Implementation of ATLAS Phase-1 Upgrade Components for LAr Calorimetry & TDAQ Systems

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ATLAS Experiment

- Largest collaboration at CERN
- Tests predictions of the Standard Model and looks for new interactions and new particles (like the Higgs)

HL-LHC: 2026

- Higher luminosity, up to 200 interactions per bunch crossing and instantaneous luminosities of 5-7.5 x 10^{34} cm^{-2} s^{-1}
- Increase data points by an order of magnitude
- Investigate high energy and statistically rare events to better understand physics beyond the Standard Model
Increased Granularity (Supercells)

- Allow for lower trigger thresholds with the same accuracy

- Allow for deployment of more advanced algorithms that produce data that are more easily understood
Lar Phase-1 Upgrades

Updated Front End Readout Electronics

Legacy

Updated

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Monitoring Board Configuration

Trigger Tower

Monitoring Board

Oscilloscope
Monitoring Board Configuration

![Monitoring Board Configuration Diagram]
Trigger Timing Control (TTC)

Legacy System

- **ROD Busy**
  - Collect Busy from ROD crates
  - Transmit the OR to the LTP
  - Produce Statistics on the Busy

- **LTP** (Local Trigger processor)
  - Receives TTC signals from CTP/LTPI/LTP chain
  - Can be a local generator of these signals
  - Transmits them to the TTCvi
  - Receives Busy and transmits it to the CTP/LTPI/LTP chain

- **TTCvi**
  - Generates the 2 channels (A & B) used for transmission of the TTC information.

- **TTCex**
  - Encodes the 2 channels on one signal and converts it to optical (up to 10 outputs)
Trigger Timing Control (TTC)

ATLAS Local Trigger Interface (ALTI)

- Performs all the functions of the four boards in the legacy system in a single board
- Less boards/connections means less opportunities for hardware to fail
- Added functionality:
  - Snapshot memory
  - Phase shift programming
  - TTC signal analyzer (can monitor its own signal)
  - Mini Central Trigger Processing (can be its own master)
- Completely backwards compatible with the current system
ALTi Power Measurement Procedure

- Measured optical power from legacy TTCex transmitters at EMF and P1 as a baseline

- Measured optical power from all 10 ALTi transmitters at EMF and P1
  - with individual transmitters turned on and with all 12 transmitters turned on

- Measured optical power from TTCex directly before front end crate (FEC) at EMF
  - after signal travels through an attenuator and fiber that mimics P1 set up

- Measured optical power from ALTi directly before FEC at EMF
Results – power from transmitter

Legacy TTCex at EMF

ALTi at EMF

Legacy TTCex at P1

ALTi at P1
Results – power before FEC at EMF
Results – predicted power before FEC at P1

Available Power as a Function of Initial Power

Predicted Available Power at P1

<table>
<thead>
<tr>
<th>P1 channel</th>
<th>Estimated Available Power</th>
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<tbody>
<tr>
<td>ALTI 1</td>
<td>17.60816</td>
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<tr>
<td>ALTI 2</td>
<td>14.4212</td>
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<td>ALTI 3</td>
<td>16.97144</td>
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<td>ALTI 4</td>
<td>21.29576</td>
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<td>ALTI 8</td>
<td>13.724</td>
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<td>ALTI 9</td>
<td>12.40856</td>
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<tr>
<td>ALTI 10</td>
<td>14.40272</td>
</tr>
</tbody>
</table>
Conclusions

- There is far greater variation in optical power across transmitters in the ALTi boards than there is across transmitters in the legacy TTCex system.

- Optical power output from ALTi transmitters follows a pattern that is not the same at EMF and at P1 (likely due to different cooling methods), which is important to consider when moving hardware from the testbed to USA15.

- ALTi transmitters that produce about 50% of the power produced by the legacy system preserve power better through fibers/splitters/attenuators and deliver comparable power to FECs.
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Questions?