ATF2 Progress Report

For CLIC Workshop 2015.01.28.

Kiyoshi KUBO

Goals of ATF2 +α

- Achievement of 37 nm beam size (Goal 1)
  - Demonstration of a compact final focus system based on local chromaticity correction
- Control of beam position (Goal 2)
  - Demonstration of beam orbit stabilization with nano-meter precision at the IP
    - Establishment of beam jitter controlling techniques at the nano-meter level with an ILC-like beam
- Understand (and solve, if possible) beam size intensity dependence
  - Goal 3 or Goal 1.5(?):
- Other studies:

Lower betay* (mainly for CLIC)

Ground motion – orbit feedforward

Development of instrumentations (beam monitors)

etc.

Status for Goal 1

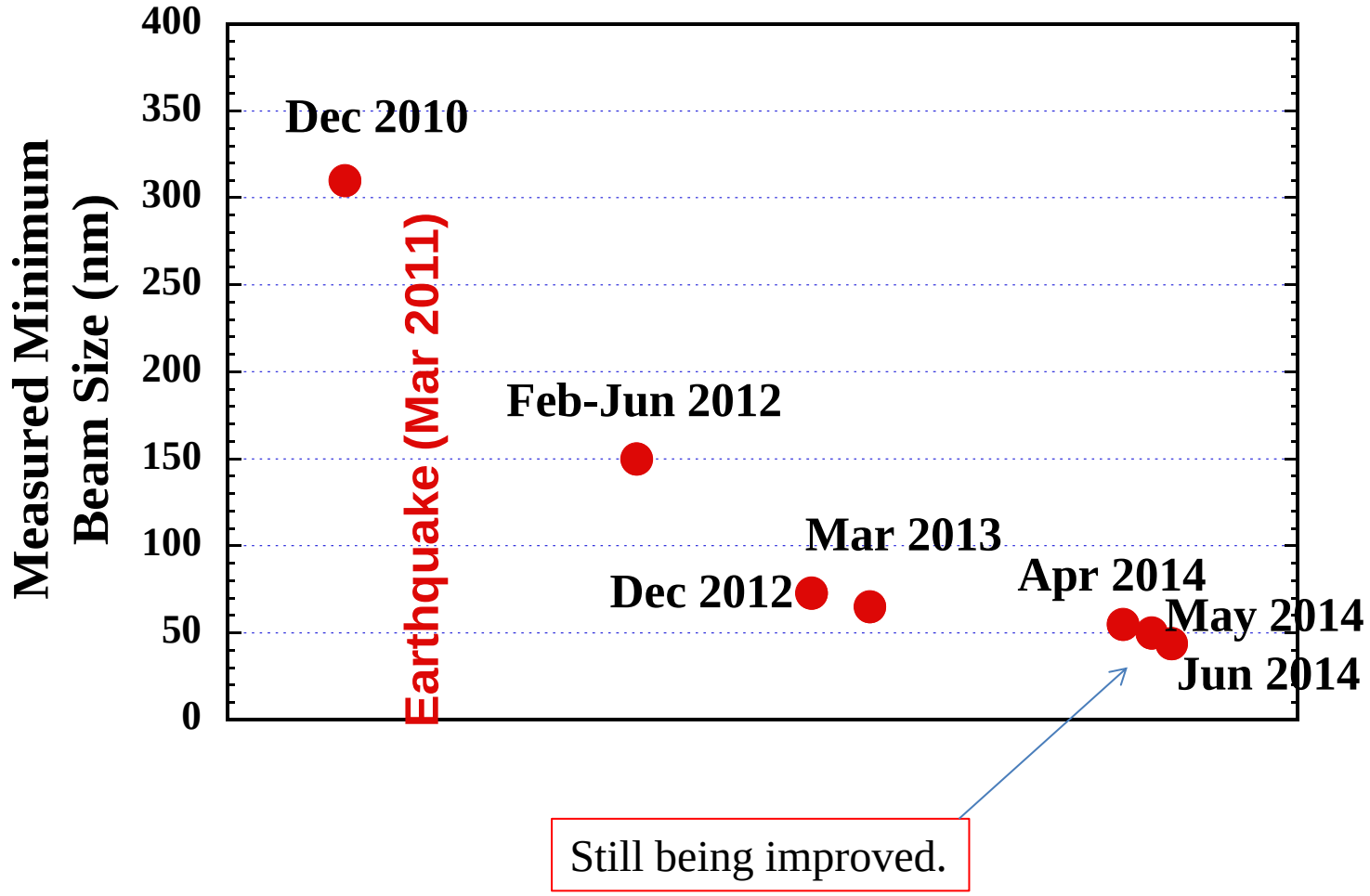
Reported in IPAC14 and ICHEP14

No significant improvement in Oct.-Dec. RUN (Mainly dedicated to IPBPM commissioning, intensity dependence studies, etc.)

- 44 nm (or smaller) beam size confirmed (design: 37 nm) at low intensity (June 2014).
  - Average of 10 consecutive measurement, with 3 nm standard deviation. (Showing the level of the stability.)
- Small beam can be achieved repeatedly and quickly, even after machine shutdown.
- Local Chromaticity correction was demonstrated.

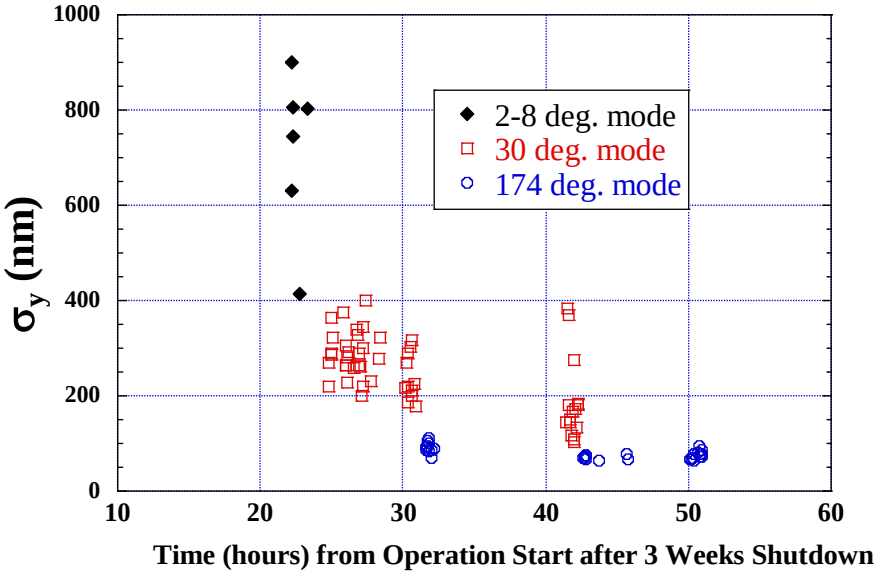
  (Without chromatic correction, beam size is ~450 nm.)
- Strong intensity dependence was observed. (It had not been expected.) → Goal 3 or 1.5

History of measured minimum beam size



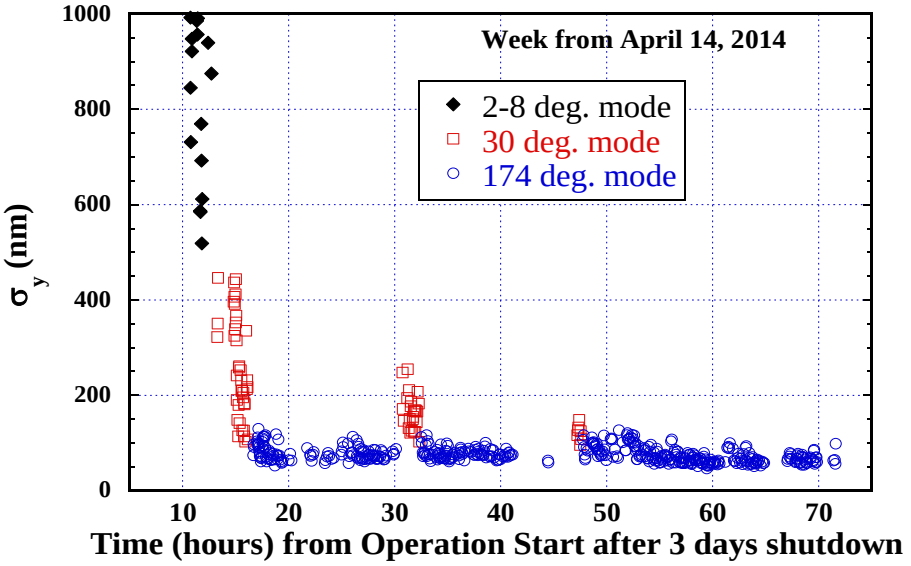
Presented in IPAC14

Beam Size Tuning
after 3 weeks shutdown
Small beam (~60 nm) observed
~32 hours from operation start
~10 hours of IP beam size tuning



Week 2014 April 7

Beam Size Tuning
after 3 days shutdown
Small beam (~60 nm) observed
~16 hours from operation start
~8 hours of IP beam size tuning

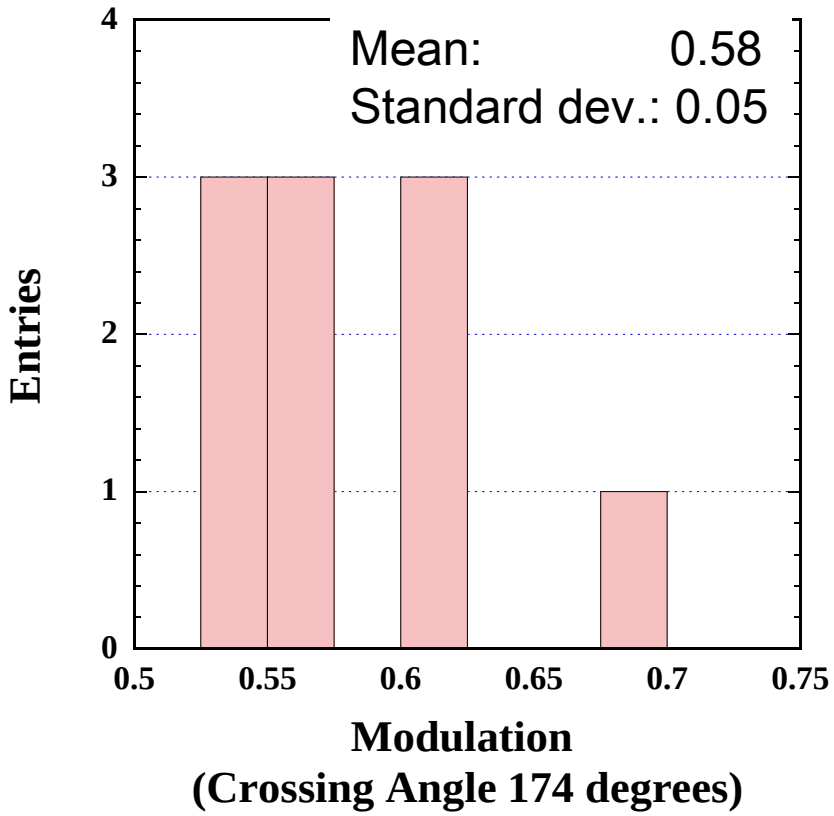


Week 2014 April 14

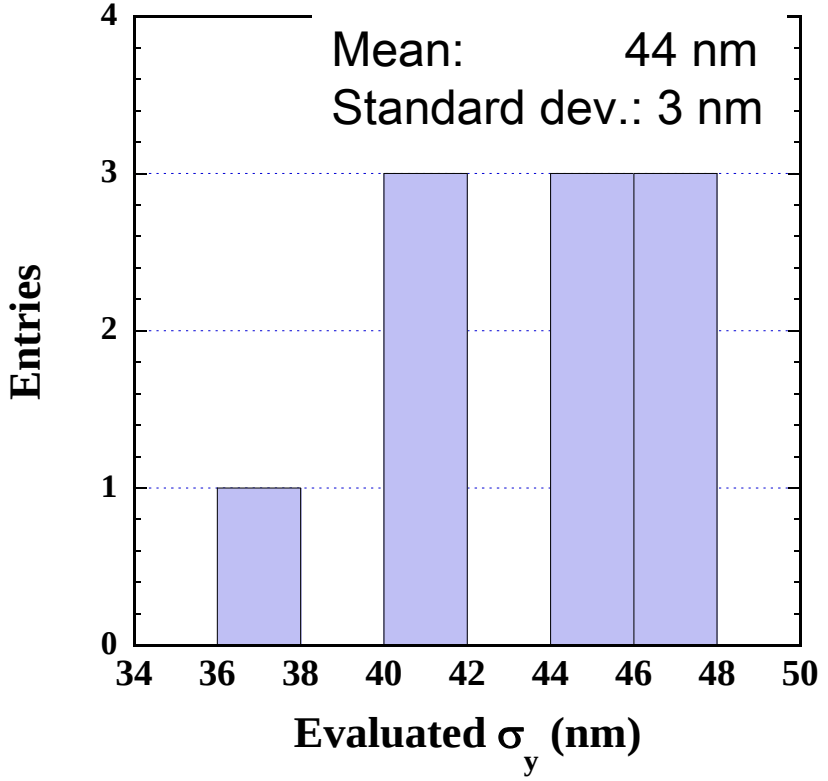
Data of Last Week before summer 2014

Presented in IPAC14

IPBSM Modulation
(174 degree Crossing angle)



Beam Size Evaluated from Modulation
(no systematic error assumed)



Bunch charge ~ 0.16 nC

Smallest observed size was 44 nm. Why not 37 nm?

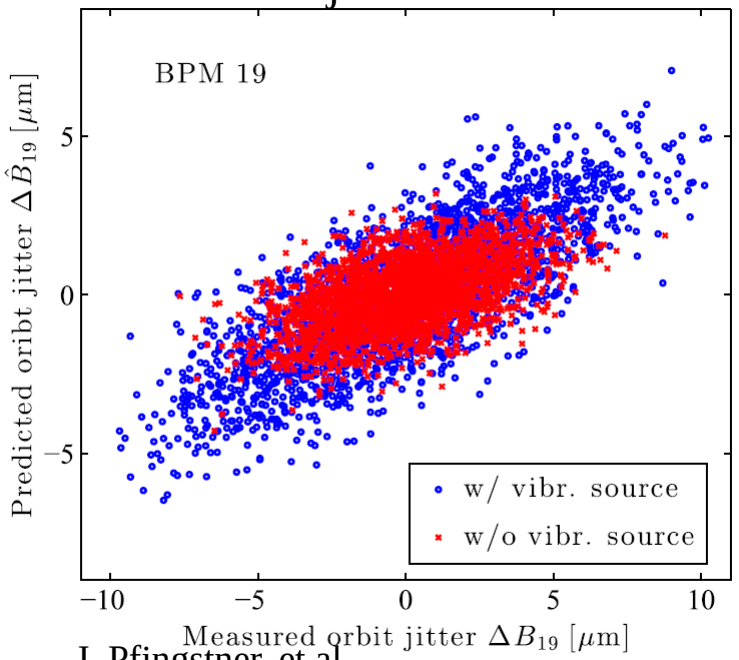
- Beam was jittering?
  - Upstream measurement indicate orbit jitter 15~30% of nominal beam size. (37 → ~39 nm, if 30% rms jitter)
  - Oscillation of Final Doublet quads caused beam position jitter at IP. (37 → 39.8 nm till summer 2014, 37 → 38.3 nm now)
- Effect of wakefeild even at low intensity (37 → ~39 nm)
- Beam size monitor was not accurate enough?
  - Stability of interference fringe phase, intensity, etc.? (next talk)
- Problem of optics?
  - Quality, or stability of magnetic fields of magnets?
  - etc. ?

QF1X, QD2X magnets vibration reduced

- Large vibration of the first two quad magnets in Extraction Line was induced by a cooling water pipe.
- Vibration reduced and beam orbit jitter significantly reduced. (amplitude factor ~0.7)
- Effect to IP position jitter ?

→ Will be Reported in following talk(s) on Ground Motion Study.

Orbit jitter before and after



J. Pfingstner, et.al.,
Phys. Rev. ST Accel. Beams 17, 122801

QF1FF magnet vibration reduced

2013: New QF1 vibration was large

2013 by Andrea JEREMIE (same analysis)	Tolerance	Measurement (between QD0)	Measurement (between new QF1)
Vertical	7 nm (for QD0) 20 nm (for QF1)	4.8 nm	30 nm

A.Jeremie 2013.8.30
ATF2 meeting

2014 summer: Shims inserted for more stable (rigid) support

QF1FF/tabletop	Vertical (nm)	Horizontal (nm)
No cooling No shims	20	150
No cooling Shims	15	95
Cooling Shims	16	120

A.Jeremie 2014.12.2
Third JCL (Journées Collisionneur Linéaire)

Improvemenr in summer 2014

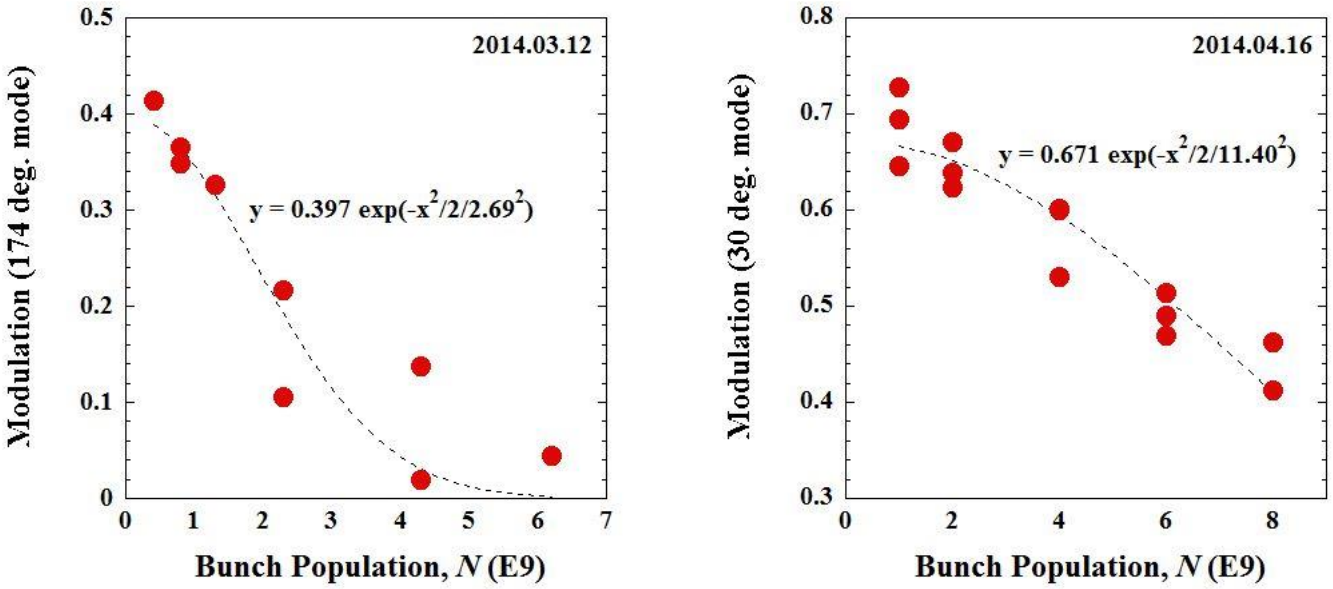
	QD0	QF1	FD Total
Vibration	4.8	30	---
Effect to beam at IP	7.3	12.6	14.6
Vibration	4.8	16	---
Effect to beam at IP	7.3	6.7	9.9

Intensity Dependence – Wakefield?

Before summer 2014

- Beam size at IP strongly depend on bunch intensity
- Various efforts to reduce wakefield (bellows shield, removal of unused structures, moves of structures from high beta to low beta region): No clear improvement.
- Theoretical and Experimental estimation of wakefield strength of some structures (cavBPM, Bellows): experiments showed factor ~2 stronger wake than calculations.
- Found wake field of OTR monitor chamber affected beam size and orbit.

Beam Size Depends on Bunch Intensity

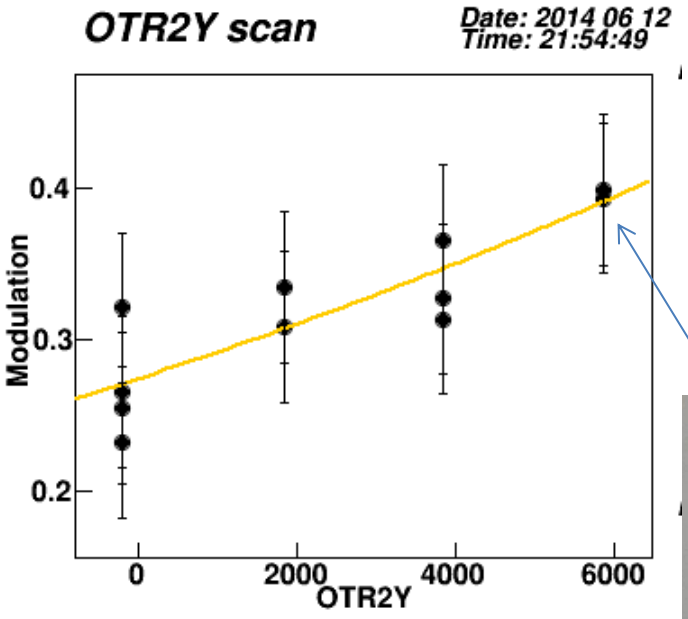


IPBSM modulation as function of bunch population. Measured with crossing angle 174 degrees (left) and 30 degrees (right).

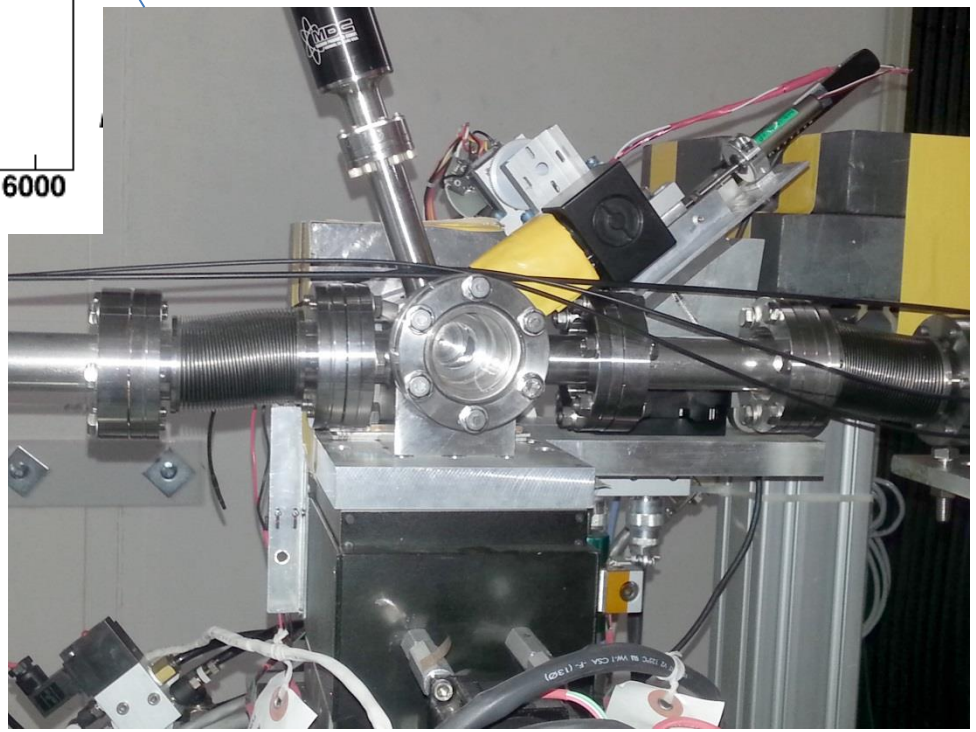
Assuming $\sigma_y^2(q) = \sigma_y^2(0) + w^2 q^2$, w is fitted as 100 nm/nC.

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

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



Before OTR2X position optimization　　After optimization　　(174 deg mode)

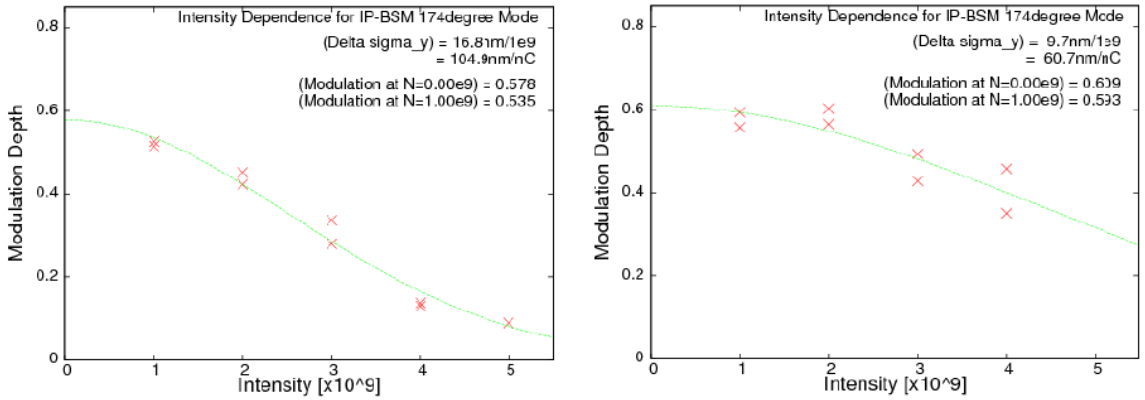


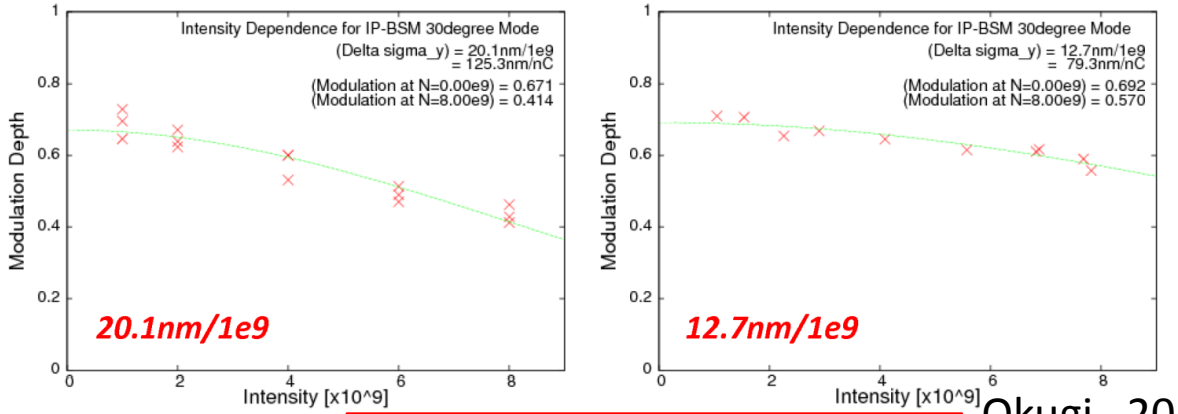
図 2　先々週測定した OTR2X の移動前後のビーム強度依存性（左は移動前、右は移動後）。

By Okugi, 2014.6.23

16.8 nm/1e9 → 9.7 nm/1e9

Removal of all OTRs　　(30 deg mode)

Intensity dependence before OTRs removal　　***Intensity dependence after OTRs removal***



Okugi, 2014.6.26 ATF Op. meeting

20.1 nm/1e9 → 12.7 nm/1e9

30 deg mode tend to give stronger dependence than 174 deg mode.

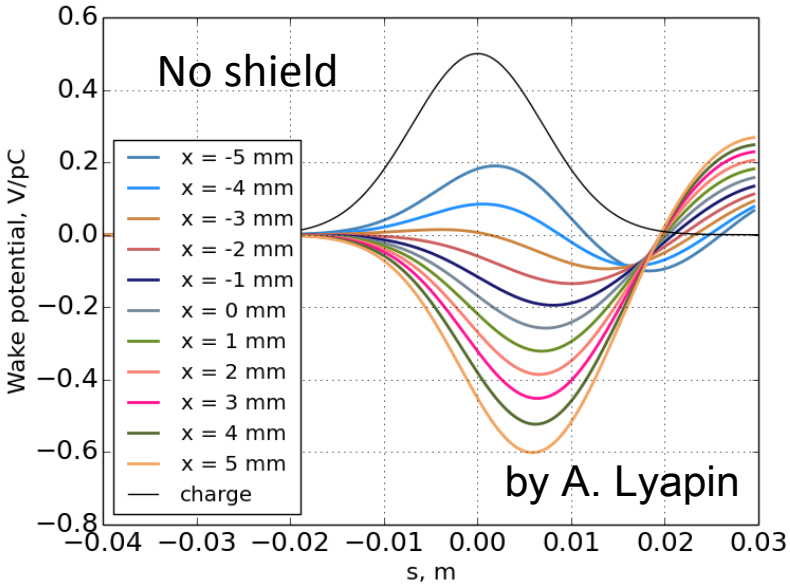
Slide by K.Kubo in ATF operation meeting Nov 7, 2014

Intensity Dependence – Wakefield

Oct-Dec, 2014

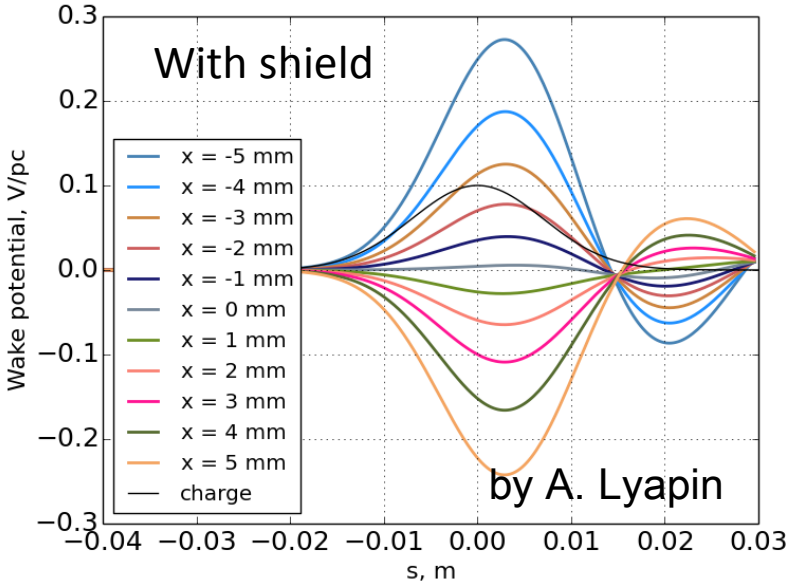
- Improved symmetry of OTR monitor chamber
  - Operation with better chamber position
- Orbit – Intensity correlation data
- Wakefield Free Steering test (later talk)

OTR monitor View Port Shield



Remove vertical asymmetry

Reduce position dependent wake (factor 0.6)



OTR Chamber wake

- Significant effect of OTR chamber position was found (June 2014)
  - Removal of all four OTRs and optimization of the chamber positions showed similar intensity dependence of the IP beam size
    - Before optimization: ~ 17-20nm/1E9
    - Removal or position optimization : 10-13 nm/1E9

- All OTR chamber view ports shielded
  - Vertical symmetry became better (optimum position is closer to chamber center)
- Response of orbit downstream and beam size at IP to vertical move of each OTR chamber.
  - Observed responses suggested the strength of wake much larger than calculations.
  - Calculations should include other moving parts?
- This apparent discrepancy does not explain strong intensity dependence of IP beam size after optimization of chamber positions.

Intensity Dependence – Wakefield

Near future

- Need more theoretical and experimental studies
- Theoretical
  - Wakefield sources not included in present calculations?
  - Transverse kick with large offset (near beam pipe radius?)?
  - Effect of orbit jitter?
  - Other effect? E.g. Small band width + energy spread increase? ?
- Experimental
  - Orbit data: Intensity dependent orbit change, WFS, etc..
  - More structures on movers?
  - ??

For Goal 2

Main Program in Oct-Dec 2014

- New IPBPM installed and commissioned
- Resolution estimation
- Intra-pulse feedback at IP

Details will be presented in following talks.

IPBPM for Gola 1 and 3

- Position jitter at IP: Significant compare with beam size?
- IPBPM as bunch tilt monitor. Sensitive enough?

Other important studies

- Beam tuning with low betay* optics
  - Betay* 0.05 mm (design x 1/2) (betax* 40 mm, design x 10)
- Ground motion – orbit feedforward study
- Beam halo measurement
  - Diamond sensor installed and data taking

Will be reported in following talks.

Near Future plans of ATF operation

- No more beam operation in 2014 fiscal year (till March 31)
- Next fiscal year (April 2015 – March 2016): Expect improved total operation period more than 2014. (will be fixed in early March)
- We should have effective beam time.

- ATF2 Project meeting Feb. 24-26
- Goal 2 and Goal 3 (or 1.5. Need discussions to decide) will be our priorities.
- Solving remaining Goal 1 issues depends on these studies.
- Continue studies on; Low betay*, Ground motion, Monitors