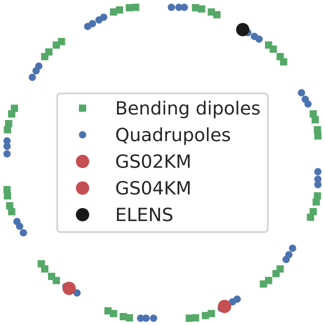
SIS18 1/2 stop band characterization vs gradient error with space charge

Goals:

- Determine and find the upper edge of $Q_y = 3.5$ stop band
- Varying controlled gradient perturbations
- Corrector magnets GS02 and GS04 powered in anti-phase
- Altering space charge conditions
- Increasing available space on the tune diagram under high intensity conditions



SIS18 survey with the corrector loop indicated

SIS18 cycle types for the experiment

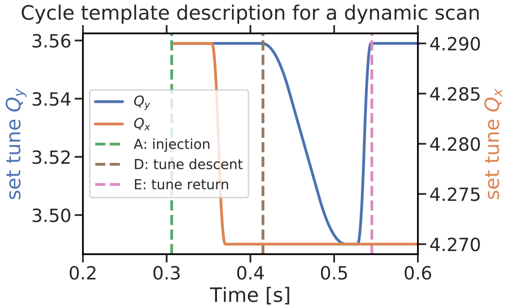
- *Dynamic*: Q_y upper edge from particle losses directly
- *Static*: emittance (beam size) growth for a working point

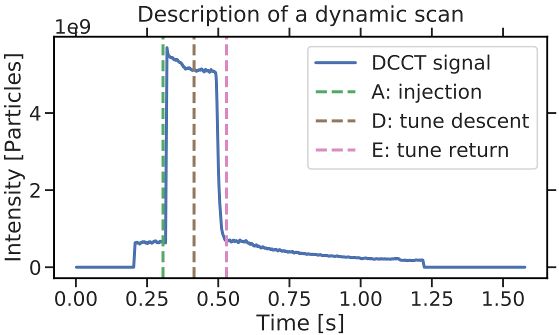
Prepared by H. Liebermann

Dynamic scans

- Slow ($\simeq$ 100 ms) change of the vertical bare tune
- Observable: particle losses (using DCCT)
- Various values of the quadrupole corrector loop (GS02 and GS04)
- Two intensities (5.5e9 and 1.1e10 particles of Argon10)

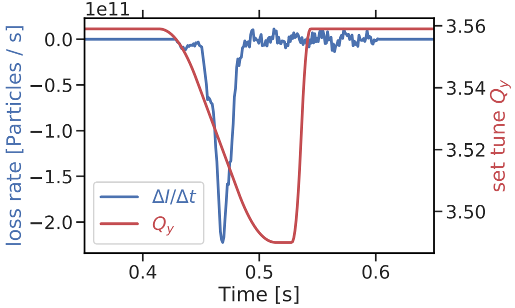
Dynamic scans

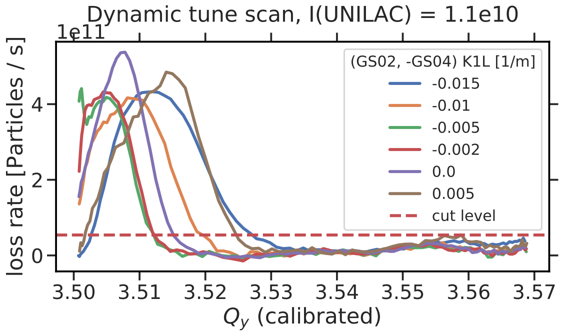




Slow change of vertical tune allowing to identify the beam interacting with the half-integer

Dynamic scans

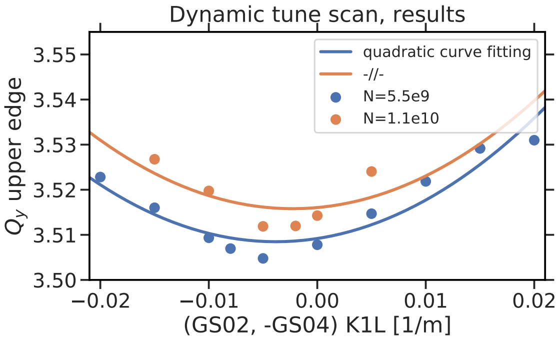




The upper edge with $\Delta N = 0.5 \cdot 10^8$ particles lost in $\Delta t = 10^{-3}$ s

Upper edge moving for varying corrector loop strengths

Dynamic scans results



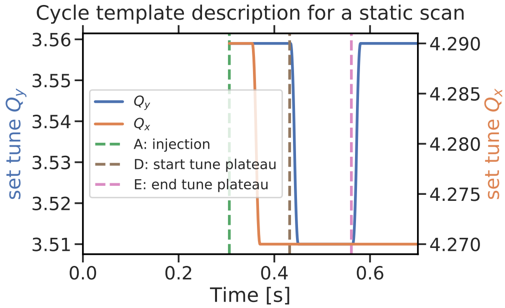
- Upper edge shift $\Delta Q_y \simeq 8 \cdot 10^{-3}$ due to SC
- Optimal (GS02, -GS04) from fit
  - K1L = $-3.8 \cdot 10^{-3}$ 1/m for N=5.5e9
  - K1L = $-2.6 \cdot 10^{-3}$ 1/m for N=1.1e10

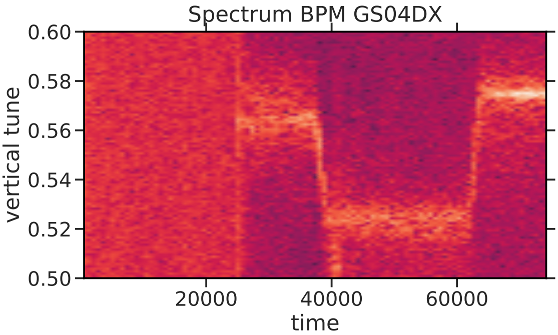
Comparison with envelope tune shift is required to complete the analysis!

Static scans

- Fast change of the vertical bare tune
- Observables: beam profiles (IPM) and particle losses (DCCT)
- Various values of the corrector loop (GS02 and GS04)
- Three intensities (3.3e9, 5.5e9 and 1.1e10 particles of Argon10)

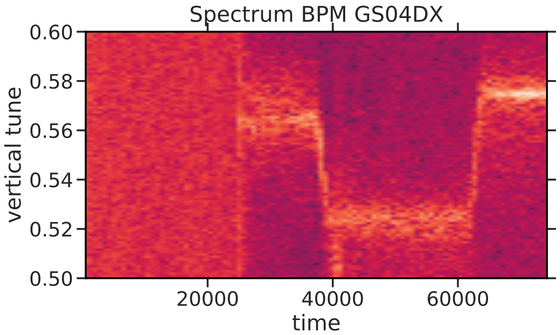
Static scans

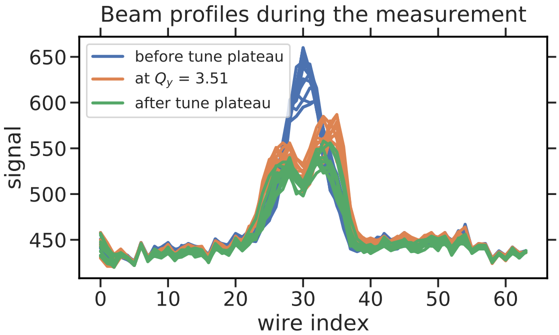




Using GS04DX BPM for the tune calibration. Other BPMs triggered at the ramp

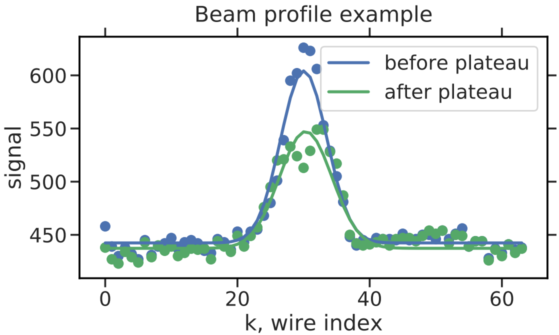
Static scans and beam profile measurements





IPM provides several recordings before, during and after tune plateau

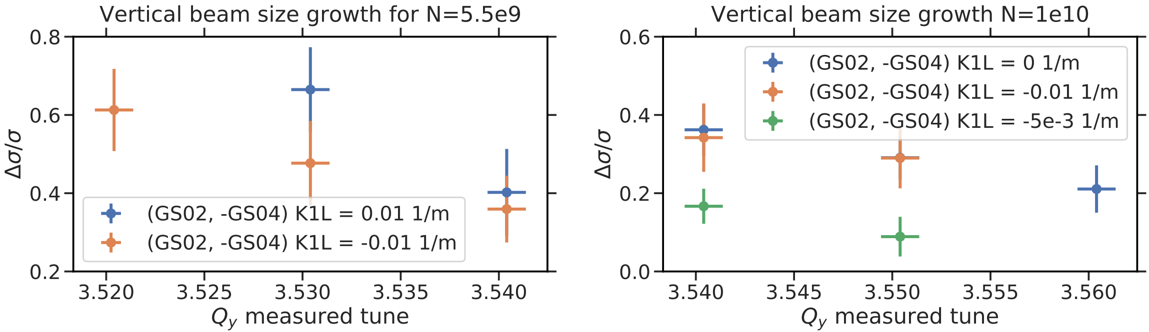
Beam profiles from IPM measurements



- Fit with $\frac{A \cdot N}{\sigma} \cdot exp[-\frac{(k-k_0)^2}{\sigma^2}] + C$
- A and C are some instrumental parameters
- DCCT provides N
- Masking four wires in the center

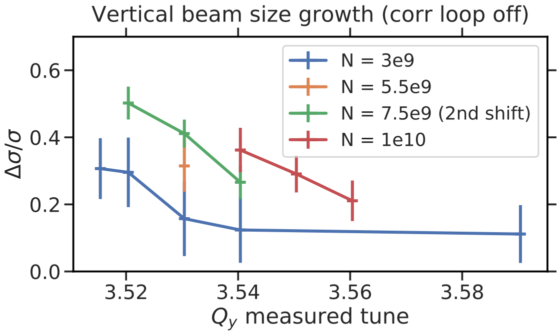
$\Delta\sigma/\sigma$ before and after tune plateau determines beam size growth accumulated on the resonance

Static scans results



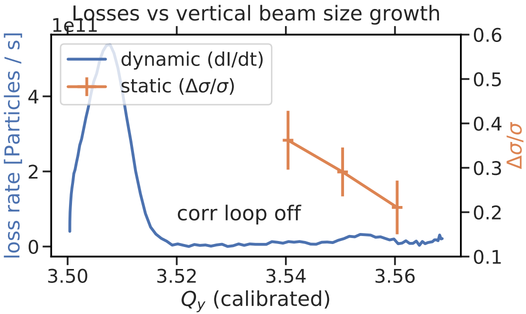
Confirming optimal values found with dynamic scans procedure provide smaller beam size growth

Static scans results



- Coarse resolution of tunes due to limited beam time
- Comparing Q_y for the same $\Delta\sigma/\sigma$
- SC ΔQ_y slightly larger than for dynamic scans

Static and dynamic scans combined



- Losses appear after significant beam size growth
- Upper edge from losses approx at $\Delta\sigma/\sigma \simeq 0.5$

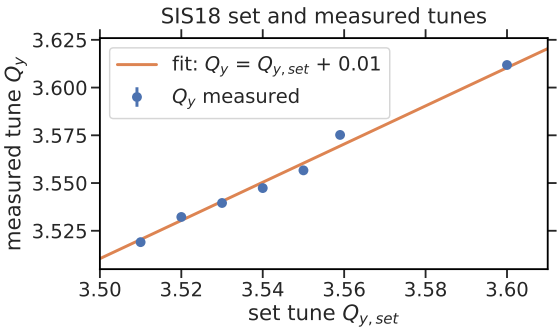
Results

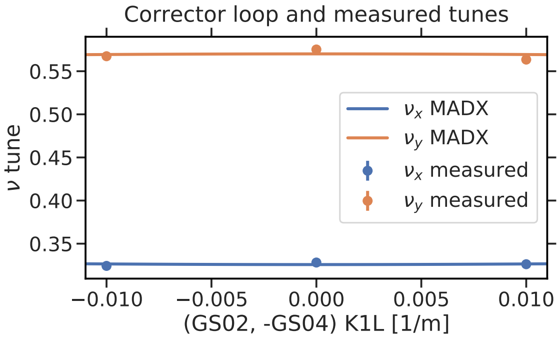
- Optimal (GS02, -GS04) K1L $\simeq -3 \cdot 10^{-3}$ 1/m (dynamic)
- Results of static scans not contradicting the results for optimal values (dynamic)
- For $\Delta N \simeq 5e9$ corresponding $\Delta Q_y \simeq 0.01$ (to be compared with analytical expression)
- Static and dynamic scans to be compared more accurately
- Cycle template can be used to make a tune diagram scan

This experiment won't be possible without the supervision of A. Oeftiger, the help from R. Singh (BPM measurements), T. Giacomini (IPM measurements), H. Liebermann (Cycle templates), C. Caliari, T. Egenolf and SIS18 team

Appendix

Calibration of betatron tunes

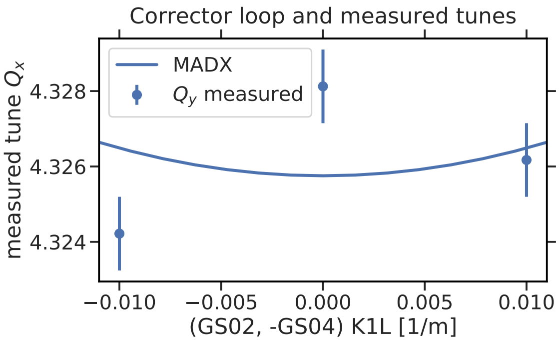


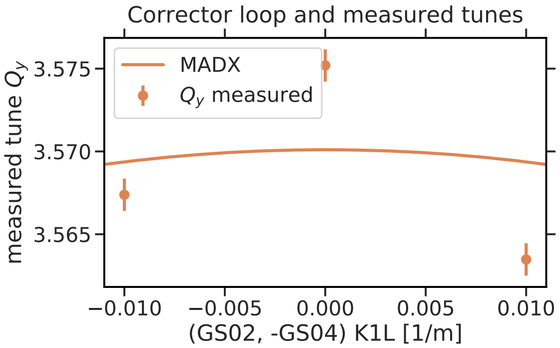


Measured tunes are in a tolerable agreement with the set tunes

Constant shift due to $\Delta K/K$ accumulated over the ring

Betatron tunes and corrector magnets





Not enough data points to use it in calibration