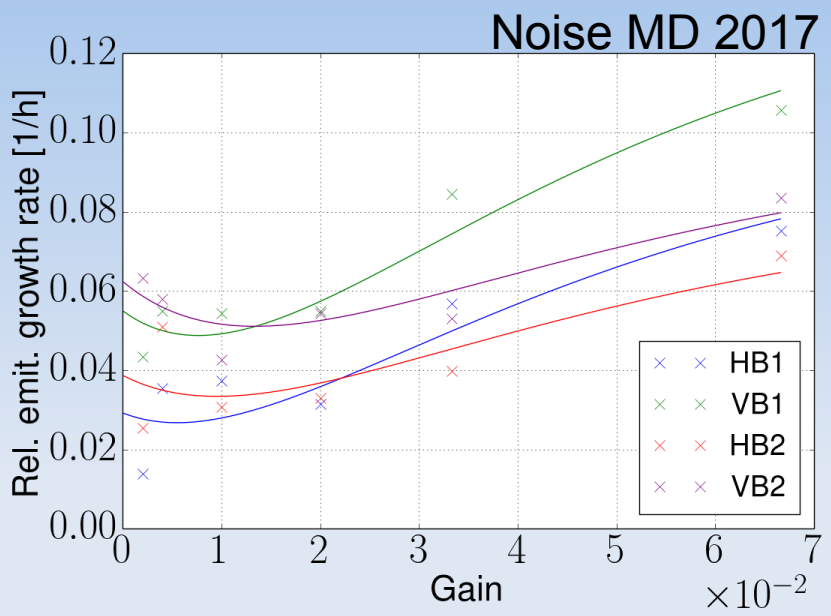
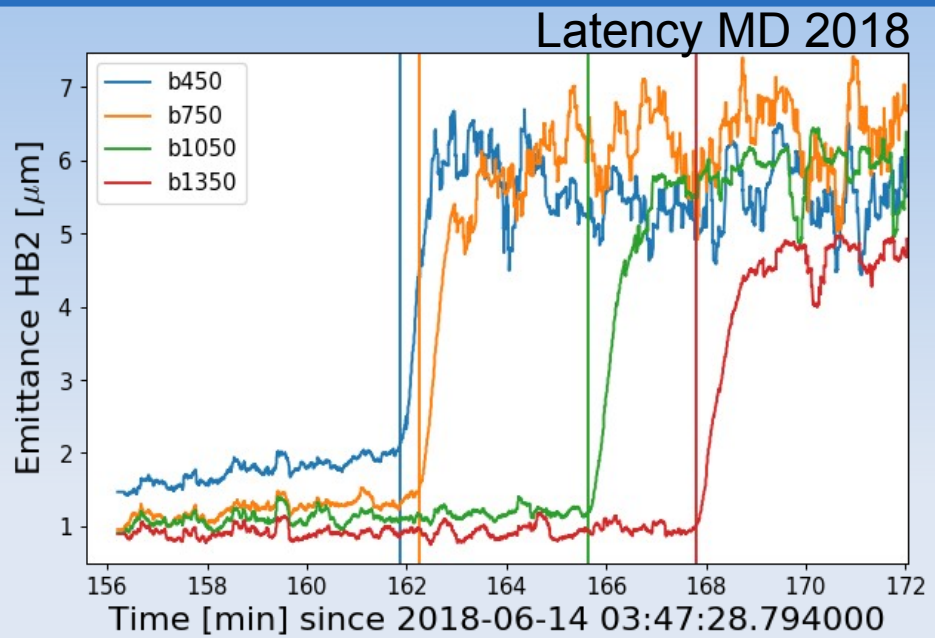
MD 4143 : Noise studies with new ADT pickups

X. Buffat, M. Albert, D. Amorim, S. Antipov, G. Crockford, S. Furuseth, J. Komppula, G. Kotzian, N. Mounet, A. Oeftiger, B. Salvant, M. Soderen, G. Trad, D. Valuch



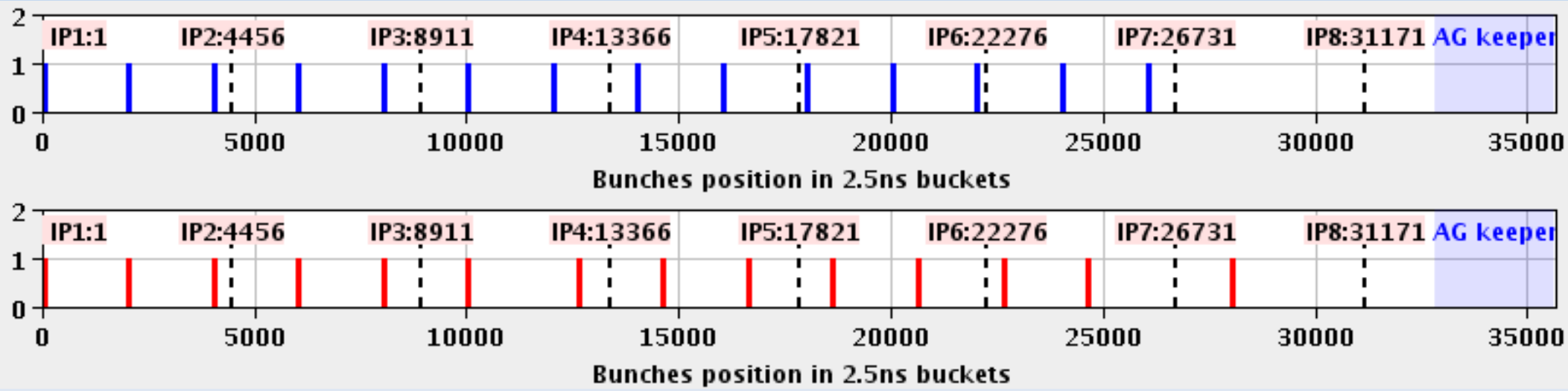


- Noise impacts both the beam quality and its coherent stability
  - The noise generated by the present ADT degrades significantly the beam quality when operating with a large gain and beam-beam parameter (HL-LHC)
  - The limits due to collective effects in the HL-LHC could be reduced with a lower noise floor

    → Test the engineering prototype of a new concept of pickup acquisition electronics with reduced noise for the ADT
- Pickups at Q8 and Q10 were equipped in both beams both plans, the two redundant modules of the ADT were re-setup :
  - Module 1 → Q9, Q10
  - Module 2 → Q7, Q8

Setup

- Filling scheme with 6 collision in IPs 1 and 5 and non-colliding bunches (no collision at all in other IPs) :



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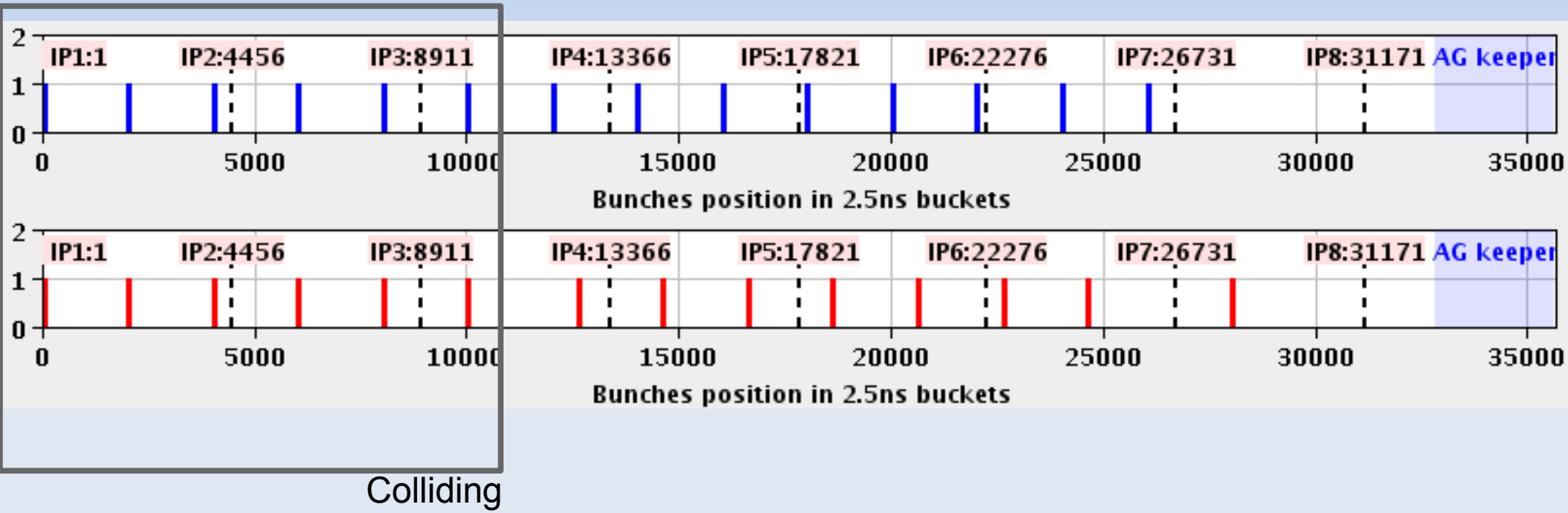

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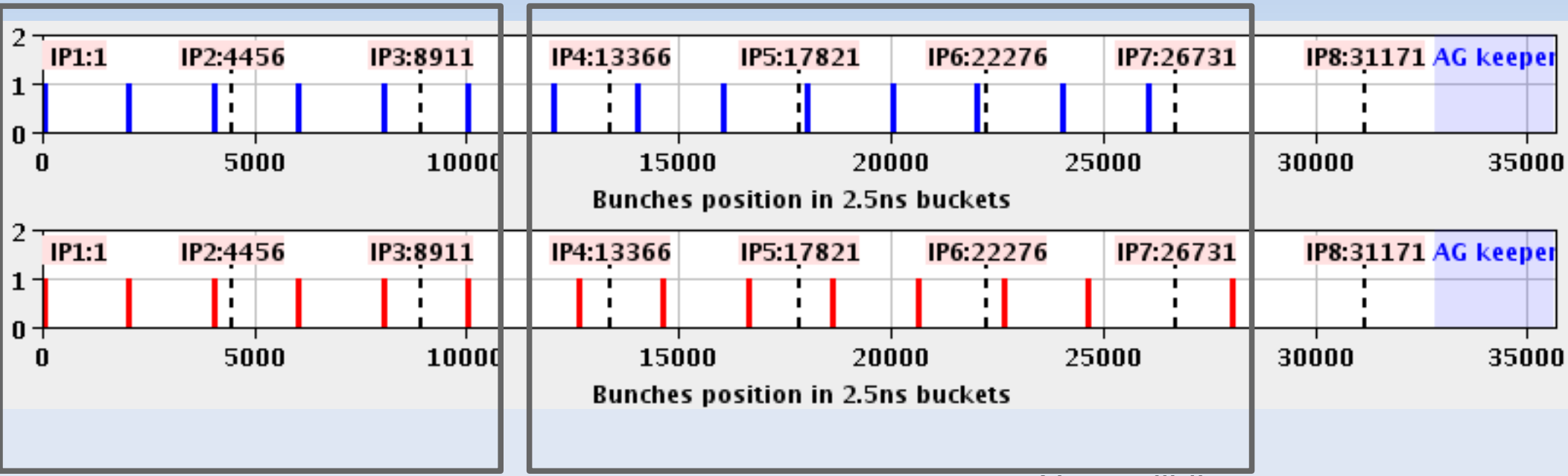

Colliding

Non-colliding

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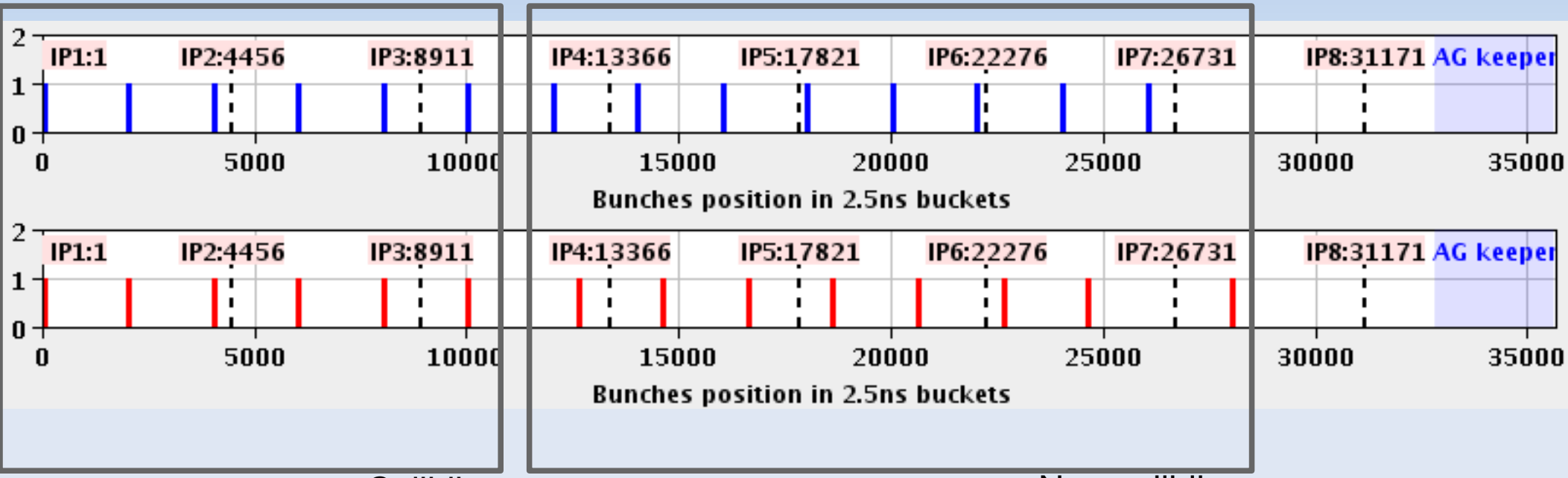

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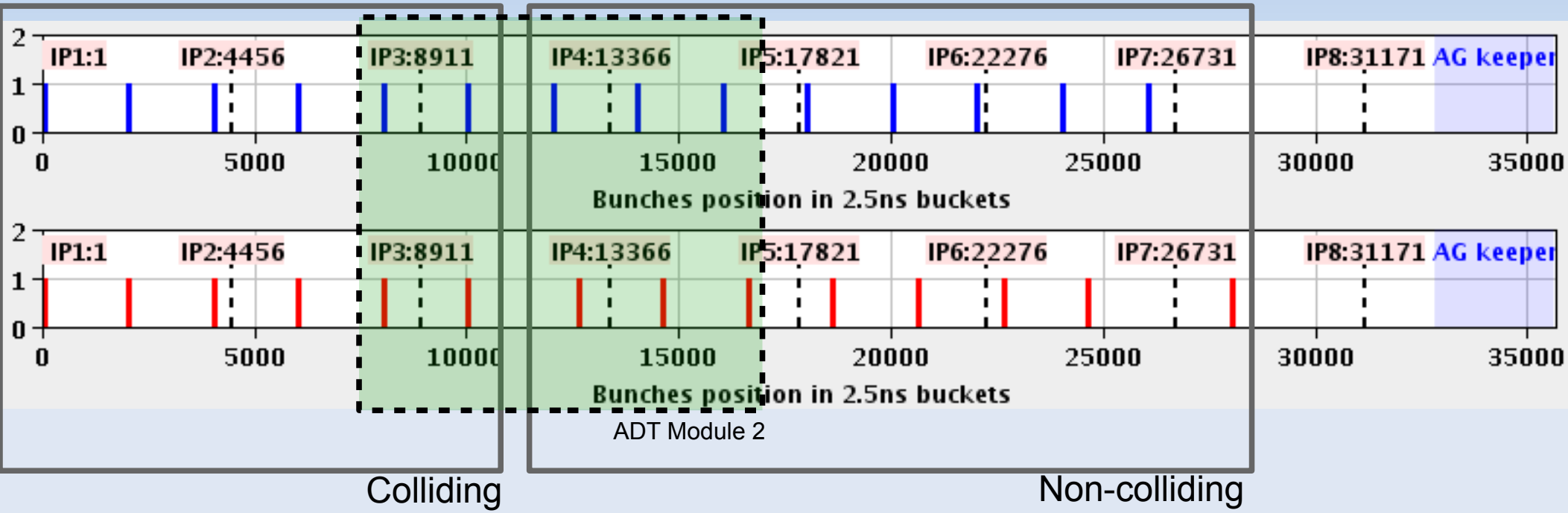

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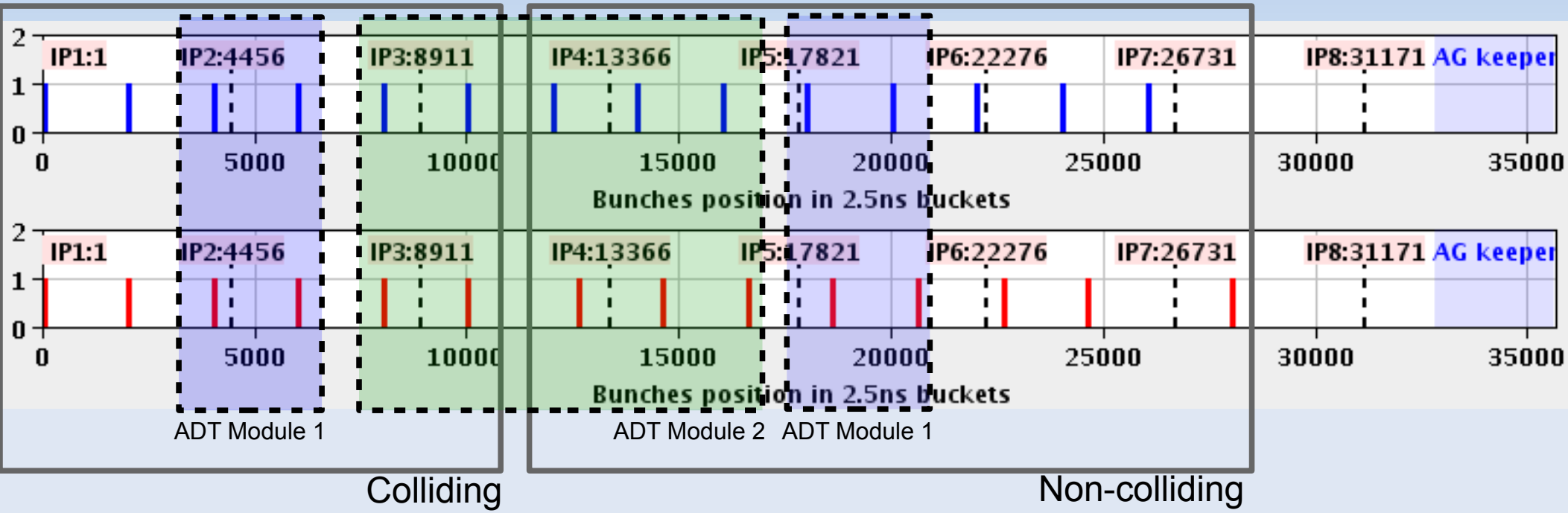

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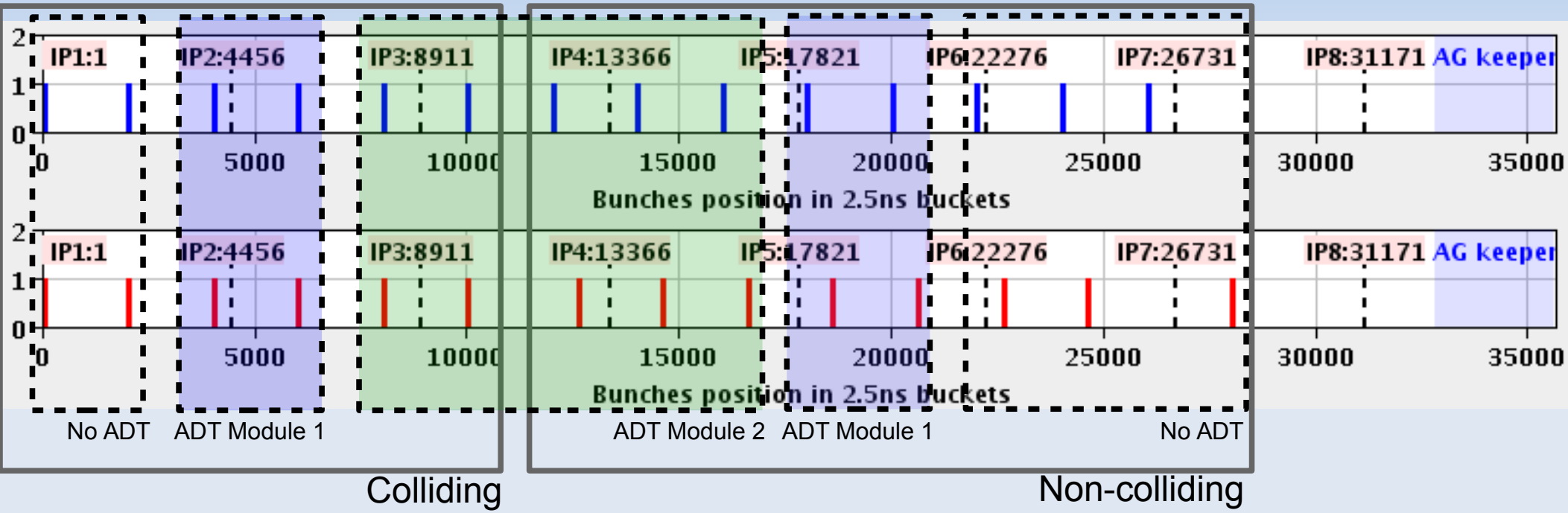

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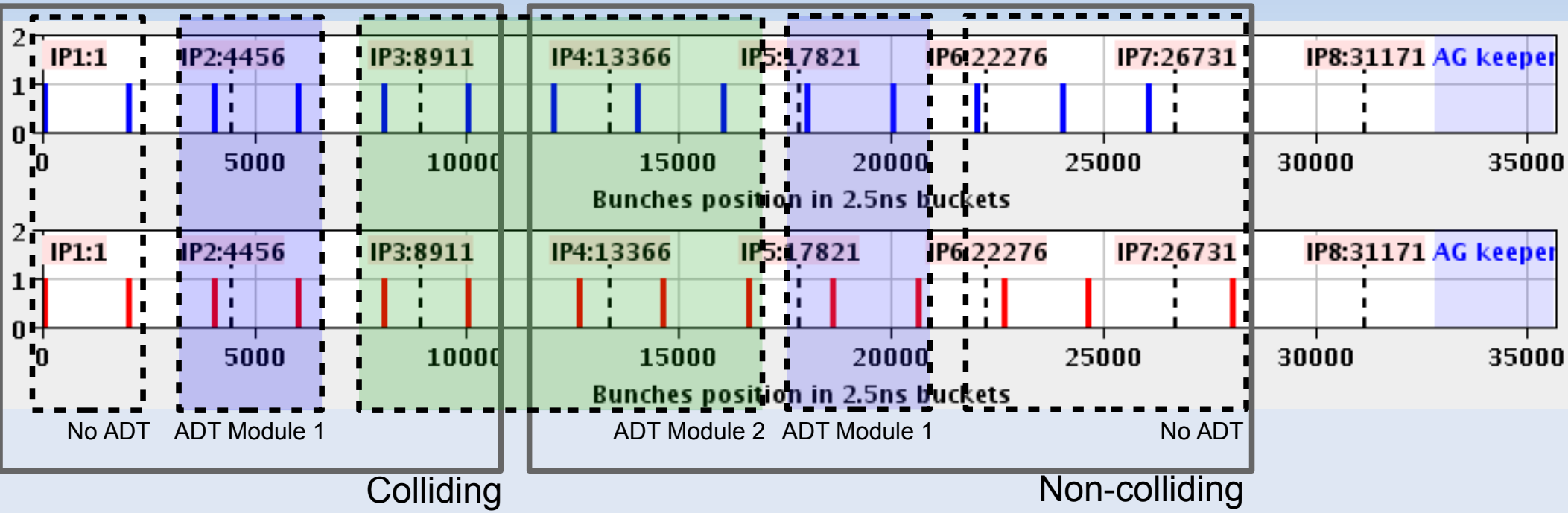

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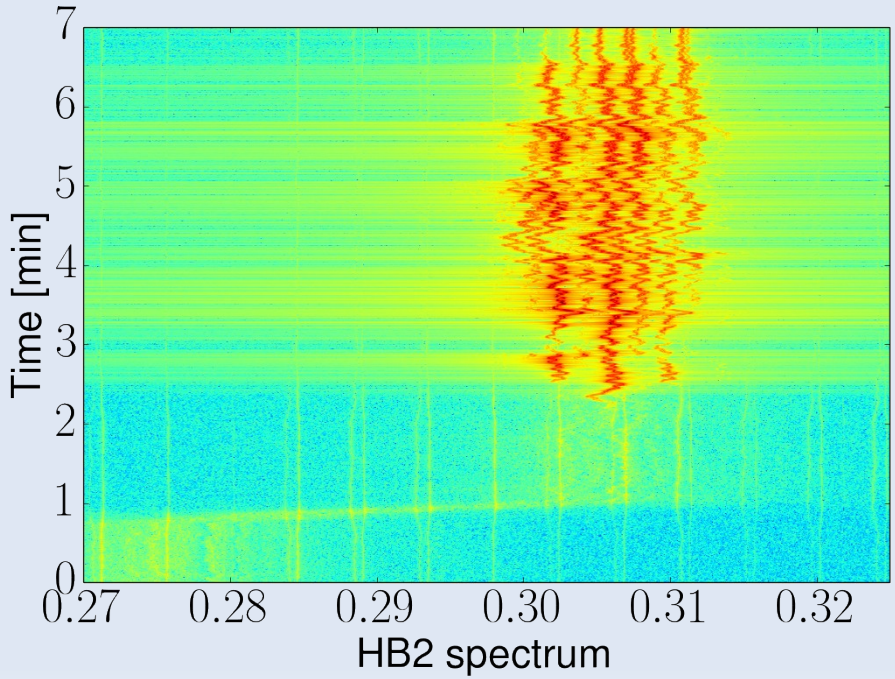
  - The masks were enabled on the colliding bunches once in collision and on the others at the start of the stability tests
  - The masks were adjusted during the MD to account for the degradation of some bunches due instabilities at flat top

First attempt

(24.10.2018)

- Smooth setting up of the ADT pickups in 5h thanks to DJGM parallelisation
  - Q10 in B1V showed issues and wasn't used
- The beam stability at flat top is know to be at the edge in this configuration with high brightness beams (critical for this MD)
  - Managed in 2017, but needed three attempts (challenging tune control with high octupoles, tight coupling correction requirement, increased chromaticity)

    → The chromaticity increase is no longer possible through the squeeze (sextupoles are out of strength)



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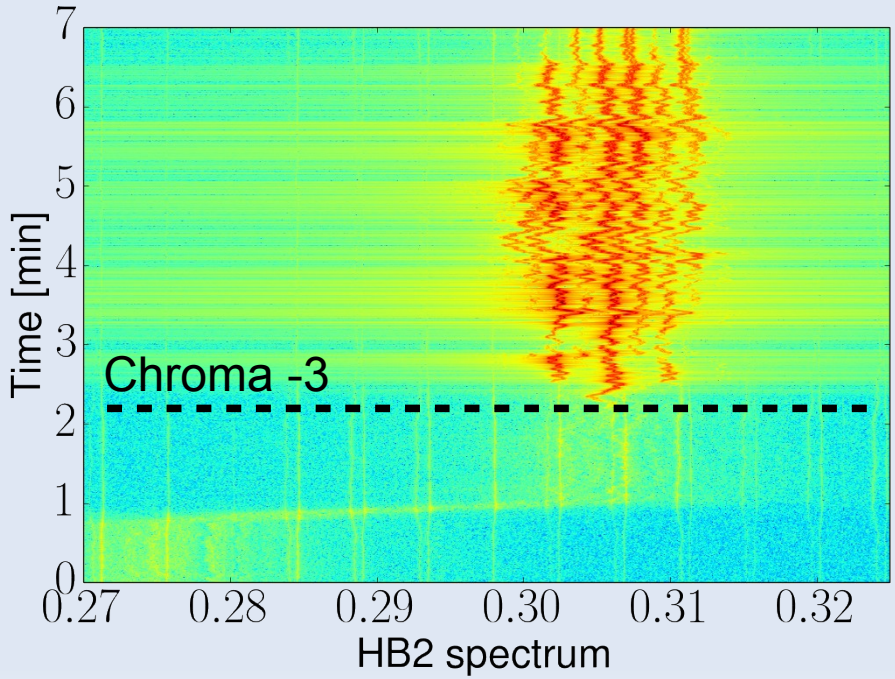

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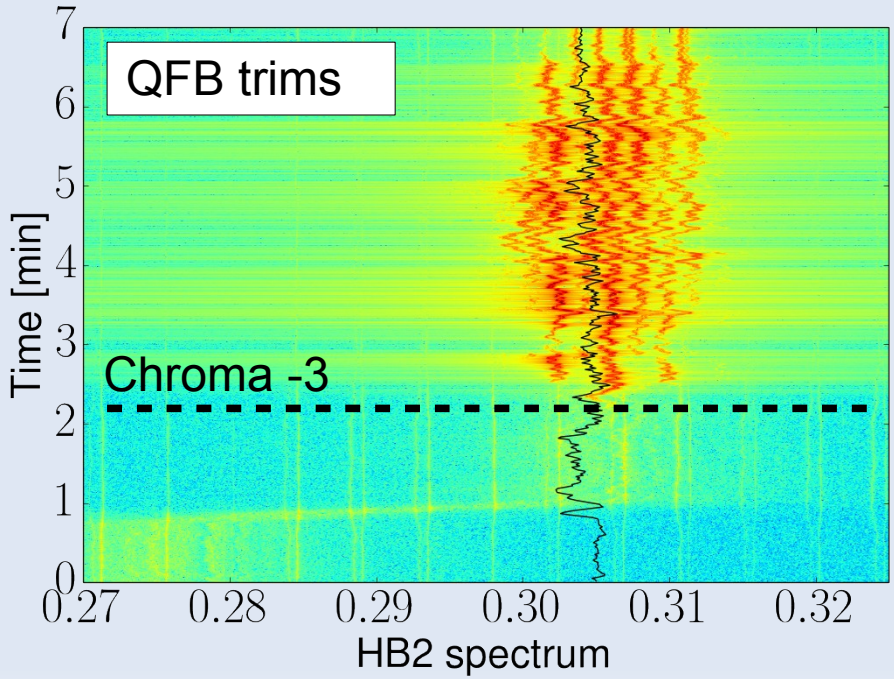

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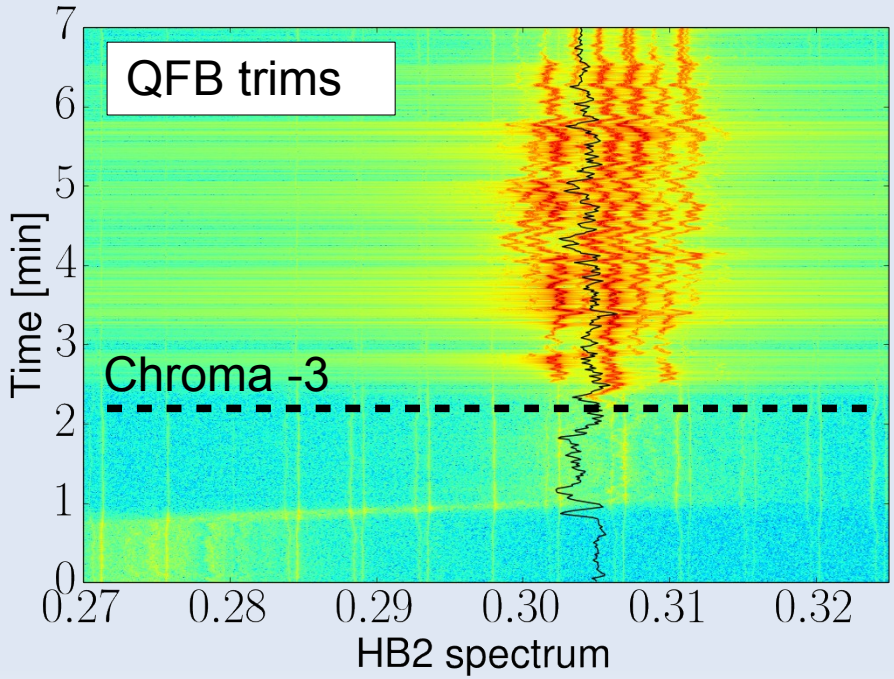

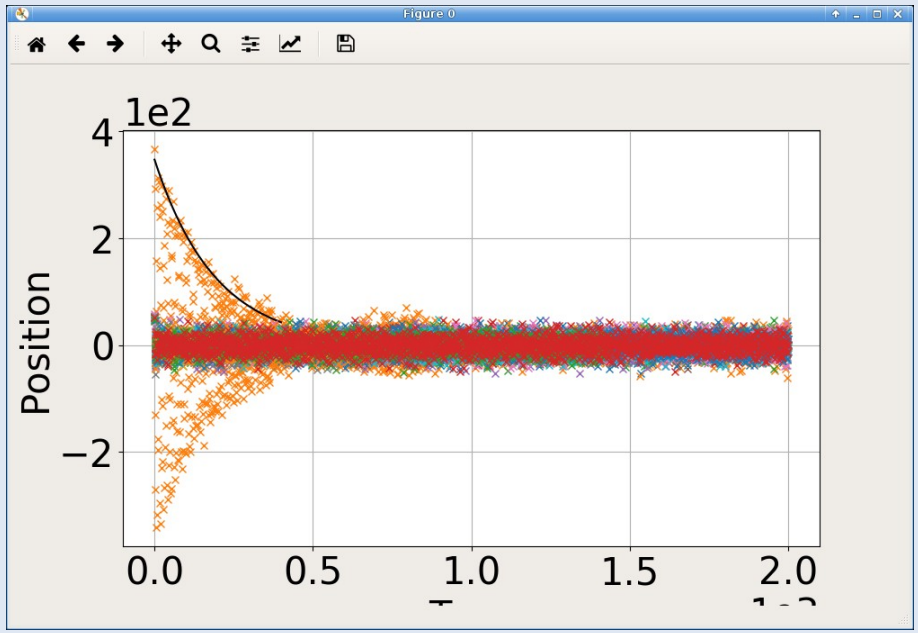

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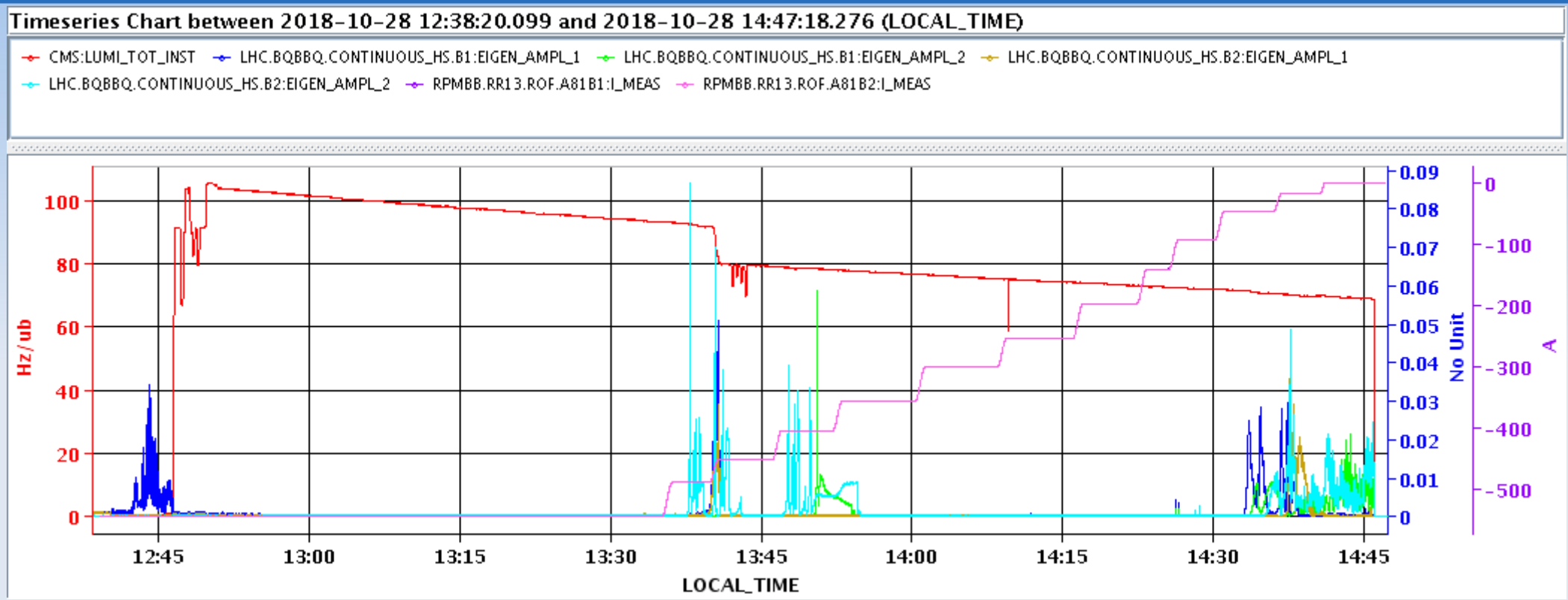
(28.10.2018)



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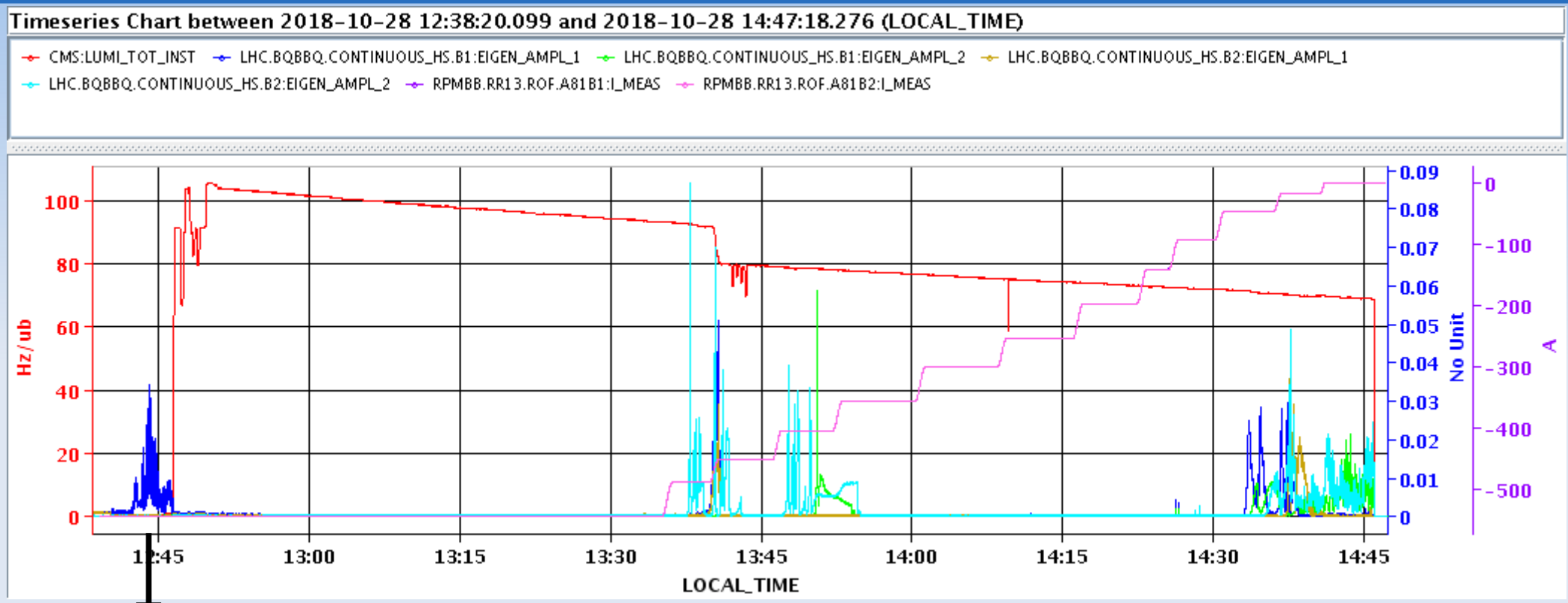

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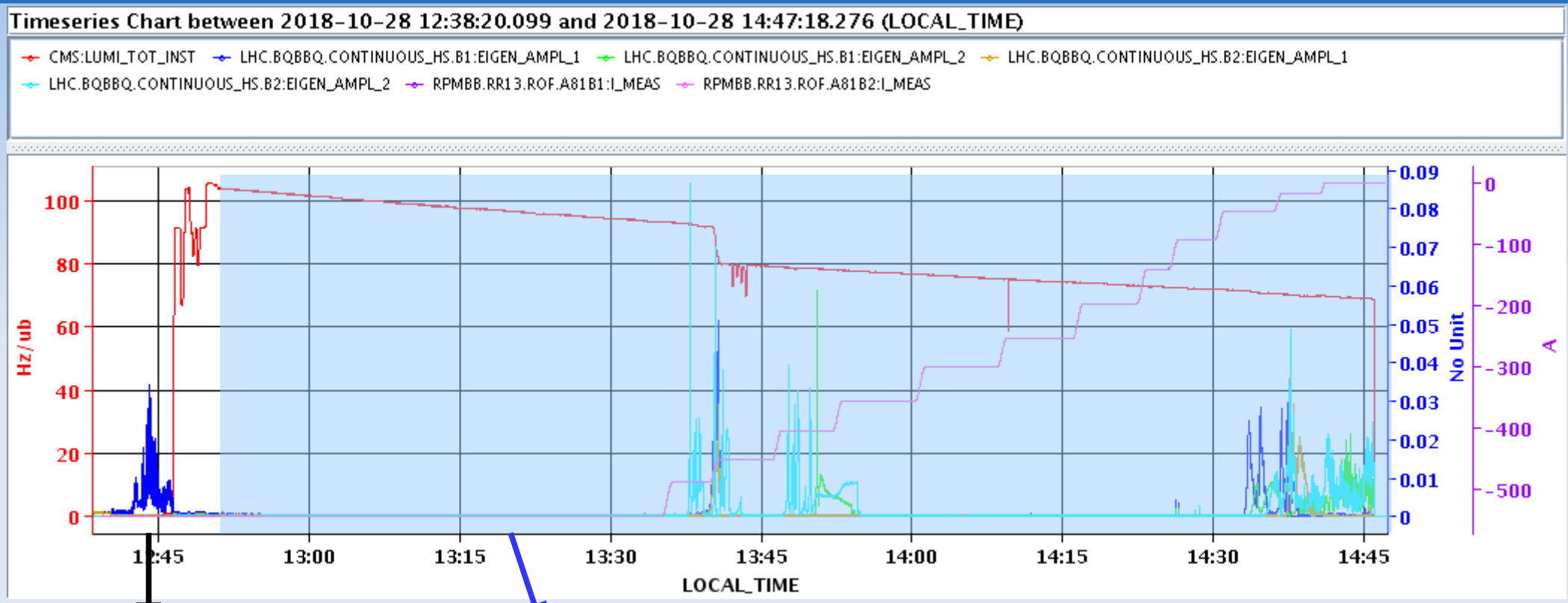

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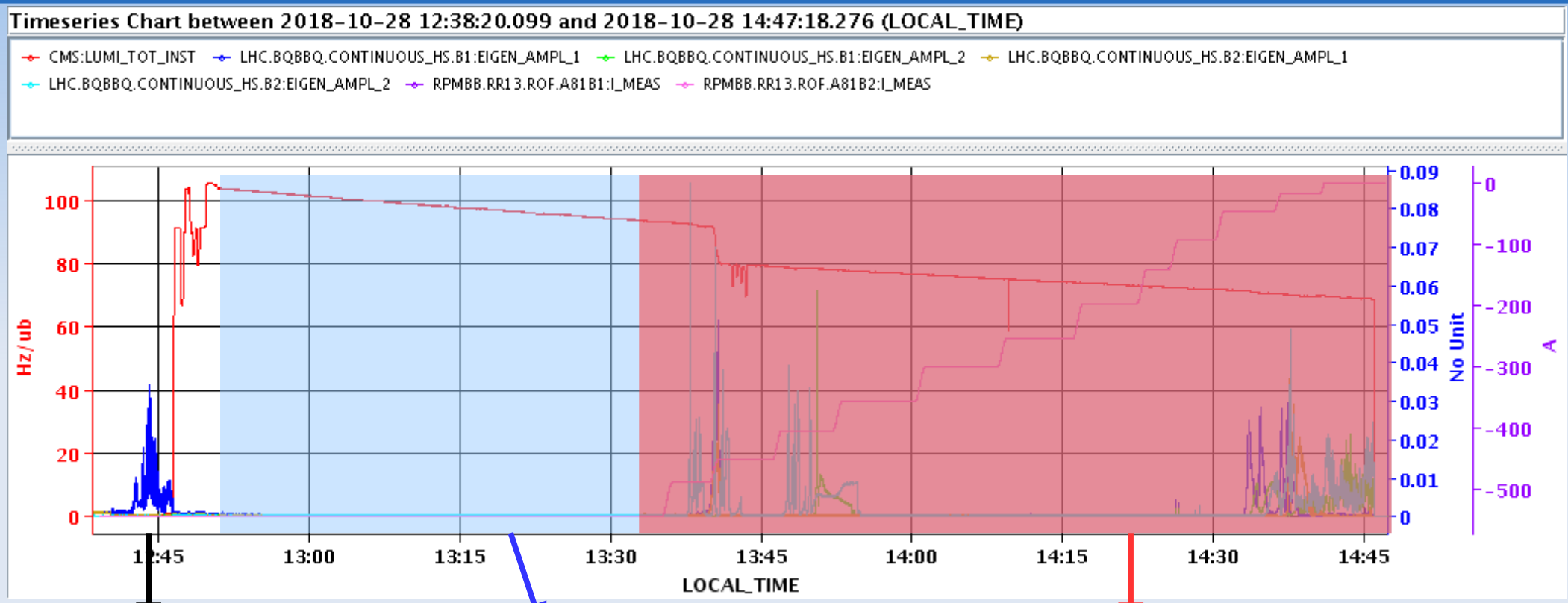

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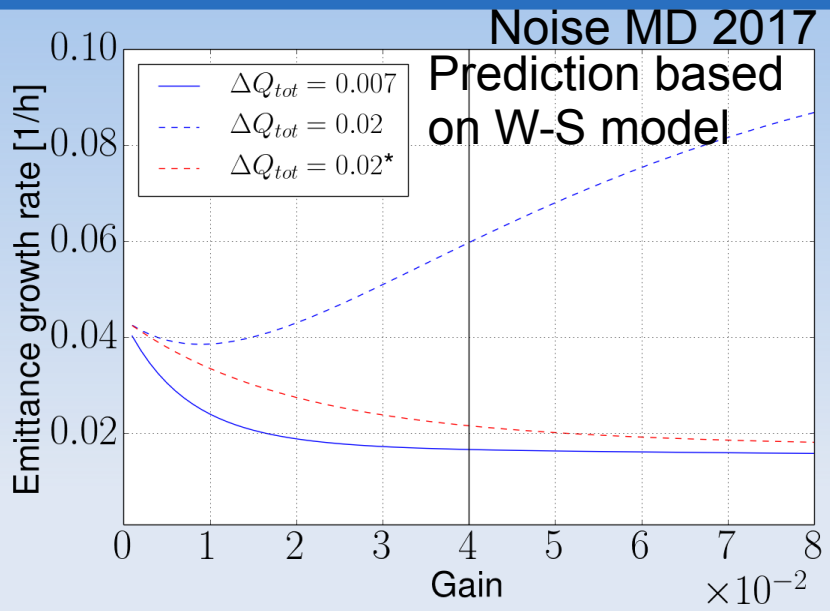
- ADT mask applied on colliding bunches for the instability study (octupole scan)

ADT gain

- Both a high beam-beam parameter and a high gain are needed to observe the mitigation of the emittance growth by the low-noise pickups



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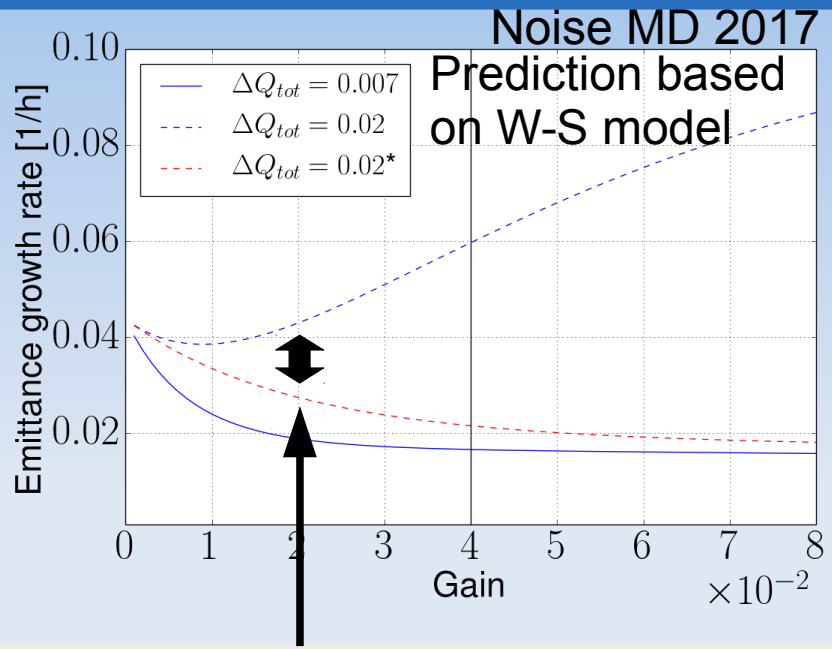
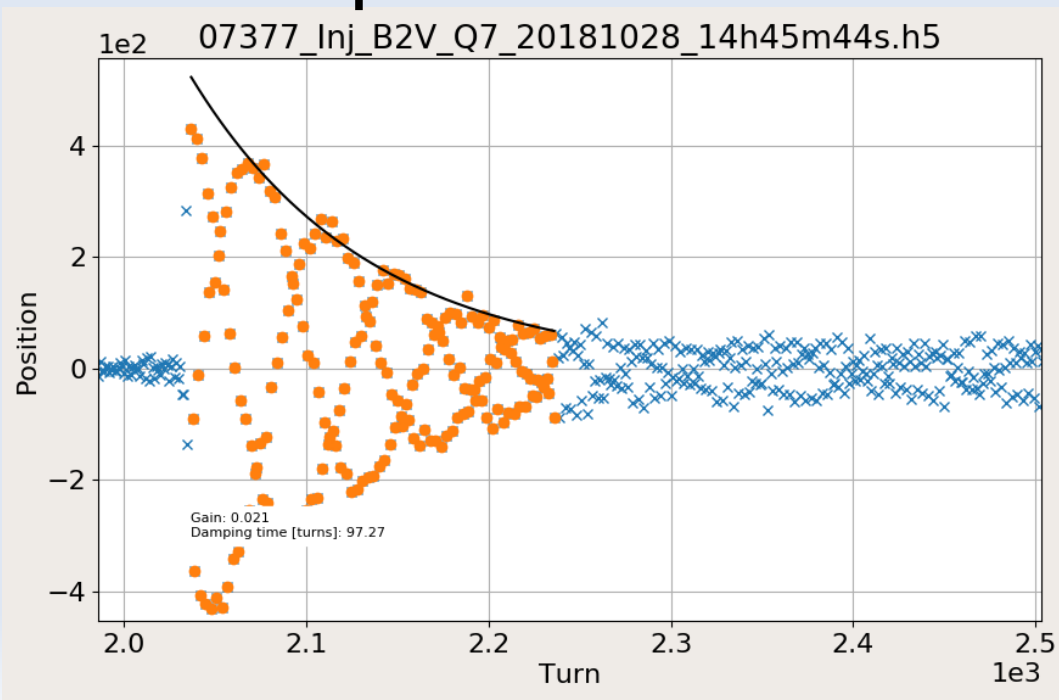
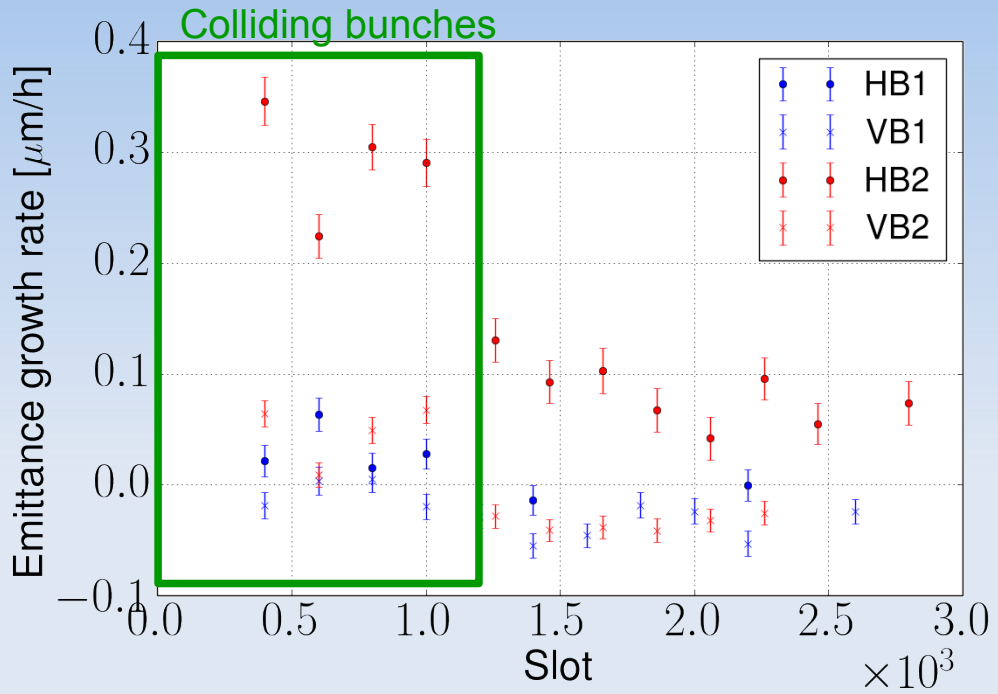
  → The large gain could not be achieved, the expected difference is in the order of 1.2%/h





Emittance observations

(fit on online CMS data)



- Colliding bunches without ADT gain are not shown since the π-mode became unstable (expected for sufficiently low chromaticity)
- Colliding bunches show a slightly larger emittance growth than others
  - The growth in the horizontal plane of B2 is overall significantly larger

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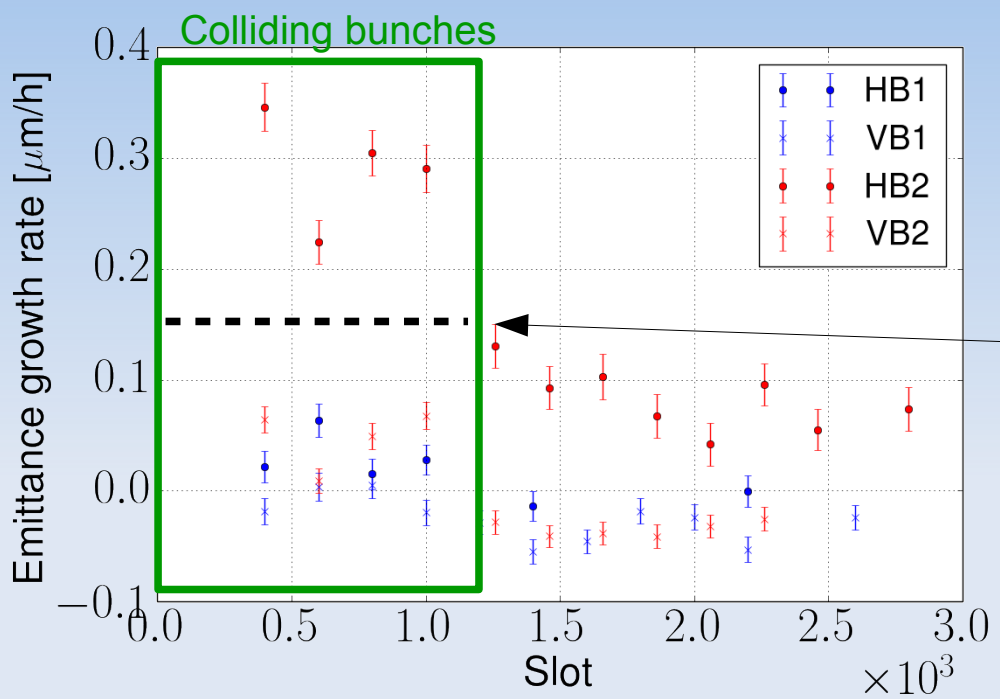

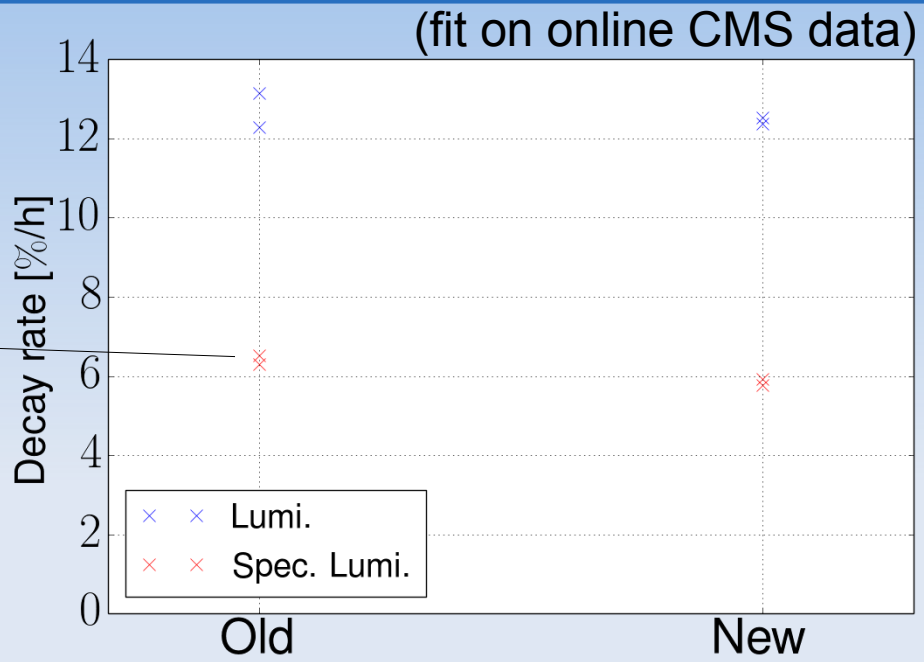

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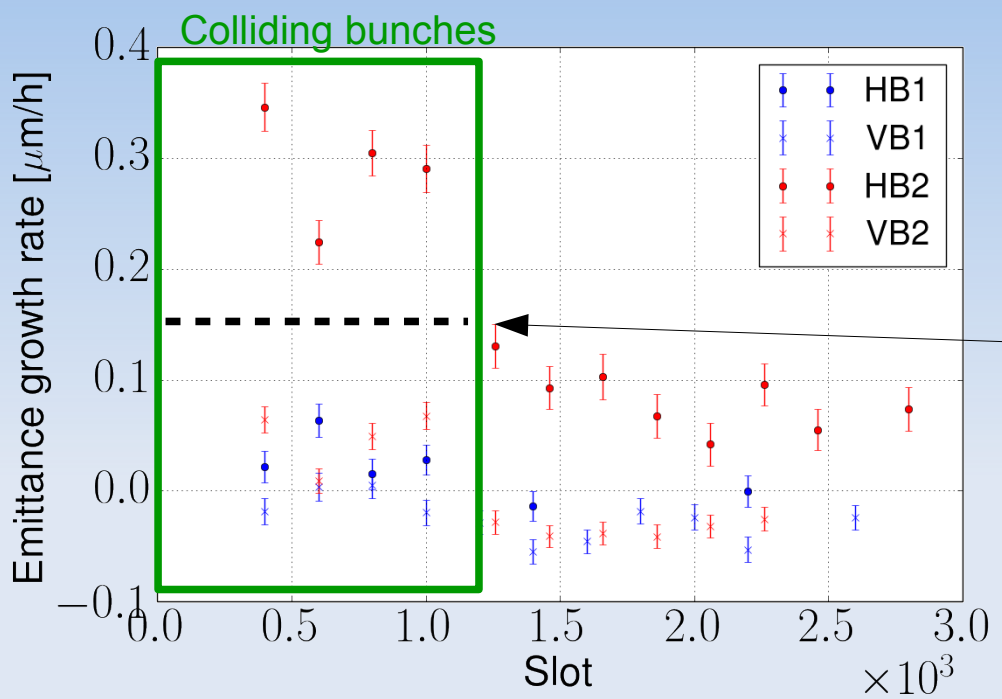

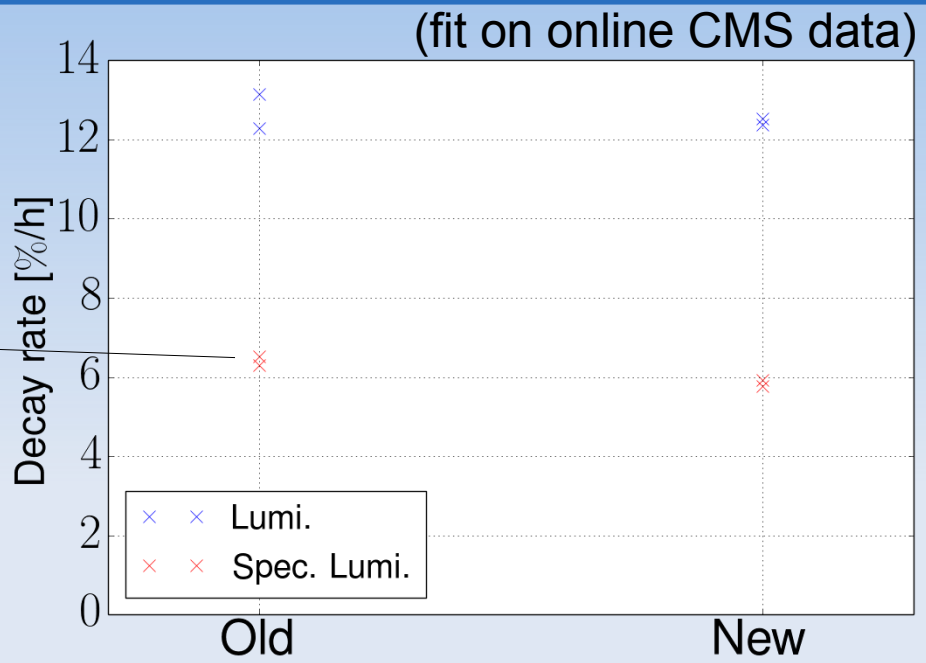

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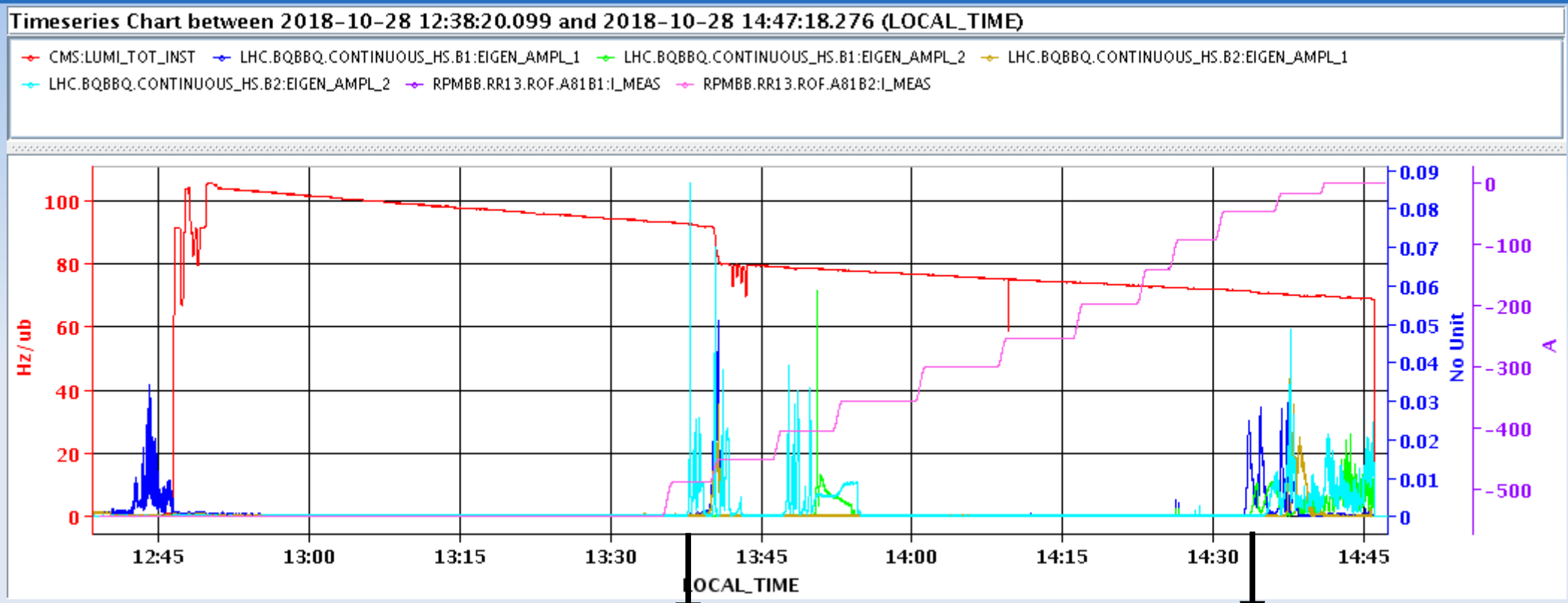
  - The growth in the horizontal plane of B2 is overall significantly larger
- The difference between the pickups is visible in the specific luminosity decay (~relative emittance growth rate). A reduction of 0.6 %/h is observed (1.2 was expected).
- The absolute value is larger than expected based on the past MD (6.4 %/h where 4 to 5 %/h was expected) and difference between planes (B2H dominates) can only be explained with a sufficiently low chromaticity

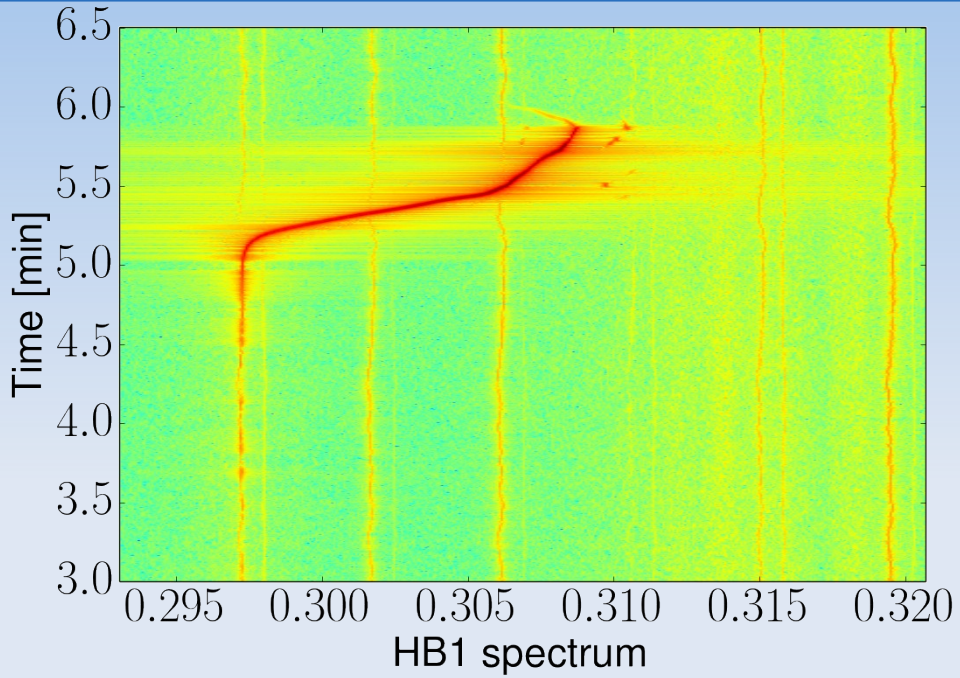
  → This can explain the difference between expected and observed improvement, to be confirmed with detailed simulations

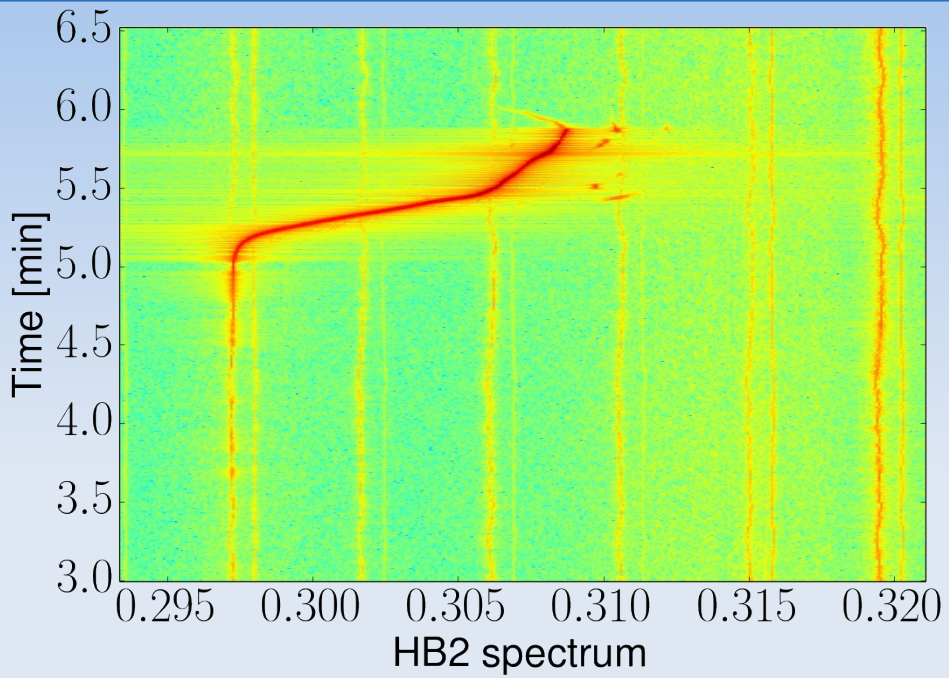
Instability threshold measurement



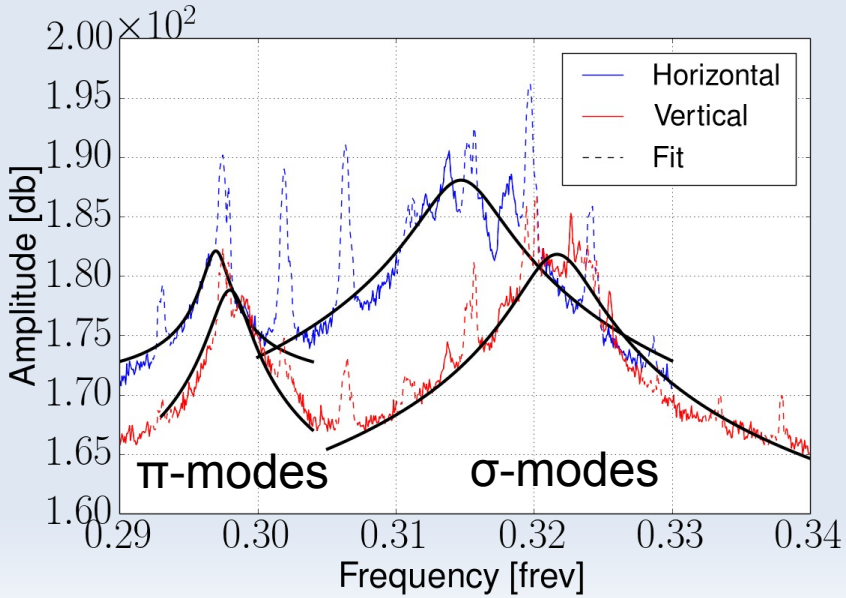
- Both colliding and non-colliding bunches without ADT became unstable at -489 A
- Other bunches became unstable at -19 A, irrespective of the ADT pickup (vertical plane)
  - Obtained -25 A during the ATS MD3 with 25ns trains of a lower brightness (horizontal plane)

Unstable coherent beam-beam mode

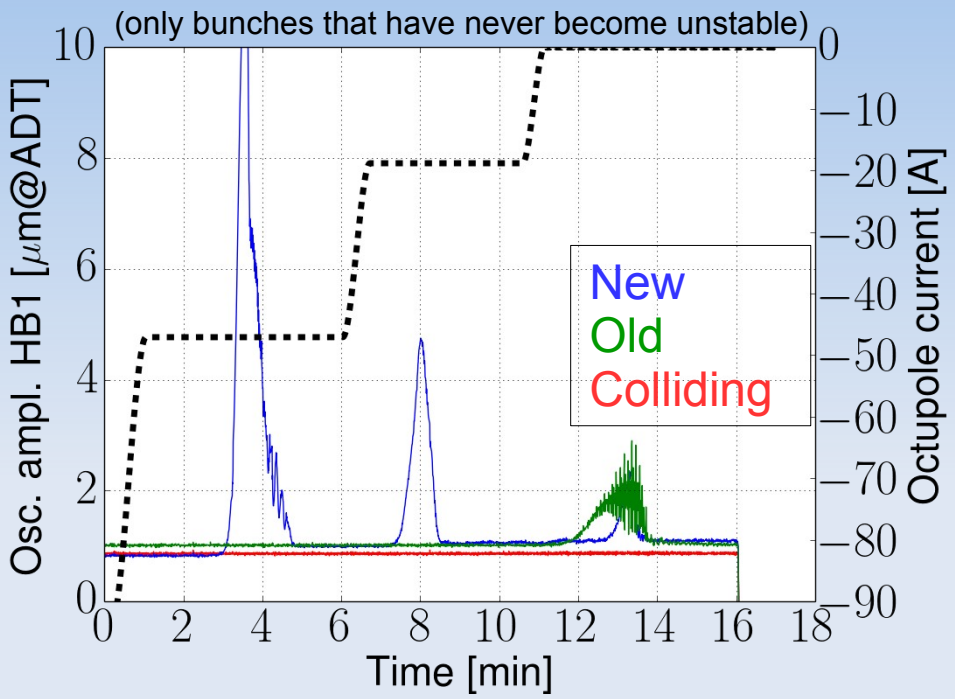


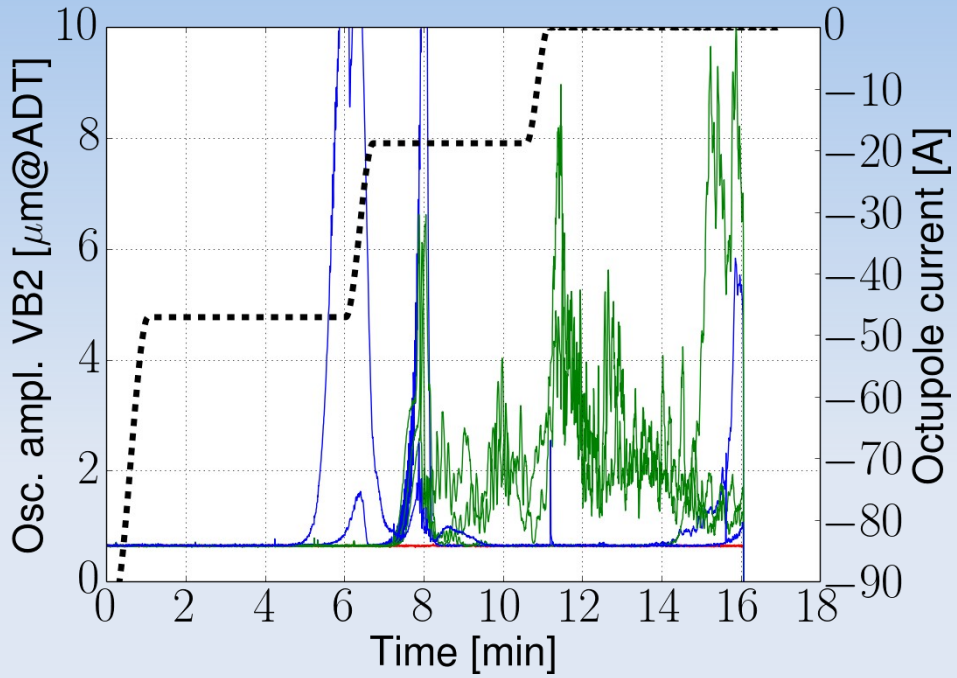


- Textbook π-mode instability at -489 A :
  - Reduction of the frequency towards the bare tune as the amplitude increases
  - Perfectly correlated in both beams
  - Only affects colliding bunches without ADT
  - Beam-beam tune shift ~ 0.02



Non-colliding bunches



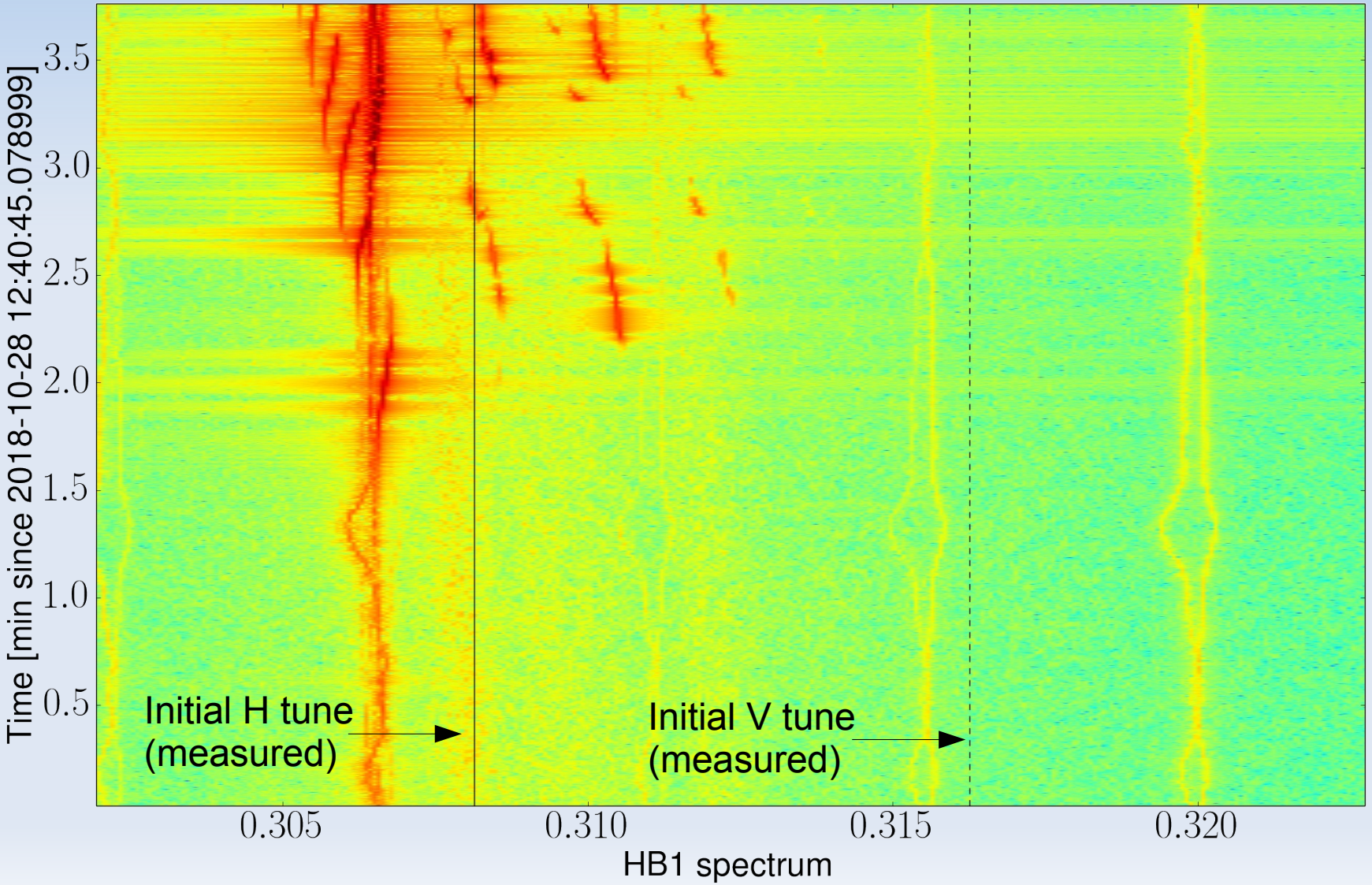


- The beam stability is more critical with the new pickups with respect to the old ones (cannot be explained by bunch-by-bunch brightness variations~10%)
  - 0 → -47 A in B1 and -19 → -47A in B2
- Despite the high brightness, the threshold is low with the old pickup (-19A)
  - Difficult to conceal with the instability at flat top with -545 A
  - There was no squeeze → identical config., except for the tunes and separation bumps

Summary

- Operation with the new ADT pickup electronics concept was successful
- A small reduction of the emittance growth rate could be measured, mainly due to the too gain that was achieved
- The beam stability was significantly more critical with the new pickups
  - Great reminder of how important is the ADT setup for the beam stability
  - The cause for the reduction of stability needs to be understood (Accuracy of the phase?)

Backup
Flat top instability



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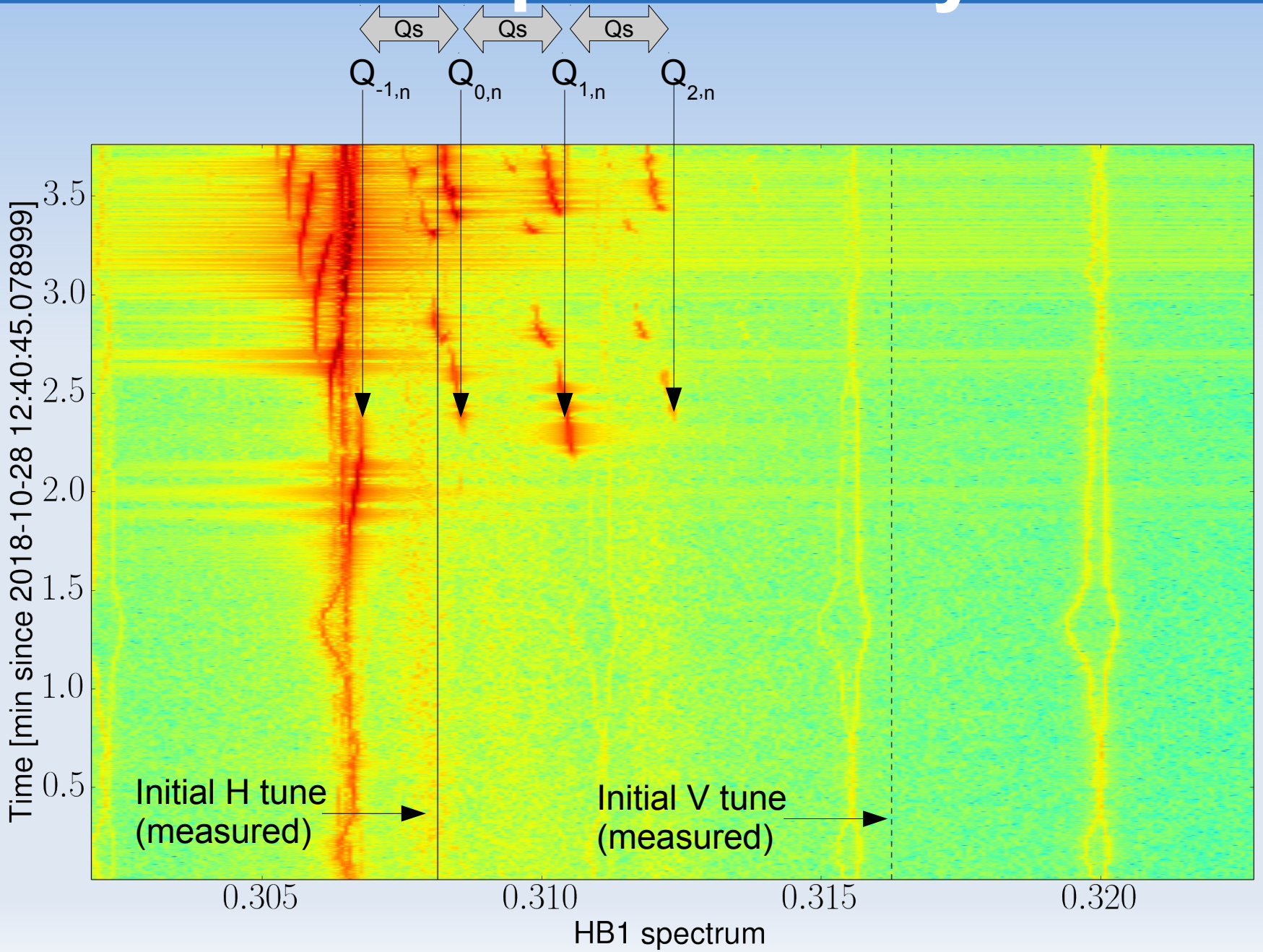

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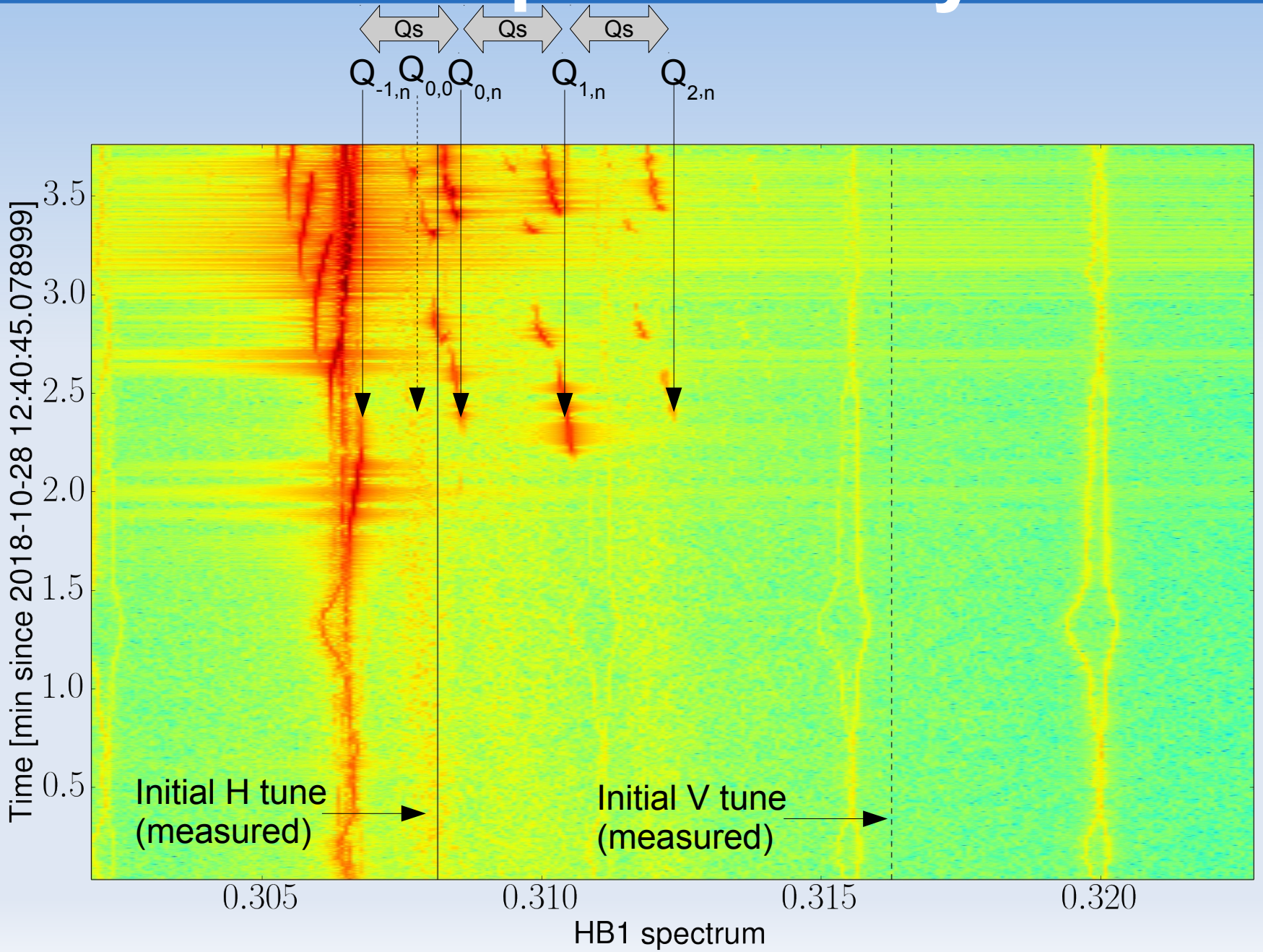

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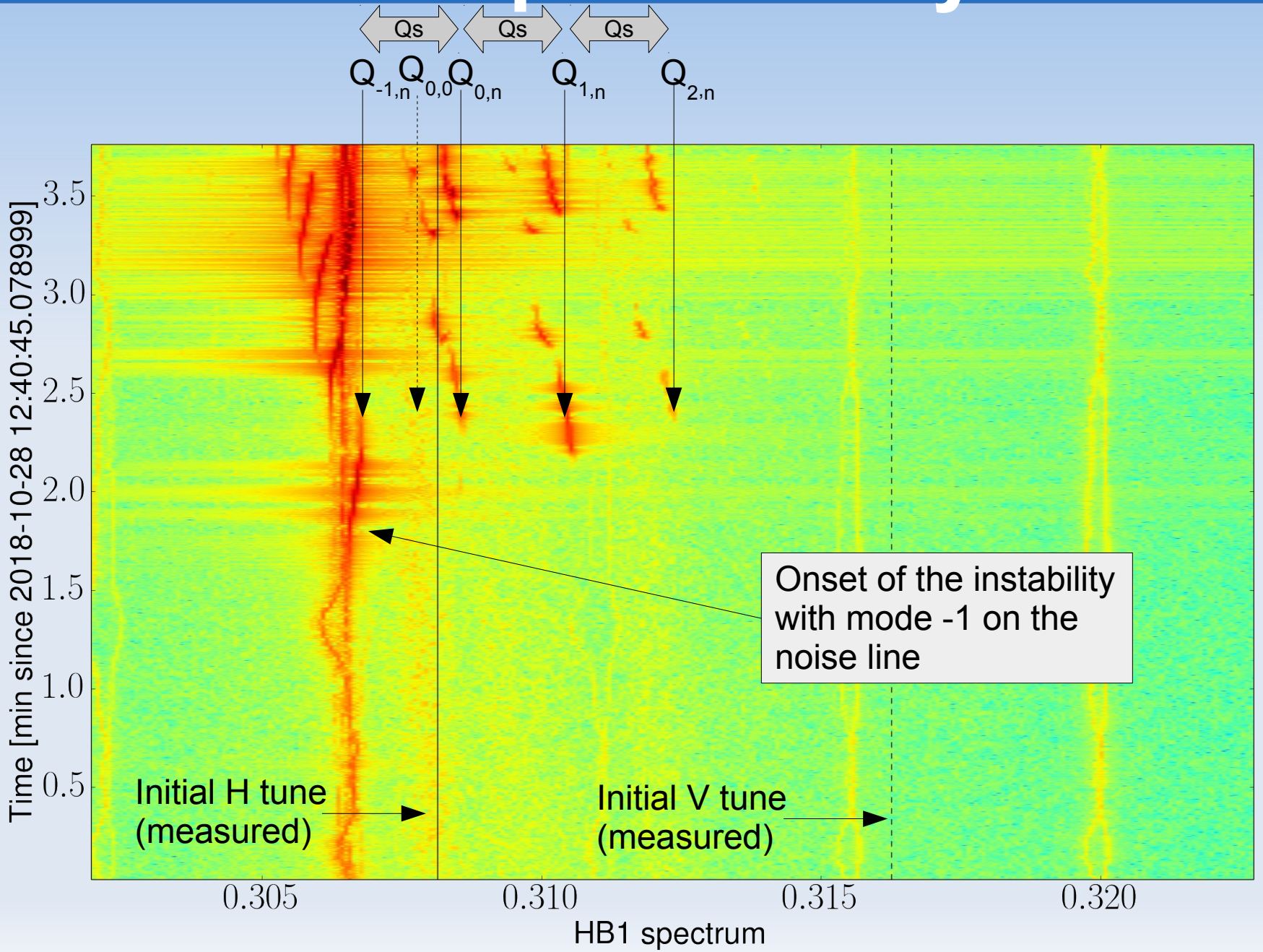

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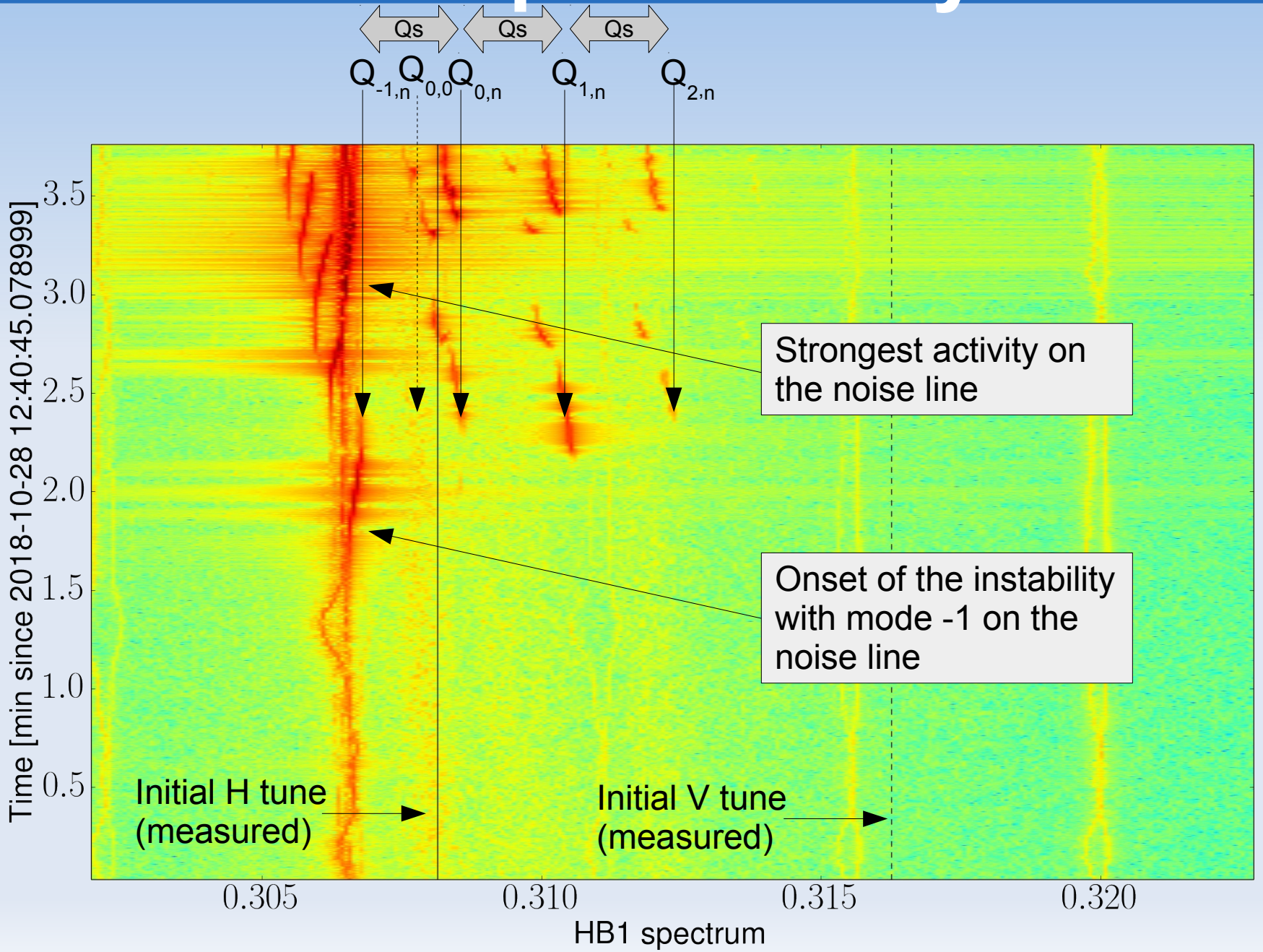

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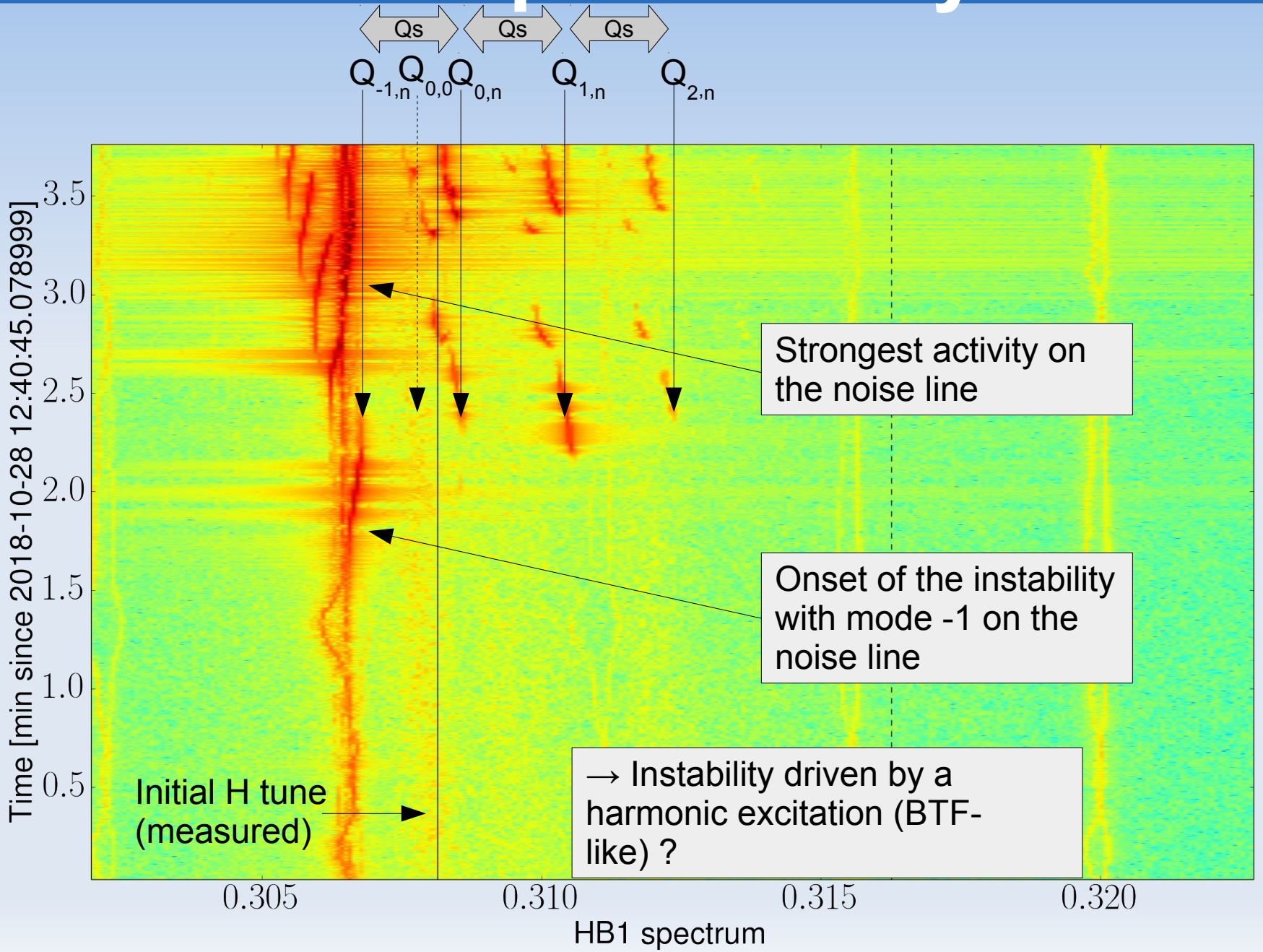

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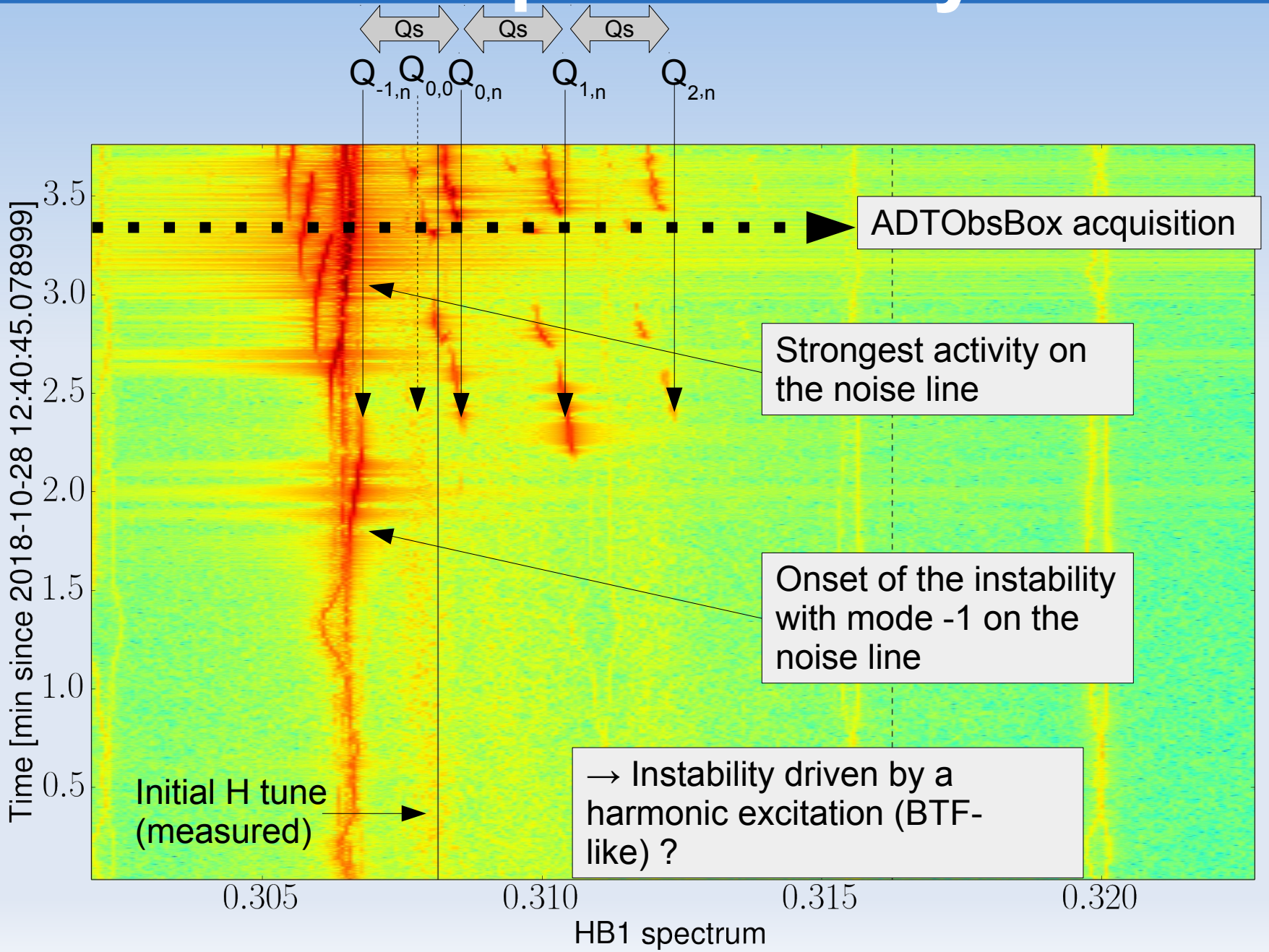

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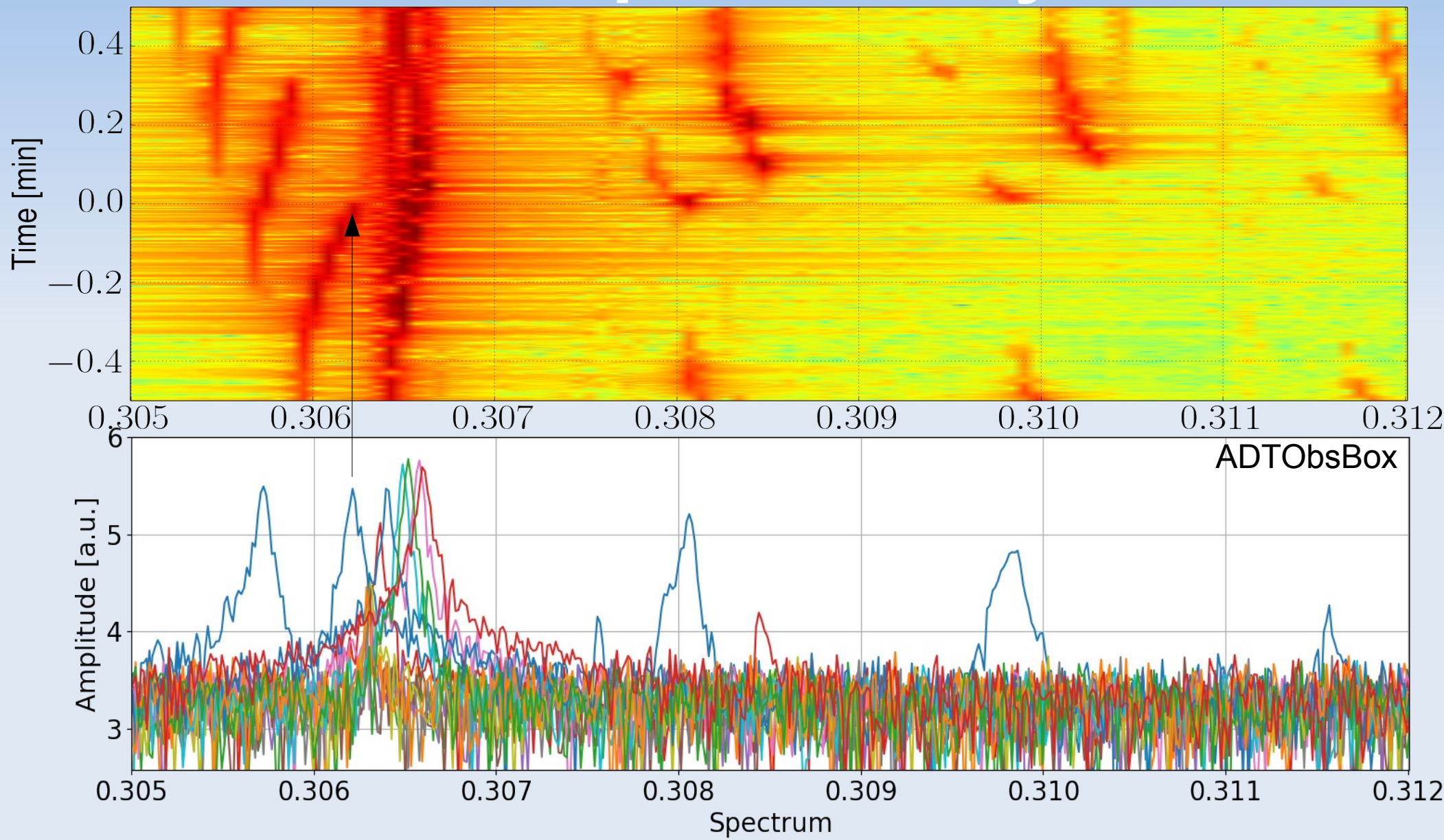

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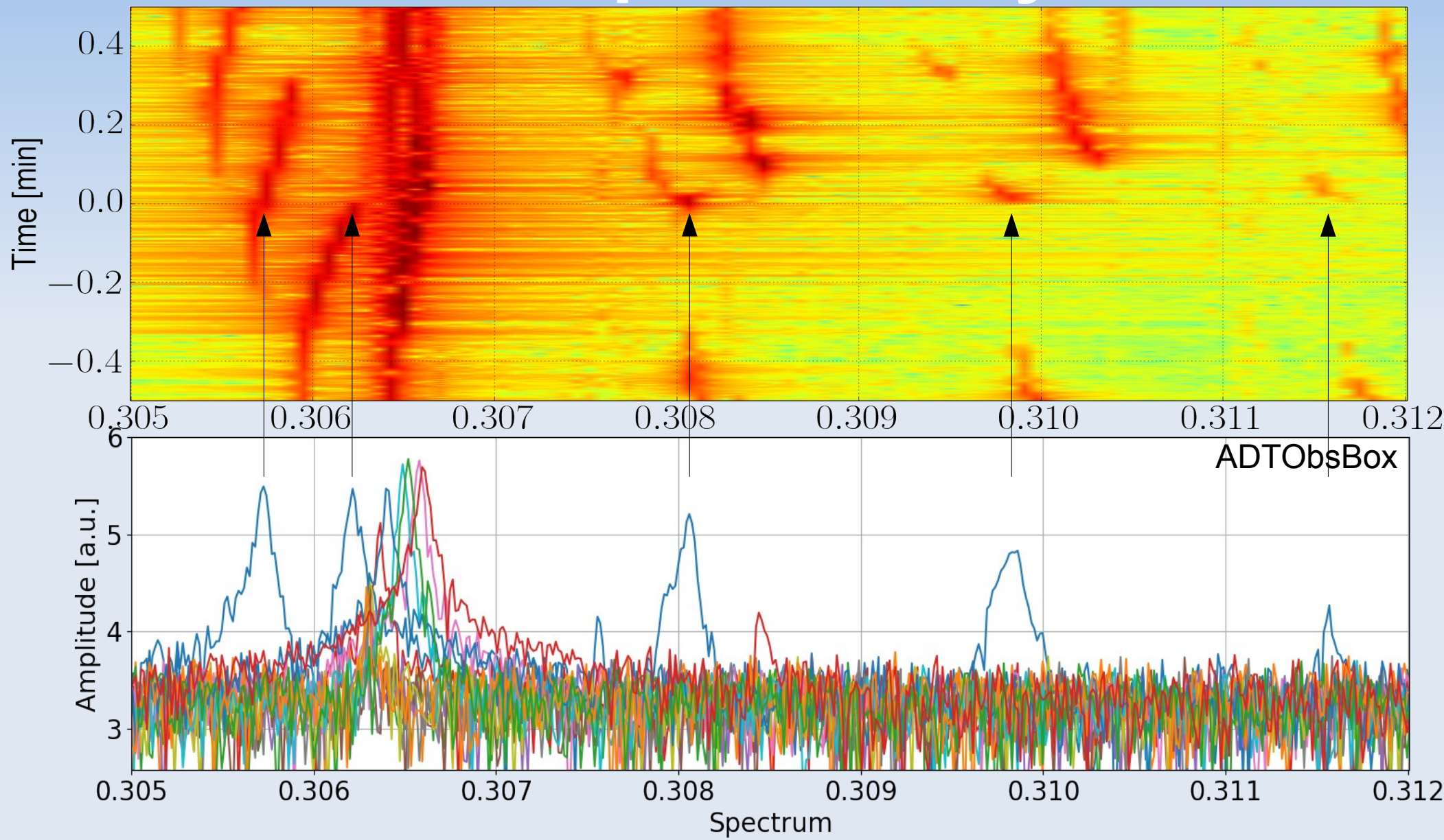

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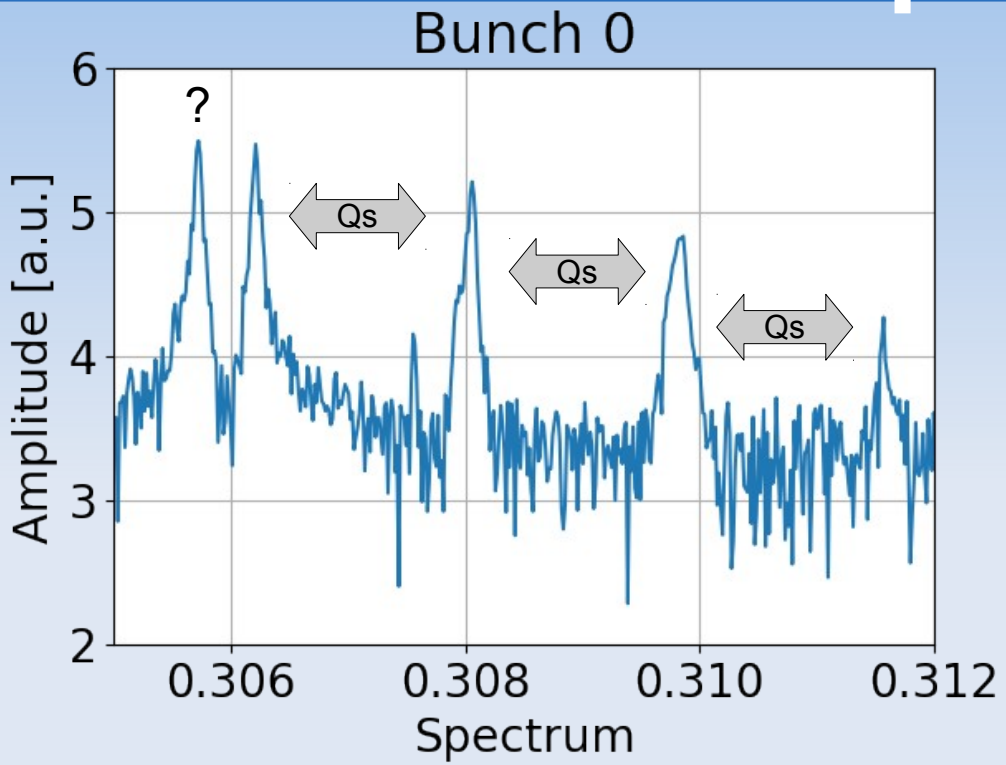
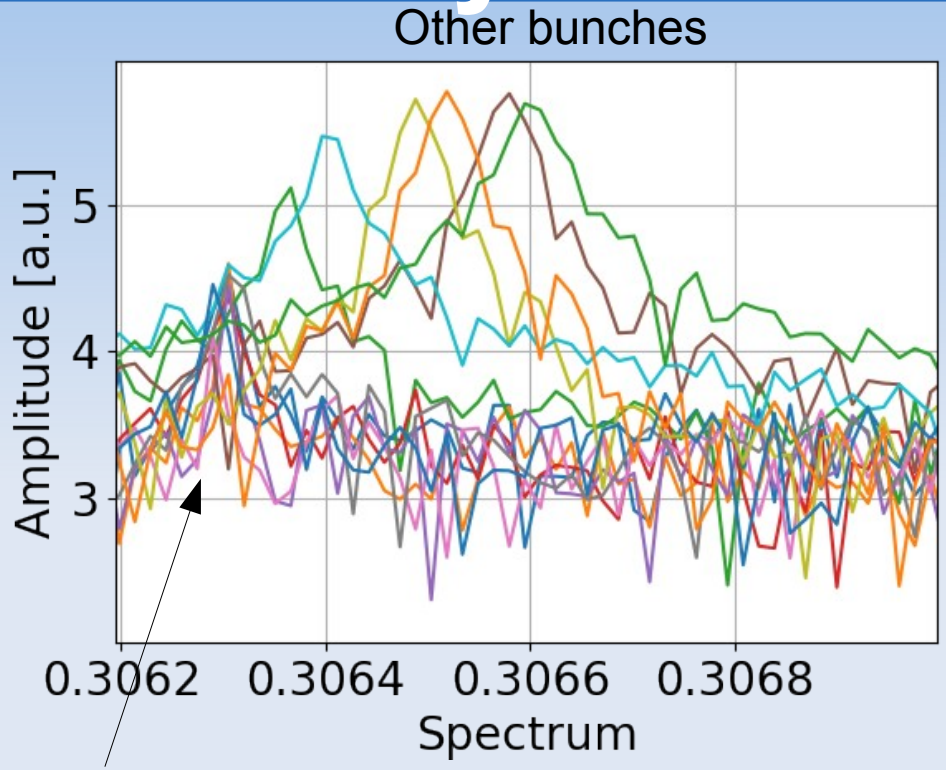
Flat top instability





- Unstable bunch with an unidentified line at 0.3057
- Bunches with a small signal at 0.3063
- Bunches with a strong signal between 0.3064 and 0.3066

→ 0, 200, 400, 600, 800, 1000, 1200, 1400, 1600, 1800, 2000, 2200, 2400, 2600

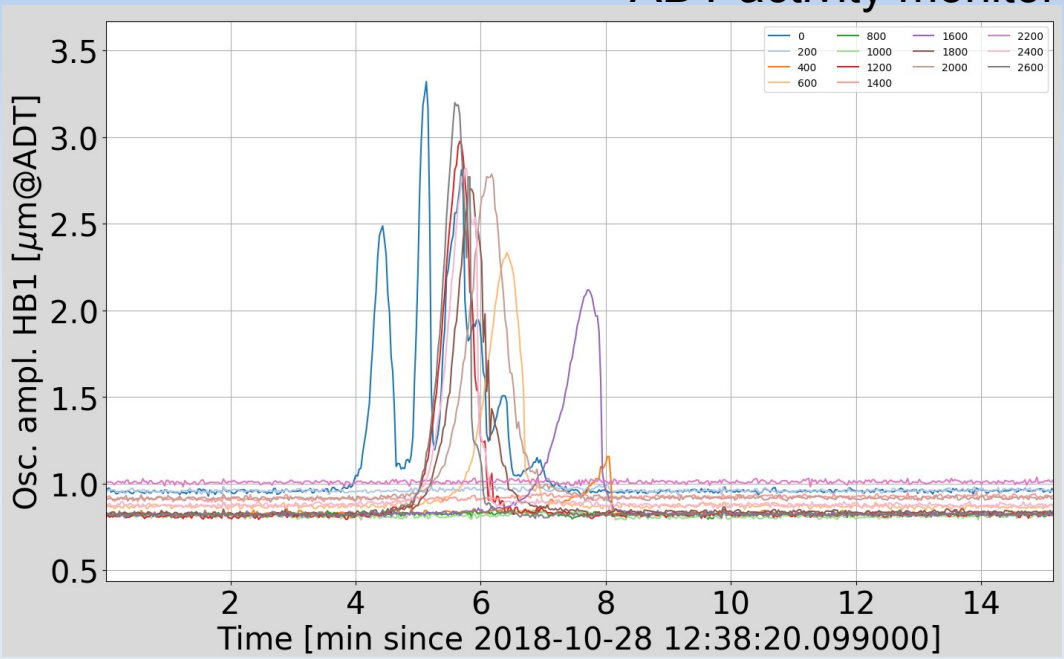
- At this point of the MD, all bunches experience the same damping signals (no mask applied)

→ Puzzling behaviour just below 69*50Hz → Q_x~0.3068

Backup
Flat top instability

0, 200, 400, 600, 800, 1000, 1200, 1400, 1600, 1800, 2000, 2200, 2400, 2600

ADT activity monitor

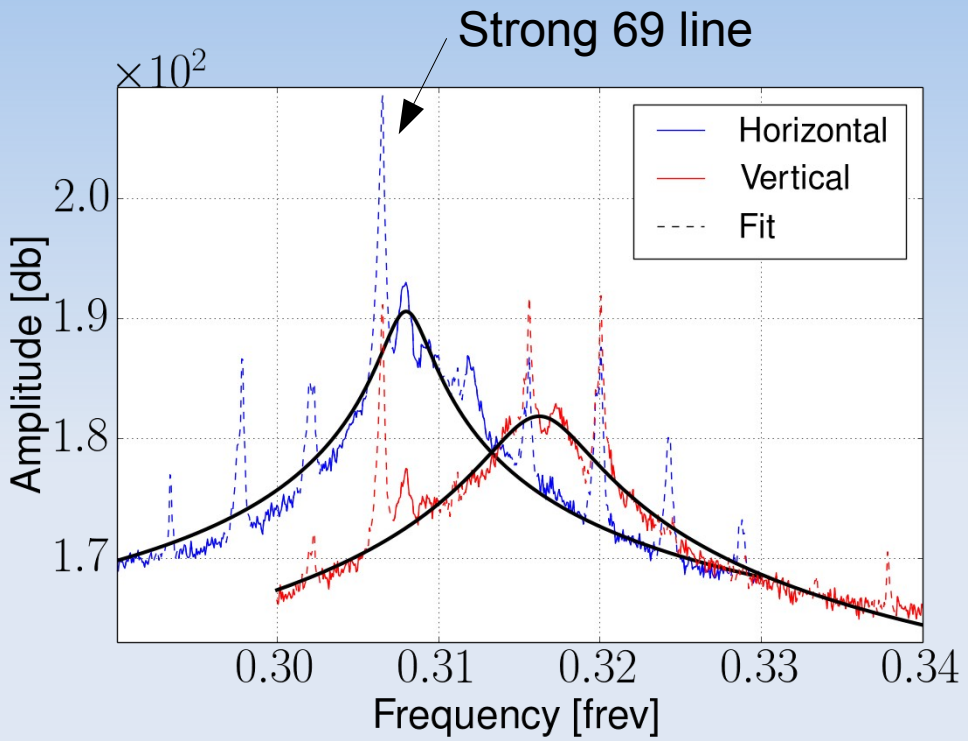


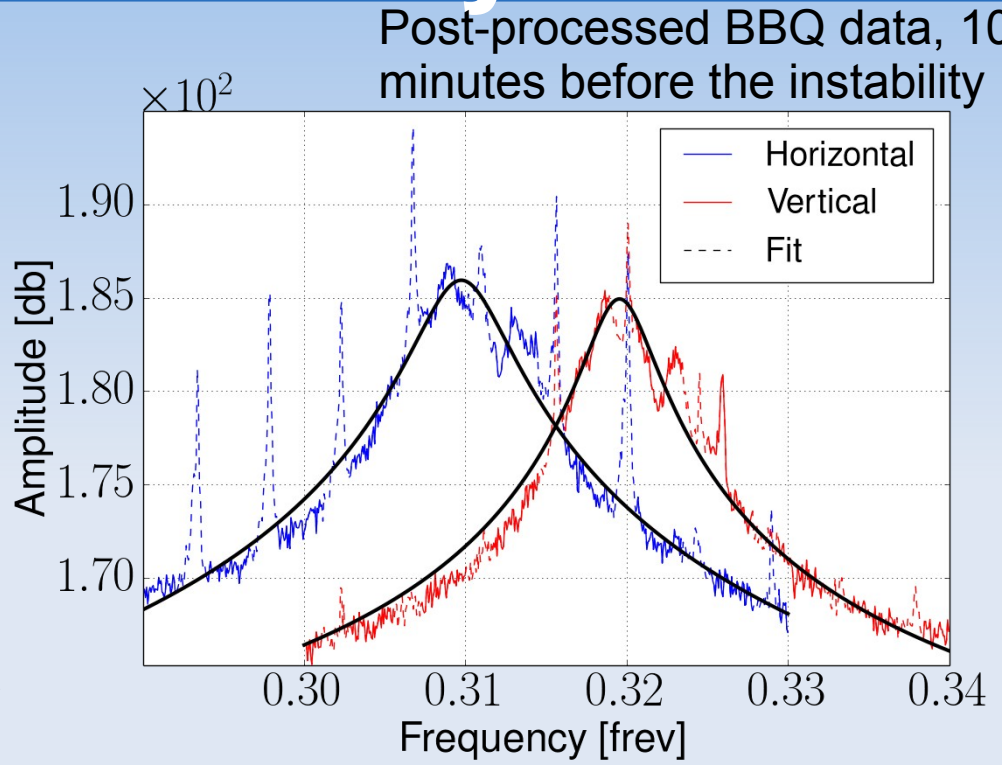
- Bunch 0 is the first bunch to become unstable, but the other bunches with a strong signal became unstable later on

  → The strong signal is an early sign of the instability

  → Is it the result of an excitation by line 69 ?

Backup
Flat top instability





- B1H spectrum is narrower than others, yet the damping times measured with single bunch kicks were similar

  → Reduced spread due to coupling ? (Tunes are off in B1, with delta Q min is 0.008 in B1, whereas perfect in B2)

  → Reduced Q' ?