Fast Ion Studies at ATF

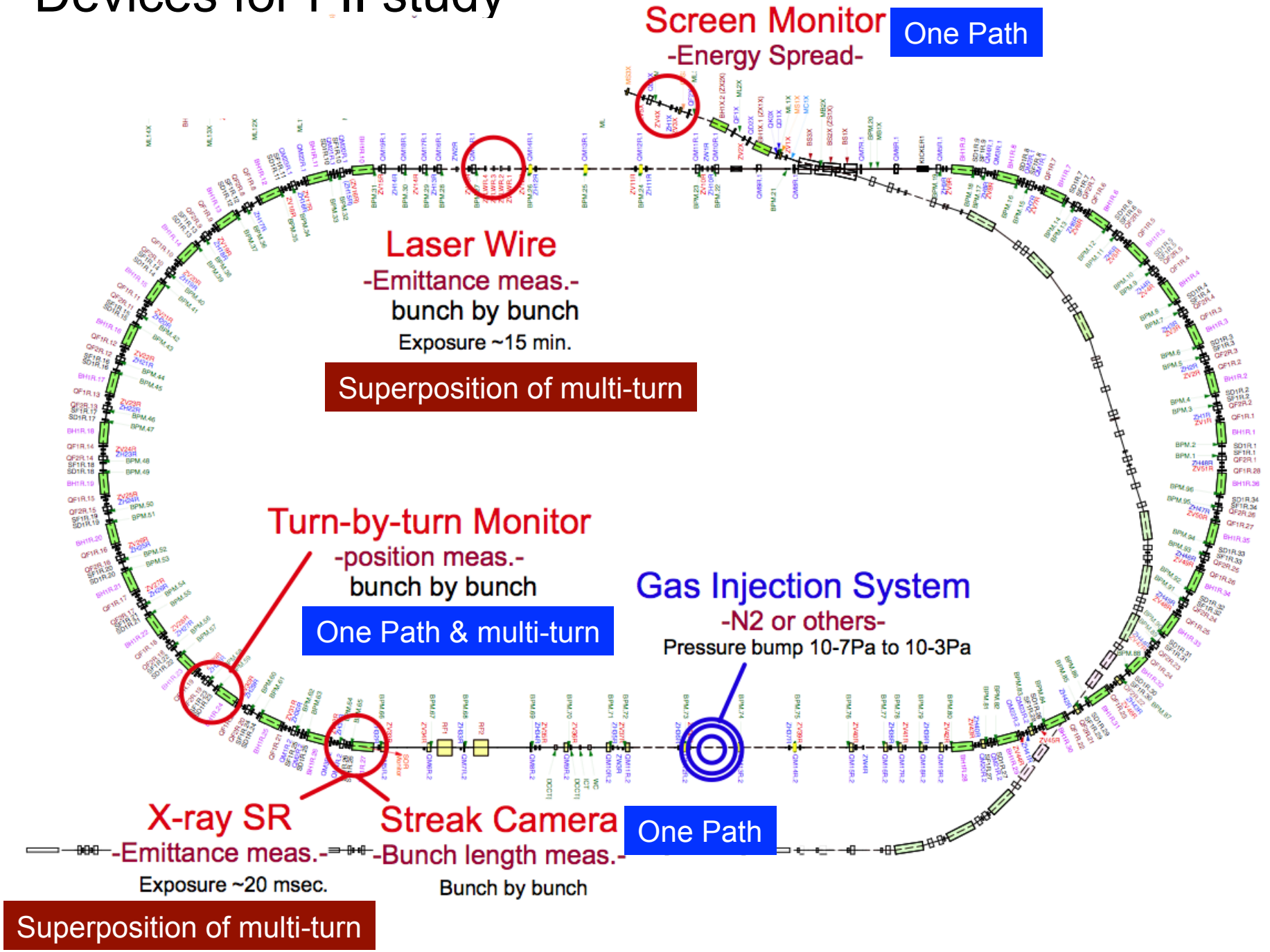
- A little update of the report on TILC09, Tsukuba.

- Recovery of the vertical emittance and a brief summary of past studies
- Status of the Laser wire system
- Issues on the multi-bunch beam
- Plan for coming months

N.Terunuma (KEK)

LCWA09, Oct. 1, 2009, Albuqurque

Devices for FII study



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

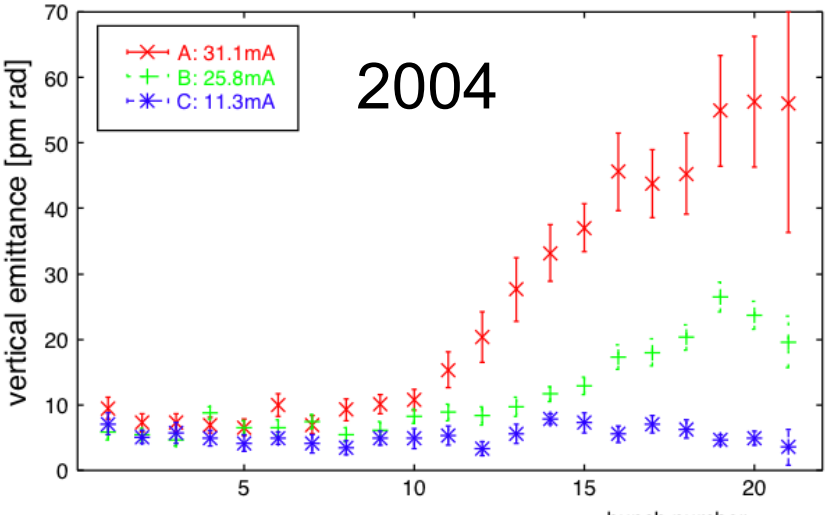
Vertical emittance of 20 bunches in ATF DR

Table 2: vacuum pressure in 2004

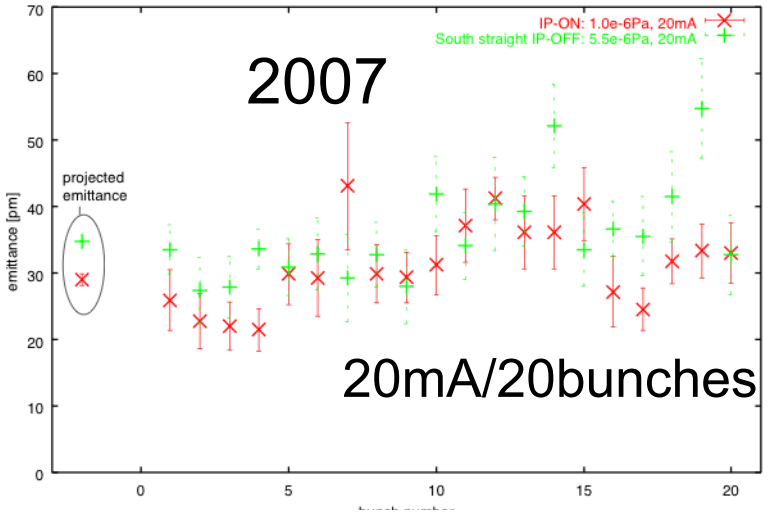
ion pump status	11mA	26mA	31mA
normal	4.0×10^{-6} Pa	6.0×10^{-6} Pa	6.5×10^{-6} Pa

Table 1: vacuum pressure in the measurements

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



Single bunch is less than 10pm.



Bunches are already bigger.
Single bunch is also bigger.

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

5mA/20bunches

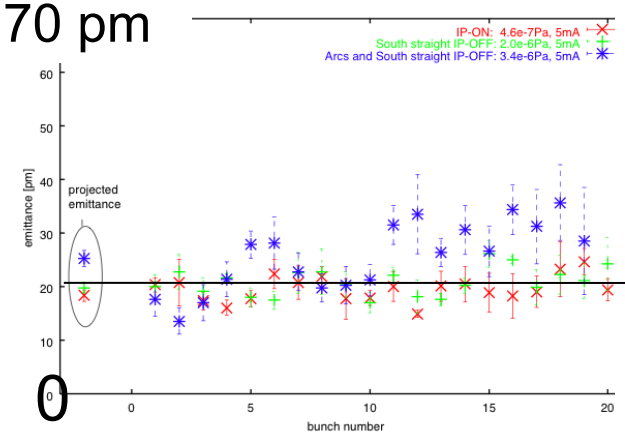


Figure 7: emittance of multi-bunch beam at 5mA/20bunches

10mA/20bunches

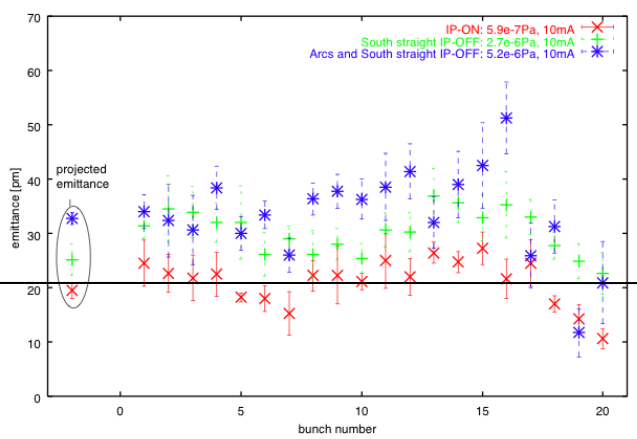


Figure 8: emittance of multi-bunch beam at 10mA/20bunches

20mA/20bunches

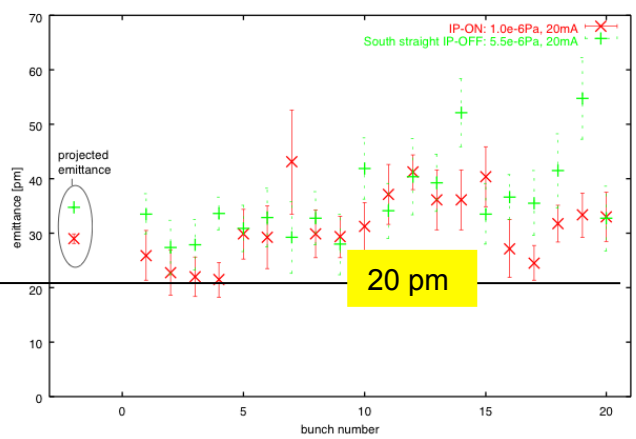


Figure 9: emittance of multi-bunch beam at 20mA/20bunches

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.

Vertical emittance became larger

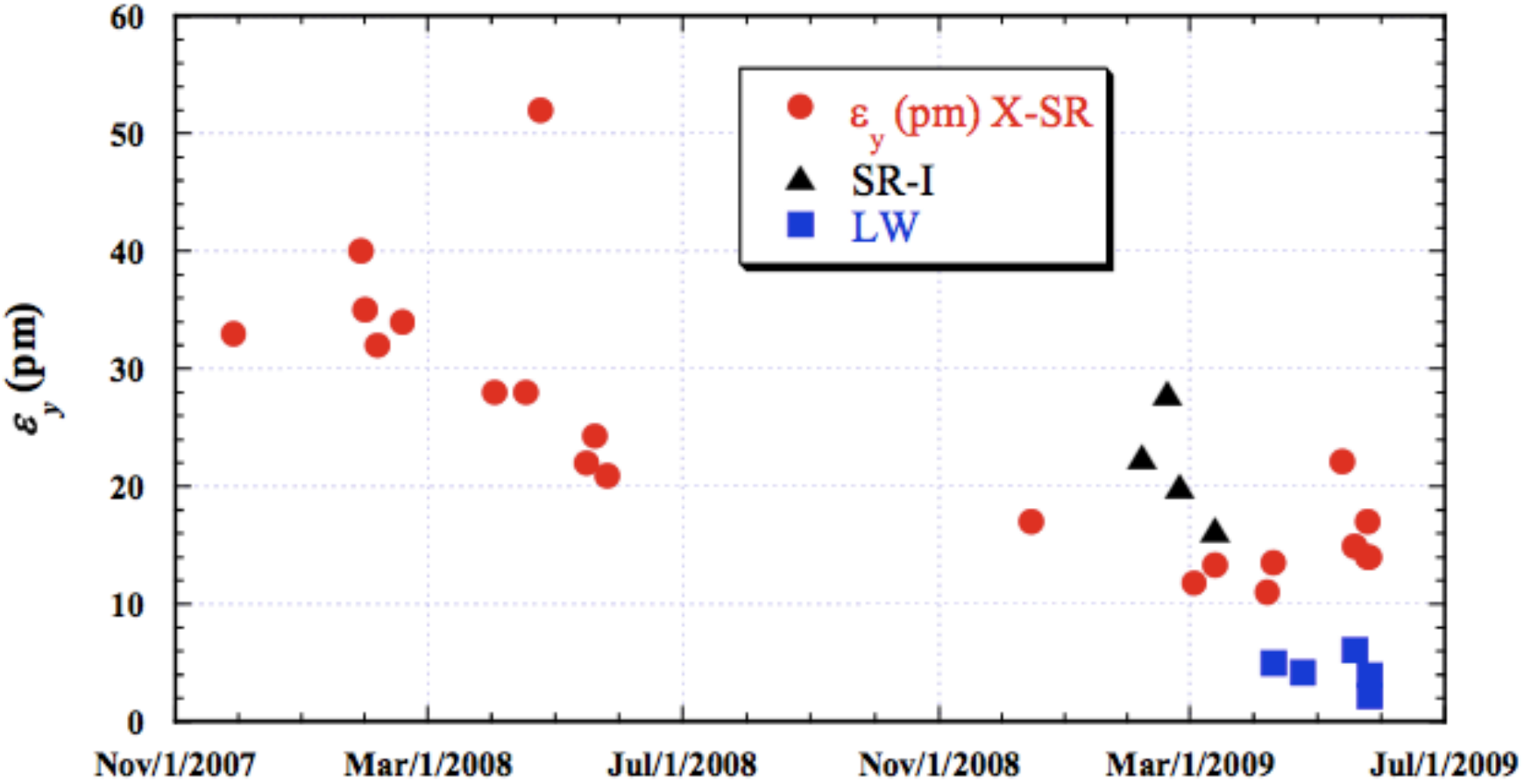
- 5~10 pm had been achieved after emittance tuning described.
- Recently, about 20~30 pm, after the same procedure of the tuning. from 2006?
- Apparent vertical dispersion and x-y coupling are worse. (? may not be always ?)
- Optics model may be bad. (e.g. tunes and orbit response to steering magnet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

Recent history of emittance in ATF DR

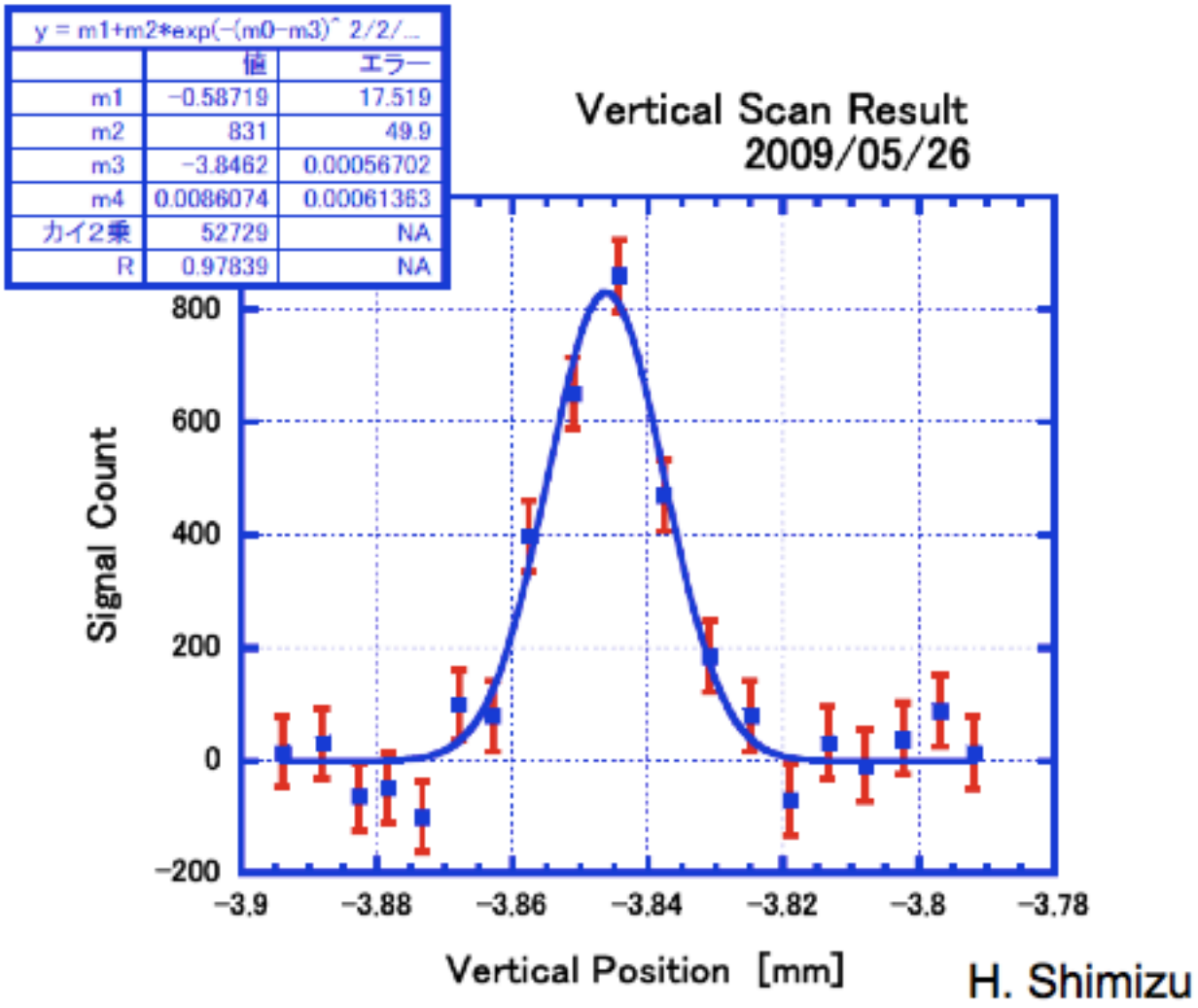


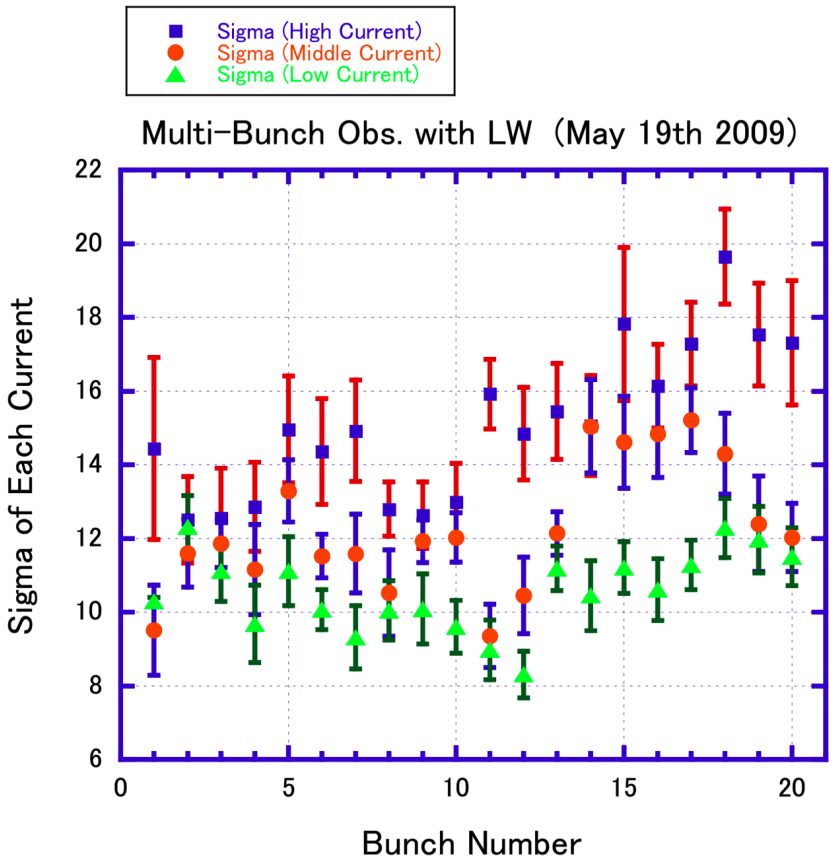
Vertical emittance < 10 pm (from Laser Wire measurement)
Smaller than limits of other monitors?

S. Kuroda and N. Terunuma

Example of DR Laser Wire measurement

s = 8.6 mm (convolution of beam size and laser size)





0.4x10^{10}/bunch

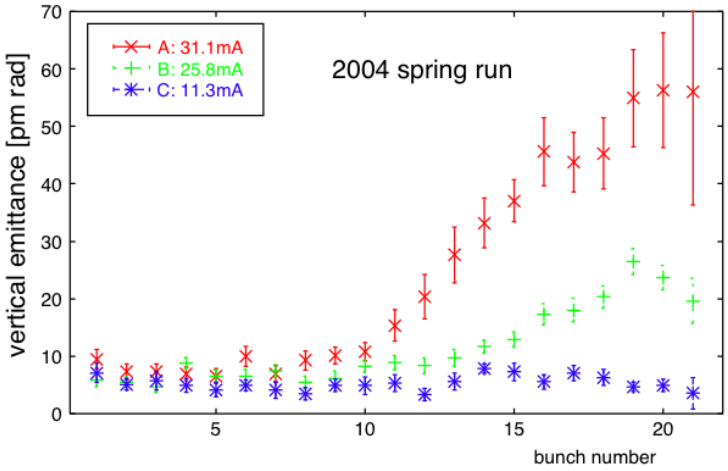
0.3x10^{10}/bunch

0.1x10^{10}/bunch

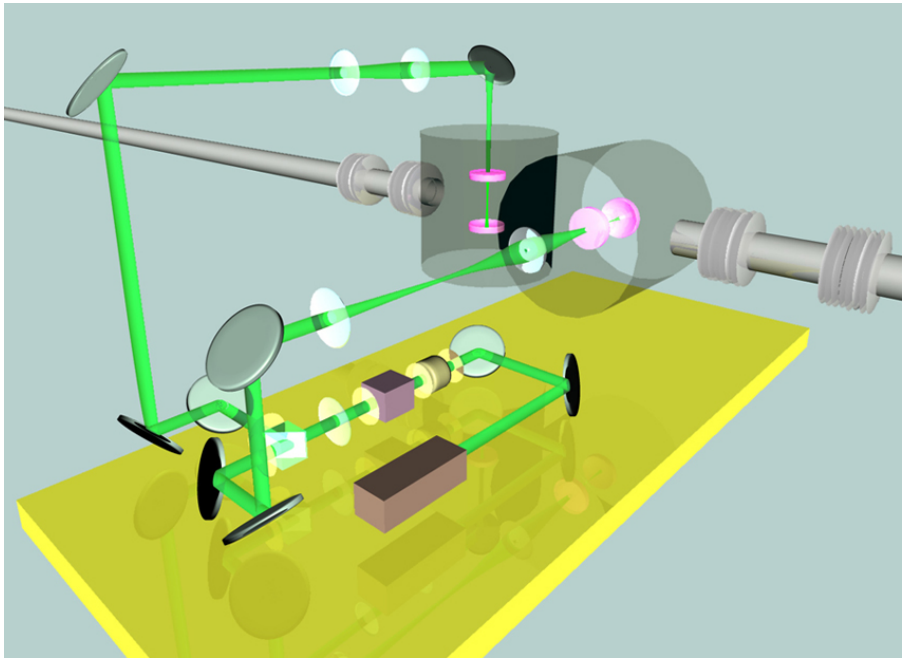
Table 2: vacuum pressure in 2004

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

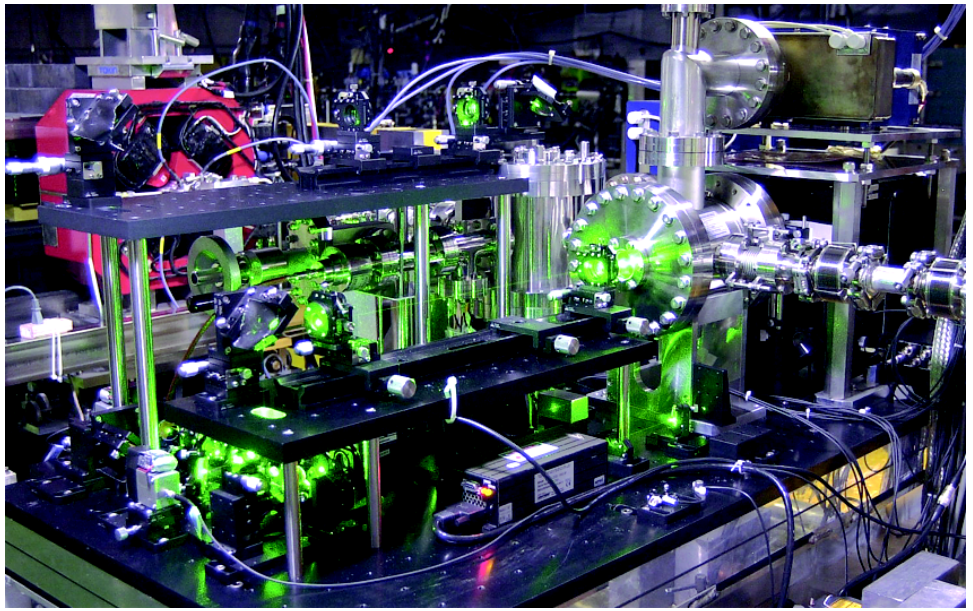
We observed a beam-size growth of 50%.
It becomes clear than the result of 2007.
Emittance growth in 2004 was much bigger.
Is the emittance really small now?
Improve the LW measurement.



Laser wire beam size monitor in DR

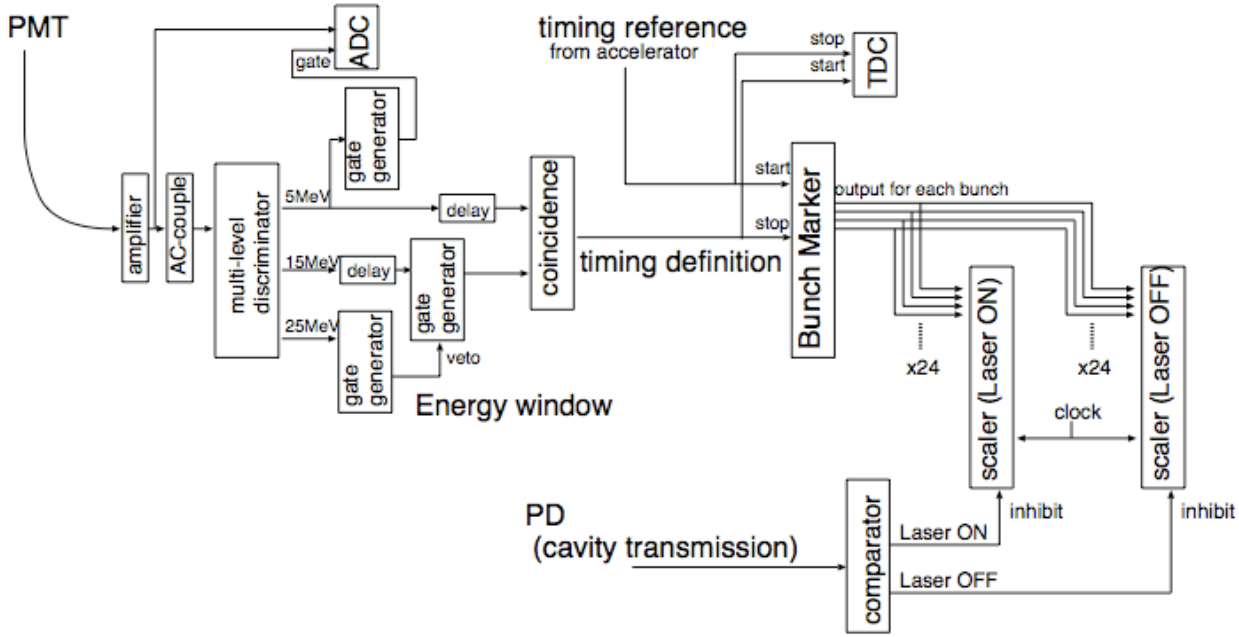


300mW 532nm Solid-state Laser fed into optical cavity

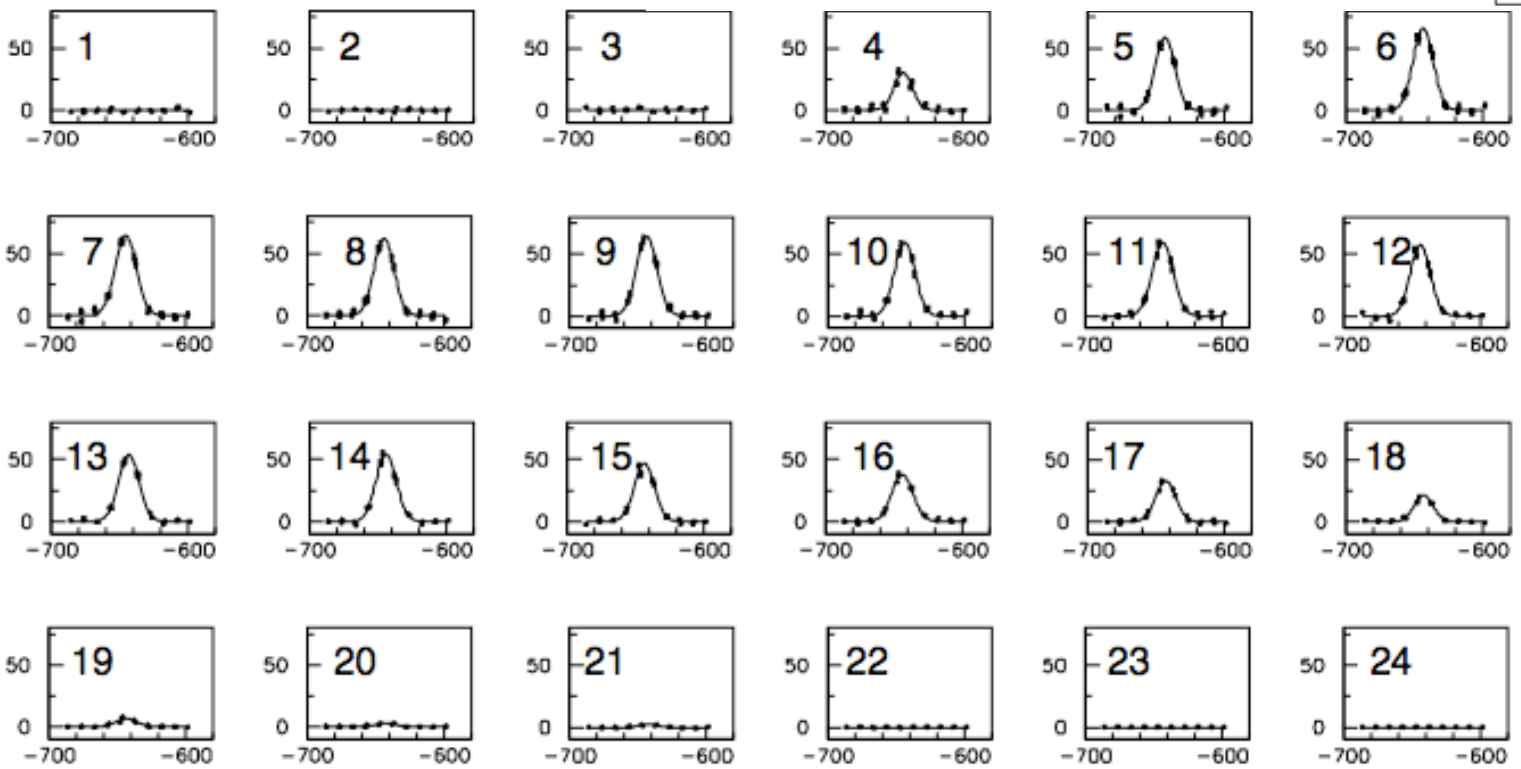


14.7μm laser wire for X scan
5.7μm for Y scan
(whole scan: 15min for X, 6min for Y)

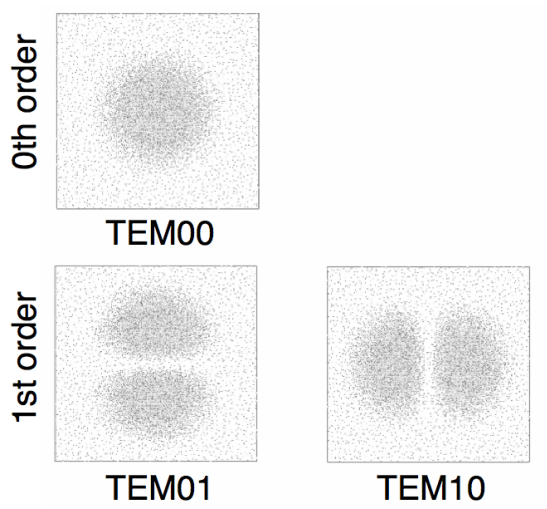
LW: multi-bunch scanning

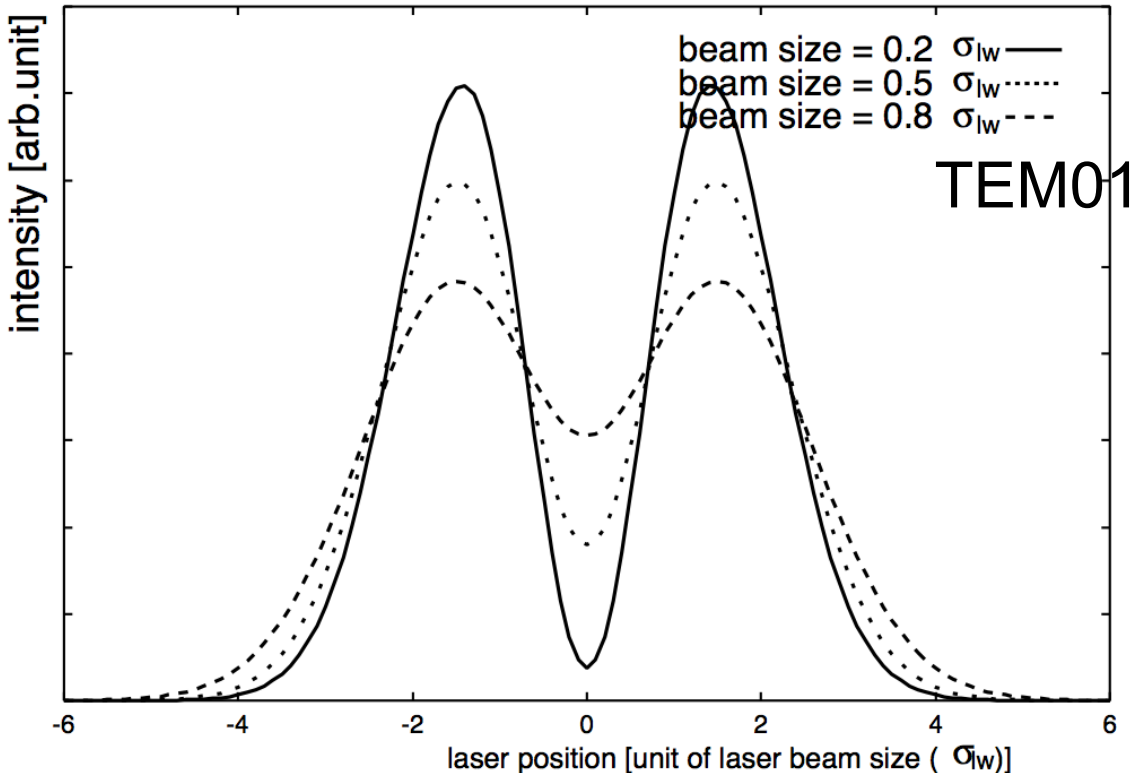


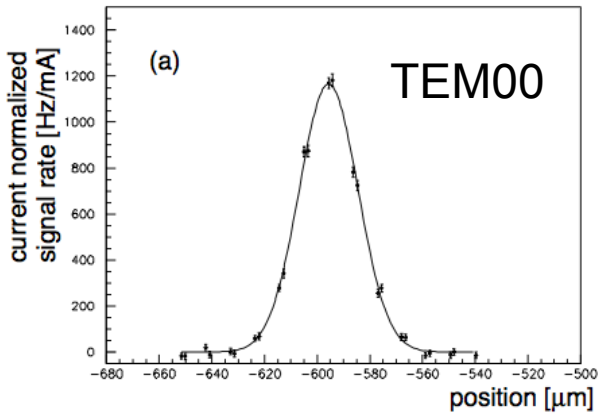
Normal condition

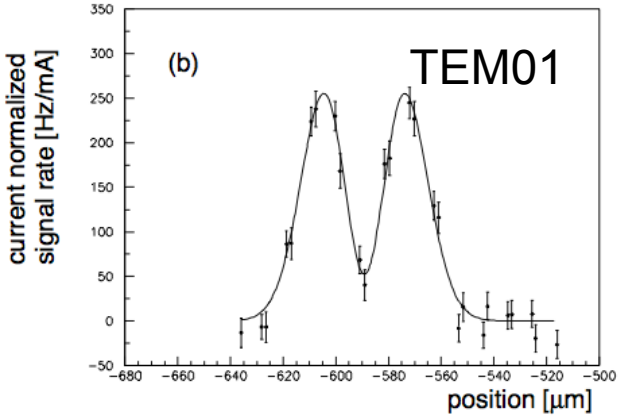


Higher Order Mode









Upgrading the Laser Wire system

(1) Non-storage mode

- Past measurements were done by storage mode only. It means the dedicated beam time is necessary.
- Measurement under the non-storage mode was prepared for the parasitic measurement.

(2) Higher order mode

- It was prepared but not fully operated.

(3) Increase the laser intensity (x3 or more)

- New fiber laser will be installed in this fall.
- We expect that the fast beam-size scanning (< a few min) or reducing the measurement errors.

(4) Software for non-expert measurement

- Increase an opportunity of beam-size measurement

Multi-bunch Injection to DR

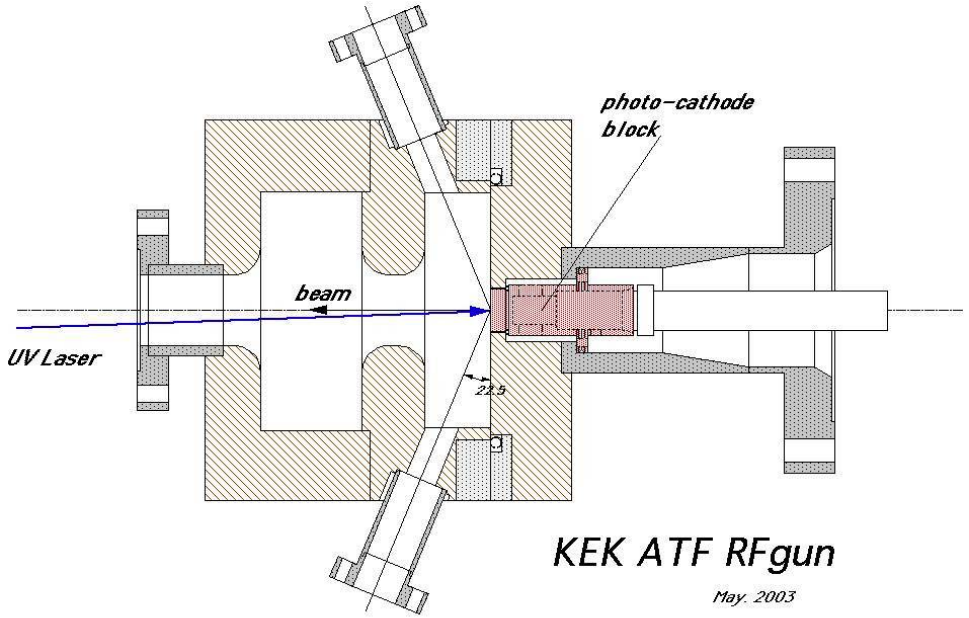
- Most of the recent R&D requests a single-bunch beam (SB).
- The ATF2 also use SB at present.
  - It will use MB when the fast kicker will supply MB with the ILC bunch spacing. (for Fast Feedback by FONT5, etc.)

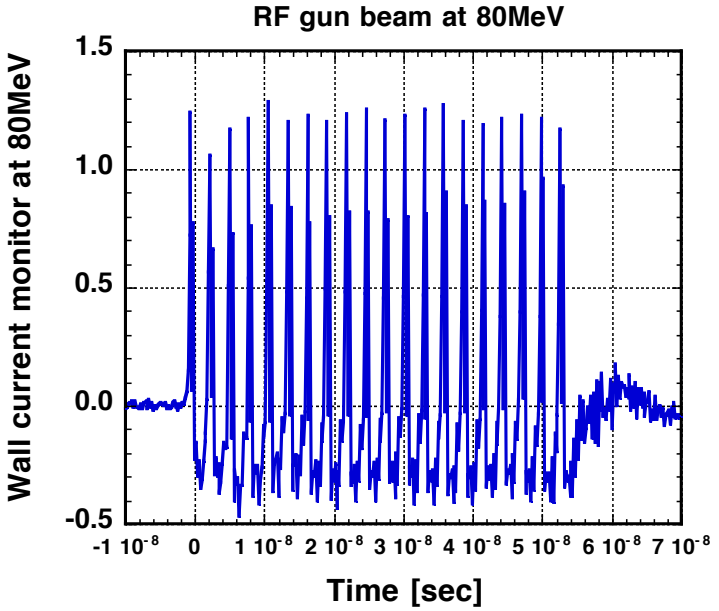
- A few R&D programs use a multi-bunch beam (MB).
  - Fast Ion, Cavity Compton, Fast Kicker (in near future)

- Injection and storage of the MB into DR should be tuned before these studies to get the intensity-flat MB.
  - Operational parameter for injection is somewhat different between SB and MB because of the beam loading issue in the linac. In addition, they are drifting due to the drift of energy in the linac.

  - Improvements on the linac were done in this summer (cooling water stability, SLED, Injector optimization,…). We expect a drift becomes much smaller, then the stable MB tuning is available on next runs.

Multi-bunch electron beam structure





Number of bunches from the RF Gun is controlled by changing the Laser pulse structure.

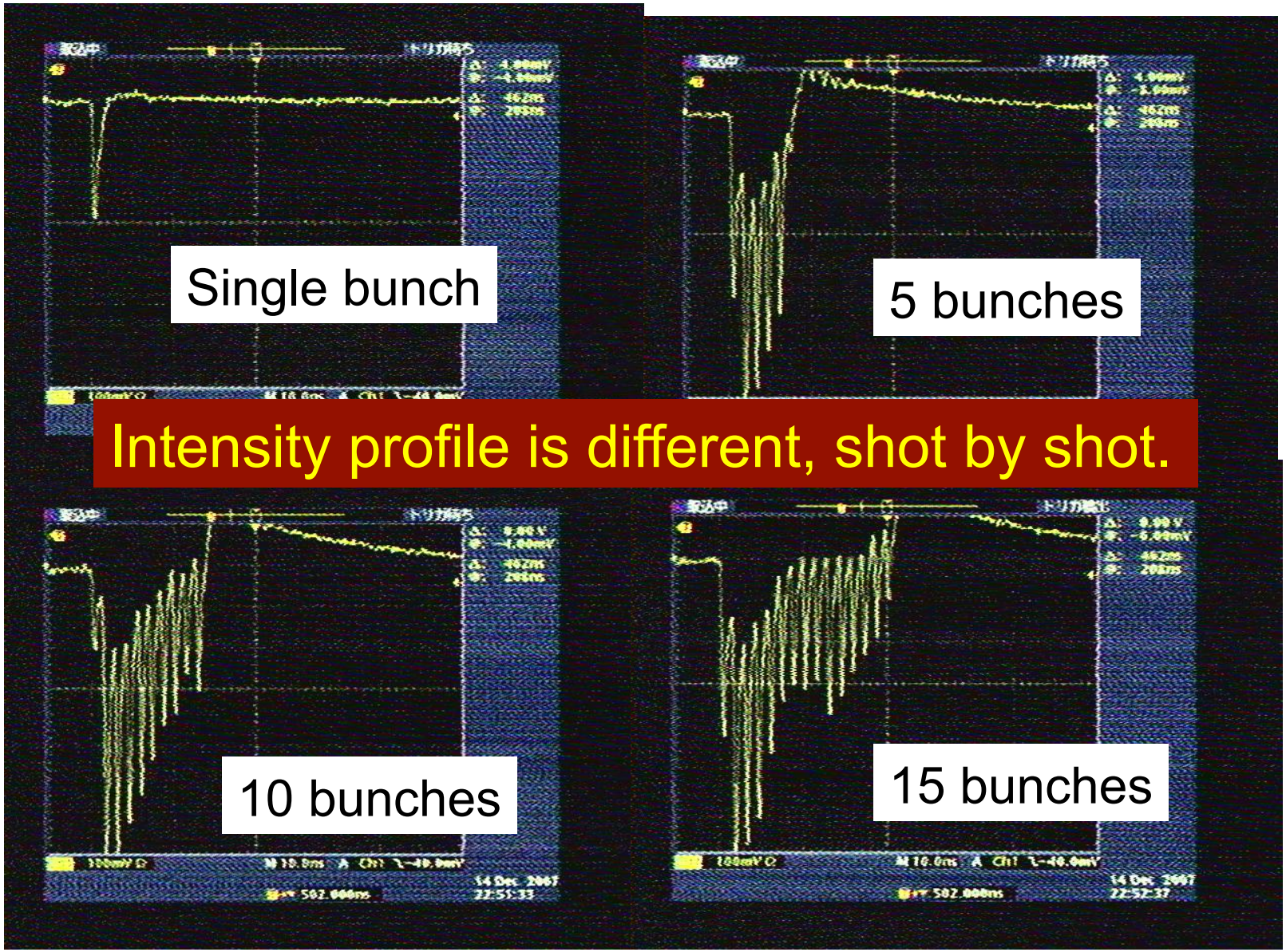
***Linac:* 1.3 GeV, 1.56 Hz, ~ 2 x 10^{10} electrons / bunch**

1 ~ 20 bunches/pulse(train) with 2.8ns spacing by 357MHz laser

and

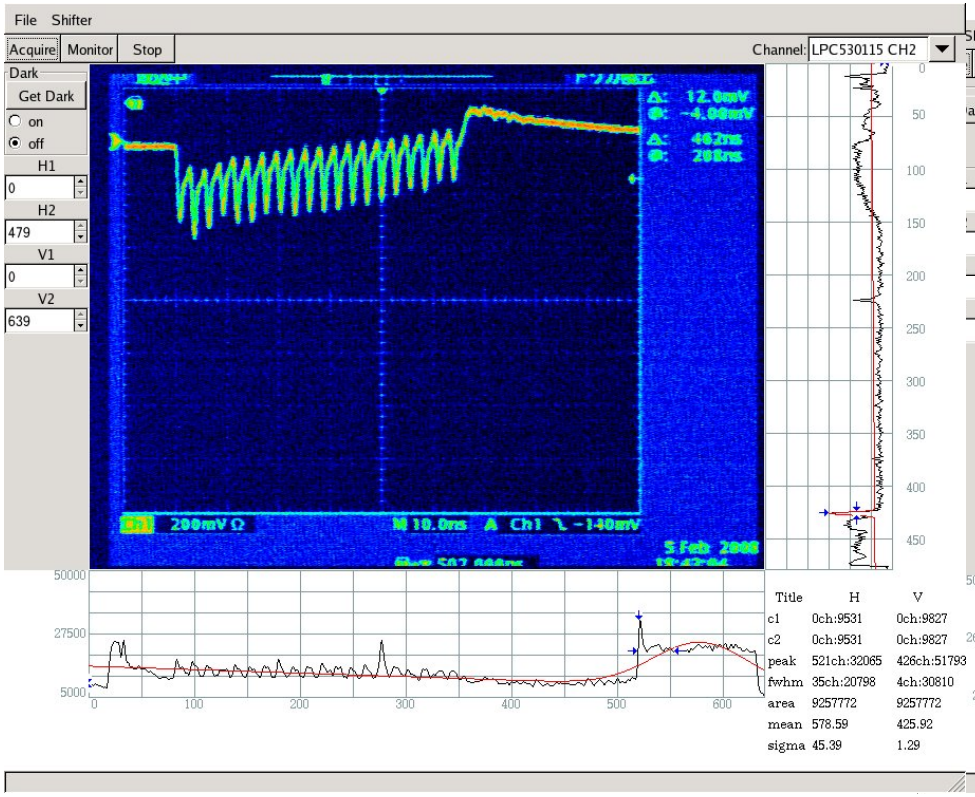
1 ~ 10 bunches/pulse(train) with 5.6ns spacing by 178.5MHz laser for Fast Kicker R&D, will be available in October 2009.

Example: Non-flat MB in DR

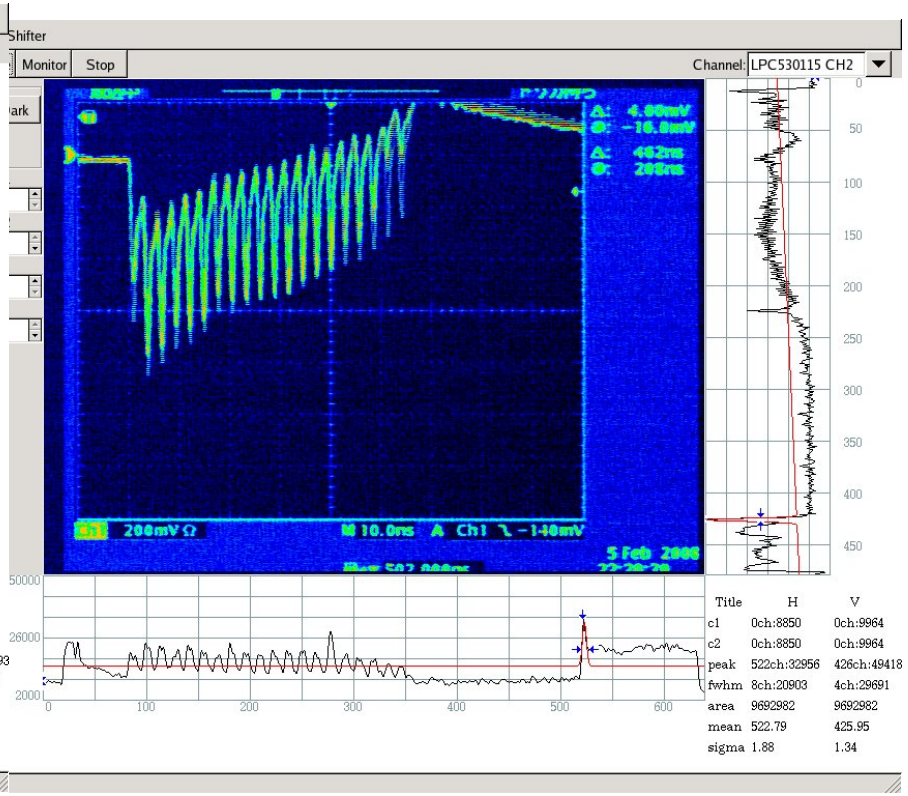


Example: well tuned flat MB

Storage efficiency of the later bunches at a higher intensity is fluctuated frequently.



0.4E10/bunch, 20bunch



1.0E10/bunch, 20bunch

Plan of FII R&D

1. We need to arrange the time for MB operation.

   - Beam time assignment: ATF (30%) and ATF2 (70%)
   - ATF includes the R&Ds for …
     emittance, cavity Compton, fast ion, fast kicker, …

   - Once per week or two weeks for FII study seems to be fine.

2. Re-confirmation of the results in 2004 is first step.

   - check the consistency etc.

3. Measurement by changing the ionization condition

   - beam intensity, ion pump ON/OFF, Gas injection,…

Summary

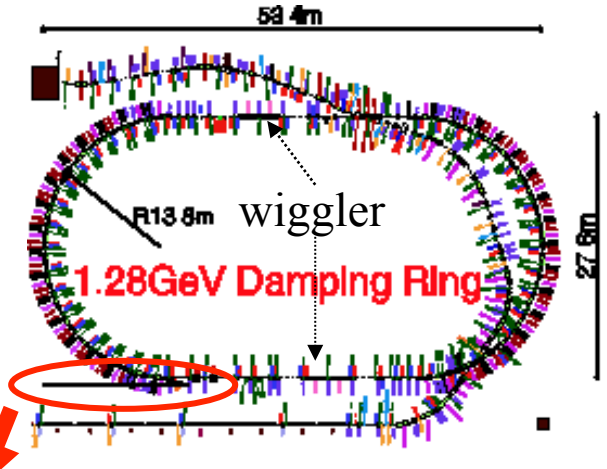
- Vertical emittance in DR is almost recovered about less than 10 pm. It should be maintained for all studies.
- Fast ion study should be well scheduled with other ATF/ ATF2 programs.
- Multi-bunch beam tuning should be well done just before the FII study.
- Local and remote participation for FII beam time are welcome.

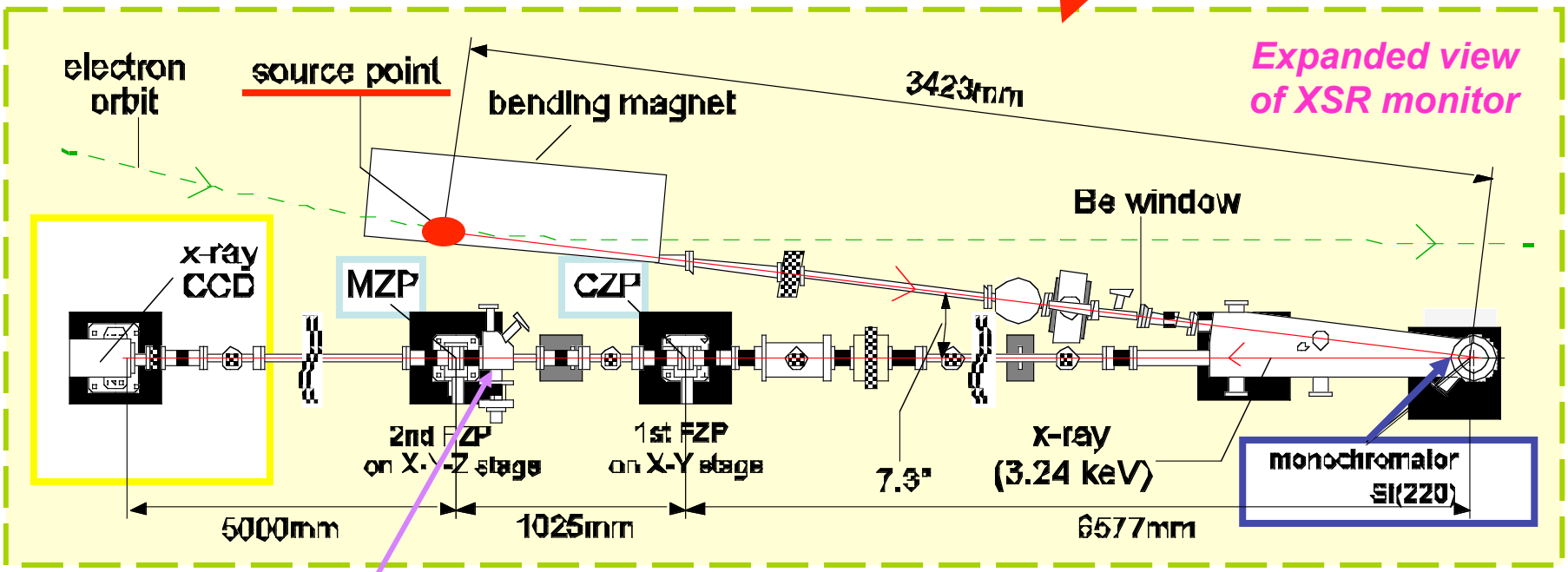
- backup slide -

Setup of XSR monitor

Principle

- Monochromated **X-ray SR(3.235keV)** is used.
  ⇒***Reduce the diffraction limit from SR-light.***
- ***Two*** **Fresnel zone plates (FZPs)** are used。
  ⇒***Obtain 20 times magnified beam image on CCD.***

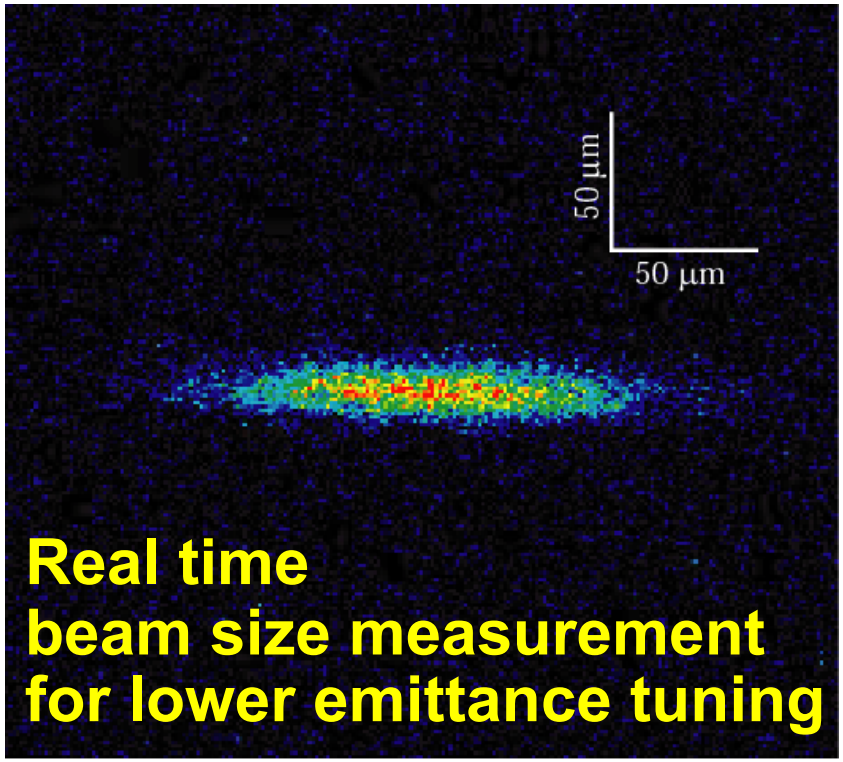


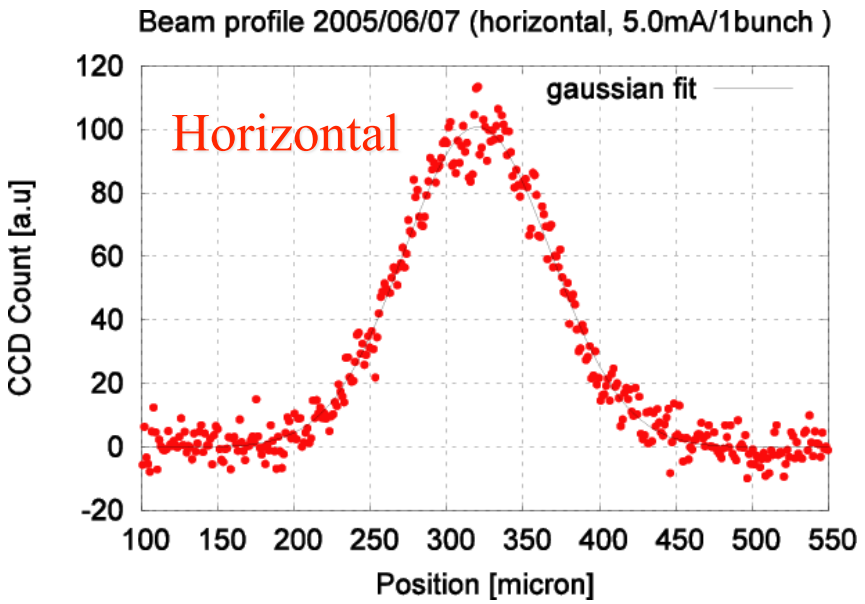


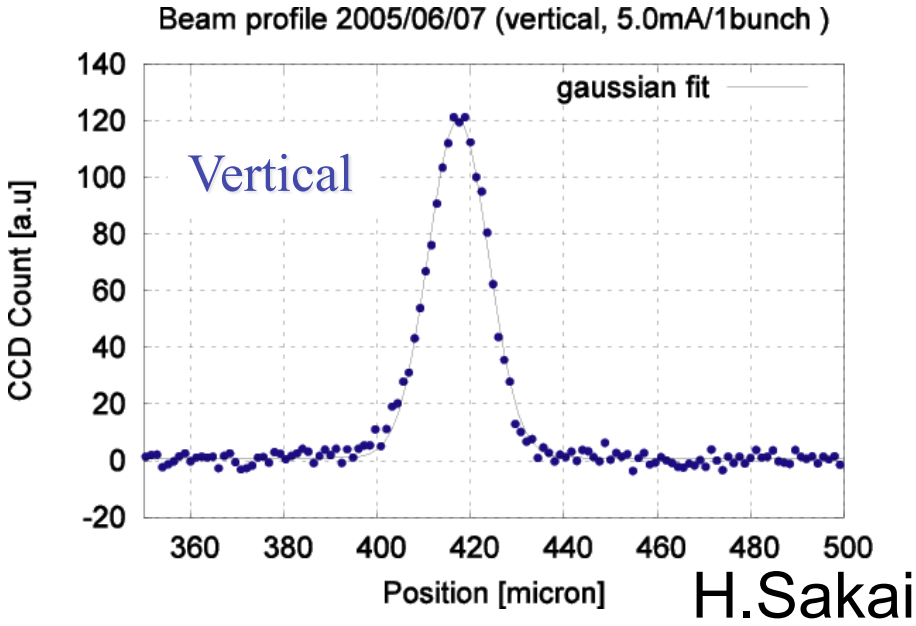
Mechanical shutter installed on April 2005
(opening shutter time <1ms) [previous >20ms]

Expected spatial resolution is less than 1μm.

Example: XSR beam image







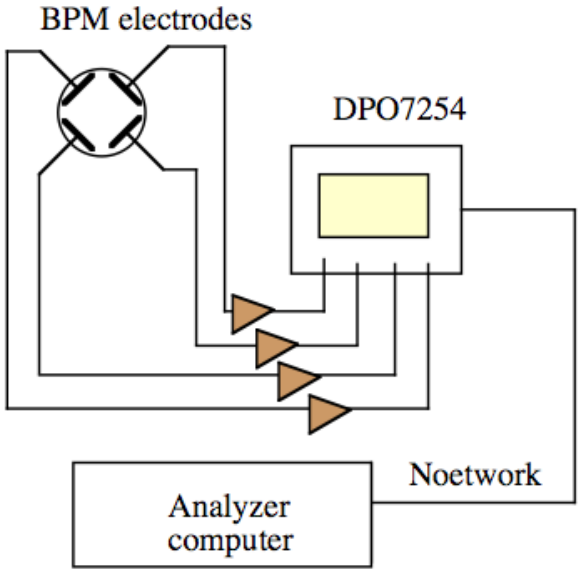
I=5.0mA, Shutter time = 1ms
(2005/06/07)

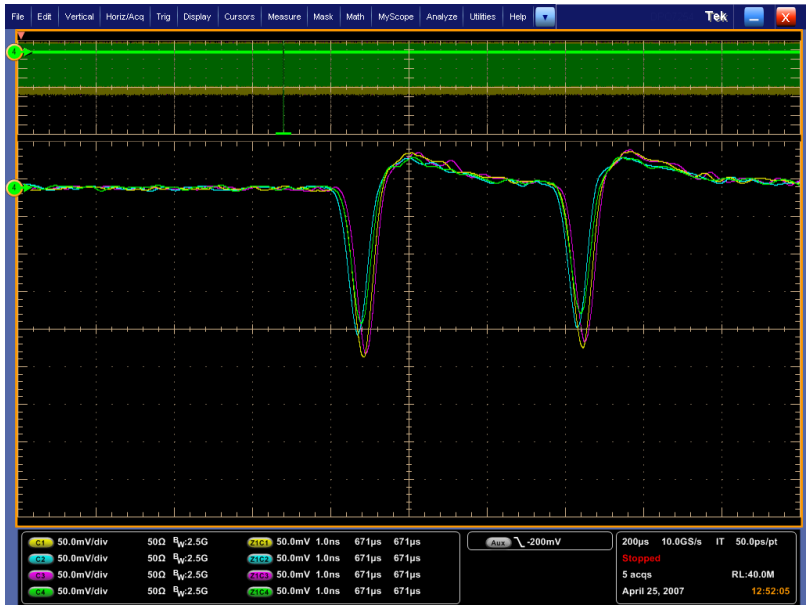
$\sigma_x = 48.2 \pm 0.5$ [μm]
$\sigma_y = 6.4 \pm 0.1$ [μm]

H.Sakai

Turn by turn position monitor

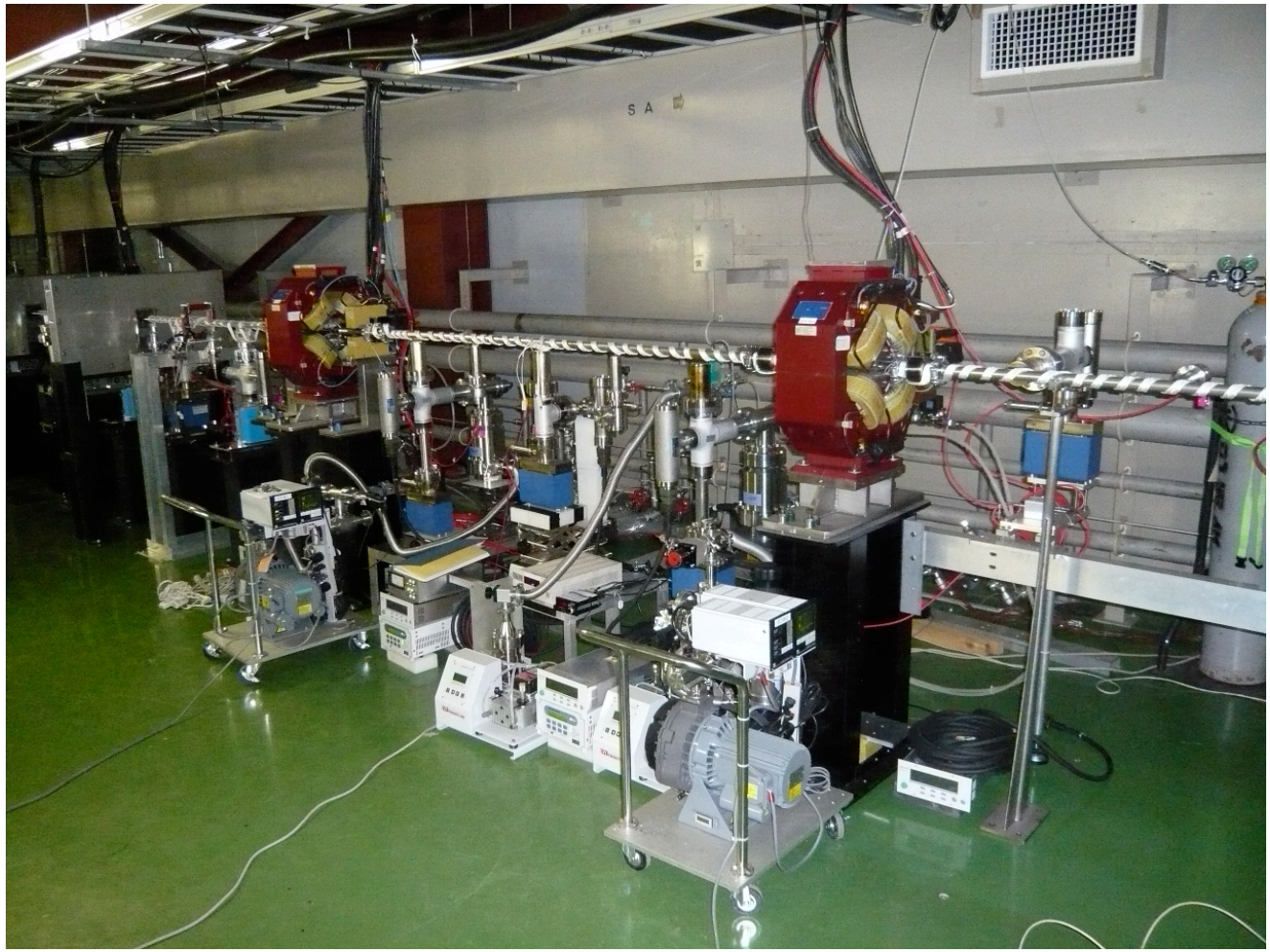
The scope can store the waveform up to 2ms with 100ps time resolution.





Gas Injection system at ATF-DR

-South straight section-



Pressure bump at ATF-DR