Machine Induced Background Monitoring with BCM1F

Diamond Based Monitor for Background and Luminosity

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Table of Content

> BCM1F Upgrade and Installation
> BCM1F Overview
> Machine Induced Background
> Data Analysis
> Machine Induced Background during LHC Collision
> Machine Induced Background during LHC Tests
BCM1F Upgrade

> Diamond based particle detector with ns time resolution
  - Machine Induced Background
  - Luminosity

> Providing successful data to CMS and LHC control room

> Motivation of BCM1F upgrade
  - 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
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
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

> 1\textsuperscript{st} bin is used for background calculations
  - Criteria: only if the previous 120 bins (30 bunches) are without collision

> Avoiding fast out of time hits in background
  - Up to 100 bins (25 bunches) after collision

> Subtracting long time out of time hits
  - 20 bins (5 bunches) right before background bin
  - Using the 2\textsuperscript{nd} and 4\textsuperscript{th} 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
> 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

> Correlation between collimator settings and background

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

High collimator opening gap
→ more high energetic beam losses
→ less secondary particles
→ less 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 for organizing this workshop!

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Heavy ion signal