

Commissioning of Timepix3 Based Beam Gas Ionisation Profile Monitors for the CERN Proton Synchrotron

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Swann Levasseur (CERN, Switzerland)

D. Bodart, S. Jensen, H. Sandberg, G. Schneider, J.W. Storey, R. Veness (CERN, Switzerland),
W. Bertsche (University of Manchester, Cockcroft Institute, UK), S. Gibson (Royal Holloway,
University of London, UK), K. Satou (J-PARC/KEK, Japan)

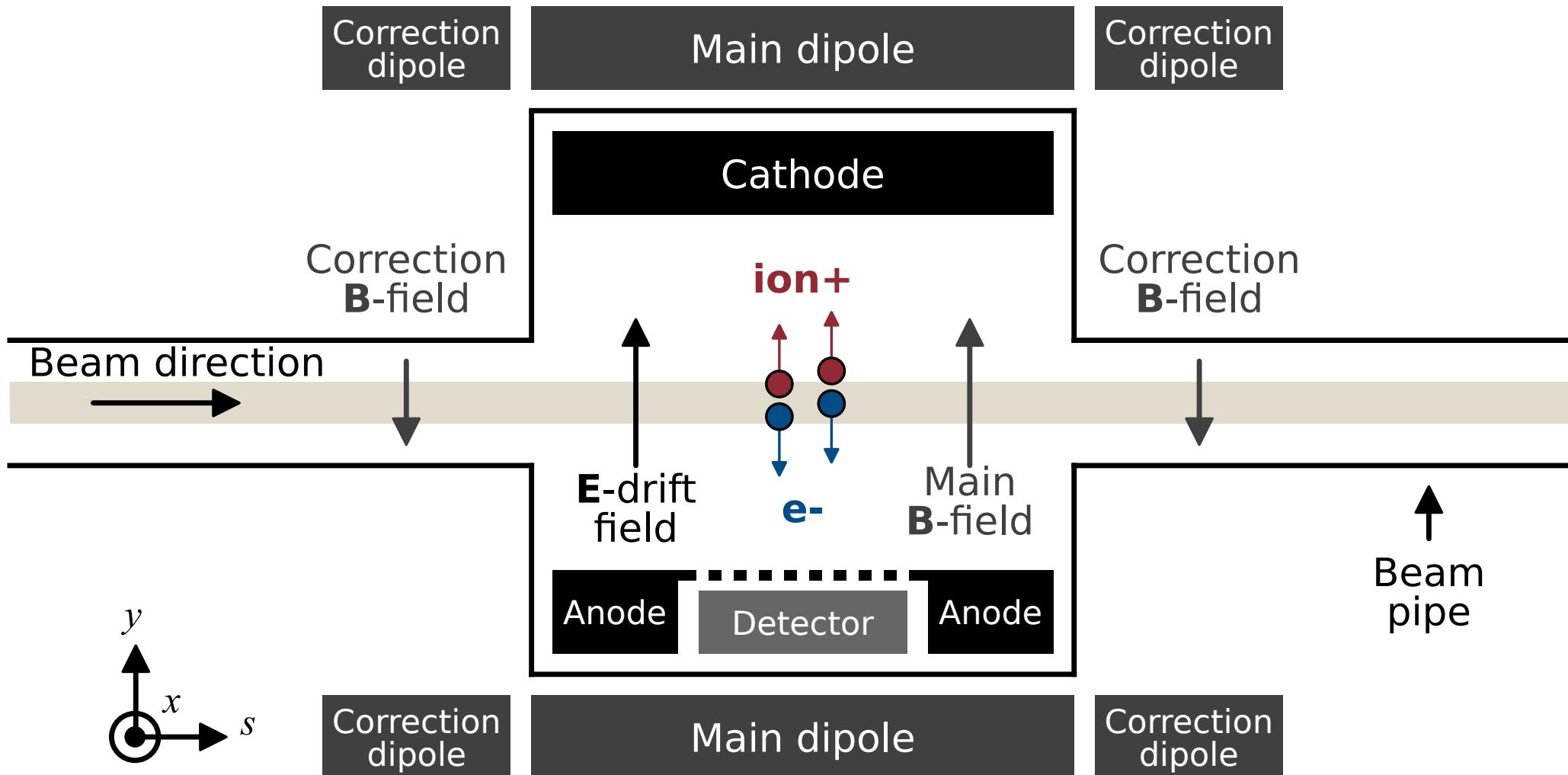
<https://bgi.web.cern.ch>

Outline

- Beam Gas Ionisation (BGI) Profile Monitor in a nutshell
- From prototype to operational
- Timepix3 detector setup and testing
- First beam measurements
- Examples of operational measurements
- Summary

Beam Gas Ionisation (BGI) Profile Monitor in a nutshell

BGI == IPM (Ionisation Profile Monitor)



From prototype to operational

Horizontal prototype
2017-2018



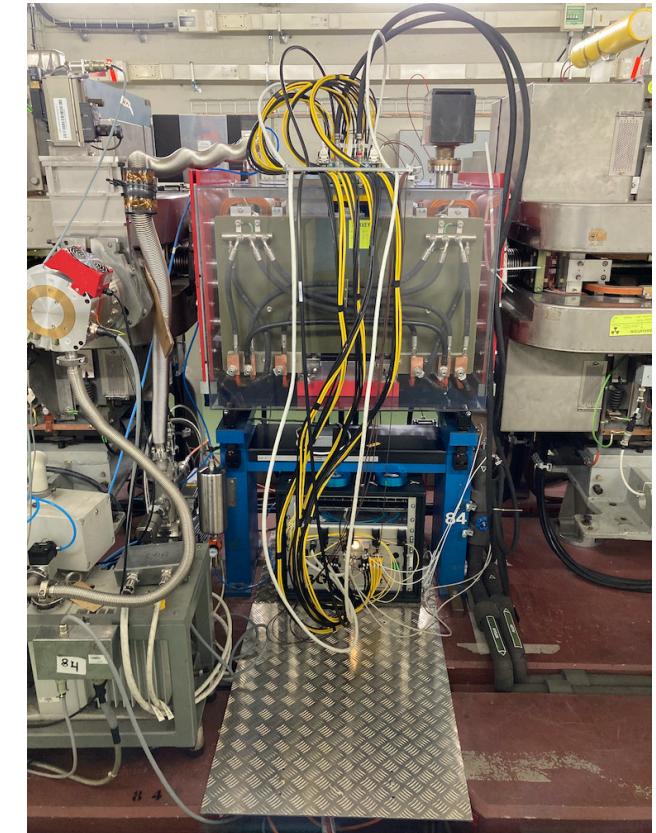
- Proved feasibility
- 1st generation detector assembly

Horizontal operational
2021

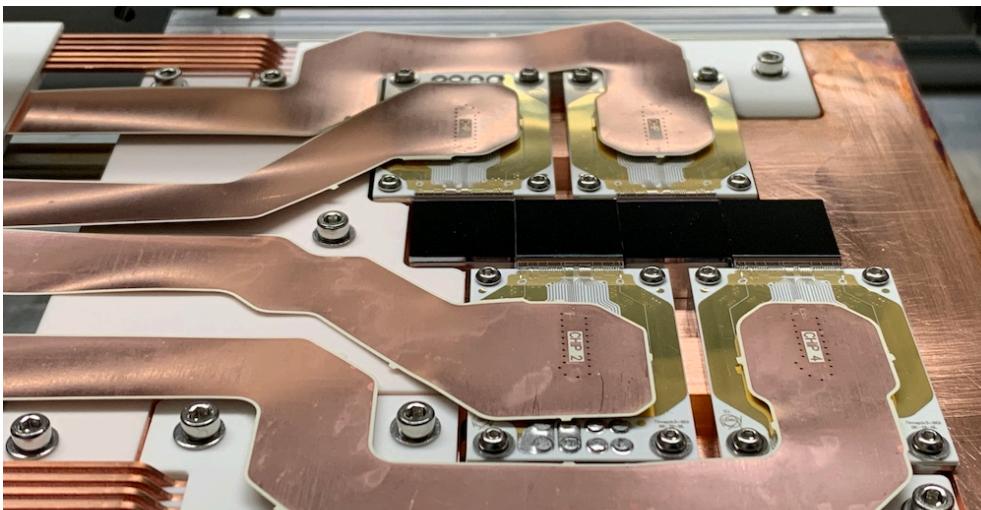
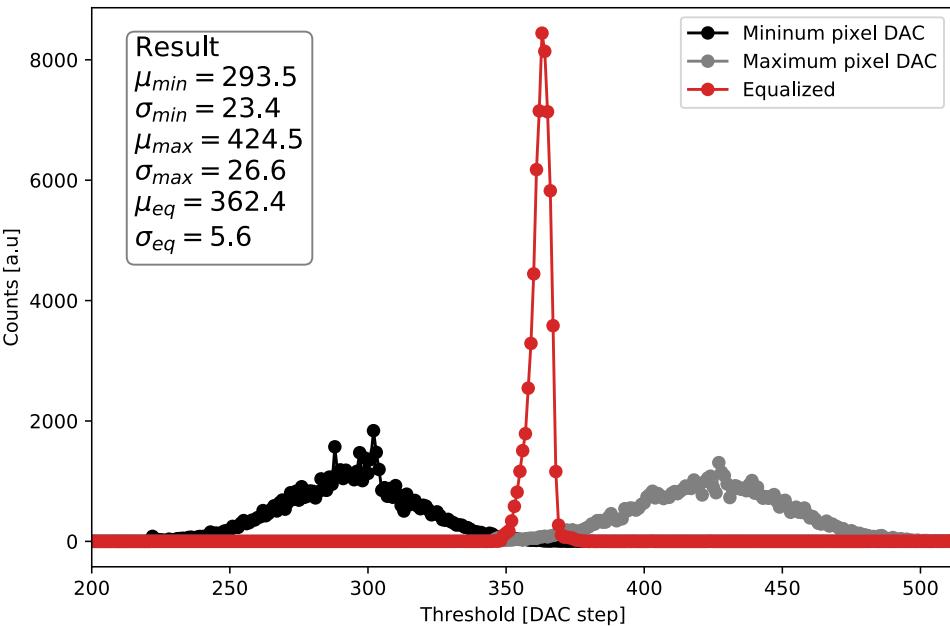


- New in-vacuum electronics and Timepix3 detectors.
- New installation of vertical vacuum chamber and magnet.
- Gas injection on both instruments.

Vertical operational
2021

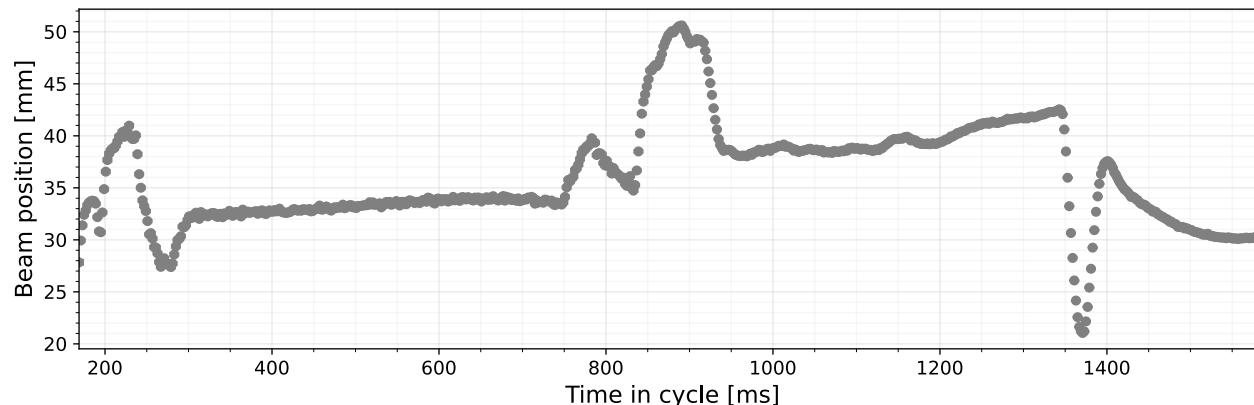
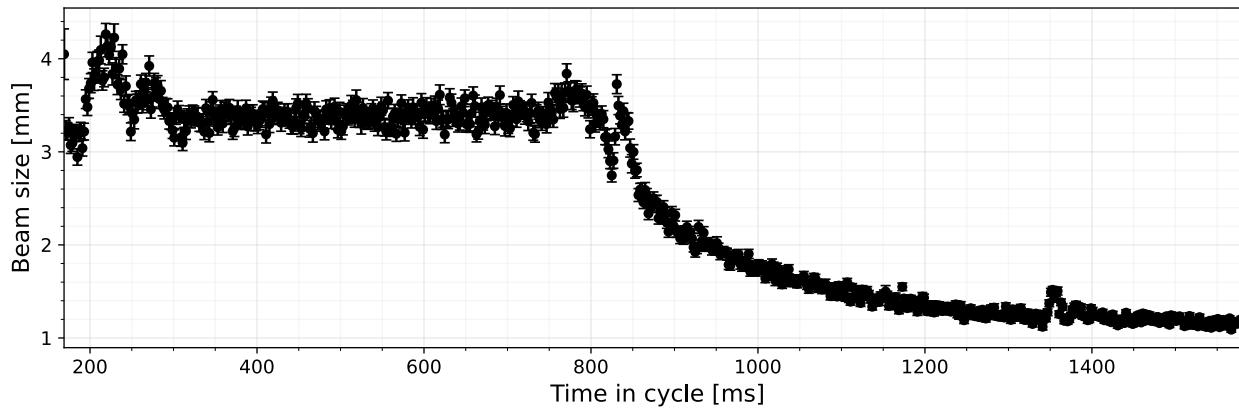
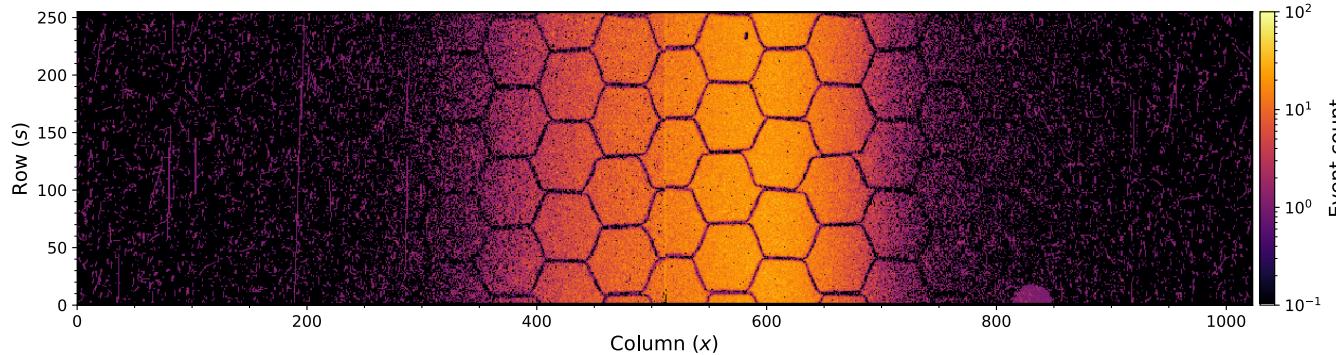


Timepix3 detector setup and testing



- Four Timepix3 detectors per BGI instrument.
- All Timepix3 detectors tested in the lab before installation in the vacuum.
- Power consumption, sensor bias current, DAC scan, equalization, threshold tuning, ionizing radiation etc.
- Tests are run before and after installation in CPS.
- No significant difference indicate that the detectors are ready for operational use.

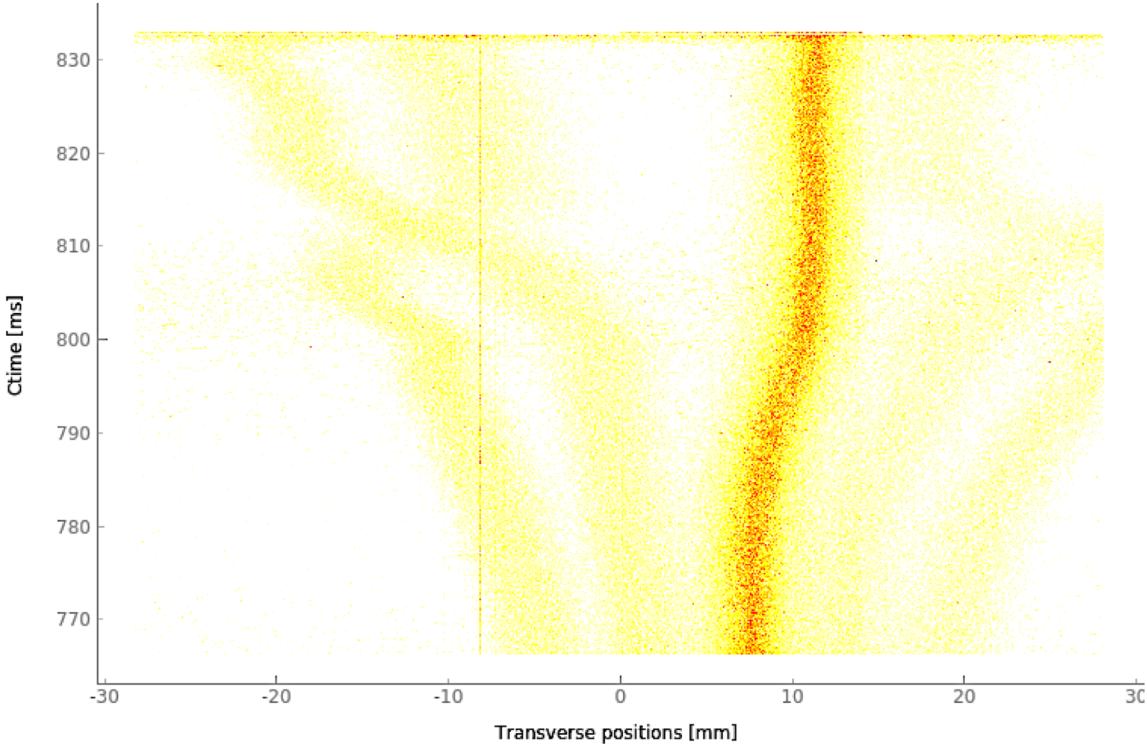
First beam measurements



- Single bunch beam recorded on the first week of beam commissioning.
- Pixel image is full 1.2 s beam cycle.
- Correction for honeycomb shadow.
- Integration window set to 2 ms.
- 600 beam profiles measured.
 - Up to 1024 profiles per cycle.
- Fit each profile with a Gaussian.
- Evolution of beam size and position throughout the cycle.

Examples of operational measurements

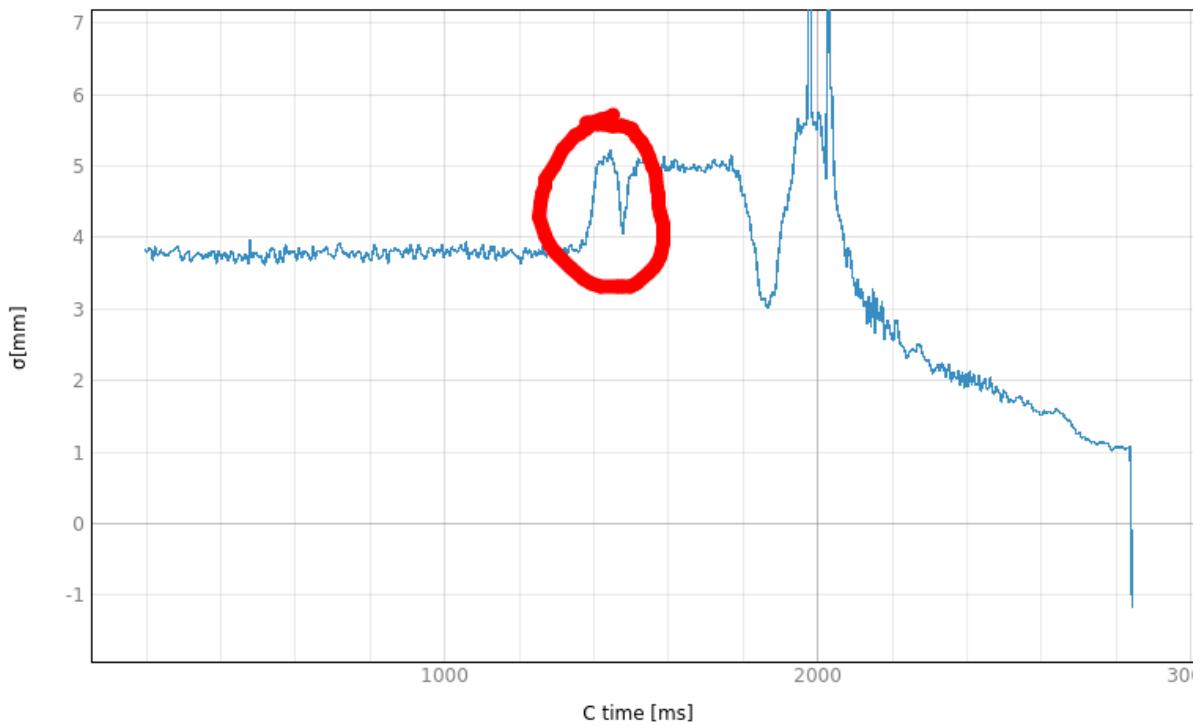
Beamlets in multi-turn extraction beam



- Beam is split into several beamlets in the transverse planes.
- Each beamlet is extracted one by one, turn by turn.
- Continuous measurements with BGI shows how the beamlets behave throughout the beam cycle.
- One beamlet (the core) has higher intensity and can be distinguished in the BGI data.

Examples of operational measurements

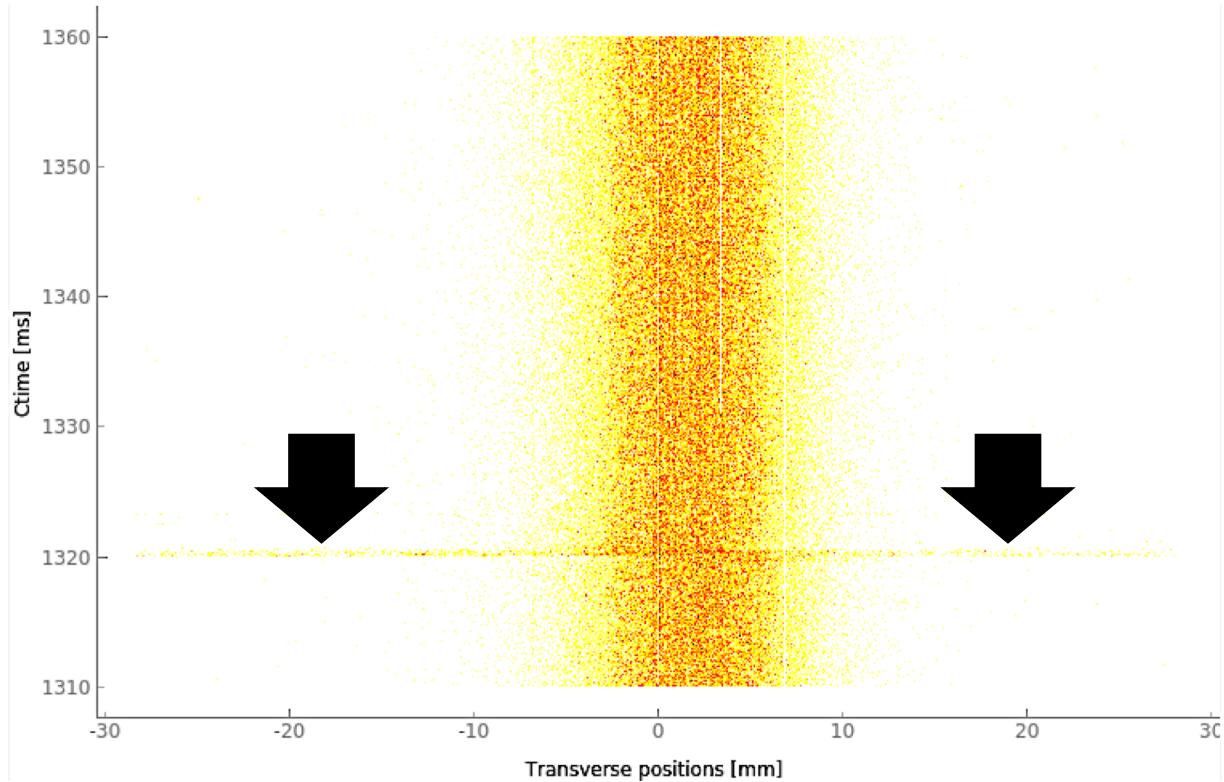
Intermediate plateau beam size squeeze



- Horizontal beam size evolution in the cycle is shown.
- At 1450 ms there is a sudden dip in the beam size.
- Corresponds to the time in the cycle where the particles are accelerated a bit before the next injection (intermediate plateau).
- Longitudinal momentum spread is increasing and decreasing at the same time.
- Couples to the transverse horizontal plane through dispersion.

Examples of operational measurements

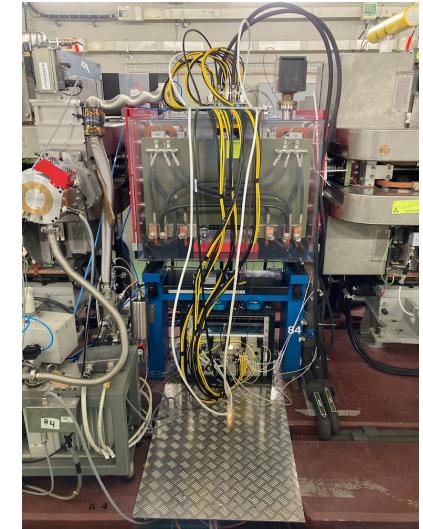
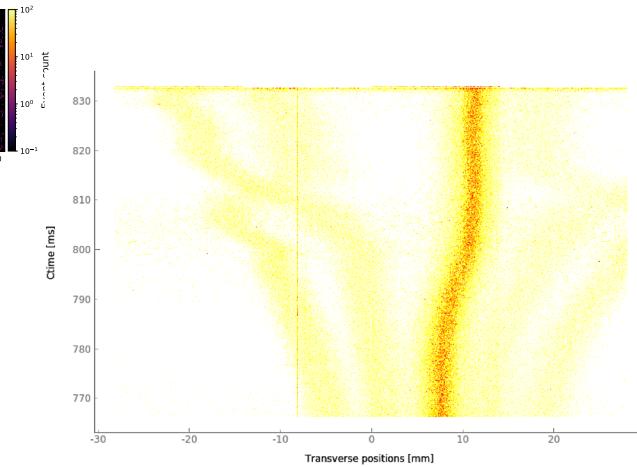
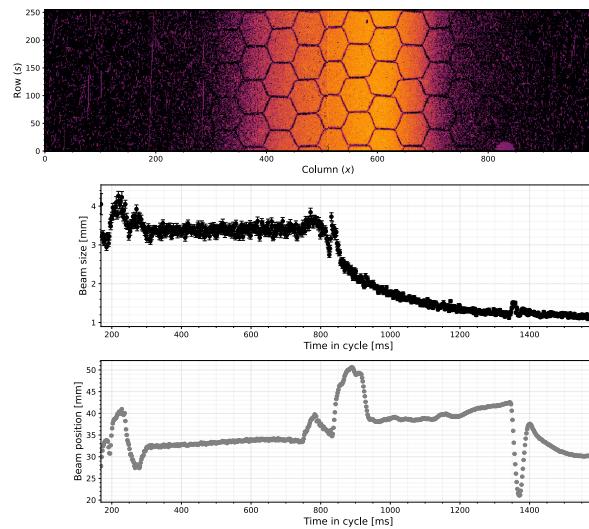
Second injection beam losses



- Part of the cycle with a stable transverse beam size
- “Glitch” visible at 1320 ms in the cycle
- Timepix3 detectors are also sensitive to beam loss
 - Normally filtered out since we are only interested in the ionisation electron signal
- Indicates something is disturbing the beam
- In this case the injection kicker magnet is active at this point (but nothing is injected)
- These losses were not visible on nearby beam loss monitors

Summary

- Two operational beam gas ionisation profile monitors have been installed in the CERN PS.
- Measures in the transverse horizontal and vertical planes in a continuous and non-invasive way.
- Instruments were commissioned and measured the first beam in March, 2021.
- Operational use of the instrument demonstrate various use cases.
- Measurements are still in progress for injection mismatch studies, beam time structure and comparison against other profile monitors.



Thank you for your attention!

