

Exploring Space Charge and Intra-beam Scattering Effects in the CERN Ion Injector Chain



THBP23

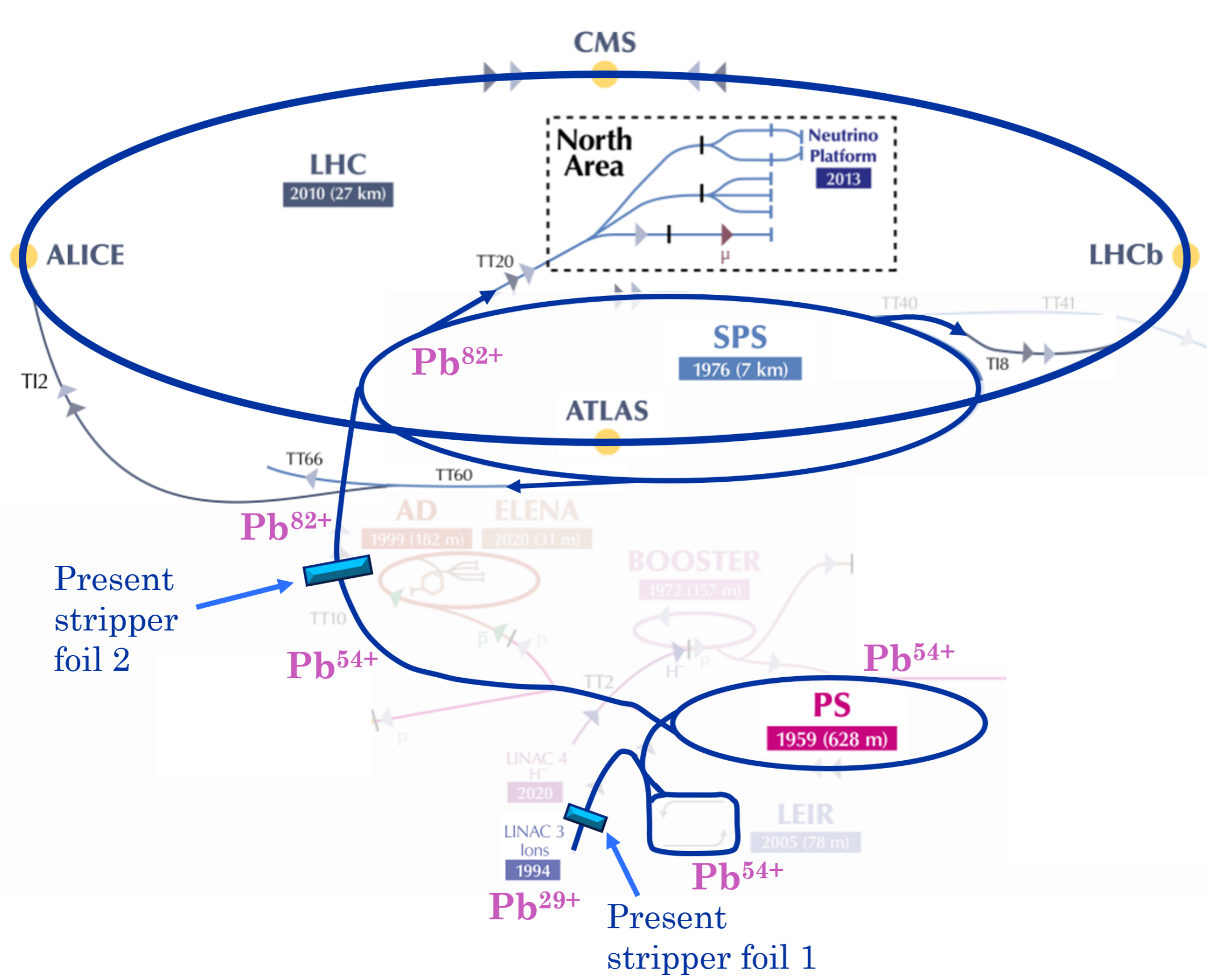
E. Waagaard, H. Bartosik, CERN, Geneva, Switzerland

Abstract

Today's LHC ion physics programme consists mostly of Pb ion collisions, but higher luminosities can possibly be achieved with lighter ions requested by ALICE3 and NA61++. Lighter ions will require much higher beam intensities from the ion injectors (LEIR, PS, SPS), potentially limited by space charge and intra-beam scattering (IBS). In this study, we present a first mapping of space charge and IBS effects on Pb beams.

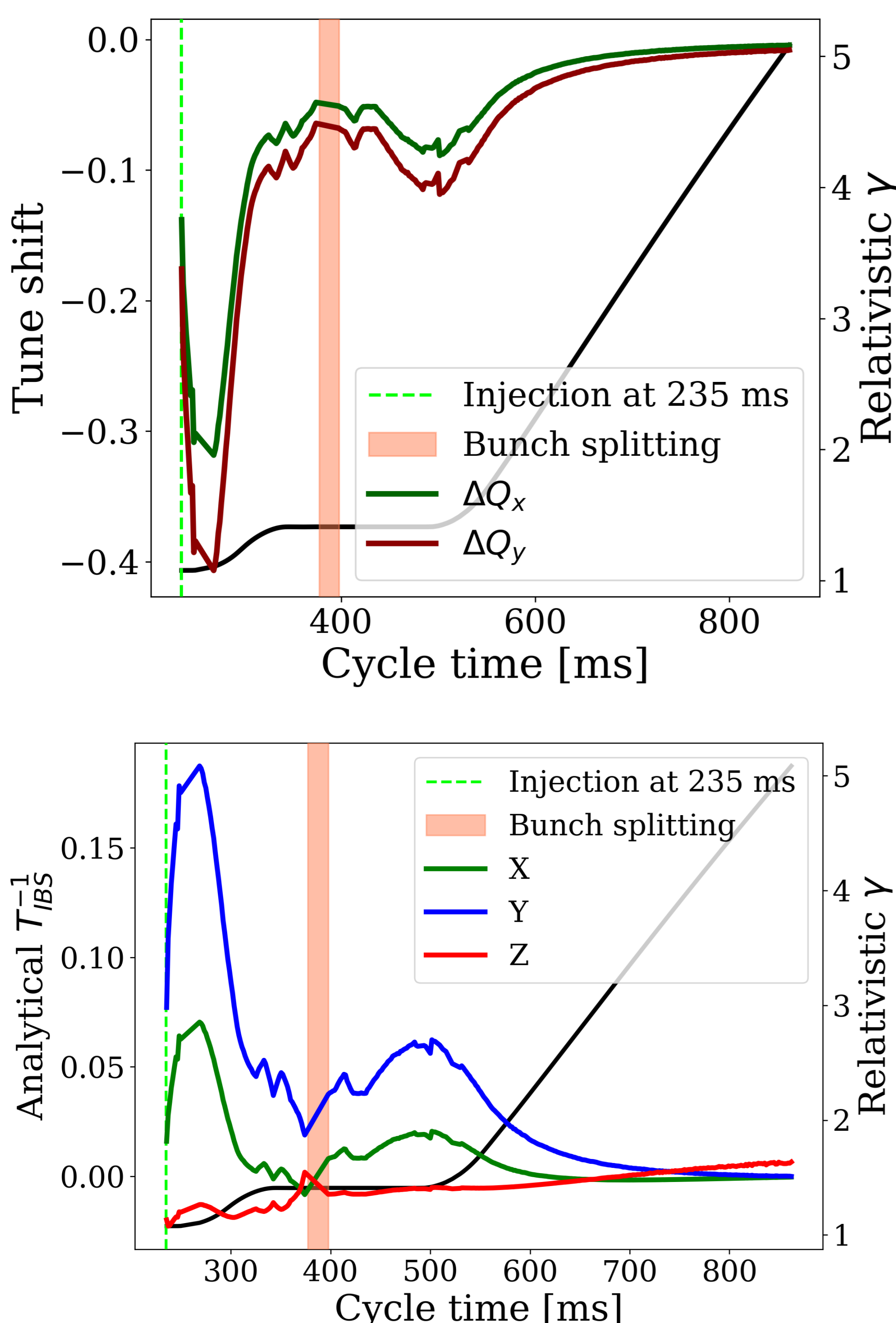
The CERN Ion Injector Chain

- Consists of LINAC3, Low Energy Ion Ring (LEIR), Proton Synchrotron (PS) and Super Proton Synchrotron (SPS)



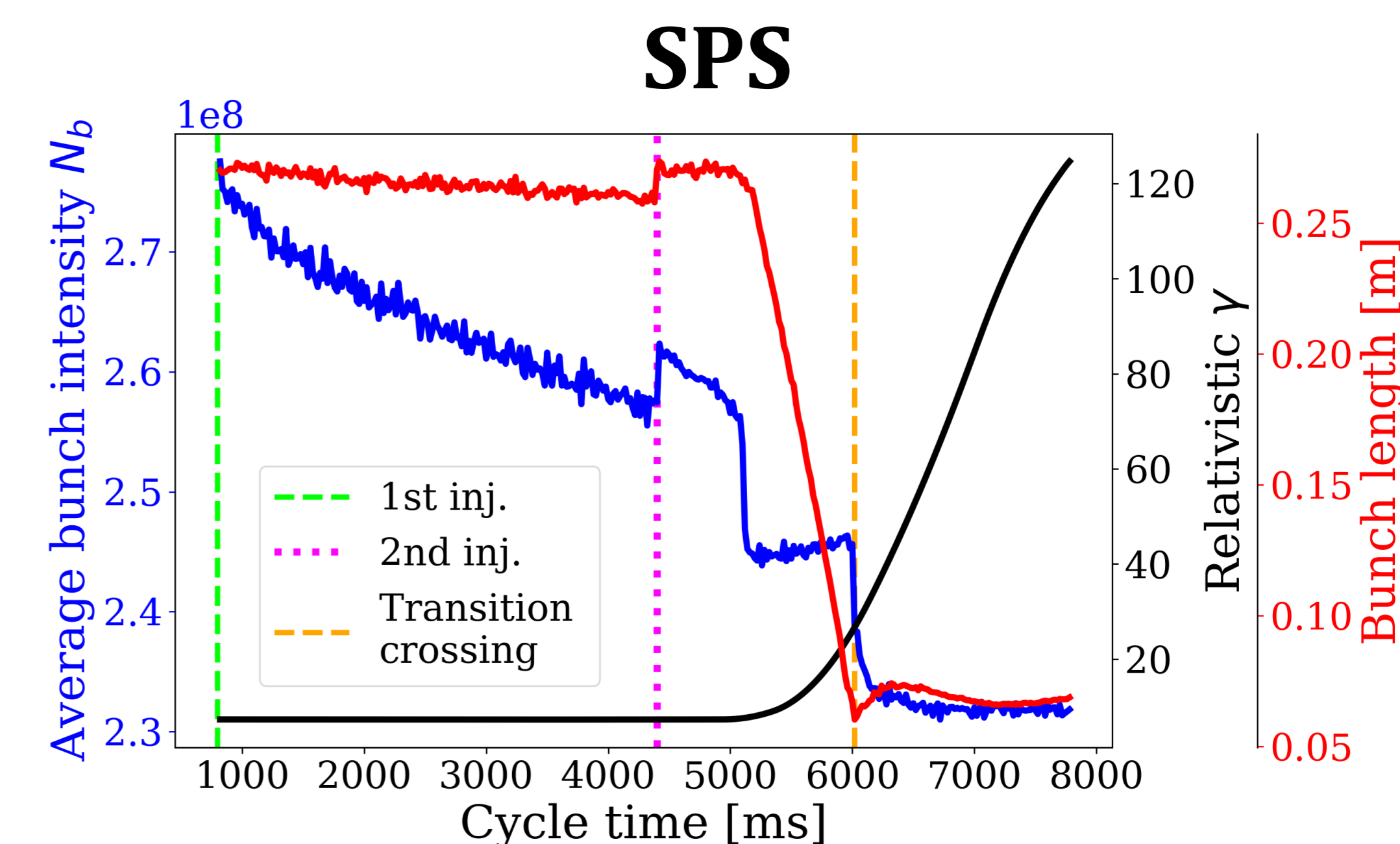
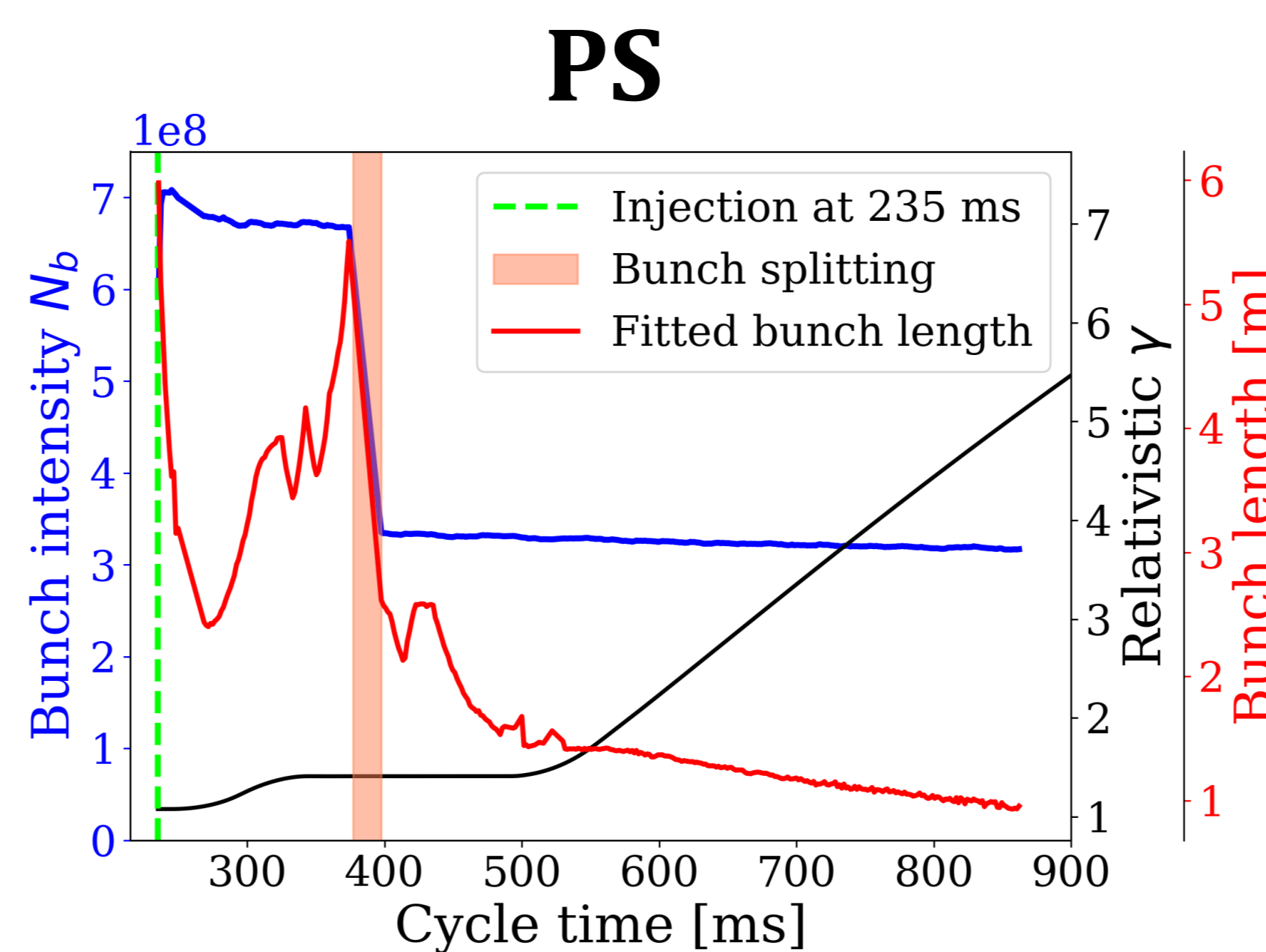
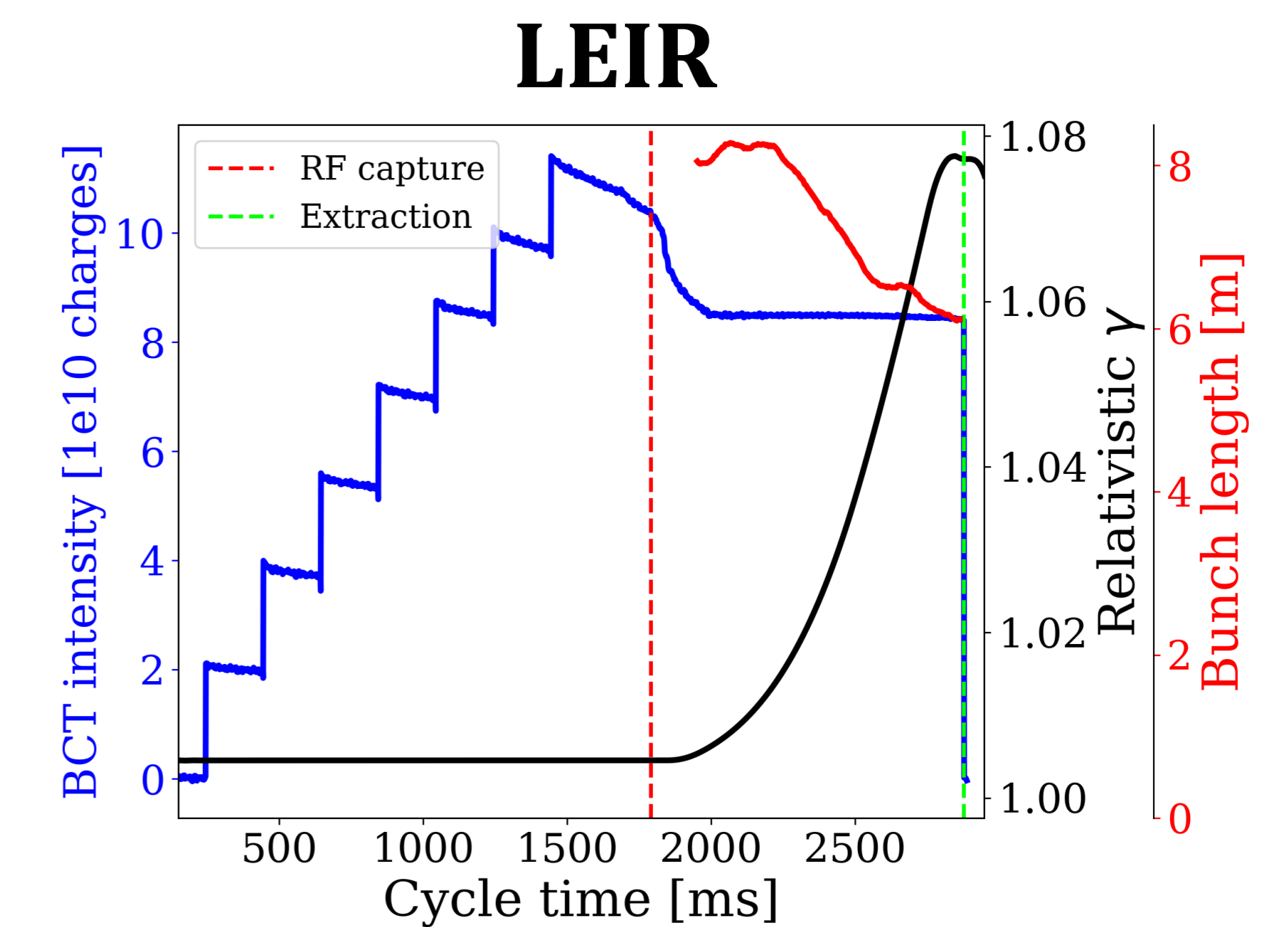
Space Charge and IBS in PS

Several steps of energy ramp with intermediate bunch splitting. Strongest tune $\Delta Q_{x,y}$ and $T_{x,y}^{-1}$ right after injection and after bunch splitting. IBS strongest in Y-plane.



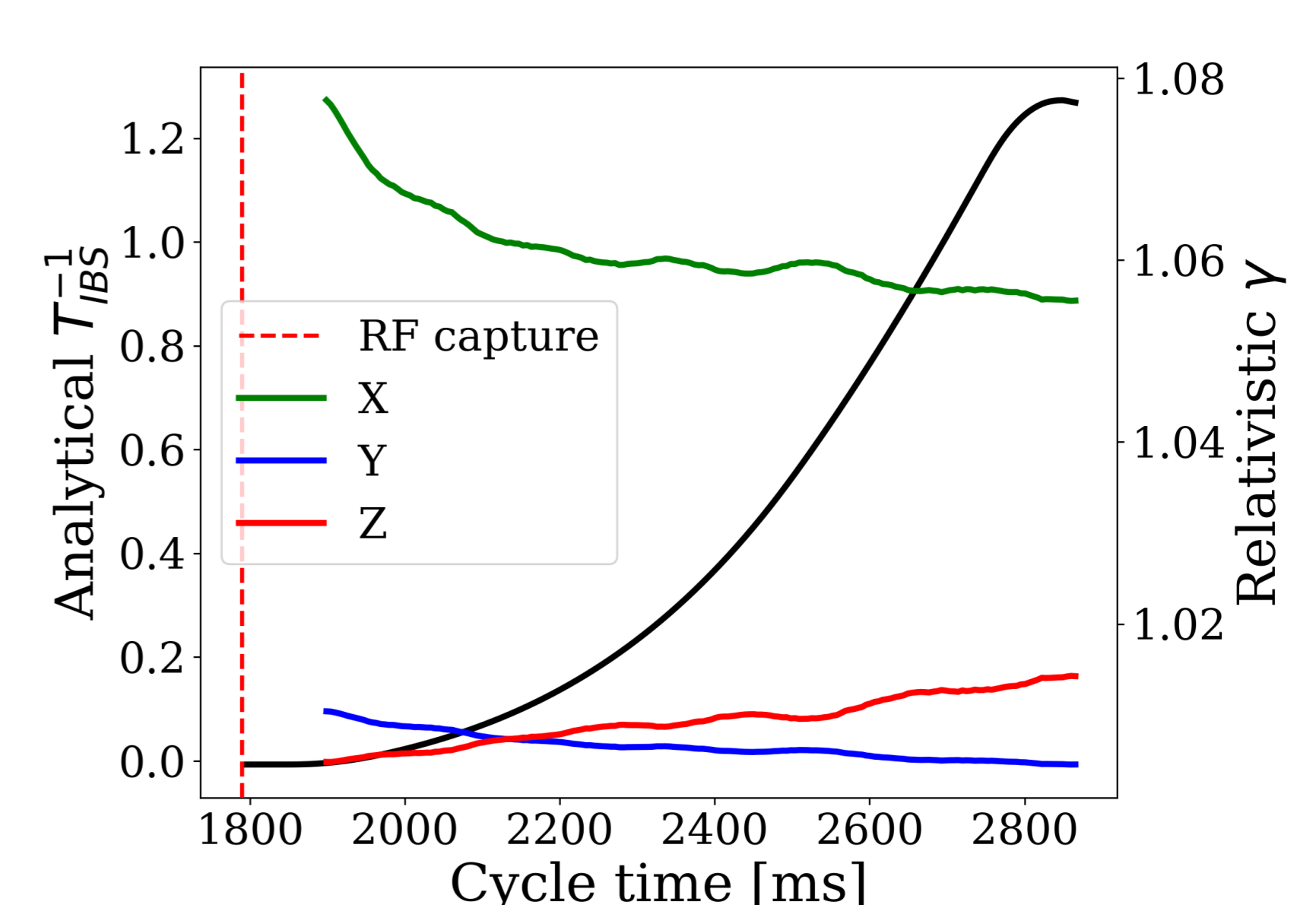
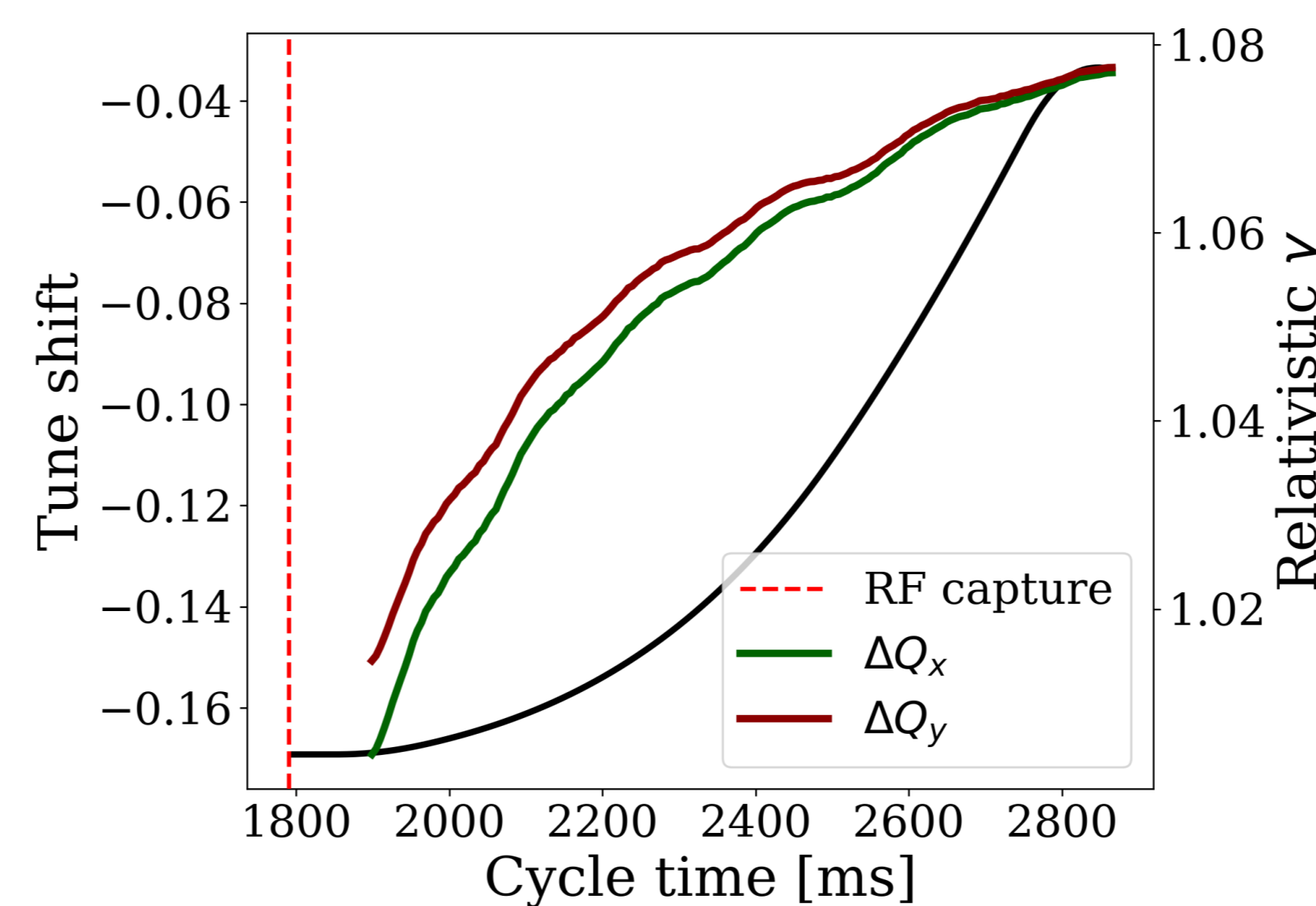
Measuring beam parameters in

- We calculate the space charge tune shift $\Delta Q_{x,y}$ and IBS growth rates $T_{x,y,z}^{-1}$ from the Nagaitsev formalism with realistic beam parameters across LEIR, PS and SPS
- We assume nominal beam parameters for emittances and momentum spread at each injection from (Bartosik & John, 2021)
- Bunch lengths in LEIR and PS are calculated from longitudinal profiles



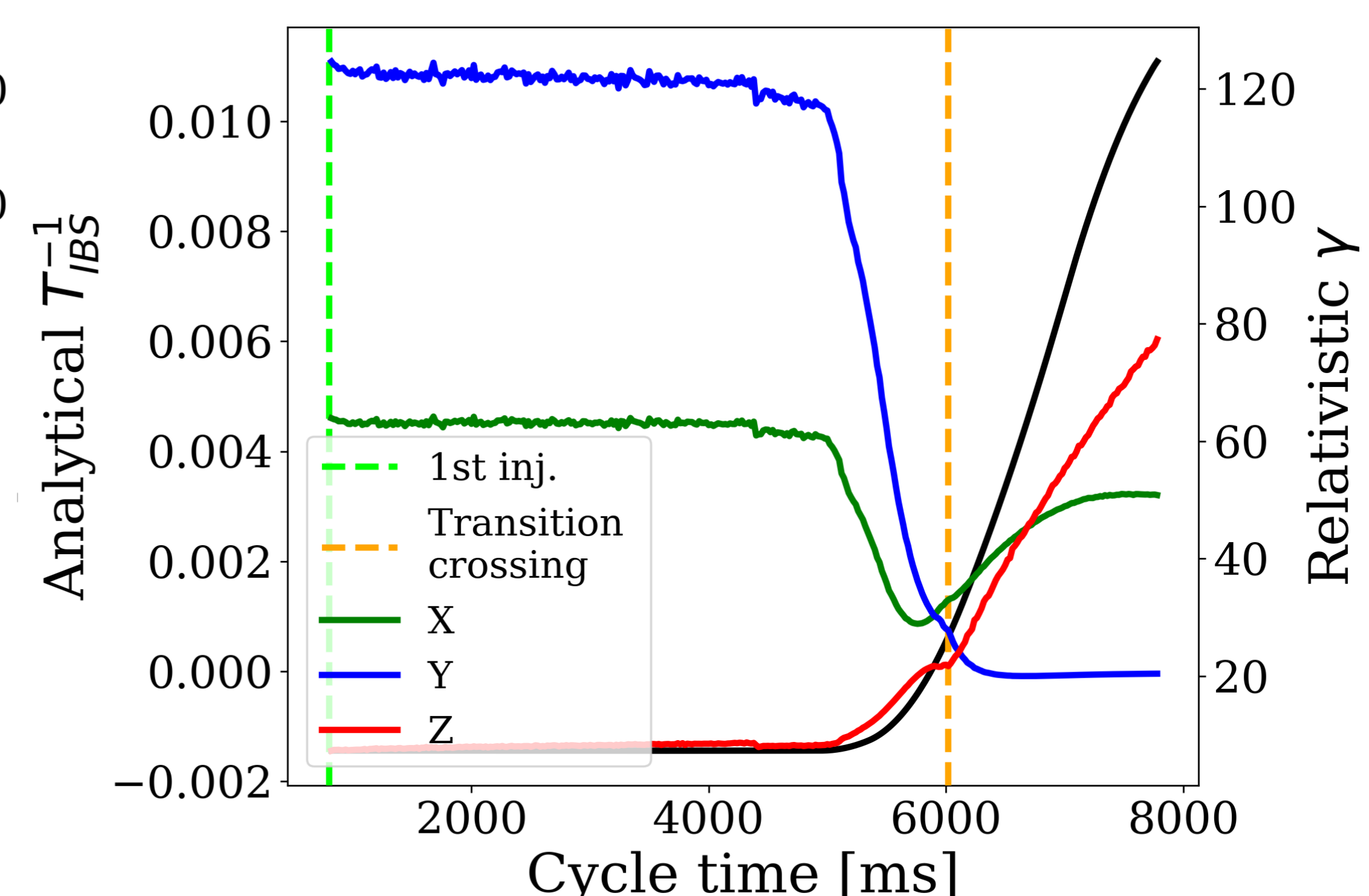
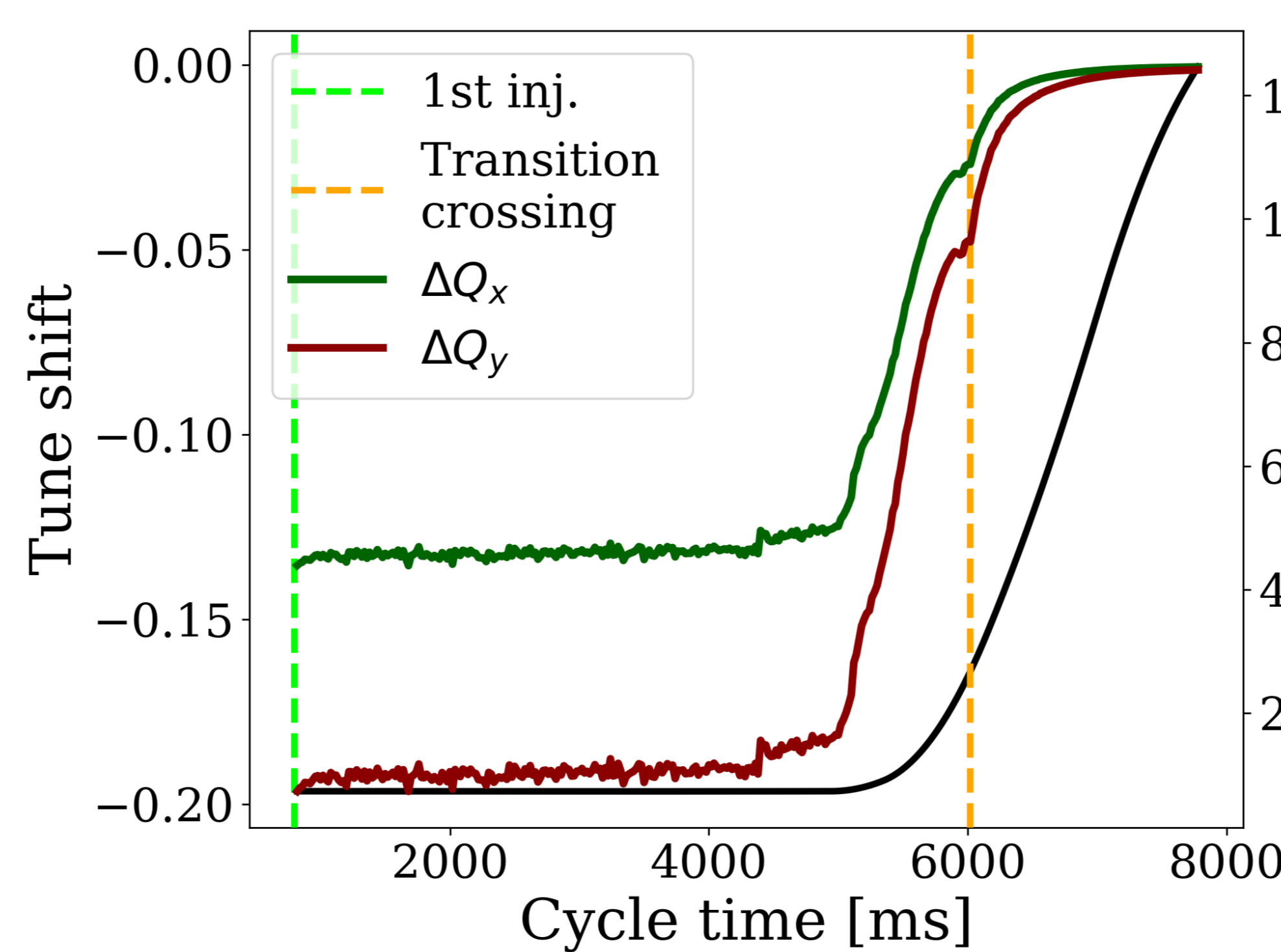
Space Charge and IBS in LEIR

Stronger $\Delta Q_{x,y}$ and $T_{x,y}^{-1}$ that decrease as the energy ramps. Largest IBS effects in horizontal plane.



Space Charge and IBS in SPS

$\Delta Q_{x,y}$ and $T_{x,y}^{-1}$ smaller than LEIR and PS, but large impact expected for 45-s LHC-filling operational cycle. T_z^{-1} increases probably due to smaller momentum spread during ramping.



Conclusions

- Space charge and IBS among most important limitations for high-intensity ion beams to the LHC and North Area experiments at CERN
- This study: first detailed mapping of space charge and IBS during operational cycles of LEIR, PS and SPS. Important milestone for Injector Model to estimate future candidate ion species.