Beam Dynamics/Diagnostics

- Observation and simulation of a fourth-order resonance with space charge – G. Franchetti
- Tune-based Halo Diagnostics – P. Cameron
- Optical Stochastic Cooling of Halo – V. Yakimenko
- AC Dipole – M. Bai

"…fourth-order resonance…" Franchetti

Measurements at the CERN–PS

(October, 15–18, 2002)

excite the resonance 4 Qx = 25 by using a single octupole

working point range: qx = 6.23 – 6.28, qy = 6.08 – 6.4

octupole strength: $K_3 = 1.215\ I\ (m^{-3})$ I = 0 ~ 400 A

momentum spread $dp/p_0 = 2.6\ 10^{-3}$

beam emittances (2σ unnormalized): ex = 9 mm mrad
ey = 4.5 mm mrad

bunch length: 200 ns

beam energy: 1.4 GeV

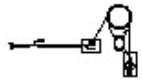
flat–top: of 1.2 seconds

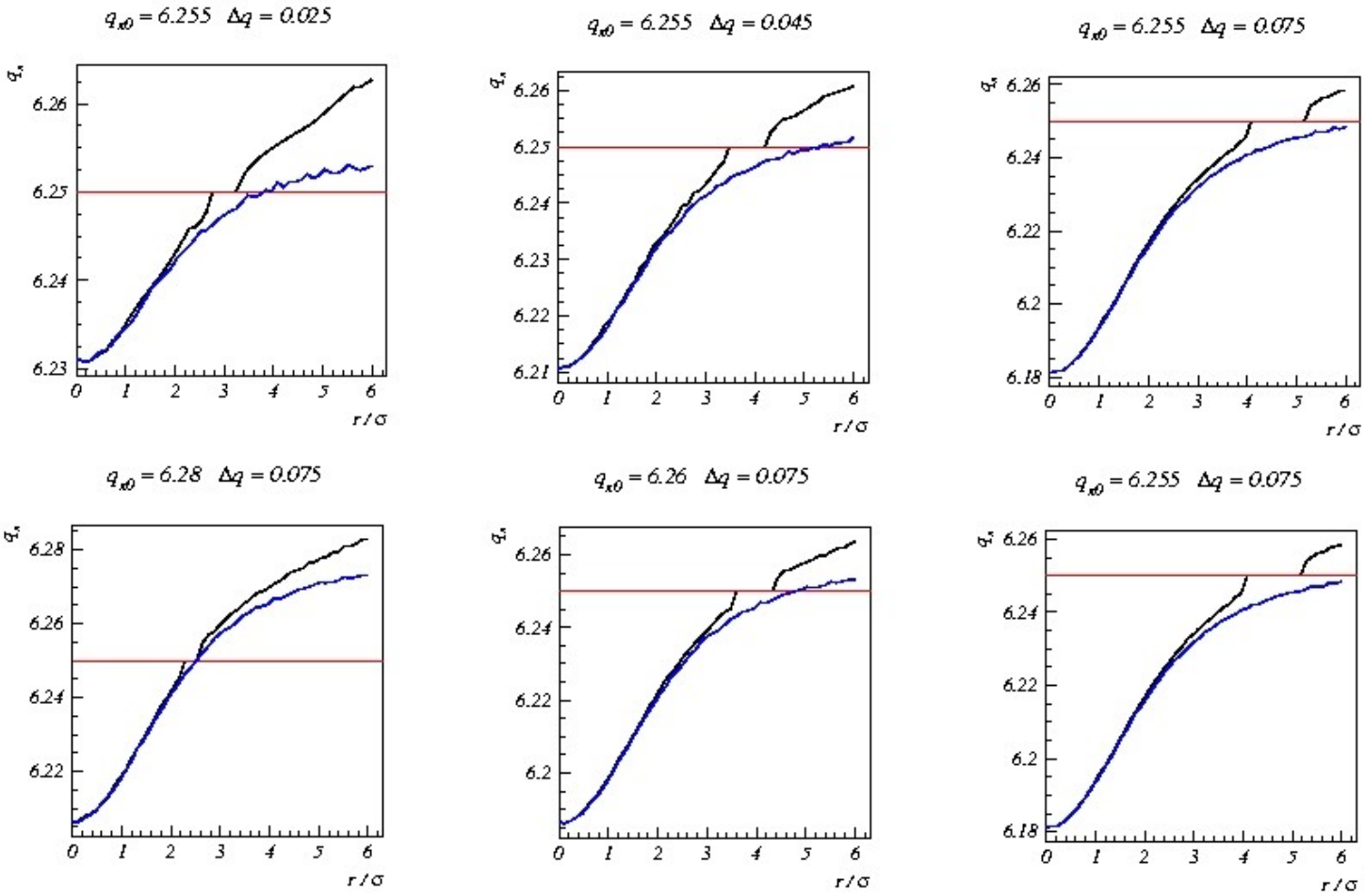
Emittance measurements: flying wire (< 1ms)

"…fourth-order resonance…" Franchetti

HALO'03

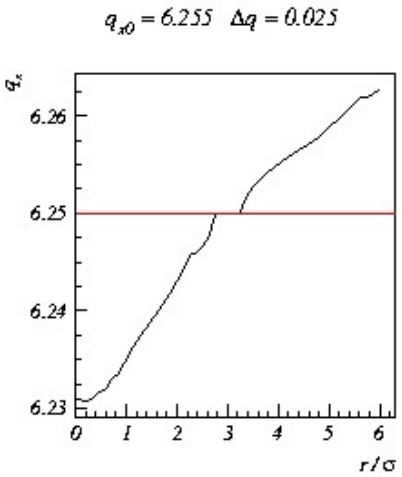
GSI

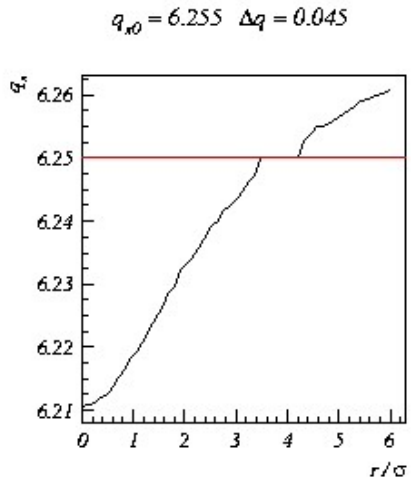


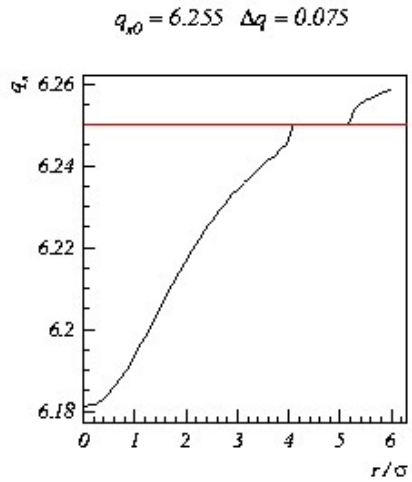


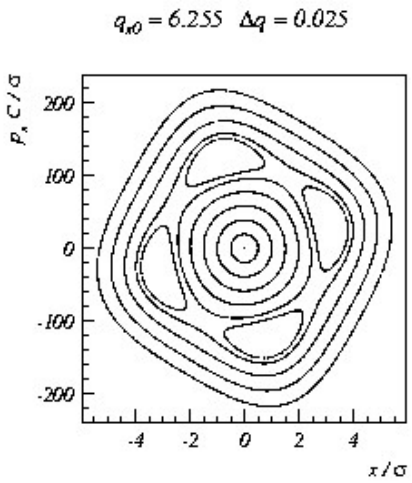
G.Franchetti

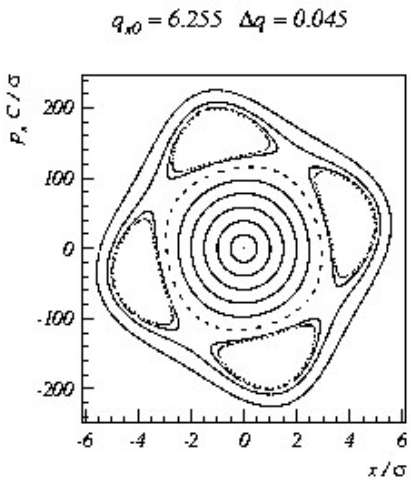
"…fourth-order resonance…" Franchetti

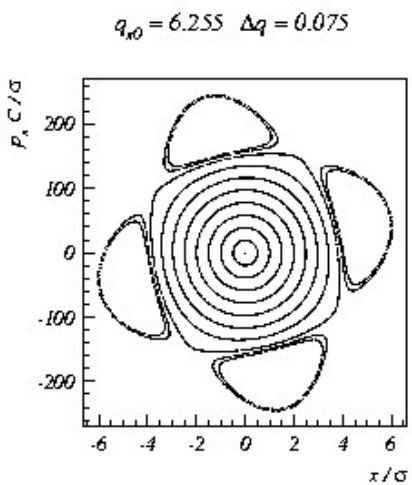












G.Franchetti

Kinds of Tune-based Tools

- Tools to **Diagnose** Halo-forming conditions

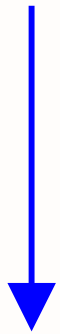
  Tools to **Avoid** Halo formation
- Tools to **Diagnose** existing Halo
  - can we see Halo with tune measurements?
  - what are the signatures?
- Tools to **Remove** Halo
  - Gap cleaning
  - Halo cooling
  - ???

'Applicable' Mechanisms

Tune related halo formation mechanisms

- **Mismatch**
- Resonances
- e-cloud effects
- Instabilities
- Beam-beam
- Tune modulation

fast



slow

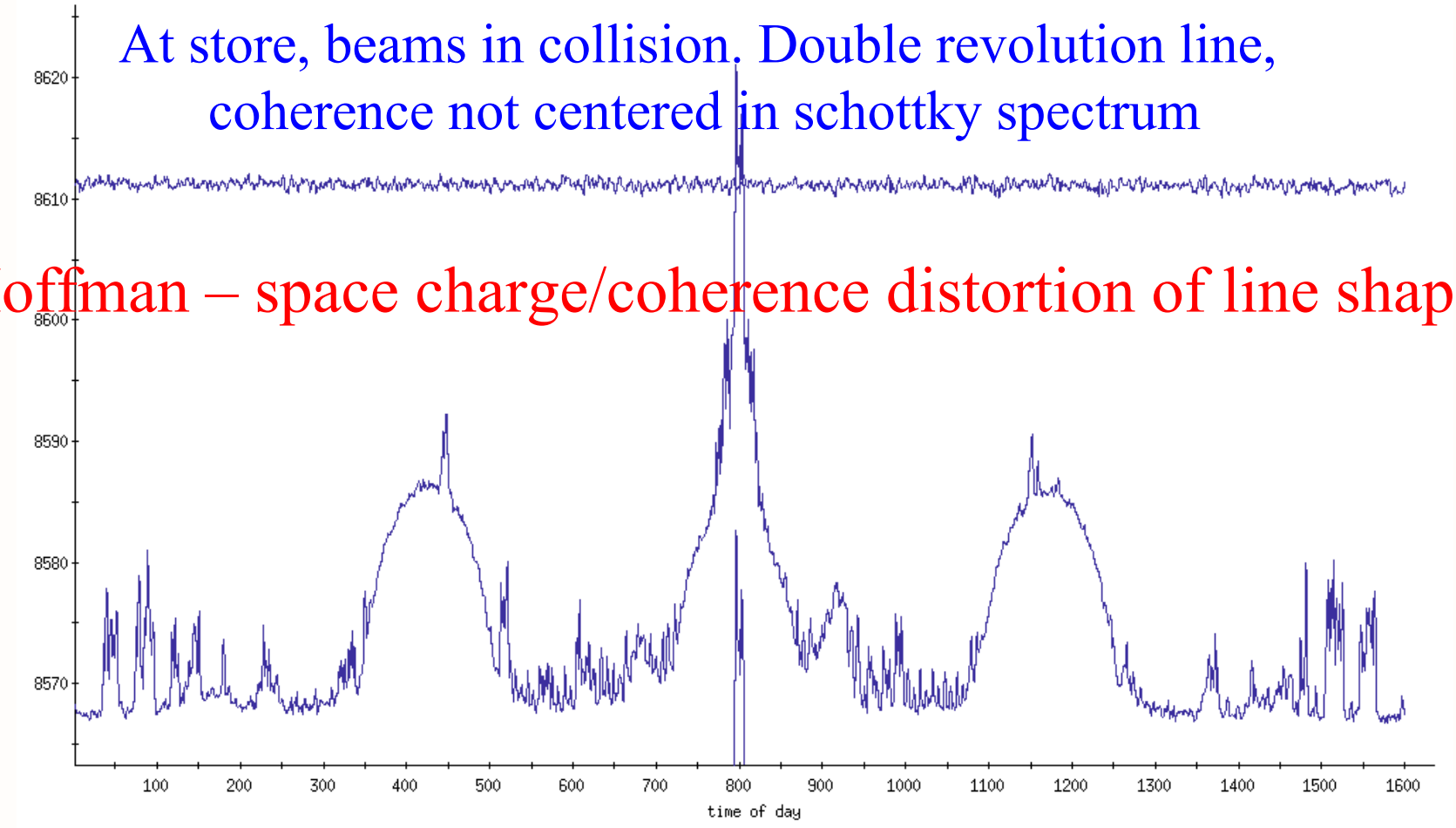
Resonances

What drives beam onto Resonances?

- **Tune**
- **Space Charge**
- Chromaticity (tune spread)
- Non-linearities
- Coupling
- ???

Islands

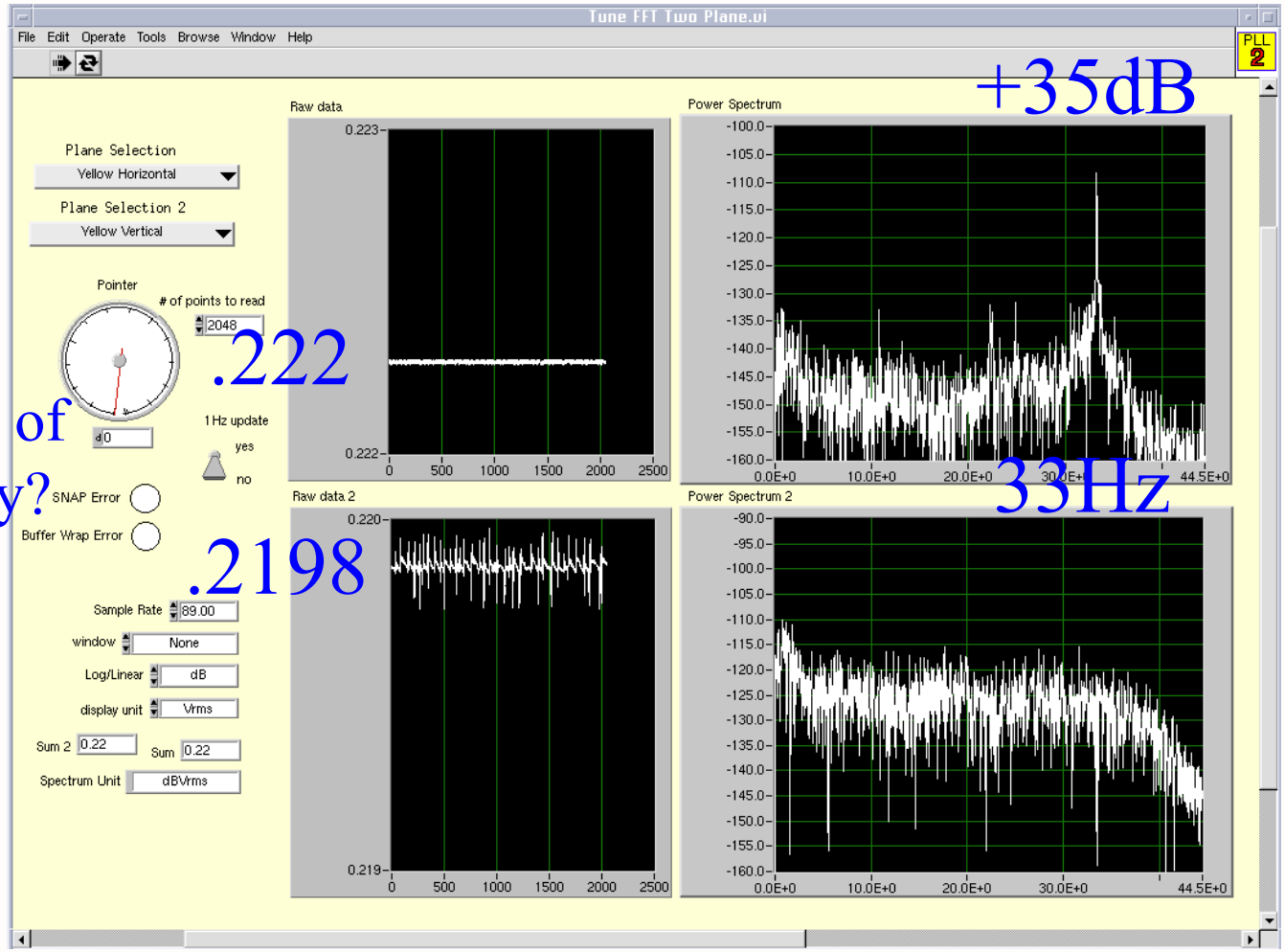
Schottky Coherence



Island at 2/9 in RHIC?

Kickers off

Position dependence of excitation frequency? resonance compensation?



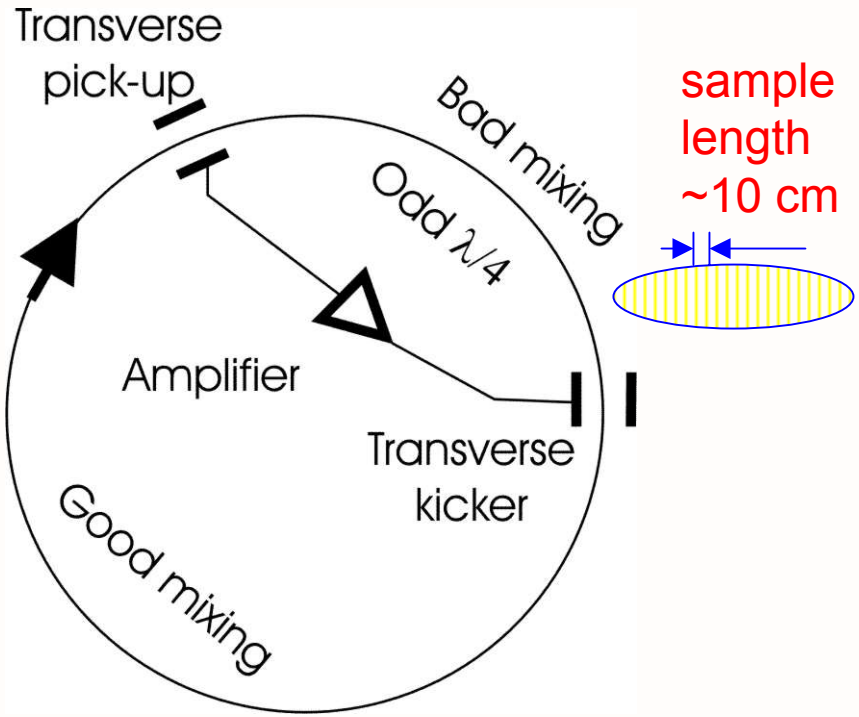
Basic idea

Stochastic Cooling

$$n_d^{ideal} \approx 2N_s \qquad N_s = \frac{\lambda}{3\Gamma}\frac{N_i}{\sigma_l}$$

In practice $n_d = 20 n_d^{ideal}$

λ~ 5 cm => bandwidth limited cooling time τ~10 hrs.

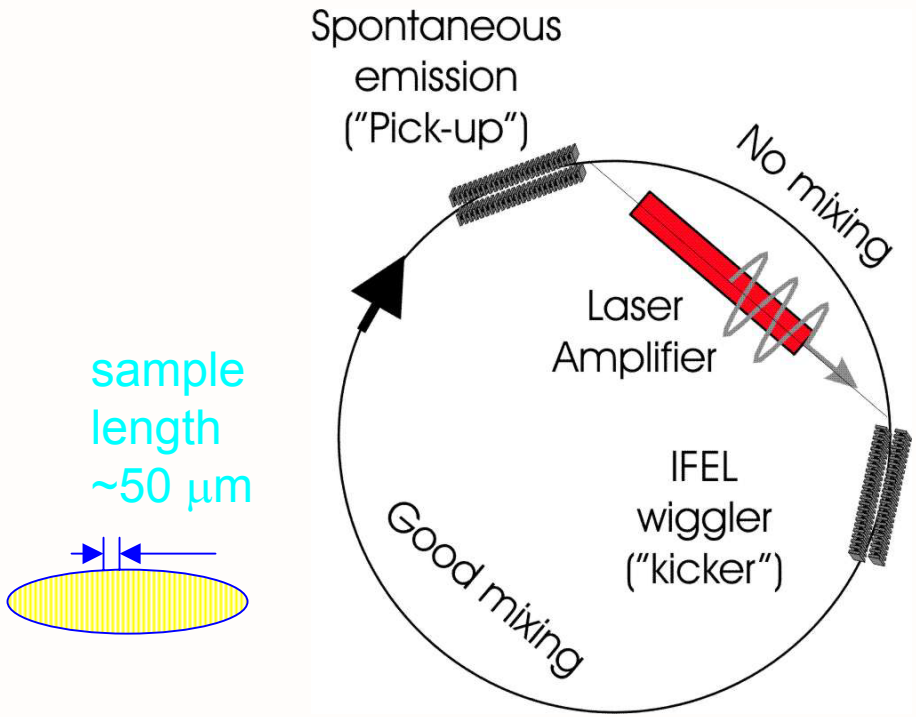


Optical Stochastic Cooling

$$n_d \approx 2eN_s$$

In practice time is amplifier limited

λ~ 12 μm => power limited cooling time τ~1 hr with 16 W; bandwidth limited **τ~9 sec!**



Halo Cooling Conclusions

- Optical parametric amplifiers with wide bandwidth operating in the infrared region (10-20 μm) open up possibility of cooling heavy ions at RHIC.
- For one hour cooling time at RHIC this requires 16 W of amplifier power
- Cooling can be applied to the tails by adjusting timing of the pump laser. Cooling time would be seconds due to small number of ions in the sample
- Optical manipulations of beams is an emerging technology which will keep progressing along with the laser and accelerator technology

"AC Dipole" – M. Bai

- Developed as a tool for spin manipulation
- Adiabatic excitation (and de-excitation) permits large amplitude coherent oscillations without emittance growth
- Uses include:
  - spin flipper
  - lattice measurements (beta fcns,…)
  - coupling
  - gap cleaning (longitudinal halo)
  - amplitude dependent tune shift, machine impedance
  - transverse halo measurements?

Coherent oscillation excited by the RHIC ac dipole