Upgrade of the ATLAS Tile Calorimeter High Voltage System

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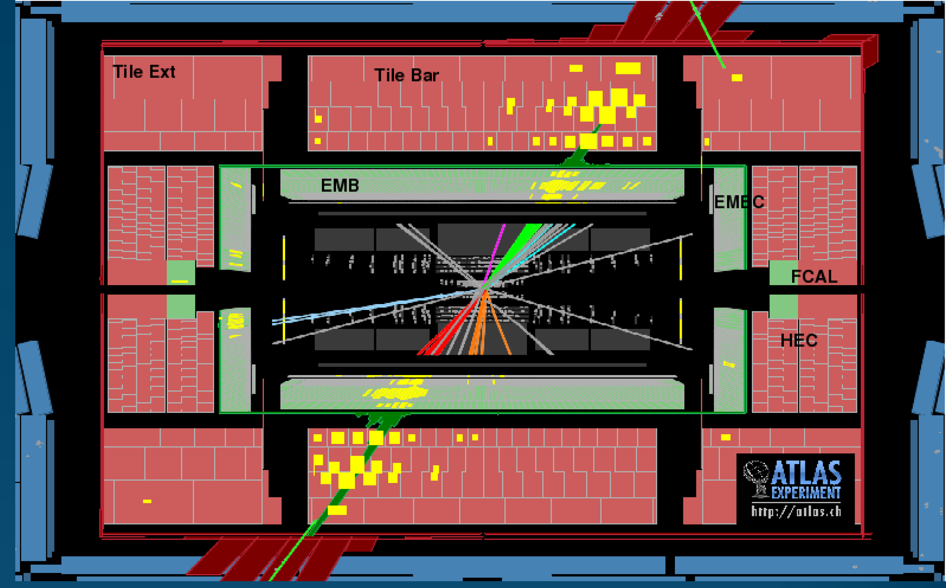


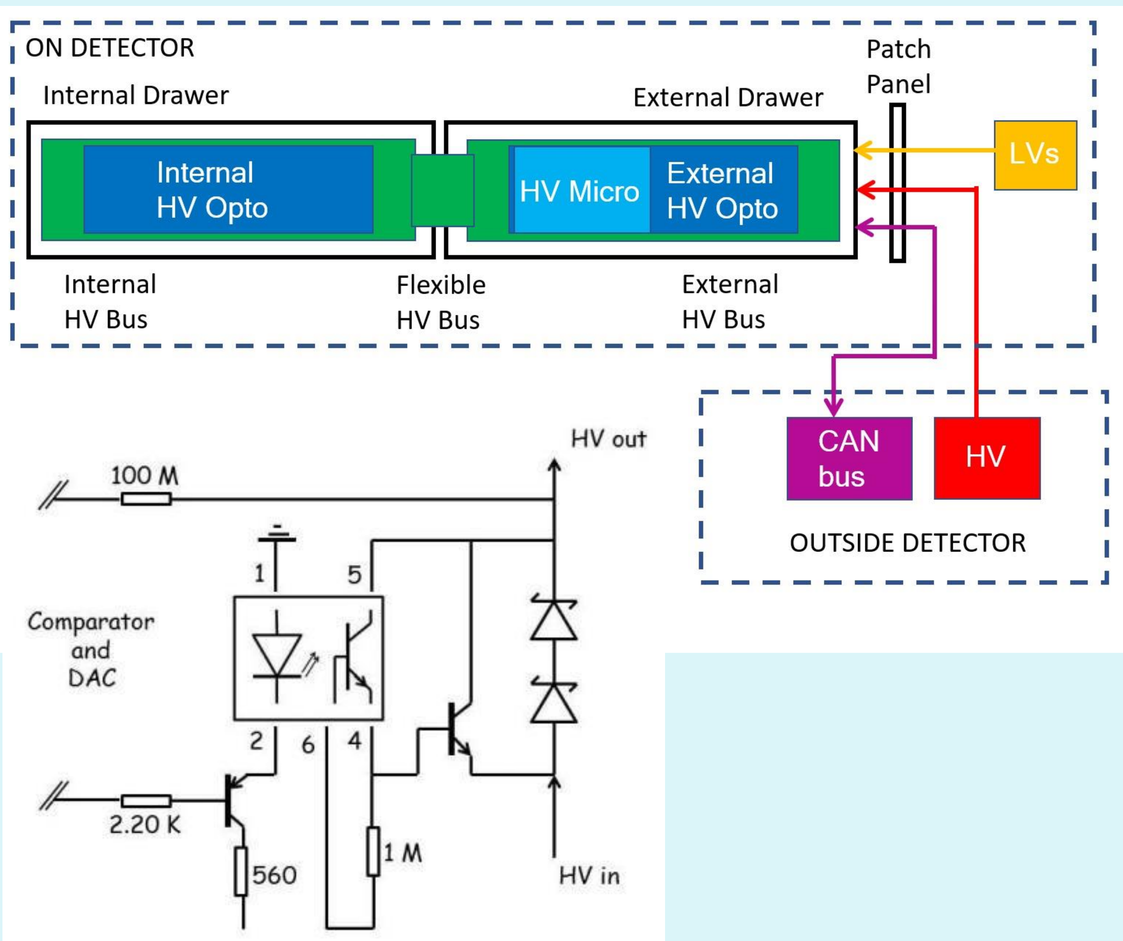
HV Upgrade main motivations and goals

- LHC upgrade aims to a luminosity increase in Phase II (High Luminosity LHC scheduled to start in 2026)
- 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

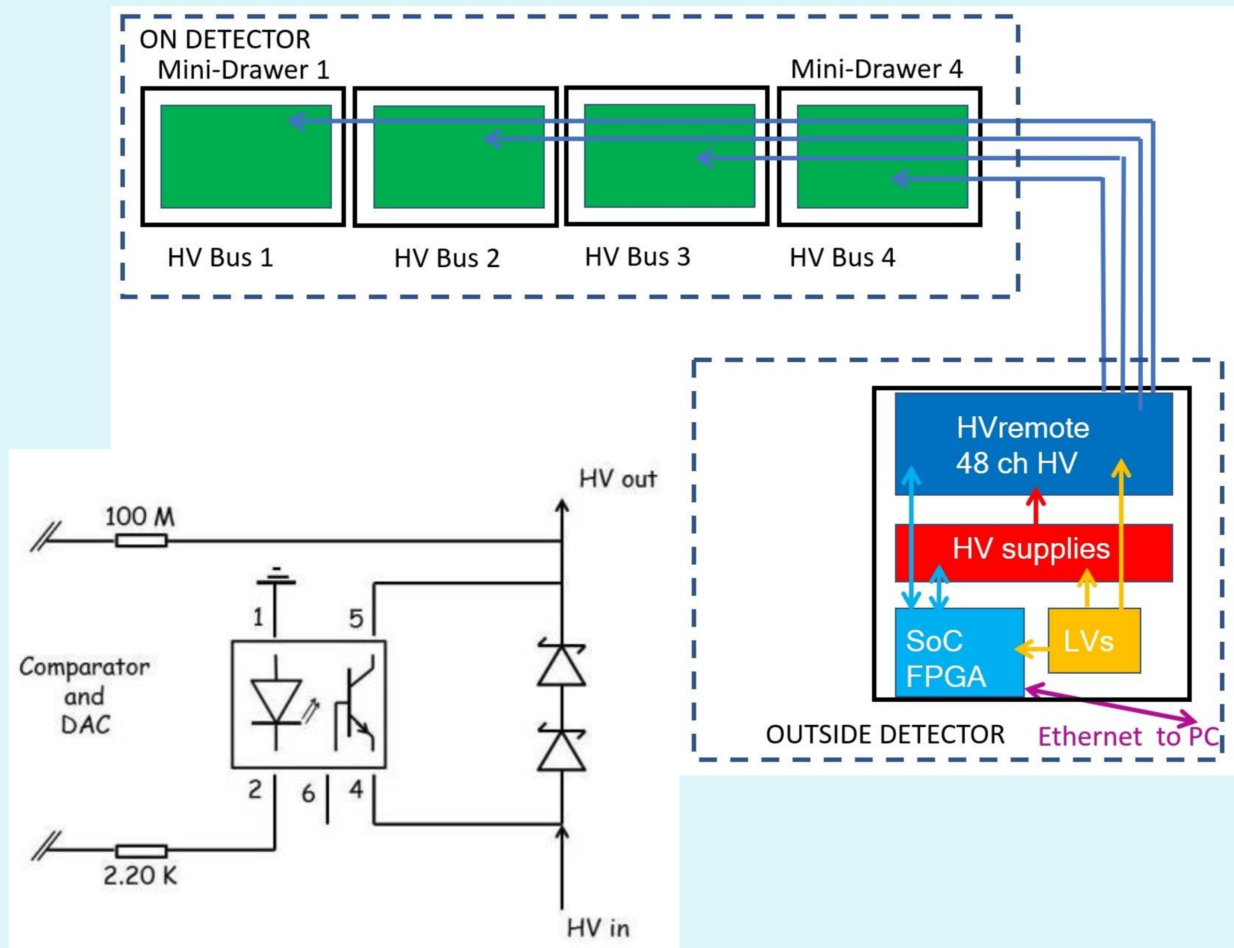
From present HV system to Phase II upgrade



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

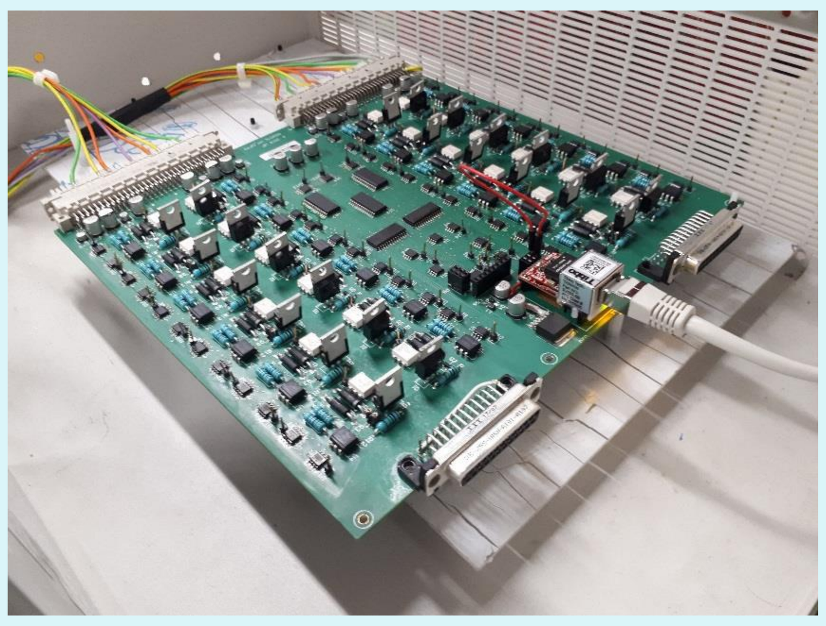


High Voltage for Phase II upgrade

- Remote regulation off-detector
- No radiation
- Permanent access for maintenance
- On/off control for each channel
- 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 loop control

HVremote prototype lab tests



24 channel prototype board on test. Primary HV supplied by a DC-DC C12446-12 module

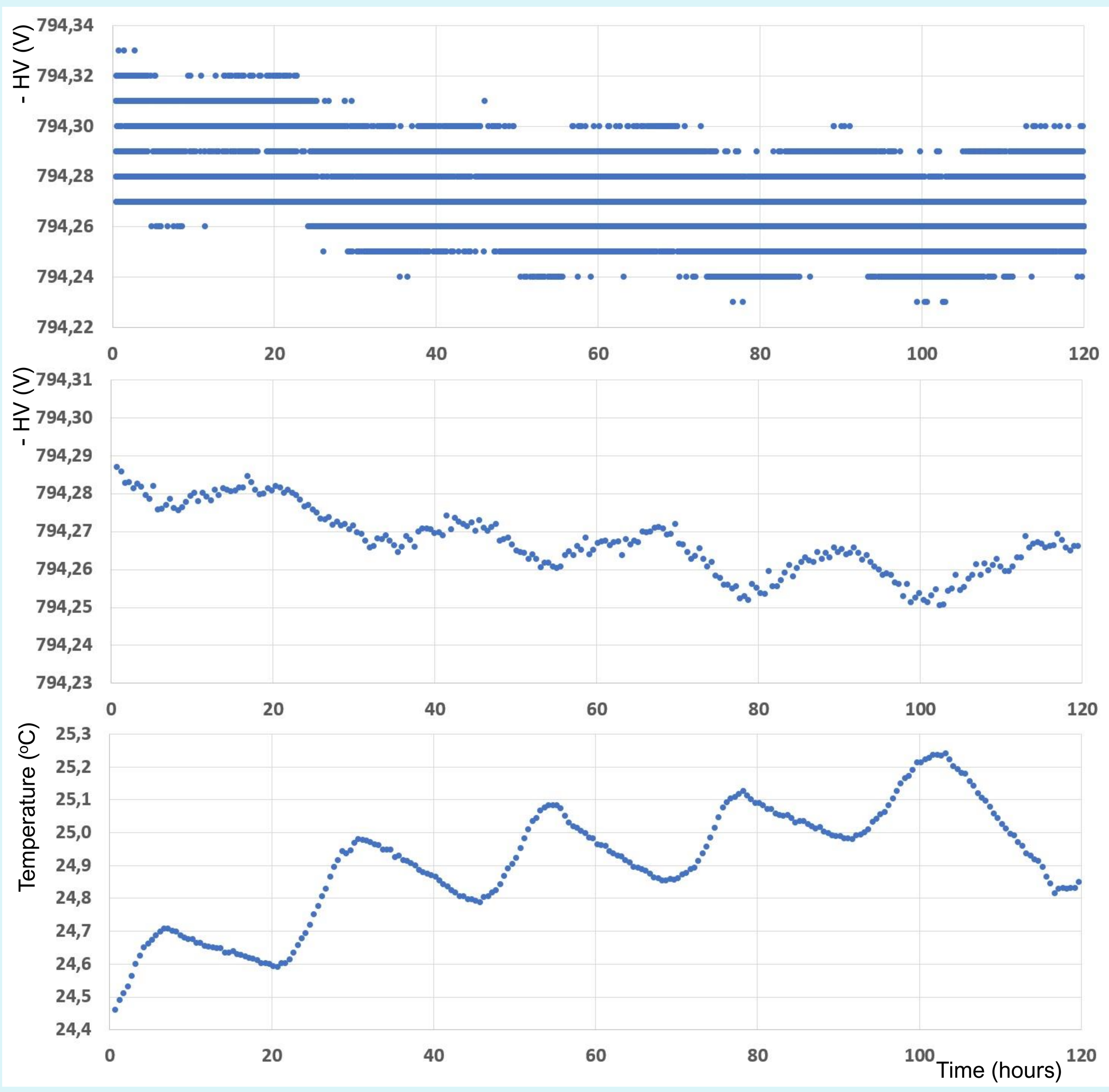
12 channel prototype

Just a modified version of the original HV Opto boards used in the Tile Calorimeter

Used to demonstrate the feasibility of the remote solution

24 channel prototype

- 6U boards with 24 channels
- One ethernet connection per board
- Implemented on/off switch for every channel (design redone in 48 channel prototype to avoid effect of dark current variations of optocoupler phototransistor)



Voltage readings from channel 1, raw data in the top (readings every 10 sec), voltage average per half hour in the center. Temperature is shown at the bottom. 5 days with stable channels.

24 channel prototypes tested in the lab for several weeks

- Tests at room temperature
- On/off mechanism ok for most of the channels but failling for a few channels that could oscillate uncontrolled between on and off due to dark current variations of optocoupler phototransistor (plots at left selected for a period of stable On channels without any oscillation on/off)
- For stable temperature (within 1 degree) HV output within 100 mV
- Variation of HV output with temperature estimated to be in the range 50-100 mV/^{o}C

48 channel prototype

- Control based on a System on Chip (SoC) board - one ethernet connection per crate to simplify board replacement procedure
- 3.3 V CMOS Logic Levels
- Compact, design unit are 4 channels
- 233 x 340 mm, prototype in production

Other 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 with 32 pairs of wires that are used for the Extended Barrel modules.

Prototypes available from 2 companies are being tested.

DB25 connectors are also being tested.

HV Bus

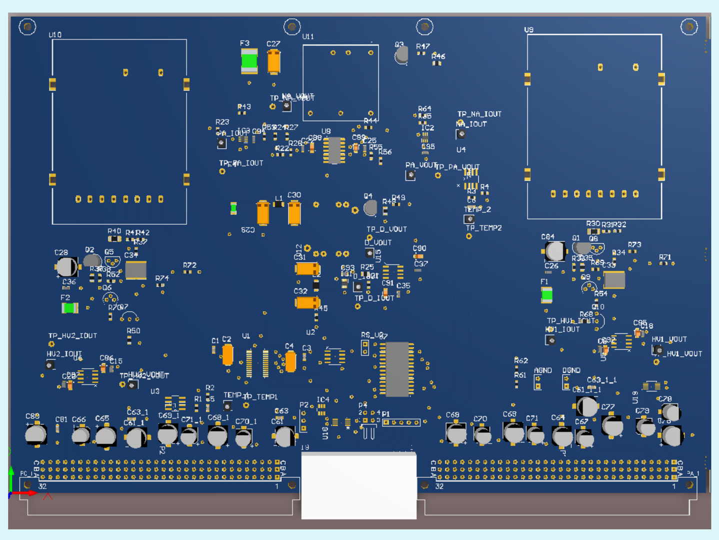
To be used inside the detector as extension of the cables. Fully passive (only 500 Ω resistors and connectors), 4 layers to have HV tracks protected in the inner layers. Prototypes being tested.

HV supplies

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

First prototype in production.

HV supply board, graphical view of first prototype in production. Dimension is 166 x 233 mm. The 2 large footprints on top are for 2 DC-DC Hamamatsu C12446-12 modules able to supply 10 mA up to -1000 V



Crates

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

Next steps

New prototype of HVremote board is in production. HV supplies board with HV + LV was designed and is also going to production. These boards will be tested using a Raspberry Pi (SoC with FPGA will come later) and will be introduced in the ongoing Demonstrator test at the ATLAS detector. New cable prototypes and connectors will also be tested in the Demonstrator. Design of the crate to house the boards is in progress. A full slice of the HV system will be tested in 2020.

References

- R. Chadelas et al., High voltage distributor system for the Tile hadron calorimeter of the ATLAS detector, ATLAS-TILECAL-2000-003, 2000, https://cds.cern.ch/record/436230
- F. Vazeille, Performance of a remote High Voltage power supply for the Phase II upgrade of the ATLAS Tile Calorimeter, JINST 11 (2016) C02050

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