# Beam Conditions Monitoring in ATLAS

Matthew Fisher
Ohio State University
for the ATLAS BCM group
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THE OHIO STATE UNIVERSITY DEPARTMENT OF PHYSICS

# Introduction

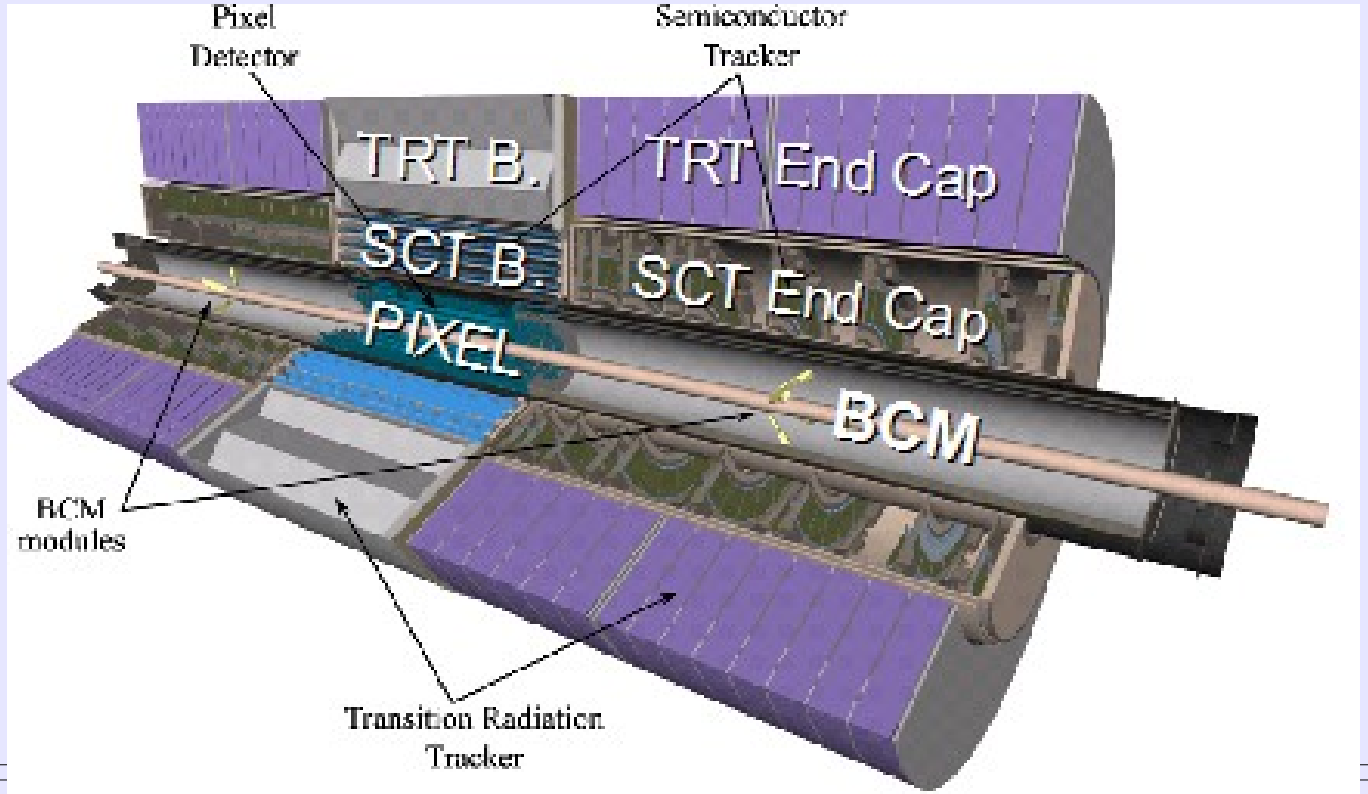
- Purpose
- Detector layout
- Data acquisition
- Detector control system
- Functions
  - Online monitoring
  - Postmortem analysis
  - Luminosity measurement
  - Beam abort mechanism
- Beam abort sensitivity

# Purpose of BCM

- Protect ATLAS by monitoring bunch by bunch beam conditions inside the detector
  - BCM beam abort capability currently disabled
  - ATLAS Beam Loss Monitor (BLM) has the ability to abort the beam based on signals integrated over 40 microseconds or longer
- Provide recent history of beam conditions after an LHC postmortem signal (sent after unplanned beam dumps)
- Measure luminosity in ATLAS

# ATLAS Beam Conditions Monitor

- Four 1 $cm^2$ detectors on each side of the interaction point
- Each detector has two diamonds, sandwiched back to back (inside of sandwich is ground, outsides are biased to HV)
- Located longitudinally 1.84 m from the interaction point at a radius of 5.5 cm
- Relativistic particles take 12.5 ns to travel from one side to the other



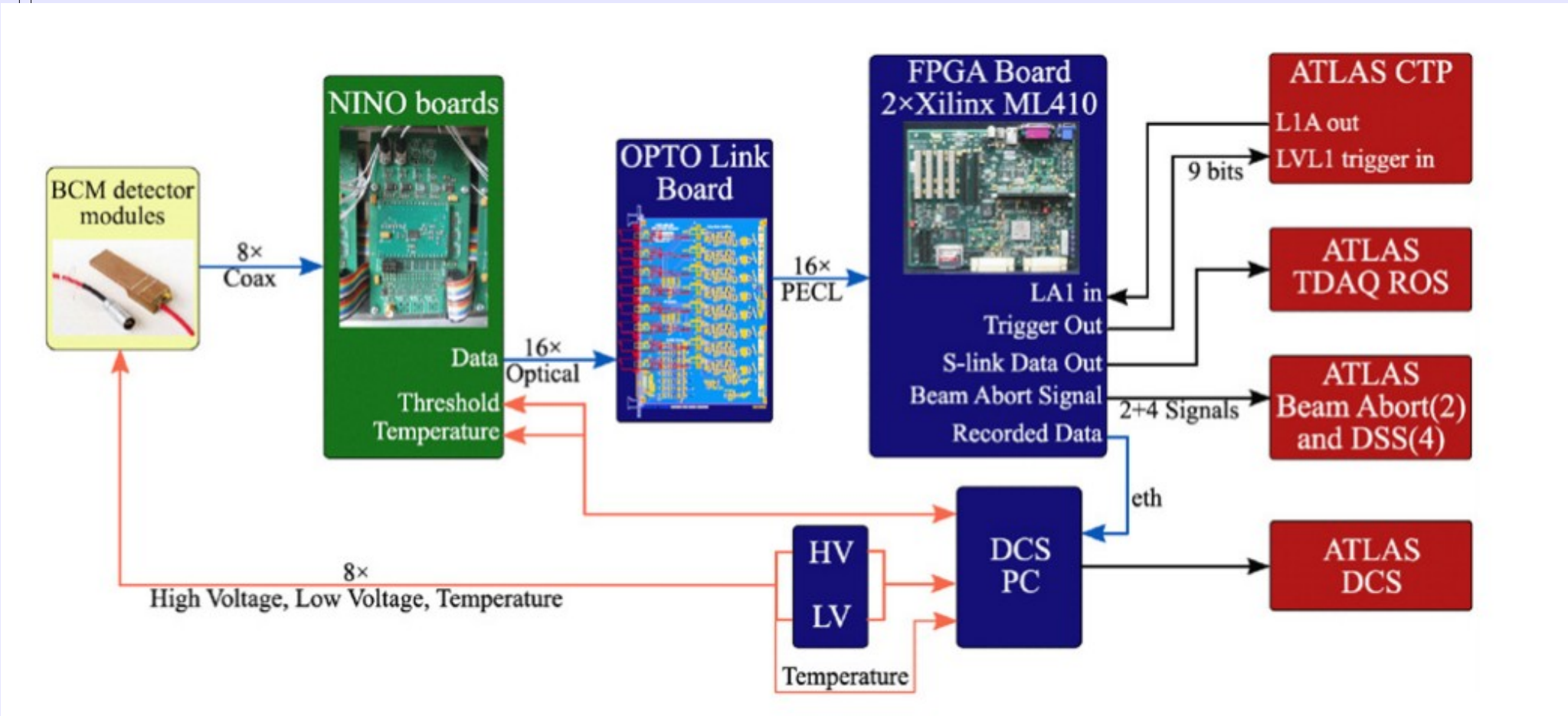
# Diamond detectors

- Diamond was chosen as the detector material because of the fast signal collection and radiation hardness required
  - The sensors are required to tolerate doses up to 500 kGy and in excess of $10^{15}$ charged particles per $cm^2$ over the lifetime of the experiment
  - Detectors plus electronics must have excellent time resolution (~1 ns rise time, 2-3 ns pulse width, 10 ns baseline restoration)

# DAQ system

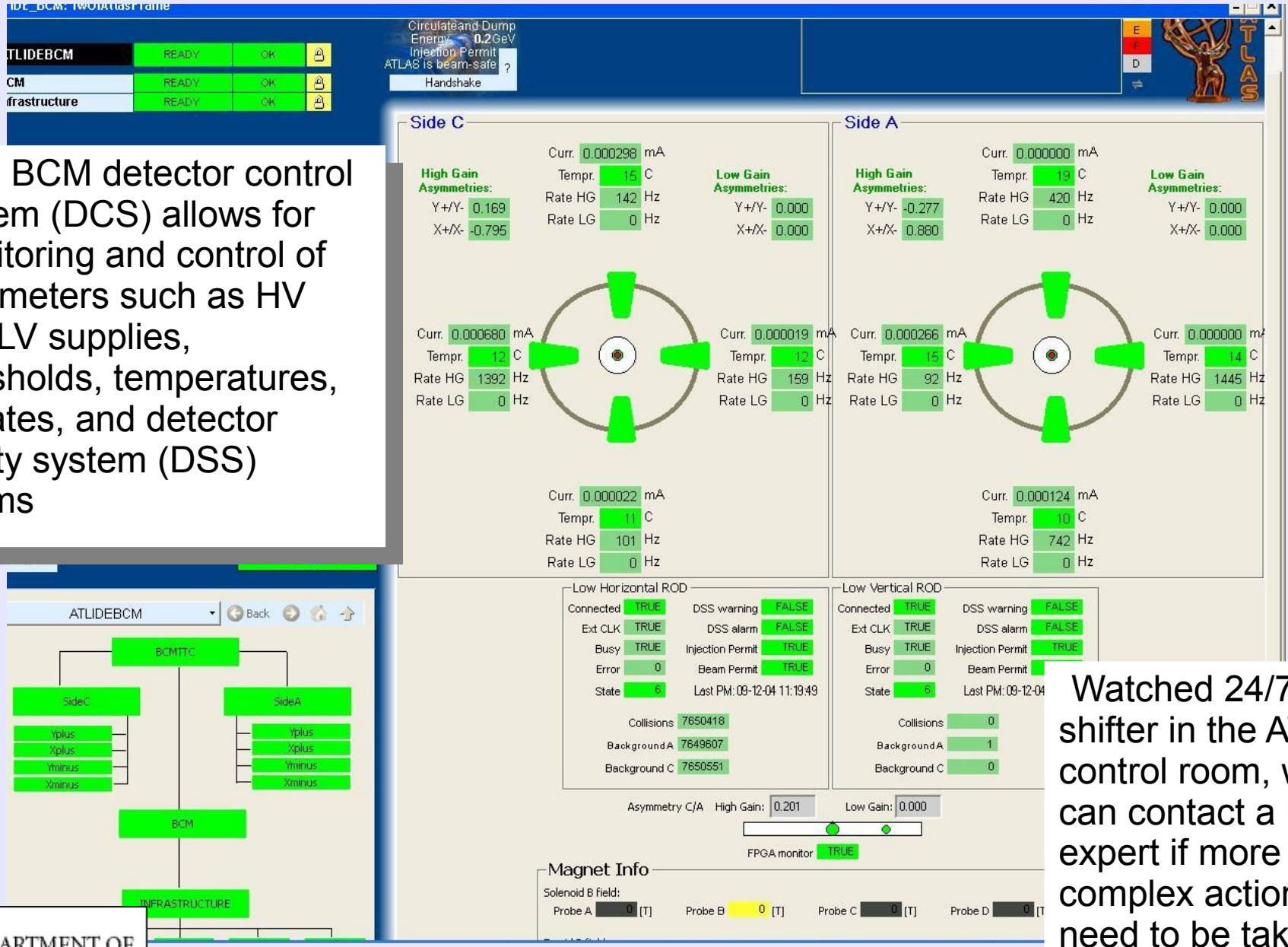
- Current signal from charged particles moving through detector material sent to an amplifer/digitizer board
- High and low thresholds applied and signal is digitized and sent optically to the counting room
- Signals are converted from optical to electronic and sent to the read out drivers (RODs) where the hit data is stored in a circular buffer
- All hit data is compared to beam abort criteria, processed for luminosity calculation, and stored temporarily in case of postmortem signal from the LHC
- Hit data is also used to fire several triggers based on in-time and out-of-time coincidences and high threshold hits, and if ATLAS sends a trigger signal, BCM data will be sent to central ATLAS DAQ
- A sample of this triggered data is used for online monitoring and all recorded ATLAS events have BCM hit data

# DAQ system schematic



# Detector control system

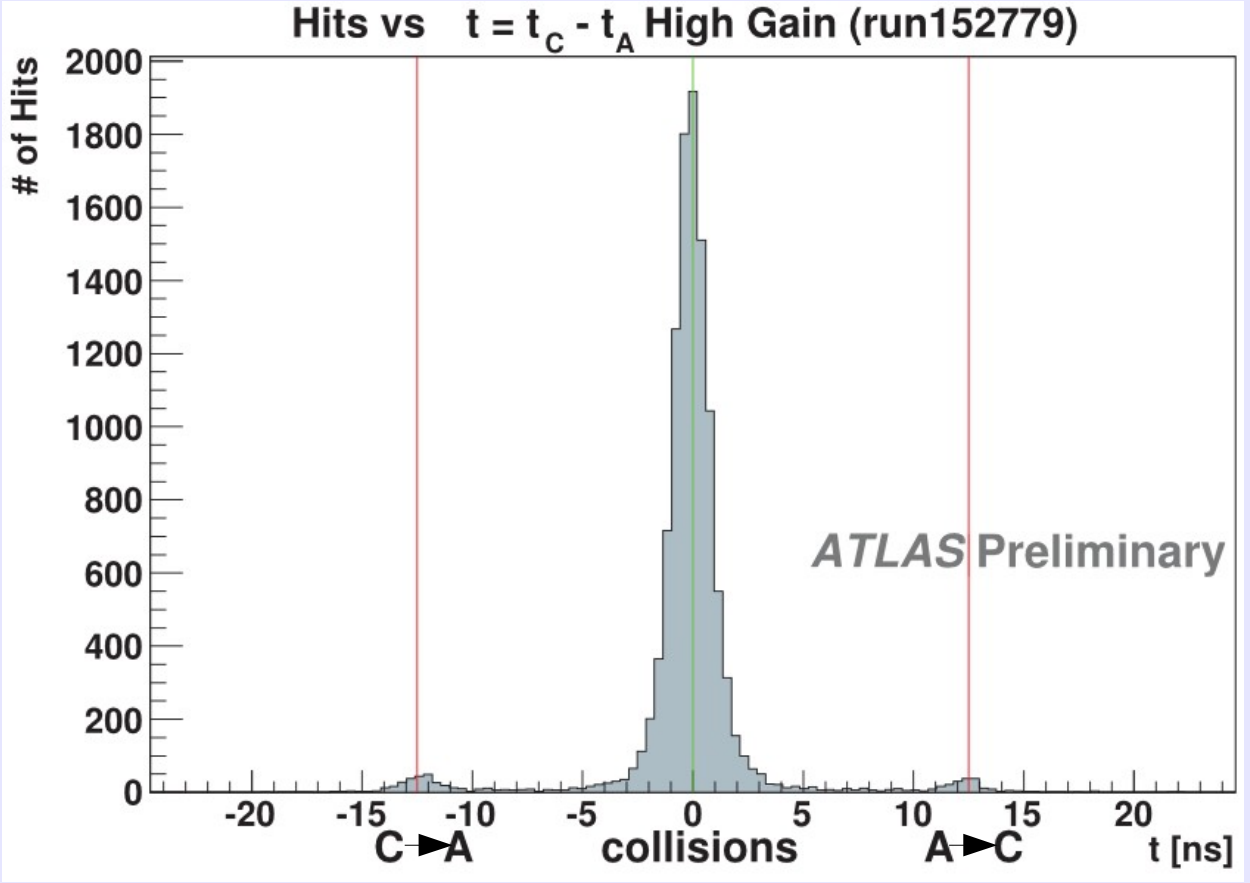
The BCM detector control system (DCS) allows for monitoring and control of parameters such as HV and LV supplies, thresholds, temperatures, hit rates, and detector safety system (DSS) alarms




Watched 24/7 by a shifter in the ATLAS control room, who can contact a BCM expert if more complex actions need to be taken

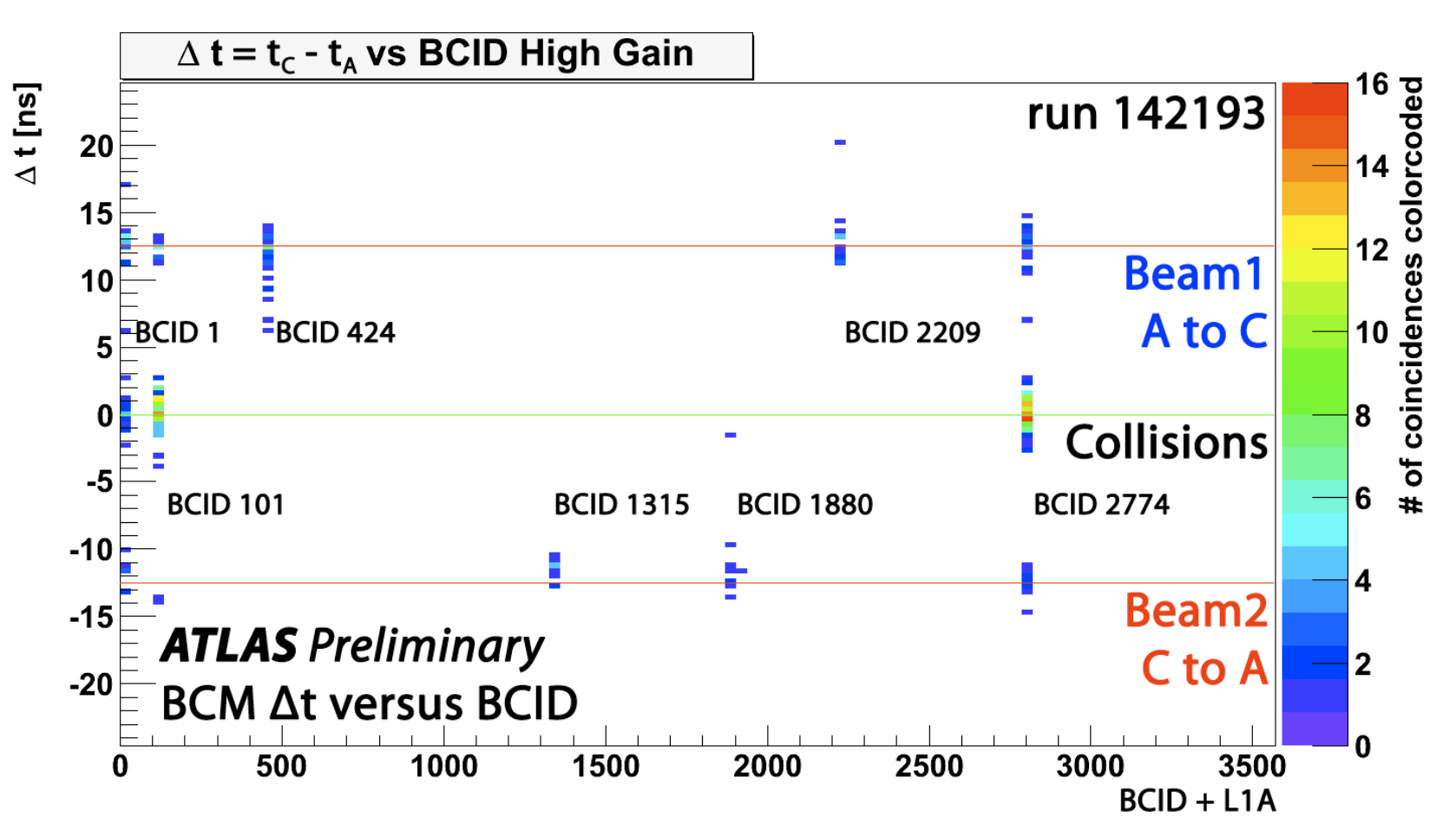
# Online monitoring

- Several plots are generated and continuously updated during normal running
- Allows the ATLAS shift crew to monitor beam conditions (checked before Pixel Detector warm start)




Peak at 0 shows collisions, peaks at +/-12.5 ns show beam background.

# Online Monitoring



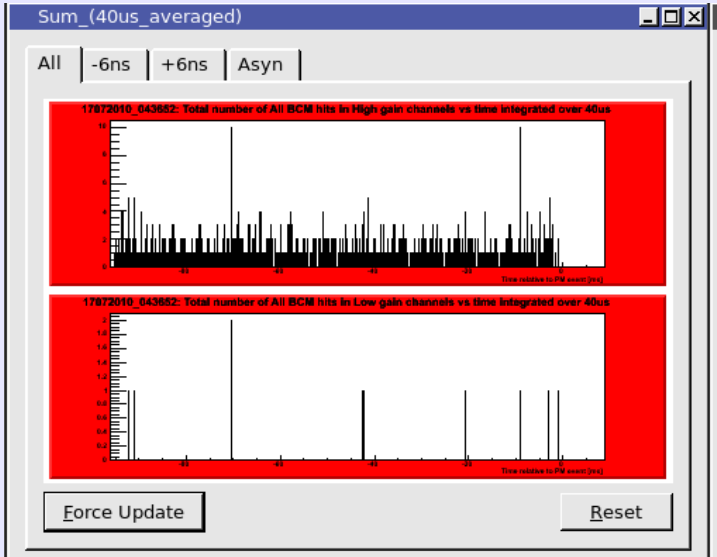

Y-axis is the same as X-axis on previous page, X-axis is bunch crossing ID number, shows difference in collisions/background for different bunches

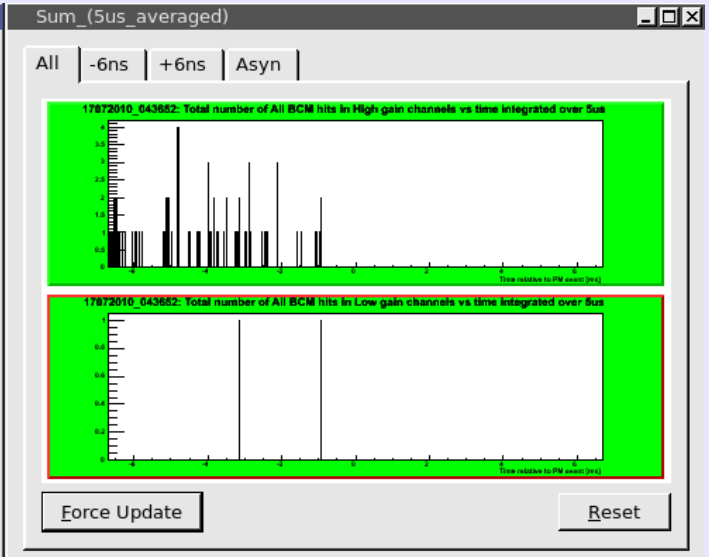
# Postmortem analysis

- Whenever the LHC dumps the beam a postmortem signal is sent
- When the BCM receives a PM signal the circular buffer is frozen and all hit information from the last 1177 orbits is read out
- Histograms are checked by the shift crew and the injection permit is only given if the beam dump is considered clean (no anomalous signals in ATLAS)
- Can provide unique information to LHC when evaluating beam aborts

# Typical postmortem histograms

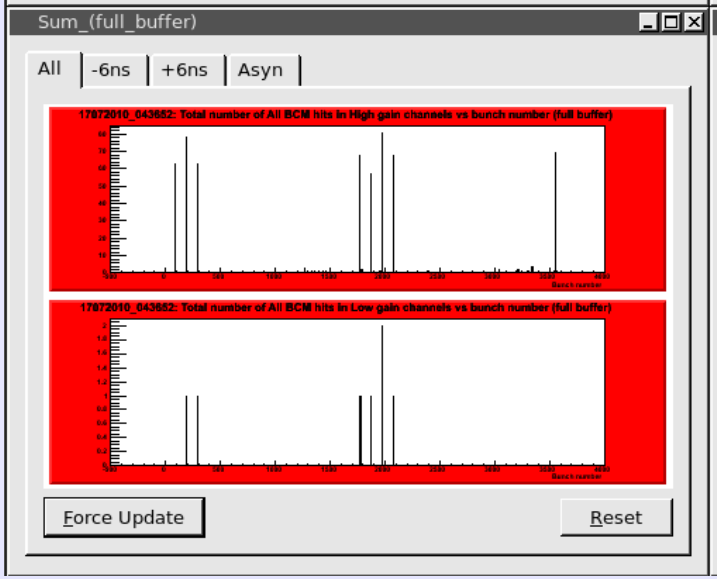
1200
orbits
40 μs/bin

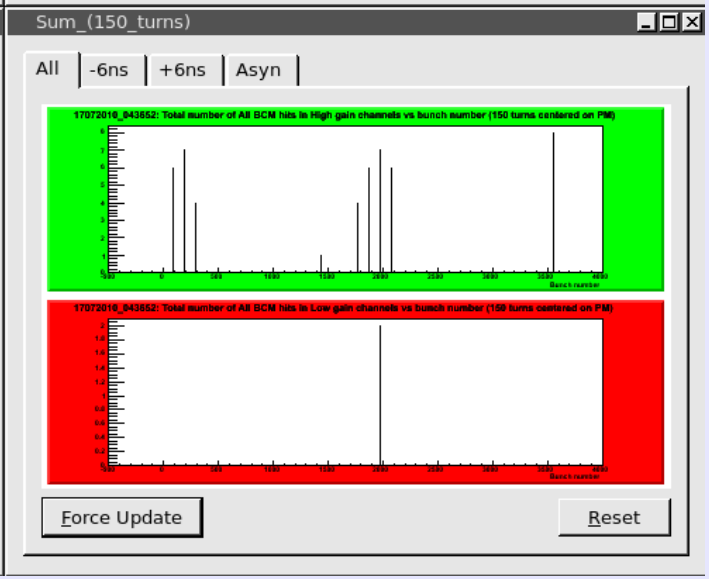



150
orbits
5 μs/bin

3600
bunches
1 bunch/bin




Last 150
orbits

July 17th 04:38; (13,8,8,8); $10^{12}$ protons

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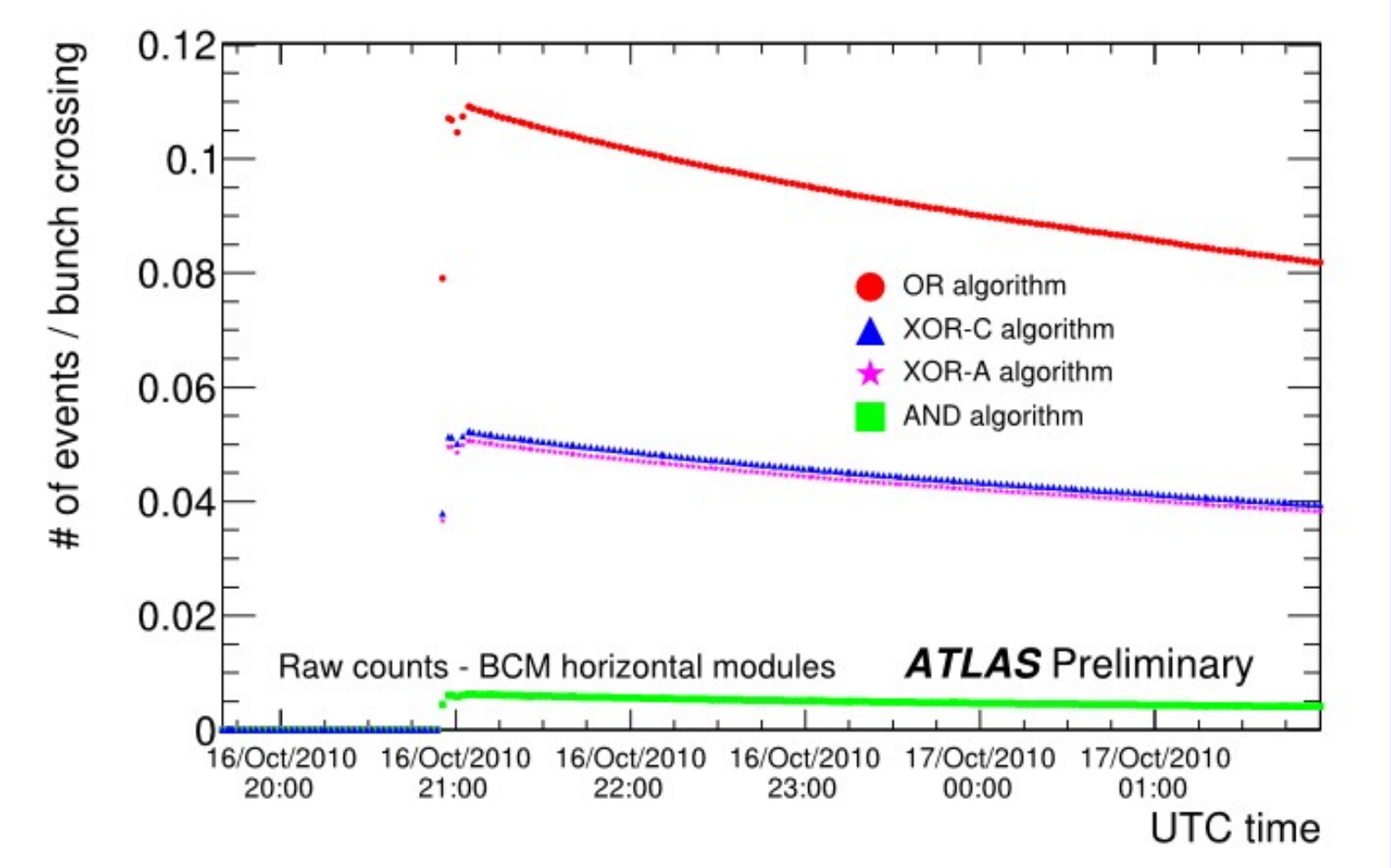
# Luminosity

- The BCM is currently used to determine luminosity in ATLAS
- Excellent time resolution allows a clean bunch by bunch measurement even at high luminosities
- Currently used for the default real-time luminosity measurement displayed on the LHC Page 1 (http://op-webtools.web.cern.ch/op-webtools/vistar/vistars.php)

# Luminosity algorithms




Four algorithms with different coincidence criteria between sides A and C.

# Beam abort algorithms

- Basic 3+3
  - Requires 3 high and 3 low threshold hits in one ROD (each ROD reads out 4 high and 4 low threshold channels)
  - In addition both RODs have to satisfy the 3+3 condition in coincidence
- X/Y
  - Requires X instances of the 3+3 condition within Y bunch crossings

# Beam abort sensitivity

- BCM caused beam aborts during early 3.5TeV commissioning
- Each detector module has 2 output channels with different thresholds
- Original design had a low threshold of about ~0.5 MIPs/cm$^2$ and a high threshold of ~5 MIPs/cm$^2$ for a ratio of about 1:10
- Unexpected features of the NINO electronics as well as the necessity of doing repairs inside the ATLAS detector made it impossible to change this until the winter shutdown
- Low threshold sensitivity is approximately the same as before, but the ratio is now ~1:200, with a high threshold of ~100 MIPs/cm$^2$
- The system is currently being evaluated to ensure that the abort threshold is suitable and that the rate of false aborts is acceptably low

# Summary

- The ATLAS BCM is working reliably
- It is helping protect ATLAS through online monitoring of beam conditions and postmortem analysis
- It is a robust luminosity detector and currently provides the official real-time luminosity measurement for ATLAS
- Beam abort functionality should soon be re-enabled