Opto-Box
Mini-Crate for ATLAS Pixel and IBL Detector Optical Modules

- 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 cm².
- 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 C₄F₁₀ fluid at 16°C.
- The motherboard distributes power and control signals to the opto-boards.
- 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.

**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, 630 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 <0.1%

**IBL Performance**

- After installation, the 256 operational IBL opto-boards are all adequately cooled below the 35°C threshold.
- The 256 operational IBL opto-boards all receive adequate current (>0.1mA) to ensure the required bit error rate of <0.1%

**Summary**

During the first LHC long shutdown (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.