Summary of session 2 on Experimental tools

Yannis PAPAPHILIPPOU

Non-linear Beam Dynamics workshop
ESRF - Grenoble, May 26th-28th, 2008

Outline

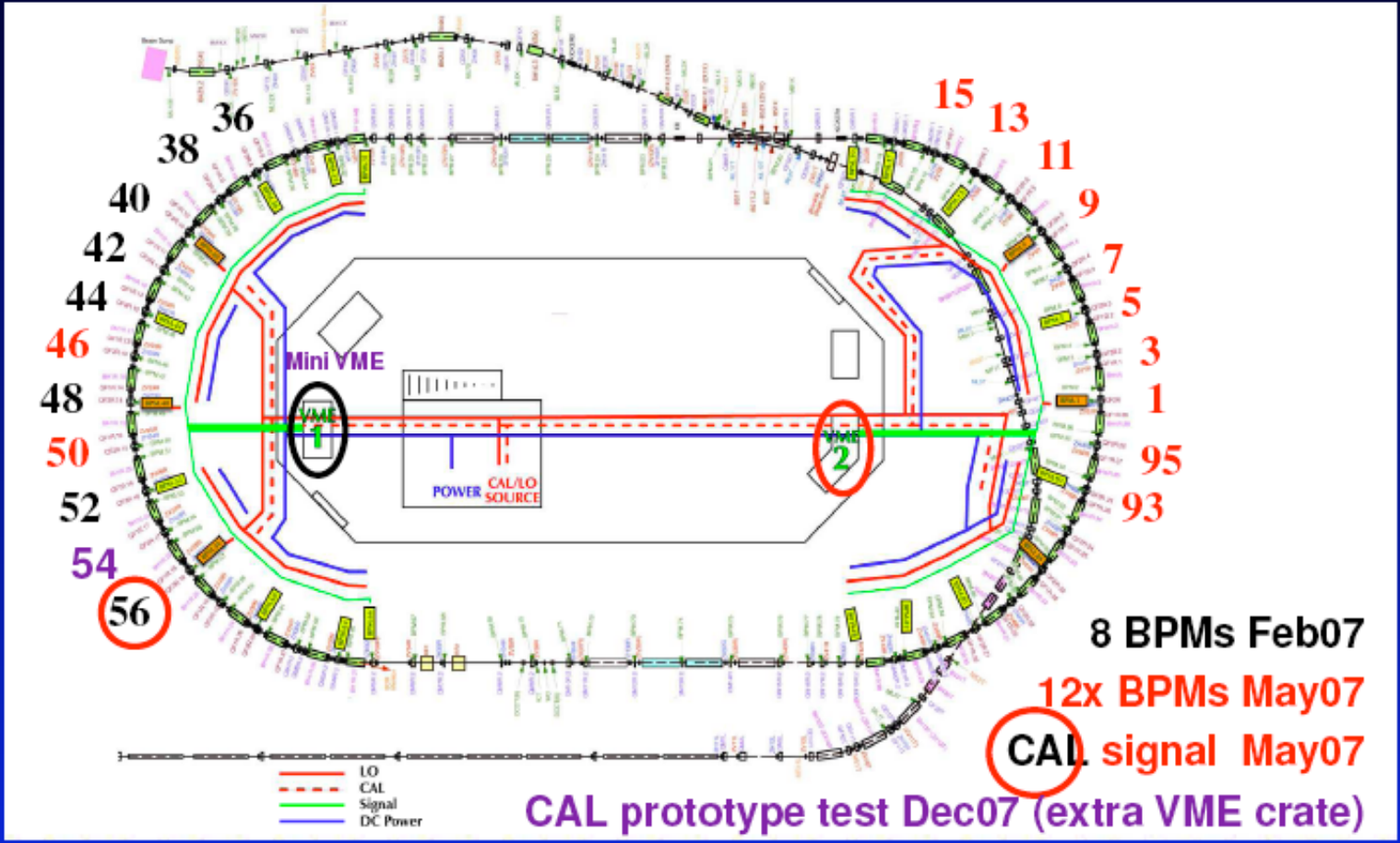
- Three talks:
  - R. Tomas, “Measurement of resonance driving terms in the ATF ring”
  - E. Plouviez, “Diagnostics for non-linear dynamics studies”
  - L. Farvacque, “Frequency maps at the ESRF”

Measurement of resonance terms in the ATF Damping Ring via the Fourier spectrum of turn-by-turn data

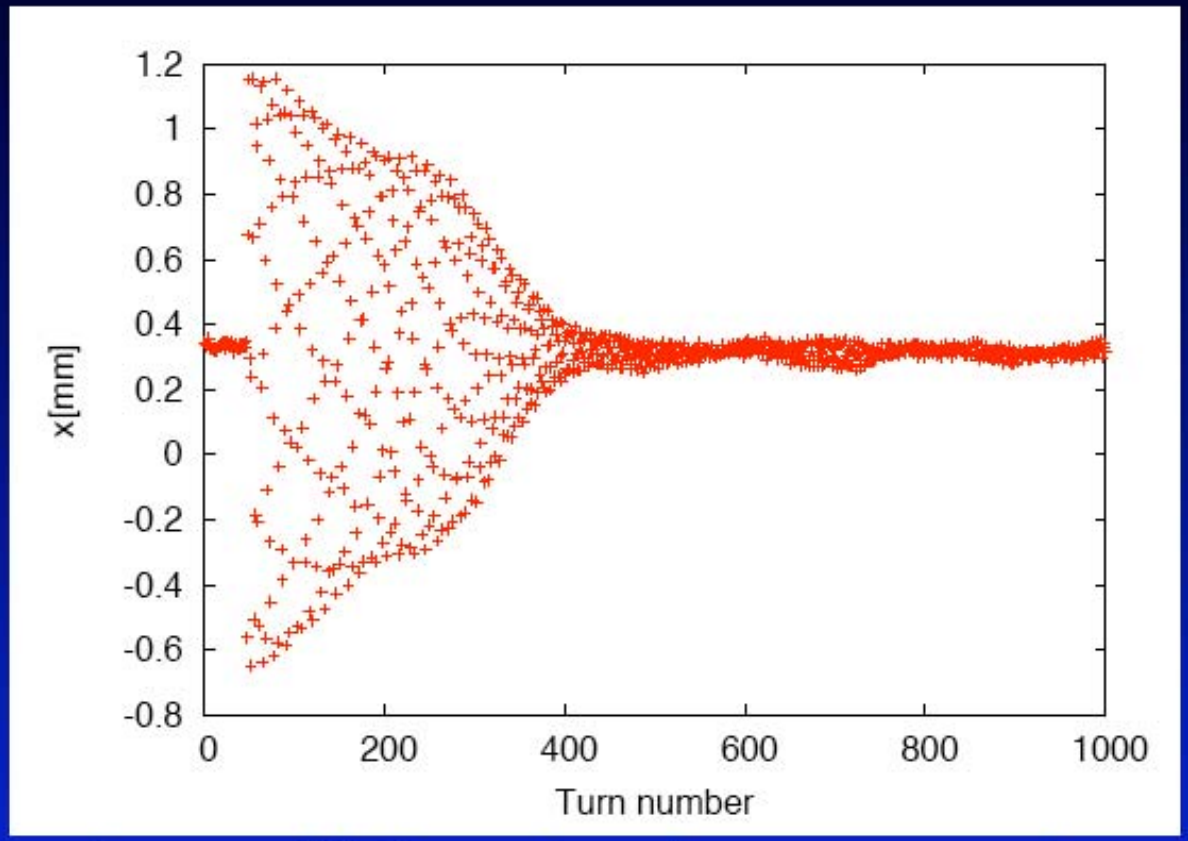
R. Tomás, F. Zimmermann, CERN
K. Kubo, S. Kuroda, T. Naito, T. Okugi, J. Urakawa, KEK

Thanks to: H. Braun and Y. Papaphilippou

ATF Damping Ring



Trun-by-turn BPM data



→ A single-turn kick excites betatron motion.

→ Filamentation damps the centroid oscillation.

What is f_{jklm}?

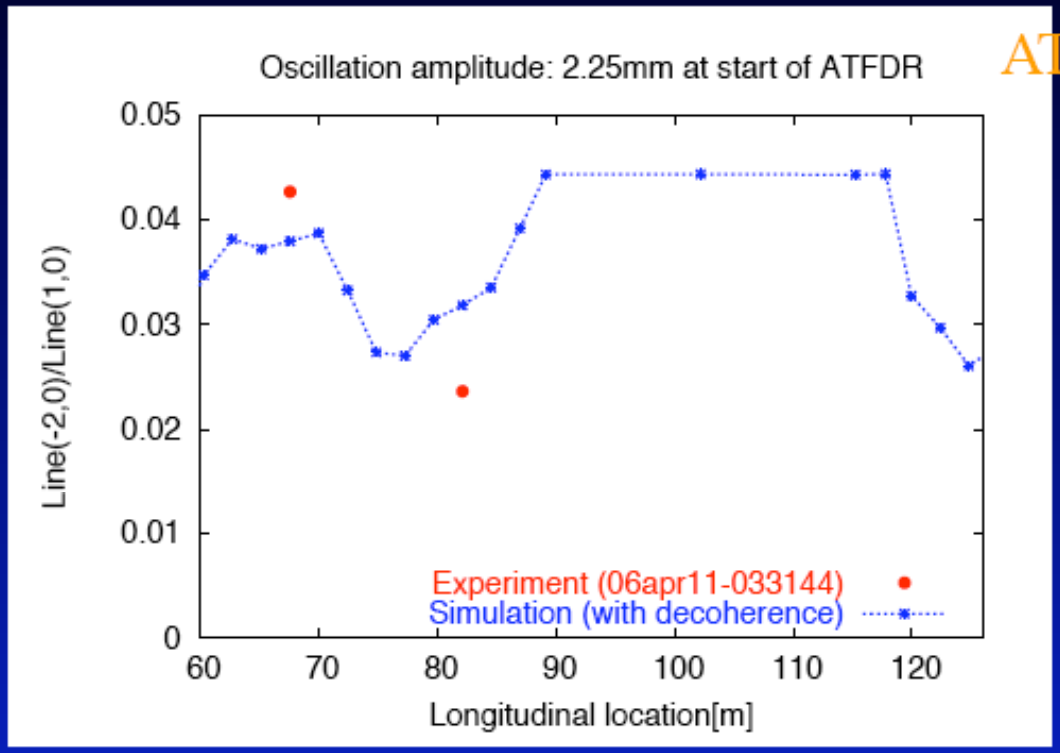
It is proportional to the Hamiltonian term h_{jklm}:

$$f_{jklm} = \frac{h_{jklm}}{1 - e^{-i2\pi[(j-k)Q_x+(l-m)Q_y]}} .$$

It drives resonances and spectral lines:

Term	Resonance	Type	Line	Plane
f_{1001}	(1,-1)	norm.	$-Q_y$	H
f_{3000}	(3,0)	norm.	$-2Q_x$	H
f_{0210}	(2,1)	skew	$2Q_x$	V
f_{0030}	(0,3)	skew	$-2Q_y$	V

Measuring (3,0) Resonance

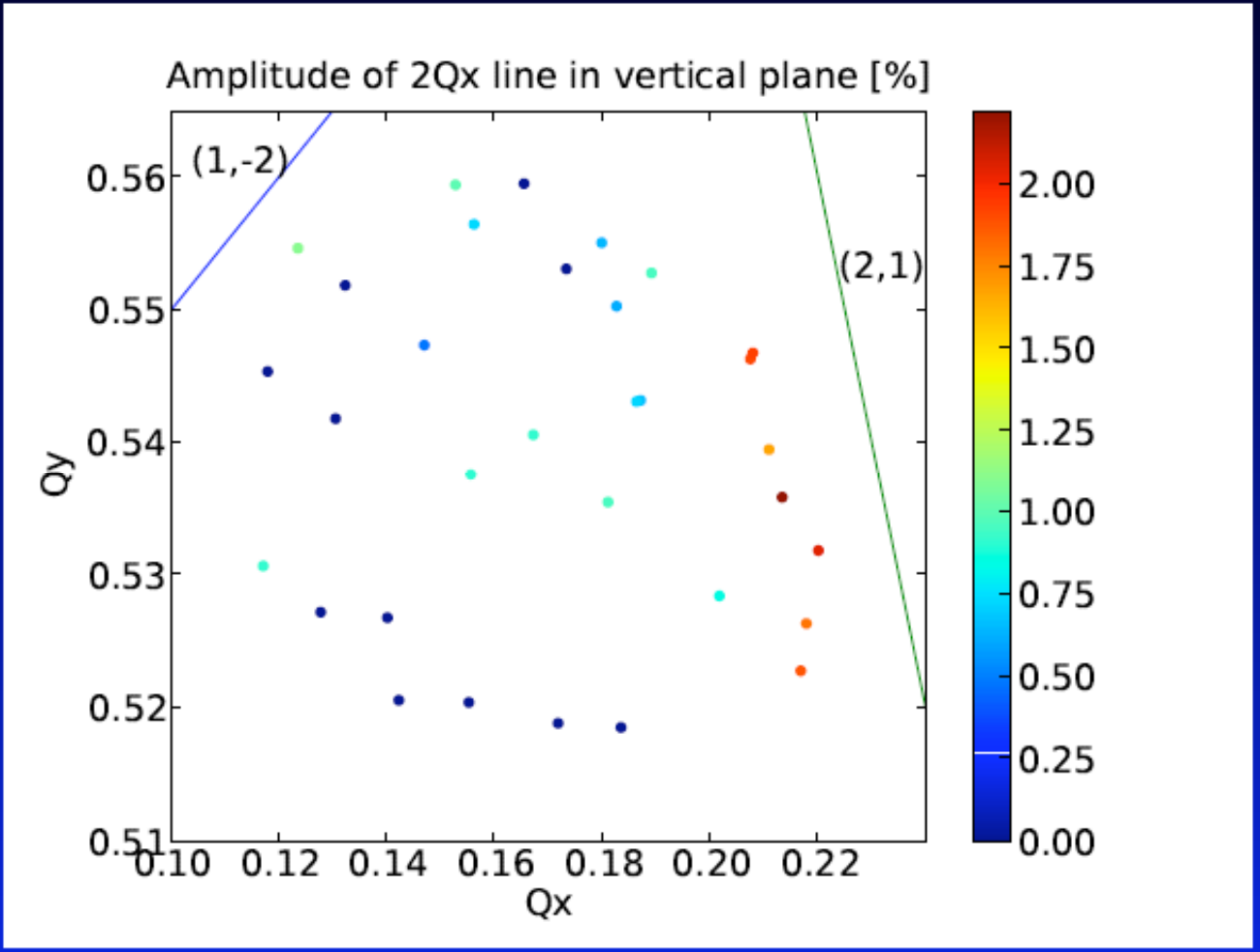


ATF report 06-08

Horizontal resonance (3,0) succesfully probed via spectral line -$2Q_x$.

However vertical plane totally unprobed.

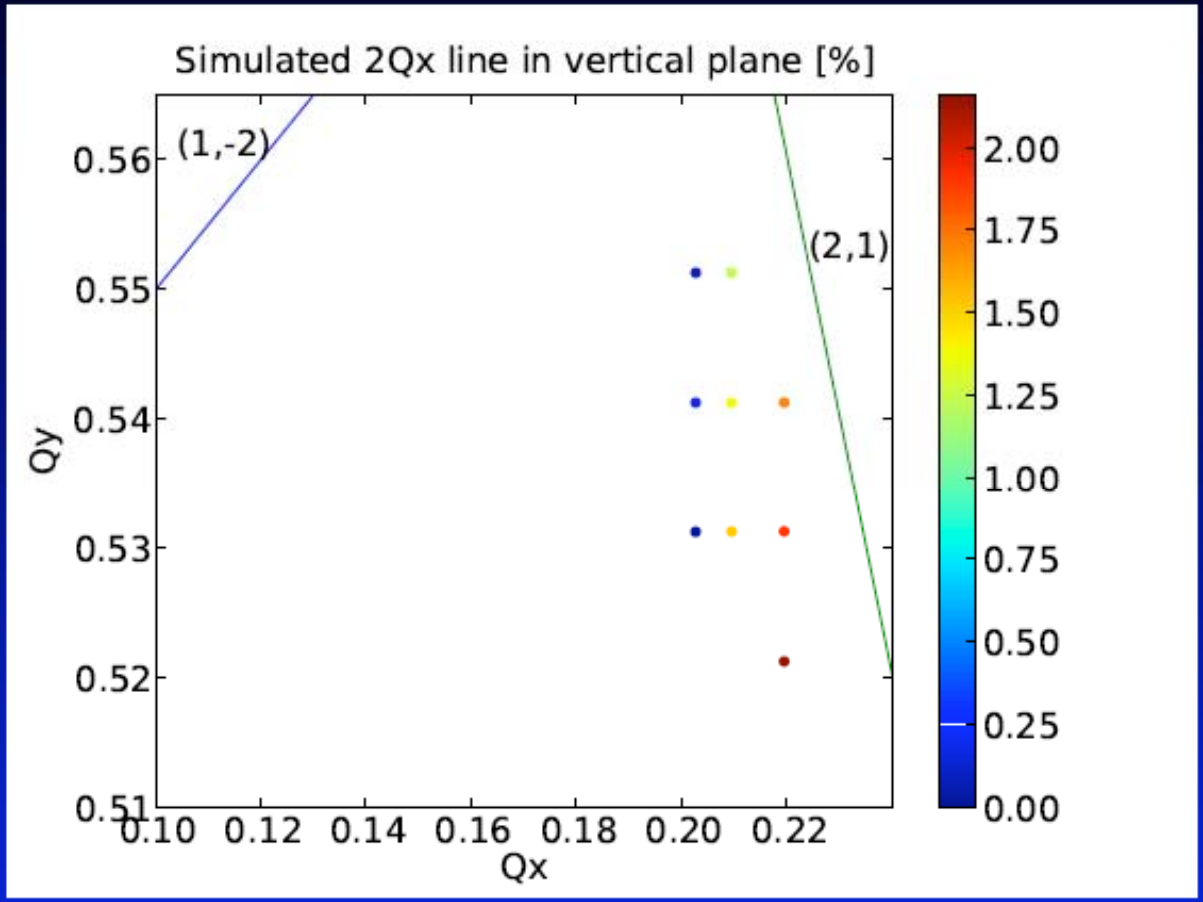
Measuring skew resonance (2,1)



→ Clear correlation between line and resonance!

→ And it seems to be large!

Simulating resonance (2,1)



→ 10mrad random tilts at the sextupoles are required to reproduce the measurement.

Conclusions

- Measurement of resonance driving terms proofs useful in ATF.
- Important coupling and skew sextupolar errors have been identified.
- A realignment of the machine is being considered to correct these errors (ATF has no skew sextupoles).
- Many turn-by-turn BPMs are being installed
- This coud allow localizing errors as in the SPS...

Diagnostics for non linear beam dynamic studies at ESRF

E. Plouviez, K. Scheidt

Production of non linears phenomenons

- Single turn kickers magnets:
- Horizontal:

injection kickers
1us rise time and fall time, 1us flat kick

- Vertical:

Dedicated kicker with similar pulse shape

- Amplitude of the kicks:
- Horizontal: 2 mrad at with β=5m
- Vertical: more than enough…(limited by the +/-4mm ID chambers physical aperture)

Used to kick a 1us pulse bunches train (1/3 filling patern)

Turn by turn measurement

From 2000 until the *Libera* implementation:

The “1000 tours” system:

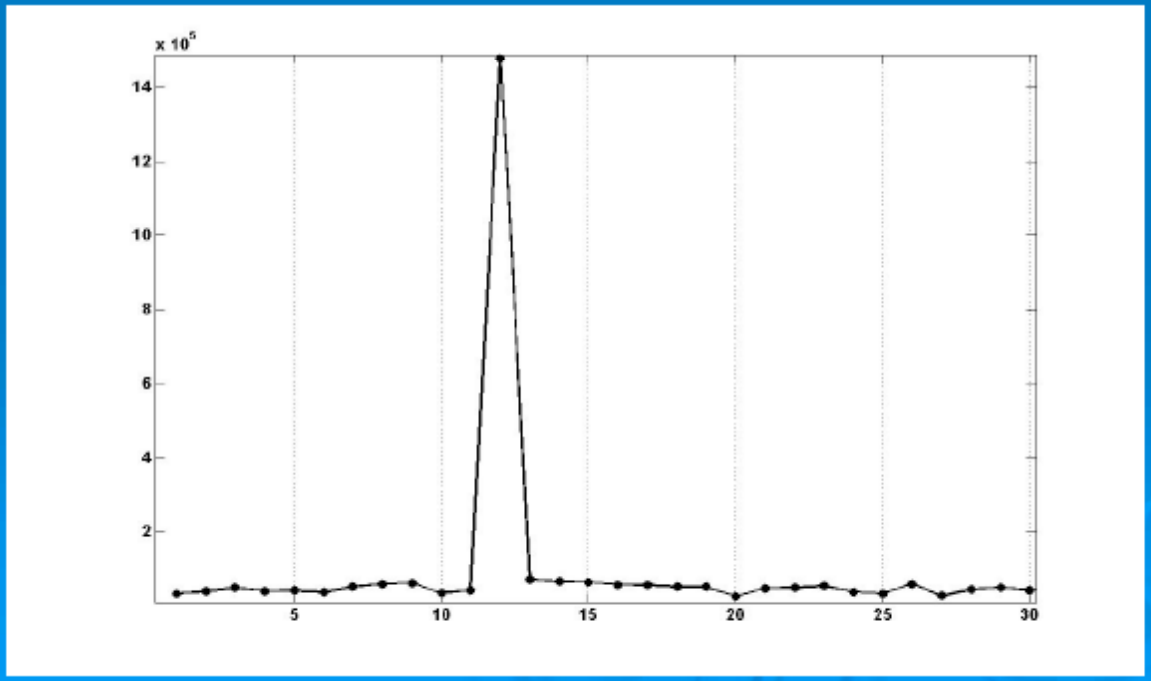
- Not a true turn by turn
- 4 measurements needed to measure an orbit
- Averaging needed to achieve a good resolution

In the future: Libera BPMs…

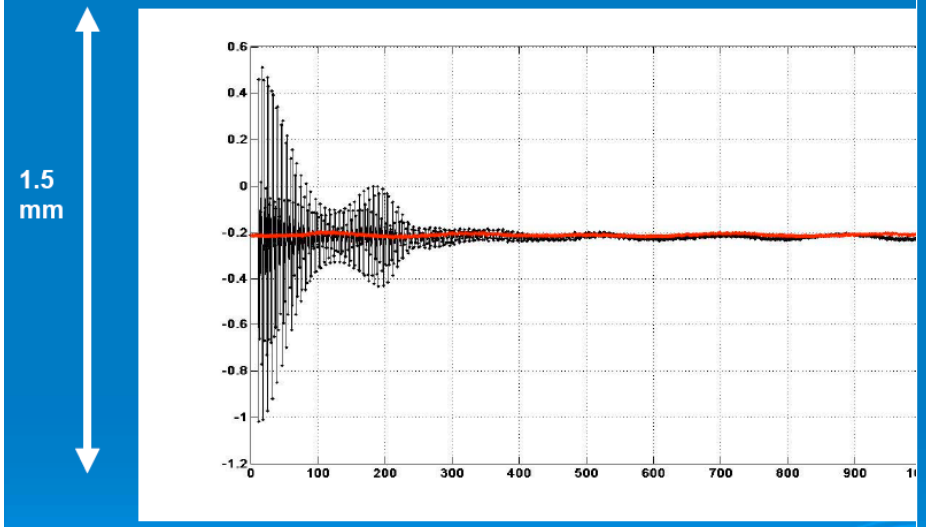
Libera customisation: true single turn filter

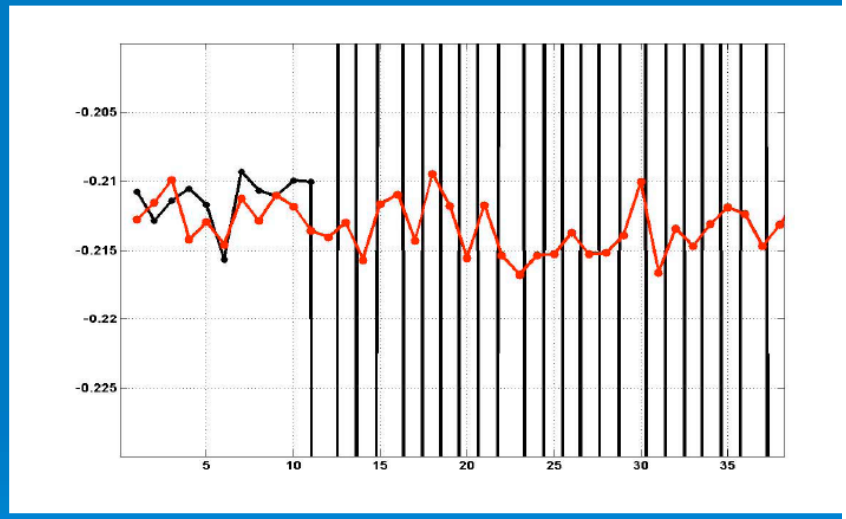
Once optimum timing adjusted inject 1/3 fill in SR and kick it out after 1 single Turn :

One single Turn should be seen on the SUM signal, without smearing



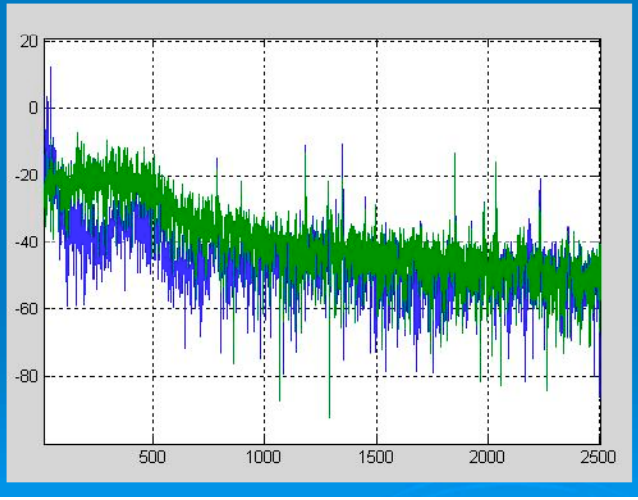
1.5mm pk-pk amplitude with 150Amp kick from Inj. Kicker-1





Noise assessed at **~1.8um rms** in Turn-by-Turn position measurement
@ 38mA 1/3 fill, Libera-C14 max. gain.

Libera resolution

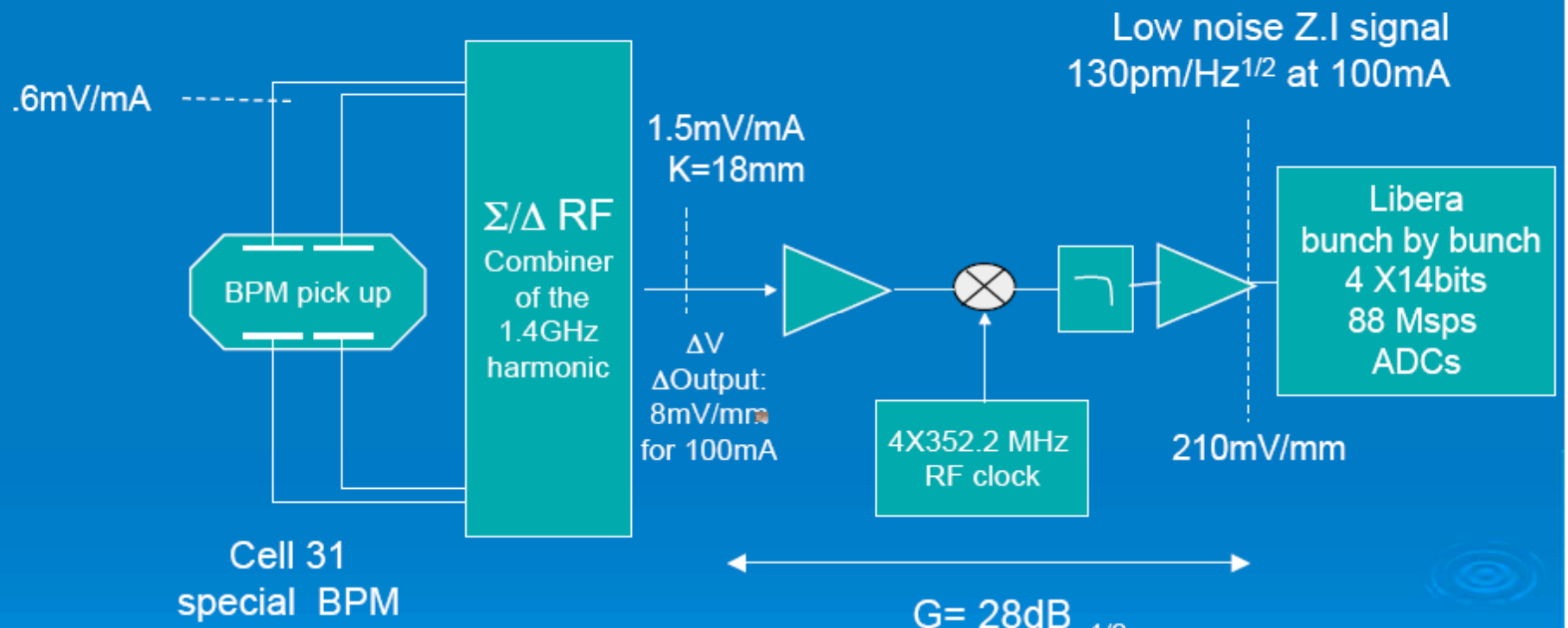


Blue : feedback OFF
Green: feedback ON
Cut off: 300Hz

Scale:
Vertical:dBμm/Hz$^{1/2}$
Horizontal:1Hz/div

=> Noise floor: 3nm/Hz$^{1/2}$

RF recombination scheme: multibunch feedback electronics



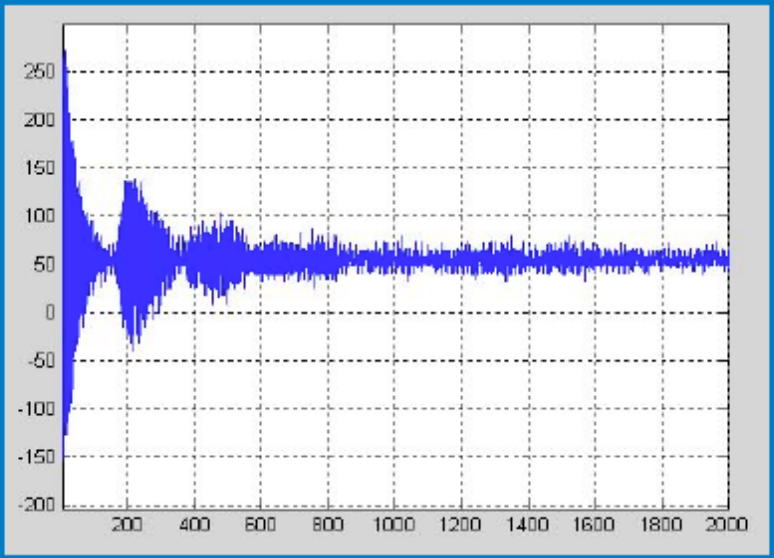
G= 28dB, N=6dB, KT=-174dBm/Hz$^{1/2}$

=> noise at the Libera input = -140dBm/Hz$^{1/2}$ =30nV/ Hz$^{1/2}$

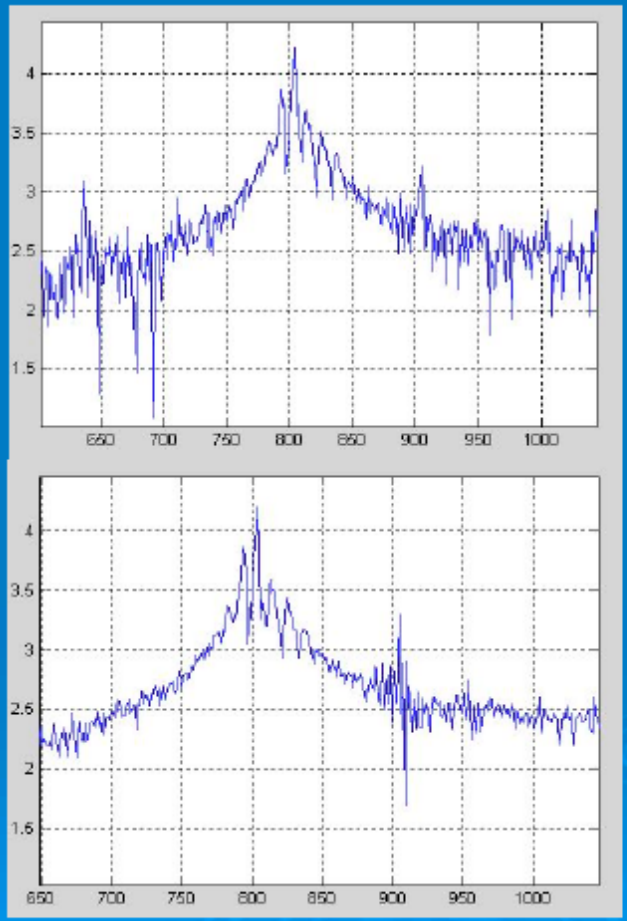
BPM sensiotivity: 8mm/V at 100mA =>**resolution= 130pm/Hz$^{1/2}$**

Bunch by bunch signal acquisition

FFT analysis



50 μm initial amplitude
Signal from one single bunch



- 40KHz zoom on the FFT of the previous signal.
- Upper plot : single bunch data.
- Lower plot: averaging over 300 bunches
- Vertical scale : 6dB/div

Bunch by bunch or mode by mode tune measurement available

Lifetime measurement

- Our normal diagnostic is parametric current transformer.
- the lifetime is derived from the I(t) signal
- Lifetime measured: 60 hours with 1 hour resolution after 60s
- 60 hours= 1.5 10^5s =>
- I resolution = 2 10^{-7} over 60s or 1.2 10^{-6}over 1s
- Resolution versus integration time is limited by : the noise in the magnetic material and the current source stability

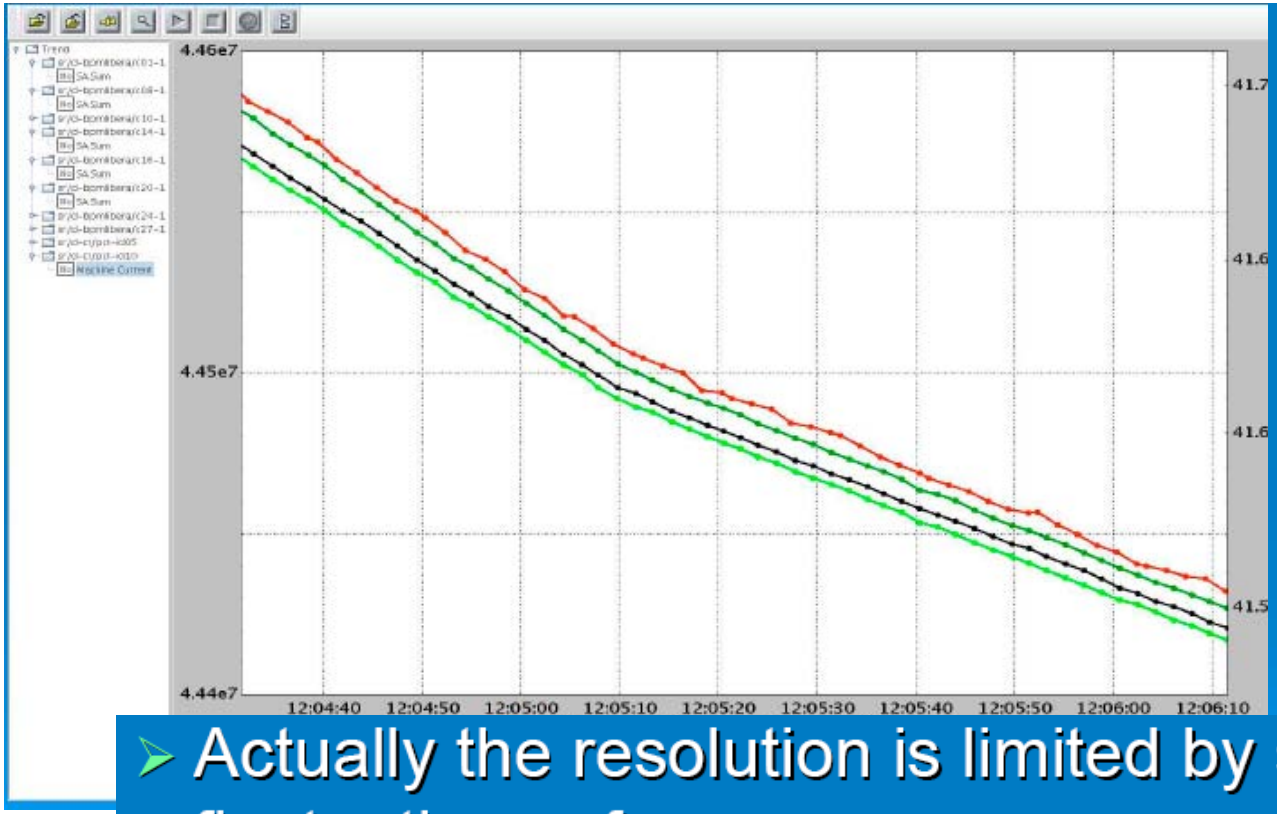
RF receiver resolution:

- $1.25\ 10^{-4}$ in 62.5 MHz => $1.5\ 10^{-8}$ in 1Hz.
- 250 hours = $(1.5\ 10^{-6})^{-1}$ so it seems to indicate that 250 hours lifetimes are measurable with a 1% resolution at a 2Hz rate !
- Is it true?

Maybe not completely:

At low current the noise of preamplifier will not be negligible compared to the ADC resolution

The drifts of the ADC reference and RF front end gain (1/f noise) should be considered…



- The RF receiver looks at least as good as a PCT, but nothing dramatic….

- Actually the resolution is limited by slow fluctuations of:
- ADC voltage reference
- RF components gain or attenuation
- So over minutes the intensity and lifetime measurements get spoiled
- But we usually have 100 to 200 BPMs electronics so we could average…

Conclusion

- A set of 100 to 200 digital BPMs can be turned into a very fast lifetime monitor fo machine study sessions for data acquisition over short time periods.

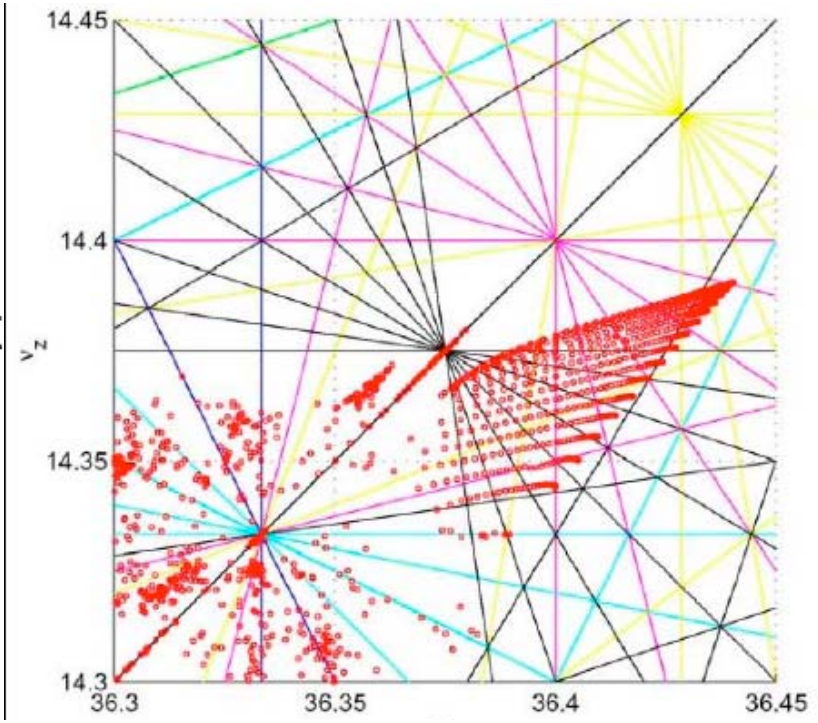
Frequency maps at the E.S.R.F.

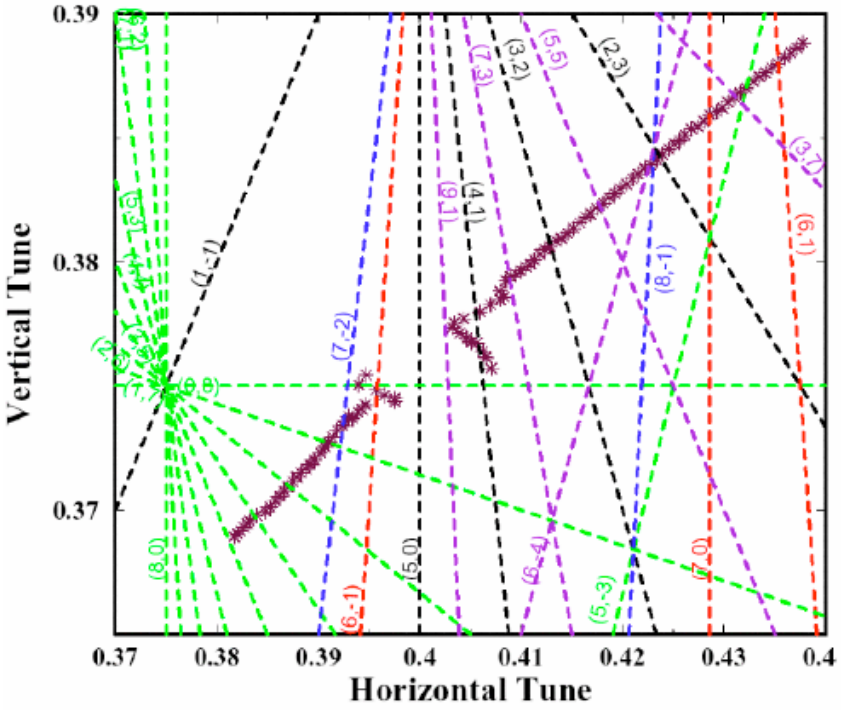
L. Farvacque

A . Ropert

History

- Frequency mapping was introduced at E.S.R.F. in 2002
  - NAFF algorithm *J. Laskar/Y. Papaphilippou*
  - Exp. Maps: *Y. Papaphilippou*
    - 1000-turn BPM system
      - Pseudo turn-by-turn: lot of averaging required
    - ADAS BPM
      - Single location
      - No linearisation of position computation
  - Simulations: *L. Nadolski*, *A. Ropert*
    - BETA





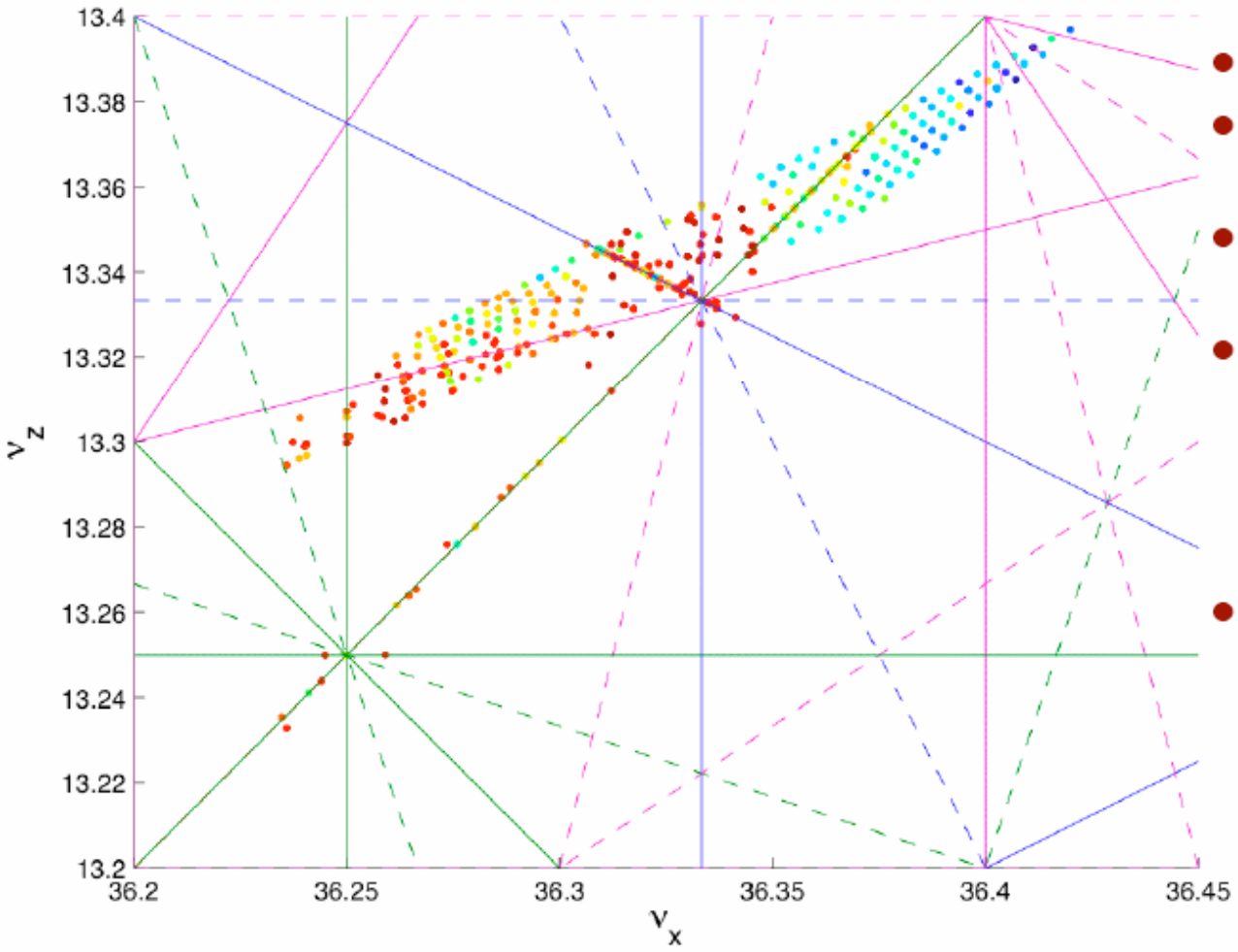
What's new in 2008

- Testing Libera BPM systems for turn-by turn measurements
  - True turn-by-turn system (no averaging): we could go closer to the limits of aperture,
  - Only 8 positions available at the moment, 224 foreseen,
  - Synchronization with kicker to be improved,
  - Software still in development.

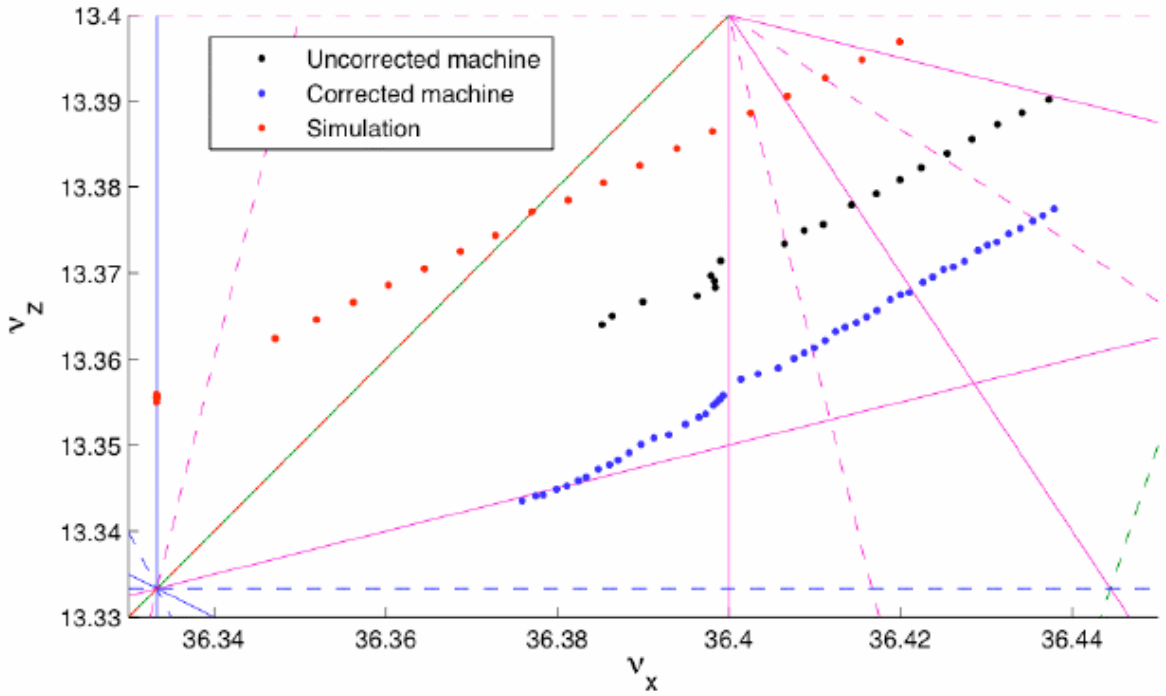
- Investigating the use the transverse multibunch feedback system to get a single bunch turn-by-turn position
  - Not yet tried

- New lattice
  - Doublets instead of triplets in straight sections
  - Vertical tune lowered by one integer
  - One additional sextupole family (S13 and S20 decoupled)

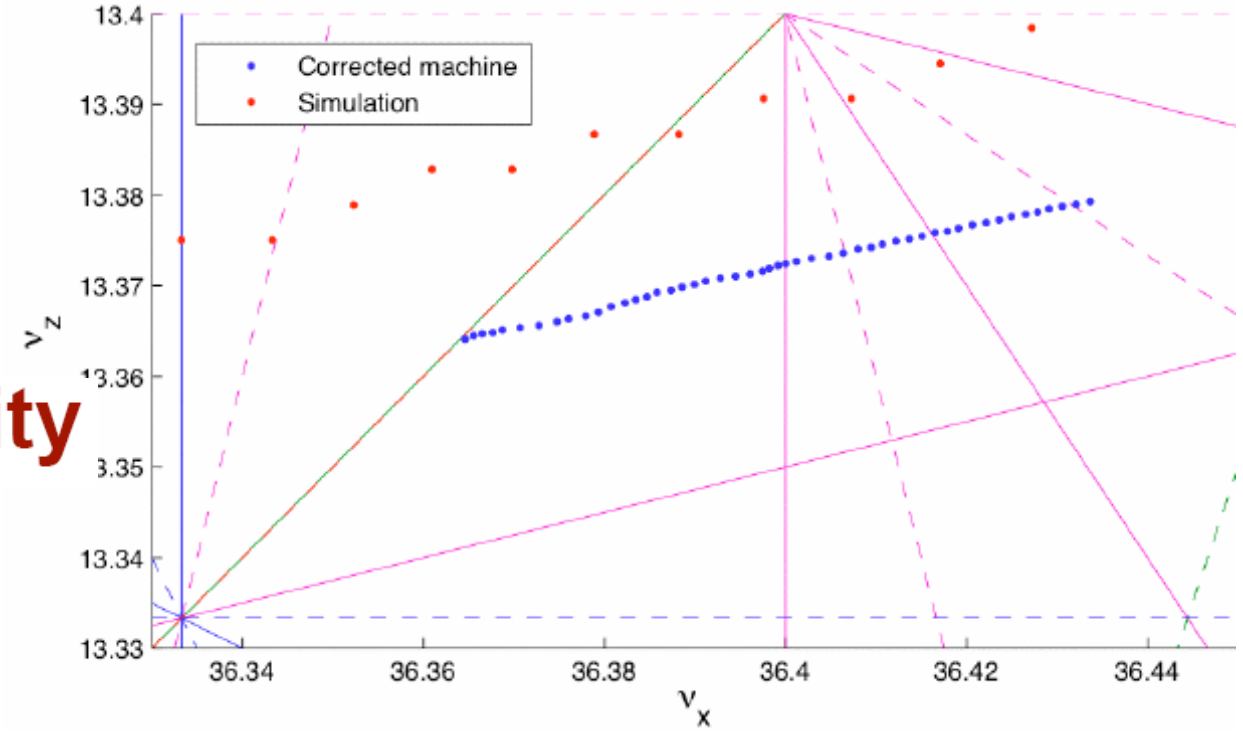
Simulation



- Present lattice
- Multibunch chromaticity
- No physical restriction
- Errors and corrections are included (except for sextupolar corrections)
- As already mentioned, we suspect the 3rd order node to be responsible for aperture limitations



Comparison



Zero chromaticity

Conclusions

- First new measurements are promising
- In a few months we should be in a much easier position to measure maps
- Mapping the x-z plane is not very interesting because of the very small vertical aperture
- We will concentrate on mapping the x-δ plane
  - Most important for lifetime
  - Where puzzling behavior happens *(see to-morrow…)*
  - But still doubts on off-momentum simulations…

Summary

- Essential experimental tools for non-linear dynamics measurements
  - A large number of high resolution turn-by-turn BPMs (Libera)
  - Full aperture single-turn kicker magnets in both planes
  - NAFF algorithm for experimental frequency maps and resonance driving term analysis