Status of Beam Gas Ionization Monitor (BGI)

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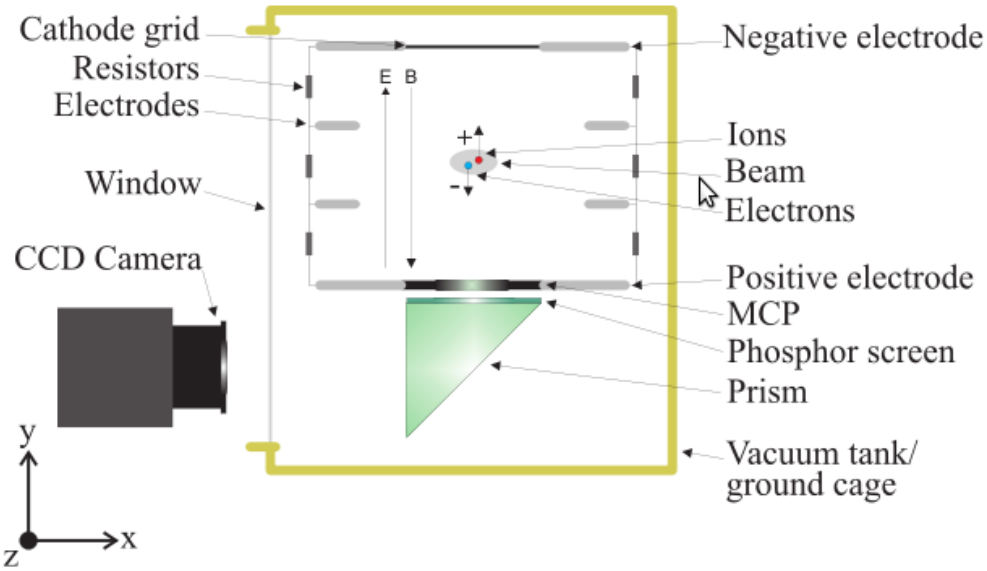
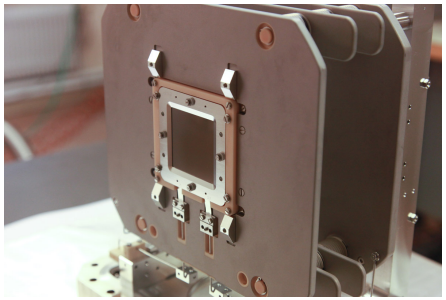
Operation principle



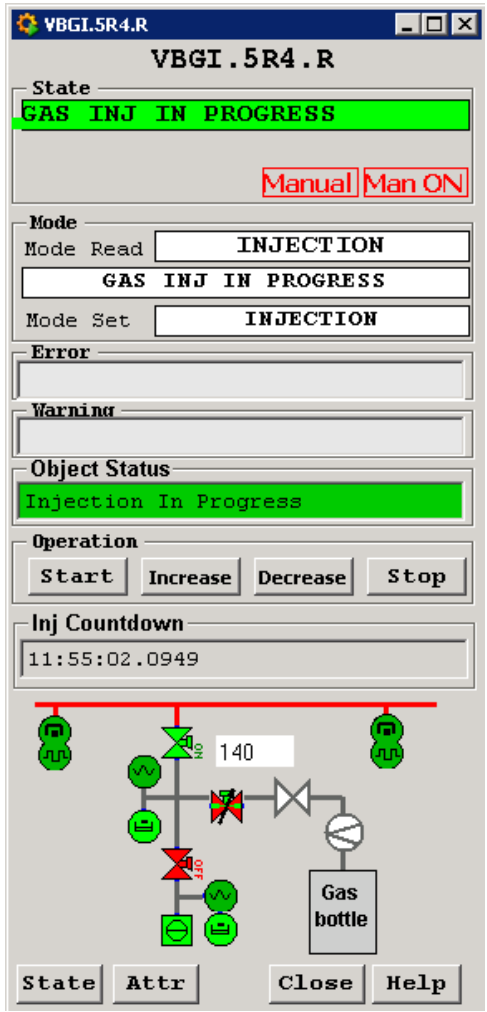


Subsystems:

- gas injection
- high voltage
- magnets
- imaging system

Gas injection system

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



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, sometimes dumps the beam)
- instabilities source: physics or hardware readout, recently diminshing (conditioning effect?)
- recent software modification - system sensitive to wrong readouts of HV (Ana)
- dangerous instabilities develope faster than 1 s

Magnets

- 0.2 T, modified to allow extraction of light
- LHC: one compensator, both magnets 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)

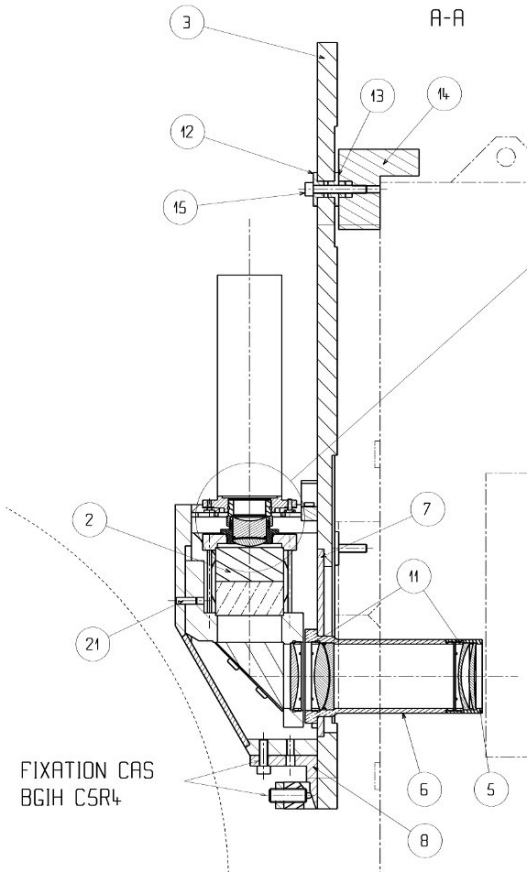
Imaging system

Vacuum part:

- MCPs exchanged during winter TS (and have better sensitivity), but not on LHC B2
- on LHC both new MCPs failed
- phosphor screen - signs of use (LHC)

Outside 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 $11.5\ \mu\mathrm{m} \times 1.6$ (taper)
- overall sensitivity: between 50 and 400 proton bunches (MCP ageing)
- front-end image processing: linux CPU

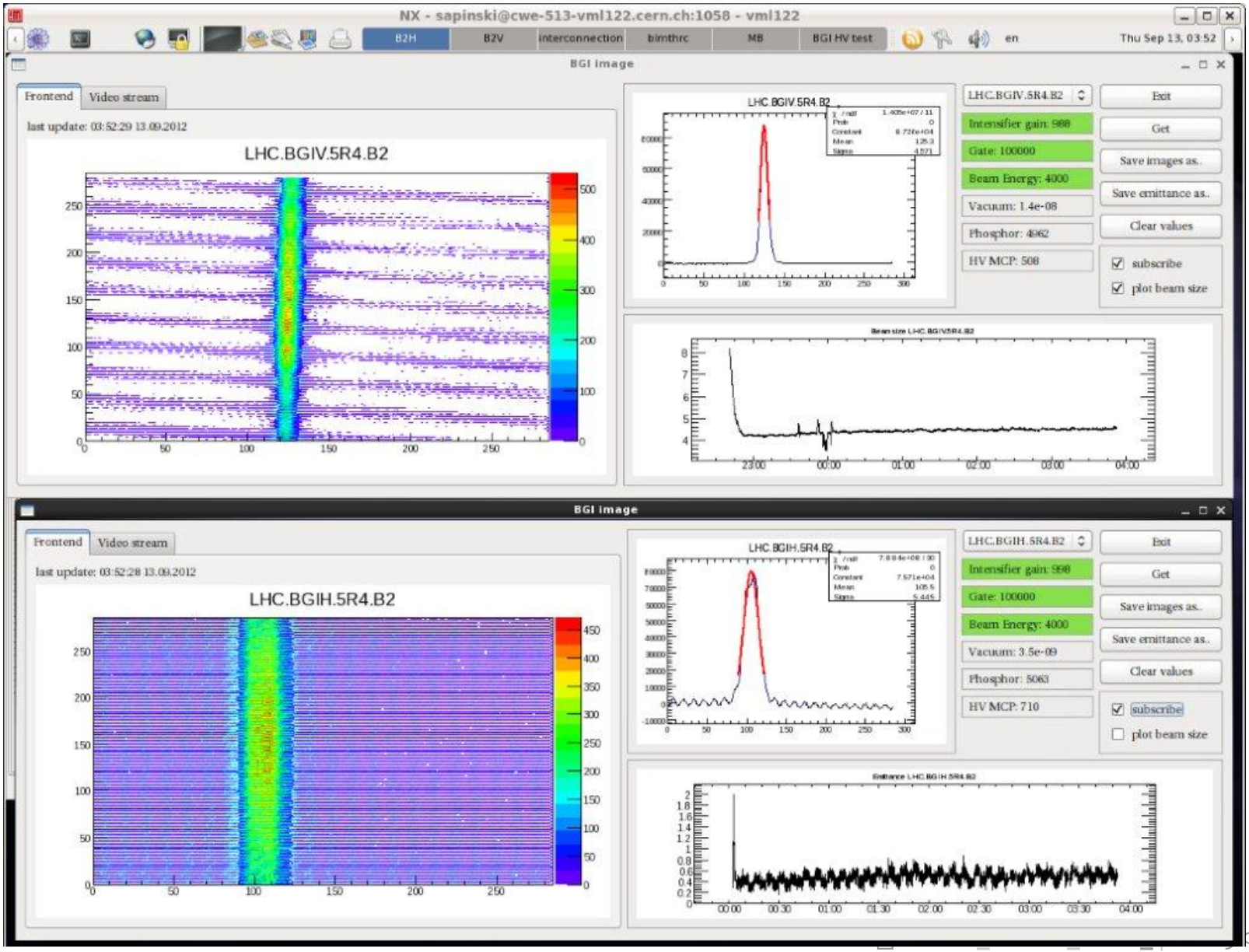


Software

Software at various levels of development.
Main pieces:

- 2 FE servers (separately HV and Image), standard FESA classes by Ana
- expert application(s) by Ana
- two fixed displays by Laurette Ponce and Maria Kuhn
- Online Image Processing (BgiOIP) tool by Bogna Blaszczyk (testing processing algorithms, fits)
- root analysis toolbox

Expert Image Processing Application (BgiOIP)

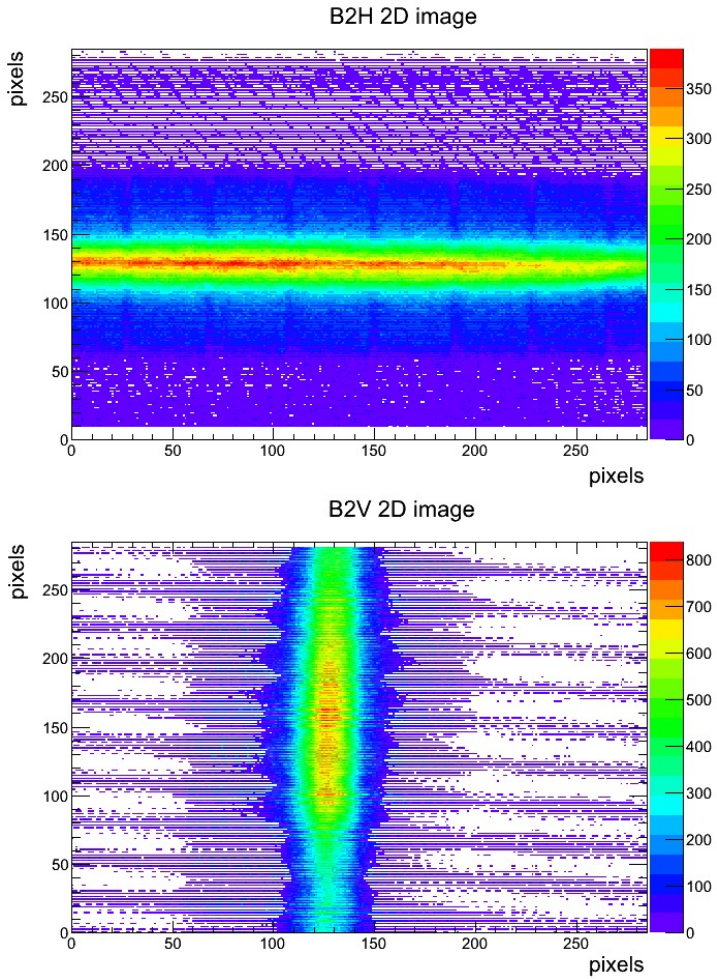


Test benches

- A test crate in the lab with optical testbench - testing electronic components, cameras and optical systems (Marcin Patecki)
- test bench with complete system in vacuum - in development

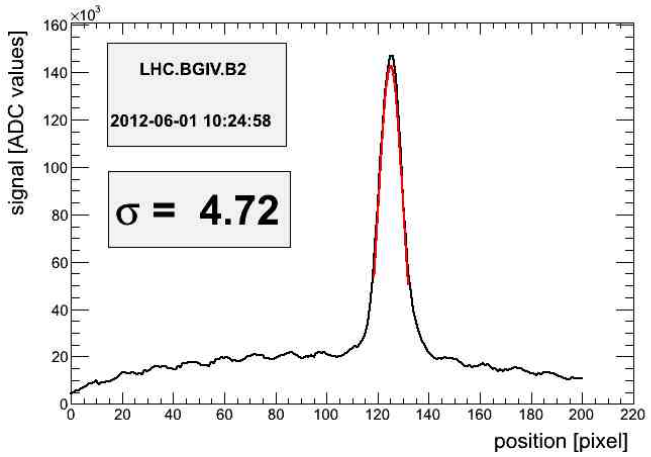
Results: 2D image

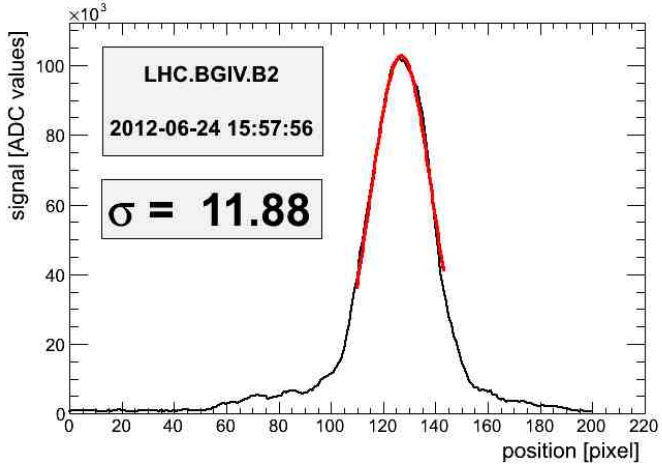
- maximum size: 768H x 575V
- line-to-line noise
- Cgrid wires issue
- image processing:
  - correction for gain variation over MCP surface
  - subtract constant noise
  - correction for grid wires (being tested)
  - Fourier filter and other image filter (development)
- images are saved manually
- profiles saved every 4 s to logging DB



Profiles and fitting

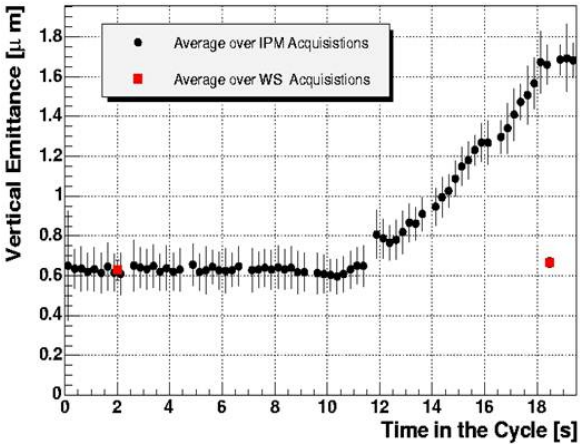
- root fitting on linux front-end
- examples plots from MD on June 24th



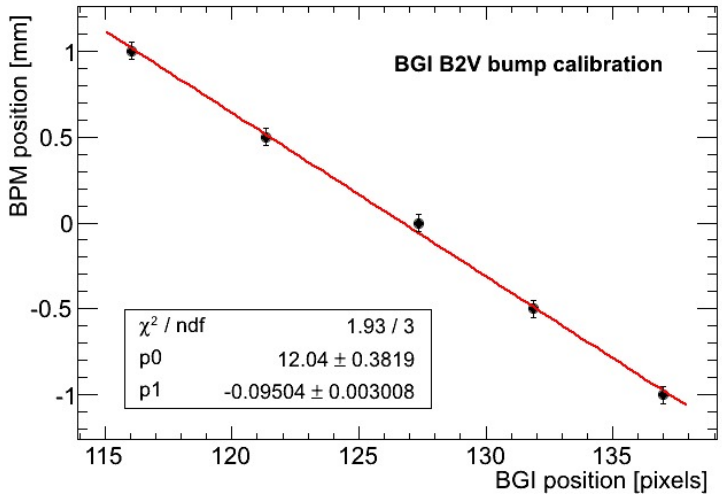


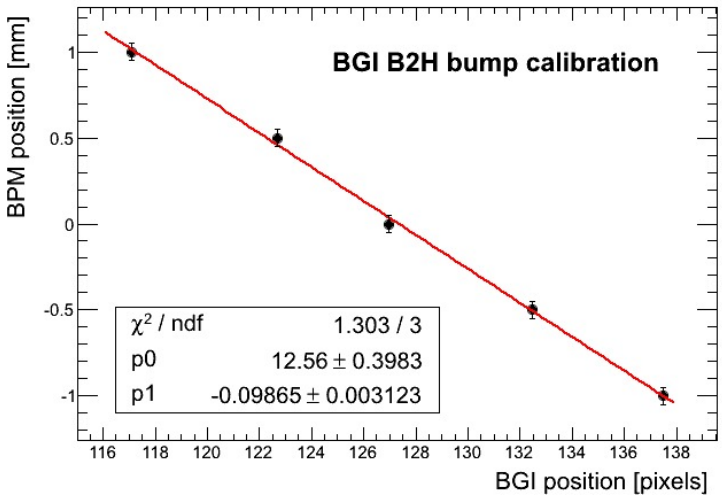
Calibration

- we hoped for simple:
  $\sigma_{\text{beam}} = p_1 \cdot \sigma_{\text{BGI}}$
- measurements in the lab and calibration with orbital bump:
  $p_1 = 95 - 115\ \mu\text{m/pixel}$
- camera tilt up to $1.1°$
- $\sigma_{\text{beam}} = p_1 \cdot \sigma_{\text{BGI}}$ not enough



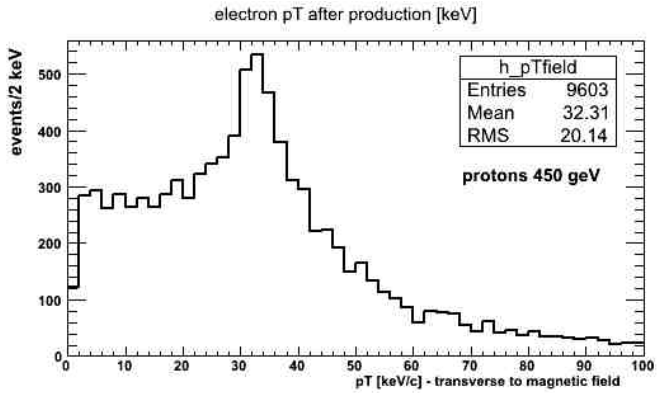
(2004 SPS data, blamed: optical resolution)

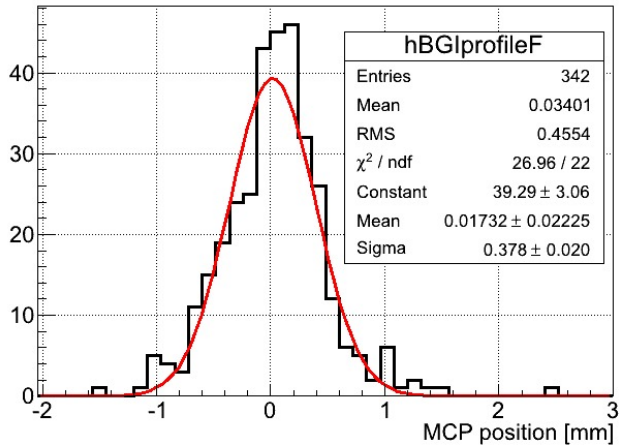




Gyroradius effect - preliminary Geant4 simulations

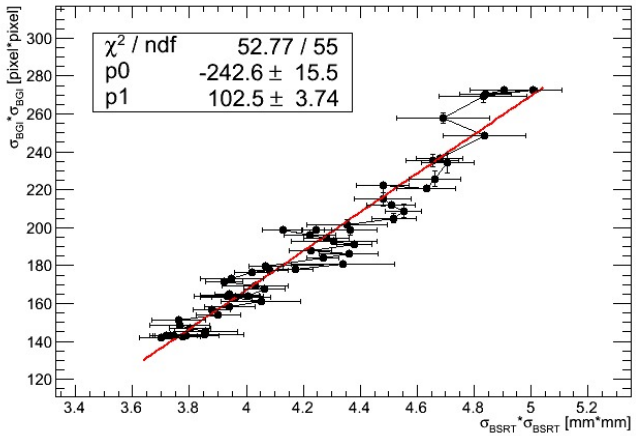
- electrons are generated transversely to the beam with average $p_T^{Bfield} = 32\ keV/c$
- $gyroradius[m] = 3.3 \frac{p_T[GeV/c]}{B[T]} \approx 0.5\ mm$
- more precise Geant4 simulations and pyECloud ongoing
- simplest formula roughly fitting to data: $\sigma_{beam} = \sqrt{(p_1 \sigma_{BGI})^2 - \sigma_{corr}^2}$





Cross-calibration with BSRT/WS

- usually no overlapping intensity region to cross-calibrate with WS
- tried with BSRT (B2, it had already mirror problem)
- BSRT itself relies on cross-calibration with WS
- use Federico method to cross-calibrate
  linear fit $\sigma^2_{BGI} = a\sigma^2_{beam} + b$
- from a and b one can get p_1 and σ_{corr}



- recently performed measurements with Pb beam and WS **during ramp**
- data analysis ongoing

SPS status

- electronics and optical systems - the same as in LHC
- detectors: different material and slightly different geometries
- production of LHC-like detectors (foreseen for installation during LS1)
- no gas injection (for the moment)
- initially signals observed (in analog channel), but then disappeared
- suspected: camera communication problem (as in LHC)
- also one camera intensifier broken (action:camera exchange)
- hope to solve during TS3
- during TS3: faulty vertical corrector magnet exchange (Jeremie Bauche)
- logging to DB will be done once system functional

CPS BGI

- not much effort spend on that up to now
- strong space constraints (1 or 2 meters available)
- solution would be permanent magnets (as in FNAL)
- multistrip-anod readout instead of camera and optical system (large beams, radiation hardness)
- fellowPhD for the project - being discussed

Summary

- **LHC B2 systems are operational** however still need to work on image processing and calibration.
- hope to make **SPS system operational during this TS**
- calibration is not straightforward (quadratic correction)
- Main efforts now: image filtering, modelling of electron in presence of beam space charge, **understanding calibration**
- vacuum test bench - to be done
- **critical: HV controler spares, power SPS magnets**
- CPS - R&D starts now, main development during LS1

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