ATLAS Upgrade

Helen Hayward et al.





Introduction

- 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)
- Paul Dervan
- David Vazquez
- Engineers:
 - Matt Brown, John Carroll, James Coleman-Mills (farewell and thanks to Dani York), Ashley Greenall
- Technicians:
 - Andy Bukowski, Liam Boynton, Warren Jones, Tom Lee, Tony Watling
 - Welcome! : Maria Queiroga Bazetto, Dave Sim, Alex Tongue,
 - Farewell and thanks to Akhil Kumar
- Academics:
 - Carl Gwilliam, Sergey Burdin, Jan Kretzschmar





Pixel Modules

Pixel Modules Assembly

- Wafer probing now 66% complete (437/700 wafers) with yield of >90%
- Pixel flex PCB and population vendors are now delivering parts for flex QC sites
- Reviews passed for module building completed in Q1 2025 => production starts!
- 3/4 hybridisation vendors qualified and ramping up bare module production
- 'Core column' issues still reducing yield: rate is ~8% of chips and ~23% of modules
- Evidence that debris from dicing or picking present in the pixel matrix is the cause
 - Size of debris sometimes difficult for vendors to see <50um
 - Different dicing methods cause different distributions of core columns



bare quad module
single bare modules



HEP annual meeting 22/05/25

Pixel modules: Production assembly and testing lines



M.Bazetto, A.Bukowski, P. Dervan, C.Gwilliam, A.Taylor, J.Taylor, D.Vazquez

- Pixel modules planned to be tested in batches of four (need to build ~8 / week)
- Current bottlenecks are the testing and reception of parts and the cold testing and thermal cycling tests
- UK Pre-production now completed 28 quad modules assembled and tested
- Slow ramp up into full production beginning now, first batch of production modules are now being assembled in the LSDC this week!



Assembled ITkPix quad module -Liverpool needs to make & test 500!



HEP annual meeting 22/05/25

System test

- Our pixel half ring system test box is our prototype facility for half-ring reception testing
- Providing feedback on the half-ring performance

Setup allowed fast feedback on a proposed late change to the grounding and shielding scheme of the pixel endcap due to issue with ceramic electrical breaks



Current is induced in RX and voltage is measured to determine frequency response on the system



- The signal injected shows a maximum in RX at 18 MHz
- Tested in different sensors within the ring
 - Results are similar for all the sensors measured
- No visible difference in sensor behavior between the injected frequencies



D. Vazquez, P. Dervan, (G.Miller)

Half ring

System Test – Cooling and Thermal cycling







In addition to running Lukasc (CO2) through the half ring we can use liquid N2 to cool down to -50 °C (currently limited to -15°C due to faulty sensor)



Thermal Study of Ring 1

Working module

Damaged module

- 12

10 °C) 10 °C)

Investigation has been done on Ring1's RD53A pixel module's temperature

- Low temperature variation across the module ($<5^{\circ}$ C)
- Reached thermal equilibrium quickly (<2s) .
- Module temp dropped ~8°C for 10°C of set cooling temp



Preparation for Thermal Cycling Ring 1

Ring 1 will be Cooled down to -55°C

- Environmental Chamber undergoing improvements in insulation to reach -20°C
- Additional smaller test box is being made to reach -55°C ٠
- Temperature / Dew-point sensors are being calibrated ready to be ٠ placed inside the EC and the test box.



Pixel Endcap Structures

• For the last 12 months intensified focus has been directed to the manufacture of the inner detector tooling and layer 2 prototypes.





As seen above, the layer 2 tooling is now cited for the first full prototyping build imminently.



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Pixel Integration Overview

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

• Integration tooling made up of 3 main components

- Detector trolley
- 'C' trolleys
- Rail assemblies

Detector trolley used to build up half cylinders around

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<image>

Complete layer of 2 half cylinders

Bosch rails to allow C trolleys to slide into final mounting position Rotate 90° between services installation and integration with matching pair



Progress at Liverpool



Aluminium profiles for trolley water jet cut by outside company with fine detailing done in workshop





Custom gearboxes used for rotation designed and then manufactured in our workshop



Materials for central trolley delivered and ready for assembly in clean room





J. Carroll, T. Jones, H. Hayward, M. Brown, J. Coleman-Mills, W. Jones

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Strip Hybrids

• Since January 2025 Liverpool is officially in production

- Start with hybrid flex array interposing and hybrid assembly
- Slow start of production with increasing weekly deliverable rates
- Interposing: as mitigation for module cracking and cold noise, we glue a 50um thick Kapton sheet under the hybrid using a compliant glue (SE4445)
 - Compliant glue mitigates stress caused by CTE mismatch during cooling of the module
 - Bonus: additional Kapton layer and SE4445 reduces cold noise significantly and it only shows up at very cold temperatures well outside the operation range
- Liverpool as barrel hybrid QC site is interposing all hybrids for the US and the UK/China clusters
 - Total ~15000 hybrids installed in ATLAS
 - Up to date, our technicians Alex Tongue and Tom Lee have interposed 144 arrays using tools developed and produced at RAL







Strip Hybrids and Modules

- Since January, our technicians Alex Tongue, Tom Lee and Andy Bukowski have started hybrid assembly
 - 2 hybrid panels / week which equals to 12 hybrid / week and a total of 195 hybrids to date
 - Few hybrids failed for various reasons but overall process is well under control
 - Hybrids have been shipped off to Sheffield and Glasgow for module assembly
 - Liverpool has exceeded the required number of assembled hybrids for the preseries phase
- In the next couple of weeks Liverpool will also start module assembly
 - Starting with 10 LS modules





PCB Cleaning

- New equipment installed in the basement of the workshop to clean PCBs
- Liverpool will clean flex circuit boards for strip barrel hybrids and pixel modules









Stave Core Assembly

Cooling Loob Sub-assembly

- Over the last year Liverpool has been producing production grade cooling loop assemblies.
- Even though we are continually building cooling loop assemblies, we have recently introduced new QC steps and adapted the procedure to improve the overall geometric accuracy.
- Hopefully in the next year Liverpool can deliver a significant amount of our production requirement. (200 off)





Stave Core Assembly

• Stave Core Assembly

- In-between building cooling loop assemblies Liverpool have also been working its way through our initial production run of stave cores.
- The initial production run of cores are labelled as "pre-series" and consists of ten cores which should be suitable to be loaded with production modules and end up in ATLAS.
- The first pre-series cores have overall been positively received at Oxford with there being a clear improvement in build quality in several key areas between prototype and pre series cores.







Summary

- We are in production phase of the the project
- Significant contributions to both Strip and Pixel Detectors
- Not possible without the dedication of our technical staff
- Thanks to the support from the dept and the ATLAS physics team
- Thanks to Carl, Sergey and Jan who are providing crucial dB tools support and development

Our continued thanks to the help and support from the workshop, AML, Mike Lockwood, hep computing, Julie, Angie and Hannah.



