

# ATF Fast Ion Study Plan

- Results in 2007, 2008
- Vertical emittance studies at ATF
- Plan

N.Terunuma (KEK)

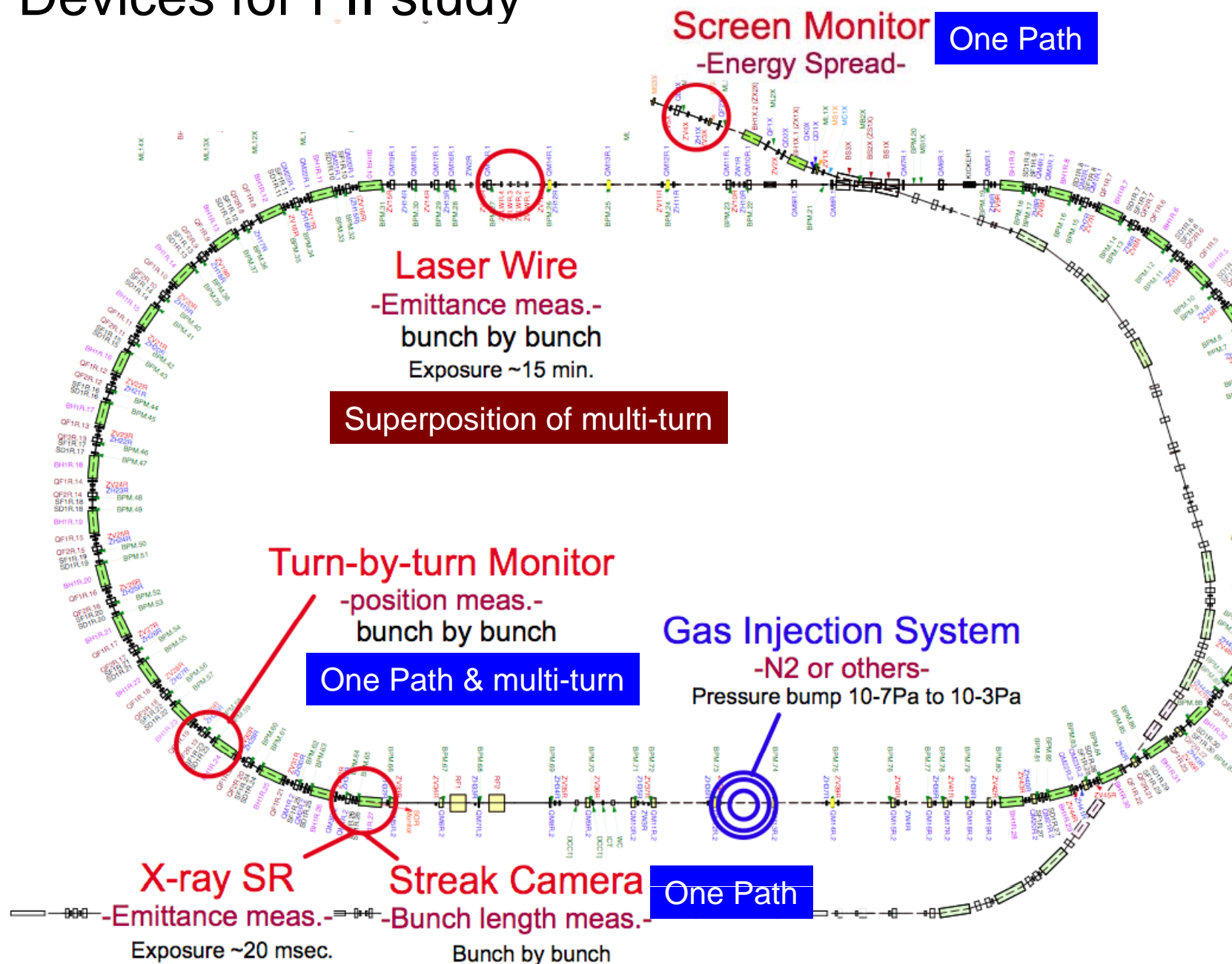
# Goals of the experiment

(according to Two proposals

(L. Wang, T. Raubenheimer and G. Xia, E. Elsen)

- **Distinguish the two ion effects: beam size blow-up and dipole instability.**
- Quantify the beam instability growth time and tune shift. The growth rate is related to the ion density (vacuum pressure, average beam line density, emittance, betatron function and so on).
- Quantify the bunch train gap effect
- Provide detailed data to benchmark simulations with experiment.

# Devices for FI study



# FII study on 2007/3/13-14 (1)

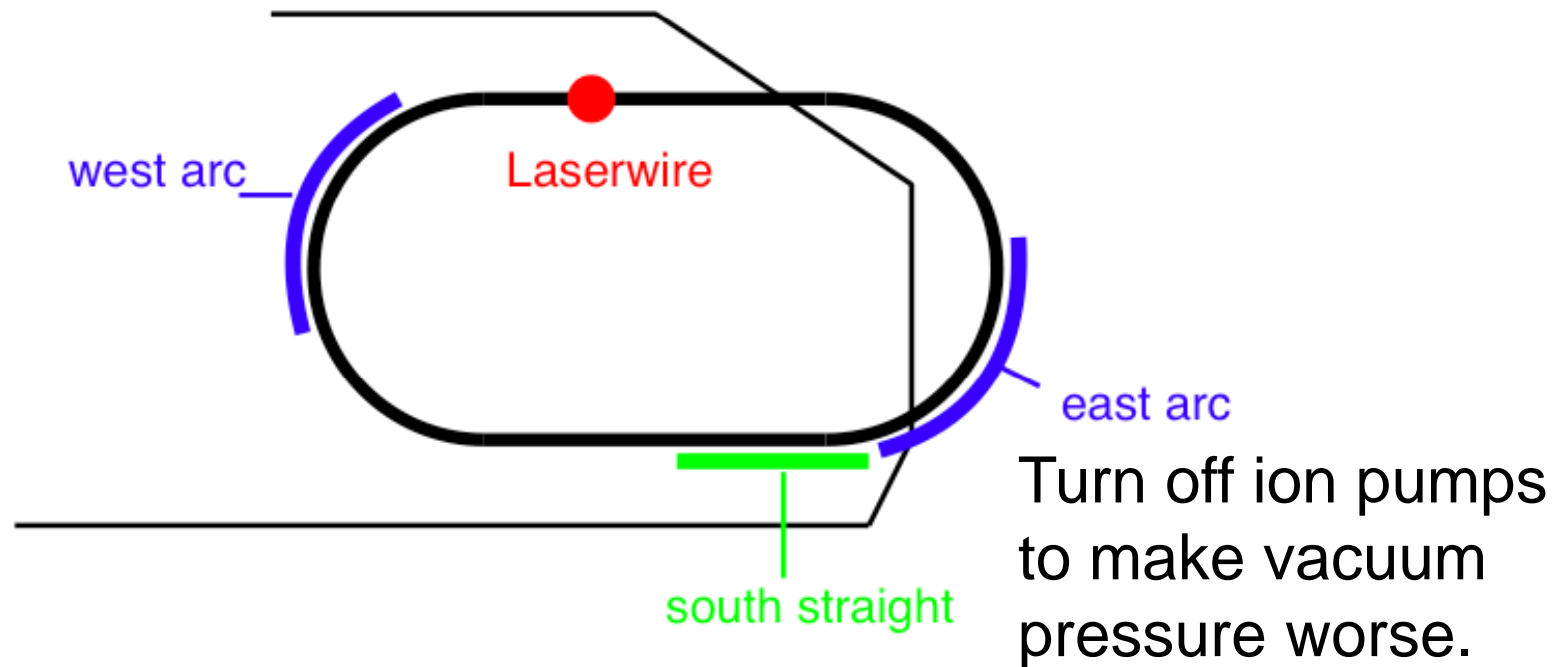


Figure 3: Sections that ion pumps were turned off in this experiment

Table 1: vacuum pressure in the measurements

ion pump status	5mA	10mA	20mA
normal	$4.6 \times 10^{-7}$ Pa	$5.9 \times 10^{-7}$ Pa	$1.0 \times 10^{-6}$ Pa
south straight OFF	$2.0 \times 10^{-6}$ Pa	$2.7 \times 10^{-6}$ Pa	$5.5 \times 10^{-6}$ Pa
both arcs and south straight OFF	$3.4 \times 10^{-6}$ Pa	$5.2 \times 10^{-6}$ Pa	

# FII study on 2007/3/13-14 (2)

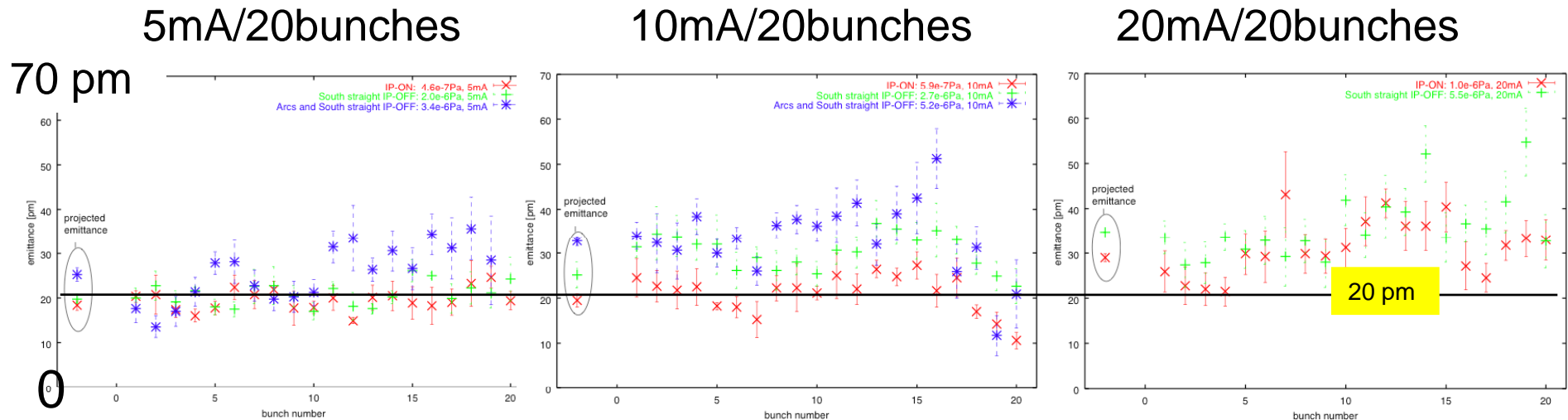


Figure 7: emittance of multi-bunch beam at 5mA/20bunches

Figure 8: emittance of multi-bunch beam at 10mA/20bunches

Figure 9: emittance of multi-bunch beam at 20mA/20bunches

We measured emittance of each bunch in a 20-bunch beam in the DR with a laser-wire monitor. **No clear emittance blow-up** along a train was observed up to 20mA/train.

**One of the reason may be the bigger vertical emittance compared with the data taken in 2004.**

# FII study on 2007/3/13-14 (3)

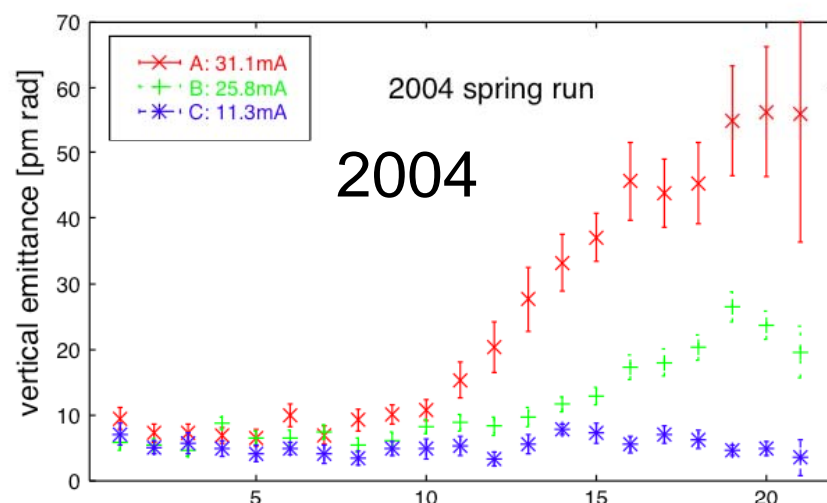
## Vertical emittance of 20 bunches in ATF DR

Table 2: vacuum pressure in 2004

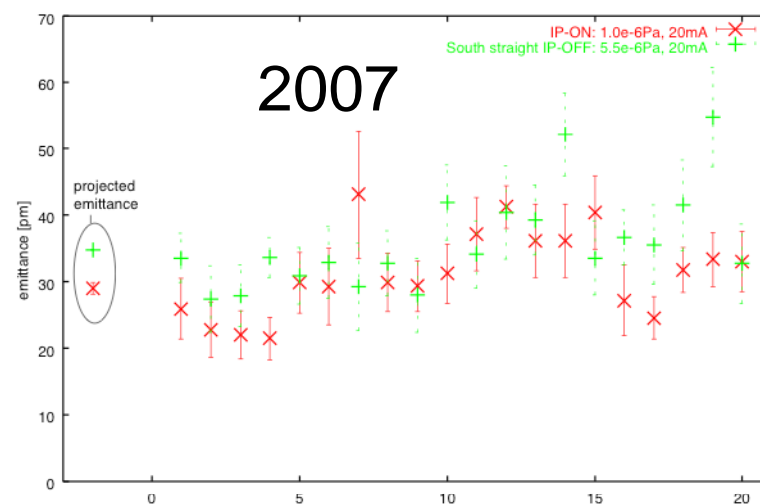
ion pump status	11mA	26mA	31mA
normal	$4.0 \times 10^{-6}$ Pa	$6.0 \times 10^{-6}$ Pa	$6.5 \times 10^{-6}$ Pa

Table 1: vacuum pressure in the measurements

ion pump status	5mA	10mA	20mA
normal	$4.6 \times 10^{-7}$ Pa	$5.9 \times 10^{-7}$ Pa	$1.0 \times 10^{-6}$ Pa
south straight OFF	$2.0 \times 10^{-6}$ Pa	$2.7 \times 10^{-6}$ Pa	$5.5 \times 10^{-6}$ Pa
both arcs and south straight OFF	$3.4 \times 10^{-6}$ Pa	$5.2 \times 10^{-6}$ Pa	



Single bunch is less than 10pm.

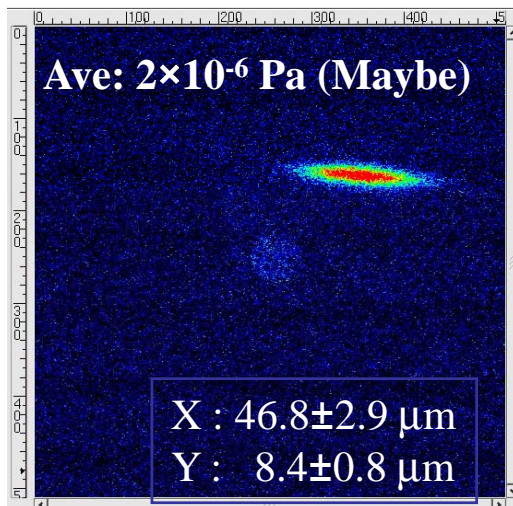
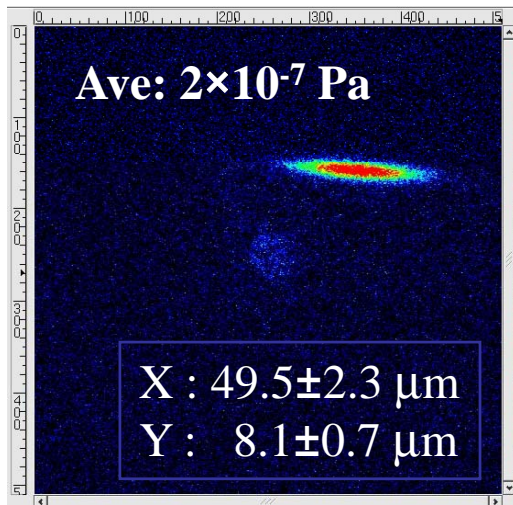


Bunches are already bigger.  
Single bunch is also bigger.



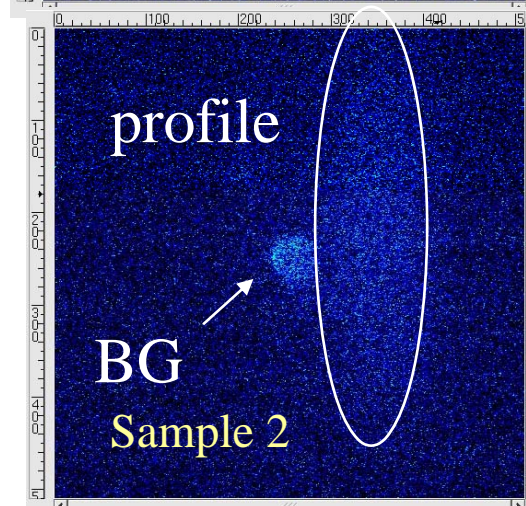
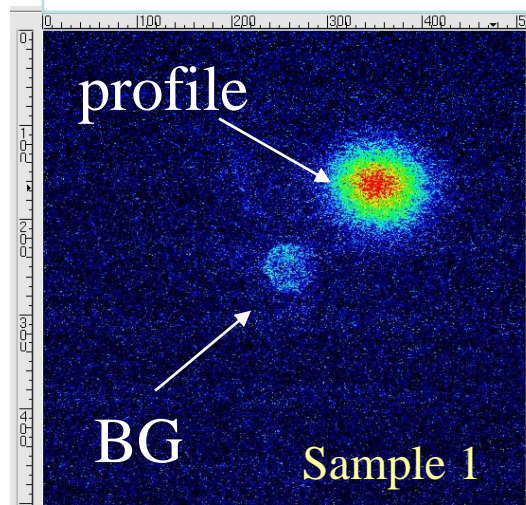
# Measured beam profile by XSR monitor, 2007/Feb-Apr.

Single bunch,  $2 \times 10^{10}$  /bunch

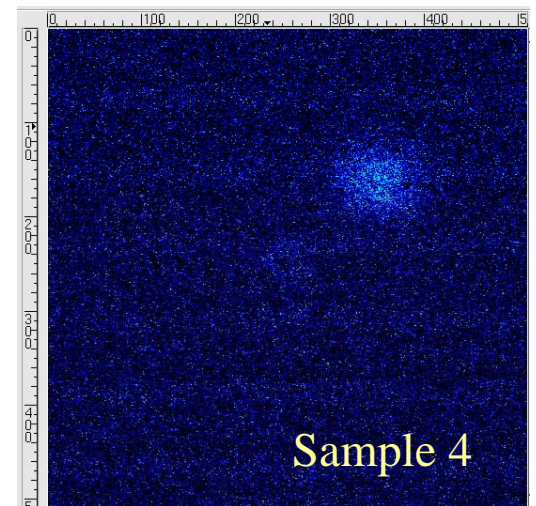
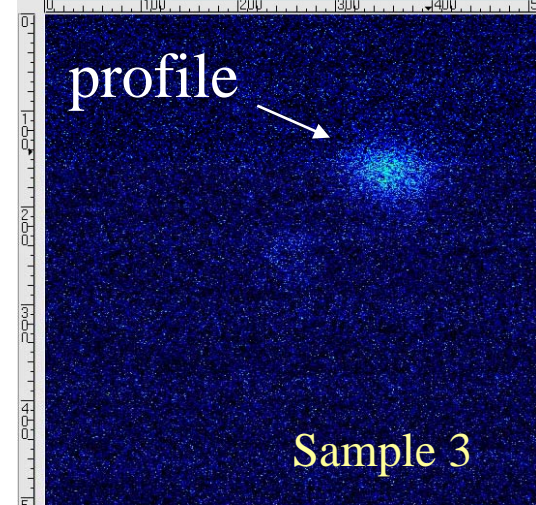


3 train mode,  $2 \times 10^{10}$  /bunch

Vacuum :  $1 \times 10^{-5}$  Pa



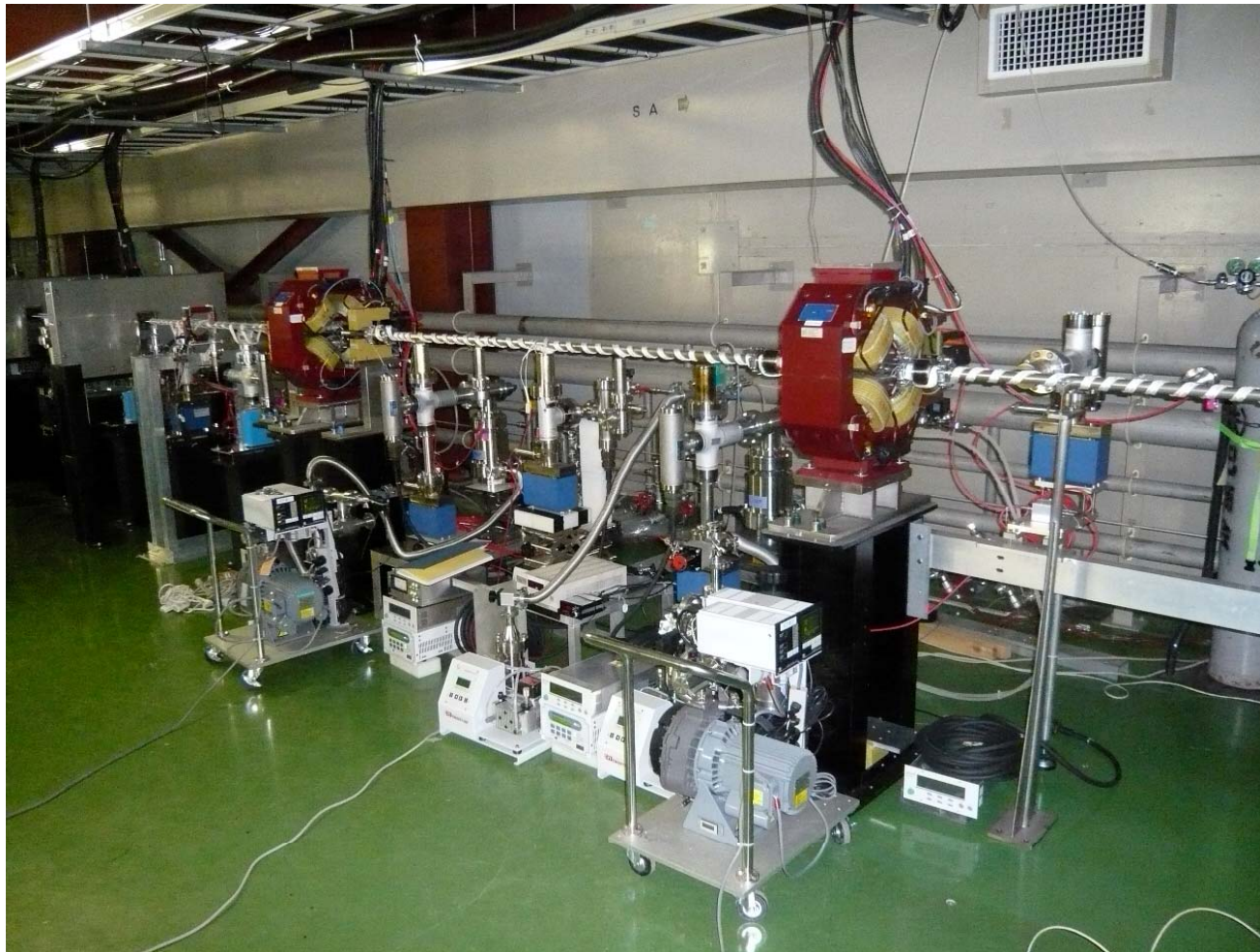
Vacuum :  $2 \times 10^{-6}$  Pa





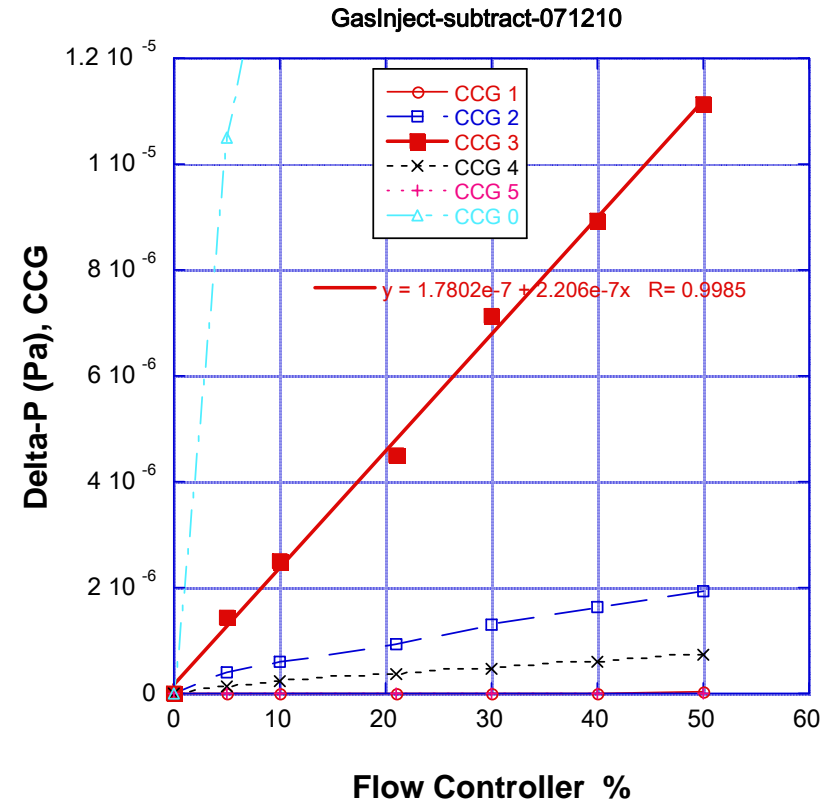
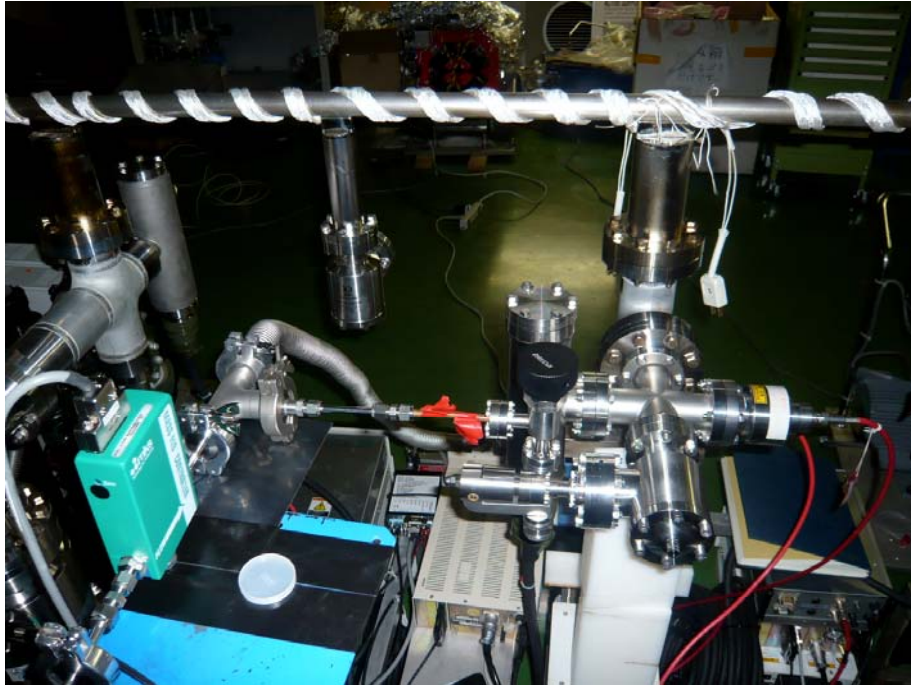
# Gas Injection system at ATF-DR

## -South straight section-





# Gas Injection system



- Continuous gas leak into the beam chamber.
- Gas flow control:
  - Fine-leak valve + flow controller(0~100%)
  - Pressure range:  $10^{-7}$  Pa ~  $10^{-3}$  Pa.

# Pressure bump at ATF-DR

Pressure bump at ATF-DR

Gas Injection System  
-N<sub>2</sub> or others-  
Pressure bump 10-7Pa to 10-3Pa

Scaled by  
monitored pressure.

RF Cavity

-N2 or others-

Pressure bump  $10^{-7}\text{Pa}$  to  $10^{-3}\text{Pa}$

Scaled by  
monitored pressure.

## RF Cavity

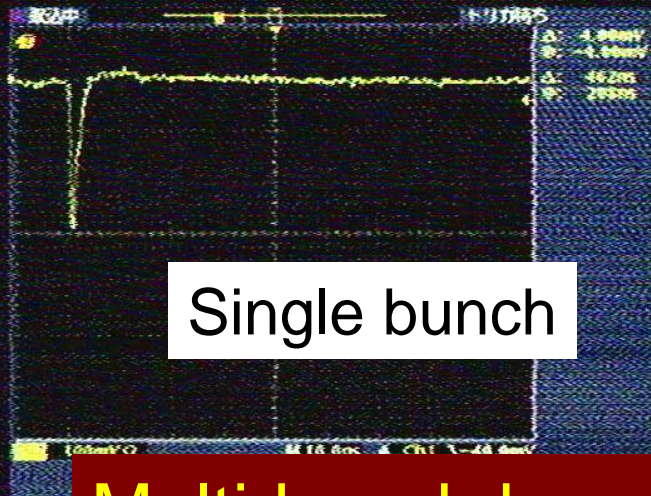


# R&D results on Dec 2007

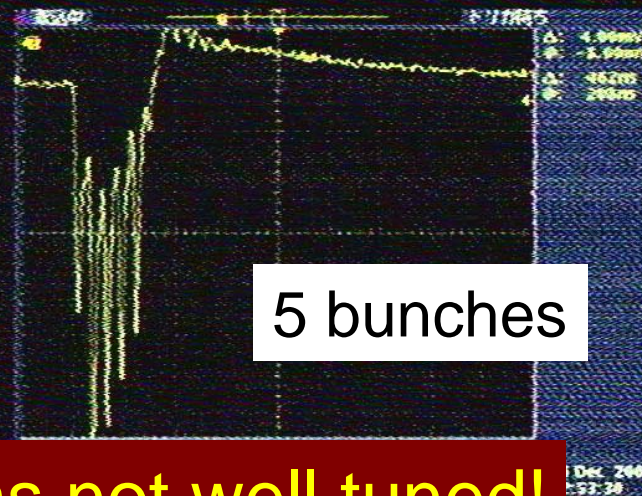
- **First shift with the gas injection system.**
  - Remote participation from DESY (Guoxing and Eckhard)
  - Check the sub-systems especially for the gas injection.
  - Gas injection system worked fine with beam.
- **Vertical emittance was about 50pm but we need 10pm or less.**
  - Beam blow up was observed by XSR in 3 train mode.
  - No significant difference by changing the number of bunches was seen.
- **Multi-bunch beam was not well tuned.**
- **Vacuum in DR, North/South, was higher than usual.**
  - Beam line was opened to install Gas system, Laser-Compton system and the fast kicker chambers in fall 2007.



# Stored bunches in DR, Dec 2007

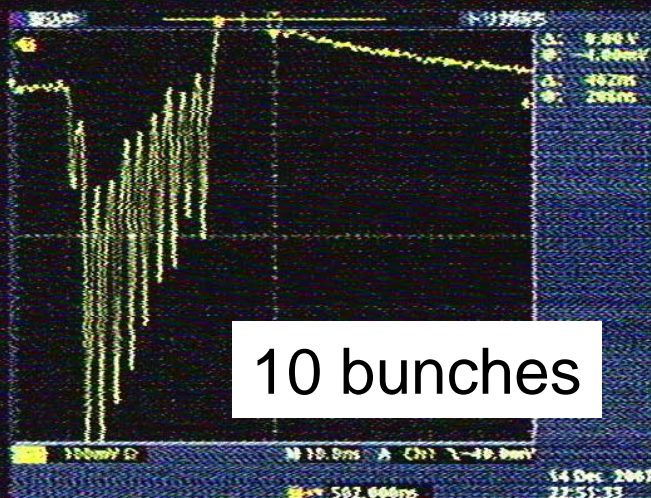


Single bunch

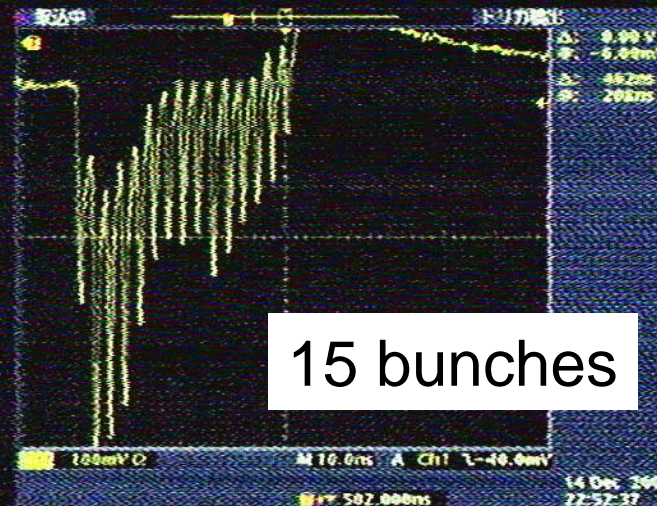


5 bunches

**Multi-bunch beam was not well tuned!**



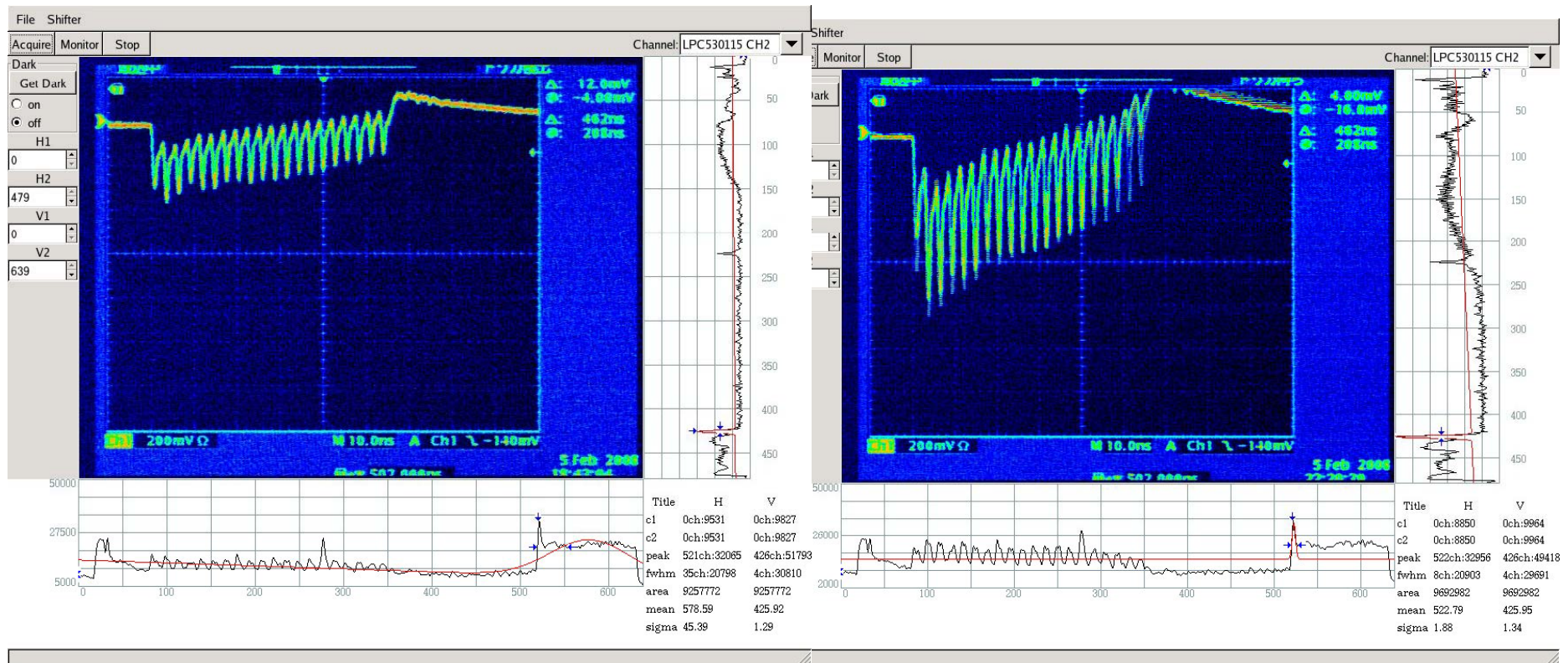
10 bunches



15 bunches



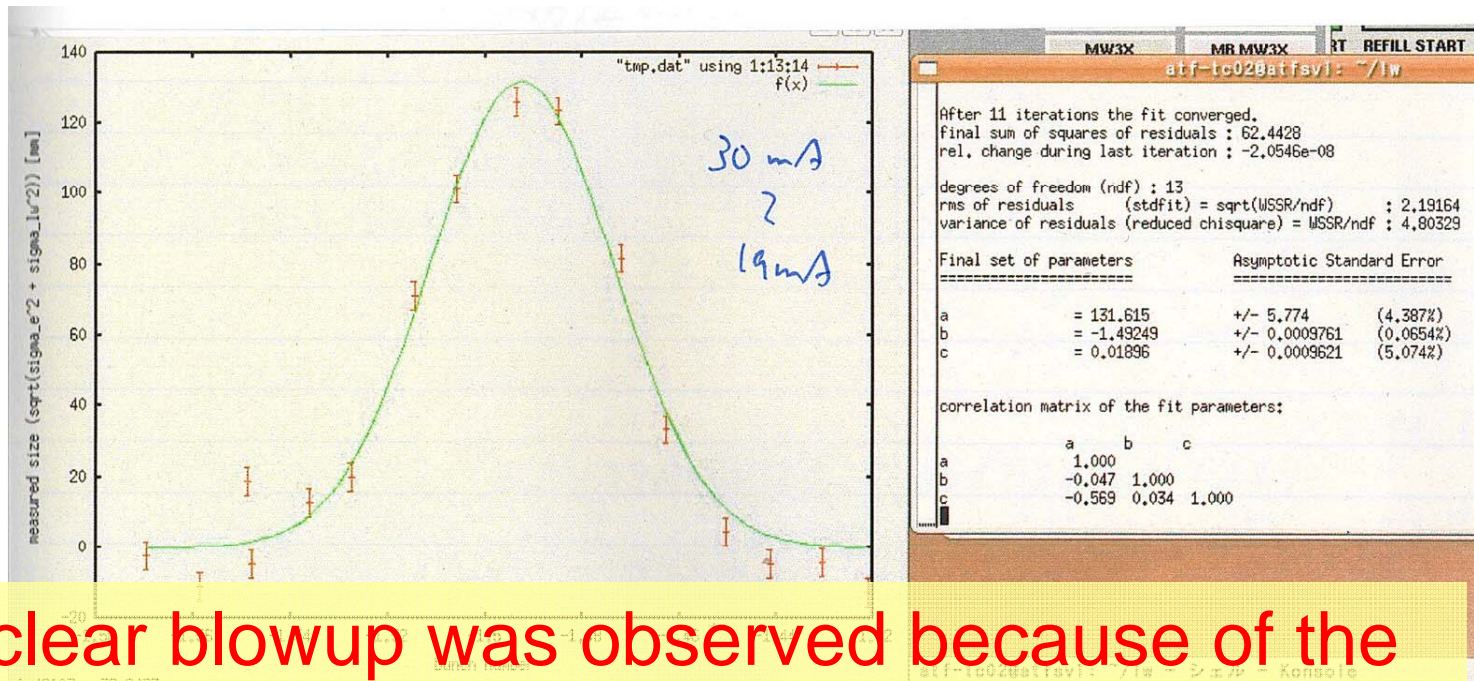
# Example of multi-bunch (DR) on 2008/Feb/5



0.4E10/bunch, 20bunch

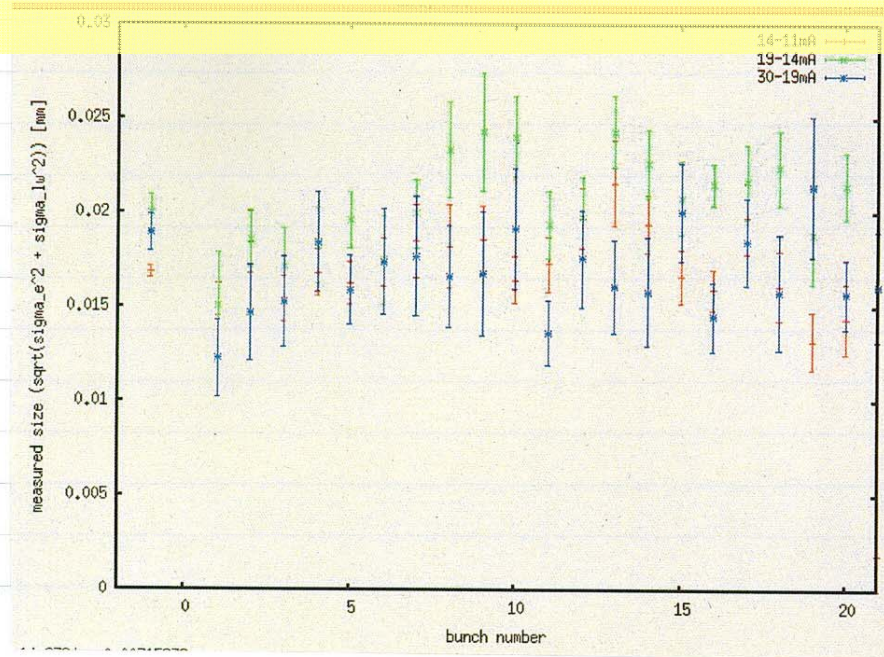
1.0E10/bunch, 20bunch





No clear blowup was observed because of the bigger emittance.

Vertical beam  
size by LW  
2008/Feb/5



# Vertical emittance became larger

- 5~10 pm had been achieved after emittance tuning described.
- Recently, about 20~30 pm, after the same procedure of the tuning. from 2006?
- Apparent vertical dispersion and x-y coupling are worse. (? may not be always ?)
- Optics model may be bad. (e.g. tunes and orbit response to steering magnet do not fit with the calculation.)

We need to solve the problem.

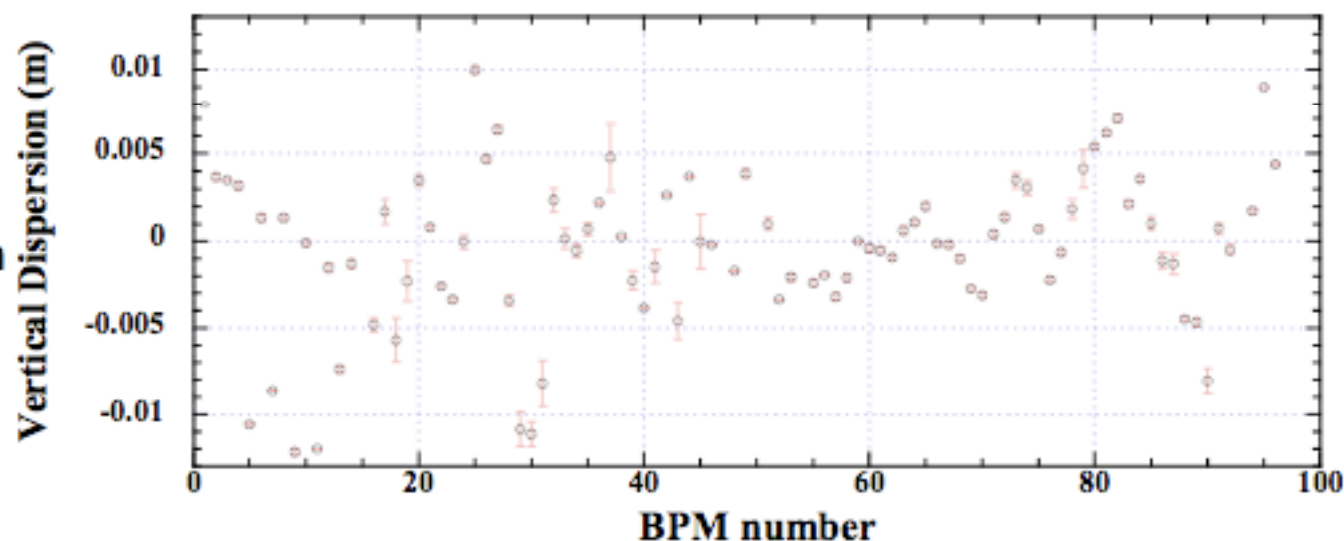
- ATF2 assumes ~10 pm.
- Many instrumentation development need small beam size. and Fast Ion Study!
- ILC damping ring requirement is 2 pm.

By K. Kubo

# Vertical dispersion, recent and old data

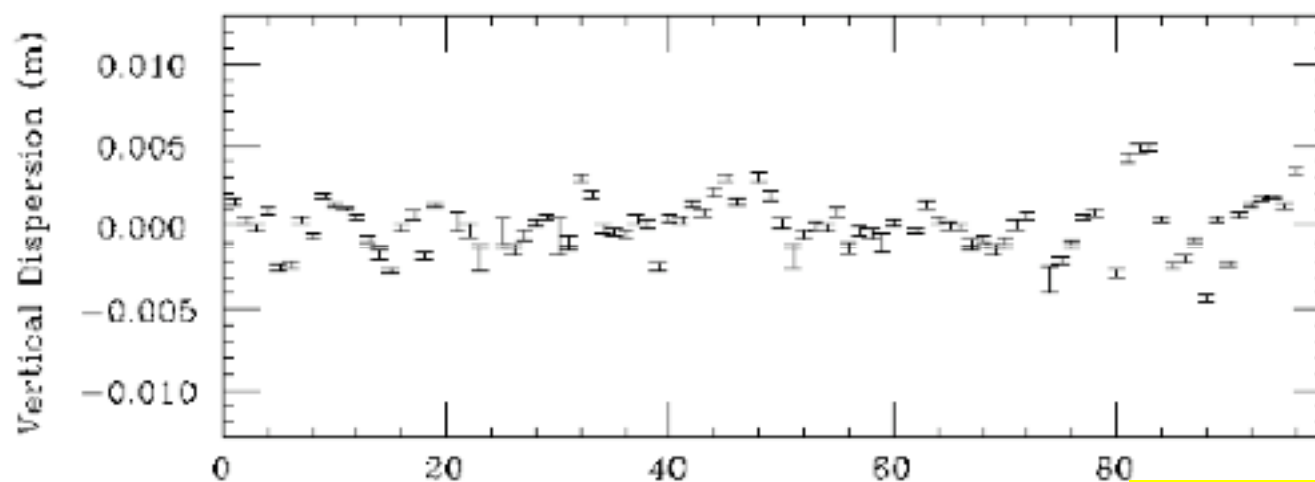
Feb.2008

RMS = 5 mm



May 2003

RMS = 3 mm

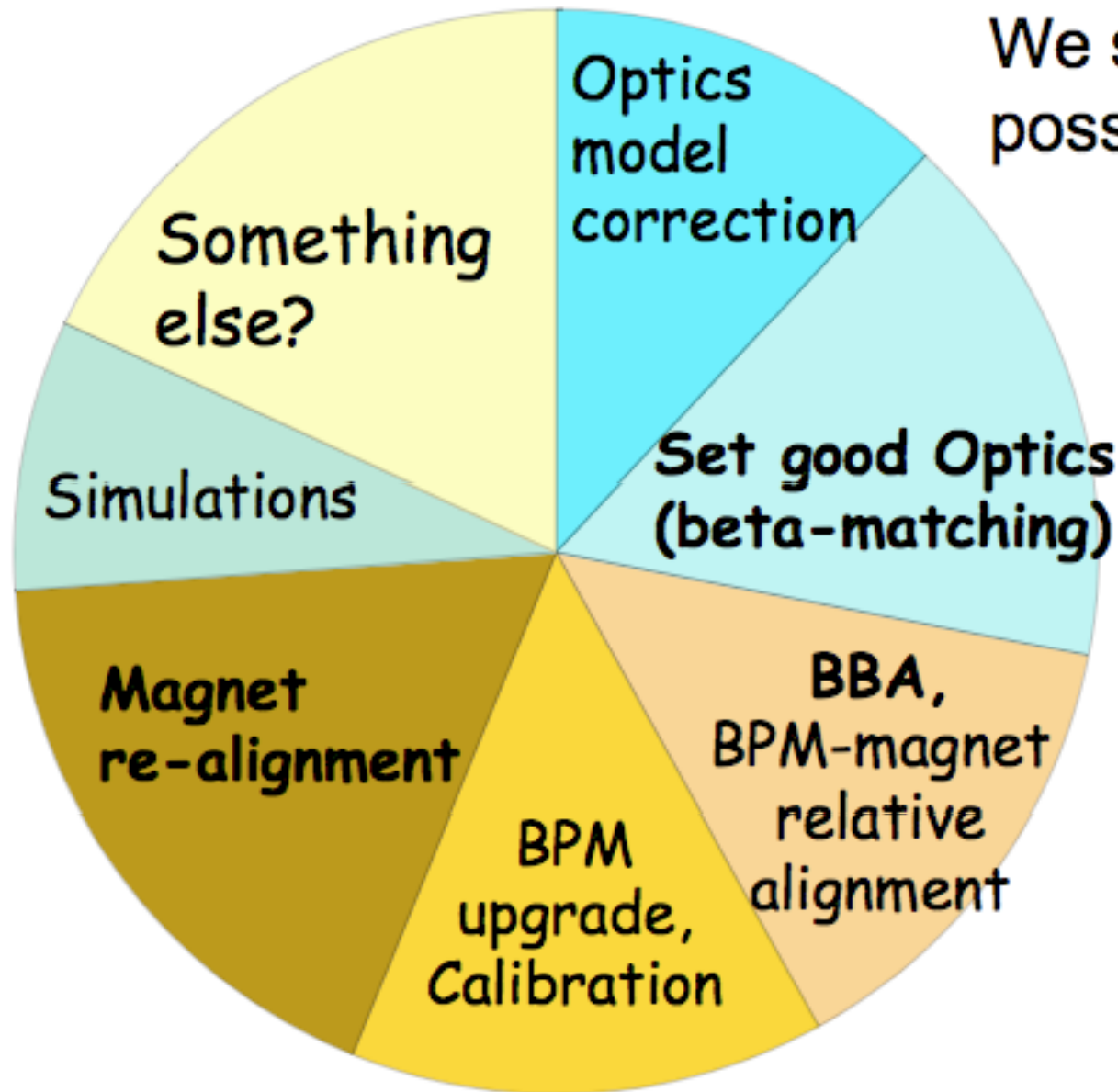


By K. Kubo



# SUMMARY: What can be done?

We should try any possibilities.

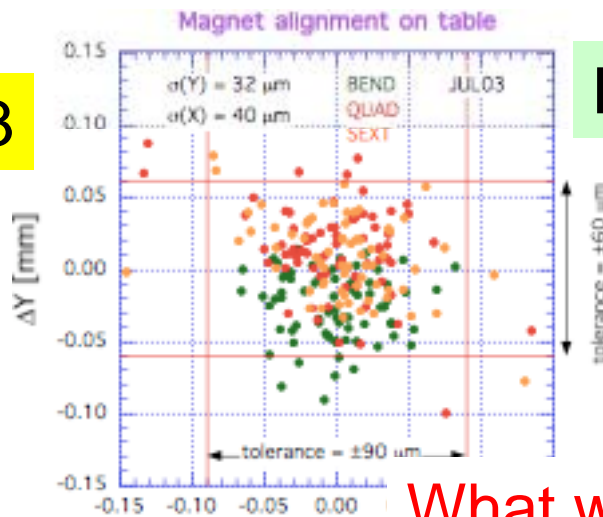


By K. Kubo

# Survey of the magnet positions in DR

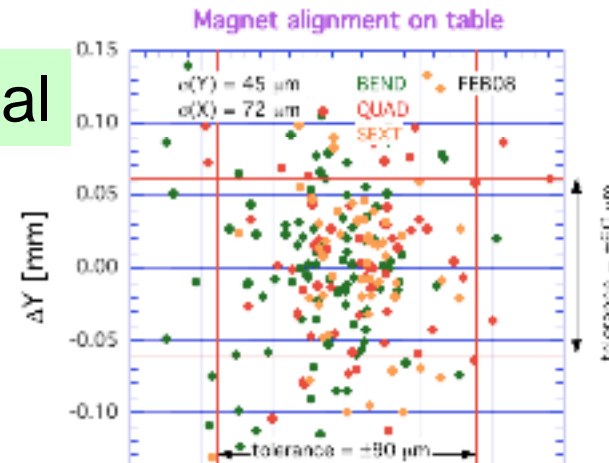
2003

$\Delta X$



Horizontal

2008



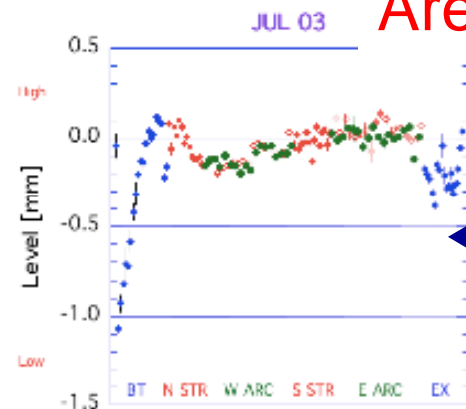
What was happened?

Is this an effect of ATF2 construction?

Are these movements in several years?

$\Delta Y$  [mm]

図4. ムーバー架台上的電磁石



Different tools  
were used for  
vertical position  
measurement.

Vertical

図6. DR水準測量 (JUL03) .

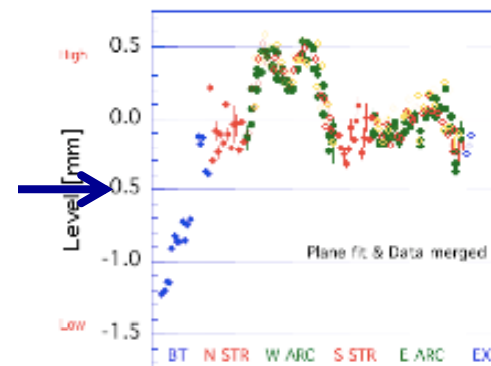
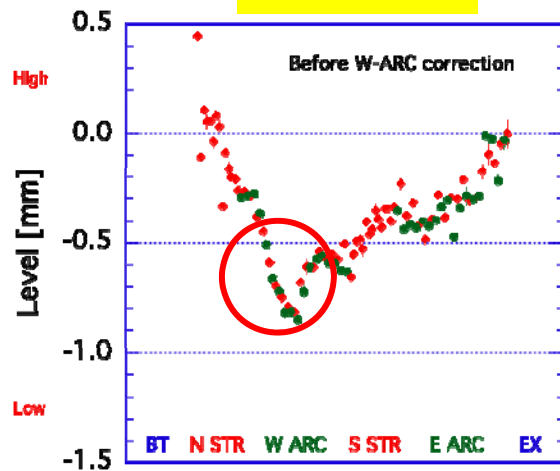


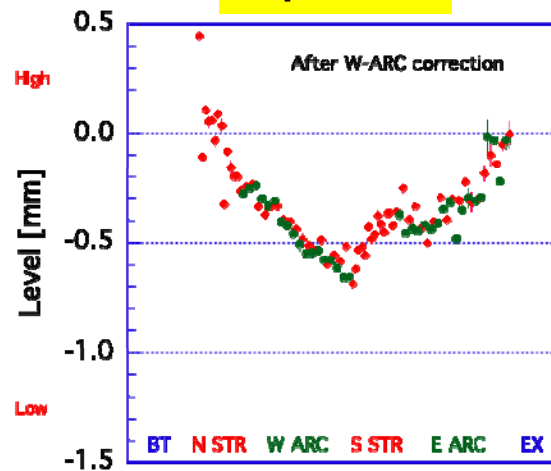
図8. SMART水準測量 (各測定点の平均値) .

# Re-align the DR magnets

Mar 08

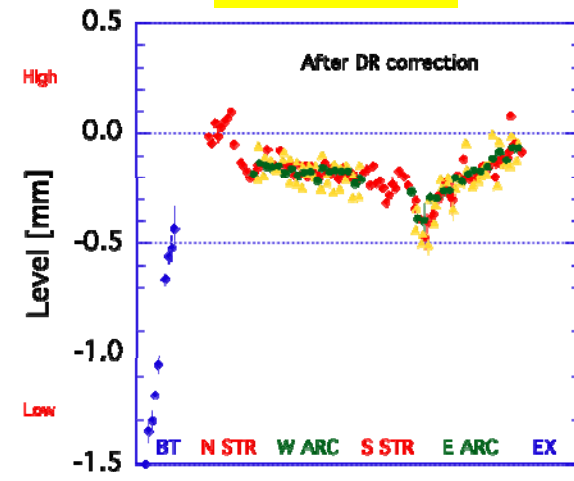


Apr 08



West arc correction  
in 2 weeks shutdown  
(ATF2 side)

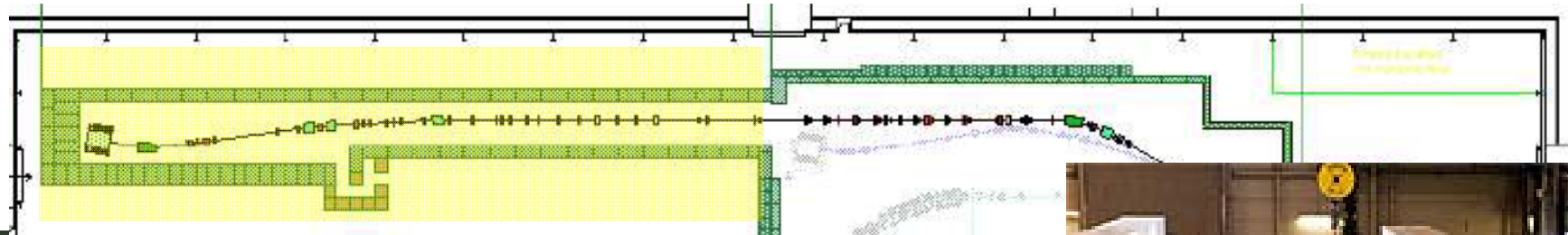
Nov 08



Whole ring correction  
in 4 weeks shutdown  
(only 1 loop, need more)

We should check the vertical emittance as soon as we re-tune the ring. **Very high priority!**

# ATF2 construction



2007-June



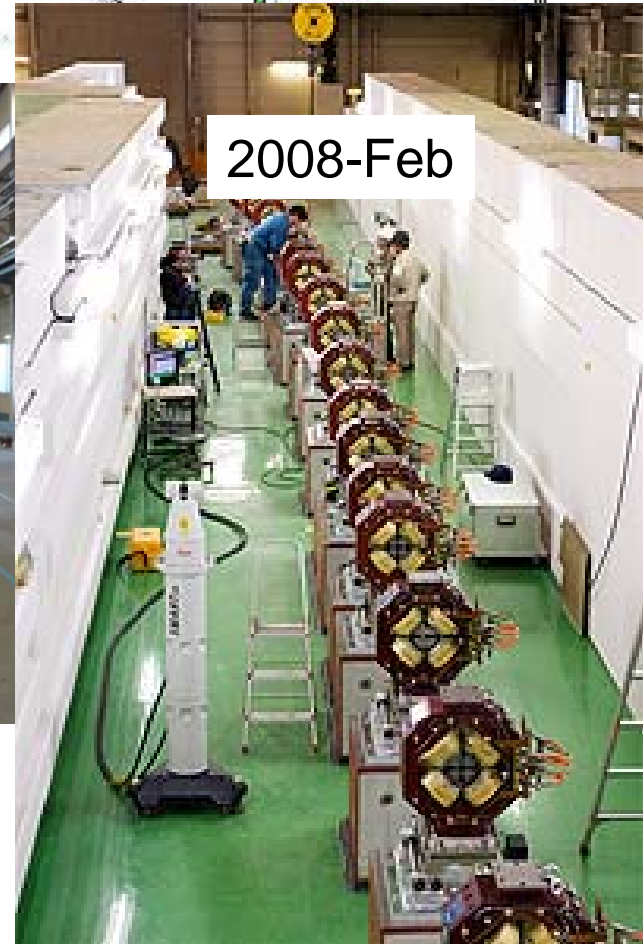
2007-Oct



2007-July-31



2008-Feb





# What should be done for FII study at ATF

- **Vertical emittance recovery/tuning**
  - Need to understand what makes 20~50pm emittance in recent DR.
  - Re-align the DR magnets and see what is happened.
  - keep DR tuned for each operation period
- **Multi-bunch beam tuning**
  - because DR is usually tuned for the single bunch beam for other R&Ds
  - It will take at least one shift just before FII shifts.
  - RFgun and Linac tuning due to beam loading, capturing in DR
  - We will Improve the timing system of the RFgun laser to avoid the rise and fall edge of pockels cell voltage.
- **Minimize the effect by vacuum breaks to see a clear effect**
  - Beam extraction R&D by Fast Kicker
    - Exchanging chambers and kickers every time for 2 weeks R&D
  - Laser-Compton system for pol. e<sup>+</sup> R&D

# Summary

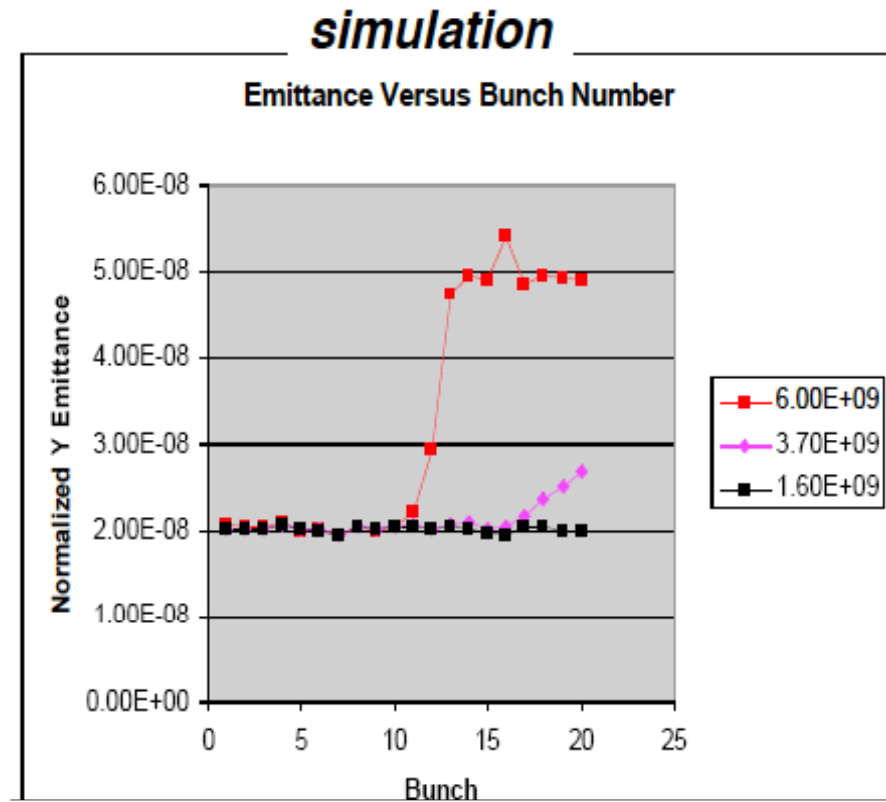
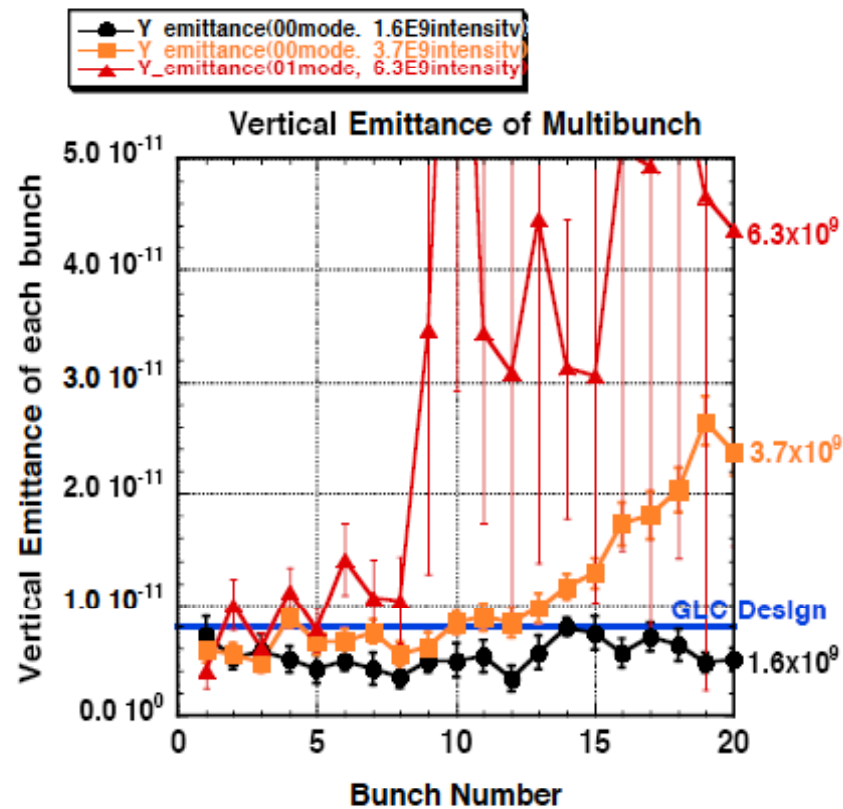
Low emittance multi-bunch beam is essential.

- Recovering the 5pm emittance is higher priority.
- Multi-bunch beam tuning should be well done just before the FII study.

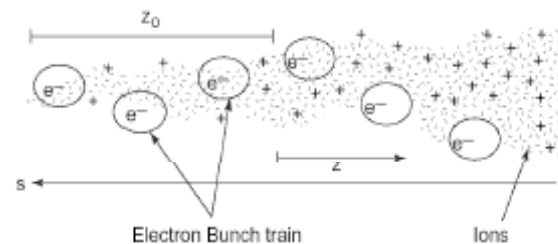
Local and remote participation for FII beam time are welcome.

A set of shifts in 1~2 weeks will be a reasonable choice for ATF programs. It will be scheduled after recover the 10pm.

# ATF 2004 result of Fast Ion Instability simulation



*Behavior of Y emittance is very similar.*



Schematic of the Fast-Beam Ion Instability