Ecloud/Feedback Simulation Results and Implications

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Outline

- Goal
- Past work & open questions
- Simulation strategy, model & tasks
- Preliminary tests
- Conclusions & outlook

Goal

- ECI and TMCI driven by stationary intra-bunch motion: high frequency modes → high bandwidth feedback system
- To study numerically the effectiveness of different feedback systems against fast headtail instabilities such as ECI and TMCI (complement to analytical and experimental methods)
- To evaluate the required specifications for the feedback system that has been deemed suitable

Past work

- Experimental observations
  - Limitation in intensity (TMCI)
  - Limitations in filling patterns (ECI)
  - Diagnostic tools: BPM, headtail monitors, emittance monitors, mode analysis
  - Stabilisation on a bunch-by-bunch level by transverse damper
- High bandwidth feedback (some examples)
  - J. Thomson: simplified and idealised feedback model
    → minimum bandwidth of 300 MHz
  - K. Ohmi: high bandwidth feedback simulations
    → 700 MHz
  - LARP collaboration: implementation of a realistic feedback system into CMAD and WARP

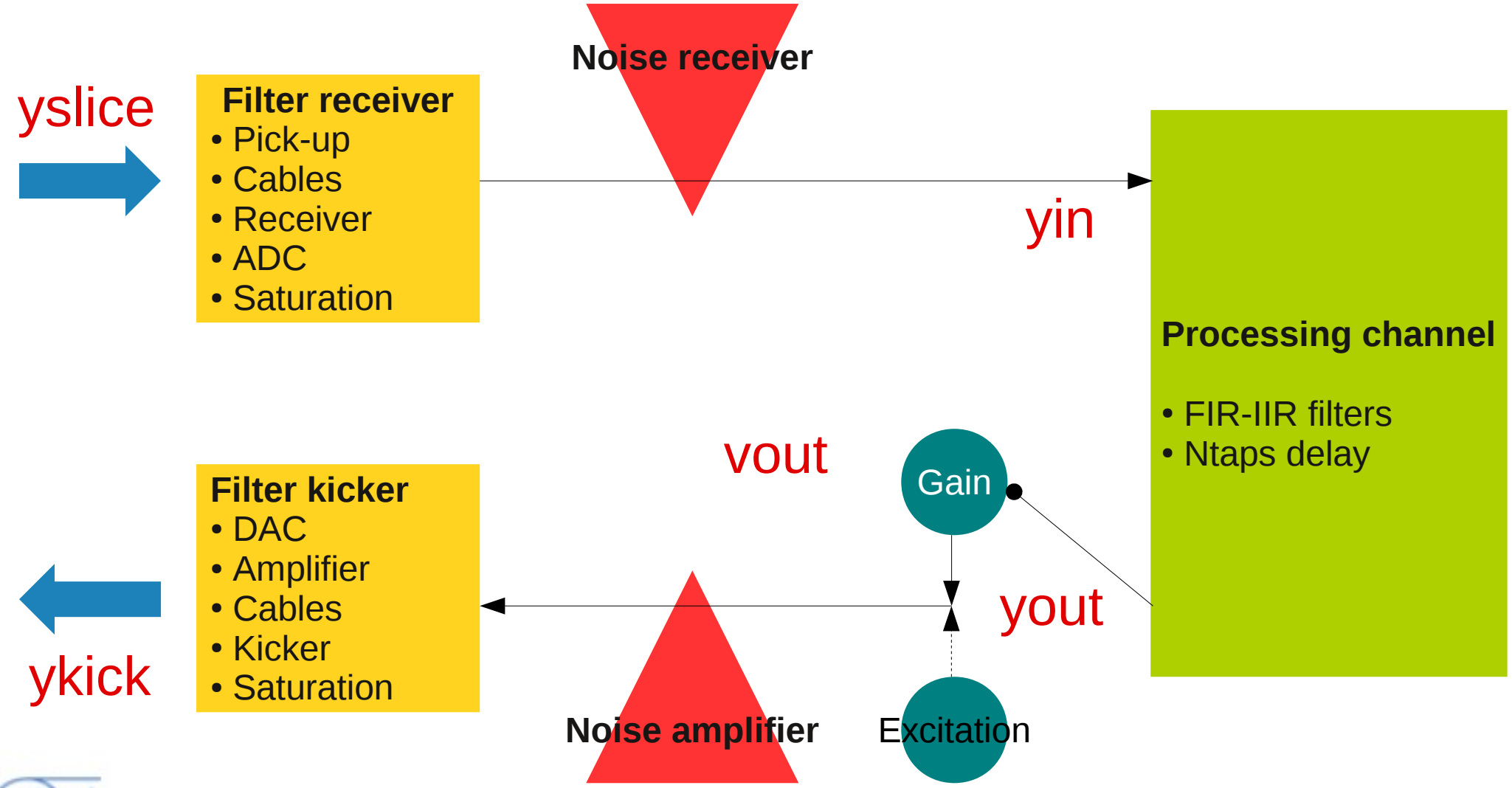
Strategy

- Readily available simulation codes to study instabilities and collective effects (CMAD, HeadTail, WARP)
- Implementation of a realistic feedback system into the available codes
- HeadTail comes in two flavours:
  - HeadTail-Impedance (multi-bunch, multi-turn) → TMCI
  - HeadTail-ElectronCloud → ECI
- The two flavours follow different strategies in their implementation → feedback system has been designed as class usable for both TMCI and ECI studies

Open question

- How to parametrize the bunch dynamics to evaluate feedback systems (correct metrics, rise times, mode spectra)
- Benchmark the different implementations of the new feedback systems using the same analysis tools
  - against each other
  - against the reduced model
  - against experimental data
- Study limits in power and noise levels, different controller algorithms and possible machine conditions

Feedback model

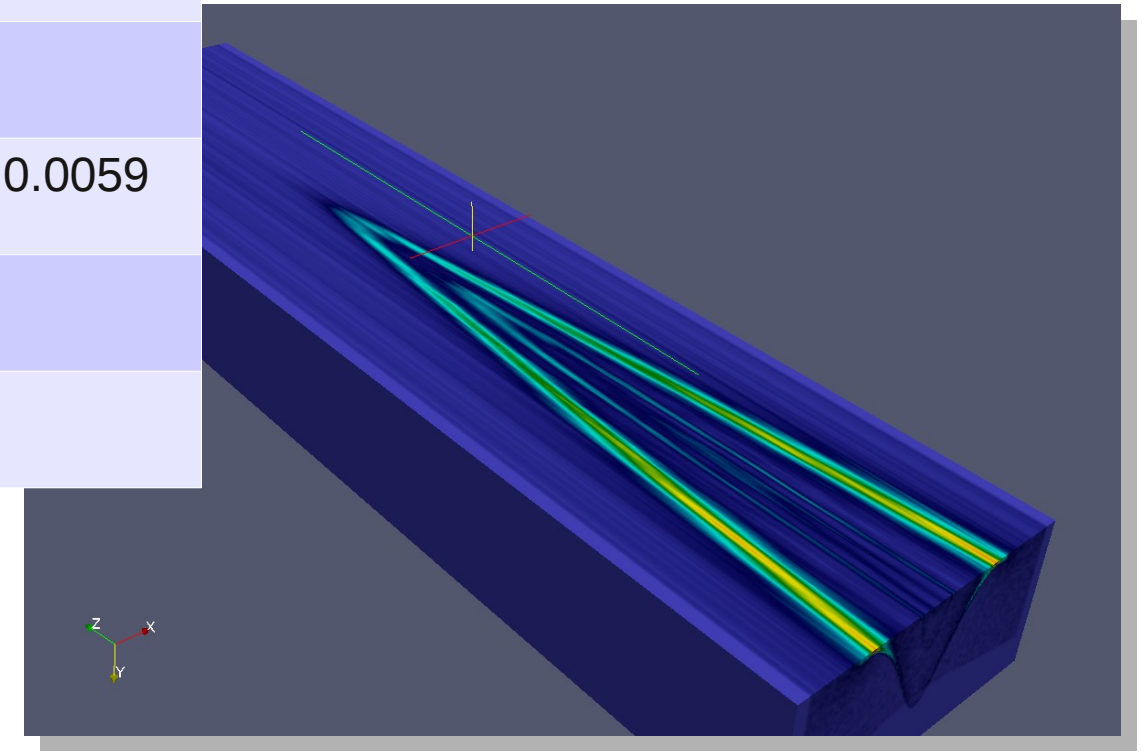


Preliminary tests

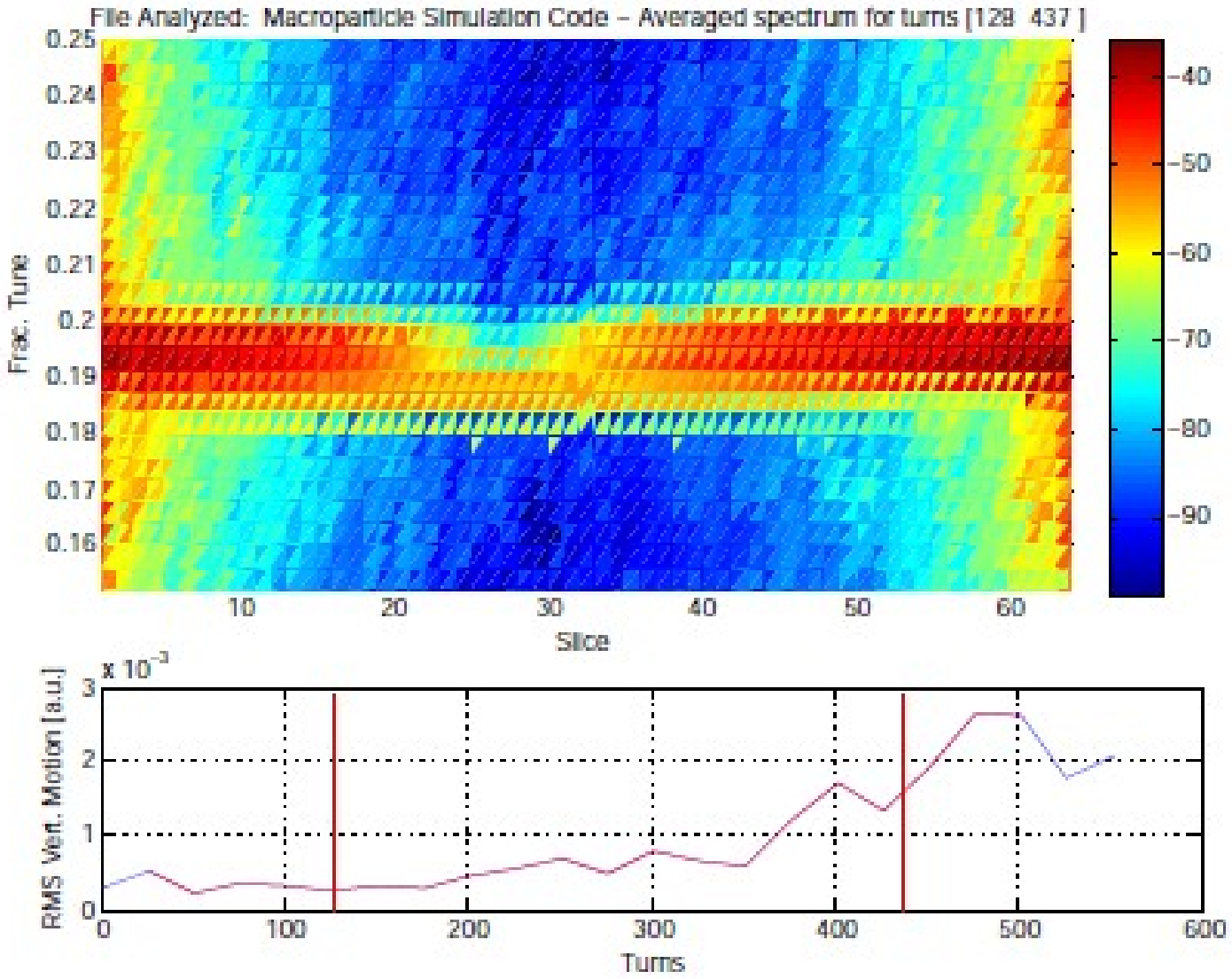
Parameters

Intensity	1.1e11 ppb
Energy	26 GeV
Emittances [epsx, epsy]	2.8, 2.8 microns
Beta-functions [βx, βy]	42, 42 m
Tunes [Qx, Qy, Qs]	26.130, 26.185, 0.0059
E-cloud region	Bends
Cloud density	5e11 m^{-3}

Dipole pinch

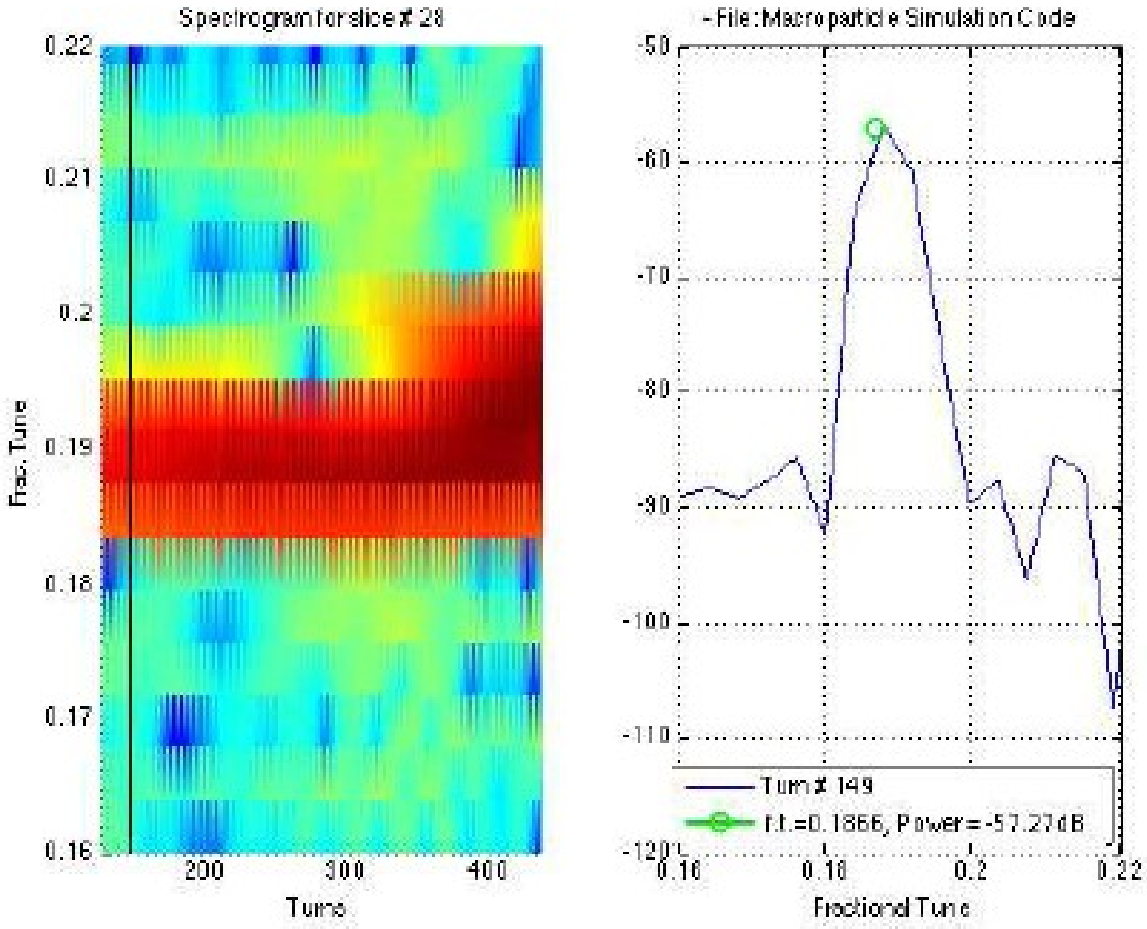


Preliminary tests – overall spectrum

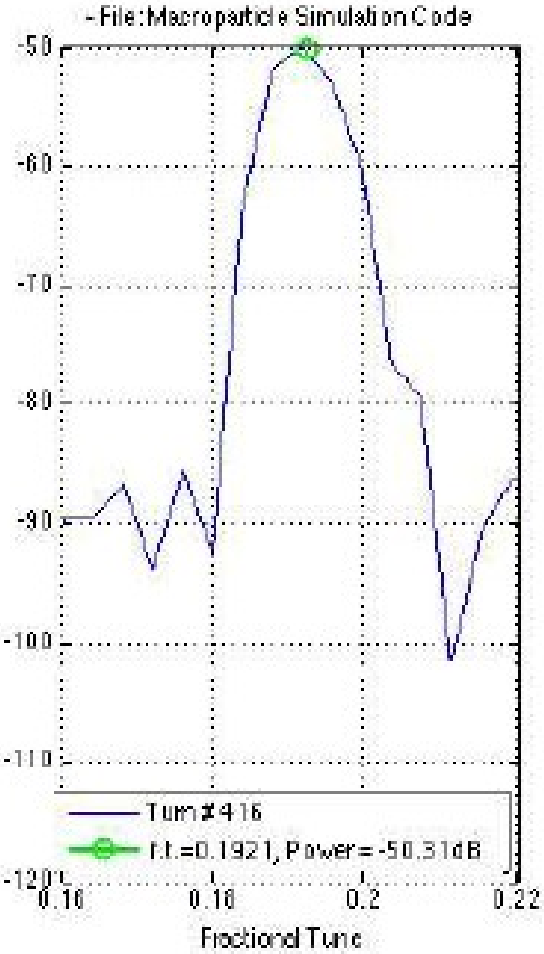


Preliminary results – slice spectrum

Turn# 149: dQ = 1.6e-3



416: dQ = 7.1e-3



Preliminary results – slice spectrum

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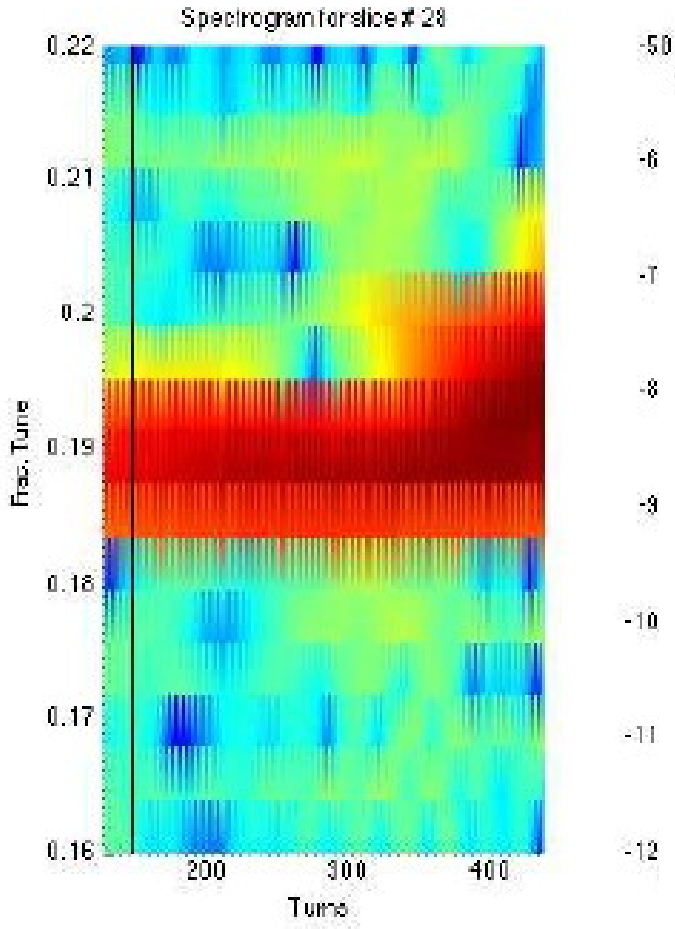

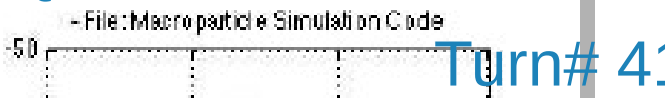

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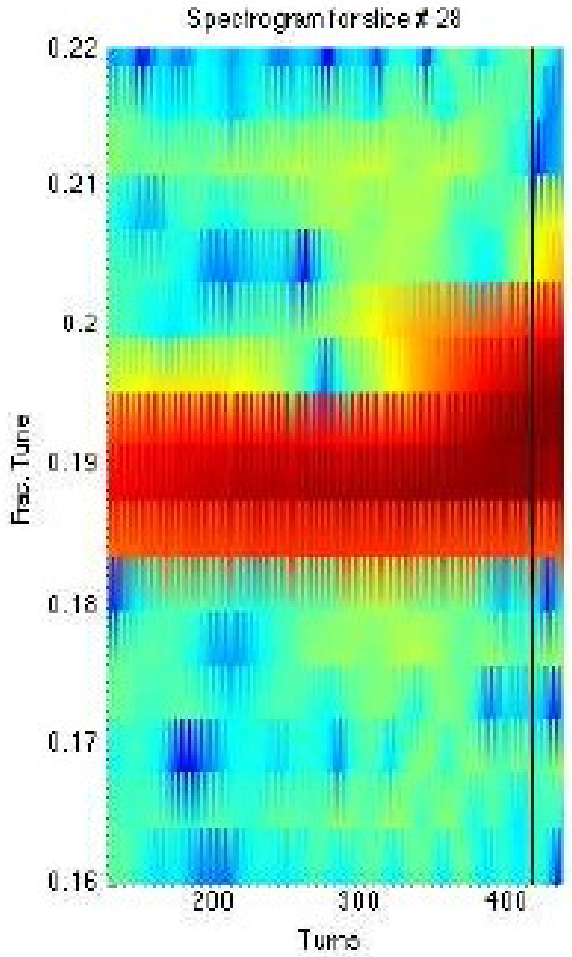
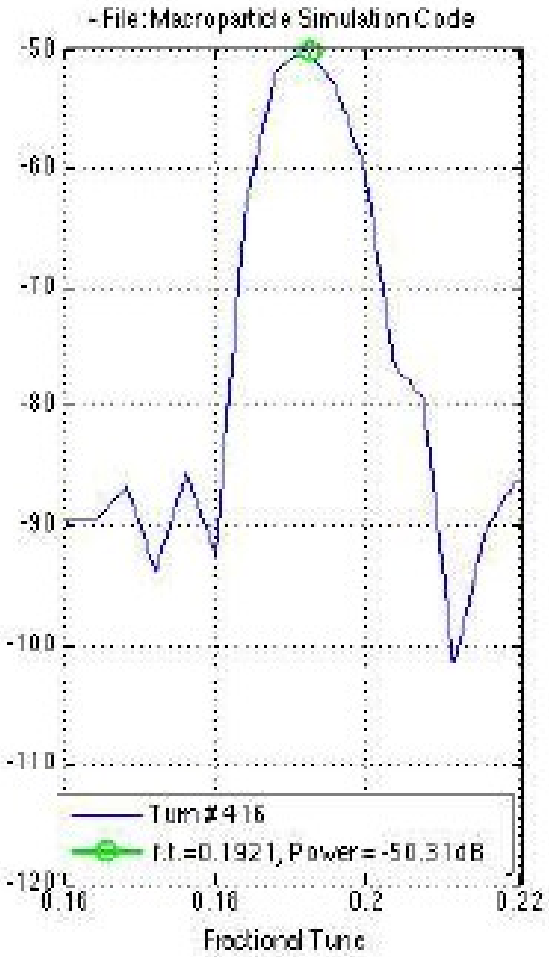
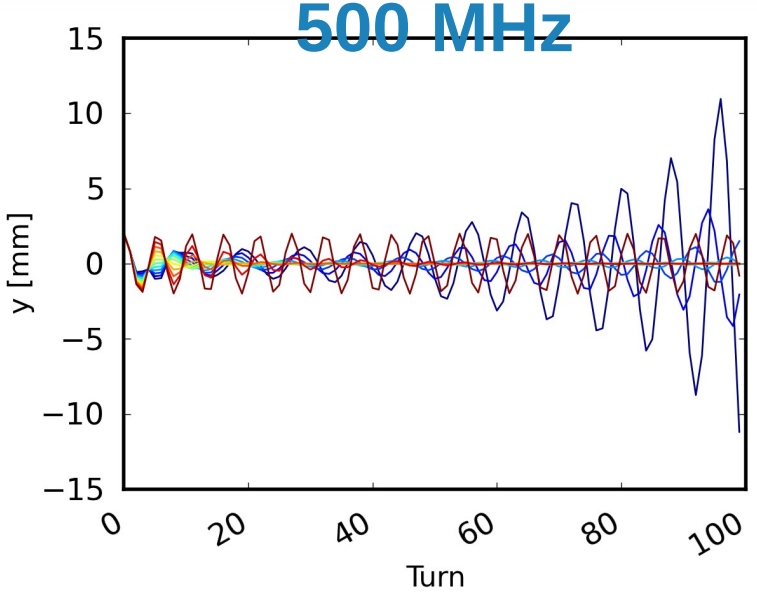
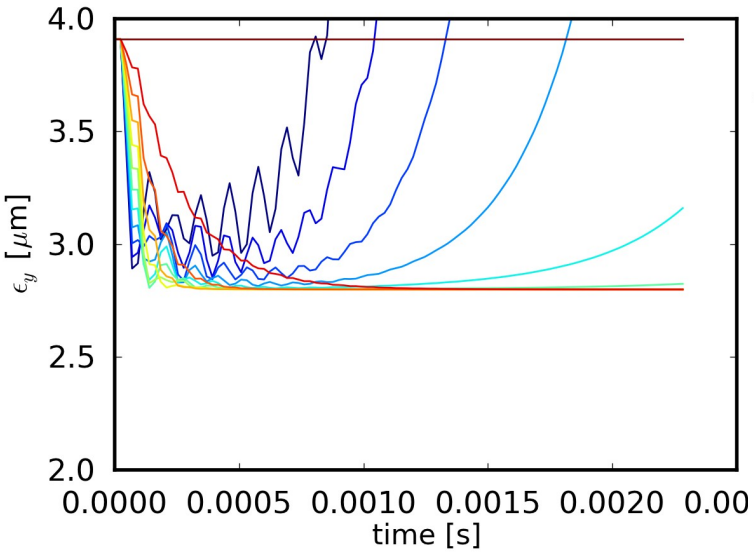




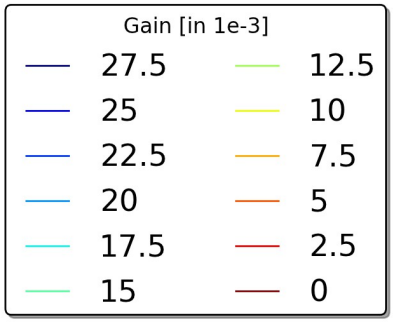
Preliminary tests

500 MHz

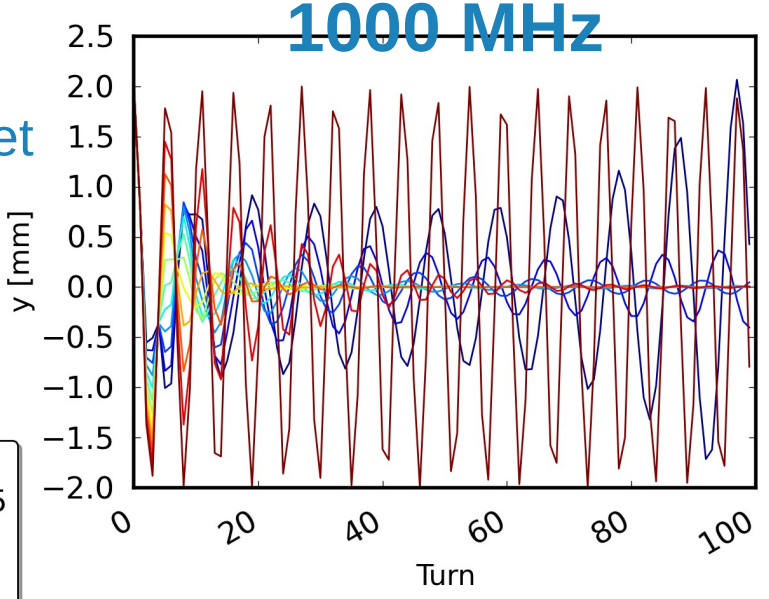


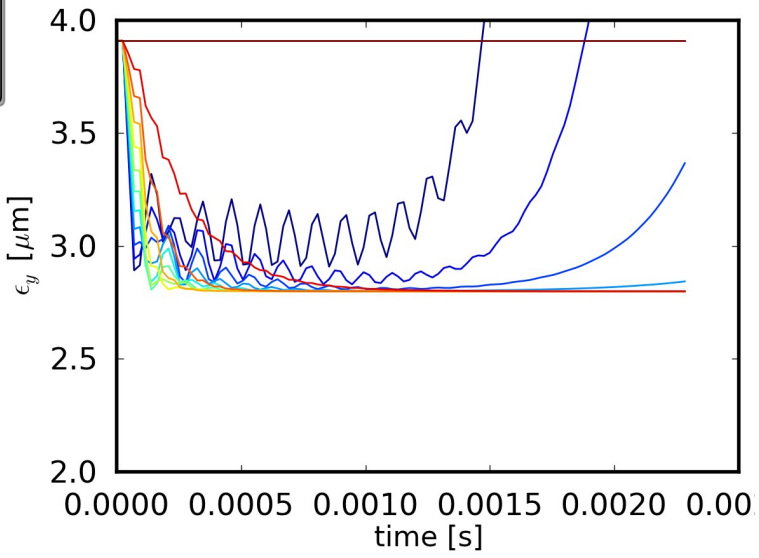


Perturbation:
2mm initial offset

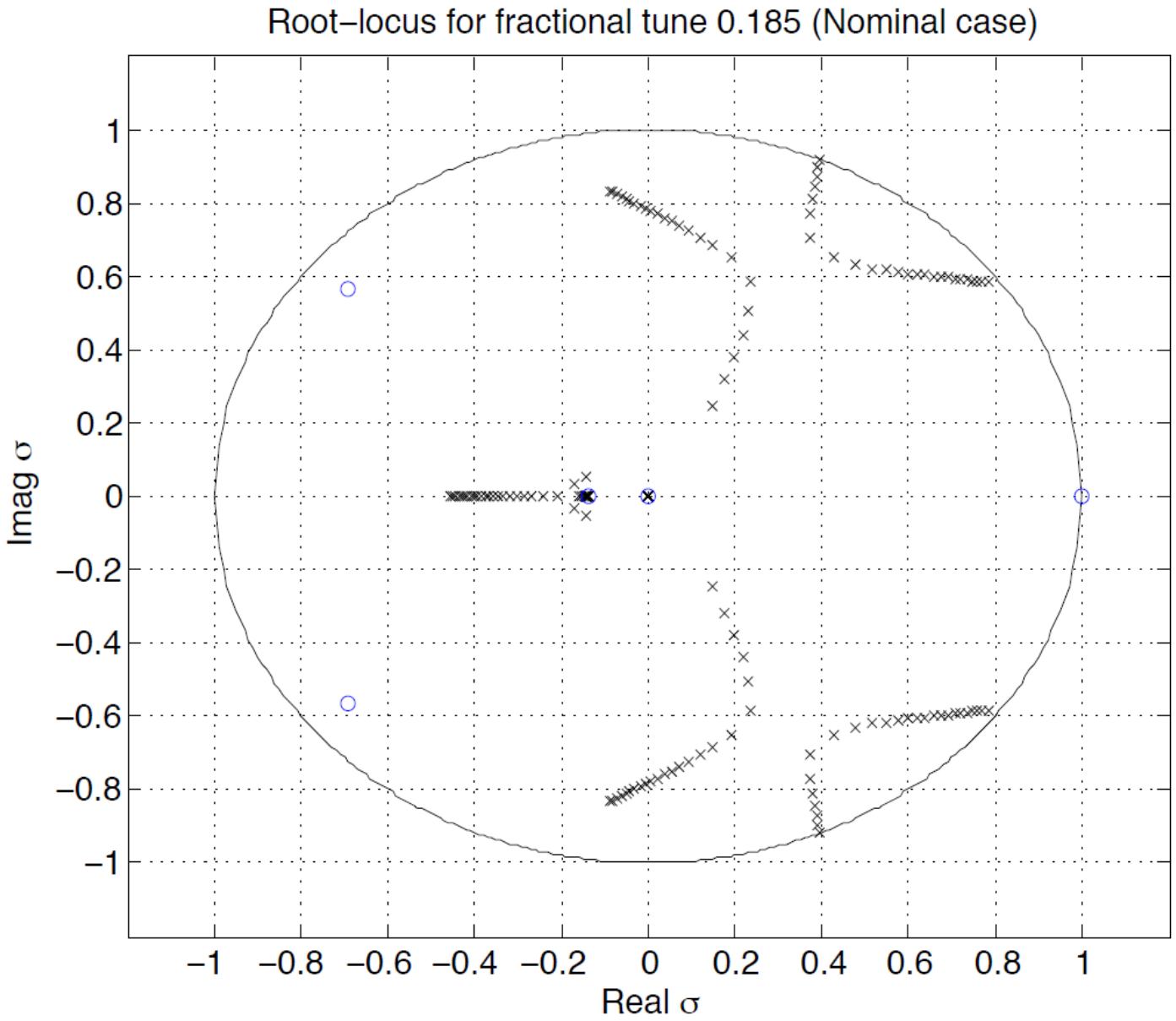


1000 MHz

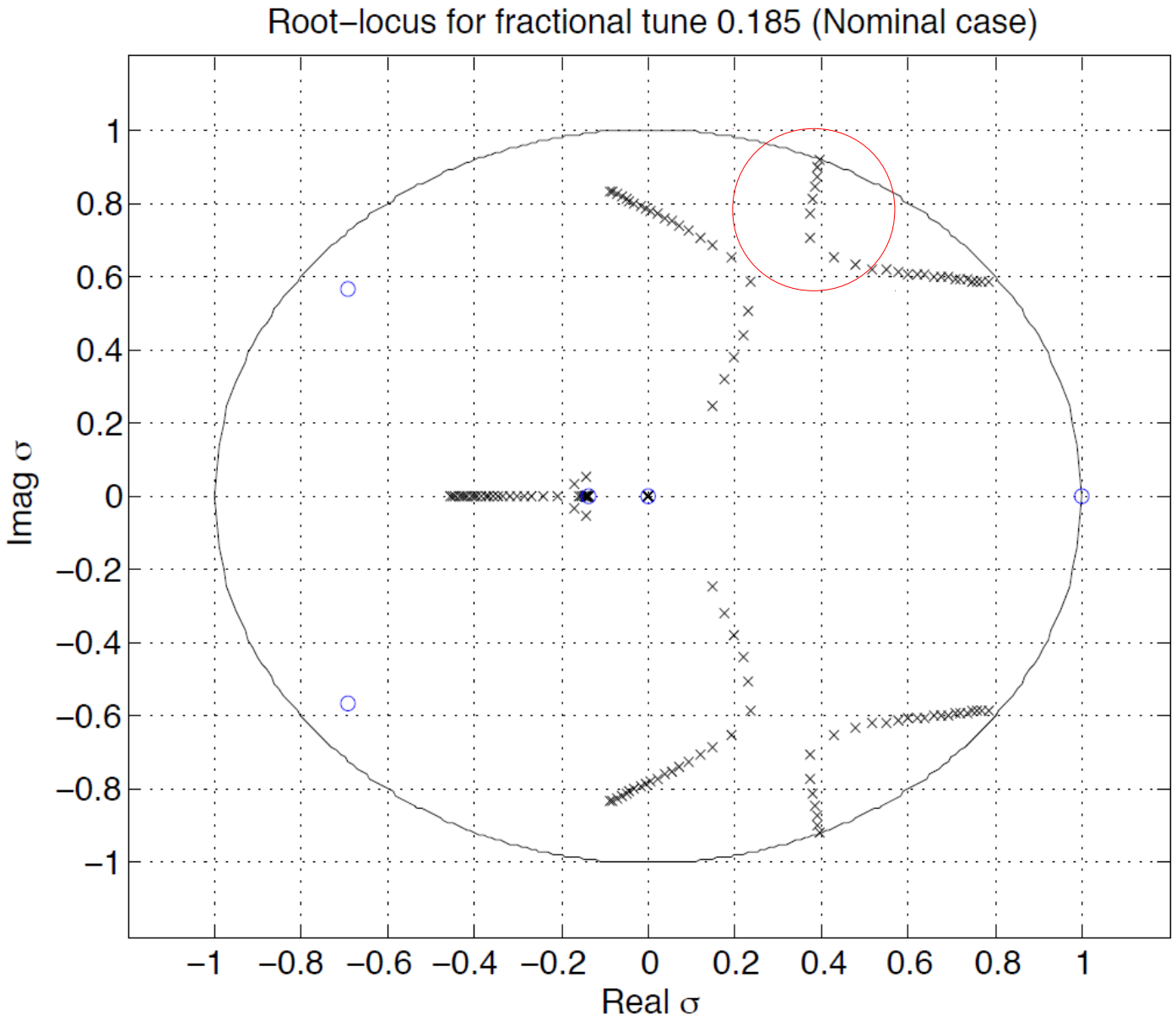




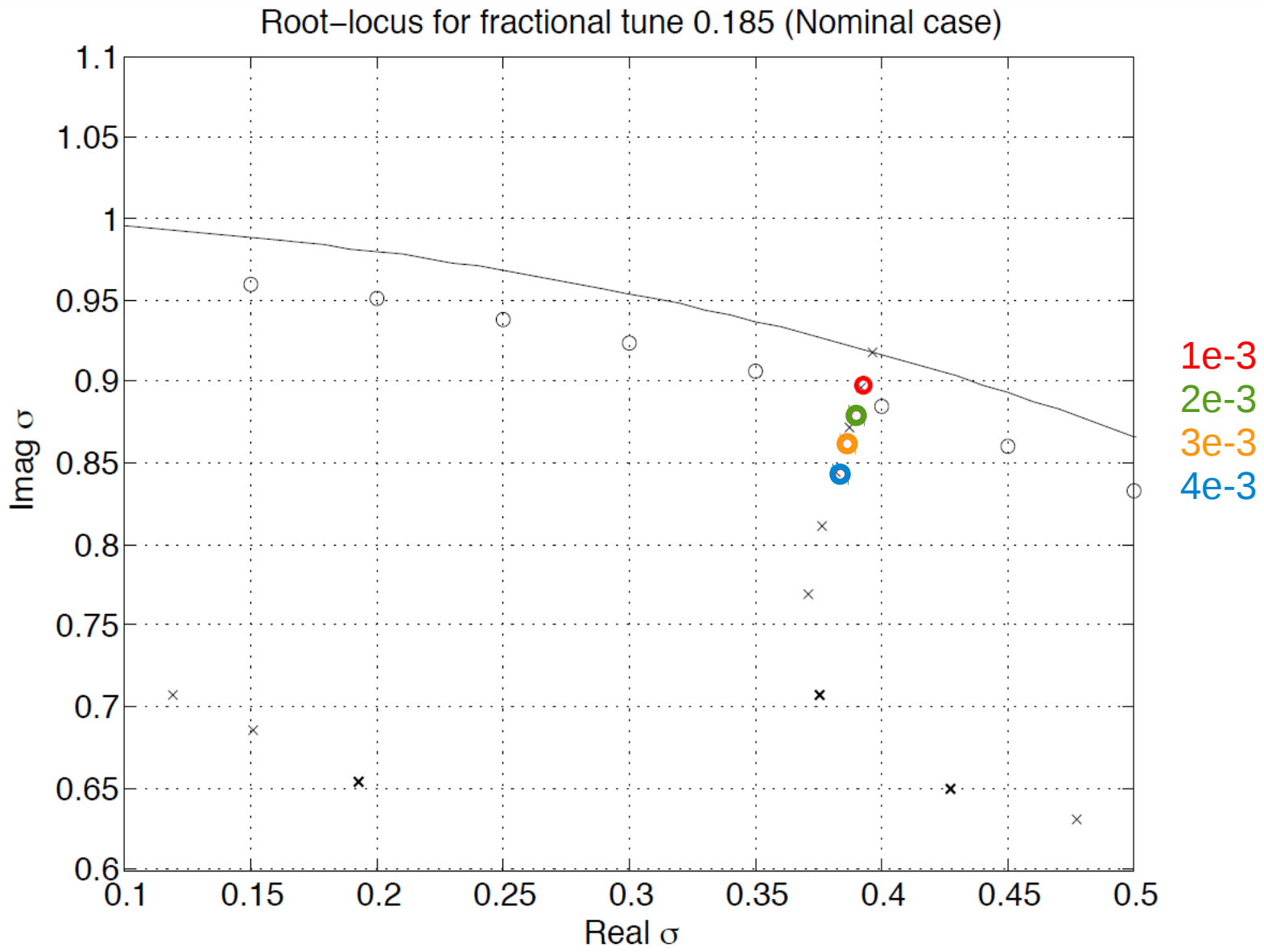
Root locus 1000 MHz



Root locus 1000 MHz

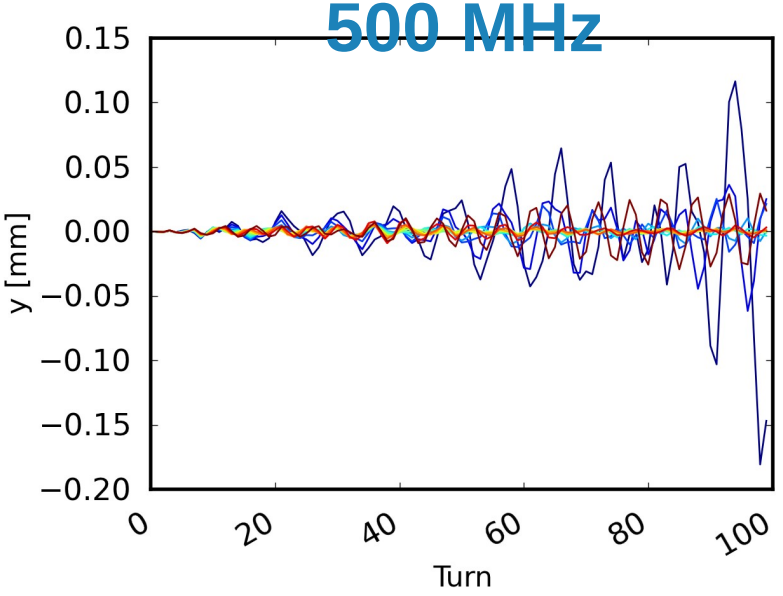


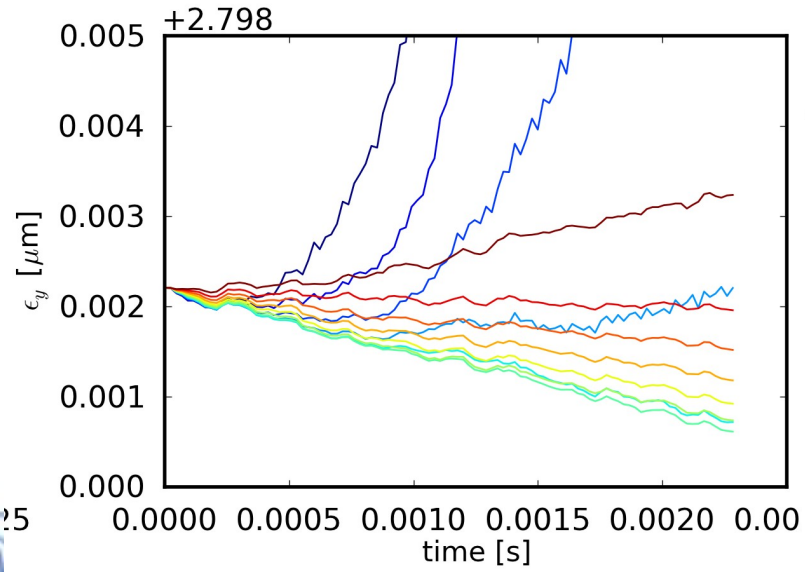
Root locus 1000 MHz



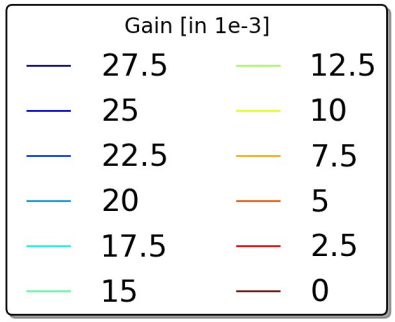
Preliminary tests

500 MHz

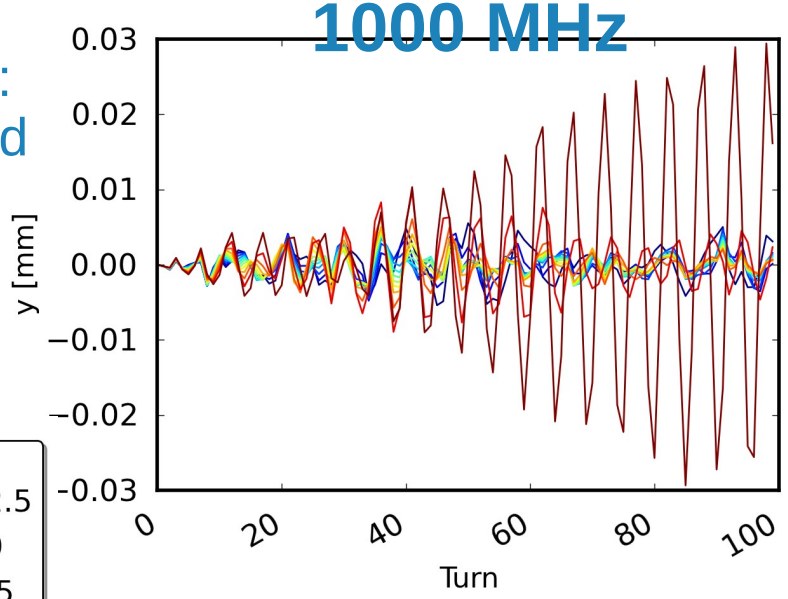


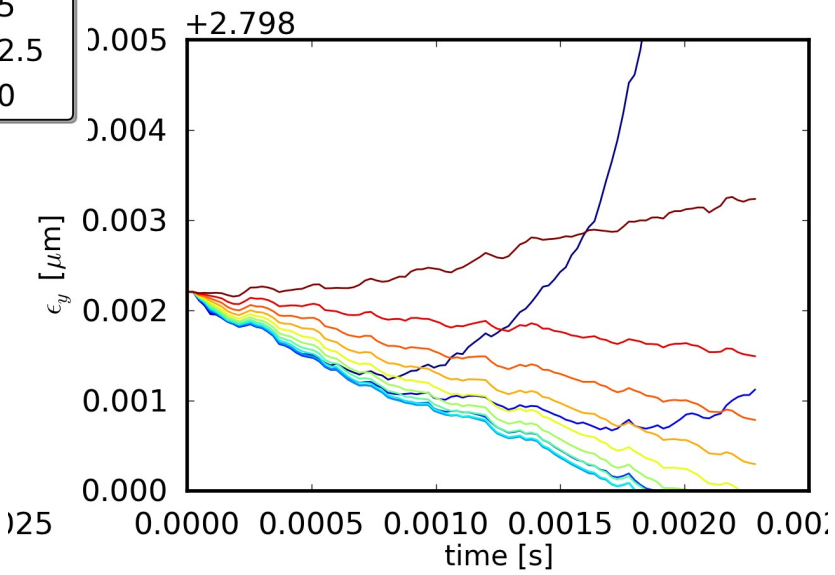


Perturbation:
Electron cloud



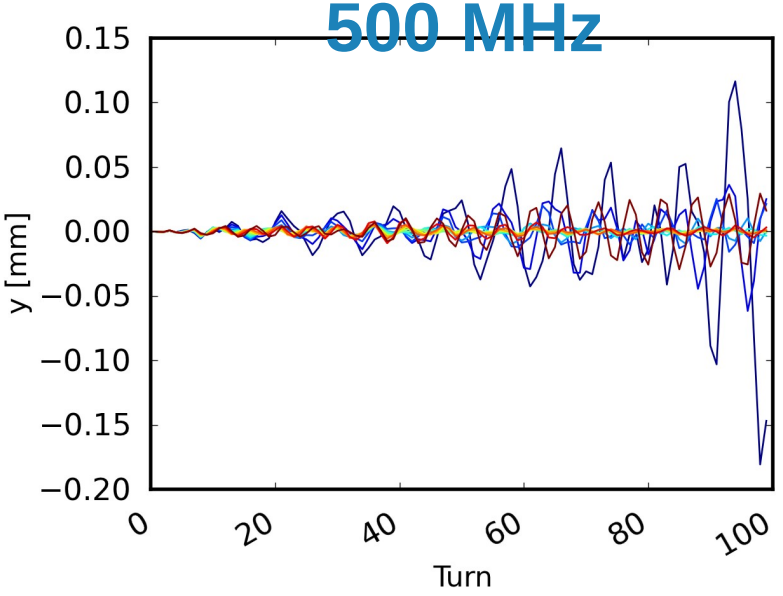
1000 MHz

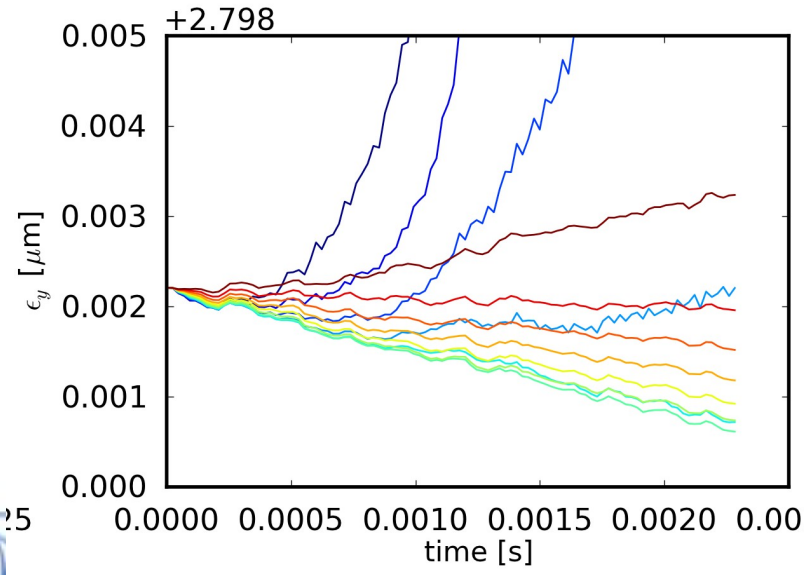




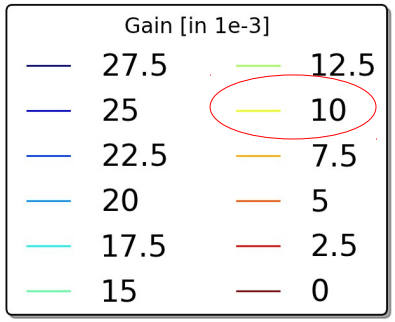
Preliminary tests

500 MHz

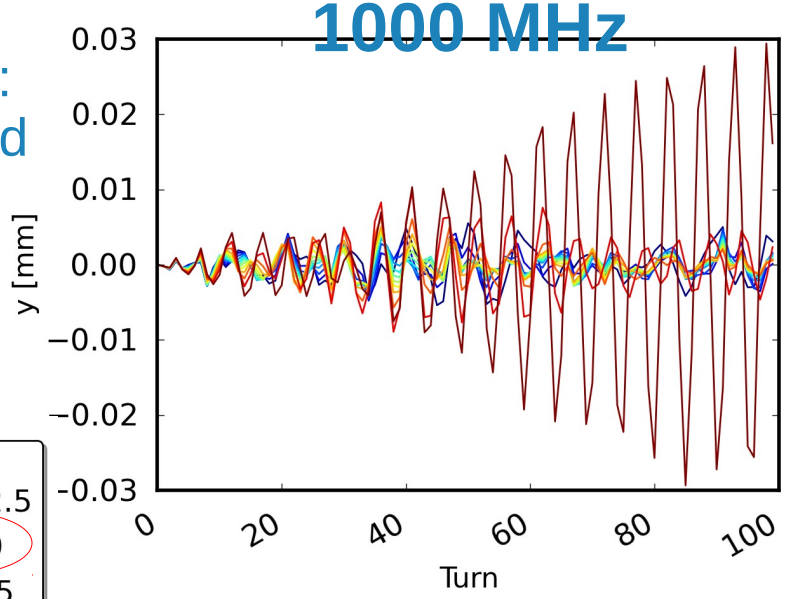


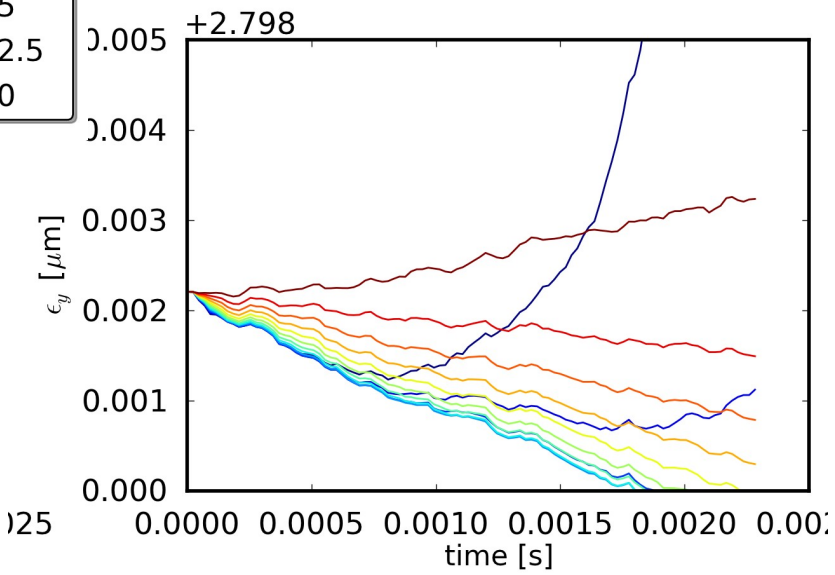


Perturbation:
Electron cloud



1000 MHz

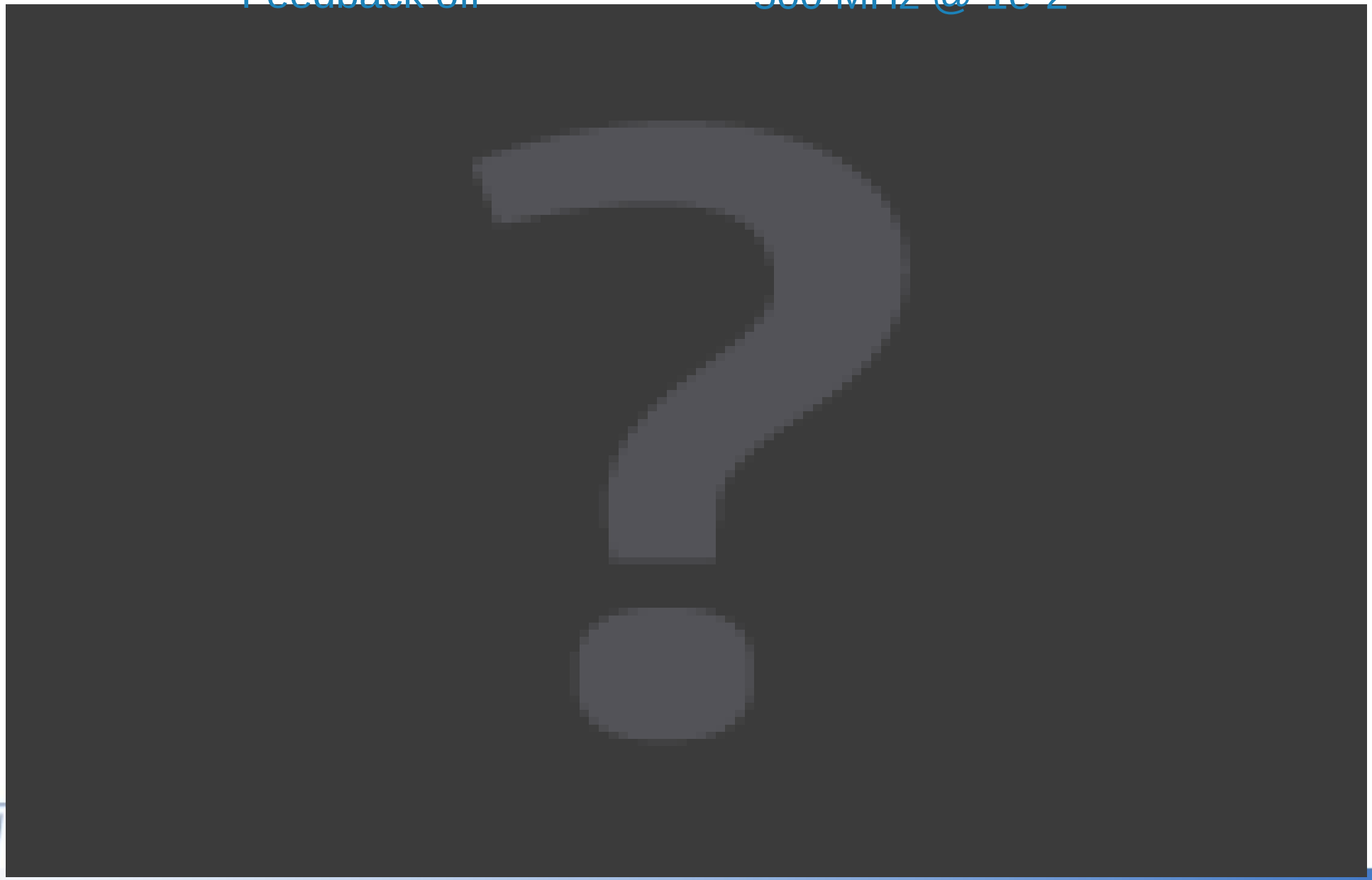




Comparison at 500 MHz

Feedback off

500 MHz @ 1e-2



Conclusion and outlook

- A realistic feedback model has been implemented in available instability codes
- For HeadTail the class design allows easy implementation in both flavours for ECI and TMCI studies
- Benchmarking has begun with analysis tools being evaluated
- Move towards realistic cases and compare with experimental data
- Study TMCI using HeadTail-Impedance with ZBASE to include the full SPS impedance model