CONTRIBUTIONS TO THE DEVELOPMENT OF THE OFF-DETECTOR ELECTRONICS FOR THE PHASE-II UPGRADE OF THE ATLAS TILE CALORIMETER

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Contents

• Tile Calorimeter Phase II Upgrades
• Schedule of Phase II upgrades
• Production of boards in South Africa
• TileCoM progress
• Demonstrator project current status
• Conclusion
• Future work
Tile Calorimeter Phase II Upgrade

• 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.

• High Voltage to be distributed remotely from USA15
• 32 TilePPr. Each one includes:
  • 1 × ATCA Carrier Base Board → 32 carriers in total
  • 4 × Compact Processing Modules → 128 AMCs in total
  • Design process centralized in Valencia
• Percentage contribution to back-end electronics
  • Witwatersrand responsible for software and firmware design of some boards of the back-end electronics
  • Production of part of the back-end electronics
    • Production and assembly of the GbE switch and TileCoM modules
    • Acquisition of part of the CPM FPGAs

Percentage contribution to back-end electronics

- University of Valencia (76%)
- University of the Witwatersrand (24%)
Schedule of Phase II upgrades

- CPM design largely based on the PPrDemonstrator
- Integration tests at CERN from Dec 2019 to Feb 2020

- CPM-v2 design from February to April 2020 –Final version
- Integration tests at CERN from Dec 2020 to Jan 2021
  - TDAQi-v1 and Carrier-v2
Schedule of Phase II upgrades

- First Carriers-v1 built by end of May 2019
- First Validation tests started in August 2019
  - PPR Demonstrator
  - ATCA Shelf
- PPR test-bench (Carrier + CPM) development in Q4 of 2019

- Carrier-v2 development between end of 2019 and summer 2020 – Final version
- Integration tests at CERN in Summer 2020 with TQAQi and CPM
- Integration tests will continue to 2021 according to TDAQi schedule
Schedule of Phase II upgrades

- First TDAQiv1 prototypes manufactured and being tested
- Integration tests at CERN from Dec 2019 to Feb 2020
  - TDAQi-v1, CPM-v1 and Carrier-v1
- TDAQi-v2 design for December 2020 – Final version
- Integration tests at CERN from August 2021 to December 2021
  - TDAQi-v2, CPM-v2 and Carrier-v2
Production of boards in South Africa

- Produced Tile PPr demonstrator PCBs in South Africa currently used in the demonstrator project
  - 8 boards produced between 2015 and 2016
  - Extensively tested and validated for several test beams
  - These boards are currently integrated and working well in the demonstrator project
- New CPM hardware and firmware design **largely based on this system**
  - Acquisition of the Kintex UltraScale FPGA by University of Witwatersrand
Production of boards in South Africa

- **Tile Switch** is currently under production
  - PCB are produced from Trax Interconnect
  - Tile Switch boards are currently being populated at Jemstech
- The switch will be used to connect the Tile electronic system to the network
  - Connection will be remotely through Ethernet using GbT protocol

See Daniel’s talk
Tile Computer on Module (TileCoM) progress

- Followed and developed necessary for Linux booting process
- First three files are used for booting and the last three files are used for user applications

- Linux operating system successfully boots and can be used for user-applications
- Full ownership of the root file system
- Connect to network through Ethernet

```
[root@localhost /]# ls -l
total 60
lrwxrwxrwx 1 root root 7 Nov 28 2019 bin -> usr/bin
dr-xr-xr-x 4 root root 4096 Nov 28 2019 boot
drwxr-xr-x 11 root root 3320 Jan 1 00:00 dev
drwxr-xr-x 68 root root 4096 Jan 1 00:02 etc
drwxr-xr-x 2 root root 4096 Apr 11 2018 home
lrwxrwxrwx 1 root root 7 Nov 28 2019 lib -> usr/lib
dr-xr-xr-x 2 root root 16384 Nov 28 2019 lost+found
drwxr-xr-x 2 root root 4096 Apr 11 2018 media
drwxr-xr-x 2 root root 4096 Apr 11 2018 mnt
drwxr-xr-x 2 root root 4096 Apr 11 2018 opt
dr-xr-xr-x 75 root root 0 Jan 1 00:00 proc
dr-xr-xr-x 2 root root 4096 Apr 11 2018 root
drwxr-xr-x 18 root root 520 Jan 1 00:01 run
lrwxrwxrwx 1 root root 0 Nov 28 2019 sbin -> usr/sbin
drwxr-xr-x 2 root root 4096 Apr 11 2018 srv
dr-xr-xr-x 12 root root 0 Jan 1 00:00 sys
drwxrwxrwx 7 root root 4096 Nov 28 2019 tmp
drwxr-xr-x 12 root root 4096 Nov 28 2019 usr
drwxr-xr-x 18 root root 4096 Jan 1 00:00 var
```
Tile Computer on Module (TileCoM) progress

- Pynq-Z2 board used as an evaluation board for TileCOM
Tile Computer on Module (TileCoM) progress

• The TileCoM evaluation board integrates successfully with the Phase II Upgrade electronics
• Tests were performed by sending packets of data to the PPr emulator in Building 175
• The TileCoM is connected to the CERN network and can be accessed remotely
The PPr demonstrator board is currently inserted in the demonstrator project.

The demonstrator was fully inserted in LBA14 end of July.

The system PPr/Demo is showing good stability in terms of links, temperature, etc.

Powered (LV, HV) and monitored from DCS and calibrated using the TDAQ.
Demonstrator project current status

- PPr demonstrator is currently operating of the ATCA for the demonstrator project
- CPM prototype will be tested in the ATCA early March for the demonstrator project
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
• Some of the boards produced in South Africa are function well in the demonstrator project
• TileCoM progress is in a good status with a fully functional operating system and integration with PPr emulator
Future work

• The next step is to use the pynq board as a JTAG to program the target FPGA (CPM)
• Remotely program the target FPGA through Ethernet XVC using the TCP/IP protocol

Hardware
• PYNQ board, PPr emulator and Computer
• Cables (USB, Ethernet) and JTAG Flying Wire Adapter

Software
• Linux Operating System
• PetaLinux tools
• Vivado Design Tools and Software Development Kit