ATF2 Recent Wakefield (Beam size Intensity dependence) Studies

Project Meeting 20170315

K.Kubo

Wakefield: Sources of intensity dependence?

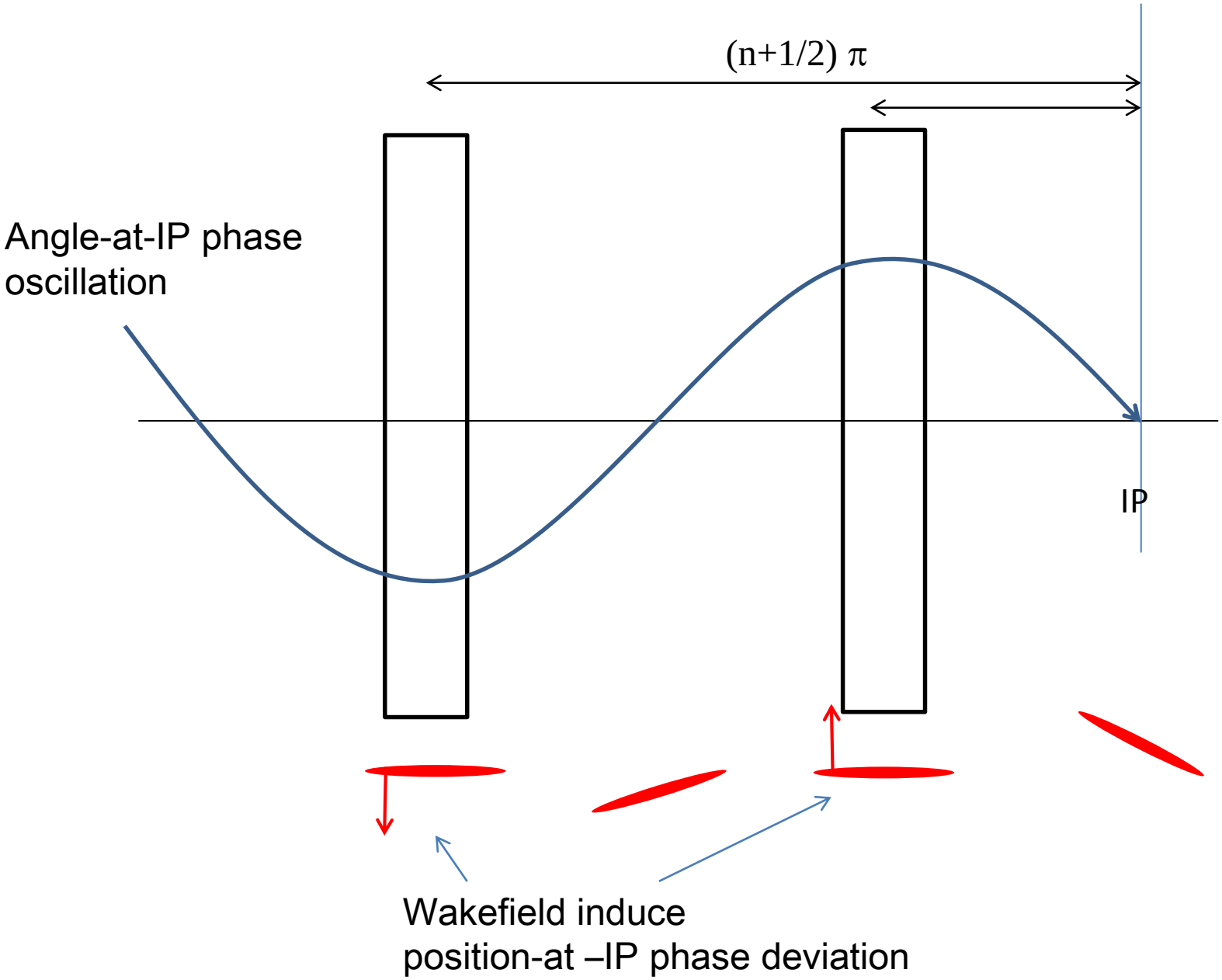
- Static Wakefield effect
  - Optimization position of wakefield source (BPM's reference cavity on mover) may cancel most wakefield of other misaligned sources.
  - May be some residual?

- Dynamic Wakefield effect
  - Cannot be cancelled by adjusting positions of wakefield sources.

Dynamic effect (wake + orbit jitter)

- Orbit jitter at wakefield sources in high-beta region can increase beam size at IP.
- We observed orbit jitter in EXT-FF line about 0.2-0.3σ of nominal beam size.

- 0.3σ “position at IP” phase jitter will increase measured beam size only 4%
- But, with wakefield, effect of “angle at IP” phase jitter can be significant.


(n+1/2) π
Angle-at-IP phase oscillation
IP
Wakefield induce position-at –IP phase deviation

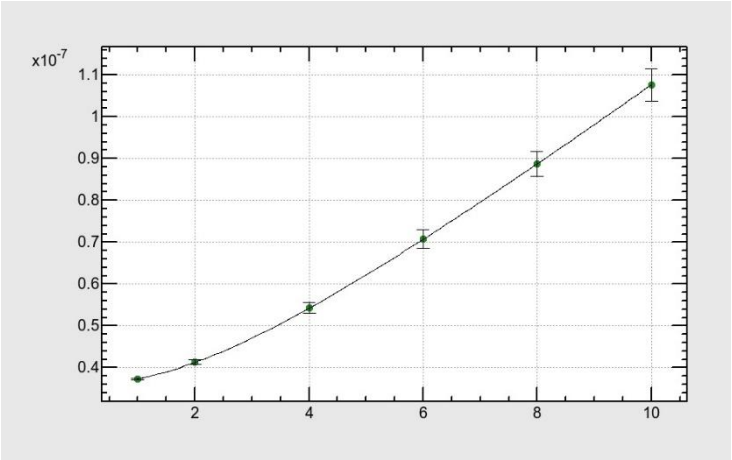
Simulation: orbit jitter + wakefiled rms beam size (projection of many pulses) and IPBSM measurement

Old config.

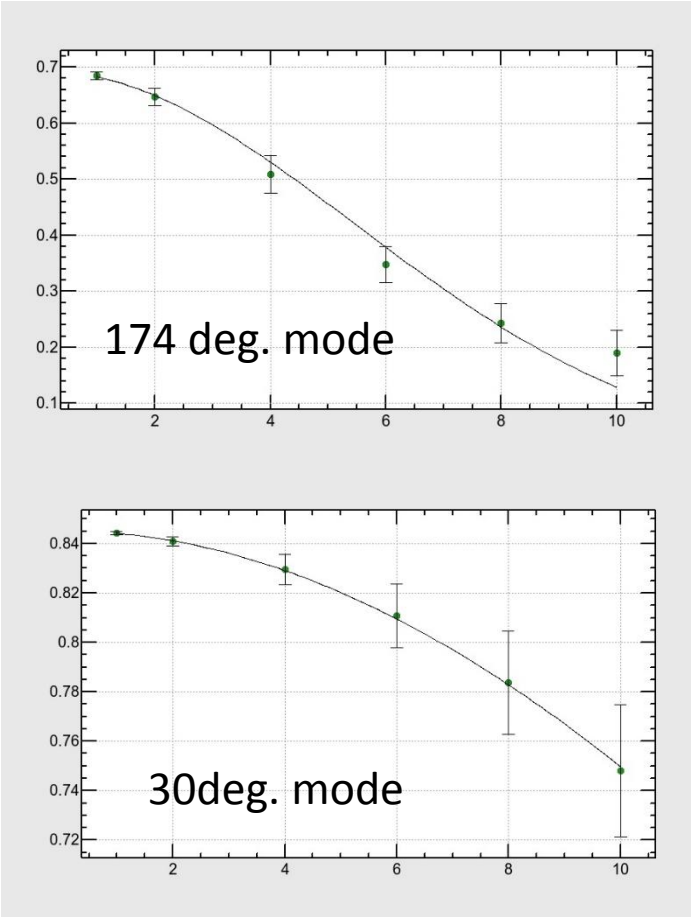
K.Kubo, 20160909 ATF operation meeting

Initial emittance 12 pm, beta* 0.1 mm, angle jitter 0.2-sigma

Projected beam size (m) vs. intensity (E9)



Modulation vs. intensity (E9)



Fitted dependence:

10.1 nm/E9 (projection)

7.8 nm/E9 (174 deg. mode)

8.0 nm/E9 (30 deg. mode)

Consistent with Okugi's result

Effect of Wakefield + Orbit jitter

Asuuming:

i-th wakefield source is at $(n+1/2)\pi$ phase to IP, beta-function β_i

"Angle at IP" jitter amplitude: *a*-sigma of nominal divergence

$$\text{effect to beam size} \propto a\sqrt{\beta_{IP}\varepsilon}\sum_i \beta_i W_i$$

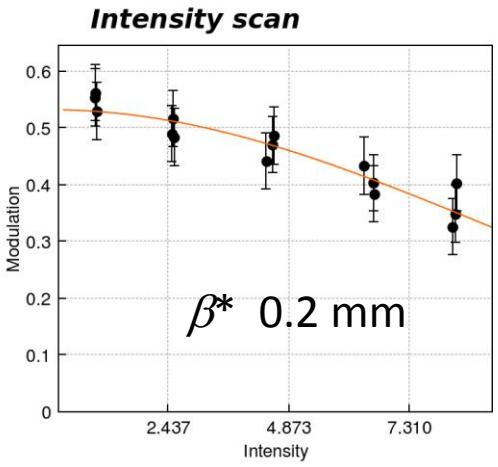
$$\text{Each wakefield source contributes as} \propto \beta_i W_i$$

$$\text{If } \beta_{IP} \text{ is changed, proportional to "angle at IP" jitter}$$

$$\because \quad \propto a\sqrt{\varepsilon/\beta_{IP}}\sum_i \beta_{IP}\beta_i W_i$$

Angle jitter constant

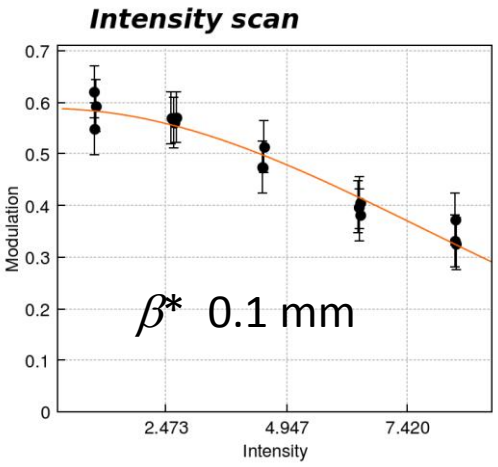
Intensity dependence data with 3 different optics (Oct. 26)



Date: 2016/10/26 Time: 16:12:20

Fit results: A*exp(-(x/B)^2/2)
Modulation: 0.533 +/- 0.021
Center: 0.000 +/- 0.000
Sigma: 9.048 +/- 0.944
Chi2/ndf: 3.4652e+00 / 13

Data file:
Intensity_fringe_
161026_161220.dat



Date: 2016/10/26 Time: 21:43:05

Fit results: A*exp(-(x/B)^2/2)
Modulation: 0.589 +/- 0.021
Center: 0.000 +/- 0.000
Sigma: 7.706 +/- 0.584
Chi2/ndf: 3.3858e+00 / 13

Data file:
Intensity_fringe_
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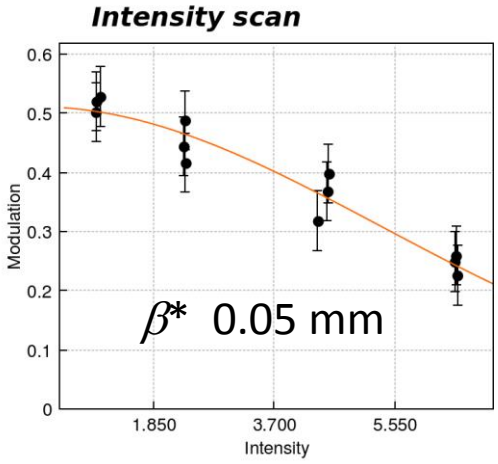


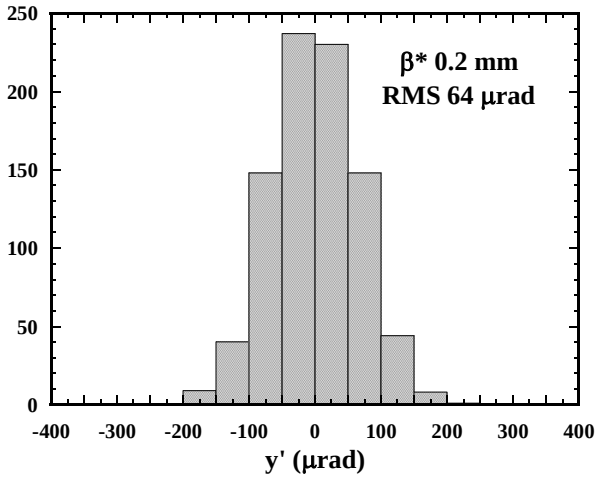
Date: 2016/10/27 Time: 01:18:52

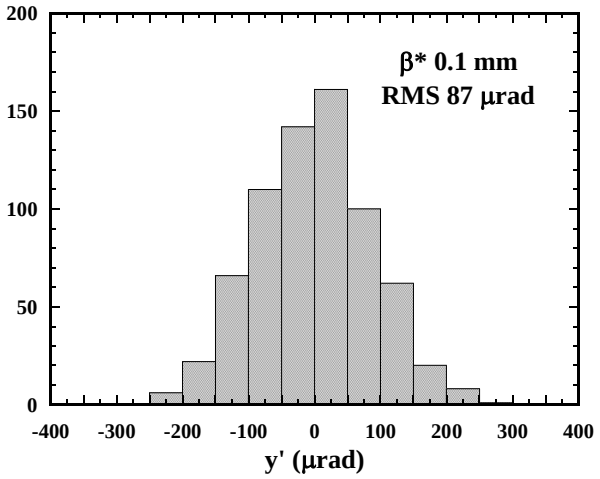
Fit results: A*exp(-(x/B)^2/2)
Modulation: 0.512 +/- 0.023
Center: 0.000 +/- 0.000
Sigma: 5.317 +/- 0.438
Chi2/ndf: 3.5965e+00 / 10

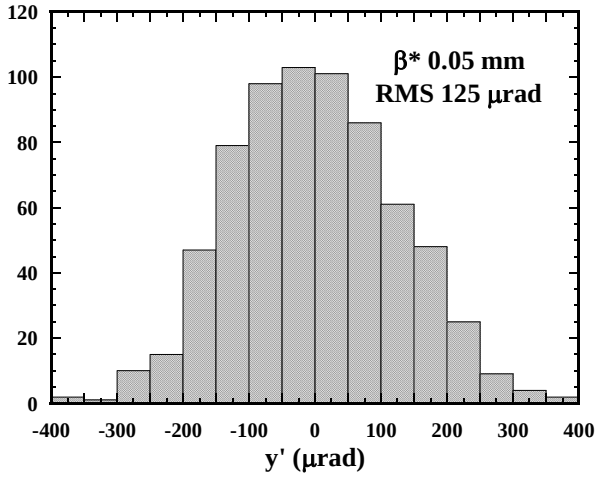
Data file:
Intensity_fringe_
161027_011852.dat

"design" beta_y*
0.2 mm
0.1 mm
0.05 mm

Angle (y') at IP distribution





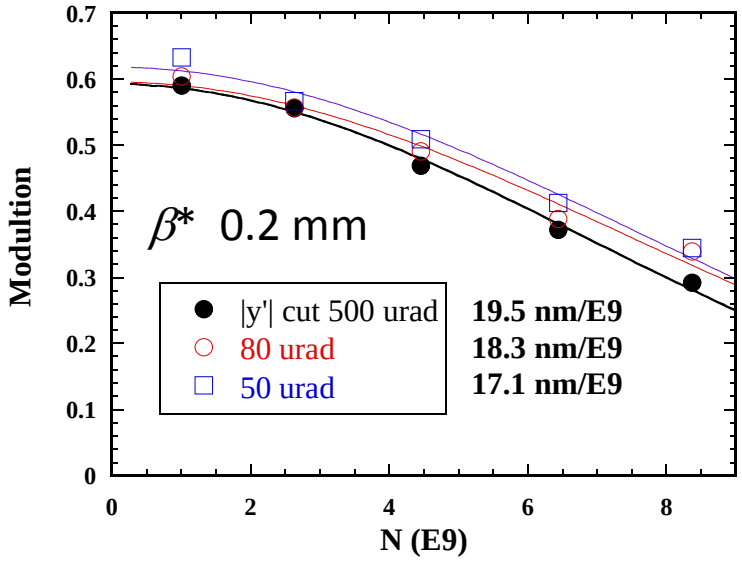


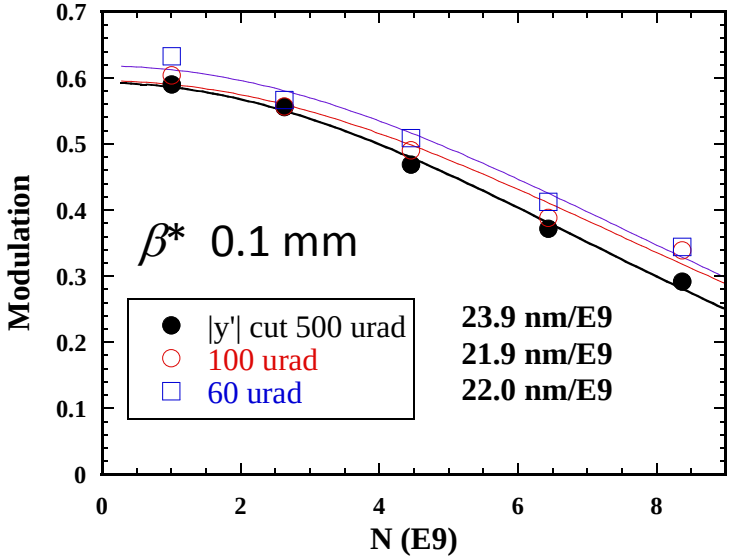
Fitted y' from BPM data
(3 highest intensity data for each beta*)

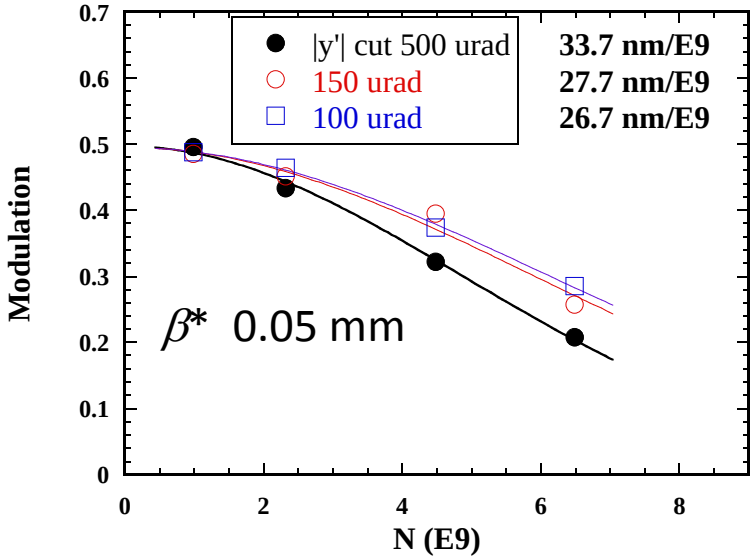
Data selection using y’ at IP (from BPM data)

- For each optics setting
  - Data selected by cutting large |y’|. Three different selections with different widths.
  - For each width, RMS of y’ is calculated.
  - For each width, intensity dependence of beam size is evaluated
- Look intensity dependence vs. RMS of y’

Modulation v. Intensity with y' cut

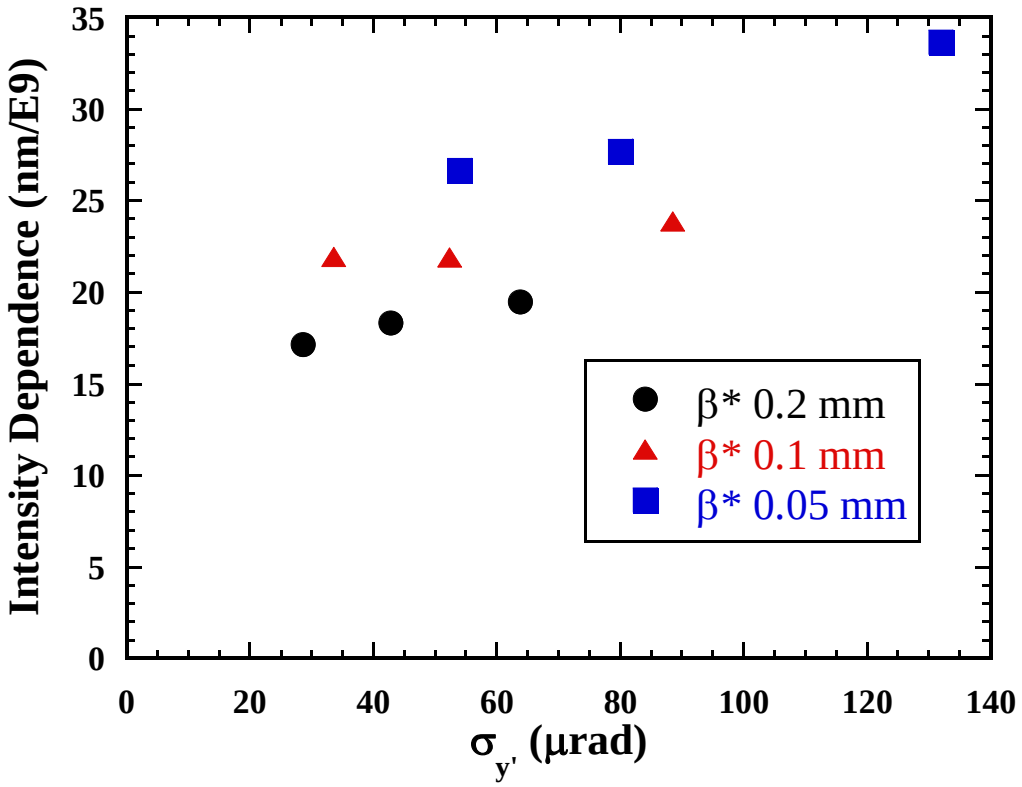






Intensity dependence reduced for narrow y' width

Intensity dependence vs. RMS of y' at IP



Clear correlation between intensity dependence and angle jitter
Intensity dependence is not proportional to angle jitter.
Lower beta* → larger dependence for the same RMS jitter.
Static wakefield effect?

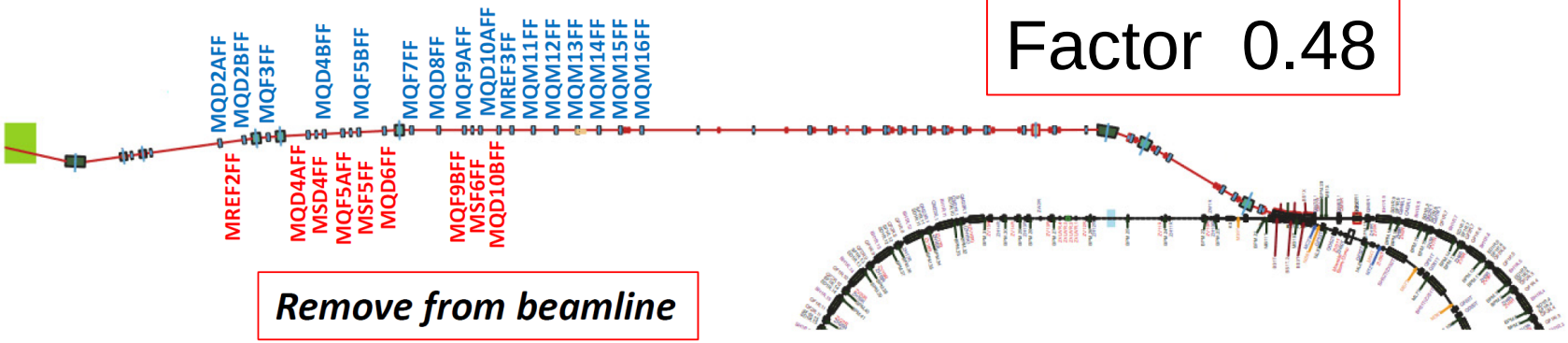
Removal of wakefield sources in November

- Remove some Cavity BPMs in high-beta region
  - Sum_beta 63600 m → 31100 m
  - Expect wakefield effect reduction by ~1/2
- Shield flange gaps
- Change chambers at bending magnet
- Remove some other components

Removal of some Cavity BPMs in Final Focus Line (High-beta region)

$$\sum \beta : \ 64000\,\mathrm{m} \rightarrow 31000\,\mathrm{m}$$

Factor 0.48



Remove from beamline

Number of elements overall ATF2 beamline

	Sensor cavity BPM	Un-masked Bellows	Flange gap
OLD Chamber	23	11	87
NEW Chamber	15	5	69
Difference	8	6	18

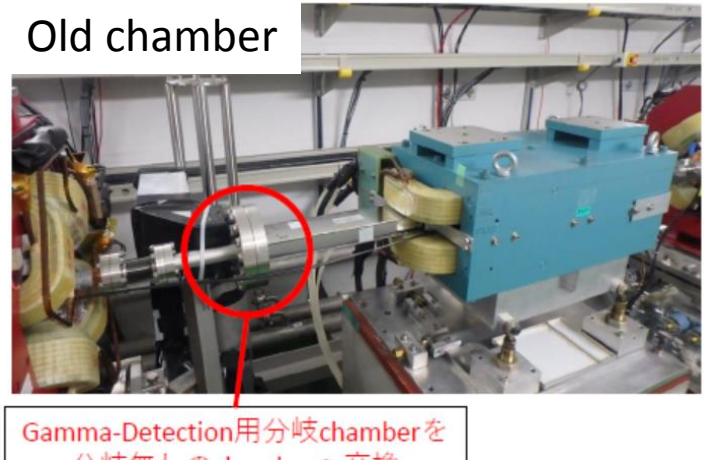
Most of the removed components are in large betaY.

Okugi, ATF Operation meeting 20160924 (modified)

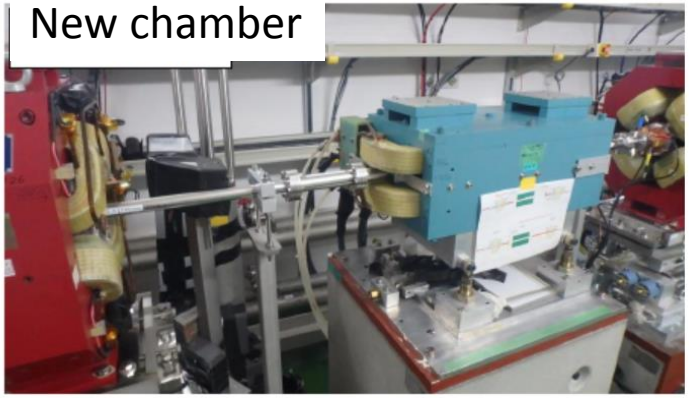
Flange gap shield

Beam Chamber at B5FF

Old chamber

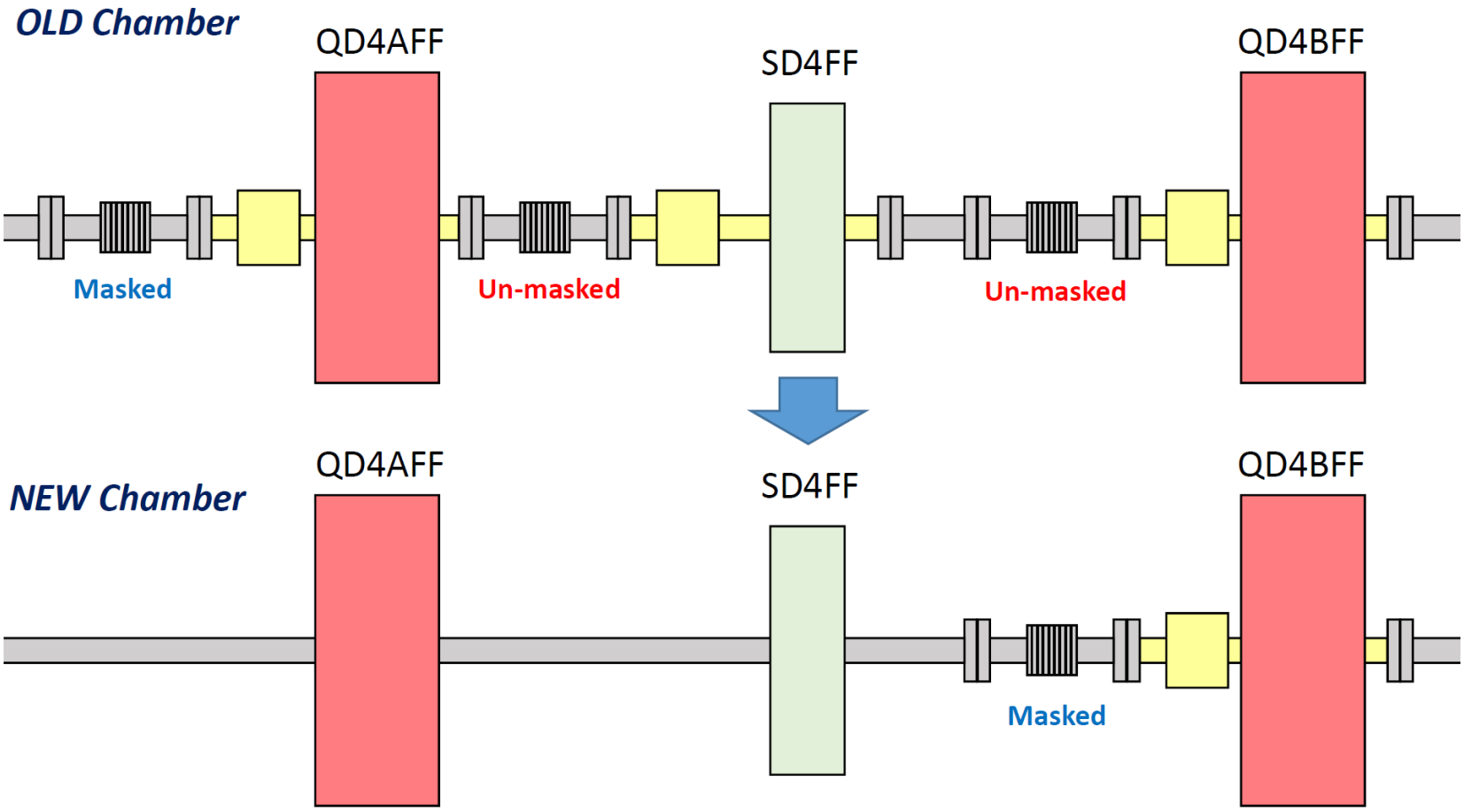


New chamber



Photos by Morikawa

Chamber Modifications in November 2016



Number of elements in QD4 section

	Sensor cavity BPM	Un-masked Bellows	Flange gap
OLD Chamber	3	2	8
NEW Chamber	1	0	3

Okugi, ATF Operation meeting 20160924

“2-Dimensional Scan”

Set different “angle at IP” phase orbit
(by changing steering magnet ZVFB1FF, orbit change monitored at MQD10AFF)
-- Change effect of all wakefield sources

Search position of MREF3FF (wakefield source on mover) to minimize beam size at IP

Result gives ratio of
effect of total wakefield sources and
effect of MREF3FF

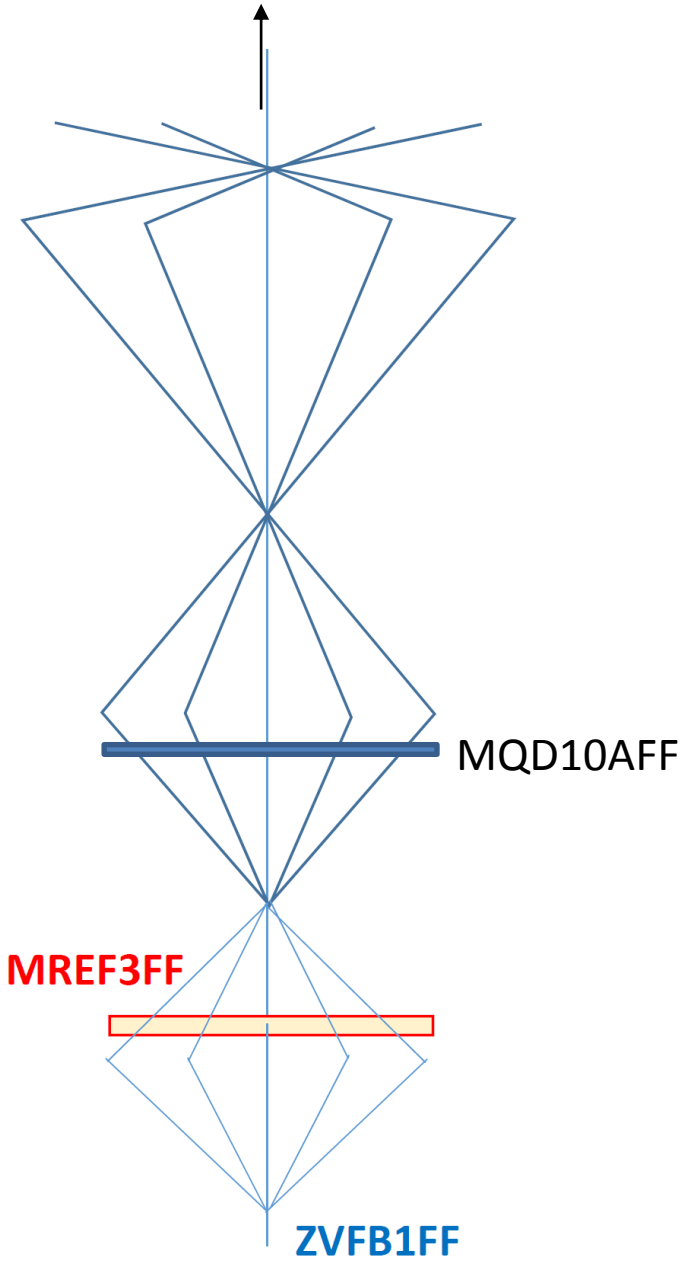
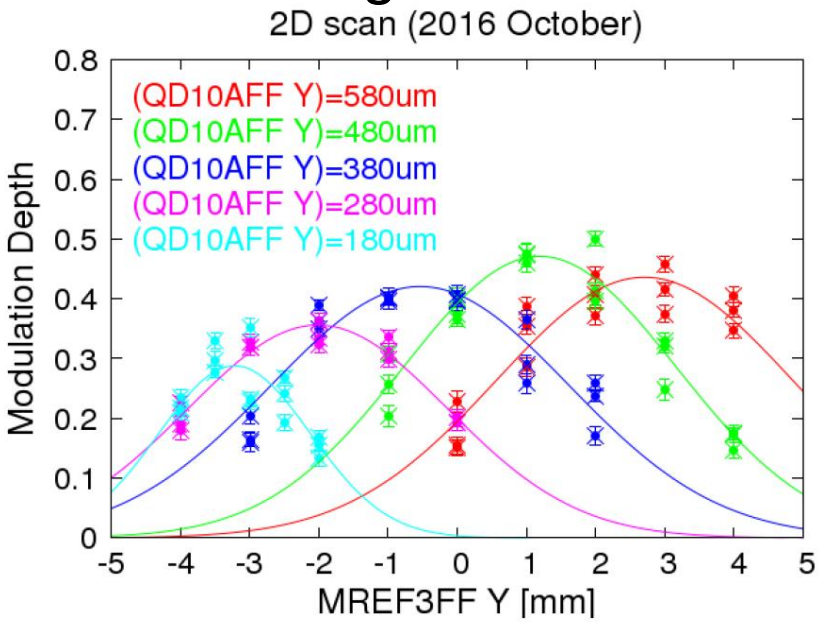


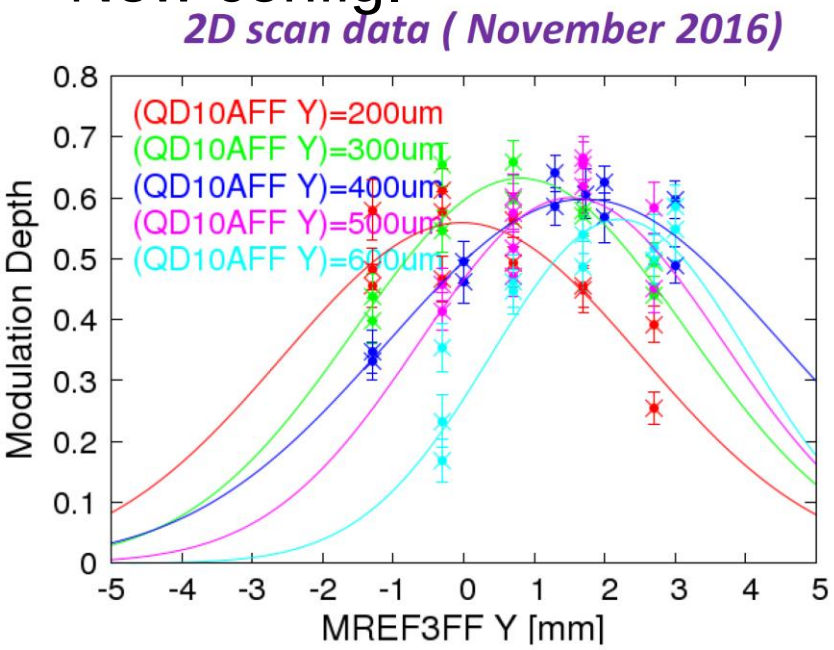
Figure by Okugi (modified)

2-D scans in Oct. and Nov.

Old config.



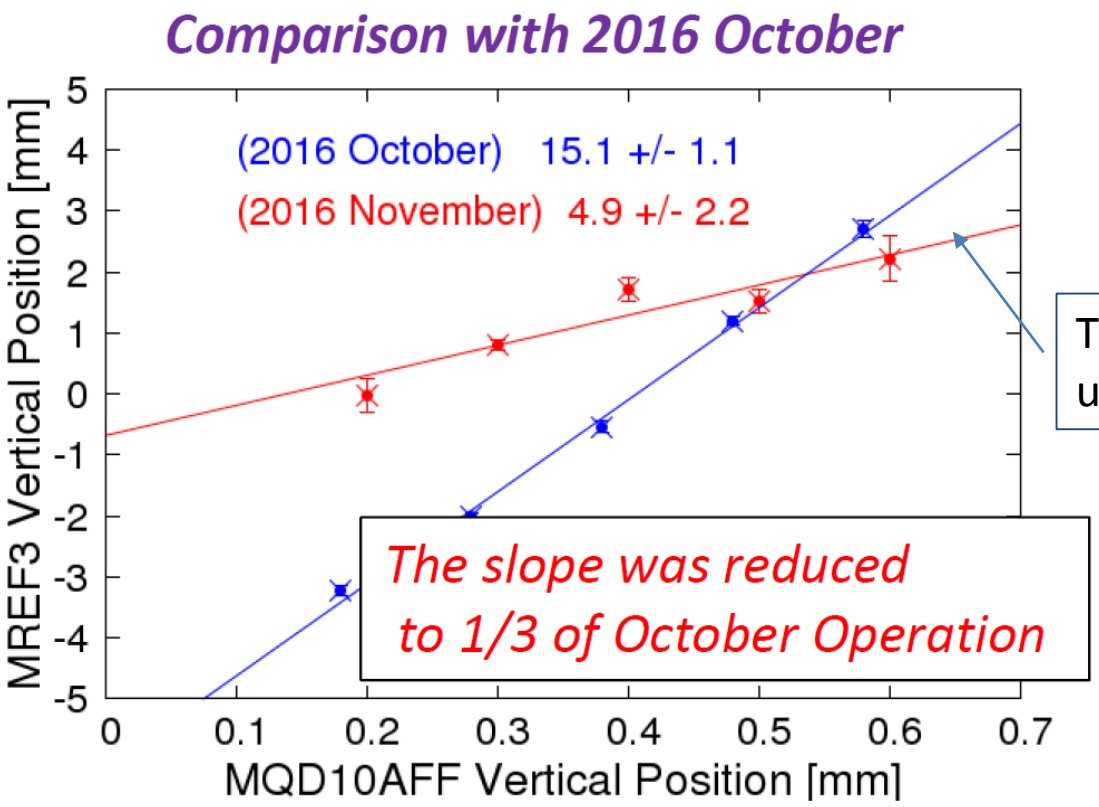
New config.



Okugi, ATF Operation meeting 20161028 and 20161125

2-D scan in Oct. and Nov.

Experiment

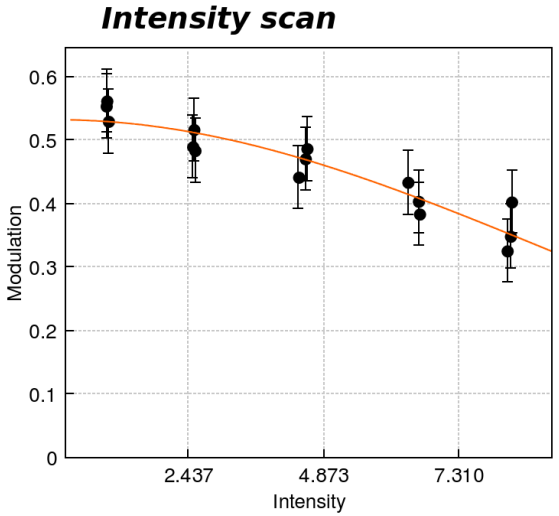


This slope may be under estimated???

Okugi, ATF Operation meeting 20161125

Intensity dependence reduced

October

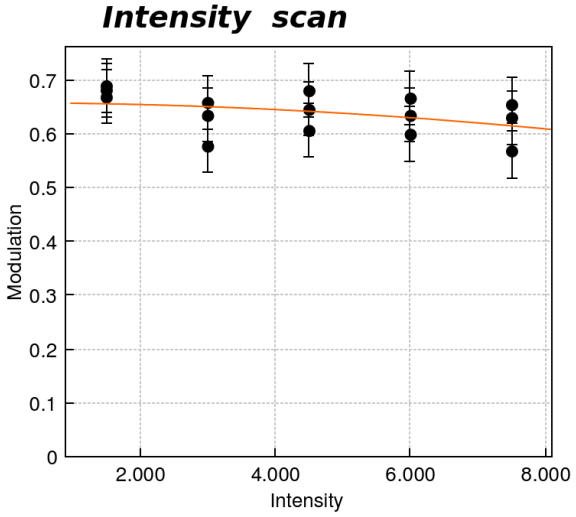


Date: 2016/10/26 Time: 16:12:20

Fit results: A*exp(-(x/B)^2/2)
Modulation: 0.533 +/- 0.021
Center: 0.000 +/- 0.000
Sigma: 9.048 +/- 0.944
Chi2/ndf: 3.4652e+00 / 13

Data file:
Intensity_fringe_
161026_161220.dat

November



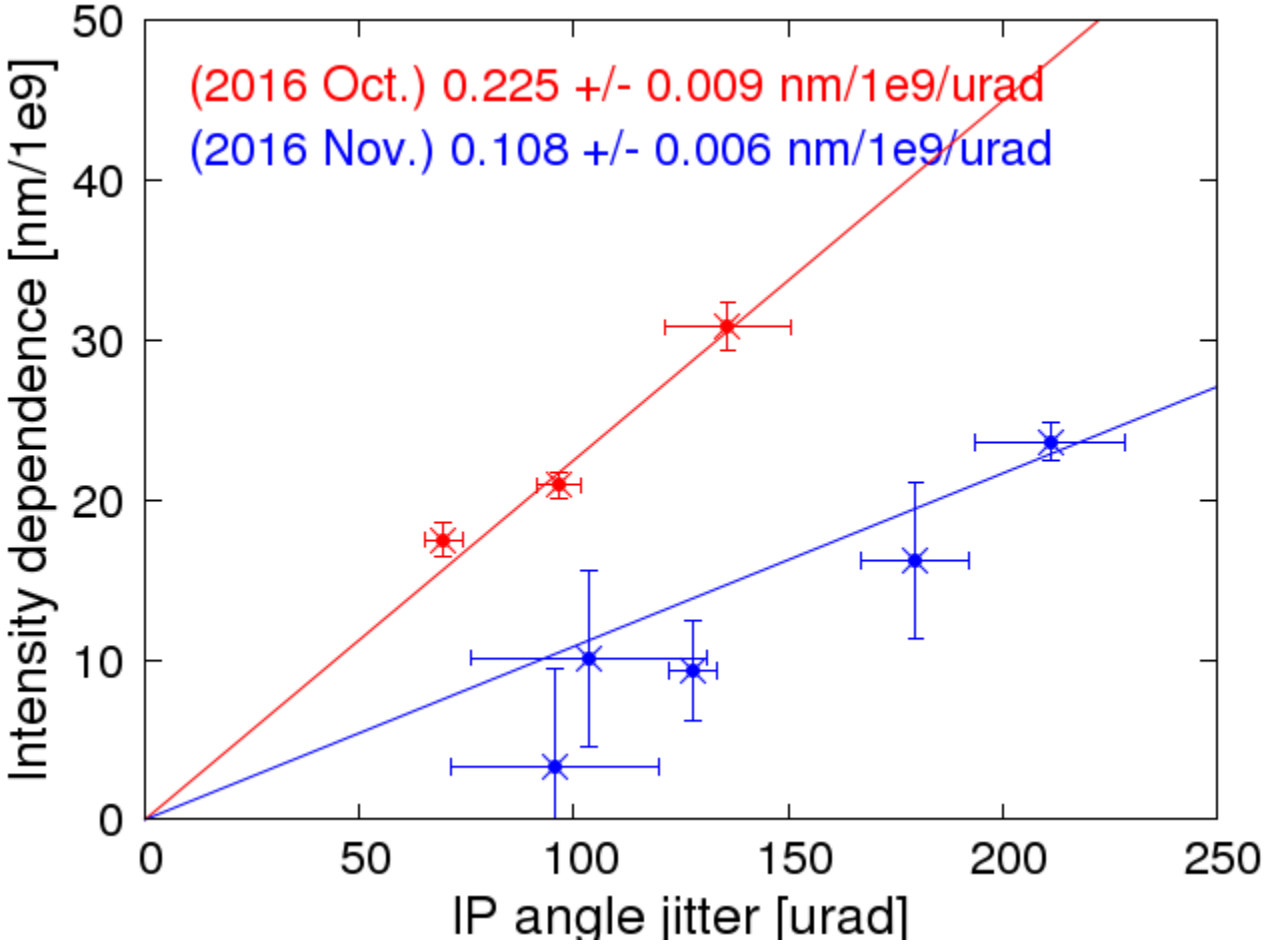
Date: 2016/11/23 Time: 20:30:36

Fit results: A*exp(-(x/B)^2/2)
Modulation: 0.658 +/- 0.021
Center: 0.000 +/- 0.000
Sigma: 20.482 +/- 9.037
Chi2/ndf: 6.6394e+00 / 13

Data file:
Intensity__fringe_
161123_203036.dat

Intensity dependence vs. angle jitter

Change beta_y* (for changing angle jitter)



Okugi, ATF Operation meeting 20161202

Discussion

- Analysis with data selection by y' at IP showed: angle jitter can partly explain intensity dependence.
- There should be other effects, which are correlated with beta_y*.

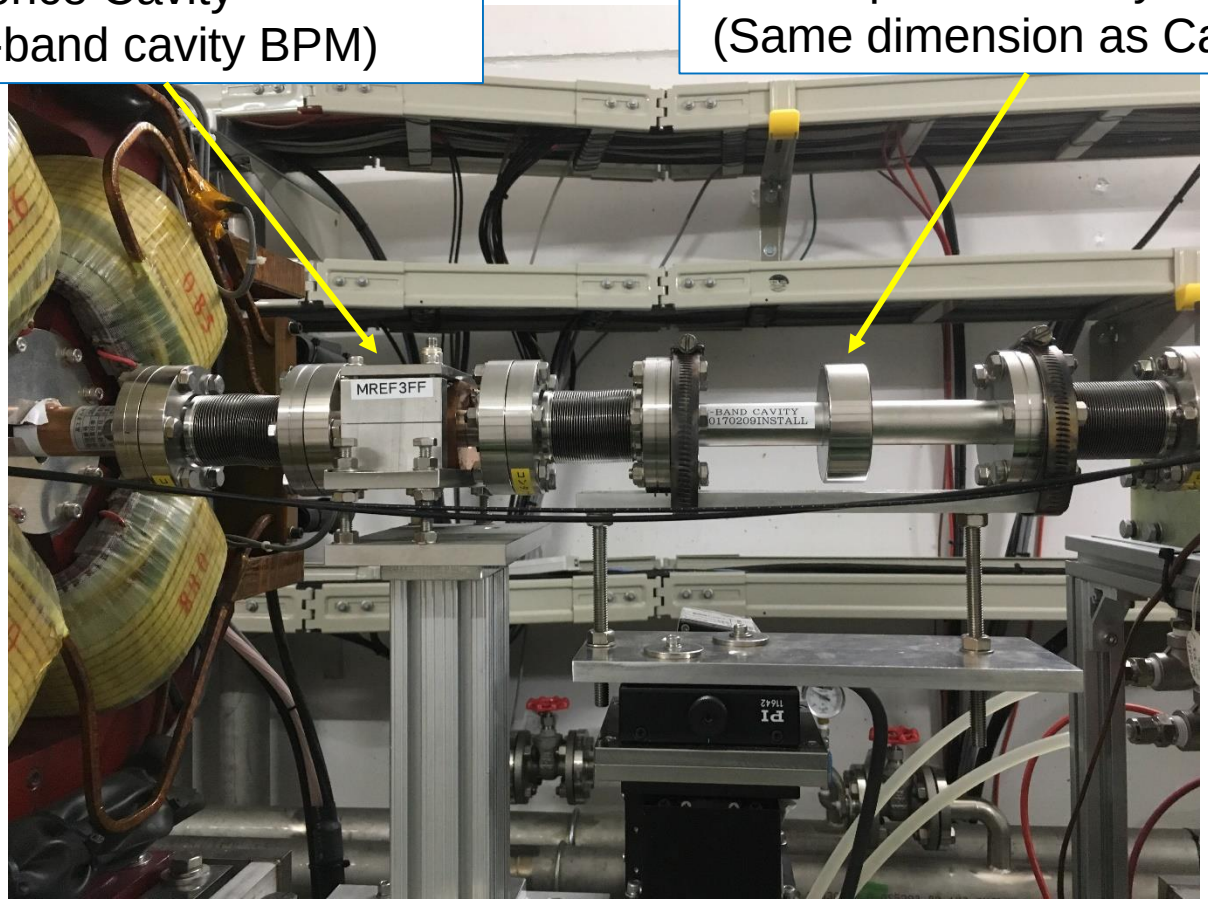
- By removing wakefield sources, in November, we observed the most of the intensity dependence is from wakefield.

- These suggest there is significant static wakefield effect.
  - Wakefield compensation by Reference Cavity on mover is not so effective as expected?
- For further studies, we have installed another type of wakefield source on mover in 2017 Feb.. (Next slides)

Two different wakefield sources on mover in high beta region

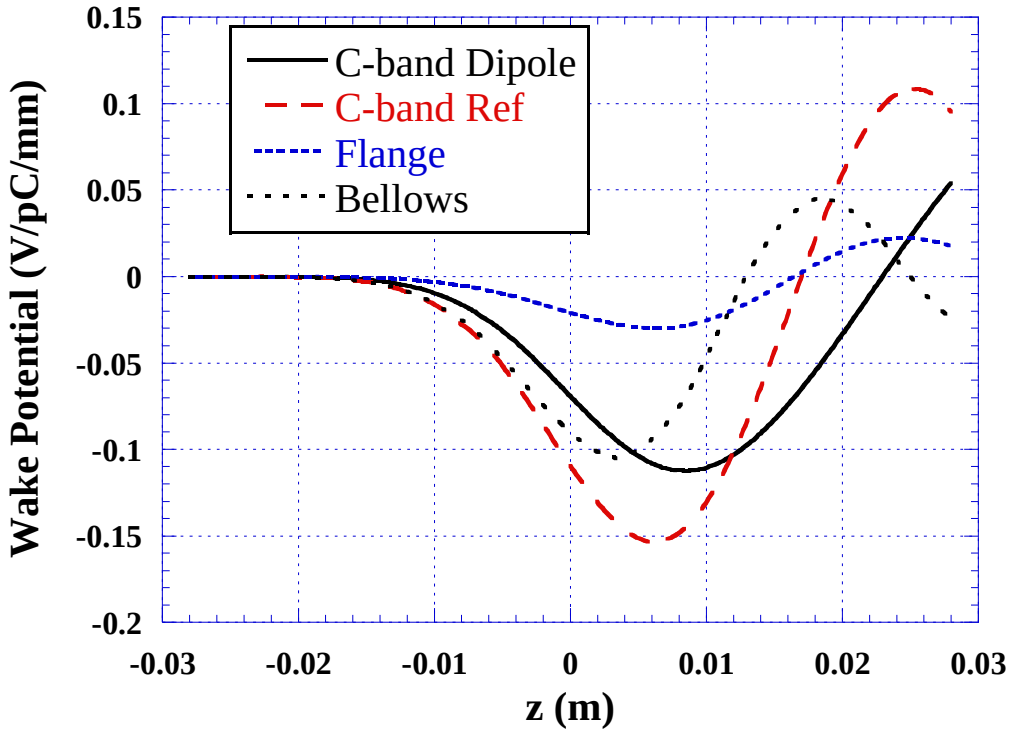
Reference Cavity
(for C-band cavity BPM)

C-band pill-box cavity
(Same dimension as Cavity BPM)



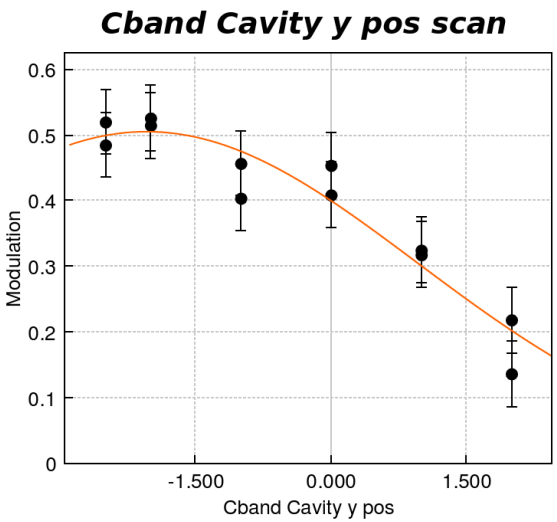
Wake-potential of components

Calculated by Alexey

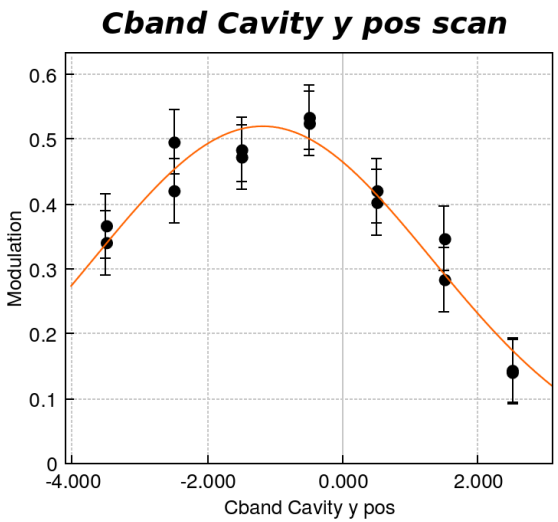


“2-Dimensional scan”: scan C-band cavity with different position of Reference cavity

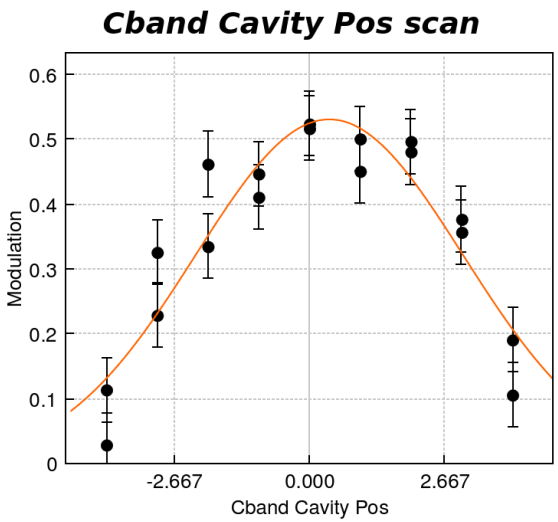
RefCav +2 mm



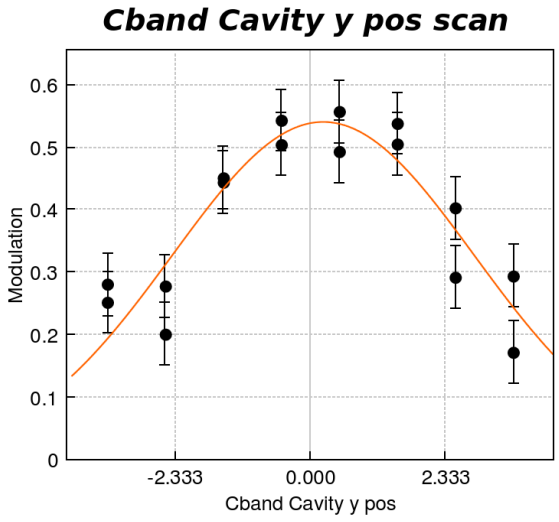
RefCav +1 mm



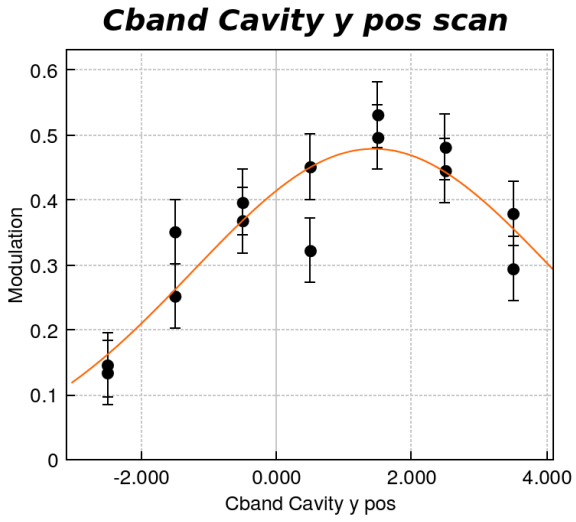
RefCav 0 mm



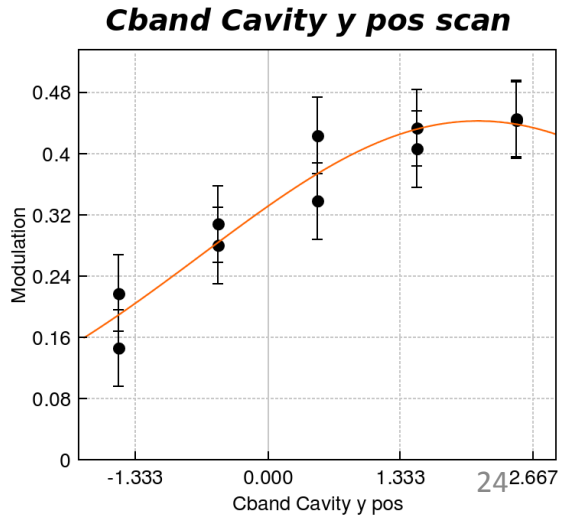
RefCav 0 mm



RefCav -1 mm

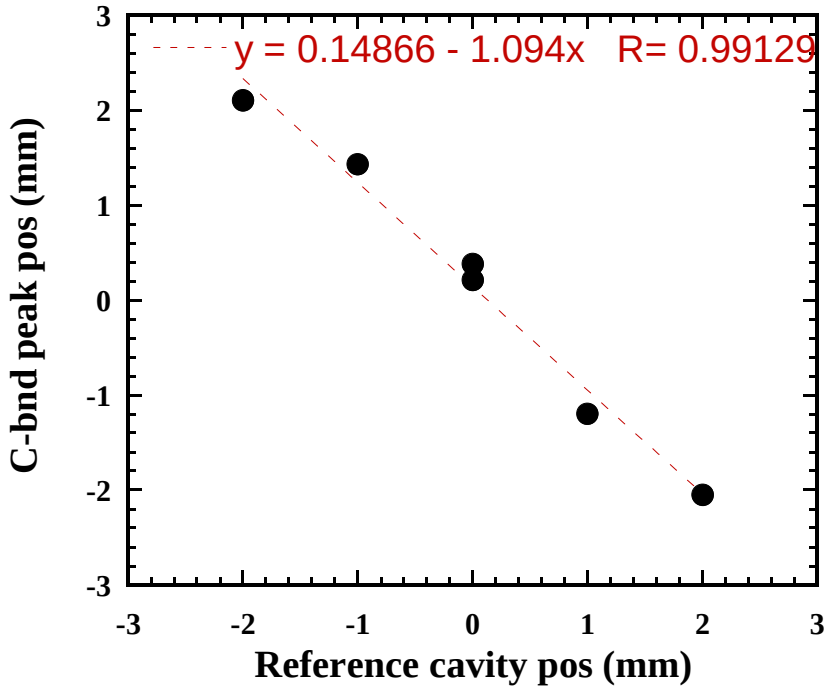


RefCav -2 mm



Result of 2-D scan -1

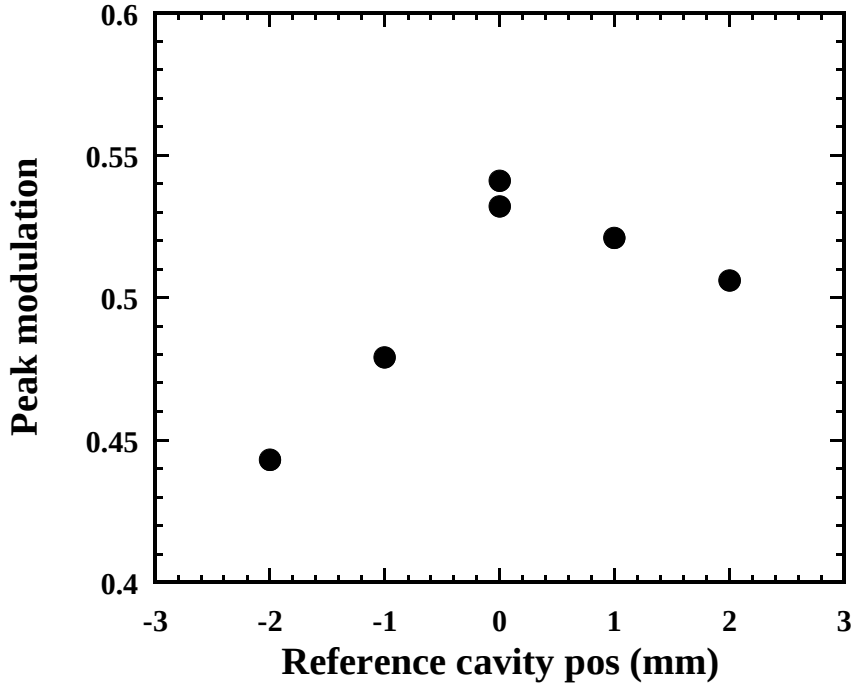
Position of C-band cavity giving Modulation peak vs. position of Reference cavity



Effect of Reference cavity move is
10~20% larger than effect of C-band cavity move

Result of 2-D scan -2

Peak Modulation vs. position of Reference cavity



Wakefields of The two sources are not completely canceled.
There is one optimum setting.
Suggesting
Two sources on mover can cancel wkaefields of others better than one.

Studies with two wakefield sources on mover

- 2-D scan
  - Suggesting having two sources on mover is better than one to cancel wakefileds of others.
  - But not confirmed. (Intensity dependence was not really reduced. (?))
- Some other data (not reported here)
  - E.g., 2-D scan with different orbit
  - No clear conclusion
- Need more data
- Maybe other wakefield sources?
  - More capacitive and/or inductive wake?????

Summary

- Wakefield + angle jitter (angle at IP phase orbit jitter) is significant source of beam size intensity dependence
  - But cannot explain all dependence.
    - Factor 1.7 larger than calculation
    - Data selected by angle at IP not consistent with the “fully dynamic” explanation.
  - There may be residual static wakefield effect.
  - Or, maybe other effects than wakefield?
- Reduction of wakefield in November. Removal of cavity BPMs, etc.
  - Expected intensity dependence reduction factor about 1/2
  - Observed 1/3 ~ 1/2
- Studies with different types of wakefield sources on mover
  - Suggesting incomplete cancellation of wakefield by one wake source. (We had expected almost complete cancellation ?)
  - Need more data.
  - More experiments with different types of wake sources?