Fast ion instability studies at ATF

Junji Urakawa (KEK) at ILC Damping Rings R&D Workshop – ILCDR06, Cornell University

1. Introduction of ATF
2. Mutibunch Emittance Study
3. Laser wire results
4. Turn by Turn and Bunch by Bunch beam position measurement by the step of 100psec for 1msec
5. Simulation by Lanfa
Emittance status

\[ E = 1.3 \text{GeV}, \quad N_e = 3 \times 10^{10} \text{ e-/bunch} \]

1 ~ 20 bunches, \quad \text{Rep} = 3.125 \text{Hz}

\[ X \text{ emit} = 2.5 \times 10^{-6} \quad \text{(at 0 intensity)} \]

\[ Y \text{ emit} = 1.0 \times 10^{-8} \quad \text{(at 0 intensity)} \]

\(-\rightarrow 2.5 \times 10^{-9} \text{ in Future}\)
Multibunch emittance study

Monitors of MB emittance

MB (or projected) Laser-wire (bunch-by-bunch signal detection with gated circuit),
Projected SR interference monitor,
X-ray SR monitor,
MB (or projected) wire scanner: (EXT-line coupling problem?)

Problem of MB emittance

Fast Ion Instability? Longitudinal multi-bunch oscillation: Damped Cavity problem?
Preliminary result of Fast Ion Instability simulation

Behavior of Y emittance is very similar. Tor’s simulation in 2004.
Scrubbing of DR example

60~70mA (20 bunch, 3 train);
1.3~1.5x10^{-6} \text{ pa} \rightarrow 1.0~1.1x10^{-6} \text{ pa}
Synchrotron Oscillation growth in 20 bunch

FFT spectrum of Multi-bunch BPM data
ATF Damping Ring BPM

Button BPM for Damping Ring

Electronics: single pass detection for 96 BPMs
**Spectrum of DR BPM**

Signal peak at ~ 1GHz

**Resolution Improvement**

Min. resolution ~ 2µm

2006/9/27
Laser wire beam size monitor in DR

300mW 532nm Solid-state Laser
Fed into optical cavity

14.7µm laser wire for X scan
5.7µm for Y scan
(whole scan: 15min for X, 6min for Y)
Beam profile by Laser wire

\[ \sigma_e^2 = \sigma_{\text{meas}}^2 - \sigma_{lw}^2 \]

\[ \varepsilon\beta = \sigma_e^2 - [\eta(\Delta p/p)]^2 \]

\( \beta: \) measured by Q-trim excitation.

2006/9/27
Emittance by Laser wire

< 0.5% y/x emittance ratio

Y emittance = 4 pm at small intensity
Experimental setup

1. laserwire
2. detector and collimator
3. data taking system
Laserwire setup

vertical wire

horizontal wire

2006/9/27
Detector

- Compton scattering
  28.6 MeV (max gamma energy)
  23.0 MeV (0.2 mrad scattering angle)

- Gamma ray detector
  [70 mm × 70 mm × 300 mm]
  CsI(pure) crystal
  2” photo-multiplier

- Time resolution
  PMT signal leading edge
  0.56 nsec resolution
  (signal energy region)
  enough to separate 2.8ns spacing bunches

2006/9/27
Beam damping measurement

- beamsize measurement as a function of storage time
New powerful data acquisition system will be installed in Nov..

Tektronix, DPO7000, 20GS/sec, 500MHz to 7.25GHz, 1msec continuous signal measurements just after triggering by the step of 100psec for fast kicker study.
Single kick result (Vertical)
Fig. 1, \( x \) vs. turn number for various initial kick angle, 0~300 turns
Fig. 3, Horizontal phase space distribution for large amplitude, turn 0 ~ 60
Fig. 4, Horizontal phase space distribution for small amplitude, turn 0 ~ 60
New powerful data acquisition system

DAQ which will be made soon

ATF local network

**ATF DR tunnel**

- DR Trigger System
- DCCT, ICT
- DR BPM

**Tektronix DPO7254 20GS/s**

- Transverse emittance, bunch length, tune, vacuum level, COD, energy spread, temperature, Acceleration Voltage

**Powerful Lap-top PC with huge memory**

- National Instruments GPIB-Enet/100

- Interface to transfer lots of related data

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2006/9/27
Lanfa Wang tried a simulation about FII at ATF. He used the similar parameters as Tor used. The optics is included. This is a weak-strong program, so only dipole oscillation can be simulated. Preliminary
Turn A
mp $(\sigma)$

$N = 1.60 \times 10^9$
$N = 3.70 \times 10^9$
$N = 6.00 \times 10^9$

P = 10 nTorr
FII at ATF

P=10nTorr

2006/9/27
Experimental Plan for study on fast ion instability

The range from several $10^9$ to $3 \times 10^{10}$ electrons/bunch

Until 20 bunches/train, changeable from 1 to 20.

Precise emittance growth measurements bunch-by-bunch.

Precise tune measurement versus the bunch intensity

Accurate beam position measurement during 1msec by the step of 100psec; huge data will be obtained.

Appropriate period is Jan., Feb. and March in 2007 because all instrumentations require the check and fine tuning for three months from now and fast kicker R&D has first priority. Anyway, I want to finish the study of fast ion instability within 2007 and 2008 at ATF.