Upgrade of the ATLAS Tile Calorimeter High Voltage System

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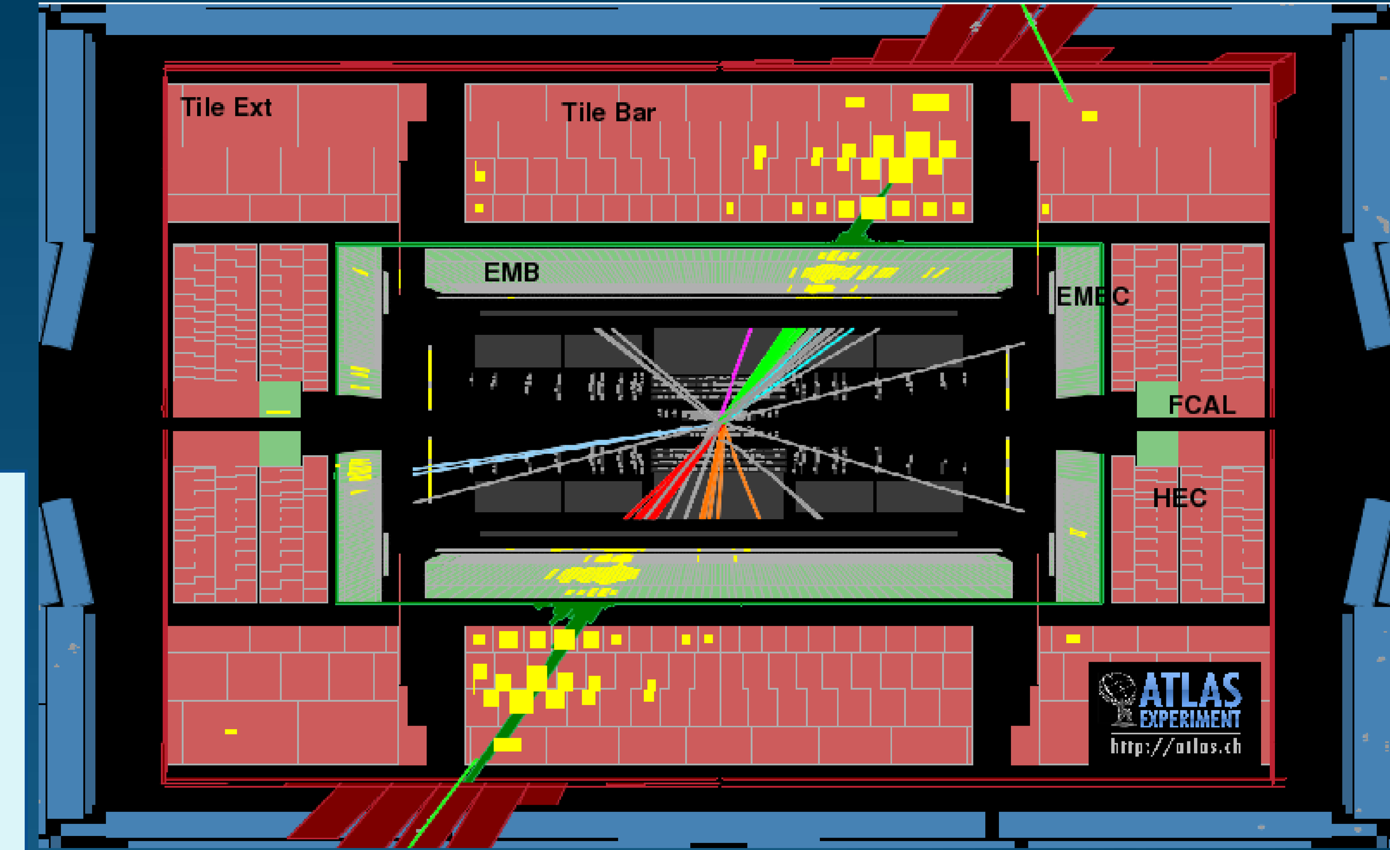


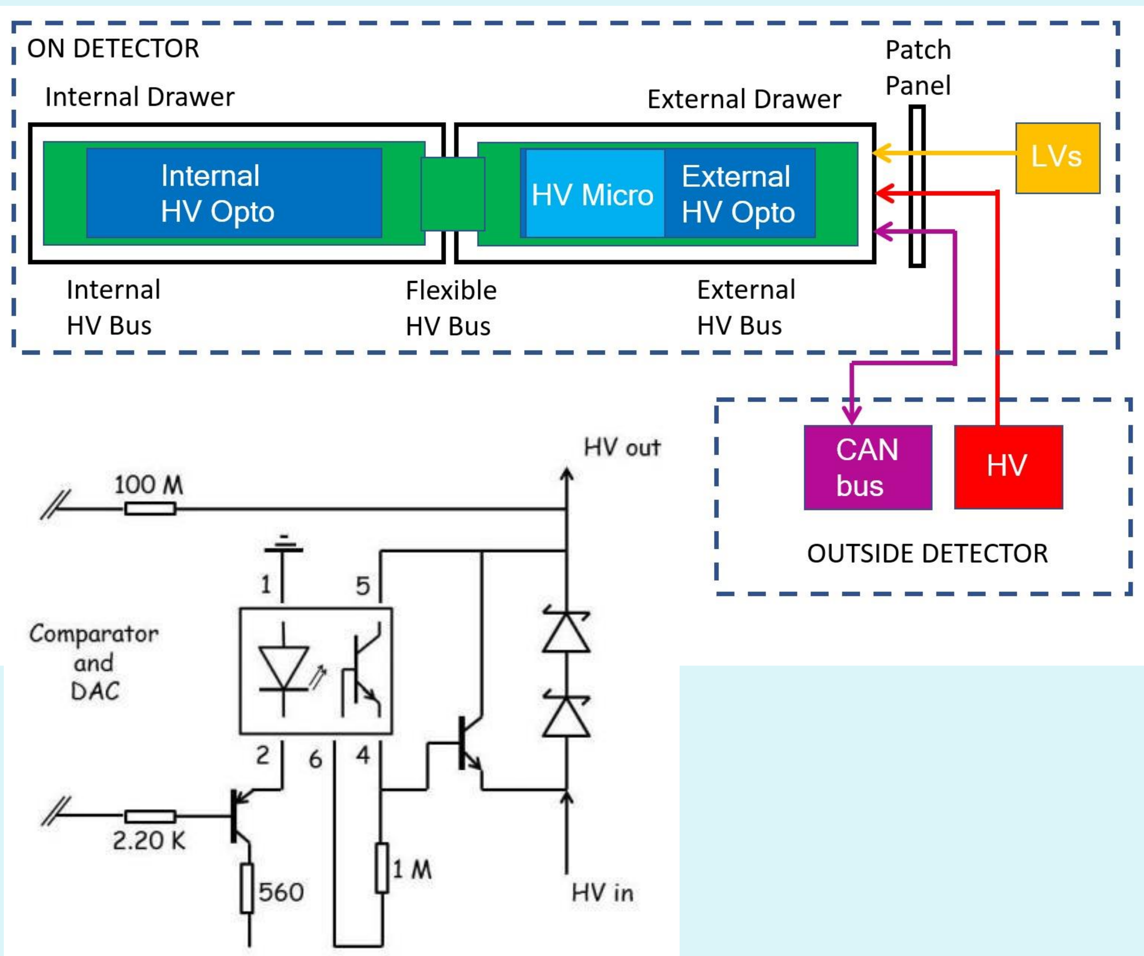
HV Upgrade main motivations and goals

- LHC upgrade aims to a luminosity increase in Phase II (High Luminosity LHC)
- Ageing of components requires new HV system
- Better radiation tolerance for increased luminosity
- Improve the reliability and reduce maintenance needs
- Need to provide 9852 voltages in ranges [-470,-830] or [-590,-950] V
- Achieve the same HV performance of previous LHC runs
- Voltage stability required: 0.5 V rms
- Precision of setting/reading: 0.25 V

Tile Calorimeter

- ATLAS central hadronic calorimeter made of steel and plastic scintillator tiles
- The scintillators are readout on both sides by two PMTs using WLS fibres
- Divided in 4 partitions, each one composed of 64 modules
- PMTs and Front End electronics mounted in 3m long drawers at the outer radius of the modules
- Measures hadrons and jet energy and direction

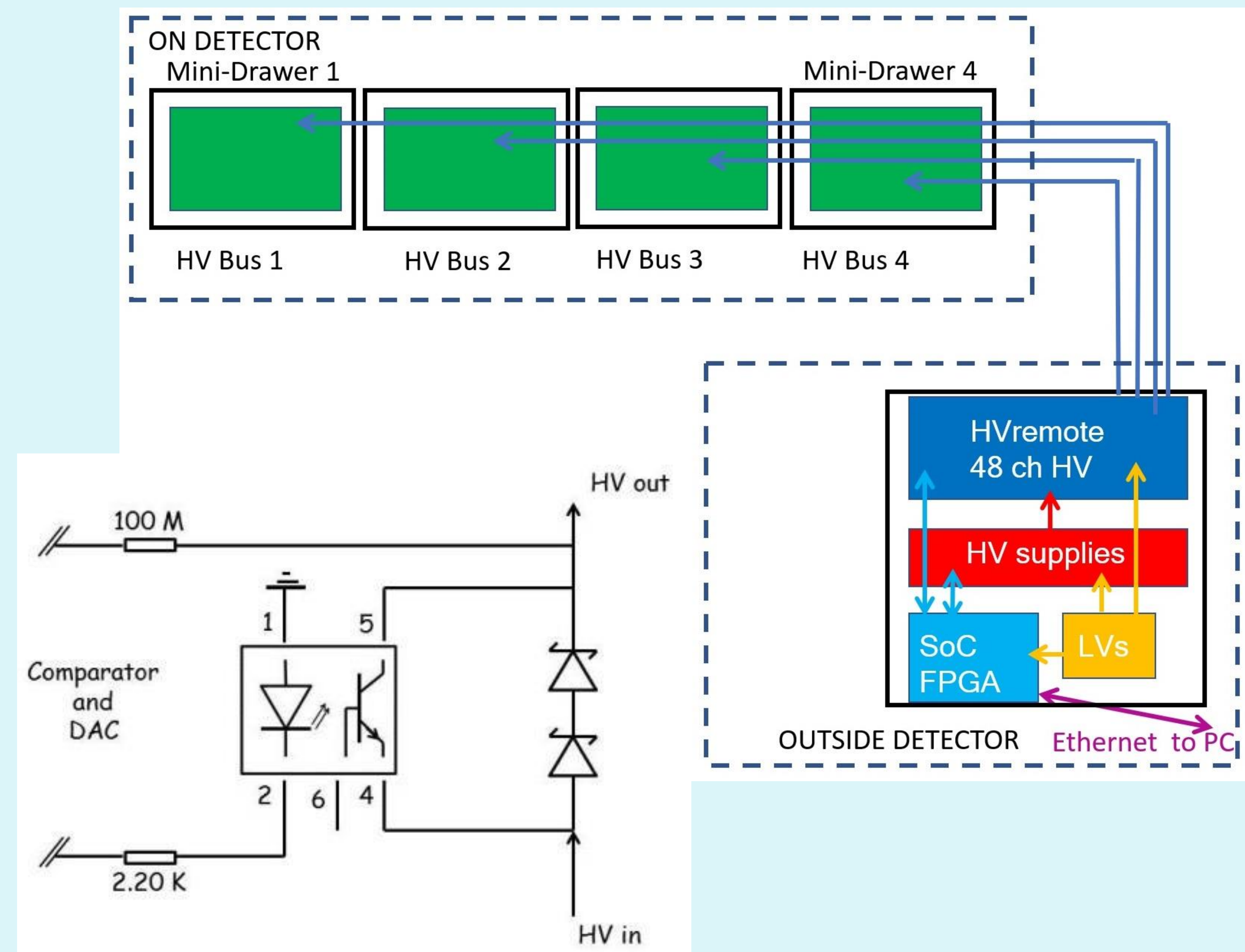
From present HV system to Phase II upgrade



Current High Voltage system

- Embedded, regulation in-detector in radiation hard board
- No access when running
- One single HV input per module
- Communication using Canbus

- Individual regulation loop: optocoupler + 2 transistors

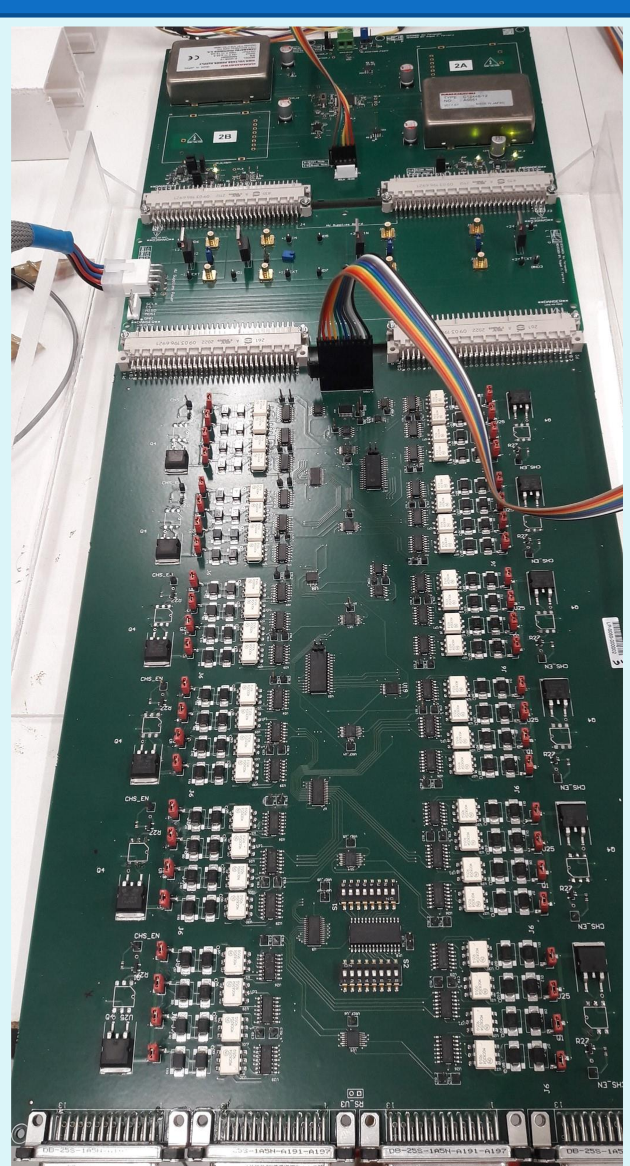


High Voltage for Phase II upgrade

- Remote regulation off-detector
- No radiation
- Permanent access for maintenance
- On/off control for each channel (by jumpers) and remote control for groups of 4 channels
- Up to 48 HV inputs per module supplied using 100 m long multiwire cables
- Passive HV bus cards
- Communication with detector control system using Ethernet

- Transistors removed from the control loop

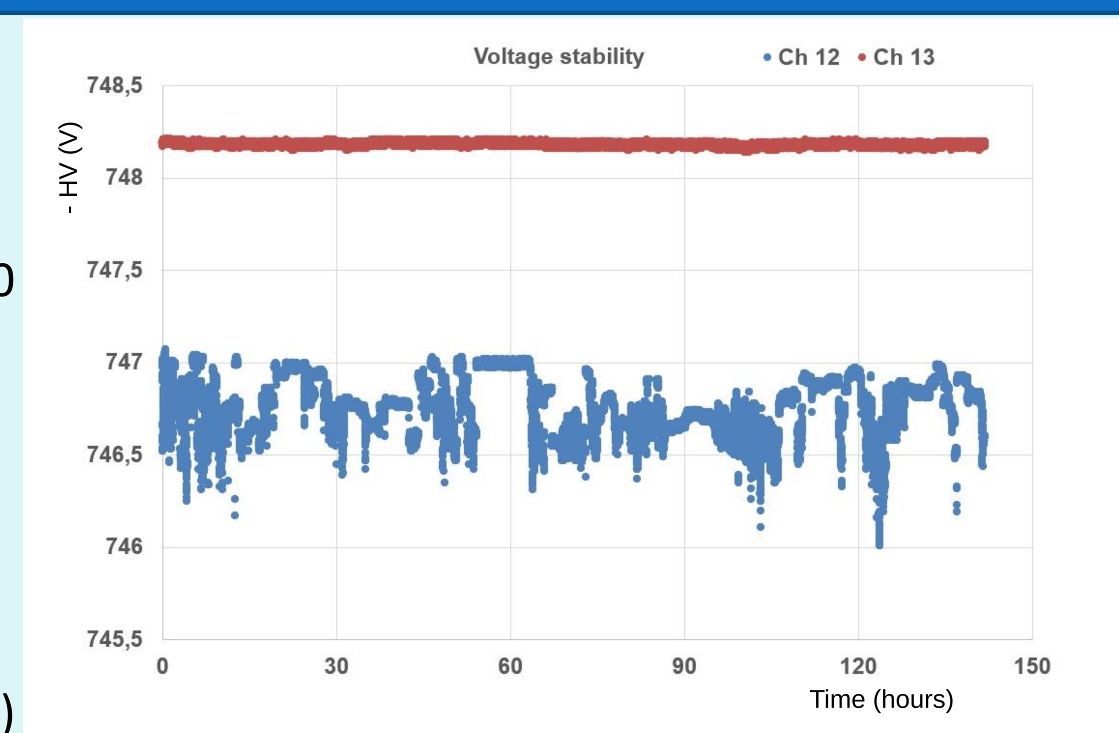
HVremote board and lab tests



HVremote board

- 6U boards with 48 channels
- SPI connection through the crate midplane
- Control based on a System on Chip (SoC) Zybo Z7-20 Zynq board - one ethernet connection per crate to simplify board replacement
- Prototypes control and monitoring still with Raspberry Pi
- Compact, design unit are 4 channels
- Implemented on/off switch for sets of 4 channels (and jumpers allowing to disable individual channels)
- Tested with HV supplies boards
- Voltage calibrated in the lab
- 1 bad channel in the board (to be corrected)

HVremote 48 channel prototype board on test with a HV supplies board and a dedicated adapter board.

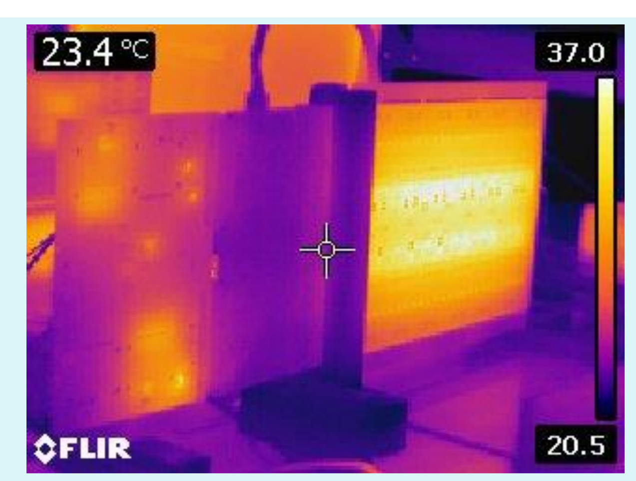


Voltage readings from channel 12 and channel 13 of the 48 channel prototype of HVremote board (readings every 10 sec using a voltmeter). Channel 13 is very stable and 12 is unstable but within +/- 0.5 V. This prototype board have one unstable channel and one bad channel to repair.

Voltage calibration

	V as function of ADC value		V as function of DAC value	
Channel	Calibration factor	offset	Calibration factor	offset
Ch 1	0,2511	-3,8550	0,2407	0,6491
Ch 2	0,2511	-4,1186	0,2421	0,5651
Ch 3	0,2512	-3,7124	0,2426	0,5581
Ch 4	0,2496	-3,7878	0,2414	0,7552
Ch 5	0,2502	-3,8007	0,2415	0,1809
Ch 6	0,2518	-3,0491	0,2420	0,1841
Ch 7	0,2508	-3,7339	0,2422	0,2635
Ch 8	0,2504	-3,7130	0,2416	0,2891
Ch 9	0,2525	-3,8069	0,2426	0,5787
Ch 10	0,2508	-3,5158	0,2422	0,5083

HVremote board prototype readings and writings were calibrated. Calibration factors for 10 channels of the HVremote board prototype showing similar values along the board.



Temperature distributions of HV supplies (left) and Hvremote boards (right). Thermal camera was very useful to identify MUX damaging in the first prototype of HVremote boards with 48 channels

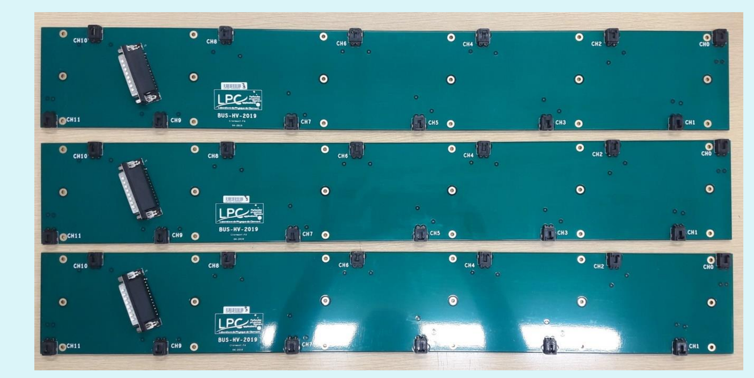
HV system components

Cable

100 m long cables will connect the HVremote boards to the detector. Worst constraint: maximum diameter of 17 mm for the cables for the Extended Barrel modules.
Design improved for a last prototype.

HV Bus

To be used inside the detector as extension of the cables. Fully passive, 4 layers to have HV tracks protected in the inner layers. Last prototype produced for test beam.



Set of 3 HV Bus prototypes produced this year following the design from LPC Clermont Ferrand

HV supplies

Board with DC-DC converters that produce the primary high voltage (tipically -830 or -950 V), and with on/off switches for the HVremote boards.

Prototype of HV supply board. It has 2 DC-DC Hamamatsu C12446-12 modules able to supply 10 mA up to -1000 V

Prototype of the crate for the boards. It has a midplane and the HVremote boards go in the back.

Crates

6U crates to house the HVremote boards in the back and the HV supply boards in front, control board and low voltage power supplies (+24 V, +12 V, -12 V and +3.3 V).

Next steps

Last generation of prototypes in use in the 2021 TileCal testbeams and HV vertical slice test. FPGA bus board to adapt SoC is in redesign for production. Test boards and new final prototypes of HVremote and HV supplies boards will be produced. Final Design Review early next year.

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