Proposals for 2025 RFD MDs

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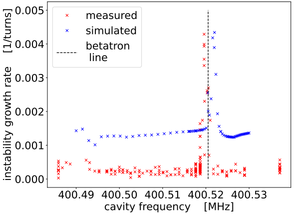
Outline

DQW studies in 2022 - 2023

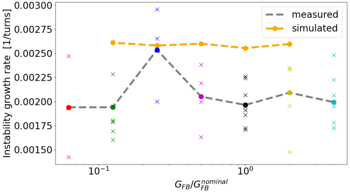
Measurements were carried out on the DQW prototypes and several interesting lessons were learned.

Two impedance-related experiments:

- Instability growth rate vs. crab cavity frequency without RF feedback
  - Successfully observed an instability when the cavity fundamental mode crosses a betatron frequency
  - In the future it could be interesting to perform the same measurement by refining the scan close to the betatron frequency (if it is possible)



- Instability growth rate vs. crab cavity standard RF feedback gain
  - No clear dependence on the feedback gain (in the range explored) as expected from simulations
  - We know that in the SPS the standard RF feedback is more effective than in the HL-LHC



We would like to continue this measurement campaign in 2024.

Outline

DQW studies in 2022 - 2023

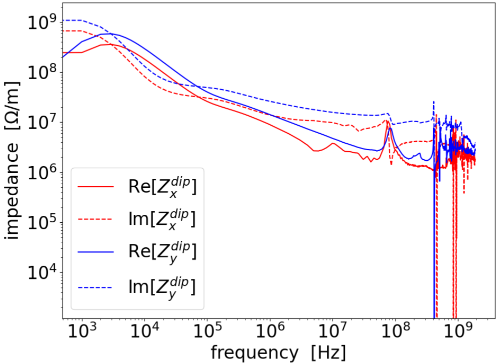
Impact of the RFD cavity

Simulations with a single-notch filter feedback

RFD measurements

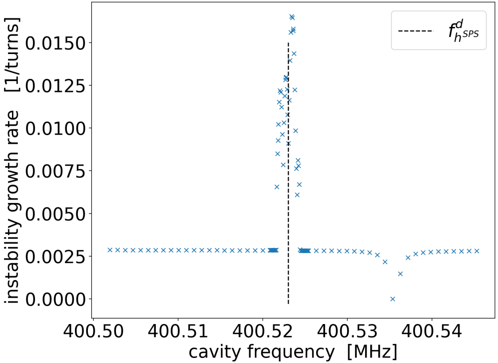
It is very interesting to move to measuring the RFD cavities in 2024 but there is the additional difficulty that the horizontal beta function at the location of the cavities is lower than the vertical one ($\beta_x^{CC} =\sim 40m$, $\beta_y^{CC} =\sim 80m$). This could mean that the weighted impedance of the cavities is lower than the SPS impedance.

On the other hand, this is partially compensated by the fact that the horizontal SPS impedance is lower than the vertical one.



RFD frequency vs instability growth rate study

In order to check that the instabilities induced by the RFD impedance could be measured in the SPS, we simulated with PyHEADTAIL the instability growth rate, varying the RFD frequency.



The instabilities which happen when the RFD is tuned close to the betatron line, are faster therefore the effect of the RFD is clearly visible.

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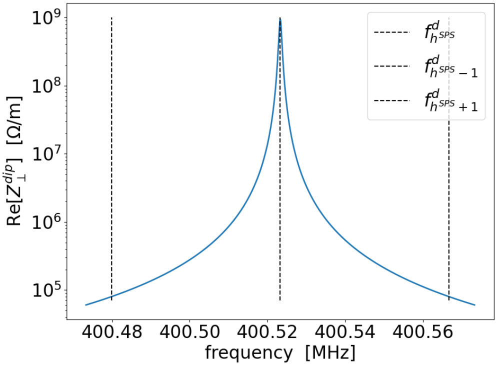
Impact of the RFD cavity

Simulations with a single-notch filter feedback

Single-notch filter feedback

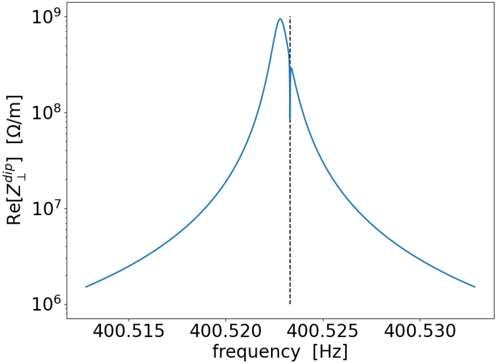
In the SPS the revolution frequency is 4 times larger than in the LHC (43KHz vs 11KHz) therefore it is enough to reduce the impedance at one betatron frequency to reduce the instability growth rate.



According to the RF colleagues, it could be doable to build a feedback system providing impedance reduction on a single line. Measuring this impedance reduction would be a first step towards the validation of the strategy to use a betatron comb filter to mitigate the fundamental mode instability.

Single-notch filter feedback

For the purpose of studying the effect of adding the notch we can produce the impedance with the notch by subtracting a narrower resonator from the crab cavity fundamental mode impedance.

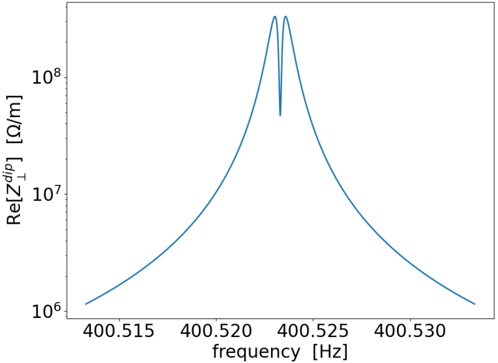


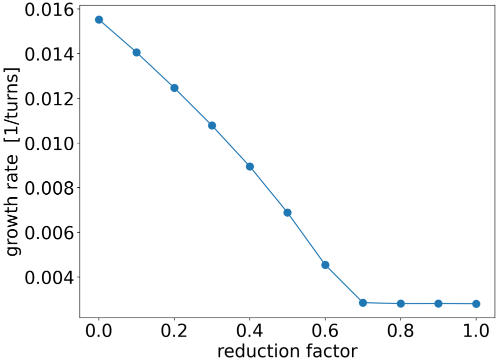
We can then play around with shunt impedance, quality factor and frequency of this resonator to study the effect and properties of the notch.

Clearly this is not a perfectly realistic description of the impedance with single-notch filter feedback, but it is a good starting point for our simulations.

Scan in reduction with RFD tuned on the betatron line

The easiest experiment to test the reduction given by the single-notch filter is to tune the RFD on the betatron line and perform instability growth rate simulations with PyHEADTAIL, scanning the depth of the notch.





The growth rate is significantly reduced, therefore this could be tried in an MD.
The sensitivity to the width of the notch is currently under study.

Conclusions

- In 2022 and 2023 we could perform measurements on the SPS DQW cavity where the fundamental mode instability was clearly observed when its frequency is close to a betatron line
- More measurements could be performed in 2024 to test the mitigation of the instabilities induced by the crab cavities fundamental mode using a betatron comb filter
- For the moment we propose one MD:
  - Tune the cavity on the closest betatron frequency, apply single-notch filter and measure the reduction in impedance scanning the depth of the notch.
- If it is doable we would also refine the frequency scan closer to the betatron frequency with and without the notch