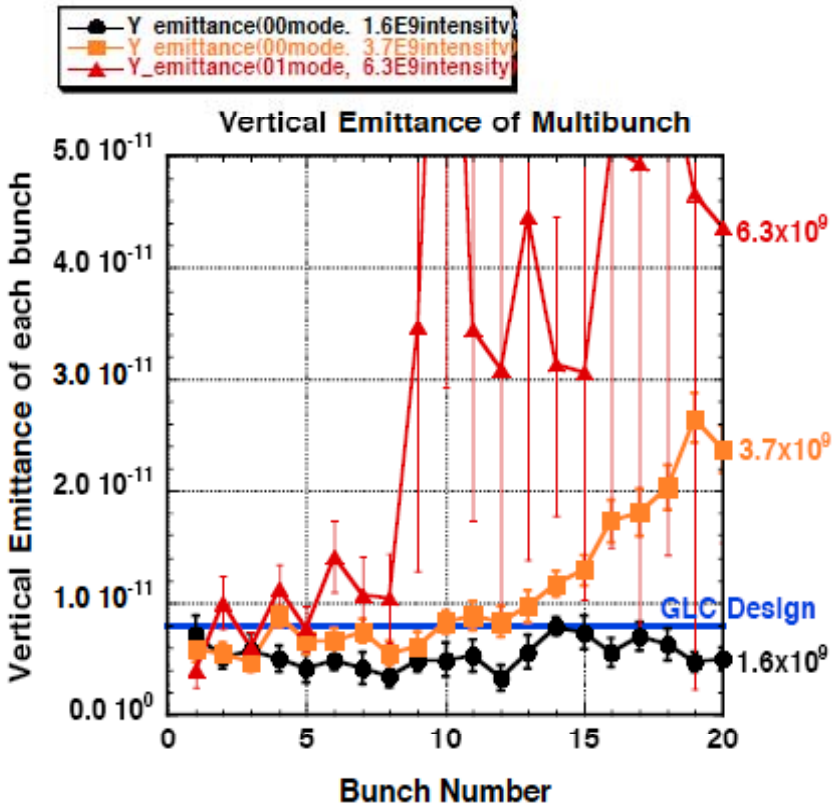
Fast Ion Studies

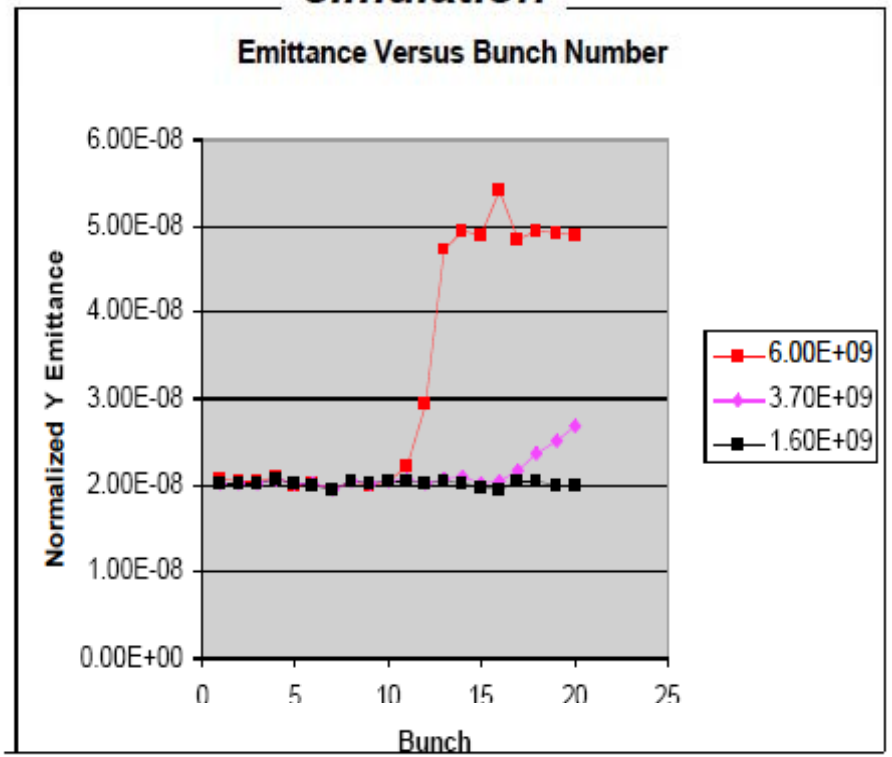
- goal and plan
- collaboration with KNU, DESY and SLAC
- status

N.Terunuma (KEK)

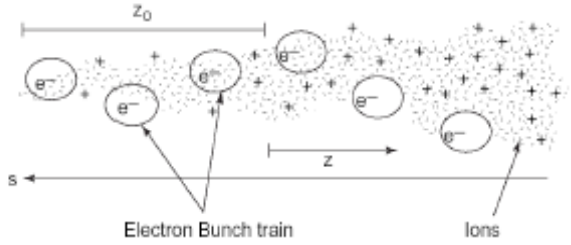
ATF 2004 result of Fast Ion Instability simulation



simulation



Behavior of Y emittance is very similar.



Schematic of the Fast-Beam Ion Instability

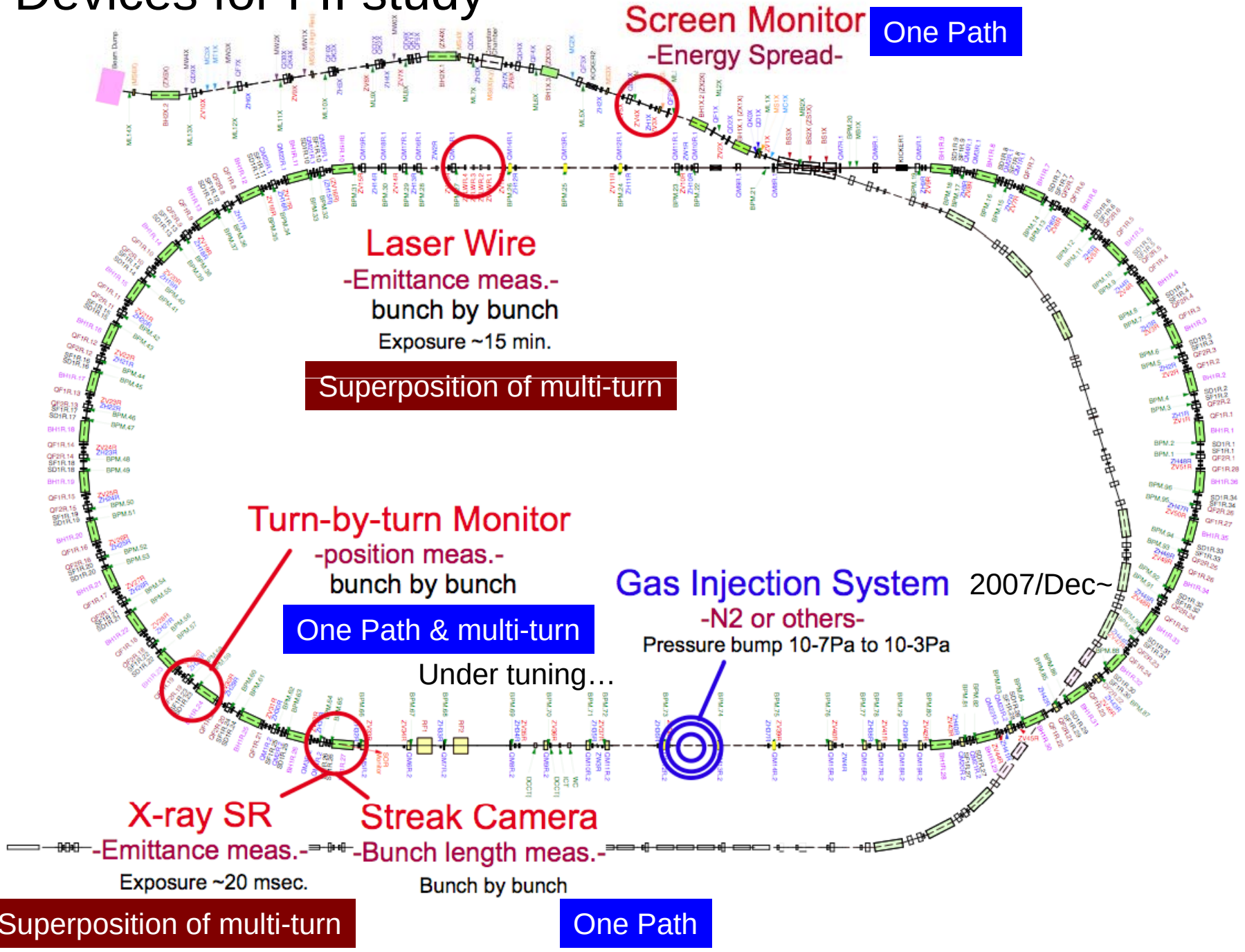
ILCDR07 at INFN-LNF

Goals of the experiment

(according to Two proposals (L. Wang, T. Raubenhimer 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.

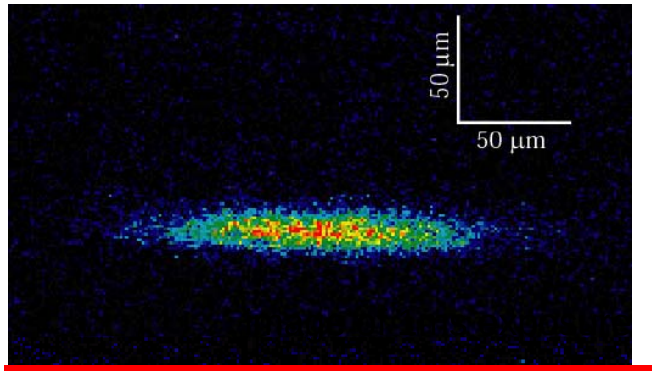
Devices for FII study



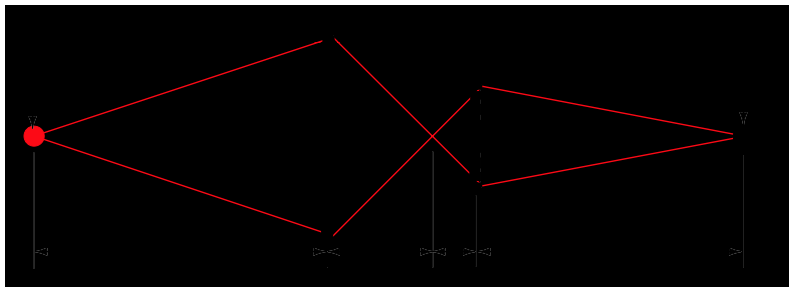
XSR beam-size monitor

ATF beam tuningのためのオンラインモニターとして運用開始

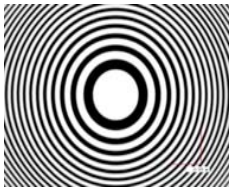
X-Ray Telescope using Zone Plate at 3.2KeV
- ***magnification : 20***
- ***resolution : ~1 μm***
- ***integration time : > 1ms***



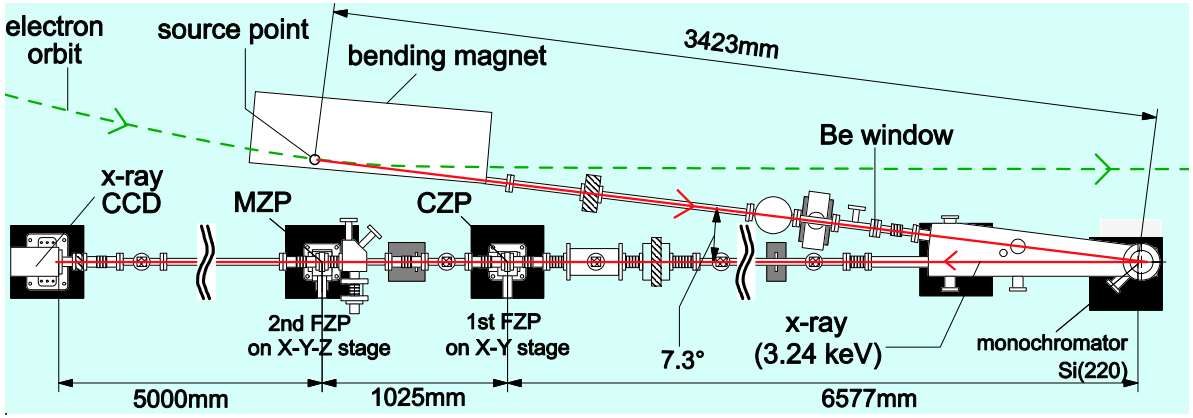
σ_x = 48.2 ± 0.5 [μm]
σ_y = 6.4 ± 0.1 [μm]



SR X-ray Optics

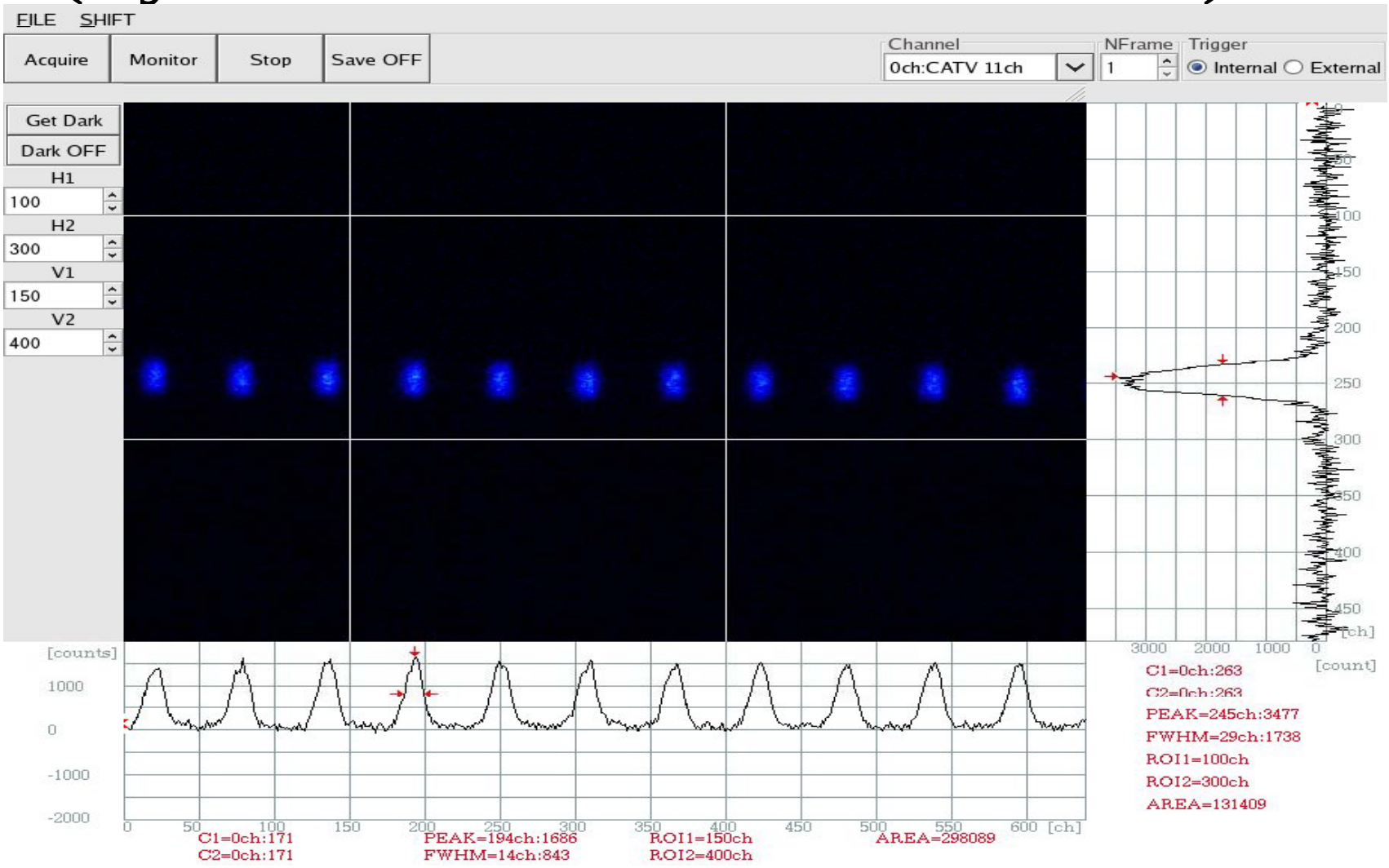


Zone plate

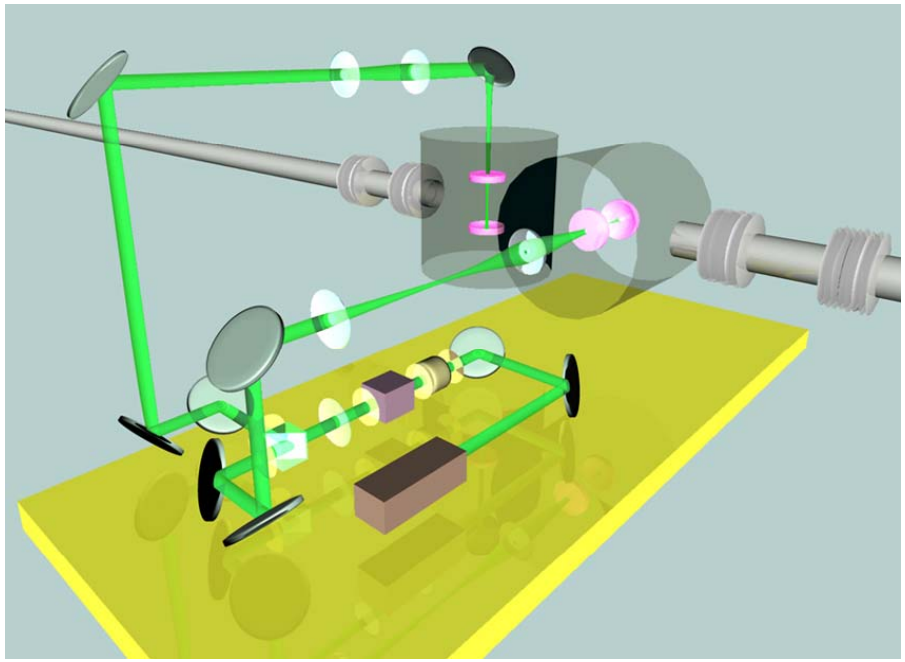


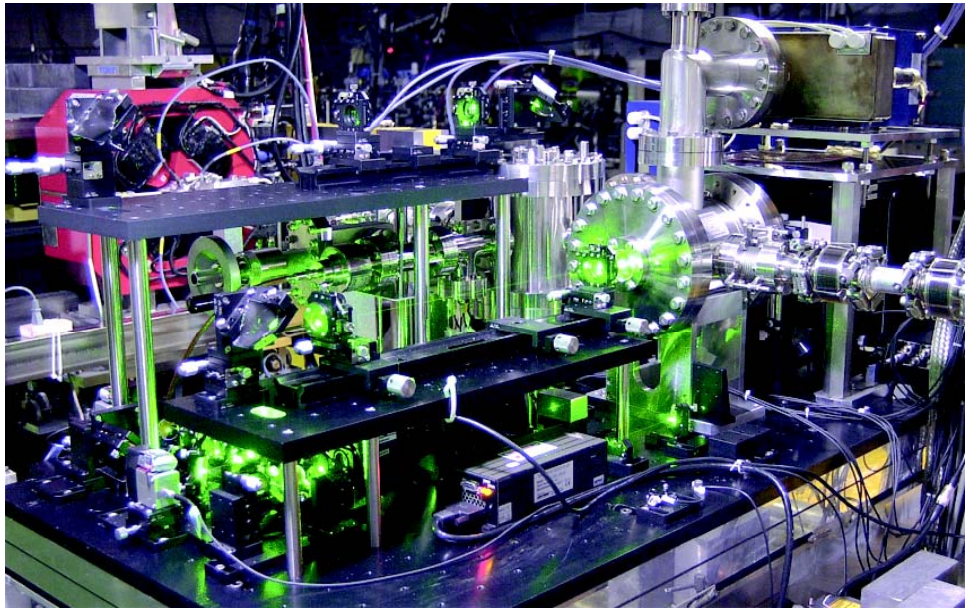
SR X-ray beam line

Bunch Length Measurement (Synchronized Streak Camera)



Laser wire beam size monitor in DR



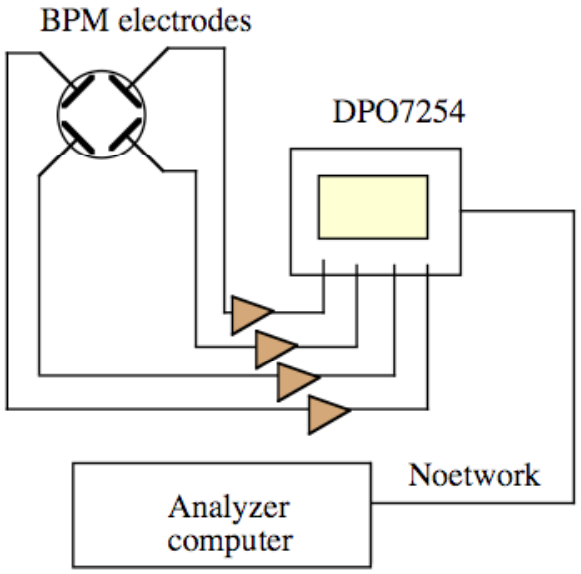


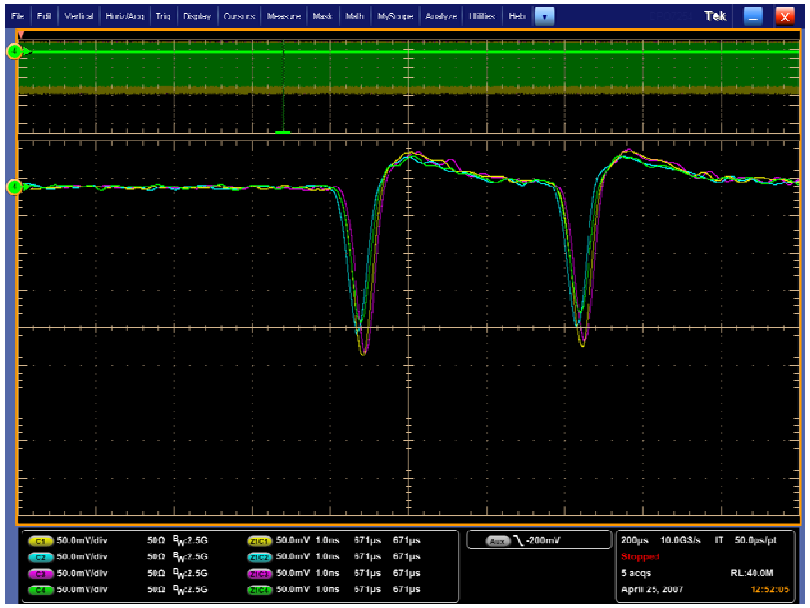
300mW 532nm Solid-state Laser fed into optical cavity

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

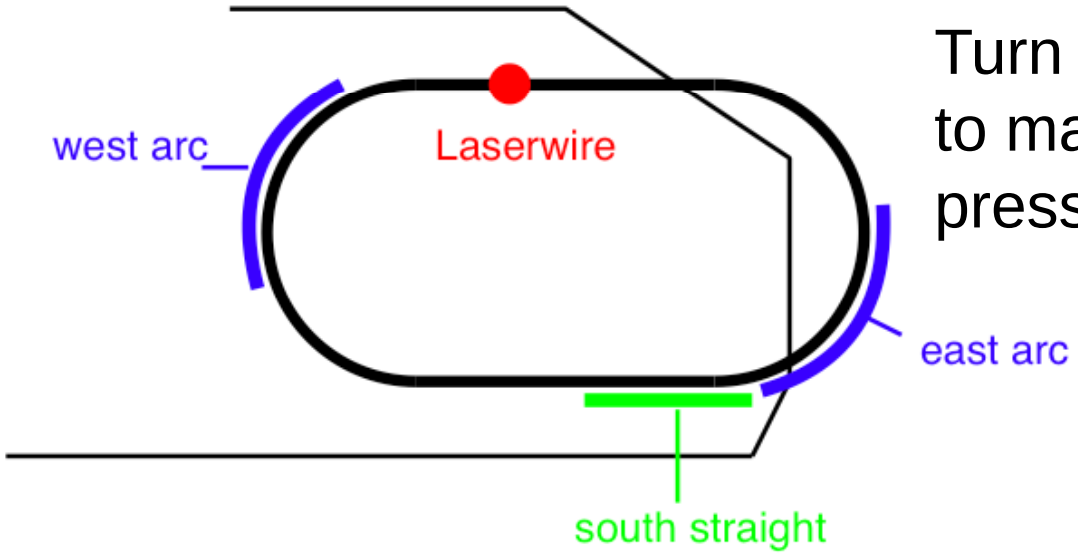
Turn by turn position monitor

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





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



Turn off ion pumps to make vacuum pressure worse.

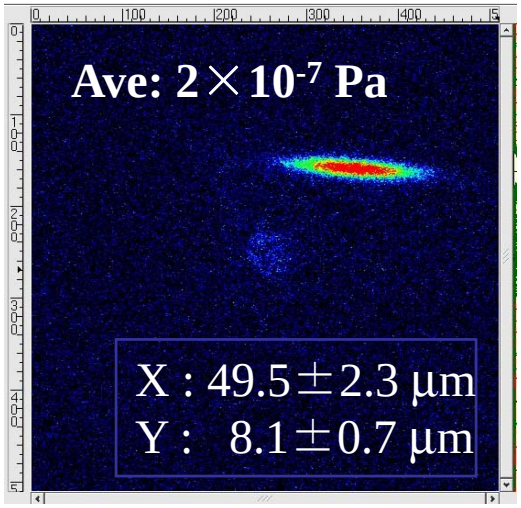
Figure 3: Sections that ion pumps were turned off in this experiment

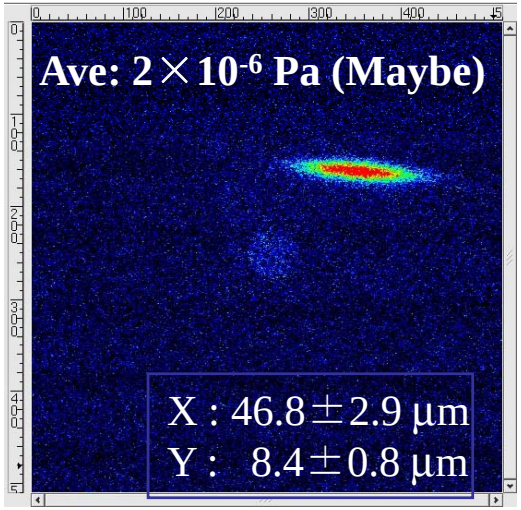
Table 1: vacuum pressure in the measurements

ion pump status	5mA	10mA	20mA
normal	4.6×10^{-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	

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

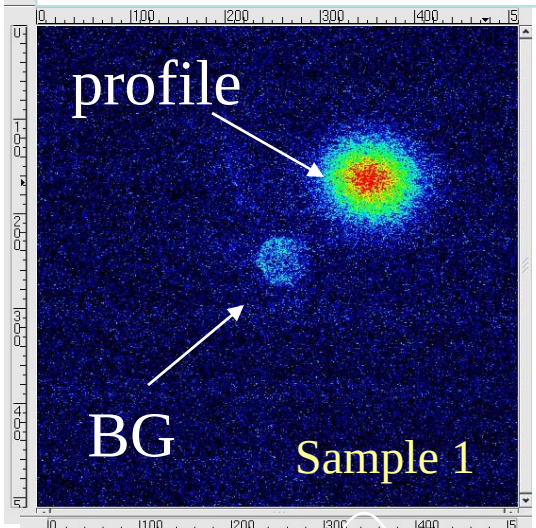
Single bunch, 2×10^{10} /bunch

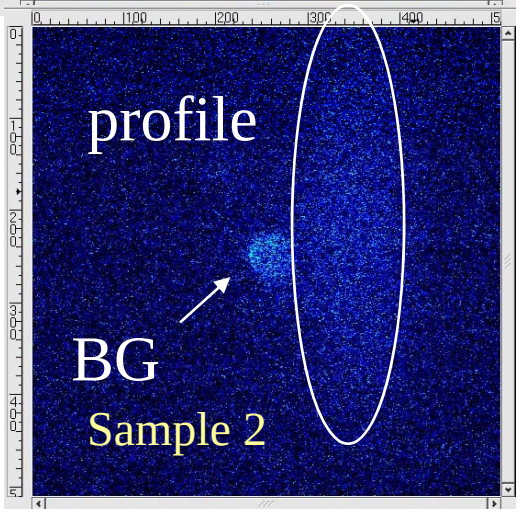




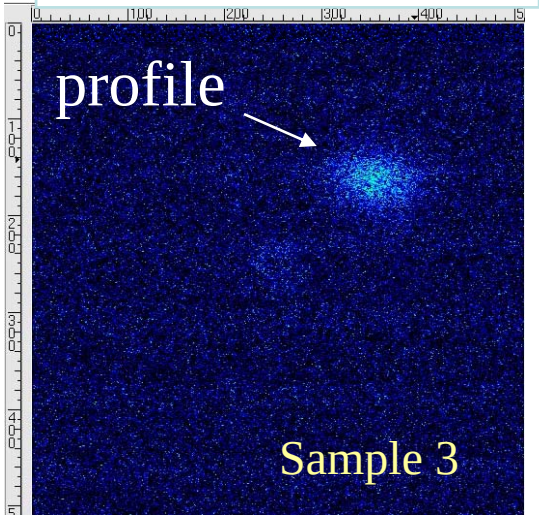
3 train mode, 2×10^{10} /bunch

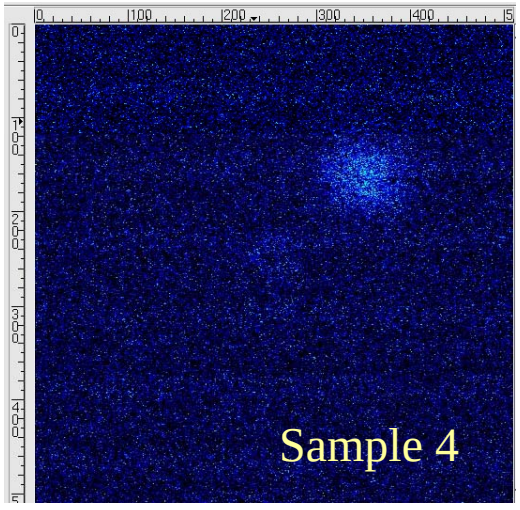
Vacuum : 1×10^{-5} Pa





Vacuum : 2×10^{-6} Pa





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

5mA/20bunches

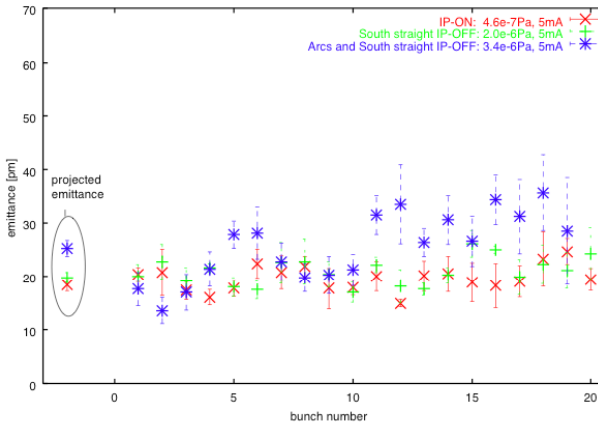


Figure 7: emittance of multi-bunch beam at 5mA/20bunches

10mA/20bunches

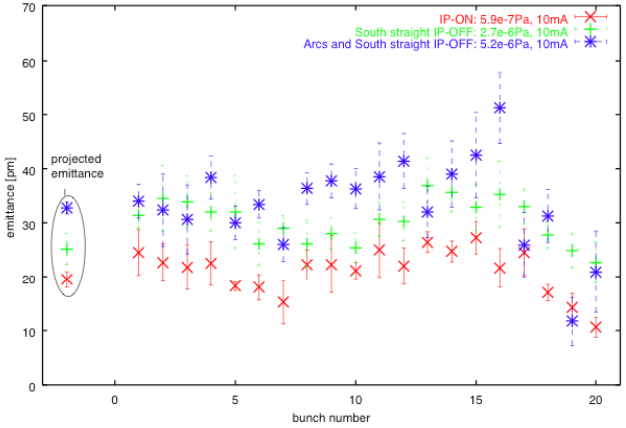


Figure 8: emittance of multi-bunch beam at 10mA/20bunches

20mA/20bunches

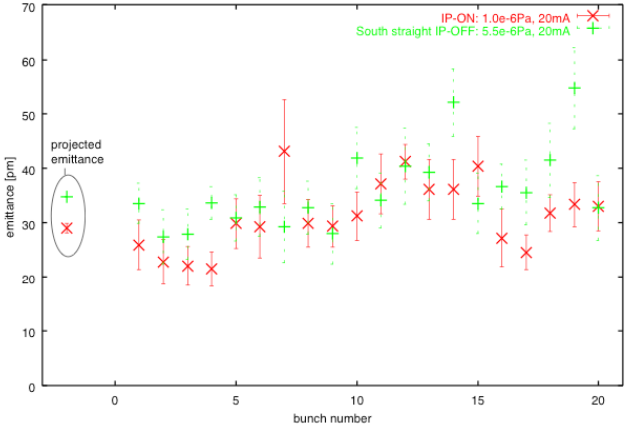


Figure 9: emittance of multi-bunch beam at 20mA/20bunches

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.

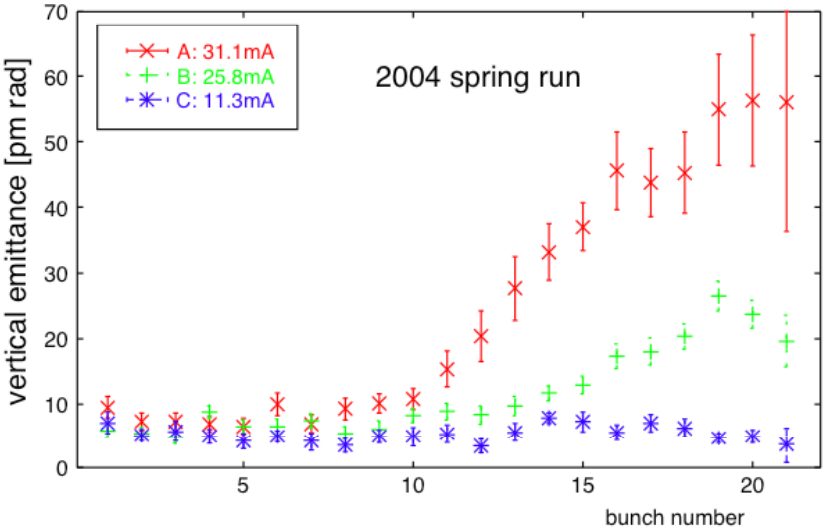
FII study on 2007/3/13-14 (3)

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	



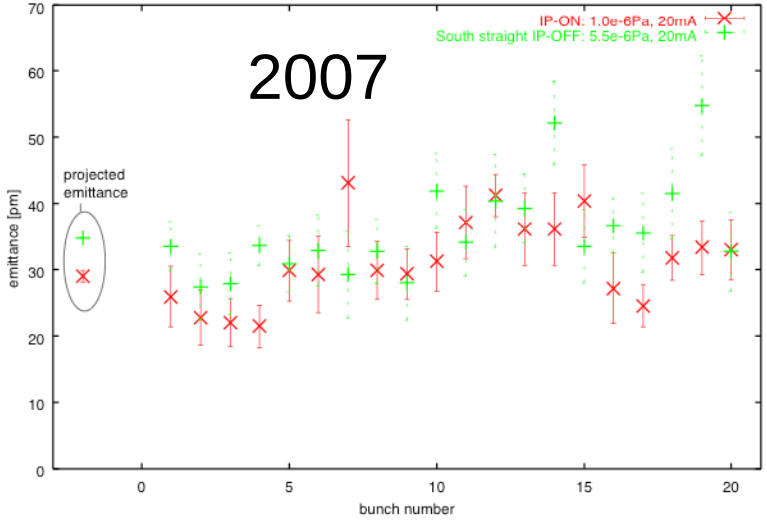


Figure 9: emittance of multi-bunch beam at 20mA/20bunches

Gas Injection system at ATF-DR

-South straight section-

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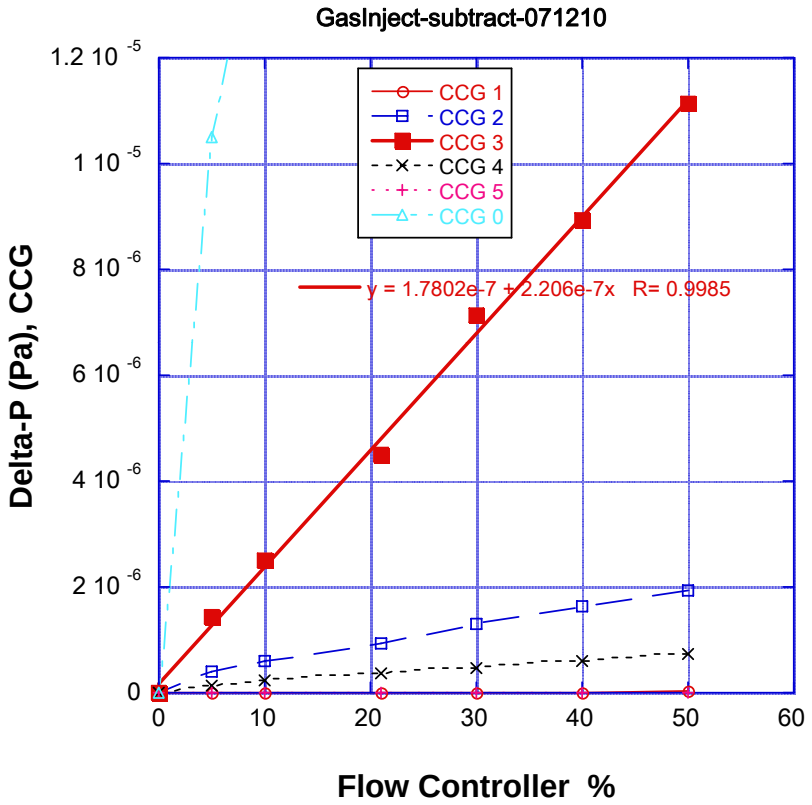
Gas Injection system

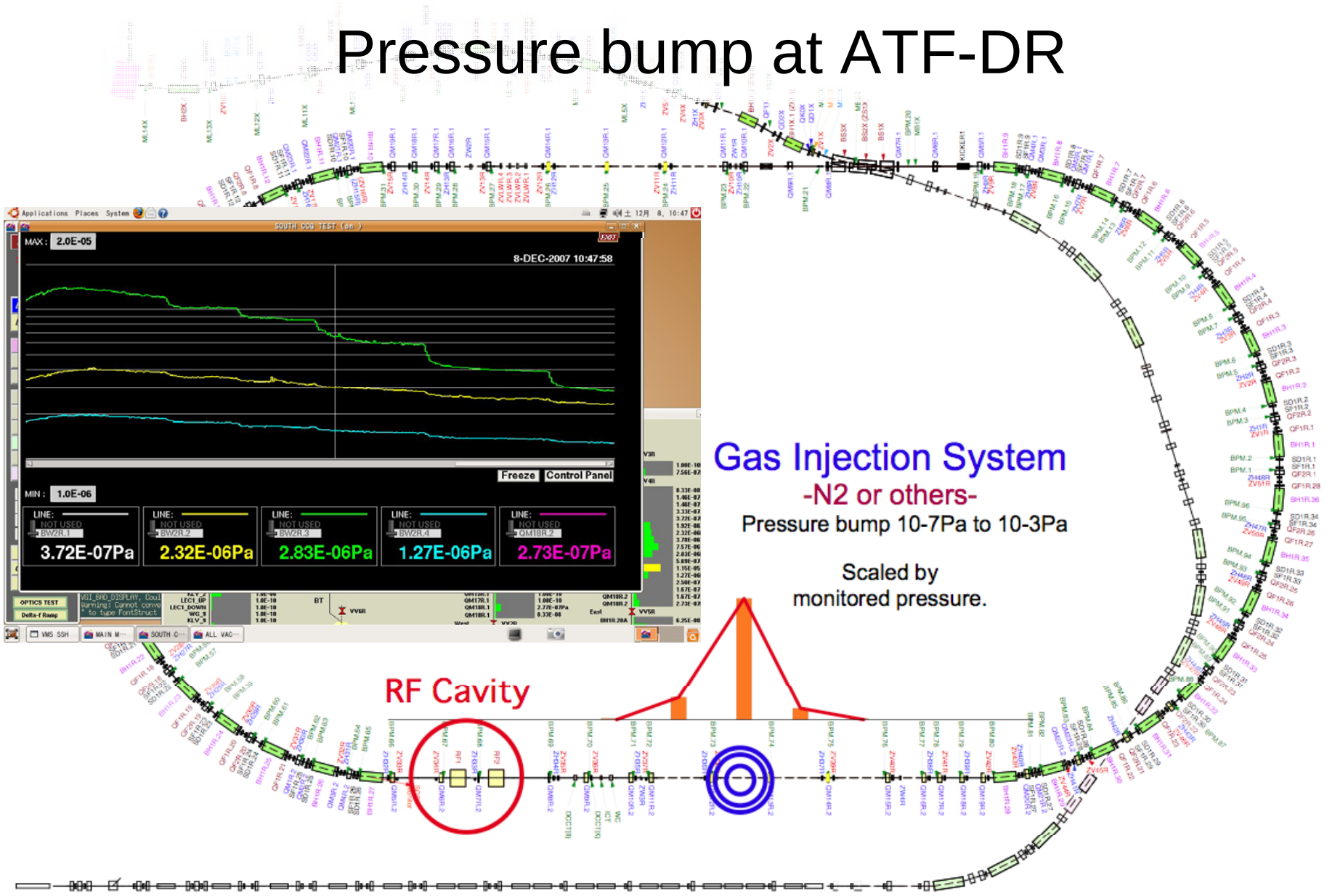


- Continuous gas leak into the beam chamber.
- Gas flow control:

  Fine-leak valve + flow controller(0~100%)

  Pressure range: 10^{-7} Pa ~10^{-3} Pa.

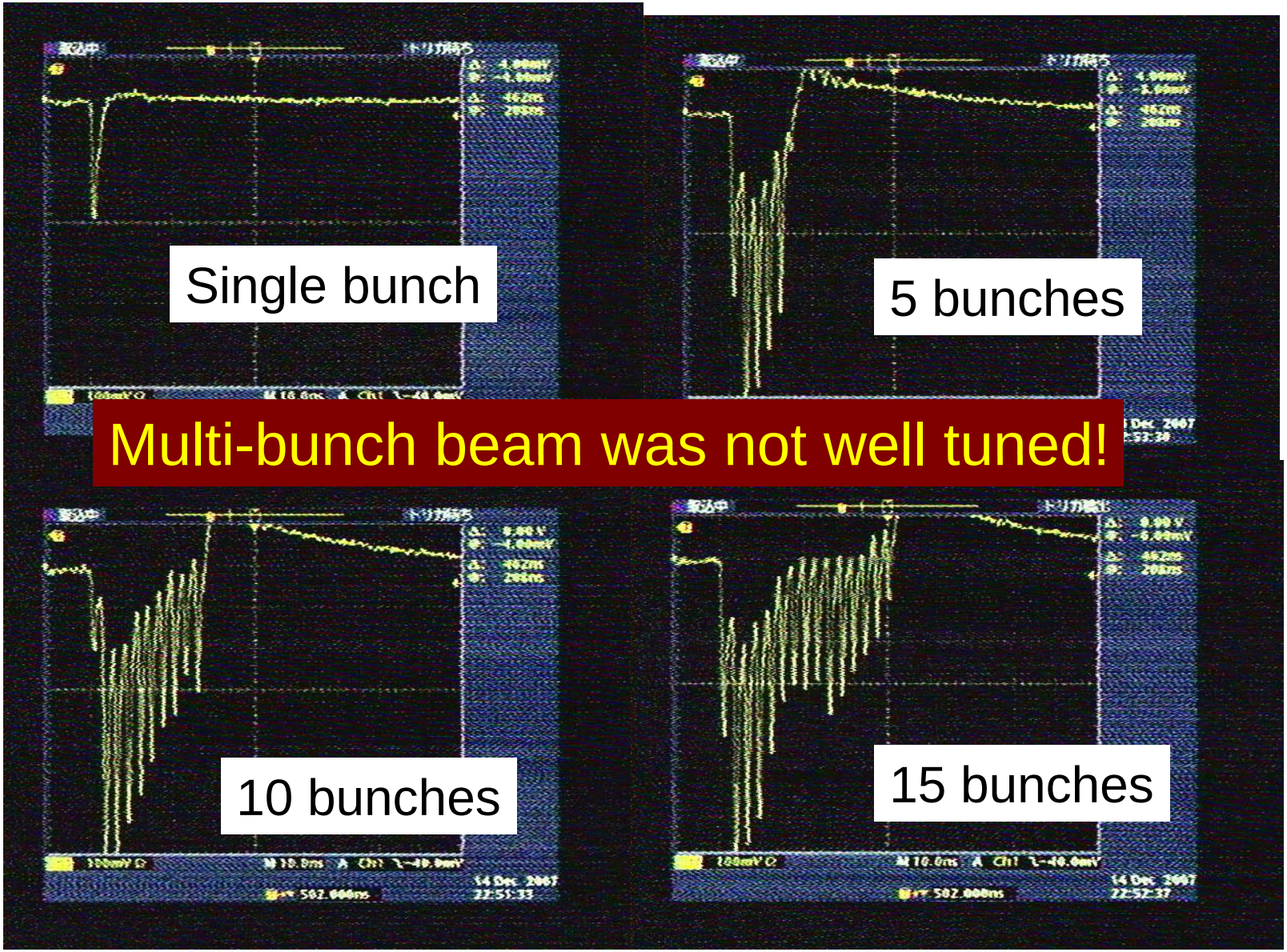
Pressure bump at ATF-DR



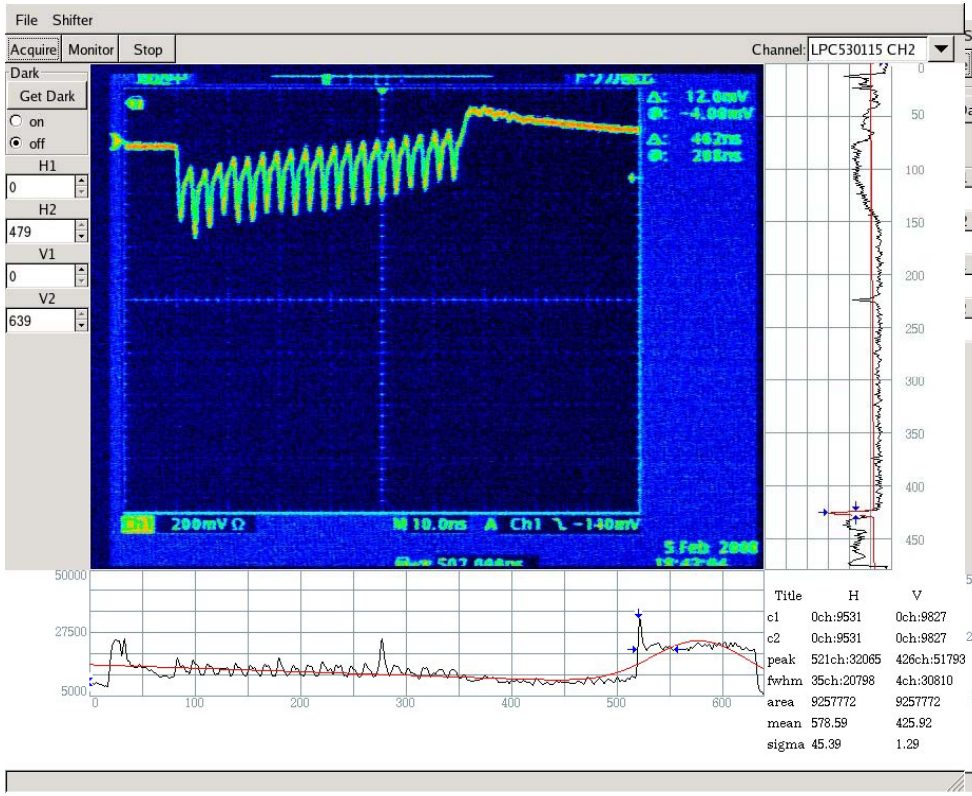
R&D results on Dec 2007

- **First shift with the gas injection system.**
  - Remote participation from DESY(Guoxing and Eckhard)
  - Check the sub-systems especially for the gas injection.
  - Done on the final shift in a week to avoid any trouble.
  - 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.

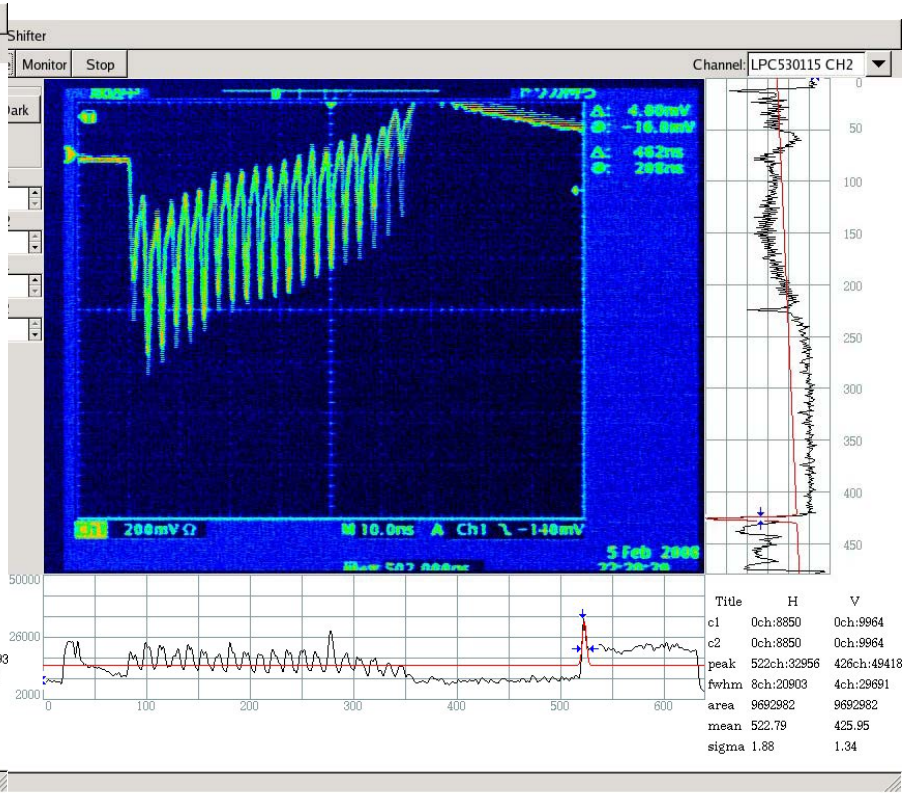
Stored bunches in DR, Dec 2007



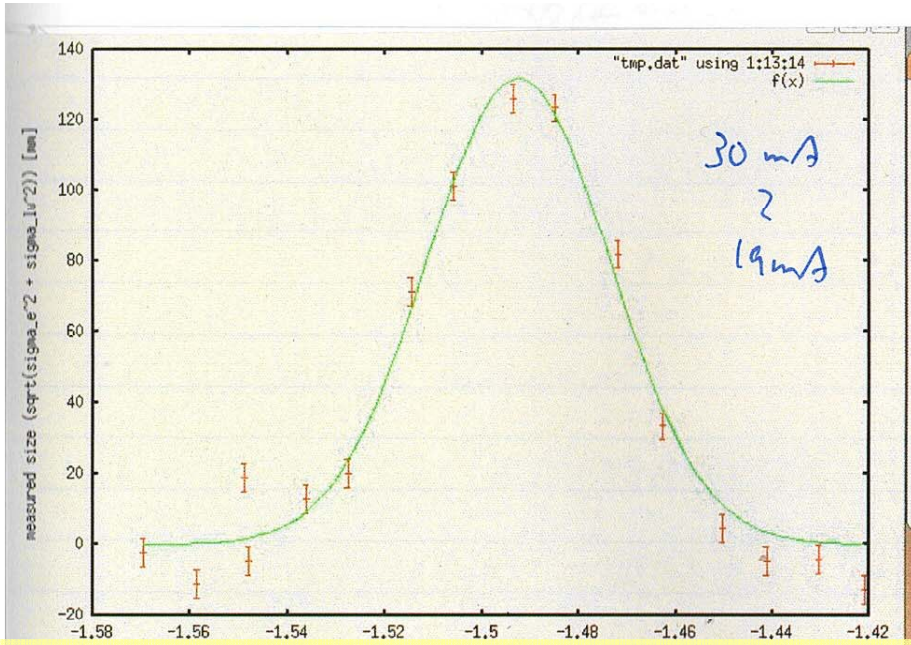
Tuned multi-bunch (DR) on 2008/Feb/5

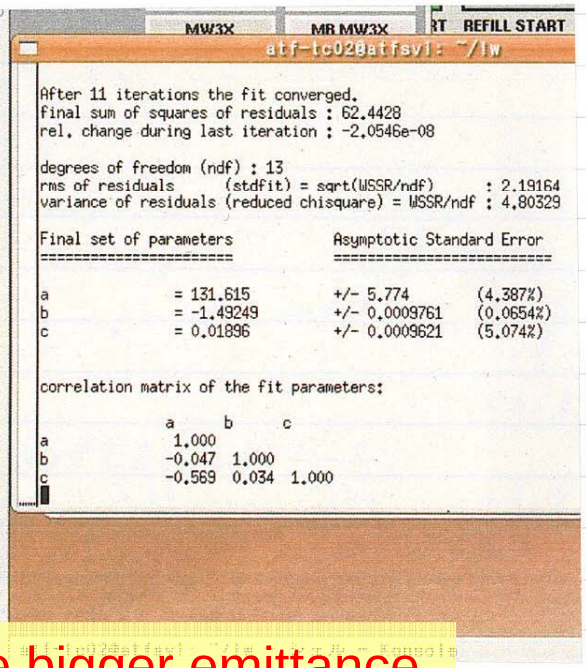


0.4E10/bunch, 20bunch



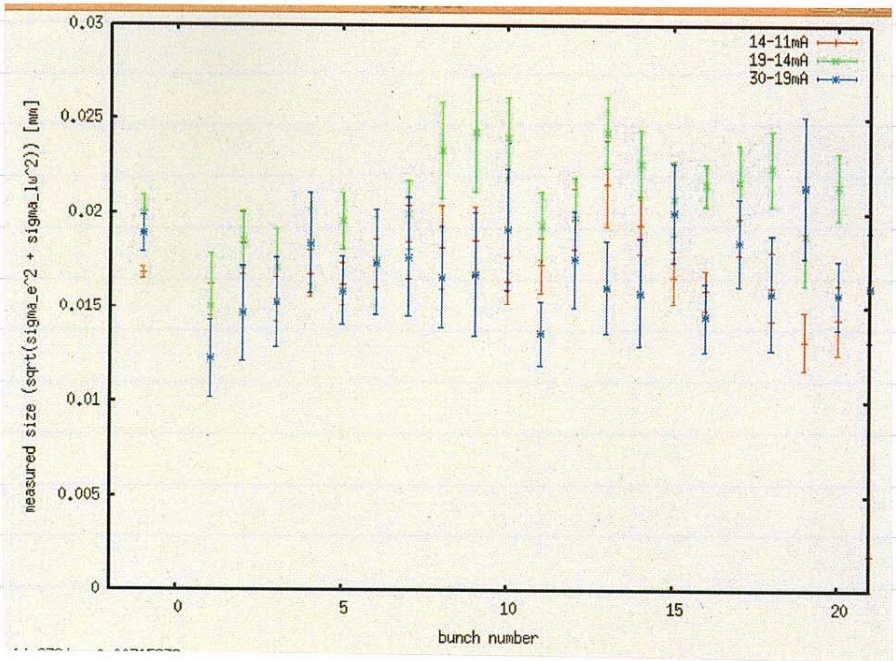
1.0E10/bunch, 20bunch





No clear blowup was observed because of the bigger emittance.

Vertical beam size by LW 2008/Feb/5



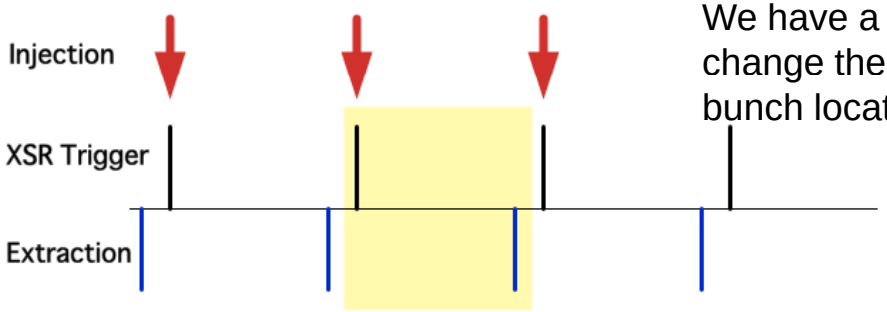
Beam-time from Jan. 2008

- FII studies with gas injection is just started.
- Tune the DR anyway
  - Lower vertical emittance is essential
    - » 5pm~10pm
    - » Scrubbing to recover the base pressure?
  - Stable multi-bunch(up to 20) beam with higher intensity
    - » 0.6×10^{10} or more
    - » Tuning and keep ECS system available
- Keep monitors available
- Take beam time in any shift if people agreed.
  - Pressure bump by gas injection will be recovered within hour(s).

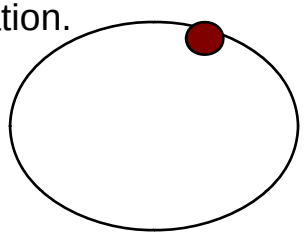
XSR images in multi-train mode

Data were taken without touching the vacuum.

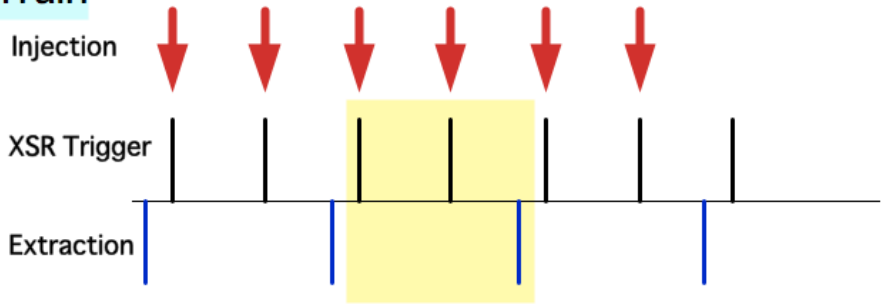
Single Train

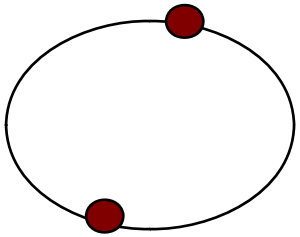


We have a little room to change the RF bucket;i.e. bunch location.

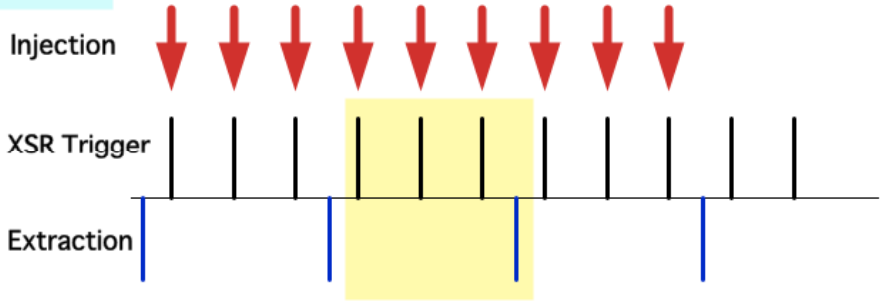


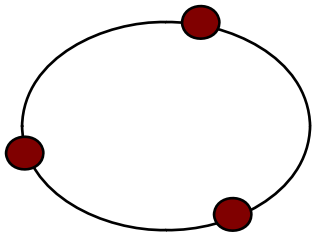
Two Train





Three Train





XSR videos

5bunches-10e9

Single bunch
1e9
5e9
10e9

Single bunch
10e9
One shot

Approach to recover the 10pm emittance

Does ATF2 construction move the magnets in DR?

- Magnet locations were checked recently.
- Re-allignment of DR will be done partially in March.

Improve the vacuum condition especially in the straight section

- Exchange Ion pumps (outgas from pumps)

DR Survey (Magnets)

Horizontal

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2003

2008

Vertical

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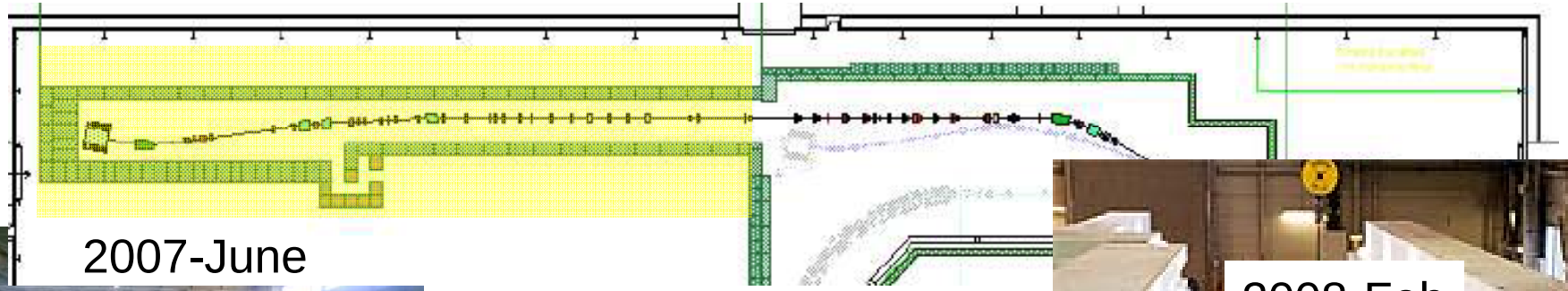
It will be measured by using more precious tools in March 2008.

ATF2 construction



2007-June

2007-Oct

2007-July-31

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2008-Feb

Improvements; done/planned

- **Vertical emittance tuning**
  - Need to understand what makes 50pm emittance in recent DR.
  - What is the origin of beam blowup measured on XSR?
  - Re-allign the DR magnets and see what happens.

- **Multi-bunch beam tuning**
  - We will Improve the timing system of the RFgun laser to avoid the rise and fall edge of pockels cell voltage.
  - Take at least one shift before FII shifts for the beam tuning.

- **Vacuum pressure improvement at North/South section**
  - Survey the performance of ion pumps.
  - An ion pump was not working and very gassy when activated.
  - Degassing with turbo pumps and re-layout the HV lines.
  - No vacuum breaks by Gas system and Laser-Compton system.
  - But an installation of the fast-kicker electrode is planned in this week.

Discussions on the FII study

Low emittance multi-bunch beam is essential.

Contribution

Beam shifts
- On site
- Remote participation

Simulations
- DESY, SLAC,…

Others
- …