ATF2 intensity dependence summary

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ATF2 project meeting, KEK

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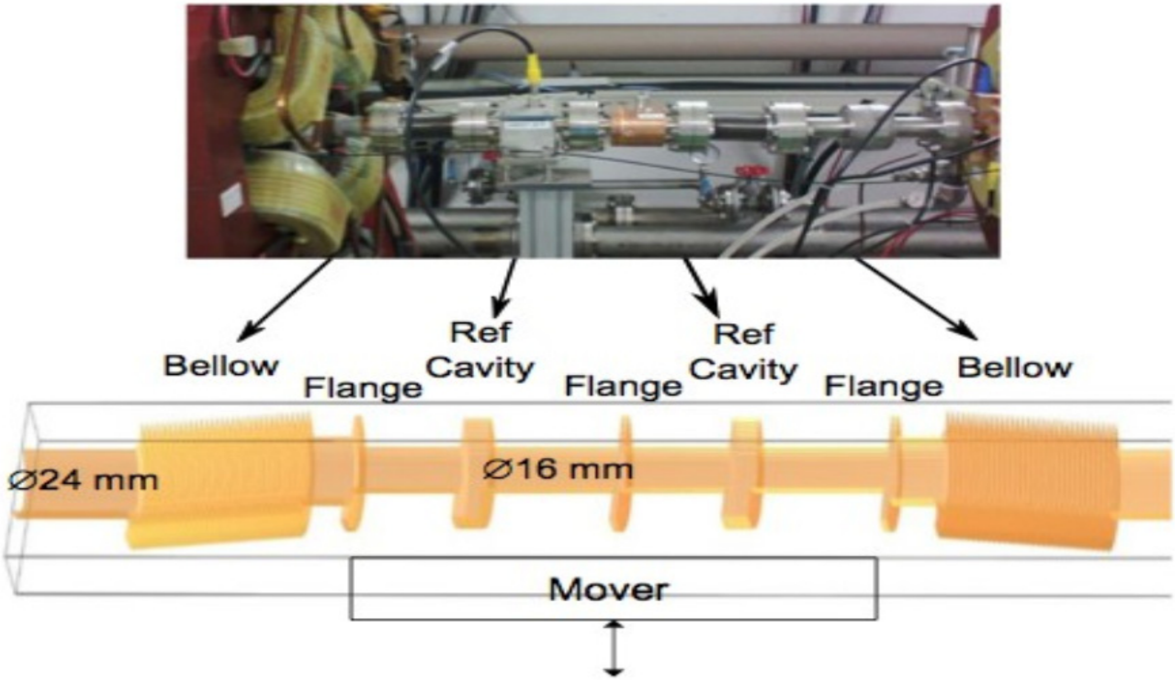
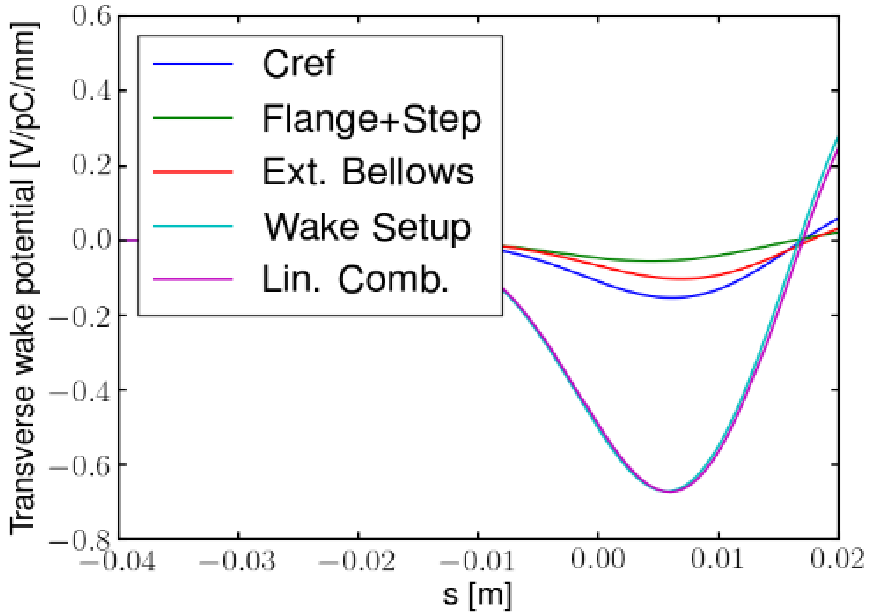
2 reference cavities, unmasked bellows, unmasked flanges





J. Snuverink et al., 18th ATF2 project meeting (2015)

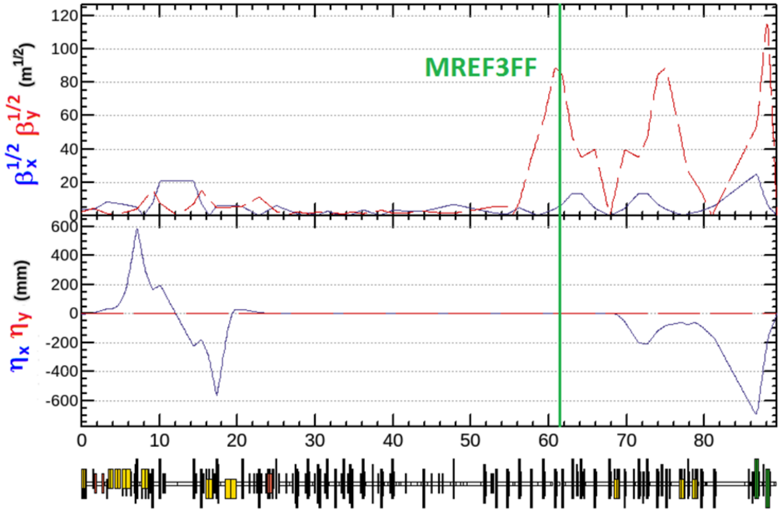
see detail in J. Snuverink et al.,
*Phys. Rev. Accel. Beams **19**, 091002 (2016)*

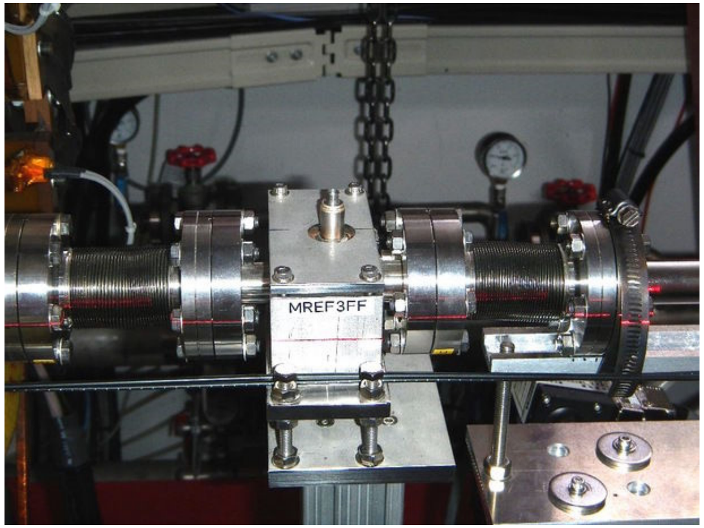
	Wakefield
Measurement	*- 0.49 V/pc/mm*
Simulation	*- 0.41 V/pC/mm*

Consistent within 20%

Wakefield kick by SAD simulation

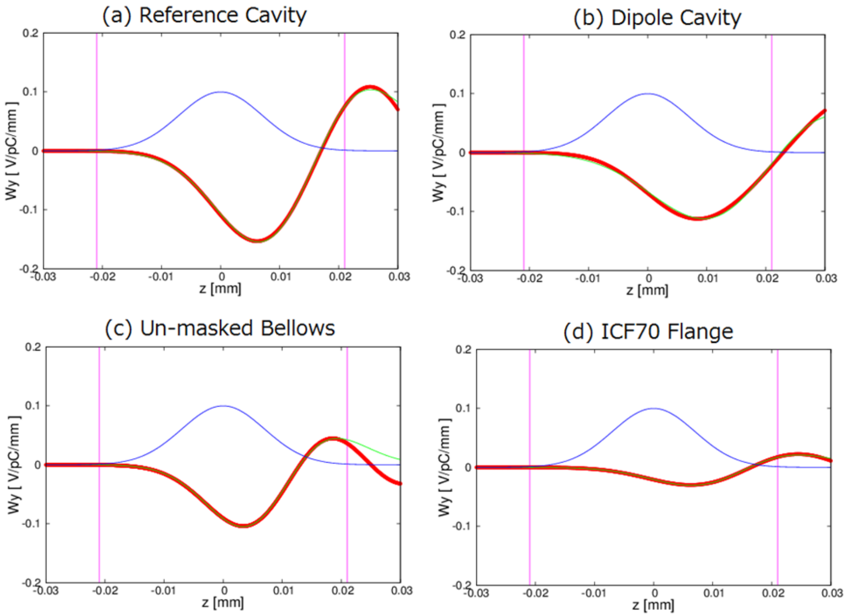
Vertical beam position was deformed along longitudinal axis.





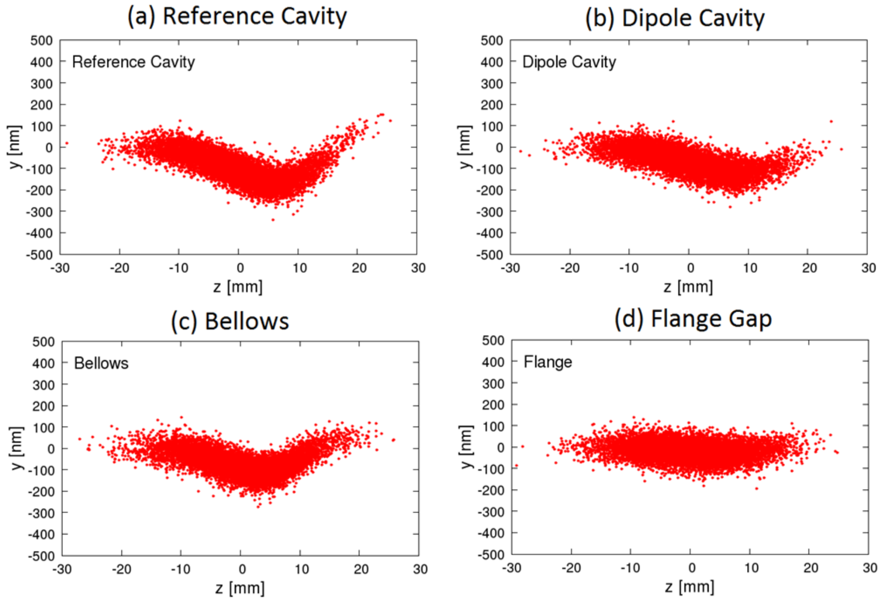
Wakefield for various wakefield source

evaluated by A. Lyapin.



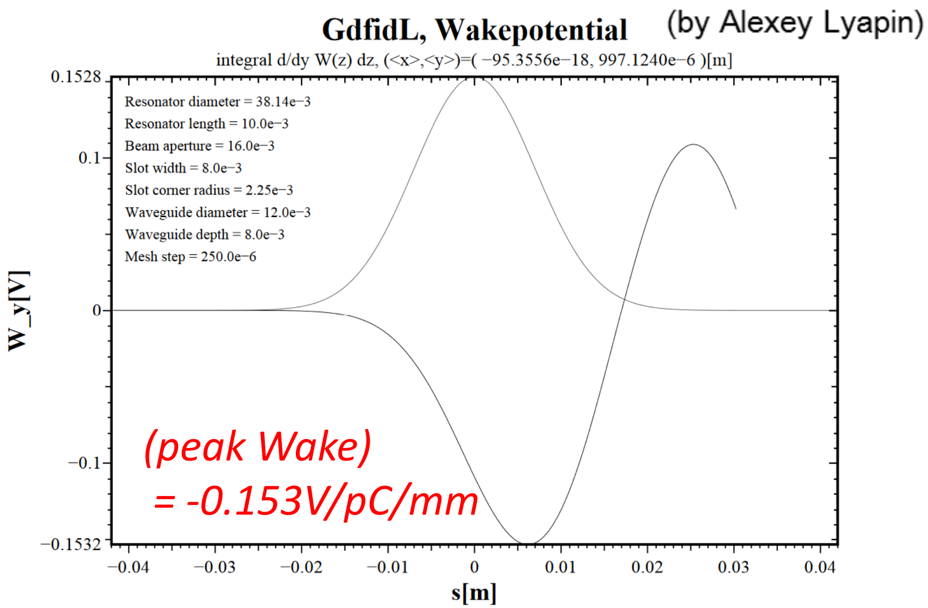
Simulated IP v-z correlation

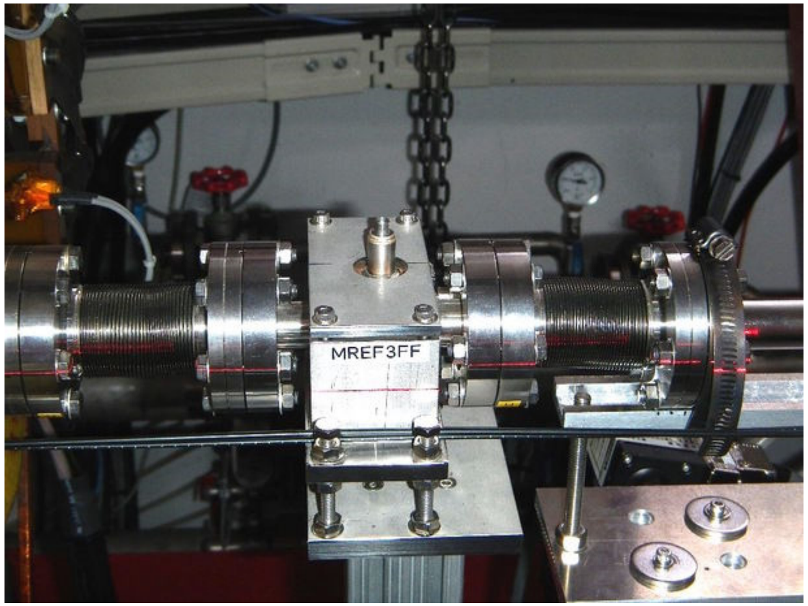
1 mm offset at $N = 1 \times 10^{10}$

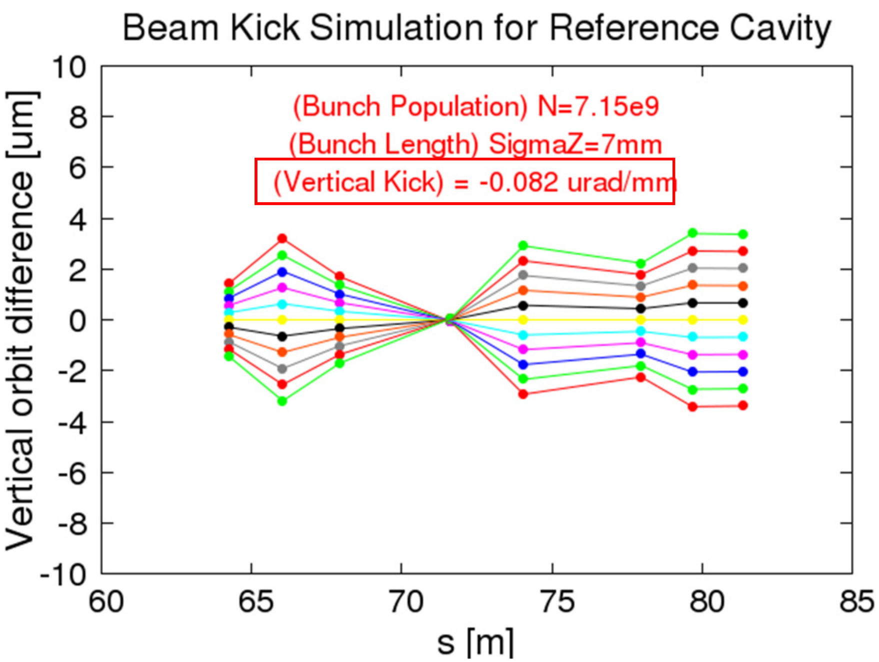


Wakefield kick evaluation by SAD tracking simulation

Wakefield kick for reference cavity was evaluated by using SAD tracking simulation.





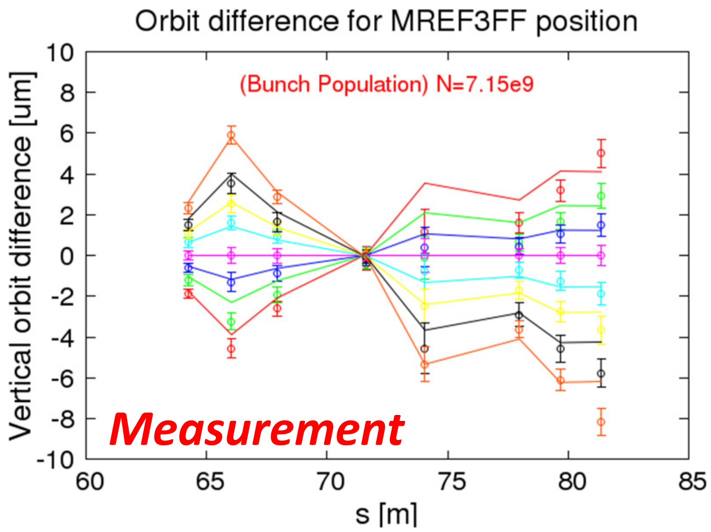


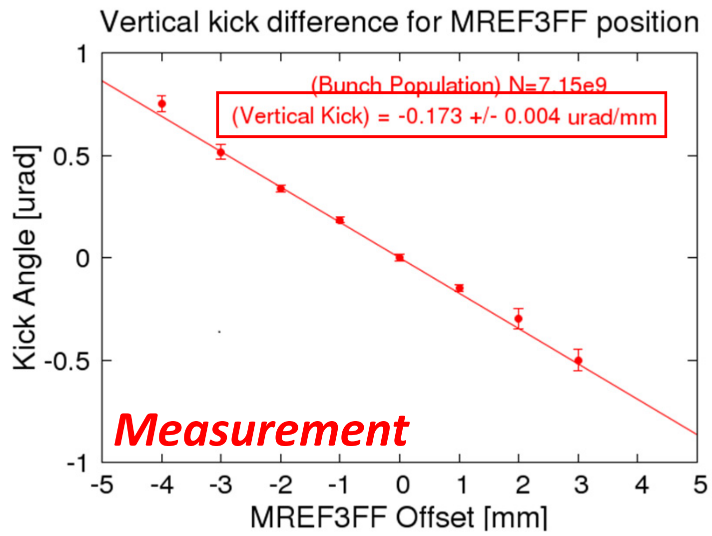
The beam orbit kick corresponds to that for - 0.092 V/pC/mm of wakefield.

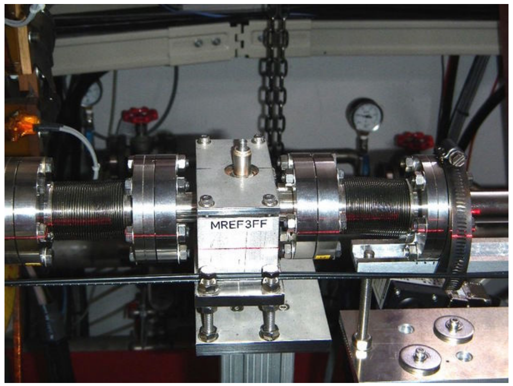
*The number (60% ; 0.092/0.153) was consistent with the average wakefield (61% of peak ; 0.41/0.67), evaluated by J. Snuverink et al. at PRAB **19**, 091002 (2016).*

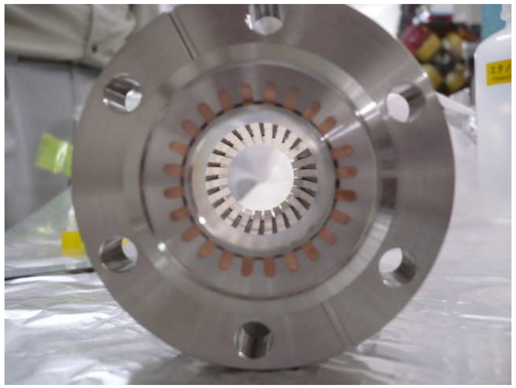
Wakefield kick of a reference cavity with masked bellows

Measurement at 2016/12/01

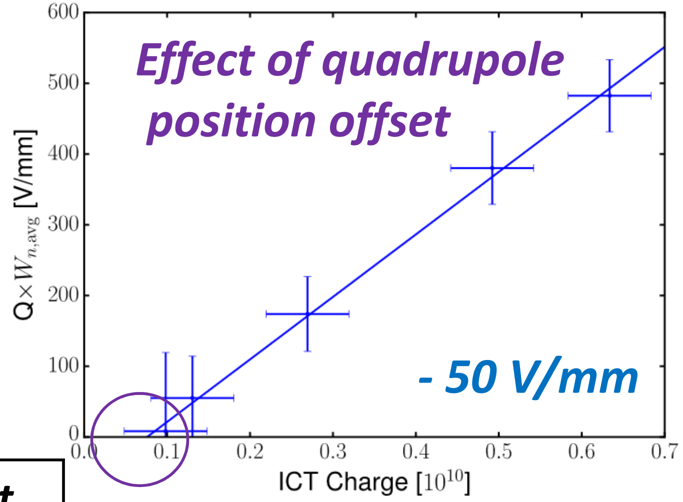








J. Snuverink et al., PR-AB 19, 091002 (2016).



Negative offset

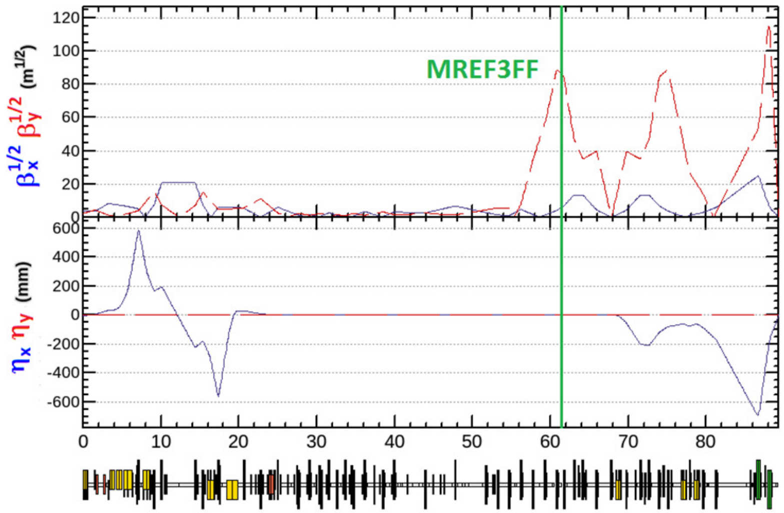
It suggest the actual kick is larger than single charge evaluation.

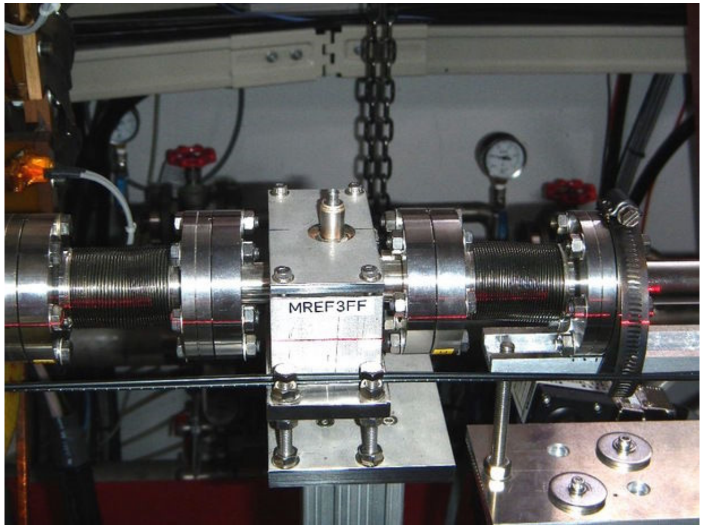
	w/o quad offset	***with quad offset***
Measurement	- 0.193 V/pC/mm	- 0.237 V/pC/mm
Simulation	- 0.092 V/pC/mm (- 0.153 V/pC/mm of peak)	

Measurement was twice as large as expectation only by reference cavity

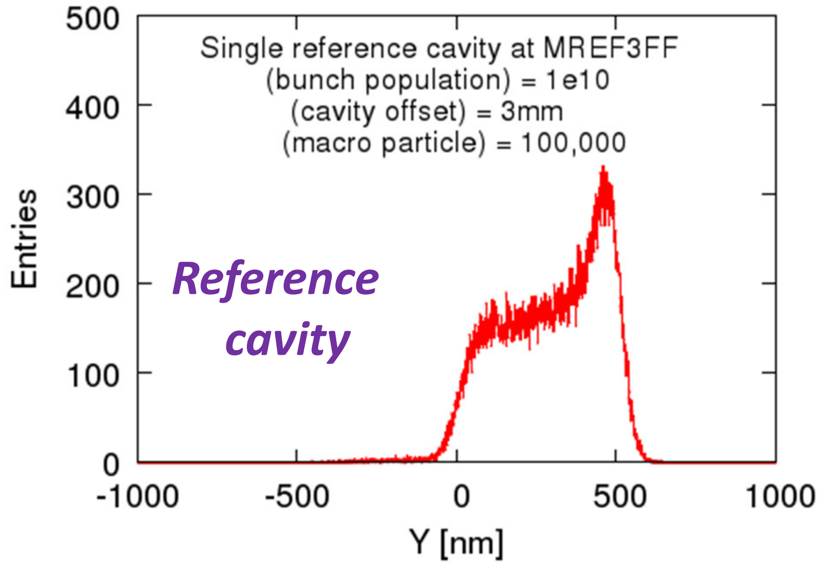
Beam size evaluation with IP-BSM 30 degree mode

The IP beam size is deformed by the wakefield.
The IP beam size is evaluated with IP-BSM.

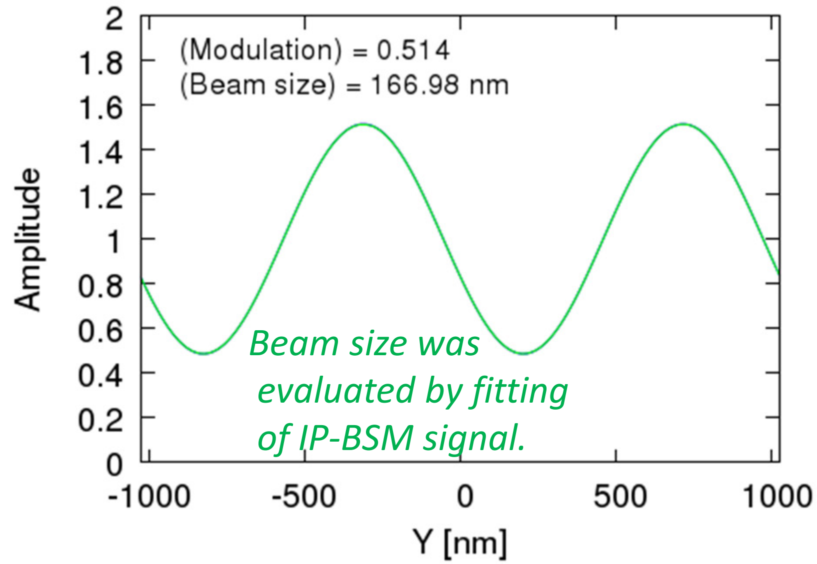




(a) IP vertical beam profile



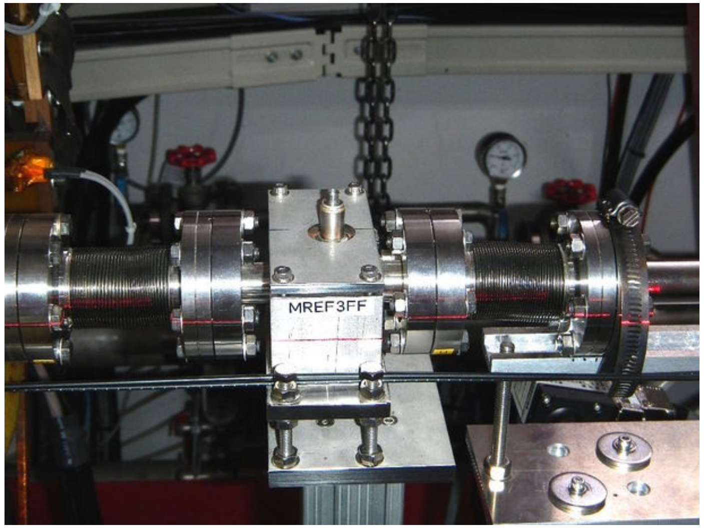
(b) IP-BSM 30 degree mode



The IP beam size was evaluated by convoluted the IP-BSM fringe pattern.

IP beam size change by wakefield of reference cavity

Comparison of simulation and measurement

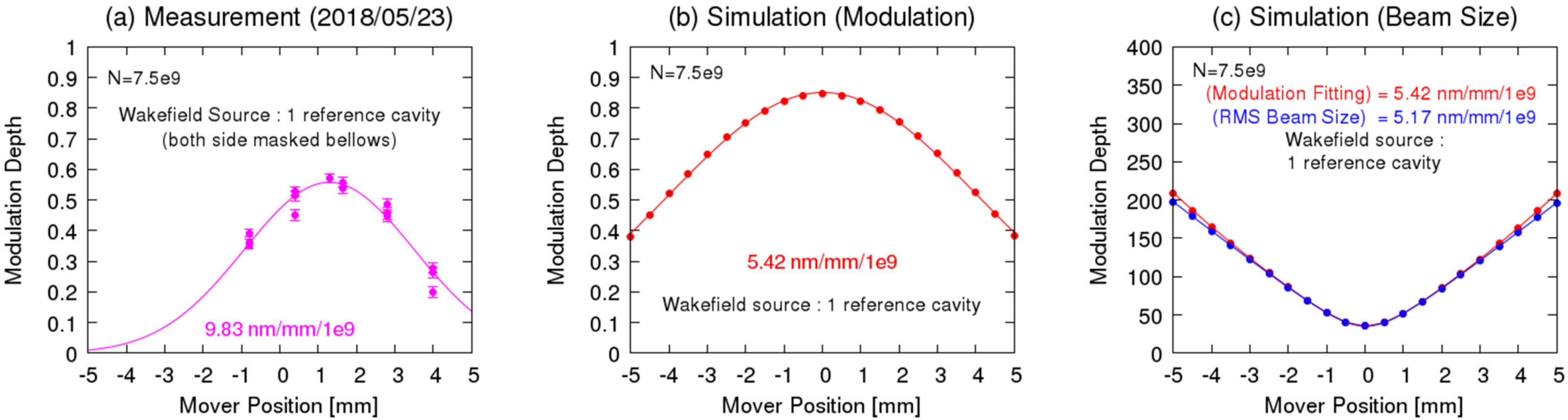


The masked bellows were put both side of the cavity.
The bellows were deformed, when the cavity was moved.

Evaluated intensity dependence

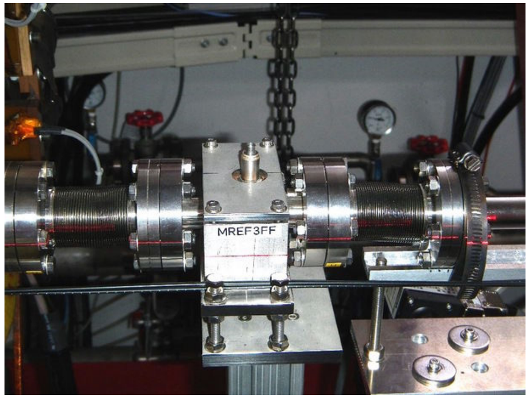
	simulation	measurement
no masked bellows	5.42 nm/mm/1e9	
with masked bellows		9.83 nm/mm/1e9

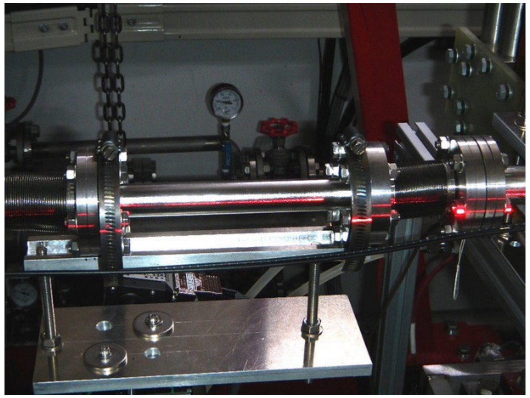
Measurement was also twice as large as simulation.

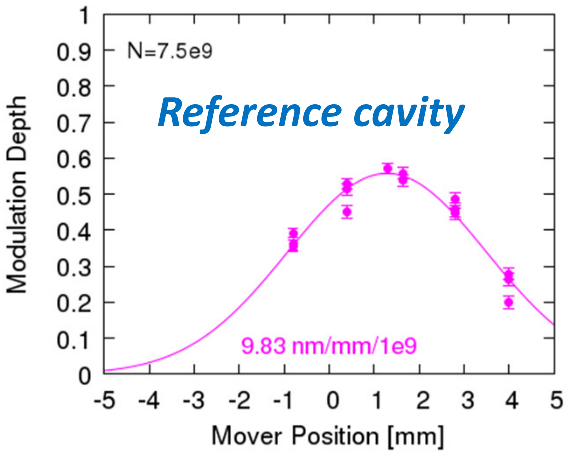


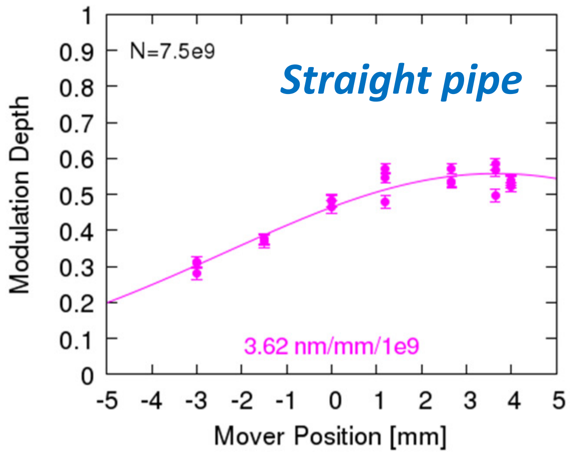
IP beam size change by wakefield of straight pipe

Effect of the masked bellows both side of wakefield source

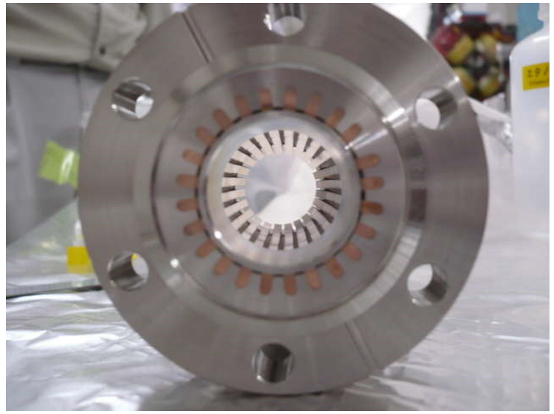








RF contact of bellows

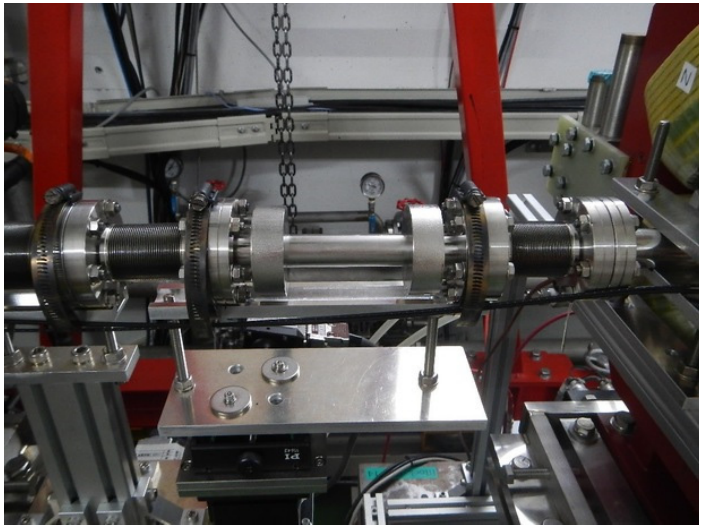


Evaluated intensity dependence

	simulation	*measurement*
Reference cavity w/o masked bellows	5.42 nm/mm/1e9	
Reference cavity with masked bellows		9.83 nm/mm/1e9
Straight pipe with masked bellows		3.62 nm/mm/1e9
Difference		6.21 nm/mm/1e9

IP beam size change by wakefield of reference cavity

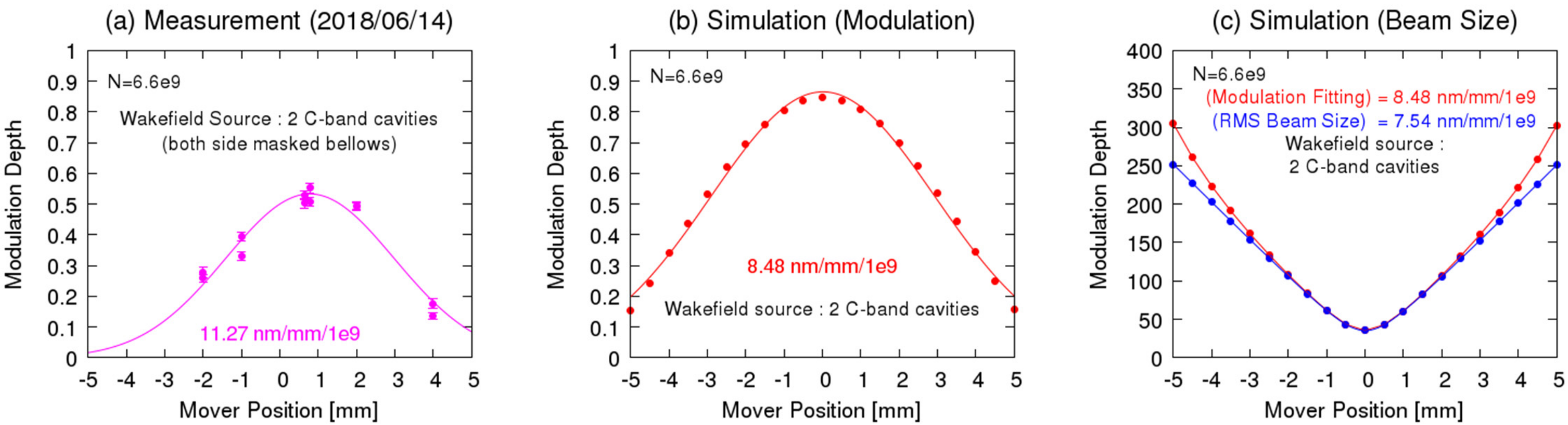
Comparison of simulation and measurement



The masked bellows were put both side of the cavities.
The bellows were deformed, when the cavities were moved.

Evaluated intensity dependence

	simulation	measurement
no masked bellows	8.48 nm/mm/1e9	
with masked bellows		11.27 nm/mm/1e9
masked bellows		3.62 nm/mm/1e9
Difference		7.65 nm/mm/1e9



Summary of wakefield for single wakefield elements

Evaluation by the beam orbit kick		simulation	measurement
2 reference cavities with un-masked bellows and flanges		- 0.41 V/pC/mm	- 0.49 V/pC/mm (1.19 of simulation)
Reference cavity	*no masked bellows*	- 0.092 V/pC/mm	
	with masked bellows		- (0.193～0.237) V/pC/mm

Evaluation by the IP beam size growth		simulation	measurement
Reference cavity	*no masked bellows*	5.42 nm/mm/1e9	
	with masked bellows		9.83 nm/mm/1e9
	masked bellows		3.62 nm/mm/1e9
	Difference		6.21 nm/mm/1e9 (1.14 of simulation)
Double C-band cavities	*no masked bellows*	8.48 nm/mm/1e9	
	with masked bellows		11.27 nm/mm/1e9
	masked bellows		3.62 nm/mm/1e9
	Difference		7.65 nm/mm/1e9 (0.91 of simulation)

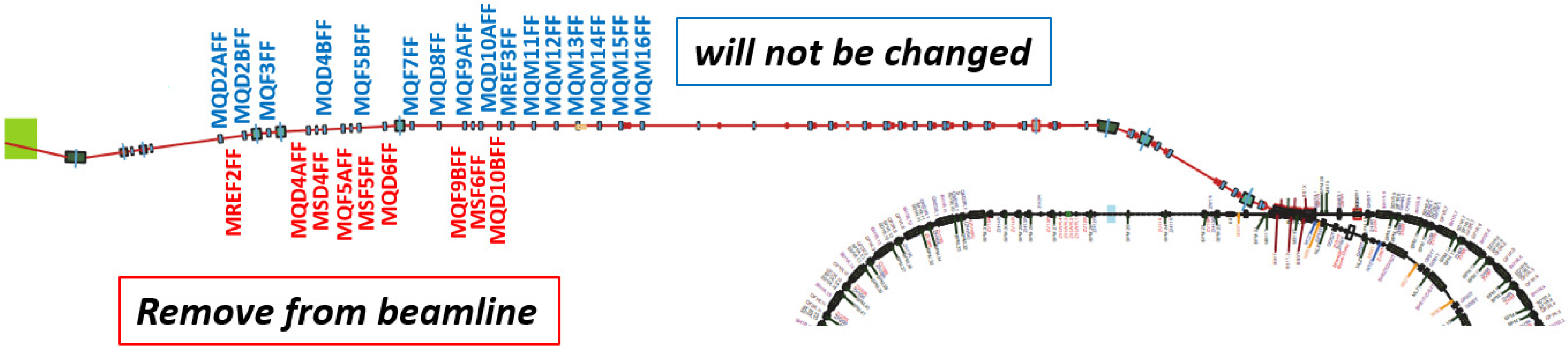
Measurements were consistent with the simulation both of the beam orbit kick and the intensity dependence of IP beam size for single wakefield elements .

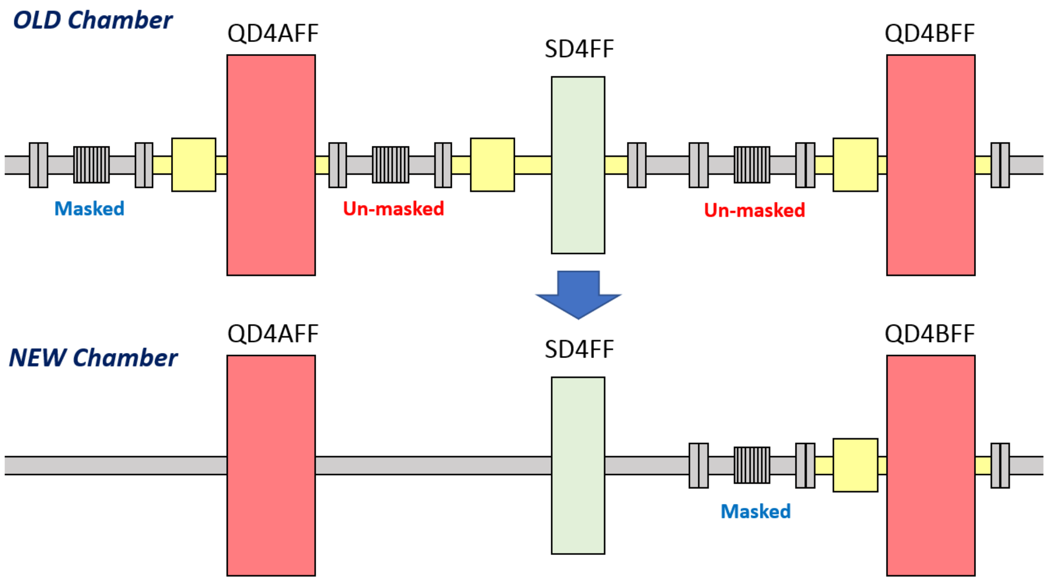
But, the wakefield kick of masked bellows was not negligible small.

Wakefield of entire ATF2 beamline

Wakefield components of ATF2 beamline

The wakefield components were reduced at 2016 November.
The wakefields for both wakefield settings were evaluated.



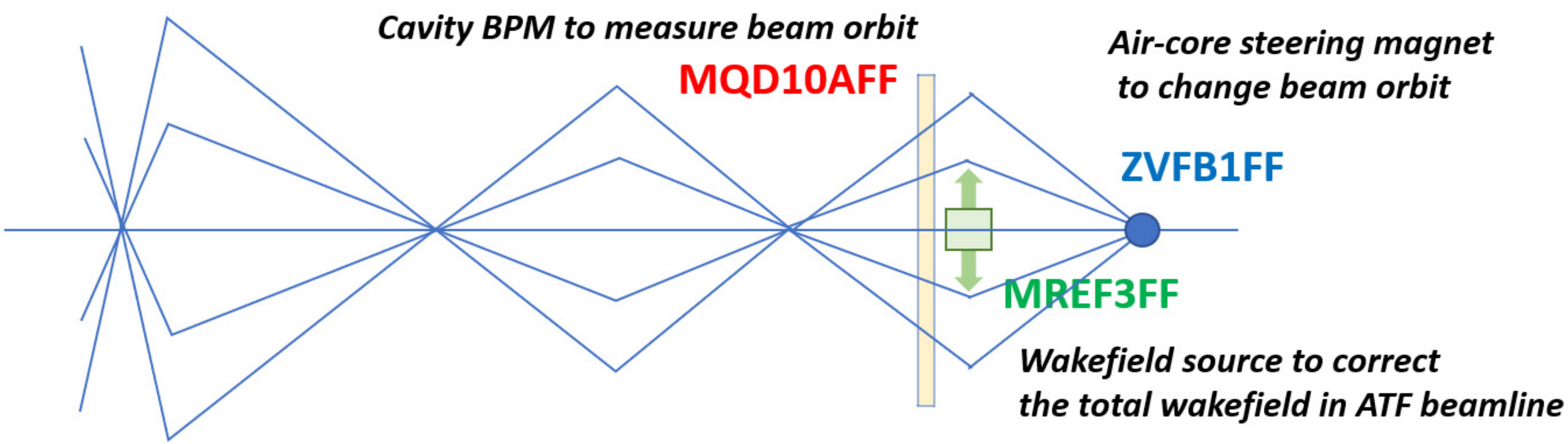


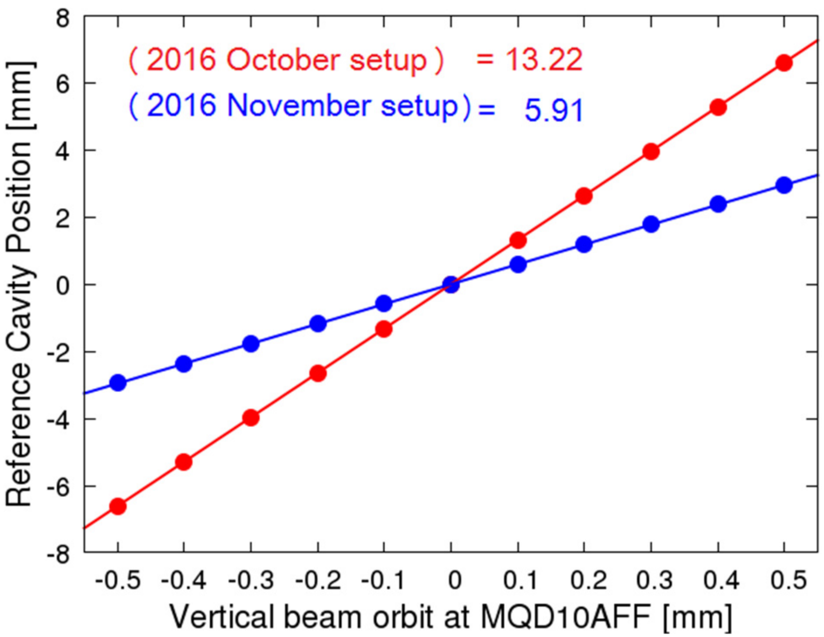
Number of elements overall ATF2 beamline

	Cavity BPM	Un-mask Bellows	Flange gap
OLD setup	23	11	87
NEW setup	15	5	69
Difference	8	6	18

Evaluation by SAD tracking simulation

Wakefield of ATF2 beamline was evaluation by normalizing the wakefield of reference cavity.
The reference cavity was put at MREF3FF location at 2016 October/November.





Beam orbit was changed by steering magnet.

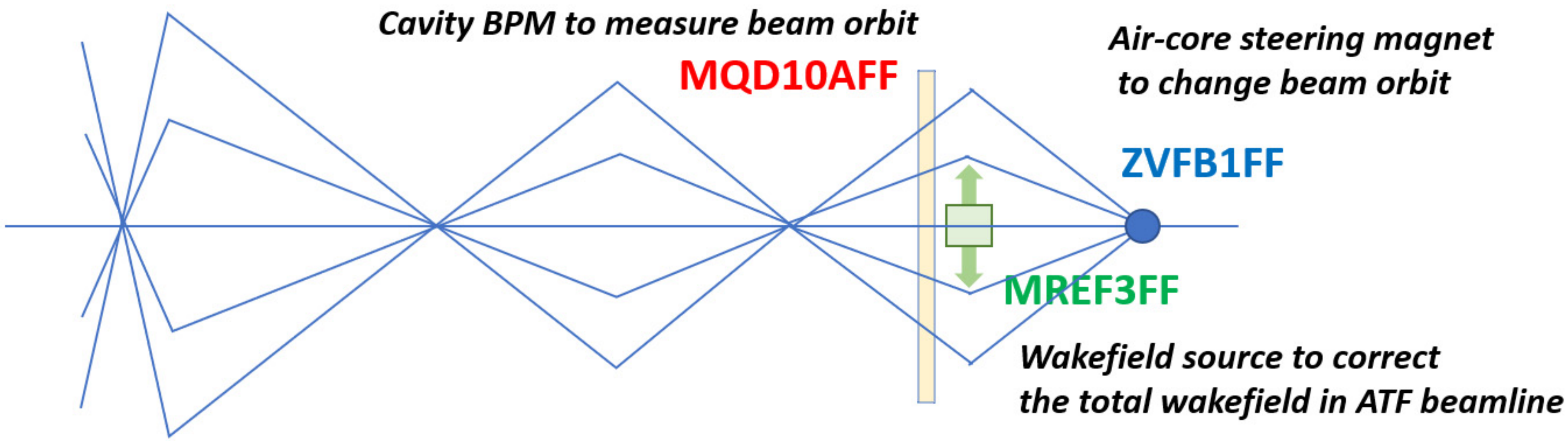
MREF3FF position was changed,
and the IP beam size was maximized.

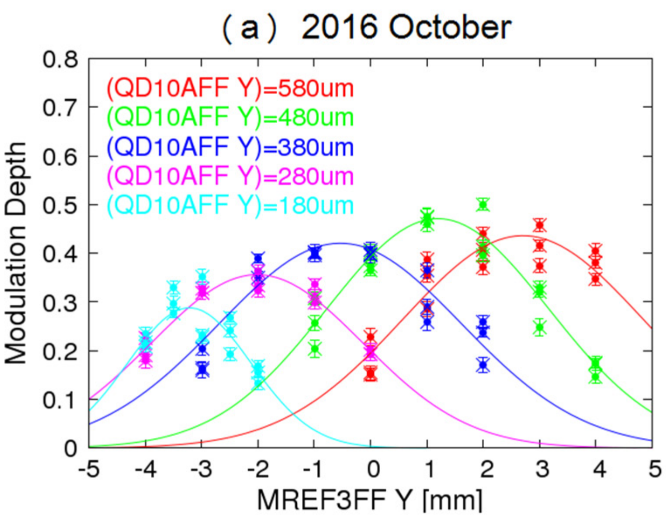
The correlation of the beam orbit
and optimized MREF3FF position was evaluated.

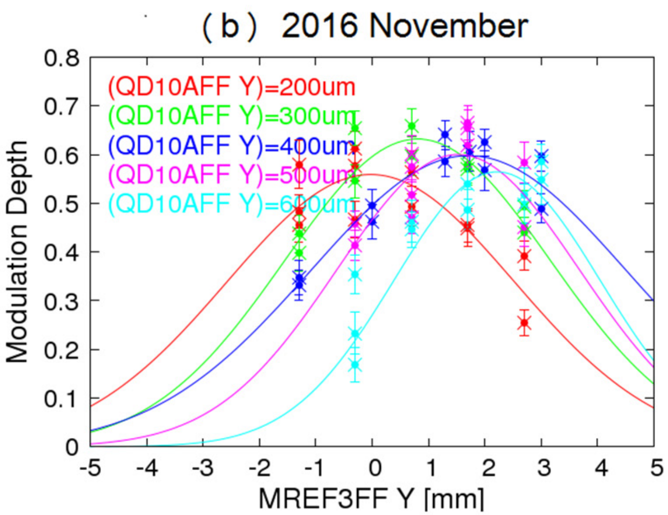
The simulation said
the wakefield was reduced more than factor 2
by the wakefield removal at 2016 November.

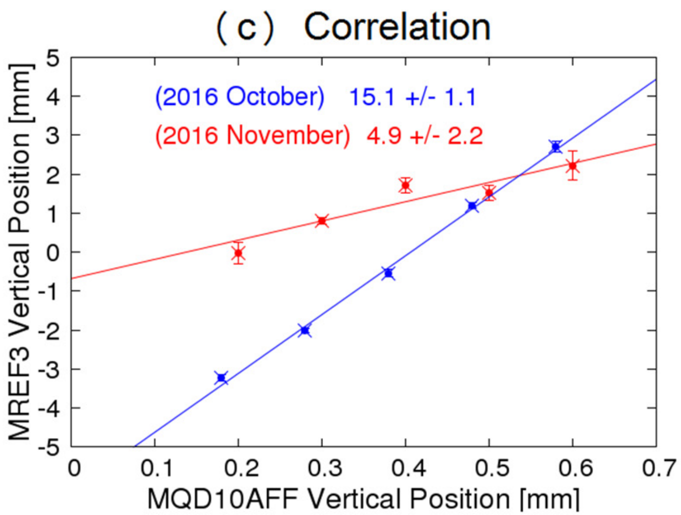
Wakefield measurement of entire ATF2 beamline

Wakefield of ATF2 beamline was evaluation by normalizing the wakefield of reference cavity. The reference cavity was put at MREF3FF location at 2016 October/November.

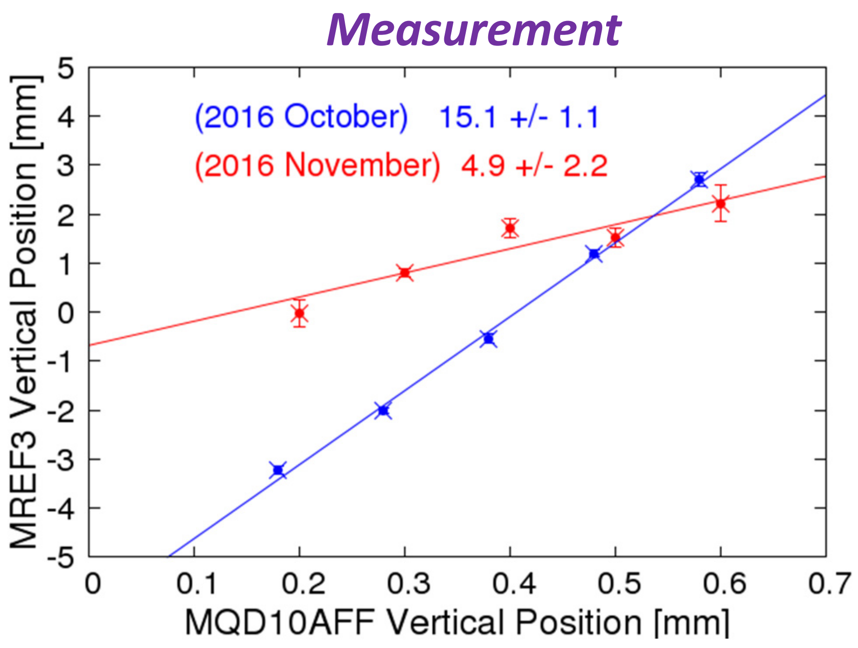


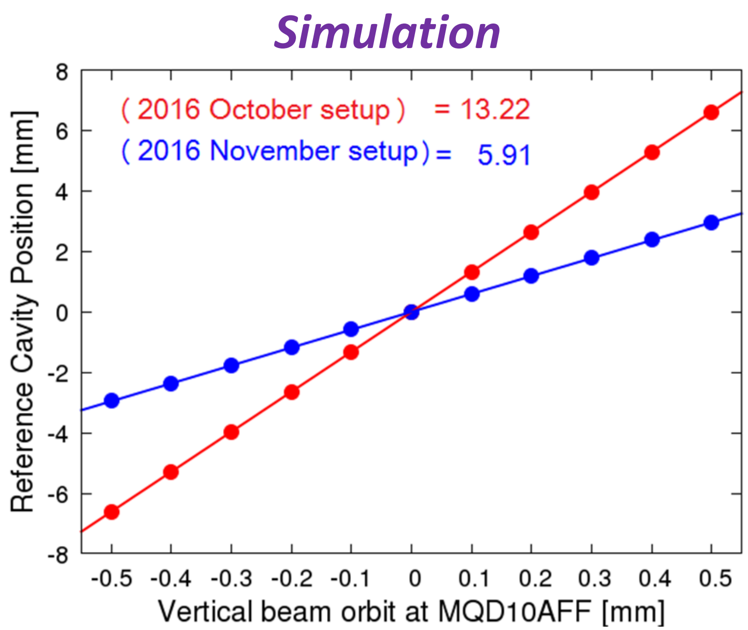






Comparison of simulation and measurement





Measured wakefield, which was normalized by the wakefield of the reference cavity, was consistent with the simulation expectation.

But, the simulation to evaluate the wakefield of entire ATF2 beamline was used that of "reference cavity only" (no masked-bellows etc.).

The wakefield effect of "reference cavity mover system" was roughly twice larger than that of "reference cavity only".

The amount of total wakefield for ATF2 beamline was also expected to twice as large as the ATF2 wakefield model in the SAD tracking simulation (effect of masked bellows etc.).

Summary

Wakefield evaluation of ATF2 beamline

The wakefield effects by single wakefield elements were consistent with the wakefield simulation both for orbit kick and IP beam size growth.
Basically, we can evaluate the ILC wakefield by using this simulation.

However, the wakefield kick of "reference cavity mover system" was roughly twice as large as that of "reference cavity only". Because the wakefield of masked bellows and masked flange gaps in "reference cavity mover system" was not negligible small.

The total wakefield of ATF2 beamline was evaluated by comparing the wakefield of "reference cavity mover system". The evaluated wakefield of ATF2 beamline was consistent with the wakefield model of ATF2 beamline.

But, the wakefields of masked bellows and masked flange gaps were not included in the ATF2 wakefield model. It was found that these wakefields were not negligible small.

Since the wakefield of "reference cavity mover system" was roughly twice as large as that of "reference cavity only", the total wakefield of ATF2 beamline was also expected to be roughly twice as large as ATF2 wakefield model.

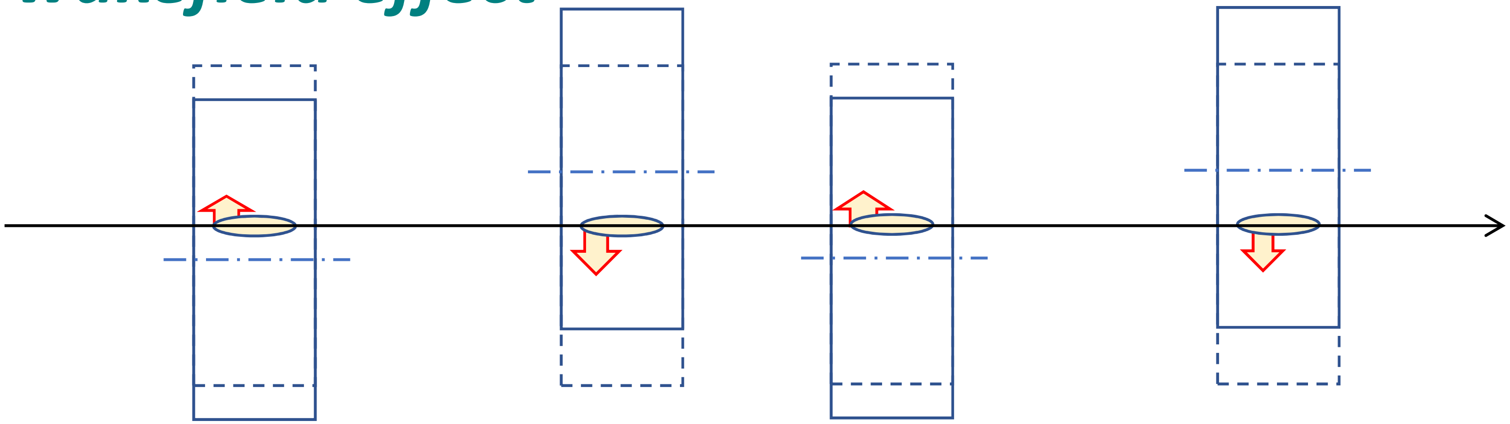
Intensity dependence reduction at ATF2 beamline

Contents

Dynamic intensity dependence evaluation and correction

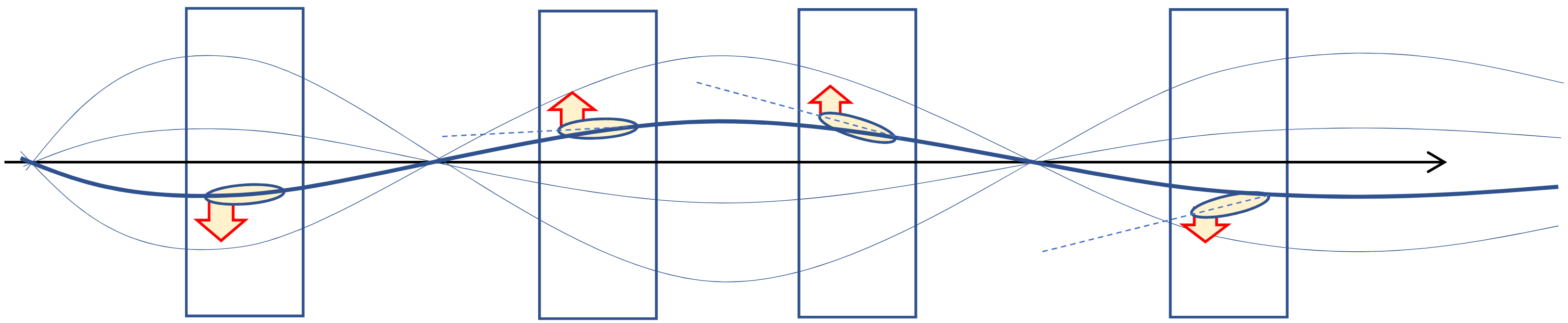
Static intensity dependence correction

Static wakefield effect



- *The wakefield is generated by* ***the misalignment and/or the beam orbit offset of vacuum component.***
- *Bunch tail is kicked by the wakefield, generated by the beam.*
- ***The kicked amplitude is proportional to the beam position offset w.r.t. the chamber center.***

Dynamic wakefield effect

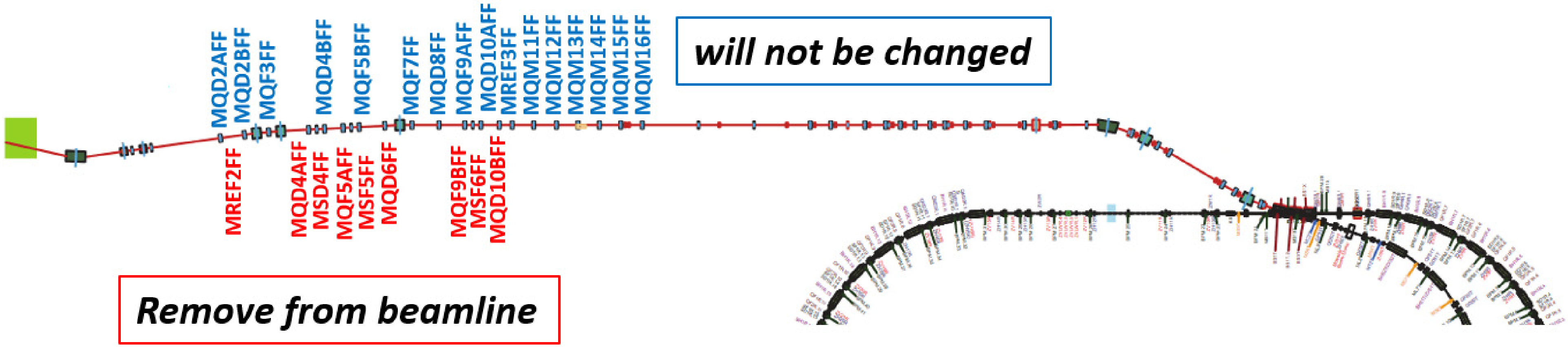


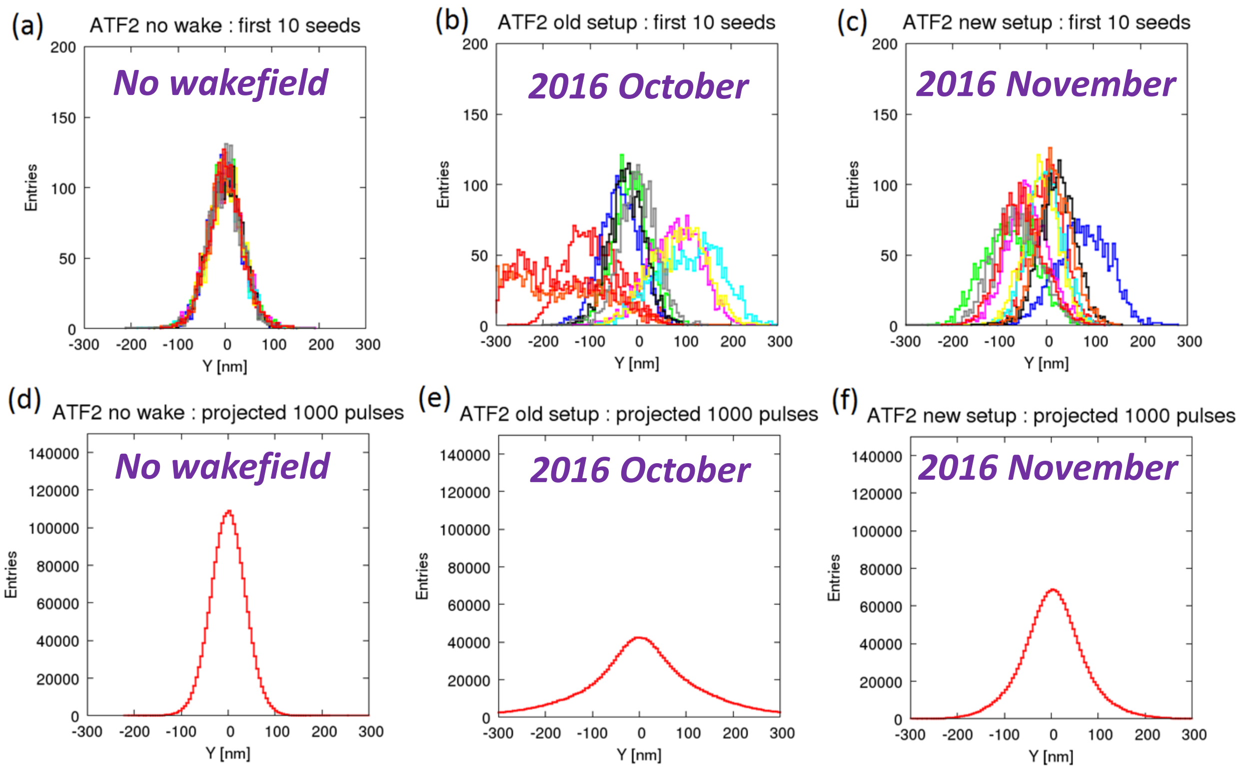
- *The wakefield is generated by* ***the beam orbit jitter of the beam****.*
- ***The effect is superposed****, because polarities of (y, y') are changed for IP angle jitter, simultaneously.*
- *Bunch tail is kicked by the wakefield, generated by the beam.*
- ***The kicked amplitude is proportional to the beam angular jitter amplitude****.*

Dynamic intensity dependence evaluation and correction

Dynamic intensity dependence simulation

The dynamic intensity dependence though IP angle jitter was simulated both for 2016 October/November wakefield setups.



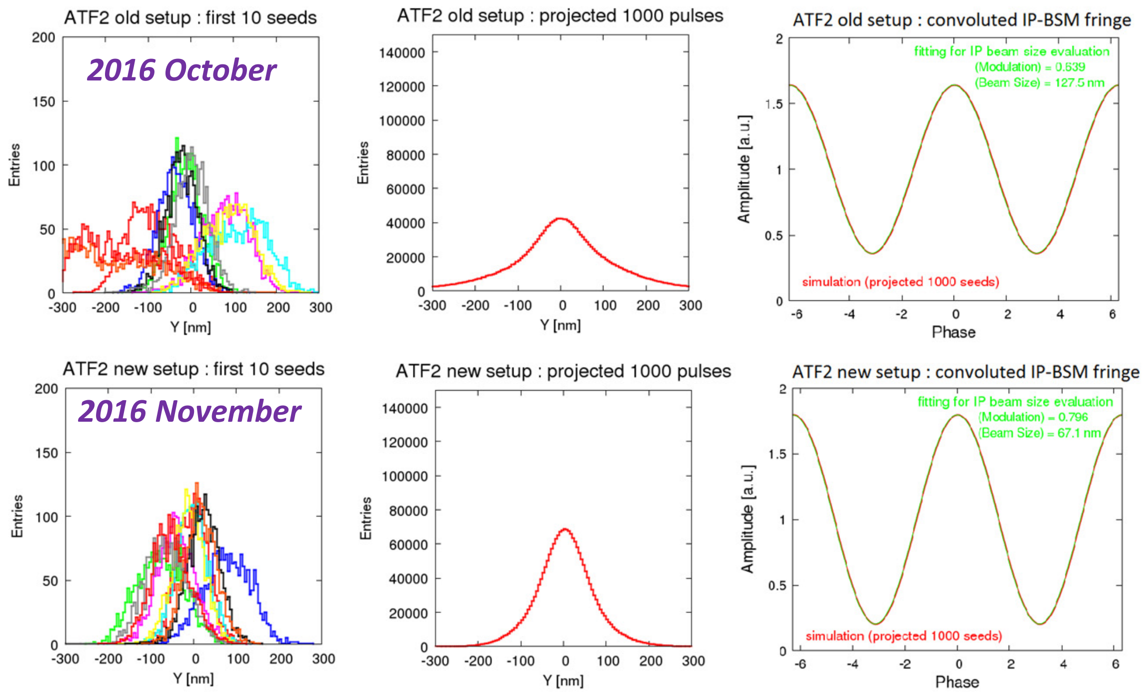


Beam had 30% of IP angular jitter. The bunch charge was assumed to $N = 1 \times 10^{10}$.

The projected beam size was increased, and the beam had a large tail by the wakefield.

The IP beam profile for no wakefield beamline is not changed, even when the beam has IP angle jitter.

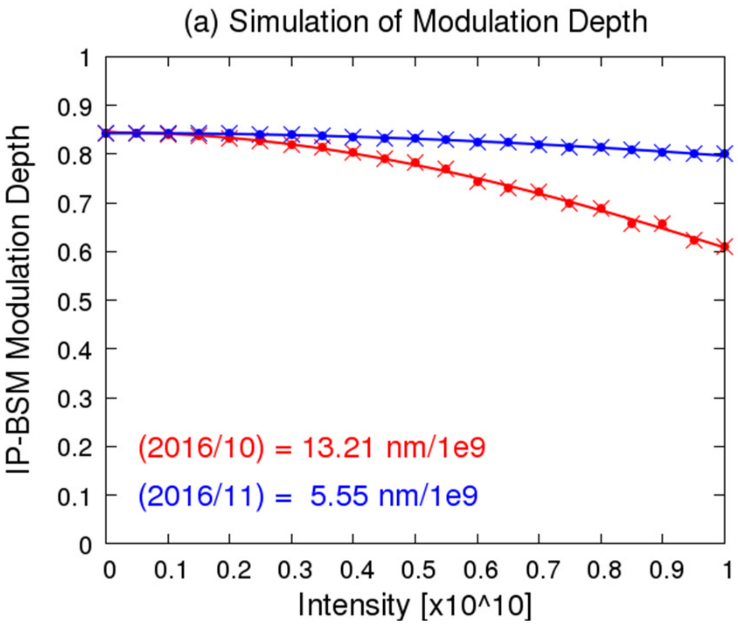
Intensity dependence simulation with IP-BSM



Beam had 30% of IP angular jitter. The bunch charge was assumed to $N = 1 \times 10^{10}$.

The projected beam size was increased, and the beam had a large tail by the wakefield.

Since IP-BSM is not single path monitor, not only IP beam size growth, but also IP position jitter affect to IP beam size evaluation.



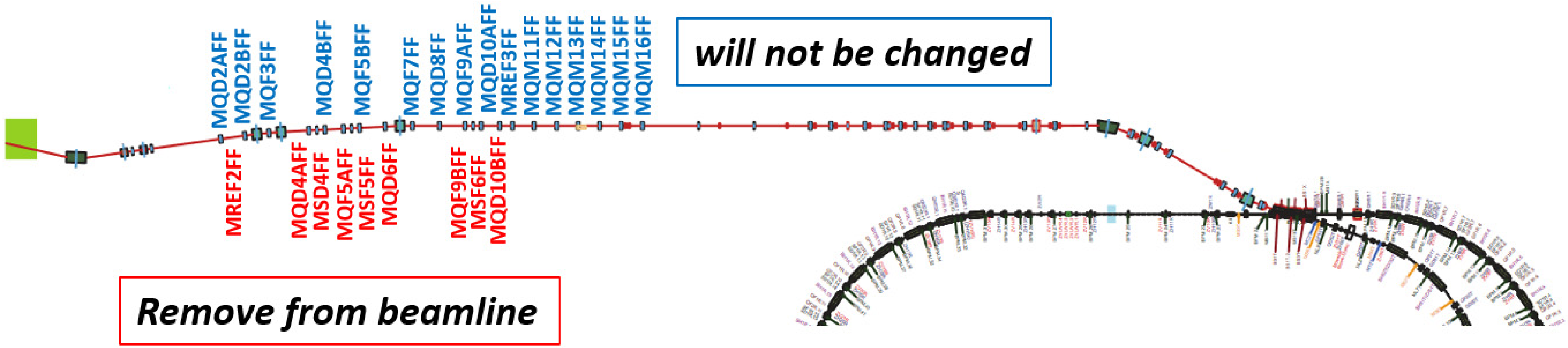
Dynamic intensity dependence was evaluated by changing the bunch charge for nominal ATF2 optics.

The IP angle jitter was assumed to be 30% of IP divergence.

Intensity dependence (simulation)

	2016 October	2016 November
Intensity Dep.	$13.21\ \mathrm{nm}/10^9$	$5.55\ \mathrm{nm}/10^9$
IP angle jitter	$104\ \mu\mathrm{rad}$	$104\ \mu\mathrm{rad}$
Normalized	$0.127\ \mathrm{nm}/10^9/\mu\mathrm{rad}$	$0.053\ \mathrm{nm}/10^9/\mu\mathrm{rad}$

Dynamic intensity dependence measurement



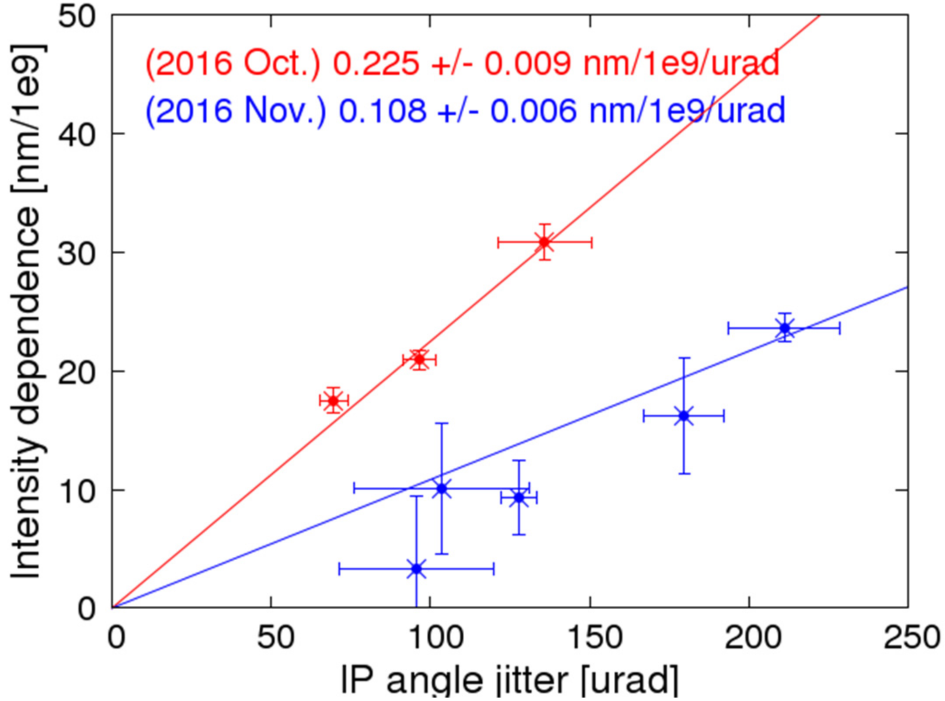
When IP beta function was changed, the IP beam divergence and the IP angle jitter is also changed.

The dynamic intensity dependence was evaluated for several beam optics with different IP beta function.

IP angle jitter was evaluated by the jitter measurement, and the intensity dependence was evaluated by IP-BSM measurement for several beam charge.

The jitter normalized intensity dependence was evaluated by taking the correlation of IP angular jitter and the intensity dependence.

Intensity dependence measurement at 2016 October/November



Comparison of simulation and measurement

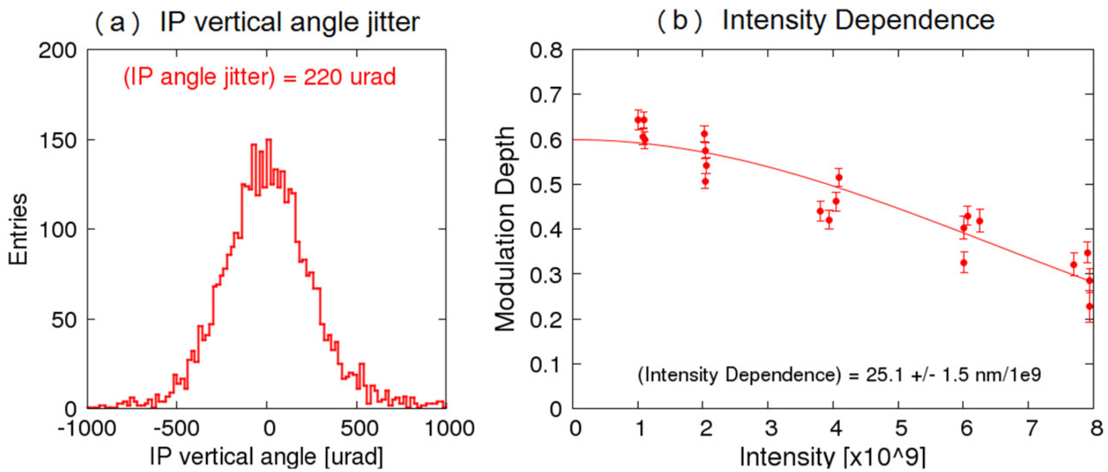
Jitter normalized intensity dependence (simulation)

2016 October	2016 November
$0.127\ \mathrm{nm}/10^9/\mu\mathrm{rad}$	$0.053\ \mathrm{nm}/10^9/\mu\mathrm{rad}$

Jitter normalized intensity dependence (measurement)

We measured the several jitter normalized intensity dependence after the wakefield reduction on 2016 November.

Example of measurement at 2018 June



Summary of the jitter normalized intensity dependence measurement

Date	Intensity dependence
2016 October	$0.225\ \mathrm{nm}/1\times10^9 e^-/\mu\mathrm{rad}$
2016 November	$0.108\ \mathrm{nm}/1\times10^9 e^-/\mu\mathrm{rad}$
2018 May	$0.125\ \mathrm{nm}/1\times10^9 e^-/\mu\mathrm{rad}$
2018 June	$0.114\ \mathrm{nm}/1\times10^9 e^-/\mu\mathrm{rad}$

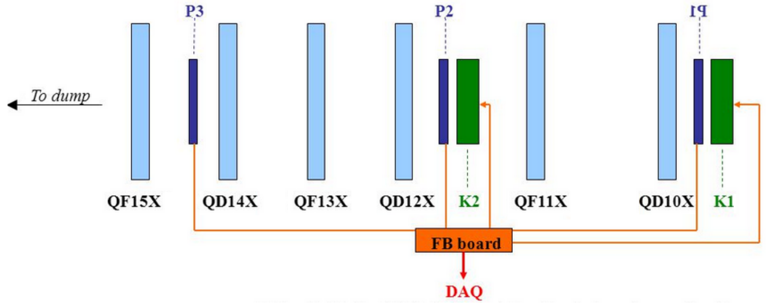
Measurement was consistent each other.

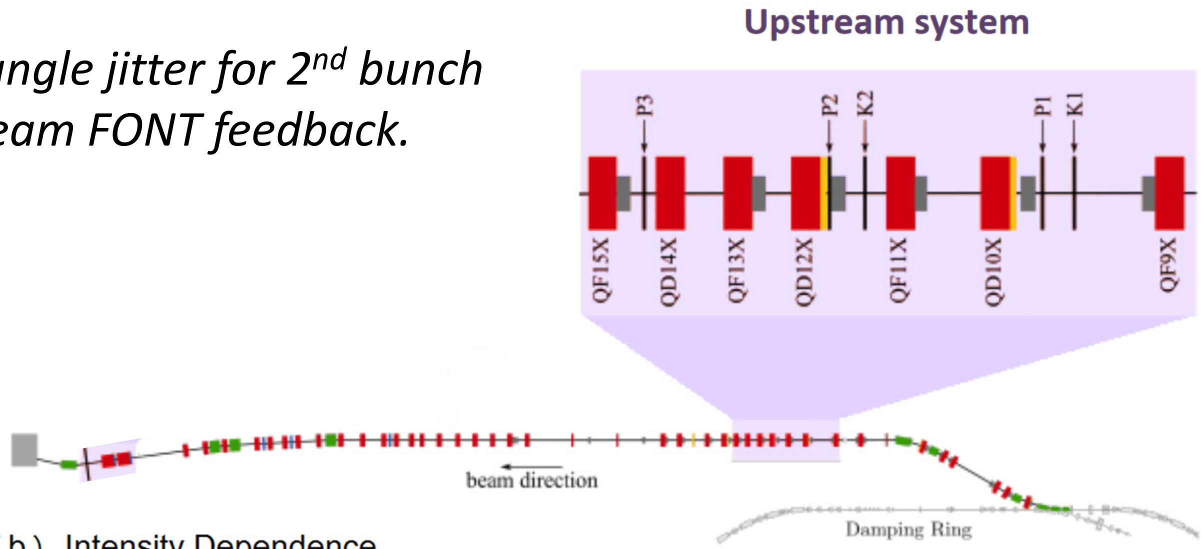
The measured intensity dependence was roughly twice as large as simulation expectation.
But, the ATF2 model was ignored the wakefield of masked bellows and masked flange gaps.

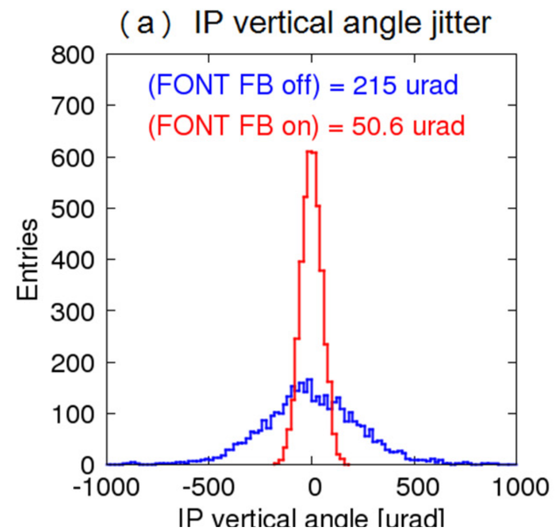
IP angle jitter reduction with upstream FONT FB

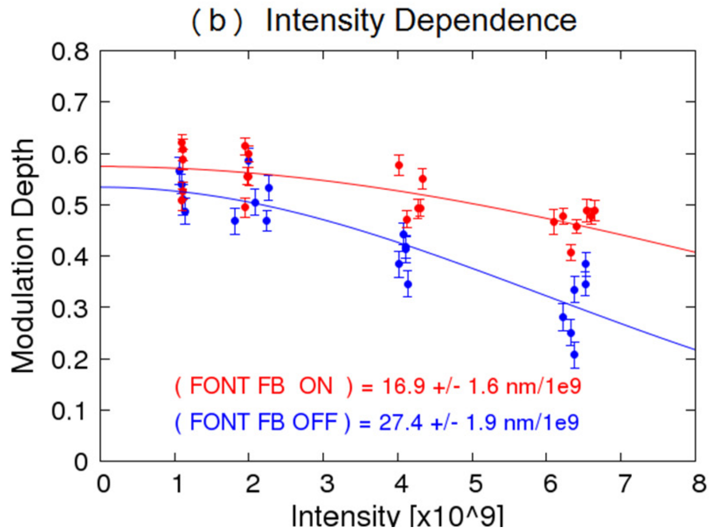
Special thanks to Oxford group for this demonstration

We can reduce the IP position and angle jitter for 2nd bunch by using 2 dimensional (y-y') upstream FONT feedback.









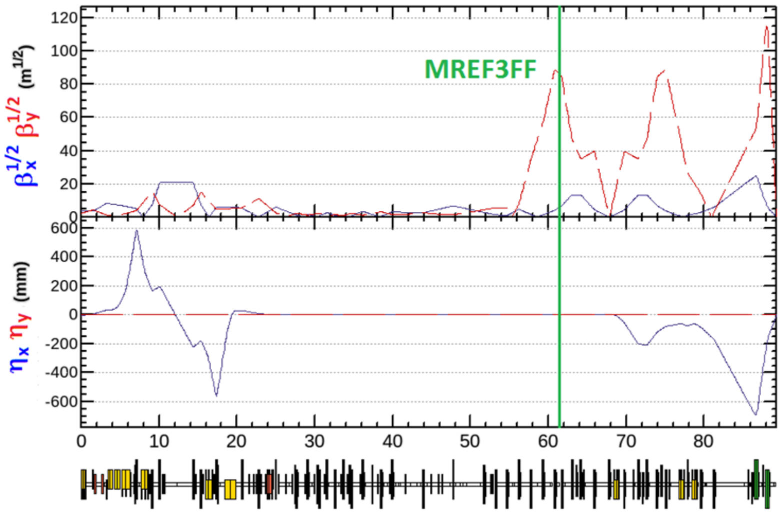
When the IP angle jitter was reduced by using the 2D upstream FONT FB, intensity dependence was also reduced.

It was confirmed that the jitter reduction with FB is effective to reduce the intensity dependence.

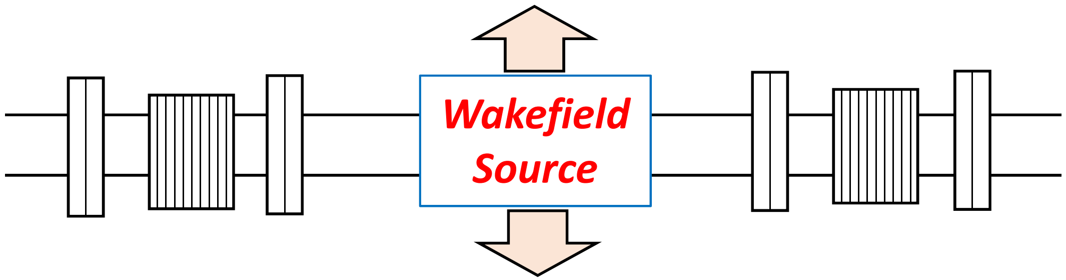
	IP angle jitter	Intensity dependence
Single bunch operation	220 μrad	25.1 ± 1.5 nm$/1 \times 10^9 e^-$
2 bunch operation without FB	215 μrad	27.4 ± 1.9 nm$/1 \times 10^9 e^-$
2 bunch operation with FB	50.6 μrad	16.9 ± 1.6 nm$/1 \times 10^9 e^-$

Static intensity dependence correction

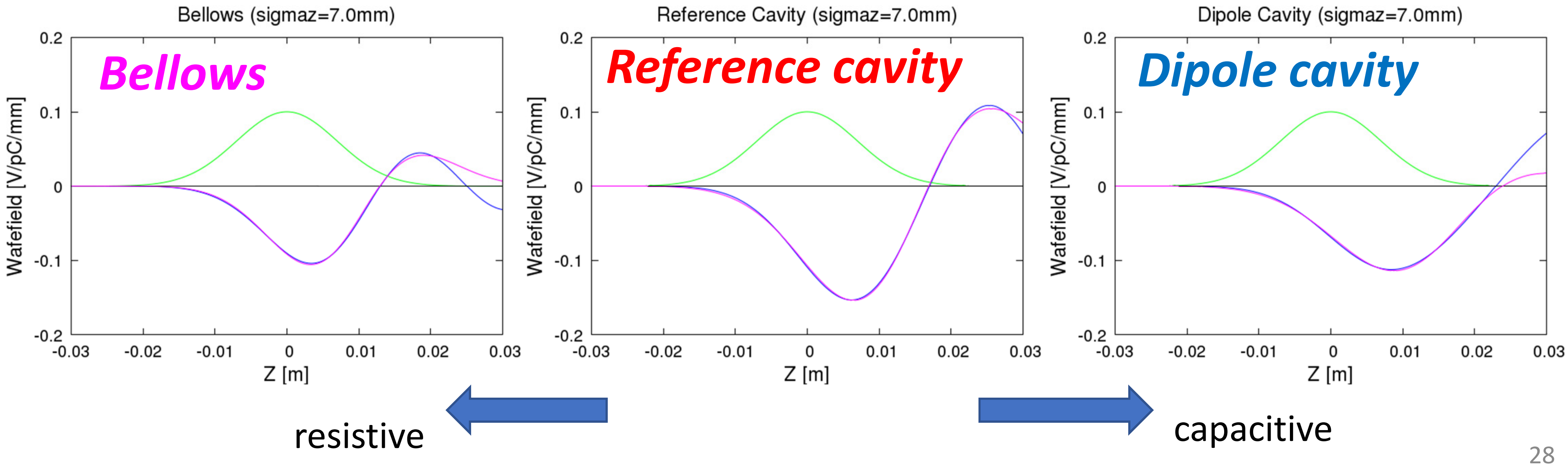
Wake source dependence of the wake field compensation



By changing the wakefield source position, the wakefield of ATF2 beamline can be cancelled.



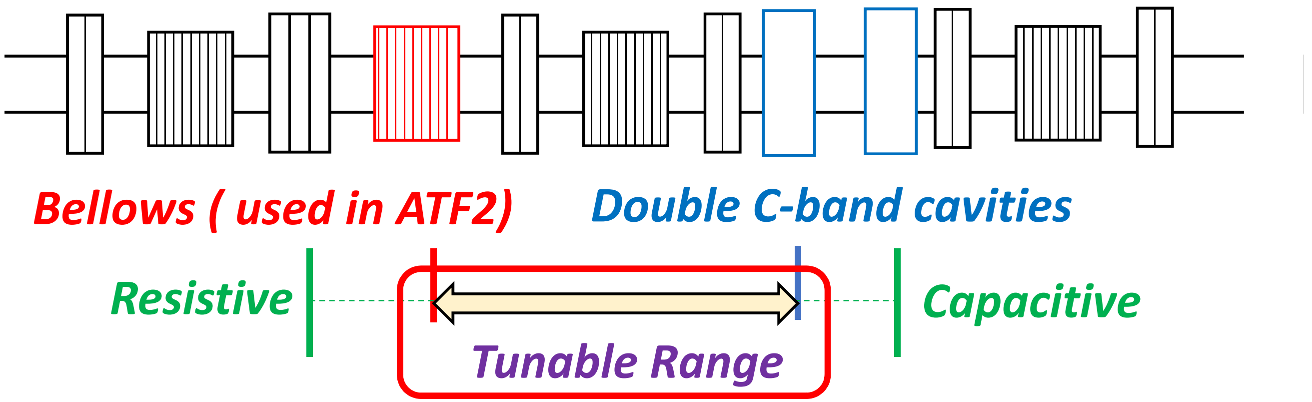
We can select several type of wakefield source for the collection.



Simulation of the wake field compensation with 2 independence wake sources

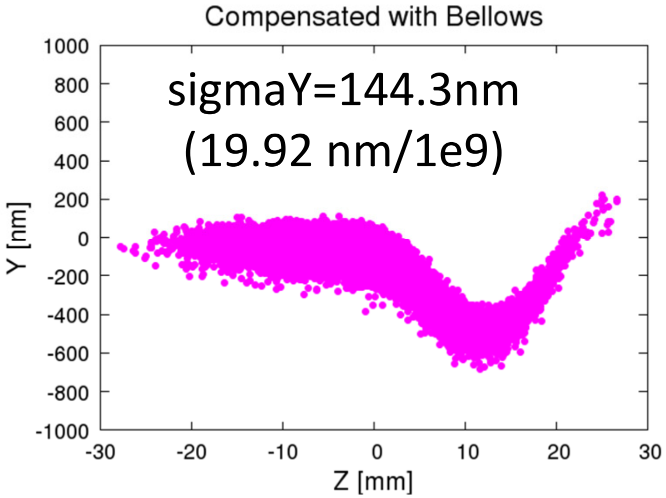
proposed at LCWS2018

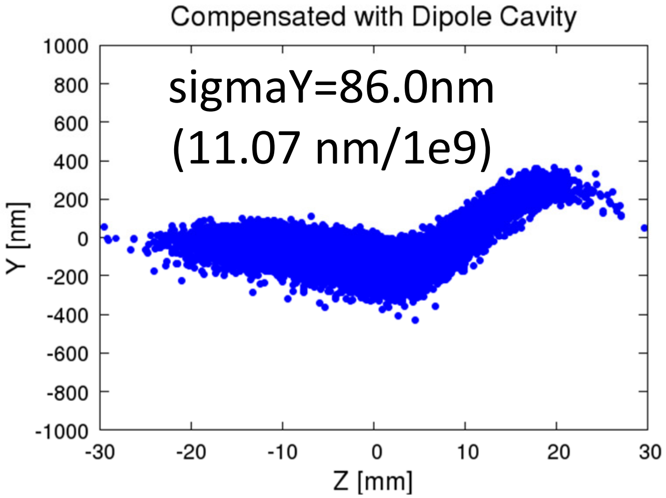
By using ATF2 nominal bellows (resistive), and C-band cavity (capacitive), the tunable range of the wakefield correction makes wider.

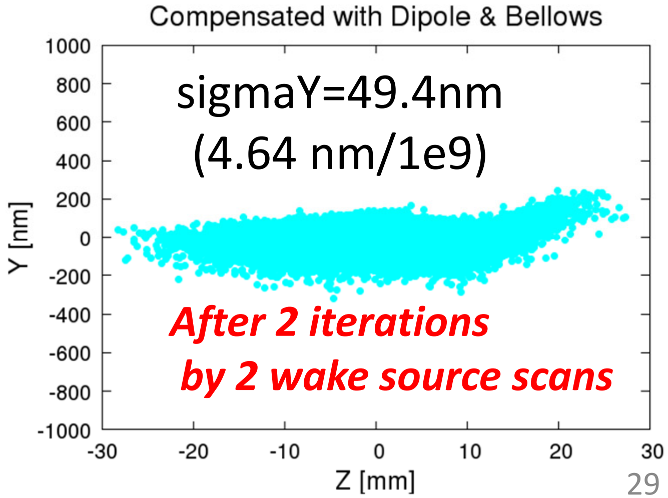


IP distribution after wake field compensation

N = 7e9 ,   (MQD10AFF) = +0.5mm



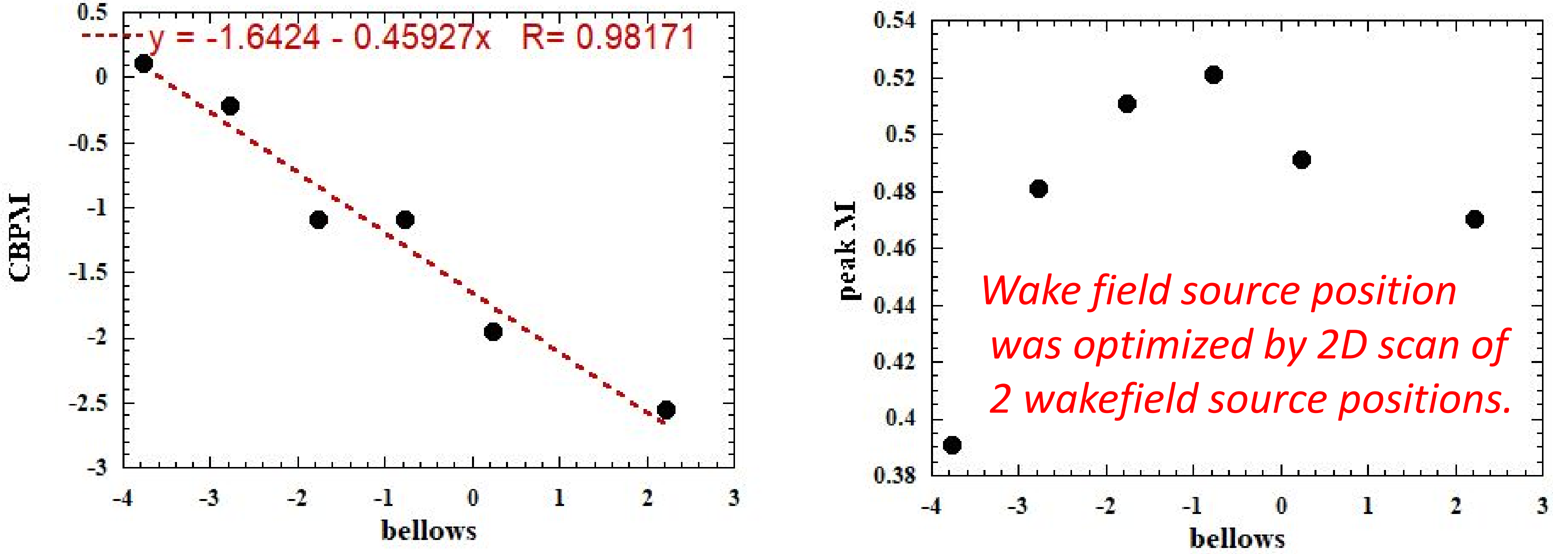




Optimization of beam orbit and wakefield sources

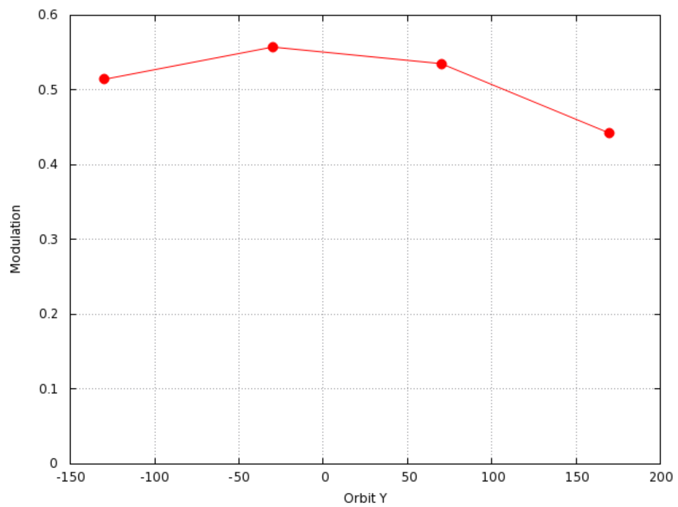
tuned by K. Kubo and M. Fukuda Updated

Optimization of wakefield sources



Wake field source position was optimized by 2D scan of 2 wakefield source positions.

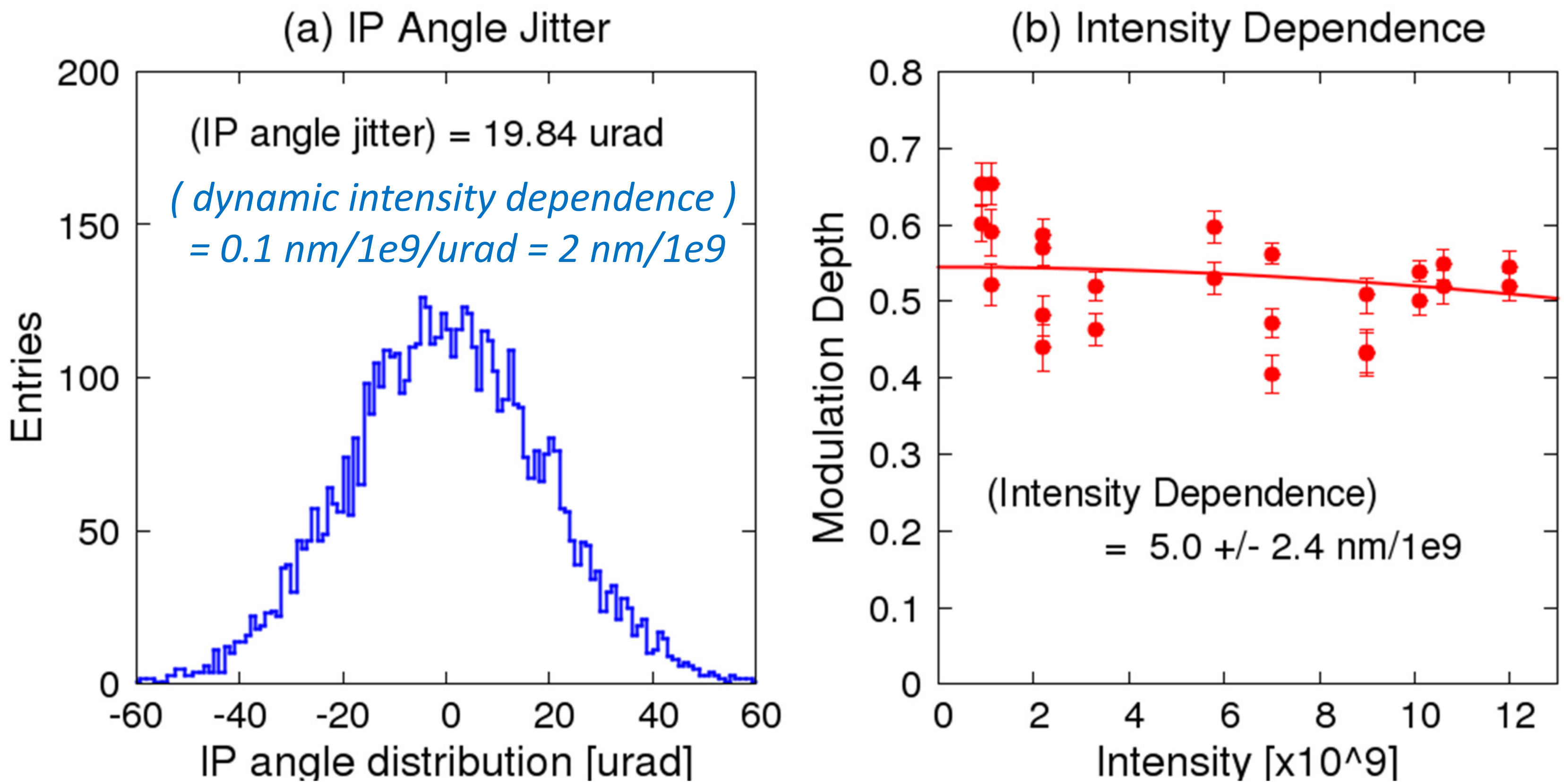
Optimization of beam orbit



FD phase beam orbit was optimized to be minimized the intensity dependence by changing ATF2 orbit FB target position.

Intensity dependence measurement *Updated*

Intensity dependence measurement after the orbit and wakefield source optimization



By using a little bit large betay optics (10 x 5 optics),*
the dynamic effect was kept to be enough small.

The minimum intensity dependence was reduced 8.5 nm/1e9 => 5.0 nm/1e9.

Summary *Updated*

Intensity dependence reduction at ATF2 beamline

The dynamic component of intensity dependence was roughly twice as large as the simulation expectation both for 2016 October/November.
The discrepancies were come from the effect of masked bellows, and flange gaps etc.

The static component : 8.8 nm/1e9 => 5.0 nm/1e9
=> the IP beam size from 37nm to 37.3 nm (0.9% beam size growth) at N=1e9

The dynamic component : 0.1 nm/1e9/urad
=> 10.4nm/1e9 for ATF2 nominal optics with 30% angular jitter.

The total intensity dependence : 11.4 nm/1e9 (dominant of dynamic effect)
=> the IP beam size from 37nm to 38.7 nm (4.7% beam size growth) at N=1e9

We demonstrated the dynamic effect of the intensity dependence can be reduced by using 2-dimensional (y-y') upstream FONT feedback (special thanks to Oxford group).
By using the feedback technique, the intensity dependence can be reduced for ILC, too.

Simulation of Intensity dependence for ILC250 IP beam size

Contents

Numerical scaling from ATF2 to ILC250 intensity dependence

Simulation of the effect for dynamic intensity dependence

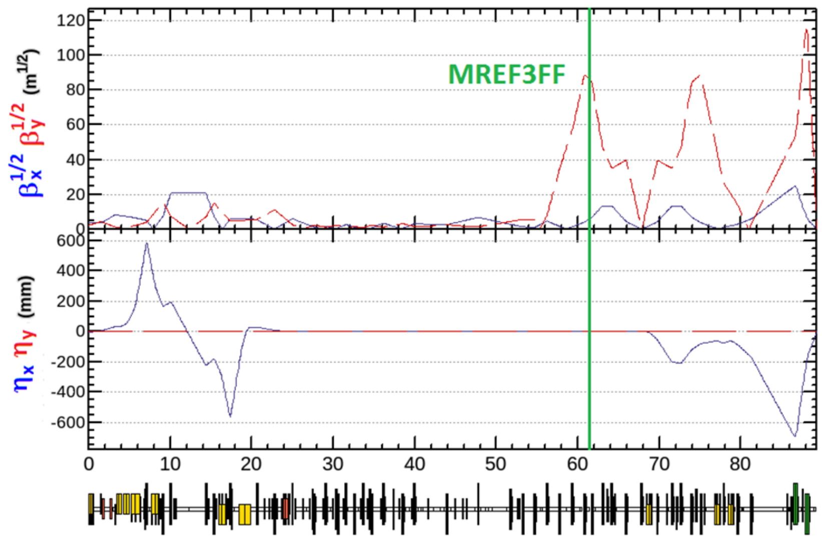
Simulation of static intensity dependence correction

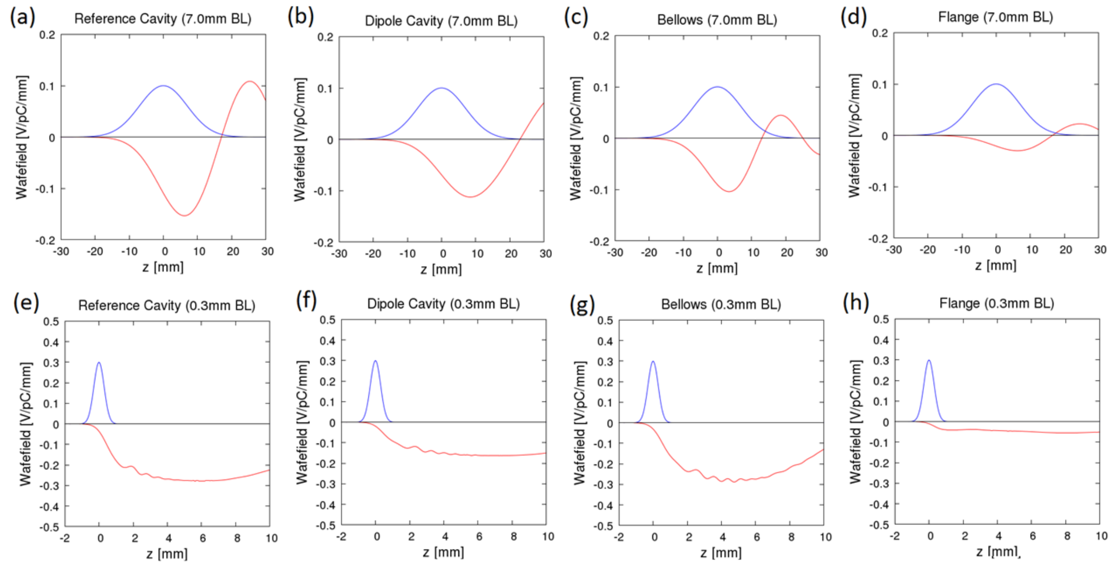
- *ATF2 tuning simulation with wakefield kick*
- *ILC250 tuning simulation with wakefield kick*

Numerical scaling from ATF2 to ILC250 intensity dependence

Wakefield effect for ATF2/ILC bunch length

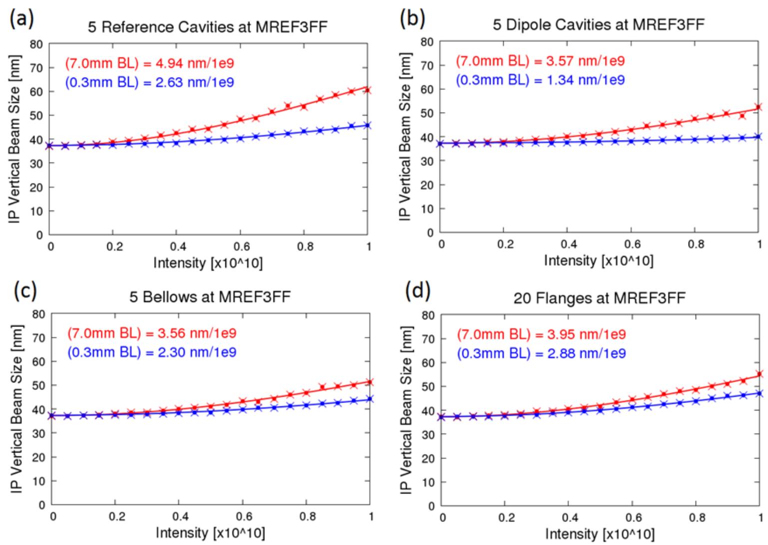
The effect was Simulated by putting wakefield source on ATF2 beamline.
Initial beam, which charge is $N = 1 \times 10^{10}$, has 30% of angular jitter





Tracking simulation

The difference is the bunch length only.



Results of dynamic intensity dependence simulation

Bunch length	5 reference cav.	5 dipole cav.	5 bellows	20 flanges
7.0 mm	4.94 nm/1×10^9	3.57 nm/1×10^9	3.56 nm/1×10^9	3.95 nm/1×10^9
0.3 mm	2.63 nm/1×10^9	1.34 nm/1×10^9	2.30 nm/1×10^9	2.88 nm/1×10^9
0.3 mm / 7.0 mm	0.53	0.38	0.65	0.73

The effect of wakefield kick for 0.3mm is smaller than that for 7mm.
The effects of bellows and flange gap are larger for ILC bunch length.
It is very important to mask the flange gap and bellows for ILC.

Numerical evaluation of dynamic intensity dependence for ATF2 and ILC250

Effect of wakefield with orbit distortion (orbit jitter) was evaluated as

$$\frac{\sqrt{\sigma^2 - \sigma_0^2}}{\sigma_0} \propto \frac{qW}{E} \sum \beta$$

q : bunch charge
W : strength of wakefield
E : beam energy
ε : emittance
β : beta-function at wake source

Evaluation by same bunch charge

evaluated by K.Kubo at ALCW2018

	ILC250	ATF2	Ratio of effect
E (GeV)	125	1.3	0.01
W (bunch length effect)	0.4～0.7	1	0.4～0.7
$\sum \beta$ (m)	3.9e5	6.1e4	6.4
Total			0.026～0.045

The ATF2 wakefield effect by random misalignment at N=1e9 corresponds to that of ILC250 at N= 2.2-3.8e10.

Numerical evaluation of static intensity dependence for ATF2 and ILC250

Effect of wakefield with random misalignment was evaluated as

$$\frac{\sqrt{\sigma^2-\sigma_0^2}}{\sigma_0} \propto \frac{qW}{E\sqrt{\varepsilon}}\sqrt{\sum \beta}$$

q : bunch charge
W : strength of wakefield
E : beam energy
ε : emittance
β : beta-function at wake source

Evaluation by same bunch charge

evaluated by K.Kubo at ALCW2018

	ILC250	***ATF2***	***Ratio of effect***
E (GeV)	*125*	*1.3*	*0.01*
W (bunch length effect)	*0.5～0.7*	*1*	*0.5～0.7*
Emittance (pm)	*1.6*	*12*	*2.7*
$\sum \beta$ (m)	*3.9e5*	*6.1e4*	*2.5*
Total			*0.033～0.047*

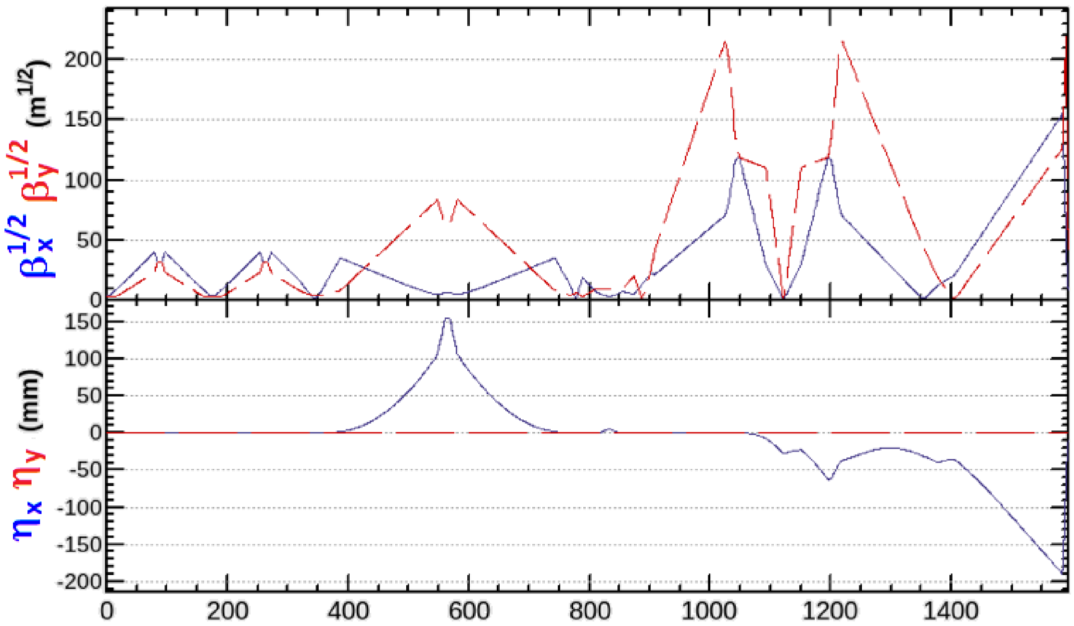
The ATF2 wakefield effect by random misalignment at N=1e9 corresponds to that of ILC250 at N= 2.1-3.0e10.

Simulation of the effect for dynamic intensity dependence

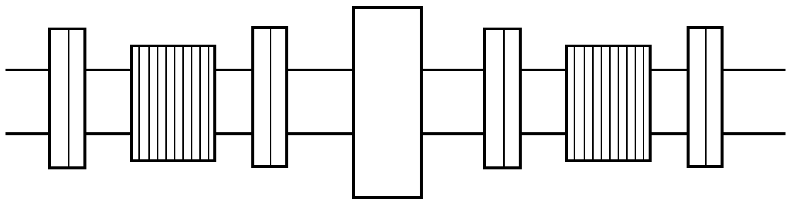
Wakefield sources of ILC beamline in simulation

Total 107 cavity BPM systems were put into the ILC collimator & final focus beamline.

Beam optics for ILC collimator / final focus



Component arrangement at BPM in simulation



	Case 1	Case 2
	1 BPM	
	2 bellows	⇒ masked
	4 flanges	⇒ masked

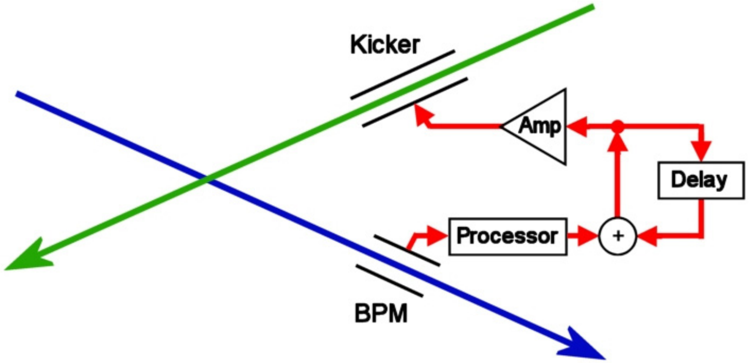
Case 1 wakefield condition *: bellows and flange gaps are not masked.*

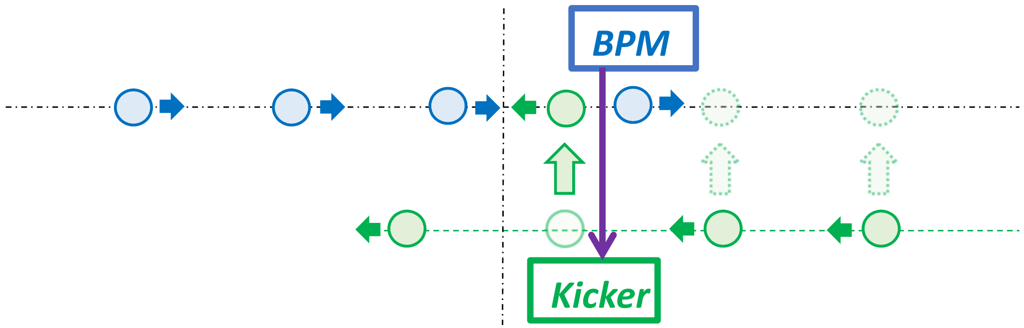
Case 2 wakefield condition *: cavity BPM wake is only put into beamline.*
(bellows and flange gaps are masked.)

The actual wakefield condition will be expected between these 2 cases.

Simulation with FONT IP position FB

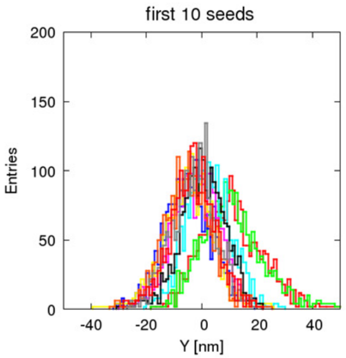
FONT IP position FB

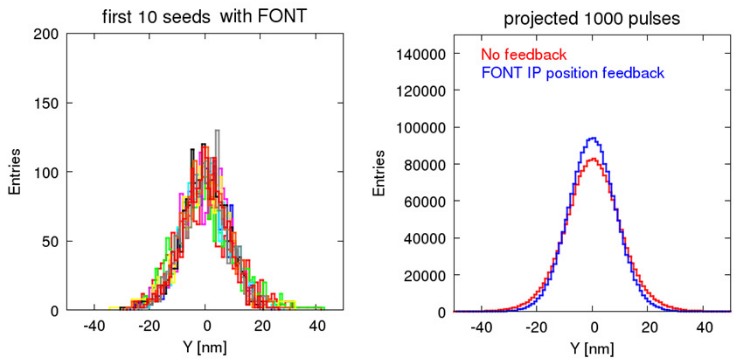




Since IP position jitter will be corrected by using FONT IP FB, the position jitter, which generated by wakefield kick, will be corrected for ILC.

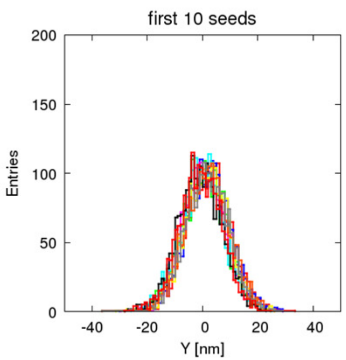
(a) Wakefiled components : Case 1

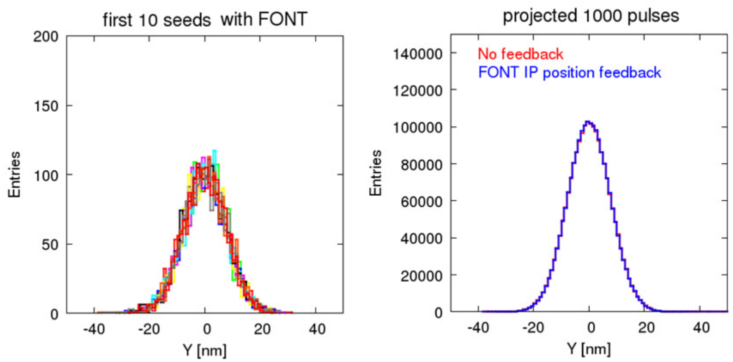




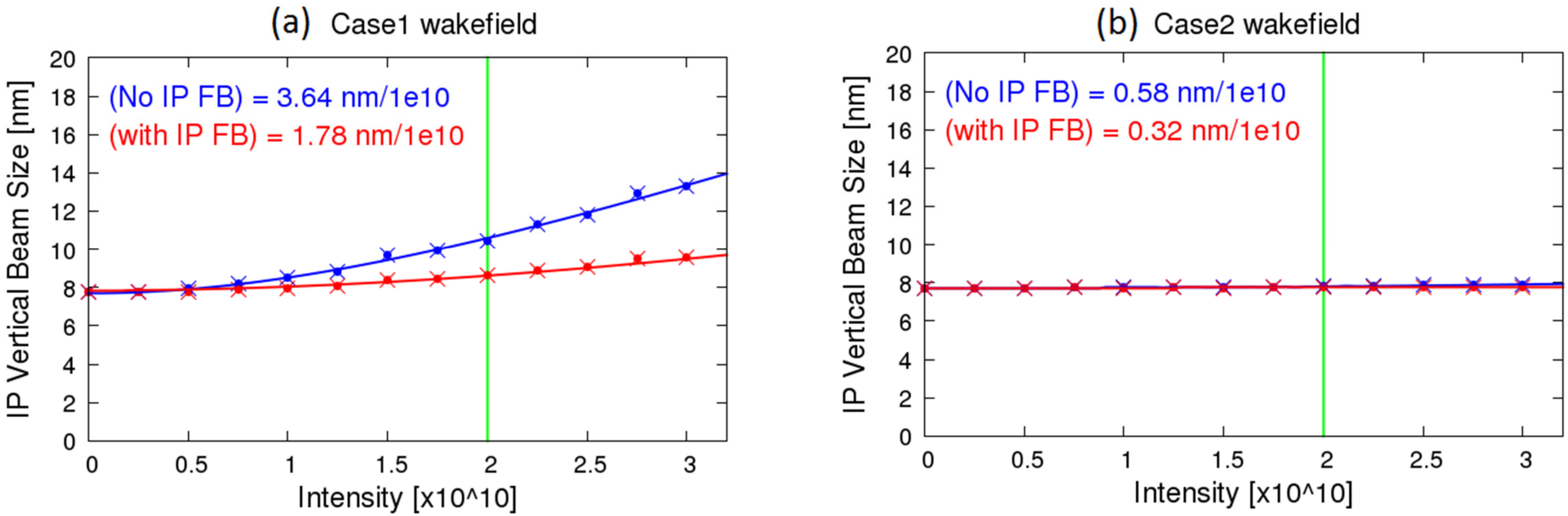
FONT IP position FB

(b) Wakefield components : Case 2





Simulation of dynamic intensity dependence for ILC

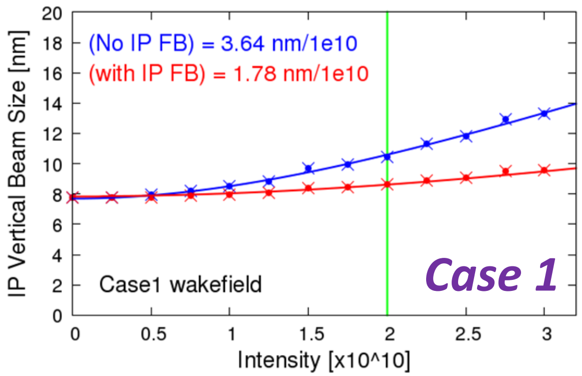


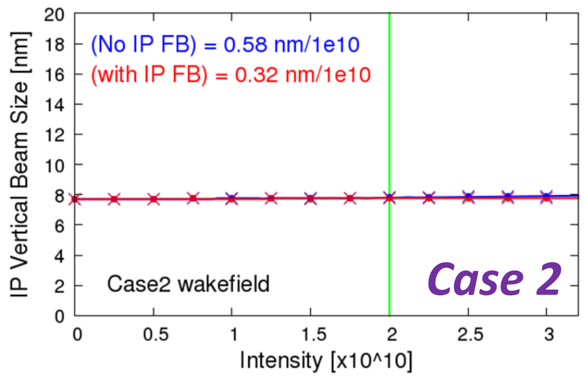
	no IP feedback	with IP position feedback
Case 1	10.57 nm (37.96%)	8.45 nm (10.27%)
Case 2	7.75 nm (1.14%)	7.69 nm (0.35%)

The dynamic intensity dependence was enough small even when any feedback will not be applied for case 2 wakefield condition.
It suggests that the wakefield mask to bellows and flange gaps are very important for ILC.

The dynamic intensity dependence was reduced to 38% -> 10% by using FONT IP position FB, even for case 1 wakefield condition.

ILC dynamic intensity dependence with 2D feedback

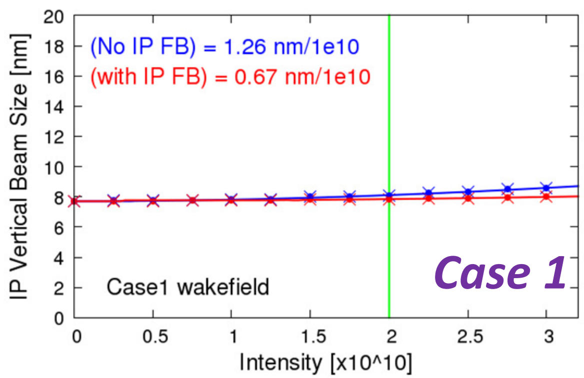


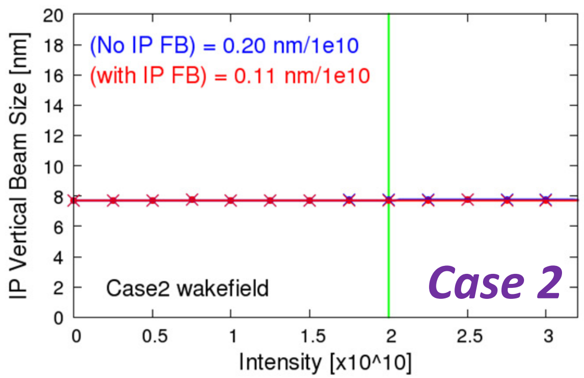


30% angle jitter

FONT 2-dimensional (y-y') upstream FB

10% angle jitter





FONT IP position FB

		no IP feedback	with IP feedback
Case 1	30% jitter	10.57 nm (37.96%)	8.45 nm (10.27%)
	10% jitter	8.06 nm (5.27%)	7.78 nm (1.52%)
Case 2	30% jitter	7.75 nm (1.14%)	7.69 nm (0.35%)
	10% jitter	7.67 nm (0.14%)	7.66 nm (0.04%)

FONT 2D (y-y') upstream FB

Intensity dependent effect was reduced to 38% -> 1.5% by using IP&2D FBs for case 1 wakefield.

Simulation of static intensity dependence correction

ATF2 tuning simulation with wakefield kick

ILC250 tuning simulation with wakefield kick

ATF2 tuning simulation with wakefield kick

ATF2 IP beam size tuning simulation procedure

Quadrupole Errors

Alignment (x,y)	100 μm
K1 strength	0.1%
K2 strength	0.1%
Rotation	100 μrad
Quad-BPM	50 μm

Sextupole Errors

Alignment (x,y)	100 μm
K2 strength	0.1%
Rotation	100 μrad
Sext-BPM	50 μm

Dipole Errors

Alignment (x,y)	100 μm
Rotation	100 μrad
Dipole-BPM	100 μm

Vacuum chamber position error
300μm

Carbon Wire
Beam orbit tuning
QF1FF strength (H)
QD0FF strength (V)
QD0FF rotation (V)
Sextupole ON
AX knob (H)
EX knob (H)
AY knob (V)
EY knob (V)
Coup2 knob (V)

→ $M_{008} > 0.30$

IP-BSM 8degree
AY knob (V)
EY knob (V)
Coup2 knob (V)

2 times

→ $M_{030} > 0.30$

IP-BSM 30degree
Y24 knob (V)
Y46 knob (V)
AY knob (V)
EY knob (V)
Coup2 knob (V)

2 times

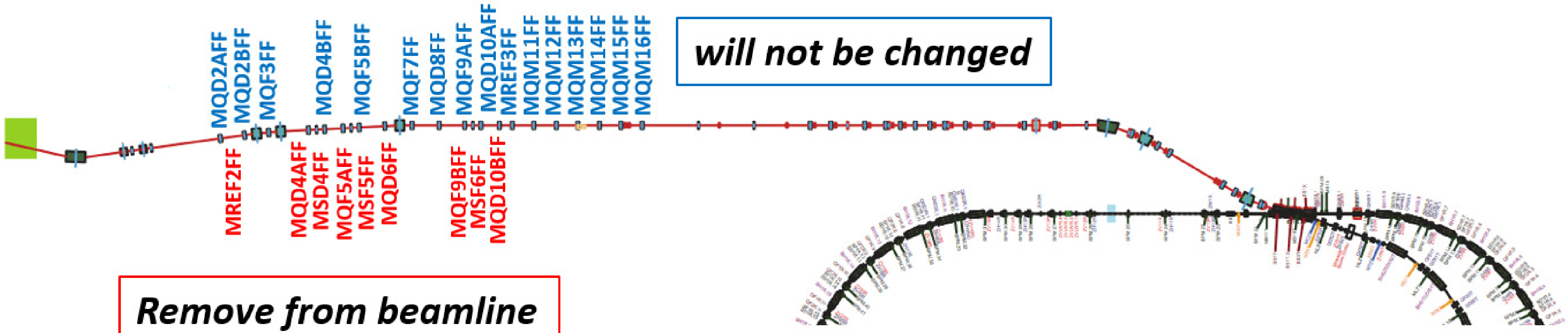
→ $M_{174} > 0.15$

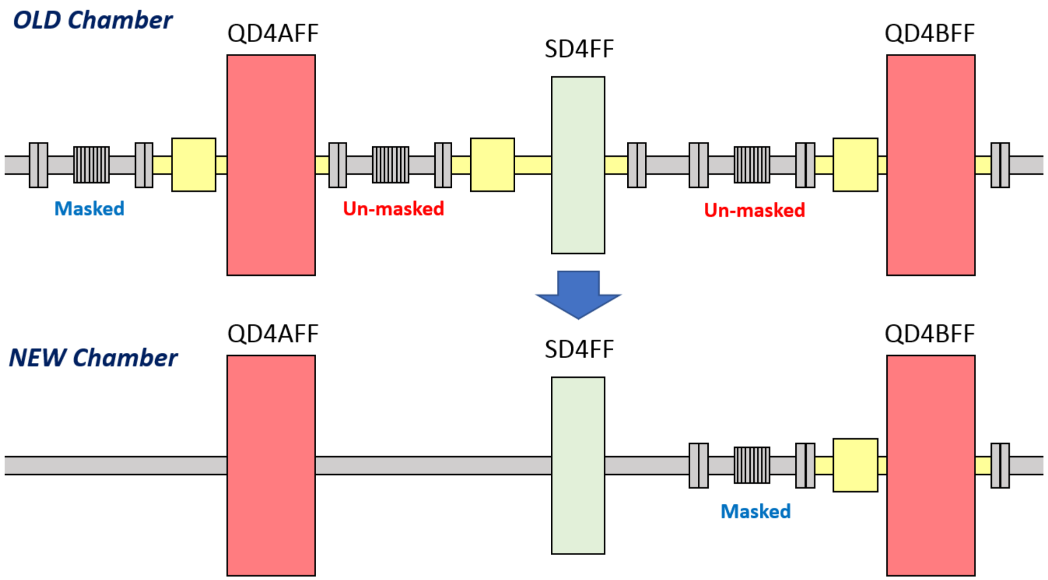
IP-BSM 174 degree
Y24 knob (V)
Y46 knob (V)
AY knob (V)
EY knob (V)
Coup2 knob (V)
Y22 knob (V)
Y26 knob (V)
Y66 knob (V)
Y44 knob (V)
AY knob (V)
EY knob (V)
Coup2 knob (V)

3 times

Wakefield components of ATF2 beamline

The wakefield components were reduced at 2016 November.
The wakefields for both wakefield settings were evaluated.





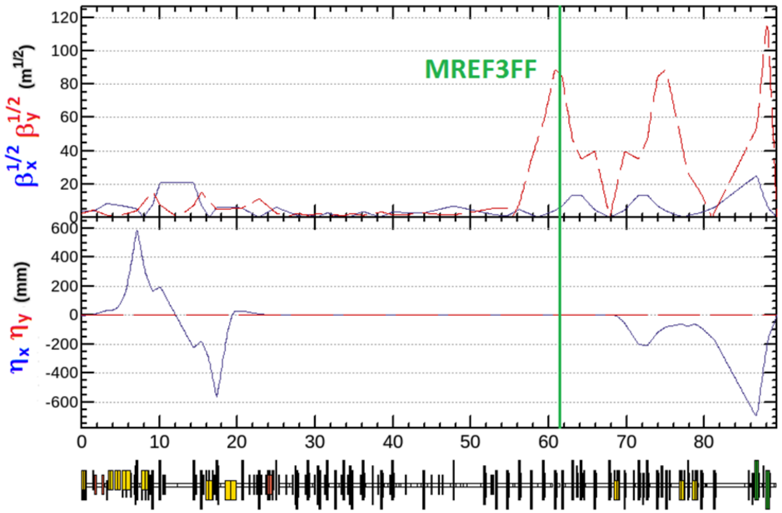
Number of elements overall ATF2 beamline

	Cavity BPM	Un-mask Bellows	Flange gap
OLD setup	23	11	87
NEW setup	15	5	69
Difference	8	6	18

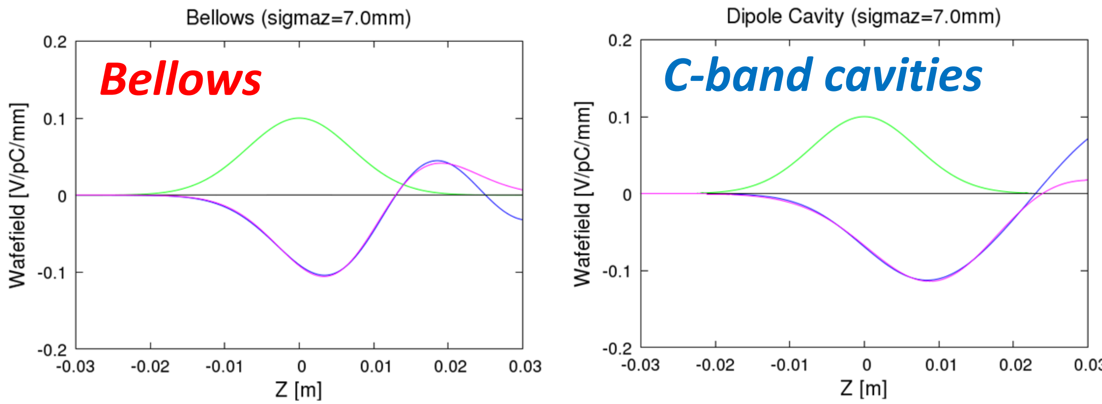
Wakefield correction with wakefield source at ATF2

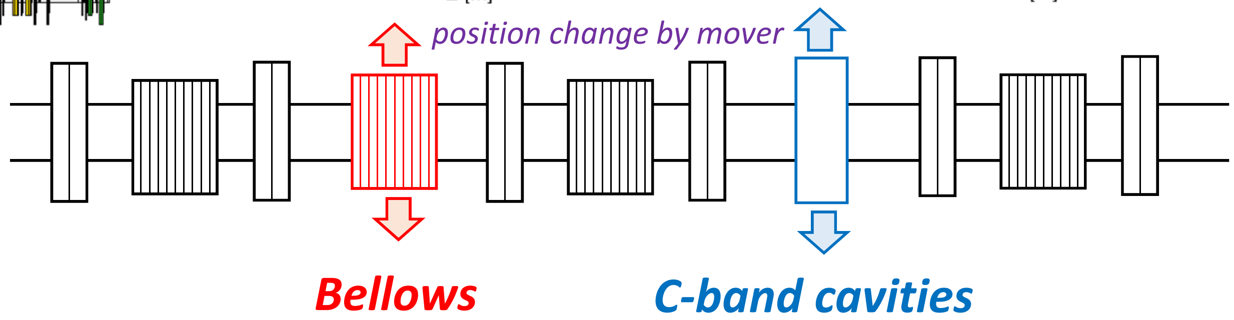
Wakefield sources on mover are put in ATF2 beamline.

The static wakefield is corrected by changing the positions of wakefield sources at ATF2.



Wakefield was simulated by A. Lyapin.

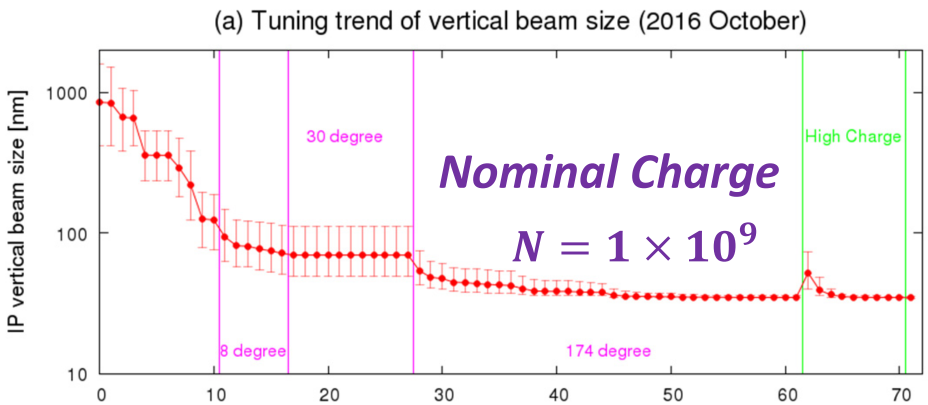


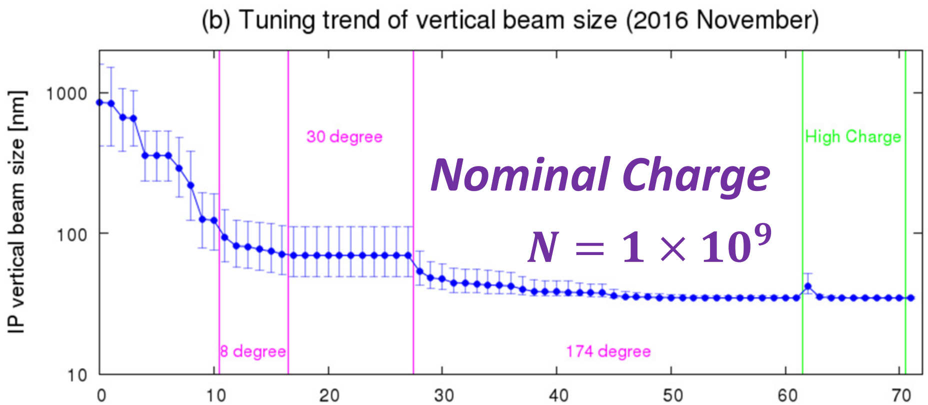


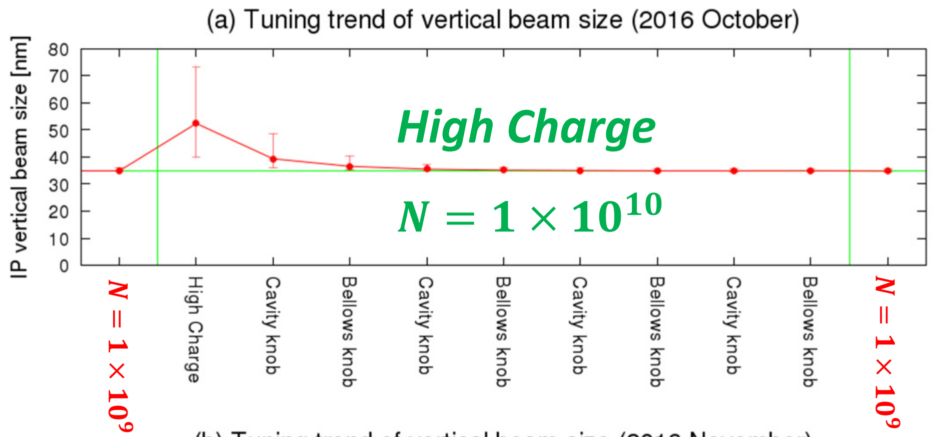
By setting the position of the wakefield sources to appropriate positions, the wakefield of entire ATF2 beamline can be corrected.

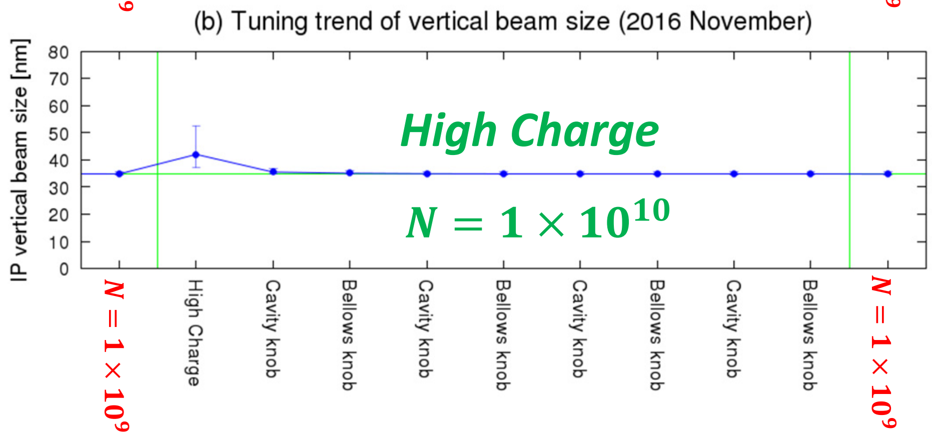
ATF2 IP beam size tuning simulation results

- IP beam size tuning is done by the low charge ($N = 1 \times 10^9$).
- After the IP beam size tuning the beam charge is increased to high charge ($N = 1 \times 10^{10}$).
- Wakefield tuning is done by wakefield knobs
- The bunch charge is reduced to the nominal charge ($N = 1 \times 10^9$).









$N = 1 \times 10^{10}$

High charge for wakefield correction

Intensity dependence can be reduced by wakefield optimization at high charge

ILC250 tuning simulation with wakefield kick

ILC250 IP beam size tuning simulation results

IP beam size can be reduced by applying the same tuning procedure of ATF2.

Quadrupole Errors

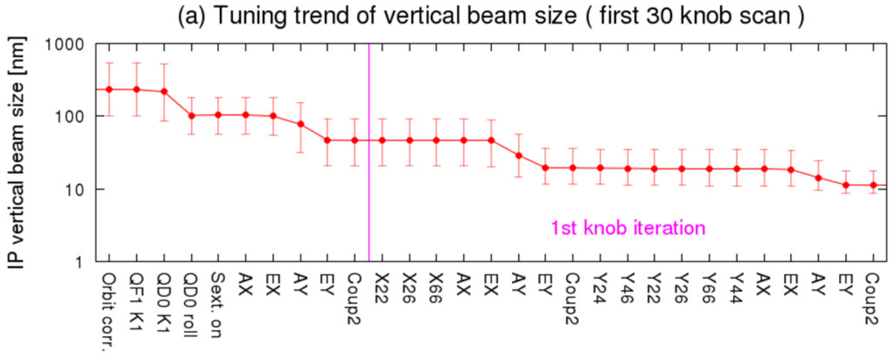
Alignment (x,y)	100 μm
K1 strength	0.01%
K2 strength	0.01%
Rotation	100 μrad
Quad-BPM	10 μm

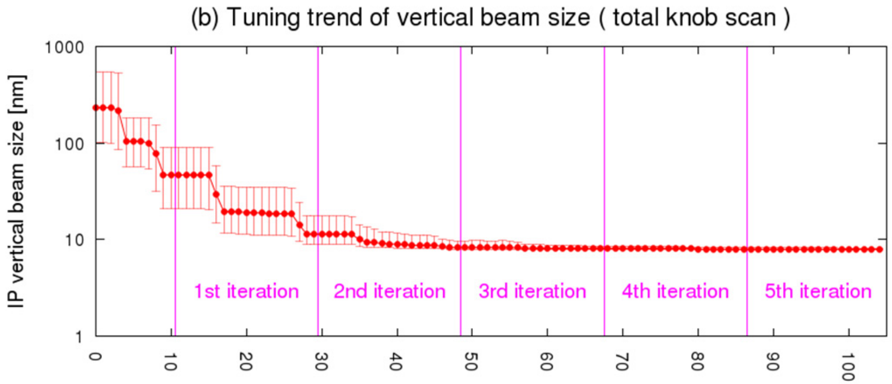
Sextupole Errors

Alignment (x,y)	100 μm
K2 strength	0.01%
Rotation	100 μrad
Sext-BPM	10 μm

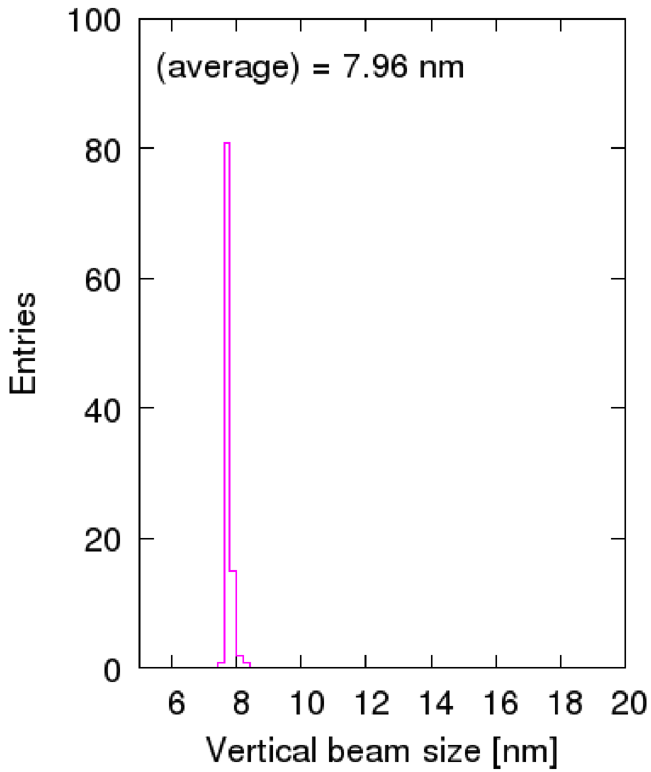
Dipole Errors

Alignment (x,y)	100 μm
Rotation	100 μrad
Dipole-BPM	100 μm





Final IP vertical beam size



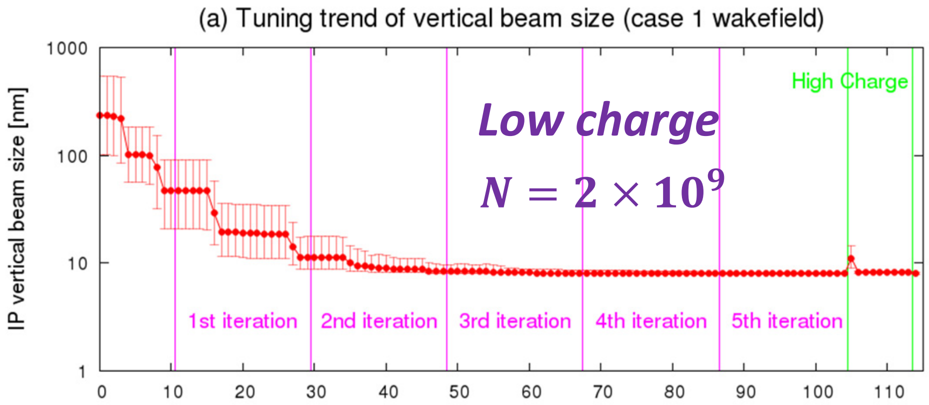
The IP vertical beam size can be reduced to less than 8nm (ideal beam size ; 7.7nm).

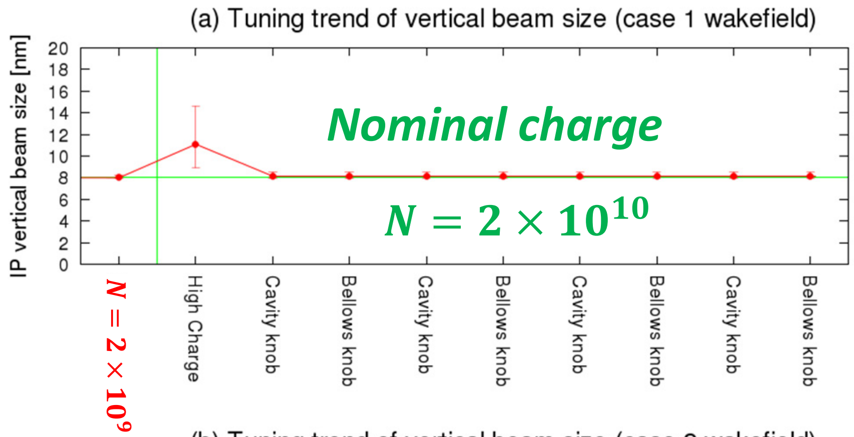
ILC250 IP tuning simulation with wakefield 1

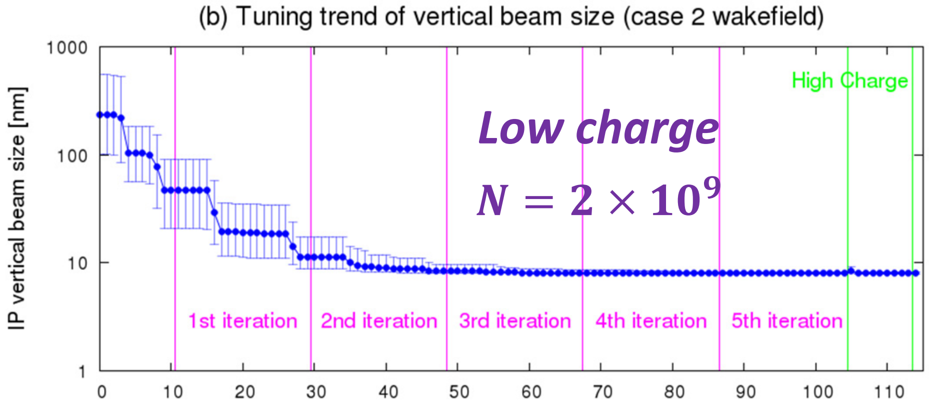
Same tuning procedure to ATF2

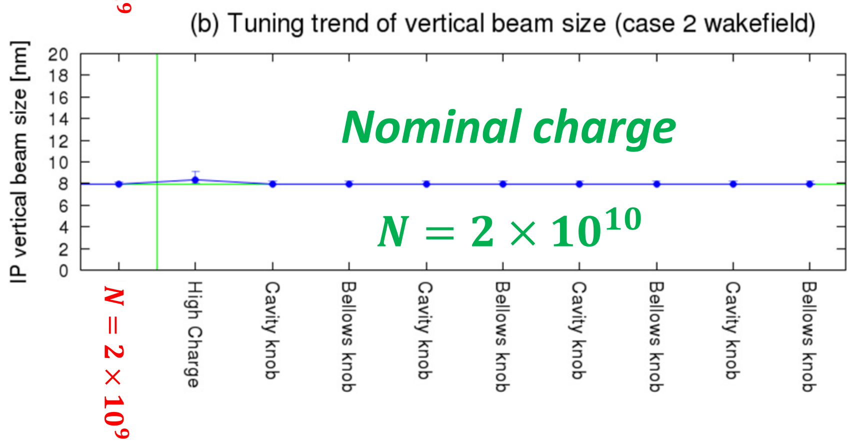
- *IP beam size tuning is done by the low charge* ($N = 2 \times 10^9$; 1/10 of nominal charge).
- *After the IP beam size tuning, the charge is increased to nominal charge* ($N = 2 \times 10^{10}$).
- *Wakefield tuning is done by wakefield knobs*

Vacuum chamber position error $300\mu m$









$N = 1 \times 10^{10}$

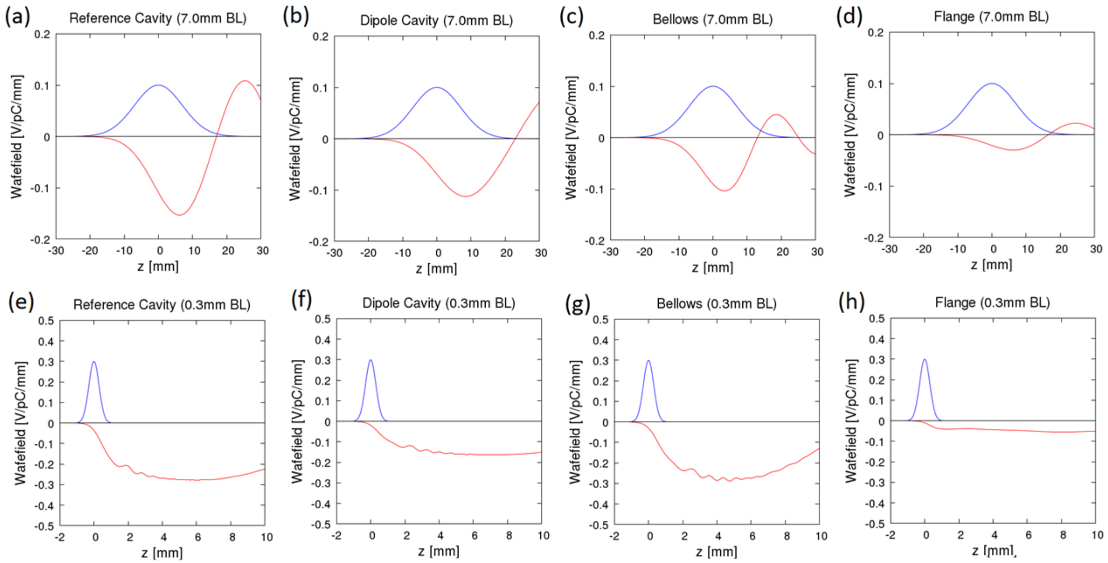
High charge for wakefield correction

Intensity dependence can be reduced

Comparison of ATF2 and ILC250 wakefield correction

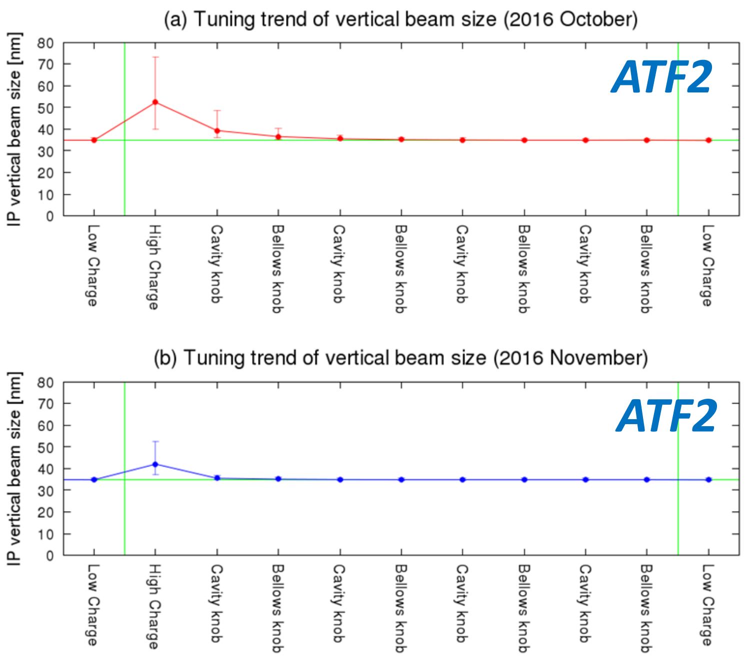
ATF2 wake
$\sigma_z = 7$ mm

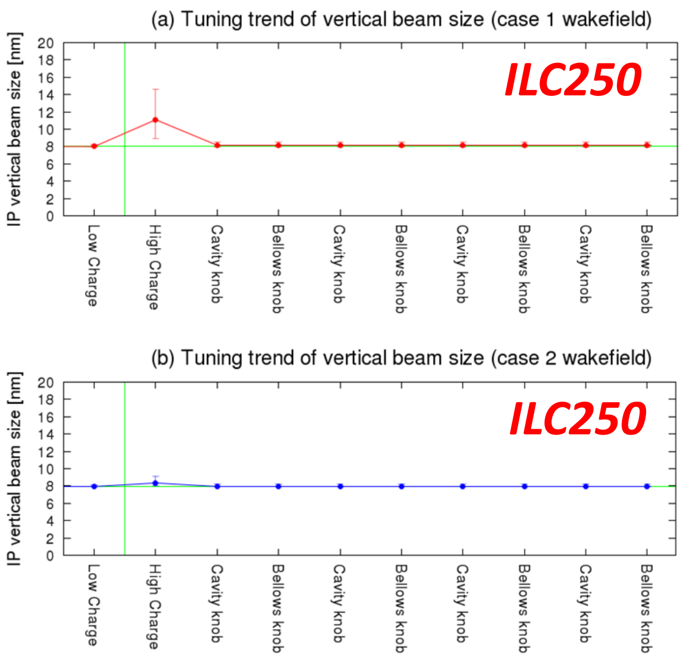
ILC wake
$\sigma_z = 0.3$ mm



Resistive & Capacitive
shape is different
for components.

Capacitive
shape is almost same
(on the rising edge)





Need with 2 different wakefield sources

Enough with a single wakefield sources

ILC250 IP tuning simulation with wakefield 2

Beam tuning was applied at nominal beam charge (N=2e10) with wakefield knob (ref. cavity).

Quadrupole Errors

Alignment (x,y)	100 μm
K1 strength	0.01%
K2 strength	0.01%
Rotation	100 μrad
Quad-BPM	10 μm

Sextupole Errors

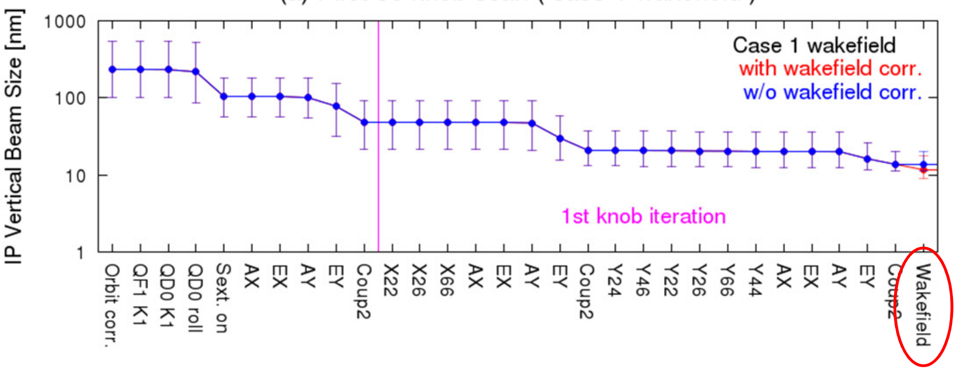
Alignment (x,y)	100 μm
K2 strength	0.01%
Rotation	100 μrad
Sext-BPM	10 μm

Dipole Errors

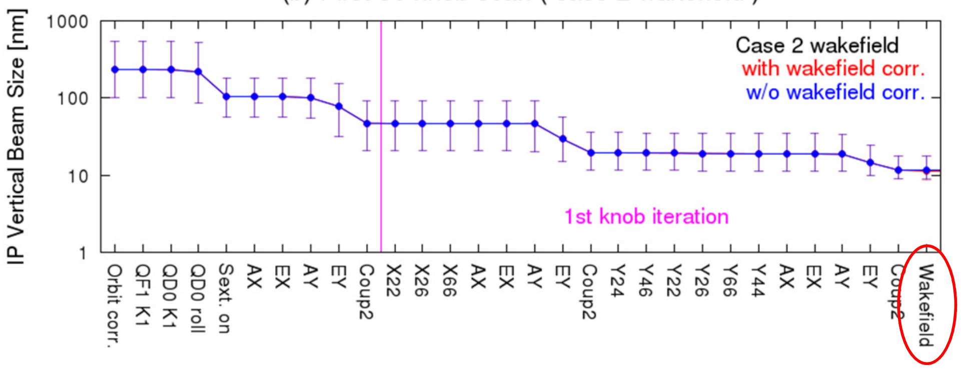
Alignment (x,y)	100 μm
Rotation	100 μrad
Dipole-BPM	100 μm

Vacuum chamber position error
$300\mu m$

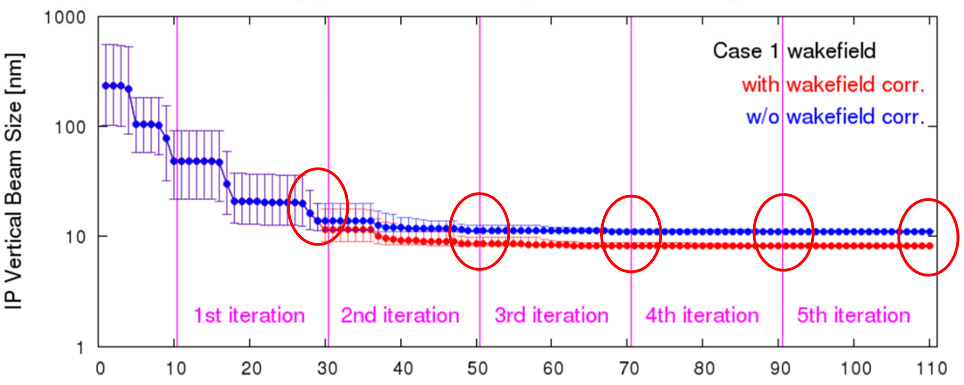
(a) First 30 knob scan (case 1 wakefield)



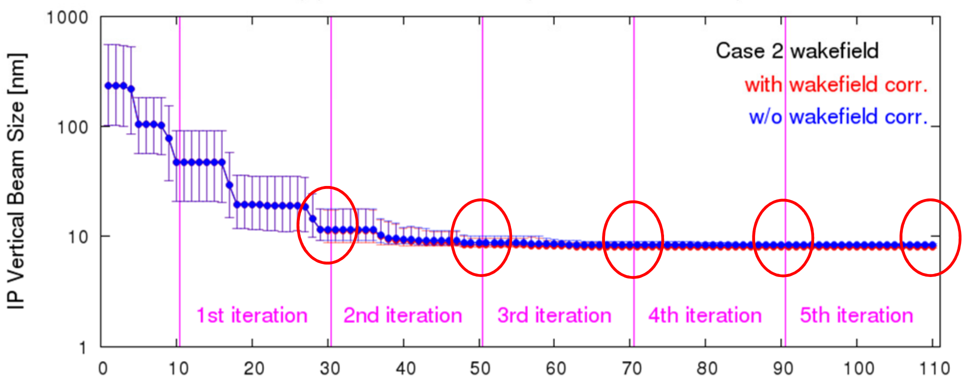
(b) First 30 knob scan (case 2 wakefield)



(c) Total knob scan (case 1 wakefield)

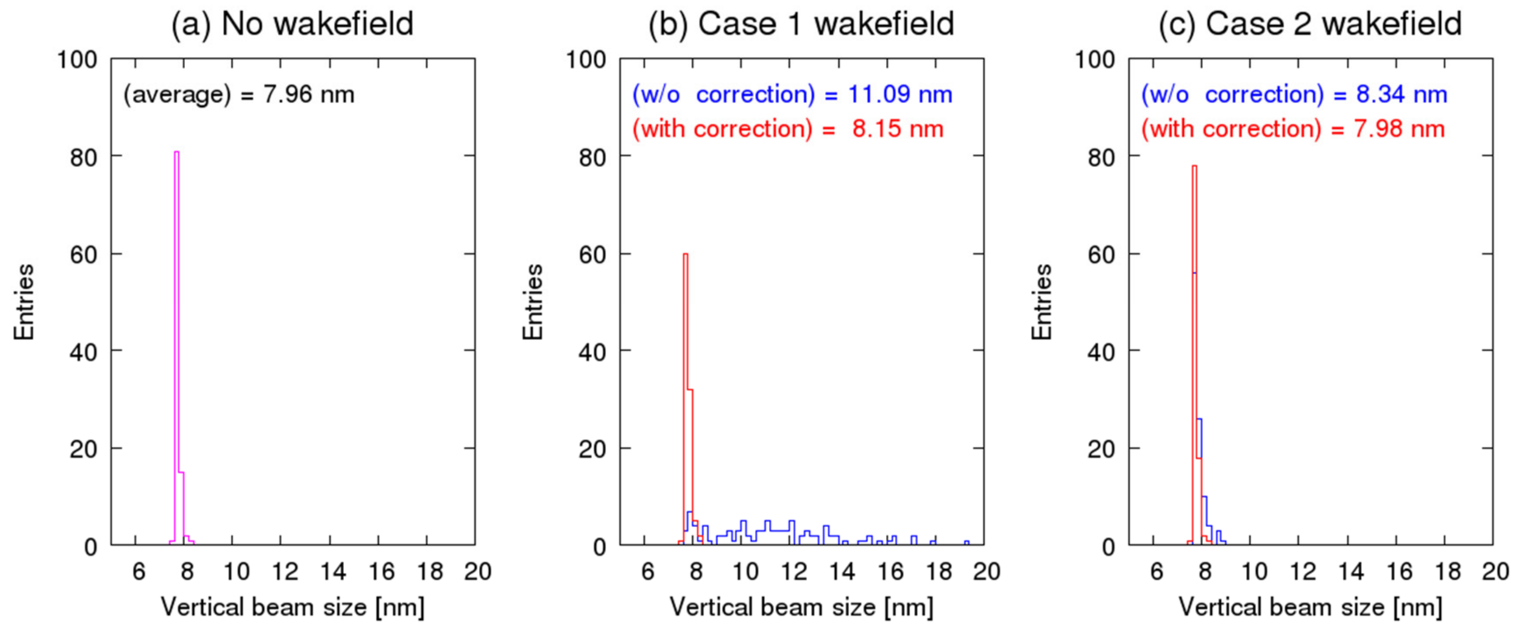


(d) Total knob scan (case 2 wakefield)



Final IP vertical beam size of beam tuning simulation

Beam tuning was applied at nominal beam charge (N=2e10) with wakefield knob.



	w/o wakefield corr.	***with wakefield corr.***
No wakefield	7.96 nm	
Case 1 wakefield	11.09 nm (39%)	8.15 nm (2.4%)
Case 2 wakefield	8.34 nm (4.8%)	7.98 nm (0.3%)

By applying the wakefield correction knob at the end of tuning routine, the IP vertical beam size growth is reduced to 39% -> 2.4% for case 1 wakefield, even if all of IP beam size tuning will be applied at nominal beam charge (N=2e10).

Summary

Simulation of Intensity dependence for ILC250 IP beam size

The static and dynamic wakefield effects of ILC250 were evaluated by tracking simulation.

The effect of wakefield kick for 0.3mm is smaller than that for 7mm.
But, since the effects of bellows and flange gap are larger for ILC bunch length,
it is very important to mask the flange gap and bellows especially for ILC.

The dynamic effect of beam size growth at ILC IP was evaluated to 38%,
when the bellows and flange gaps will not be masked.

However, the dynamic beam size growth was reduced to 1.5%
by using both IP FONT position feedback and 2-dimensional (y-y') upstream FONT feedback.

The beam tuning simulation was done with static wakefield effect (no resistive wall)
for ILC final focus system.

When we assumed the 300um alignment errors for vacuum elements,
the IP beam size growth was 39%, when the bellows and flange gaps will not be masked.

By putting the wakefield correction knob scan in the IP beam size tuning routine,
the static component of the IP beam size growth was reduced to be 2.4%,
even when all of the tuning routine will be performed at nominal beam charge.