

Experimental

**Particle Physics** 

# Module Development for the Phase-2 ATLAS ITk Pixel Upgrade

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### Abstract

In the high luminosity era of the Large Hadron Collider, the instantaneous luminosity is expected to reach a peak value of 7x10<sup>34</sup>cm<sup>-2</sup>s<sup>-1</sup> with 200 proton-proton interactions per bunch crossing on average.

To cope with the resultant increase in occupancy, bandwidth and radiation damage, the ATLAS Inner Detector will be replaced by an allsilicon system, the Inner Tracker (ITk). The innermost part of ITk will consist of a state-of-the-art pixel detector, with an active area of 12.8m<sup>2</sup>, which will provide tracking capability up to  $|\eta|=4$ .

This poster will highlight some of the progress that has been made in developing the Pixel Detectors moving towards full production.



## Layout and Sensors





An outline of the ITk Pixel detector showing the 5 layers Layers 0-1 : Inner System (IS) Layers 2-4: Outer System (OS) Outer Barrel (OB) Endcaps (EC) Quad modules consisting of 4 ASICS bump bonded to a single sensor are used for layers 1 (100 $\mu$ m thick sensor) and 2- 4 (150 $\mu$ m thick sensor) (left), OB quads have a carbon fibre wirebond protection (mid). Triplets consisting of 3 single detectors connected by a flex make up layer 0 and 0.5 (right)

## **Quad Module Flex Layout**

The flexible PCB proved to be a challenging design that had to be optimised for:

- Production, >10,000 flexes to be made
- Mechanical robustness
- Low Cu for bump bond



# Quad module assembly tooling

Tools developed to provide high levels of flatness, ±25µm measured on the back plane, and repeatability for assembling quad modules while providing >80% area glue coverage

High precision chuck to hold bare quad



- Ease of power/data connection
- Low power dissipation

ZIF data connector – Power connector –

## **Parylene coating**

After wirebonding all modules are parylene coated for HV isolation (left) including accidental humidity exposure and increased wirebond strength (right). Parylene exhibits radiation hardness up to  $10^{16} n_{eq}/cm^2$  and 7MGy





and mate quad and flex together with an accuracy of  $\pm 100 \mu$ m horizontally and vertically.



Glue application Flex chuck and stencil tool

Metrology of assembled quad module using the tooling shown. Extreme flatness allows easy observation of PCB traces.



Voltage (V) 0 5 10 15 20 25 30 Total thickness (μm)

## Thermal cycling tests

All modules will be thermally cycled from +60°C - -55°C to ensure they have been properly assembled from good parts.



X-ray hits on two RD53A modules one with parylene (left) and without (right) after 100 thermal cycles.

No bump delamination after 100 thermal cycles and no degradation in performance with parylene coating

### Future

Pre-production of Pixel modules is beginning. Institutes are ramping up facilities in preparation for production of 9164 modules. Integration with the production database is ongoing.