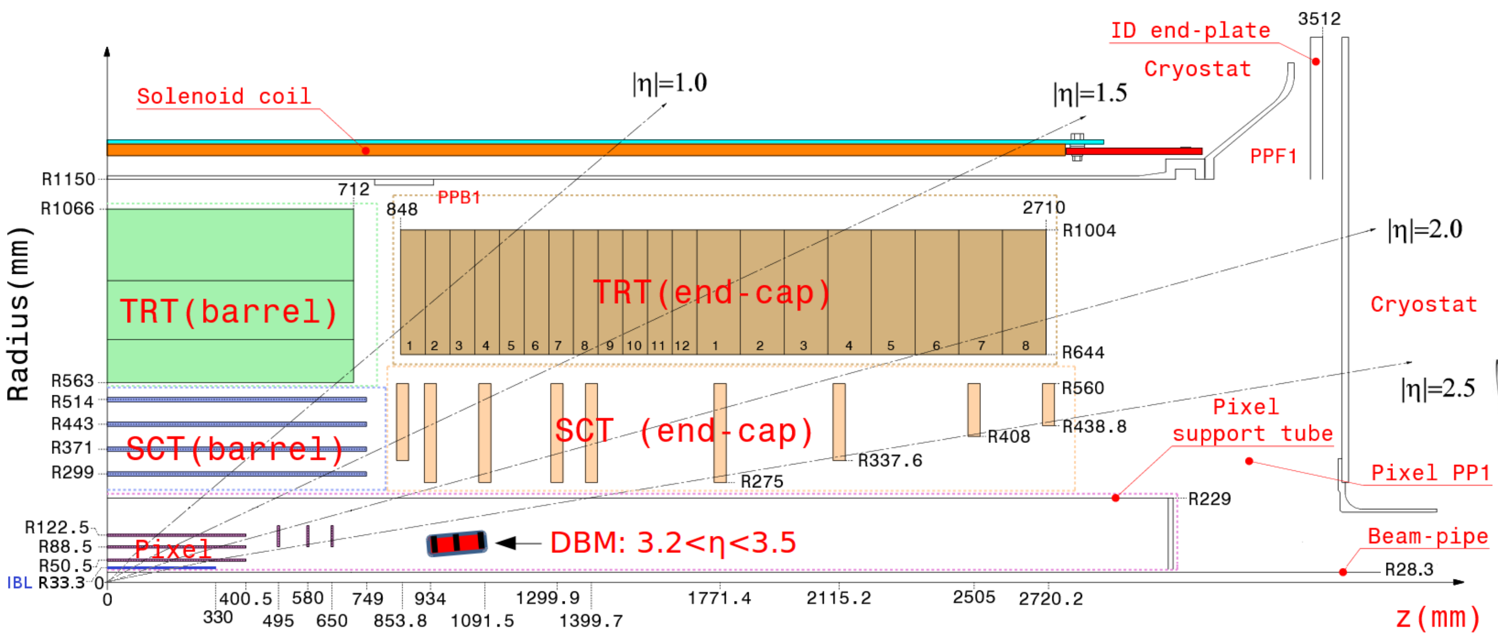
THE DETECTOR CONTROL SYSTEM SAFETY INTERLOCKS OF THE DIAMOND BEAM MONITOR.

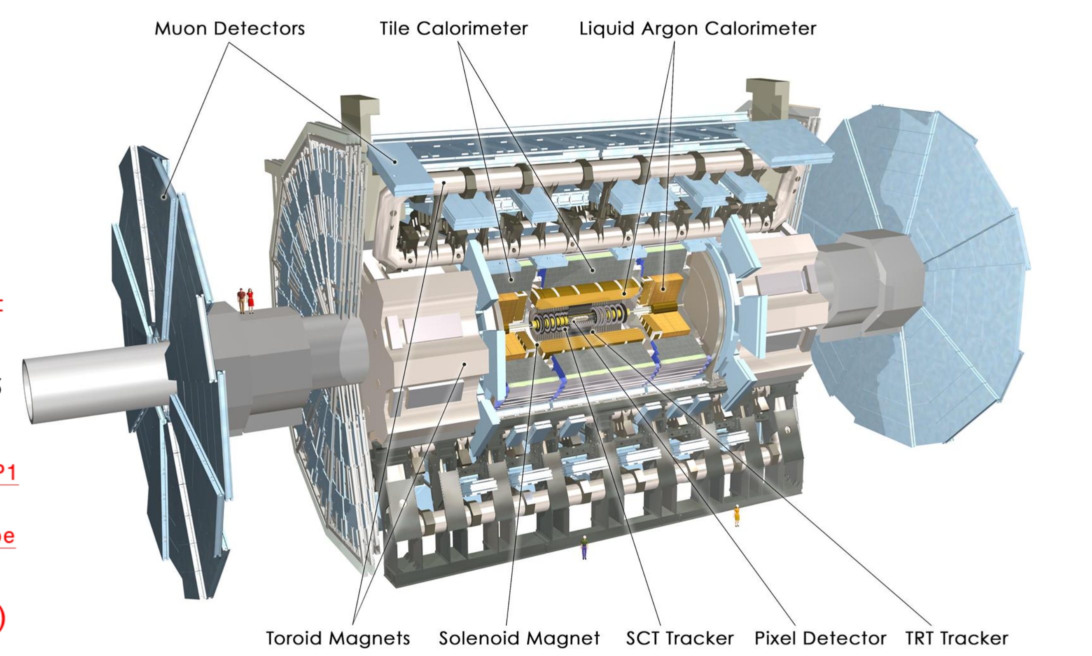
Introduction

The ATLAS (A Toroidal LHC ApparatuS) experiment is one of the two general purpose detectors under operation at the Large Hadron Collider (LHC) at CERN. The ATLAS detector searches for new physics in high-energy collisions of protons (up to 14 TeV). The inner detector is the first part of ATLAS to see the decay products of the collisions, so it is highly compact and very sensitive. It consists of three different systems of sensors all immersed in a magnetic field parallel to the beam axis - Pixel Detector, Semiconductor Tracker, and Transition Radiation Tracker.

The Diamond Beam Monitor (DBM) is a bunch-by-bunch luminosity monitor, designed to provide an accurate luminosity measurement. It is a part of the Pixel Detector and placed in its support structure close to the beam pipe.

At the ATLAS experiment, the Detector Control System (DCS) is used to oversee the hardware conditions and ensures a safe, a correct and an efficient experiment operation. The DCS design is based on the commercial SCADA software package WinCC Open Architecture from Siemens.

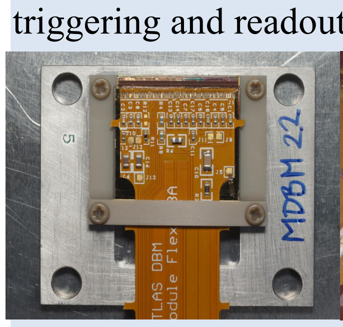




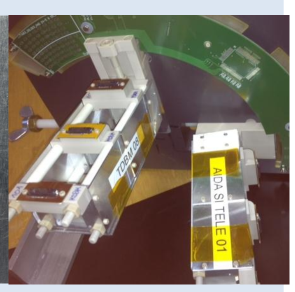
DBM specification

DBM consists of 4 tracking telescopes on either side of the interaction point and each is made out of 3 diamond and 1 silicon telescopes. Each telescope consists of 3 diamond/silicon sensors with FE-I4 readout chips.

The telescopes are connected pairwise to a hitbus chip to allow for specialized triggering and readout.



FE-I4 chip



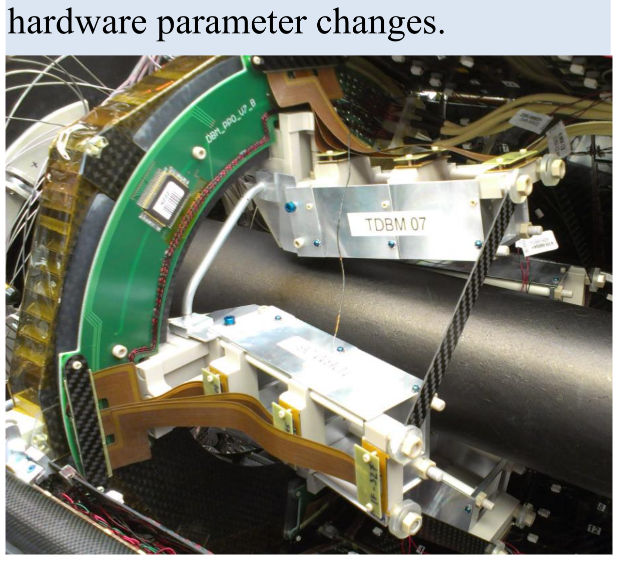
2 mounted telescopes

FE-I4 is the pixel readout chip which is used by DBM and IBL. Its specs:

- 50 microns x 250 microns with 26880 readout channels (336 x 80);
- operation temperature -5 to 10 °C;
- data link speed 160 Mbit/s.

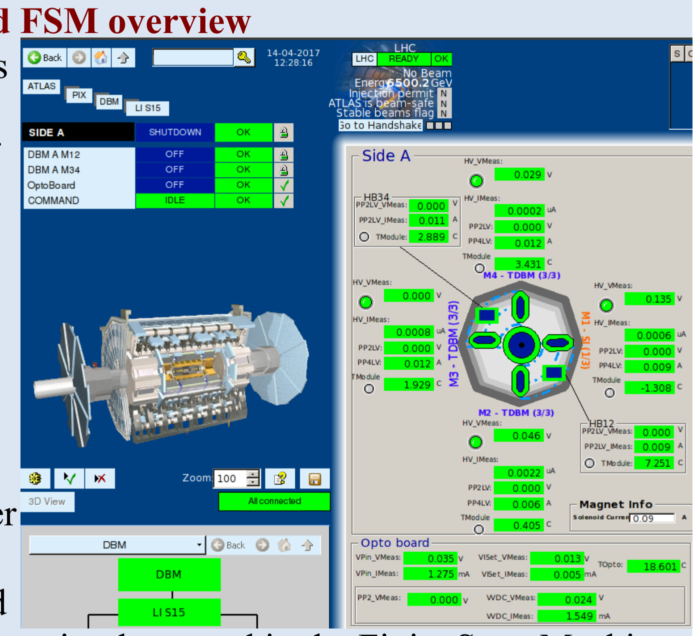
The DBM FE-I4 data is used for luminosity estimation.

The DBM telescopes are mounted very close to the beam pipe: 90 cm from IP and 8 cm from the beam. The safety interlocks have been implemented to provide an automatic reaction on hardware parameter changes.

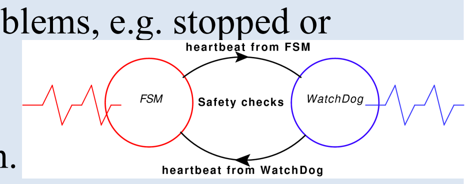


DCS and FSM overview

The Detector Control System (DCS) is responsible for the supervision of the detector equipment, the reading of operational parameters, the propagation of the alarms and the archiving of operational data. Along with a set of commands, which are used for the detector operation, a list of software interlocks is implemented into the DBM DCS, which reacts to the hardware parameter changes in an automated way.



The control scripts which evaluate and summarize the status of the hardware are implemented in the Finite State Machine (FSM). The DBM FSM contains commands, states and status definition and all of their safety interlocks. All software safety checks, being the most crucial part of the DBM normal operation, are duplicated in a WatchDog script which like FSM is the part of the DCS. This way if FSM experience any problems, e.g. stopped or crashed, then the safety interlocks will be applied by the WatchDog. FSM and WatchDog generate heartbeats every 5 seconds to check that they function.

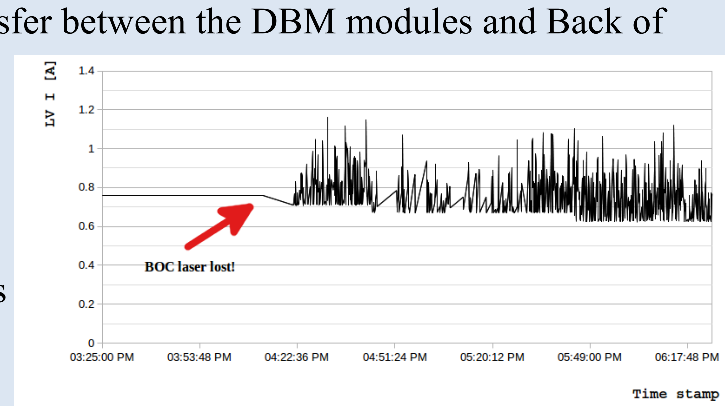


Main safety software interlocks

- The basic safety interlocks implemented for DBM are Temperature (T) and Low Voltage Current (LV I) monitoring. The maximum T is 30 °C and the maximum LV I is 1.4 A for each telescope. If any monitored value exceeds this limits the device will be switched OFF, either by the FSM or the WatchDog.

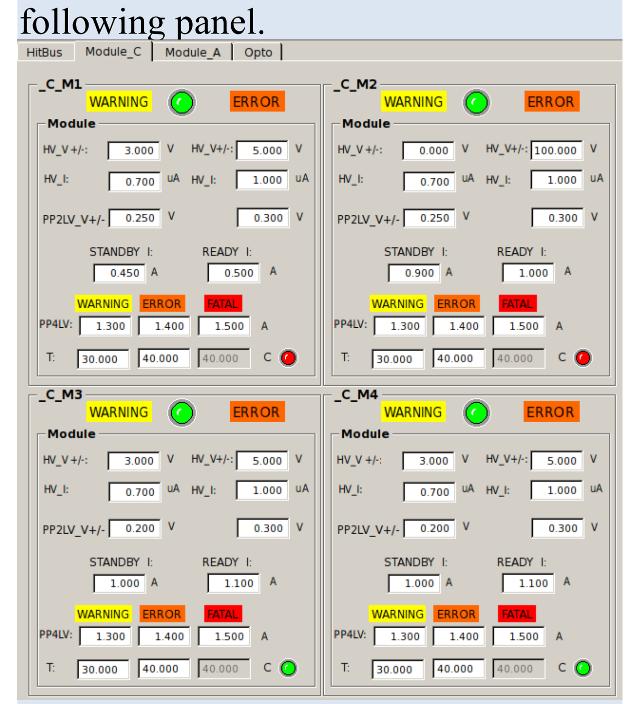
As the checks are performed each time the monitored value is changed, it allows to apply the corresponding interlocks action to the device immediately without unnecessary checks when the monitored value is not changed, e.g. when the device is OFF.

- A second important safety interlock is implemented for the OptoBoard, the device which provides the optical data transfer between the DBM modules and Back of Crate (BOC).
- BOC power and OptoBoard Pin Current ensure that the BOC laser is ON and that the telescopes do not come into undefined state. If the BOC laser is OFF, e.g. BOC is not powered or OptoBoard Pin Current is not in a good range, then modules will be switched OFF.



Laser lost simulation for the diamond telescope

Most of the limits are stored as "data points" and can be changed using the following panel.



In this way the limits can be adjusted on the fly, rather then having the hard-coded values, which would require a restart of the FSM tree in order to apply the changes.

Summary

The DBM has been designed to complement the existing luminosity detectors in the ATLAS experiment. It is mounted in the a high-radiation forward region of the experiment and very close to the interaction point. That is why the safe hardware operation has high priority. For this reason two different procedures, FSM and WatchDog, have been implemented to provide a real-time processing on the hardware operational parameters and an immediate reaction to the hardware danger. They constantly monitor around 90 different hardware channels and ensure safe, correct and efficient experimental operation of the DBM.

Grygorii Sokhrannyi, on behalf of the ATLAS PIXEL DBM group.

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