

Measurement of Stability Diagram at IOTA at Fermilab



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Introduction - Stability Diagram Measurement

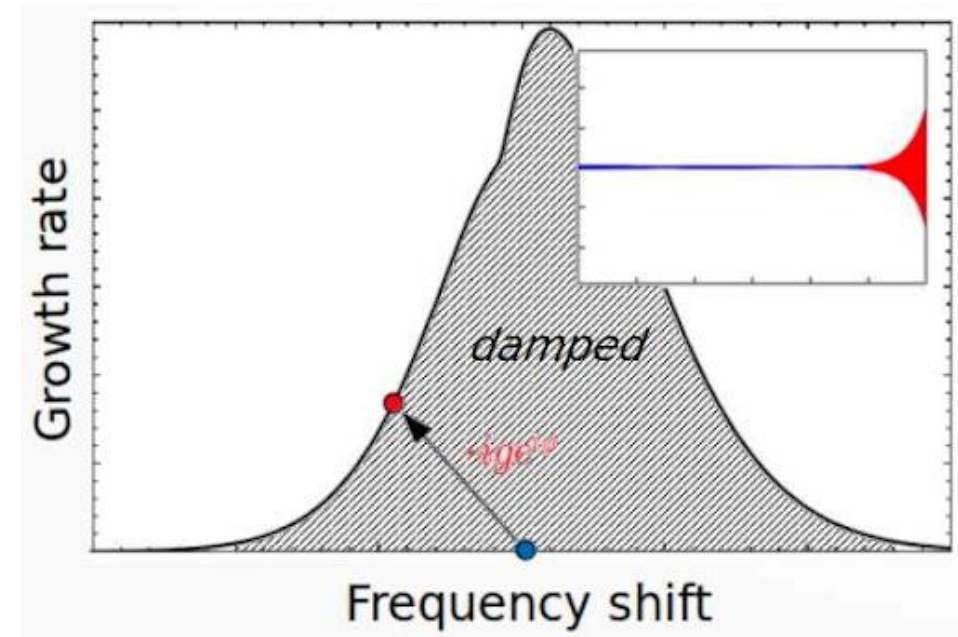
- One can revert polarity of transverse feedback to excite a collective mode, creating an **antidamper**.
- Antidamper supplies constant wake force on the beam, producing a coupling impedance such as (g is gain, ϕ is phase of feedback):

$$Z(\omega) \propto g e^{i\phi} \delta(\omega)$$

- The impedance shifts the frequencies of collective modes by (g is growth rate):

$$\Delta\omega \propto -i g e^{i\phi}$$

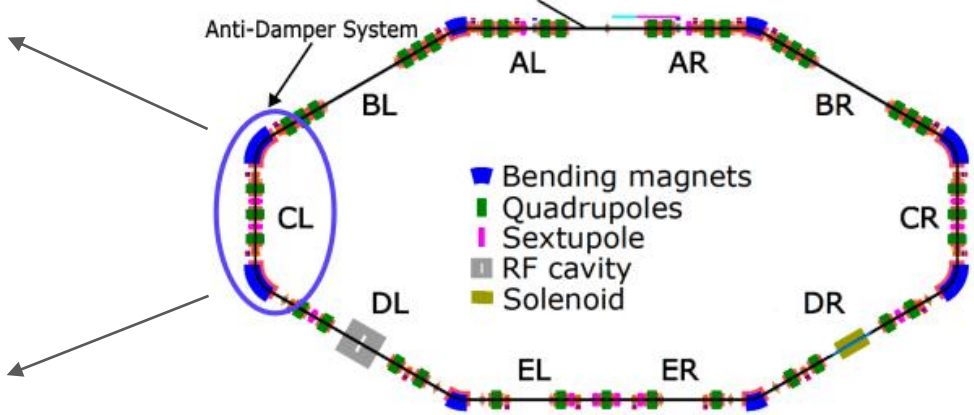
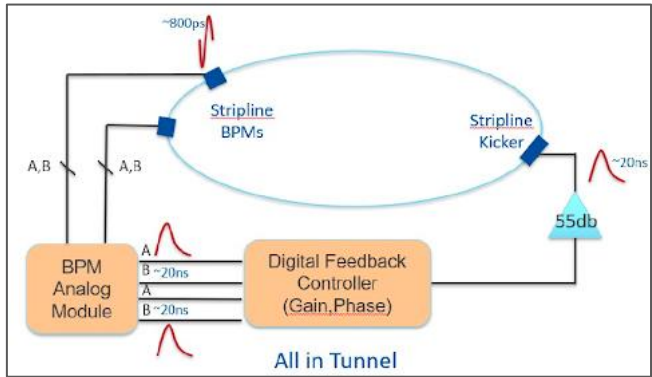
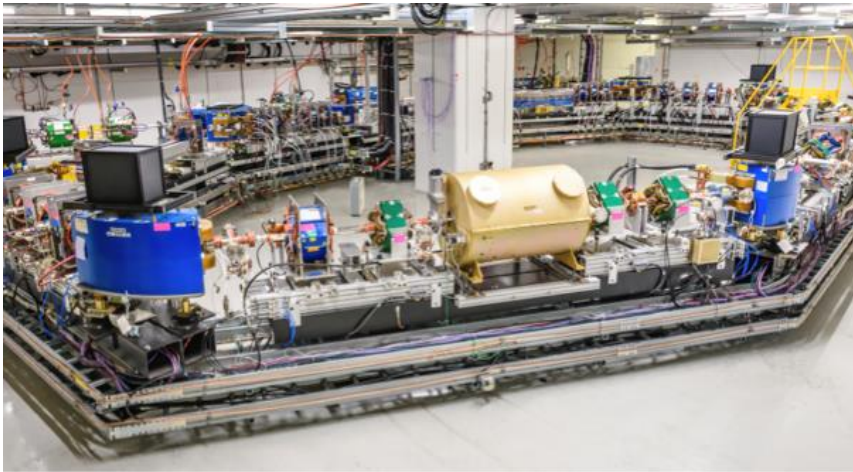
- So independently adjusting the gain and the phase delay, can set the feedback transfer function anywhere in the complex plane, giving a source of controlled impedance.
- Observing at what feedback gain the beam is unstable, one can obtain the **stability diagram**.



I. Fadelli, "A procedure to directly measure the strength of landau damping," Phys. Org, 2021. <https://phys.org/news/>

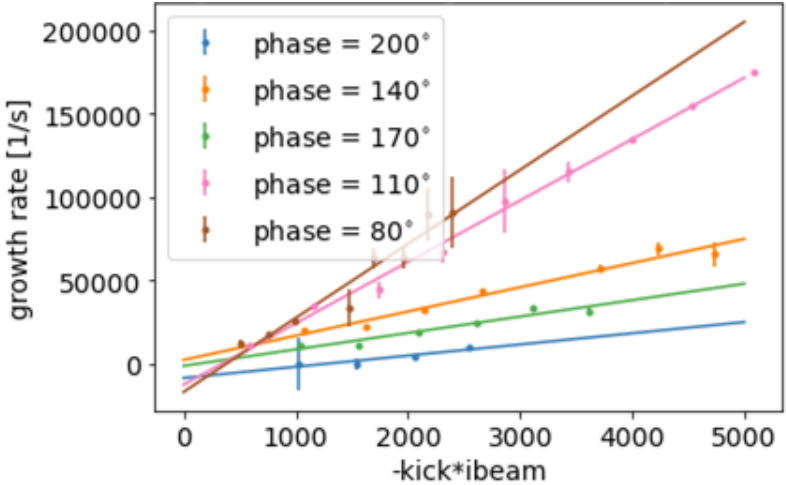
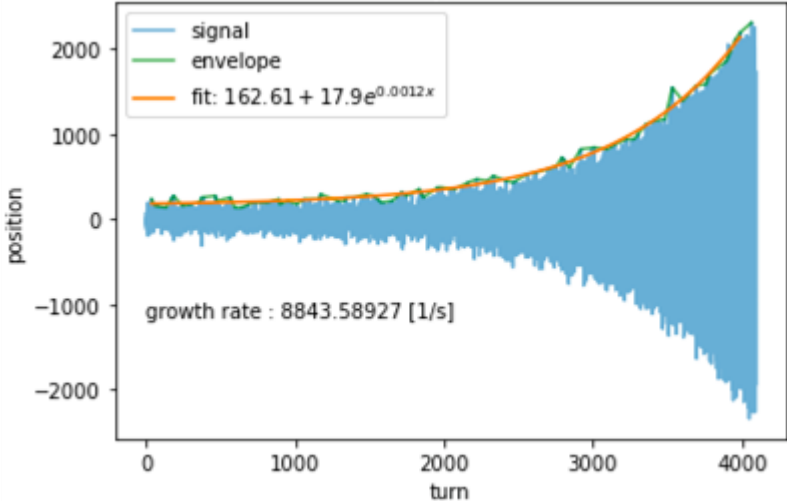
Introduction - Experiment at IOTA at Fermilab

- We are working towards measuring the stability diagram at the Integrable Optics Test Accelerator (IOTA) at Fermilab.
- Beam gets kicked by the kicker. The total phase from the two BPMs is adjusted to supply the phase change.
- The stripline BPMs measure the beam position and are ~ 110 degrees in phase advance apart so that (x, x') can be measured in a single Turn.
- Results from BPMs used to adjust gain/phase until instability is observed.



Current Results

- The first experimental goal was to incite and measure the growth rate of an instability with the anti-damper.
- A sweep through the phases was then performed towards making a stability diagram.
- The growth rates at instability were analyzed as a function of the experimental kick of the beam.
- The linear fits can be extrapolated to get the instability growth rate at an experimental kick threshold.



Next Steps and Acknowledgments

- Data collection began just two weeks ago and is being completed this week, with tight sweeps of phase and gain.
- Will obtain and study stability diagrams for ranges of octupole settings, as well as in both the horizontal and vertical plane.
- Additionally, the results from IOTA will expand upon those from the LHC to investigate the impact of the machine's impedance on the stability diagram.

S. A. Antipov et al., “Proof-of-principle direct measurement of landau damping strength at the large hadron collider with an antidamper,” Phys. Rev. Lett., vol. 126, p. 164 801, 2021.
doi:10.1103/PhysRevLett.126.164801

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Thank you!

Come stop by!

THAFP03