Studies of transverse instabilities in the CERN SPS

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Motivation of the study

• For the LIU project the SPS is supposed to accelerate intensities, nearly twice as high as the current ones. One of the major intensity limitations in the SPS is the vertical Transverse Mode Coupling Instability (TMCI).
• To relax the demand on the RF power supplies the Q22 optics with intermediate transition energy has been proposed and has to be investigated.
• Octupoles introduce amplitude detuning which leads to a tune spread and creates Landau damping. They also contribute a second order chromaticity.
• To stabilize possible horizontal single bunch instabilities which occurred during recent high intensity (2e11 ppb) multi-bunch runs in the SPS the effect of the octupoles is investigated.

TMCI studies in the SPS

• Measurement in the vertical plane of the Q22 optics.
• The chromaticity is set to 0.7, the intensity is ramped up to find the TMCI threshold
• The TMCI threshold in the Q22 optics is found at 2.5e11 ppb.
• As expected from theory chromaticity can stabilize the beam.
• Simulations reproduce the observations in the machine well. But the 'island of slow instability' predicted in simulations, was not observed during measurements.

Octupole contribution investigation

• Measurement in the horizontal plane of the Q20 optics with an intensity of 2e11 ppb.
• Chromaticity: -2 for $K_{LOF}$ and $Q_x^*$ scan; -1 for $a_{xx}$ scan to produce a horizontal mode 0.
• Using three groups of Landau octupoles the LOF, LOD and LOE.
• For the $K_{LOF}$ scan only the $K$ values of the LOF are changed.
• MADX is used to calculate settings for all three octupole groups resulting in only $Q_x^*$ or only $a_{xx}$ in the horizontal plane for the respective scans.

Conclusion

• The TMCI threshold has been deeply investigated in the new Q22 optics for the first time and has been found at 2.5 ppb. Simulations reproduce this observation well.
• The influences of different parameters on the TMCI threshold have been studied during the measurements.
• The stabilizing mechanisms of the octupoles in the SPS have been measured. By compensating other contributions of the octupoles, the damping of pure $a_{xx}$ and pure $Q_x^*$ was investigated. For positive octupole values $Q_x^*$ seems to dominate.