ATLAS ITk Upgrade for HL-LHC:
Cooling Strategy for Stave Reception Tests

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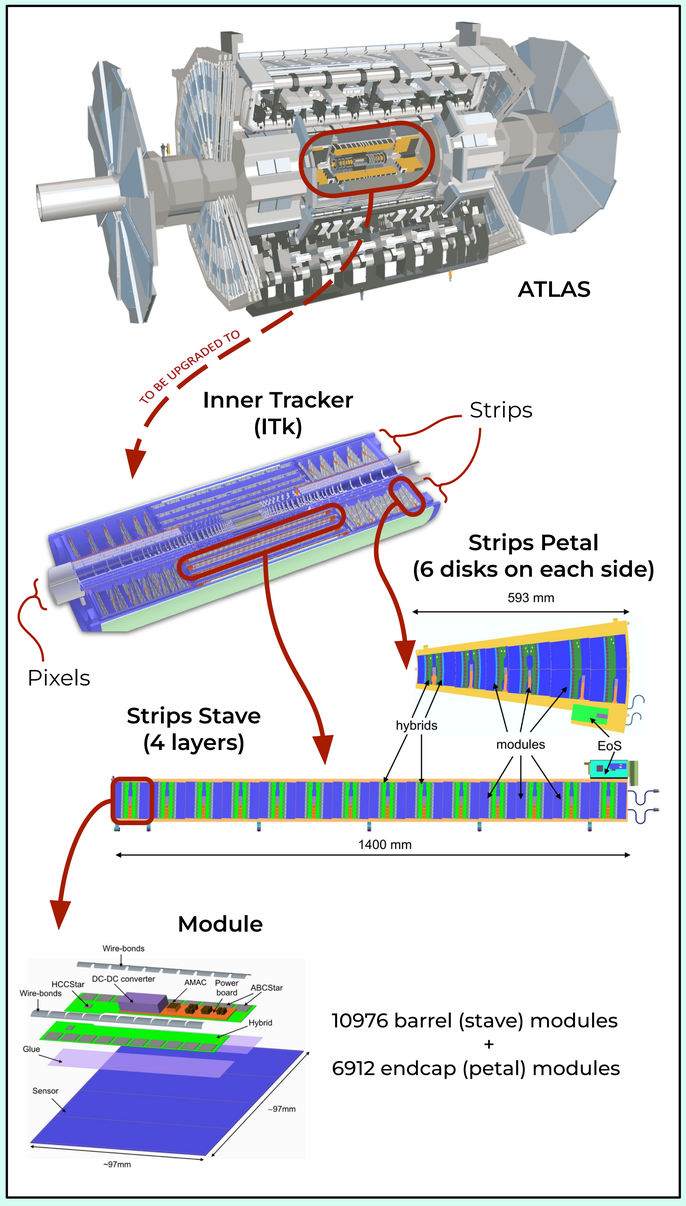
Background



10976 barrel (stave) modules
+
6912 endcap (petal) modules

Figure 1: A look at strips modules in the ATLAS Inner Tracker

What is the Inner Tracker (ITk)?

- All-**silicon** high-resolution sensors for tracking charged particles.
- Composed of:
  - **Pixels**: compact, first line of detection
  - **Strips**: surround pixels

Why upgrade the current Inner Detector?

- The current Inner Detector cannot sustainably perform under HL-LHC conditions (integrated luminosity up to **4000 fb^{-1}**).
- High trigger rate requires **faster readout channels**.

When will the upgrade take place?

- ITk construction **ongoing**: receiving components, testing, and assembling.
- Installation scheduled for Long Shutdown 3 (LS3) **from 2026 to 2029**.

Introduction

- Staves and petals need to be **tested at CERN** before ITk assembly.
- **Wire bonds** on the chips may pop if they get too hot during reception tests.
- **Silicon sensors** may experience thermal runaway and get damaged if overheated.
- **Objective:** Verify the effectiveness of the available pressurized perfluorohexane (**C_6F_{14}**) cooling system in ensuring temperature control of the stave during its testing.

Methods

- Test using a **thermomechanical (TM) stave**, i.e. a stave with no real sensors or readout chips.
- Use digital-to-analog converter (**DAC**) to change the voltage across resistors in the stave to increase its **temperature**.
- Autonomous Monitoring And Control chips (**AMACs**) record module temperatures.
- Compare coolant performance with booster pump (**9 bars**) and without (**3 bars**).

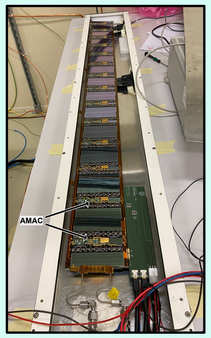


Figure 2: The thermomechanical stave used to test cooling system

Results

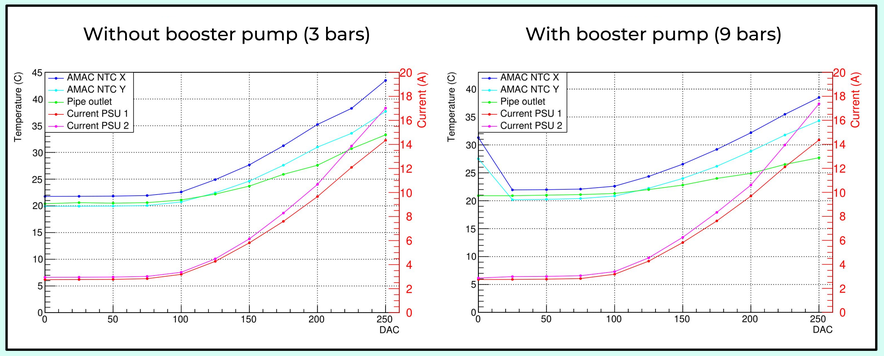


Figure 3: Current and average module temperatures with pressurized coolant

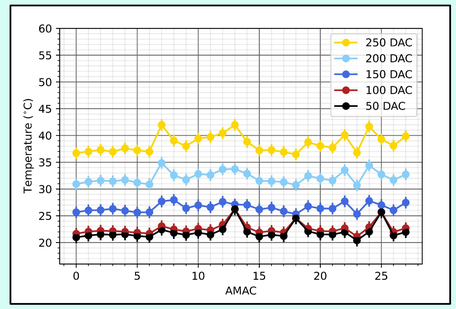


Figure 4: Temperature recorded by each AMAC at various DAC with coolant at 9 bars

Discussion

- C_6F_{14} at 9 bars with 250 DAC can keep the stave **under 40°C**.
- C_6F_{14} is **modestly more effective at 9 bars** than at 3 bars.
  - The improvement is small under 125 DAC.
- **No discernible trend** in temperature variations between modules in a stave.
- Modules closer to coolant influx did not show cooler temperatures.
- Module temperatures used as a **proxy** for wire bond temperature.

Conclusion

The cooling system using C_6F_{14} pressurized at 9 bars is adequate for keeping the stave from overheating during reception tests. The cooling system cools all modules relatively evenly.

References

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Acknowledgements

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