LHC TMCI threshold measurement in the LHC

Results and analysis details

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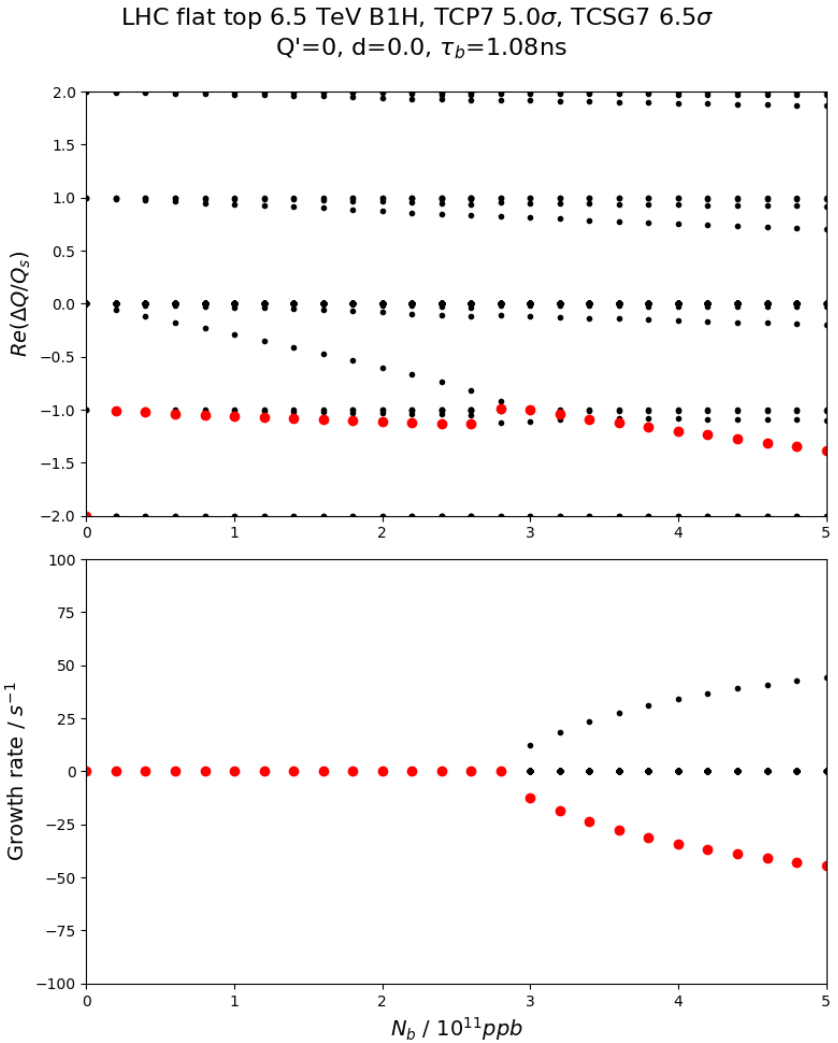
Goal

- From simulations, the coupling of modes 0 and -1 is the most critical
- Measure the tune shift vs. intensity
- From this measurement, infer the TMCI threshold



MD procedure

- Two fills with different bunch intensities
  - First fill: 0.6, 1.0, $1.25 \cdot 10^{11}$
  - Second fill: 0.8, $1.9 \cdot 10^{11}$
- Kick all the bunches with the ADT
  - Both beams at the same time
  - H plane first, V plane 2000 turns after H plane
- Record bunch-by-bunch and turn-by-turn position
- Close collimators and repeat procedure

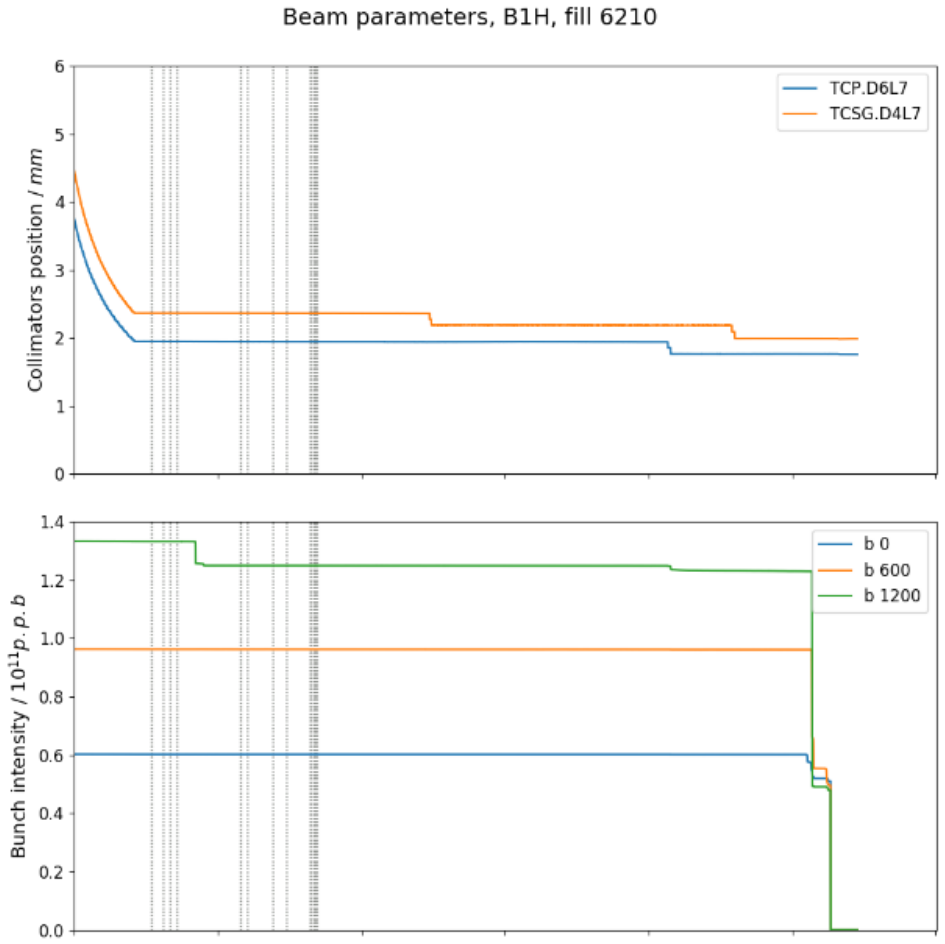
Data treatment

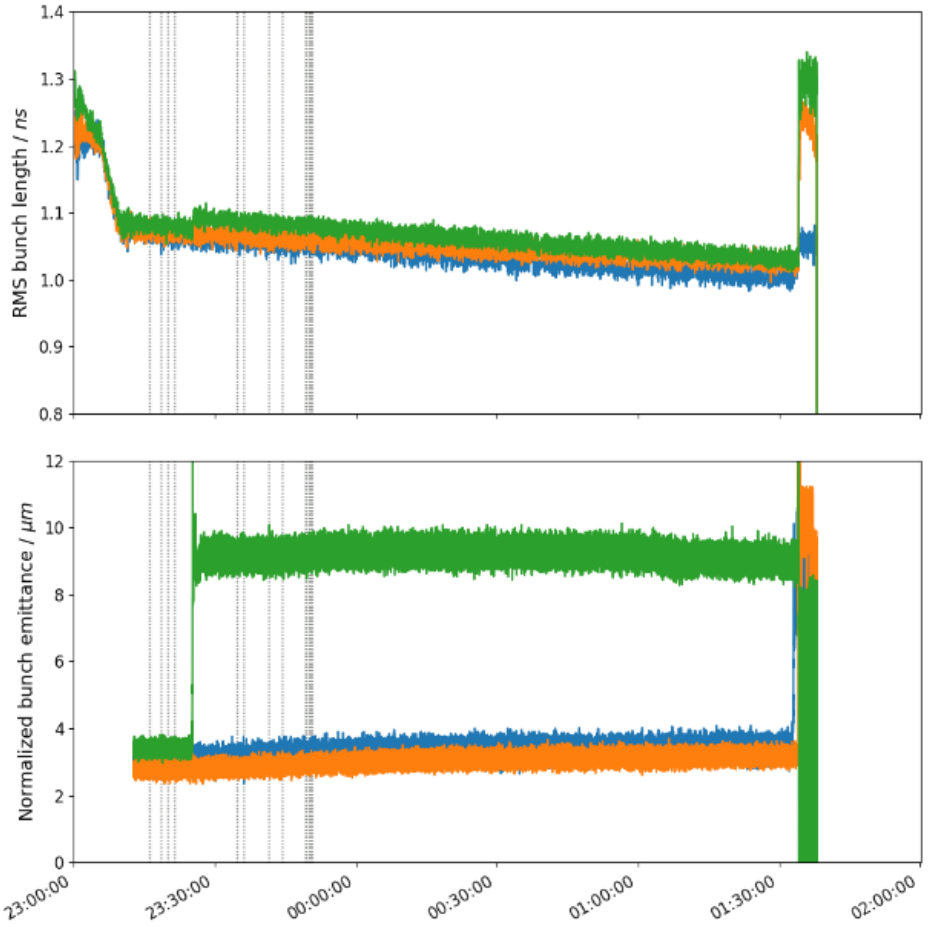
- From bunch by bunch position for each kick
  - Extract the tune with PySUSSIX
  - Number of turns used depend on the data
    - Start at the max value of the transverse displacement
    - End when the displacement is ~20% of the max value
  - ~200-400 turns of data

- For each collimators positon step:
  - Multiple kicks recoreded
  - Average and std of the tune

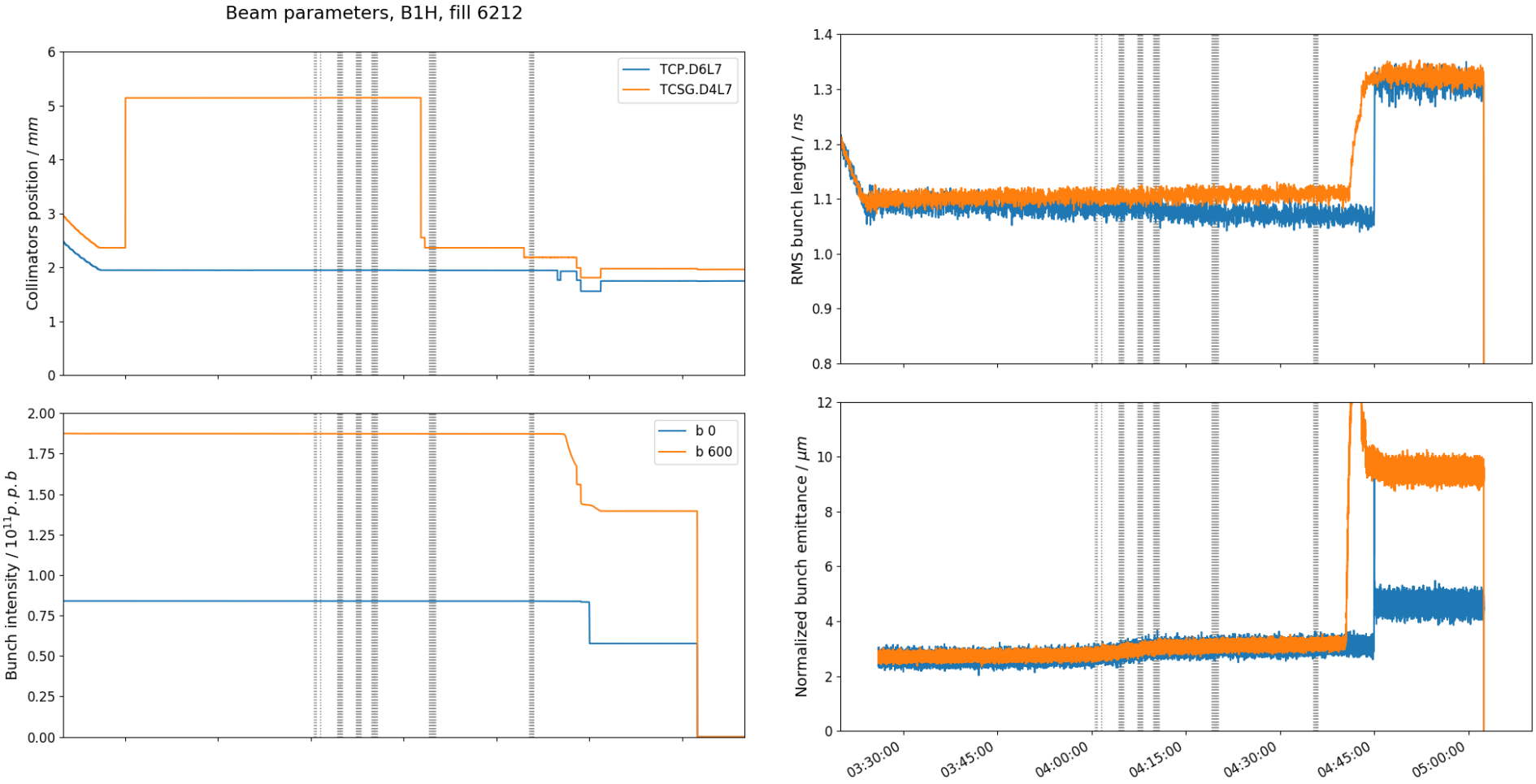
- Remove the baseline tune: perform a linear least squares regression with the tune from the different bunches

B1H
Fill 6210

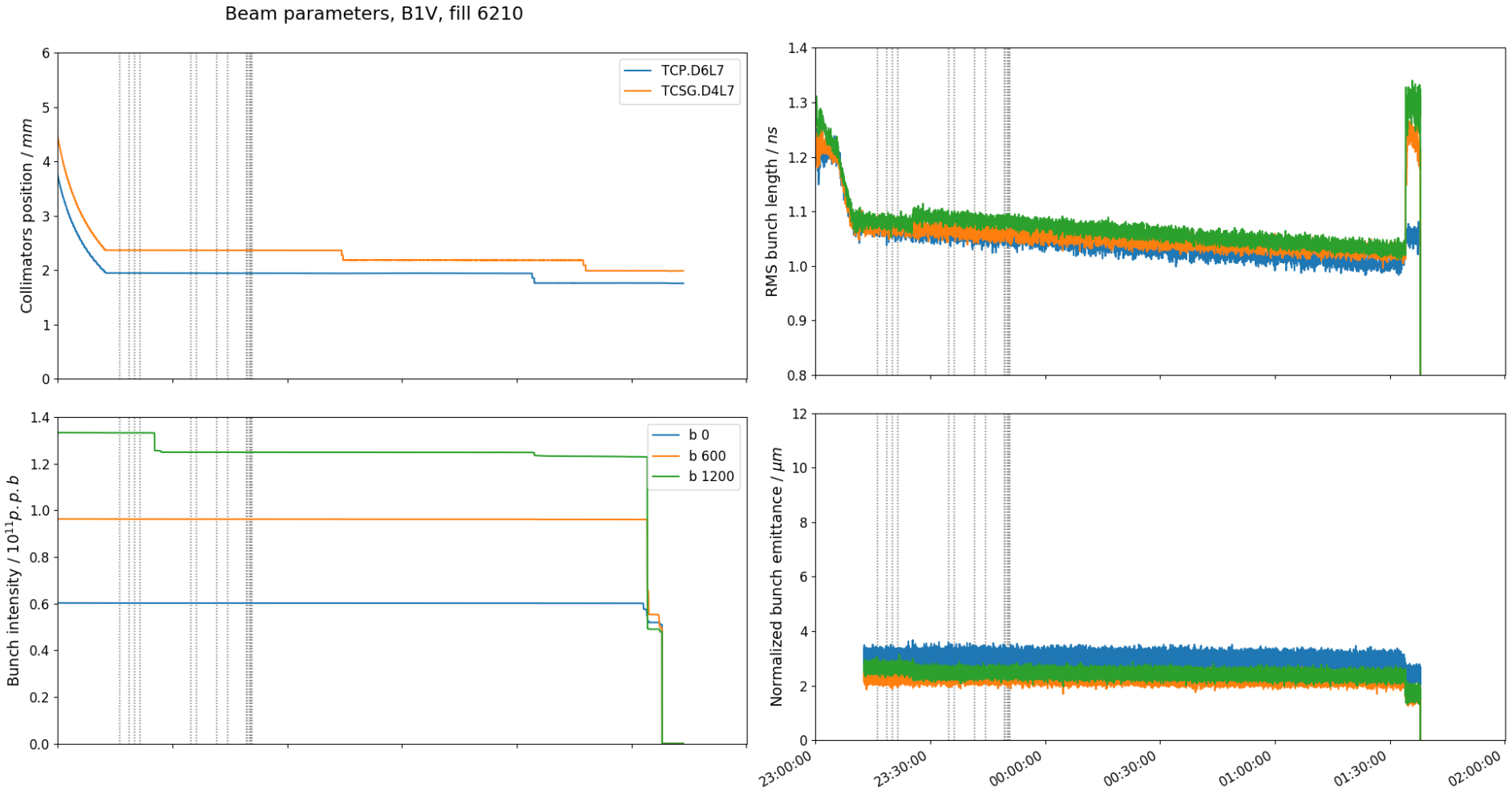




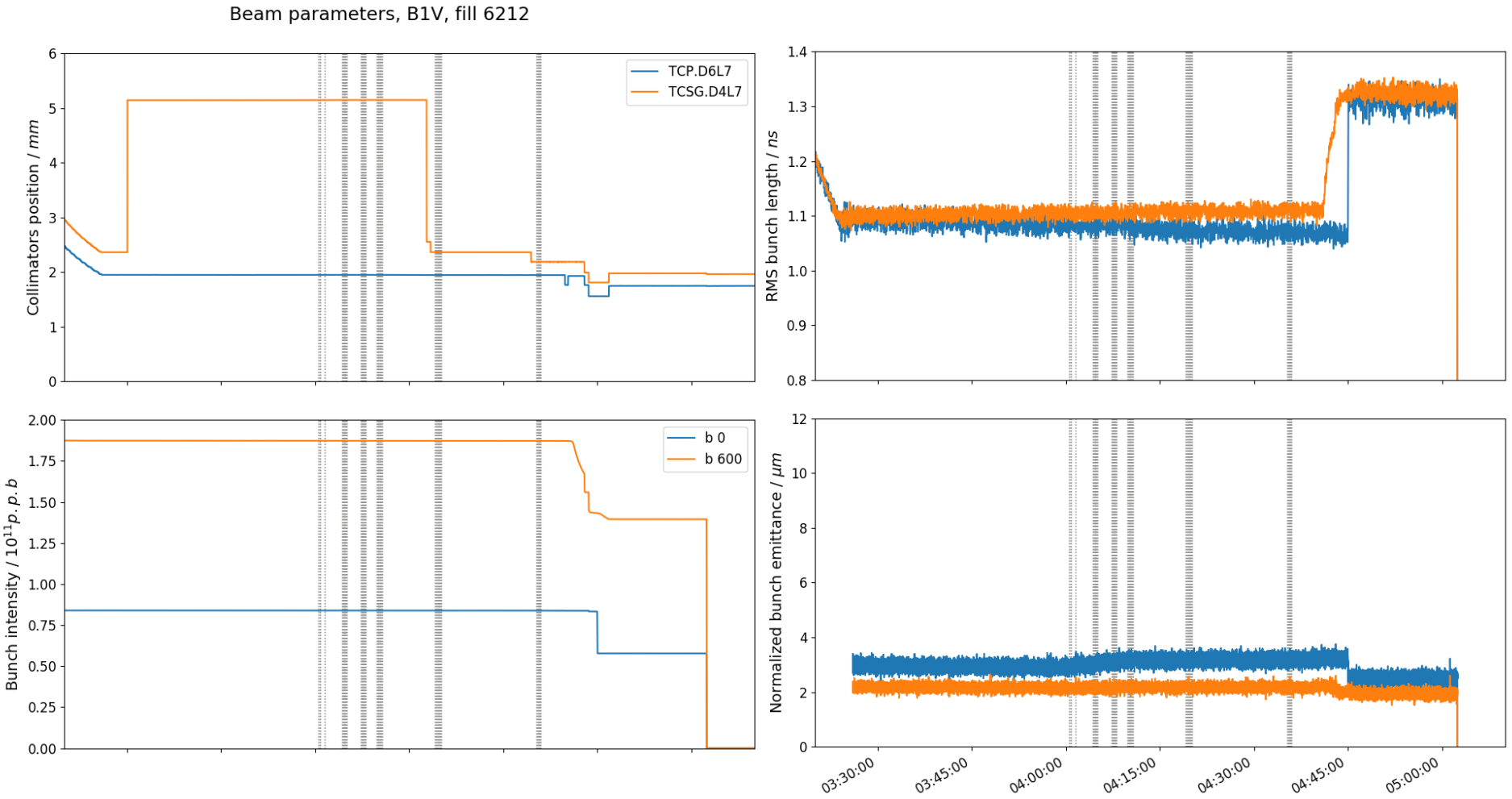
B1H
Fill 6212



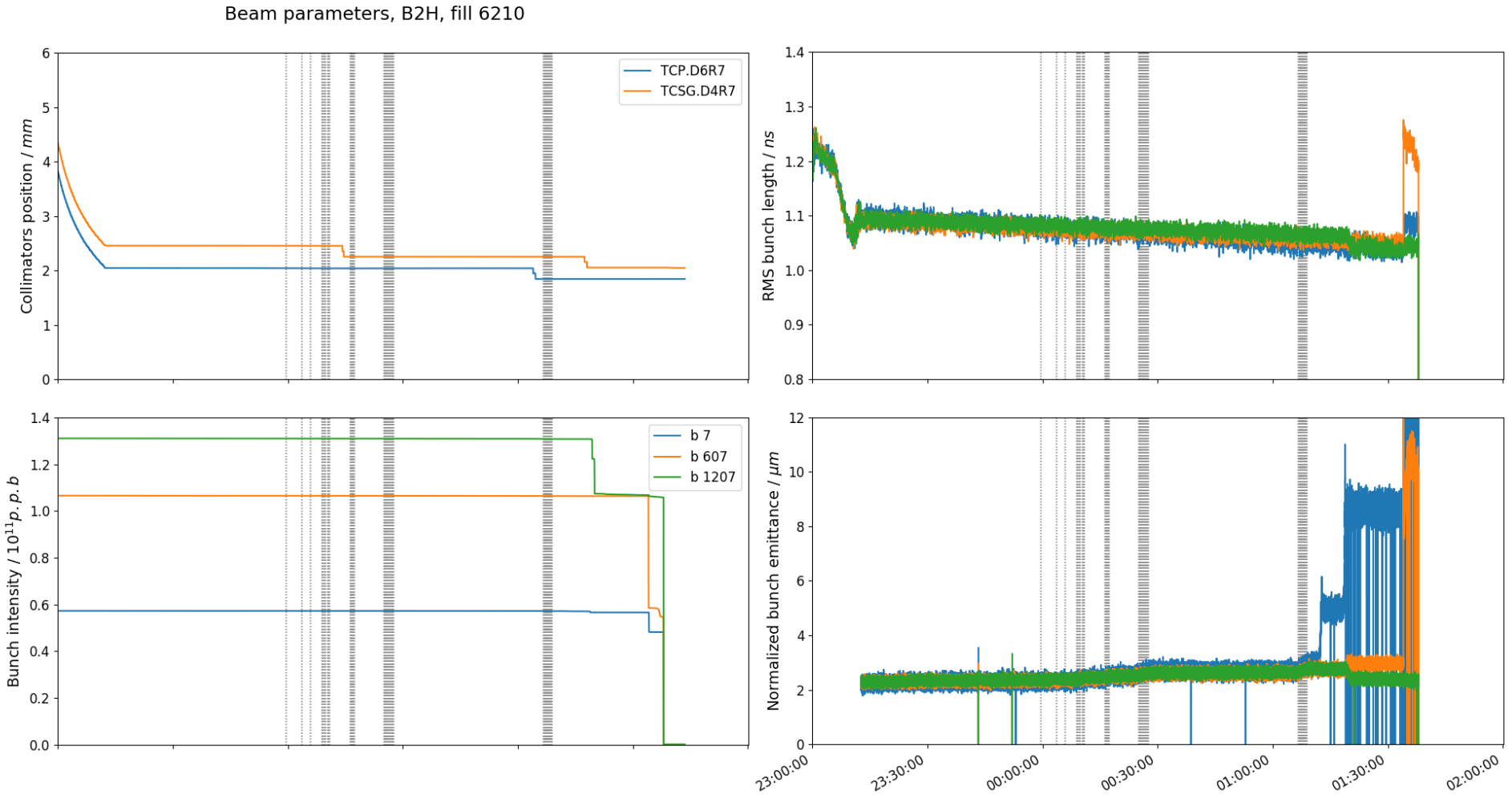
B1V
Fill 6210



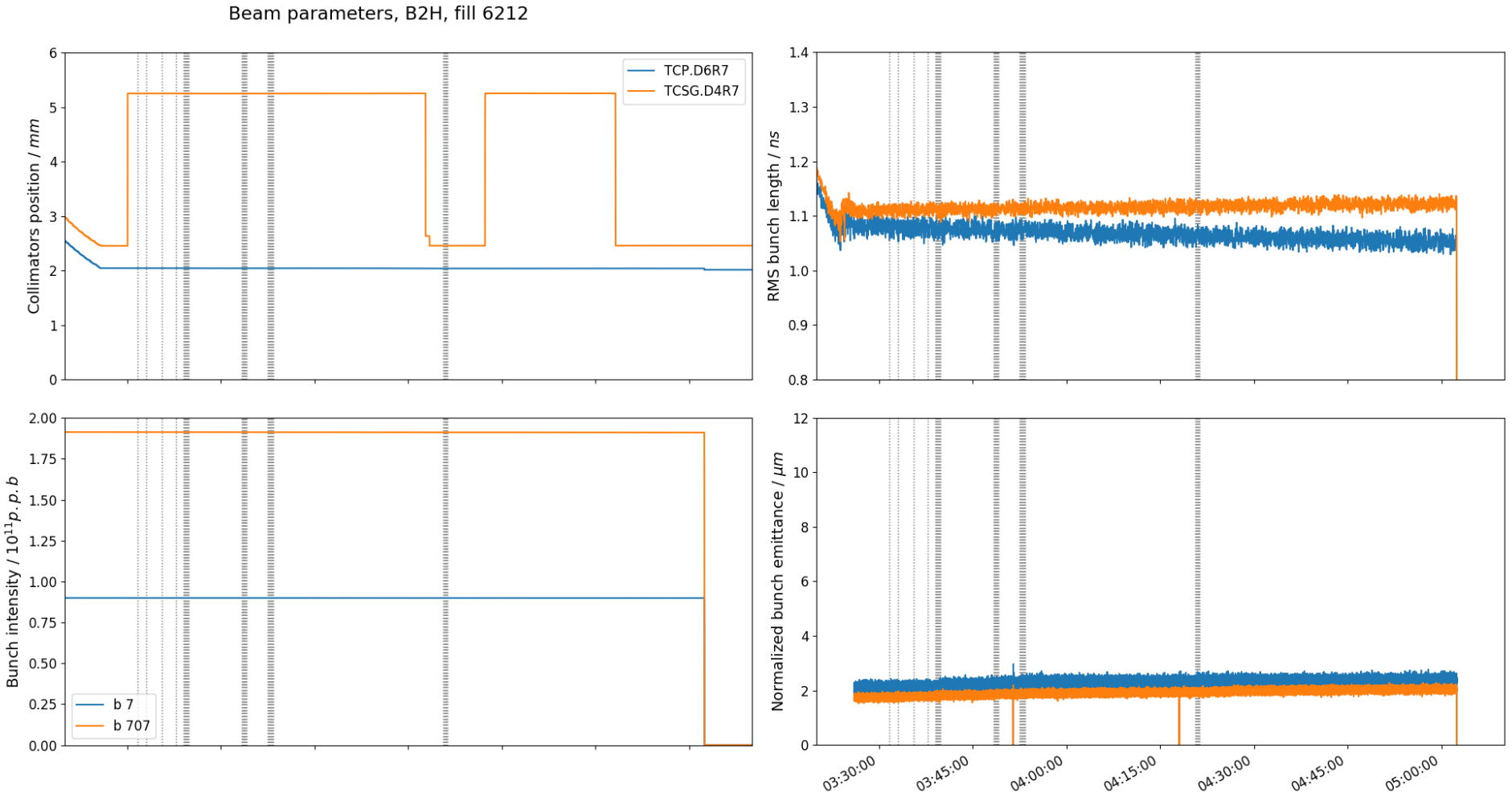
B1V
Fill 6212



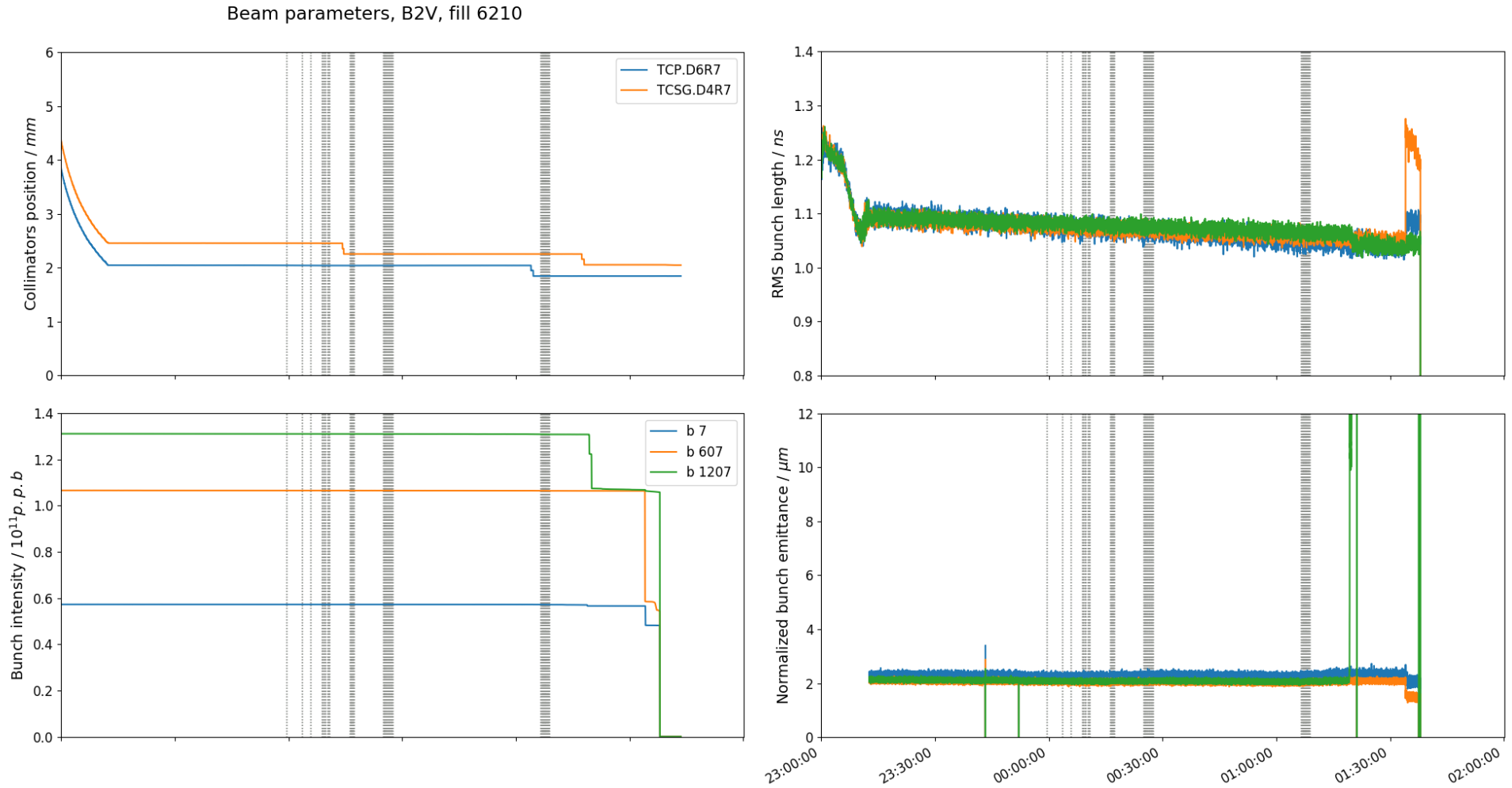
B2H
Fill 6210



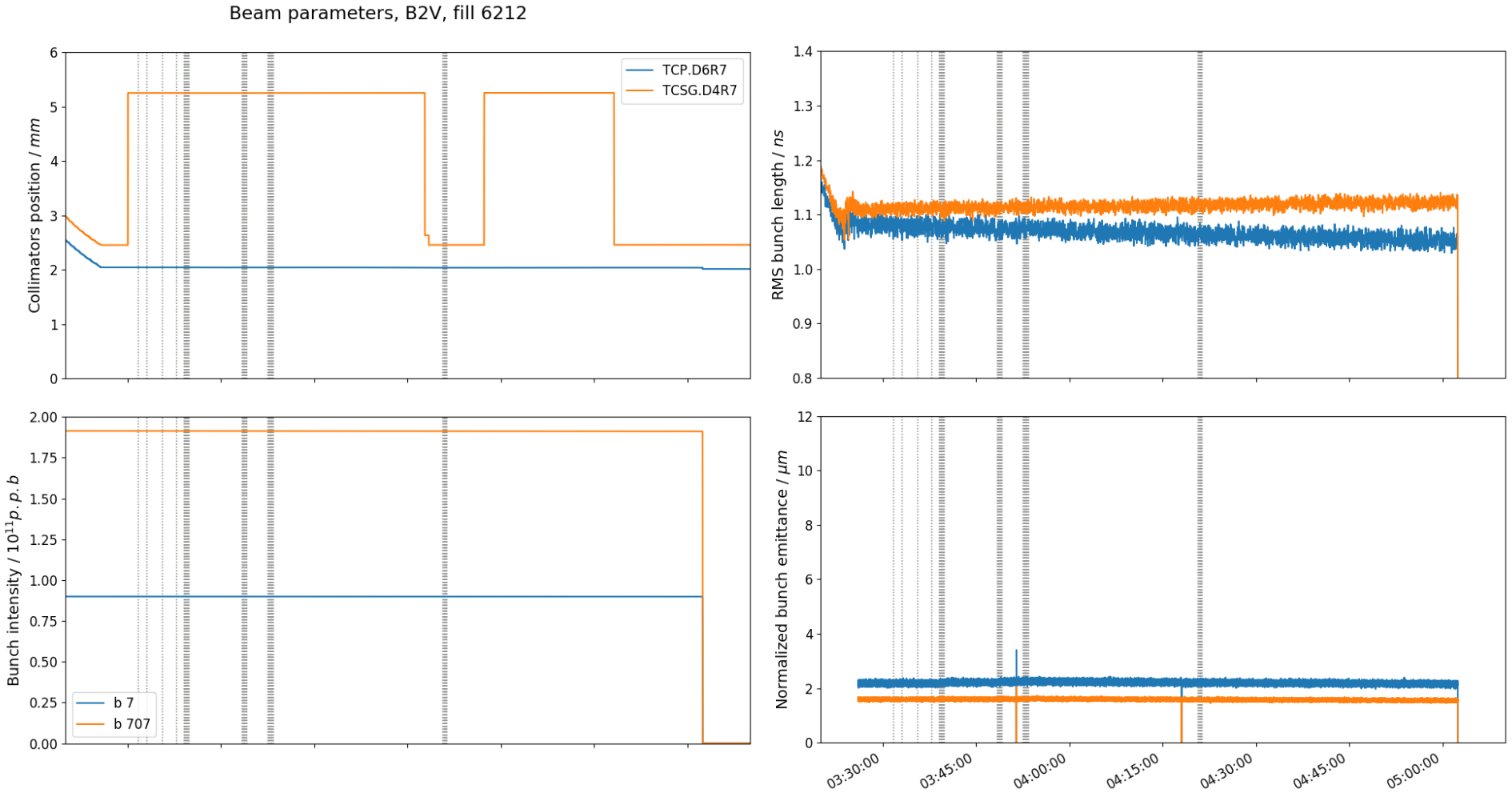
B2H
Fill 6212



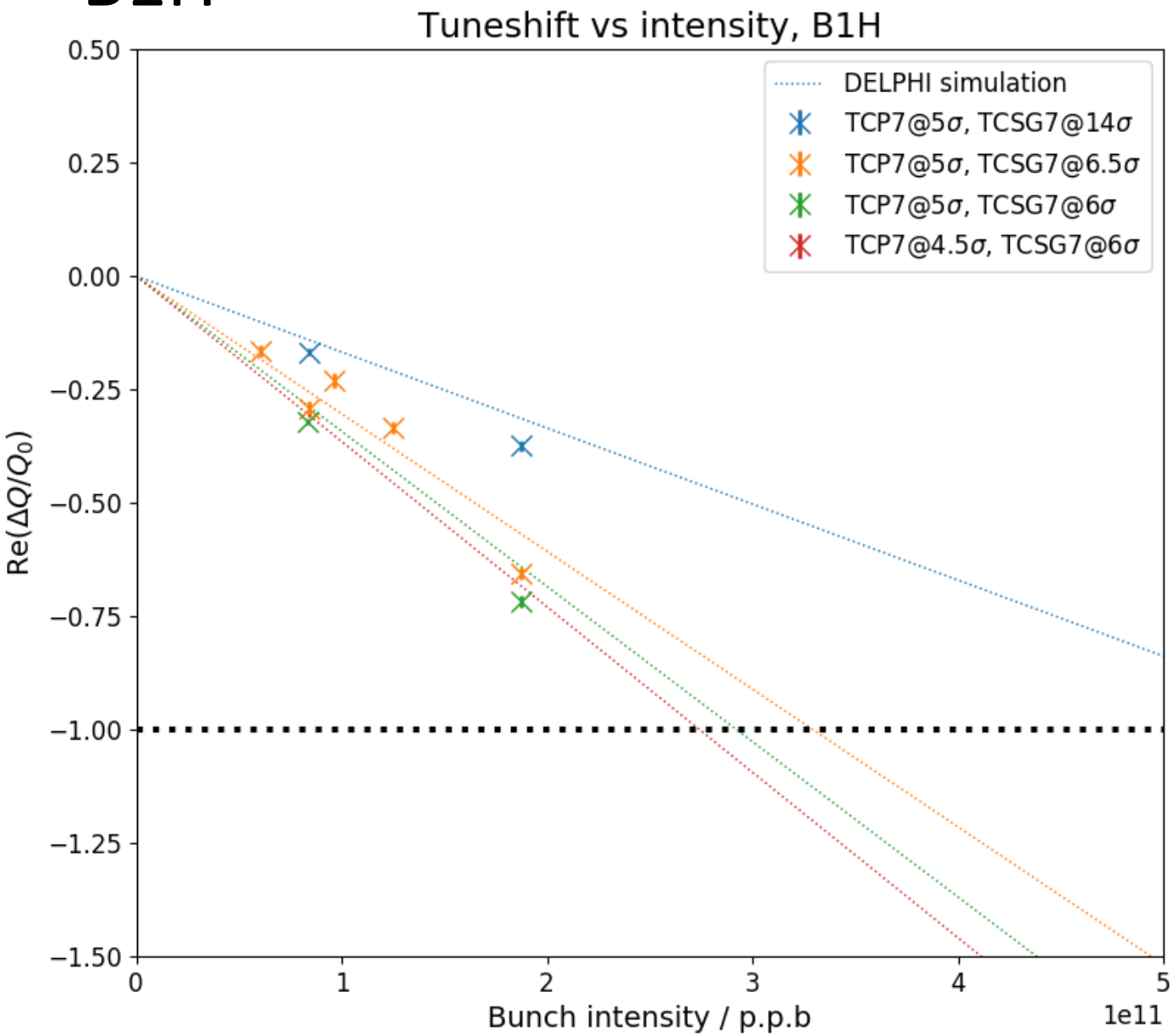
B2V
Fill 6210



B2V
Fill 6212

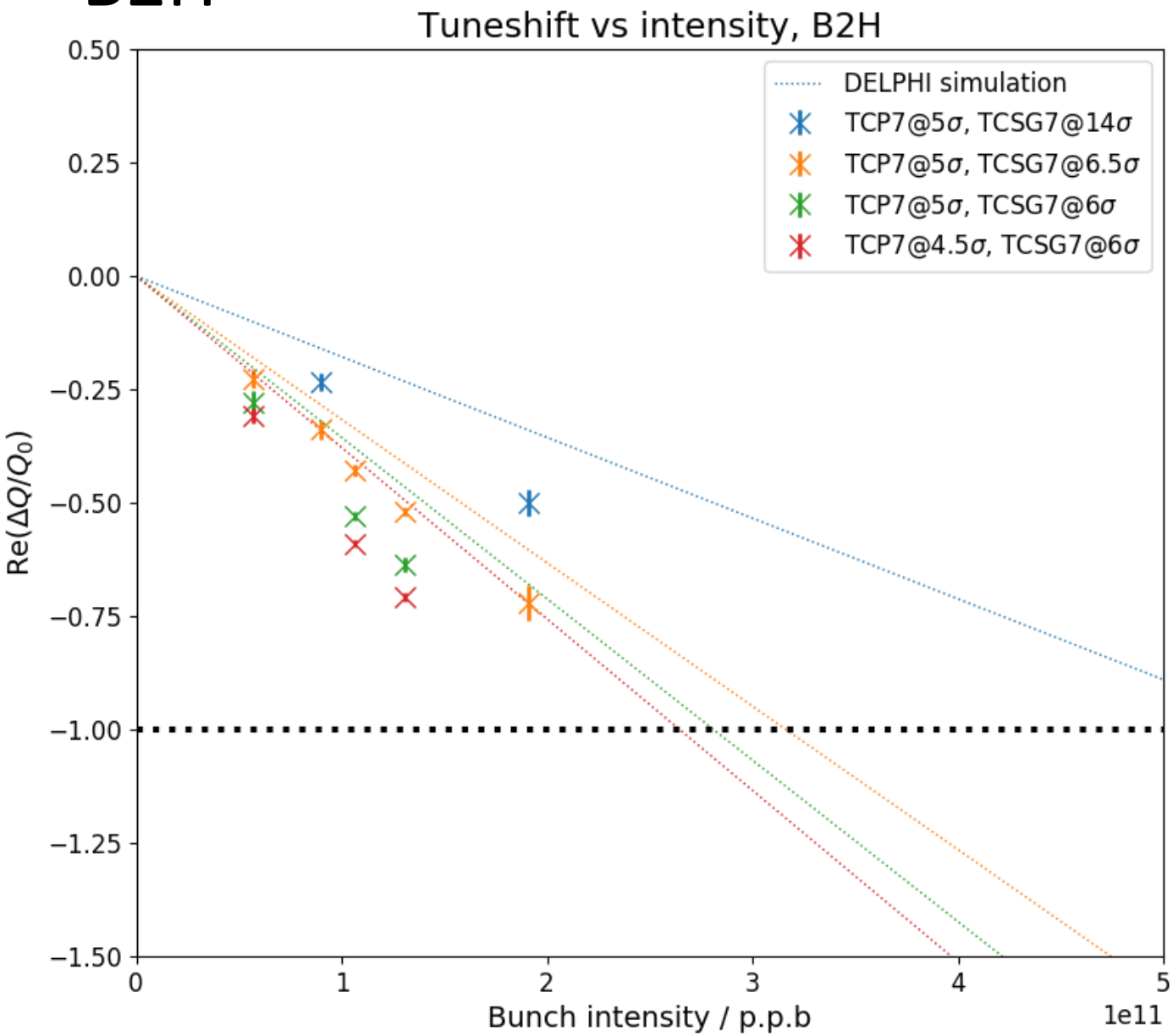


B1H



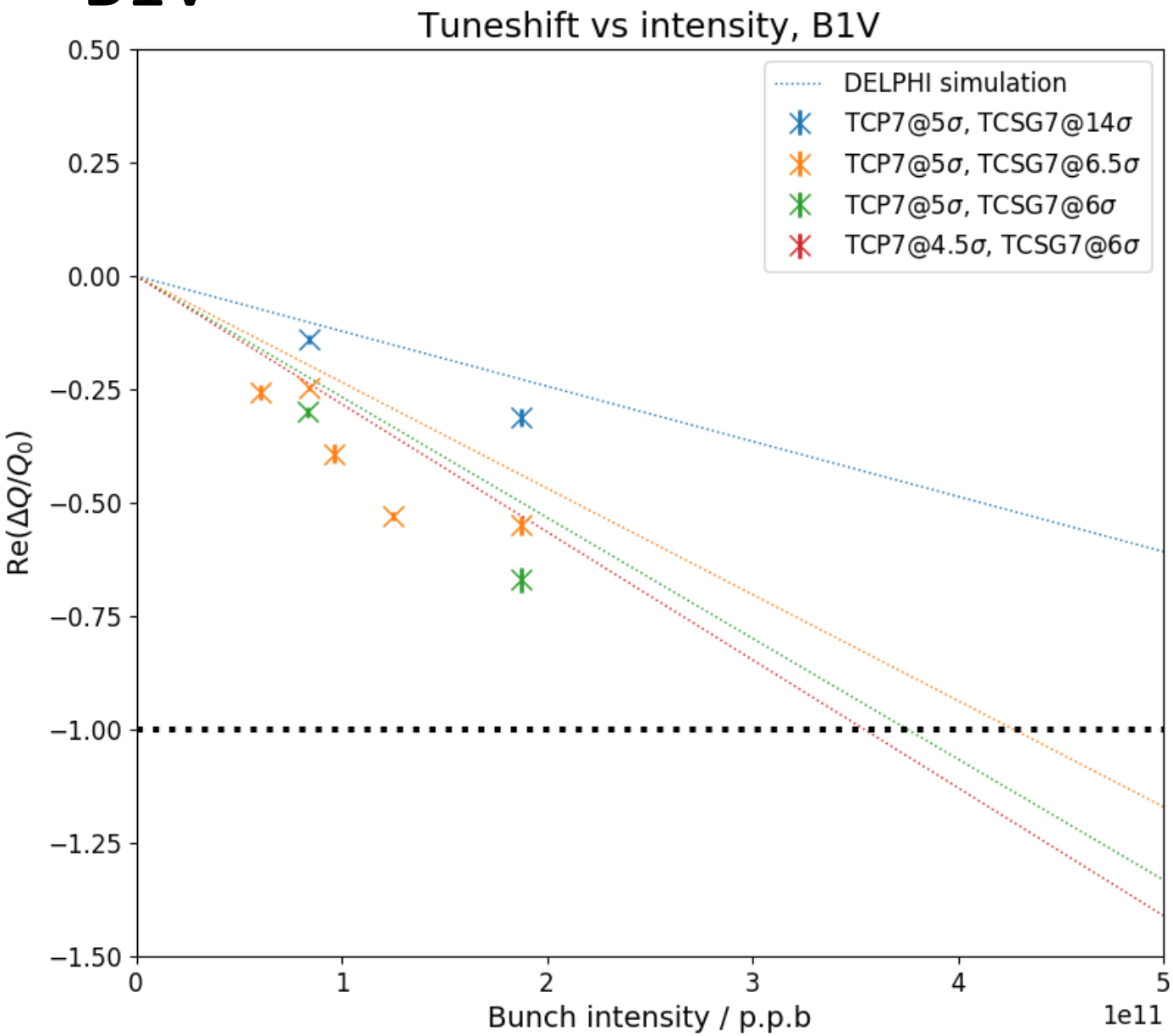
Crosses: measurements
Dashed lines: DELPHI simulations

B2H



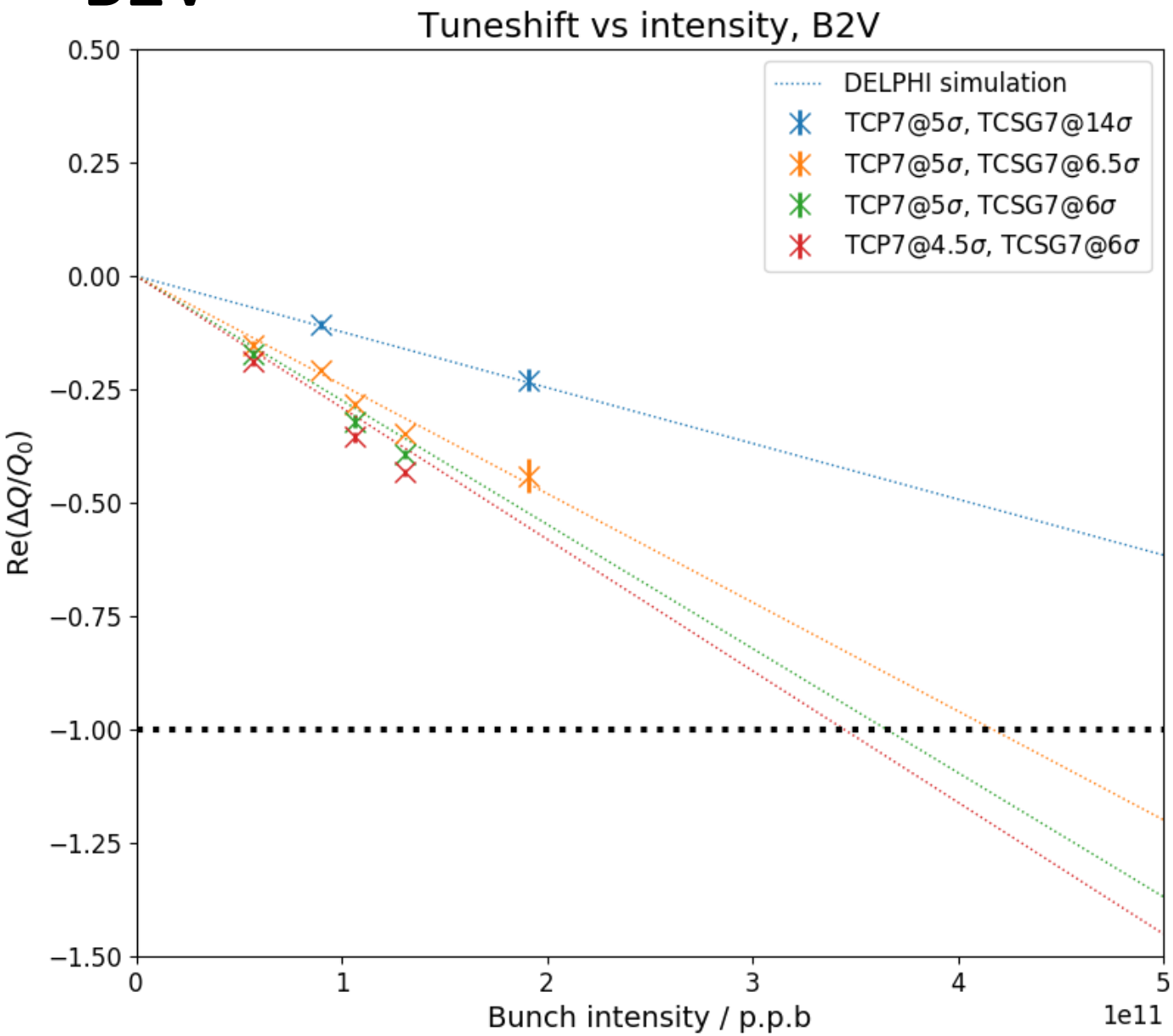
Crosses: measurements
Dashed lines: DELPHI simulations

B1V



Crosses: measurements
Dashed lines: DELPHI simulations

B2V



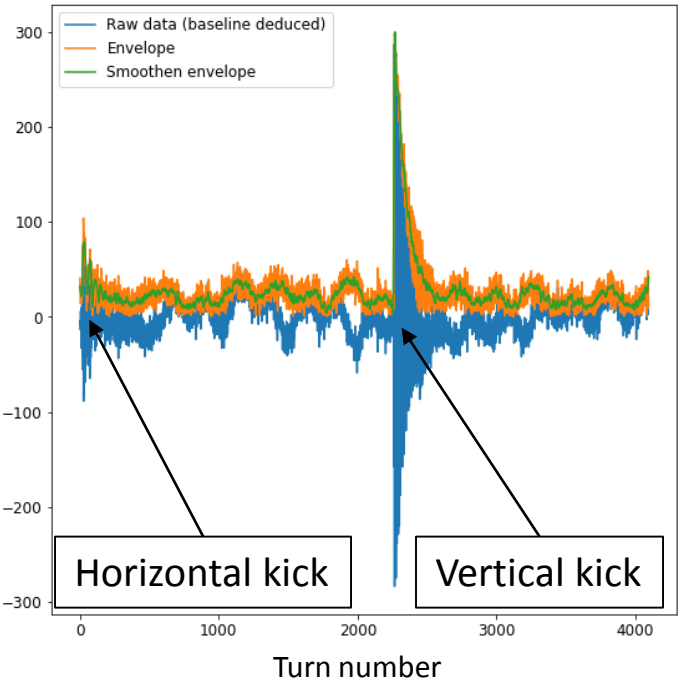
Crosses: measurements
Dashed lines: DELPHI simulations

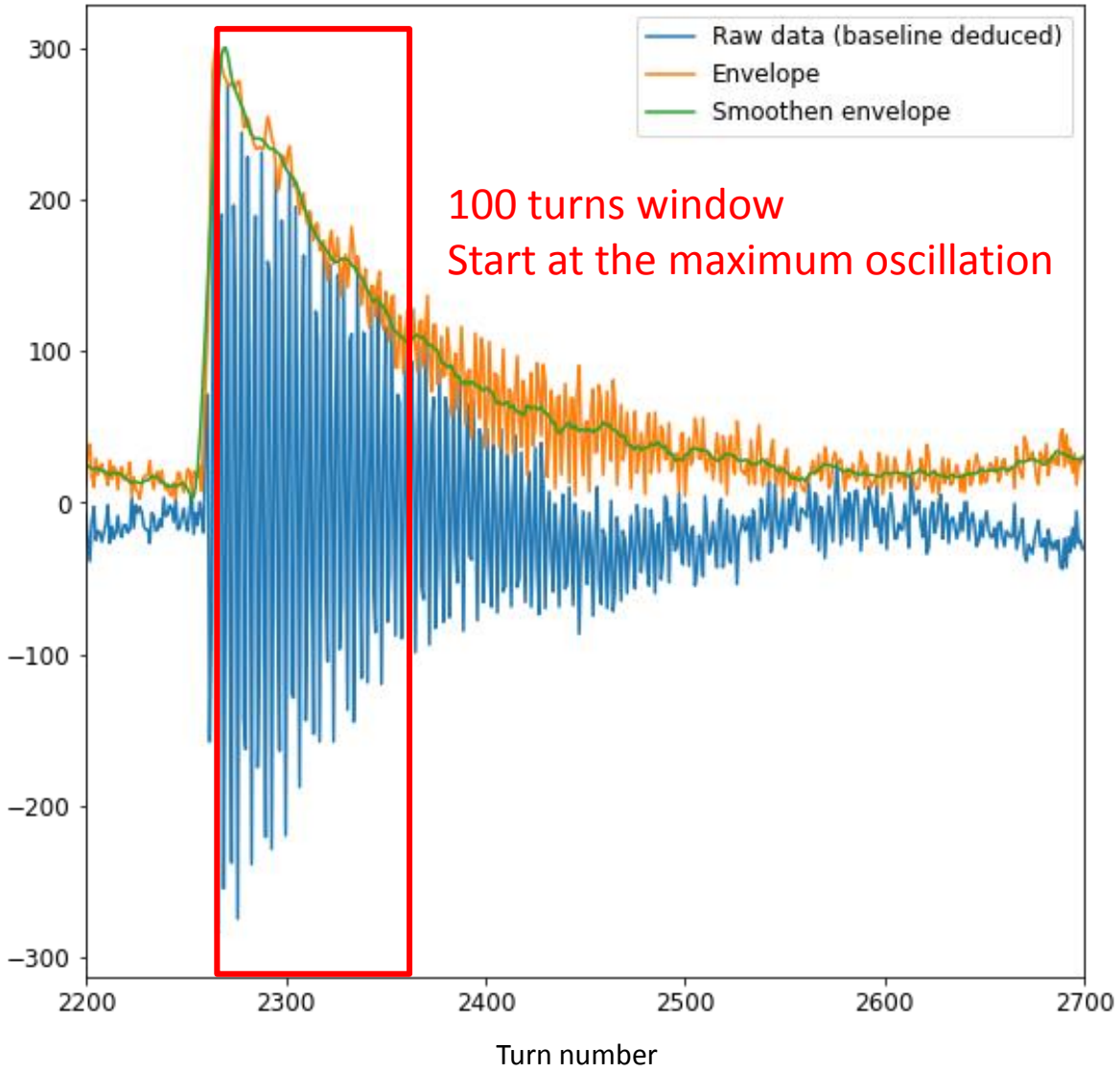
Convergence of SUSSIX

- Study the tune convergence versus:
  - Number of turns used for the analysis
  - Starting position of the analysis window

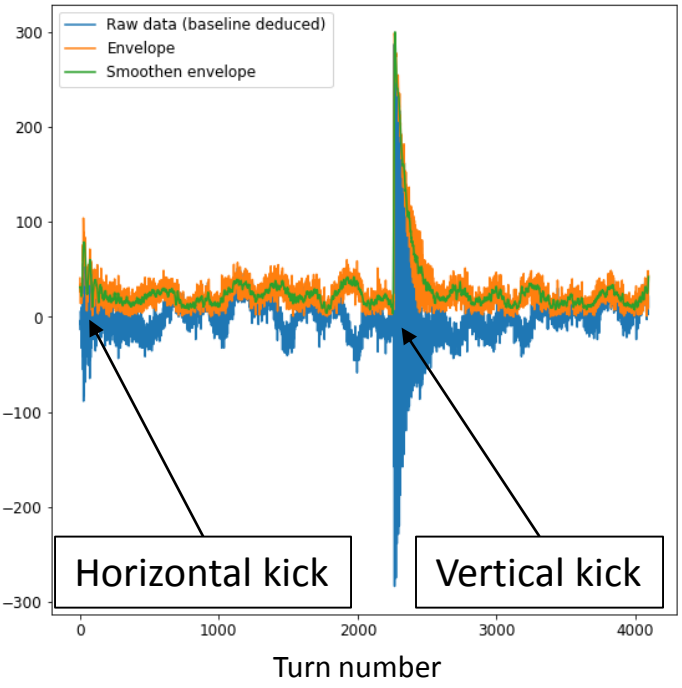
- The reference starting position is at the maximum amplitude of the oscillation

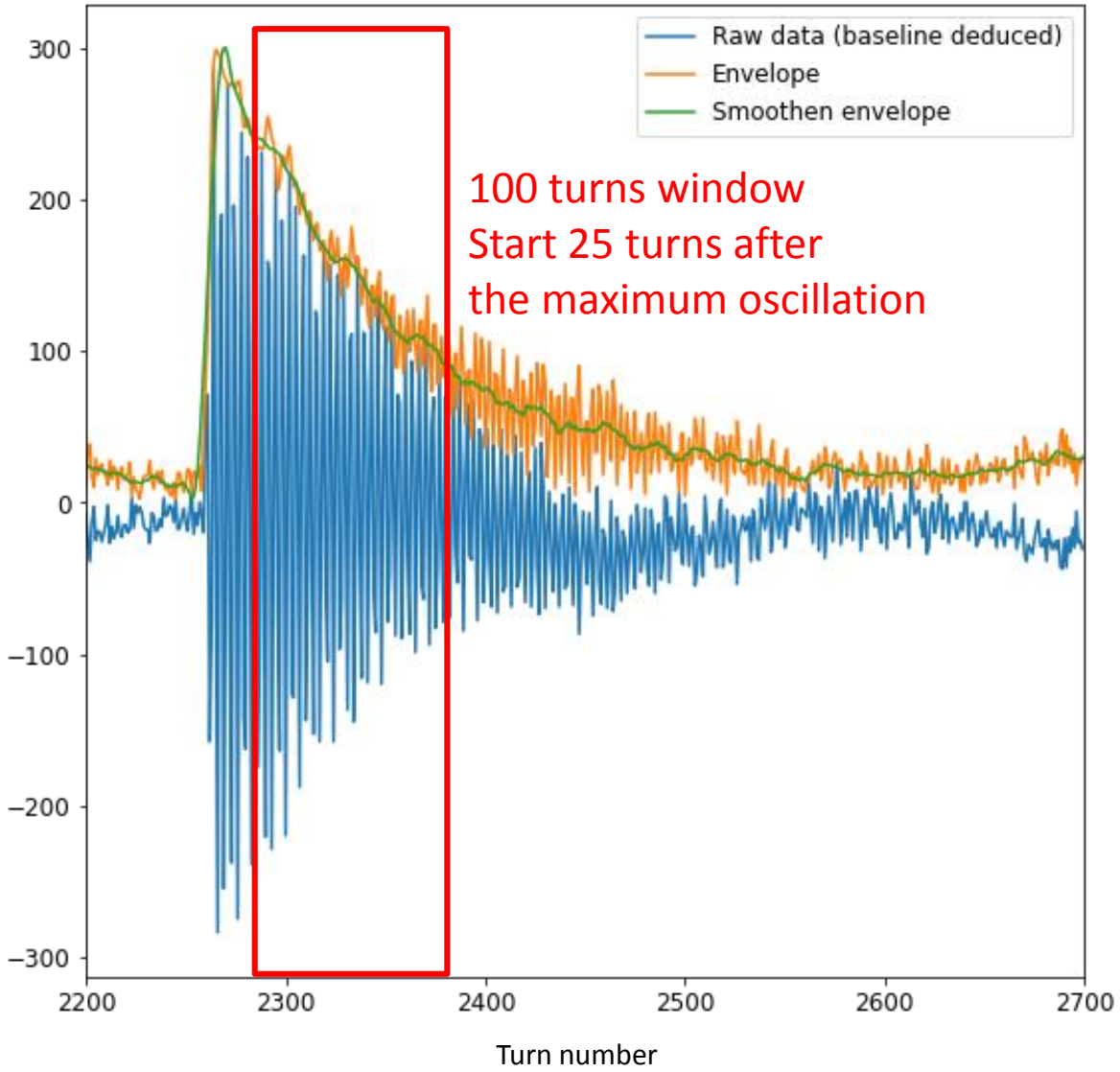
Convergence of SUSSIX



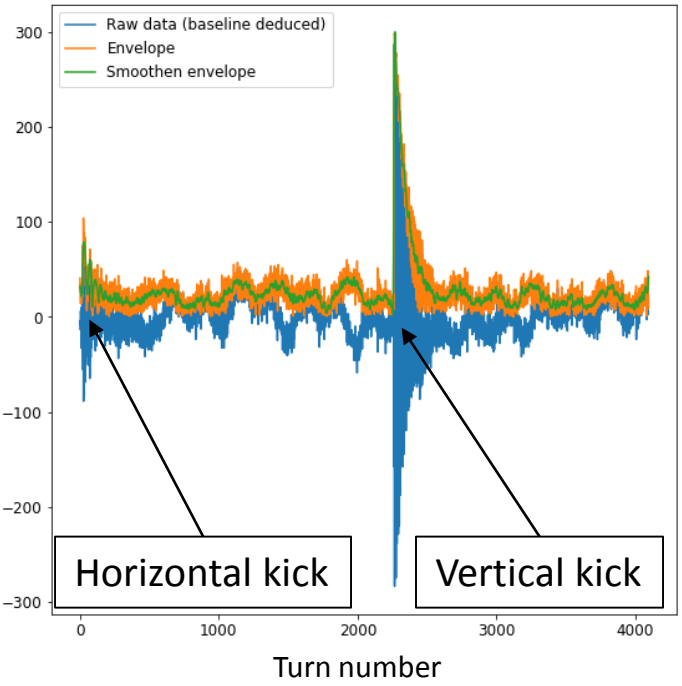


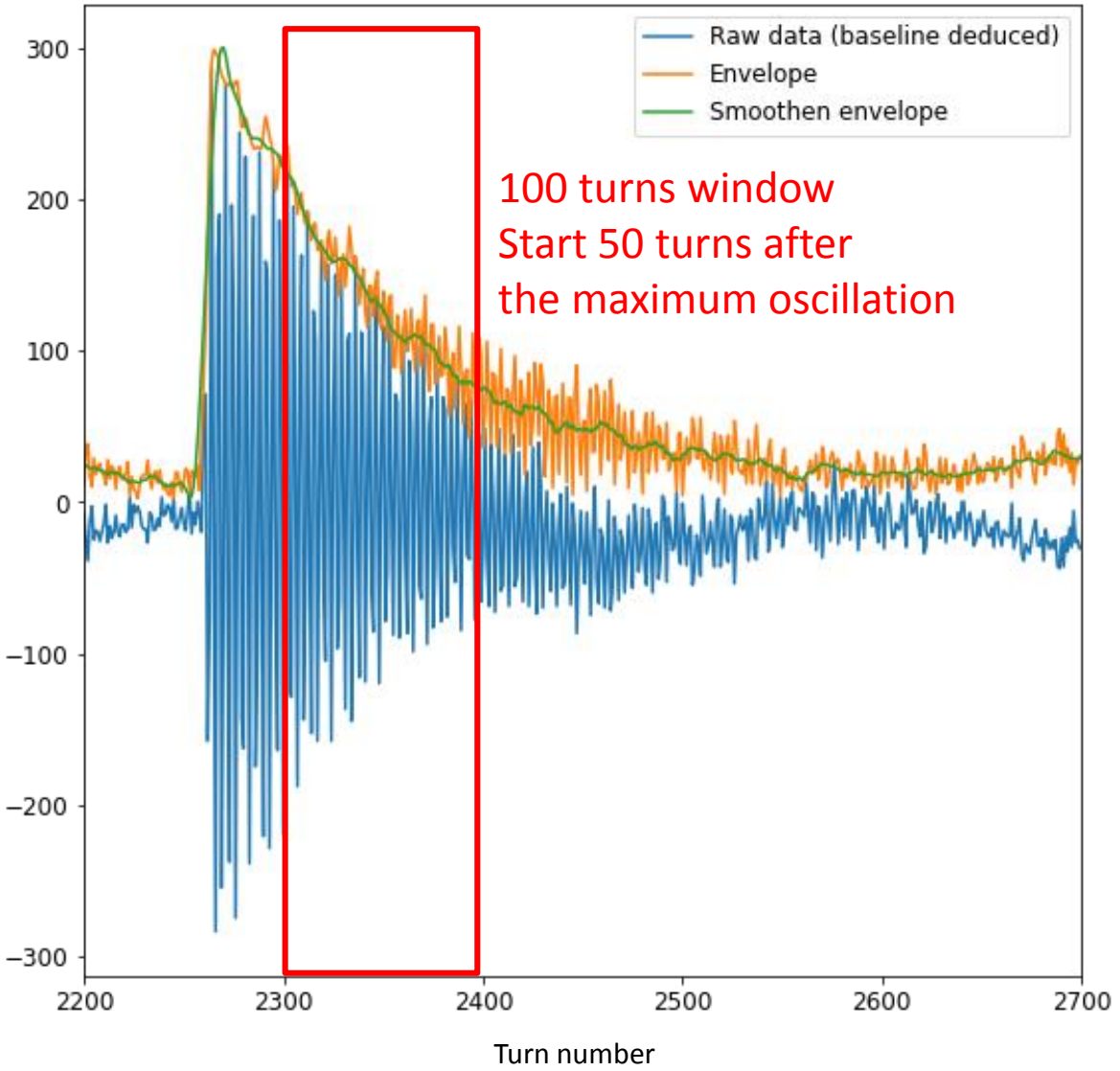
Convergence of SUSSIX



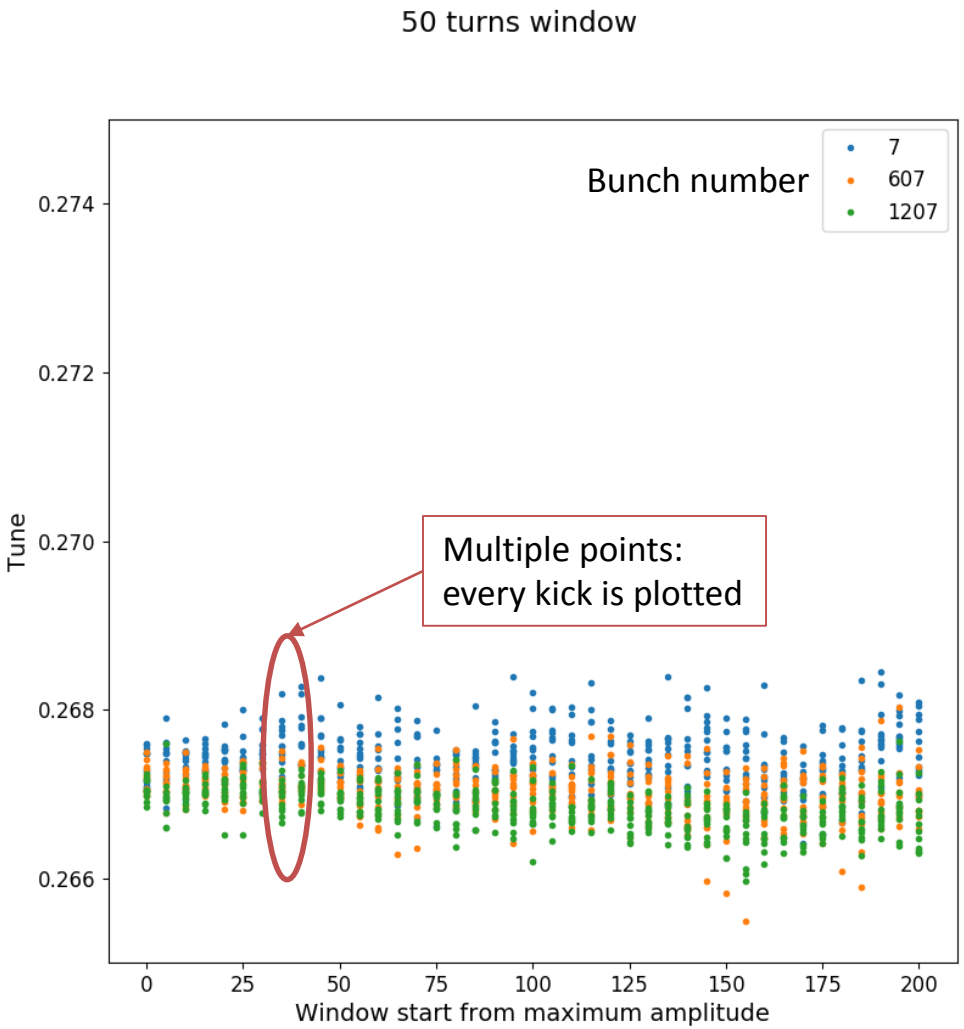


Convergence of SUSSIX



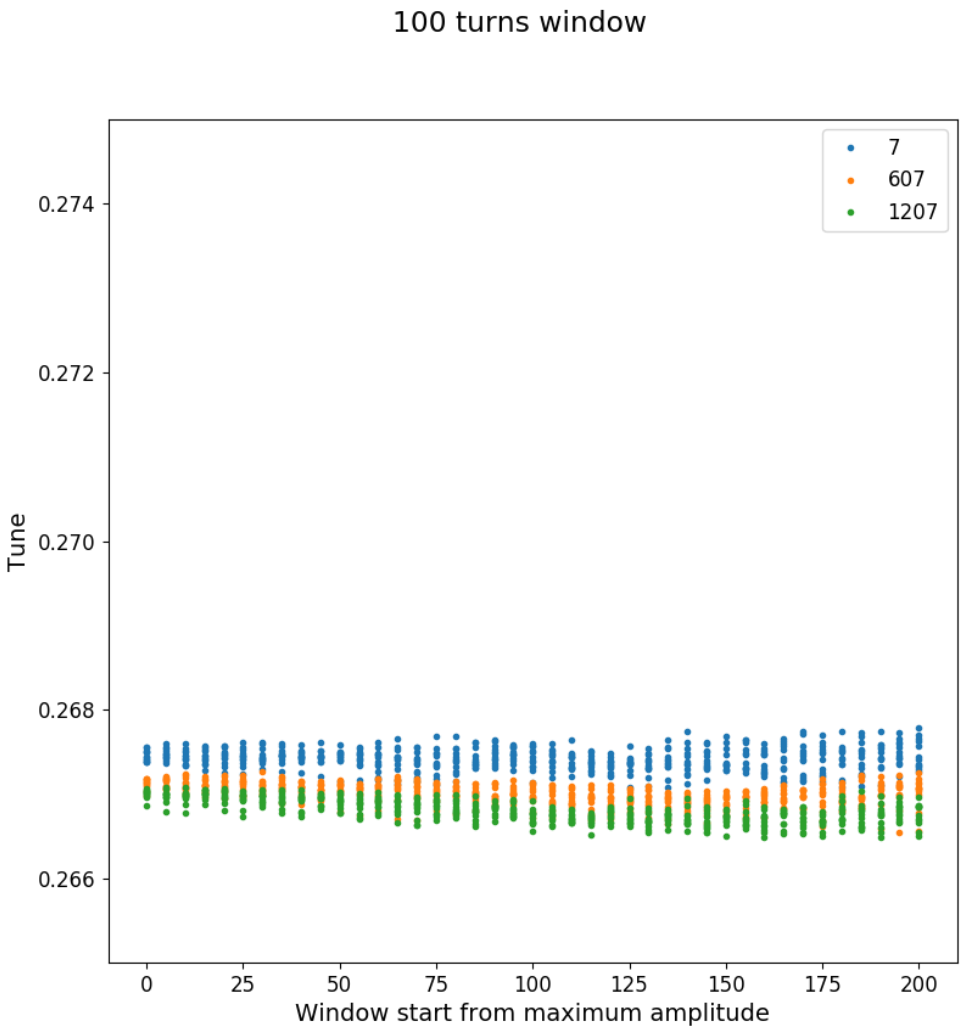


Convergence of SUSSIX

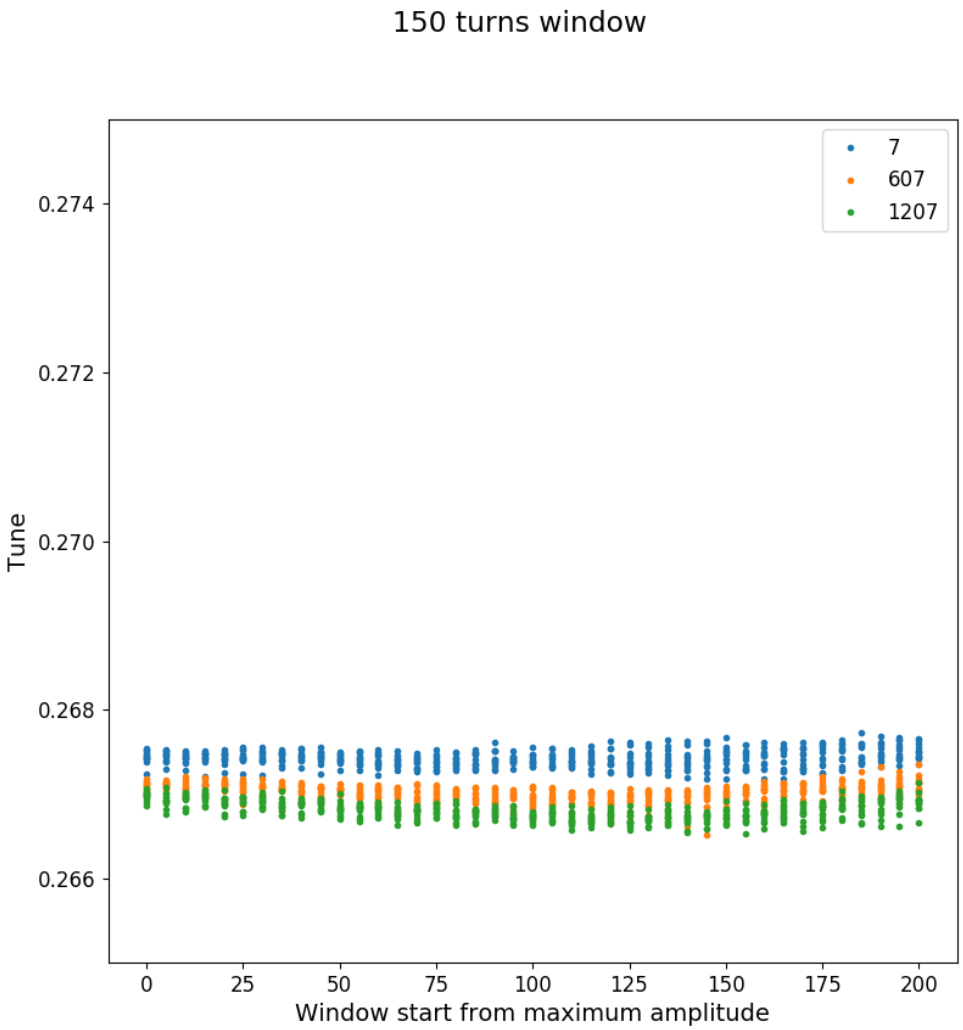


Fill 6210
B2H
Nominal collimators

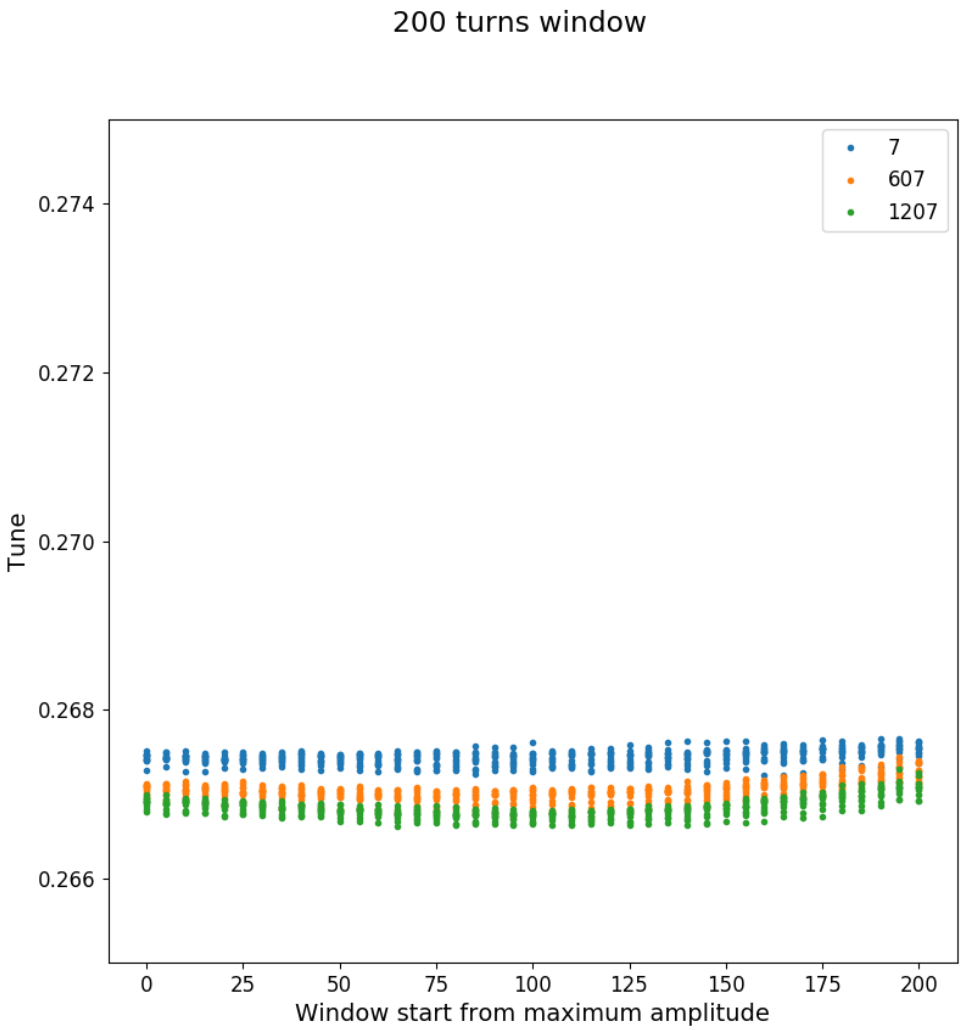
Convergence of SUSSIX



Convergence of SUSSIX



Convergence of SUSSIX



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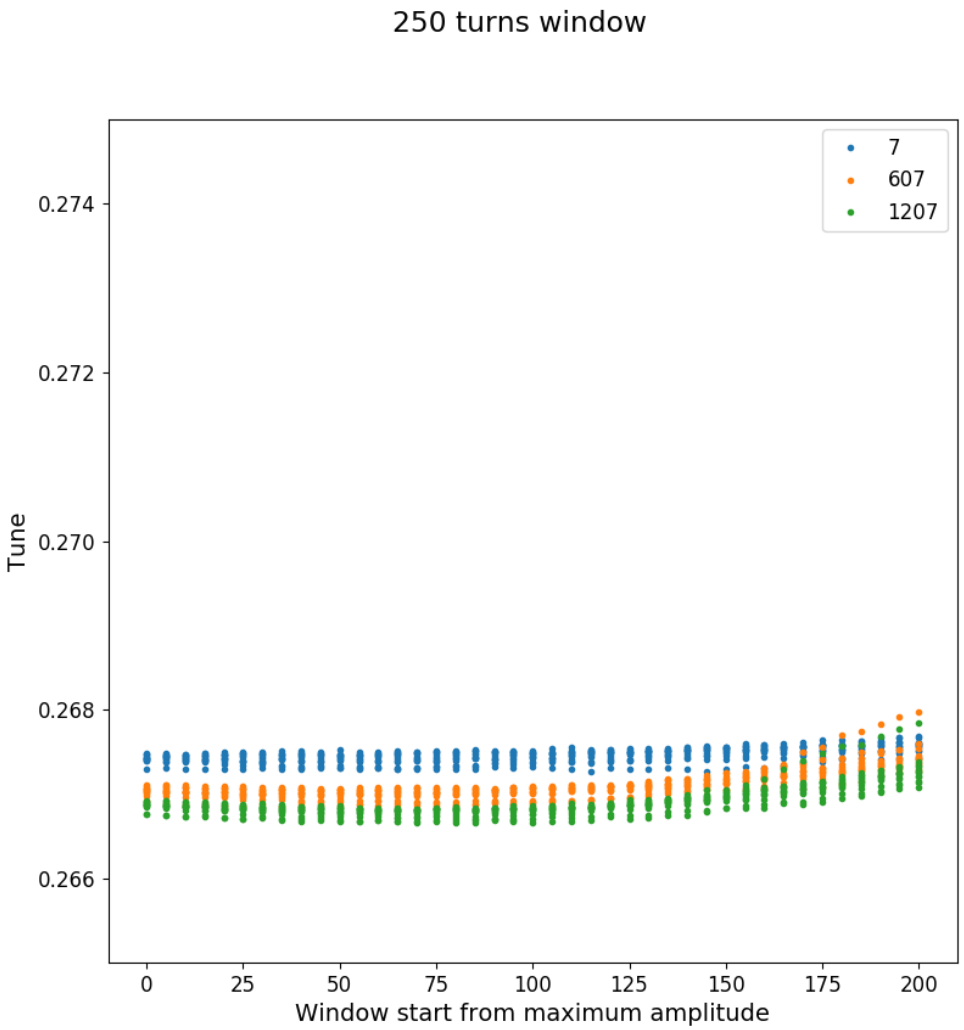
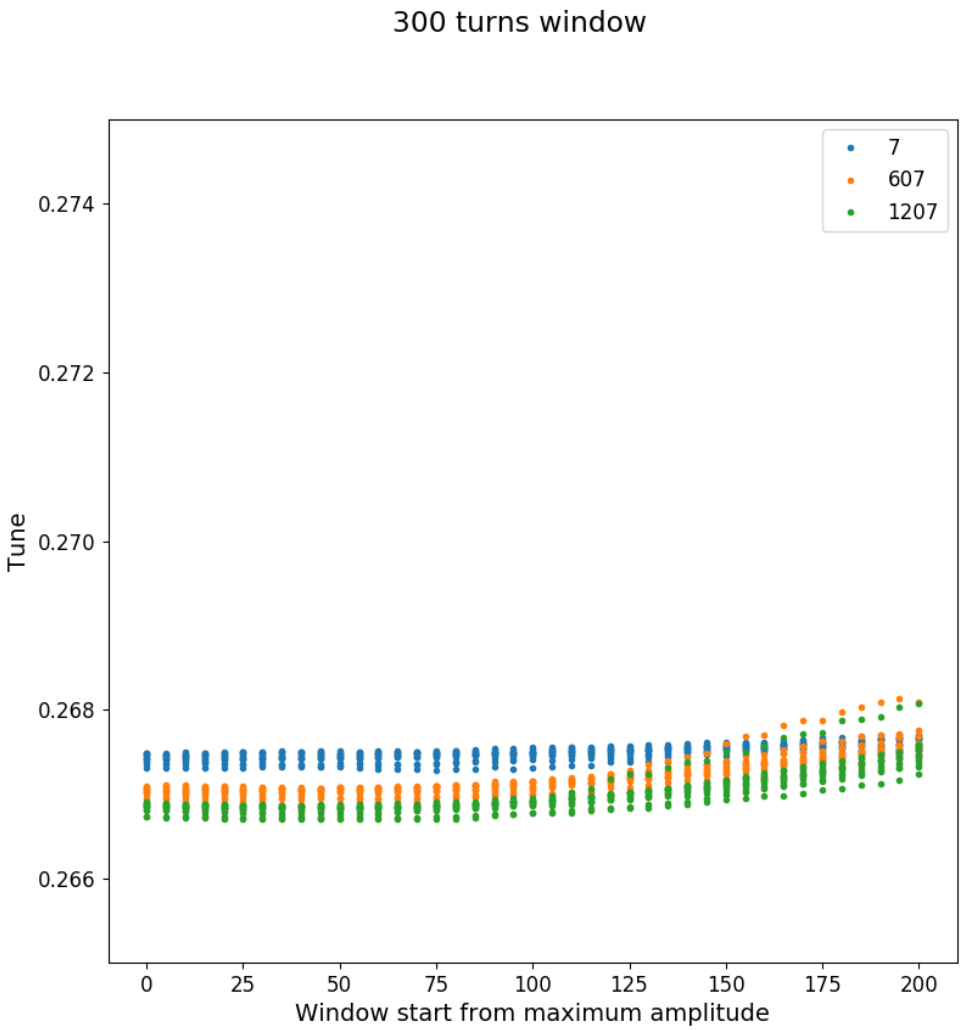
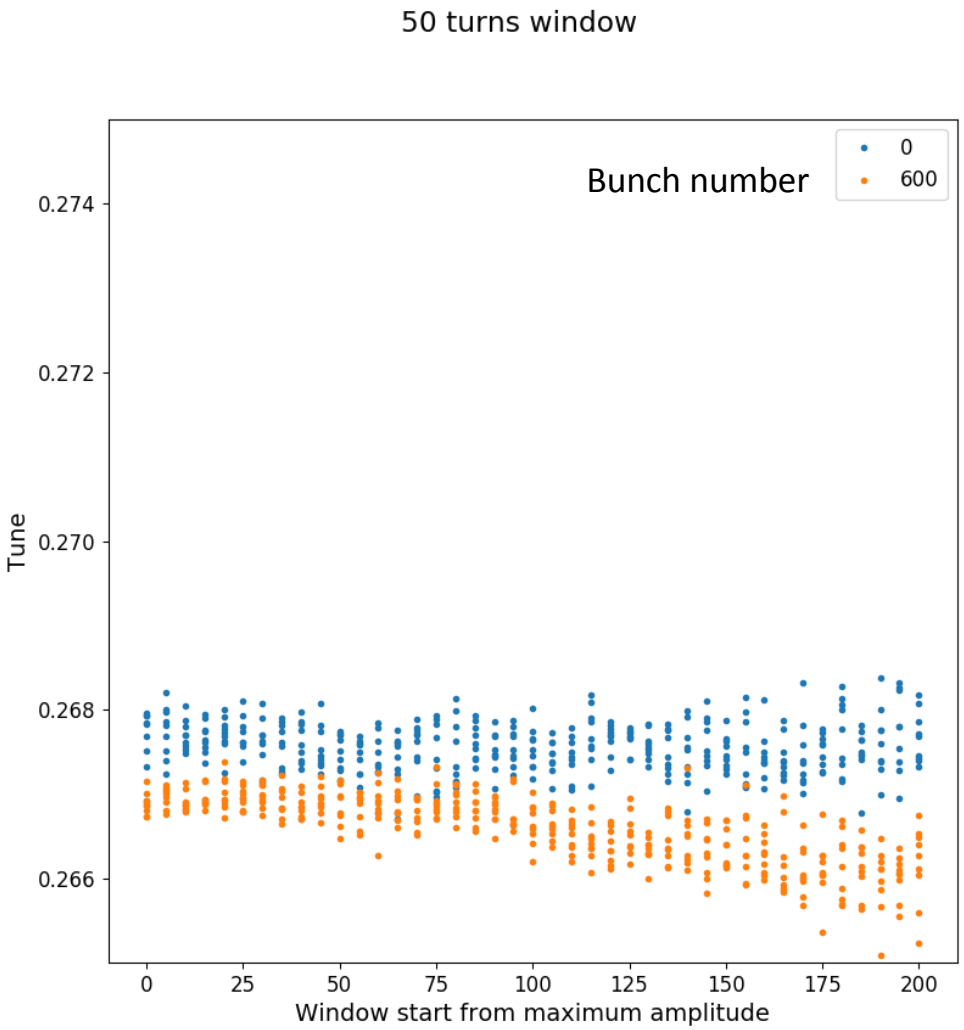


Convergence of SUSSIX

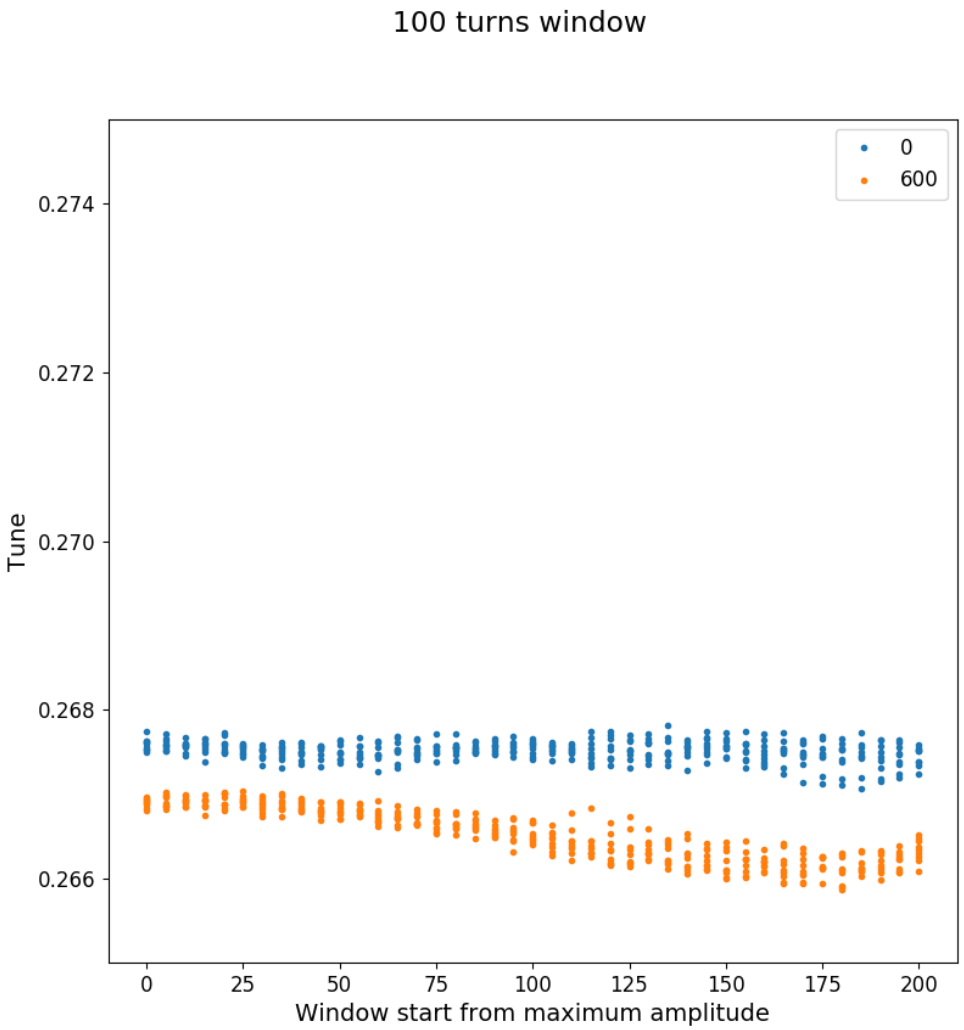


Convergence of SUSSIX

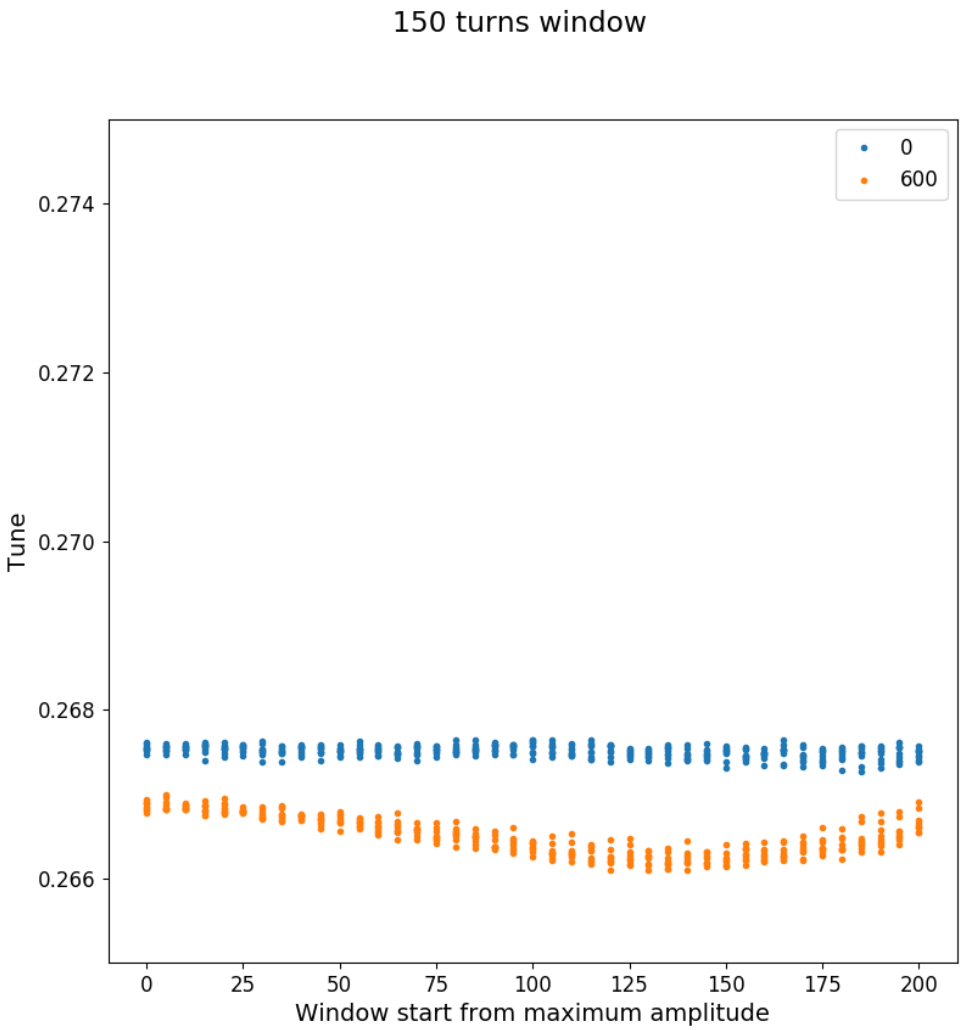


Fill 6212
B1H
Nominal collimators

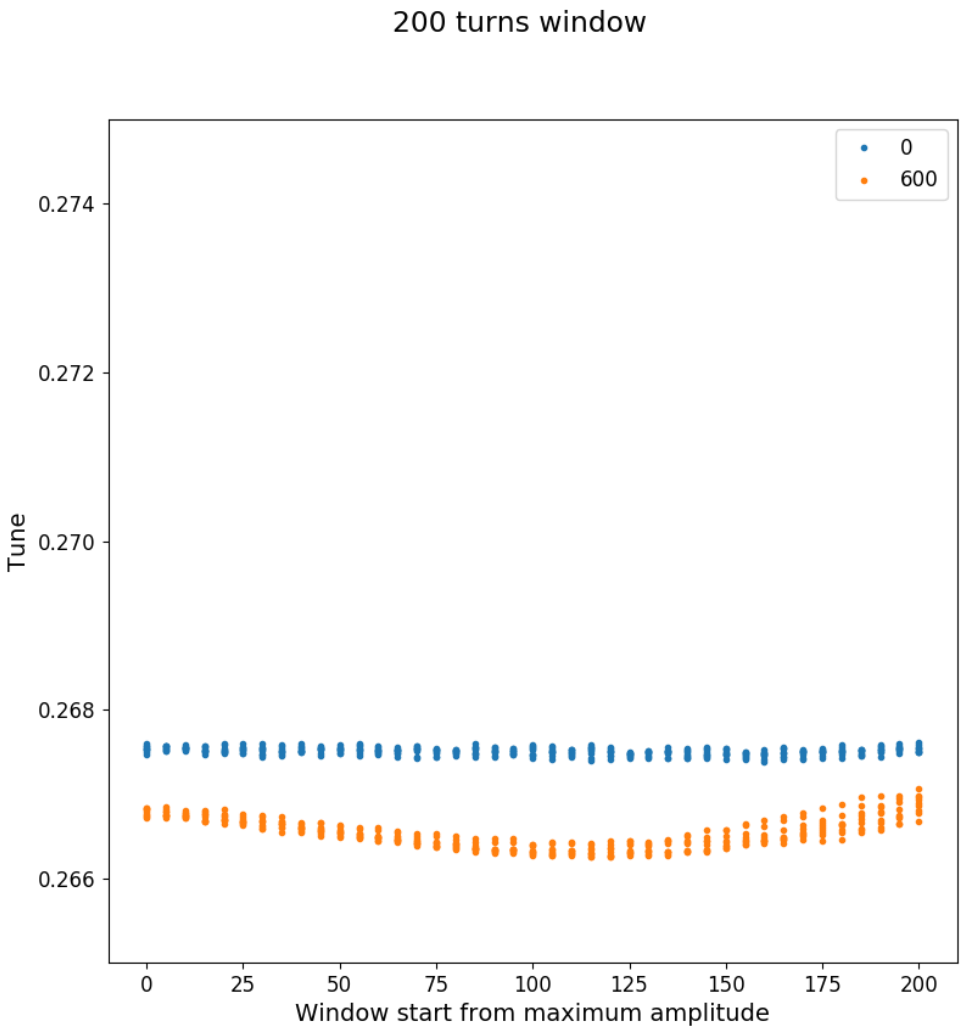
Convergence of SUSSIX



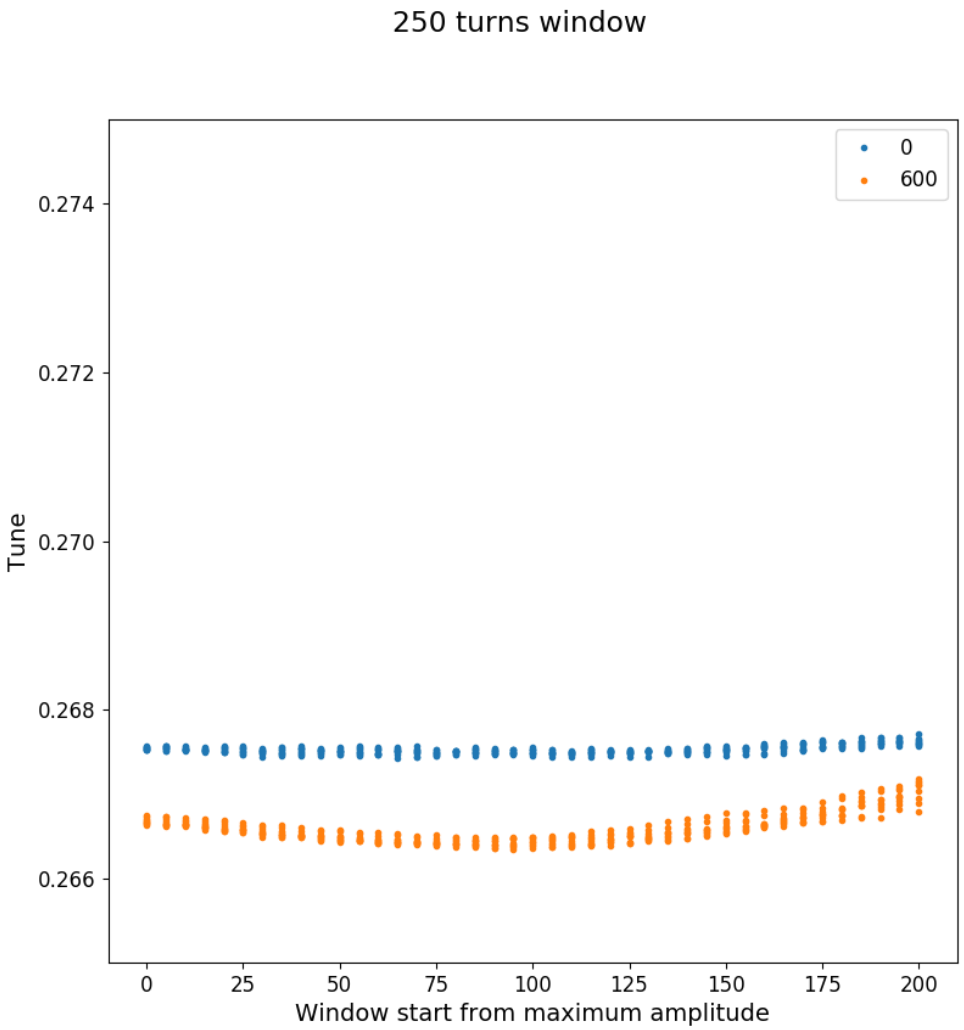
Convergence of SUSSIX



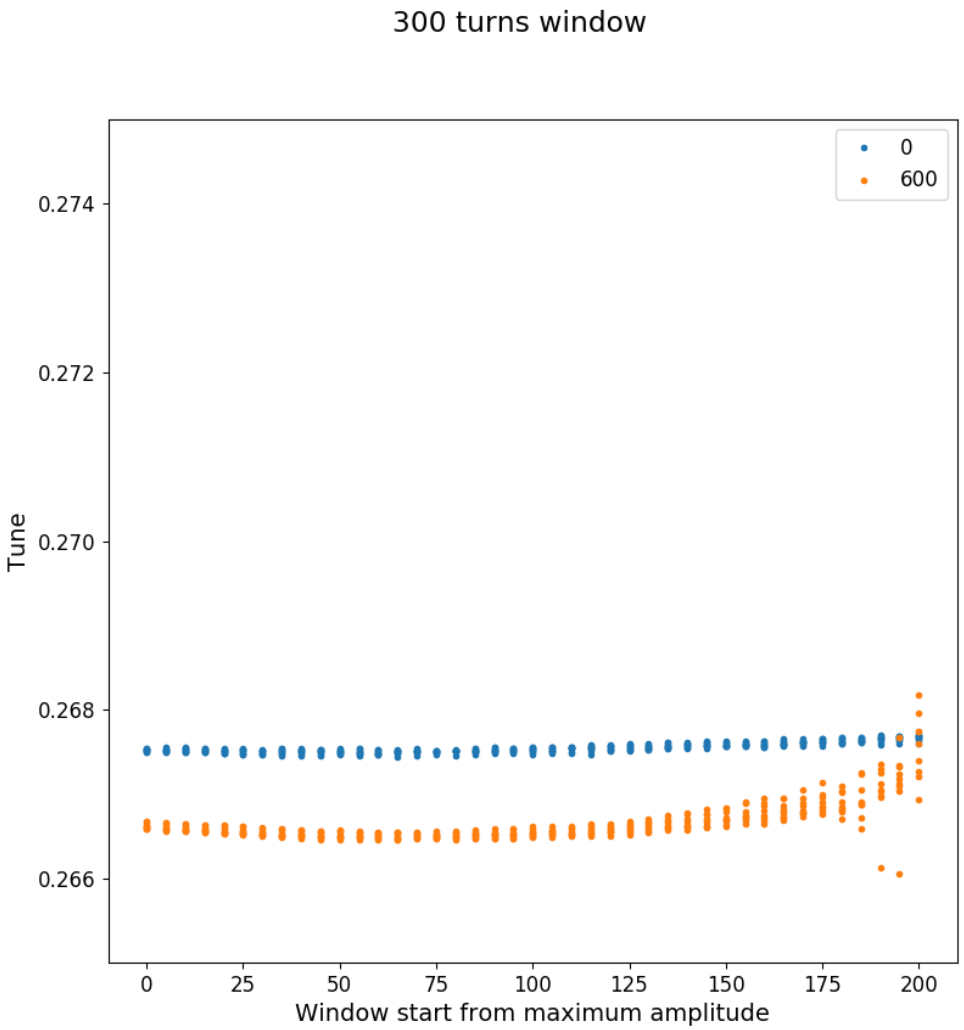
Convergence of SUSSIX



Convergence of SUSSIX

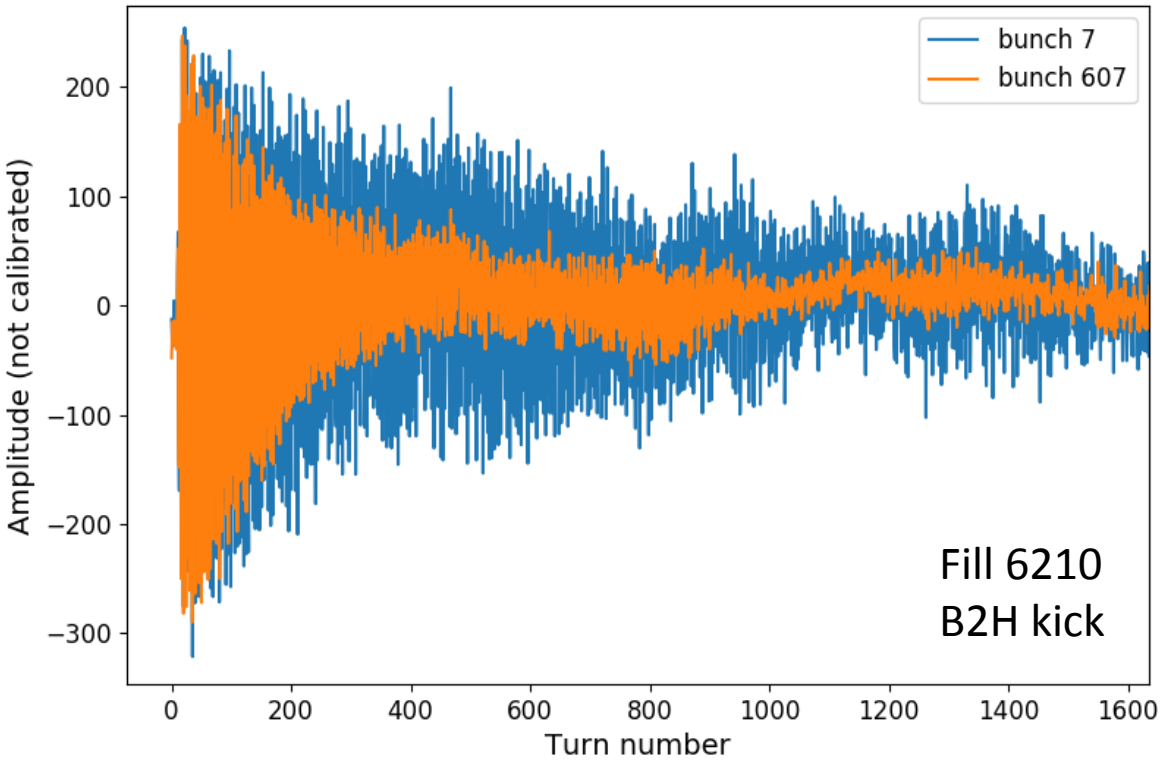


Convergence of SUSSIX



Convergence of SUSSIX

- The decoherence time is sometimes different between bunches



Conclusion

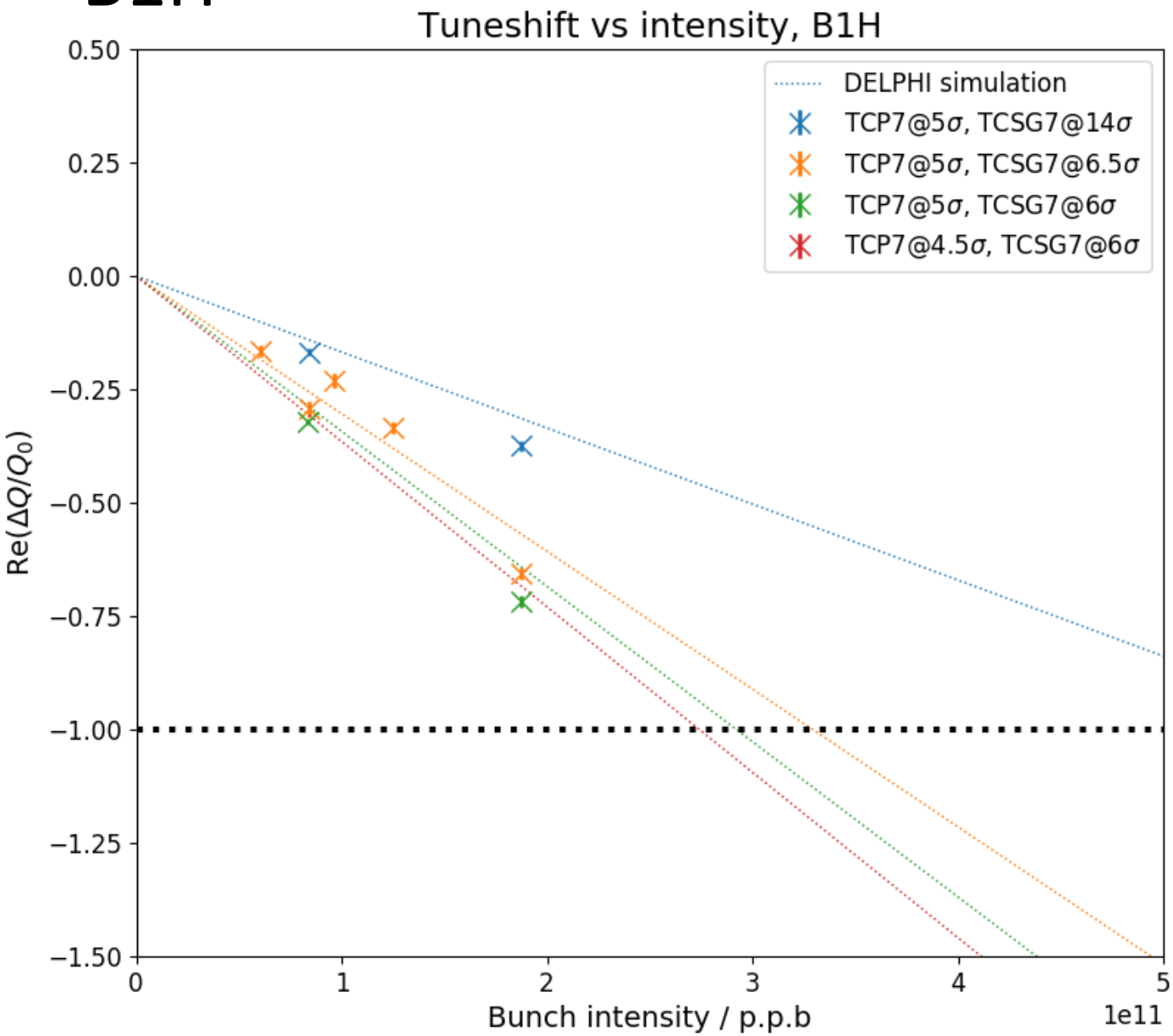
- The collimators position change has a visible impact on the tune shift
- A tuneshift reduction is clearly visible with the HL-LHC equivalent impedance
- There is still some

- The effect of momentum spread / chromaticity / octupoles are being investigated
  - Could have an effect on the decoherence time and the tune measurement

Treated results with a fixed number of turns in SUSSIX

- Treated results with a fixed window
  - 200 turns
  - Start from the maximum amplitude

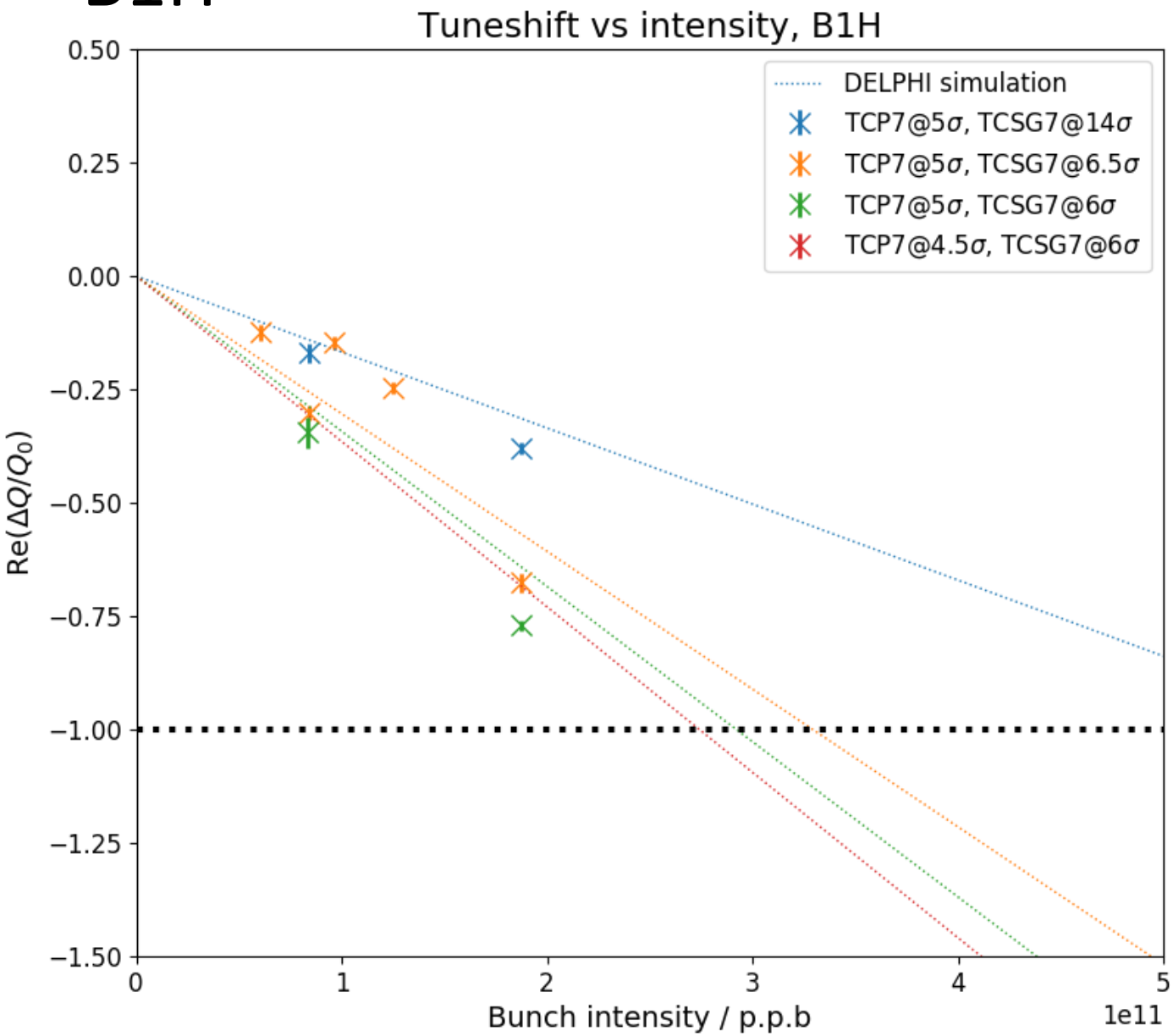
B1H



Crosses: measurements
Dashed lines: DELPHI simulations

SUSSIX Adaptive window

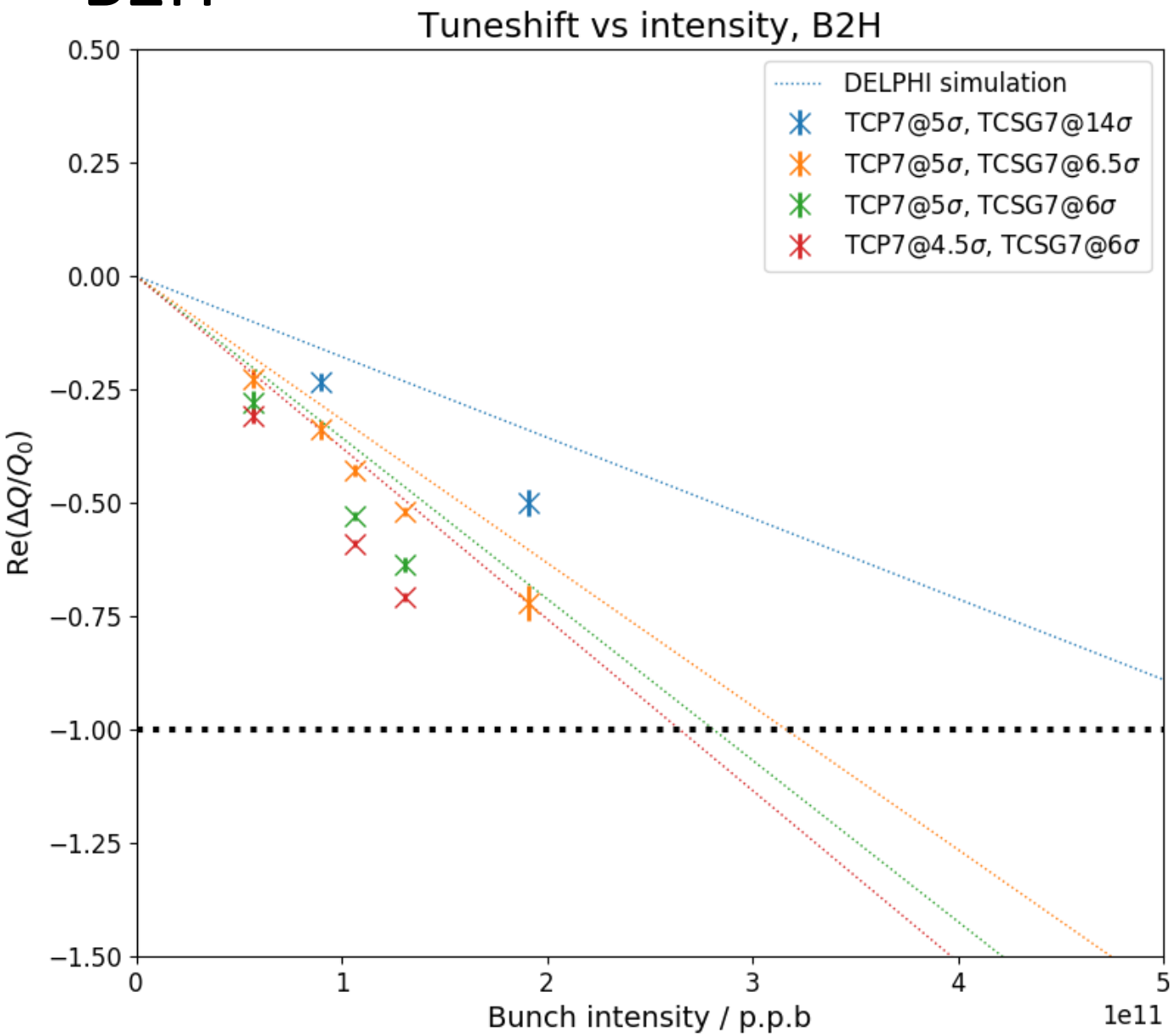
B1H



Crosses: measurements
Dashed lines: DELPHI simulations

SUSSIX Fixed window

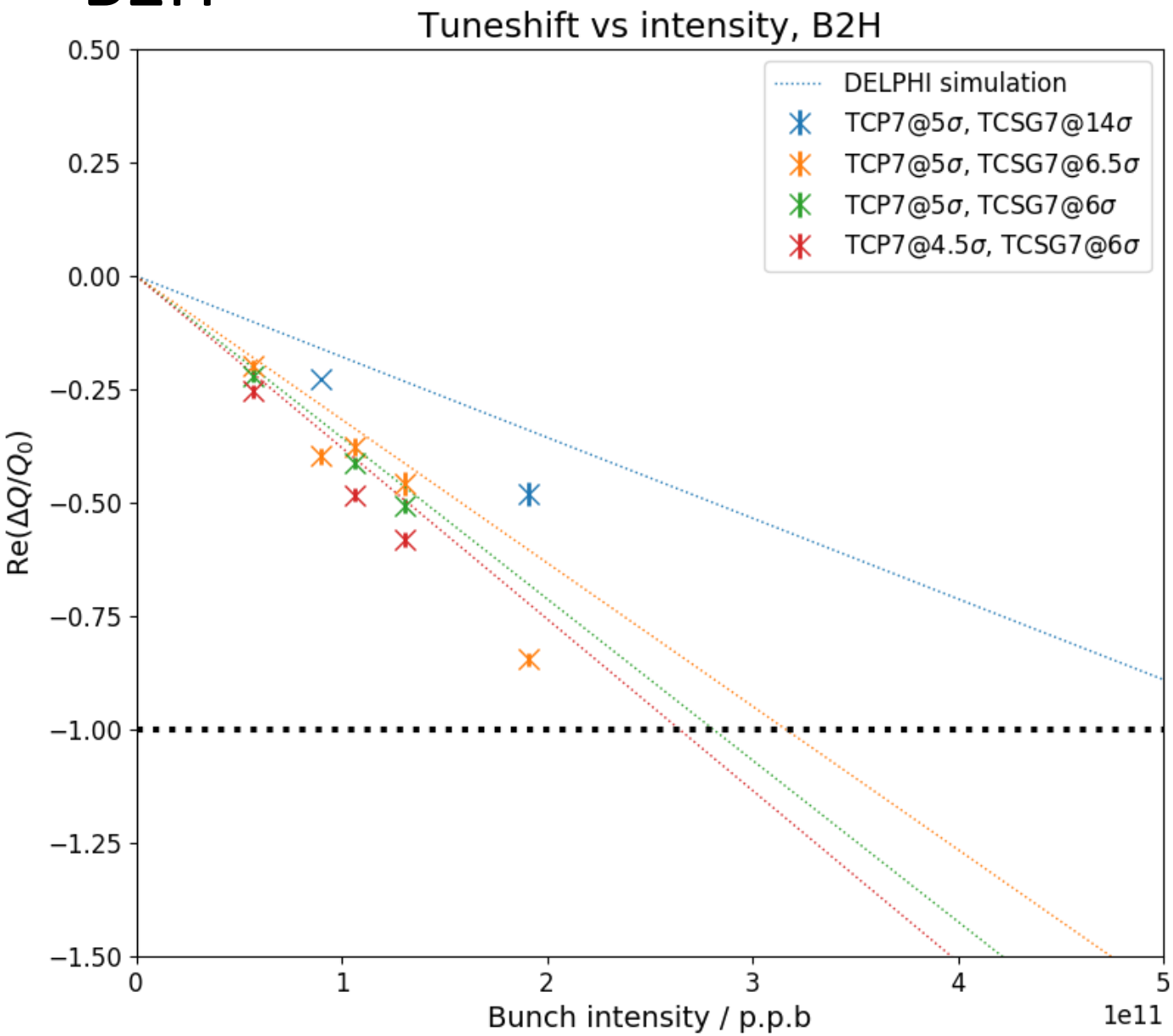
B2H



Crosses: measurements
Dashed lines: DELPHI simulations

SUSSIX Adaptive window

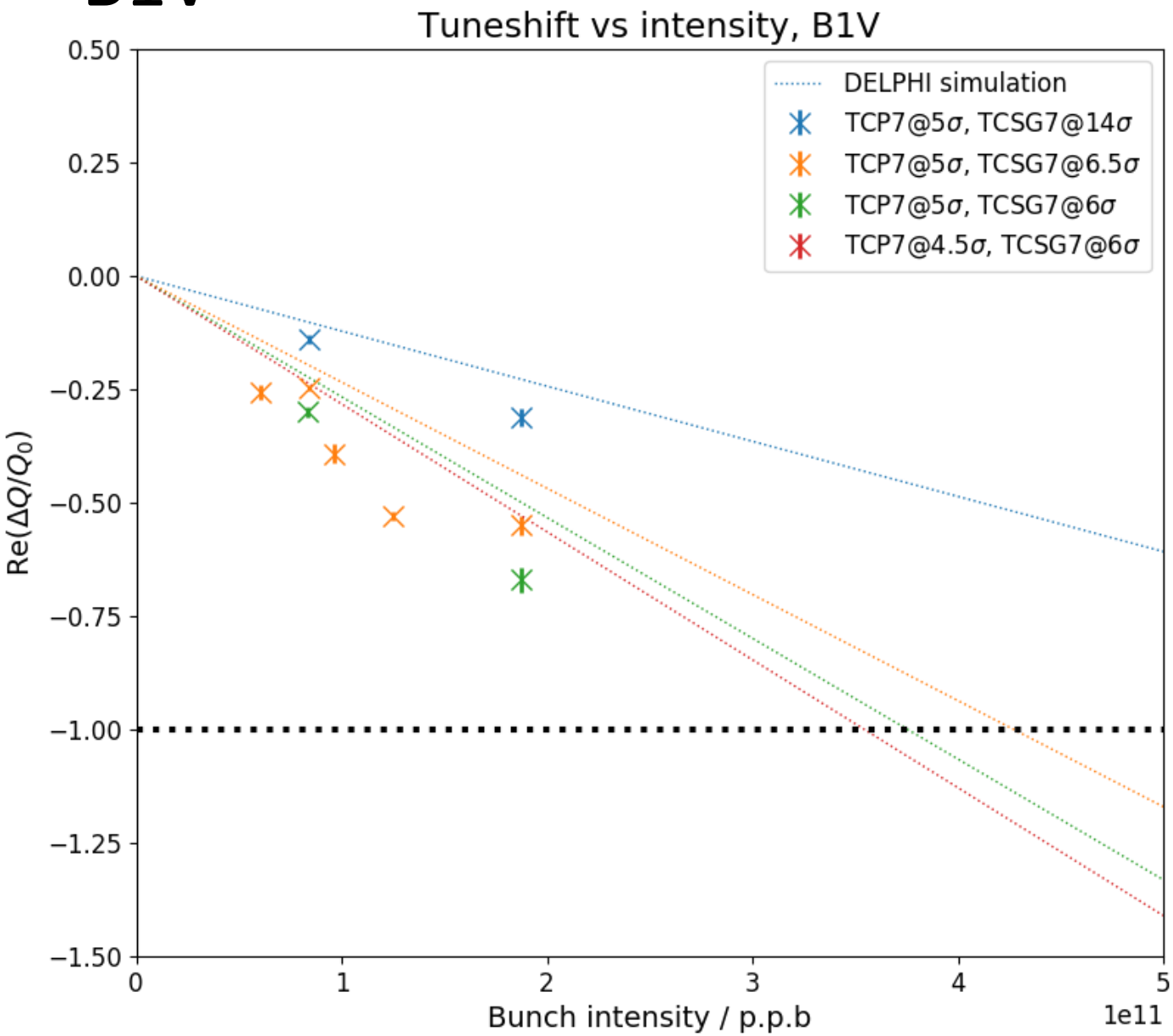
B2H



Crosses: measurements
Dashed lines: DELPHI simulations

SUSSIX Fixed window

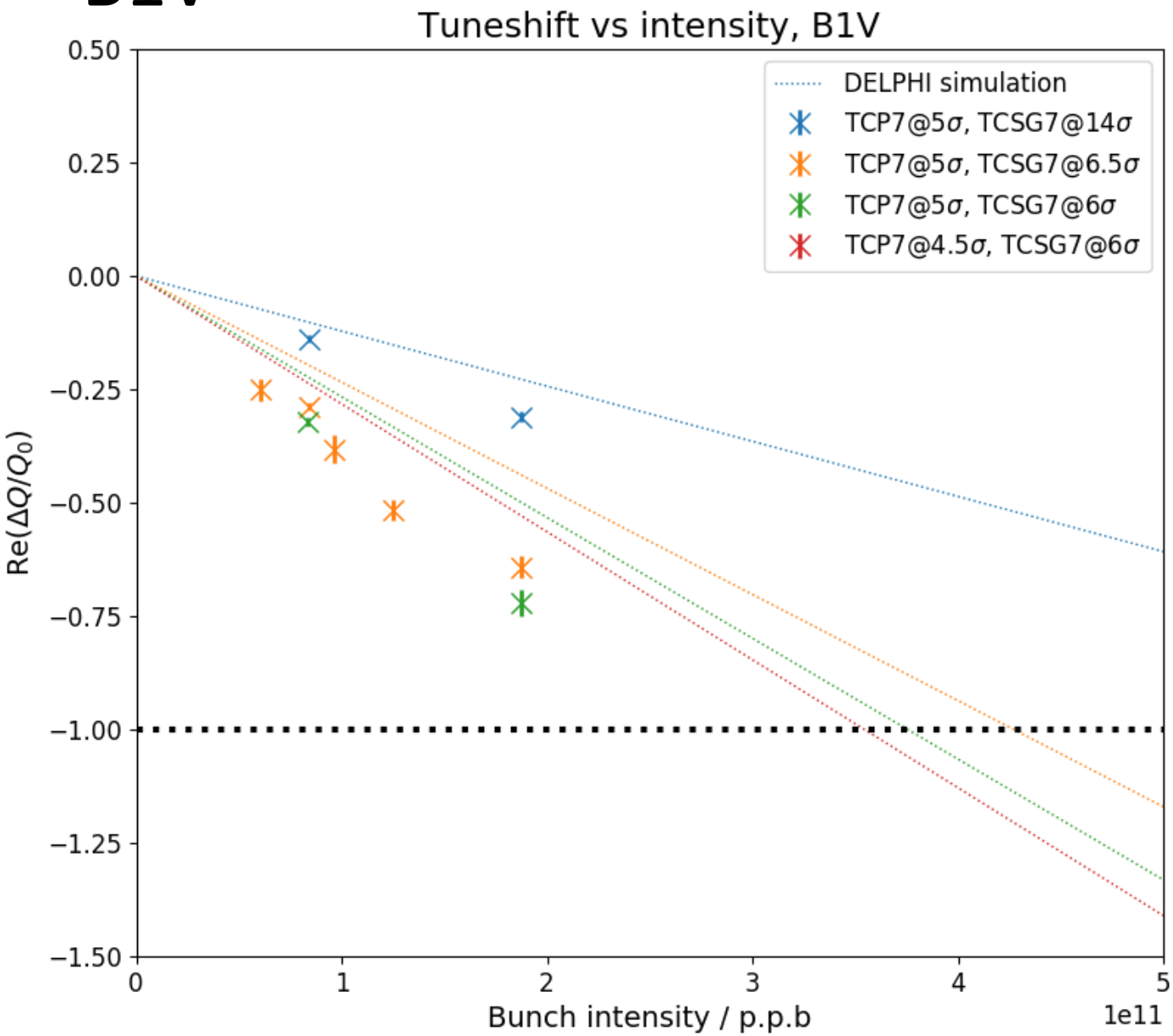
B1V



Crosses: measurements
Dashed lines: DELPHI simulations

SUSSIX Adaptive window

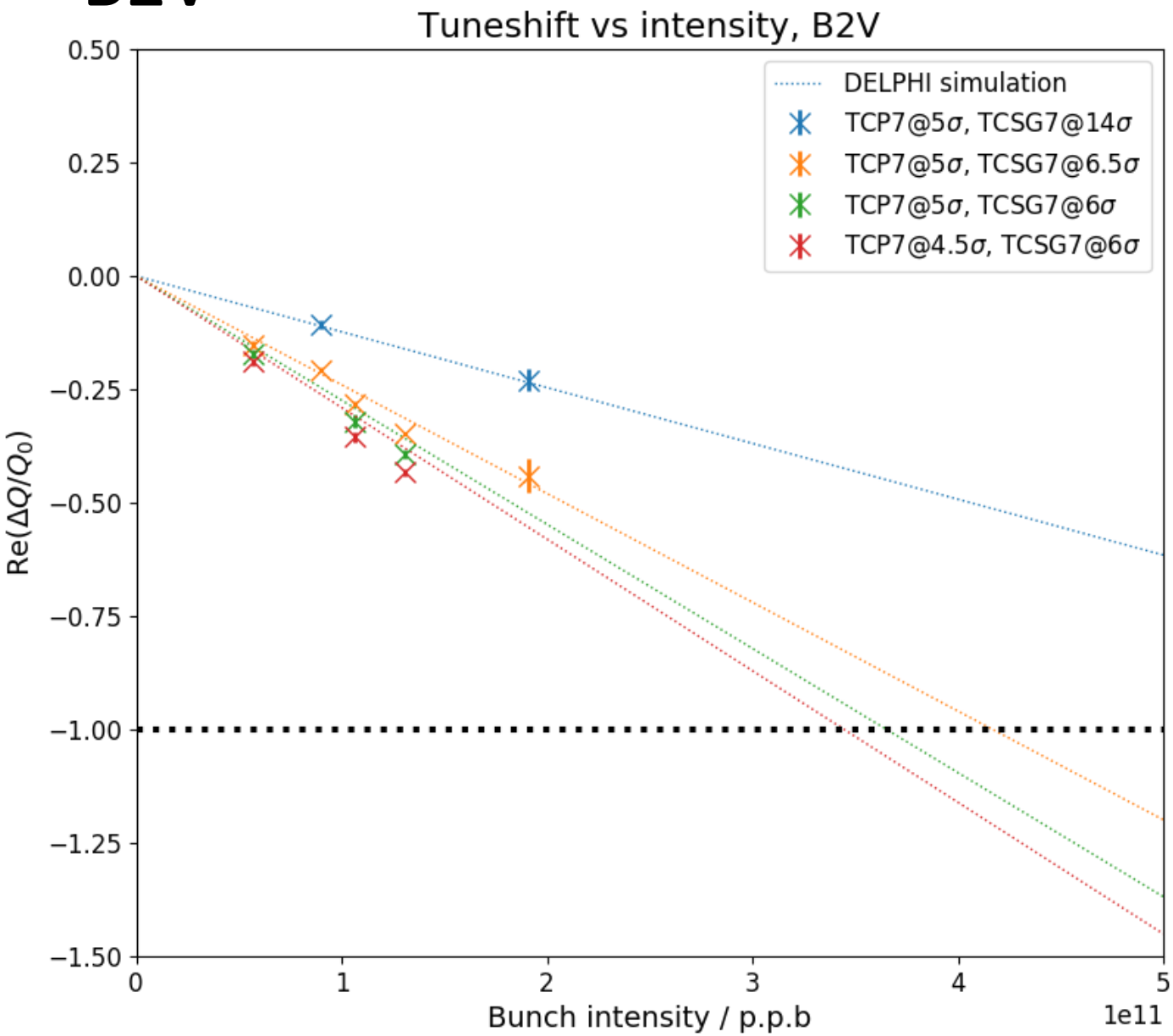
B1V



Crosses: measurements
Dashed lines: DELPHI simulations

SUSSIX Fixed window

B2V



Crosses: measurements
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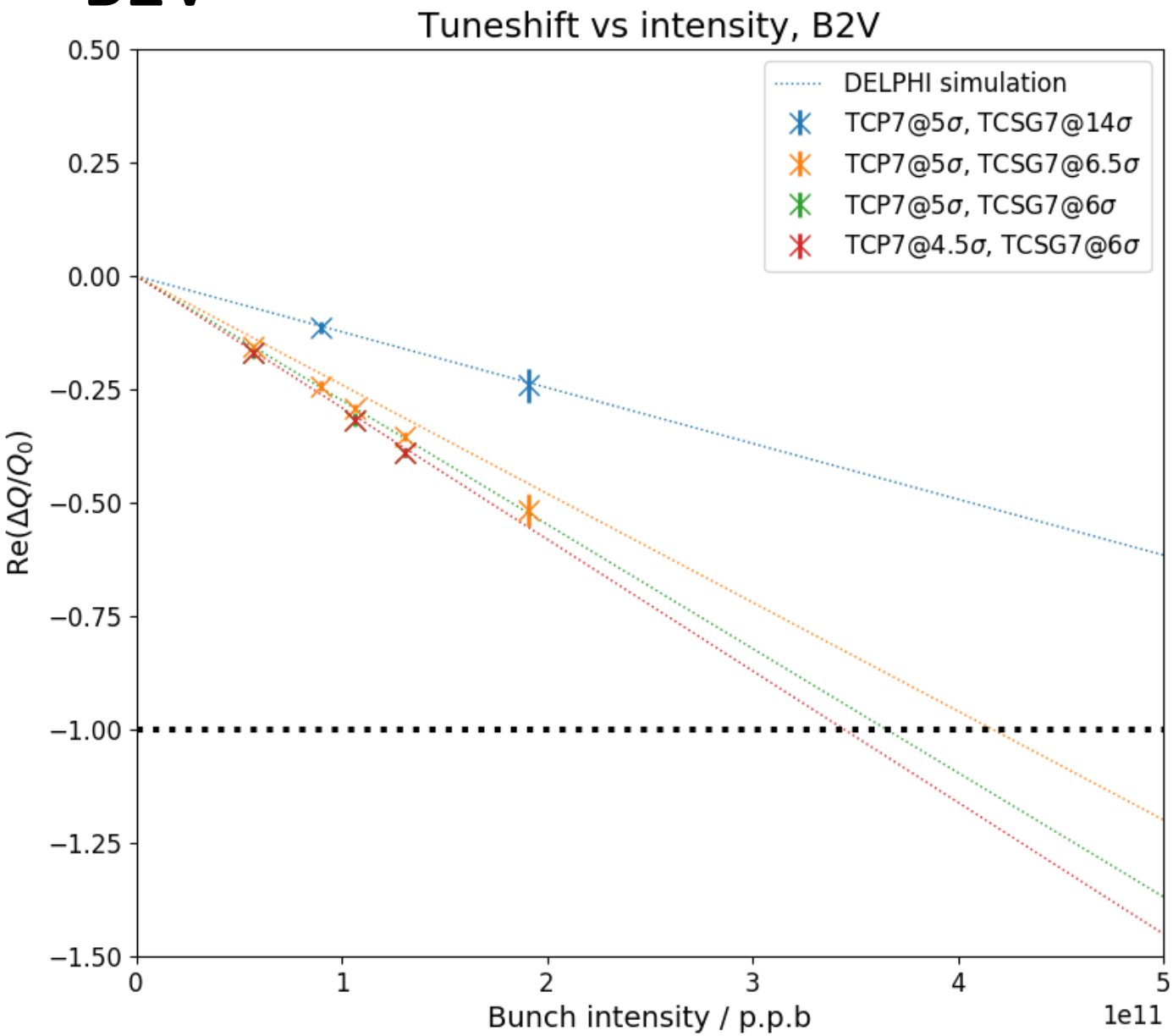
SUSSIX Adaptive window

B2V



Crosses: measurements
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SUSSIX Fixed window