

# EMMA: Toward acceleration

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# EMMA's main goals

- Serpentine acceleration (or acceleration outside the bucket.)
- Fast resonance crossing without beam deterioration.
- Large acceptance in both longitudinal and transverse.

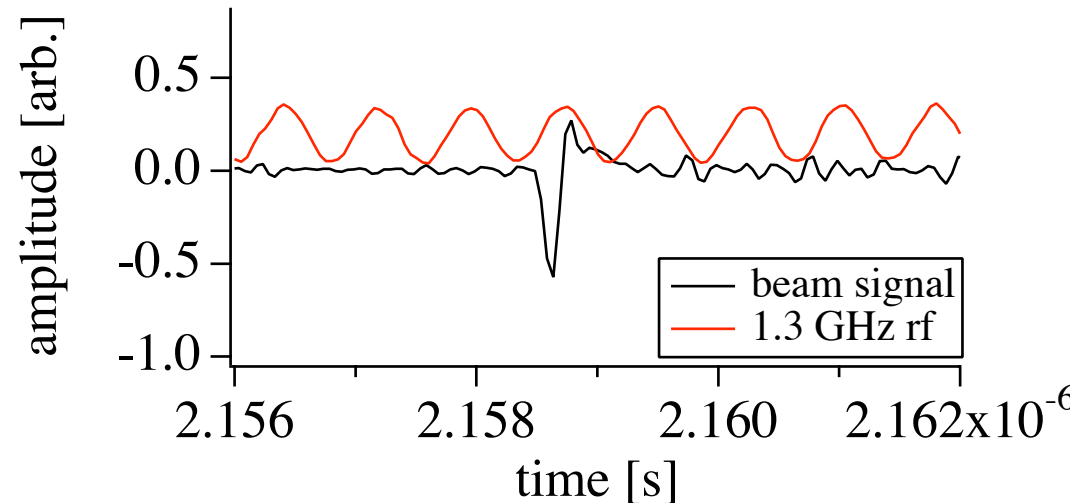
# Things have been done

- Injection between 14.5 and 20.5 MeV/c equivalent\* momentum.
- There is a few stopbands in between.
- Tune is lower than expected, but within error bar.
- Time of flight per turn is about 50 ps lower.
- A few 10 of thousands circulations.
- ALICE beam is always 12.5 MeV/c. Change magnet strength keeping QD/QF ratio constant.

# Acceleration (1)

*signals*

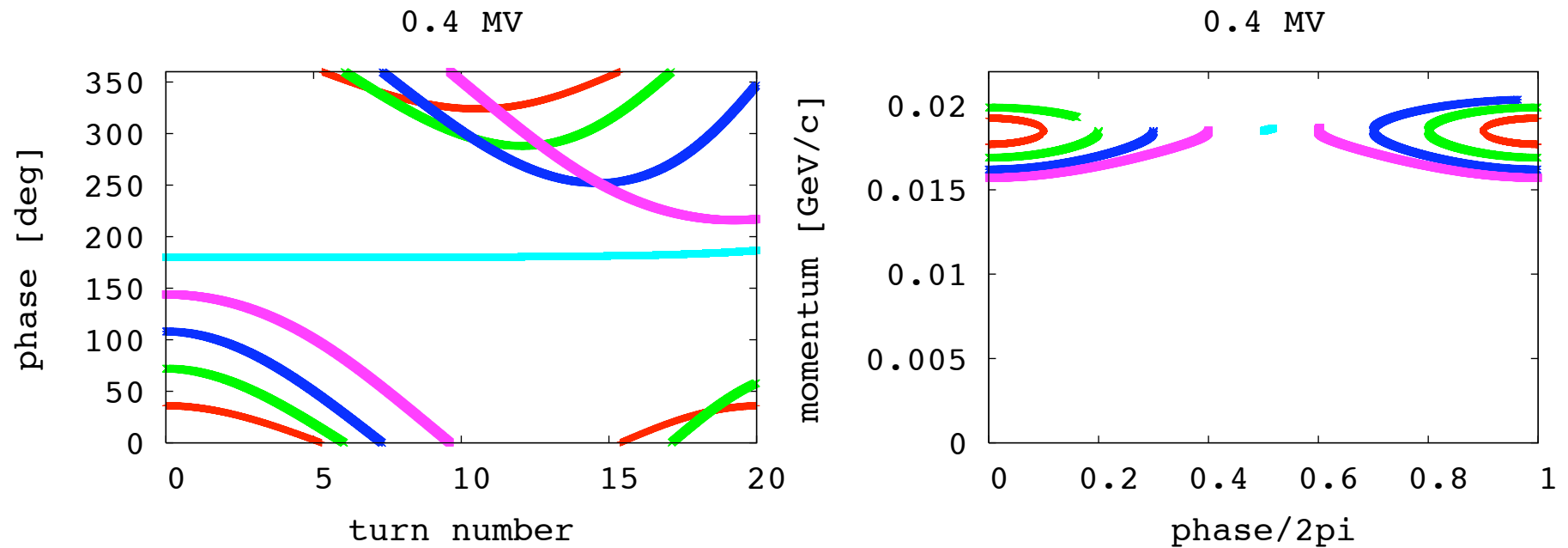
- Relative phase vs turn.
  - Relative phase measurement.
- Cell tune vs. turn.
  - BPM measurement (H and V)
- Horizontal position.
  - BPM measurement (H)



# Acceleration (2)

*without serpentine channel*

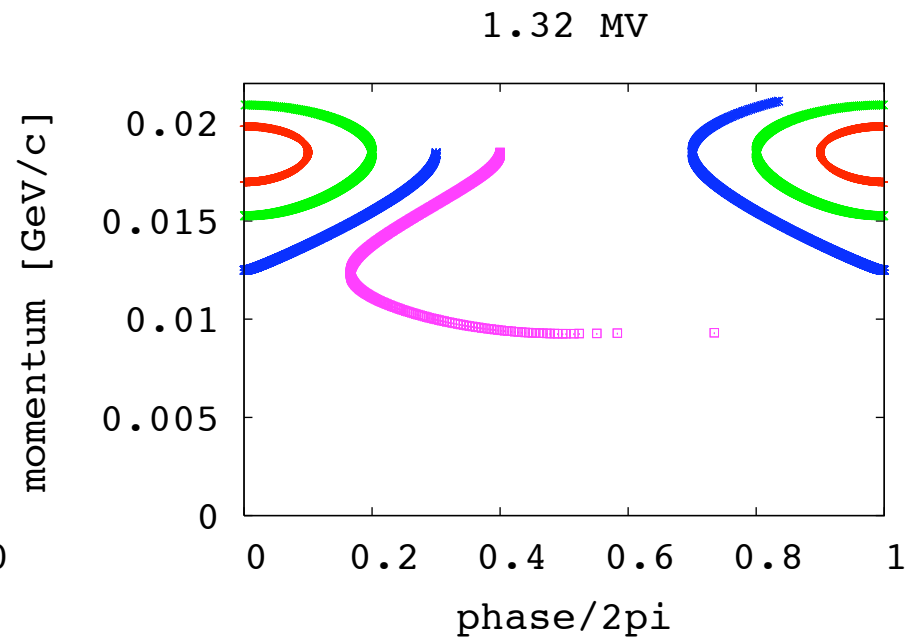
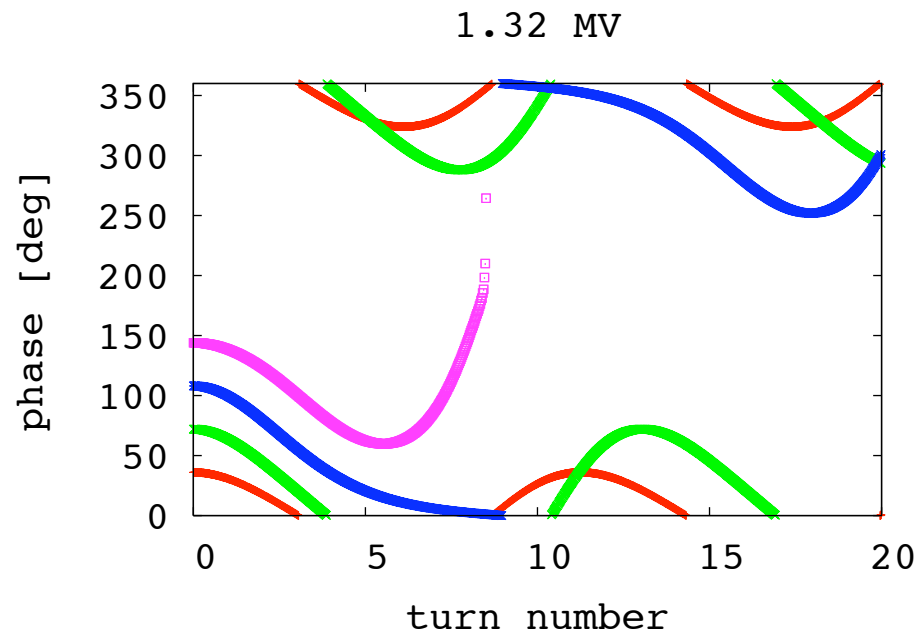
- With 0.4 MV per turn, rf buckets are separated.
- Shows an ordinary synchrotron oscillation.



# Acceleration (3)

*with serpentine channel*

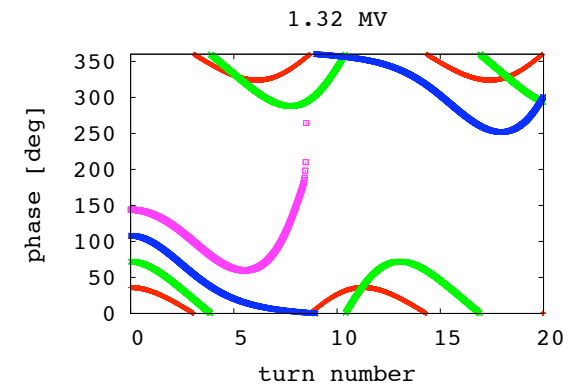
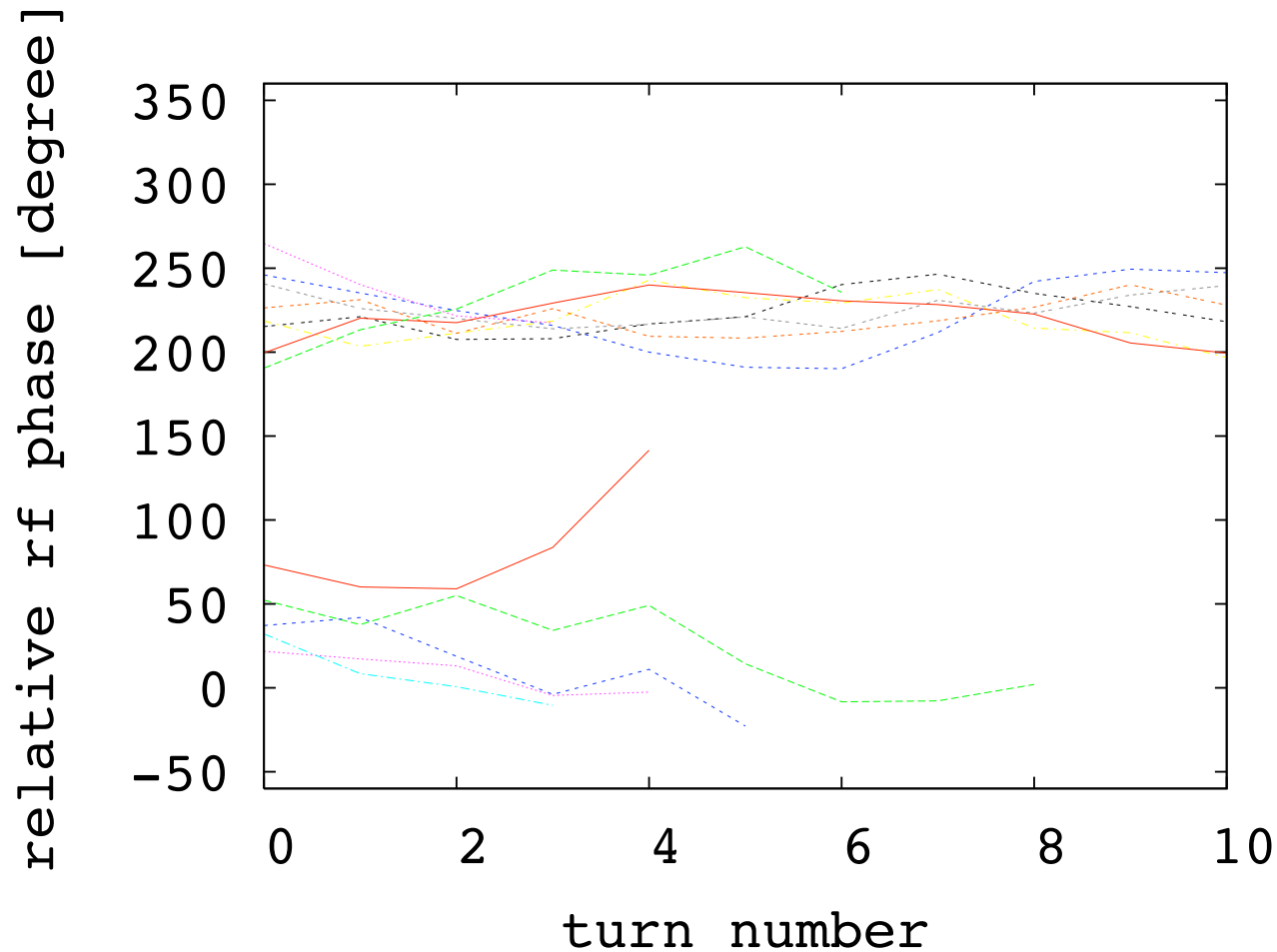
- With 1.32 MV per turn, a beam in serpentine channel behaves differently.



# Acceleration (4)

*measured phase signal*

- A beam does not survive.



# Two major problems identified

- rf vector sum of 19 cavities is lower than expected. Cavity phase was not correctly adjusted.
- Closed orbit distortion was rather large ( $\sim \pm 5$  mm) in both horizontal and vertical.
- Only 12 BPM signals (either H or V) are available at one time.

# Cavity phase (1)

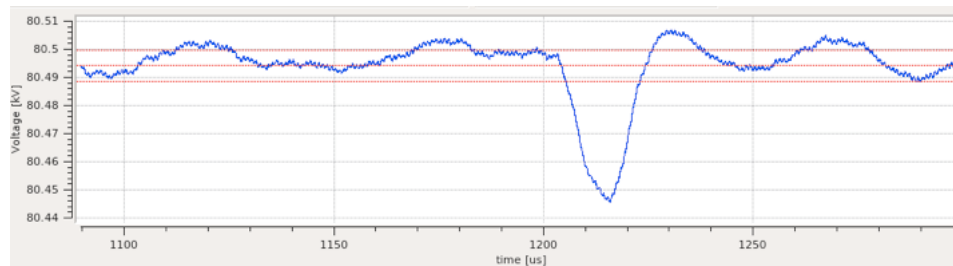
## *methods of measurement*

- The difference between each cavity is  $72 \times 360 / (42/2) = 153.28$  degree.
- There was not way to set except cable length. Remember frequency is 1.3 GHz.
- Recently we found we can use beam loading signal to adjust individual phase.

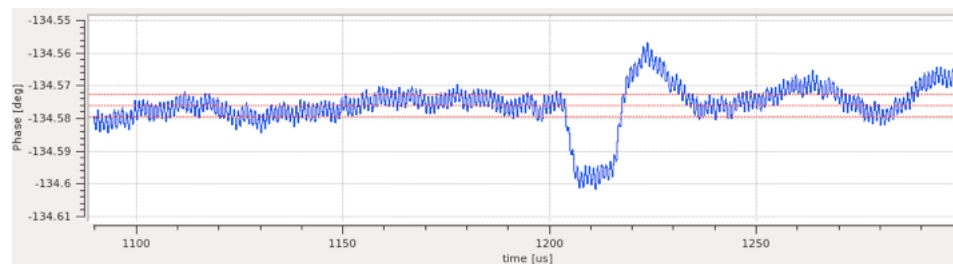
# Cavity phase (2)

*beam loading signal*

- Monitored amplitude



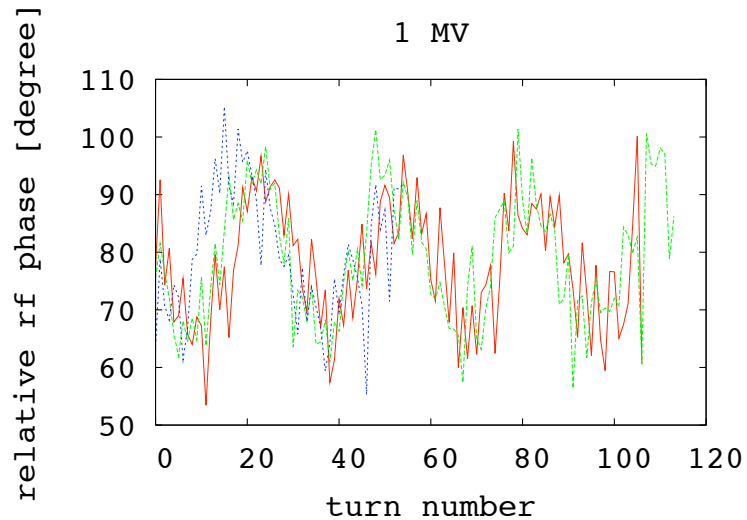
- Monitored phase



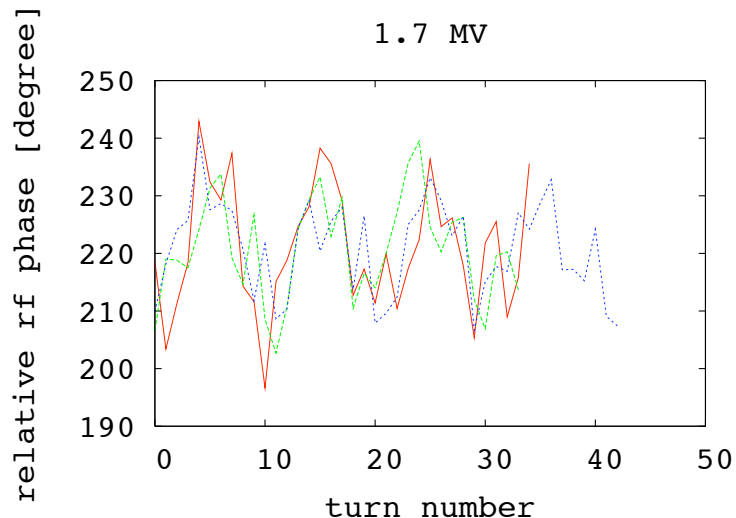
- As a function of rf phase, observe sign of loading signal.

# Cavity phase (3)

*synchrotron oscillations*



- Before adjustment, ~20 turns with 1 MV.
- It should be ~14 turns.
- Beams sees only a half.



- After adjustment, ~10 turns with 1.7 MV.
- It should be ~11 turns.
- Agree with calculation.

# Cavity phase (4)

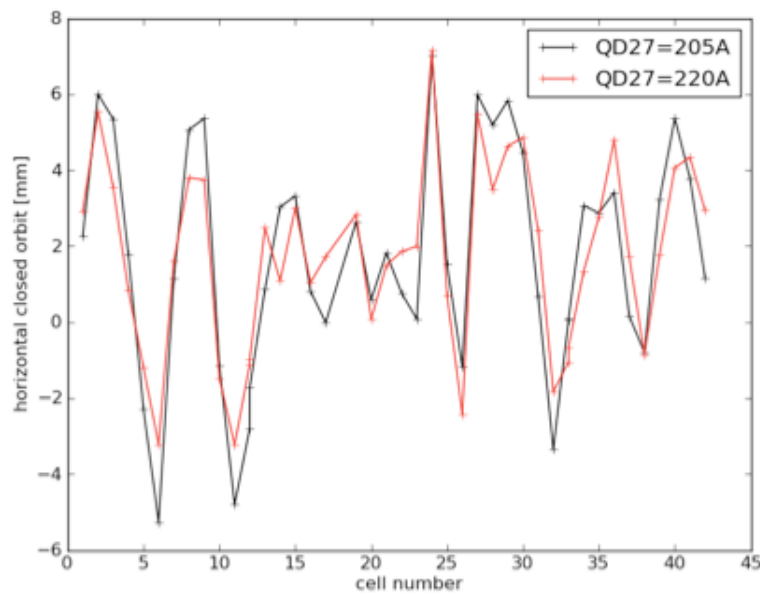
*rf voltage for serpentine channel*

- Two rf bucket merges and create serpentine channel with more than 0.9 MV per turn.
- There should be enough rf voltage after adjusting individual cavity phase.

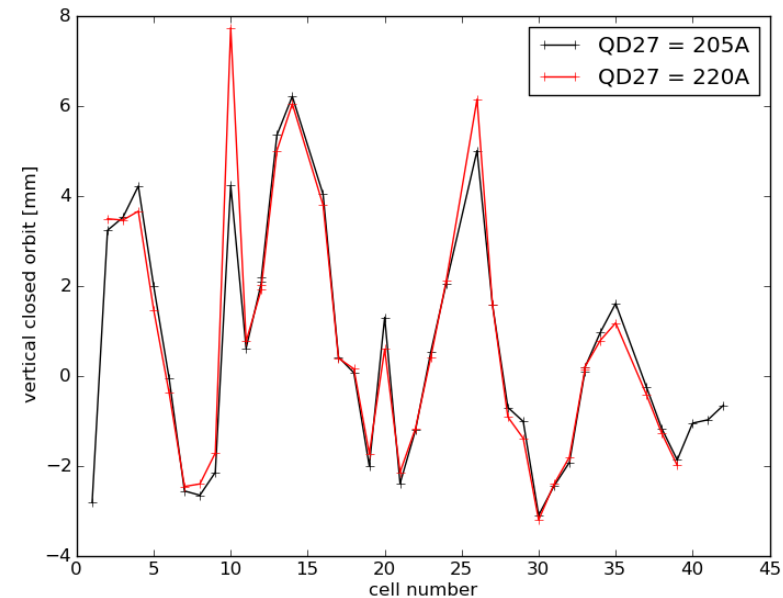
# Closed orbit distribution (1)

*before correction*

- Both horizontal and vertical has COD of  $\sim \pm 5$  mm.



Horizontal



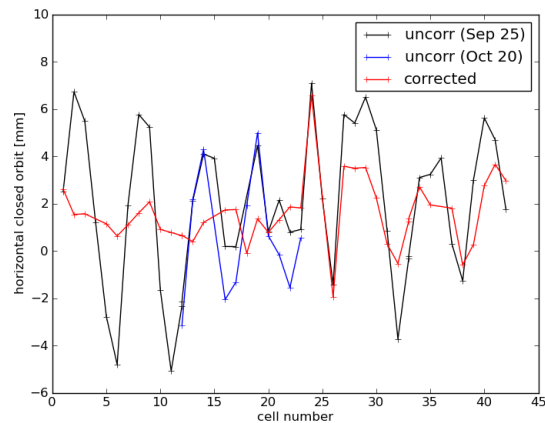
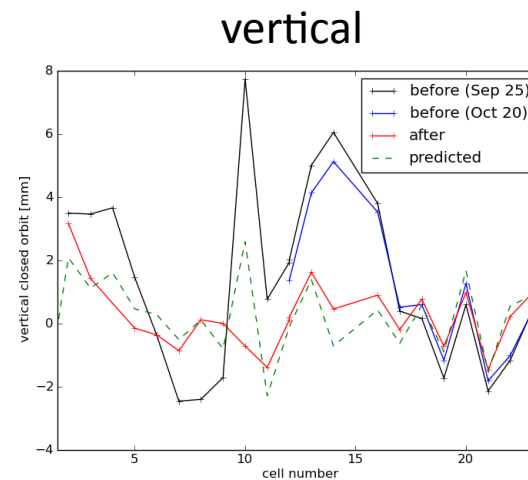
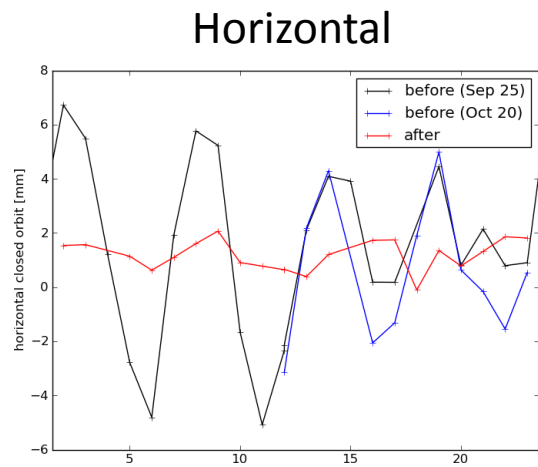
vertical

- Hard to explain by misalignment: 1 mm corresponds to 50  $\mu\text{m}$ .

# Closed orbit distribution (2)

*after correction*

- After correction.

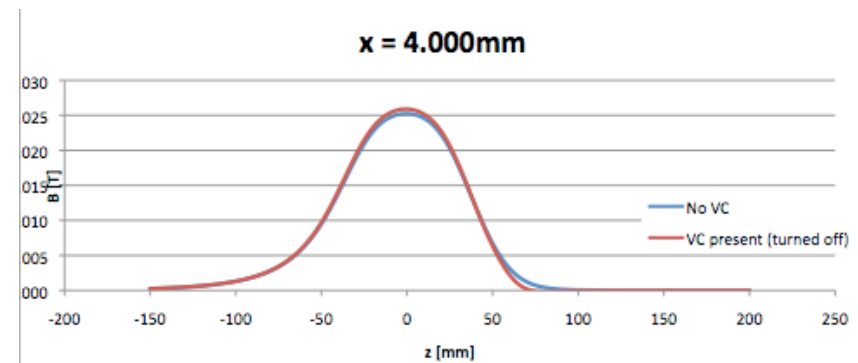
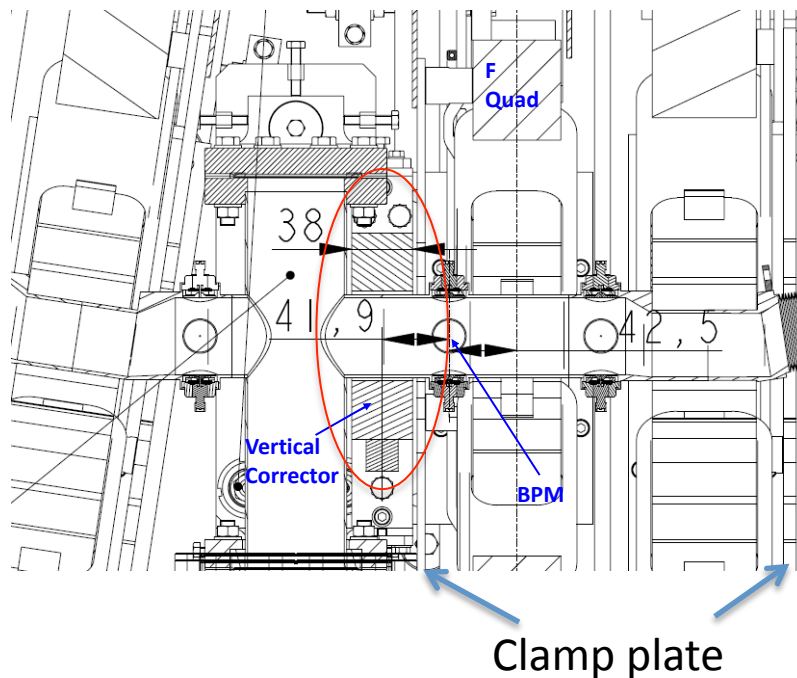


- COD is reduced to  $\sim \pm 1$  mm
  - Shift of 84 magnets in H
  - 16 V corrector in V

# Closed orbit correction (3)

*possible source*

- V corrector next to QF magnets.
  - Only 16 cells out of 42 cells.
  - Integrate field changes at least 2%.



# Closed orbit correction (4)

*simulated COD*

- If there is misalignment of 1 mm in QF next to the vertical corrector,

# Summary

- rf vector sum should be enough.
- COD is corrected, but not for all the momentum range.
- Acceleration/acceleration?