AD performance studies

D. Cotte, M. Delrieux, H. Damerau, Y. Dutheil,
A. Huschauer, A. Lasheen, B. Mikulec

Many thanks to the PSB/PS shift crews for their support during the MDs and to Foteini and Simon for preparing the PSB beams!

IPP MD days, 3 February 2025

Motivation

- **Lots of studies in previous years to understand apparent low transmission in FTA**
  - Low transmission indicated with BCTs
  - Several optics studies performed without drastic improvement
  - Studies with BLMs and BTVs on the other hand showed little to no beam loss in PS→FTA transfer [1]

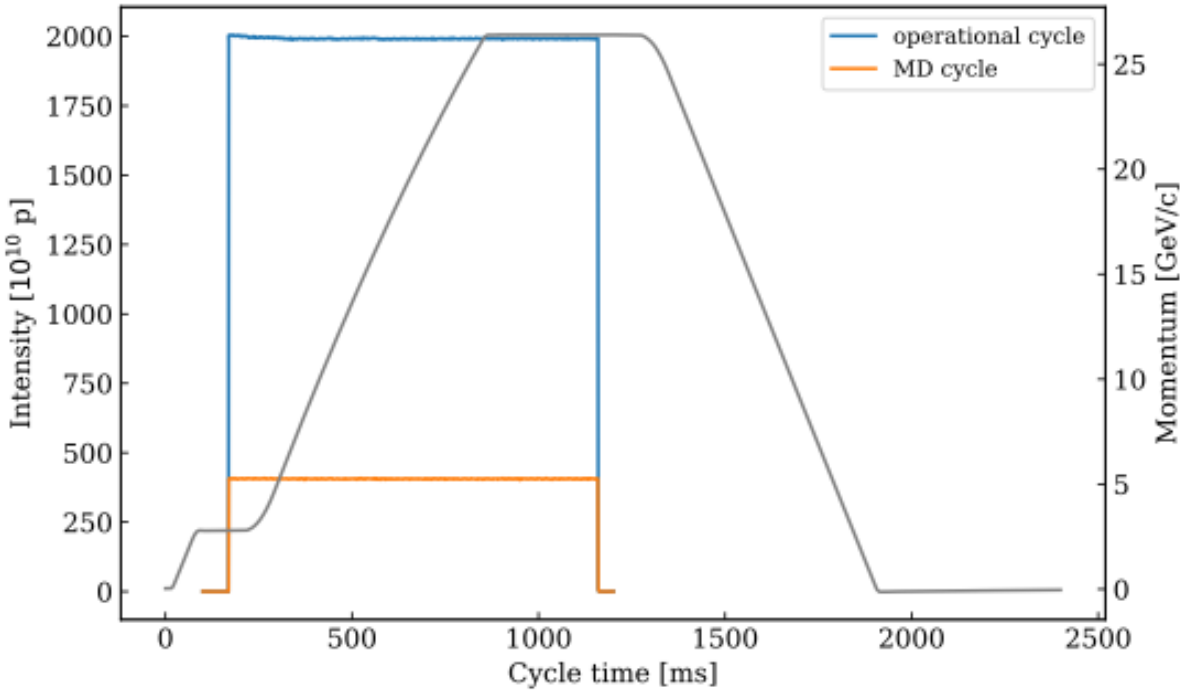
- **Studies to improve the antiproton yield**
  - Several studies performed to investigate dependency of the yield on the beam size on target
  - Again, mainly modifying the optics in the transfer lines

- **Above points motivated MDs in the ring to evaluate beam quality at extraction**
  - Especially looking at the conservation of transverse emittances along the cycle
  - Three different brightness variants prepared by Foteini in the PSB

[1] Y. Dutheil, "Losses in FTA, optimisation or reconfiguration", IPP, 26 April 2024

MD12943_AD_24 cycle preparation

- **Started from the operational MD cycle**
  - Taking only single bunch from PSB R4



MD12943_AD_24

- **Started from the operational MD cycle**
  - Taking only single bunch from PSB R4
  - 3 different tags available in PSB to adjust brightness (low, intermediate and nominal emittance)

Low emittance

ε_h [mm.mrad]	ε_v [mm.mrad]
2.637	2.388
2.674	2.738
6.517	5.895
2.658	2.867

Intermediate emittance

ε_h [mm.mrad]	ε_v [mm.mrad]
3.214	3.397
3.305	3.56
6.571	5.975
3.537	3.836

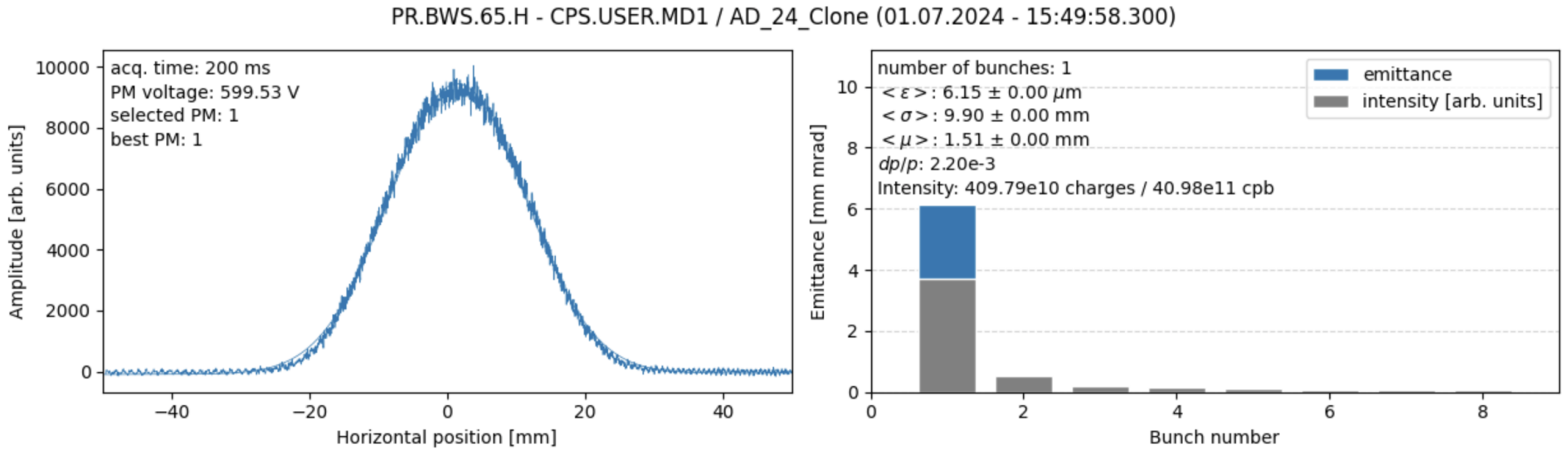
Nominal emittance

ε_h [mm.mrad]	ε_v [mm.mrad]
4.811	4.22
4.628	4.168
6.457	5.885
4.885	4.622

Logbook entry 01.07.2024

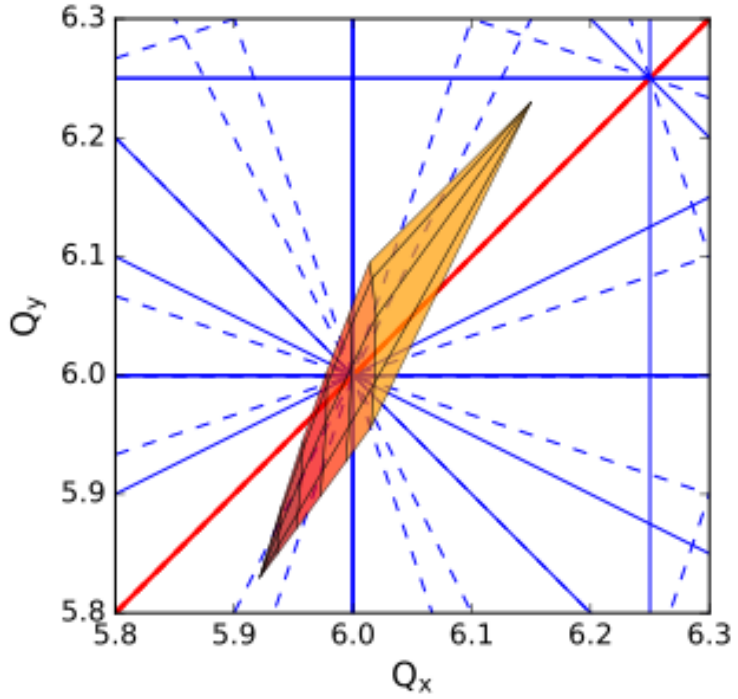
MD12943_AD_24

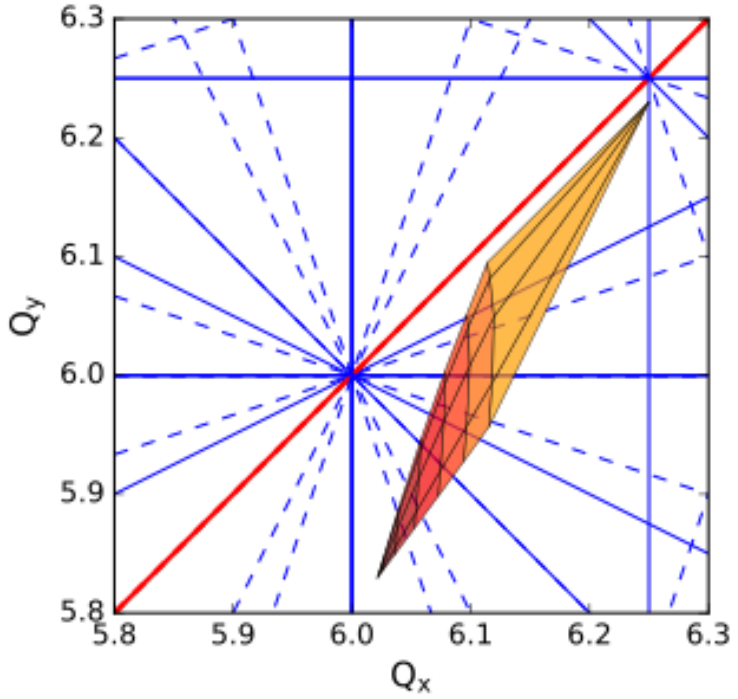
- **Started from the operational MD cycle**
  - Taking only single bunch from PSB R4
  - 3 different tags available in PSB to adjust brightness (low, intermediate and nominal emittance)
- **Continued MD with low-emittance tag**
  - Significant horizontal blow-up measured in the PS (vertical plane not verified at the time)

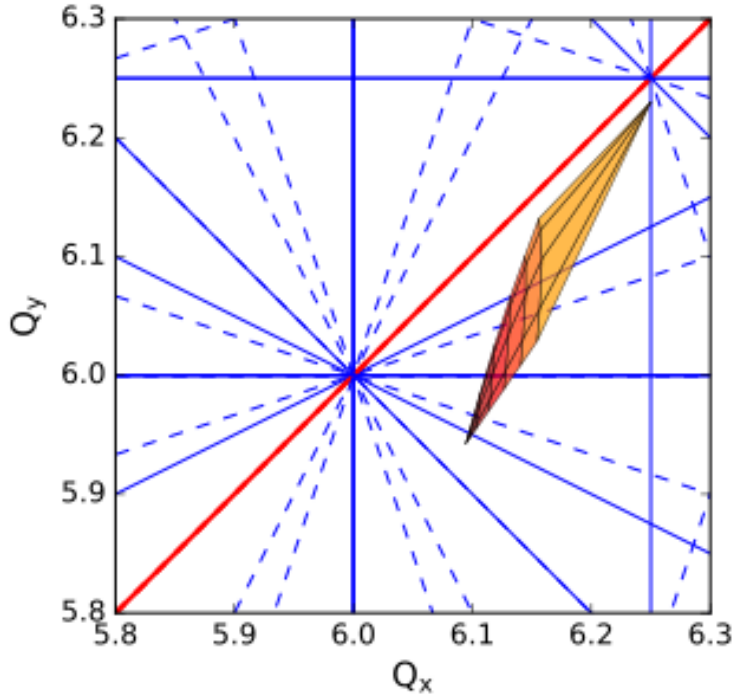


MD12943_AD_24

- **Large space charge tune spread of AD-beam with low emittance tag**
  - Mitigation:
    - adjusted horizontal tune (no margin to adjust vertical tune)
    - introduced additional (intermediate) plateau

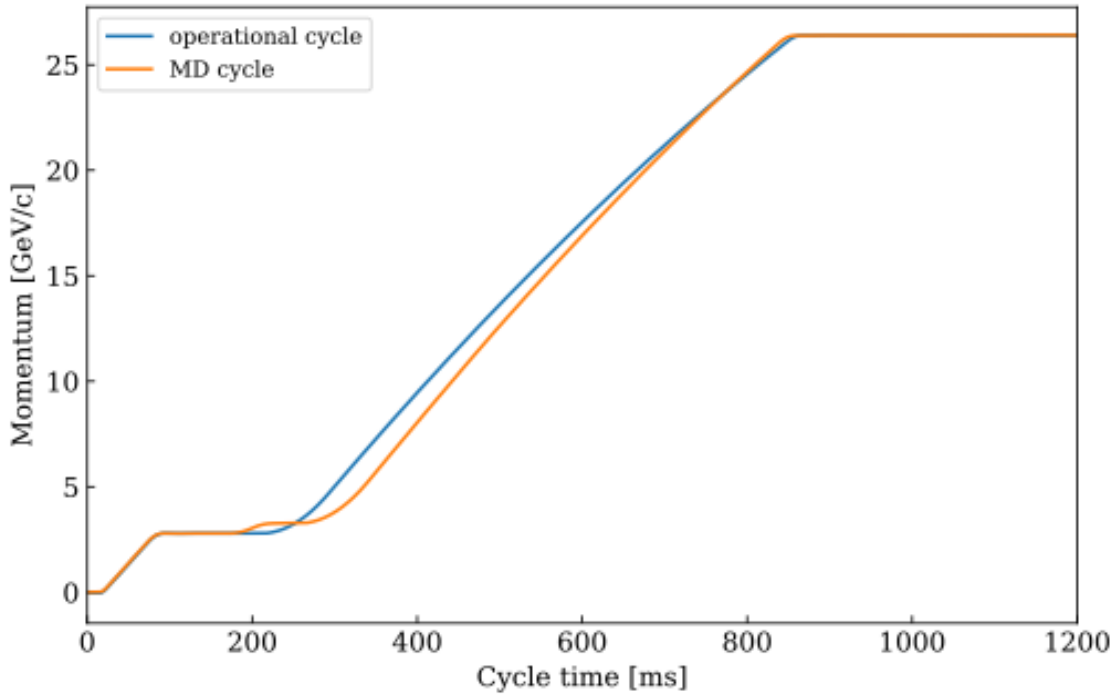






MD12943_AD_24 – intermediate plateau

- **Large space charge tune spread of AD-beam with low emittance tag**
  - Mitigation:
    - adjusted horizontal tune (no margin to adjust vertical tune)
    - introduced additional (intermediate) plateau



Comparative emittance measurements

- **Large space charge tune spread of AD-beam with low emittance tag**
  - Mitigation:
    - adjusted horizontal tune (no margin to adjust vertical tune)
    - introduced additional (intermediate) plateau
    - transverse emittance preservation significantly improved using single bunch from R4

Measurement at C1135	Operational cycle	MD cycle
Horizontal emittance [mm mrad]	**8.4**	**3.5**
Vertical emittance [mm mrad]	**4.3**	**3.4**

Logbook entry 01.07.2024

Comparative emittance measurements

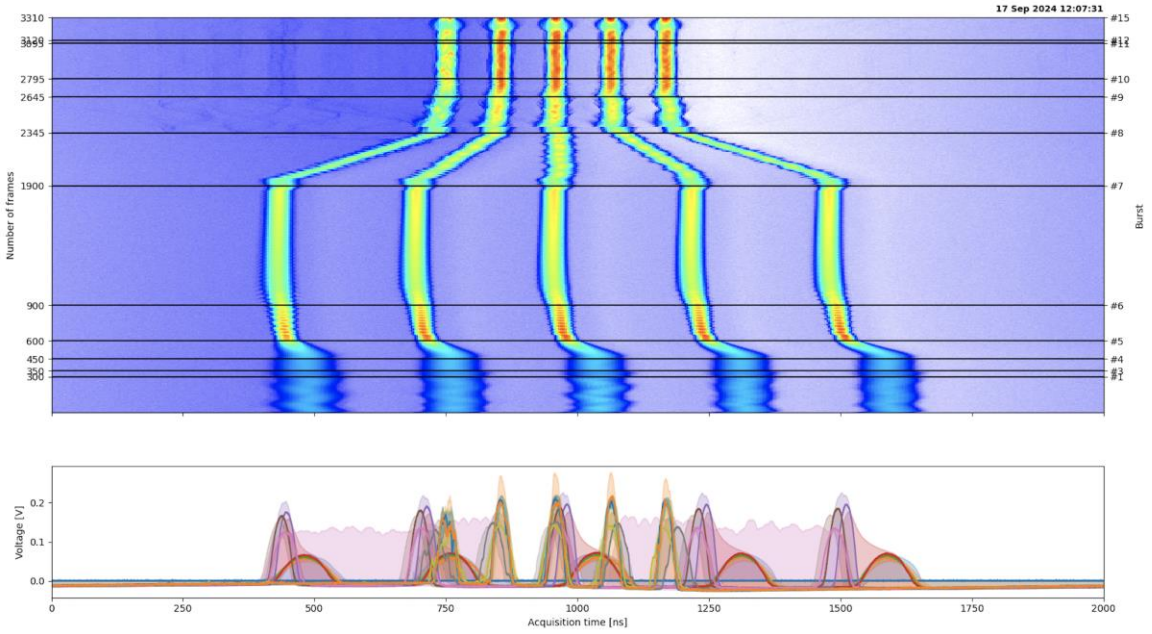
- **Large space charge tune spread of AD-beam with low emittance tag**
  - Mitigation:
    - adjusted horizontal tune (no margin to adjust vertical tune)
    - introduced additional (intermediate) plateau
    - transverse emittance preservation significantly improved using single bunch from R4
      - **however**: improvement **could not be reproduced** a few weeks later / **source of discrepancy not understood**

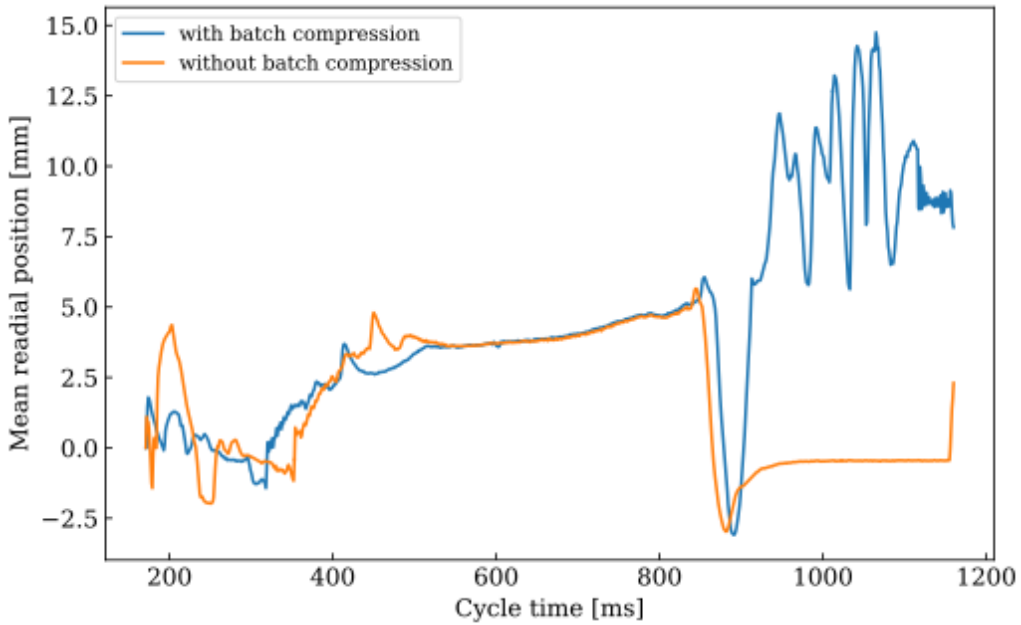
Measurement at C1135	Operational cycle	MD cycle
Horizontal emittance [mm mrad]	**8.4**	**8.5**
Vertical emittance [mm mrad]	**4.3**	**3.6**

Logbook entry 25.07.2024

Impact of the batch compression

- BC to reduce bunch spacing before extraction to the AD (final bunch spacing 105 ns)
- Important variations of the mean radial position after synchronization and during BC





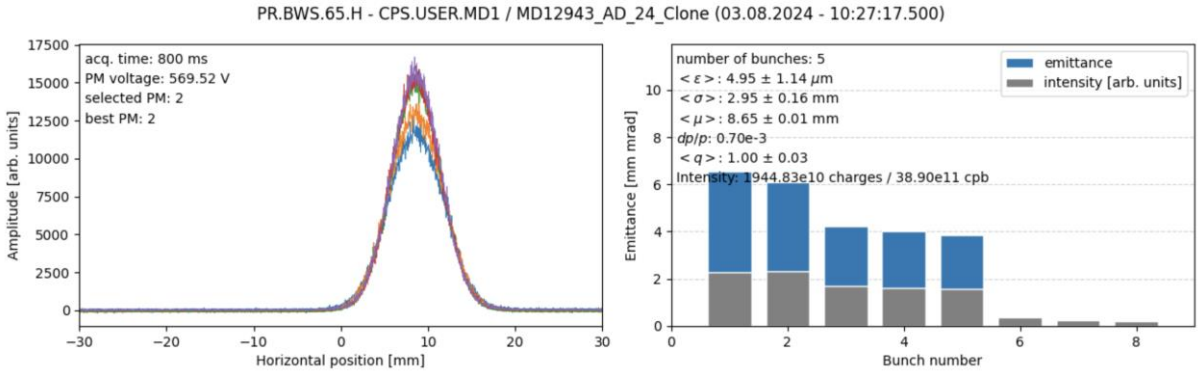
Impact of the batch compression

- BC to reduce bunch spacing before extraction to the AD (final bunch spacing 105 ns)
- Important variations of the mean radial position after synchronization and during BC

→ **significant horizontal emittance blow-up observed**

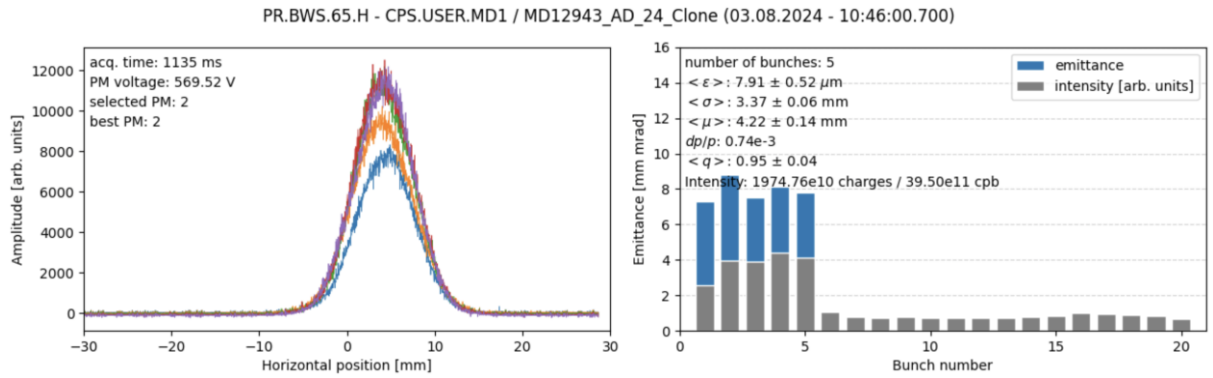
→ **emittance blow-up absent without BC**

- to be checked: impact of **variation of long. emittance** between bunches

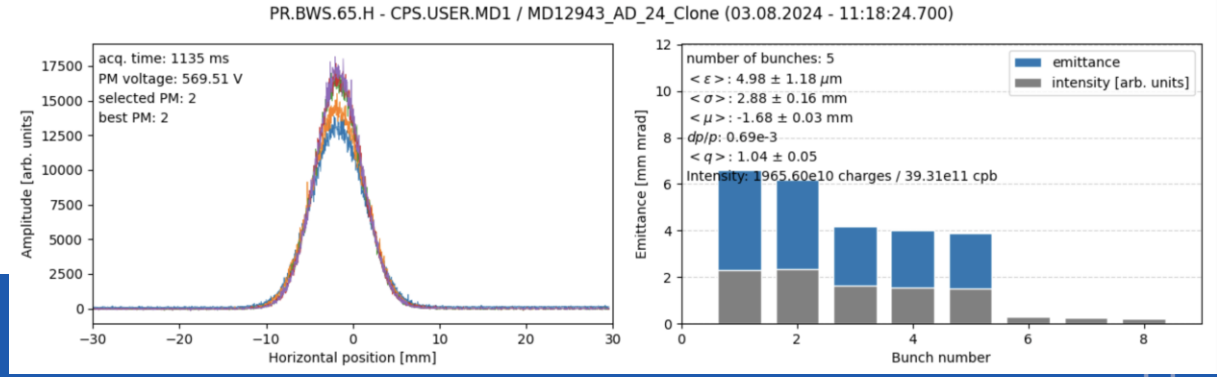


C800, before flat top

C1135 with BC



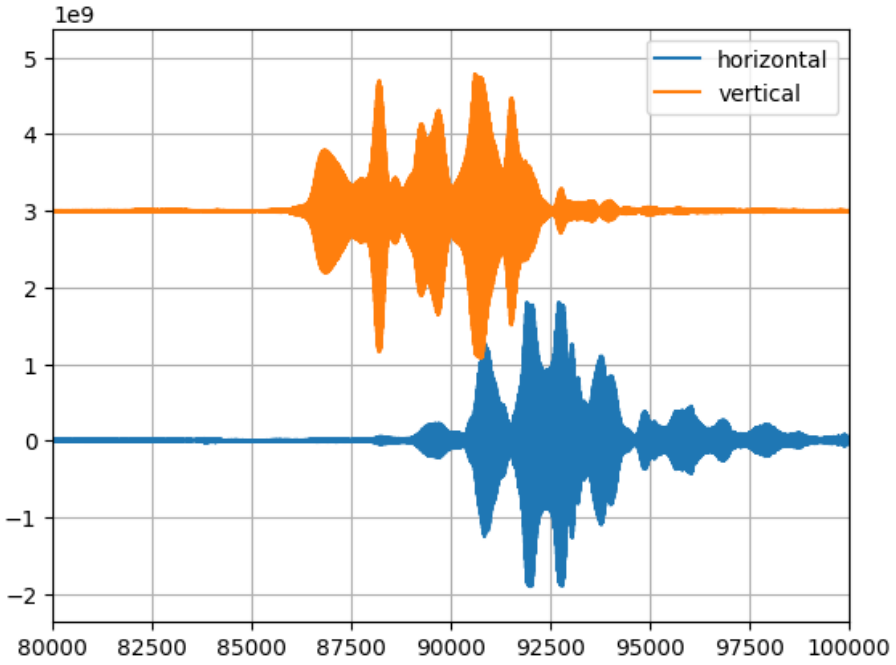
C1135 without BC

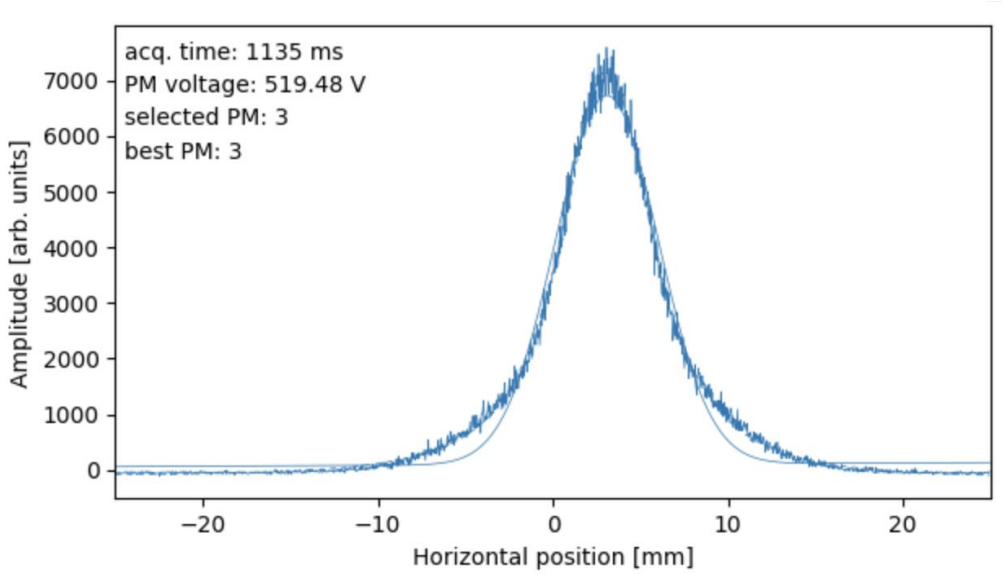


Logbook entry 01.08.2024

Large shot-to-shot variations of horizontal emittance at flat top

- **Horizontal instability** during the ramp **cured** by adjusting **horizontal chromaticity**

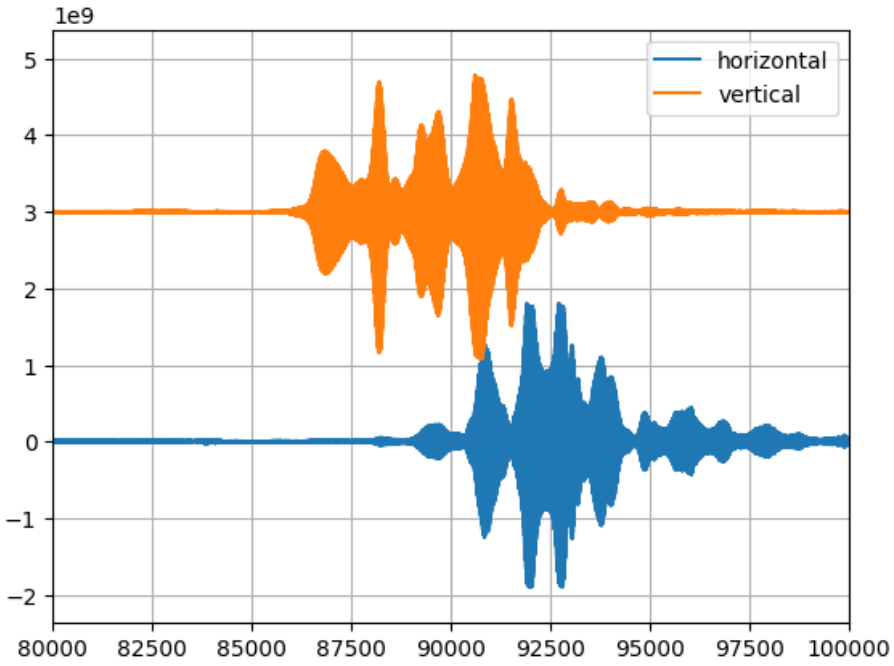


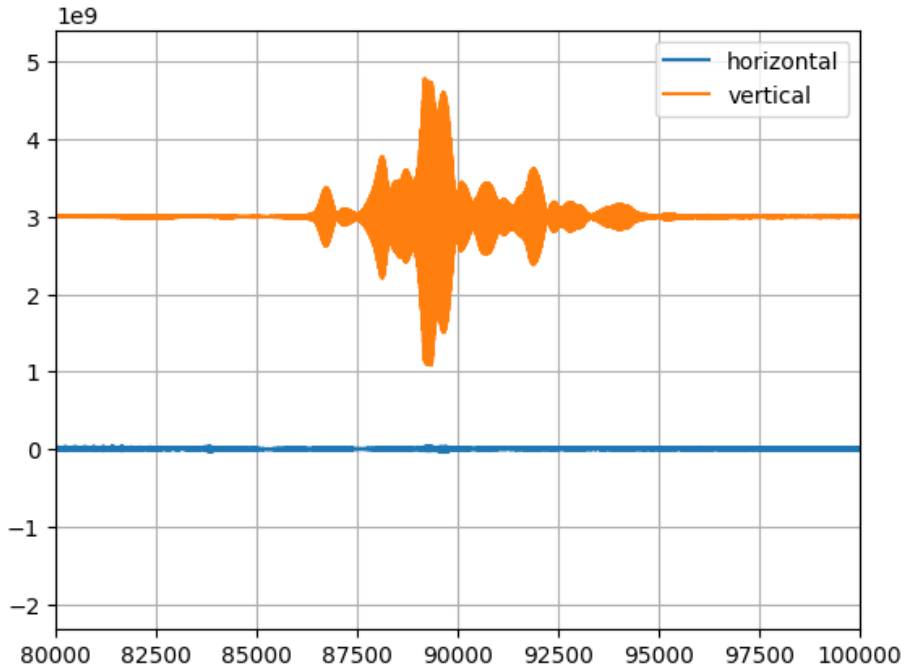


Logbook entry 02.08.2024

Large shot-to-shot variations of horizontal emittance at flat top

- **Horizontal instability** during the ramp **cured** by adjusting **horizontal chromaticity**
- Reduction of vertical oscillations by increasing longitudinal blow-up
  - complete suppression not possible
  - however, no significant fluctuation of vertical emittances observed





Logbook entry 02.08.2024

Conclusions

- **Transverse beam parameters for the AD beam in the PS: room for improvement**
  - Clear indication of emittance blow-up during the batch compression
  - Somewhat conflicting results between single and multi-bunch measurements

- **Plans for 2025**
  - Perform additional MDs, ensuring transverse stability from the beginning
  - Repeat observations with and without batch compression
    - Profit from automated bunch-by-bunch tomography for correct bunch-by-bunch emittance measurements
    - Evaluate the impact of the different harmonic changes along the batch compression on the emittance growth