# Analysis of the performance of the new electronics PU and first attempt of optics-based-BPM calibration

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# Outline

- Summary of measurements performed between September and December.
- Introduction to the measurement system: Excitation, measurement and analysis.
- Analysis of the resolution of the data using two different methods of acquisition
- Analysis of the resolution of the BPMs as a function of the intensity.
- First beta-beating analysis for different scenarios. Where can we obtain better resolution?
- Conclusions.

# Overview of the measurements

- September & October.  Several measurements were performed in order to have a preliminary results
    - Using the kicker alternating between the  planes at 2.5 kV
    - Several measurements of chromaticity for different values of the sextupoles
    - Changes in the configuration of the AC-dipole
    - When trying to go higher in intensity we got a security alert on the kicker. We decided then to increase the safety limit and to perform the measurements at 2 kV
- November
    - 15/11/2017. Objective: Intensity studies
        - Summary : Due to problems in the configuration of the beam the acquisition started late. Only possible to measure the RING 2 at different intensities with sextupoles on.
    - 17/11/2017 Objective: Complete the intensity studies for the rest of the rings
        - Summary: The MD started with the measurement of the chromaticity for different currents of the sextupoles. Due to a misunderstunding of the results, it was tough that the quality of the data was better without the sextuples switched on. The measurements were performed in the four rings. Ring 2 was only measured at one intensity
- December
    - 04/12/2017 How stable can we control the intensity? For a fixed number of turns
    - 06/12/2017 Objective. In previous MDs it had been seen that the if increasing the intensity of the beam. The tune was changing with the intensity of the beam. Increasing the delta of the tune between the beam and the AC-dipole.
        - Problem. Fluctuactions on the intensity lead to fluctuations on the tune and therefore not a stable excitation of the beam

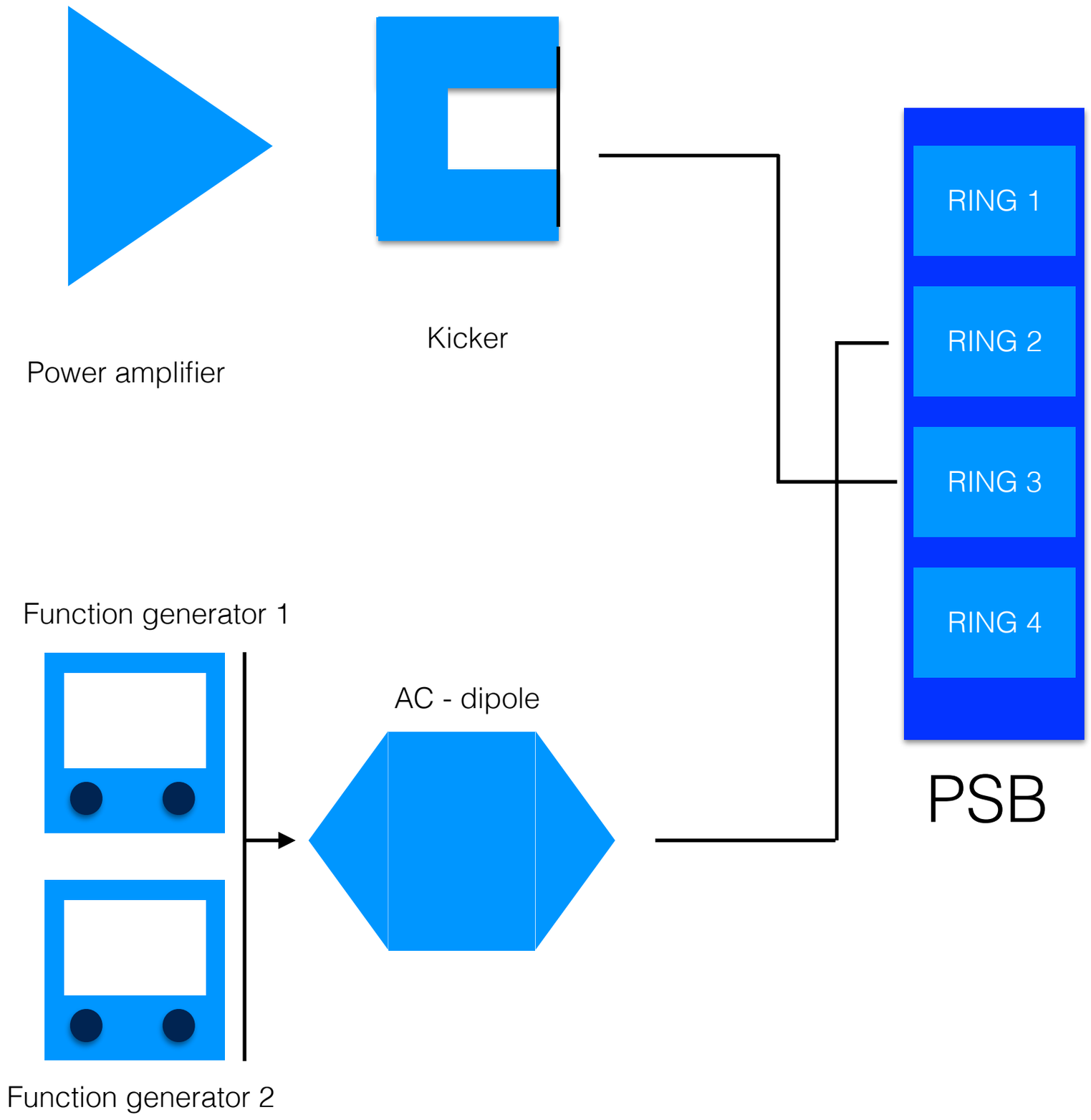
# Measurement principle (I)

## EXCITATION

- Two external elements are used for the optics measurements: These elements apply transverse momentum kicks to the beam, shifting it to a larger phase space amplitude and inducing betatron oscillations which can be observed in the BPMs

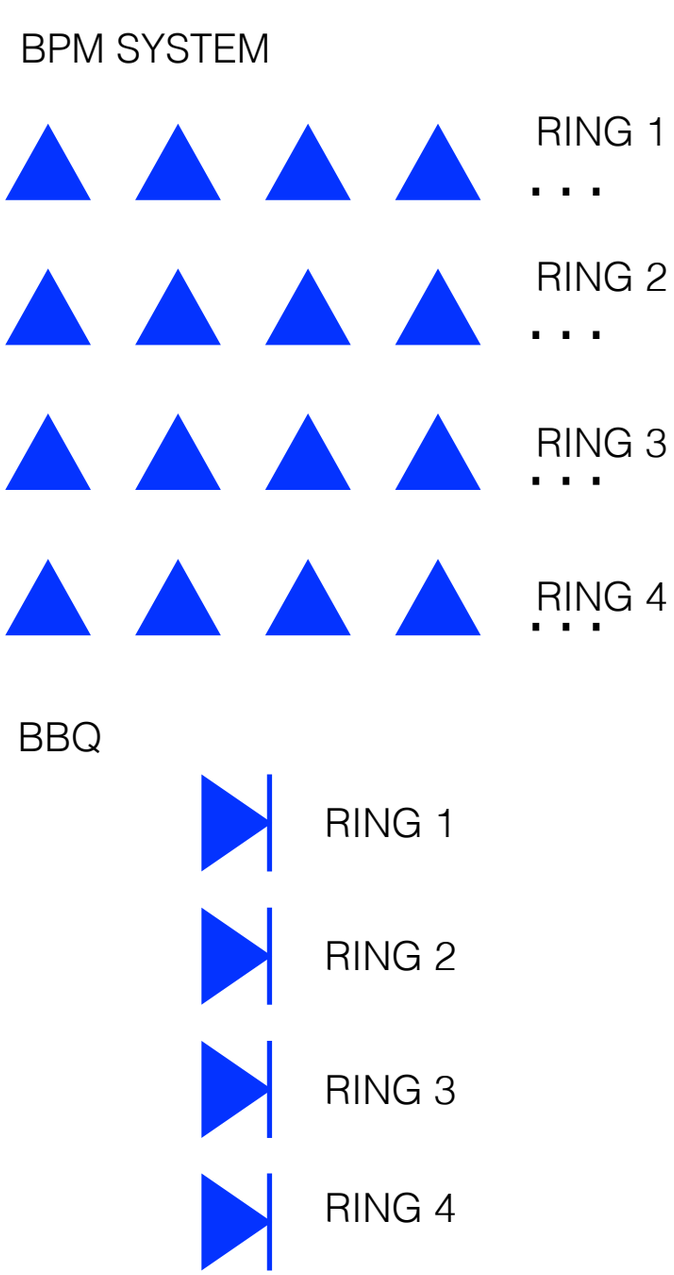
  - Single kicker.  The single kicker is the excitation that is normally being used for the tune measurements

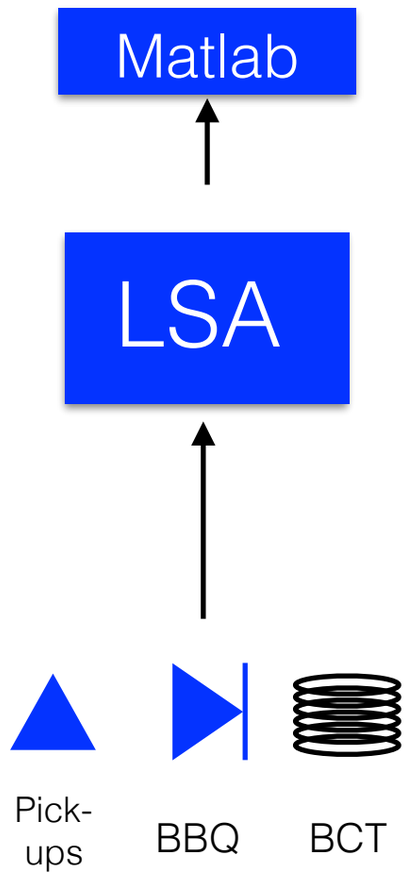
  - ADT (Only in the vertical plane) controlled by a combination of two function generator. One function generator controls the envelope while the other controls de sinusoidal excitation.

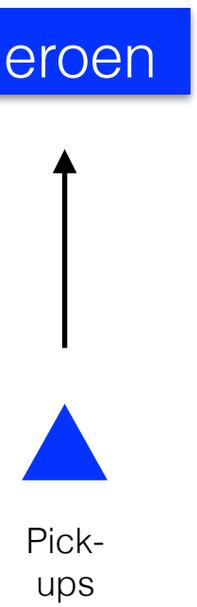


# Measurement principle (II)

## MEASUREMENT



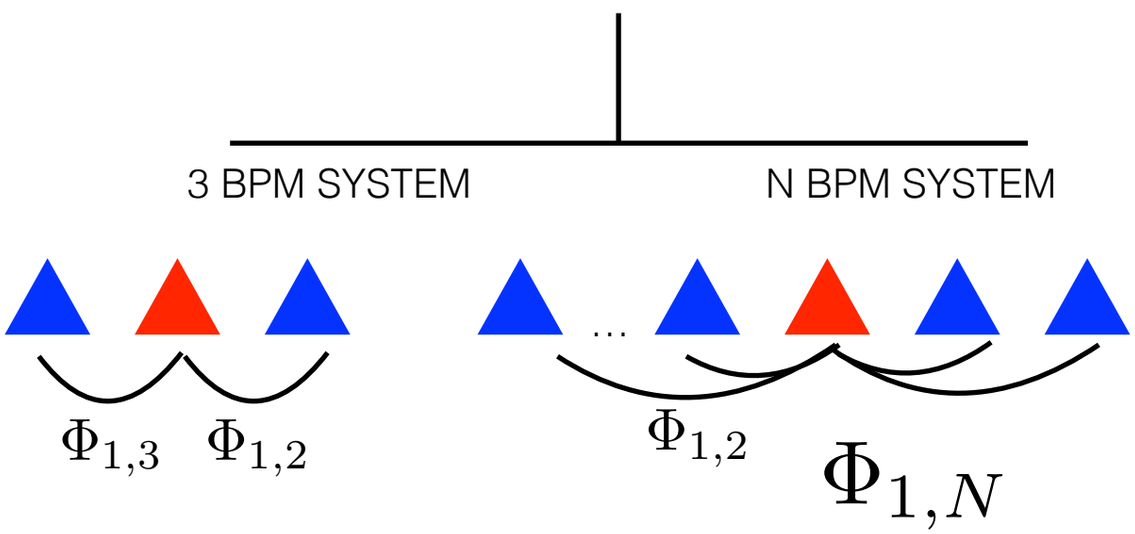

## ANALYSIS

TIME DOMAIN

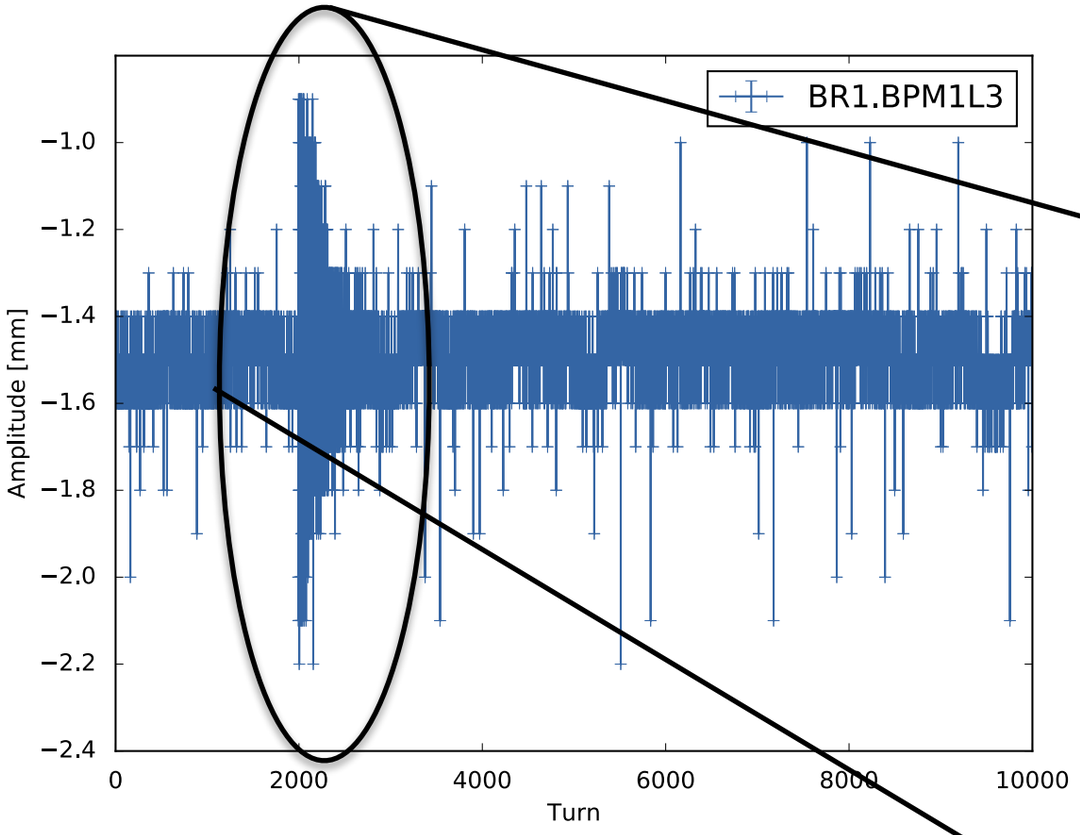
- Recording the center of charge of the beam each time it
- circulates through the PSB.
- The information of all the BPMs recorded for all the turns is
- saved in a Matrix.
- The data is lately cleaned using SVD method

FREQUENCY DOMAIN

- A Fourier analysis is performed to the Turn by turn data recorded by the BPMs and the BBQ data.
- The main peak of the frequency analysis in each plane will give the value of the tune

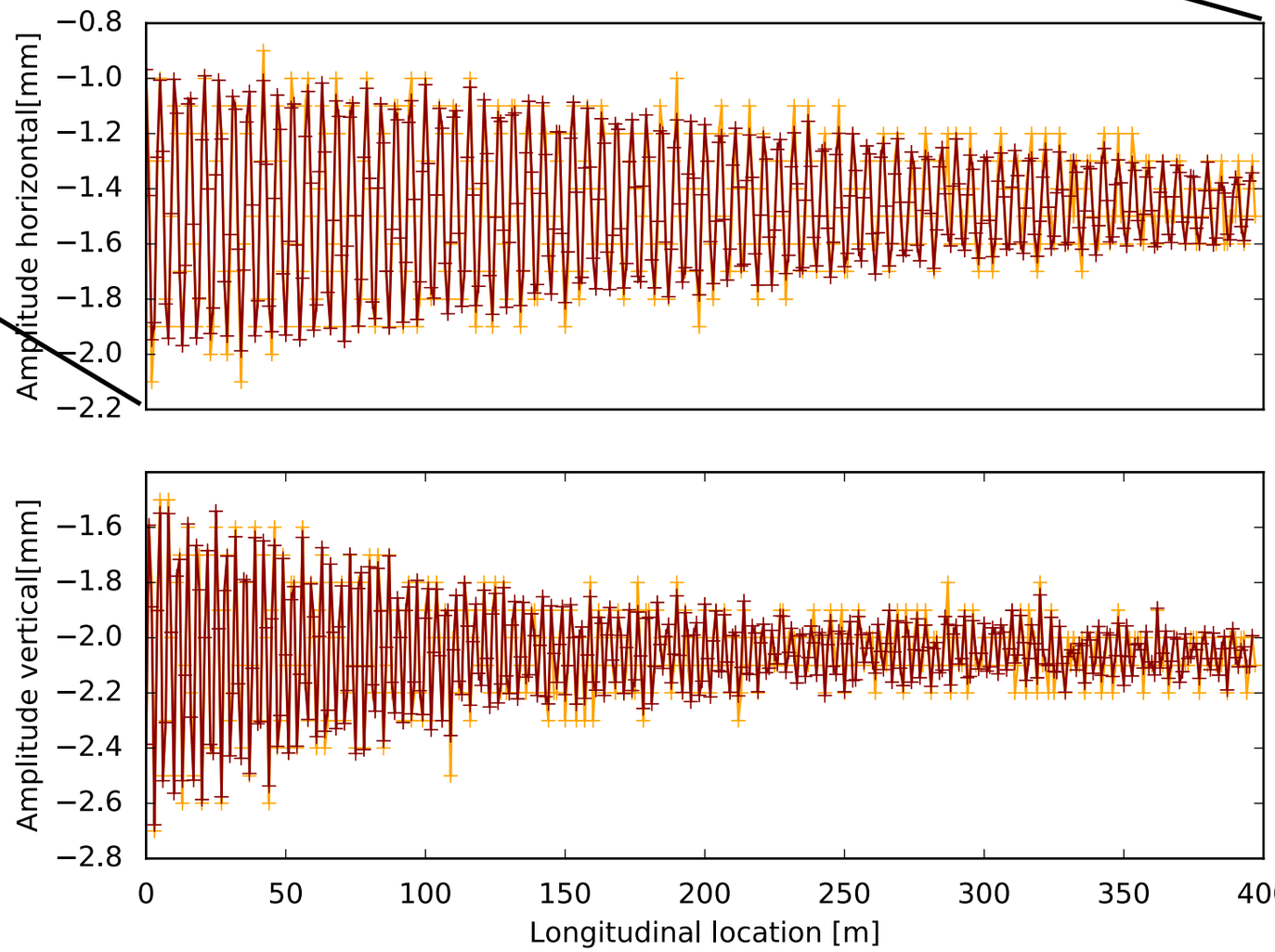


# Comparison of the two acquisition methods (I)

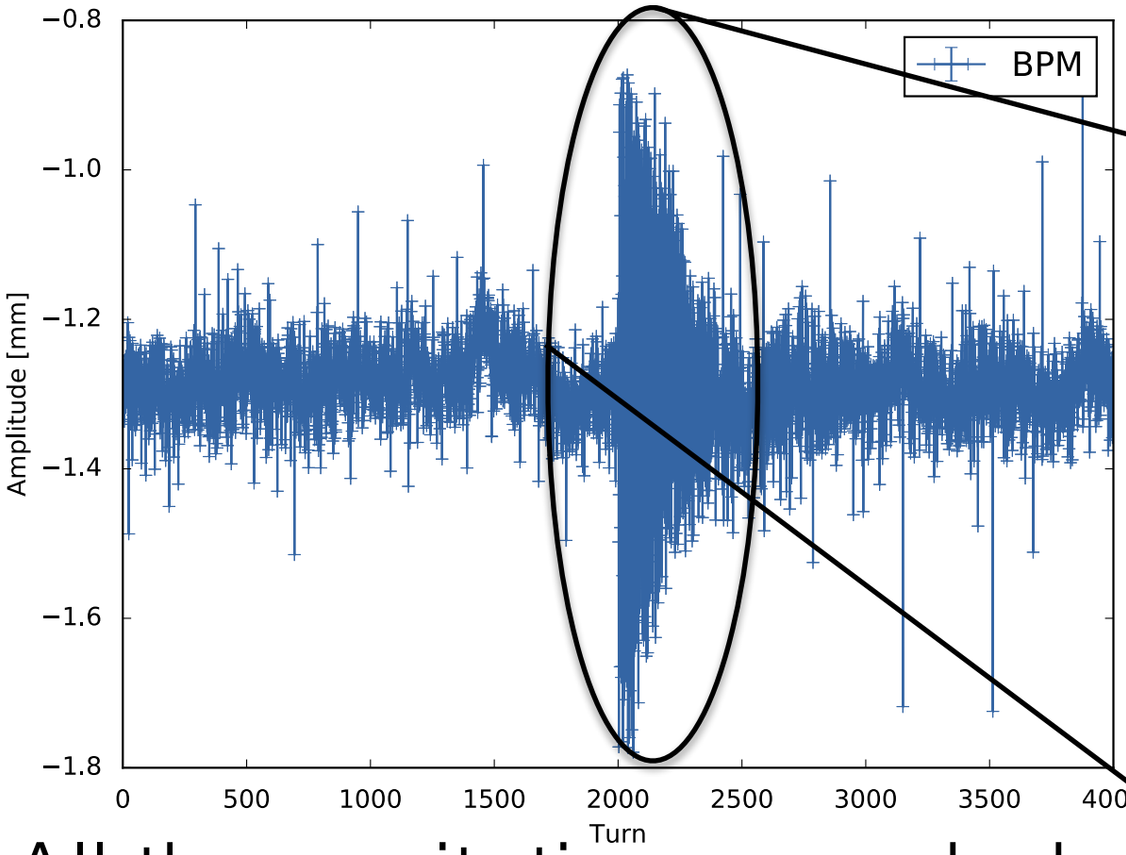



All the excitation recorded

MATLAB

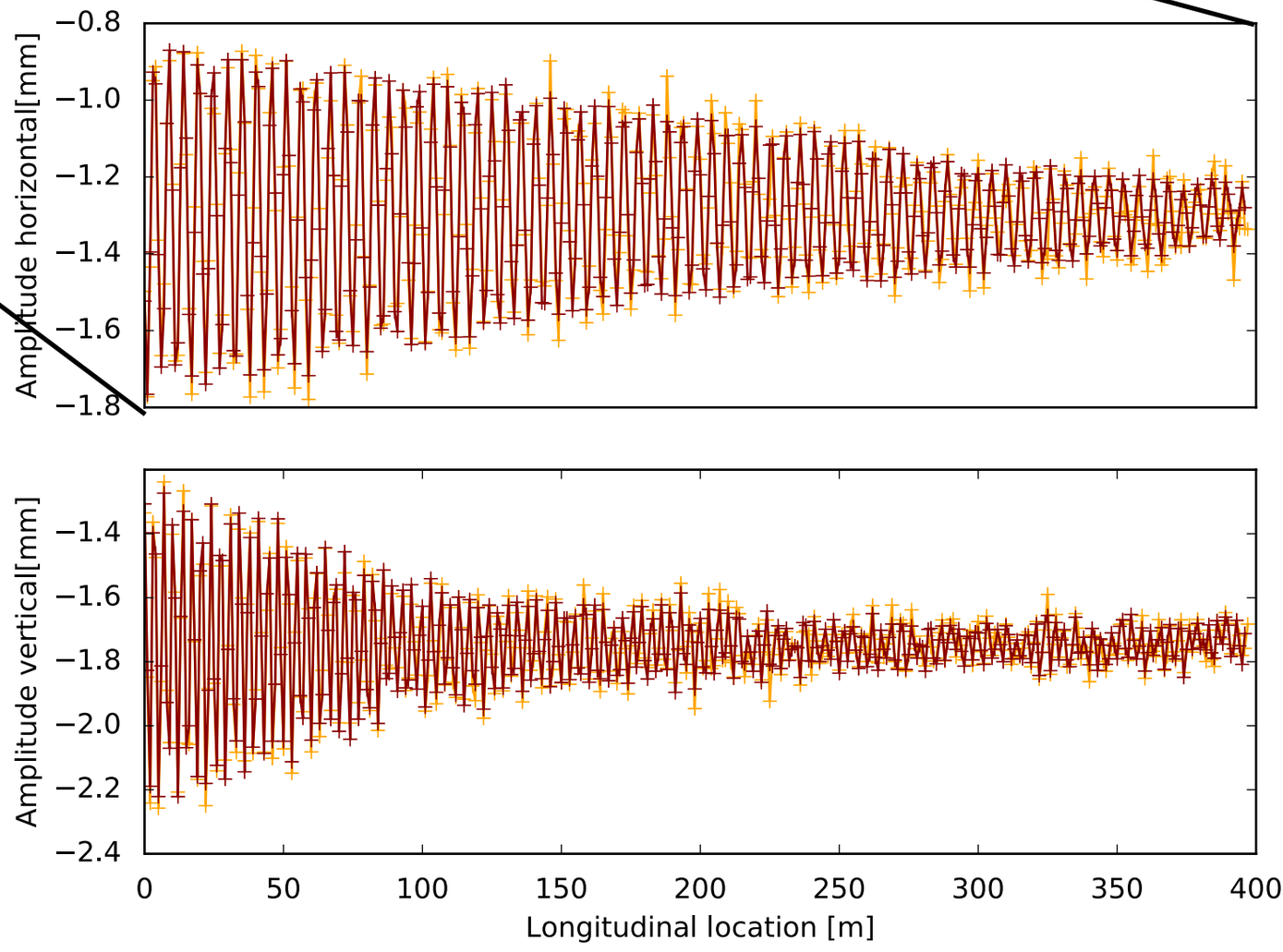


# Comparison of the two acquisition methods (II)




All the excitation recorded

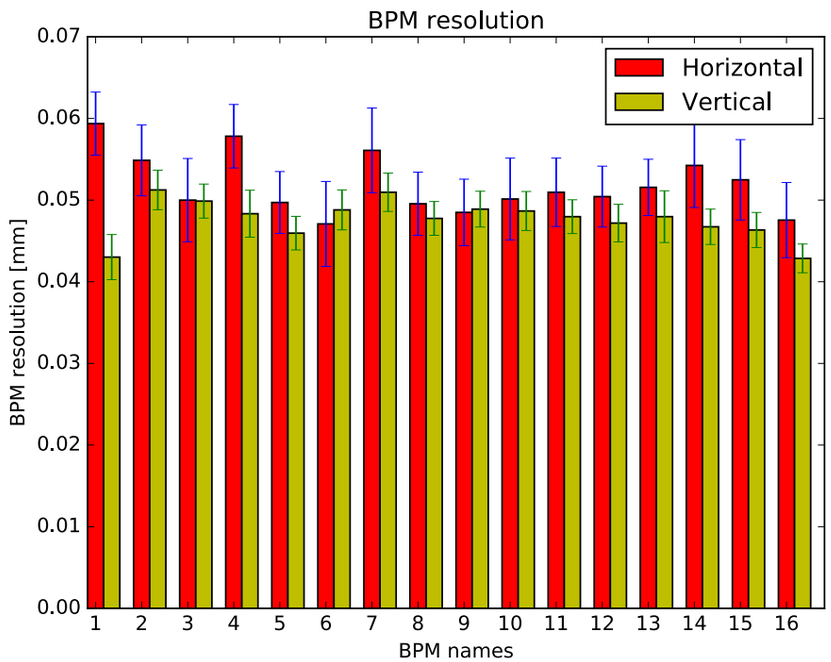
Jeroen



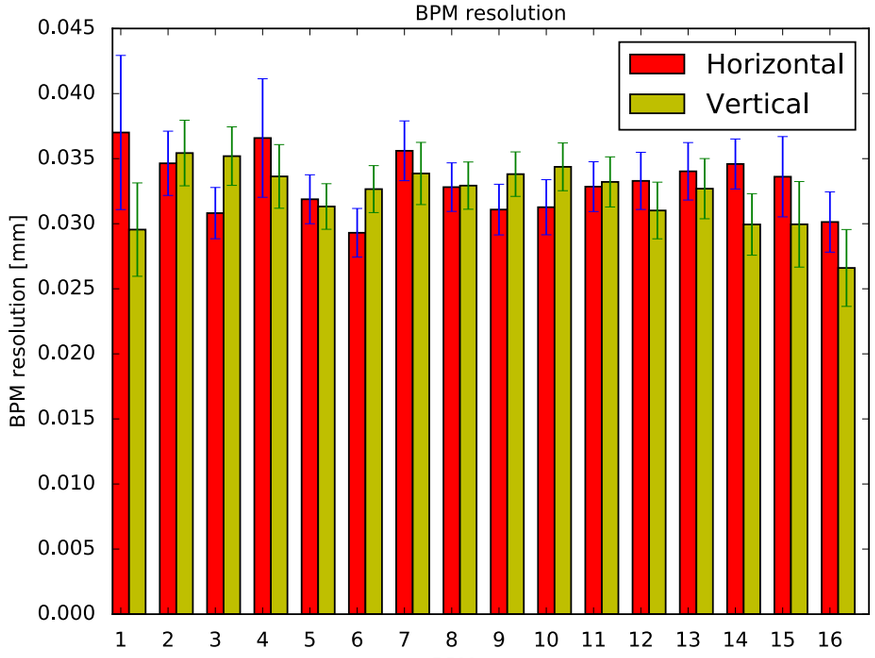
# Ring 1: Prologue (III): Comparative of the measurements

Intensity 125e10

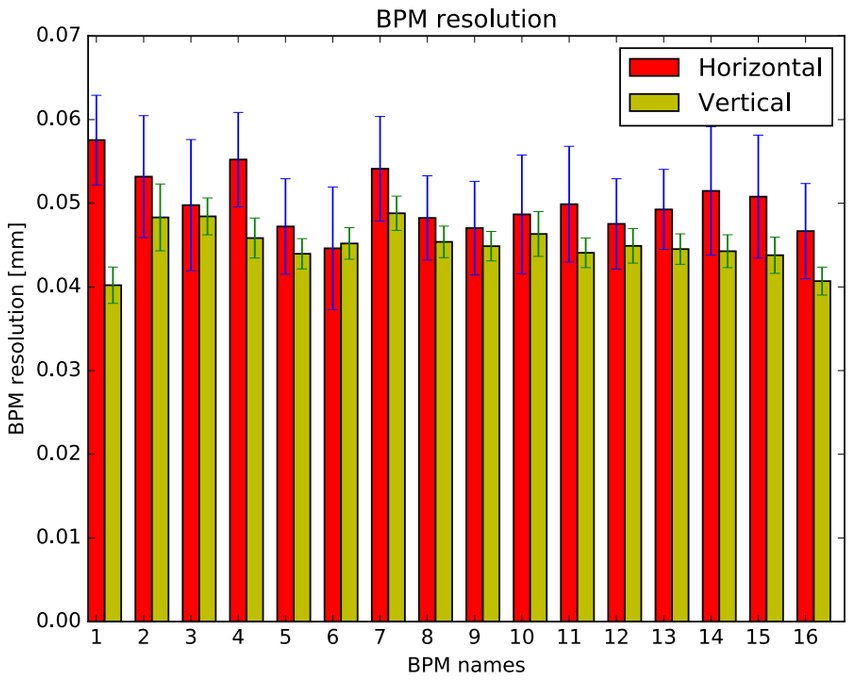
MATLAB

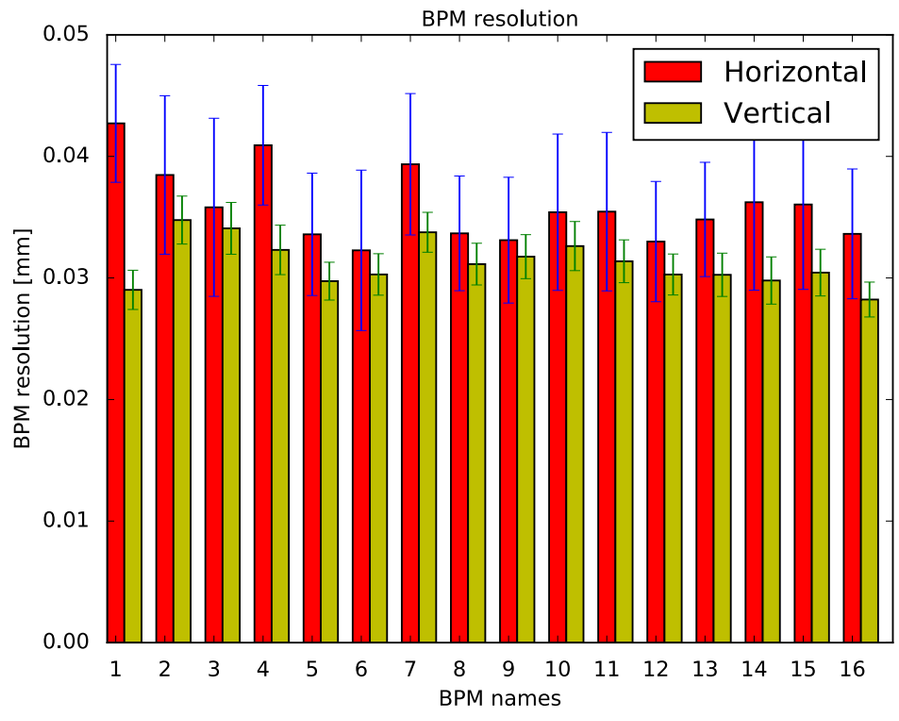



Jeroen




Intensity 250e10



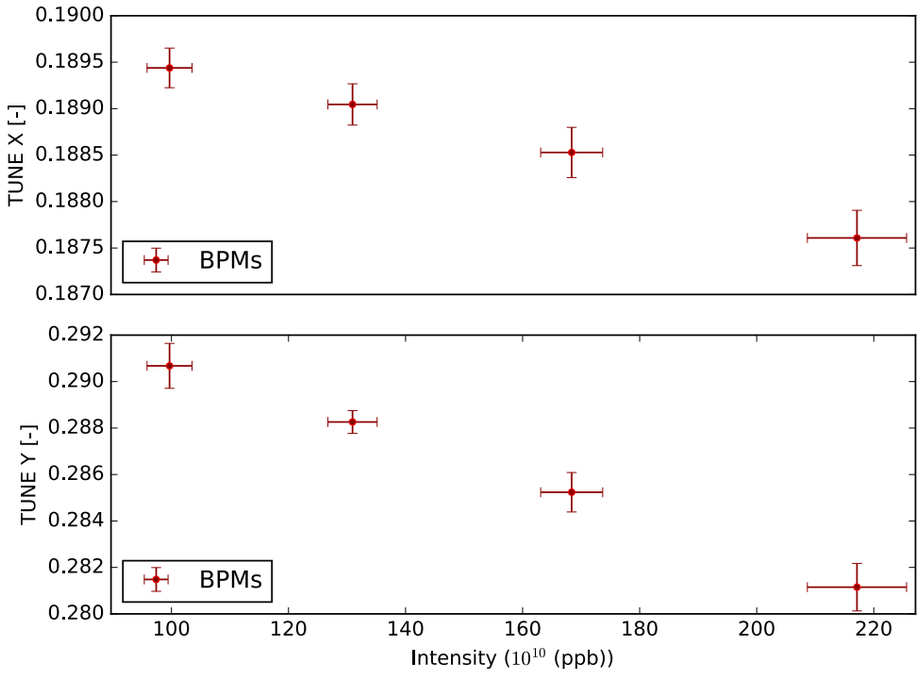



# Ring 1: Prologue

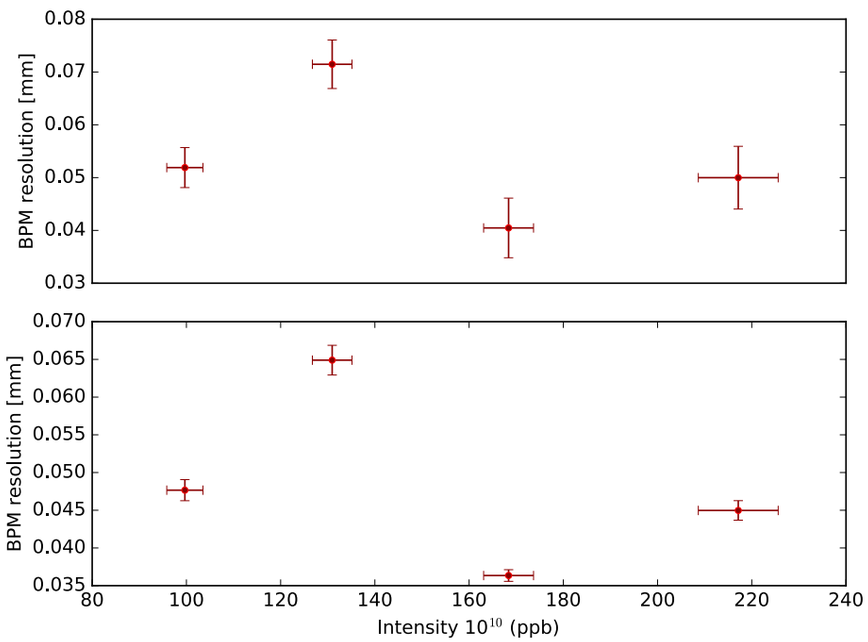
- Summary of the measurements performed the **17/11/2015: Optics measurements for different beam intensities.**
- Configuration of the measurements:
    - Sextuples set to 0 A and kicker used for the excitation with a voltage of 2kV

**MATLAB**

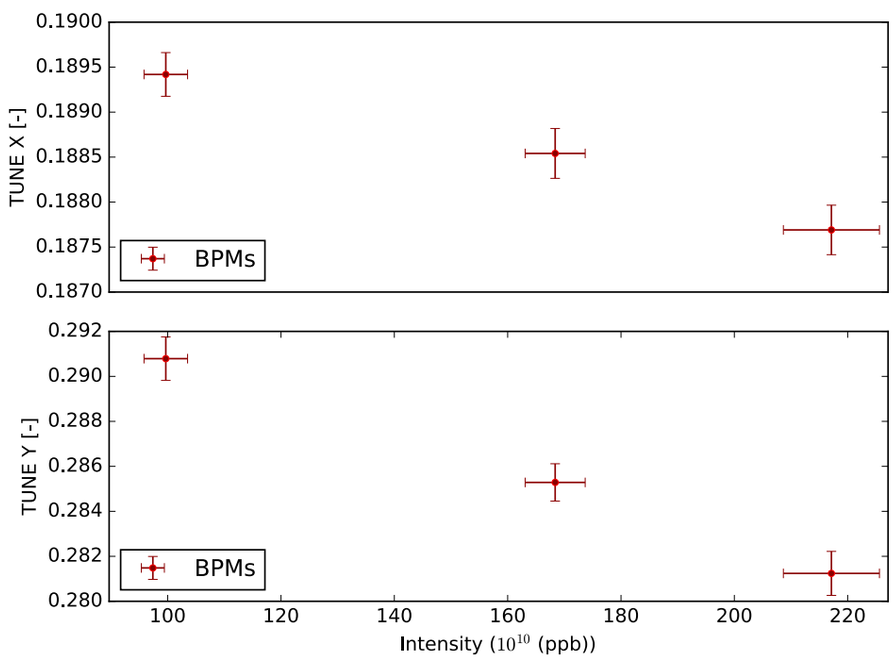
**Tune dependency with the intensity**

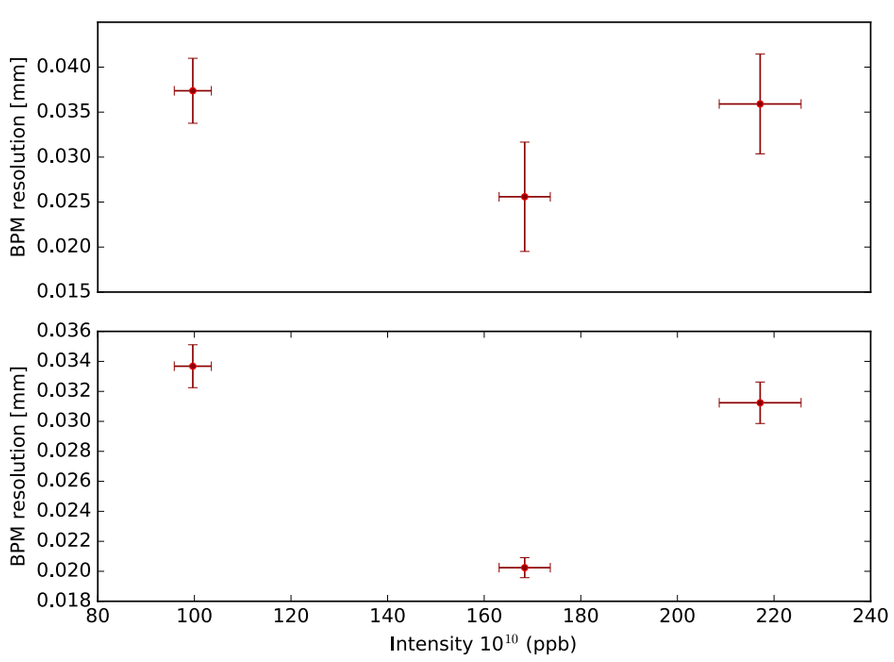



**BPM resolution with intensity**




**JEROEN**

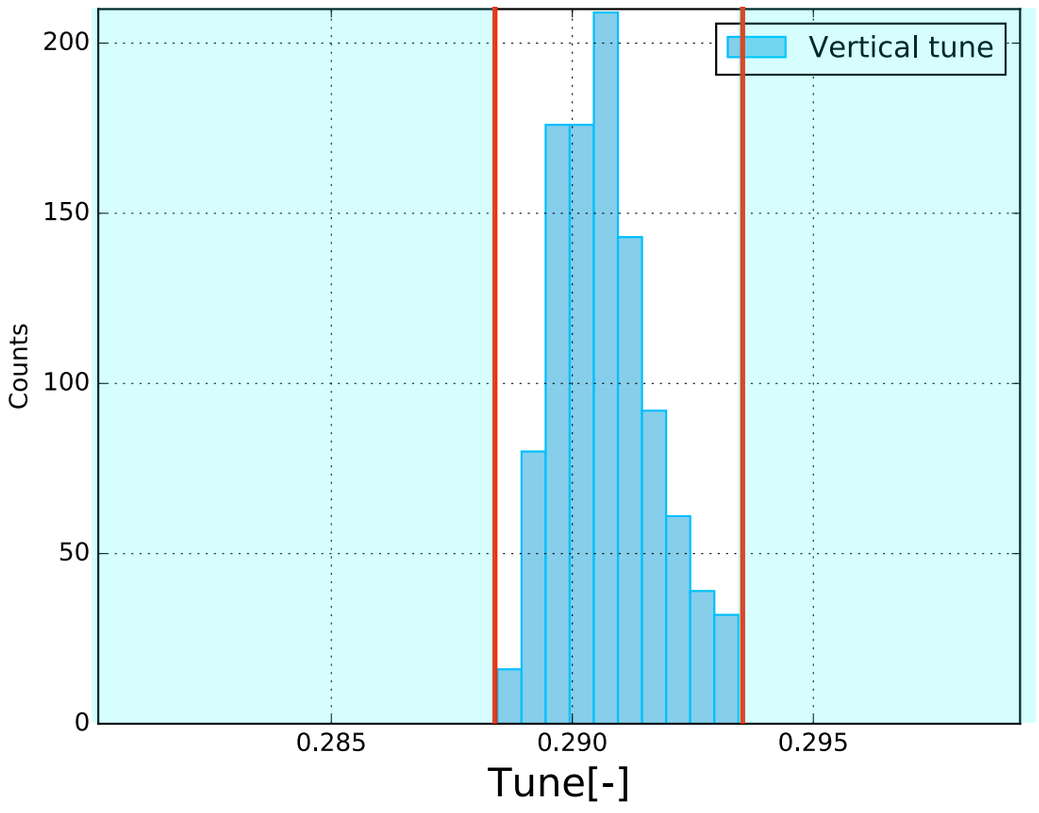


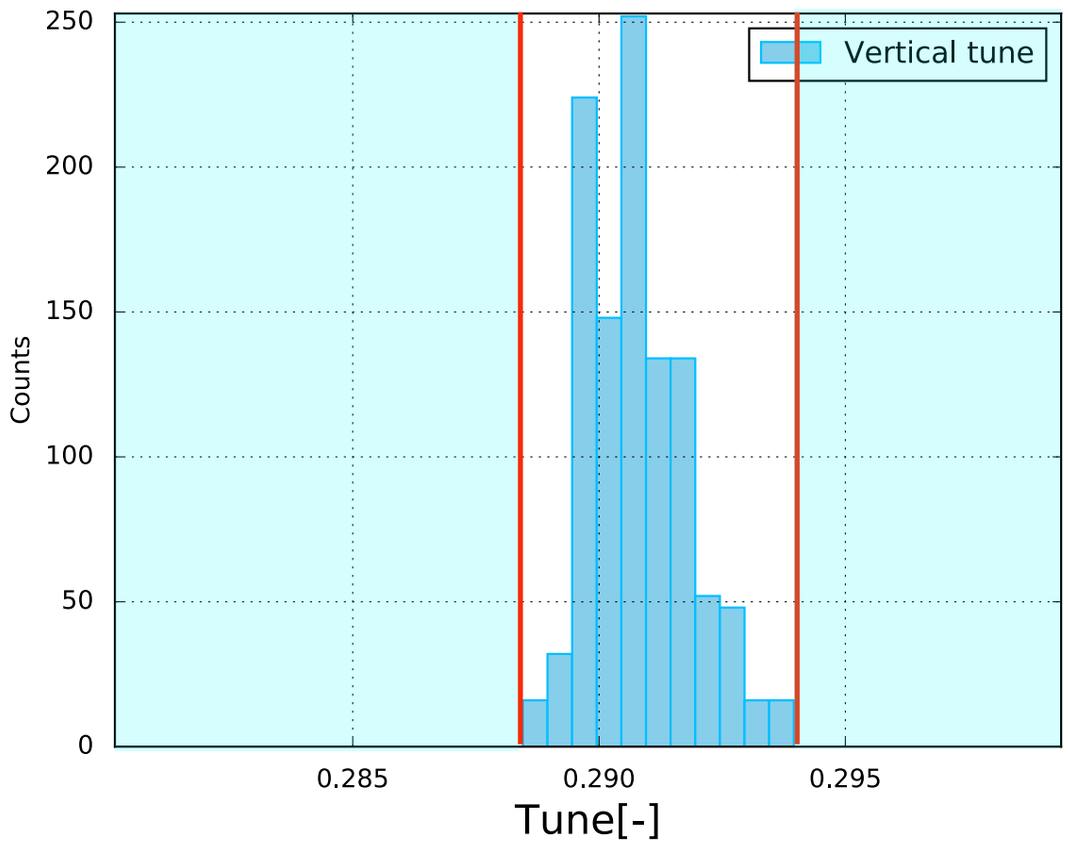
# Ring 1: Prologue (III): Tune stability

Tune stabilty is of a great importance for the future studies using AC-dipole
Histogram done with different kicks for a fix beam intensity.
Tune spread of this measurements can be used for defending a safe are for the operation of the AC-dipole

## Matlab



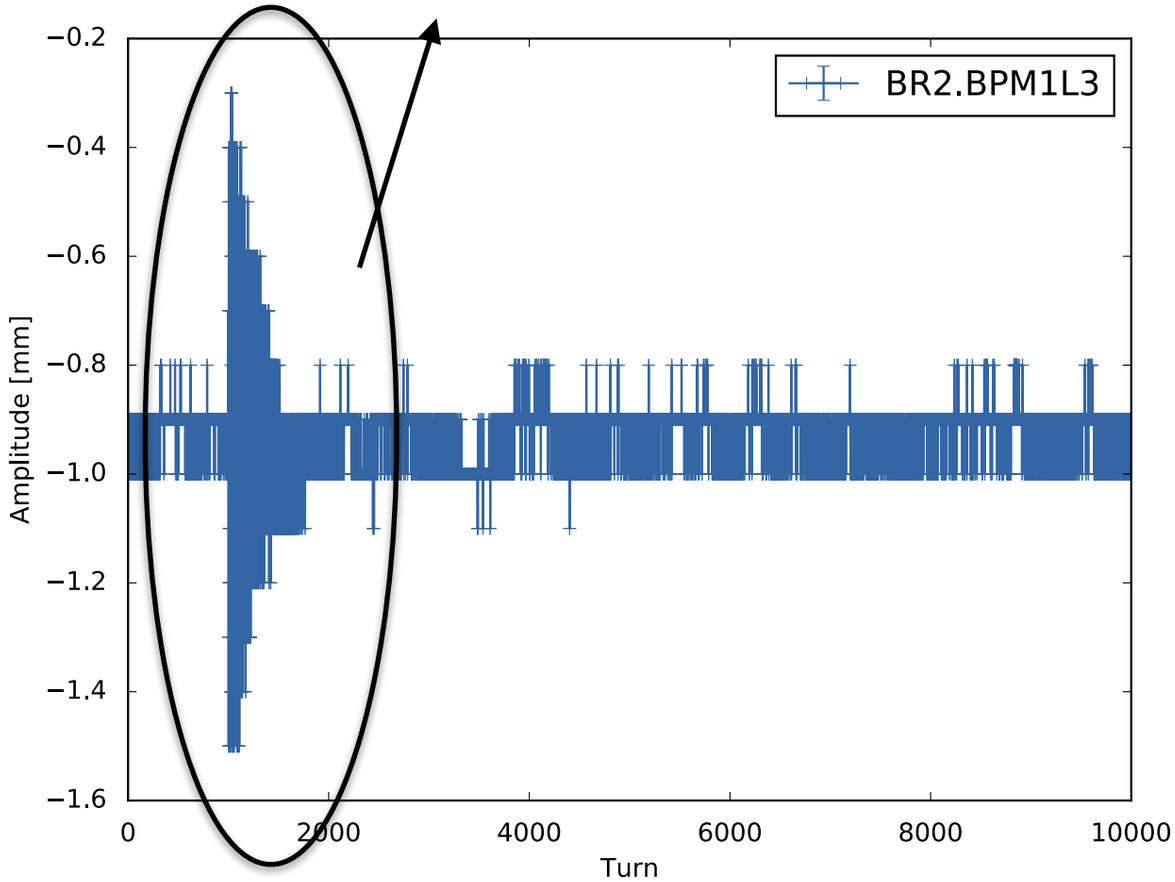

## Jeroen



# Ring 2: The Fellowship of the Ring (I)

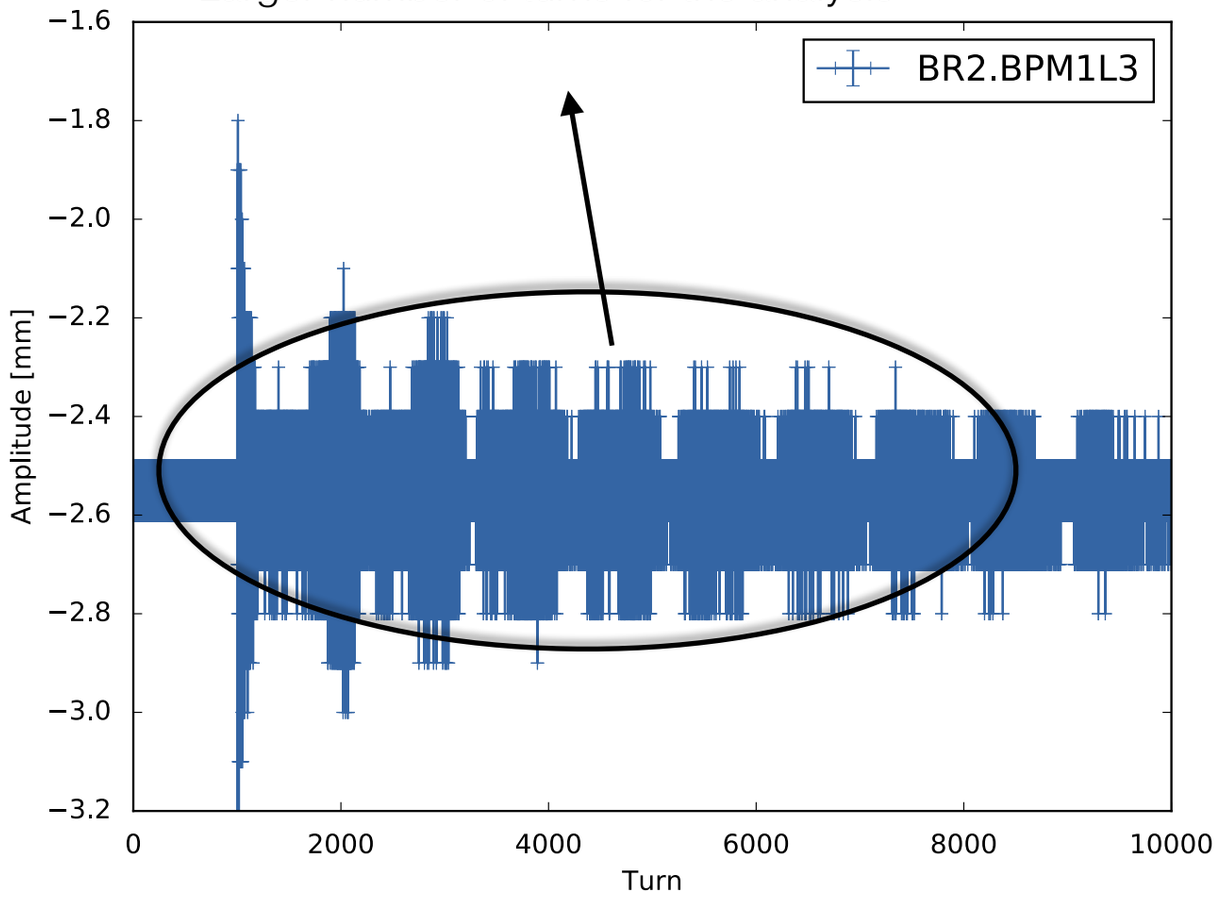
- Measurements performed with the kicker by increasing the voltage of the kicker.
- Values of the current 175e10

Larger amplitude



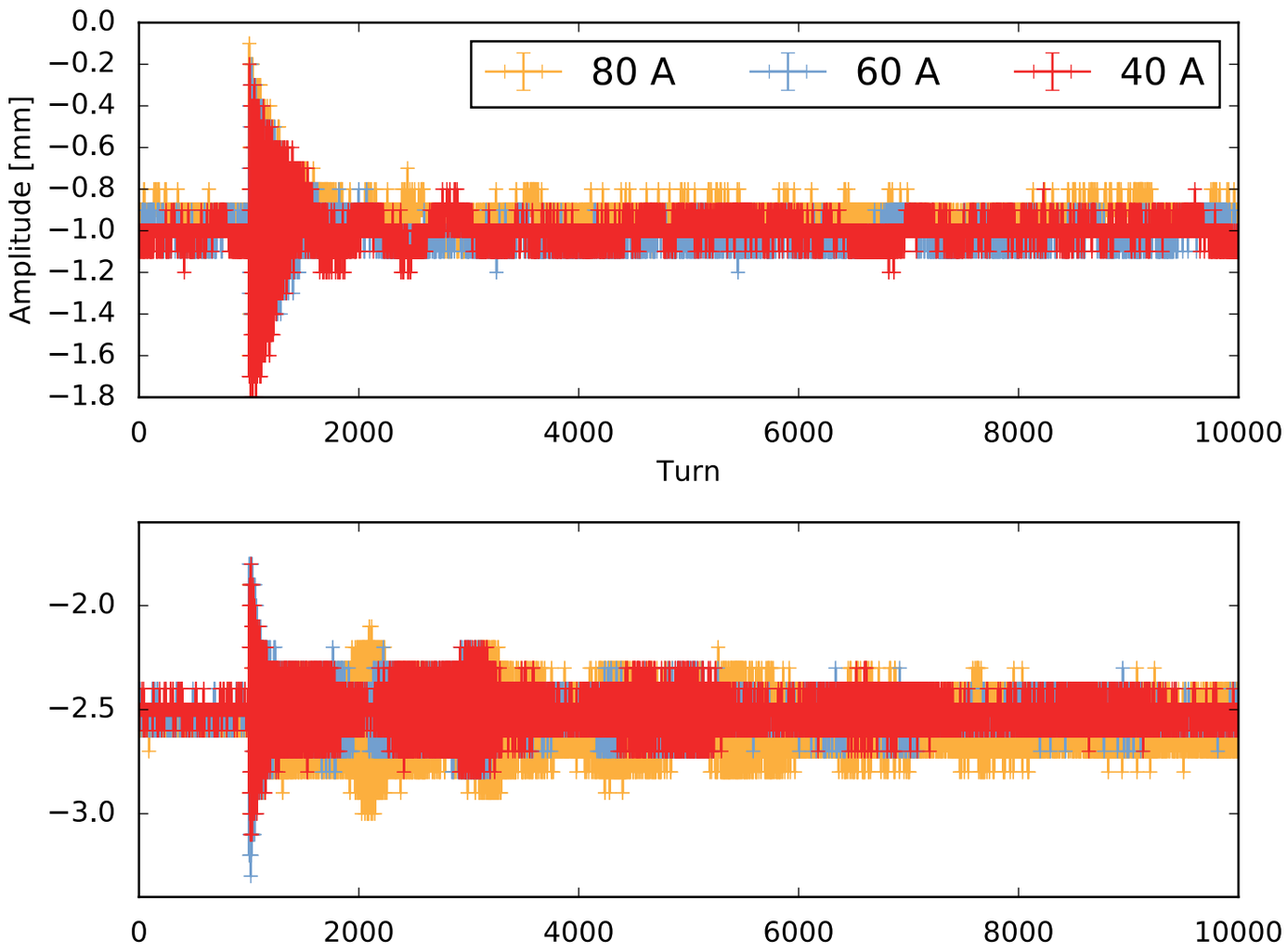

Horizontal

Larger number of turns for the analysis




Vertical

# Ring 2: The Fellowship of the Ring (II)




Attempt to increase the length of the excitation by powering the sextuples in the vertical plane.
The chromaticity was decreasing while increasing the sextupolar current
Small increase in the length of the oscillations for 80 A.
A measurement with larger number of decimals could improve the understanding of the effects of the sextuples in the vertical plane.

$\chi_v\ 0A$ -1.19

$\chi_v\ 40A$ -0.82

$\chi_v\ 60A$ -0.42

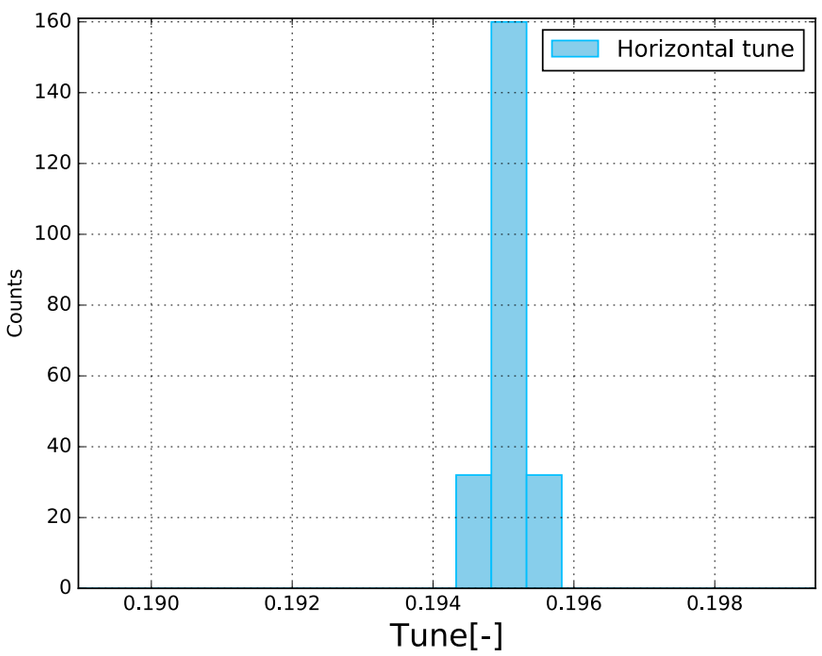
$\chi_v\ 80A$ -0.01

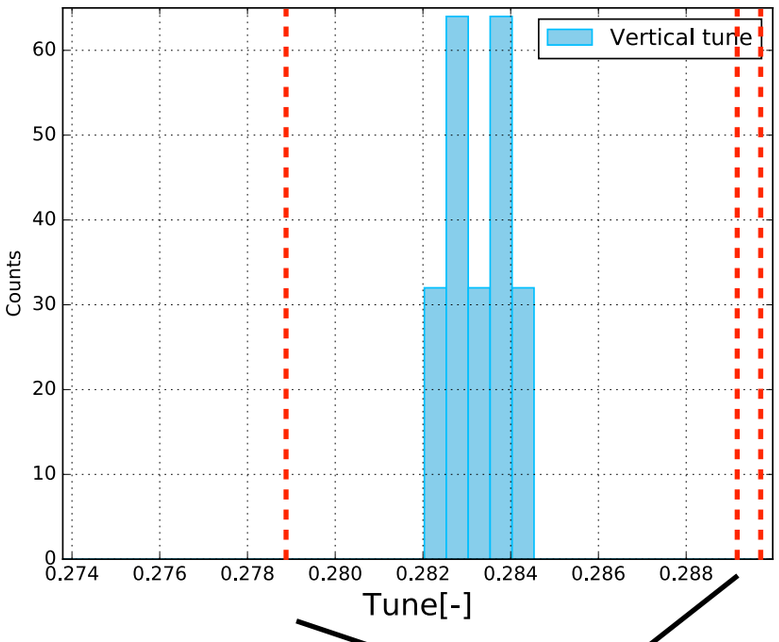
Work in progress

# Tune stability for different intensities

Smaller tune spread in the tune that in the RING 1, this can be due to by the increase in the kick amplitude

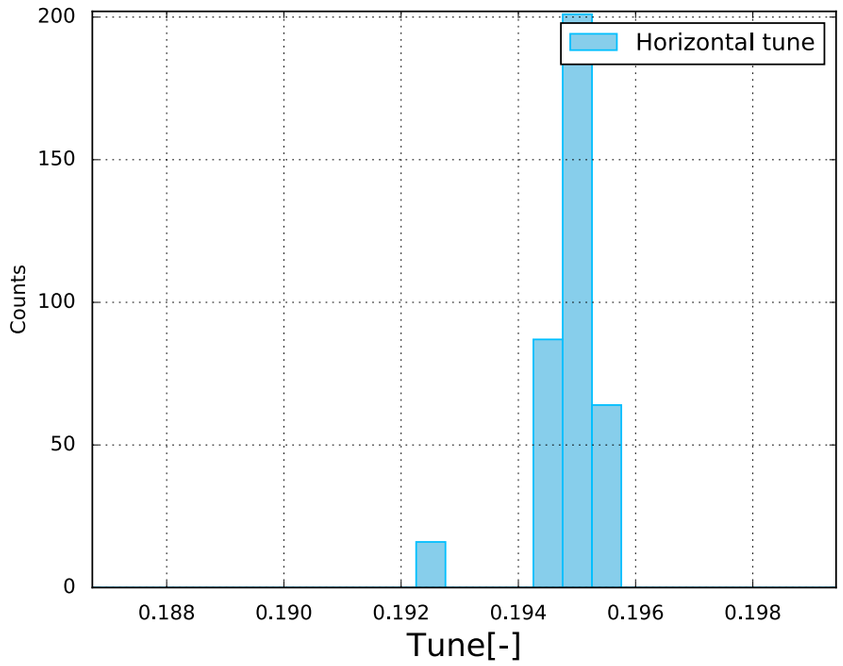
## 200e10

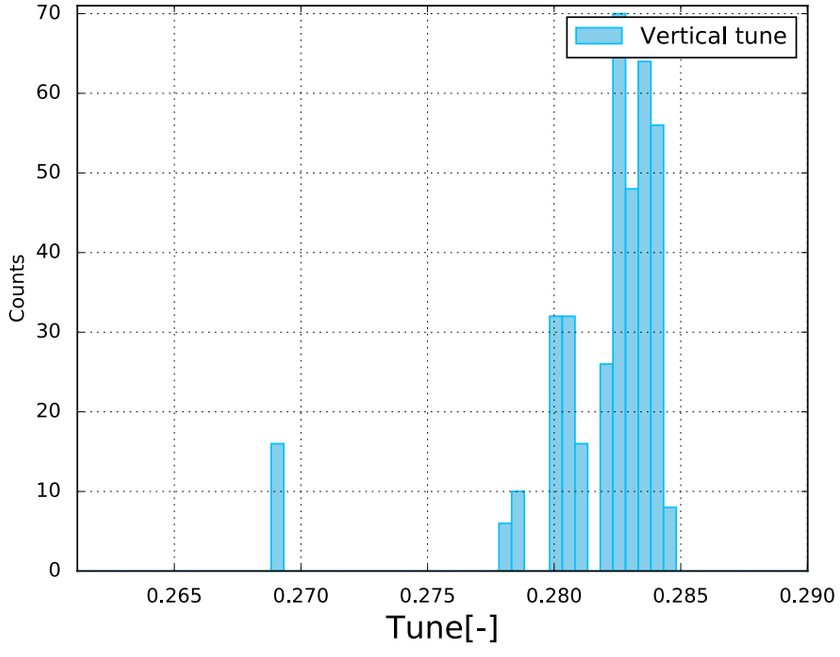


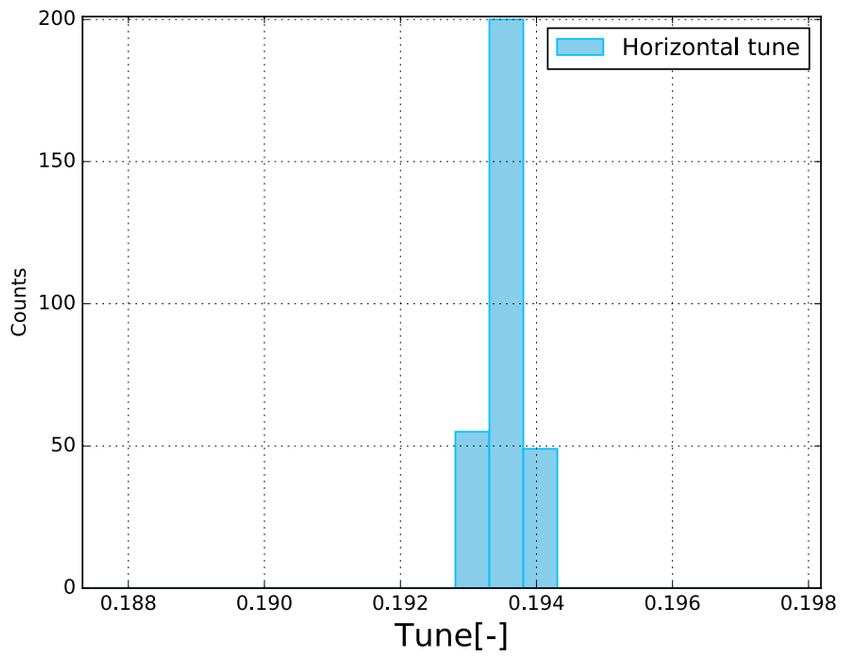

AC-dipole driven excitation

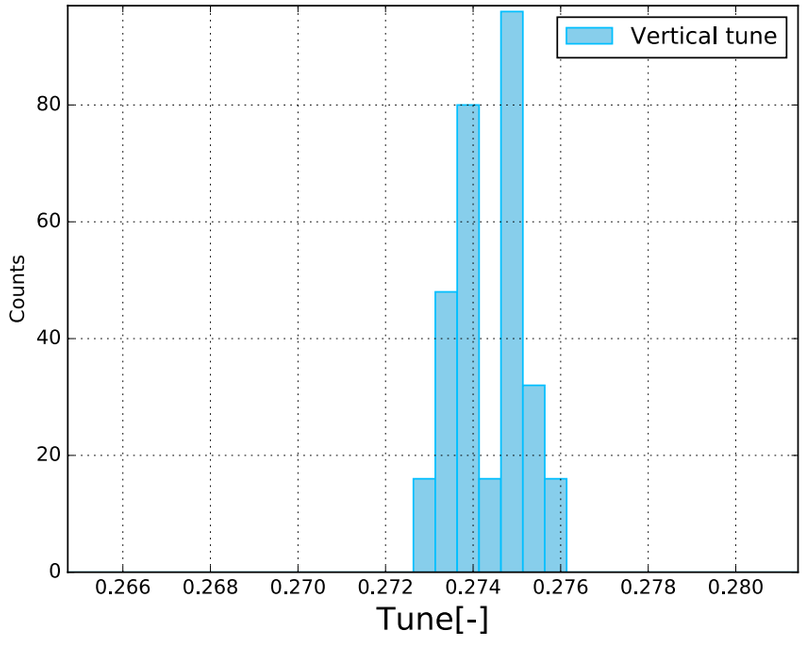
## 250e10




## 300e10



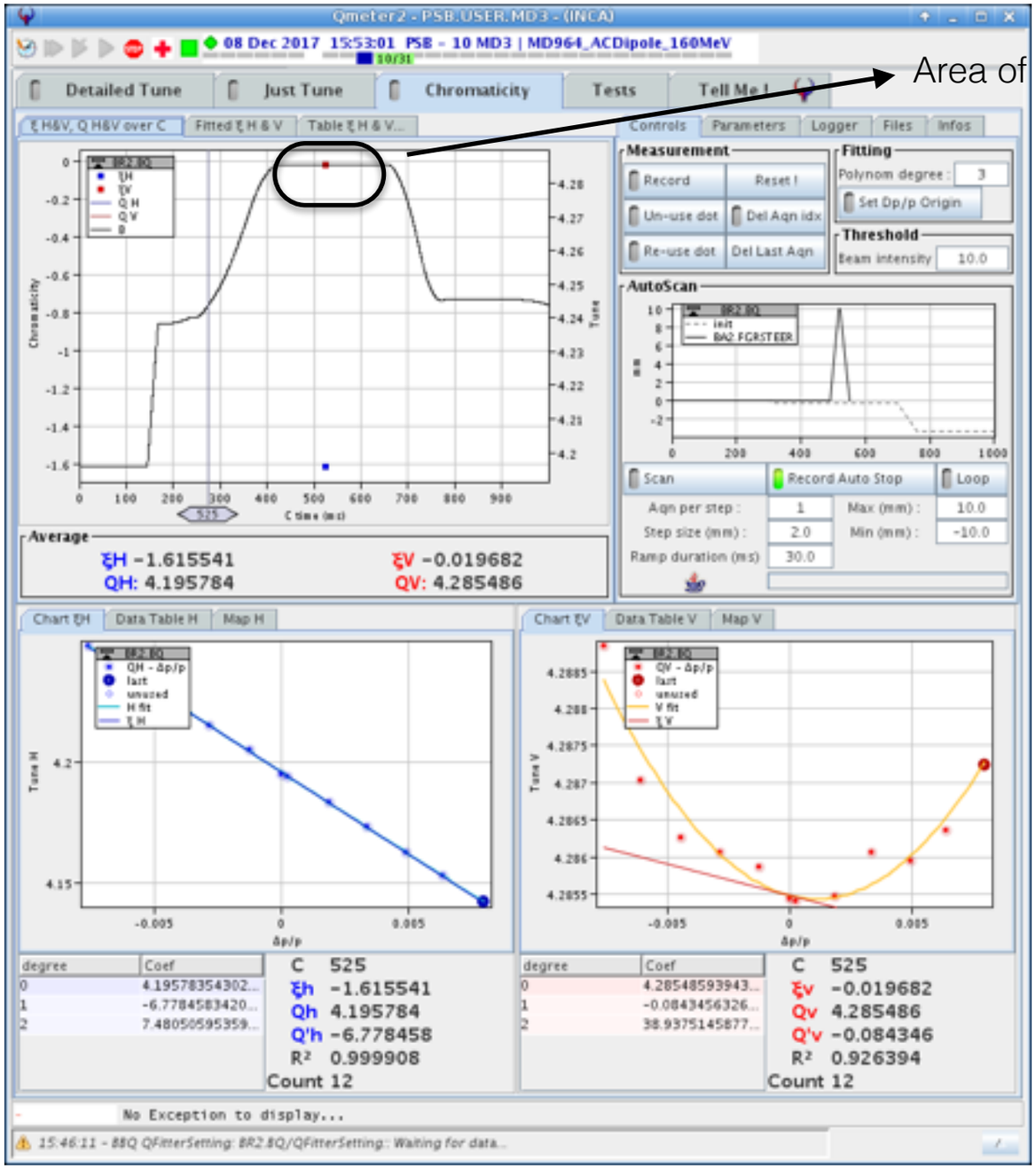



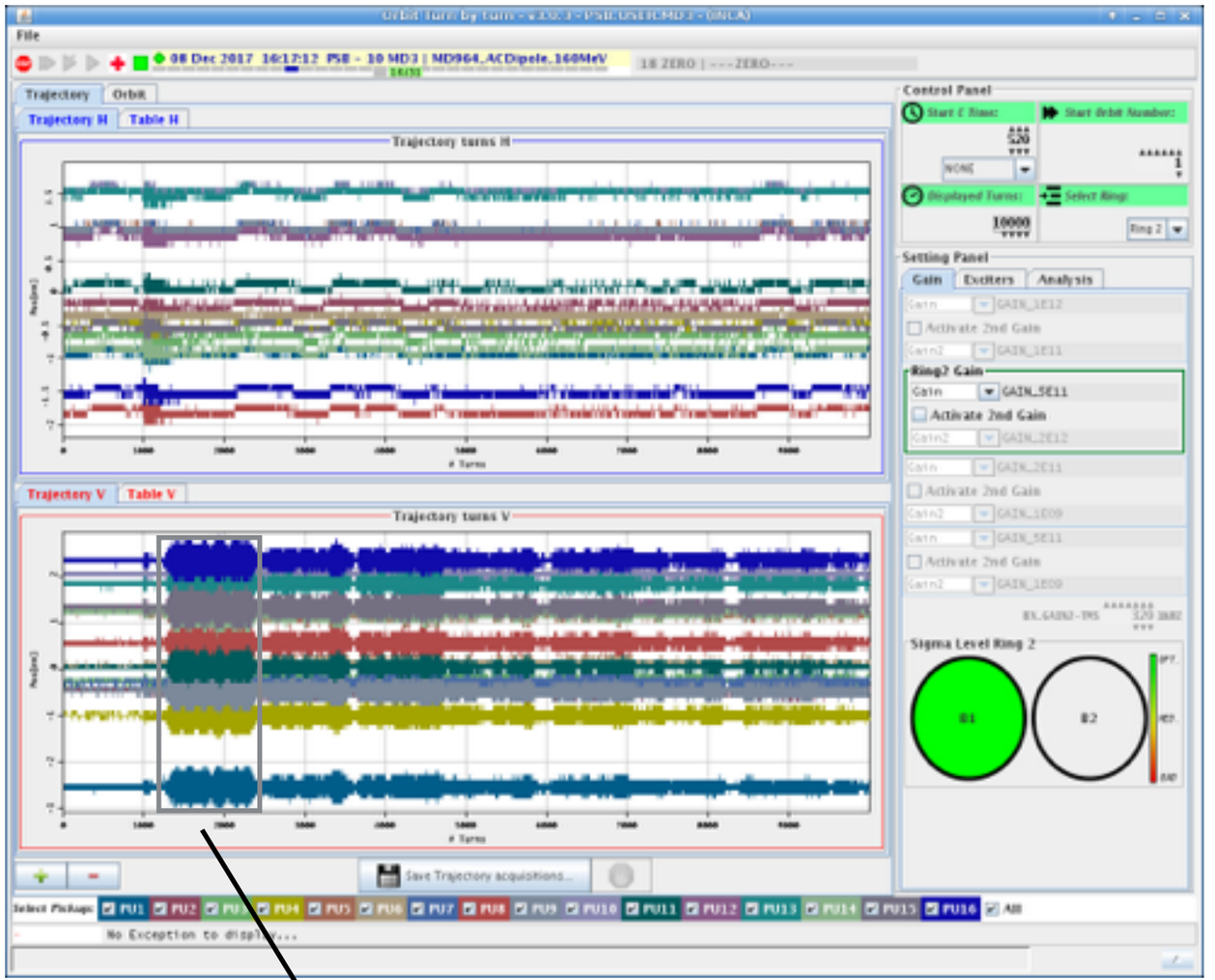
# Excitation using AC-Dipole (I)

Configuration of the AC-dipole measurements .
Intensity 200e10
Sextupoles 80 A

AC dipole 290

Area of operation of the AC dipole

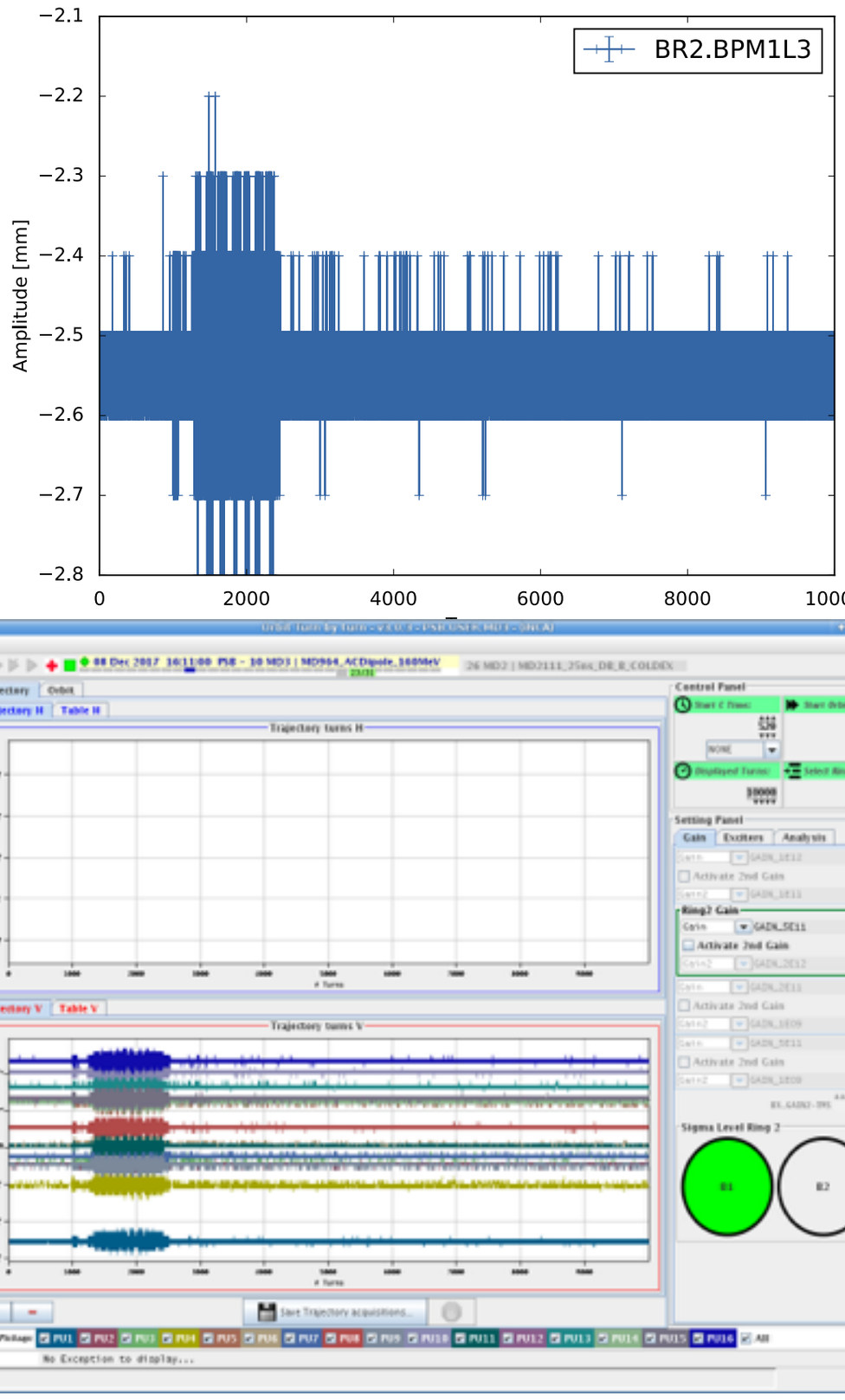


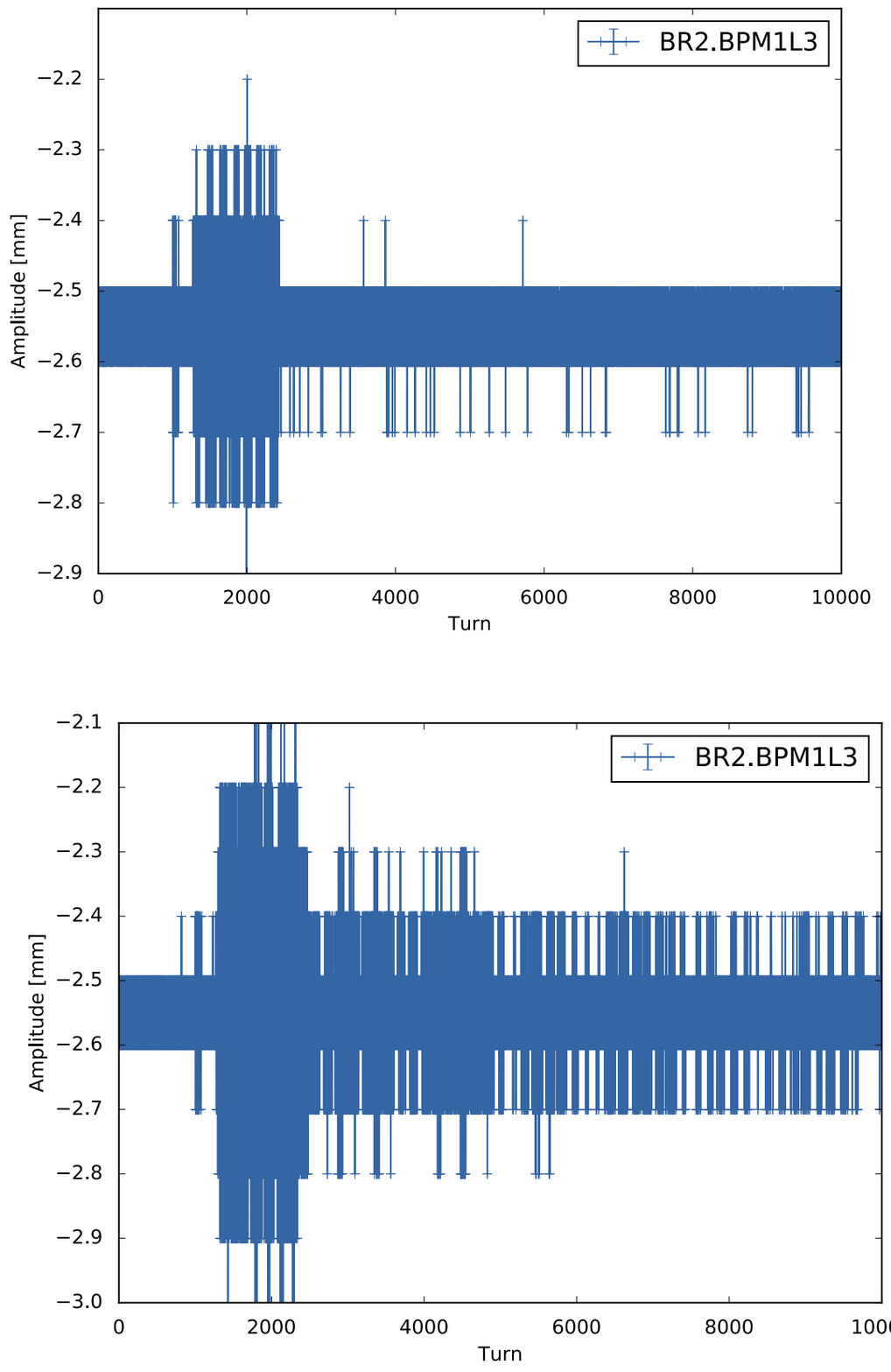

Excitation of the AC-dipole

# Excitation using AC-Dipole (II)

## AC Dipole tune .279

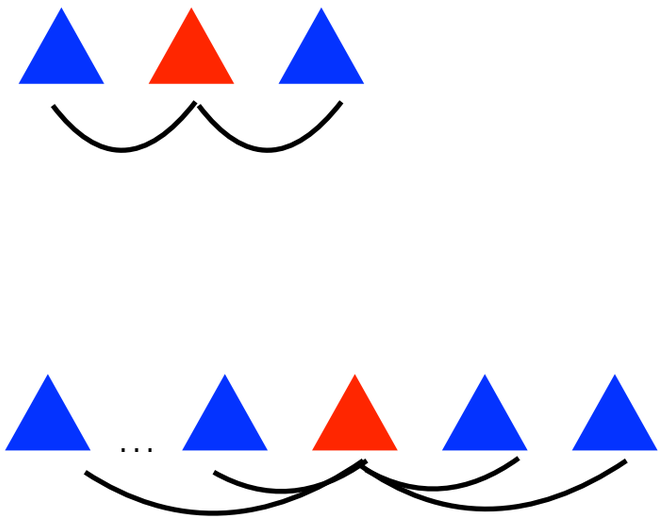



## AC Dipole tune .291

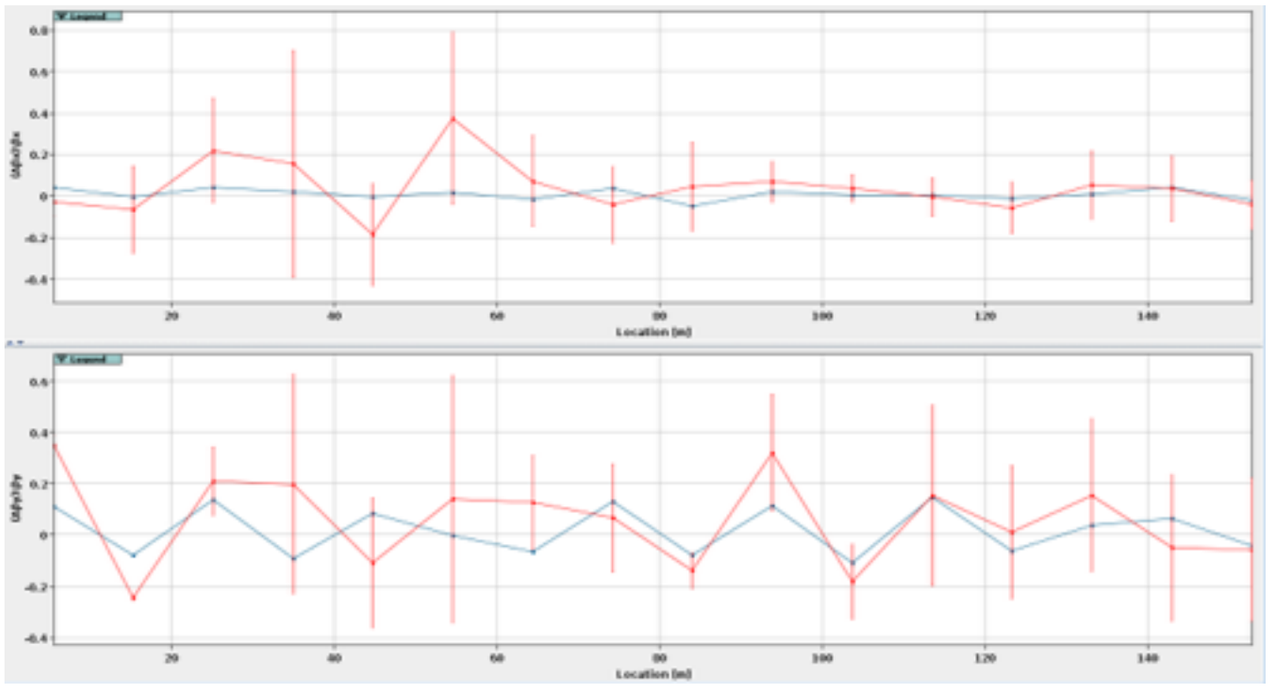


# Problems in the beta function reconstruction

Phase advance between the BPMs : Problems using the 3-BPM method



Different reconstruction of the beta function



The N-BPM method extends the range of BPMs that are being considered in the analysis. In order to improve the accuracy of the measurements, the method uses the measured errors of the lattice

Errors that have to be provided for the analysis.

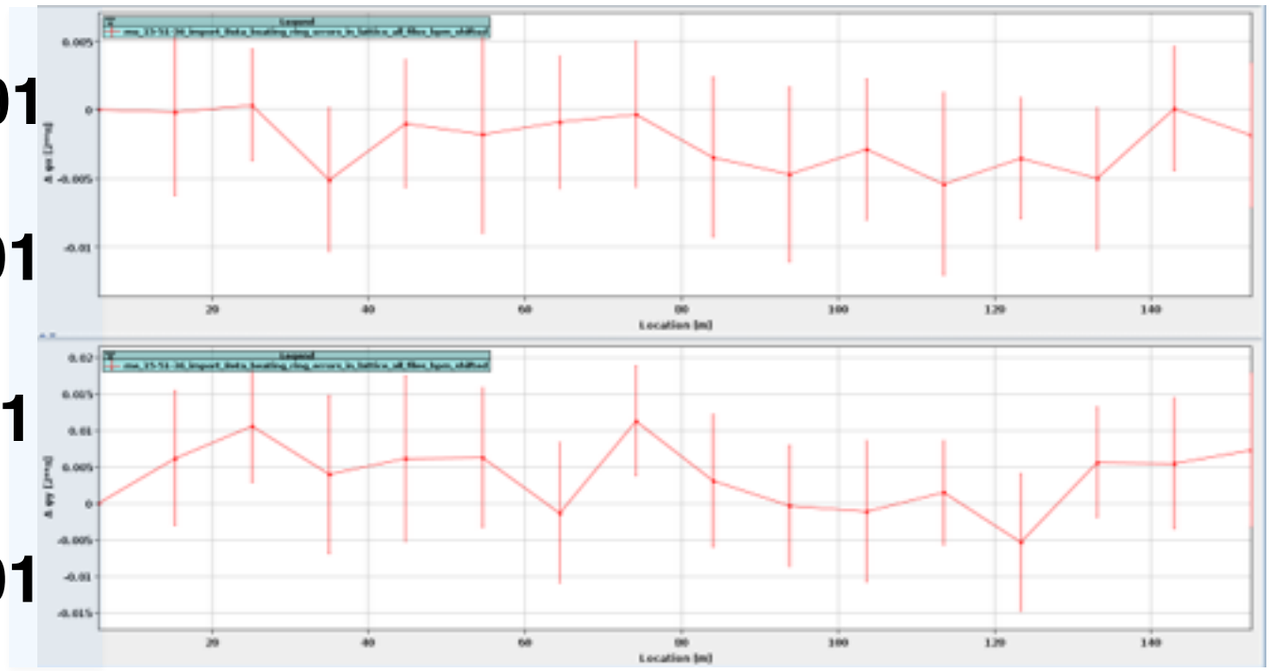
- BPM misalignment
- Quadrupolar misalignment
- Quadrupolar strength

→ Work in progress

# Problems in the beta function reconstruction (II)

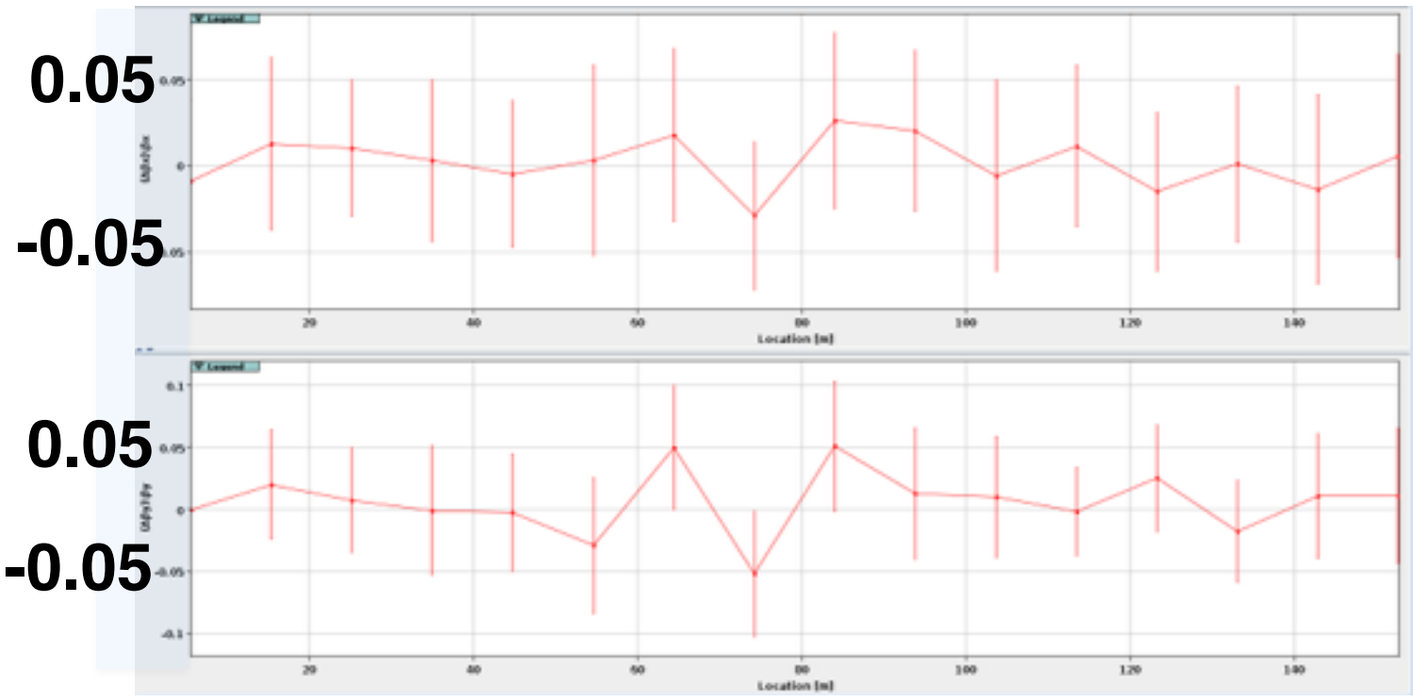
## Ring 1 125e10

Phase beating : phase difference with respect the value predicted by the model. Average and std including different kicks for each BPM




Beta beating : $$\frac{\beta_{measured} - \beta_{model}}{\beta_{model}}$$

Average and std including different kicks for each BPM



# Conclusions

- As a result of comparing two Methods: Jeroen and Matlab, it can be seen that a larger number of digits will improve the quality of the results
- Limitation of the kicker voltage leads to a safety operation of the machine. Can we go higher in voltage?
- First tests of the AC dipole show unclear results. A larger number of decimals will help. Additionally a  further test are that can be done will be increase the excitation.
- Using 2.5 kV excitation we have been able to obtain first promising results of beta-beating measurements, with a beta-beating rms of around 5% and an uncertainty of 5%

Future plans: Measurements at different tunes (try to calibrate BPM gain)