Machine Induced Background Monitoring with BCM1F

Diamond Based Monitor for Background and Luminosity

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BRIL Beam Radiation Instrumentation and Luminosity

DESY

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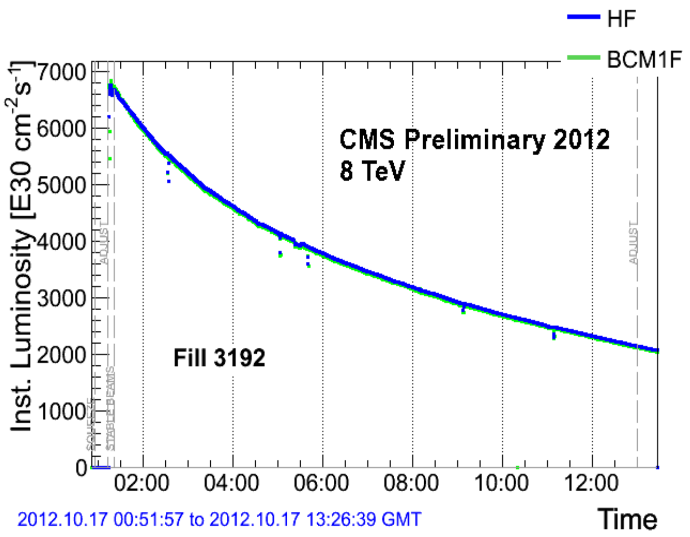
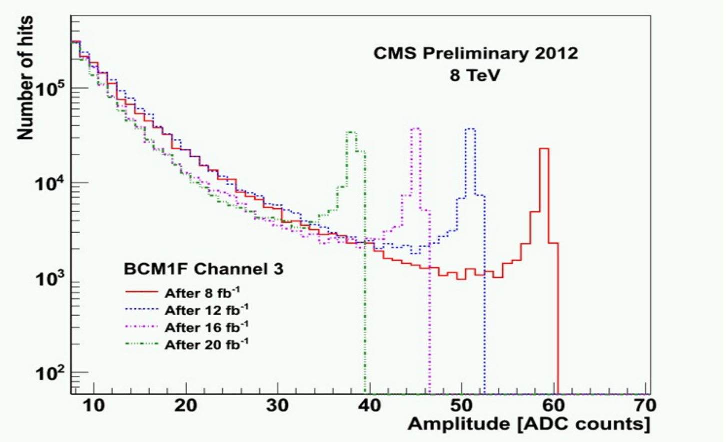
  - Higher luminosity
  - Smaller bunch spacing (50ns → 25ns) and shaping time of 25ns of the old FE
  - Radiation damage of diamond sensors
  - Radiation damage of optical hybrids
  - Signals from heavy ions (material activation) causing overshoots and inefficiencies

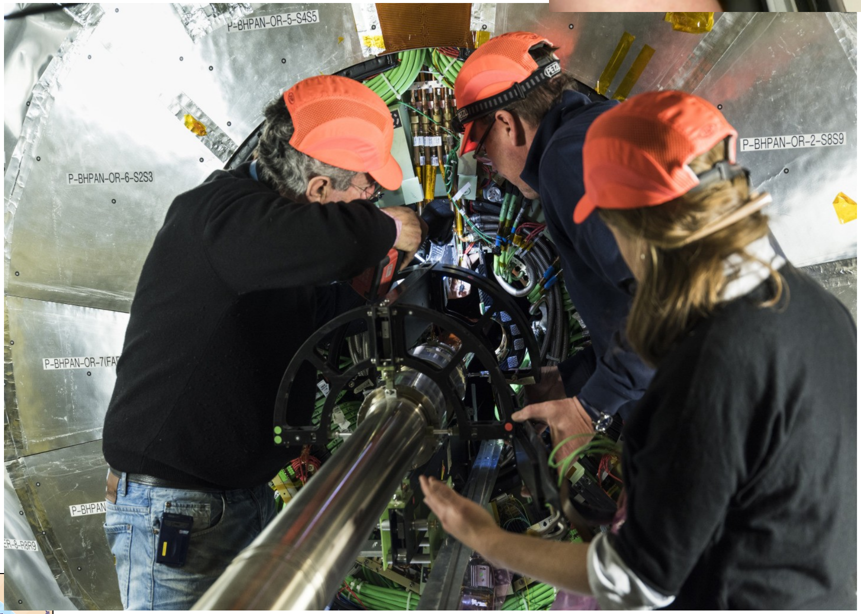


Decrease of dynamic range



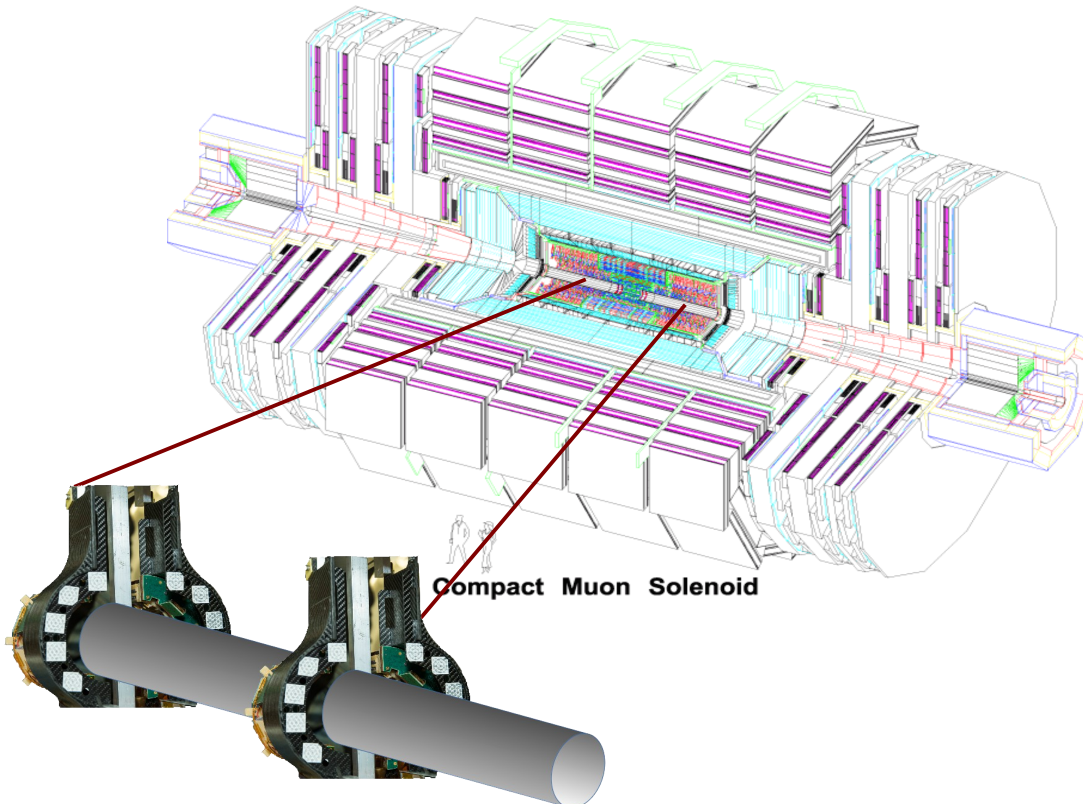
BCM1F Installation

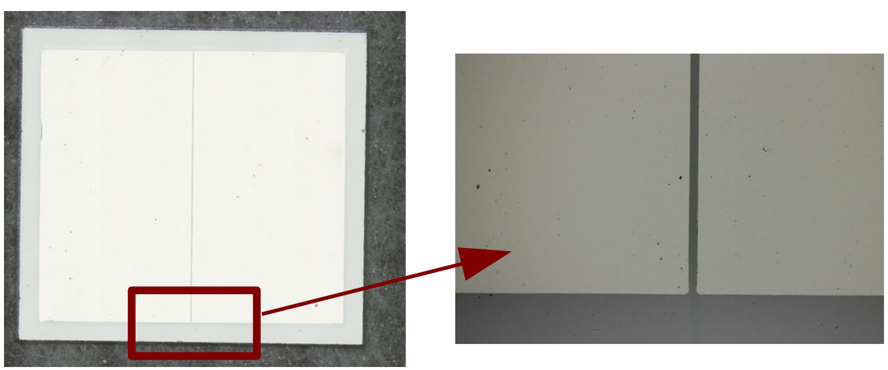
> Successful installation of upgraded BCM1F in spring 2015

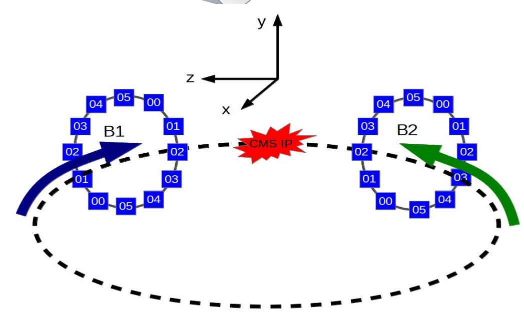


BCM1F Overview

- Inside the CMS detector
  - 1.8m away from interaction point
  - 6.9cm from beam axes
- 12 sCVD diamond sensor on each end of CMS
  - Two pad metallization
  - Reduction of signal occupancy

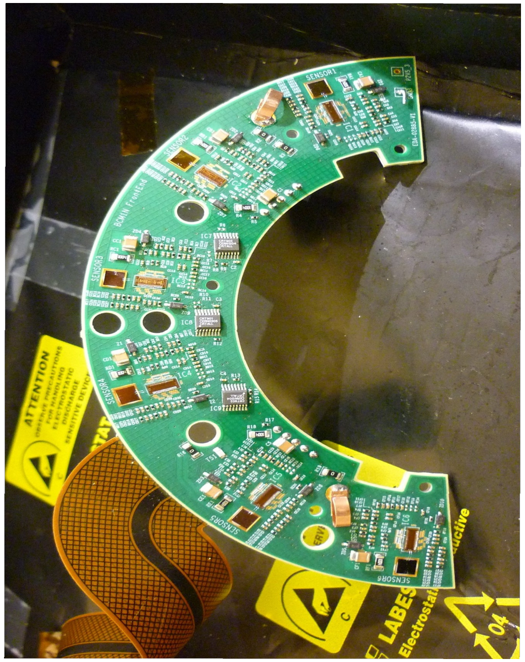


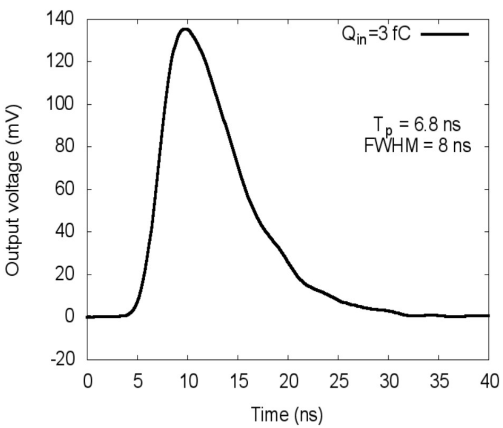




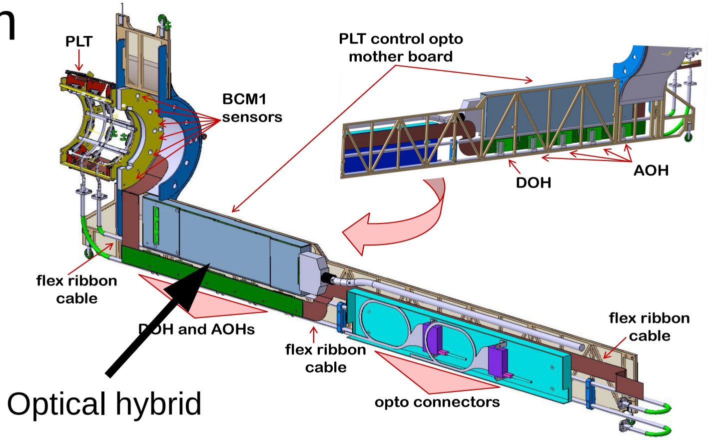
BCM1F Overview

- Sensor together with amplifier are placed on a C-Shape
  - Dedicated FE-ASIC on commercial 130nm CMOS technology
  - Signal conversion of 50mV/fC
  - FWHM of less than 10ns
- Electrical signals is converted to optical signal
  - Optical hybrids are placed further away from beam pipe (reduction of radiation damage)
- Optical signals are sent to the counting room



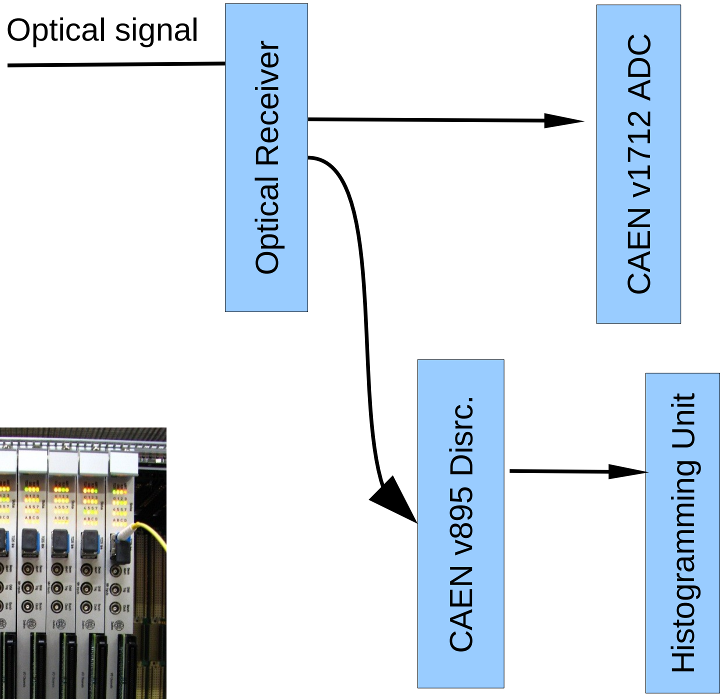


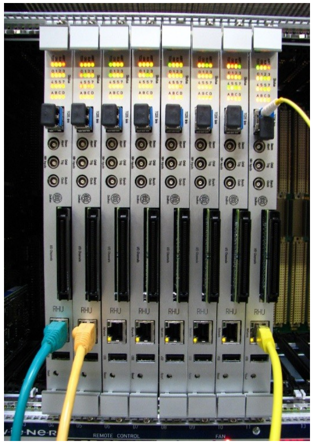
Timing test for FE-ASIC with MIP-Like signal

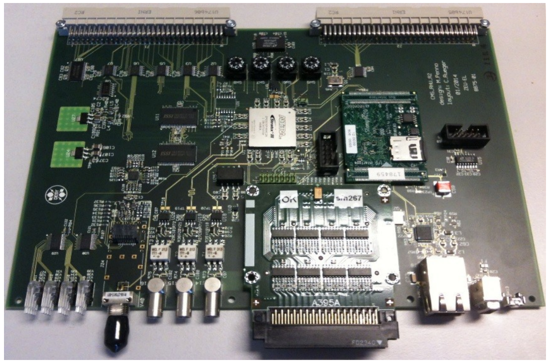


BCM1F Overview

- Optical signals are converted to el. Signal
  - Opto receiver module
- CAEN v1712 ADC
  - Signal sampling (talk O. Karacheban)
  - Additional uTCA will be used (talk M. Guthoff)
- CAEN v895 Discriminator
  - Blocking small signals (noise)
- Realtime Histgramming Unit RHU
  - Produced in DESY Zeuthen
  - Dead time free
  - 6.25ns time resolution
  - Bunch-by-bunch measurements
  - Histogramming arrival time of signals within one LHC orbit

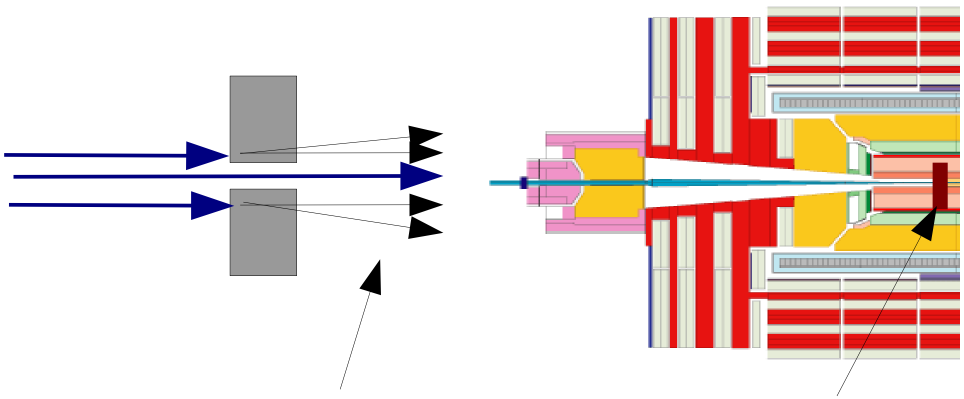






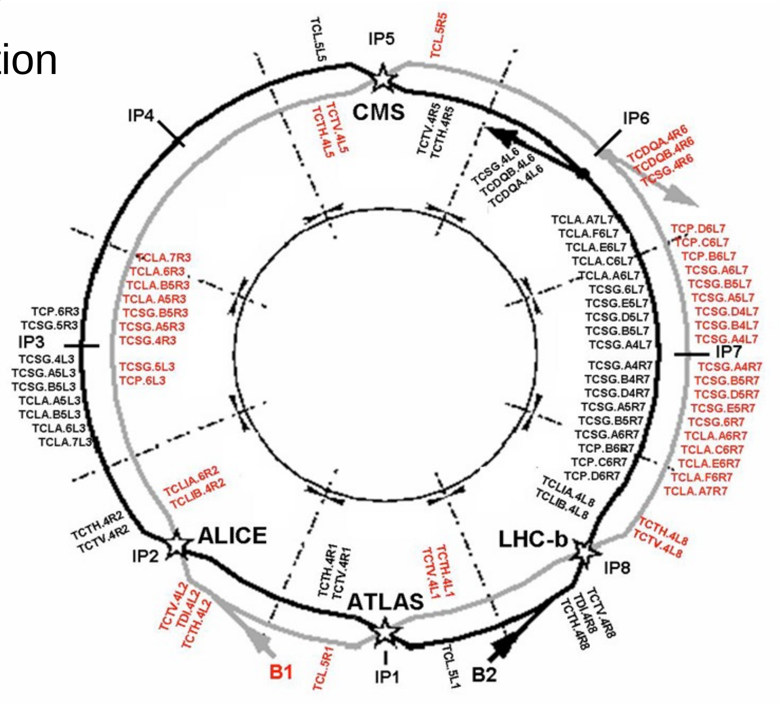
Machine Induced Background

- Beam losses coming with a bunch
- Bunch particles interact with residual gas particles
- Deviated bunch particles interact with collimators
  - Interception of high energetic beam losses
  - Protection in case of adverse beam condition



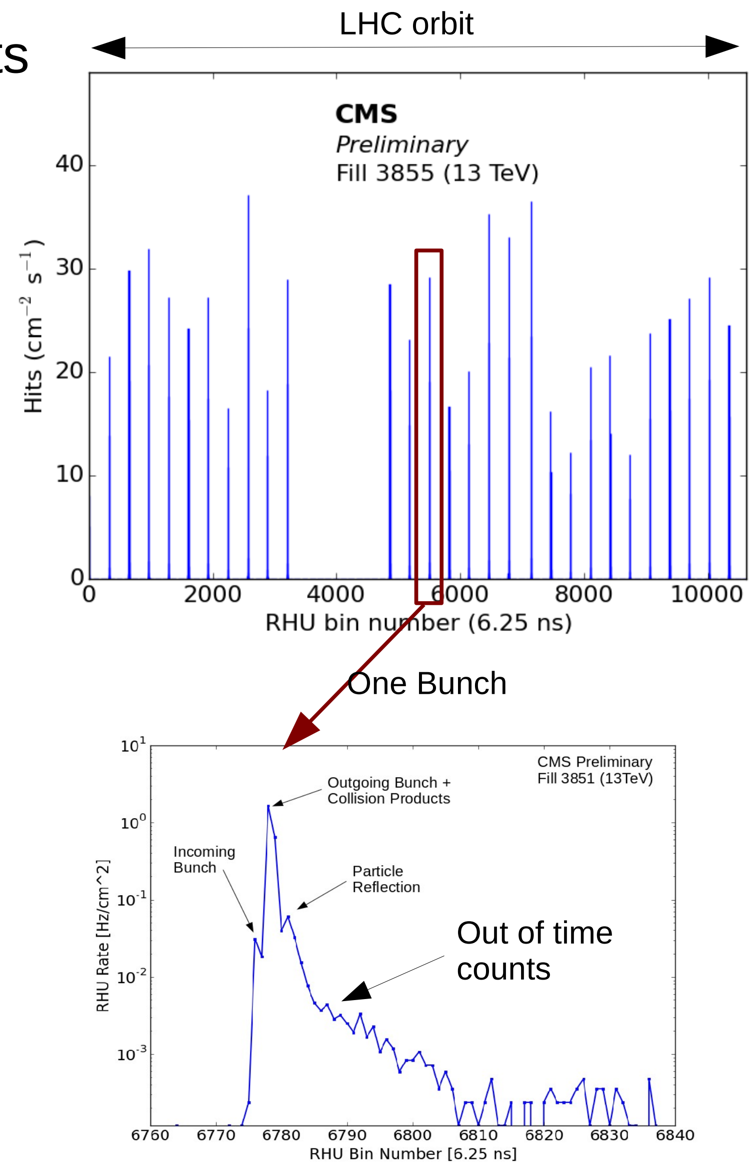
Secondary particles

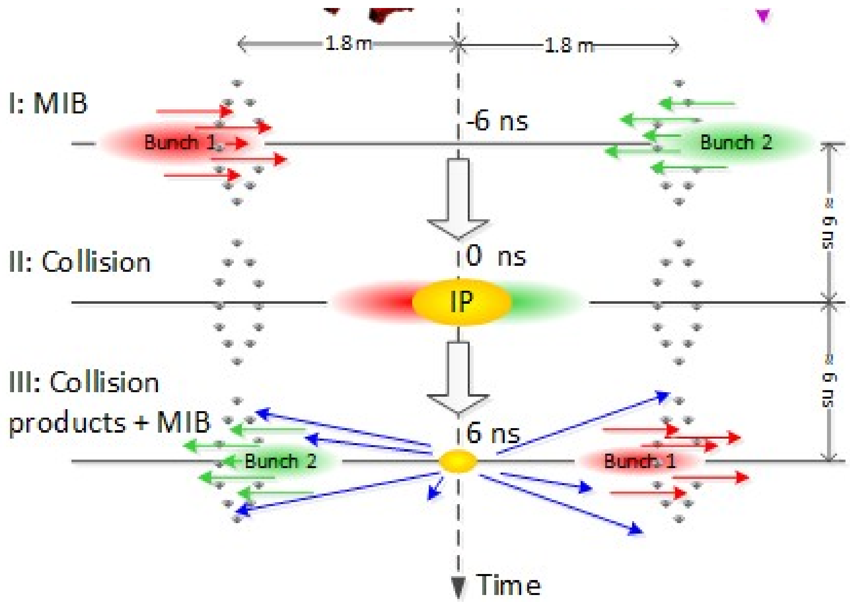
BCM1F



Data Analysis

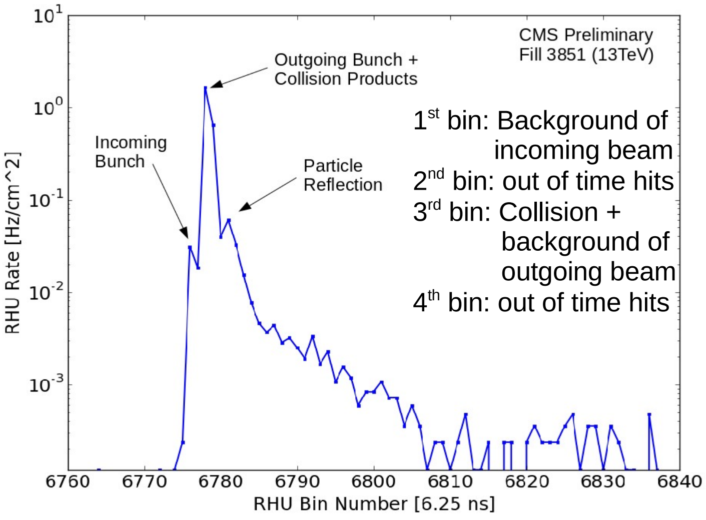
- RHU integrates count over 4096 LHC orbits
  - Binning of 6.25ns
- Bunch spacing 25ns
  - 4 bins per bunch
- Separation of background and collision products

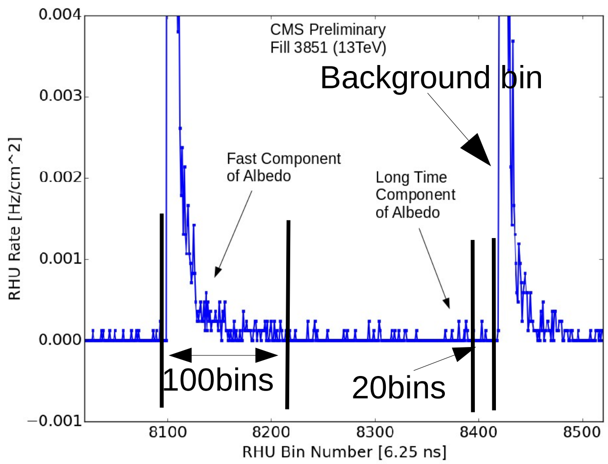




Data Analysis

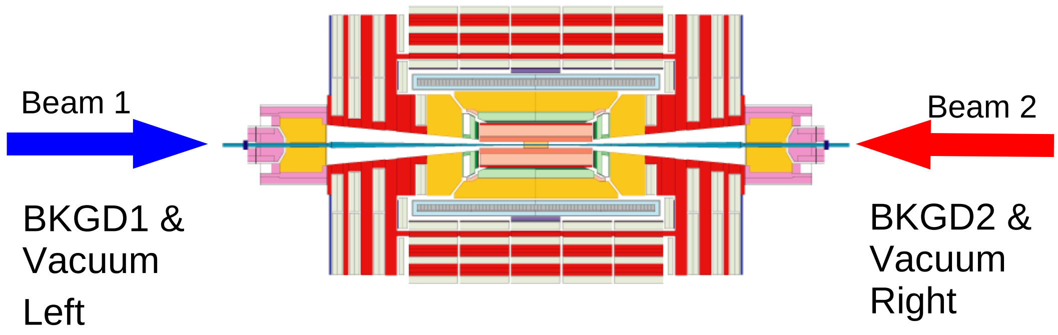
- 1st bin is used for background calculations
  - Criteria: only if the previous 120 bins (30bunchses) are without collision
- Avoiding fast out of time hits in background
  - Up to 100bins(25bunches) after collision
- Subtracting long time out of time hits
  - 20bins (5bunches) right before background bin
  - Using the 2nd and 4th bin of bunches
- Normalizing by bunch current and conversion to count rate per cm^2 per s

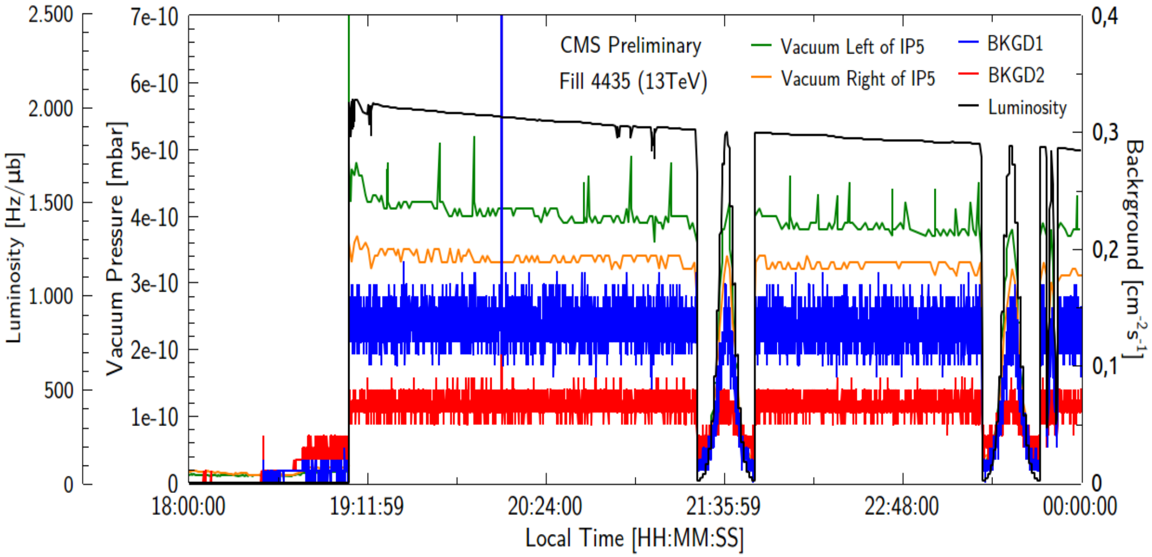




Machine Induced Background during LHC Collision

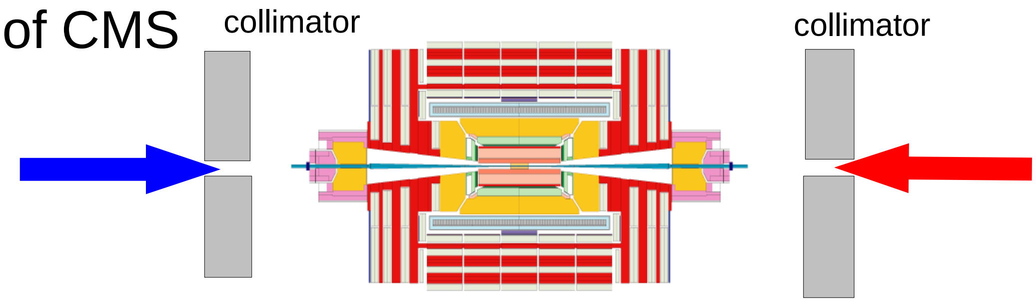
- BKGD1 corresponds to beam 1(incoming on left side of CMS)
- BKGD2 corresponds to beam 2 (incoming on right side of CMS)
- Background follows the vacuum pressure
  - Beam losses interact with residual gas particles
- Increase of vacuum and background while start of collision
  - Collision products leading to outgasing
  - Increase of vacuum pressure





Machine Induced Background during LHC Tests

> Collimators located on each side of CMS
  - Absorb luminosity debris
  - Prevent CMS from high energetic beam losses

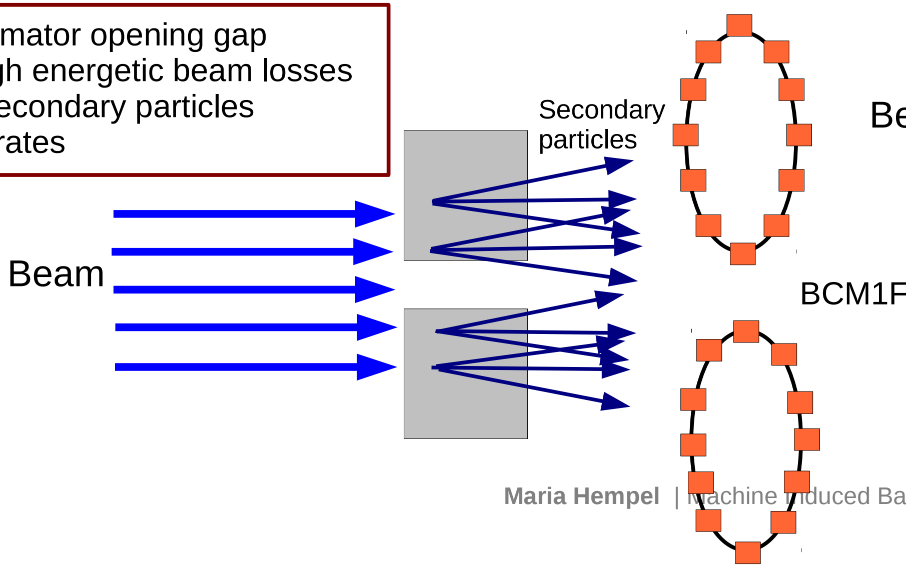


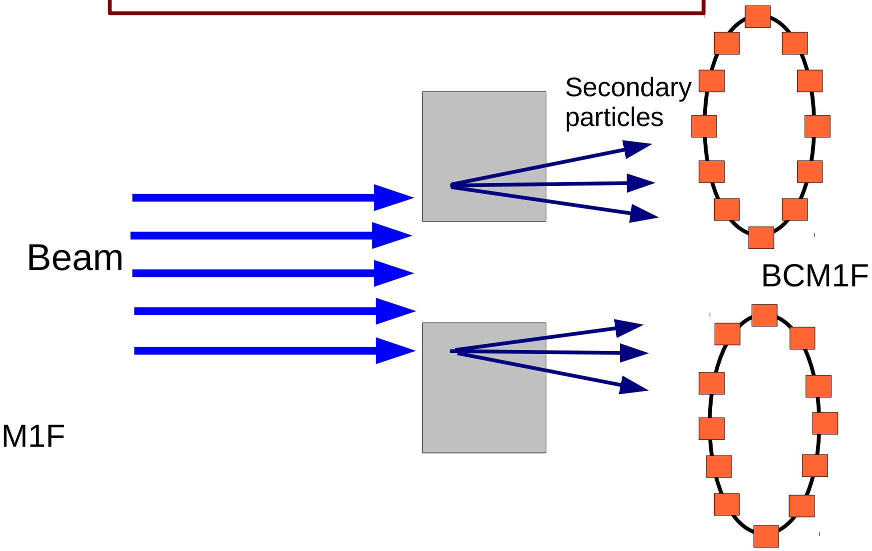
> Excitation of beams for different collimator opening gaps
  - Provoking beam losses

High collimator opening gap
→ more high energetic beam losses
→ less secondary particles
→ less rates

> Correlation between collimator settings and background

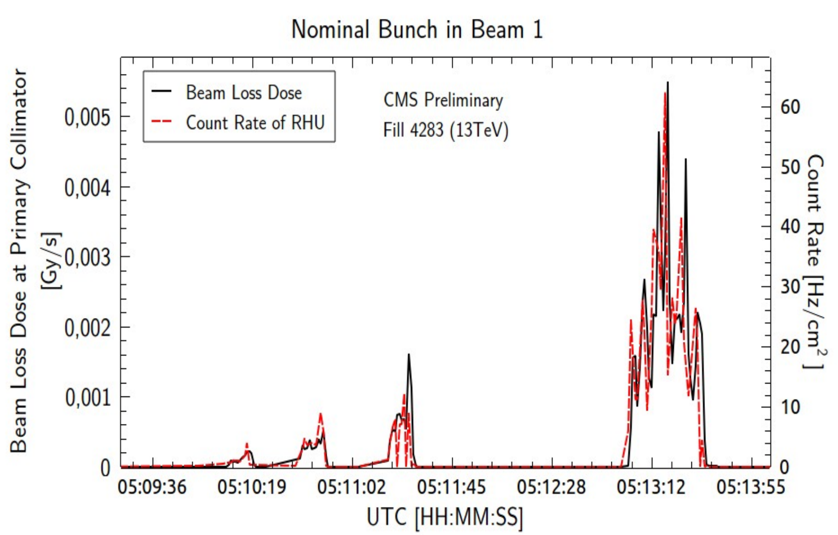
Small collimator opening gap
→ less high energetic beam losses
→ more secondary particles
→ higher rates

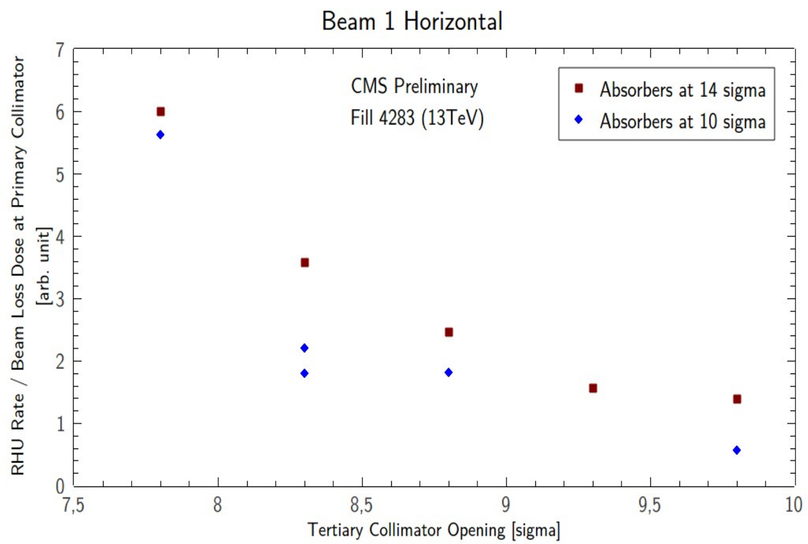




Machine Induced Background during LHC Tests

- Correlation between LHC beam loss monitor (ionization chamber) and RHU count rate (BCM1F)
- Decrease of RHU rates with higher collimator opening gap as expected
- RHU measured background correlates with collimator settings





Summary

- Delivers valuable information to CMS and LHC control room
  - Luminosity
  - Machine induced background
- Successful installation of the upgraded BCM1F detector in spring 2015
- Background rates of BCM1F are sensitive to vacuum pressure and independent of collision rate
- Background rates of BCM1F are sensitive to collimator settings

Thank you

Thank you for organizing this workshop!

Thank you to the CMS BRIL group, DESY and its workshop, GSI, Princeton and all other people I forgot to list!

Backup

> Heavy ion signal