PS simulations using PTC-ORBIT

ORBIT User Manual

- Can be found here:

  http://neutrons.ornl.gov/APGroup/Codes/ORBITUserMan1_10.pdf

- Has not been updated since July 1999

First approach

- Idea: testing the PTC-ORBIT vs. machine for beams not space charge dominated.
- PS condition: Injection energy
- As I work before transition, I only use low quadrupoles to set the tunes with natural chromaticities.

Second approach

- Idea: testing PTC-ORBIT specific abilities using more complex beams

- This is the core part of my work

Multipolar errors

- The dipolar errors were determined by simulating beams with errors and matching these simulations with measured PS orbit.
- A document written at PS building time contained errors that were greater than those measured: some correction has been made in the magnets.
- Mariusz Juchno provided us with an analysis of the higher order multipolar errors from simulations.

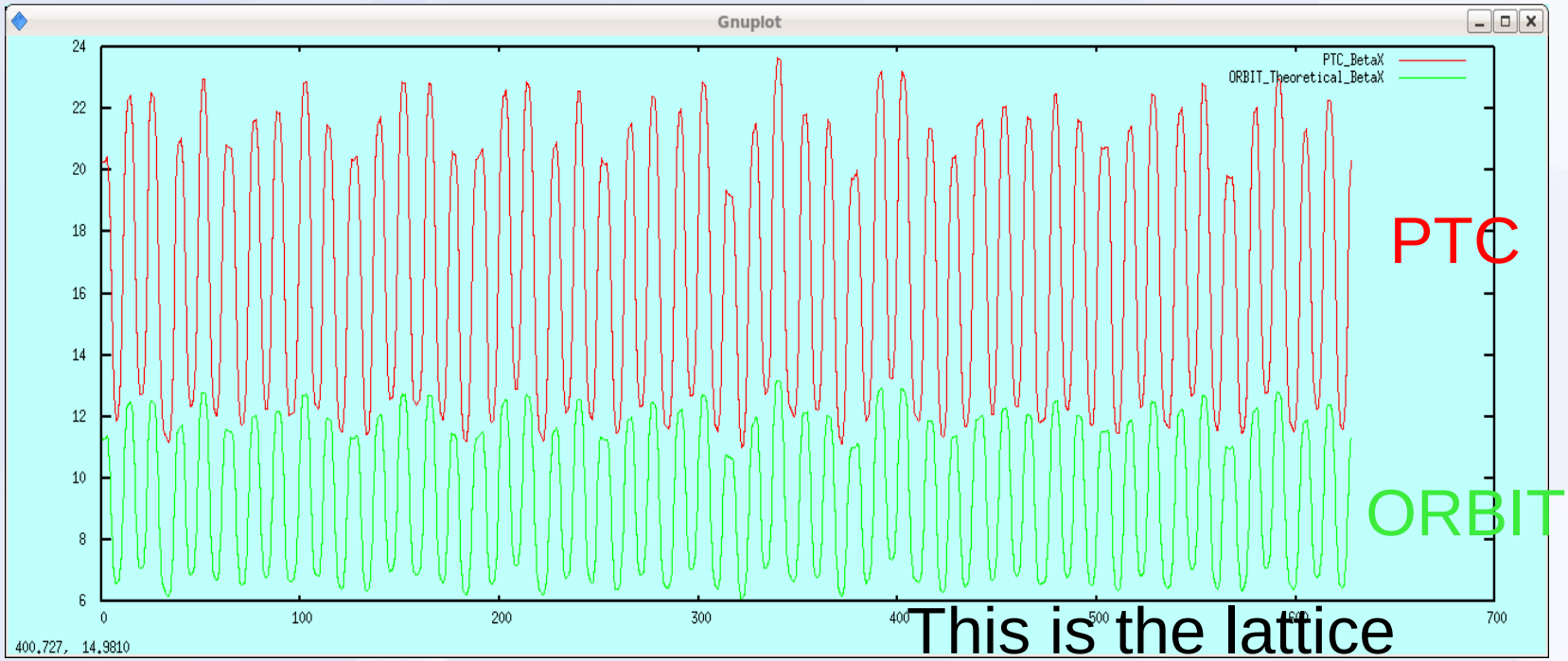
Problems

- I have nearly no accelerator or particle physics knowledge
- Time- and memory-consuming execution
- No real user manual and little help from the programmer

Problems

- Code not finished:
  - I advise to use Path Manager instead of the injection module
  - The aperture module is not working
  - The tune computing module is giving some surprising results

Strange results



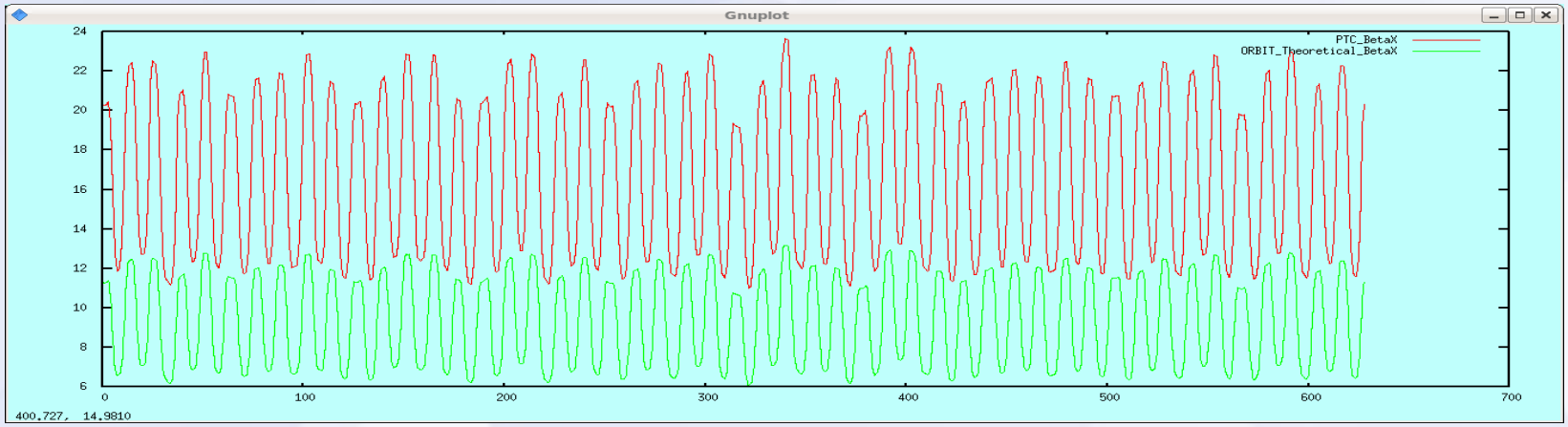
PTC

ORBIT

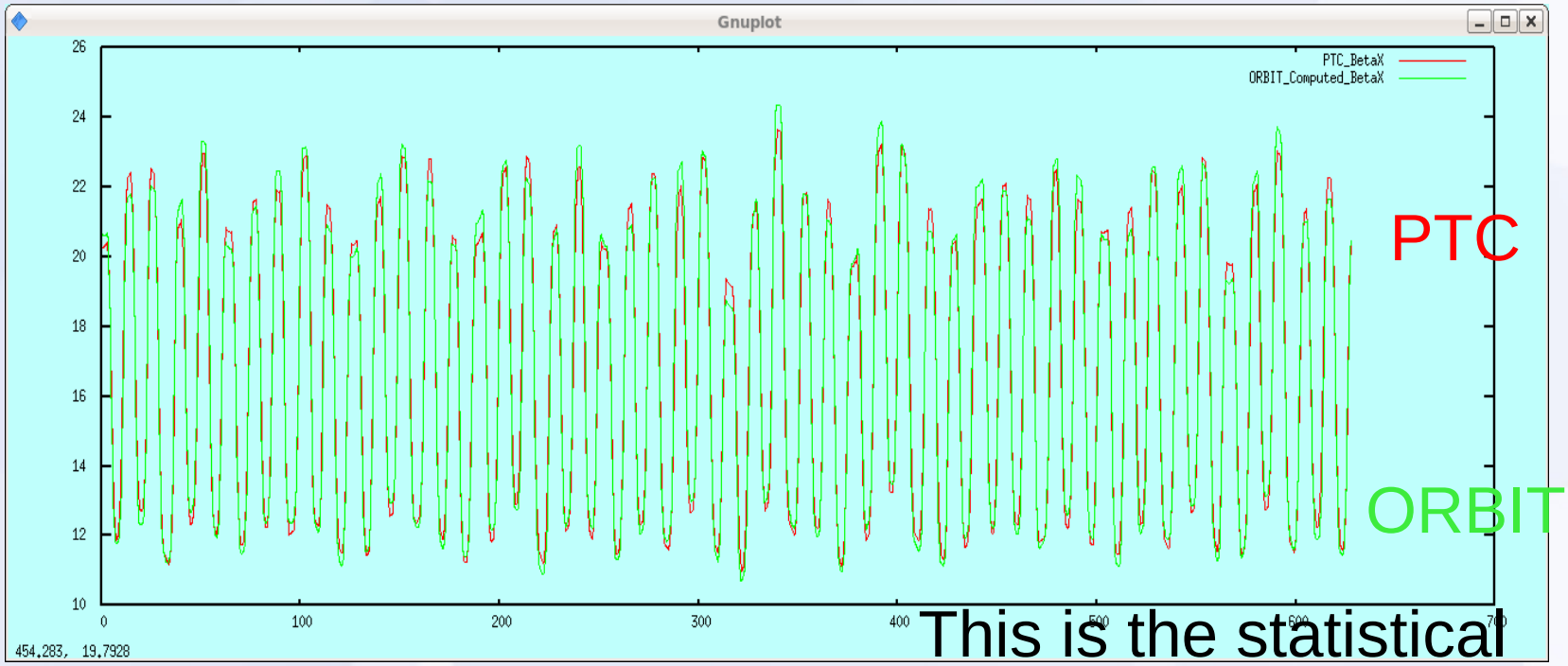
This is the lattice horizontal beta function

Strange results

The horizontal beta function used as lattice definition by ORBIT is incorrect



Strange results



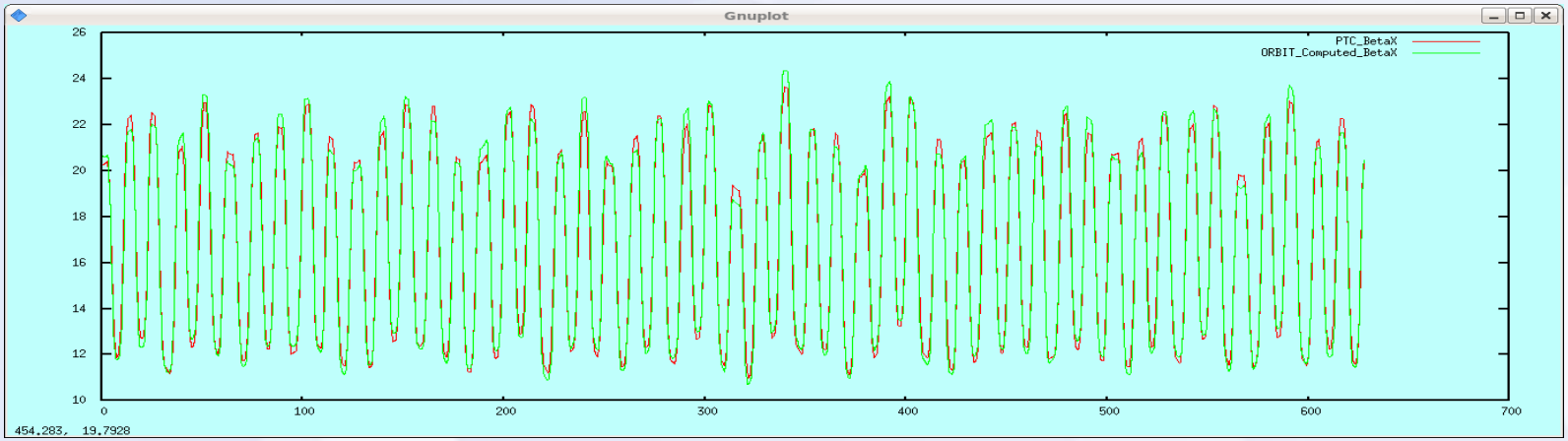
PTC

ORBIT

This is the statistical horizontal beta function

Strange results

Hopefully, the statistical horizontal beta function is correct.

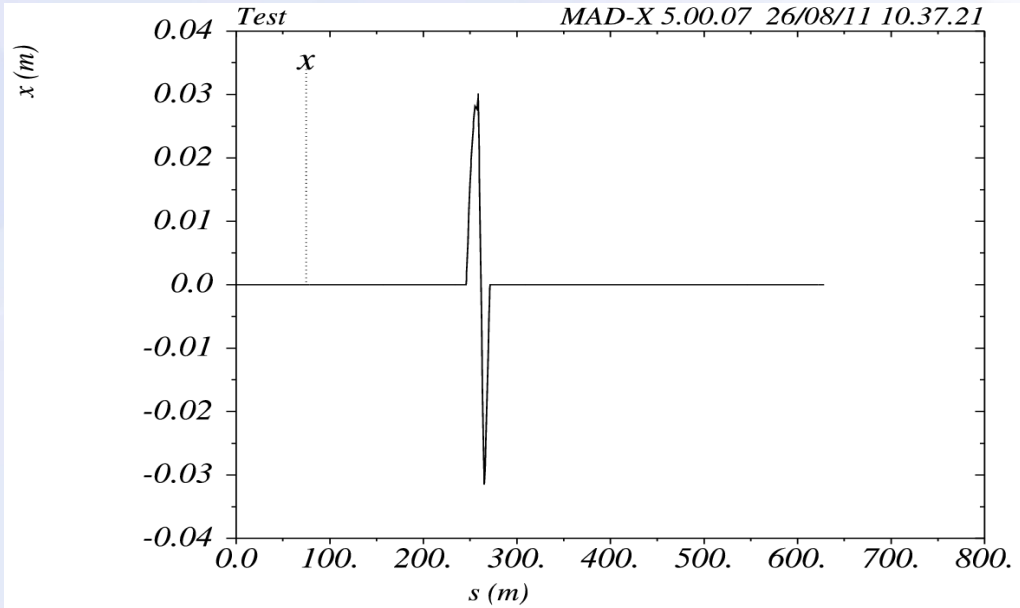


Simulations: injection

- PTC-ORBIT main contribution: time-evolving elements

- Injection bump at 1.4 GeV
- No RF, no space charge
- No multipolar error
- Tunes: H=6.2 V=6.3

- 4 bumpers that close the bump

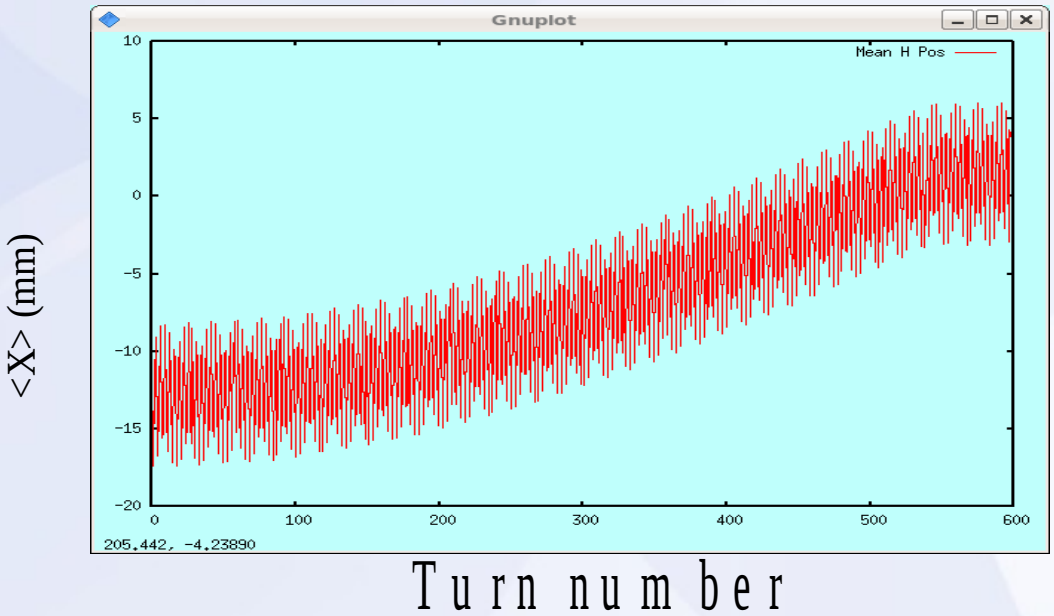


Simulations: injection

- PTC-ORBIT main contribution: time-evolving elements

- Same values as before but multiplied by a cosinus to amortize the dump

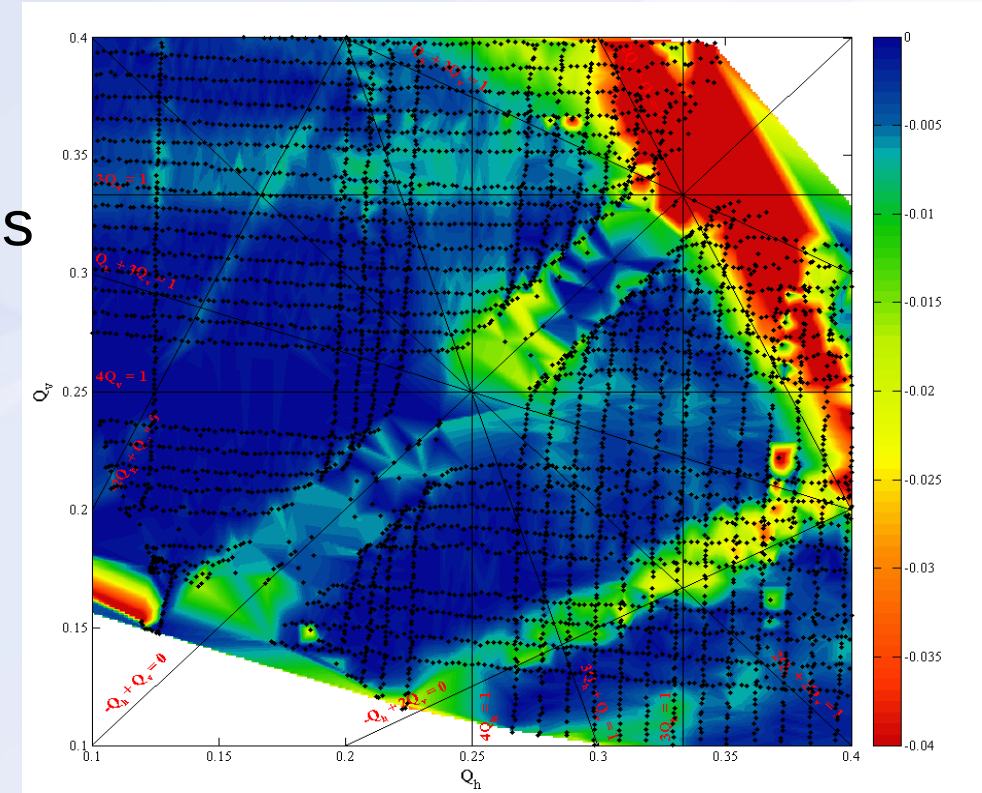
- These are the <X> shortly after the last bumper
- RMS Emittances:
  H: 0.265 mm.mrad
  V: 0.270 mm.mrad



Experimental results

- Elena's resonance measurements

- The color indicates the particle losses.
- Blue is stable while red is not.
- Only black points are measurements, the rest is interpolation
- Objective: reproduce it using simulation

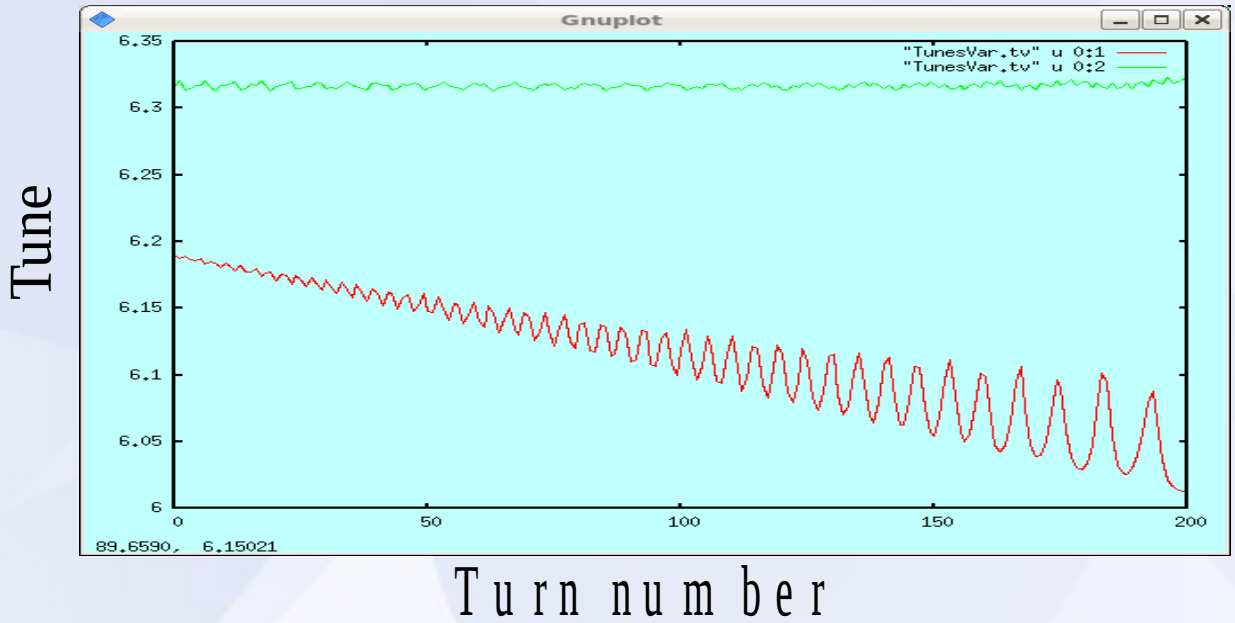


Simulations: tune

- Injection: 1.4 GeV without bump
- No space charge
- Only dipolar errors
- Tunes: H=6.2→6.05 V=6.3
- Emittances RMS (mm.mrad): H=0.265 V=0.27

Simulations: tune

Varying tune is possible

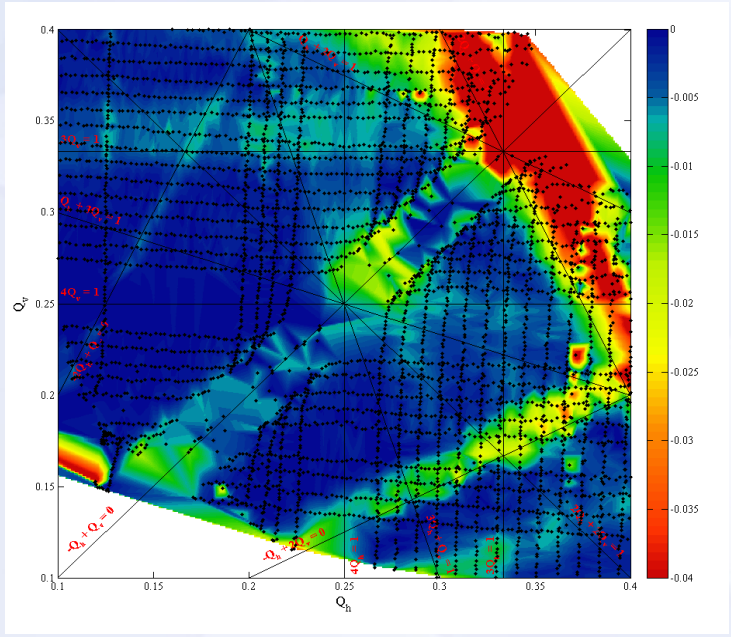


Vertical

Horizontal

Conclusion

- Failure due to lack of time and due to status of the code when started
- Some resonance have been observed



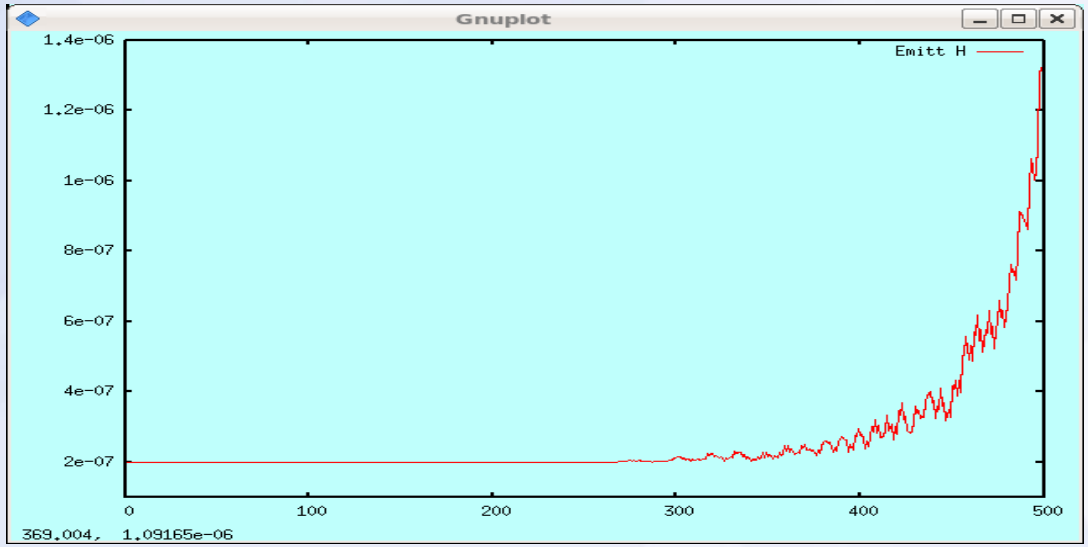
Simulations: resonance

- Integer resonance:
- Injection: 1.4 GeV without bump
- No space charge
- Only dipolar errors
- Tunes: H=6.2→6.0 V=6.3
- Emittances RMS (mm.mrad): H=0.265 V=0.27

Simulations: resonance

- Integer resonance

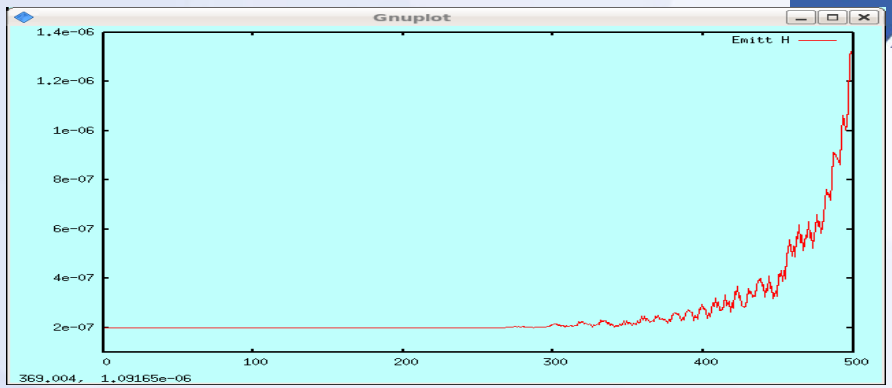
Horizontal RMS Emittance (m.rad)



Turn number

Simulations: resonance

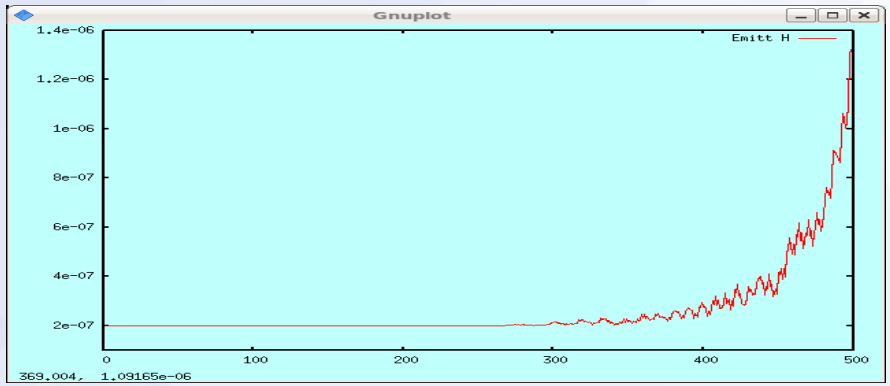
- Integer resonance



- It was chosen to consider that the beam entered the resonance band when emittances had increased by more than 10%.
- As the tune computations were no longer reliable at that position, the band width was determined using the tune evolution function programmed.

Simulations: resonance

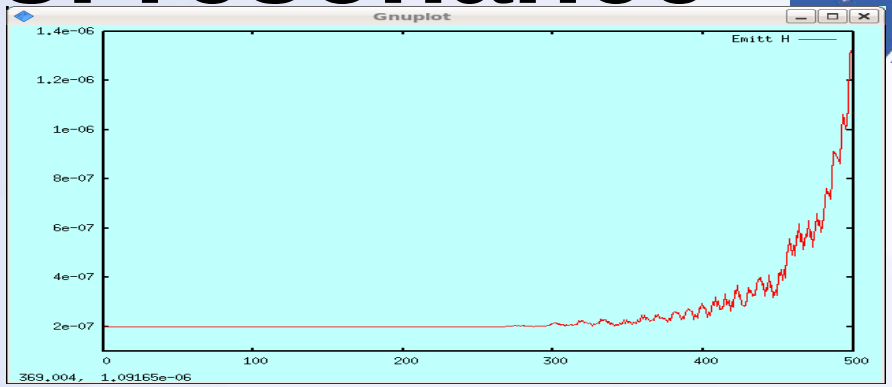
- Integer resonance



	Horizontal resonance	Vertical resonance
Measurements	0.05	0.03
Simulations	0.008	0.011

Simulations: resonance

- Integer resonance



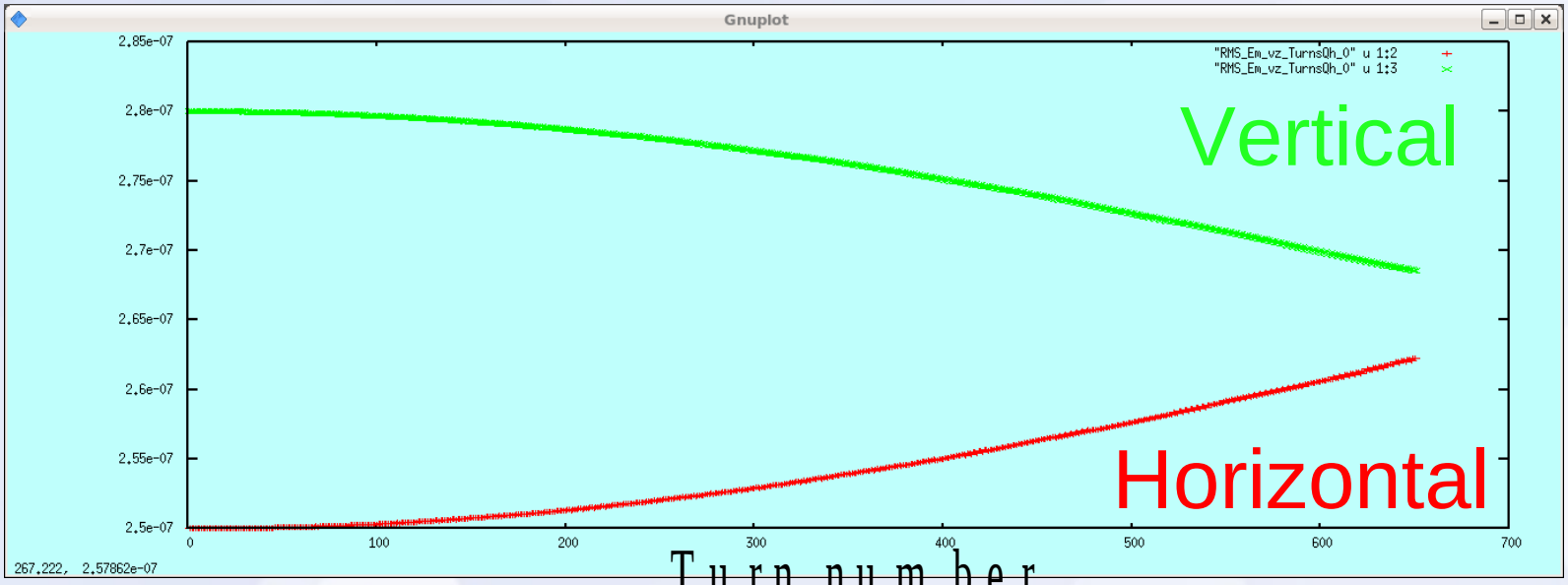
- Many factors can explain the difference between these values:
  - No space charge,
  - No higher order multipolar errors,
  - Different definition of the band width,
  - ...

Simulations: resonance

- Emittance coupling:
- Injection: 1.4 GeV without bump
- No space charge
- No RF
- Only dipolar errors
- Tune constant: H=6.33 V=6.33
- Various durations and RMS emittances

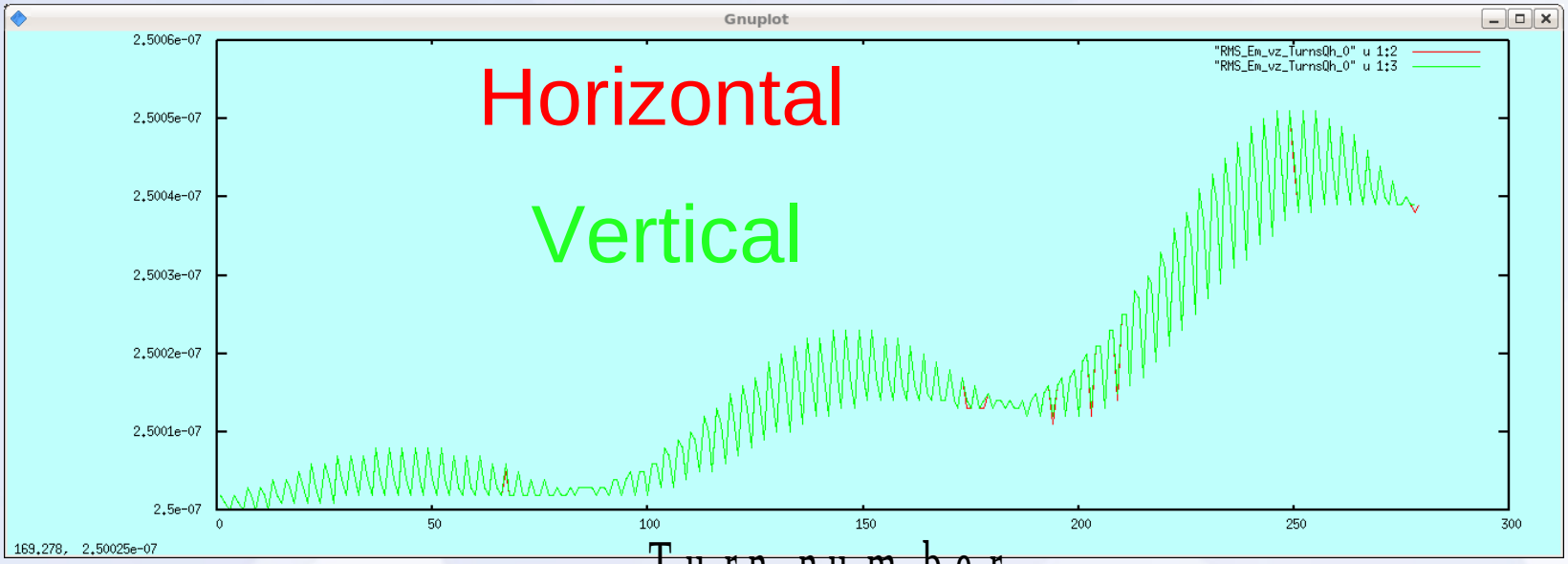
Simulations: resonance

- Emittance coupling:RMS Emittances (m.rad)



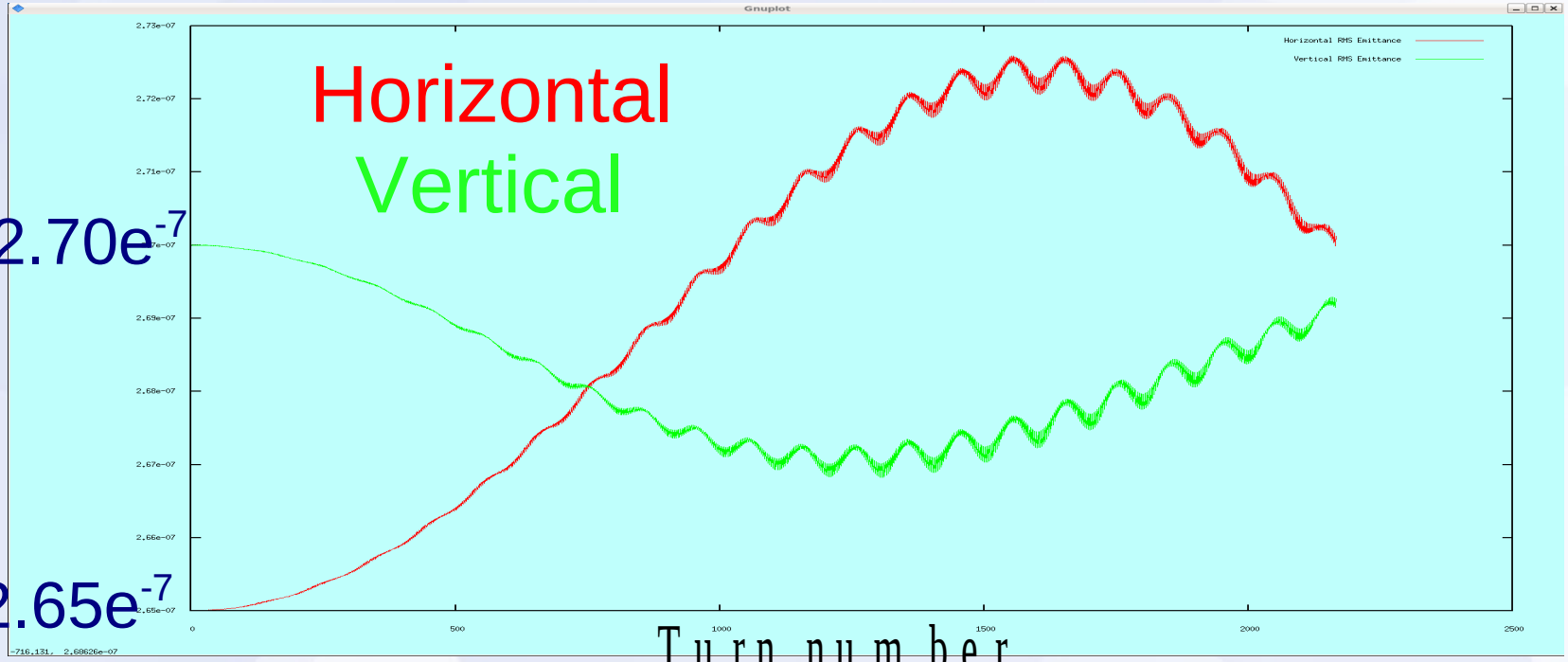
Simulations: resonance

- Emittance coupling:RMS Emittances (m.rad)



Simulations: resonance

- Emittance coupling: RMS Emittances(m.rad)



Simulations: multiple effects

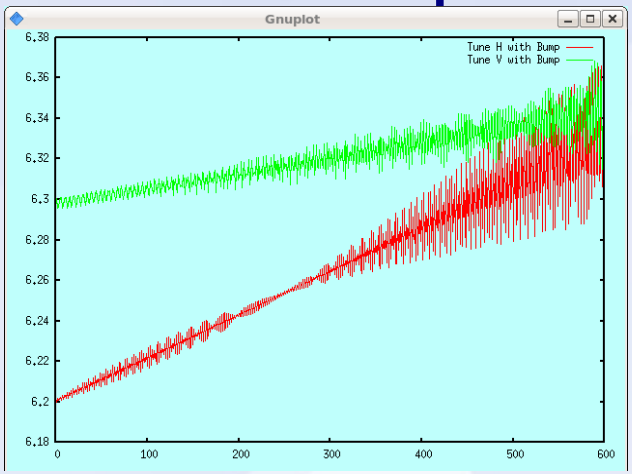
- Injection : 1.4GeV with bump
- No space charge
- No RF
- Only dipolar errors
- Tunes varying
- RMS Emittances (m.rad): H=2.65e^{-7} V=2.70e^{-7}

Simulations: multiple effects

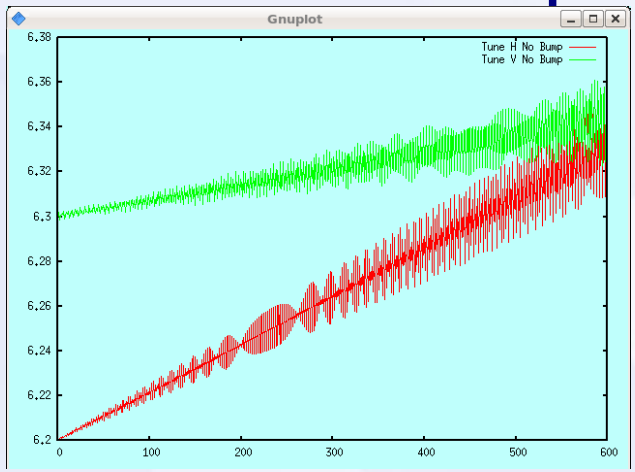
- Bump and Tune variation

Horizontal Tune Vertical Tune

With bump



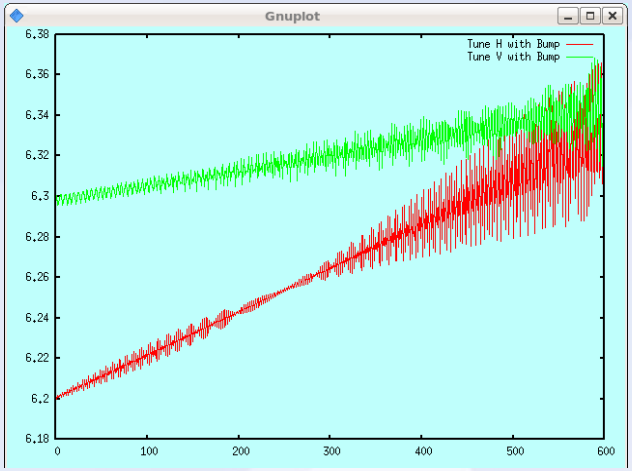
Without bump

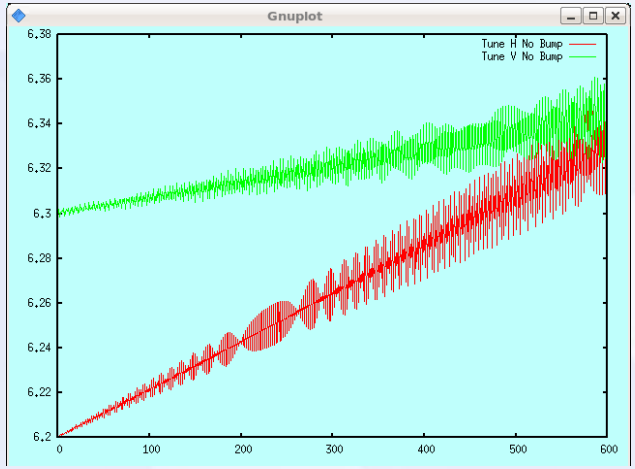


Simulations: multiple effects

- Bump and Tune variation

  The oscillation are slightly more important but the trend is correct



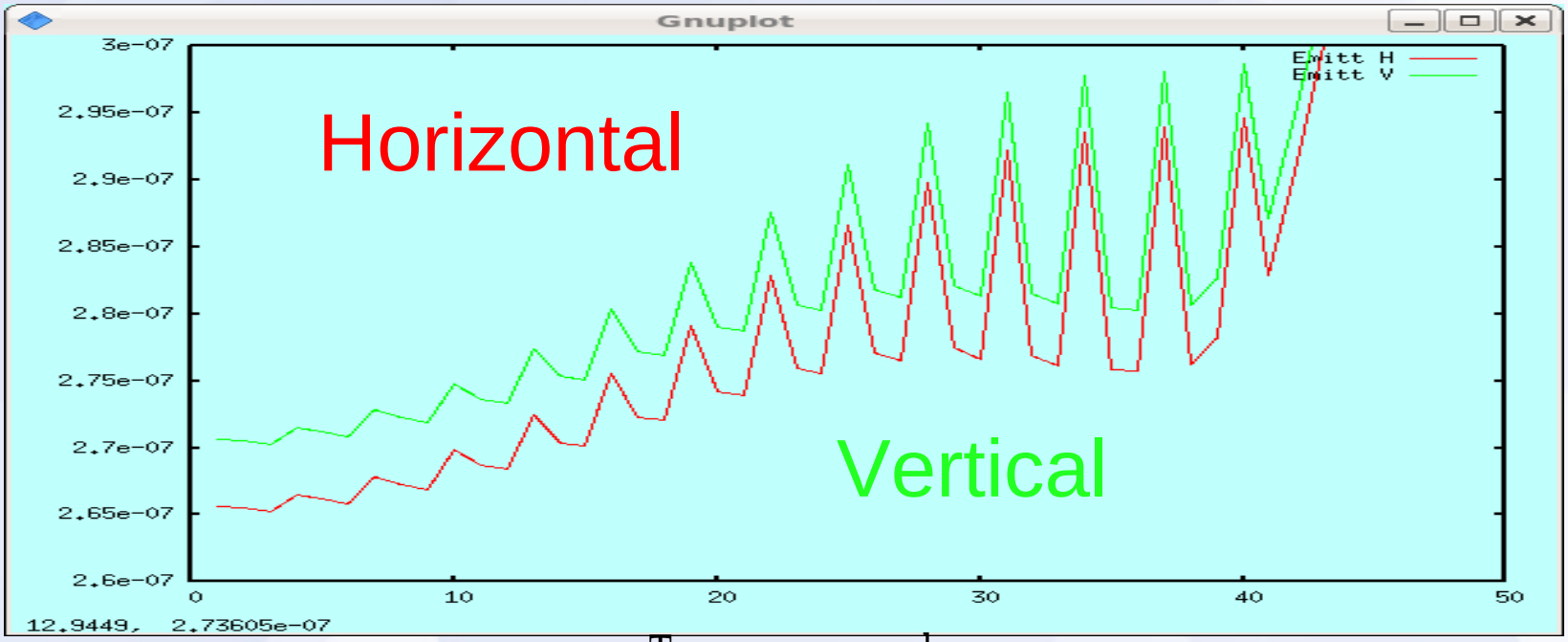


Simulations: resonance

- Injection: 1.4 GeV without bump
- No space charge
- No RF
- Dipolar, quadrupolar and sextupolar errors
- Tunes constant: H=6.33 V=6.33
- RMS Emittances (m.rad): H=2.65e^{-7} V=2.70e^{-7}

Simulations: resonance

- Sextupolar resonance: RMS Emittance



Simulations: others

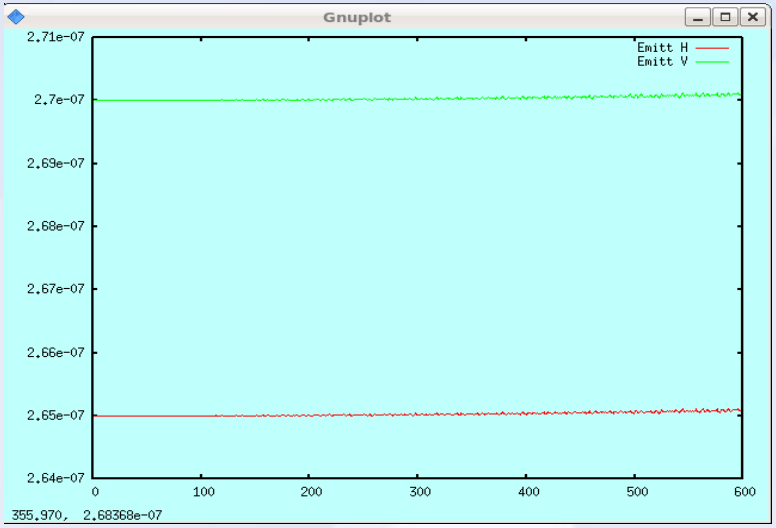
- Injection: 1.4 GeV without bump
- Space charge
- No RF
- Only dipolar errors
- Tunes constant: H=6.2 V=6.3
- RMS Emittances (m.rad): H=2.65e^{-7} V=2.70e^{-7}

Simulations: others

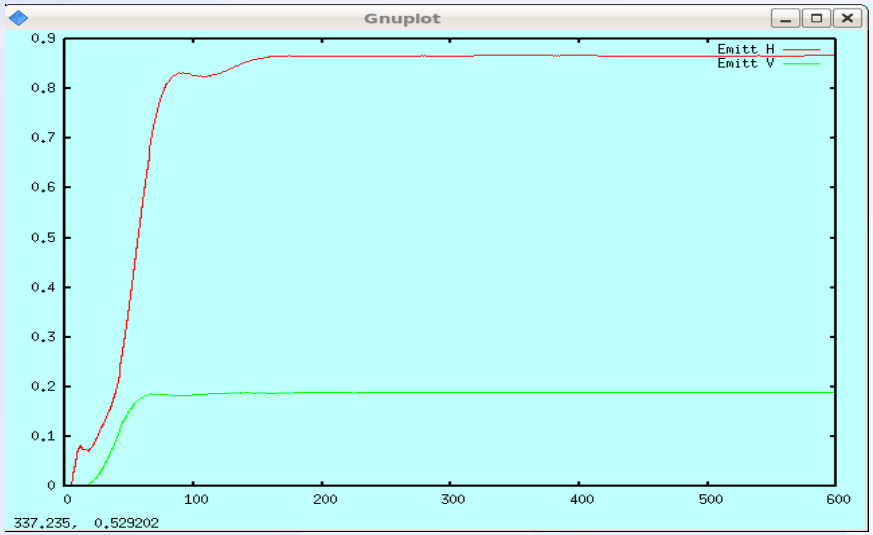
- Space charge: RMS Emittances (e^{-7}mm.mrad)

Horizontal Vertical

Without space charge



With space charge

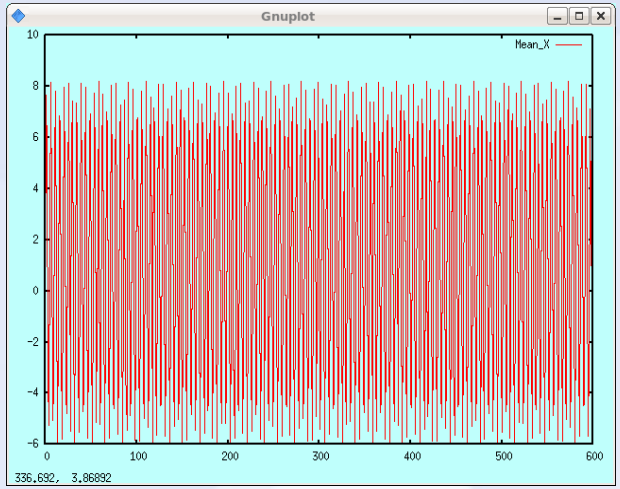


Simulations: others

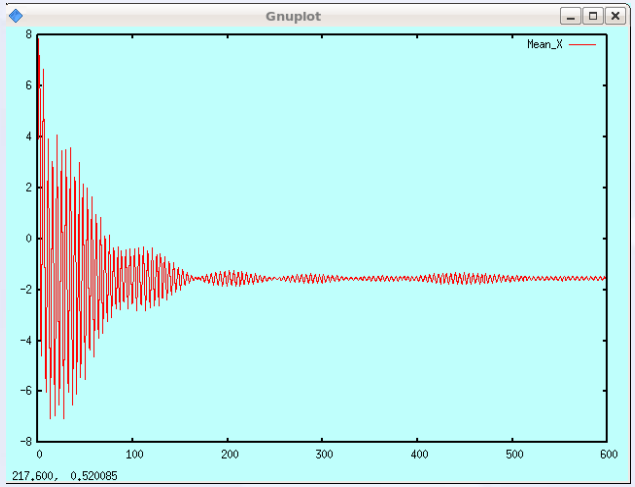
- Space charge

<X>(mm)

Without space charge



With space charge

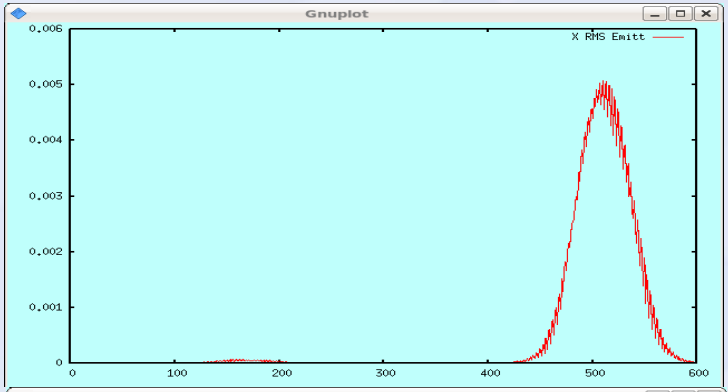


Simulations: others

- Injection: 1.4 GeV without bump
- No space charge
- Radio frequency with multiple harmonics and currents
- No multipolar error
- Tunes: H=6.3 V=6.2
- RMS Emittances (m.rad): H=2.65e^{-7} V=2.70e^{-7}

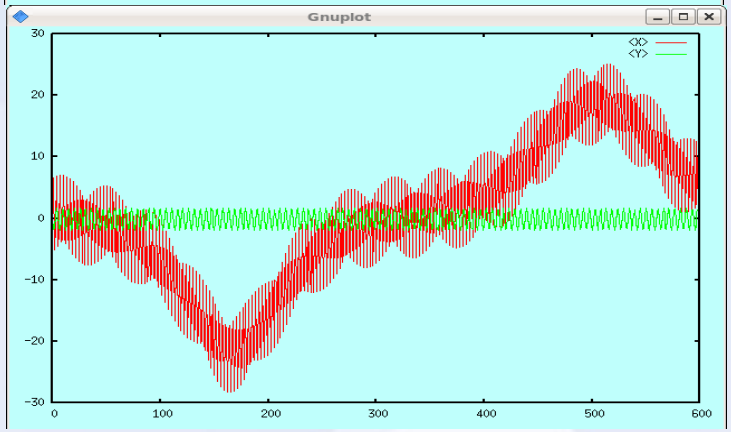
Simulations: others

Radio Frequency: current = 50 kV Harmonic = 8



RMS Horizontal Emitance

(m.rad)



<X> <Y> (mm)

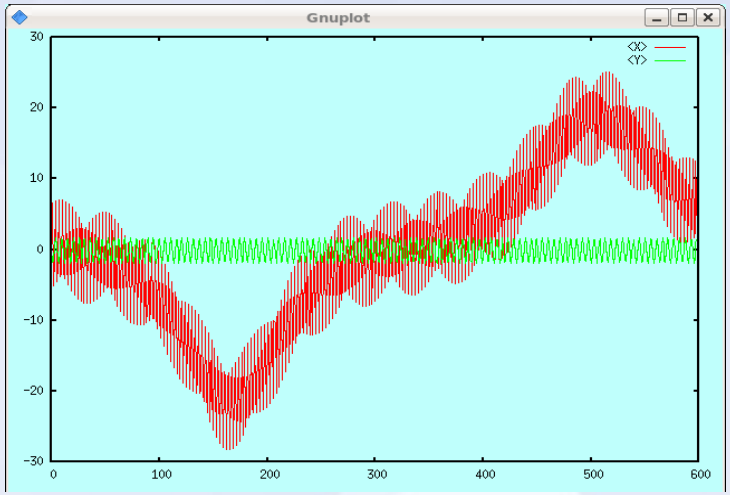
Turn number

Simulations: others

- Radio Frequency: V = 50 kV

Harmonic:

8



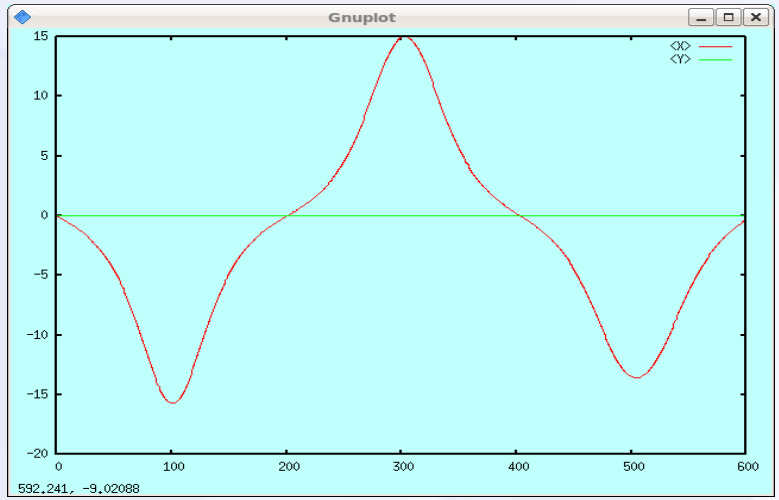
<X>

<Y>

(mm)

Turn number

16



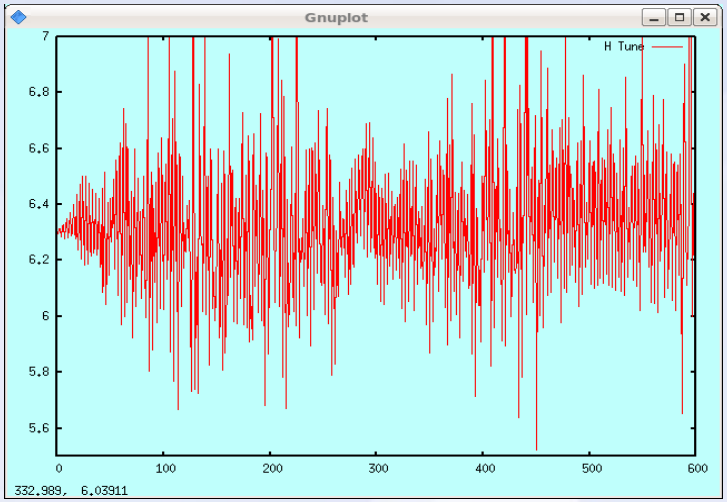
Turn number

Simulations: others

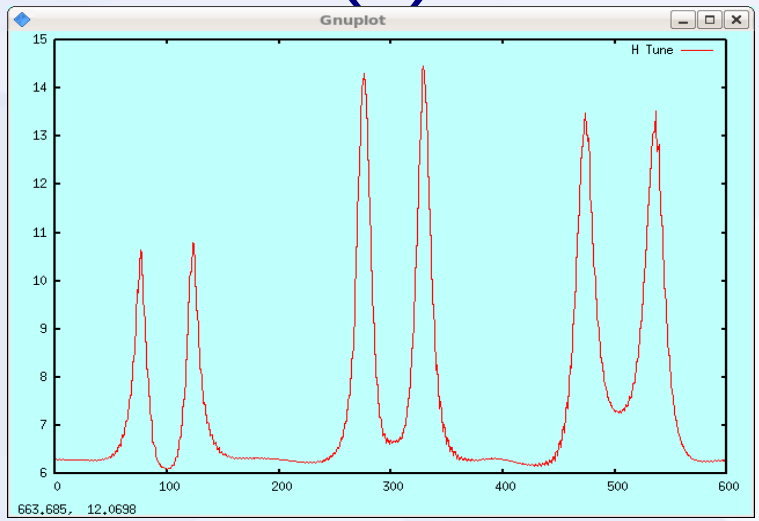
- Radio Frequency: V = 50 kV

Harmonic:

8



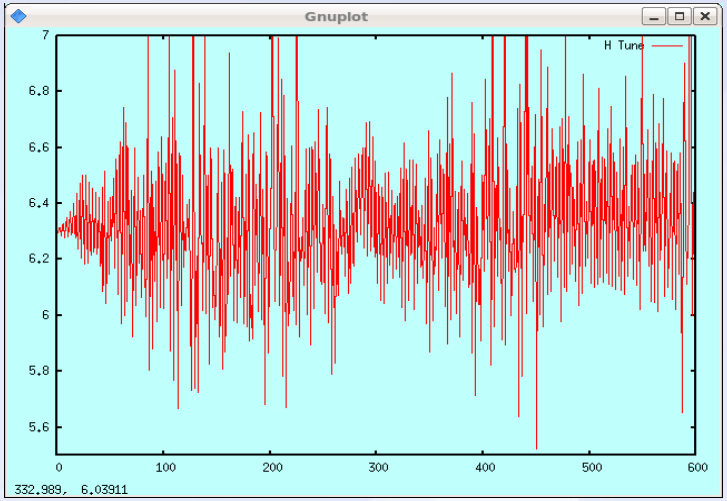
16 (?)



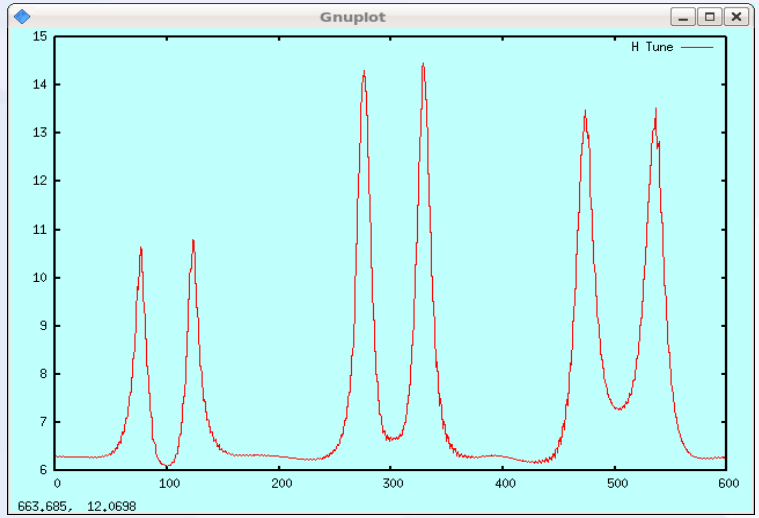
Simulations: others

- Radio Frequency:

Unexpected and unexplained result



Tune H

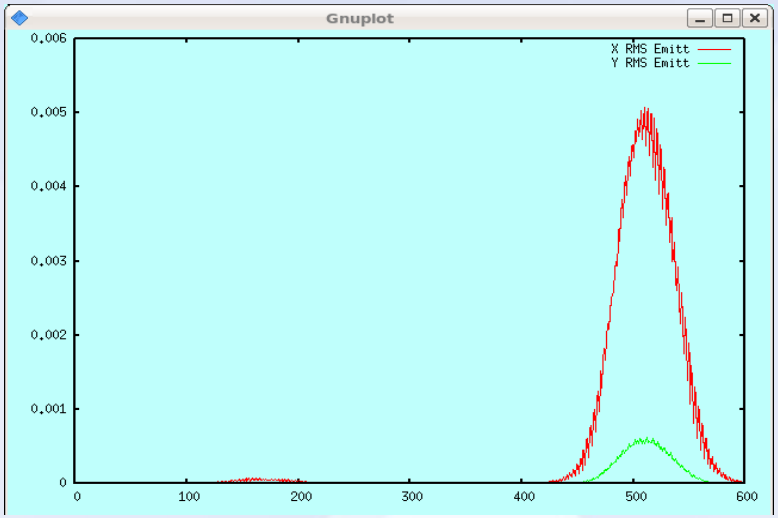


Simulations: others

- Radio Frequency: V = 50 kV

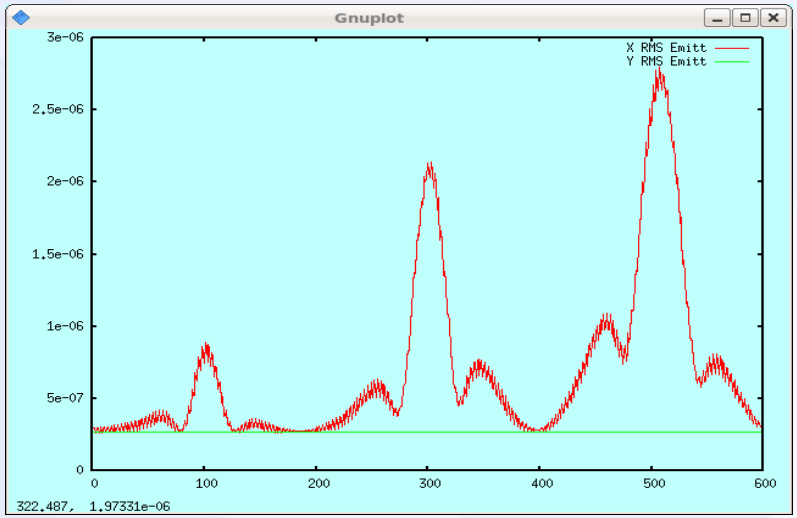
Harmonic:

8 RMS Emittances(m.rad) 16



H

V



Simulations: others

- Radio Frequency: V = 50 kV

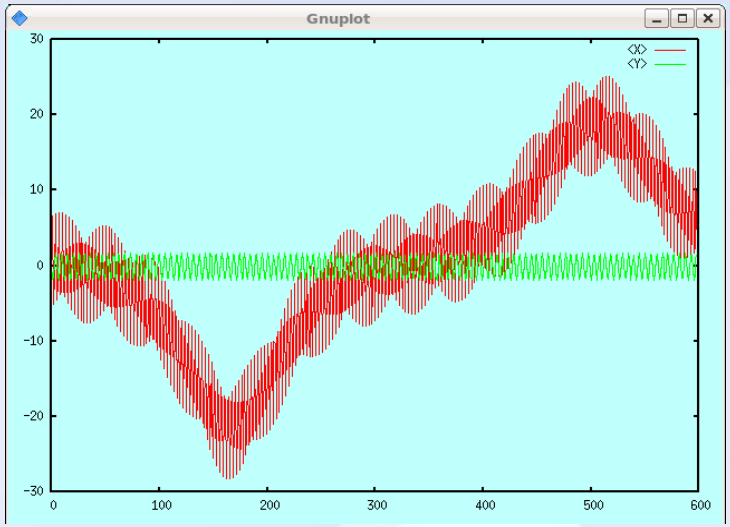
- The peak amplitude is quickly increasing which is unexpected.
- The pseudo-period of the peaks is approximately the synchrotronic period.

Simulations: others

- Radio Frequency: Harmonic = 8

V:

50kV

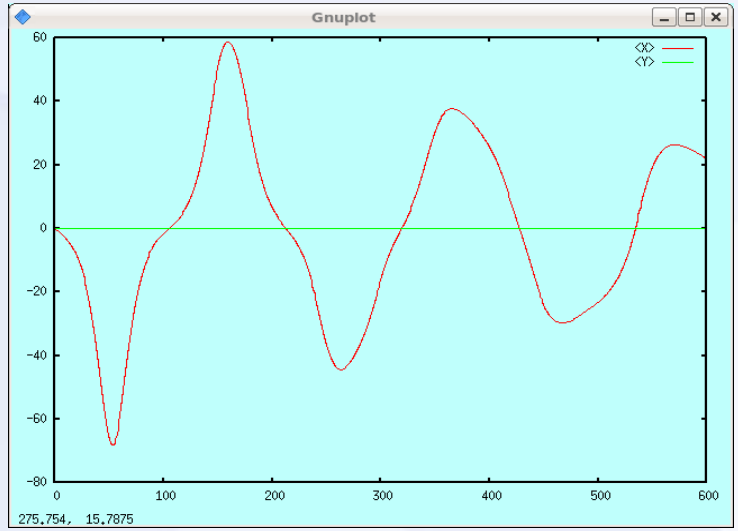


<X>

<Y>

(mm)

500kV



Turn number

Turn number

I thank you for your attention