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Brief report of Space Charge 2013 at CERN

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Purpose

Main goal is to identify a way to improve LHC injector chains from space charge point of view.

All injectors, PSB, PS and SPS's beam quality is or will be suffered from space charge effects.

e.g. Incoherent tune shift of 0.3 for more than 10 s in SPS!

Limits: space charge/brightness

- PSB at 160 MeV
  - **Very confident** to run with $\Delta Q_y \approx -0.3$
    (and reasonable hope for $\Delta Q_y \approx -0.36$, or 1.4 μm/2.4e12 p+)

- PS at 2 GeV
  - **Very confident** to run with $\Delta Q_y > -0.26$ (and reasonable hope to increase to $\Delta Q_y \approx -0.30$, with 180 ns long bunches, giving 1.6 μm/2.4e12 p+)
  - Then looks reasonably well matched to what PSB can provide

- SPS: ε_{xv} [μm] $\approx -1.22\ N_b$ [e12] / ΔQ_y, with Q20 optics at 26 GeV
  - Present **assumption** is to run with $\Delta Q_y \approx -0.15$
  - Gives 1.2e11 p+/um or 1.6 um for 2.0e11 p+
  - Need to increase to $\Delta Q_y \approx -0.18 - 0.20$ for 50 ns beam, or 1.2 μm for 2e11 p+

Fundamental question:
why different space-charge limits for different machines?

S. Gilardoni

Two type of resonances

Resonance by lattice imperfections

Can be seen by tune scan with low intensity beams.

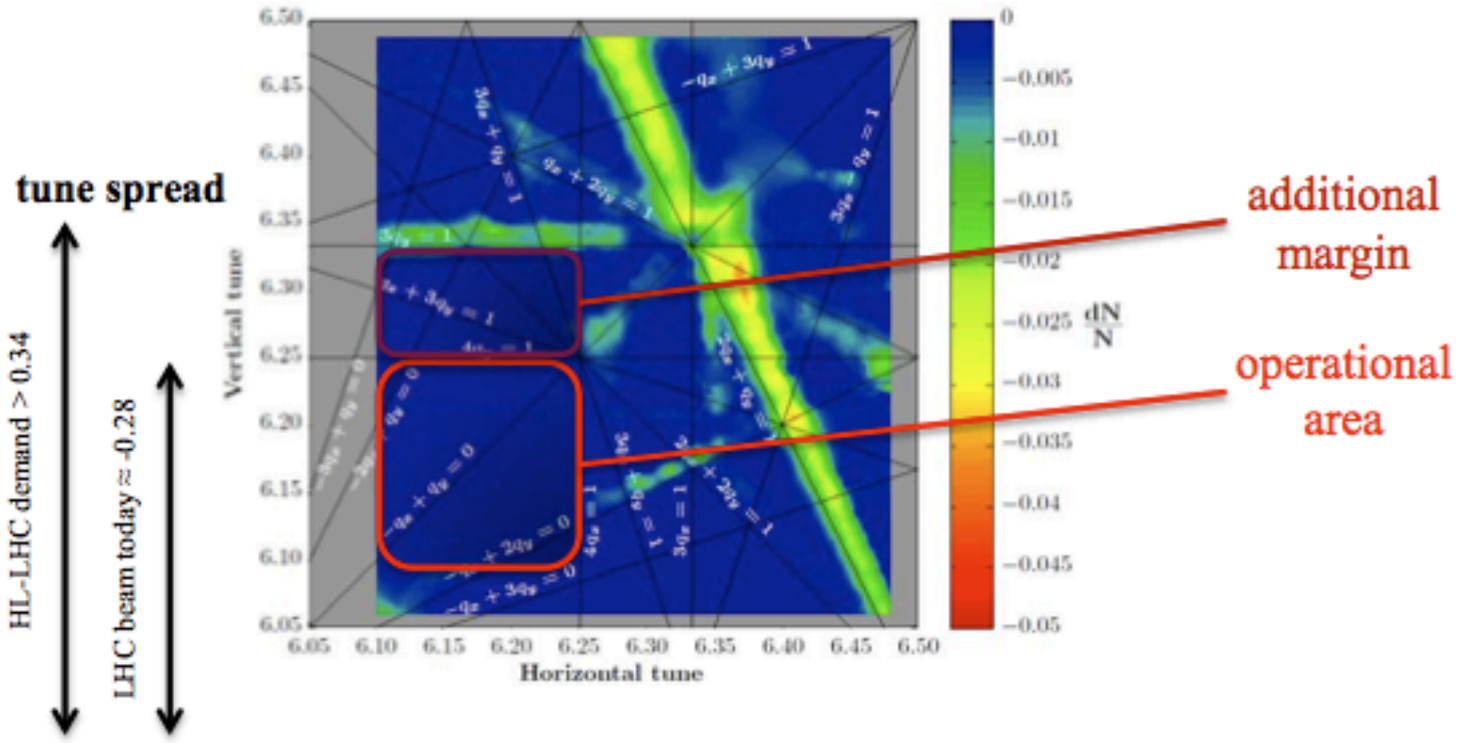
Resonance by space charge potential

Only appears with high intensity beams.

c.f. Observed in KEK-PS in 1990s.

Identification of dangerous resonances

Combination of both scans



- measurements suggest possibility to increase working point
- but even then: available area not large enough to accommodate HL-LHC beam → **resonance compensation**

A. Huschauer

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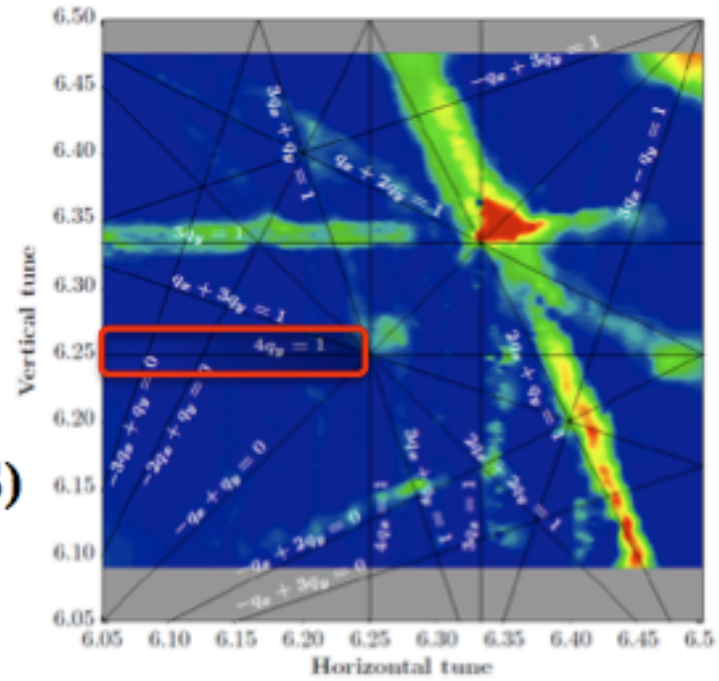
Conclusion

- suggested by the presented measurements: the resonance $3q_y=1$ constitutes the **major limit** for increasing the space charge tune spread
- resonance **compensation successfully** implemented
- ready for **tune spreads** in the order of HL-LHC **(> -0.3)**?
  → unfortunately **NOT**!
- resonance $4q_y=1$ not found to be excited by the magnetic errors, **BUT** seems to be **excited by space charge** (see talk of R. Wasef, Space charge studies in the CERN PS)
- additional **compensation scheme with octupoles** to be studied



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On high intensity study in FFAG

Resonance lines should be identified before high intensity try.

In which tune area can be scanned?

Probably along the line with constant *k* only.

Can we simulate the interplay between lattice octupole and space charge octupole?

Is the sign of lattice octupole help or harm?

How the resonances can be compensated, at least by lattice imperfections?

Easiest way is to restore the periodicity.