Electron Trajectory Reconstruction

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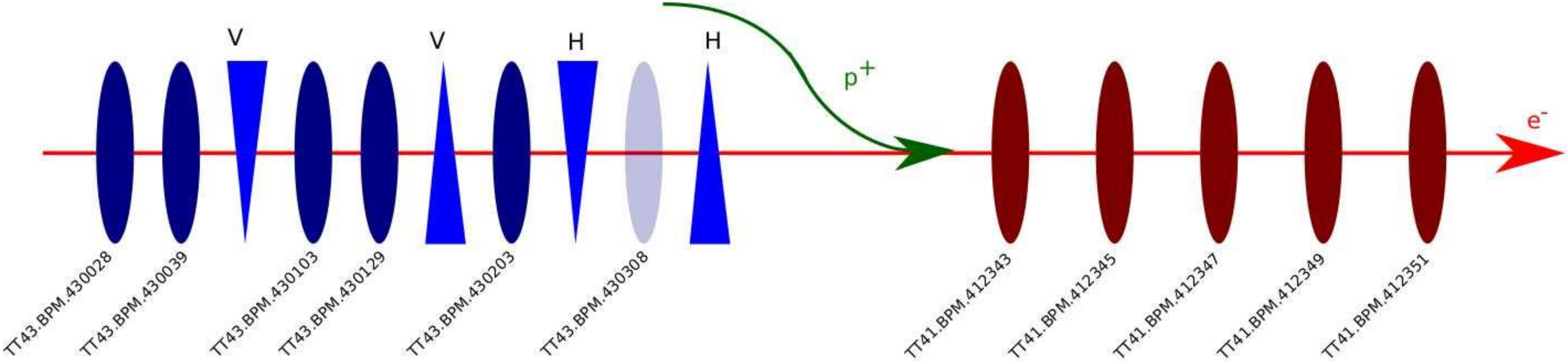
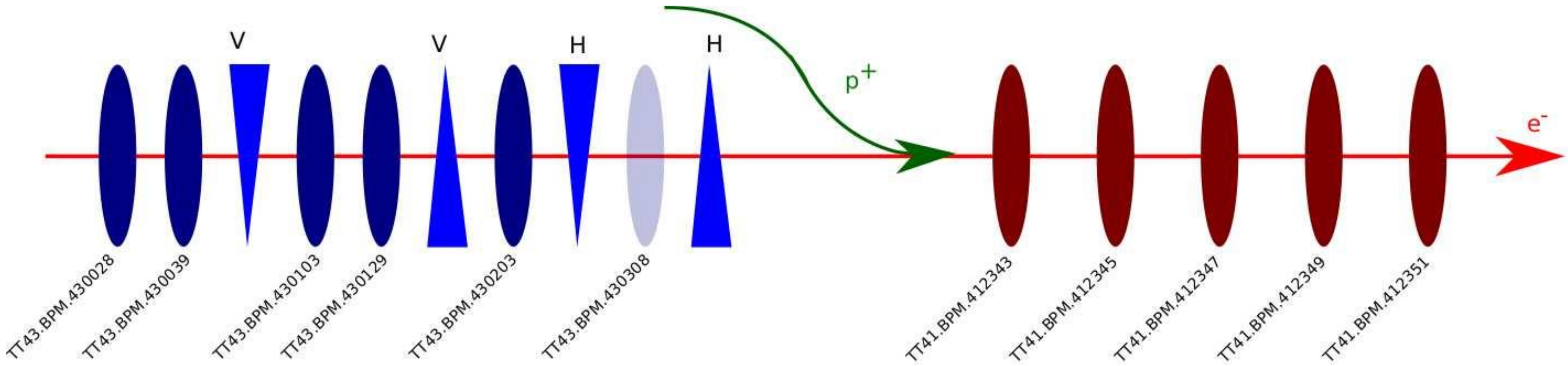
AWAKE Beamline

- Protons affect the reading of downstream electron BPMs
- We cannot use these eBPMs to predict where the e- and p+ cross in the plasma source



Idea (F. Velotti)

- Can we use a model using the upstream eBPMs to predict the downstream ones?



Model

- Assume the position of the e- and p+ is determined by the betatron oscillation and dispersion

$$y_{BPM} = \sqrt{\beta_i} \cdot y_{\beta_i} + D_i \cdot \delta_P$$

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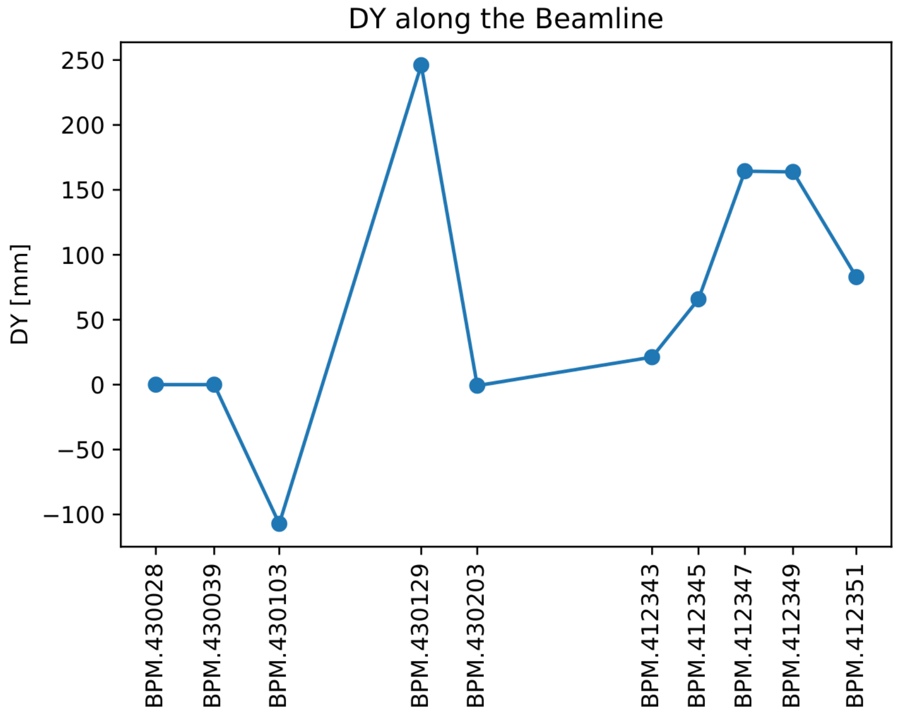
- Dispersion and beta function are given by the MADX model
- The betatron oscillation and the momentum offset are unknown



Momentum Offset

- If the energy of the beam is different than of the design, the beam is diverted more/less by the dipoles than desired.
- The energy of the e- beam from the gun changes from event to event.
- We need to compute the momentum offset for each event.

Momentum Offset

$$y_\beta = A\cos\big(2\pi \cdot \mu(s)\big) + B\sin\big(2\pi \cdot \mu(s)\big)$$

- Select two eBPMs (430103 and 430129) with a shift of π in phase

$$y_{BPM1} = \sqrt{\beta_1} \cdot y_{\beta_1} + D_1 \cdot \delta_P \qquad y_{BPM2} = \sqrt{\beta_2} \cdot y_{\beta_2} + D_2 \cdot \delta_P \qquad y_{\beta_1} = -y_{\beta_2}$$

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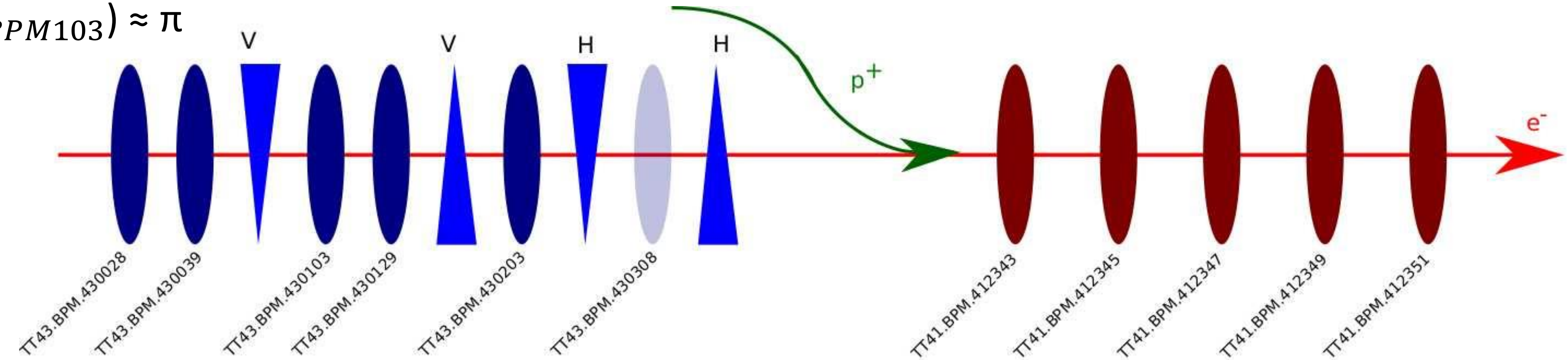
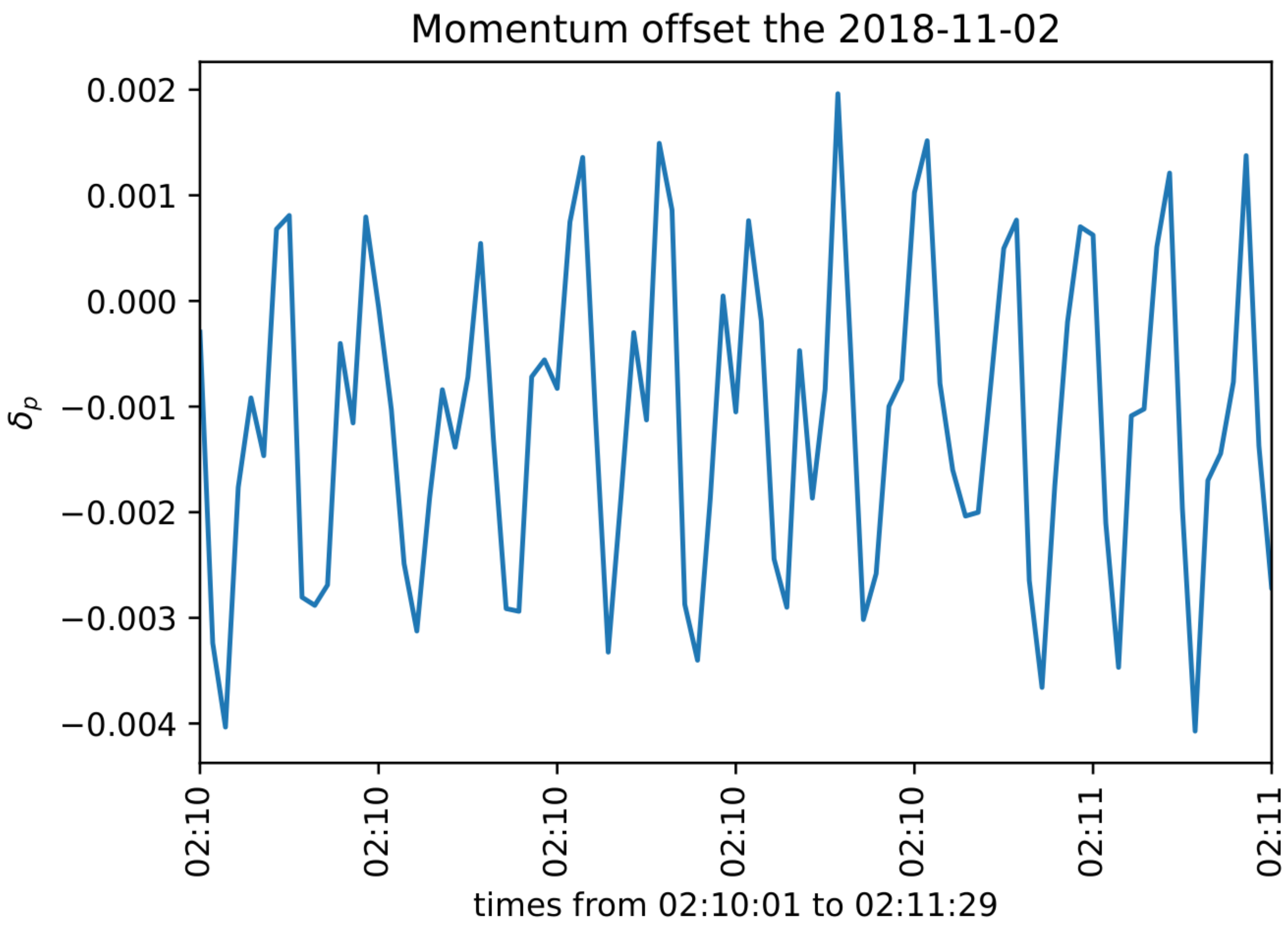
- Check:

$2\pi\ \mu(s_{BPM129})$ - $2\pi\ \mu(s_{BPM103}) \approx \pi$

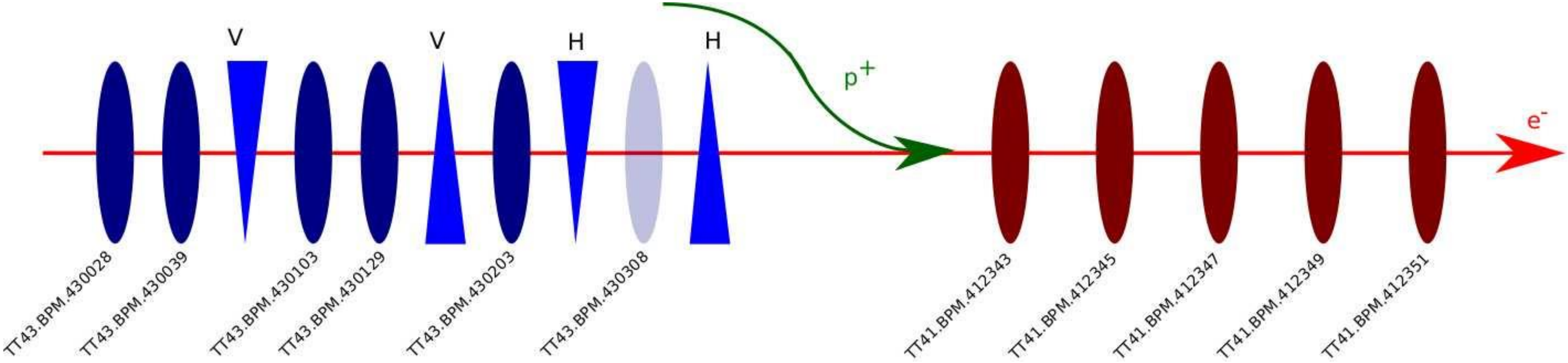


Momentum Offset



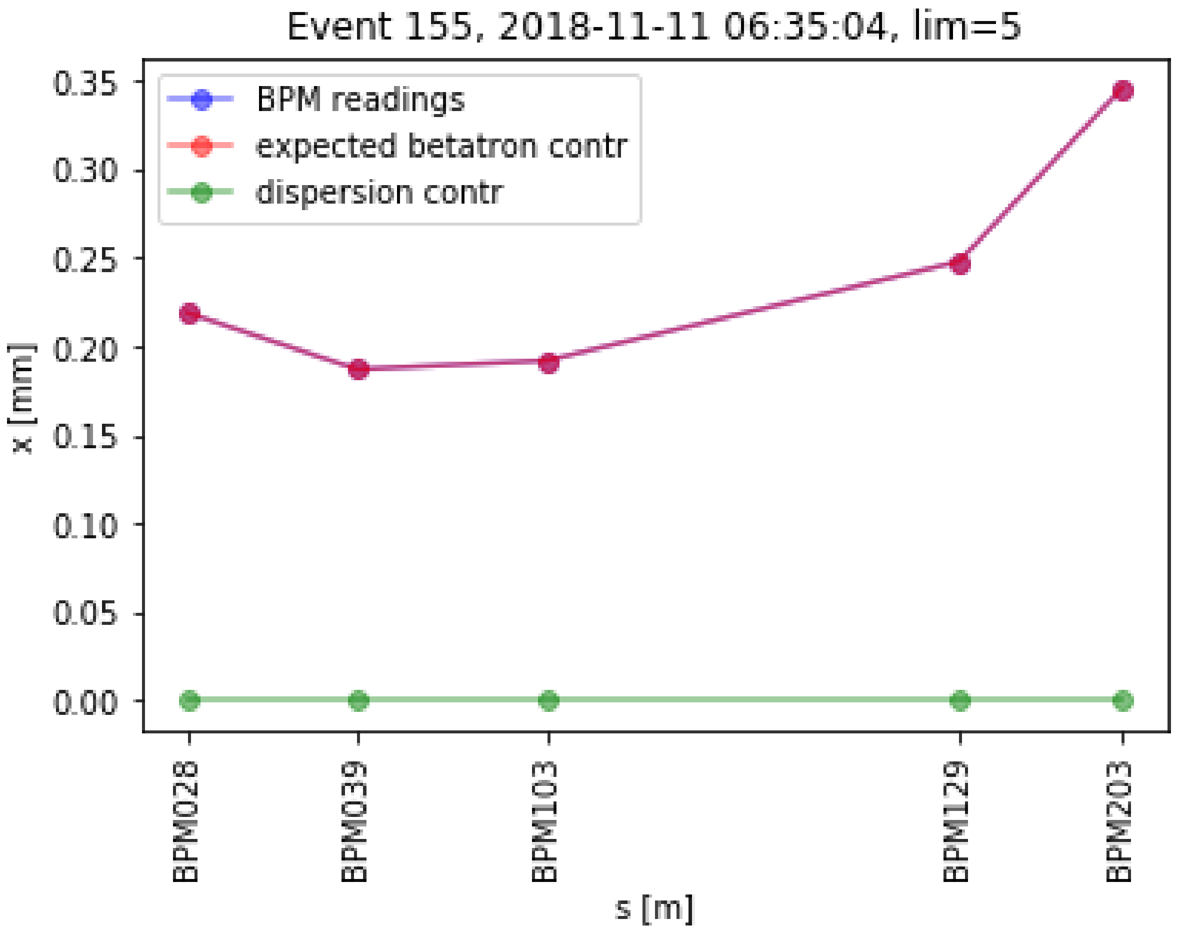
Betatron Oscillation

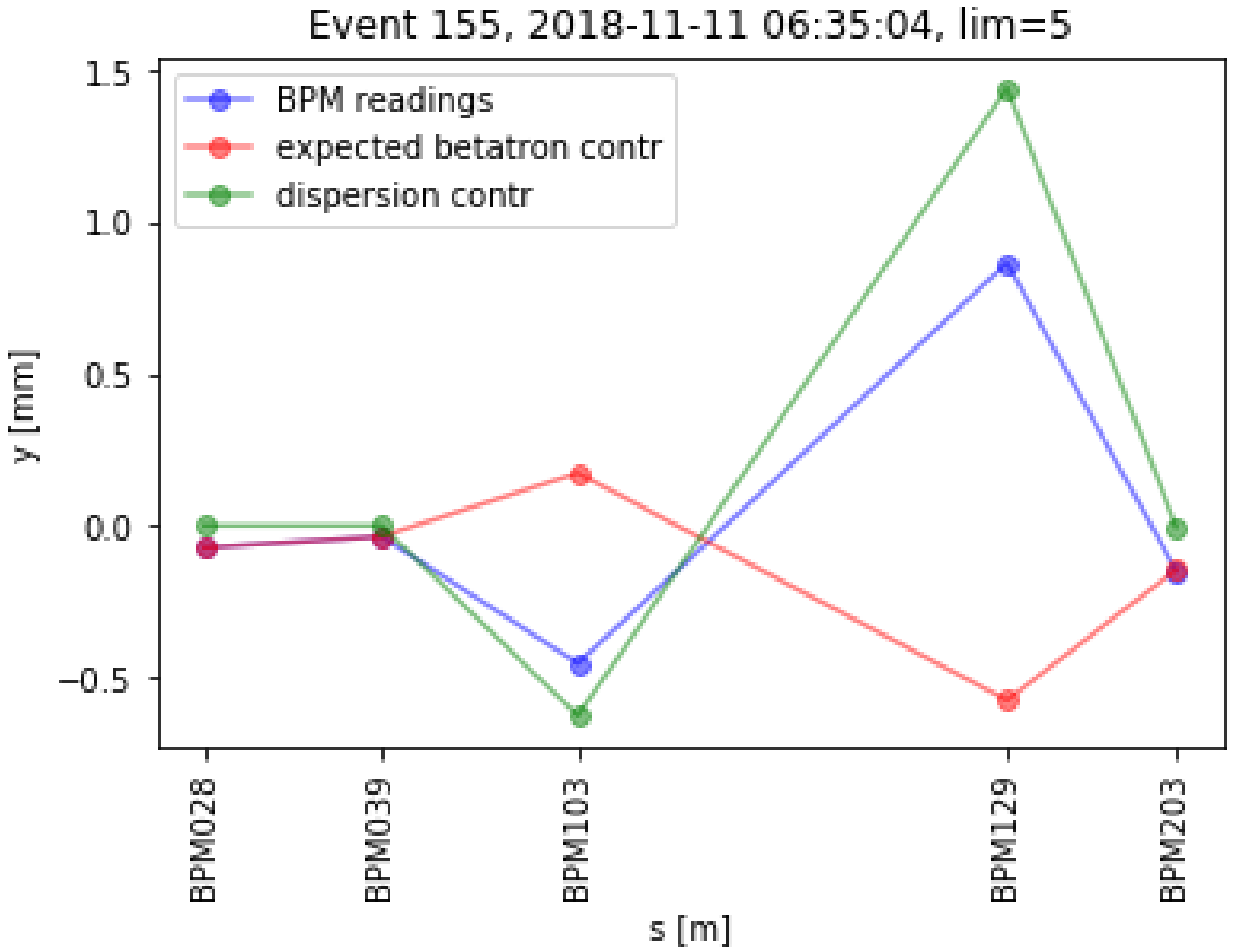
- Use the eBPMs with proper readings and use $\sqrt{\beta_i} \cdot y_{\beta_i} = y_{BPM} - D_i \cdot \delta_P$



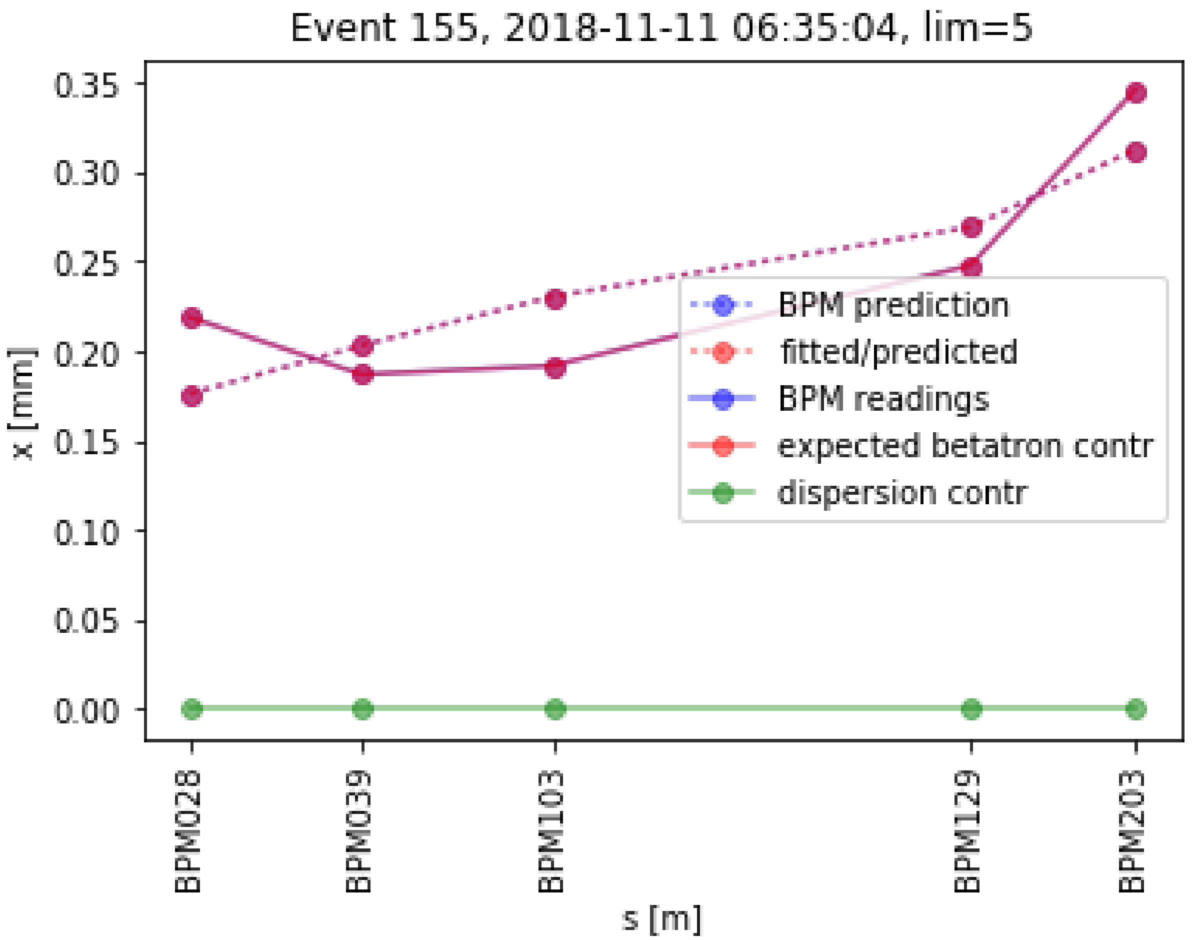
Betatron Oscillation

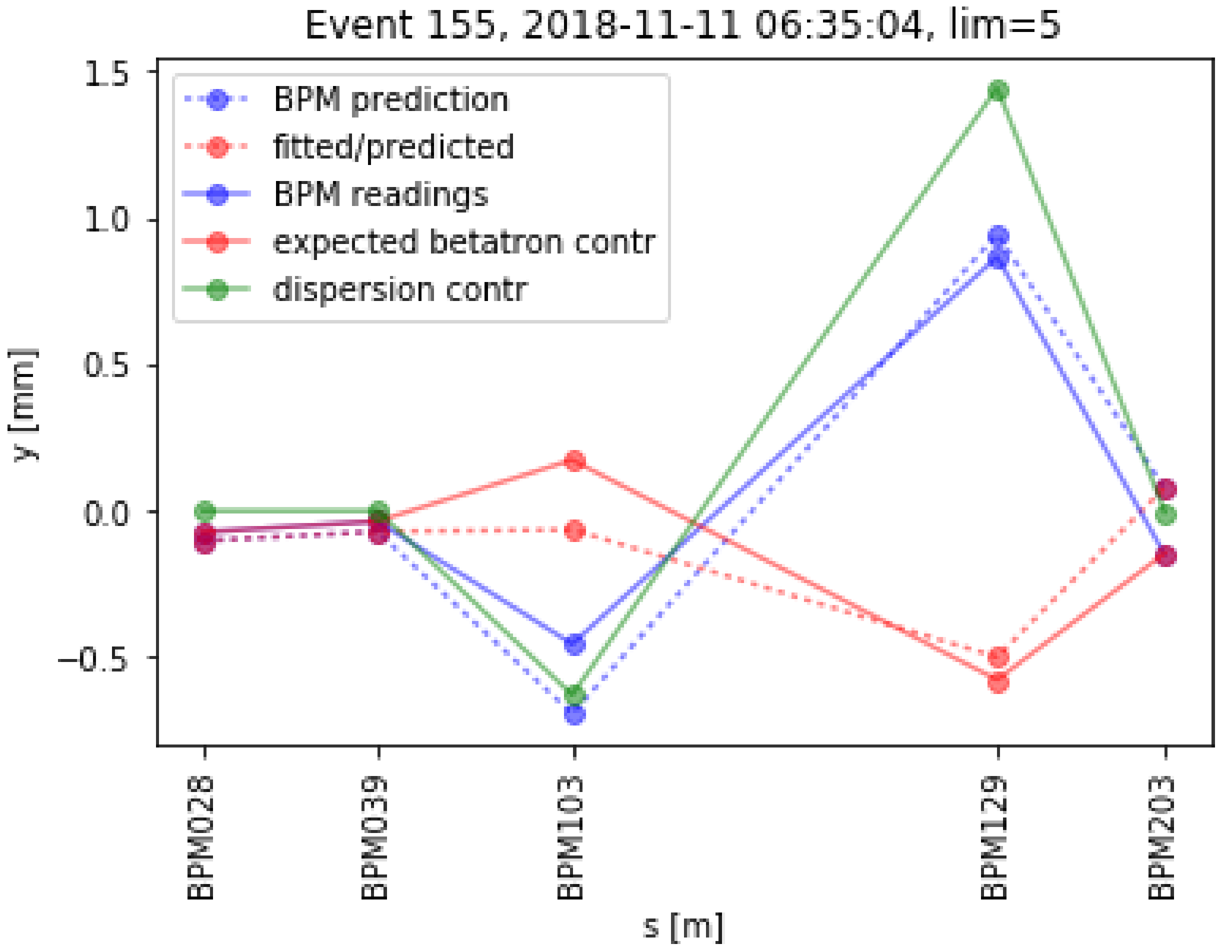
using $\sqrt{\beta_i} \cdot y_{\beta_i} = y_{BPM} - D_i \cdot \delta_P$





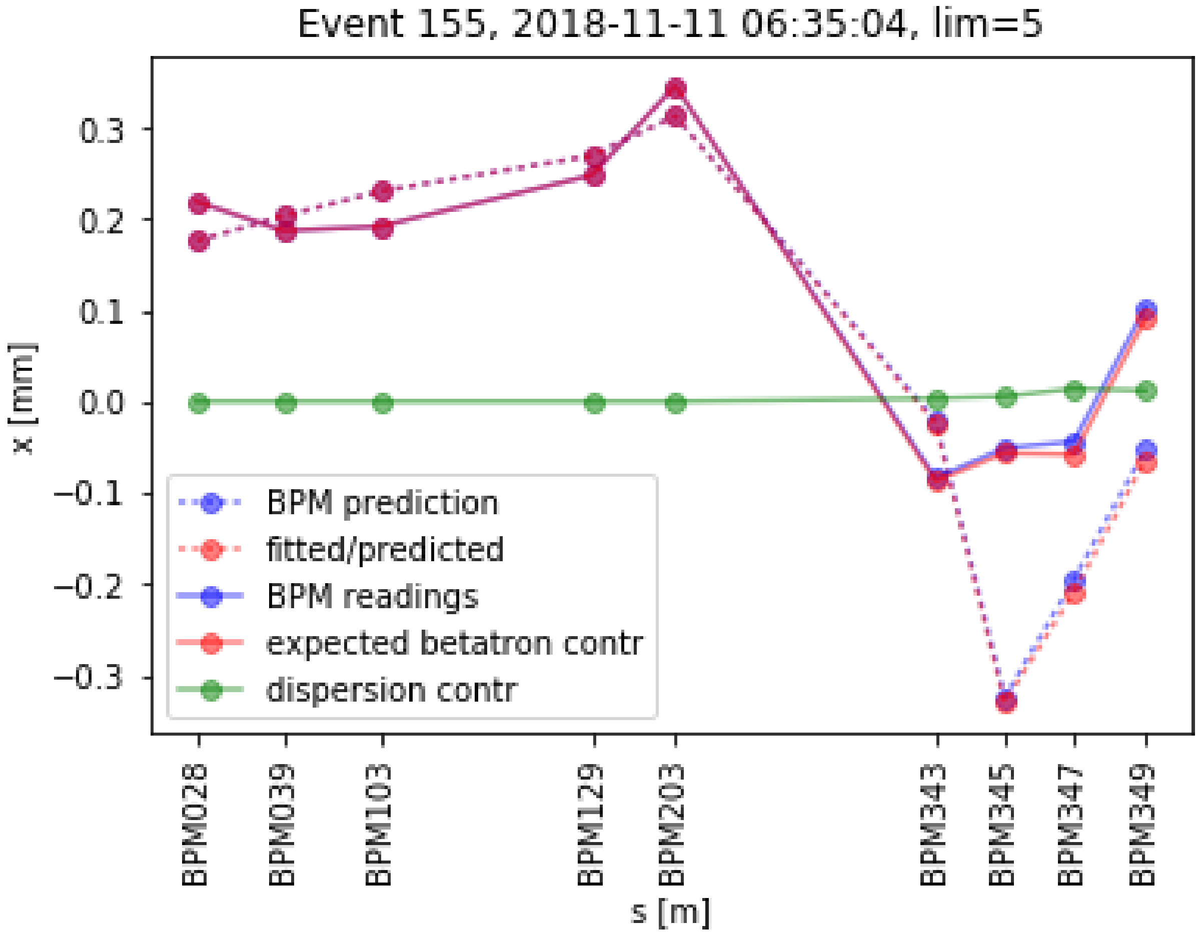
Betatron Oscillation

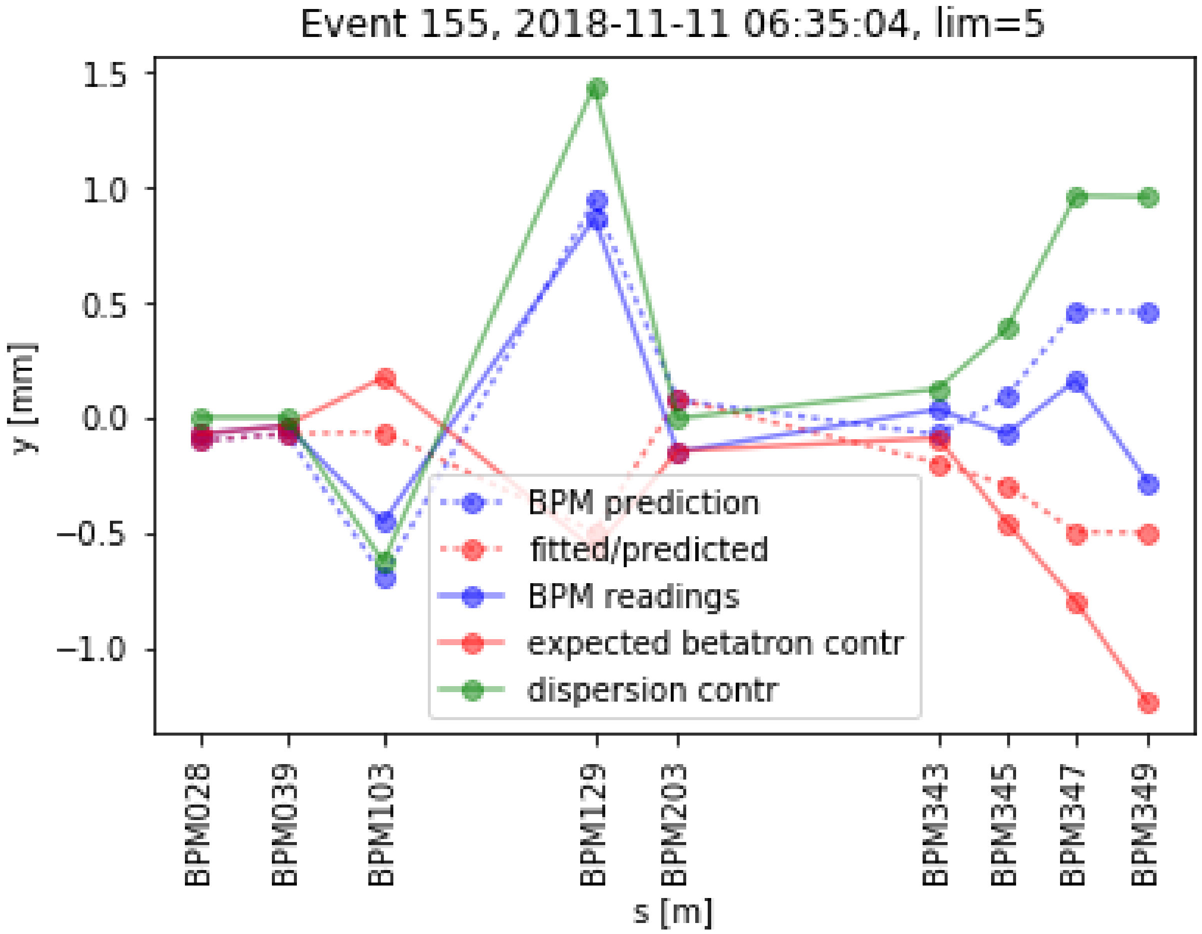




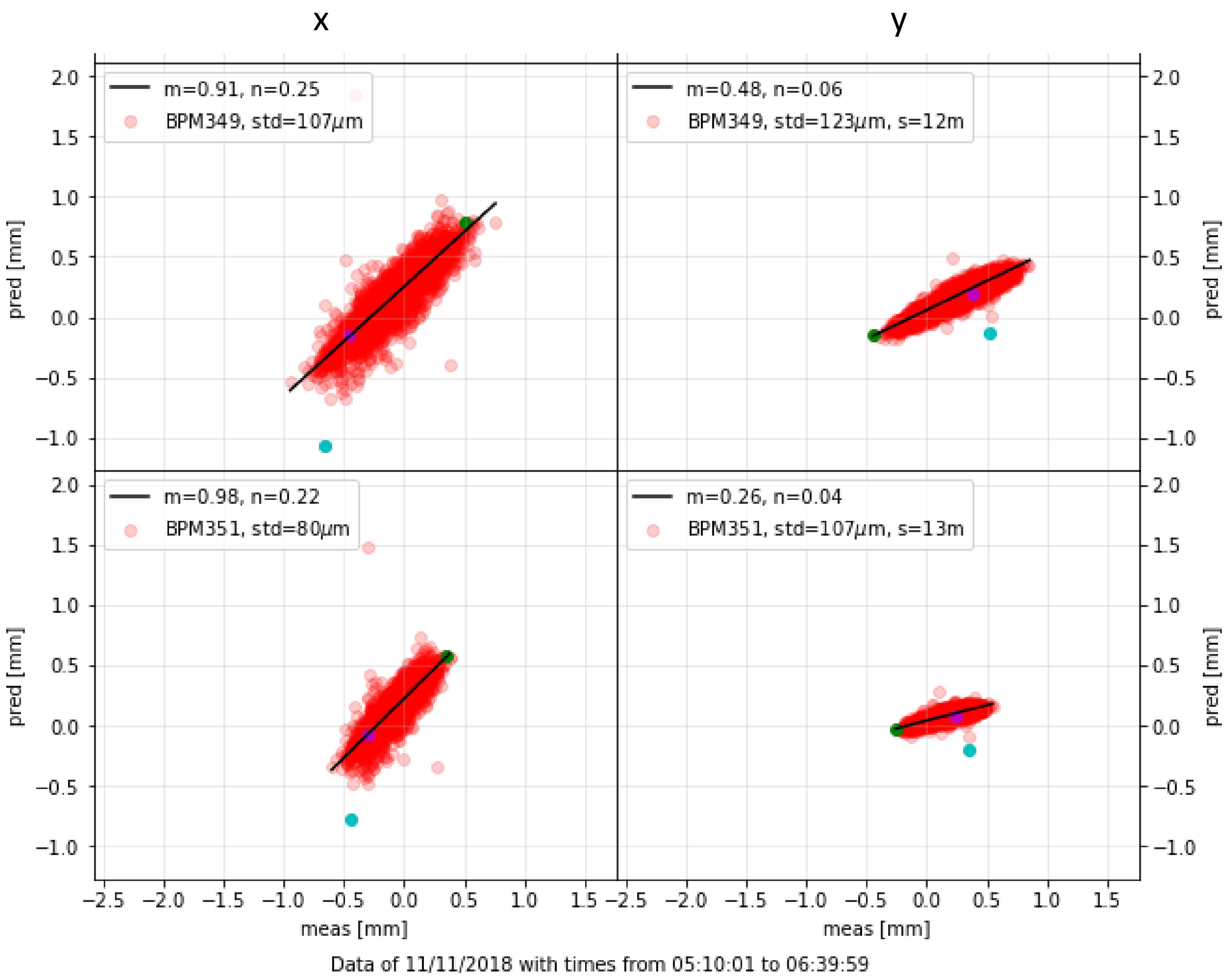
Results

$$y_{BPM} = \sqrt{\beta_i} \cdot y_{\beta_i} + D_i \cdot \delta_P$$



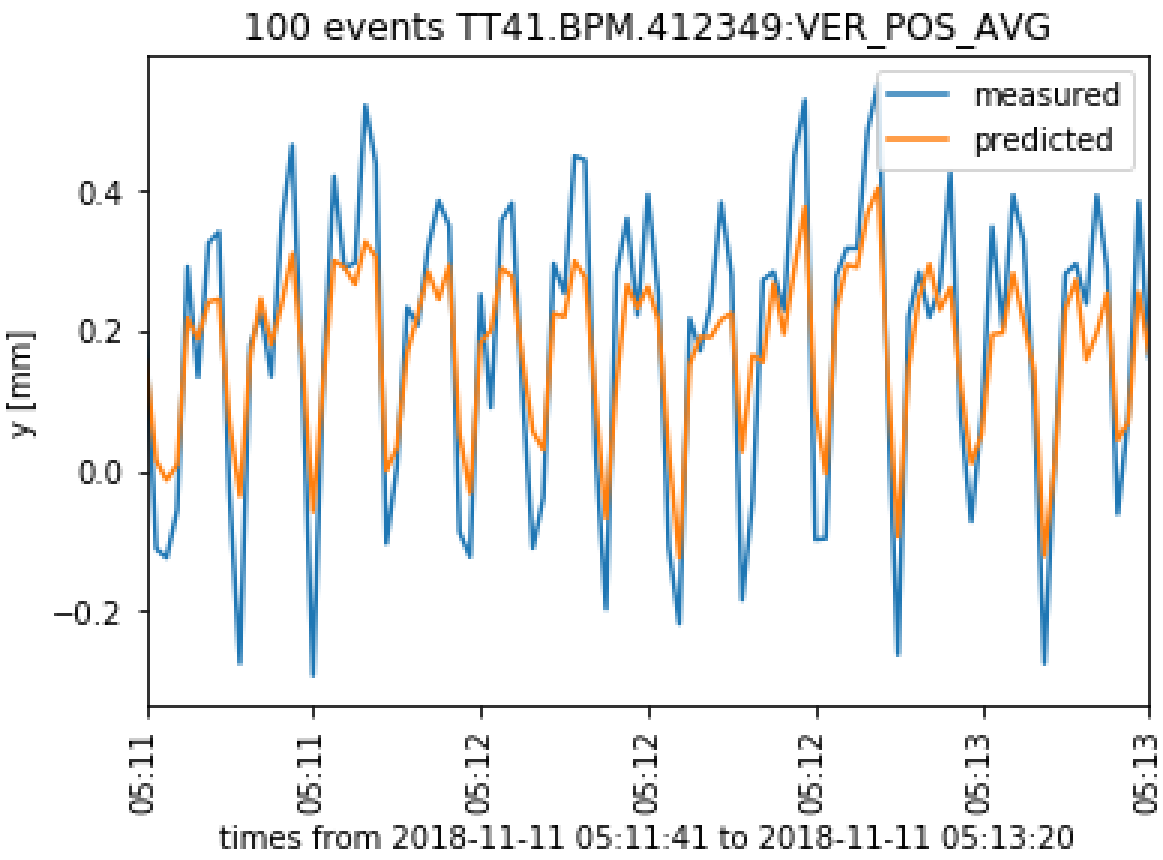


Results

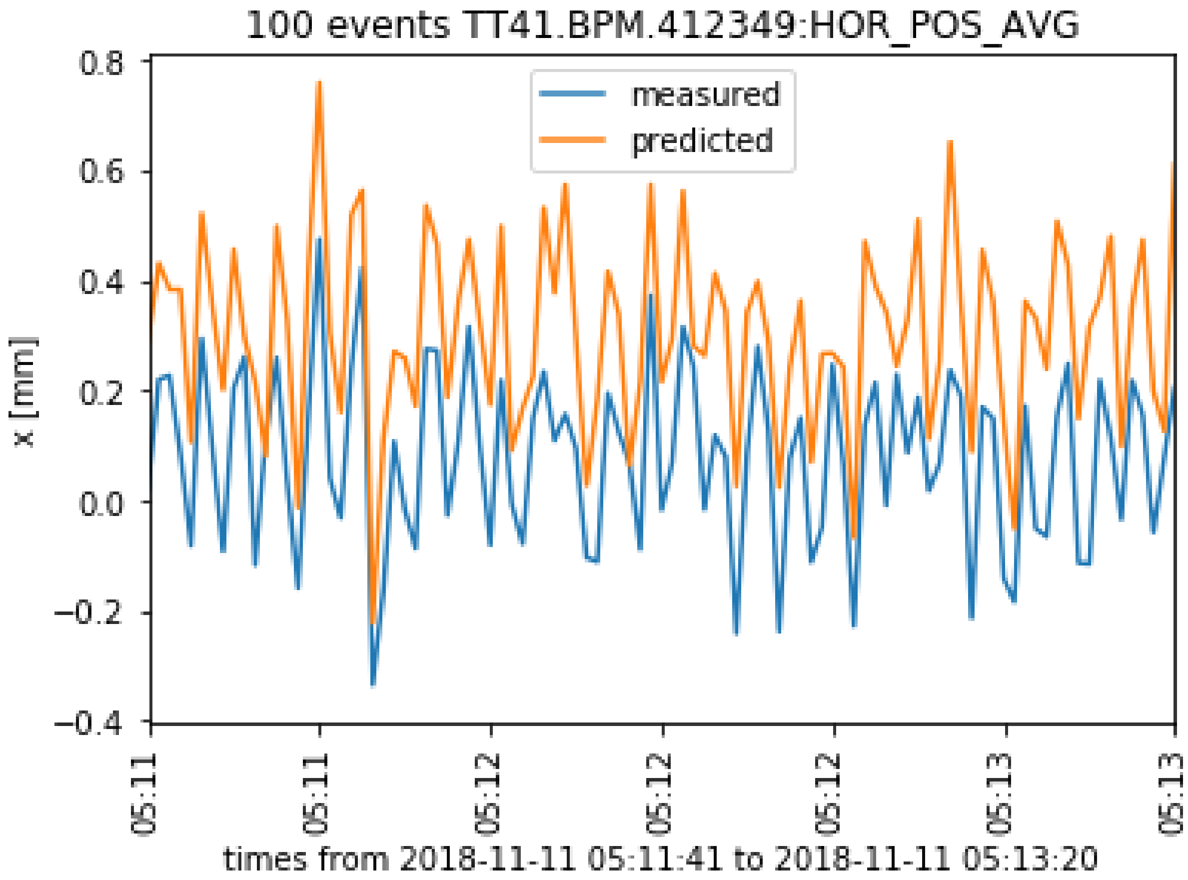


x
y
m=0.91, n=0.25
BPM349, std=107μm
m=0.48, n=0.06
BPM349, std=123μm, s=12m
m=0.98, n=0.22
BPM351, std=80μm
m=0.26, n=0.04
BPM351, std=107μm, s=13m
pred [mm]
meas [mm]
Data of 11/11/2018 with times from 05:10:01 to 06:39:59

Results



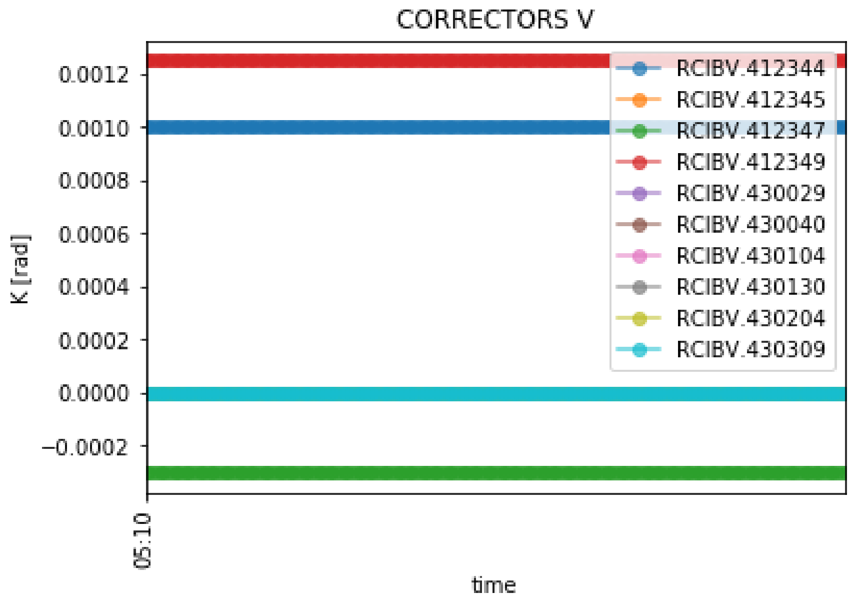
100 events TT41.BPM.412349:VER_POS_AVG
measured
predicted
y [mm]
0.4
0.2
0.0
−0.2
05:11
05:11
05:12
05:12
05:12
05:13
05:13
times from 2018-11-11 05:11:41 to 2018-11-11 05:13:20

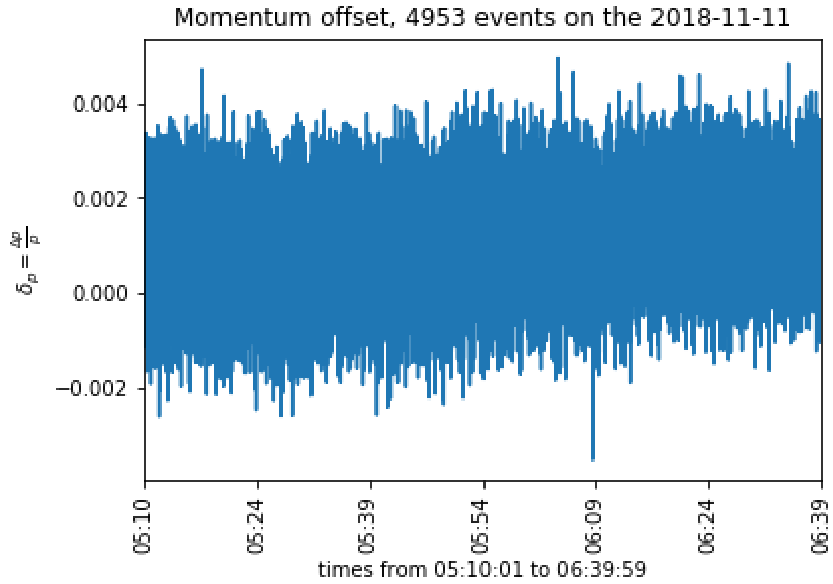


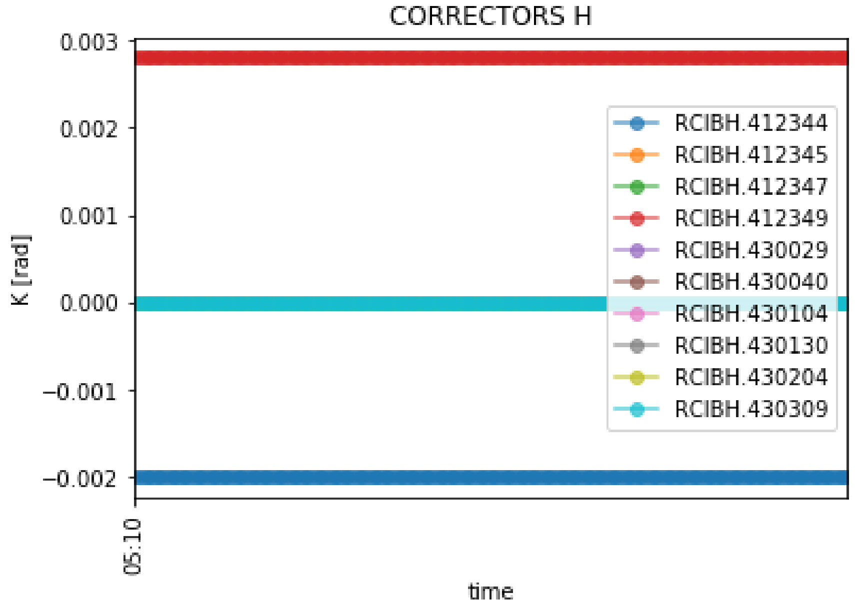
100 events TT41.BPM.412349:HOR_POS_AVG
measured
predicted
x [mm]
0.8
0.6
0.4
0.2
0.0
−0.2
−0.4
05:11
05:11
05:12
05:12
05:12
05:13
05:13
times from 2018-11-11 05:11:41 to 2018-11-11 05:13:20

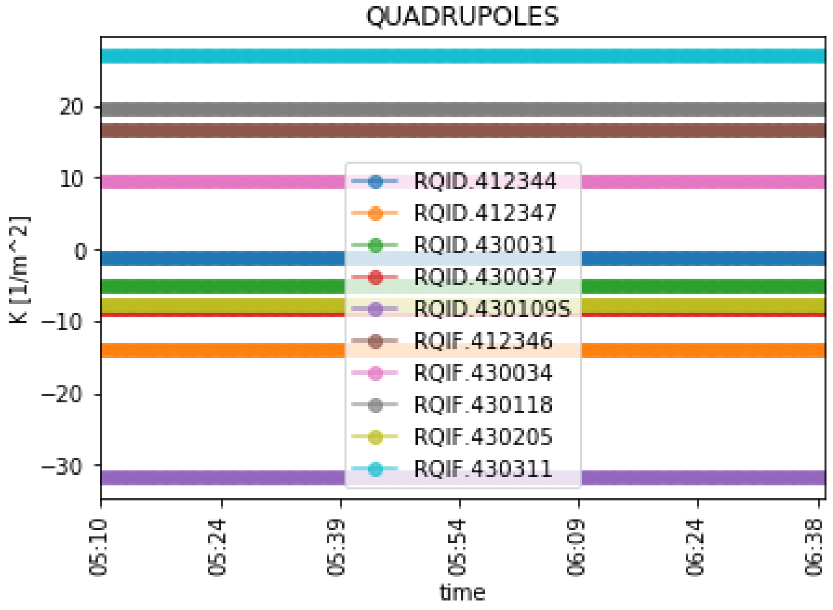
Results

Problem

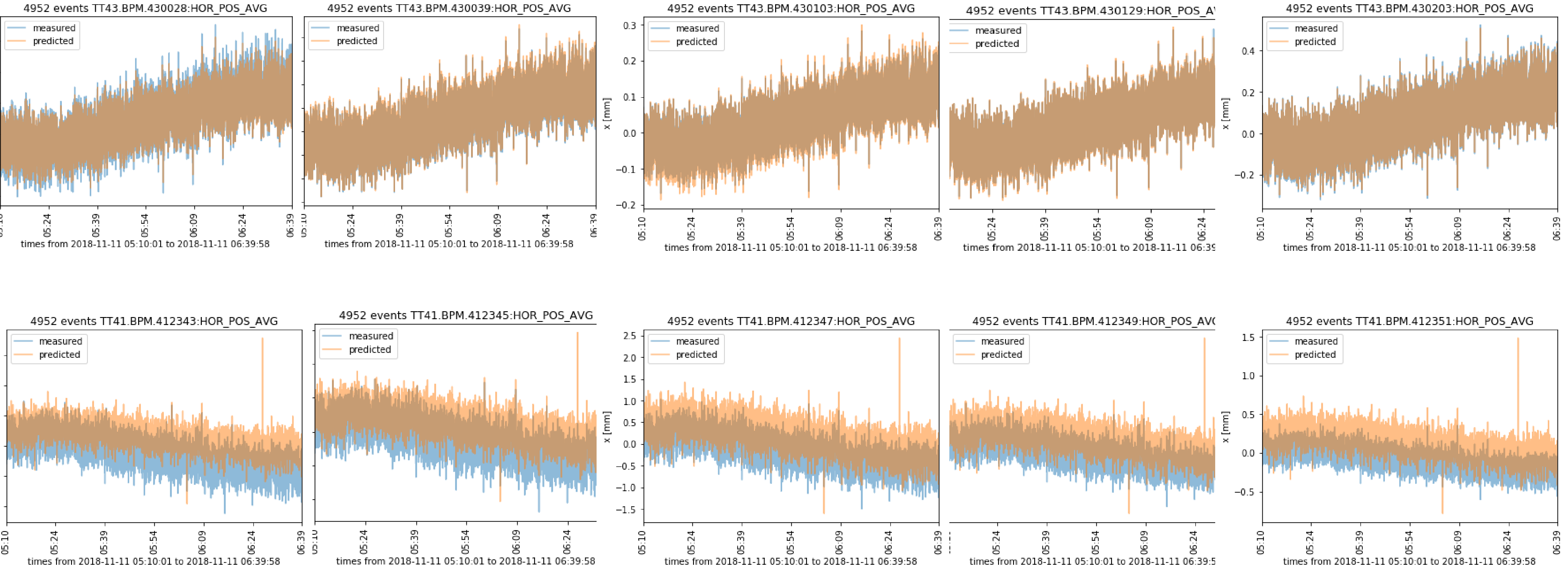




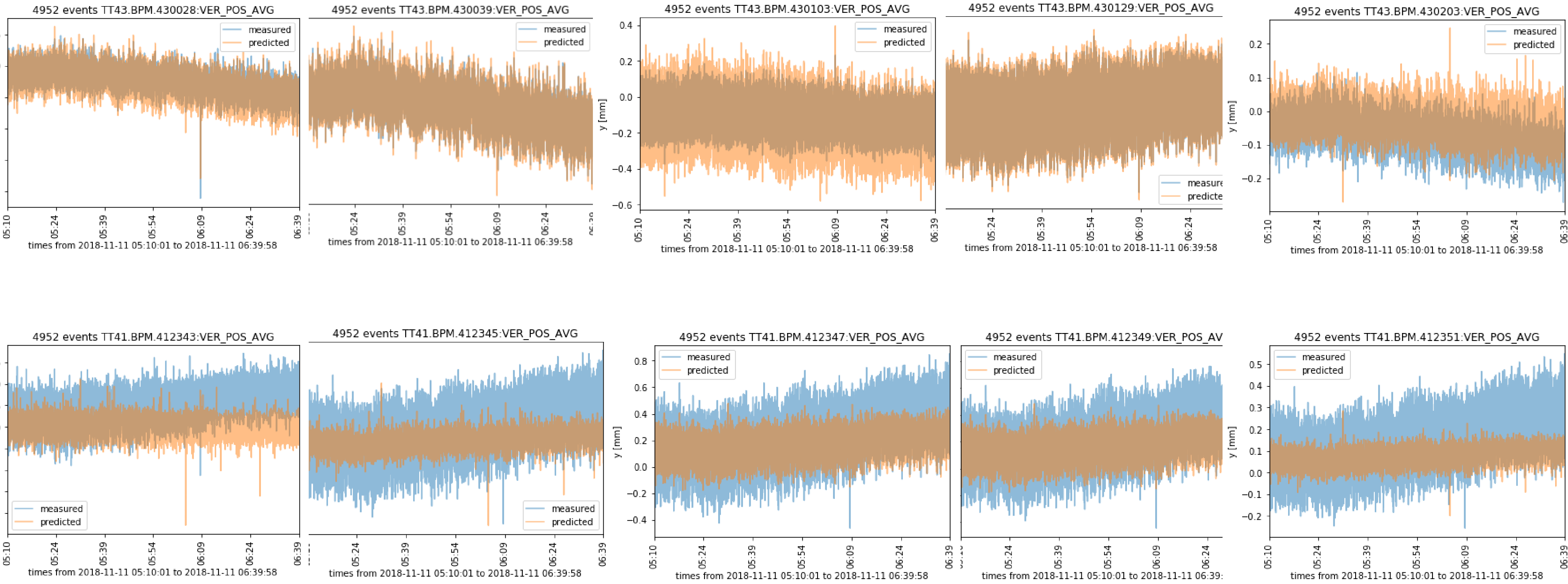




Results -Problem



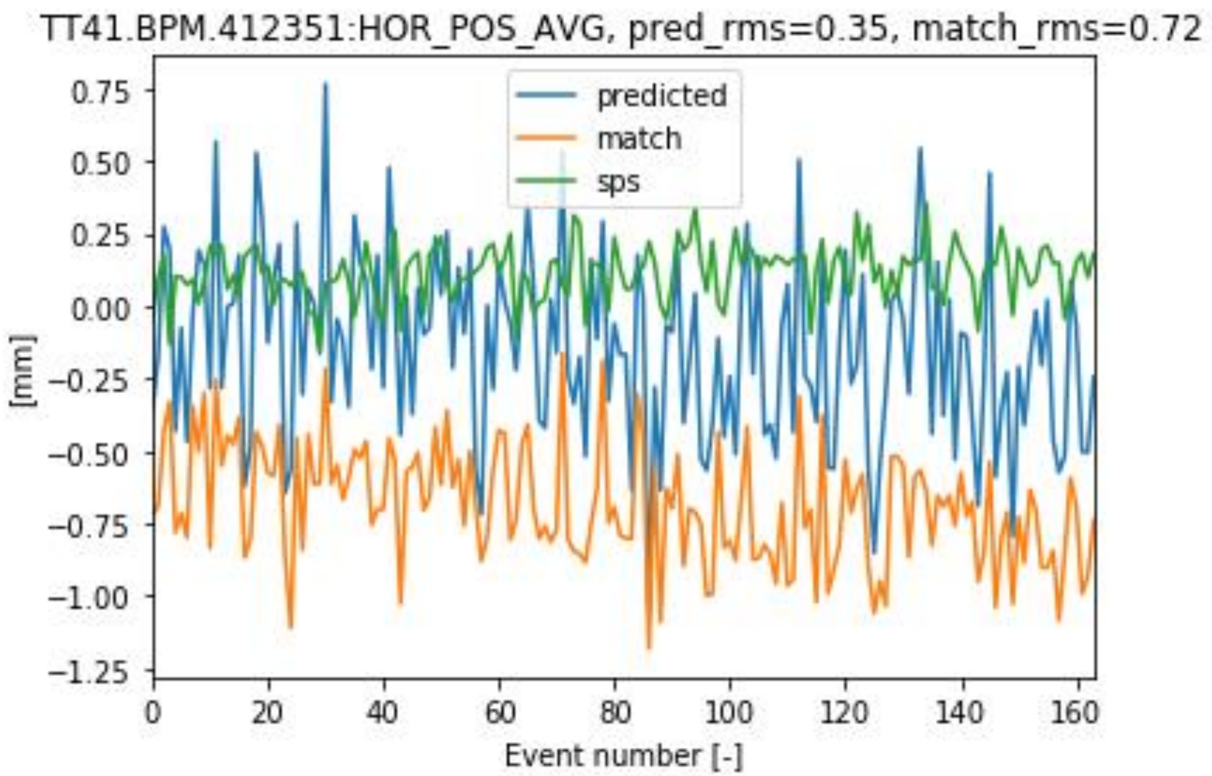
Results -Problem

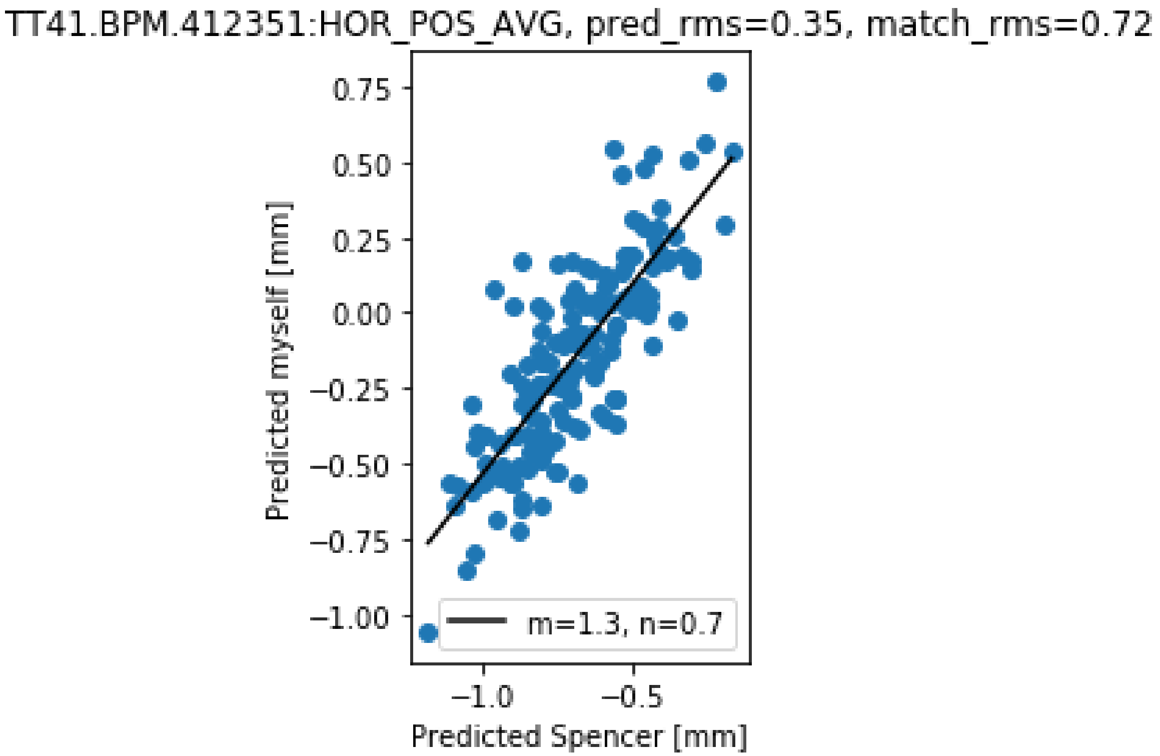


Improvements

- Use the 10Hz data (until now 1Hz or extraction)
- Investigate shift (include dipoles into MADX?)

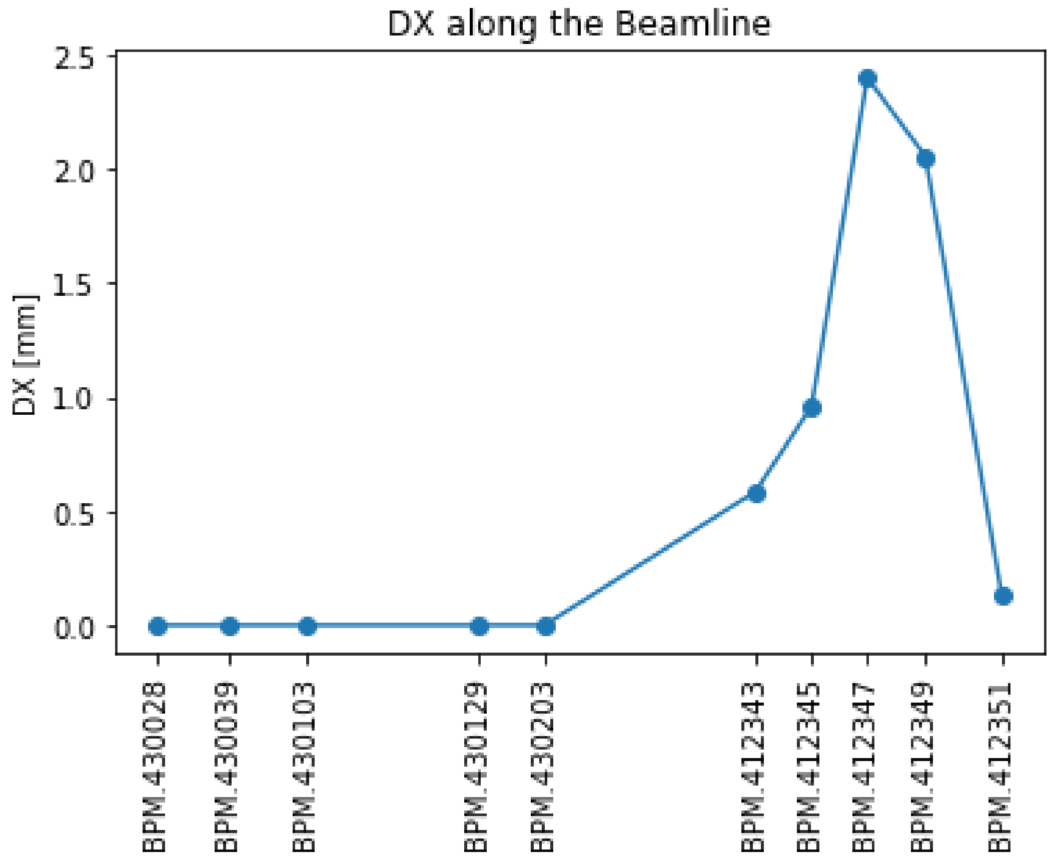
Comparison with Spencer's Results

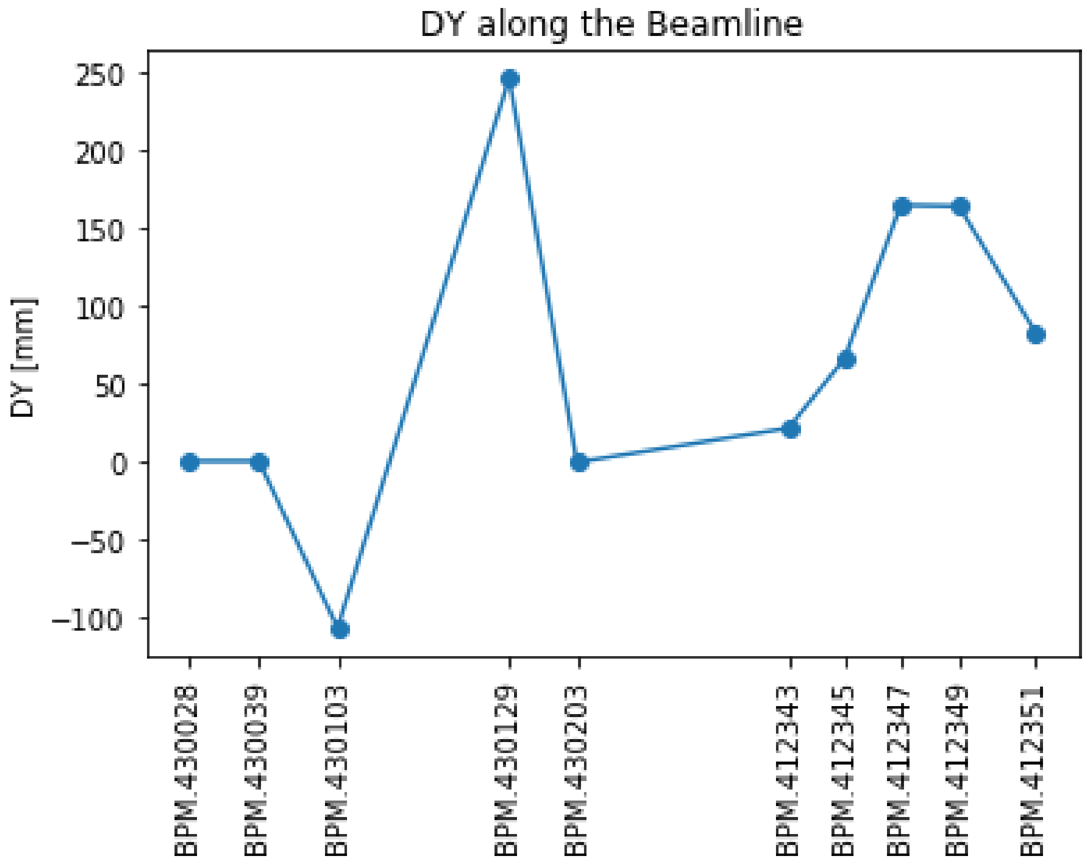




Thank you!

Betatron Oscillation

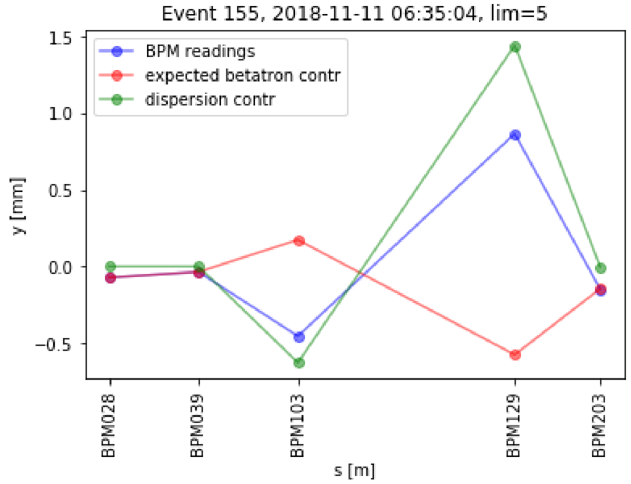


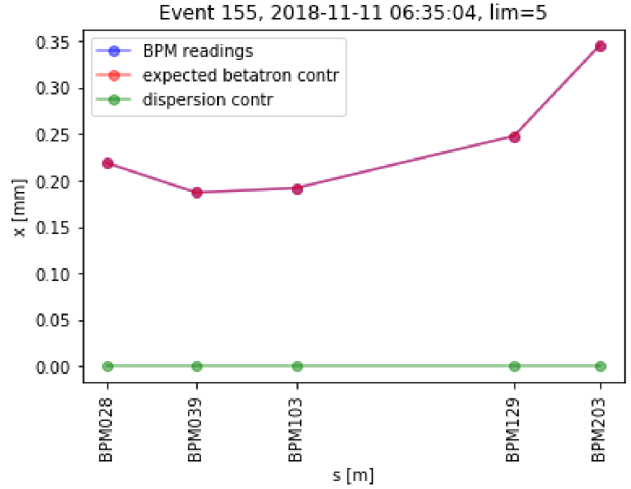


Betatron Oscillation check

$$y_\beta = A\cos(2\pi \cdot \mu(s)) + B\sin(2\pi \cdot \mu(s))$$

$y_{\beta 103}$ [μm]	$y_{\beta 129}$ [μm]
127	-38
29	-9
105	-31
27	-8
48	-14
60	-18
23	-7





$$y_{BPM2} = \sqrt{\beta_2} \cdot y_{\beta_2} + D_2 \cdot \delta_P$$

$$y_{\beta_1} = -y_{\beta_2}$$

$$\mu(s_{BPM129}) - \mu(s_{103}) = 0.49$$

$$\delta_P = \frac{\sqrt{\beta_1} \cdot y_{BPM2} + \sqrt{\beta_2} \cdot y_{\beta PM2}}{\sqrt{B_1} \cdot D_2 + \sqrt{B_2} \cdot D_1}$$

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