

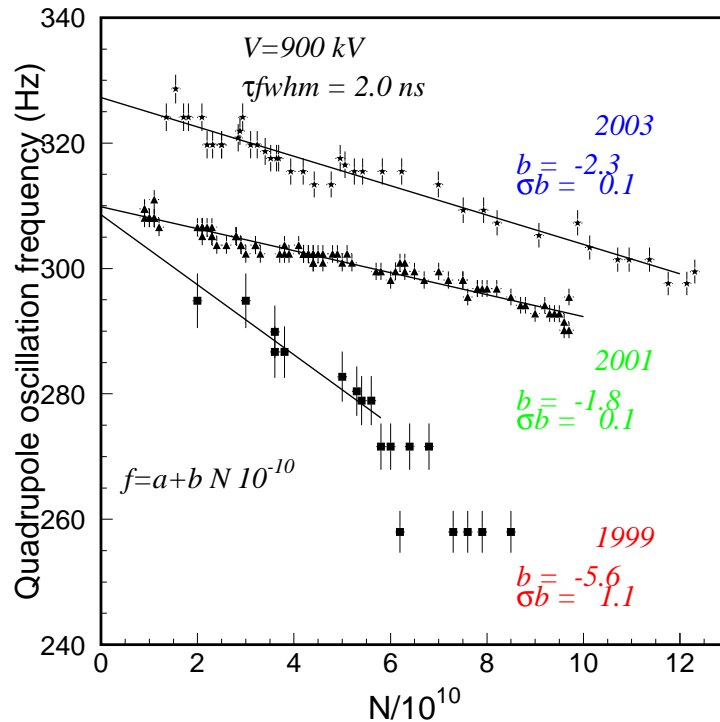
Loss of Landau damping in the SPS. Undamped quadrupole oscillations

GSI, March 30, 2006

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- Measurements at 26 GeV/c
- Model for parabolic bunch
- Effect of synchrotron frequency distribution

Quadrupole frequency shift - measurements



- Measurements of quadrupole frequency shift with intensity are used to monitor impedance changes in the SPS (slope was reduced by a factor 2.5)
- After impedance reduction (2001) the quadrupole oscillations are not damped anymore starting already from some moderate intensities ($\sim 2 \times 10^{10}$) → studies

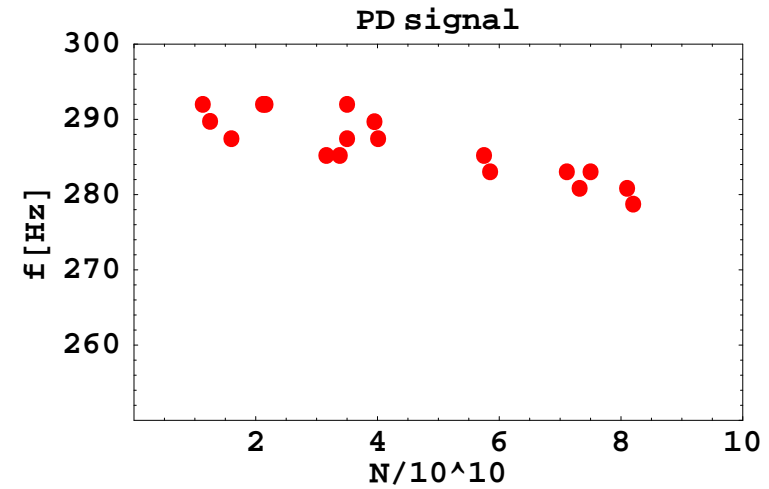
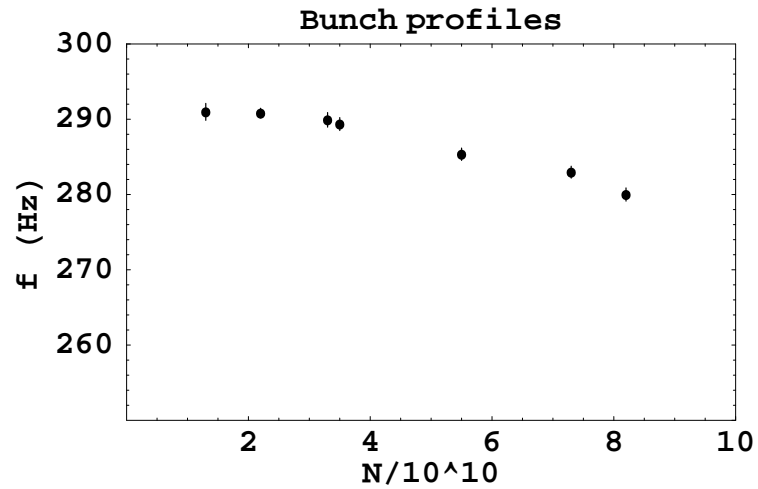
Quadrupole frequency shift - measurements

Experimental set-up

- 26 GeV/c (14 GeV/c - less clear data)
- Constant mismatched voltage 700 kV (500 kV, 900 kV) → quadrupole oscillations after injection
- Change of intensity in PSB
- Bunch: $\tau = 2.5$ ns, $\epsilon = 0.14$ eVs
- Methods of bunch observation:
 - Mountain range display of bunch profiles
 - Peak detected (PD) signal
 - Schottky spectrum of PD signal

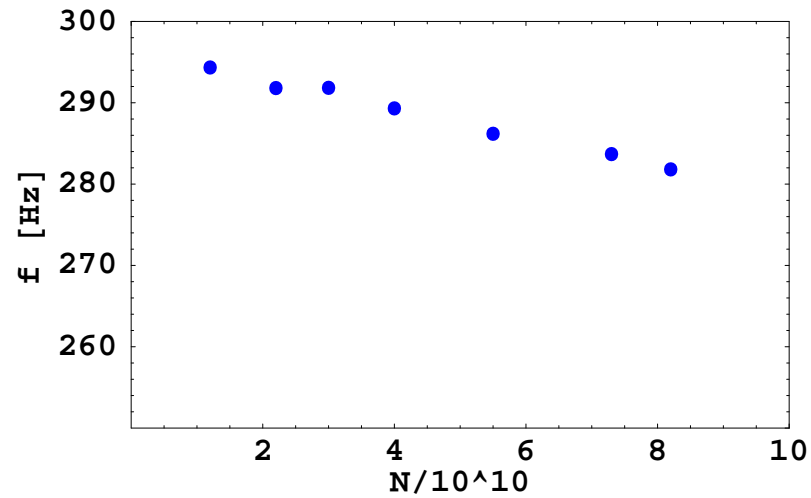
Quadrupole frequency shift - measurements

Coherent oscillation frequency

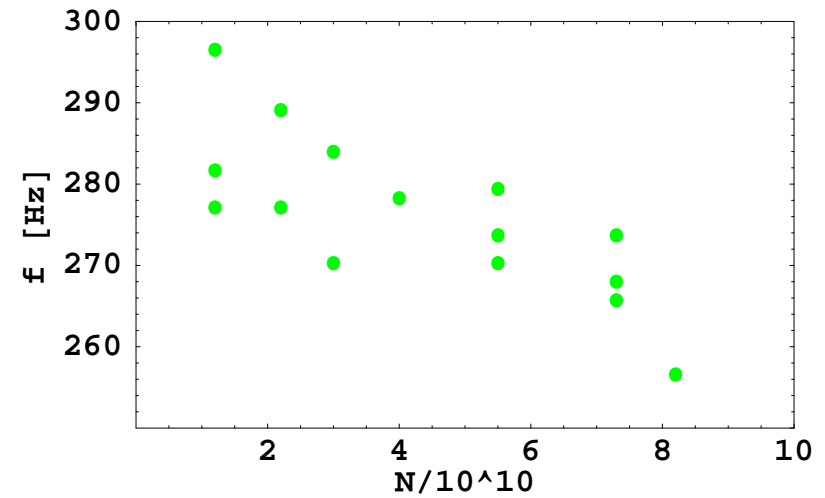


PD Schottky spectrum - measurements

coherent frequency

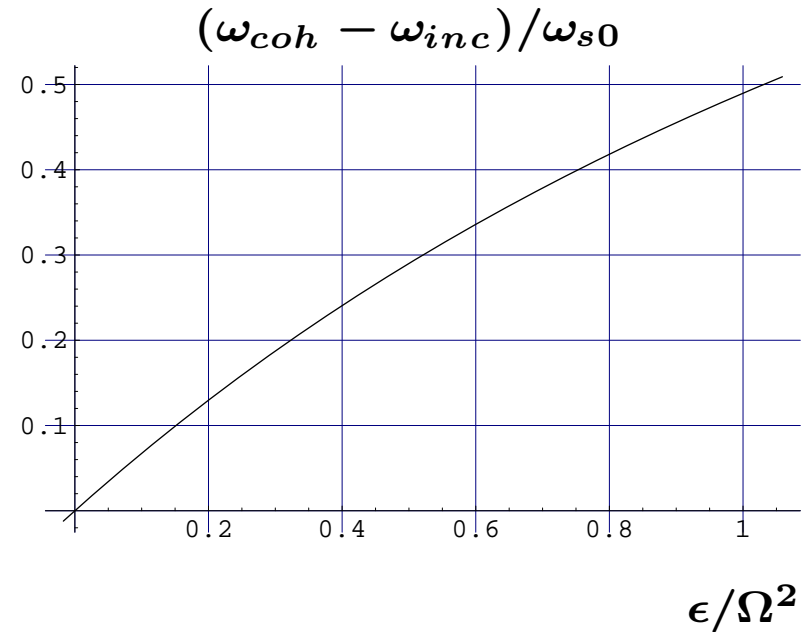
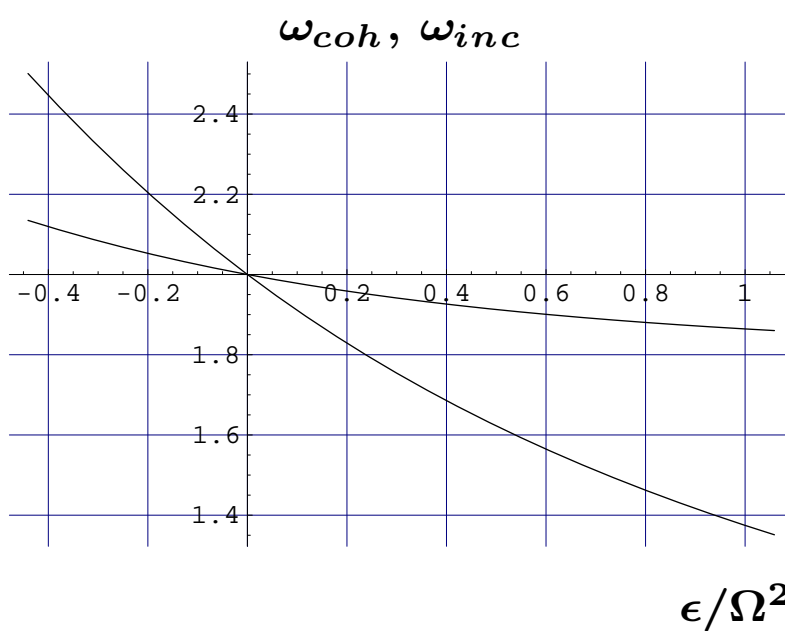


incoherent band



Quadrupole frequency shift - calculations

Coherent and incoherent oscillation frequencies



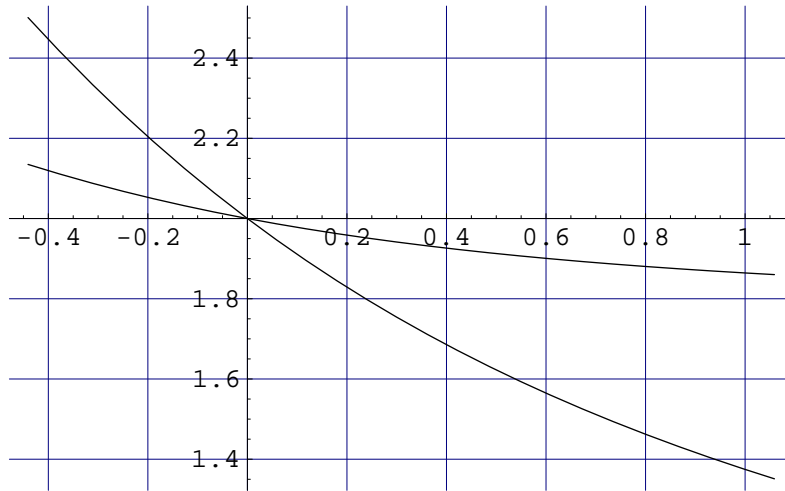
- Exact solution for parabolic bunch in mismatched linear voltage ($\omega_{s0}^2/\Omega^2 = 1.27$), synchrotron frequency spread = 0.13

$$\epsilon/\Omega^2 \simeq 4.0 \cdot 10^{-3} \frac{N_b}{10^{10}} \frac{\text{Im}Z}{n} \tau_0$$

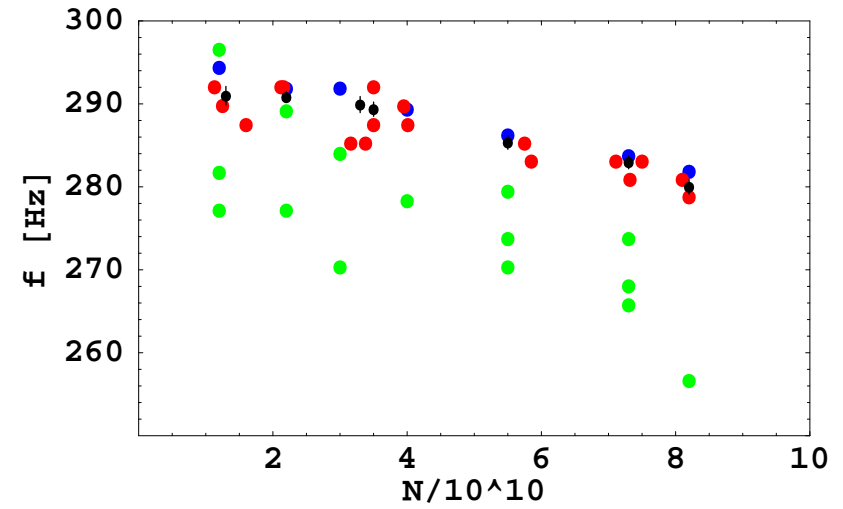
$0 < \epsilon/\Omega^2 < 0.45$ for $0 < N_b < 10^{11}$ and $\text{Im}Z/n = 5 \text{ Ohm}$

PD Schottky spectrum - measurements

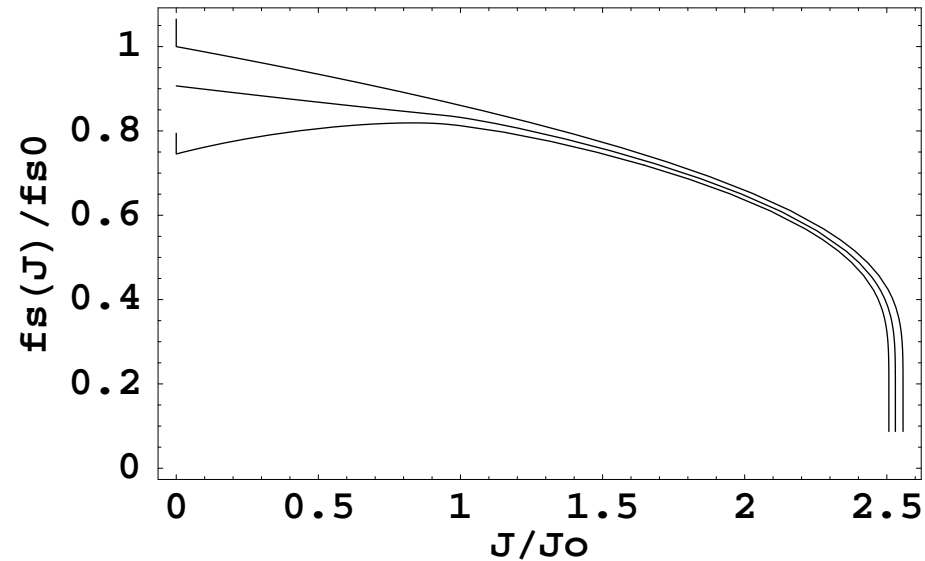
calculated



measured



Synchrotron frequency distribution



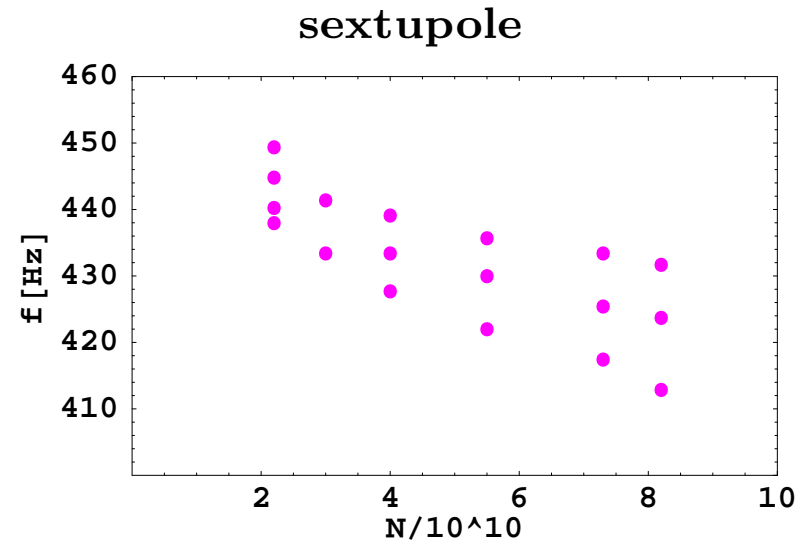
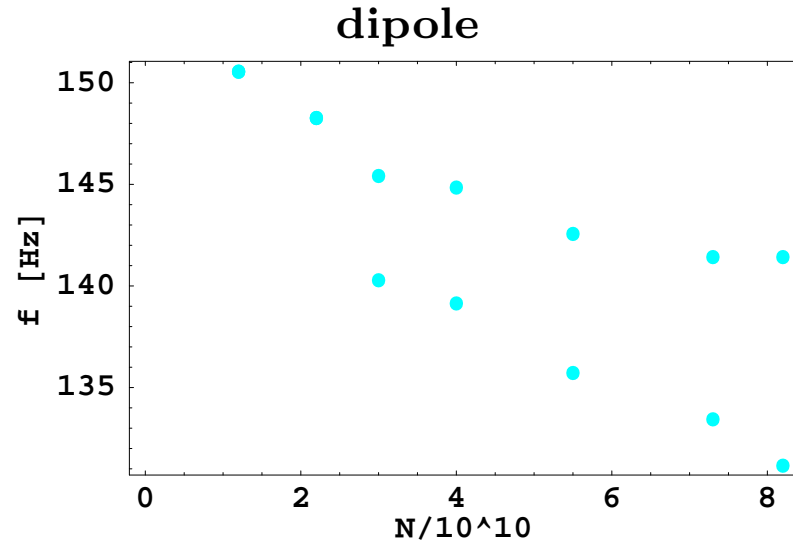
Binomial line density distribution with $\mu = 2.5$, $x_b = 1.5$.

Potential well of the form:

$$W(x) = 1 - \cos x + \lambda(1 - x^2/x_b^2)^\mu$$

Example: $\lambda = 0, 0.1, 0.2$

PD Schottky spectrum - measurements



PD Schottky spectrum - measurements

