Observation of Crab Crossing with Streak Camera

2007/3/19

KEKB Review

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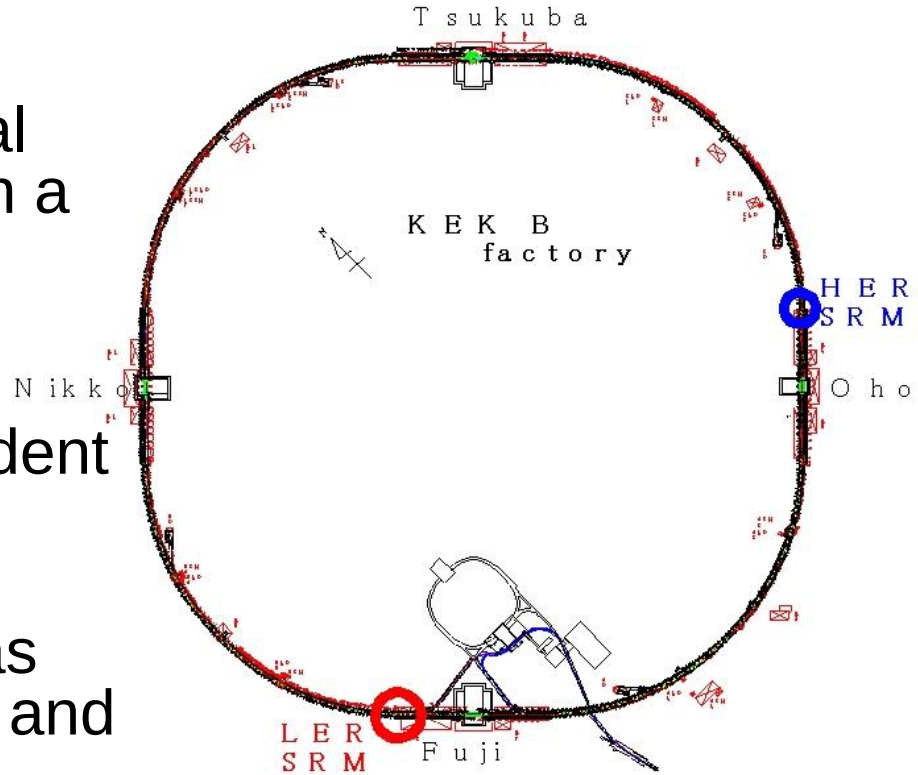
Introduction

- We use streak cameras to observe Crab Crossing.
- For this purpose, a streak camera is installed in synchrotron radiation monitor (SRM) hut of each ring.

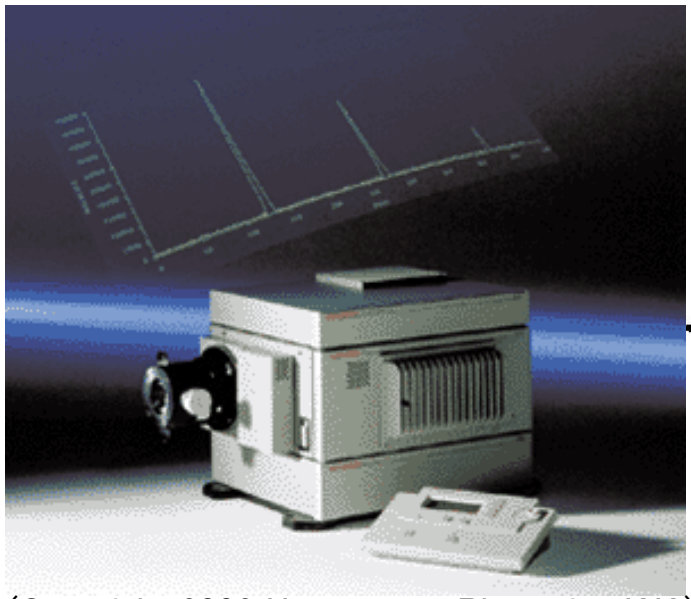
Introduction : KEKB SRM

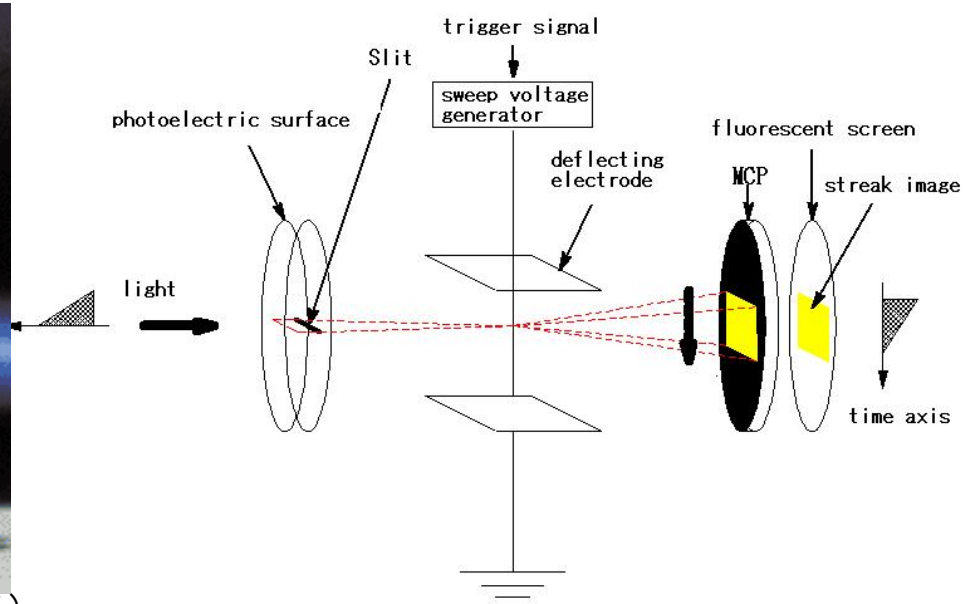
- We use the synchrotron radiation from the individual beam bunches produced in a weak bending magnet to measure the beam size.
- High and low energy rings (HER, LER) have independent SRMs.
- The light path from weak bending magnet to cameras are 35m and 38m for HER and LER, respectively.



Introduction : Streak Camera

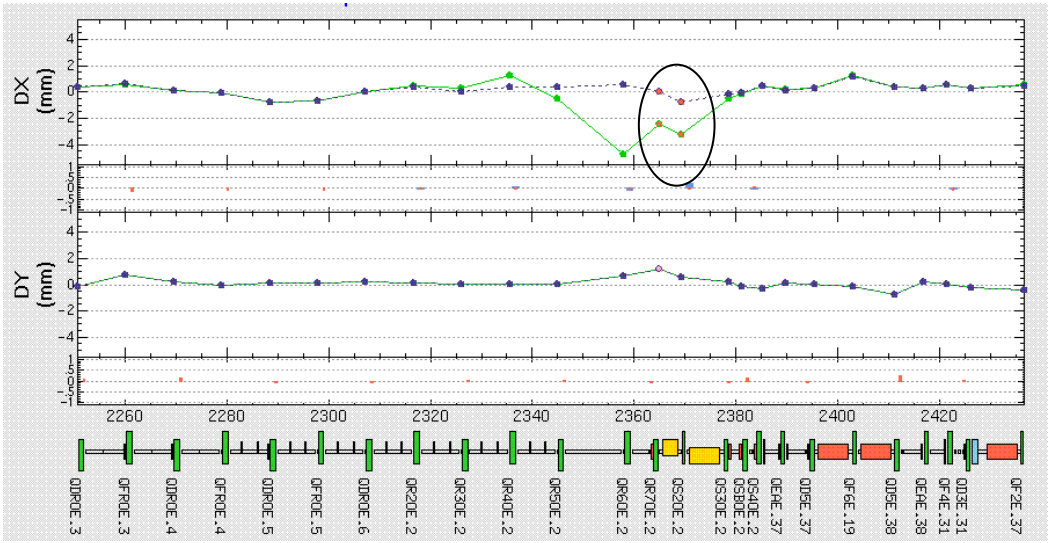
- The streak camera (Hamamatsu C5680) is used to measure the bunch length and bunch-by-bunch beam size.
- Beam profile (Longitudinal vs Horizontal) is measured to check the crabbing angle.

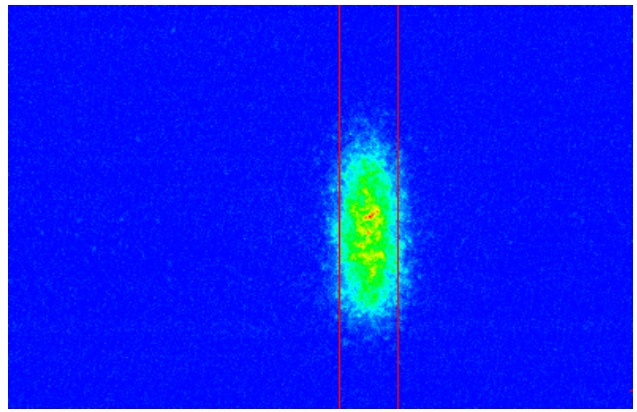


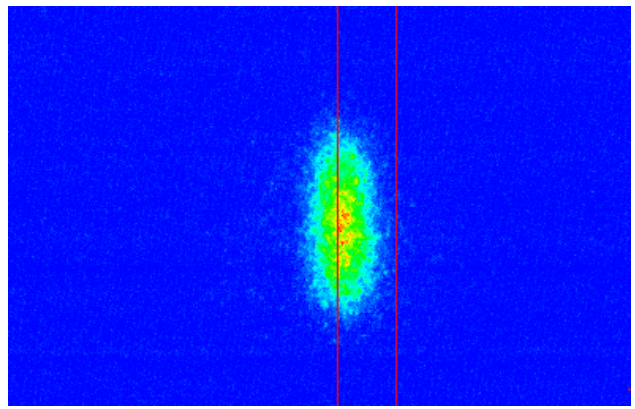


Calibration

- Longitudinal scale (time) is calibrated by Hamamatsu.
- Parallel bump (±2mm) is set for horizontal size calibration.

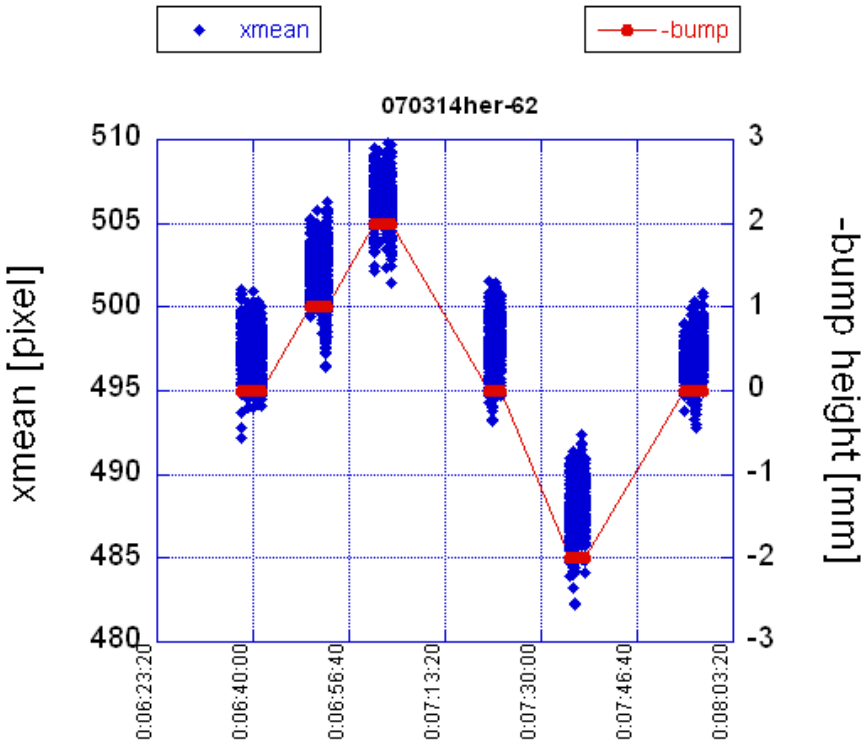


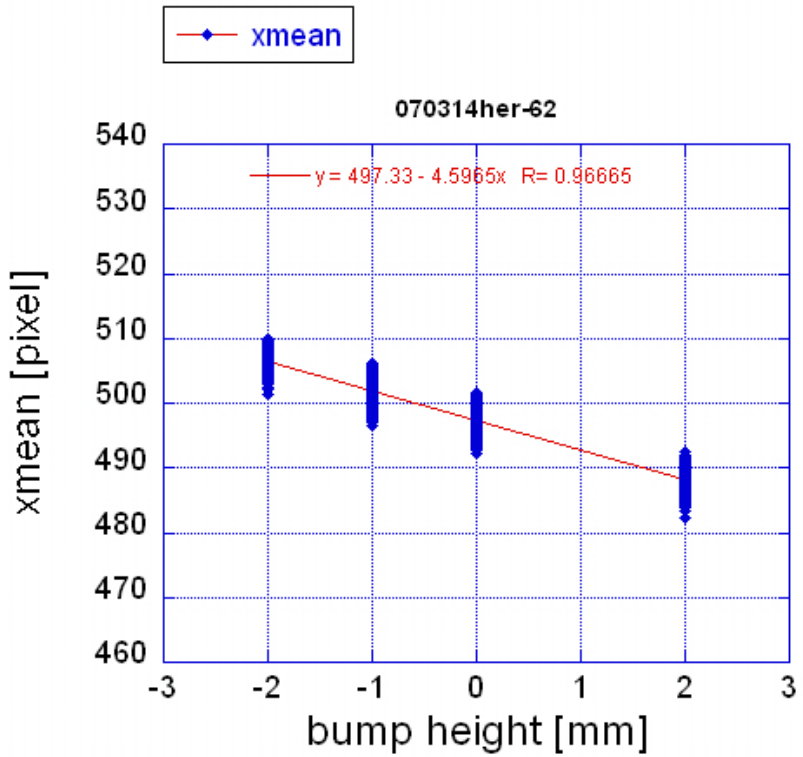




Calibration

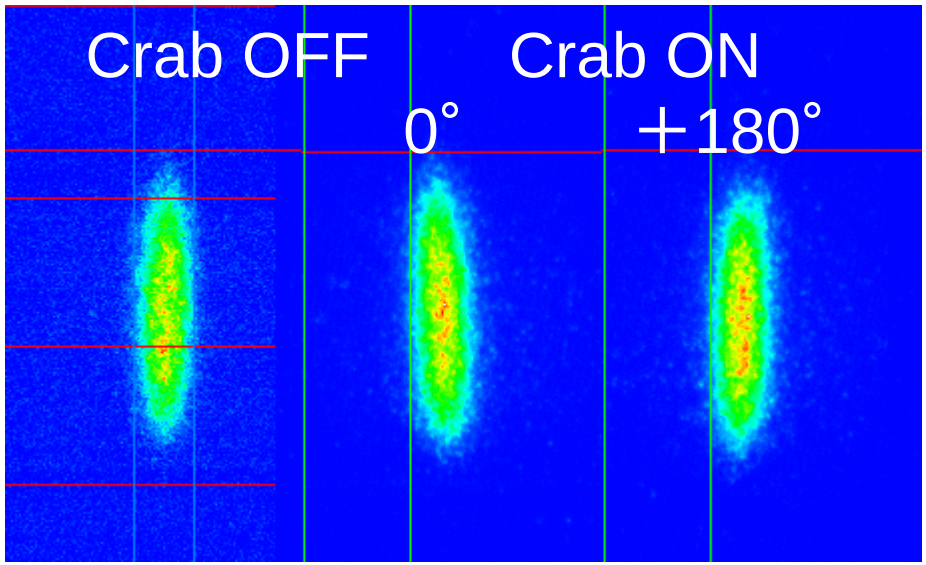
- Calibration constant is calculated by fitting of bump height vs streak camera pixels.



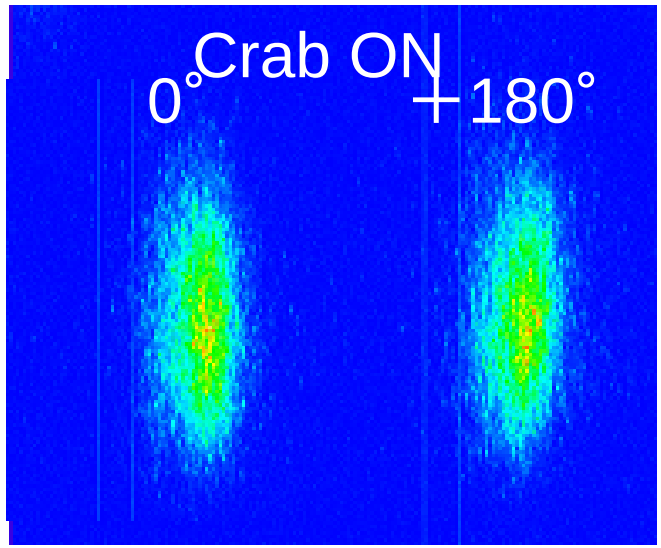


Measurement : 2007/2/19 Crab ON

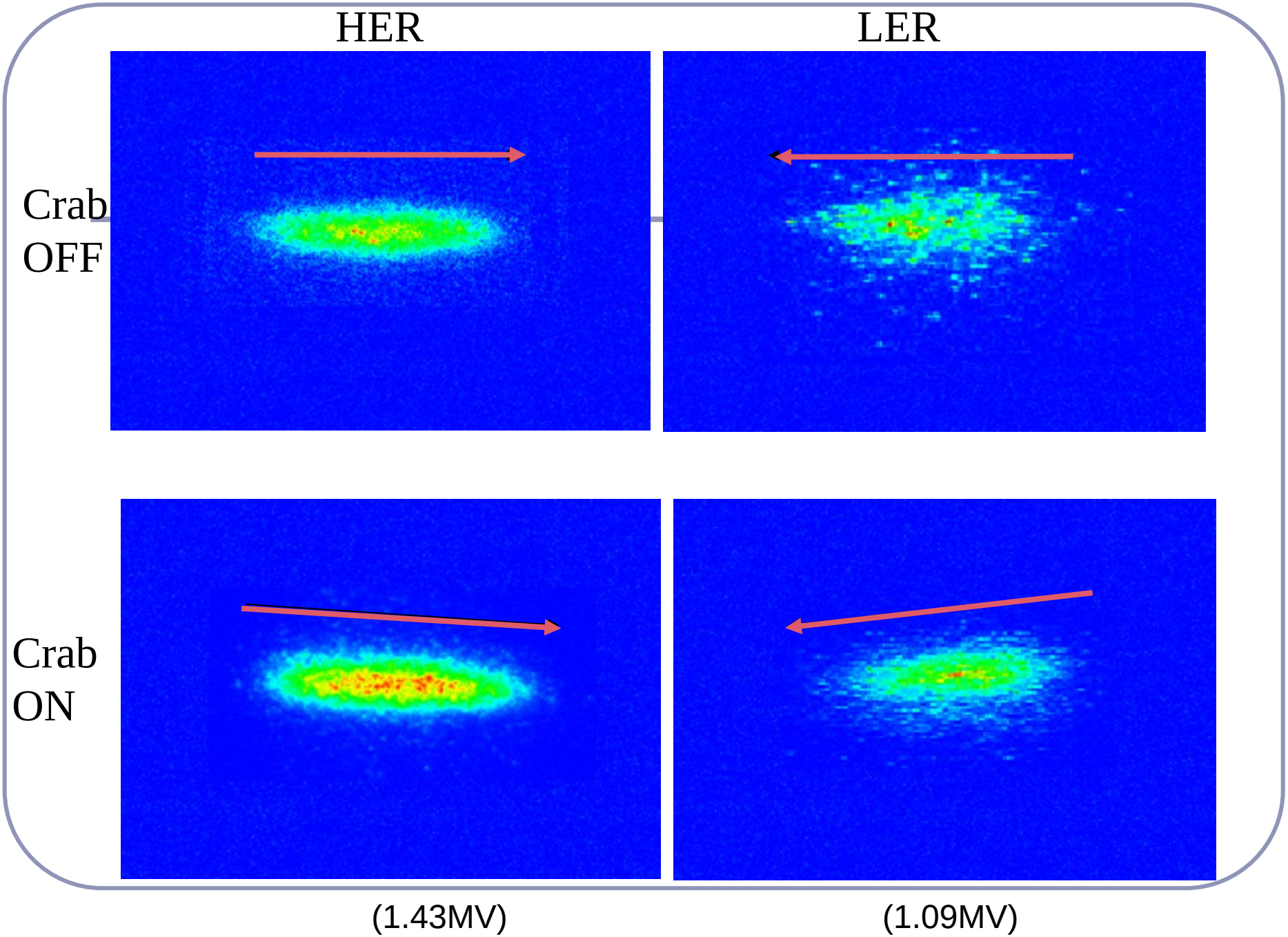
- 1mA/single bunch was injected into both rings after Crab ON to check the crabbing.
- The opposite direction tilt was also checked by changing the crab phase 180˚ .



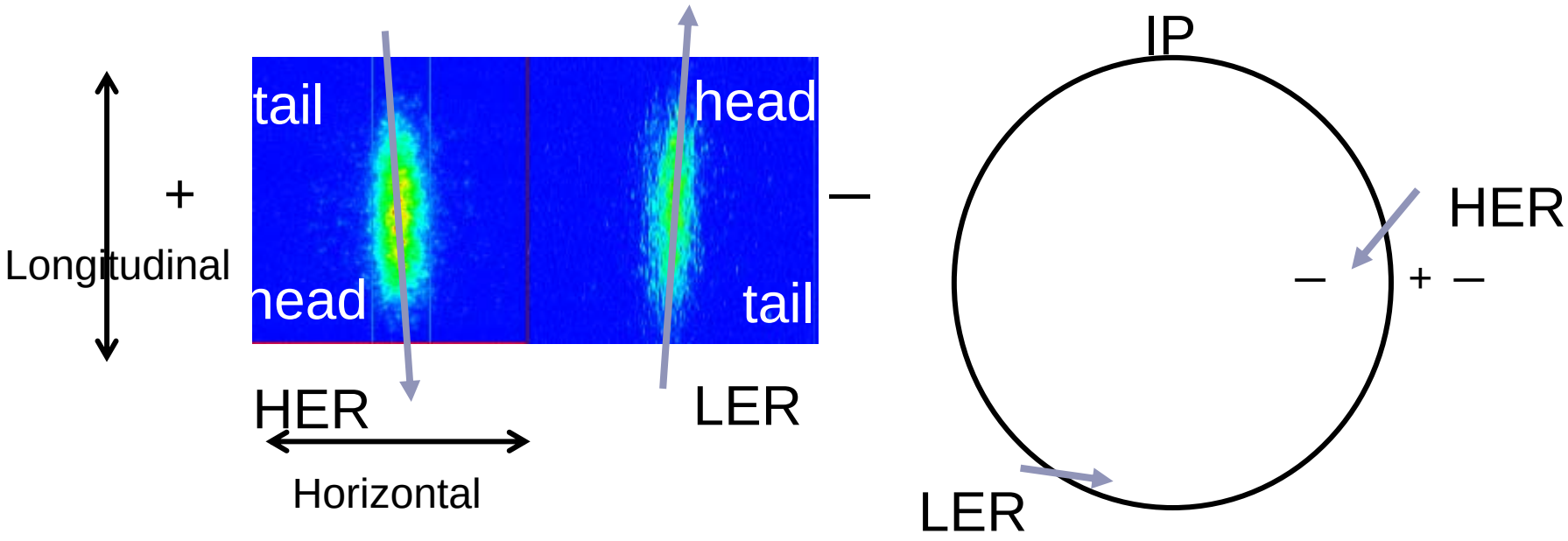
HER(1.43MV)



LER(0.9MV)


HER
LER
Crab
OFF
Crab
ON
(1.43MV)
(1.09MV)

Measurement : Crabbing Direction Check



Longitudinal direction and tilt direction were checked.
Both beam are tilted to the inside of the ring at the SR emission point.

Measurement : Crabbing angle @ SRM

$$\frac{\phi_{SRM}}{\phi_{IP}} = \sqrt{\frac{\beta_{SRM}}{\beta_{IP}}} \frac{\cos\left(\pi\nu - \left|\psi_{crab} - \psi_{SRM}\right|\right)}{\cos\left(\pi\nu - \left|\psi_{crab} - \psi_{IP}\right|\right)}$$

$$\phi_{IP} = 11 mrad,$$

$$\phi_{SRM\,(HER)} = 39.1 mrad,$$

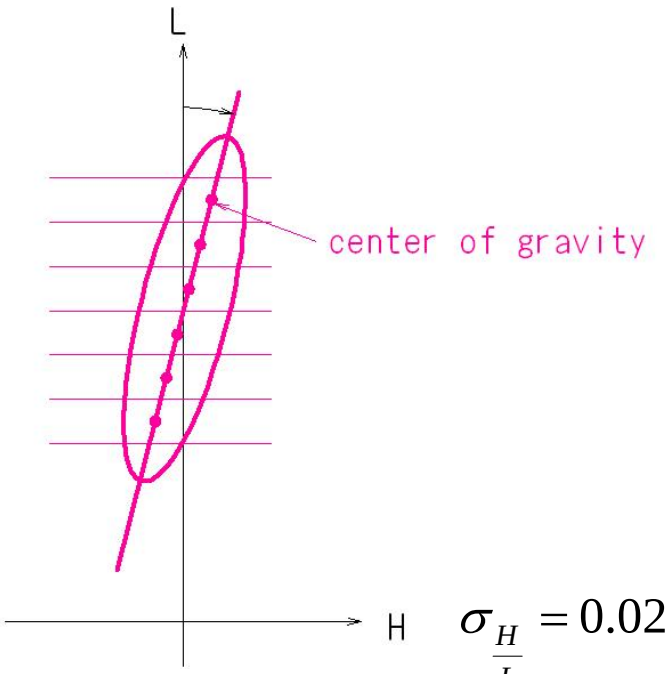
$$\phi_{IP(LER)} = 43.7 mrad$$

	HER		LER	
	β H	ν H	β H	ν H
Crab	199.977	11.2498	74.0000	10.2500
SRM	25.8768	35.3627	24.1507	21.3615
IP	0.8	44.5114	0.59	45.5098

(2/21 optics)

Sign does not change between IP and SRM.

Measurement : Accuracy of measurement

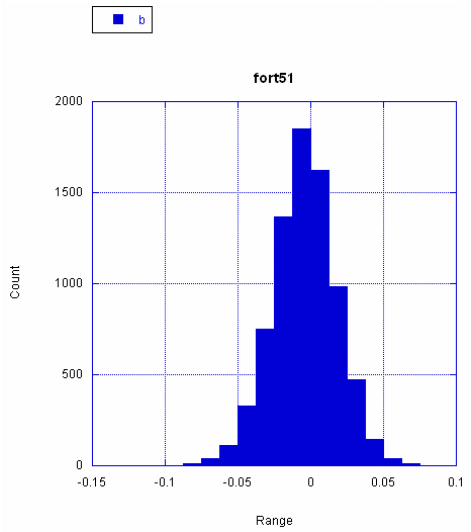


- Bunch is divided into several pieces (10) and each center of gravity is calculated.
- The centers of gravity are fitted with a linear function, H = a + b × L .
- “b” corresponds to the tilt of the bunch.
- The width of the “b” distribution with Crab OFF beam is 0.022.

$$\sigma_{\frac{H}{L}} = 0.022 \times \frac{512/180[ch/mm]}{16.413 \pm 2.75[ch/mm]}$$

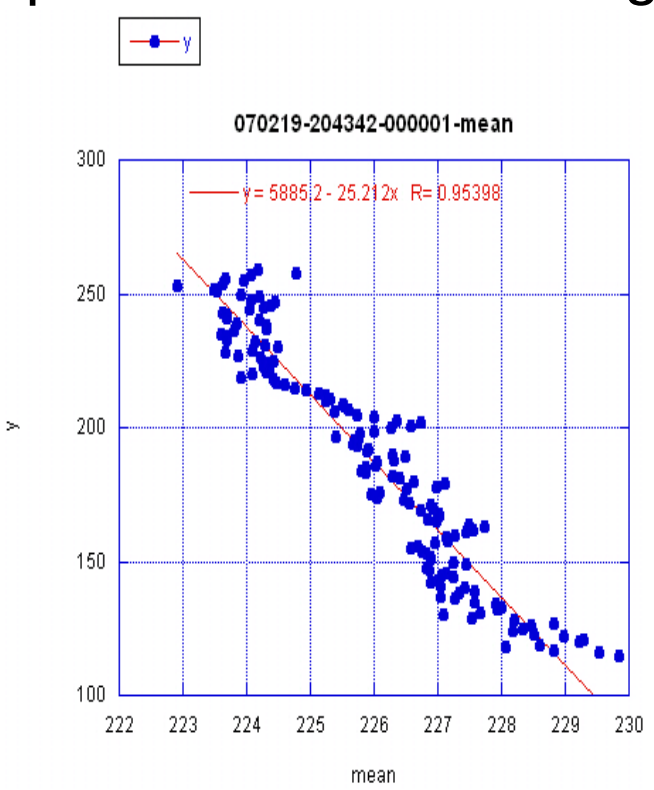
$$= (3.8 \pm 0.657) \times 10^{-3}[rad]$$

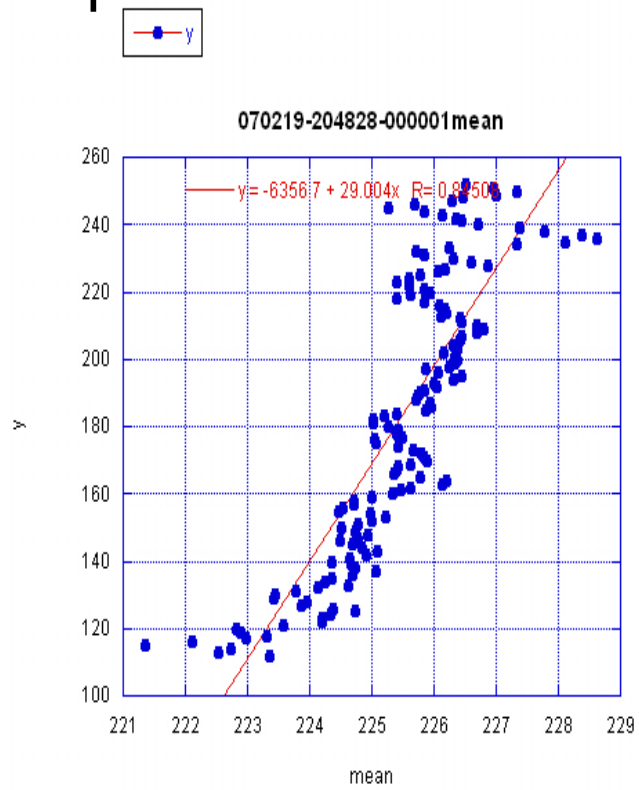
Accuracy of the measurement～10%



Measurement : Fitting example

- Result of calculated tilt is similar whether using 10 pieces case or all longitudinal pixels.

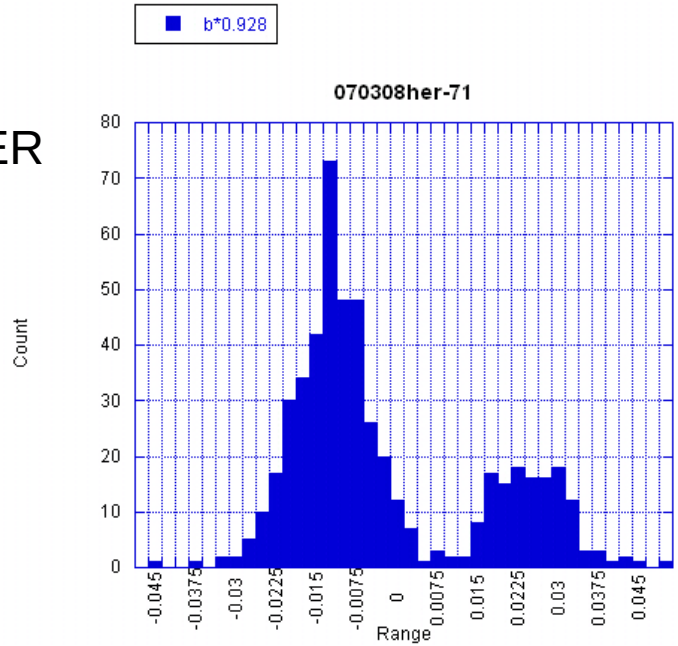




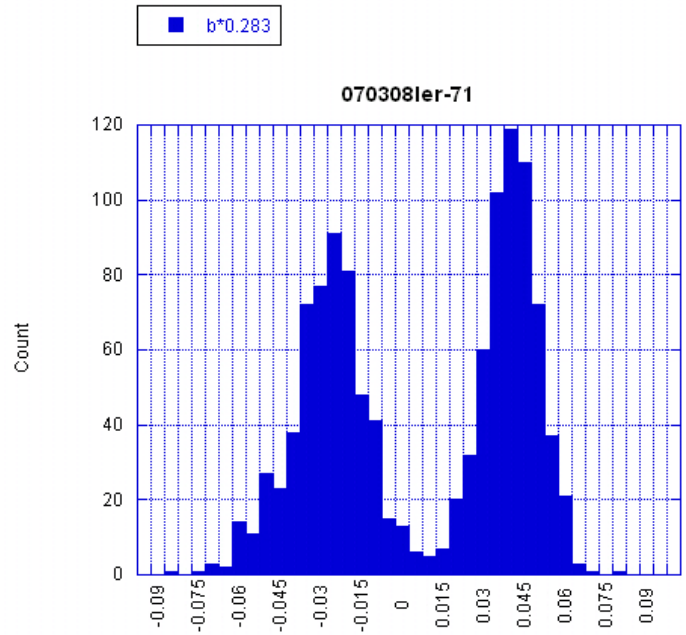
Measurement : tilt

- The results of the tilt calculations are shown below.
- The two peaks correspond to the two sweep phase of the streak camera.
- LER values are consistent with the expected value, but HER values are off by a factor of 2.

HER

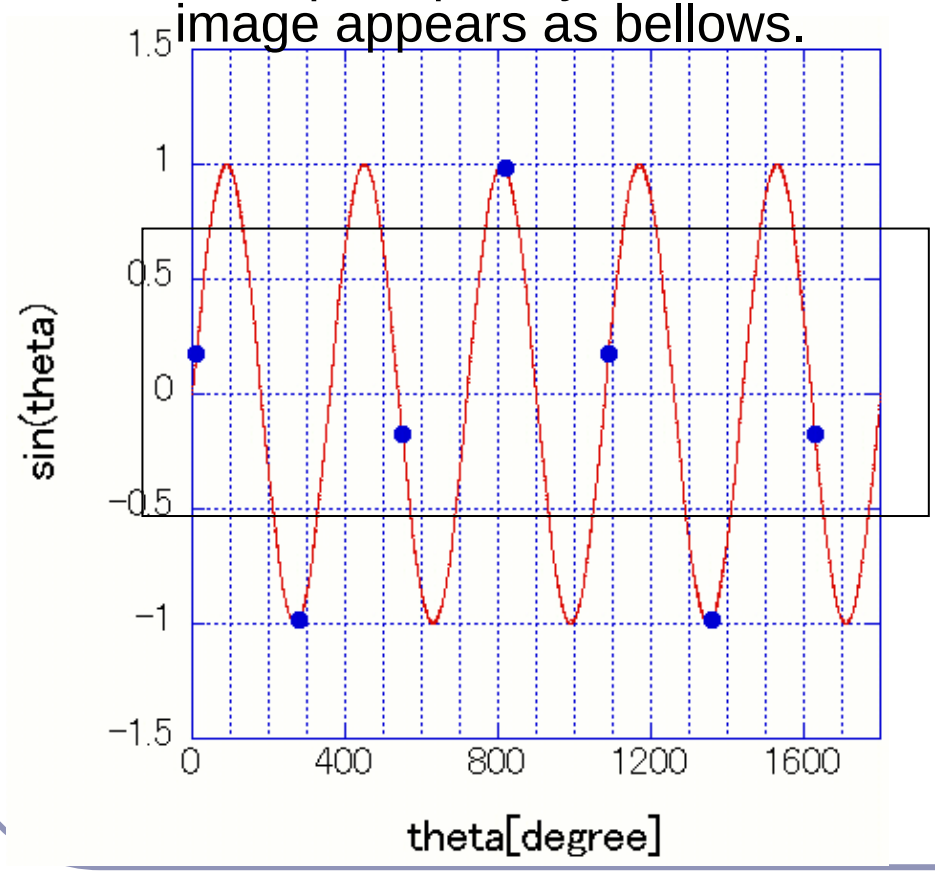


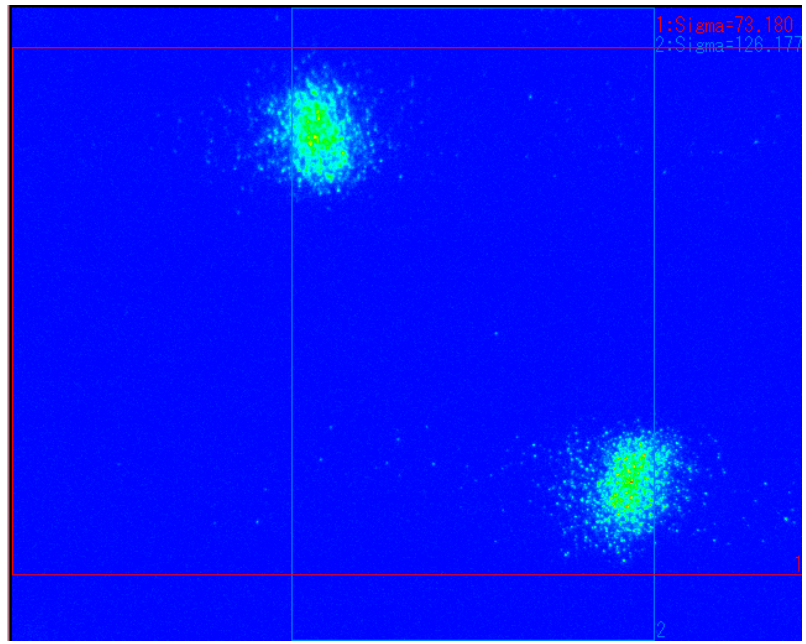
LER



Measurement : tilt

- Sweep frequency of streak camera is ¼ of KEKB RF and the image appears as bellows.





Summary

- Crabbing is observed with the streak cameras.
- Crabbing angle is measured quantitatively, and the LER angle is consistent with the expected angle from optics calculation.
- Inconsistency of the HER crabbing angle with the expected value will be studied.

Measurement : HER tilt

- I checked about the HER inconsistency.
  - The fitting result of the tilt are constant when the number of dividing peaces.
  - The calibration bump shape is changed for the SR to hit against the same place of extraction mirror, and the result dose not change.
  - Longitudinal beam size are 6.4mm and consistent with expected value but the calibration constant should be checked.