Linac Upgrade:

Beam Instrumentation

(Nondestructive Beam-Energy-Spread Monitor System)

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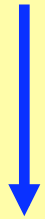
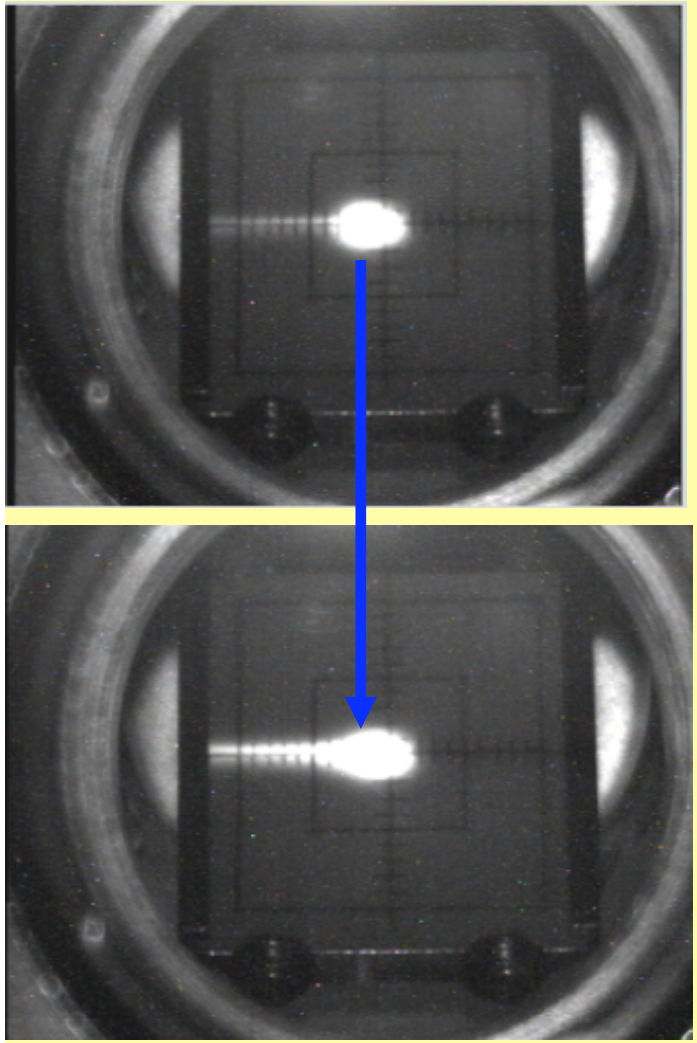
= Motivation =

- Beam feedback controls of the KEKB injector linac are very important for **stable beam operation**:
  - Beam position feedback (works)
  - Beam energy feedback (works)
  - Beam energy-spread feedback (*under construction*)



Nondestructive Beam-energy-spread monitor is strongly required !!

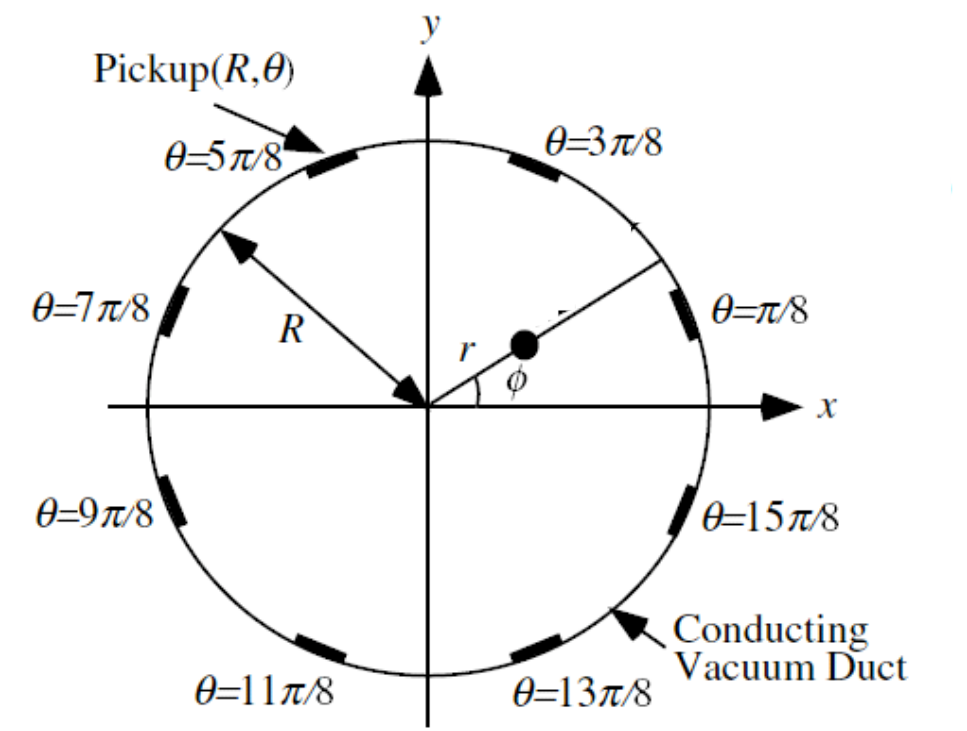
= Energy-Spread Monitor =
Screen Monitor (@$\eta_x \neq 0$)



- Energy spread can be measured by using Fluorescent Screen-Monitor.
- “Eye Measurement”
- ”Destructive” beam monitor (Not desired).

- Quantitative measurement
- Nondestructive monitor is needed.

Energy-Spread Monitor using BPM



Strip line-type BPM with eight electrodes is used as :

- Nondestructive Energy-spread monitor

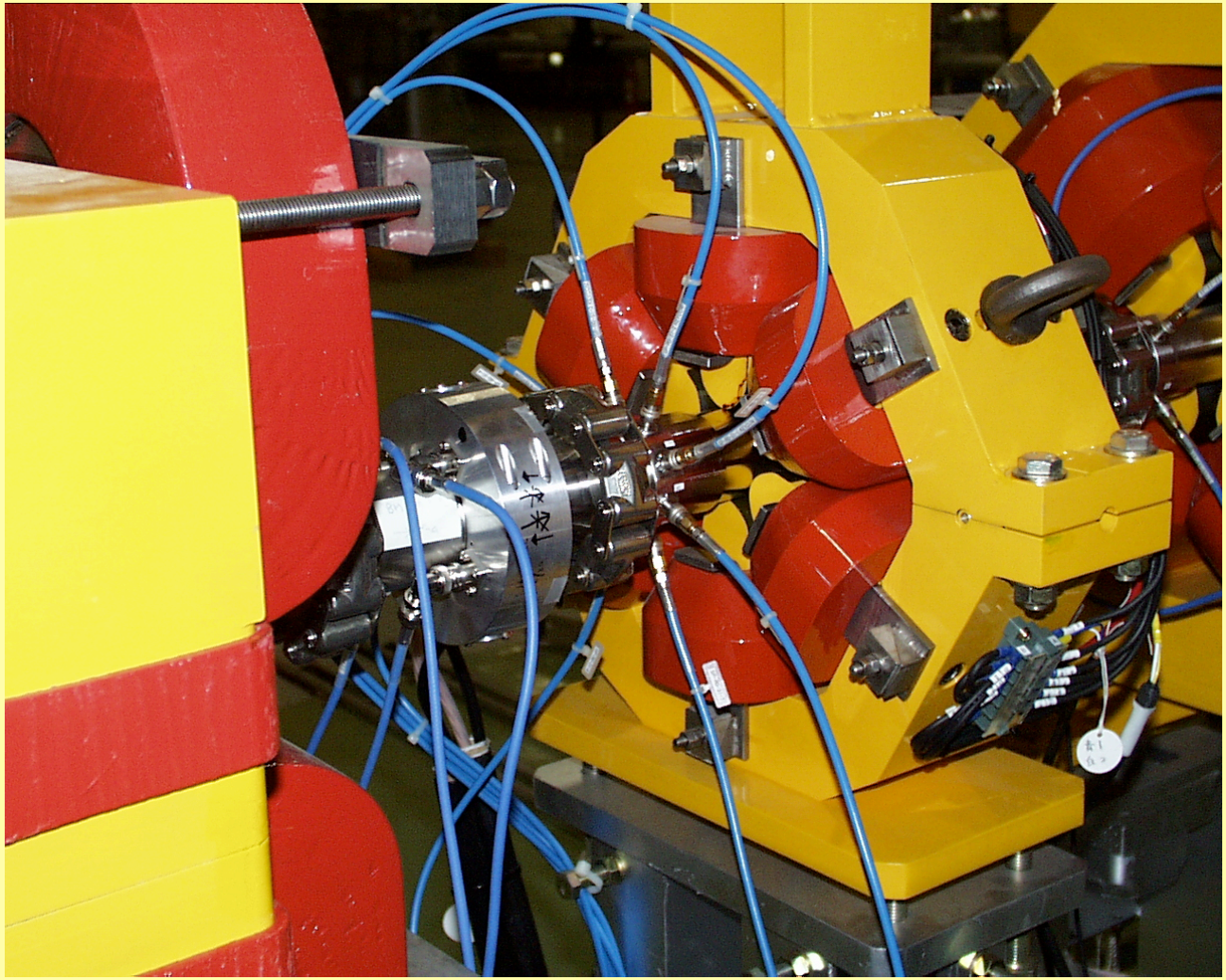
(Measurement of Quadrupole moment Jq)

- Quantitative measurement
  - $\theta \neq 0,\ \pi$
- SR may hit the electrodes.
  - $\theta \neq \frac{\pi}{4}, \frac{3\pi}{4}, \frac{5\pi}{4}, \frac{7\pi}{4}$
- Quadrupole moment term will vanish.

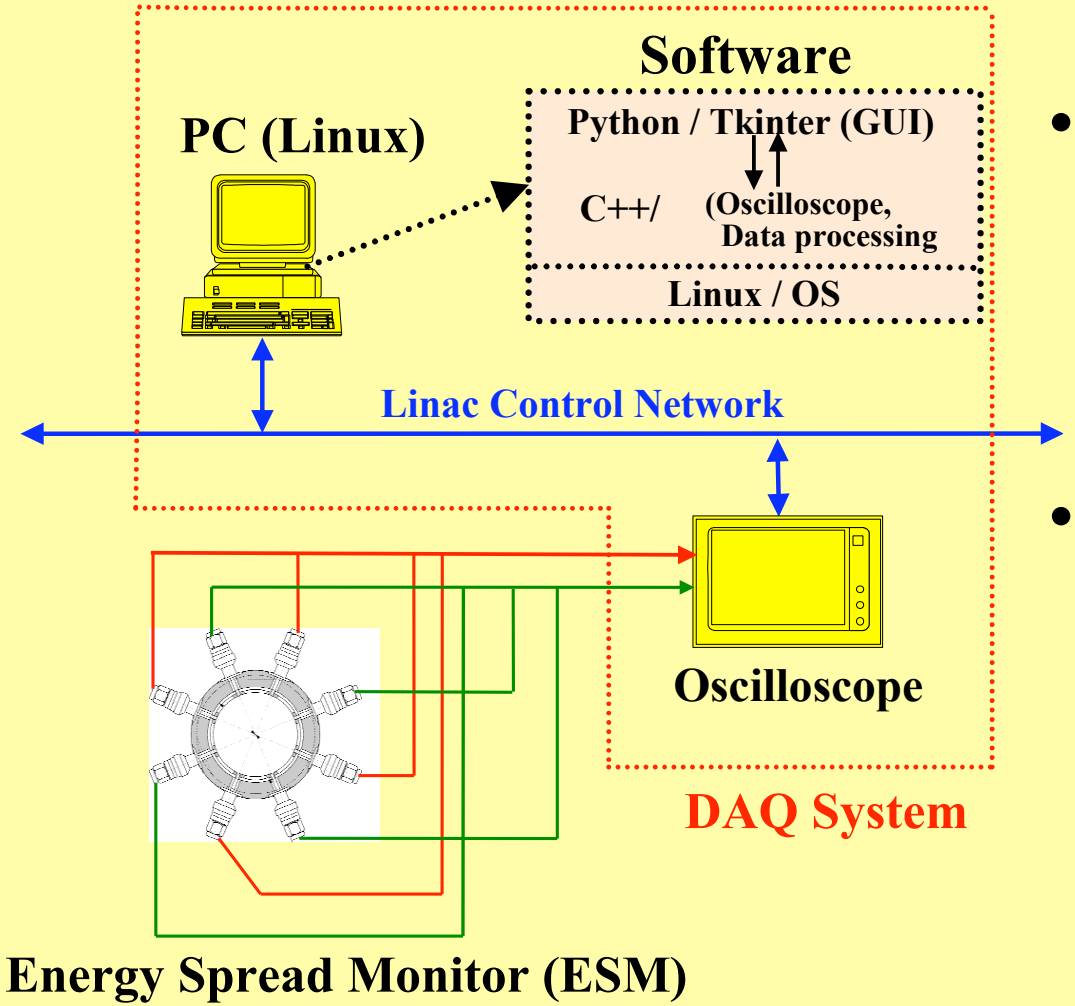
$$Jq = \frac{1}{R^2}\left(\langle x^2\rangle - \langle y^2\rangle + \langle x\rangle^2 - \langle y\rangle^2\right) \cong \frac{\sum_{i=1}^{8} V_i \cos 2\theta}{\sum_{i=1}^{8} V_i}$$

$$\langle x^2\rangle - \langle y^2\rangle \cong \left(\eta_x \frac{\Delta E}{E}\right)^2 + \beta_x \varepsilon_x - \beta_y \varepsilon_y + g$$

Beam Energy-Spread Monitor with Eight Stripline Electrodes ($@\eta_x \approx 0.72$ m)

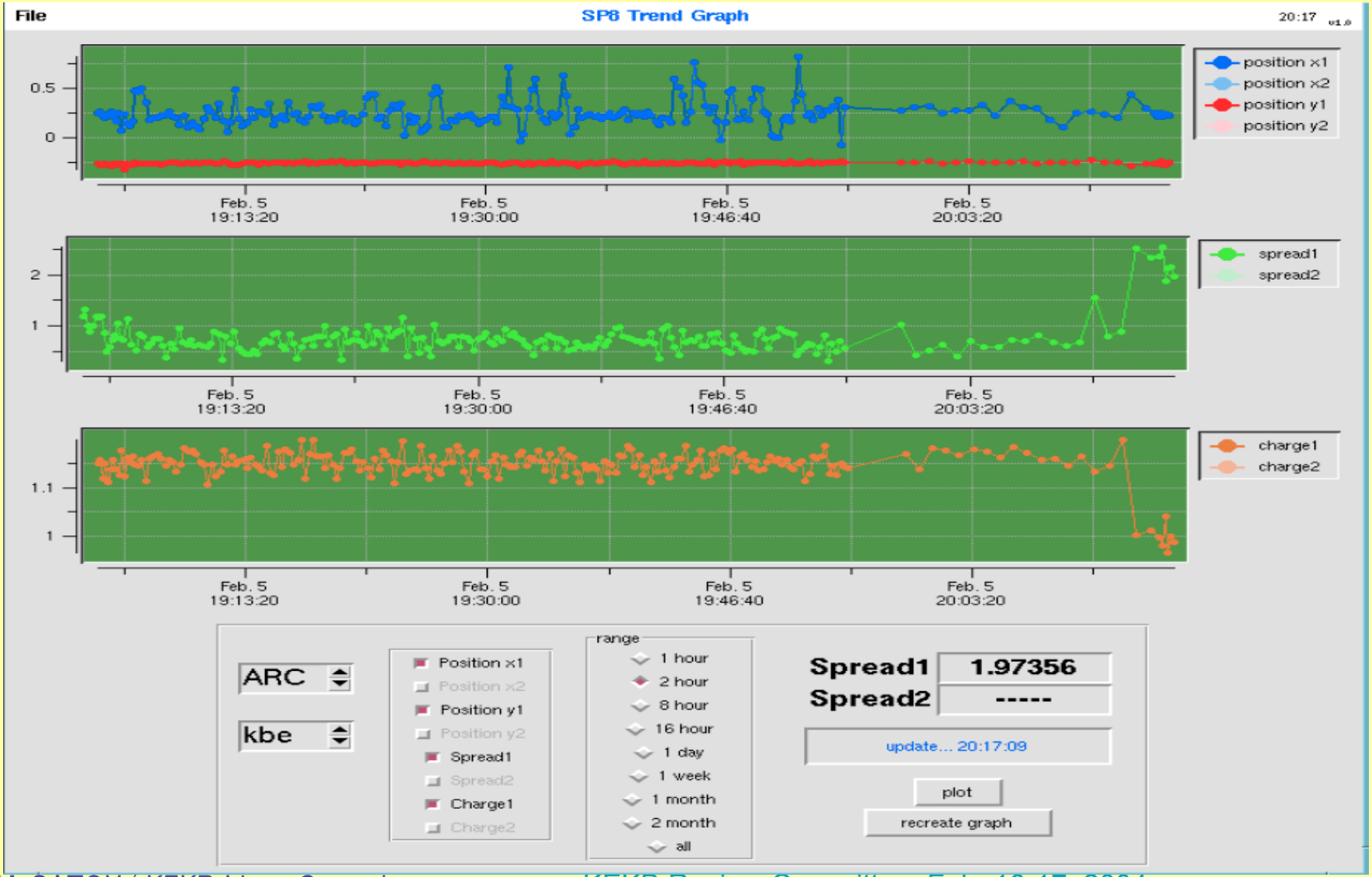


= DAQ System =

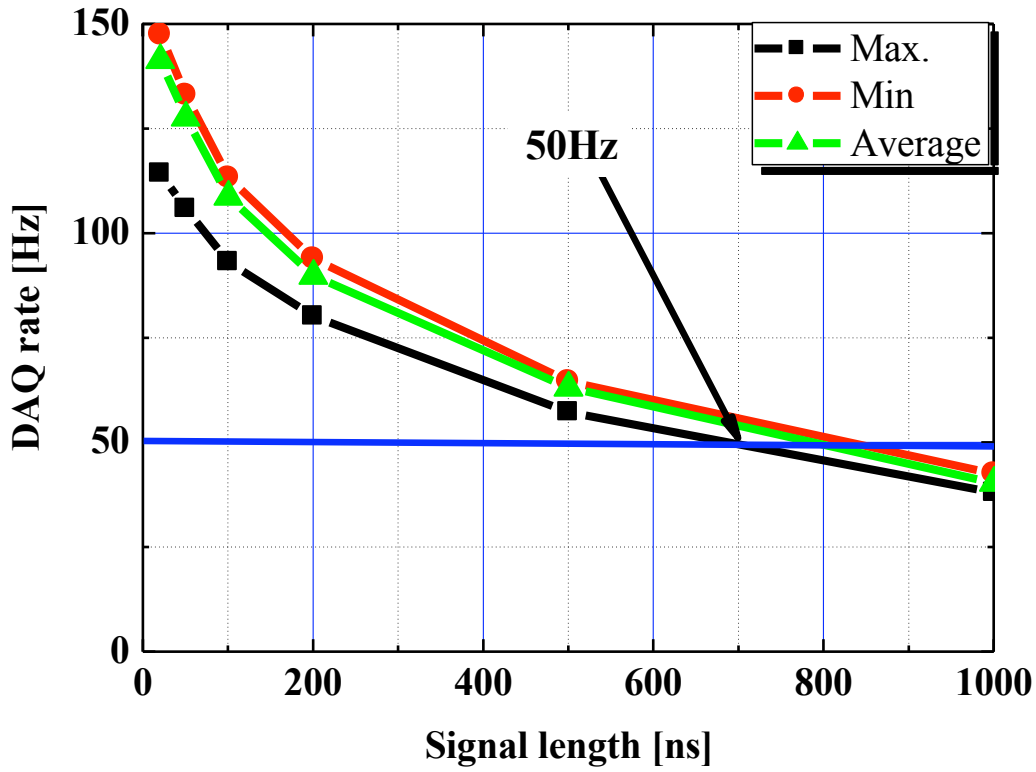


- It consists of only two parts. (Oscilloscope and PC)
- Simple system setup can enhance the system reliability.

Trend plot Software



DAQ rate

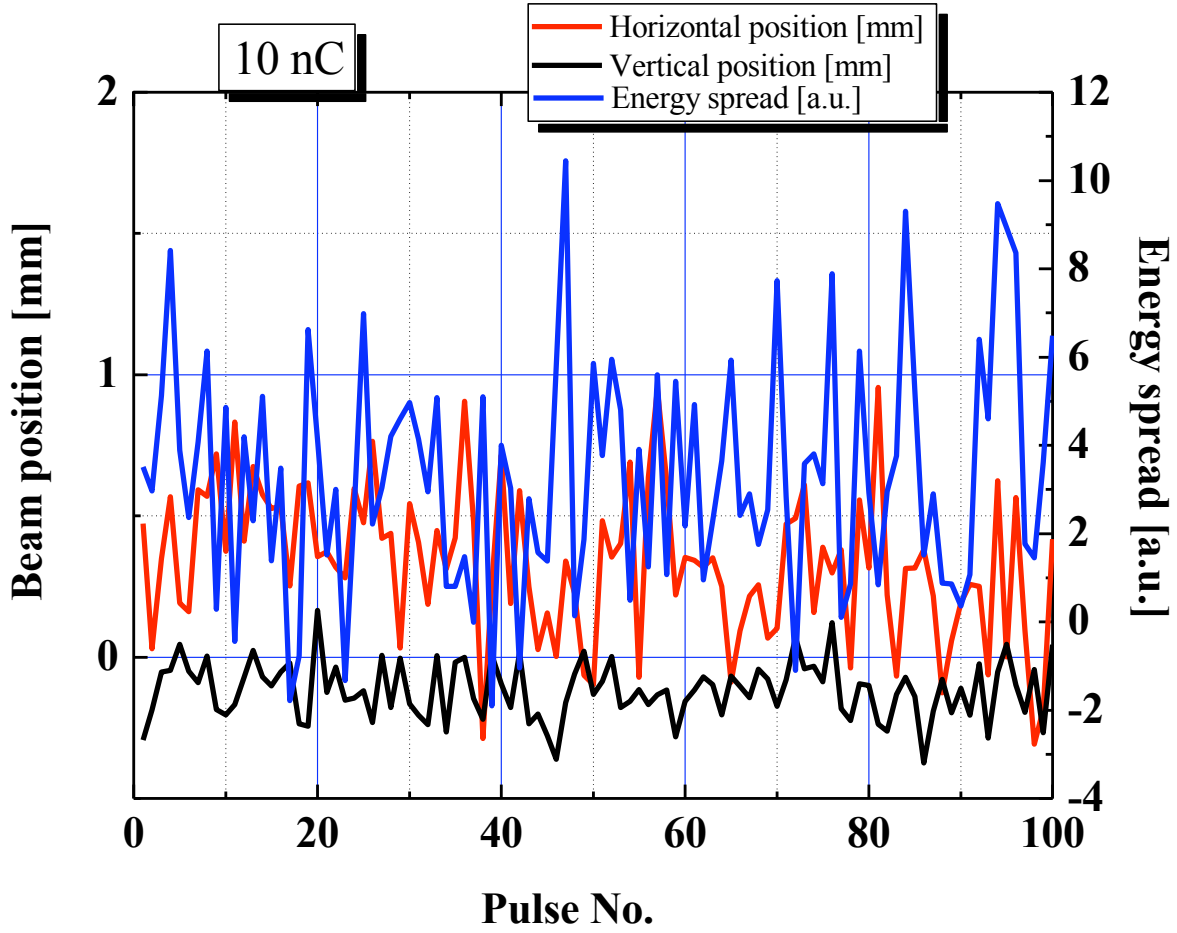


- Two bunch operation, signal width ~ 500 ns

(interval : 96 ns)

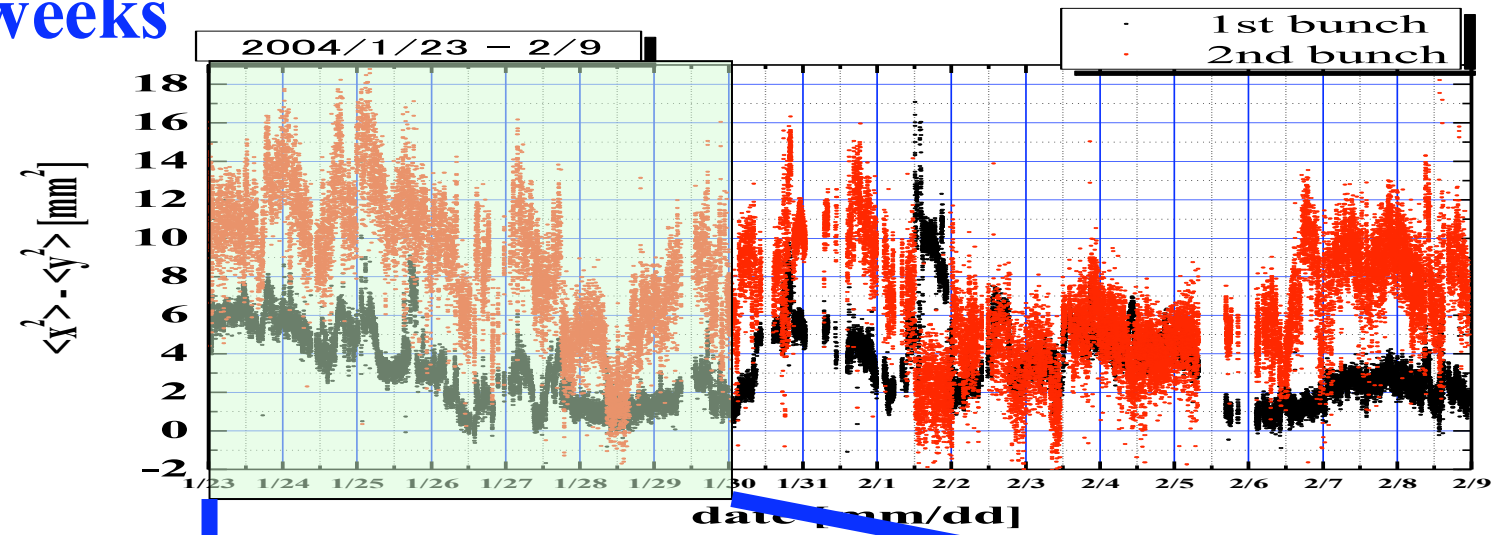
- Oscilloscope can obtain a waveform data up to 50 Hz.
- Each bunch (1st and 2nd bunch) data can be simultaneously obtained.

Pulse-to-Pulse Measurement in 50 Hz mode

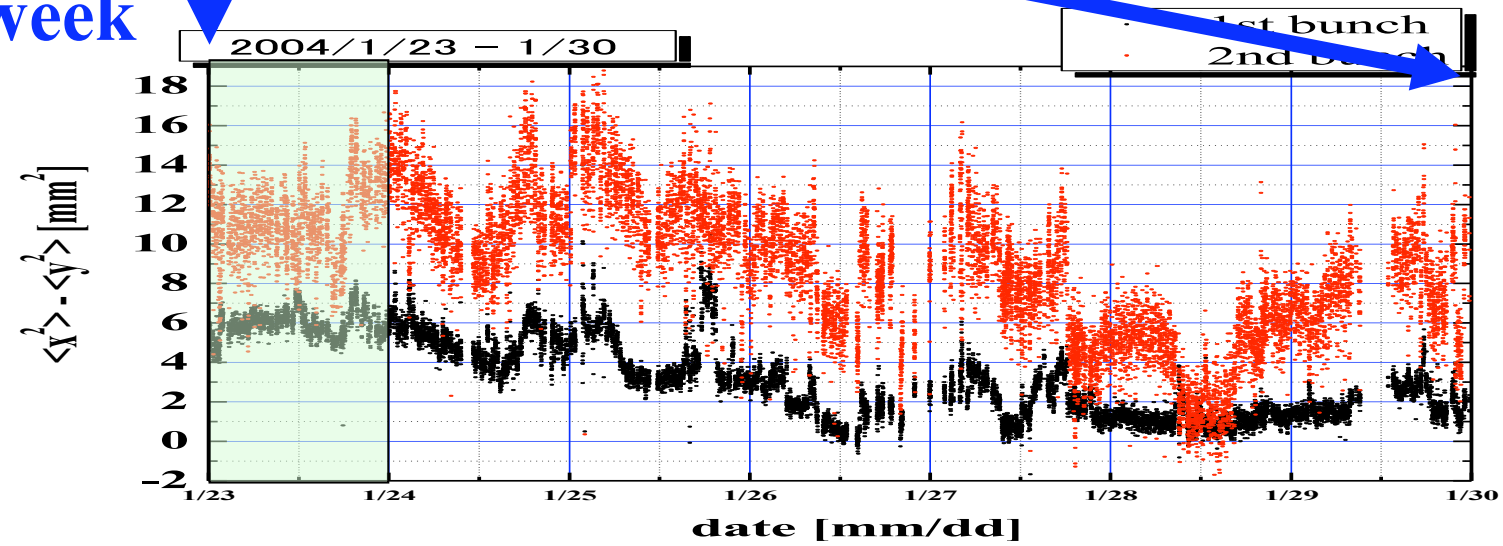


= Results of Data Analysis =

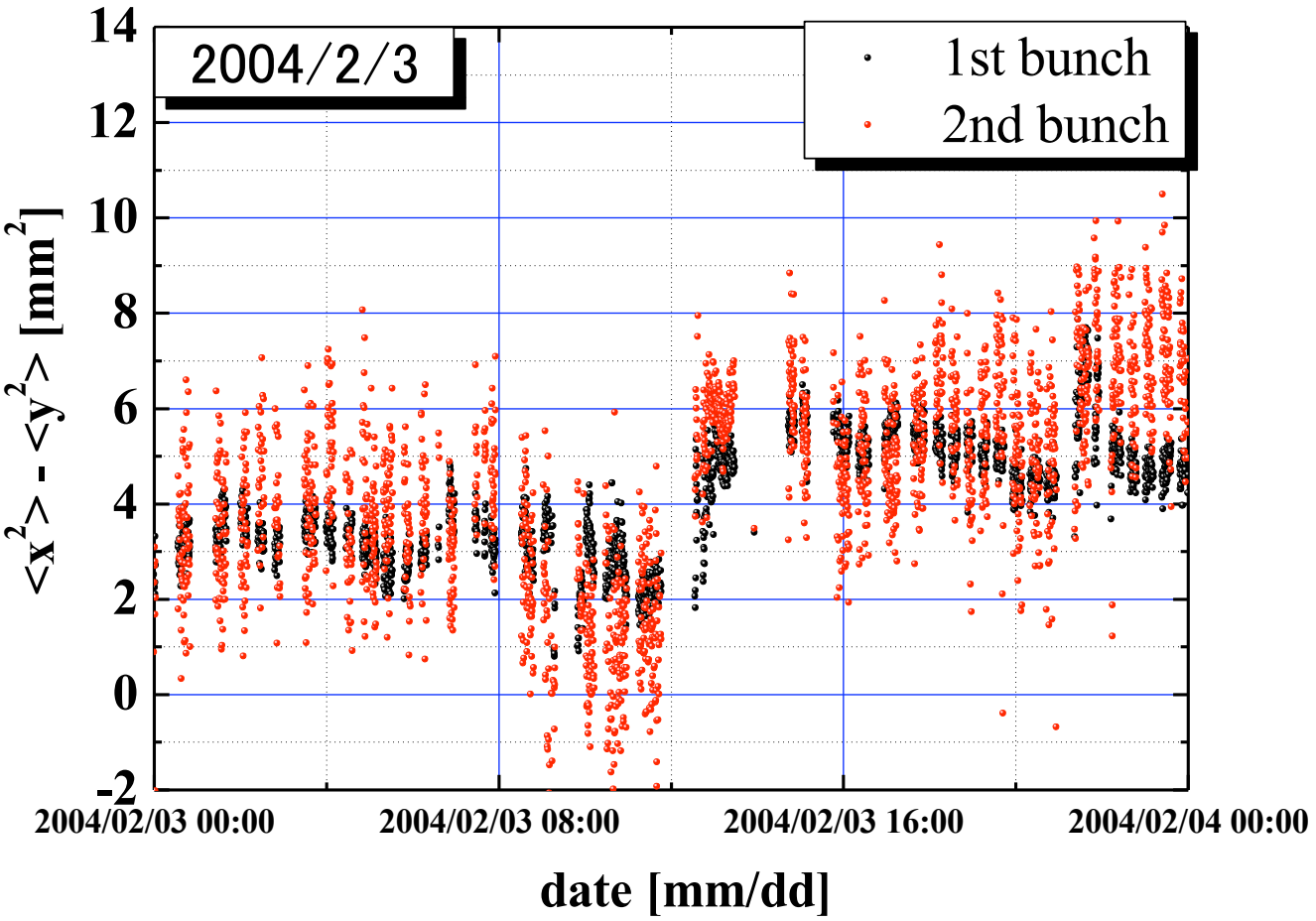
2 weeks



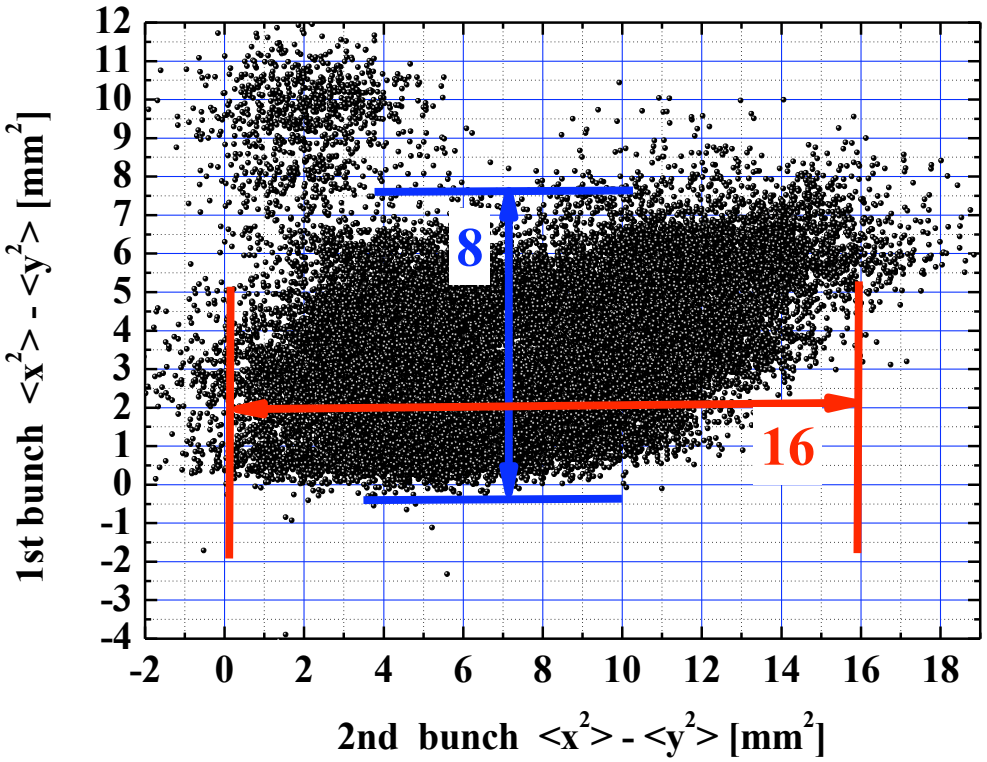
1 week



1 day Fluctuation of Energy-Spread

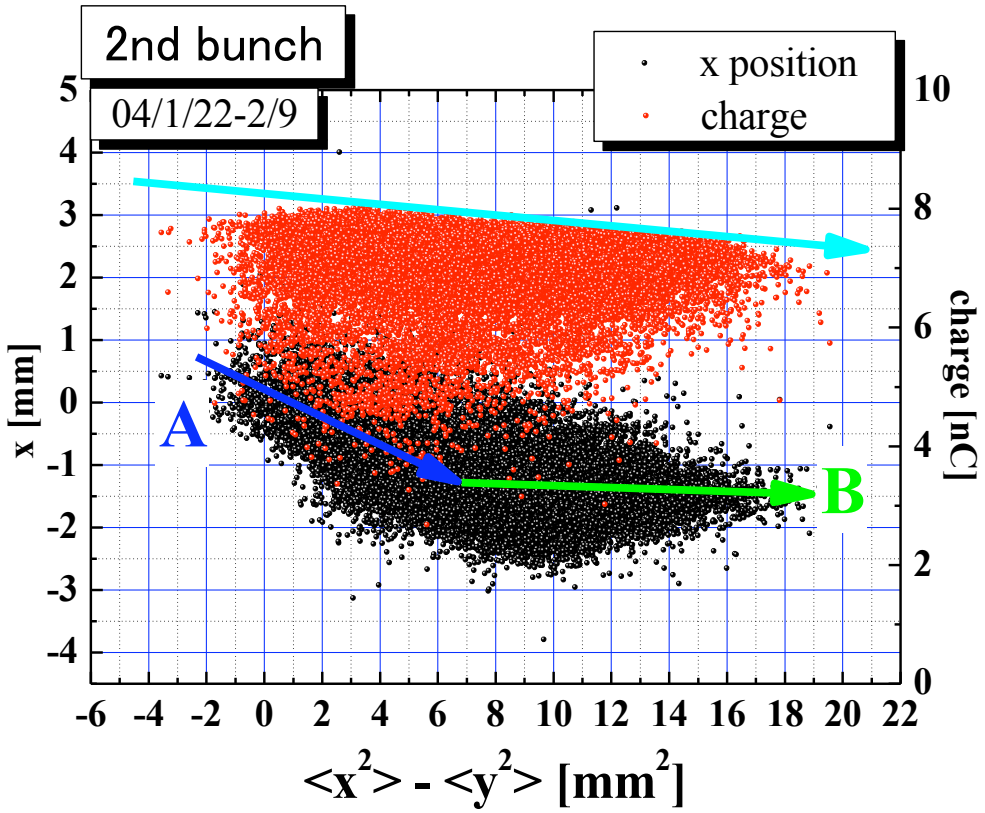


Energy-Spread Fluctuation (1st vs. 2nd bunch)



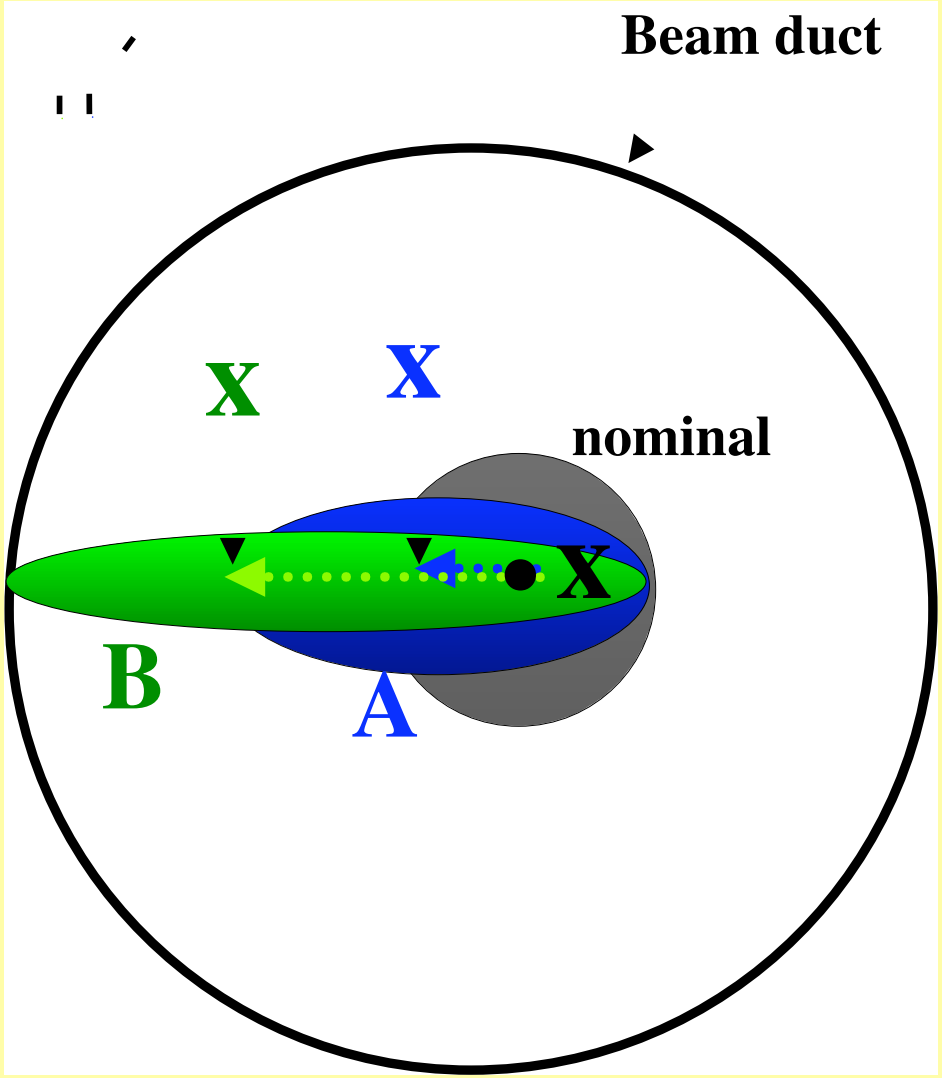
- The 2nd bunch energy spread is about twice larger than that of 1st bunch.
- Each bunch may be accelerated on the different phase of S-band RF.

2nd Bunch Position and Charge vs. Energy-Spread trend



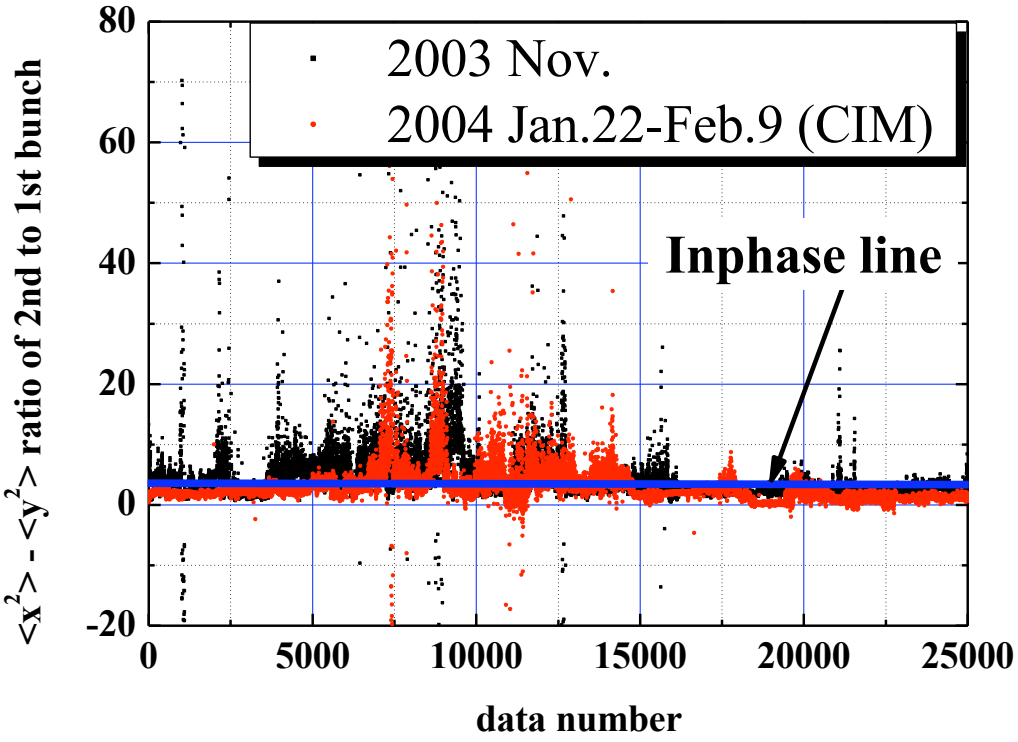
- As the energy-spread increase, beam charge decrease linearly.
- The inclination changes at energy spread “6” (A and B).

2nd Bunch Position and Charge vs. Energy-Spread trend (cont'd)



- As the energy spread increases, the horizontal position move toward left.
- Above the energy spread "B", horizontal position is almost constant.
- Beam tail will be cut by the beam duct.

Energy-Spread Fluctuation ratio of 2nd to 1st bunch



- "Inphase line" :

1st and 2nd bunch energy spread varies almost inphase.

- As the displacement from this line increases:

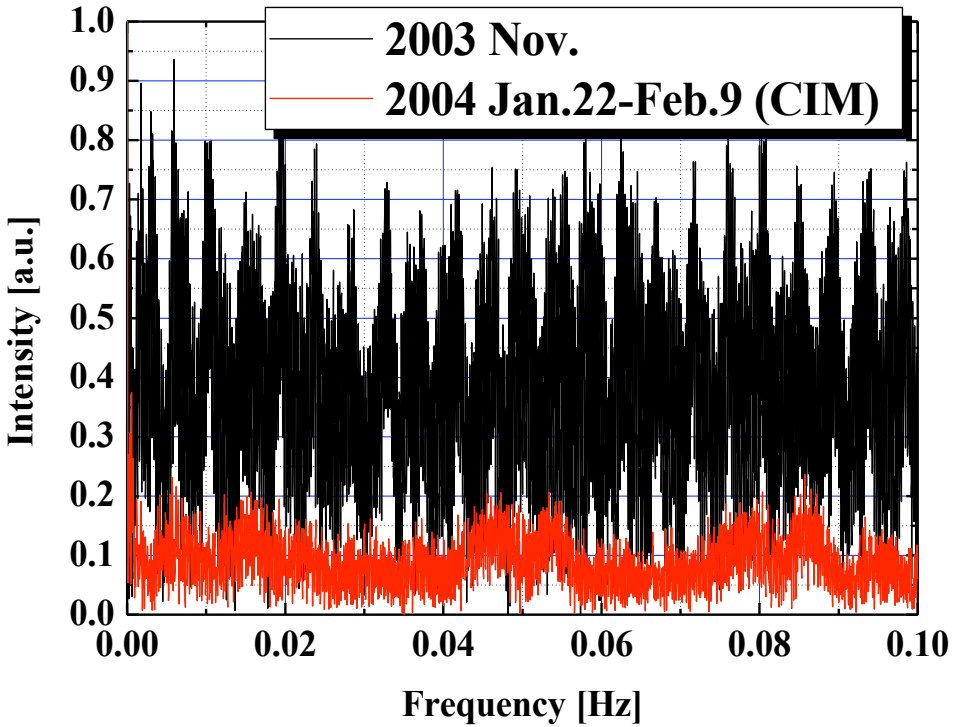
Energy spread fluctuation of each bunch

↓

independent.

(*) CIM: Continuous injection mode

FFT Analysis of energy spread fluctuation ratio ($2^{nd}/1^{st}$)



- Result of FFT is different between Continuous Injection Mode (CIM) and previous operation mode (Injection was carried out in every hour.)

Summary & Future Plan

- Nondestructive Energy-Spread Monitor (Quantitative measurement) and fast DAQ system were developed for the **Energy-Spread Feedback System**.
- It works well in the daily operation.

- The fluctuation of 2nd bunch energy spread is larger than that of 1st bunch (approximately double).
- More detailed data analysis is needed.

- The Energy-Spread Feedback System will be tested in the near future.