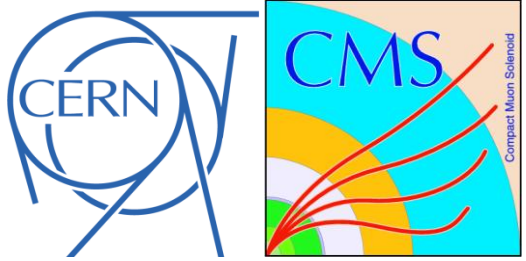


CMS beam condition monitoring for experimental protection during 2010 and Outlook

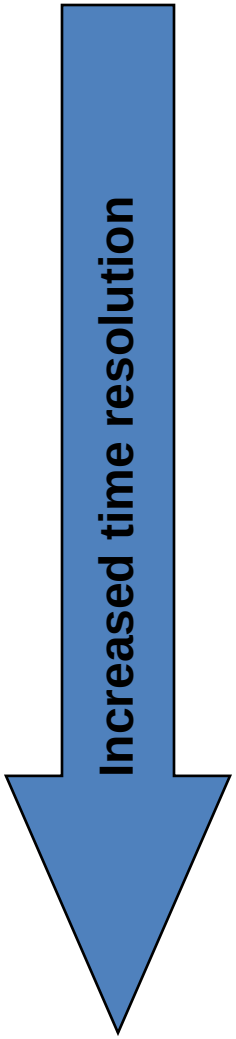
Moritz Guthoff

CERN / KIT Karlsruhe

On behalf of the CMS-BRM Group.

BRM Subsystems

Subsystem	Location	Sampling time	Function	Readout + Interface
Passives TLD + Alanine	In CMS and UXC	Long term	Monitoring	---
MEDIPIX	USC and UXC	1 minute	Monitoring	CMS Standalone
RADMON	18 monitors around CMS	1s	Monitoring	Standard LHC
BCM2 Diamonds	At rear of HF z=±14.4m	40 us	Protection +Monitoring	CMS + Standard LHC
BCM1L Diamonds	Pixel Volume z=±1.8m	Sub orbit ~ 6us	Protection (in commissioning)	CMS + Standard LHC
BSC Scintillator	Front of HF z=±10.9,14.4 m	(sub-)Bunch by bunch	Monitoring	CMS Standalone
BCM1F Diamonds	Pixel volume z=±1.8m	(sub-)Bunch by bunch	Monitoring	CMS Standalone
BPTX Beam Pickup	175m upstream from IP5	200ps	Monitoring	CMS Standalone



Total number of diamonds used: 32 pCVD and 8 sCVD. Many more with the PLT.

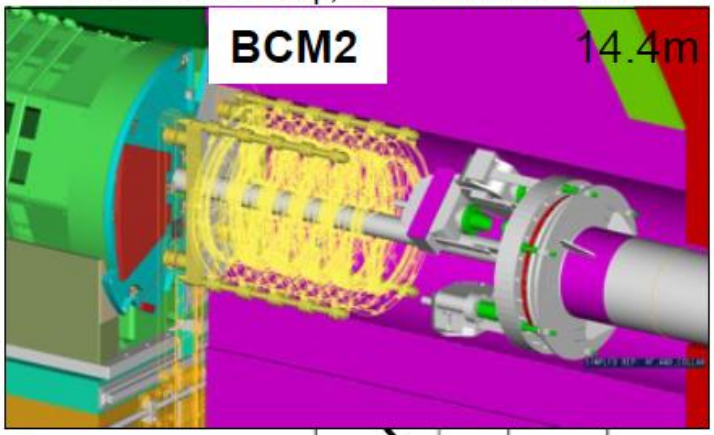
BCM2: Leakage current monitor

Location: z=± 14.4m, r=29cm, 5cm

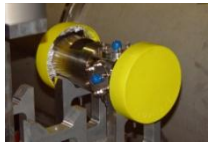
8 stations in φ, 24 sensors total

Readout: 25kHz / 40 us

Front End: BLM tunnel cards



BPTX: 175m



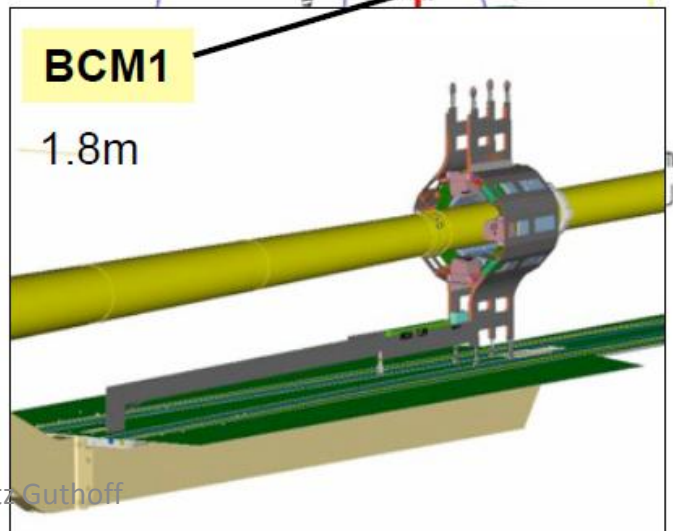
BCM1L: Leakage current monitor

Location: z=±1.8m, r=4.5cm

4 stations in φ, 8 sensors total

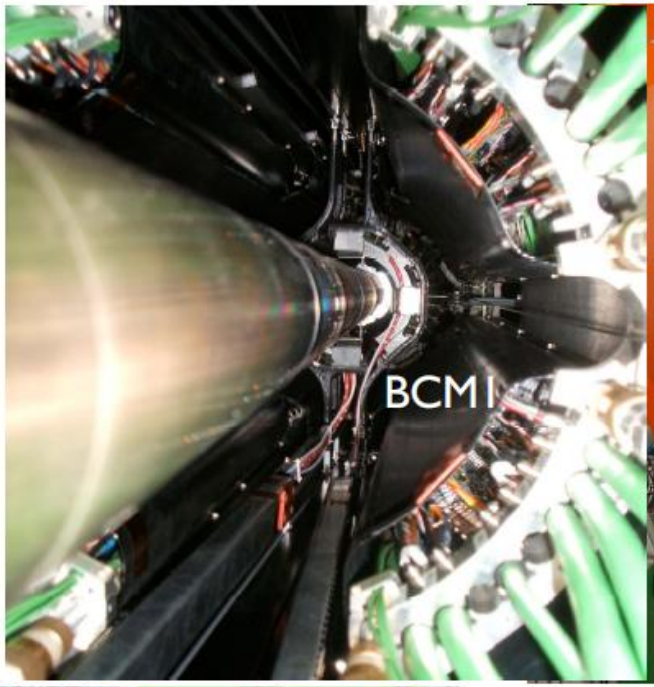
Readout: 200kHz / 5us

No front end electronics



Sensors: 1cm² polycrystalline cvd Diamond

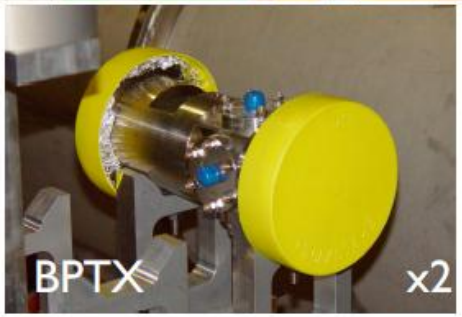
Pictures

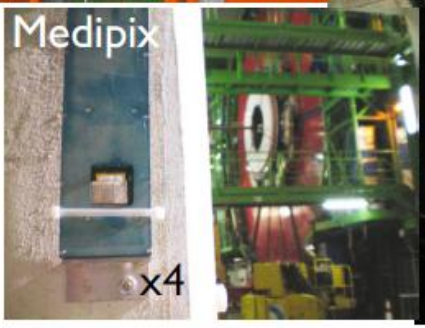

BCM1


BCM2
BSC2


BSC1


RADMON
x20


BPTX
x2


Medipix
x4


Passives
x160

Status BCM2

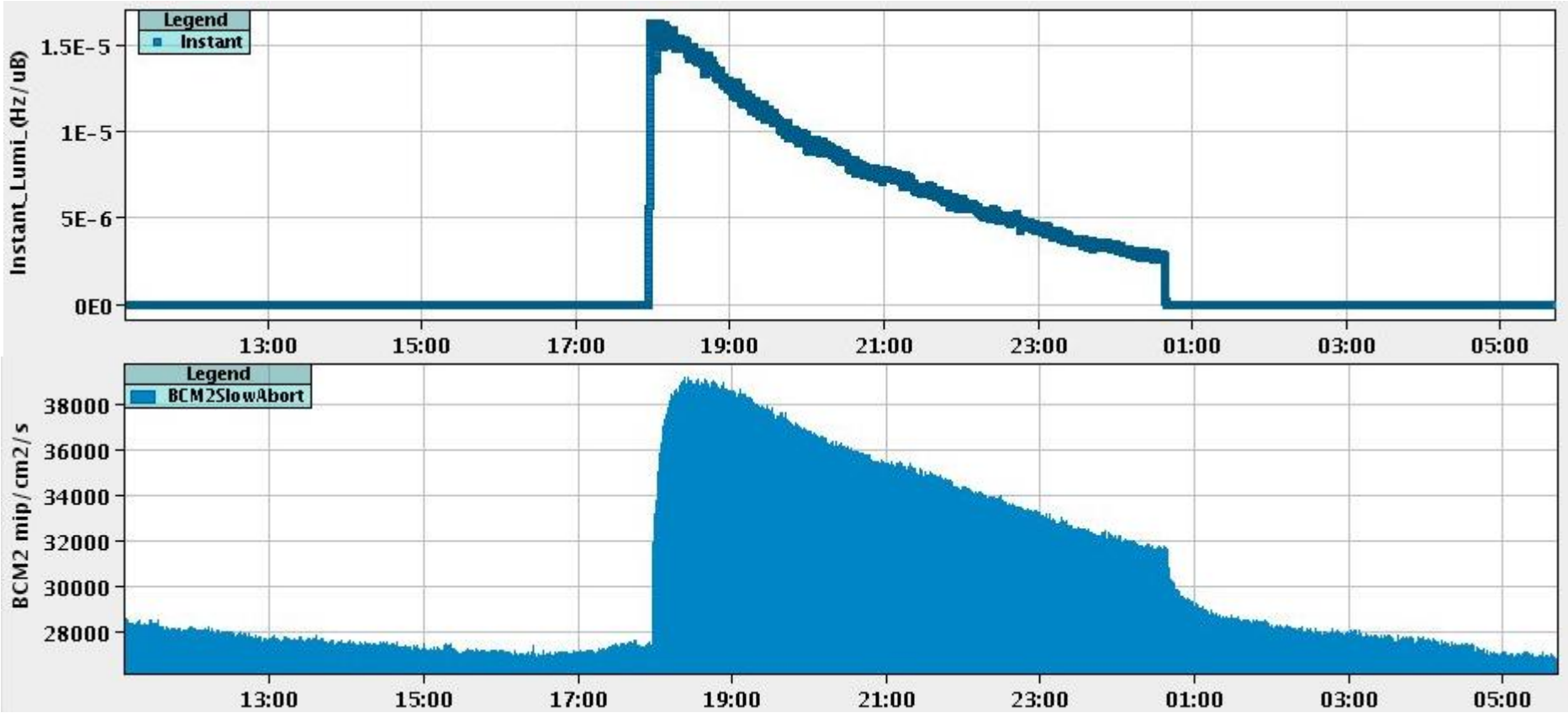
- Leakage current monitor, measuring MIP equivalent.
- Serves as a transparent extension to LHC Beam Loss Monitors.
  - Uses the same readout electronics.
  - Cross calibration with BLM tubes in testbeams. -> data is directly comparable.
- Since beginning of 2008 run active in beam abort.
- No beam abort (false or real) so far.
- Good data quality, only a minor issue with „spikes“ due to readout electronics.

Thresholds

- Thresholds for abort are issued by pixel&tracker community. Based on CDF experience an testbeams:
  - Harmful are ~10^9 MIP/(los*cm^2). Choose ~10^6 as abort.
  - Running Sum 1: 40us, 10uA, protection against fast losses.
  - Running Sum 10: ~5s, 1uA, protection against capacitor discharge in HV filter.
  - Running Sum 12: ~83s, 300nA, protection against long-timescaled bad condition. (Three times the expected current @nominal luminosity.)

BCM2 signal with heavy ion

- Long rise time and long decay after lumi due to activation of material.
- Seen also by independent nearby detector (BSC2).
- Besides that it follows the lumi nicely.

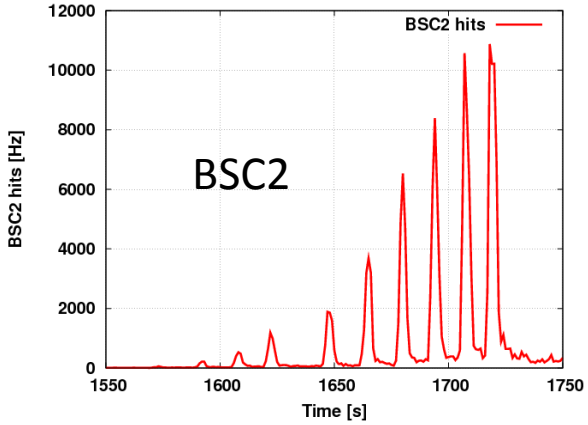


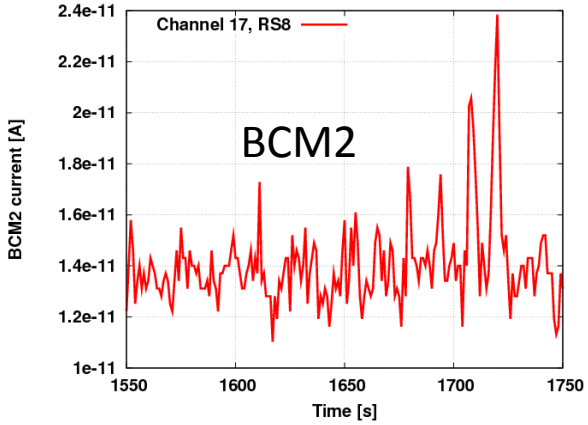
What to do with the data.

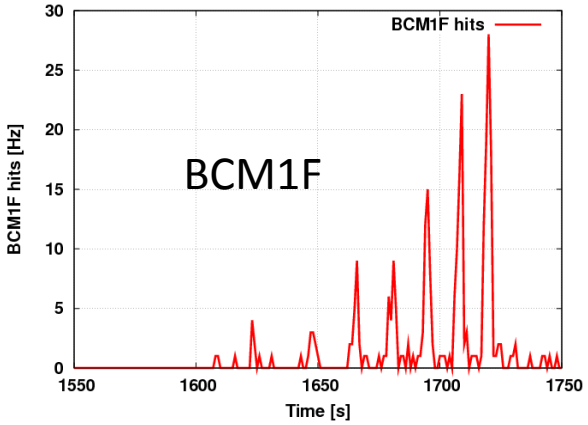
- We have good data since November 2009. There were signals since the first day.
- Compare the data with simulation. Preliminary analysis show a three times higher signal in BCM2 as expected from simulation, presently under study.
- Looking at correlations between detectors at different positions give information about what part of the signal is machine induced background and what is pp-signal.
  - Since the outer ring of BCM2 diamonds is shielded from the IP a inner/outer ratio is interesting.
- Comparing data from scintillators (@BCM2 location) with BCM2 or BCM1 fast MIP counter with BCM1L(leakage current monitor) help to get rid of detector effects like pumping. Can be used for activation studies.

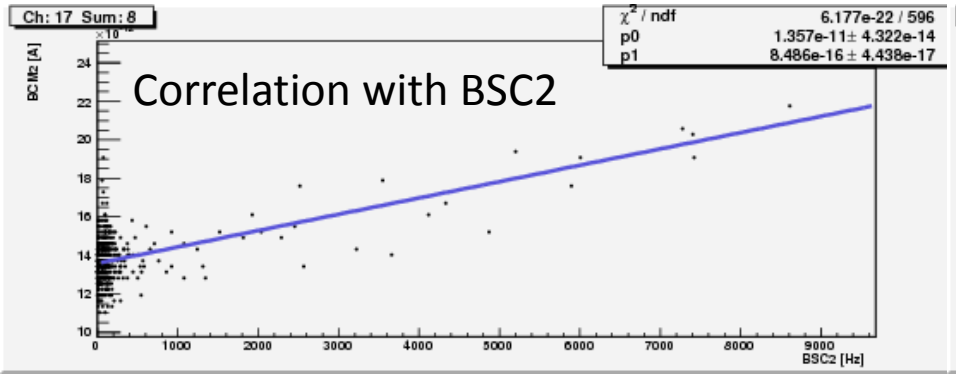
Data from beam tuning

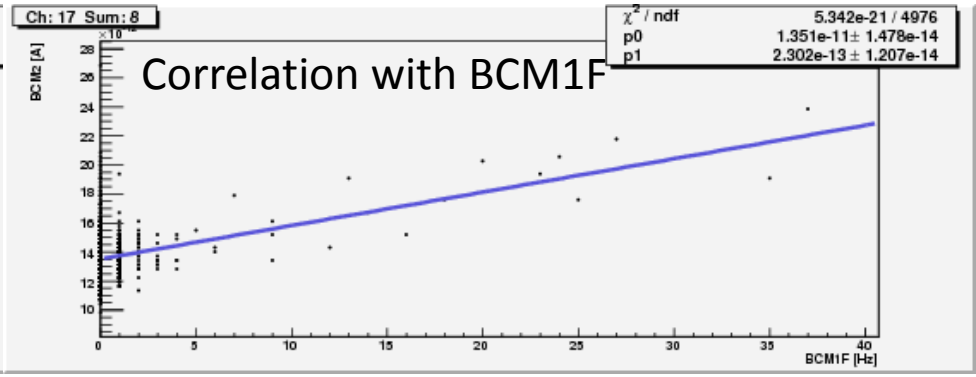
- During first LHC run beam 2 was tuned. While doing so beam halo scratched the last collimator before CMS (TCT).





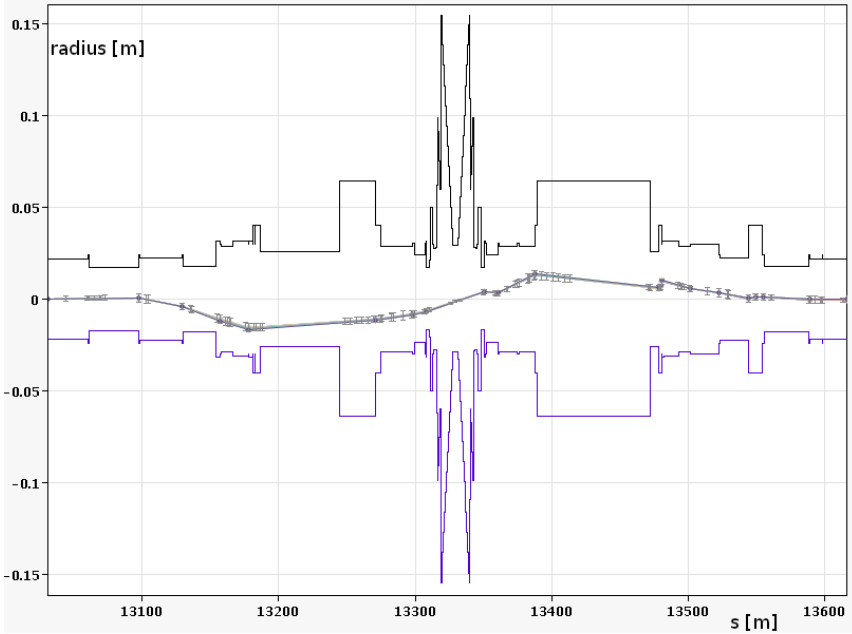


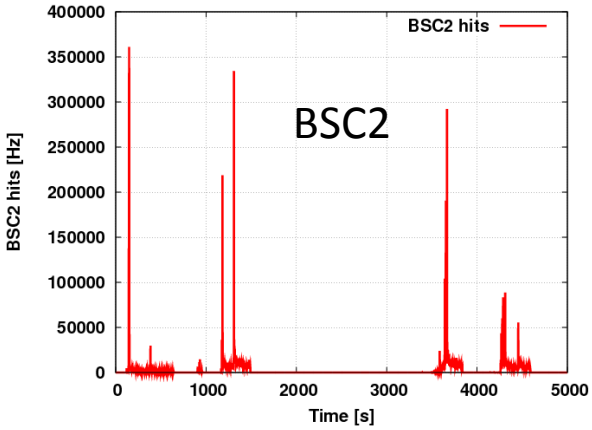


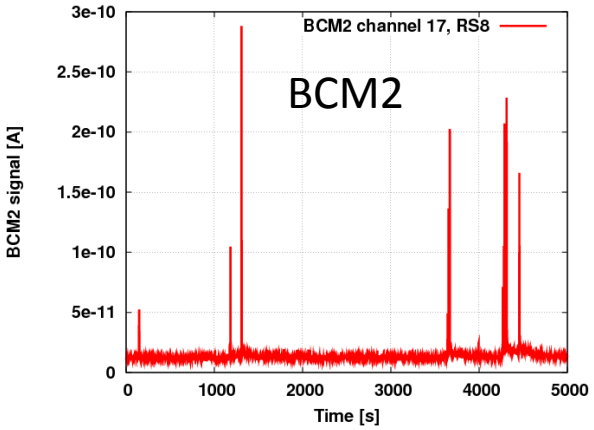


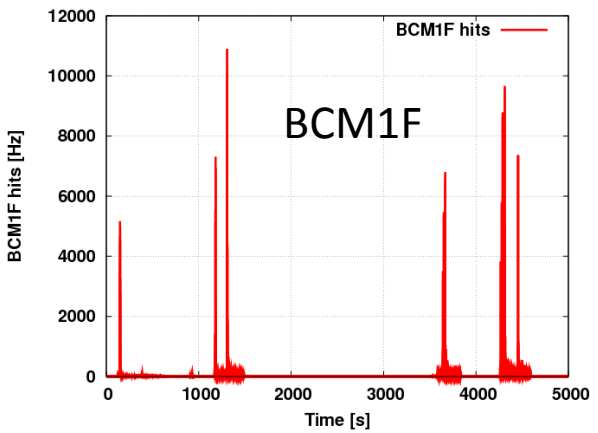
Apperture scan

- The beam was steered close to the collimators to see at what position the losses are to high. This produced losses at may differen positions.





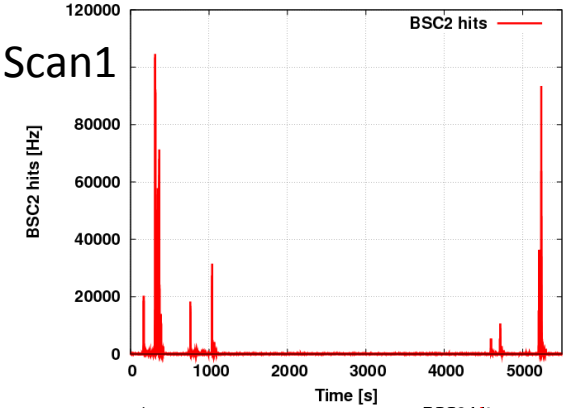


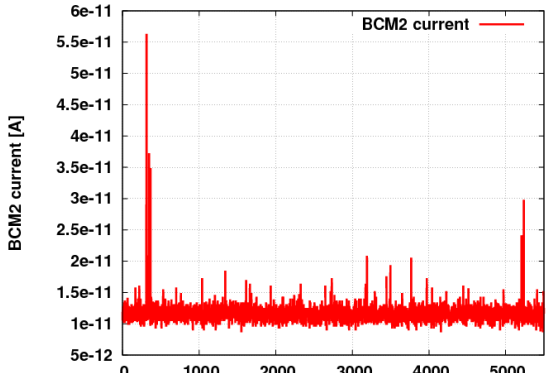


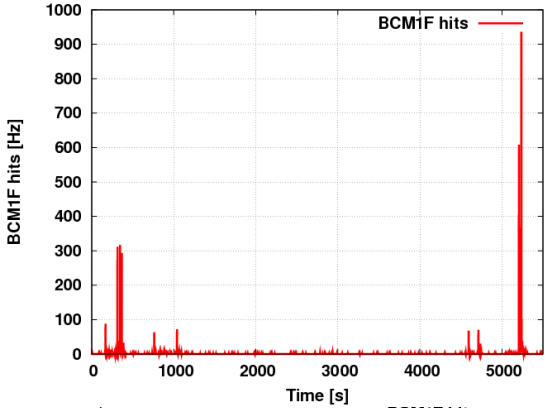
Collimator scans

- Modification of collimators produced losses in different positions. The origin of the particles in CMS was always the last collimator (TCT).

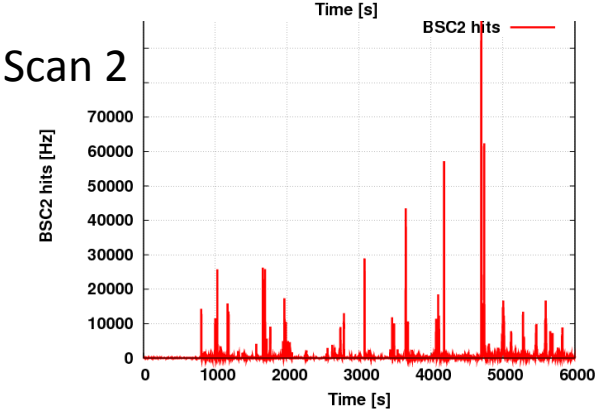
Scan1

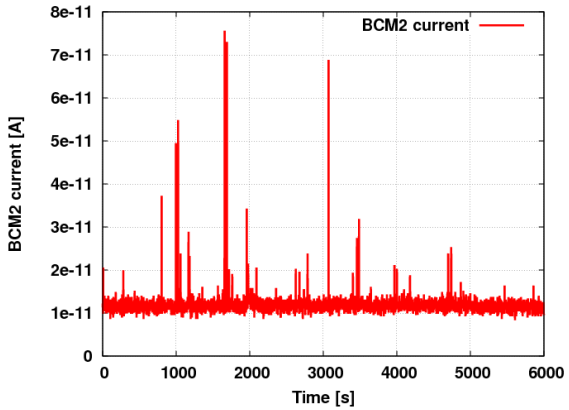


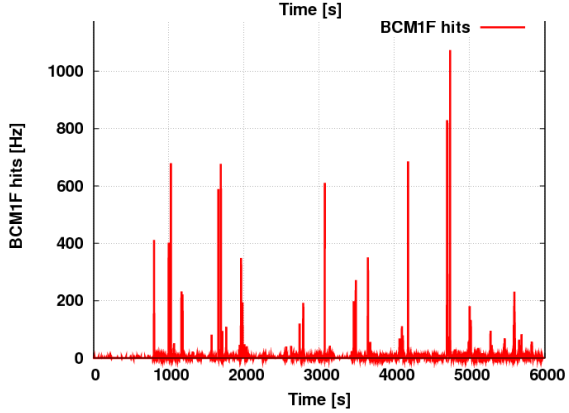




Scan 2

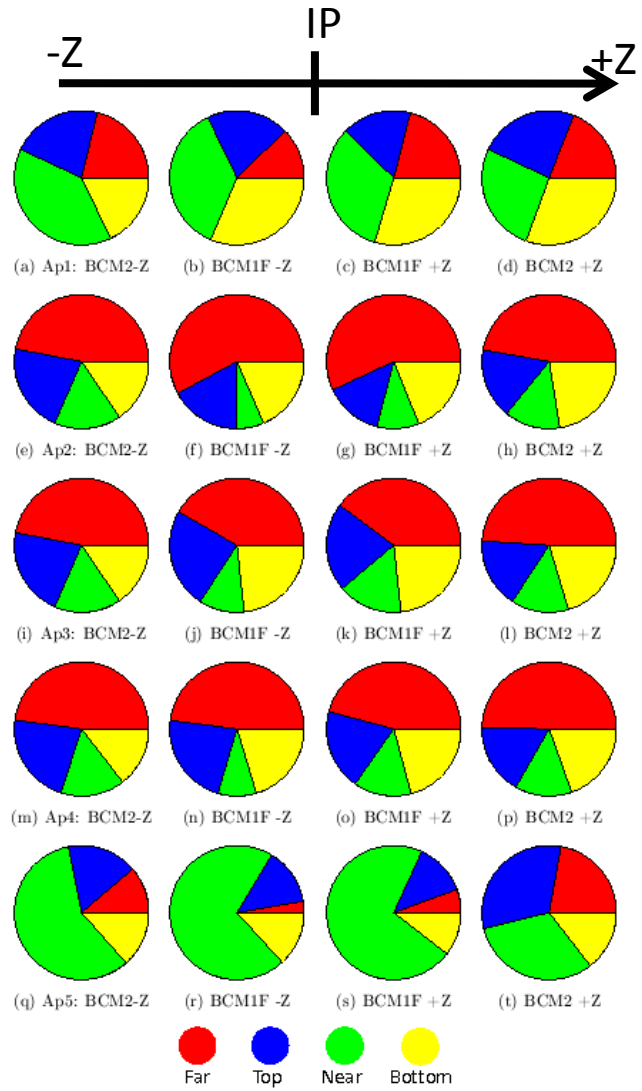






Signal shape in phi

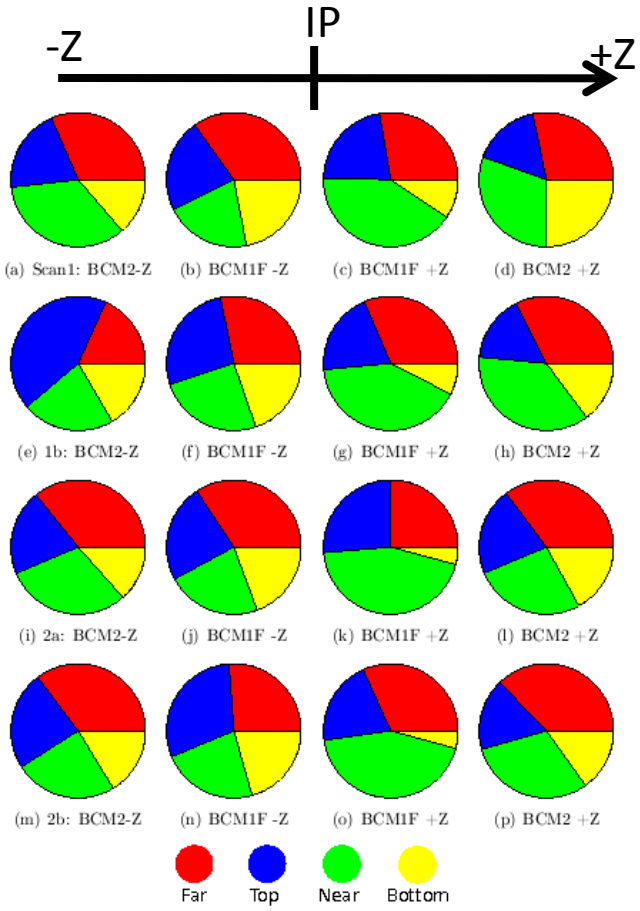
Aperture Scan, strong asymmetry in phi in different runs.



Different scans

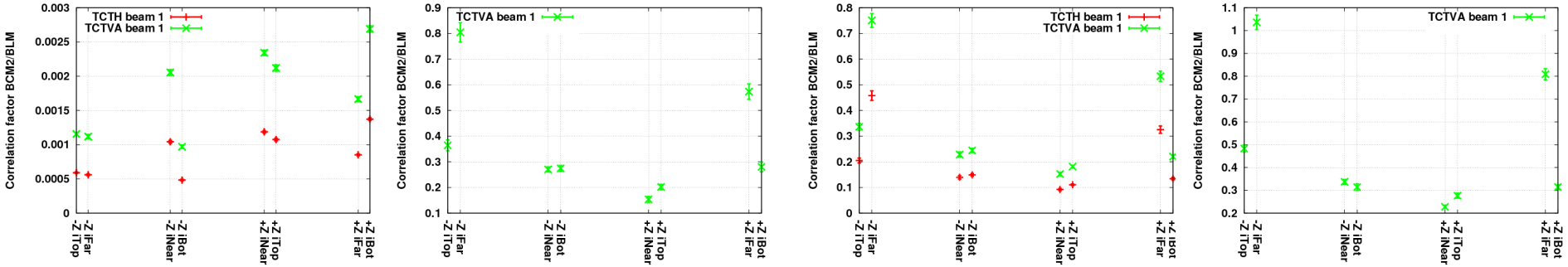
Collimator Scan

More homogeneous signal distribution for all scans.

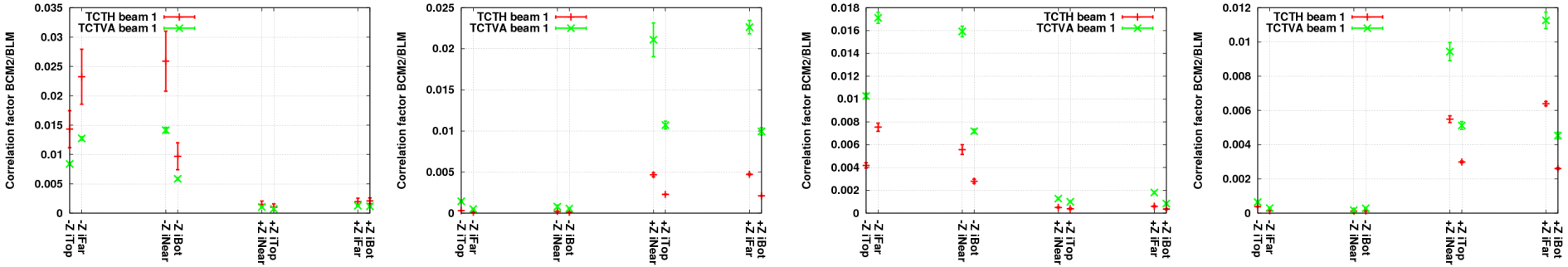


BLM correlation

- Correlation factor a measure of shielding efficiency.
- Aperture scan factors showing large spread, possible indication for very different loss locations leading to different shielding efficiencies.



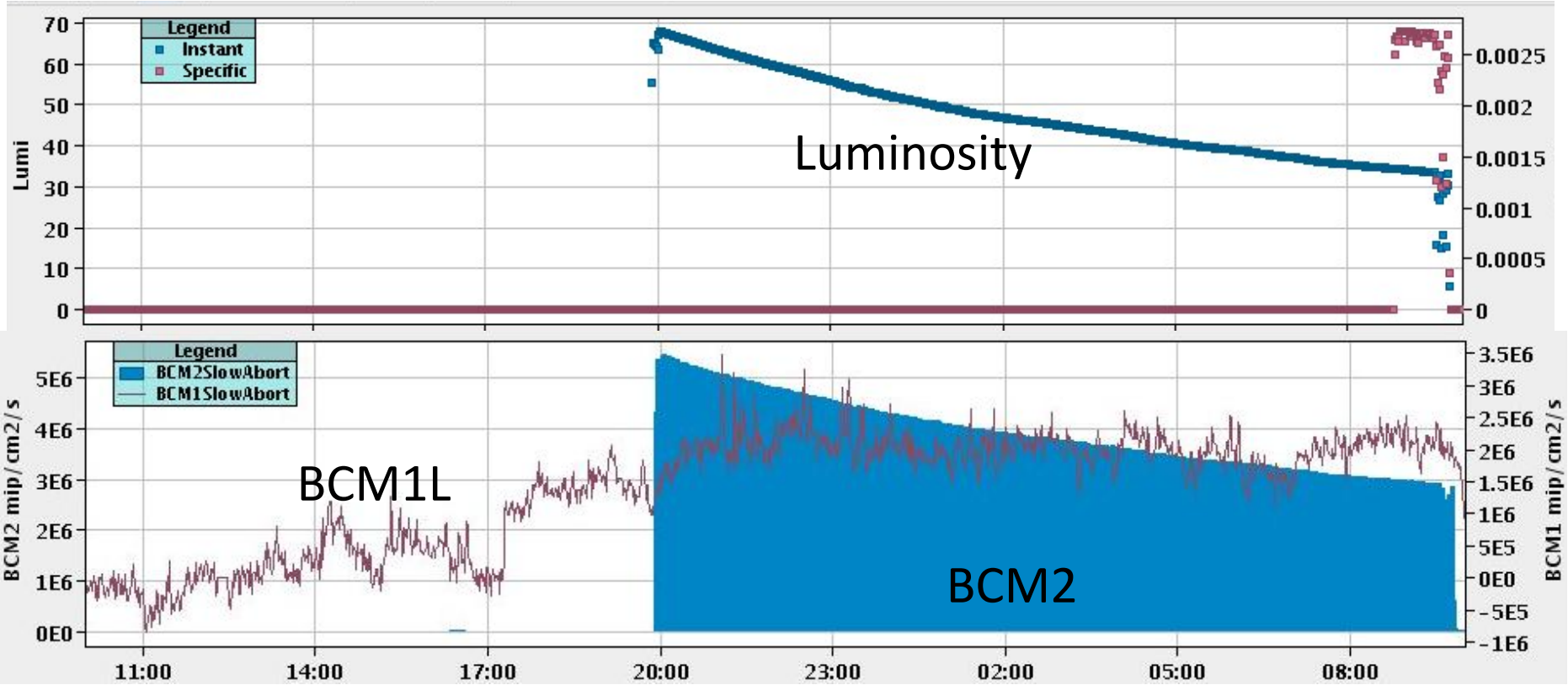
- Collimator scan factors showing small spread, losses from similar locations (TCT), forward shielding more efficient (smaller factors).



Collimator Losses: 1-3% reach BCM2

BCM1L

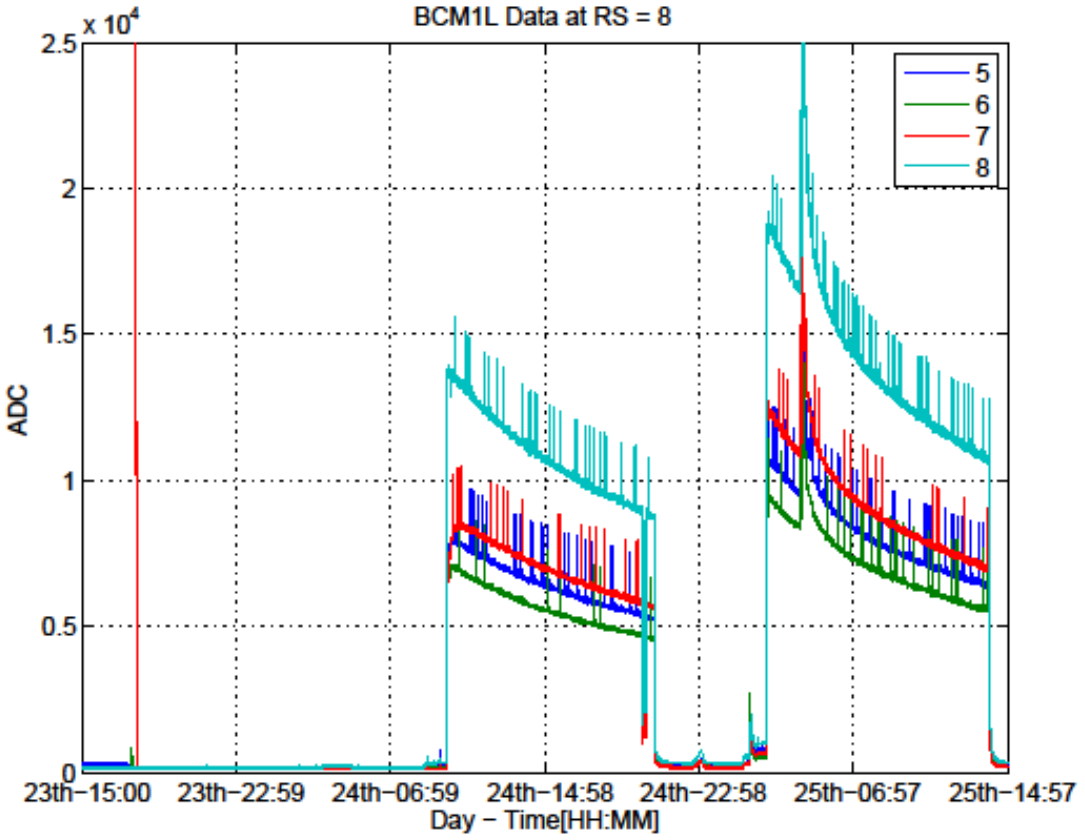
- Intended as an orbit and abort gap monitoring system.
- Due to high noise not applicable.
- Long time drifts make monitoring impossible.



Test of BCM1L diamonds with BCM2 test-readout

- Two pp-fills recoded.
- Signal follows nicely the luminosity.
- Ignore the spikes (electronics problem)

- There is also data from the heavy ion run.
- This can be used for activation studies (comparison with BCM2).

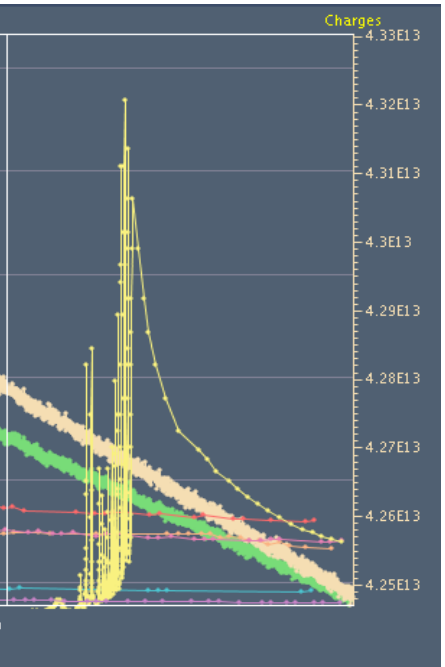


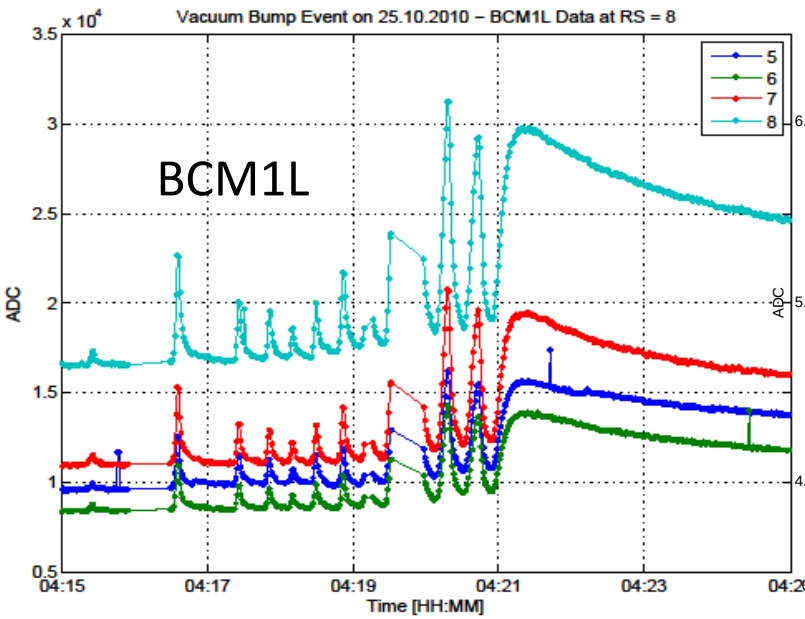
Future of BCM1L

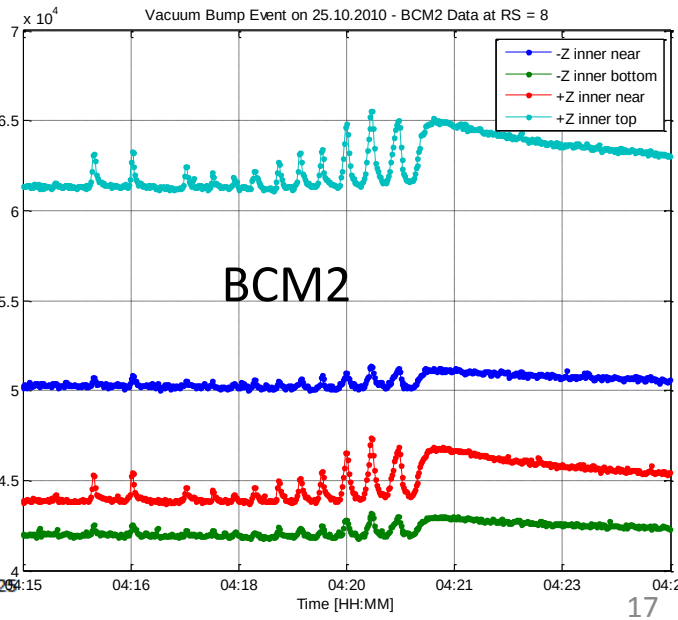
- Possible advantages of the BCM1L readout are going to be abandoned:
  - BCM1L is better on short timescales.
  - Orbit monitoring -> will be done by BCM1F.
- BCM1L readout will be replaced by BCM2 readout during shutdown 2010/2011.
  - Better comapairibillity betwenn BCM2 and BCM1L diamonds.
  - BCM2 readout better on longer timescales.
  - Only one system has to be maintained.

Vacuum Bump (25.10.2010)

- During luminosity vacuum got bad and produced losses in all BRM detectors.
- Biggest loss seen so far.
- Very nice event to study correlations between different monitoring systems and the ration of pp-signal and background. This helps to discriminate background events from luminosity.







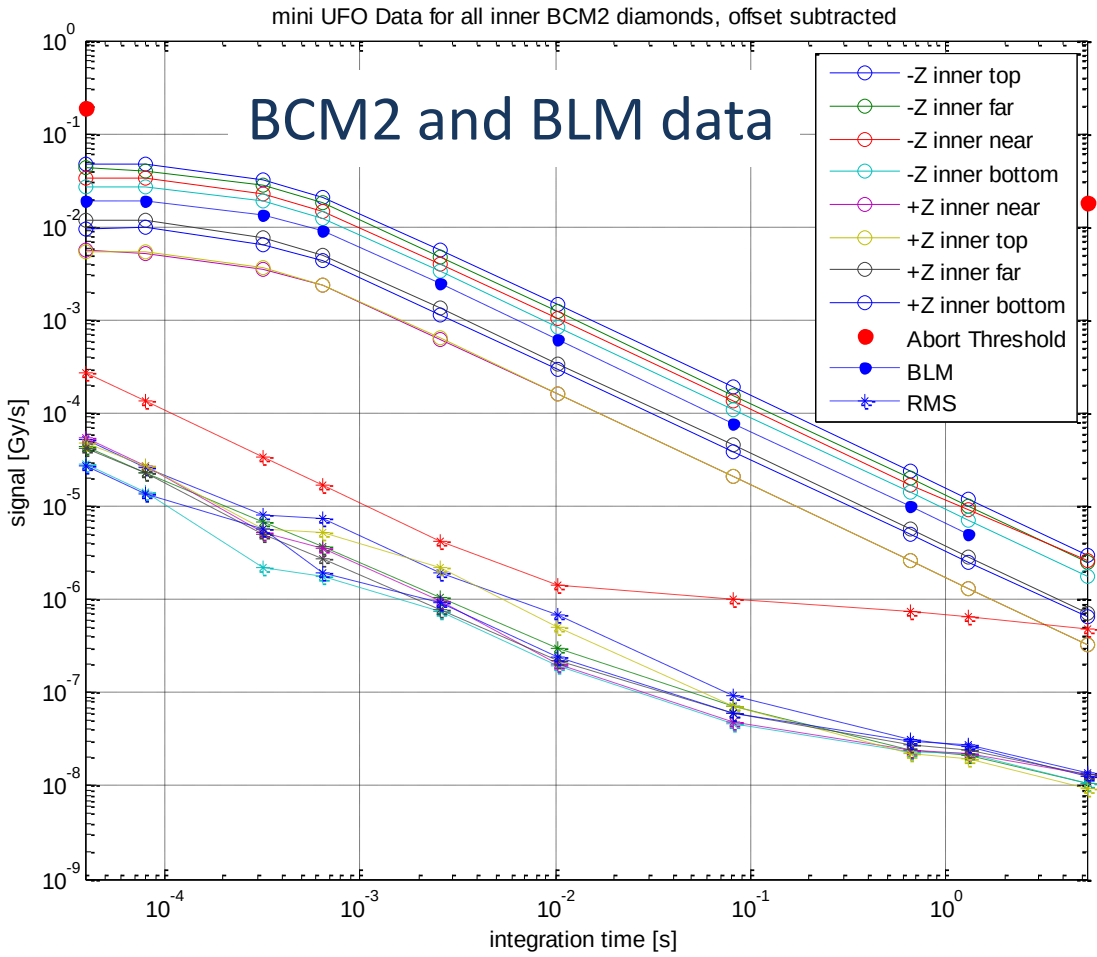
Unknown Falling Objects

- UFO: Short burst of high loss seen normally in LHC Beam Loss Monitors. Length ~ 1-2 ms.
- UFOs caused lots of beam dumps.
- Occurrence seems correlated with beam intensity. Precise understanding is needed.
- Properties of UFOs are consistent with small objects falling into the beam and becomming vaporized.
- Only one UFO seen in CMS BCM detectors so far.

The CMS UFO

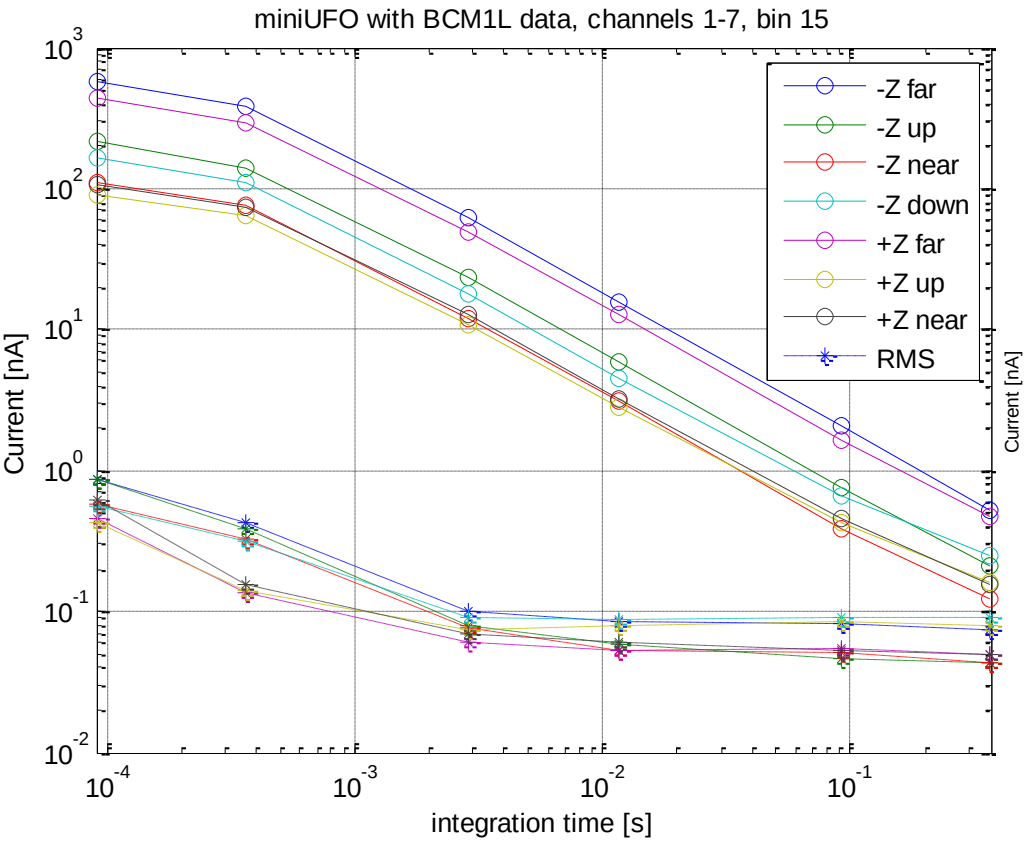
On this plot:

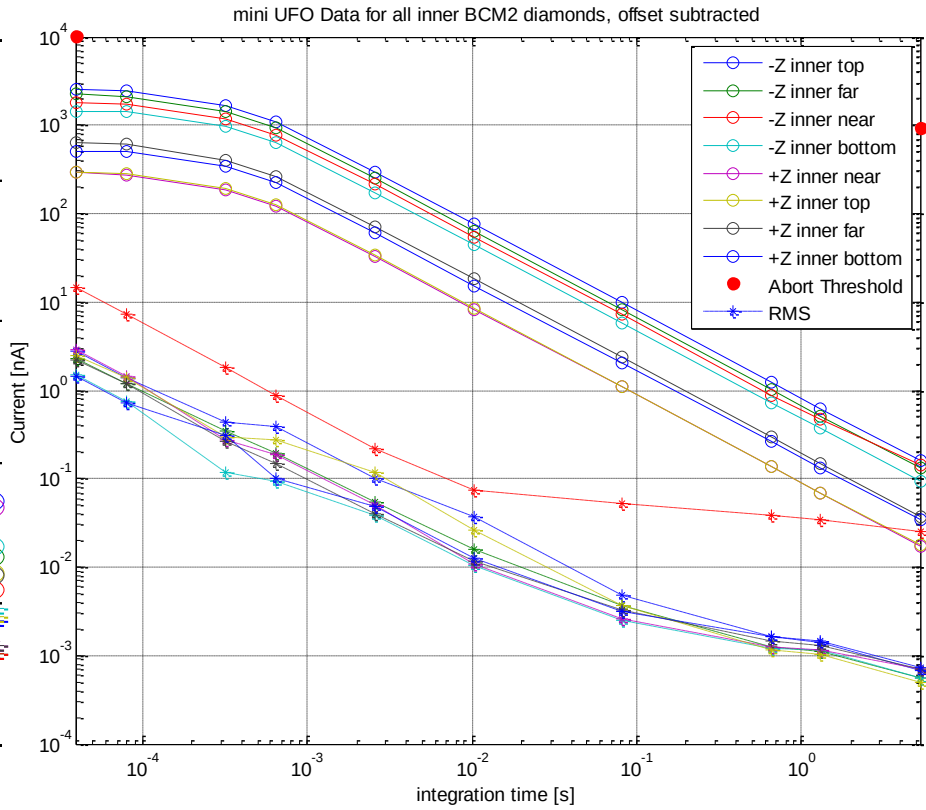
- Signal height and RMS for all inner diamonds @ different Running Sums.
- Offset is subtracted.
- 40 values (1 value/sec) for offset and RMS calculation.



- BCM2 is a transparent extension to the BLM system: Data can be directly compared.
- Event duration ~320µs.
- Reached 25% of abort.
- If there would have been thresholds for RS 3-5 we might have dumped the beam.

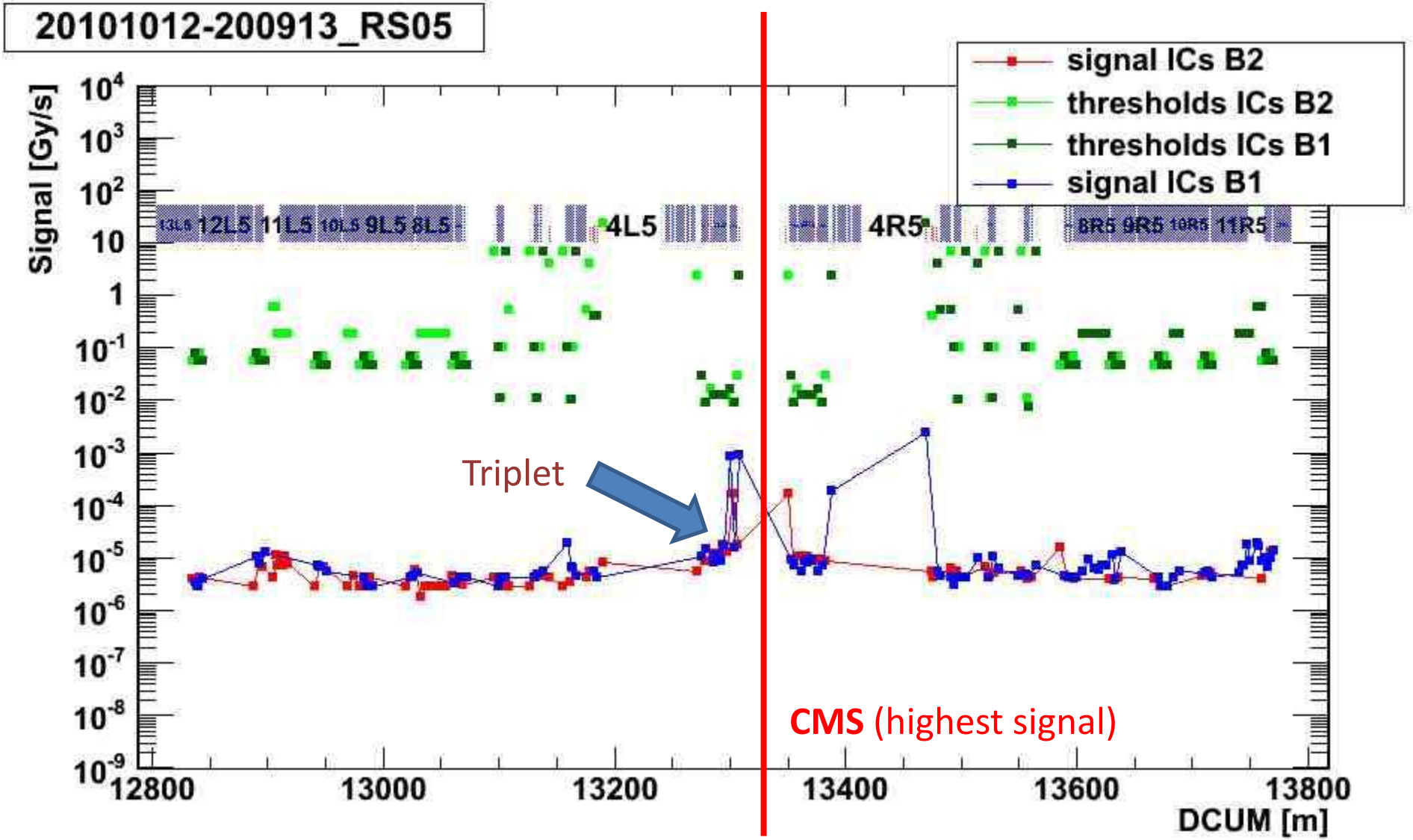
CMS UFO: BCM2 and BCM1L Data





- BCM1L data for bin 15 (sum over whole orbit).
  -> 90µs timescale, not 6µs.
- BCM1L seems capable of registering short events.

BLM Data for the same event.



E. Nebot: Search for “UFO”s, MPP meeting 12.11.2010

Protection so far....

- No conditions so far (for CMS) would have been bad enough to fire ABORT.
- No failures of the system.
- CMS is confident that the BCM protection system is performing correctly.

- There have been 2 events which have had very significant loss rates in CMS during 2010:
- UFO (Fast Loss, 12.Oct.10): 25% of ABORT
- Vacuum bump (Slow Loss, 25.Oct.10): 4% of ABORT

- ABORTS are clean - losses at CMS are very low.
- However, when the collimators at the abort region were not properly setup at the beginning of 2010 (first few days), losses were seen.
- Very important for CMS that the collimators are correctly set.

Protection in the future

- BCM1L will be switched to BCM2 readout during this X-mas shutdown. After commissioning it will play the same role in the abort as BCM2.
- No changes in threshold due to higher luminosity.

Upgrade plans

- BCM2 should not be changed unless necessary. A redesign of the forward region would require changes to BCM2.
- Frontend Readout is maintained by the BLM group. We would have to implement changes as well. Hopefully no spikes any more sometime in the future.
- In case of redesign we would prefer two inner diamond rings instead of inner and outer. Two positions might help to discriminate the background better than a inner/outer relation.
- Analyze all diamond detectors to understand the properties better. See Steffens talk.

Thank You

Further reading:
PhD thesis Steffen Müller: Beam Condition Monitor 2
and the Radiation Environment near CMS at the LHC.

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Wolfgang-Genter-Programme
of the BMBF

Bundesministerium
für Bildung
und Forschung