ATF DR Study
Dec. 08 - Apr. 09

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ATF DR Study Group

TILC09-GDE meeting, Tsukuba, 2009

Goal of the Study

- We have measured ε_y of 5-10pm in 1999. But since then we hardly measured such low emittance because the other R&D have been majority of the ATF study.
- Typical emittance measured in 2008 was 20-30pm.
- These days, some experiments require low emittance in DR.
  - For ATF2 σ_y*=70nm, ε_y=24pm is needed.
  - For ATF2 σ_y*=35nm, ε_y=12pm is needed.
  - For study of fast ion instability, ε_y<10pm is needed.
  - For ILC DR study, goal emittance is ε_y=2pm.

- Our goal: to reproduce as small emittance as 5-10pm, and then challenge to lower emittance such as 2pm.

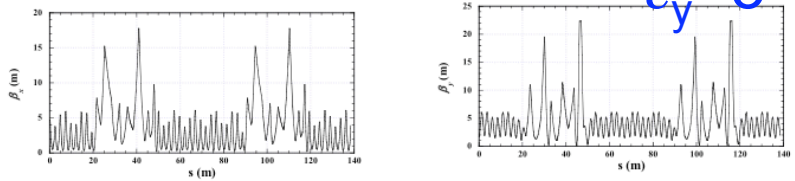
What's New in DR Operation

- Start with 'design optics' and optics correction(β beat correction)
- DR re-alignment in summer 2008
- Introduction of electric load for DR main bend.
- (New QM7R.1 with larger bore radius)
- …

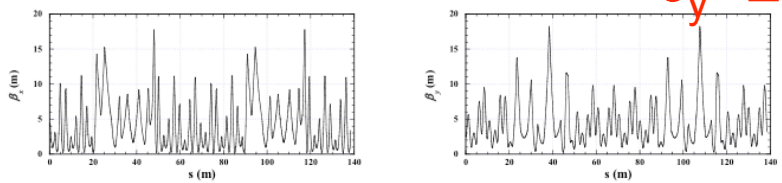
DR Optics

Optics mismatching ?

calculated from setting Dec. 10, 1999 ε_y=5~10pm



calculated from setting May 16, 2008 ε_y=20~30pm

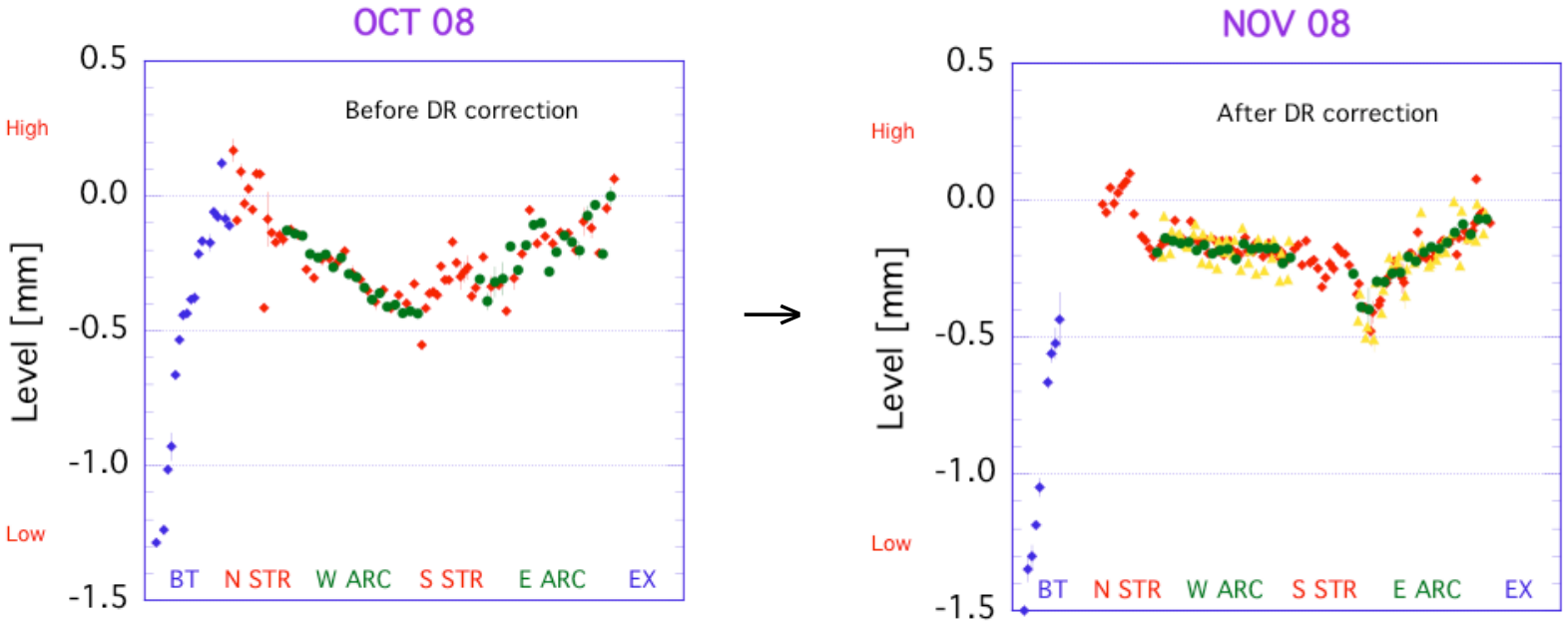


Kubo pointed out that the optics distortion is the one of the source of large emittance in DR.

Kubo, Special ATF2 Project Meeting,KNU,2008

- 'design optics' was made in 2007
  - Re-matching
  - Tune adjustment to measured tune
- DR commissioning has started with 'design optics' in Nov. 2008.

DR Re-Alignment in Summer Shutdown 2008



M.Takano

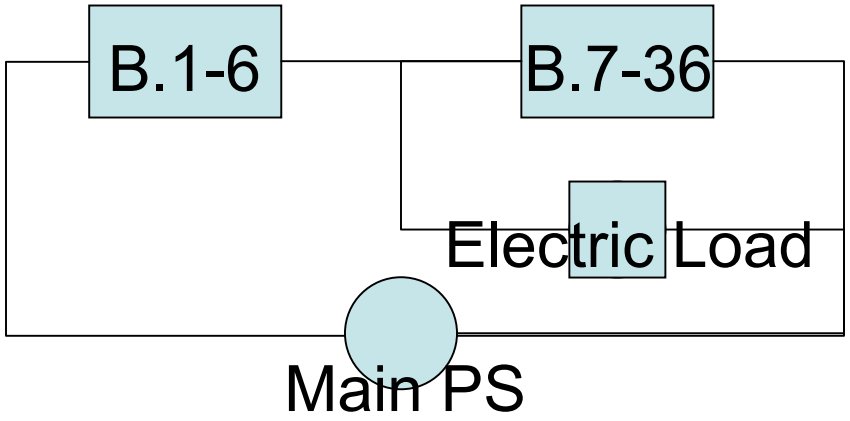
Alignment done for

V position: All around the ring

H position: Straight section

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.



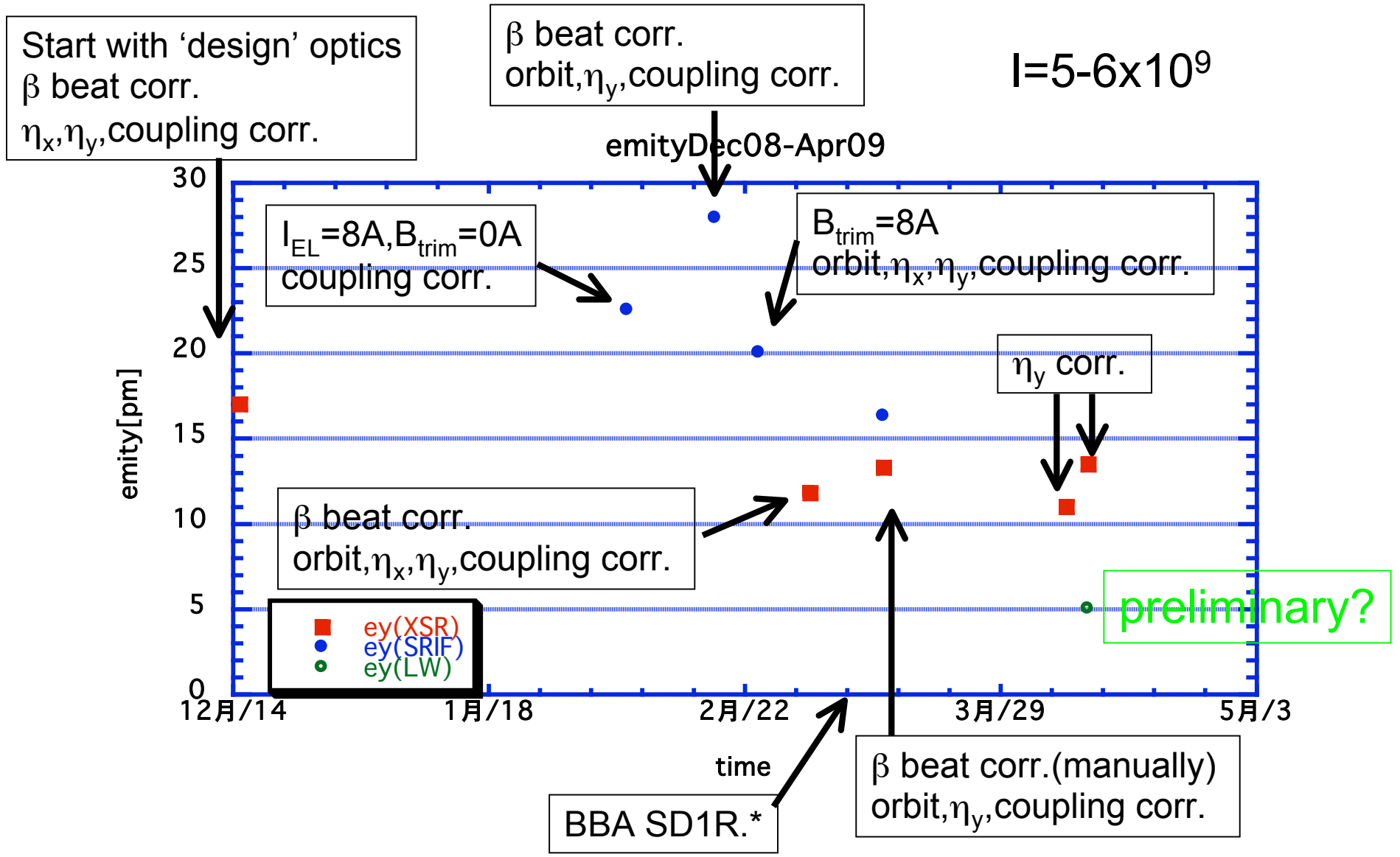
Emittance Tuning

- β beat correction
  - Using QM trim, new QM7, IHEP Q trim and QF1&2(for tune adjustment)
- Orbit correction
  - Using correctors for several settings of the Bend trim and electric load
- Dispersion correction
  - η_x in straight section is corrected by QM trim
  - η_y is corrected by correctors
- Coupling correction
  - ONLINE correction: Correction of vertical leakage of the horizontal kicks by a couple of horizontal correctors.
  - OFFLINE correction: The same as ONLINE correction but using data by all the horizontal corrector in the arc.
  - Correction is done by Skew Q winding trim coil of SX.

Emittance Measurement

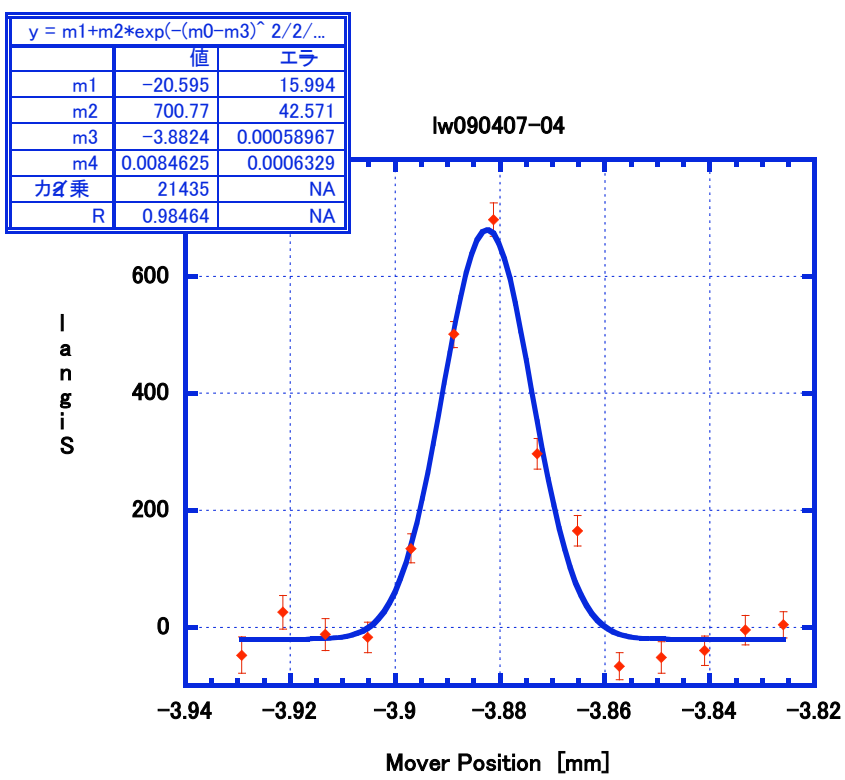
- Beam size measurement
  - SR Interferometer
    - Quick measurement, 5ms
    - Minimum beam size can be measured is ~5-6um
    - Suffering from mechanical vibration
  - XSR monitor
    - Quick measurement, 20ms→50Hz oscillation?
    - Minimum beam size can be measured is ~5-6um
    - Less mechanical vibration but still.
  - Laser wire
    - A few ten minutes requires for measurement
    - ‘design’ laser waist size is 6.5um→going to higher mode, beam size of 1um can be measured.
- Beta function measurement
  - Fitting β of Qs nearby which were obtained from tune slope.

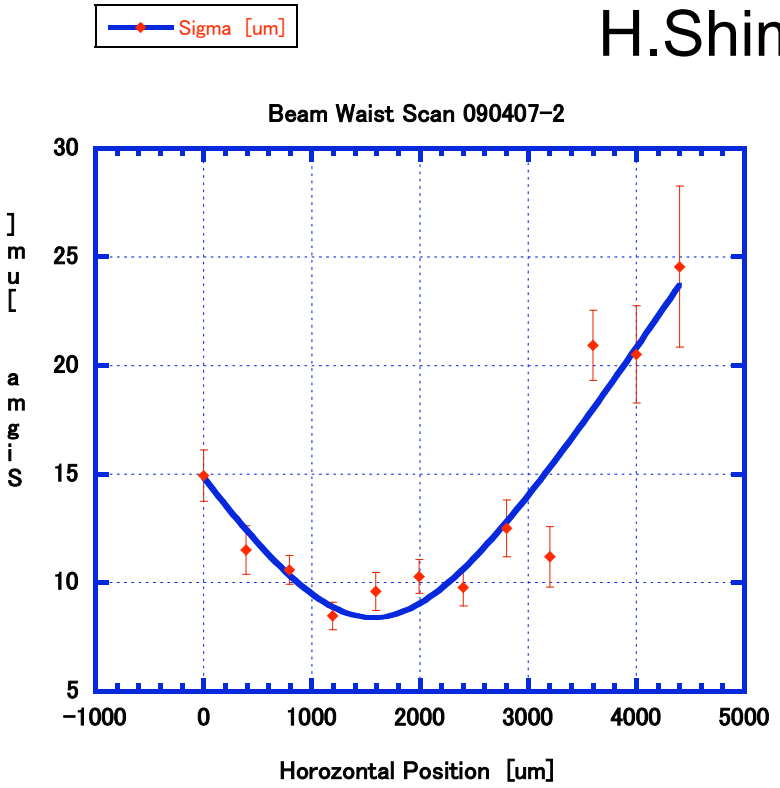
Beam Tuning Summary



Laser Wire Measurement

H.Shimizu





Minimum size measured=8.46um
Measured Laser waist=5.96um
→ e beam size=~6um

Scanning in horizontal position
Fitting with

$$\sigma^2_{\text{Obs.}} = \sigma_e^2 + \sigma^2_{\text{LW}} = \sigma_e^2 + \frac{\lambda}{4\pi} z_0 \left\{ 1 + \frac{(z-c)^2}{z_0^2} \right\}$$

e beam size=6.41±1.07um

Assuming β_y~5m, ε_y=~7pm

Summary and Discussion

- Now the vertical emittance of ATFDR is ~12pm(by XSR monitor).
- Measurement errors
  - 10% for both of beam size(by XSR) and b measurement statistically. Then the error of measured emittance is ~14%.
- Need to check minimum σ_y measurable by XSR.
  - When we measured ε_y=12pm, σ_y=~6um and β_y=~3m. If the 50Hz oscillation is σ_{50Hz}=~4um which was observed in 2007, ε_y=~6.6pm?
- Need confirmation of laser wire measurement.

- For much smaller emittance:
  - Some BPMs in DR are fluctuating by O(100um). Stabilization of these BPM→emittance tuning becomes more powerfull?
  - Full ORM analysis will improve the emittance?
  - Need reliable monitor(e.g. LW w higher order mode)