

STATUS OF THE LLRF SYSTEM FOR SARAF PROJECT PHASE II

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Introduction

The LLRF channels required in the frame of the SARAF-LINAC [1] contract shall drive rebunchers and accelerating cavities in CW mode only. Requirements for amplitude and phase field control were determined by the beam dynamic study: 1% and 1°. Considering the error during calibration of the system and the other sources of instability during operation (amplifiers, cables, etc.), the requirements for the LLRF regulation are:

- Amplitude stability < 0.1%
- Phase stability < 0.1°

Cavity specification

Frequency: 176 MHz.
2 kinds of copper cavities: 1 RFQ and 3 rebunchers.
2 kinds of SC cavities: Low- and high-beta cavities (0.09 and 0.18).
Max. beam current: 5 mA.

Typical Q_L for SC cavities: 1.10^6 ,
Typical Q_L for rebunchers: 3500.

Disturbance

Helium bath pressure:
Typically ± 5 mbar.
Sensitivity of SC cavities: < 5 Hz/mbar

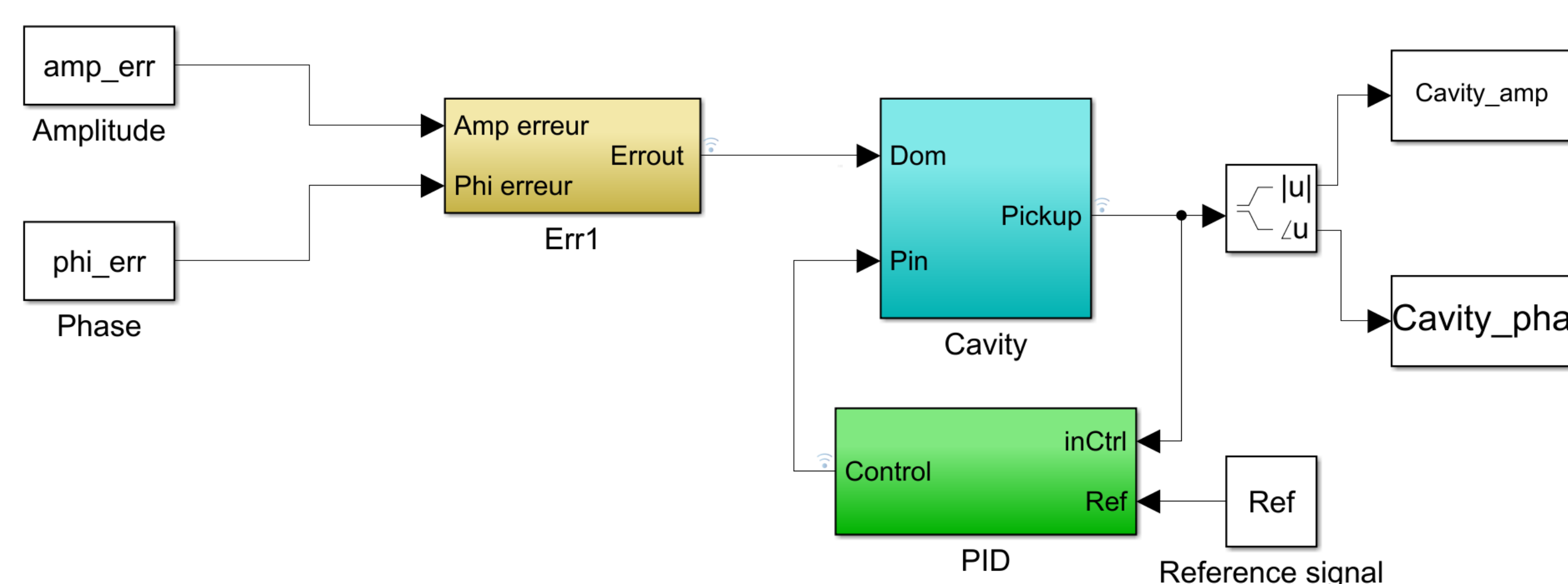
Beam loading:
100% of Eacc, 160° for SC cavities.
11% of Eacc, 90° for rebunchers.

Requirement

Required PID gain for SC cavities: > 140

Modelling

The LLRF was modelled with MATLAB/Simulink [2, 3].



LLRF MATLAB/Simulink model

- [1] N.Pichoff et al., "The SARAF-Linac project 2019 status.", Proc. IPAC'19, Melbourne, Australia, 2019.
- [2] C. Schmidt, "RF System Modeling and Controller Design for the European XFEL", Thesis dissertation, 2010.
- [3] M. Luong and O. Piquet, "RF control system modeling", Report, IP-EUROTRANS, 2017.

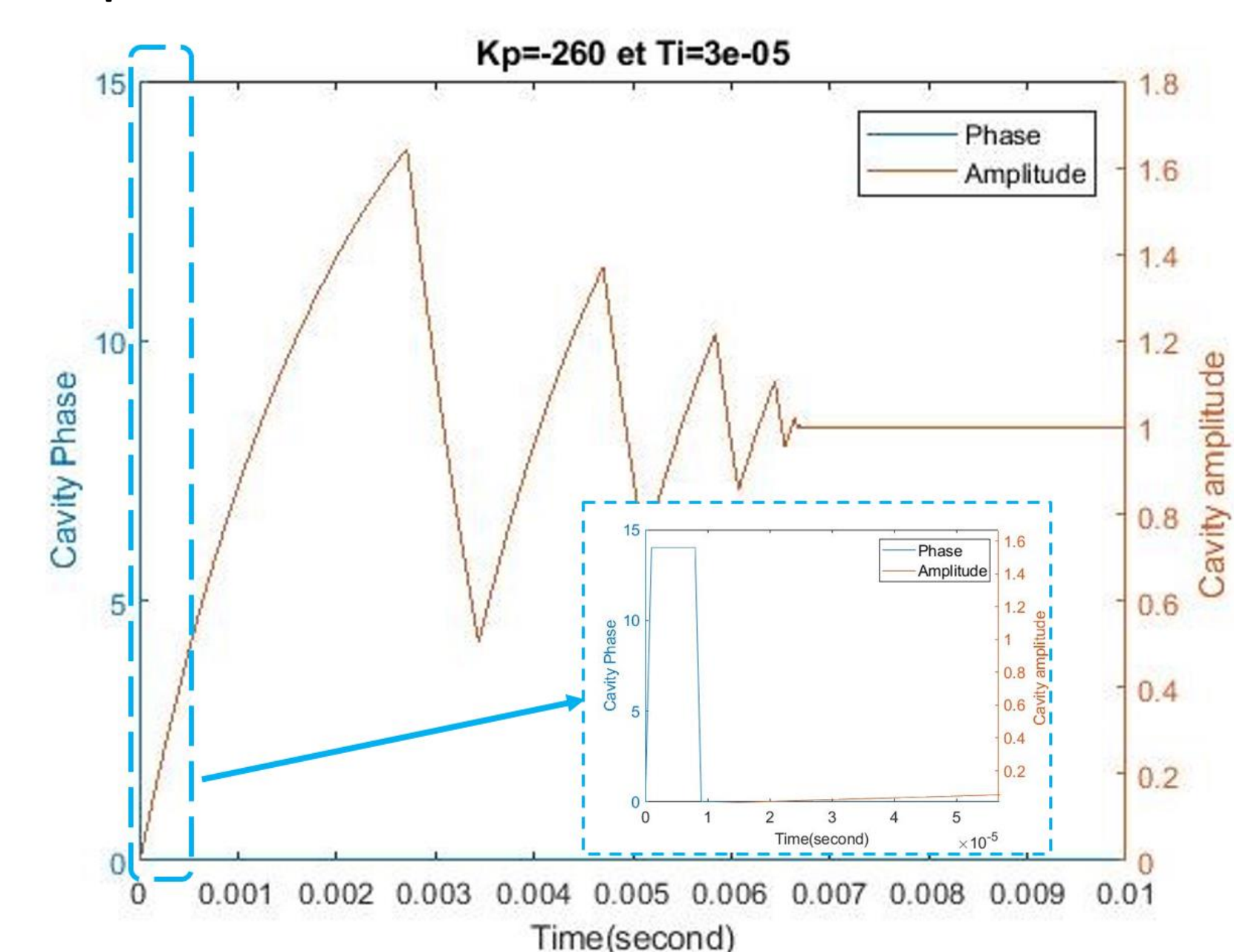
Results

Estimation of the maximal acceptable gain, according to analytical model, for 8 μ s delay:

- for SC cavities: 226,
- for rebunchers: 1.4.

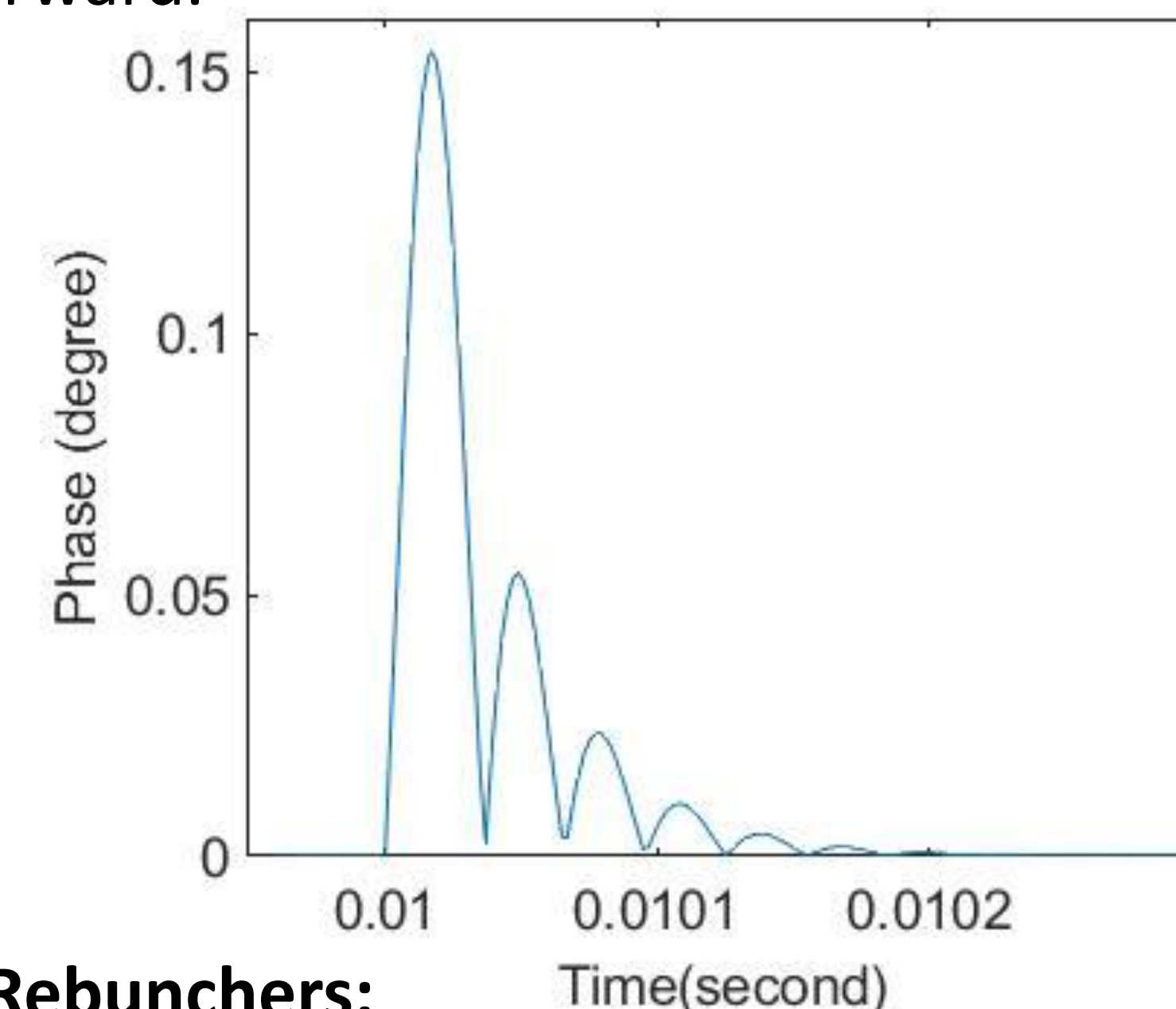
Startup of the SC cavity:

Requires 7 ms, even without feedforward.
Feedforward not required.



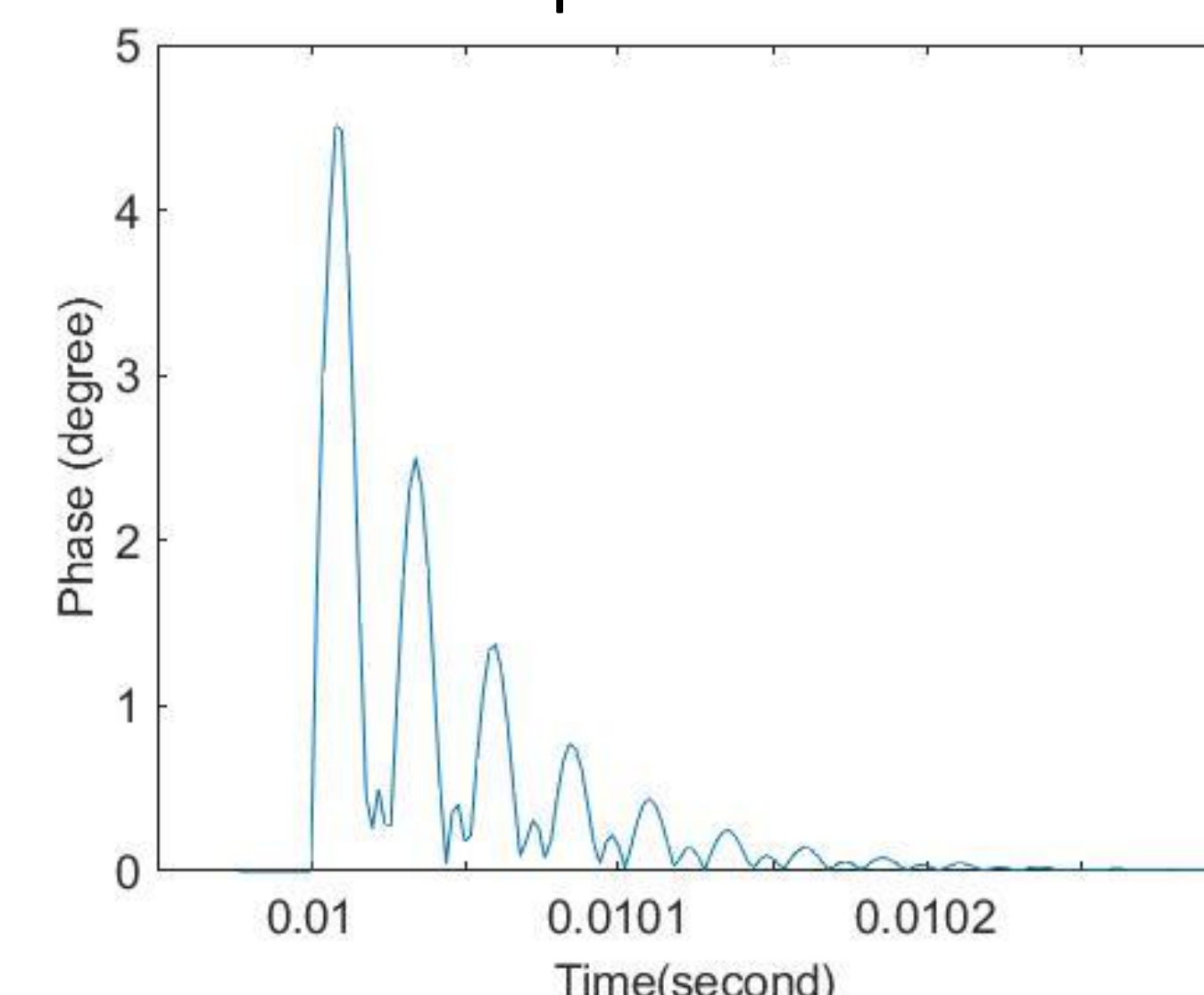
Beam loading/SC cavity:

Exceeds 0.1° deviation during less than 10 μ s. → Acceptable even without feedforward.



Beam loading/Rebunchers:

150 μ s to recover. → Could be acceptable even without feedforward.



Conclusion

The simulated results give us data to configure it and define if feedforward is necessary or not. The public bidding of LLRF system for SARAF project is well passed. The test bench at laboratory is under preparation and the first prototype LLRF system will be ready for test on 2020.