Test Beam Studies of Prototype Modules for the ATLAS ITk Strip Detector

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Zurich

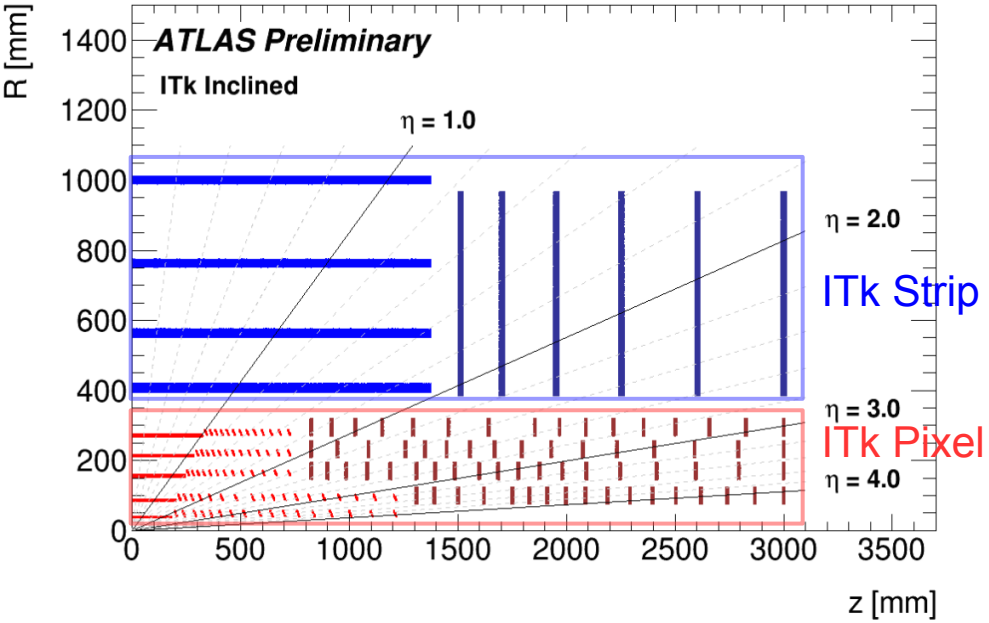
HELMHOLTZ ASSOCIATION

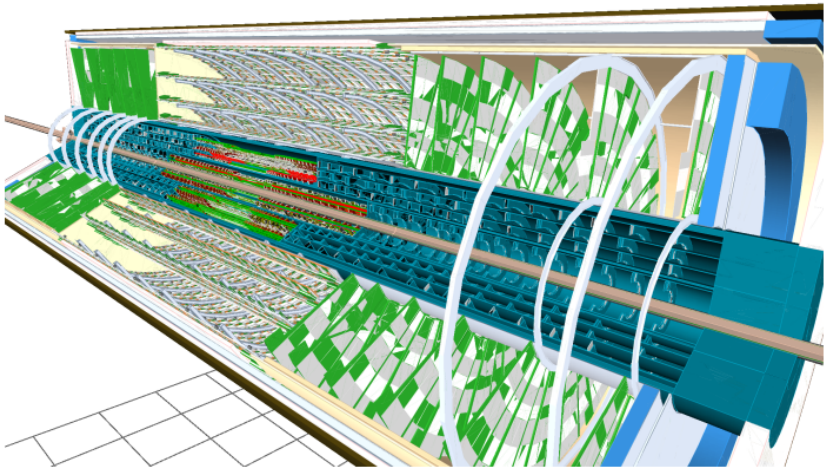
ATLAS EXPERIMENT

DESY

Overview of the ATLAS ITk Strip Detector

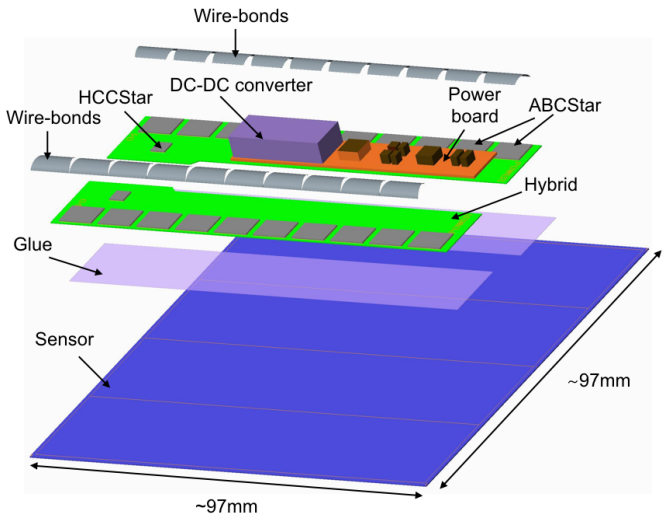
- Replacement of the ATLAS Inner Detector with the Inner Tracker (ITk) for the Phase-II upgrade
- The strip detector has a silicon area of ~165m^2 and ~18k modules

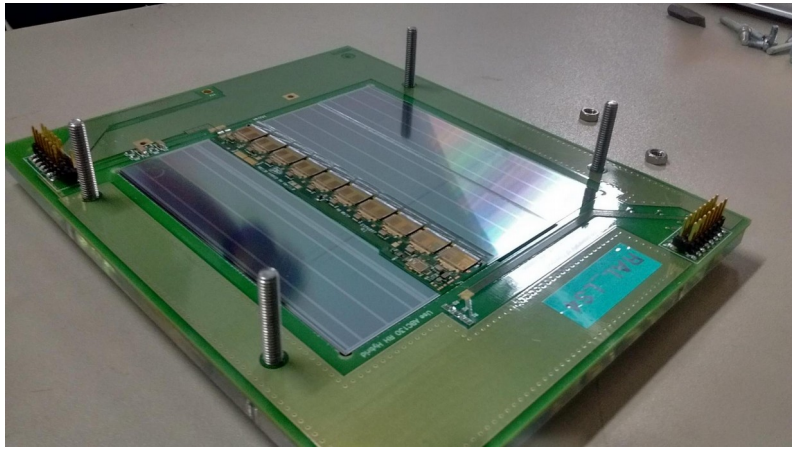




ATLAS ITk Strip Modules

- n^+-in-p float zone silicon sensors, active area ~10x10cm^2, 300µm thickness and 74.5µm strip pitch
- Hybrids glued directly to silicon sensors
- ATLAS Binary read-out Chip (ABC) and Hybrid Controller Chip (HCC) glued and wire-bonded to hybrid
- Module production expected to start in 2020

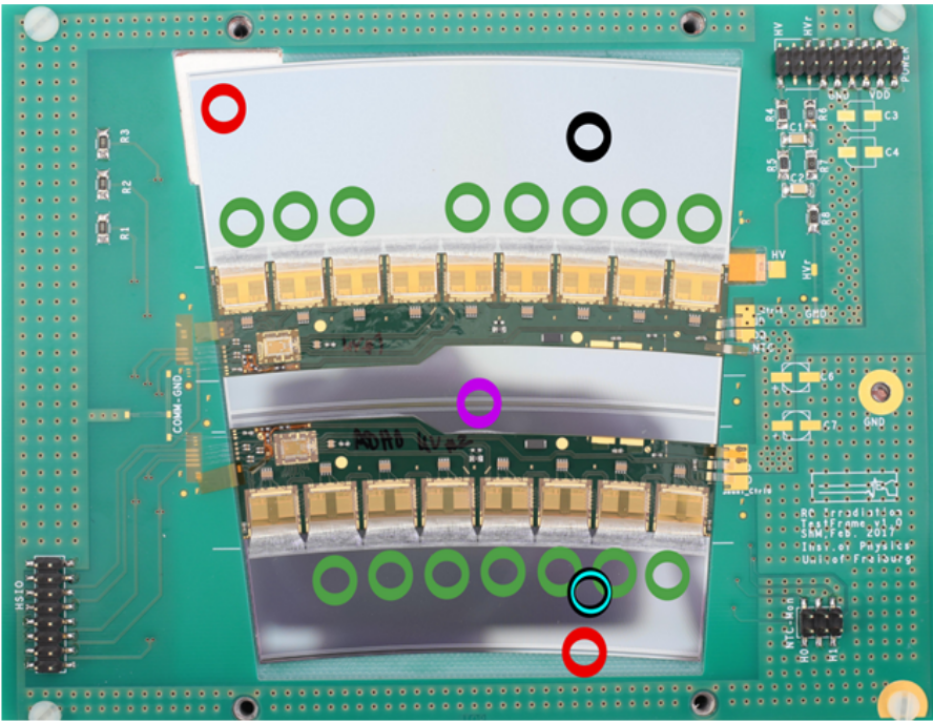




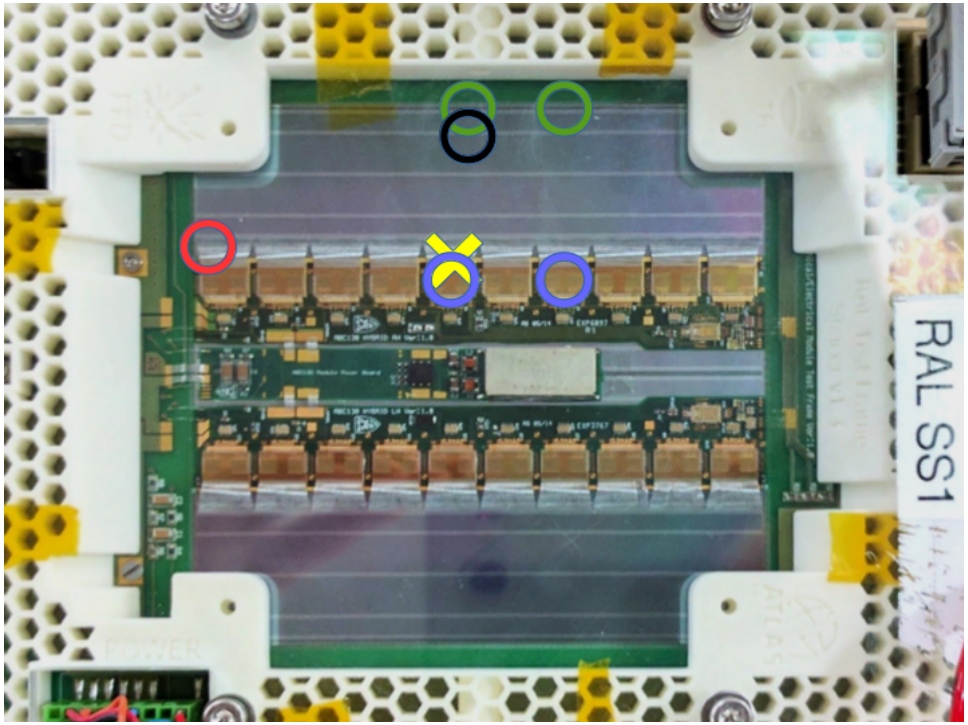
DUTs and Measurement Points

- Inner end-cap module (R0) with radial strips
- Short Strip barrel module (SS) with power board (FEAST chip)

EC R0



Barrel SS

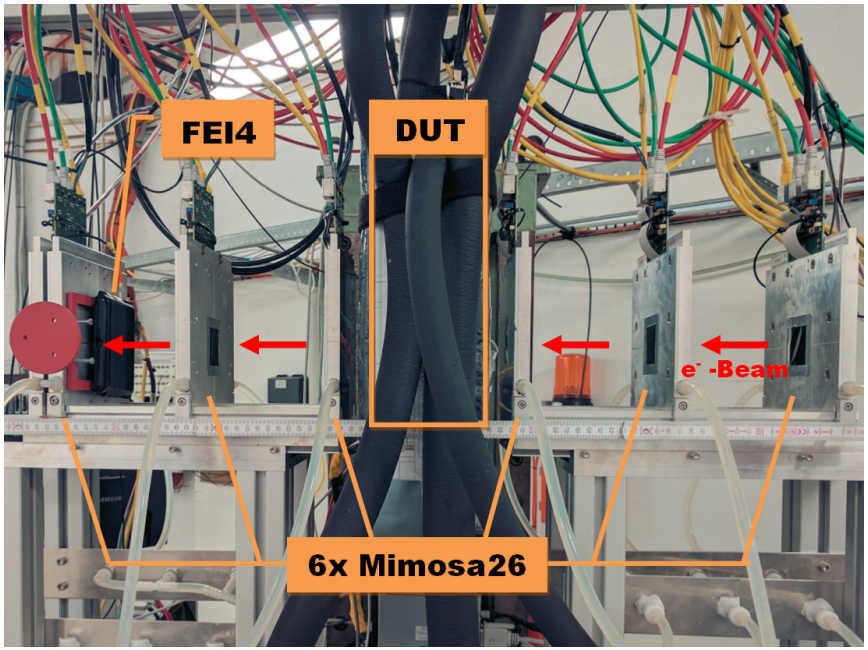


- Lengthy procedure for every DUT

Set-up

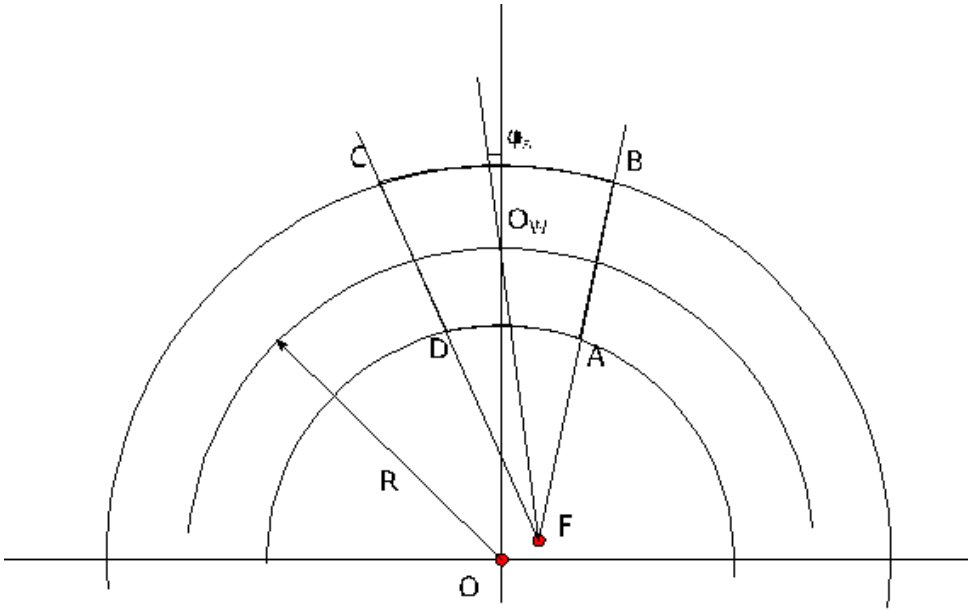
- EUDET-type telescope + FE-I4 plane
- Cooling with Peltier elements + water:

  - we could not reach the target temperature
- Among the first EUDAQ2 users
- Custom EUTelescope with GBL



Radial Reconstruction

- End-cap R0 module has radial strips with rotated annulus shape



- Modifications to GBL code for radial geometry:

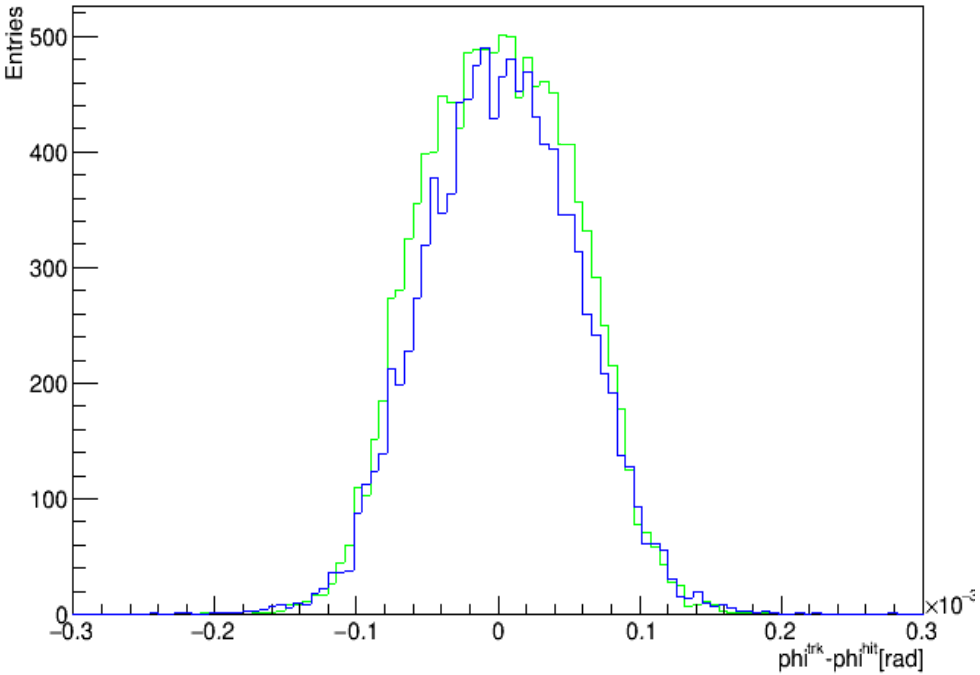
  1) Pattern Recognition: to assign a DUT hit to a track a criterion on the angular distance track/hit is set

  2) Track Fitting/Alignment: the residuals are calculated in radial coordinates

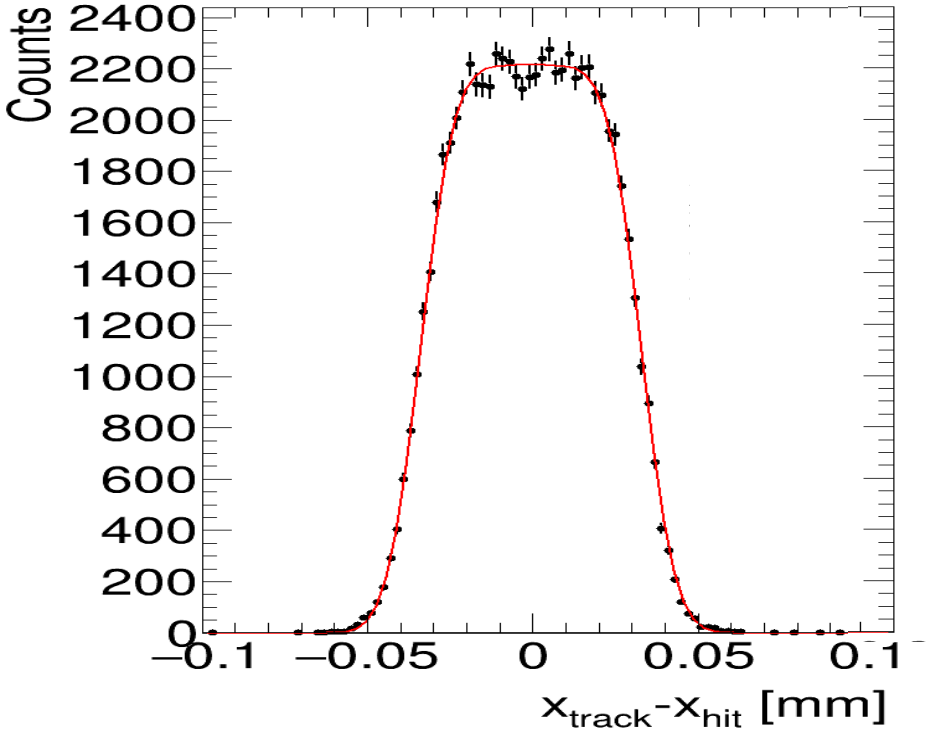
Residuals and Tracking Resolution

- Tracking resolution estimated fitting with smeared error function
- ≈6μm tracking resolution at DESY @ 4.8GeV

EC R0



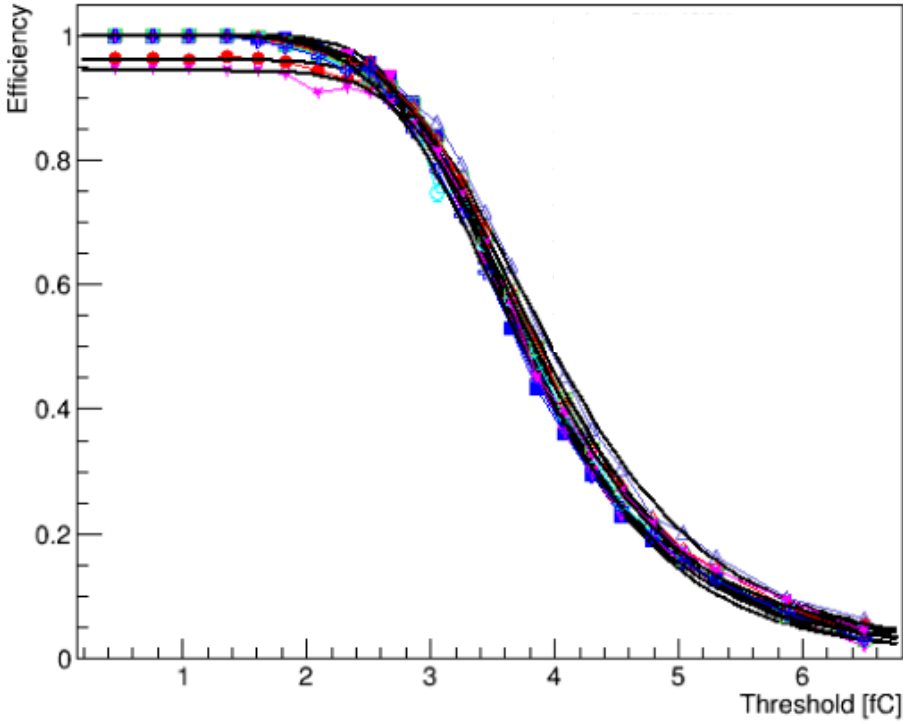
Barrel SS



Efficiency

- Efficiency comparable in all the positions for both DUTs
- Median Charge ≈4fC (25k electrons)
- Fluctuations mainly due to calibration

EC R0



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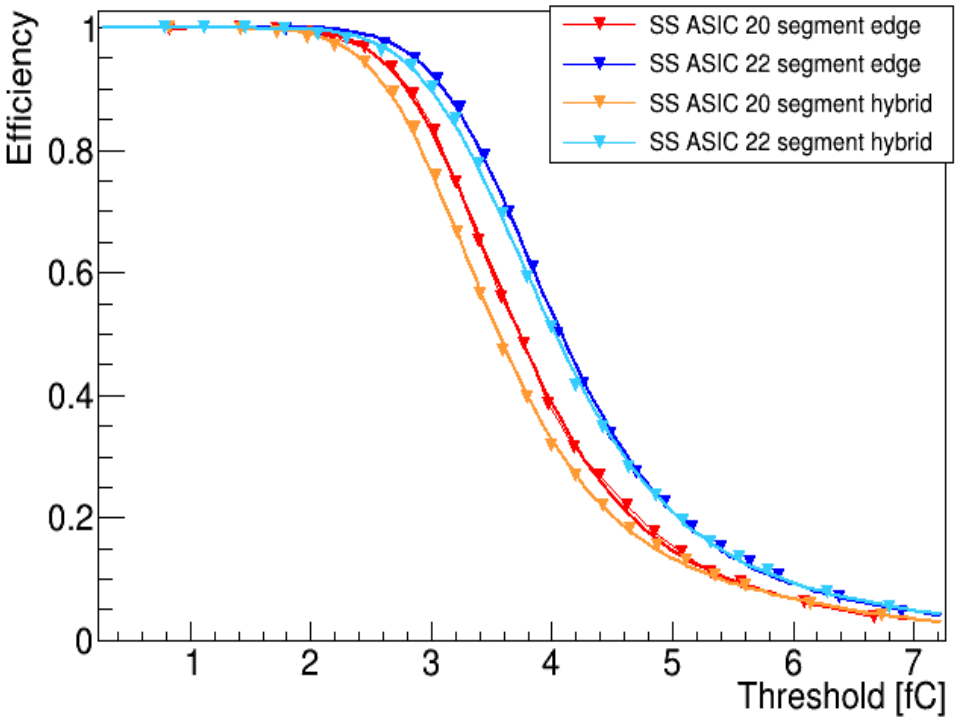
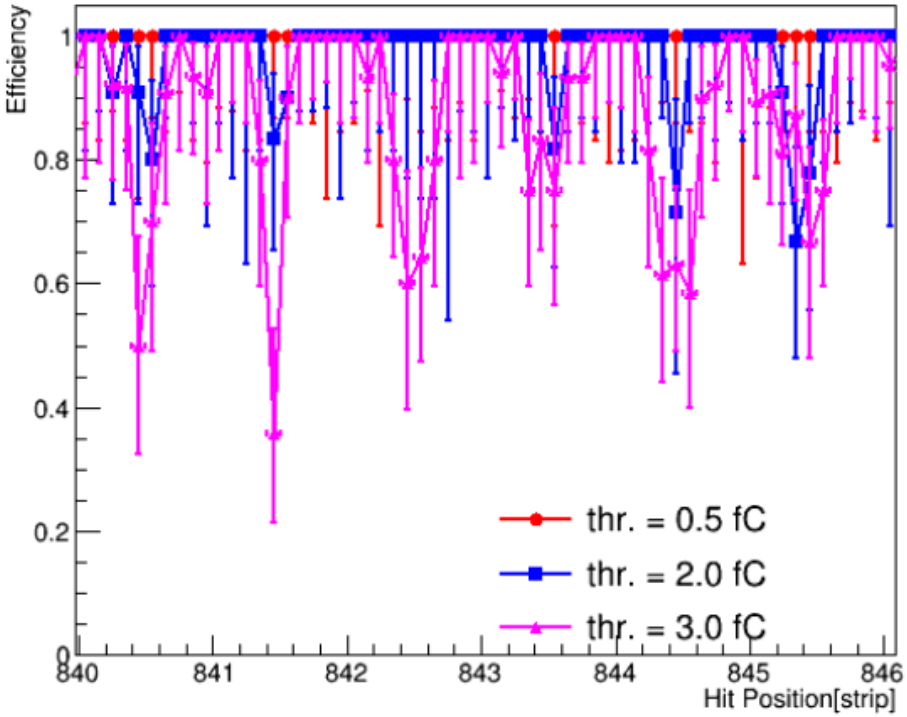
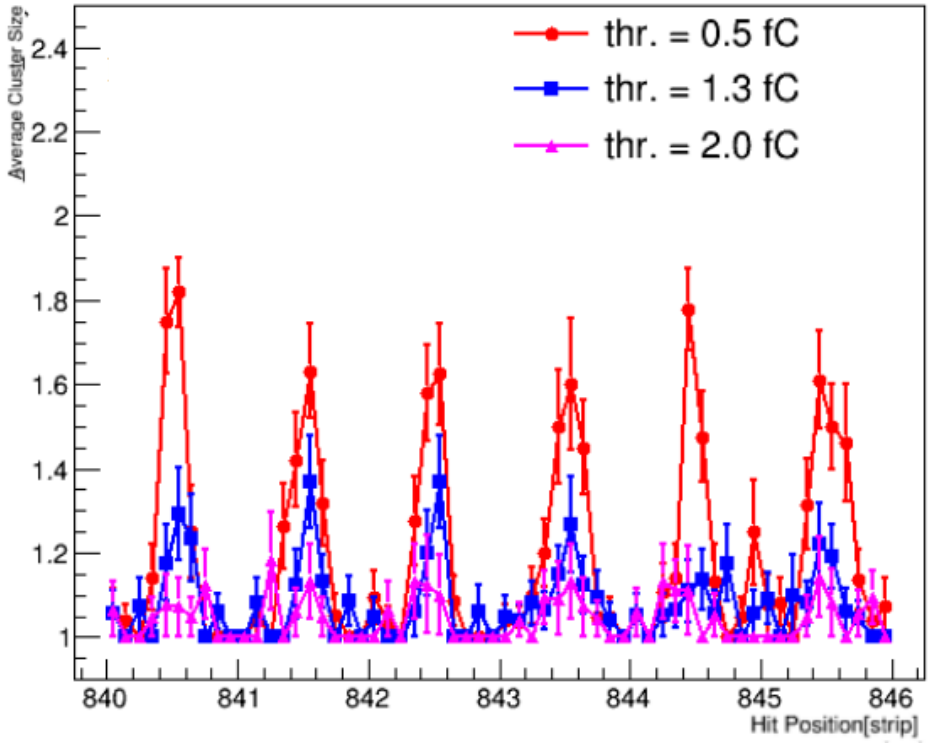


Inter-strip Cluster Size and Efficiency

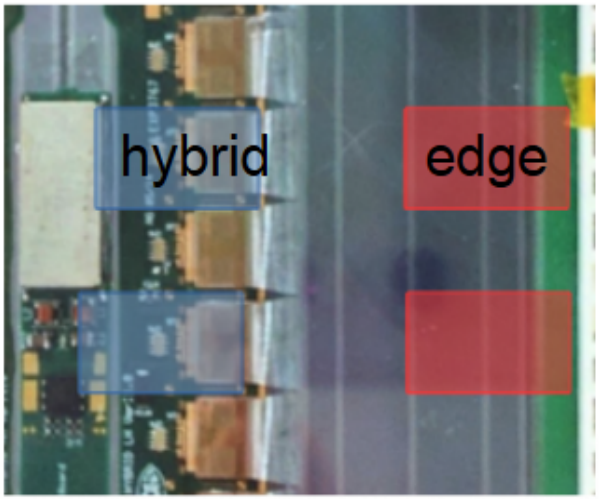
EC R0

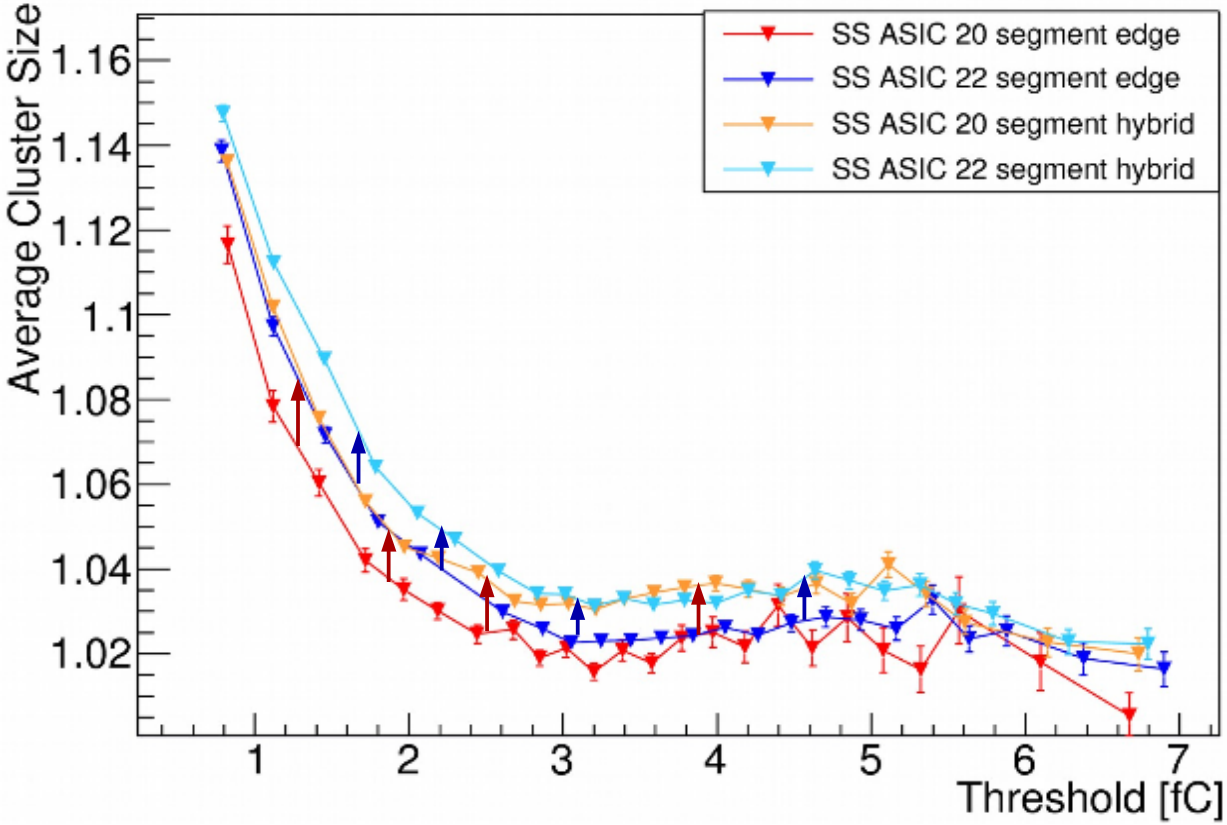




Effect of Hybrid/Glue

- The effects of gluing the hybrid directly on the sensor are not totally know

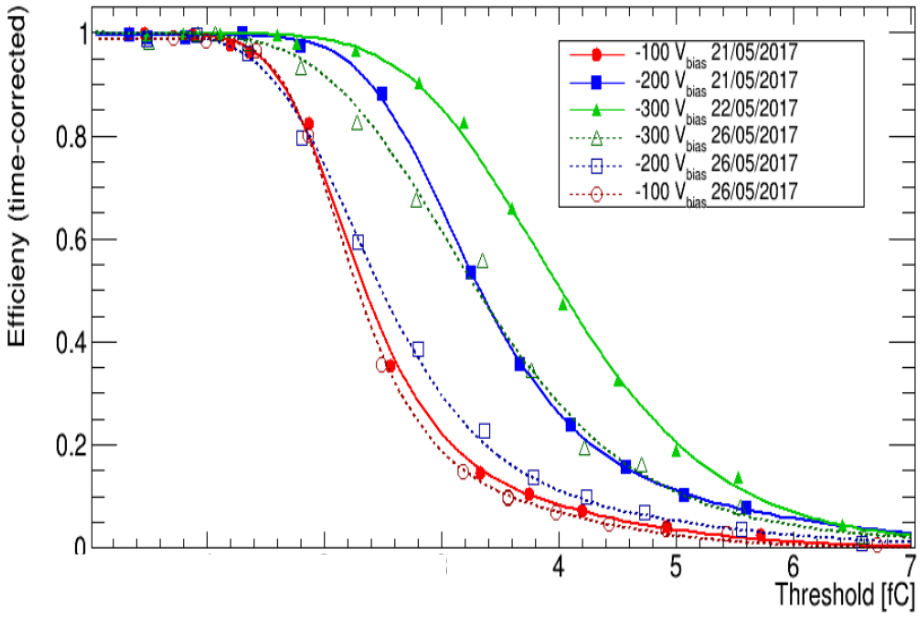


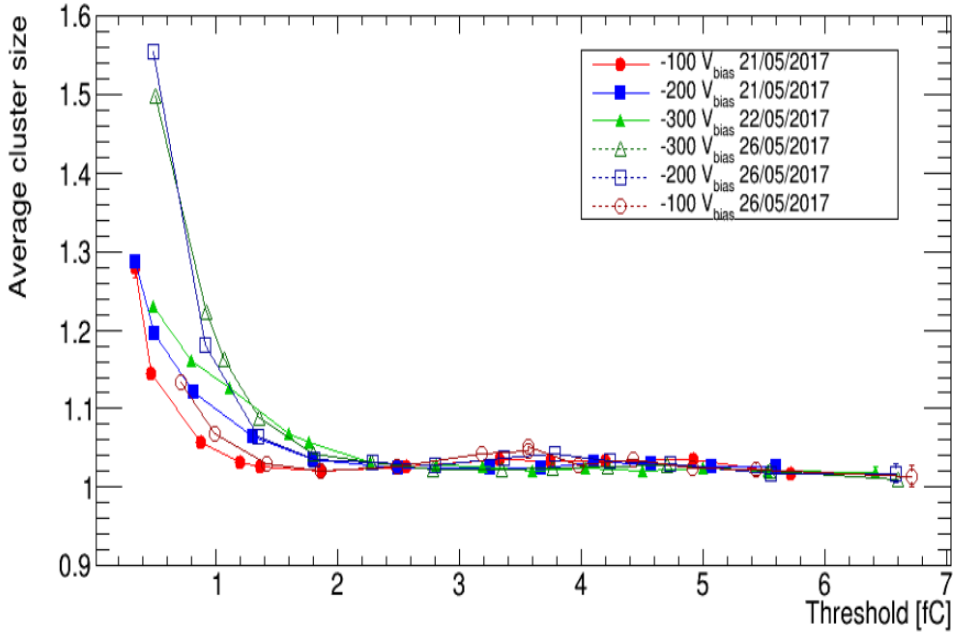


- Small (0.02) increase of cluster size in strips with glue
- Effect on the future operations totally negligible

Long Term Effects

- Probe station measurements found some long term effects over time scales of days, in particular for underbiased sensors (V_{dep}≈300V)
- Threshold scans performed with EC R0 at the beginning of beam time and after ≈5 days of bias at 400V

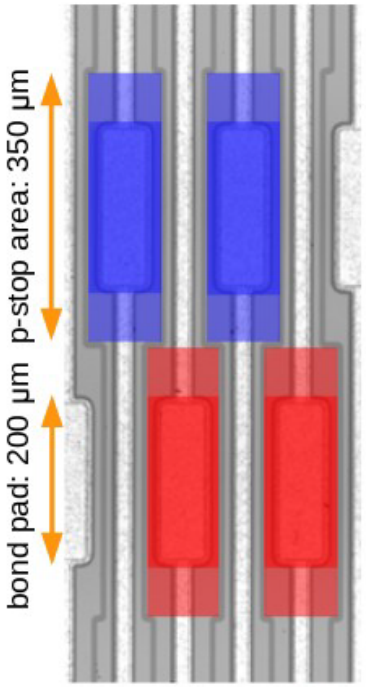


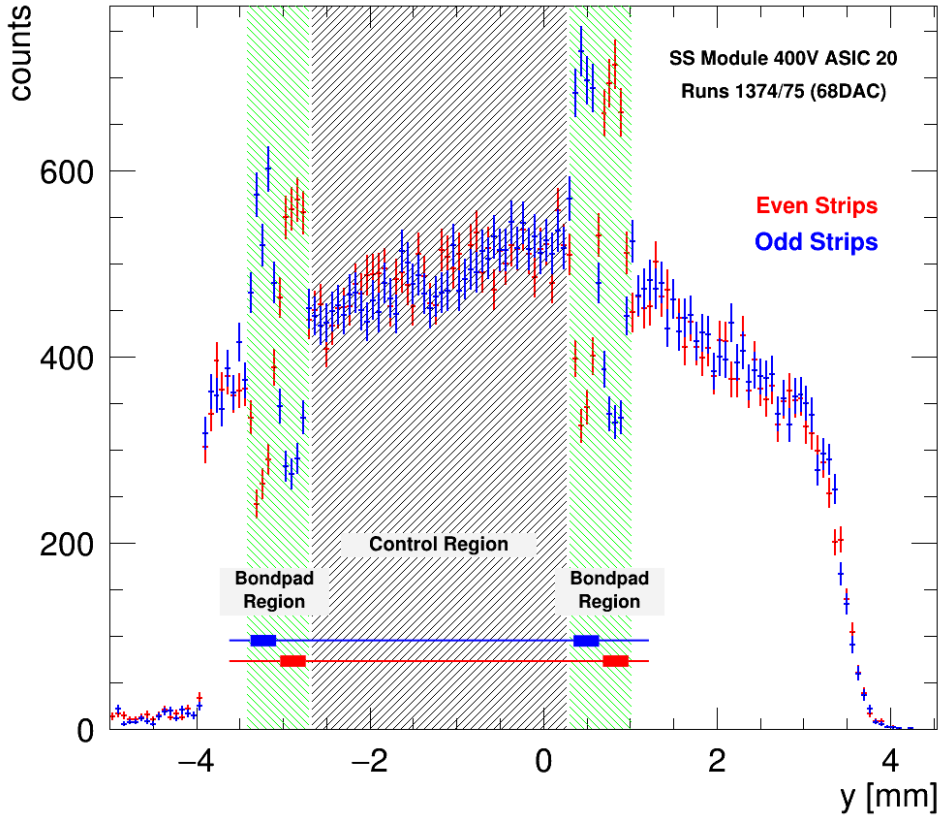


- Collected charge is decreased by more than 10% at 200 and 300V
- Charge sharing visibly increased

Bond Pads/Edge Efficiency

- Bond pads show a clear signature on the direction along the strip





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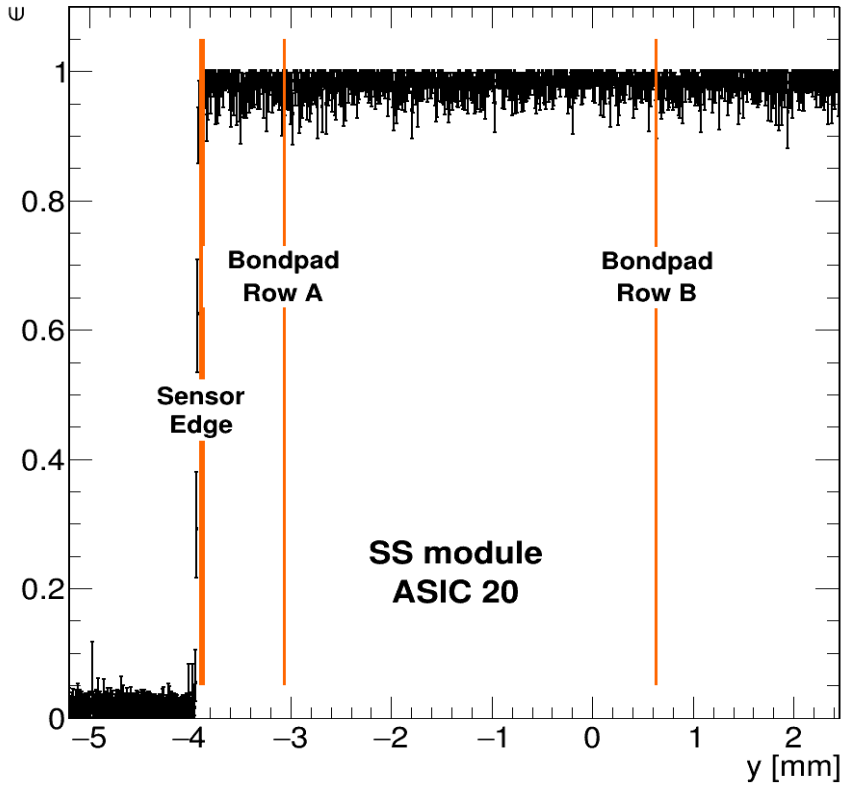
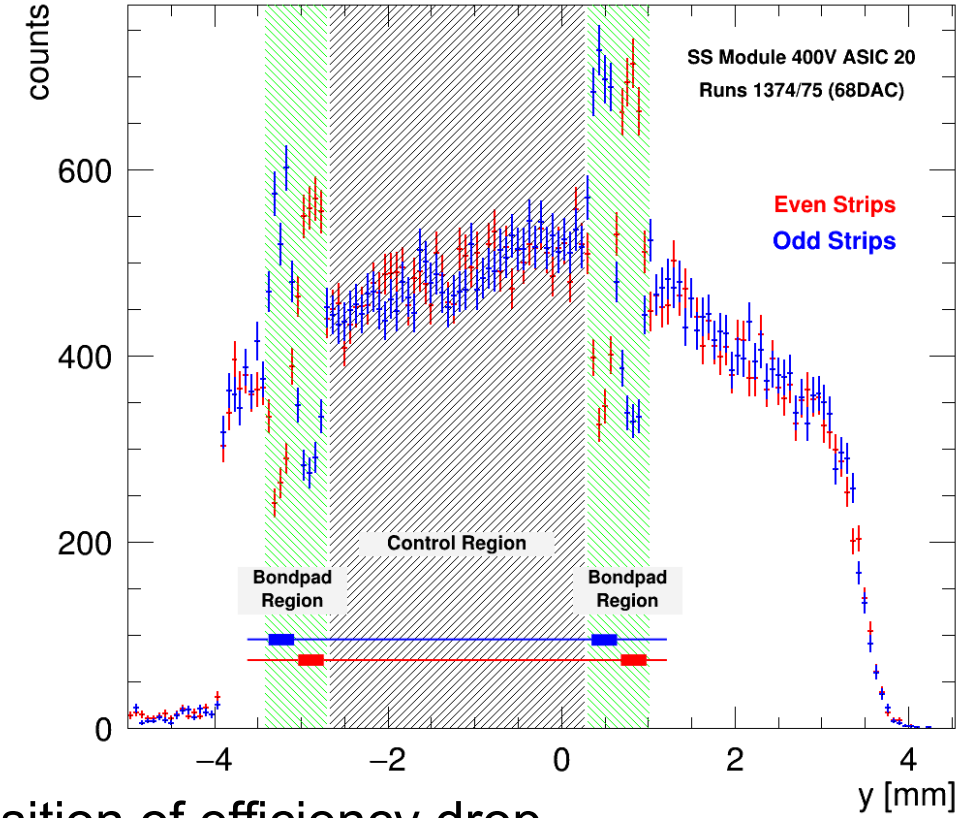




- Very good reference to test the position of efficiency drop

Conclusion

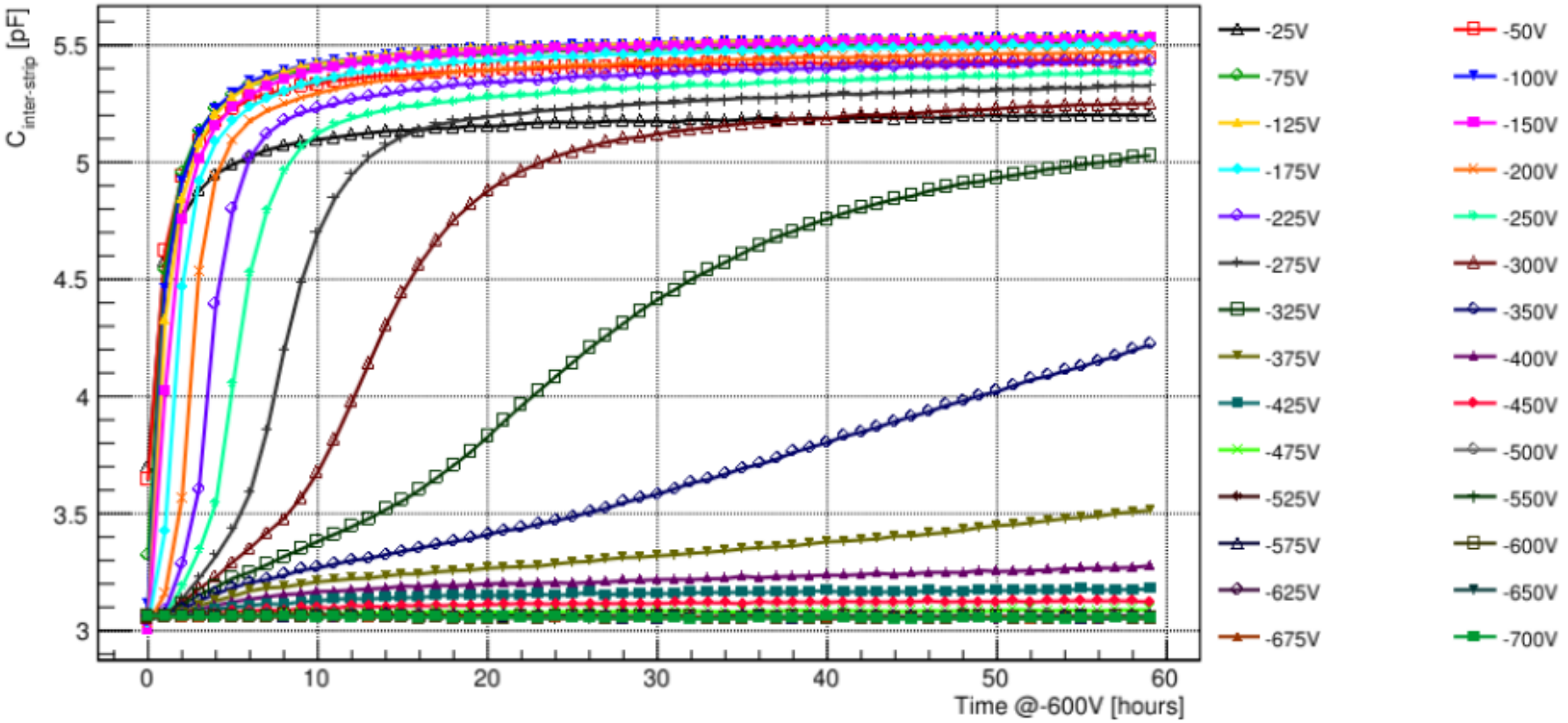
- Performance of the last iteration of prototype modules generally consistent with expectations

- Some effects have to be further investigated

- Plans for 2018:

  - new sensor iteration
  - new FE chip
  - double sided objects

Backup: Probe Station Long Term Effect



Backup: EC R0 Cluster Size