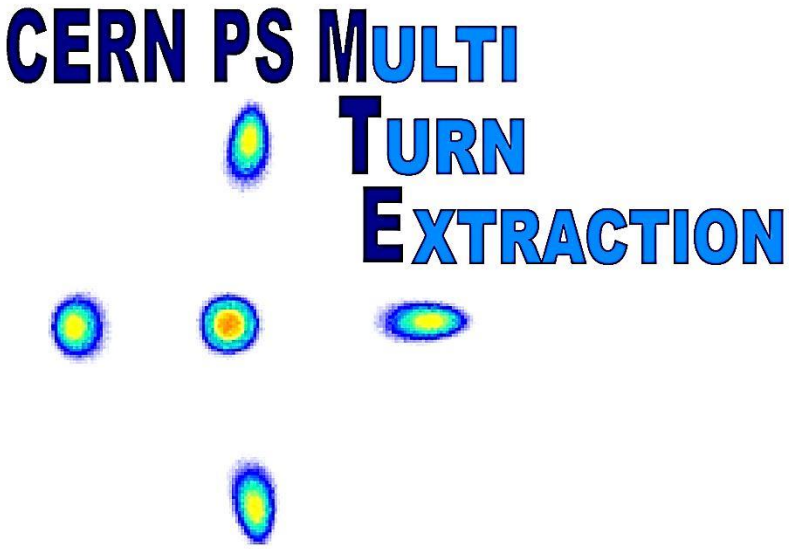

Optics measurements in PS islands

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Introduction

- CERN PS, in spite of its venerable age, is constantly pushed to improve its performances in order
  to accept high brightness (LHC) or special manipulation beams (MTE).

- The Multi-Turn Extraction is a new extraction scheme developed to replace the so-called Continuus Transfer.
  It is based on transverse beam splitting by means of crossing a resonance which has been excited by a combination of non-linear magnets.

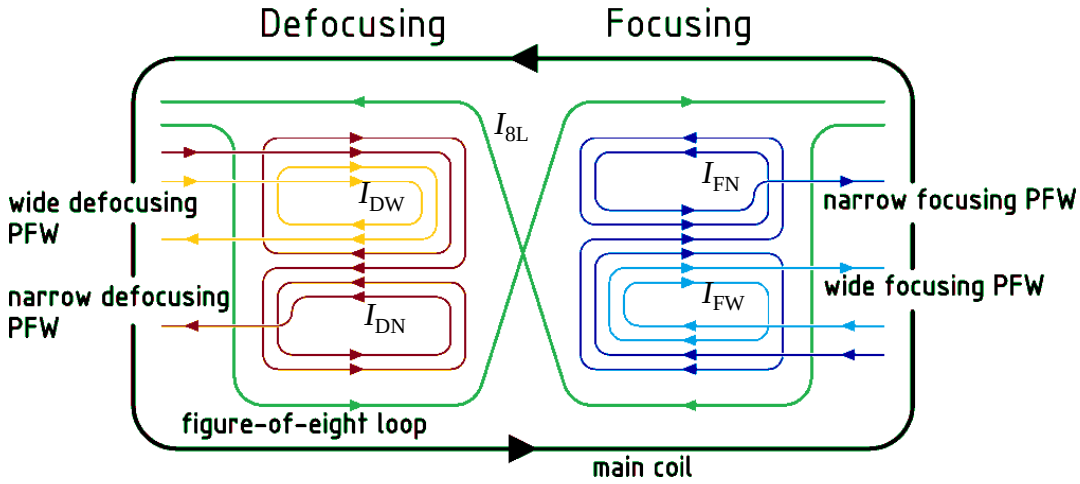
- The beam is then splitted into several beamlets having same optical parameters and a remaining core, without any mechanical action.

- This requires a precise knowledge of the PS behaviour, especially the non-linear one.

- That's why, in the framework of the Multi-Turn Extraction study, several beam measurement campaigns have been performed so as to probe the optics conditions of the beam and to improve the PS model.

Introduction

CERN PS is made of 100 combined-function magnets. Additional Pole Face Windings (PFWs) allow better control of linear and non linear dynamics.



PS magnets model used for tracking reproduces PS Main Units by a combination of multipole kicks.

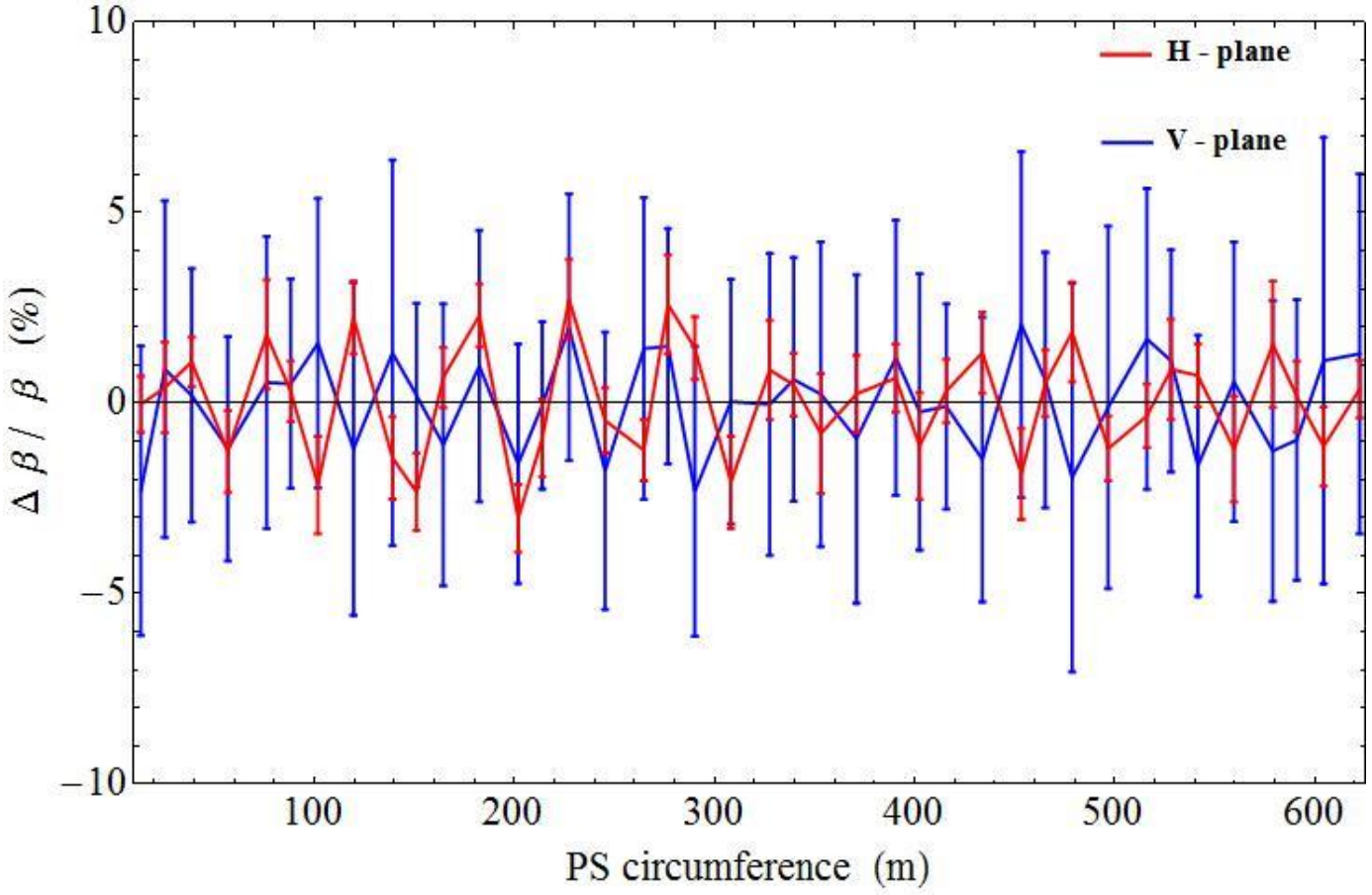
These kicks have been matched in order to reproduce the tune variation vs dp/p measured in the PS.

Beta-Beating measurements

Beta-beating measurements

Beta-beating has been measured at 14GeV, first for « standard » PS, with only additional pole-face windings turned on, without any MTE non-linear magnets.

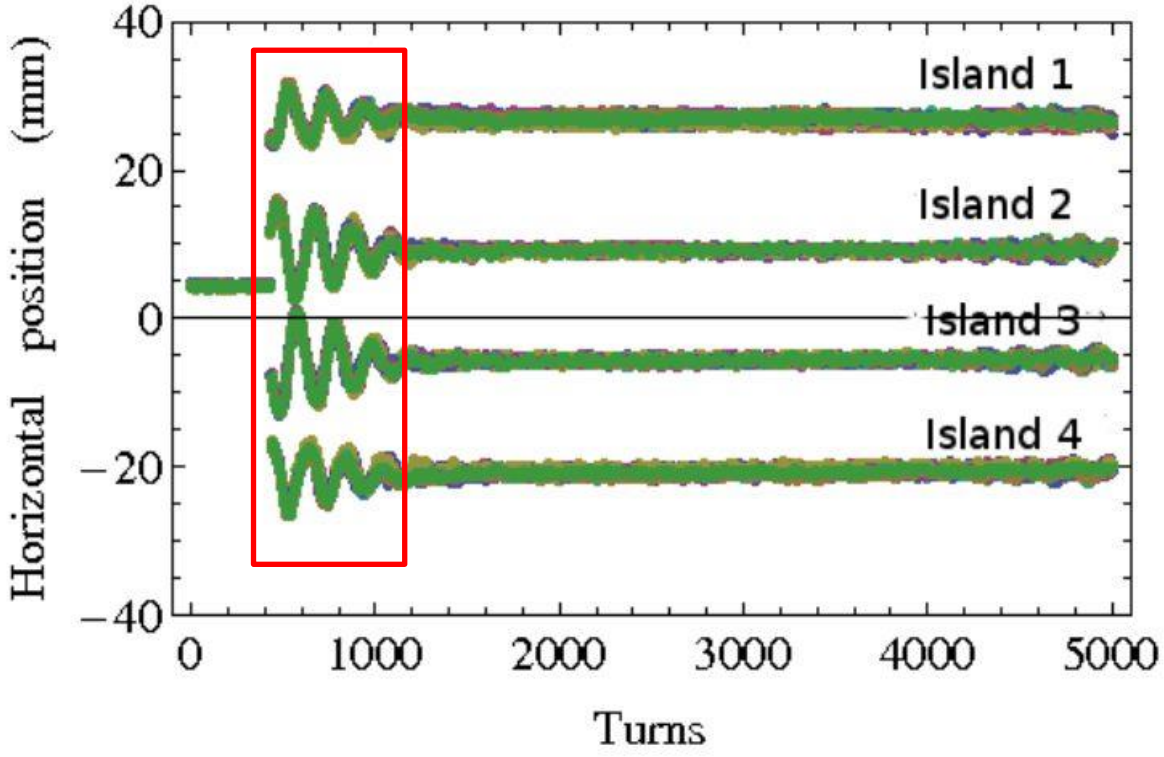
The beam is transversally excited and its position measured turn by turn using the 40 BPMs available in the PS.



Peak value around 3%

Beta-beating measurements

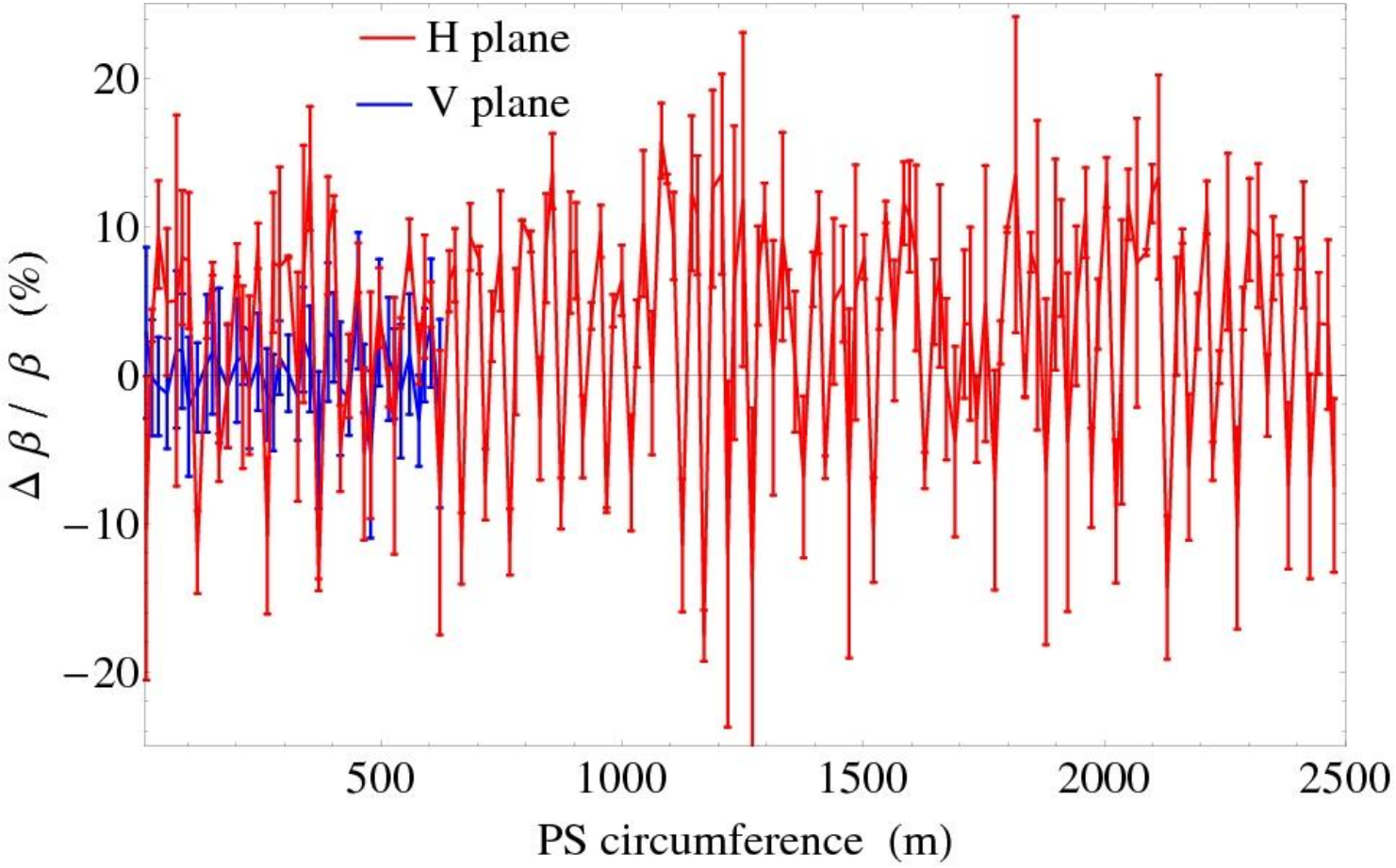
As PS BPM only show charges center-of-mass, normal MTE operation beam can't be used for our studies. In order to be able to distinguish islands a pencil beam is kicked into one islands.



The filamentation just after kick into islands allows us to probe the island optics conditions.

Beta-beating measurements

Same measurement done for MTE islands. In this case the bunch motion in the horizontal plane is periodic over four-machine turns.

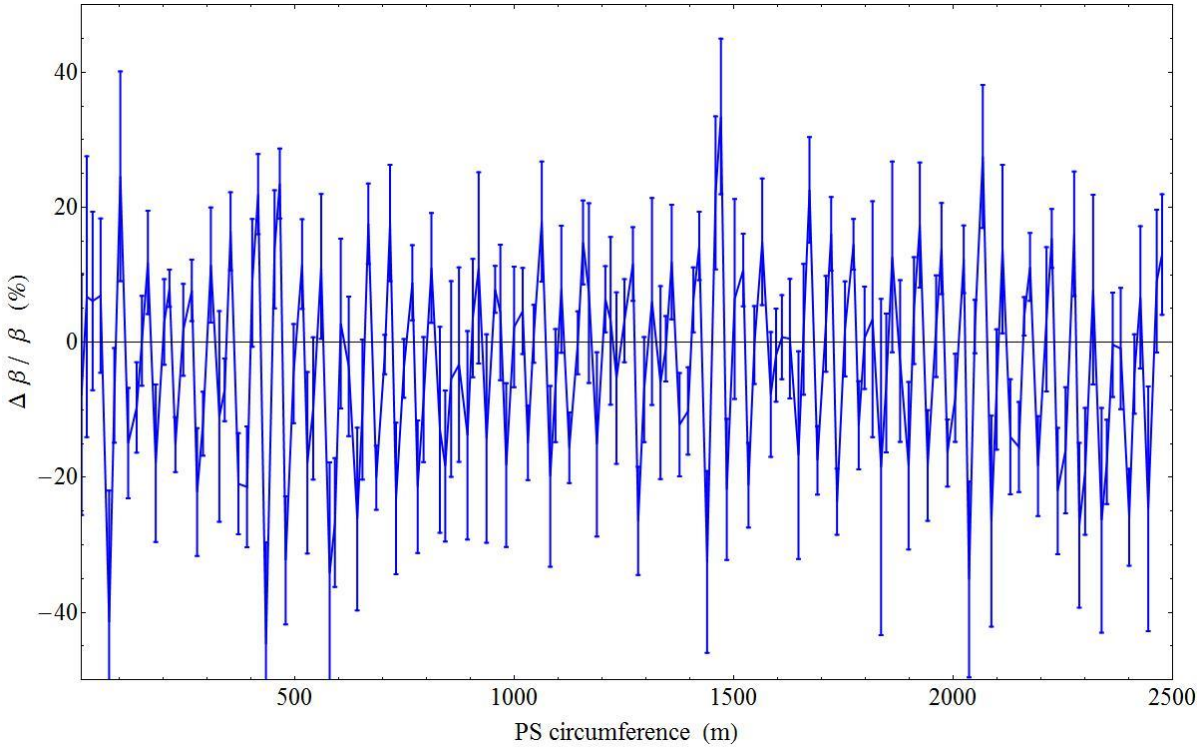


Still around zero beating for vertical plane.

Much larger and no more compatible with zero BB in horizontal plane.

Beta-beating measurements

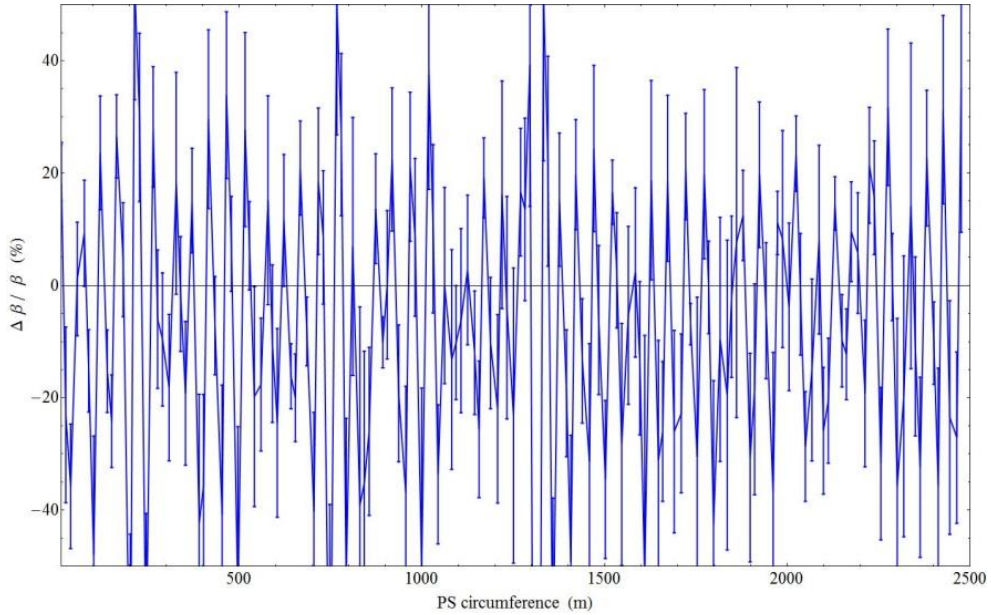
By properly setting the horizontal tune it is possible to change the amplitude of stable islands.
And then to measure the beta-beating for different island positions.



Average island position
25mm

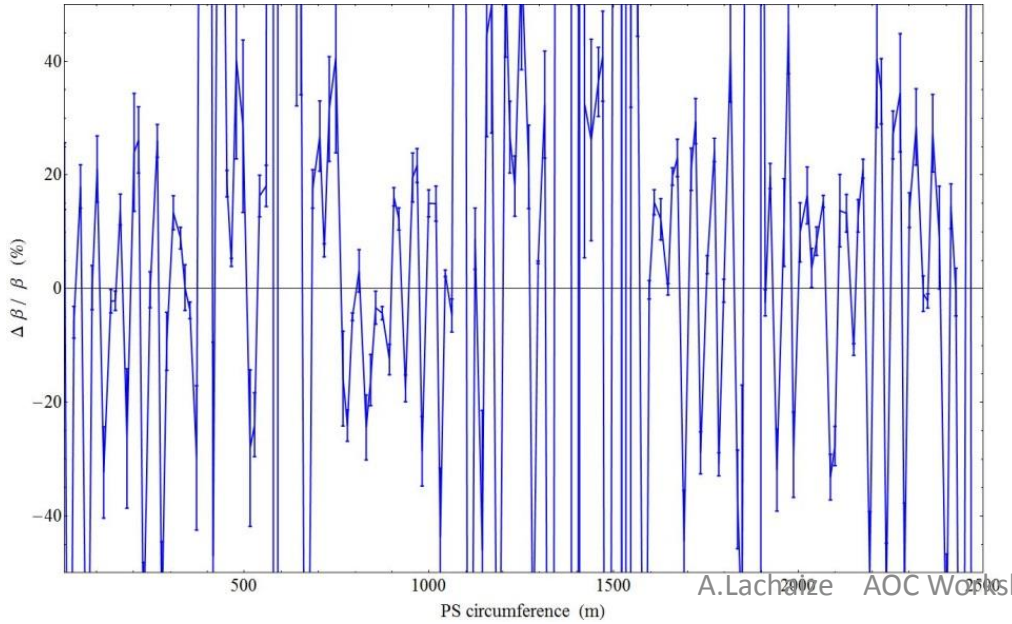
Average BB : 3%
Peak BB : 15%

Beta-beating measurements



Average island position
26.5mm

Average BB : -5%
Peak BB : 14.5%

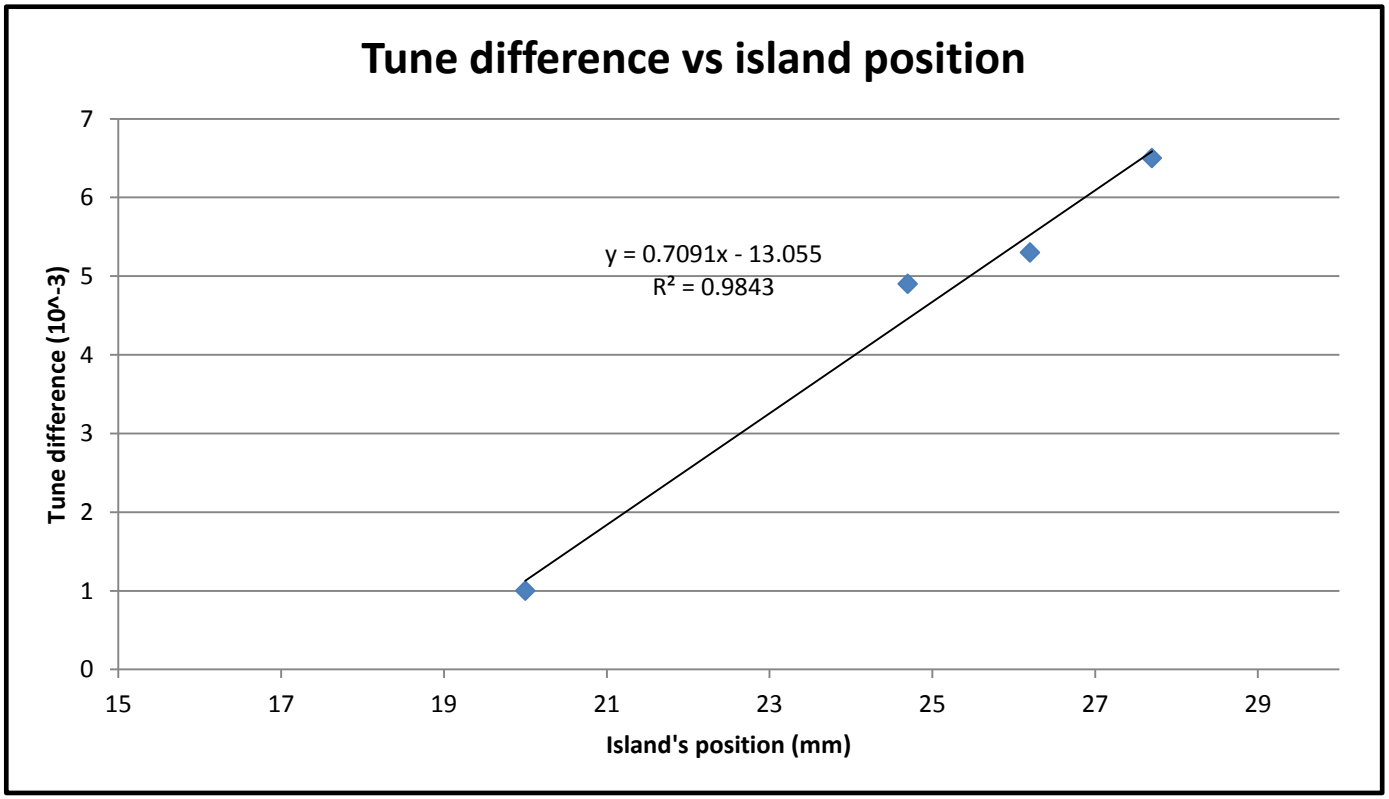


Average island position
27.5mm

Average BB : 42%
Peak BB : 500%

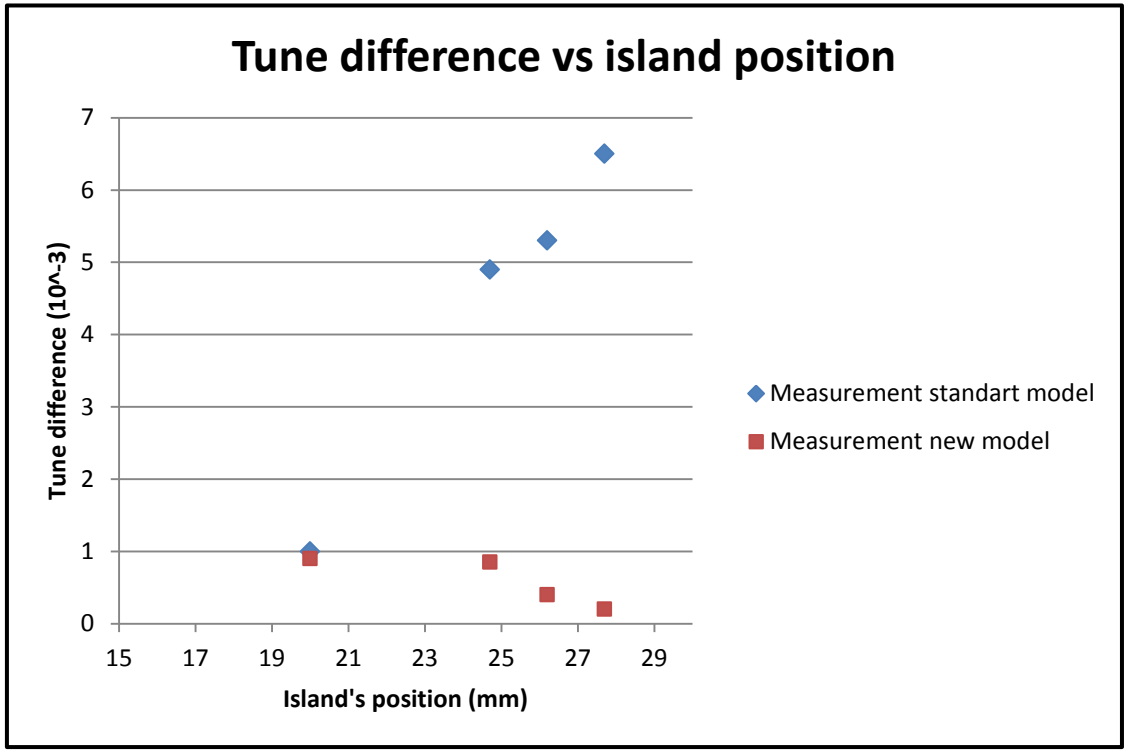
Beta-beating measurements

A clear increase of the beta-beating with island position is visible.
This comes from a discrepancy between island's tune given by the model and the measured one.

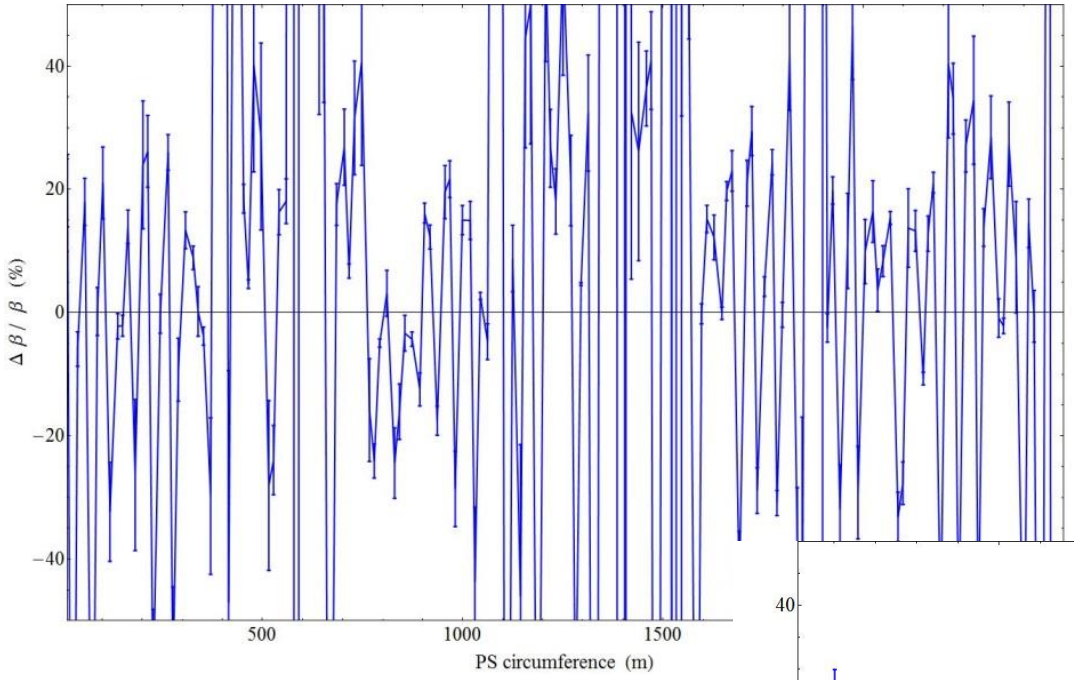


Beta-beating measurements

An additional octupole is then add into the PS magnet model, at the center of each Main Unit. It is used to change the detuning with amplitude. After re-matching using the worst case new BB calculation is made for all cases.



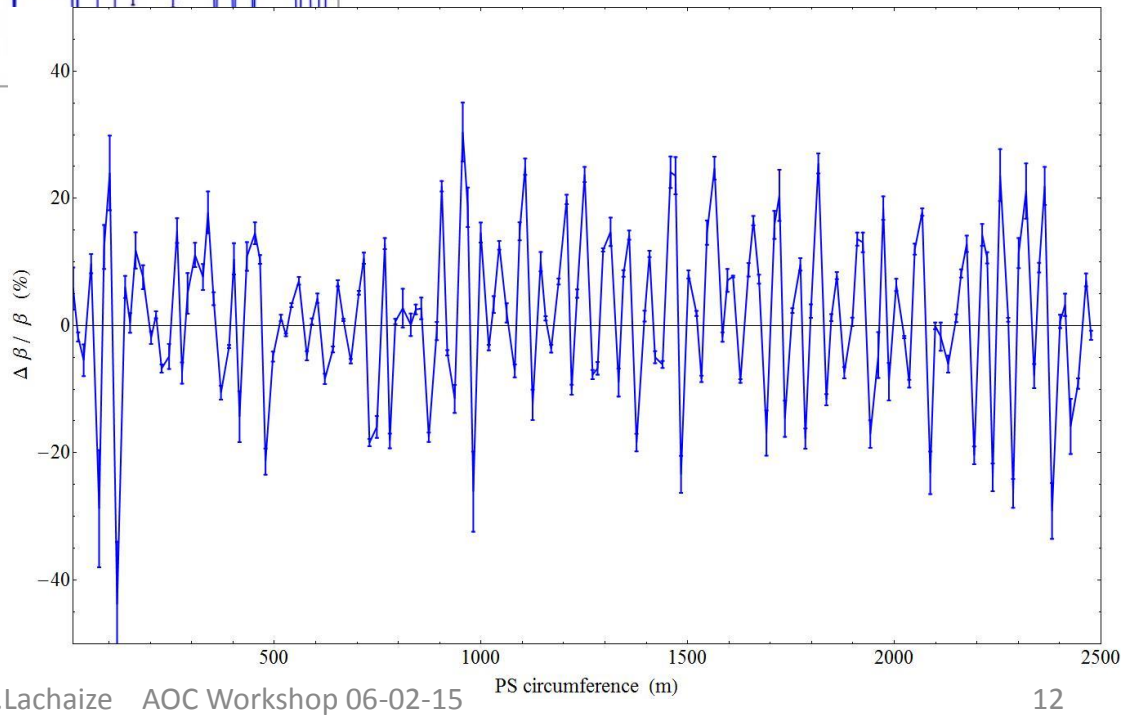
Beta-beating measurements



Island position 27.5mm

First BB calculation

Average BB : 42%
Peak BB : 500%

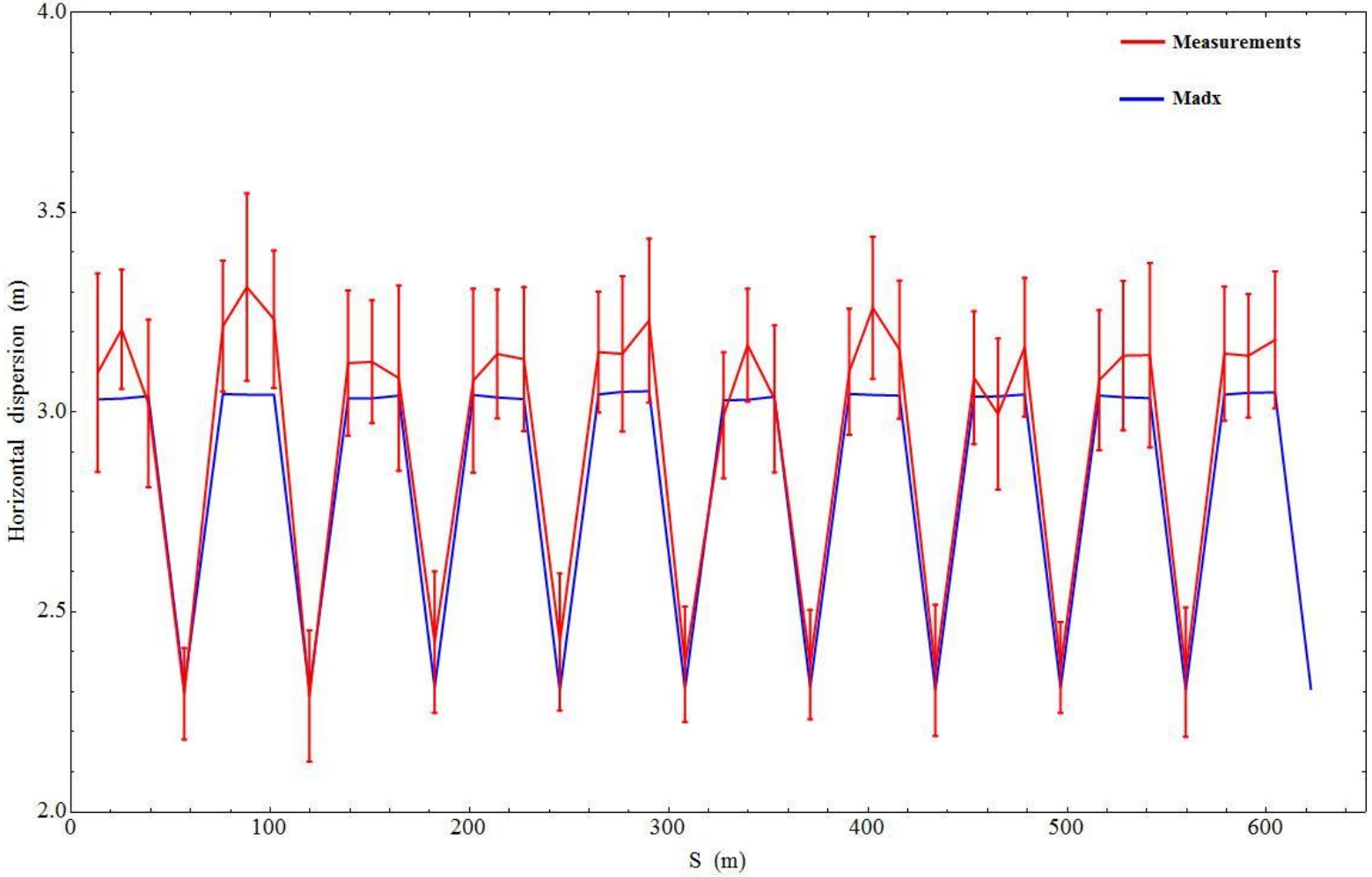


Second BB calculation, after insertion of additional octupole

Average BB : 2%
Peak BB : 13%

Dispersion measurement

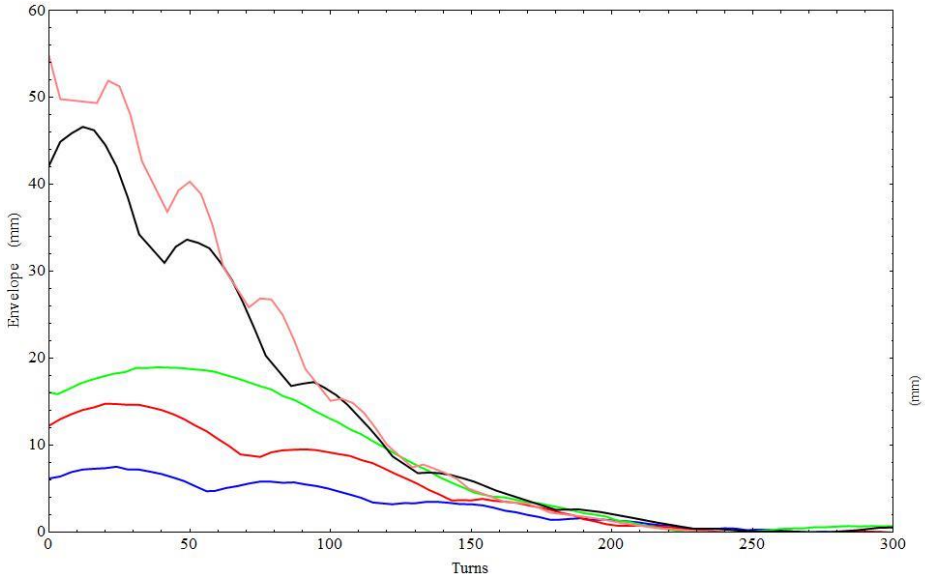
By measuring the beam orbit for various dp/p, the dispersion can be reconstruct all along the ring, and compared to the model.

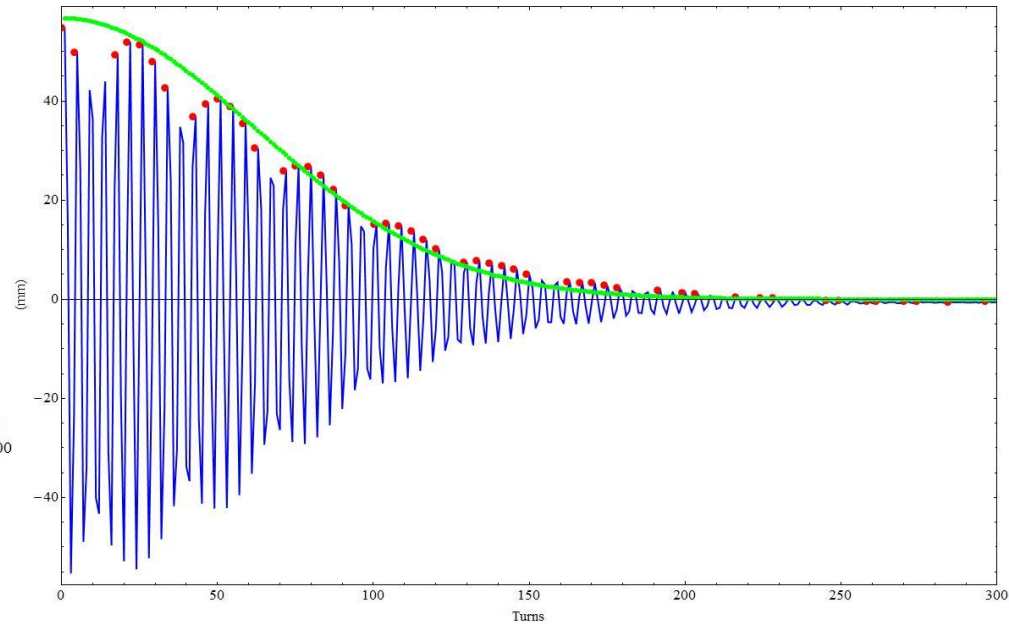


Chromaticity / detuning measurements

The non-linear dynamics has been probed by means of kicking the beam to high amplitude and analysing the decoherence data to extract chromaticity and detuning with amplitude.

Measurements have been performed at 14GeV, for PS with PFWs only.

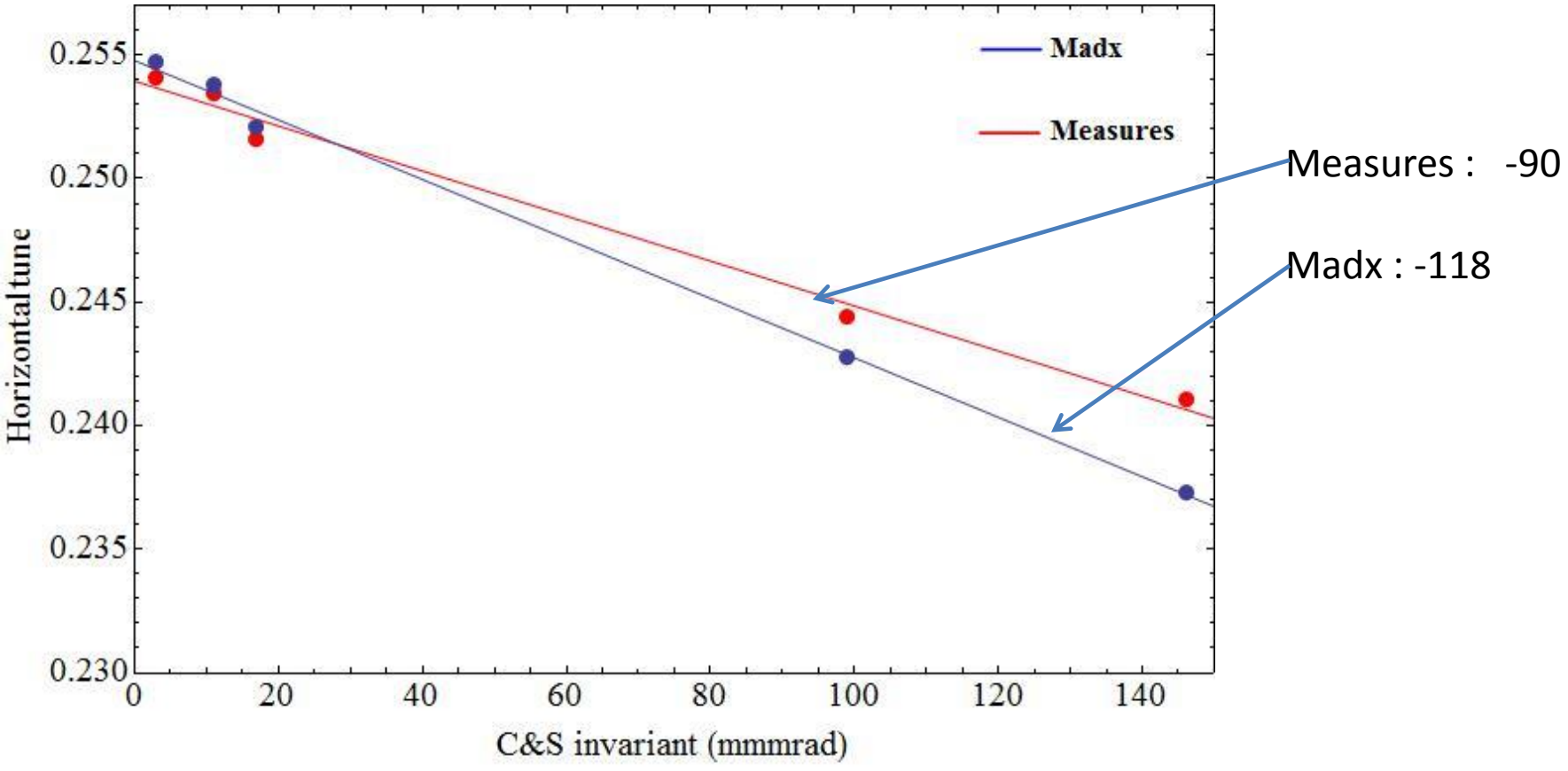




Then PS model has been tested by reproducing the measurements using distribution tracking with Madx-PTC.

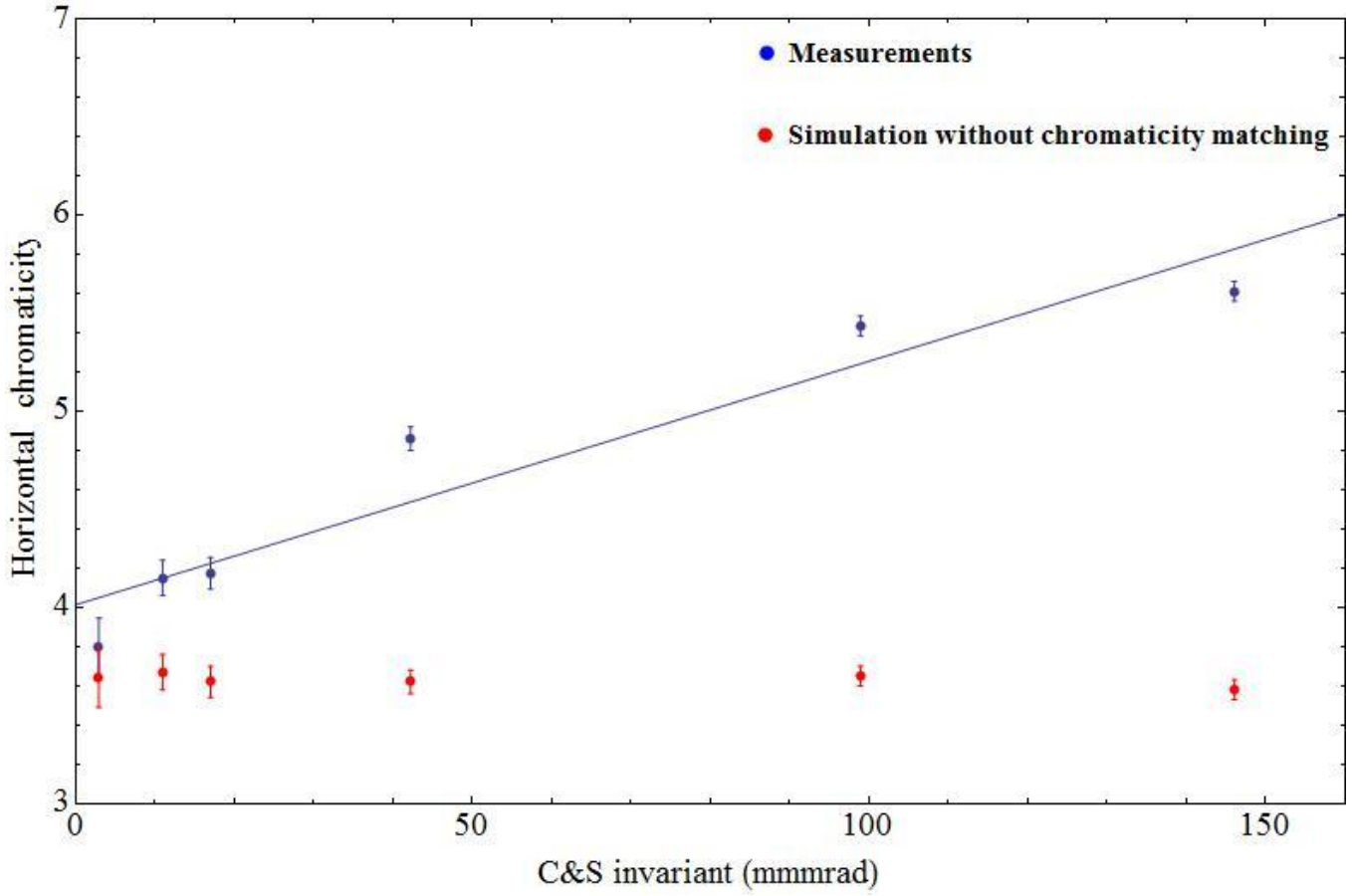
Chromaticity / detuning measurements

These measurements show a first discrepancy with the model concerning detuning with amplitude. Detuning given by model is higher than detuning extract from measures.



Chromaticity / detuning measurements

A second discrepancy appears after calculation of linear chromaticity vs kick amplitude extract from decoherence analysis.



PS model does not reproduce the linear chromaticity increase with kick amplitude.

Chromaticity / detuning measurements

As for MTE islands tune correction, one or more octupoles have been add to PS Main Units.
Different configurations tested :

One octupole at the center of each MU
One octupole at various positions in each half unit.

Best results obtained with only one octupole installed at the center of each MU. New detuning with amplitude given by the model is very close the the measured one and the new model reproduces quiet well the linear chromaticity increase.

RDT measurements

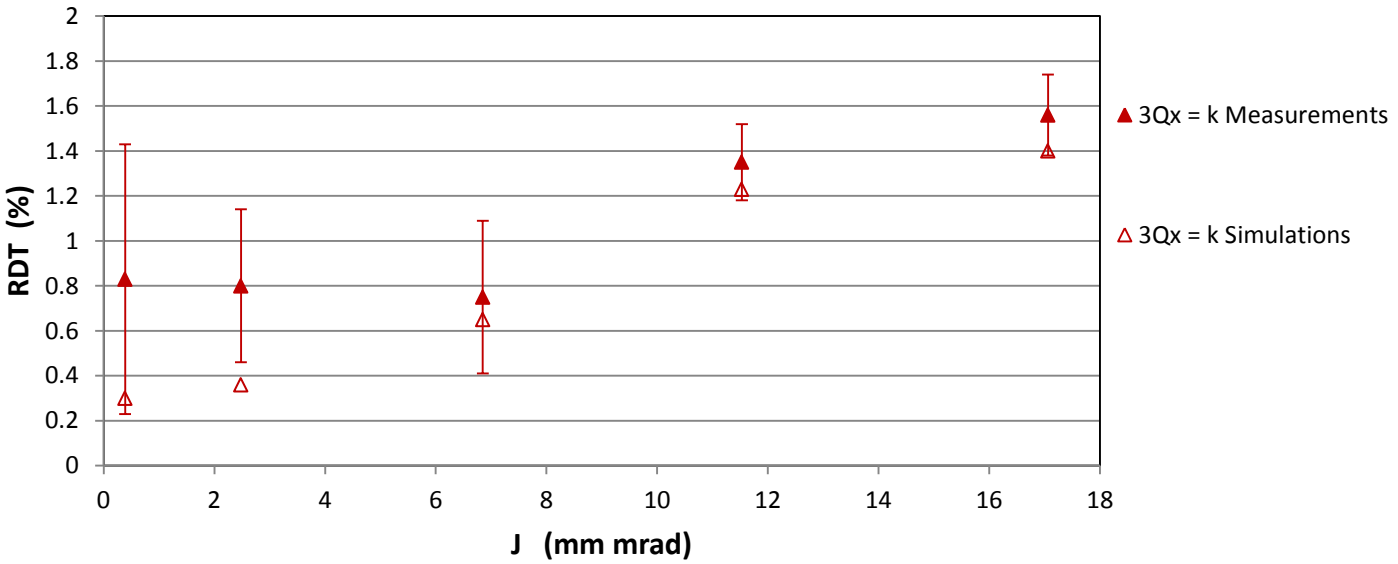
RDT measurements

After β-beating calculation, the software package for optics measurements developed for the CERN LHC has been applied to both measurements and tracking data for driving terms measurements.
Turn-by-turn data are Fourier-analysed to obtain the amplitudes of the various spectral lines. All measurements have been performed in the horizontal plane.

Measurements have been done at 14GeV in various conditions.

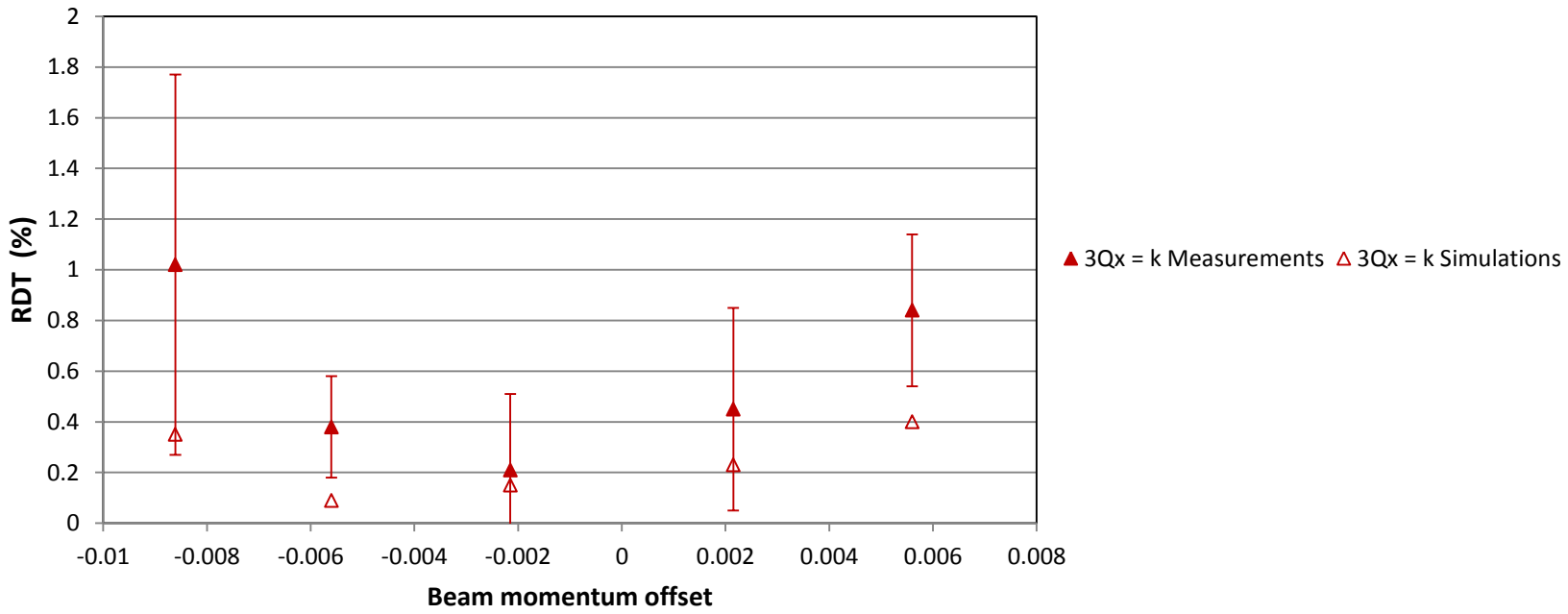
- Kick at various amplitude with PFW's and MTE sextupole
- Kick at constant amplitude and various dp/p
- Kick in MTE islands at various positions

RDT measurements



Kick at various amplitude, MTE sextupole turned on.

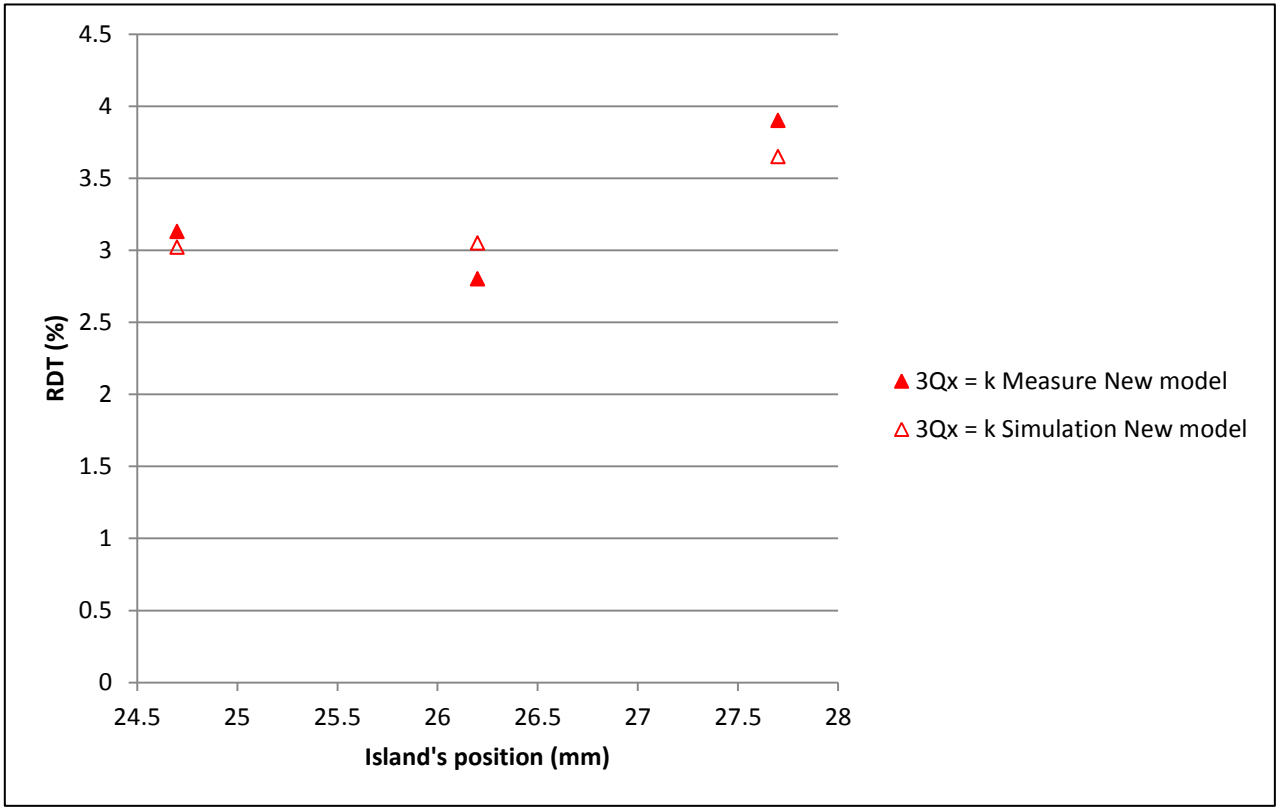
RDT measurements



Kick at constant amplitude, and various dp/p

RDT measurements

Kick in MTE islands, for various island's position.



Conclusion

- Several beam measurements have been done on the PS, including first time beta-beating measurements, both for standard beams and for stable islands corresponding to the new Multi-Turn Extraction scheme.

- Results show an excellent agreement between model and measures for standard beams on axis. Some discrepancies have been found for stable island optics

- Measurements shows some discrepancies (linear chromaticity, detuning with amplitude) with the model when looking at higher amplitudes, correction scheme has been proposed, based on additional octupoles in PS magnets, leading to good reproducibility.

- First Resonance Driving Terms measurement has been carried out. Results are great for sexupolar terms. Study still under progress for other RDT such as octupolar terms.