



# Opto-Box

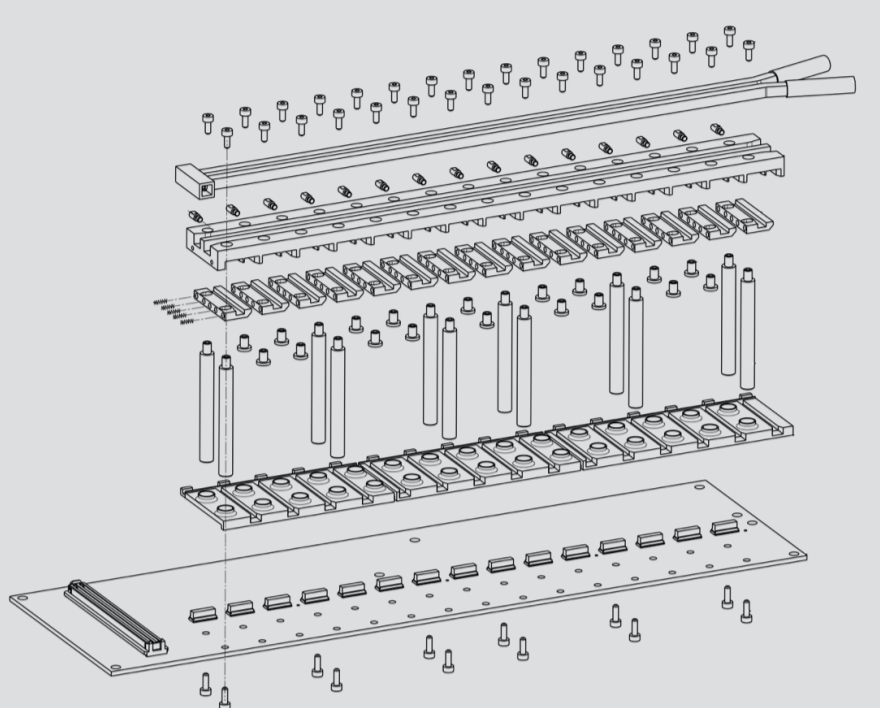
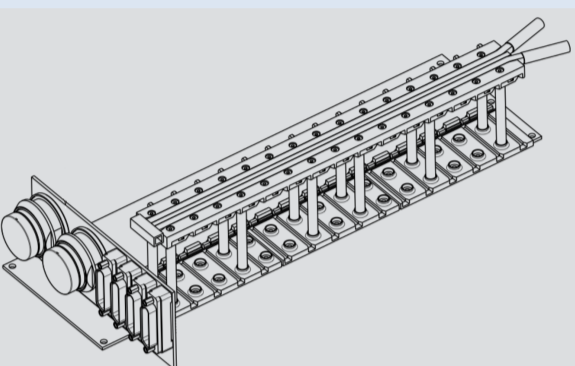
## Mini-Crate for ATLAS Pixel and IBL Detector Optical Modules

ICNFP2015, Crete  
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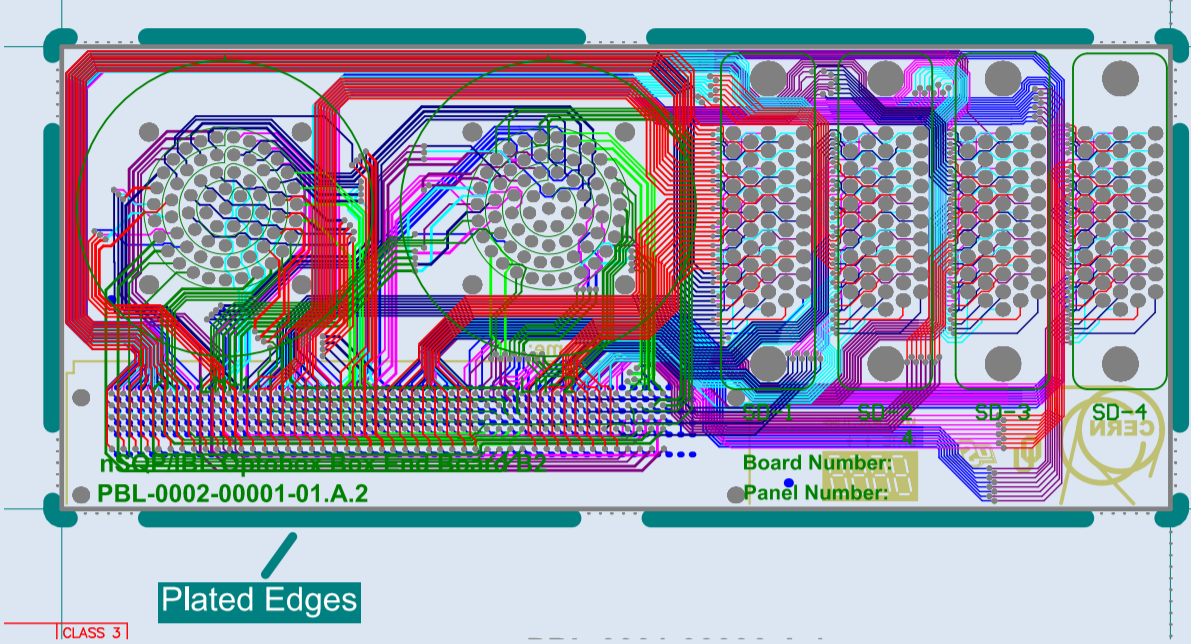


- ATLAS is a toroidal **general-purpose particle detector** based at the Large Hadron Collider (LHC) at CERN.
- The Pixel and IBL detectors are the innermost systems, they provide crucial **tracking** and **vertexing** functions.
- These detectors produce **electronic** signals, which must be converted to **optical** signals for read out.
- The opto-box is a custom mini-crate for housing optical modules (opto-boards), which process and transfer this **optoelectronic data**.
- The system tightly integrates **electrical, mechanical, and thermal** functionality into a small package of size 35x12x8 cm<sup>3</sup>.
- Special attention was given to ensure proper **shielding, grounding, cooling, high reliability, and environmental tolerance**.
- Many novel solutions were developed for the **custom design** and manufacturing.

### Design



**Mechanical drawings** show the **custom design**; a slot and spring mechanism keeps the opto-boards in place and allows for easy loading and extraction.

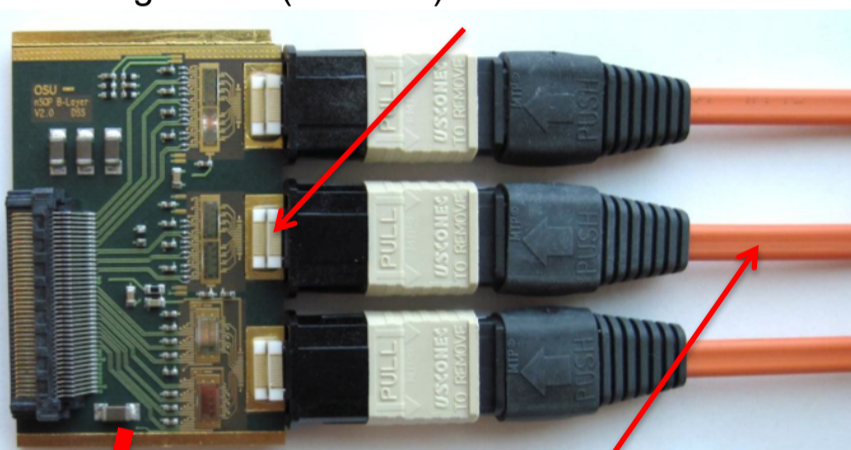


Printed circuit board (PCB) fabrication panel for the end board. Solid copper internal layers and edges provide electromagnetic **shielding** and **grounding**. ENIG (gold) plating provides high **reliability**. The boards passed **quality control** before assembly.

The **cooling pipe** carries away heat using C<sub>6</sub>F<sub>14</sub> fluid at 16° C.

The **motherboard** distributes power and control signals to the opto-boards.

24 **opto-boards** convert signals between electrical and optical form by using Vertical-cavity surface-emitting-lasers (VCSELs).



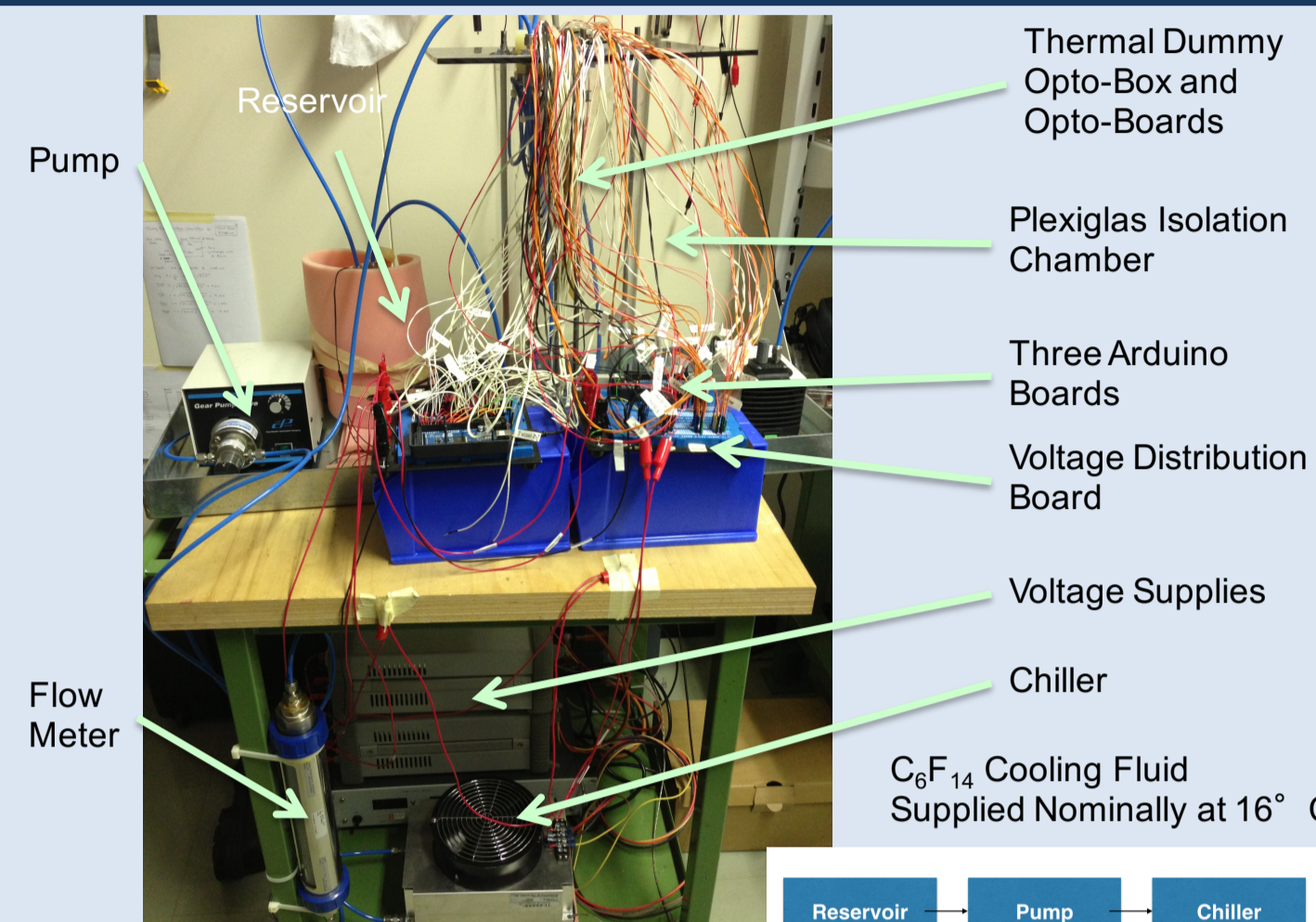
**Optical fibers** carry signals between the opto-boards and the read-out electronics.

The **end board** transfers power and control signals from six cables into the motherboard.

24 **Electrical Readout (ER)** bundles carry electrical signals between the opto-box and the Pixel and IBL detectors.

24 **connector boards** connect the ER bundles, the motherboard and the opto-boards.

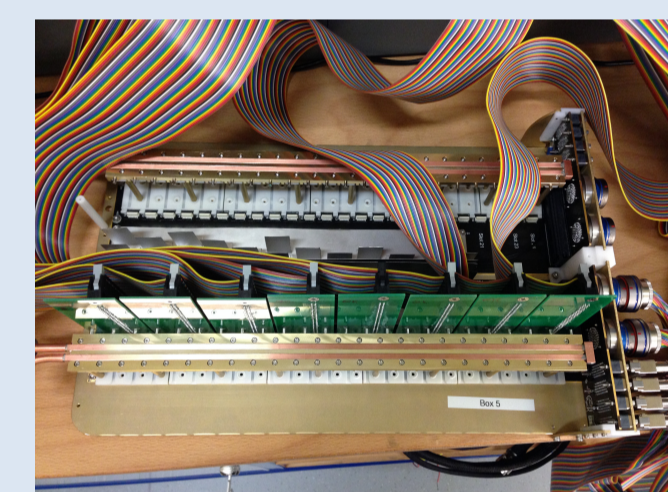
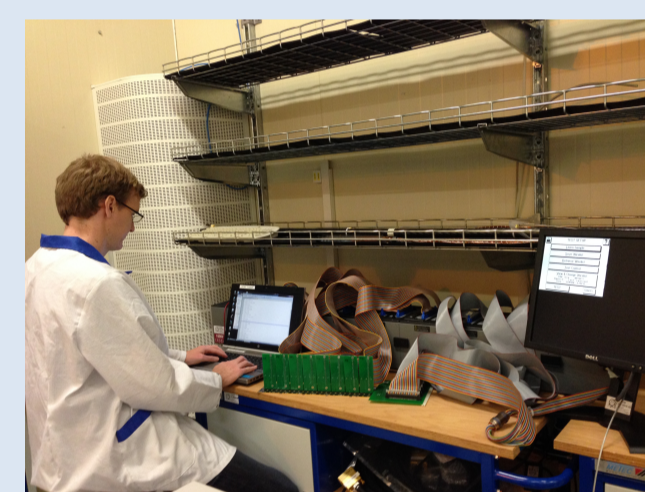
### Thermal Tests



The opto-boards produce heat, which must be carried away by the cooling fluid.

**Adequate cooling** was measured (< 35° C) and no heat leaked into the surrounding environment.

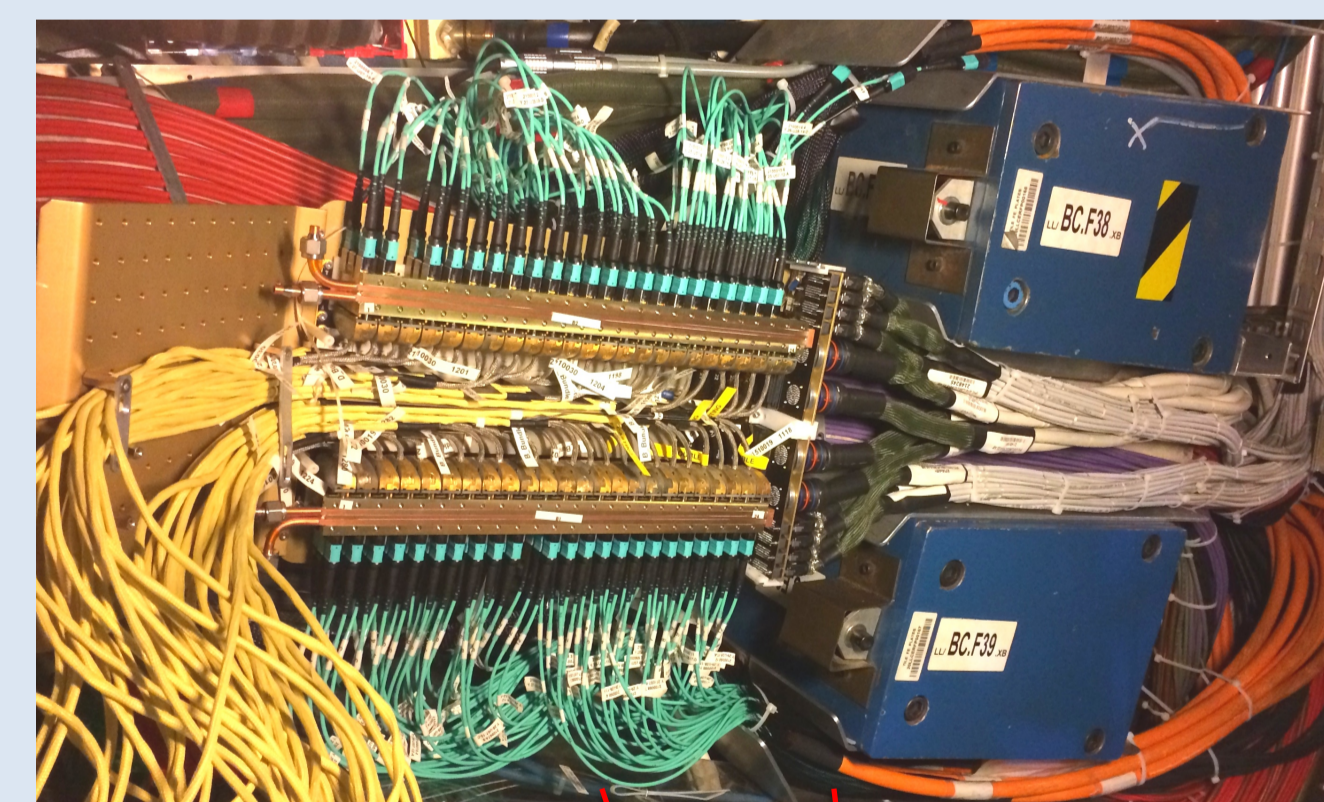
### Electrical Tests



After assembly, 600 connections on each motherboard and end board were again **quality controlled** for continuity.

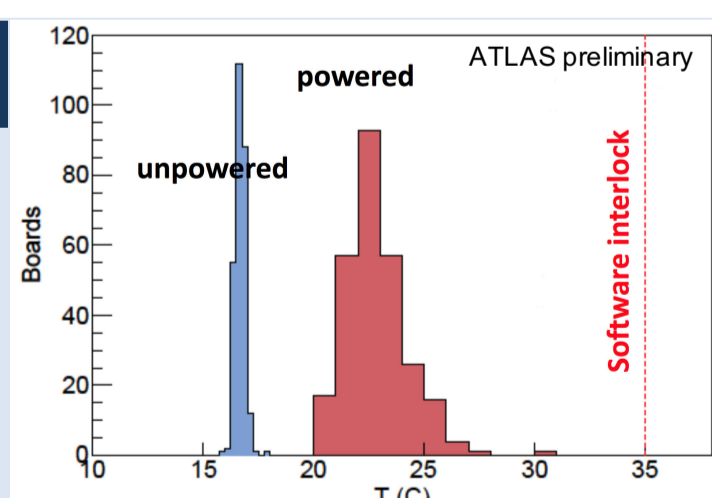
### Installation

In total, six Pixel and one IBL opto-boxes are installed on each side of ATLAS. They are mounted next to the blue Liquid Argon (LAR) Calorimeter crates.

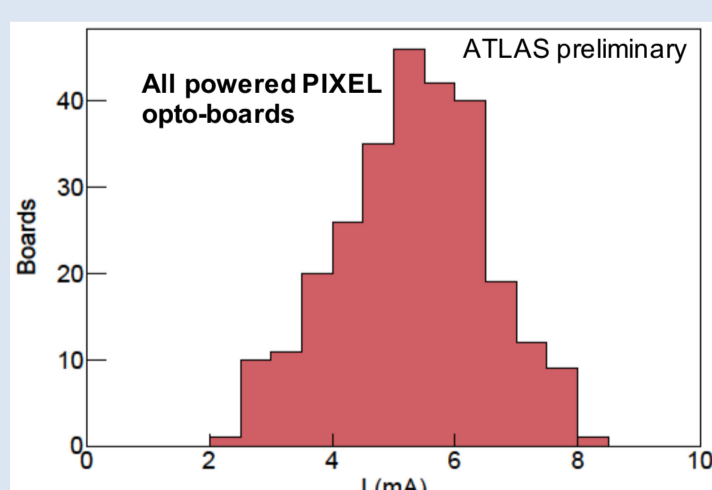


### Pixel Performance

After installation, the 272 operational Pixel opto-boards are all **adequately cooled** below the 35° C threshold.

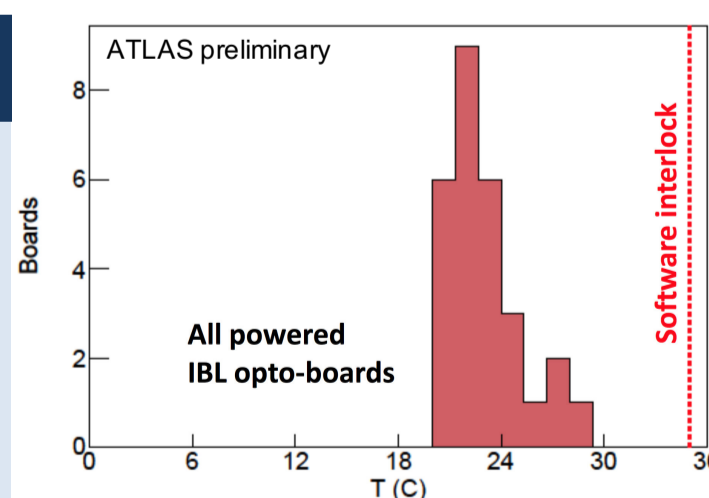


The 272 operational Pixel opto-boards all receive adequate current (>0.1mA) to ensure the required bit error rate of <10<sup>-9</sup>.

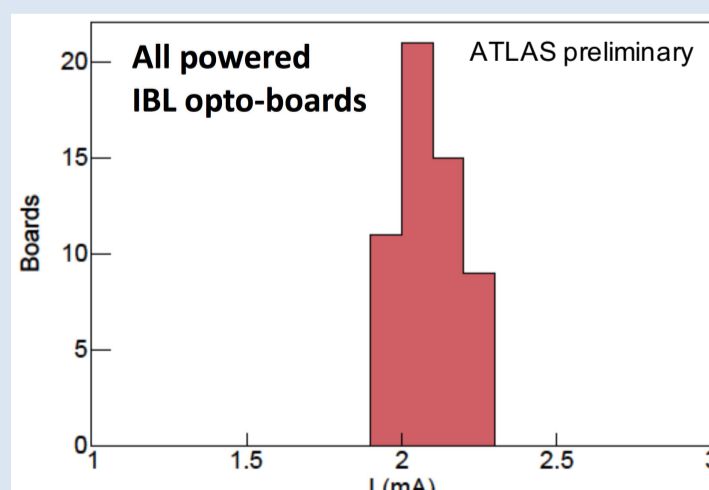


### IBL Performance

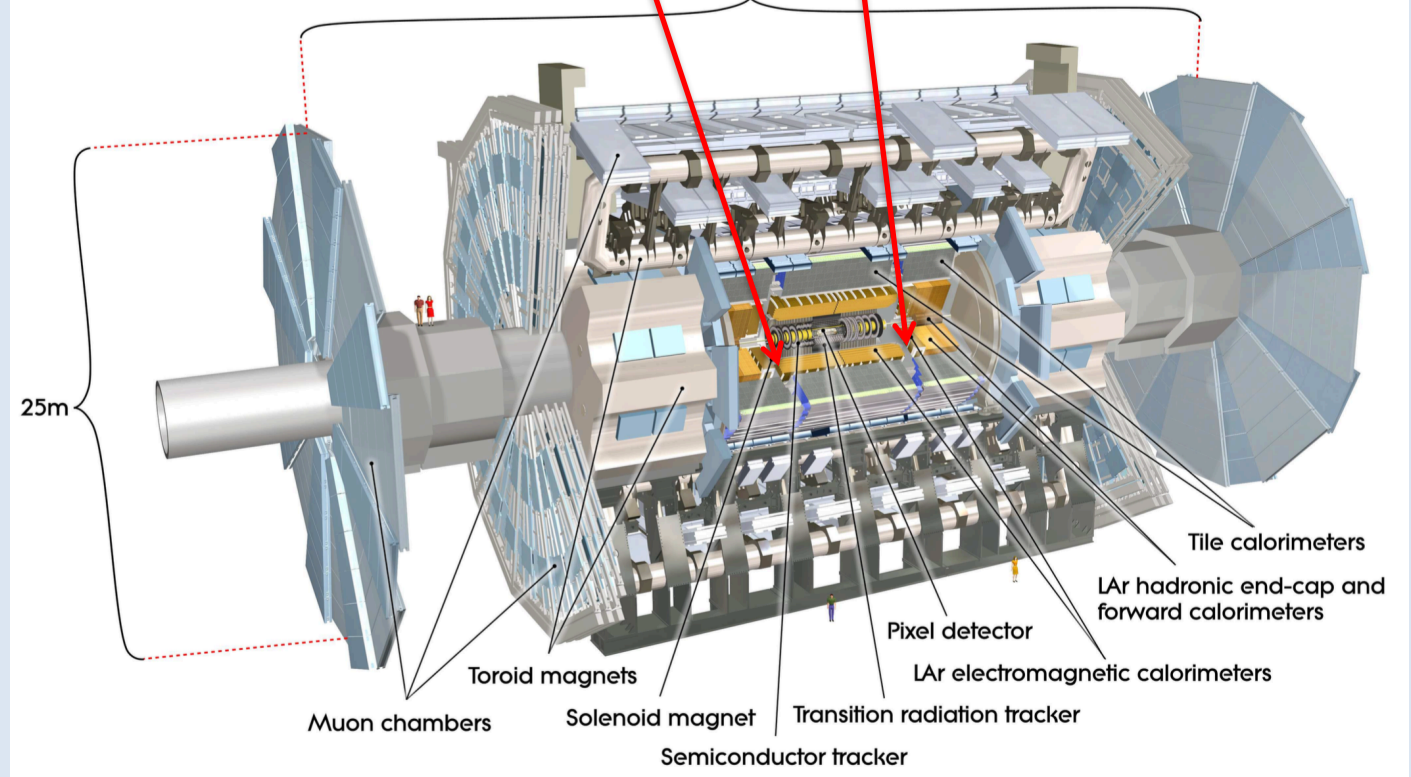
After installation, the 28 operational IBL opto-boards are all **adequately cooled** below the 35° C threshold.



The 28 operational IBL opto-boards all receive adequate current (>0.1mA) to ensure the required bit error rate of <10<sup>-9</sup>.



### ATLAS Detector



### Summary

During the first LHC long shut down (LS1) we moved the optoelectronic signal transceiver modules of the ATLAS Pixel Detector (opto-boards) to a new location outside of the inner detector. This was motivated by past pixel module failures in order to **increase ease of access** to the system during future data taking runs. This system needed to fit into available space, so a **custom mini-crate** (opto-box) was designed, constructed and loaded with new opto-boards. Much thought was given to high-density **system integration**, especially cable and thermal management. New **high reliability** opto-boards (including application specific integrated circuits, or ASICs) were also developed and produced. In addition, this system was implemented to support the new Insertable B-Layer (IBL) of pixel modules also installed during LS1 – where the pixel opto-box has 24 slots and the IBL opto-box has 15. In total, **fourteen** opto-boxes have been installed on the ATLAS detector.

The opto-boxes provide ATLAS Pixel and IBL detectors with **reliable, tightly integrated, and serviceable** mini-crates and modules for the optoelectronic data transfer system. They are currently operational as an integral part of **data collection** for LHC run 2.