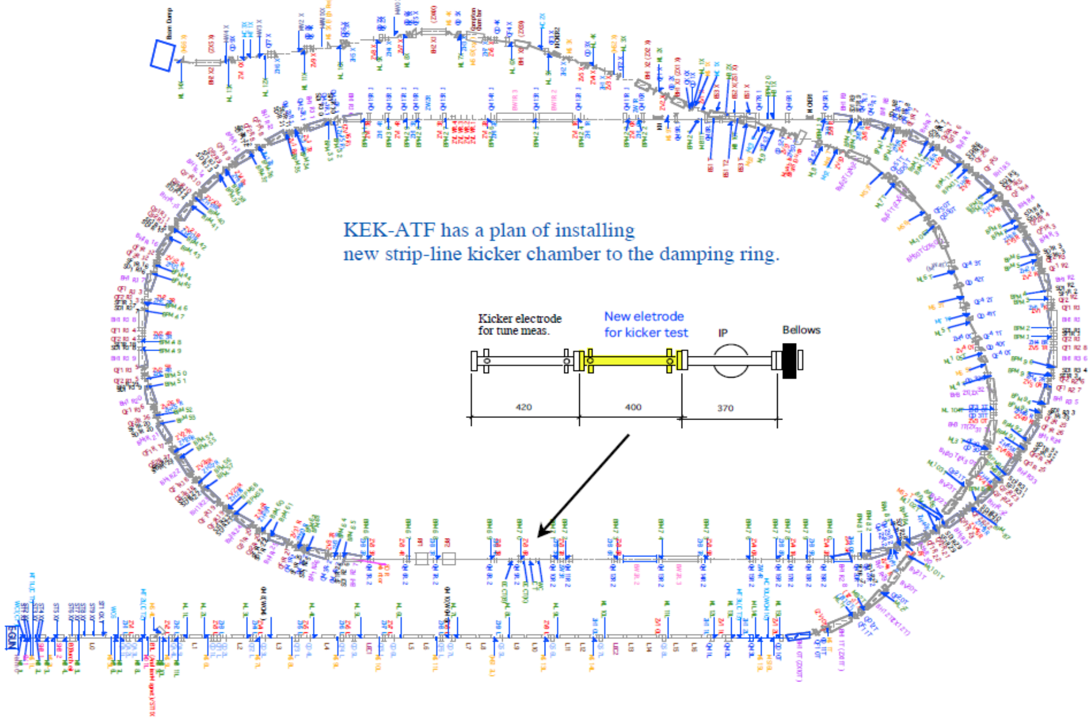
Fast ion instability studies at ATF

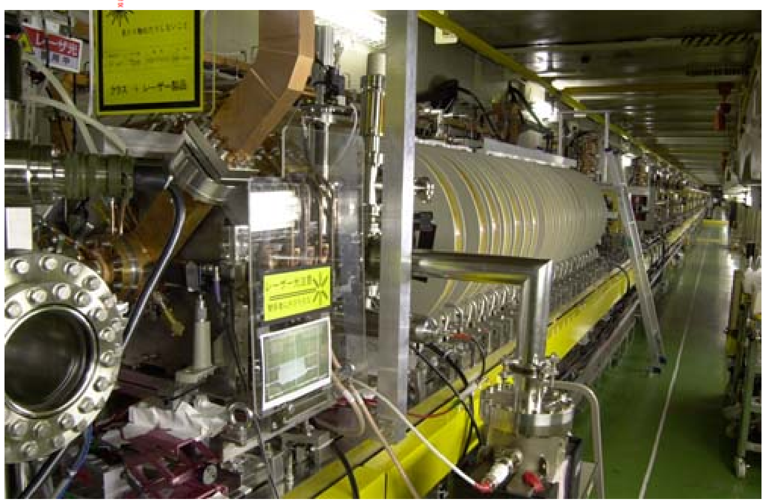
Junji Urakawa (KEK) **at ILC Damping Rings R&D Workshop – ILCDR06, Cornell University**

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*

ATF Introduction

Beam kick test at ATF





Emittance status

E=1.3GeV, $N_e=3x10^{10}$ e^-*/bunch*

1 ~ 20 bunches, *Rep=3.125Hz*

X emit=$2.5x10^{-6}$ **(at 0 intensity)**

Y emit=$1.0x10^{-8}$ **(at 0 intensity)**

-→$2.5x10^{-9}$ **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,

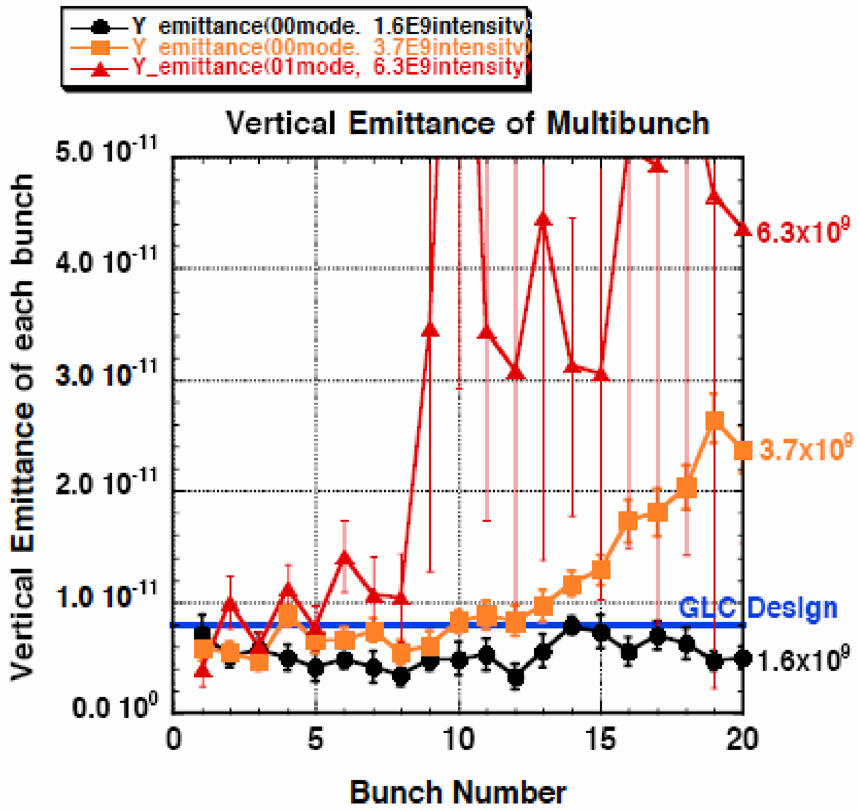
MB (or projected) wire scanner:

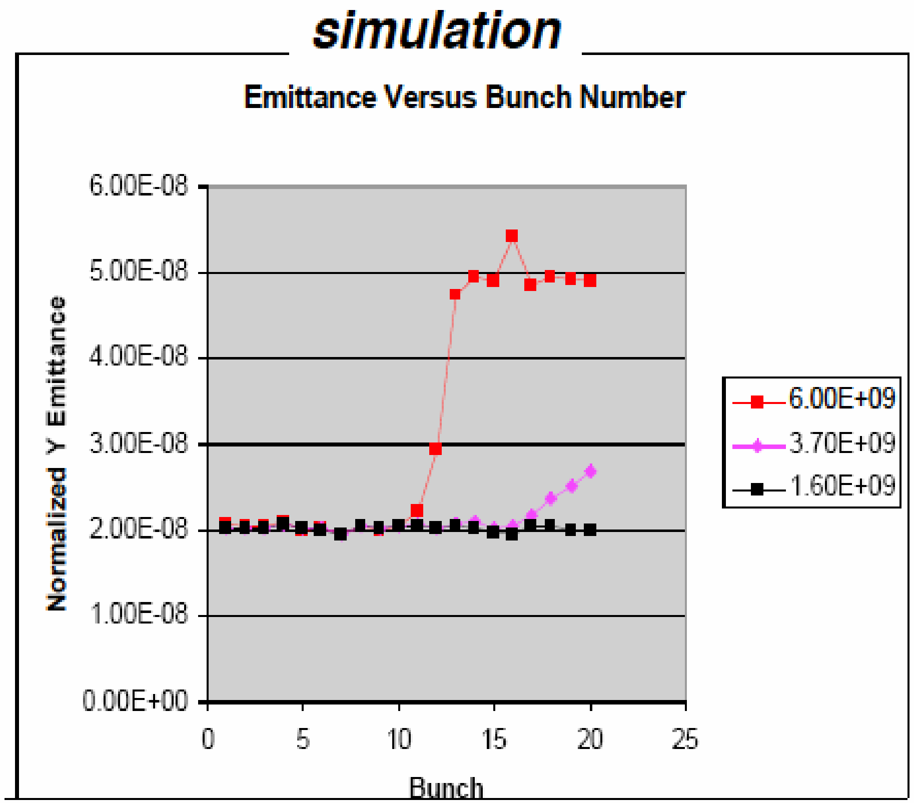
(EXT-line coupling problem?)

Problem of MB emittance

Fast Ion Instability ? Longitudinal multi-bunch oscillation : Damped Cavity problem?

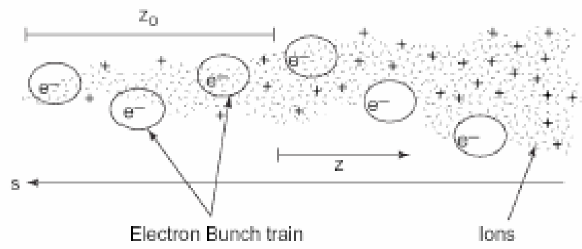
Preliminary result of Fast Ion Instability simulation





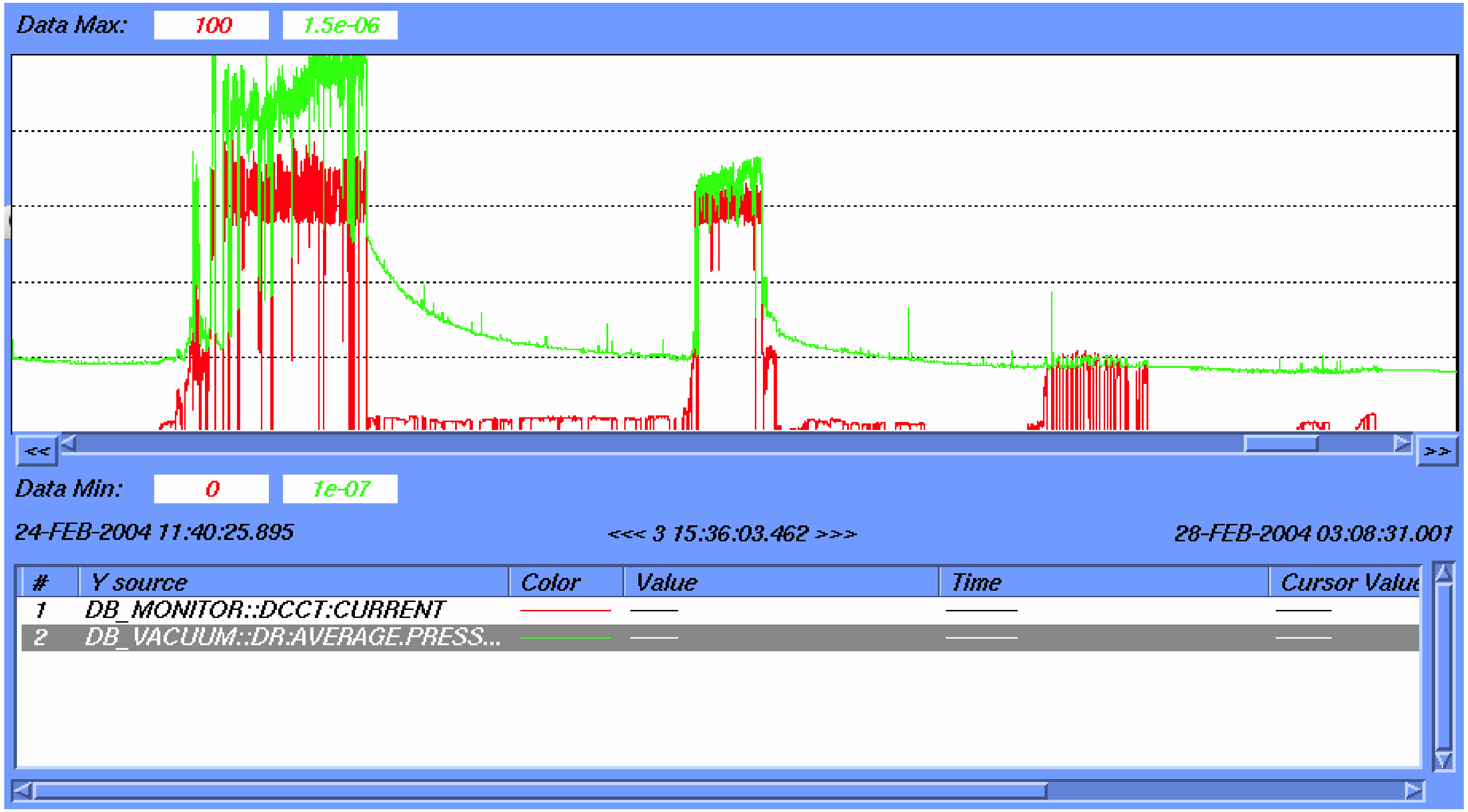
Behavior of Y emittance is very similar.

Tor's simulation in 2004.



Schematic of the Fast-Beam Ion Instability

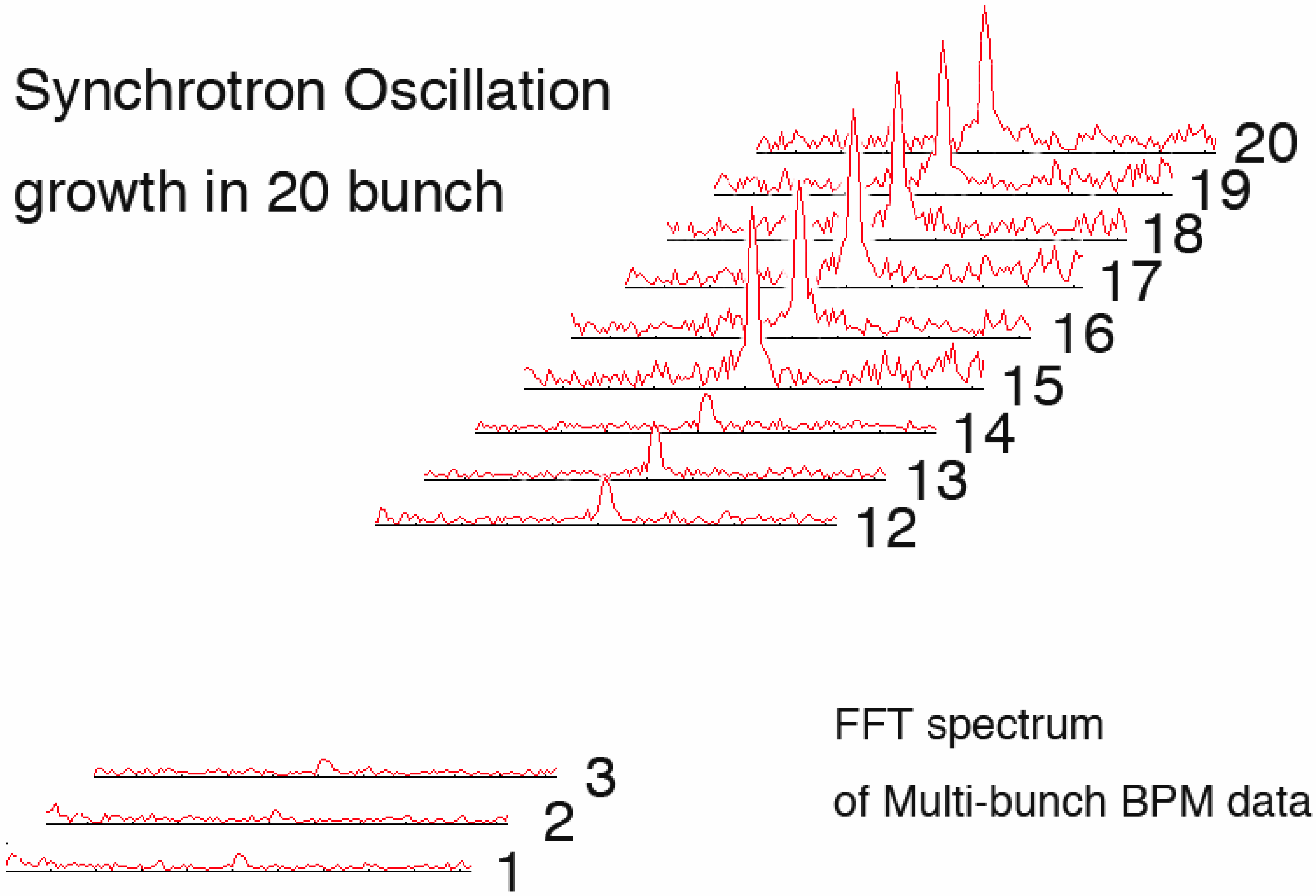
Scrubbing of DR example



60~70mA (20bunch, 3train);

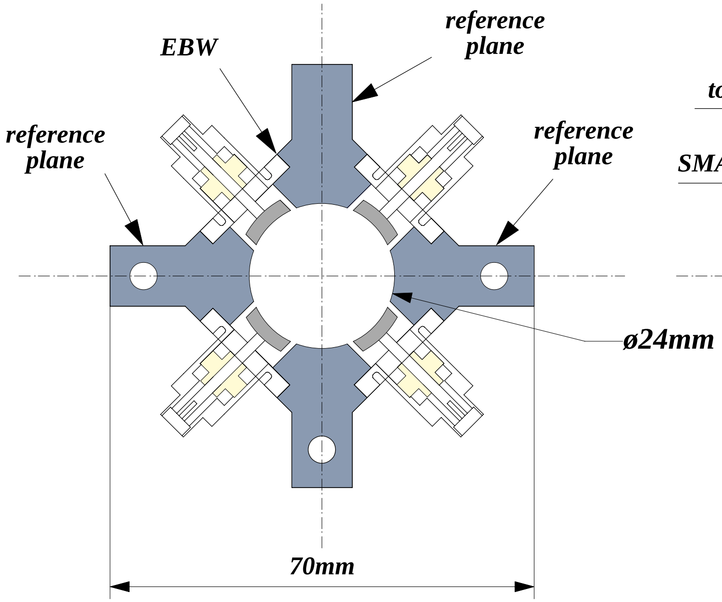
1.3~1.5x10^{-6} pa --> 1.0~1.1x10^{-6} pa

Synchrotron Oscillation growth in 20 bunch

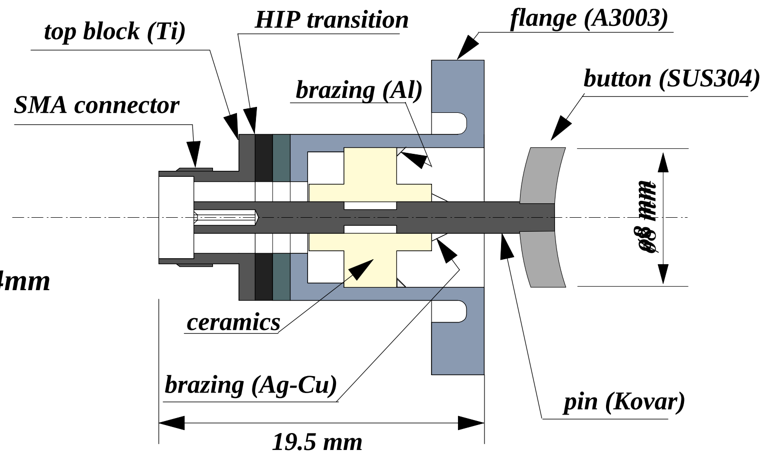


FFT spectrum of Multi-bunch BPM data

ATF Damping Ring BPM



cross section of BPM camber

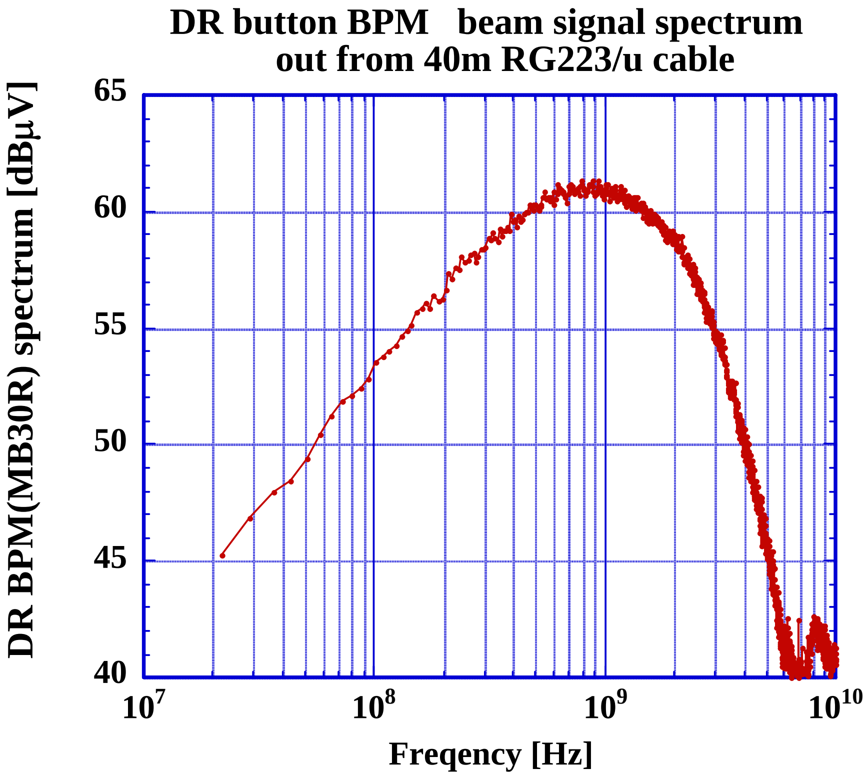


Button electrode assembly

Button BPM for Damping Ring

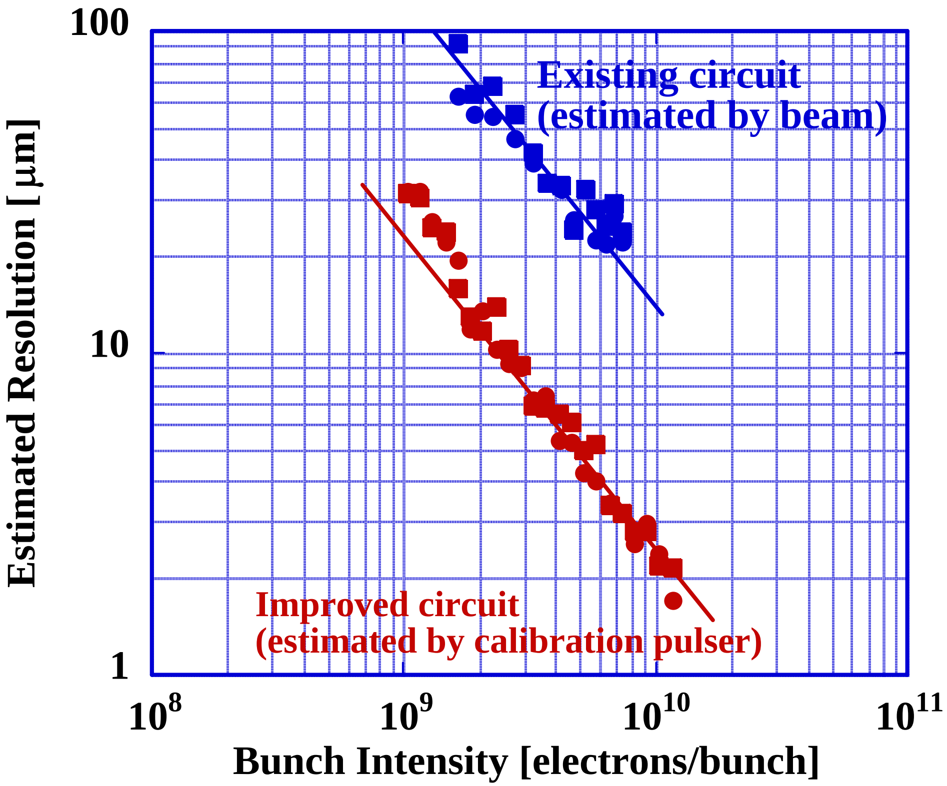
Electronics: single pass detection for 96 BPMs

Spectrum of DR BPM



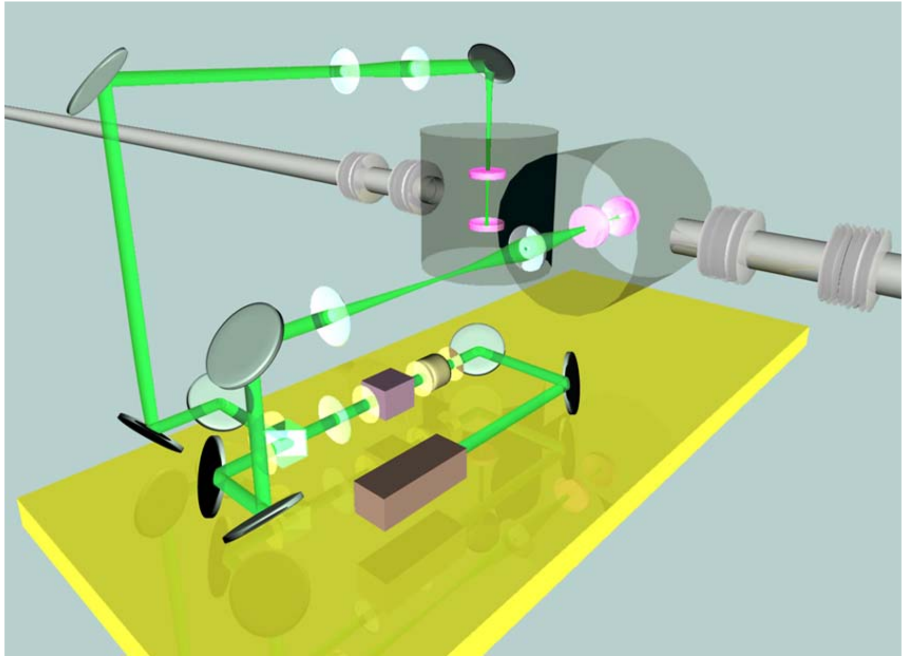
Signal peak at ~ 1GHz

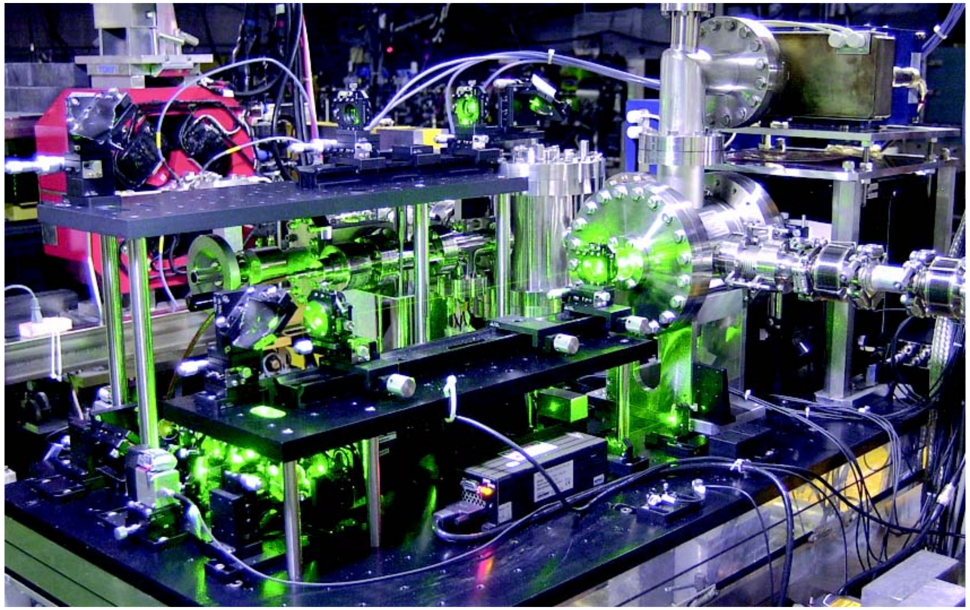
Resolution Improvement



Min. resolution ~ 2µm

Laser wire beam size monitor in DR

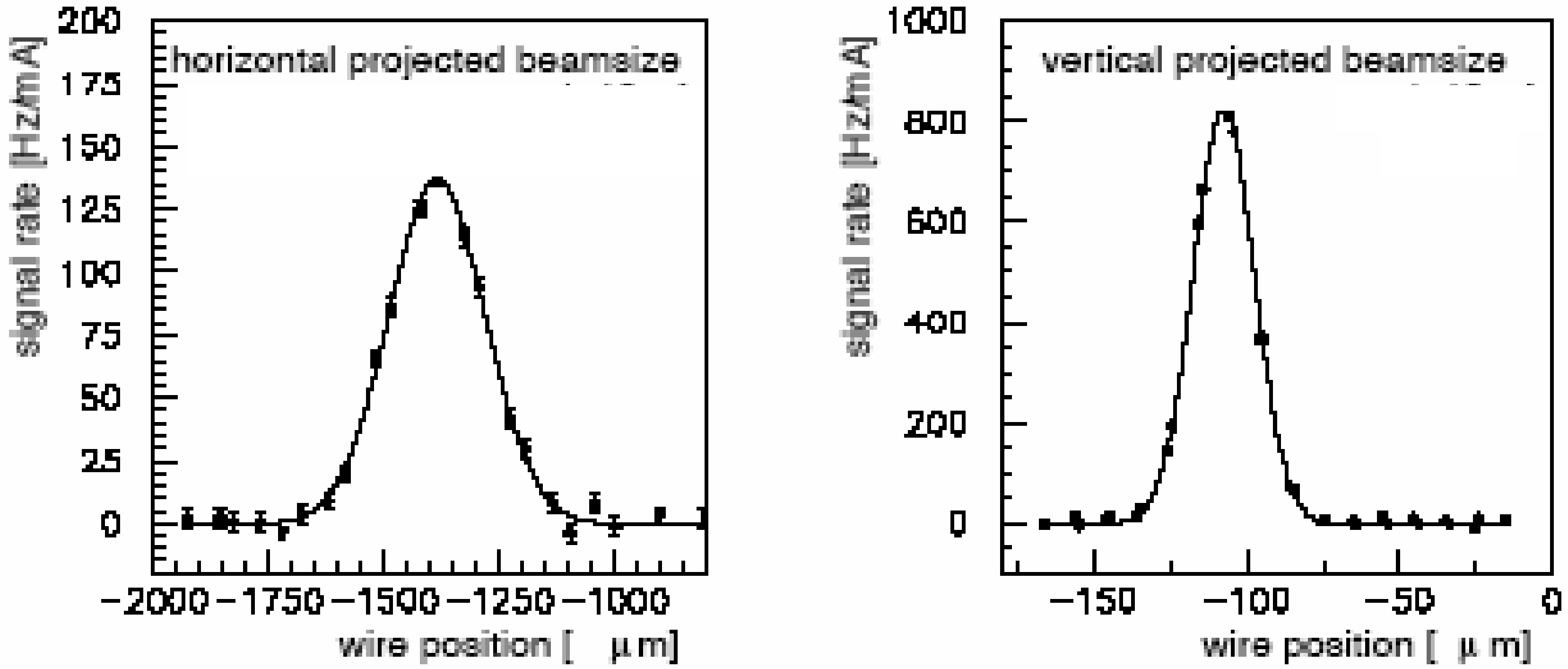




300mW 532nm Solid-state Laser
Fed into optical cavity

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

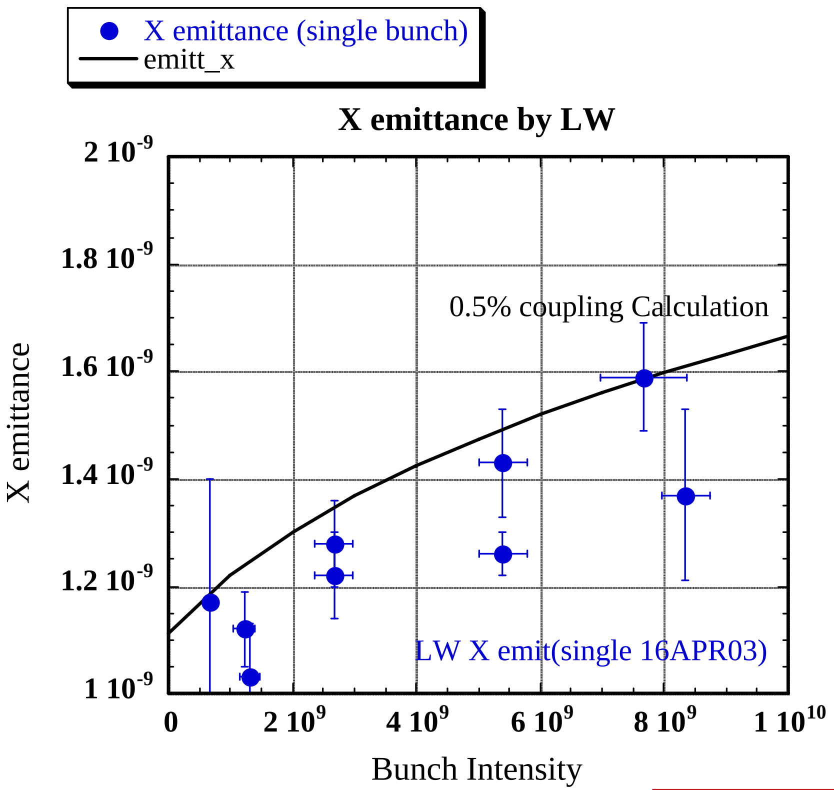
Beam profile by Laser wire

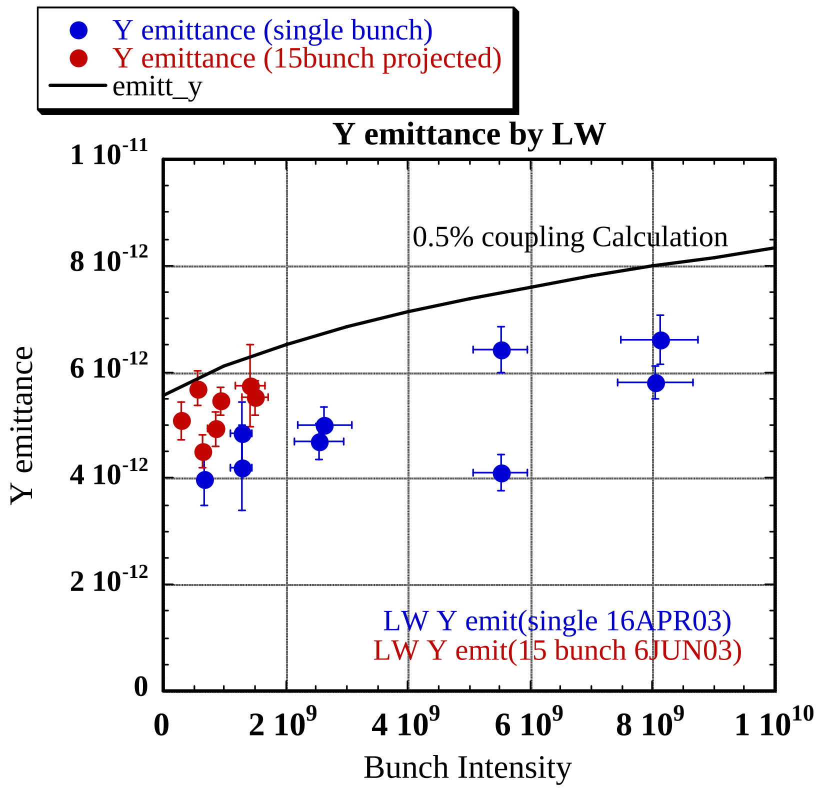


$$\sigma_e^2 = \sigma_{\mathrm{meas}}^2 - \sigma_{lw}^2$$

$\varepsilon\beta = \sigma_{\mathrm{e}}^2 - [\eta(\Delta p/p)]^2$ β:*measured by Q-trim excitation*

Emittance by Laser wire





< 0.5% y/x emittance ratio

Y emittance =4pm at small intensity

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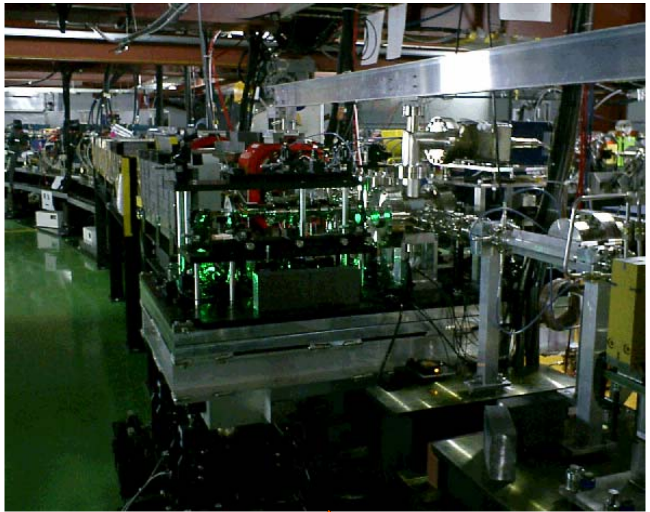
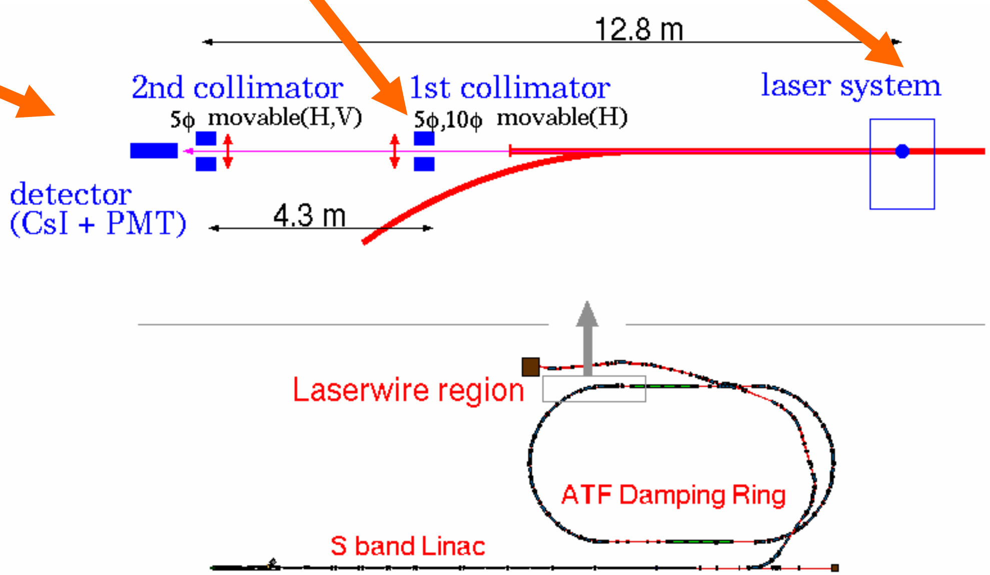
Achievement of Ultralow Emittance Beam in the Accelerator Test Facility Damping Ring

Y. Honda,[1] K. Kubo,[2] S. Anderson,[3] S. Araki,[2] K. Bane,[3] A. Brachmann,[3] J. Frisch,[3] M. Fukuda,[6] K. Hasegawa,[14] H. Hayano,[2] L. Hendrickson,[3] Y. Higashi,[2] T. Higo,[2] K. Hirano,[13] T. Hirose,[15] K. Iida,[12] T. Imai,[9] Y. Inoue,[7] P. Karataev,[6] M. Kuriki,[2] R. Kuroda,[8] S. Kuroda,[2] X. Luo,[11] D. McCormick,[3] M. Matsuda,[10] T. Muto,[2] K. Nakajima,[2] Takashi Naito,[2] J. Nelson,[3] M. Nomura,[13] A. Ohashi,[6] T. Omori,[2] T. Okugi,[2] M. Ross,[3] H. Sakai,[12] I. Sakai,[13] N. Sasao,[1] S. Smith,[3] Toshikazu Suzuki,[2] M. Takano,[13] T. Taniguchi,[2] N. Terunuma,[2] J. Turner,[3] N. Toge,[2] J. Urakawa,[2] V. Vogel,[2] M. Woodley,[3] A. Wolski,[4] I. Yamazaki,[8] Yoshio Yamazaki,[2] G. Yocky,[3] A. Young,[3] and F. Zimmermann[5]

Experimental setup

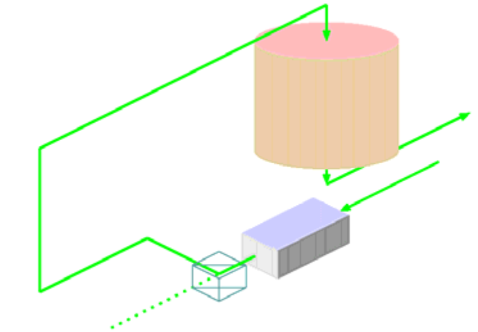




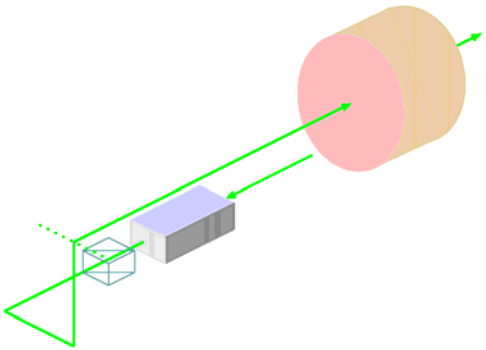
1. laserwire
2. detector and collimator
3. data taking system

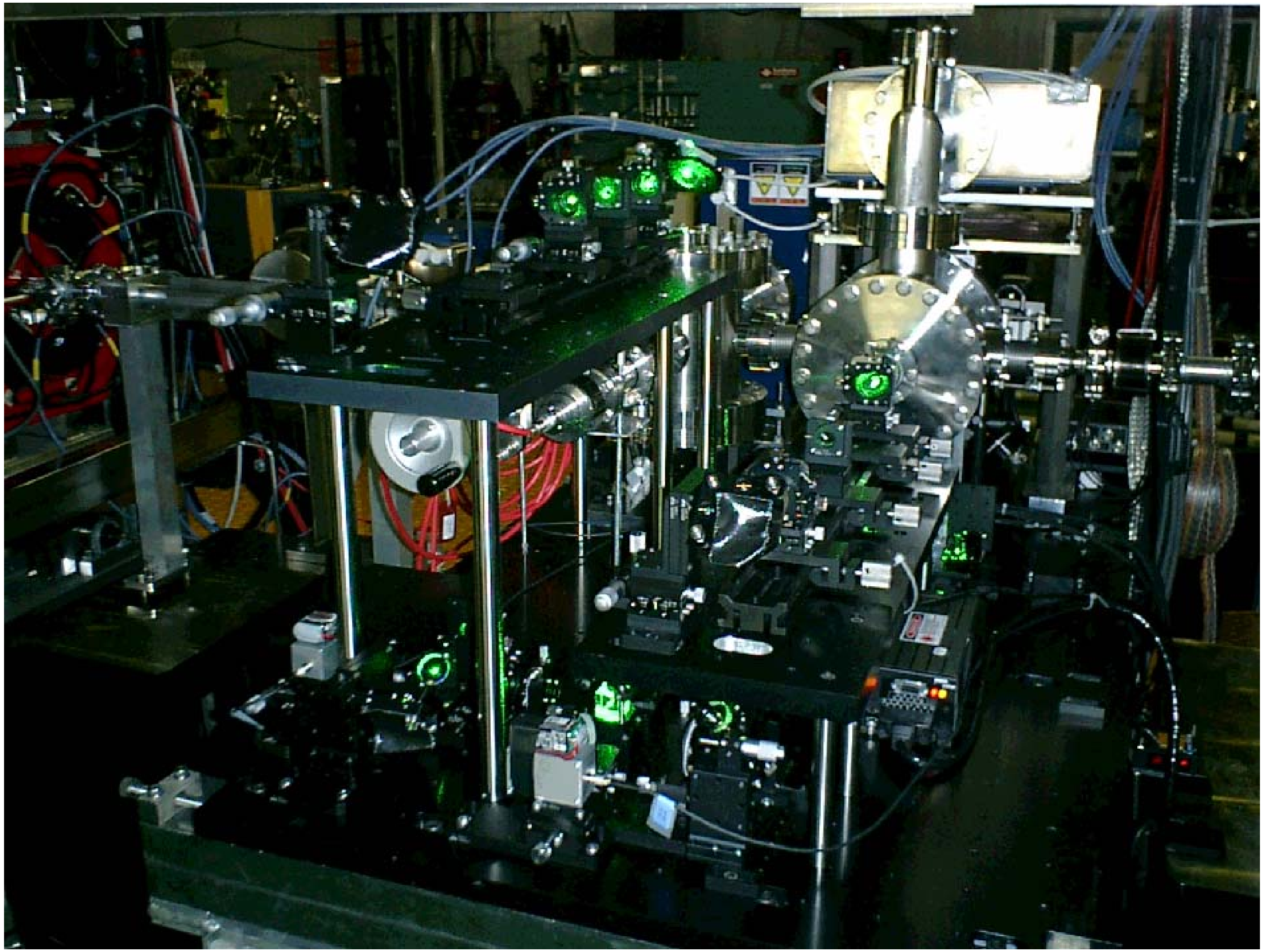
Laserwire setup

vertical wire



horizontal wire



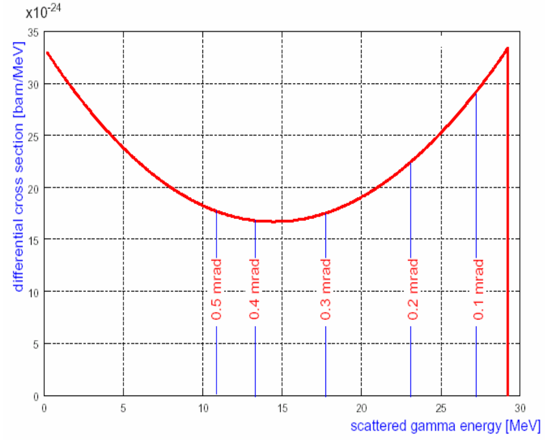


Detector

- Compton scattering

  28.6 MeV (max gamma energy)

  23.0 MeV (0.2 mrad scattering angle)

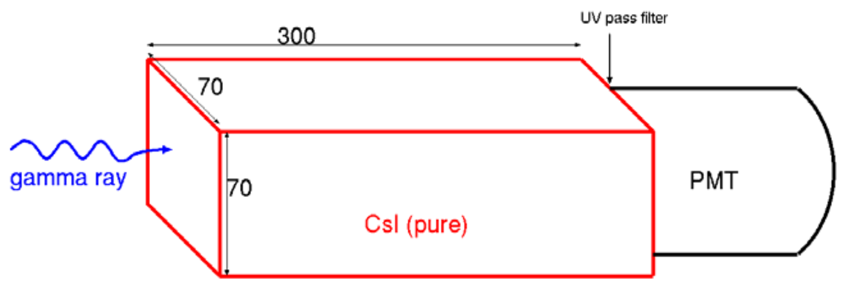


- gamma ray detector

  [70 mm × 70 mm × 300 mm]

  CsI(pure) crystal

  2” photo-multiplier



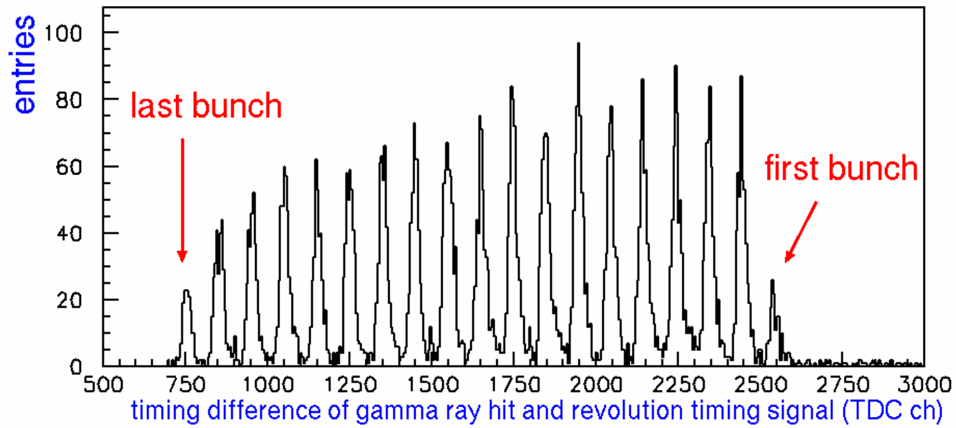
- time resolution

  PMT signal leading edge

  0.56 nsec resolution

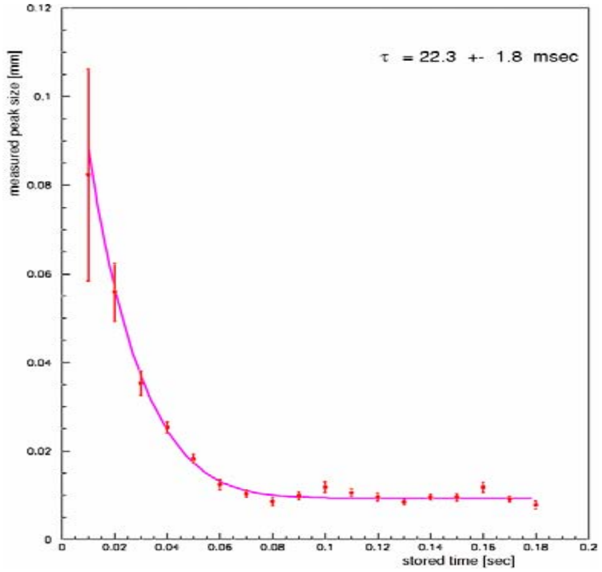
  (signal energy region)

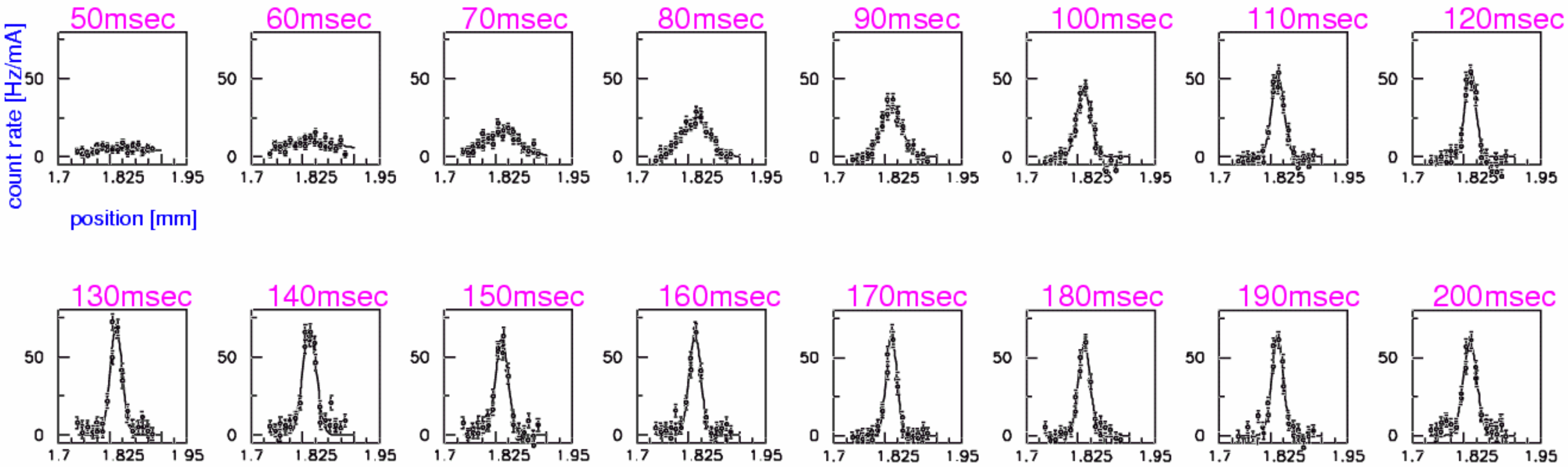
  enough to separate 2.8ns spacing bunches



Beam damping measurement

- beamsize measurement as a function of storage time

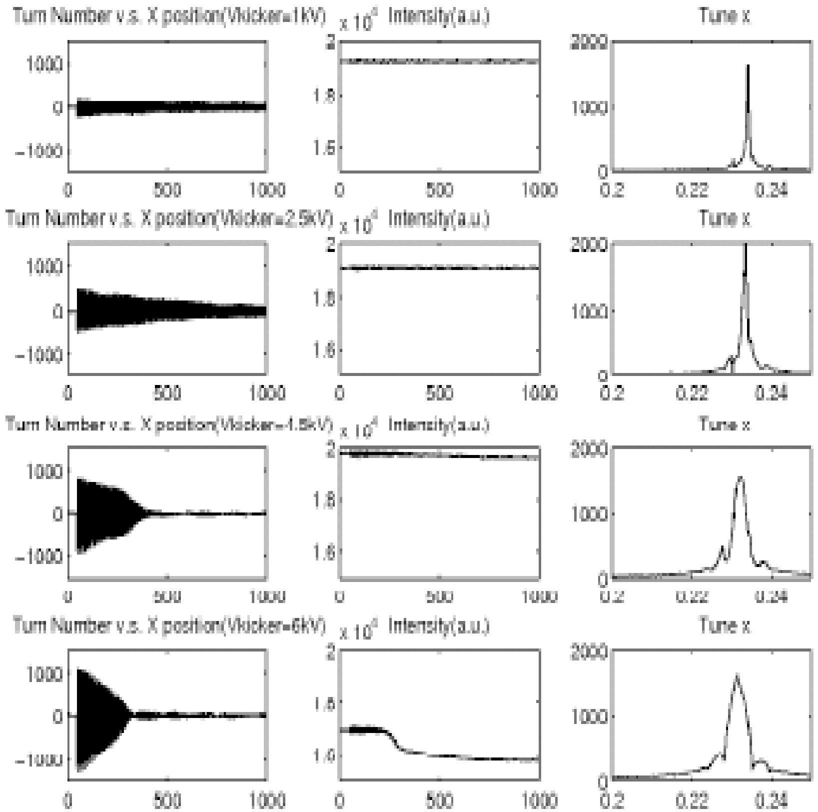




New powerful data acquisition system will be installed in Nov..

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(Horizontal)



Single kick result(Verticall)

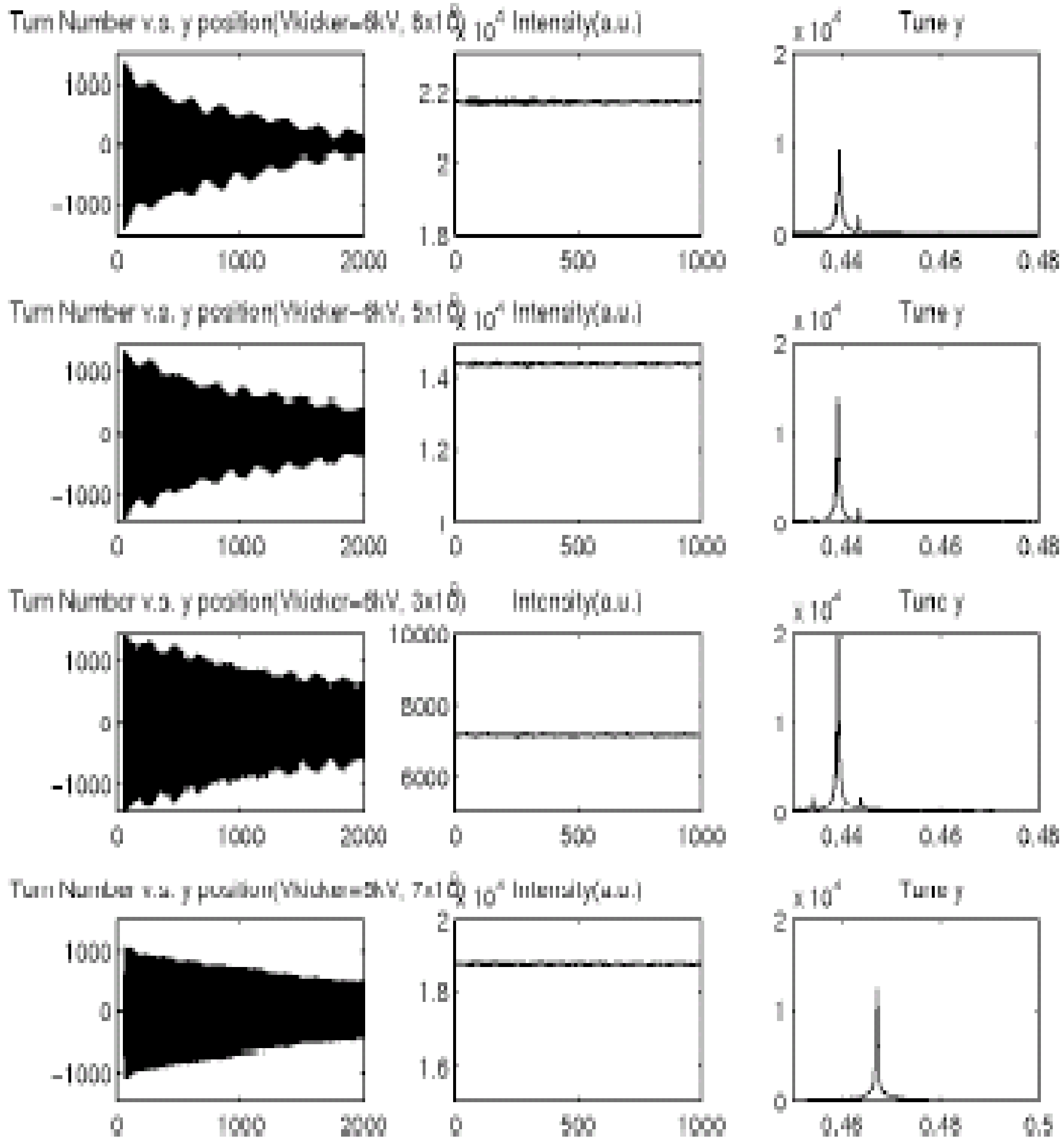


Fig.1, x vs. turn number for various initial kick angle, 0~300 turns

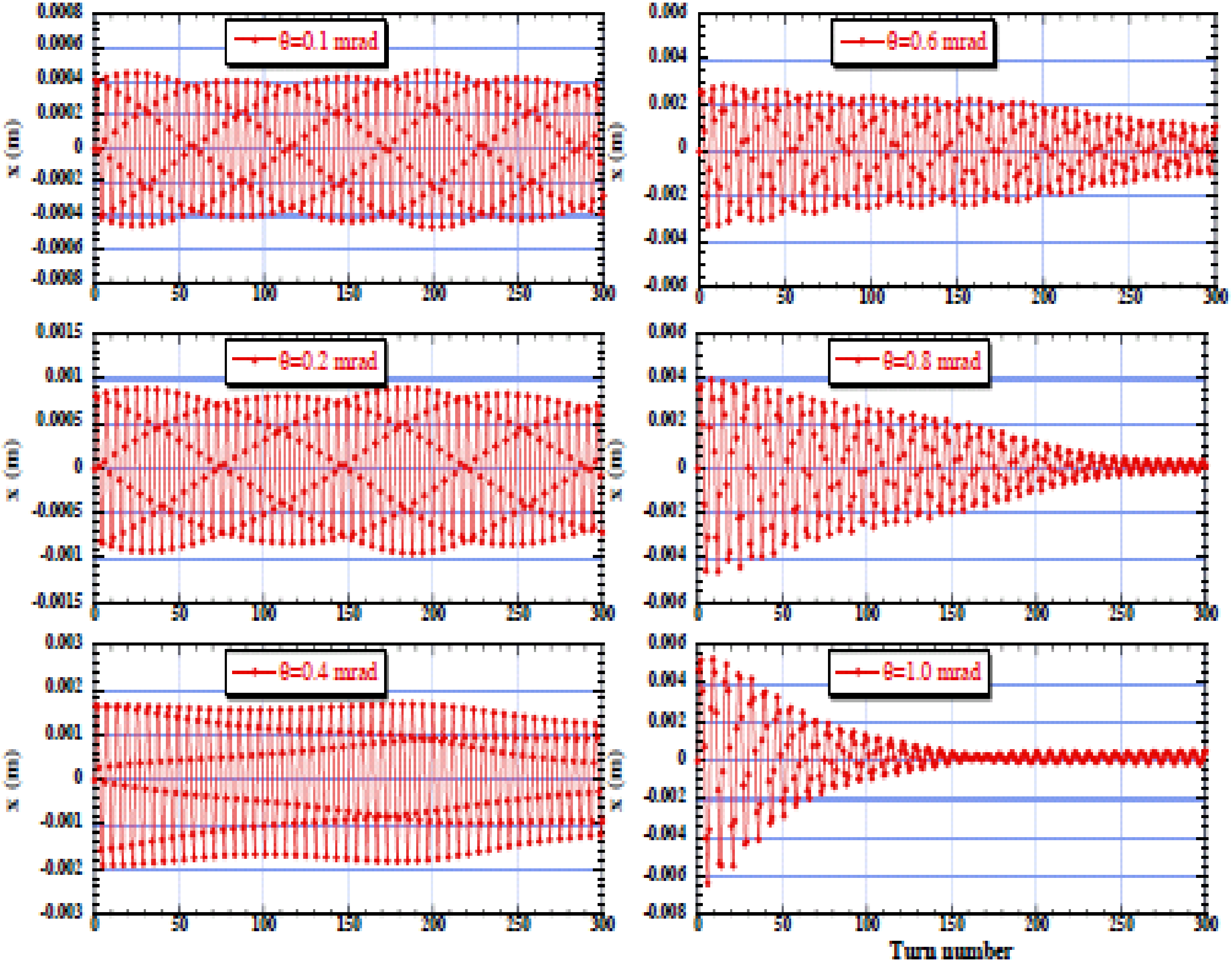


Fig. 3, Horizontal phase space distribution for large amplitude, turn 0 ~ 60

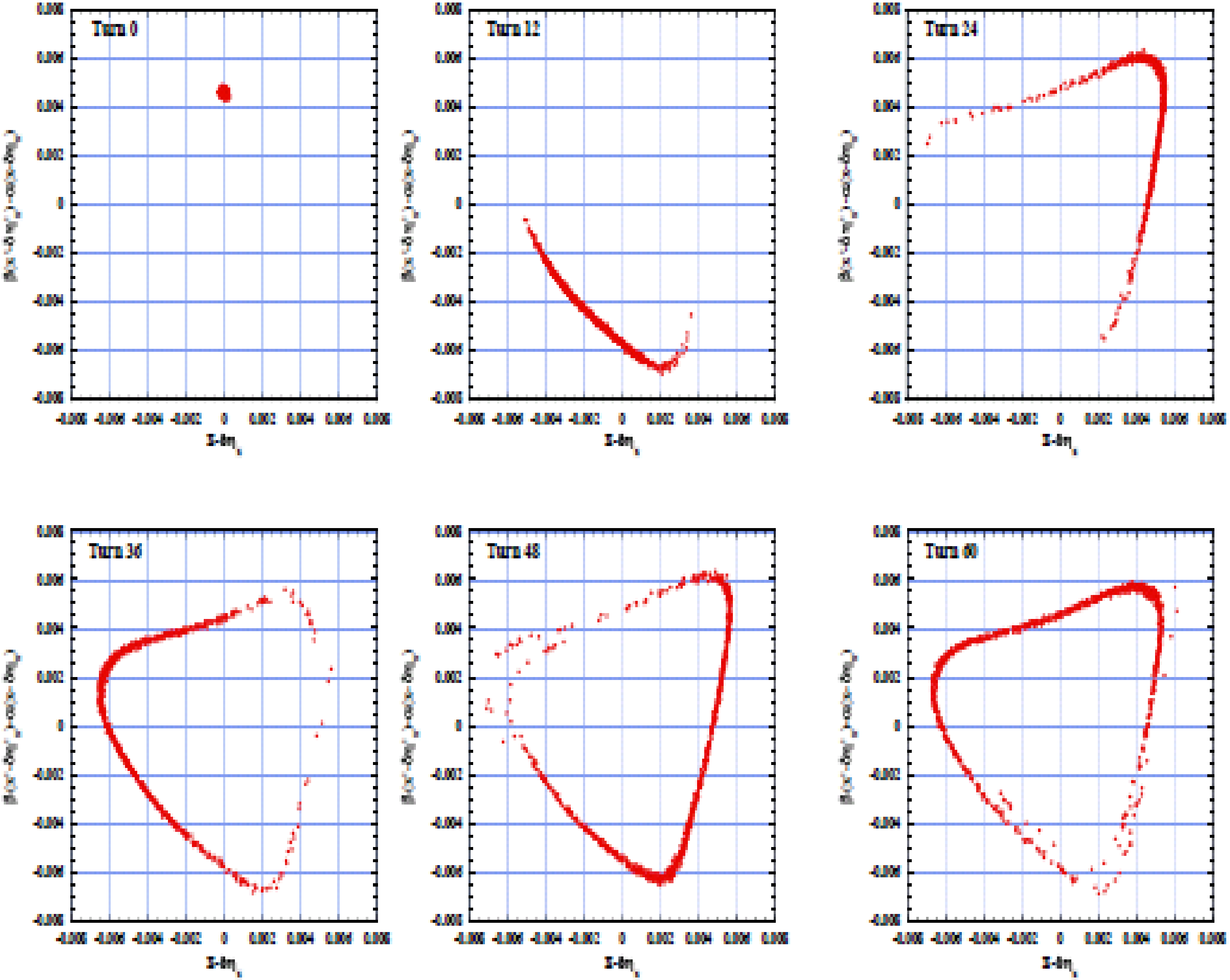
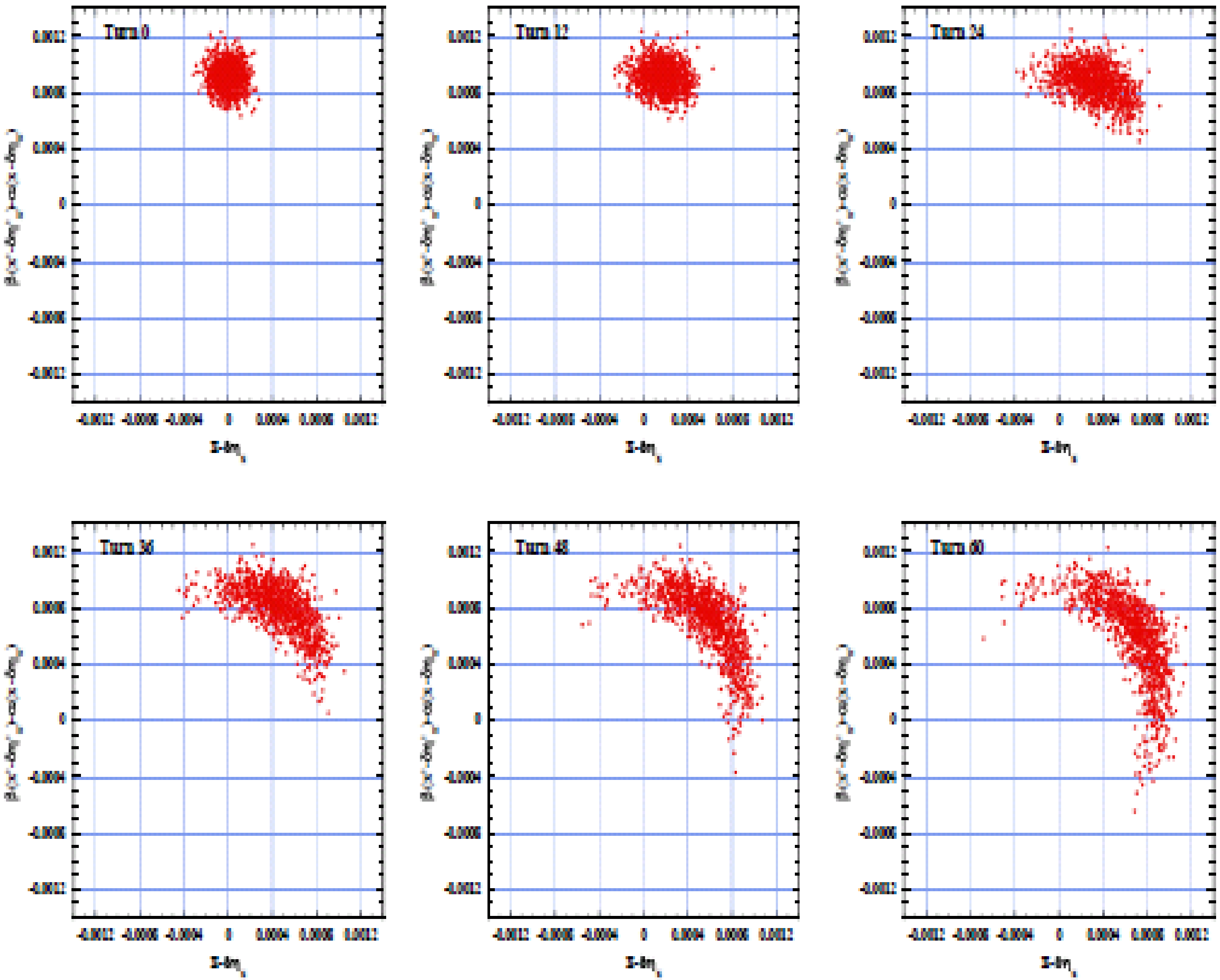
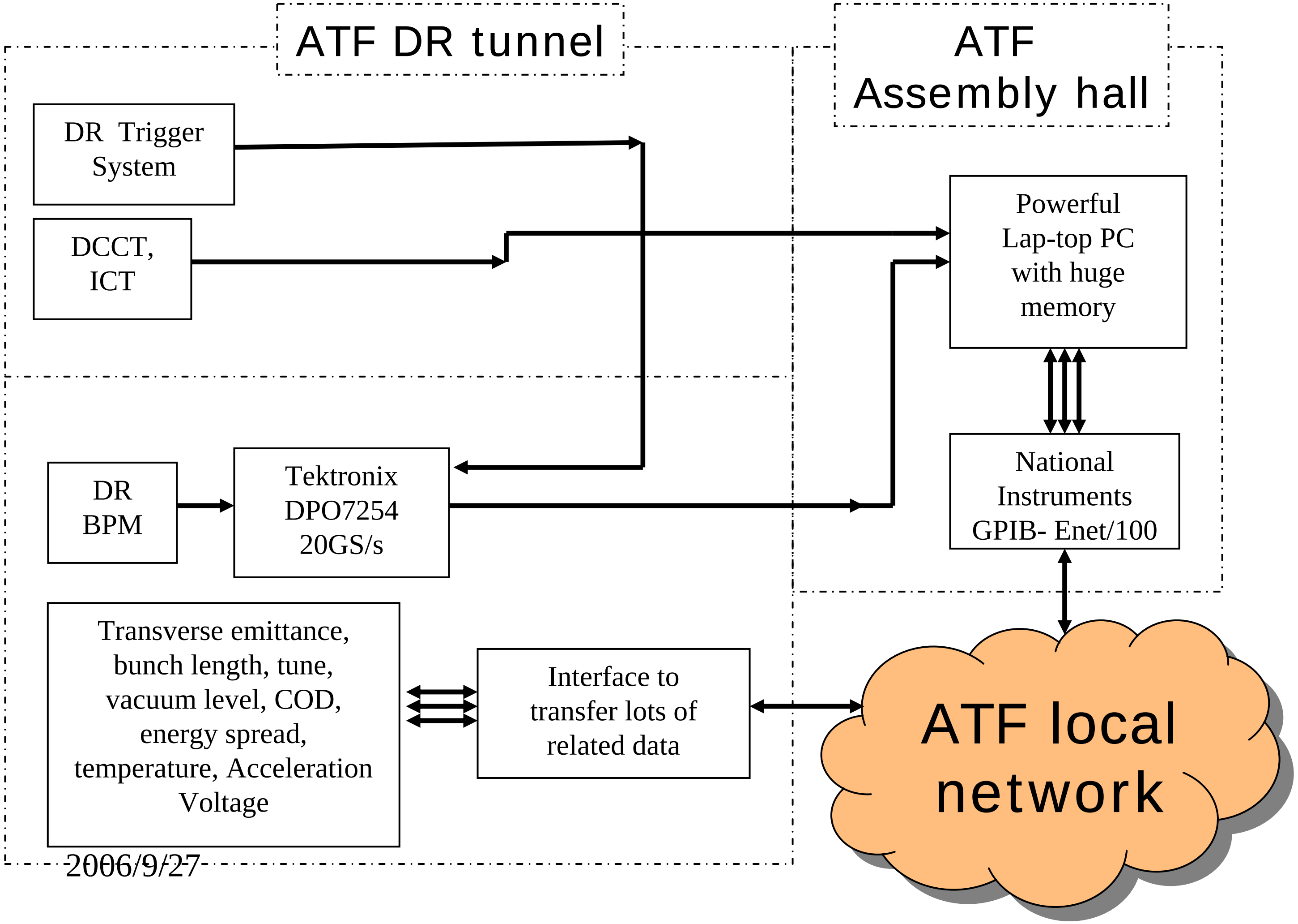


Fig. 4, Horizontal phase space distribution for small amplitude, turn 0 ~ 60

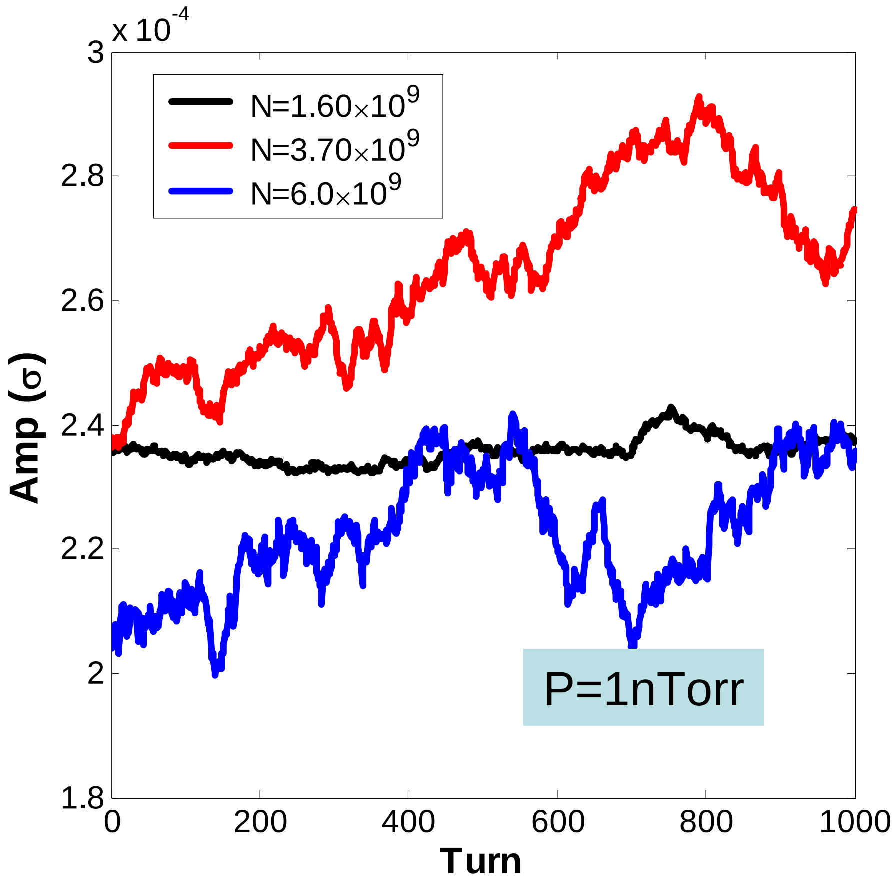


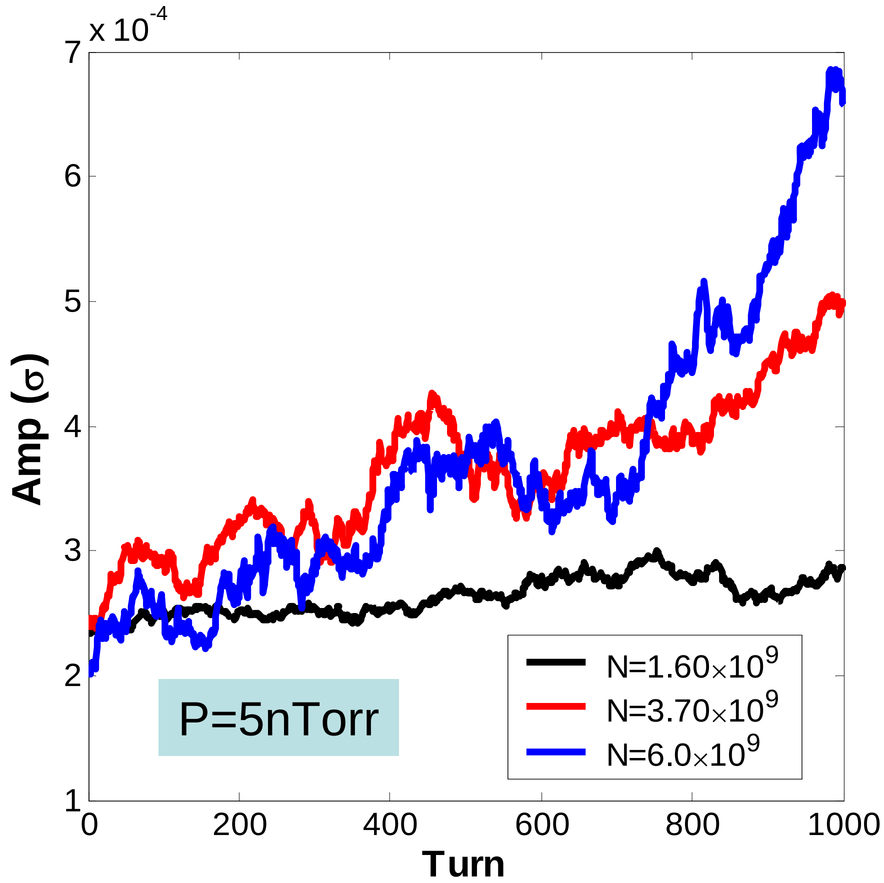
New powerful data acquisition system

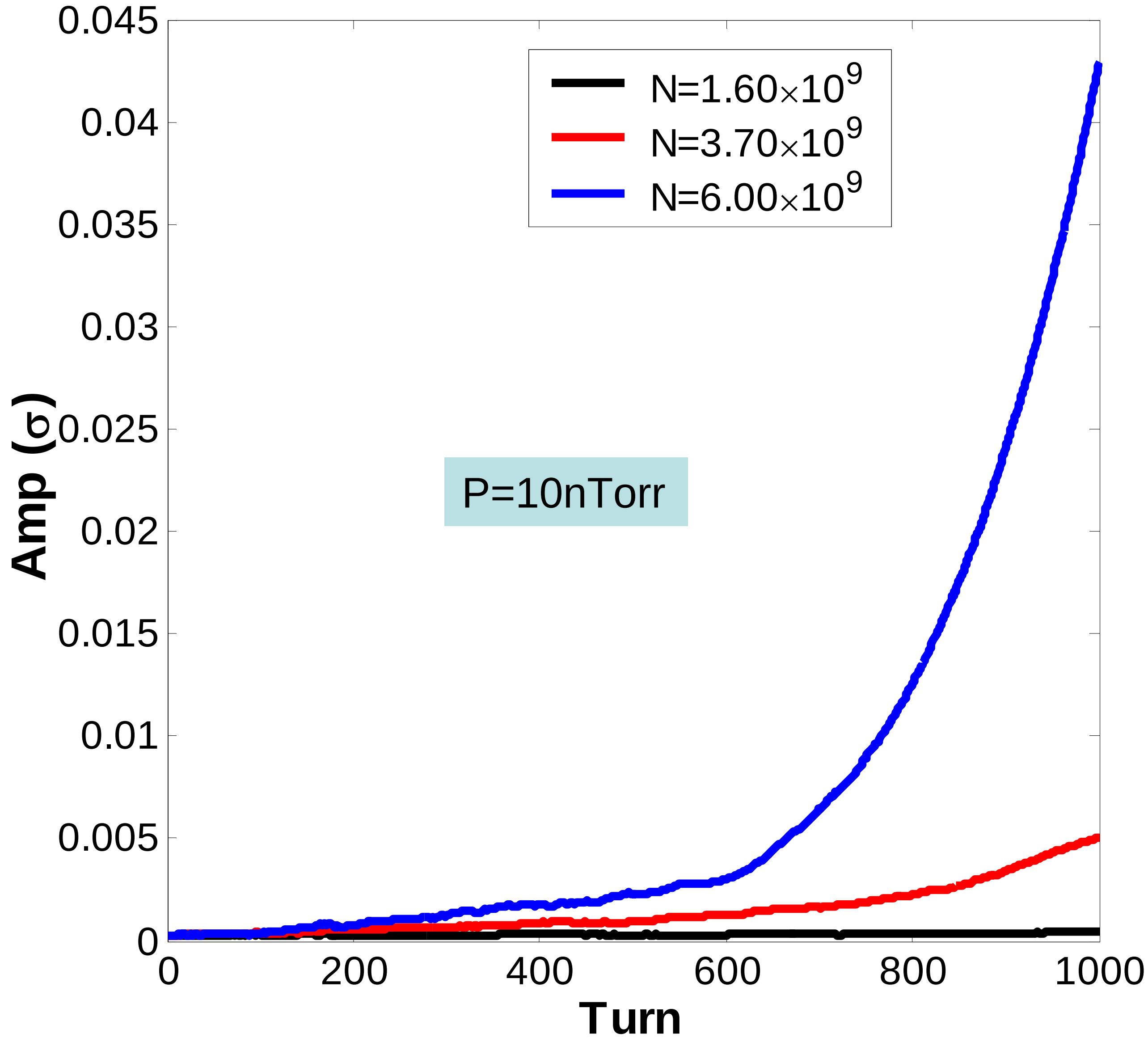
DAQ which will be made soon



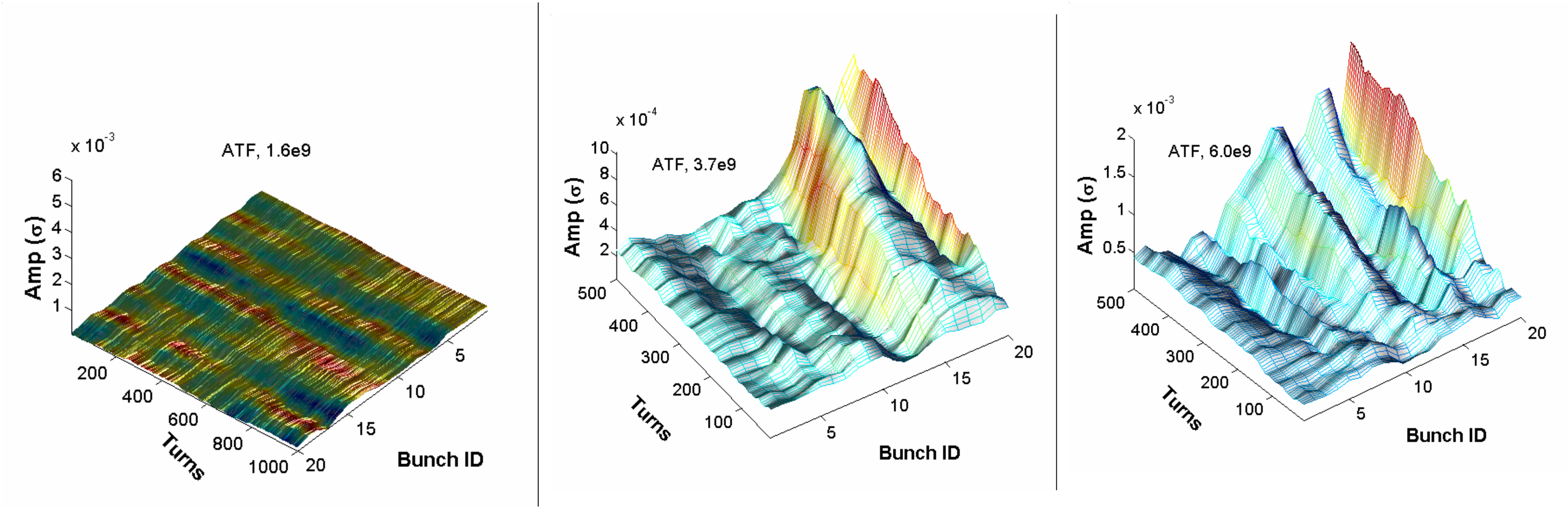
Lanfa Wang tried a simulation about FII at ATF. He used the similar parameters as Tor used. The optics is included. This is a weak-strong program, so only dipole oscillation can be simulated. **Preliminary**






0.045
0.04
0.035
0.03
0.025
0.02
0.015
0.01
0.005
0
Amp (σ)
N=1.60×10^9
N=3.70×10^9
N=6.00×10^9
P=10nTorr
0
200
400
600
800
1000
Turn

FII at ATF



P=10nTorr

Experimental Plan for study on fast ion instability

The range from several 10^9 to $3x10^{10}$ 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.