The First Experience with LHC Beam Gas Ionization monitor

IBIC 2012
Tsukuba

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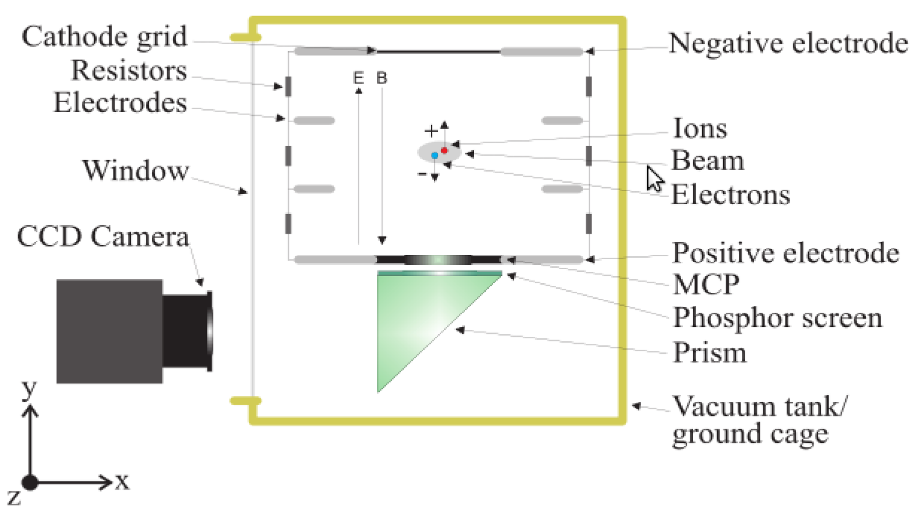
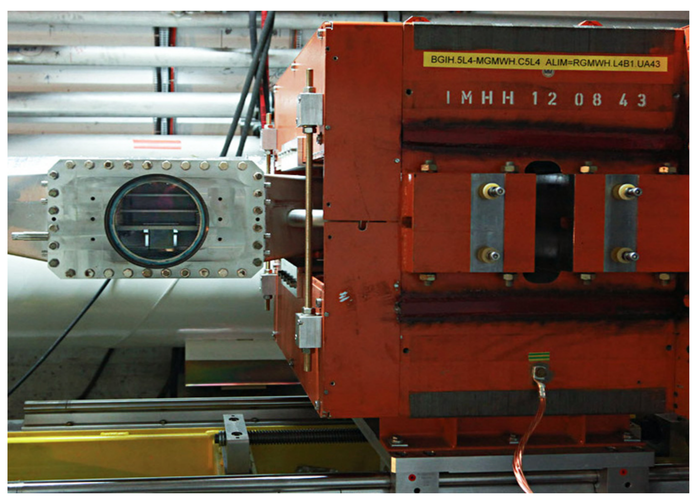
Abstract: *The Beam Gas Ionization Monitors (BGI) are used to measure beam emittance on LHC. This paper describes the detectors and their operation and discusses the issues met during the commissioning. It also discusses the various calibration procedures used to correct for non-uniformity of Multi-Channel Plates and to correct the beam size for effects affecting the electron trajectory after ionization.*

LHC BGI



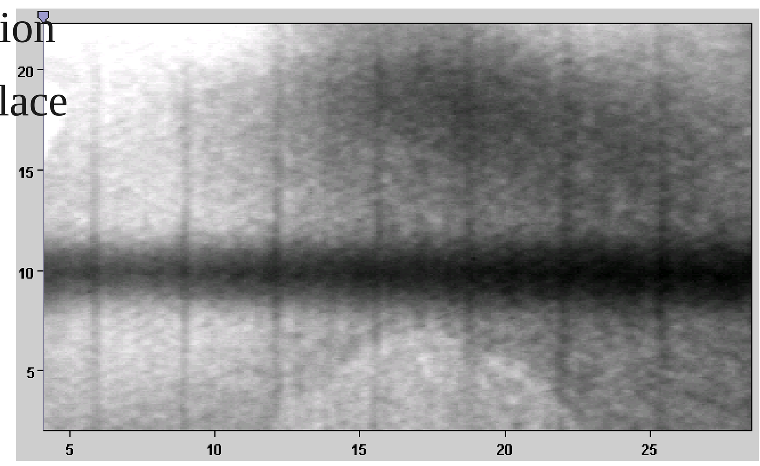


LHC BGI with magnet displaced: a viewport with electrodes can be seen.

- Measuring electrons
- Pressure 10^{-8} mbar (Neon)
- Magnetic field 0.2 T
- Electric field: 4 kV / 8.5 cm
- Photonis MCP
- Phosphor screen
- 7 lens optical system
- Thermo-Scientific CID8712D1M-XD4 camera - intensified
- In-house frame grabber (BTV VME card)

MCP usage

- Analog image registered during EGP calibration
- Clean sign of MCP gain deterioration in the place of the beam and Frisch grid
- Decided to exchnage MCPs during Witner Technical Stop (2011/12)
- Due to technical problems only 2/4 done
- Interestingly the pattern is seen on the phosphor screen as well
- BGIs with new MCP were fragile
- one damaged by high electron signal during scrubbing run
- Second developed HV problem (probably not MCP but Phosphor) and is not operational



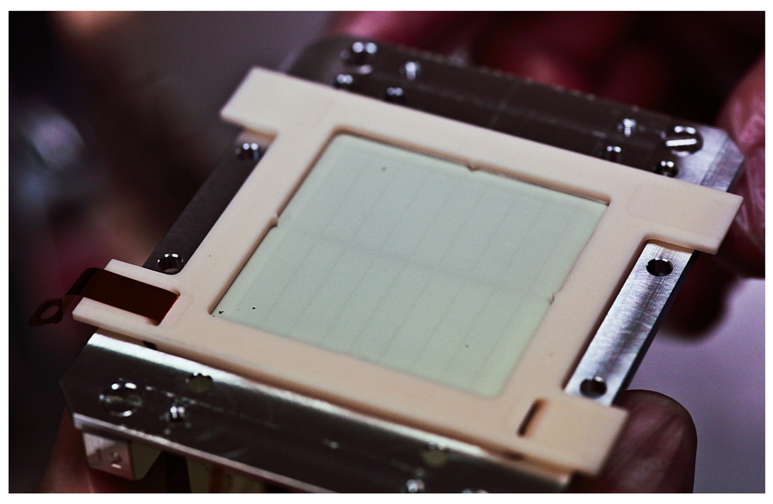
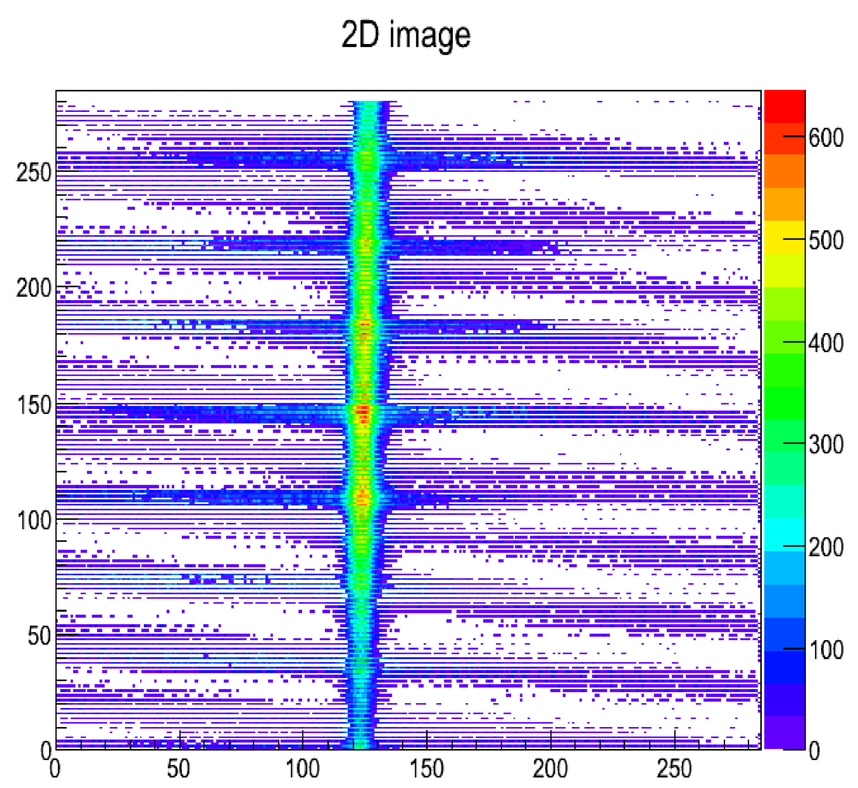


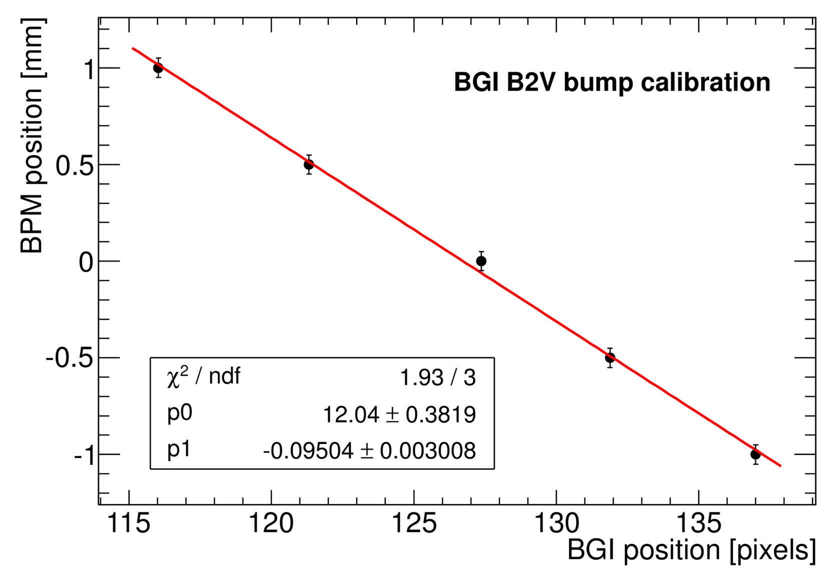
Image processing



- The two other detectors operational
- Typical image after digitization
- Various effect/artefacts present:
  - Gain decrease
  - CCIR signal readout pattern
  - Frisch grid pattern also seen (thermionic/secondary emission?)
- Investigating Fourier filters
- Trying to maximize the signal (gas, optical system modifications)

Calibration with orbital bump

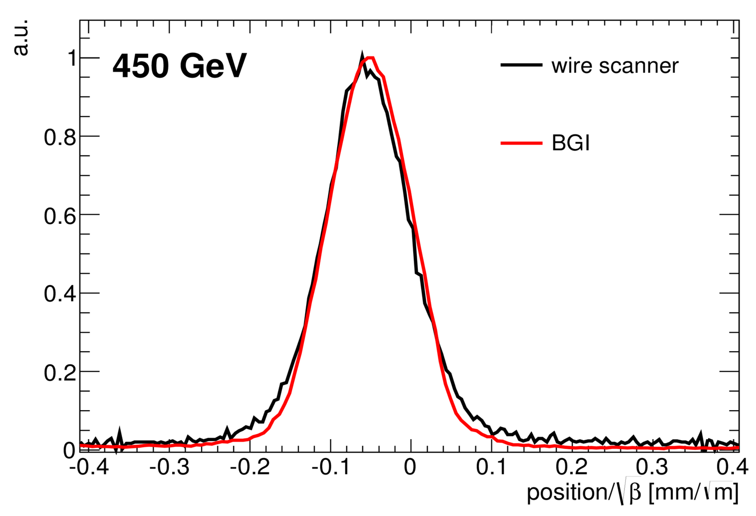
- Orbit is displaced in the location of BGI
- Thanks to large precision of BPMs this shift is very well controlled
- Numerous measurements (BPM versus BGI position) has been done
- Typical value obtained is 95 μm/pixel
- But Lab measurements: 115 μm/pixel

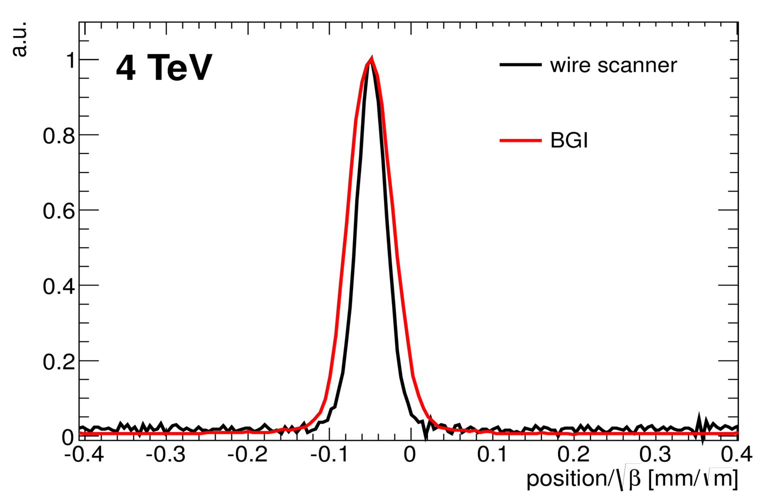


No BPM in vicinity of BGI: space of 60 m without BPMs and with magnetic elements. Worries about orbit interpolation error.

Decided to install BPM close to BGI during LS1.

Intercalibration with Wire Scanner





- Normally not possible to use wire scanner and BGI in the same beam intensity range

  Limits from:
  - wire damage threshold
  - low sensitivity of BGI

- Pb beam offers unique opportunity
- Measurements done in September 2012 comparing $\sigma_{BGI/WS}/\beta$
- Good agreement at injection
- Beam significantly larger at flat top in BGI
- Optical β:

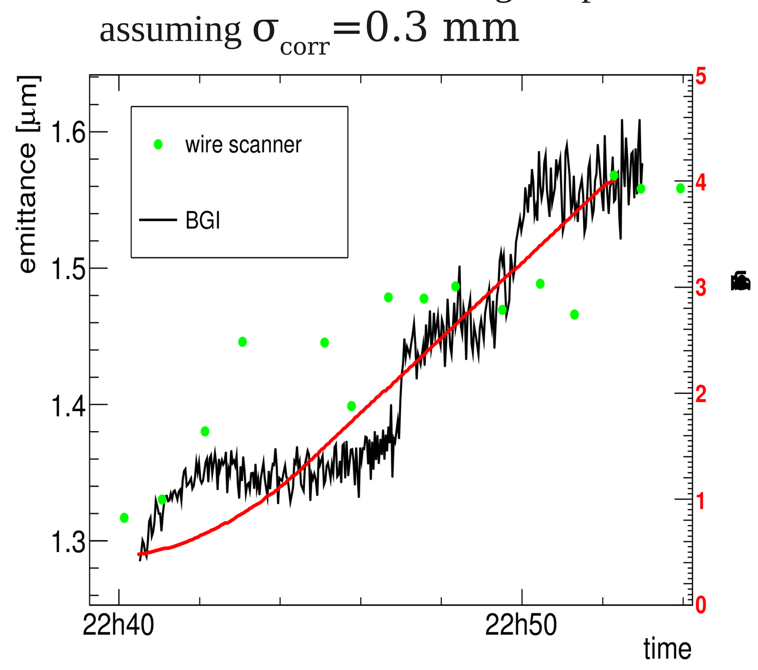
B2V [m]	WS	BGI
injection	418.95	217.19
Flat top	451.04	225.35

Correction in quadrature

Possible reasons:

- distortion of electron position due to beam space charge
- contribution from electron-emitting elements
- smearing of electron position due to gyroradius;
- smearing due to dispersion of the electrons produced in MCP (about 32 μm)
- optical point spread function (22 μm);
- cross-talk between pixels in the camera.

Emittance evolution during ramp assuming σ_{corr}=0.3 mm



Currently it is assumed that all these effects can be corrected in quadrature:

$$\sigma_{beam}=\sqrt{\sigma_{BGI}^2-\sigma_{corr}^2}$$

Conclusions

Initial results of the BGI commissioning on LHC beams are presented. Main aspects concerning the signal processing, scale calibration and correction of the MCP ageing are discussed. A necessary quadratic correction to the beam size measured by the BGI is shown. Preliminary results for ion beam are promising.

Literature:
- H. Refsum, ” Design, Simulation and Testing of a 2D Electron Source Based Calibrating System for a Proton Beam Ionization Profile Monitor”, CERN thesis 2004.
- http://beta-beating.web.cern.ch
- D. Kramer et al., CERN-AB-2005-072
- J. Egberts, thesis

ACKNOWLEDGEMENTS: Authors want to thank: Michaela Schaumann, Didier Calegari, Francois Bellorini, Vincent Baglin