Along the Chain MDs: Tail Studies

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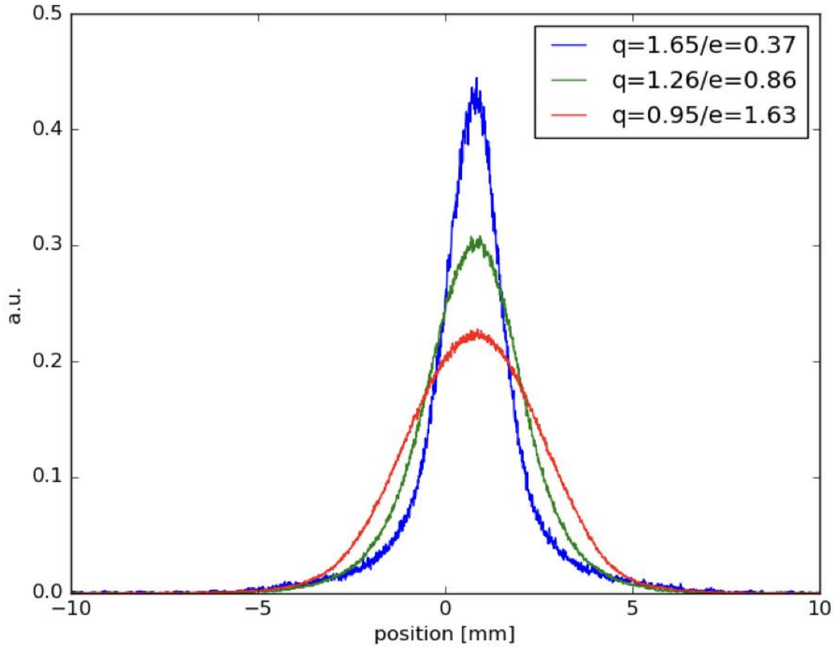
Motivation

- *Large non-Gaussian tails created in the LHC injectors propagate to the LHC and contribute to losses and affect luminosity production*
- *Efforts have been made to limit this tail population along the injector chain*

LINAC 4

Impact of L4 distribution (F. Asvesta IPP 02/08/2024)

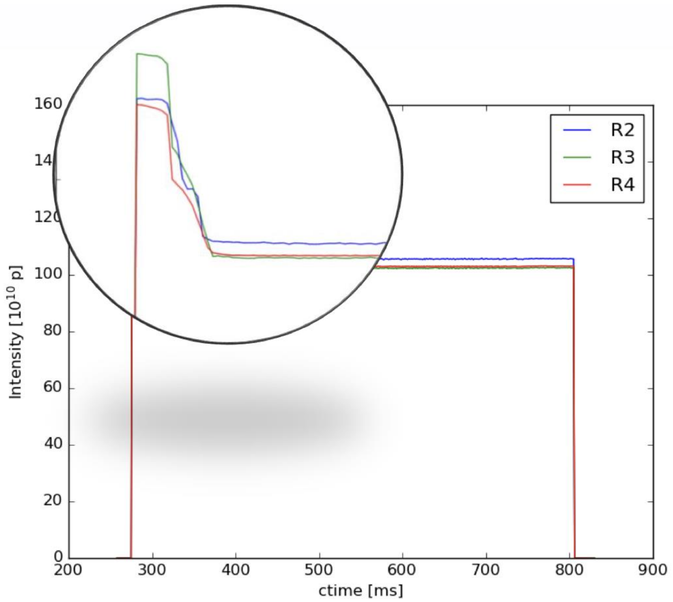
- *Transverse distribution measurements in PSB R1, at different parts of the L4 pulse, while minimizing Δp/p. Tails increase as we move on the pulse*
- *Larger energy spread show more populated tails*
- *For high intensities injected in the PSB, we start getting PSB effects blowing up the emittance, hiding the tails in terms of q-factor.*
  - Tail extend is still dominated by L4 distribution

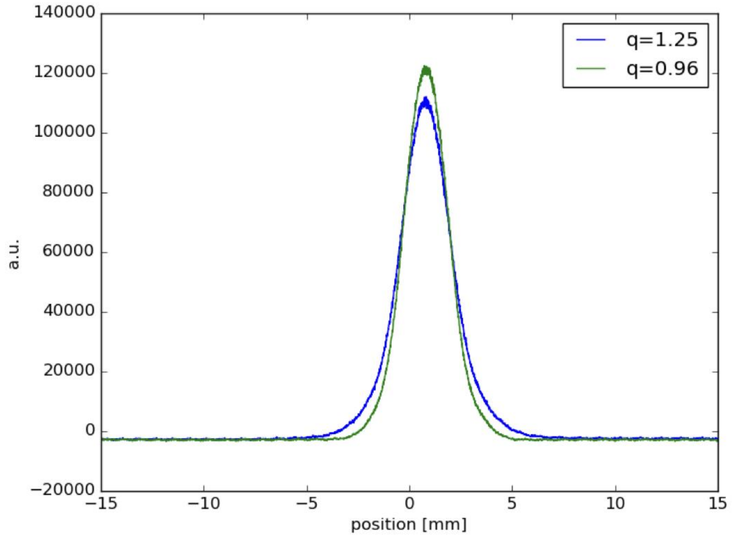


Optimization on the PSB

Scraping on PSB at injection energy

- Scraping at PSB with transmission reduction of ~10%
- The tails are not repopulated after scraping during the PSB cycle, due to careful working point evolution and updated resonance compensation settings.
  - ➡ Gaussian profiles are provided at PS injection

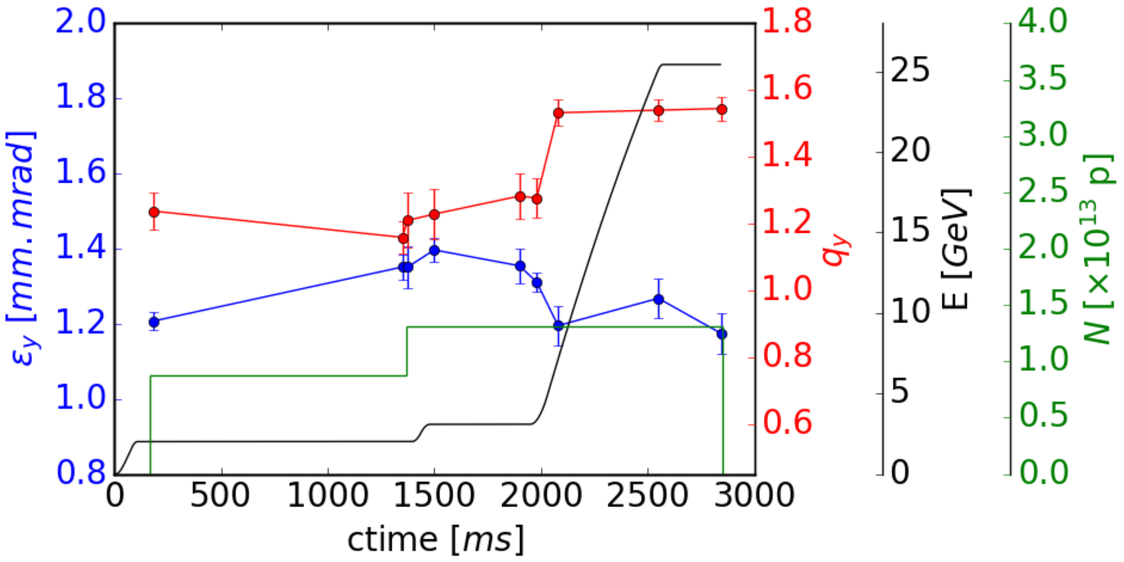


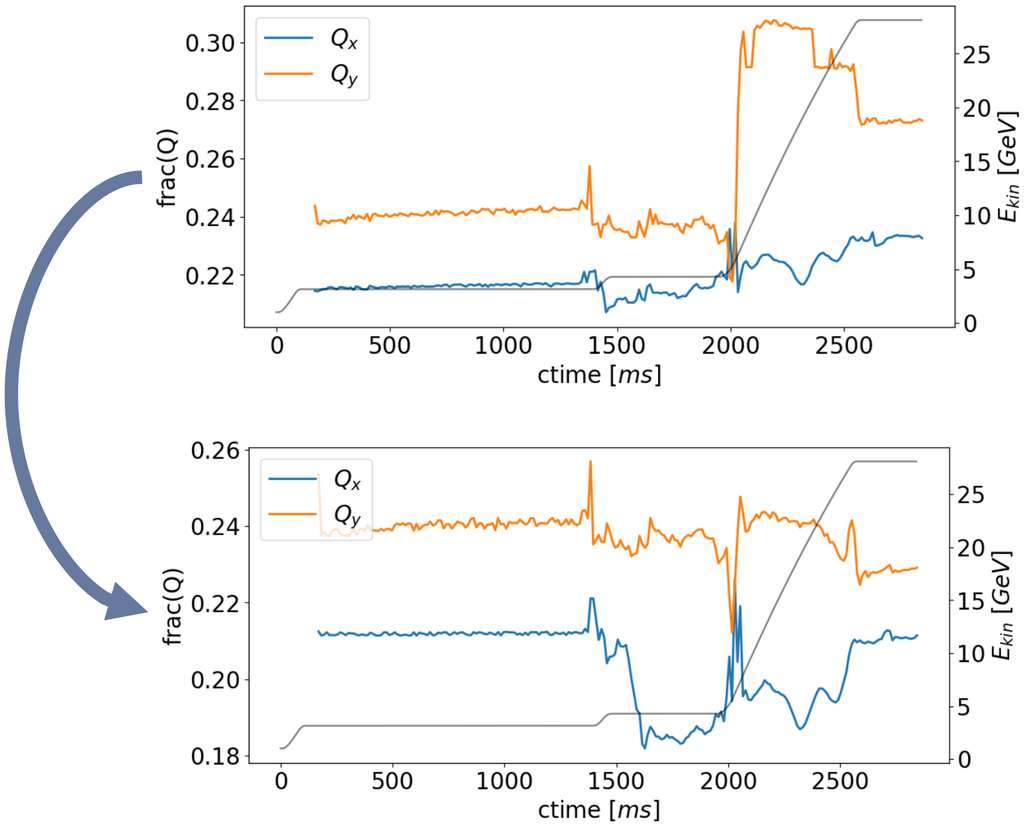


Tune Optimization on PS

Major tail population increase

- *Vertical tail increase during transition crossing with a 20% increase of the q-factor*
- *Working point optimization during transition crossing*

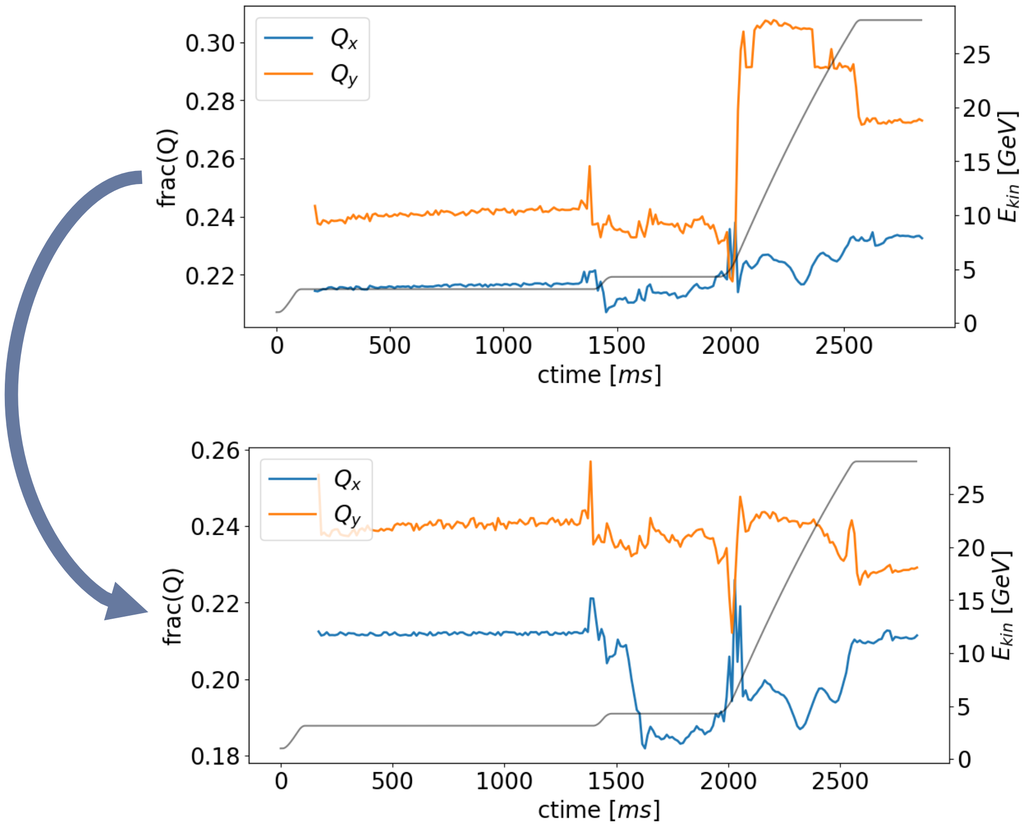




Tune Optimization on PS

Working point optimization

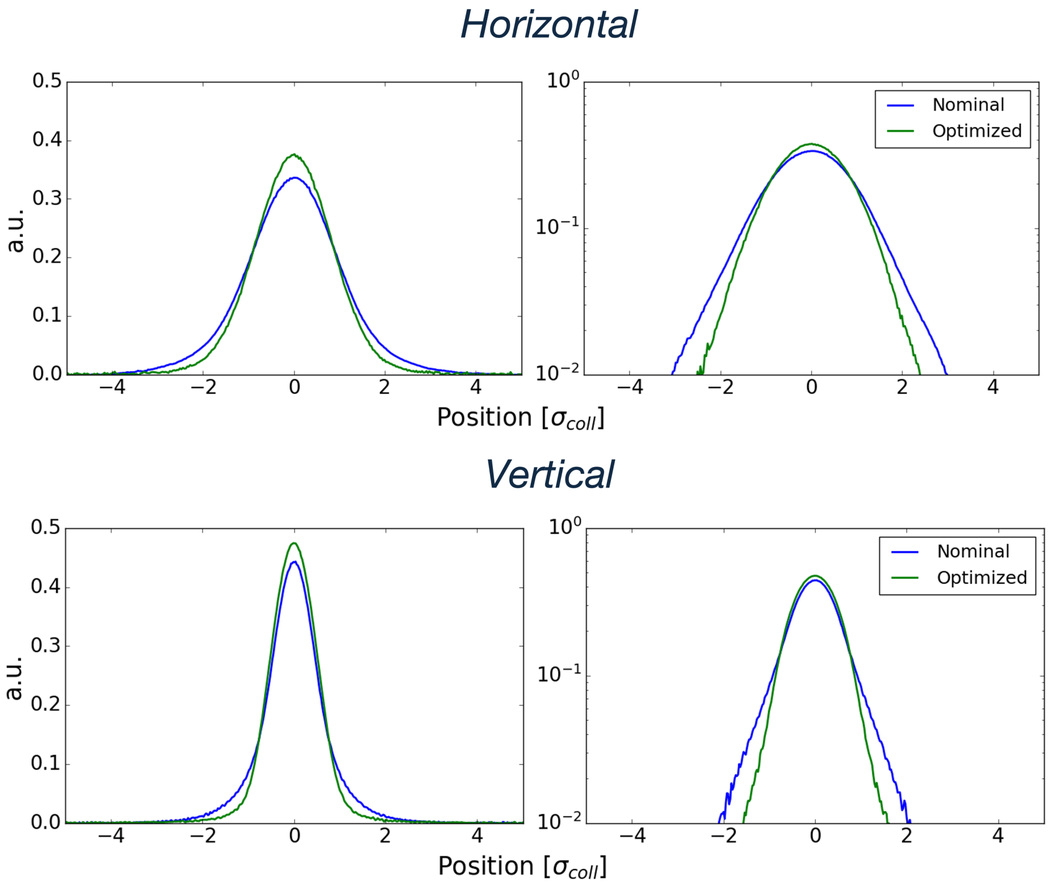
- Decrease horizontal tune before and during transition to avoid horizontal – vertical coupling
- Decrease vertical tune after transition to avoid drift to higher order resonances



Tune Optimization on PS

Working point optimization

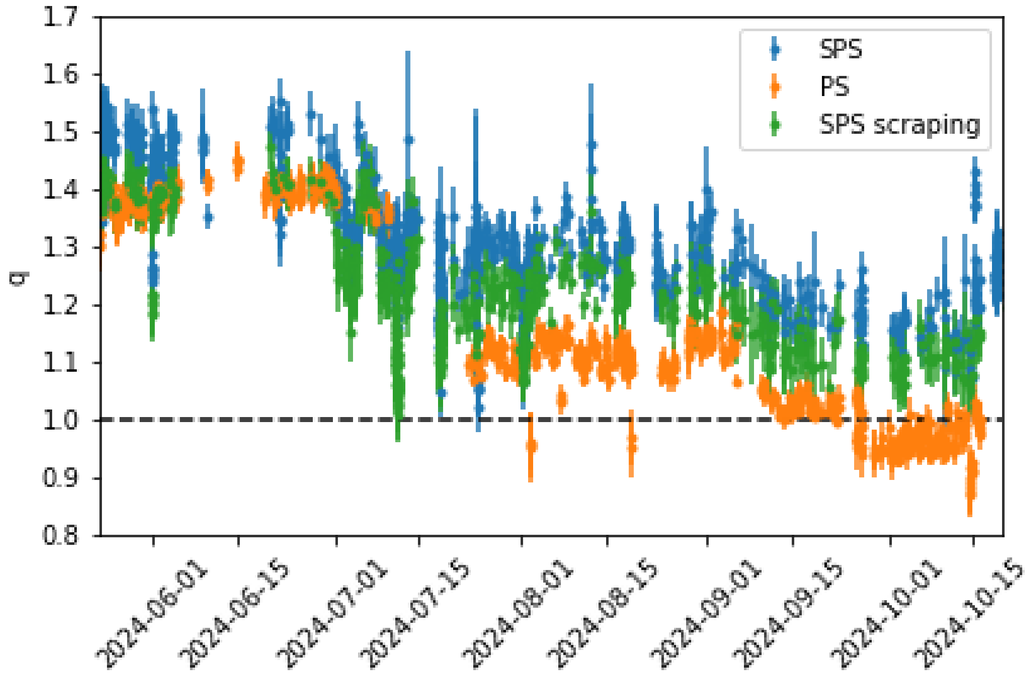
- Decrease horizontal tune before and during transition to avoid horizontal – vertical coupling
- Decrease vertical tune after transition to avoid drift to higher order resonances
- Tails and emittances at PS extraction after the optimization:
  - H: $\varepsilon_x = 0.79$, $q_x = 1.06$
  - V: $\varepsilon_y = 0.86$, $q_y = 1.01$



Tails at SPS

Tail population from PS to SPS

- *Tail population from PS to SPS and during the SPS cycle*
- *For profiles with less populated tails from the PS, the difference with the SPS is larger*
- *This growth needs to be followed-up with MDs during 2025*
- *Scraping at SPS to minimize these generated tails*

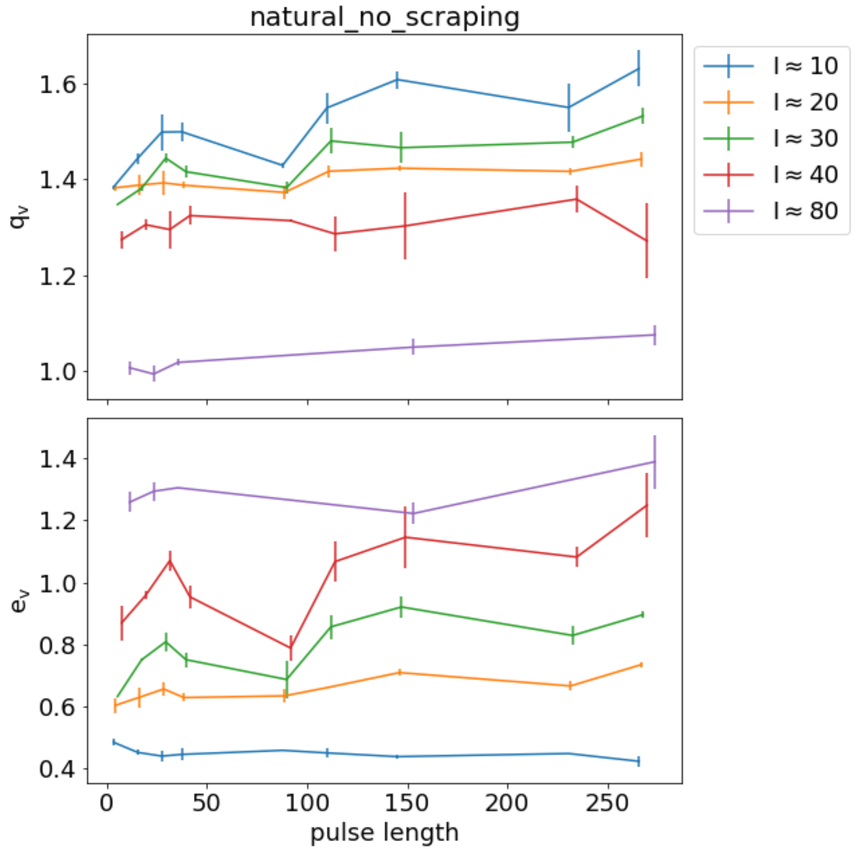


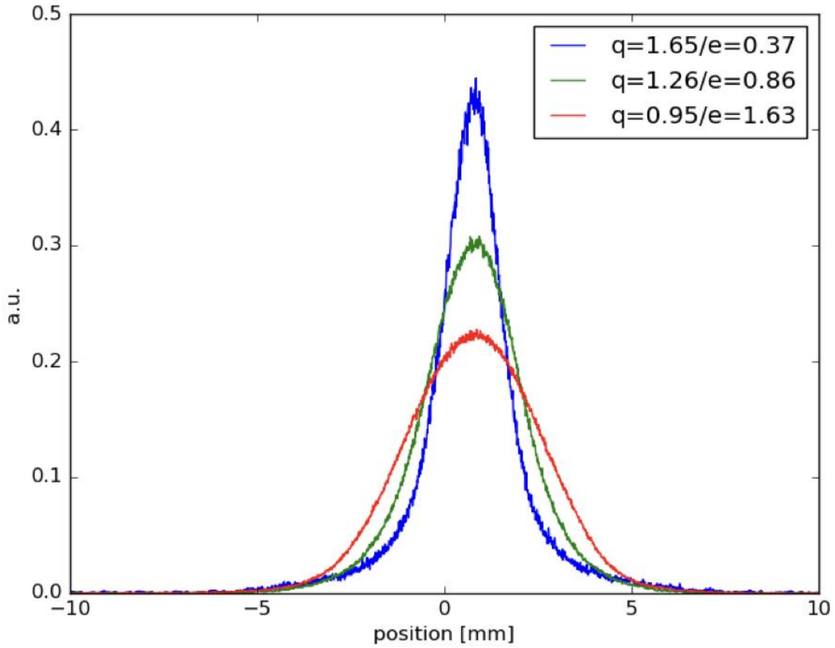
Overview

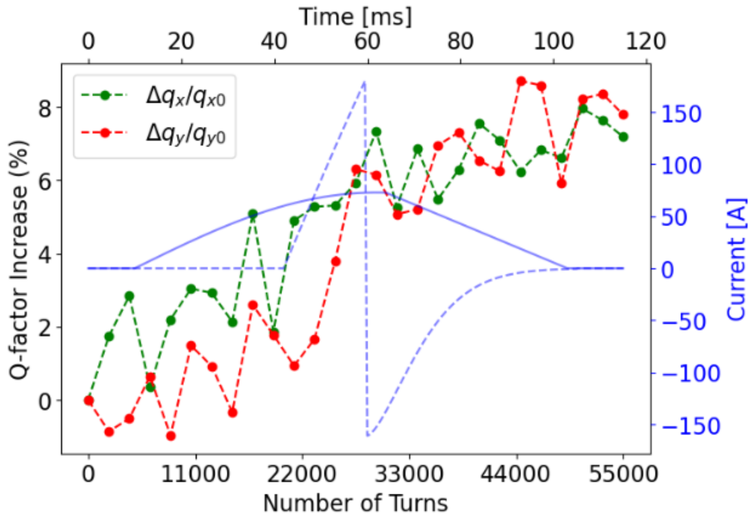
- *Efforts to minimize non-Gaussian tail population for better performance in the injectors and the LHC*
- *On LINAC4, larger energy spreads show more populated tails. Need of follow-up studies along the L4 pulse with the higher current configuration*
- *With scraping at PSB injection, the booster could provide Gaussian beams at PS injection*
- *The large tail population increase at the PS during transition energy crossing was limited after working point optimizations, maintaining almost Gaussian profiles*
- *Tail increase from PS to SPS and during the SPS cycle that needs to be followed-up with MDs during 2025*

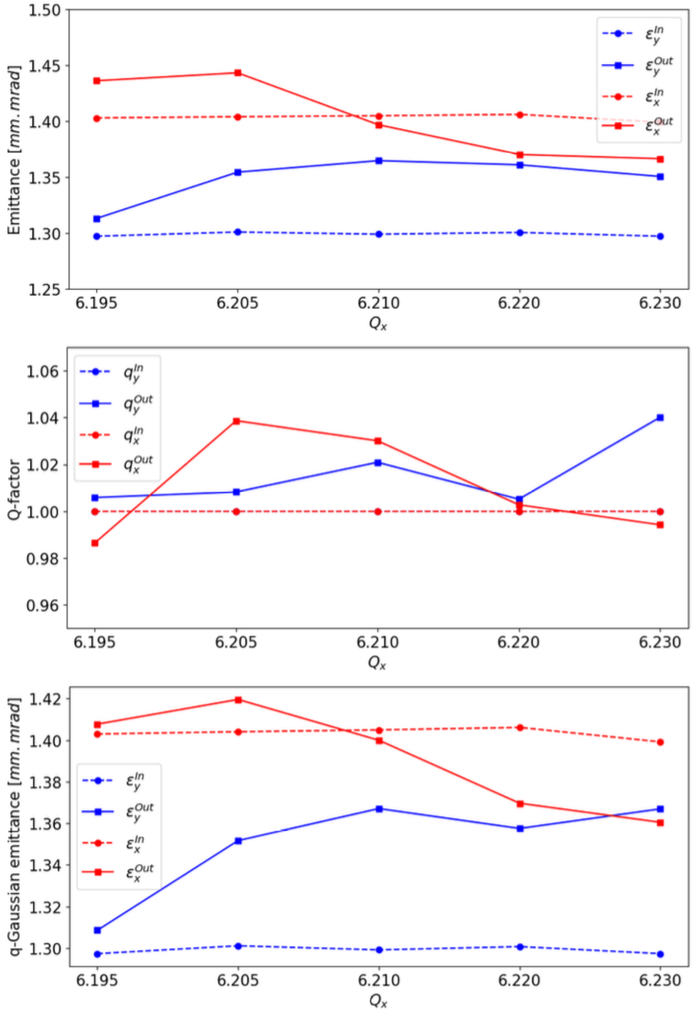
Thank you for your attention!

Backup Slides


natural_no_scraping
I ≈ 10
I ≈ 20
I ≈ 30
I ≈ 40
I ≈ 80
q_v
e_v
pulse length


q=1.65/e=0.37
q=1.26/e=0.86
q=0.95/e=1.63
a.u.
position [mm]


Time [ms]
0
20
40
60
80
100
120
$\Delta q_x/q_{x0}$
$\Delta q_y/q_{y0}$
Q-factor Increase (%)
Current [A]
Number of Turns
0
11000
22000
33000
44000
55000


Emittance [mm. mrad]
ε_y^{In}
ε_y^{Out}
ε_x^{In}
ε_x^{Out}
Q_x
Q-factor
q_y^{In}
q_y^{Out}
q_x^{In}
q_x^{Out}
q-Gaussian emittance [mm. mrad]
6.195
6.205
6.210
6.220
6.230