Resonance Stop-bands Compensation at Booster Ring of HIAF

J. Li#, J.C. Yang, IMP CAS, Lanzhou, 730000, China

Abstract: Booster Ring (BRing) of the High Intensity heavy-ion Accelerator Facility (HIAF) in China is designed to stack 0.3-1.0·10^{11} number of $^{238}U^{35+}$ ions in injection and deliver over such intensity beam in extraction. However, the depressed tune spread caused by space charge effect crosses the low-order resonance stop-bands after getting bunched. To keep a low beam loss during crossing, resonance stop-band compensation scheme is proposed covering the whole process of RF capture and early acceleration.

INTRODUCTION

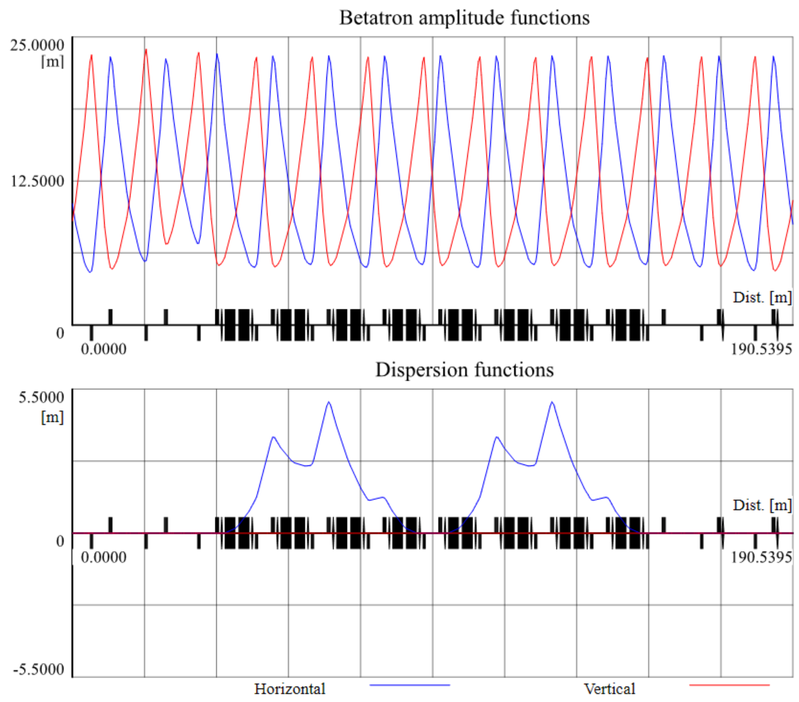


Fig. 1 Twiss parameters at one super-period

A three-folding symmetry lattice. Each super-period consists of an eight-FODO-like arc and over 70m long straight section. Typical ion: **$^{238}U^{35+}$** (0.017-0.8GeV/u), proton (0.048-9.3GeV)

SPACE CHARGE EFFECT AND RESONANCE

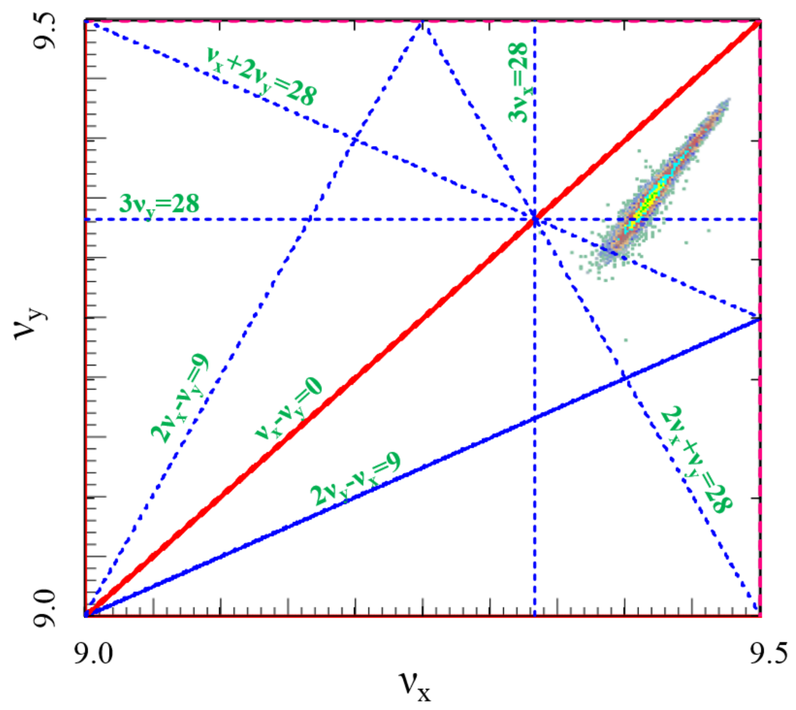


Fig. 2 Spread of 1.0·10^{11} number of $^{238}U^{35+}$ and concerned low-order resonances

Distribution: uniform (T), Gaussian (L); Bunching factor 0.4 (dual); Beam emittance equals to acceptance 200/100 π·mm·mrad! Nominal working point (9.47,9.43); Smaller emittance results in larger tune spread and more resonances crossing.

TUNE STOP BANDS AND SOURCES

Stopbands compensation concerned at the BRing:

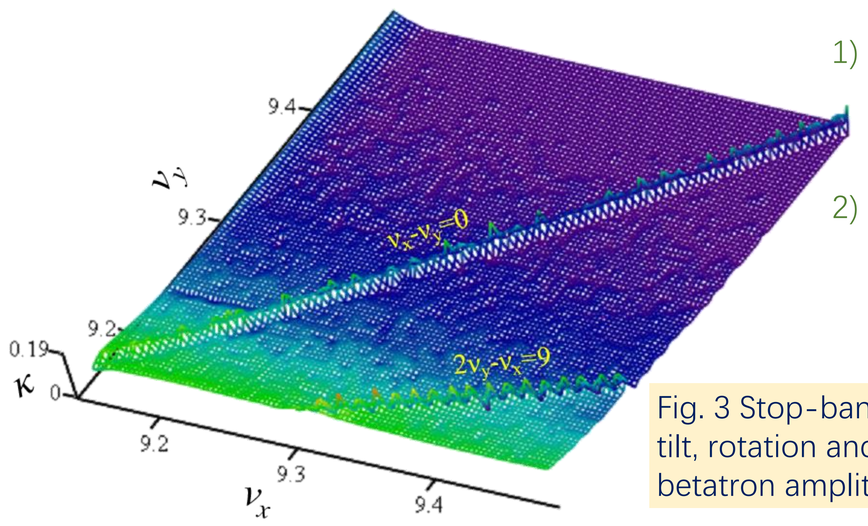
1) Half-integer resonances $2\nu_y$=19 and $2\nu_x$=19: stopbands width 0.002, to be compensated with quadruple field added upon exist quadruples;
2) Linear coupling difference ν_x-ν_y=0: to be compensated with skew quadruple field generated by additional cores and windings combined with orbit-correctors;
3) Third-order betatron resonance $3\nu_x$=28, ν_x+$2\nu_y$=18 and systematic resonance $2\nu_y$-ν_x=9: to be compensated with chromaticity correction sextuples;
4) Third-order betatron resonance $3\nu_y$=28, $2\nu_x$+ν_y=28: to be compensate with new added skew sextuples.

Compensation elements layout:

I) Phase advance Δϕ between elements follows:

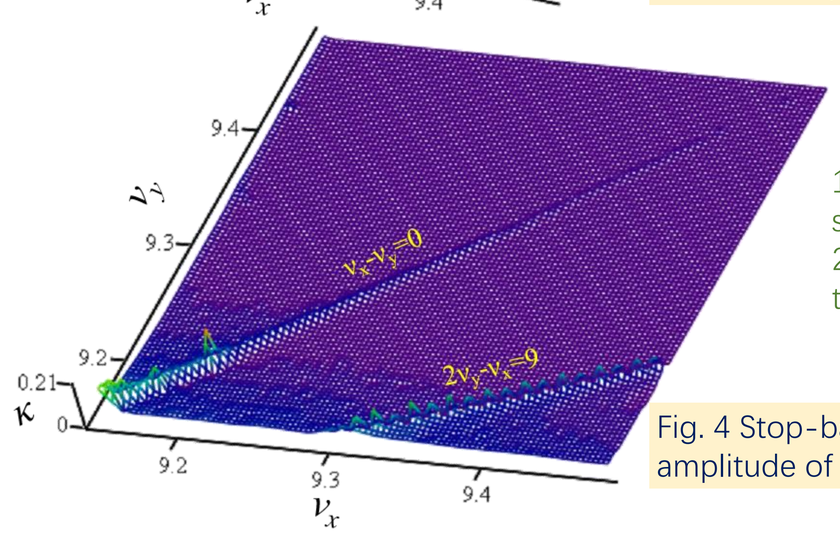
$$\frac{\Delta\emptyset}{Q_{x,y}}M \to (n+\frac{1}{2})\pi$$

II) Large ratio between the two transverse betatron functions



1) Resonance stop-bands: linear coupling ν_x-ν_y=0 and systematic resonance $2\nu_y$-ν_x=9;
2) Tilt contributes the most, offset the second and rotation the least.

Fig. 3 Stop-bands by magnets tilt, rotation and offset, and betatron amplitude together



1) Weaker contribution to stopbands;
2) Ridges grows closing to integer-resonances.

Fig. 4 Stop-bands by betatron amplitude of ions

COMPENSATION RESULT

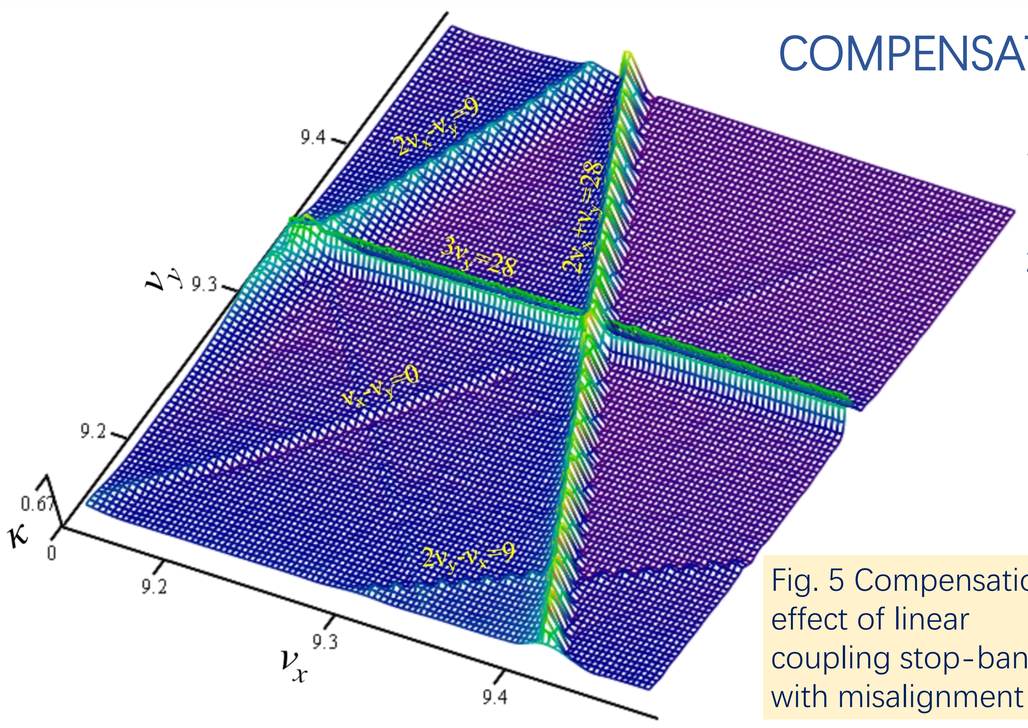


Fig. 5 Compensation effect of linear coupling stop-band with misalignment

1) Most part of the linear coupling stop-band is compensated;
2) Compensation also excites two betatron 3rd-order resonances

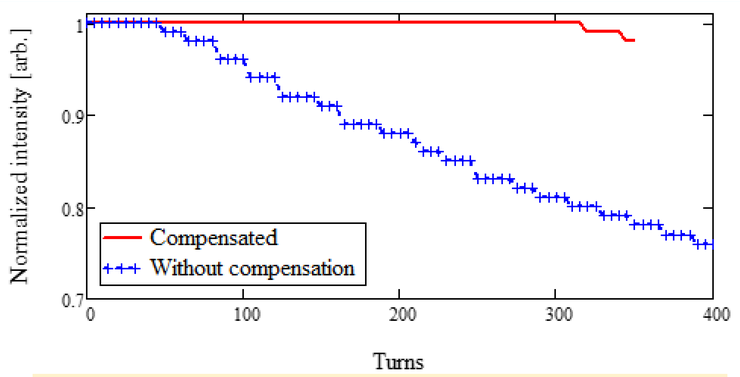


Fig. 6 Beam intensity evolution in compensation checking under enhanced tilt misalignment

CONCLUSION

Space charge effect of high intensity uranium ions stacking at the BRing induces depressed tune spread and low-order stop-bands crossing. Their compensation details are discussed. The compensation results are checked by tracking as well.

#Corresponding author: lijie@impcas.ac.cn