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

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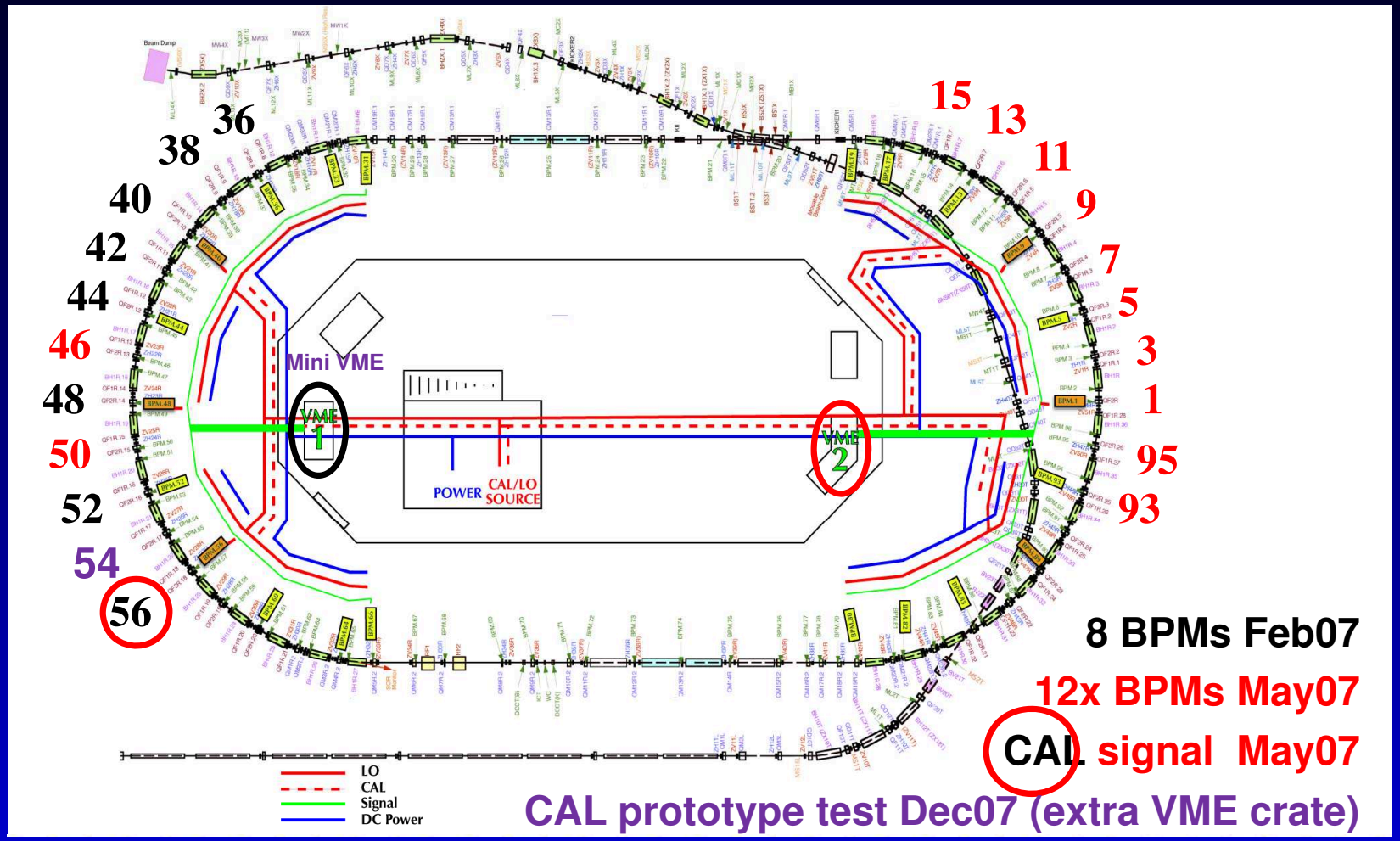
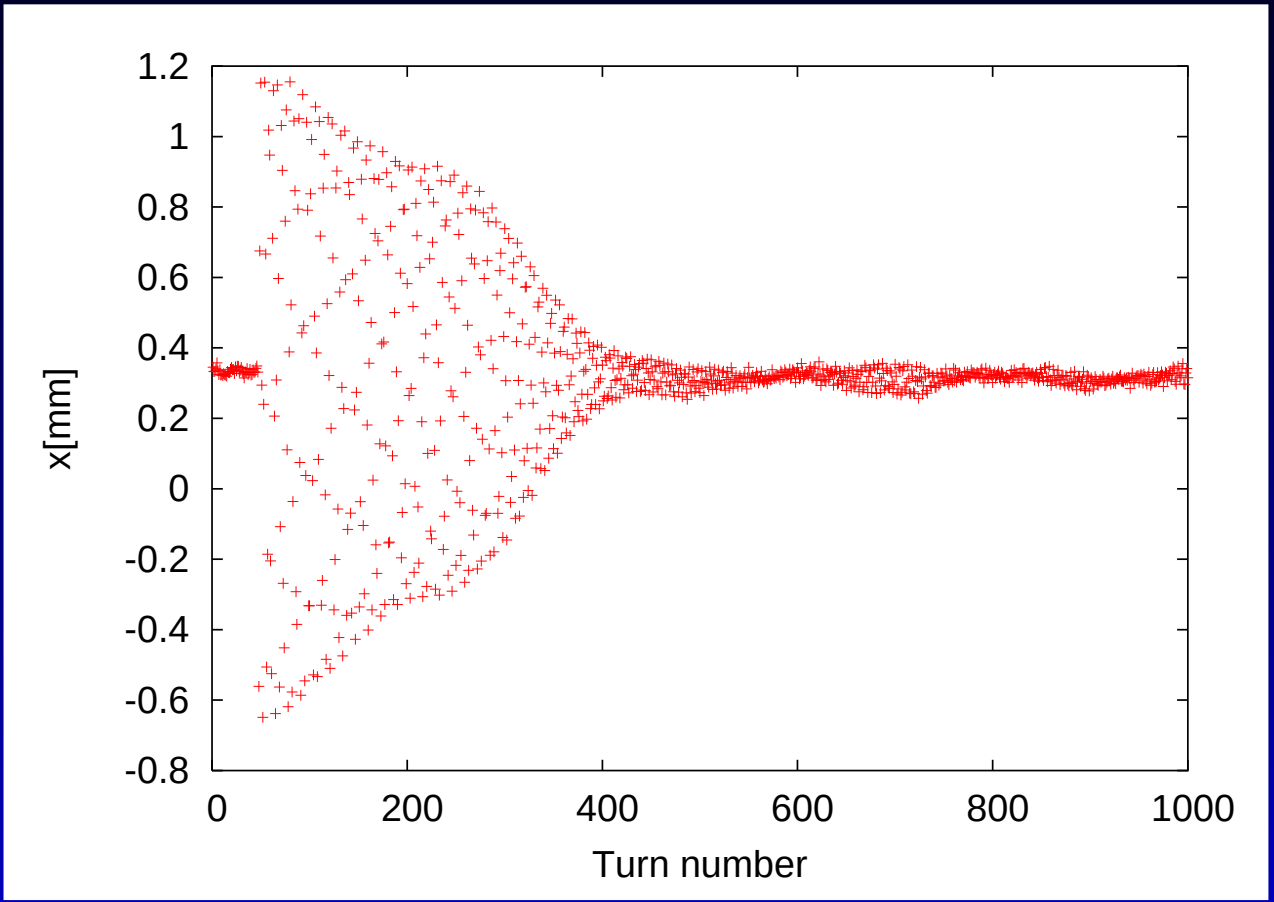
ATF Damping Ring



Trun-by-turn BPM data



→ A single-turn kick excites betatron motion.

→ Filamentation damps the centroid oscillation.

Measurement from BPM data

Momentum reconstruction from 2 BPMs:

$$p_{12}(N) = (x_1(N) + x_2(N)\sin\delta)/\cos\delta$$

Description of the motion:

$$\begin{aligned} x_1(N) - ip_{12}(N) \;=\; & \sqrt{\beta_{x1}}\Big\{\sqrt{2I_x}e^{i(2\pi\nu_x N+\psi_{x_1})} - \\ & 2i\sum_{jklm} j\, f^{(1)}_{jklm}(2I_x)^{\frac{j+k-1}{2}}(2I_y)^{\frac{l+m}{2}} \times \\ & e^{i[(1-j+k)(2\pi\nu_x N+\psi_{x_1})+(m-l)(2\pi\nu_y N+\psi_{y_1})]}\Big\} \end{aligned}$$

$\rightarrow f^{(1)}_{jklm}$ can be inferred from the FFT

What is f_{jklm}?

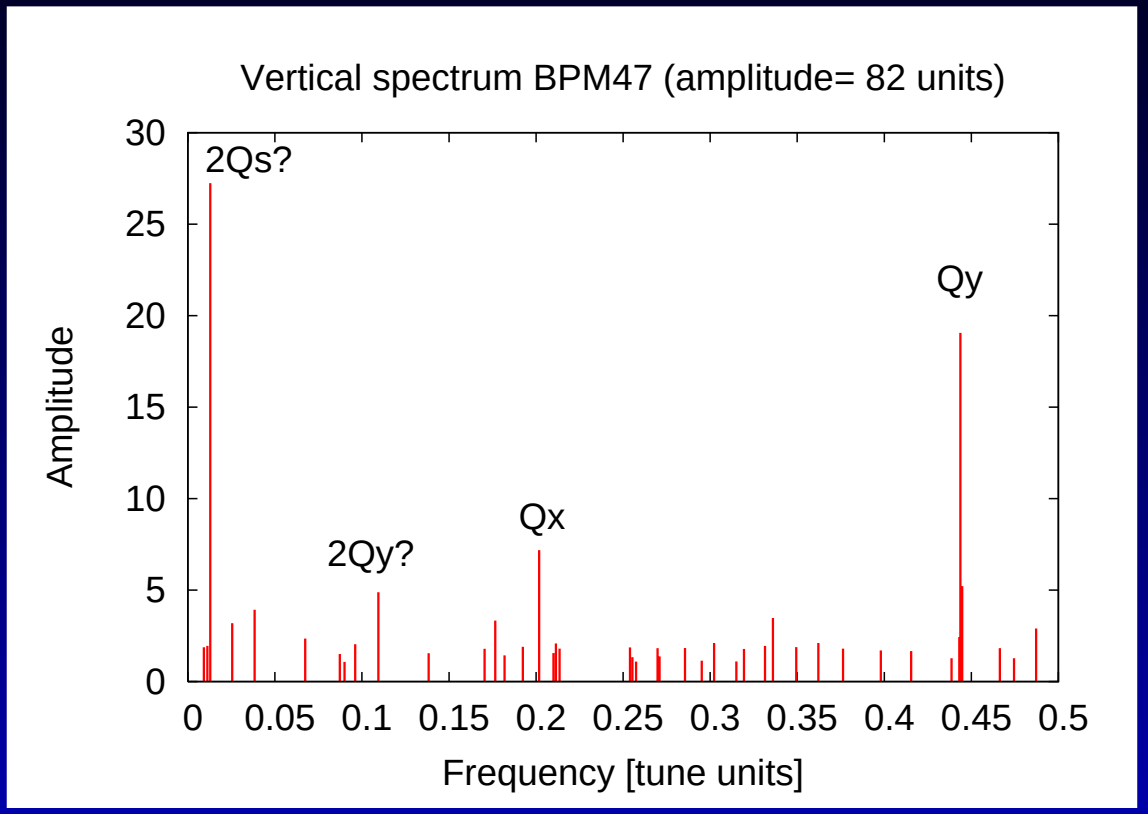
It is proportional to the Hamiltonian term h_{jklm}:

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

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

Spectrum example (vertical)



Q_x line comes from linear coupling.

$2Q_y$ line related to resonance (0,3). This resonance is driven by skew sextupoles.

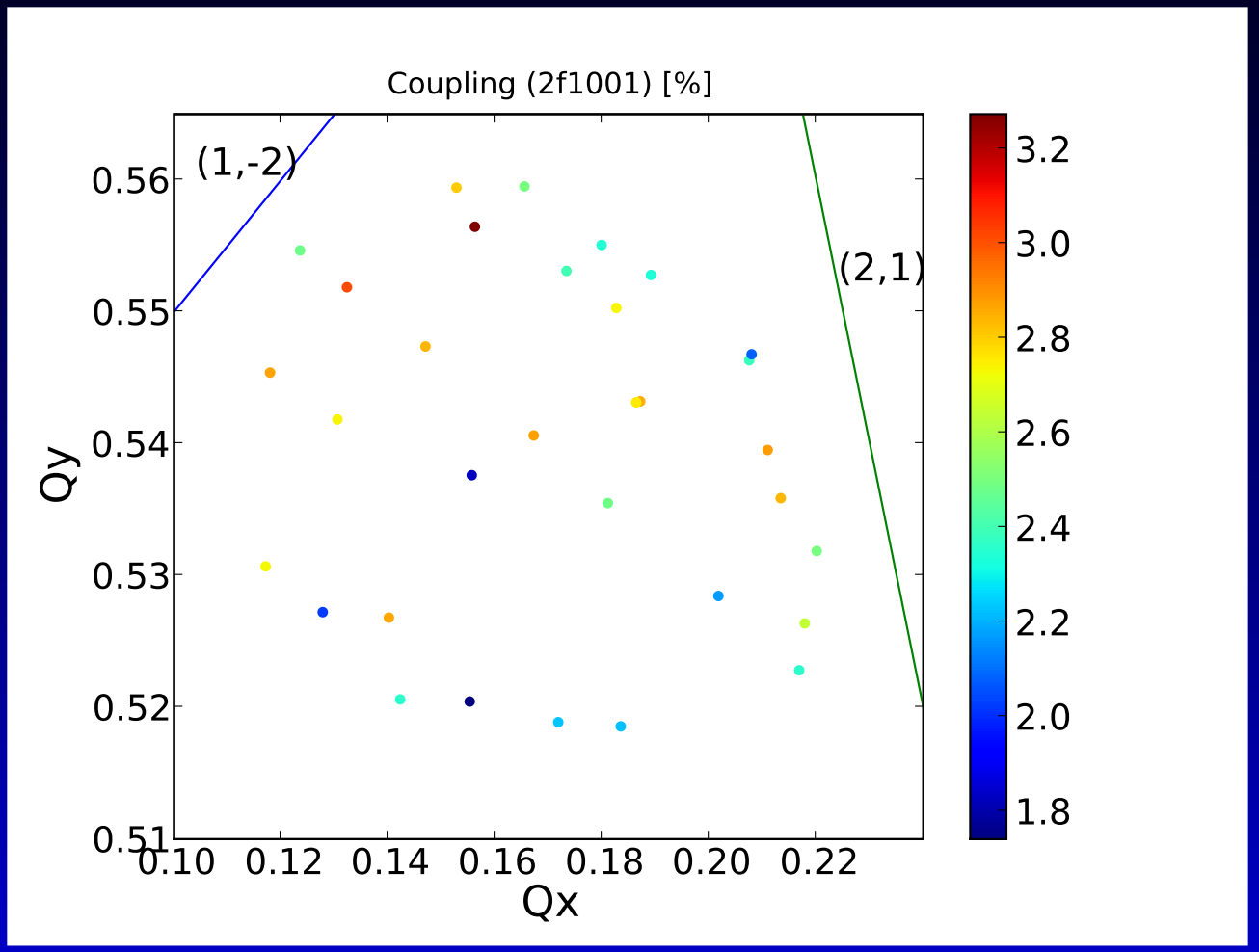
Coupling measurement: f_{1001}

$$2|f_{1001}| = \sqrt{\frac{\mathrm{line}(0,1)_\mathrm{h}}{\mathrm{line}(1,0)_\mathrm{h}}\frac{\mathrm{line}(1,0)_\mathrm{v}}{\mathrm{line}(0,1)_\mathrm{v}}}$$

$\longrightarrow$ Calibration independent
$\longrightarrow$ Kick independent

$\longrightarrow$ Model independent

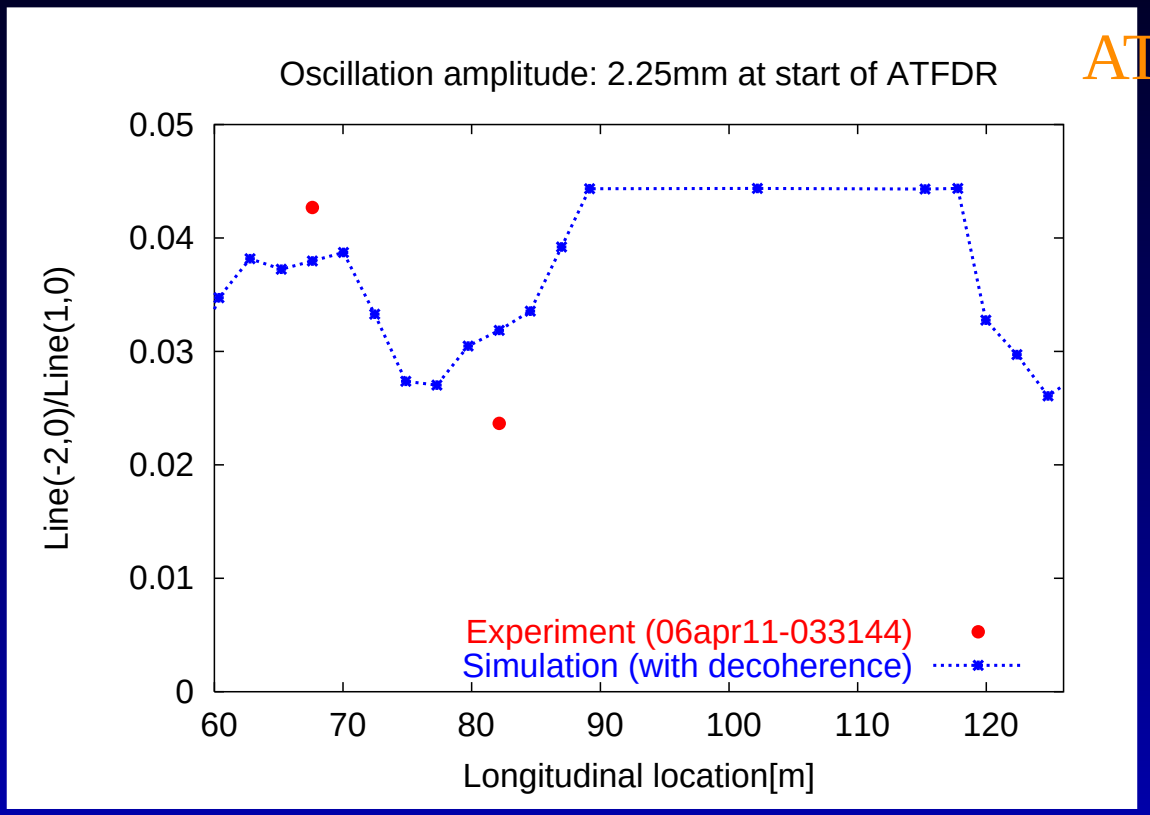
Measuring f_{1001} in ATF



Average coupling = 2.5% $\pm$ 0.3%, (quite flat).

Measuring (3,0) Resonance

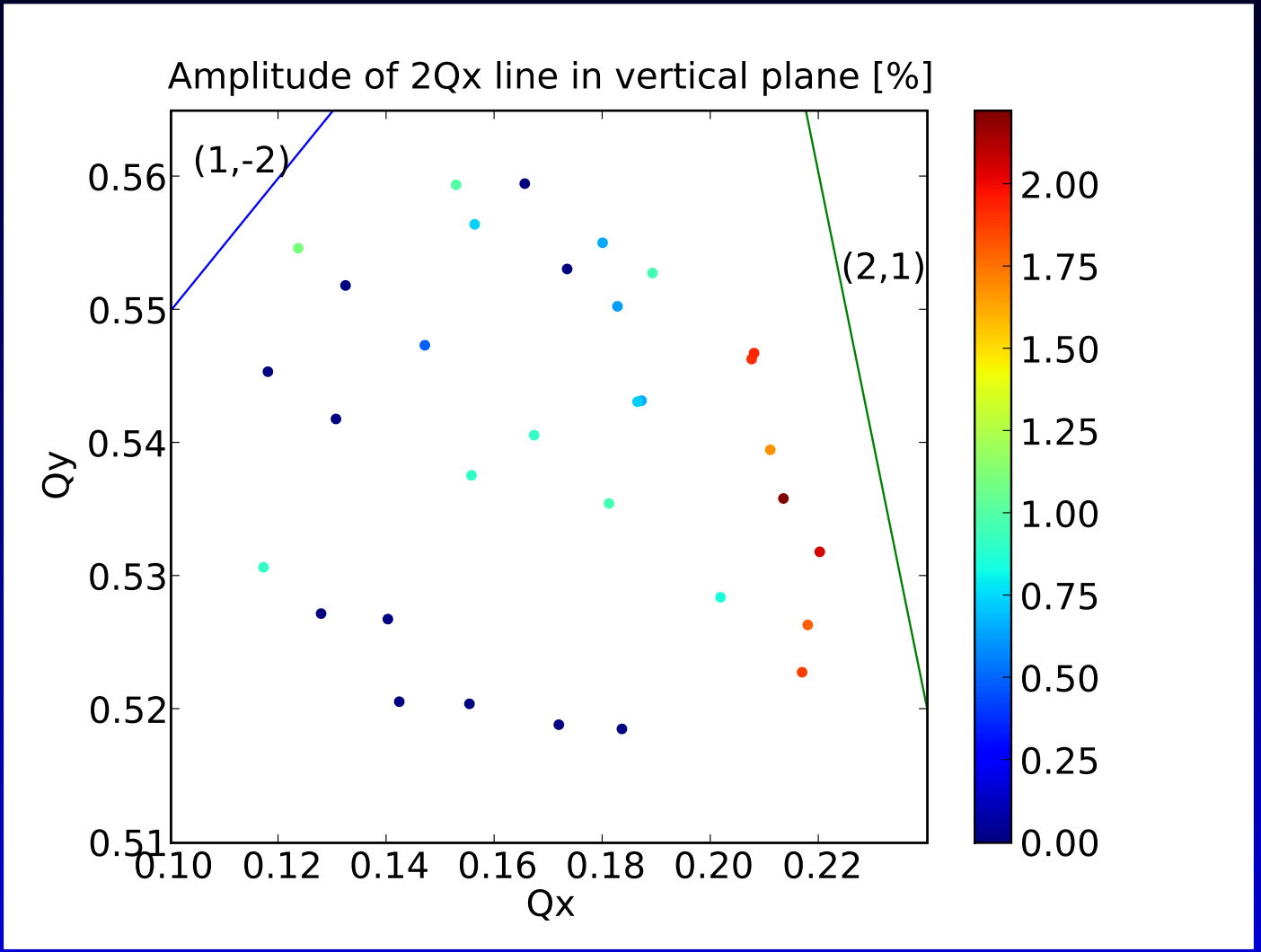
ATF report 06-08



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

However vertical plane totally unprobed.

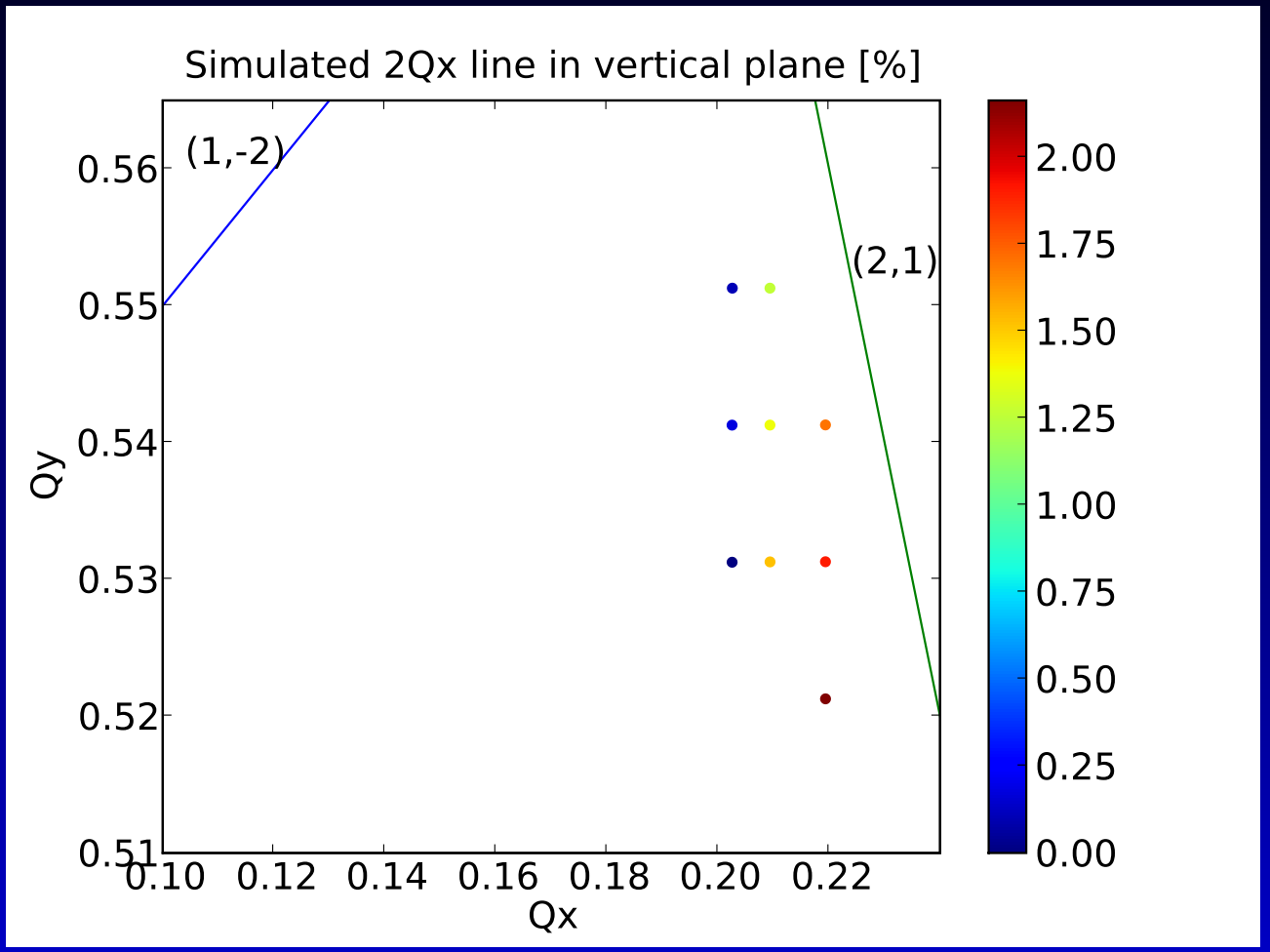
Measuring skew resonance (2,1)



→ Clear correlation between line and resonance!

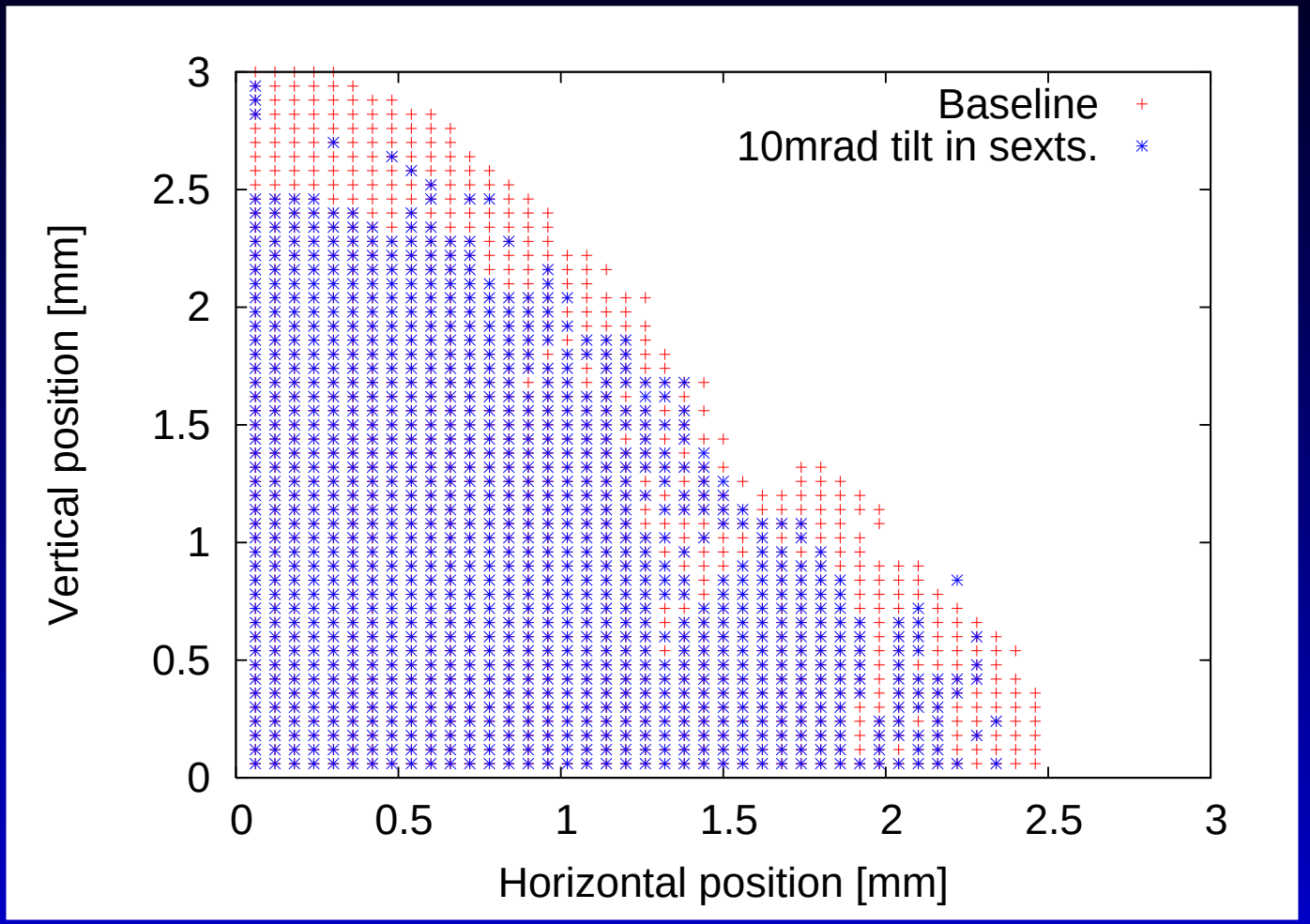
→ And it seems to be large!

Simulating resonance (2,1)



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

Computing DA with sextupole tilts

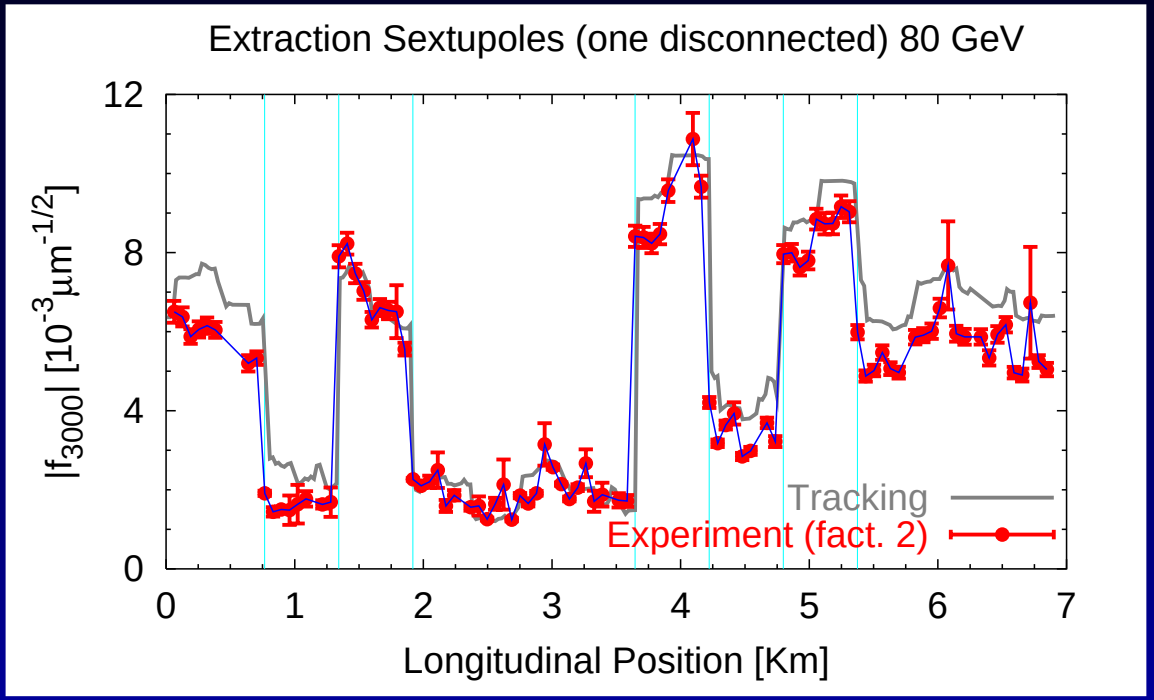


→ 10mrad tilts certainly have an impact on DA!

Conclusions

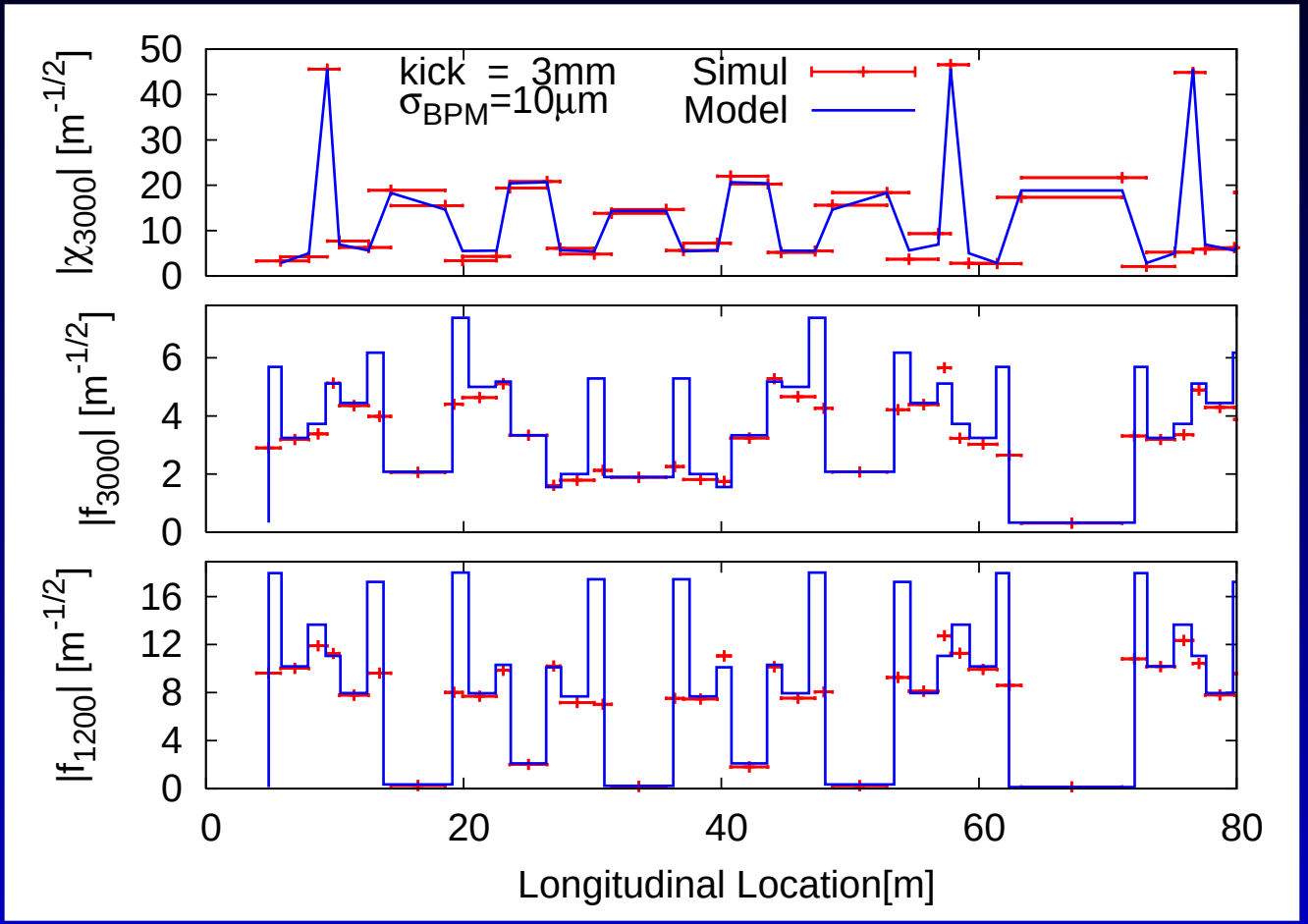
- Measurement of resonance driving terms proofs useful in ATF.
- Important coupling and skew sextupolar errors have been identified.
- A realignment of the machine is being considered to correct these errors (ATF has no skew sextupoles).
- Many turn-by-turn BPMs are being installed
- This coud allow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

SPS experience



http://www.tesisenxarxa.net/TESIS_UV/AVAILABLE/TDX-0219104-131907/rogelio.pdf

Realistic simulations for ALBA



Some references

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... and many more...