ATF2 update

T. Tauchi,

ILC PAC, 15 -16 May 2012, Fermilab, USA

ATF2 : Goal - I (- 2012)

A. Achievement of 37nm beam size

A1) Demonstration of a new compact final focus system;
proposed by P.Raimondi and A.Seryi in 2000,

A2) Maintenance of the small beam size
(several hours at the FFTB/SLAC)

Goal - II (2013 -)

B. Control of the beam position

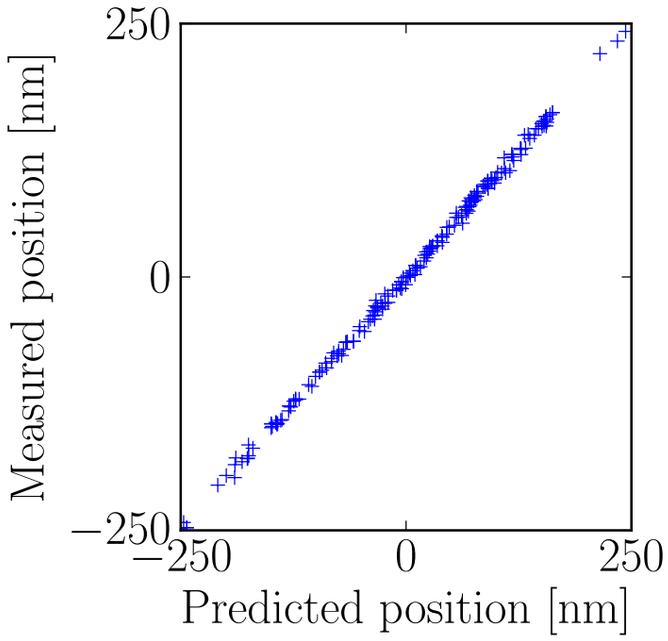
B1) Demonstration of beam orbit stabilization with
nano-meter precision at IP.
(The beam jitter at FFTB/SLAC was about 40nm.)

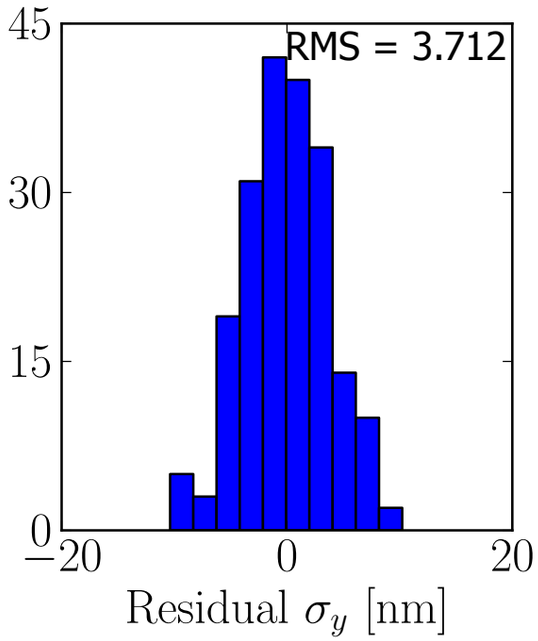
B2) Establishment of beam jitter controlling technique
at nano-meter level with ILC-like beam

For Goal 2 :

Preliminary result of IPBPM

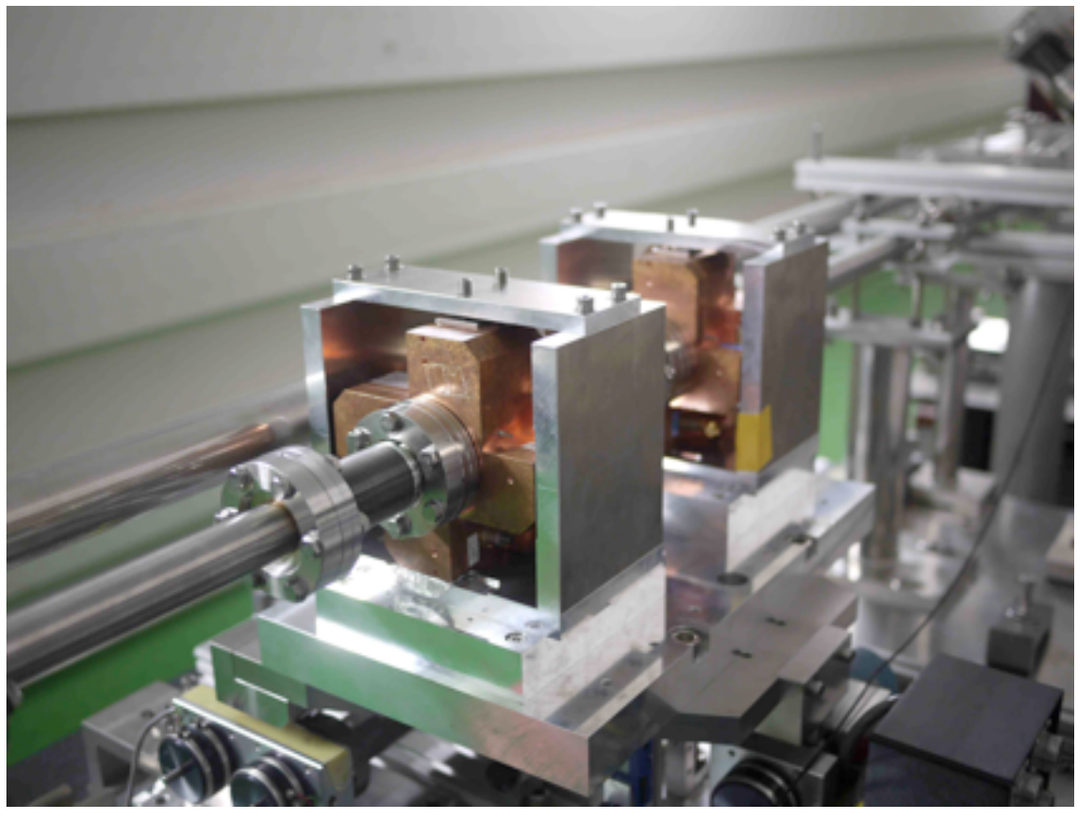
PhD thesis, YoungIm Kim (KNU)





RMS = 3.7 nm

Charge > 0.70 10^{10} electron/pulse



Data taken three shifts in three weeks in November to December, 2011, i.e. 1shift/week and 8h/shift

Published resolution :

8.72 +- 0.28 (stat.) +- 0.35 (sys.) nm

Y. Inoue et al, Phys. Rev. ST Accel. Beams 11, 062801 (2008)

Parameters	unit	ATF2	ILC	CLIC	S-KEKB (LER/HER)
Beam Energy	GeV	1.3	250	1500	4/7
L*	m	1	3.5-4.5	3.5	0.47/1.3
$\gamma\varepsilon_x$	m-rad	5×10^{-6}	1×10^{-5}	6.6×10^{-7}	$2.5/3.3\times10^{-5}$
ε_x	nm	2	1.0 (DR)	0.1 (DR)	3.2/2.4
$\gamma\varepsilon_y$	m-rad	3×10^{-8}	4×10^{-8}	2×10^{-8}	$1.0/1.2\times10^{-7}$
ε_y	pm	12	2(DR)	1(DR)	13/8.4
β^*_x	mm	4	21	6.9	32/25
β^*_y	mm	0.1	0.4	0.07	0.27/0.41
η'	rad	0.14	0.0094	0.00144	
σ_E	%	~0.1	~0.1	~0.3	0.08/0.06
Chromaticity	L^*/β^*_y	$\sim10^4$	$\sim10^4$	$\sim5\times10^4$	$1.7/3.2\times10^3$
σ^*_x	μm	2.8	0.655	0.039	10.2/7.8
σ^*_y	nm	37	5.7	0.7	59/59

Parameters at ATF2

3.11 Earthquake

IP Parameter	nominal	May 2010	Feb 2011	Dec 2011	Feb 2012
Beam energy	1.3GeV	1.3GeV	1.3GeV	1.3GeV	1.3GeV
Emittance in x	2 nm	1.7nm	1.8-1.7nm	2nm	1.8nm
Emittance in y	12 pm	<10pm	27-28pm	~50 pm wakefield@mOTR	15.6 pm
Beta function in x	4 mm	4cm	10mm	1cm	4cm
Beta function in y	0.1mm	1mm	0.1mm	0.5mm	0.3mm
beam size in x	2.8 μm	~10 μm	-	9.2μm/2	11.2μm
beam size in y	35 nm	300 nm 8deg.mode	1.8um@PIP C-wire	850nm 5deg.mode	165nm 30deg.mode

57 m

41.2 m

Final Focus System

Beam Diagnostics

Coupling Correction

Dispersion Cor. (H, V)

Extraction

QK4X QK3X QK2X QK1X QS2X QF6X

QF1X QS1X ZV1X Y X

ZV10X ZV9X

6m

KEX2

ATF DR

MS1X

Septa

KEX1

Final Focus System (38m)

Beam Diagnostics (12m)

LAPP table

LW signal

BSM

(IPBPM)

ML2FF

ICT

MPIP

QD0 QF1

SD0 SF1

IP

BSM signal

MW1IP

MSPIP

MS2FF

MREF1 QF3

QD2A QD2B B1 B2

SD4 QD4A QF5A QD4B MREF2 QF5B SF5 SK1 QD6 B5 QF7 QD8 QF9A SF6 QF9B MREF3 QD10B QD10A MFB1 QM11 12 13 14 15 16 nBPMs

MFB2 (10nm) LW1X(1um) ZH1 ZV1 feedback ZH10X QF21X ICT MW3X MW4X OTR3

feedback QD20X OTR2 MW2X ZV11X OTR1 ZH9X QF19X MW1X OTR0 ZV10X MW0X QD18X QK4X

MS1FF

Beam Tuning: Summary of Fall 2011

Highlights

ILC PAC

October

- h/w & s/w checkouut
- OTR upgrades
- Magnet mover upgrades
- HAPS polarity reverser installation

November

- Resumption of ATF2 tuning operations
- Joint ATF2/IPBSM ops
- ATF2 BBA
- OTR commissioning

December

- Extracted emittance studies
  - New coupling correction procedures
- ATF2 tuning with IPBSM
- Optics &background studies
- New s/w
  - Grid scan

11-13 January **13th ATF2 Project meeting**

Beam Tuning: IP tuning

- In 2010 operation, the minimum beam size was around 300nm with both 10x10 nominal optics and 1x2.5 Edu's optics.

- In 2010 December, we checked <xy> and sextupole strengths.

- In 2011 December, the extraction emittance was increased and the minimum beam size at IP also increased to be around 1um.

We must understand

– reason why the present IP beam size was limited to be 1um.
(difference from 2010 operation)
– reason why the 2010 IP beam size was limited to be 300nm.

First Goal: Discussion at the 13th ATF2 project meeting, KEK, 11-13 January, 2012

We agree that in order to get Goal 1 it is necessary to have a dedicated period of time focused only on that activity.

The agreed planning for 2012 is.

- January – March: R&D and checking
- April - June: Training and R&D
- October - December: Goal 1

Notes:

- Modification of linac modulators have to be made during summer shutdown, these means that some commissioning has to be made after summer. In order not to interfere with the Goal 1 period the re-starting of the Fall could be made 1or 2 weeks before (mid June – mid September electric power reduction)
- After checks in the Ext line some hardware work could be necessary and maybe also some commissioning has to be accorded

First Goal: Discussion at the 13th ATF2 project meeting, KEK, 11-13 January, 2012

We agree in the following actions:

- Identify the “teachers” for giving the training (G. White, M. Woodley, KEK team…)

- List of contents of the training course

- Coordinator for teaching and organization of the focus Goal 1 period

- Planning group integrated by the responsible of the R&D groups, webex meeting for identify the PhD students/postdocs participating in the effort with a face to face meeting before the training period.

Consensus on new “goal 1” strategy

1. Prepare 12 “students” for ATF2 operation (coordinated by S. Kuroda)

   ➔ 5 students were trained in April, 2012

2. Eight weeks dedicated “goal 1” operation in October-December

   - daily & weekly meetings ➔ review progress, modify the planning,…
   - commissioning and operation plan jointly defined and supported:

   several paths can appear and may be valid, but single decision essential to avoid confusing the “students” in the control room !

   - overall coordinator in addition to weekly / daily shift management:

   based on-site, experienced in machine physics and management for efficient communication flow between all contributors

Agreement at the ATF2 session, KILC12, Daegu, Korea, 24 April, 2012

1 2012

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				

Emittance growth study at the extraction line as a function of intensity, y' bumps around BS1X, w/ & w/o the 2nd kicker - strong intensity dependence observed
Beam Based Alignment (BBA) at FFS - found large offset (~1mm) at sextupoles

Re-alignment of septum's, especially septum-3 - 0.5mr vertical kick confirmed
- to correct it, the 1'st kicker rotated 60mr (counter-clockwise)
We found and confirmed the wakefield effects at the m-OTRs (1/25) , i.e. resolved the large emittance growth and the ceiling of beam size of about 1um in December.
IPBSM : 420nm by 2-8 deg. mode

2 2012

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			

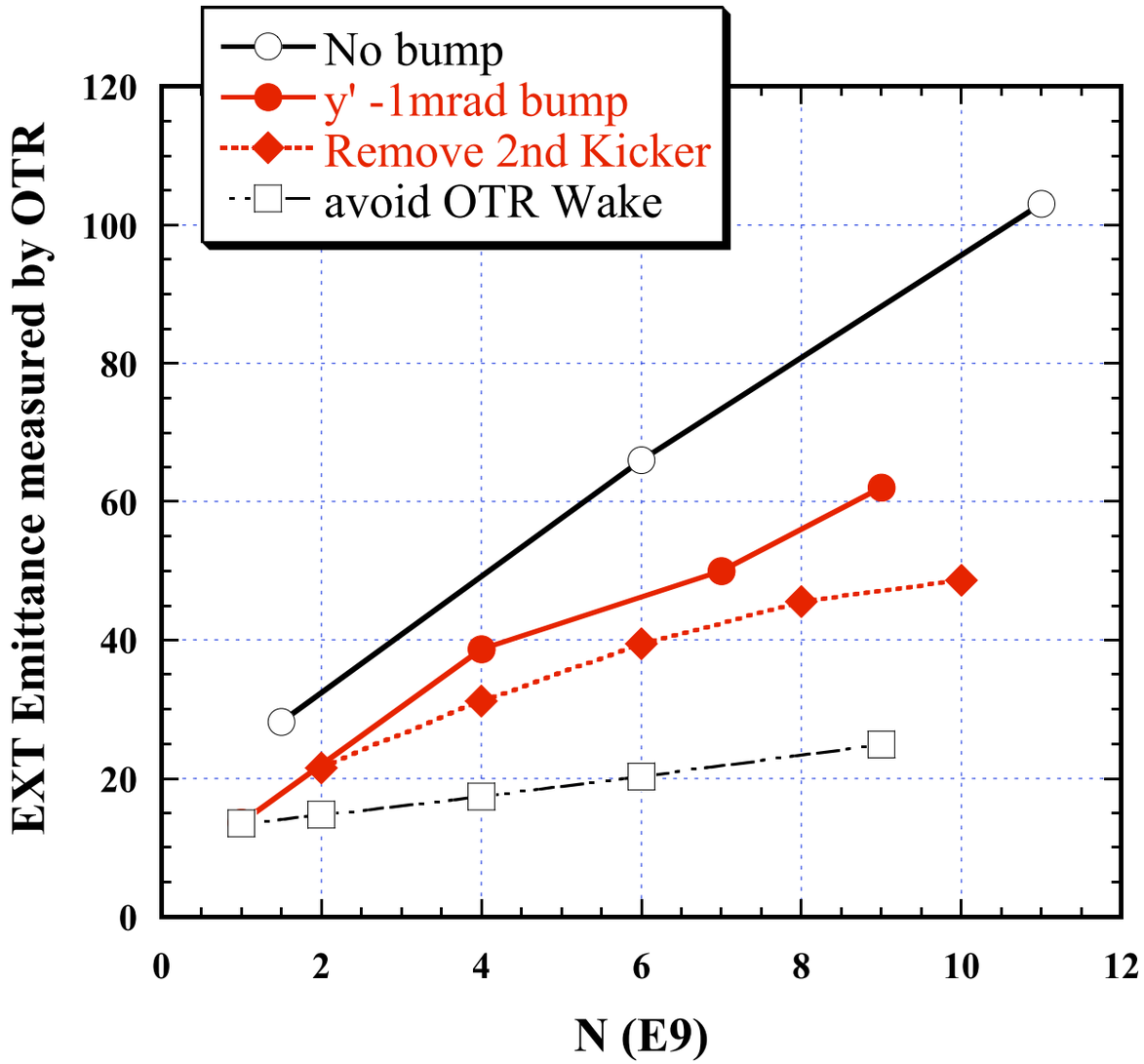
Emittance growth by vertical bumps (±0.5, 1mm) at septums - no significant effect
FF Optics of 10(β^*_x) x 5(β^*_y) and 10(β^*_x) x 10(β^*_y) for IPBSM commissioning
IPBSM : first test with beam-lock (BeamLok, i.e. pointing lock) system,
the view-port window damaged

Trouble of DR cooling system - recovered by replacing the controller unit (2/14)
IPBSM : w/ reduced intensity by 60% to avoid destroying the viewport, mirrors
- large intensity imbalance if two laser beams - cured by replacing a damaged prism
- 3.89 to 7.32 to 30 deg. mode : M=0.402, 202nm (2/17)

Angular jitter (1st kicker) was measured to be 3.5×10^{-4} (2/20) w/o the 2nd kicker.
OTR3X has very large horizontal position dependence of beam size and intensity.
IPBSM : FF Optics of 10(β^*_x) x 3(β^*_y)
- 3.89 to 8 to 30 deg. mode : M=0.522, 165nm (9 measurements, 2/23)
- beam size as a function of SK1FF strength for non-linear correction
- checked 174 deg. mode ; no modulation seen
- laser was not stable, so laser wire (LW) scan was frequently needed, i.e. once/hour

other R&Ds :
Cavity Compton (DR)

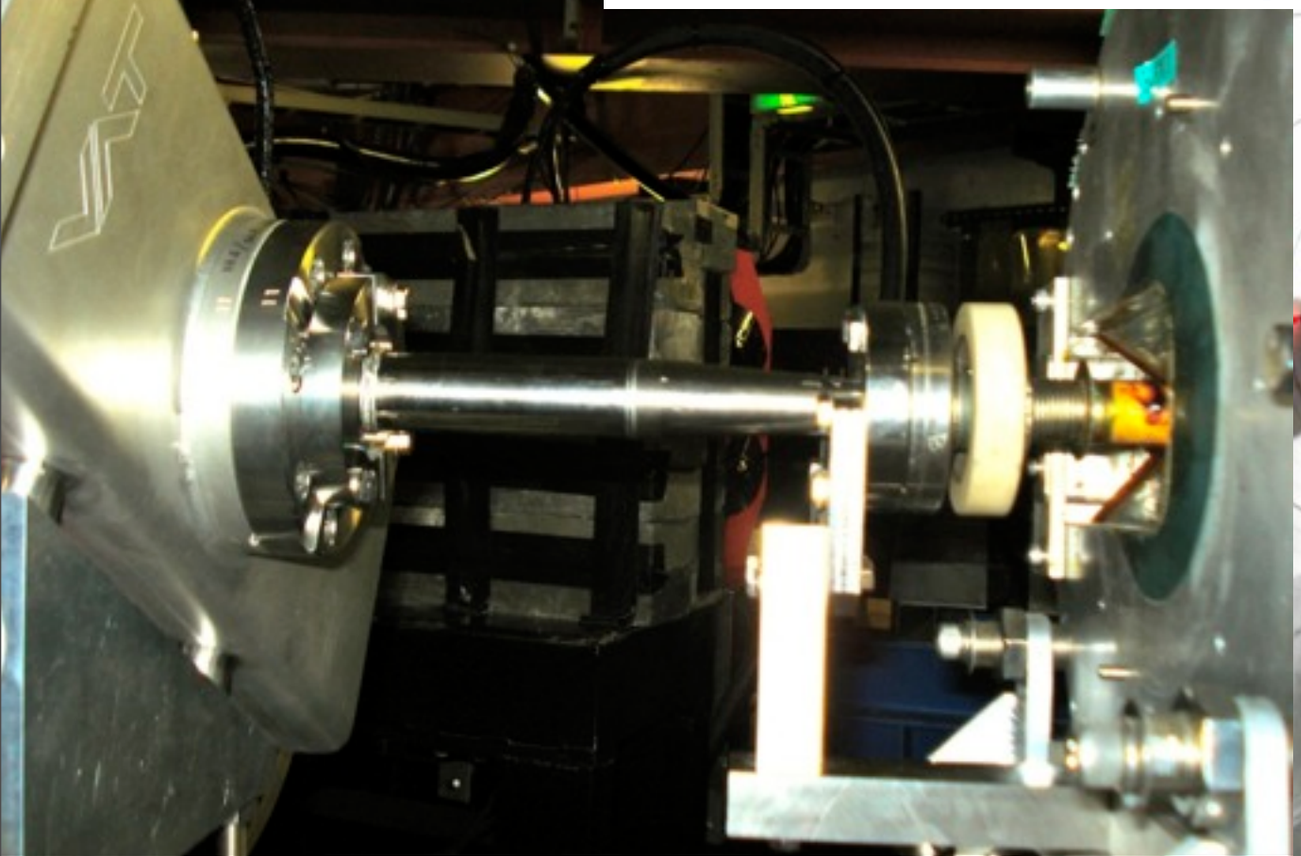
Summary of EXT Emittance

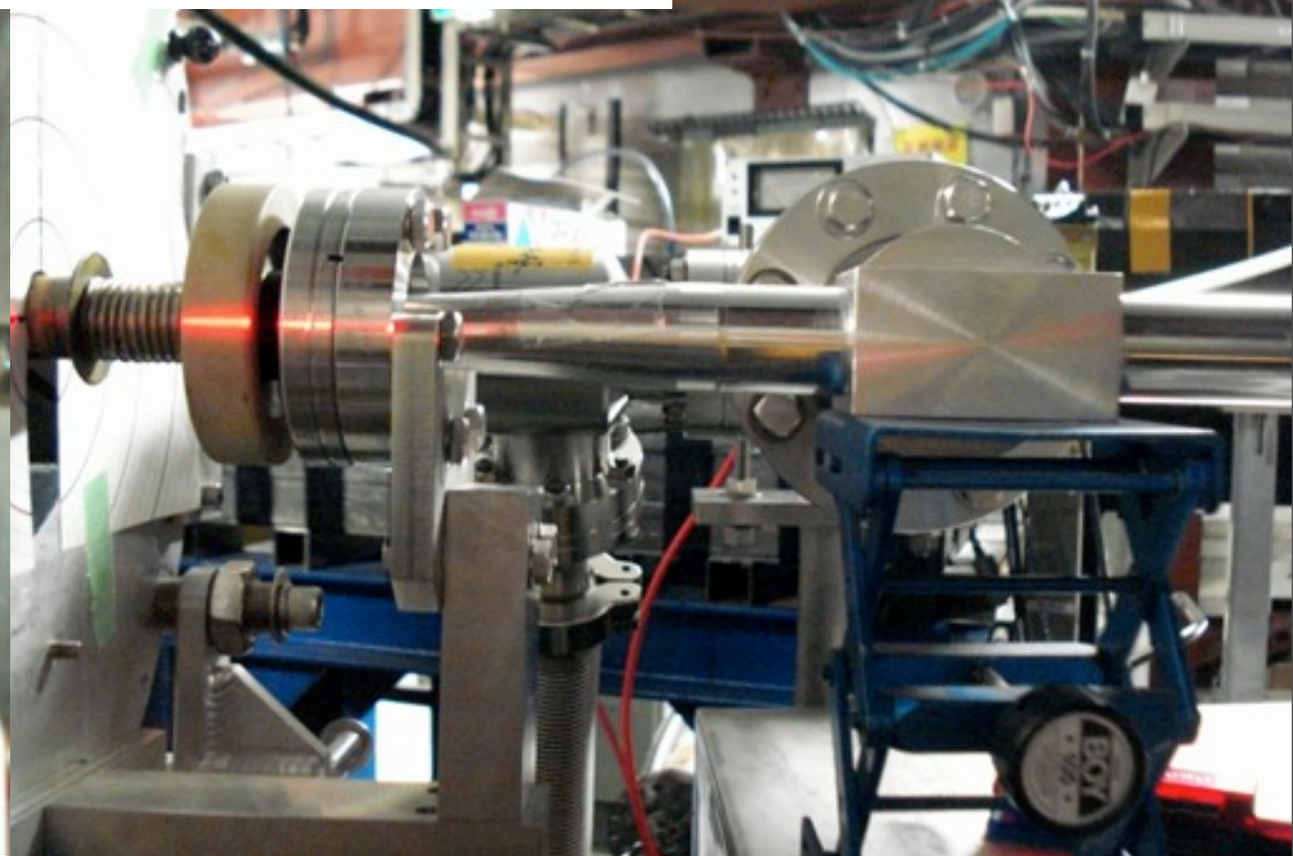


Vertical orbit change had some effect.
Removal of 2nd kicker had some effect.
Wakefield of OTRs had significant effect.

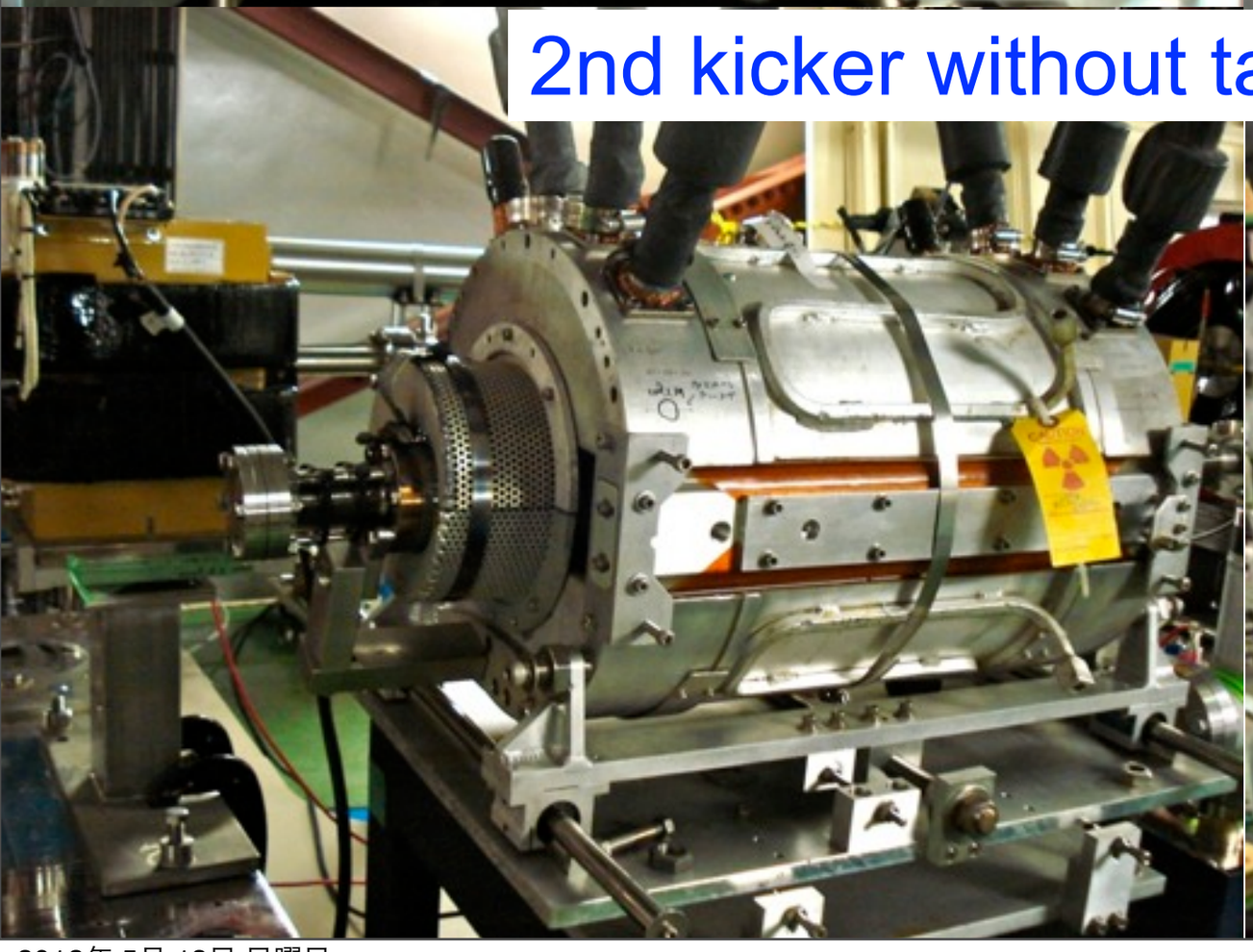
by K.Kubo, 3 Feb. 2012

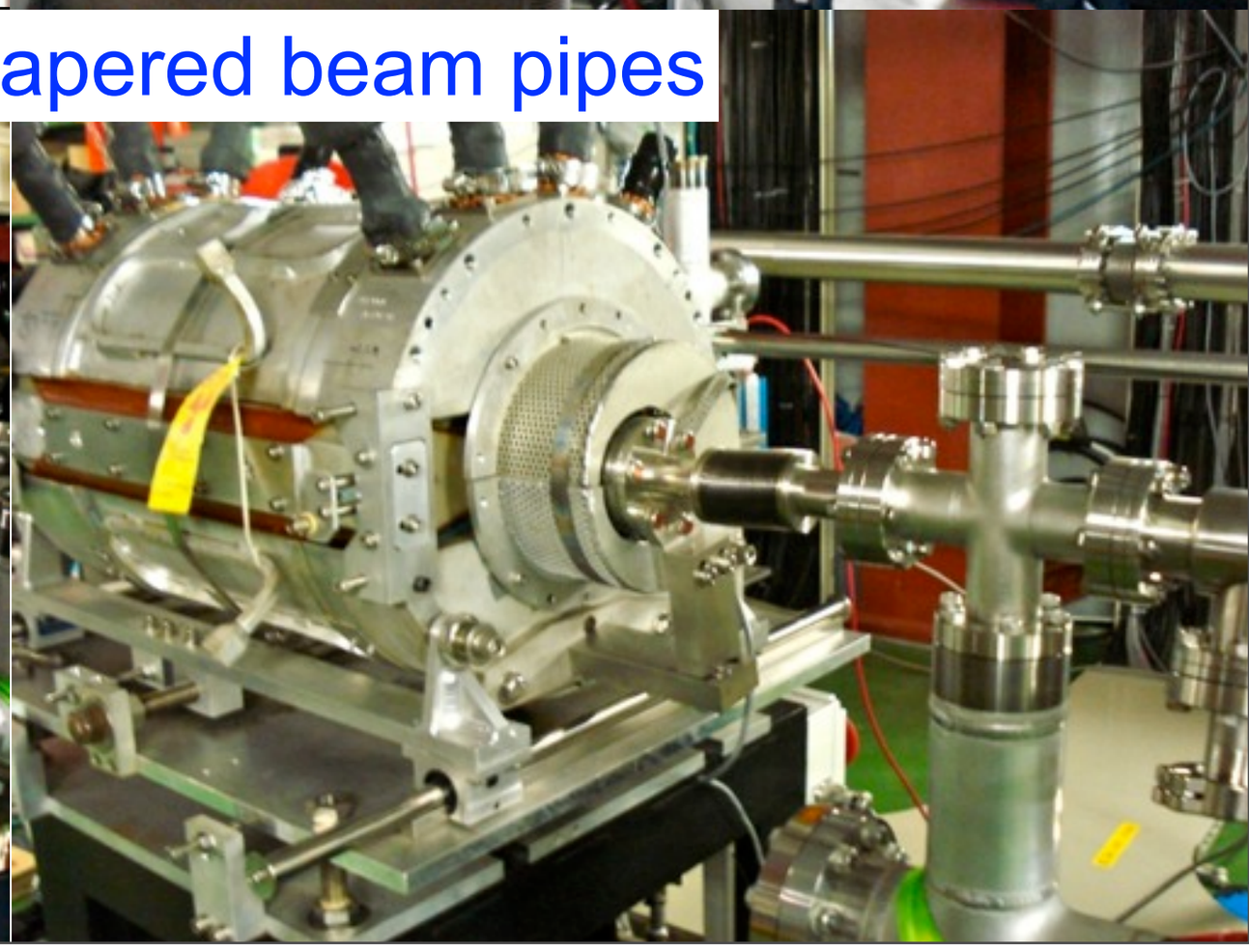
1st kicker with tapered beam pipes



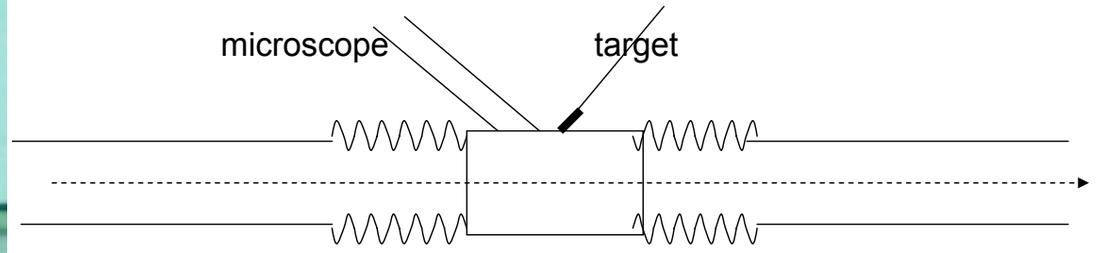


2nd kicker without tapered beam pipes

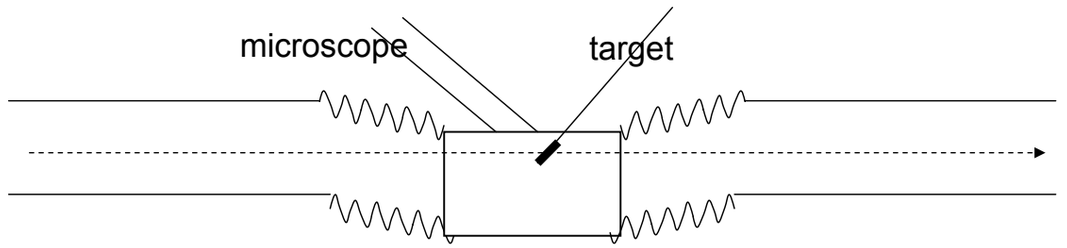




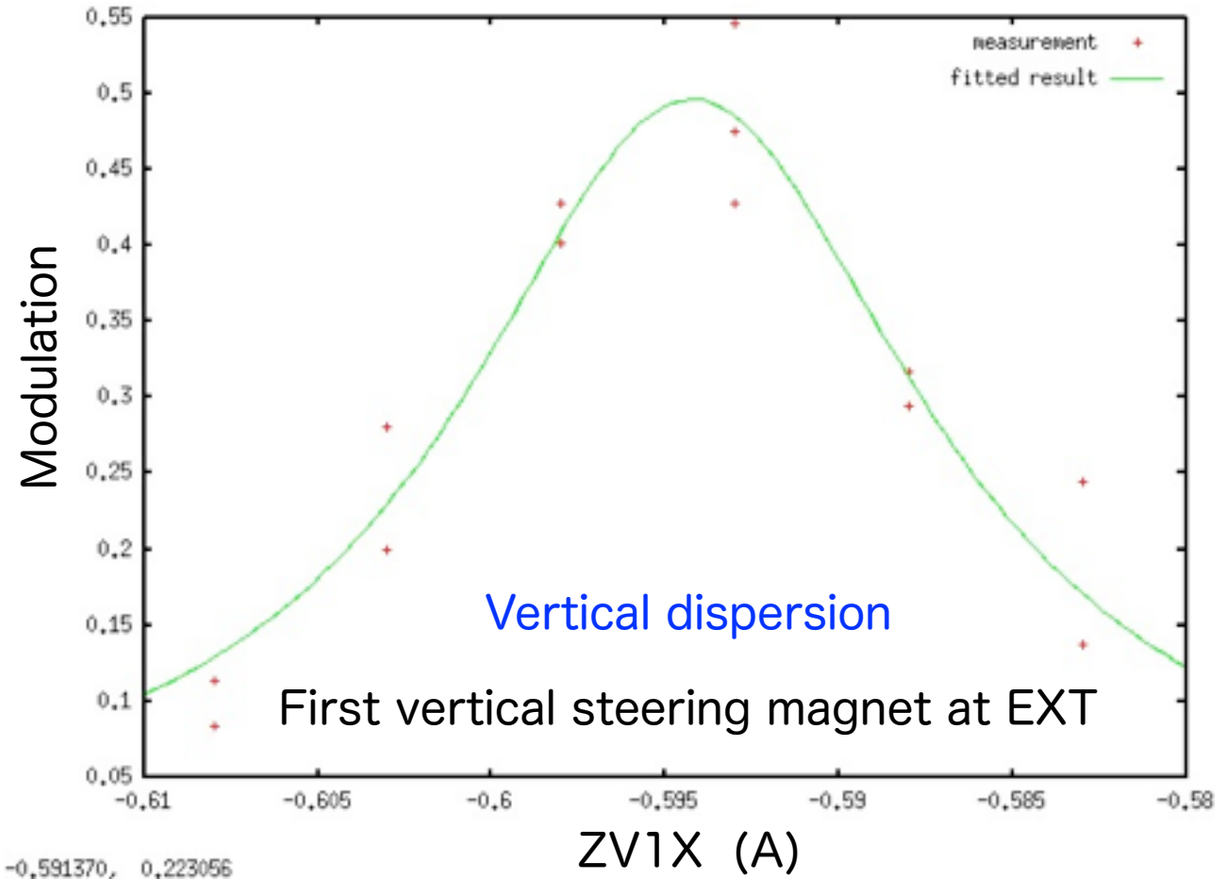
‘NonOTR position’: No significan wakefiled

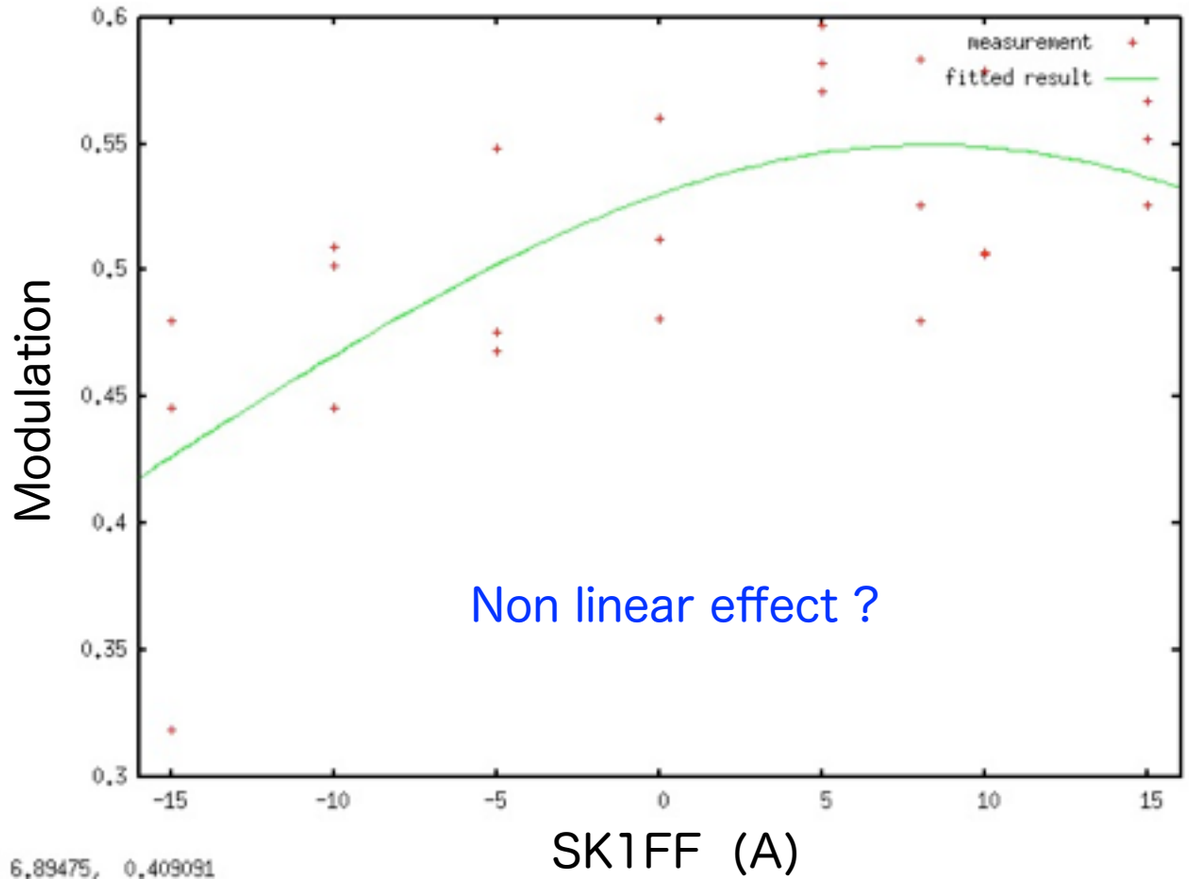


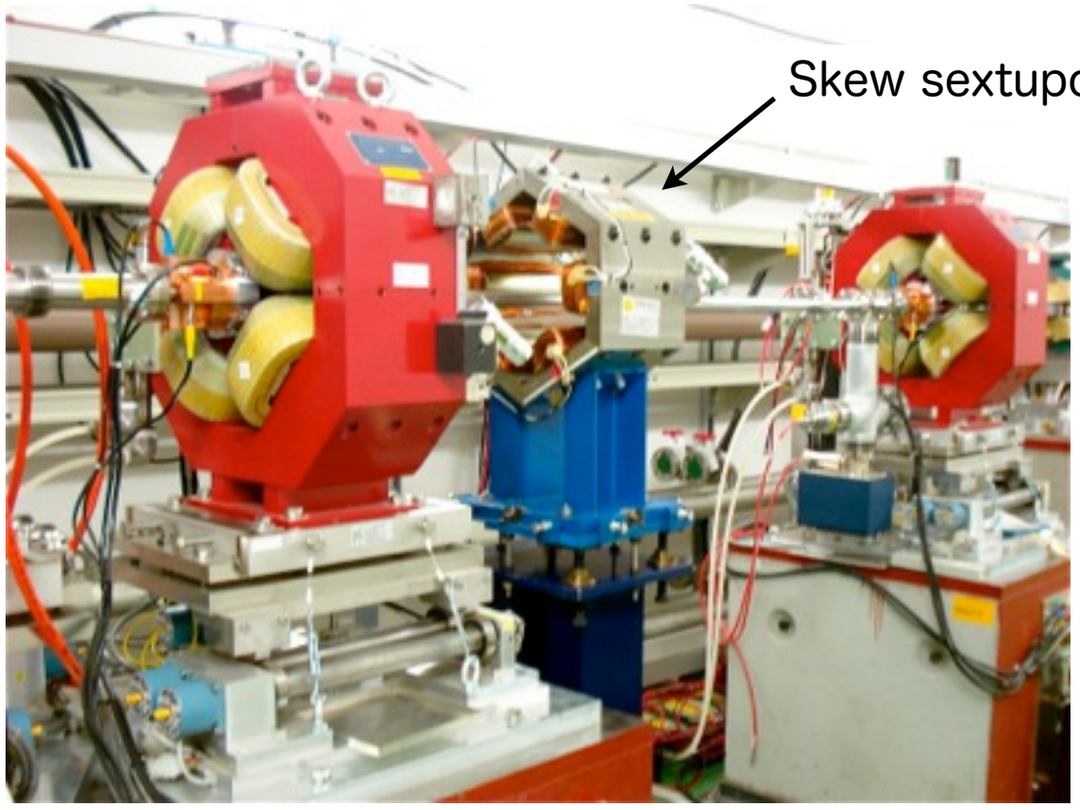
‘OTR position’: Lens of scope should be close to the target for measreument.
Significant wakefiled affect downstream. (Even if target is not inserted.)



Some studies at the 30 deg mode on Feb 23, 2012

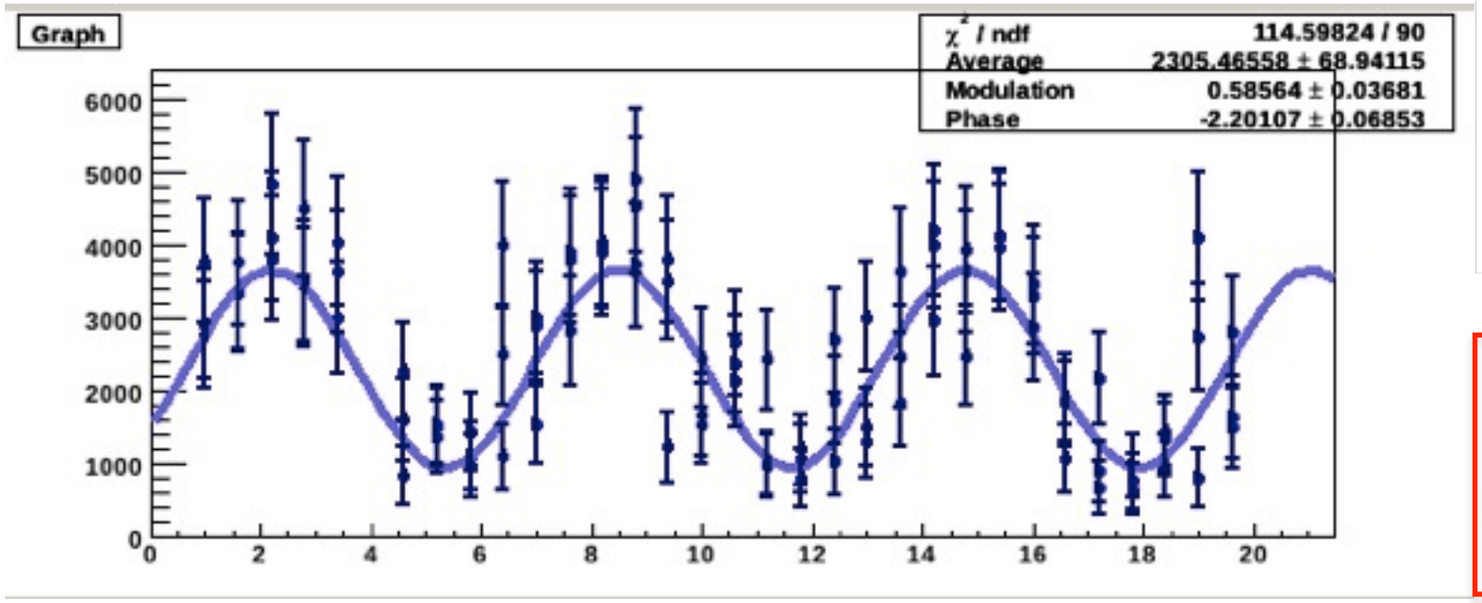


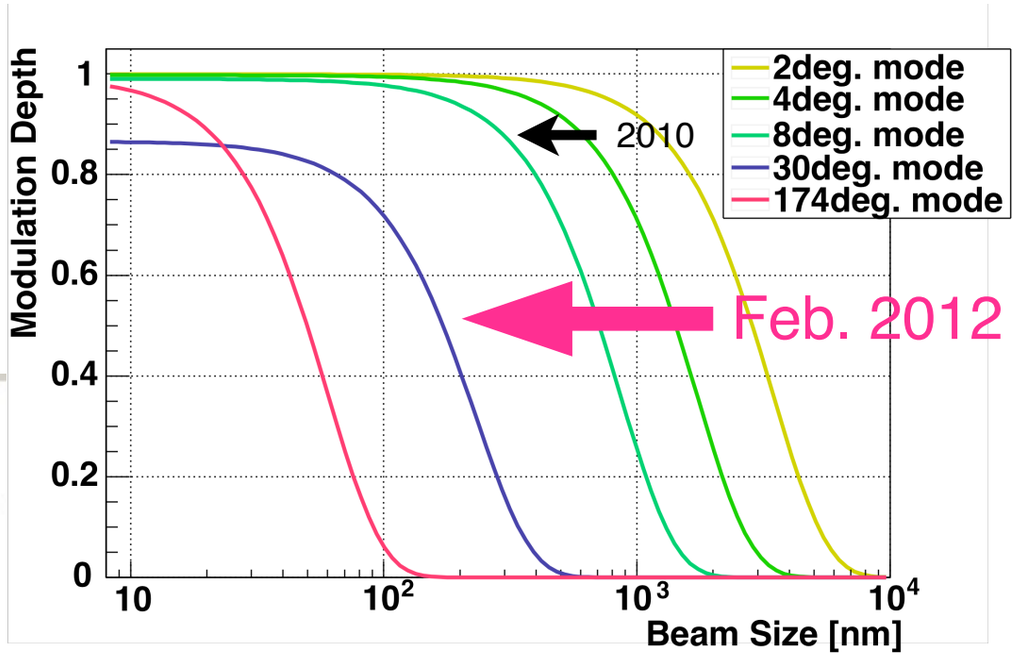




A Skew Sextupole magnet was installed at upstream of QF5B in January, 2011.
power supply : ±20A
(w/o cooling)

30 deg mode fringe scan on Feb 23, 2012





$$M = 0.52 \pm 0.010 \text{ (stat)}$$

$$\sigma_y^* = 167.9 \pm 1.8 \text{ (stat) [nm]}$$

2/23: 30 deg	M	ΔM	σ_y^*	$\Delta\sigma_y^*$	avg E_{sig}/ beam current [GeV / 10^9e]
13:12	0.583	0.032	145.55	6.77	2227
13:16	0.480	0.032	177.73	5.55	2293
13:20	0.543	0.037	157.93	7.16	2285
13:22	0.463	0.040	182.91	6.72	2222
13:26	0.586	0.037	144.69	7.86	2306
13:29	0.520	0.040	165.23	7.44	2301
13:32	0.521	0.037	164.86	6.97	2318
13:35	0.532	0.021	159.99	4.024	2198
13:42	0.472	0.021	180.333	3.53	2121

Table 1.2: M and σ_y^* measured from 9 consecutive stable interference scans at 30 deg mode. Errors are from fitting using a new automated scan software at ATF2 that uses energy deposit from the 4 front detector layers and ON/OFF method

- 10 β^*_x x 3 β^*_y optics
- S/N ~ 1
- Signal jitter ~ 22%
- BG fluctuation ~ 10%

Checkout of 174 deg mode on Feb 23, 2012

Laser wire scan (online)

Test | Laser shutter OK | MIrror 2X OFF | Laser shutter OK

174 mode wire — FileSelect

Crossing Angle 174.00[degree] Prism Position -2.97

Upper patI

Start | Stop

21:31:05 Laserwire range scan program fi

Center	Range	Step	Nread
0.2468	0.0150	0.0010	1

Copy present position to center

Mirror 5X: Original 0.2468
Present 0.2442
Fit peak 0.2442

Copy fit peak to center

Intensity Cut [e9] 4.000 < I < 10.000

Fit Mode layer 1-4 — Recalculation

Saved: /atf/data/ipbsm/lwscan/ lwscan_meas120223_212916.dat

Lower patI

Start | Stop

21:10:40 Laserwire range scan program finished.

Center	Range	Step	Nread
4.7307	0.0250	0.0010	1

Copy present position to center

Mirror 6X: Original 4.7300
Present 4.7337
Fit peak 4.7337

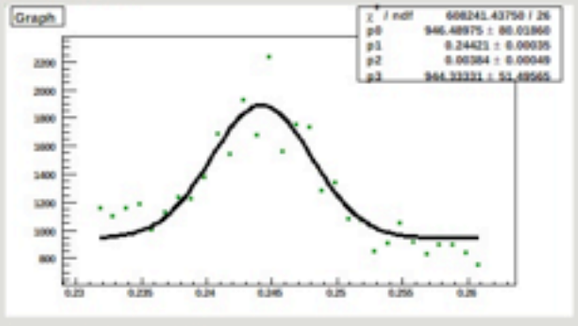
Copy fit peak to center

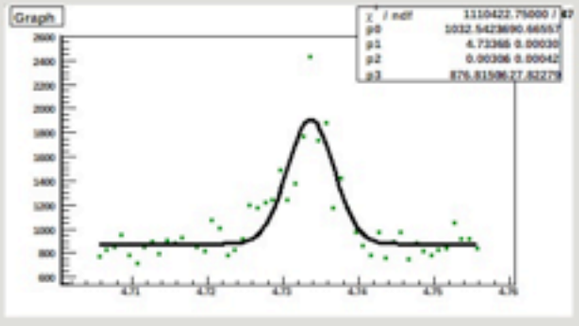
Intensity Cut [e9] 4.000 < I < 10.000

Fit Mode layer 1-4 — Recalculation

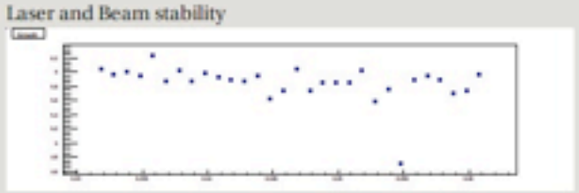
Saved: /atf/data/ipbsm/lwscan/ lwscan_meas120223_210714.dat

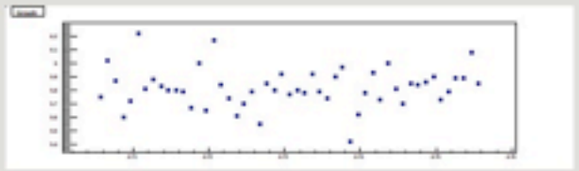
Energy deposit





Laser and Beam stability





Check Peak Position Start Stop

1X 1Y 2X 2Y

Zscan 174 degrees

Start | Stop

Phase Scan Range

Min	Max	Step	Navi
1.00	20.00	0.60	4

Origin Phase Position 4.35
Current Phase Position 4.72

Intensity Cut [e9] 4.000 < I < 10.000

Fit Mode layer 1-4

Crossing Angle 174.00

Mirror 6Y Scan Range

Center	Range	Step
4.2670	0.0200	0.0010

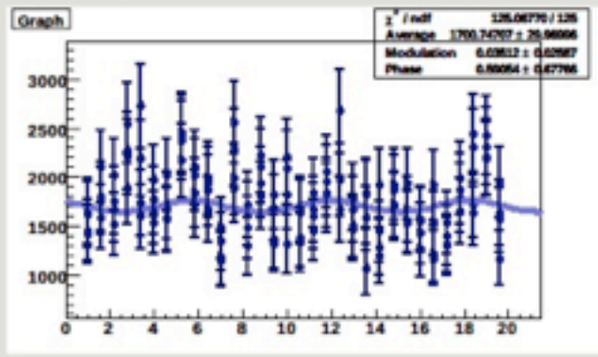
Copy present position to center

Mirror 6Y Position 4.2860
Origin 6Y Position 4.2670
Fit peak 4.2666

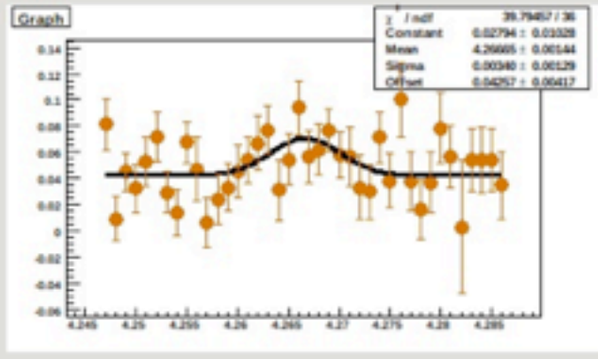
Copy fit peak to center

01:00:46 Z scan program finished.

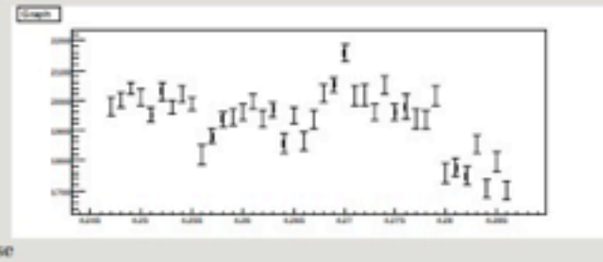
meas120224_005805.dat



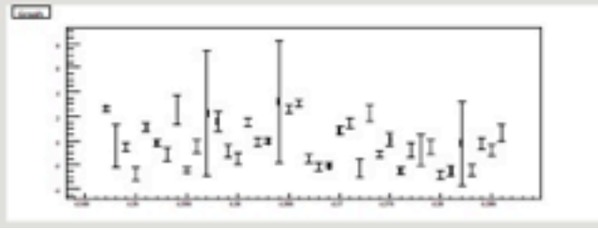
Modulation



Energy



Phase



6Y position	/atf/data/ipbsm/interefere/
4.2470	meas120223_231105.dat
4.2480	meas120223_231353.dat
4.2490	meas120223_231636.dat
4.2500	meas120223_231919.dat
4.2510	meas120223_232208.dat
4.2520	meas120223_232449.dat
4.2530	meas120223_232740.dat
4.2540	meas120223_233014.dat
4.2550	meas120223_233307.dat
4.2560	meas120223_233600.dat
4.2570	meas120223_233838.dat
4.2580	meas120223_234122.dat
4.2590	meas120223_234414.dat
4.2600	meas120223_234647.dat
4.2610	meas120223_234923.dat
4.2620	meas120223_235212.dat
4.2630	meas120223_235456.dat
4.2640	meas120223_235740.dat
4.2650	meas120224_000029.dat
4.2660	meas120224_000329.dat
4.2670	meas120224_000609.dat
4.2680	meas120224_000854.dat
4.2690	meas120224_001139.dat
4.2700	meas120224_001413.dat
4.2710	meas120224_001657.dat
4.2720	meas120224_001938.dat
4.2730	meas120224_002225.dat
4.2740	meas120224_002511.dat
4.2750	meas120224_002750.dat
4.2760	meas120224_003029.dat
4.2770	meas120224_003309.dat
4.2780	meas120224_003553.dat
4.2790	meas120224_003843.dat
4.2800	meas120224_004133.dat
4.2810	meas120224_004426.dat
4.2820	meas120224_004718.dat
4.2830	meas120224_005007.dat
4.2840	meas120224_005251.dat
4.2850	meas120224_005528.dat
4.2860	meas120224_005805.dat

3 2012

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

other R&Ds :
LW OTR (EXT)
m-OTRs (EXT)
Low-Q IPBPM (LINAC)
FONT (EXT)
Cavity Compton (DR)

Slow orbit feedback installed in order to make a flat orbit in both directions at FF
- successfully tested by using ZH8X, ZH9X, ZV9X, ZV10X

IPBSM : laser was too unstable to be use the beam size measurement. (3/7)
- frequently failed to seed the laser, but checked at 6 and 30 deg. modes

IPBSM : half mirror, viewport window were broken - replaced them (vacuum break)
- changed the reducer 2nd lens (f=-250mm) for large spot at viewport window(3/15)
- very large signal fluctuation, so adjusted the rear mirror to align a seeding laser
- 5.72 deg mode; M=0.348, 1.23um; 30 degree mode checked by LW scan

Repetition rate of all LINAC modulators was changed from 12.5 to 6.25Hz (3/16).
- expect good stability of beam at LINAC (the RF power reduced by half)

4 2012

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					

other R&Ds :
LW OTR (EXT)
UK-BPM (EXT)
LW (EXT)
FONT(EXT)
Cavity Compton (DR)

The training program was started at orbit tuning at EXT and FF since this April.

IPBSM : rear mirror was exchanged for good profile (3/26)
-first, we could not be operated due to the seeding problem; 10(β^*_x) x 5(β^*_y)

OTR3 mechanical adjustment was done by -π rotation of mirror for CCD camera.

Change RF frequency (-7kHz) for adjusting to Ring circumference (4/19,9:25)

IPBSM : Seeder was exchanged for good BUT (4/19); 10(β^*_x) x 1(β^*_y)
- 6 deg. mode, M=0.46, 1um, turning on the slow orbit feedback
- 30 deg. mode : failed the z-scan, i.e. no modulation detected

IPBSM : FF Optics of 10(β^*_x) x 1(β^*_y) and vertical emittance=20pm by m-OTR
- laser path drifted on the vertical table due to BeamLok issue, but the profile is OK
- 7.96 deg. mode, M=0.758, 446nm (4/26)
- 30 deg. mode : very small modulation (M<0.1)
- BeamLok was recovered by adjustment of mirrors downstream of HG; M=0.13 (4/26)
- Large vertical dispersion was found, i.e. max η_y=0.2m, due to the slow orbit FB by ZV9X and ZV10X with large vertical orbit at the EXT entrance (4/27)
- Max η_y=5cm by correction by ZV1X, ZV2X; multiknob responses were reproduced.

IPBSM System

Mirror box (upstream)

Mirror box (downstream)

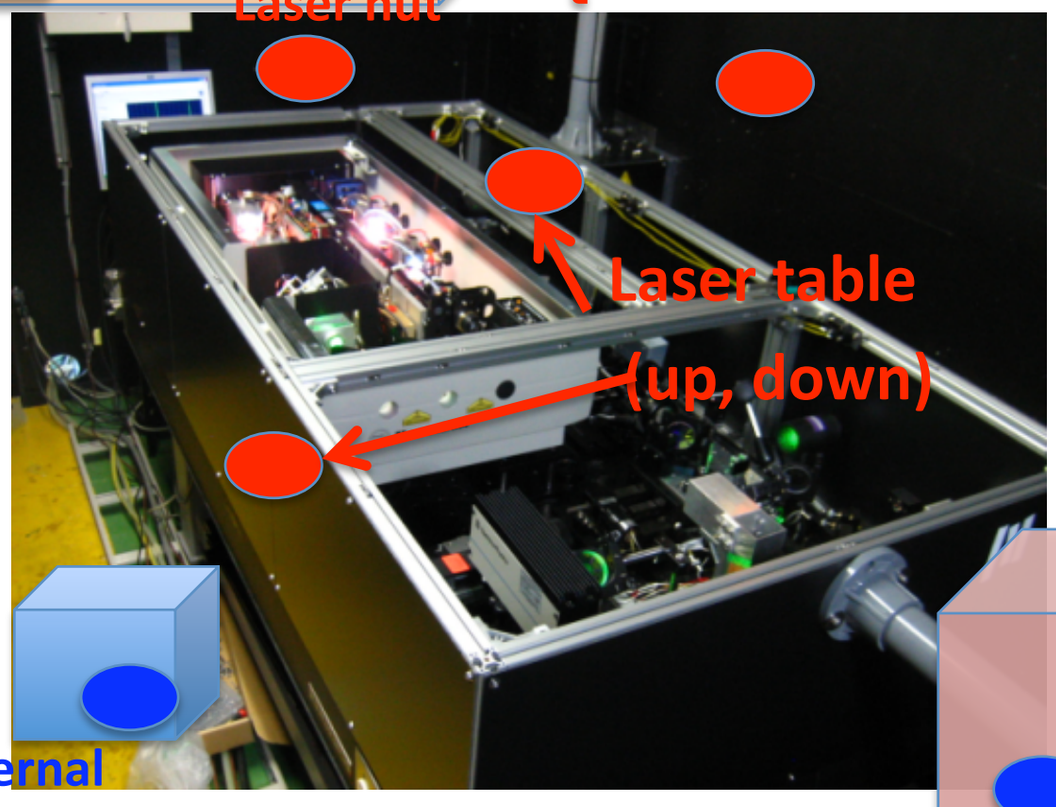
Transport line

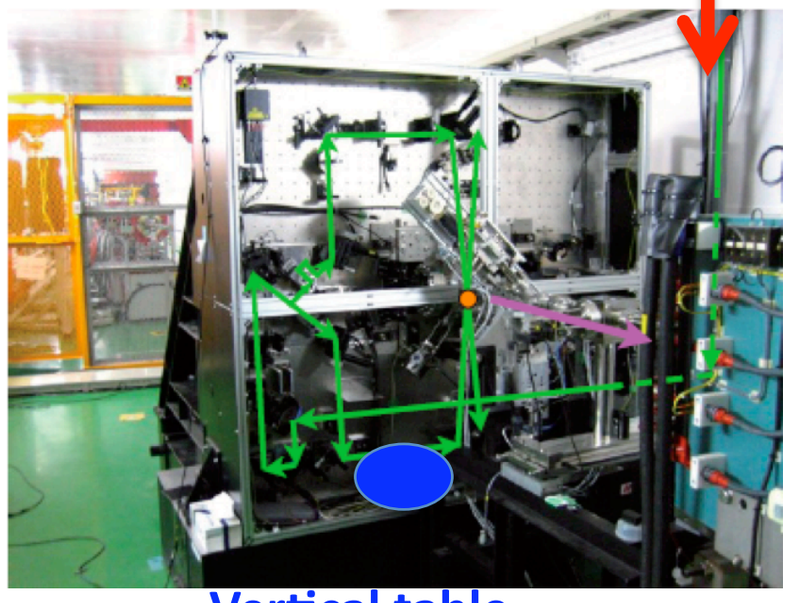
External cooling water

DAQ room

Laser clean booth

Laser hut



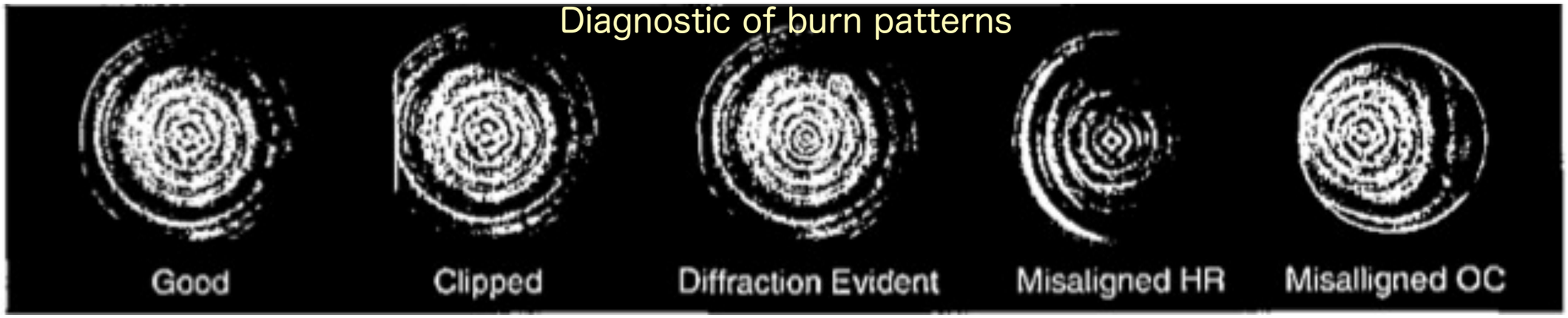


Vertical table

Internal cooling water

Temp. control unit

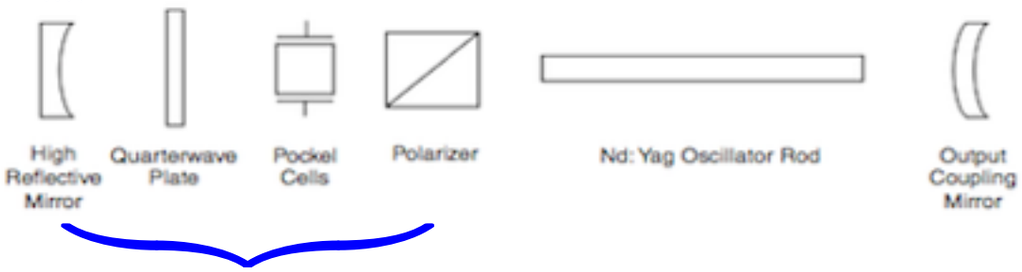
Laser system of IPBSM



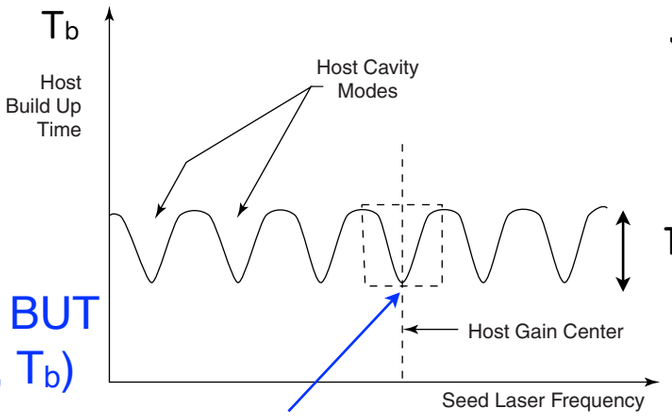
rear mirror M_1

Oscillator (laser resonator, cavity)

M_2

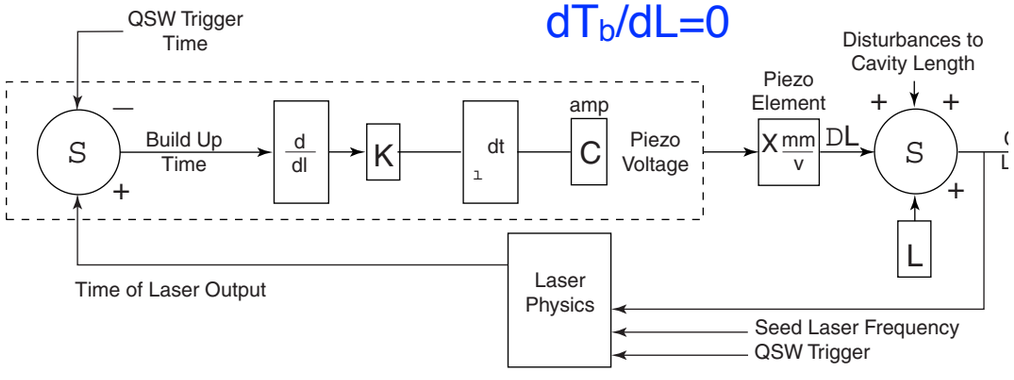


Q-Switch

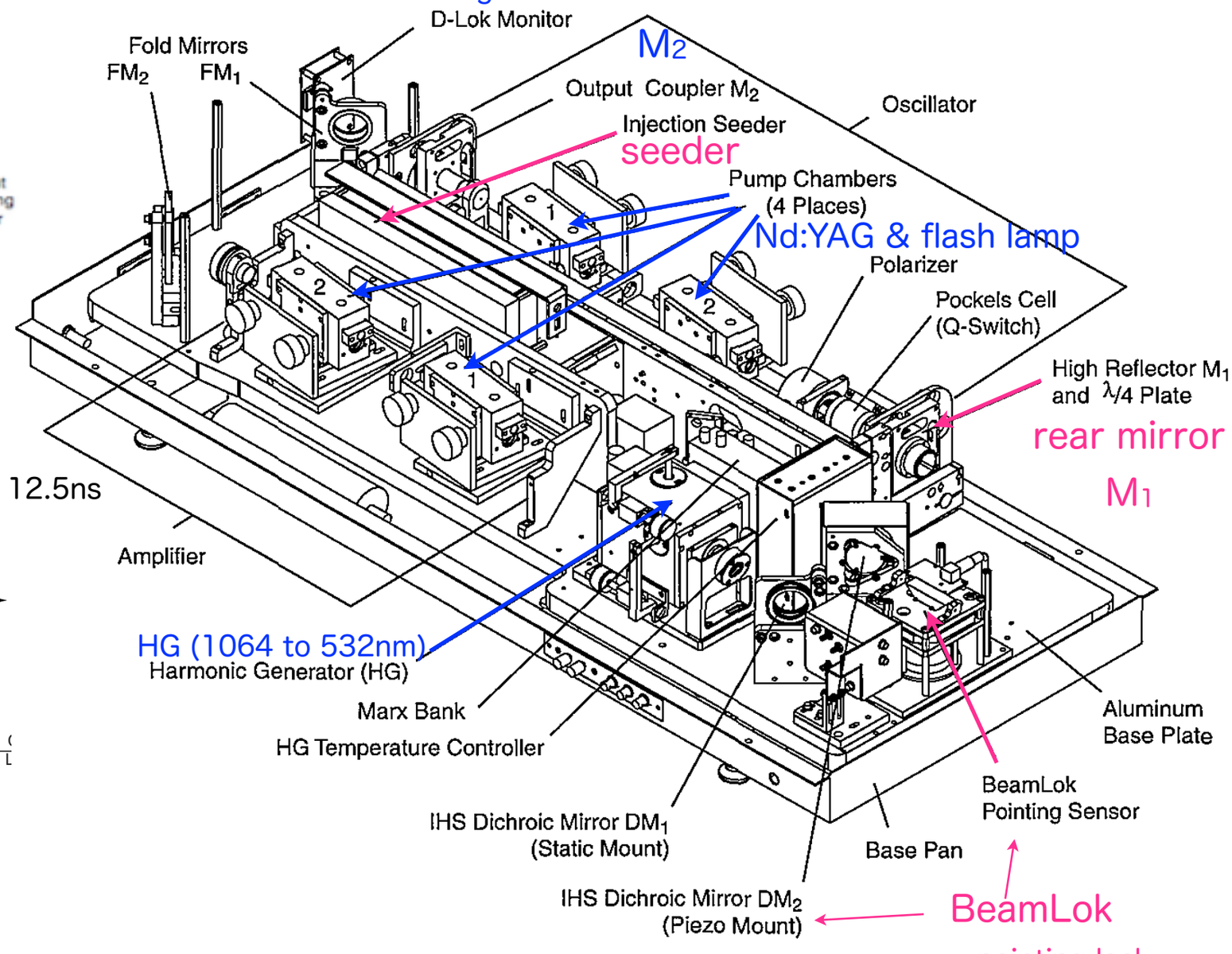


Seeding minimization of BUT (Build Up Time, T_b)

$dT_b/dL=0$

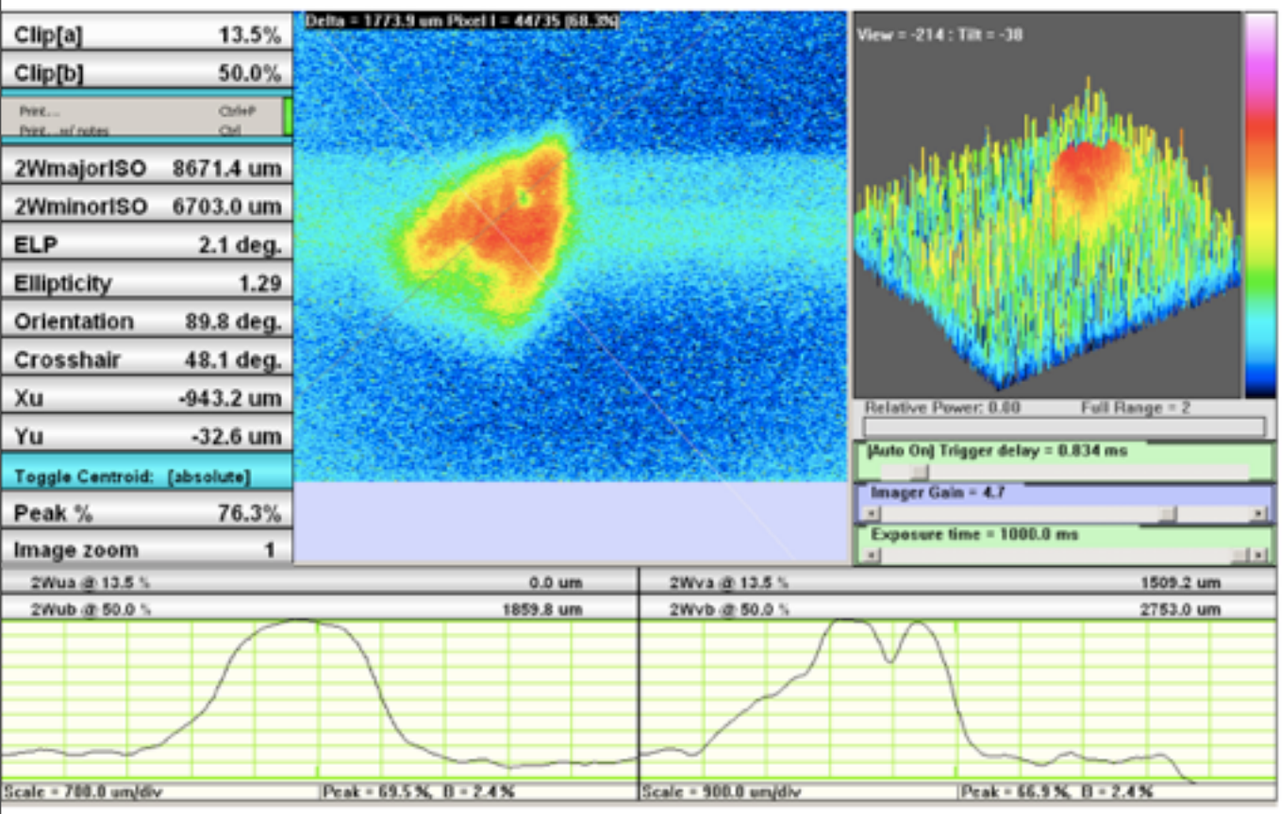


divergence lock

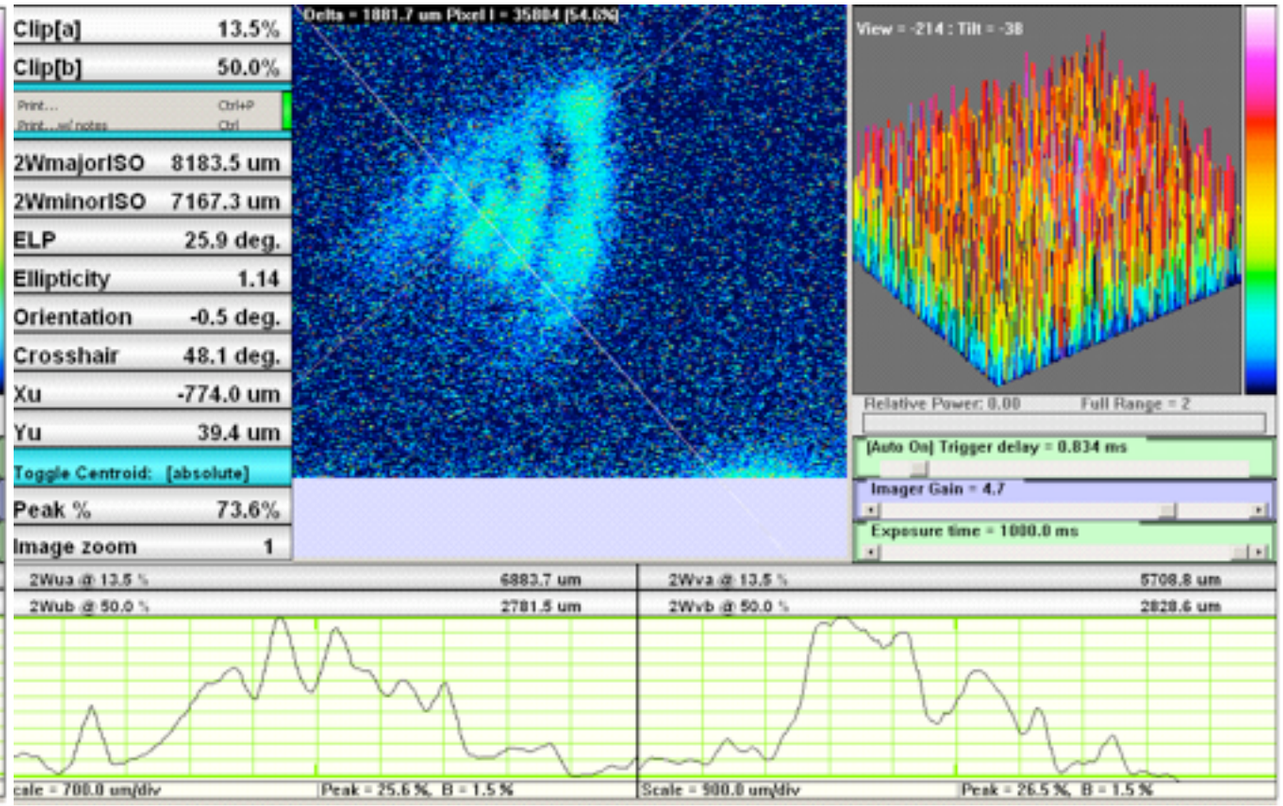


re 3-5: Frequency Control Loop Block Diagram

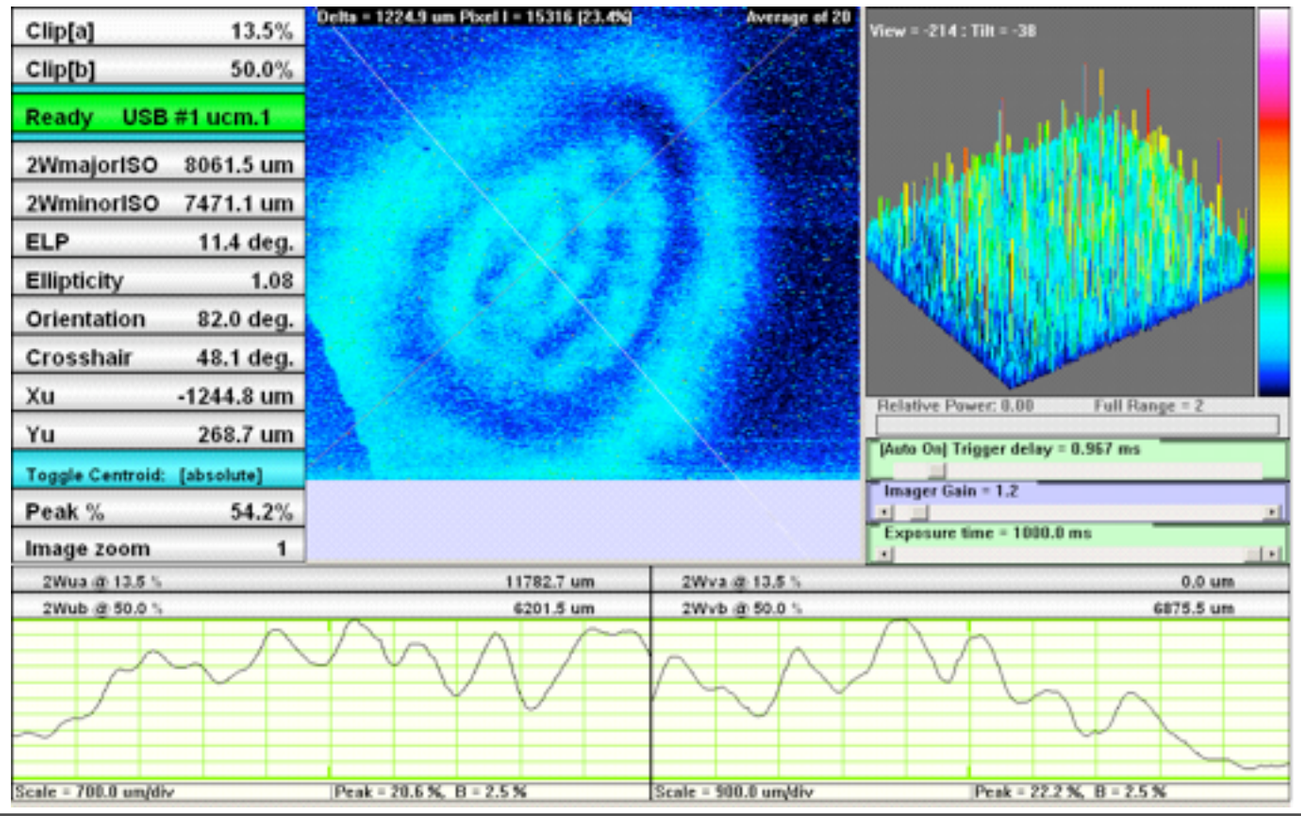
Original reducer 2nd lens (f=-175mm), 3/9



Changed the reducer 2nd lens (f=-250mm), 3/15



Rear mirror was exchanged , 3/26 , at present , i.e. the curvature radius from 5m to 6m



<u>After the exchange:</u>

rounder-like profile,
much less “spots”

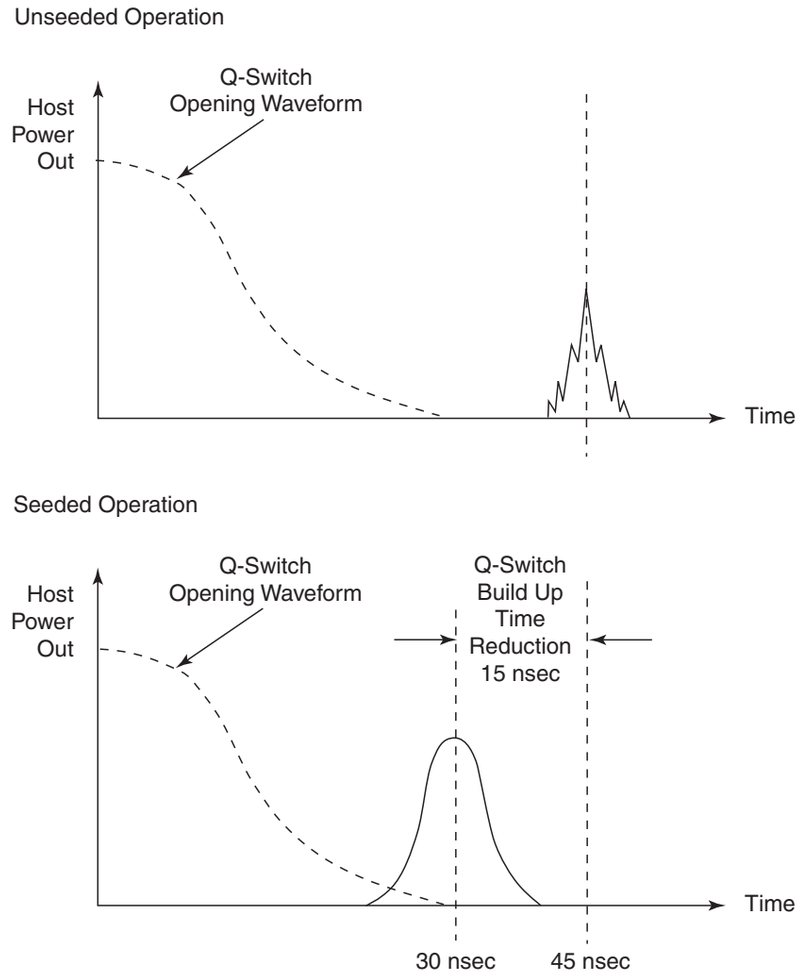
Exchange of Seeder, Flash lamp : Apr-May, 2012

◆ **Seeding unstable** even after mirror adjustment

➔ **Exchanged seed laser**

Now seeder is stable !!

Remain at appropriate laser build-up timing (12.5 ns faster than self seeding)

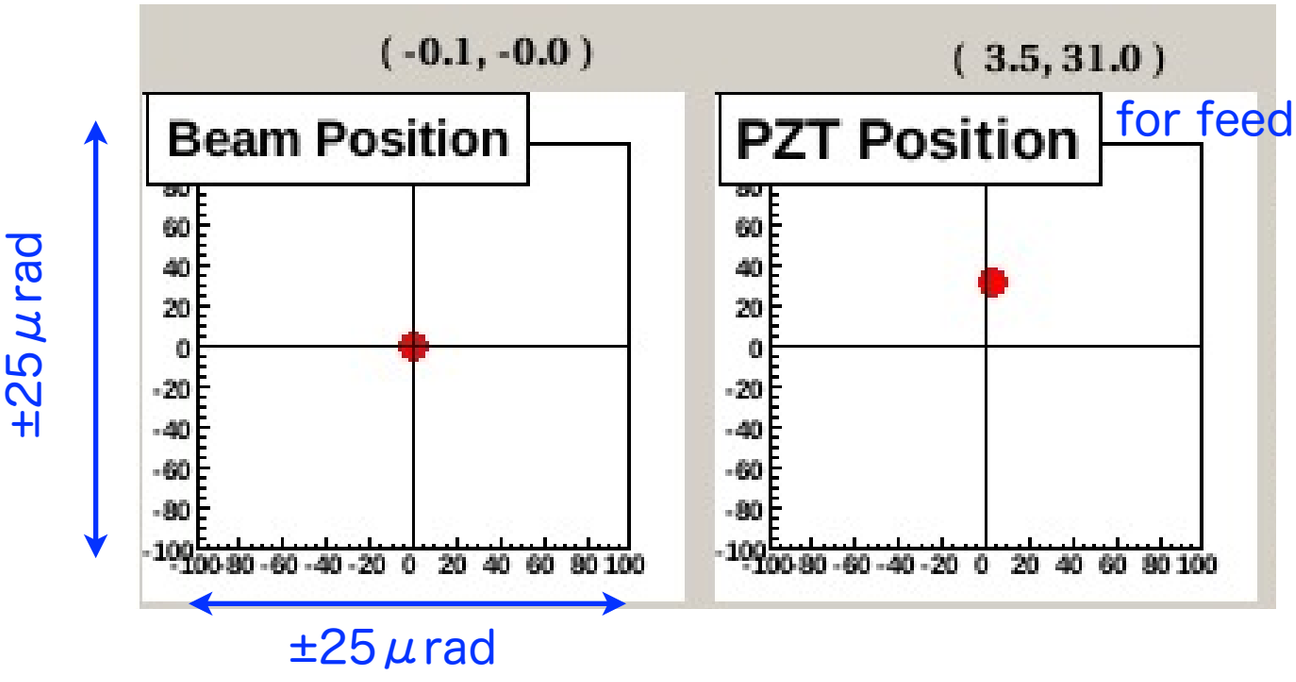


◆ **Exchanged flash lamps** since remainder shots not enough to last until end of spring run

◆ **Exchanged BeamLok feedback piezo(“PZT”) mount**

Adjusted BeamLok Position 1.5 hrs after test run

with BeamLok, i.e. pointing feedback < ± 25 μrad



BeamLok feedback currently functions well

File Options Tools View Help

Open | Properties | Channel List | Print | Zoom In | Zoom Out | Zoom Reset | Refresh

Unstable behavior of the seeder

Data Mac 34.14 34.14 34.14 34.14 34.14 34.14 34.14 34.14 34.14 34.14 34.14 34.14 34.14 34.14 34.14 957.1 3.2 5000 4.2

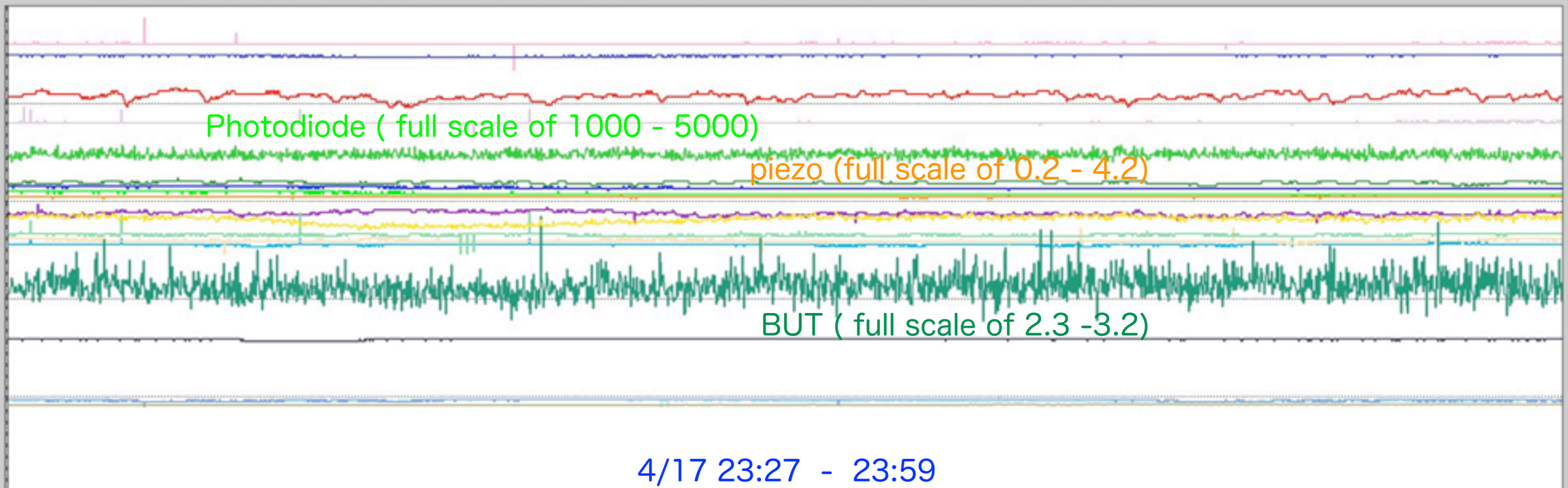
4/11 23:28 - 23:59

File Options Tools View Help

Open | Properties | Channel List | Print | Zoom In | Zoom Out | Zoom Reset | Refresh

new seeder, i.e. after the exchange

Data Mac 34.14 34.14 34.14 34.14 34.14 34.14 34.14 34.14 34.14 34.14 34.14 34.14 34.14 34.14 34.14 957.1 3.2 5000 4.2



4/17 23:27 - 23:59

Conclusions

1. IPBSM 30 deg. mode was fully commissioned.
2. The vertical beam size could be reduced to 165nm.
3. The 174 deg. mode operation and function were verified.
4. IPBSM laser system has troubles of seeder, rear mirror, reducer and BeamLok, etc. . They were overcome by replacements, adjustments and modifications. Further improvement is planned for stable operation in the optical system by applying phase monitor and alignment-feedback.
5. We will have a dedicated period of ATF2 beam tuning for the goal 1 in October through December, 2012, by training students and postdocs for this purpose.
6. R&Ds are progressing towards the goal 2.