MKP Waveform Measurements - Ion Run

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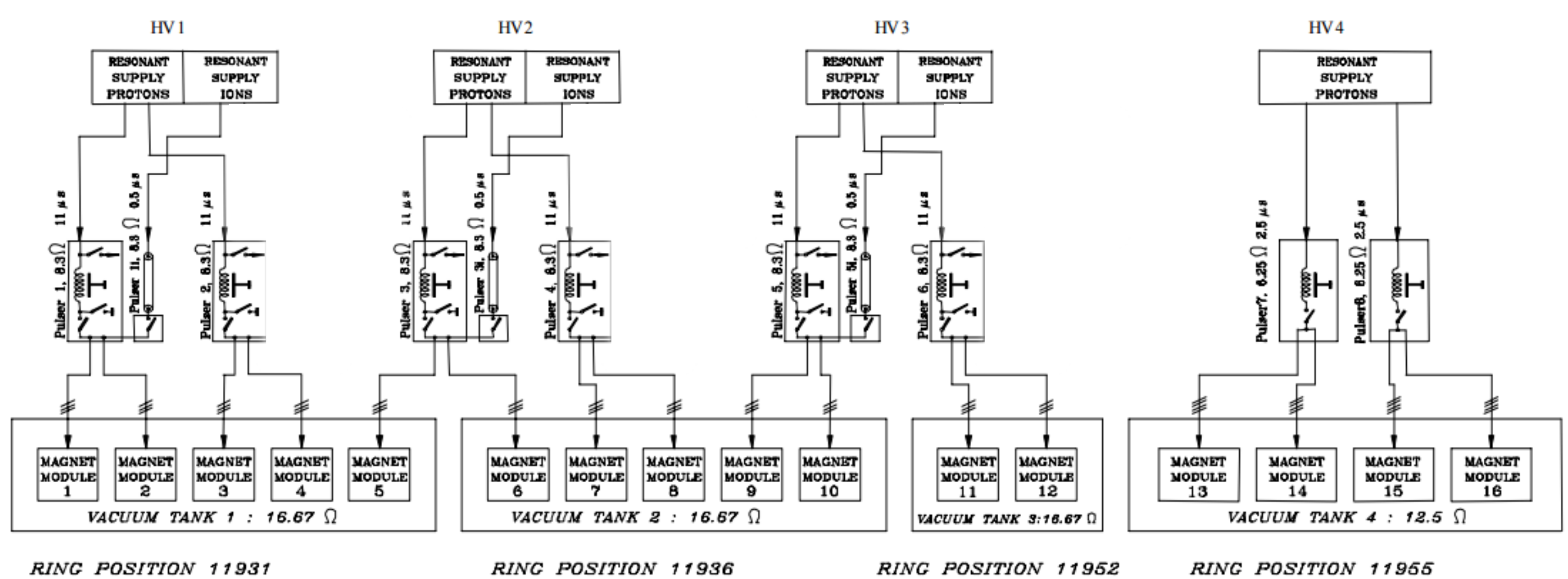
Outline

- Introduction
- MKP waveform Measurements BEFORE improvements
- MKP waveform Measurements AFTER improvements
- Amplitude detuning measurements results
- Conclusions

MKP System

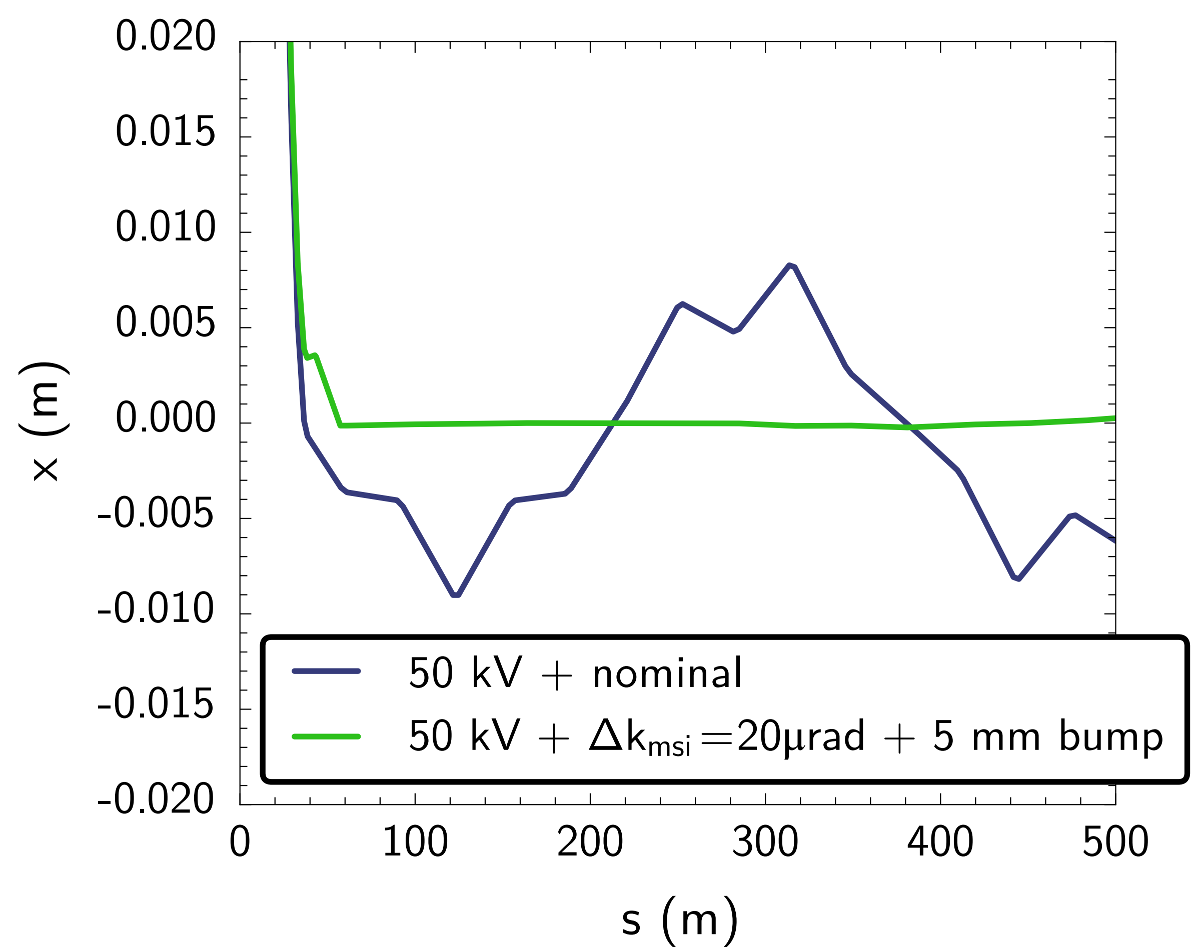
- Composed of 4 tanks:
  - The first 3 are made with "S type" magnets (5 + 5 + 2 =12) => 150 ns rise time (from specs), long pulse but weaker than the L type
  - The last tank is made with "L type" magnets (4) => 225 ns rise time (from specs), short pulse but stronger than the S type
- 8 switches for 4 HV generators => the first 3 power the first 3 tanks and the last powers the 4th tank



MKP settings

- 26 GeV/c LHC p+: use all magnets at 48 kV
- 14 GeV/c FT p+: use only MKP-S at 49 kV
- 17.4 GeV/c/u ions: were using all magnets at 31 kV
  - In order to reduce the batch spacing, we re-matched the injection trajectory to use only the first 3 magnets (faster rise time)
  - To reduce the strength of the MKP, a 3 correctors bump was also added at injection

Parameter	Unit	Value
V_{MKP}	kV	49
k_{MSI}	mrad	10.736
A_{bump}	mm	6.7

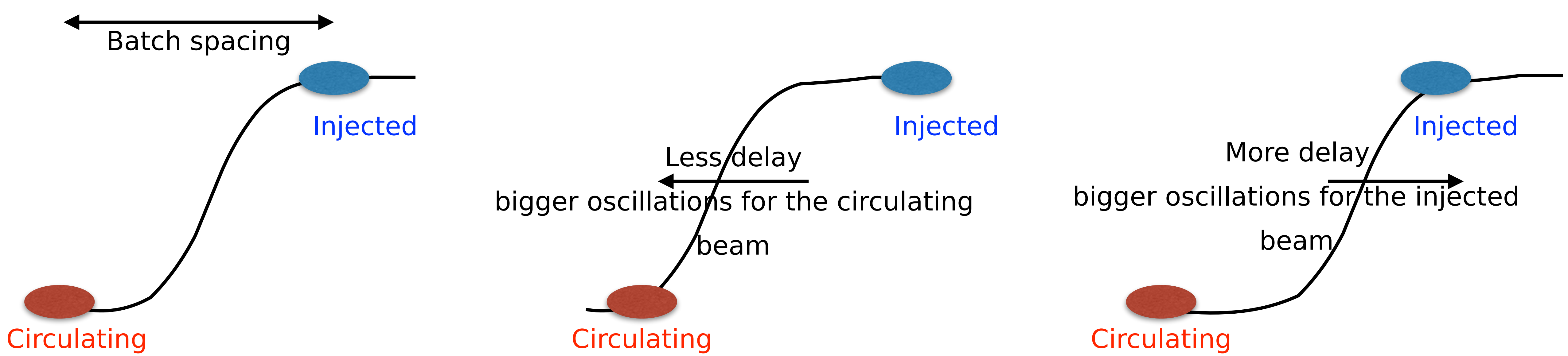


Measurements Methodology

- No usable screens available in the SPS injection region

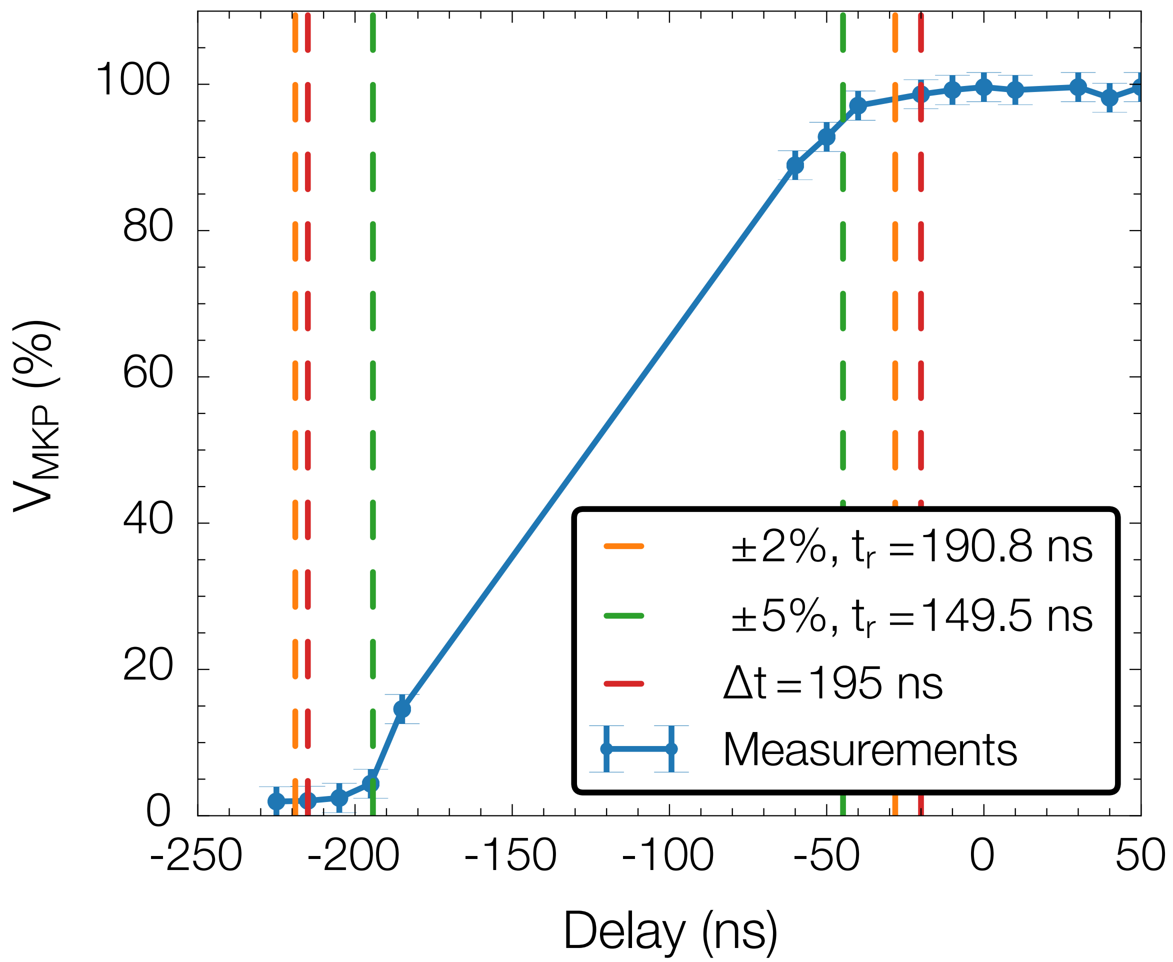
- One way of measuring the MKP waveform is to use the injection oscillations caused by changing the MKP strength or delay => using the turn-by-turn and bunch-by-bunch acquisition of the LHC BPMs installed in LSS5

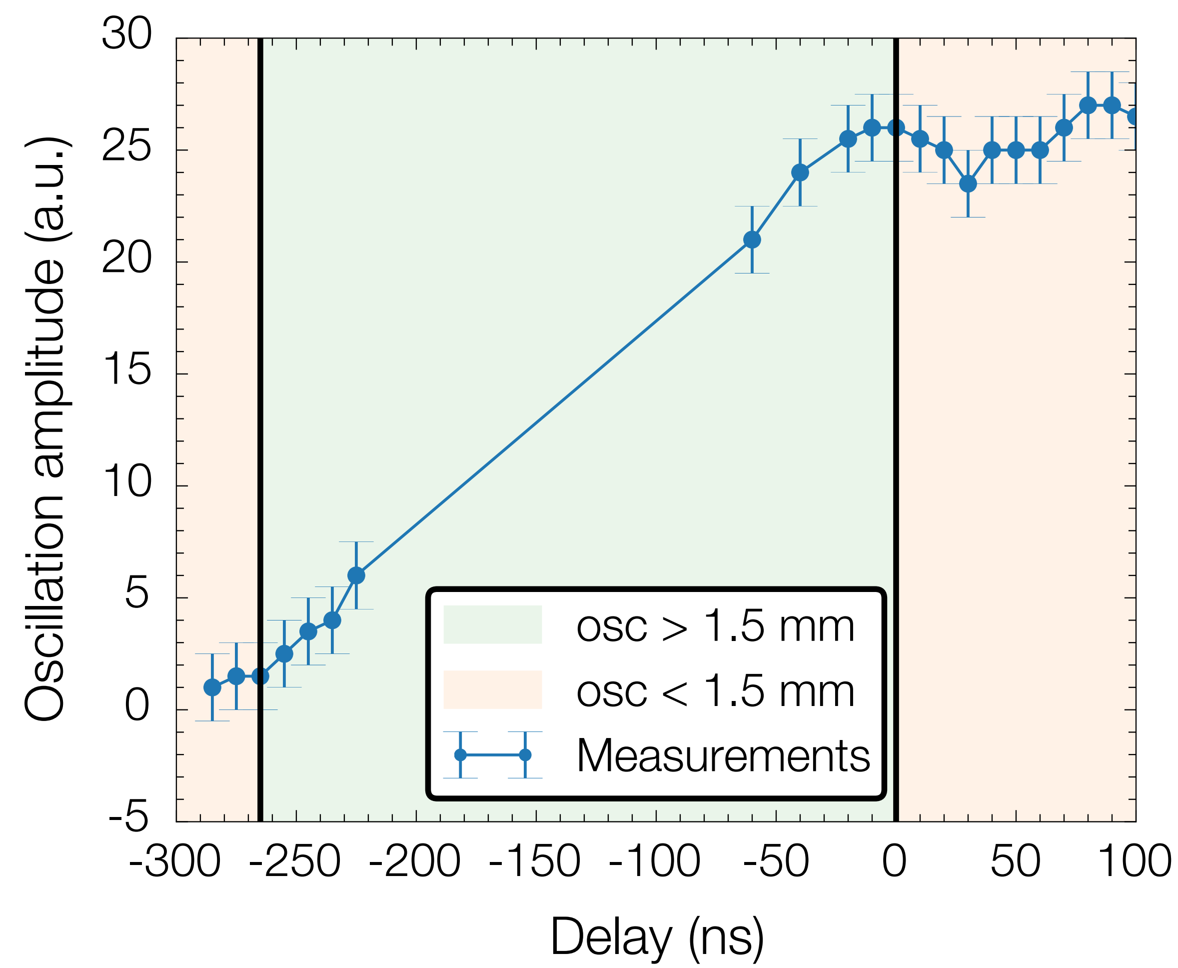
    - The limitation here is that we cannot measure the full waveform => the beam at some point is completely lost before reaching the LHC BPMs (LSS5)



MKP rise time measurements

- The rise time was measured with ion beam with the new injection trajectory in the 2 modes of operation: only 3 magnets and 4 magnets

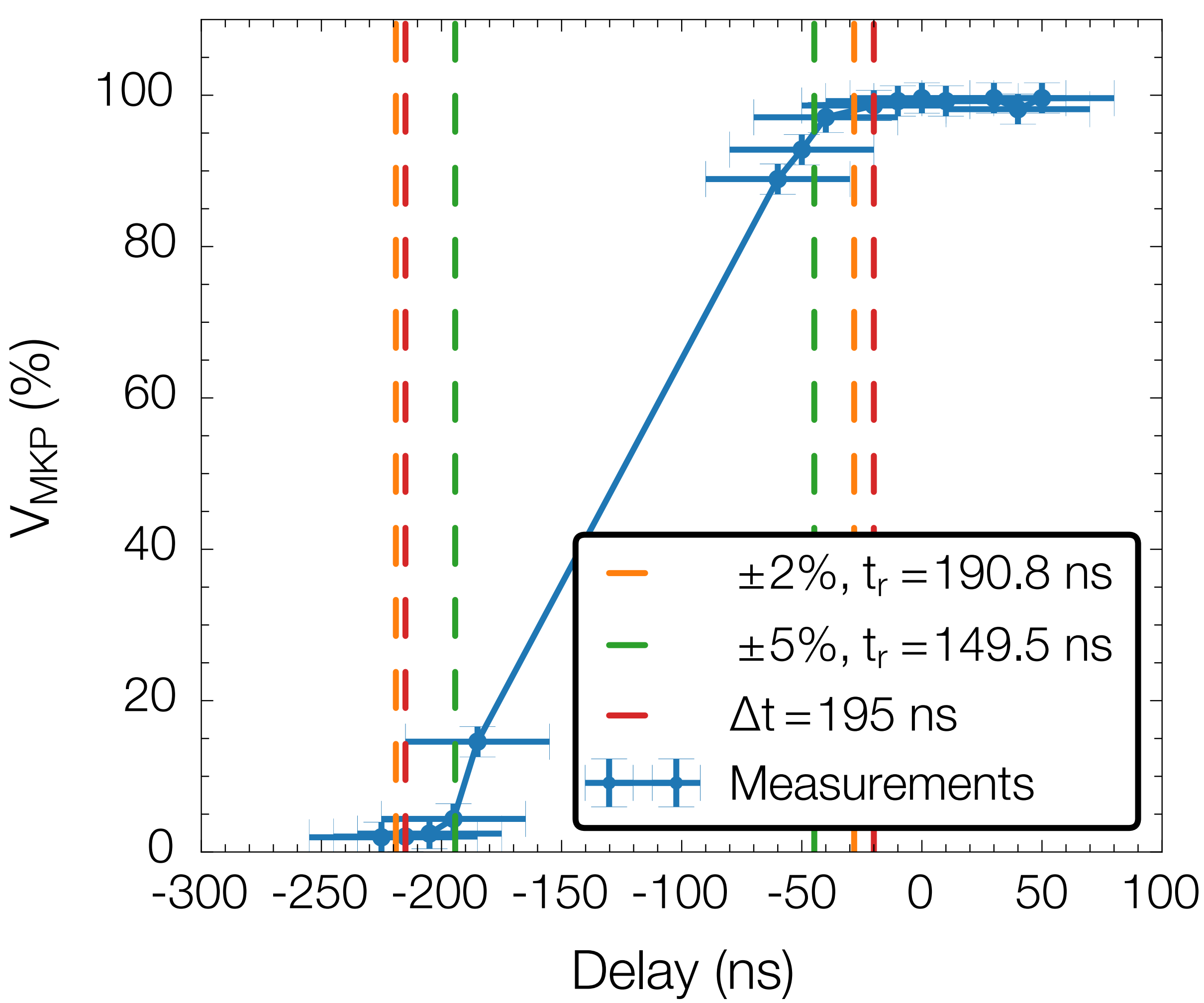


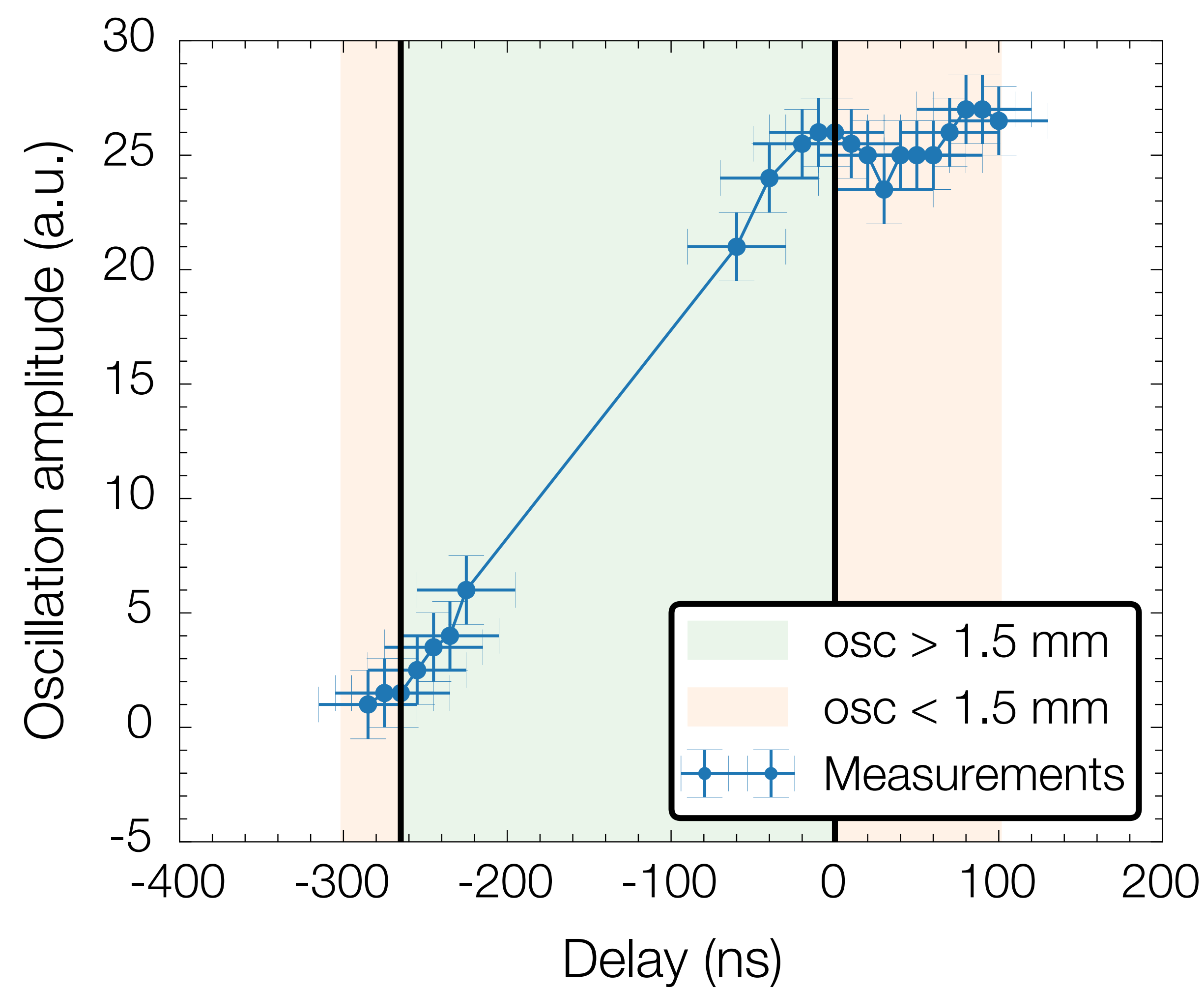


MKP rise time measurements

- The rise time was measured with ion beam with the new injection trajectory in the 2 modes of operation: only 3 magnets and 4 magnets

- Etienne found an error in the pre-pulse handling that caused a jitter of about <u>30 ns!</u>





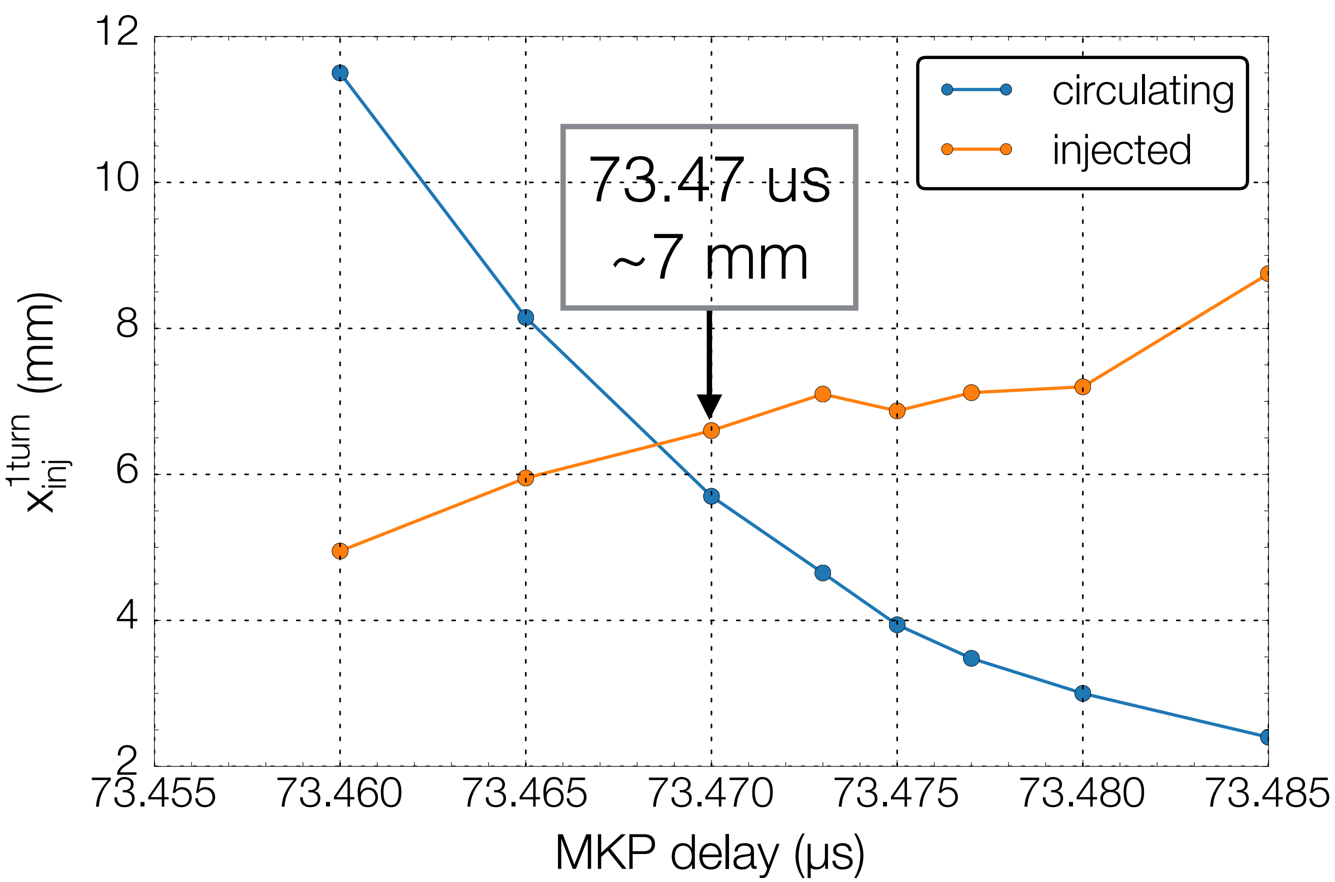
MKP Improvements

- The source of the +/- 30 ns jitter was found and the problem was fixed
- The switch that showed the worst rise time (3rd one) was replaced during source refill
- All the switches were re-synchronised with the first one
- Still a +/- 5 ns jitter should be considered due to some of the switches

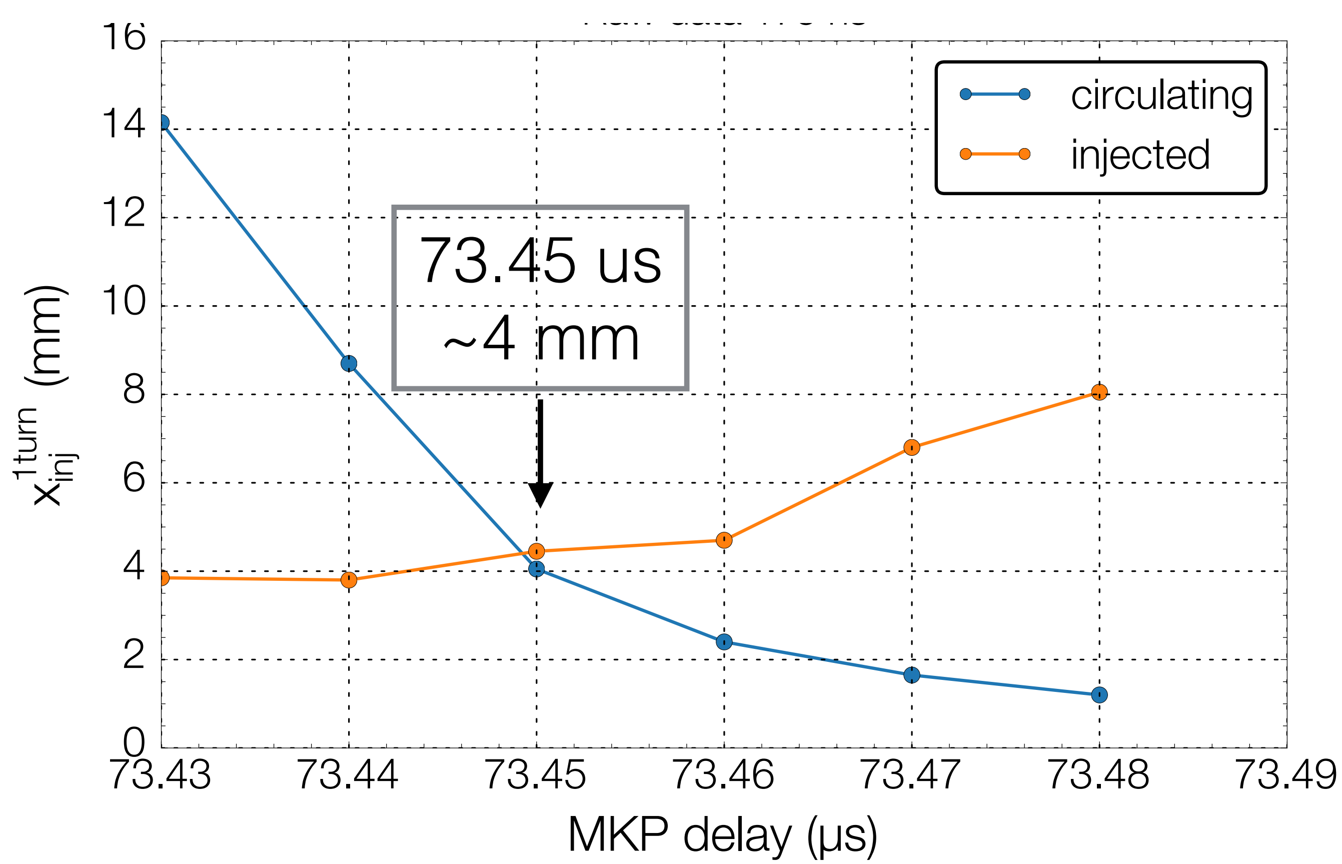
MKP rise time - 3 Gen

- The rise time was re-checked with these modifications to try to optimise the 150 ns and 175 ns injections

150 ns

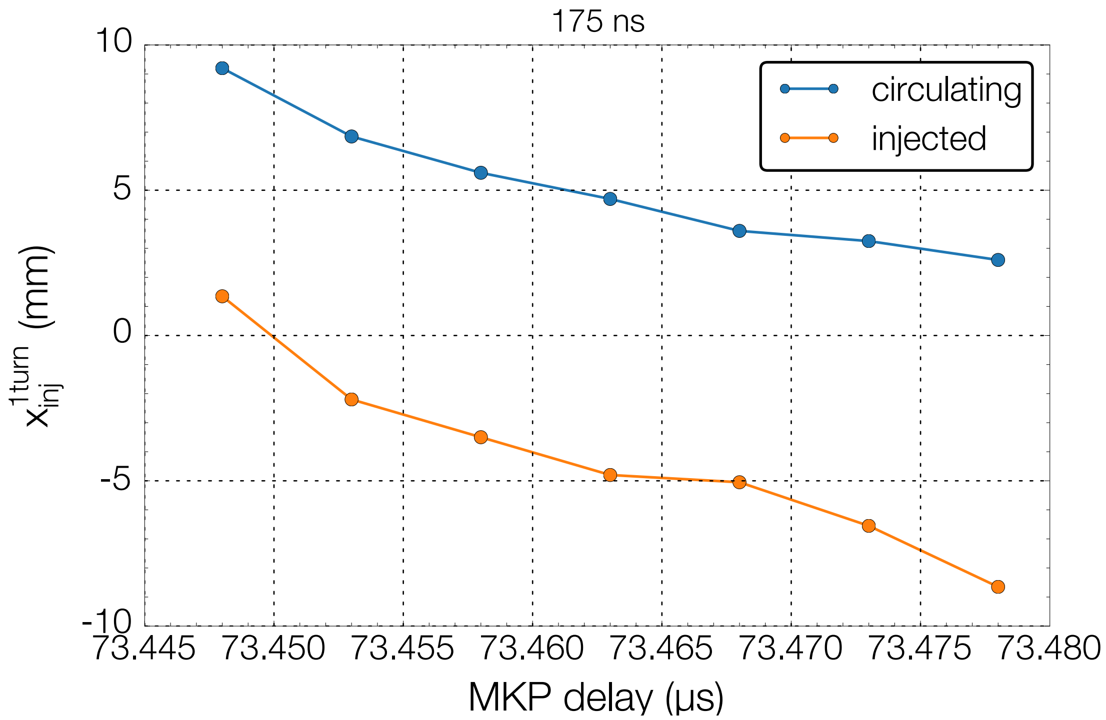


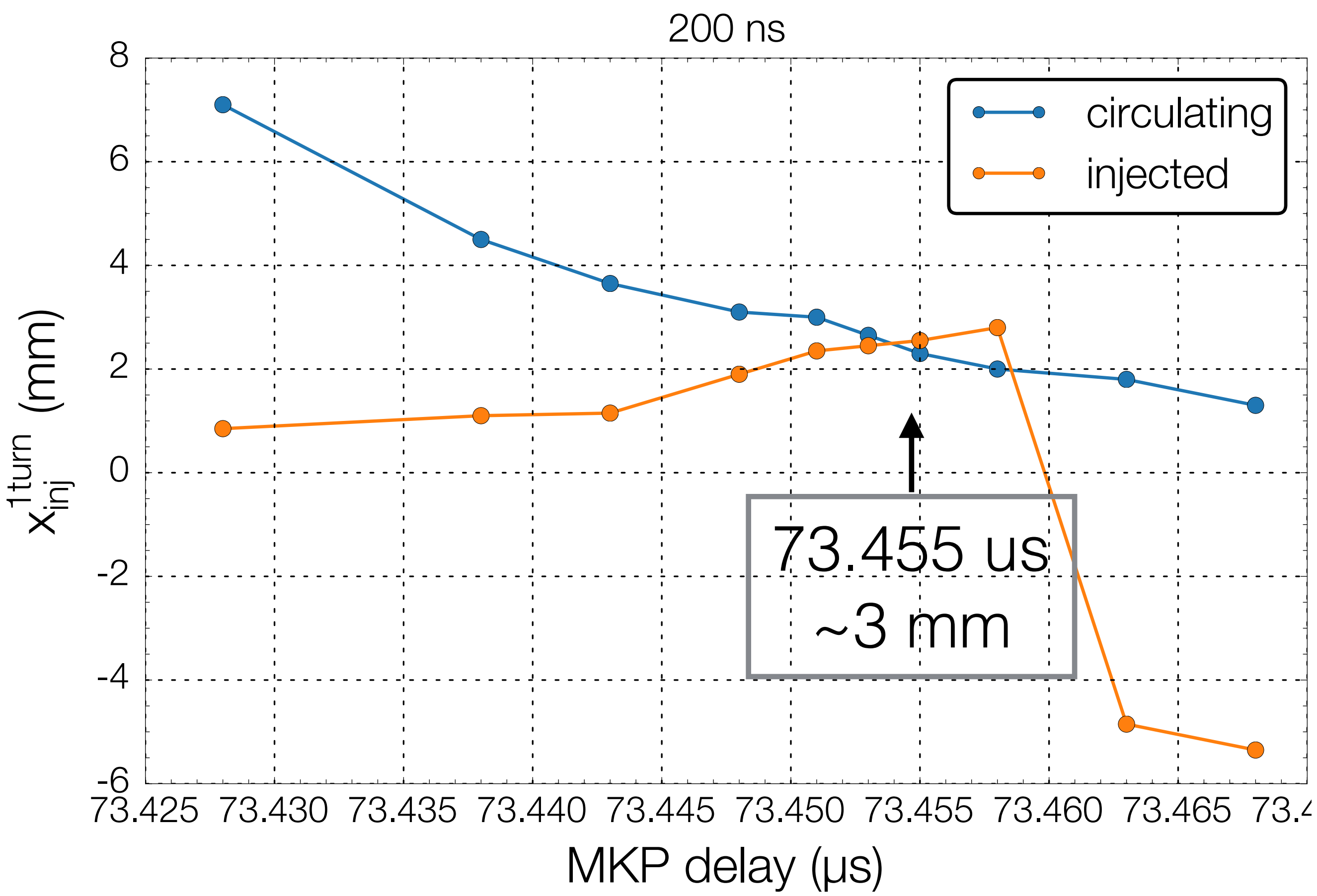
175 ns

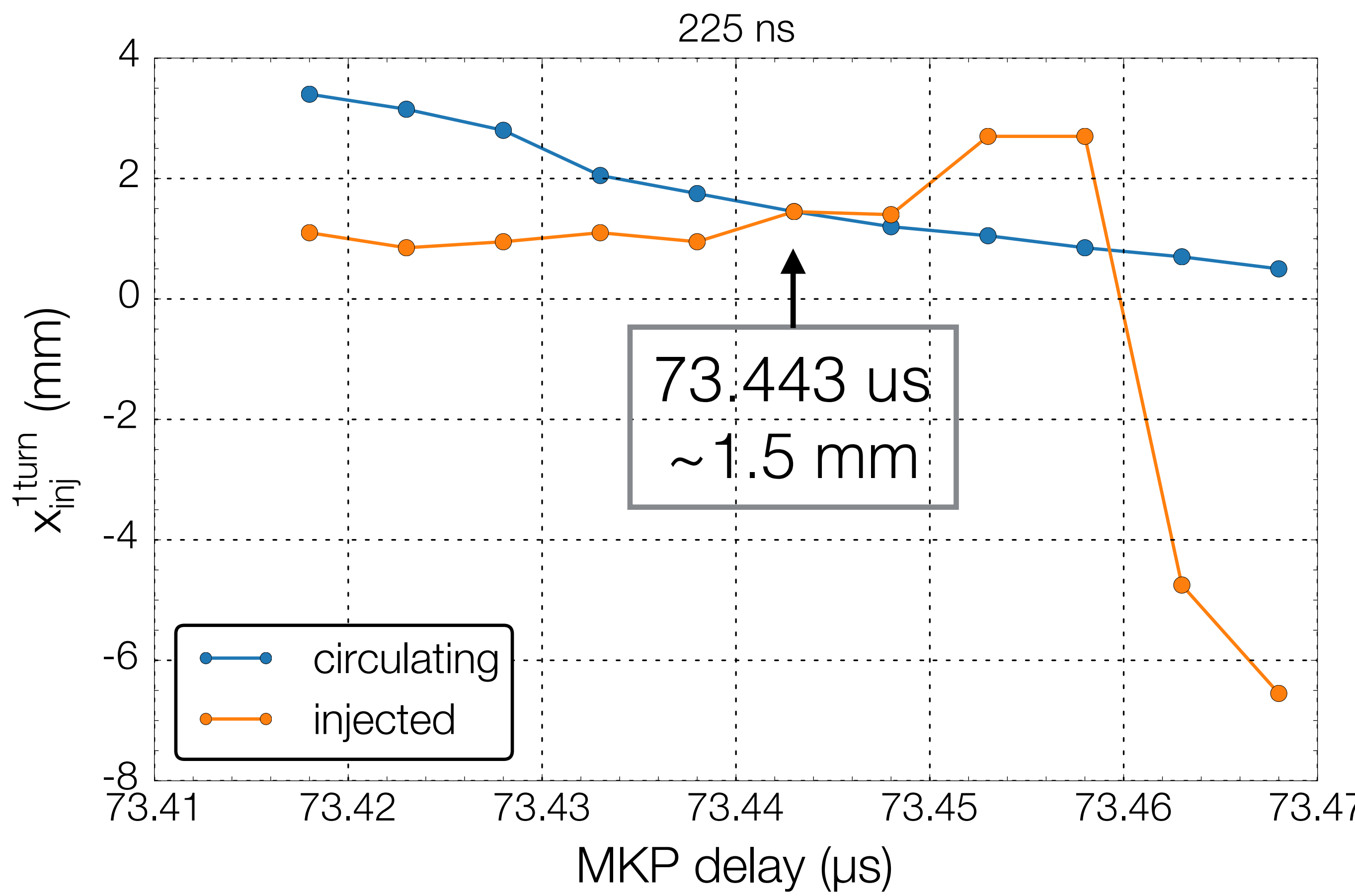


MKP rise time - 4 Gen

- The rise time was re-checked also with all generators to check the minimum possible batch spacing in view of the 2016 proton run





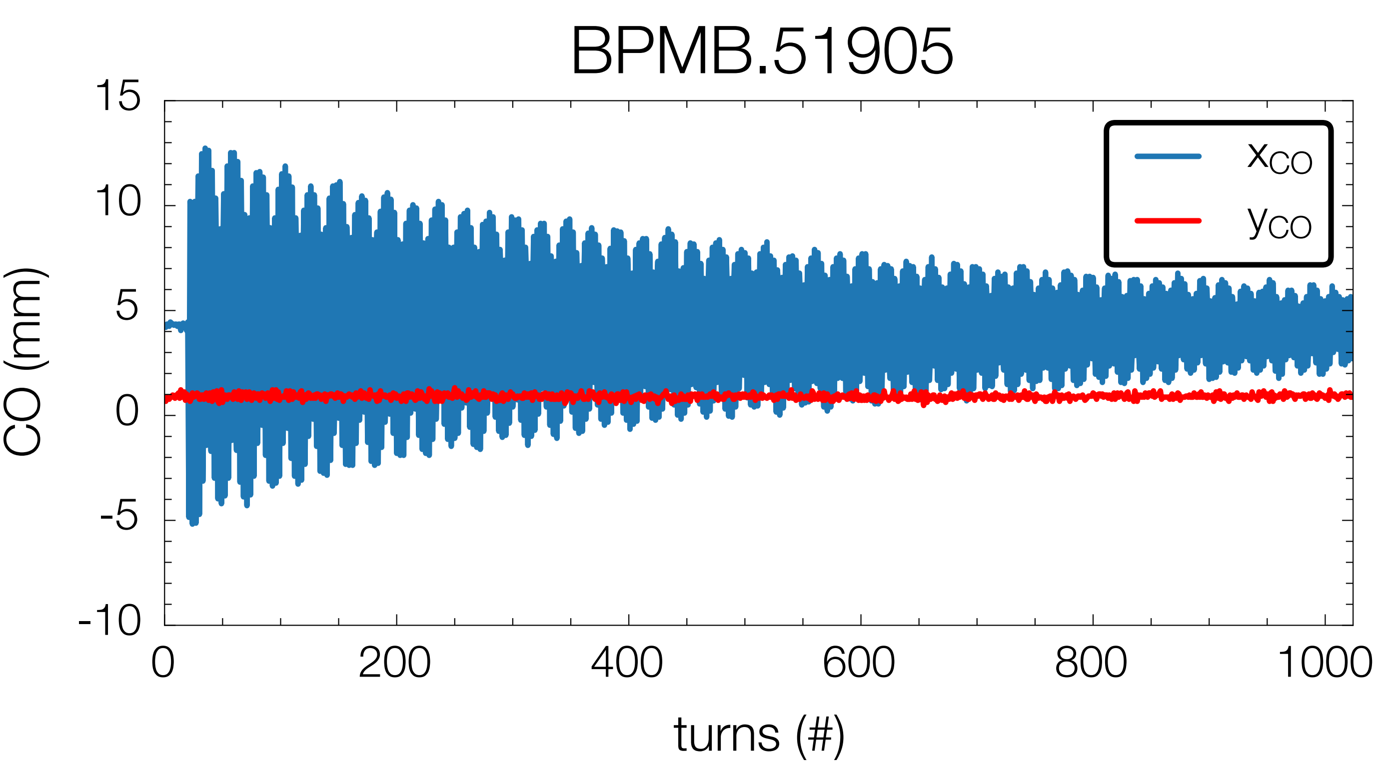


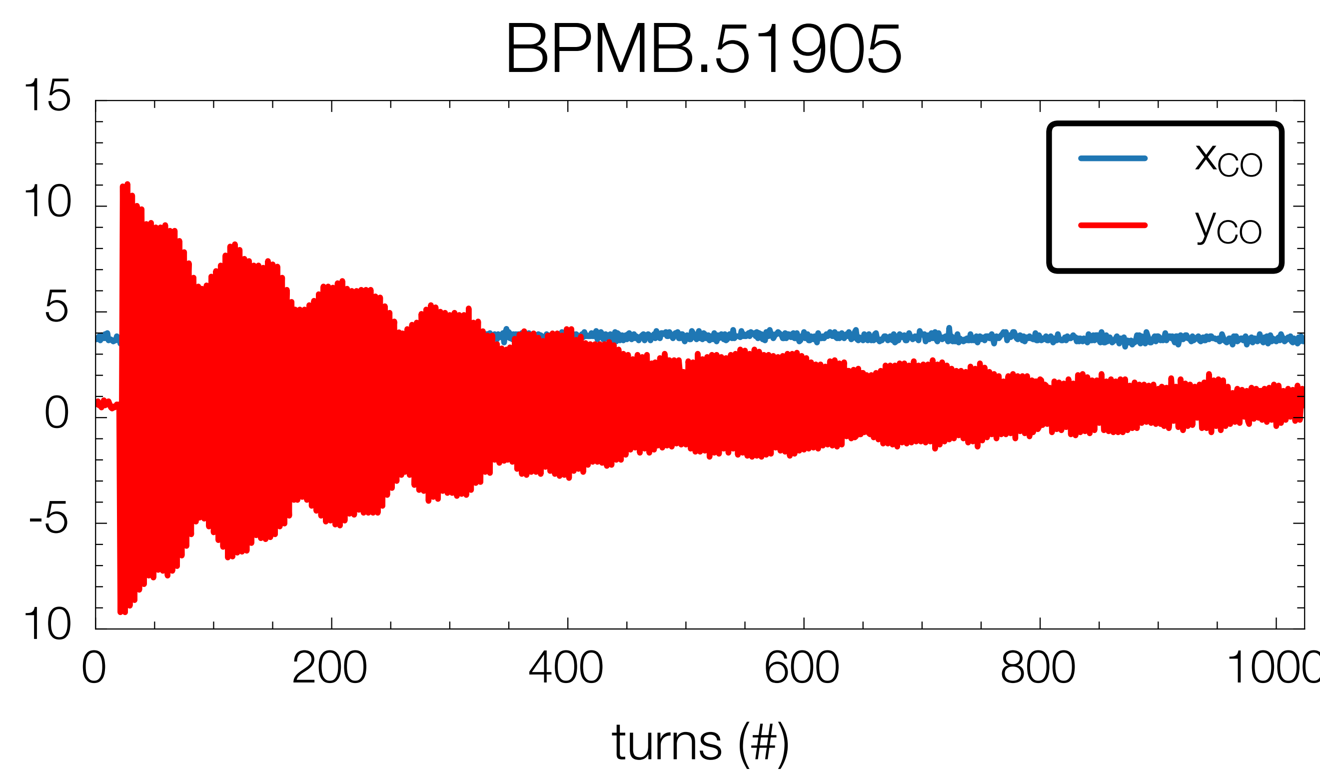
First try with 150 ns batch spacing into LHC

- Before discovering the problem that caused the 30 ns jitter, a first attempt to inject into LHC was made
- Both beams were injected but high losses at the TCDIs were recorded (~75% of dump level)
- The beam was then dumped due to some bunches with too low intensity - also a second attempt was made but the losses at the TCDIs triggered a dump
    - Beams heavily scraped at the TCDI on the horizontal plane - most likely due to very populated tails caused by high amplitudes reached at injection (with the 30 ns jitter the MKP could give **up to 15% kick to the beam**!!)
    - Amplitude detuning measurements were requested to study this…
    - Simulations of tail population (with damper on and big injection errors) will then be set up to understand what was observed and to check where the limits are

Amplitude Detuning Measurements

- Procedure:
  - The beam was kicked at flat bottom with the MKQH/V
  - 6 steps in kick strength done => up to 8 kV (max)
  - turn-by-turn data for 2 bunches taken from LHC BPMs - we didn't manage to use the multi-turn application to use all SPS BPMs…
  - Octupoles off (settings left as default for ions)
  - Chroma knob not touched either…and not measured!!





Amplitude Detuning Measurements

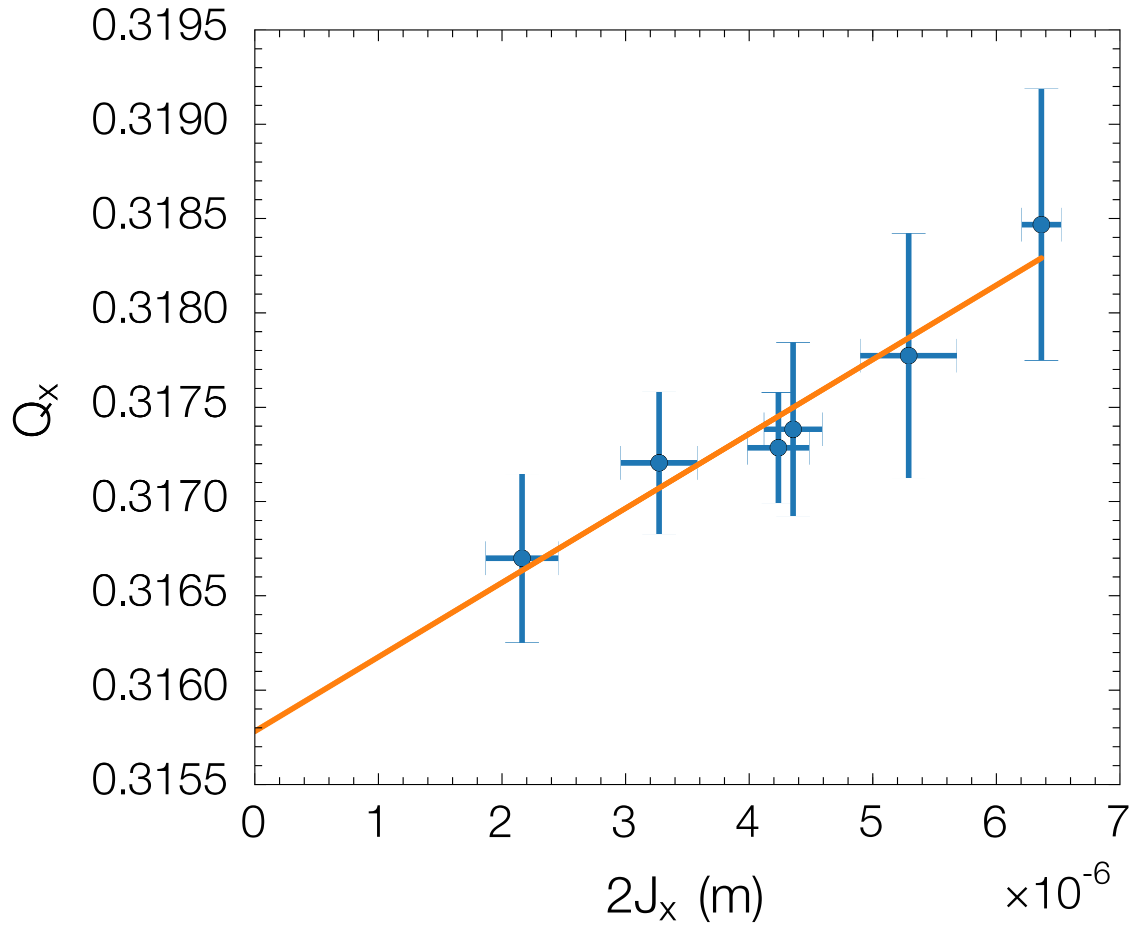
- The action was then calculated from the BPM data

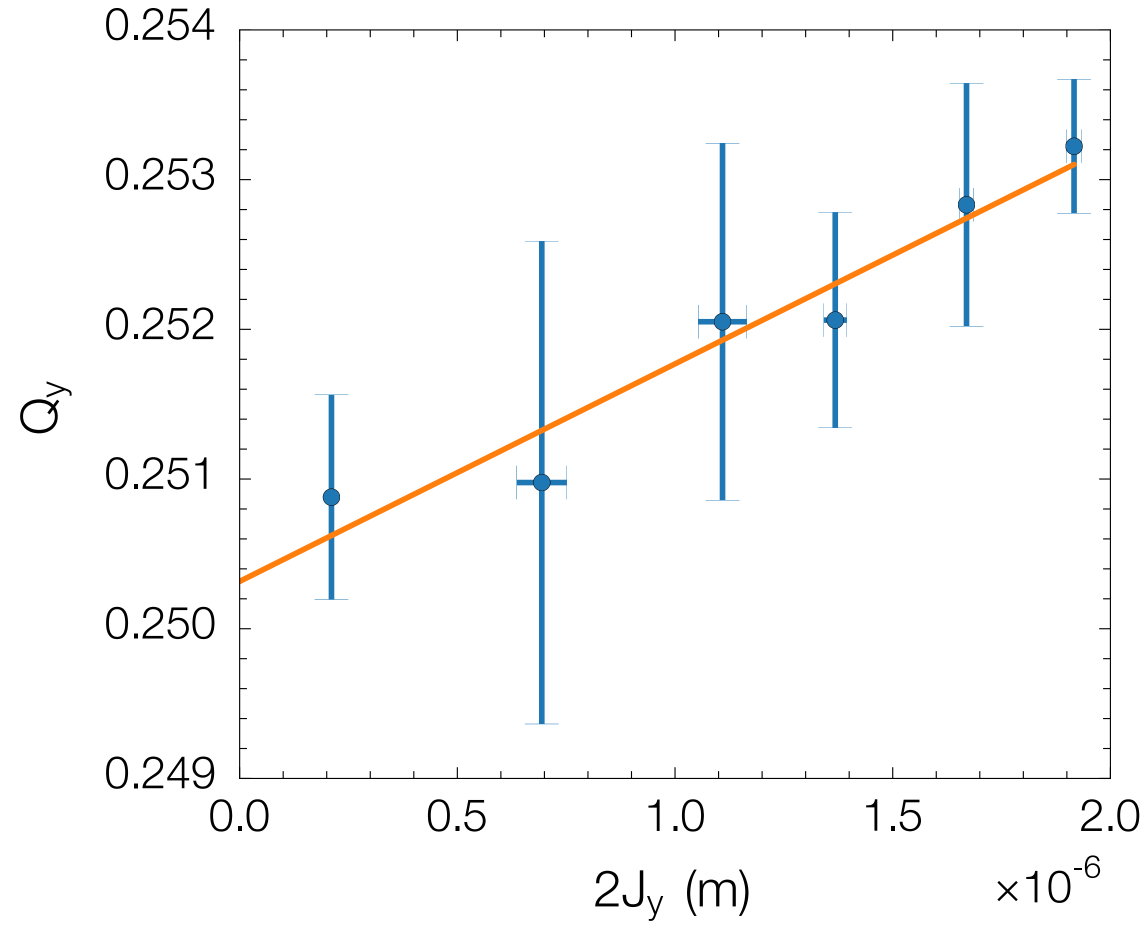
$$J_x = \frac{1}{2}(\overline{x}^2 + \overline{p_x}^2)$$

- A linear fit gives then the detuning coefficients

$$c_{xx} = 394.2\ m^{-1}$$

$$c_{yy} = 1453.1\ m^{-1}$$





Amplitude Detuning Measurements

- Simulations on-going to estimate the tail populations due to the SPS non linearities and the big amplitudes touched at injection

- First results show a significant increase in the tail populations…but still needed careful checks!

- The increase of the tail populations will be then compared with the observed losses at the TCDIs (from the IQC)

Conclusions and Outlook

- The MKP waveform was measured in both modes of operation, i.e. 3 and 4 generators
  - For 3 generators, a rise time of 150 ns (+/- 5%) was measured and, after a careful setting of the system, was also used for physics into the LHC
  - For 4 generators, a rise time of 225 ns (+/- 1%) was measured and a very promising batch spacing of 200 ns was also tested - still needs to be validated with protons this year
- Natural amplitude detuning in the SPS with ions at flat bottom have been done to create a model that explains why such big losses in at the TCDIs have been observed
  - This model will then be used to understand how much we can push the batch spacing
  - The same methodology is planed to be used also for the injection into LHC to see if there is any margin for improvements there too

Backup

Waveform 4 Gen