ATF Plans for Emittance Tuning

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• What’s New in ATF Operation
• DR Emittance
  – Emittance tuning and measurement
  – Measured emittance
  – Data for check and comparison
• Summary and Discussion

ALCPG09/GDE meeting, Albuquerque, 2009
DR Emittance

- We have measured $\varepsilon_y$ 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 $\sigma_y^* = 70\text{nm}$, $\varepsilon_y = 24\text{pm}$ is needed.
  - For ATF2 $\sigma_y^* = 35\text{nm}$, $\varepsilon_y = 12\text{pm}$ is needed.
  - For study of fast ion instability, $\varepsilon_y < 10\text{pm}$ is needed.
  - For ILC DR study, goal emittance is $\varepsilon_y = 2\text{pm}$.

- Goal of DR Study Group: to reproduce as small emittance as 5-10pm, and then challenge to lower emittance such as 2pm.
What’s New in ATF 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
- ...

- Off course, the biggest issue is the new ATF2 FF and EXT line.
DR Optics

• ‘design optics’ was made in 2007
  – Re-matching
  – Tune adjustment to measured tune

• DR commissioning has started with ‘design optics’ in Nov. 2008.

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

Optics mismatching?

calculated from setting Dec. 10, 1999

\( \varepsilon_y = 5 \sim 10 \text{pm} \)

Kubo, Special ATF2 Project Meeting, KNU, 2008

Optics mismatching?

calculated from setting May 16, 2008

\( \varepsilon_y = 20 \sim 30 \text{pm} \)
DR Re-Alignment in Summer Shutdown 2008

Alignment done for
V position: All around the ring
H position: Straight section

M. Takano
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.
DR 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
  – $\eta_x$ in straight section is corrected by QM trim
  – $\eta_y$ 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.
DR 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 \( \beta \) of Qs nearby which were obtained from tune slope.
Measured DR Emittance

2008 spring
Start with ‘design’ optics

2009 spring
I=5-6x10^9

SD trim BBA

Electric load

emityNov07-May09KG3.5
Minimum size measured=8.46um
Measured Laser waist=5.96um
→ e beam size=\(~6um\)

Scanning in horizontal position
Fitting with
\[
\sigma_{\text{obs}}^2 = \sigma_z^2 + \sigma_{\text{lw}}^2 = \sigma_z^2 + \frac{\lambda}{4\pi\sigma_0} \left\{ 1 + \frac{(z-\epsilon)^2}{\sigma_0^2} \right\}
\]

e beam size=6.41±1.07um

Assuming $\beta_y \sim 5m$, $\epsilon_y \sim 7pm$
No significant current dependence could be seen. There must be intra-beam scattering effect → emittance already smaller than measurement limit?
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 $\varepsilon_y=20\text{pm}$ measured by XSR, $\sigma_y=7.7\text{um}$ with $\beta_y=3\text{m}$. $\alpha_y=7.7\text{um}$ 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.
Summary and Discussion

• DR emittance
  – The vertical emittance of ATFDR is ~12pm (by XSR monitor).
  – Measurement errors
    • 10% for both of beam size (by XSR) and $\beta$ measurement statistically. Then the error of measured emittance is ~14%.
  – Need to check minimum $\sigma_y$ measurable by XSR.
    • When we measured $\varepsilon_y = 12$ pm, $\sigma_y = \approx 6$ um and $\beta_y = \approx 3$ m. If the 50Hz oscillation is $\sigma_{50Hz} = \approx 4$ um which was observed in 2007, $\varepsilon_y = \approx 6.6$ pm?

• Plans for much smaller emittance:
  • BPM upgrade
  • Full ORM analysis will improve the emittance?
  • Need reliable monitor (e.g. LW w higher order mode)