



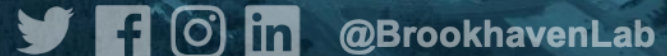
RHIC Accelerator Physics EXperiment (APEX) Program – FY 2024

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# APEX 24-13: Validation of transition crossing with HSR screens

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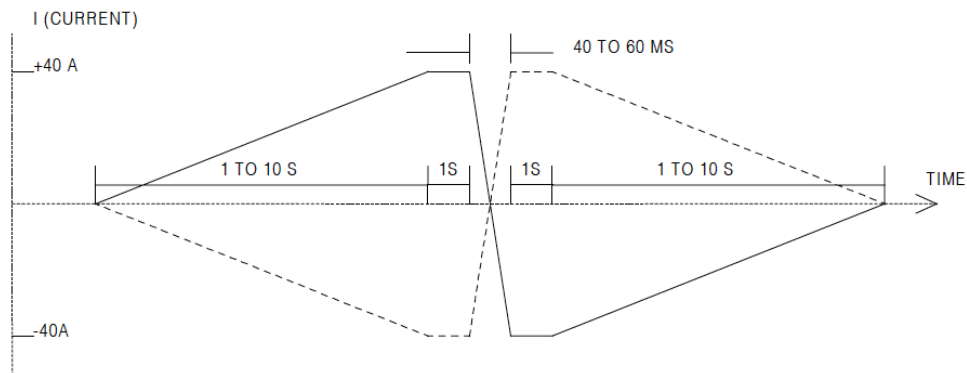
# MOTIVATION

- In a rippling quadrupole field  $K(t) = K \sin \omega t$ , the eddy currents induced in the HSR screens will shield the field in such a way that the field seen by the beam becomes:

$$K(t) = \frac{K}{\sqrt{1 + \omega^2 \tau^2 / 4}} \sin \left[ \omega t - \tan^{-1} \frac{\omega \tau}{2} \right] \quad \text{where } \tau = \frac{1}{2} \mu_0 \sigma_c b d$$

“damp”
“delay”

- At transition energy,  $\gamma = 23$  for gold beams, the RF phase flips and, within 40 ms, the gamma transition jump quad fields flip to ensure beam stability.



POWER SUPPLY OUTPUT CURRENT WAVEFORM

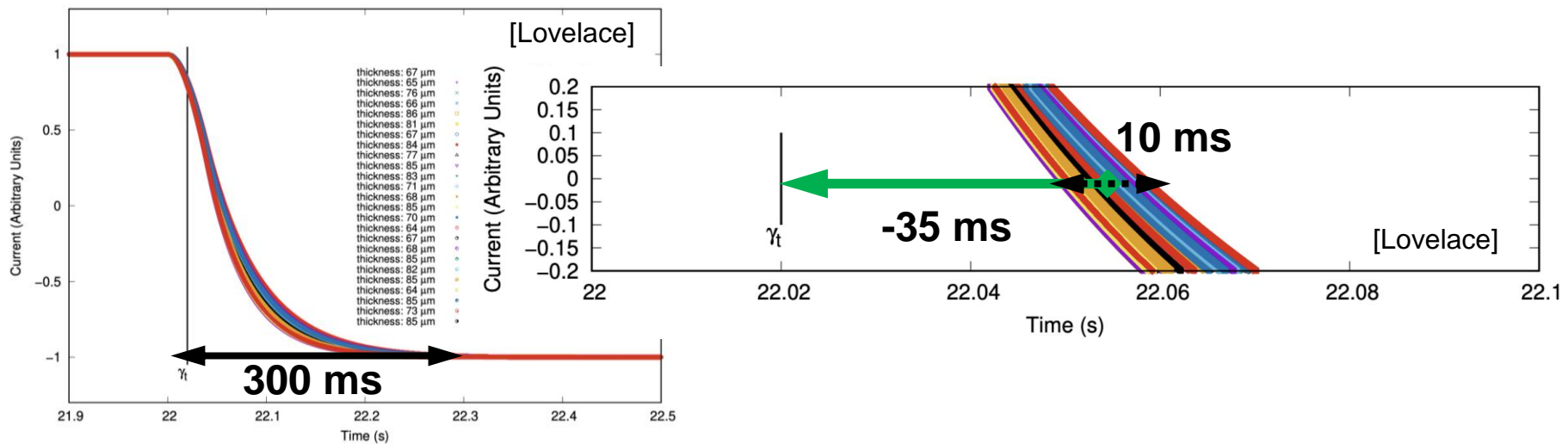
# MOTIVATION

- The expected distribution of copper thickness  $d$  and conductivity  $\sigma_c$  (via RRR) at the HSR screens ( $\sim 15\%$ ) will introduce an spread on the field response at the gamma transition jump quadrupoles.

$$K(t) = \frac{K}{\sqrt{1 + \omega^2 \tau^2 / 4}} \sin \left[ \omega t - \tan^{-1} \frac{\omega \tau}{2} \right]$$

“damp”                      “delay”

where  $\tau = \frac{1}{2} \mu_0 \sigma_c b d$



# MOTIVATION

- RHIC has 48 gamma transition jump quadrupoles per ring. There are two families, “gt” for dispersion change and “qt” for tune adjustment. In RHIC, as for the EIC’s HSR, these quads are powered in sets of 4.

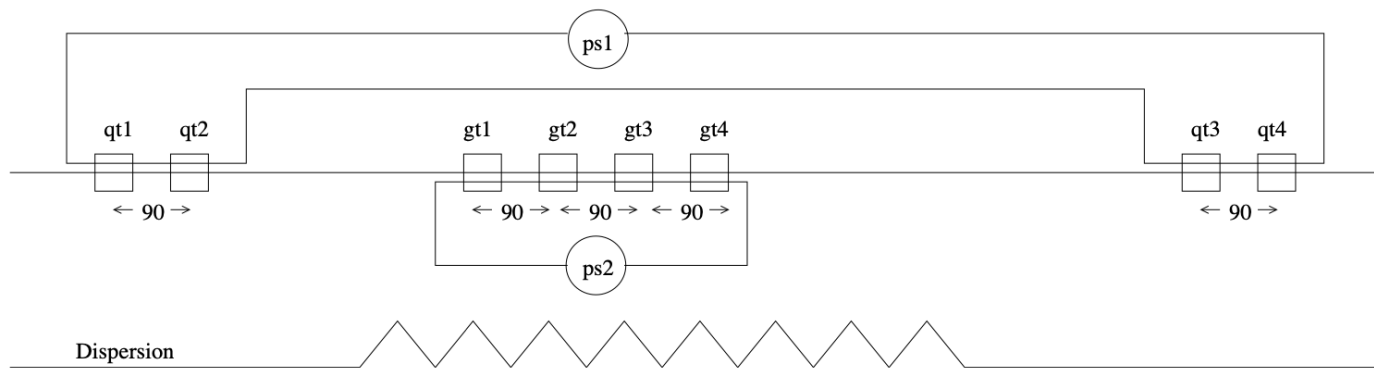
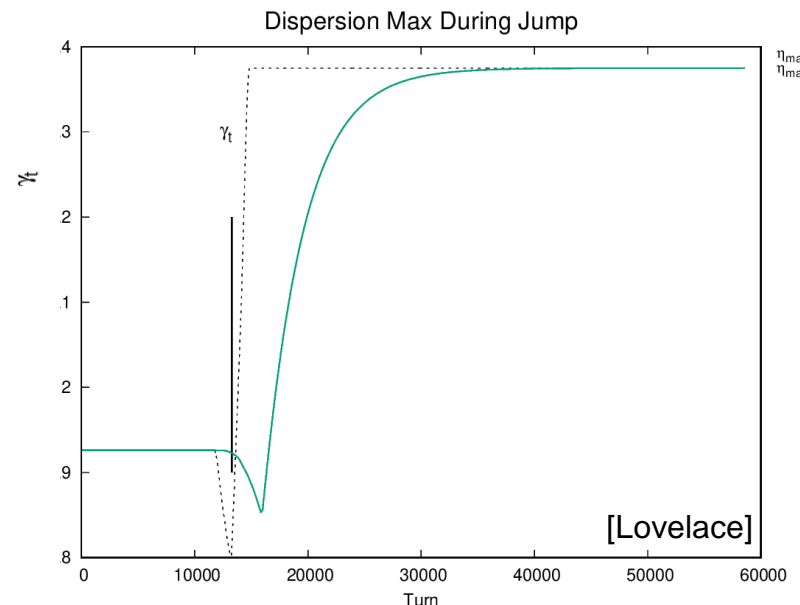
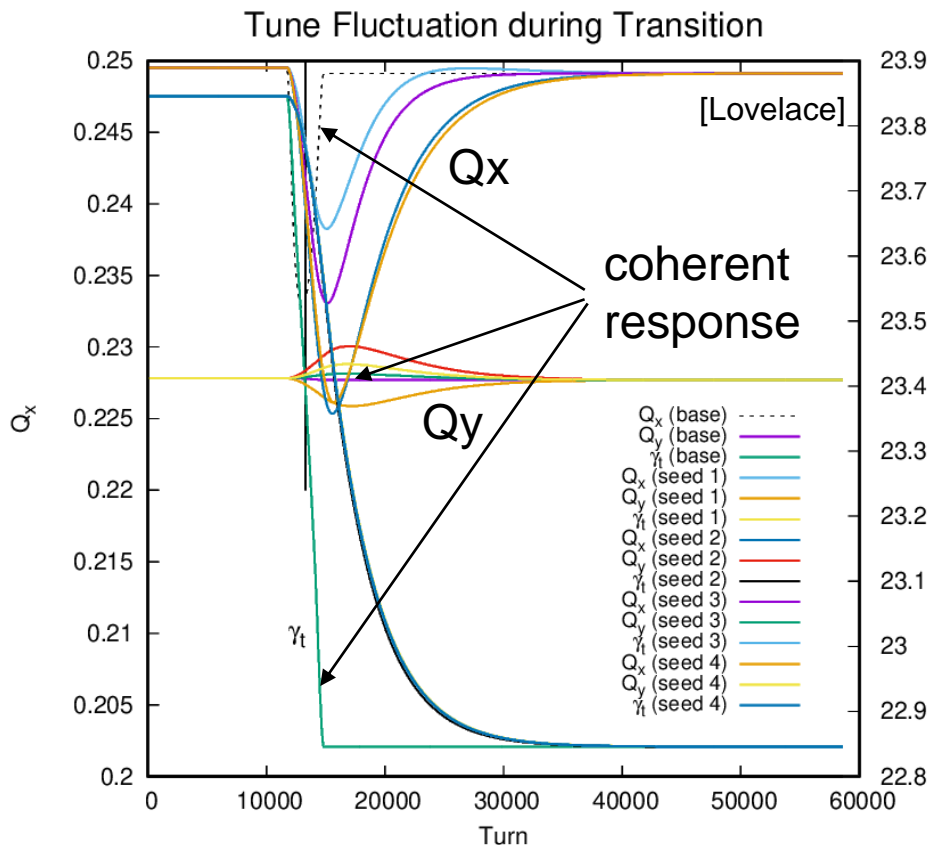


Figure 1: Arrangement of quadrupoles for transition jump

- During HSR operations, the global delay can be corrected by timing the power supplies. The spread within jump quads of the same power supply will remain.

# MOTIVATION

- Transverse dynamics simulations assuming no power supply timing correction have shown that the tune shift resulting from the field response spread (or incoherent response) does not lead to resonance crossing, although the time to return to the design tune is longer.



# APEX STUDY PROPOSAL

- Goal*
- Validate transition crossing with delay introduced by HSR screens to the transition jump quadrupole fields.
  - Transverse beam dynamics studies found no showstoppers. The APEX will also assess impact on longitudinal dynamics.

*Benefits* The study will assess if the current screen design and specs enable transition crossing w/o compromising beam stability.

# APEX STUDY PROPOSAL

## *Procedure*

**Day I – Dry Run** (verify controls script)

**Day II – Study**

- Injection Au beam in Yellow ring with 6 or 12 nominal bunches  
(Transition crossing is bunch-intensity sensitive)  
(Yellow ring will become the EIC's HSR)
- Flip jump quads polarity within 20 ms w.r.t. transition energy, while RF phase flip is done synchronously with transition energy.
- Repeat for different jump quad combinations and delay values.  
(Controls will define parameter to set delay value.)

### Caveats:

- In RHIC, one power supply powers a set of 4 jump quads, so delay is adjusted from set to set. With HSR screens, instead, each quad in a set delivers a different delay.
- Quadrupole field changes momentum compaction which defines transition energy

## *Resources*

Inst.: BPM; BLM; DCCT, WCM; BBQ; IPM

Apps: Standard plus script to delay jump quad power supply timing  
w.r.t. transition energy.

Time: 8 hours

Team: Guillaume Robert-Demolaize, Henry Lovelace III, John Morris,  
Freddy Severino, Mike Blaskiewicz, Silvia Verdu-Andres,+ MCR crew

## *Hazards*

None, no intentional beam loss

# APEX STUDY PROPOSAL

*Data analysis* Online and offline

*Results* Report in APEX weekly meeting and the EIC Design Report.