

# Production and Validation Plans of the TileCal PreProcessor Modules for the ATLAS Phase-II Upgrade

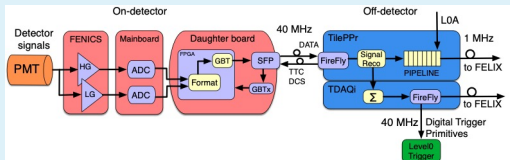
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## The TileCal Electronics Upgrade

The **Tile calorimeter (TileCal)** is the central hadronic calorimeter of the **ATLAS experiment** at the LHC, providing energy measurements of hadronic particles.

To operate under **HL-LHC** conditions, TileCal will adopt a **fully digital trigger and readout architecture**, replacing the existing electronics. Without an **analog trigger**, the on-detector electronics must transmit the full digital data stream, reaching a total rate of **40 Tbps** across the detector. To handle this data flow, new off-detector electronics have been developed, with the **Tile PreProcessor (TilePPr)** as their core element.



On- and off-detector electronics diagram

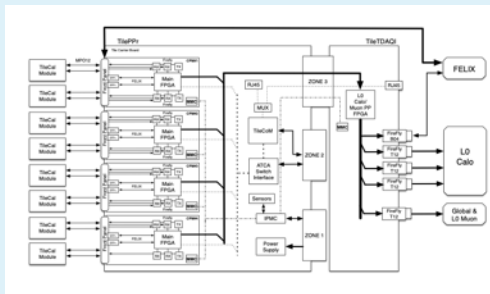
## Tile PreProcessor

The **TilePPr** is a modular **ATCA-based system** designed to provide the processing, readout, control and trigger interfaces required by the Phase-II TileCal electronics.

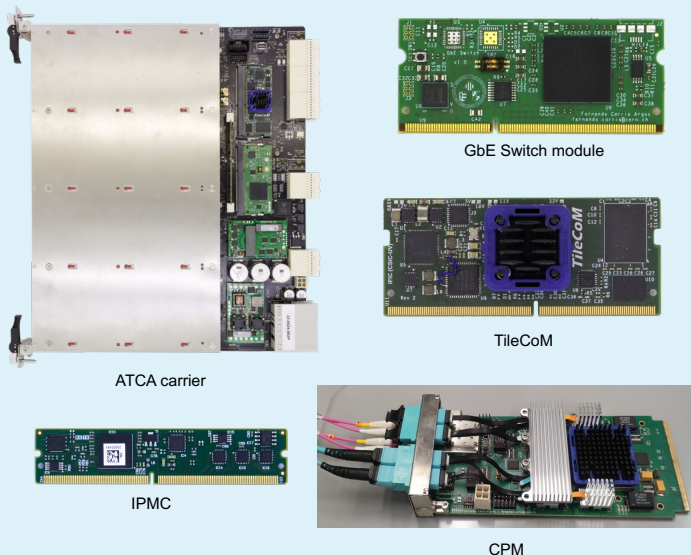
Each TilePPr comprises an **ATCA Carrier Base Board (ACBB)** hosting **four Compact Processing Modules (CPMs)**, a **TileCoM**, a **GbE Switch module** and an **IPMC module**. The CPMs receive the full digital data stream from the TileCal modules and perform the online **energy and time reconstruction**. Then they transmit trigger information to the **Tile TDAQi interface (TDAQi)** and timing and readout information to **FELIX**. The **TileCoM** provides control, monitoring and remote programming of the TilePPr, while the **GbE Switch** provides Ethernet connectivity. Power, monitoring and protection are managed through the **IPMC** and on-board sensors. TileCal modules and CPMs connect through **Samtec Firefly optical modules**.

### Key system requirements

- 32 TilePPrs, with 4 CPMs per TilePPr
- 32 × RX 9.6 Gb/s TileCal → CPMs
- 16 × TX 4.8 Gb/s CPMs → TileCal
  - Send commands and LHC synchronous clock
- Up to  $7 \times 9.6$  Gb/s links per CPM → TDAQi
- $2 \times 9.6$  Gb/s links per CPM ↔ FELIX
- **Deterministic-latency processing** for online trigger operation
- Continuous **power, temperature and link monitoring**



Block diagram of the TilePPr module

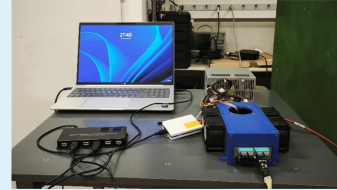


## Production and Quality Certification

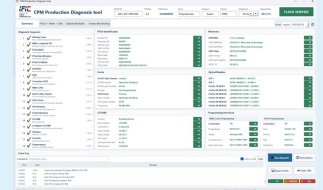


ACBB: 40 units → 2 units/week  
CPM: ~155 units → 8-12 units/week

- Preproduction completed (>10% total Carriers and CPMs)
- Production expected to finish by beginning of 2028

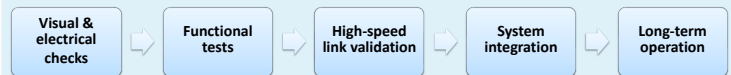


CPM Standalone Testbox



CPM Diagnosis Testbench

Dedicated **end-to-end QA programme** certifies every board before installation.



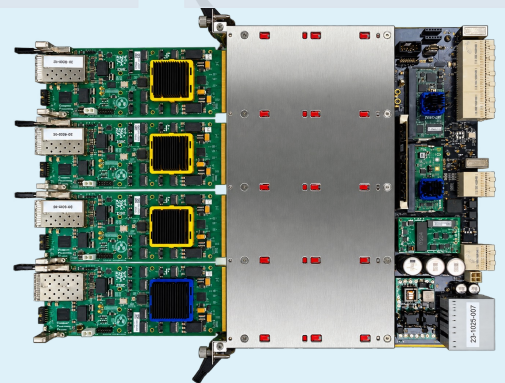
### ATCA Carrier Base Board (ACBB)

1. **Fabrication QC** — manufacturer report
2. **Reception & ID** — serial label, production Daughter Board entry, visual inspection
3. **Standalone electrical tests** — rails, Power-Good, basic functions
4. **ATCA assembly** — IPMC power negotiation; TileCoM, GbE Switch, CPM, TDAQi installation
5. **System tests** — sensors, JTAG, backplane GbE, high-speed CPM→TDAQi
6. **Long-term QA** — ≥4 days under load; PRBS BER tests (must be <10<sup>-15</sup>) and eye diagrams; accept & ship

### Compact Processing Module (CPM)

1. **Identification** — internal ID + ATLAS serial label
2. **Visual & electrical checks** — voltages, connectors, component integrity
3. **Mechanical assembly** — front panel, AMC mechanics, FireFly + heatsinks
4. **Automated diagnosis** — test box: memories, clocks, optics, GPIO, programming
5. **High-speed communication validation**
  - Optical links to front-end
  - Communication with TDAQi through ACBB

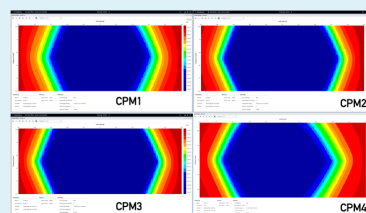
Fully assembled TilePPr with the four CPMs



## Validation results

**High-speed links:** Eye-diagram measurements demonstrate the quality of the **CPM→TDAQi** links and the **on-detector data reception paths**, with representative results shown for each CPM.

**Thermal & protection behaviour:** Continuous temperature monitoring verifies operation within defined limits. Exceeding configured thresholds generates **alarms** and **corresponding protection actions**.



CPM – TDAQi eye diagrams



On-detector – CPM eye diagrams