Emittance Growth Estimation of Crab Cavity Ramping on LHC Beam 1 Lattice

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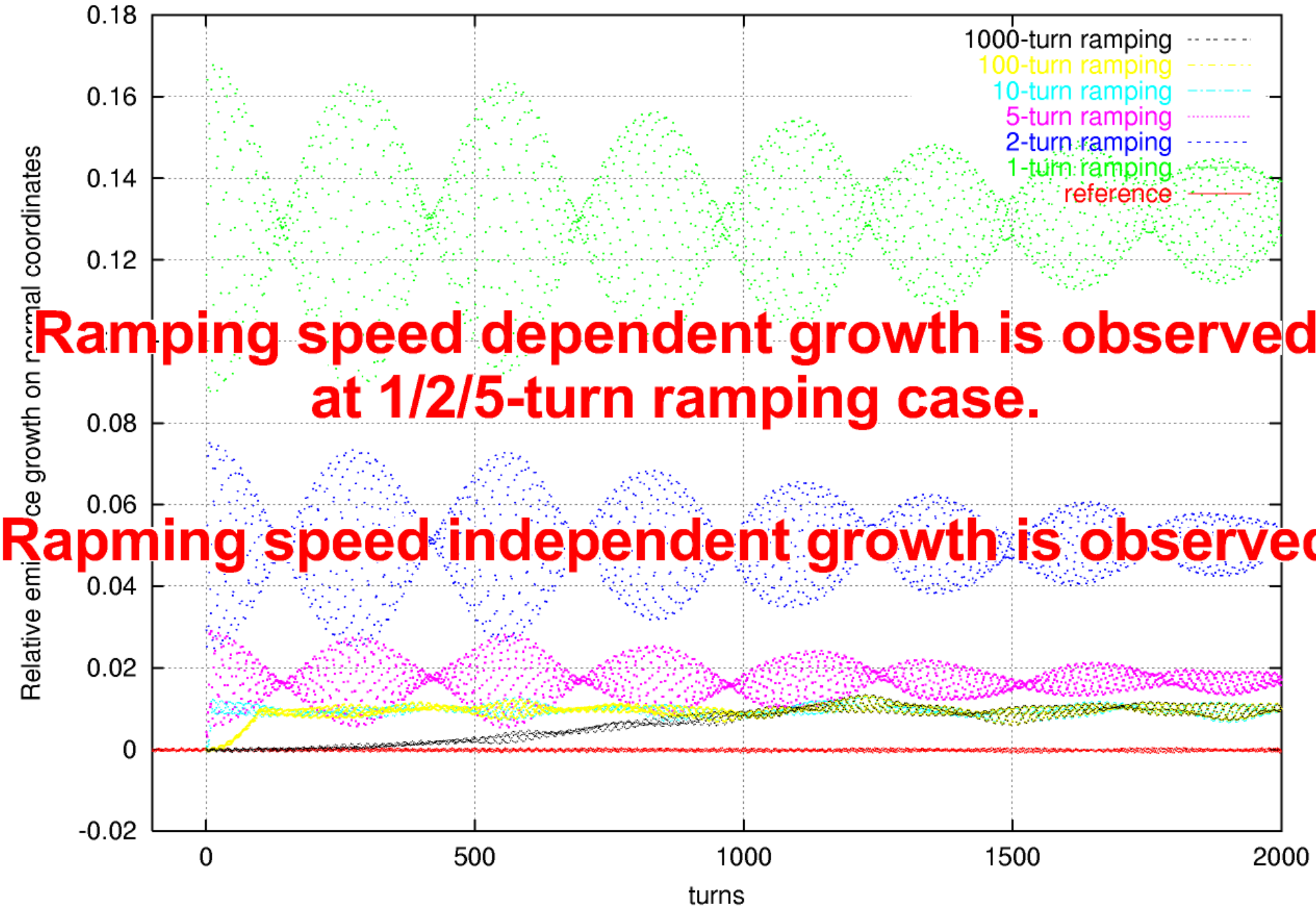
Simulation Configuration

- Simulation Method
  - 6D-Particle Tracking with Turn-by-Turn Crab Cavity Voltage changes
  - Number of Particles: 10000
  - Particle Distribution: Gaussian generated by PRNG
  - Initial Emittance: from Design Report
    - $\sigma_{x,y} \sim 16.7 \times 10^{-6}$m at ip1/5, $\sigma_z \sim 7.55 \times 10^{-2}$m
  - Emittance is estimated on the normal coordinate(by linear transformation)
- Optics Model
  - LHC Beam1 collision optics on SAD
    - Translated from V6.503@2008/07/14
  - Crab cavity is inserted at -35m upstream point of ip4
  - Crab crossing angle: 285 μrad at ip5
  - Crab frequency: 400MHz

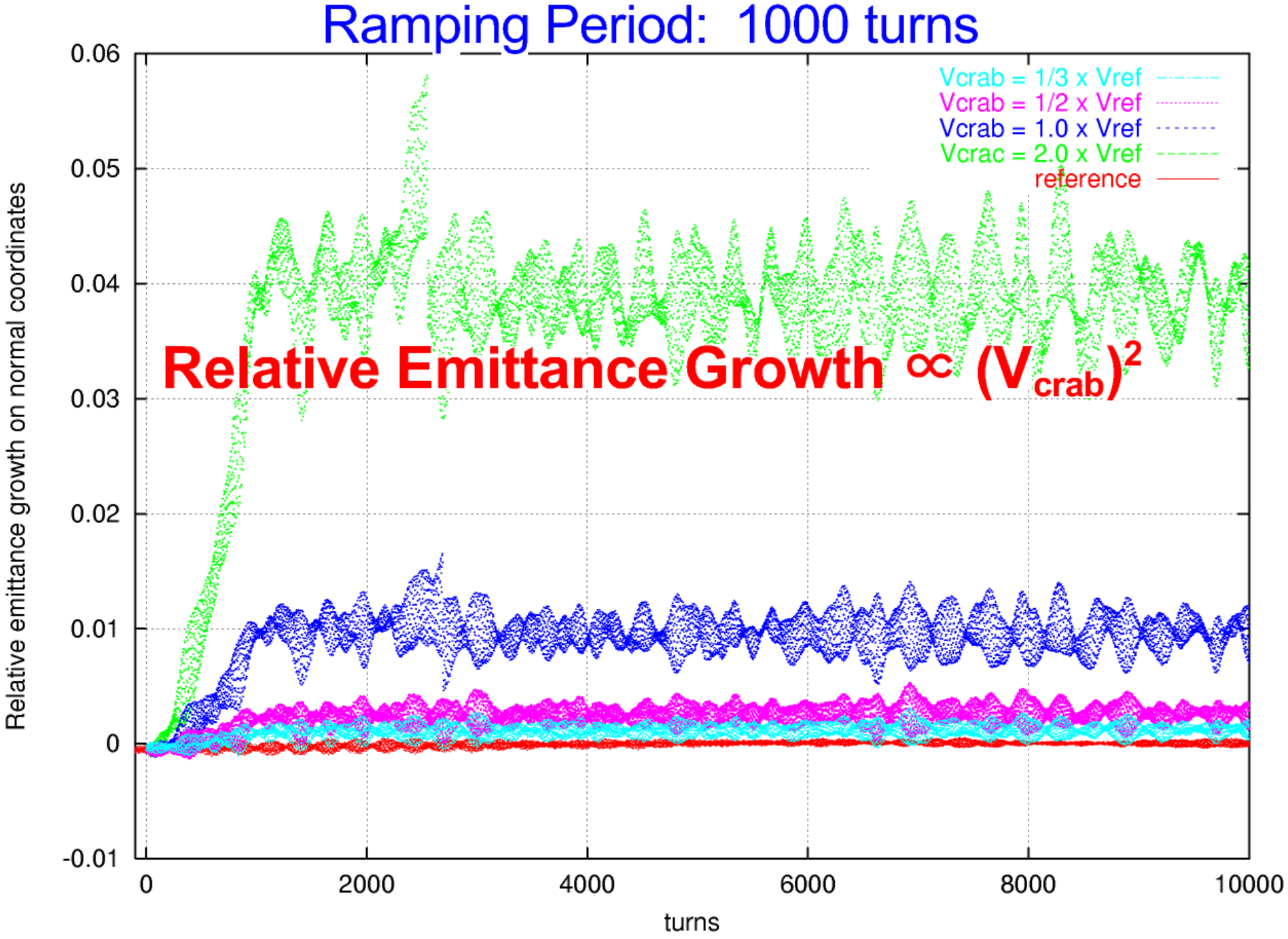
Ramping Speed Dependency



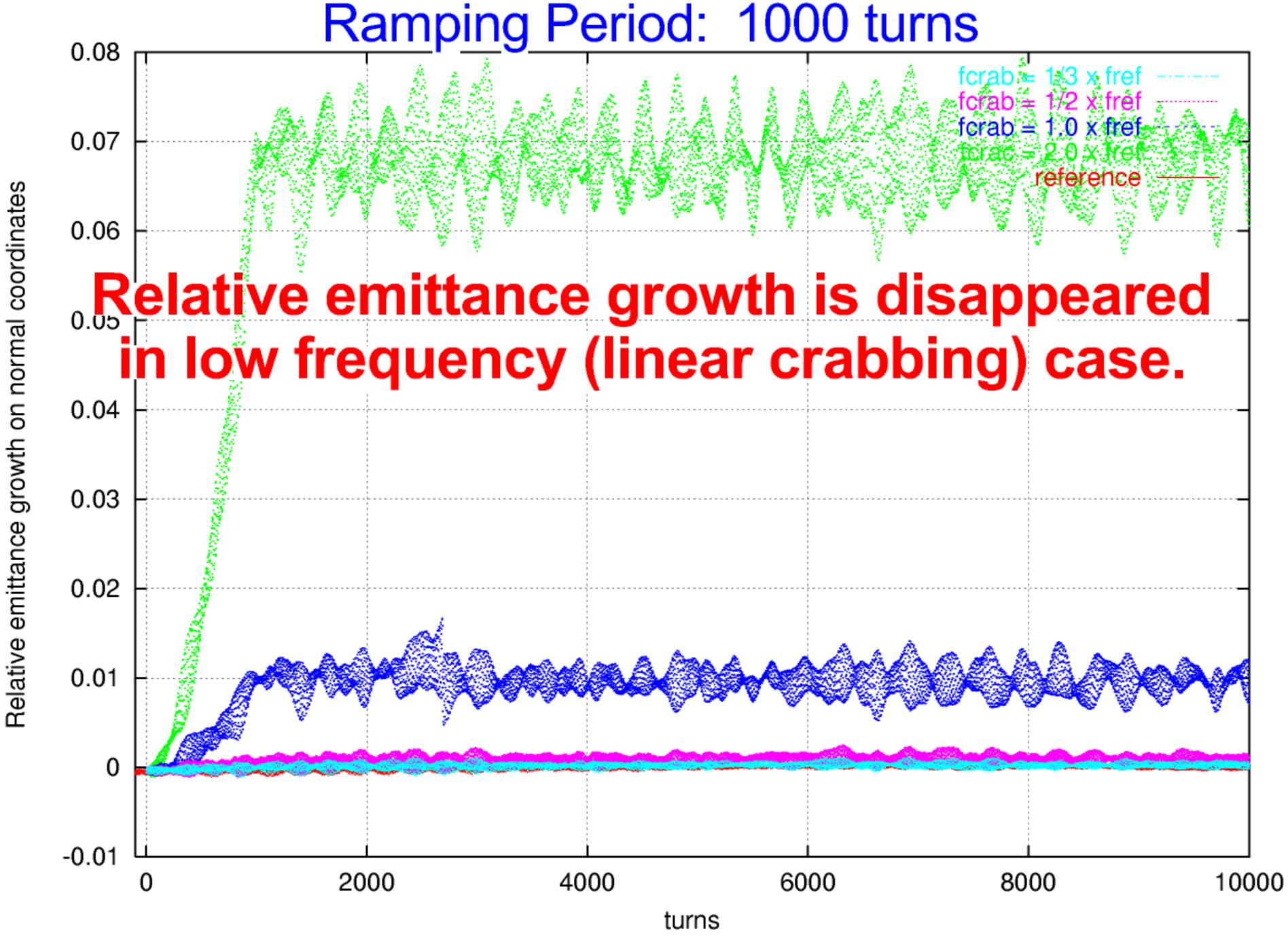
Ramping speed dependent growth is observed at 1/2/5-turn ramping case.

Rapming speed independent growth is observed.

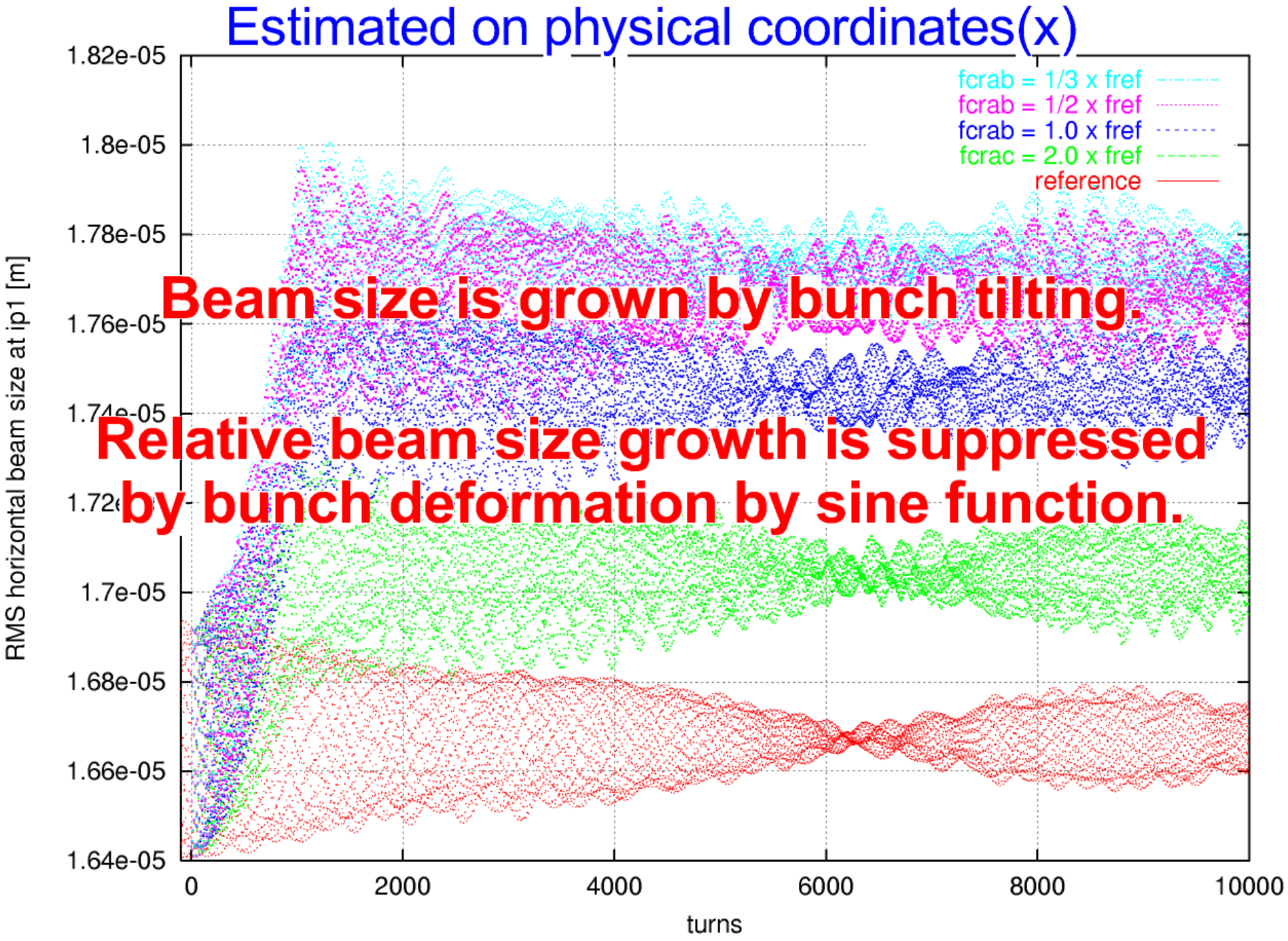
Crab Cavity Voltage Dependency



Crab Cavity Frequency Dependency

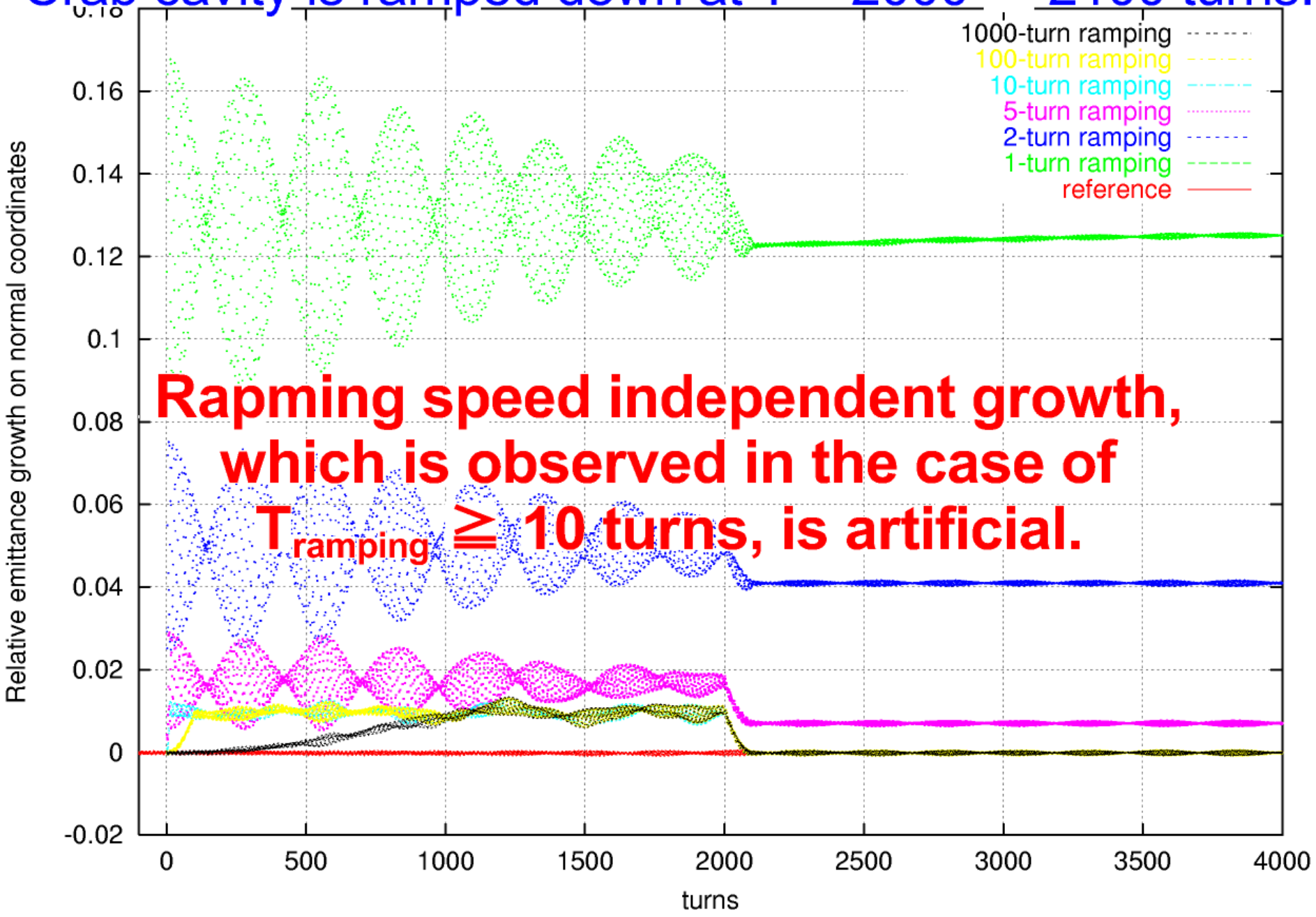


Crab Cavity Frequency Dependency 2



Adiabatic Ramping Down

Crab cavity is ramped down at T = 2000 ~ 2100 turns.



Rapming speed independent growth, which is observed in the case of $T_{ramping} \geqq 10$ turns, is artificial.

Summary & Conclusion

- Summary
  - Ramping Speed Dependent Emittance Growth
    - Observed in the case $T_{ramping} < 10$ turns
  - Ramping Speed Independent Emittance Growth
    - Artificial growth depends with non-linearity of transformation between normal and physical coordinates.
    - It WOULD be solved by non-linear normal coordinate transformation.

- Conclusion
  - Emittance growth by crab cavity voltage ramping is no-problem in single particle dynamics.