Present Status of KEK-ATF

S.Kuroda(KEK)
on behalf of ATF team

Introduction

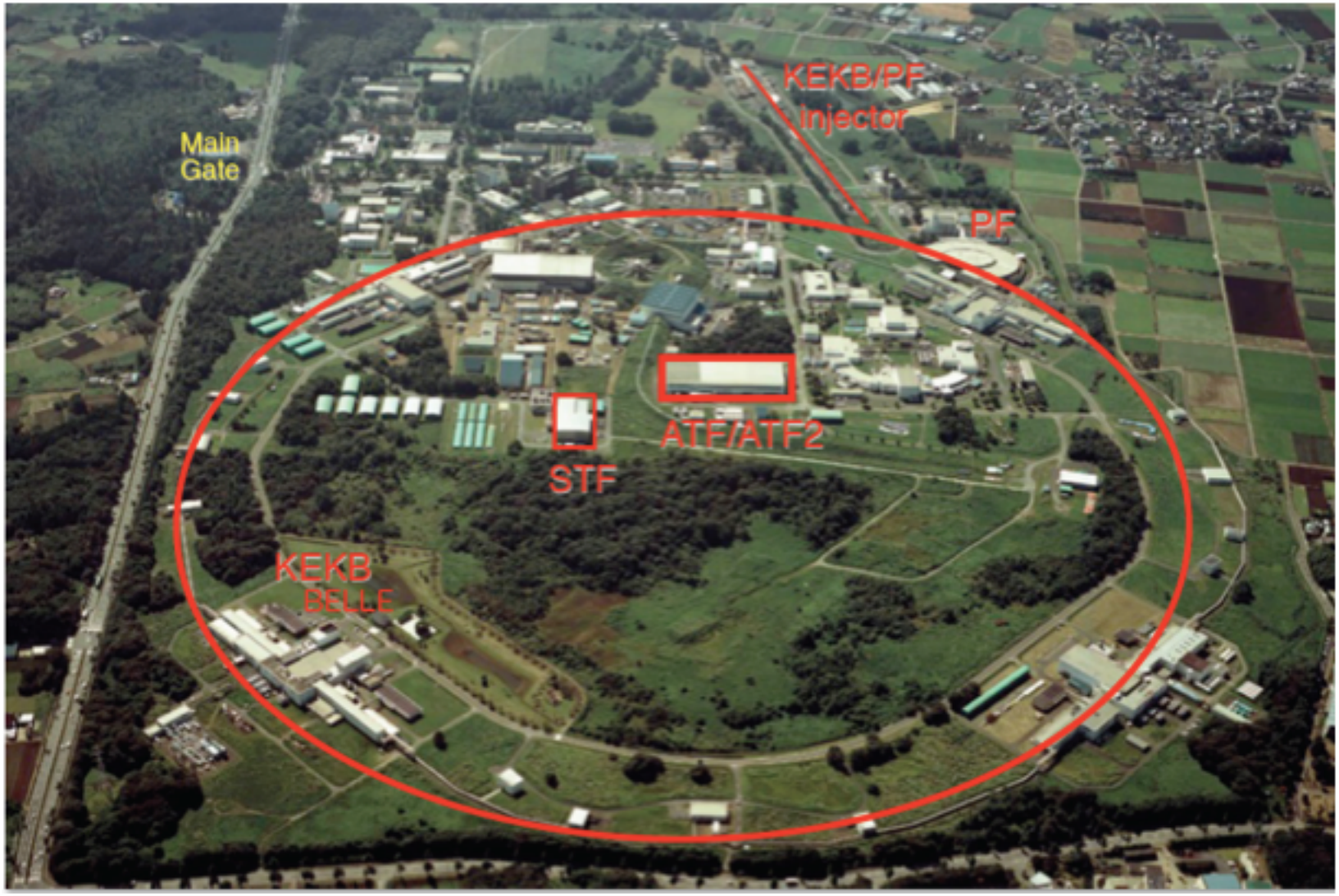
Recovery from the earthquake 3.11

DR performance(emittance)

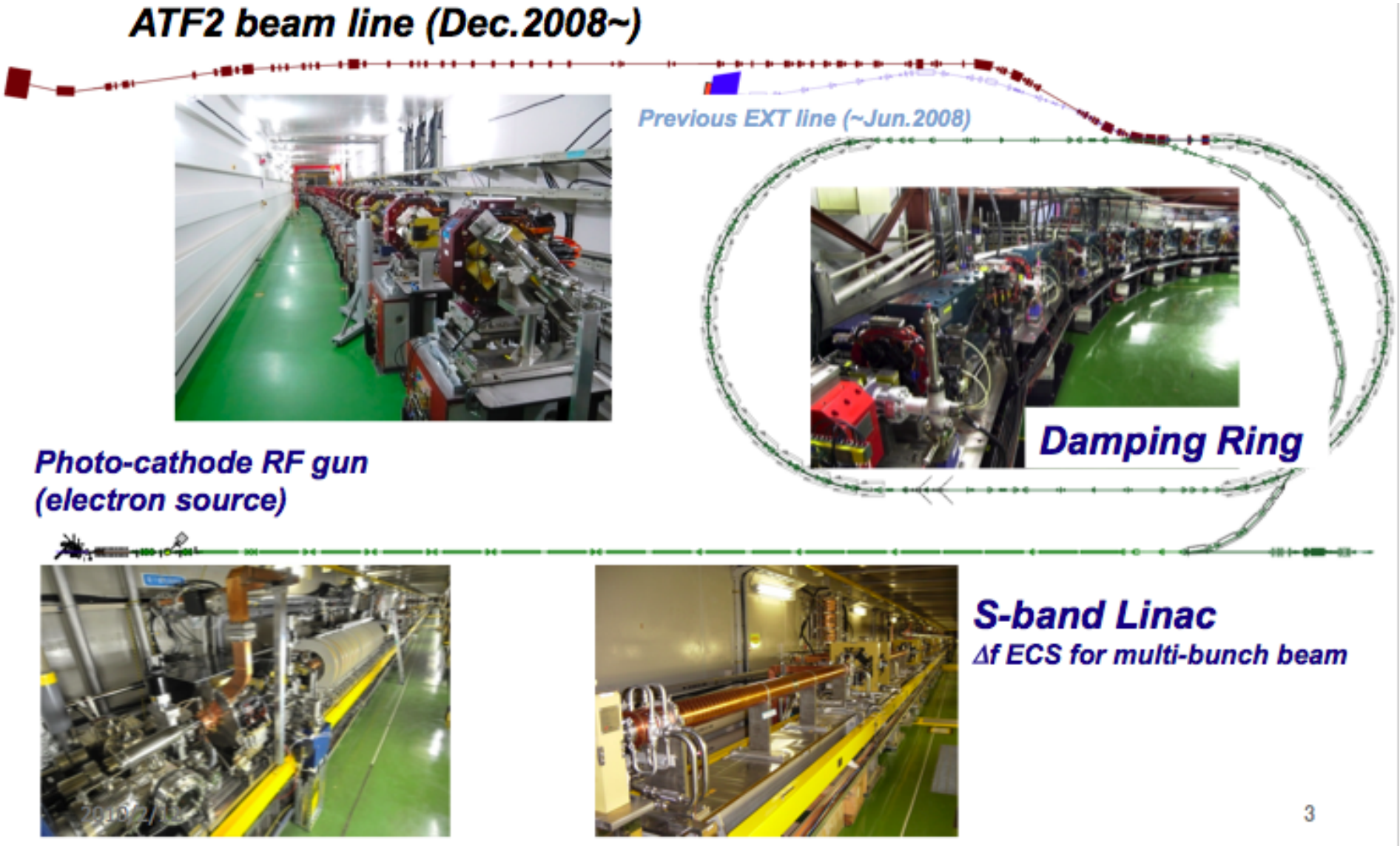
ATF2 project

Other activities

ATF@KEK



ATF accelerator complex



ATF International Collaboration

CERN
DESY
IN2P3
- LAL
- LAPP
- LLR

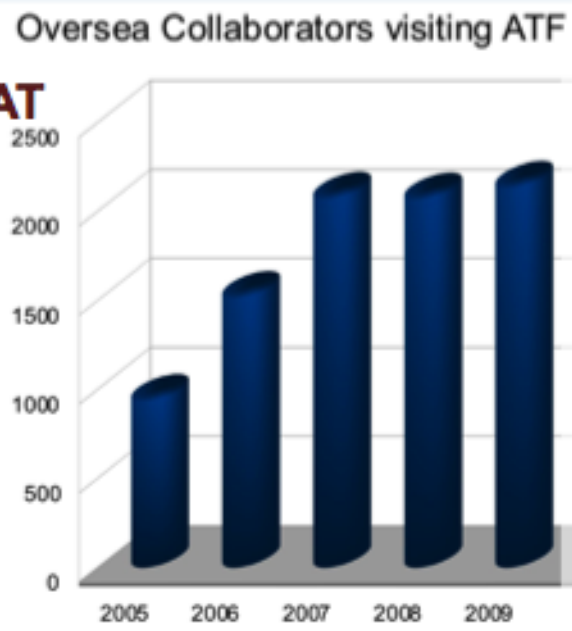
John Adams Inst.
- Oxford Univ.
- Royal Holloway Univ.

Cockcroft Inst.
- STFC, Daresbury
- Univ. of Manchester
- Univ. of Liverpool

University College London
INFN, Frascati
IFIC-CSIC/UV
Tomsk Polytechnic Univ.

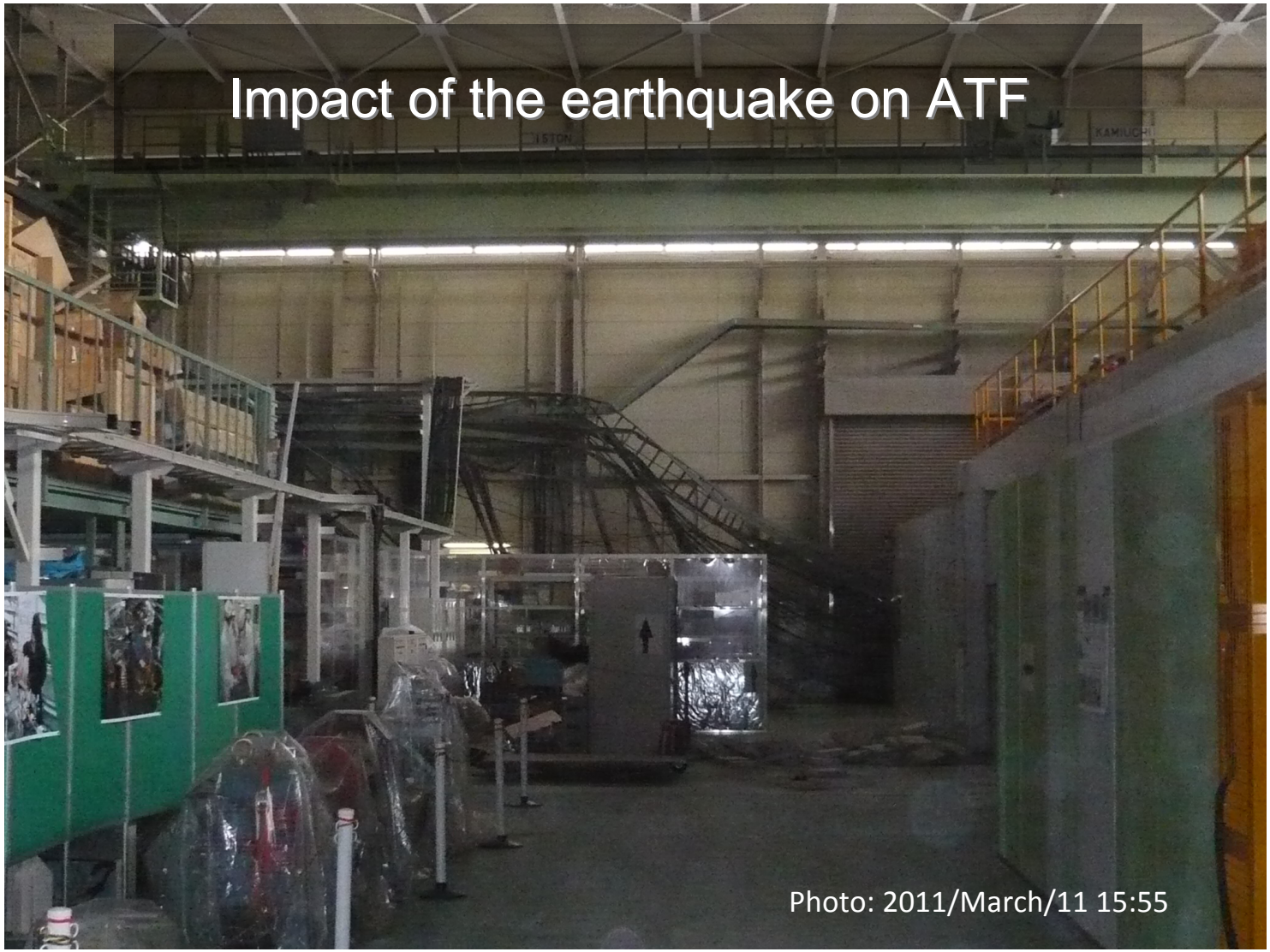
KEK
Waseda U.
Nagoya U.
Tokyo U.
Kyoto U.
Tohoku Univ.
Hiroshima U.
IHEP
PAL
KNU
RRCAT

SLAC
LBNL
FNAL
Cornell Univ.
LLNL
BNL
Notre Dome Univ.



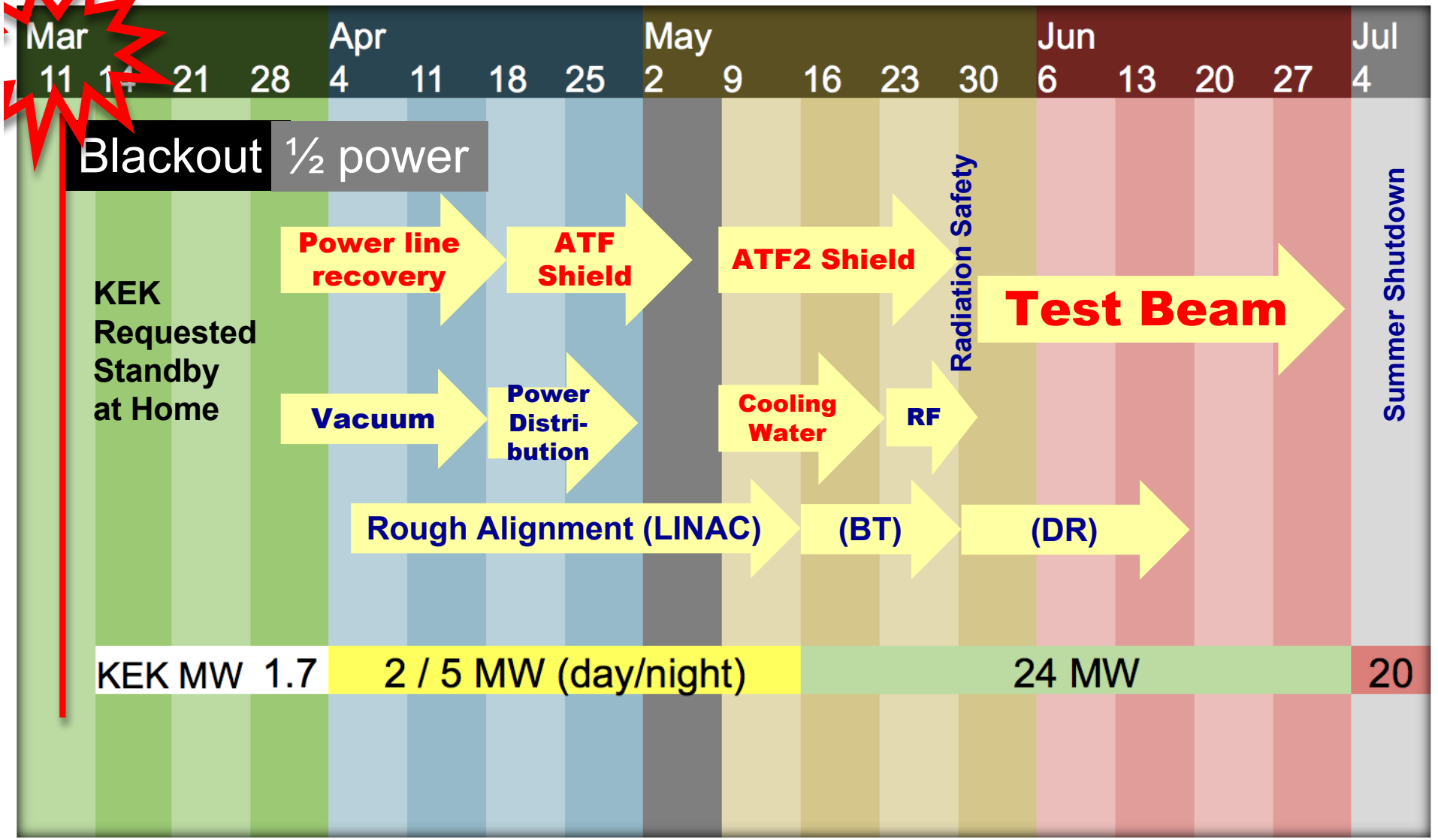
Oversea
25 Institutes,
~70 people,
~2000 people-days
+
KEK and Japanese Universities(6)

Recovery from the Earthquake 3.11.2011

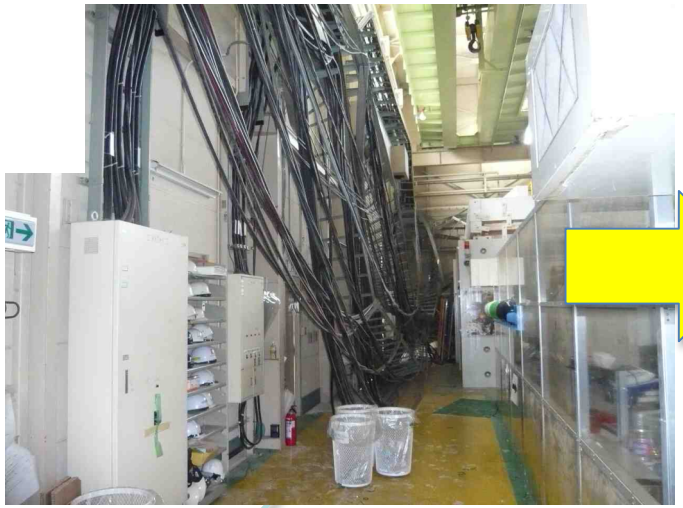


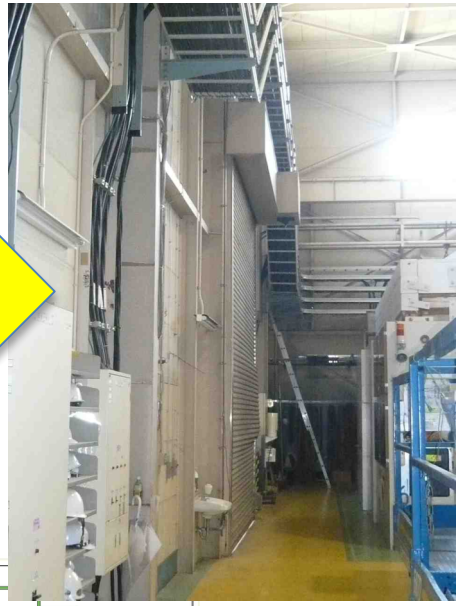
Reported in LCWS2011(Granada,Spain) by N.Terunuma

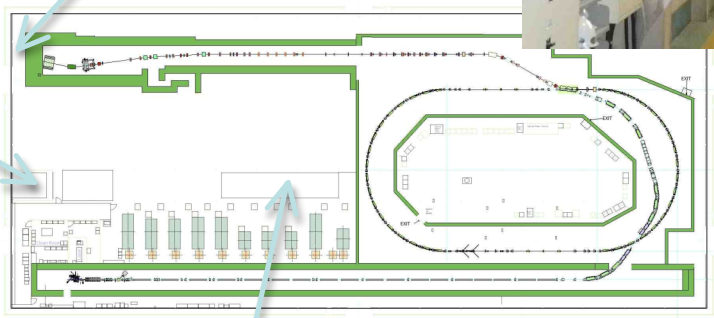
Recovery History for Test Beam

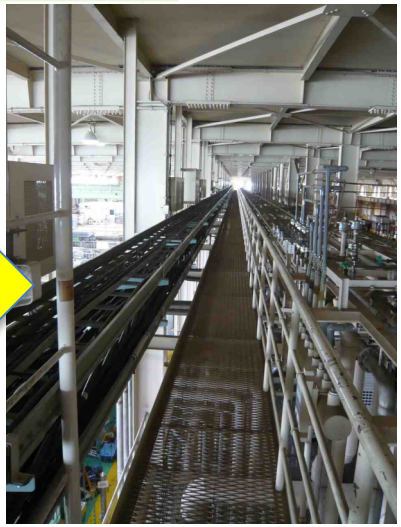


Main Power Lines



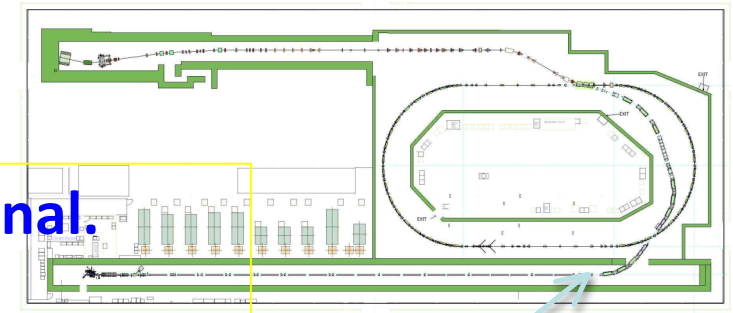




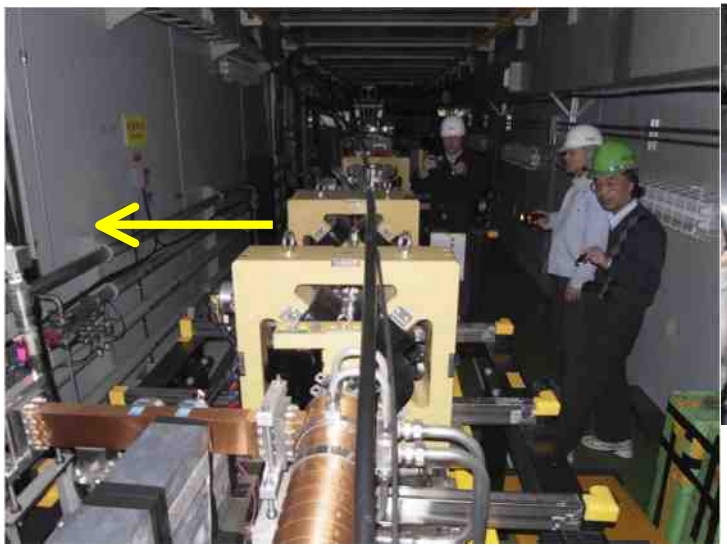


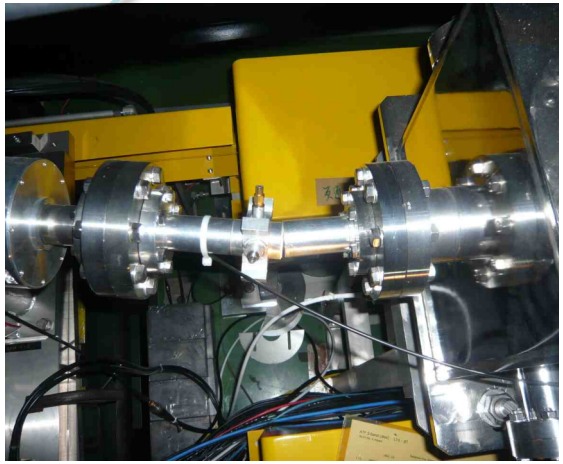
Recovered in April

ATF LINAC

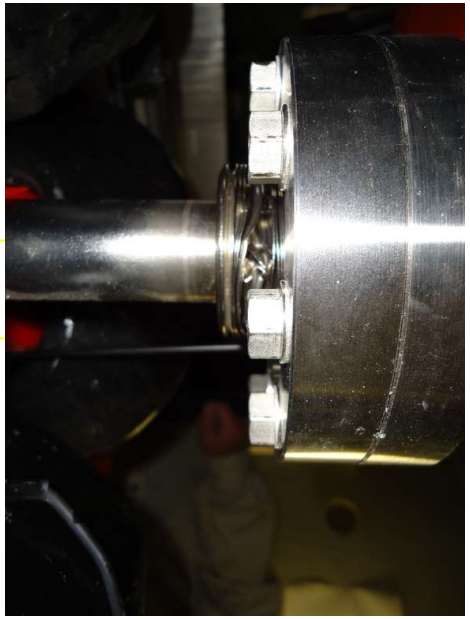


QM2L table was backed to the original.
Chambers were exchanged.

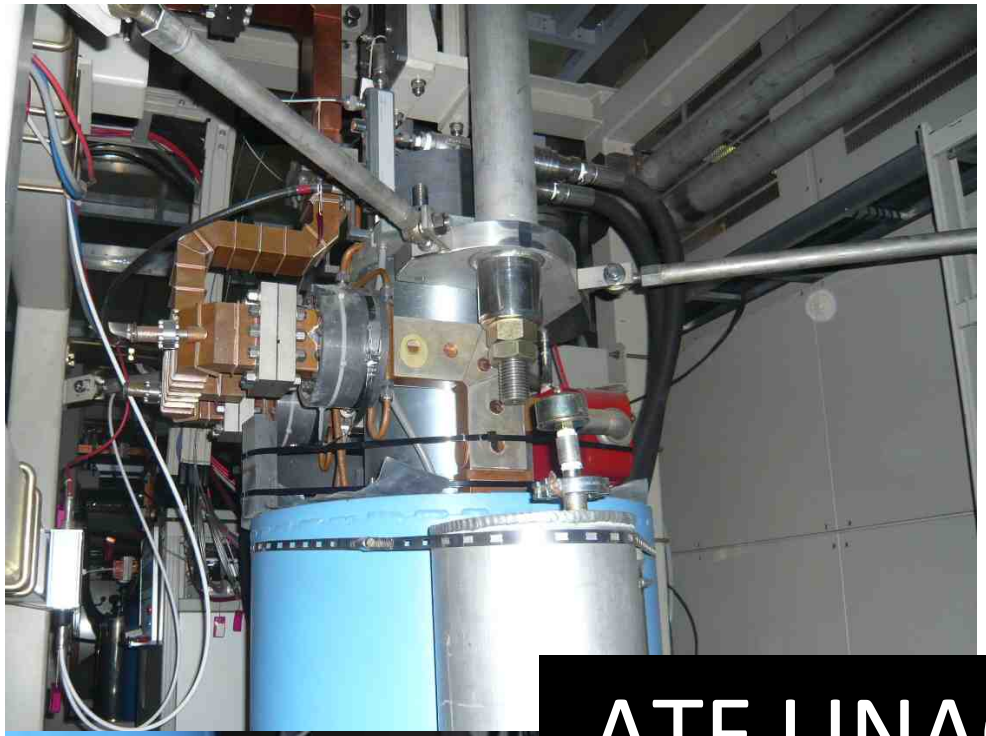




QD10L bellows was exchanged.



All were repaired in March!

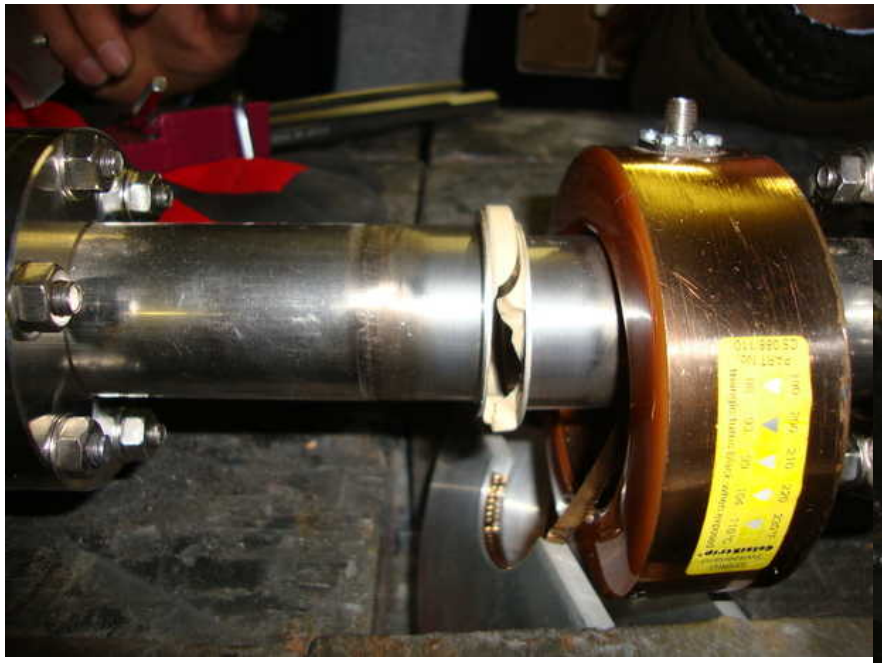


ATF LINAC Klystrons

Repaired in April.

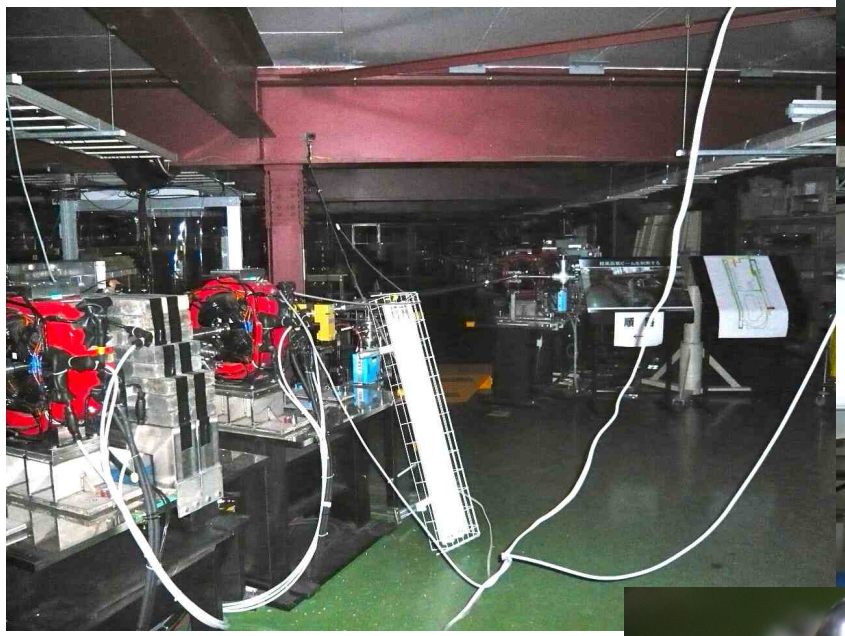
Beam Transport

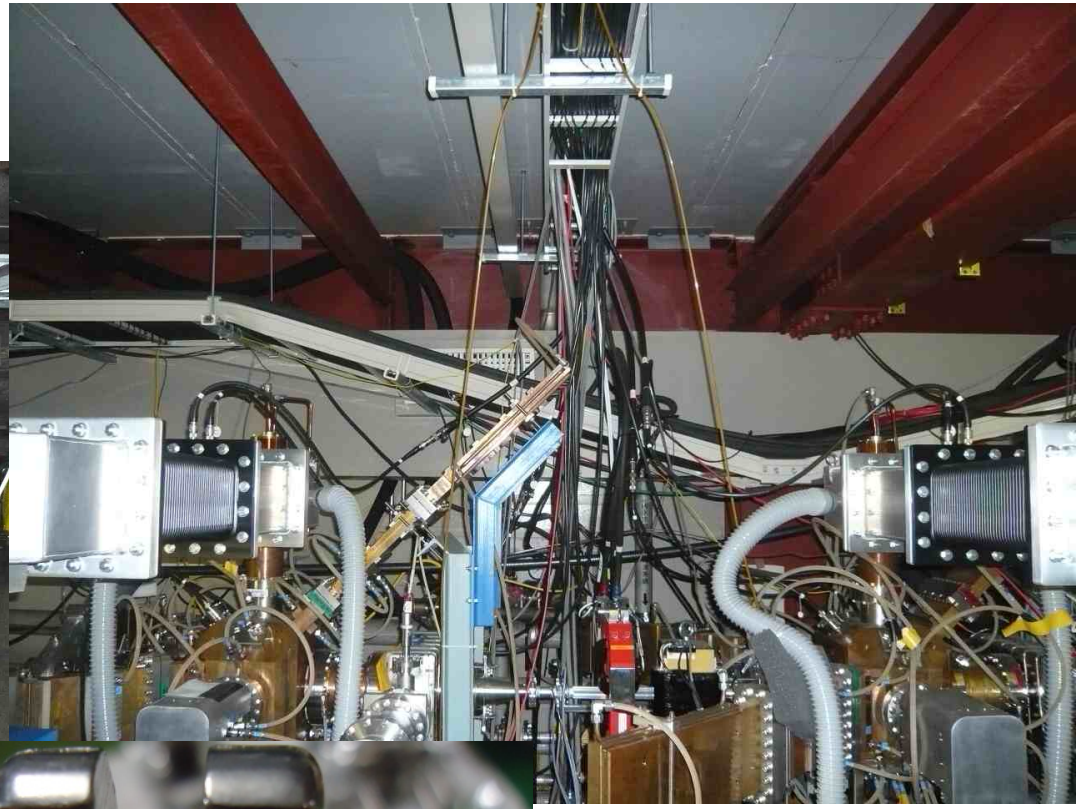
Fallen Pb blocks were cleared.
Ceramic of the CT monitor and a bellows were exchanged.

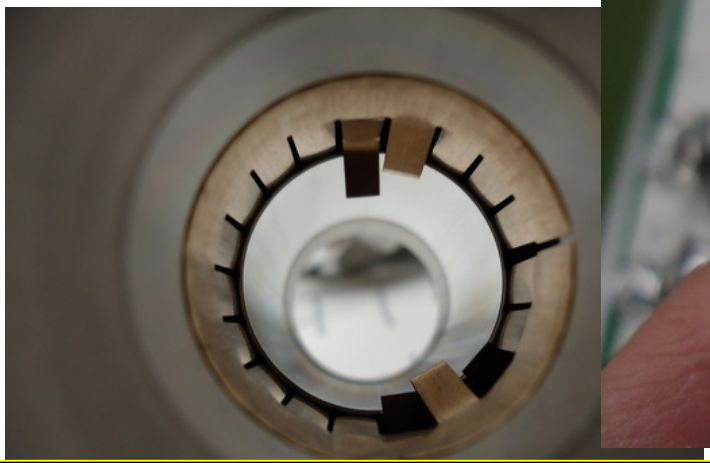


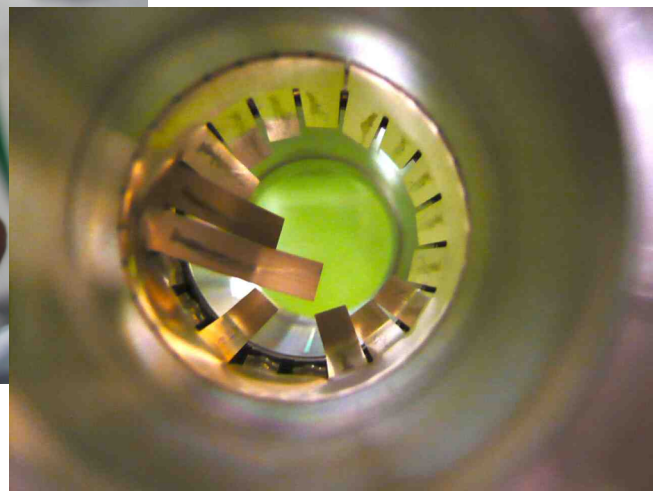
Repaired in April.

Damping Ring



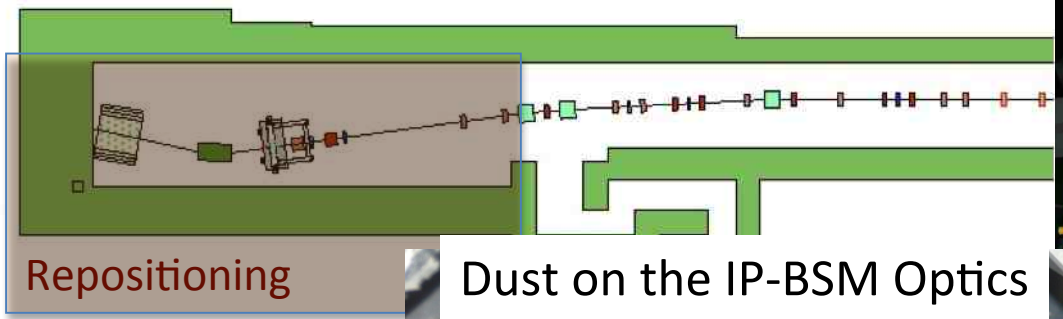


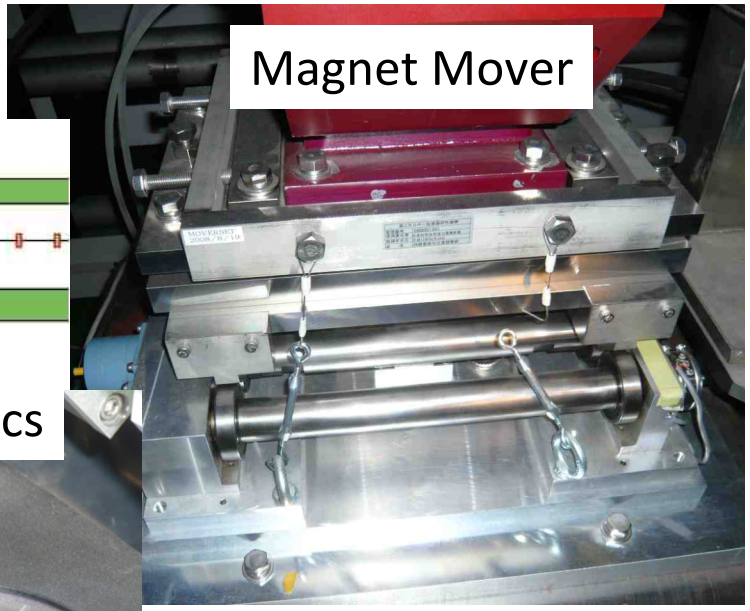


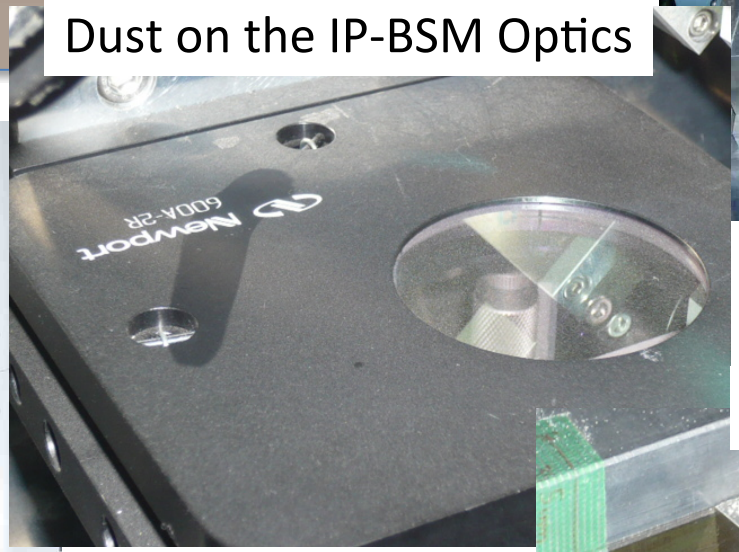


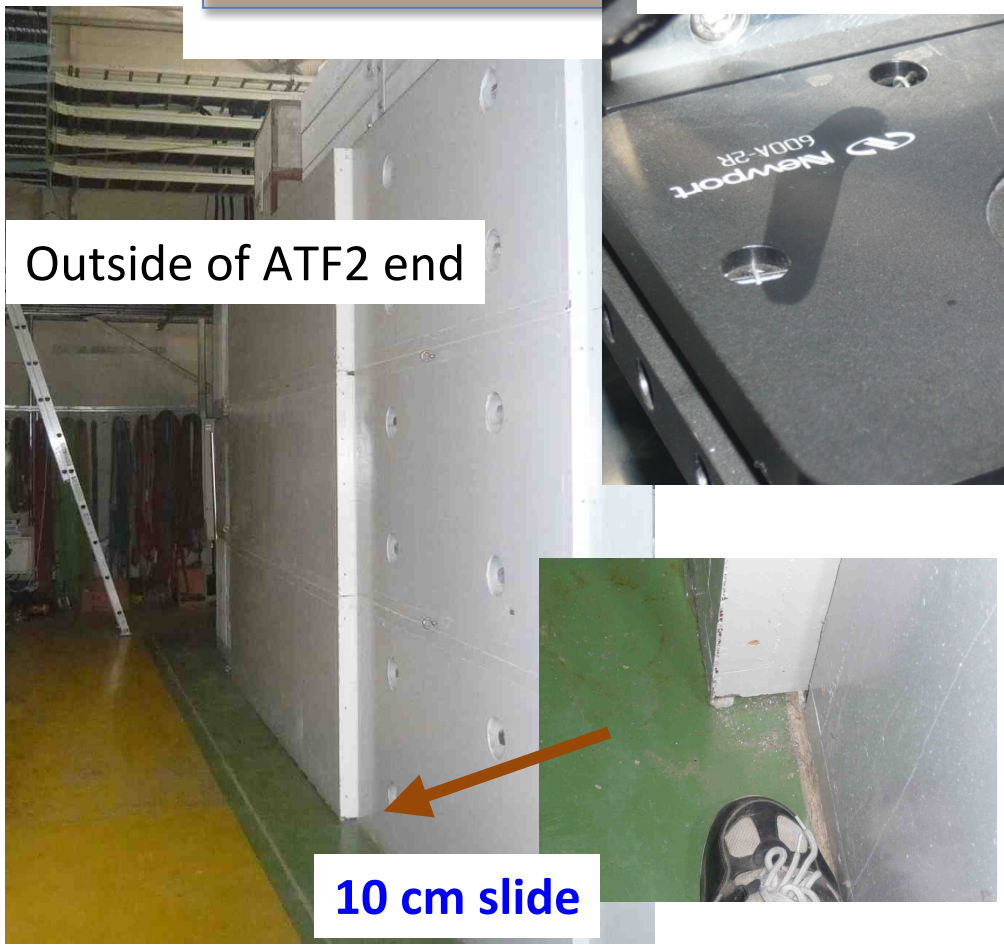
Repaired in April/May

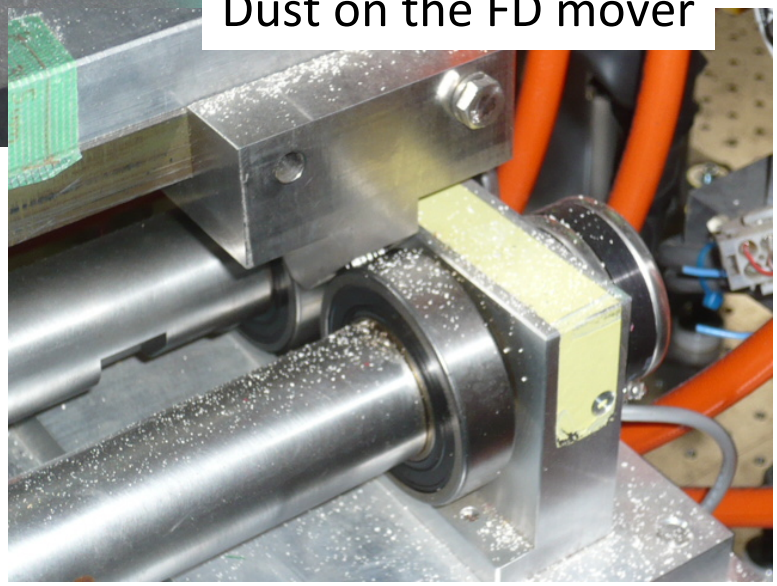
ATF2 beam line



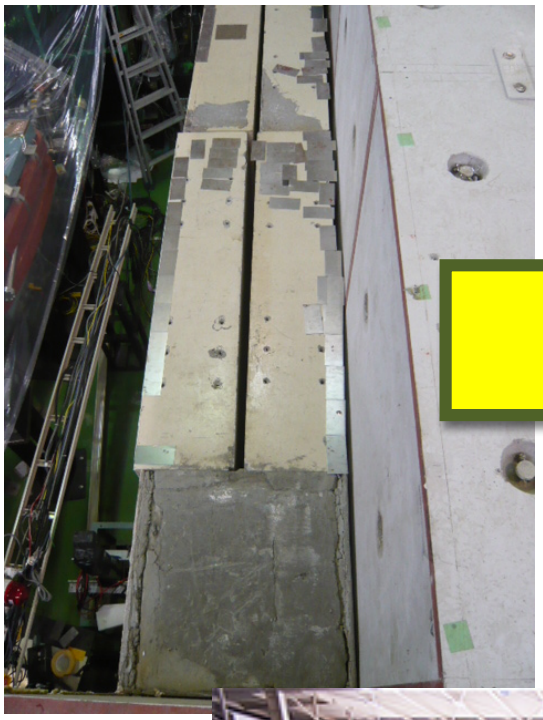






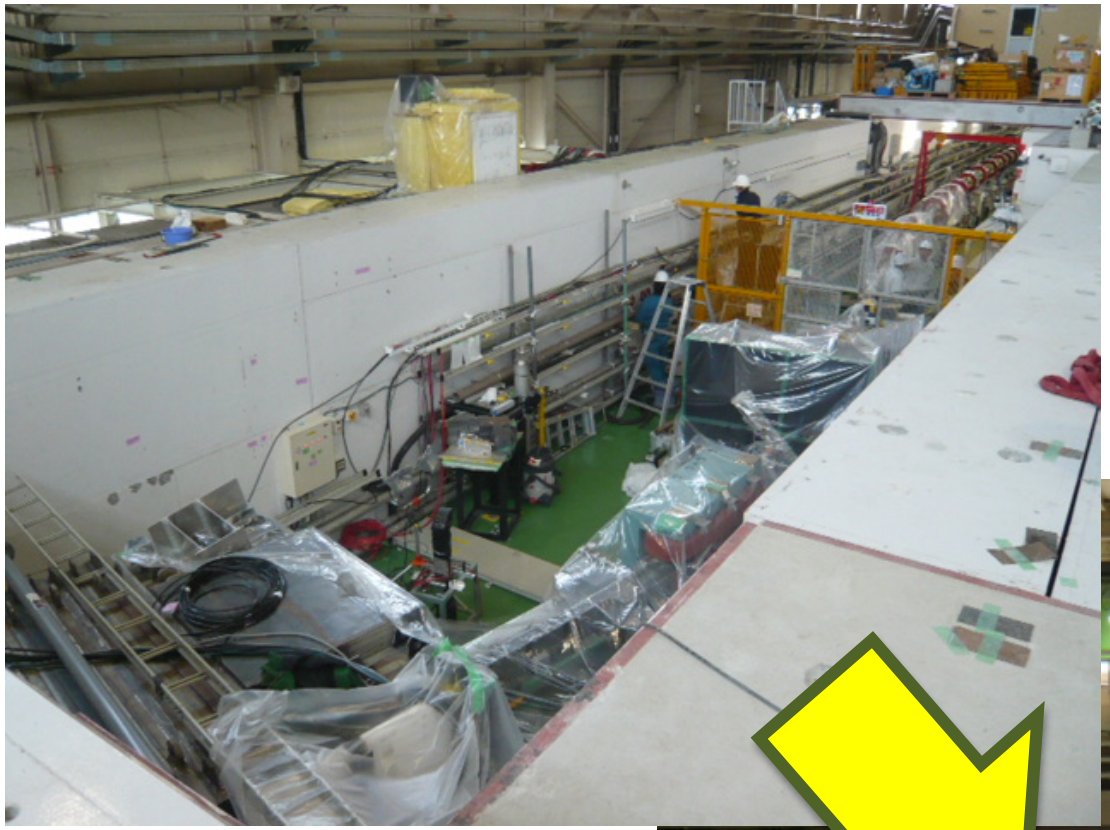


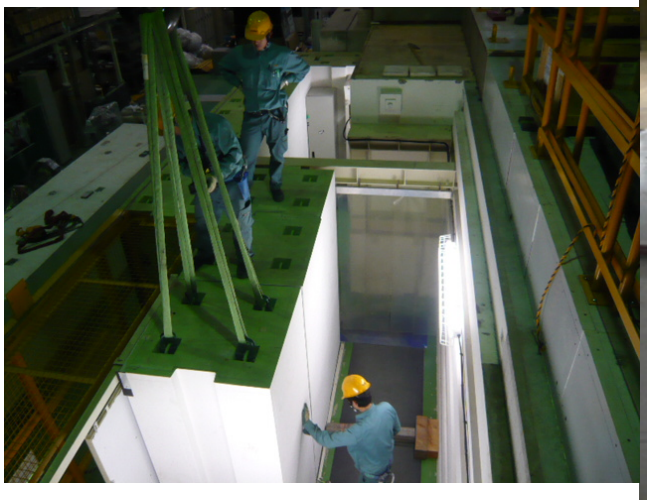
ATF2 FD/IP shield works: re-positioning



Big work! 3 weeks

ATF2 FD-IP area



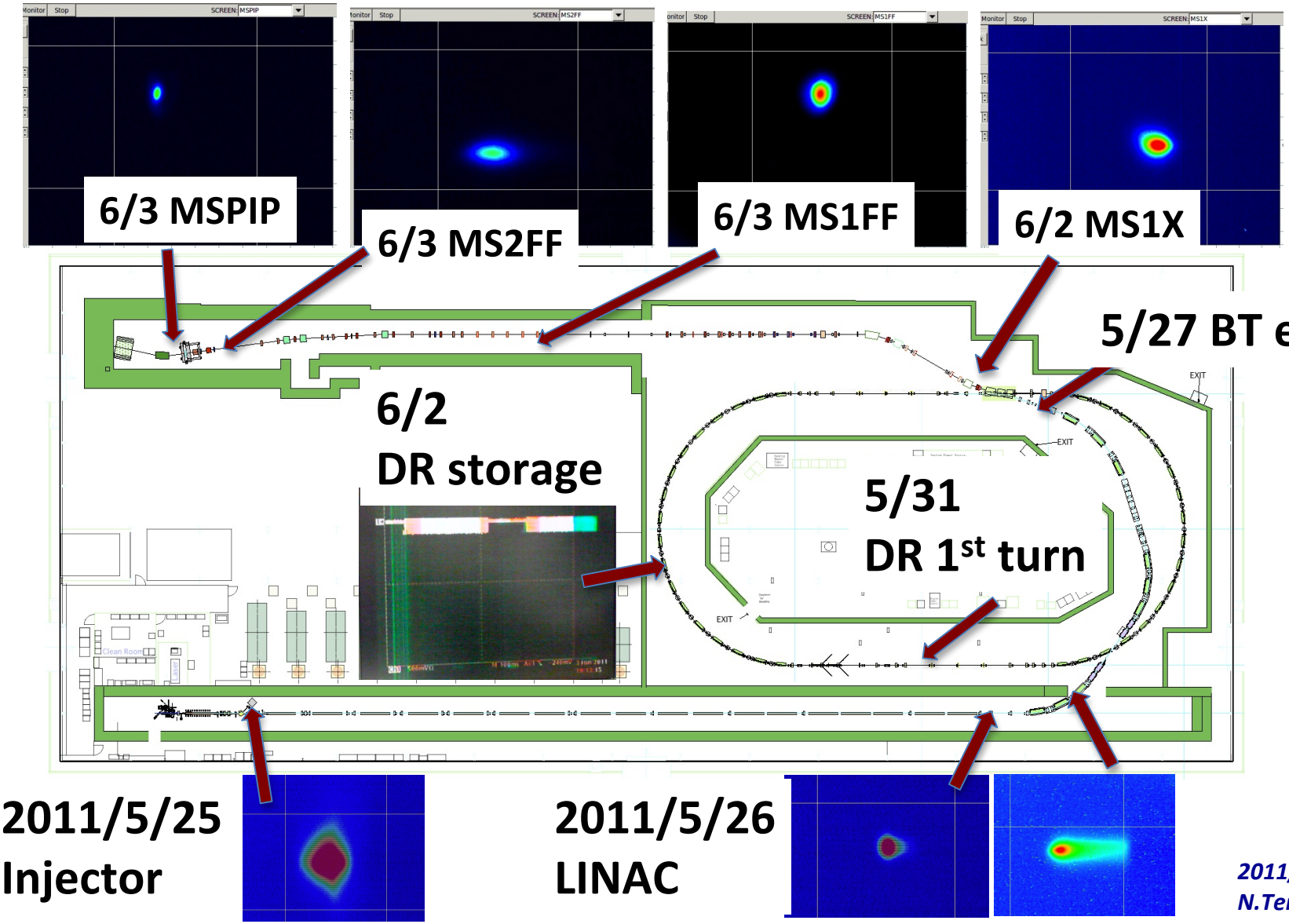


Recovered in May

Checkout of Electricity and Water in May

A test beam passes all beamline

Single bunch, 0.78 Hz, 0.3 x 10^{10} e/bunch DR&ATF2

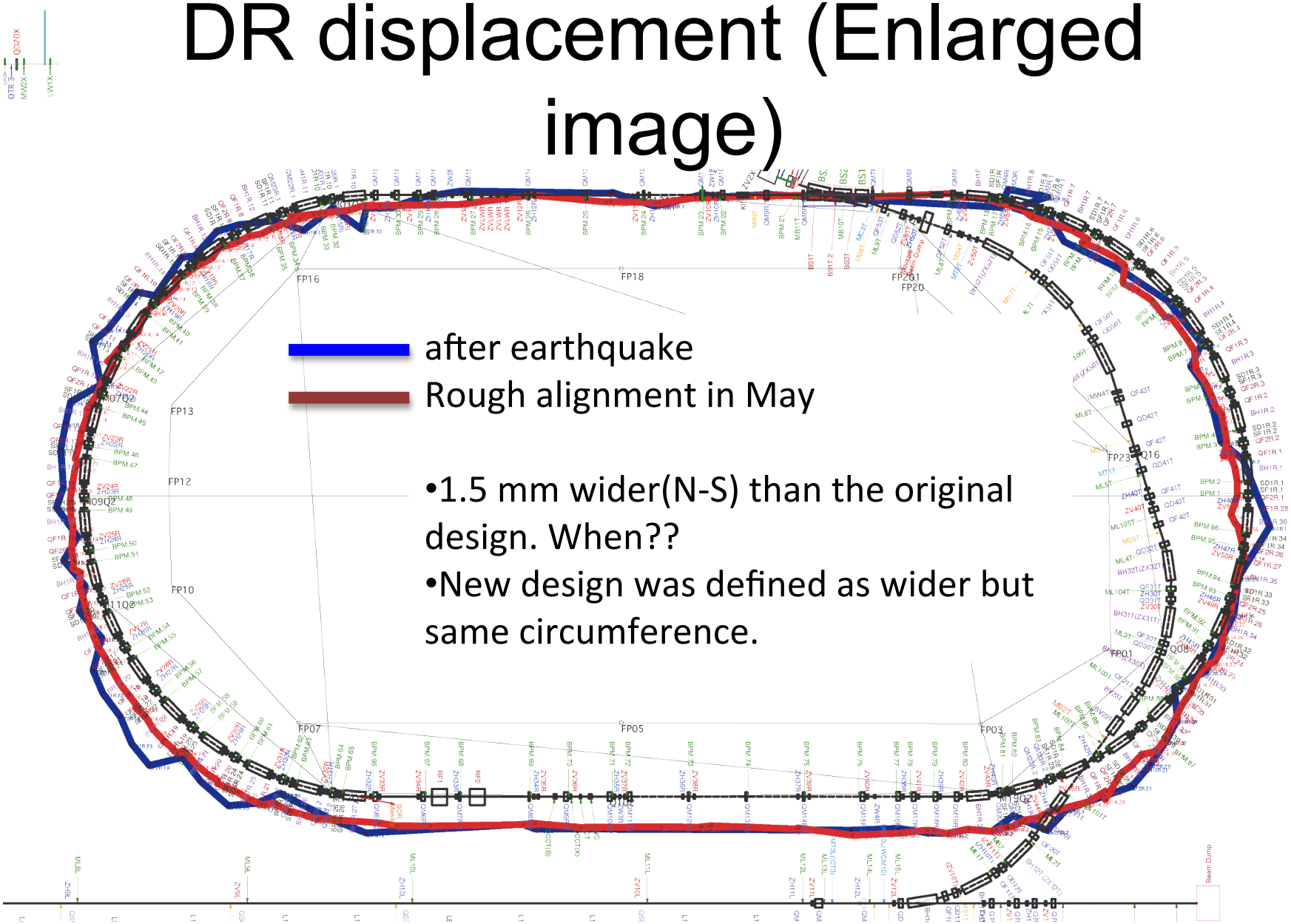


2011/06/03
N.Terunuma

Damping Ring Study in 2011-2012

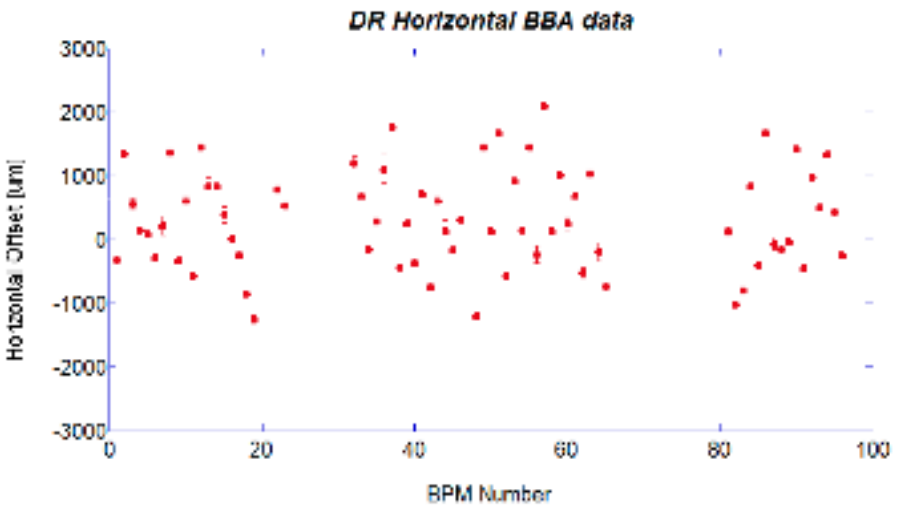
- In Summer Shutdown
  - Fine alignment
    - New DR geometry based on measurement
      - Distance of North & South section became longer by ~1.3mm
- In Oct.2011-Mar.2012 Run
  - Weekly emittance tuning
    - η correction
    - Coupling correction
  - BBA
    - Arc section and a part of Inj/Ext area
  - New DR Optics (by Kubo's report)
    - K1 of combined B was newly estimated from Steer-BPM data
    - DR optics re-matching with the new K1 of B

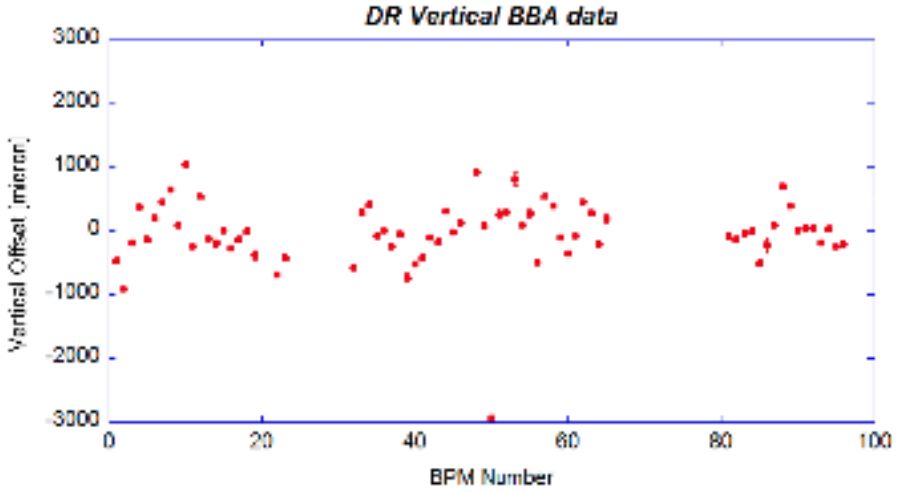
DR displacement (Enlarged image)



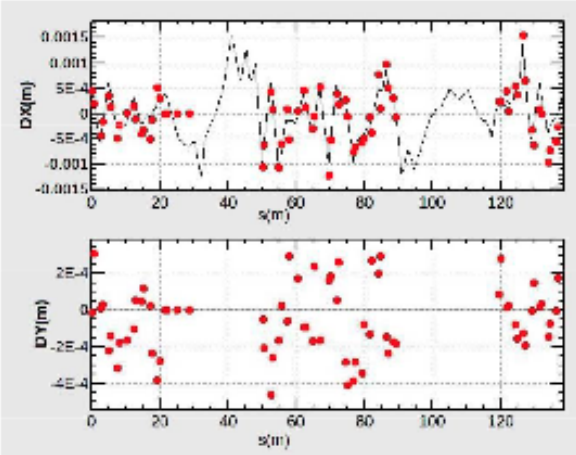
DR BBA

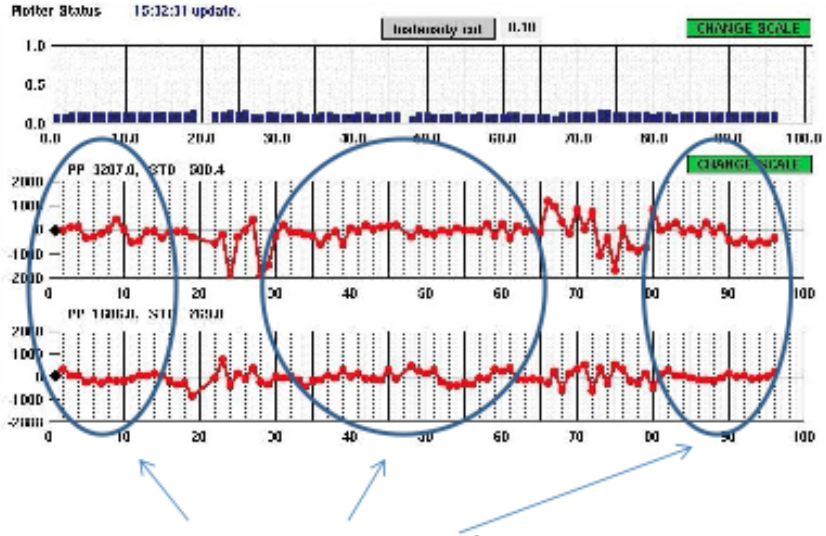
Measured BPM Offset





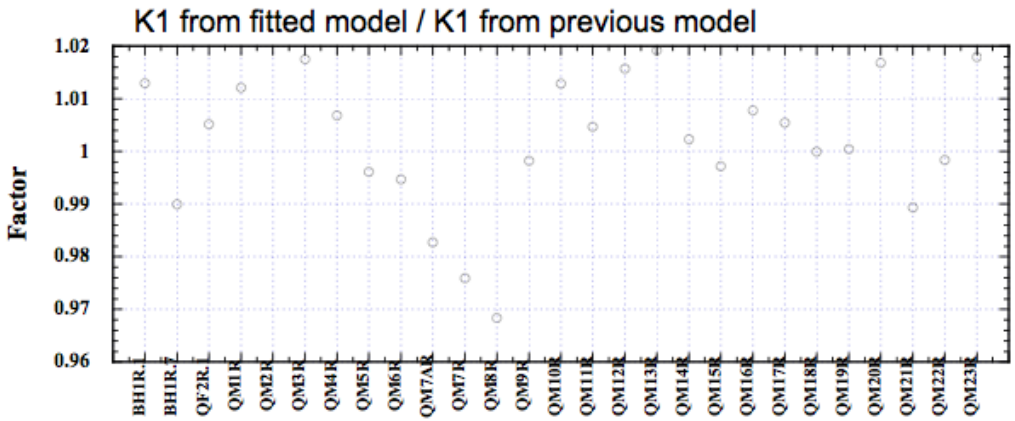
With the offset, orbit correction looks fine.





DR Optics

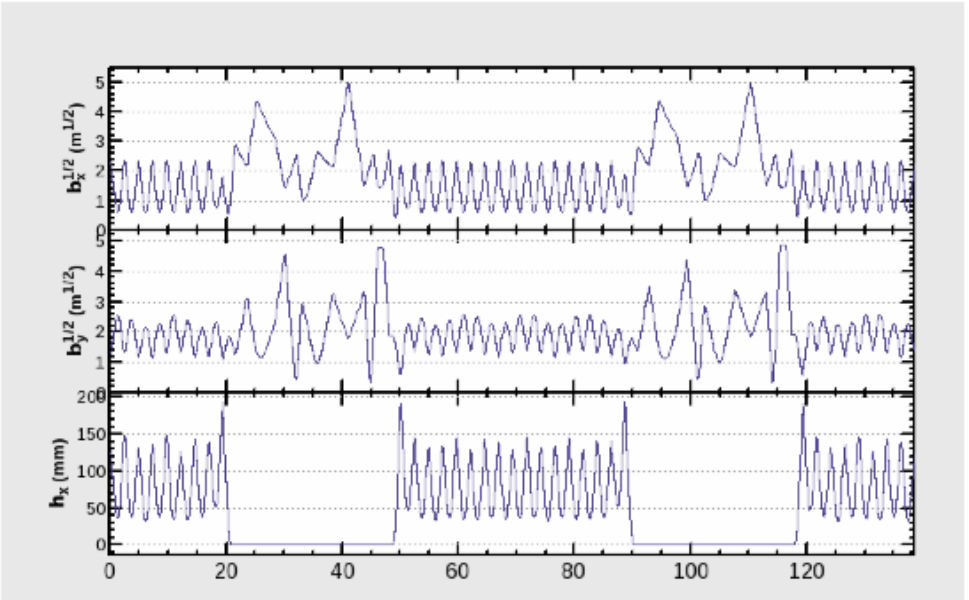
Correction factors



Ring is not symmetric in the new model
BH1R.1~6 and BH1R.7~36 have different K1
→ **Need to design new optics**

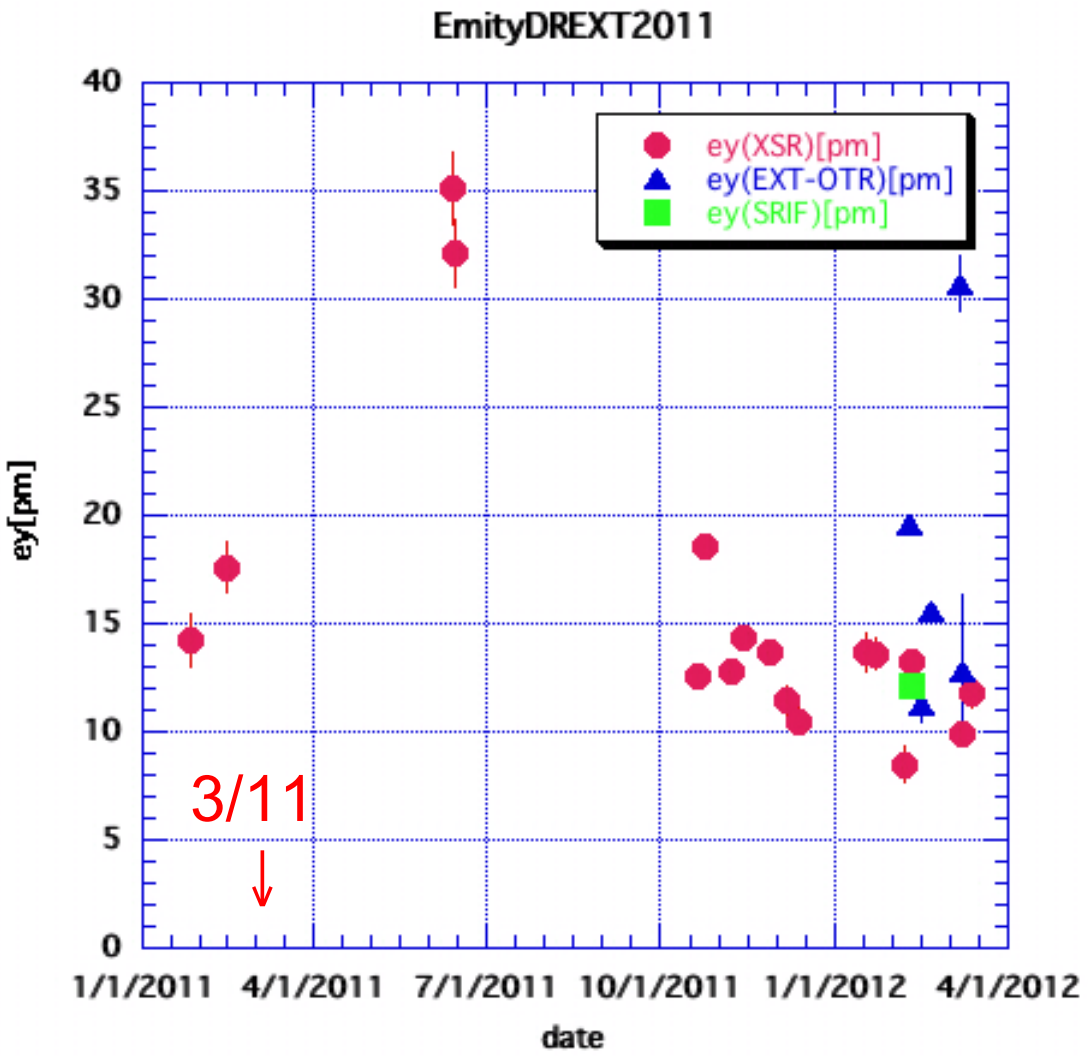
ORM analysis gives correction factors of Q strength including combined B → new design optics

New design



K.Kubo ATF2 proj. mtg. (KEK) 2012

Summary of ε_y of ATF-DR 2011-2012

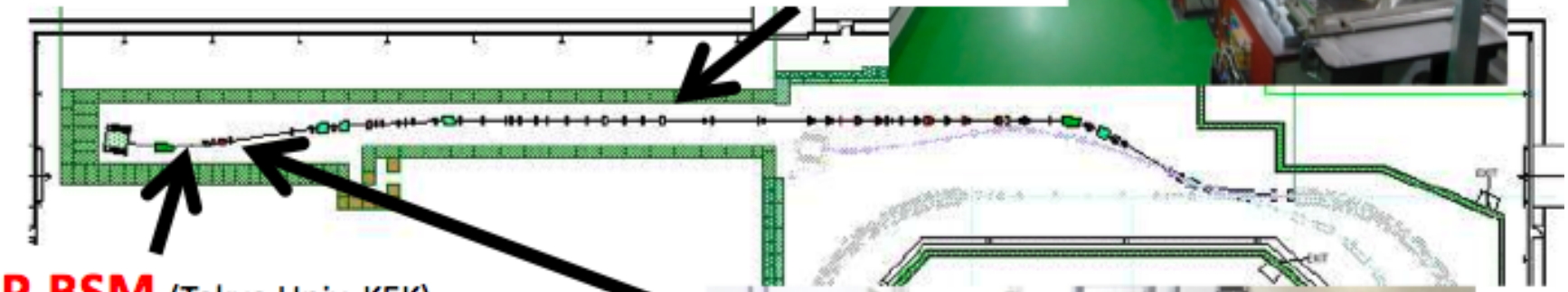


ATF2 Project

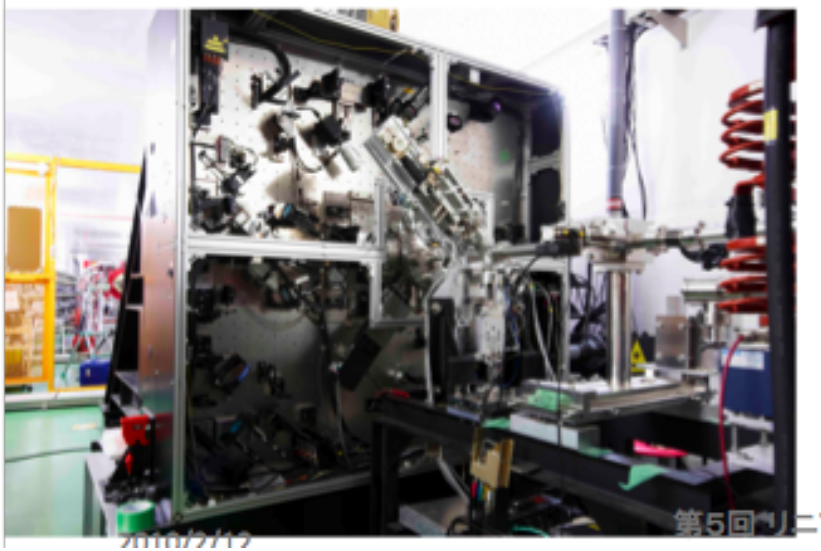
ATF2 Beamline

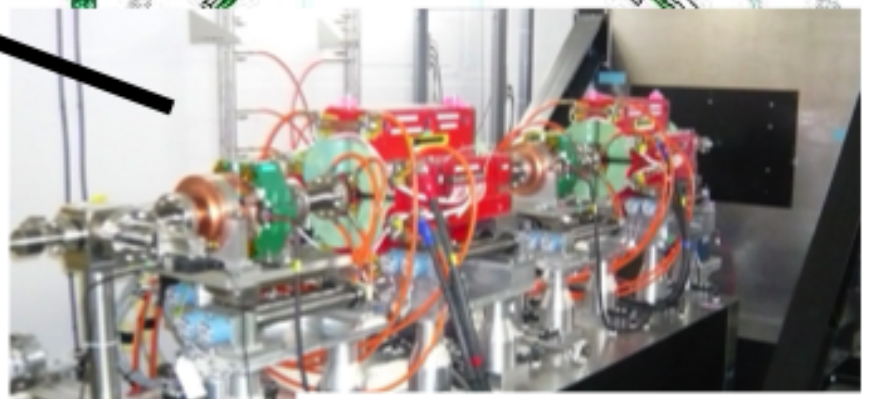
Final Focus beamline

Magnets and Movers (IHEP, SLAC, KEK)
C-band BPM (PAL, SLAC, KEK)
Support Table (KEK)



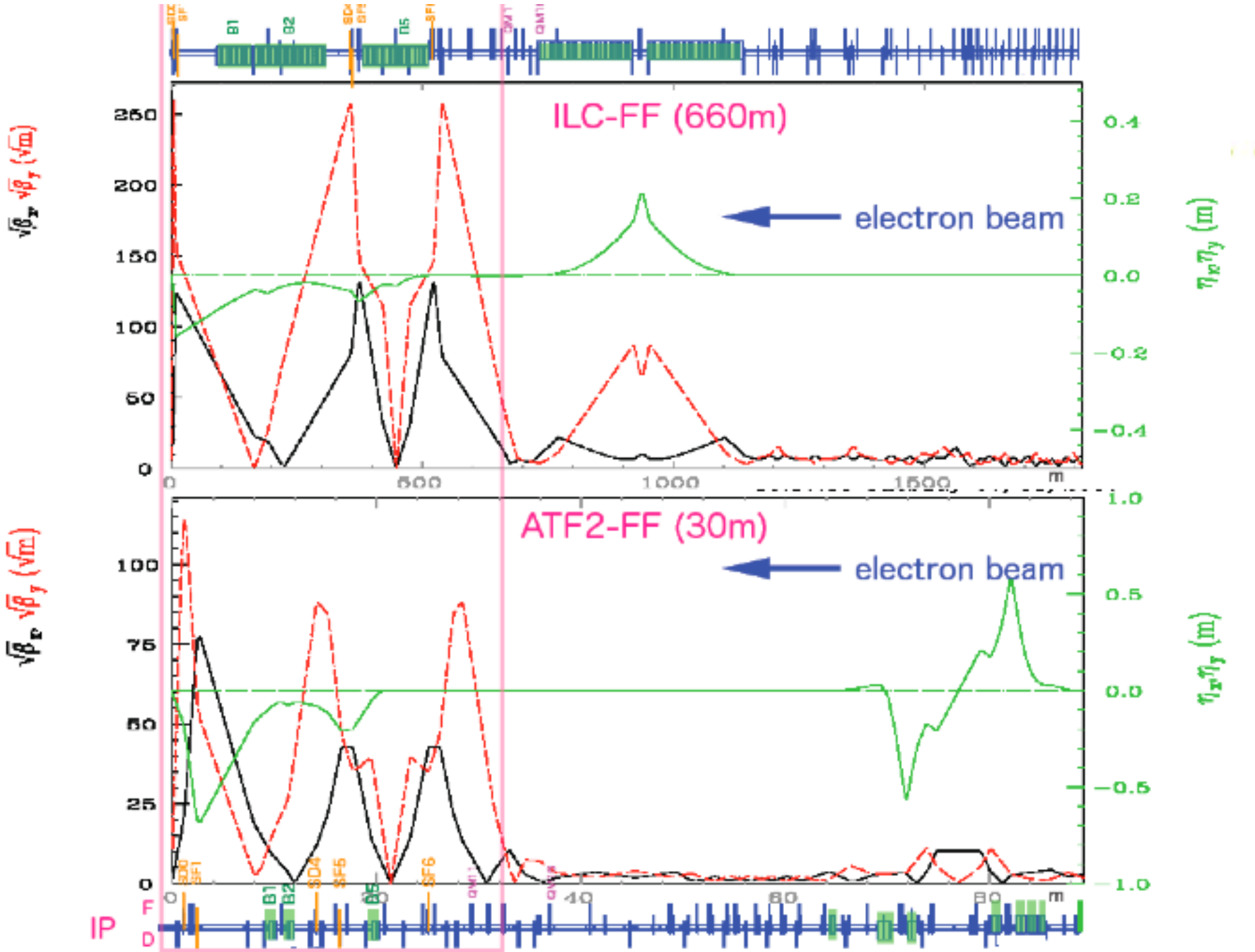
IP-BSM (Tokyo Univ, KEK)





Final Doublet system

Magnets and Movers (SLAC)
S-band BPM (KNU)
Supports and Table (LAPP)


ILC-FF (660m)
electron beam
ATF2-FF (30m)
electron beam
IP
F
D
m

ATF2 parameters & Goals A/B

ATF2 proposed IP parameters compared with ILC

Parameters	ATF2	ILC
Beam Energy [GeV]	1.3	250
L* [m]	1	3.5 – 4.2
$\gamma\,\epsilon_x$ [m-rad]	3×10^{-6}	1×10^{-5}
$\gamma\,\epsilon_y$ [m-rad]	3×10^{-8}	4×10^{-8}
β_x^* [mm]	4.0	21
β_y^* [mm]	0.1	0.4
η' (DDX) [rad]	0.14	0.094
σ_E [%]	~0.1	~0.1
Chromaticity W_y	$\sim 10^4$	$\sim 10^4$

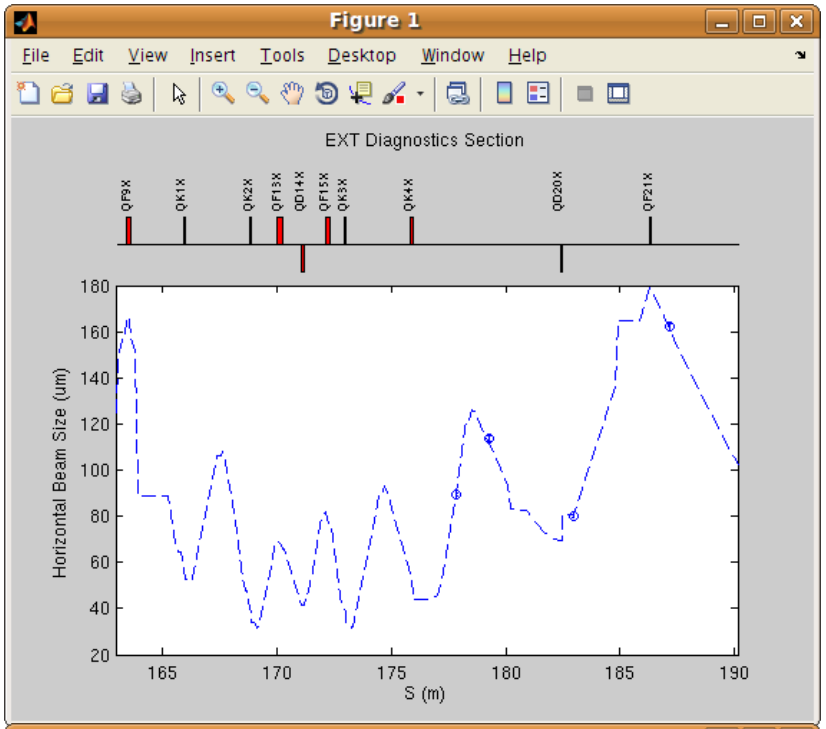
- Scaled design of ILC local-chromaticity correction style optics.
- Same chromaticity as ILC optics.

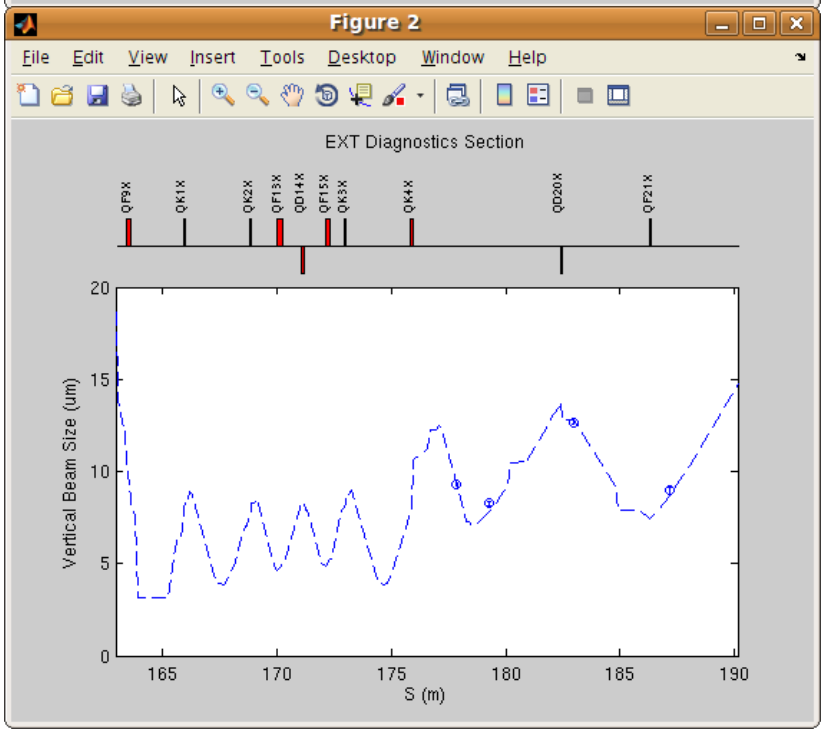
- ATF2 goal for beam size is ~37nm
- ATF2 goal of 37nm, scaled to 250 GeV, would correspond to 2.7nm (~twice smaller than ILC design value of 5.7nm)
- The intermediate "ILC-scaled" milestone of ATF2 is ~80nm

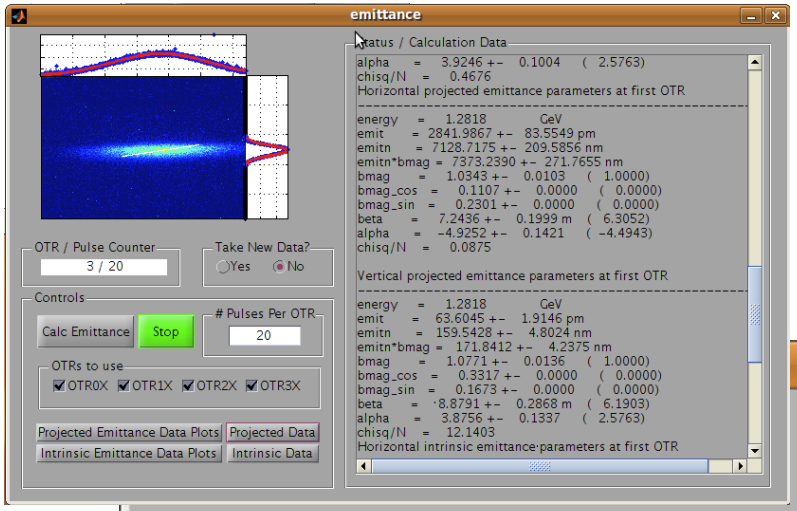
ATF2 Beam Tuning

- Orbit tuning
  - IPBSM background
- Matching
  - η (by QS*) and coupling(by QK*) correction
  - OTR measurement $\rightarrow$ α, β and emittance
  - Optics matching with matching Q(QM*FF)
- IP beam size tuning
  - (FD scan)
  - Linear knob scan
  - SD4FF and SK1FF scan
    - These scans are to be iterated.
- IP beam size monitor
  - IP Carbon WS
  - IPBSM(Shintake)
    - 2-8 deg. mode for 300nm < beam size < a few um
    - 30 deg. mode for 100nm < beam size < 300nm
    - 174 deg. mode for 25nm < beam size < 100nm

OTR measurement







Horizontal projected emittance parameters at first OTR

energy	= 1.2818	GeV	
emit	= 1842.5785 +-	17.5301 pm	
emitn	= 4621.8449 +-	43.9716 nm	
emitn*bmag	= 5273.3916 +-	90.7055 nm	
bmag	= 1.1410 +-	0.0114	(1.0000)
bmag_cos	= -0.3931 +-	0.0000	(0.0000)
bmag_sin	= 0.2781 +-	0.0000	(0.0000)
beta	= 4.3883 +-	0.0395 m	(6.3369)
alpha	= -2.8200 +-	0.0383	(-4.5304)
chisq/N	= 7.0061		

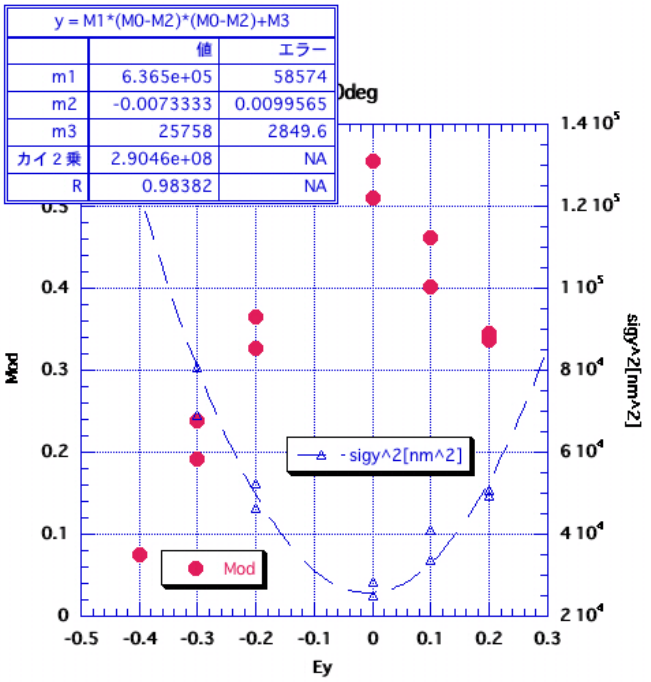
Vertical projected emittance parameters at first OTR

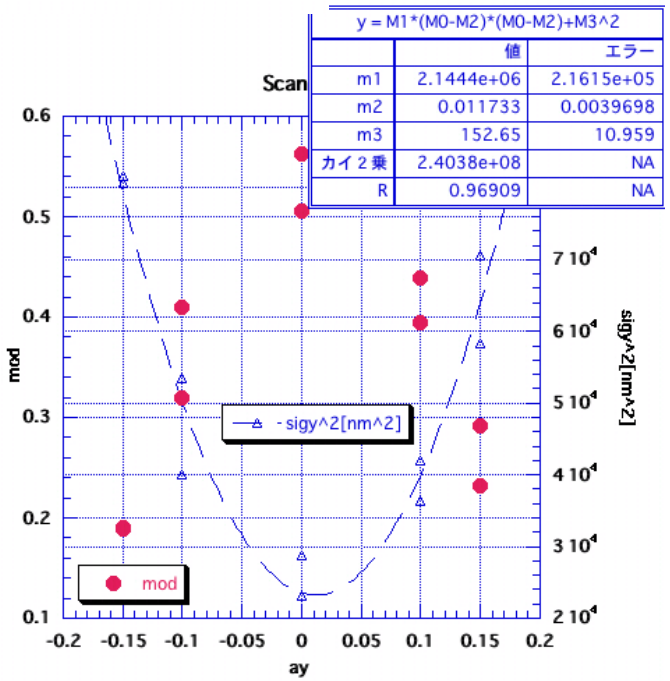
energy	= 1.2818	GeV	
emit	= 15.5583 +-	0.3348 pm	
emitn	= 39.0256 +-	0.8399 nm	
emitn*bmag	= 39.2490 +-	0.8830 nm	
bmag	= 1.0057 +-	0.0019	(1.0000)
bmag_cos	= -0.1051 +-	0.0000	(0.0000)
bmag_sin	= -0.0173 +-	0.0000	(0.0000)
beta	= 5.7387 +-	0.1171 m	(6.3764)
alpha	= 2.4380 +-	0.0422	(2.7281)
chisq/N	= 19.5090		

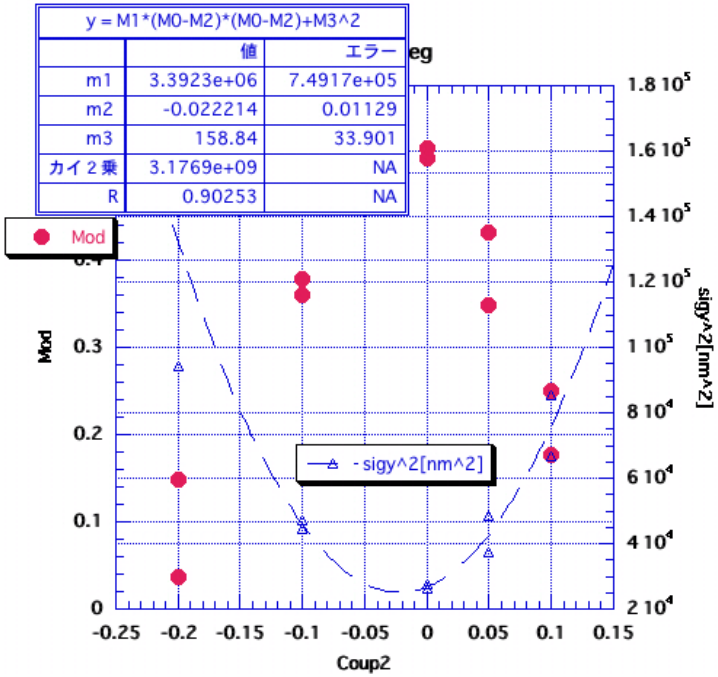
OK

Linear Knob Scan

‘Linear knob’ is made from linear combination of SX movers, and they are ‘orthogonalized’.





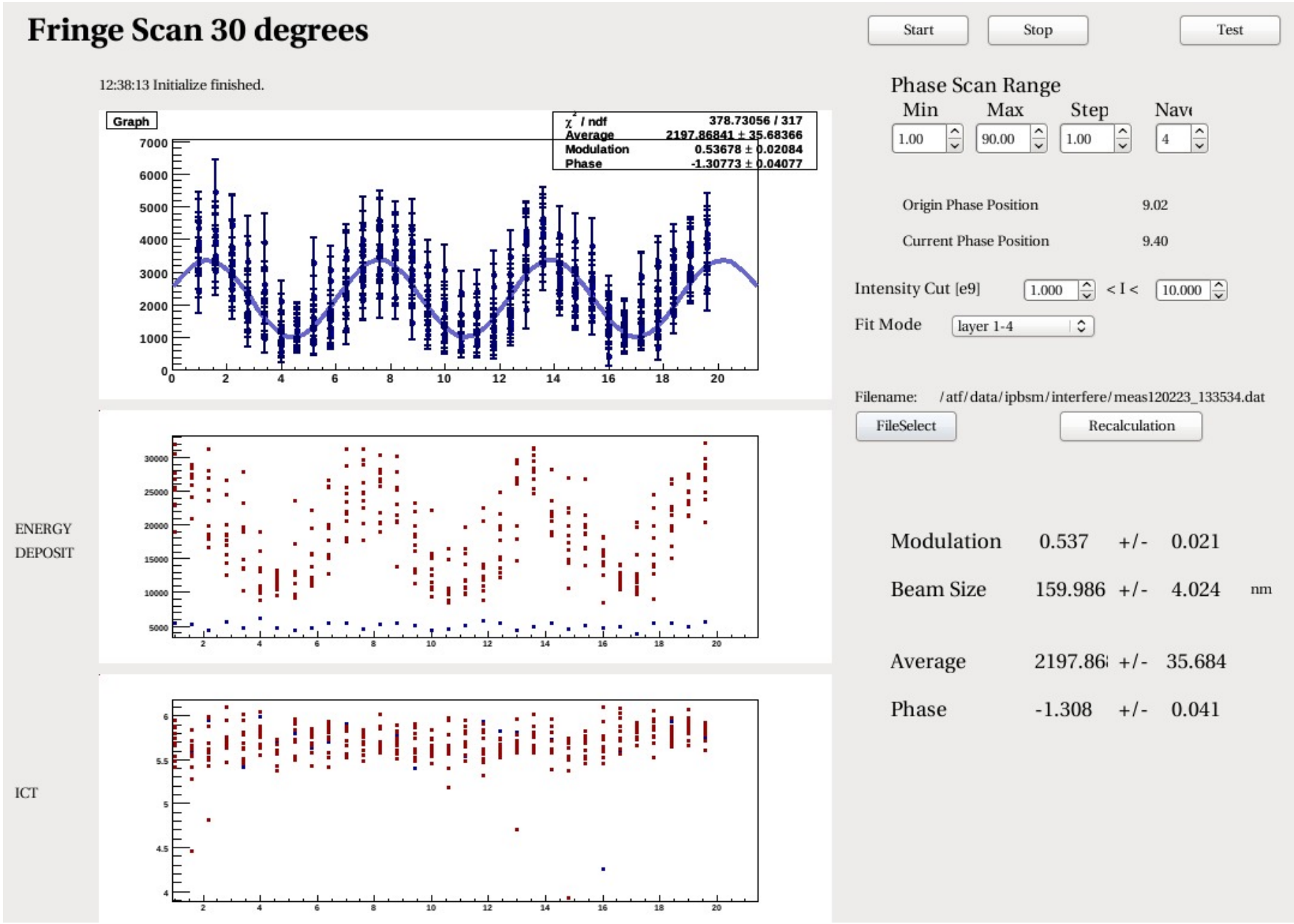


Tuning History/Results 2012

N x M Optics: $(\beta_x^*, \beta_y^*)=(N\ \beta_{x\ design}^*, M\ \beta_{y\ design}^*)$
Bigger N,M→bigger beam size but lower BG for IPBSM

- -17Feb. 10x10 optics
  - Successful meas. in 30deg. mode
  - σ_y=203nm
- 21-24Feb. 10x3 optics
  - 30deg.mode meas. → σ_y=160nm
  - Trial of 174deg. Mode
    - But no modulation measured. Expected σ_y is almost at the edge of measurement limit.
- 7-15Mar. 10x1 optics
  - 30deg.mode meas. → σ_y=160~180nm
  - Many troubles: optical parts(mirror, lens,…) were broken.
- 15-16Mar. 10x5 optics for IPBSM study

Example of Fringe Scan



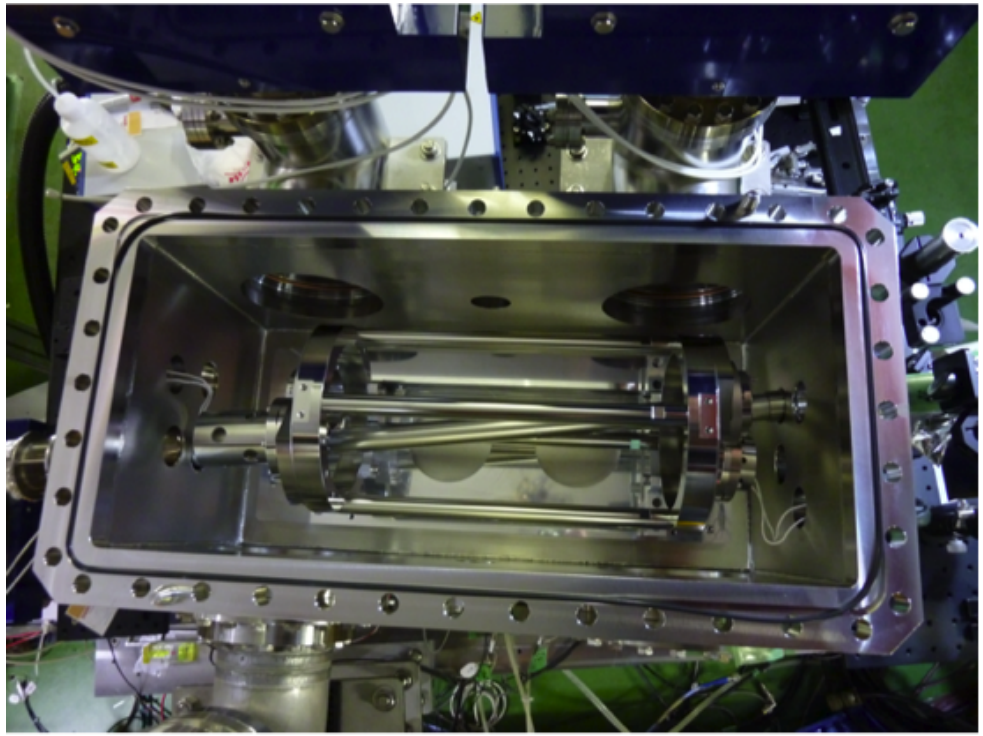
Other Experiments in ATF

- Pol e+
  - Collision experiment of e- and LASER in resonant chamber
- FONT
  - Fast feedback for ATF2/ILC
  - Quickly restarted from the EQ
- EXT LW
  - Recovery work in Fall 2011
  - OTR target was installed and is studied.
- IP and Low Q Cavity BPM
  - Low Q BPM study at the end of LINAC(Mar. 2012)
- Multi-OTR system in EXT
- ….

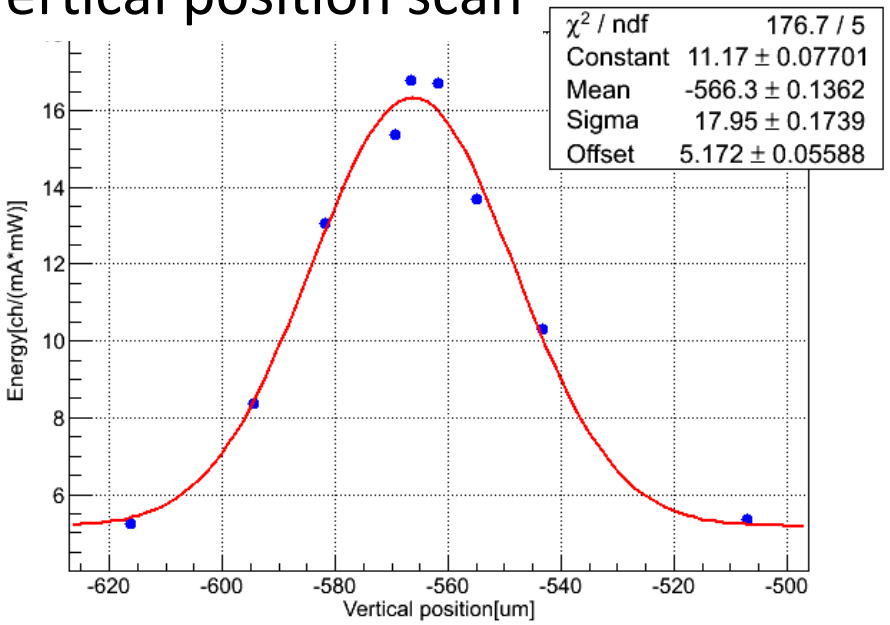
Pol e+ Experiment

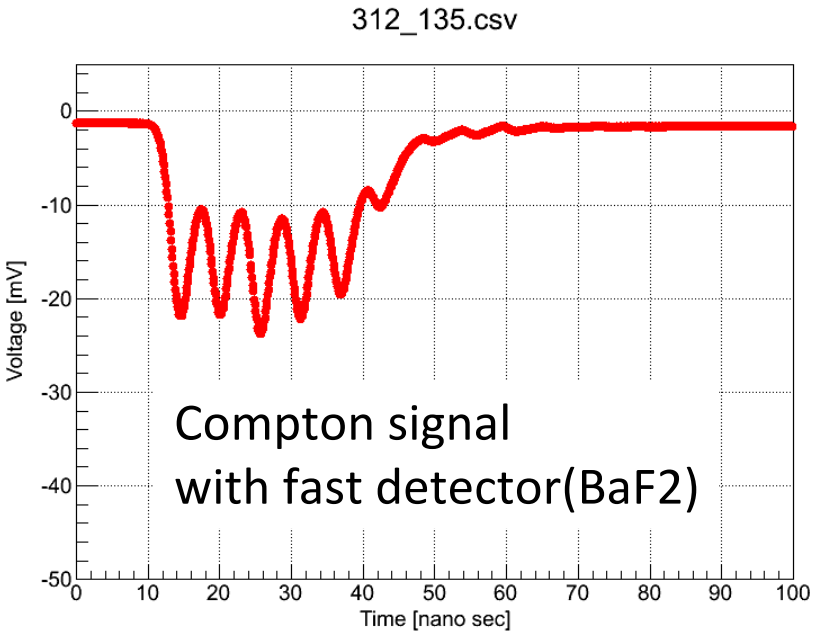
3D 4-mirror cavity (Hiroshima, KEK)

mode-lock Laser
357MHz, 10W



vertical position scan





Summary

- ATF was quickly recovered from the earthquake 3.11 2011.
- Damping ring is operated with ε_y~10pm and study for further smaller emittance is on going.
- There is a big progress in ATF2 project in 2012 where σ_y~160nm. IPBSM, however, is still to be studied and there are also many things to be overcome.
- There are also other active experiments/project in ATF.

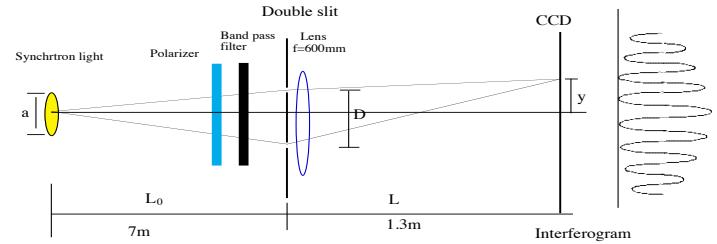
Thank you

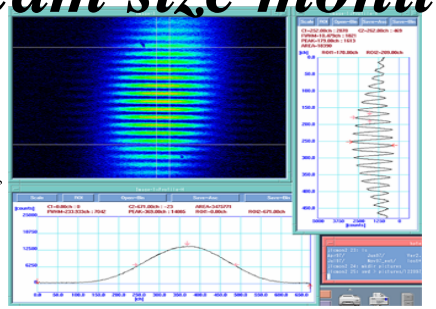
Back Up

Beam Size Measurement in DR

SR interference beam size monitor

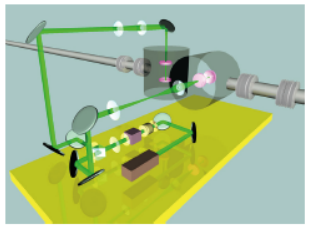
Layout of the SR-interferometer

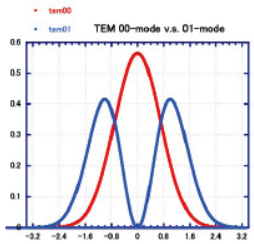


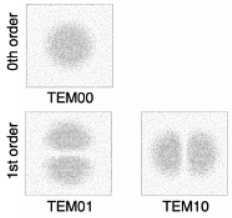


$$I = \pi a J_0\{1+\exp[-(\frac{2\pi Da}{\lambda L_0})^2]\bullet\cos(\frac{2\pi Dy}{\lambda L})\}$$

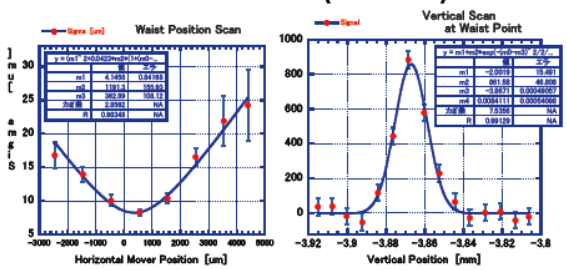
Laser wire beam size monitor in DR





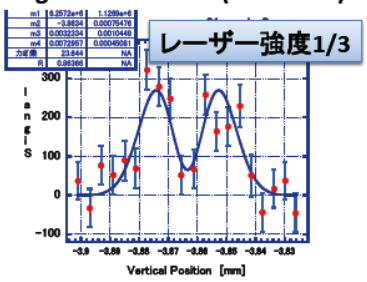


Fundamental mode(00 mode)



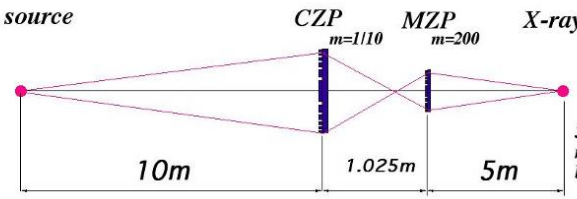
σ_e=4.1±0.8um

Higher order mode(01 mode)

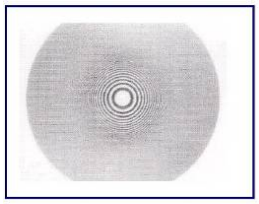


σ_e=3.2±1.0um

X-ray SR monitor using zone plate (Tokyo Univ.)



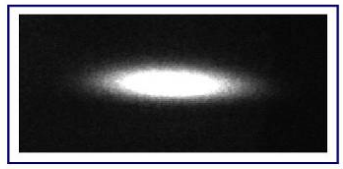
3.23KeV(0.384nm) SR
magnification 20
beam size resolution 1.87μm



microscope image of zone plate

CZP : 3mm dia.
6497 zone rings
minimum zone width 108nm

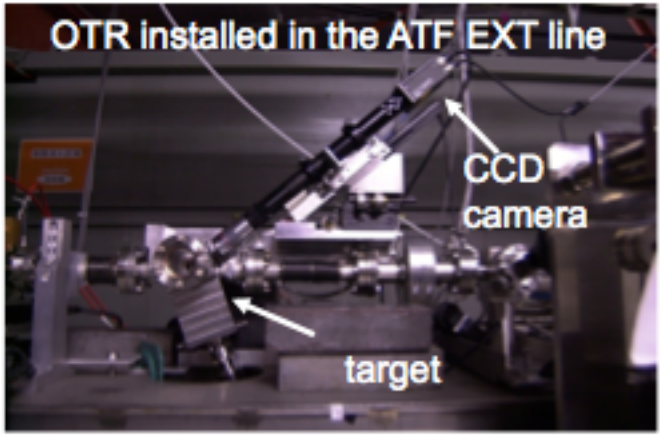
MZP : 75μm dia.
584 zone rings
minimum zone width 127nm

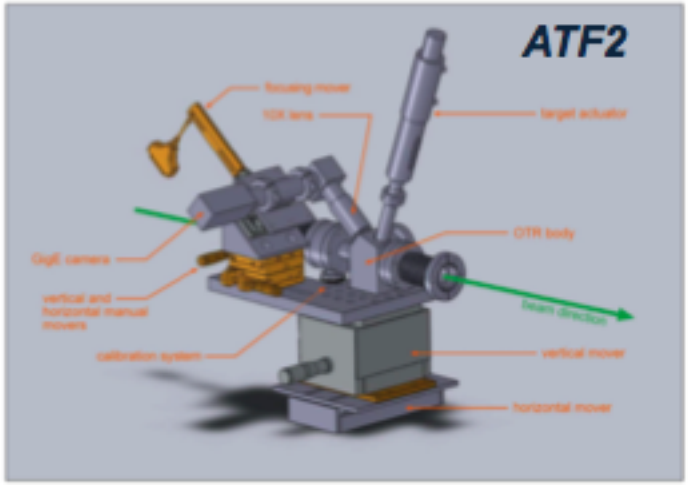


Beam image (x:46.2, y:10.2μm)

OTR Monitors at ATF2

IFIC (CSIC-UV)/SLAC/KEK





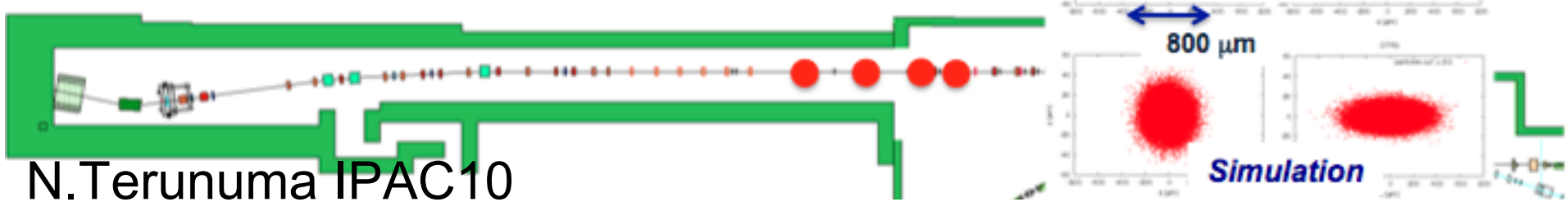
OTR (Optical Transition Radiation) monitor developed at ATF demonstrated the ability to measure a 5.5 μm beam size in one pulse.

- *damage of (Be)Cu target for smaller beam*

Multiple OTR monitors for the ATF2

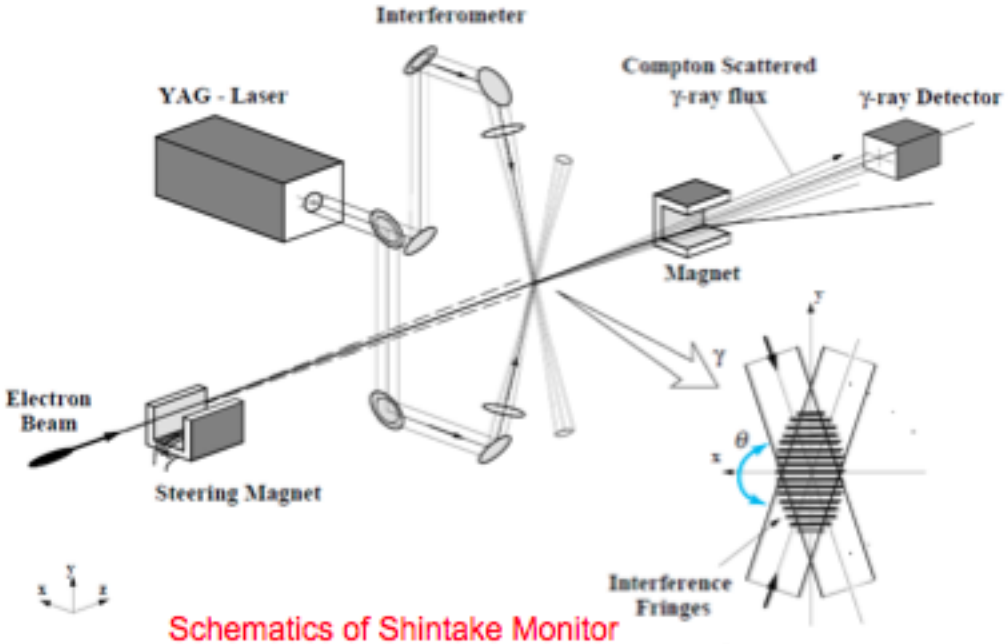
- ***realize the fast emittance measurement***
- *4 OTR monitors near the Wire Scanners*
- *improved resolution of about 2 μm*
- *thin aluminized (1200Å) Mylar target*

The first test of multi-OTR system at ATF2 will be done in June 2010.



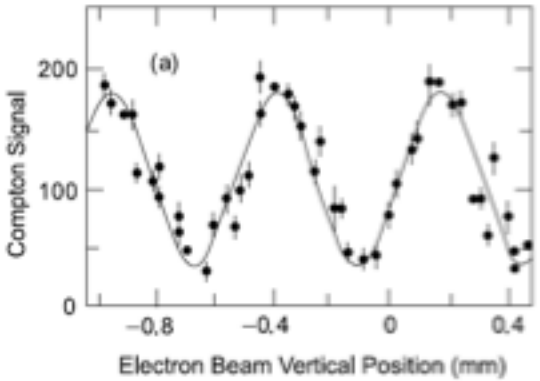
Principle of Laser Interference Beam Size Monitor (Shintake Monitor)

N.Terunuma IPAC10



Schematics of Shintake Monitor

FFTB



Measured signal in FFTB at SLAC
T. Shintake *et al.*, 1992
σy~65 nm beam size was measured

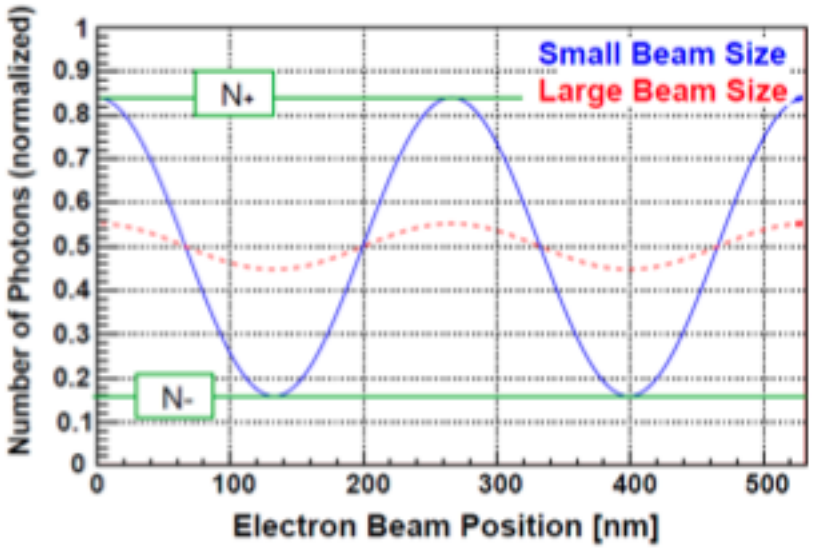
Modulation depth

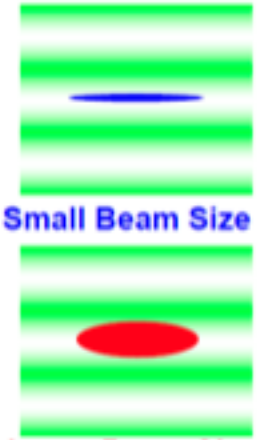
$$M \equiv \left|\frac{N_+ - N_-}{N_+ + N_-}\right| = \frac{\text{Amplitude}}{\text{Average}}$$

Beam Size

$$\sigma_y = \frac{d}{2\pi}\sqrt{2\log\left(\frac{|\cos\theta|}{M}\right)}$$

d: fringe pitch θ: crossing angle





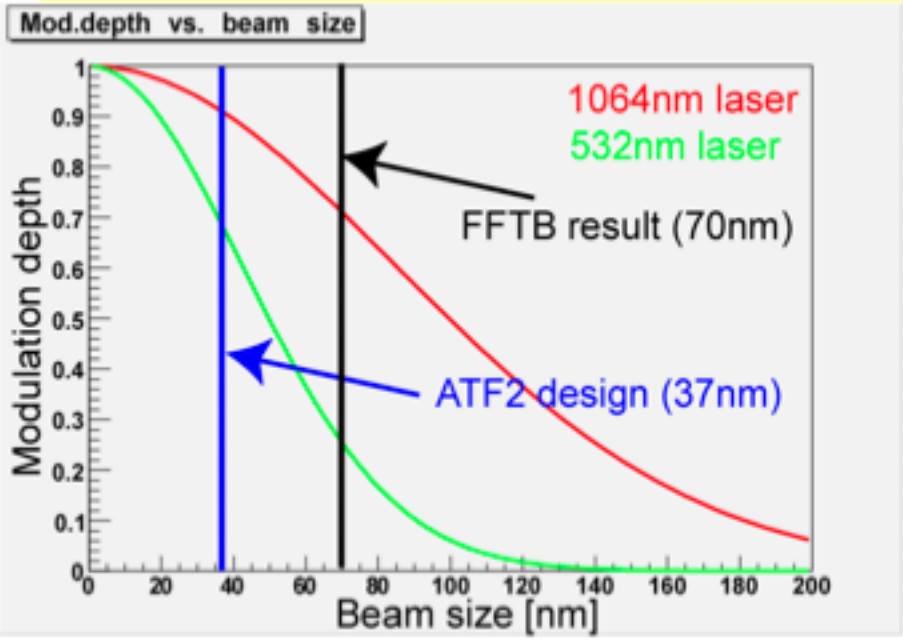
Laser Interference Fringe Monitor for ATF2

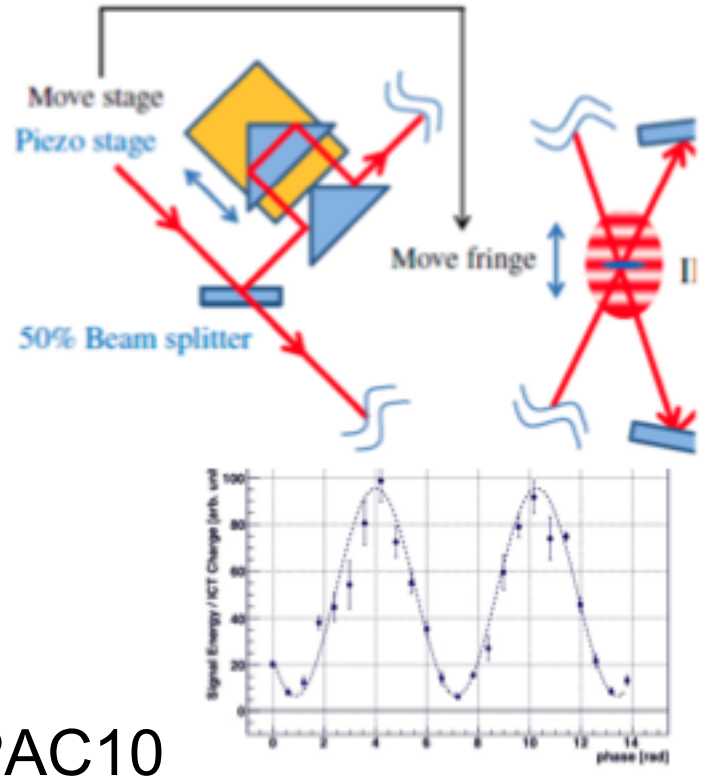
Univ. Tokyo/KEK

FFTB ~70nm -> ATF2 37nm

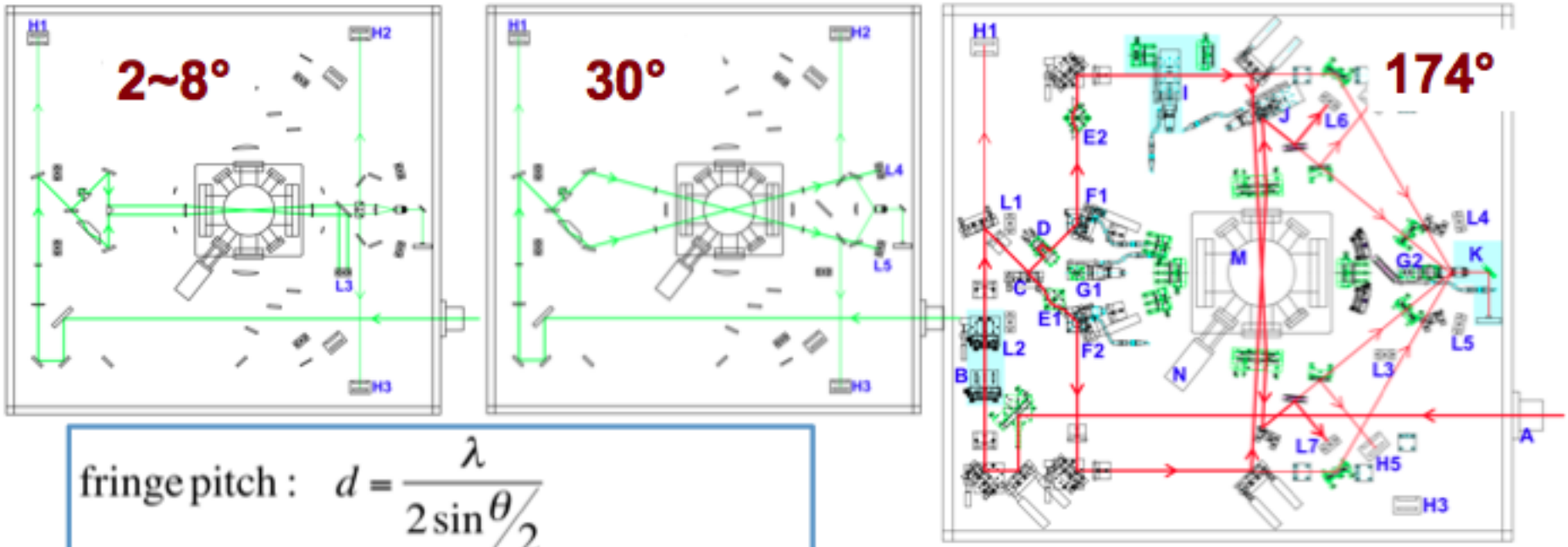
Modifications for ATF2

- Laser wavelength (1064 → 532 nm)
- add 2~8 deg. laser crossing
- new fringe phase control/stabilization
- Multi-layer γ-ray detector





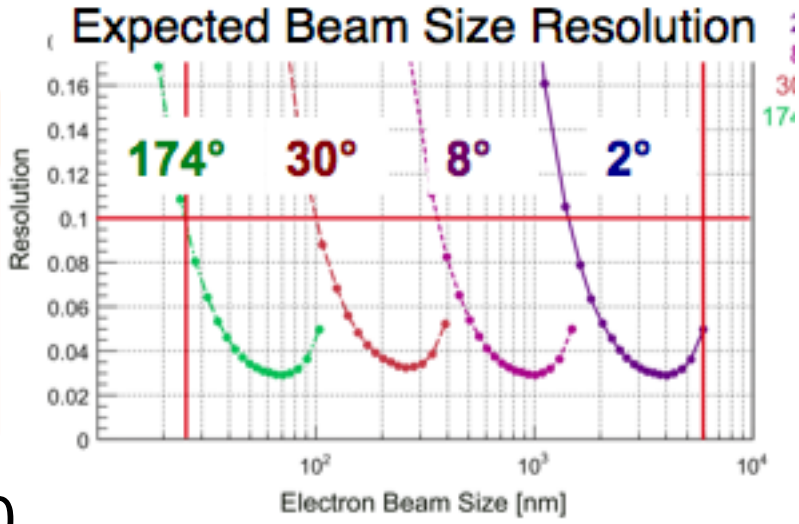
Laser Interference Fringe Monitor for ATF2



$$\text{fringe pitch}: \quad d = \frac{\lambda}{2\sin\theta/2}$$

λ = laser wavelength, θ = crossing angle

	174°	30°	8° ⟷	2°
Fringe pitch	266 nm	1.03μm	3.81μm	15.2μm
Minimum	25 nm	100 nm	360 nm	-
Maximum	100 nm	360 nm	-	6 μm

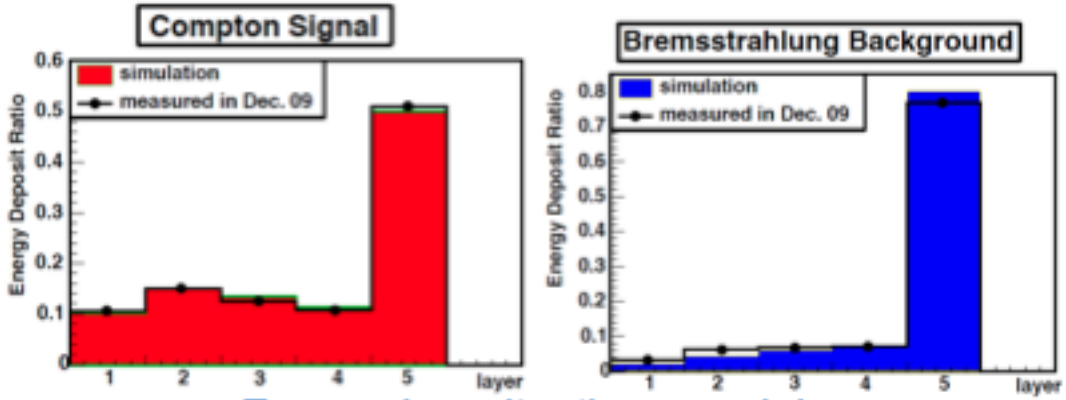


IPAC10

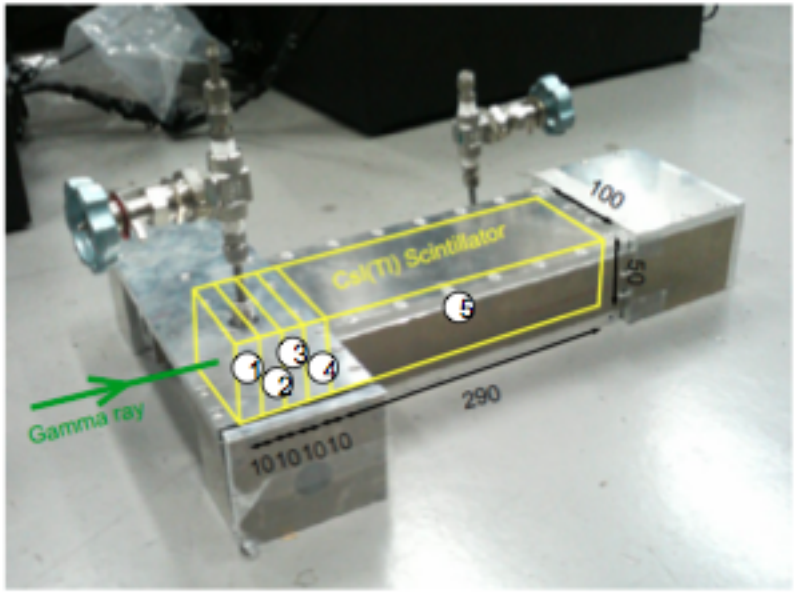
N.Terunuma IPAC10

Gamma-ray Detector

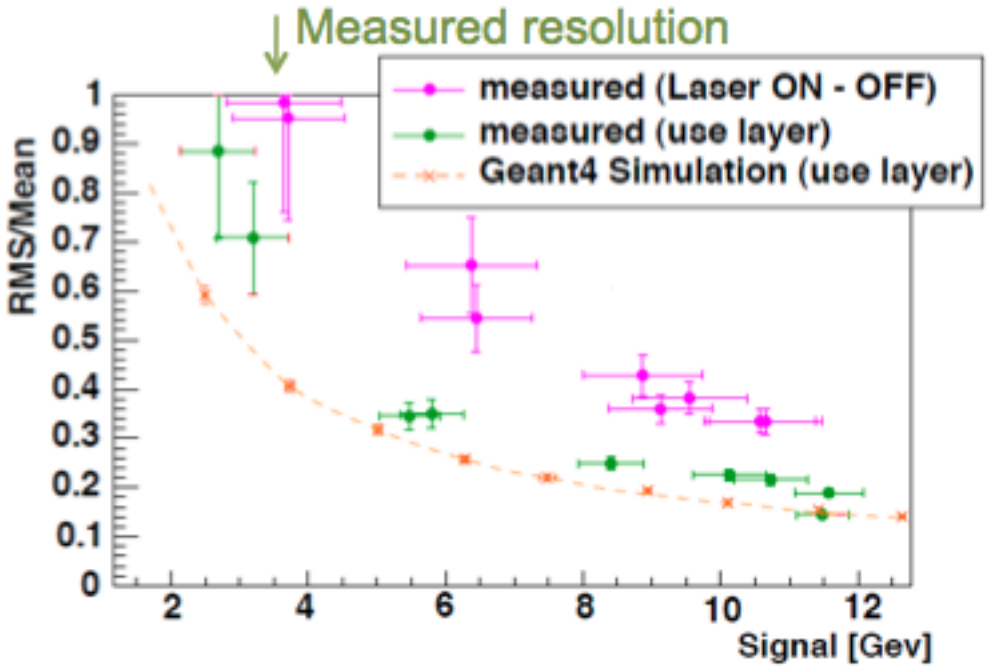
- Use multi-layerd calorimeter
  - CsI(Tl), 4 thin layers + 1 bulk
- Calculate the amount of Compton signal and the background using the difference of energy deposit on each layer.



Energy deposit ratio on each layer

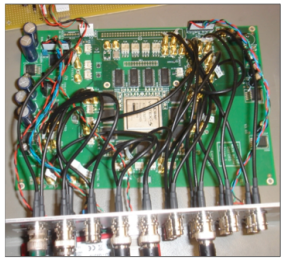


Multi layered gamma-ray detector



N.Terunuma IPAC10

FONT5 digital FB board



Xilinx Virtex5 FPGA

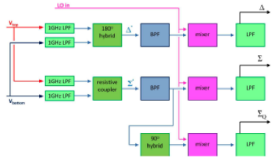
9 ADC input channels
(TI ADS5474)

4 DAC output channels
(AD9744)

Clocked at 357 MHz
phase-locked to beam

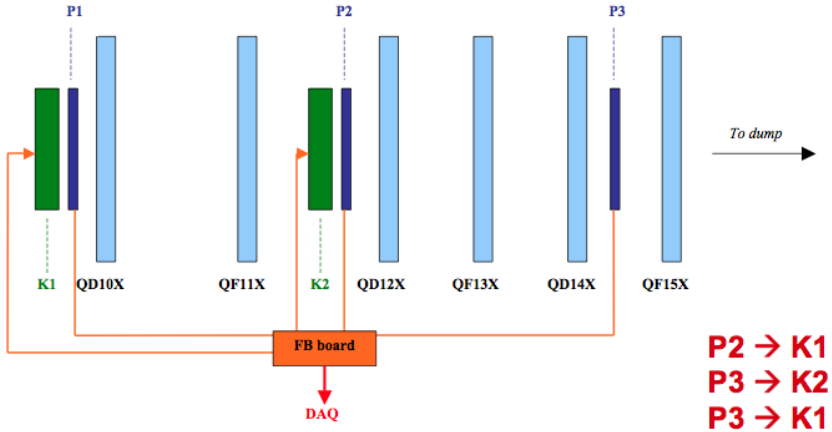
4x faster than FONT4

BPM processor architecture



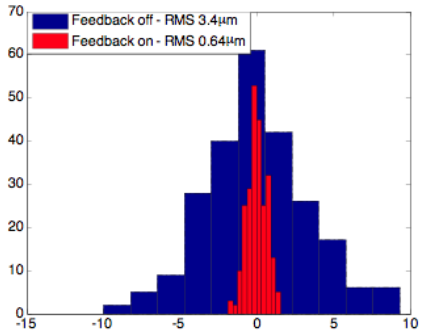
FONT

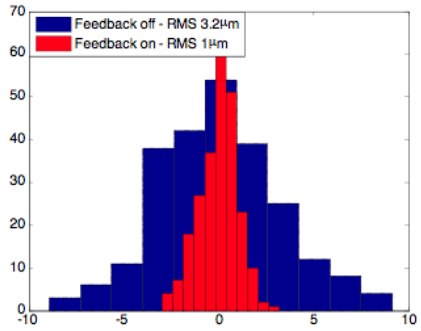
FONT5 setup December 2011



Feedback Performance

(example FB Run 6 13/12)





Summary

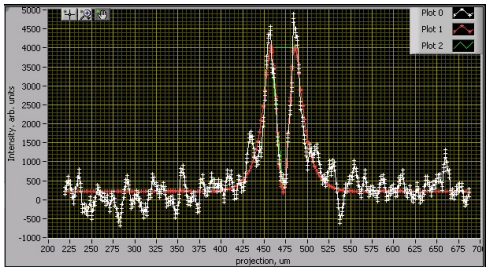
We have an enormous amount of data from December 2011 shifts – analysis just started

- Made significant hardware improvements
- Routinely obtain sub- 0.5 μm BPM resolution
- Re-established FB with better performance
- Instrumented downstream BPMs
- Starting to study/understand jitter propagation

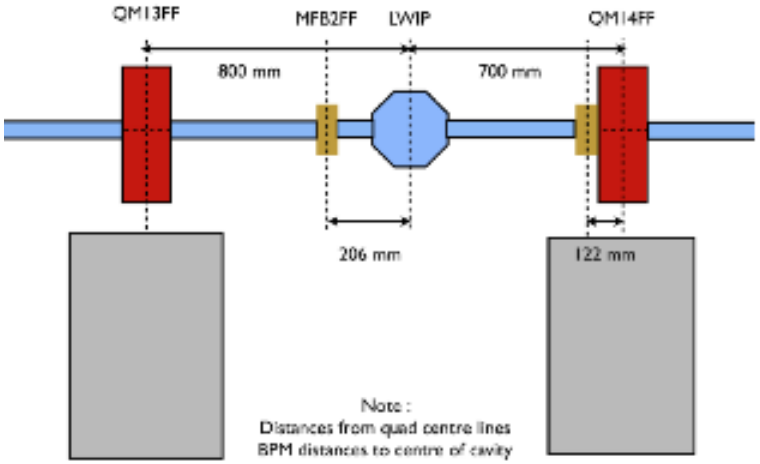
P.Burrows ATF2 prj.mtg 2012

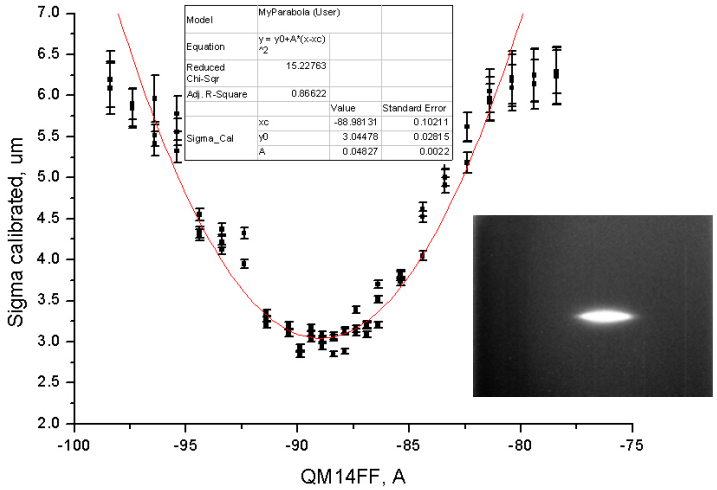
EXT LW

Recovered from the EQ in the Autumn run in 2011. Laser-e^- collision signal is not yet seen. OTR target was installed for optimization of collision and cross calibration. OTR study in Mar.2012.



OTR double image





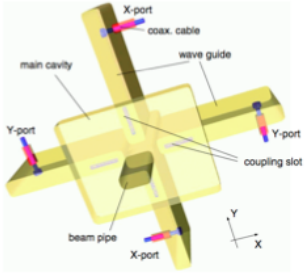
e^- beam size minimization by QM14

IPBPM

IPBPM Characteristics

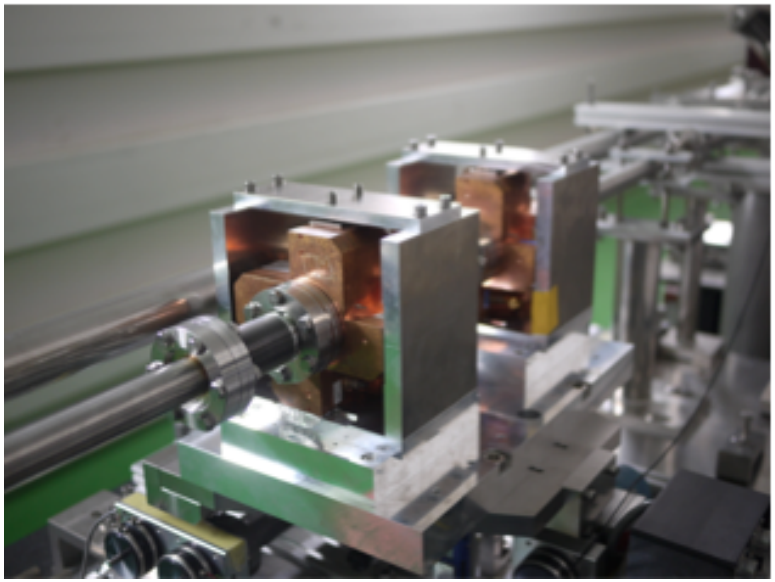
- Rectangular cavity shape
  - To isolate the x and y dipole modes
    - X (5.712 GHz) / Y (6.426 GHz)
- Low angle sensitivity
  - The cavity length in the z direction L : 6 mm
- Ultra high position sensitivity
  - Expected to be large angular jitters @ the IP
  - The beam vertical divergence $\sigma_y^{*\prime}$: 345 μrad
  - The coupling constants β
    - X (1.4) / Y (2.0)

Structure of the IP BPM

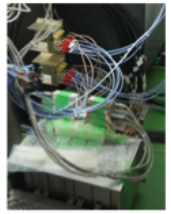


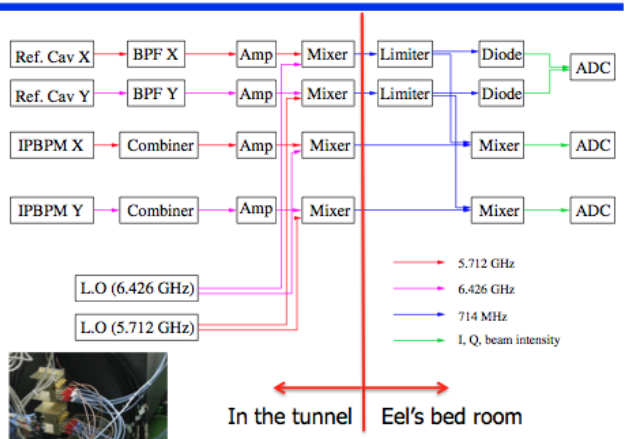
Simulated parameters of IPBPM

parameter	f_0 (GHz)	β	Q_L	Q_0	Q_{ext}	$(R/Q)_0$	τ (ns)
x	5.712	1.578	2070	5337	3382	0.549	58
y	6.426	3.154	1207	5015	1590	1.598	30



Electronics





Total processing electronics gain : 40 dB
The minimum detectable signal : -95 dBm

Resolution - Homodyne

Vertical

Charge : 0.5 ~0.6 x 10^{10}, Unit [nm]

	40 dB	30 dB	20 dB
One point	10.0	15.0	16.0
Filter	6.90	8.12	9.05
Integration	6.73	7.55	10.09

Horizontal

	40 dB	30 dB	20 dB
One point	20.0	39.0	72.0
Filter	14.52	26.14	50.08
Integration	16.50	23.91	35.00

- SVD Residual
- Charge normalized
- Working on heterodyne data

- One point
  - Choose one sample point
- Filter
  - Use gaussian filter for removing noise on the homodyne signal
  - Choose one sample point
- Integration
  - Integrated few sample point
  - Same as charge ADC

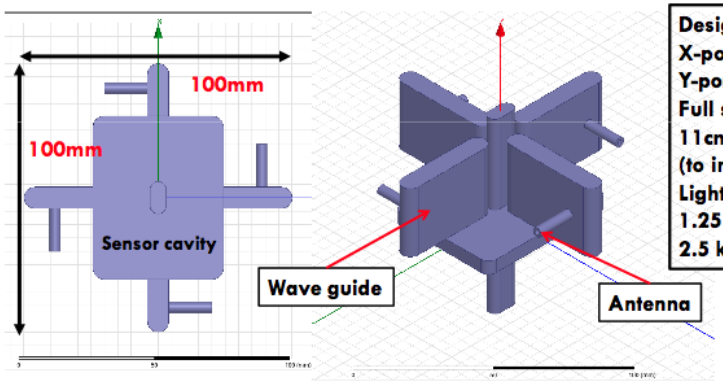
- Did few scans for finding filter width, sample point and integration width

Y.Kim ATF2 prj.mtg 2012

Low-Q Cavity BPM

11cm Low-Q IP-BPM design

11cm Low-Q IP-BPM drawings of HFSS



Designed frequency
X-port: 5.712 GHz
Y-port: 6.426 GHz
Full size :
11cmx11cm
(to install IP-Chamber)
Light weight:
1.25 kg (Single)
2.5 kg (Double)

Results of HFSS simulation

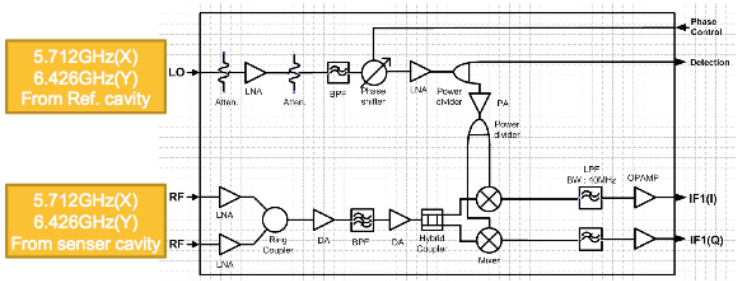
11cm AL ver.

Port	f_0 (GHz)	β	Q_0	Q_{ext}	Q_L	τ (ns)
X-port	5.7123	4.992	4026.58	806.67	672.04	18.72
Y-port	6.4255	5.684	4014.13	706.16	600.51	14.87

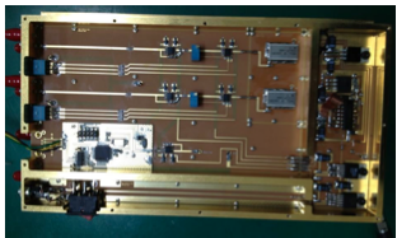
14cm AL ver.

Port	f_0 (GHz)	β	Q_0	Q_{ext}	Q_L	τ (ns)
X-port	5.7050	4.48	4005.53	894.80	731.41	20.40
Y-port	6.4217	6.17	3903.95	632.36	544.21	13.49

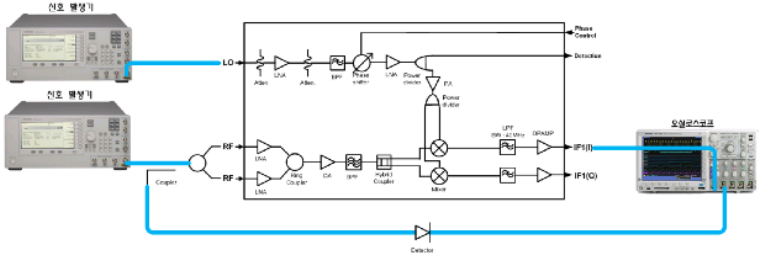
SIMPLIFIED SCHEMATIC

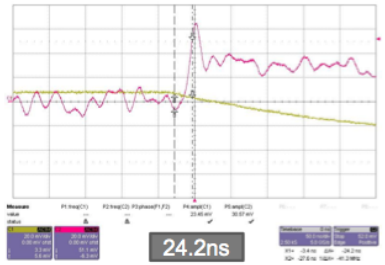


Simplified schematic of the IP-BPM signal processing electronics.



LATENCY





24.2ns < 40ns
(FONT requirement)

A.Heo and S.Jang ATF2 prj.mtg 2012