Upgrade of the ATLAS hadronic Tile calorimeter for the High luminosity LHC

Siarhei Harkusha, Institute of Physics, Minsk, Belarus on behalf of the ATLAS Tile Calorimeter System

**ATLAS Tile Calorimeter**
- Central hadronic calorimeter of the ATLAS detector at the Large Hadron Collider (LHC)
- Sampling calorimeter made of alternating thin steel plates and scintillating tiles
- Scintillating tiles read out by 2 photomultipliers (PMT) via wave length shifting fibres
- Divided into long and 2 extended barrels along the beam direction and segmented azimuthally into 64 modules

**Present system → Upgraded system**
- Fully digitized signals will be provided to the first level trigger instead of analogue limited one to improve precision and granularity information
- On-detector pipeline memories will be moved to off-detector to increase performance and radiation hardness
- To increase reliability of the system:
  - 12 PMTs will be read out by 4+4(redundant) links instead of 48 PMTs read out by 1+1 links
  - 4+4 low voltage power supply (LPVS) units will provide power to 12 PMTs instead of 1 unit which supplies power to 48 PMTs now
  - 4+4 high voltage (HV) units will supply power to 12 PMTs instead of 2 HV units which supply power to 24 PMTs now

**Status**
- Most components passed radiation tests for high luminosity
- Demonstrator has been interfaced with legacy control, monitoring, and calibration infrastructure

**Summary**
- The Upgraded LHC for High Luminosity LHC (HL-LHC) will deliver five times the LHC nominal instantaneous luminosity
- The ATLAS upgrade, in 2024, will accommodate the detector and data acquisition system for the HL-LHC
- Tile Calorimeter will undergo a major replacement of its on- and off-detector electronics. All signals will be digitized and transferred to the off-detector electronics, where the signals will be reconstructed, stored, and sent to the first level of trigger at a rate of 40 MHz. This will provide better precision of the calorimeter signals used by the trigger system and will allow the development of more complex trigger algorithms. Changes to the electronics will also contribute to the reliability and redundancy of the system.

**Front End Boards (FEB): 3 options**
- Process PMT signals
- Slow integration for Cesium calibration
- Charge injection calibration (CIS)

**Upgraded 3-in-1: Discrete elements**
- Passive pulse shaping
- Bi-gain amplification (1x, 32x)
- Analog trigger output

**FATALIC: Current conveyor in ASIC chip**
- Tri-gain (1x, 8x, 64x)
- Signal digitization

**QIE: Charge integration in an ASIC chip**
- No pulse shaping
- Signal digitization

**Tile Preprocessor**
- Receives high-speed data from on-detector electronics
- Provides data to the first level triggers
- Saves data in pipelines pending trigger decision
- Signal reconstruction
- Interface with ATLAS data acquisition system
- Monitoring, data control system
- Trigger, timing and control signals to FEB

**Tile Calorimeter Upgrade design: Tile Hybrid Demonstrator**

**Upgraded system**
- Tile Hybrid Demonstrator module is being developed using the new electronics while conserving compatibility with the current system. The demonstrator is undergoing extensive testing and is planned for insertion in ATLAS during the next possible opening at the end of 2016.

**Daughter board: Compatible with 3 FEB**
- Data concentration and control system
- 2x redundancy data transmission to off-detector
- On detector electronics timing management

**Low Voltage Power Supply**
- Same reliable components
- More modular and redundant
- Point of load regulators

**High voltage (HV) regulation: 2 options**
- Individual PMT control (in both options)
  - Remote HV (one option)
    - Off-detector
    - HV to each PMT separately
  - Local HV / HV Opto (another option)
    - Improved monitoring and radiation hardness
    - HV supplied to 6 PMTs

**Summary**
- The Upgrade for High Luminosity will be chosen after extensive test-beam studies.
- There will be two more test beam campaigns in summer and fall 2016. Three different front-end and two HV options are presently being produced. Control and calibrations tests have proved successful in the demonstrator, all legacy systems have been interfaced. The test-beam was during two weeks in October 2015. There will be two more test beam campaigns in summer and fall 2016. Three different front-end and two HV options are presently being investigated for the upgrade, a final solution will be chosen after extensive test-beam studies.