Beam Monitors DR/MR

The 22nd KEKB Accelerator Review Committee

2018/3/14

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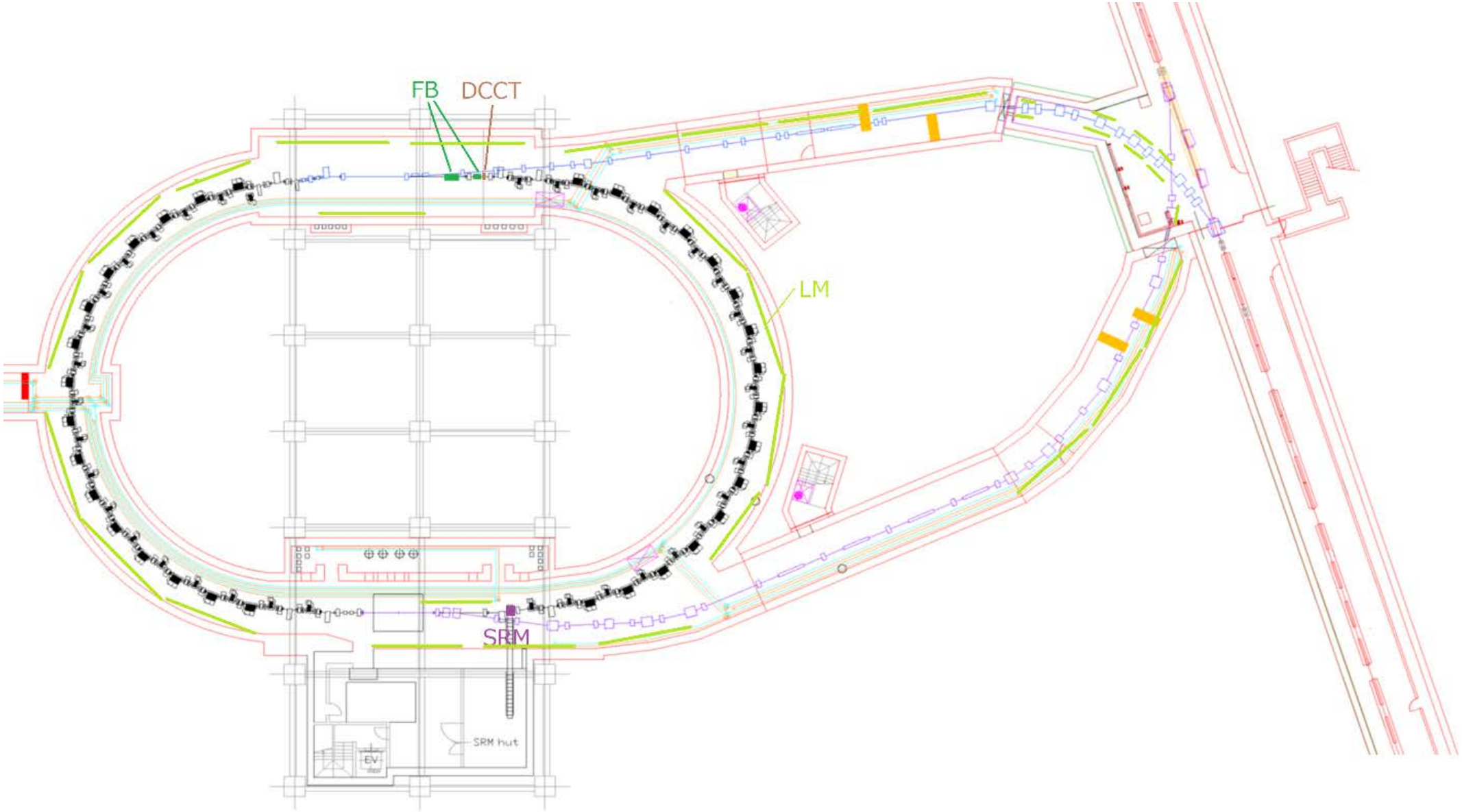
Introduction

System	Quantity		
	HER	LER	DR
Beam position monitor (BPM)	465	444	83
Displacement sensor	110	108	0
Transverse bunch feedback system (FB)	2	2	1
Longitudinal bunch feedback system (LFB)	(1)	1	0
Visible SR size monitor (SRM)	1	1	1
X-ray size monitor (XRM)	1	1	0
Beamstrahlung monitor (LABM)	1	1	0
Betatron tune monitor	1	1	1
Beam loss monitor (LM)	184		34
DCCT	1	1	1
CT	1	1	(1)*
Bunch current monitor	1	1	0
IP-FB	1	1	0

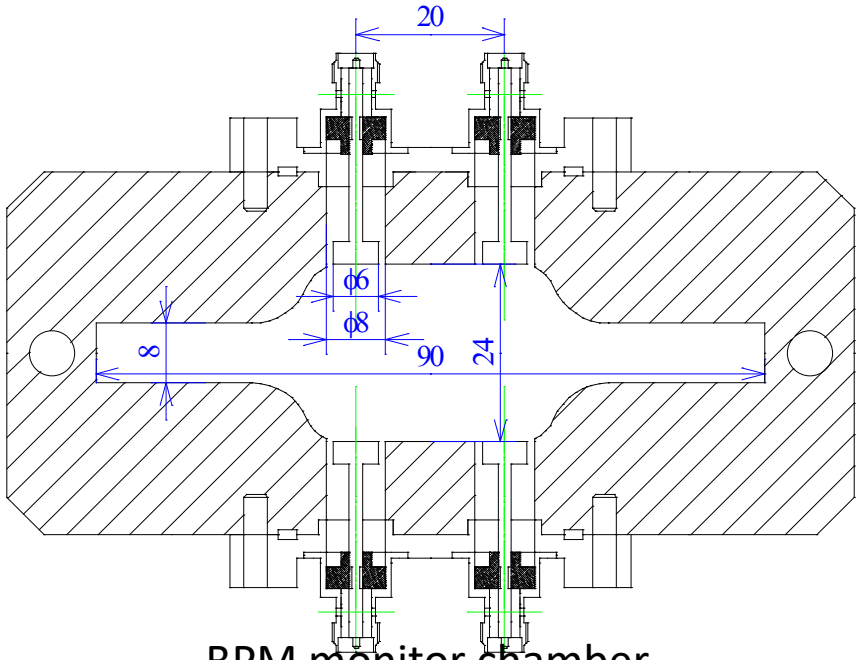
*substitution equipment

DR

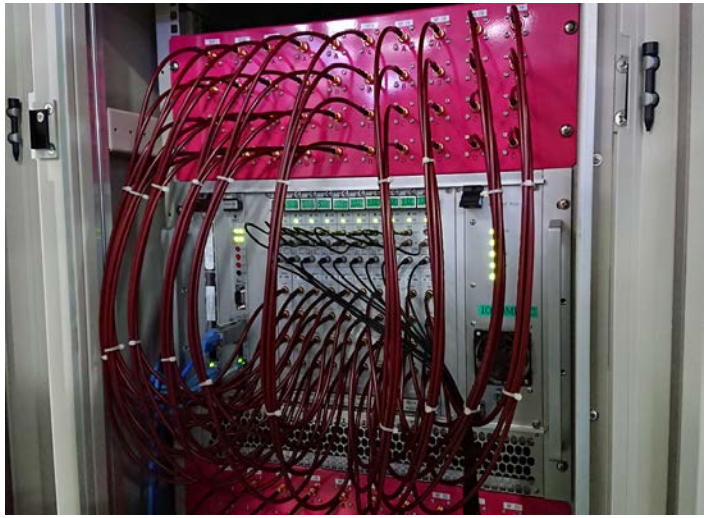


BPM (1)

- Sensor : Button electrode with ϕ6mm.
- Chamber : Two button electrodes are attached to one flange.
- Detector:
  - Digitex 18K11 Log-ratio detector (VME 1W)
    - Memory 32k word/ch
      - Memory size too large, limit the length down to 2k/ch by software
        - » Due to slow CPU power of VME IOC.



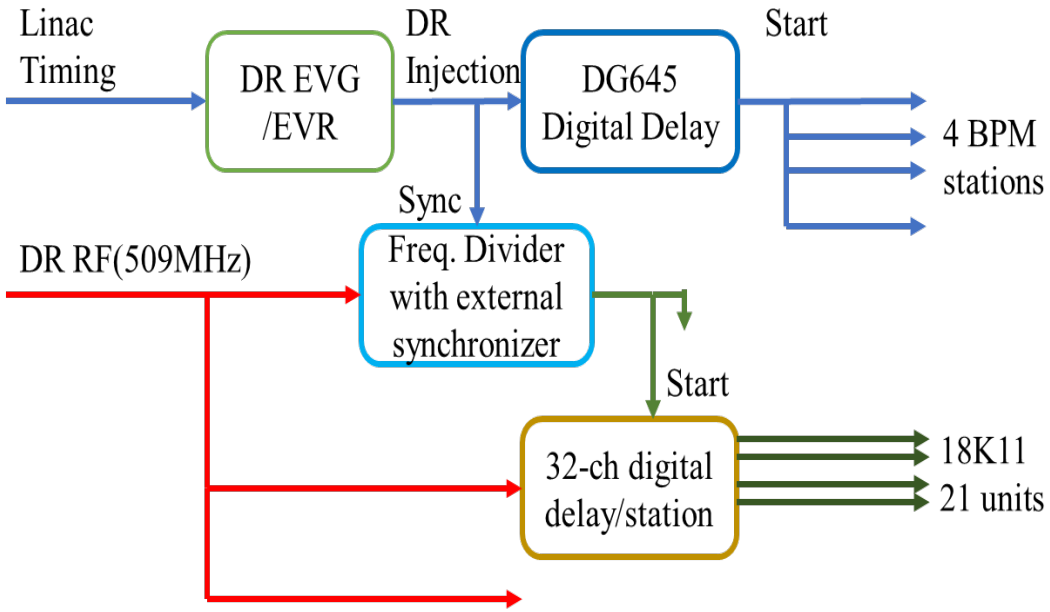
BPM monitor chamber

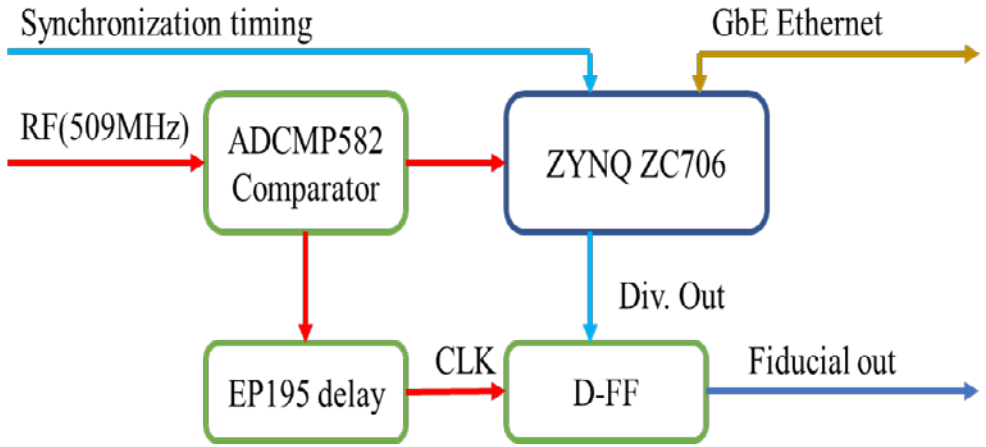


Digitex 18K11

BPM (2)

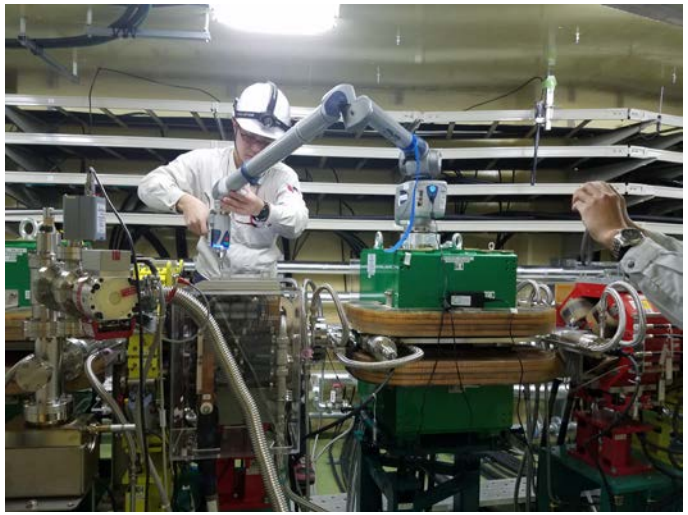
- Timing:
  - Wideband band pass filter (Center 504 MHz BW~24 MHz), needed to adjust the cable delay within 4 ns.
  - Universal frequency divider (1/230 for DR) with external synchronization function using ZYNQ FPGA.
  - 32 ch digital delay (508MHz) using ZYNQ FPGA.
    - Adjust the delay with 2 ns step for each modules (21 / rack).



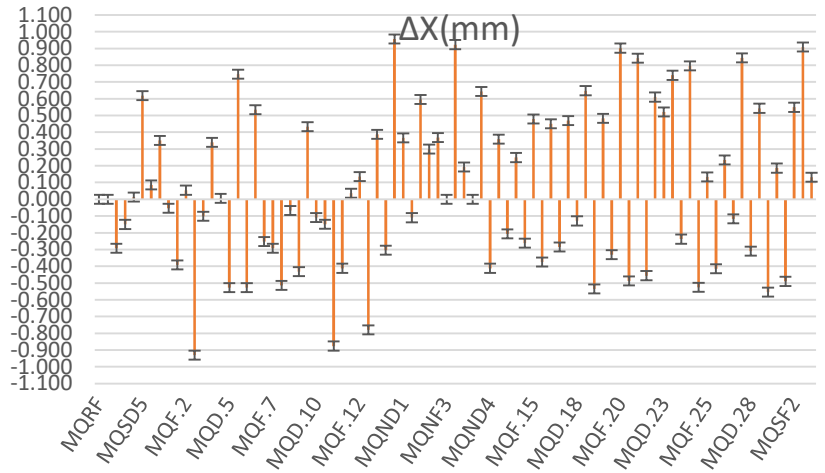


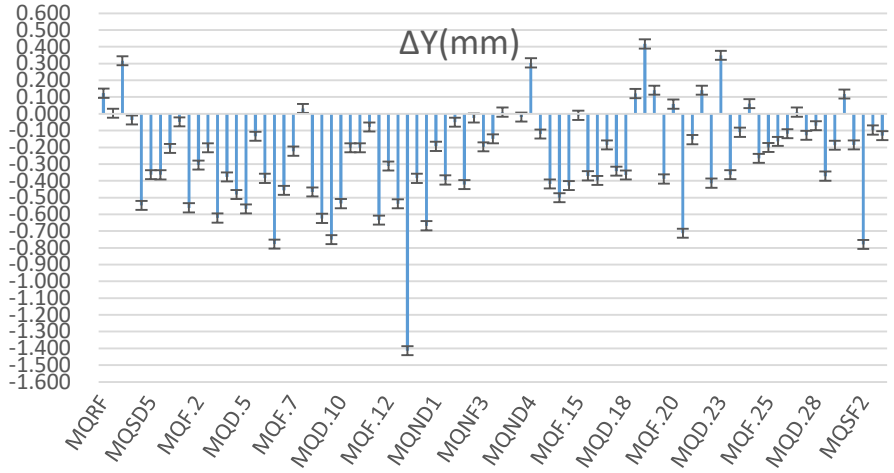
BPM (3)

- Before commissioning:
  - Measured the cable length from BPM panel in the tunnel to the BPM station using Network Analyzer-based TDR (E5071C) and adjusted them within O(mm).– the measured standard deviation was around 30 ps with typical cable length of 30 m.
  - Survey with FARO 3D-ARM and preset offset in EPICS database.



BPM survey

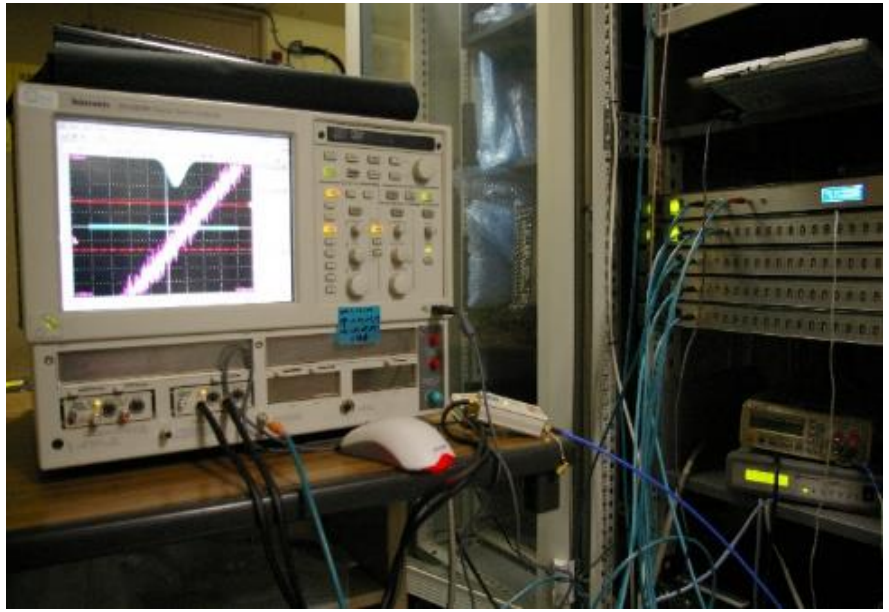


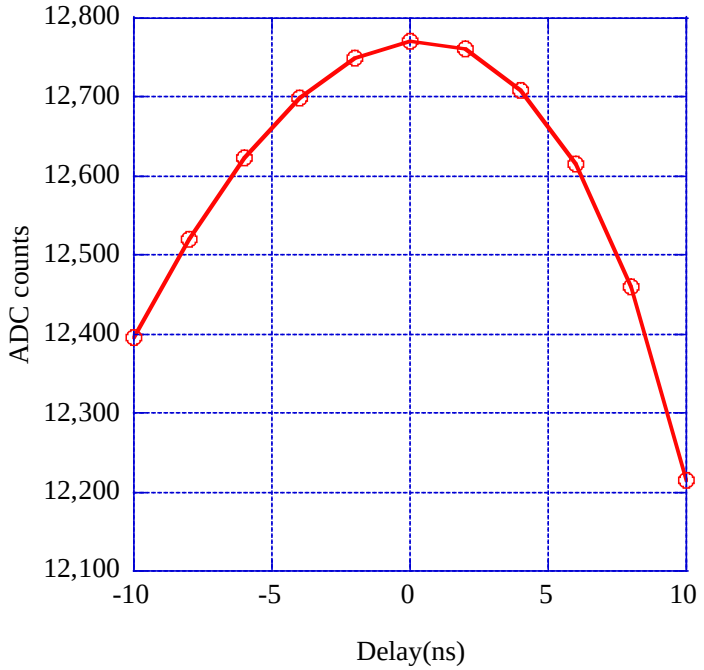


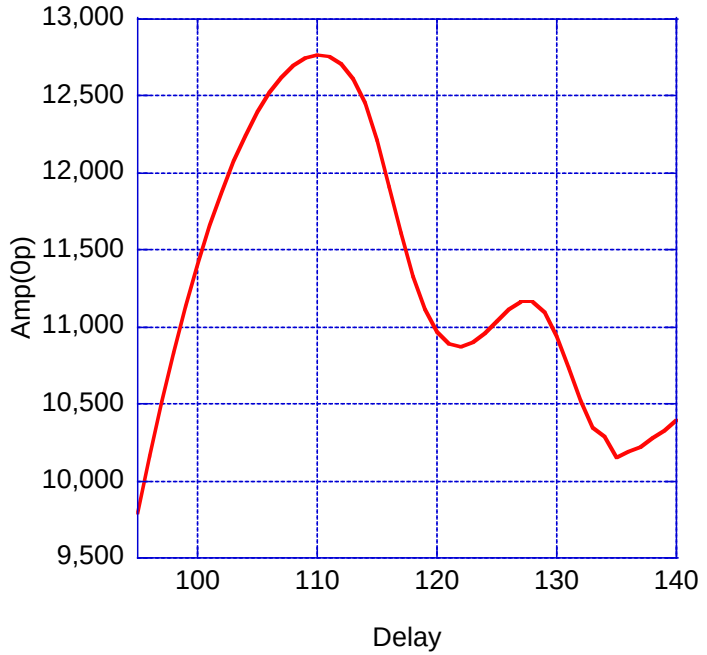
Survey results

BPM (4)

- Before first turn:
  - Measured the response of detector (18k11) to clock pulse at a test bench, and found that the best timing of a beam from falling edge of the clock is 369ns.
  - Measured the clock timing with a broadband oscilloscope as trigger by an incident beam in first BPM of each BPM station and set each delay.

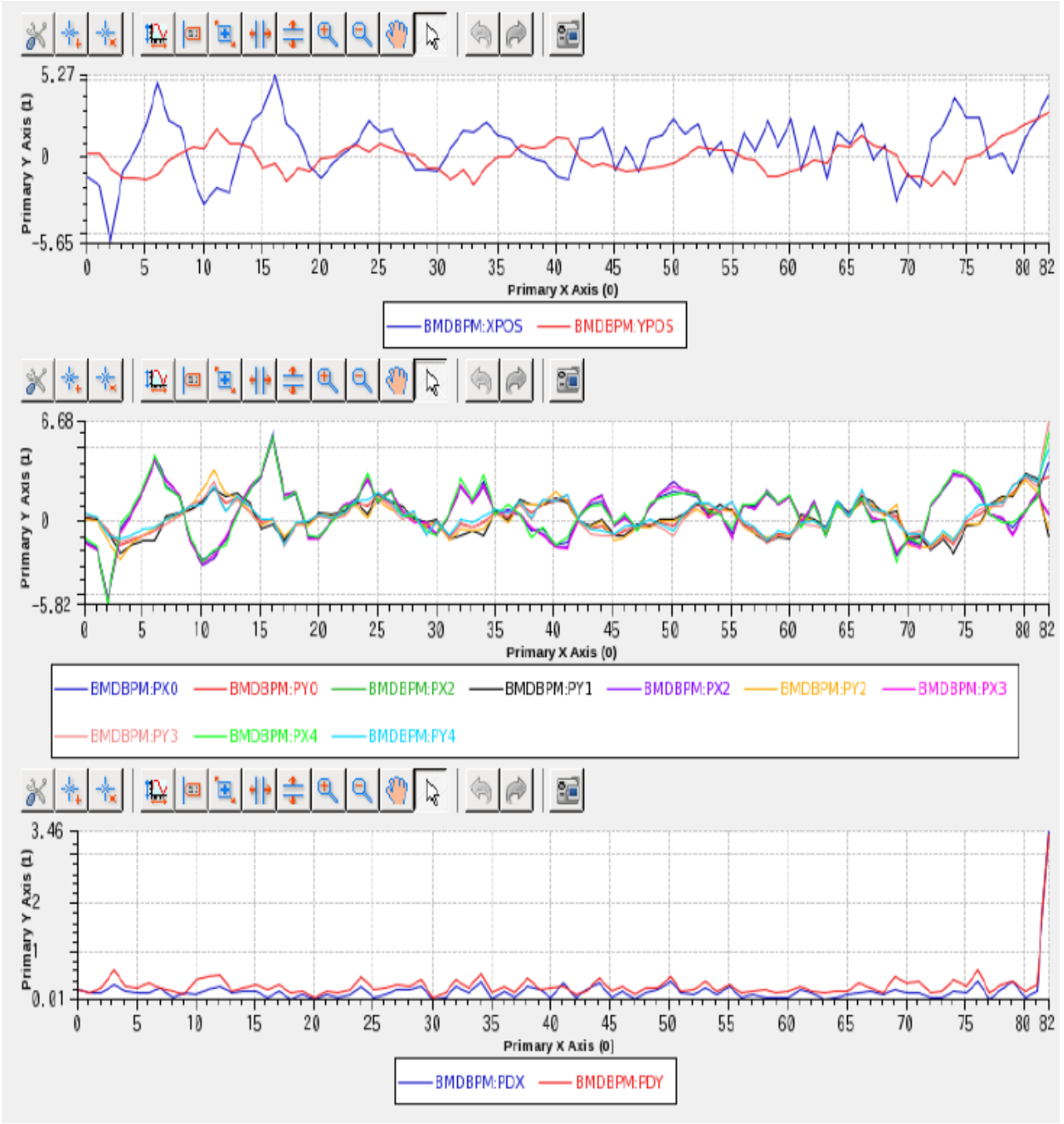






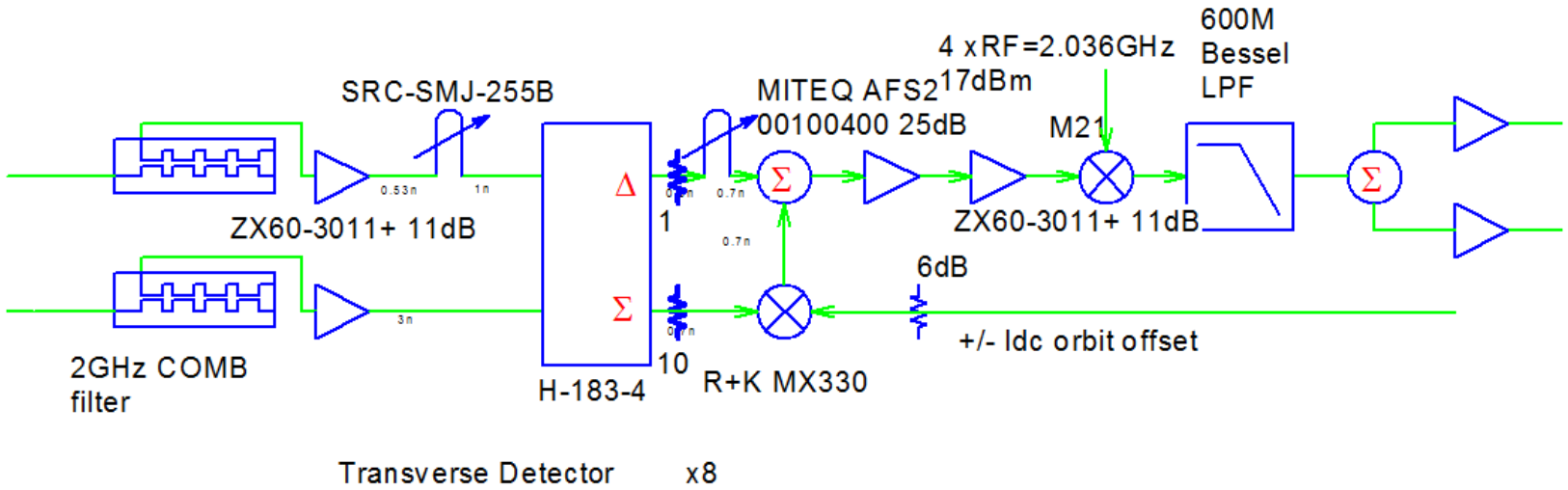
BPM (5)

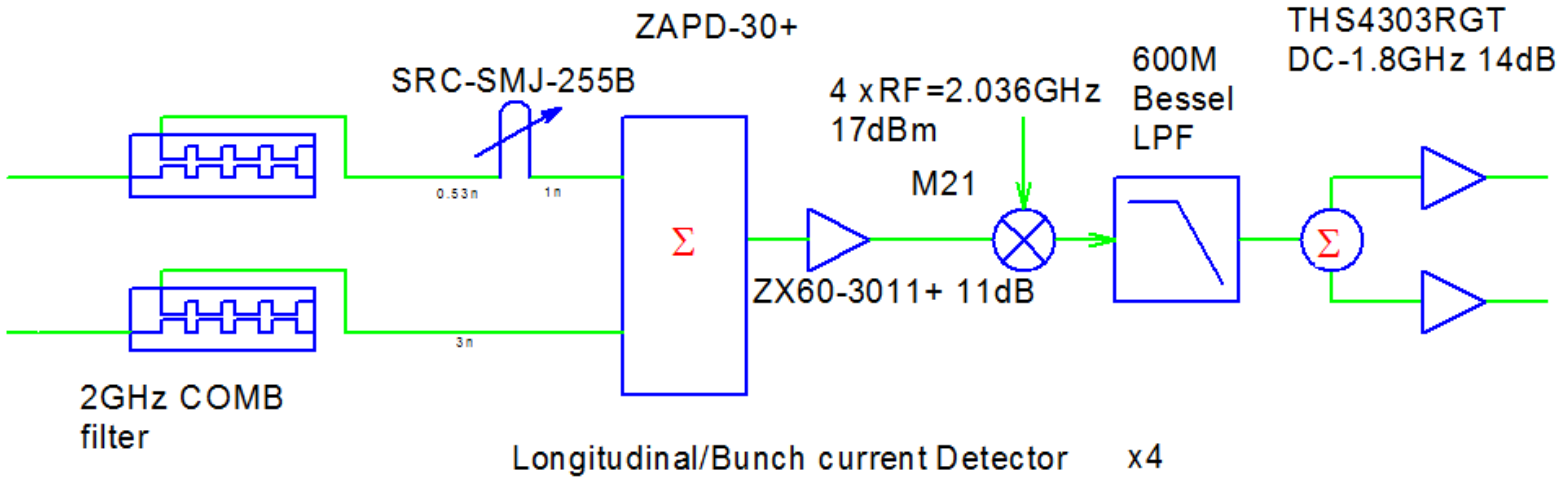
- Status:
  - All BPMs are working well.

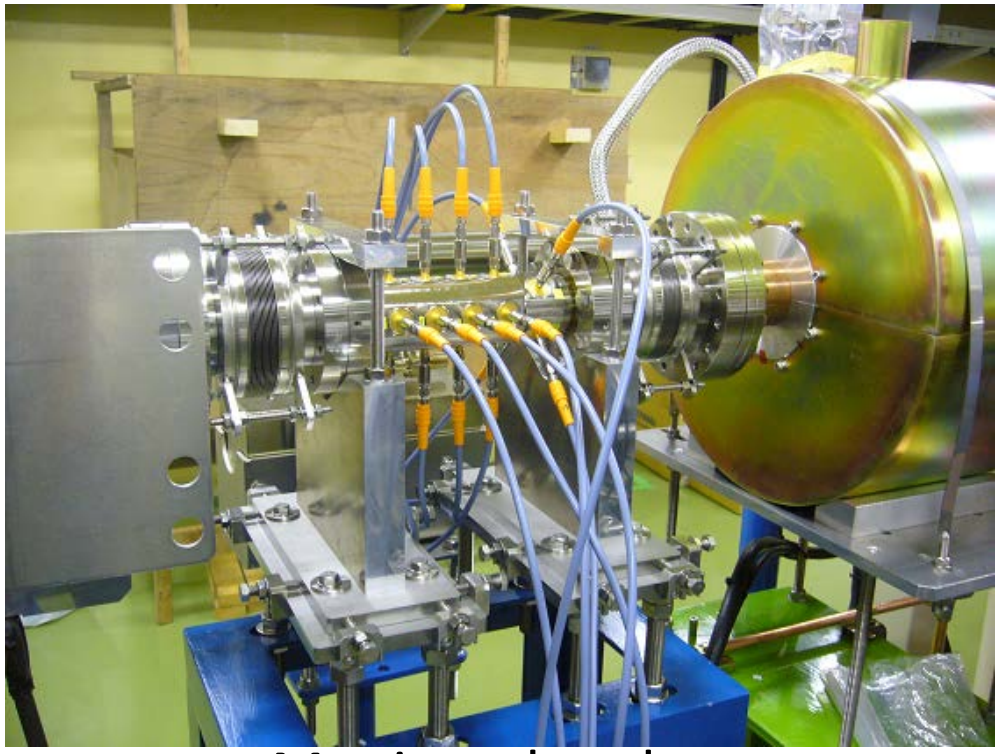


FB (1)

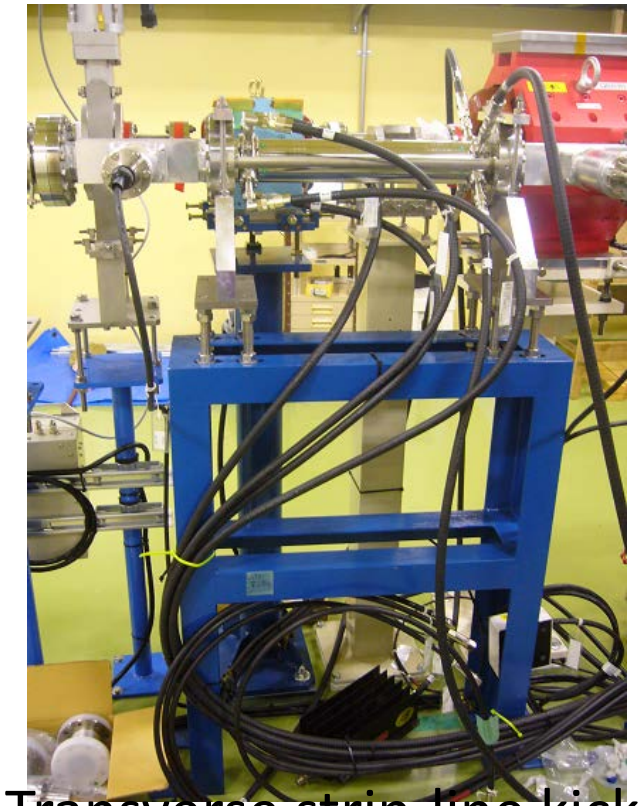
- Damp the residual bunch oscillation at injection or extraction.
- Digital filter : iGp12 with firmware matched with DR
- Power amp : 250W x 4 (reuse of KEKB)



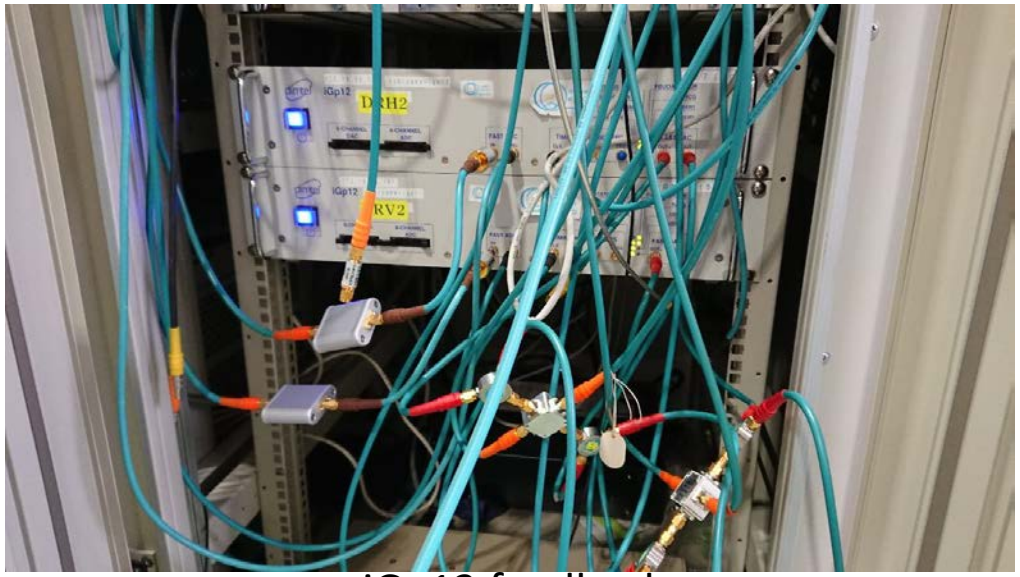




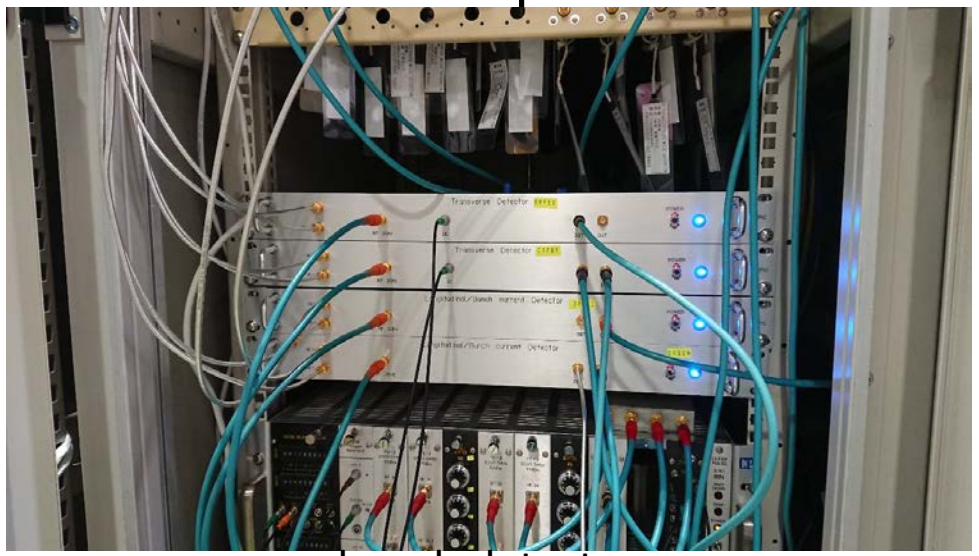
Monitor chamber



Transverse strip-line kicker



iGp12 feedback processor



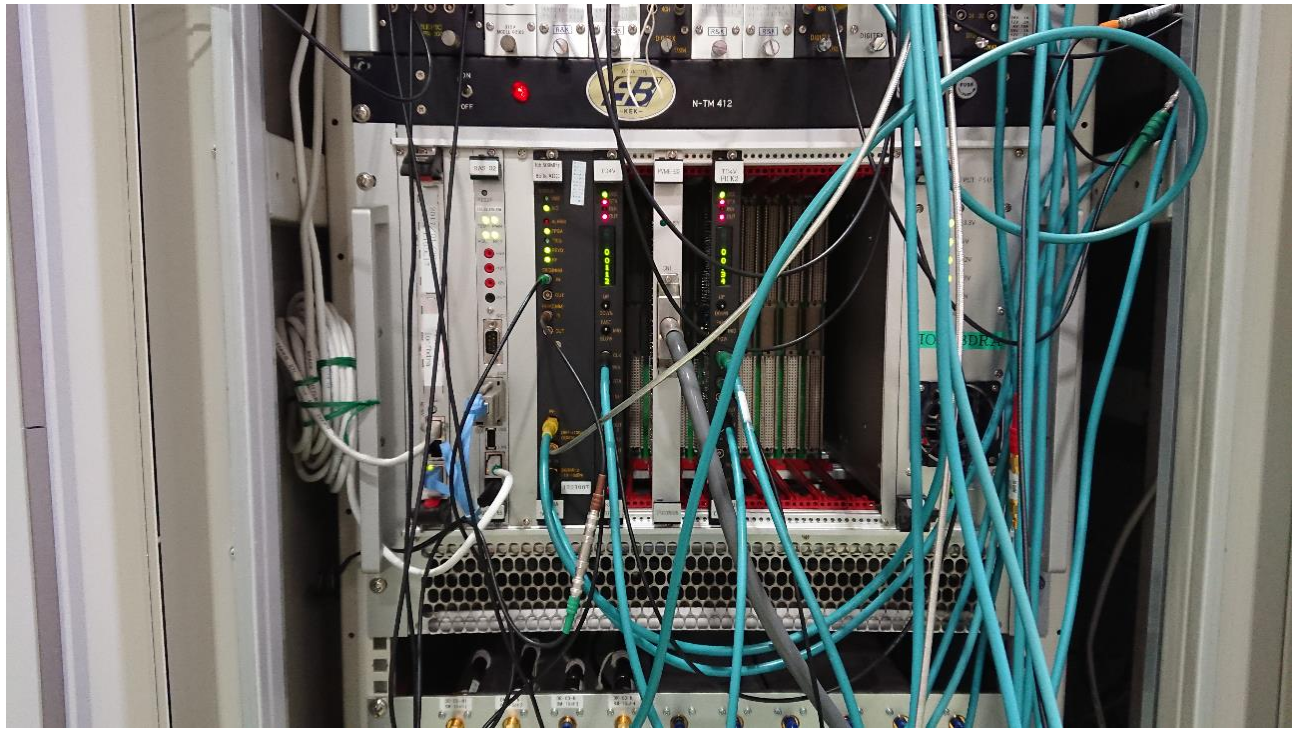
bunch detector

FB (2)

- Status
  - Roughly adjusted the phase shift of iGp12 processors for both horizontal and vertical planes.
  - Successfully excited betatron oscillation with stable amplitude using single-bunch PLL excitation function of iGp12.
  - Tek RSA306 real time spectrum analyzer to observe spectrum (using VNC connection from CCR).

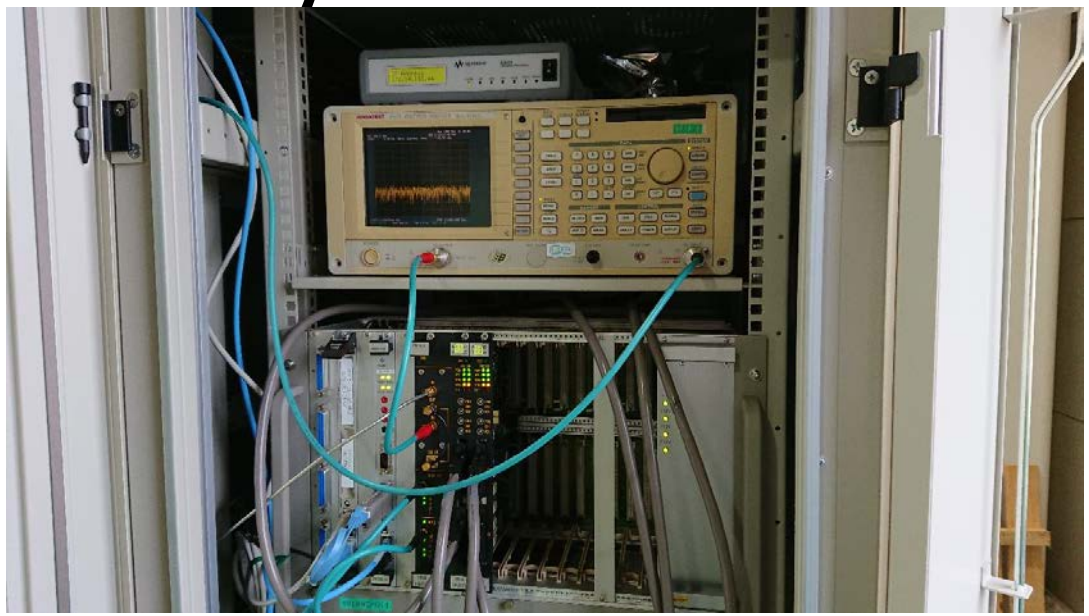
Bunch current monitor

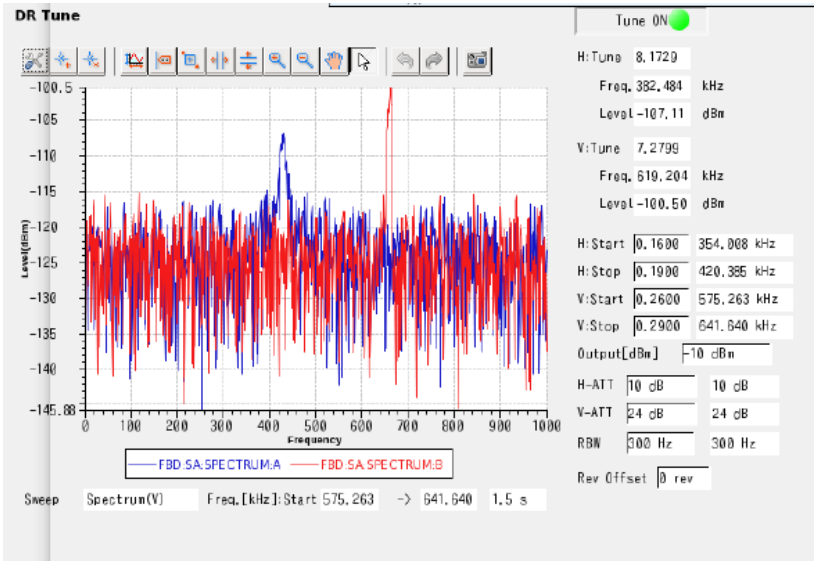
- System:
  - Detection circuit (same as used in MR)
  - VME board (Digitex 18K10)
- Status:
  - Working well.



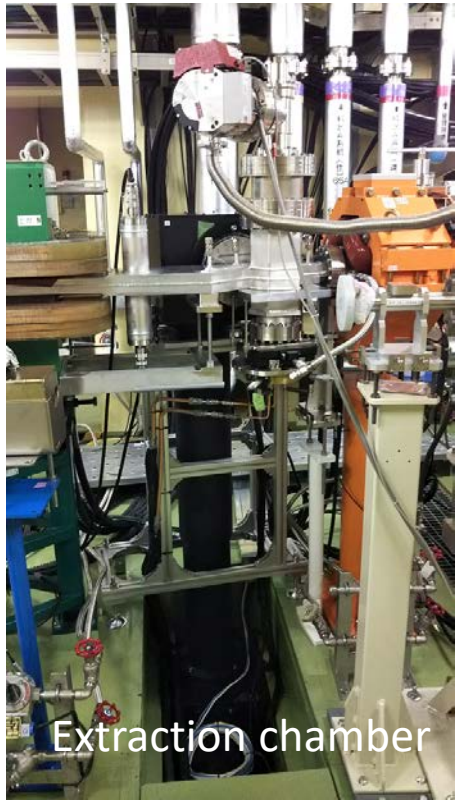
Betatron tune measurement system

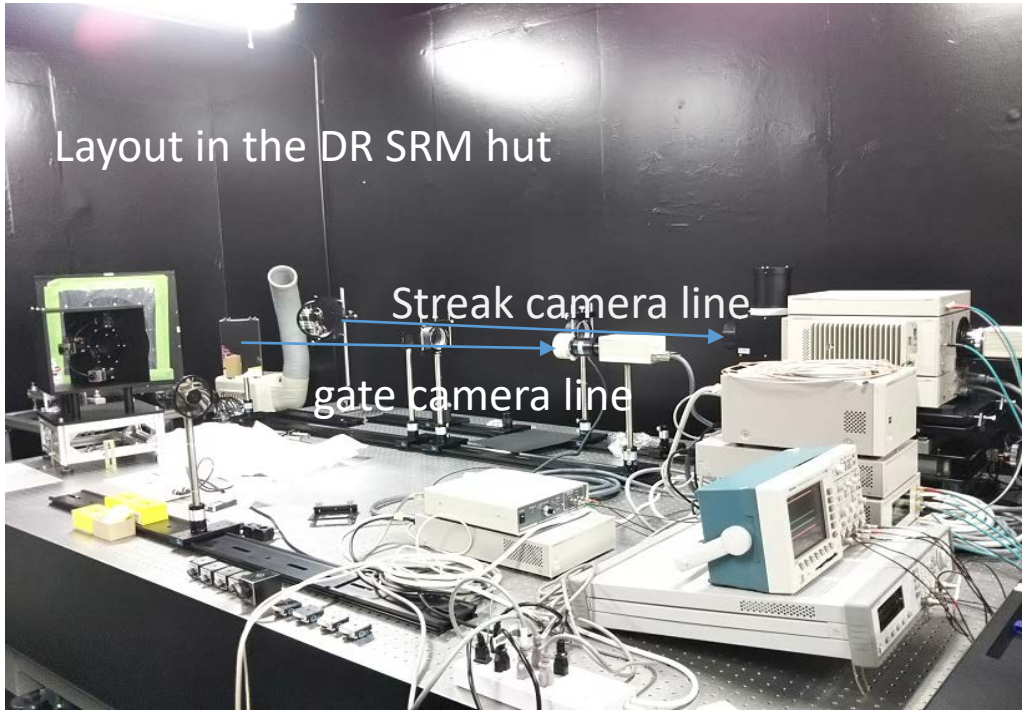
- System
  - Down-convert the tracking generator output of the spectrum analyzer, and drive beam.
  - Observe the electrode output directly with spectrum analyzer.
- Status:
  - Tune measurement system is working well.





SRM(1)



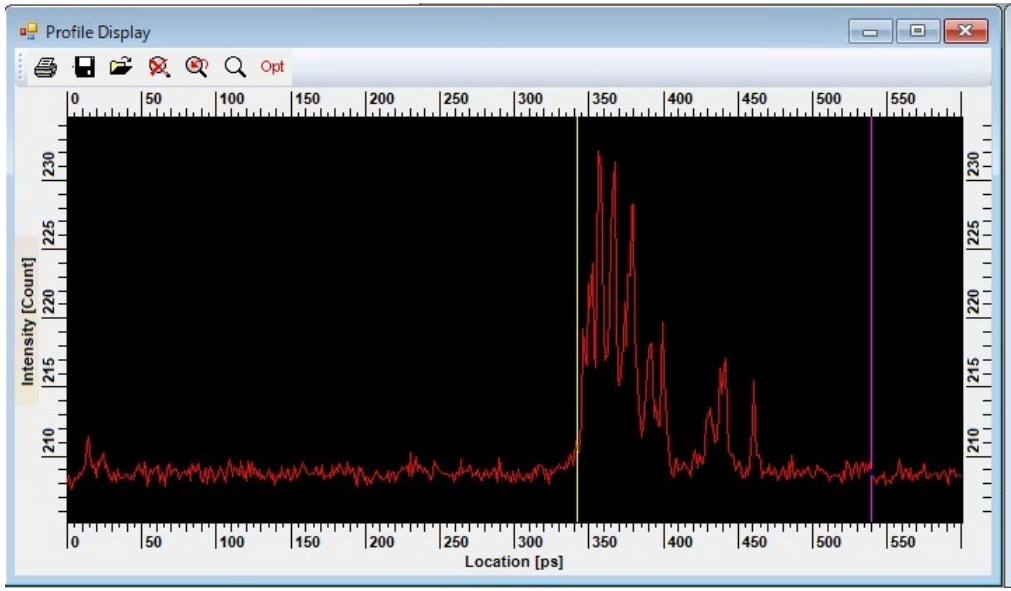


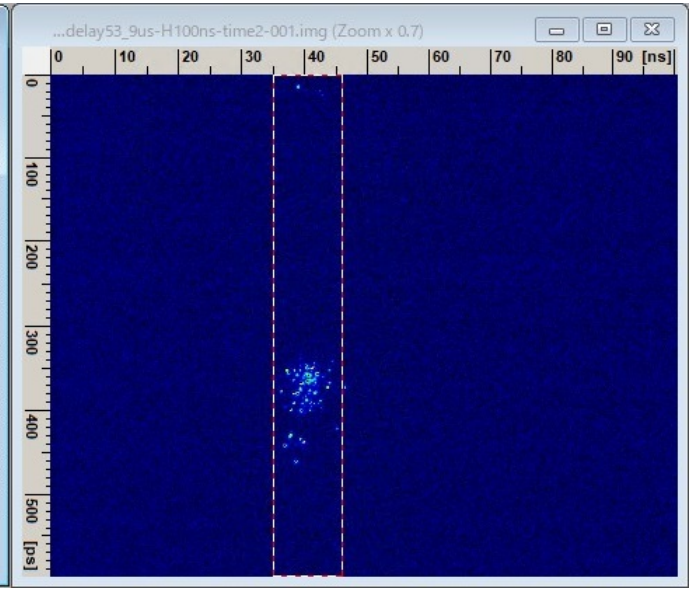
- Source bending magnet :
  - Bending radius of 3.14m
  - Just after extraction line
- Extraction mirror : Be(Recycled from KEKB MR)
- Detector:
  - Streak camera, gate camera
- Status:
  - Completed alignment of light path and adjustment of camera.
  - Data acquisition of damping beam size and length.

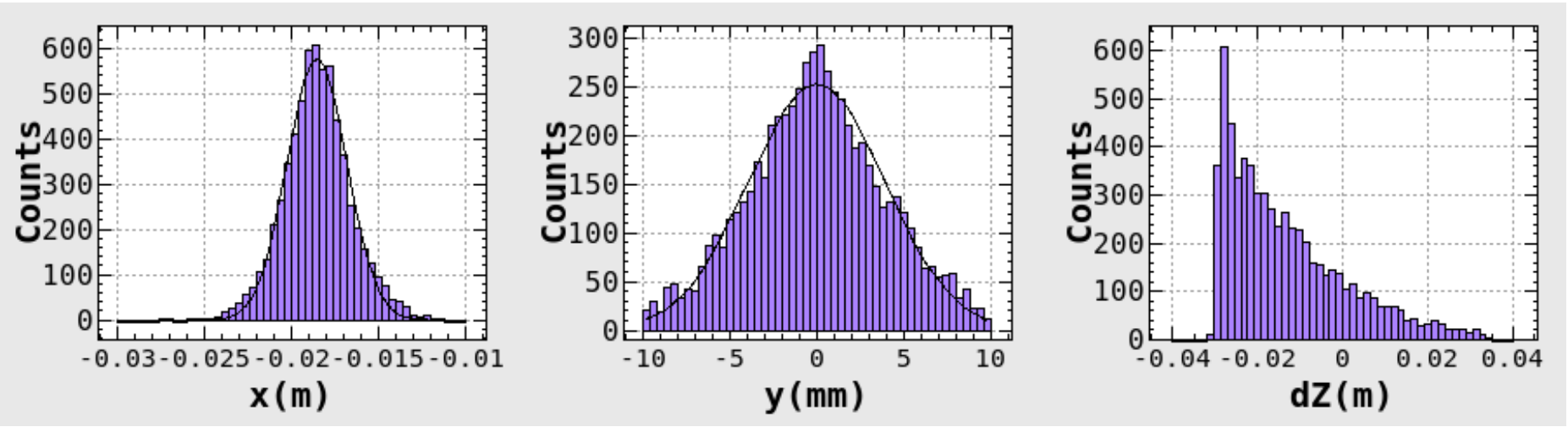
SRM (2)

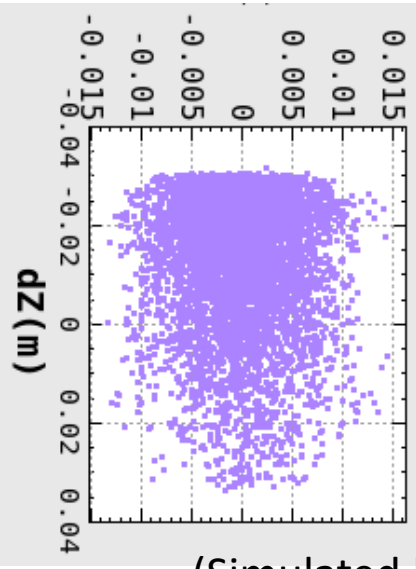
Streak camera measurement

Bunch shape of just after injection is not clear and could not decide the bunch length, but the shape is similar to calculated one.





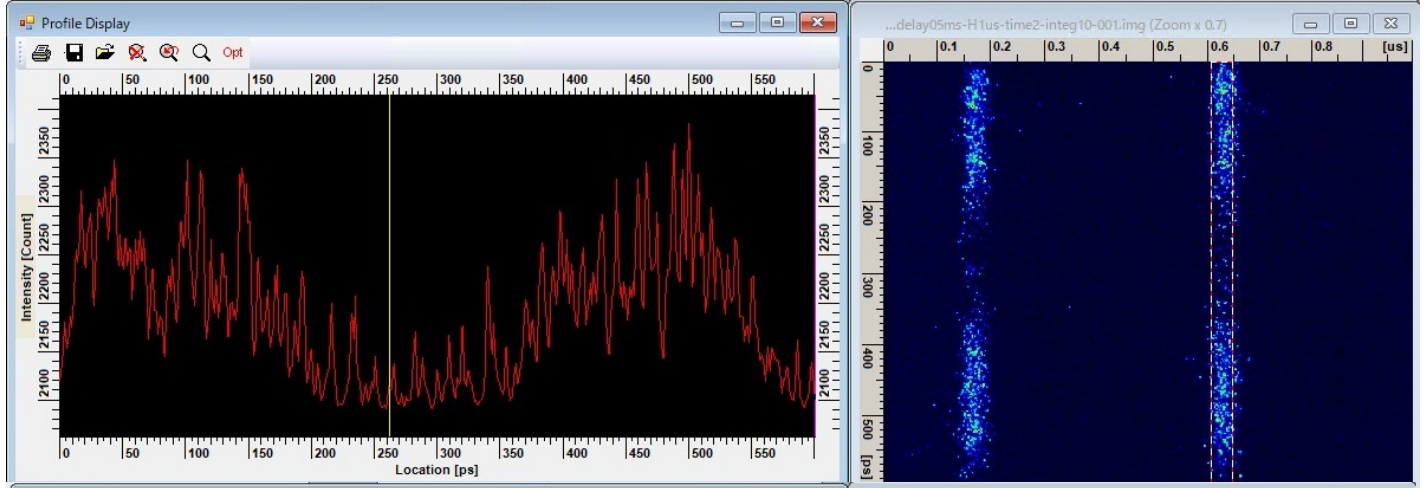


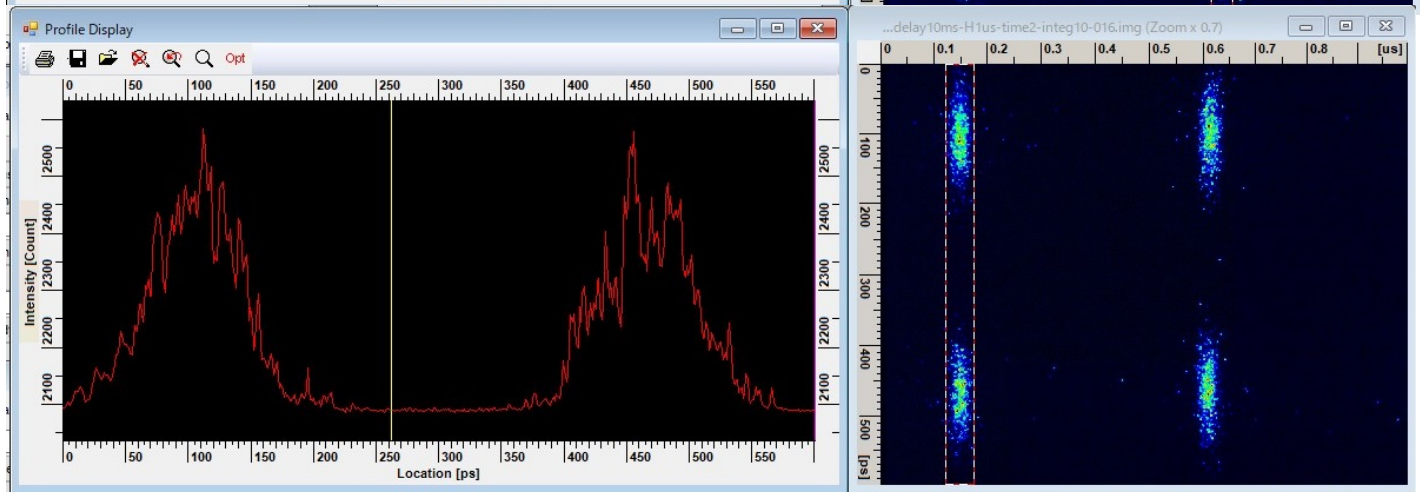


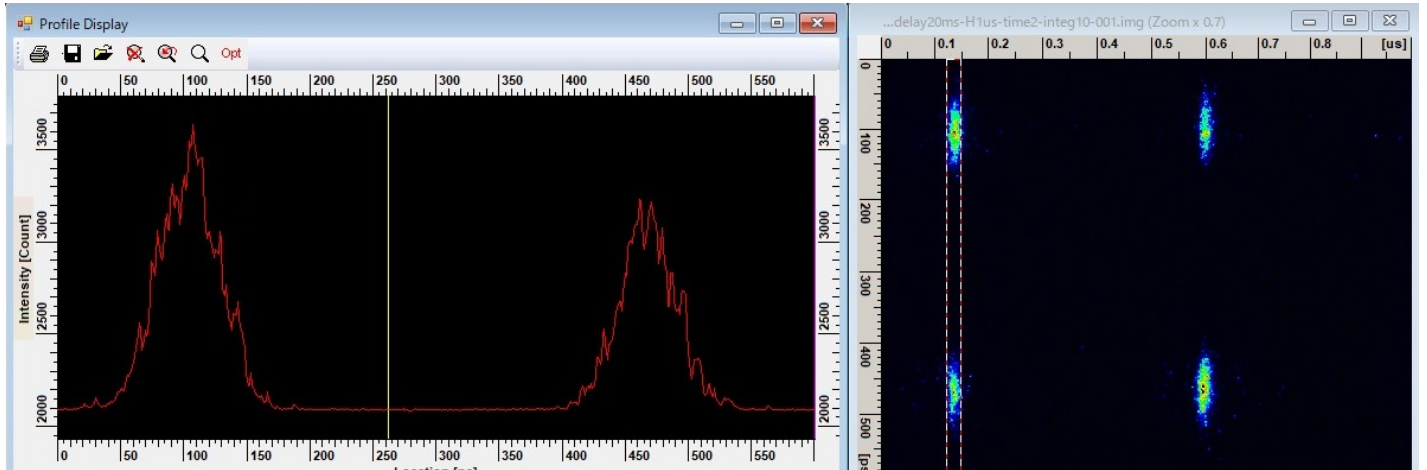
(Simulated by N.Iida)

SRM(3)

- 5ms
- 10ms
- 200ms

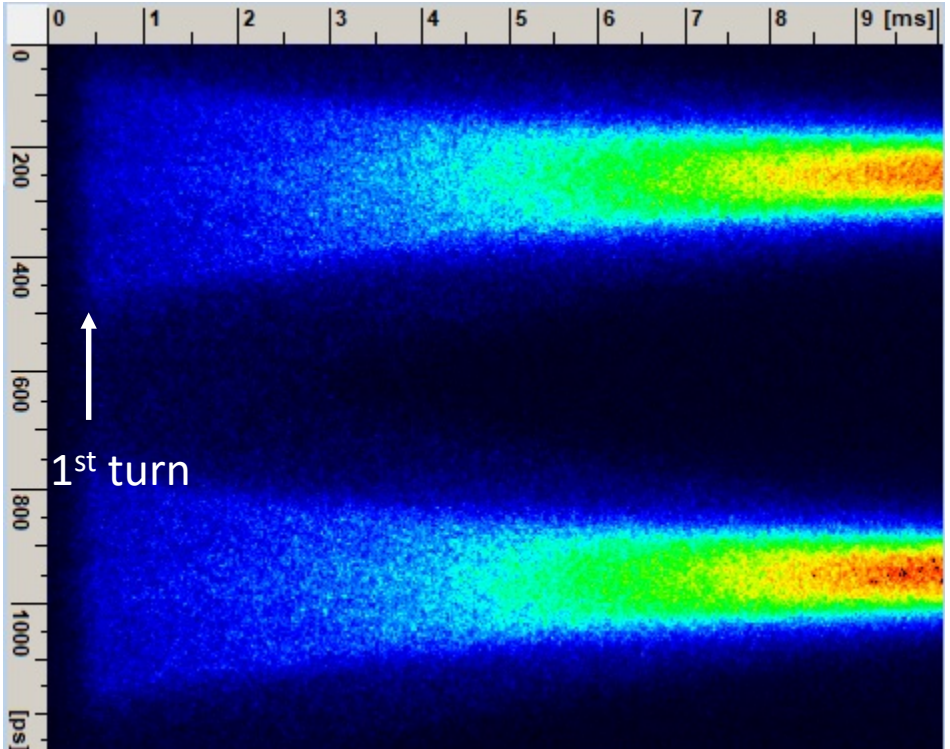


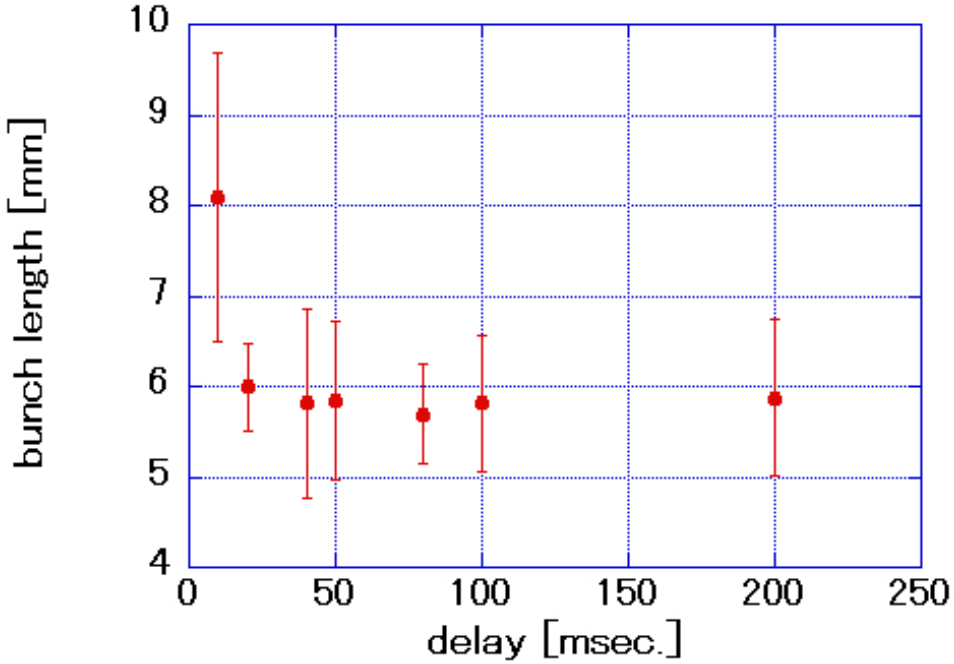




SRM(4)

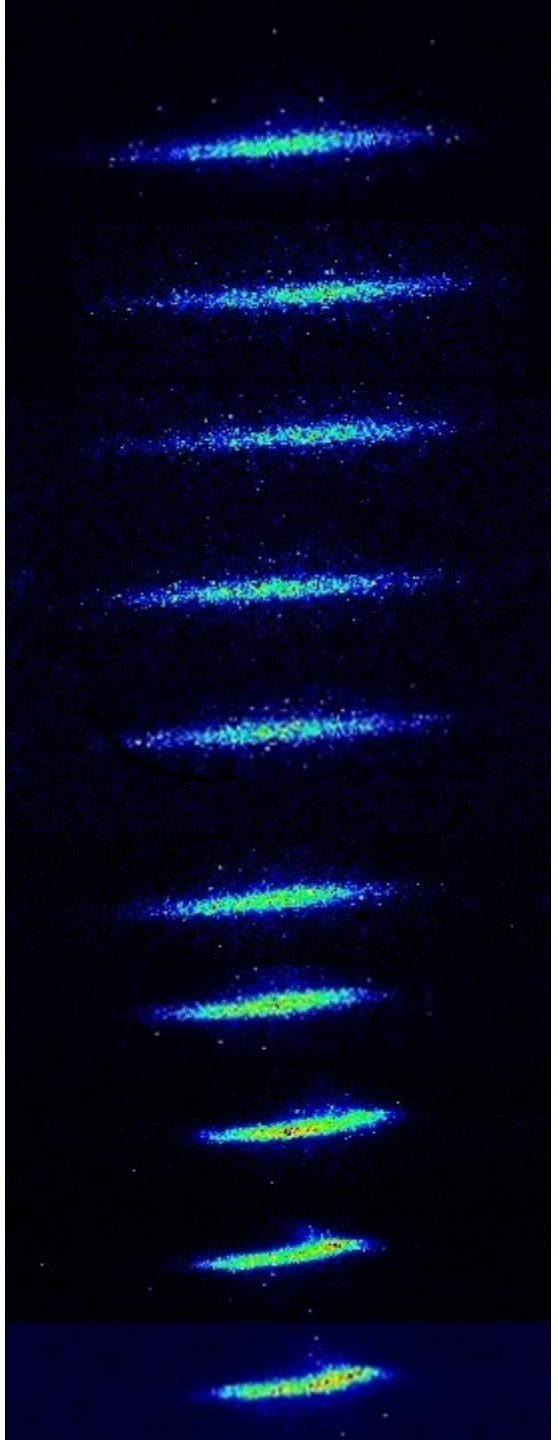
- Bunch length
  - Damped around 20msec after injection.
  - Absolute value is near the design value (6.5mm).





SRM(5)

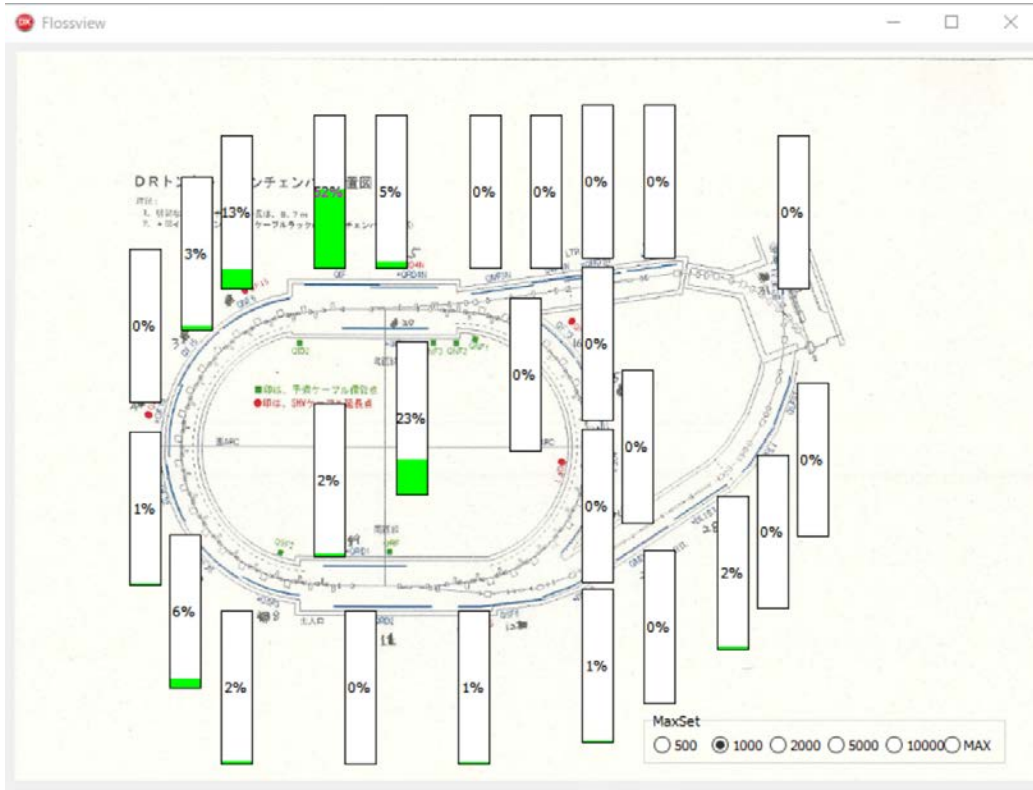
- Transverse beam shape
  - Measured single shot for each turn by gate camera.
  - Damped shape is observed.
    - The quantitative analysis was difficult since light intensity was not enough and could not use BPF for measurement.
  - Measure again with higher bunch current.



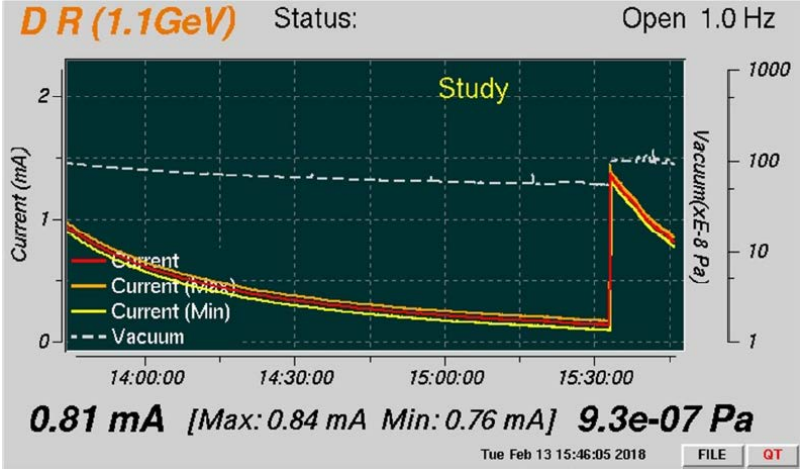
LM

- Purpose
  - Used for commissioning, injection tuning and monitoring in routine operation.
  - Abnormal beam loss stops the injection to the ring.
- Specification:
  - Calculated beam loss
    - 2.5% @ injection point.
    - 2.7% @ arc sections.
    - 20% @collimator.
- Sensor : Ion chamber (9 m FC-20D co-axial cable)
  - Covers all of the tunnel.
  - Recycled from linac
  - Sensitive down to the loss of around 0.1mA/s
- Readout : Integrator (0.1,0.3,1ms) and amplifier(× 1,10,100,1000)
- Status:
  - Working well.
  - I/L threshold set to 2V since extraction septum trouble caused higher beam loss near SRM hut.
  - Raise I/L level, after checking the radiation level at the beam loss.


Ion chamber on tunnel wall

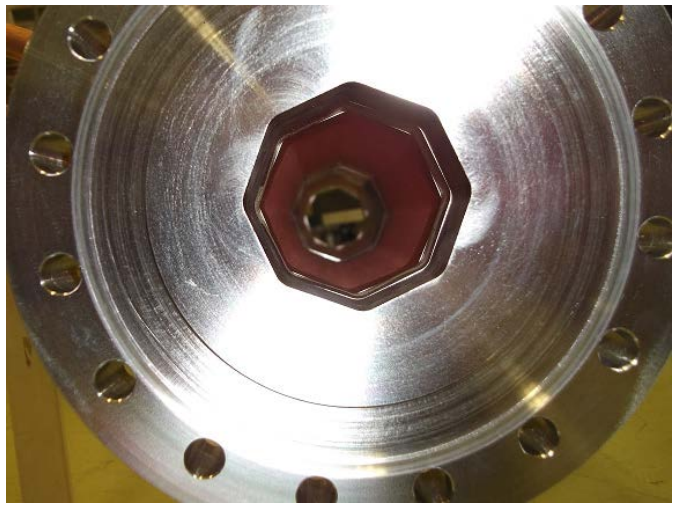


DCCT

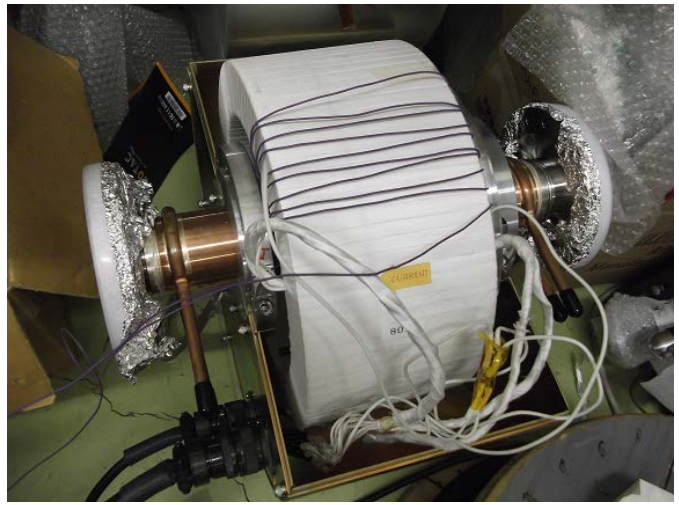


- Specification:＜200mA, σ=30μA
- Chamber : Octagonal ceramic chamber + Core (Recycled from MR).
- Readout : Modification for DR.
- Take the current data continuously at about 5ksps using Keysight 34465A DMM.
- Status:
  - Current measurement working well.
  - Chamber direction was reversed w.r.t. e+, and corrected by software.
  - Injection stop when the current exceed threshold (17mA).

DCCT Chamber



Ceramic chamber



Core

MR

BPM

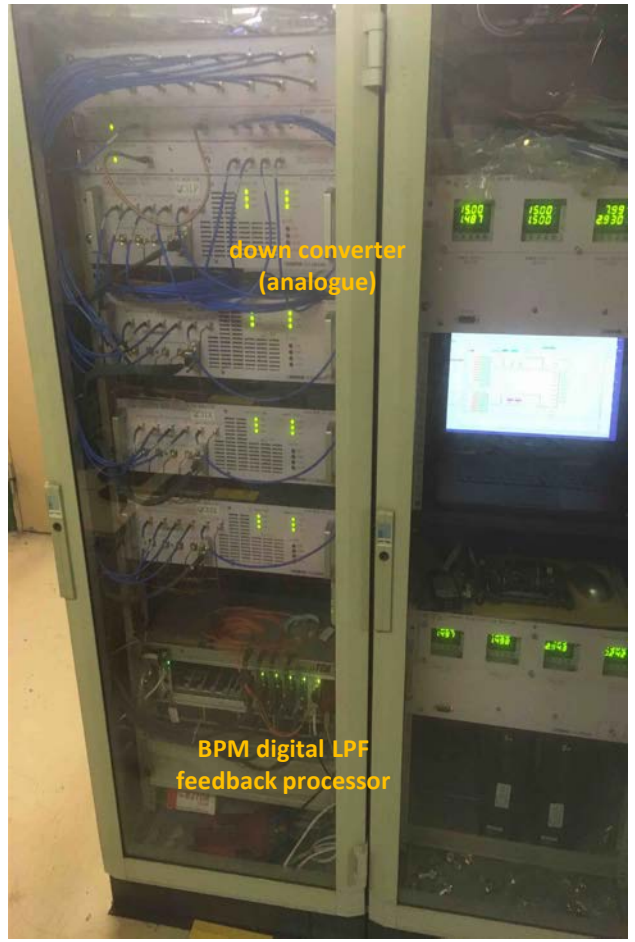
- Added 22 gated turn-by-turn monitor units mainly around IR and injection points
  - In total, 139 units have been installed.

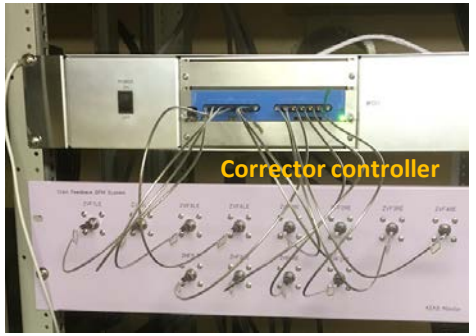
FB

- Replaced 4 x AR250A250 amplifiers for LER transverse FB with R+K CA010K251-5757R 500W x 4 amplifiers.
  - Much better time response, higher power.
- Replaced damaged high power attenuators (1.5kW)
  - HER :1
  - LER longitudinal : 1
- Replaced water chiller system for LER longitudinal kickers.
  - Much better reliability, higher cooling power.
- Heating of amplifiers room (~35 C Fuji B4)– need much higher cooling power. Replacement of air-conditioners is planned.

BPM detector and feedback controller for vertical collision feedback

- Specification:
  - BPM position resolution < 1 μm (with > 500mA)
  - Repetition of feedback 5kHz to 32kHz
  - Feedback bandwidth 100Hz
- BPM detector:
  - Analog down converter followed by digital LPF
- Feedback controller:
  - Feedback processor and Corrector controller
  - Conforming to μTCA specification
- Status:
  - The detector was tested in Phase 1 operation.
  - All devices already have been installed in Tsukuba control room.





XRM

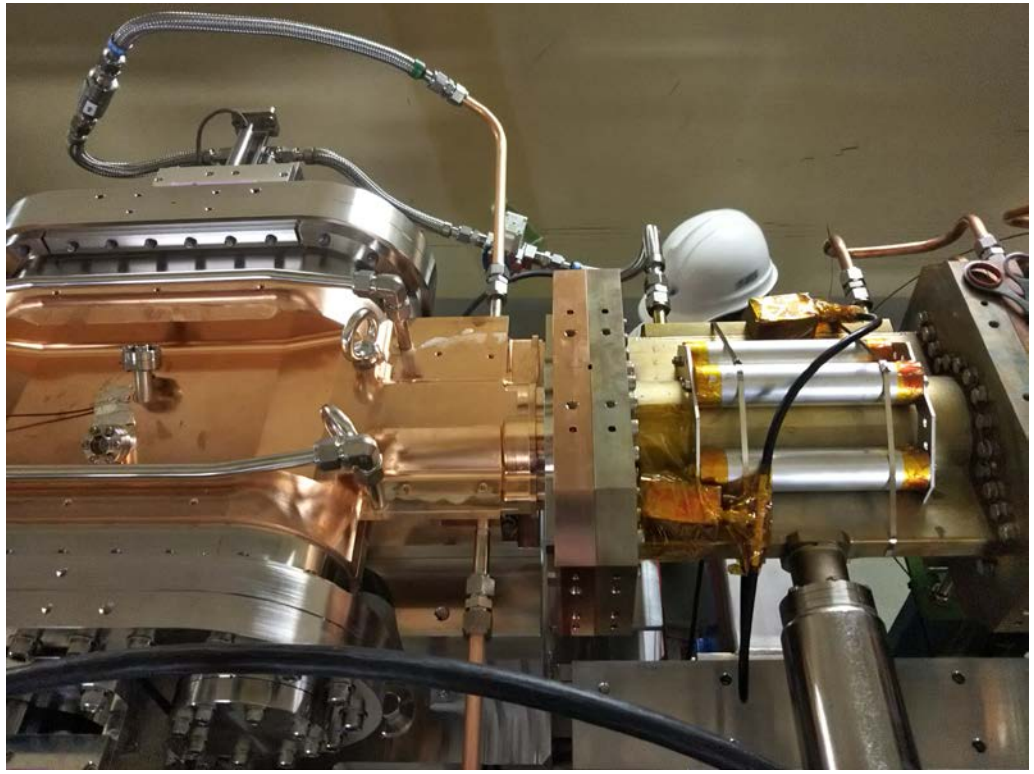
- Made Helium enclosure in detector box to minimize scattering and ozone production.
- Changed Be filters in LER and HER to much thinner ones to eliminate suspected source of image smearing due to scattering (LER: 500µm→200µm, HER:16mm→200µm).
- Changed HER masks to re-optimize for softer X-ray spectrum as a result of changing Be filters.
- Developed readout software for vacuum gauge controller and reader.

SRM

- Investigated magnification of system which was higher than expected.
  - Injected a laser beam from source point to measure slit ratio, and concluded that extraction mirror caused the effect.
- New wider mirrors to increase light intensity at streak cameras.
- Examined streak camera and then found degradation of streak tube.
  - Will be replaced in future.

LM

- Added 31ch IC to cover all of the ring.
- Attached PIN PD’s to 6 new collimators.



Summary

DR

- All monitors are working well without any serious problem.
- All monitors can measure normally.
- Tune up further more with a progress of phase-II commissioning.

MR

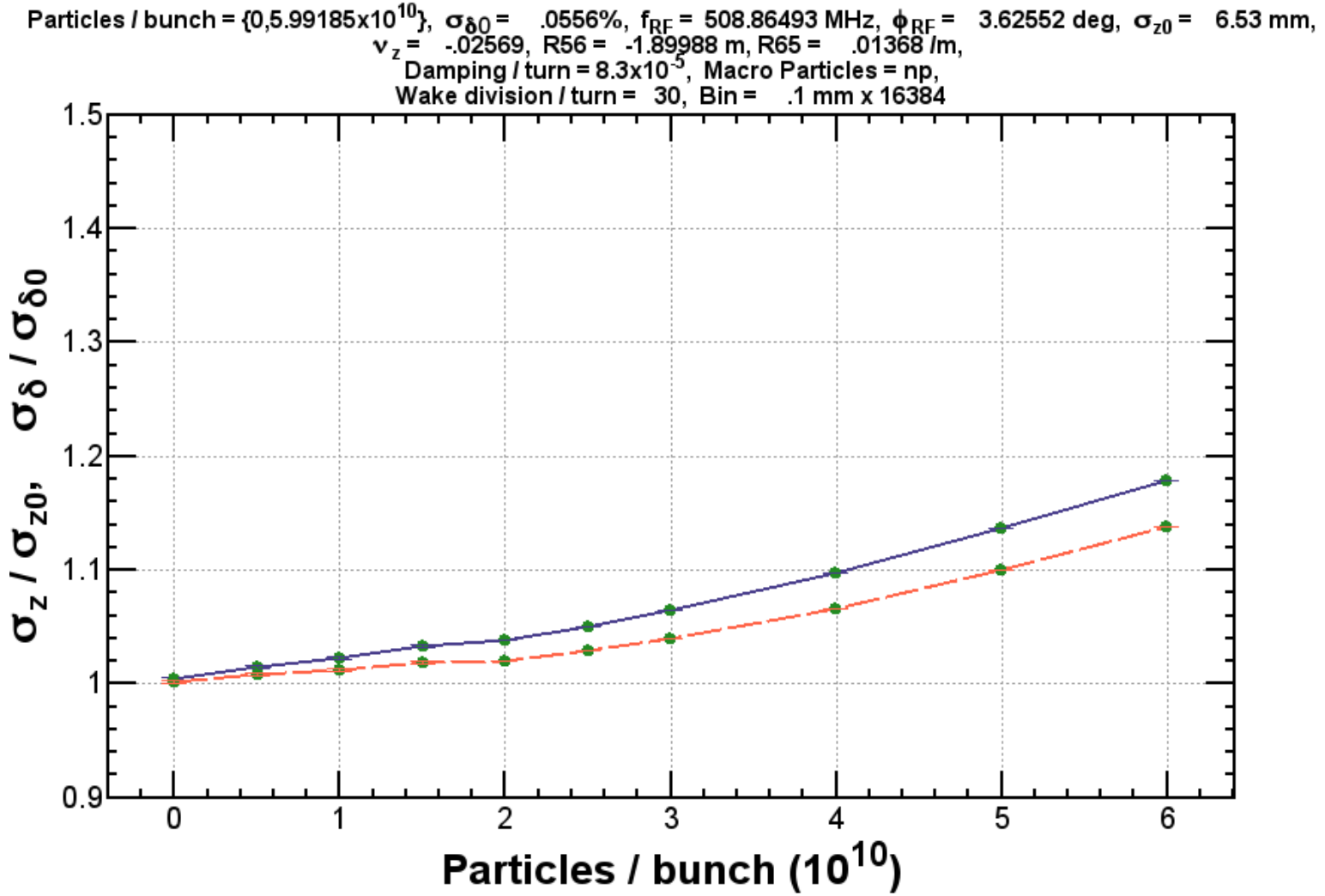
- Ready for the Phase-II commissioning.

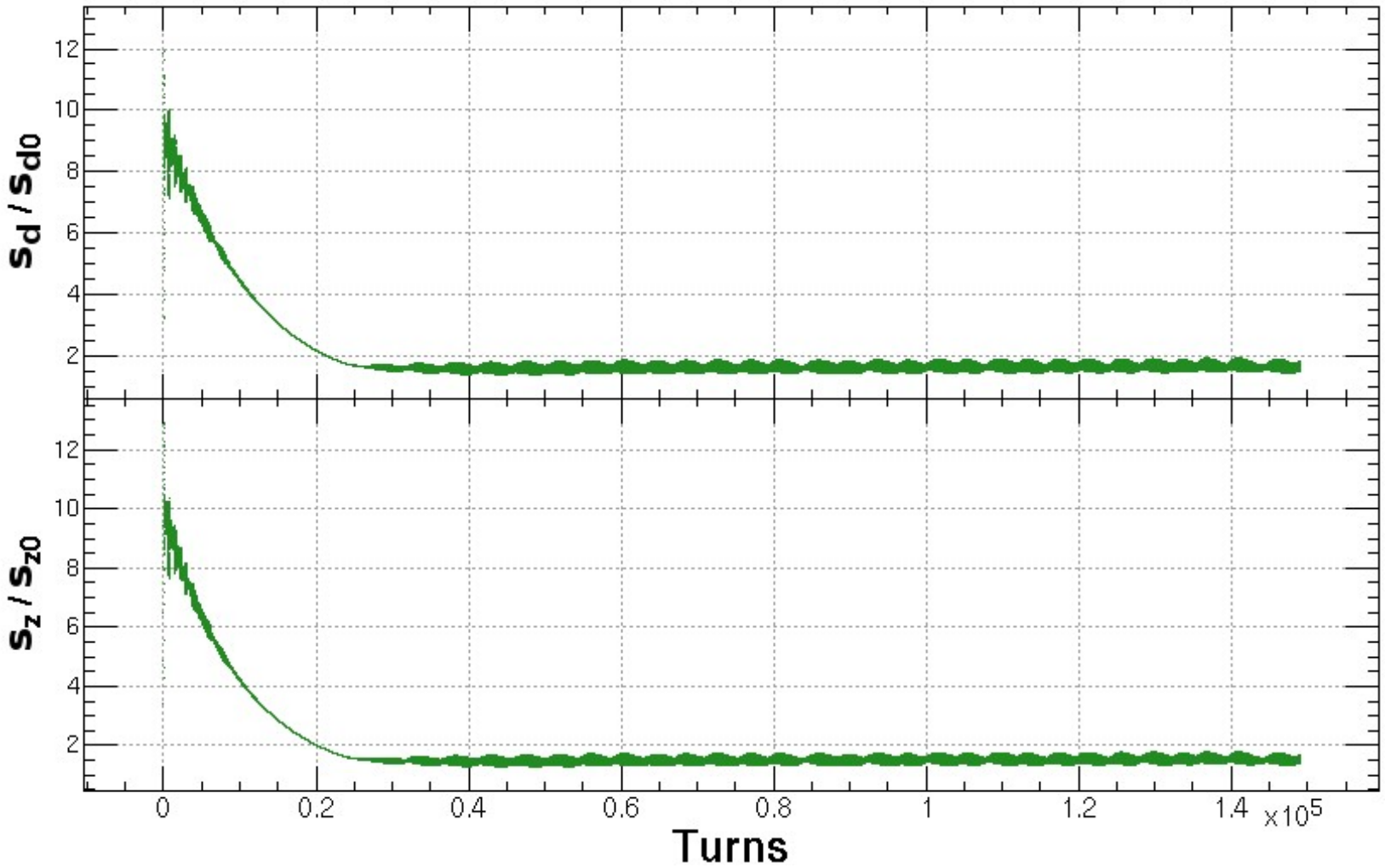
32ch digital delay

IP FB

Bunch Length @ DR by simulation

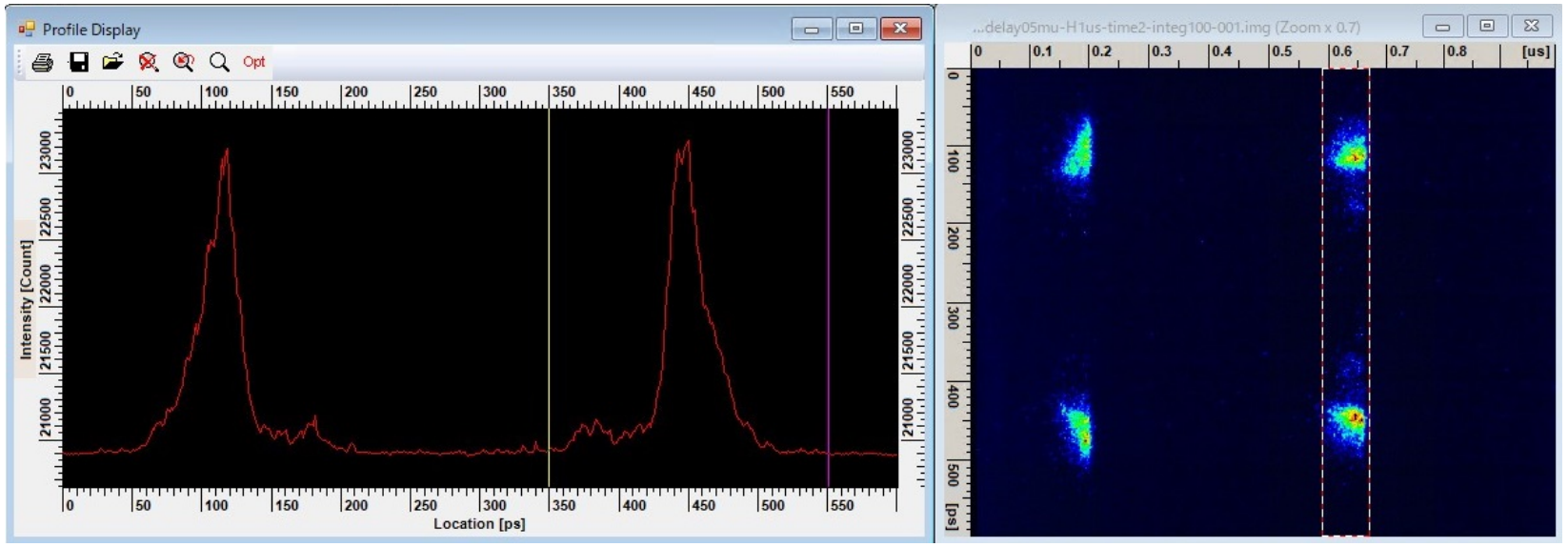
- σz=6.5mm



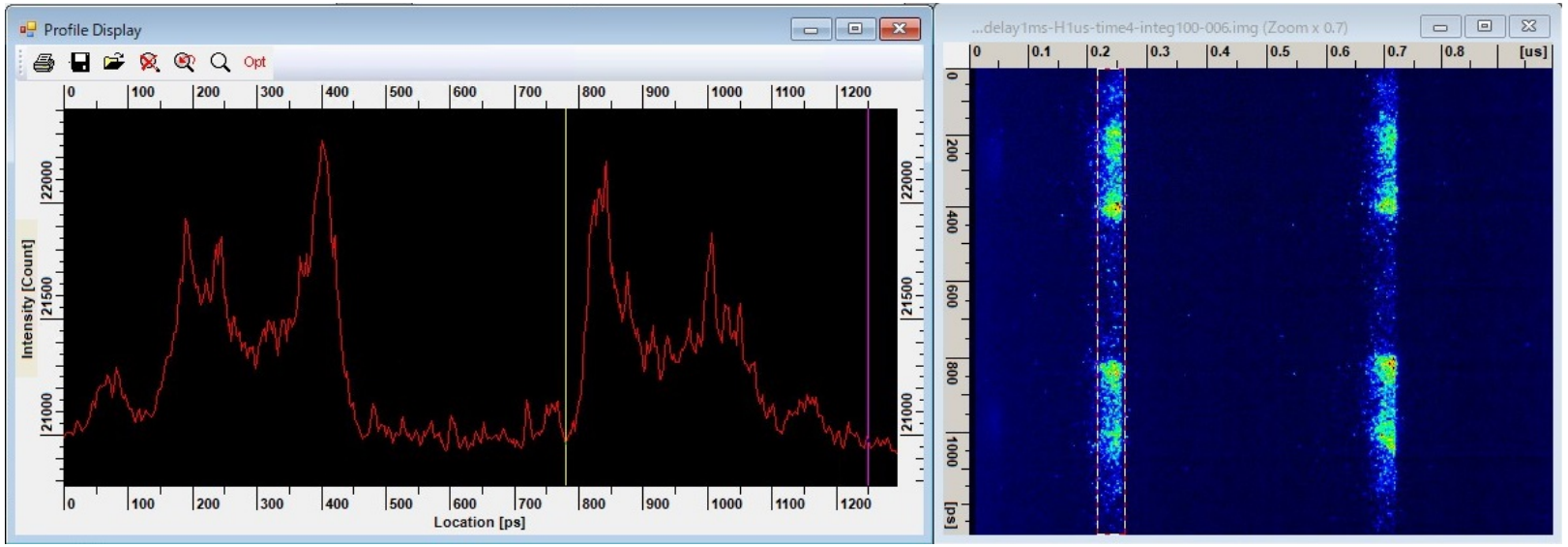

s_d / s_{d0}
s_z / s_{z0}
12
10
8
6
4
2
0
0.2
0.4
0.6
0.8
1
1.2
1.4
x10^5
Turns

Streak camera measurement

- 1st turn (integration of 100 turns.)

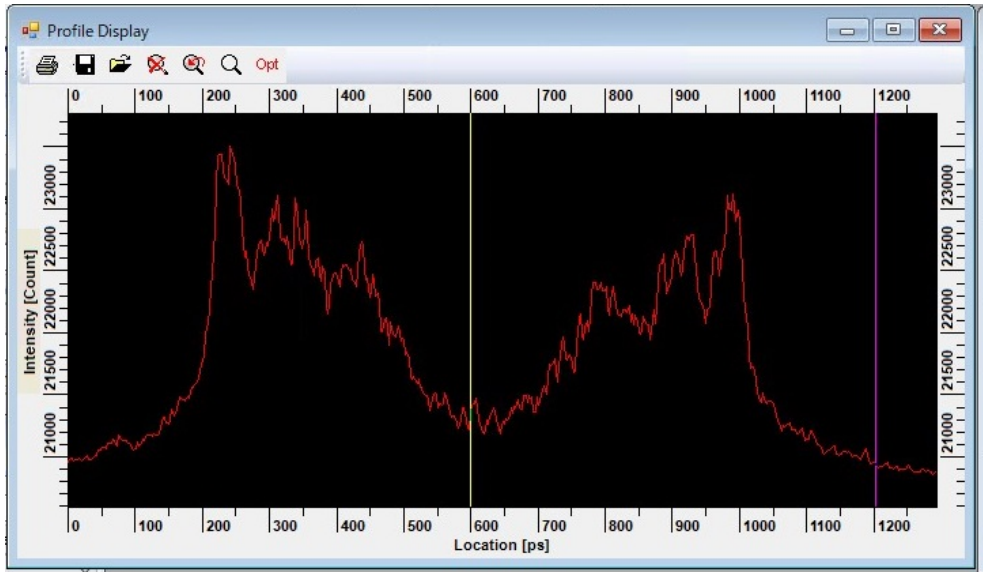


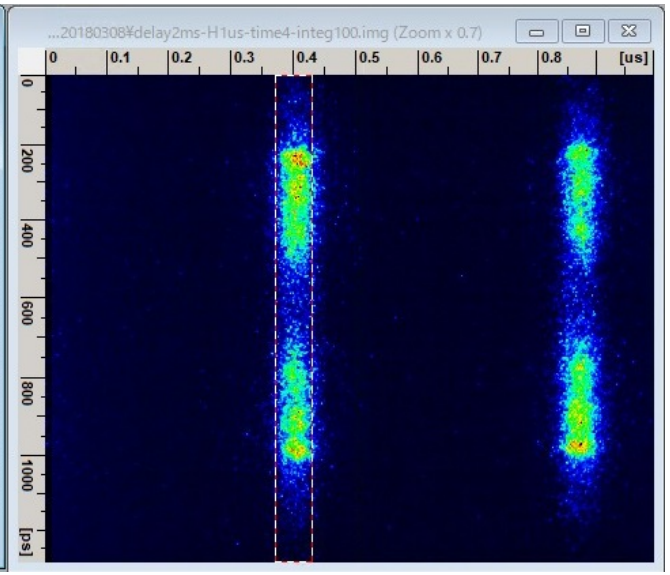
- 1ms after injection(integration of 100 turns)



Streak camera measurement

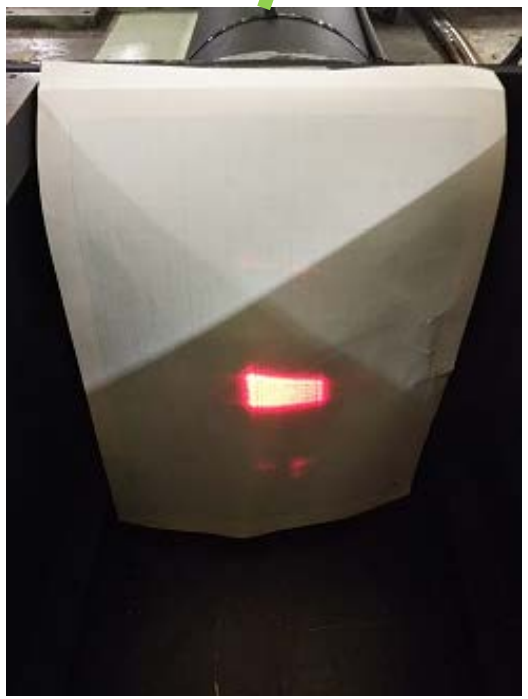
- 2ms after(integration of 100 turns.)

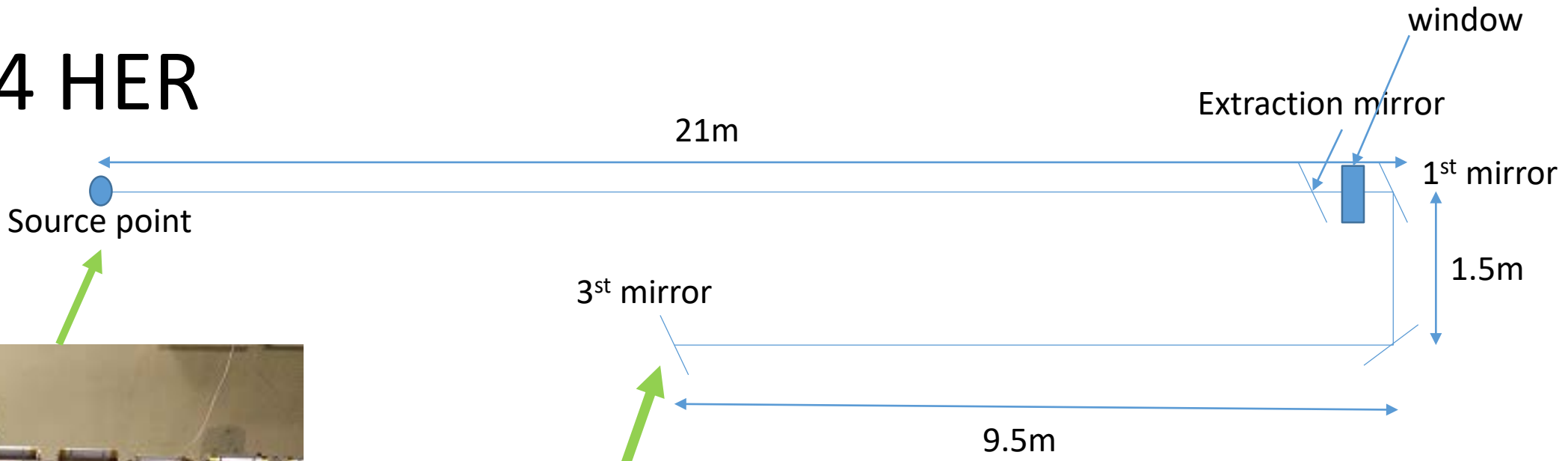




Dithering interface

D4 HER




window
Extraction mirror
21m
1st mirror
Source point
1.5m
3st mirror
9.5m