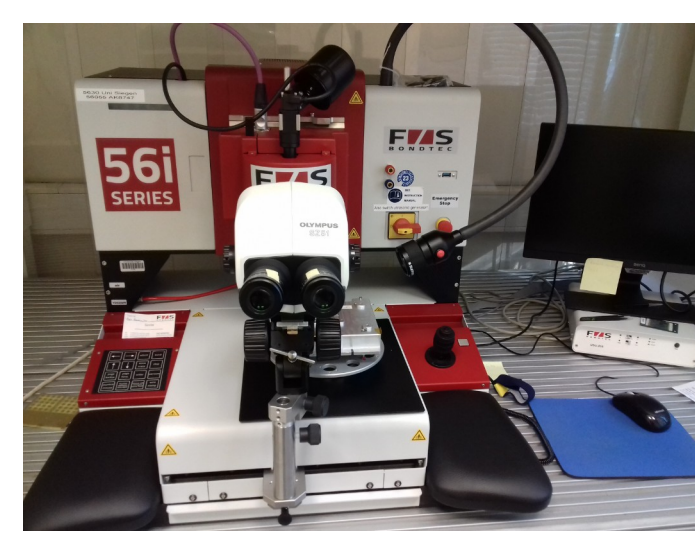
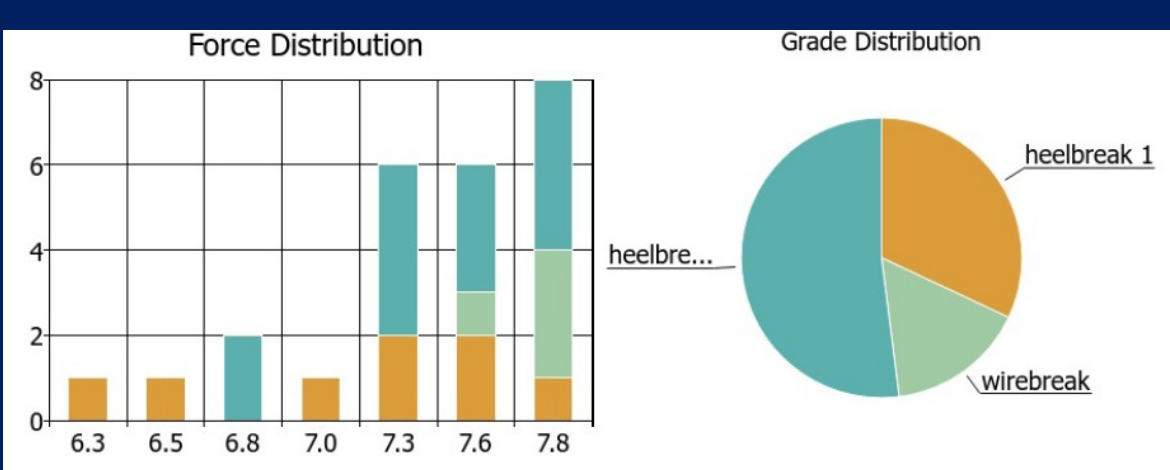


Figure 8: Wire bonding setup

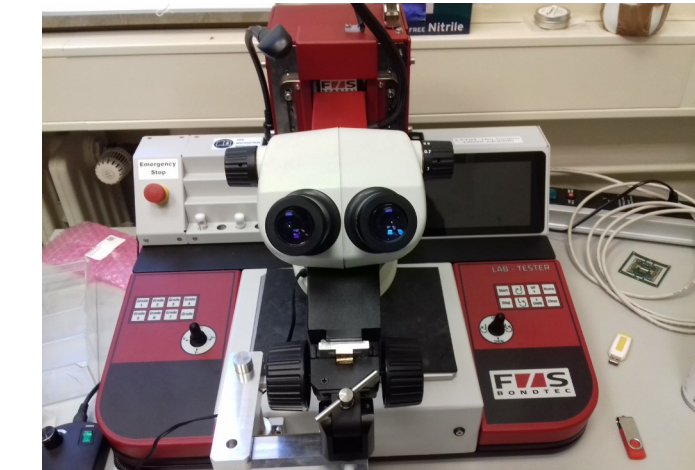


Figure 9: Pull testing machine

6. RD53B digital module testing

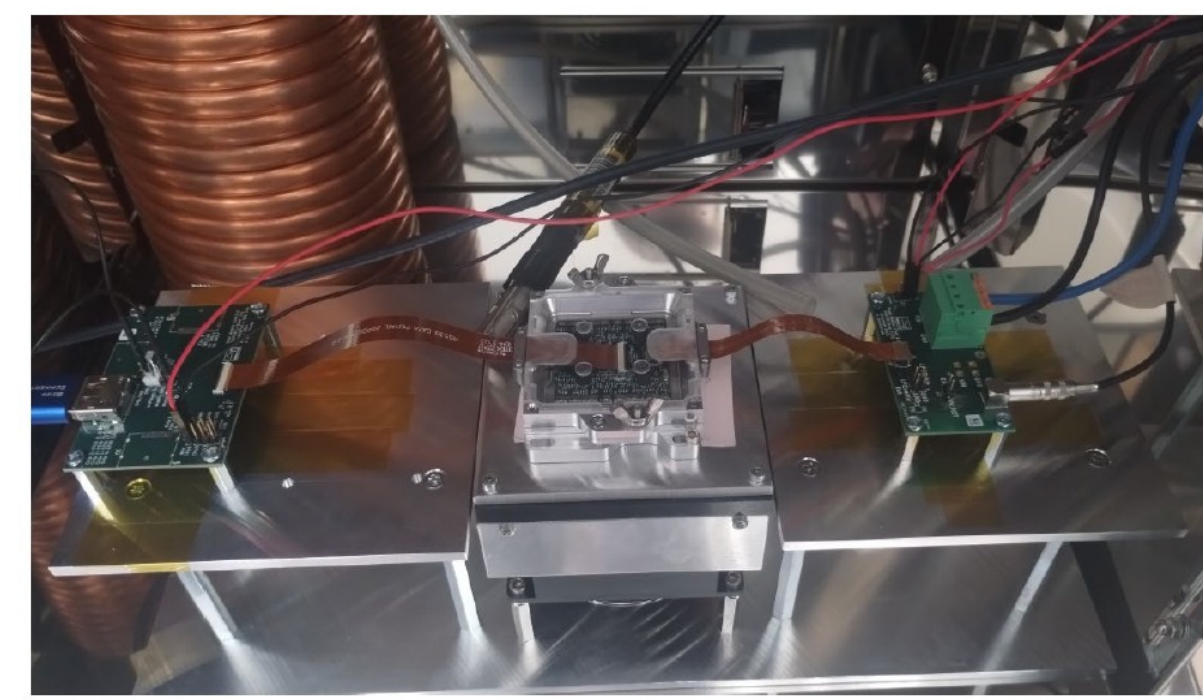


Figure 10: RD53B testing setup in climate chamber

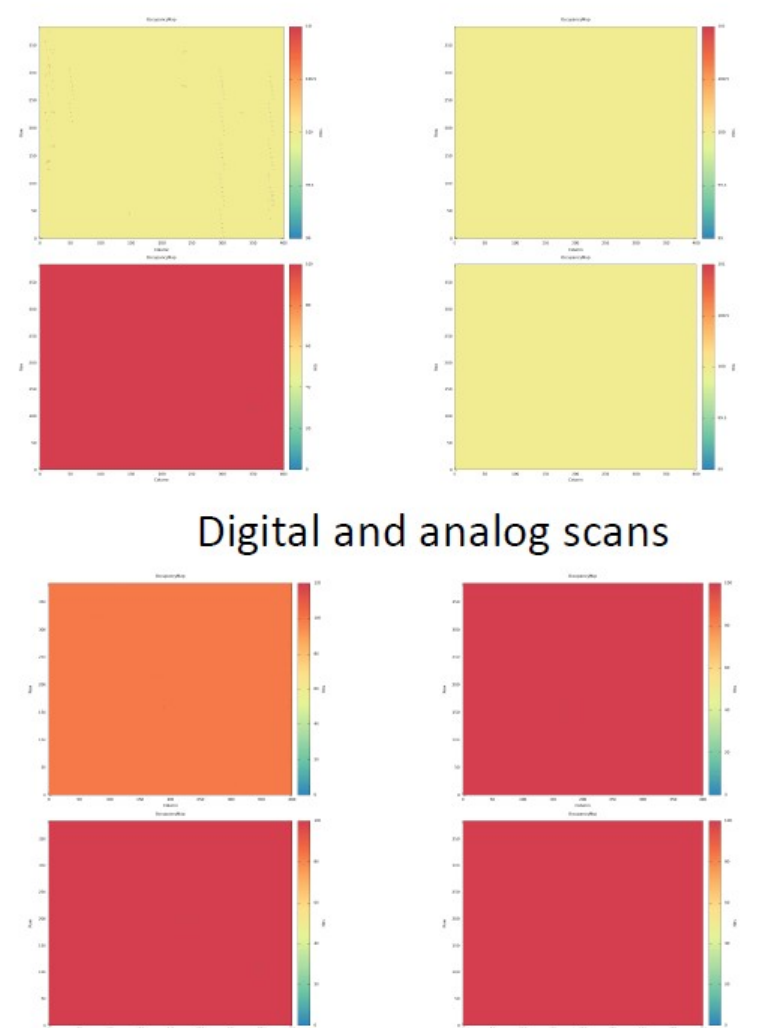


Figure 11: Digital and analog scan results

7. Real RD53B module with sensor

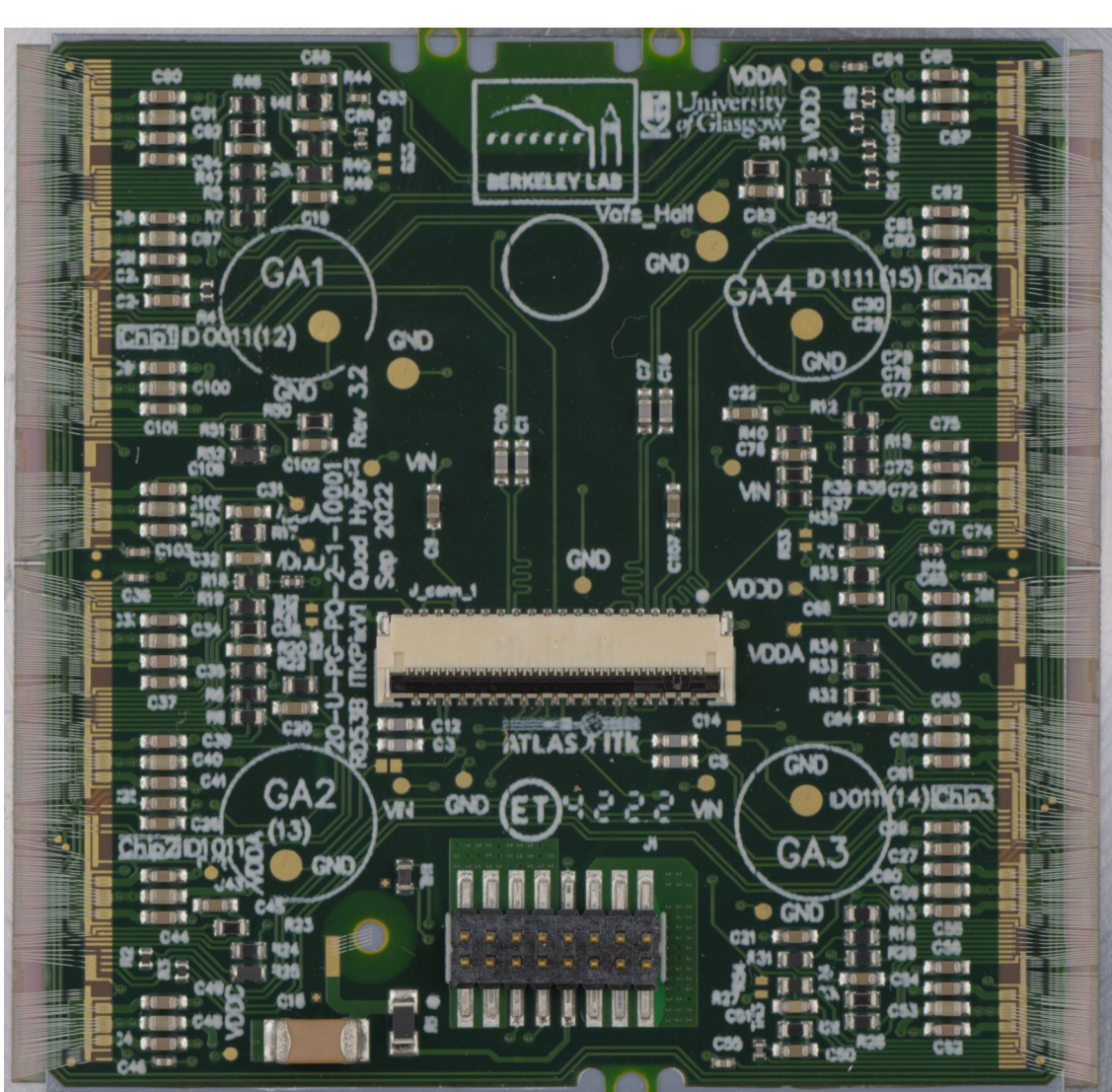


Figure 12: RD53B real module

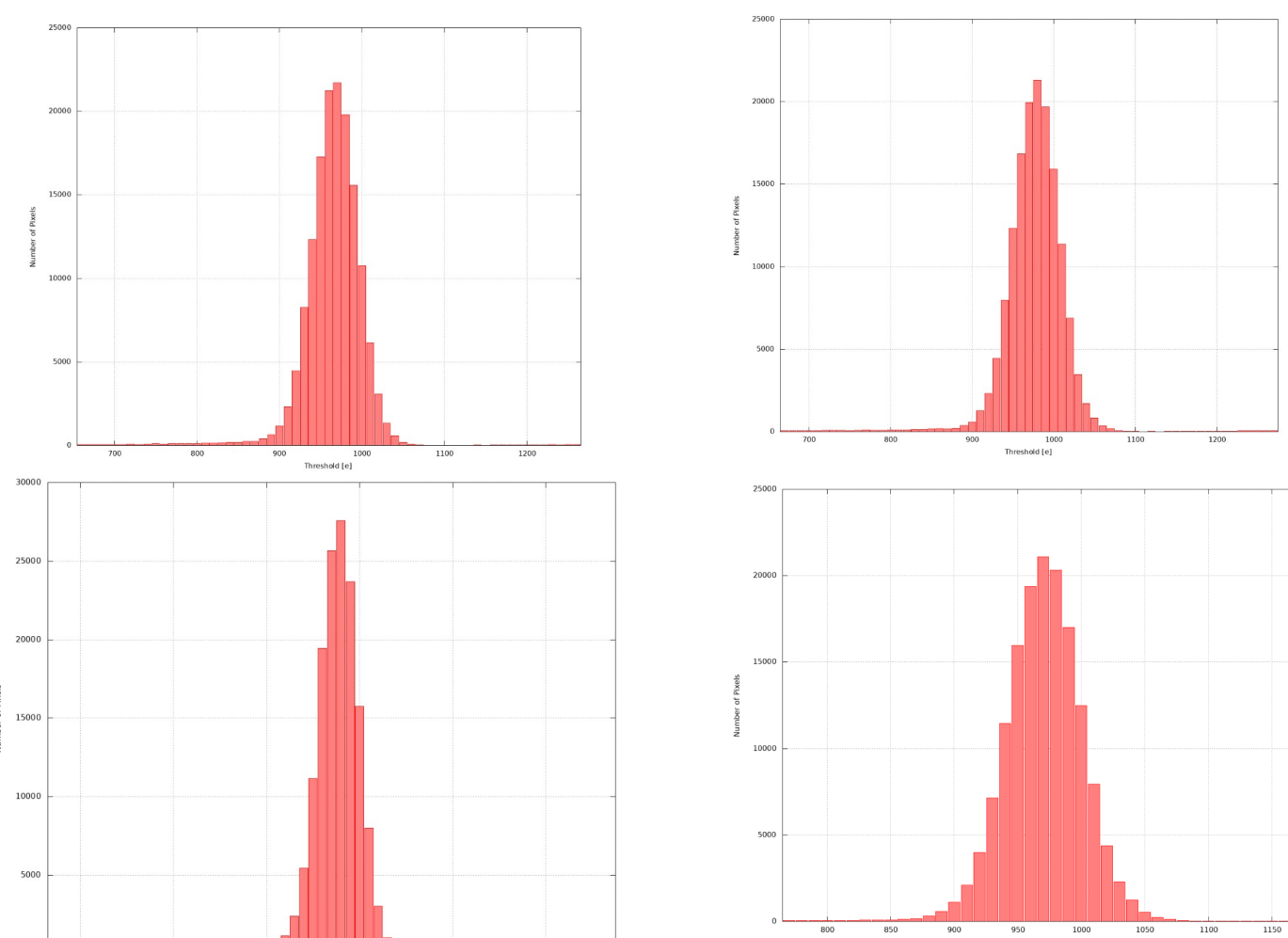


Figure 13: Thresholds after tuning

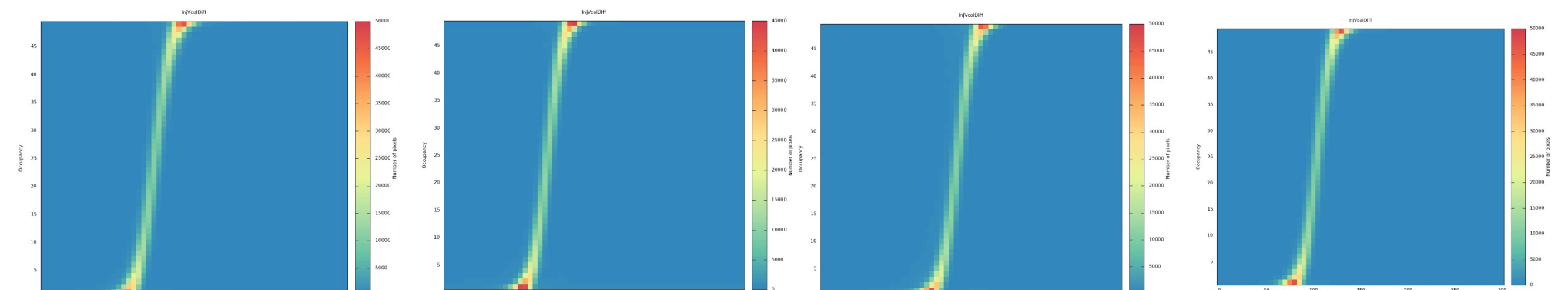


Figure 14: S-curves for the quad module

Summary:

- A lot of experience obtained during the RND phase of the module assembly
- The concept of common RD53A ITk pixel modules was proven by the Outer Barrel demonstrator at CERN
- The pre-production phase is started. Production of the pixel modules will start after the final qualification of the assembly and testing groups.