

Injection Chicane Beta-Beating Correction for Enhancing the Brightness of the CERN PSB Beams

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Introduction

Š A new **charge exchange injection system** [1] was developed for the CERN PS Booster (PSB) in the context of the LHC Injectors Upgrade Project (LIU) [2].

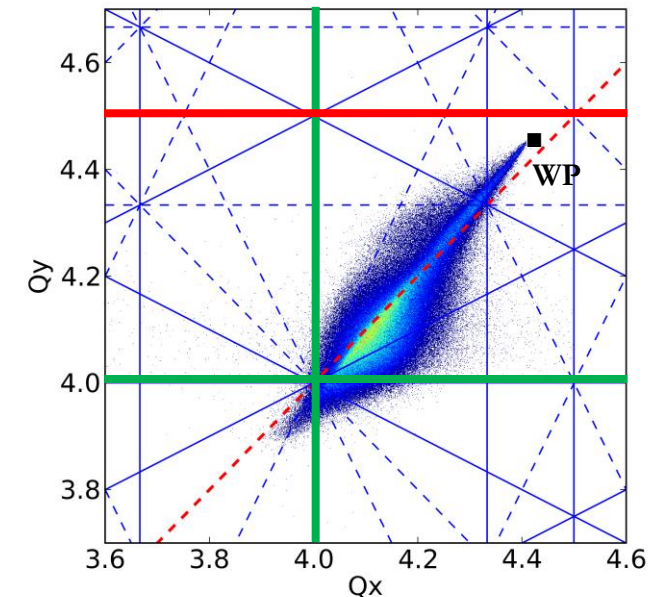
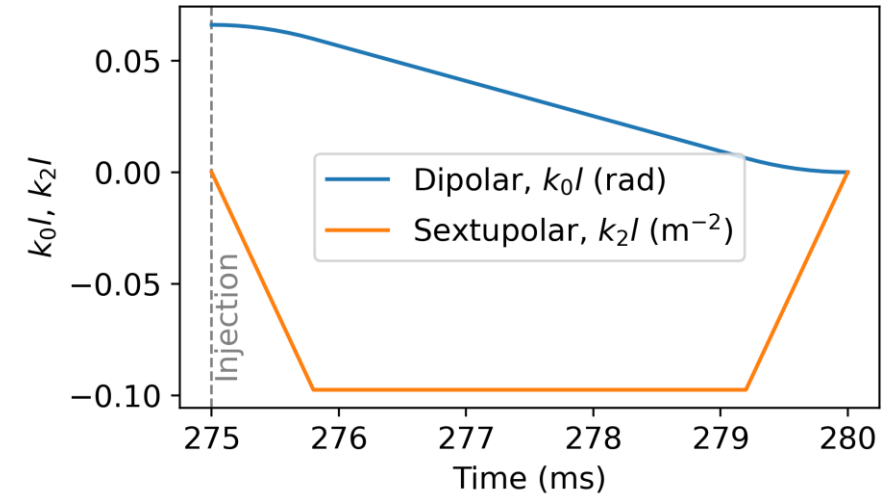
Š The injection chicane magnets induce strong **focusing errors** in the vertical plane [3]:

- i. through **edge focusing**,
- ii. and eddy currents in the vacuum chamber → generate a sextupolar component → beam enters with an offset → **feed-down effects**.

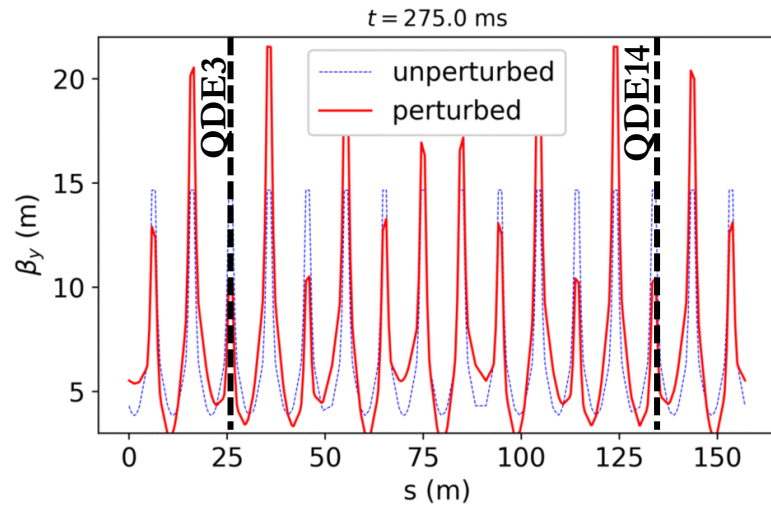
Š The achievable beam brightness in the PSB is limited by the space charge effects at injection [4]:

- tune spread can exceed values % [5]
- to avoid beam degradation due to the **integer resonances**, the machine is operated with working points (**WP**) very close to the **half-integer resonance**.

Š The focusing errors induce optics perturbations (**β -beating and tune distortions**) in the vertical plane which are **strongly enhanced** in the proximity of the half-integer resonance and can lead to **beam losses**.

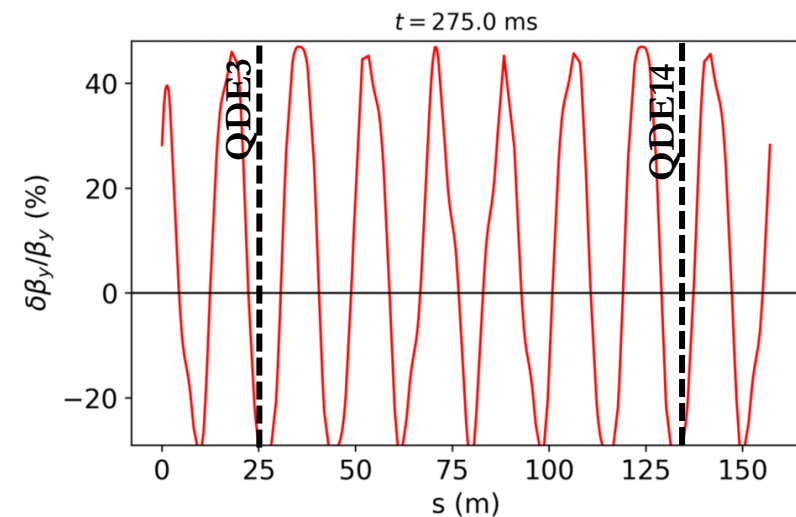
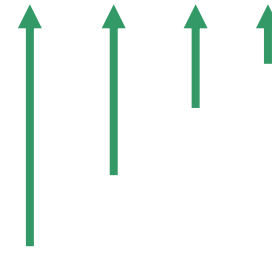


Simulations of the PSB Injection Chicane Optics Perturbations

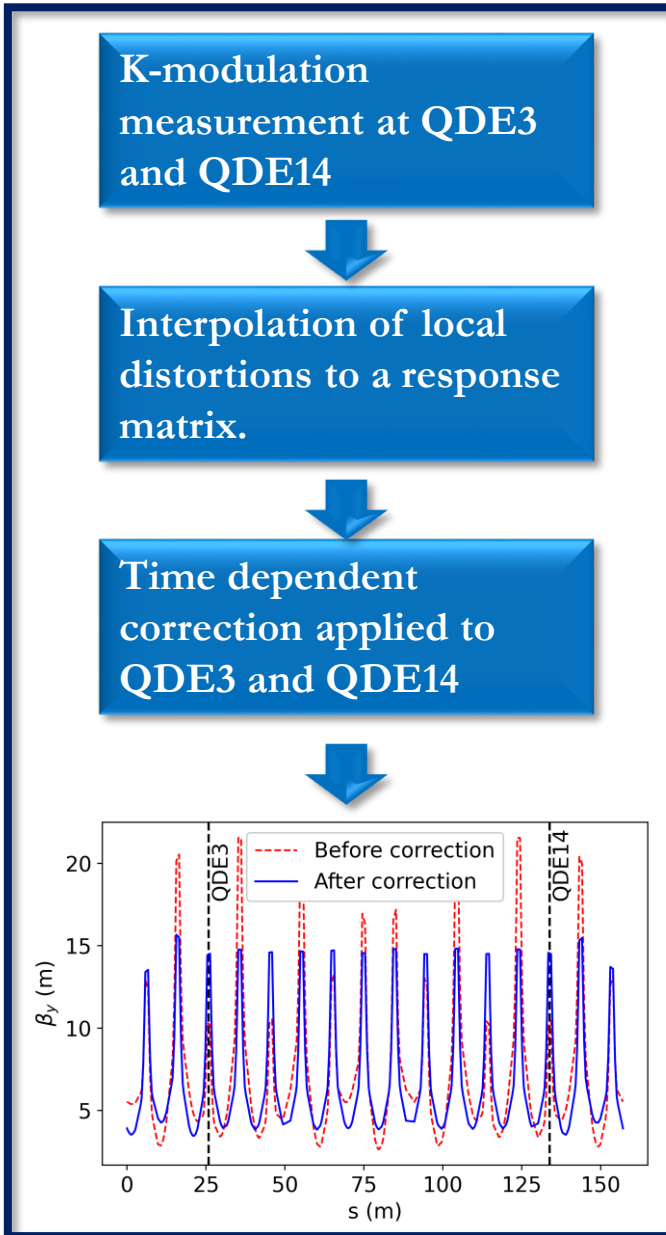


Š The β_y -beating **dynamically changes** during this collapse of the injection chicane.

Š β_y -beating is dynamically **compensated by correcting the local distortions** at the position of two individually powered quadrupoles (**QDE3 and QDE14**) [6].

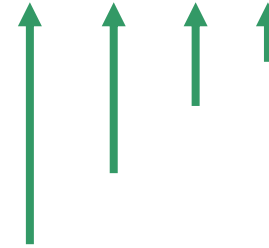


Simulations of the PSB Injection Chicane Optics Perturbations



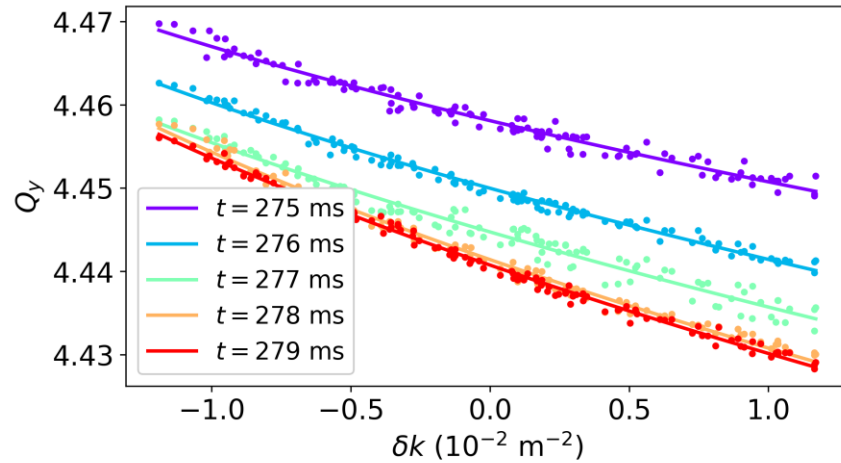
- Š The β -beating **dynamically changes** during this collapse of the injection chicane.
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Extensive
simulation
studies
[7,8]



- Š Local β distortions at QDE3 and QDE14 measured with **K-modulation**.
- Š The dynamic β -beating **correction strengths** are calculated by interpolating the local distortions to a **response matrix** and then applied to QDE3 and QDE14.

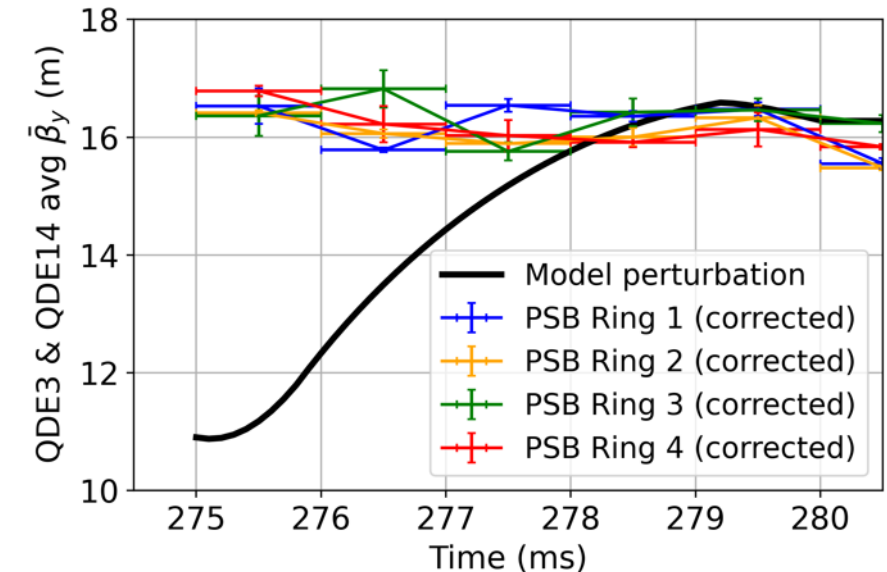
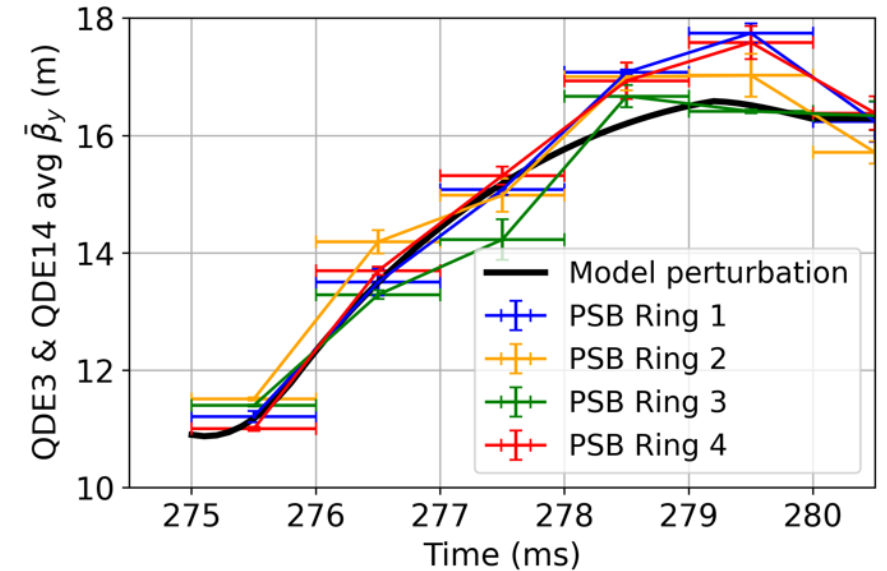
β -beating Measurement and Correction at the Injection of the PSB



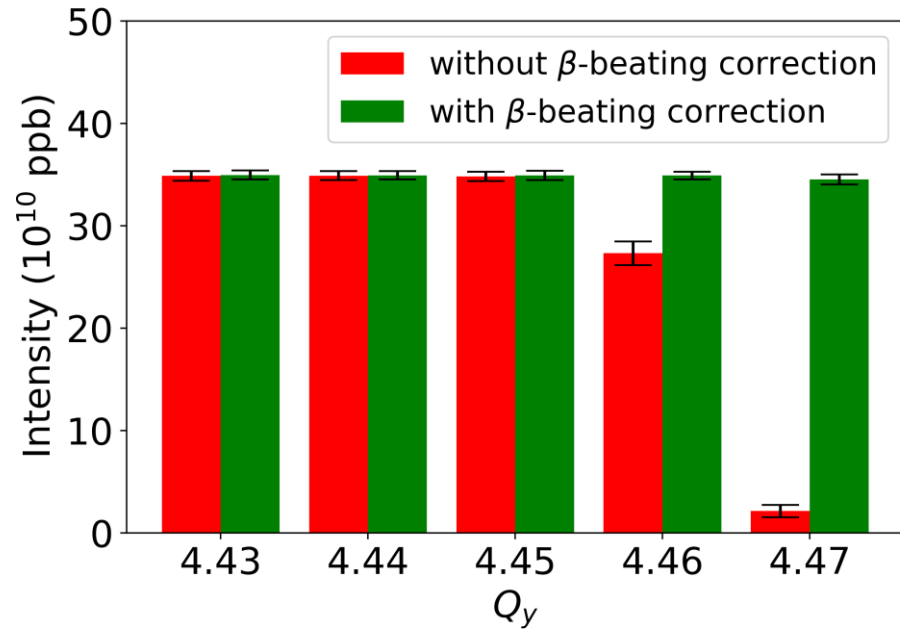
Š Measurement of the β -function at QDE3 with k-modulation. Similar results for QDE14 and also for the other rings of the PSB.

Š Average QDE3 & QDE14 local β distortions for all rings: **excellent agreement between the expected and the measured perturbation** → good modelling of the injection chicane error sources and the machine lattice.

Š After correction applied: β -function remains constant and close to the unperturbed value → **dynamic correction of the β -beating** throughout the fall of the chicane.

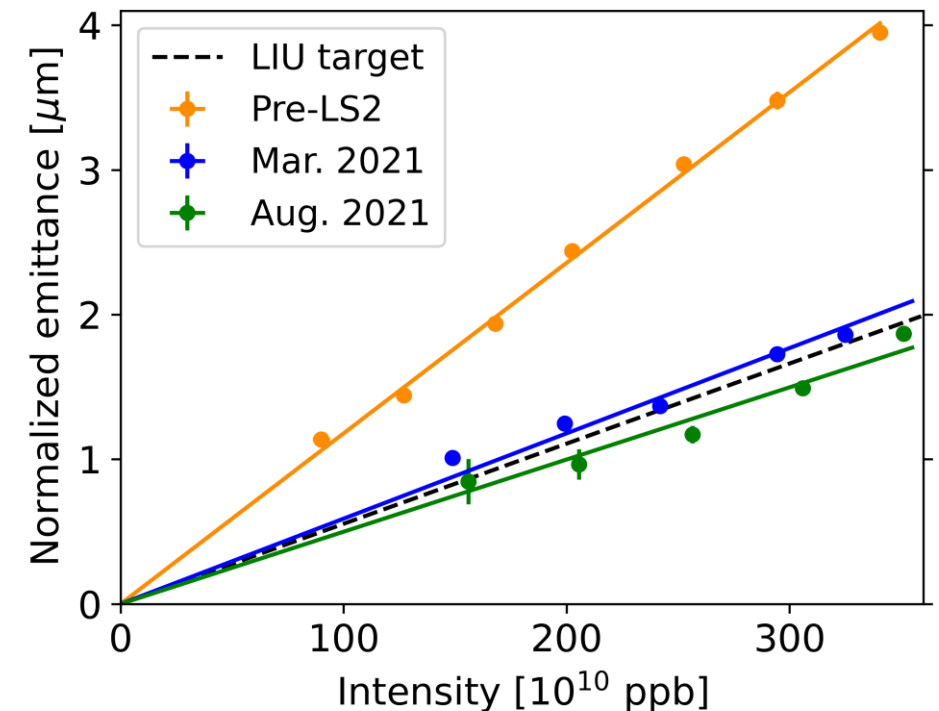


Impact on Beam Parameters



- Š Correction of the β -beating: allowed the **stable beam operation much closer to the half-integer resonance**.
- Š Working points closer to the half-integer resonance, i.e. further away from the integer resonance: **smaller emittance blow-up** for the same intensity and space charge tune spread.

Š β -beating correction, resonance correction scheme improvements [9], working point and tune evolution optimization: **beam brightness gain at extraction of the PSB (green points)**



Conclusions and Outlook

- Š Strong vertical **-beating is induced by the magnets of the H⁻ injection chicane** after the LIU upgrades in the PSB.
- Š The injection chicane **-beating was measured using k-modulation at the expected levels** and then **dynamically corrected** using the defocusing quadrupoles QDE3 and QDE14.
- Š The correction allowed a stable operation of the beam with working points closer to the half-integer resonance **which mitigated the interaction of the beam with the integer resonance**, contributing to an **increased beam brightness**.
- Ø Work to inject above the half-integer resonance without considerable beam degradation to further increase the brightness is ongoing.

Thank you for your attention!

References

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