



# Diamond detectors in the CMS BCM1F

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CARAT 2010  
GSI, 13-15 December 2010

*On behalf of the DESY BCM and CMS BRM groups*

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# Outline:

1. Introduction to the CMS BRM
2. BCM1F:
  - Back-End Hardware and DAQ.
  - Data analysis: ADC, scalers, TDC, studies of Luminosity measurement.
3. Online information
4. BMC1F modules for a LHC Beam Loss Monitor
5. Summary



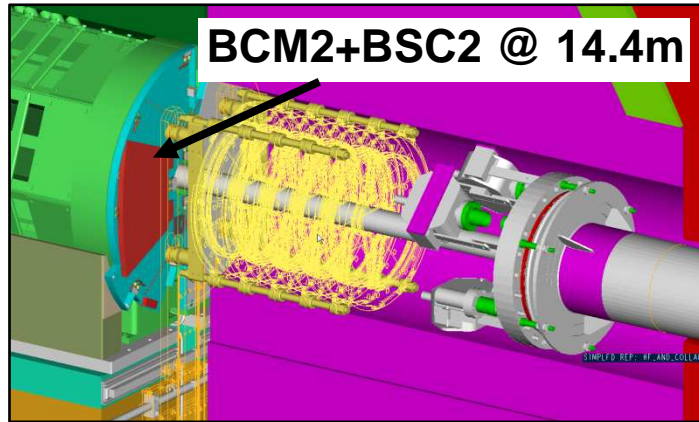
# 1- The CMS Beam conditions and Radiation Monitoring (BRM) system

- It is composed of different subsystems to monitor the beam conditions and radiation field in and around CMS over time scales that range from bunch by bunch to long term monitoring.
  - *BCM2: diamond based current monitor (Beam Abort & BKGD3).*
  - *BSC1 & 2: Beam Scintillator Counters (triggers, rates/time info of bkgd. (BKGD2) and coll. products).*
  - *BPTX: beam pick-up (triggers).*
  - *BCM1F: diamond detector for beam halo and coll. products*
- The purpose is: to provide real-time diagnosis of beam halo conditions and initiate protection procedures in the event of dangerous situations for the CMS detector.

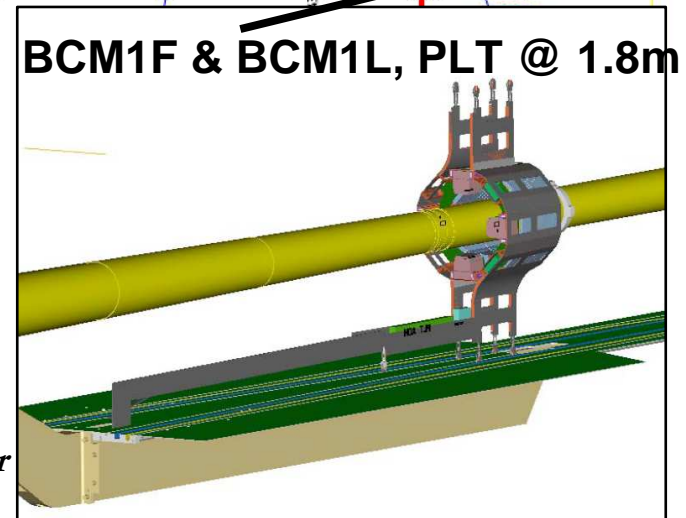
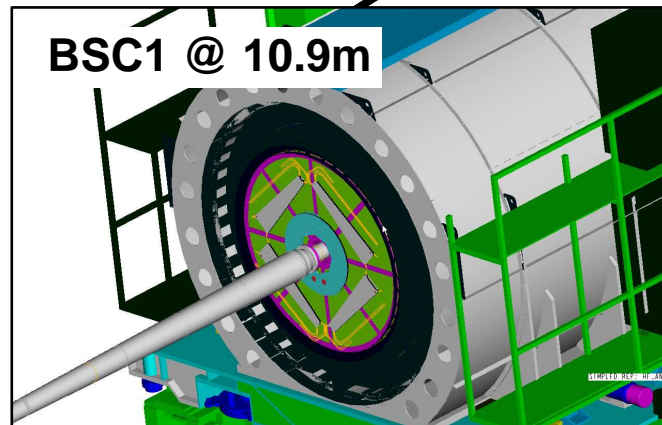
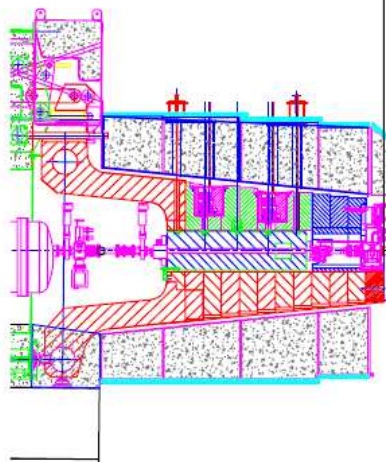
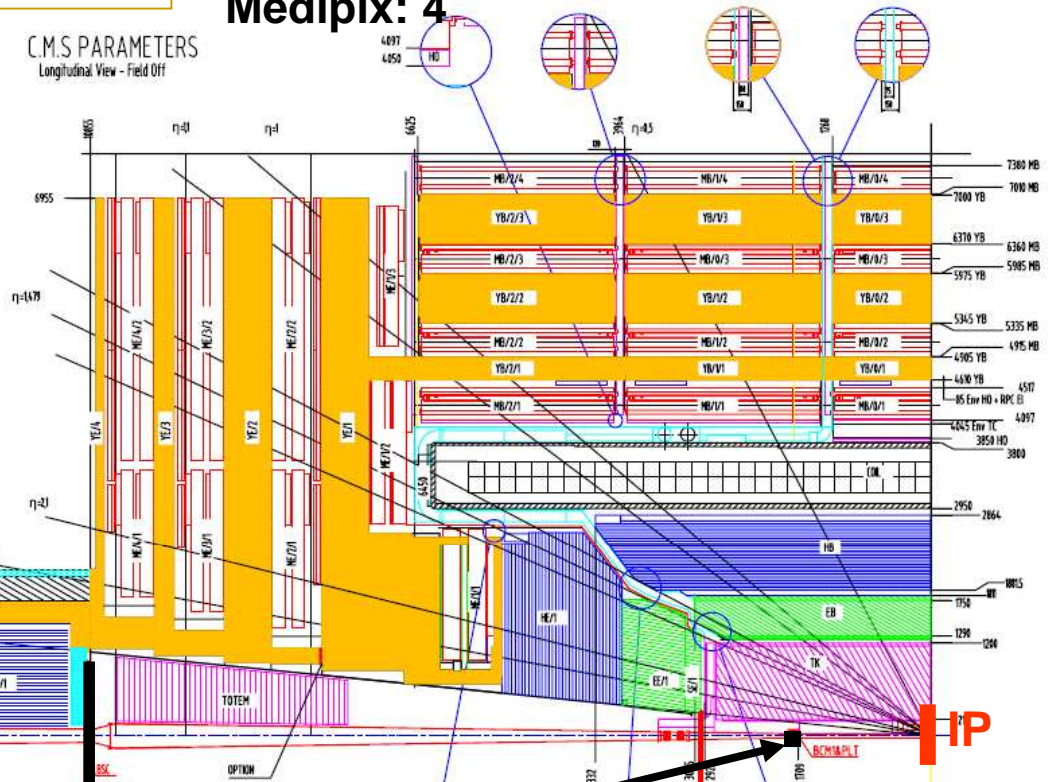


# BRM subsystems in CMS

**RADMON: 18 monitors around UXC**  
**PASSIVES: Everywhere**  
**Medipix: 4**



C.M.S PARAMETERS  
 Longitudinal View - Field Off



←  
**BPTX: 175m**



## 2- BCM1F: Beam Condition Monitor (Fast)

*It is a particle detector with nanosecond time resolution measuring the beam Halo particles and collision products.*

### Tasks:

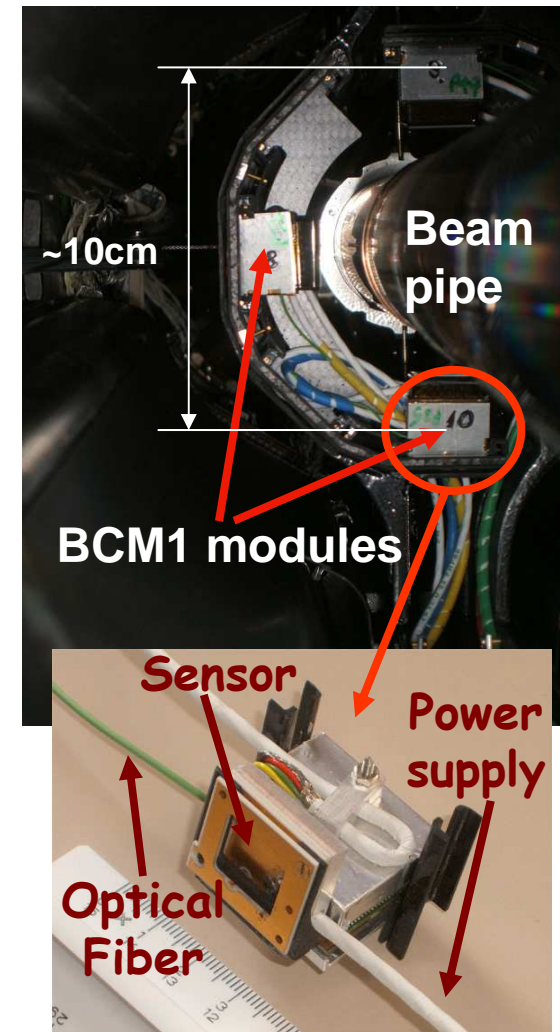
- Monitoring and protection.
- Currently it provides BKGD1 to LHC.

### Requirements:

- Detection of MIPs.
- Low power and radiation hardness.

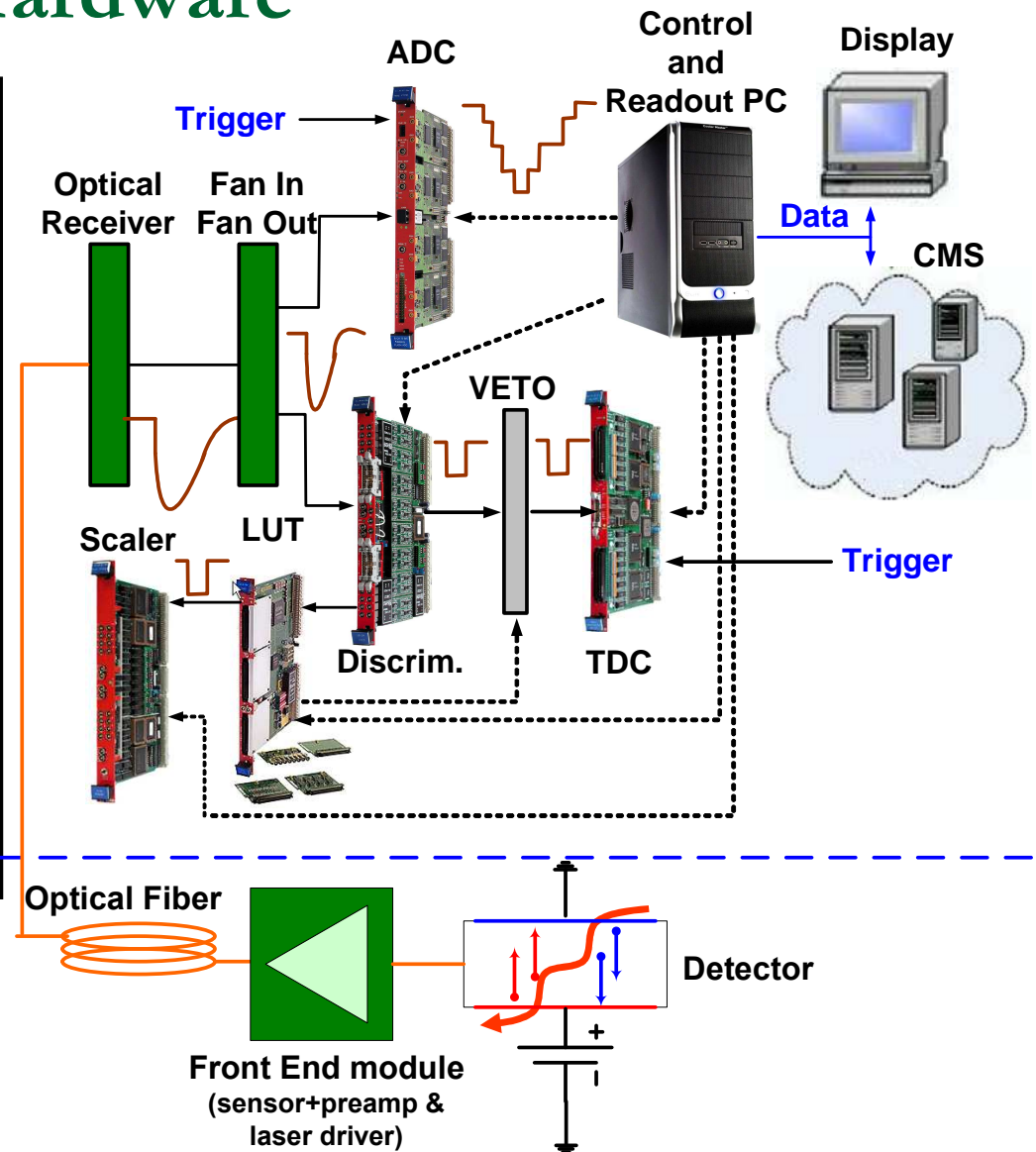
### Design:

- 4 Single Crystal Chemical Vapor Deposition (sCVD) diamond sensors ( $5 \times 5 \times 0.5 \text{ mm}^3$ ).
- 4 modules at  $Z = \pm 1.8 \text{ m}$  ( $\sim 6.25 \text{ ns}$ ) on both sides of the CMS IP,  $r < 5 \text{ cm}$ .



# BCM1F Back-End Hardware

VME DAQ modules		
Device	Task	Features
Scaler	Hit rates/sec	~1 sec latency
ADC	Signal sampling (baseline stability, signal spectra...)	4.5mV/bin 500Ms/sec
TDC	Time info (ToF, Bunch ID)	0.8ns/bin, 10ns double hit resolution ~1sec latency
LUT	coincidences in pair of detectors: collision products, Beam Abort detection, ...	Programmable general purpose board



**ADC: Analog to Digital Converter**

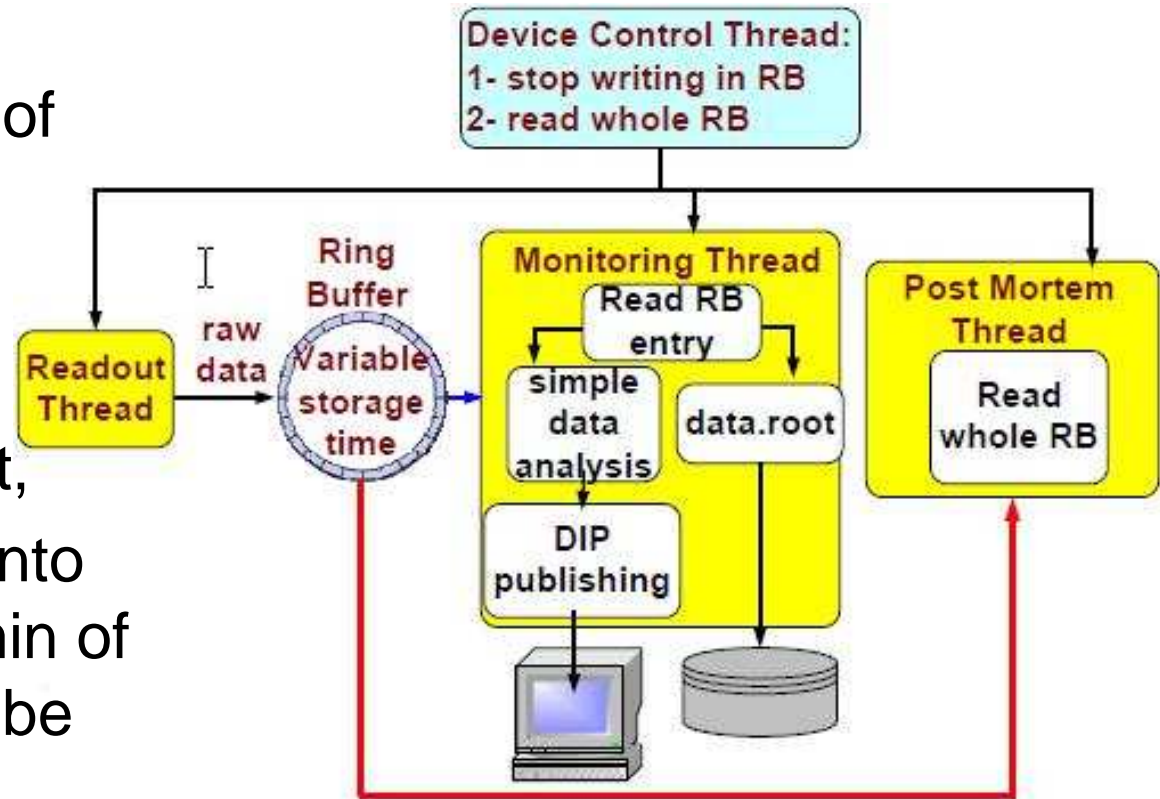
**TDC: Time to Digital Converter**

**LUT: Look-Up Table**



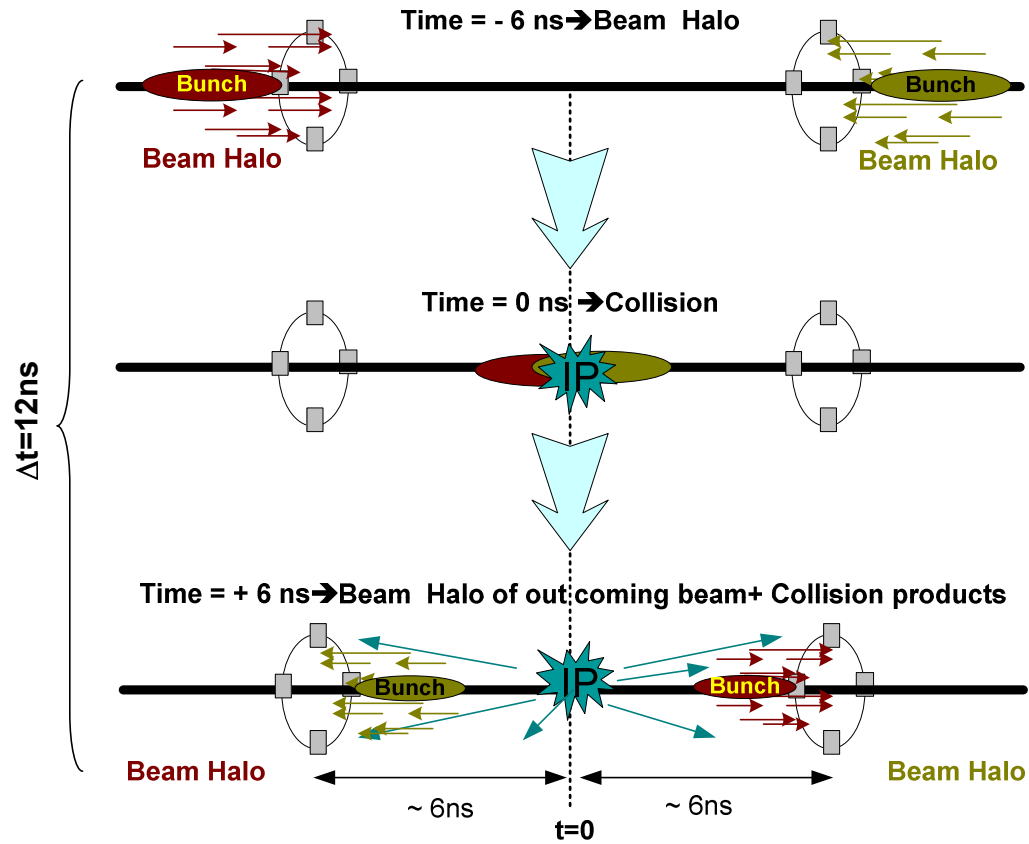
# Ring Buffer

- A software RB will be implemented in each of the DAQ modules.
- In case of beam abort, no more data will go into the RB and the last min of operation of LHC will be retrieved for the Post Mortem analysis.

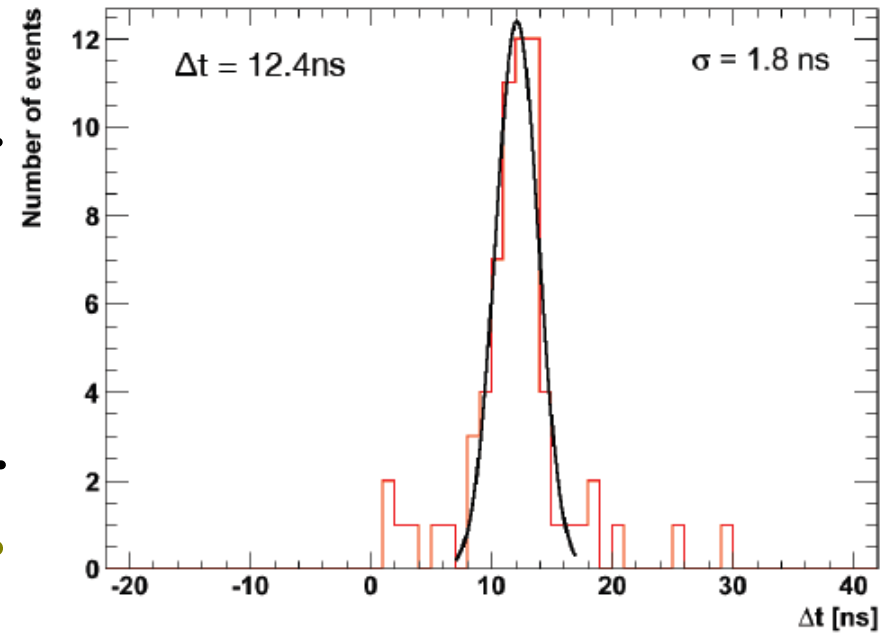


*Scheme of DAQ concept with RB*

# What BCM1F should see...



ToF measured from  
ADC data of beam halo  
(2008 first data with beam)



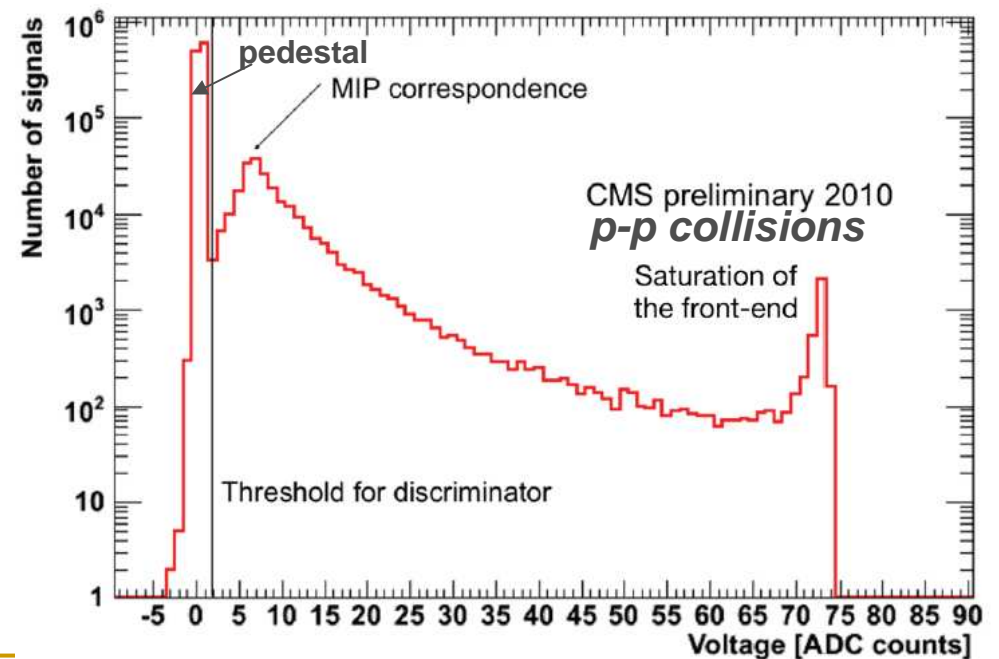
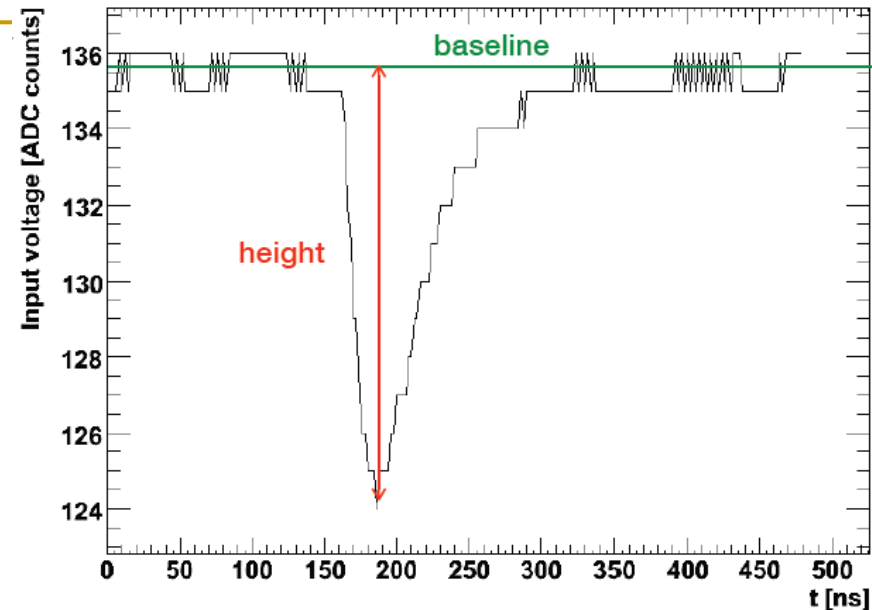
NIM A614,433 (2010)





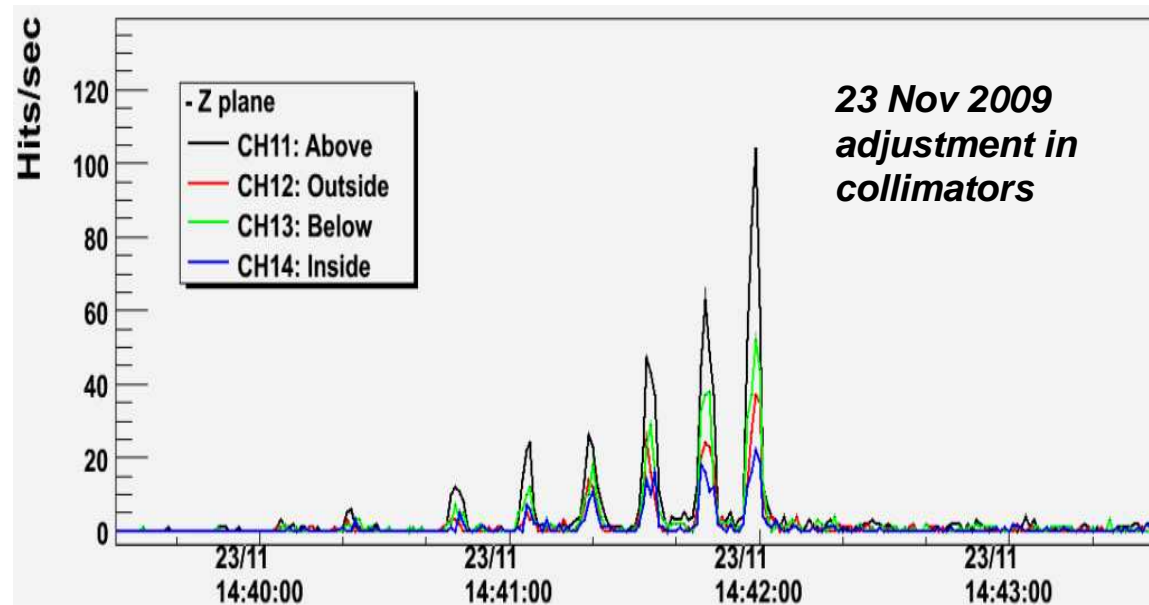
# Signal sampling with the ADC

- Monitoring using the ADC data:
  - Baseline stability
  - Pulse height (radiation damages would cause degradation)
- Provides the  $V_{thr}$  for the discriminators from the signal height spectrum.



## Scalers rates

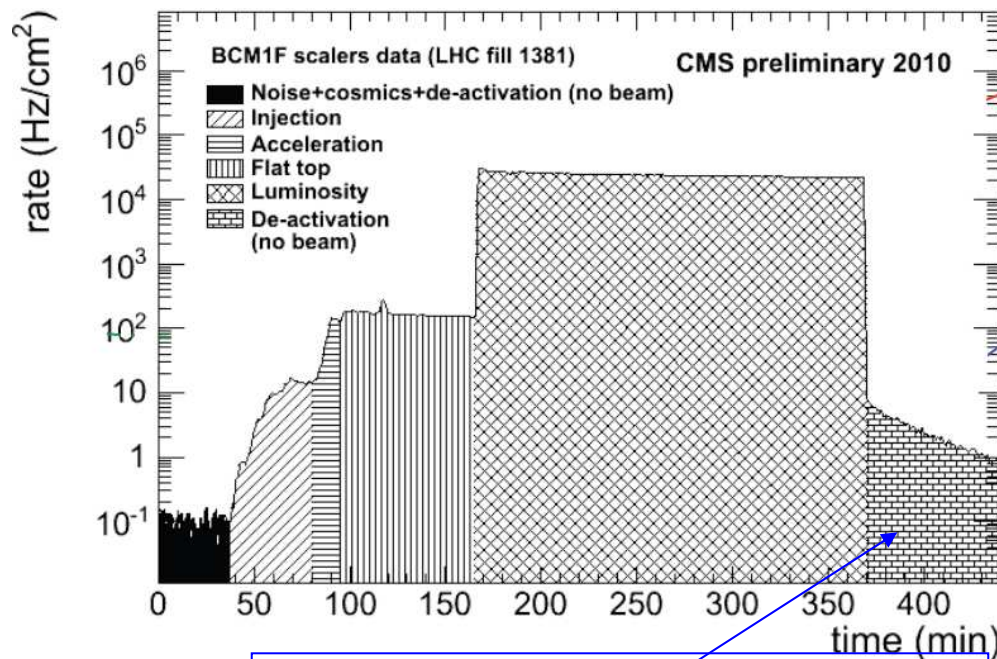
- BCM1F scalers provide count rates and are used as BKGD1 in LHC.
- They are monitored in the control room and account for the high sensitivity of BCM1F to beam halo and collision products.



# BCM1F rates during a fill

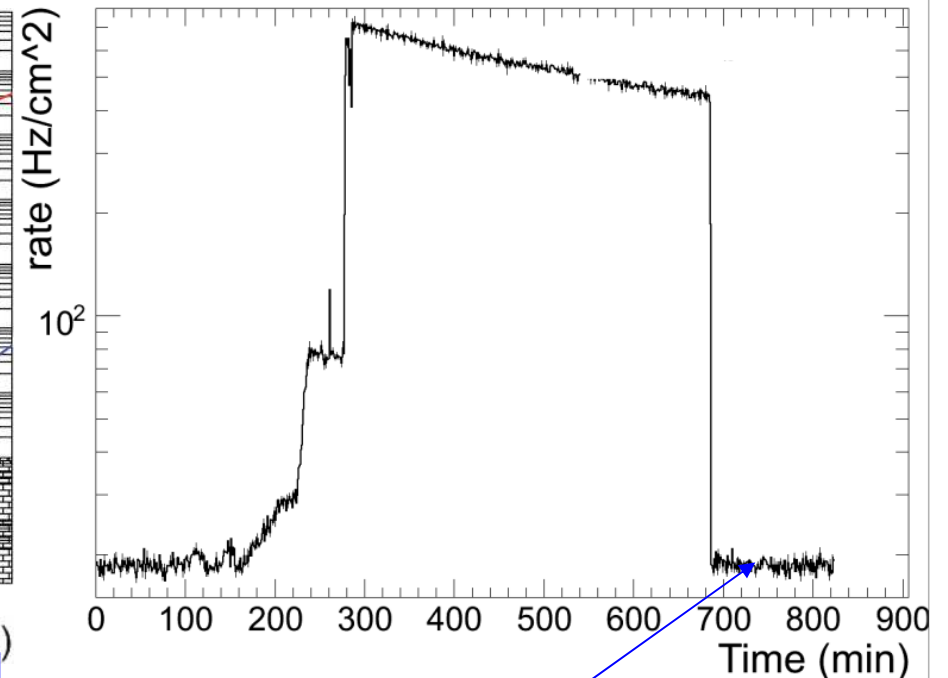
- Performance of BCM1F characterizing the different steps of an LHC fill.

Protons



No beam, possible de-activation of material around BCM1F ( $\tau \sim 34$  min)

Heavy Ions

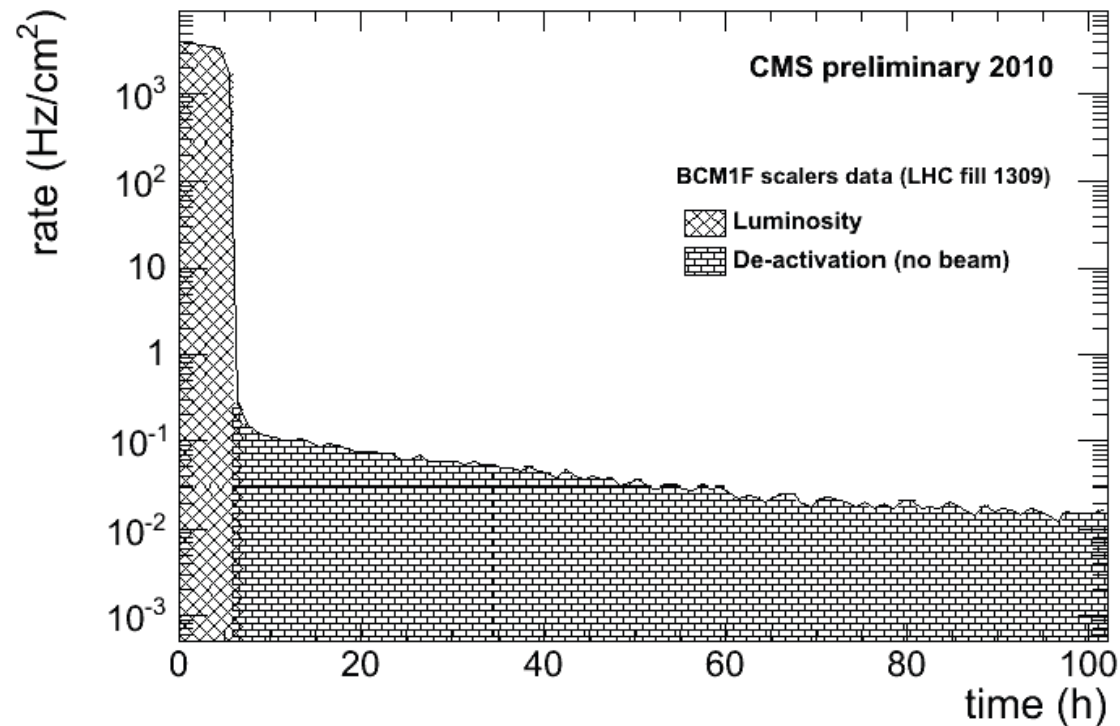


No beam, no obvious de-activation



# Possible de-activation around BCM1F (long time scale)

- During a long period without beams, a slope in the BCM1F rates is observed ( $\tau = 40$  h).
- Possibly due to deactivation of the material around BCM1F.



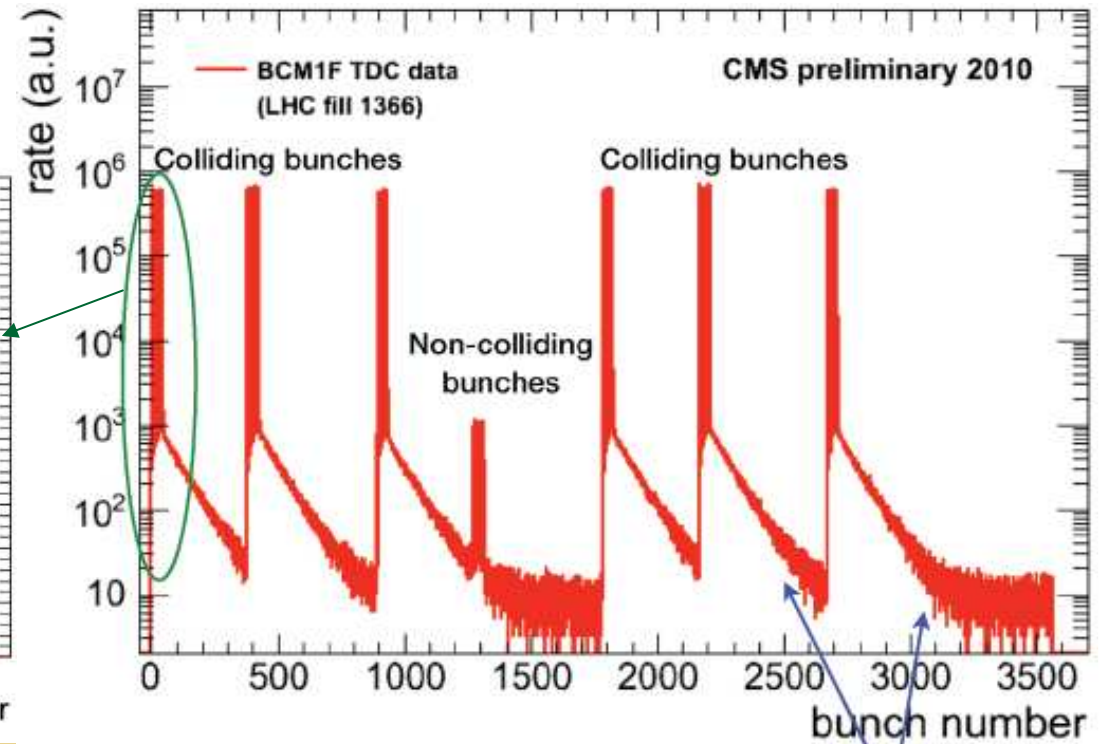
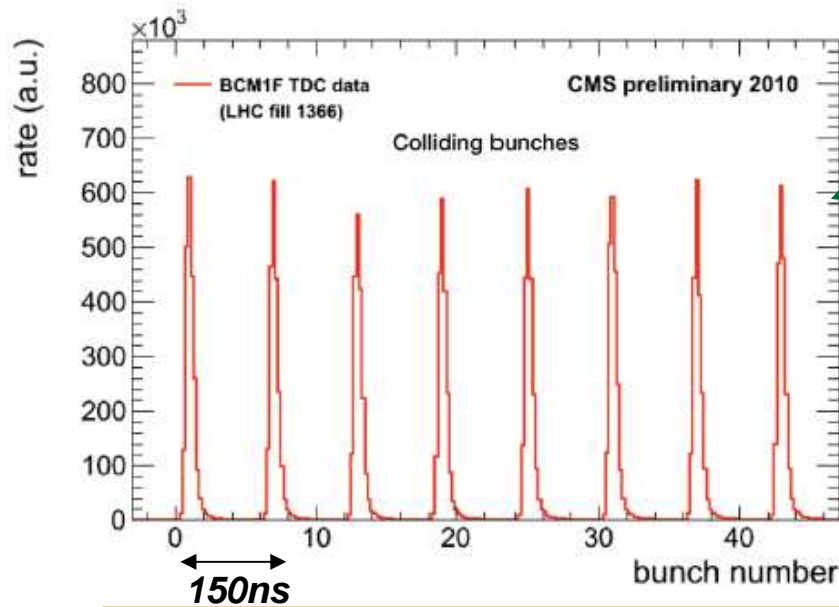
# Analysis of TDC data

The TDCs deliver time information of the beam halo and collision products.

- Bunch identification:** using the the time provided by the TDCs with respect to the orbit trigger is converted into bunch number using the LHC number scheme

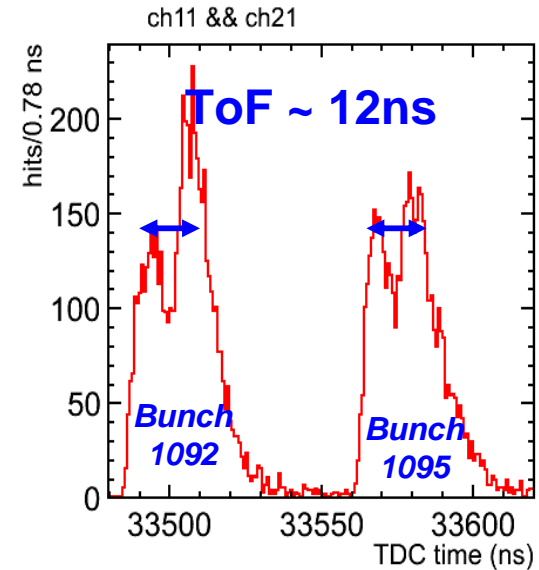
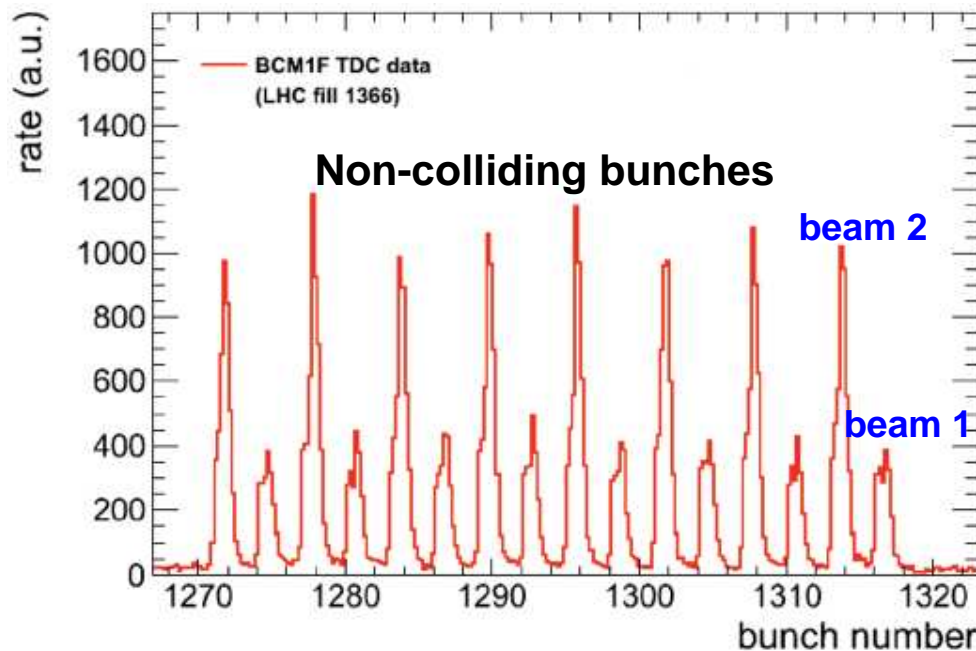
$$BN = \frac{t_{TDC} - 6290}{24.95} + 1$$

(Proton run)



- **ToF** → from non-colliding bunches

- **Bunch by bunch conditions**

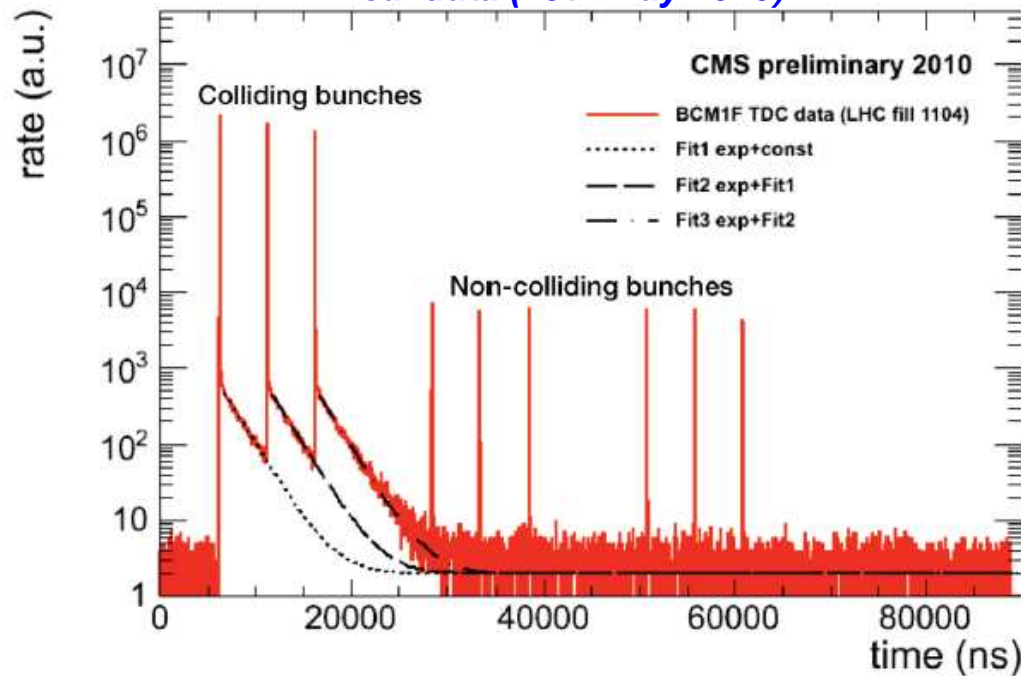


*Reported by LHC operators as an increase in the vacuum pressure on the side where beam 2 enters the CMS detector.*

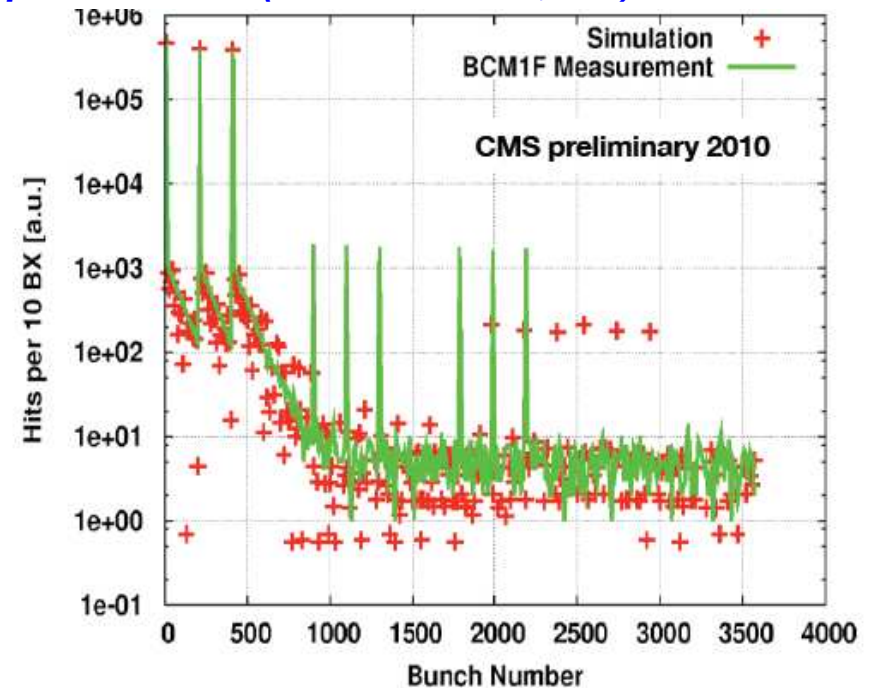
# The Albedo effect

- **p-p collisions** produce long tails, of exponential and constant shapes.
- The long exponential component has a 'lifetime' of  $(2.12 \pm 0.02) \mu\text{s}$ .
- Simulations with FLUKA show good agreement with the data. Tails are mostly populated by electrons and positrons (up to 400 bunch crossing) and by neutrons and photons
- No clear Albedo seen with HI

Real data (15th May 2010)



FLUKA simulation of bunch crossings at 7 TeV pp interactions (Steffen Mueller, KIT)



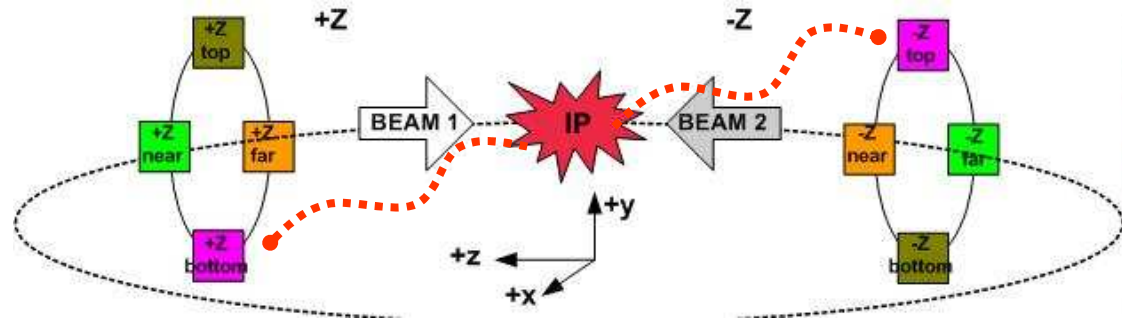
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# Supplementary CMS Luminosity monitoring

- Can BCM1F account for collision products? → *the LUT was programmed to detect coincidences in pairs of back-to-back detectors*

*Coincidences scheme in LUT*

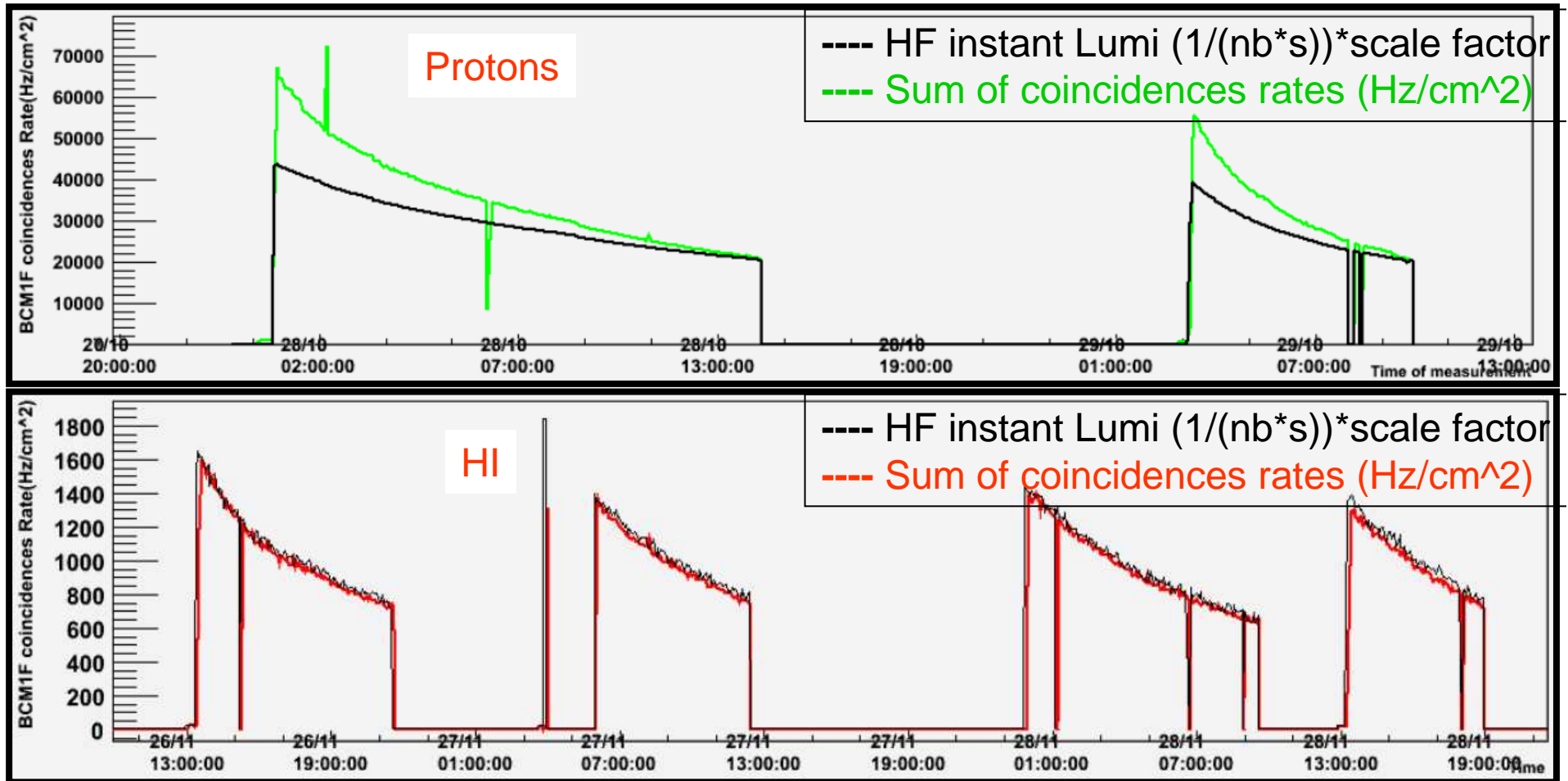


## Luminosity estimation: correlation with HF

- In CMS, the Luminosity is provided by HF in sections of 23.3 sec.
- We integrate the coincidences over several Lumi sections and scale HF Lumi.



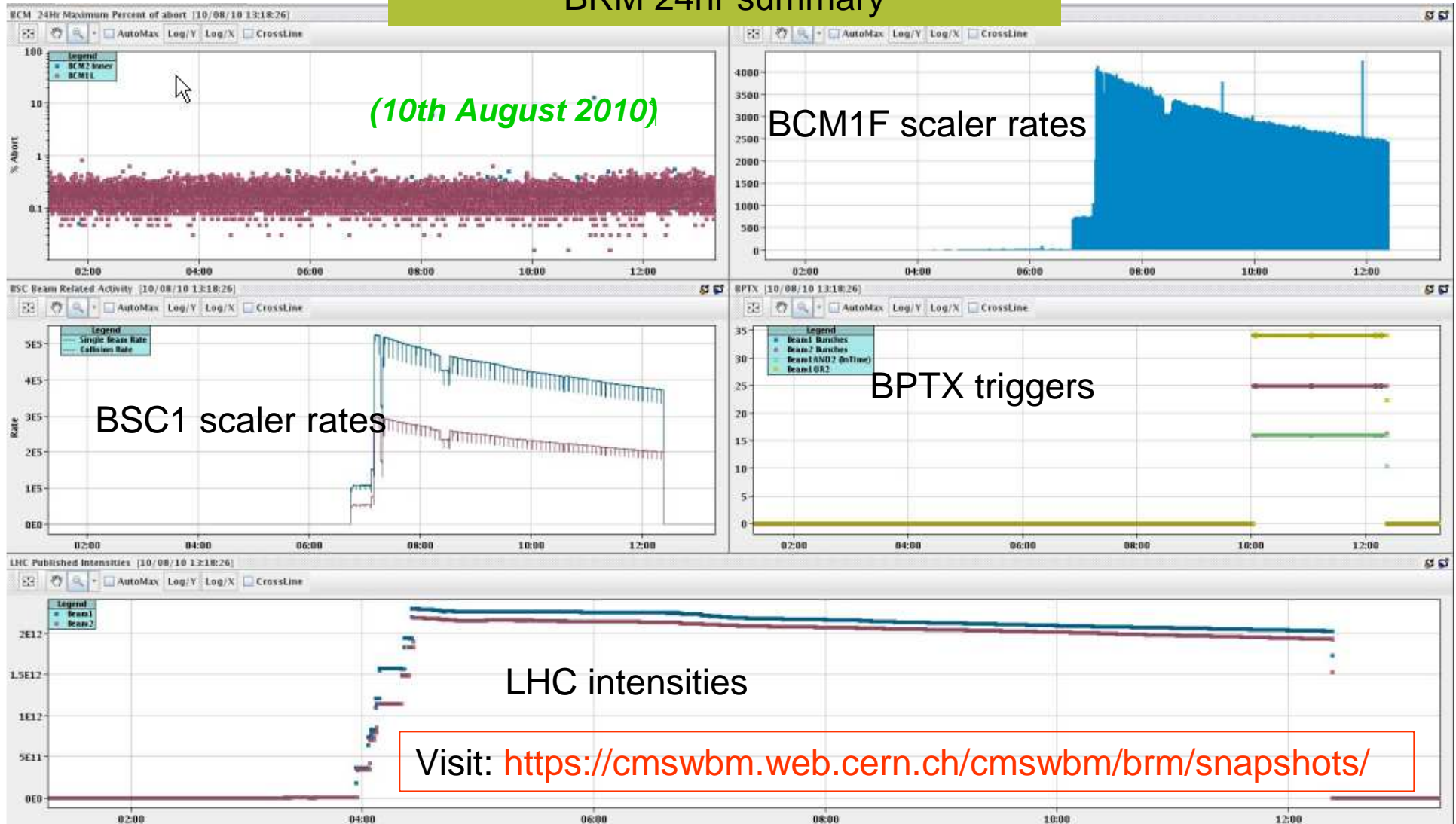
- **Proton runs:** BCM1F registers higher rates at the beginning of collisions. This effect needs further study.
- **HI runs:** HF instant Lumi and BCM1F coincidences rates show a good correlation. Agreement is promising....



# 3- Online information:

## BRM 24hr summary

(10th August 2010)

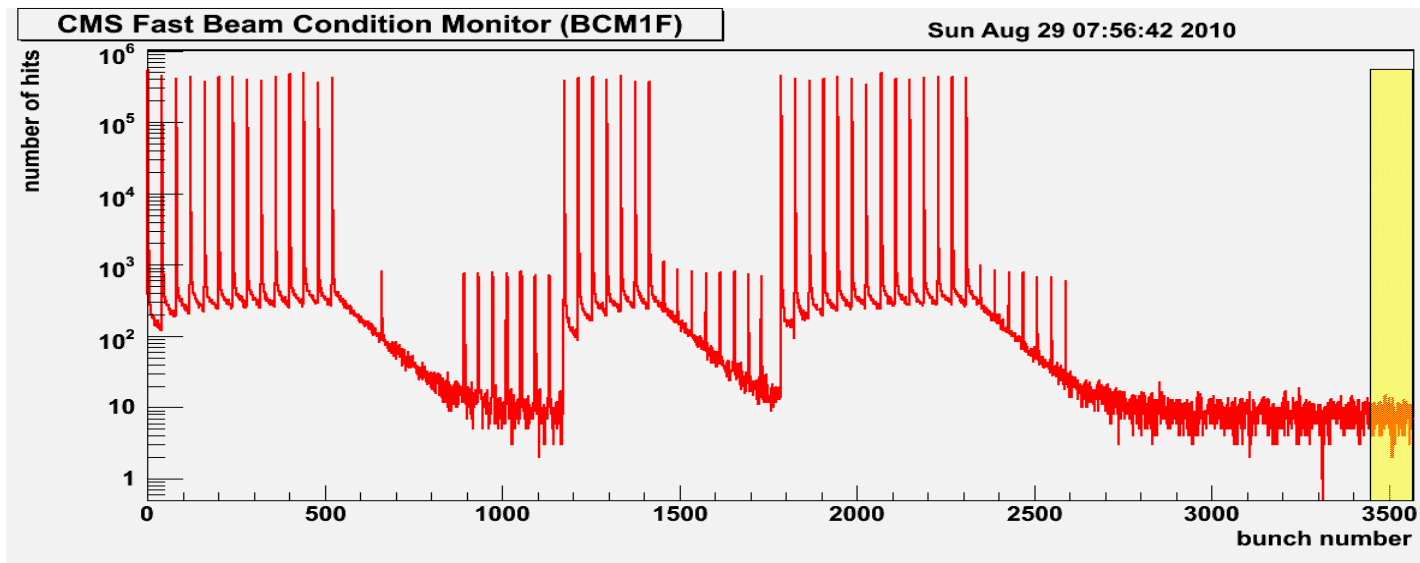


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## LHC bunch structure



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## 4- BMC1F modules for a LHC Beam Loss Monitor

- BCM1F is considered by the LHC Beam Instrumentation group as being useful as a beam loss monitor for LHC at several positions around the orbit
  
- 8 additional channels using new diamonds and spare parts of the FE will be delivered to LHC in 2010.



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## 5- Summary

- The CMS Fast Beam Conditions Monitor (BCM1F) is presenting an excellent performance and producing very interesting and important results.
- It has shown to be an essential tool for beam conditions monitoring in CMS.
- Preliminary studies are very encouraging to use BCM1F also as a luminosity monitor for CMS.
- LHC has shown interest in our detectors and some modules will be assembled for Beam Loss monitoring.

Thank you!

