



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

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HEPP2020

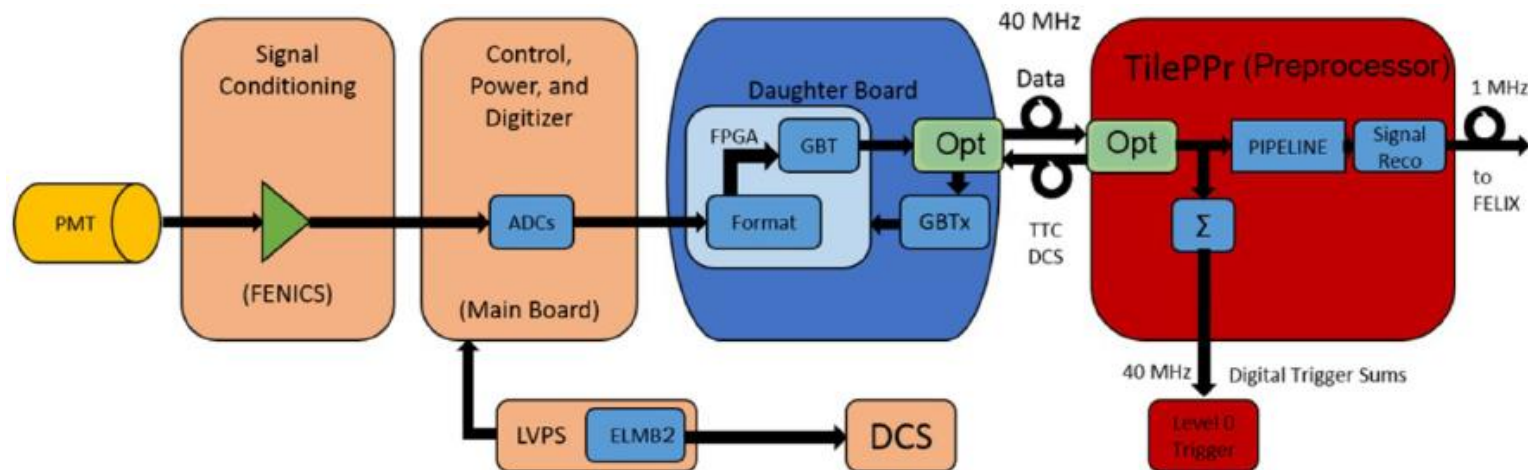
31 January 2020

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Tile Calorimeter Phase II Upgrade

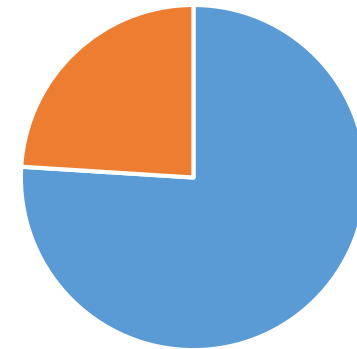
- Complete replacement of Front-End and Back-End electronics
 - Due to radiation and time aging
 - To be compatibility with full digital TDAQ and trigger processing at 40 MHz (L0) and to fulfill Phase-II radiation requirements.
- High Voltage to be distributed remotely from USA15



ATLAS-Tile Back-end electronics

- **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

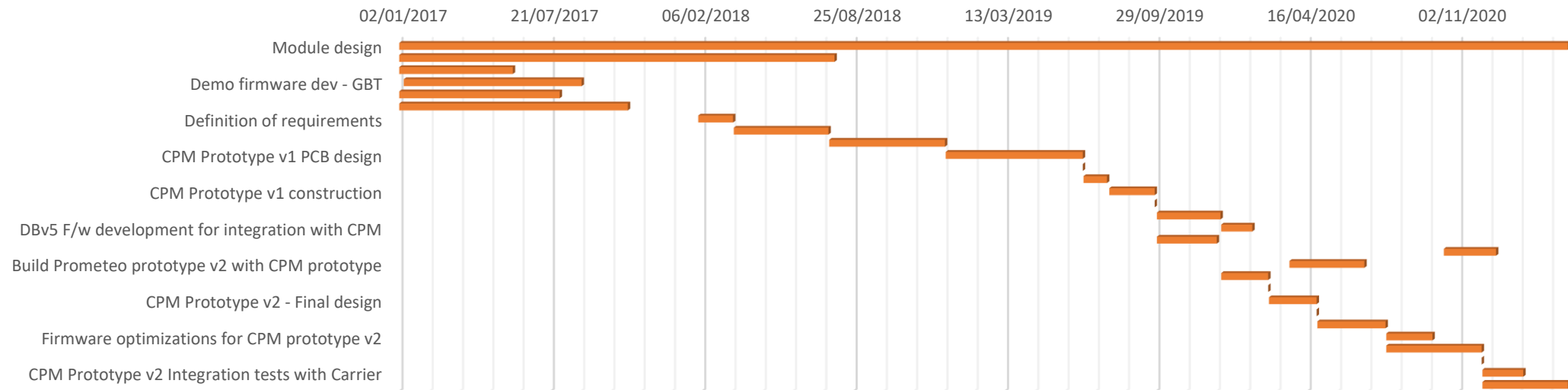
Percentage contribution to back-end electronics



■ University of Valencia (76%) ■ University of the Witwatersrand (24%)

Schedule of Phase II upgrades

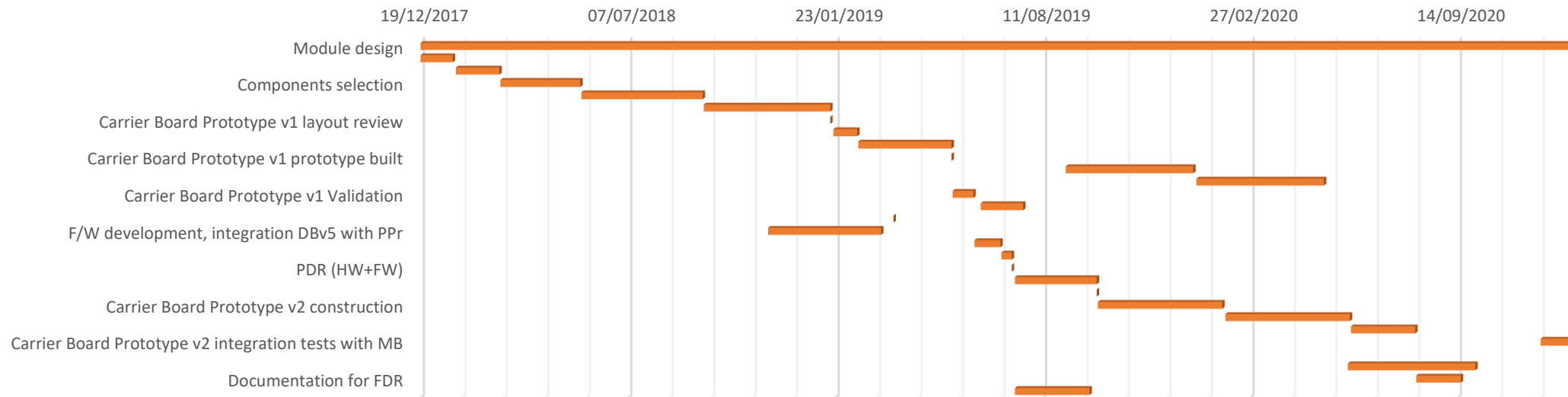
CPM schedule-Design



- 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

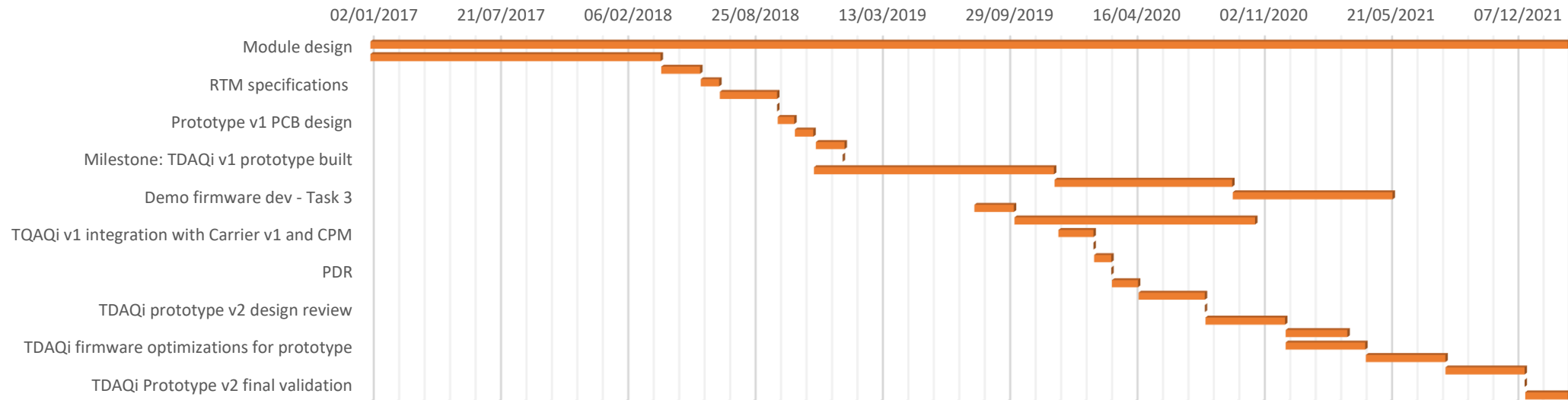
Carrier schedule -Design



- 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

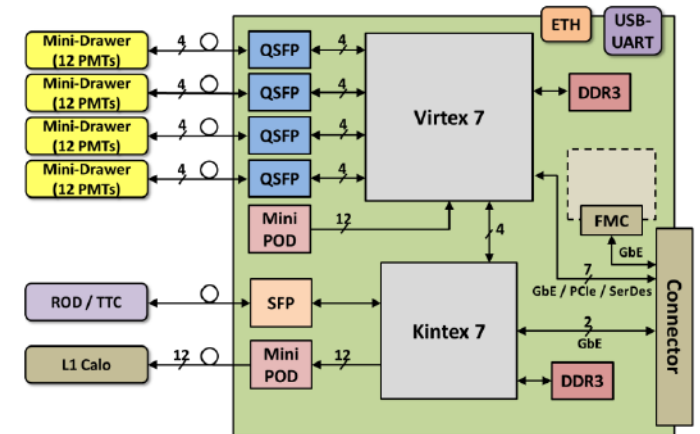
TDAQi Schedule



- 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

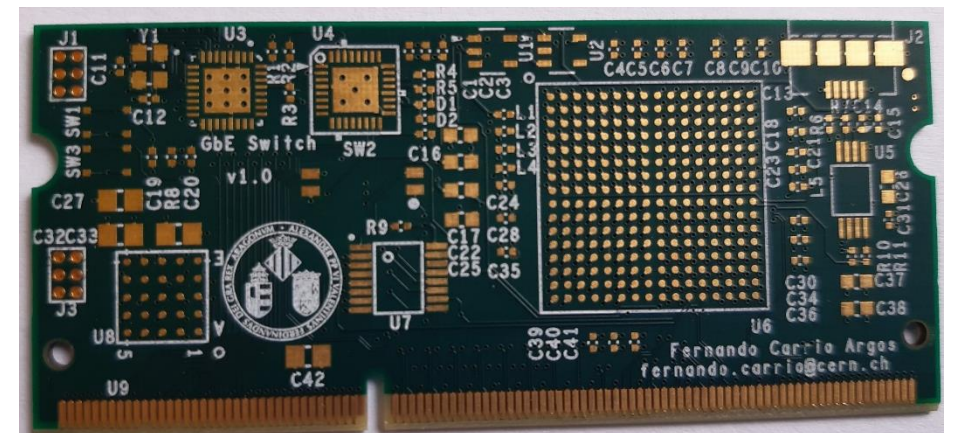
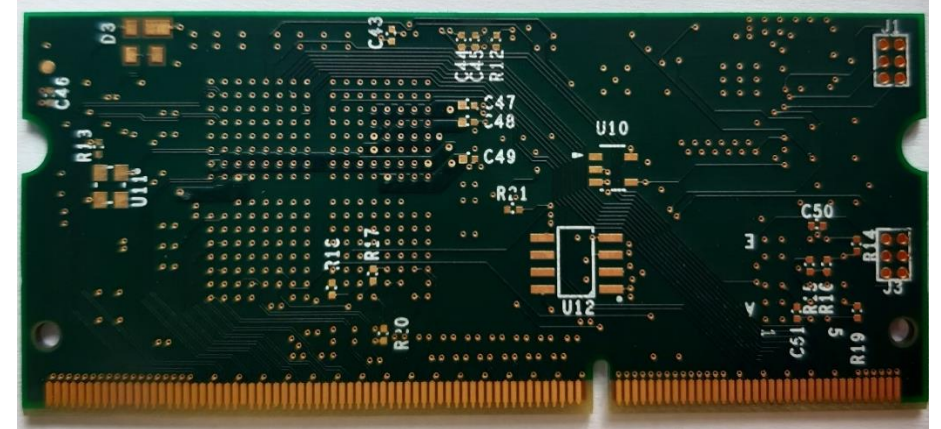
- Produced Tile PPr demonstrator PCBs in South Africa currently used in the demonstrator project
 - 8 boards produced between 2015 and 2016
 - Extensively tested and validated for several test beams
 - These boards are currently integrated and working well in the demonstrator project
- New CPM hardware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



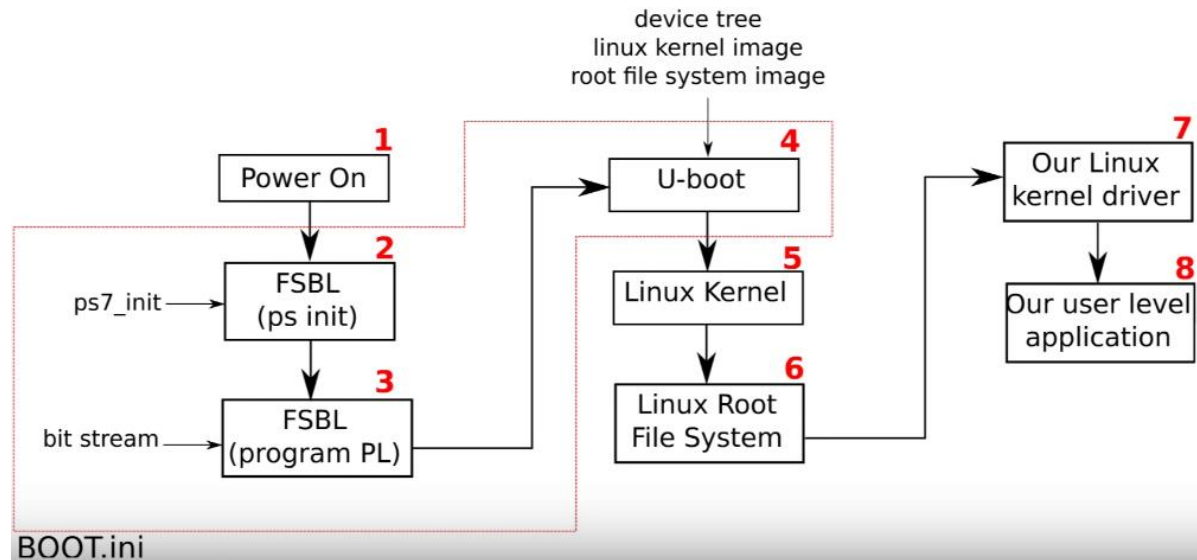
Production of boards in South Africa

- **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 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



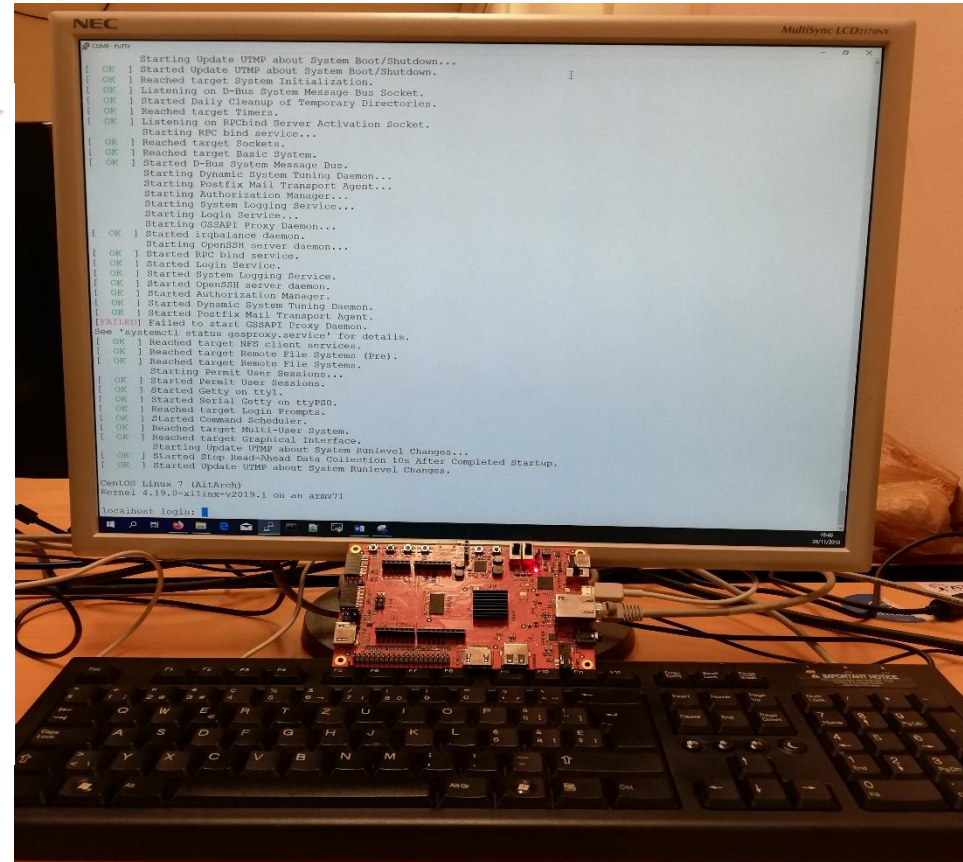
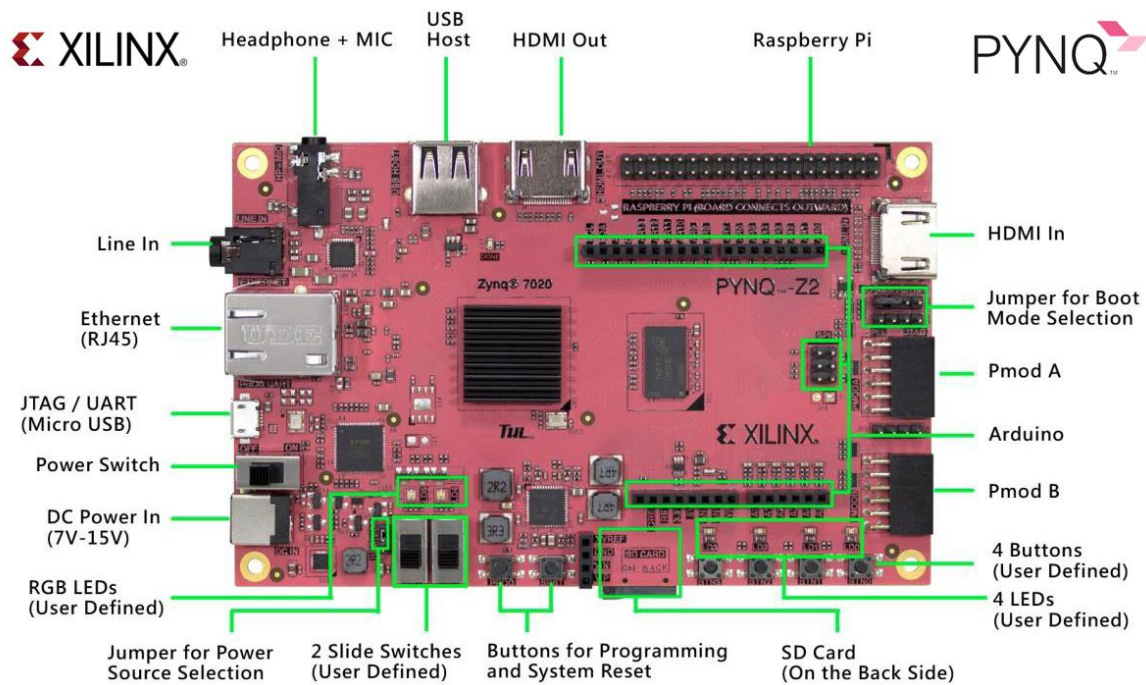
- Linux operating system successfully boots and can be used for user-applications
- Full ownership of the root file system
- Connect to network through Ethernet

- 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

```
[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
drwx----- 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-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 8 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
drwxrwxrwt 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
```

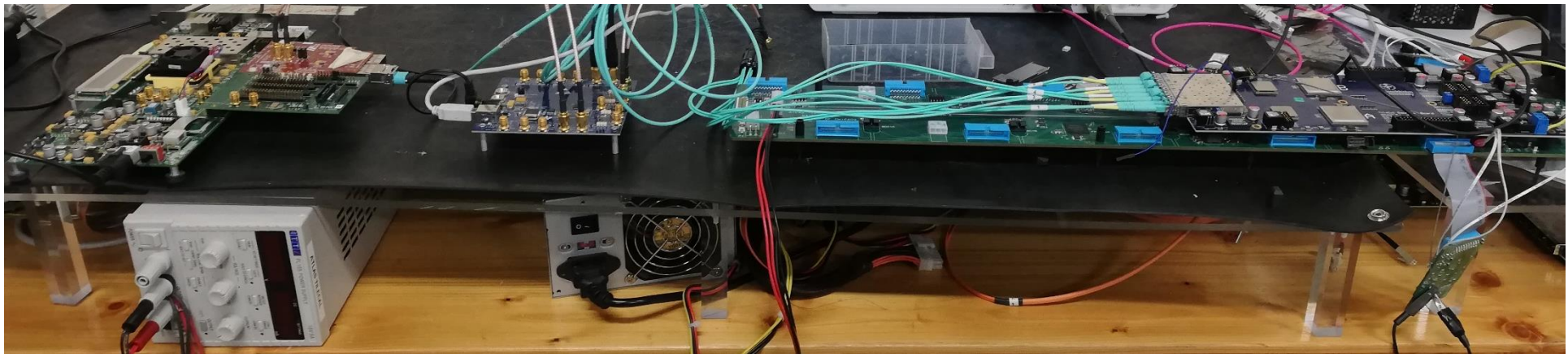
Tile Computer on Module (TileCoM) progress

- 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

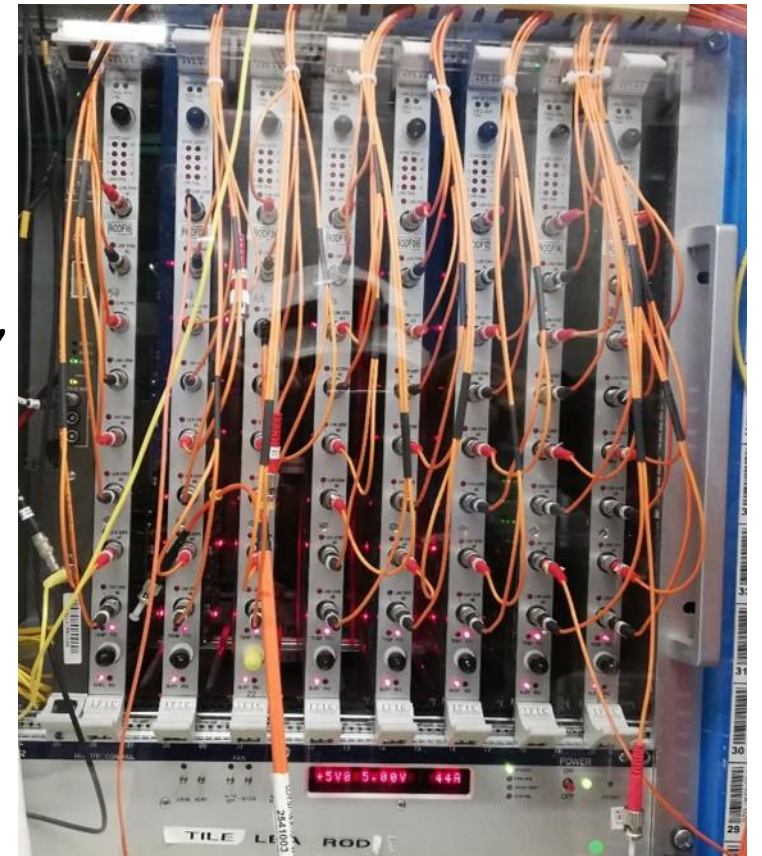


Off-Detector Electronics

On-Detector Electronics

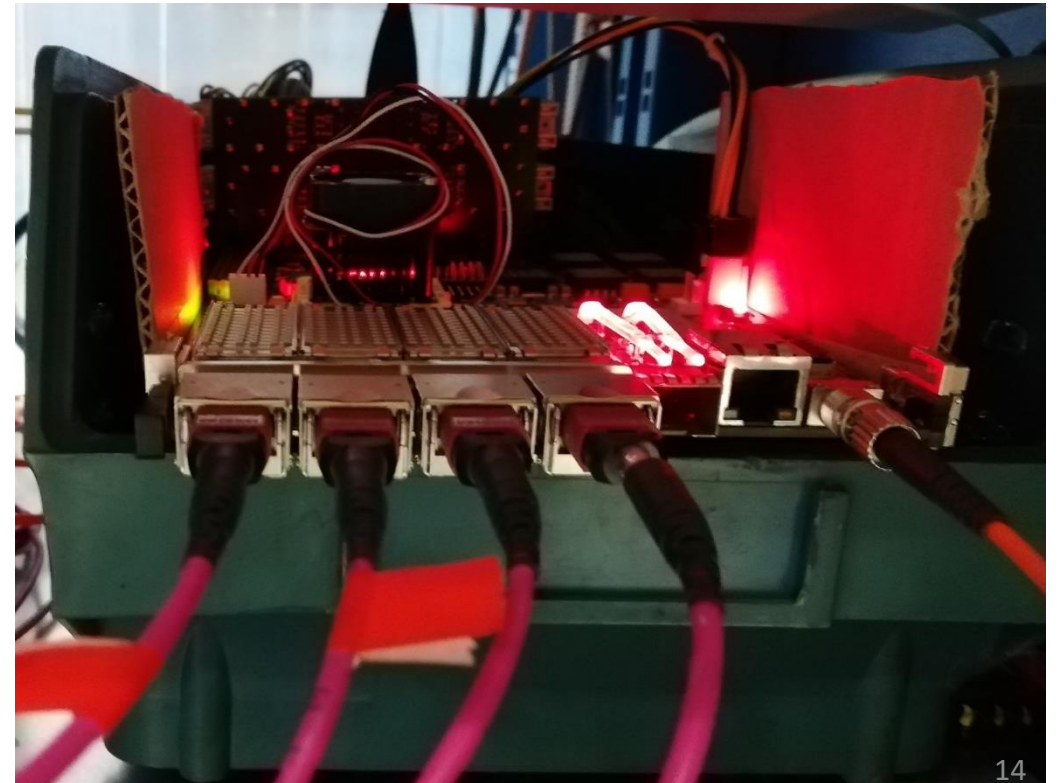
Demonstrator project current status

- 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

