Status of Beam Gas Ionization Monitor (BGI)

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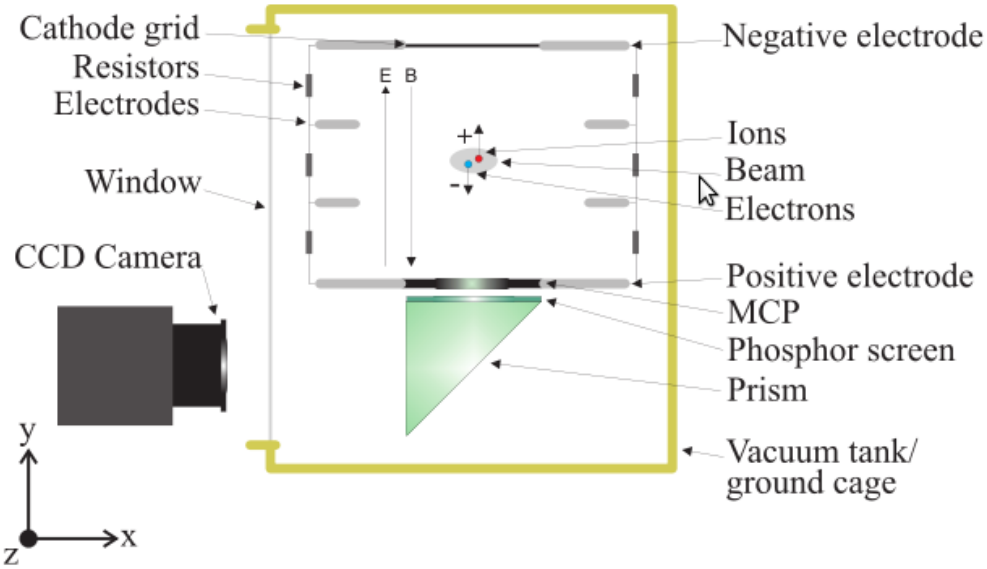
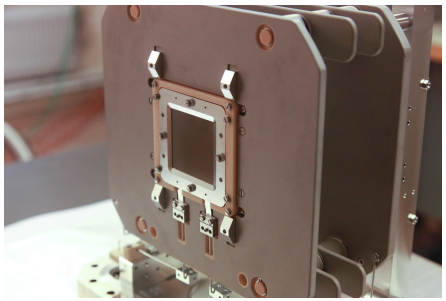
Operation principle

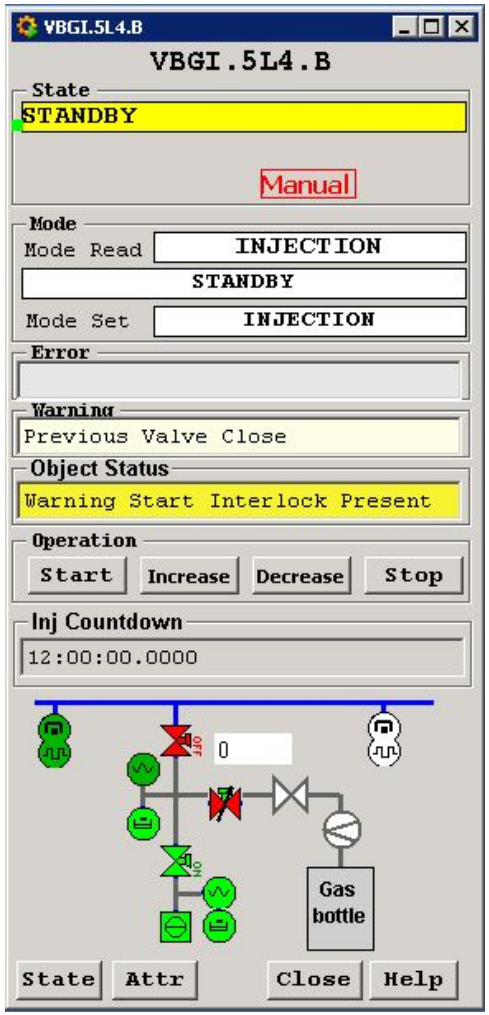




- HV seen by beam: 4 kV (2 kV seen by electrons)
- magnetic field: 0.2 T
- EGP for correction of MCP degradation

Gas injection system

- responsible VAC
  (V. Baglin, D. Cagliari, F. Bellorini)
- works OK
- manual start of injection (from PVSS application, lhcop can do it)
- manual stop of injection or automatic stop after 12 hours
- no gas injection in SPS (enough signal)



HV system

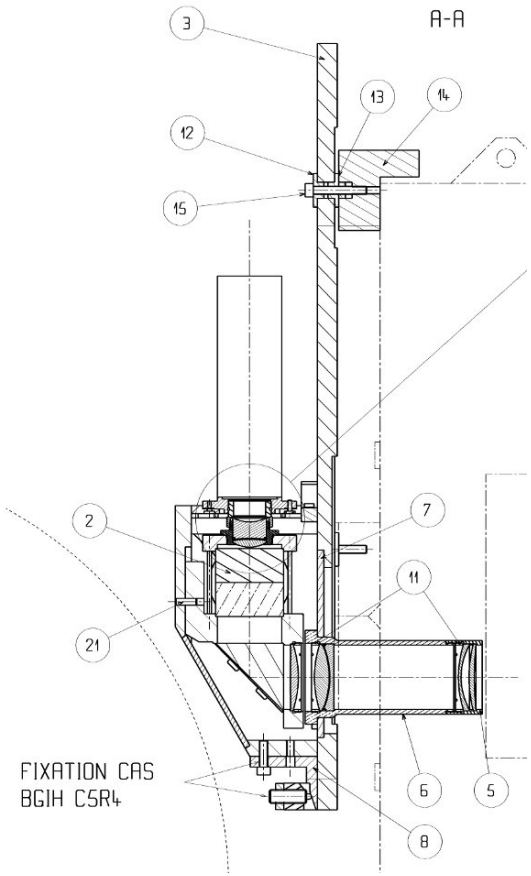
- controller: CERN-made VME card (1990's)
- lack of spares (used also for WS PMT)
- gave problems when switching to linux CPU
- CERN-made power supply
  (up to 12 kV, used up to 6 kV)
- instabilities observed (system shuts down)
- instabilities source: physics or software, recently diminishing (conditioning?)
- no operation on HV with beam in machine
  (wait for end of fill)

Magnets

- 0.2 T, modified to allow extraction of light
- LHC: one compensator, both on single power converter, always on, no issues
- SPS: two compensators (3-corrector bump), two power converters, potentially dangerous when one fails (investigate solutions for LS#1)
- in addition one of the vertical correctors have short-circuit, will be exchanged during TS#3 (J. Bauche)

Imaging system

- MCPs on beam 1 exchanged during winter TS (and have better sensitivity), but one broke during scrubbing run
- phosphor screen - signs of use
- one prism in vacuum
- 7-lens and one prism system outside vacuum, resolution $22\ \mu\mathrm{m}$
  (D. Kramer et al., CERN-AB-2005-072)
- rad-hard camera Thermo Scientific CID8712D1M-XD4, pixel $11.5\ \mu\mathrm{m} \times 1.6$
- overall sensitivity: between 50 and 800 proton bunches (MCP ageing)



Software

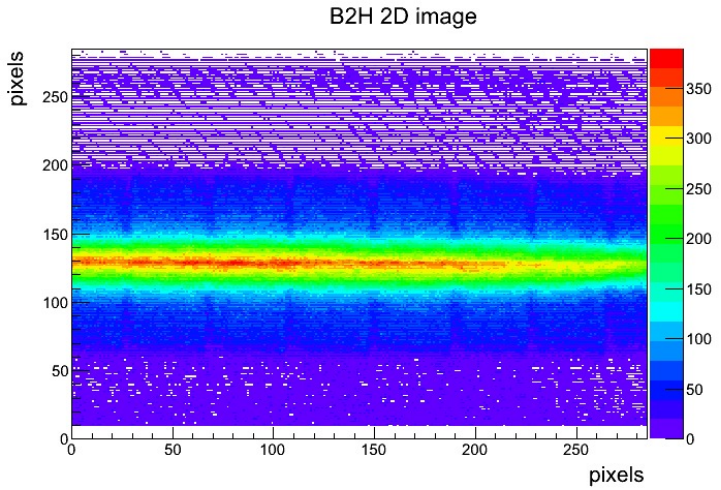
Software at various levels of development.
Main pieces:

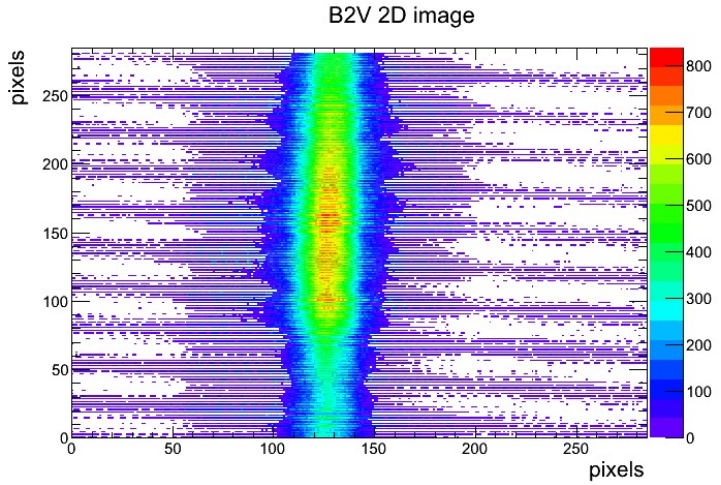
- FE server, standard FESA classes by Ana
- expert application by Ana
- two fixed displays by Laurette and Maria
- Online Image Processing (BgiOIP) tool by Bogna
  (testing processing algorithms, fits)
- root analysis toolbox

A test crate in the lab with optical testbench
(right now off - manufacturing elements which went to SPS)

2D image

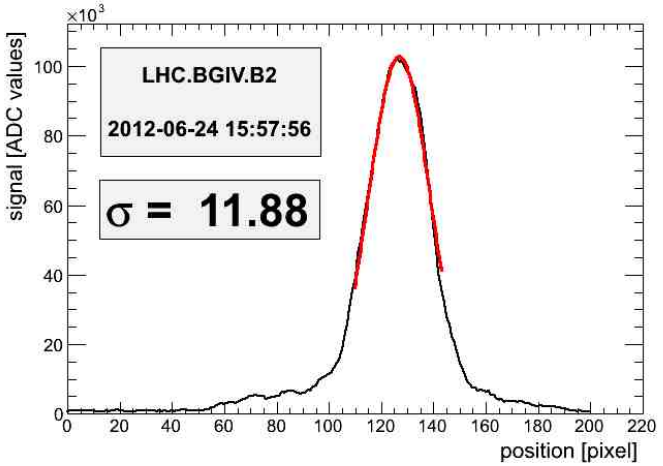
- maximum size: 768H x 575V
- line-to-line noise
- cameras rotation (TS#2)
- Cgrid wires issue
- image processing:
  - correction for gain variation over MCP surface
  - subtract constant noise
  - correction for grid wires (tbd)
- images are saved manually (csv) or BgiOIP
- profiles saved every 4 s to logging DB

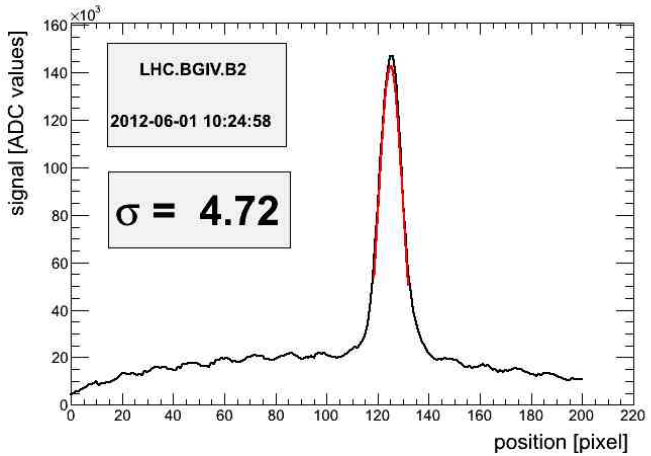


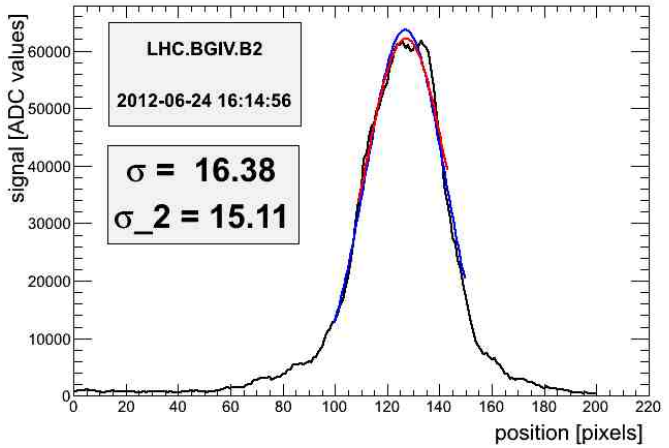


Profiles and fitting

- avoid tails, fit beam core
- special procedure tested, not optimal for large beams
- plots from MD June 24th - beam blowup with ADT at injection
- and 4 TeV flat top

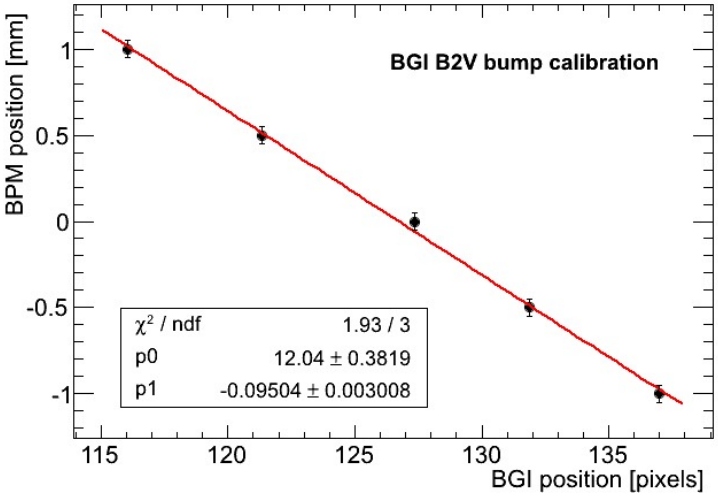


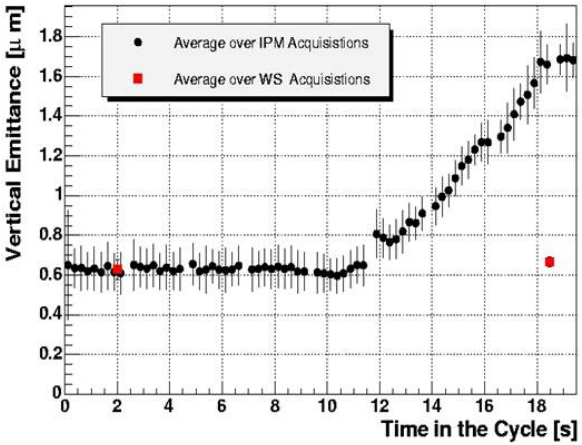




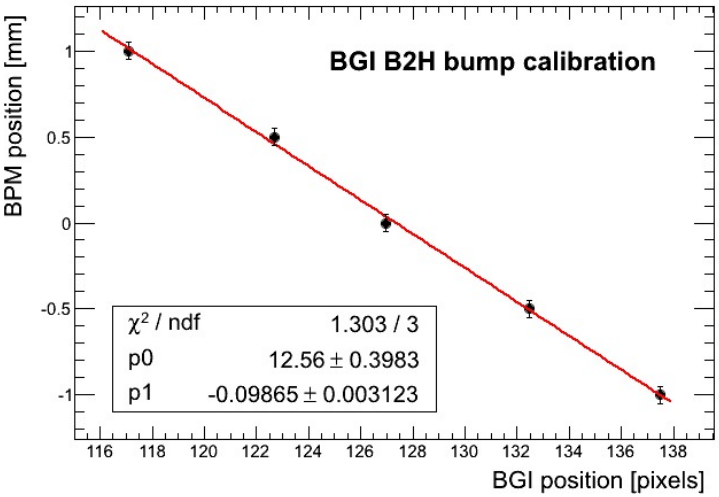
Calibration with orbital bump

- simple procedure, profiting from BPM precision
- BGI in YASP this year - easier operation
- $95 - 110\ \mu\mathrm{m/pixel}$
- camera tilt $1 - 2°$
- $\sigma_{\mathrm{beam}} = \mathrm{p}_1 \cdot \sigma_{\mathrm{BGI}}$ not enough



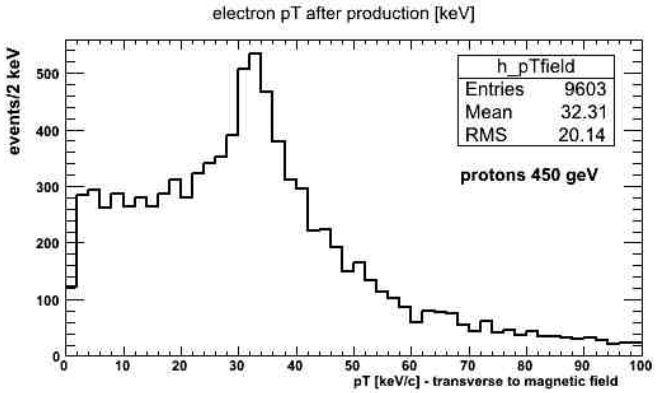


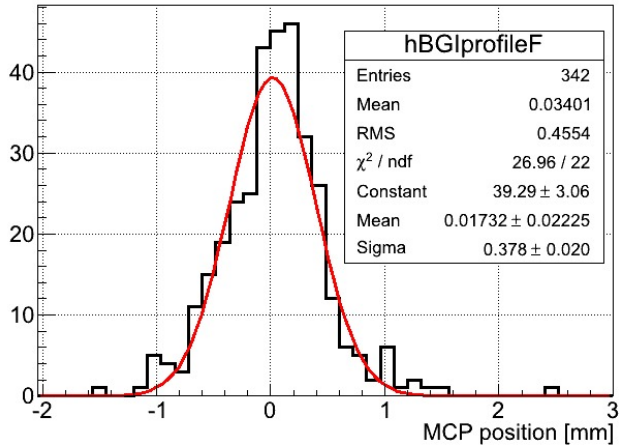
(2004 SPS data, blamed: optical resolution)

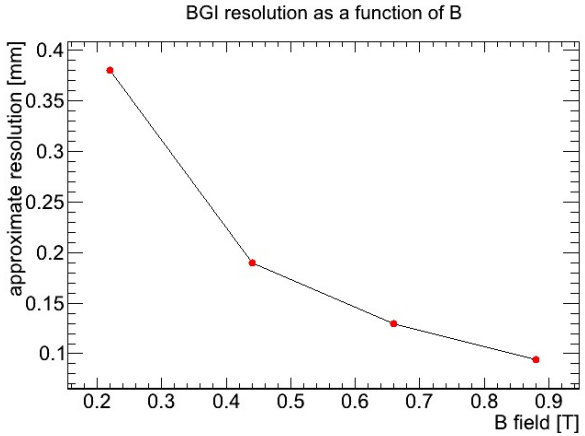


Gyroradius effect - Geant4 simulations

- discussion with Reine triggered fast Geant4 simulation
- electrons are generated transversely to the beam with average $p_T^{Bfield} = 32\ keV/c$
- $gyroradius[m] = 3.3 \frac{p_T[GeV/c]}{B[T]} \approx 0.5\ mm$

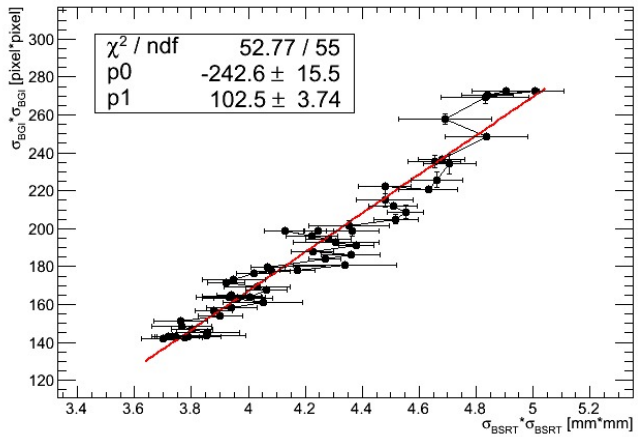


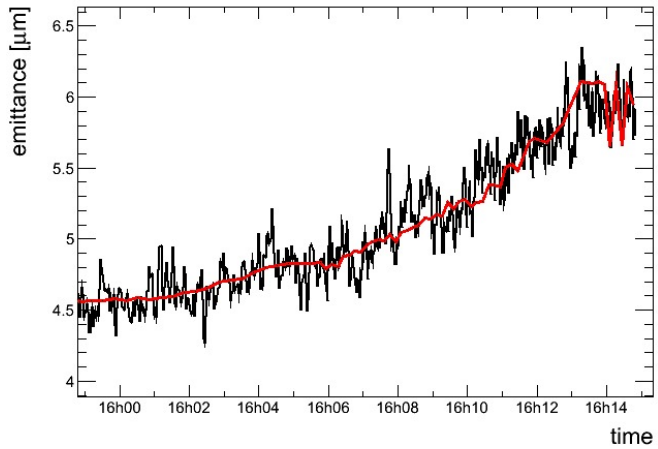




Cross-calibration with BSRT/WS

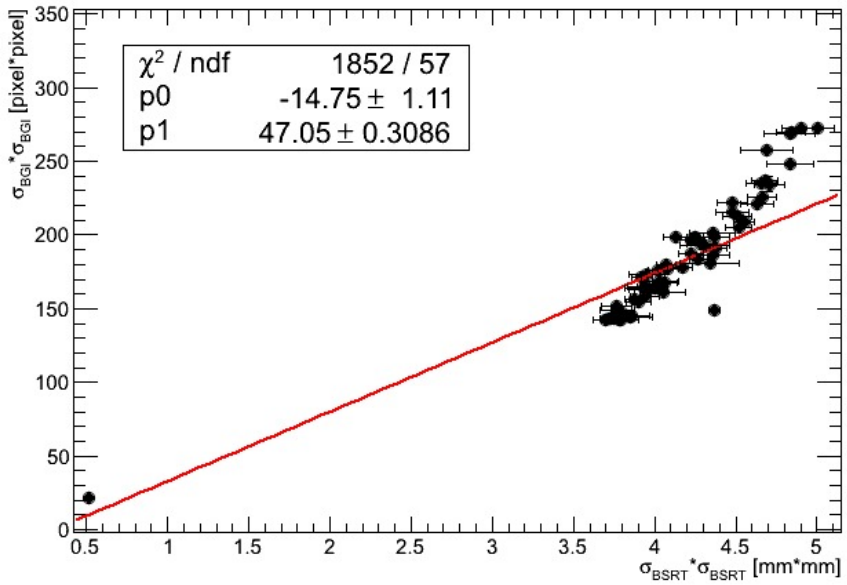
- plan B: use the simplest model with PSF (as BSRT)
- $\sigma_{beam} = \sqrt{(c\sigma_{BGI})^2 - \sigma_{corr}{}^2}$
- use Federico method to cross-calibrate
  linear fit $\sigma^2_{BGI} = a\sigma^2_{beam} + b$
- continue modelling, because our PSF is not really gaussian
- add space charge effect
- continue cross-calibration with BSRT(B2) and WS(B1)
- BSRT itself relies on cross-calibration with WS





Cross-calibration with BSRT/WS

Example of difficulties, maybe quadratic correction is not enough?



Possible reasons:

- nongaussian PSF
- space cherge effect
- ...

- Emittance during ramp - problematic!
- How to get intermediate emittance data?

Summary

- **Hardware is ready** for continuous monitoring of beam emittance
- except of LHC.B1V (serious problem - LS#1) and SPS.V (working on it)
- The reinforcements arrived (Bogna and Marcin)
- BGI measurement is **model dependent** (not like WS)
- Need to take **more data** especially cross-calibration
- After recalibration (to be done after TS) we'll start providing emittance data based on quadratic correction
- Continue work on model

Further reading I

Calibration of LHC BGI monitors with orbital bump
EDMS-1130606

Geant4 simulation of electron trajectories in BGI
EDMS 1182412

BGI results of BI MD June 24, 2012
EDMS-1230249