ATF DR Overview

S.Kuroda (KEK)

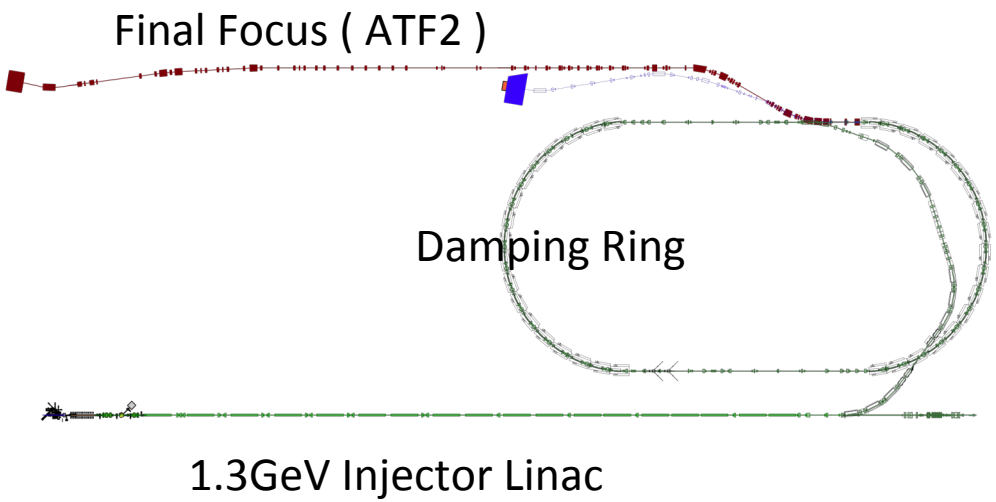
Introduction

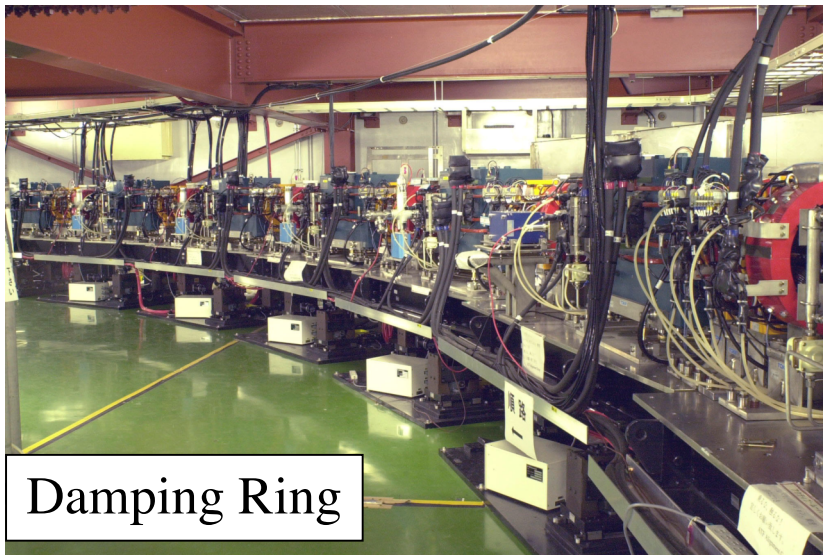
Low emittance history

Present status

GDE Review 3rd Apr.2013

Introduction





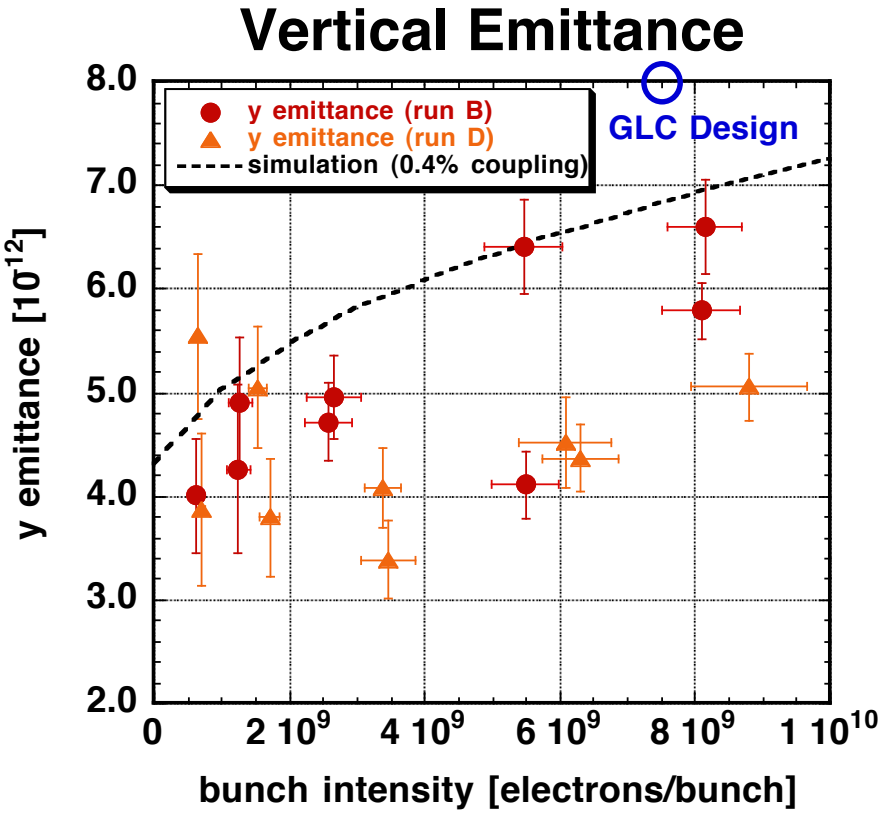
ATF History

~1990 design started
1997 beam operation started
~2000 $\varepsilon y<5pm$
2008 ATF2 commissioning

ATF DR main goal
Low emittance generation
Done in ~2000
Supply low emittance(good quality) beam to other R&D study

Emittance History in DR

- There were great efforts to achieve low vertical emittance since DR commissioning.
- From the end of 2000 to 2002, we observed very low vertical emittance in DR about 10 pm.
- After further improvement of hardware, with software and simulation works, we constantly achieved lower than 5 pm at low intensity (N →0), and lower than 8 pm at high intensity (N~1E10)., which was lower than "designed" emittance. (2003)



Emittance History in DR (2)

After this low emittance achievement

We have not really pursued lower emittance.

R&D of instrumentations were main tasks at ATF.

Emittance was as large as 20~30 pm (from 2006 ?) !!

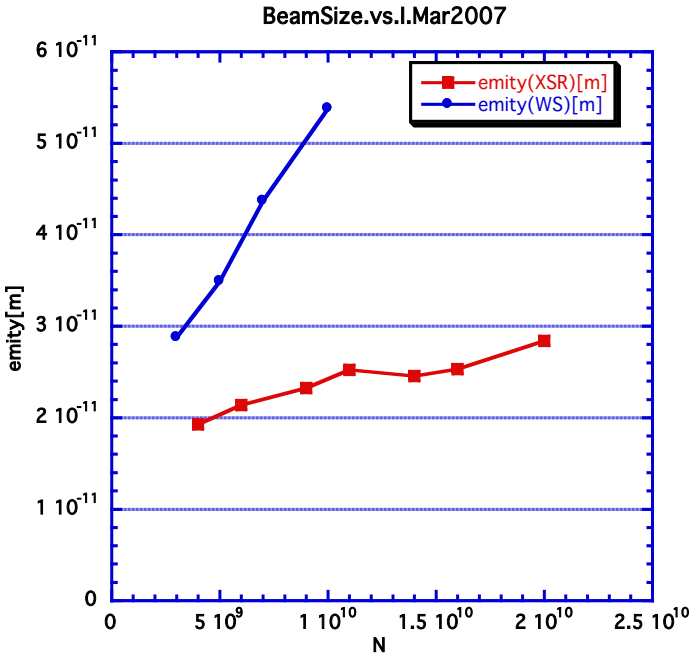
Why?

- No clear answer.

We have to make it small again

(smaller than before if possible)

- For ATF2

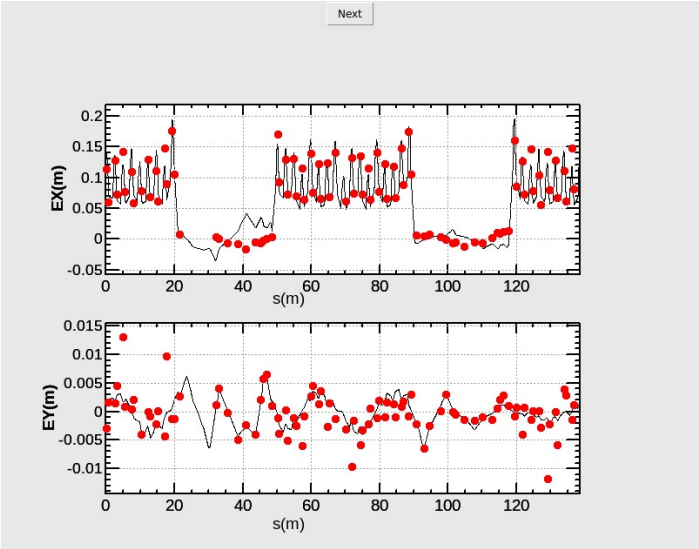


XSR meas. βx=1.69m 13Mar2007

WS meas. Δp/p=9e-4 15Mar2007

Recovery to Low Emittance in 2009

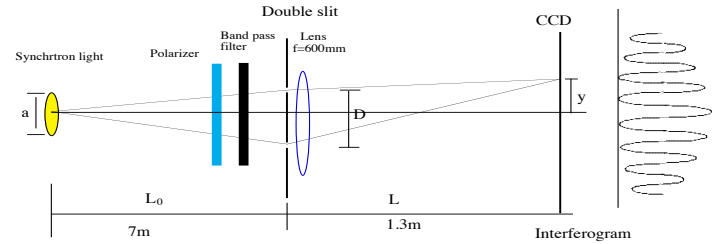
- Hardware issue
  - Re-alignment of magnets in DR
  - Introduction of electric load to correct DR main bend.
  - Beam size monitor improvement →following slides
- Start with 'design optics'
- Beam tuning method
  - β beat correction
    - Correction with QM18R.1&QM15R.2 trim.
  - Dispersion correction
    - η_x in straight section is corrected by QM trim
    - η_y is corrected by correctors
  - Coupling correction
    - Correction of vertical leakage of the horizontal kicks by a couple of horizontal correctors.
    - Correction is done by Skew Q winding trim coil of SX.

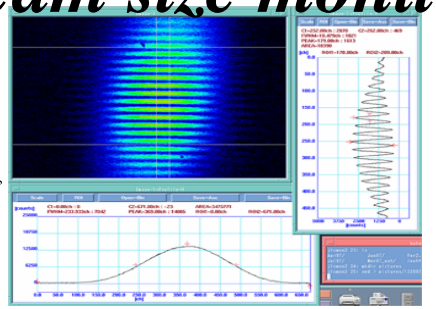


Beam Size Monitors in DR

SR interference beam size monitor

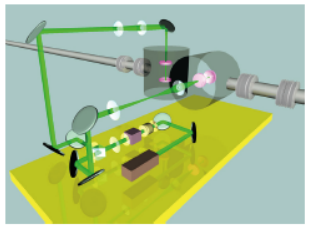
Layout of the SR-interferometer

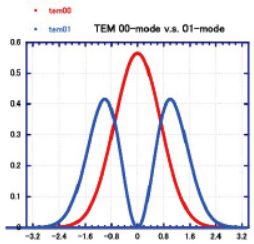


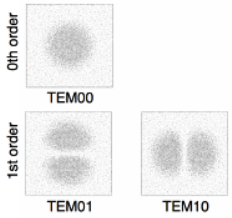


$$I = \pi a J_0\{1+\exp[-(\frac{2\pi Da}{\lambda L_0})^2]\bullet\cos(\frac{2\pi Dy}{\lambda L})\}$$

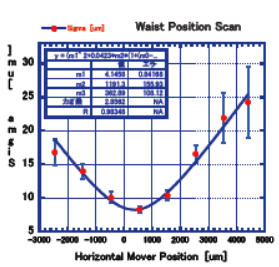
Laser wire beam size monitor in DR

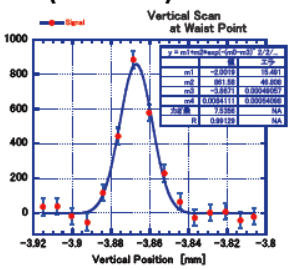






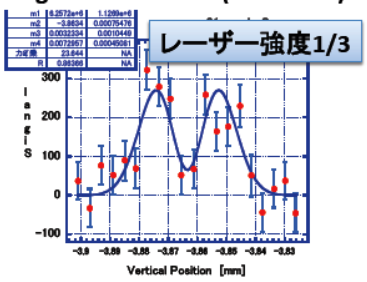
Fundamental mode(00 mode)





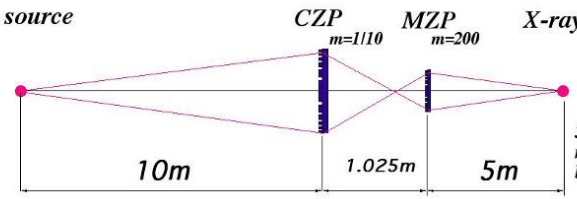
σ_e=4.1±0.8um

Higher order mode(01 mode)

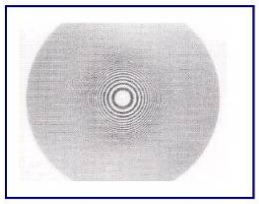


σ_e=3.2±1.0um

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



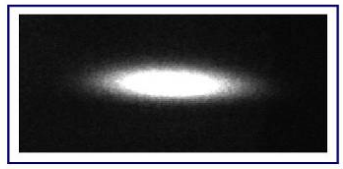
3.23KeV(0.384nm) SR
magnification 20
beam size resolution 1.87μm



microscope image of zone plate

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

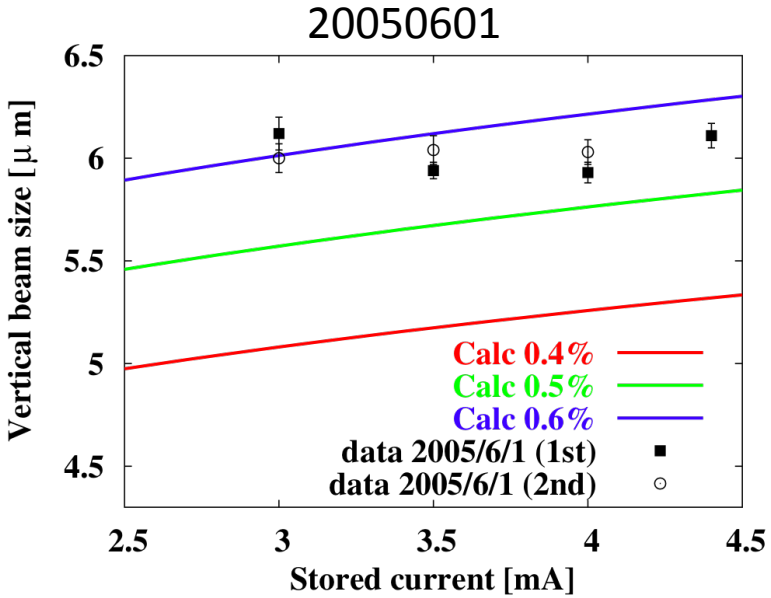
MZP : 75μm dia.
584 zone rings
minimum zone width 127nm

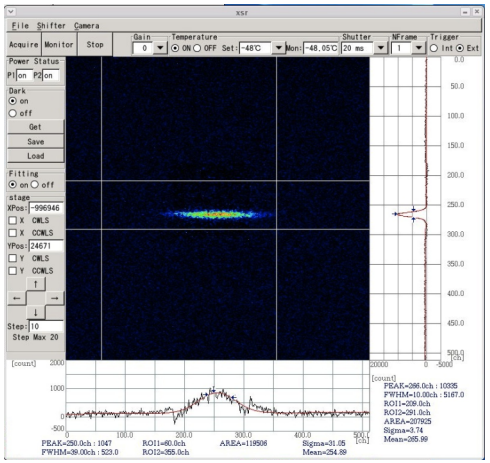


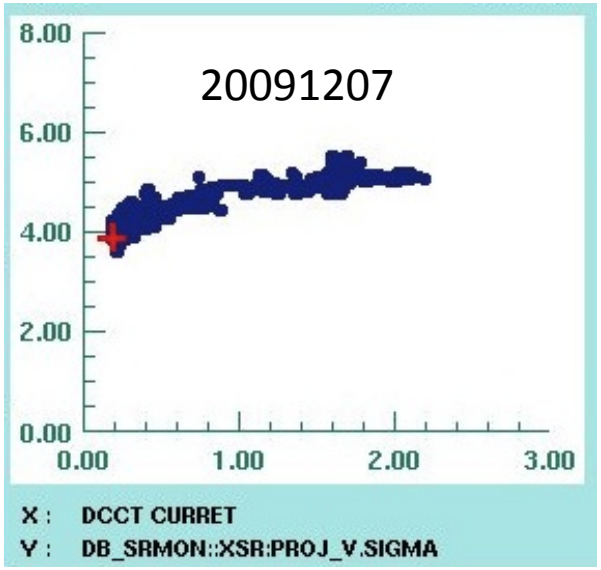
Beam image (x:46.2, y:10.2μm)

Improvement of Vertical Emittance measurement (½)
XSR monitor

T.Naito





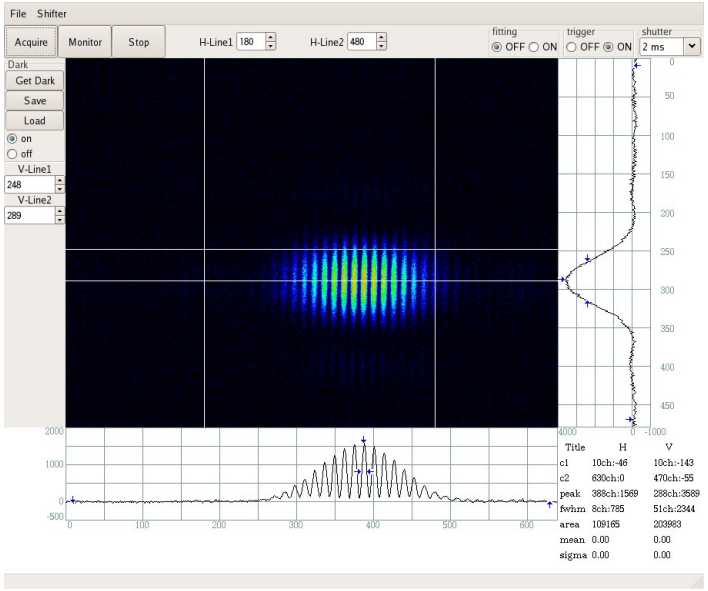


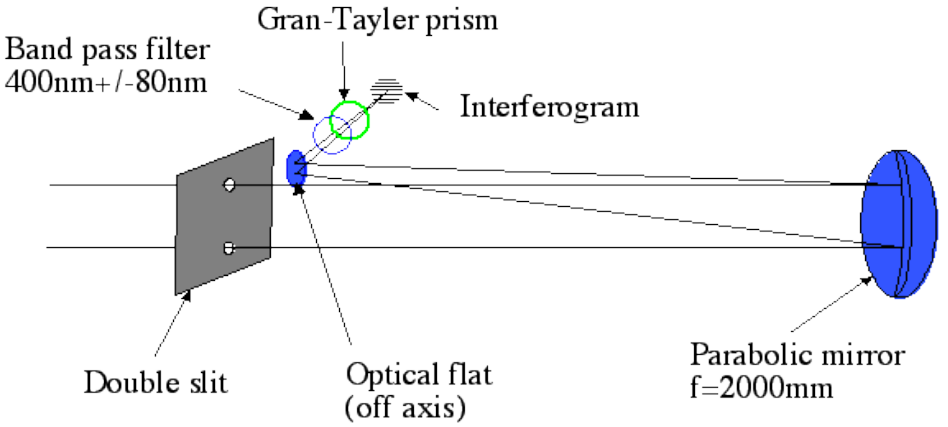
The X-ray SR monitor(XSRM) was affected by the mechanical vibration of the air blower for the RF waveguide. The air blower was located near the grating mirror of the XSRM. The beam profile was smeared and the measured vertical beam size was always larger than 6um. After insert air cushions between the air blower and the ground, the measured vertical beam size was recorded less than 4um, which is not yet limited by the monitor.

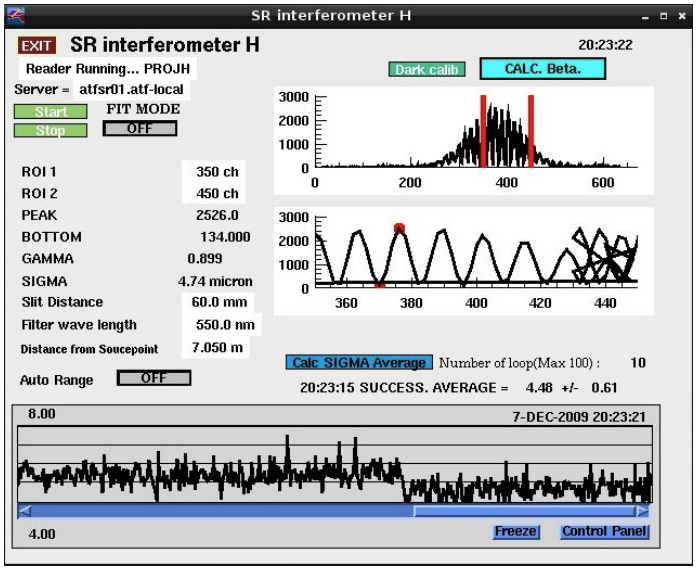
Improvement of Vertical Emittance measuremen(2/2)

SR interferometer

T.Naito







Double slit separation of 40mm was mainly limited by effective aperture of optical path between the source point and interferometer. In this time, the optical path was re-aligned, and as a result, the effective aperture was increased. According to this re-alignment the double slit separation was expanded up to 60mm. To reduce air turbulence, the optical path was covered with air tight duct. To reduce mechanical vibration of the mirrors on the optical table, the optical axis was rotated 90 degree. After these treatment, the measurement could clearly respond the beam size change from 5um to 4um. (left)

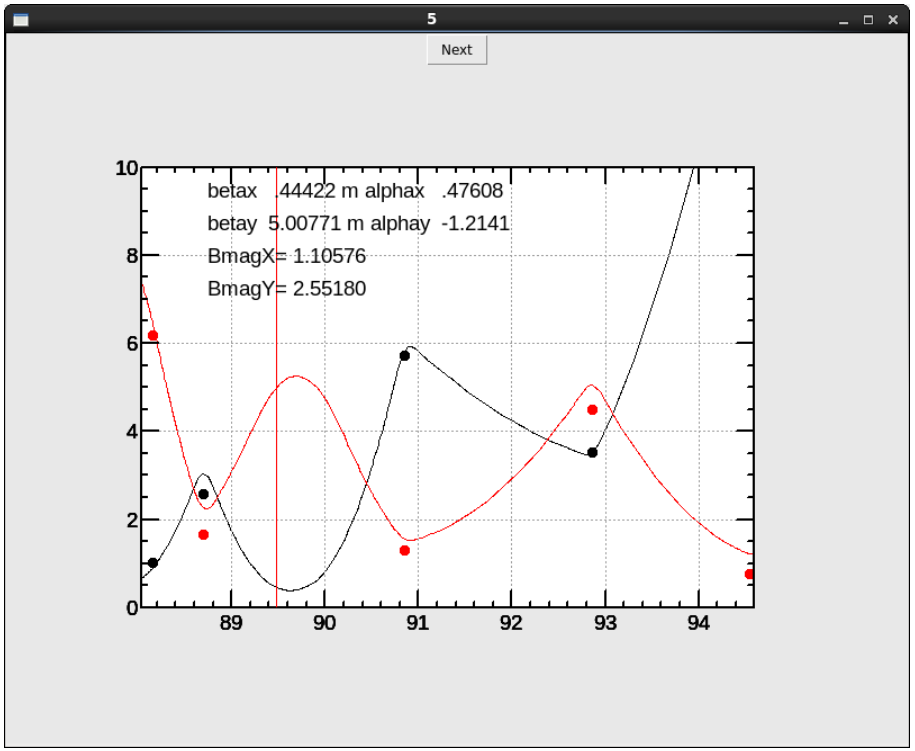
Beta Measurement

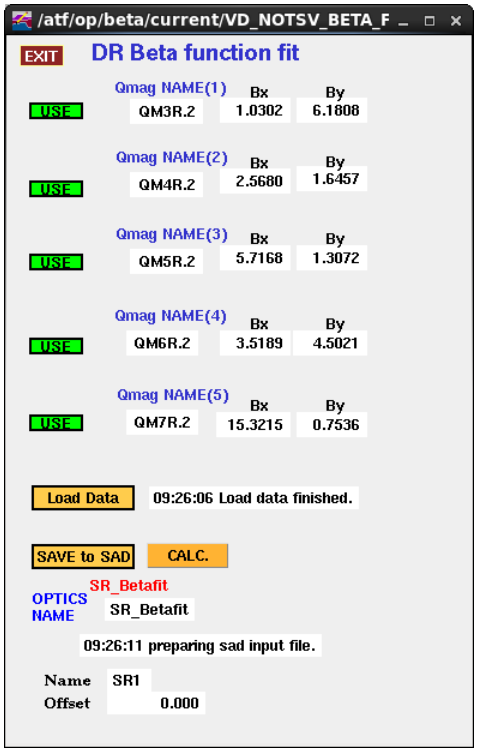
- Emittance is calculated by the formula;

$$\sigma_y^2=\beta_y \varepsilon_y$$

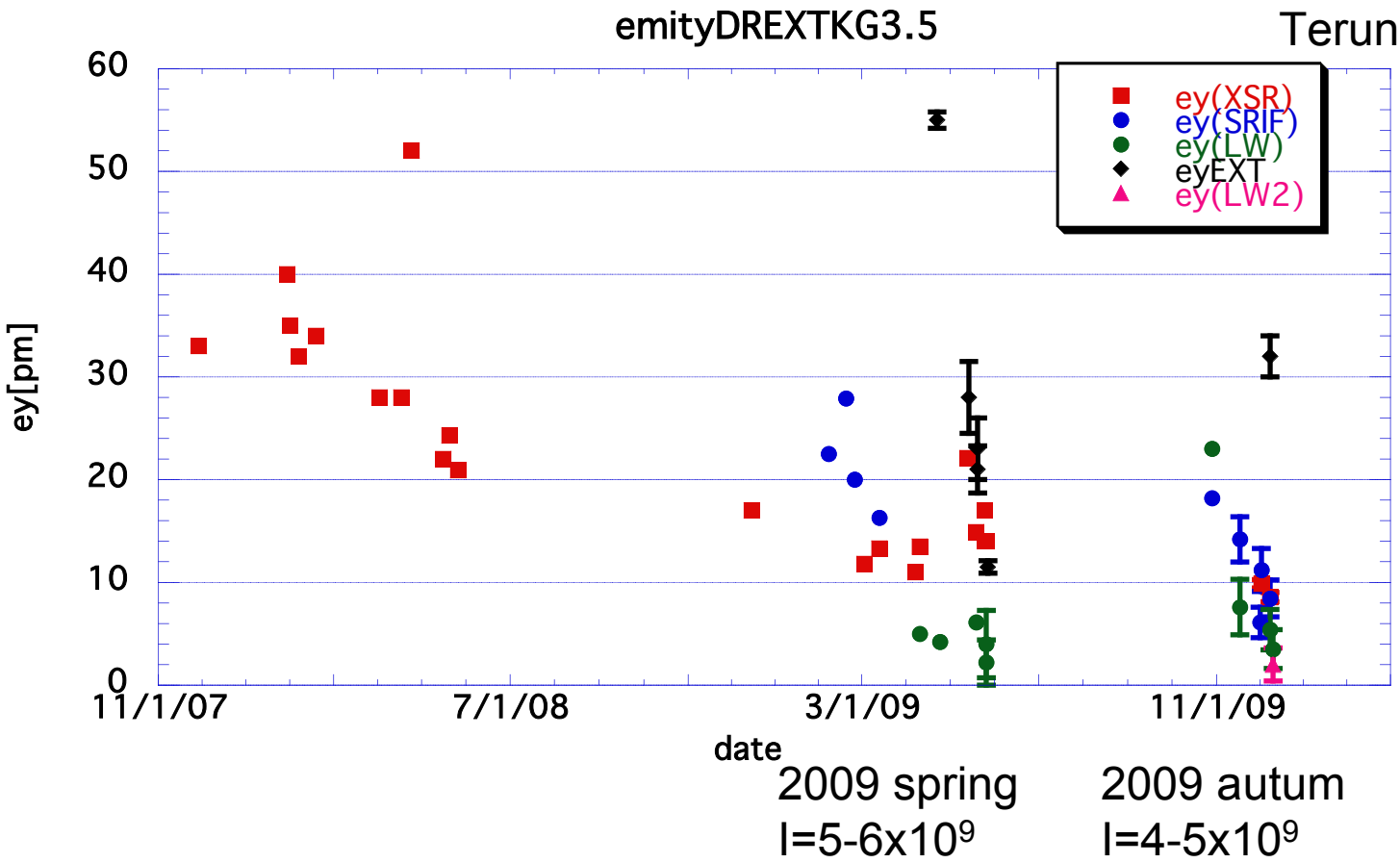
β is calculated by fitting the β s at near Qs, which are measured by tune slope.

ex.)->





DR Emittance Summary

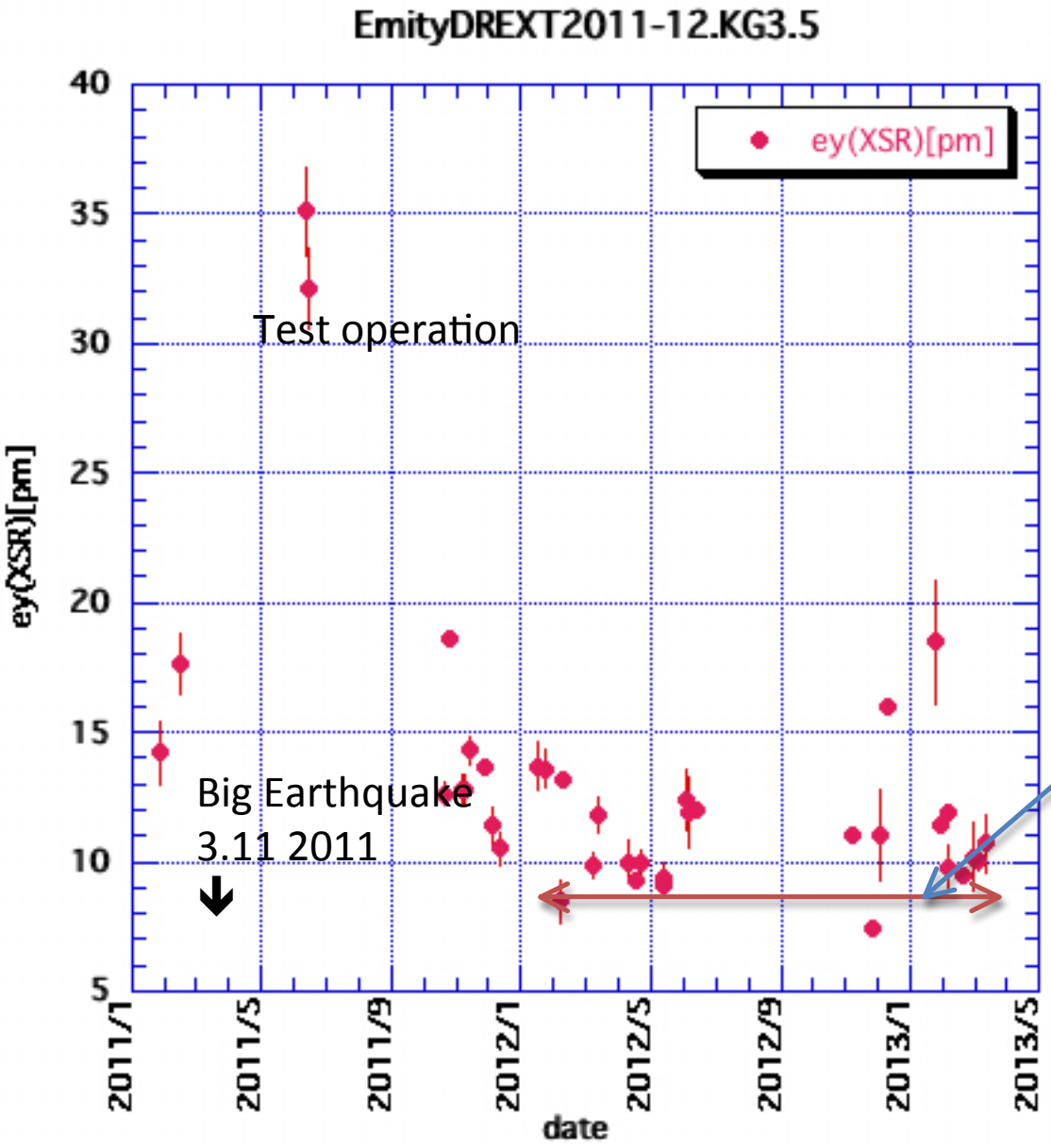


Low emittance was recovered in the operation 2008-2009.
Measured ε_y=8.56±0.46/ 8.43±1.79/ 3.50±1.78/ 2.00±1.61pm
by XSR/ IF/ LW00/ LW01.
Study for the discrepancy is still on going.

Present Status

- After the emittance recovery in 2009, new DR BPM electronics was installed(FNAL).
- Long shut down period
  - Alignment work
- Start-up after long shut-down
  - β beat correction if necessary
  - Horizontal dispersion correction if necessary
  - Routine tuning as below
- Start-up after short shut-down
  - Routine tuning
    - η_y is corrected by correctors
    - Coupling correction

Emittance Summary 2011-2013



Emittance in DR is around 10-12 pm

Summary and Discussion

- Low emittance of ε_y<10pm was measured in early 2000's. Since then, the emittance had been slightly high as 20-50pm.
- With several efforts, low emittance was recovered again in 2009. The low emittance is successfully kept still now 2013.
- New beam size monitor is expected to be necessary for further lower emittance study.
  - eg. Pulse LW in DR…

Back-up

ATF International Collaboration

CERN
DESY
IN2P3
- LAL
- LAPP
- LLR

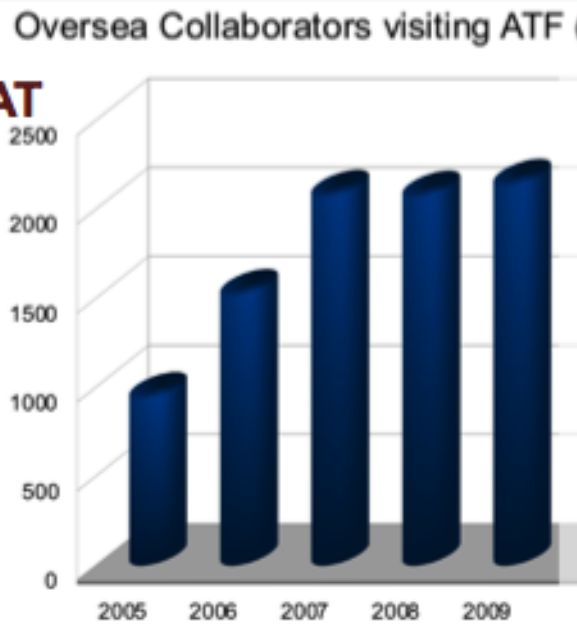
John Adams Inst.
- Oxford Univ.
- Royal Holloway Univ.

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.

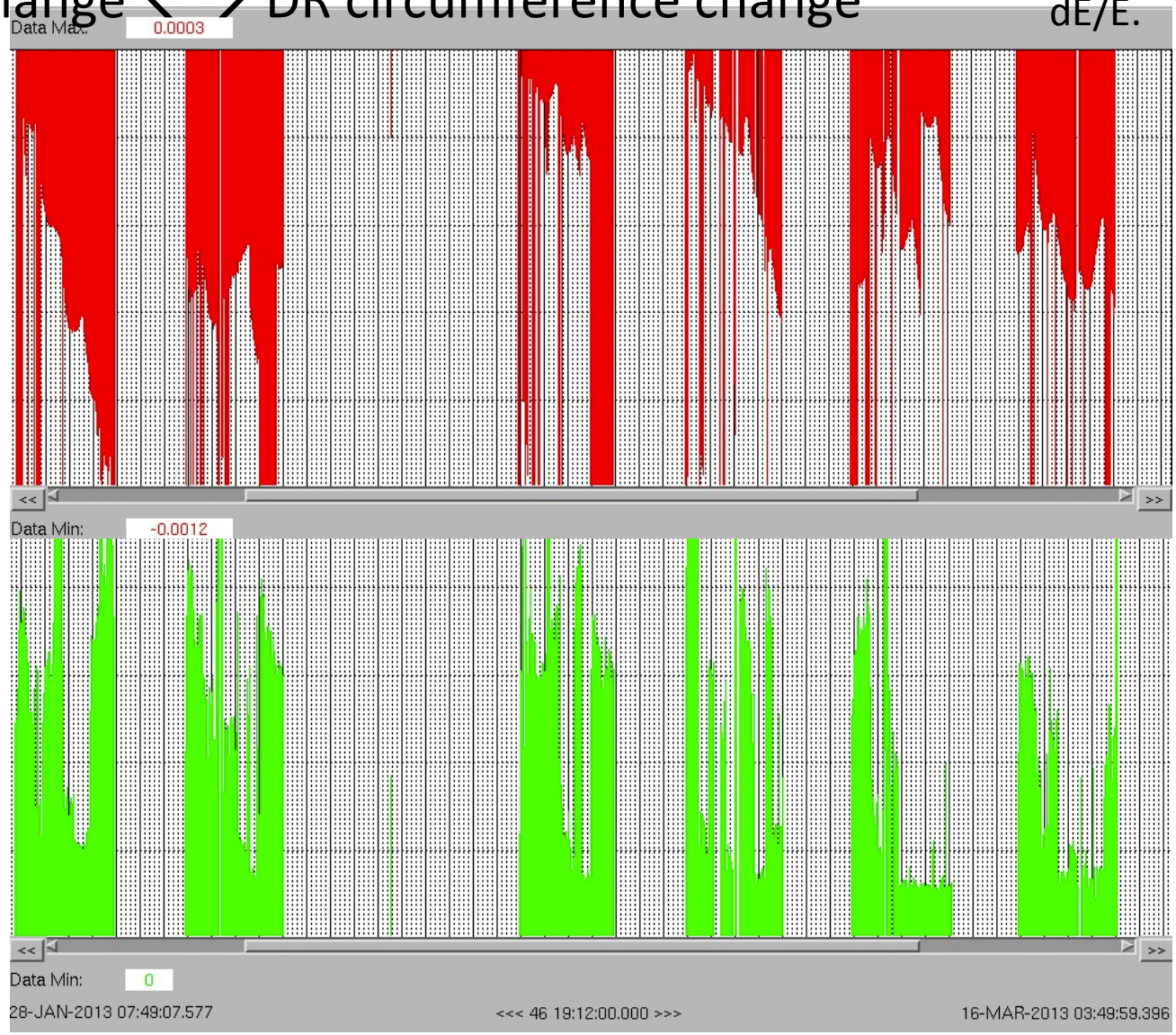


Oversea
25 Institutes,
~70 people,
~2000 people-days
+
KEK and Japanese Universities(6)

dE/E Measurement(Jan.-Mar. 2013)

- dE/E is calculated as <x/η> in DR arc(K.Kubo).
- dE/E change ←→ DR circumference change

LINAC frequency is changed to compensate dE/E.

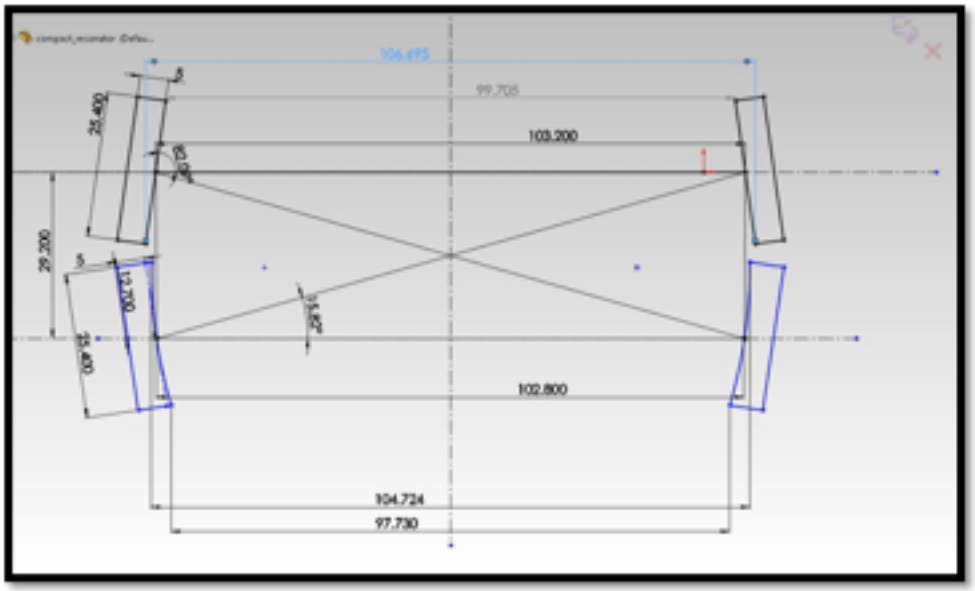


dE/E

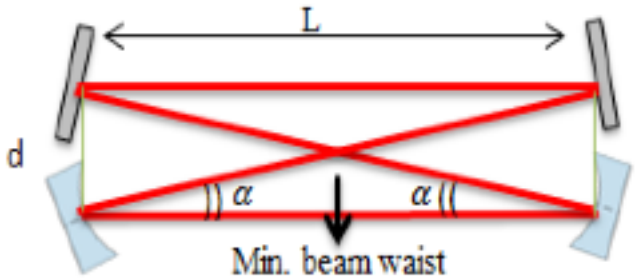
DR Intensity (1e10)

Compact 4 mirror laser wire system

Length of optical cavity = 103 mm
Side by side distance = 29.2 mm
Radius of Curvature = 101.81 $\pm$ 0.2 mm



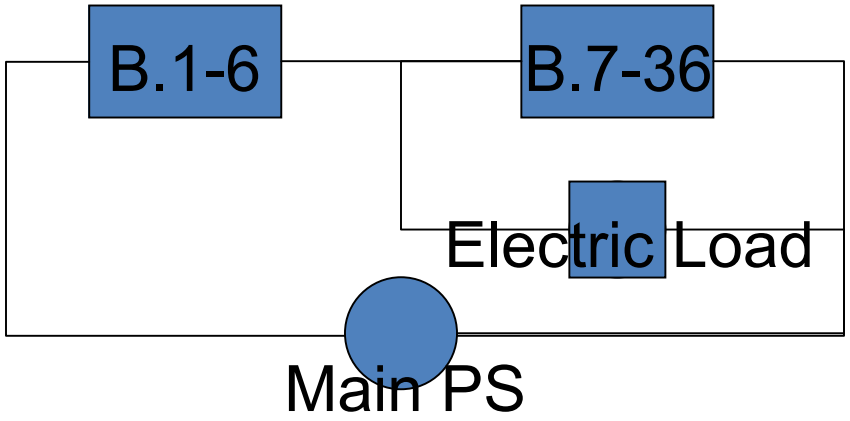
Minimum Beam waist
σ_s= 4 μm, σ_T = 14 μm
Wavelength = 532 nm



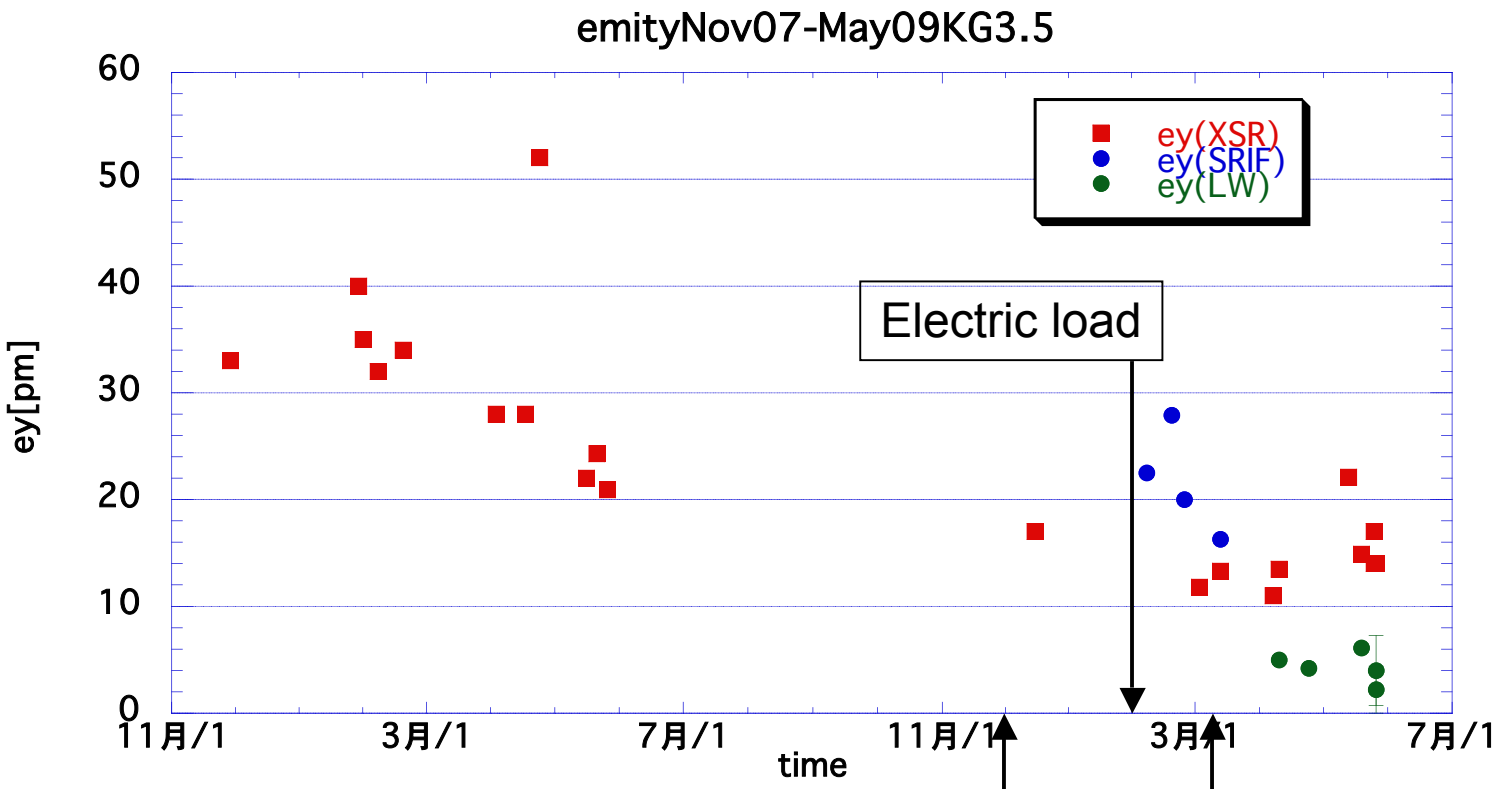
A.Rawankar

Electric Load for DR Main Bend

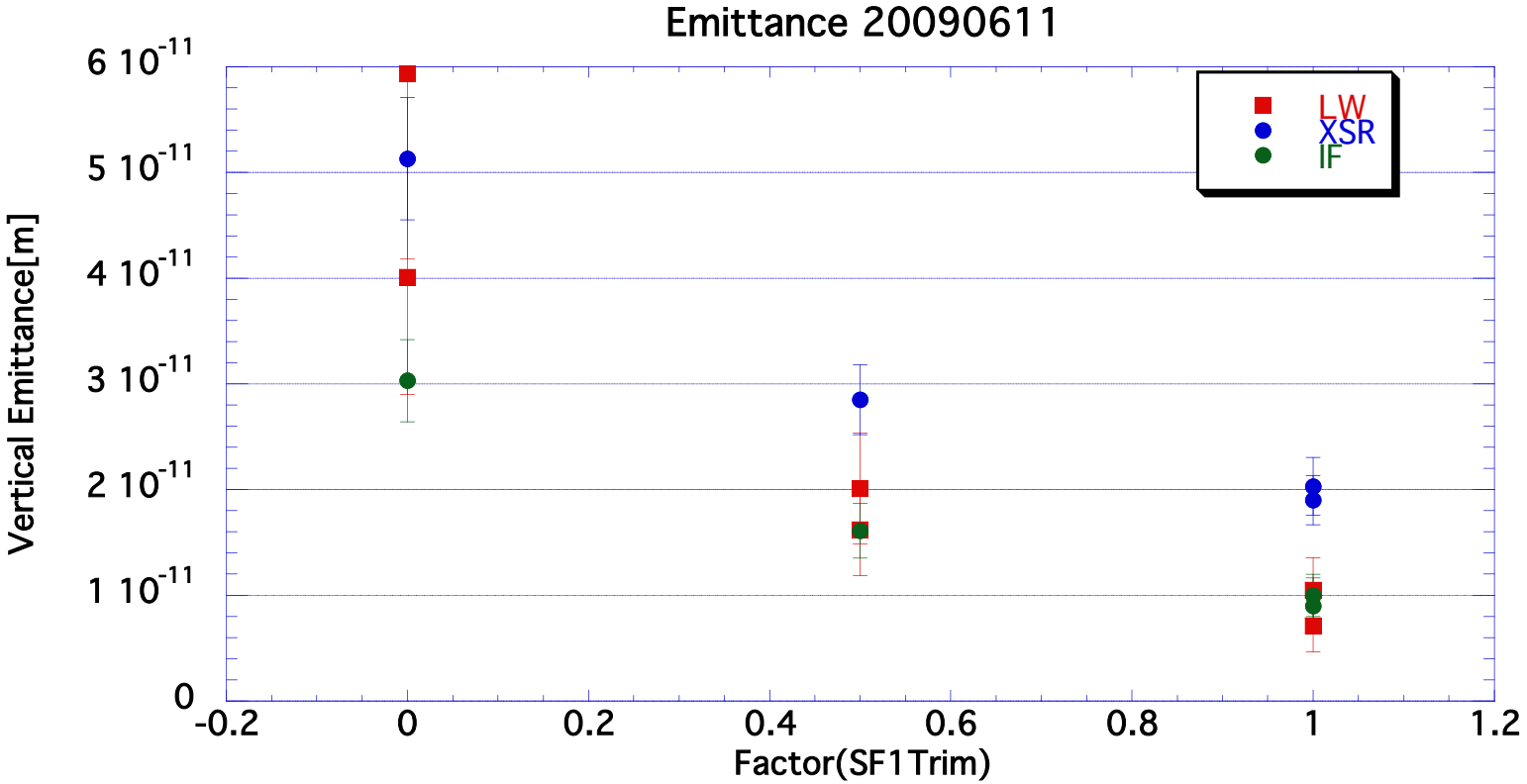
- 36 B magnets in DR
- 6 of them were productions of different maker from the others, and the field characteristics is slightly different.
- Correction has been done by trim coil, but it does not seem enough. The trim current <8A due to heat-up of the coil(the coil is air-cooled).
- Introduction of electric load is expected to improve the DR orbit, …
- I_{EL}<13A, by power dissipation.



Measured DR Emittance



Measurement Method Comparison in Big Emittance Case



- Change skew Q strength(Factor=1(normal correction) ↔ Factor=0(no correction))
- Discrepancy seems to begin at Factor>0.5. When ε_y=20pm measured by XSR, σ_y=7.7um with β_y=3m. σ_y=7.7um is already beyond the XSR measurement limit?
- At Factor=0, all the measurement agree within error bars, but the error bar is very big.
- IF measurement result is very close to LW one. IF setup was tuned up well by an expert(T.Mitsuhashi) before the measurement.