Update on the wakefield measurement mover setup

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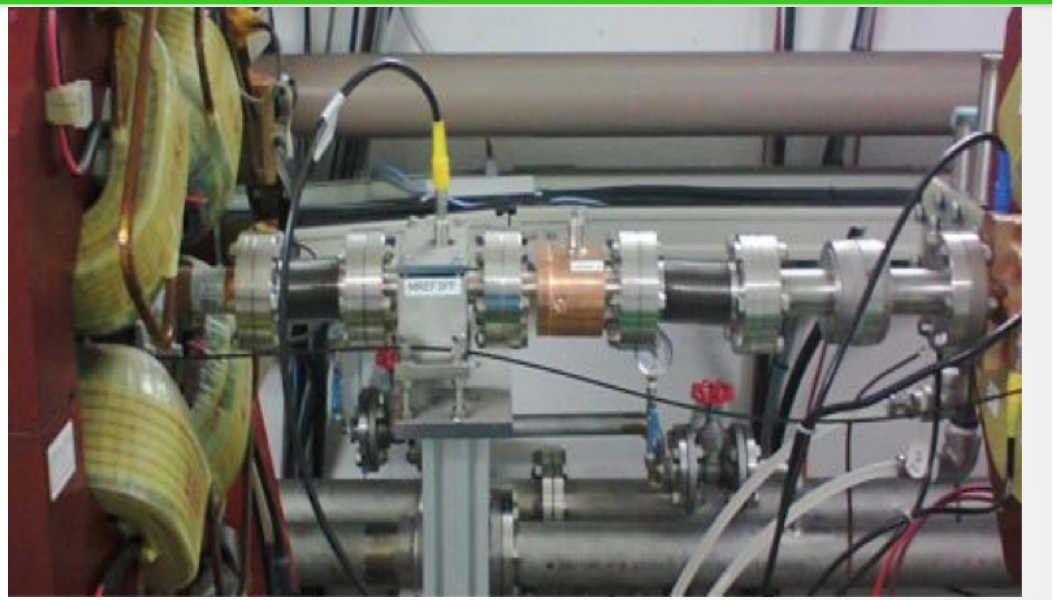
Outline

- Short recap
- Updated wakefield simulations
- Updated orbit study

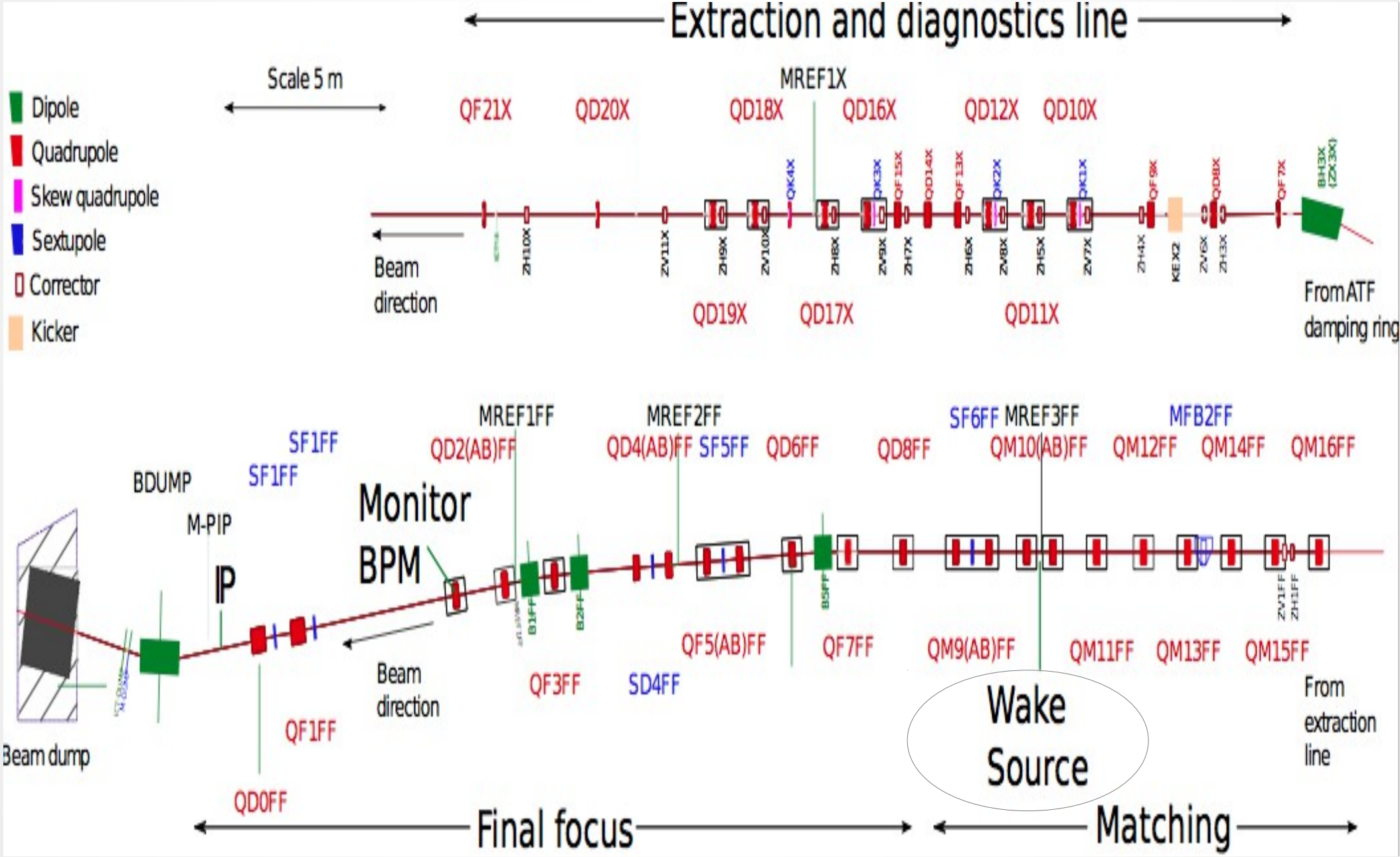
Wakefield studies

- Goal: measure wakefield kick from Cavity BPM
  - Induces bunch tilt
  - Look at orbit change
- Effect is measurable, but some unknowns
    - Bunch length
    - Exact geometry
- Dedicated shifts April 2013
  - Using mover setup
  - 3 setups were measured:

    1 ref. cavity, 2 ref. cavities, 3 bellows
  - Here only 2 ref. cavity setup discussed



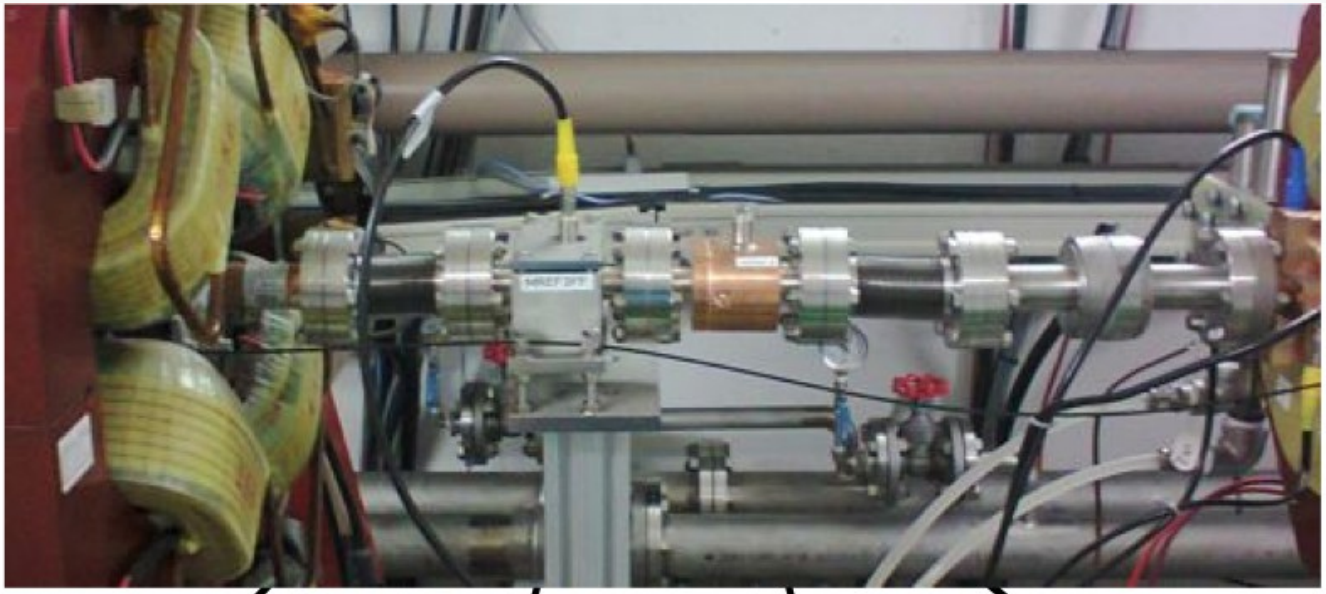
ATF2 layout

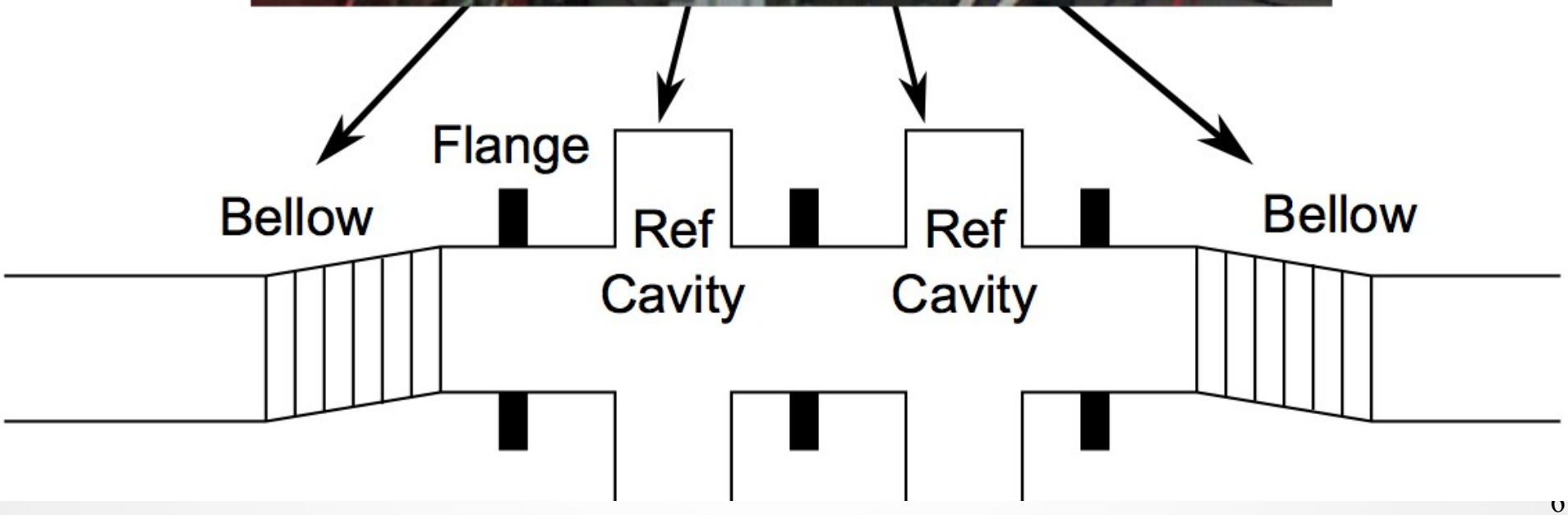

Extraction and diagnostics line
Scale 5 m
Dipole
Quadrupole
Skew quadrupole
Sextupole
Corrector
Kicker
MREF1X
QF21X
QD20X
QD18X
QD16X
QD12X
QD10X
Beam direction
QD19X
QD17X
QD11X
From ATF damping ring
MREF1FF
MREF2FF
SF6FF
MREF3FF
MFB2FF
SF1FF
QD2(AB)FF
QD4(AB)FF
SF5FF
QD6FF
QD8FF
QM10(AB)FF
QM12FF
QM14FF
QM16FF
BDUMP
M-PIP
IP
Monitor
BPM
QF5(AB)FF
QF7FF
QM9(AB)FF
QM11FF
QM13FF
QM15FF
Beam direction
QF3FF
SD4FF
QF1FF
Beam dump
QD0FF
Wake Source
From extraction line
Final focus
Matching

Wakefield

- Geometrical wake fields have been computed numerically with GdfidL (http://www.gdfidl.de)
  - 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)
- Wake field shape dependent on beam shape itself
  - Bunch length
  - Beam offset

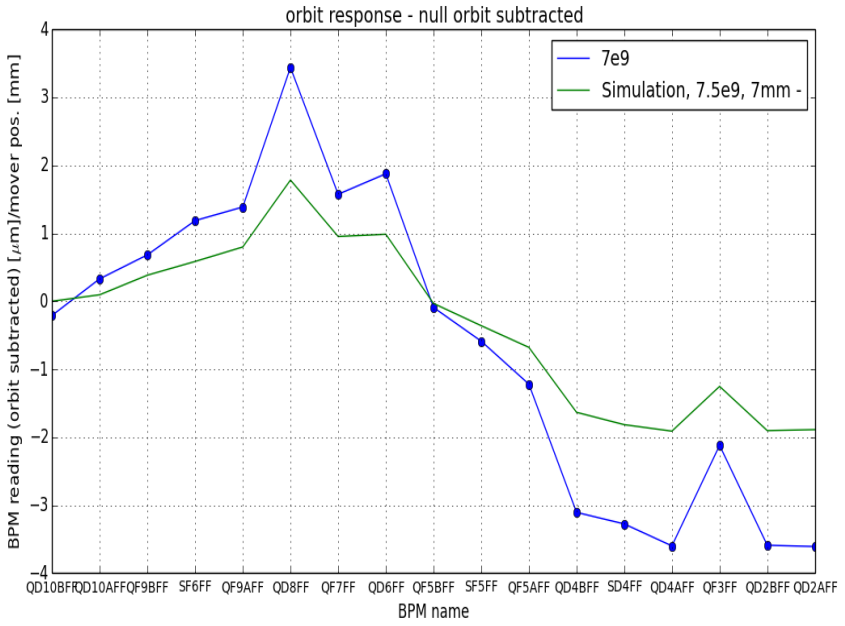
Wakefield compensation setup

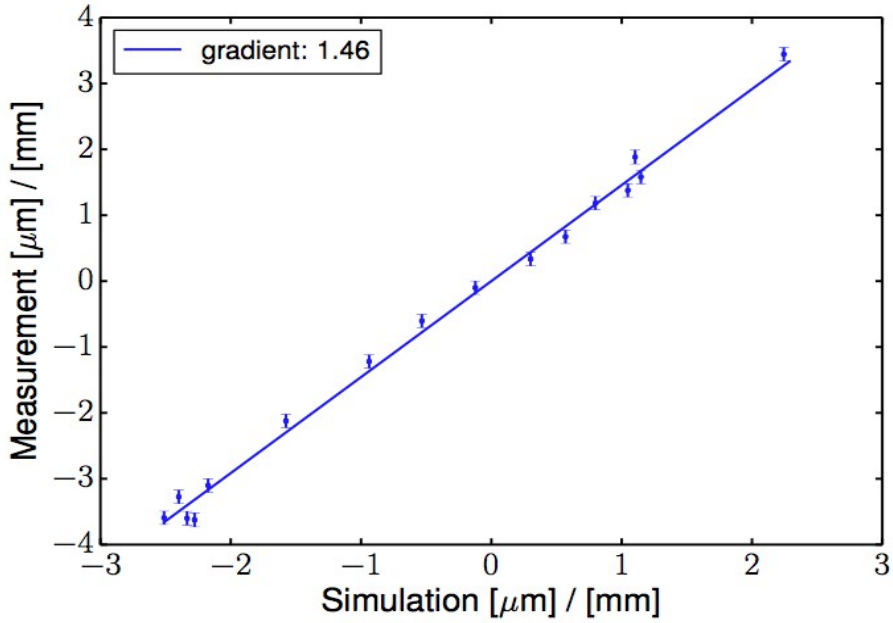




Comparison with simulation – LCWS13

- Measured orbit shape agrees well
- Measured effect is a factor 1.5 larger than simulation (numerical calculation + tracking)
- Already reduced from factor of 1.8, by adding flanges
- For more details see LCWS 2013 talk
- Possible discrepancy might be due to bunch length, charge or underestimation by simulation



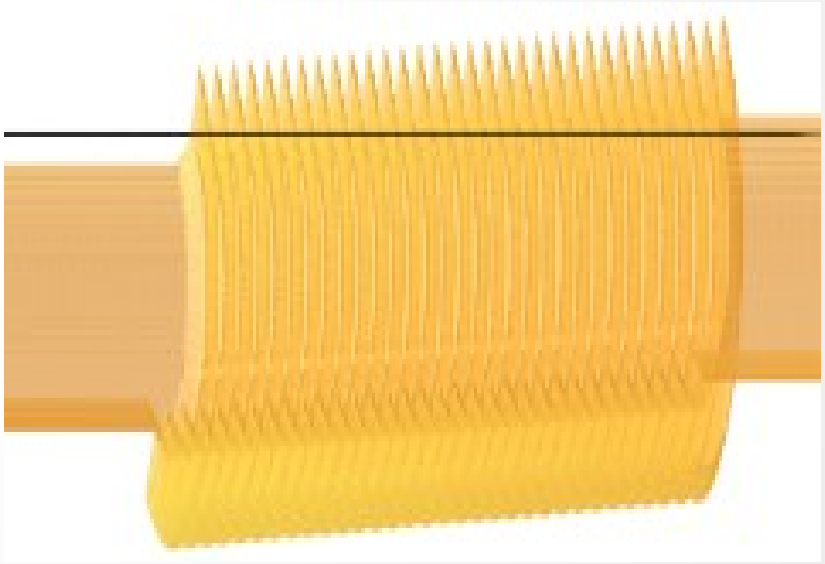


Simulation improvements

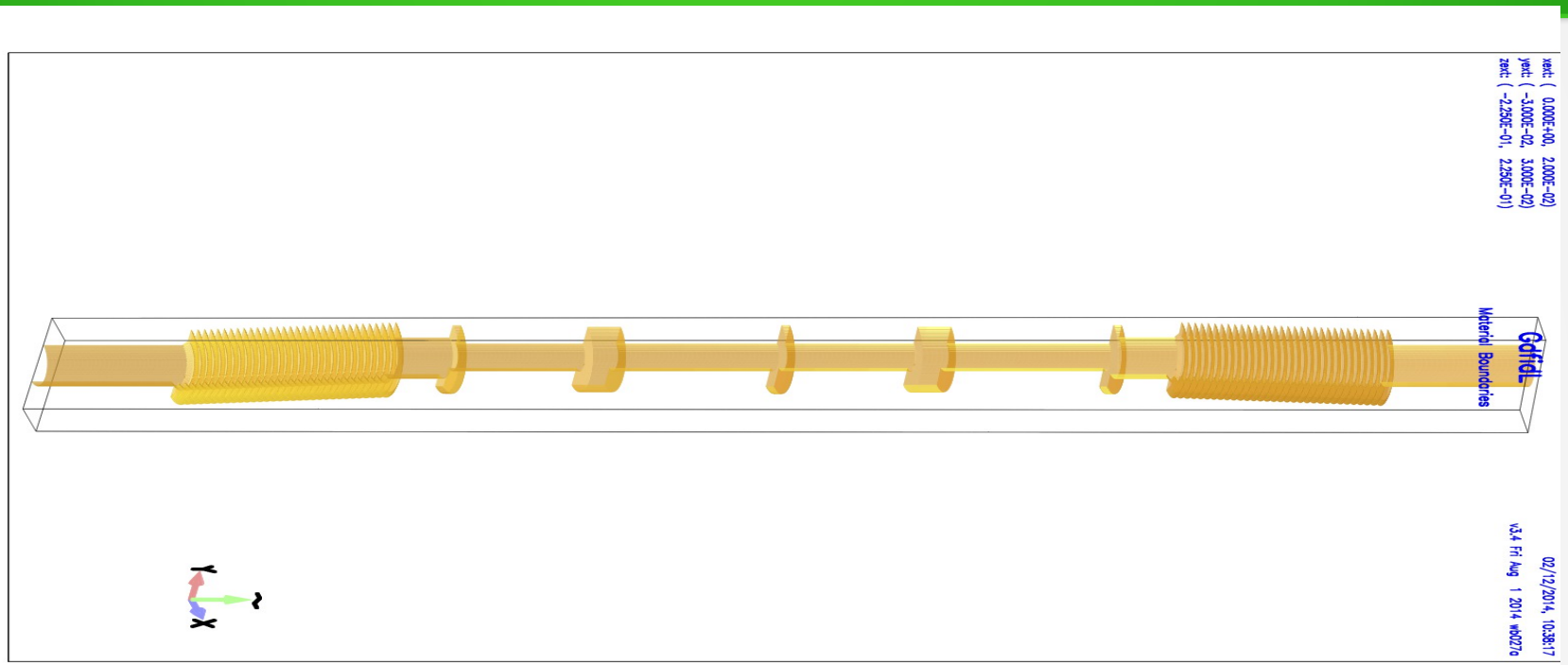
- Combined flange and aperture step

  (24mm to 16mm)

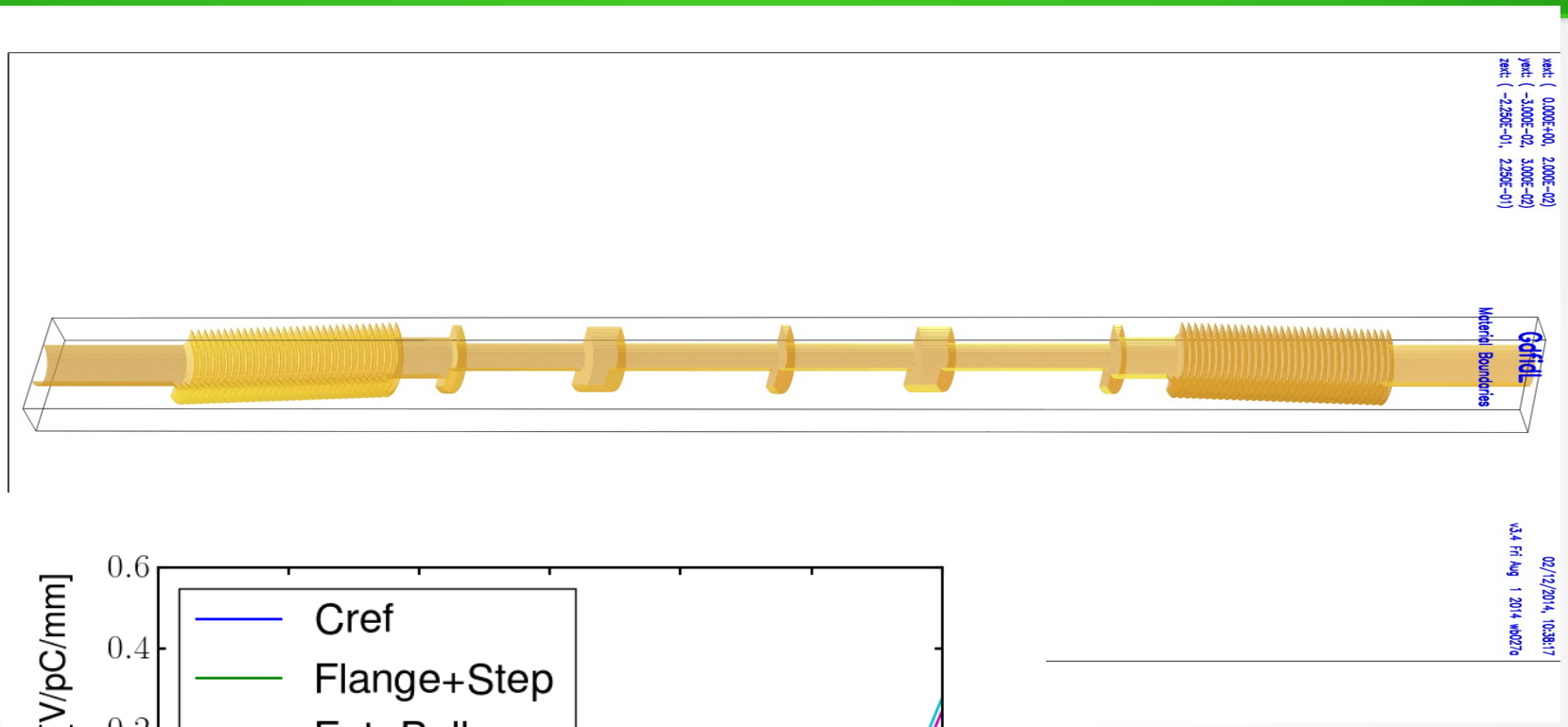
  - Aperture step inside flange
  - Before separately added, but not a good approximation
- Bellows now simulated as tilted and longer
  - Before straight bellows and multiplied by 0.5

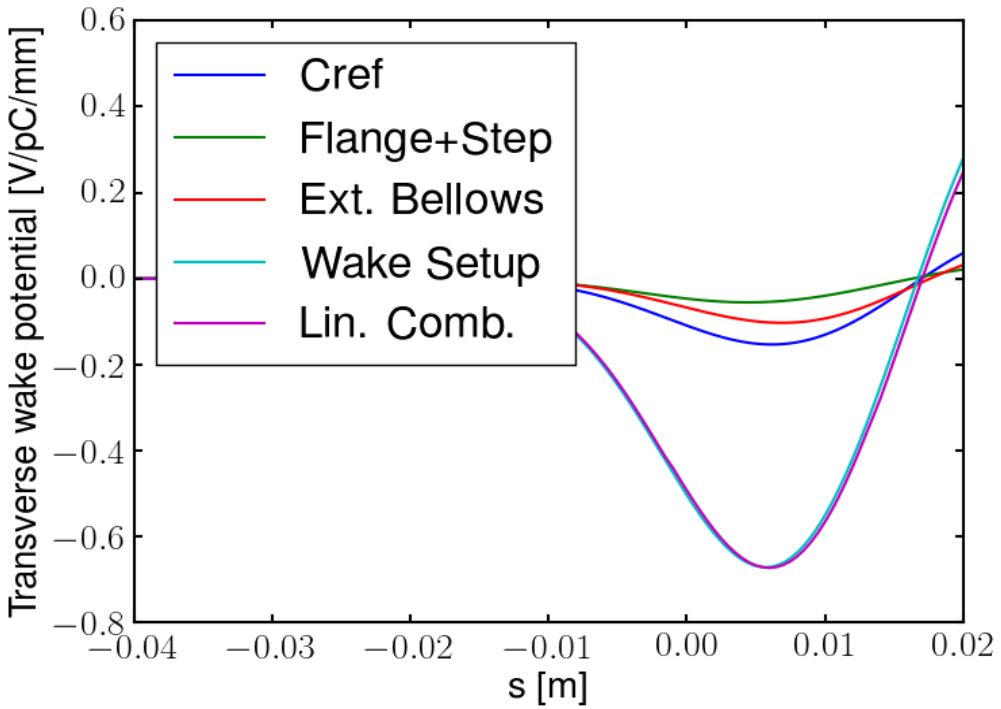


Combined simulation



Combined simulation





Simulated wakefield of whole setup increased by 30% wrt earlier simulations

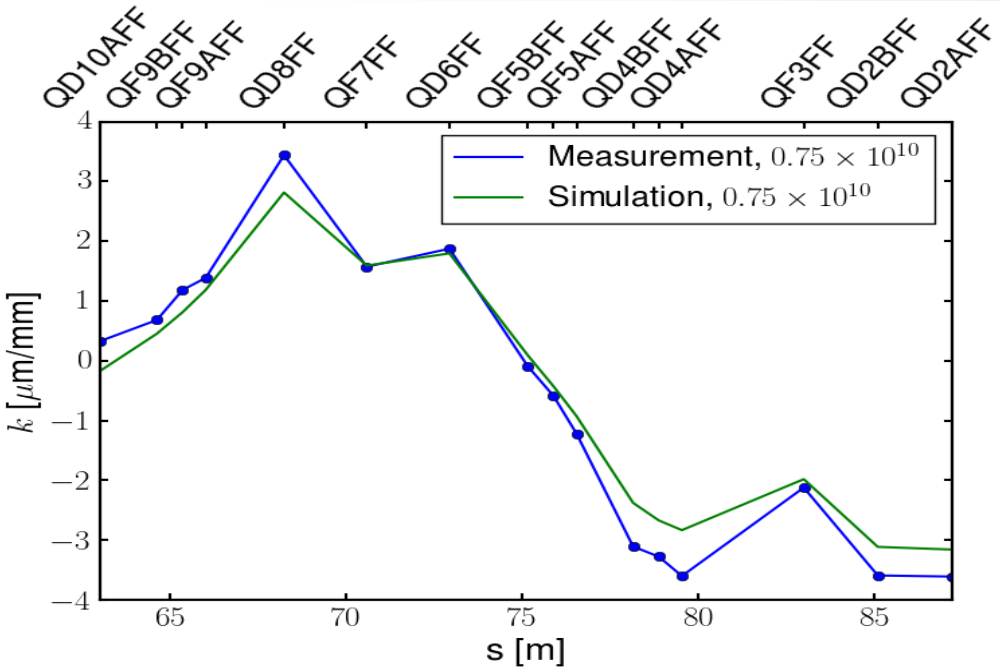
Combined setup and linear combination by adding individual components agree

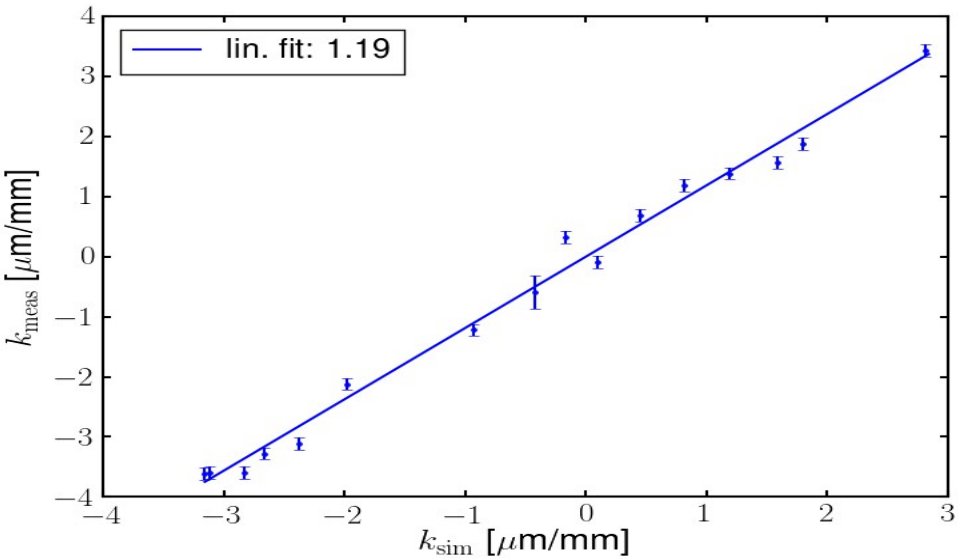
Comparison with simulation

- Measured orbit shape agrees well
- Now about a factor 1.2 larger than simulation

  (numerical calculation + tracking)
- Possible remaining discrepancy might be due to bunch length, charge or (still) underestimation by simulation
- Now within experimental uncertainty:
  - bunch length (about half a mm in DR, effect on wakefield 5-10%)
    - Not measured in extraction line
  - charge

    (ICT calibration error 5-10%)





Conclusions

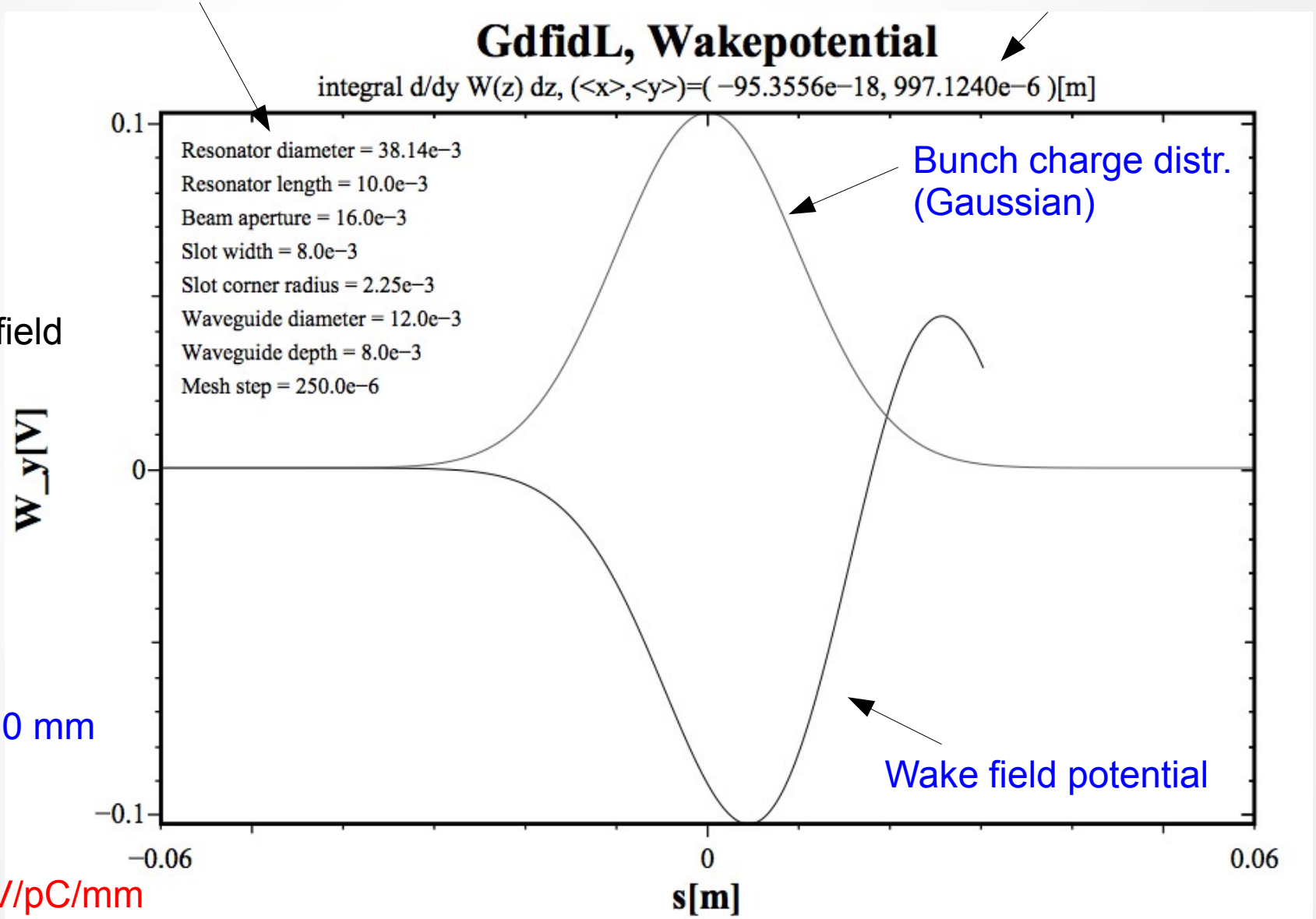
- An update to the wakefield measurements with mover setup was presented
- Wakefield from reference cavity measured in downstream beam orbit
- Wakefield EM-simulations were improved (more realistic)
  - Total increase of 30% in wakefield strength
- Much better agreement between simulation and data
  - Improved from a factor 1.5 to 1.2
  - Remaining difference within experimental uncertainty
- The increased wakefield strength might also explain the observed beam size dependence wrt the mover setup
- PRSTAB paper is close to finished (under review)

Backup

GdfidL: wakepotential

Geometry parameters

Beam offset



Bunch charge distr. (Gaussian)

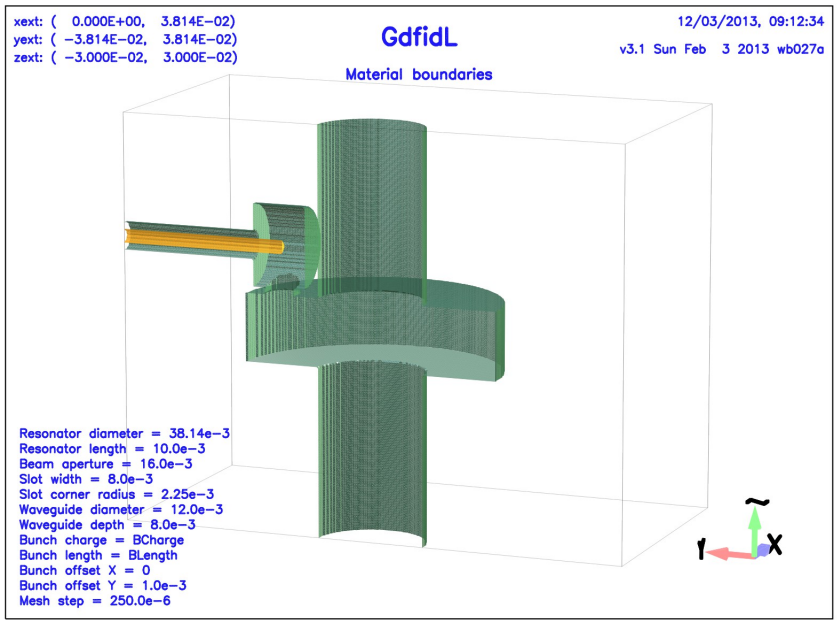
Wake field potential

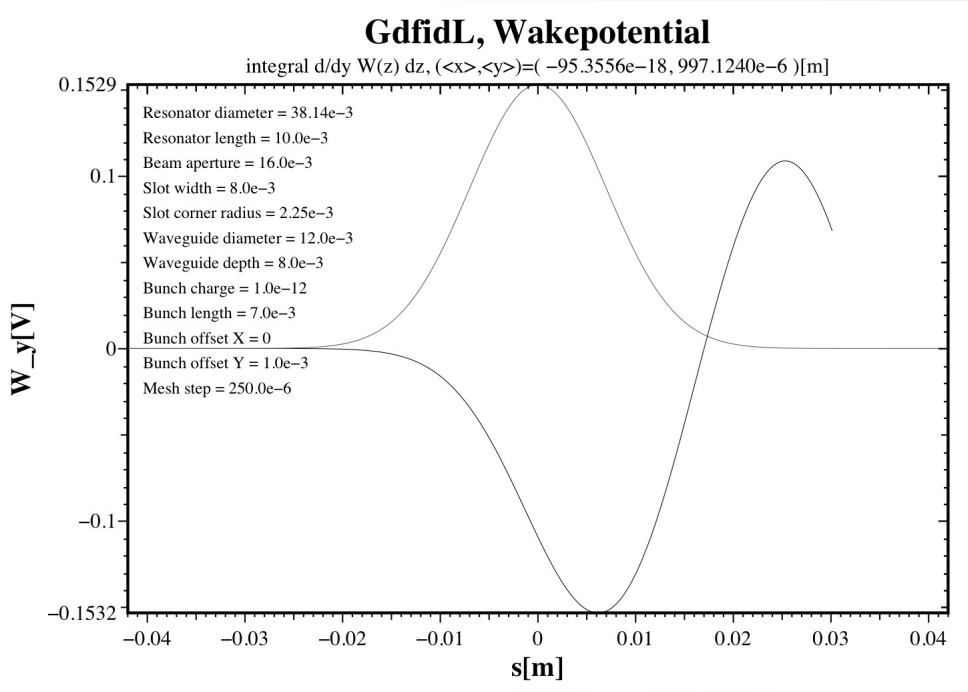
Wake field (V)

Bunch length 10 mm
Charge 1pC
1mm offset

Wakefield: 0.1V/pC/mm

C-band reference

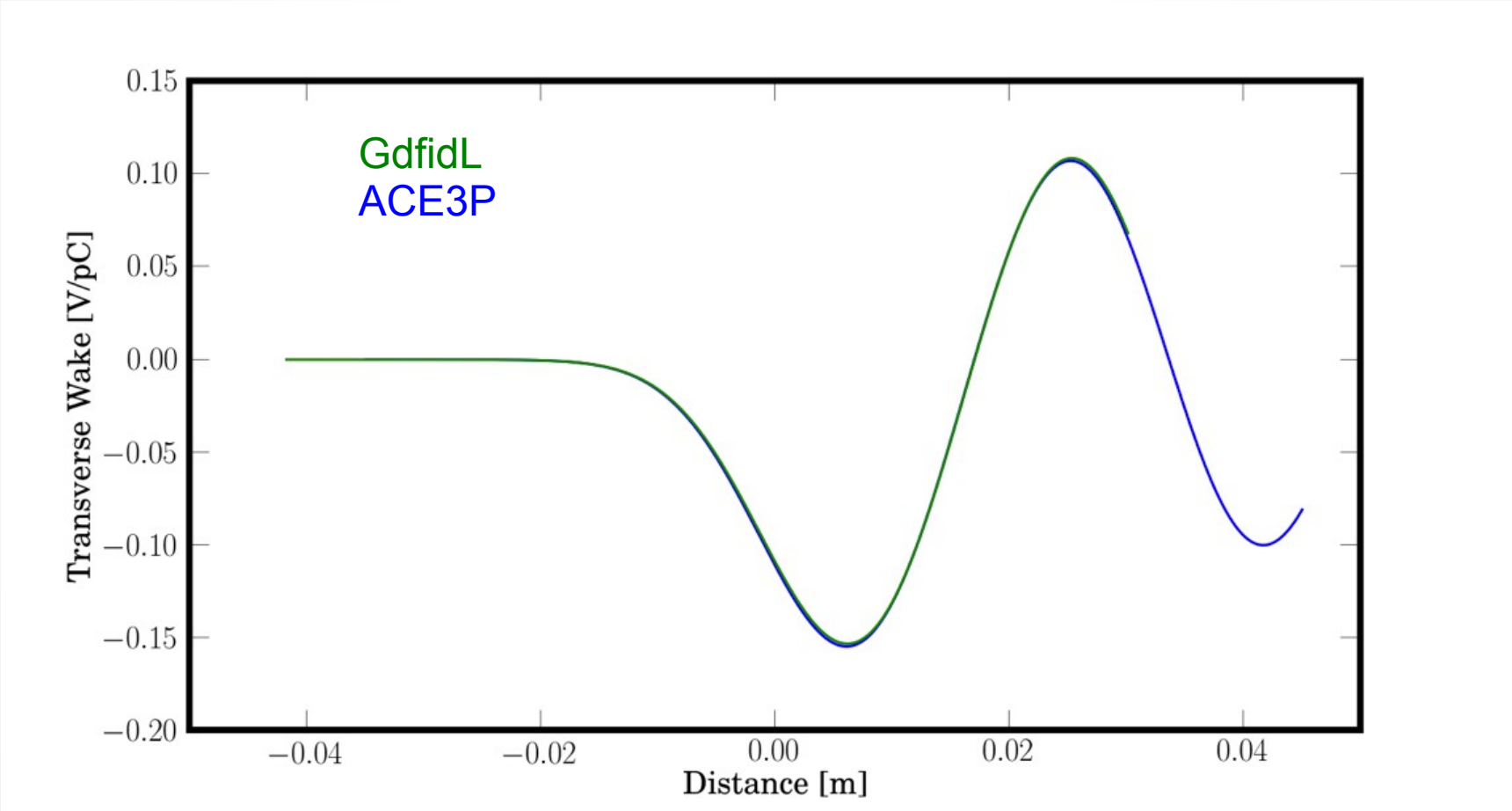




- Higher impedance than position cavity (smaller aperture and diameter)
- Used to be 4 in the beamline, now 1 providing the reference signal and 2 in the test location in April

Agreement GdfidL / ACE3P

ACE3P: https://portal.slac.stanford.edu/sites/ard_public/acd/Pages/Default.aspx



Rob Ainsworth (RHUL)

Orbit analysis

- Take all upstream BPM readings
- All BPM readings averaged subtracted
- Find contribution between those BPM readings and downstream BPM readings
- Subtract orbit jitter per pulse (by matrix inversion)
- Remaining correlation with MREF setup movement will give wakefield kick
- Reference setup ideally placed with high resolution cavity BPMs both upstream and downstream

Orbit analysis 2

- Divide BPM data wrt to reference cavity mover:
- Upstream orbit matrix A (n_1 BPMs x m pulses)
- Downstream orbit matrix B (n_2 BPMs x m pulses)
- Calculate correlation X (n_1 x n_2):
  - $AX=B \rightarrow X = A^{-1}B$ (inversion with SVD method)
- Residuals R (n_2 x m) (since over-constrained system):
  - $R = AX - B$

ICT charge vs measured wake field