



# ATLAS BCM abort logic

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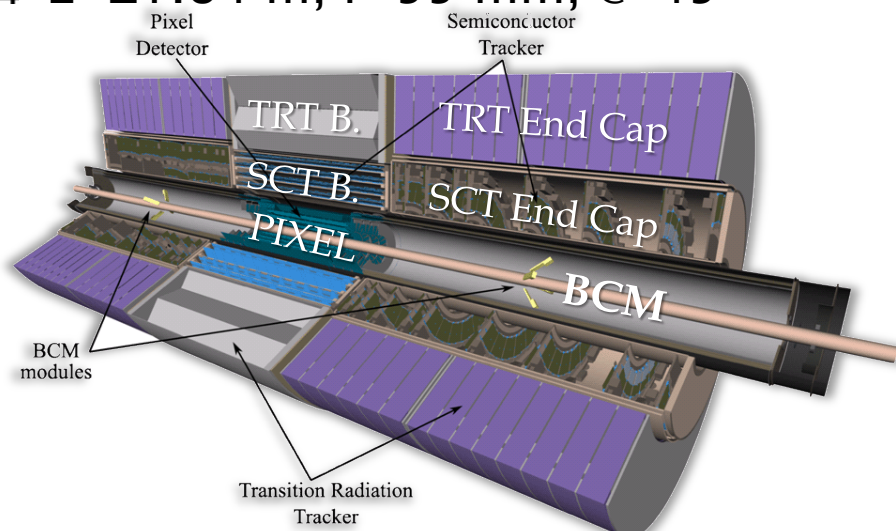
*MPP, December 2012*



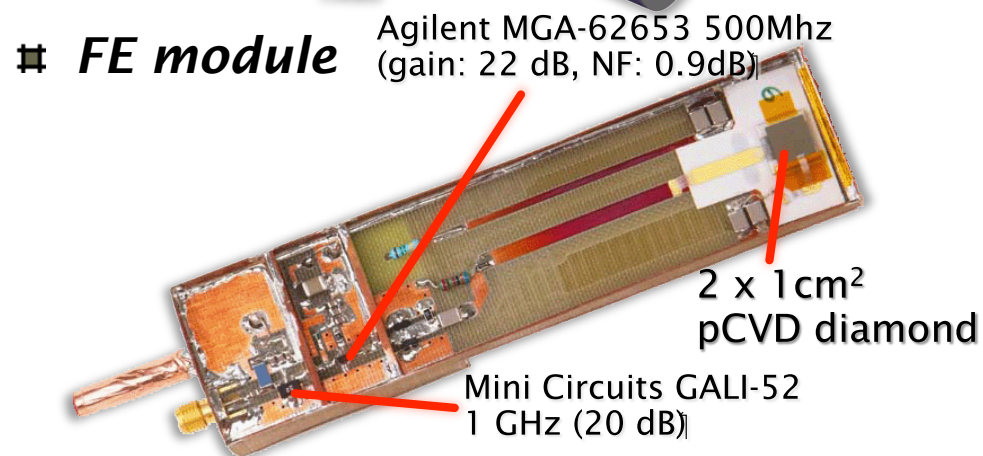
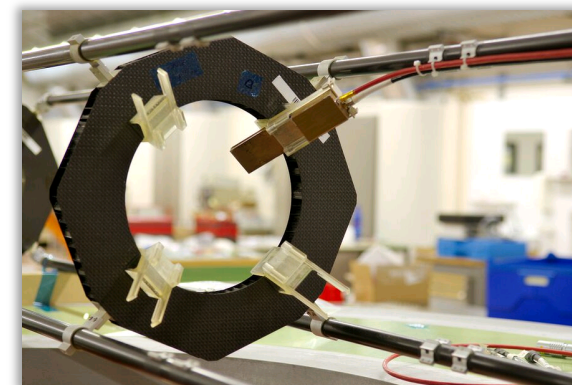
CERN, 07/12/2012

# ATLAS BCM – Intro

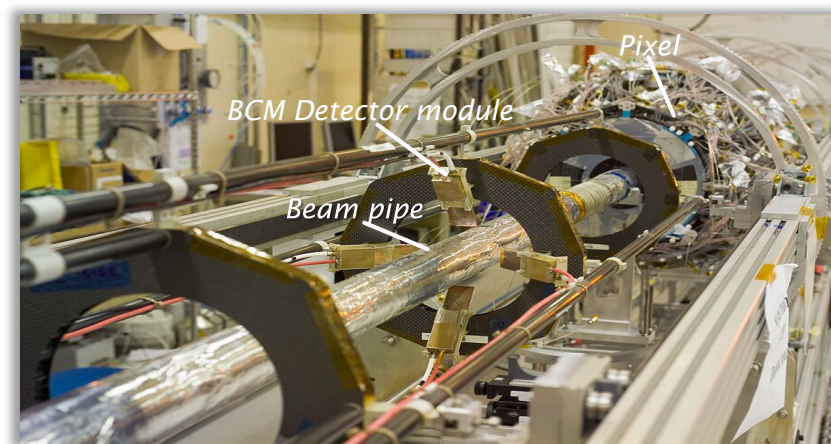
- # 4 BCM detectors installed inside PIXEL volume on each side
- #  $z = \pm 1.84$  m,  $r = 55$  mm, @  $45^\circ$



- # Installation on PIXEL structure



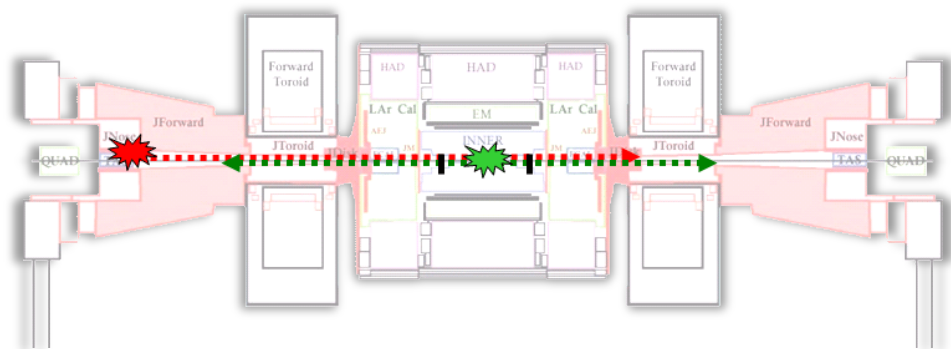
- # Together with PIXEL detector



# ATLAS BCM – Intro 2

## Protection of ATLAS

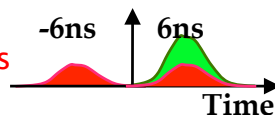
- # In case of anomalous beam behaviour and large losses
- # Distinguish between interactions and background (scraping of collimators, beam gas,...)
- # Fast signal and baseline restoration (<10ns)



■ ■ 2 detector stations, symmetric in z

★ TAS (collimator) event:  $\Delta t = 2z/c = 12.5 \text{ ns}$

★ Interaction:  $\Delta t = 0, 25, \dots \text{ ns}$



## In addition

- # Collision rate/background rate monitoring (with single MIP sensitivity)
- # Bunch-by-bunch Luminosity measurement
  - # counting charged particles

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

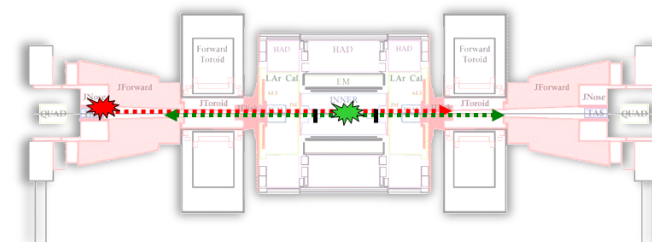
BC rate  $\rightarrow$   $N_{\text{BX}}$   $\rightarrow$   $N_{\text{pp}}$   $\rightarrow$   $(L)$   $\rightarrow$   $r_{\text{tr}}$   $\rightarrow$   $P_A$   $\rightarrow$  probability of track going to side A  
 $N$  number of tracks per pp  
 $N_C$  number of pp in single BC (function of luminosity)

## Triggering:

- # BCM provides 6 different inputs to ATLAS Central Trigger Processor (CTP)
- # In time coincidences, out of time coincidences, high multiplicity,...

# ATLAS BCM time (ABT)

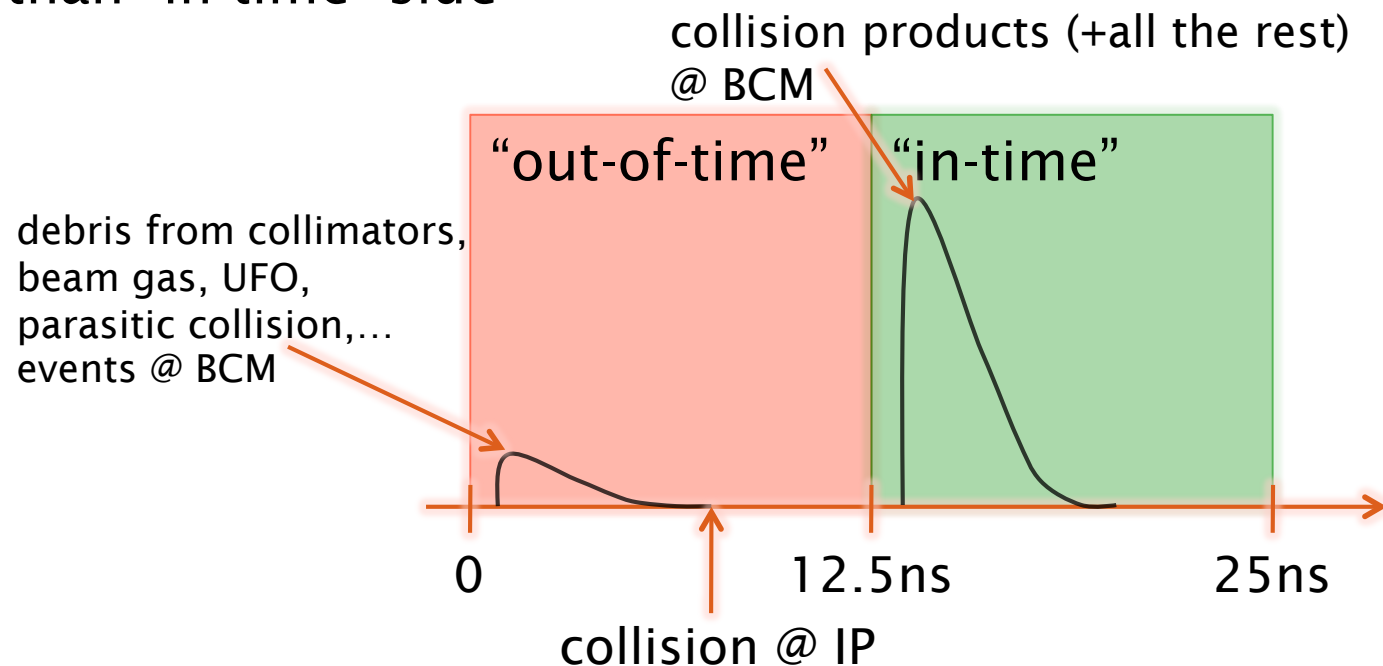
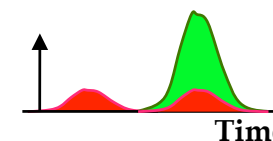
- # We count time in buckets of 25ns
- # Collision happen  $\sim 6$ ns before the collision product reach BCM sensors
- # Non-collision events (collimators, UFOs, parasitic collisions, beam-gas,...) reach “out-of-time” side  $\sim 1/2$ BC (12ns) earlier than “in-time” side



■ 2 detector stations

★ TAS event:  $\Delta t = 2z/c = 12.5$ ns

★ Interaction:  $\Delta t = 0, 25, \dots$  ns



# BCM PRO

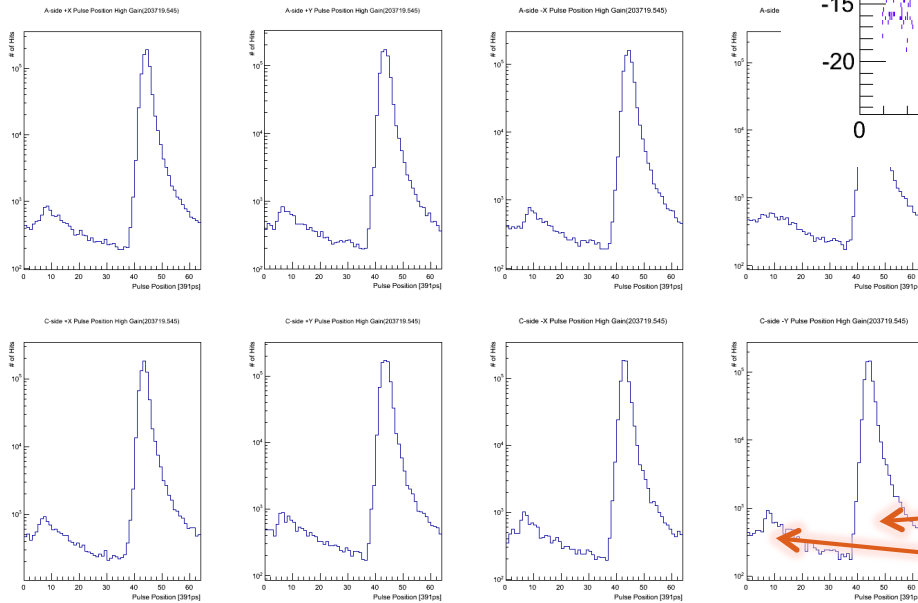
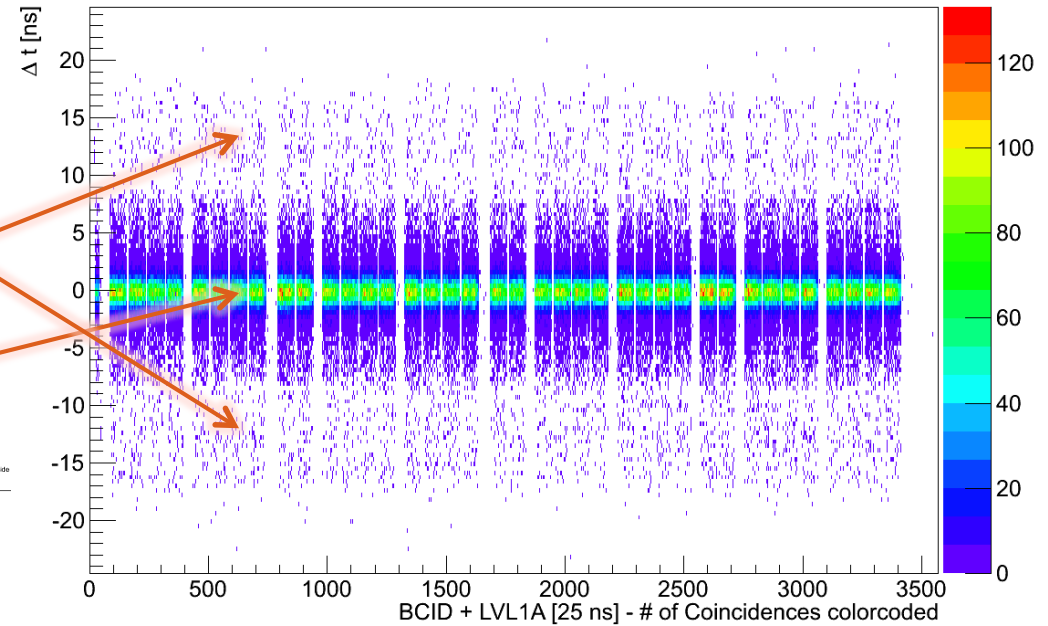


# ABT difference of hit on A vs. hit on C side

# ABT

background collisions

$\Delta t = t_C - t_A$  Aligned vs BCID High Gain



collisions+BG

BG only





# 2011 ATLAS-BLM beam dumps

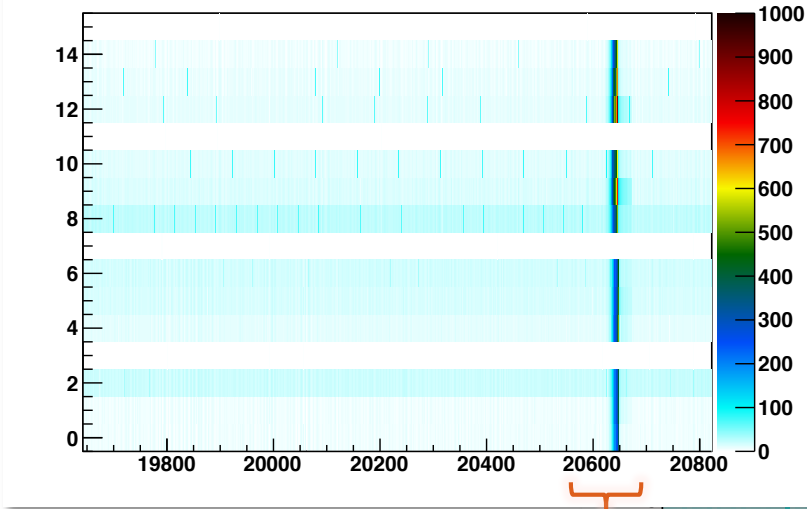
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- # 31/07/2011 @6:47  
C→A (beam 2)
- # 17/08/2011 @9:48  
A→C (beam 1)
- # both exhibit a “UFO” like time behavior
- # beams were extracted in ~4 orbits after ATLAS BLM thresholds were reached
- # BCM signal was still increasing in high threshold channels (“ABORT” channels) – far from saturation
- # @ BLM BA request ABORT channels did not see any substantial signal
- # clearly visible from BCM PM buffers that there was a lot C→A background (31/07) and A→C background (17/08)

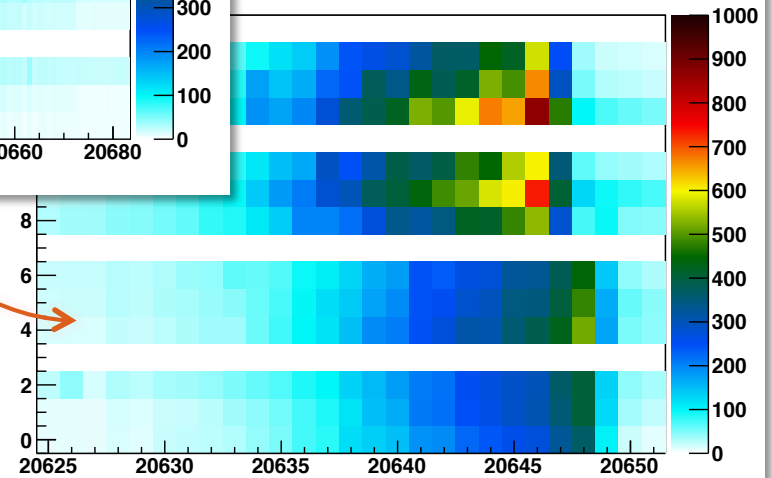
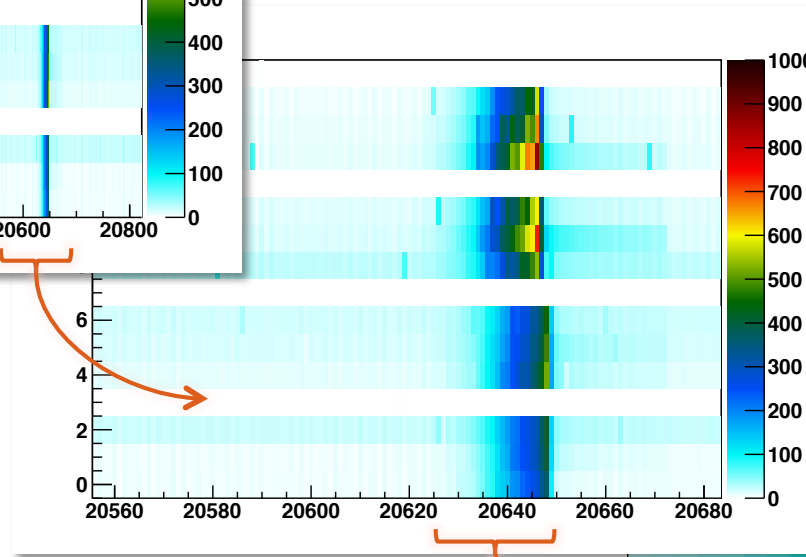
# 31/07/2011 @ 6:47 – BLM PM buffer



PM History

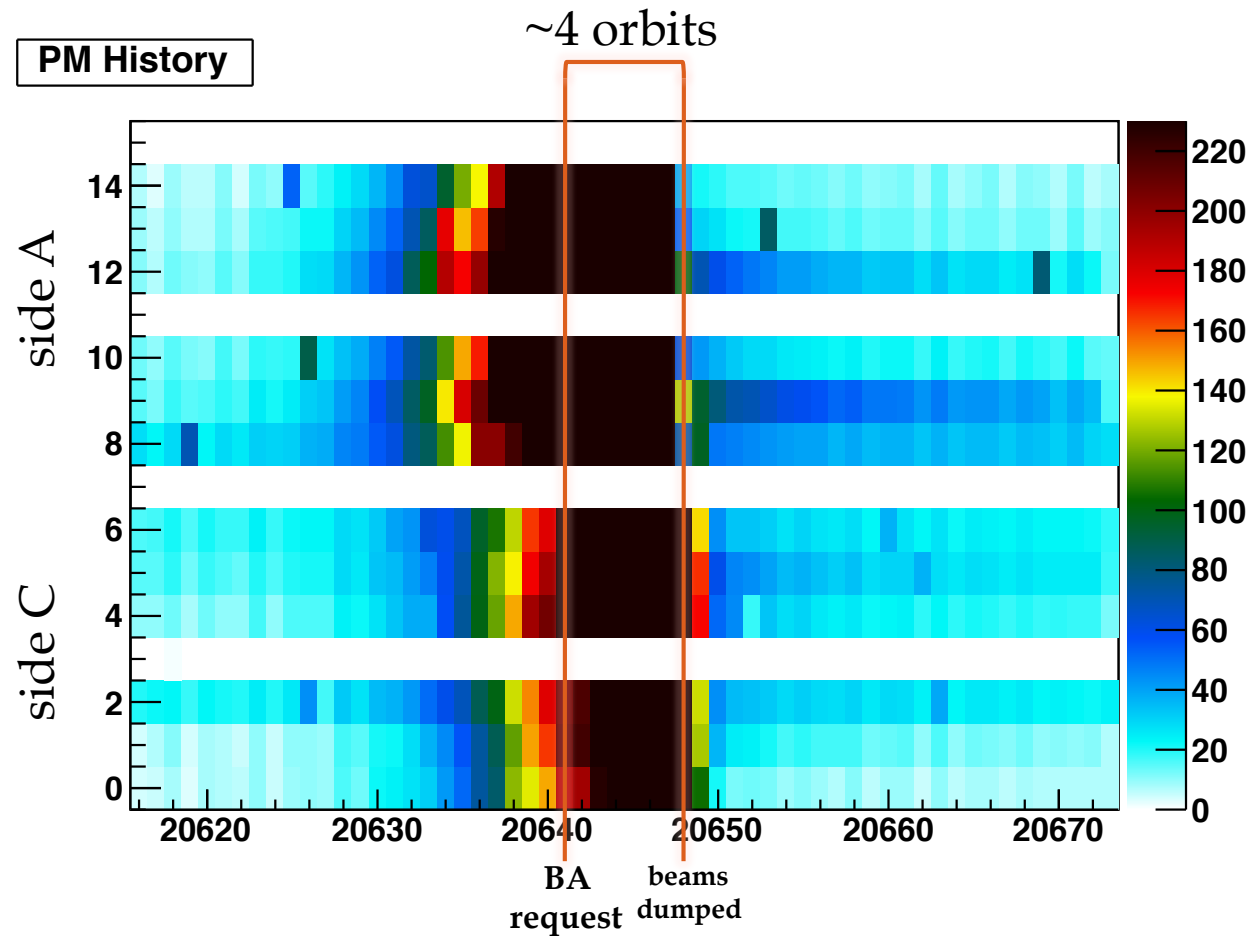


40  $\mu$ s time bins  
i.e.  $\sim 1/2$  orbit





# Abort condition: **230 hits on both sides and simultaneous in 2 channels (i.e. 2+2)**

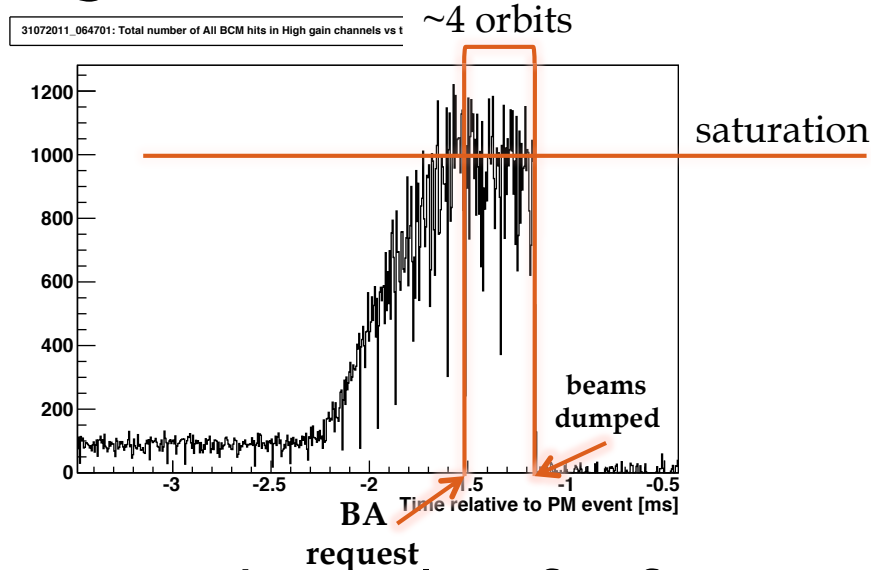




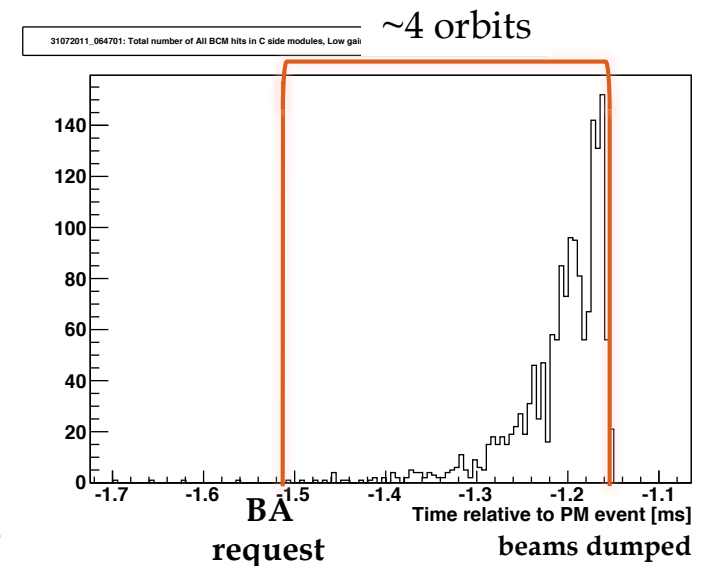
# 31/07/2011 @ 6:47 – BCM PM buffer



## # High gain channels – saturate at $\sim 1\text{ k}$ in $5\mu\text{s}$ bin



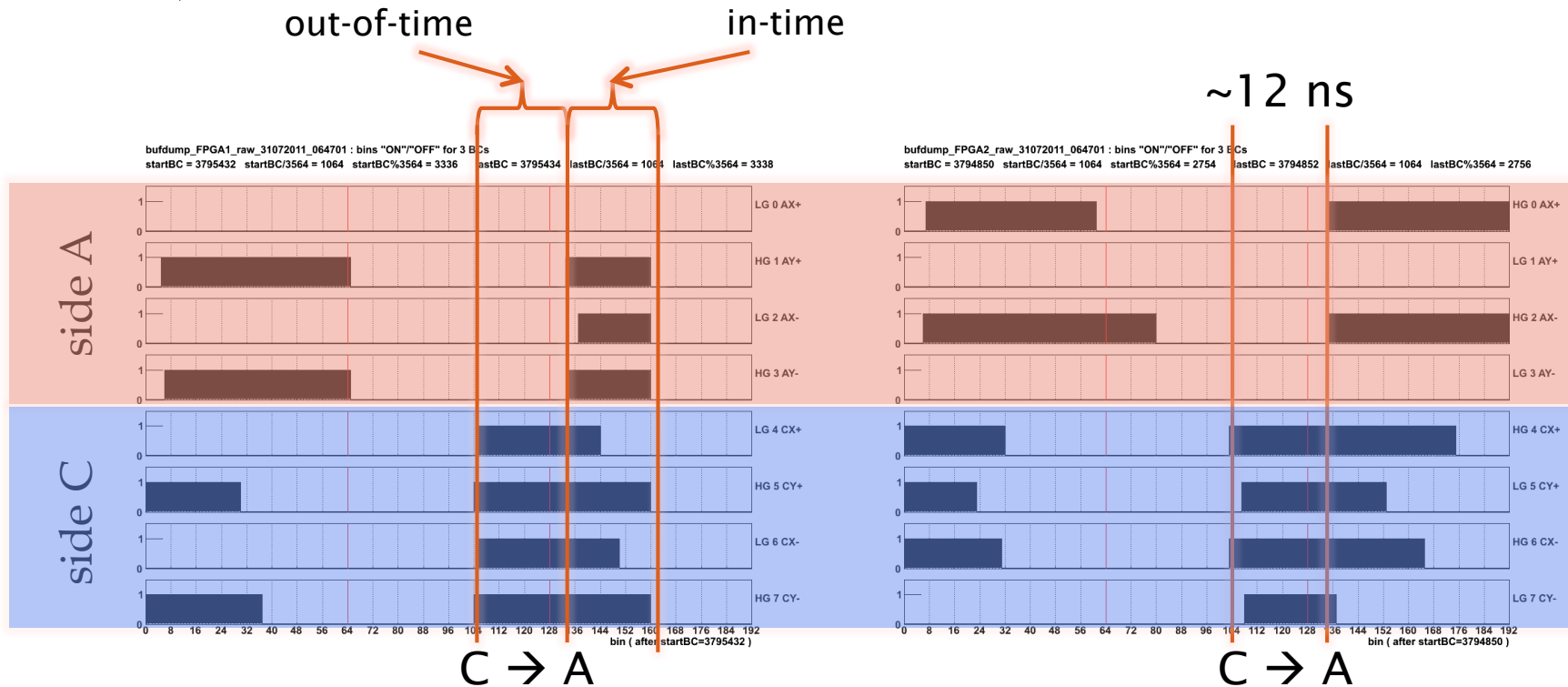
- # **Low gain** channels – far from saturation but substantial signal which looks to be exponentially increasing before beams were extracted ( $\sim 140/1\text{ k}$ ).  
Note: when BLM fired – there was almost no signal in HT BCM channels



# 31/07/2011 @ 6:47 – BCM timing



- # Looks like most events are coming from C→A (beam 2)
- # two example plots of 3 BC worth of data (1 per each ROD)



# BCM – Beam abort condition – “the old way”



- # 3 signals in a BC (do not distinguish “in-time” from “out-of-time”) out of 4 high threshold channels connected to ROD0 in coincidence with the same condition on ROD1
- # → BA threshold can be reached with signals from IP collisions
- # Required that this happens twice in 1 orbit + 1 BC (to eliminate a single “trouble bunch”)
- # Old RODs (ROD0 and ROD1) have a heavily patched input stage → pickup from digital signals (such as GSM,...)
- # Due to this accidentally dumped LHC once (December 2009)
- # Complicated timing calibration procedure

# BCM – Beam abort condition – “the new way”



- # 3 “in-time” signals on A (or C) side coincident with 3 “out-of-time” signals on the opposite side
- # → Trigger only on background events (IP collision events have only “in-time” signature)
- # Required that this happens twice in 1 orbit + 1 BC
- # Much improved input stage – much better signal integrity
- # No indication of noise pickup
- # Did not come even close to abort threshold since the new firmware is fully operational
- # New RODs rebooted the last time ~2 month ago for testing purpose



# Recent operation experience

- # New RODs fully functional since August 2012
- # Counters accumulated in the last 55 days
- # Assuming Poisson distribution with 39 M events with 1 “out-of-time” hit and 30 events with 2 coincident “out-of-time” hits → estimated frequency of 3 coincident “out-of-time” hits is  $\sim 10^{-5}$  in the last 55 days
- # “In-time” events with 3 coincident hits on A or C – 40

BCM Counters							
Beam Monitor	In-time Multiplicity (combined)		Out-of-time Multiplicity (combined)		Multiplicity (per side)		
Late Coincidence	1009851	Mult. 1	804397702	Mult. 1	39099921	Intime 2A+	241227
Early Coincidence	13	Mult. 2	1861220	Mult. 2	30	Intime 2C+	610574
Background Beam1	78	Mult. 3	236	Mult. 3	0	Intime 3A+	7
Background Beam2	231	Mult. 4	0	Mult. 4	0	Intime 3C+	33
		Mult. 5	0	Mult. 5	0	Outofime 2A+	6
		Mult. 6	0	Mult. 6	0	Outofime 2C+	11
		Mult. 7	0	Mult. 7	0	Outofime 3A+	0
		Mult. 8	0	Mult. 8	0	Outofime 3C+	0

# Summary

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- # BCM with fully commissioned new firmware operational from August 2012
- # Improved input to RODs
- # No indication of any operational problem observed
- # ATLAS BCM is a redundant safety system to ATLAS BLM for protection of ATLAS Inner Detector
- # December is the last opportunity to test the full chain with protons before 2015

→ We would like to activate the CIBU input for ATLAS BCM