Overview of the production preparations for the ATLAS ITk strip end-cap detector at DESY.

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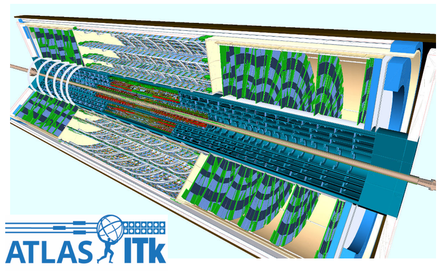
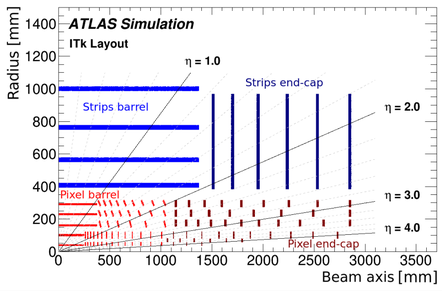
ATLAS ITk Strip End-Cap Detector.



» the **ATLAS Inner Tracker (ITk)** will replace the current tracking detector in the **HL-LHC** phase to cope with the challenging conditions (radiation, pile-up)

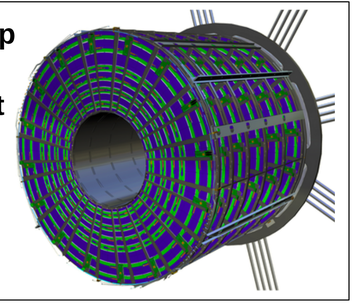
» the tracker is an **all-silicon** detector with **pixel** and **strip** detectors arranged in a central **barrel** region and two **end-caps** in the forward regions



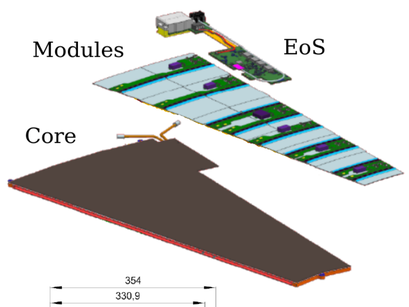
» the main building block of the **strip end-cap** detector are the so-called **petals**

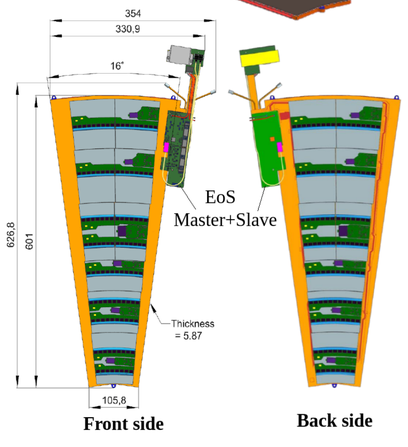
» each end-cap consists of a **global support** structure providing mechanical support and connection to the services for six **disks**

» each end-cap disk is populated with 32 petals, requiring in total the **production of 384 petals** for both ITk strip end-caps



Petal Design.



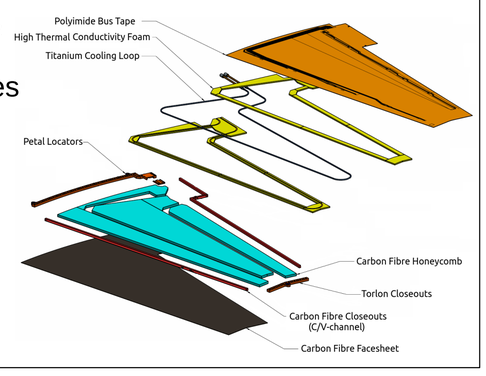


» the **petal** consists of the local support structure, the **core**, the directly glued on sensing elements, the silicon strip **modules**, and the also glued on off-detector interface board, the **end-of-substructure**

» the petal concept follows a **modular approach** for the assembly of components and minimizes the **material budget** of the detector (e.g. direct gluing, wire-bonding)

» the wedge-shaped **petal core** is a light-weight sandwich structure and provides:

- **mechanical support** for the modules
- dual-phase CO_2 **cooling** via the embedded Ti pipes
- **electrical connectivity** for power and data transmission via a polyamide-copper based bus tape



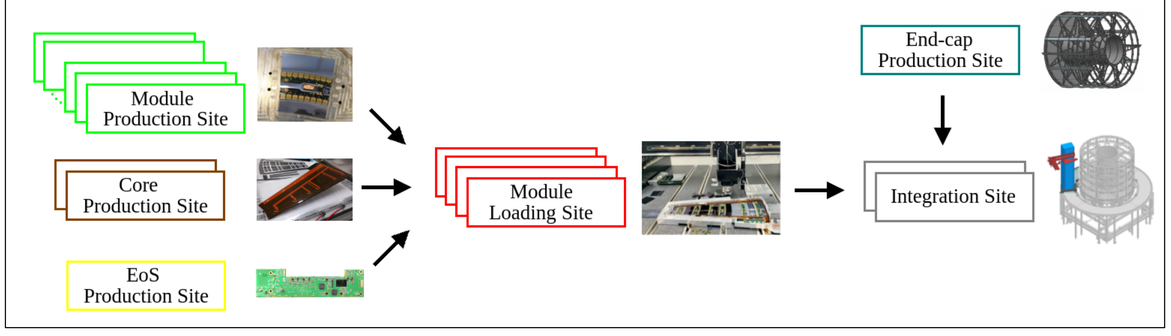
Production Planning.

» the production of the ITk strip end-caps is **distributed over institutes worldwide**

» the petal design allows a **modular production chain** for the individual components

» the **main production steps** to fully populated petals integrated in the end-caps are:

- **module building**: assembly of modules from silicon strip sensors and electronics circuitry with readout ASICs and power electronics
- **core manufacturing**: machining of raw components for the local support structure and final assembly of petal cores
- **module-on-core loading**: gluing of six different types of modules and the end-of-substructure boards as off-detector interface on both sides of the petal cores
- **end-cap insertion**: placement of finished petals into the global end-cap support

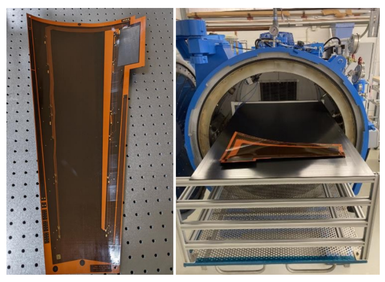


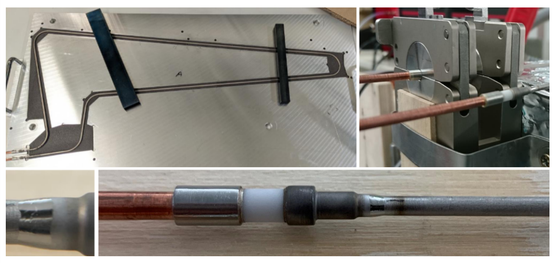
Petal Core Manufacturing.

Co-curing of facesheets

» co-curing of three layers of K13C2U carbon fiber pre-preg (0°-90°-0° orientation) with polyamide-copper bus tape in autoclave process (3 hours @ 120°C, 3bar)

» implemented qualified step-by-step process of material preparation, lay-up, co-curing in autoclave and final inspection with report to production database





Orbital welding of cooling loops

» bending and cutting of titanium pipes (OD= 2.275mm, wall thickness = 160µm)

» orbital welding of electrical break assemblies (CeramicSeals) to Ti pipes

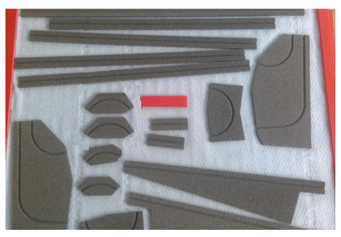
» implemented qualified process with final inspection (e.g. pressure and leak test)

Machining of thermal foam sets

» pre-machining of thermal foam parts for cooling unit from bare foam block with CNC machine

» high thermal conducting CF-based foam (Allcomp K9) surrounding the cooling loop for good thermal contact

» optimized process with inspection and packaging of parts



Core assembly at industry partner

» shipment of raw components for core building to industry partner (AVS @ Spain)

» final assembly in optimized, high throughput process using different glue interfaces

» quality control at company before shipment to DESY and IFIC for final, detailed QC tests

Quality Control Methods.

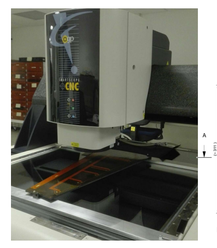
» a detailed **quality control** and **quality assurance** strategy was developed by the collaboration over the last years to ensure **good quality objects** for the detector

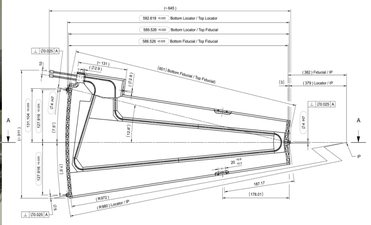
» the **specifications** of the petal core in terms of **geometry** as well as the **mechanical**, **electrical** and **thermal** behavior are tested with the following QC methods

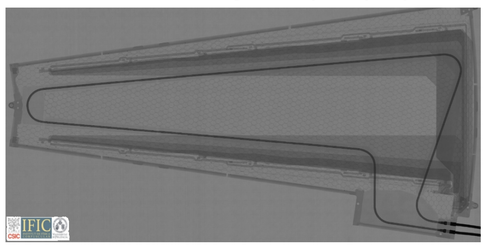
Metrology with SmartScope

» geometrical metrolgy of petal locators for position, diameter and planarity

» control measurement of local flatness within module regions (<50µm)







X-ray imaging and delamination check

» control of the assembly process via X-ray imaging of full petal core

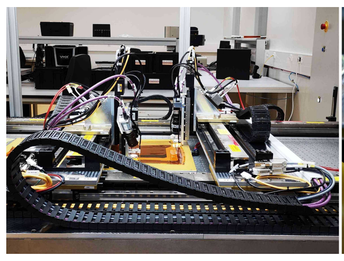
» delamination check between facesheet and cooling unit with coin tapping method

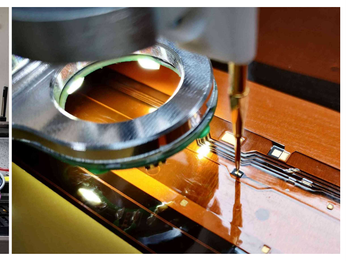
Electrical testing of bus tape

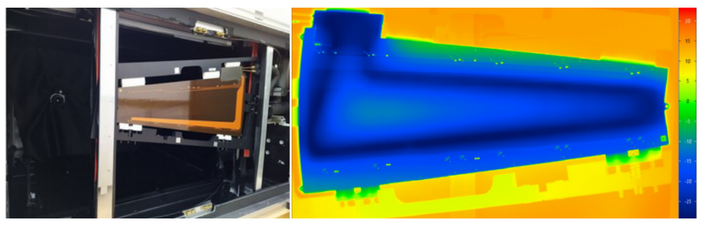
» automatic measurement of electrical lines in bus tape with robotic system using needle probes

» repetition at three stages: bare, co-cured and on-core bus tape

» check for eventual shortages and measuring of resistance and HV leakage of/between lines







Thermal performance check

» IR thermography on petal core surface to check thermal performance and eventual defects in thermal contact path

» cooling to operation temperatures of -35°C with MARTA dual-phase CO_2 system

Conclusion.

» the ITk strips end-cap project has successfully **finished the R&D phase** and is now transitioning into the **pre-production phase**

» **t**he ATLAS internal **site qualification process** for the institutes manufacturing and building components – from modules to cores – is ongoing

» at DESY, the pre-production for petal cores has **started successfully** and the first **pre-production grade cores** are expected from the industry partner soon

Outlook.

» within the phase of pre-production, all involved institutes can **verify and test** the developed **processes for manufacturing and assembly** of components

» the **multi-stage QC methods** can be validated with production grade objects and the **time planning and logistics** for shipping of components will be proven

» overall, the project is heading with great steps **towards production** of the ITk strip end-cap to be ready for the high-luminosity upgrade of the LHC

HELMHOLTZ
RESEARCH FOR GRAND CHALLENGES

References

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• J.-H. Arling, Detection and Identification of Electrons and Photons, DESY-THESIS-2020-022 (2020)
• A. Renardi, The silicon strip detector of the ATLAS Inner Tracker, DESY-THESIS-2022-008 (2022)

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