



ATLAS BCM and BLM Status

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F9 Seminar

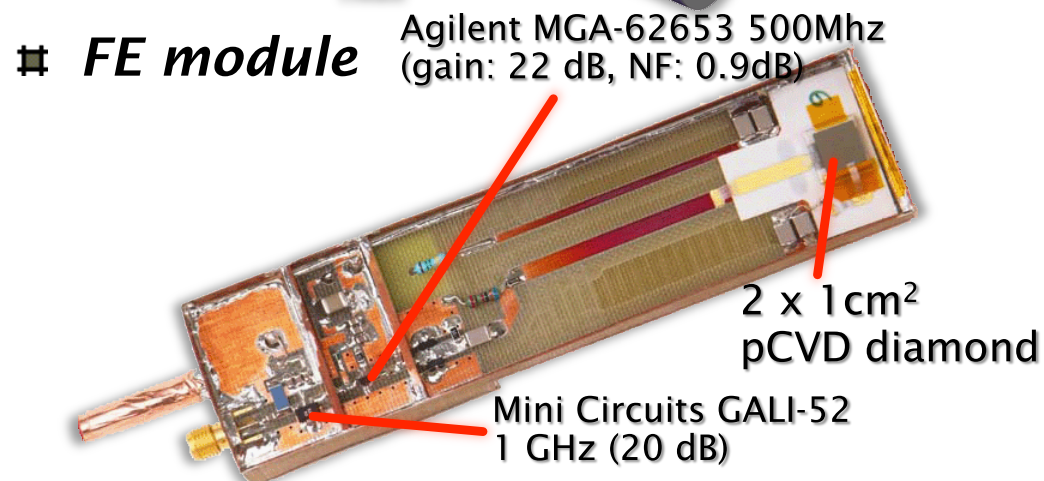
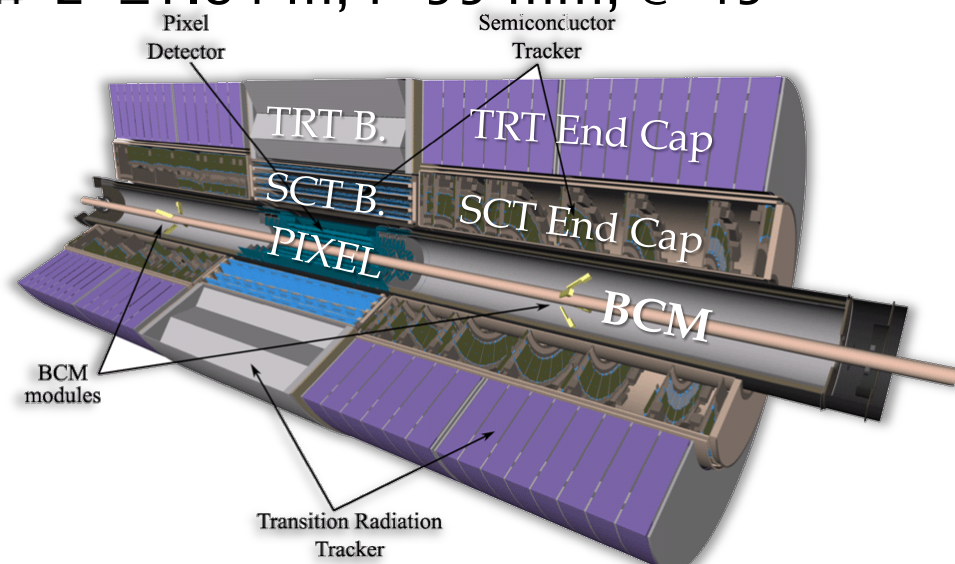


IJS, 10/05/2010

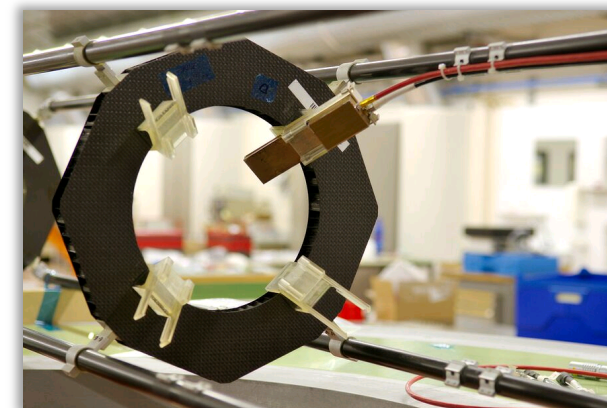
ATLAS BCM system



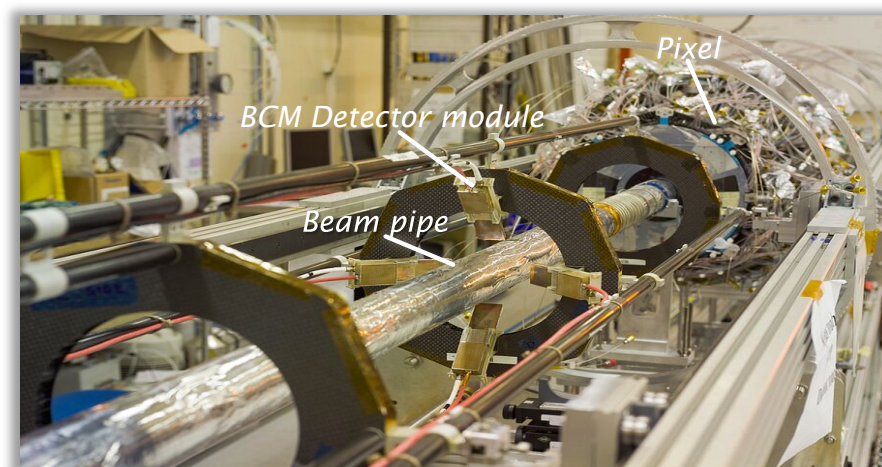
- # 4 BCM detectors installed inside PIXEL volume on each side
- # $z = \pm 1.84$ m, $r = 55$ mm, @ 45°



- # Installation on PIXEL structure



- # Together with PIXEL detector

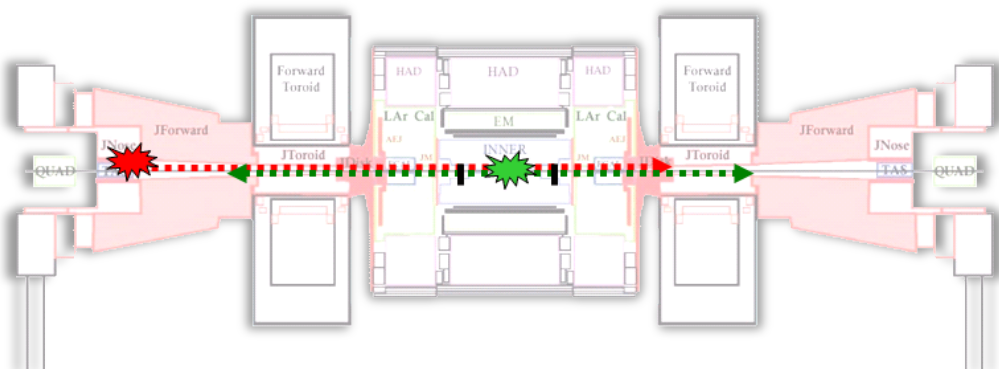


Main goal – protection of ATLAS In addition

- In case of anomalous beam behaviour and large losses
- Distinguish between interactions and background (scraping of collimators, beam gas,...)

- Collision rate/background rate monitoring (with single MIP sensitivity)
- Bunch-by-bunch Luminosity measurement
 - counting tracks, coincidences
 - zero counting,...

→ better than 12.5 ns width+baseline restoration



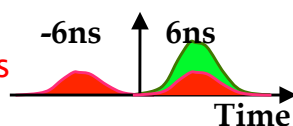
$$N_A = N_{BX} N_{pp} (L) r_{tr} P_A \quad N = N_A + N_C \quad N_A \approx N_C$$

BC rate \rightarrow N_{BX}
 number of pp in single BC (function of luminosity) \rightarrow N_{pp}
 probability of track going to side A \rightarrow r_{tr}
 number of tracks per pp \rightarrow P_A

■ Triggering:

- BCM provides 6 different inputs to ATLAS Central Trigger Processor (CTP)
- In time coincidences, out of time coincidences, high multiplicity,... can be programmed in readout board

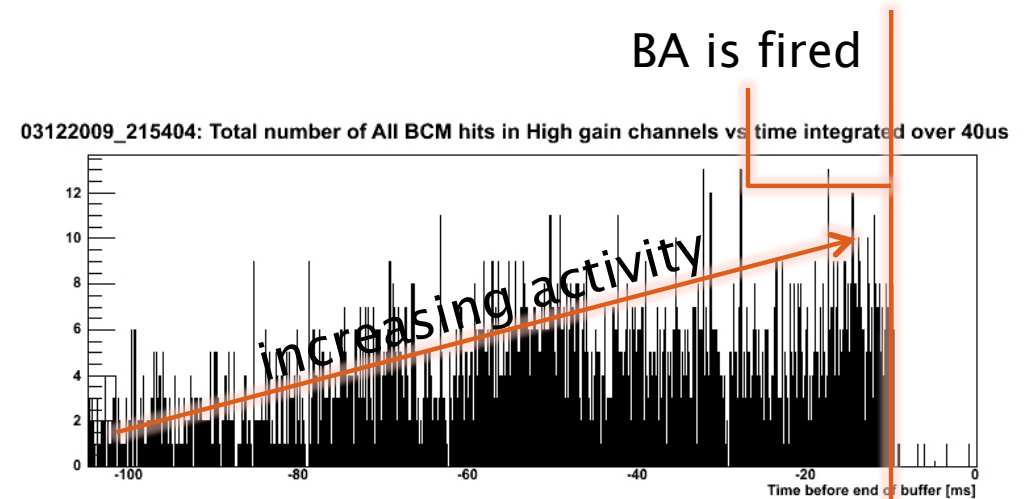
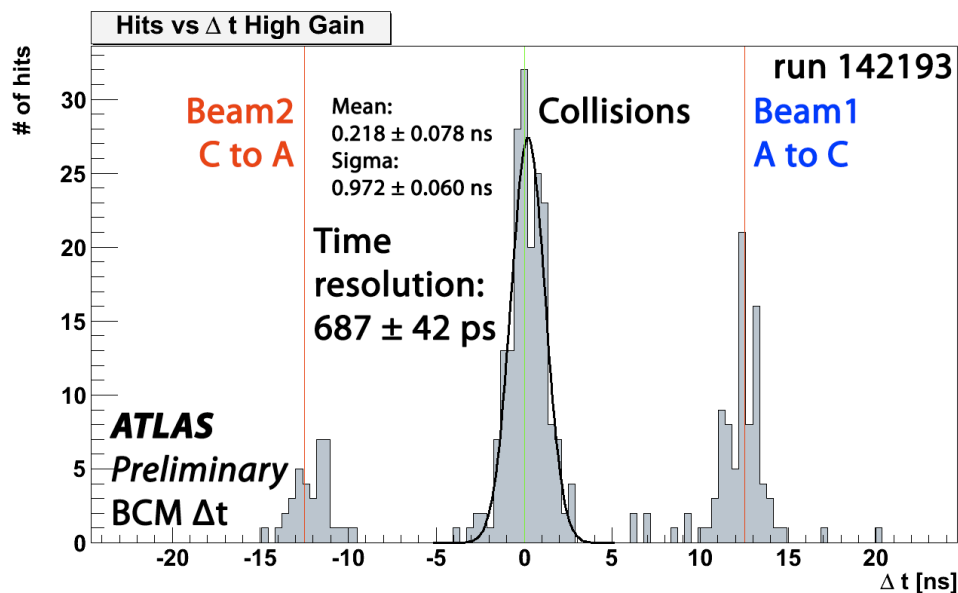
- 2 detector stations, symmetric in z
- TAS (collimator) event: $\Delta t = 2z/c = 12.5 \text{ ns}$
- Interaction: $\Delta t = 0, 25, \dots \text{ ns}$



ATLAS BCM Results



- Time difference hit on A side to hit on C side
- Most of data reconstructed offline
- Sub ns resolution of BCM clearly visible (0.69 ns) without offline timing corrections applied
- Beam dump fired by BCM during LHC aperture scan
- Ready to (over!)protect ATLAS



← 1177 LHC orbits – ~100 ms →

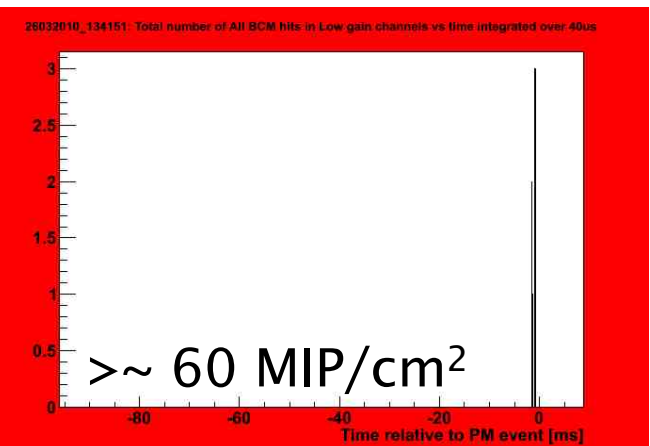
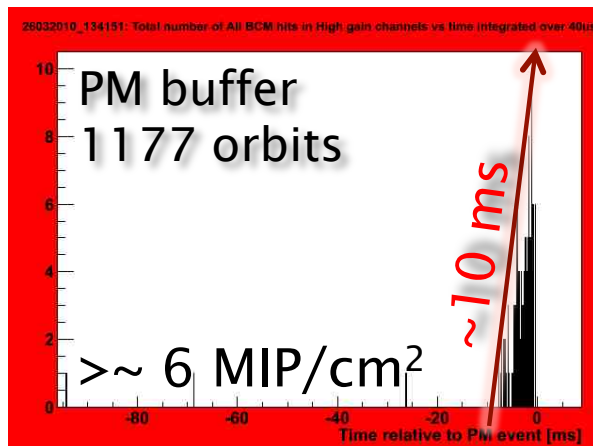
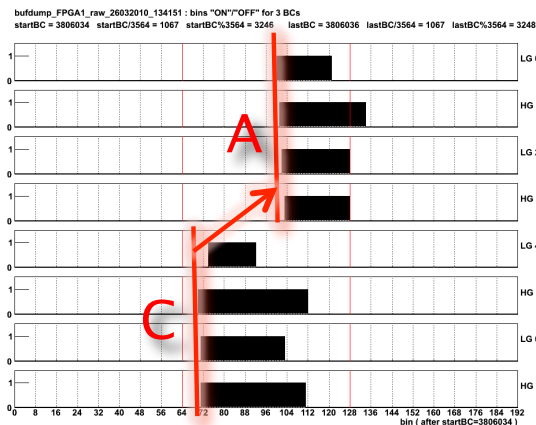
after BA is fired the buffer is recorded for additional 100 LHC orbits (~10 ms)

~10 ms

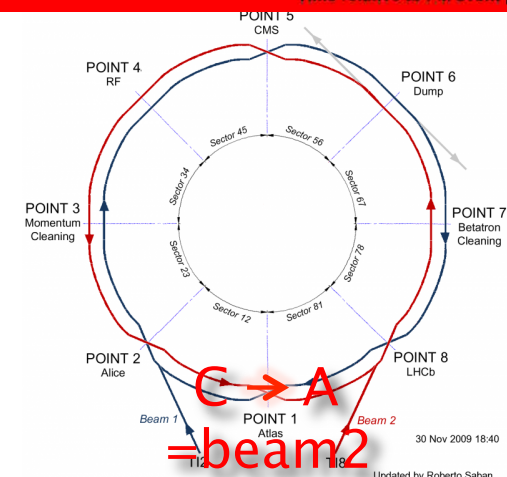
BCM – recent events



- BCM aborted LHC beams on March 23, 18:05 at nominal thresholds (collimator studies at 3.5TeV)
- BCM was active till Friday March 26, 13:41 – BA at reduced sensitivity (more collimator studies at 3.5TeV)



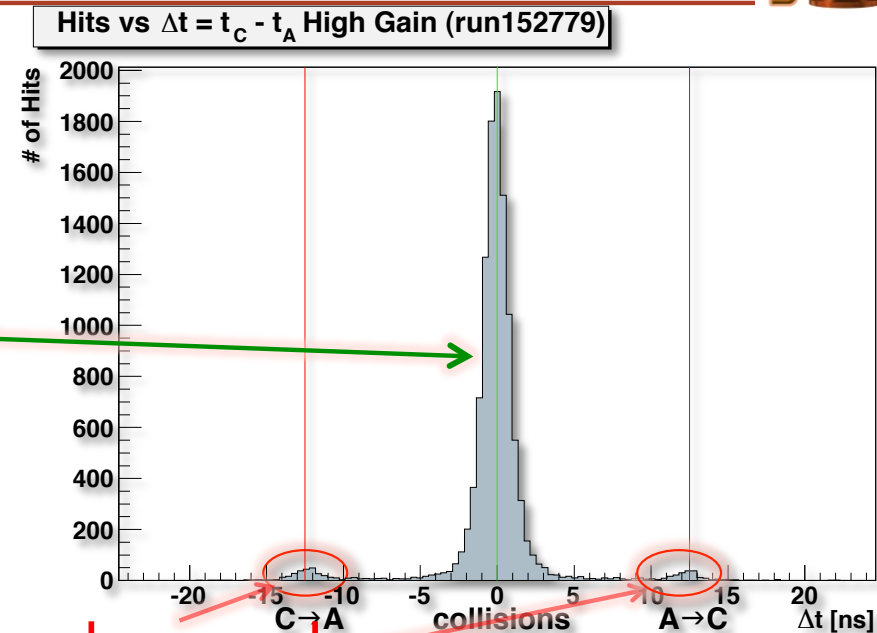
- Since then BCM is disabled from BA and IP logic – still records PM buffers for analysis. While out of the BA and IP logic it is set to nominal thresholds.



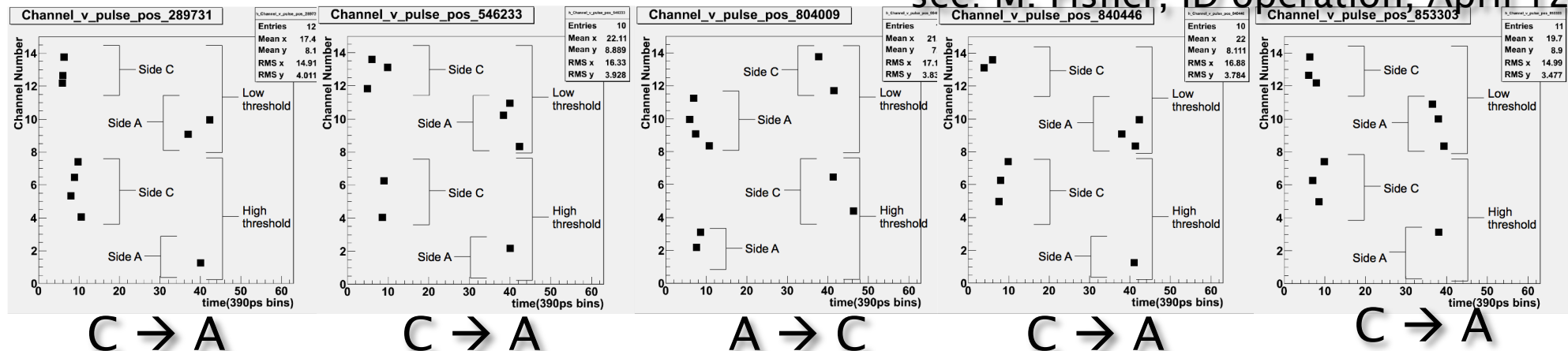
BCM – performance



- Excellent timing performance
- Useful to monitor beam conditions
- Most of the activity recorded in ATLAS coming from **collisions**
- Checked run 152166 (offline) for 5 instances of lost IP (3+3 condition in one ROD) → all are coming from **background**
- No instance of BP loss (simultaneous IP loss on both RODs)



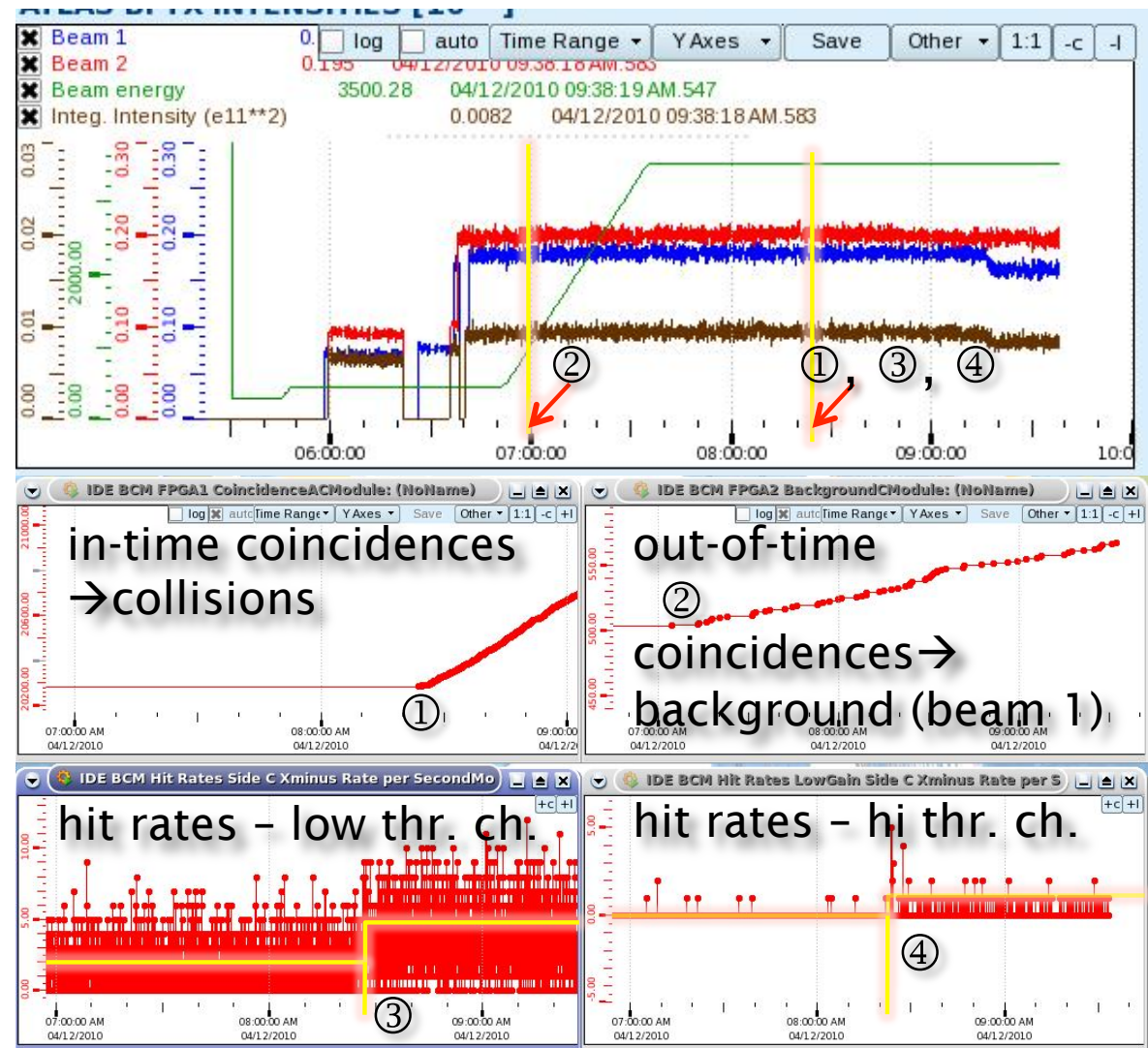
see: M. Fisher, ID operation, April 12



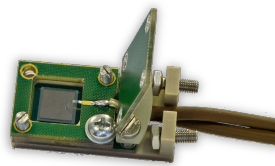
BCM – performance II



- Monitoring beam conditions at the start of the fill – real time measurement of collision and background (beam 1, beam 2) rates
- Rates and in-time coincidences start increasing at collapse of the separation bump
- Out of time coincidences (background) start increasing shortly after LHC ramp starts

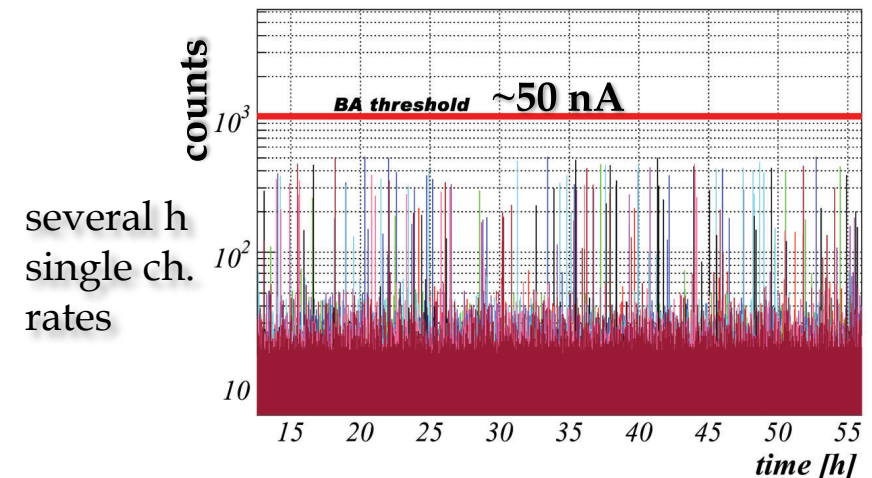
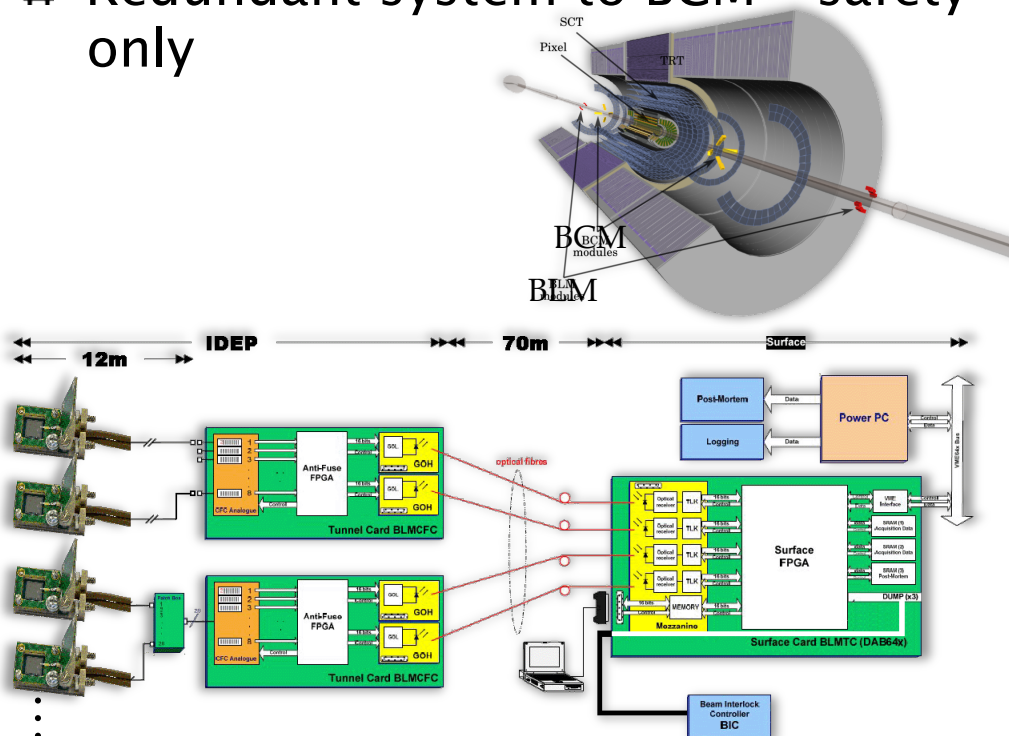


BLM overview



- 8x8mm² 0.5mm thick diamond sensors used
- 6 sensors on each side (A and C) installed on ID End Plate
- Readout adopted from LHC BLM system with minor modifications
- Redundant system to BCM – safety only

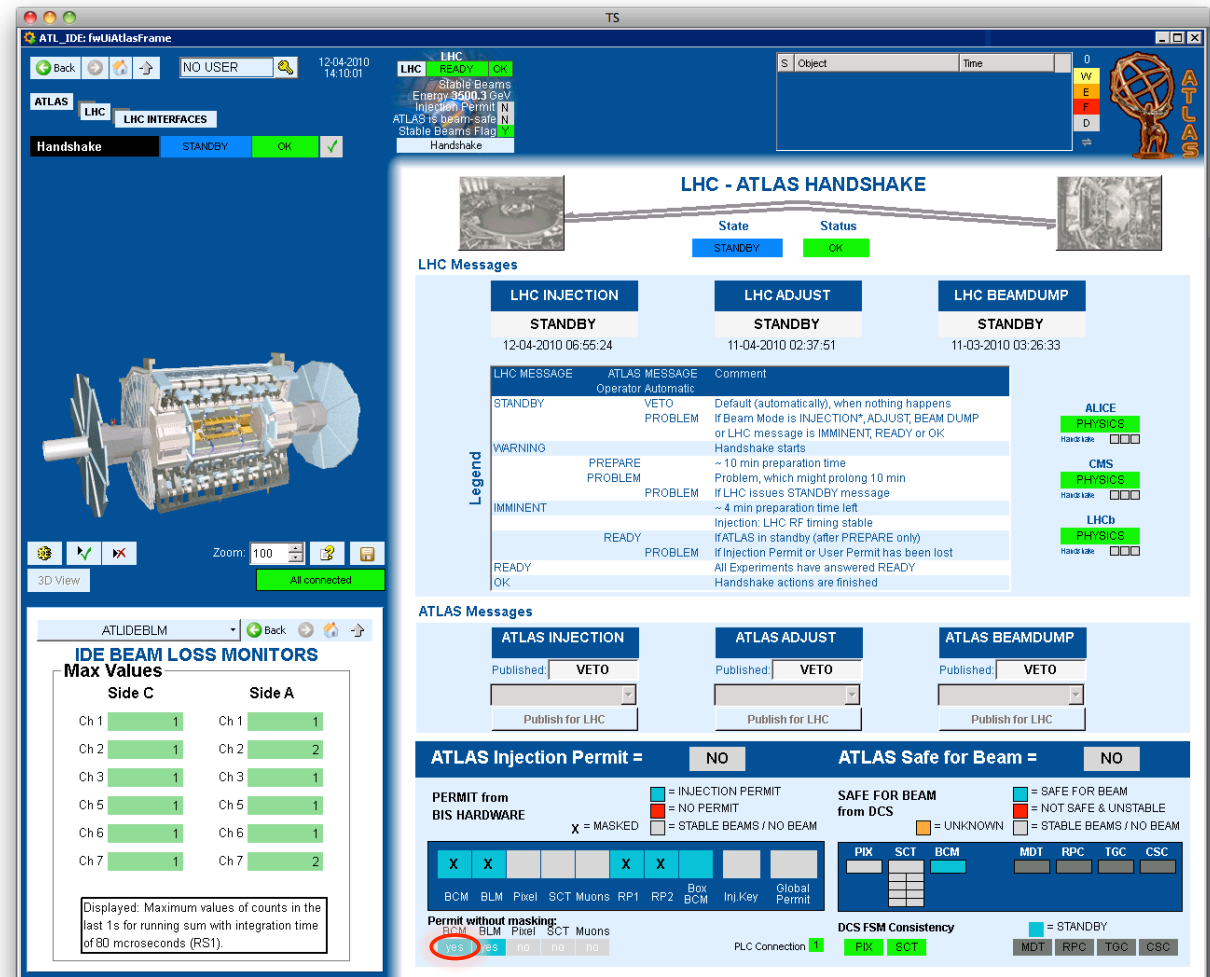
- 7 TeV p on TAS collimator gives ~1 MIP/BLM module → ~1 fC of charge
- 25 pA of current “spike” for single occurrence (possible with pilot bunch)
- 40 nA of current for continuous loss (only when full LHC bunch structure)
- Diamond dark currents
 - In magnetic field, should be O(10 pA)
 - Erratic currents, several nA w/o magnetic field
- Require 2 ch. Above threshold simultaneously



BLM status



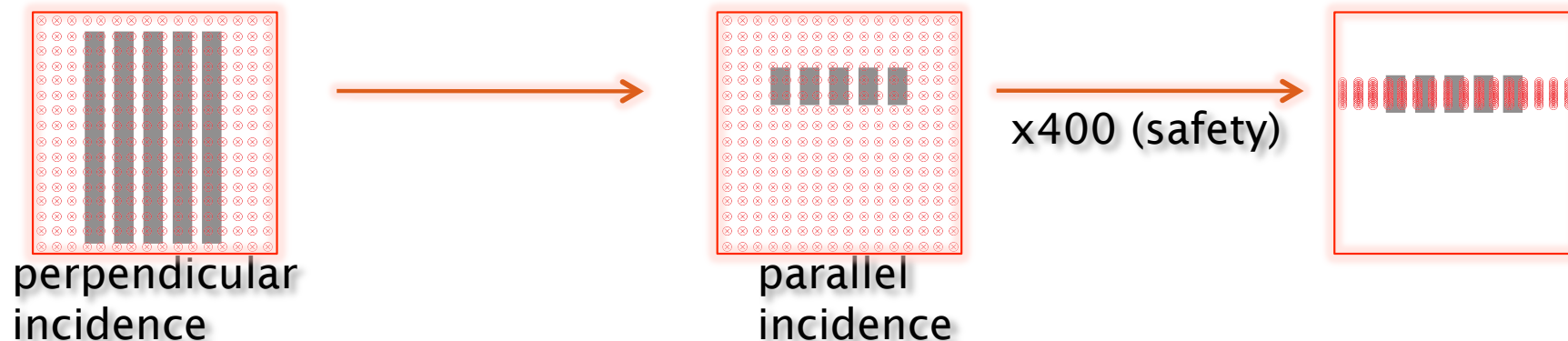
- BLM BP and IP signals correctly propagated to BIS now – no instance of IP or BP drop since
- Thresholds increased for factor of 10 (to 500nA)
- IP/BP logic tested with injected current to readout channels
- Is recording PM buffers and monitoring rates
- The event of the last BCM beam dump was under the LSB of BLM
→ no apparent difference in BLM PM buffers recorded so far.



ATLAS SCT safety limit

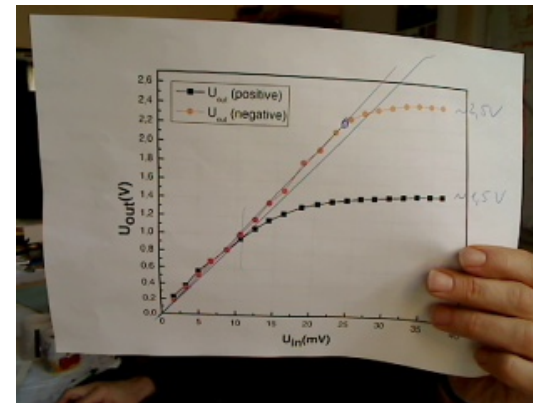


- Most conservative estimate: 5 nC limit in one strip in 25 ns which corresponds to **$1.25 \cdot 10^7 \text{ MIP cm}^{-2}$**
- Imagining all MIPs exactly parallel to strips and that all of them are forced into SCT module – this boils down to **$25,000 \text{ MIP cm}^{-2}$**



- This is very conservative estimate which is compatible with current limit set on BLM thresholds.
- 100% SCT occupancy – 45 MIP/cm^2 (more than 500x lower than the above), max. occupancy seen so far – 2% (ROS monitoring). See: S. McMahon contribution at “ID operation”, April 12.
- Currently Pixel seems less sensitive to beam accidents than SCT. Tested to 10^{10} MIP/cm^2 for incidence along the sensor in 40 ns.
[doi:10.1016/j.nima.2006.04.086](https://doi.org/10.1016/j.nima.2006.04.086)

- ✦ For losing IP **3 out of 4 high thr. and 3 out of 4 low thr. channels** are required in **25 ns coincidence** (so called 3+3 condition). Threshold cited below are for single high thr. channel.
- ✦ BP requires coincidence of IP drop on both RODs
- ✦ **Nominal conditions:** HV=1000V, thr=300mV
 - single channel threshold ~ 10 MIP/cm² within ~ 1 -2 ns
- ✦ **Reduced sensitivity:** HV=400V, thr=1000mV
 - single channel threshold ~ 60 MIP/cm² within ~ 1 -2 ns
- ✦ High thr. vs. low thr. signal splitting currently $\sim 1:10$. Will go to the maximum allowed (limited by the saturation of FE) of 250
 - saturation at output ~ 1 V
→ 250 MIP
(0.5 kMIP/cm²)
- ✦ **NEW!** After modification and at **nominal conditions** (important for luminosity monitoring!) will go to:
 - single channel threshold **~ 250 MIP/cm² within 25 ns** (factor 2 not to exceed FE range – thr. can be easily increased for 3x)



- For loosing IP require that 2/6 channels exceed threshold within 40 μs on A or on C side. BP is lost when A and C side lower IP simultaneously
- 1 MIP in BLM diamond sensor ($\sim 1 \text{ fC}$ charge) in 40 μs causes equivalent current of $\sim 25 \text{ pA}$.
- BLM thresholds originally set to $\sim 50 \text{ nA}$ (= 23 bits) in 40 μs integration channels.
- Recently thresholds increased 10 fold still to be within safety margins for SCT
- Current thresholds:
 - 230 bits \rightarrow **37 kMIP/cm²** within 40 μs
 - In addition requiring 2 out of 6 channels to meet this condition within 40 μs either on A or on C side to drop IP.
 - And in addition requiring this on both (A and C) sides simultaneously to drop BP.

BCM:

- # Modification → 25 fold increase of effective threshold with a quick fix during the technical stop → 2 fold
- # Commissioning of X/Y algorithm to avoid triggering IP/BA on single occurrence of abort condition

BLM:

- # Run with current settings (compatible with SCT most conservative damage limit)
- # Develop automatic post-mortem analysis tools
- # Try to understand instrumentation pickup (well below current abort thresholds but above previous – 10 times smaller – one)
- # Use ATLAS BLM actively in BA and IP logic

- # SCT (most conservative) damage threshold:
25 kMIP/cm² within 25 ns
- # BCM threshold after technical stop:
250 MIP/cm² within ~1-2 ns
- # BLM threshold:
37 kMIP/cm² within 40 μ s
- # Very different thresholds at single-bunch and multi-bunch LHC operation
- # Currently ATLAS BLM included in BP and IP logic.
ATLAS BCM currently monitors beam conditions + luminosity but not in BP and IP logic.