ATF2 Goal 1

Toshiyuki OKUGI, KEK
2014/ 2/ 13
ATF TB&SGC meeting, KEK

Beam Instrumentations

We have two very important instrumentations to achieve the ATF2 goal 1.

1. IP-BSM

- should be stable the measured modulation.

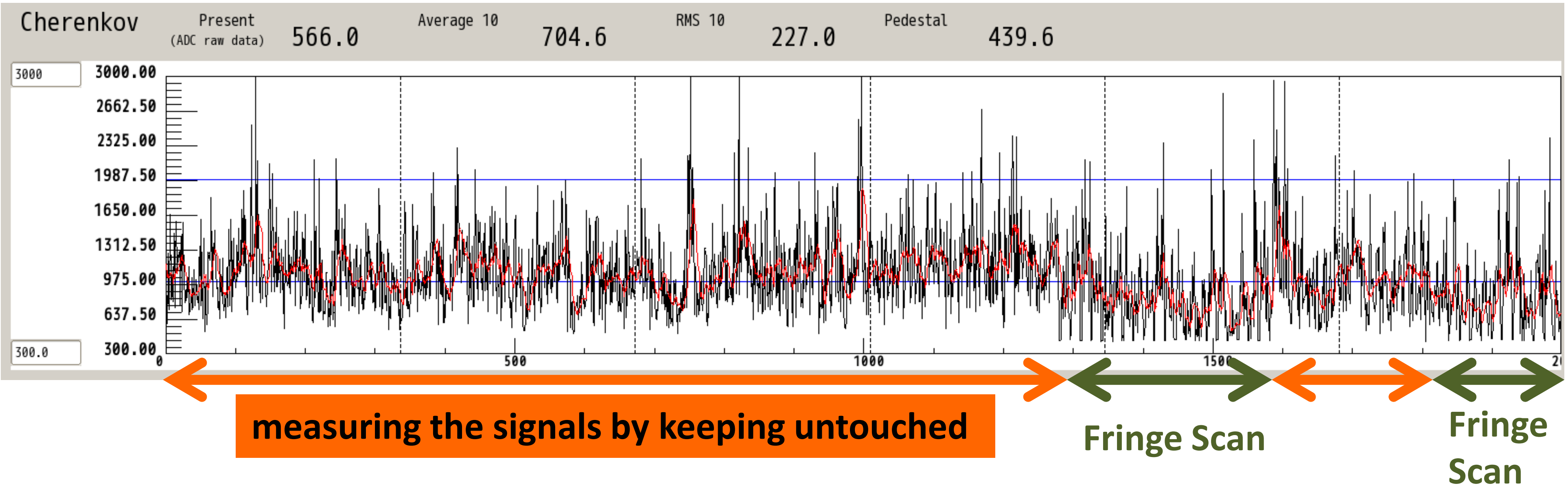
2. IP-BPM

- should be available as the ATF2 online monitor.

IP-BSM status

- In Jan/Feb runs, the beam size measurement by IPBSM was very difficult especially for the “fringe scans”.
- **We observed the unacceptable level of drift (50% or more) of the Compton signal. It destroyed the modulation profile.**
- Periodic drop about several tens of seconds was observed.
- In addition, the jitter was relatively bigger than before.

Cherenkov Signal (ADC raw data)



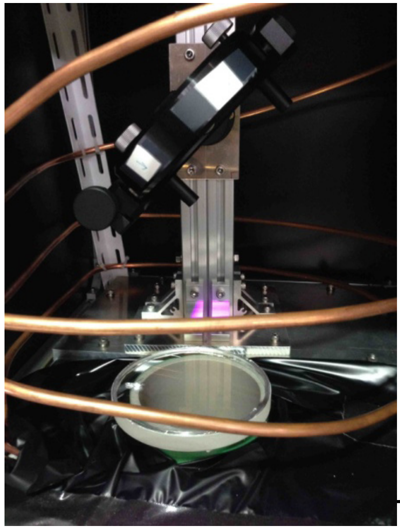
Survey with Engineer, Feb 10th

We called the detail survey by the laser company. It was done on Feb/10th. A CCD tool to monitor the laser profile at IP was prepared and helped this survey.

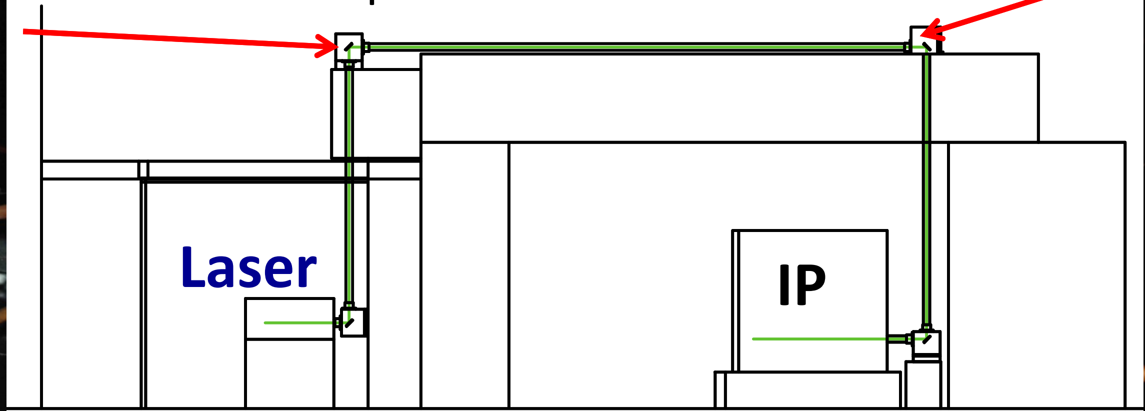
- **Setting of the laser oscillator is fine as expected.**
- **The cooling water unit is also working well and stale.**
- **Retuning the temperature controller of the Harmonic Generator (1064→532nm) reduced the amplitude of the drift about a half.**
- **Other laser components are passive and may not be candidates of the drift source.**

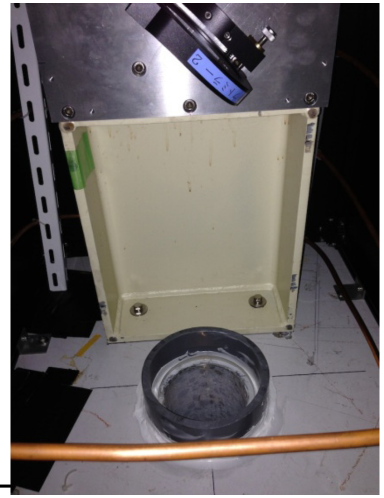
- We also discussed about other possibility and suspected the air turbulence in the laser transport.

Shut the air flow by optical-flat windows

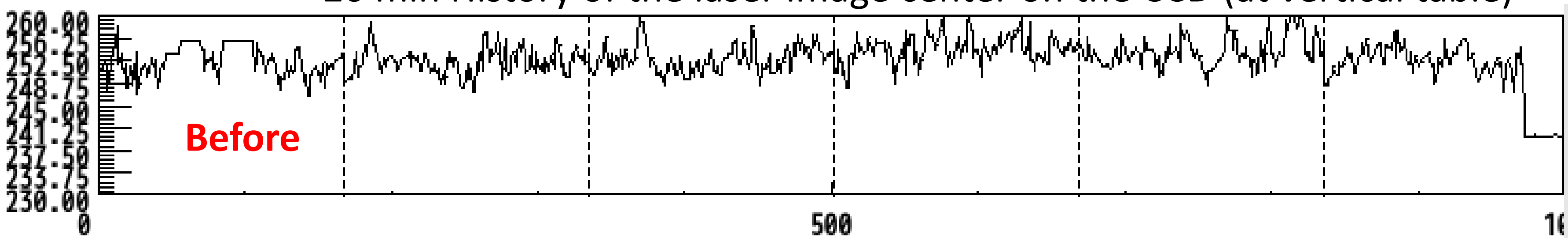


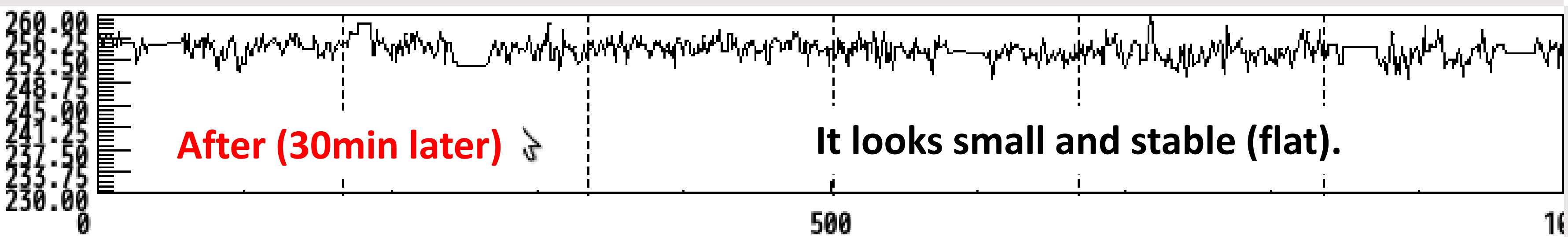
transport on the shield block





20 min History of the laser image center on the CCD (at vertical table)



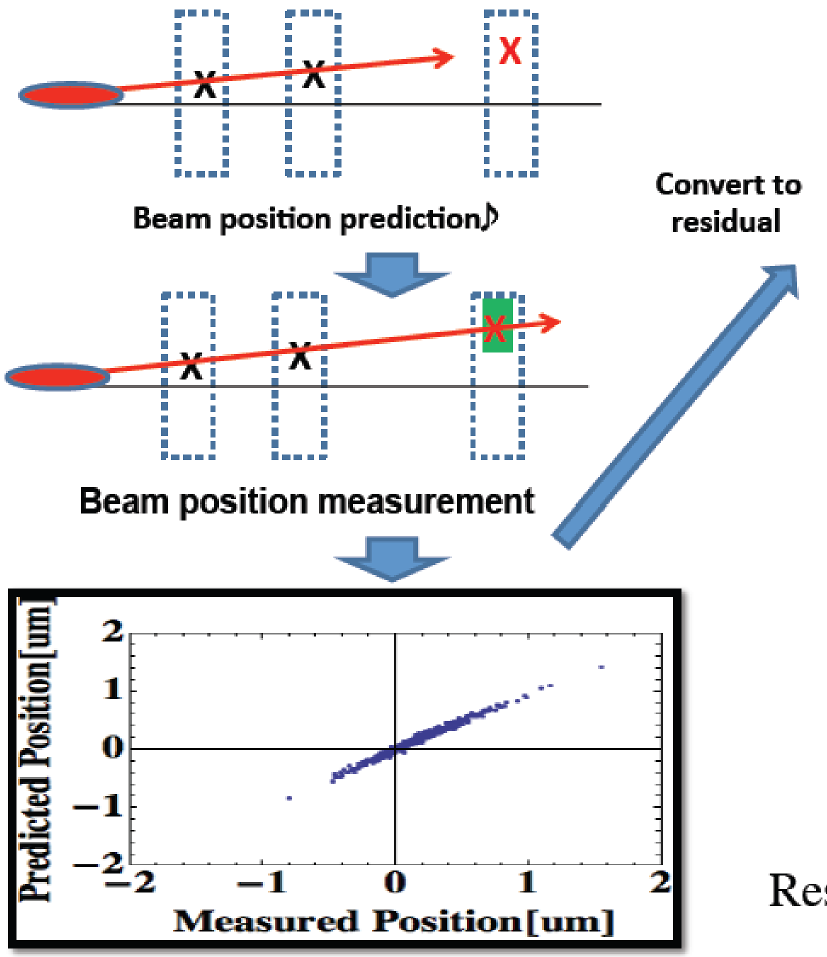


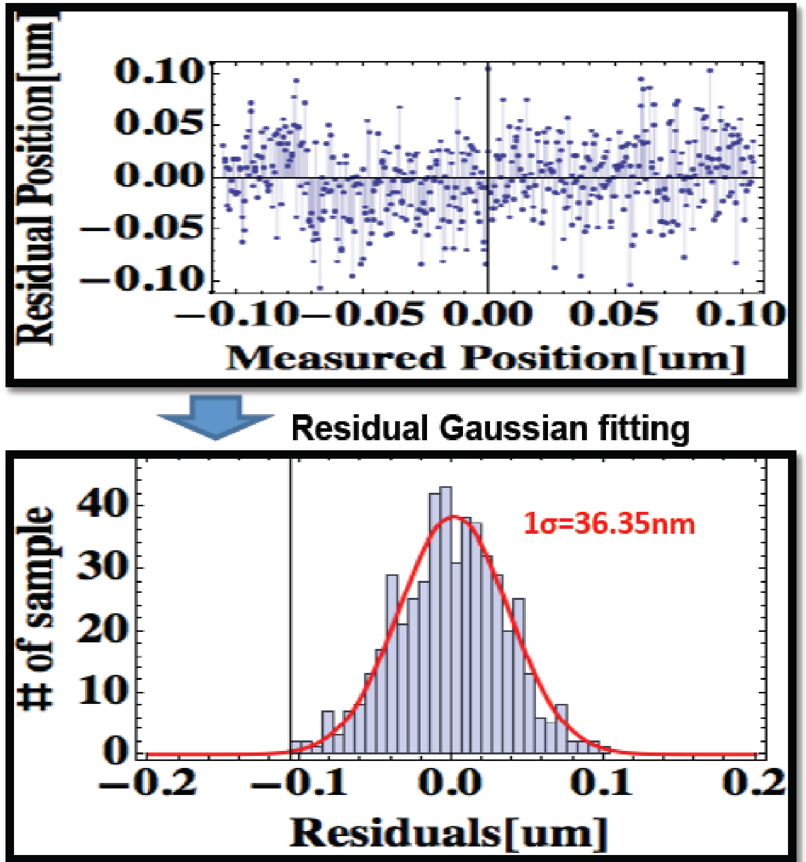
We expect stable laser transport than previous beam operation.

Present IP-BPM status

Most of the present beam test was done by the following condition

- *100x1000 optics*
- *30dB attenuation*
- *High current (N=6.3e9)*

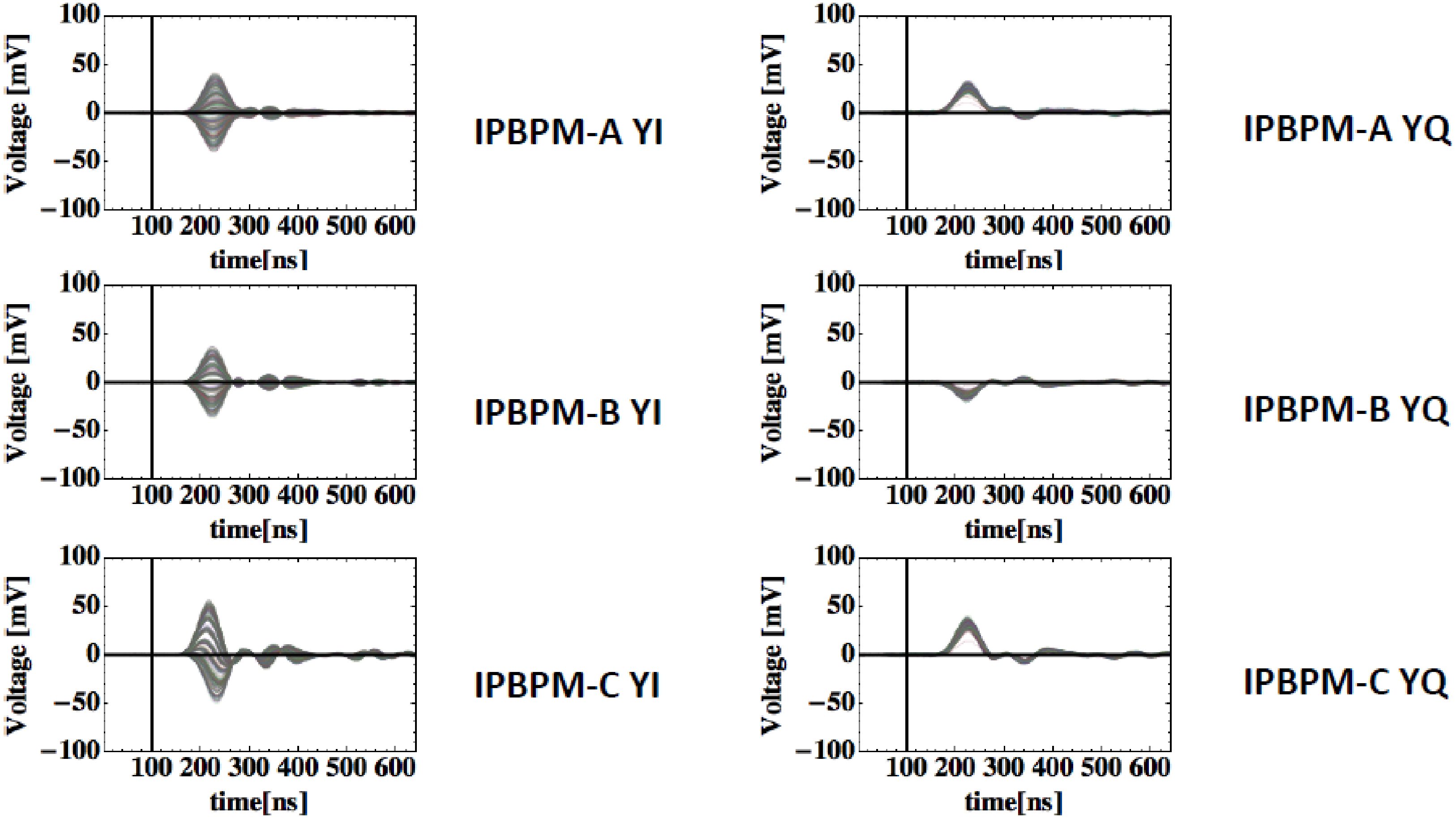




$$\text{Resolution} = \frac{\text{Residual}}{\text{Calibration factor}} = 36.35\ \text{nm}$$

Nonlinearity of IP-BPM Signal

2014/01/31 day shift data 30dB att. case



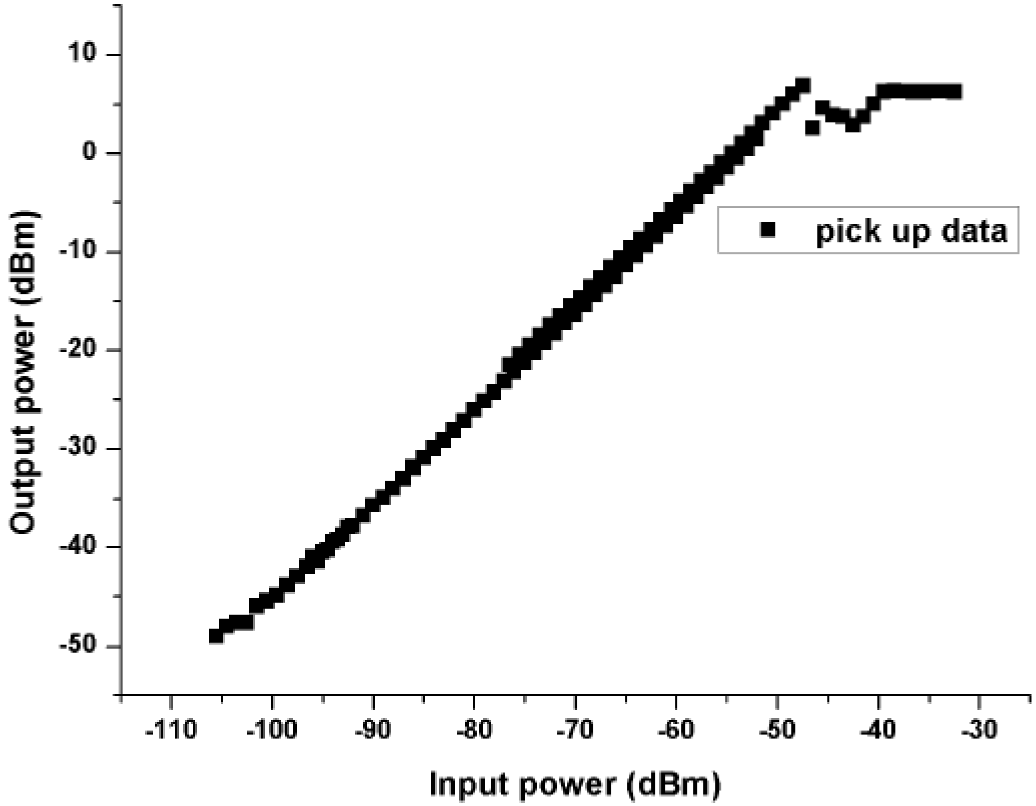
The IPBPM-C peak point of YI signal shows non-linear behavior due to different vertical mover position. This non-linearity effects to calibration study.

Linearity of Electronics

Current electronics conversion gain was set to near the 54dB. The linear range was from -46dBm to near the -100dBm.

The limit thermal noise of electronics was enough to detect 2nm beam position. However, if we want a more wide dynamic range with 0dB att. case then we should reduce conversion gain than now.

So, yesterday and today we will change the conversion gain of three electronics from 54dB to 45dB.



We expect wide dynamic range than previous operation

Discussions …

IP-BSM

The first priority by 2014 March is to recover the IP-BSM stability to that in 2013 spring operation.

In order to measure less than 40nm beam size, we require more stable system than 2013 spring.

IP-BPM

The requirement of IP-BPM to ATF2 goal 1 study is

- < 20nm resolution
- 30um dynamic range at N=1e9.
  (enough only with IPB and IPC)

The IP-BPMs are required not only performance test, but also preparation for goal 1 study.

We will discuss how to proceed the IP-BPM study in this spring run in the session on 2/14.

Study with 10x1 optics

Now, we operate the ATF2 with 10x1 optics at N=1e9.
- 10x1 optics ---- reduce the effect of the multipole field error
- N = 1e9 ---- strong intensity dependence of IP beam size

The difficulty of the vertical beam size tuning at ILC IP is comparable to ATF2 10x1 optics.

Rough Evaluation of Nonlinear Component in ATF2 Beamline

When we assumed the beam size at quadrupoles as $\sigma_{x,y} \propto L^* \sqrt{\dfrac{\varepsilon_{x,y}}{\beta^*_{x,y}}}$,

the effect of multipole field to IP beam size can be roughly scaled as

$$Y_{24} \propto L^{*2} \sqrt{\frac{\varepsilon_x \varepsilon_y}{\beta^*_x \beta^*_y}} \Big/ \sqrt{\varepsilon_y \beta^*_y} = L^{*2} \varepsilon_y \sqrt{\frac{\varepsilon_x}{\beta^*_x}} \qquad (5th\ order\ aberration) \propto L^{*5} \frac{\varepsilon_x^2}{\beta_x^{*2}} \sqrt{\frac{\varepsilon_x}{\beta^*_x}} \Big/ \sqrt{\varepsilon_y \beta^*_y} = L^{*5} \frac{\varepsilon_x^2}{\beta_x^{*2}} \sqrt{\frac{\varepsilon_x \varepsilon_y \beta^*_y}{\beta^*_x}}$$

etc.

		ILC	ATF2(1x1)	ATF2(10x1)
2nd order	Y46	1	0.91	0.91
	Y24	1	6.50	2.05
	Y22	1	3.76	0.38
	Y26	1	0.52	0.16
	Y66	1	0.07	0.07
	Y44	1	11.14	11.14
3rd (horizontal)		1	17.80	0.56
4th (horizontal)		1	84.33	0.84
5th (horizontal)		1	399.55	1.26

Chromatic aberration

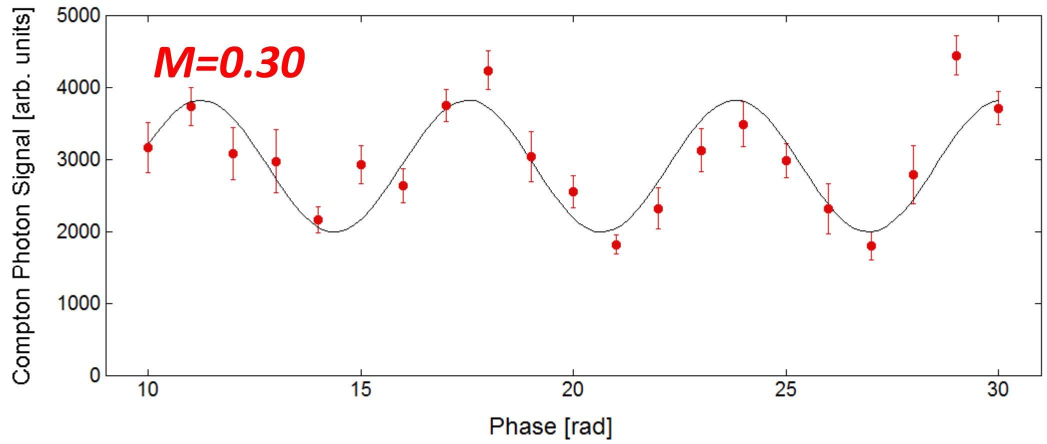
Generate by Sextupole

Allowed component of quadrupoles

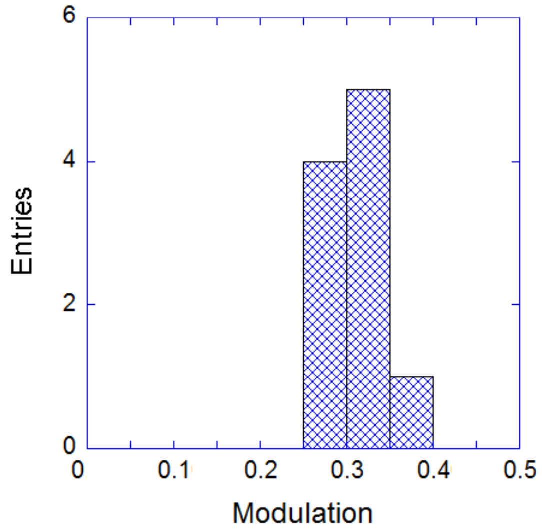
The effect of ILC higher order multipole field is comparable to ATF2 10x1 optics.

IP beam size are measured with IP-BSM (Shintake Monitor)

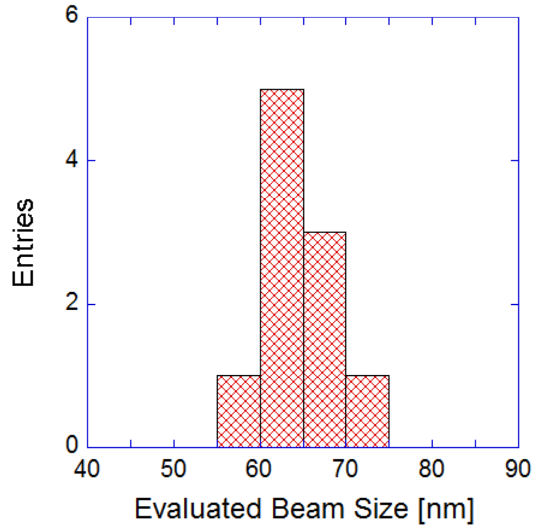
Example of the typical measured modulation by IP-BSM.



Modulation depths of measurement on 03/08/2013



Evaluated IP beam size of measurement on 03/08/2013



by assuming to be C=1.0
(No systematics for IP-BSM)

No beam jitter subtraction

Present status of ATF2 vertical beam focusing

	ILC - 500GeV		ATF2		
	RDR	TDR	10 × 1 optics		1 × 1 optics
	Design	Design	Design	Achieved	Design
Beam Energy	250 GeV		1.28 GeV		
L*	3.50m		1.00 m		
εx[nm] × εy[pm]	0.02 × 0.07		2.0 × 12		
σp/p	0.12%	0.12%	0.10%	0.06%	0.10 %
βx*[mm] × βy*[mm]	21 × 0.40	11 × 0.48	40 × 0.10		4 × 0.10
σy* [nm]	5.3	5.9	37	< 65	37
L*/βy*	8750	7292	10000		10000
L*/βy* × σp/p	10.5	8.75	10.0	6.0	10.0

Strength of chromatic aberration

- The difficulty of 10x1 optics is comparable to that of ILC.
- ATF2 achieved to focus the beam to less than 65nm by using with the local chromaticity correction scheme

Discussions …

The beam instrumentation devices are very important for ATF2 goal 1.

1. IP beam size tuning with 2nd order knob
(IP-BSM should be stable)

2. Jitter subtraction at IP
(IP-BPM requirement 10-20nm resolution with +/-30um dynamic range)

The study items with 10x1 optics

The investigation of the jitter sources and the jitter propagations.

The investigation of the head -tail offset at IP

1. with IP-BPM pickup (T.Shintake at ILC domestic review)

2. with C-band RF kicker (G.White at the 17th ATF2 project meeting)

Study with 1x1 optics

The difficulty of the horizontal beam size tuning at ILC IP is comparable to ATF2 1x1 optics.
But, the difficulty of the vertical beam size tuning for ATF2 10x1 optics is much difficult to ILC .

Furthermore, the large beam tail s are expected for ATF2 1x1 optics.

Horizontal IP beam size issue of ATF2

Horizontal IP Parameters for ILC and ATF2

	ILC - 500GeV		ATF2	
	RDR	TDR	10x1 optics	1x1 optics
Beam Energy	250 GeV		1.28 GeV	
L*	3.50m		1.00 m	
$\sigma p/p$	0.12%		0.10%	
εx	0.02nm		2.0nm	
βx^*	21mm	11mm	40mm	4mm
σx^*	0.65um	0.47um	8.9um	2.8um
$L^*/\beta x^*$	167	318	25	250
$L^*/\beta x^* \times \sigma p/p$	0.20	0.38	0.025	0.25

Strength of chromatic aberration

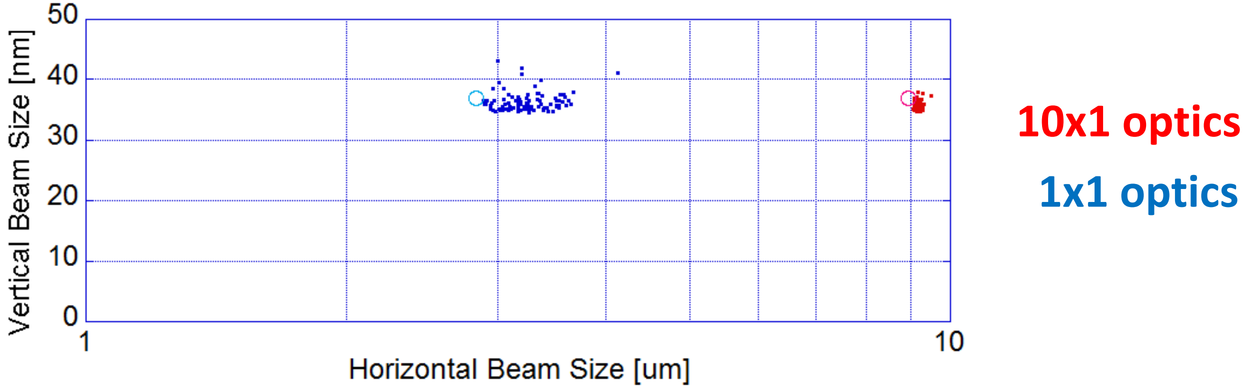
The horizontal chromaticity for ATF2 10x1 optics is much smaller than ILC.

Results of Beam Tuning Simulation

Errors for the tuning simulation

Quadrupole Sextupole	Misalignment	Δx	100 μm (Gaussian)
		Δy	100 μm (Gaussian)
		$\Delta \theta$	200 μrad (Gaussian)
	Strength Error	ΔK	0.1% (Gaussian)
Bend	Misalignment	$\Delta \theta$	200 μrad (Gaussian)
	Strength Error	ΔK	0.1% (Gaussian)
BBA Accuracy			±100 μm (uniform)
IP-BSM Accuracies	2-8 degree mode		±100 nm (uniform)
	30 degree mode		±20 nm (uniform)
	174 degree mode		±8 nm (uniform)
Wire Scanner Accuracy			±800 nm (uniform)

Result of IP beam tuning simulation (core beam size)



Expected IP horizontal beam size growth for 1x1 optics (20%) was larger than 10x1 optics(3%).

	β_x^*	β_y^*		σ_x^* [μm]		σ_y^* [nm]	
				r.m.s.	core	r.m.s.	core
Original (1×1 optics)	4 mm	0.1 mm	Design	2.83 (linear optics)		34.6 (linear optics)	
			Linear	4.17 ± 0.32	3.50 ± 0.26	86.9 ± 13.2	72.2 ± 10.1
			Linear+2^{nd} order	4.07 ± 0.31	3.43 ± 0.22	44.3 ± 2.5	37.9 ± 1.8
Present (10×1 optics)	40 mm	0.1 mm	Design	8.94 (linear optics)		34.6 (linear optics)	
			Linear	9.24 ± 0.07	9.16 ± 0.07	47.1 ± 2.5	43.5 ± 1.6
			Linear+2^{nd} order	9.24 ± 0.07	9.16 ± 0.06	36.5 ± 0.9	36.0 ± 0.9

The large tail was expected for 1x1 optics.

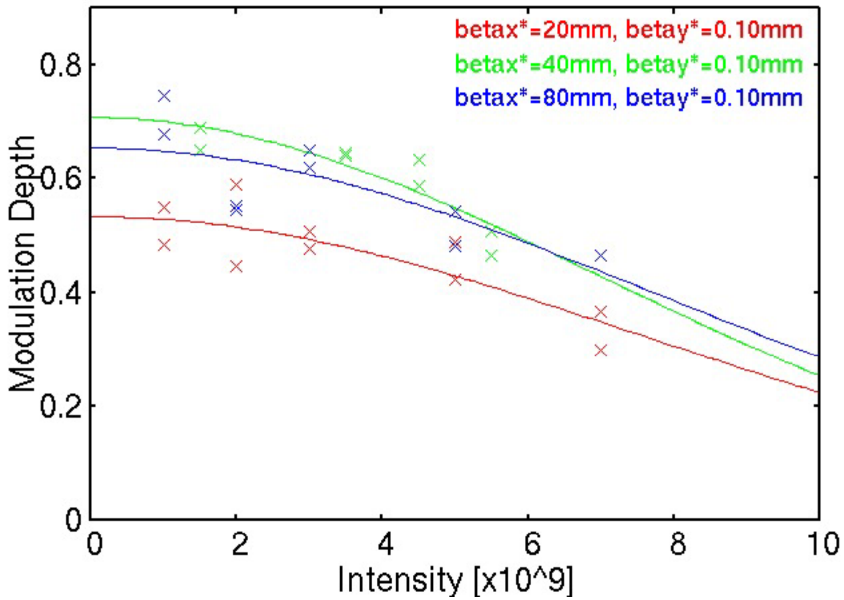
Since the IP horizontal IP beam size affects to the luminosity for ILC, it is important the IP horizontal beam size tuning, too.

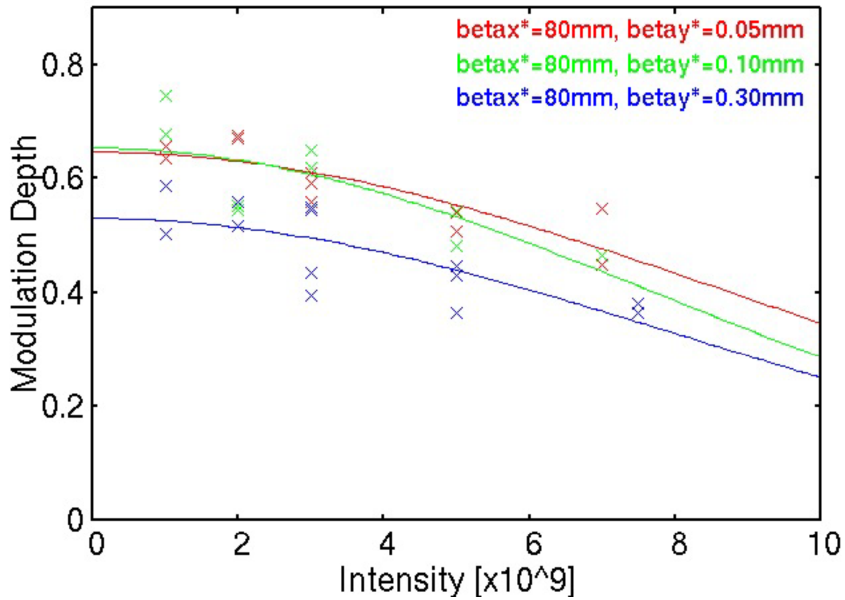
The IP horizontal beam size tuning for ATF2 10x1 optics is much easier than ATF2 1x1 optics and ILC.

We should investigate whether the tail folding octupoles (CERN proposed) help to reduce the beam tail ?

Study of the intensity dependence

High intensity is not only important to investigate of source of the intensity dependence, but also important to improve the resolution of IP-BPM (important to ATF2 phase 2 study).





We have two study items about the intensity dependence

1. Shielding the vacuum pumping port.

2. Wakefield free

Beam Schedule in February and March

2 2014						
Su	Mo	Tu	We	Th	Fr	Sa
						1
2	**3**	**4**	**5**	**6**	**7**	8
9	10	11	12	13	14	15
16	**17**	**18**	**19**	**20**	**21**	22
23	**24**	**25**	**26**	**27**	**28**	

3 2014						
Su	Mo	Tu	We	Th	Fr	Sa
						1
2	**3**	**4**	**5**	**6**	**7**	8
9	**10**	**11**	**12**	**13**	**14**	15
16	17	18	19	20	21	22
23	24	25	26	27	28	29
30	31					

... Beam

Study Items

IP-BPM ; Performance study
Preparation to be used to goal 1 study

IP-BSM ; Recovery to last spring run stability
Phase jitter study

Study with 10x1 optics ; strongly depends on the IP-BPM, IP-BSM
Jitter source (Juergen; end of Feb./first week of Mar.)
Jitter propagation
head-tail offset, if kicker available

Intensity Dependence ; wakefield free steering, shielding of port

The schedule from 2014 April will be discuss at the ANNECY ATF2 meeting on 3/17-19