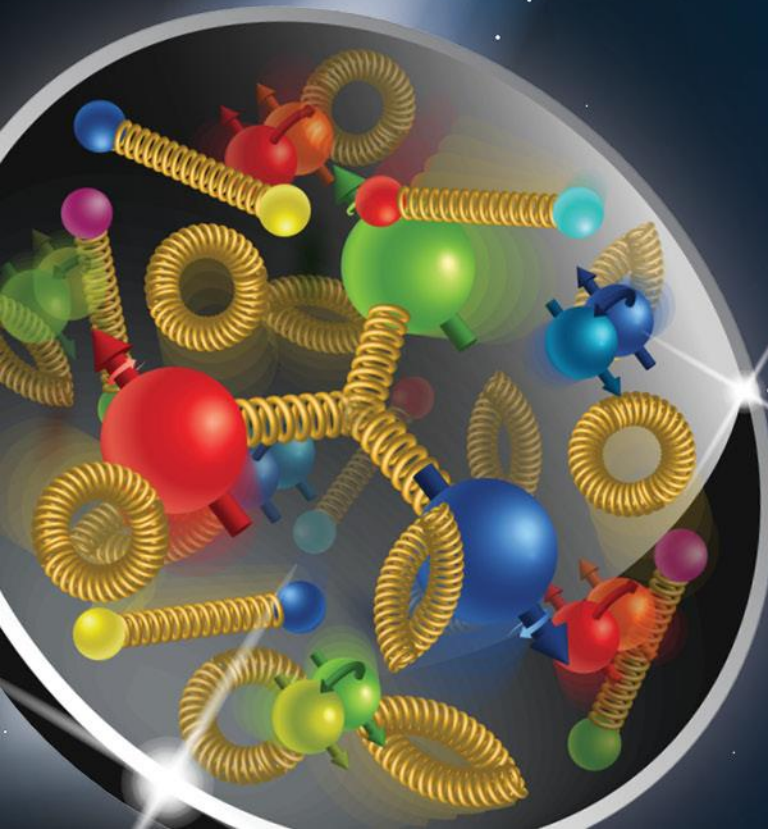


# Instability during debunch

Michael Blaskiewicz

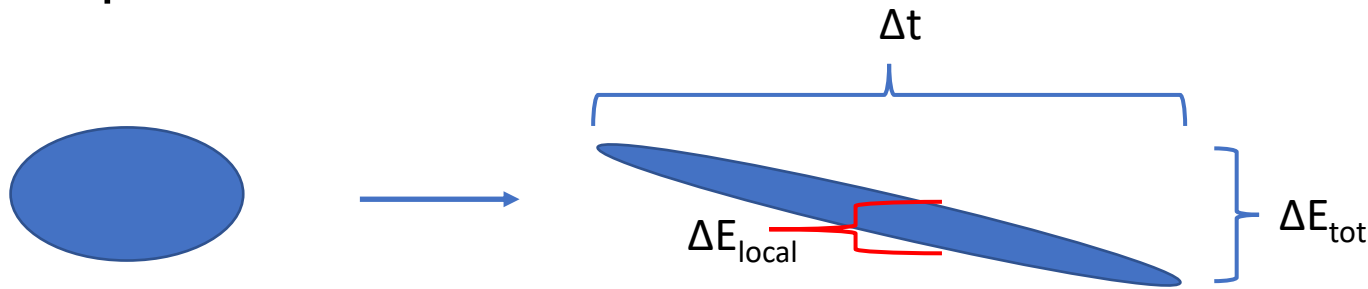
February 26, 2024



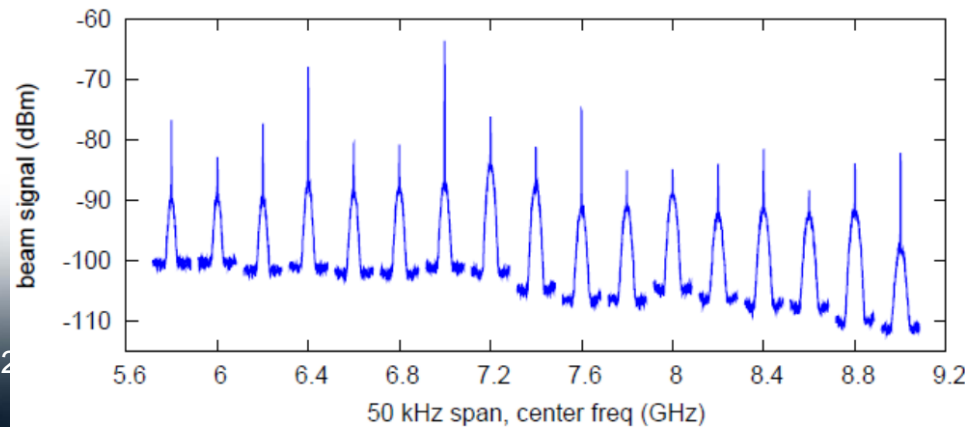
Electron-Ion Collider

# Basic idea

- Suppose you have a single bunch in the accelerator and turn the RF quickly to zero.
- As the beam debunches the local energy spread drops.



- Microwave stability scales as  $Z I_{\text{peak}} / \sigma_E^2 < K$
- The growth rate depends on  $Z$  and is calculable assuming a known momentum distribution.
- The longitudinal pickup is well understood.
- Cable attenuation will be measured.



# Growth rates

Coasting beam instabilities

$$I(\theta, t) = I_0 + I_1 \exp[in(\theta - \omega_0 t) - i\Omega t]$$

For a normalized frequency distribution  $\rho(\omega)$

$$1 = i \frac{2\pi\eta I_0 Z_{\parallel}(n\omega_0)}{T_0^2 E_T / q} \int_{-\infty}^{\infty} \frac{d\omega}{n(\omega - \omega_0) - \Omega - i\varepsilon} \frac{d\rho}{d\omega}$$

For a rectangular distribution of half width  $\Delta$

$$\Omega^2 = (n\Delta)^2 + in \frac{2\pi\eta I_0 Z_{\parallel}(n\omega_0)}{T_0^2 E_T / q}, \quad Z_{sc} = in \frac{Z_0}{\gamma^2} \ln\left(\frac{b}{1.5\sigma}\right)$$

Above transition  $\eta > 0$  so space charge drives instabilities.

It will be a challenge to disentangle a useful signal.

Doing the experiment at injection and at high energy will help.

# Experimental Plan

- title: broad band impedance measurement
- spokesperson: Mike Blaskiewicz
- Team: Mike, Kevin Mernick, Alexei Blednykh, MCR
- goal: measure broad band longitudinal impedance
- benefits: helpful for EIC planning
- description:
  - Inject a single proton bunch into 9 MHz. 197 is off and cavity damper is inserted.
  - Reduce voltage until bunch length is maximum.
  - Snap off voltage
  - Take turn by turn data with longitudinal Schottky pickup.
  - Take turn by turn WCM data at same time for instantaneous current and  $dp/p$
  - After doing injection measurements we ramp to top energy and repeat, this will greatly reduce the effects of space charge.
- Hazards: no hazards
- resources: fast scope, various pickups
- applications: wall current monitor, rf ramps, specialized code from Kevin
- time: 2 , 4 hour blocks. One if all is good the first time.
- personnel: MCR, Mike, Kevin Mernick, Alexei Blednykh
- Analysis
  - Mike/Alexei will do calculations and present. Write a tech note if warranted.