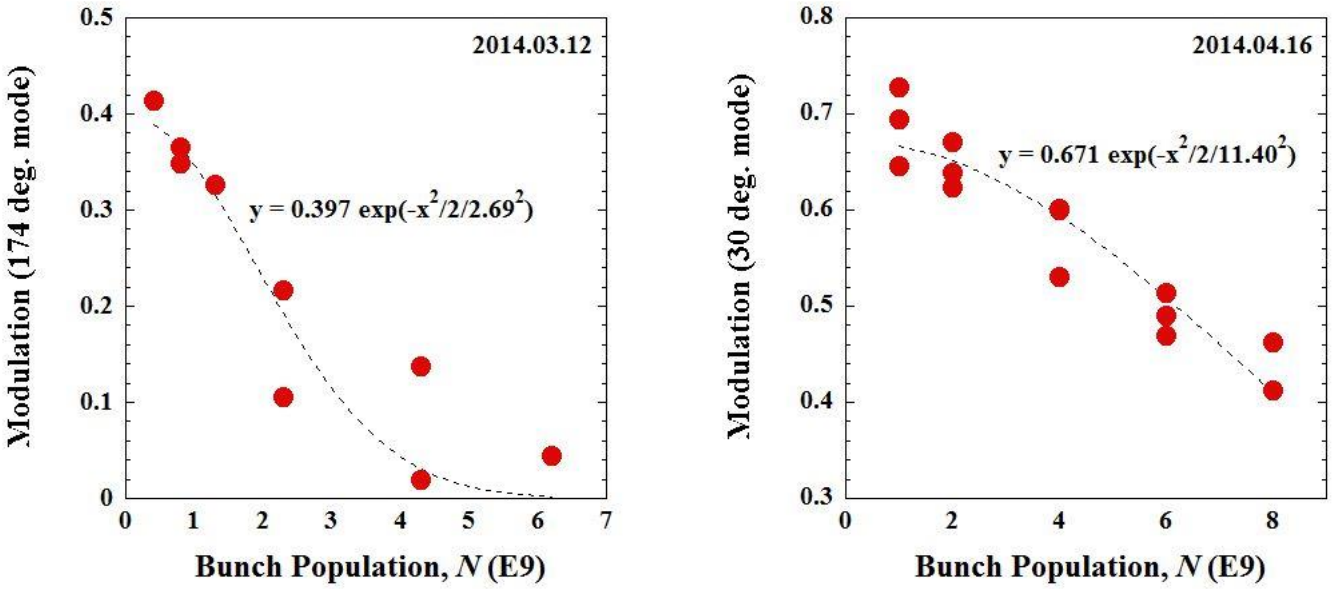
Intensity dependence of Beam size at IP and Wakefield in ATF2

K. Kubo 2014.10.

ICWS14

Beam Size Depends on Bunch Intensity



IPBSM modulation as function of bunch population. Measured with crossing angle 174 degrees (left) and 30 degrees (right).

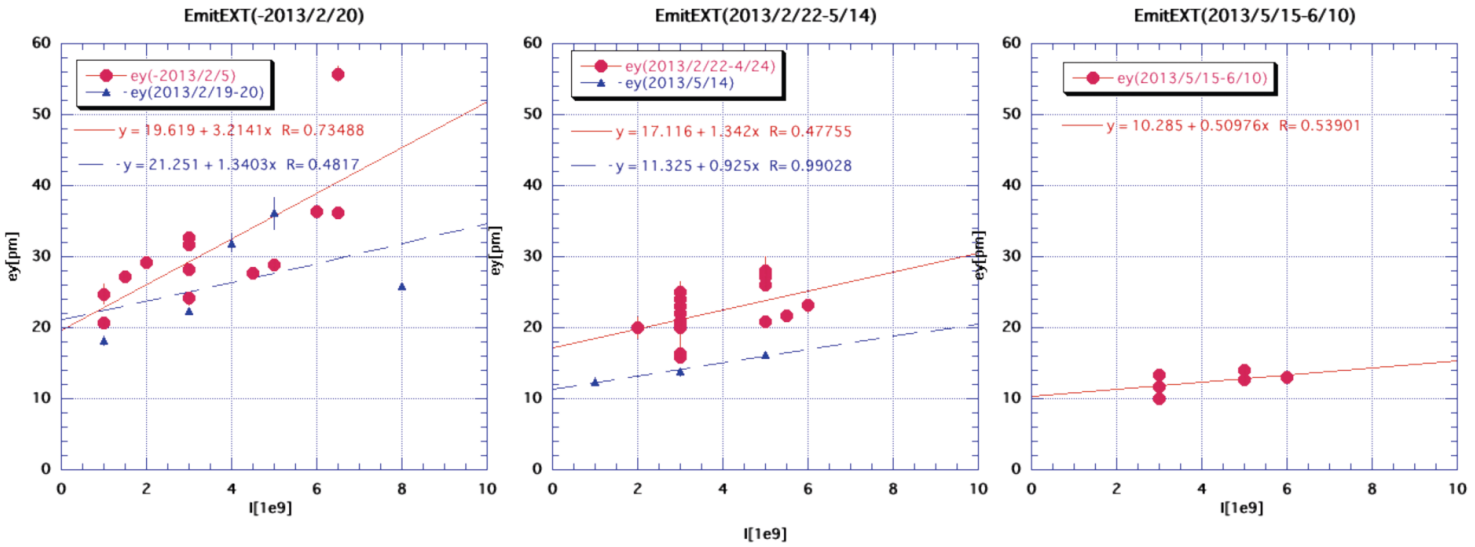
Assuming $\sigma_y^2(q) = \sigma_y^2(0) + w^2 q^2$, w is fitted as 100 nm/nC.

$\Rightarrow$ Measured minimum beam size (at 0.1 - 0.16 nC) may be larger than zero - intensity beam size by 2 - 3 nm.

K.Kubo IPAC14

Intensity dependence of upstream emittance

Summary of ε_y of ATF-EXT 2012-2013

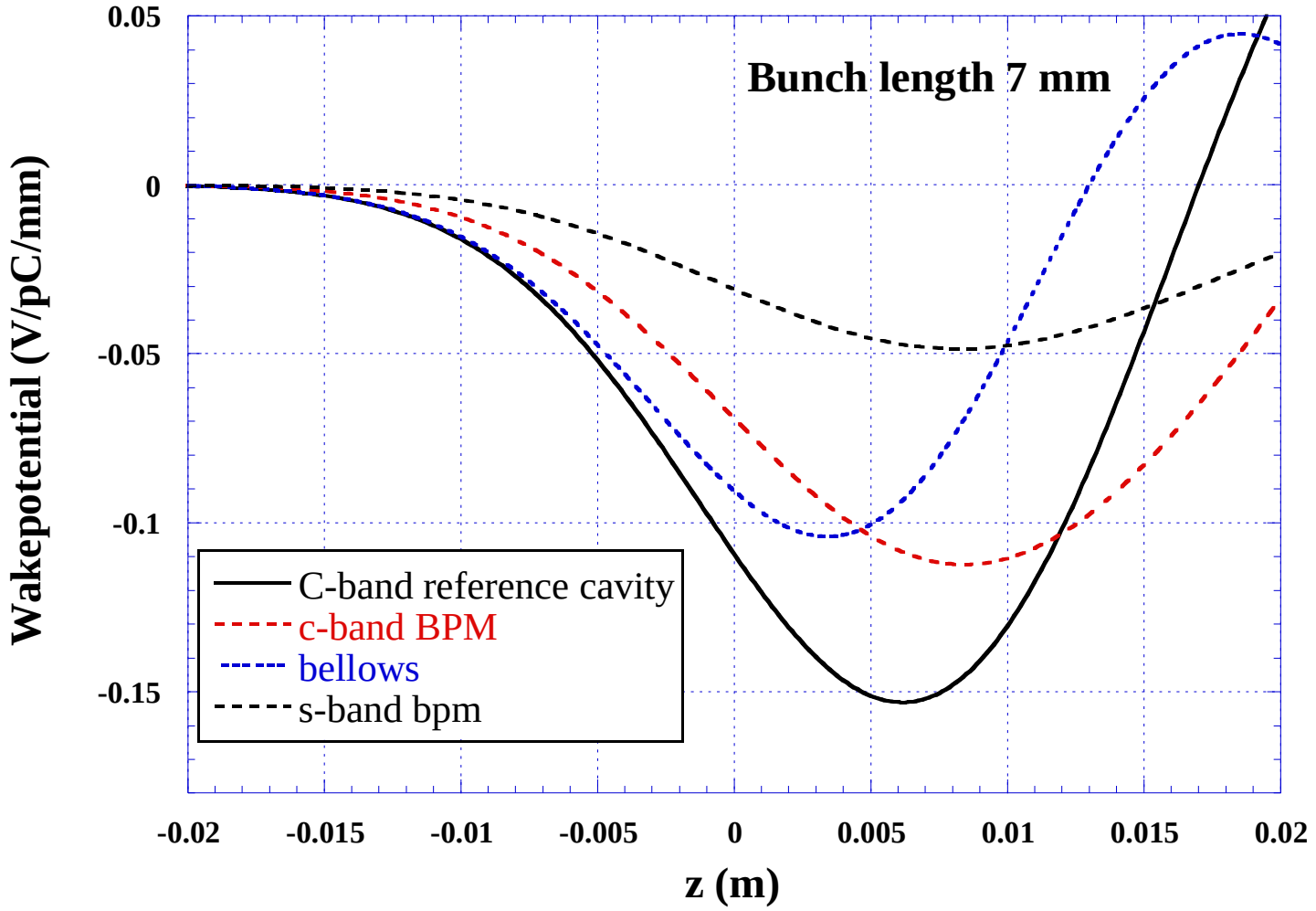


- -2012/2/20 large ε_y and strong I dep.
- Monitor tuning and coupling correction made ε_y closer to DR one.

S. Kuroda, 17th ATF2 Project Meeting
Feb. 2014

Small effect to IP beam size

Examples of wake calculations



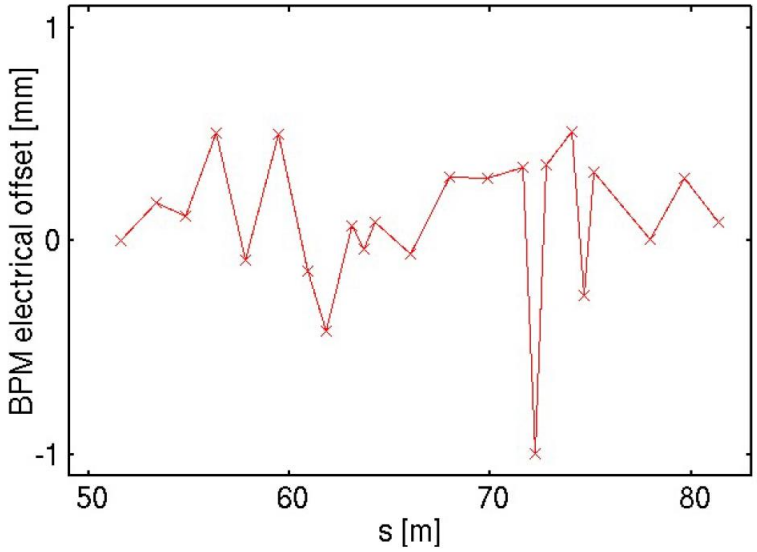
Calc. by A. Lyapin

There are much more calculations

Okugi's slide in ATF2 proj. mtg. Feb. 2014

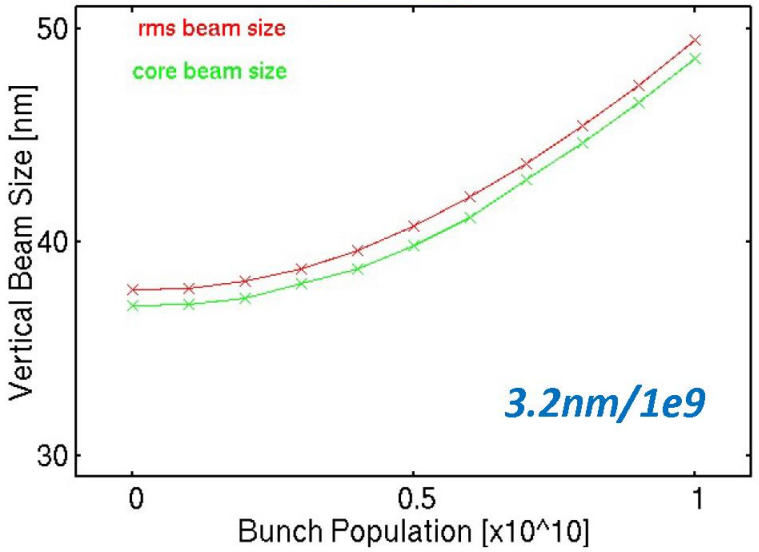
Expected beam size growth from the cavity

Beam orbit with respect to electrical center of C-band BPMs



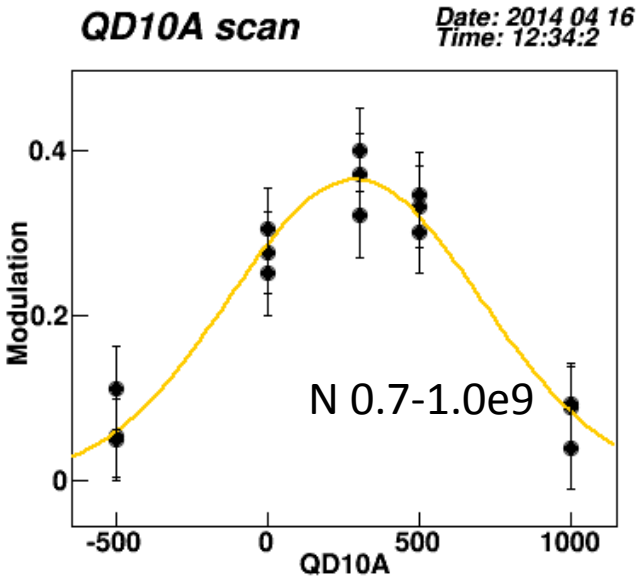
Expected IP vertical beam size growth

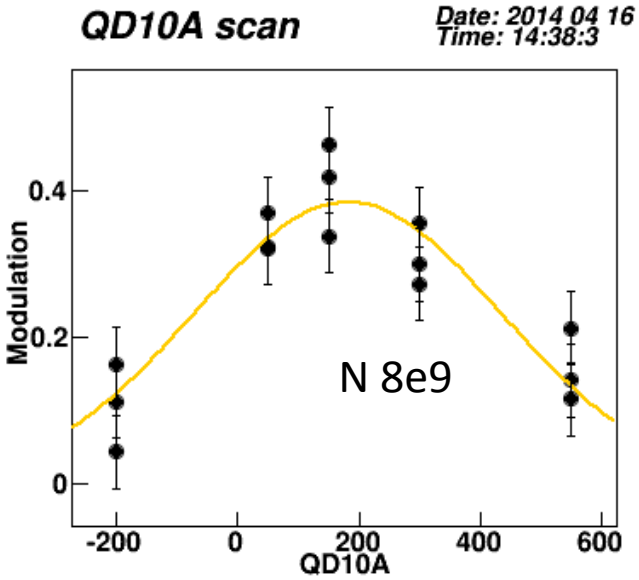
For V=-0.16V/pC/mm



Factor 6 smaller dependence calculated than observation.
(This calc. Included cavity BPMs only.)

http://atf.kek.jp/twiki/bin/view/ATFlogbook/Log20140416d





IP beam size vs. Feedback Target Position at QD10A

Feedback used 1 steering mag. ZV9X
Orbit change is "angle at IP" phase:
wakefield change affect beam size.

Assuming $\sigma_y^{*2} = \sigma_{y,0}^{*2} + a^2 y_{\mathrm{QD10A}}^2$

$a \approx 1.0\times10^{-4} \quad (q = 0.7 \sim 0.1\mathrm{nC})$

$a \approx 6.5\times10^{-4} \quad (q = 8\mathrm{nC})$

If $a = bq + c,$

$b \approx 4.8\times10^{-4}\,[1/\mathrm{nC}],\ c \approx 2.4\times10^{-4}$

Expected from calculations including only Cavity BPM wakefield:

$b \approx 1.7\times10^{-4}\,[1/\mathrm{nC}]$

Factor ~3 bigger than calculation

K.Kubo 20140418 ATF Operation meeting

What these observations mean?

- Wakefield downstream of ZV9X is about 3 times bigger than calculated from cavity BPMs. (This is rough estimation.)

- Other Wakefield sources are misaligned larger than cavity BPMs. (This is reasonable.)

Studies using on mover sources

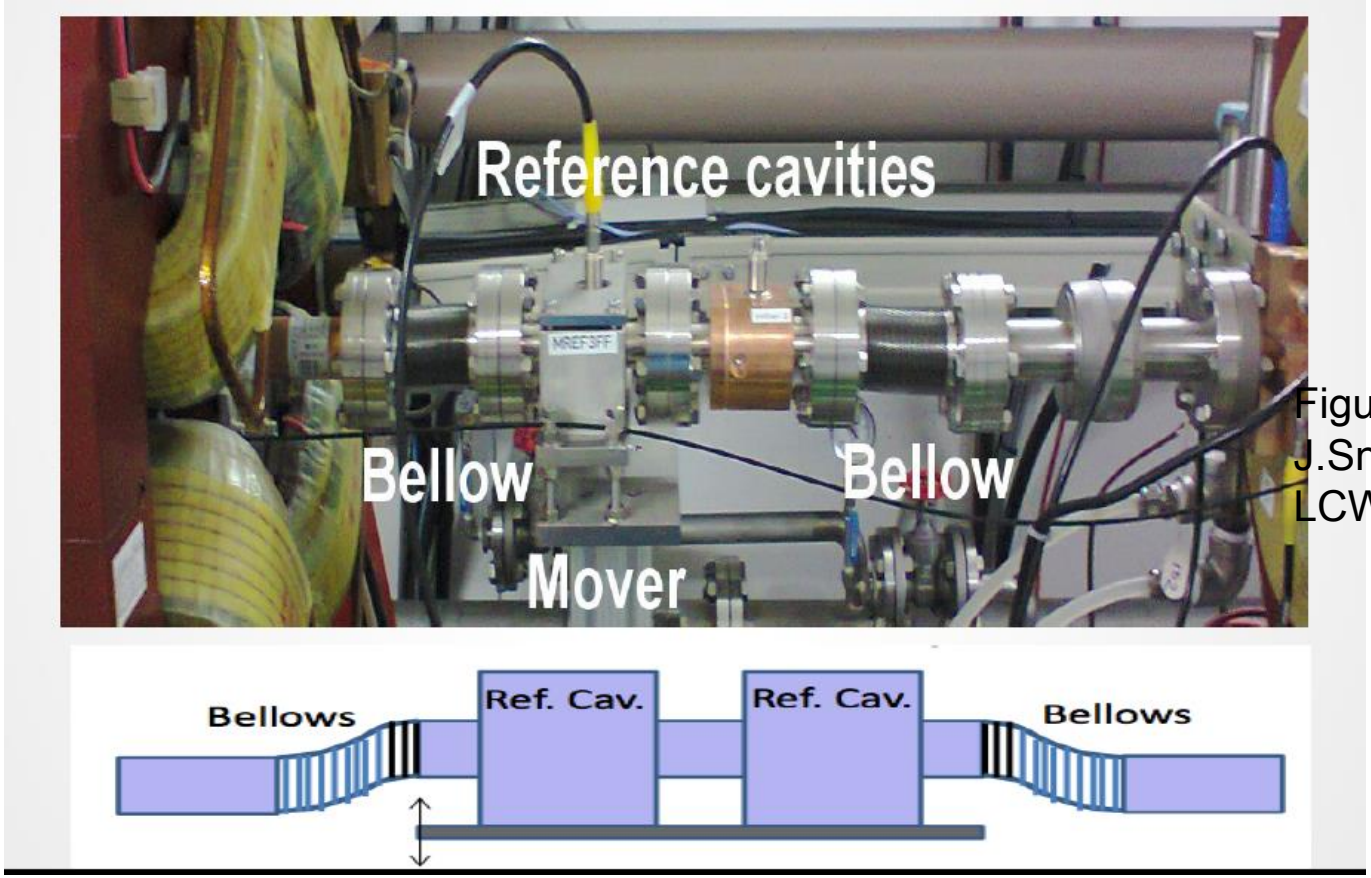


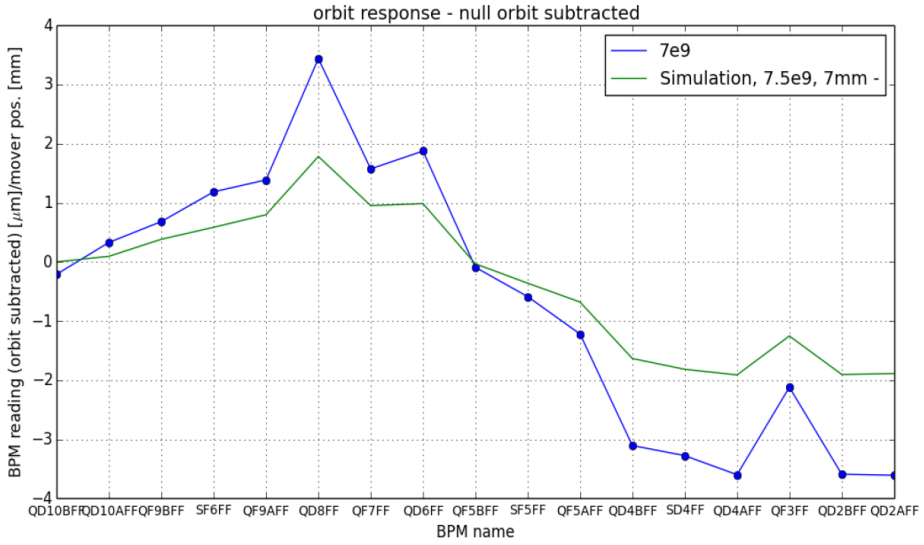
Figure:
J.Snuverink, et.al.,
LCWS2014

Configuration changed: 2 ref. cav, 1 ref. cav ,1 bellows, narrow beam pipe

Measure Vertical orbit change and Vertical beam size at IP.

Comparison with simulation

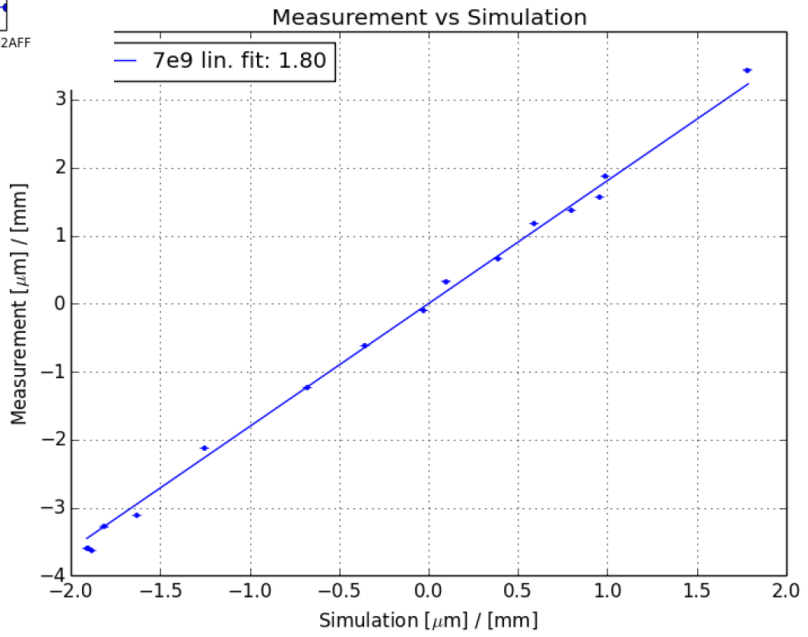
J.Snuverink, et.al., LCWS2014



Wake source on mover experiment
-- orbit change

- Measured orbit shape agrees well
- Measured effect is 0.7 V/pC/mm
- About a factor 1.8 larger than simulation (numerical calculation + tracking)
- Reduced from earlier factor of 2.0

- Possible discrepancy might be due to bunch length or underestimation by simulation



IP beam size vs mover position experiment and calc.

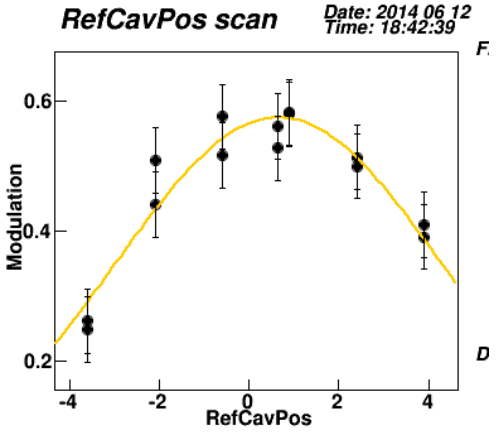
ATF2 weekly meeting 20130708 K.Kubo

Effect of wake source at the mover, offset 1 mm, bunch charge 1 nC.
IP beam size increase (nm/mm/nC)

$$\left(\text{Assuming}\quad \sigma_y^{*2} = \sigma_{y,0}^{*2} + a^2 q^2 \Delta_y^2\right)$$

	C-band ref.	No mask Bellows	Masked Bellows
Experiment	55	47~50	7
Calc	32.2	22.6	?

Moves of bellows at both ends assumed to be moves of half bellows.



Factor 1.7 – 2.2 larger than calculation
consistent with orbit change measurement

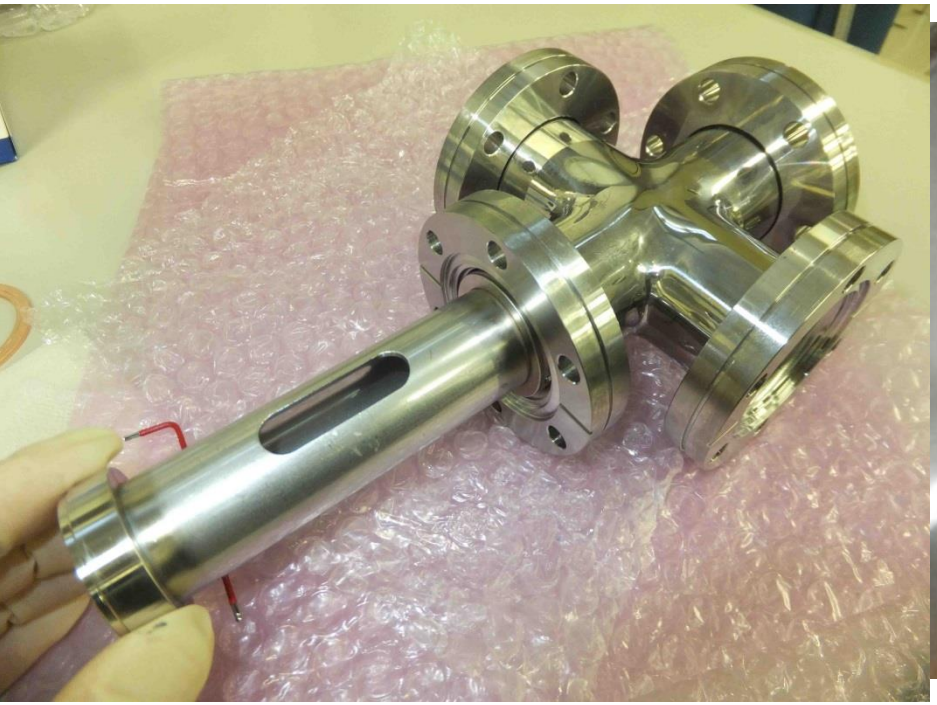
Efforts to reduce wakefield

- Shield Bellows, vacuum ports
- Remove some cavity BPMs, reference cavities, Wire scanners
- Move some components from large beta to low beta region
- Make vertical symmetry of vacuum ports
- Wakefield source on mover (for study and cancelling)
- Alignment (beam pipes, etc.)

Mostly done in FF line (high beta-function).

Wakefield mitigation

Shielding the wakefield sources especially in the high-beta regions.



Pump Port (Mar 2014)

Bellows (May 2013)

Slide from N.Terunuma in
AWLC14, Americas Workshop on Linear Colliders 2014, May 12, Fermilab

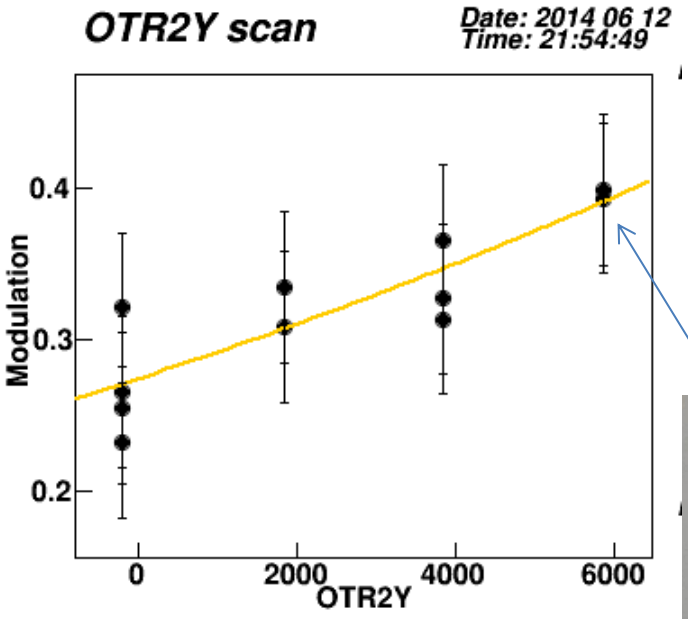
Recent Wakefield calculations

Calc. by A. Lyapin

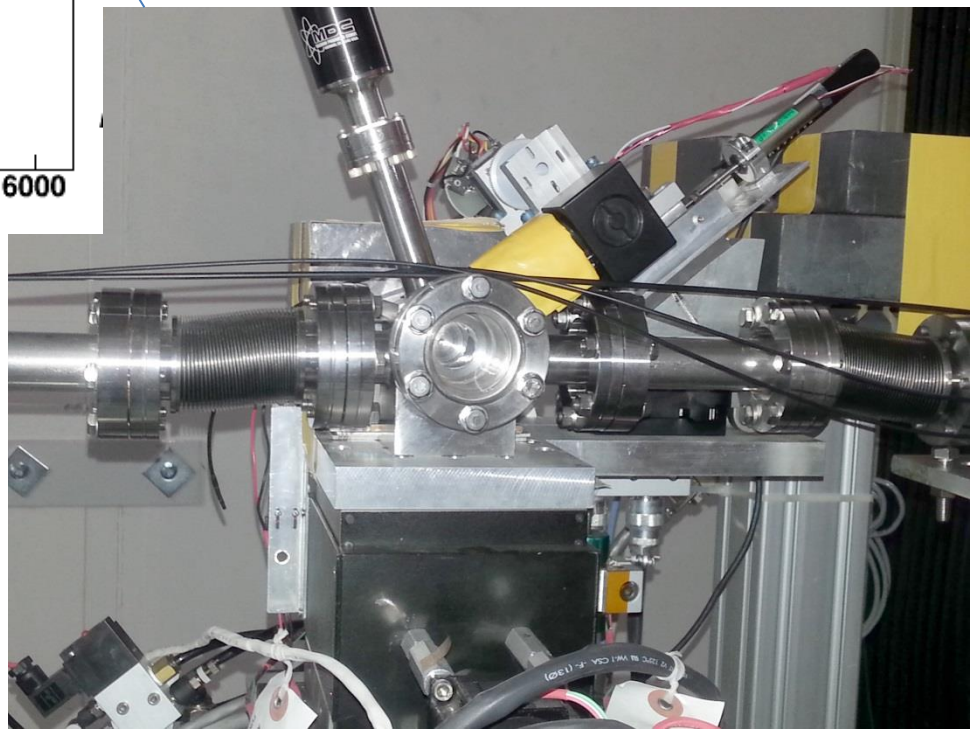
- Steps of IP Chamber – IPBPM
  - Wake of IP chamber entrance (end plate) is small
    - 0.05 V/pC/mm
  - Wake of IPBPM is small if it is aligned within order of 0.1 mm
    - 0.6 V/pC/mm
- Step after QD0
  - No problem
    - 0.03 V/pC/mm

- OTR Chamber

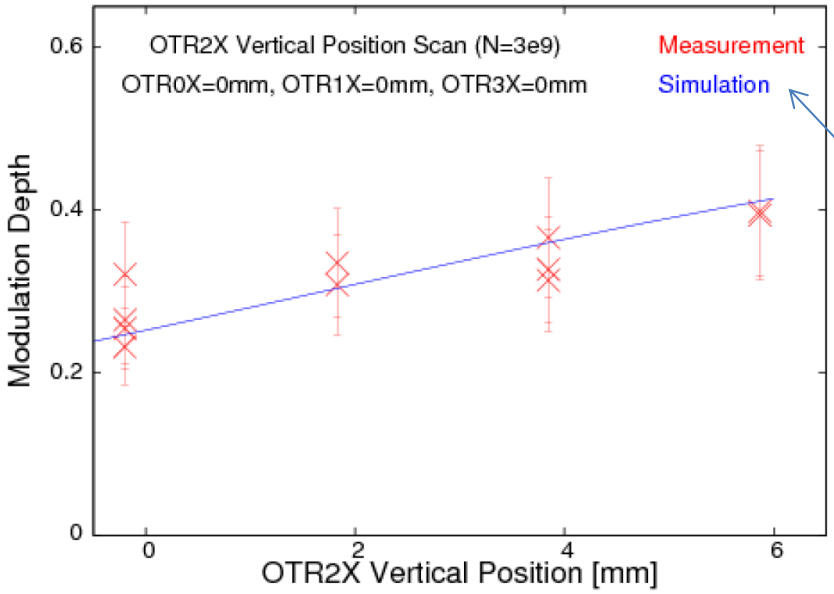
Effect of OTR monitor chamber (beam size monitor in EXT line) to IP vertical beam size was found (June 2014)



IPBSM 174 degrees
N~3E10

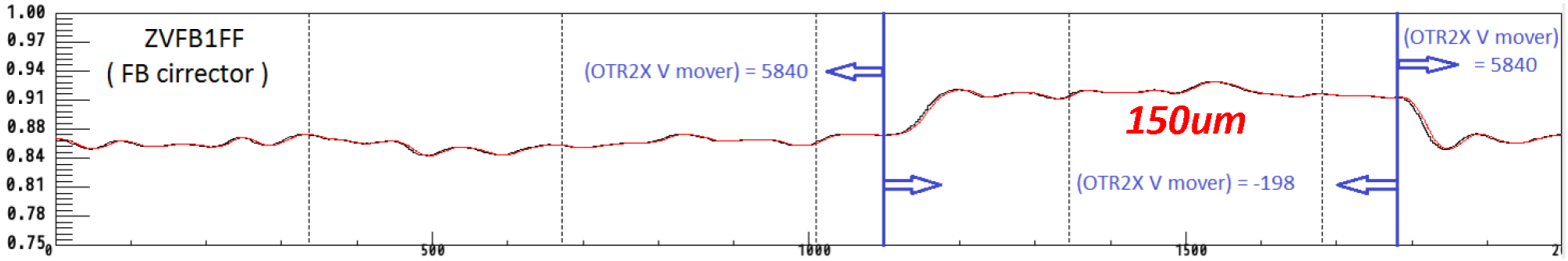


OTR2X Vertical Position Scan at N=3e9



0.3 V/pC/mm assumed

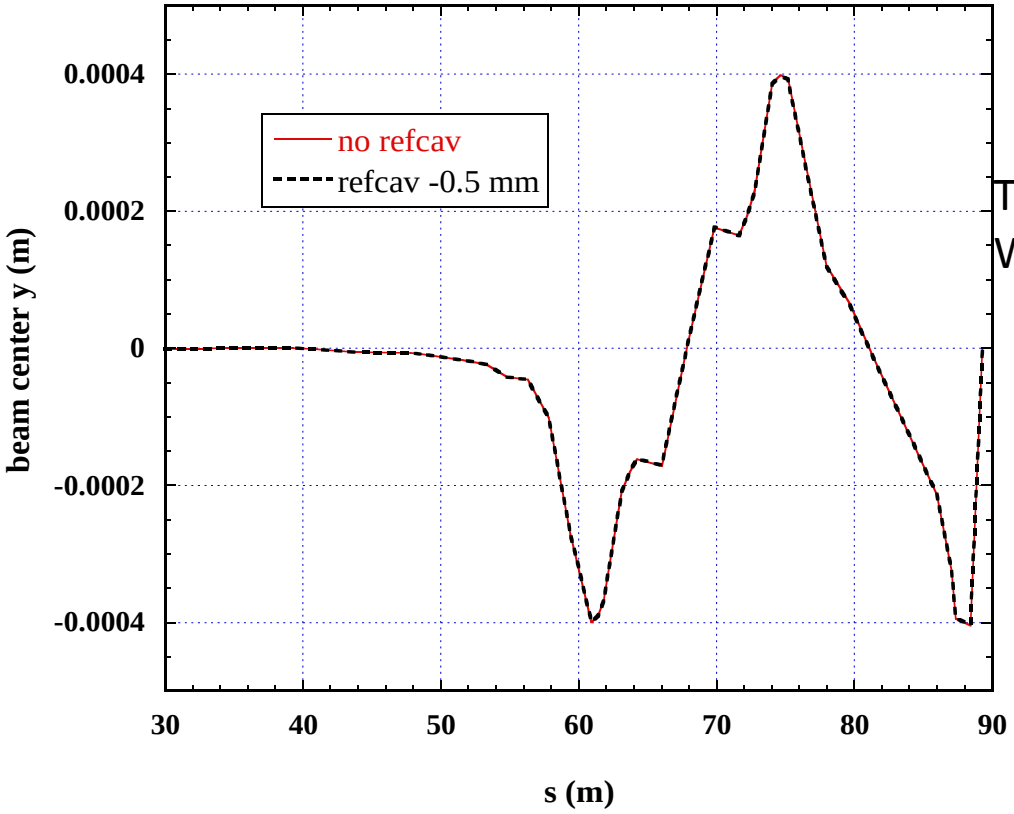
(Beam position difference at QD10AFF for y=0, 6mm) = 170um (simulation).



Okugi, 2014.6.26 ATF Op. meeting

Effect to orbit in FF

Center of mass position at BPMs, Bunch charge 5 nC
All OTRs offset 0



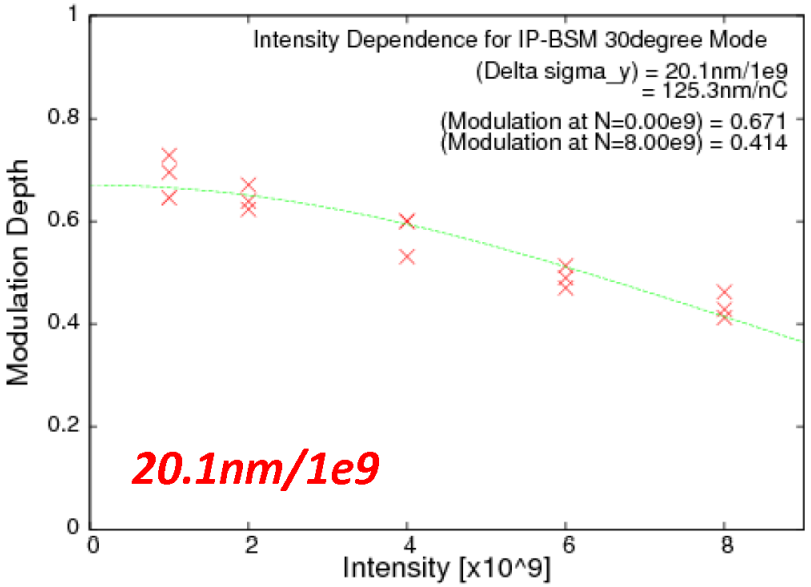
Tracking simulation using SAD
Wakefield: by A. Lyapin

OTR wake affect FF orbit significantly, but RefCav on mover does not.

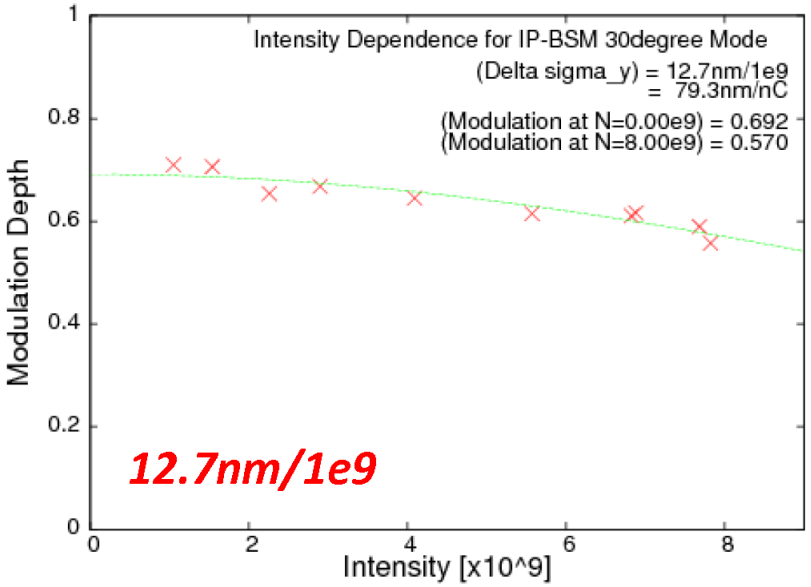
All OTR monitors were removed from beam line
in the last operation week of June, 2014.

Intensity Dependence

Intensity dependence before OTRs removal



Intensity dependence after OTRs removal

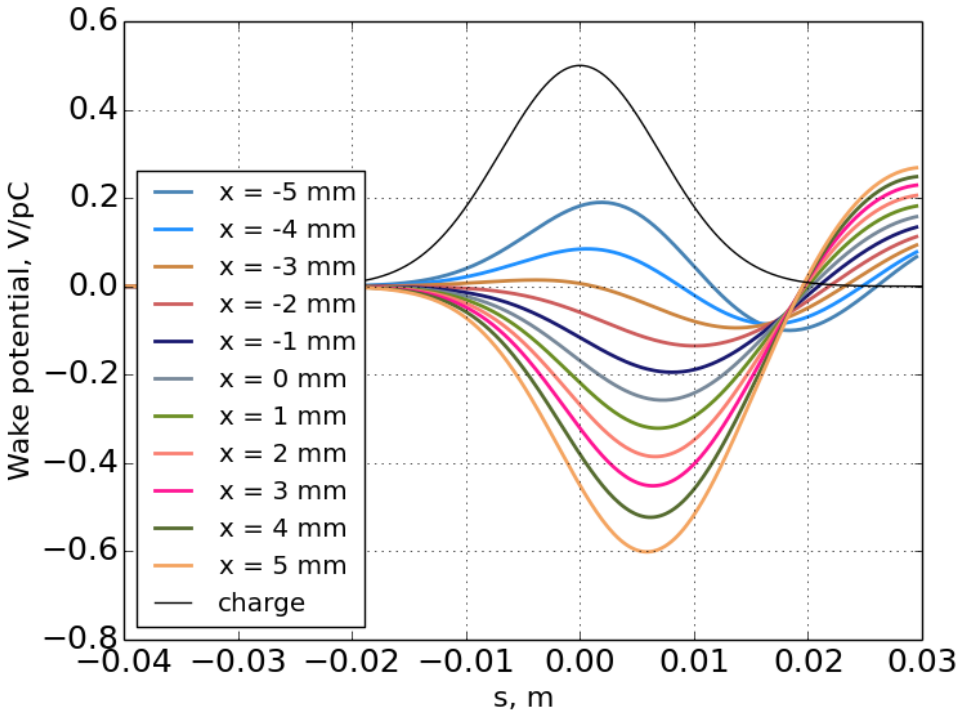


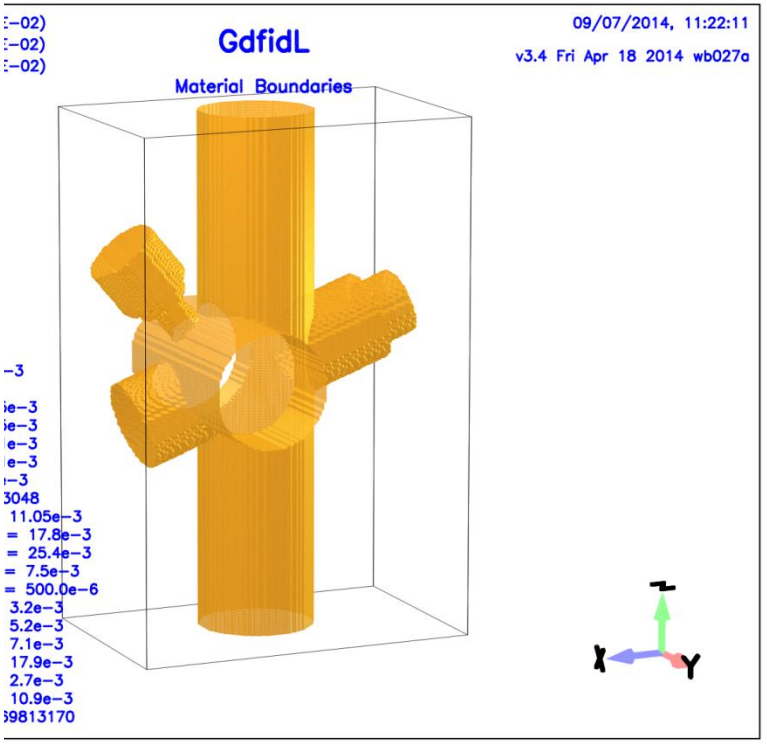
The intensity dependence was reduced for flat orbit without any offset devices.

However, still some intensity dependence was observed.

Okugi, 2014.6.26 ATF Op. meeting

Calculated Wakefield of OTR monitor chamber (by A. Lyapin)





0.08 V /pC/mm

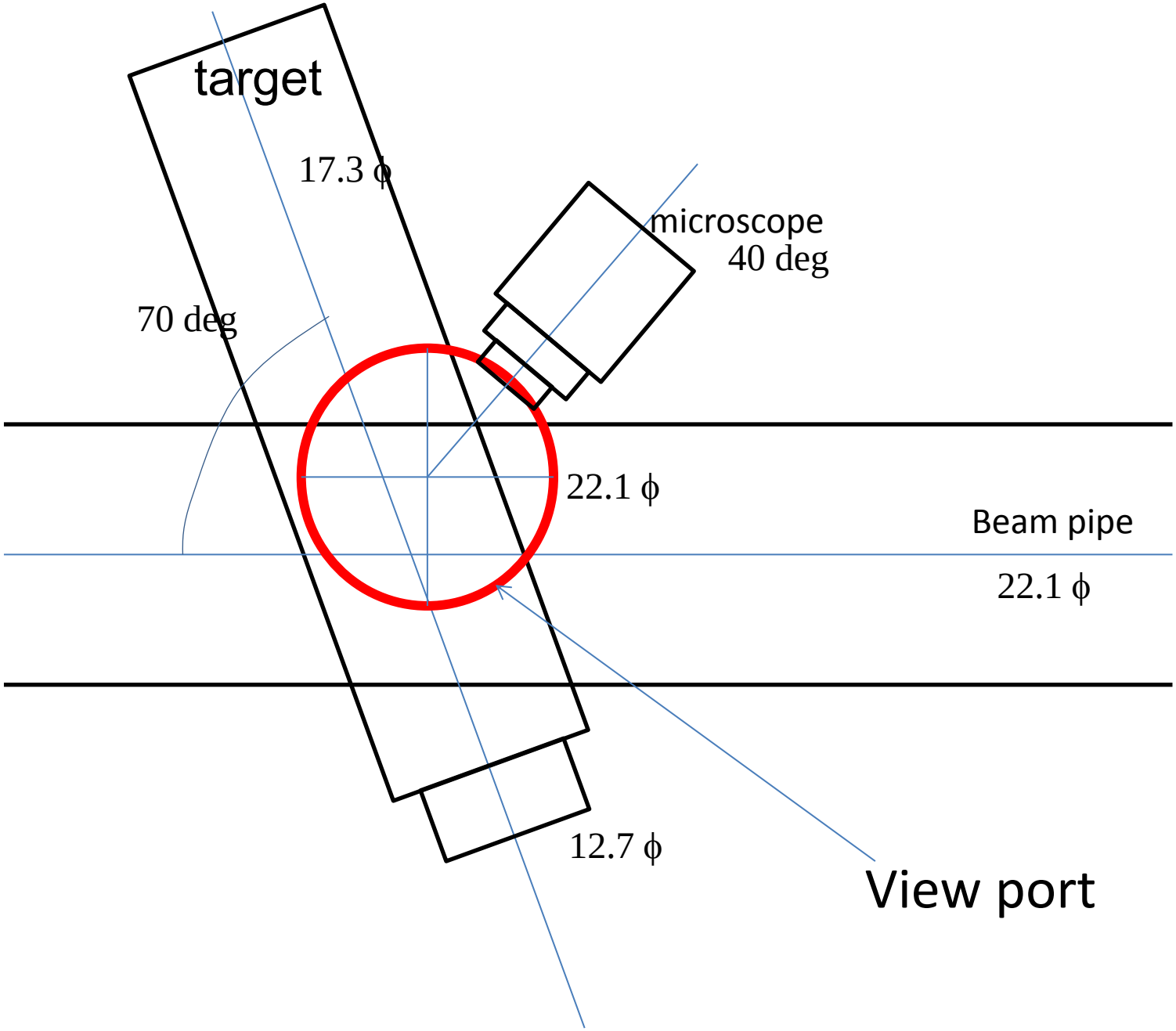
0.25 V/pC for centered beam

Okugi's assumption for explaining experimental data

0.3 V/pC/mm

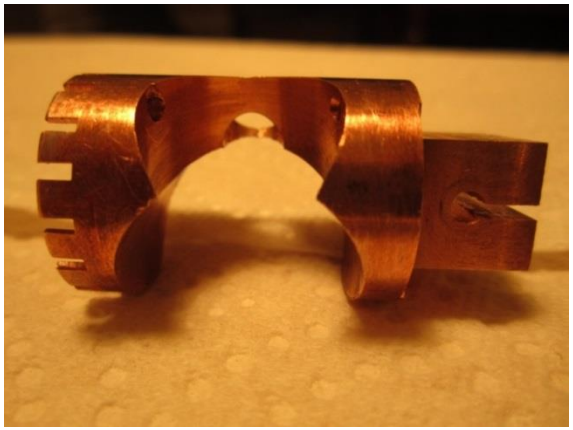
1.5 V/pC for centered beam

K.Kubo's analysis also showed differences by factor of 5~7. (2014.8.1 ATF2 meeting)


target
17.3 ϕ
microscope
40 deg
70 deg
22.1 ϕ
Beam pipe
22.1 ϕ
12.7 ϕ
View port

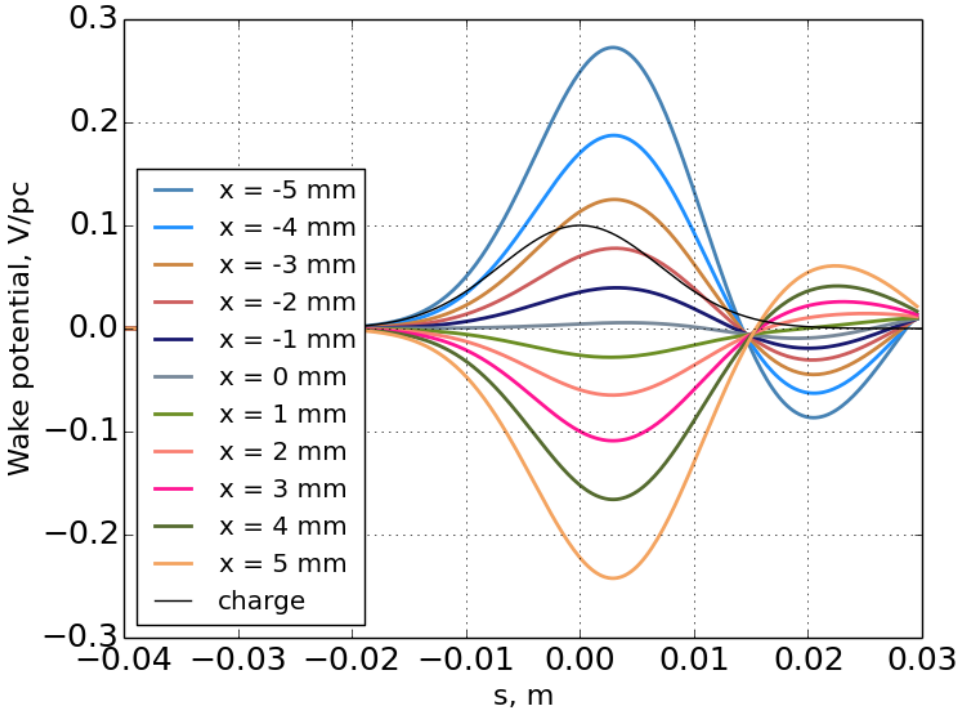
OTR chamber modification plan

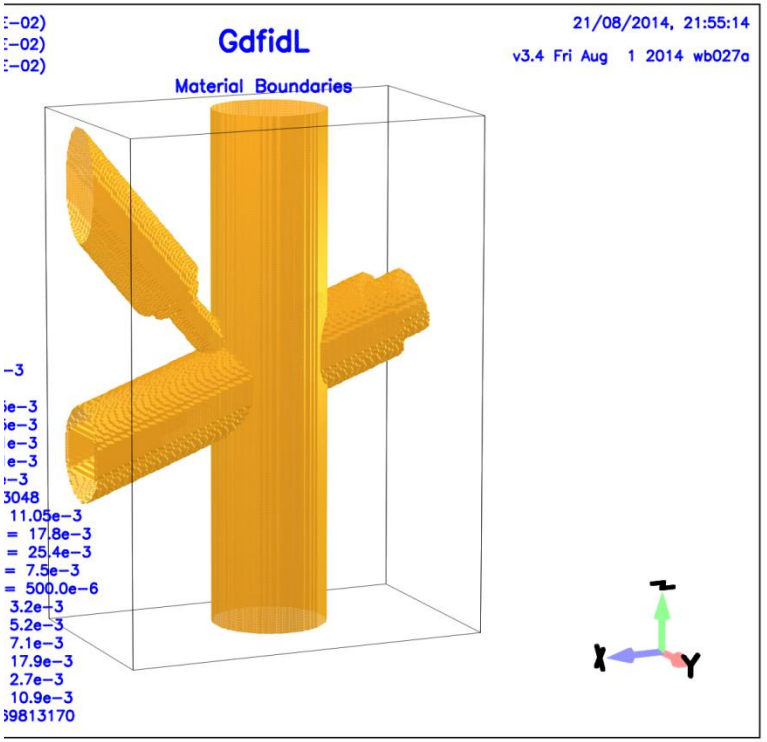
- Horizontal View Port makes vertical asymmetry
  - Strong Wakefield for beam going through beam pipe center
- Shielding the view port planned before next operation (next-next week).



Photos by D. McCormick

Calculated Wakefield of modified OTR monitor chamber (by A. Lyapin)





Vertical symmetry will be much better.

Very weak wake for beam going through center of beam pipe.

Dependence on beam offset: ~ 0.05V/pC/mm.

Summary

- Significant Intensity dependence
  - Beam size growth ~100 nm/nC
  - Factor ~3 bigger than from only cavity BPMs.
- Wake source on mover
  - Factor ~2 bigger than calculation (orbit and beam size)
- Significance of OTR monitor chamber wake was found
  - Factor ~6 stronger than calculation.
  - Will be improved from next operation.
- Efforts to reduce Wakefield
  - Mostly done in FF line (high beta-function)
  - Need to consider in upstream (relatively small beta but worse alignment.)
- Still much more studies needed. Many unknowns.
- Understanding intensity dependence is “Gola 3” of ATF2