Modification of CMS BCM thresholds

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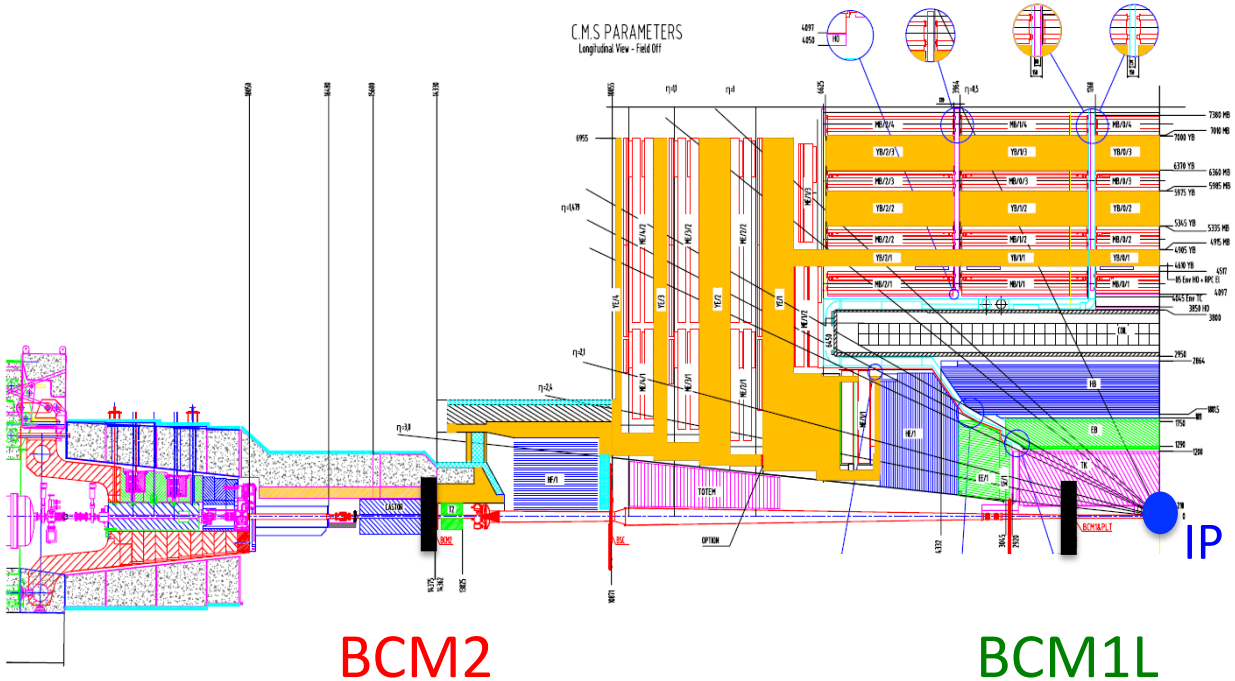
- Overview of the BCM system:
  - Hardware implementation
  - Threshold assumptions
- Motivation for changes.
- Changes to the system:
  - Modification of BCM2 thresholds.
  - Activation of BCM1L in the abort.

System Overview

- Two systems: BCM2 and BCM1L
- Detector: 1x1cm^2 polycrystalline diamonds.



BCM2
Z = ± 14.4m

BCM1L
Z = ±1.8m

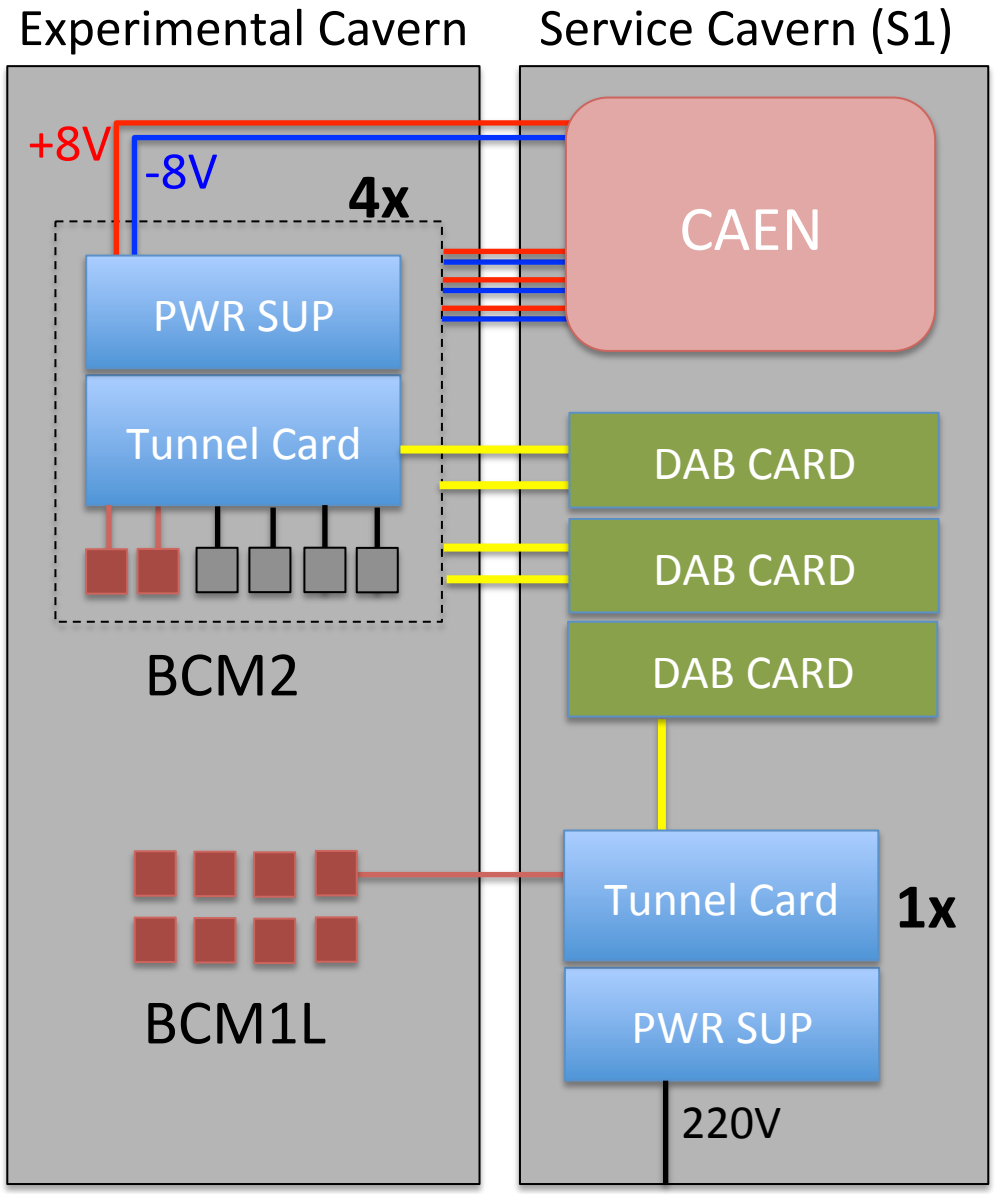
BCM2

- two rings per side
- Inner ring (r=4.5cm): 4 diamonds
  Active in abort
- Outer ring (r=28cm): 8 diamonds
  Not in abort

BCM1L

- one ring per side
- 4 diamonds (r=5cm)
- Close to pixel.
- Has been activated in abort since this TS.

Electronics



- Almost identical to BLM system.
- All DAB cards are in one VME crate.
- Tunnel cards have the reset relay replaced by a MOSFET.
- BCM2 TCs are supplied with LV from CAEN module.
- BCM1L has ~150m frontend cable, TC in service cavern.

Motivation of thresholds

- Running Sum 1 (40 µs):
  - 10^9 MIP/cm^2 per "short-loss", is the damage threshold defined by the tracker community.
  - Since 40µs is the shortest integration time: this is used for a "short-loss".
  - Safety factor of 1000 is applied -> threshold: 10^6 MIP/cm^2/40µs
  - Calculates to a detector current of 36µA. Used as abort threshold: 10µA.
- Running Sum 10 (5.2 s):
  - Present HV filter leads to HV sagging with very high detector currents (Order >1µA).
  - Only necessary for BCM2. Will be unnecessary once HV filter are replaced.
- Running Sum 12 (83.9 s):
  - Very long time scaled bad conditions damage pixel unnecessarily.
  - Defined by pixel community to be 3x the expected rate at luminosity of 10^{34}/cm^2/s.
  - The current threshold was set some years ago with a level way above the expected at that time: 290nA detector current.
  - This was based on expected rates from Monte Carlo simulations.

Thresholds BCM2, prior to this TS

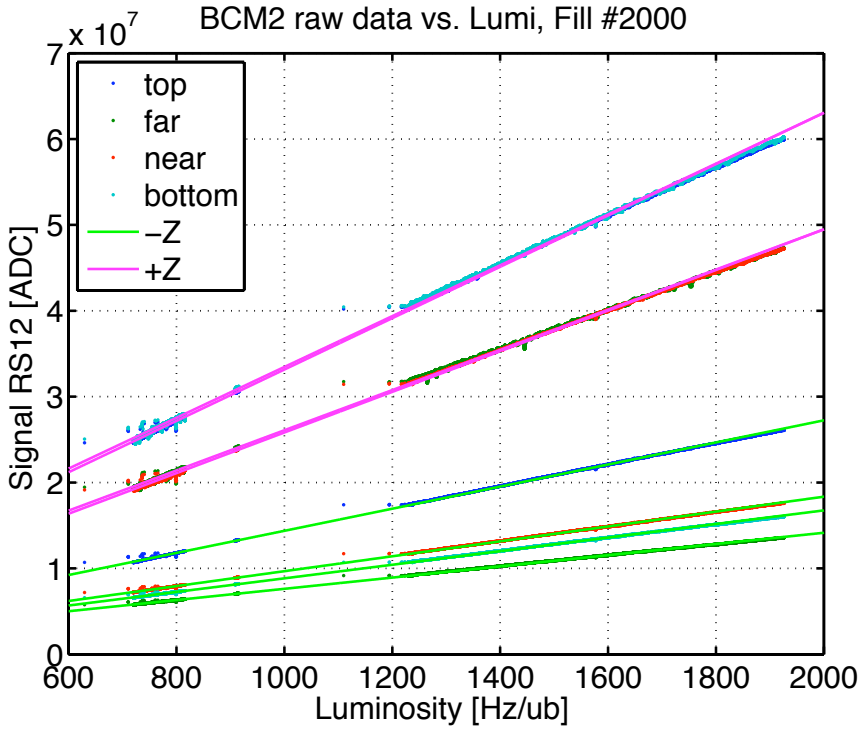
Running Sum	Time [s]	Threshold [ADC]	Threshold [A]	Flux in MIPs	MIP Rate [Hz]	Dose [Gy]*	Dose [Gy/s]
RS 1	40 µs	2050	10 µA	3.3×10^{5}	8.25×10^{9}	7.42×10^{-6}	0.19
RS 10	5.2 s	26 M	0.9 µA	4.1×10^{9}	7.9×10^{8}	0.094	0.018
RS 12	83 s	126 M	0.29 µA	2.0×10^{10}	2.4×10^{8}	0.456	0.0054

- At the moment (~$2 \times 10^{33}/cm^2/s$) some diamonds reach 0.14 µA ≈ 50% of the abort threshold on RS 12.
- Need to increase these thresholds.

* Conversion factor: *3.62×10^{-9} Gy/BLMBIT*

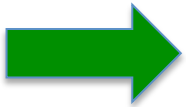
BCM2 signals vs. Lumi

- Base the new thresholds on data driven assumptions.
- Linear behavior of the signal with luminosity.
- Extrapolating the expected signal at $3x10^{34}/cm^2/s$ and use this as threshold.
- Every channel gets its own threshold.



New BCM2 RS 12 thresholds

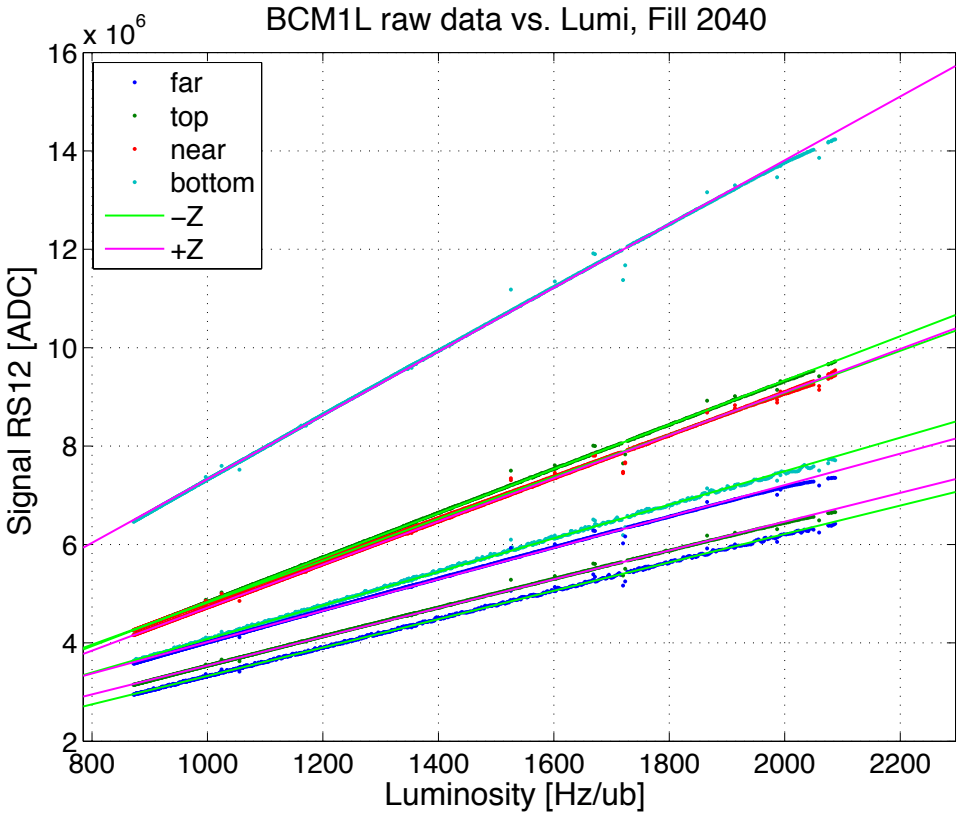
BCM2 inner	RS12 new Threshold [ADC]	RS12 new Threshold [nA]	Efficiency	Corresponding MIP flux estimation [MIPs/s]
-Ztop	390527041	909.27	0.38	1.95E+09
-Zfar	199123384	463.62	0.19	
-Znear	263300833	613.05	0.26	
-Zbottom	240163762	559.17	0.23	
+Znear	716178979	1667.48	0.88	
+Ztop	906825226	2111.37	0.69	
+Zfar	709923318	1652.92	0.69	
+Zbottom	899393726	2094.06	0.87	
Average	540679534	1258.87	0.52	
Std dev (±)	299675324 (55.4%)	697.74 (55.4%)	0.290 (55.4%)	5.0E+08 (25.7%)
Old thresholds (Same for all channels)	126000000	290		2.40E+08



New RS 12 thresholds increased on average by factor ~2.5
Implemented during this TS

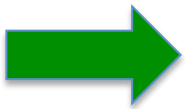
BCM1L

- BCM1L is running stably since connected to BLM electronics.
- Has been activated in the abort system for higher redundancy.
- We will use the same threshold recipe as for BCM2. (Except there is no RS 10 threshold.)
  - RS1: 10 µA
  - RS12: data driven



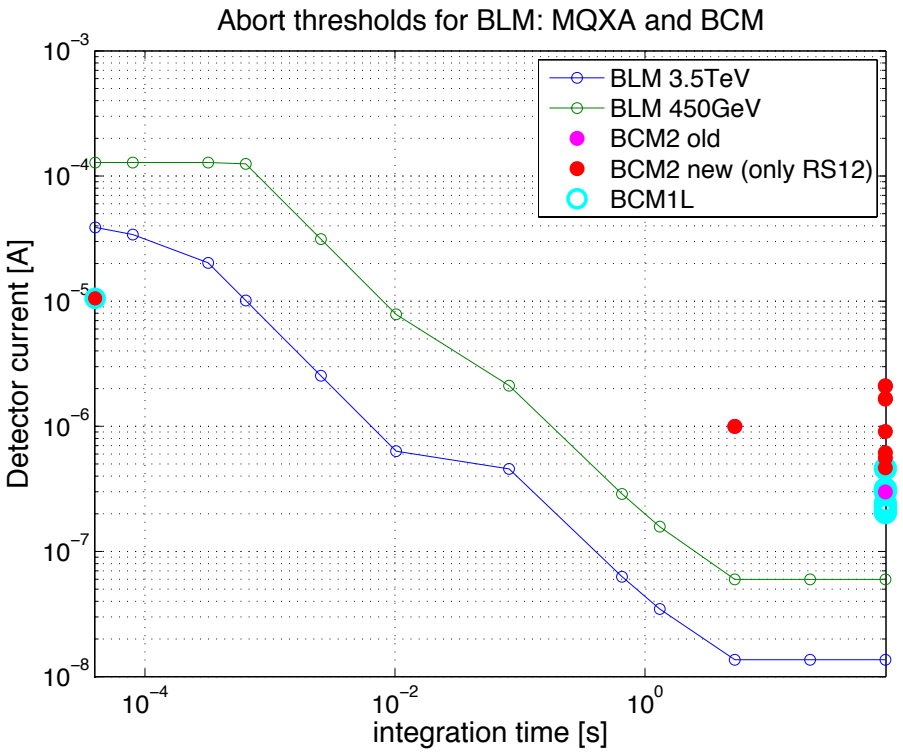
BCM1L: RS 12 thresholds

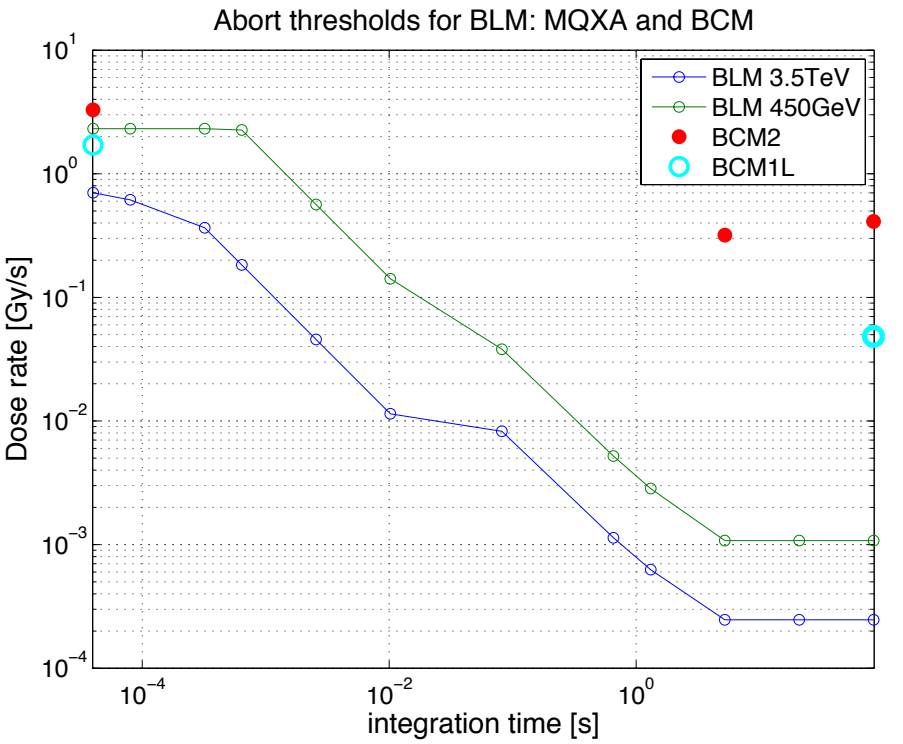
BCM1L	RS12 Threshold [ADC]	RS12 Threshold [nA]	Efficiency	Corresponding MIP flux [MIPs/s]
-Zfar	87873922	204.6	0.72	2.32E+08
-Zup	135960561	316.56	1.12	
-Znear	129644221	301.85	1.06	
-Zdown	104286111	242.81	0.86	
+Zfar	98240648	228.73	0.81	
+Zup	89607286	208.63	0.74	
+Znear	132339414	308.13	1.09	
+Zdown	196930210	458.51	1.62	
Average	121860297	283.73	1	
Std dev (±)	35989643 (29.5%)	83.79 (29.5%)	0.295 (29.5%)	6.8E+7 (29.5%)



Implemented during this TS

Comparing BLM and BCM thresholds





- Left plot shows a comparison of the detector current.
- Right plot tries to convert this into Gy/s:
  - Compensating the signal by the average efficiency loss.
  - Converting the diamond signal to a BLM signal (factor 9.48)
  - Using the same conversion factor to Gy/s as used for the BLM.

Conversion factor: *3.52x10^{-9} Gy/BLMBIT*

Conclusions

- Threshold modifications were necessary:
  - BCM2 RS 12 signals close to old thresholds.
  - Channel by channel data driven thresholds.
- New data driven recipe for calculating the optimal abort threshold for RS 12 established.
- BCM1L activated in abort with threshold assumptions identical to BCM2.
- Changes implemented during this TS.
- Abort system validated by CMS/BRM and BE/CO.