KYUSHU UNIVERSITY 2011
100th Anniversary

Beam commissioning of 150 MeV FFAG accelerator at Kyushu University

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KYUSHU UNIVERSITY

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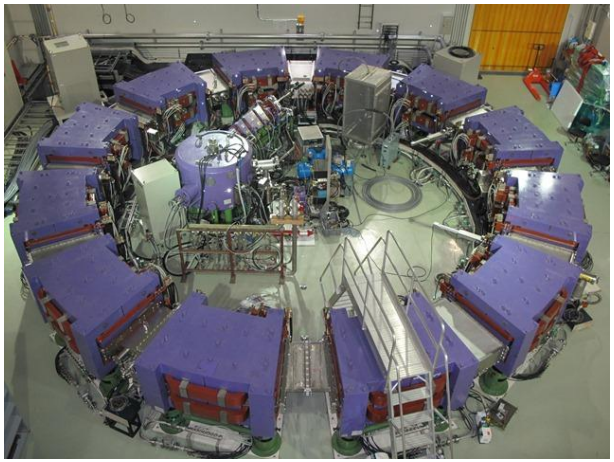
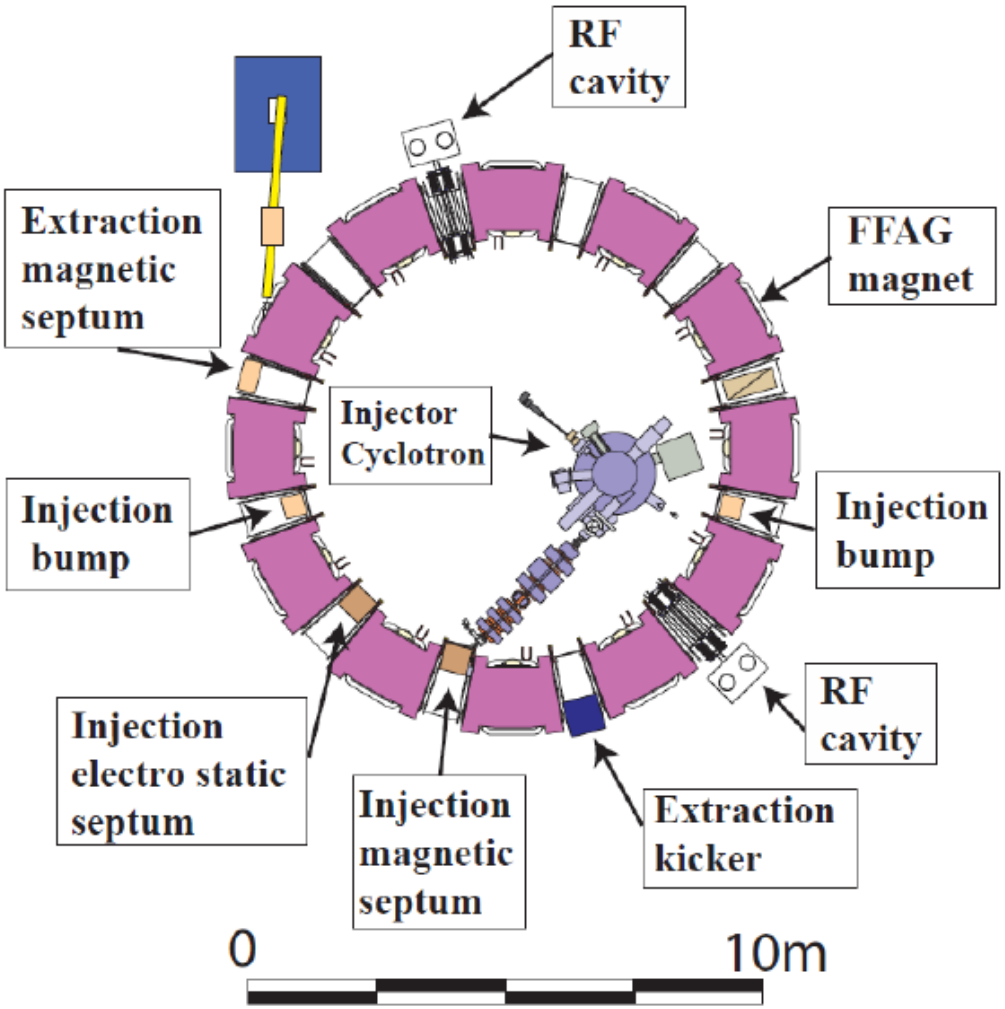
Current status of 150 MeV FFAG accelerator

1. Overview of 150 MeV FFAG Accelerator
2. Experimental results of beam commissioning
3. Upgrade ion source of injector cyclotron
4. Power test of RF acceleration system
5. summary



1-1. 150 MeV FFAG Accelerator



magnet	Radial sector type (DFD-triplet)
Cell	12
K-value	7.62
Beam energy	10 ⇒125 MeV (12 ⇒ 150 MeV)
Radius	4.47 ⇒ 5.20 m
Betatron tune	H: 3.69～3.80 V: 1.14～1.30
Max. field	F-field: 1.63 T
(along orbit)	D-field: 0.78 T
Circ. freq.	1.55～4.56 MHz
Repetition	100 Hz
Mean current	1.5 nA

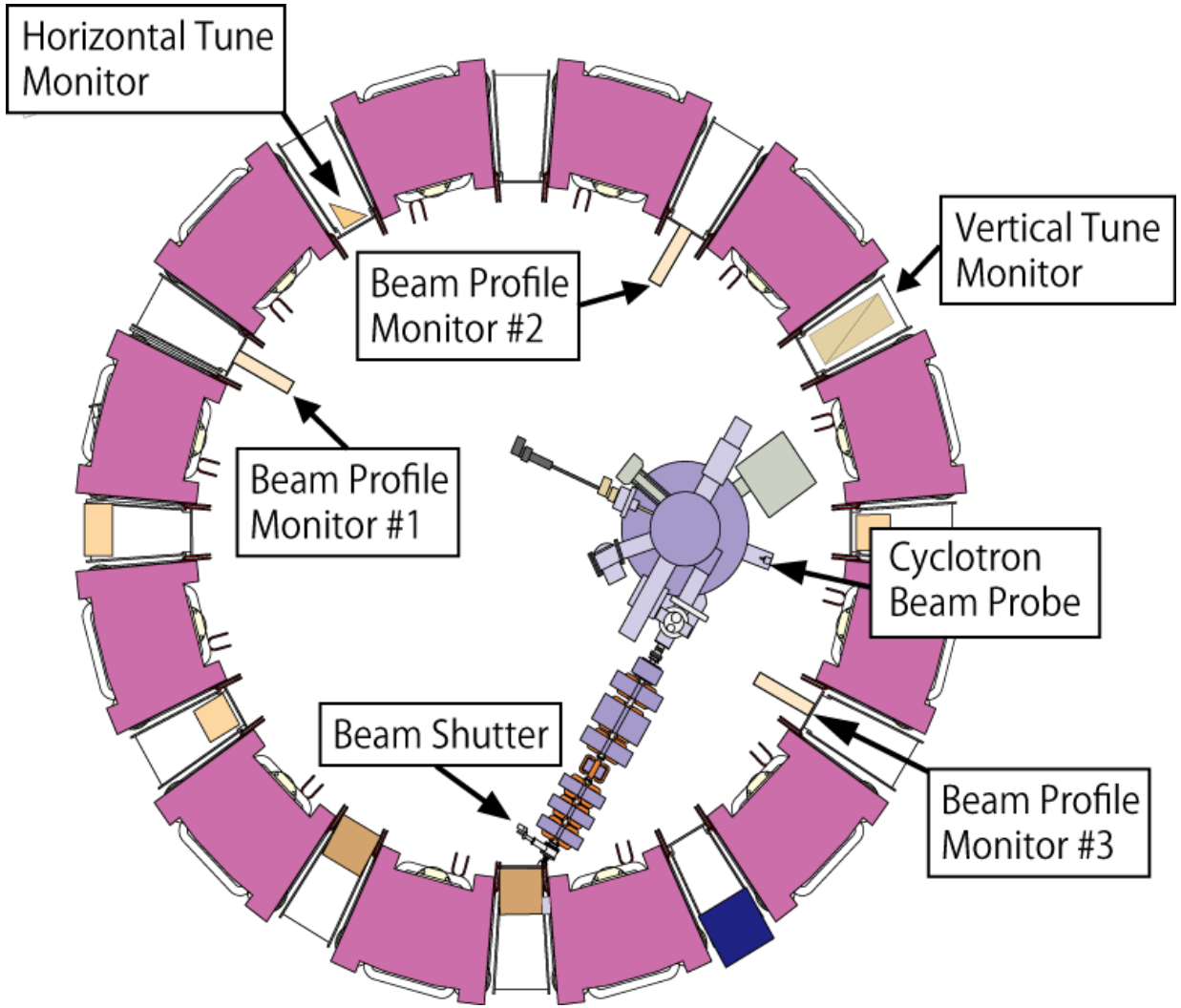
1-2. Injector cyclotron

Design parameters of Baby-Cyclotron

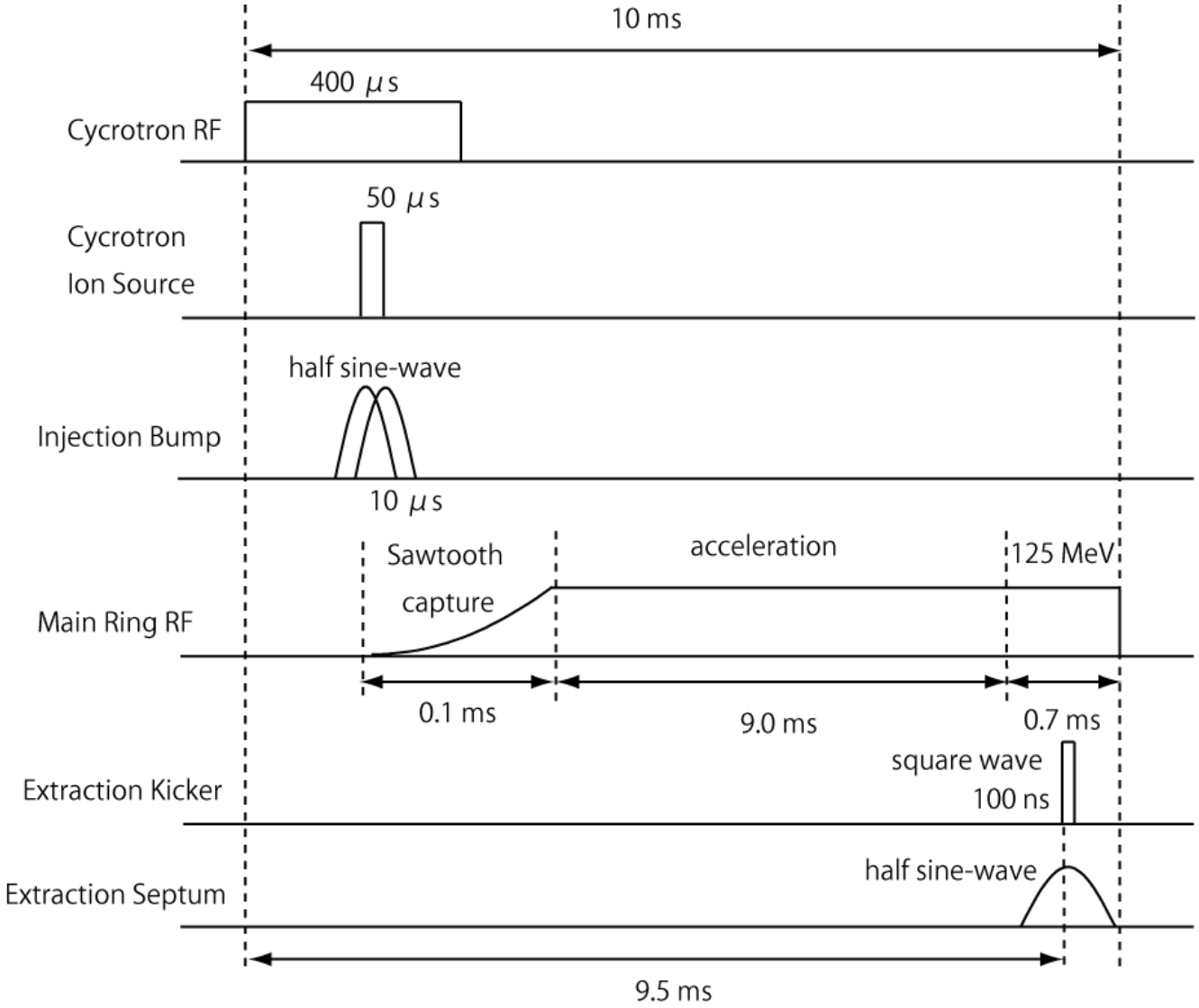
Energy	10 MeV (proton)
Type	AVF Cyclotron
Ion Source	Internal PIG (LaB6 cathode)
RF Dee Voltage	40 kV
Extraction Radius	300 mm
Magnetic field	Max. 1.54 T
RF Frequency	47 MHz (2^{nd} harmonic)
Beam Current	15 μA

JSW Baby-Cyclotron

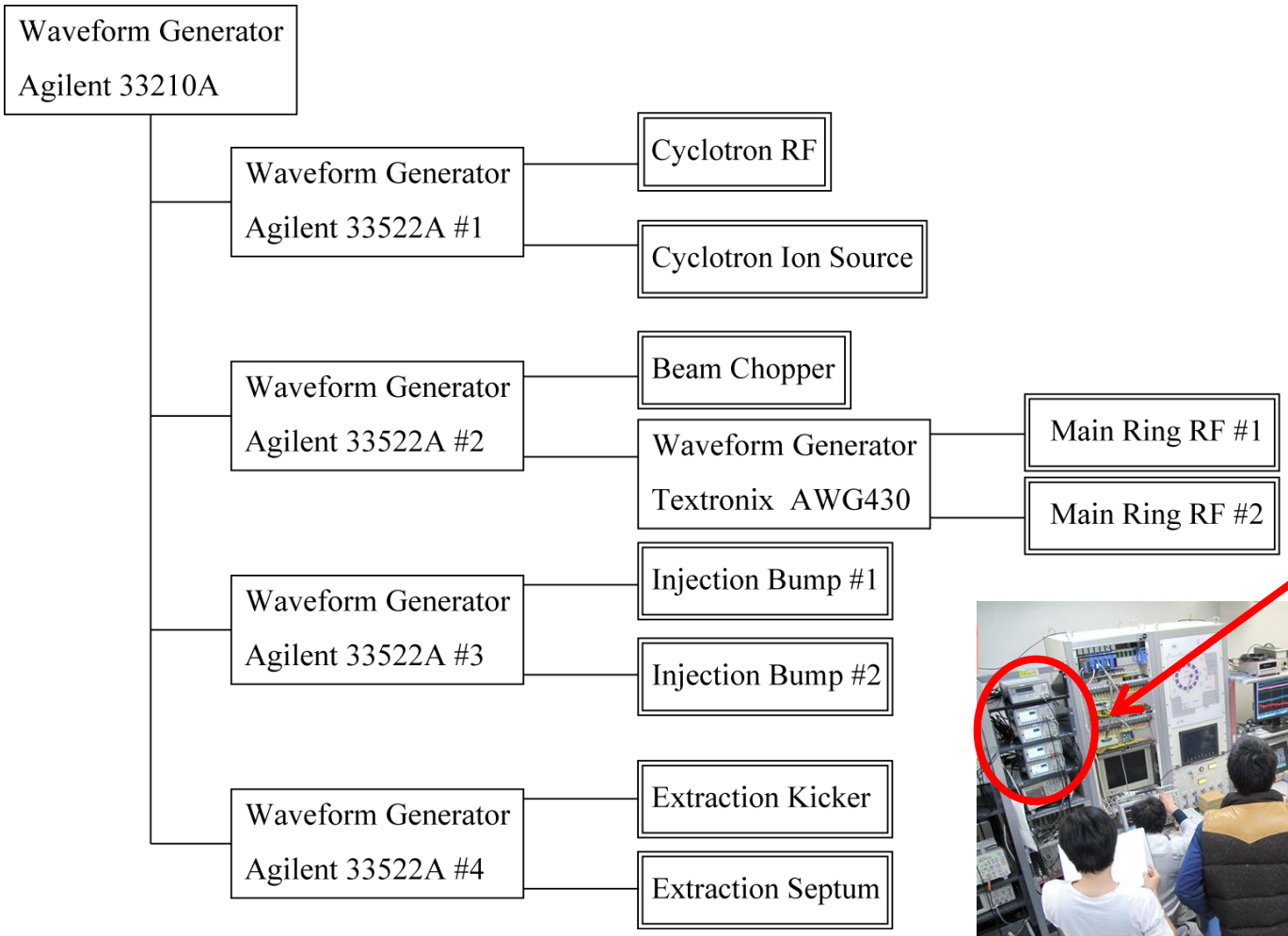
1-3. Layout of beam monitors



1-4. Timing chart



1-5. Block diagram of timing system



Timing system

Control room

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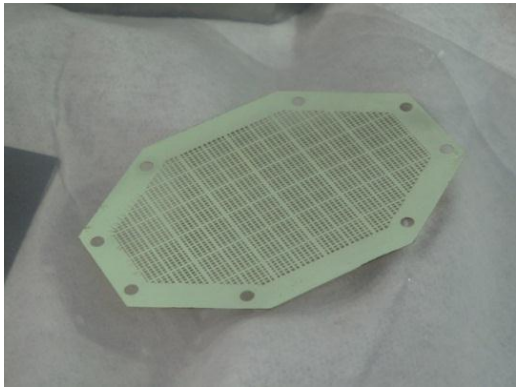
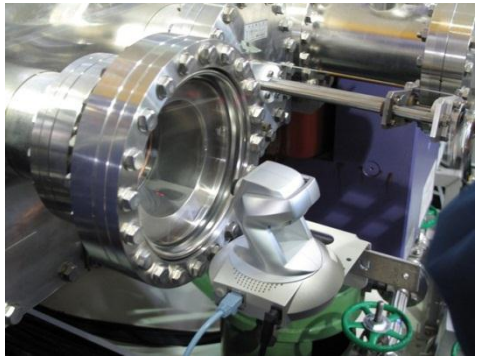
2-1. Beam commissioning log

2011	Oct.	Injector cyclotron (Ion source)
	Nov.	Commissioning of power source of the main ring
	Dec.	Beam injection into the main ring
2012	Jan.	The 1st turn was observed
	Feb.	Circulating beam was observed
	Apr. – Jun.	Maintenance period (Saving electricity and budget)
	Jul. – Aug.	Construction and power test of RF cavity
	Sep.	Beam study of beam injection

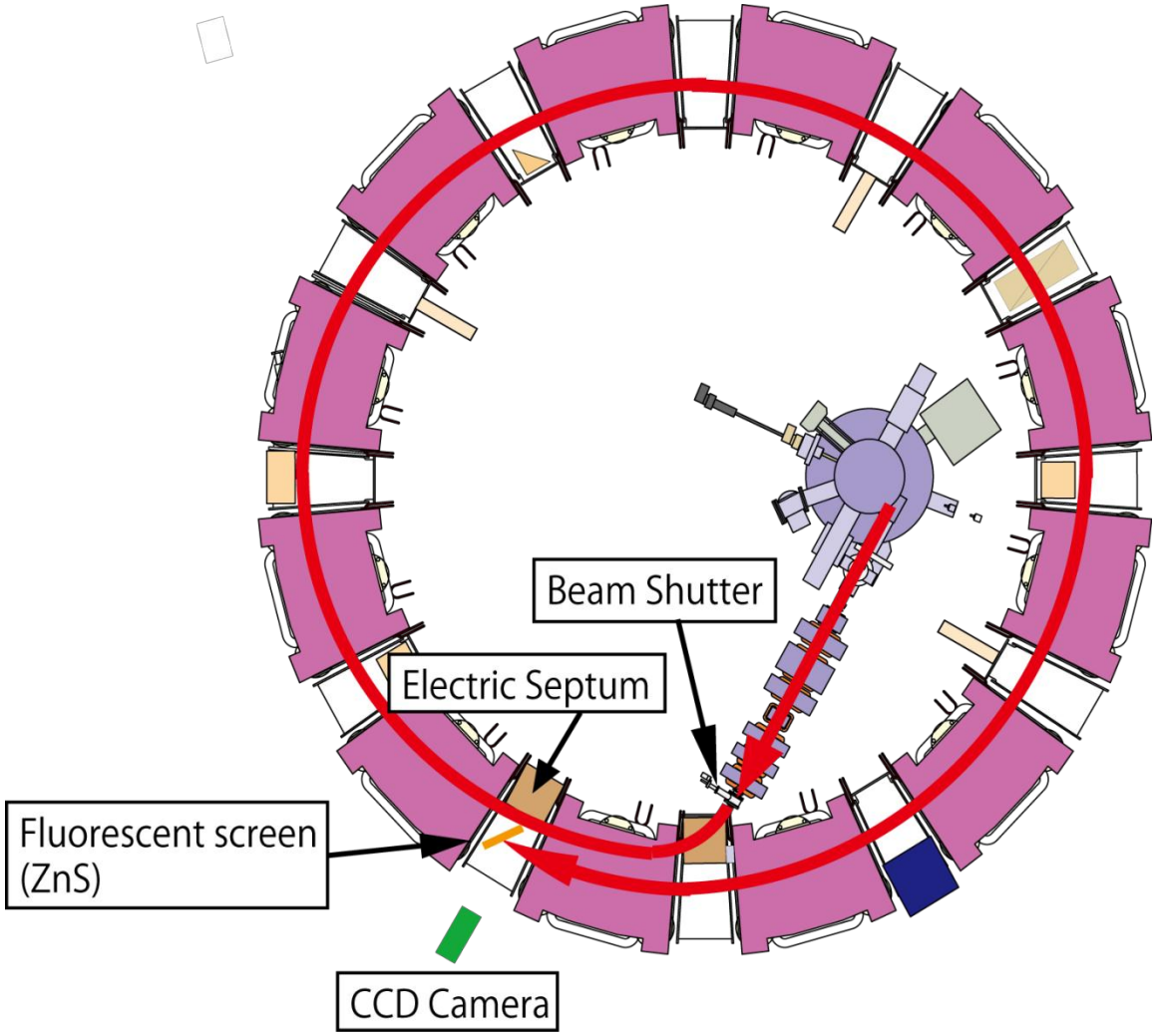
2-2. Beam injection (single-turn injection)



Fluorescent screen
(provided by RCNP)

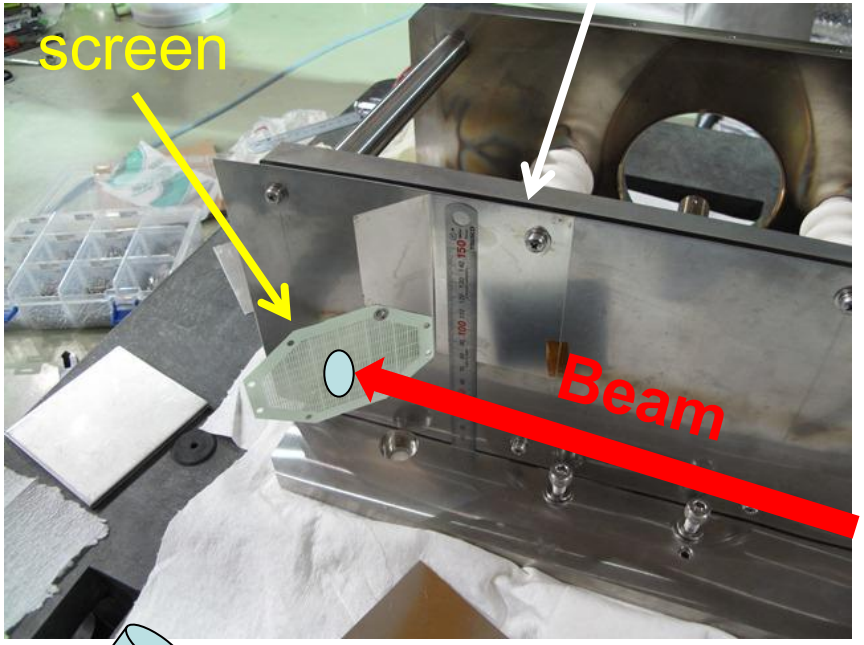


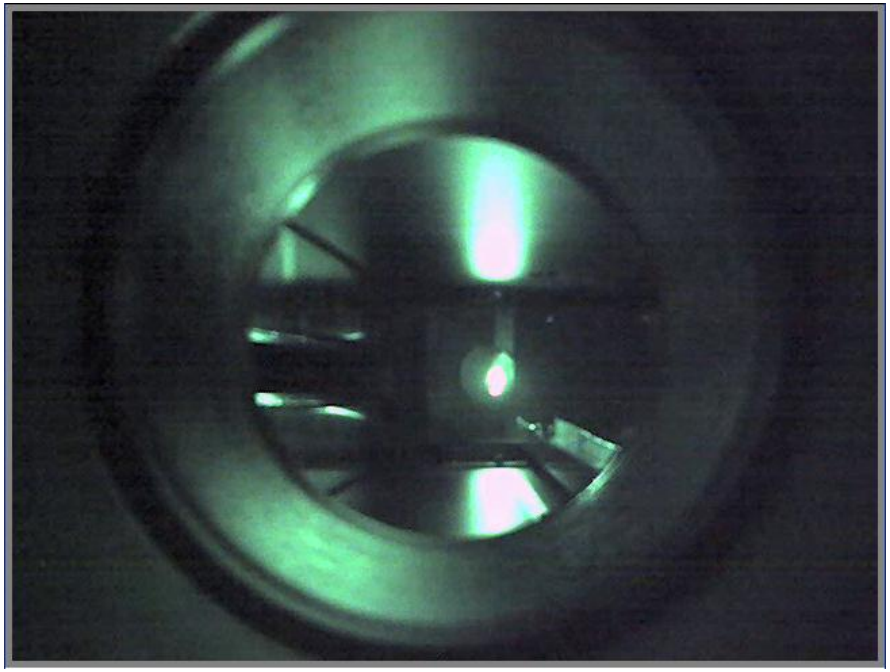
CCD Camera

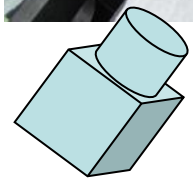


2-2. Beam injection (single-turn injection)

Electric septum

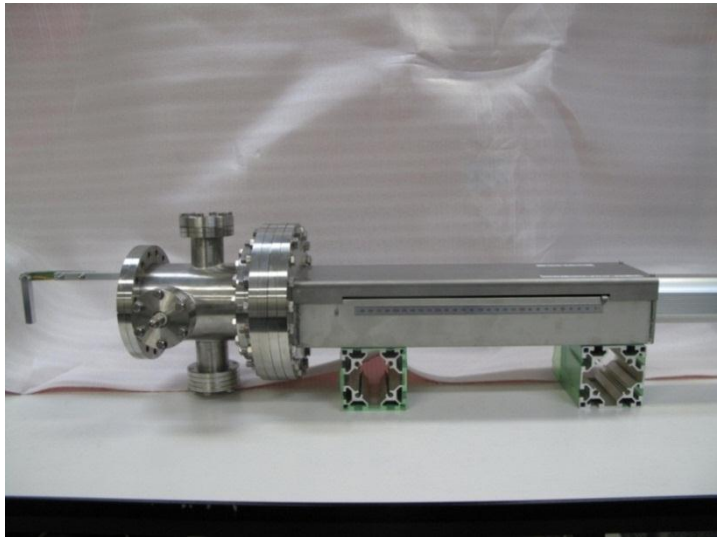


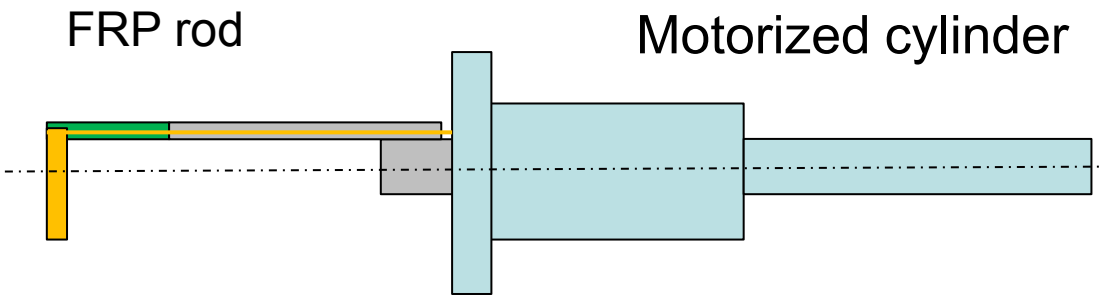




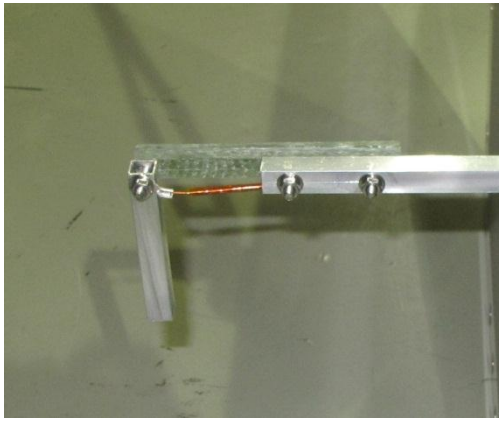
CCD Camera

2-3. Measurements of beam position





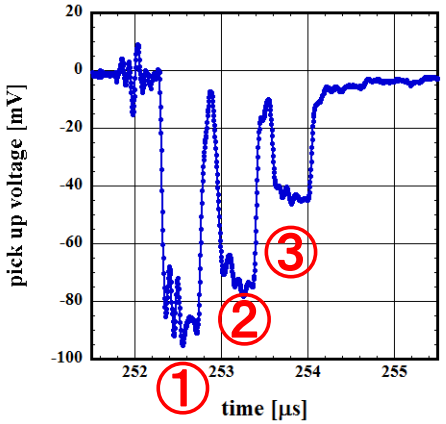
Electrode
(w=10mm)

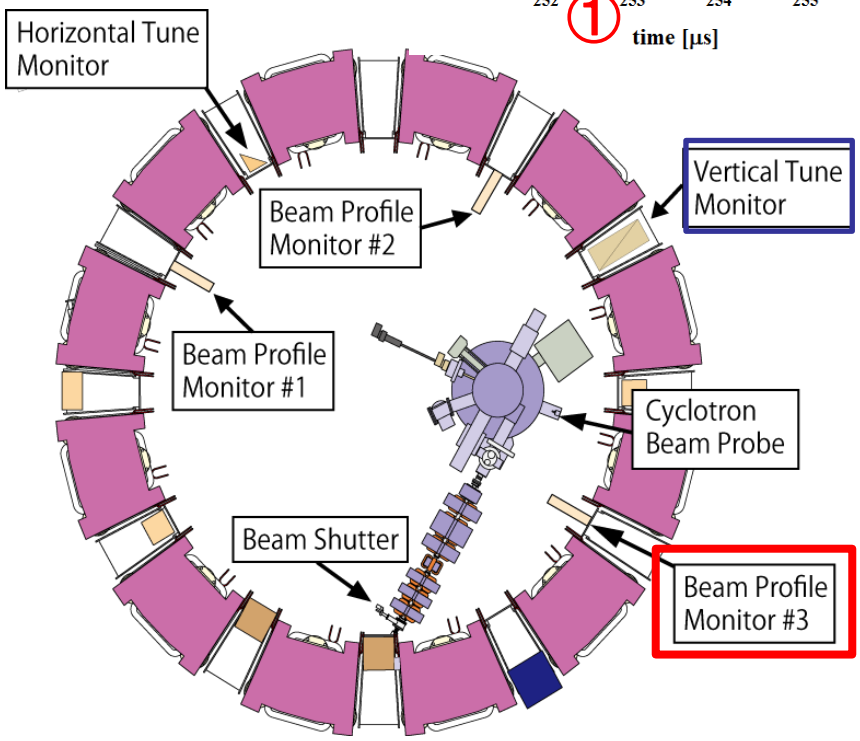


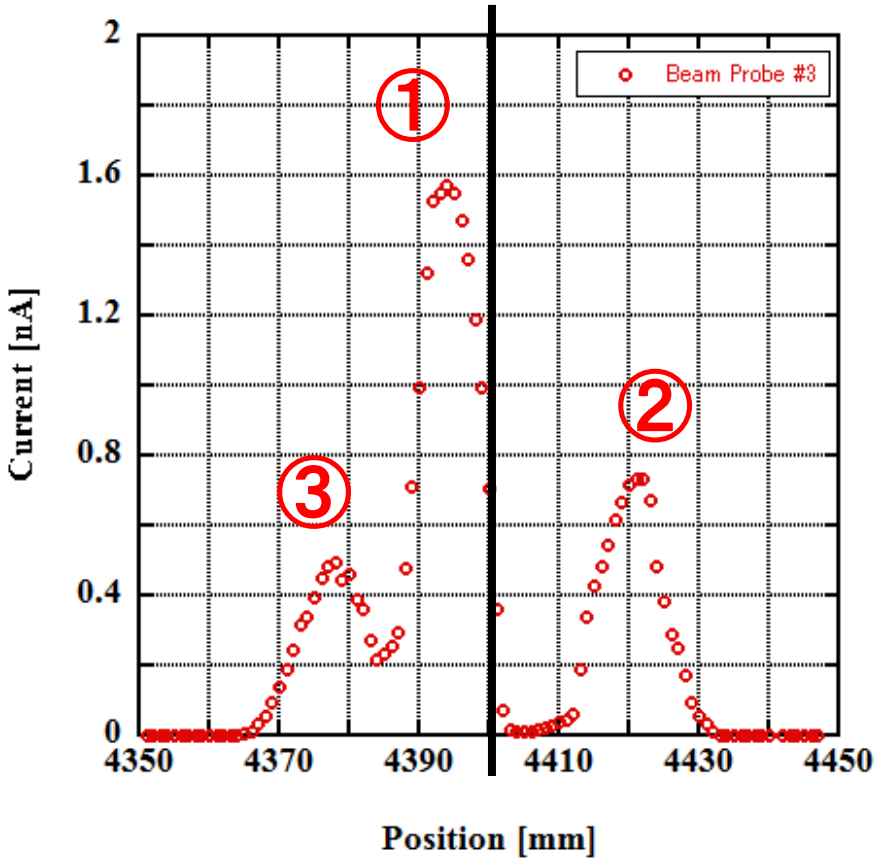
Range of motion: 300 mm
Accuracy: 0.2 mm
Control system: PLC + LabView

2-3. Measurements of beam position

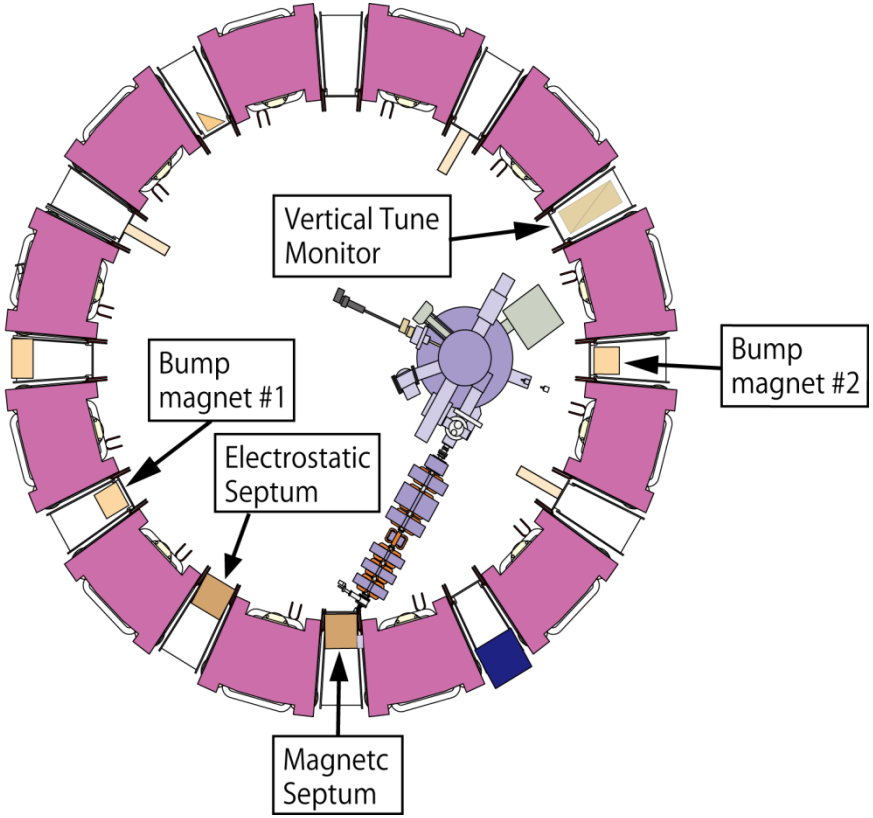
Closed orbit
~ 4400 mm

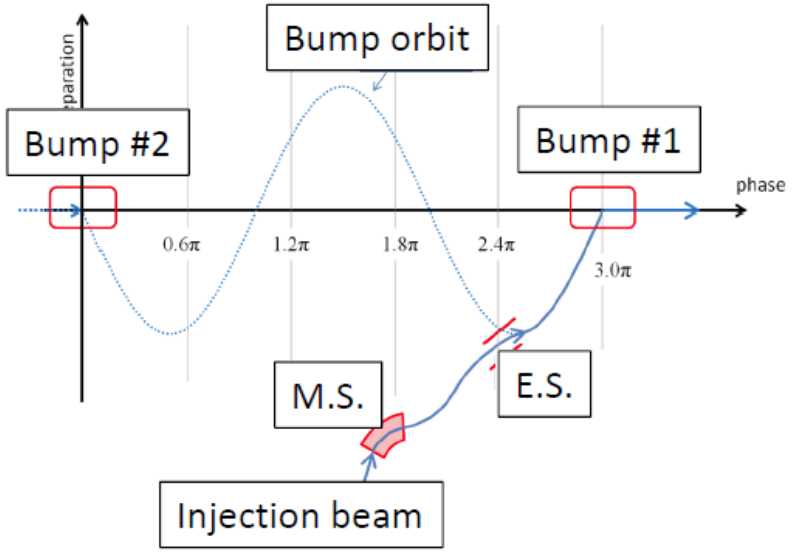


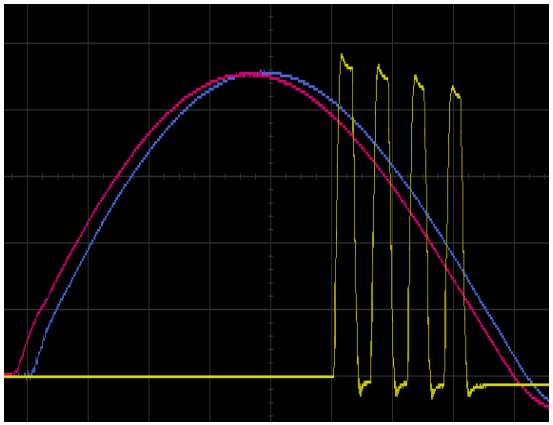




2-4. Beam injection (multi-turn injection)

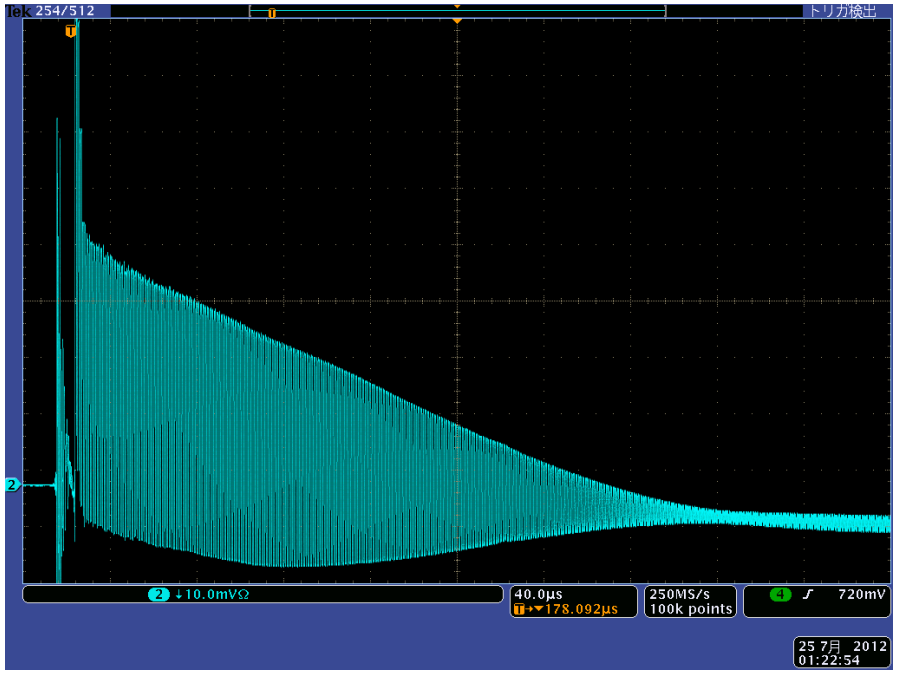






Details will be described in Mr. Kuratomi's presentation.

2-4. Beam Injection (multi-turn injection)

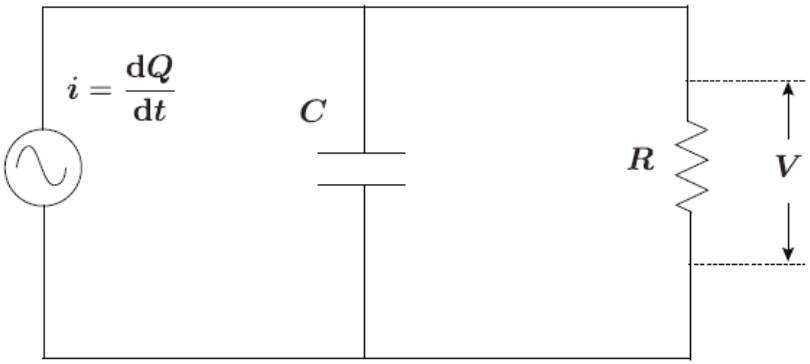


9th February 2012

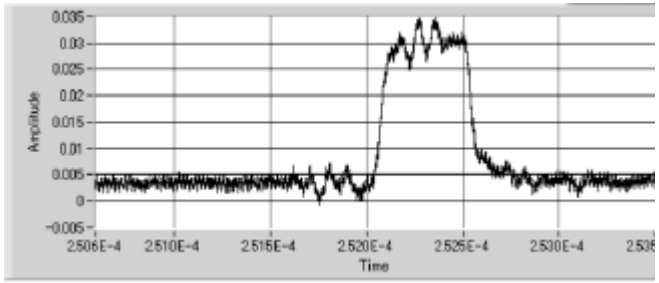
The first circulating beam was observed.

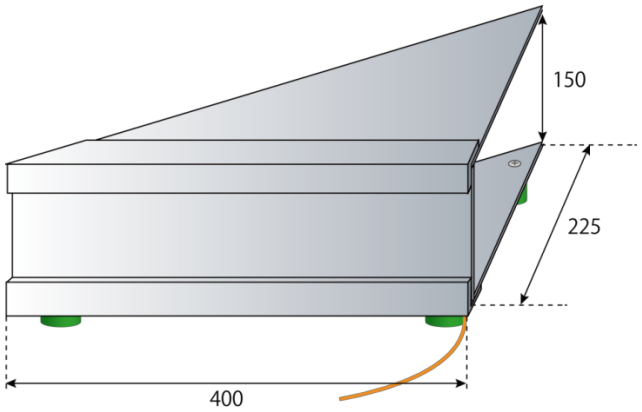
2-5. Tune measurements

Capacitive pickup monitor
R: Resistance 1 MΩ
C: 540 pF (horizontal monitor)
125 pF (Vertical monitor)

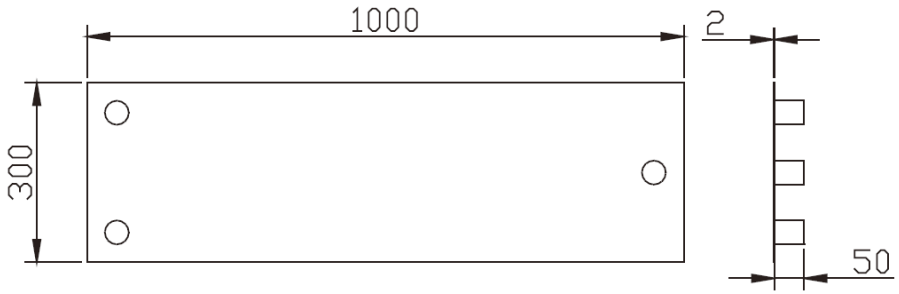


Equivalent circuit



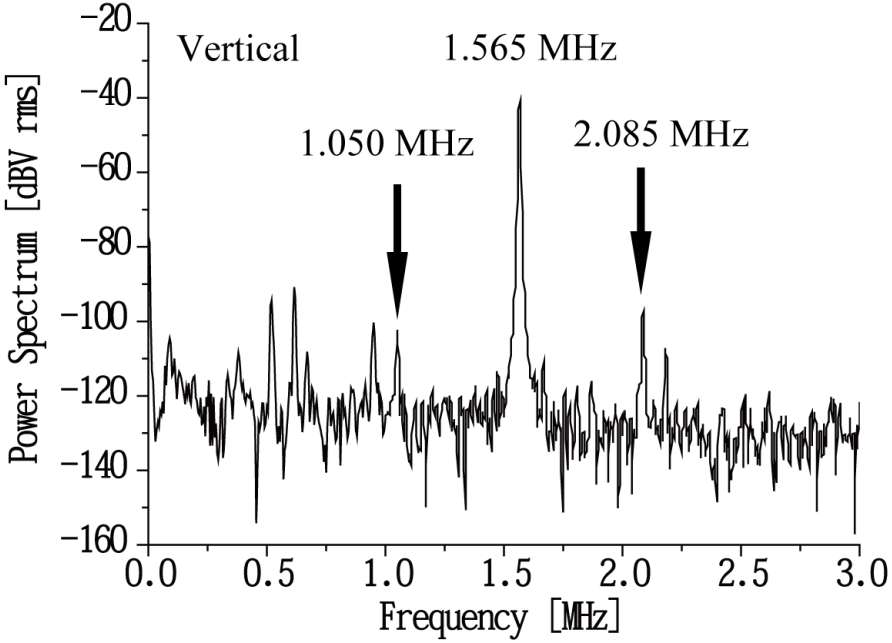


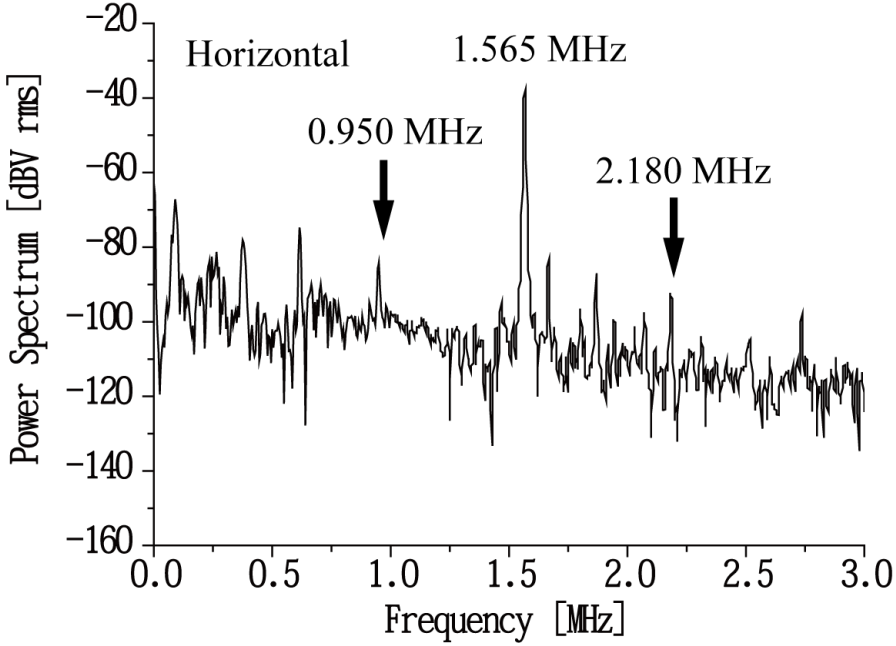
Horizontal tune monitor



Vertical tune monitor

2-5. Tune measurements





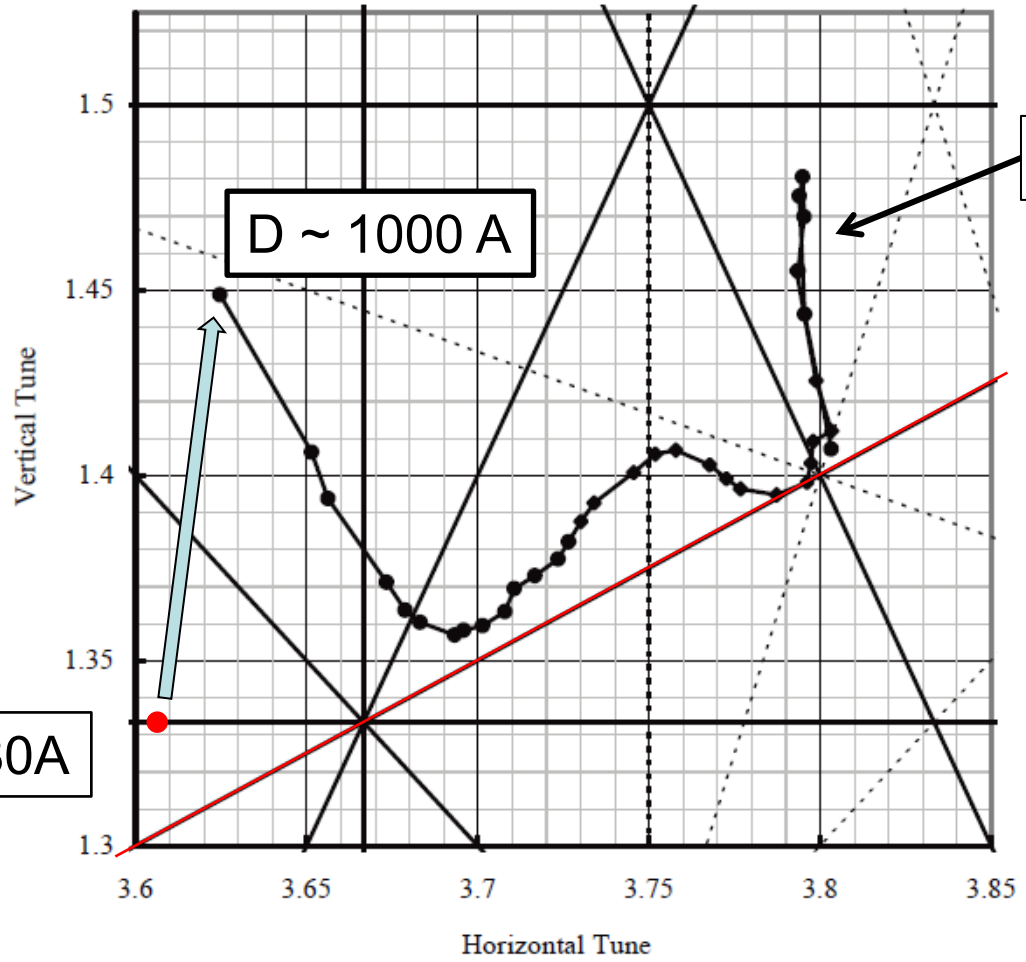
$$c = \frac{|f_{side} - f_{rev}|}{f_{rev}}$$

$f_{rev} = 1.565$ MHz

$\nu_v = 1.331$

$\nu_h = 3.607$

2-5. Tune measurements



D ~ 1000 A

Measured tune at KEK

$v_h - 2v_v = 1$

D = 780A

At KEK

$\frac{\Delta v_v}{\Delta I}$ =5.5 x 10^{-4} [1/A]

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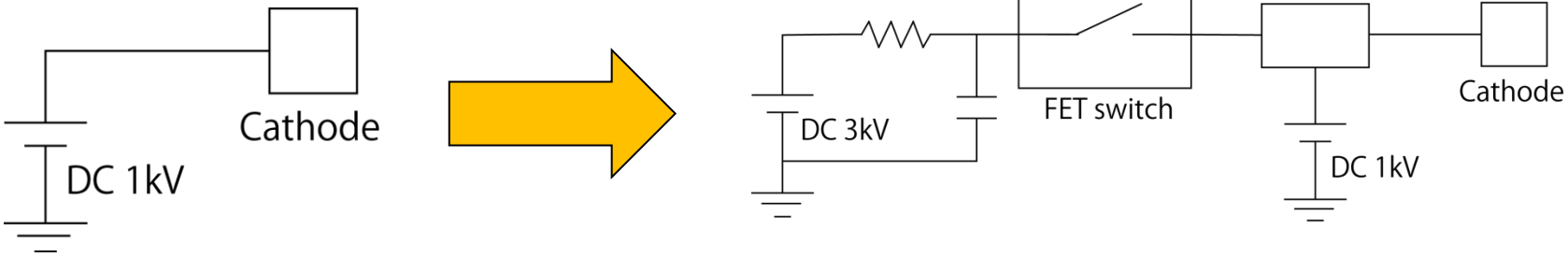
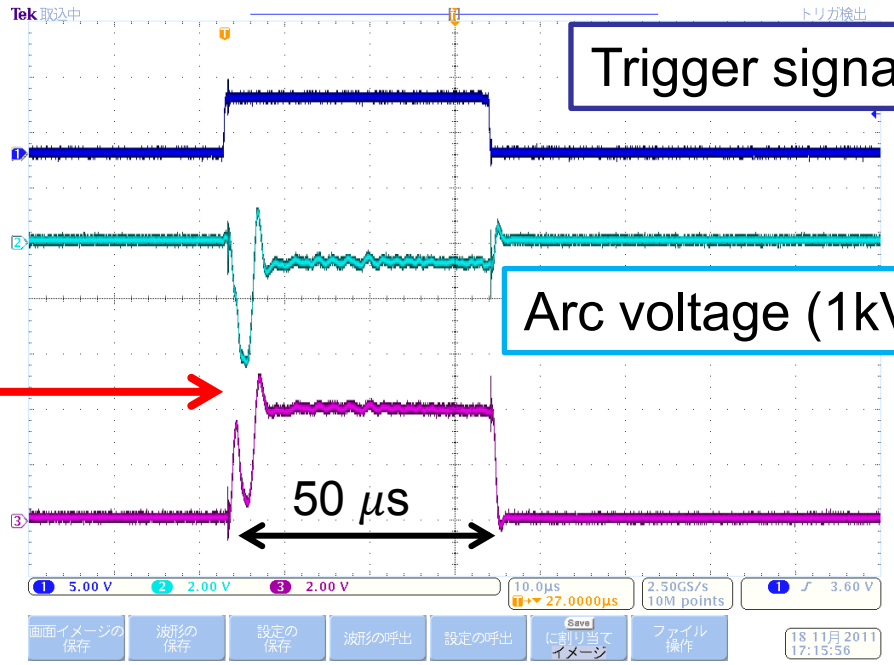
3. Upgrade ion source of the cyclotron





Arc current: 0.5 A -> 20 A

Measured beam signal -> about 3 times larger

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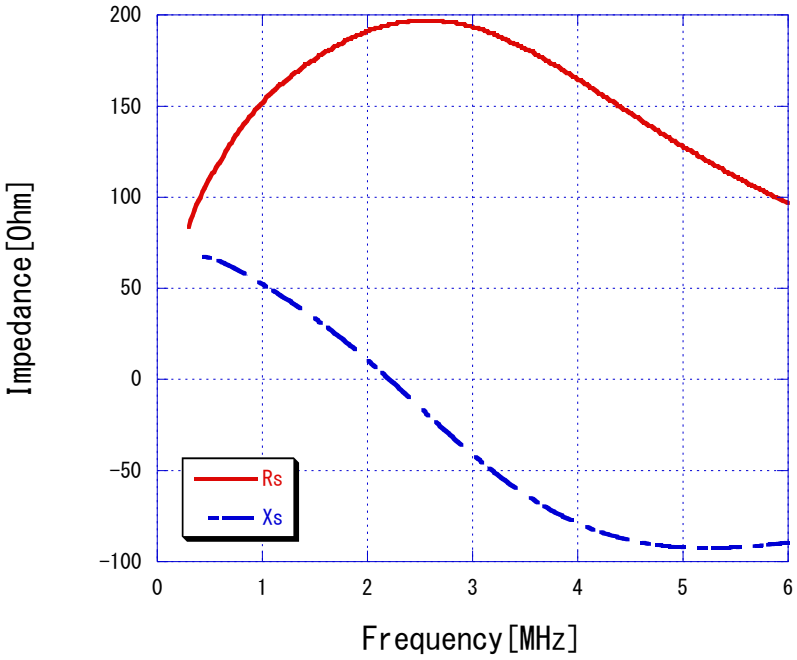
4-1. Power test of RF system

Function Generator → Transistor Power Amplifier → Main RF Amplifier → MA Cavity

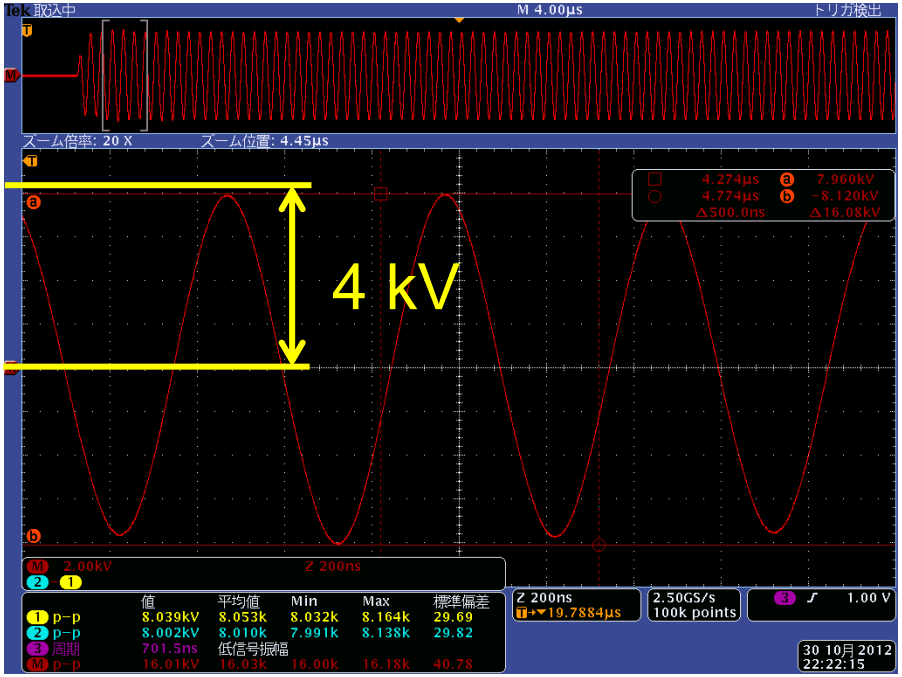
Gap Voltage	4 .0 kV/cavity
RF frequency	1.5 – 4.2 MHz
Power tube	4CW15000E × 2
Class	B class, Push-pull
Core material	FINEMET (FT-3M)
RF output power	200 kW

Details will be described in Mr. Inaoka's presentation.

4-2. Power test of RF system



Impedance of the RF cavity



Measured RF voltage

Output RF voltage: 4.0 kVp.
We are now in preparation for installing the RF cavity

Summary

The beam commissioning of 150 MeV FFAG has gone smoothly.

We are now in preparation for installing the RF cavity. Beam acceleration will be carried out in 2012.

Measurements of beam position