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IOTA Nonlinear Integrable Optics Experiment: Landau Damping

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Run 2b Proposal

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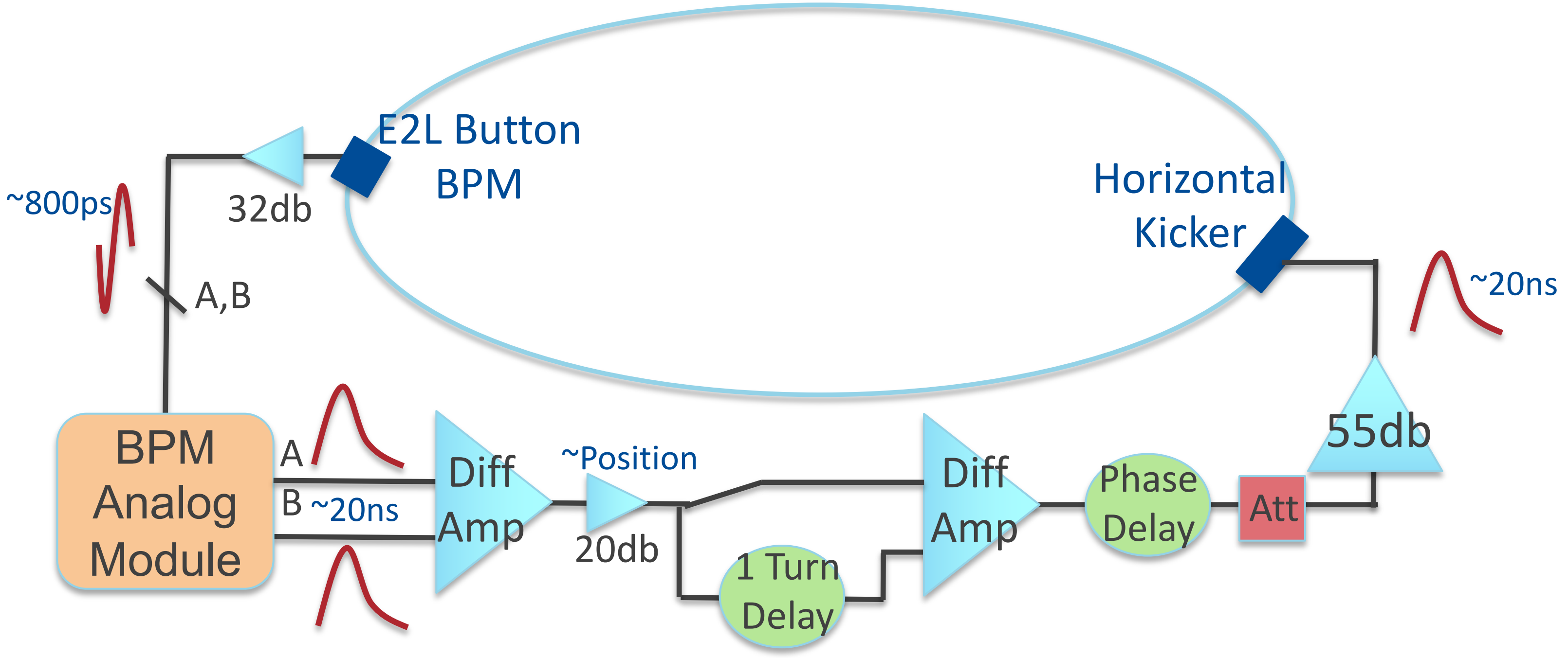
Motivation/Theory

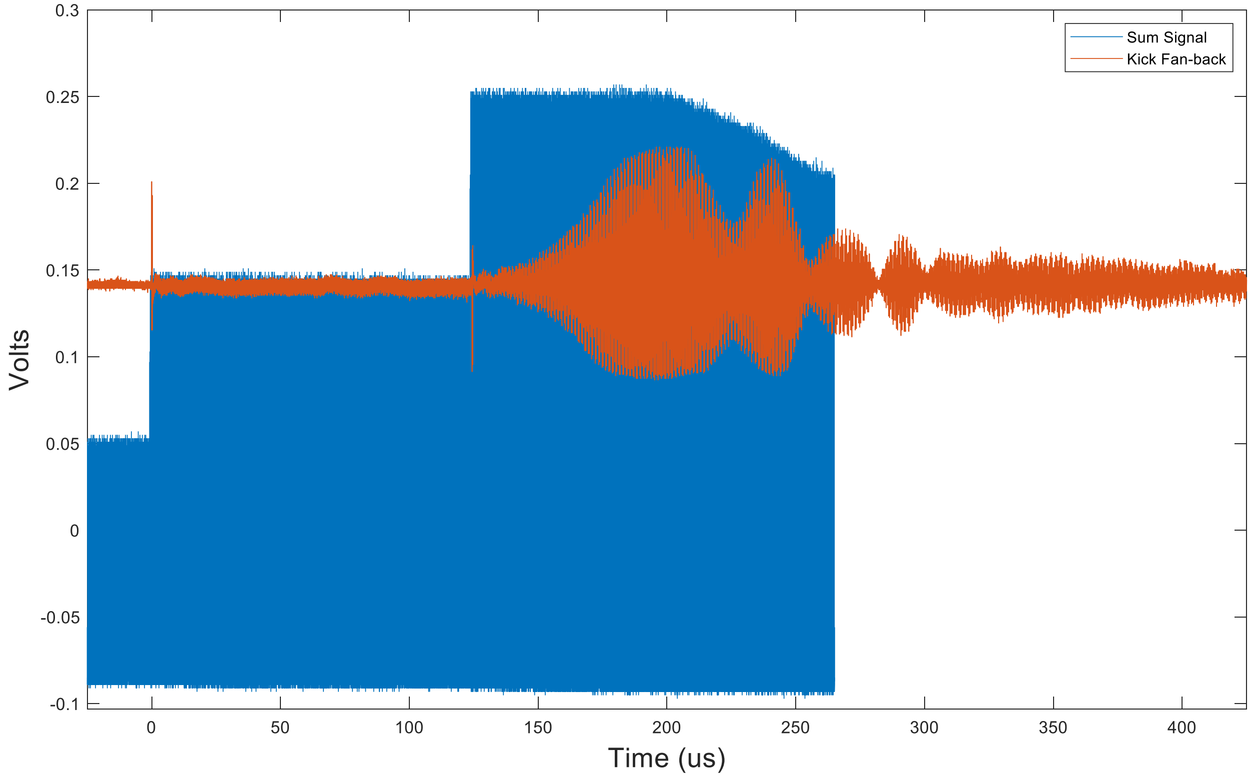
- Landau Damping provides damping mechanism via tune spread
- Octupoles provide a means to increase tune spread and increase the stable region via Landau Damping
- Octupoles introduce strong non-linearities at large amplitudes
  - Reduce dynamic aperture and lifetime
  - Landau damping sensitive to tails of beam
  - Can change chromaticity via feed-down effects

Feedback System Overview



- Use horizontal button electrodes on E2L bpm with 32db RF pre-amplifier on each button
- BPM analog module based upon RF envelope detector conditions fast doublet into longer pulse – provides 32db of programmable gain control
- Implement 1 turn notch filter delay and phase delay with cable
- Use one plate of the horizontal strip-line to kick beam

Inducing Instability – Positive Feedback



- Instability triggered by changing gain in analog module
- Ability to provide relatively controlled instabilities

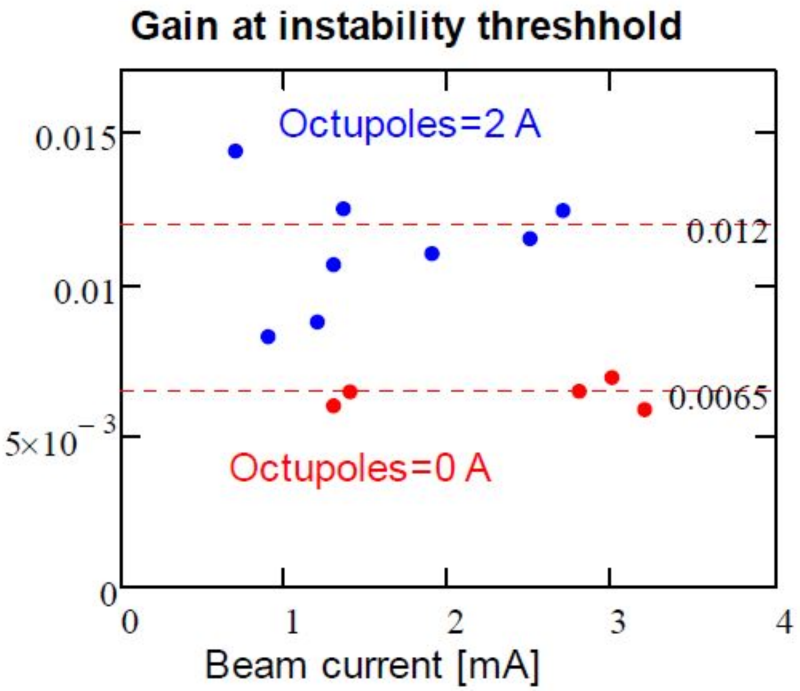
Instability Threshold Study

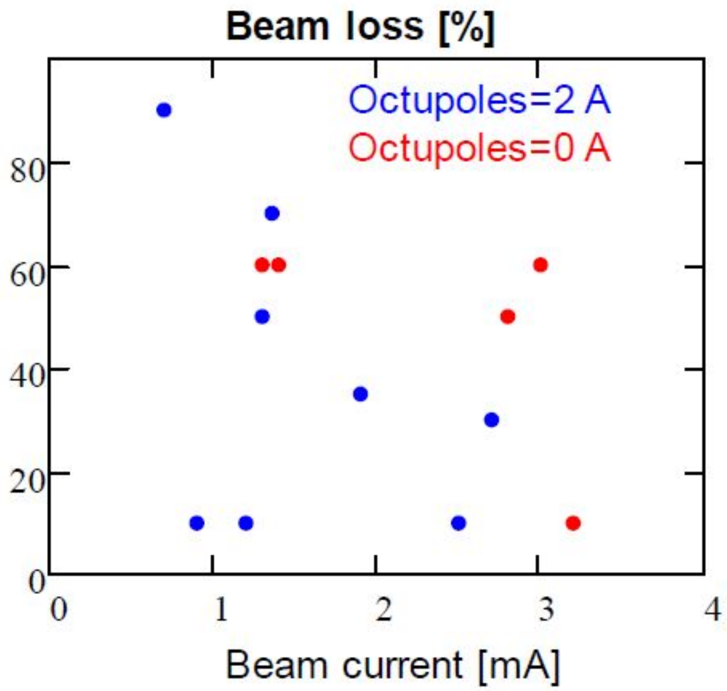
- Study the gain threshold for fast instability as a function of beam current and octupole current
- With nominal emittance (~160-170um), step the feedback gain until a fast instability occurs (>10% beam loss)

$$Gain = Ibeam * 10\text{^}(-\frac{att_{db}}{20})$$

- The analog module attenuators were stepped in 1-2db steps until a fast instability occurred
- After each instability, wait for synchrotron radiation damping to restore beam to nominal emittance

Instability Threshold vs Gain





- See approximately factor of 2 increase in the instability threshold with octupoles at 2A as compared with 0A

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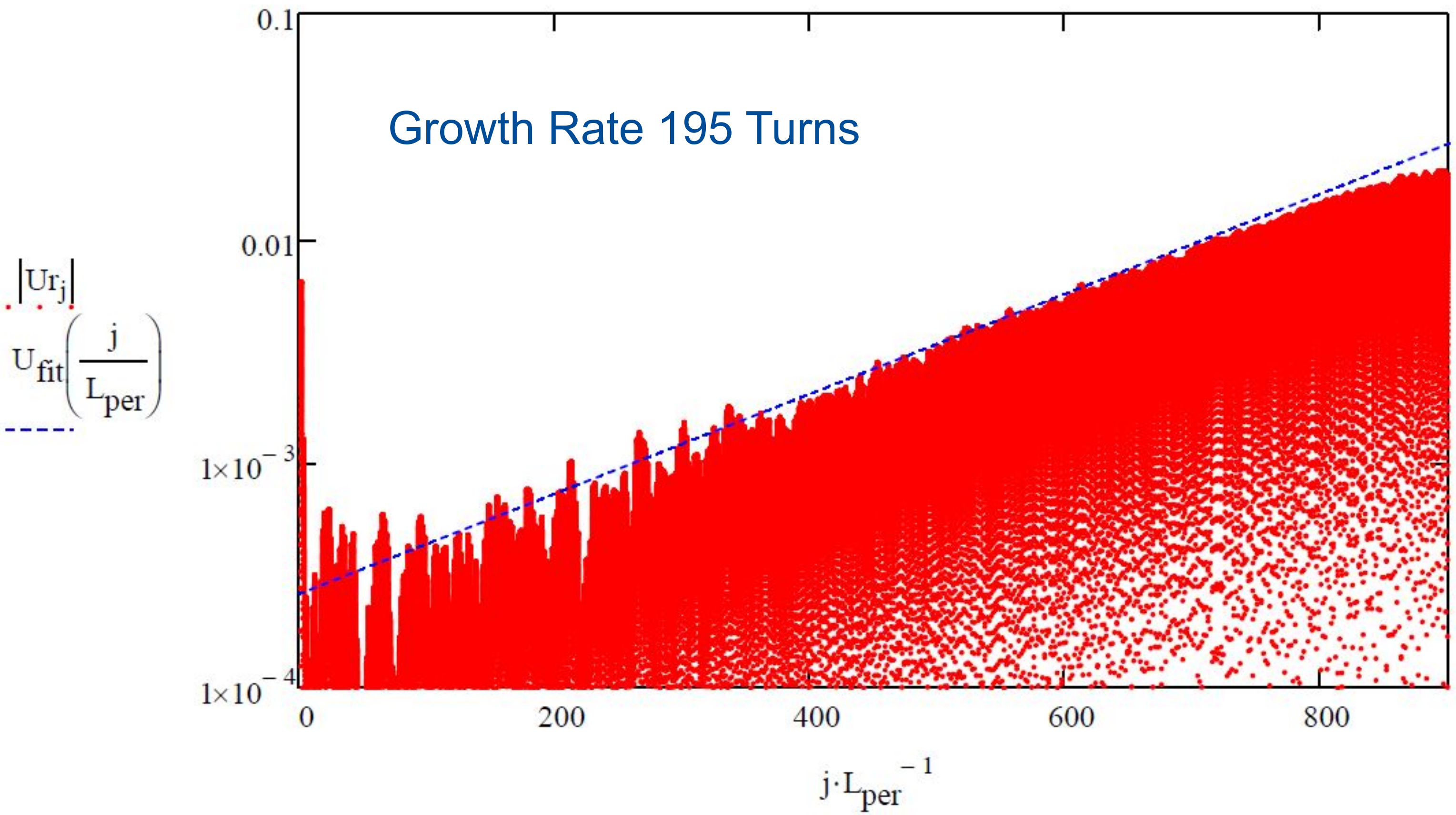
Instability Octupoles 0A – Growth Rate

$n_{inst} := 195$

$U_{fit}(n) := 0.00026 \cdot \exp\left(\frac{n}{n_{inst}}\right)$

$U_b := \frac{1}{Ns} \cdot \left(\sum_j Us_j\right)$

$U_b = 0.141$



Plan for Run 2b

- System improvements
  - Implement damper by simply swapping analog module for E2L
  - Ability to collect BPM turn-by-turn data
  - Matlab acquisition scripts to set gain and collect data (*.mat files)
- Required Personal
  - Myself and optics expert (Valishev or Romanov)
- Participants
  - Lebedev and Burov
- Requirements
  - Beam in IOTA (higher current better)
  - DCCT, Sync Light, BPMs
  - Preferred Longitudinal Damper operational

Plan for Run 2b

- Experimental Data
  - Beam at nominal emittance - wait for beam to cool (~5min) or re-inject
  - Induce instability and collect TBT data
  - Repeat procedure with Octopules powered – vary current
  - Repeat procedure with Non-linear magnet powered - vary strength
- Shift 1 (~4 hours)
  - Commission anti-damper (timing and phase) – 30 min
  - Commission Matlab data acquisition scripts – 30 min
  - Collect experimental data with remaining time – 5 data points at each setting
- Analyze data for quality and anomalies
- Shift 2 (~4 hours)
  - Collect further data based upon analysis