ATLAS ITk Pixel Module Electrical Quality Control

Emily A. Thompson on behalf of the ITk Pixel module QC developers

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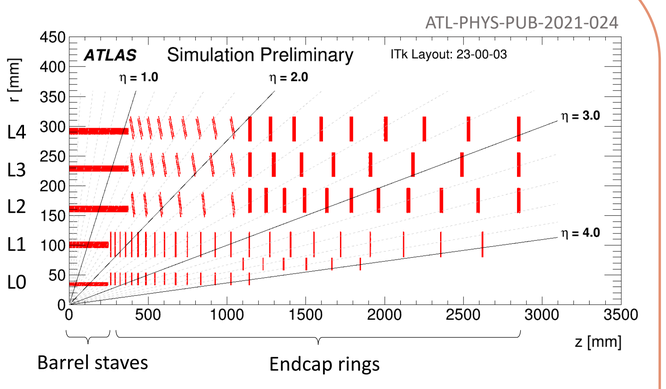
The ATLAS ITk Pixel detector

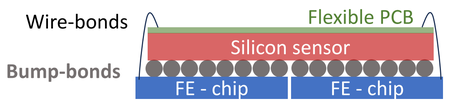
New silicon pixel tracking detector will be installed for High-Luminosity LHC (~2029)

→ 13 m^2 active pixel area

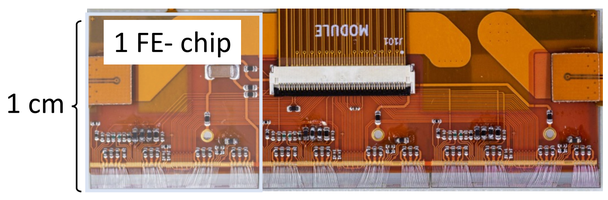
→ other flashy stats



Basic building block: **pixel module**

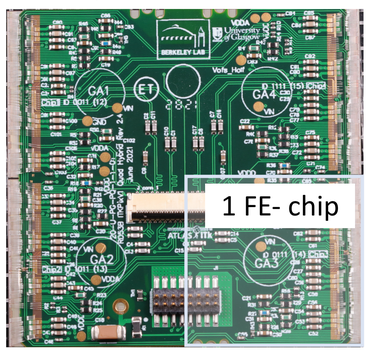


600 “triplet” modules:



250 µm 3D silicon sensor, 50 x 50 µm pixels (barrel: 25 x 100 µm)

8000 “quad” modules:



150 µm planar silicon sensor (L1: 100 µm)

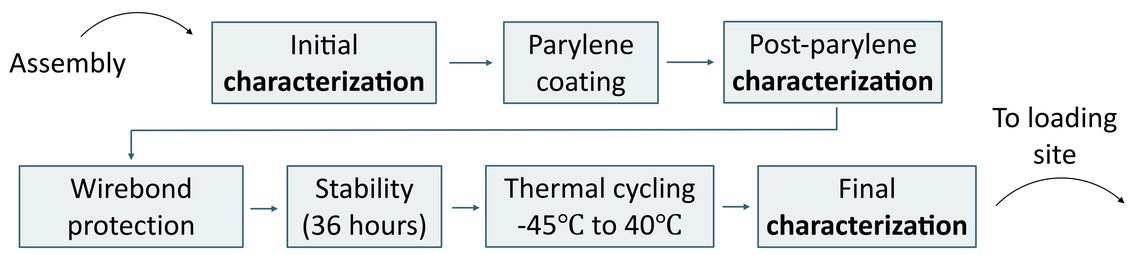
Electrical QC procedure and challenges

Goal of module electrical QC:

1. Remove problematic modules early-on in testing procedure
2. Identify systematic issues in assembly / testing procedure
3. Identify highest performing modules for integration into final detector

Module testing is distributed globally across **25 different sites**

Modules are also tested in **several stages:**



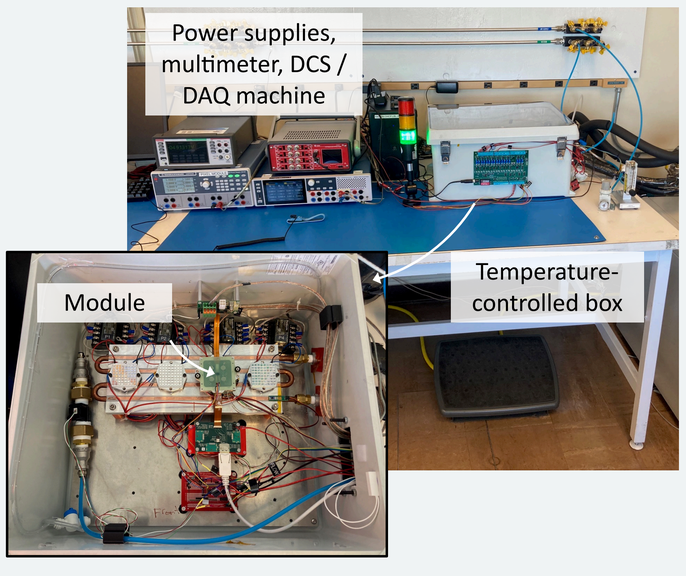
Characterization: Full set of electrical tests at warm (20 °C) and cold (-15°C) temp

All other stages: Minimal set of electrical tests

Ensuring uniformity across testing sites and consistency across testing stages is the major challenge of module QC

Electrical QC software tools and dataflow

Module-QC-■-tools: set of python packages developed for collection and analysis of QC data with minimal requirements (python >= 3.7, YARR DAQ, command-line control of lab equipment)



Module-QC-**Measurement**-Tools

- Records FE-chip internal voltages and currents
- Communicates with lab equipment

Measurement data

Module-QC-**Analysis**-Tools

- Calculates meaningful quantities, performs fits, makes diagnostic plots
- Sets pass/fail status of each FE-chip

Local DB

- Intermediate aggregation place of QC data
- Web-application viewer and GUI for management of QC data

Module history

Electrical-QC summary

Production database

Global data aggregation

Module info

Module-QC-**Database**-Tools

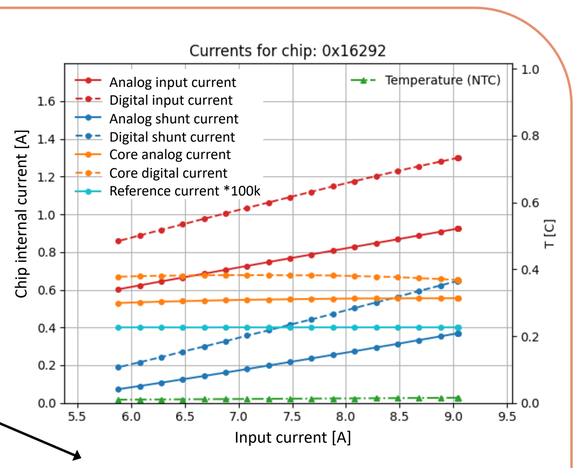
- Queries Local DB for module info from previous stage
- For first testing stage, produces module info from wafer-probing data store on Prod. DB

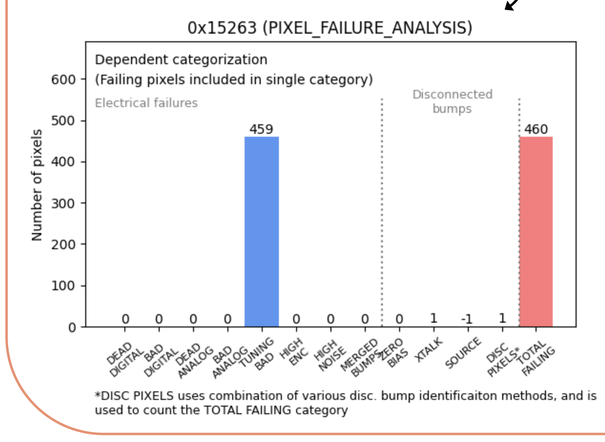
QC data
Module info
User action
Automated

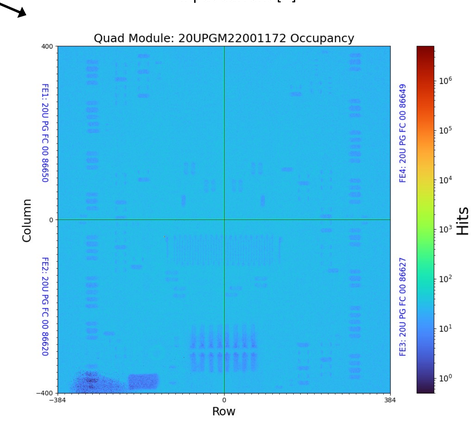
Electrical QC tests

Module QC tests the electrical functionality of each FE-chip on a module

- Calibration of charge injection, internal ADCs
- Shunt-LDO powering scheme and built-in protections
- Performance of pixels and connectivity of bump-bonds







Status & future work

Parallelization
Automation
Tools to analyze QC data – across modules and stages

- Full set of QC tests for single stage: X hours
- Limited mostly by measurement time
- Full QC procedure for single module, all stages: X hours
- Foresee to store 32TB of electrical testing data