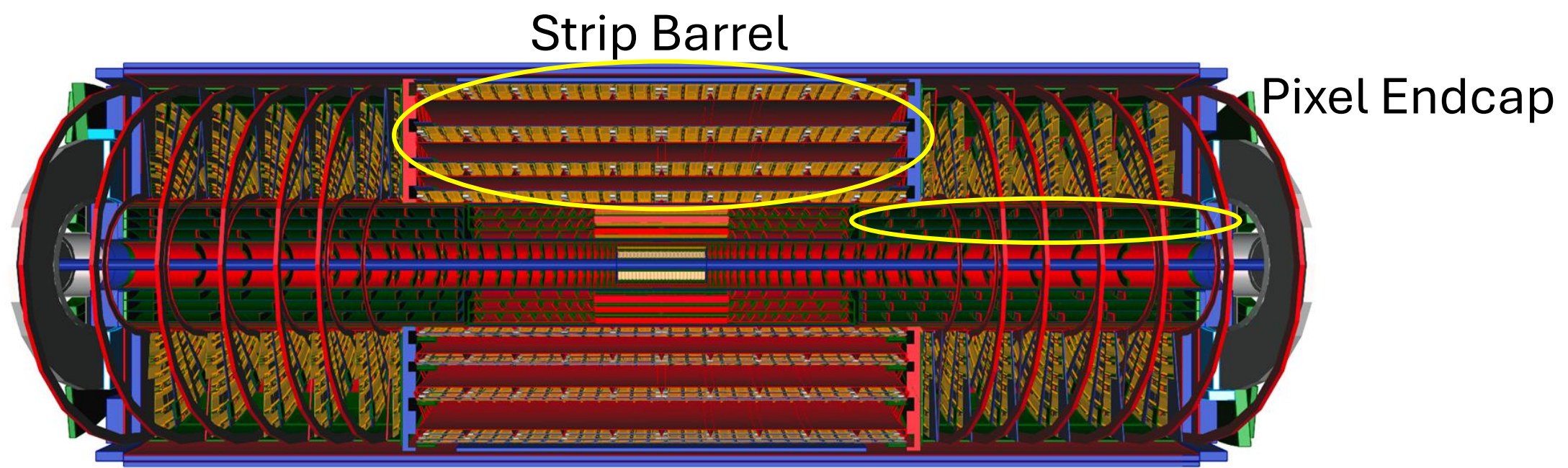


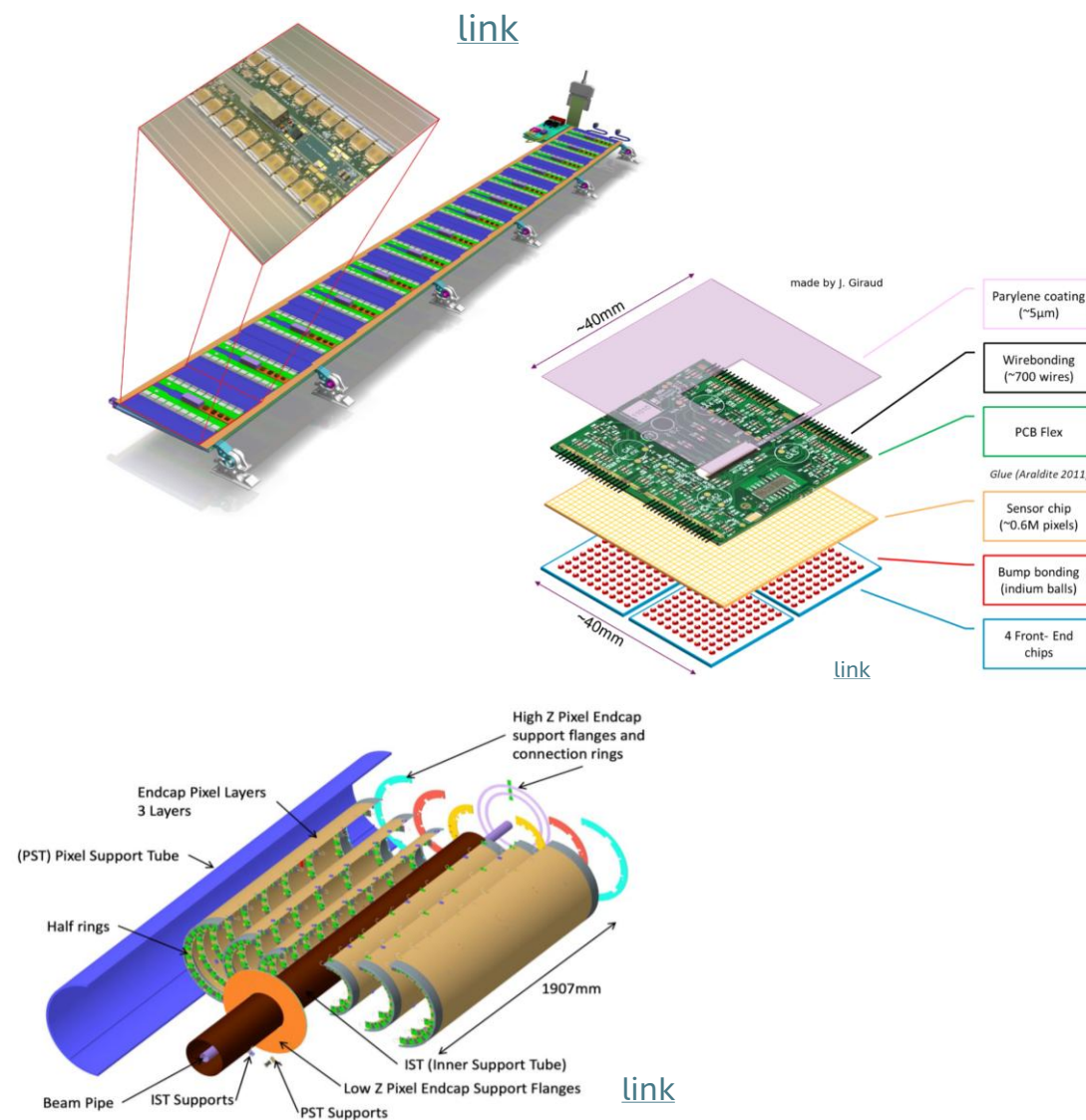


# ATLAS ITk Upgrade



Sven Wonsak on behalf of the team

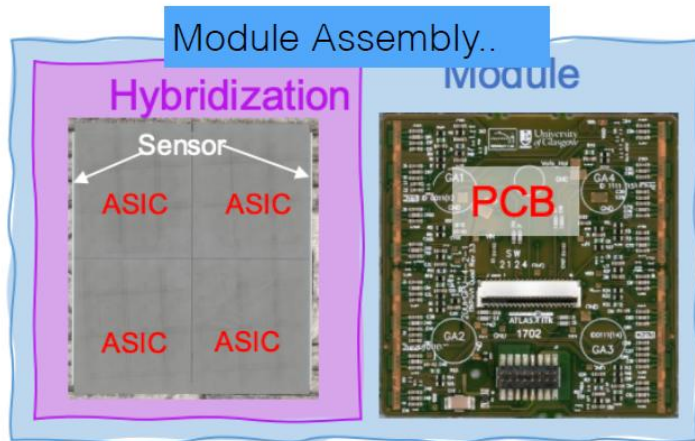
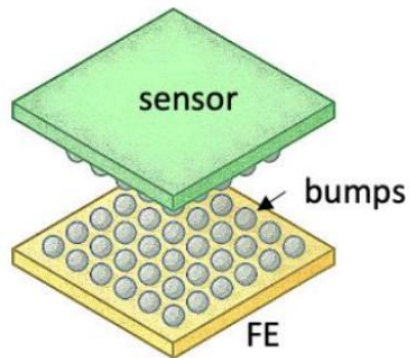
- Helen Hayward (PI, Pixel Endcap co-Ordinator, Pixel Integration UK WPL)
- Tim Jones (Pixel Integration UK WPL)
- Jon Taylor (Pixel Module UK WPL)
- Sven Wonsak (Strip Database Lead)
- David Vazquez
- Engineers:
  - Balint Bogdan (for a few months), Matt Brown, John Carroll, James Coleman-Mills, Ashley Greenall, Carl Metelko, Kieran Bridges
- Technicians
  - Maria Queiroga Bazetto, Andy Bukowski, Liam Boynton, Warren Jones, Tom Lee, Dave Sim, Paul Sinclair, Alex Tongue, Tony Watling
- Academics/RAs:
  - John Anders, Carl Gwilliam, Sergey Burdin, Nikolaos Rompotis
- PhD QT Students:
  - Stephen Randles (finished), Oliver Goodall, Shirsendu Roy
- Regular External Visitors:
  - Graham Miller (Manchester), Lingxin Meng (Lancaster)
- Paul Dervan will be missed.





# Pixel Module Assembly

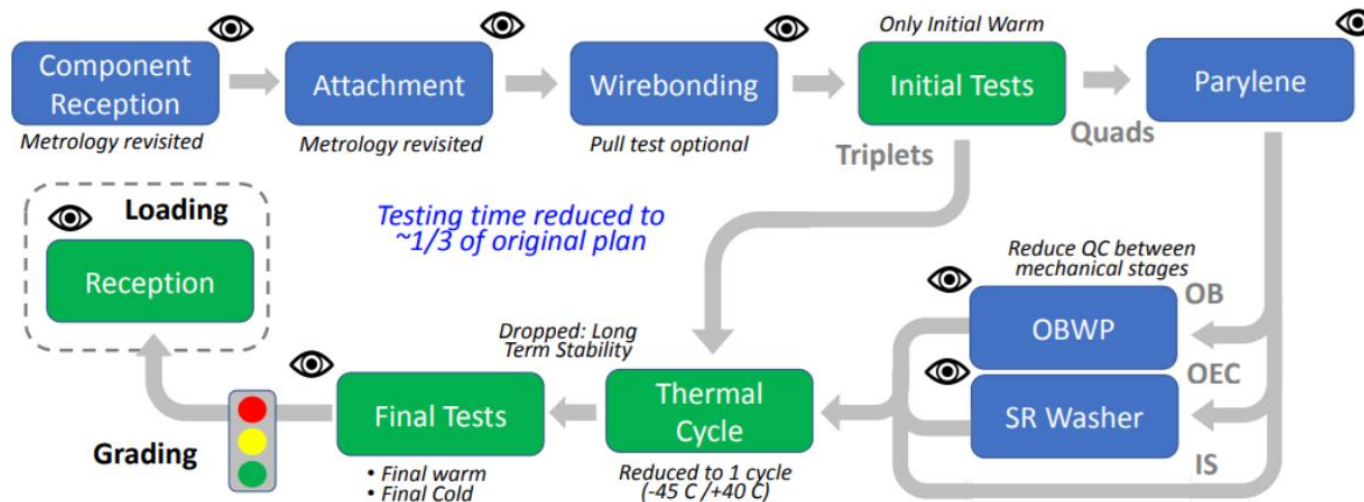
Hybridization in industry



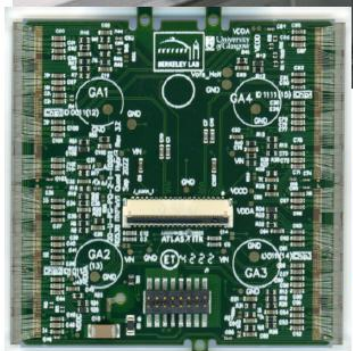
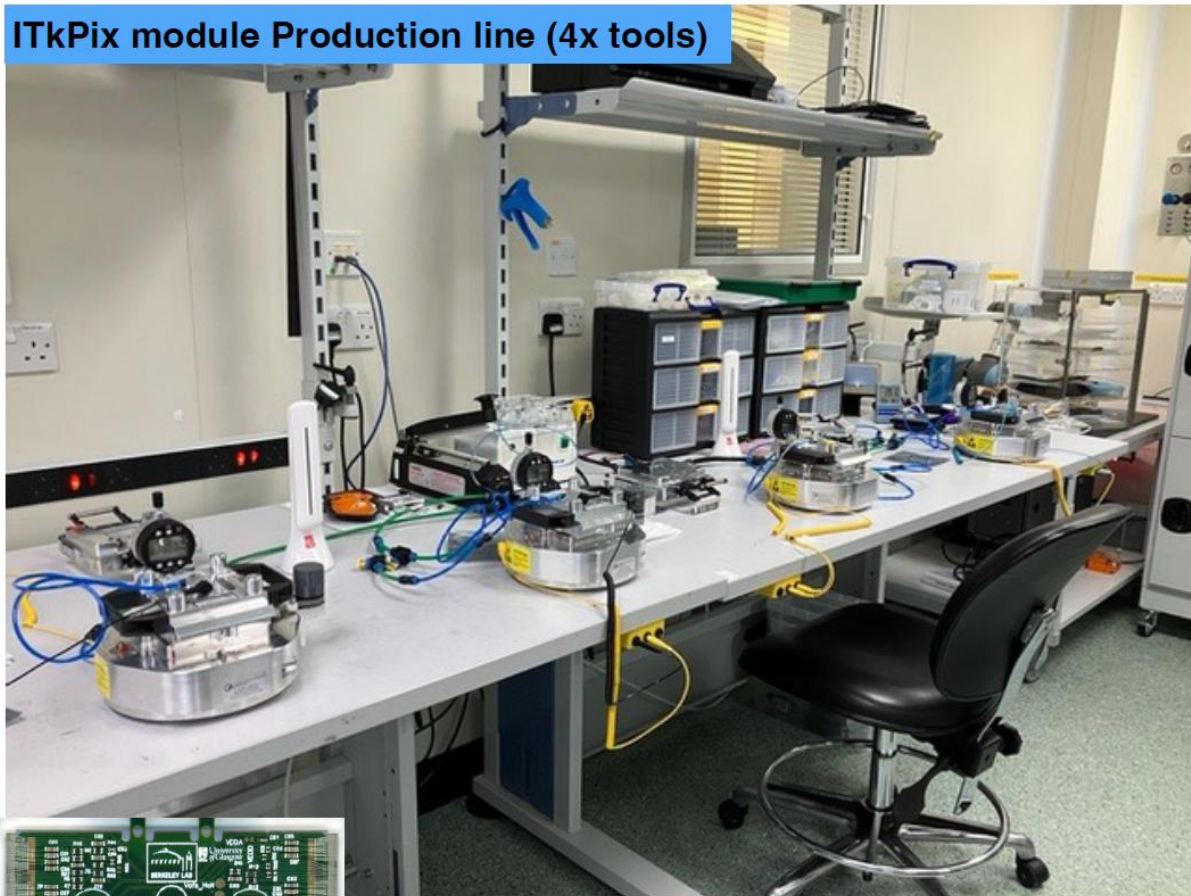
Assembled ITkPix quad module - Liverpool needs to make & test 600!



Updated according to Yield Task Force recommendations

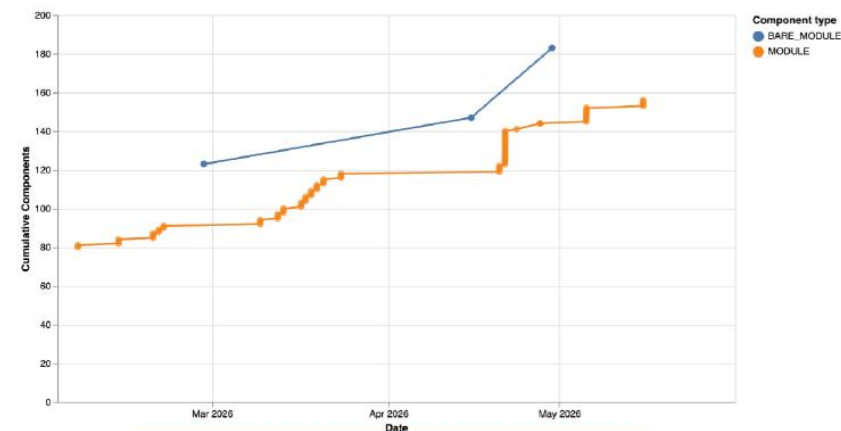


ITkPix module Production line (4x tools)



Assembled ITkPix  
module with wirebonds

- Production is well underway!
- Liverpool has assembled 152 / 600 pixel modules required for the EndCap
- We need to build 8 modules / week to meet our current schedule
- An assembly rate of >10 modules / week has been demonstrated
- Assembly includes the following steps:
  - Reception testing of components (VI, metrology)
  - Gluing of flex PCBs to silicon
  - QC of assembled modules (VI, metrology)
  - Wire-bonding and pull tests
  - Parylene masking, coating and de-masking



<https://itk-flask.web.cern.ch/>

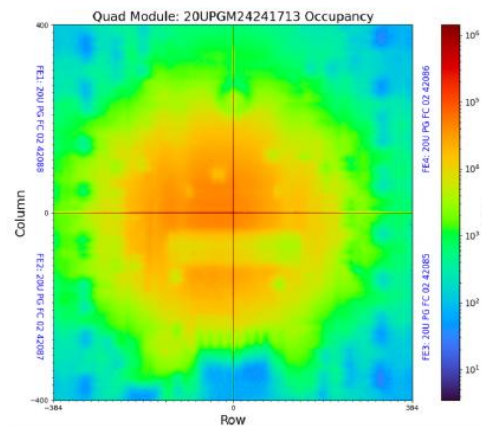
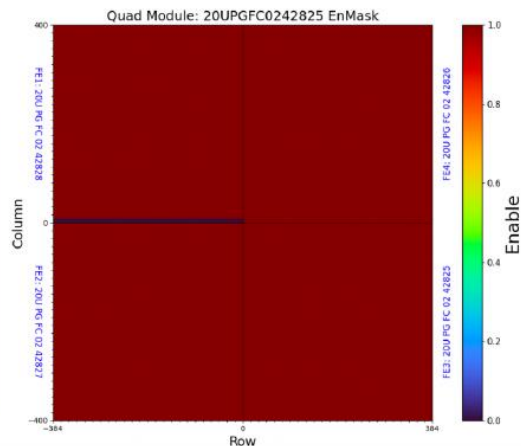


- Pixel modules planned to be tested in batches of four (need to build and test ~8 / week)
- Testing line currently running at 75% (3/4 test stands operational)
- Ramp up to 100% in the near future with additional computing resources
- A testing rate of 10 modules / week has been demonstrated
- Tests include the following steps:
  - Electrical characterisation at room temp. (repeated 3 times after different stages)
  - 10x thermal cycles from -45deg. to +25deg.
  - Electrical characterisation at -15deg. including source scans
- **Yield for last batch of 27 modules ~78% (ITk requires 72%)**

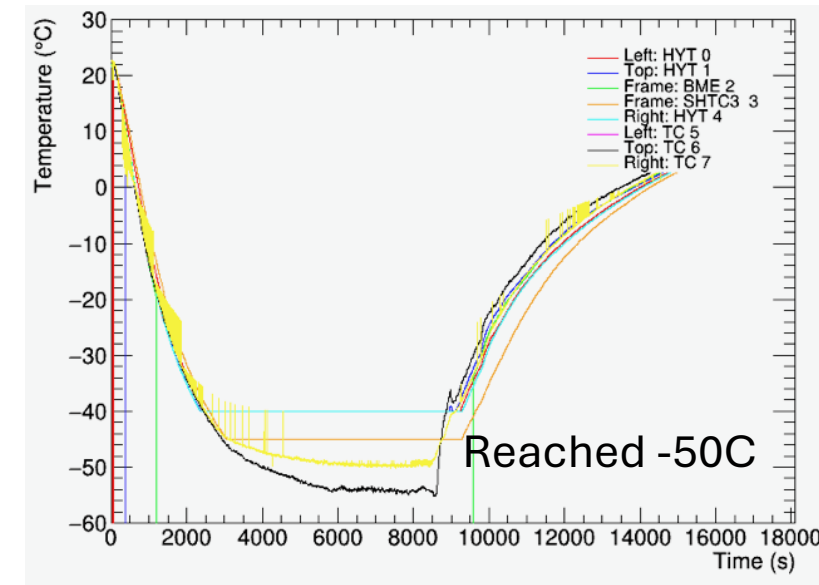
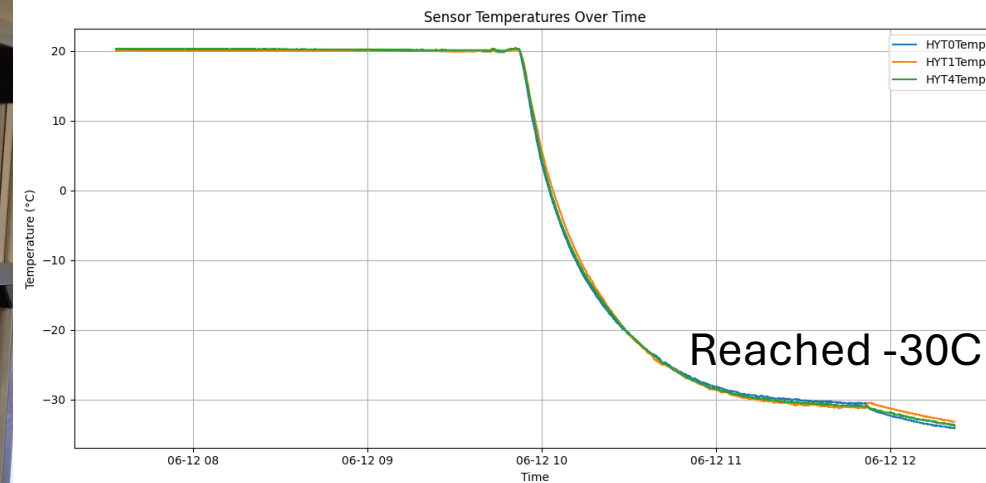
ITkPix module testing line (4x test stands)



Modules with low amounts of disabled 'core-columns' still pass QC



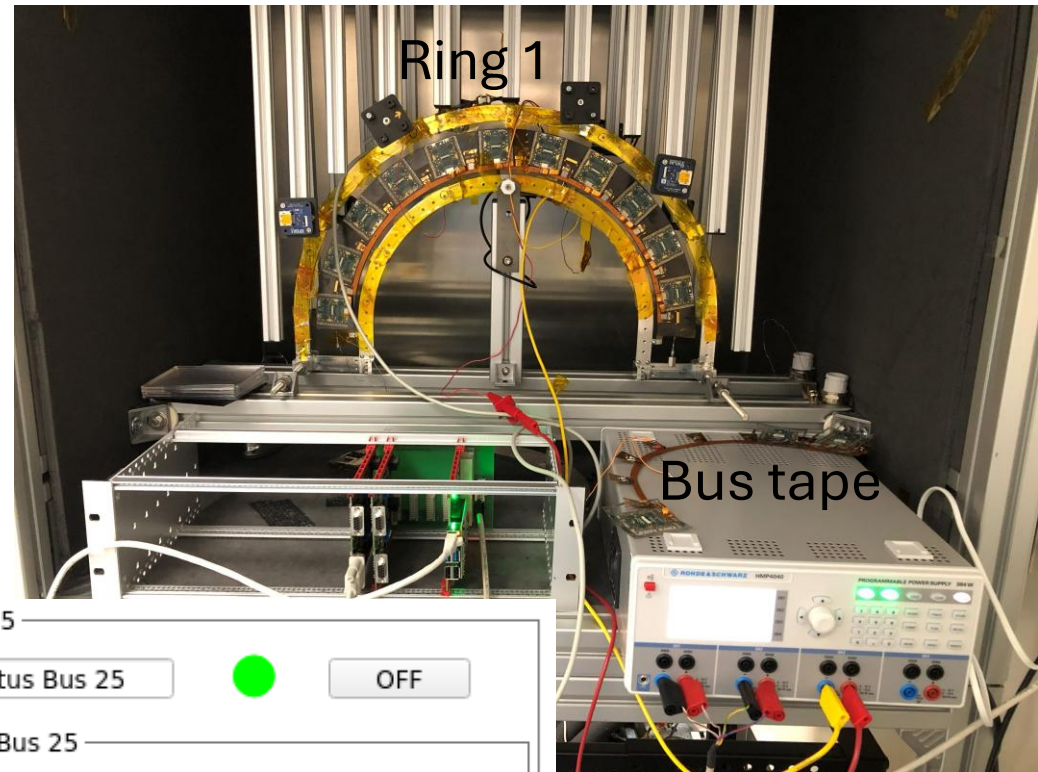
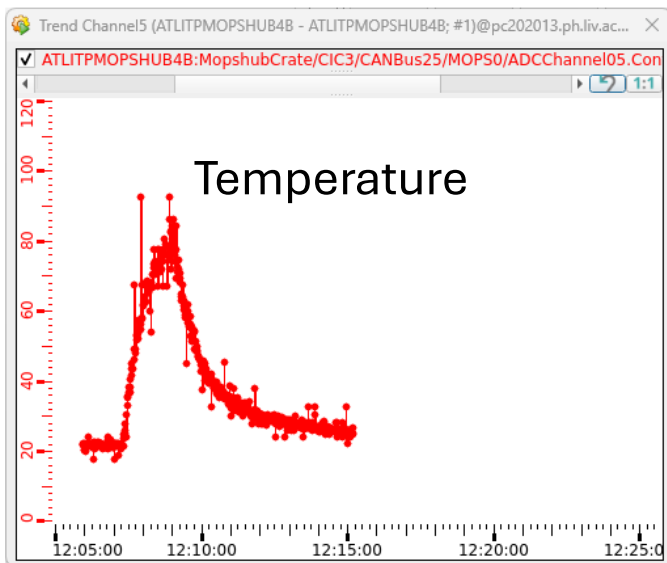
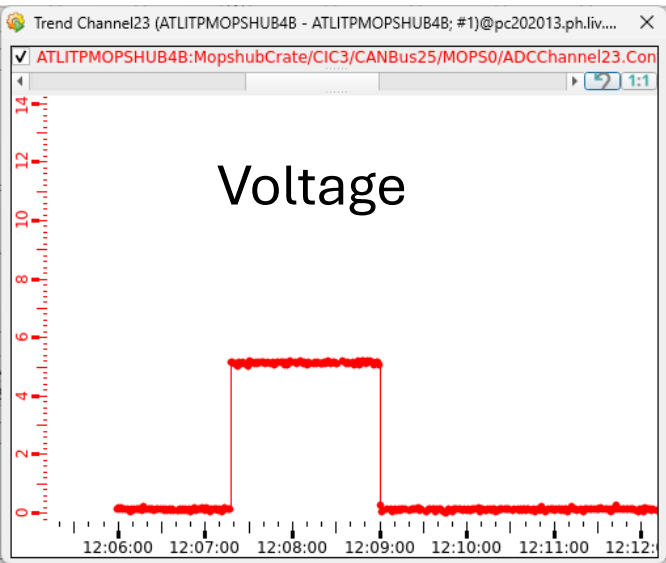
Sr90 source scan to check for disconnected bumps



- First tries of cooling down reached  $-30^{\circ}\text{C}$   $\rightarrow$  added insulation to test box helped to lower T
- Managed to thermal cycle Ring 1 down to  $-50^{\circ}\text{C}$
- Data on modules show same performance before and after the cycling



# Pixel Outer Endcap Integration



- Liverpool is configuring DCS monitoring for Integration
- Managed to readout similar setup than Ring 1
- Finished tests with Ring 1
- Testing more recent bus tapes
- Ring 2 will arrive at Liverpool sometime soon

CAN Bus 25

Power Status Bus 25 ● OFF

---

ADC CANBus 25

Vmon[V]	Imon[A]	VCAN[V]	TEMP[°C]	-
0.958	6.371	0.953	25.93	-

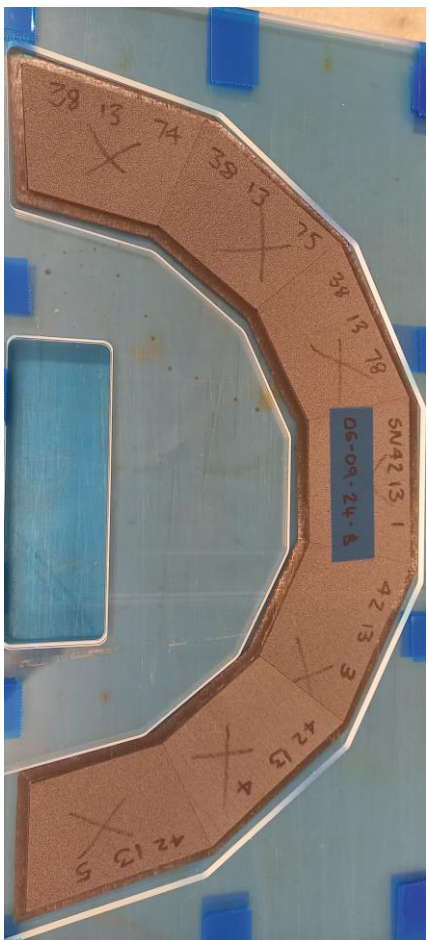
---

Connected MOPS

<span style="color: green;">●</span>	MOPS	<span style="color: purple;">●</span>	MOPS
<span style="color: purple;">●</span>	MOPS	<span style="color: purple;">●</span>	MOPS



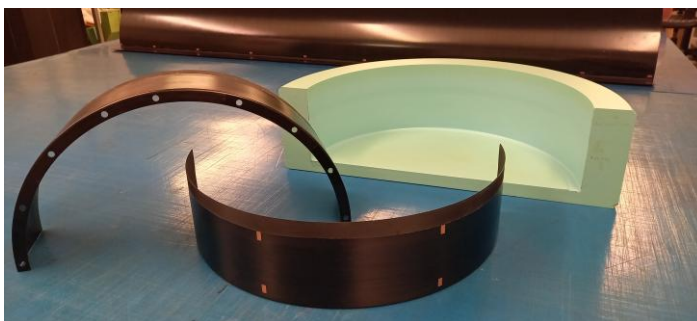
# AML ATLAS Upgrade Activities



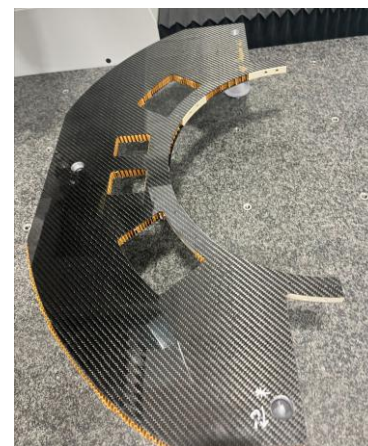
Pixel Half-Sandwich: co-cure foam trapezoids onto CF  
46 L3 HS assembled to date



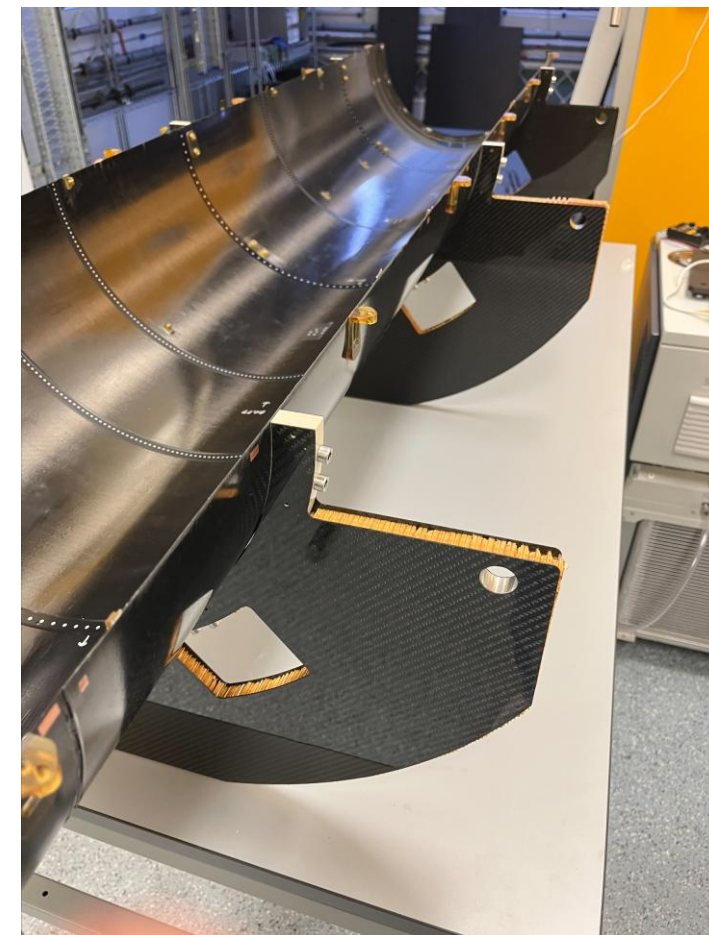
## Pixel Endcap Half-Cylinder



## Half-Cylinder end flange and mould



## Radial Support



## Half-Cylinder with End Flanges and Radial Support

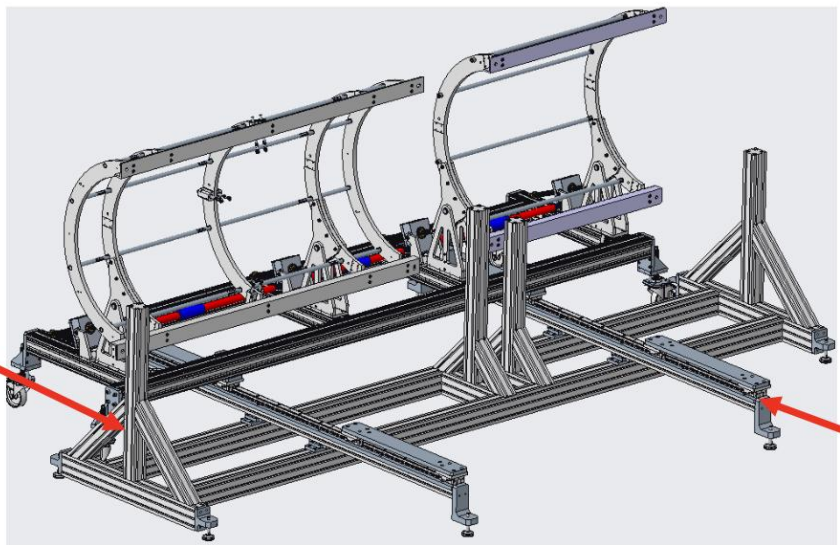


## Pixel Integration Overview

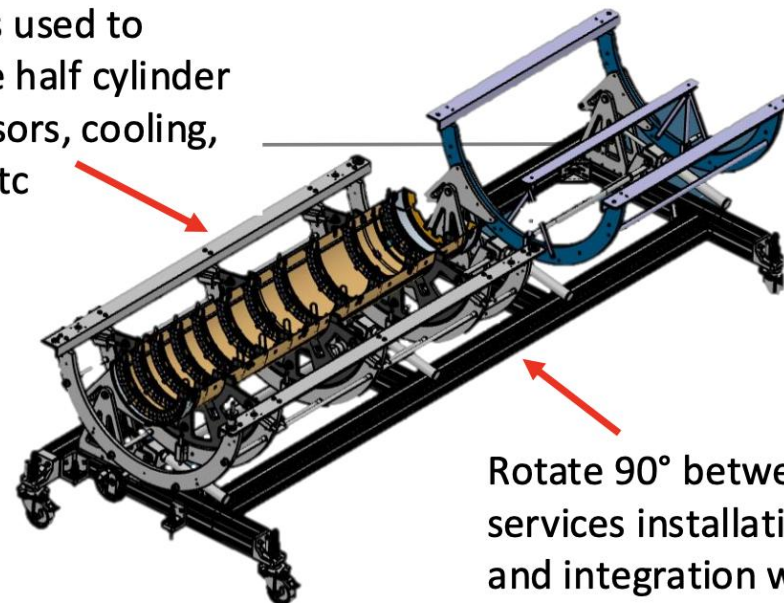
- Integration tooling made up of 3 main components

- Detector trolley
- 'C' trolleys
- Rail assemblies

Detector trolley used to build up half cylinders around



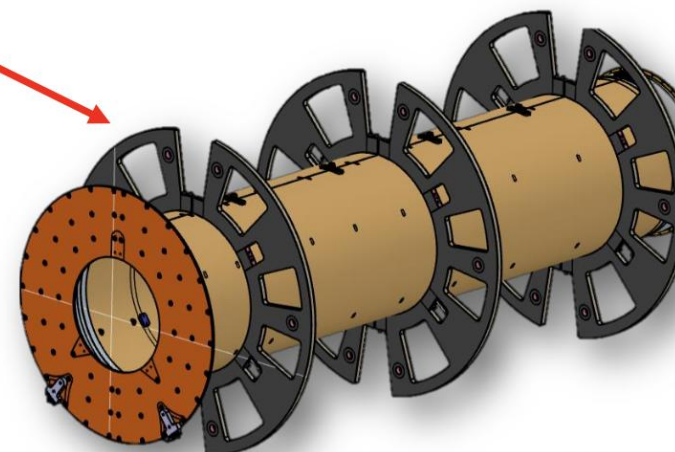
C trolleys used to assemble half cylinder with sensors, cooling, cabling etc



Rotate 90° between services installation and integration with matching pair

Complete layer of 2 half cylinders

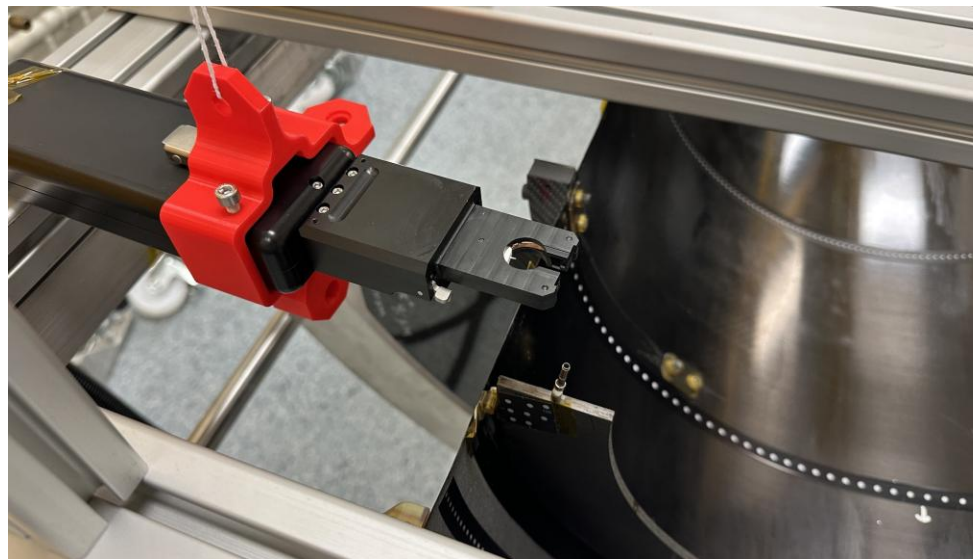
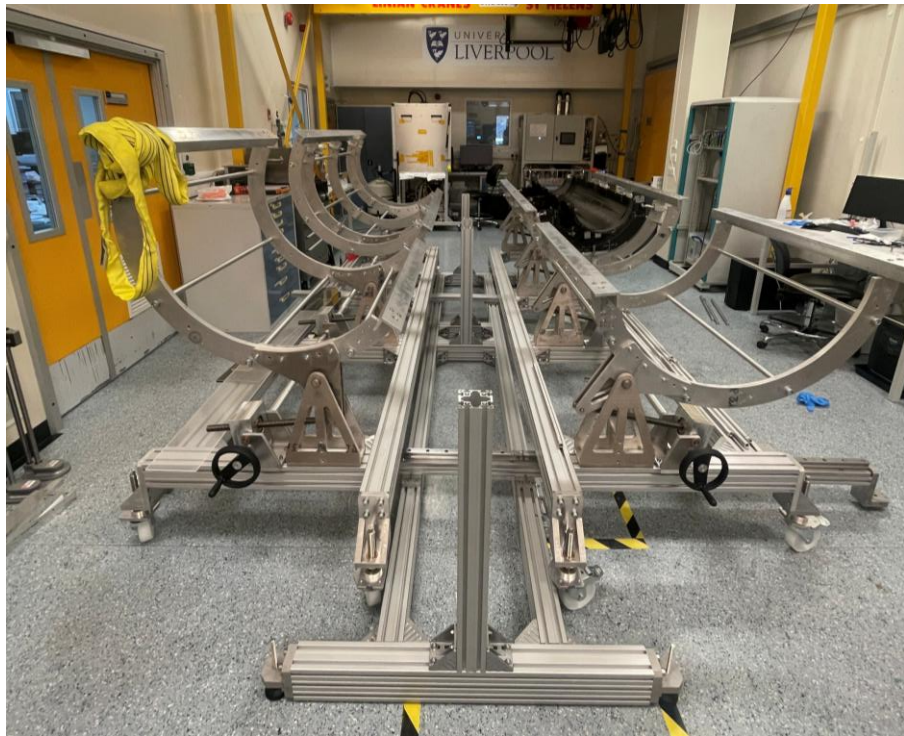
Bosch rails to allow C trolleys to slide into final mounting position





# Integration - status

- 'C' trolleys are fully assembled
- Rails commissioned
- Central trolley being refined to ensure accurate and repeatable mating
- Working with Sheffield and Milan on welding strategy



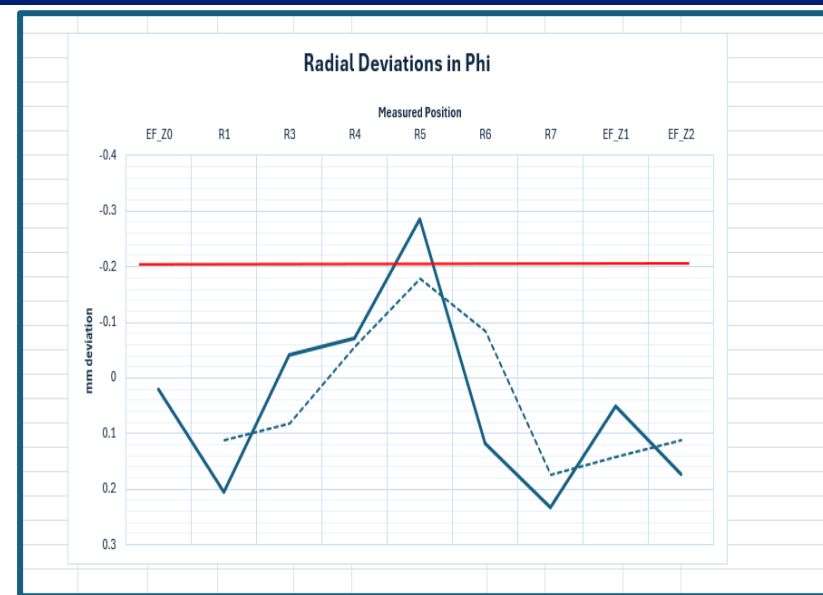
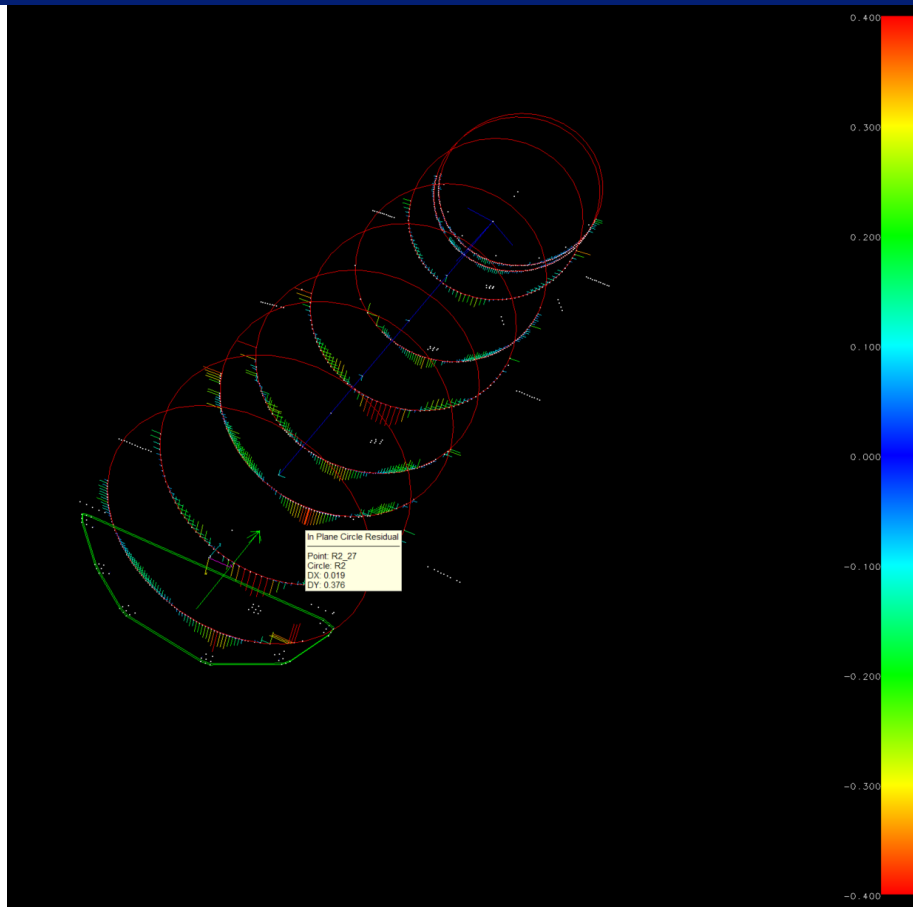
- We have completed a ½ size test box to thermal cycle a half-cylinder down to -55°C for QA
- Preparing a full size box to fit a loaded HC on a cradle



# Pixel Endcap Assembly



Detector cylinder in integration tooling for photogrammetry (above) and to the right the photogrammetry data reconstruction of the cylinder in V-stars software



V-stars data graphically represented in Excel

Atlas- QC metrology of the cylinder using photogrammetry from V-star. Ensuring compliance with the technical drawings. In progress, preliminary results show promising results demonstrating a highly accurate build and excellent repeatability for the next iterations to a tolerance of 50um.

In January 2026 we completed the advanced feature training and can now monitor changes to the geometry of the assembly, reconstruct the cylinder and track non-conformities.

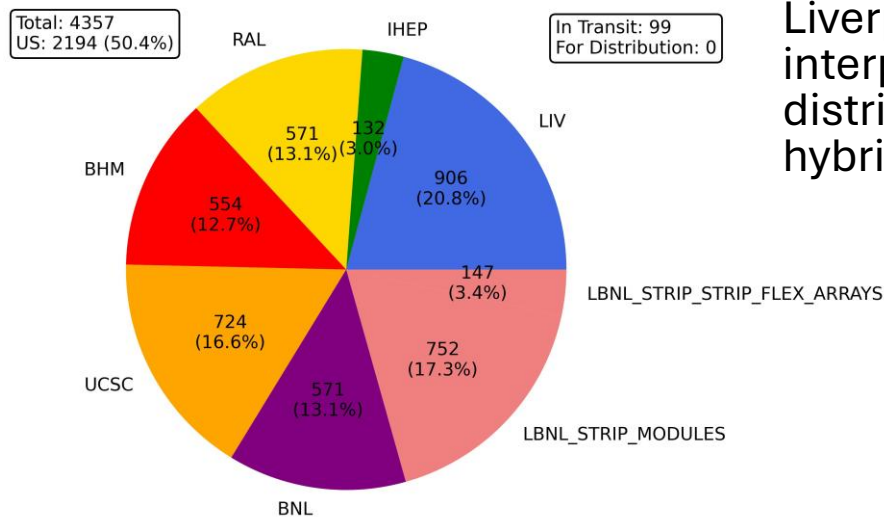


Warren approves!



- Liverpool is reception and QC site for all barrel hybrid flexes
  - Total ~15000 hybrids installed in two flavours (X & Y)
- Workflow:
  - Bare flexes arrive in Liverpool
  - Production Database registration and initial QC (pull tests, thickness, stretch/shrinkage, Test coupon reflow)
  - SMD population with UK vendor
  - After reception, PCB cleaning
  - Interposing of circuits
  - Distribution (US, other UK hybrid assembly sites)
- We assemble hybrids for Glasgow, Sheffield and Liverpool
  - ASIC gluing
  - Wire-bonding of ASICs
  - Burn-In Test

Interposed X Flex Distribution

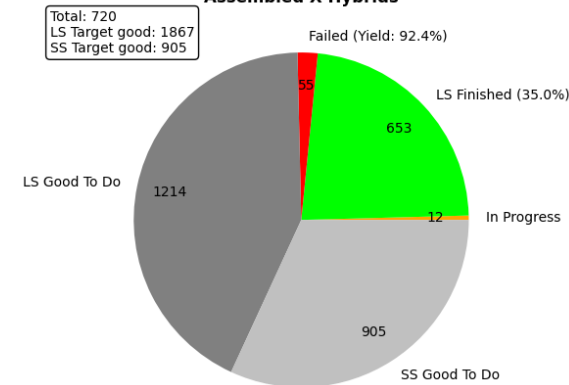


Liverpool has interposed and distributed ~4500 hybrid flexes



Crate with 20 hybrid panels, each holding 6 hybrids

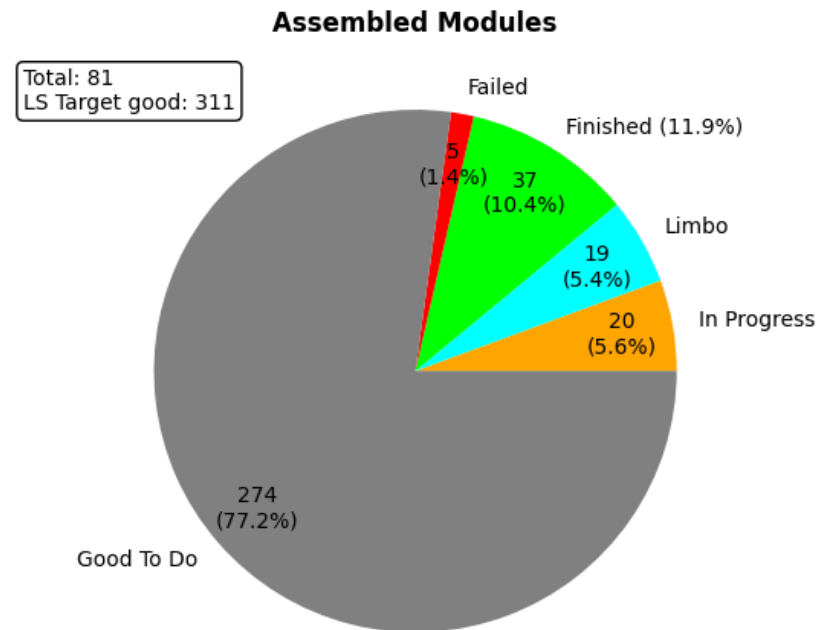
Assembled X Hybrids



653 hybrids assembled and distributed (35% of LS target)



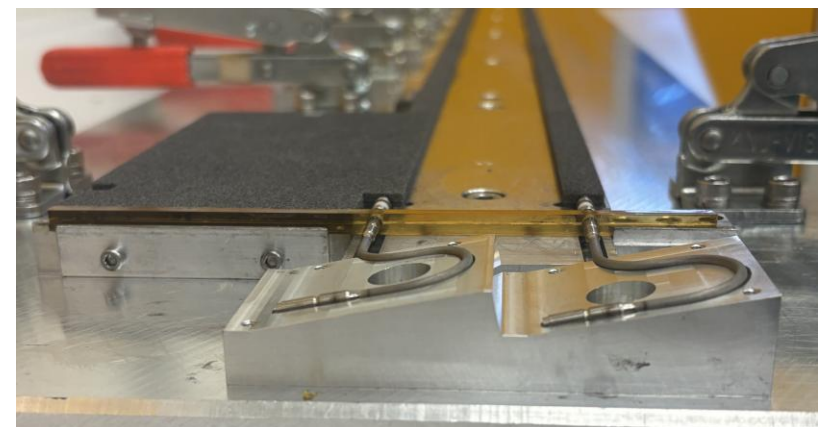
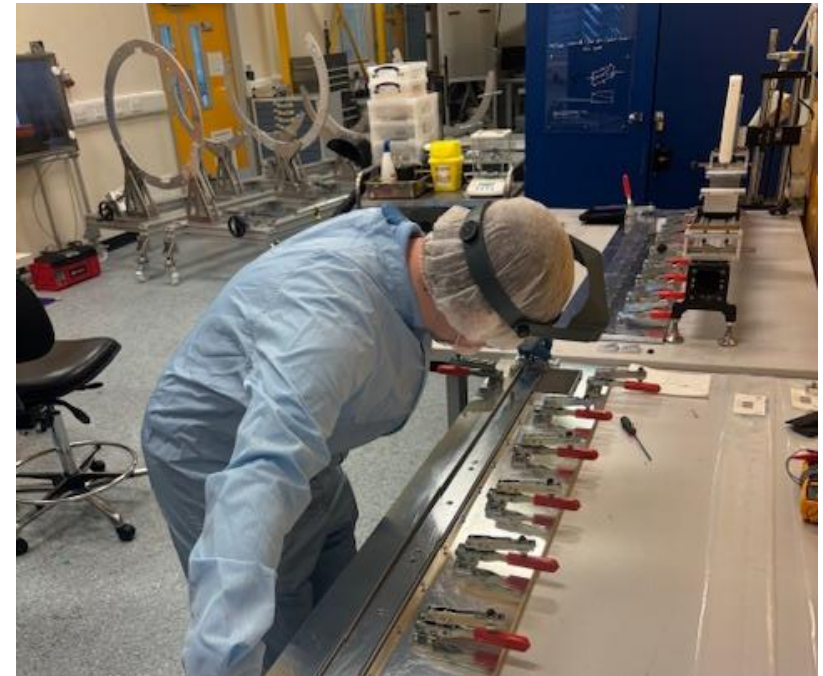
- For integration purposed, build Strip Barrel from outside to inside
  - Start with LS modules (only X hybrid) and then switch to SS modules (X & Y hybrid)
- Liverpool module assembly is at lower rate compared to other UK sites because of our work with flex hybrids
  - We will not build SS modules because each SS module requires 2 hybrids
- Since earlier this year our thermal cycling box is in operation
  - Backlog of tests removed





- **Cooling Loob Sub-assembly**

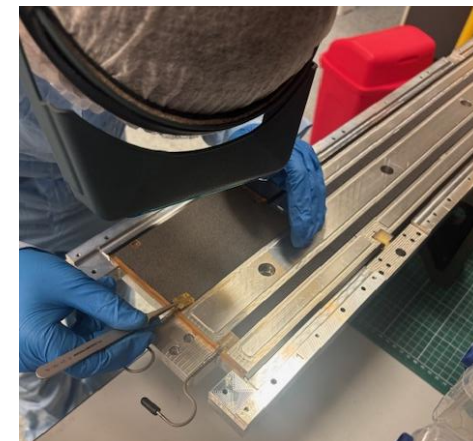
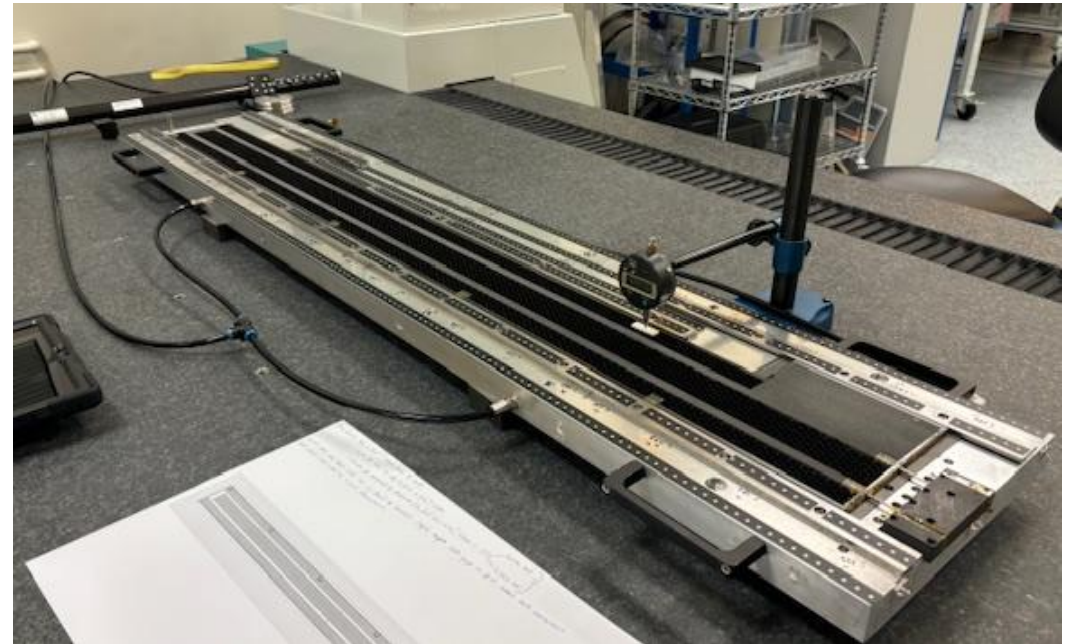
- Liverpool has continued producing production grade cooling loop assemblies. This means the loops leaving Liverpool are destined to be used in production grade cores, ultimately ending up in ATLAS !
- Even though we are continuing to build production cooling loop assemblies, we continue to adapt the procedure and tooling to improve the finished assembly.
- Liverpool have built 65 production loops out of 200. Liverpool's build rate has increased however we are still limited by part availability.





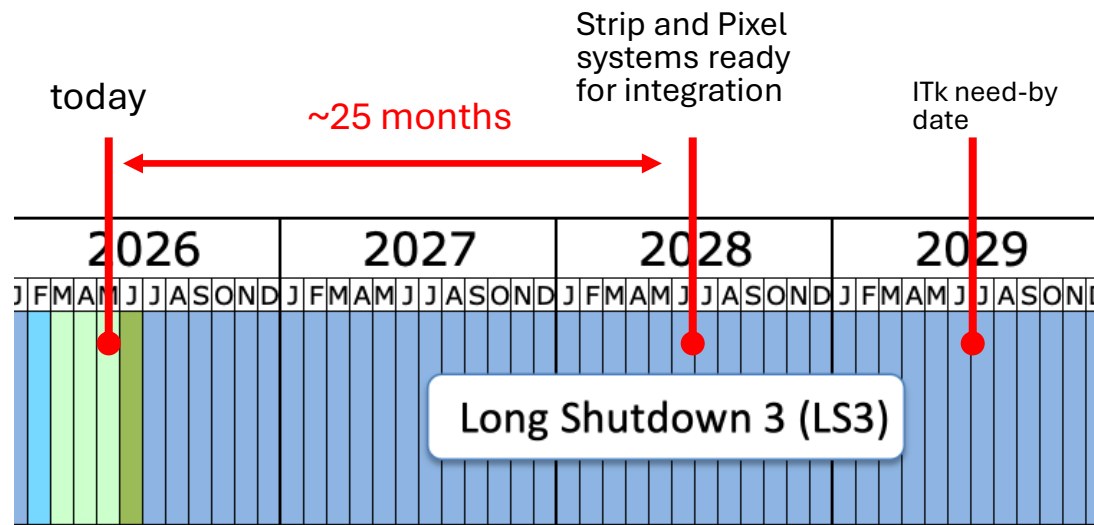
- Stave Core Assembly

- In-between building cooling loop assemblies Liverpool have built their allocated x10 pre-series production cores and now building full production cores.
- The total number of production cores is now x15 for Liverpool.
- With Tony Watling joining Liverpool's effort directed at WP-14 we hope that cores build rate continues to improve over the next year.





- Production is ongoing and making good progress
- This would not be possible without the continued support from the workshop, AML, Mike Lockwood, HEP computing, Angie, Hanah and Julie



<https://lhc-commissioning.web.cern.ch/schedule/LHC-long-term.htm>