South African contribution towards the ATLAS Tile Calorimeter PreProcessor

Author: Mpho Gift Doctor Gololo
Co-Author: Prof. Bruce Mellado

University of the Witwatersrand

SAIP2021
Contents

• ATLAS Tile Calorimeter Phase II Upgrades

• Tile Pre-Processor Overview

• South African contribution
  • Main functionalities of the TileCoM and Tile GbE Switch
  • Production of boards in South Africa
  • Firmware and Software developments

• Conclusion
Tile Calorimeter Phase II Upgrade

• ATLAS Tile Calorimeter Phase II Upgrade to accommodate an increase in the luminosity
• Complete replacement of Front-End and Back-End electronics
  • Due to radiation and time aging
  • To be compatibility with full digital TDAQ and trigger processing at 40 MHz (L0) and to fulfill Phase-II radiation requirements.
• New readout strategy for HL-LHC: On-detector electronics will transmit digitized data to the off-electronics at the LHC frequency (40 Tbps to read out the entire detector!)
ATLAS Tile Pre-Processor (TilePPr) Overview

• TilePPr is part of the off-detector electronics for the ATLAS TileCal electronic chain
• The main functionality of this board is data processing using FPGAs
• Contribution from South Africa is mainly focused on the TileCoM and the Tile GbE
• These two boards are mainly used for control and monitoring of the system
South African contribution

- 32 TilePPr boards for the final design
- Contributing 24% of the Tile PPr
- Production of boards in S.A.
- Current focus on the TileCoM and Tile GbE Switch

Percentage contribution to off-detector electronics

- University of Valencia (76%)
- University of the Witwatersrand (24%)
TileCoM Hardware Components

- **Main components:**
  Zynq UltraScale+ ZU2CG, 2GB DDR4 SD card, GbE, USB 2.0, SPI, I²C, UART, 82 x GPIO
  PCB with 10 layers (1.2 mm), FR4
- **Test board to validate all functionalities**
  - Layout stage. PCB to be produced in Feb
  - All GPIO routed to a HPC FMC connector
  - Emulates carrier’s clocking schema
  - Ethernet RJ45 (DCS interface)
  - USB, UART, PCIe x4 ports
Functionality #1: FPGA programming

- Configuration of CPM, TDAQi and on-detector FPGAs
  - 4 Remote JTAG chains for on-detector KU+ and Cyclone IV FPGAs
  - 1 Master JTAG chain for the 4 CPMs + TDAQi
- Two options under evaluation
  - Implementation of Xilinx Virtual Cable IP cores
  - Custom JTAG controller without TDO check (mods to disable TDO checkings)
- **Update the entire detector electronics configuration at the same time in few minutes**
Functionality #2: PPr and DCS system

- Interface with the DCS system through dedicated GbE port
  - TileCoM runs an OPC UA Server as middleware
- Sensor monitoring reading from ATCA carrier, RTM and on-detector electronics
  - Power consumption, optics diagnostics, temperature sensors, ...
  - I²C interface for reading local ATCA carrier sensors
  - CPMs retrieve sensor data from on-detector through GBT links
  - TileCoM reads out sensor data from CPM and RTM through GbE (IPbus)
- Control and monitoring of the HV distribution (HV Opto) → not baseline for Phase-II
Functionality #3: TDAQ interface

• Interface to the TDAQ system for system monitoring / configuration
• Slow control and configuration of the PreProcessors
  • Configuration of the ATCA carrier and CPMs: clocking, power, optical modules, GbE switch, ...
  • Monitoring of ATCA on-board sensors, CPM sensors and on-detector electronics sensors through I2C and GbE
Production of boards in South Africa

- **Tile GbE Switch production**
  - 6 Tile GbE switch boards have been produced from South African companies
  - These boards passed the electrical and communication tests
  - All the developments from S.A are have been tested using these boards and are all working as expected

- **TileCoM Production of boards**
  - The PCB is designed in Valencia
  - First prototypes are currently tested for electrical and communication tests
  - Production of these boards will commence in the last quarter of 2021
  - All the remaining TileCoM boards will be produced and tested in South Africa before integration at CERN
Current SA contribution towards TilePPr

• The current contribution towards the TilePPr is implementation of the monitoring system for the ATLAS Tile Calorimeter Phase II upgrade system
• This is in terms of the firmware and software developments using the TileCoM
• All the developments are currently tested on the Avnet Ultra96-V2 Zynq UltraScale+MPSoC evaluation board
Current SA contribution towards TilePPr

- TileCoM Embedded Linux
- CPM Emulator board
- Network Router
- Power supply
- Tile GbE Switch
- TileCoM evaluation board
2021 contribution schedule towards the TilePPr

- All the developments for the TileCoM have been deployed in schedule time
- The production of the TileCoM board will commence soon in S.A
- Integration tests of these developments are currently taking place

### 2021 Plans for the SA Tile PPr project

<table>
<thead>
<tr>
<th>Start Date</th>
<th>Duration</th>
</tr>
</thead>
<tbody>
<tr>
<td>1/4/2021</td>
<td></td>
</tr>
<tr>
<td>2/23/2021</td>
<td></td>
</tr>
<tr>
<td>4/14/2021</td>
<td></td>
</tr>
<tr>
<td>6/3/2021</td>
<td></td>
</tr>
<tr>
<td>7/23/2021</td>
<td></td>
</tr>
<tr>
<td>9/11/2021</td>
<td></td>
</tr>
<tr>
<td>10/31/2021</td>
<td></td>
</tr>
<tr>
<td>12/20/2021</td>
<td></td>
</tr>
</tbody>
</table>

- OPC-UA development first project
- Integration of OPC-UA first project with the SCADA
- OPC-UA development Second project
- Integration of TileCoM with Tile-PPr and TDAQ FPGAs
- ATLAS TileCal Note
- Production of TileCoM in SA
Conclusion

• Working towards Phase II upgrades of the Tile Calorimeter
• South African contribution to the off-detector electronics development
  • University of Valencia (76%) & University of the Witwatersrand (24%)
  • This involves developments and production of boards in South Africa
• The prototypes of Tile GbE Switch produced in South Africa are functional
• Production of TileCoM boards will commence in the last quarter of 2021
• All the software and firmware developments are fully functional
• Integration tests of these software and firmware developments will begin early 2022