Optics measurements during transition crossing in the PS

12/11/2024
OMC meeting

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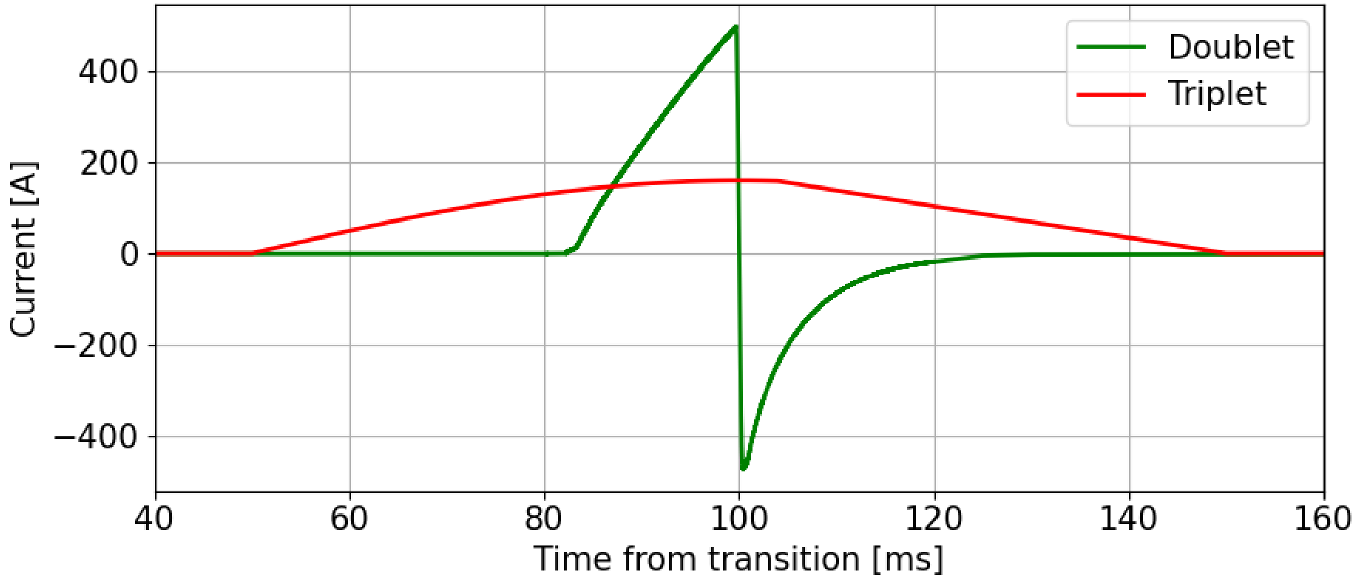
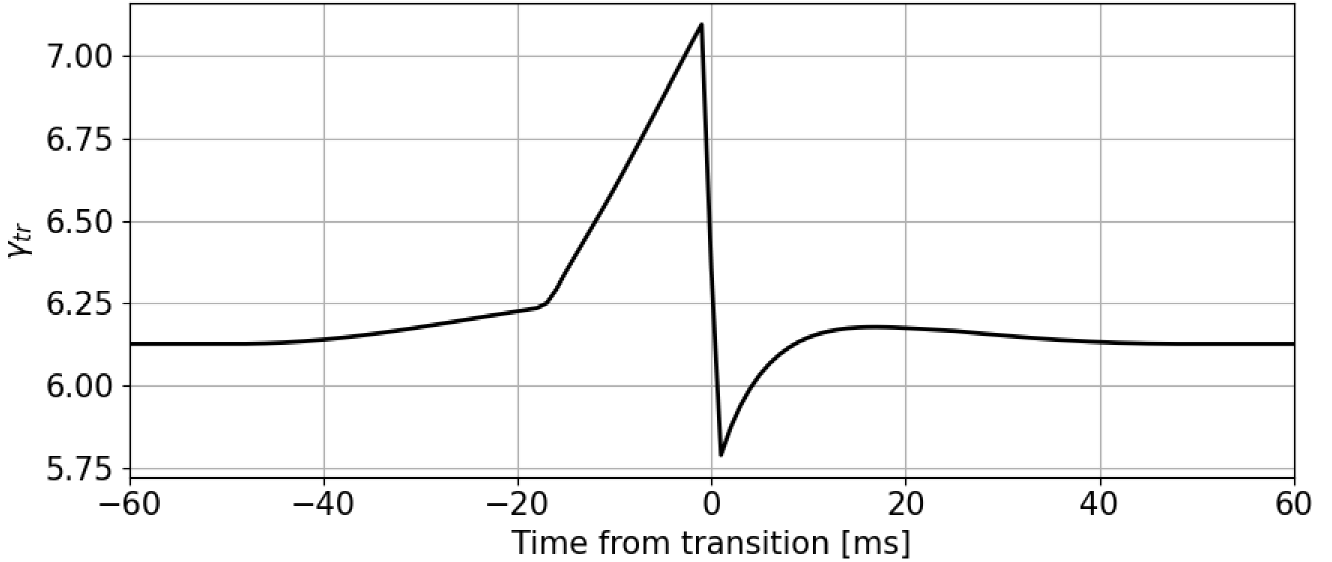
M. Bozatzis, E. Maclean, PS OP

Gamma-jump scheme





- **Doublet** and **triplet** quadrupoles powered to change the γ_{tr} for stability during transition crossing (gamma-jump scheme).
- Goal: **measure the induced optics perturbations.**
- Gamma-jump scheme was **scaled down and applied at PS flat-bottom (FB)** (thanks to Ewen).

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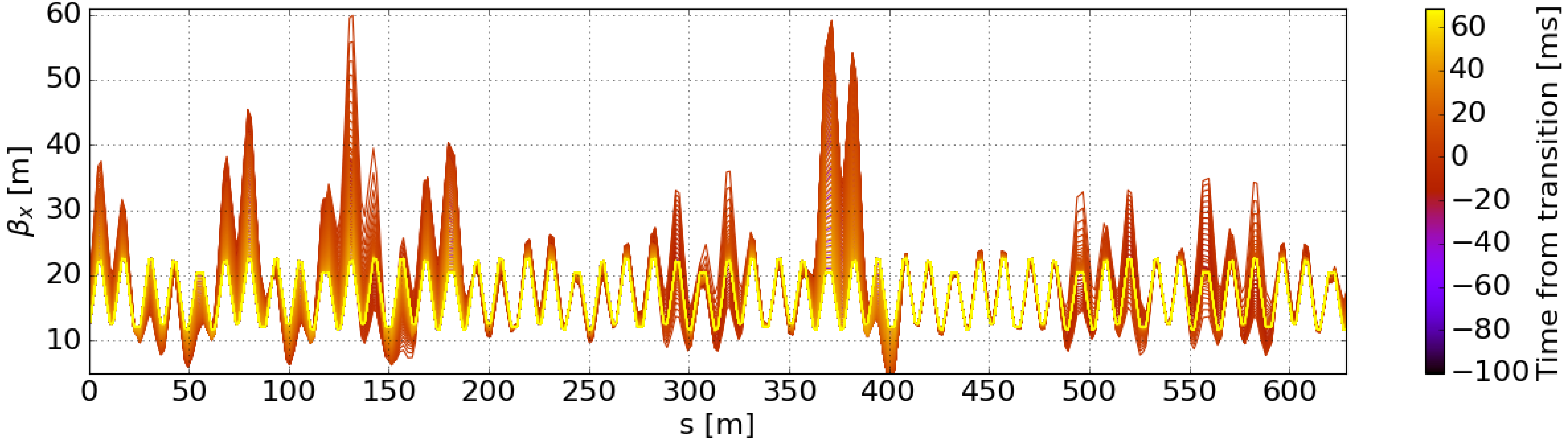
Expected optics perturbations



- Variation of the horizontal β-function during the gamma-jump scheme.

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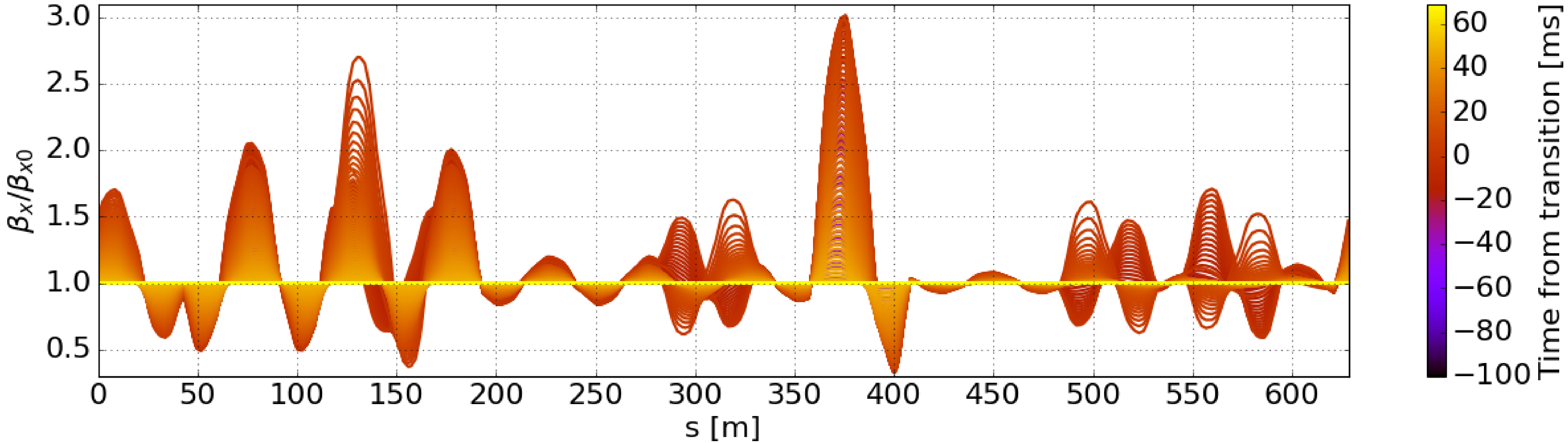
Expected optics perturbations



- Variation of the horizontal β-function during the gamma-jump scheme.
- Relative change of **up to 300%.**

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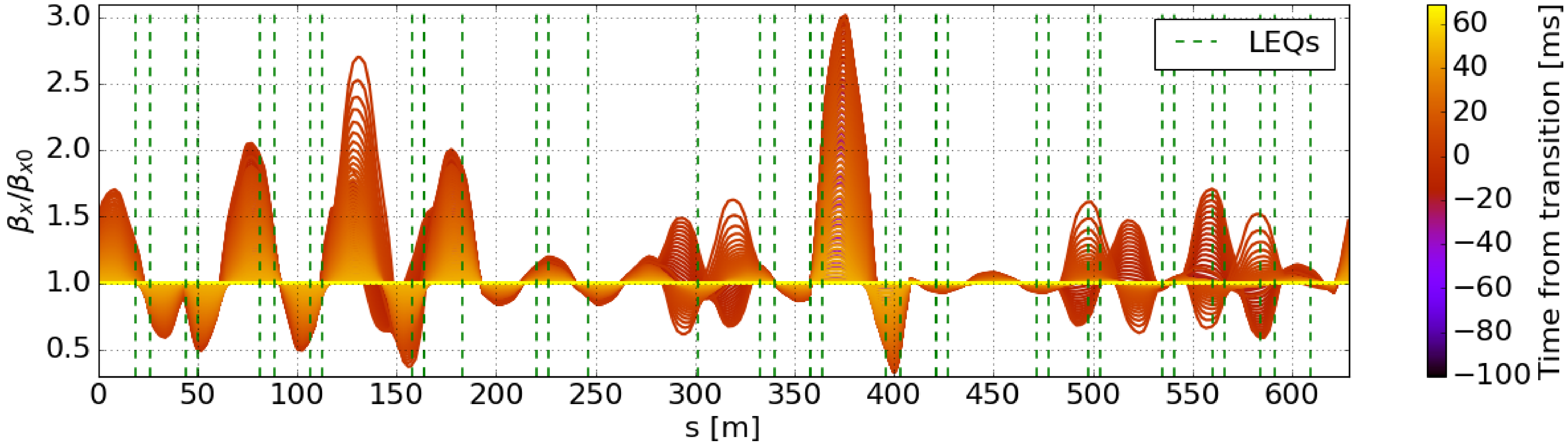
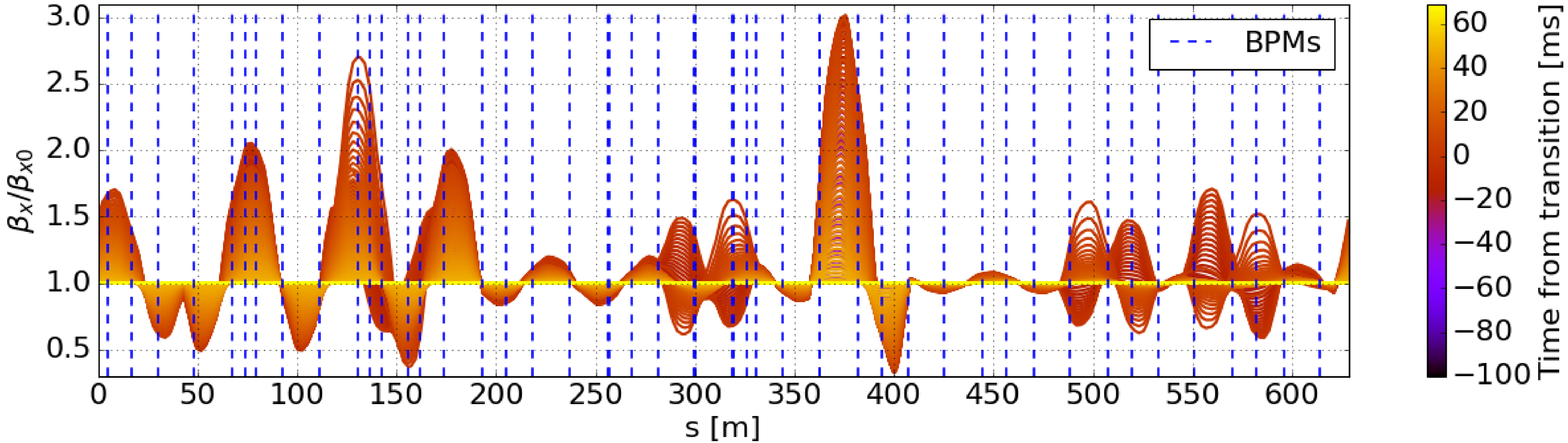
Expected optics perturbations



- Variation of the horizontal β-function during the gamma-jump scheme.
- Relative change of **up to 300%.**
- Optics measured using two methods:
  1) K-modulation in **Low Energy Quads (LEQs)** (not all of them…).

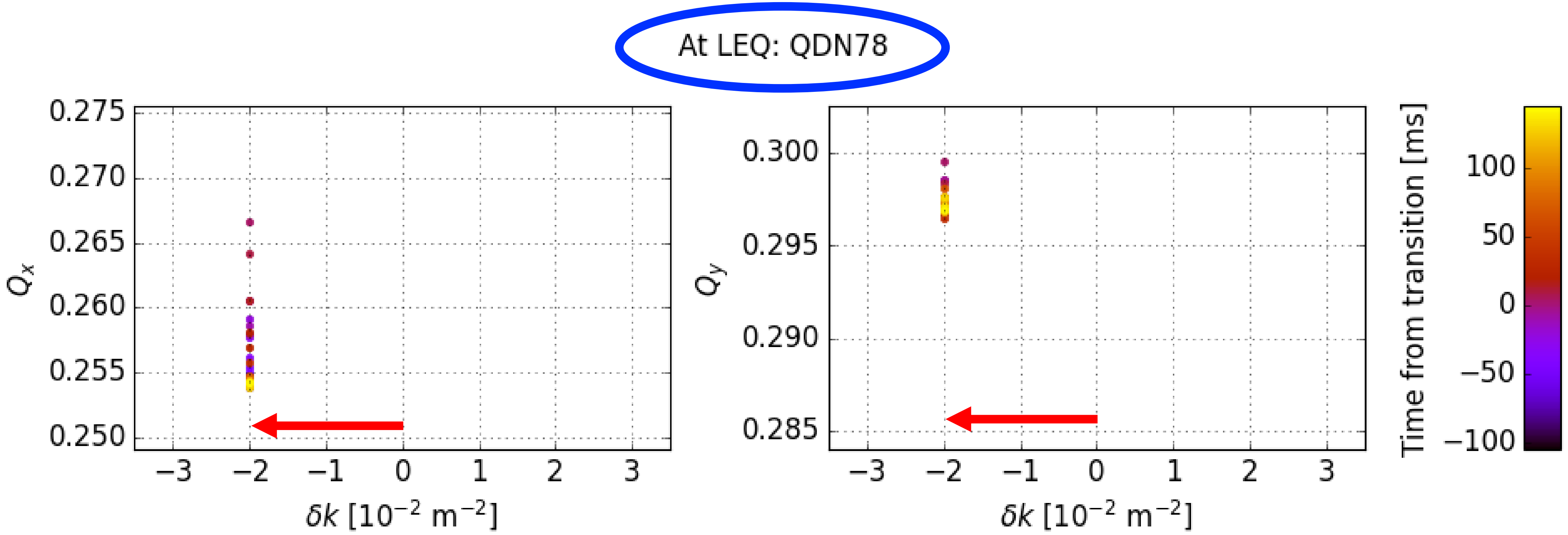
Expected optics perturbations



- Variation of the horizontal β-function during the gamma-jump scheme.
- Relative change of **up to 300%.**
- Optics measured using two methods:
    1) K-modulation in **Low Energy Quads (LEQs)** (not all of them…).
    2) Turn-by-turn **BPM** data using an AC dipole excitation (minus some faulty ones…).

K-modulation in LEQs

- Each **individual quadrupole** strength was varied "statically": constant **δk shift** along the full FB (similar to PSB injection chicane beta-beating measurements).
- Tune measured with BBQ using chirp excitation every 3 ms (~1350 turns) for ~200ms.



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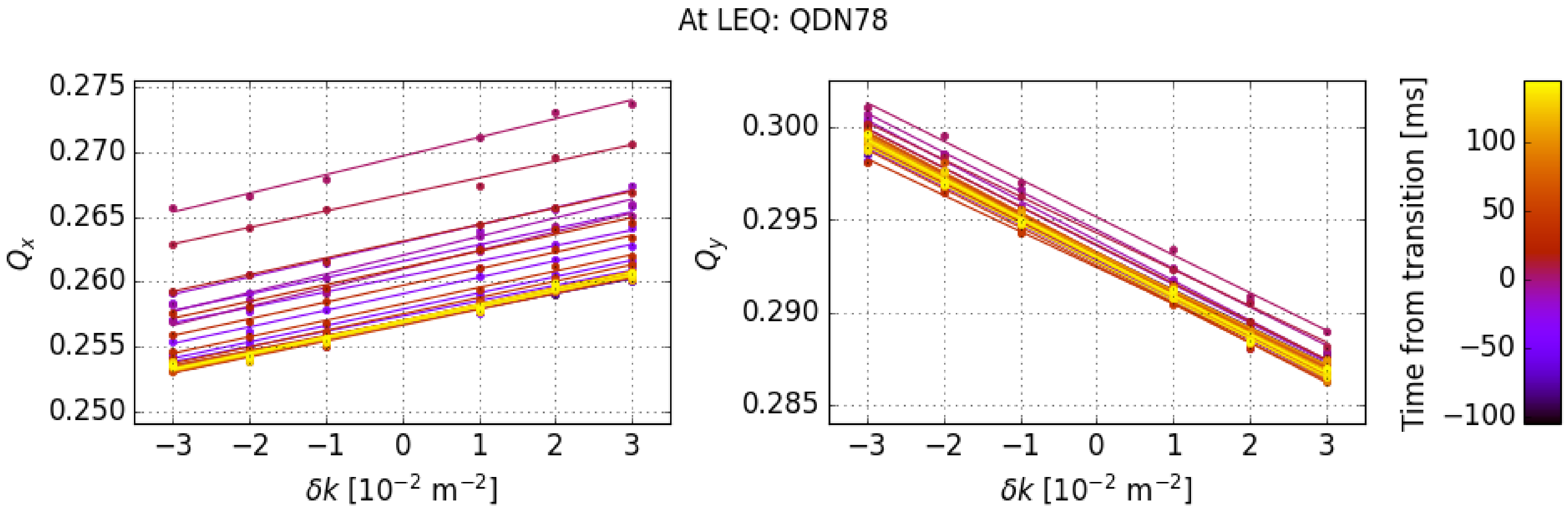

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K-modulation in LEQs

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- Tune measured with BBQ using chirp excitation every 3 ms (~1350 turns) for ~200ms.
- Tune shift is proportonial to local beta-function (fitted).
- Same was repeated for ~36 LEQs.

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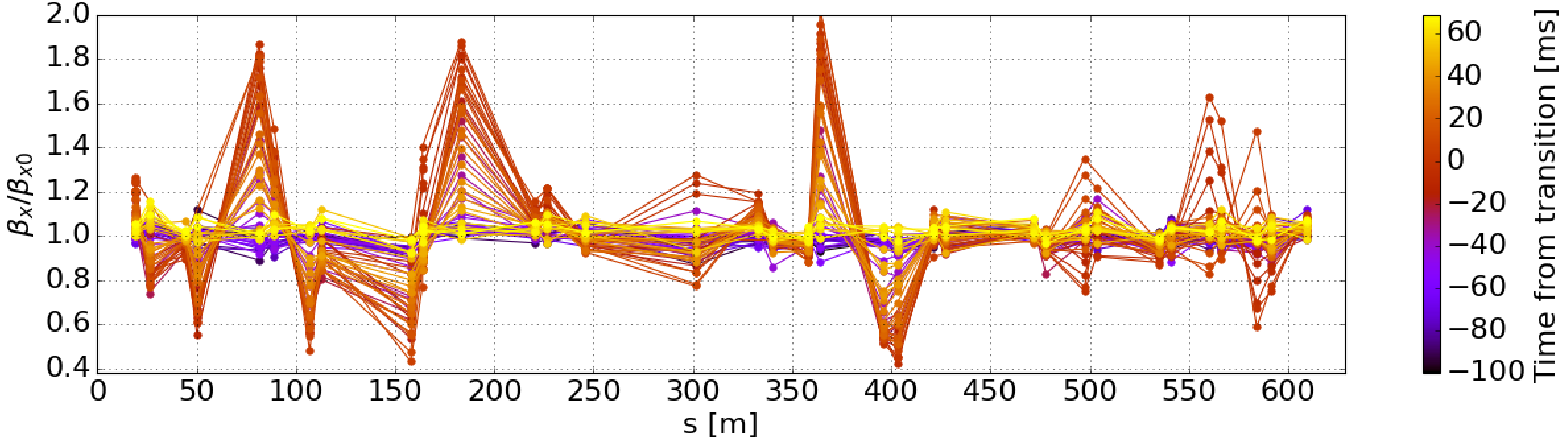
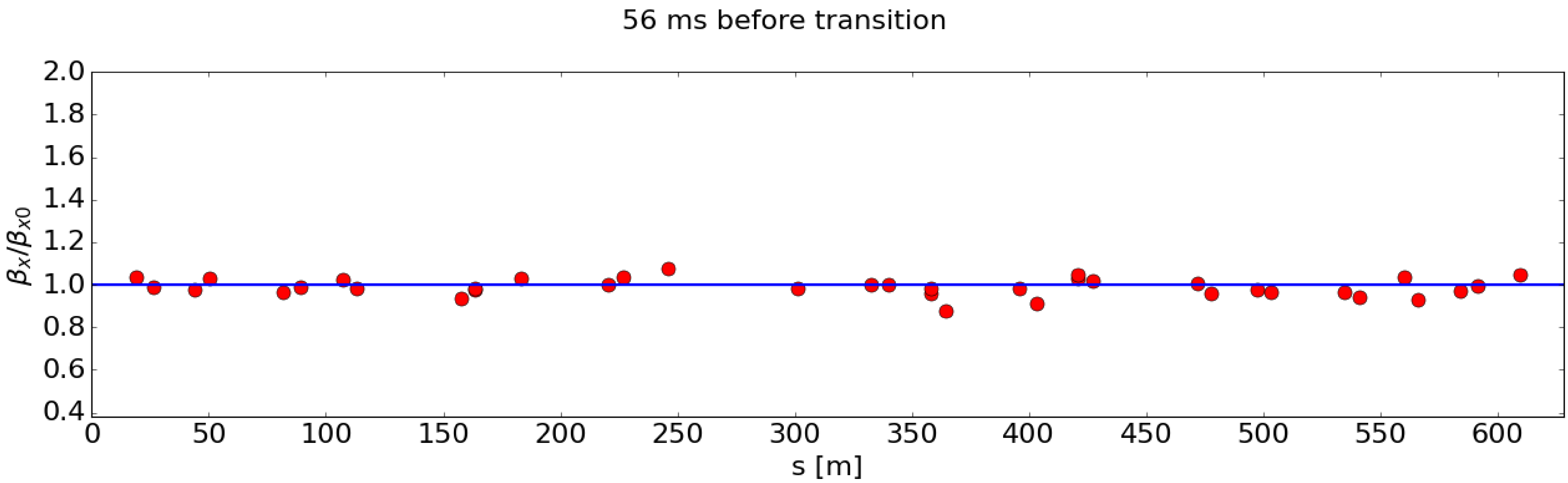
Measured optics perturbations

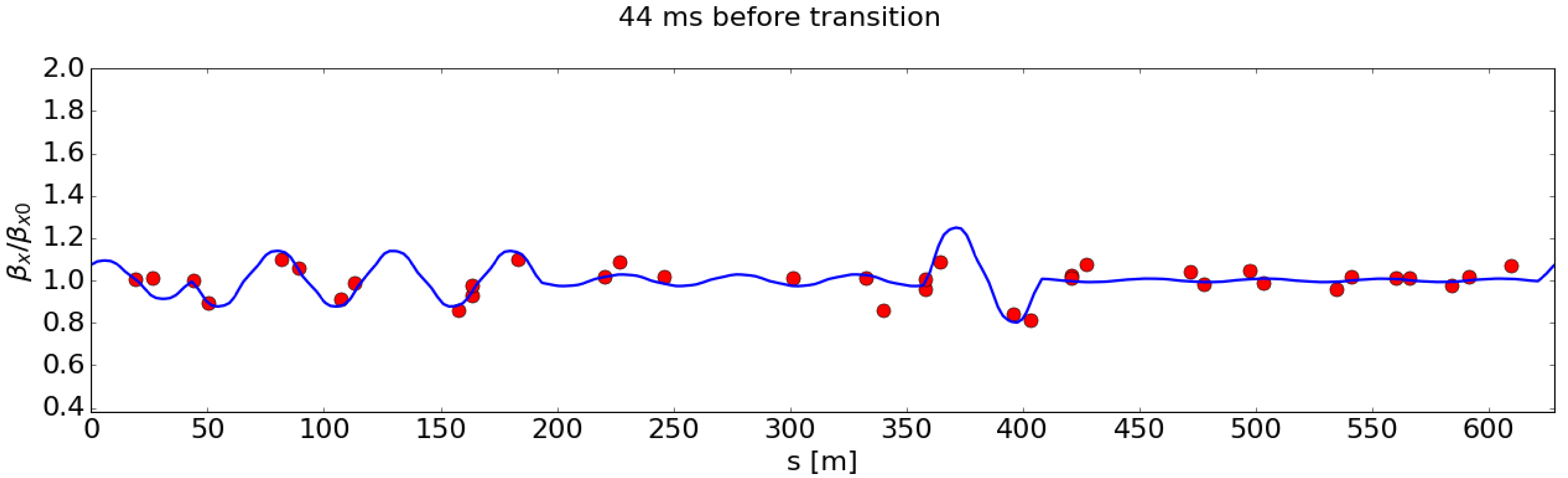


- Measured relative beta change of up to 200% at the locations of the LEQs.

Measured vs. expected optics perturbations



Comparison with the model



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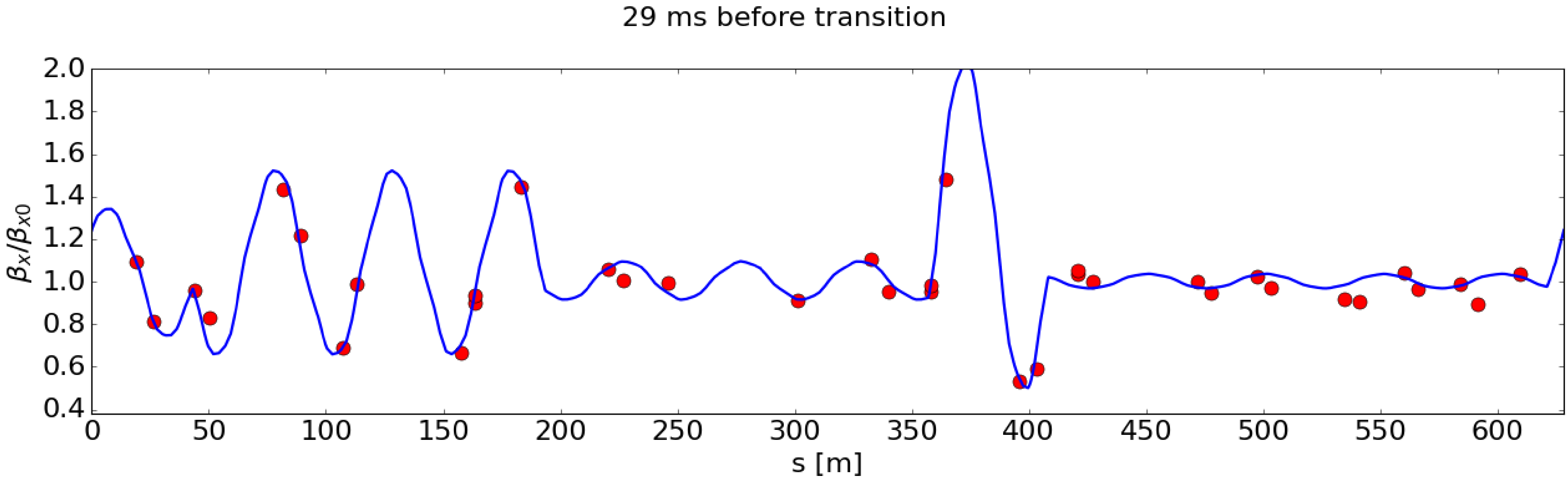

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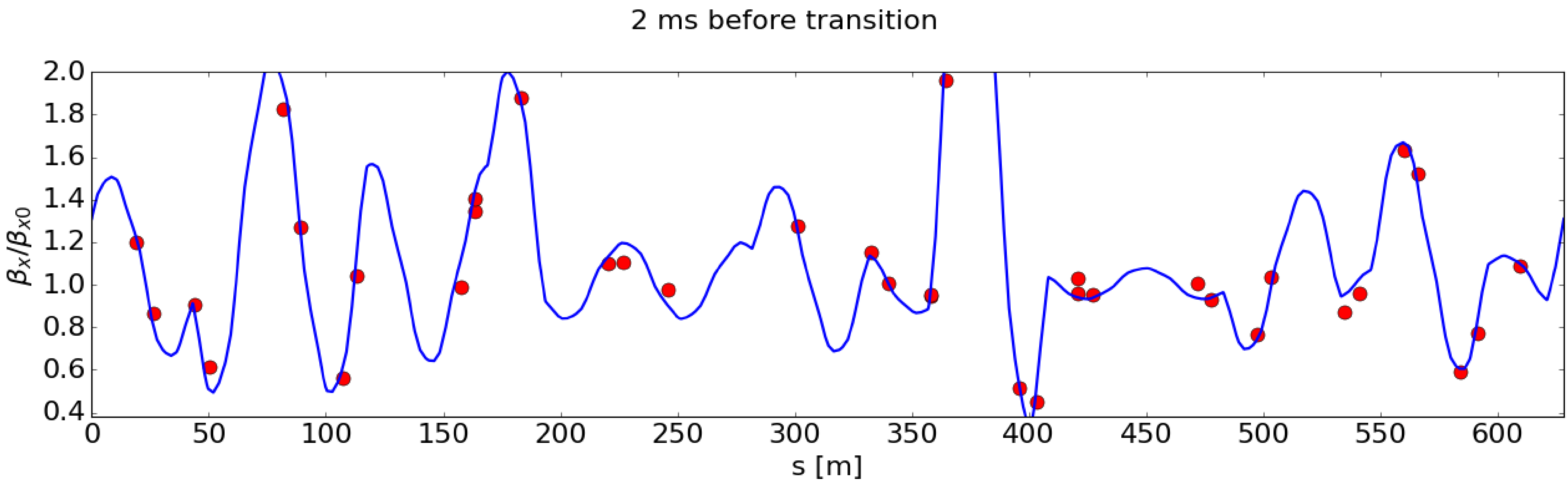

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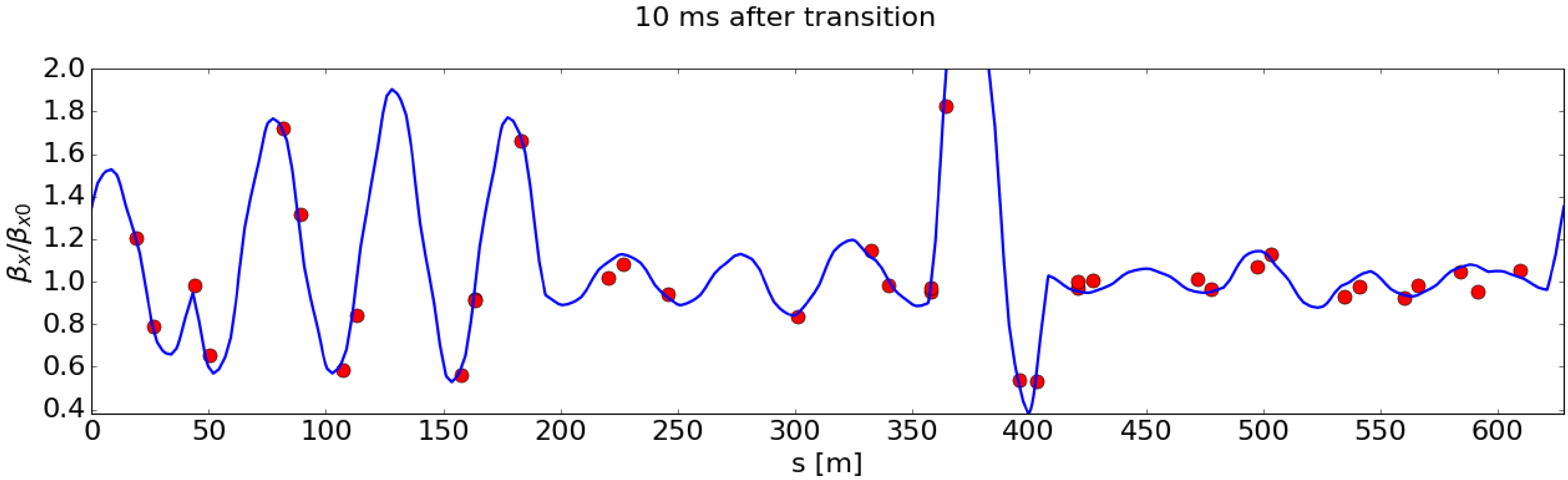

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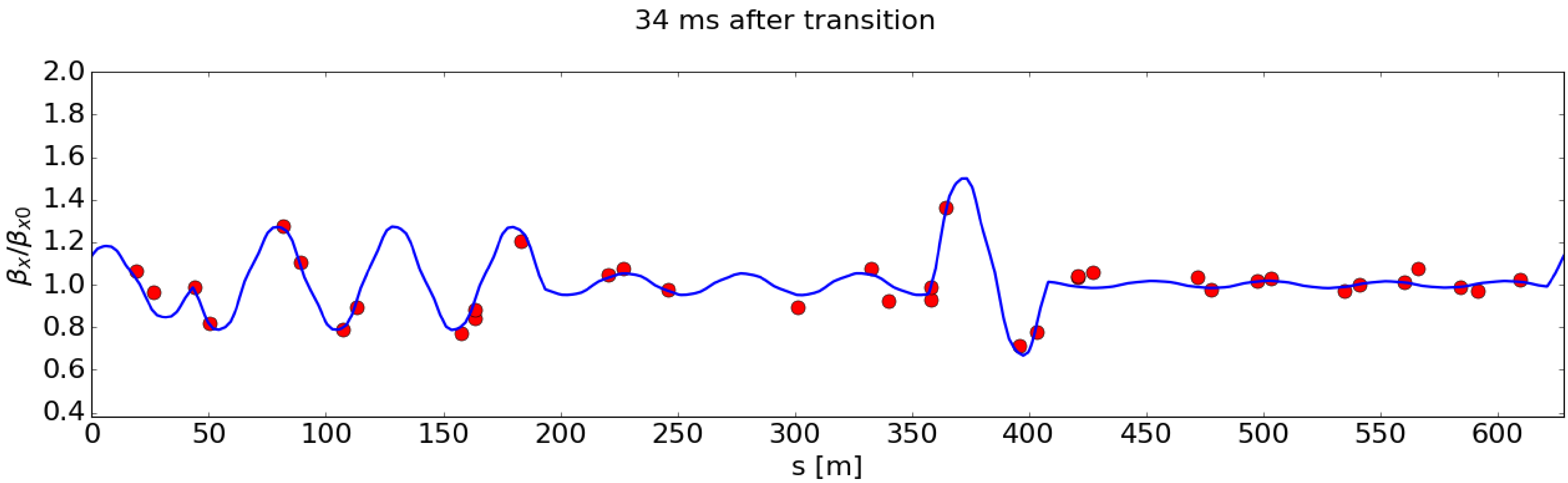

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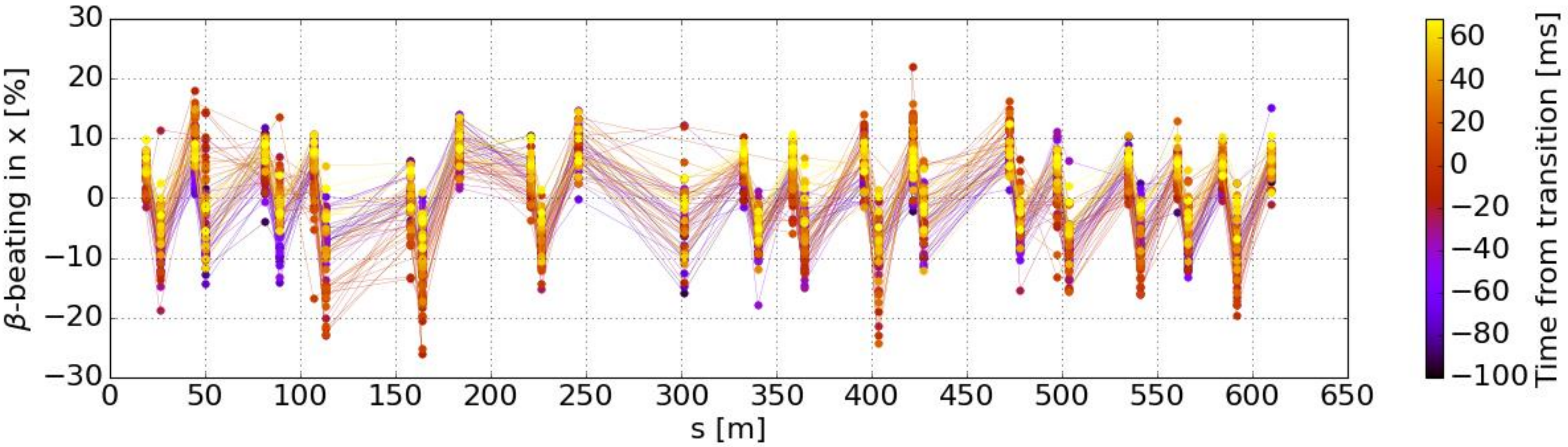
Beta-beating

$$\beta - beating = \frac{\beta_{meas} - \beta_{model}}{\beta_{model}}$$



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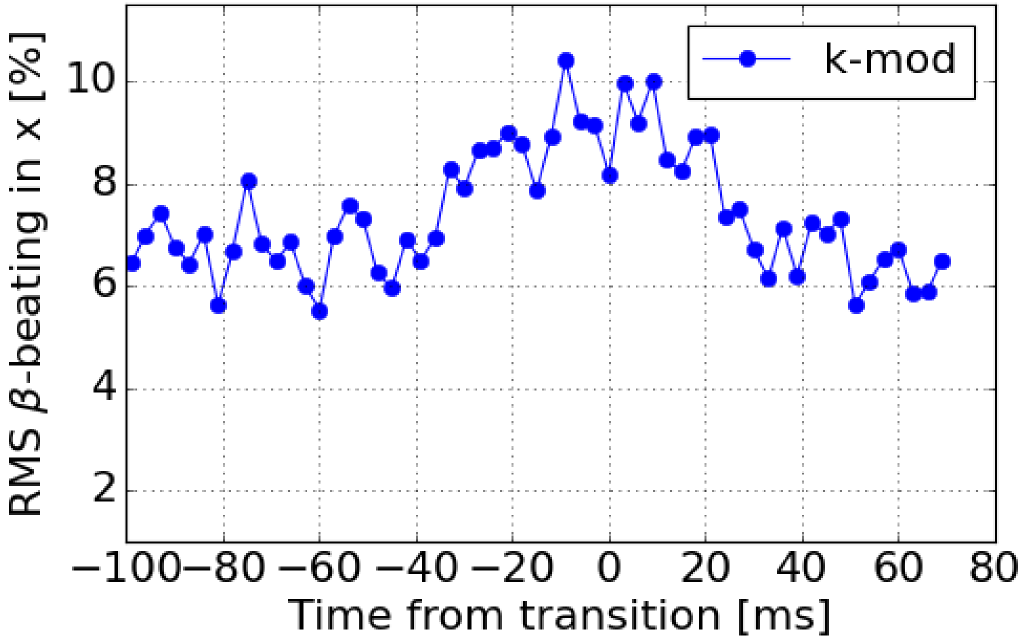

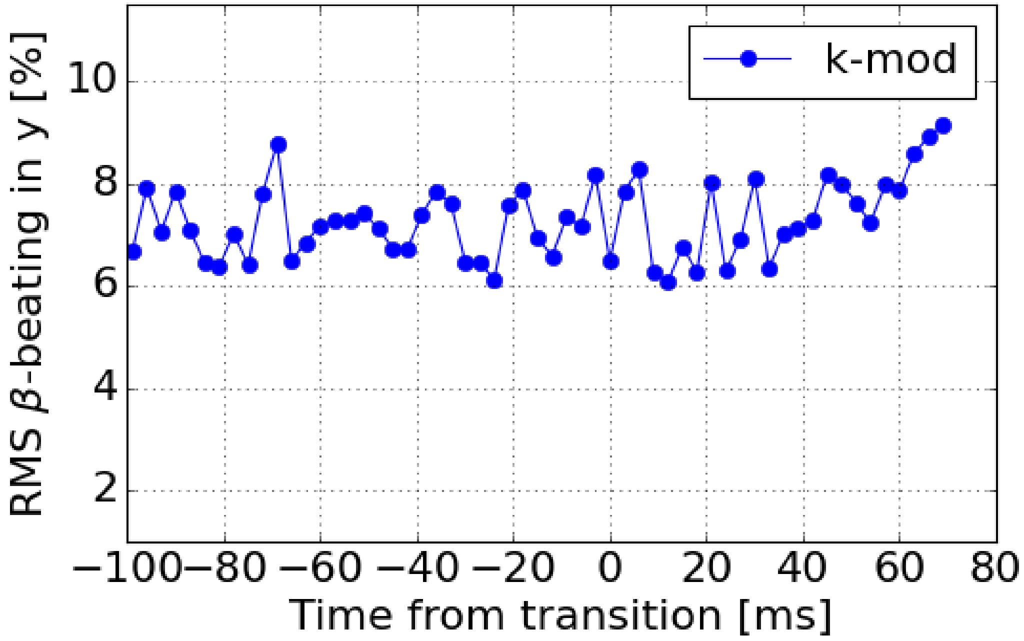

- Using k-modulation: RMS beta-beating **6-10% in x** and **6-8% in y**.
    - Are there any known calibration errors for the LEQs?

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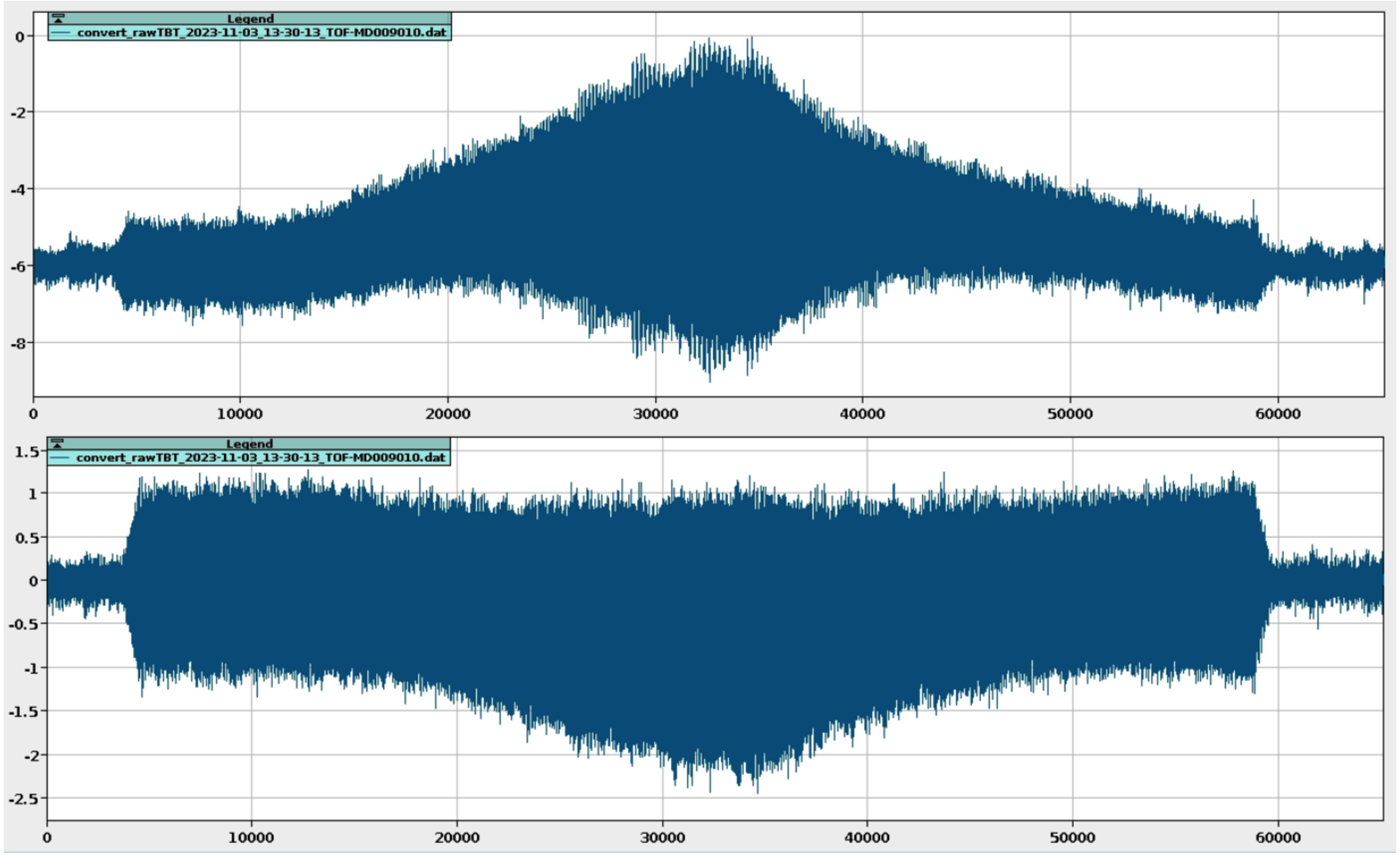
AC dipole excitation

- Disabled LEQ & PFW, all multipoles but skew quads, orbit correctors.
- Exciting with AC dipole close to natural tunes.
- BPM data analyzed every ~2000 turns to get phase beating and beta from the inter-BPM phase advance.



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Beta-beating (beta from phase)

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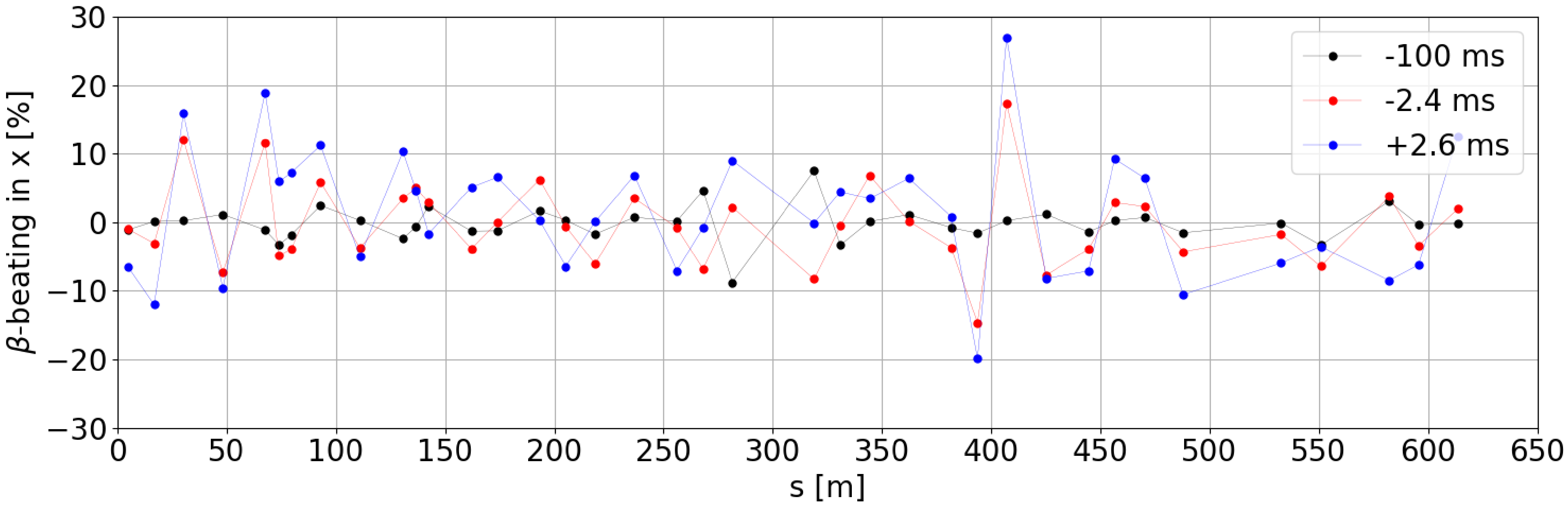

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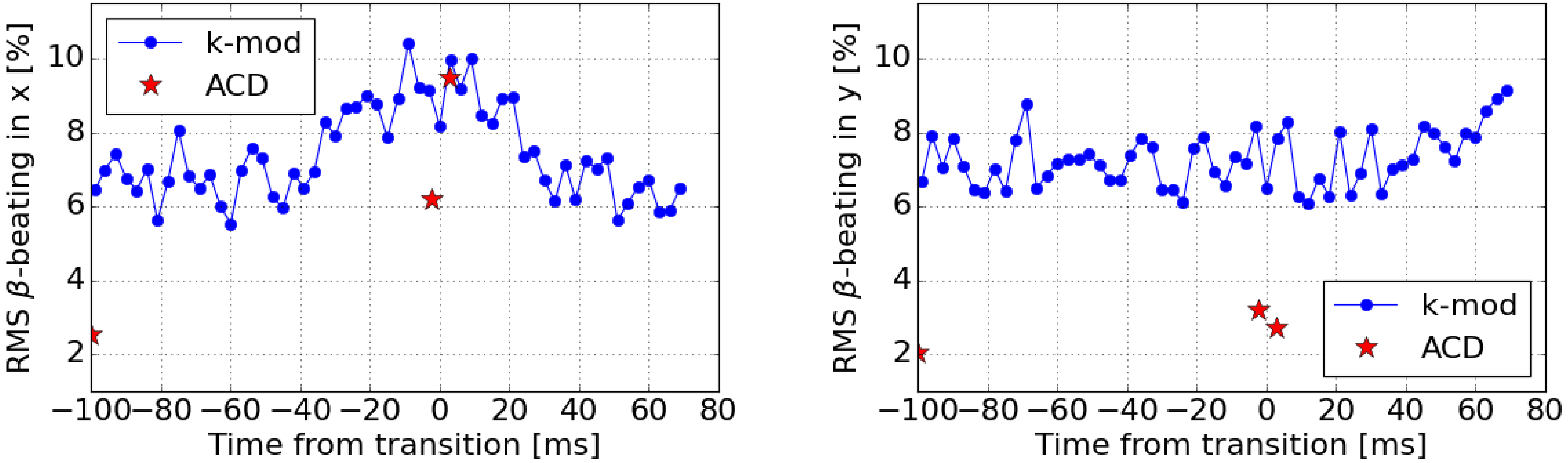

- Using k-modulation: RMS beta-beating **6-10% in x** and **6-8% in y**.
  - Are there any known calibration errors for the LEQs?
- Using ACD: RMS beta-beating **6-10% around transition in x**, significantly **smaller in y**.
  - Even smaller beta-beating when powering only triplet (see backup slides).

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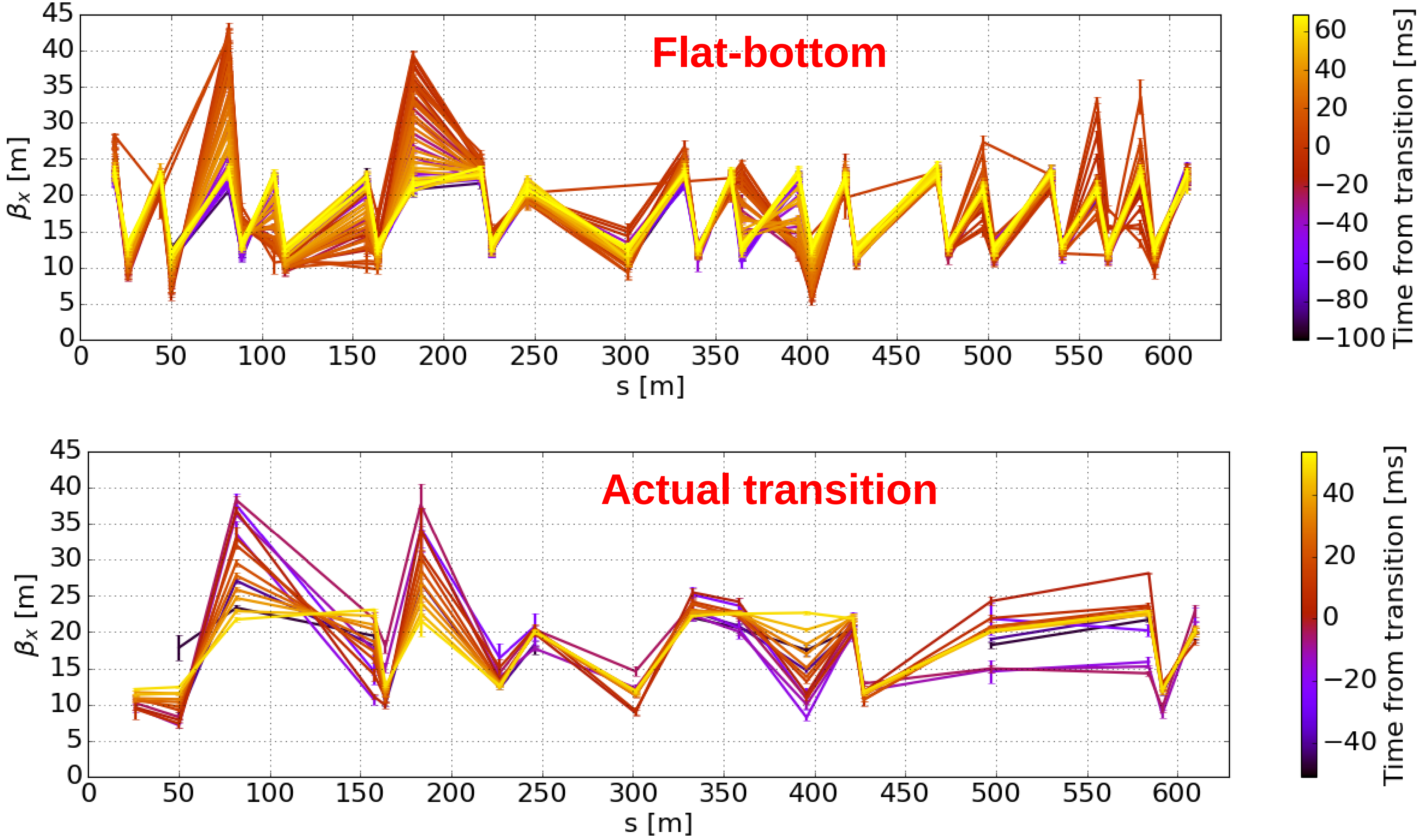
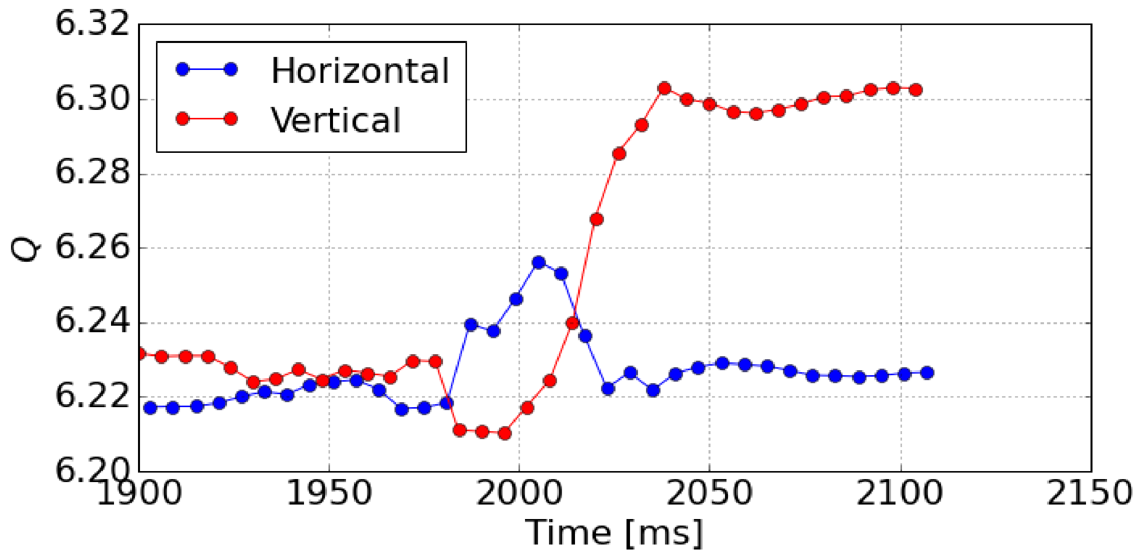
Measurements at actual transition

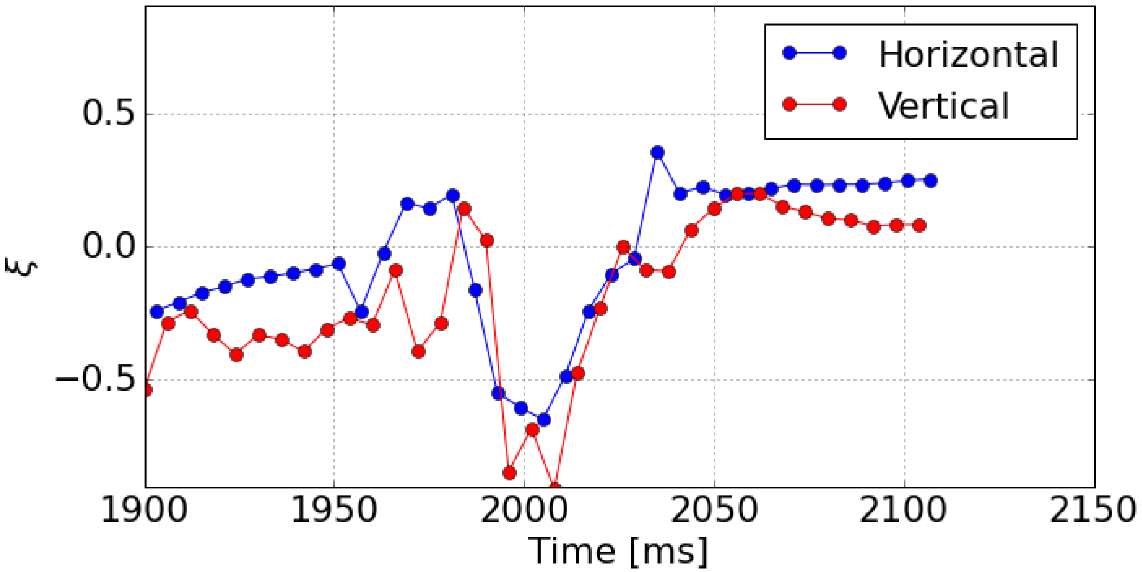
- K-modulation was applied during the actual transition crossing.
- Despite difficulty of the tune measurement, there are similar characteristics as the FB.



Measurements at actual transition

- K-modulation was applied during the actual transition crossing.
- Despite difficulty of the tune measurement, there are similar characteristics as the FB.
- Tune & chromaticity vary significantly during actual transition. Makes it hard to have a reliable model to compare.





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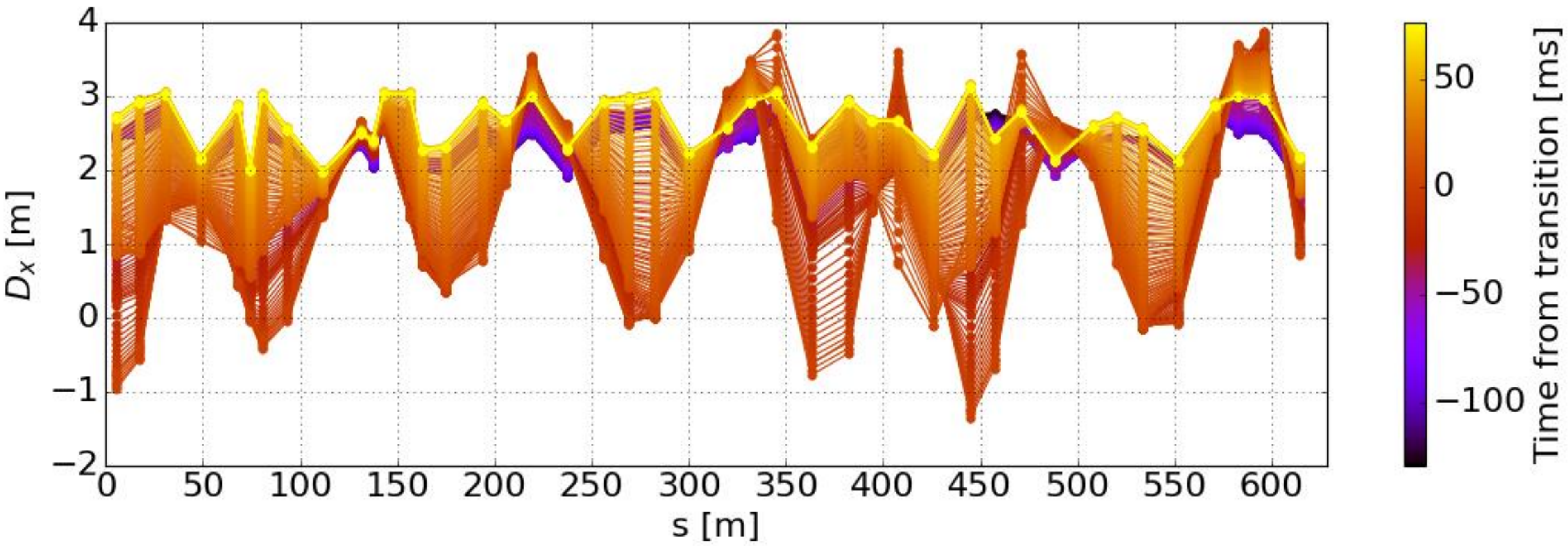
Measurements at actual transition



- Dispersion also measured during transition by measuring the tune for different radial steerings.

- Very tricky to reconstruct momentum offset since momentum compaction is needed …
  - An average dp/p has been assumed throughout the whole transition.

- Measured relative beta change of up to 150%.

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Summary

- Optics measurements during gamma-jump scheme at FB:
  - Strong optics perturbations (of up to 300%) measured with k-modulation & ACD excitation.
  - RMS **beta-beating between 6-10% using k-modulation**.
  - RMS **beta-beating between 6-10% in x and 3% in y using ACD** data (fewer points).
- Optics measurements during actual transition:
  - Measured beta-functions with k-modulation show **same characteristics** with the ones measured at FB.
  - Difficult to have a reliable model to compare due to strong distortions in the tune, chromaticity, radial position.
  - **Dispersion also measured during transition** (difficult to have accurate estimate of momentum offset).

- See presentation of Miltos on potential impact of gamma-jump scheme on beam emittance and tails here (space charge meeting 28/08/2024).

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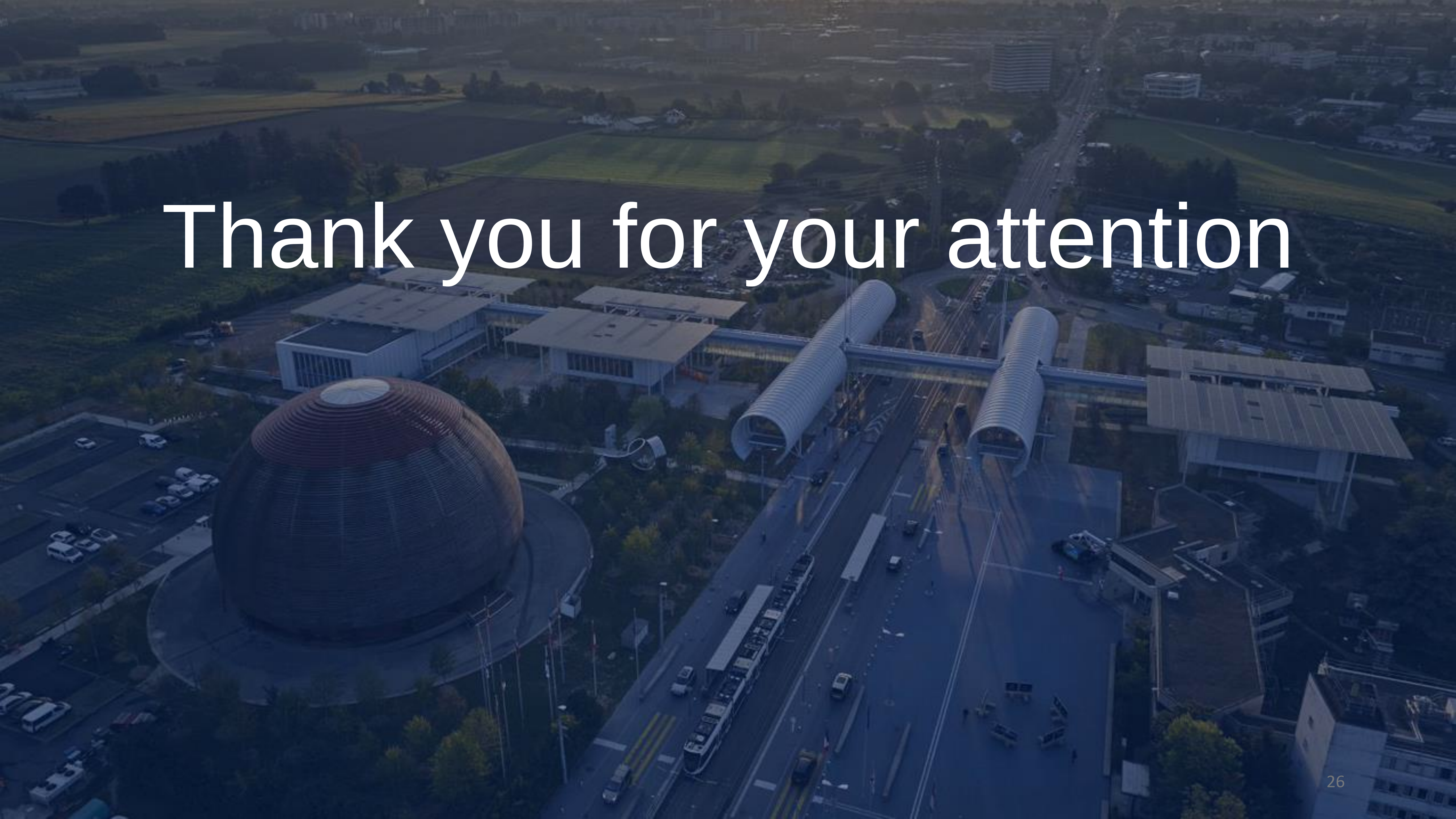
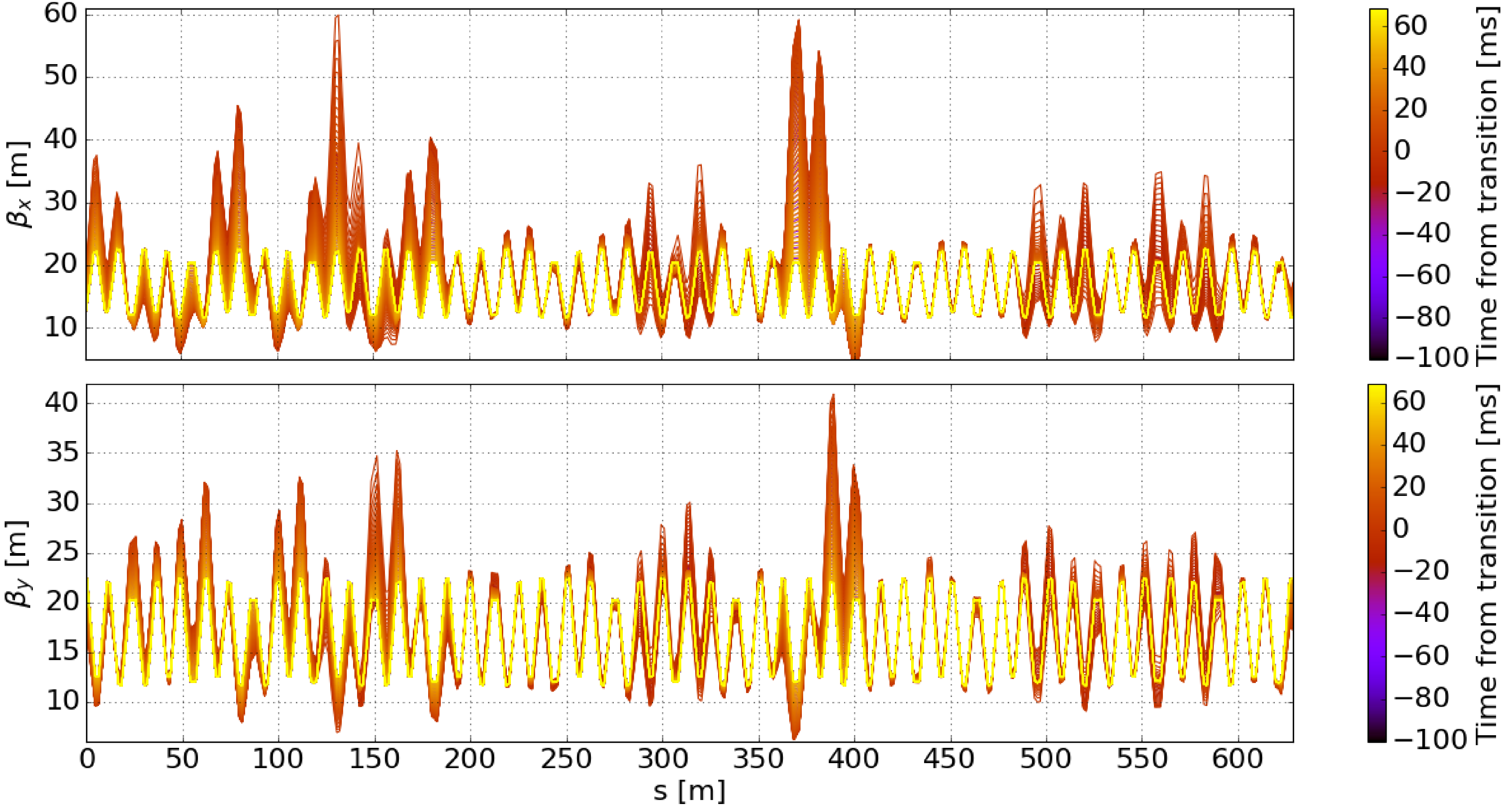


Thank you for your attention

Beta-variation along transition knobs (FB)



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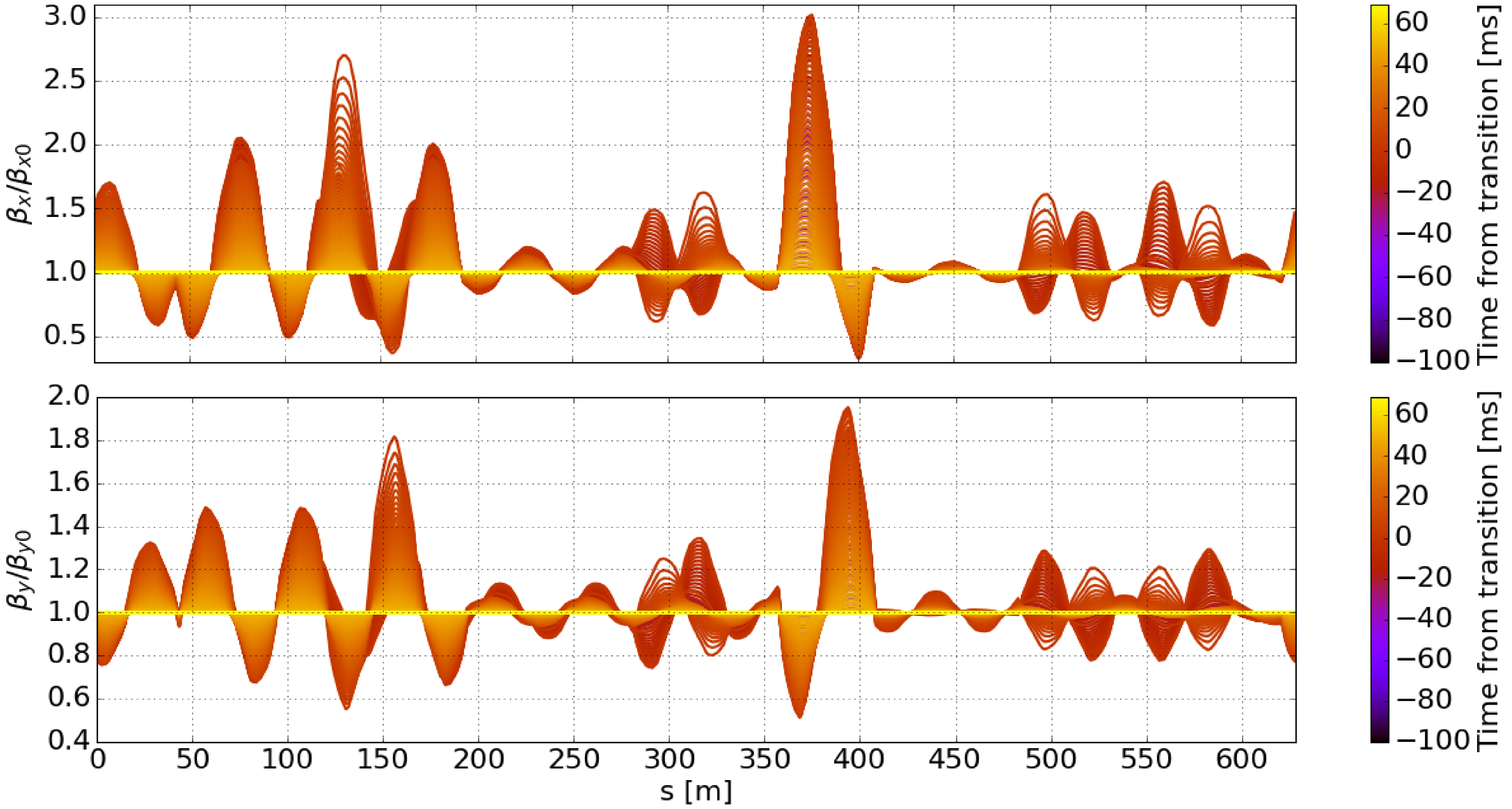

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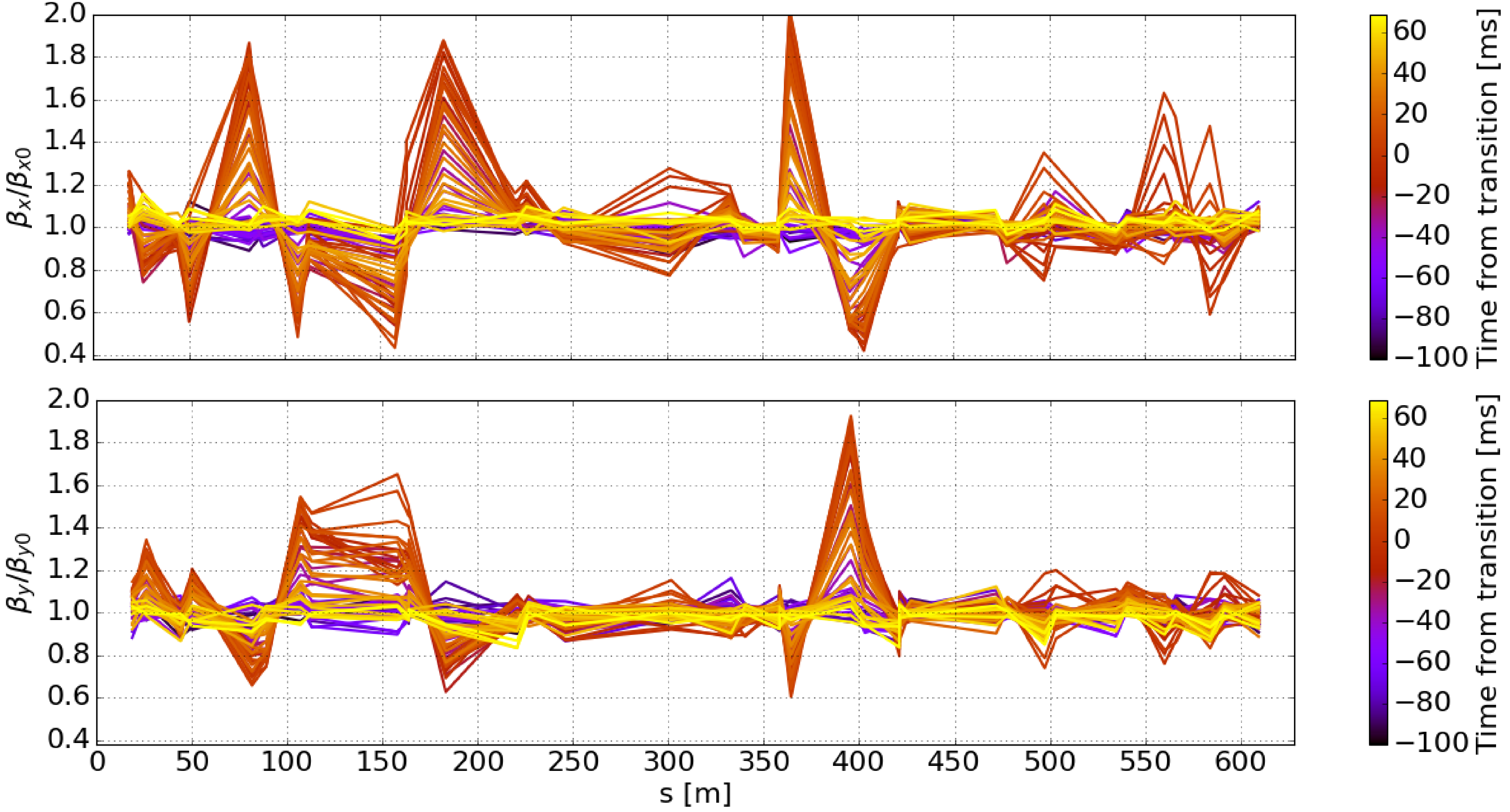
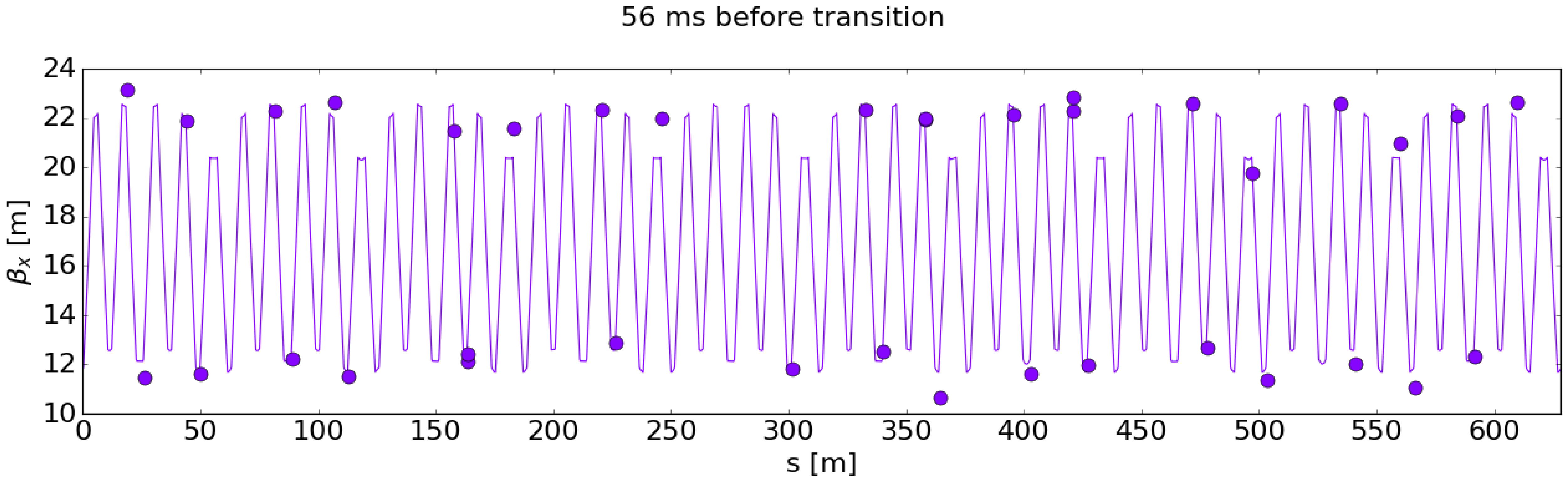
Measured beta-variation along transition knobs (K-mod, FB)



Comparison with the model



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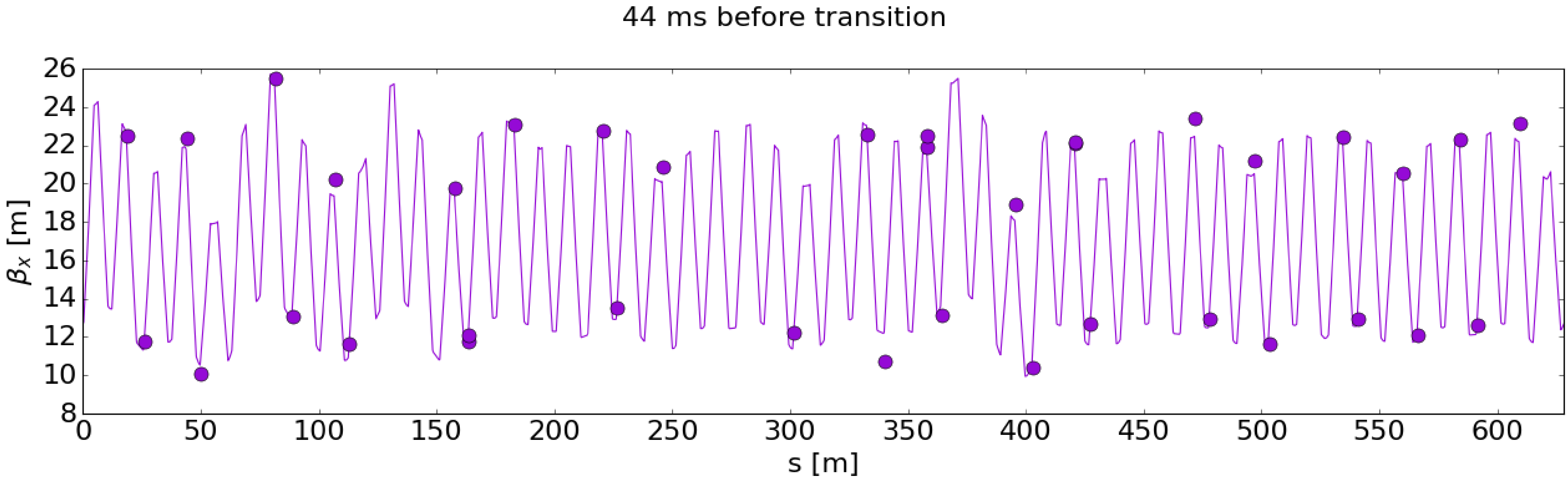

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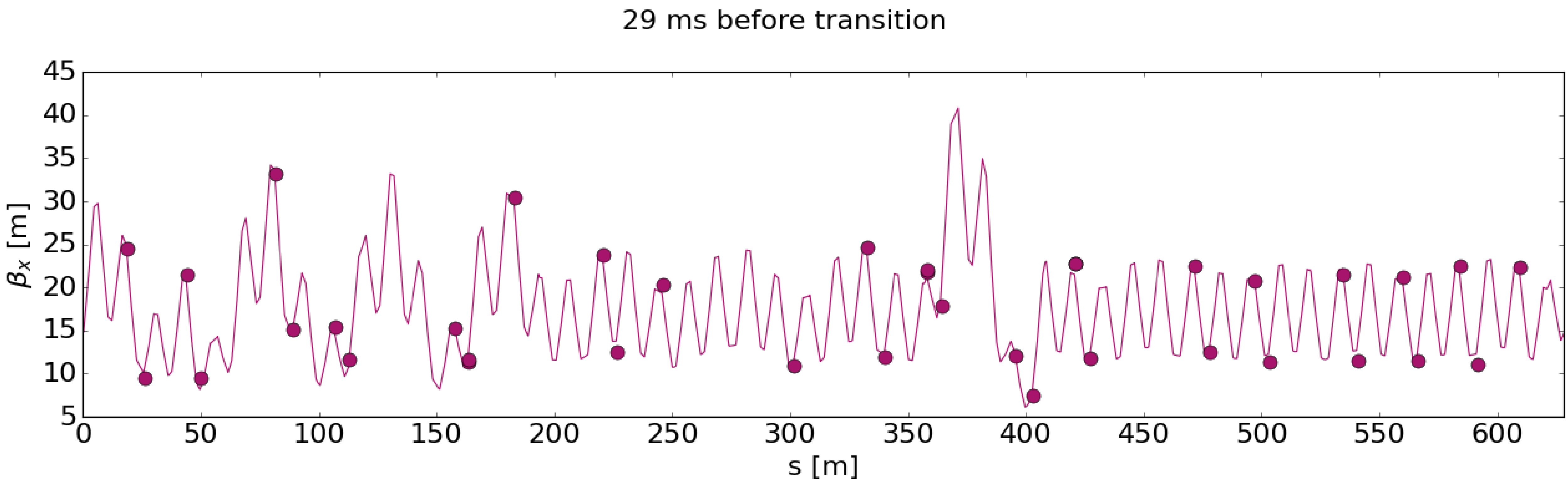

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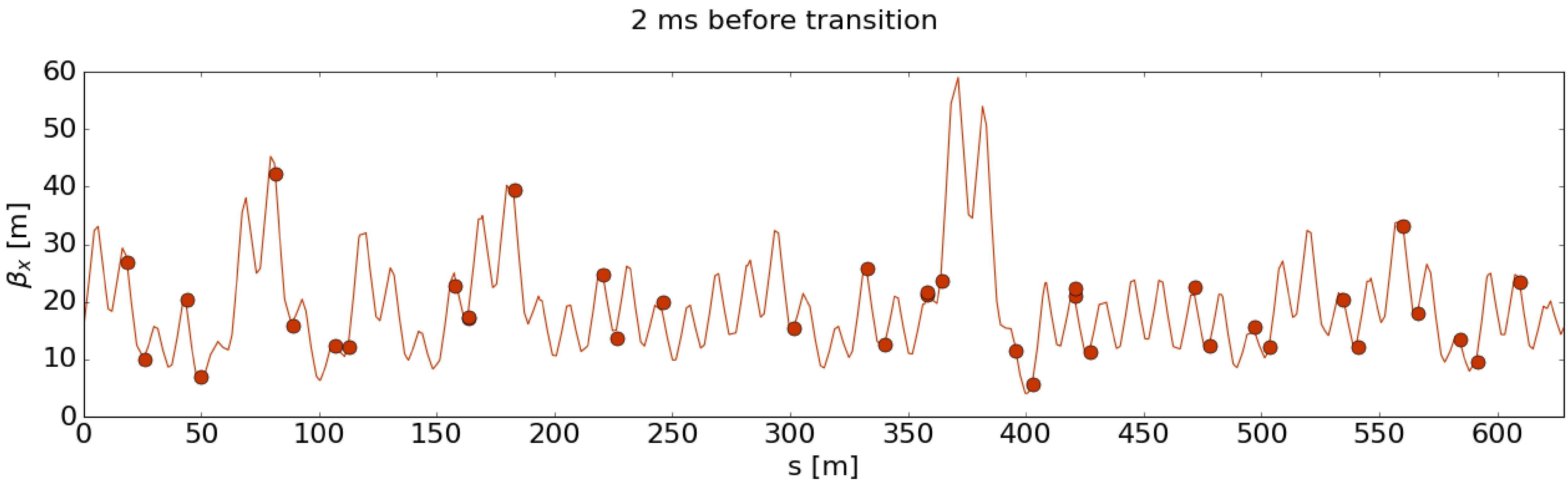
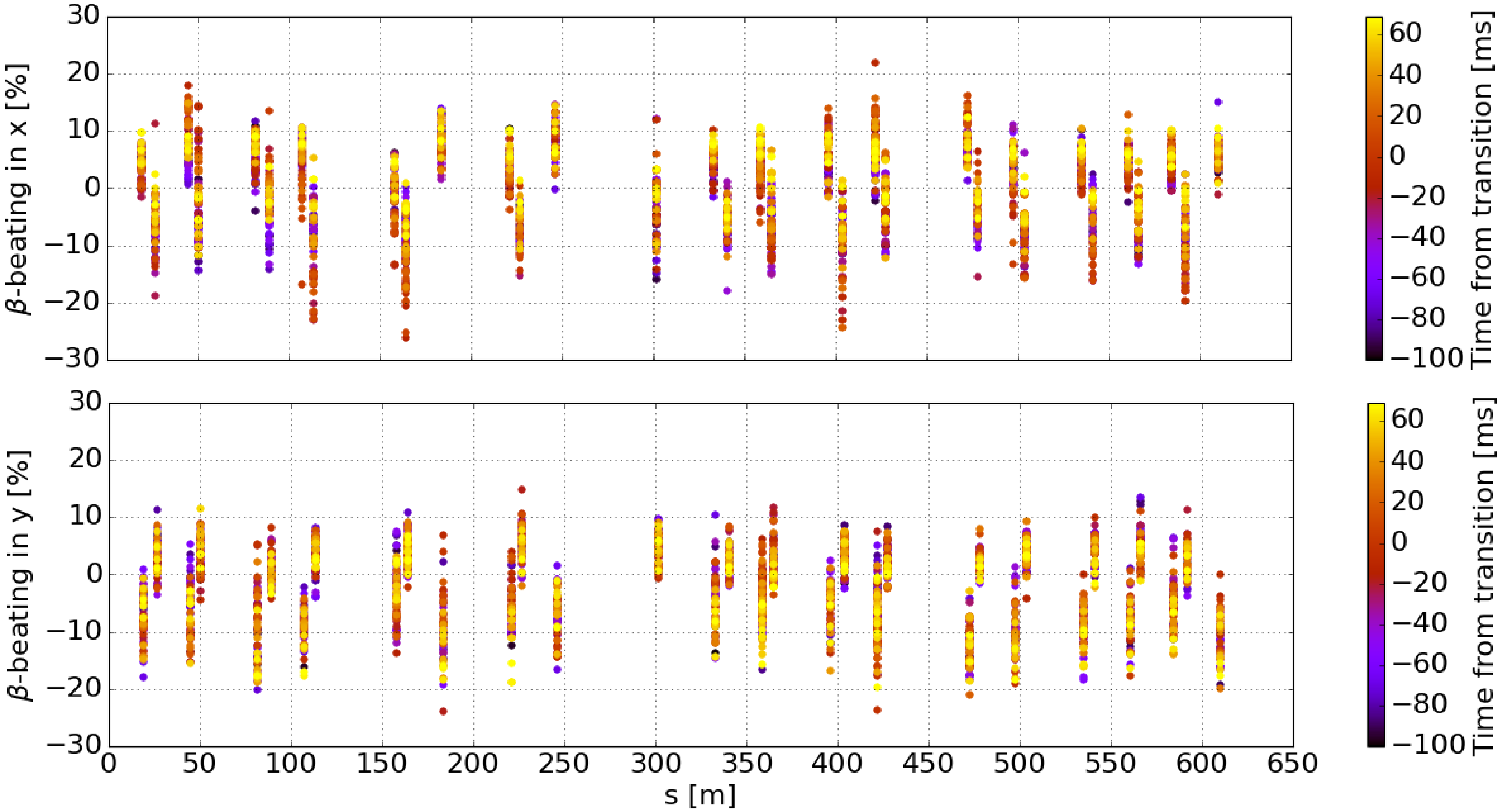
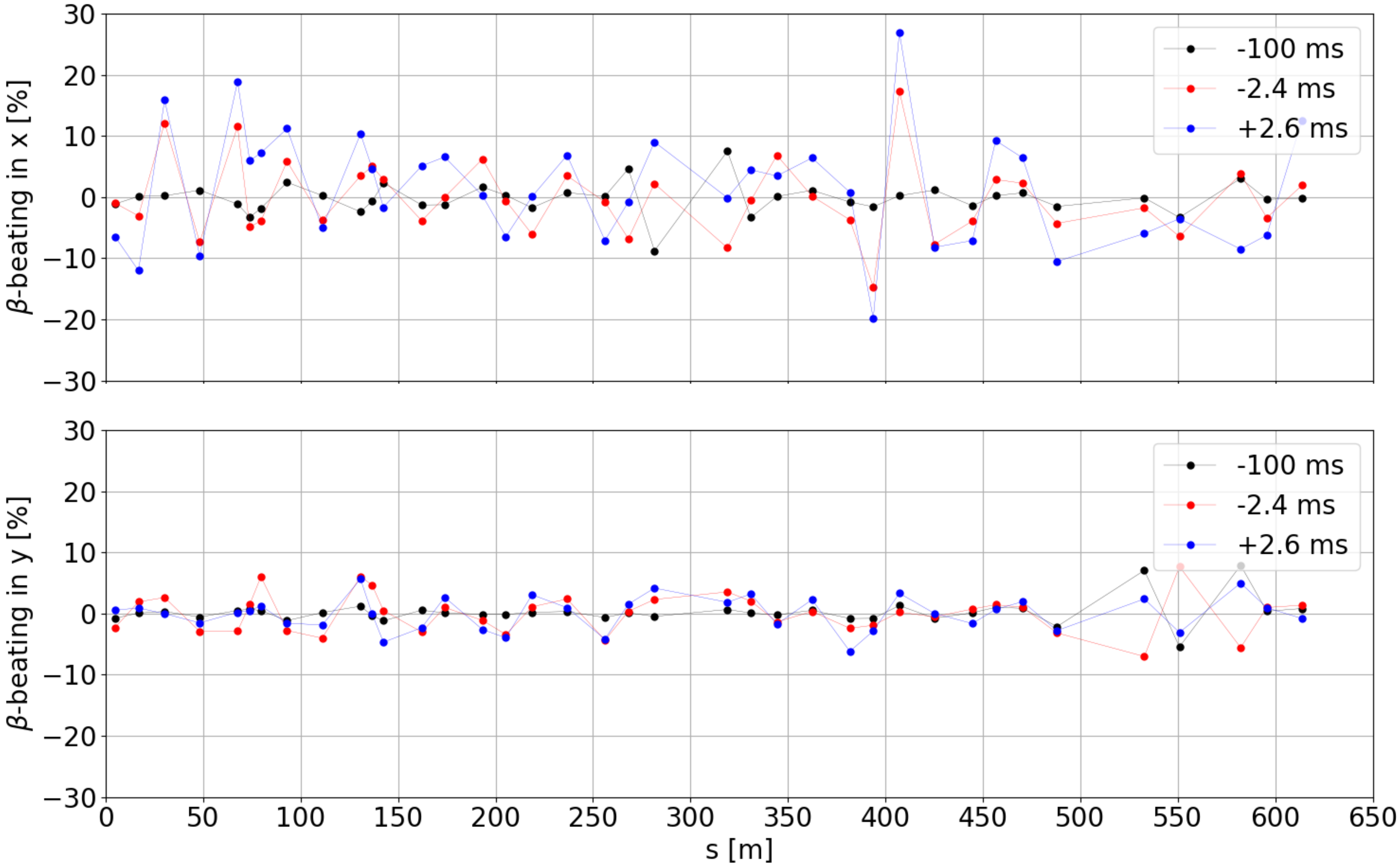


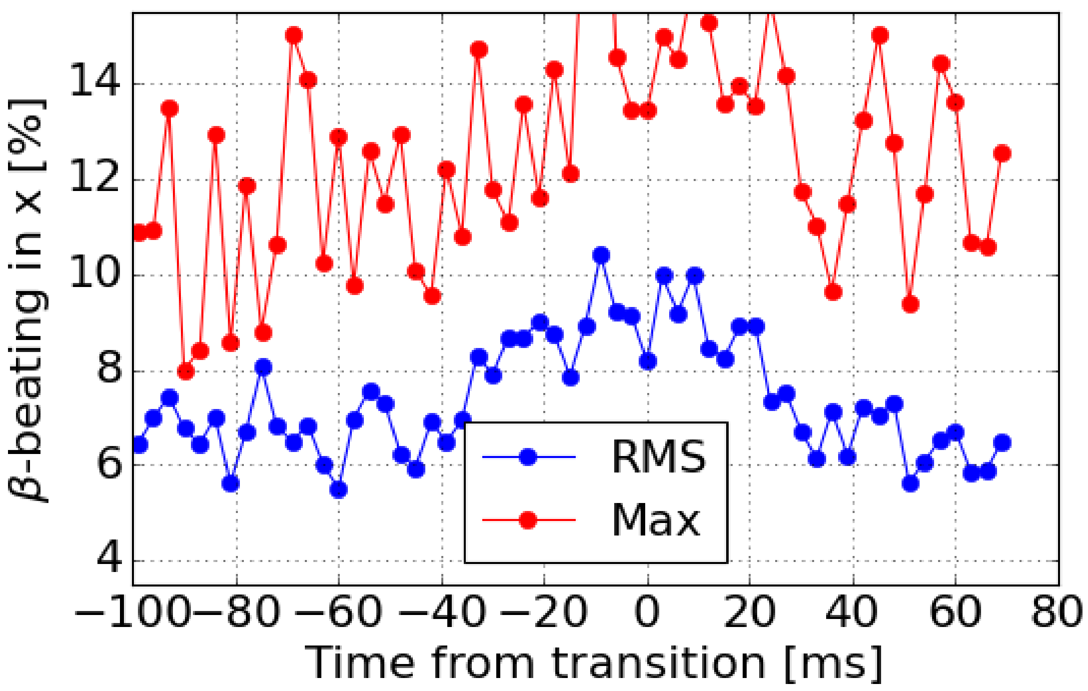
Beta-beating along transition knobs (K-mod, FB)

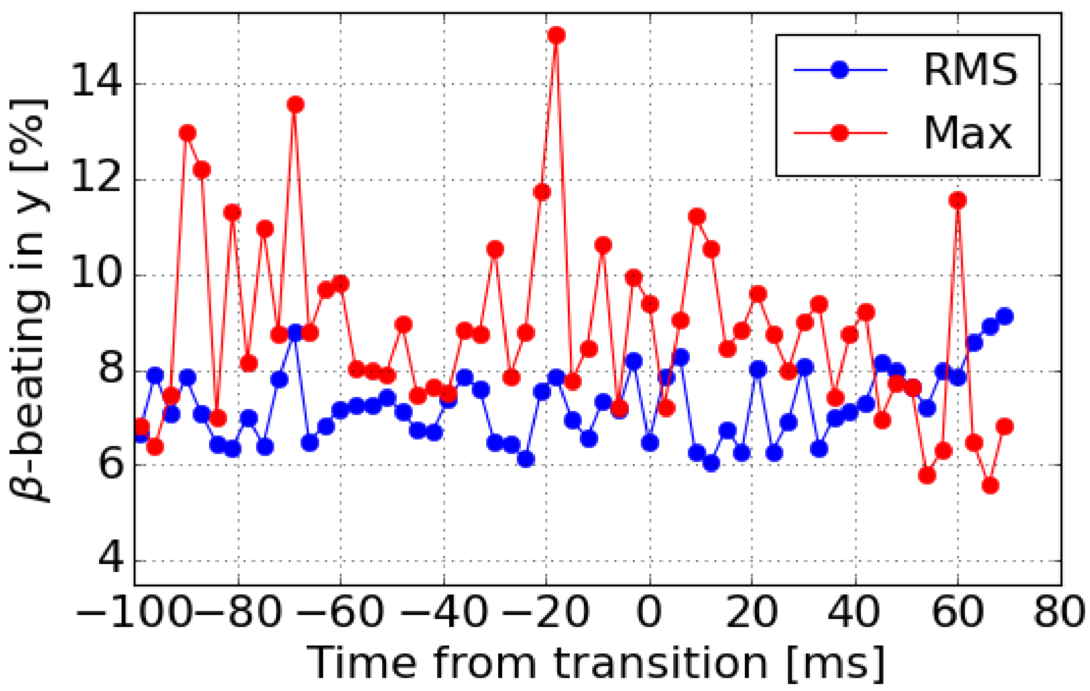


Beta-beating along transition knobs (ACD, FB)



Beta-beating along transition knobs





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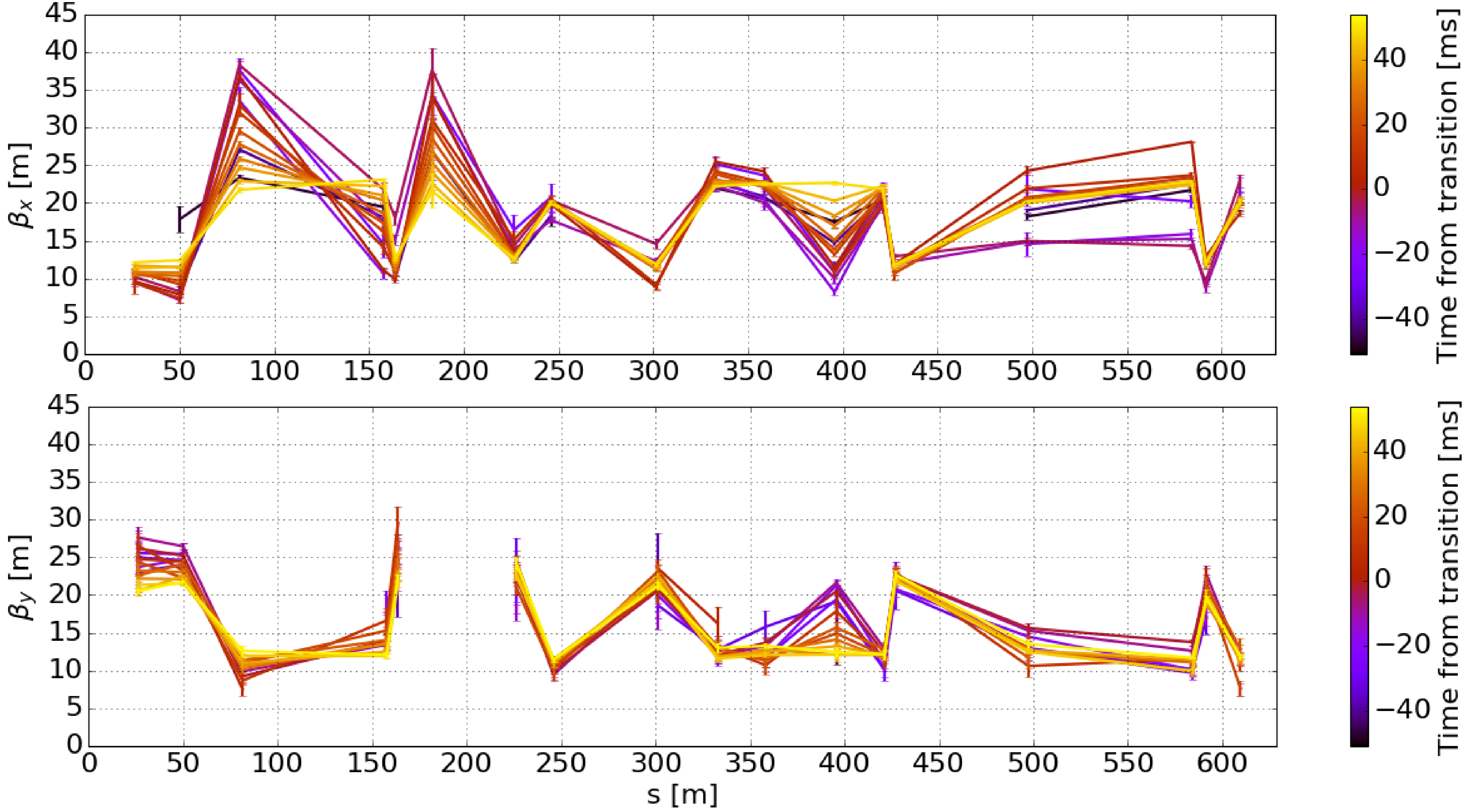
Measured beta along transition (K-mod)



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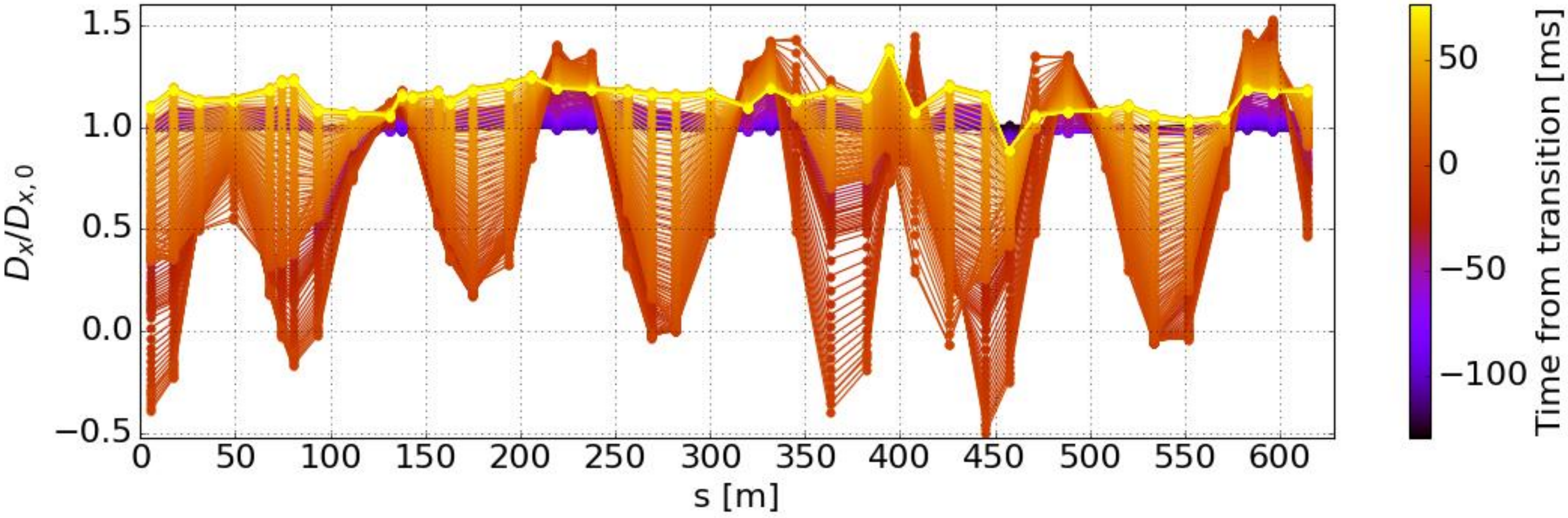
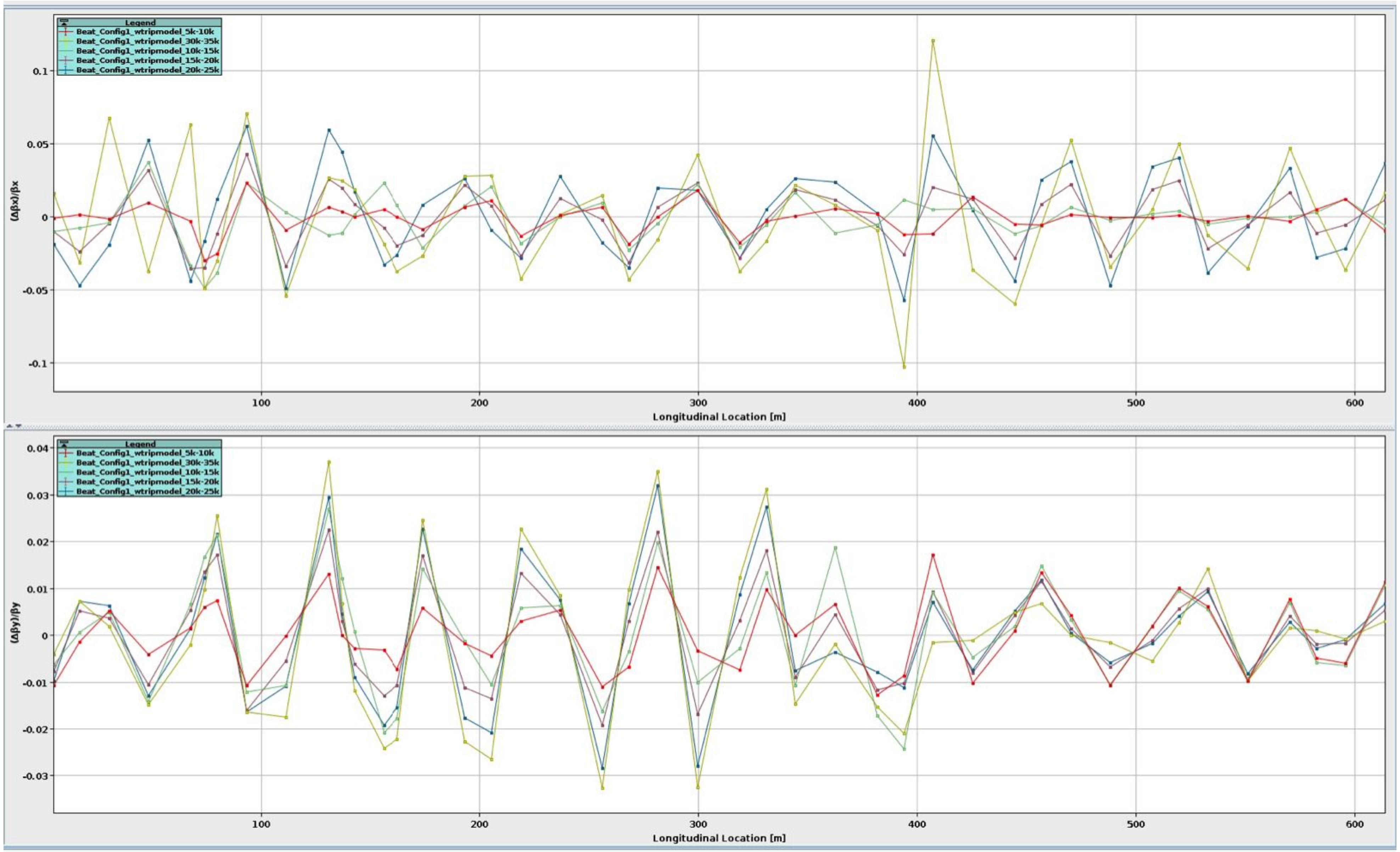
Relative dispersion variation during transition



Beta-beating using ACD powering only triplet



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