ATF2 Results

T. Tauchi,

IWLC 2010, CERN and CICG,19 October 2010

References :

ATF2 Proposal, KEK Report 2005-2

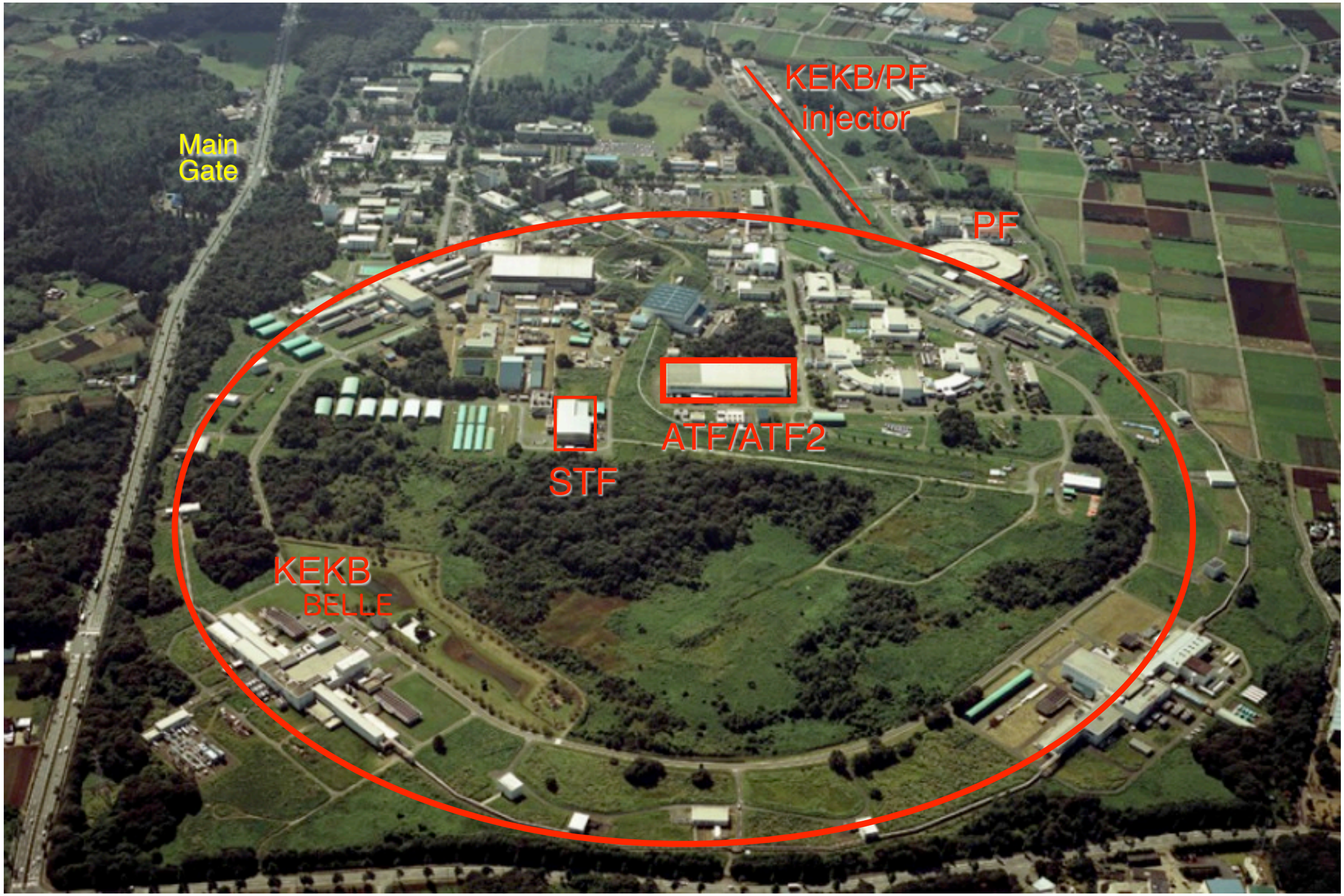
ATF2 Proposal Vol.2, KEK Report 2005-9

ATF home page : http://atf.kek.jp/

with 110 authors (25 research institutes around the world)

KEK High Energy Accelerator Research Organization

in Tsukuba site, Japan



ATF International Collaboration

CERN
DESY
IN2P3
- LAL
- LAPP
- LLR

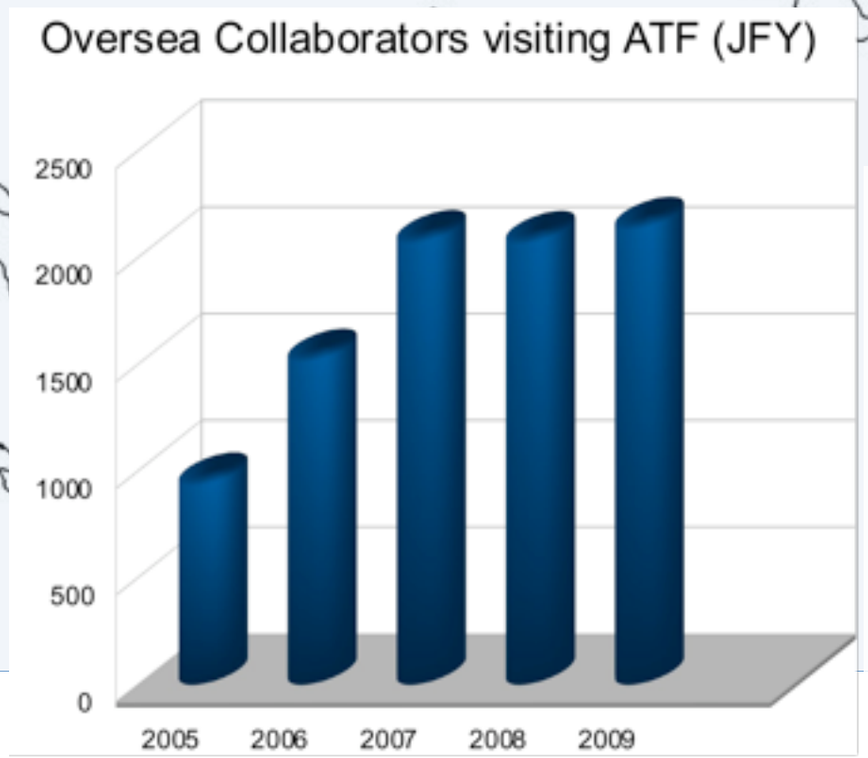
John Adams Inst.
- Oxford Univ.
- Royal Holloway Univ.

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.



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

ATF2 : Goal - I

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

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

Publication of First Results by May 2009

in PR-STAB 13, 042801 (2010)

PHYSICAL REVIEW SPECIAL TOPICS - ACCELERATORS AND BEAMS **13**, 042801 (2010)

Present status and first results of the final focus beam line at the KEK Accelerator Test Facility

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(ATF Collaboration)

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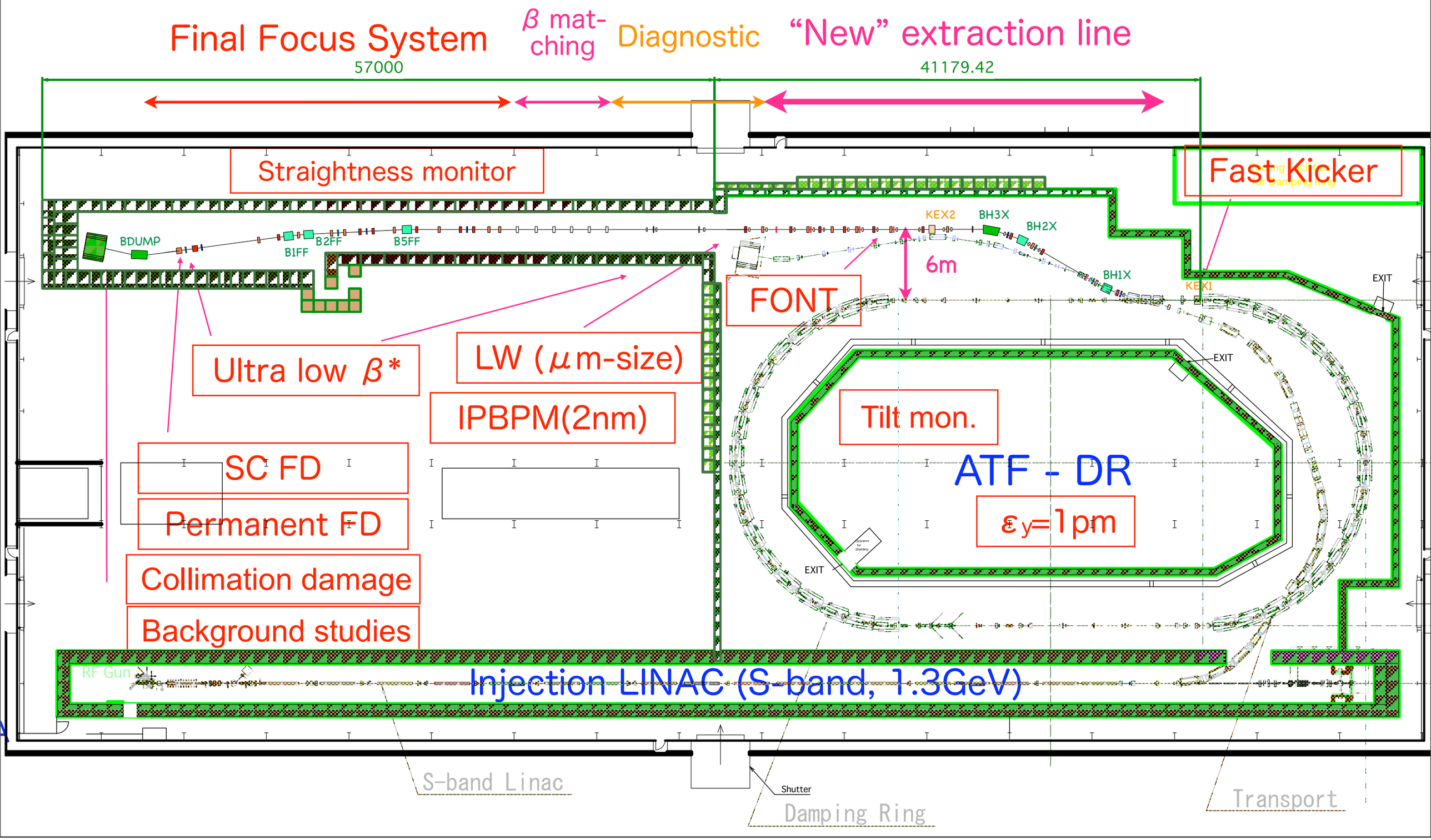
(Received 1 November 2009; published 21 April 2010)

ATF2 is a final-focus test beam line which aims to focus the low emittance beam from the ATF damping ring to a vertical size of about 37 nm and to demonstrate nanometer level beam stability. Several advanced beam diagnostics and feedback tools are used. In December 2008, construction and installation were completed and beam commissioning started, supported by an international team of Asian, European, and U.S. scientists. The present status and first results are described.

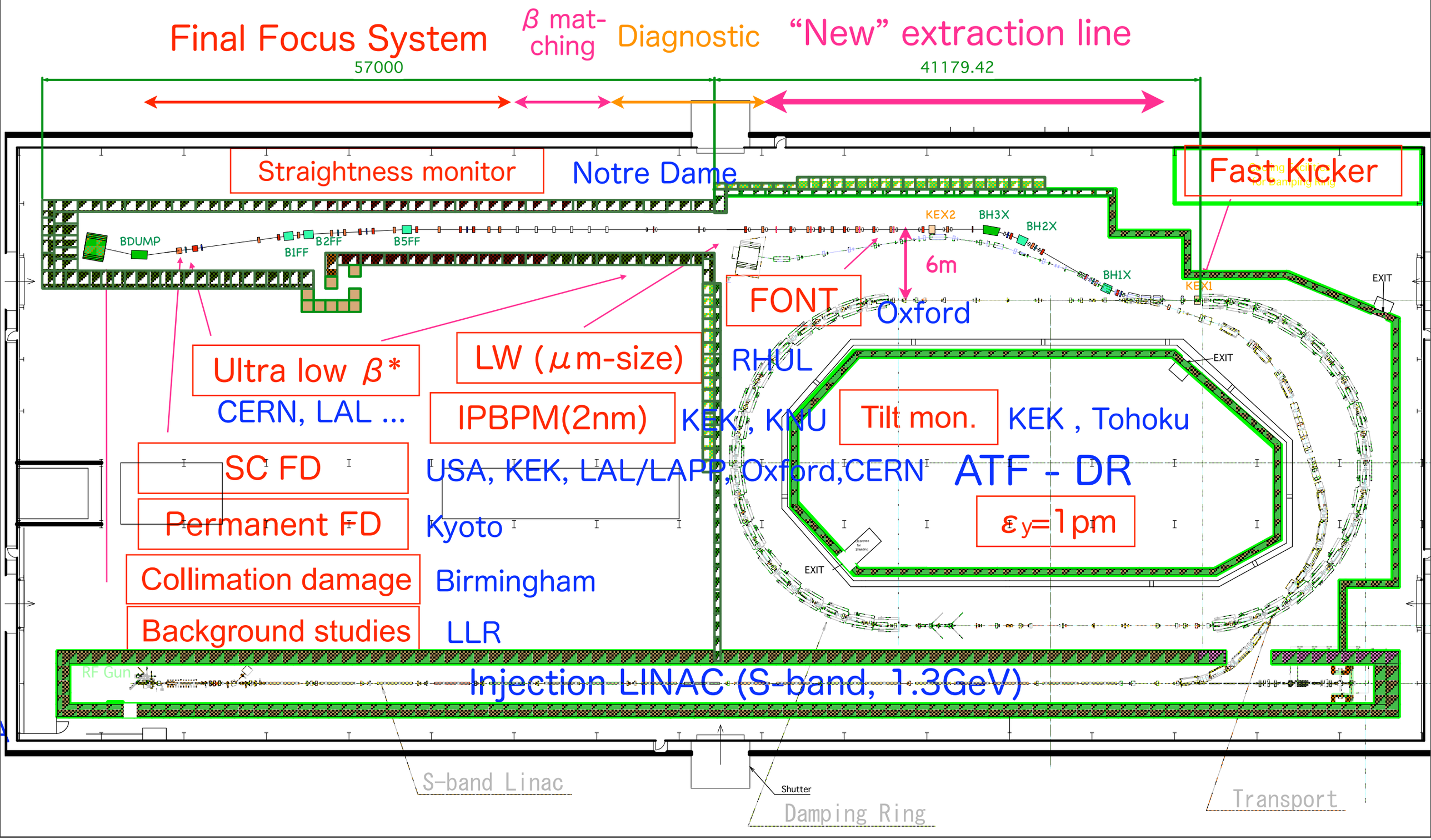
ATF2 beam line and planned/proposed R&Ds

2008 - 2010 - 2012 (- 2014 - ?)

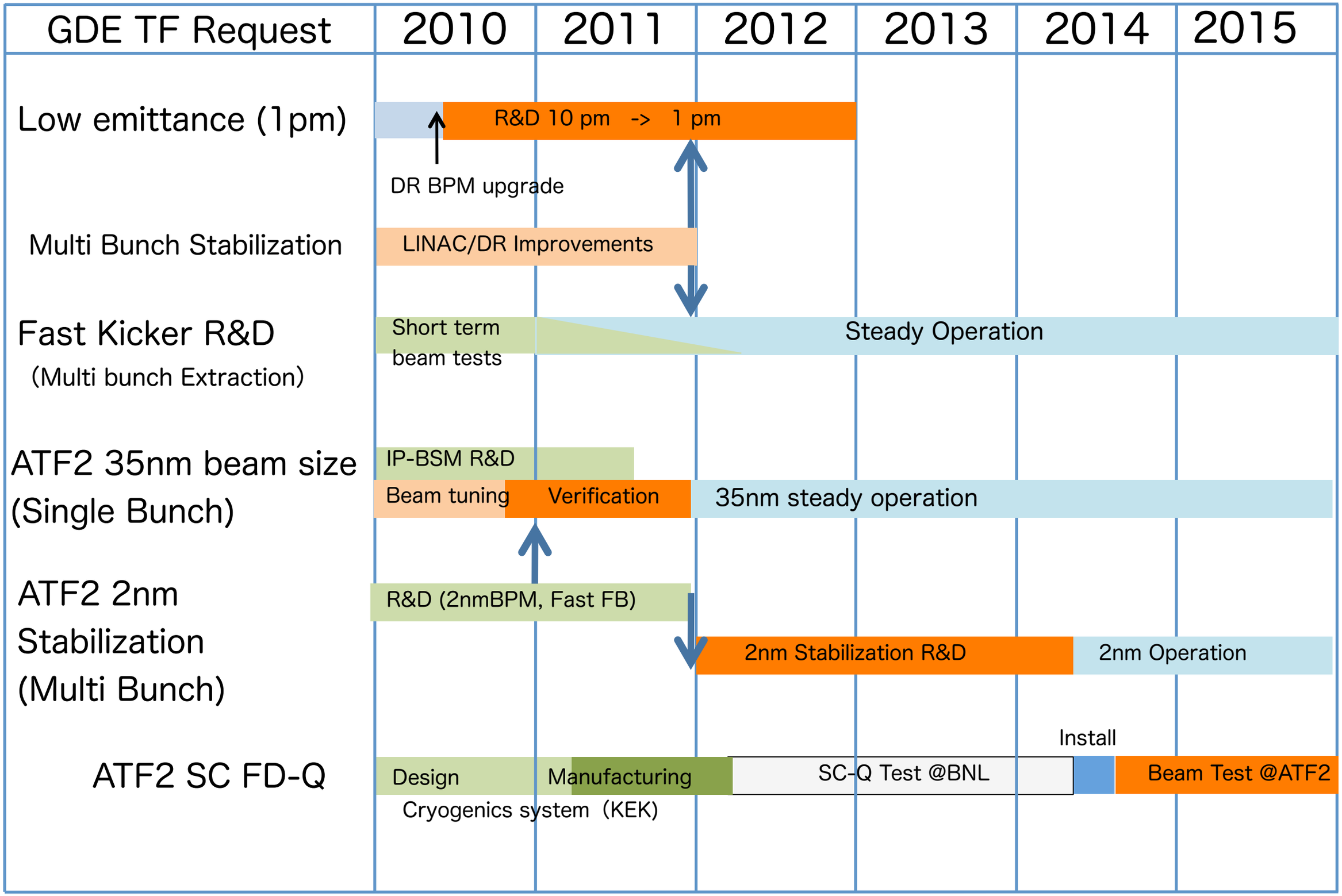


ATF2 beam line and planned/proposed R&Ds

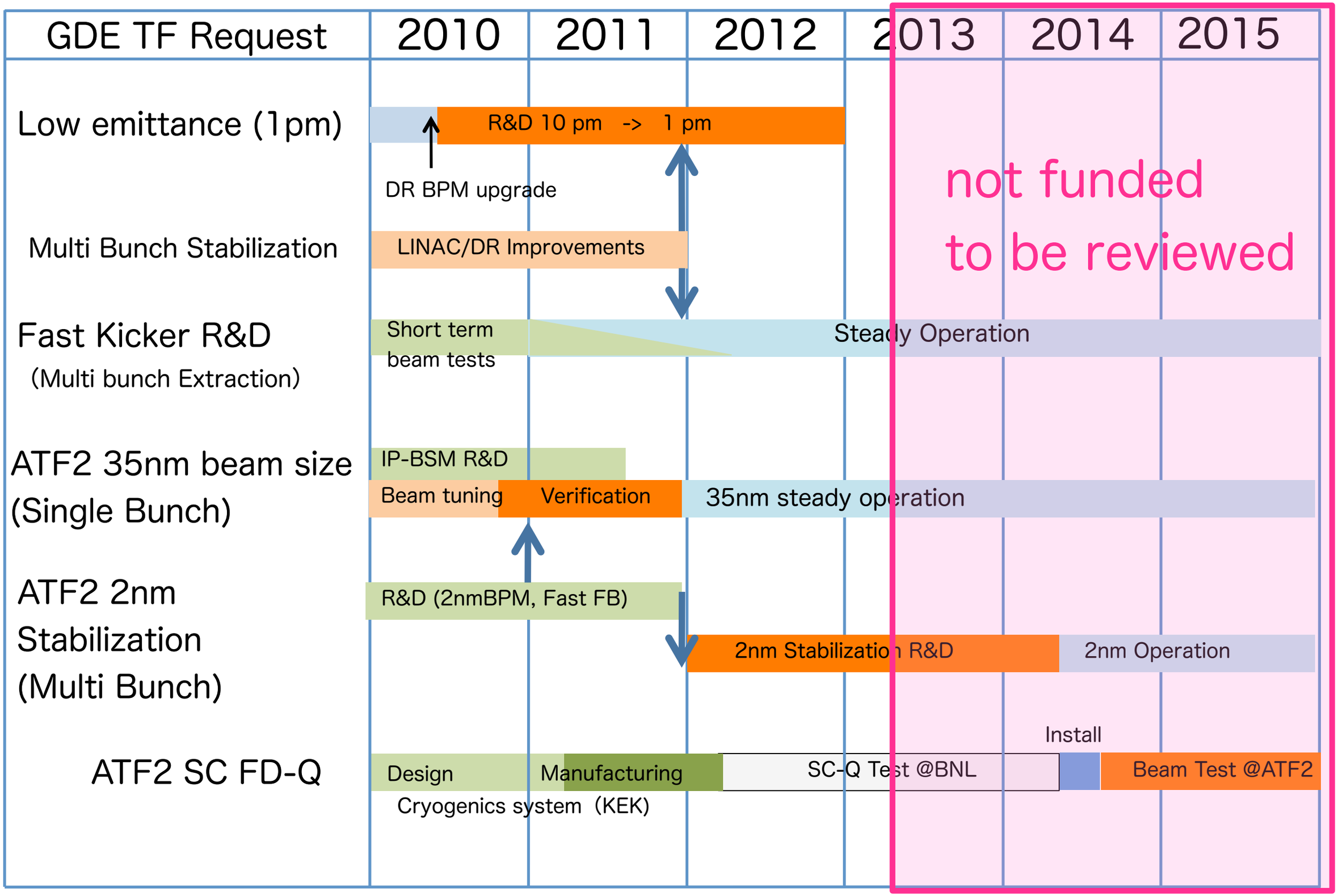
2008 - 2010 - 2012 (- 2014 - ?)



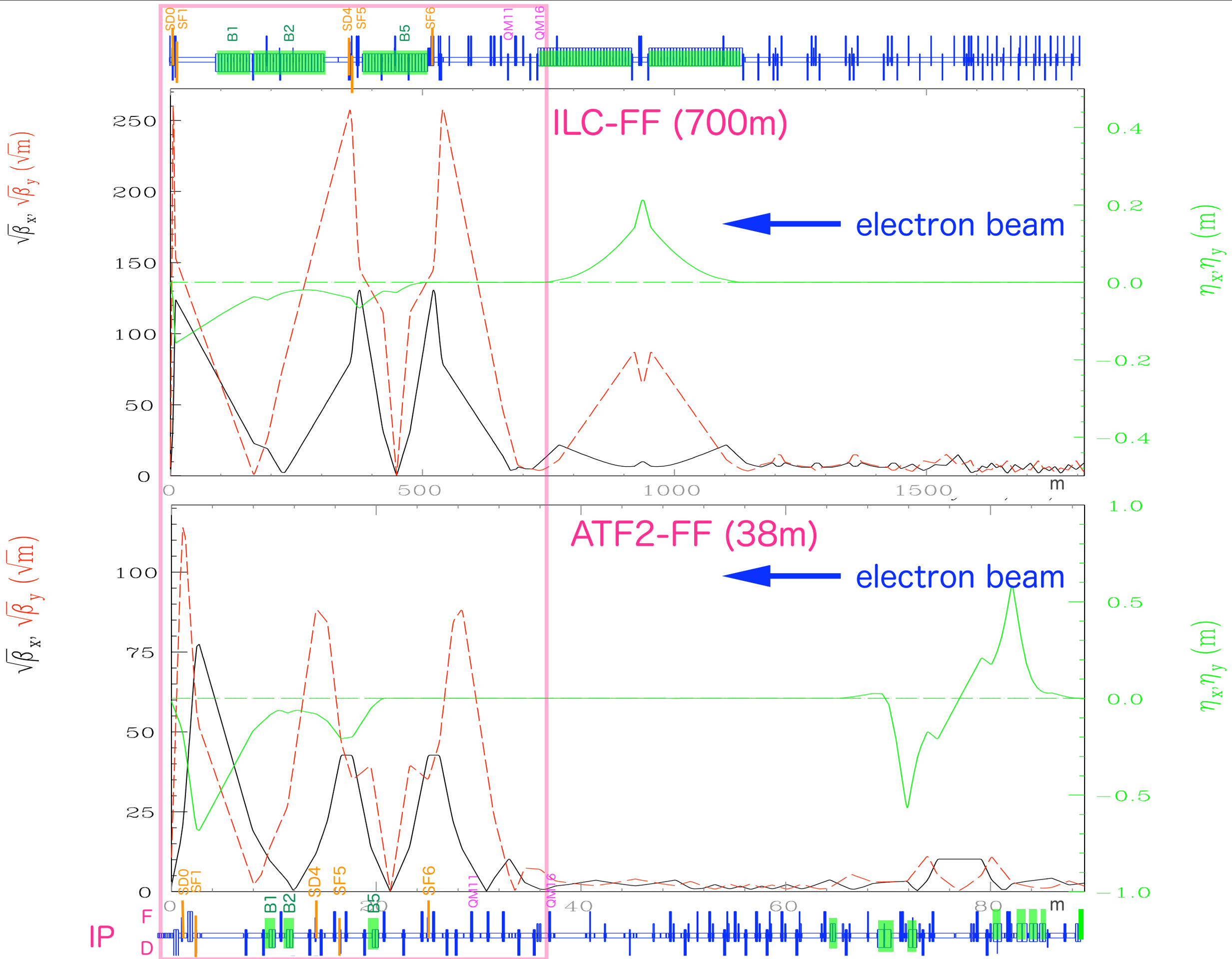
ATF long term plan

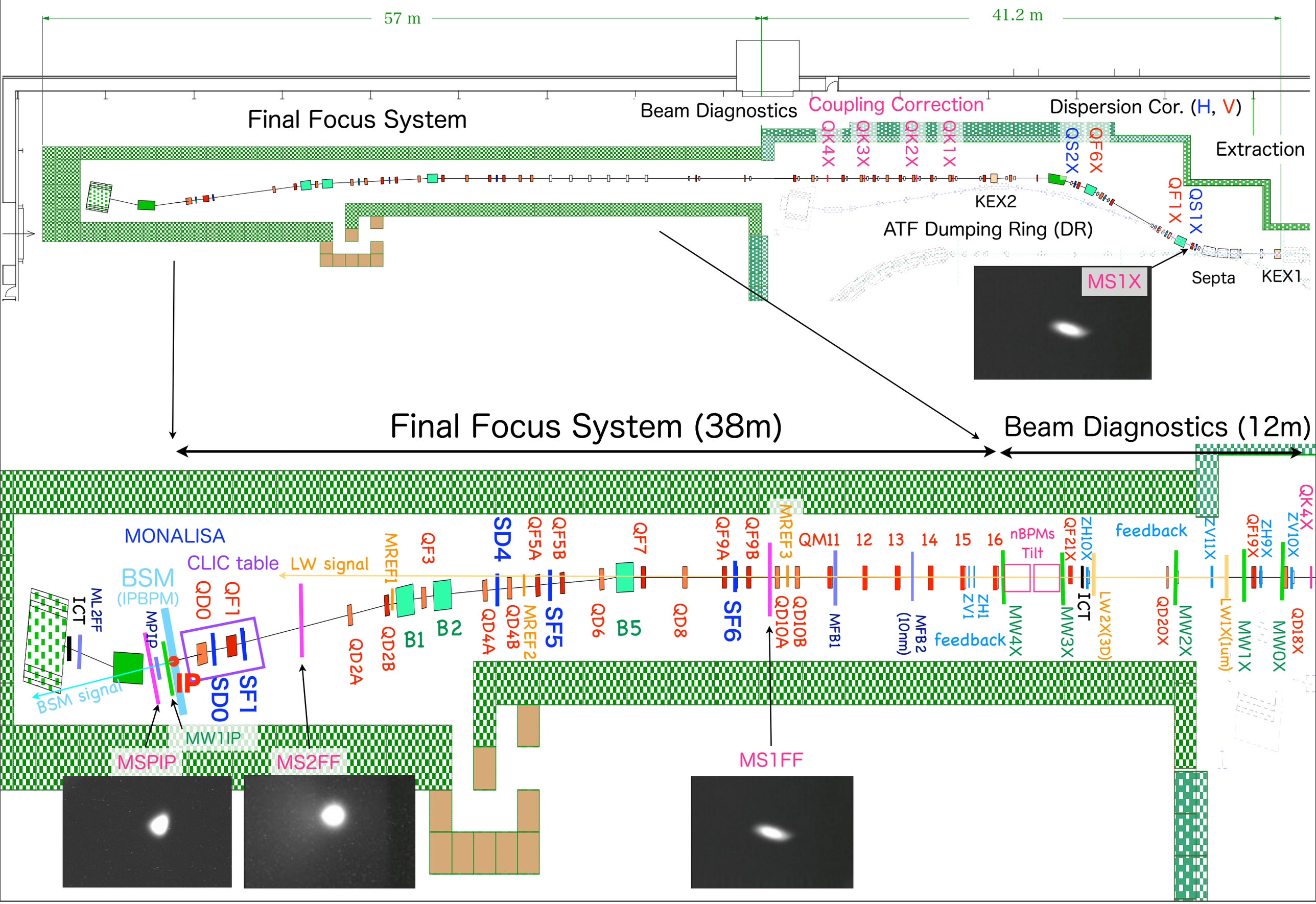


ATF long term plan



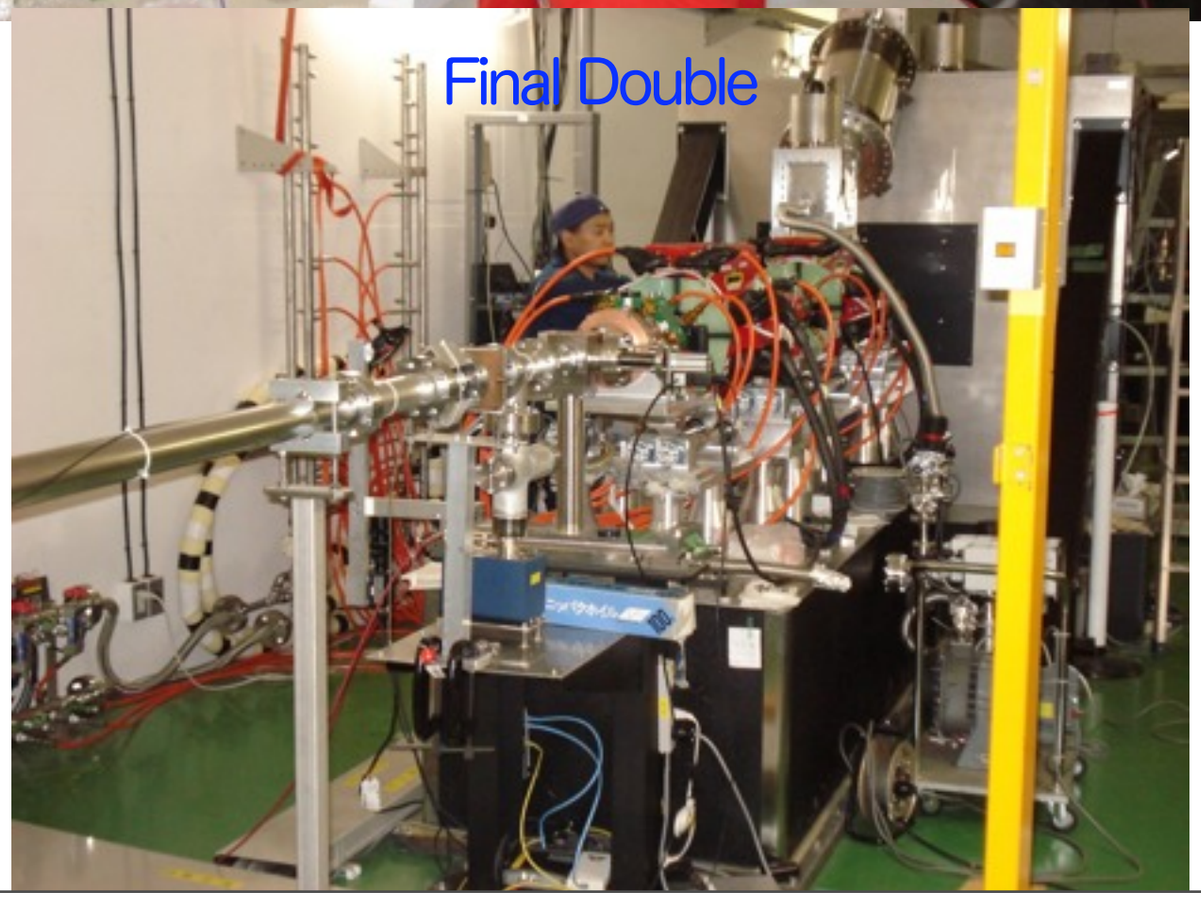
Parameters	unit	ATF2	ILC	CLIC	S-KEKB (LER/HER)
Beam Energy	GeV	1.3	250	3000	4/7
L*	m	1	3.5-4.5	3.5	0.47/1.3
$\gamma\varepsilon_x$	m-rad	5×10^{-6}	1×10^{-5}	6.6×10^{-7}	$2.5/3.3\times10^{-5}$
ε_x	nm	2	1.0 (DR)	0.1 (DR)	3.2/2.4
$\gamma\varepsilon_y$	m-rad	3×10^{-8}	4×10^{-8}	2×10^{-8}	$1.0/1.2\times10^{-7}$
ε_y	pm	12	2(DR)	1(DR)	13/8.4
β^*_x	mm	4 (8)	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(4.0)	0.655	0.039	10.2/7.8
σ^*_y	nm	37	5.7	0.7	59/59


SD0
SF1
B1
B2
SD4
SF5
B5
SF6
QM11
QM16
ILC-FF (700m)
electron beam
$\sqrt{\beta_x}, \sqrt{\beta_y}\ (\sqrt{m})$
$\eta_x, \eta_y\ (m)$
m
ATF2-FF (38m)
electron beam
IP
F
D


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
KEX2
ATF Dumping Ring (DR)
MS1X
Septa
KEX1
Final Focus System (38m)
Beam Diagnostics (12m)
MONALISA
CLIC table
LW signal
BSM
(IPBPM)
ML2FF
ICT
MPIP
QD0
QF1
IP
SD0
SF1
BSM signal
MW1IP
MSPIP
MS2FF
QD2A
MREF1
QD2B
QF3
B1
B2
SD4
QD4A
QD4B
MREF2
QF5A
SF5
QF5B
QD6
QF7
B5
QD8
QF9A
SF6
QF9B
MREF3
QD10A
QD10B
QM11
MFB1
12
13
MFB2
(10mm)
14
15
ZH1
ZV1
16
nBPMs
Tilt
MW4X
feedback
QF21X
MW3X
ZH10X
ICT
LW2X(3D)
QD20X
MW2X
feedback
ZV11X
LW1X(1um)
QF19X
MW1X
ZH9X
ZV10X
MWOX
QD18X
QK4X
MS1FF


IP

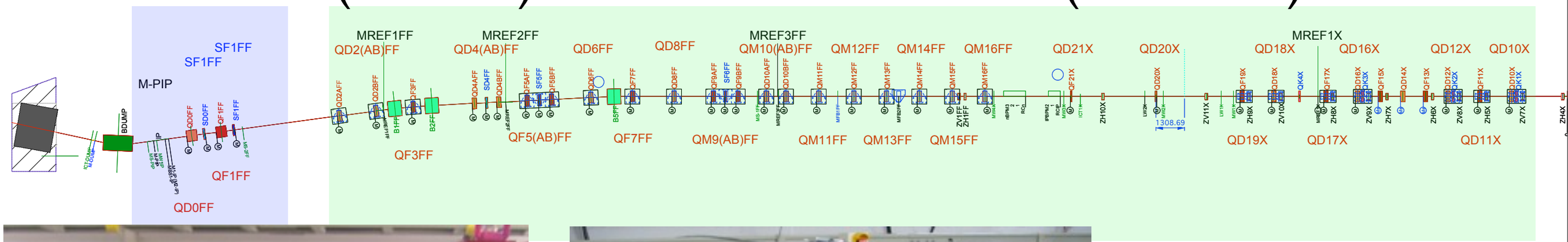

Shintake
Monitor
IP

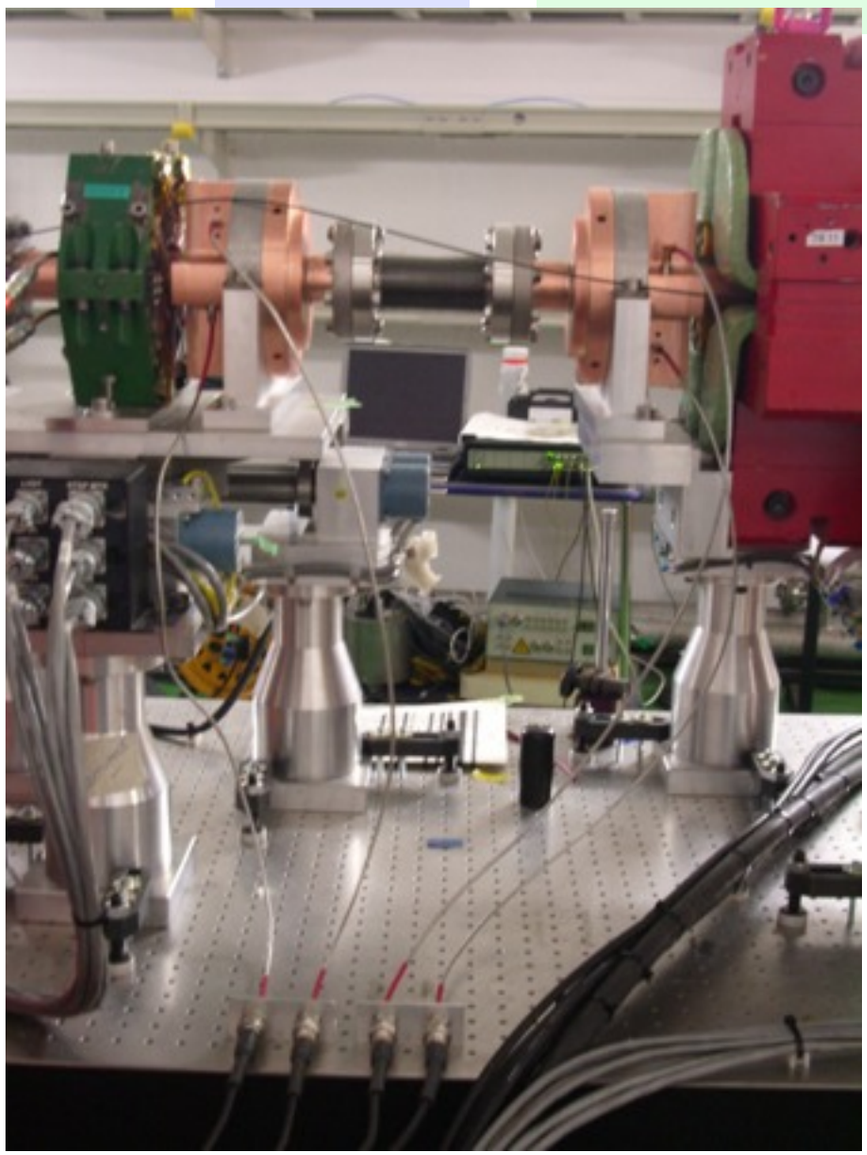

Final Double

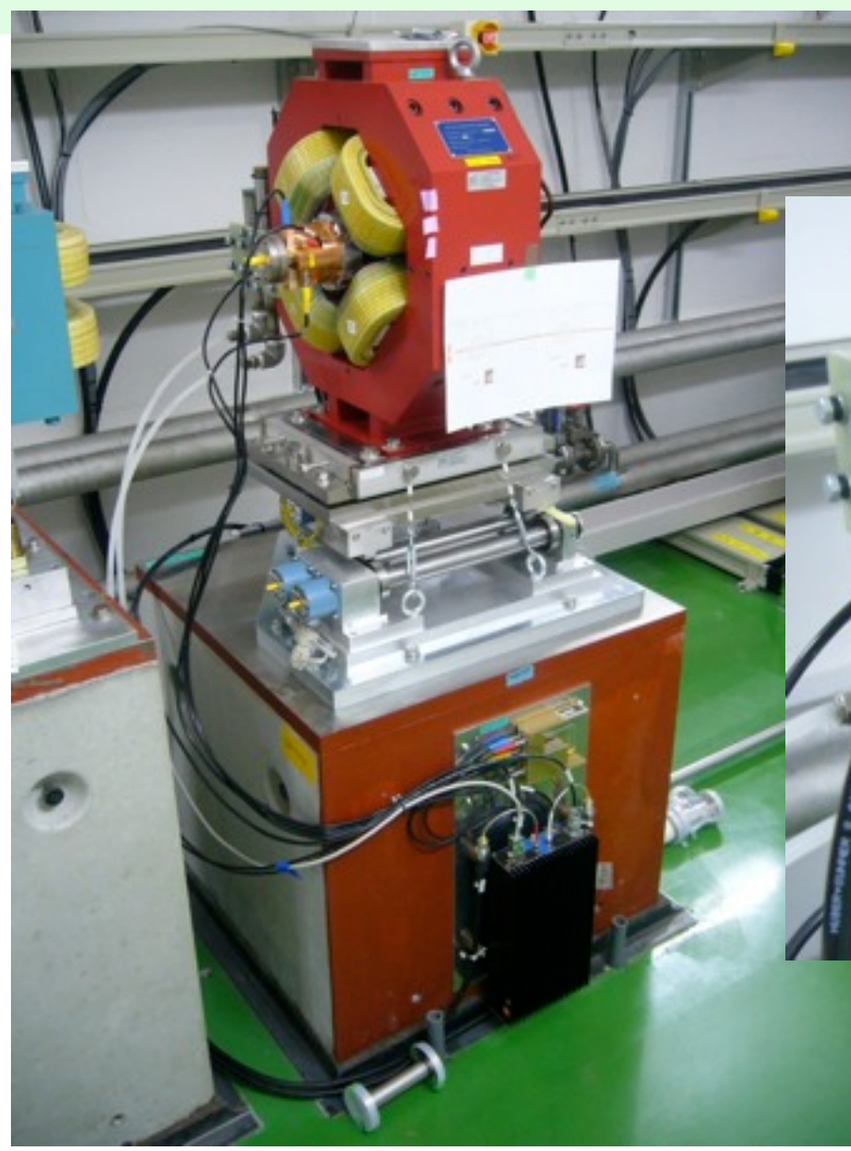
ATF2 BPM layout

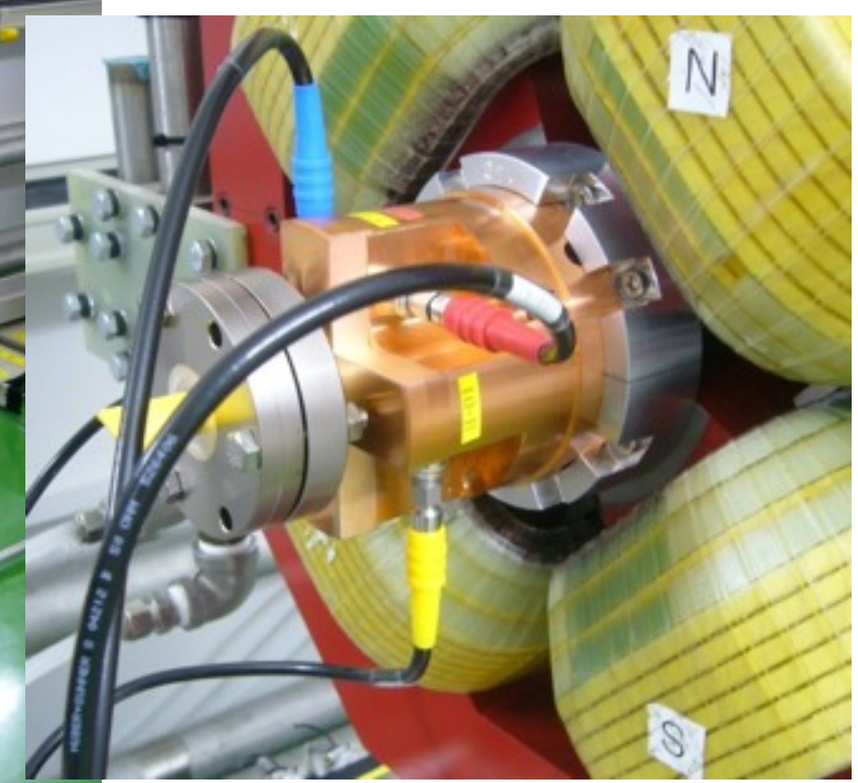
S-Band BPMs (4+1 ref.)

C-Band BPMs (33+4 ref.)

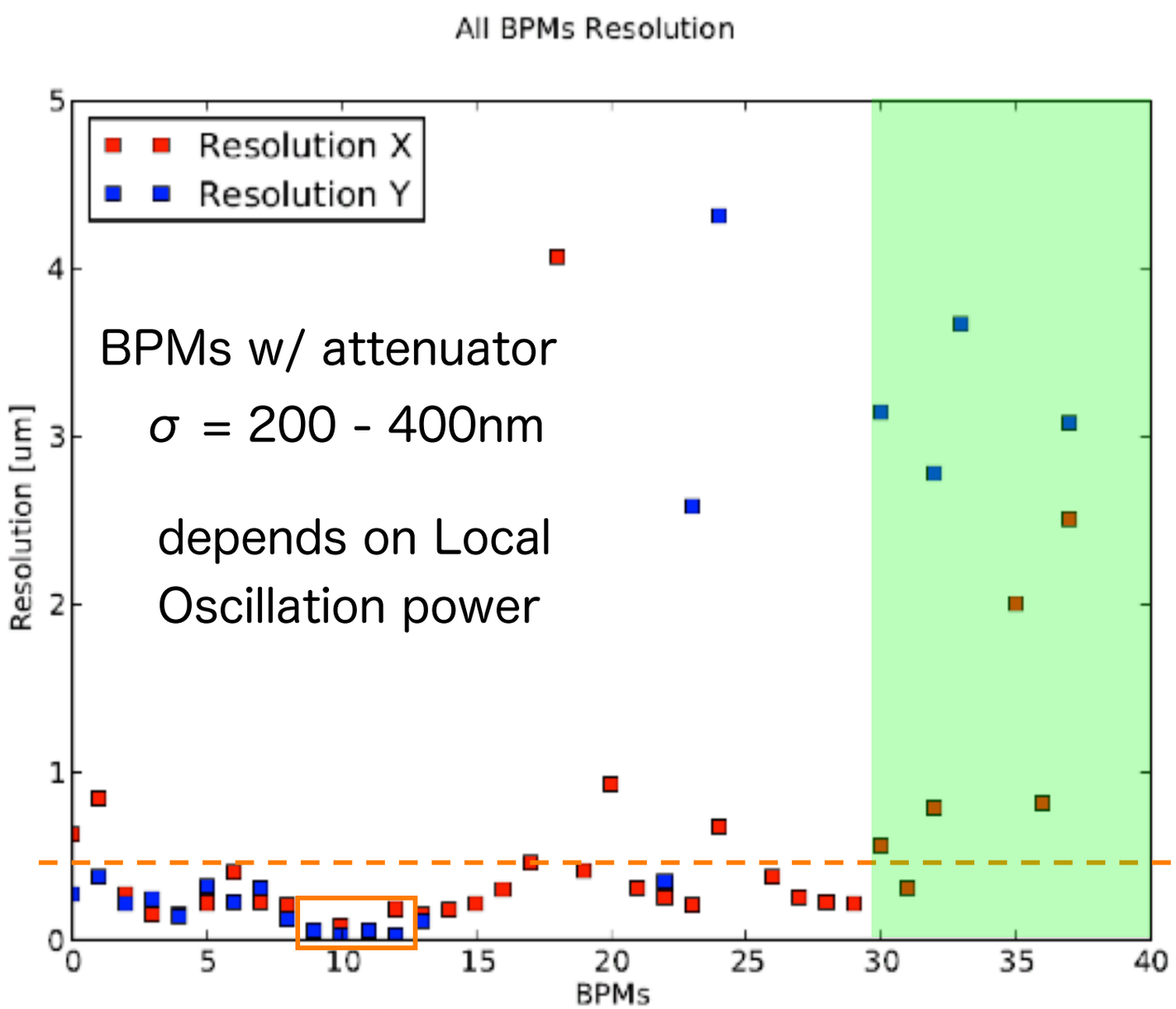




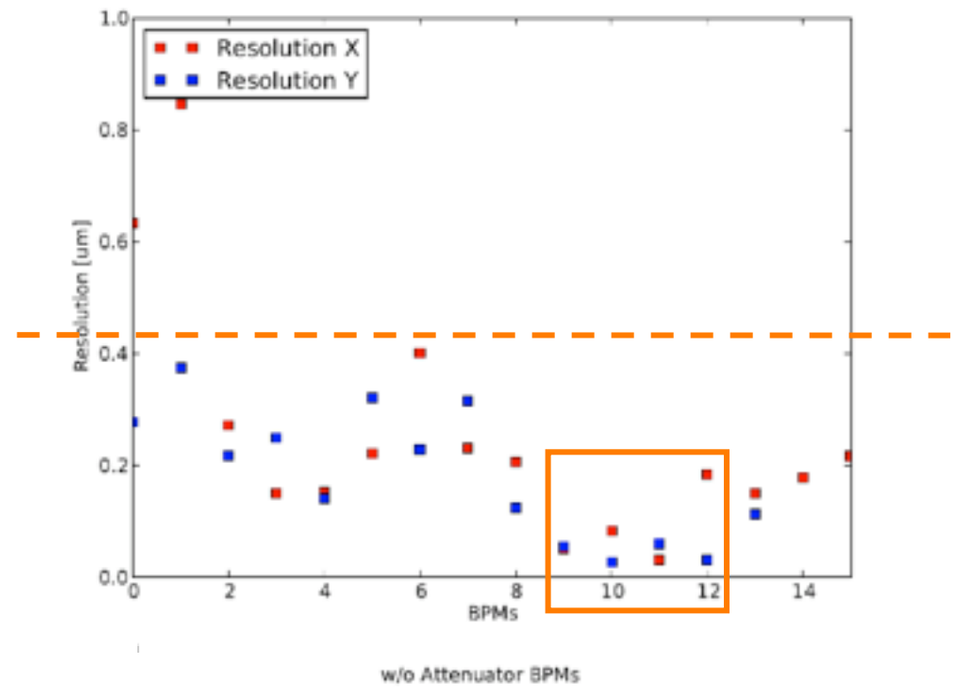


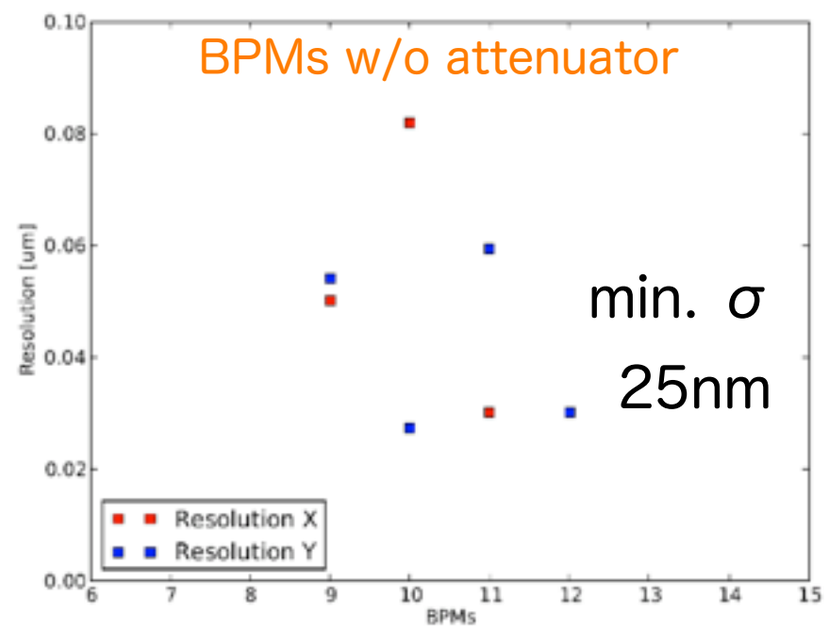


All BPM Resolution Determination



BPMs
w/o attenuator





bluekyi83@knu.ac.kr

Results of Continuous Run

for a week of 17-21 May, 2010

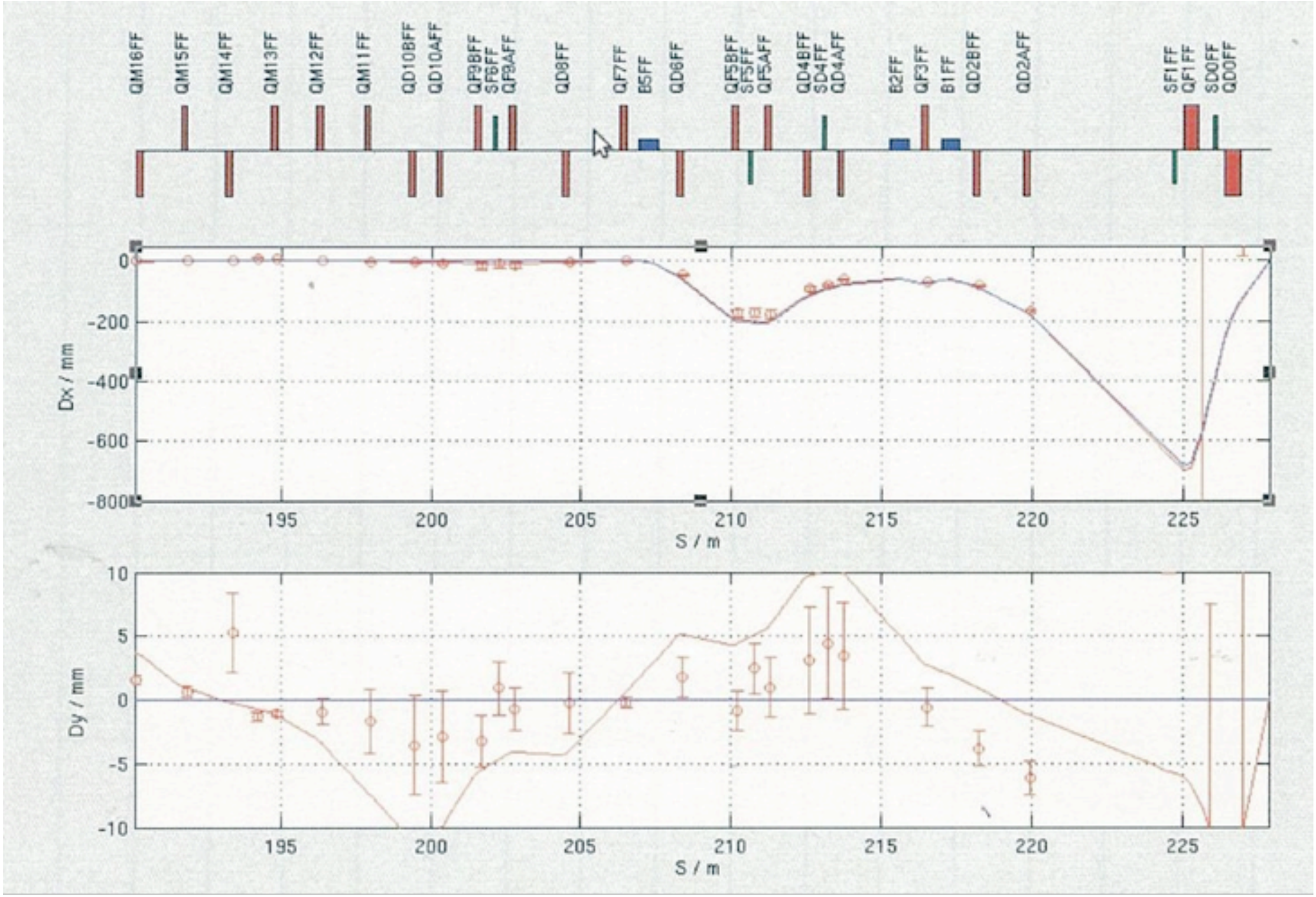
Purpose : to tune the beam size as small as possible

Optics : 10 times $\beta^*_{x,y}$: σ^*_y=110nm for ε_y=12pm

Tuning Tasks (comments)

1. Startup
2. DR tuning - COD, dispersion, coupling corrections ...
3. EXT & FFS C-band BPM calibration
4. FFS S-band BPM calibration
5. Initial EXT & FFS setup
6. EXT dispersion measurement and correction (x & y)
7. EXT Twiss + emittance calculation at IEX match point (x & y)
8. EXT coupling correction : not needed in this time
9. IPBSM preparation
10. Horizontal IP diagnostics (IP wire scanner) : -0.7% smaller QF1 strength for Dx
11. Horizontal IP re-matching (if required)
12. Vertical IP diagnostics (IP wire scanner) : +5 mrad roll of QF1 for coupling
13. Vertical re-matching (if required)
14. FFS Model diagnostics (if required)
15. IP multiknob tuning with IPBSM vertical beam size mode : 3 iterations
16. IPBSM study : confirmed σ_y minimum at the setting points of 5 sextupoles

Results of dispersion correction



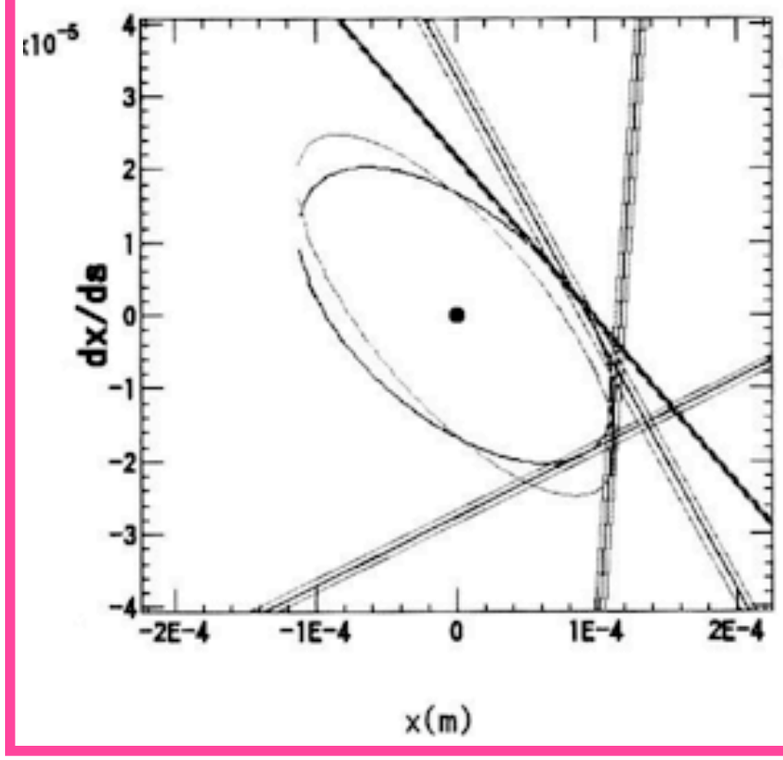
EXT

$\varepsilon_x = 1.9^{+0.5}_{-0.8}$ nm

$\varepsilon_y = 13^{+1}_{-2}$ pm

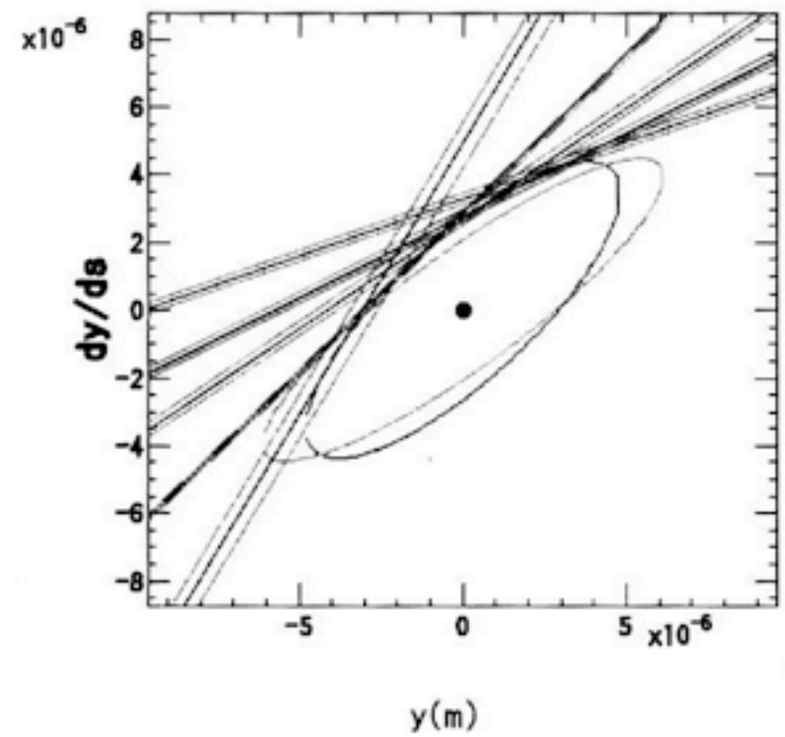
05/18/2010 04:43:39 K.Kubo

emittanceX 1.884 + .053 - .079 (nm)

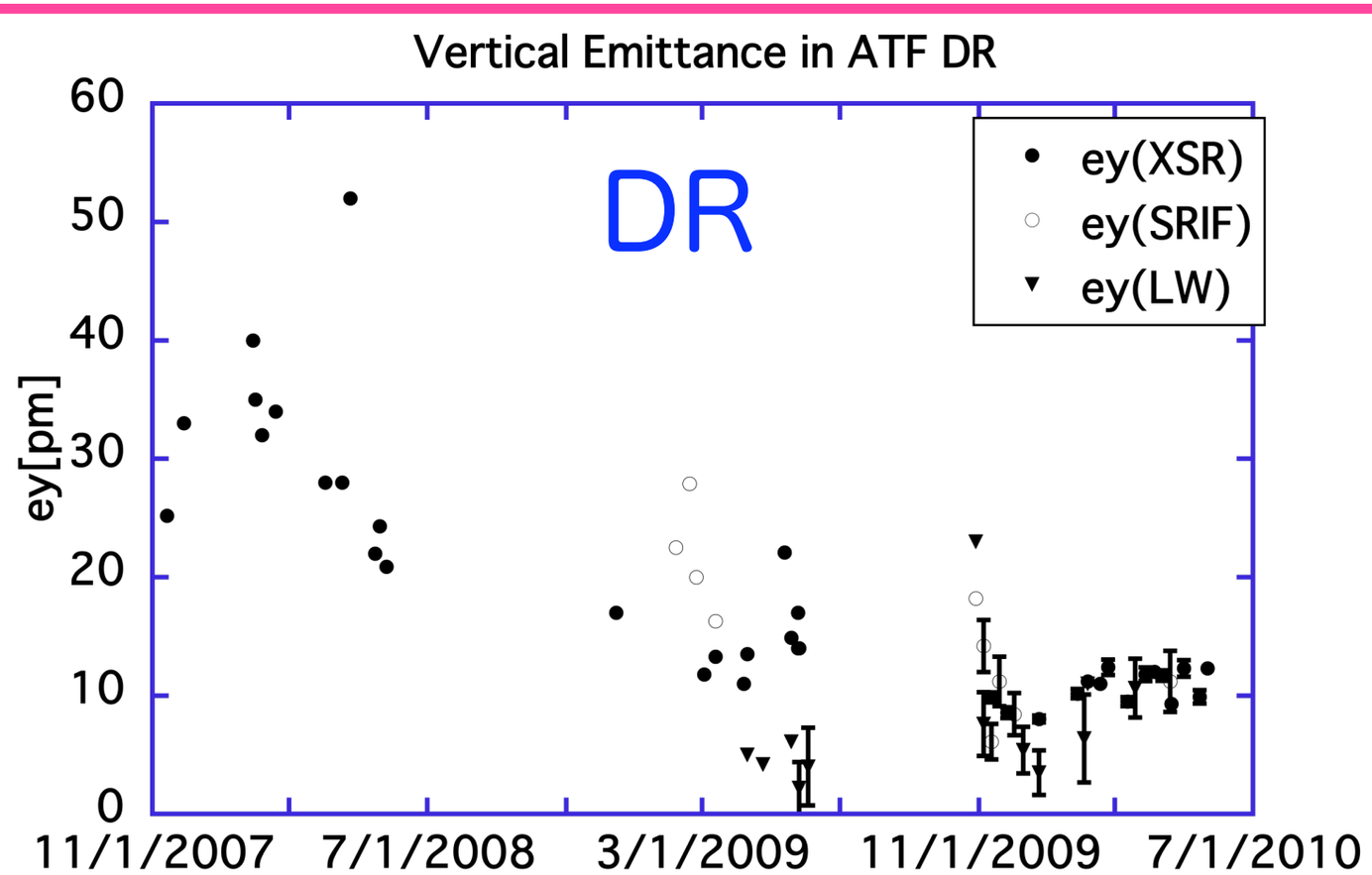


alphaX	at IEX	.680
betaX	at IEX	6.700(m)
alphaX	at MW1X	1.147
betaX	at MW1X	8.371(m)
alphaX	at MW2X	.262
betaX	at MW2X	3.861(m)
alphaX	at MW3X	2.570
betaX	at MW3X	17.136(m)
alphaX	at MW4X	1.150
betaX	at MW4X	5.235(m)
BmagX		1.084

emittanceY .013 + .001 - .002 (nm)



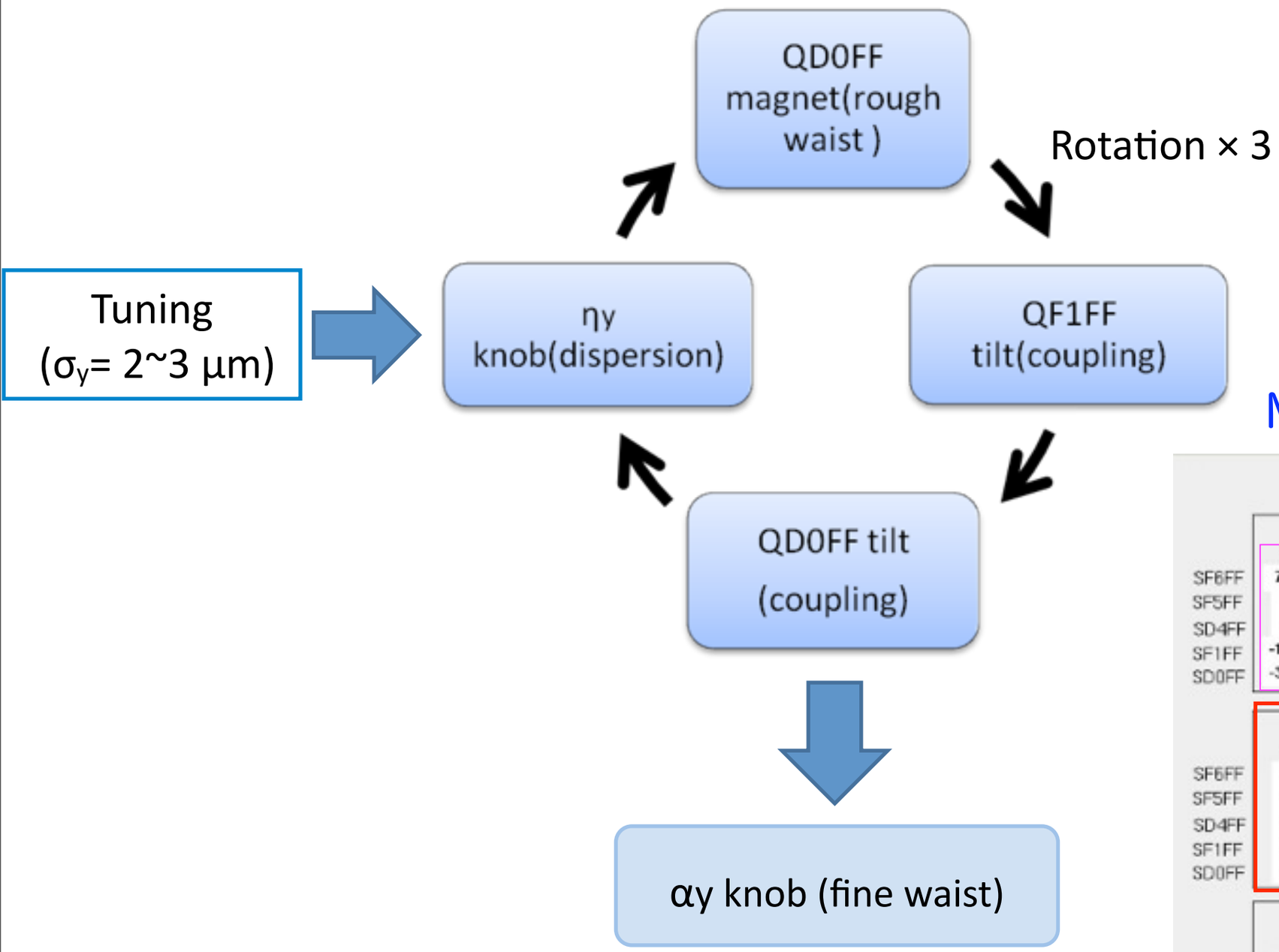
alphaY	at IEX	-1.314
betaY	at IEX	1.816(m)
alphaY	at MW0X	3.350
betaY	at MW0X	11.033(m)
alphaY	at MW1X	-1.528
betaY	at MW1X	6.384(m)
alphaY	at MW2X	-3.199
betaY	at MW2X	21.508(m)
alphaY	at MW3X	-.048
betaY	at MW3X	4.138(m)
alphaY	at MW4X	-.823
betaY	at MW4X	6.927(m)
BmagY		1.137



$\varepsilon_y = 10$ pm

IPBSM Beam Size Tuning scheme

(tested multi-knob, 16 April, 2010)



Multi-knob by 5 Sextupoles

used

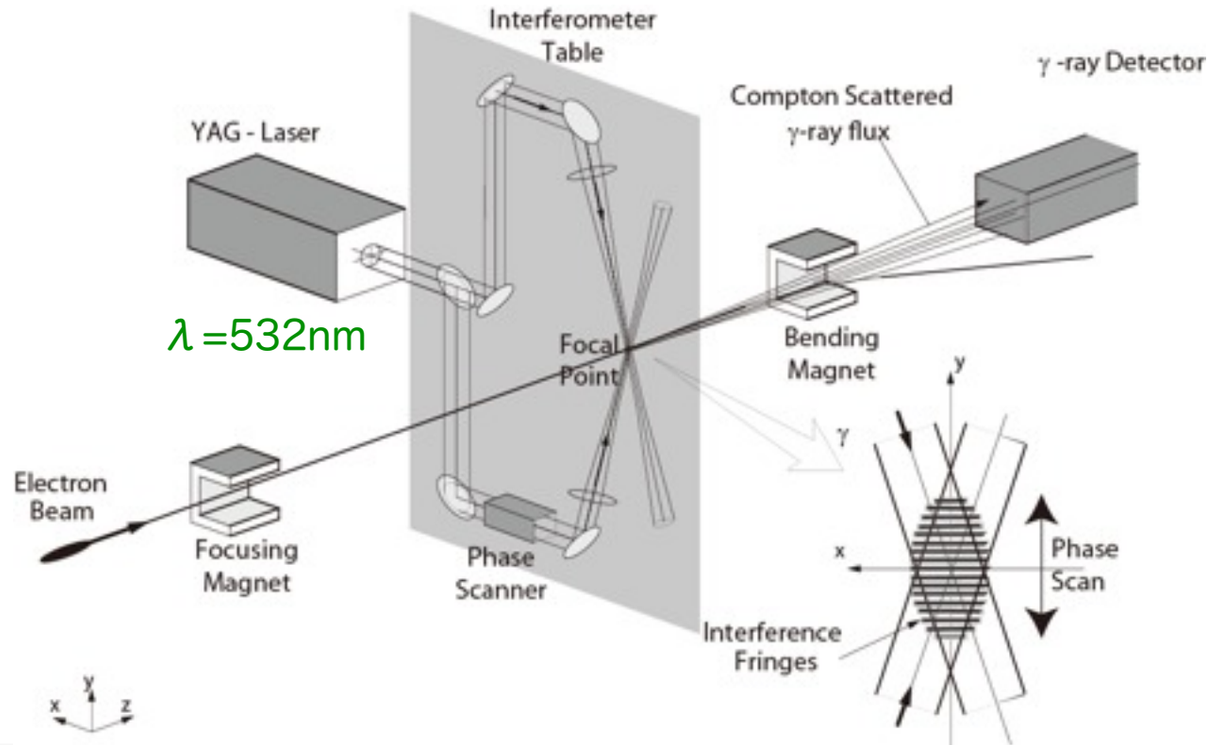
Multi-knob Definition Panel

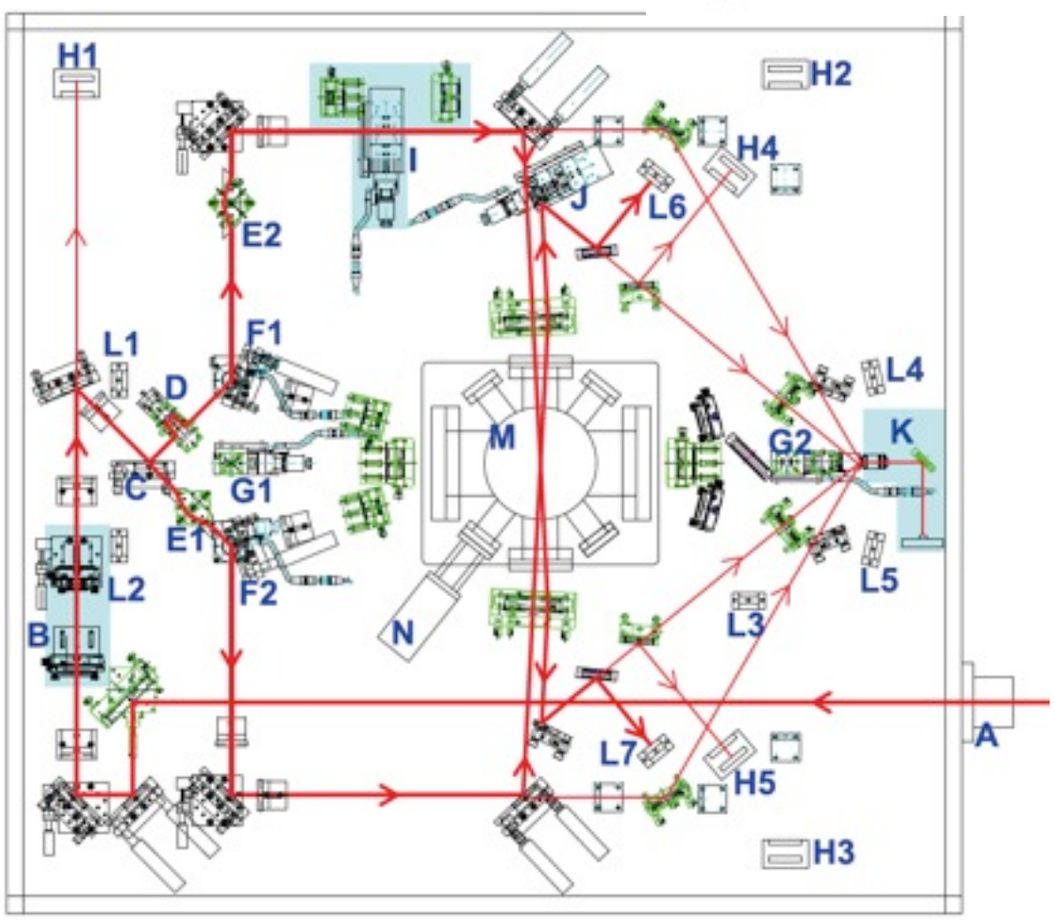
	Ax			Ex			Ay		
	x	y	tilt	x	y	tilt	x	y	tilt
SF6FF	700.0	0.0	0.0	95.0	0.0	0.0	0.0	0.0	0.0
SF5FF	0.0	0.0	0.0	-175.0	0.0	0.0	400.0	0.0	0.0
SD4FF	0.0	0.0	-1.0	0.0	0.0	0.0	0.0	0.0	0.0
SF1FF	-185.0	0.0	0.0	100.0	0.0	0.0	-160.0	0.0	0.0
SD0FF	-300.0	0.0	0.0	-25.0	0.0	0.0	-300.0	0.0	0.0

	Ey			Coup1			Coup2		
	x	y	tilt	x	y	tilt	x	y	tilt
SF6FF	0.0	-60.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SF5FF	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SD4FF	0.0	-300.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SF1FF	0.0	-230.0	0.0	0.0	200.0	0.0	0.0	0.0	0.0
SD0FF	0.0	300.0	0.0	0.0	0.0	0.0	0.0	200.0	0.0

	Spare1			Spare2			Spare3		
	x	y	tilt	x	y	tilt	x	y	tilt
SF6FF	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SF5FF	0.0	0.0	0.0	0.0	200.0	0.0	0.0	0.0	0.0
SD4FF	0.0	0.0	0.0	0.0	0.0	0.0	0.0	200.0	0.0
SF1FF	-160.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SD0FF	-300.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Shintake Monitor System at IP

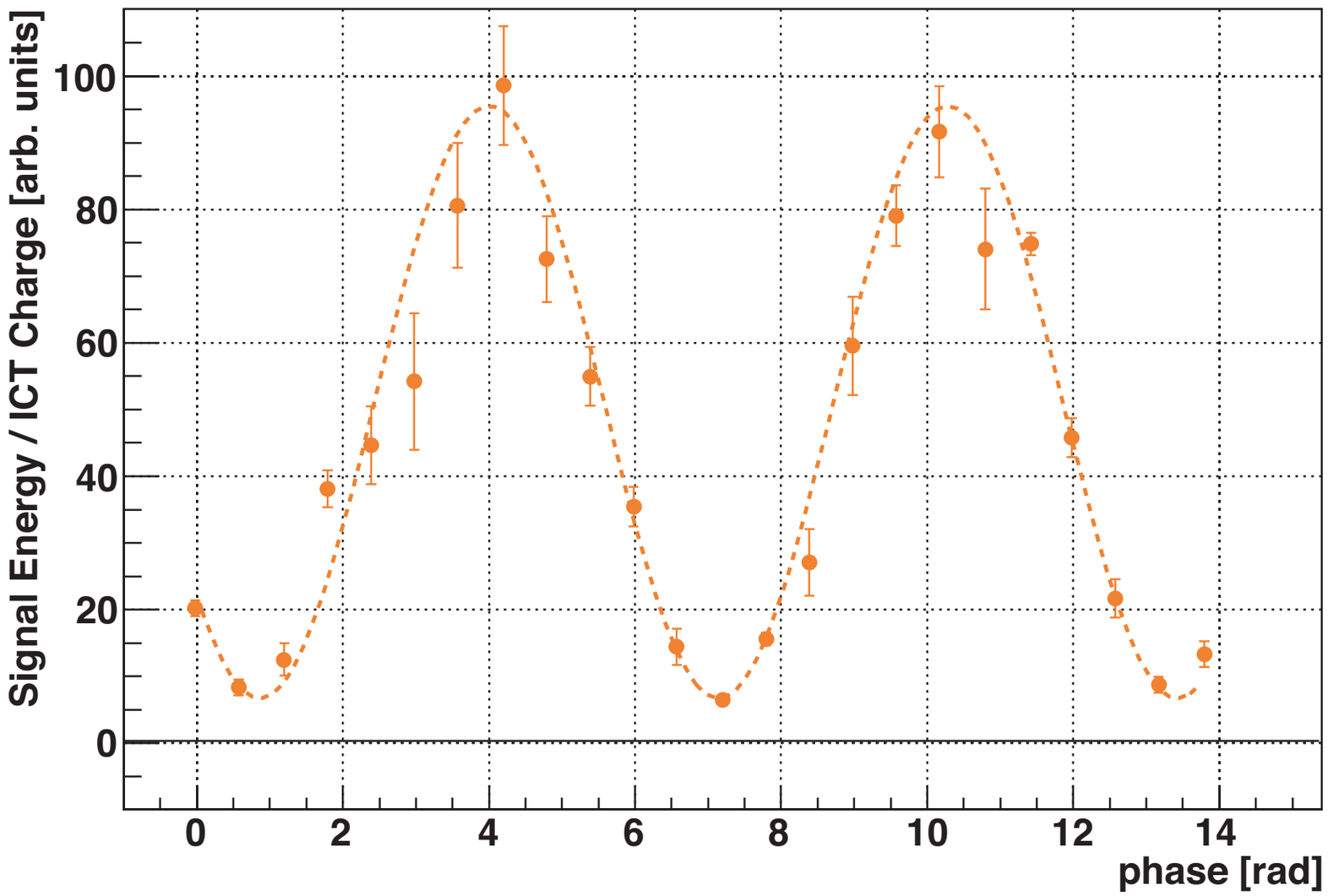




Laser path diagram (174 deg crossing angle)

The vertical optical table installed at ATF2 beam line

Shintake Monitor Best Result , 20 May 2010



Crossing angle (θ) : 8°

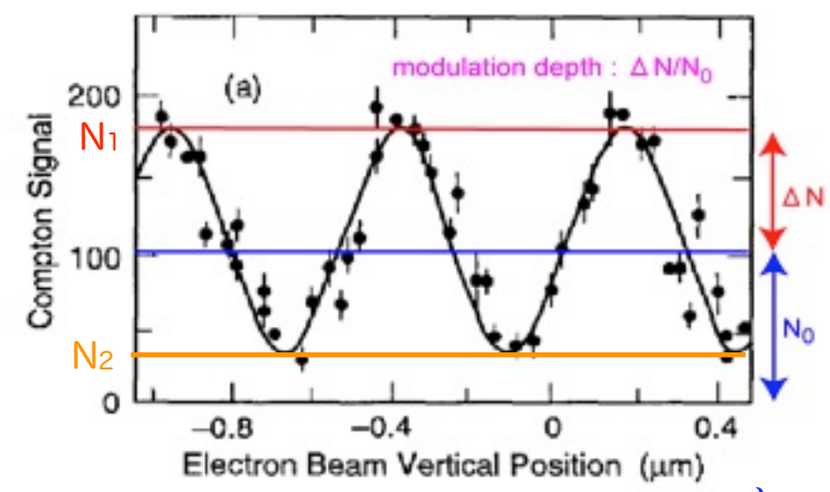
Pitch : 3.81 μm

Modulation (M) : 0.87

Beam size (σ_y) : 310 ± 30 nm

How it works as follows

$M = (N_1 - N_2)/(N_1 + N_2)$



$$\sigma_y = \frac{d}{2\pi}\sqrt{2 \cdot \ln(|\cos\theta|/M)} \qquad d = \frac{\lambda}{2 \cdot \sin\frac{\theta}{2}}$$

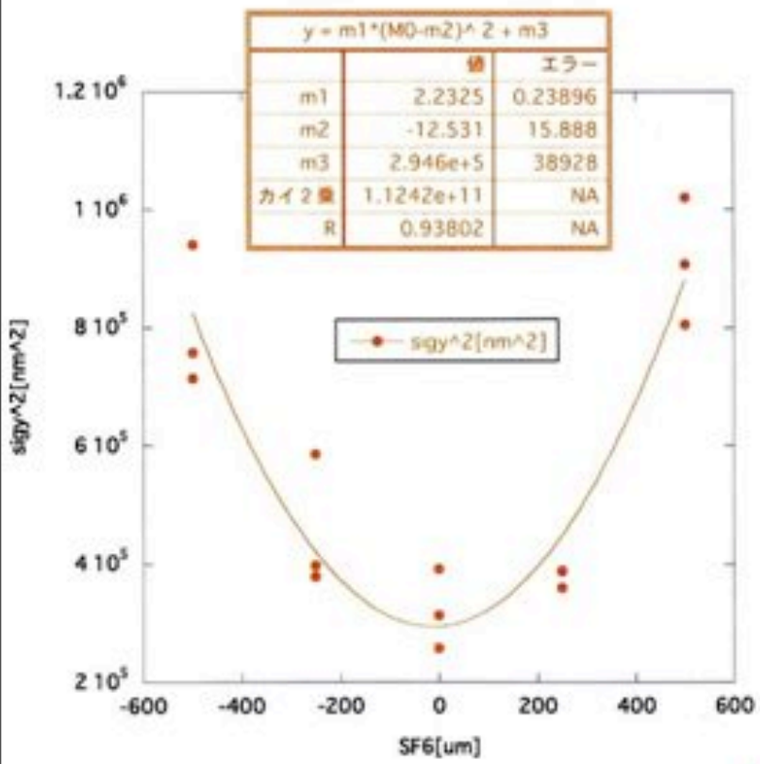
Wave length 532nm, width=8ns

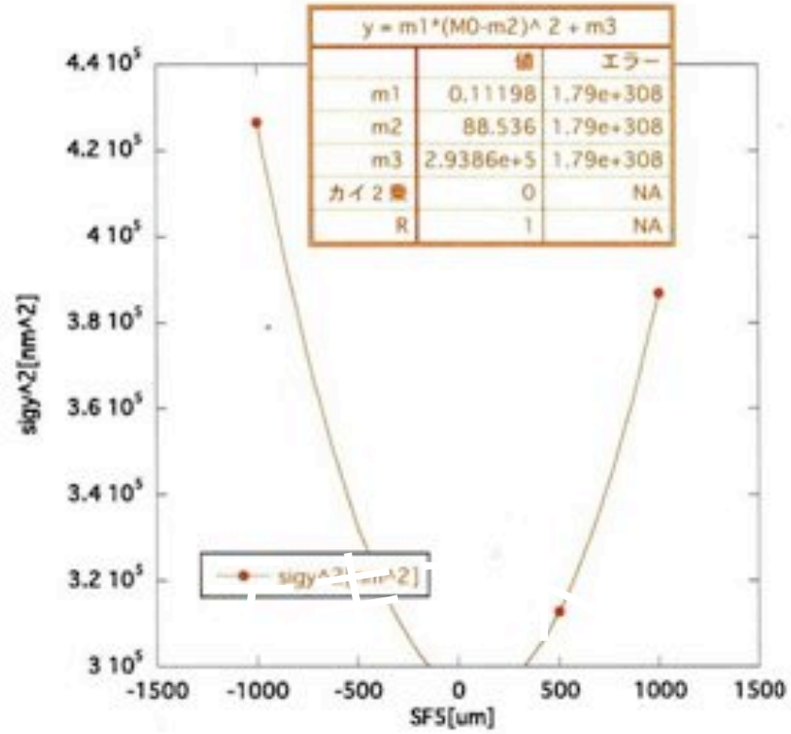
$\Delta\nu/\nu = 1.6 \times 10^{-7}$

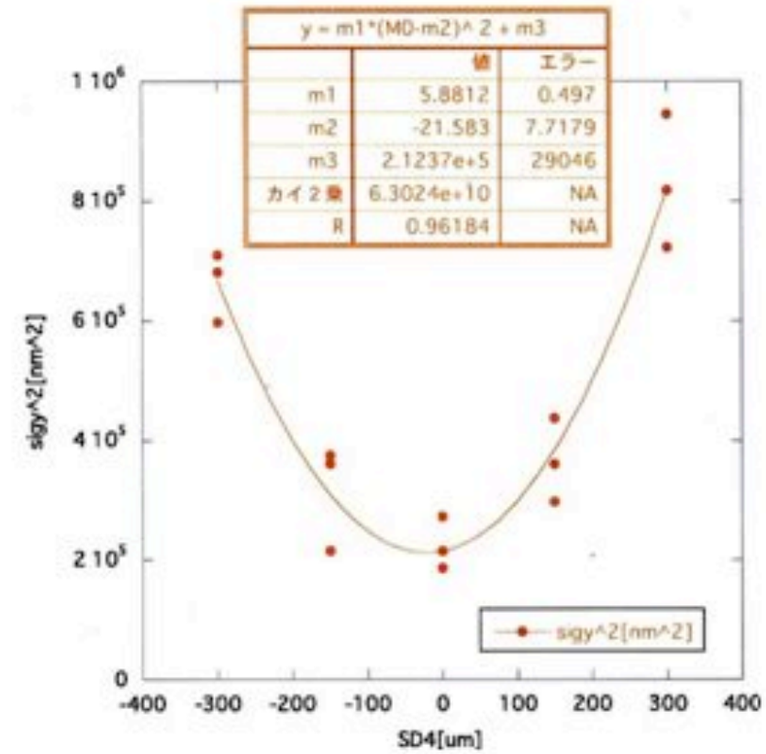
Laser intensity = 2.8×10^{13} W/cm^2

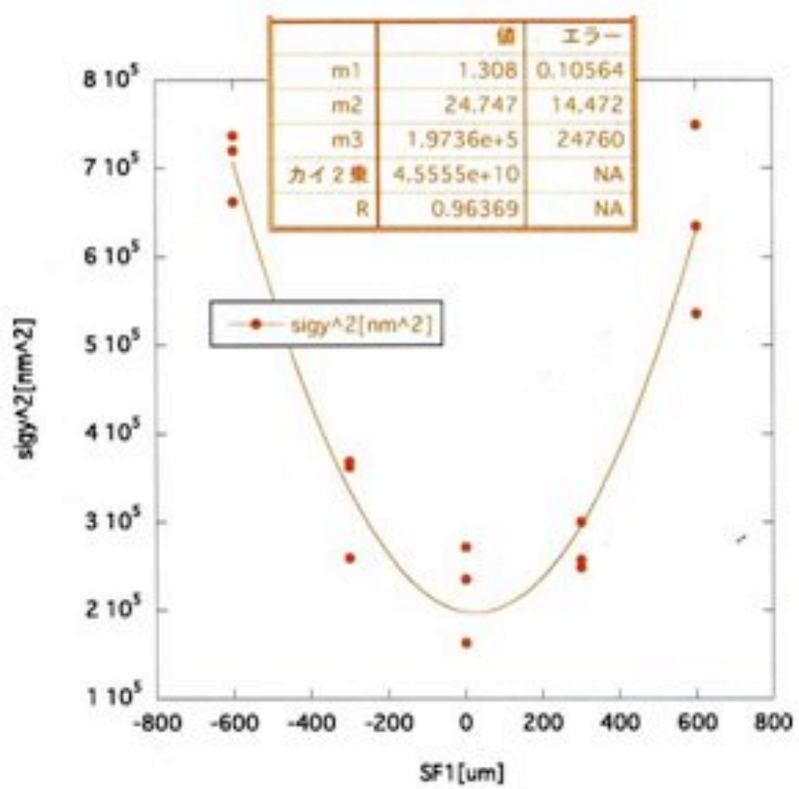
$a_0 = 1.7 \times 10^{-4}$

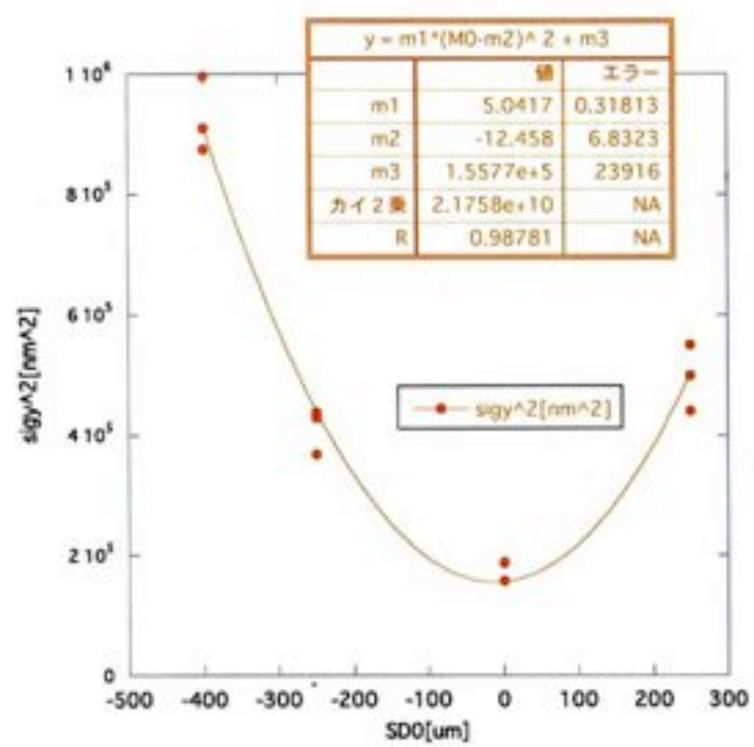
Beam sizes (σy) were minimum at setting positions of the 5 sextupoles after the multi-knob tuning.











Summary

DR vertical emittance to < 2pm as the ILC-DR

BPM electronics was upgraded after IPAC10, June 2010.

Fast kicker studies next study in October, 2010

(1) Good performance for single bunch beam, i.e. angular jitter of about 4×10^{-4}

(2) Need improvements for multi-bunch beam

for the FID pulser, BPM system, stable generation and storage in DR

R&Ds for the 2nd goal of ATF2 and ILC-BDS

(1) FONT5 : good progress, i.e. very impressive results

(2) IPBPM : tested at the upstream, wakefield effects seen,

KNU electronics will be updated at KNU.

(3) LW : installed and tested in the last run in April, 2010

(4) Multi-OTR system was installed in May, 2010.

ATF2 < 100nm and 37nm by December, 2010, and March 2011, respectively

(1) All the instruments have been commissioned; i.e. BPMs, IPBSM etc.

(2) Beam tuning knobs have been developed and were also commissioned.

(3) The continuos run was successful to achieve 300nm beam size;

Improvements during this summer, e.g. FD alignment, Shintake monitor, BPMs