The BGV team


…and significant support by LHCb collaboration & BE-BI community
Outline

• The BGV Demonstrator
  • Detector Design
  • Readout System

• BGV Data Analysis
  • Analysis Method
  • Results from 2016 LHC Run

• Summary
The BGV Demonstrator

• Non-destructive beam size measurement
  • Based on the reconstruction of beam-gas interaction vertices
  • Independent of accelerator intensity or energy
  • Target to estimate bunch-by-bunch beam size with a resolution of about 10% in 5 minutes
The BGV Demonstrator
Detector Design

• Tracking Detector
  • Consists of 2 stations (‘near’ and ‘far’)
  • 4 scintillating fiber (SciFi) modules per station
    • Each pair of modules is perpendicularly placed
    • Module read out by 16 Silicon Photo Multipliers (SiPMs) of 128 channels each
Detector Design

• Tracking Detector
  • Photons are generated in the fibers & detected by several pixels of the SiPM
  • The signal of each channel is the sum of all fired pixels within the channel
  • The crossing point is calculated as a weighted mean of the cluster’s channels
Detector Design

- Hardware Trigger
  - Based on scintillator plates
  - Three stations, ‘veto’, ‘signal’, ‘confirm’
    - ‘confirm’ station to be commissioned during LHC 2017 run
  - Read out through Photomultiplier Tubes (PMT)
  - Combination of all signals is used as trigger
Readout System

LHC Tunnel

Hardware Trigger

Analog Front-End
[40MHz]

LHC Alcove

Digitization
- Data corrections
- Zero-suppression
- Cluster recognition

CPU Farm
- Track reconstruction
- Vertex localization
- Beam size determination

60m

Hardware Trigger

Analog Front-End
[40MHz]

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[1MHz]
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BGV Data analysis

• Triggering issues
  • In 2016 the majority of the events did not contain any “reconstructible” tracks
  • Reduced statistics
  • The distribution of the points of closest approach to the z-axis for the reconstructed tracks matched the simulation
Analysis Method

- **Impact parameter** $d_{xy}$
  - Distance of closest approach of reconstructed tracks to the z-axis

- **Azimuthal angle** $\phi$
  - Angle between the x-y projection of the track & the x-axis

Use tracks & impact parameter correlations to measure beam position and size.
Analysis Method

• Beam Position
  • Using the impact parameter to azimuthal angle correlation, the position can be calculated as:

\[ d_{xy} = x_0 \sin(\phi) - y_0 \cos(\phi) \]
Analysis Method

• Beam Size
  • Using the impact parameter correlation of tracks produced by a beam-gas interaction the beam size is measured as:

\[
\langle d_{xy}^{(1)} d_{xy}^{(2)} \rangle = \sigma_{\text{beam}}^2 \cos(\phi_1 - \phi_2)
\]

• Assuming that \( \sigma_x = \sigma_y \) at BGV location (optics)
LHC 2016 Run Results

Initial results with limited statistics

Beam position
\[(x, y) = (-0.79\, \text{mm}, 0.29\, \text{mm})\]

Beam Size
\[\sigma_{\text{beam}} = 0.37\, \text{mm} \pm 0.13\, \text{mm}\]
Summary & Outlook

• First commissioning steps were successfully completed
• Transverse beam profile measured with 0.13mm statistical error
  • Not yet allowing for a full comparison with other instruments
• Several enhancements for 2017:
  • Zero-suppression in the read-out FPGAs Increase statistics (100x)
  • Trigger upgrade Improve the event selection
  • Cross-calibration with other LHC instruments