BCM/BLM thresholds of LHC experiments vs LHC BLMs

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126th SPS and LHC Machine Protection Panel Meeting

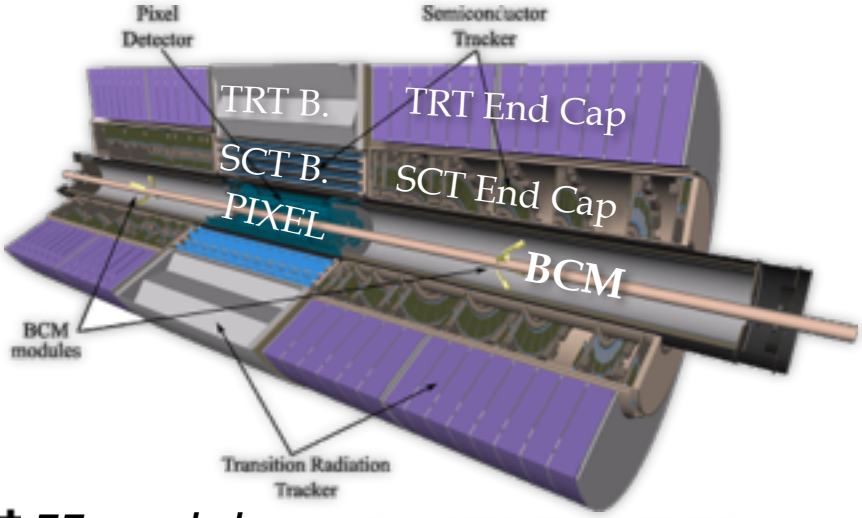
13/05/2016

Introduction

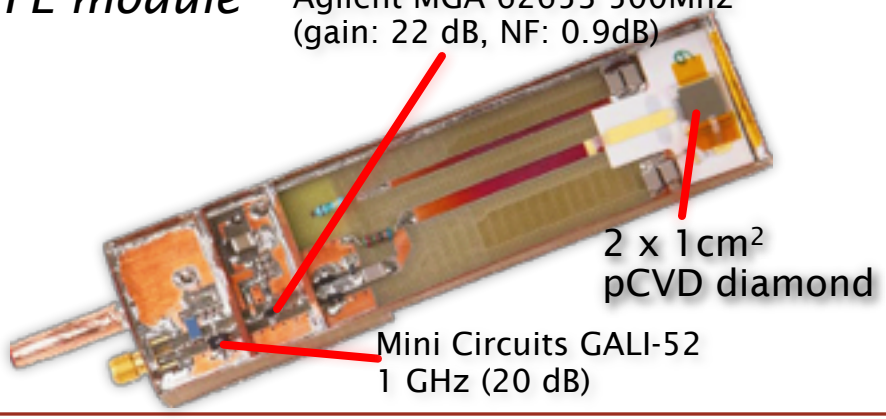
- During April there were three events where ATLAS BCM/BLM system gave beam abort flag:
  - 14/04/16 19:00:33 BCM
  - 17/04/16 02:39:44 BCM
  - 24/04/16 22:44:24 BLM

ATLAS BCM – Intro

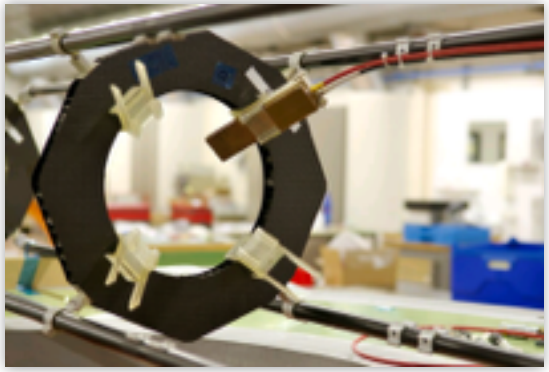
- 4 BCM detectors installed inside PIXEL volume on each side
- z=±1.84 m, r=55 mm, @ 45°



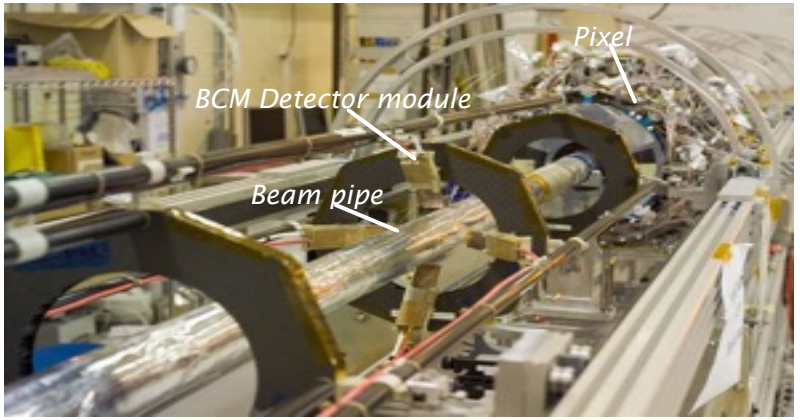
- *FE module*



- Installation on PIXEL structure

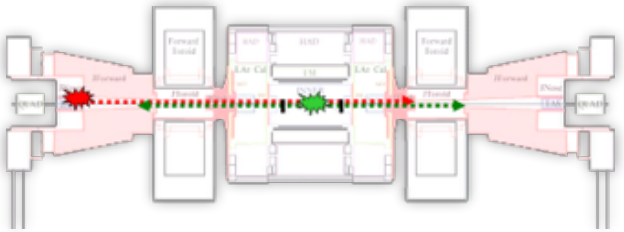


- Together with PIXEL detector

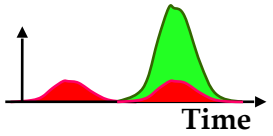


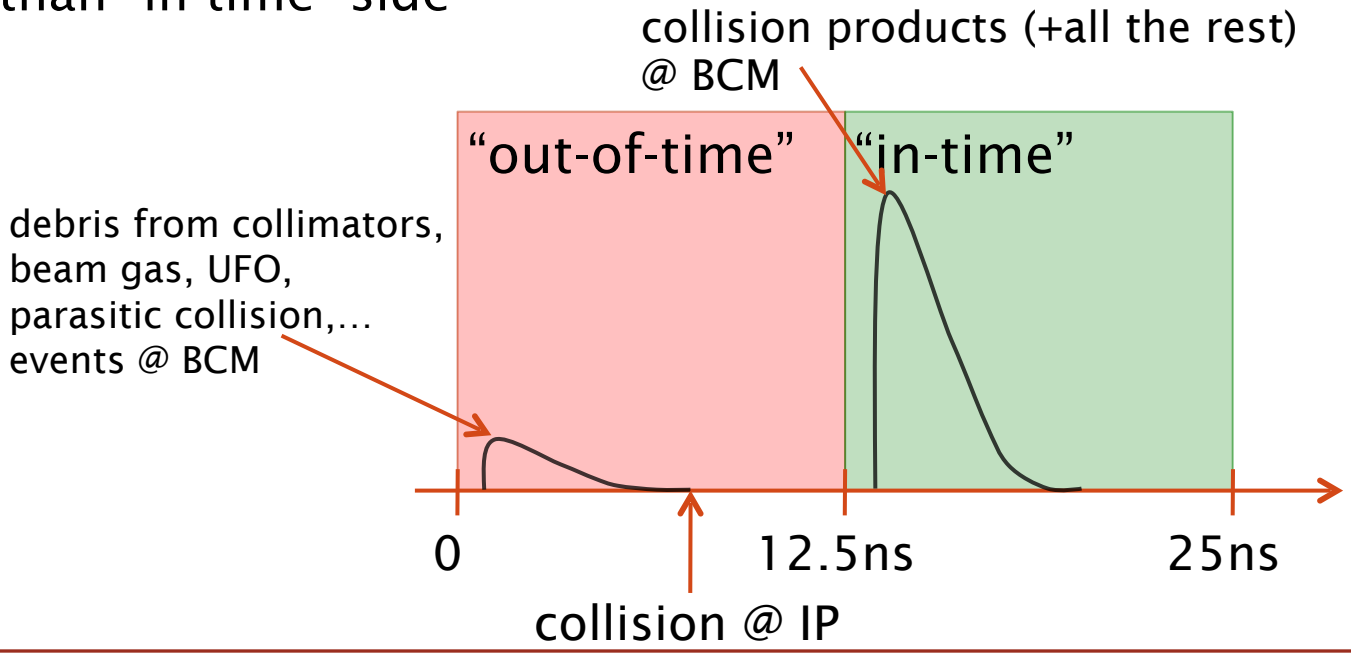
ATLAS BCM time (ABT)

- We count time in bins of .39 ns grouped in buckets of 25ns
- Collision happen ~6ns before the collision product reach BCM sensors
- Non-collision events (collimators, UFOs, parasitic collisions, beam-gas,…) reach "out-of-time" side ~1/2BC (12ns) earlier than "in-time" side



2 detector stations
TAS event: Δt=2z/c=12.5ns
Interaction: Δt = 0, 25, … ns





BCM – Beam abort condition

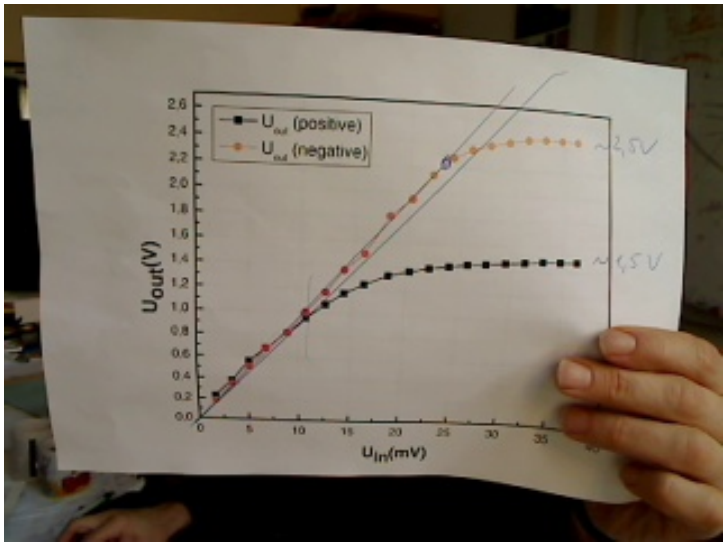
- 3 or 4 “out-of-time” signals on A (or C) side coincident with 3 or 4 “in-time” signals on the opposite side (on high threshold “abort” channels)
- → Trigger only on background events (IP collision events have only “in-time” signature)
- In addition X/Y — required that this happens twice in 1 orbit + 1 BC
- Much improved input stage – much better signal integrity
- No indication of noise pickup
- Very stable operation
- List of BCM “dumps” (nonr during STABLE BEAMs):
  - 2015/07/03 MD/Ramp
  - 2015/07/22 MD
  - 2015/09/24 Injection
  - 2015/10/05 FlatTop
  - 2016/17/04 MD

BCM threshold

- Threshold cited below are for single high thr. channel.

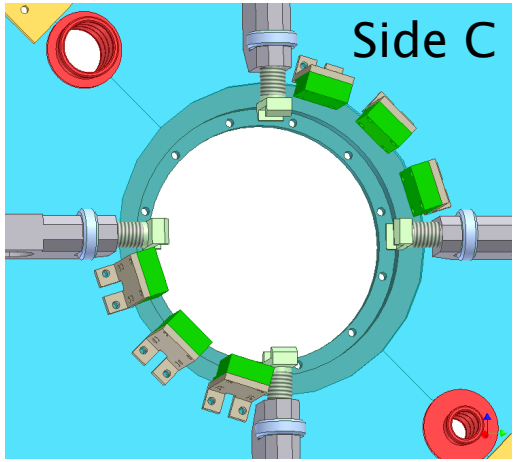
- Nominal conditions: HV=1000V
  - High thr. vs. low thr. signal splitting currently ~1:150.
  - saturation at FE output ~1V
    ~ 250 MIP
    ~(0.5 kMIP/cm2) at
    nominal cond.

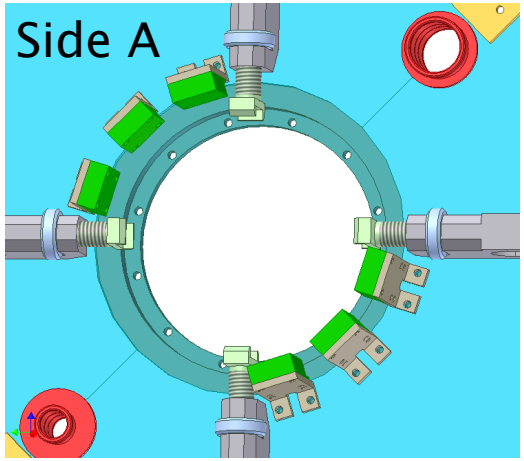
- Single channel threshold set to
  ~250 MIP/cm2 within 25 ns
  (factor 2 not to exceed FE range)



ATLAS BLM – Intro

- 6 BLM modules installed on Inner Detector End Plate on each side
- Z-position of the inner skin of the End Plate is 3457mm for both sides
- Read out with LHC BLMCFC and BLMTC
- Only one BLMTC and two BLMCFC crates (one for A and one for C side)
- Slight modification of HW (B field) and FW (ATLAS specific)
- Much simpler than BCM

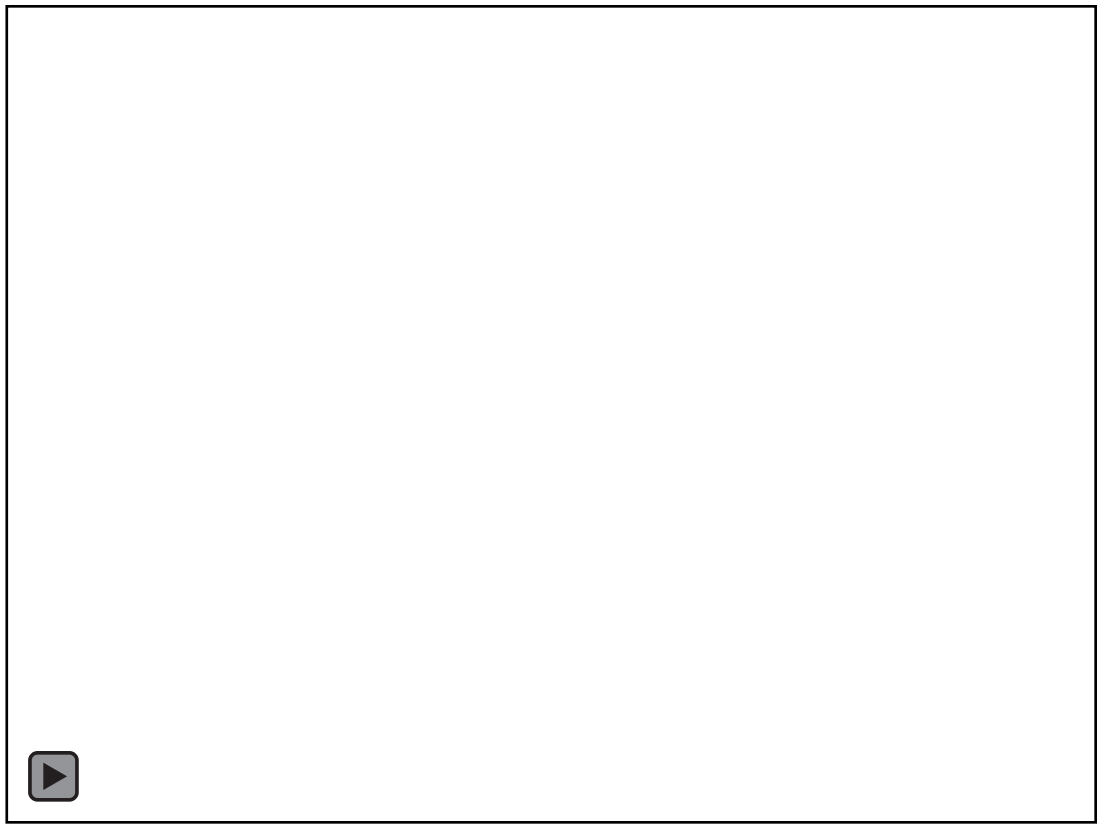




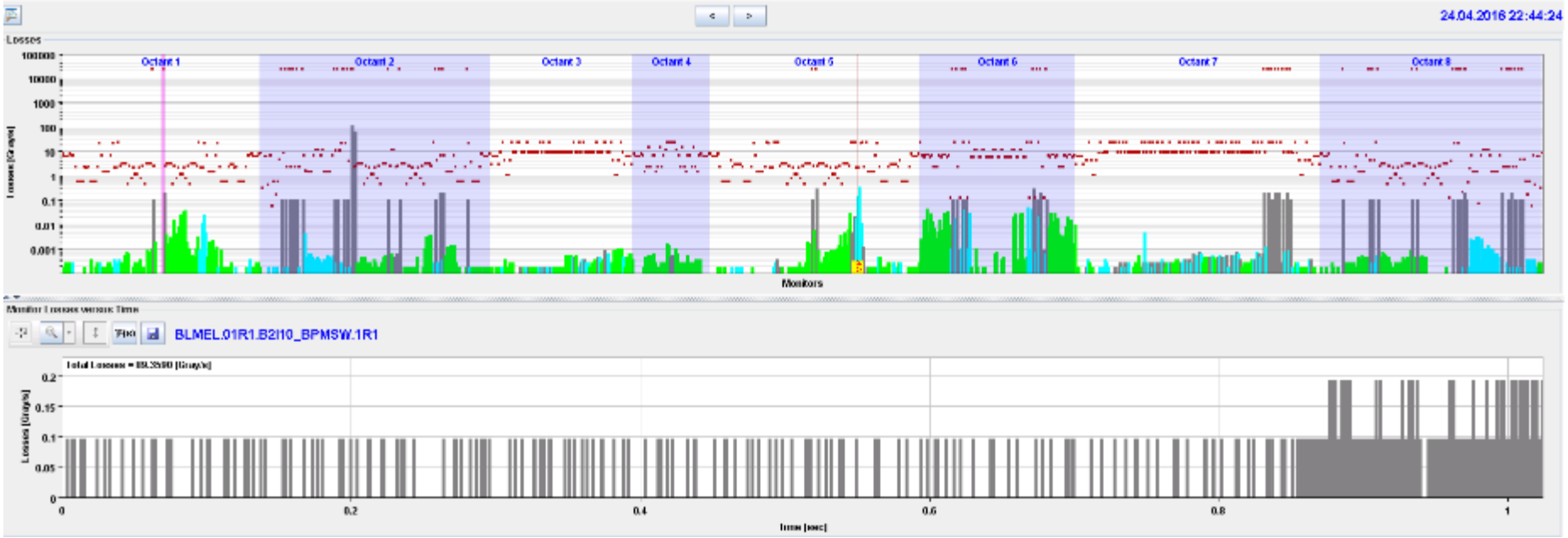
BLM threshold

- For loosing IP — require that 2/6 channels exceed threshold within 40 μs on A or on C side (ATLAS FW!). BP is lost when A and C side lower IP simultaneously
- 1 MIP in BLM diamond sensor (~1fC charge) in 40 μs causes equivalent current of ~25 pA.
- BLM thresholds set to:
  - ~750 nA (= 350 bits) in 40 μs integration channels.
  - 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**
  - Compatible with ATLAS Inner Detector "danger level" (in the most unlikely event of all particles coming along Si strips)

14/04/16 19:00:33

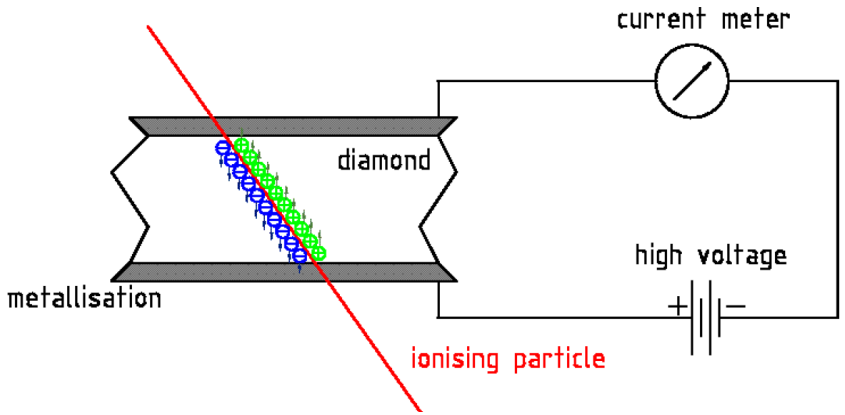


24/04/16 22:44:24

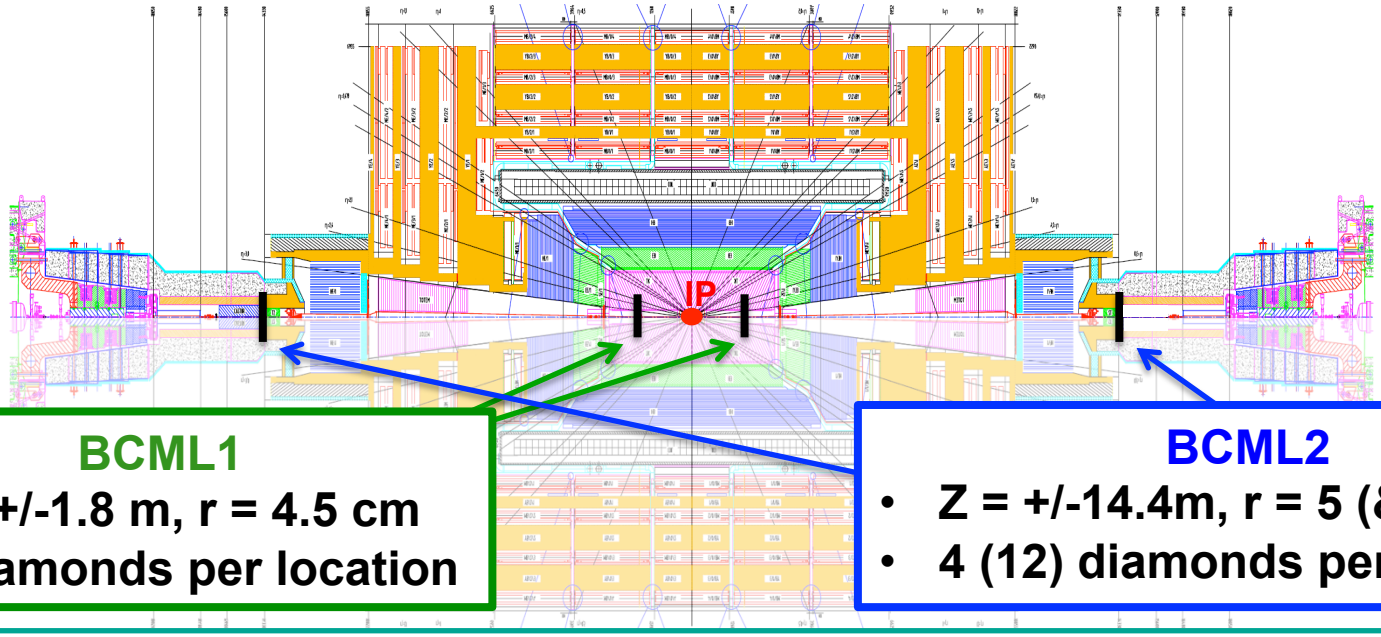


Beam loss system at CMS
BCML (Beam condition monitor leakage)

- Based on pCVD diamond sensors
- In total 16 active beam abort channels
- Working principle similar to BLM tubes, signal readout identical



Positions of diamond detectors at CMS



BCML1
- **Z = +/-1.8 m, r = 4.5 cm**
- **4 diamonds per location**

BCML2
- **Z = +/-14.4m, r = 5 (& 28) cm**
- **4 (12) diamonds per location**

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Definition of BCML thresholds at CMS

Running sum I: 40µs

- Based on tracker community's damage tolerance: 10^9 MIP/cm²
- Adding of a safety margin of 1000: 10^6 MIP/cm²
  10^6 MIP/cm²/40µs ~ 30µA (6150 ADC) for undamaged pCVD
- Even more conservative threshold set to **10µA (2050ADC)**

Running sum IV: 640µs

- New introduced in 2016 in for BCML1 because of reduced sensitivity in RS1.
- Definition equal to RS1 definition:
  10^6 MIP/cm²/640µs ~ 1.88µA (6150 ADC) for undamaged pCVD

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Definition of BCML thresholds at CMS

Running sum XII: 83s

- Thresholds is based on a data driven extrapolation
- Set to 3 x the expected signal (EDMS numbers: 1157274v3, 1236236v1)

The CMS BCML threshold definition for 2016 can be found in the EDMS document 1611082v1.

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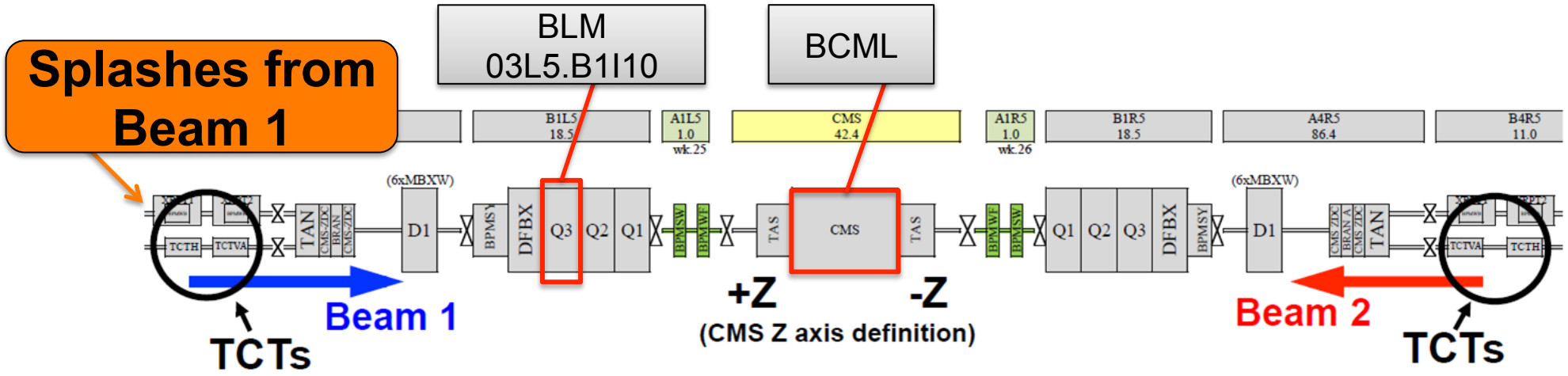
Splash events on 29th of march 2016

- Comparison between BLM tube (03L5.B1I10) and BCML detectors during splash events.
- Splash events created by Beam1 hitting the collimators upstream of CMS.
- Splash events with highest intensity caused a trigger of the beam abort by some of the BCML detectors.



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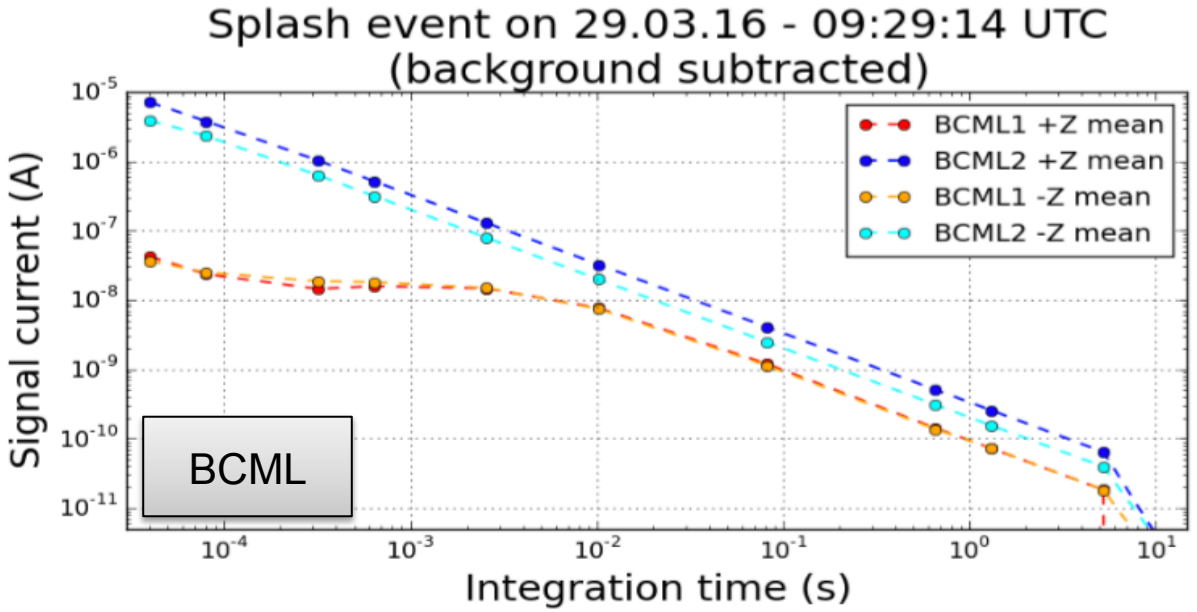
Splash events on 29th of march 2016

BCML2:

- RS1 +Z: up to 2200 ADC
  107% of beam abort
- RS1 –Z: up to 1090 ADC
  53% of beam abort
- (RS4: up to 2480 ADC)

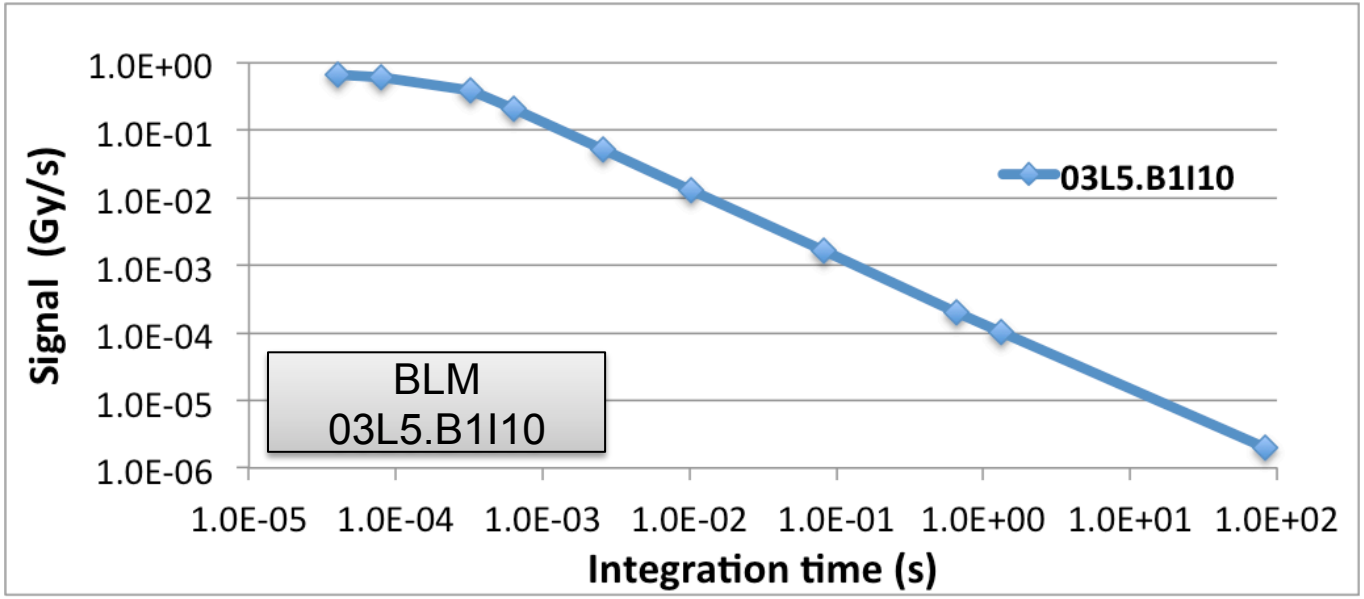
BCML1:

- RS4: up to 115 ADC
  3% of beam abort



BLM:

- RS1:
  20% of beam abort
- RS3:
  32% of beam abort
- RS4:
  31% of beam abort



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