

# Updates of wakefield study

R. Ainsworth, S.Boogert, A.Lyapin, **J.Snuverink**  
(JAI-RHUL)  
Y.I. Kim (JAI-Oxford)  
T. Okugi (KEK)

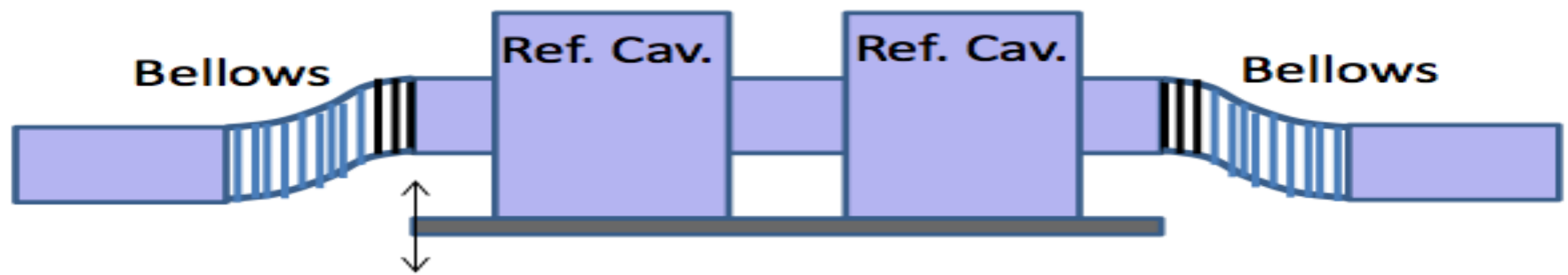
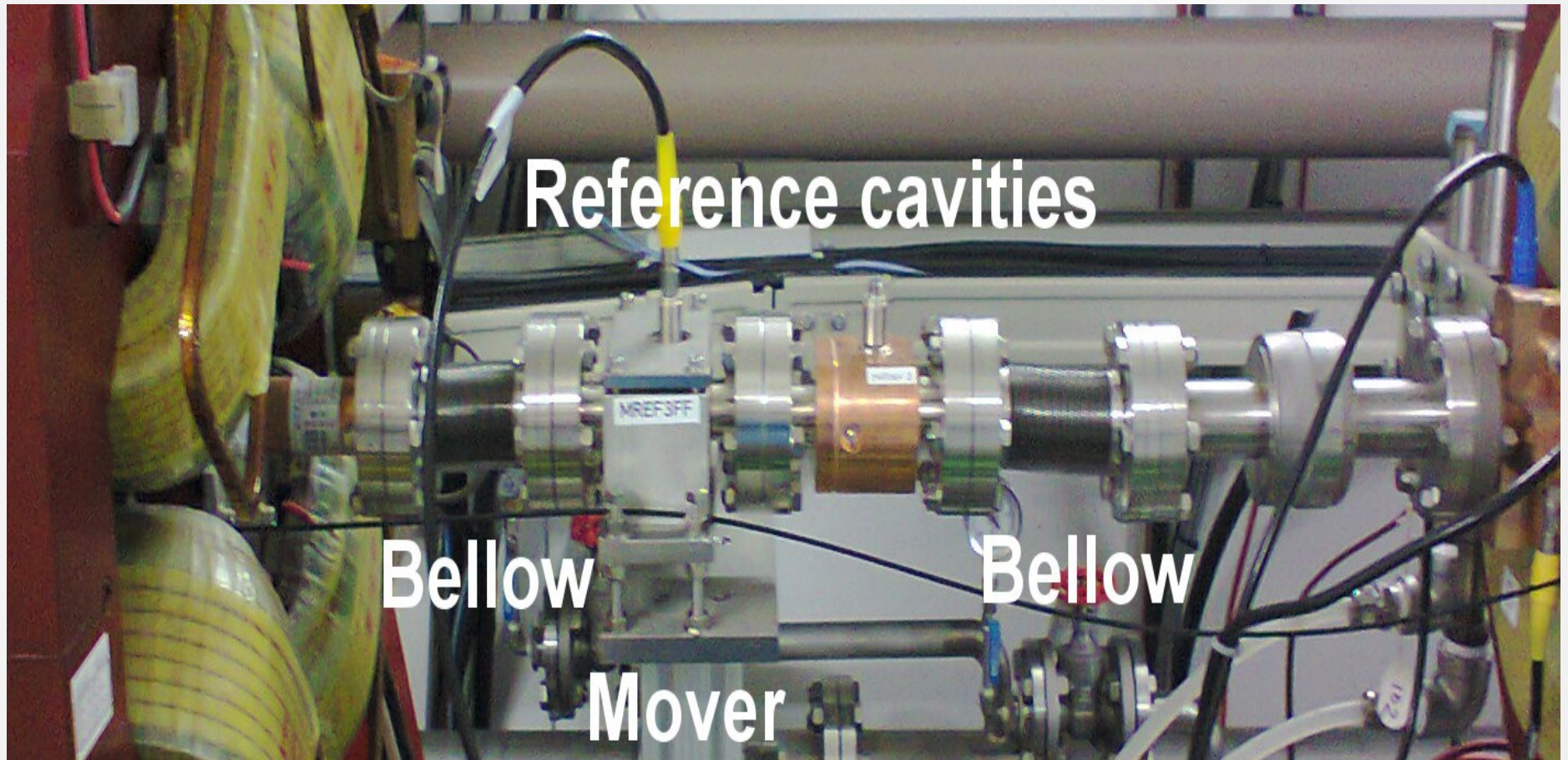
08/07/2013



# Outline

- Wakefield Calculations
- Beam size (IPBSM) vs Beam orbit
- Beam orbit

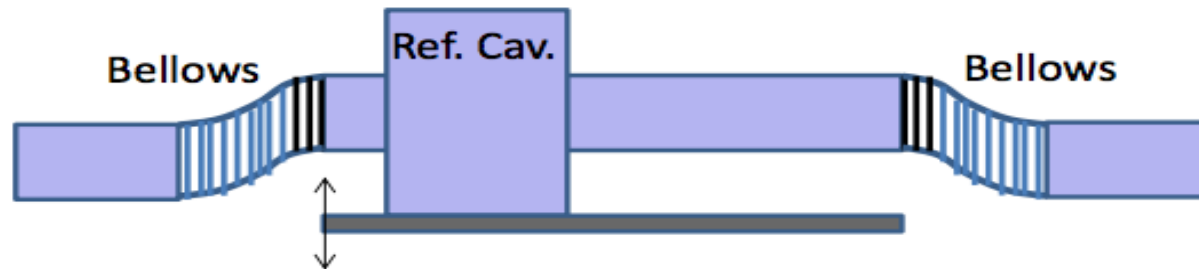
# MREF3FF setup



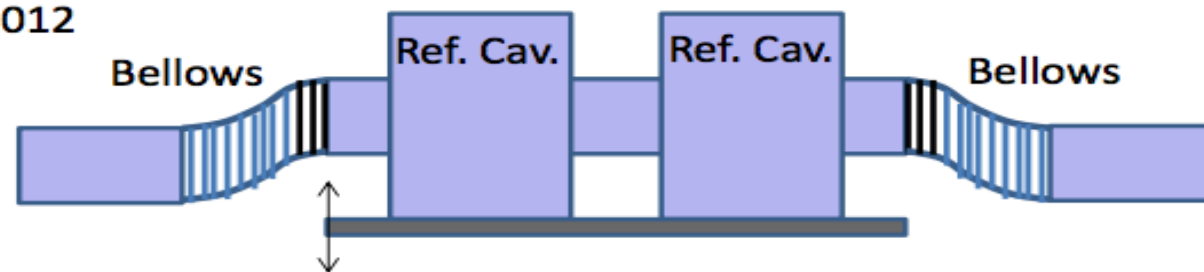
# Setup

## on-mover wakefield source

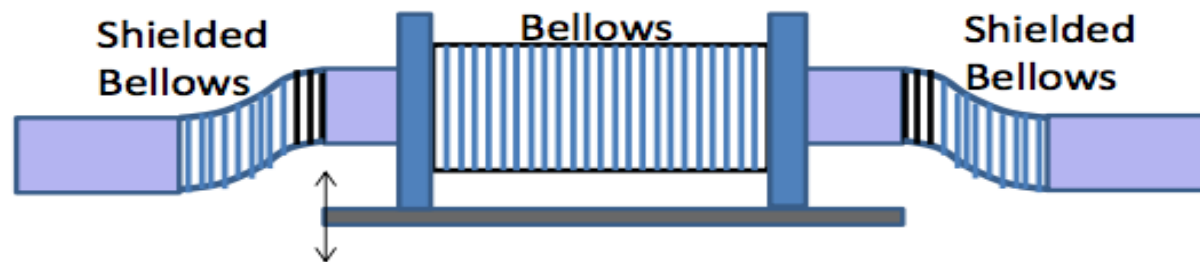
Dec.2012



Dec.2012 – April 2012



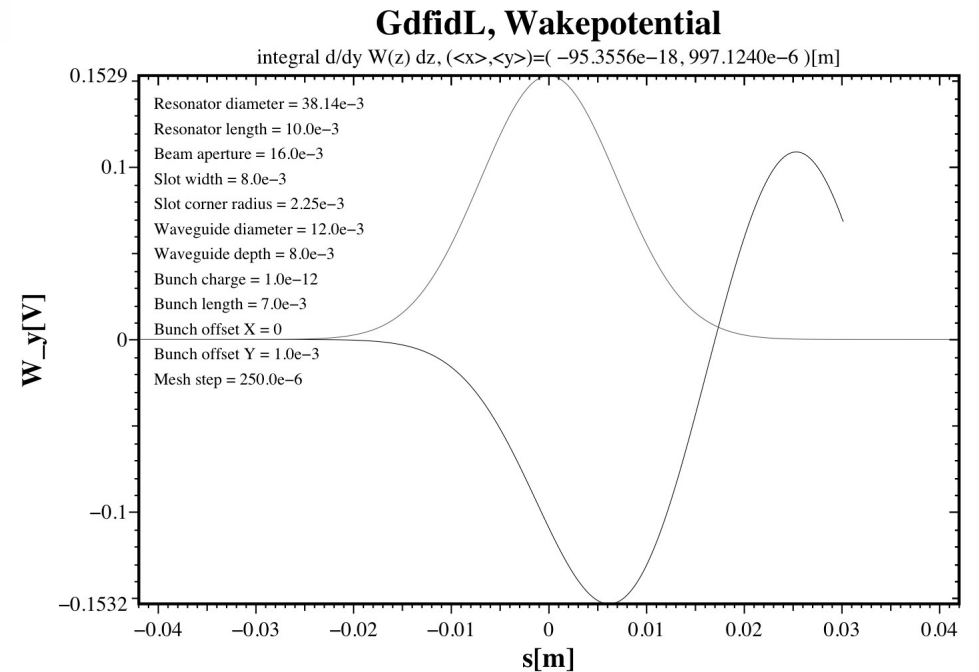
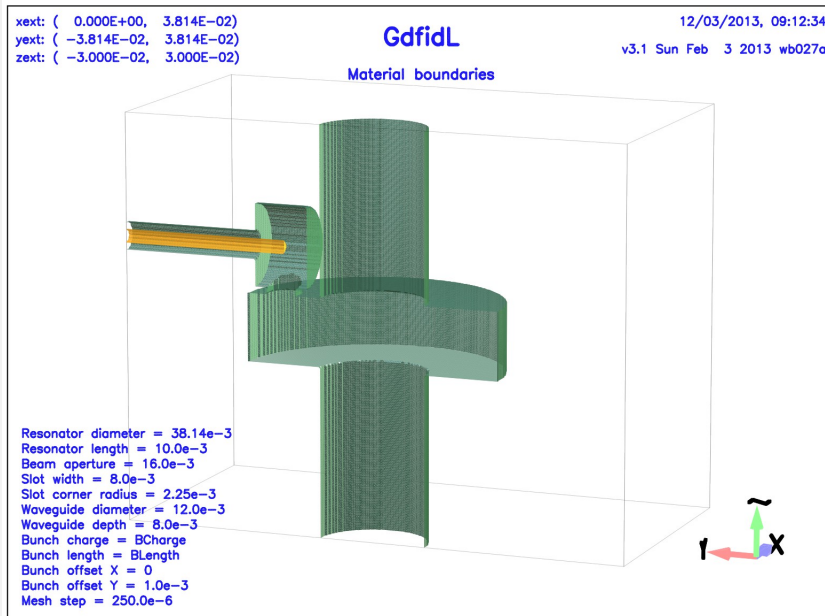
May 2012



# Wakefield

- Geometrical wake fields have been computed numerically with GdfidL (<http://www.gdfidl.de>) and ACE3P
  - Electromagnetic fields calculator in any 3D-structure
  - Finite element method
  - All higher modes included (up to cut-off frequency)
- The beam is represented as a line charge traveling along the z-axis with optional offsets in x and y, Gaussian distribution in z
- CPU and labor-intensive simulations (A. Lyapin and R. Ainsworth)
- Wake field shape dependent on beam shape itself
  - Bunch length
  - Beam offset

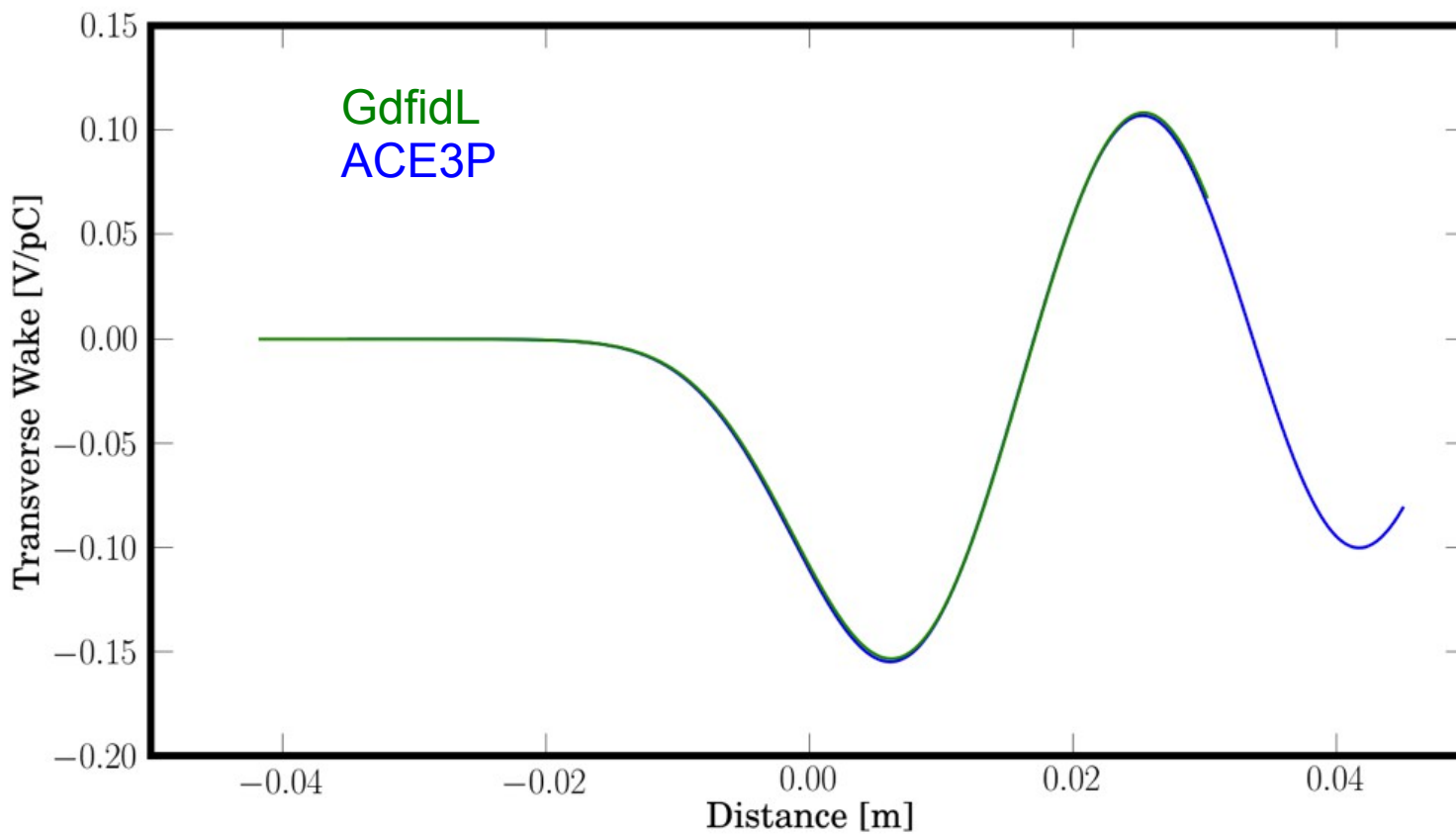
# C-band reference



- Higher impedance than position cavity (smaller aperture and diameter)
- Used to be 4 in the beamline, now 1 providing the reference signal and 2 in the test location

# Agreement GdfidL / ACE3P

ACE3P: [https://portal.slac.stanford.edu/sites/ard\\_public/acd/Pages/Default.aspx](https://portal.slac.stanford.edu/sites/ard_public/acd/Pages/Default.aspx)



R. Ainsworth (RHUL)

# Wakefield

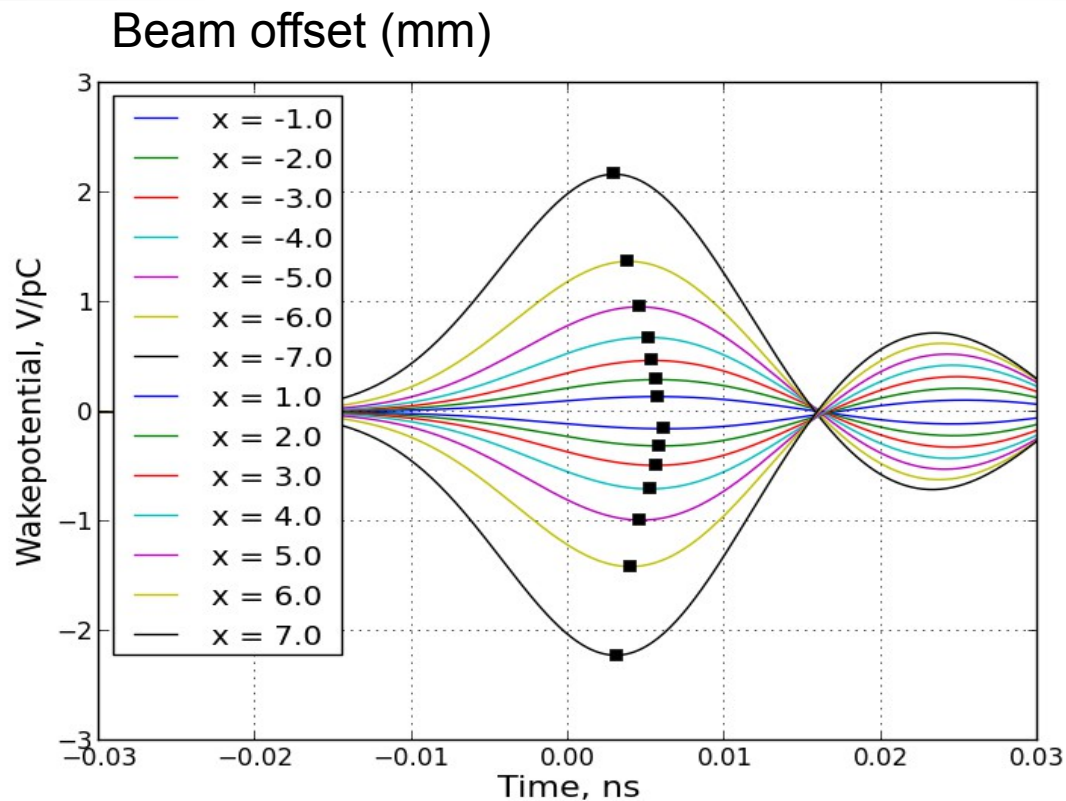


R. Ainsworth



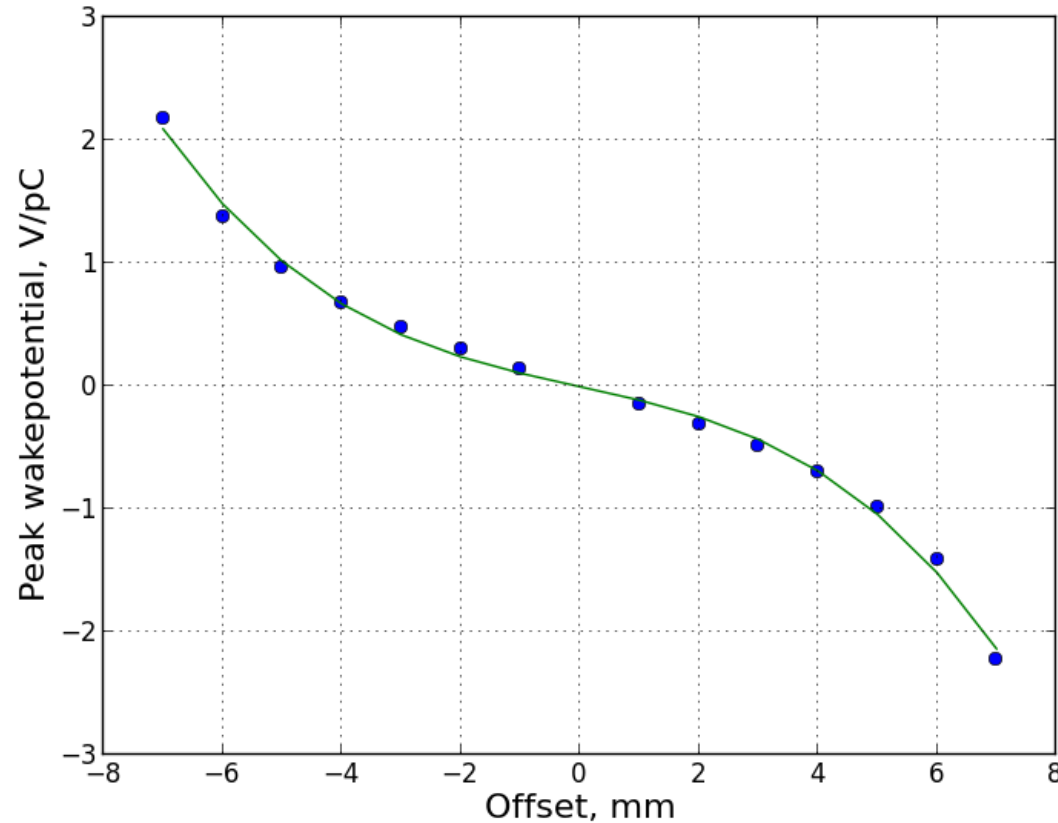
# Non-linearity with offset

- Experimental data suggests non-linear component for large offsets
- Can happen very close to the wall
- Mistake in interpreting calculations was discovered
- Confirmed now by both ACE3P and GdfidL



Non-linear after ~3mm

# Non-linearity with offset



Piwinski: Impedances in Lossy Elliptical Vacuum Chambers, DESY 94-068

$$\langle \Delta y' \rangle \sim \left( \frac{y_0}{g} - \frac{2\pi^2}{3} \left( \frac{y_0}{g} \right)^3 \right) + O \left( \left( \frac{y_0}{g} \right)^5 \right) \quad g = \text{aperture (gap width)}$$

# Analysis IPBSM + orbit (T. Okugi)

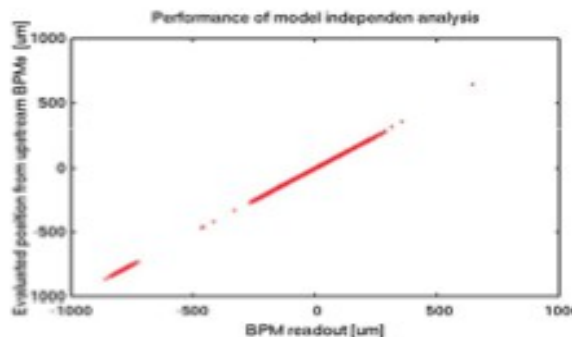
# Analysis IPBSM + orbit (T. Okugi)

*The orbit kick by wake with BPM information in IPBSM fringe scan data was analyzed.*

*The orbit differences at BPMs were analyzed by the following procedures.*

- 1) subtracted the orbit jitter effect by model independent analysis with the upstream BPM information (MQM16FF-MQD10BFF).*

*Example)*

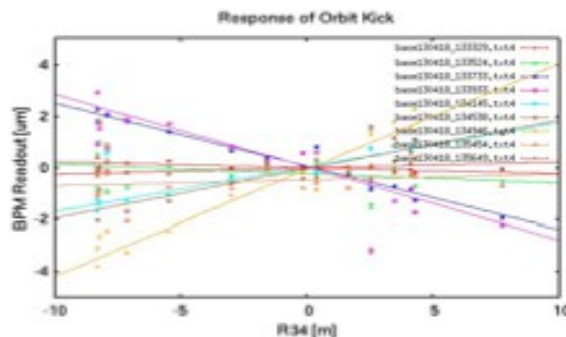


*Since the orbit difference was um order and the orbit jitter was a coupled 100um, it is very important to subtract the orbit jitter.*

- 2) the orbit difference at the BPMs were evaluated by comparing the BPM position at the first fringe scan data in "cavity mover position scan".*

- 3) the kick angle was evaluated by the comparing the position difference and R34 at BPMs.*

*Example)*



*The kick angle was evaluated with the information of the C-band BPMs (MQD10AFF-MQD2AFF).*

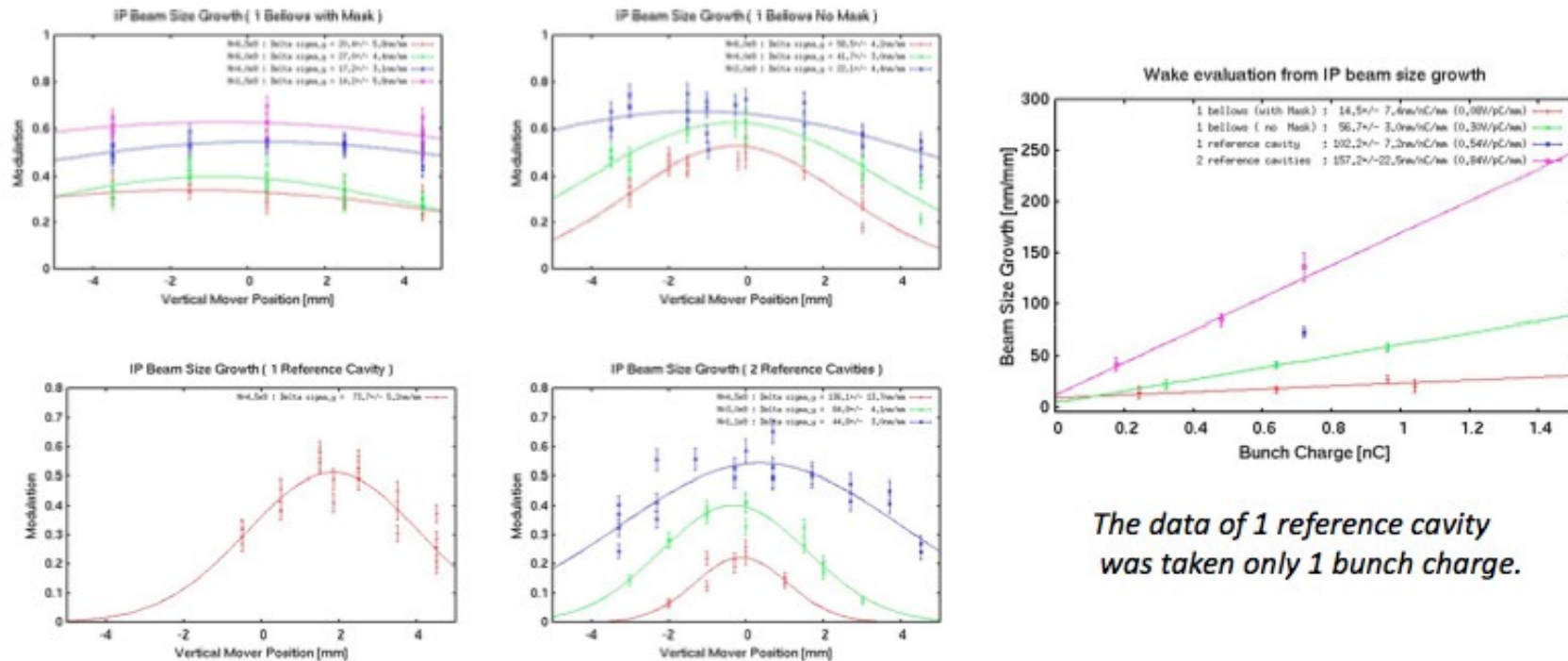
*This is the data with maximum orbit difference. Typical orbit difference was less than 1um.*

# Analysis IPBSM (T. Okugi)

We evaluate the orbit kick for the following "Mover position scan data".

- 1) 1 bellows (with mask) on mover
- 2) 1 bellows (no mask) on mover
- 3) 1 reference cavity on mover
- 4) 2 reference cavities on mover

The beam size growth by "Mover position" dependences and evaluated wake were as follows.

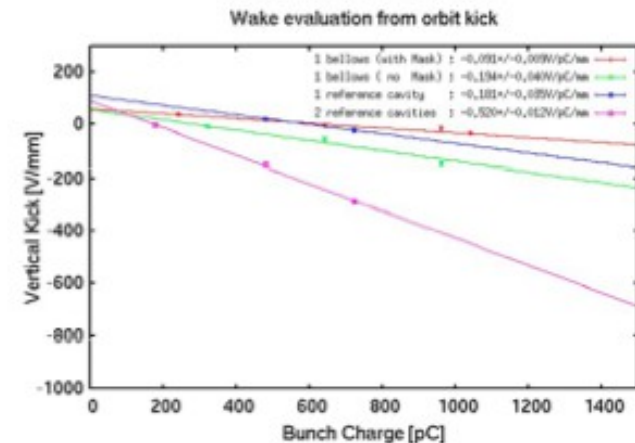
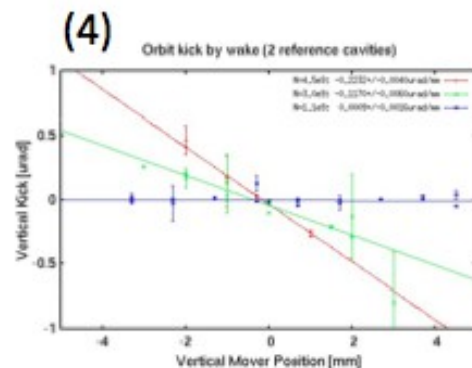
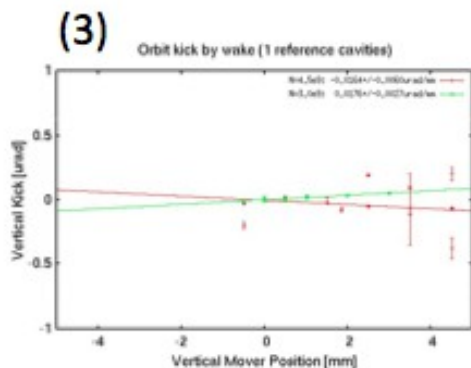
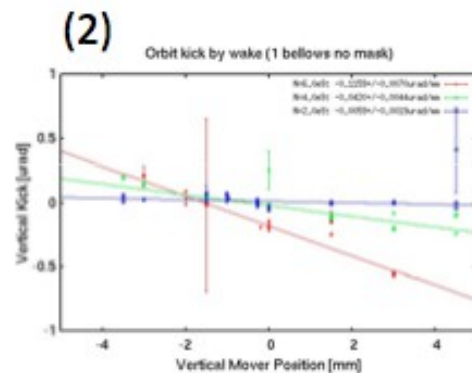
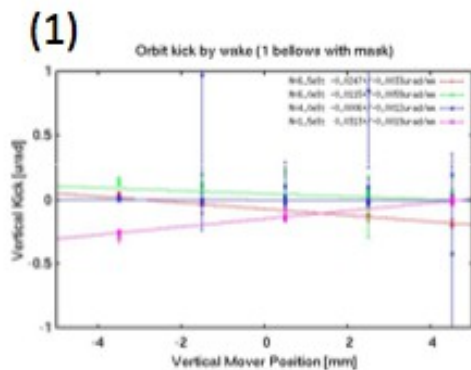


The data of 1 reference cavity was taken only 1 bunch charge.

# Analysis orbit (T. Okugi)

## Evaluated wake by orbit kick

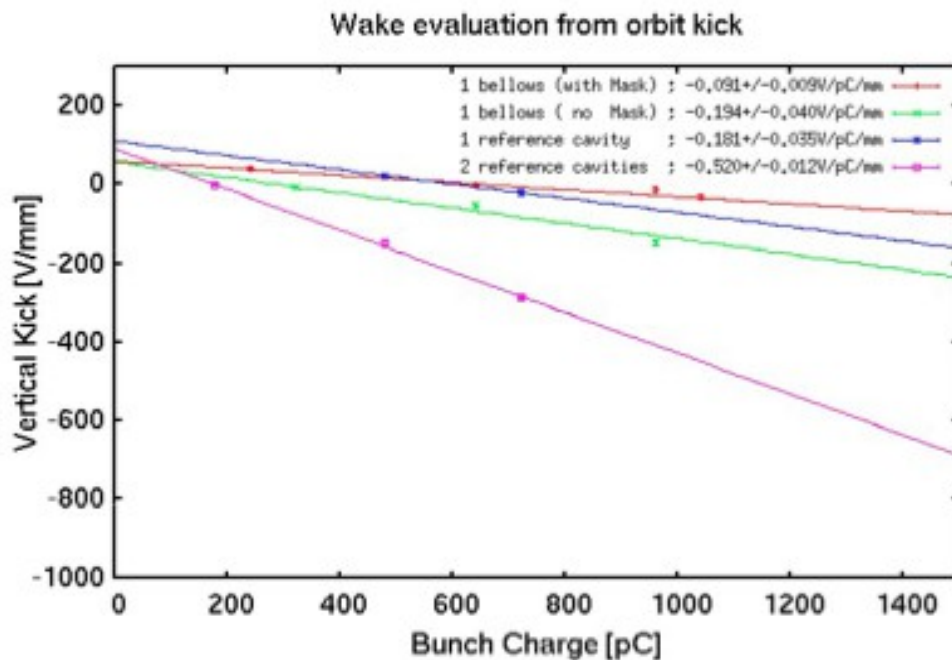
- 1) 1 bellows (with mask) on mover
- 2) 1 bellows (no mask) on mover
- 3) 1 reference cavity on mover
- 4) 2 reference cavities on mover



*There was a mover position dependence even if the bunch charge was zero.*

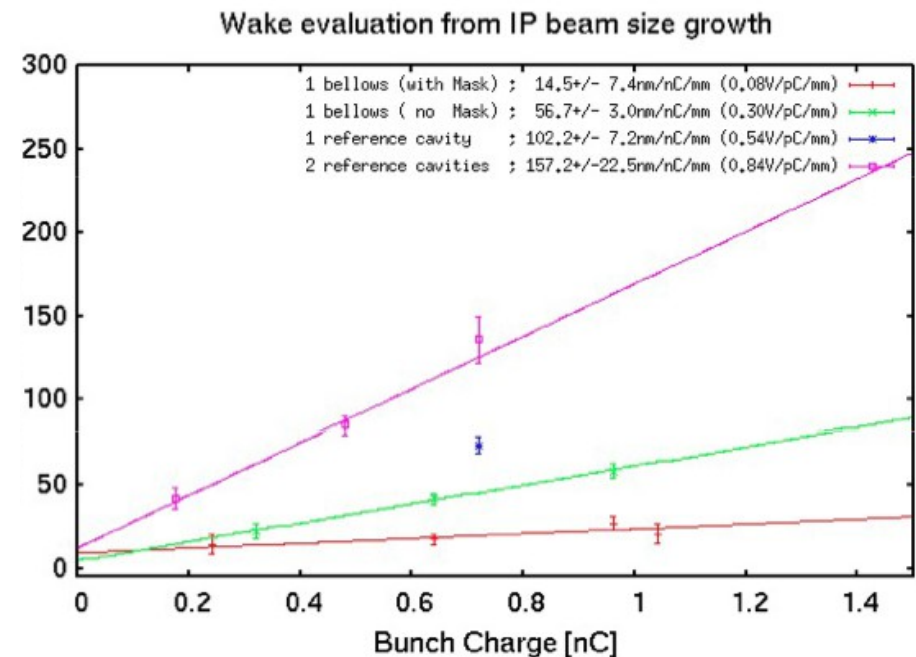
*When then mover was moved by 1mm, the QD10AFF was moved by 0.1-0.2um by the stress of bellows in between mover and quad (??).*

# Analysis IPBSM + orbit (T. Okugi)



*There was a mover position dependence even if the bunch charge was zero.*

*When the mover was moved by 1mm, the QD10AFF was moved by 0.1-0.2 $\mu$ m by the stress of bellows in between mover and quad (??).*



*The data of 1 reference cavity was taken only 1 bunch charge.*

# Summary (T. Okugi)

	Orbit kick (av.)	Orbit kick peak	IP beam size growth
1) 1 bellow (with mask)	0.091 V/pC/mm	0.150 V/pC/mm	0.08 V/pC/mm
2) 1 bellow (no mask)	0.194 V/pC/mm	0.322 V/pC/mm	0.30 V/pC/mm
3) 1 reference cavity	0.181 V/pC/mm	0.299 V/pC/mm	0.54 V/pC/mm
4) 2 reference cavities	0.520 V/pC/mm	0.858 V/pC/mm	0.84 V/pC/mm

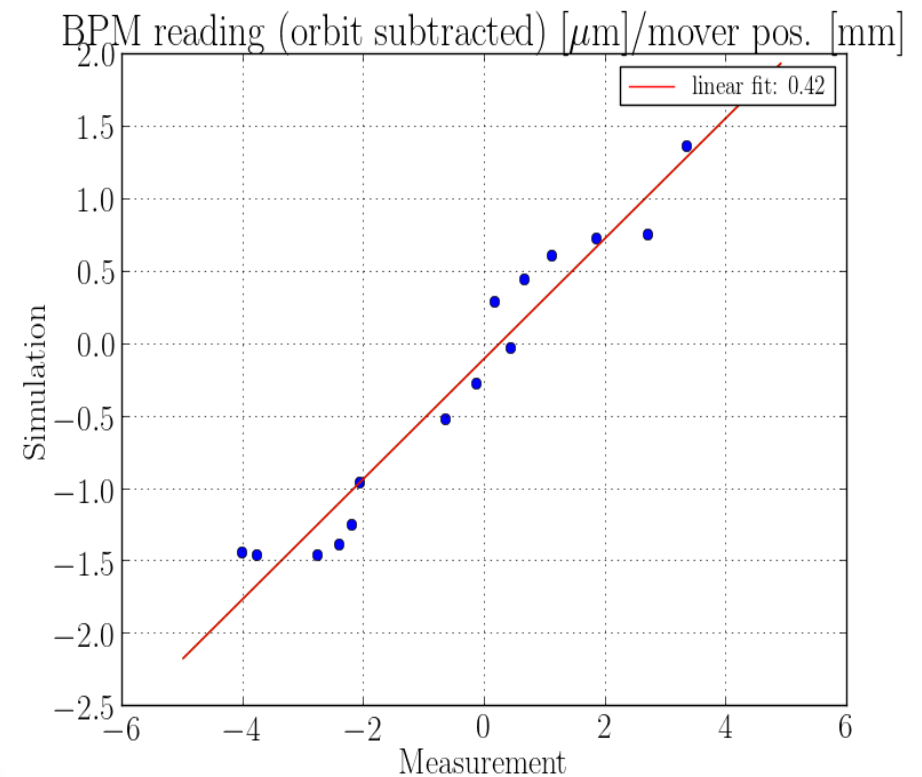
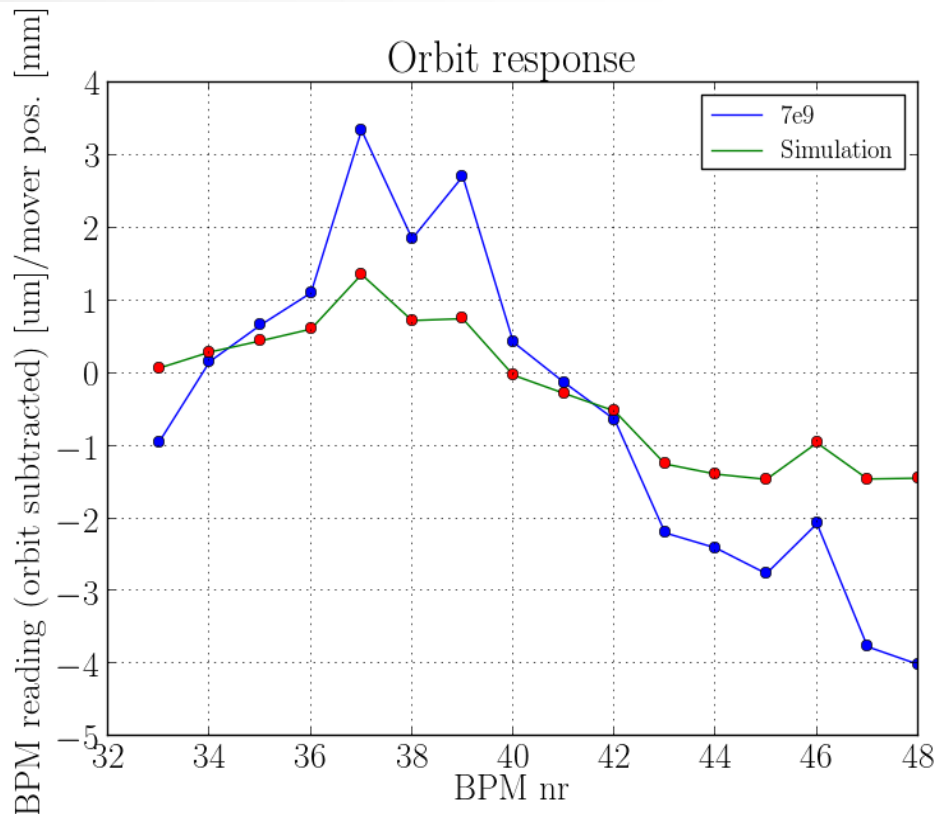
- Only 1 data point for case 3
- Good agreement between orbit response and IPBSM beam size for case 2 and 4



# Updates Orbit Analysis

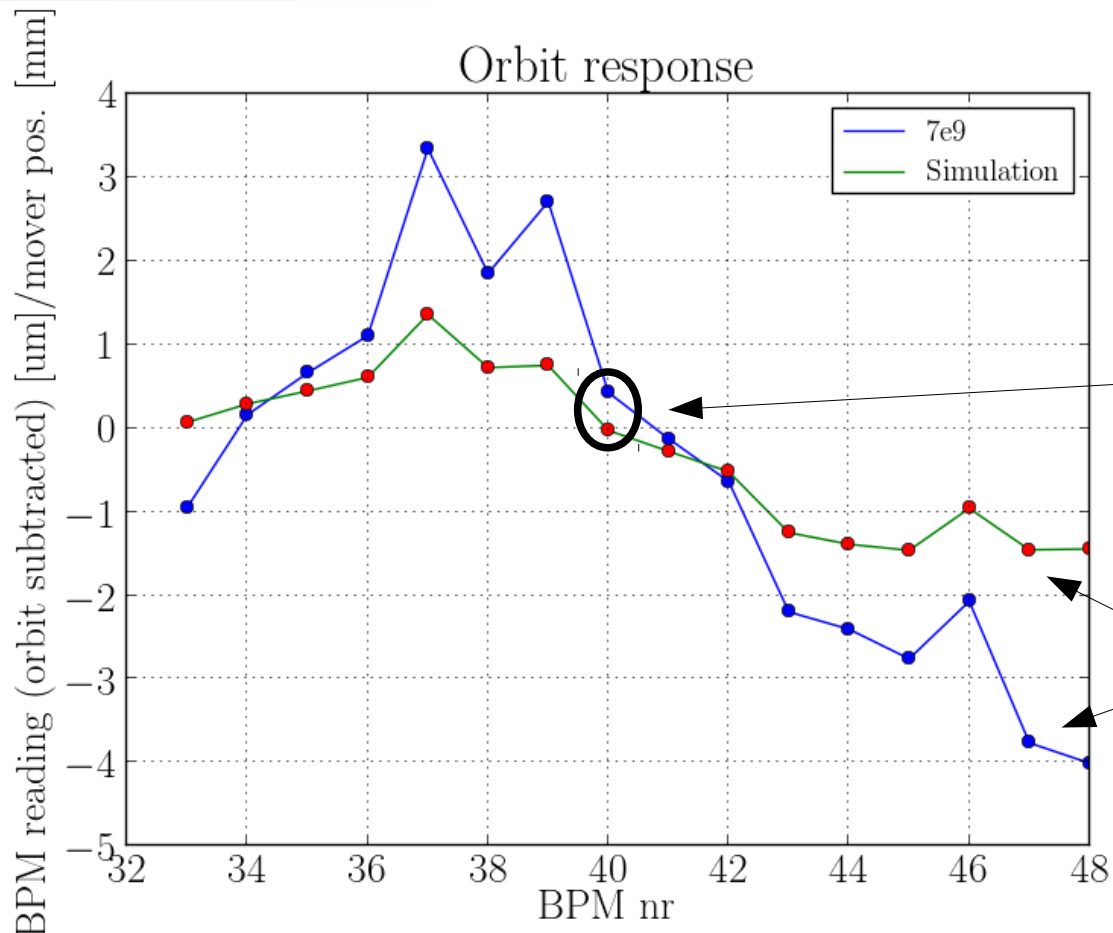
# Comparison with simulation

## 2 reference cavity setup



Measured effect ( $0.8 \text{ V/pC/mm}$ ) about a factor 2 larger than simulation (numerical calculation + tracking)  
Measured orbit shape agrees well with simulation

# Comparison with simulation



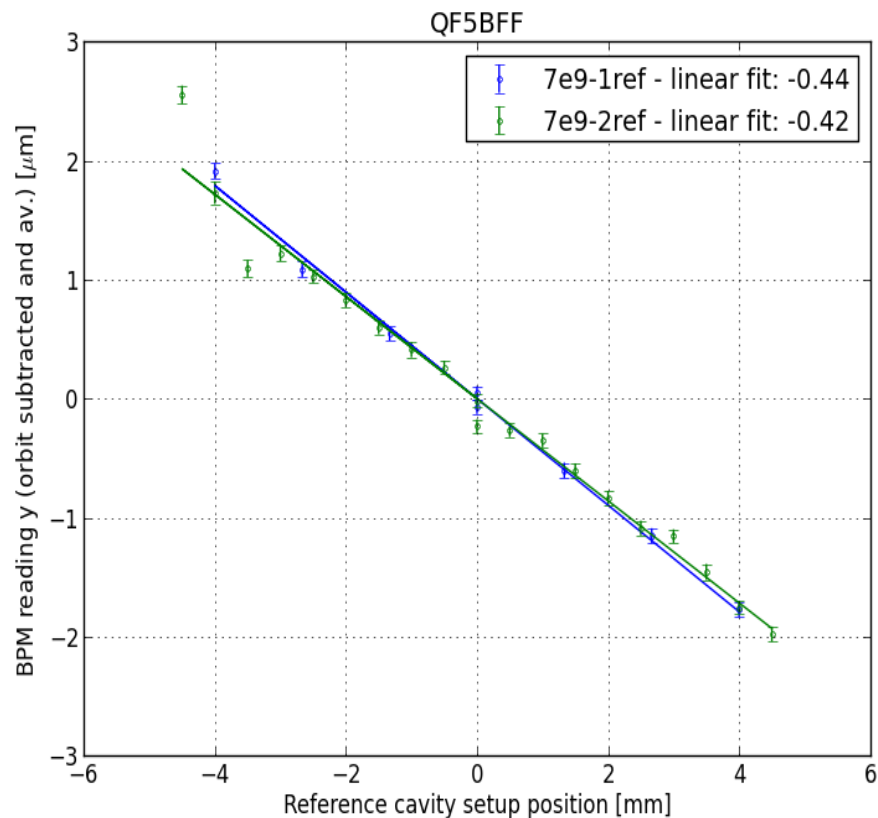
From optics there should be no response for QF5BFF

Some shape mismatch with simulation

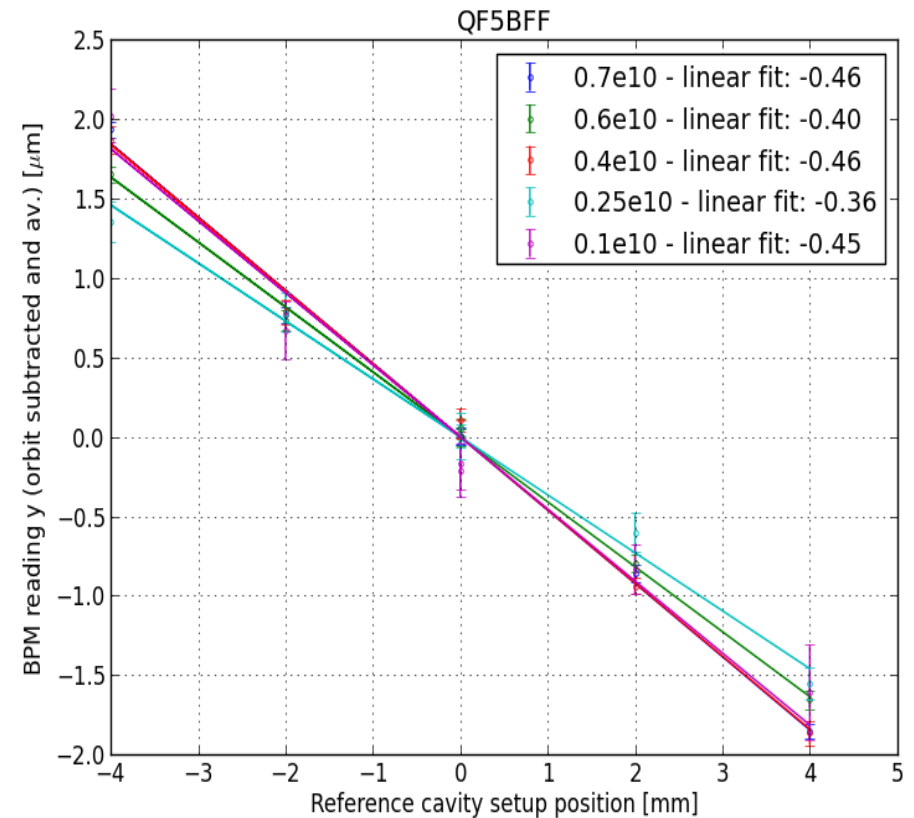
2 reference cavity setup

# QF5BFF

1 vs 2 ref cavities



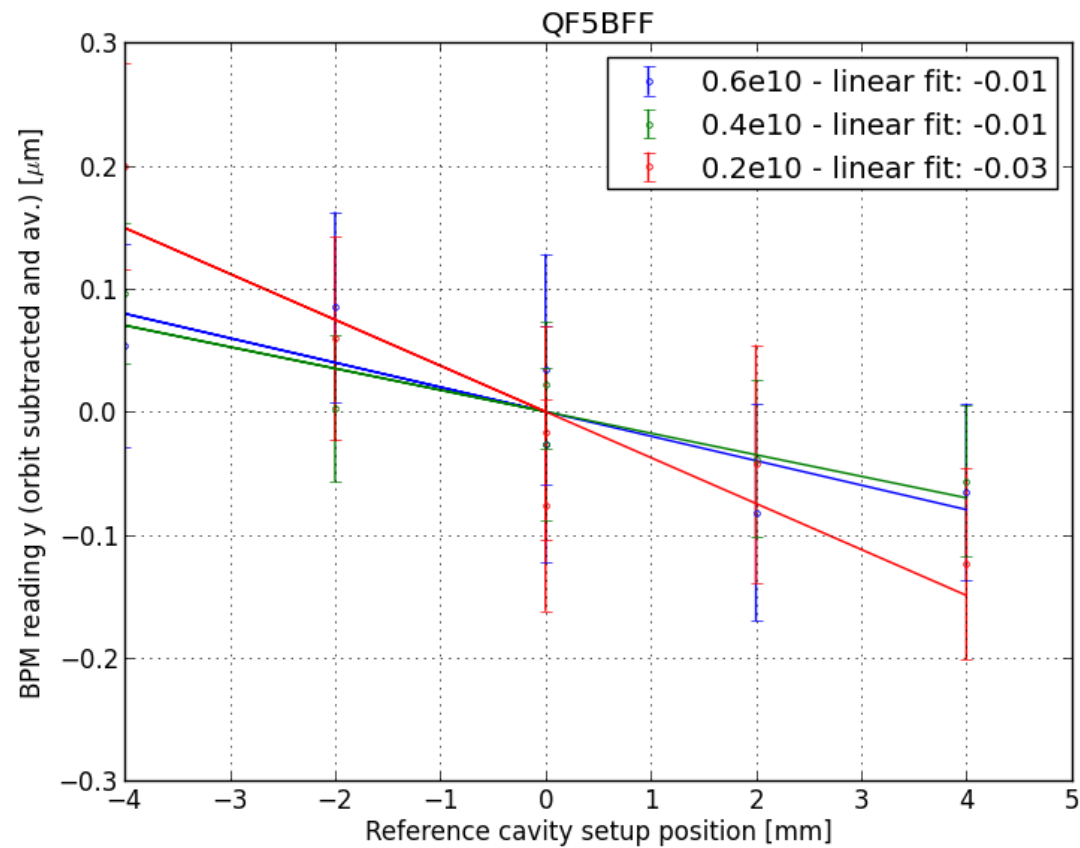
2 ref cavities



Same slope independent of charge or setup!  
Most likely explanation: move of QD10AFF and QD10BFF  
Already known, but hadn't realised this made such an impact on the orbit

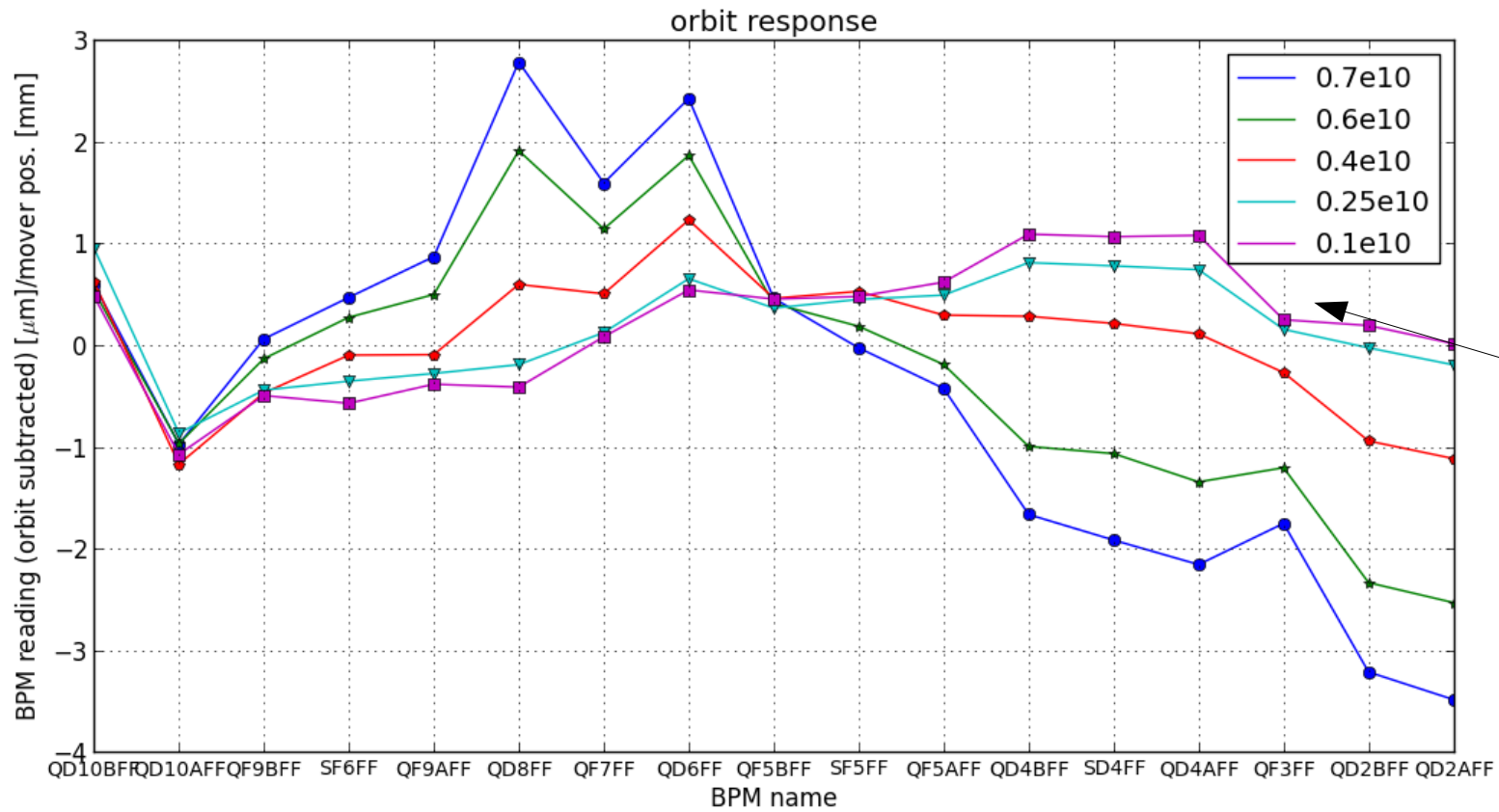
# QF5BFF

No slope ( $\sim 0.0$   $\mu\text{m} / \text{mm}$ ) for April bellow setup



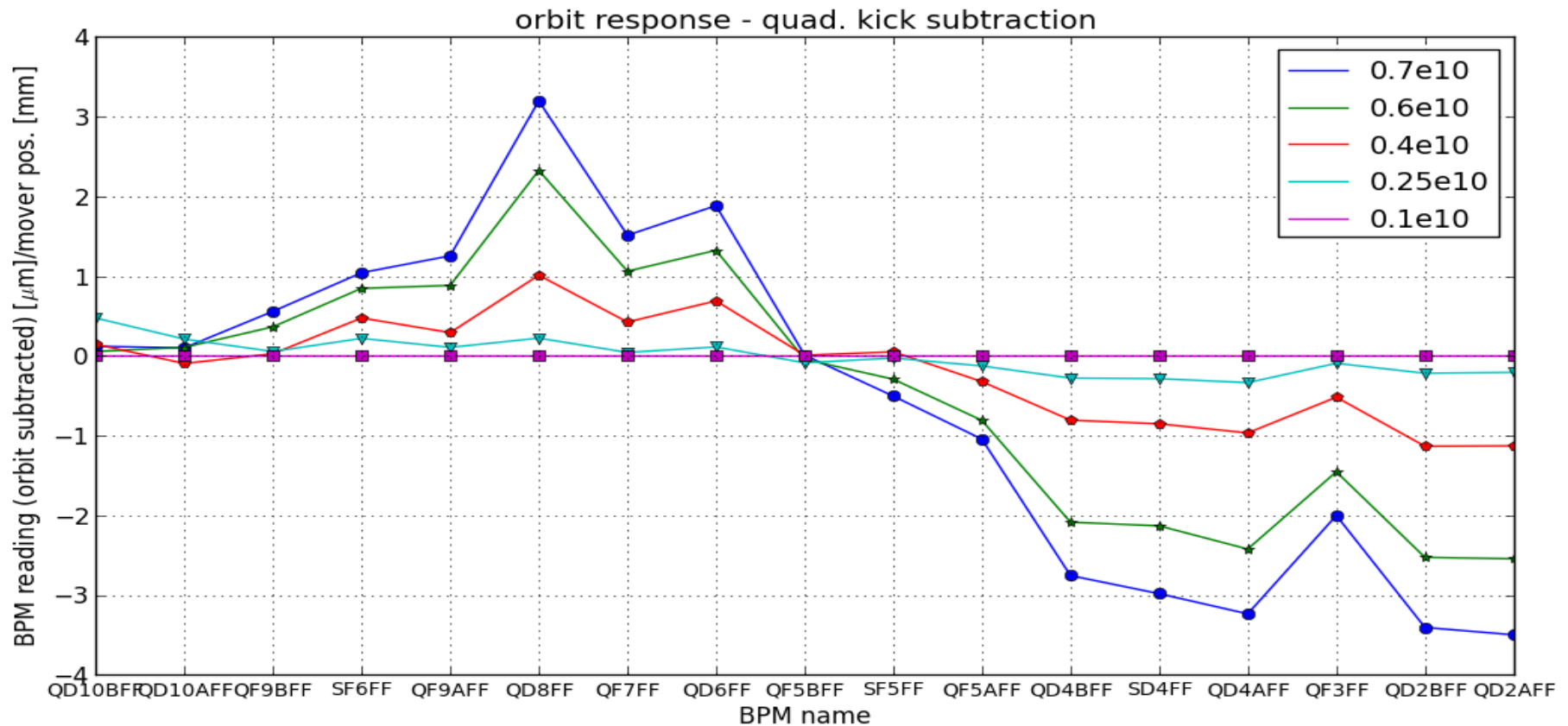
# Orbit response

## Charge scan 2 ref cavities



Wrong sign for low charge

# Orbit response



- Here crude quadrupole kick subtraction (subtracting low charge orbit)
- Improved match to simulation orbit response
- Quadrupole kick subtraction needs to be done carefully
- Will reduce measured effect (probably)

# Conclusions

- 3<sup>rd</sup> order effect confirmed in calculation
  - Needs to be taken into account for ref. cavity mover positions larger than ~ 3 mm
  - This will slightly change (lower) some earlier reported measurement values
- Orbit and beam size measurement show good agreement (T. Okugi)
- Kick from move of QD10AFF needs to be taken into account
  - Move varies with setup
  - Will improve match to simulation
- Expect updates soon