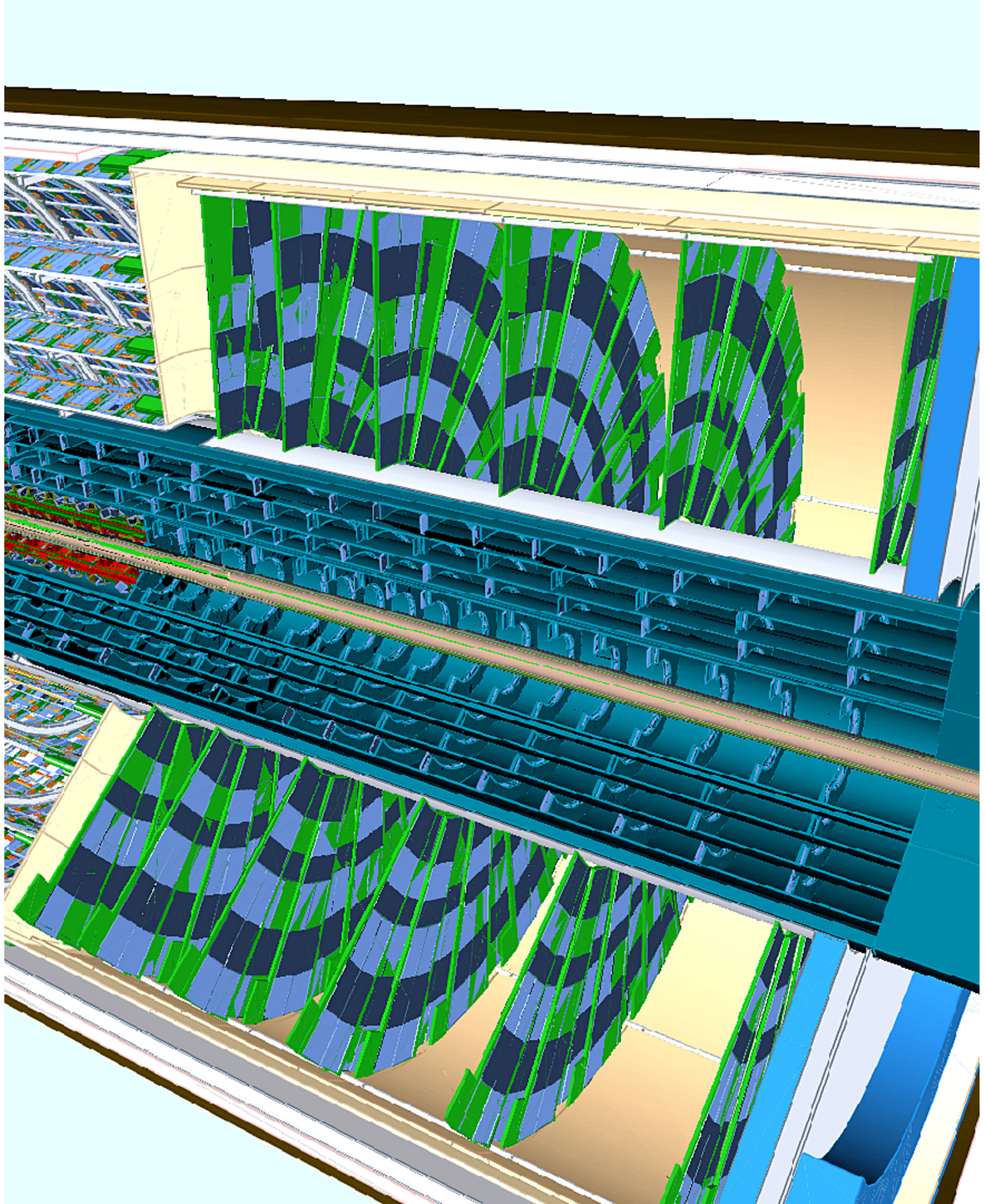
ATLAS ITk activities at SFU, TRIUMF and UBC

CAP 2018

Francesco Guescini

TRIUMF Postdoctoral Research Fellow



Discovery, accelerated

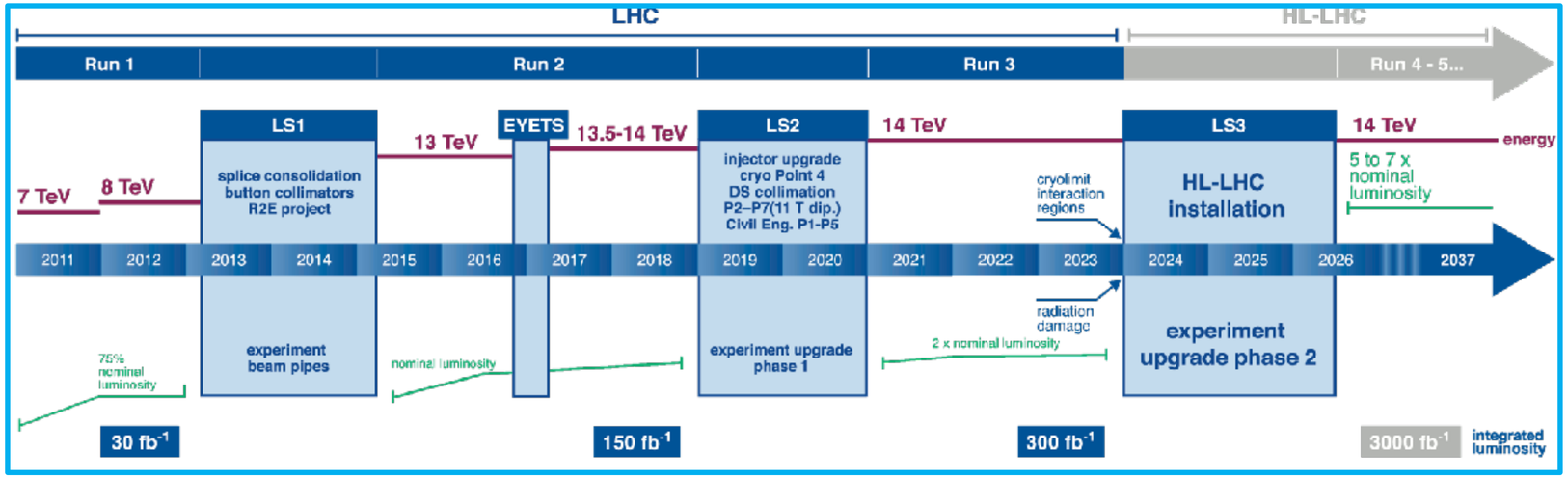
- ATLAS Inner Tracker
- module building
- petal building
- production plans
- readout

Nigel Hessey, The ATLAS Upgrade for the High-Luminosity LHC
Wednesday, June 13th, 8:00, W1-3 PPD session

The Large Hadron Collider (LHC) at CERN will be upgraded to a new machine, the High Luminosity LHC, staring up in 2026 with seven times the current luminosity. The ATLAS experiment will then collect 3000 fb^{-1} of proton collisions at 14 TeV centre-of-mass energy. This large data set will increase the discovery reach and allow higher precision in many measurements. The ATLAS detector needs several improvements to cope with the unprecedented luminosity and radiation damage.

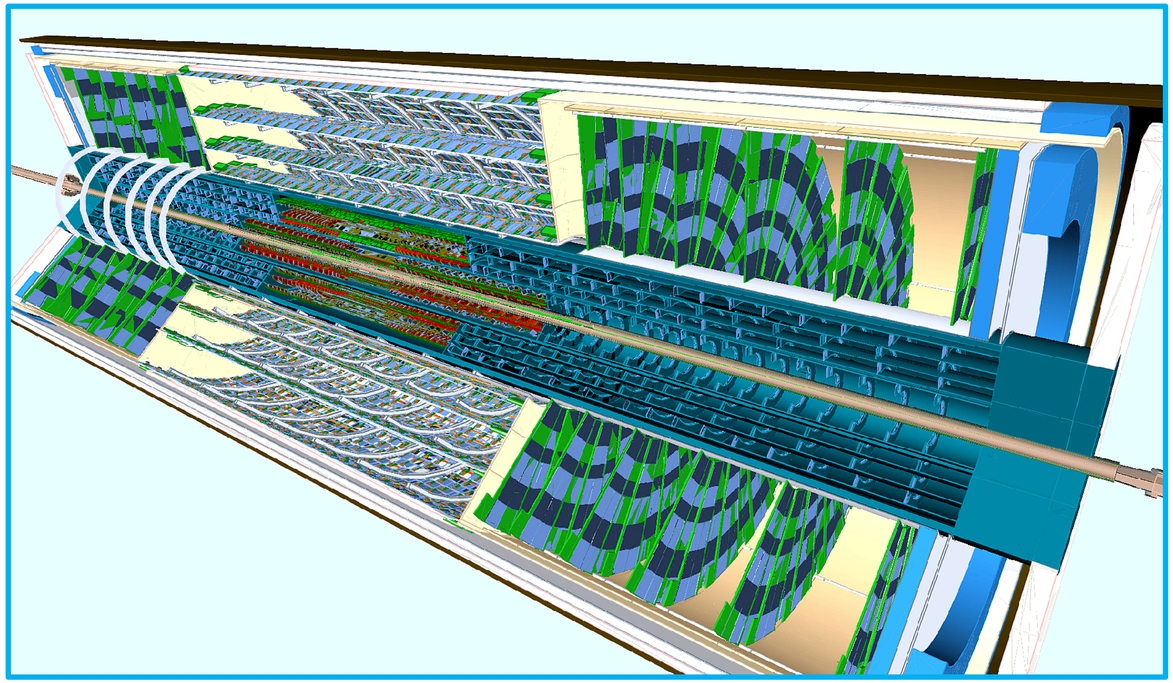
This talk will summarise the new physics reach and describe the planned detector and trigger improvements, concentrating on the Canadian contributions in the liquid argon calorimeter and the new silicon inner tracker.

HL-LHC and ATLAS Phase-2



ATLAS-TDR-025

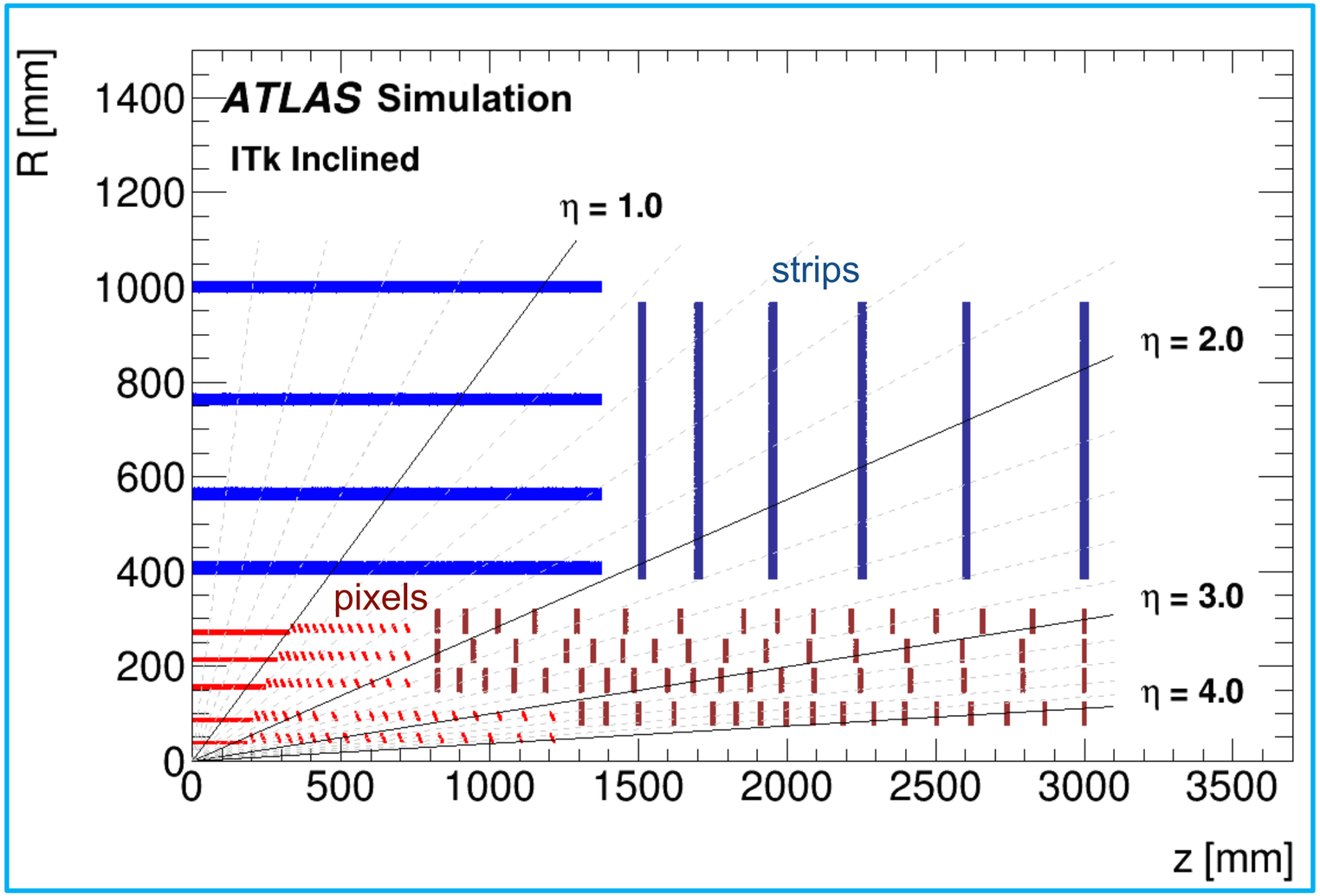
- High Luminosity LHC and ATLAS Phase-2 (2024)
  - increased **instantaneous** LHC **luminosity**: ~7.5 10^{34} cm^{-2} s^{-1}
  - increased **pile-up**: 200 interactions/ bunch crossing
  - increased **radiation** damage
  - **4000 fb^{-1}** integrated luminosity
  - **>10 years** data taking
- replace current ATLAS Inner Detector (2024-2025)
  - IBL, pixels, SCT, TRT



ATLAS-TDR-025

ATLAS Inner Tracker

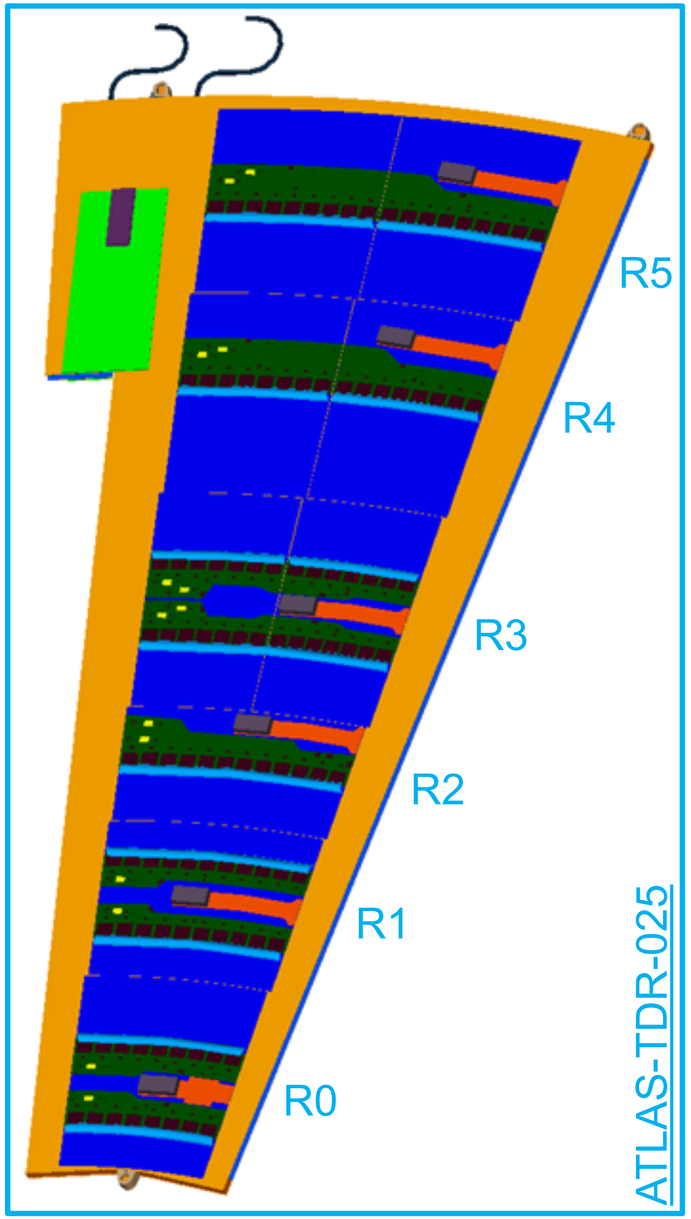
- ATLAS Inner Tracker:
  all-silicon tracking detector
  - pixels
    - track reconstruction coverage up to |η| = 4.0
  - **strips**
    - 4 barrel layers
    - 6×2 end-cap discs
- **Canada**: contributing to the production of the ITk strip end-cap discs

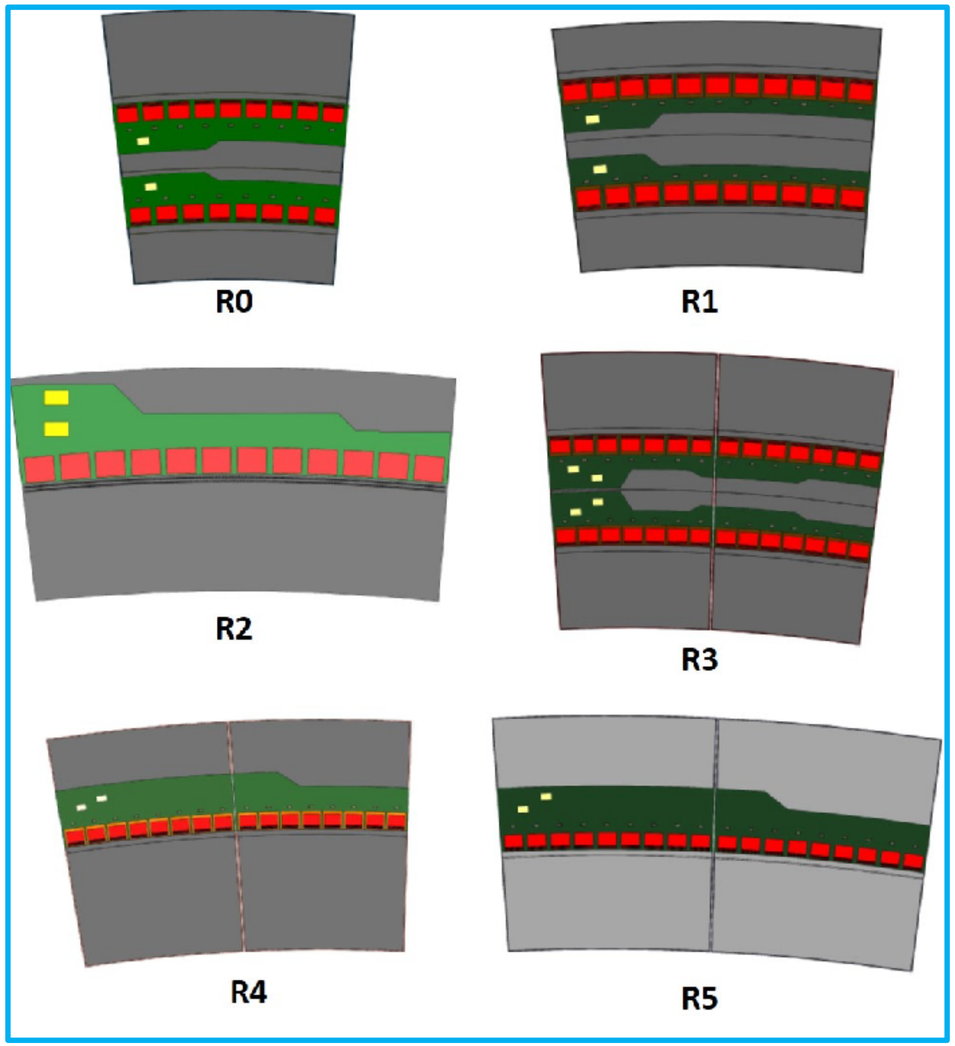


ATLAS-TDR-025

ITk petals

- end-cap discs divided in **32 petals**
- **carbon** support structure
  - sheet, honeycomb, sheet
  - embedded cooling line
- embedded **cooling** line for bi-phase CO_2
- **double-sided** petals
  - identical sides
  - 6 modules per side
    - 3 single-sensor modules (R0-R2)
    - 3 double-sensor modules (R3-R5)
- **6 sensor types**
  - R0 to R5
  - stereo annulus shape
- 40 mrad **stereo angle** between strips on opposite petal sides
- End-of-Structure **readout** card and bus tape

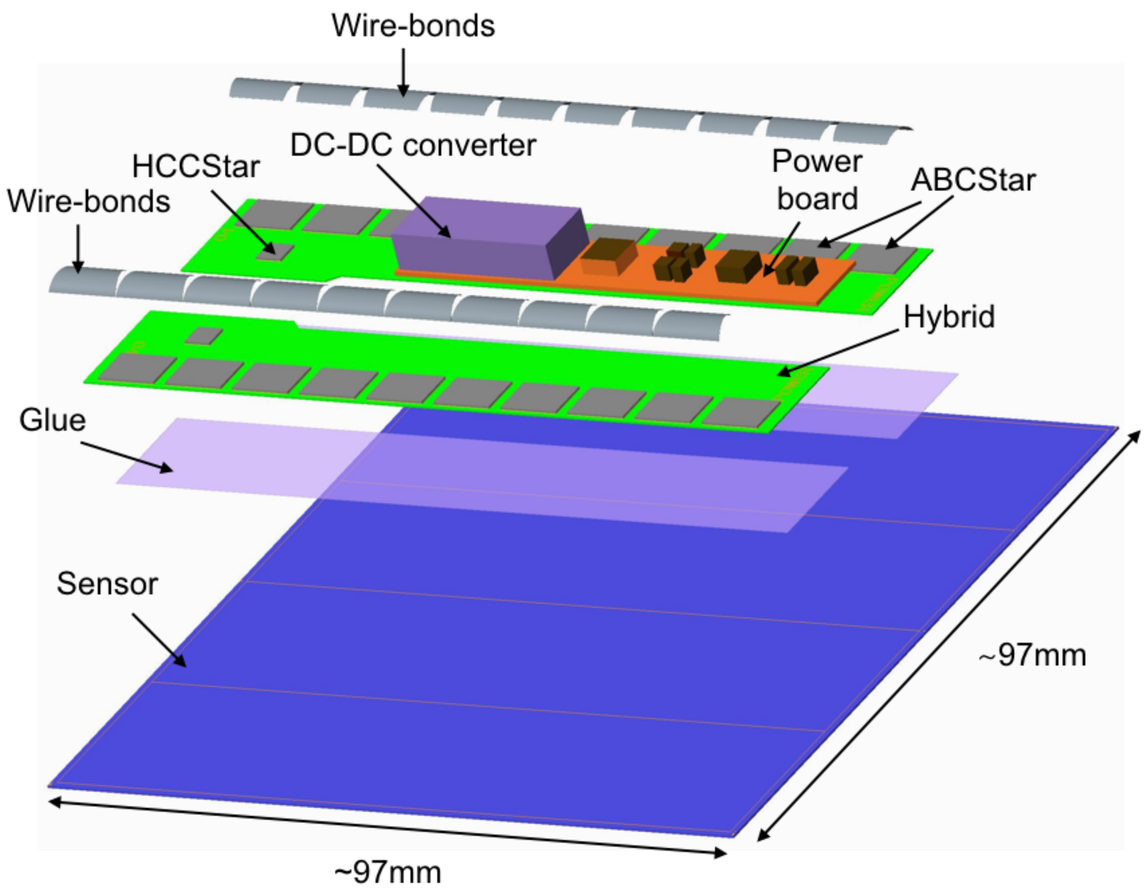




ATLAS-TDR-025

ITk strip modules

- silicon strip **sensor**
  - n-in-p silicon sensor
  - 2 or 4 strip rows
  - 69-85 μm strip pitch
- **hybrid**
  - Kapton flex hybrids carrying electronics
  - 1 hybrid per pair of strip rows
- **electronics**
  - front-end ASICs: ATLAS Binary Chips (**ABCStar**)
  - Hybrid Control Chip (**HCCStar**)
- **power board**
  - DC-DC converter
- **glue**
  - sensor-hybrid: epoxy glue
  - hybrid-ABC/HCC: UV glue
- electrical connections done via **wire-bonds**

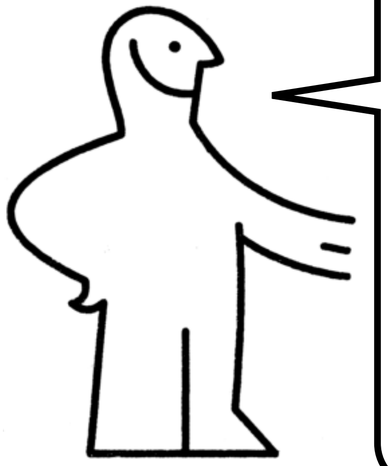


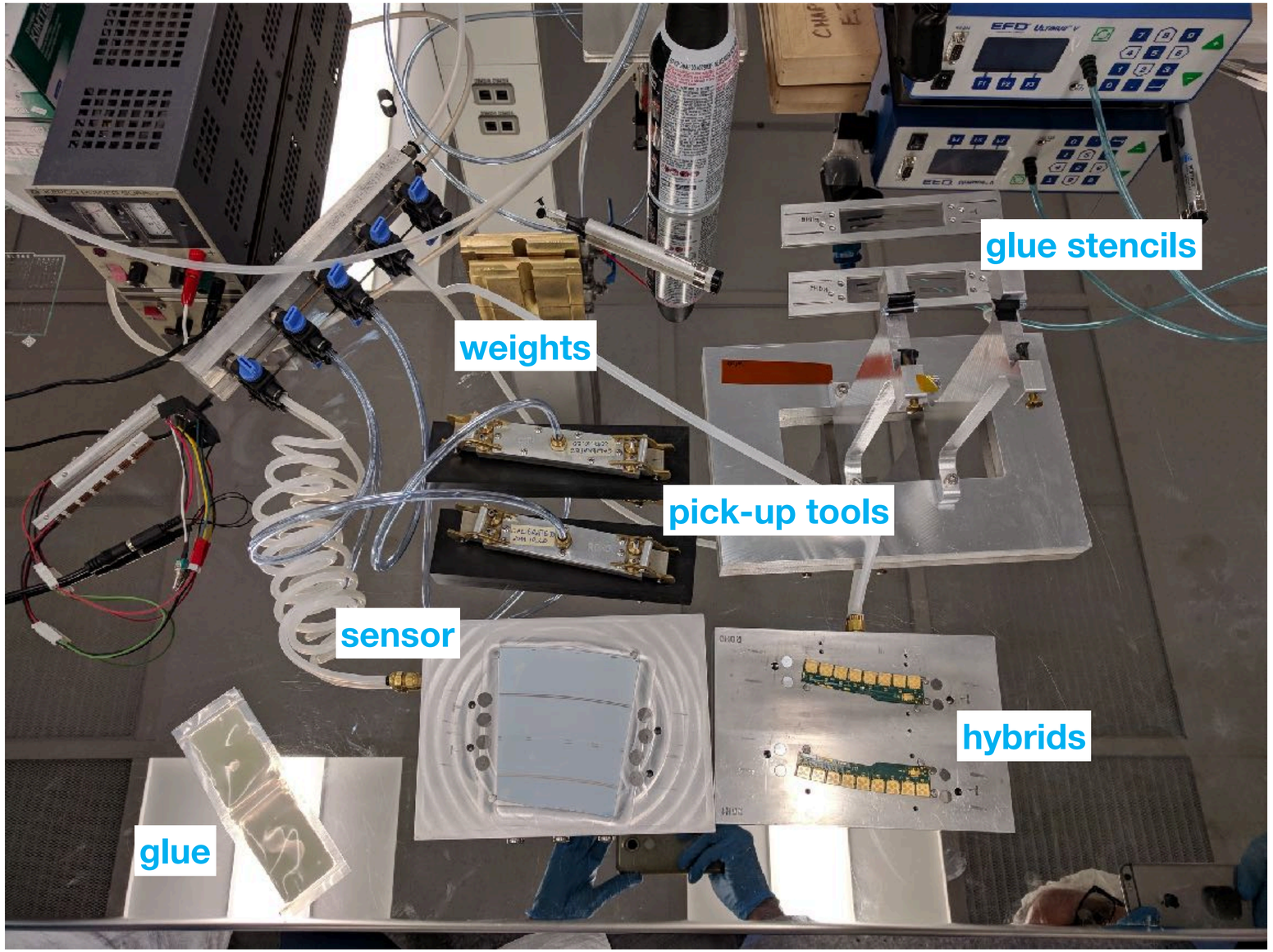
ITk strip barrel module

ATLAS-TDR-025

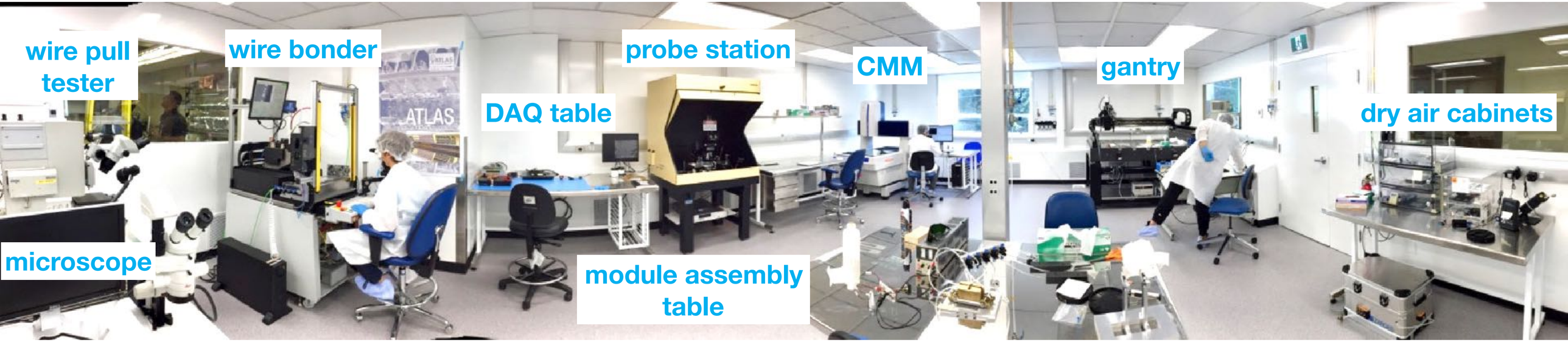
ÏTk Ř0 mødůĻe

- ITk **production** to start in **2019**
- ITk sites ramping up with **pre-production**
  - site qualification
- **R0** is the **benchmark** test module for ITk strip end-caps

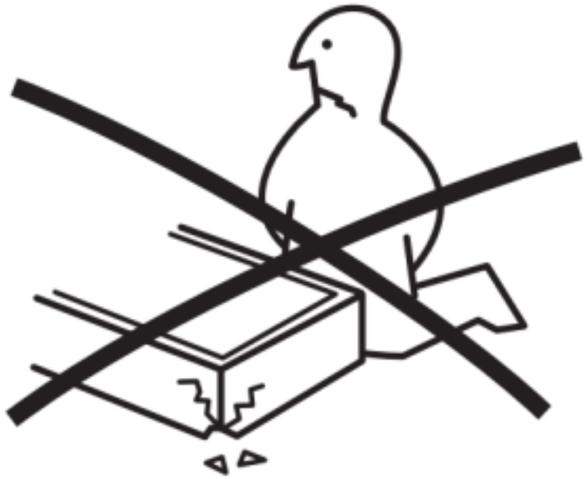




TRIUMF ITk cleanroom



- dedicated ITk cleanroom at TRIUMF
  - **module assembly table**: practice and perform module building
  - **gantry**: glue deposition (and more)
  - **CMM**: module metrology
  - **microscope**: optical inspections
  - **probe station**: sensor tests
  - **wire bonder and wire pull tester**: bonding and bond strength testing
  - **DAQ table**: module testing
  - **dry air cabinets**: storage of components and modules

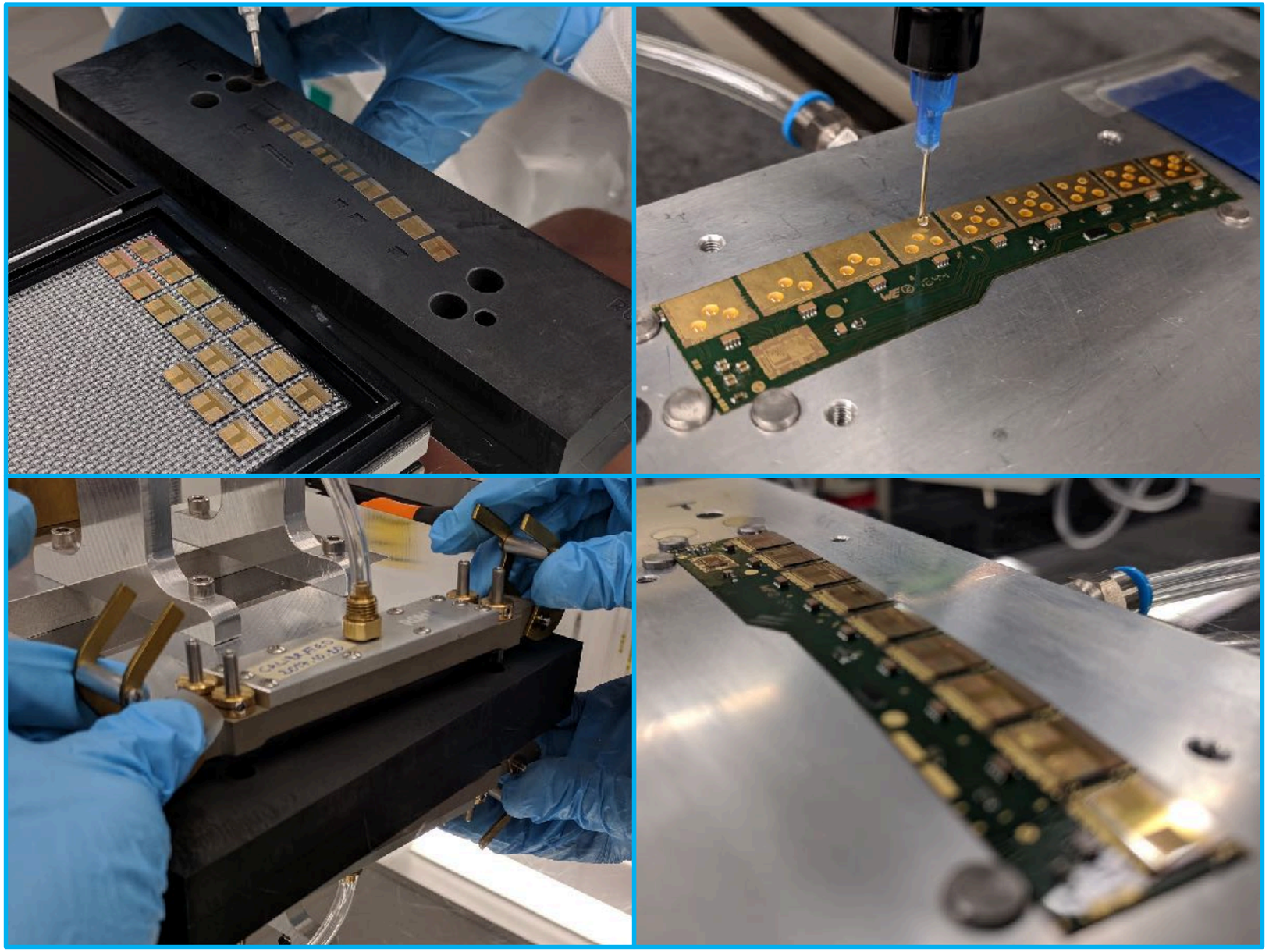


R0 hybrid building

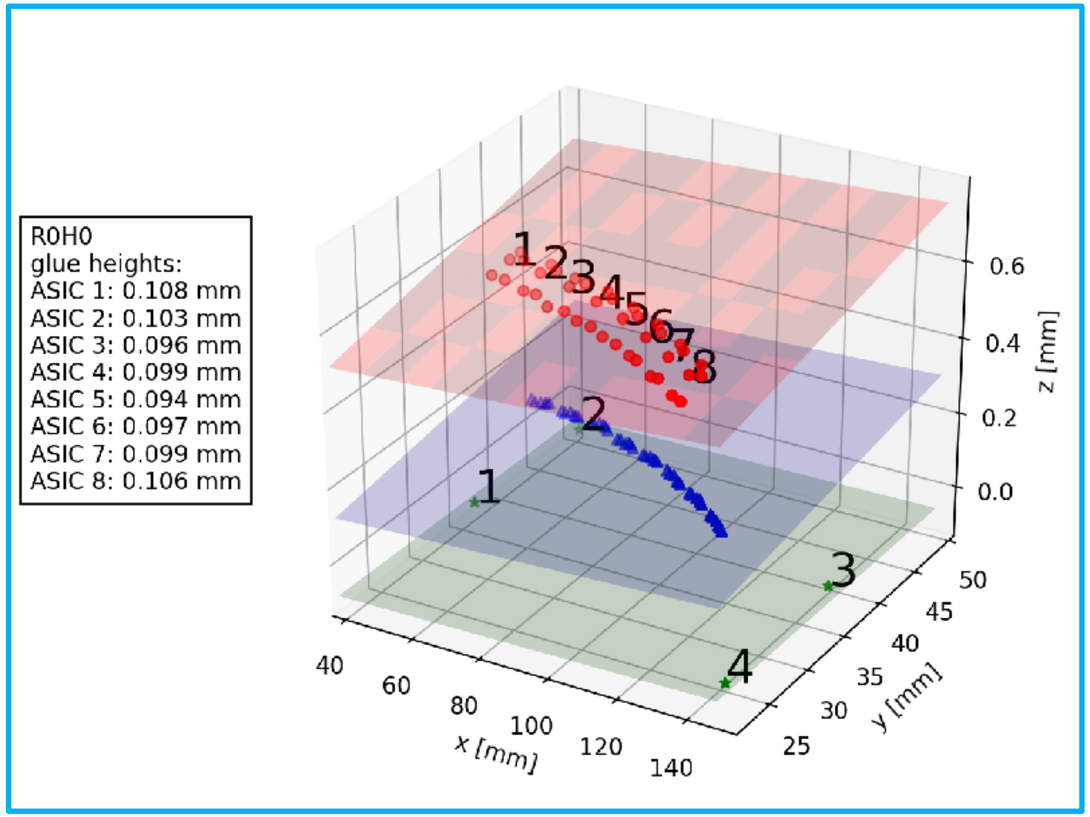
- practiced and fine tuned complete module building procedure on **mechanical R0s** and **glass ASICs**

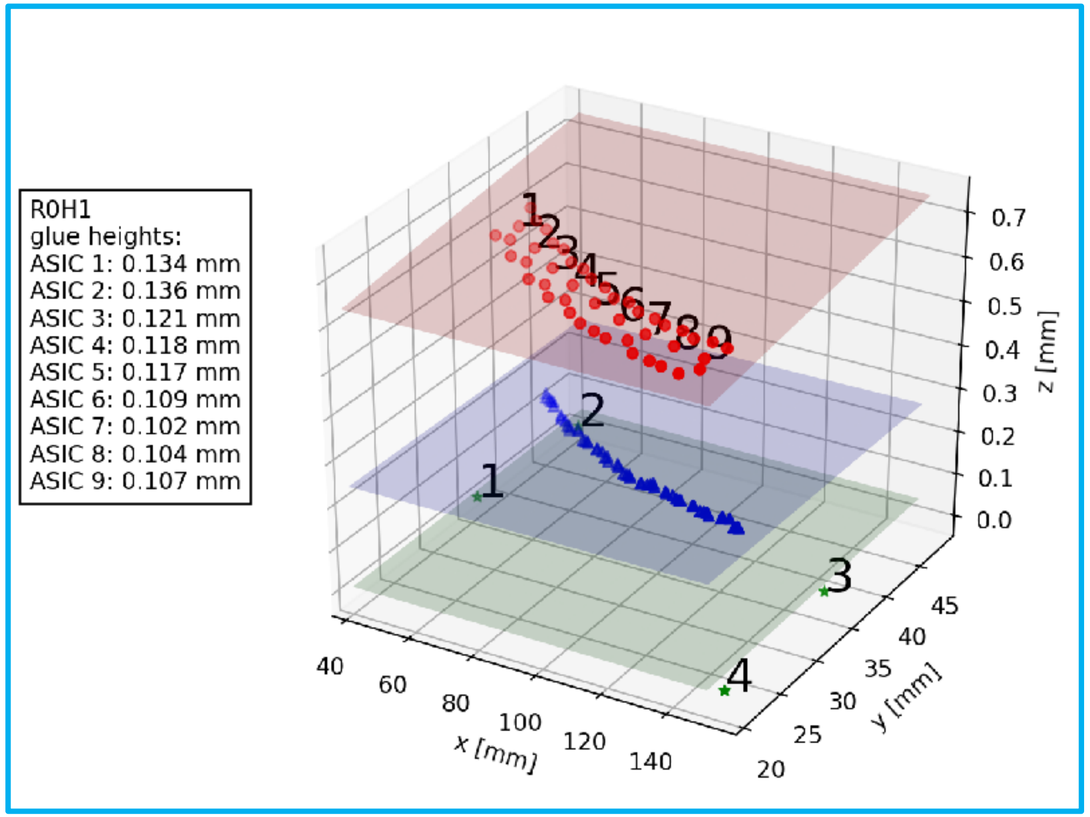
- ASICS picked with vacuum pen and placed in loading tray
- glue pattern dispensed by gantry
- ASICS picked up and loaded onto the hybrid by means of vacuum pick-up tool

- same building procedure for both R0 module hybrids (R0H0 and R0H1)
  - R0H1 shown here



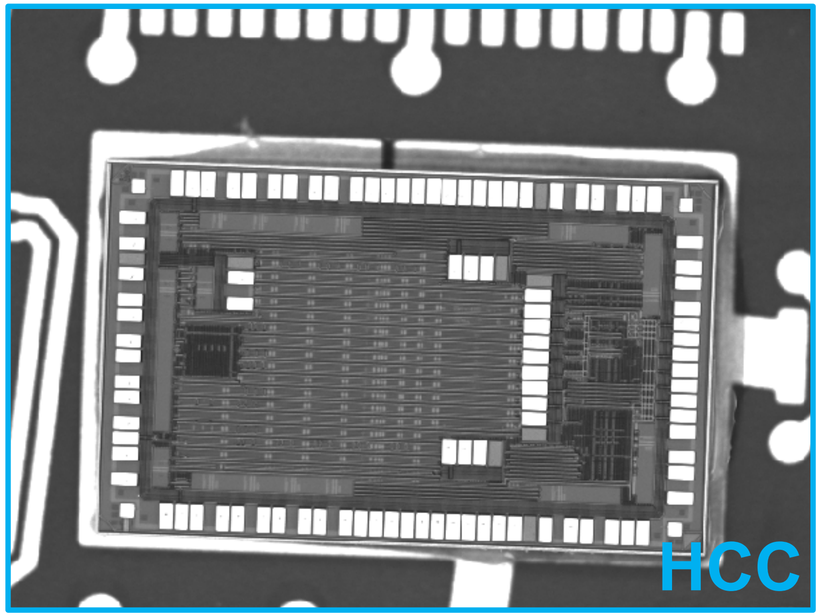
R0 hybrids metrology

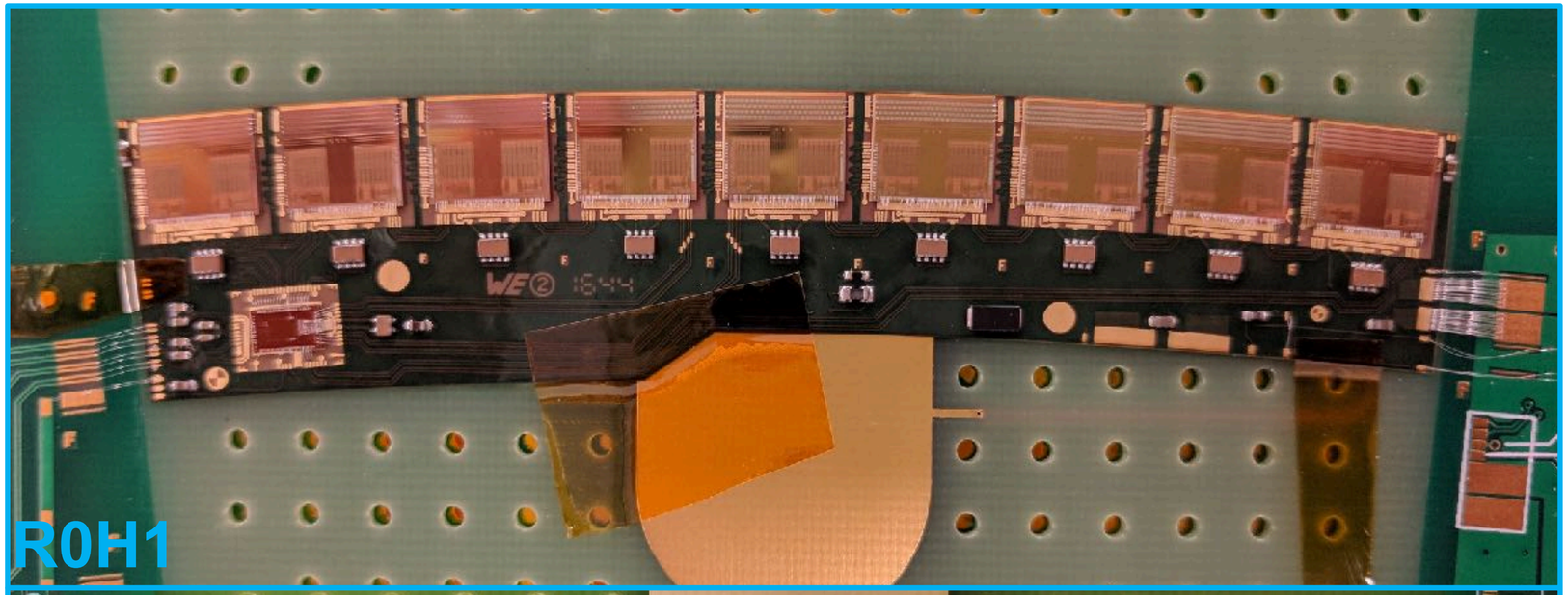


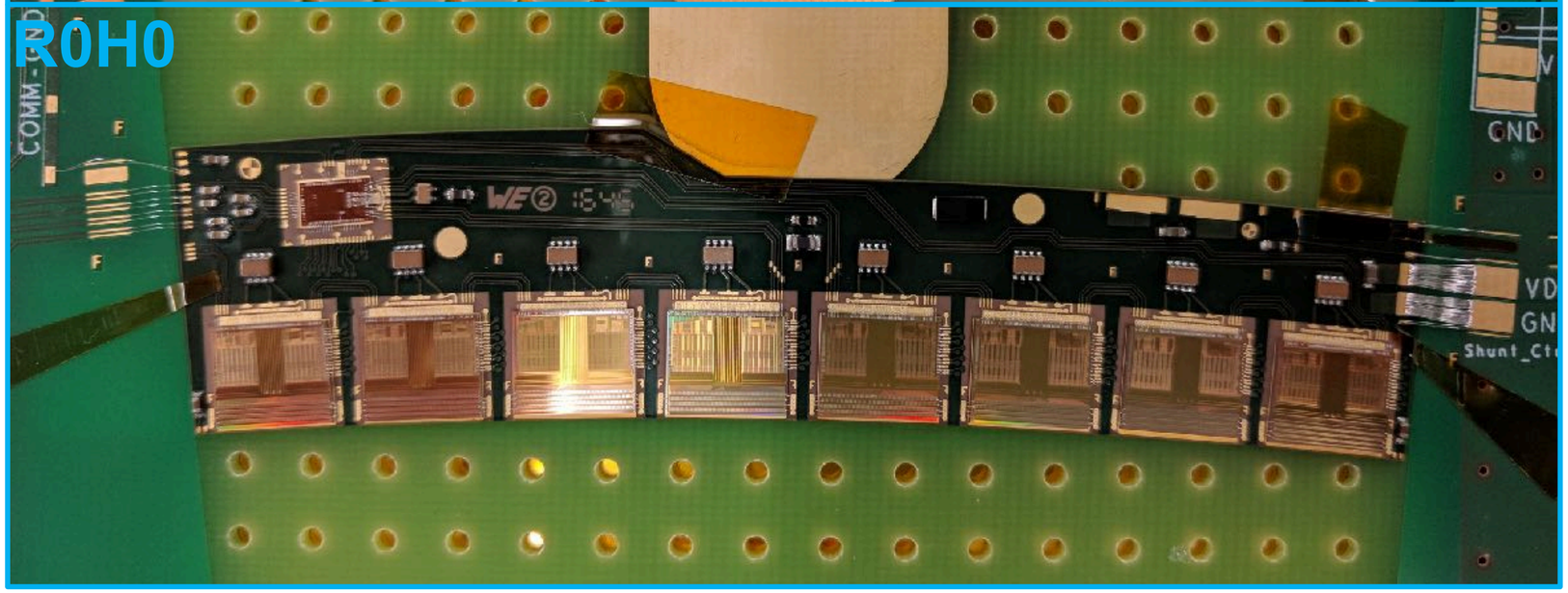


- R0H0 and R0H1 hybrids measured with **CMM**
- **ASIC glue height** target set to **120 µm**
- measured heights well within specs: **< ±40 µm**

R0 hybrids testing



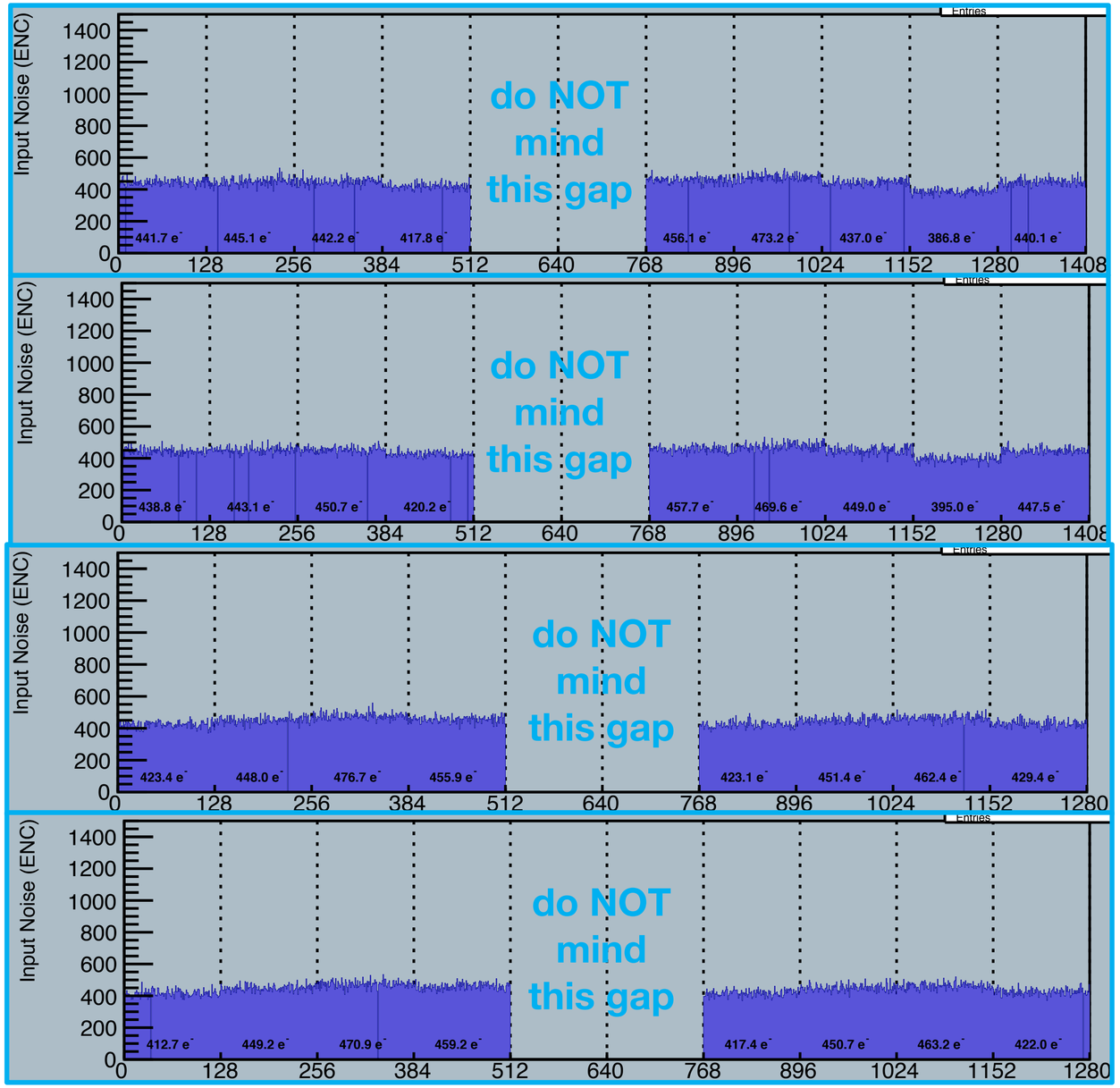




- **HCC** chips placed **by hand**
- hybrids **loaded and bonded** to test frames
- independent R0H0 and R0H1 **electrical tests**

R0 hybrids DAQ

- successfully **read data** from both hybrids
- same **DAQ setup** as for full module
- noise levels **within expectations**



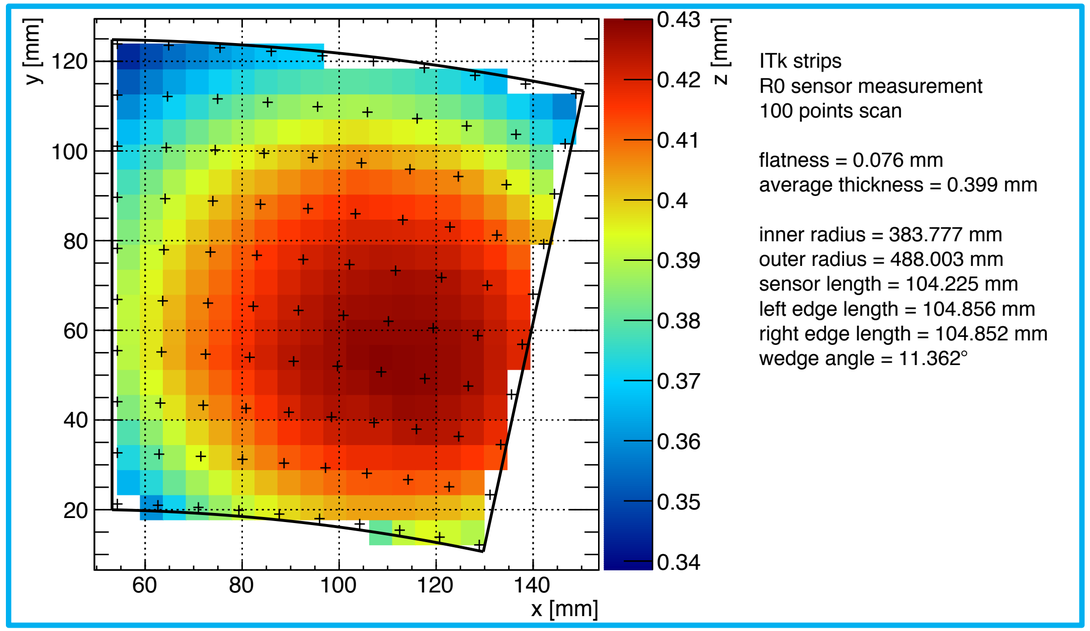
R0H1 stream 1

R0H1 stream 0

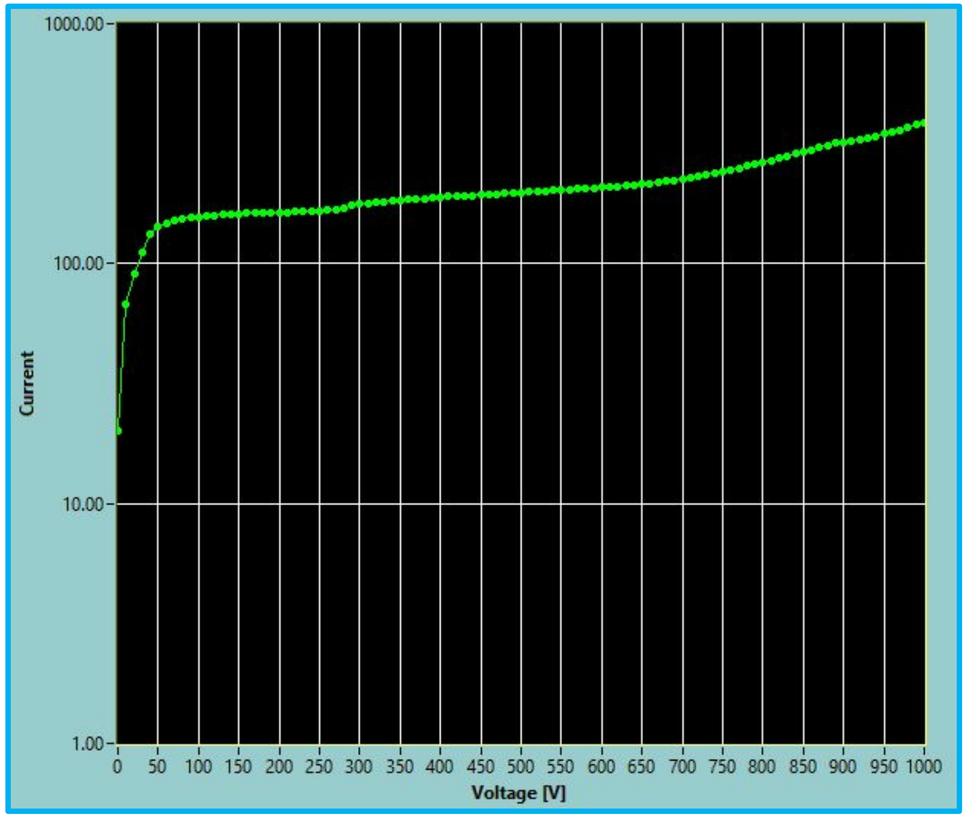
R0H0 stream 0

R0H0 stream 1

R0 sensor testing



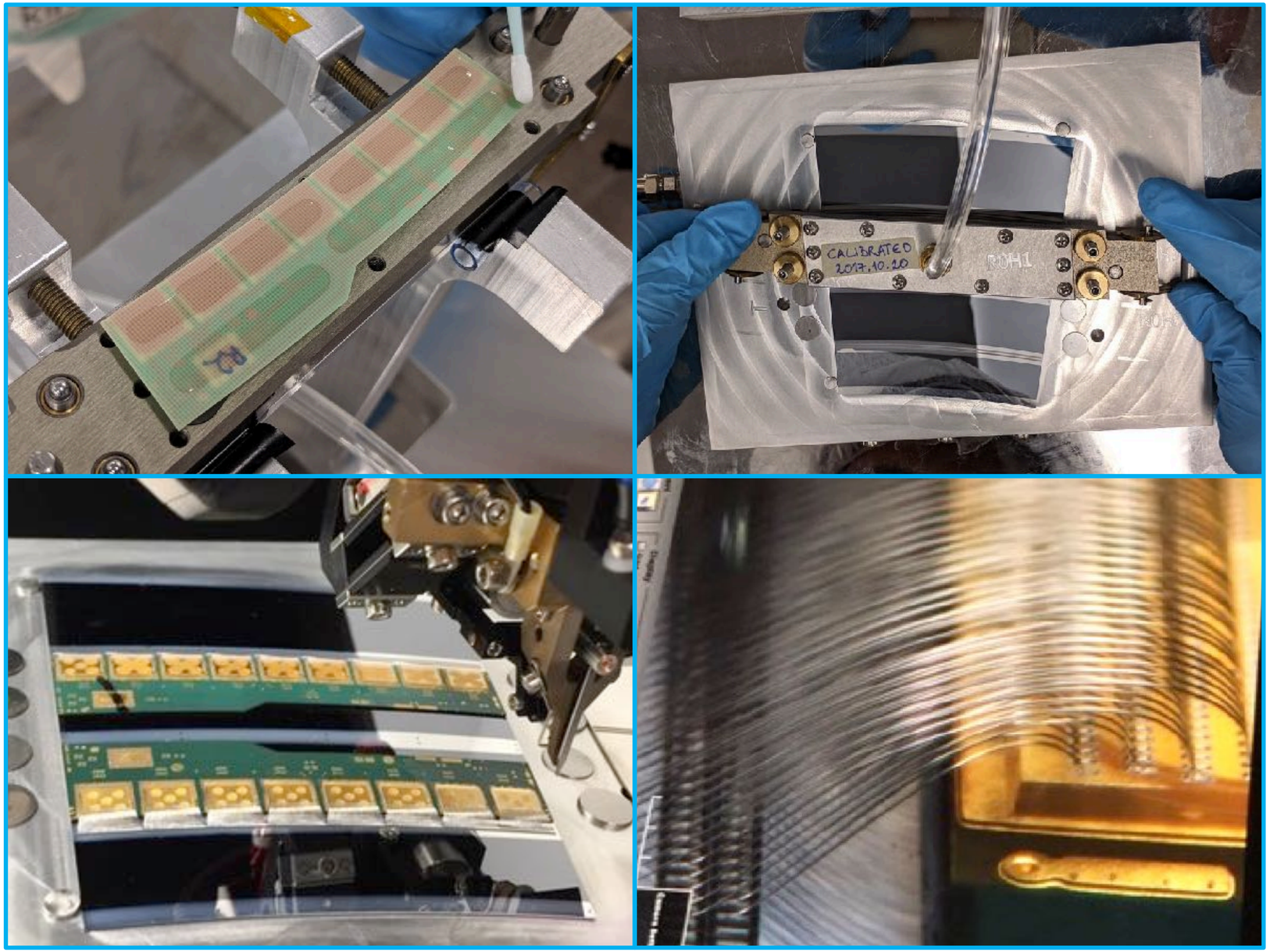
- **sensor** surface scan
- measure **flatness**
  - bowing structure
  - **76 µm** (< 200 µm required)
- measure shape and cut precision



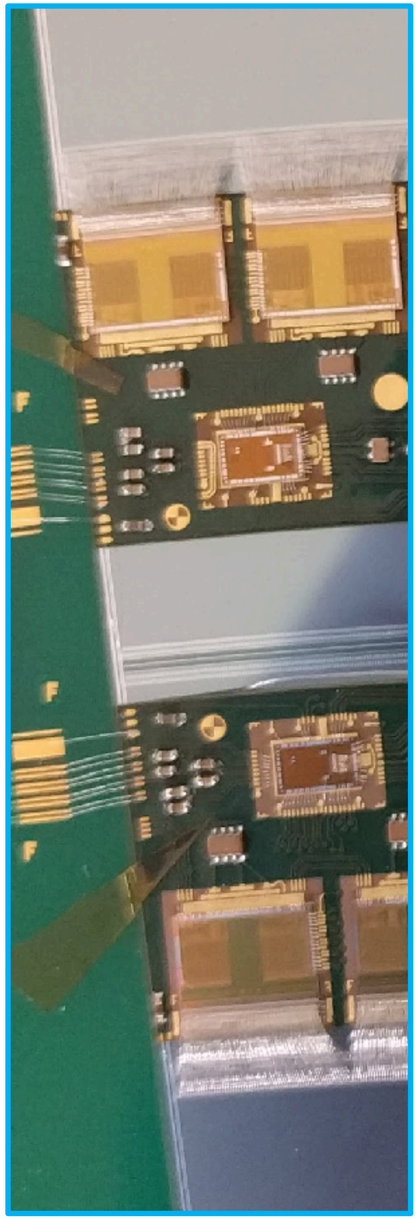
- IV and CV curve measurements
- **breakdown** voltage **above 1000 V**
  - >700 V required
- sensor depleted at 300 V

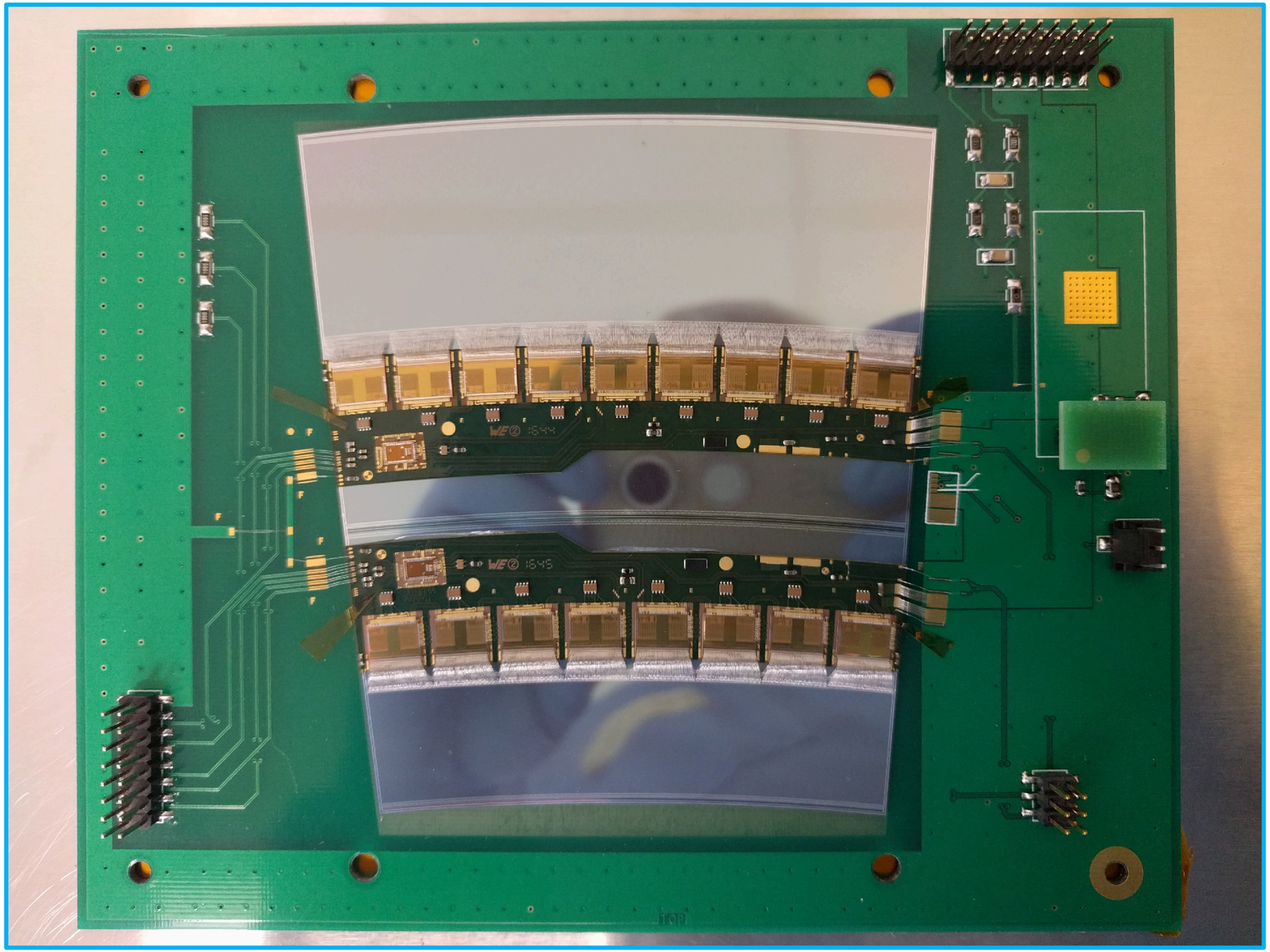
R0 module building

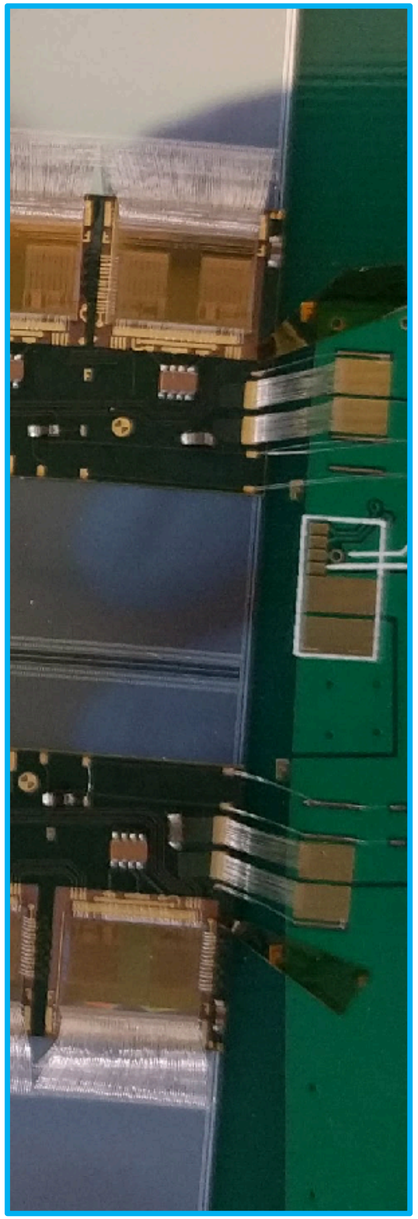
- hybrids glued onto the sensor
  - epoxy glue
  - same loading tools as for ASICs-to-hybrid gluing
- hybrids **wire bonded** to the sensor
  - **4-layers** of wire bonds
  - 25 μm aluminium wire
  - ~15 m of wire bonds per module
  - ~1 hour



R0 module





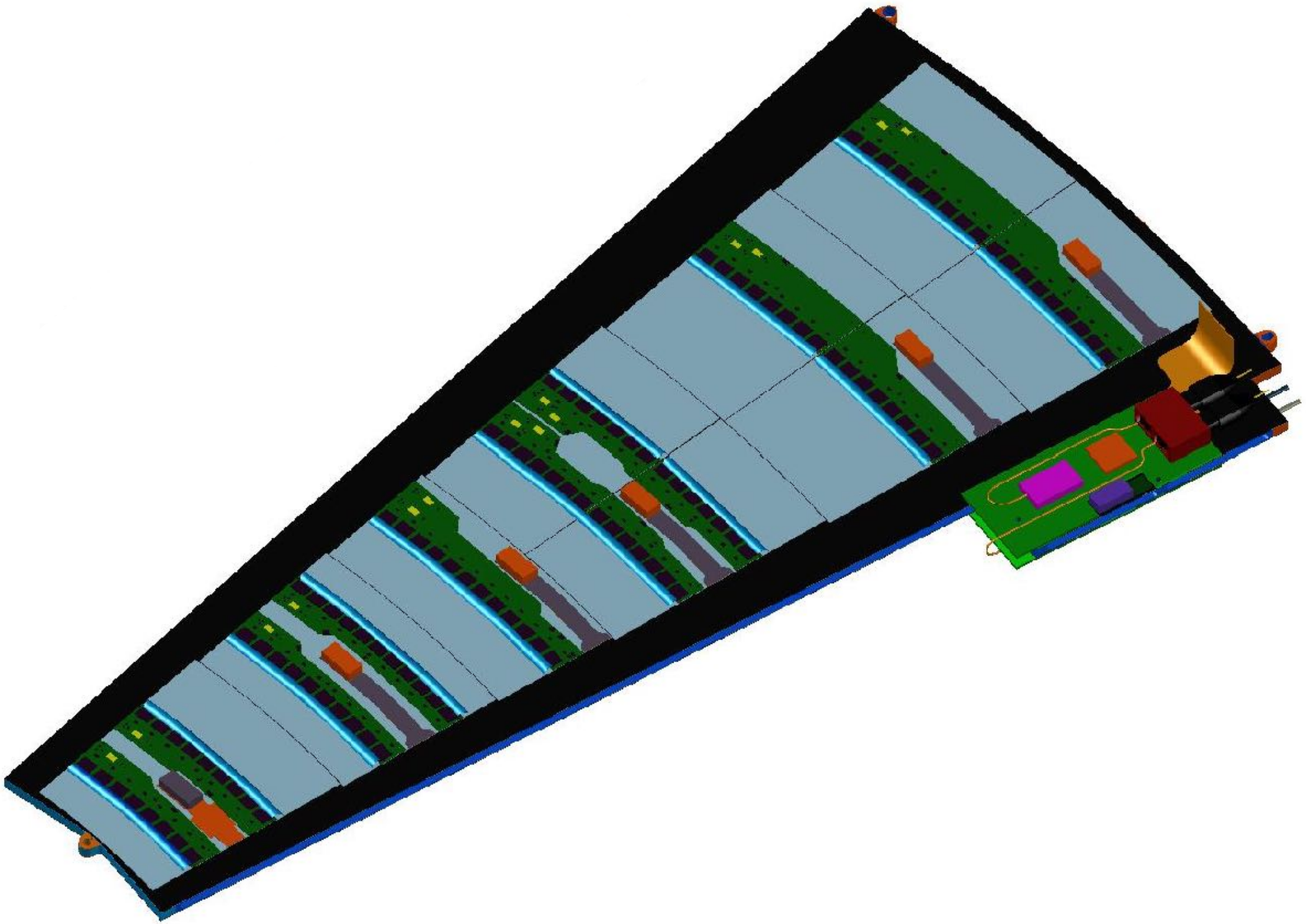


petal building

- accurate placement of modules on the **petal core**

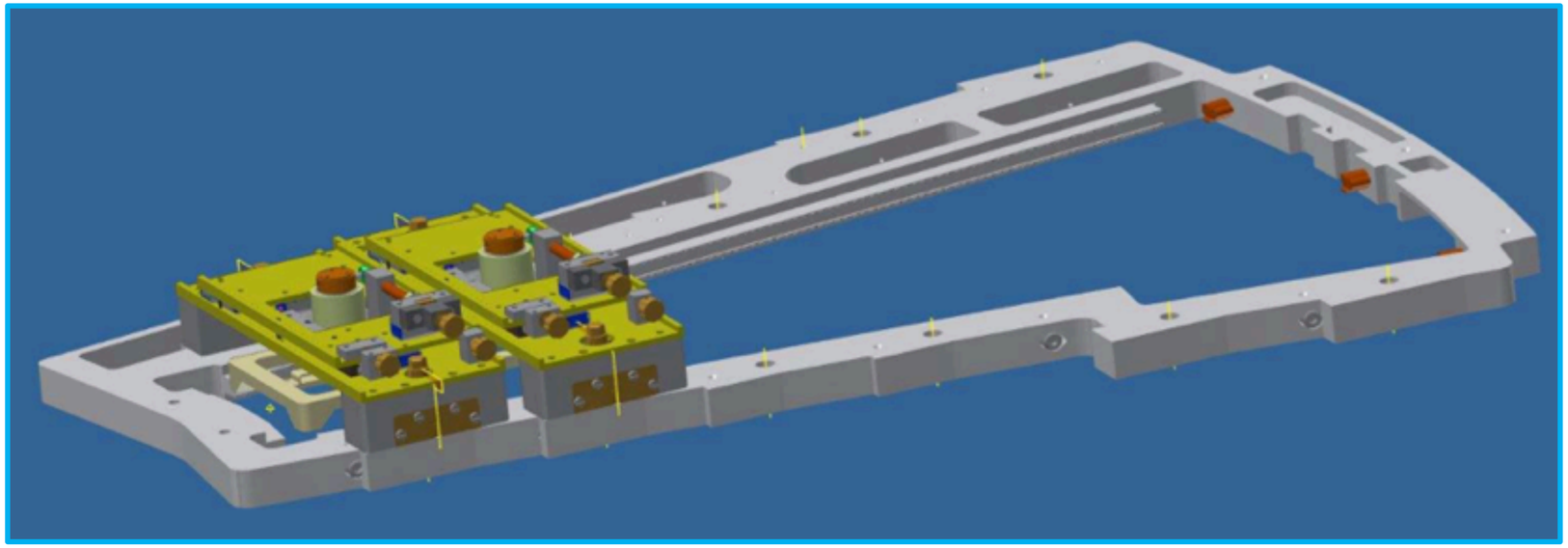
- Vancouver is **one of the four** ITk end-cap petal loading sites
- SFU is **leading** the module-on-petal loading activities

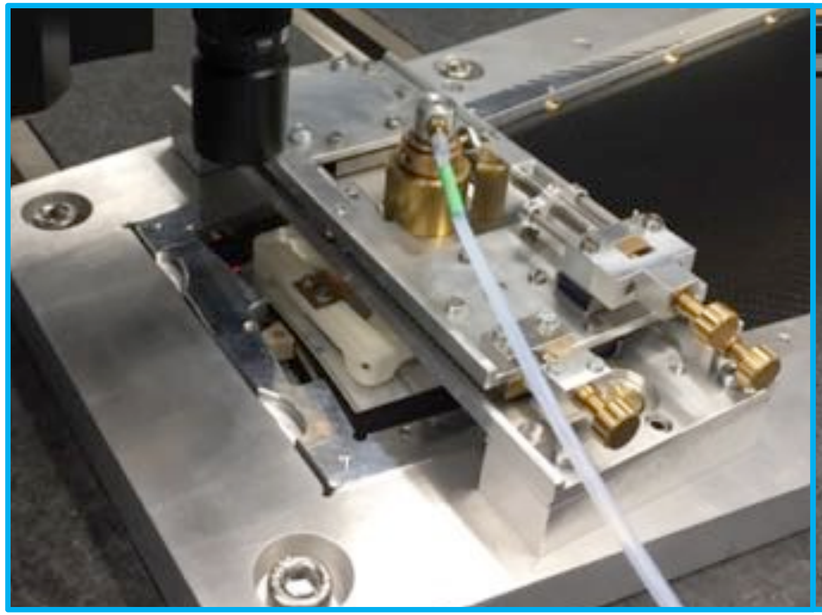
- **two strategies** being investigated
  - **baseline**: manual with bridges
    - gantry used for inspection
  - **advanced**: fully automatized
    - gantry used for inspection and module loading

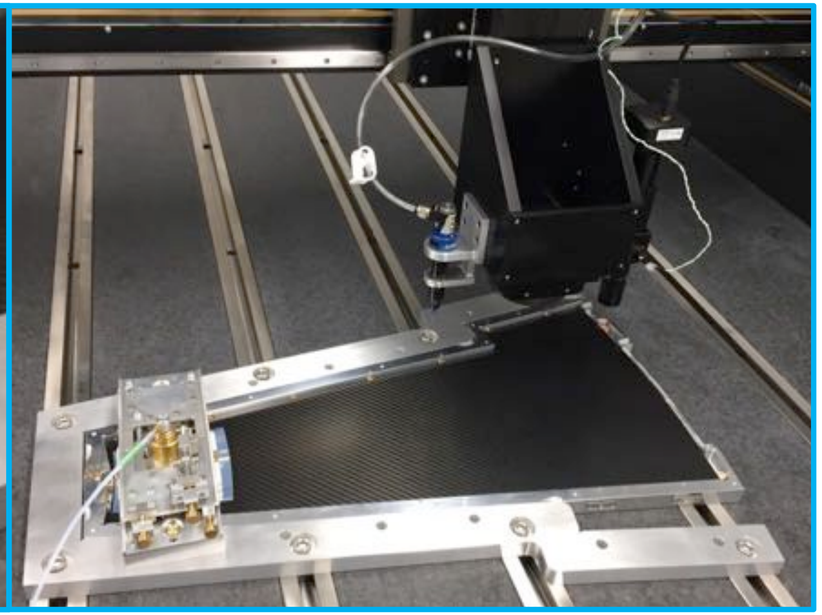


petal building: baseline

- modules loaded using **bridges**
- **manual** alignment
  - translation and rotation bridge fine controls
- gantry and microscope used for module **position survey**
- **iterative** procedure until precision reached

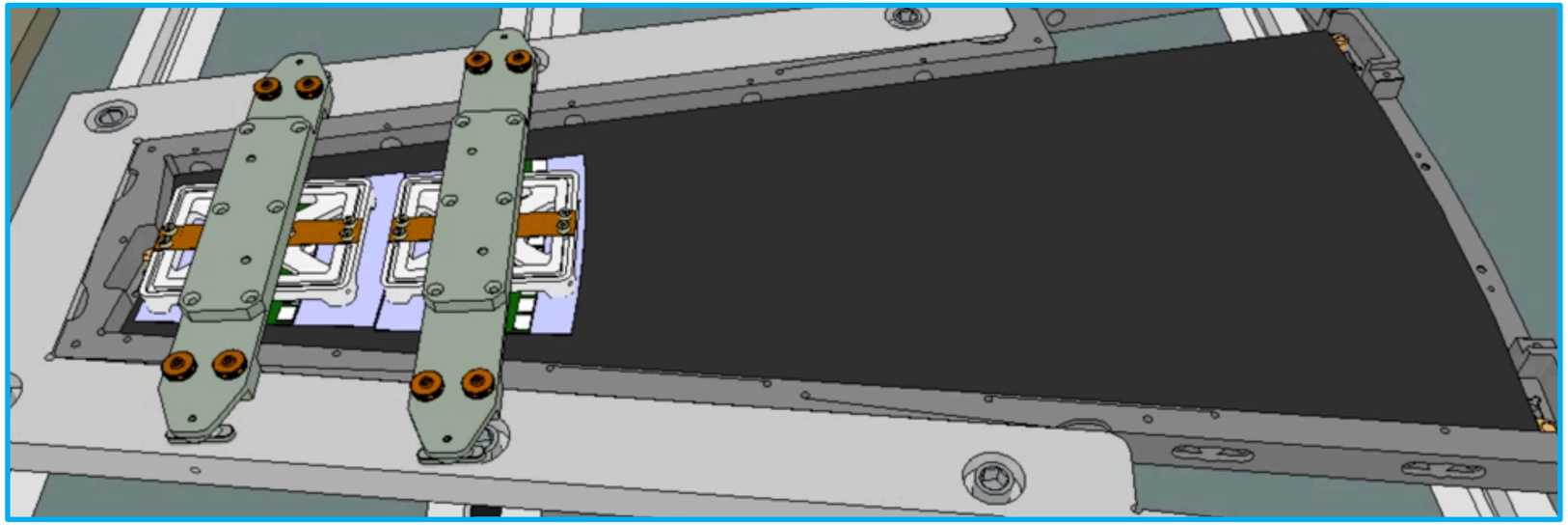


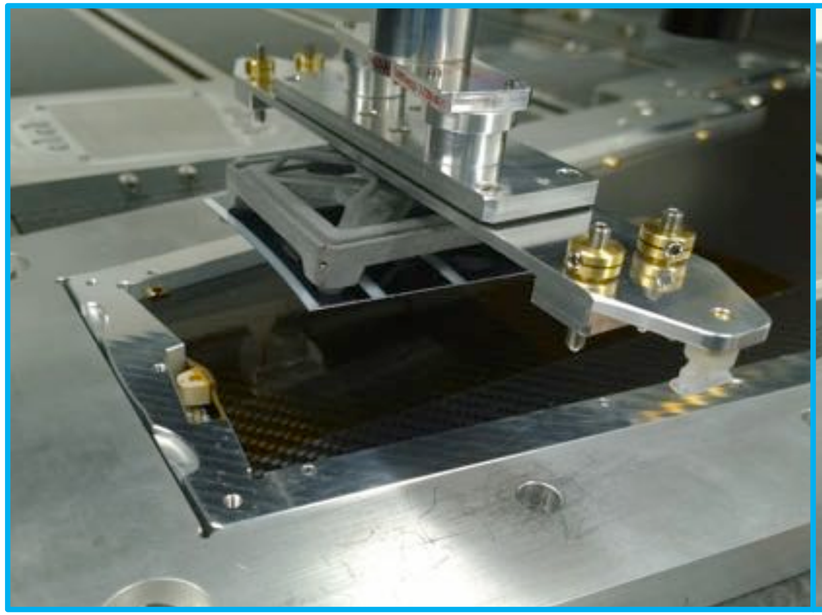


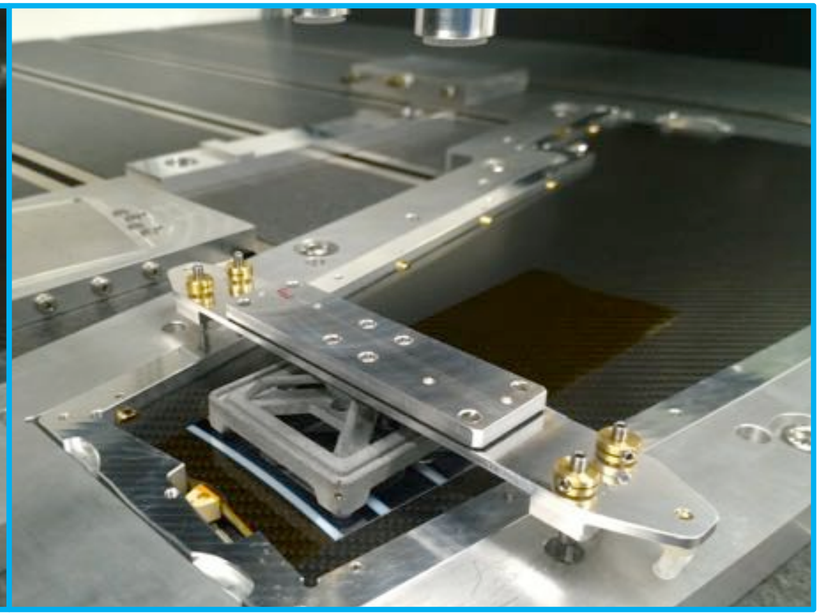


petal building: advanced

- **automatized** module-on-petal loading
- relies completely on the gantry and module pick-up tools
- gantry used for **module loading and position survey**
  - inspect petal
  - deposit glue
  - inspect module
  - pick-up loading tool
  - pick-up module
  - load module onto the petal
  - release pick-up tool
- see it (virtually) in action

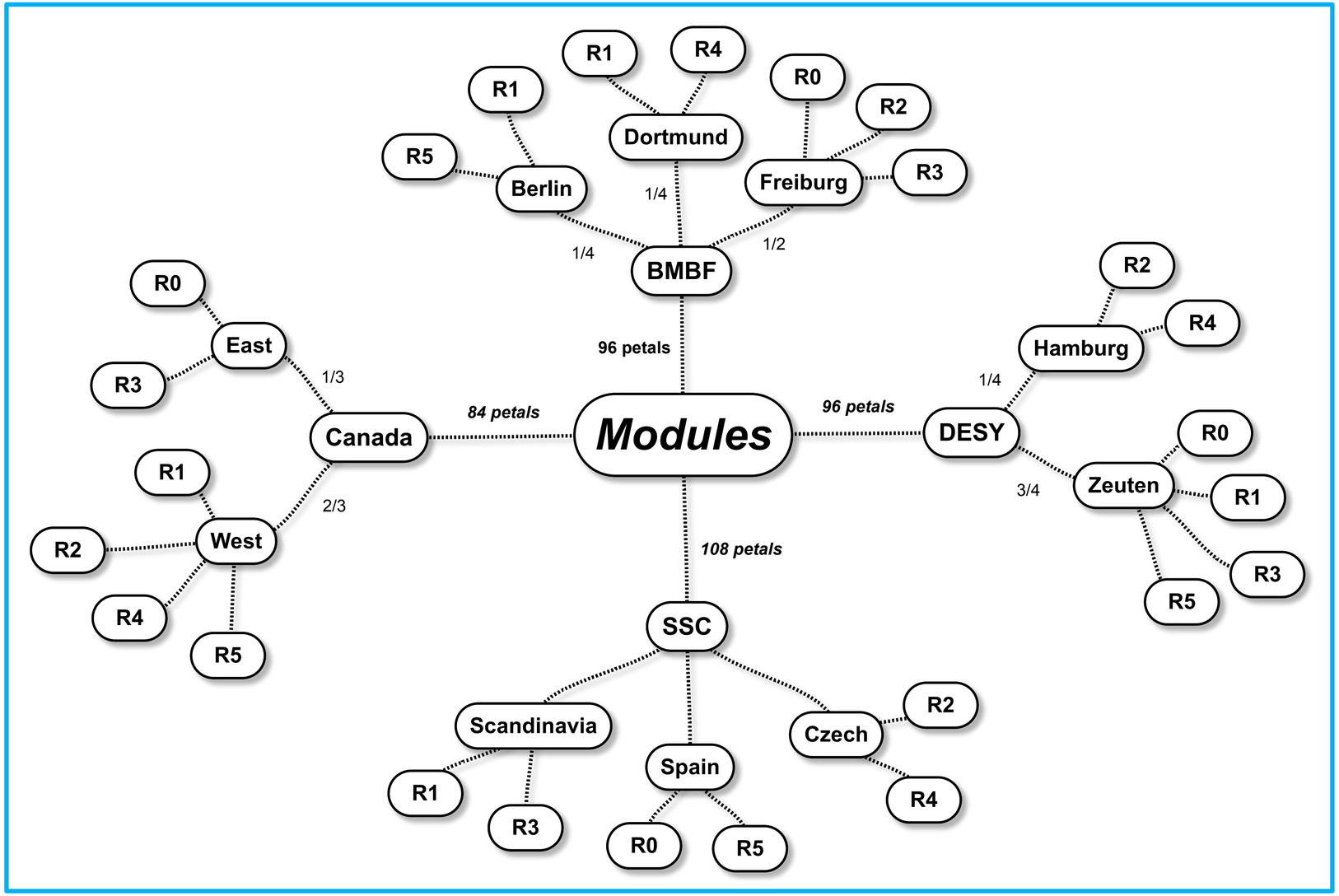






ITk production plans

- ATLAS Canada producing **84 petals** out of 384
- SFU, TRIUMF and UBC to take care of **loading petals** with modules from all ATLAS Canada institutes
- **module production** split among ATLAS Canada institutes
  - 504 modules in Eastern Canada
  - 1008 modules in Western Canada
- **hybrid production** taken care by Carleton and Toronto for all Canadian modules

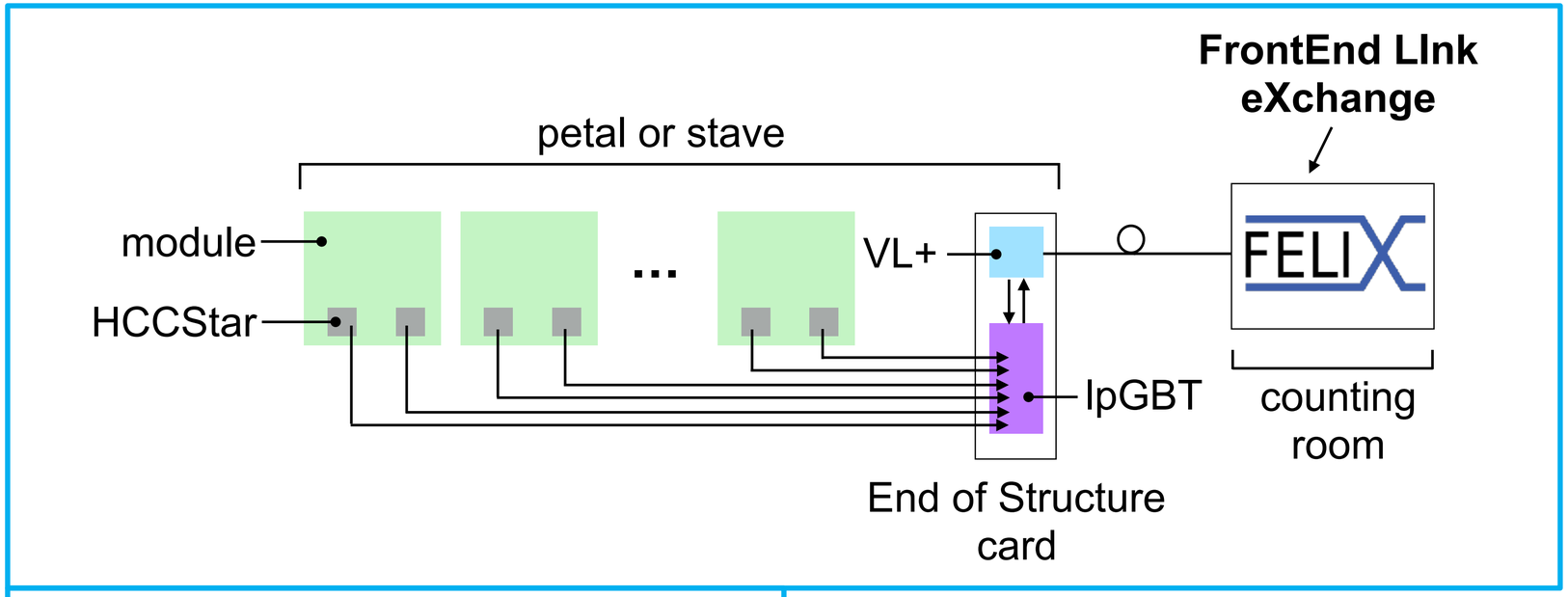


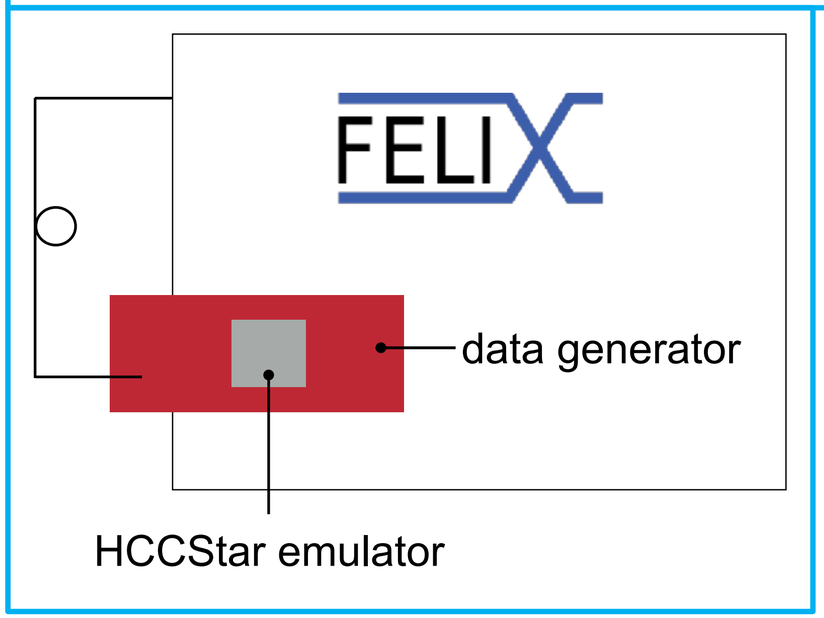
ITk strips readout

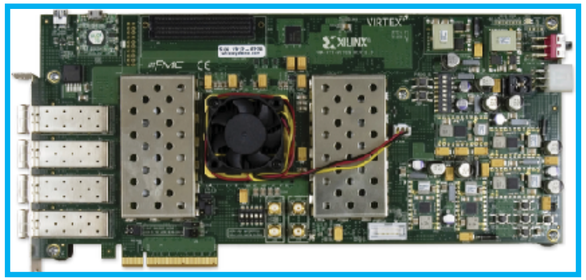
- new **detector-independent** ATLAS readout
  - **Front-End LInk eXchange**

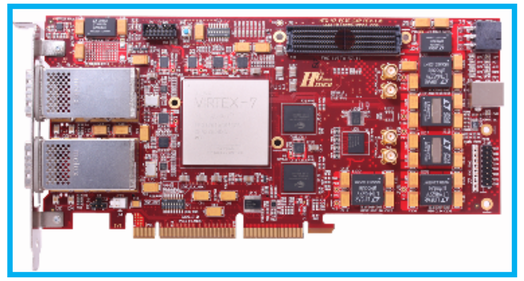
- UBC working towards providing ITk Strips **FELIX-based readout**

- building FELIX + ITk strips data generator test bench
- generator mimics the on-detector **readout** using an HCCStar emulator
  - UBC firmware module generates **HCCStar-like data**
  - use existing **data generator** infrastructure to produce HCCStar streams for FELIX





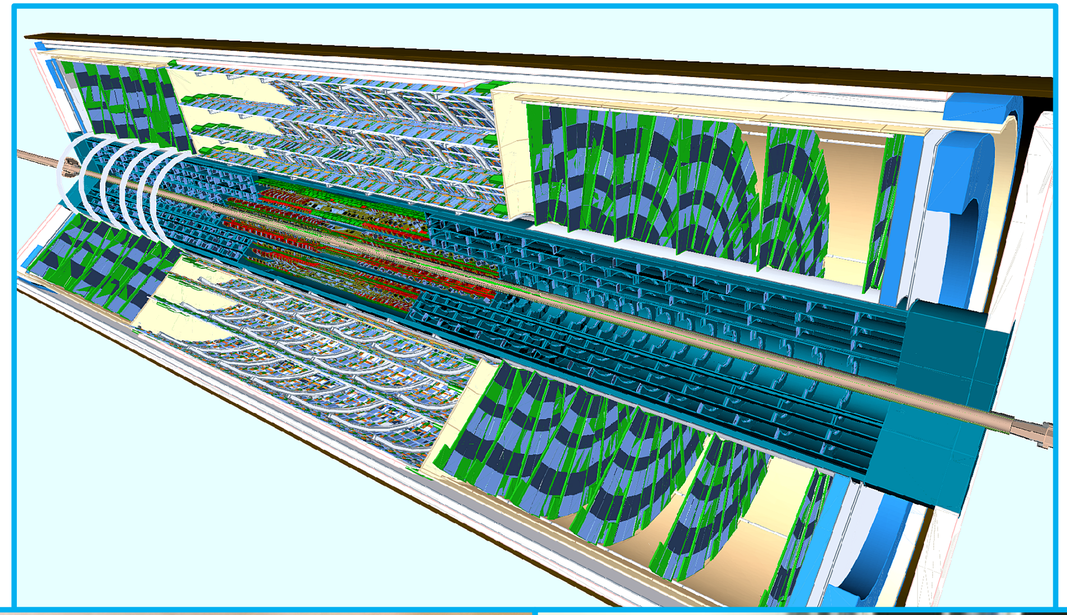


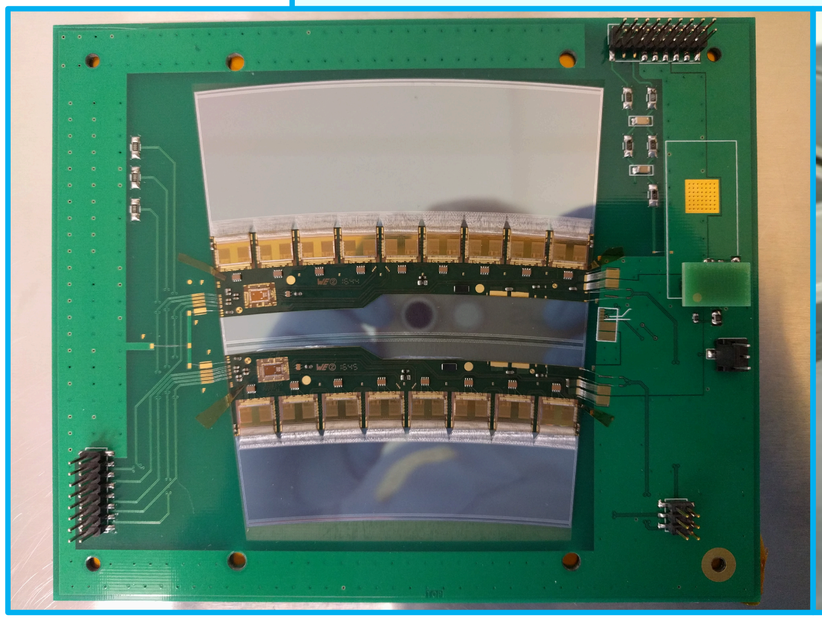


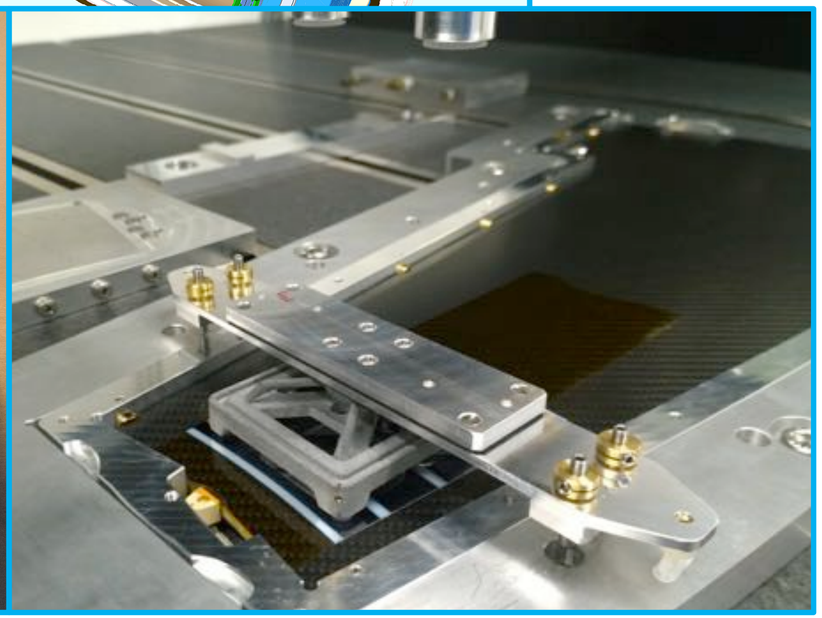
conclusions

- successfully built the **first ITk R0 module** in Vancouver
- Vancouver leading effort for **module-on-petal** loading
- Vancouver working on **ITk strips readout**
- ITk **production** to start in 2019

- ATLAS **Inner Tracker** Phase-2 upgrade
  - Nigel Hessey's presentation







TRIUMF SFU UBC

thank you
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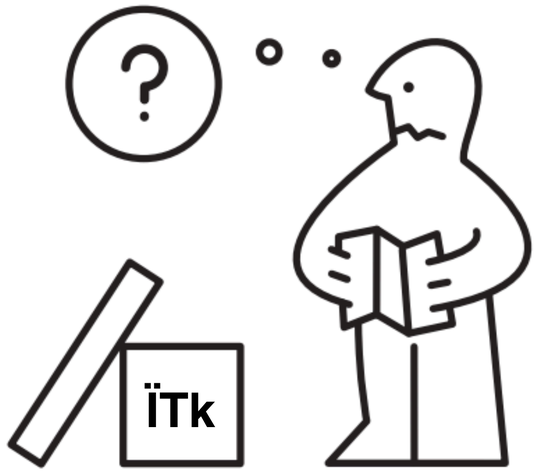

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