FII studies at KEK-ATF

N.Terunuma (KEK)

ILCDR07 at INFN-LNF

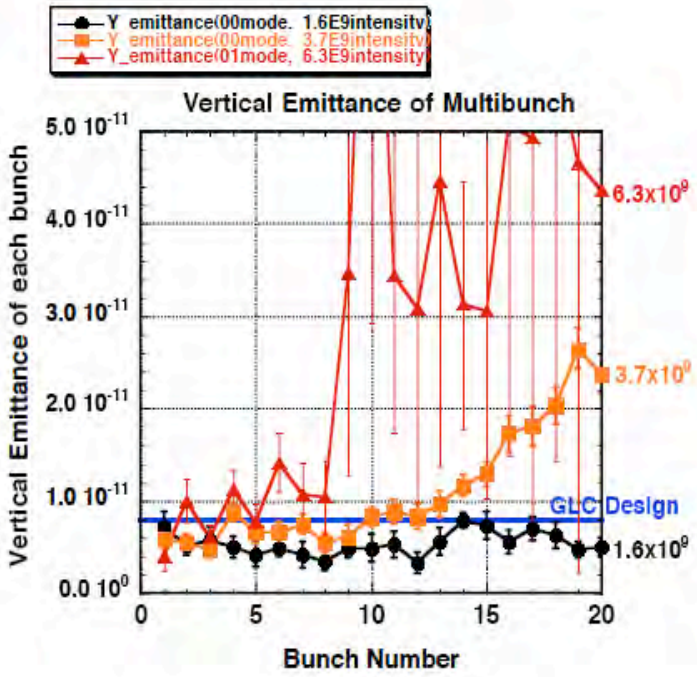
Goals of the experiment

(according to Two proposals (L. Wang, T. Raubenhimer and G. Xia, E. Elsen)

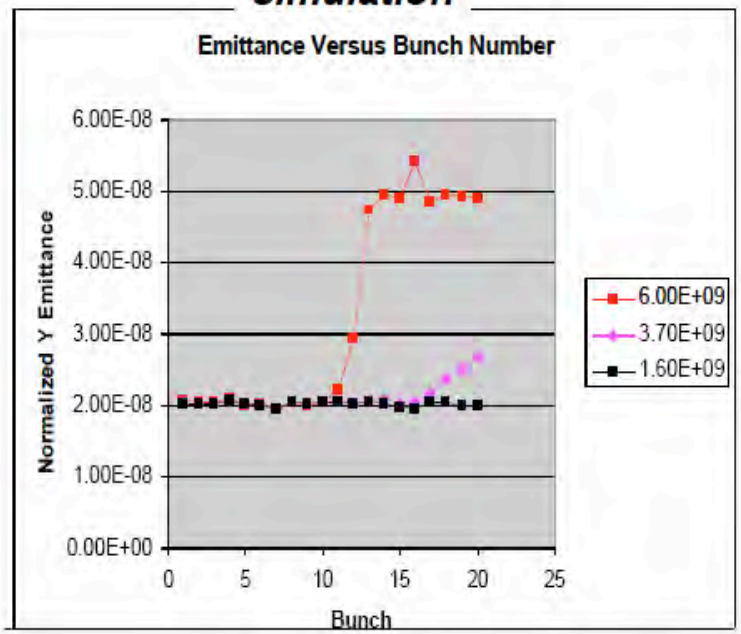
- Distinguish the two ion effects: beam size blow-up and dipole instability.
- Quantify the beam instability growth time and tune shift. The growth rate is related to the ion density (vacuum pressure, average beam line density, emittance, betatron function and so on).
- Quantify the bunch train gap effect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

Results obtained at ATF-DR in 2004

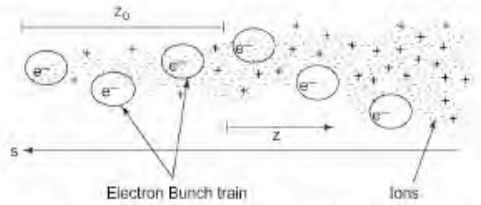
Preliminary result of Fast Ion Instability simulation



simulation

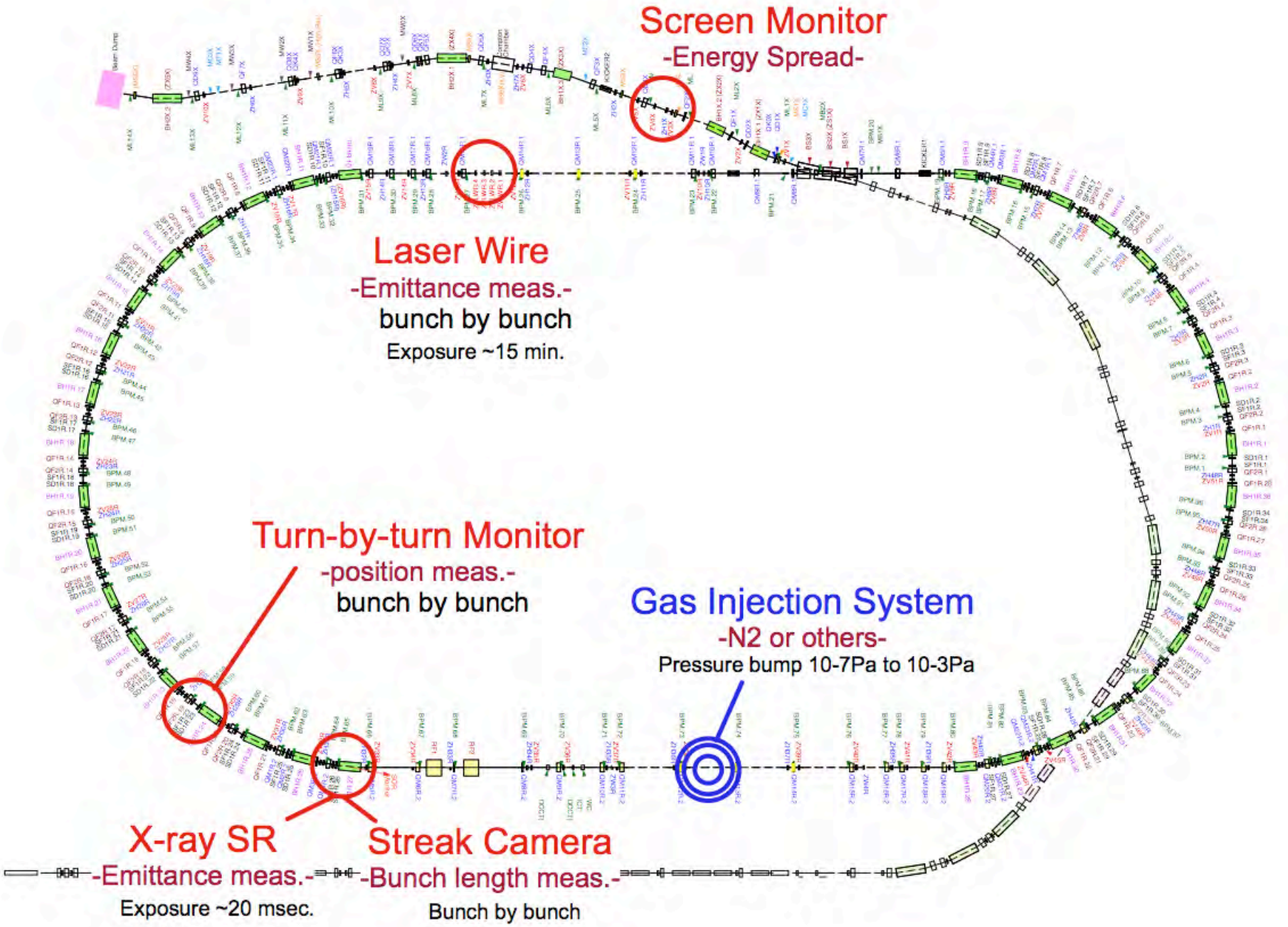


Behavior of Y emittance is very similar.

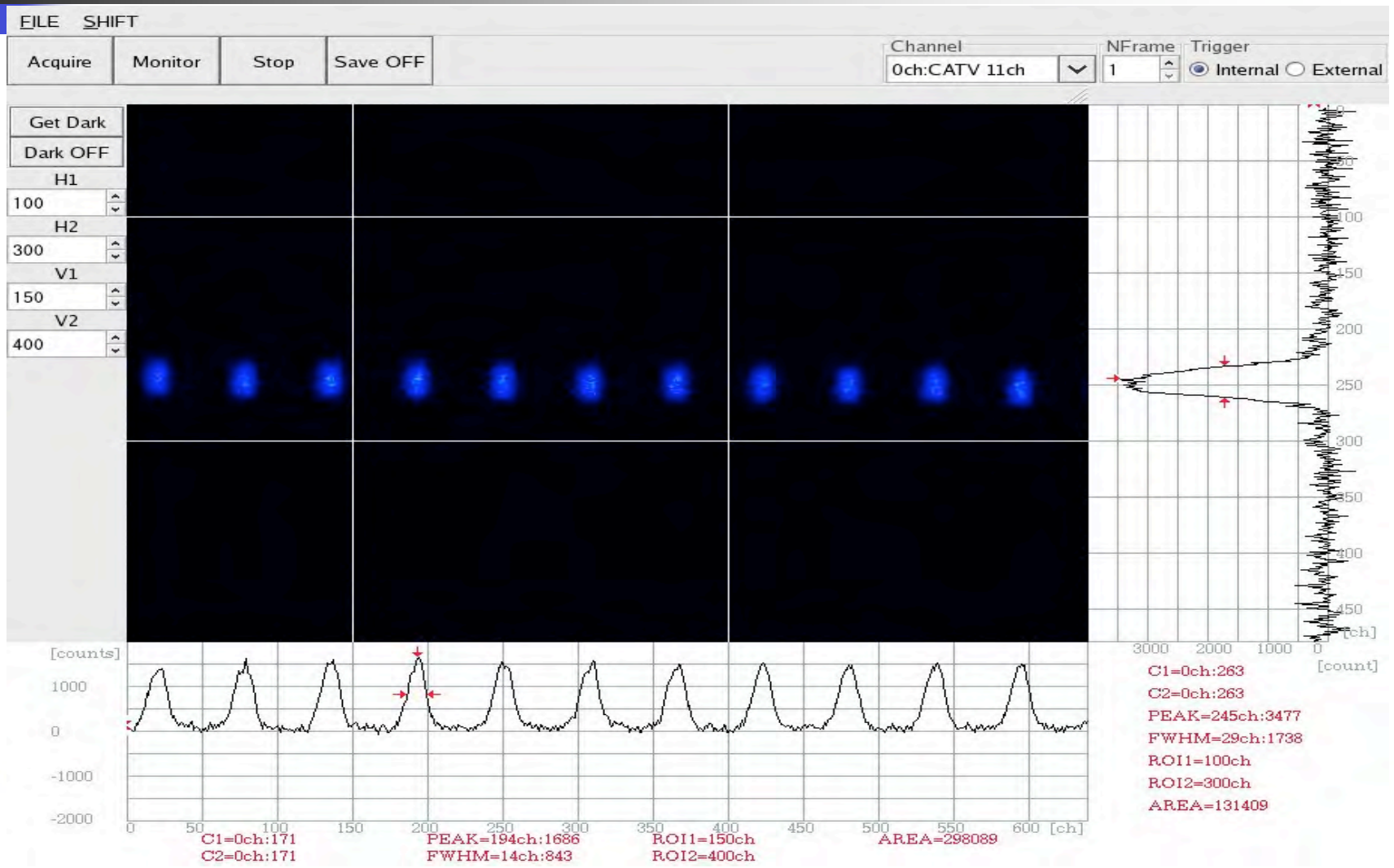


Schematic of the Fast-Beam Ion Instability

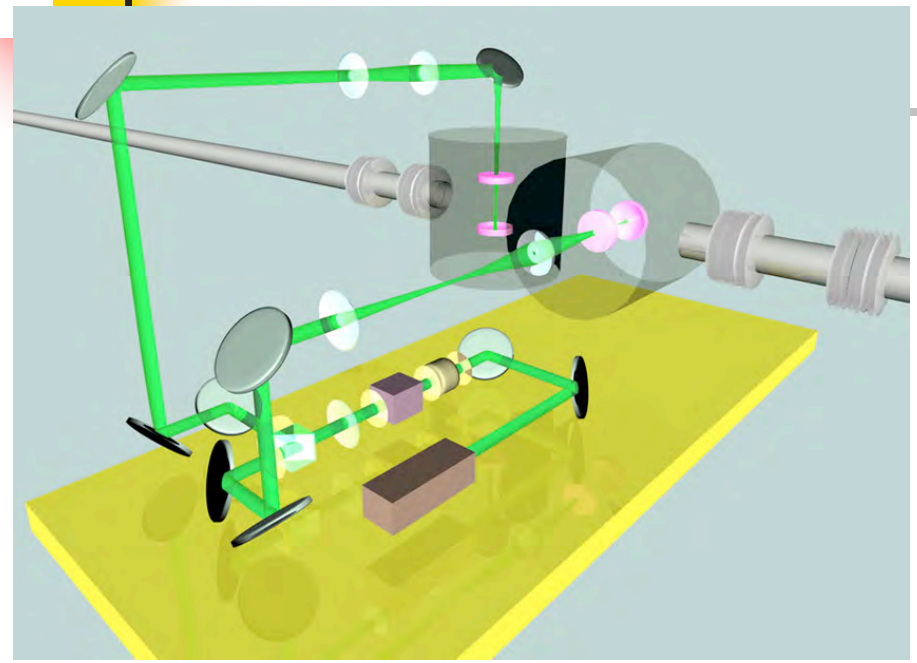
Devices for FII study

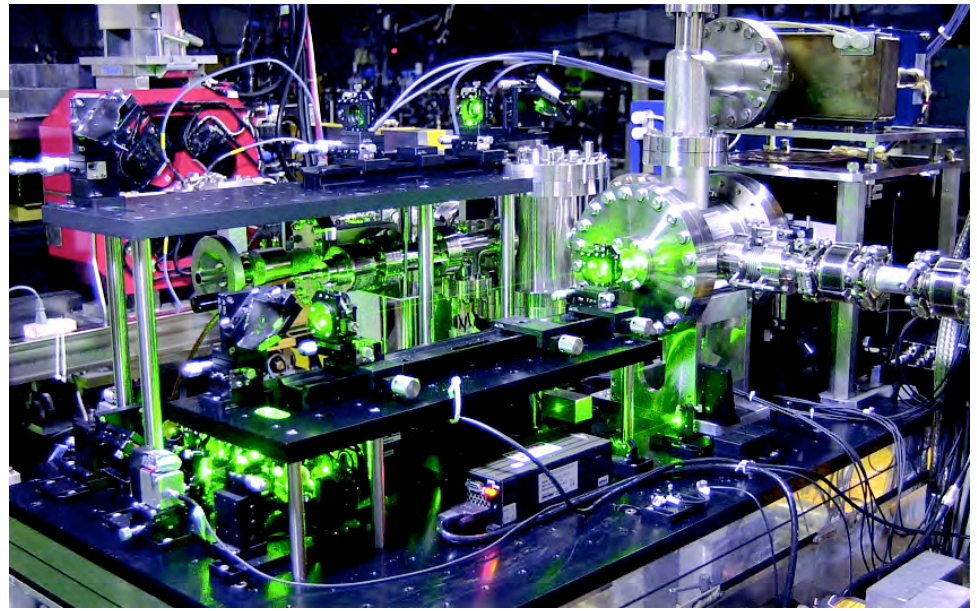


Bunch Length Measurement (Synchronized Streak Camera)



Laser wire beam size monitor in DR



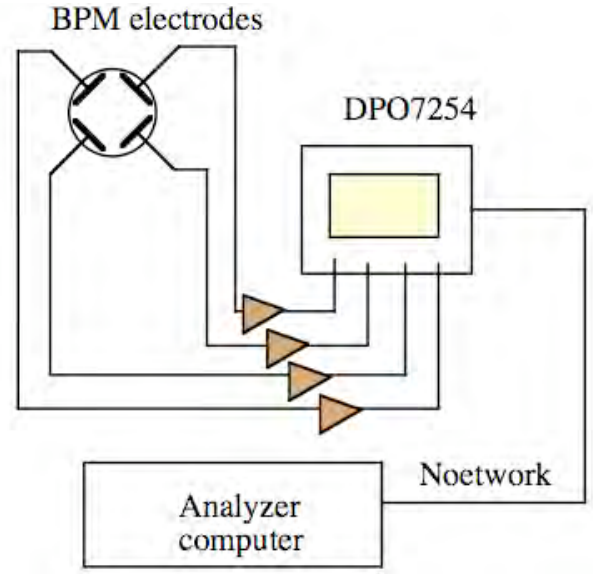


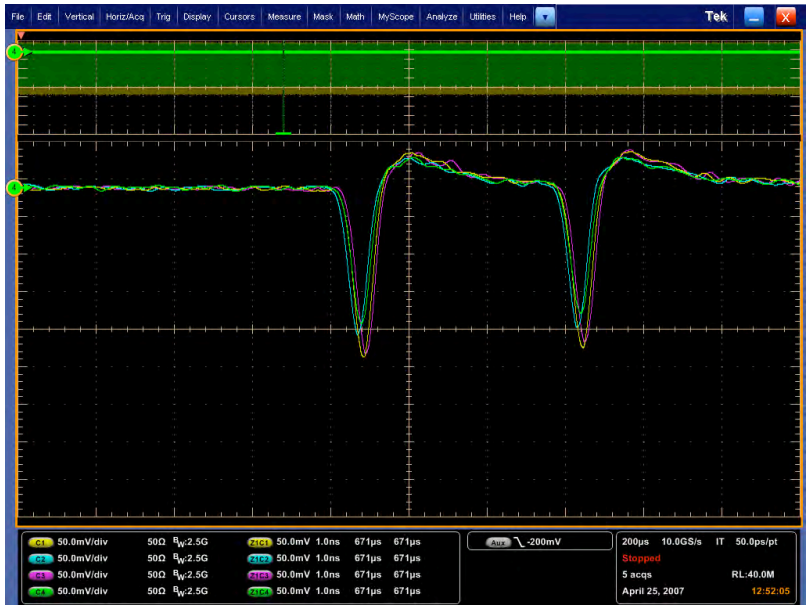
300mW 532nm Solid-state Laser fed into optical cavity

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.





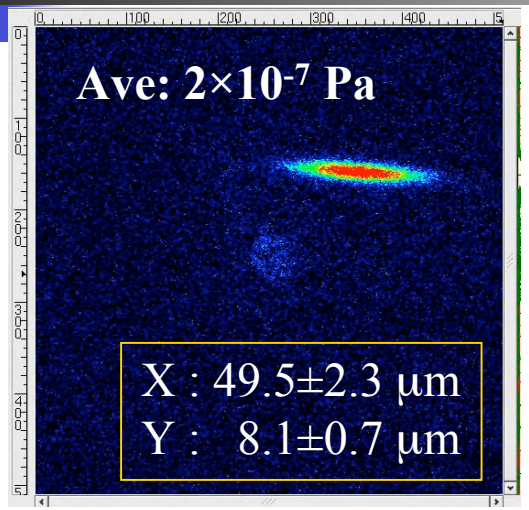
Measured beam profile by XSR monitor, 2007/Feb-Apr.

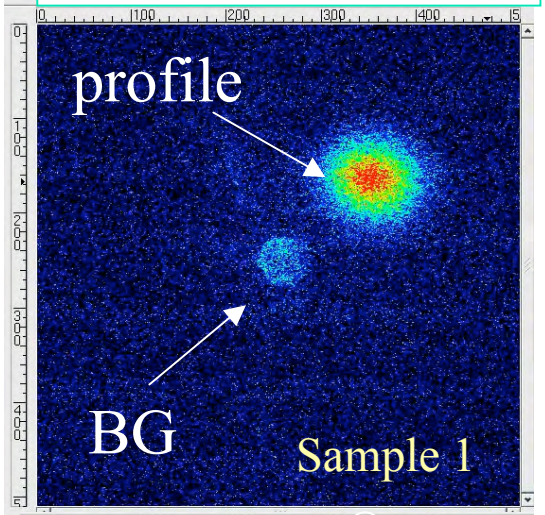
Single bunch, 2×10^{10} /bunch

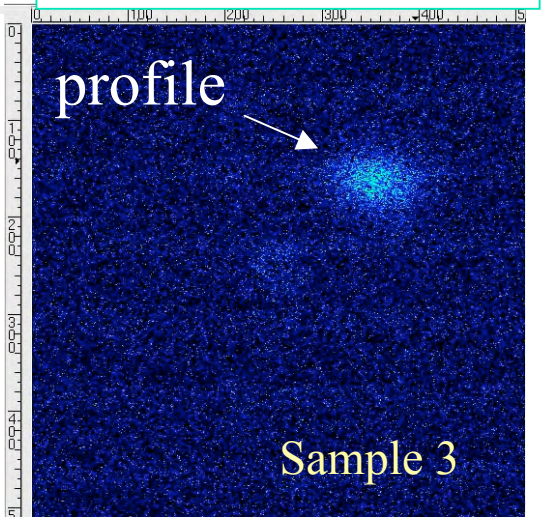
3 train mode, 2×10^{10} /bunch

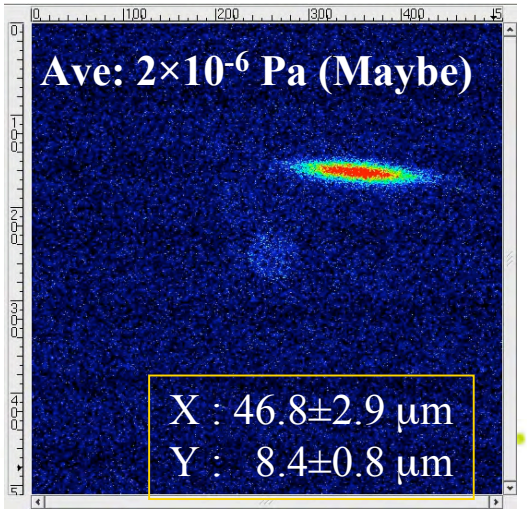
Vacuum : 1×10^{-5} Pa

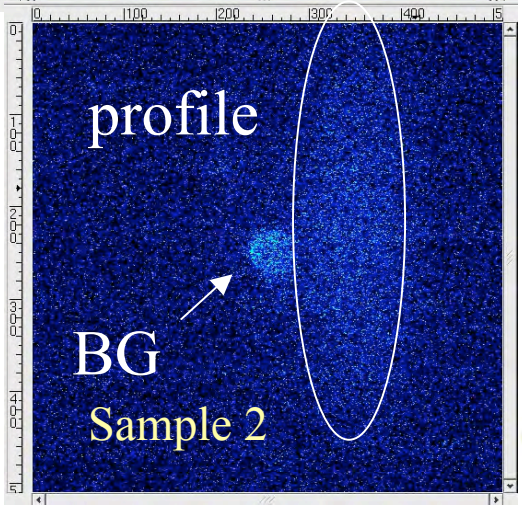
Vacuum : 2×10^{-6} Pa

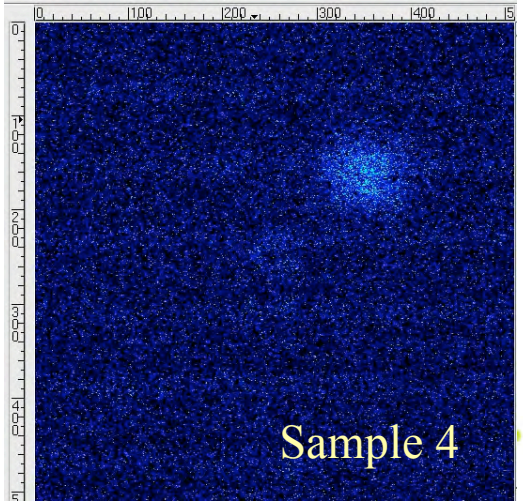




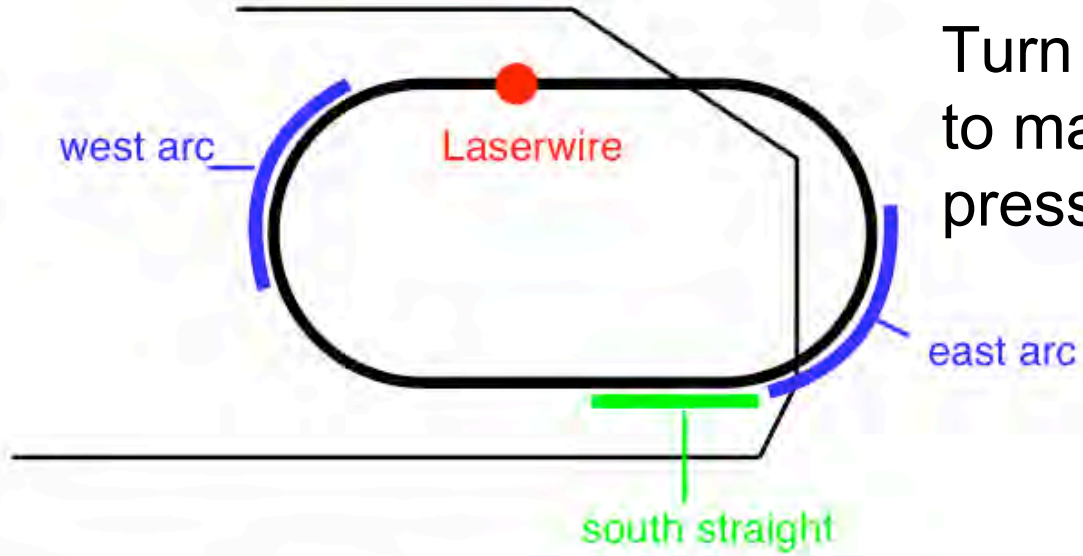








FII study on 2007/3/13-14 (1)



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	

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

5mA/20bunches

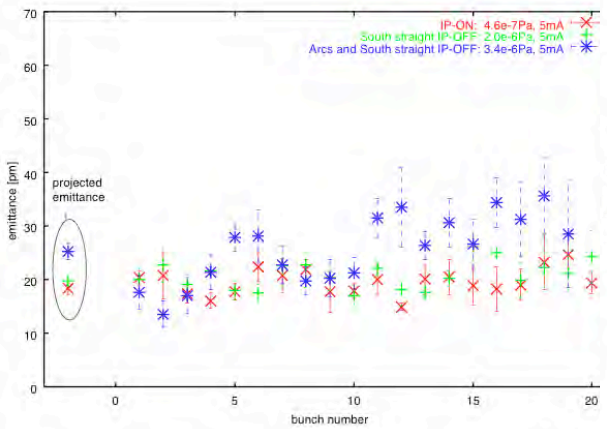


Figure 7: emittance of multi-bunch beam at 5mA/20bunches

10mA/20bunches

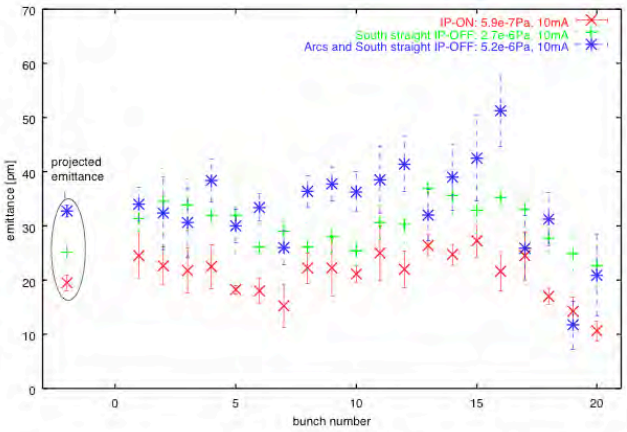


Figure 8: emittance of multi-bunch beam at 10mA/20bunches

20mA/20bunches

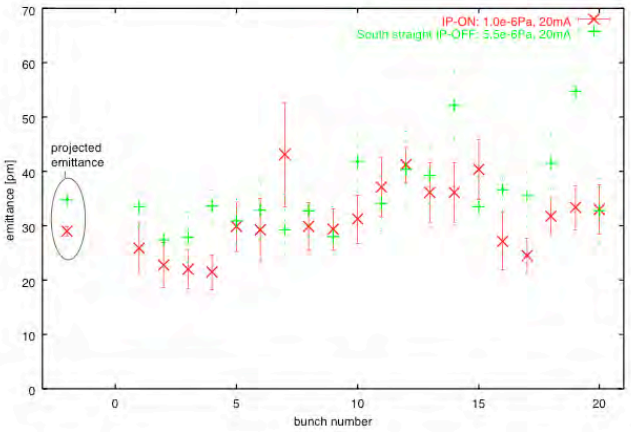


Figure 9: emittance of multi-bunch beam at 20mA/20bunches

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.

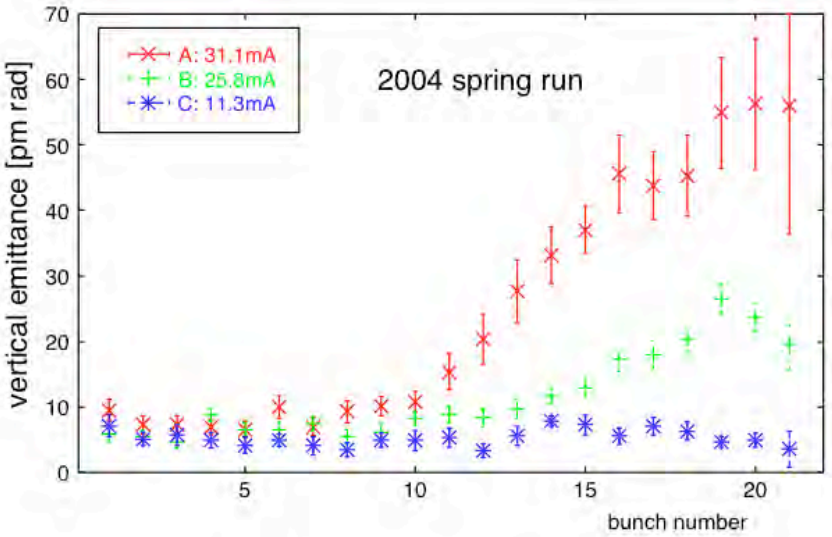
FII study on 2007/3/13-14 (3)

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	



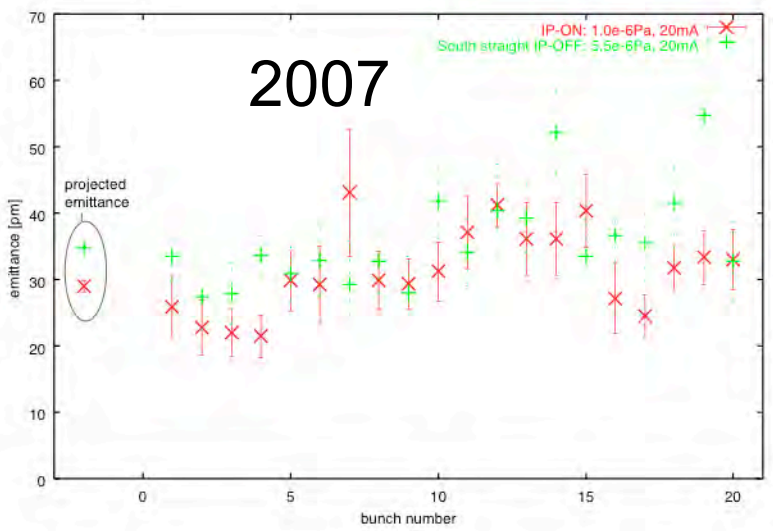
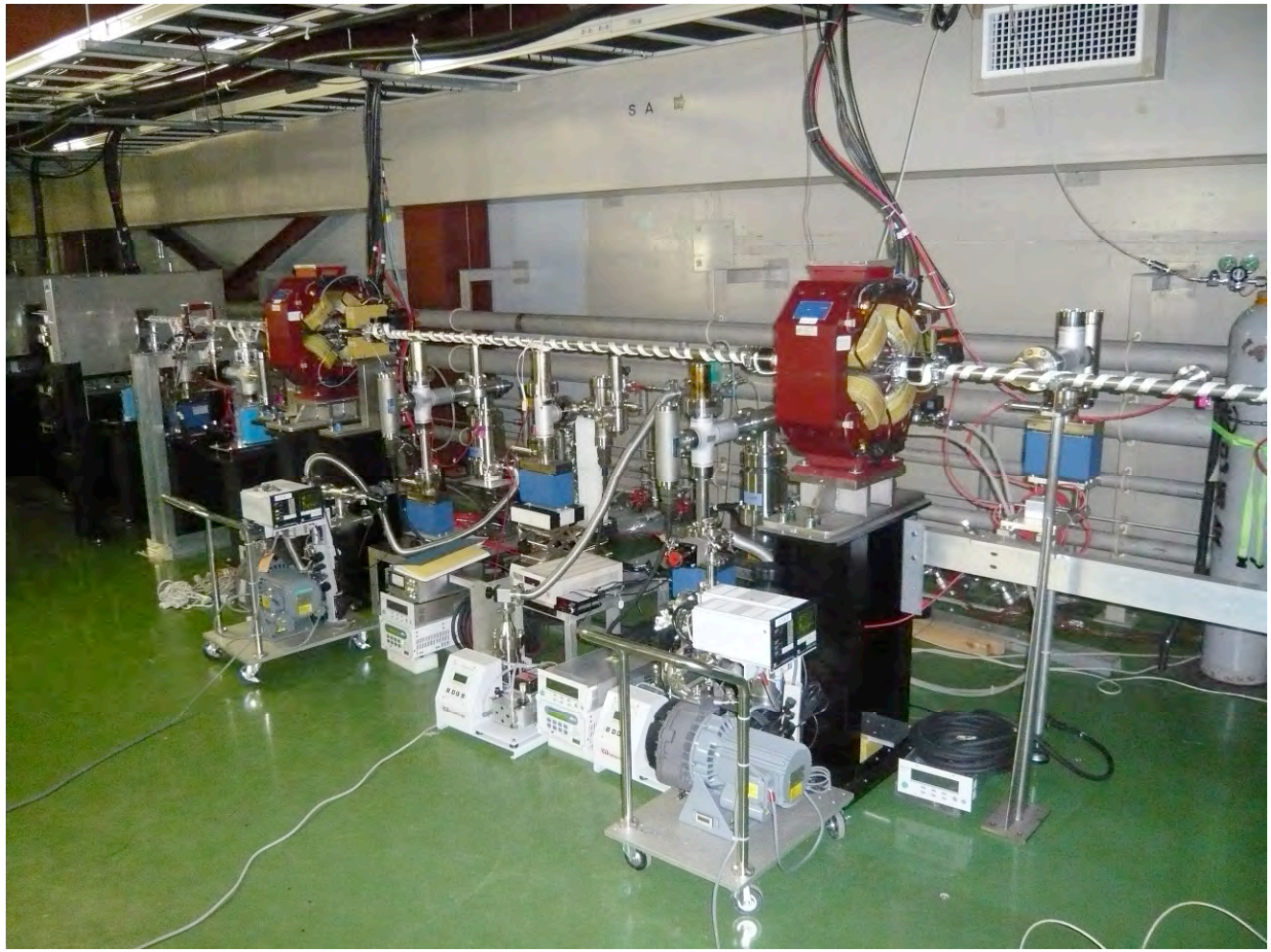


Figure 9: emittance of multi-bunch beam at 20mA/20bunches

Gas Injection system at ATF-DR

-South straight section-

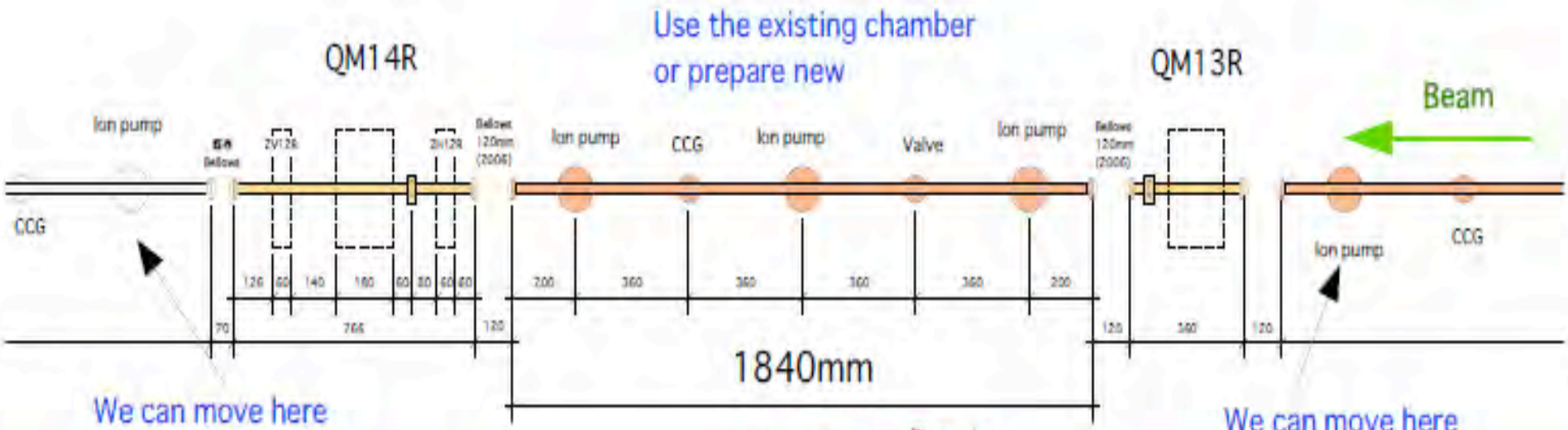


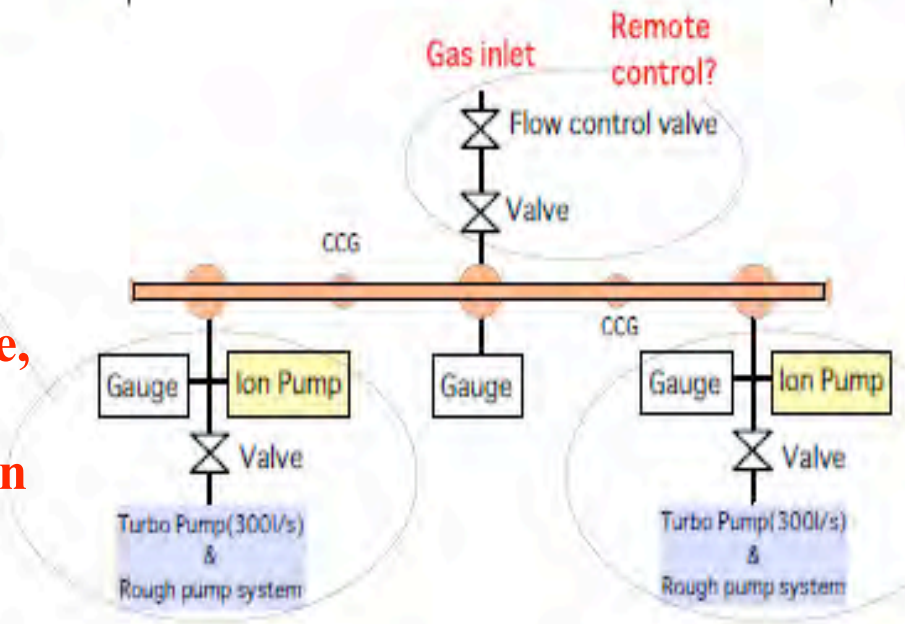
Possible location of Gas inlet chamber for fast ion study

South straight section of ATF damping ring

2007/Mar/02 N.Terunuma, KEK

Good pressure bump

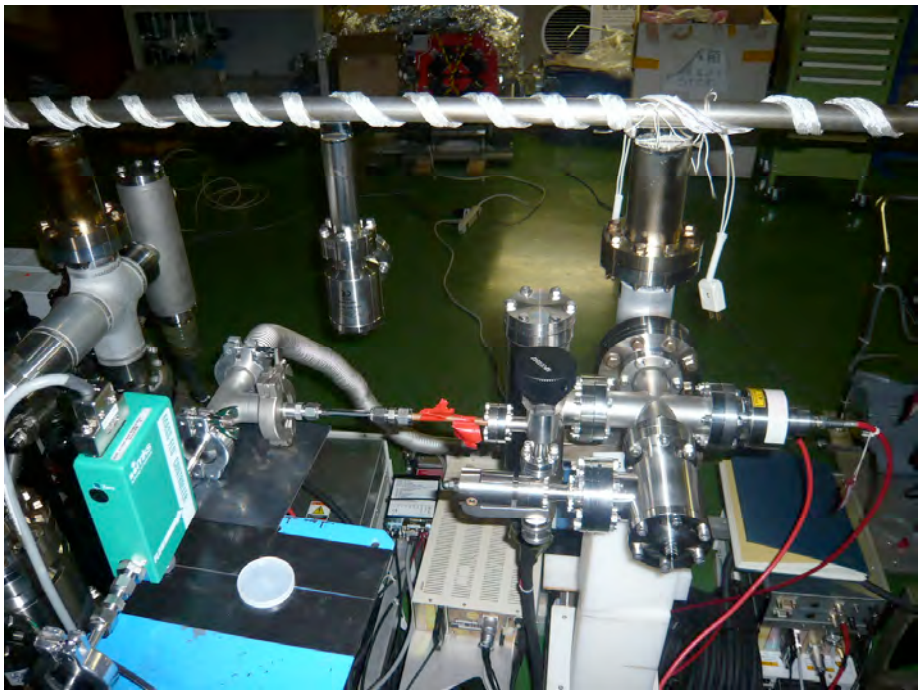


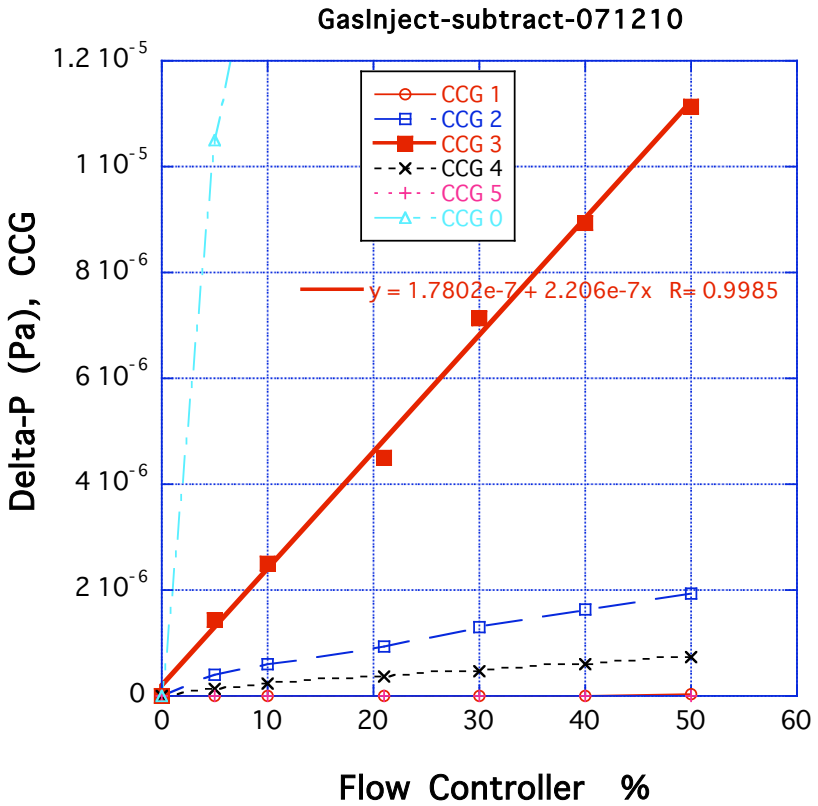


From vacuum gauge, we evaluate the pressure distribution precisely.

Beam sees 24mm diameter beam pipe with pumping slots.

Gas Injection system





- Continuous gas leak into the beam chamber.
- We can control the leak rate of N_2 gas.
- Pressure range: 10^{-7} Pa ~10^{-3} Pa.

Changing the flow controller

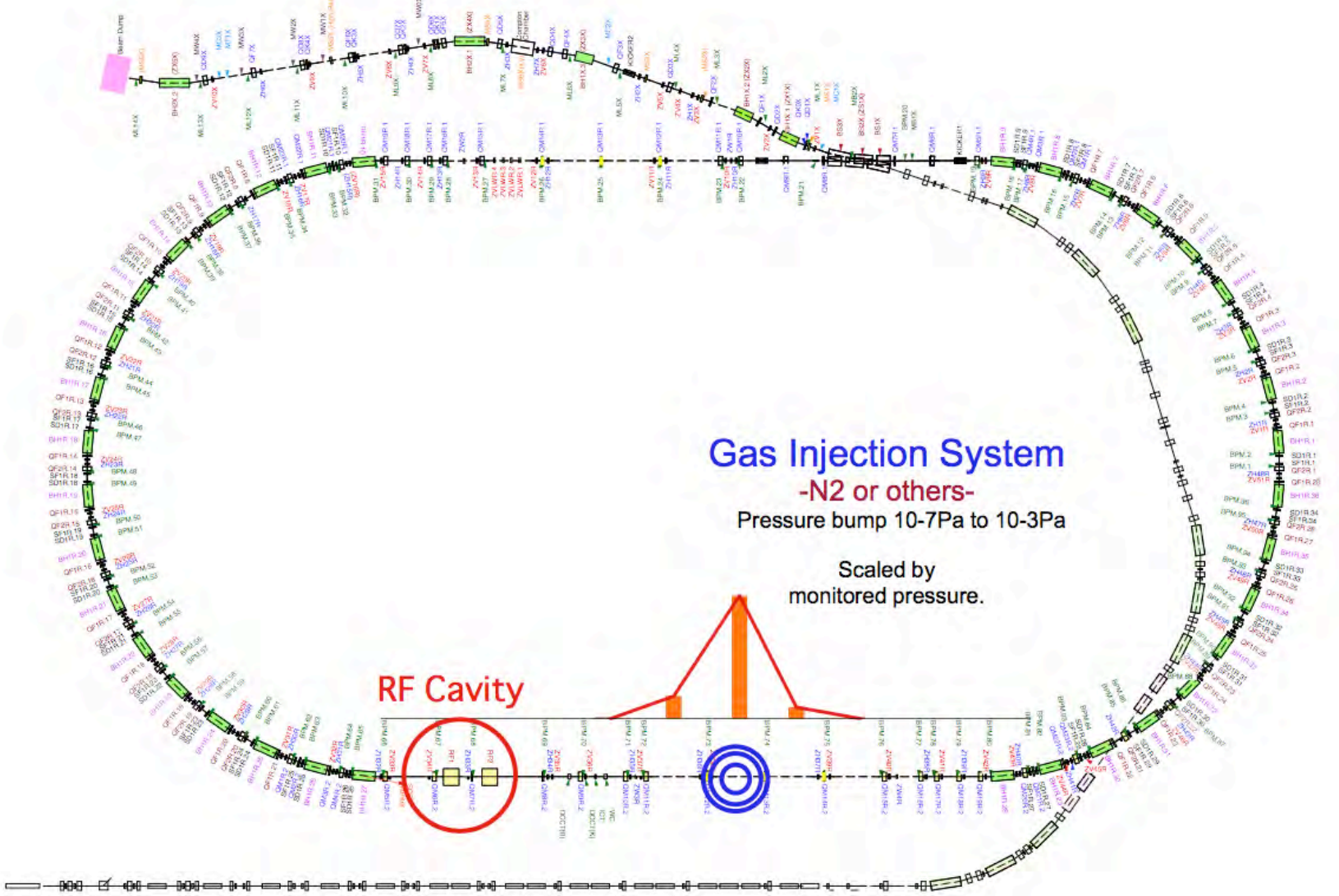
First beam shift with gas injection on Dec. 14

- It was a first time that the gas injection system operated under the beam. Extra beam-time was scheduled before the weekend shutdown.
- It was a system check because of
  - poor emittance (DR was not tuned well) and
  - some monitors were not available.
- Effect on the DR sub-system was carefully monitored.
  - Check the pressure distribution toward the RF Cavities.
  - Max. pressure for other devices
    - » Injection/Extraction Kicker uses the total pressure for interlock.
  - Find the needs of modification

First beam shift with gas injection on Dec. 14 -continued-

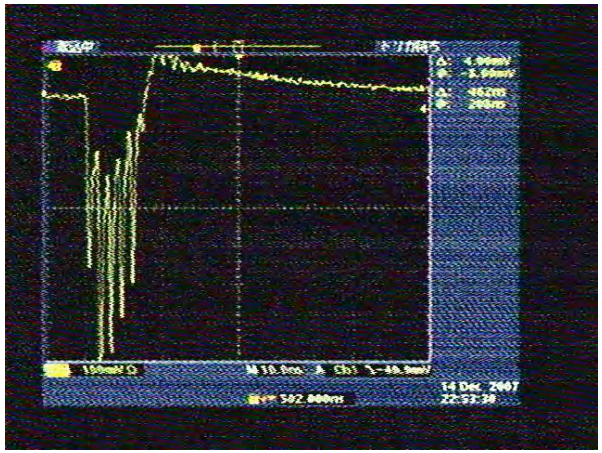
- Beam condition need for FII
  - Low emittance: less than 10pm
  - Multi-bunch beam
    - » 20 bunches / train
    - » 0.3E+10 electrons / bunch or more
- Last shift (12/14)
  - Emittance y ~ 50pm?
    - » caused by many works/installations done in summer shutdown.
    - » Poor vacuum?
  - Not enough time for multi-bunch tuning
    - – 15 bunches / train
    - – 0.3E+10 / bunch
  - Can not proceed the FII study anyway.

Pressure bump at ATF-DR

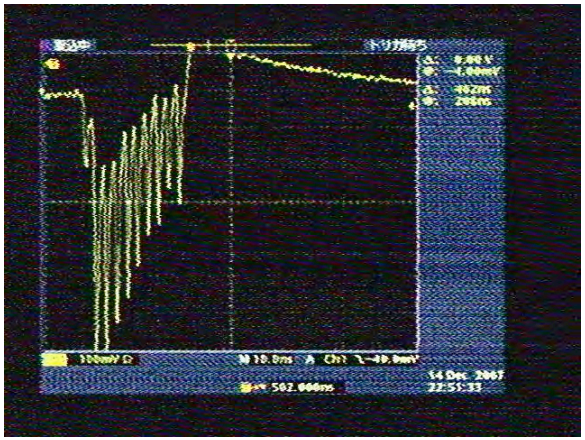


Stored multi-bunch beam in DR

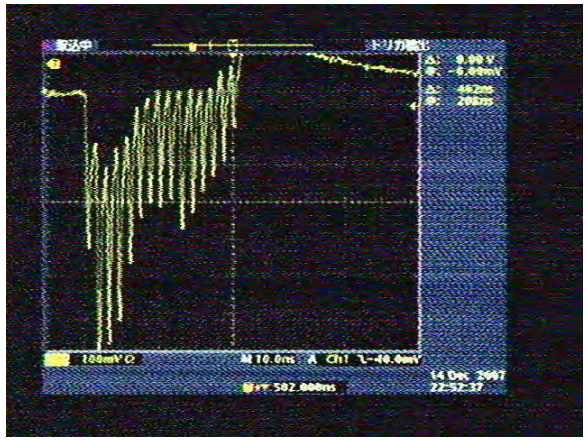
Single bunch



5 bunches, 2.8ns spacing



10 bunches, 2.8ns spacing



15 bunches, 2.8ns spacing

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).