PRISM
status report

Osaka University
Akira SATO

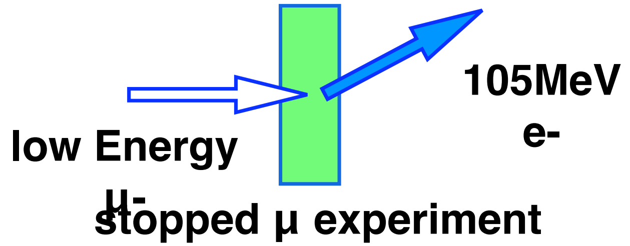
24th Jan. 2006 / ISS2 @ KEK

PRISM

Phase Rotated Intense Slow Muon source

Search for Lepton Flavor violation

$B(\mu\text{-}N \rightarrow e\text{-}N) < 10^{-18}$



High Intensity

intensity : 10^{11}-10^{12} $\mu^{\pm}$/sec

beam repetition : 100-1000Hz

muon kinetic energy : 20 MeV (=68 MeV/c)

high power p beam,

super cond. solenoid pi capture

large acceptance FFAG

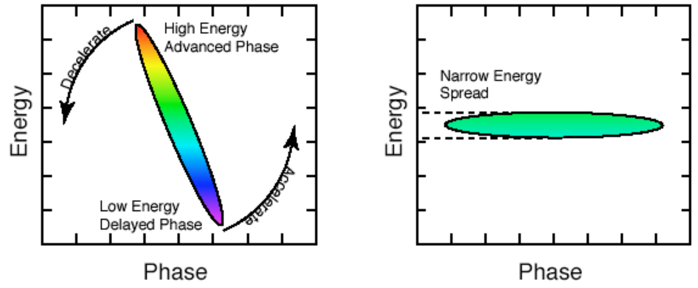
Narrow energy spread

kinetic energy spread : ±0.5-1.0 MeV

Less beam contamination

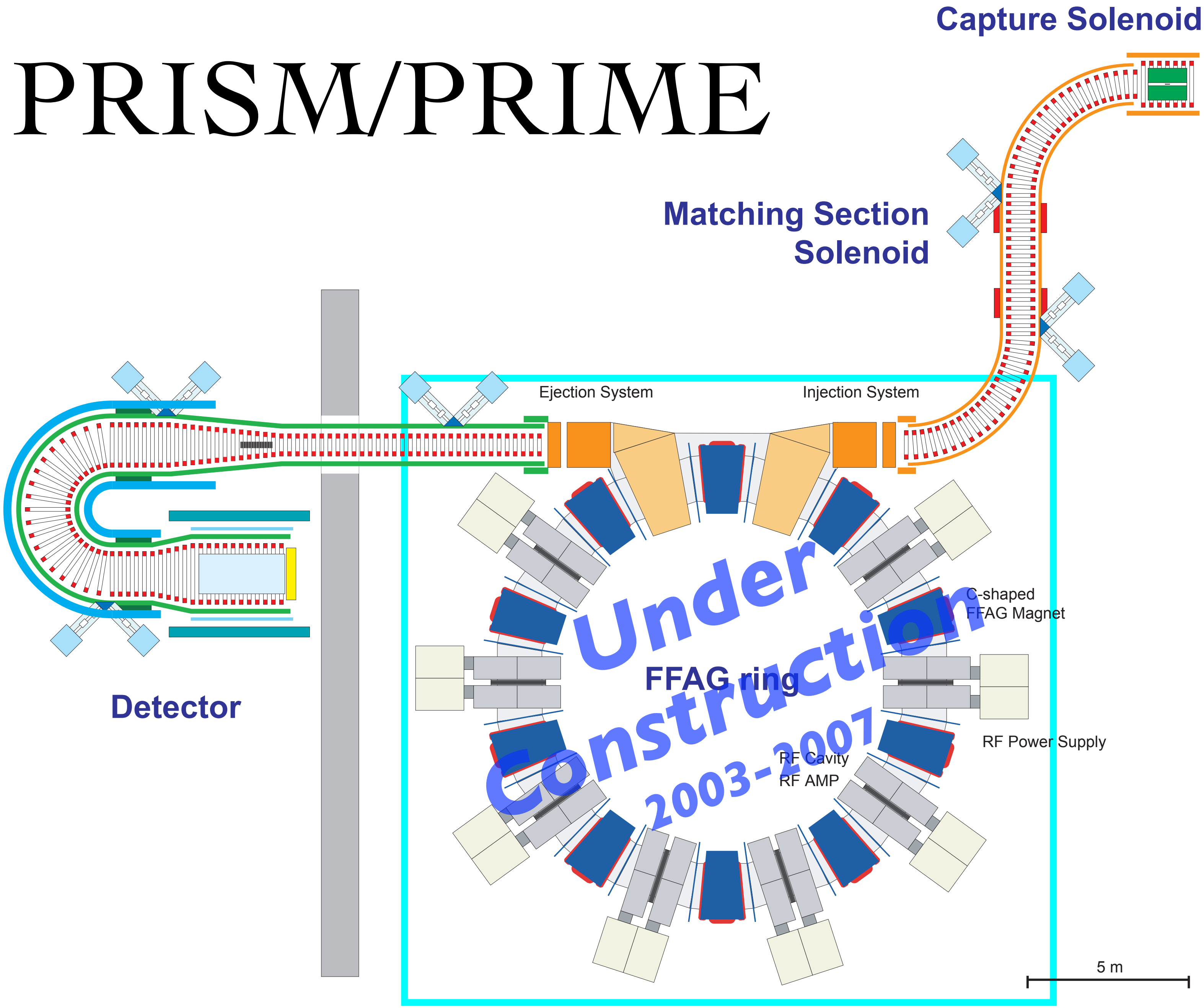
π contamination < 10^{-18}

phase rotation



long flight length in the FFAG

PRISM/PRIME


Capture Solenoid
Matching Section
Solenoid
Ejection System
Injection System
C-shaped
FFAG Magnet
FFAG ring
RF Power Supply
RF Cavity
RF AMP
Detector
5 m
Under
Construction
2003-2007

PRISM-FFAG Features

- Radial sector type, Scaling FFAG
- **Large transverse acceptance**
  - Horizontal : 38,000 π mm mrad
  - Vertical : 5,700 π mm mrad
- **High field gradient RF system**
  - field gradient ~200kV/m (~2MV/turn)
    - quick **phase rotation** (~1.5μs)
    - large mom. acceptance (68MeV/c +- 20%)

Contents

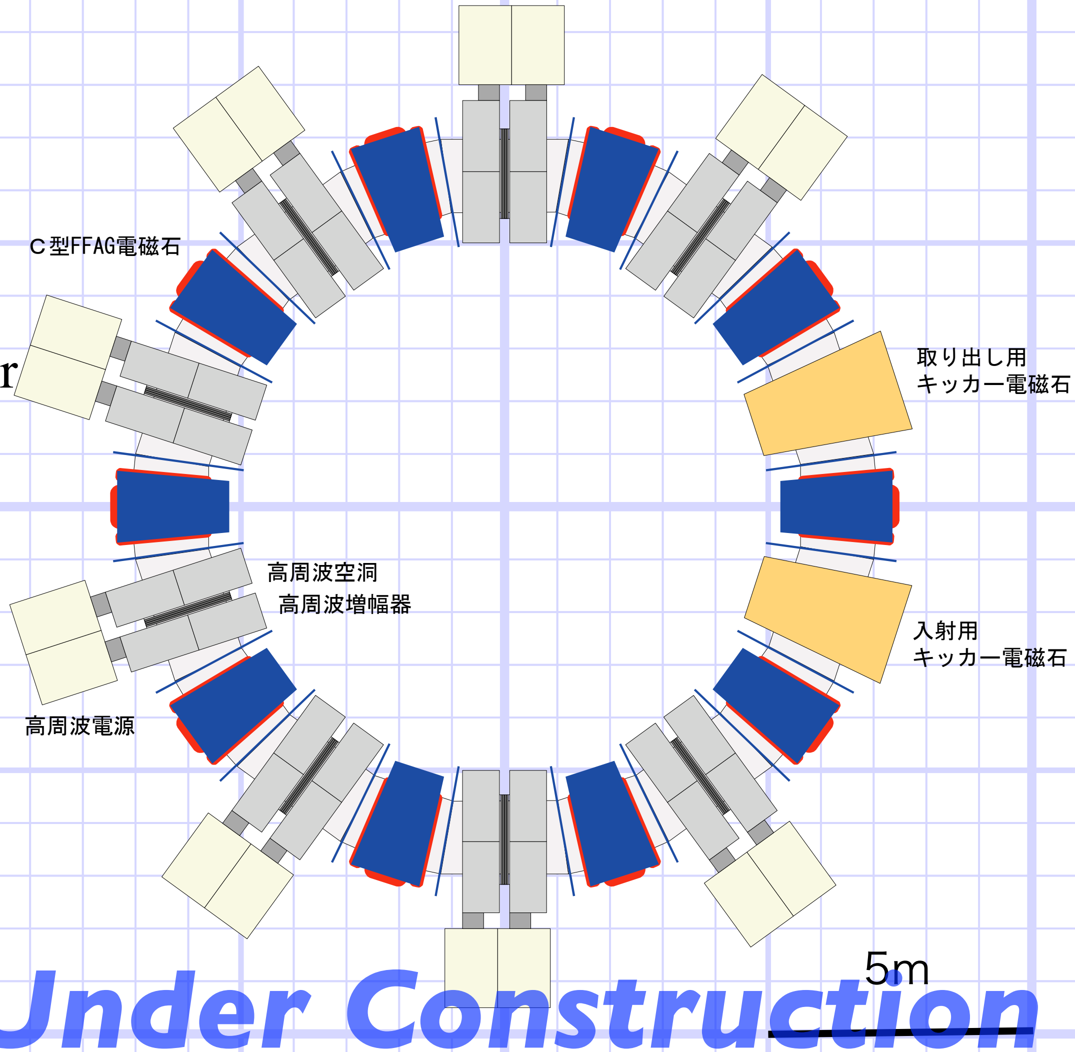
- PRISM-FFAG
  - Lattice
  - Magnets
  - RF system
- Injection/Extraction
  - Vertical scheme
  - Kicker design

PRISM-FFAG

PRISM-FFAG

Phase Rotator

- N=10
- k=4.6
- F/D(BL)=6.2
- r0=6.5m for 68MeV/c
- half gap = 17cm
- mag. size 110cm @ F center
- Radial sector DFD Triplet
  - $\theta_F/2$=2.2deg
  - θ_D=1.1deg
- Max. field
  - F : 0.4T
  - D : 0.065T
- tune
  - h : 2.73
  - v : 1.58



Under Construction

2003-2007

Construction Schedule

- Beam optics design : done
- RF R&D : done
- Magnet design : done
- **2005/12 - 2006/03 : Construction of 3 magnets**
  - 2006/03 - 2006/04 : Field measurement in KEK
  - 2006/04 - : Beam dynamics study
- 2006/04 - 2006/11 : Construction of 7 magnets
- 2006/12 - : Construction of FFAG-ring
- 2007 : Commissioning and performance test

Feature of PRISM-FFAG Magnet

scaling radial sector (C-shaped)

Conventional type. Have larger circumference ratio.

triplet (DFD)

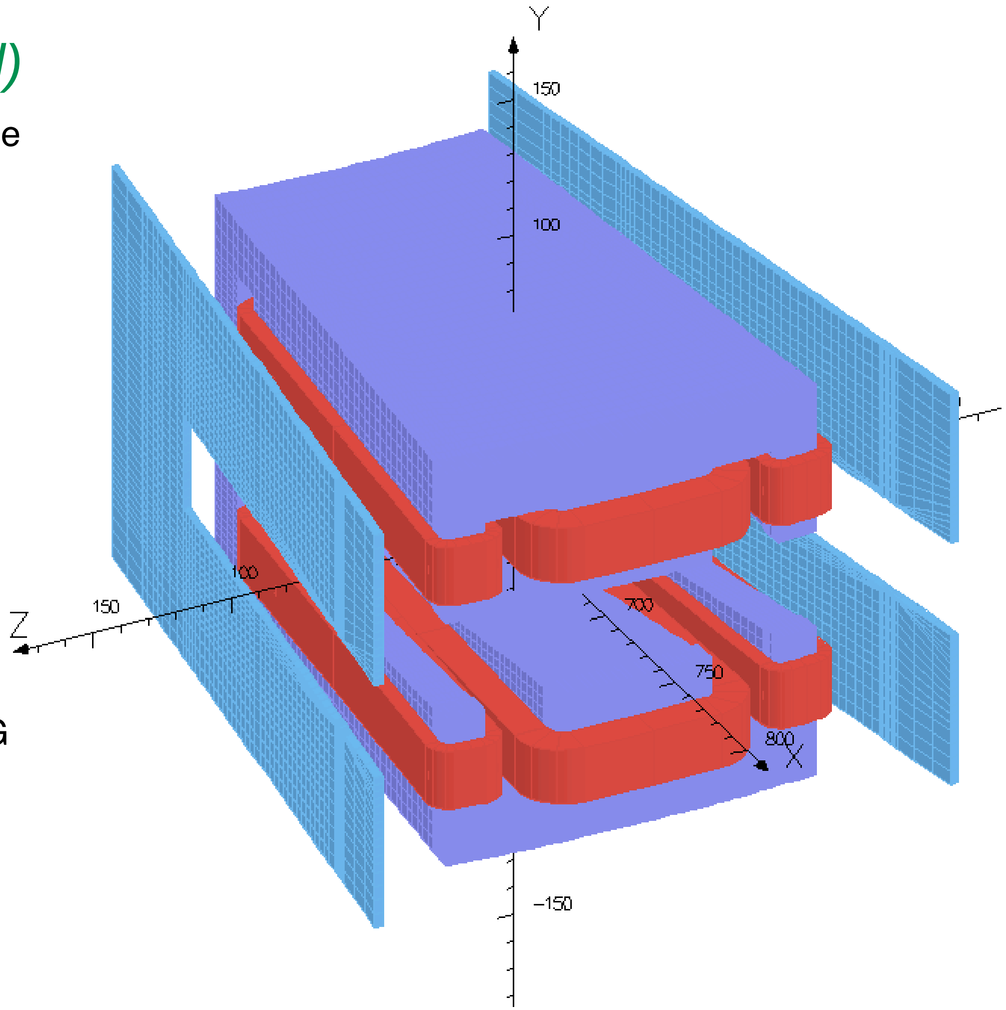
F/D ratio is variable. Ds have field crump effects to realize the large packing factor. the lattice functions has mirror symmetry at the center of a straight section.

large aperture

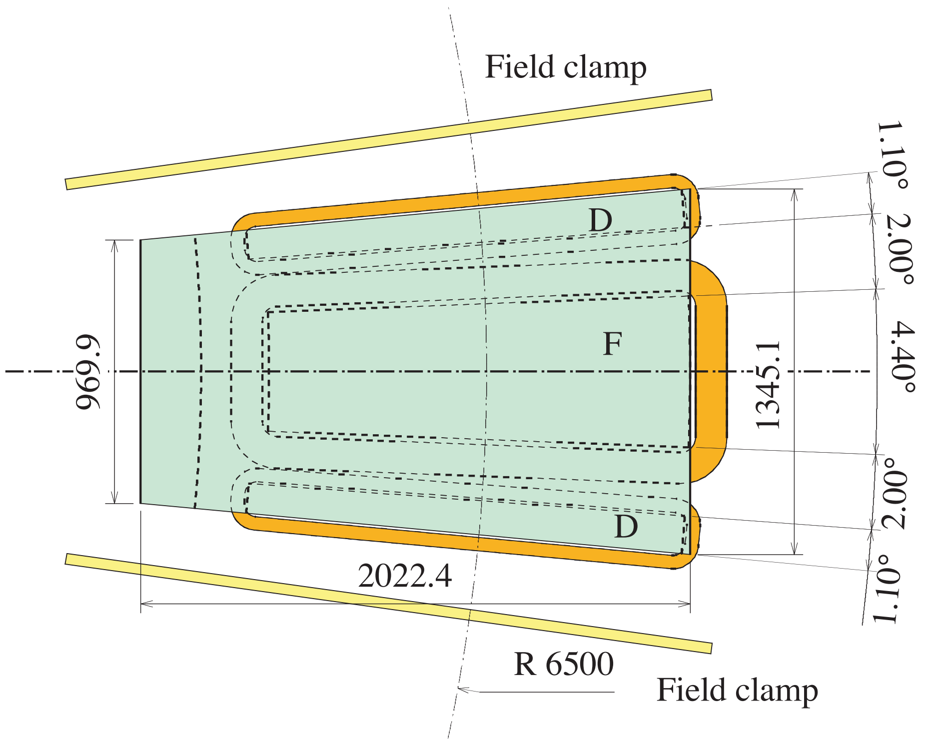
important for achieve a high intensity muon beam.

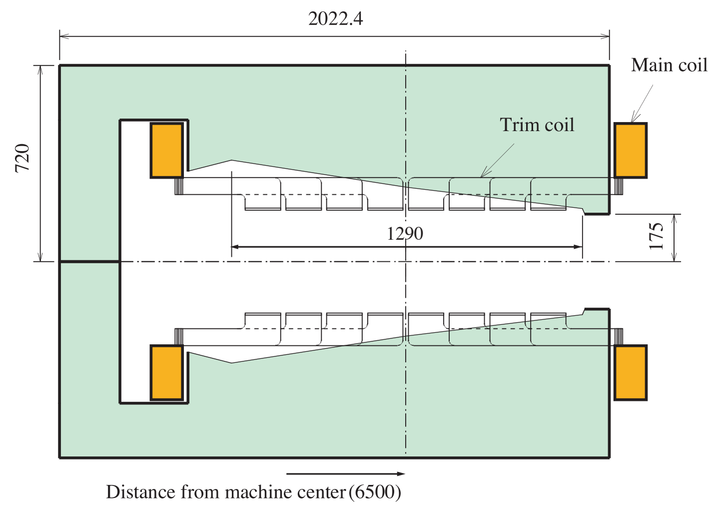
thin

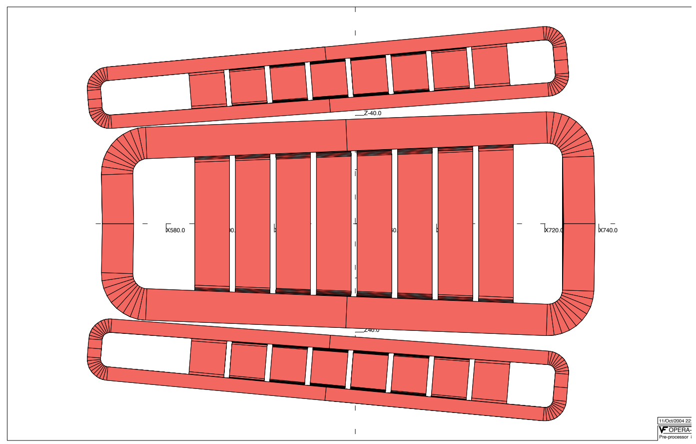
Magnets have small opening angle. so FFAG has long straight sections to install RF cavities as mach as possible



VECTO

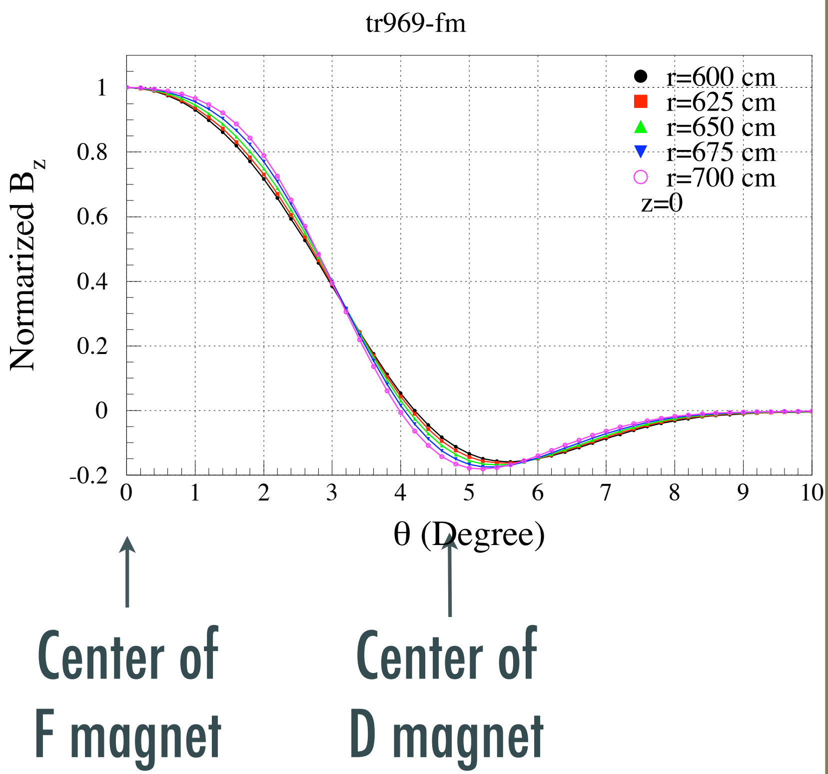


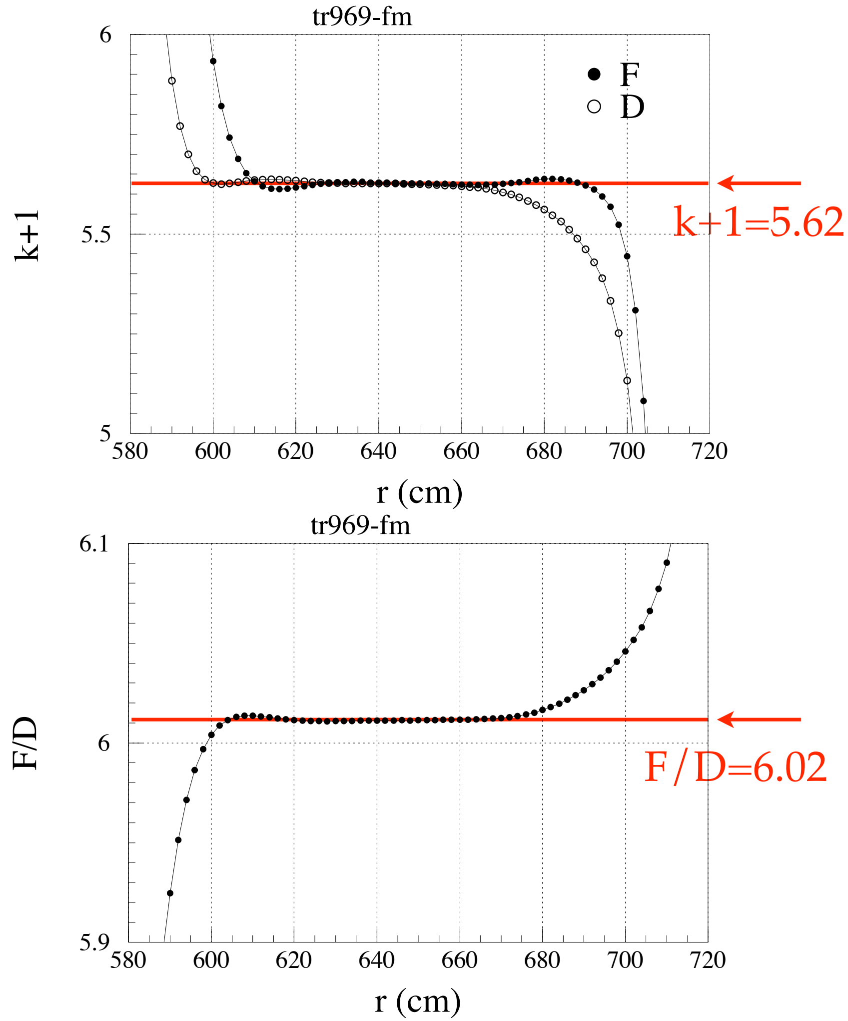




- Total Mass of yoke: 14 t / cell
- F Main coil : 78000 A*T / coil (F/D=4)
- D Main coil : 26000 A*T / coil (F/D=4)
- F trim coil : 1200 A/coil
- D trim coil : 500 A/coil
- Electric Power for F Main coil : 740 kW/Ring
- Electric Power for D Main coil : 441 kW/Ring

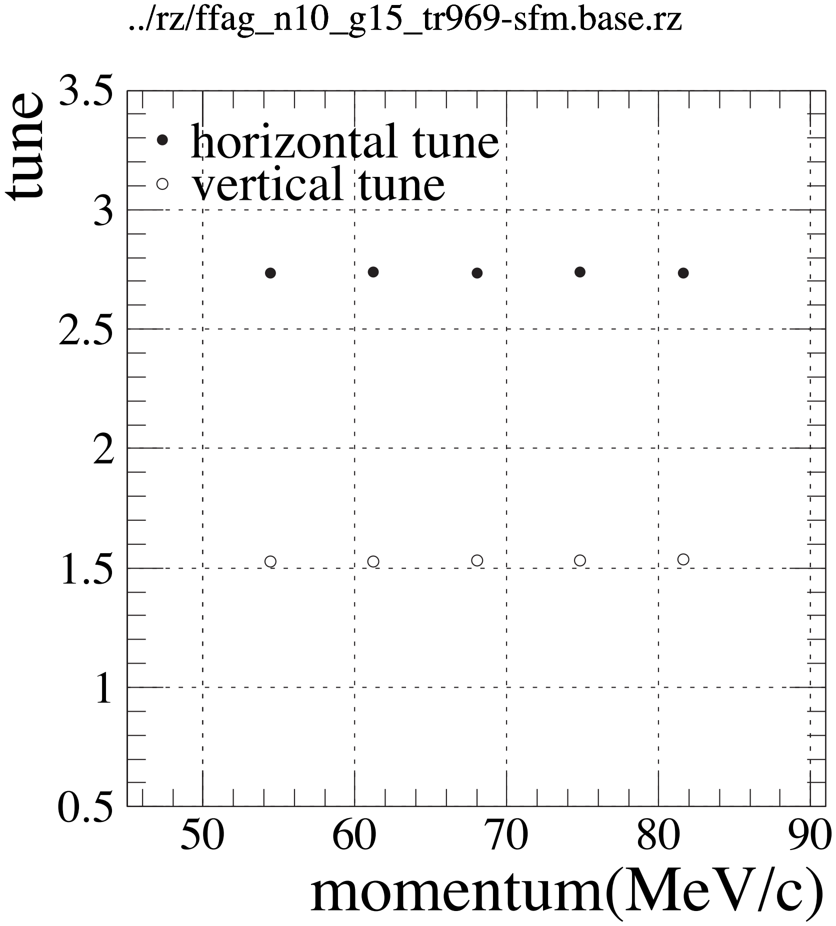
Field Calculation

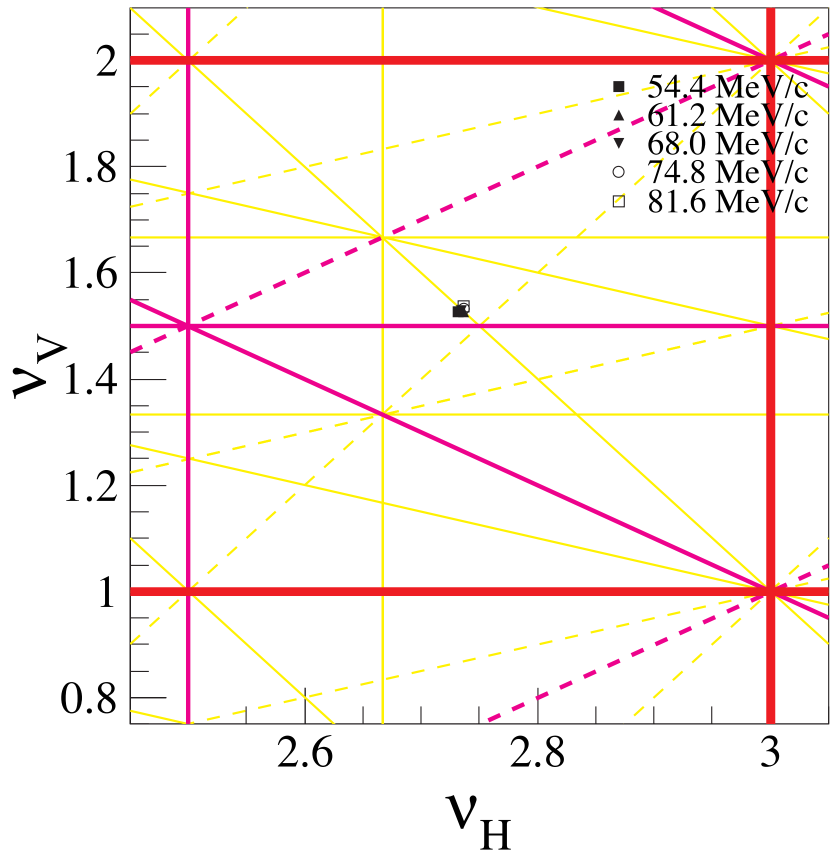




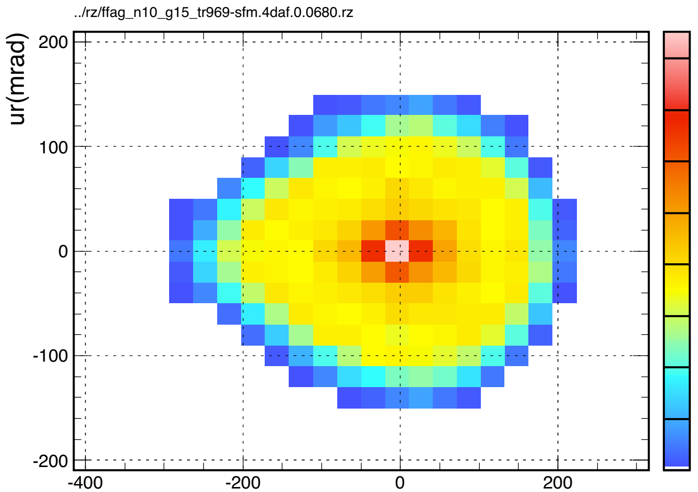
Y. Arimoto

Zero Chromaticity

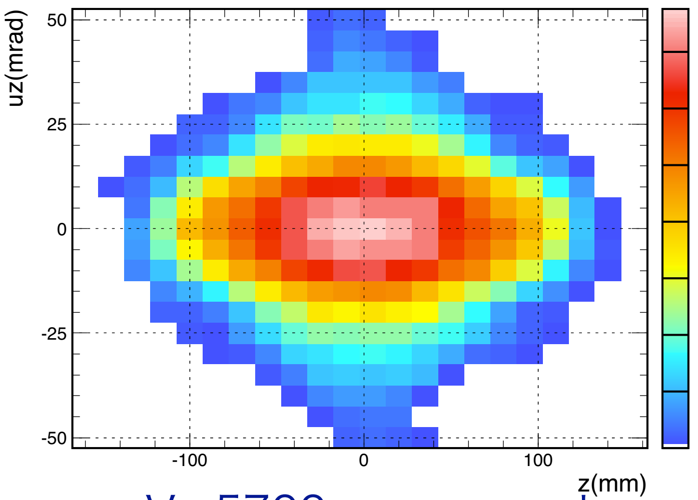




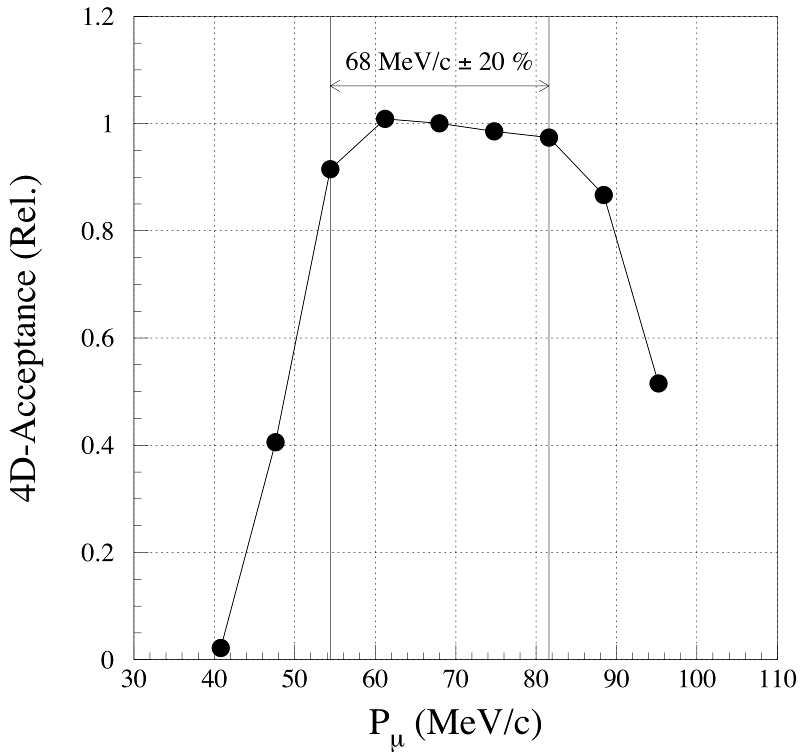
4D Acceptance

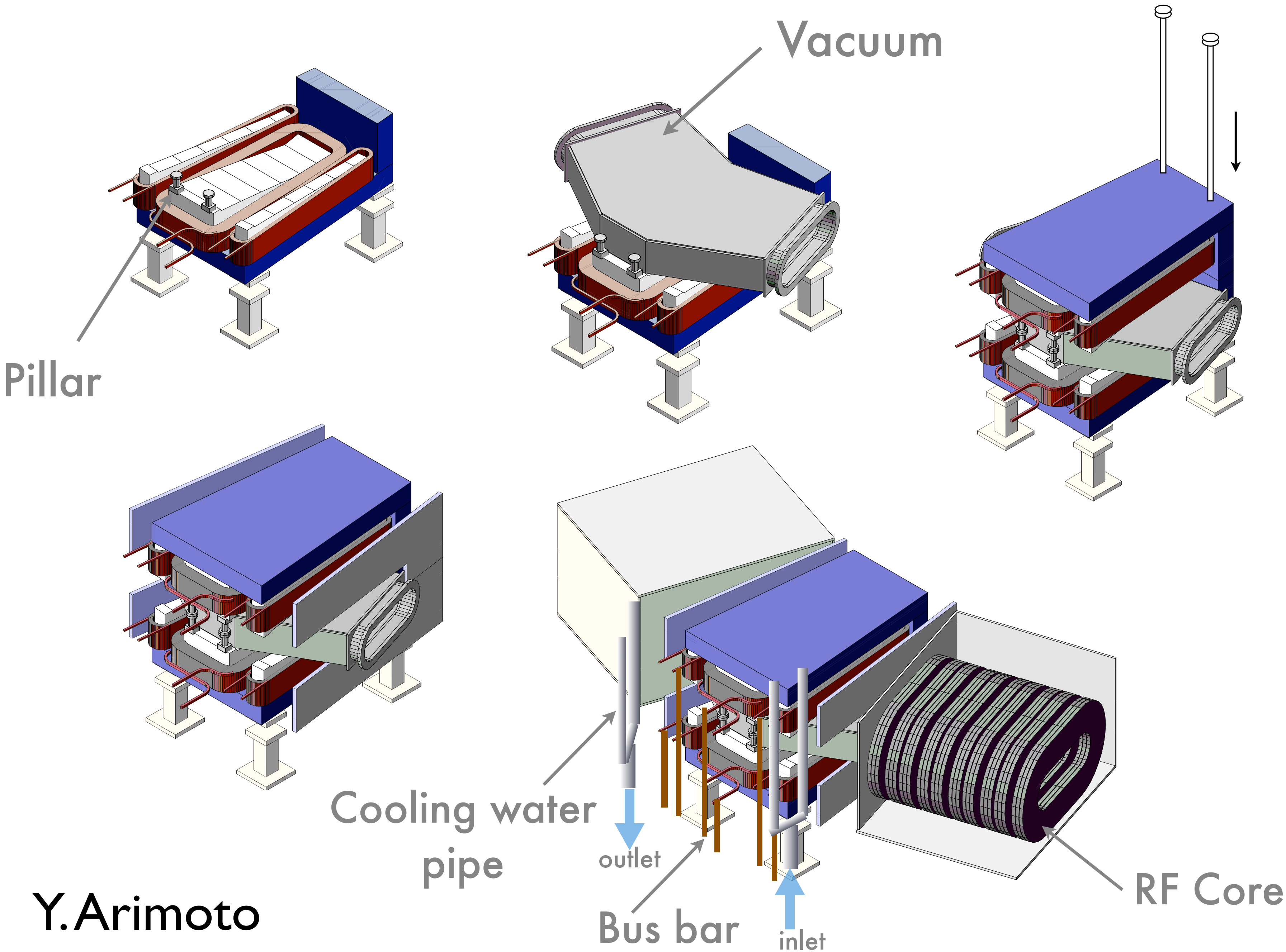


H : 38000π mm mrad



V : 5700π mm mrad





Vacuum
Pillar
Cooling water pipe
outlet
Bus bar
inlet
RF Core

Y.Arimoto

Status of Construction

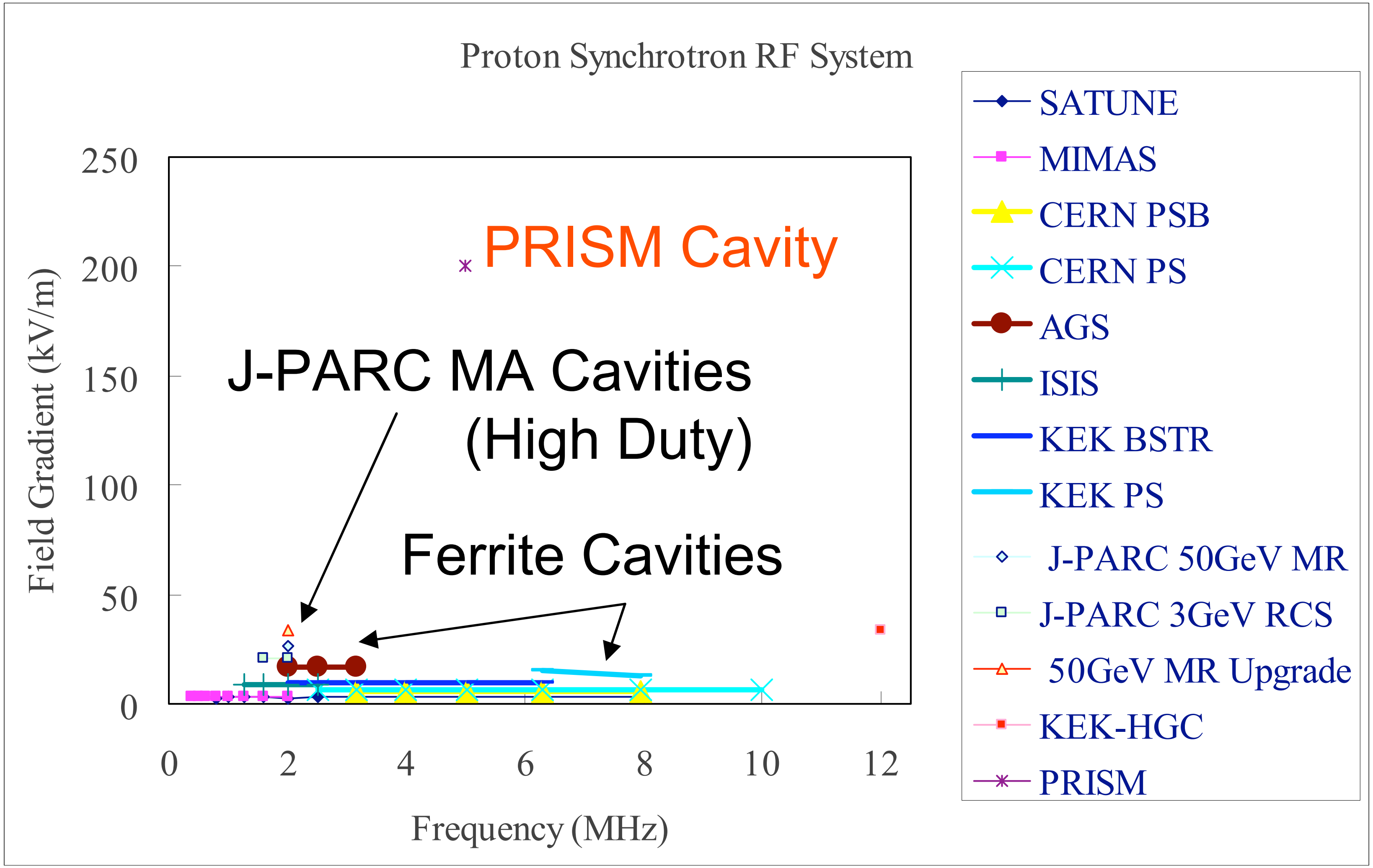
- Main coils have been produced.
- 3 FFAG magnets will be build by Mar. 2006.
- Field measurement in Mar.-Apr. at KEK

D coils

F coils

RF System

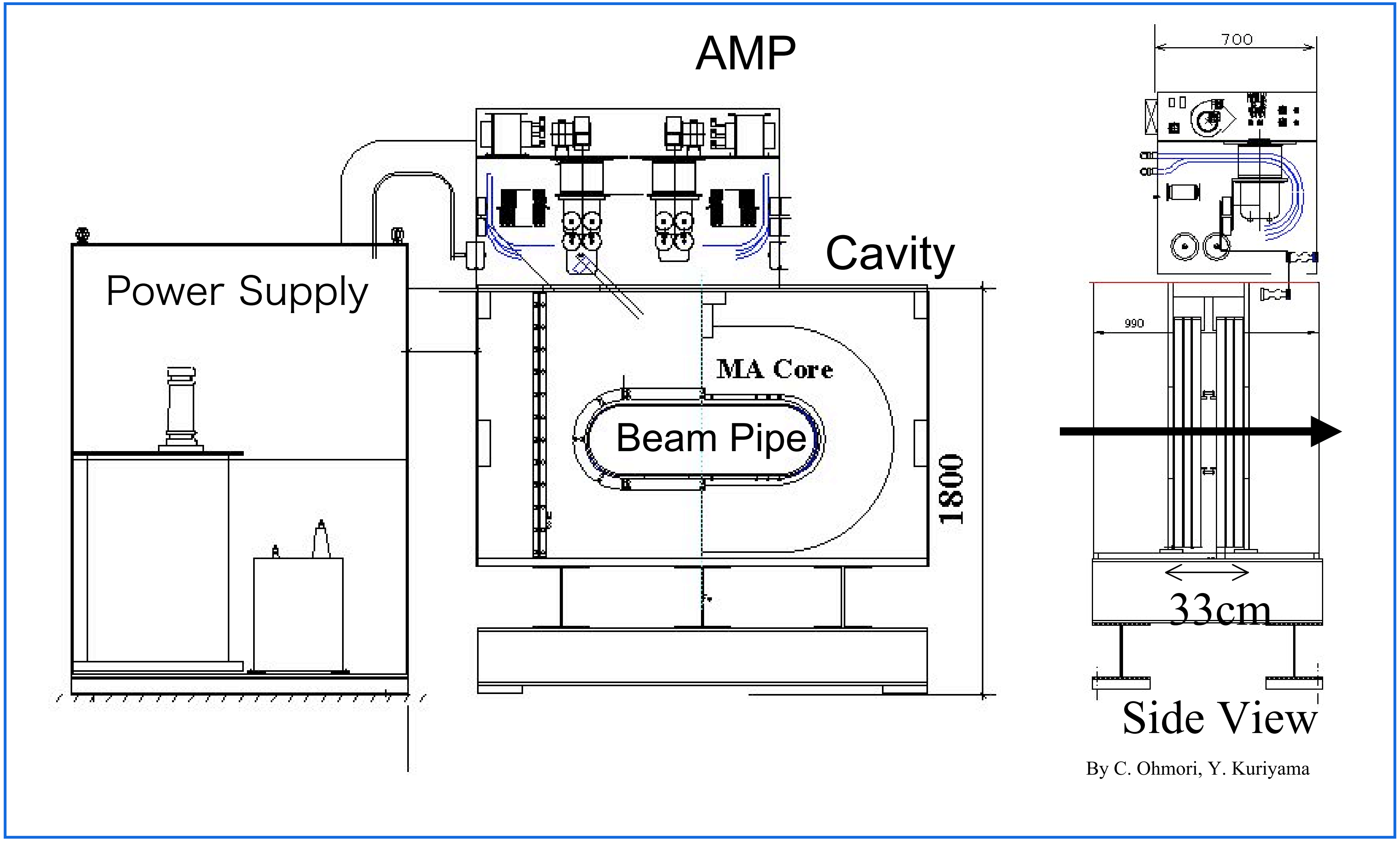
High field gradient RF



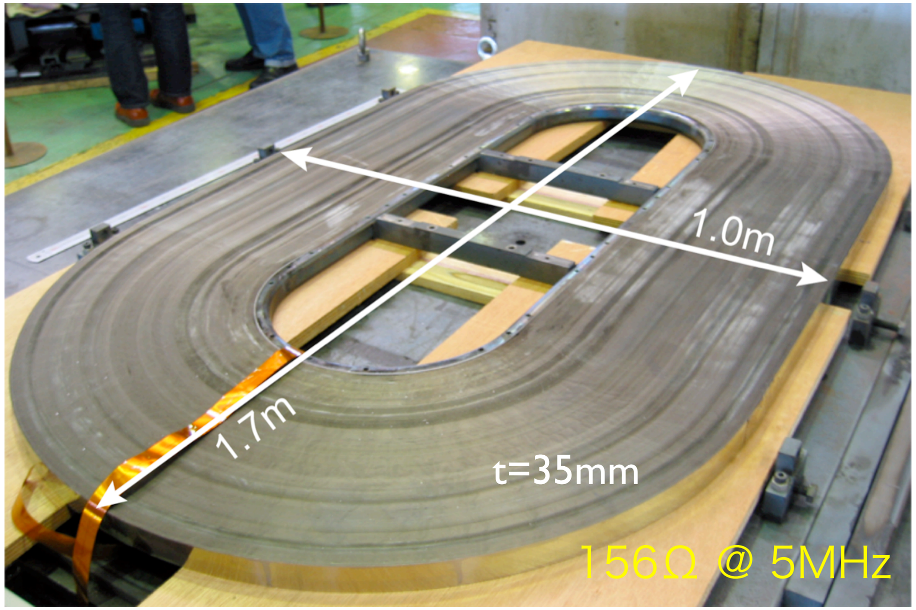
Parameters of RF system

Number of gap per cavity	5
	33cm/gap
Number of core per gap	6
core material	Magnetic Alloy
core shape	race track
core size	1.7m x 1.0m (inner 1.0m x 0.3m)
Shunt impedance	0.9kohm/gap
Field gradient	150~200kV/m
Flux density in core	~320 Gauss
Power tube	4CW100kE, DC33-37kV, 1.5MW (peak for 10us), Max current 60A
	Air cooling (duty 0.1%)

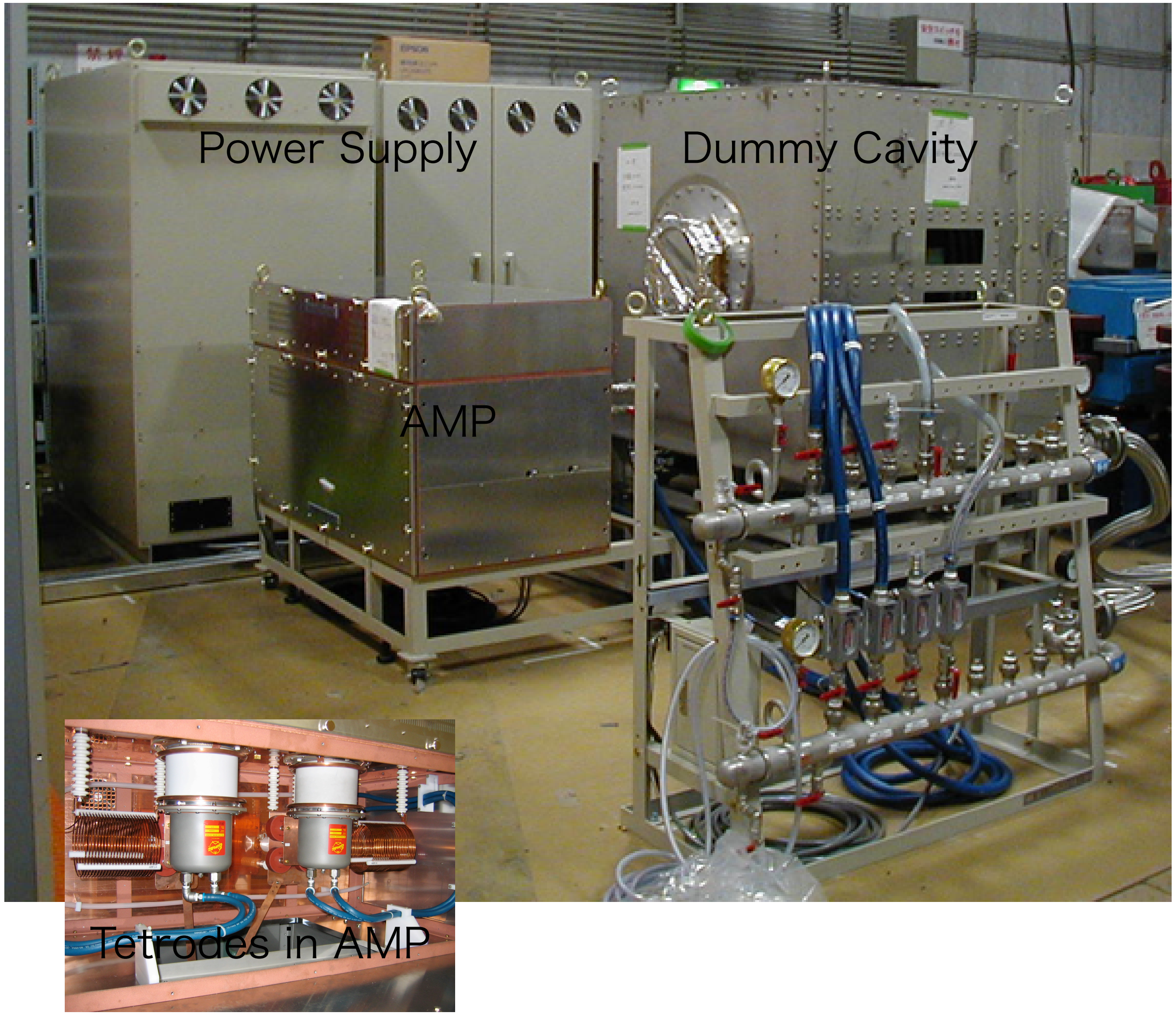
PRISM-RF System

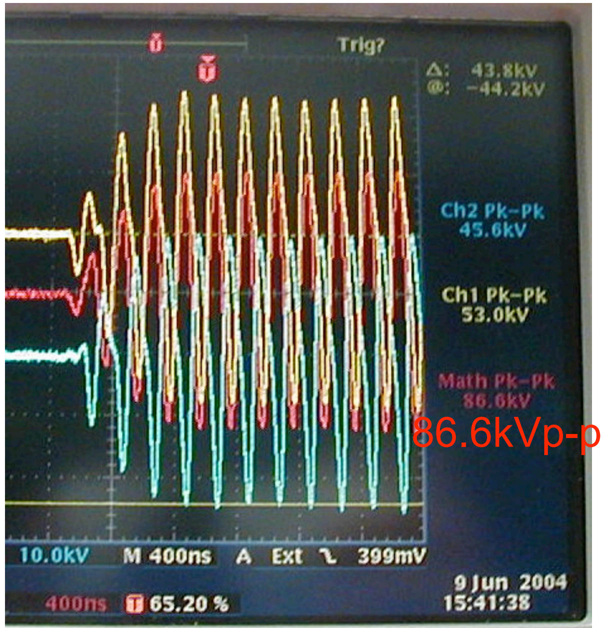


Prototype Cavity



RF AMP R&D

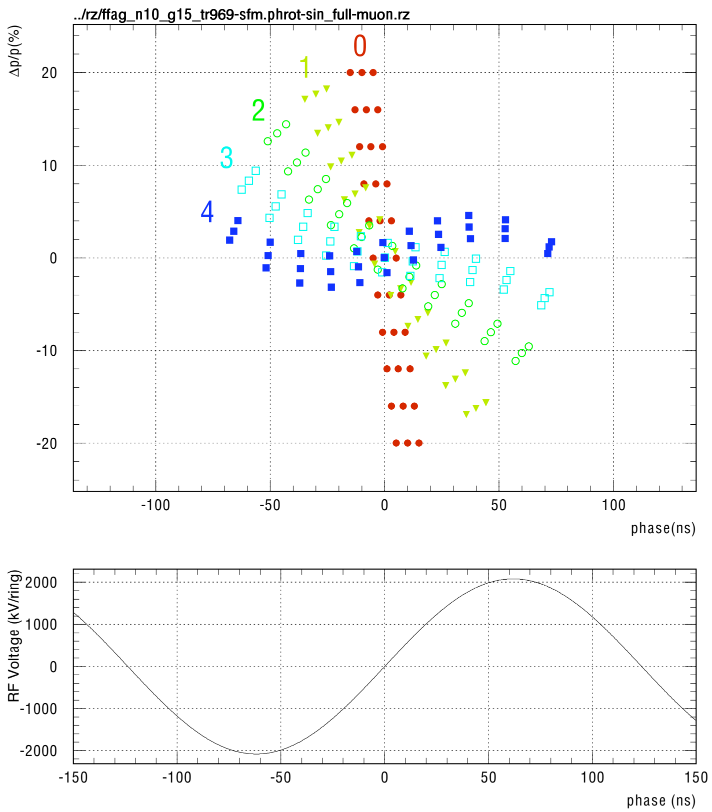




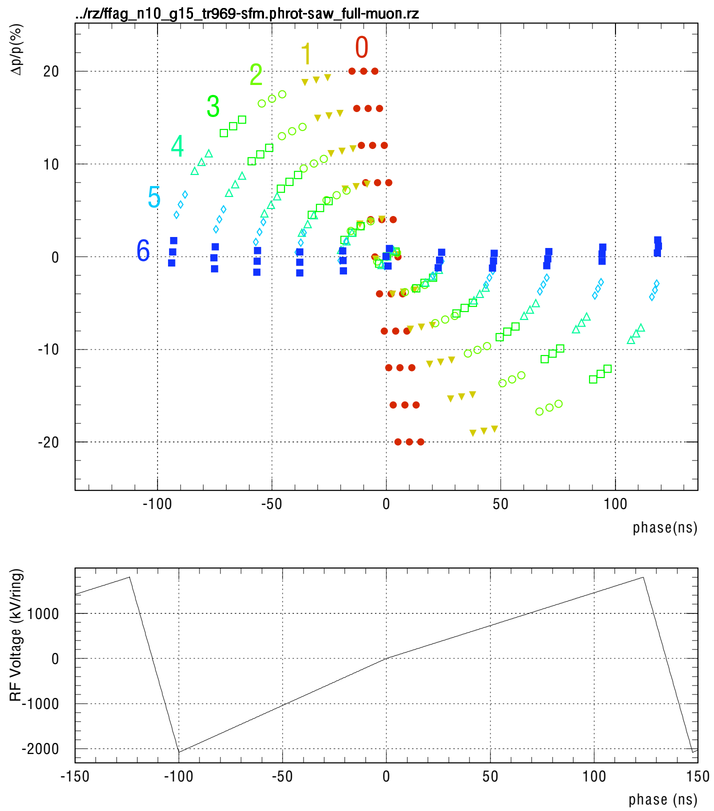
43kV/gap
w/ 734Ω dummy cavity
@5MHz

expected gradient
w/ PRISM-cavity (954Ω)
56kV_gap = 170kV/m

RF Wave Shape



Δp /p : 4%
num. of turn : 4
time : 1.0μs
μ survival rate : 68%

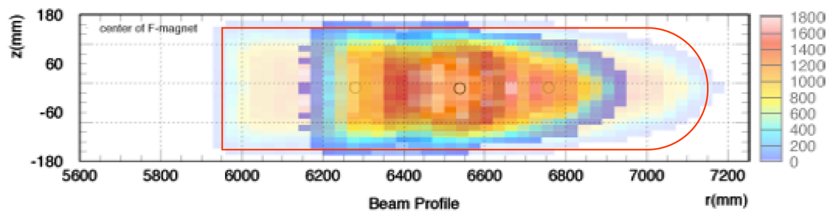


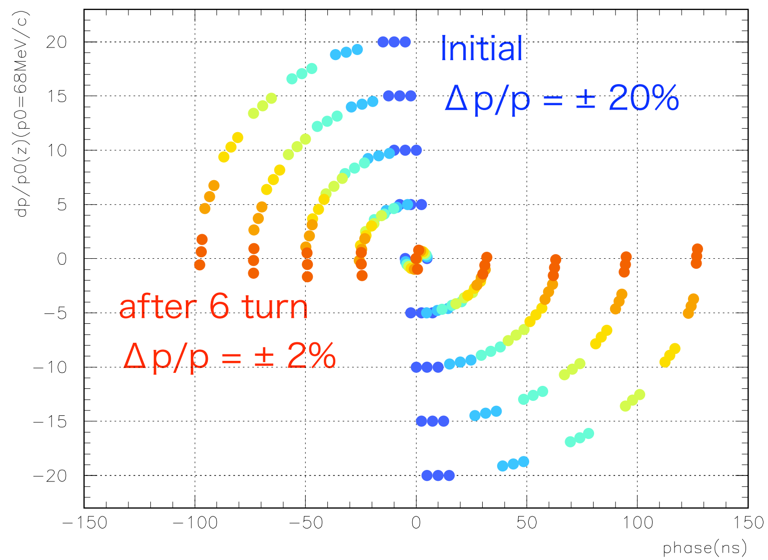
Δp /p : 2%
num. of turn : 6
time : 1.5μs
μ survival rate : 56%

Injection / Extruction

Muon Beam

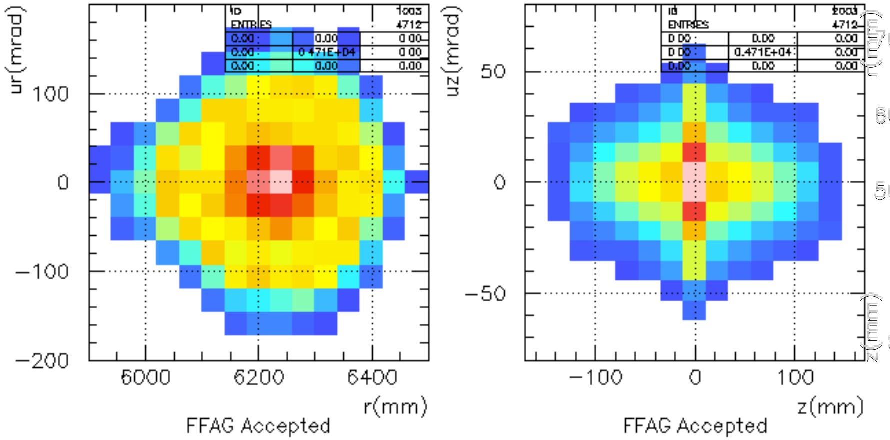
- at Injection
  - momentum : 68MeV/c+-20%
    - beam size
      - 100cmx30cm
  - time dist.: 40ns(/270ns)
    - kicker fall time < 230ns
- at Extraction
  - momentum : 68MeV/c+-2%
    - beam size
      - 70cmx30cm
  - time dist. : 200ns(/270ns)
    - kicker rise time < 70ns



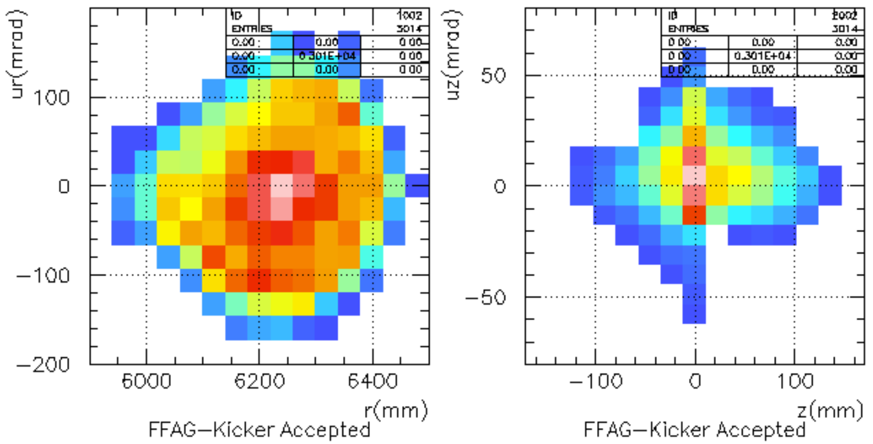


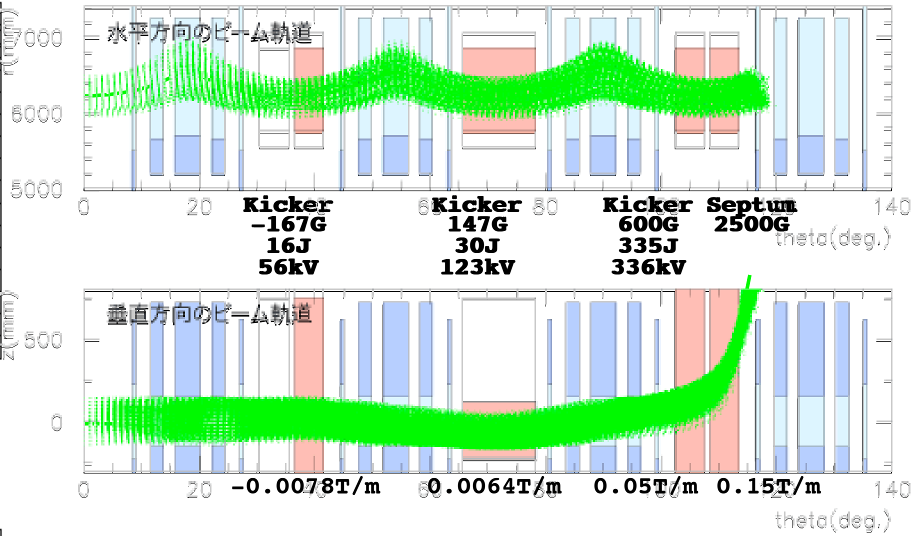
Vertical Extraction

FFAG's 4D Acc. : 1.0G(mm mrad)^2



FFAG-Kicker's 4D Acc. : 0.64G(mm mrad)^2

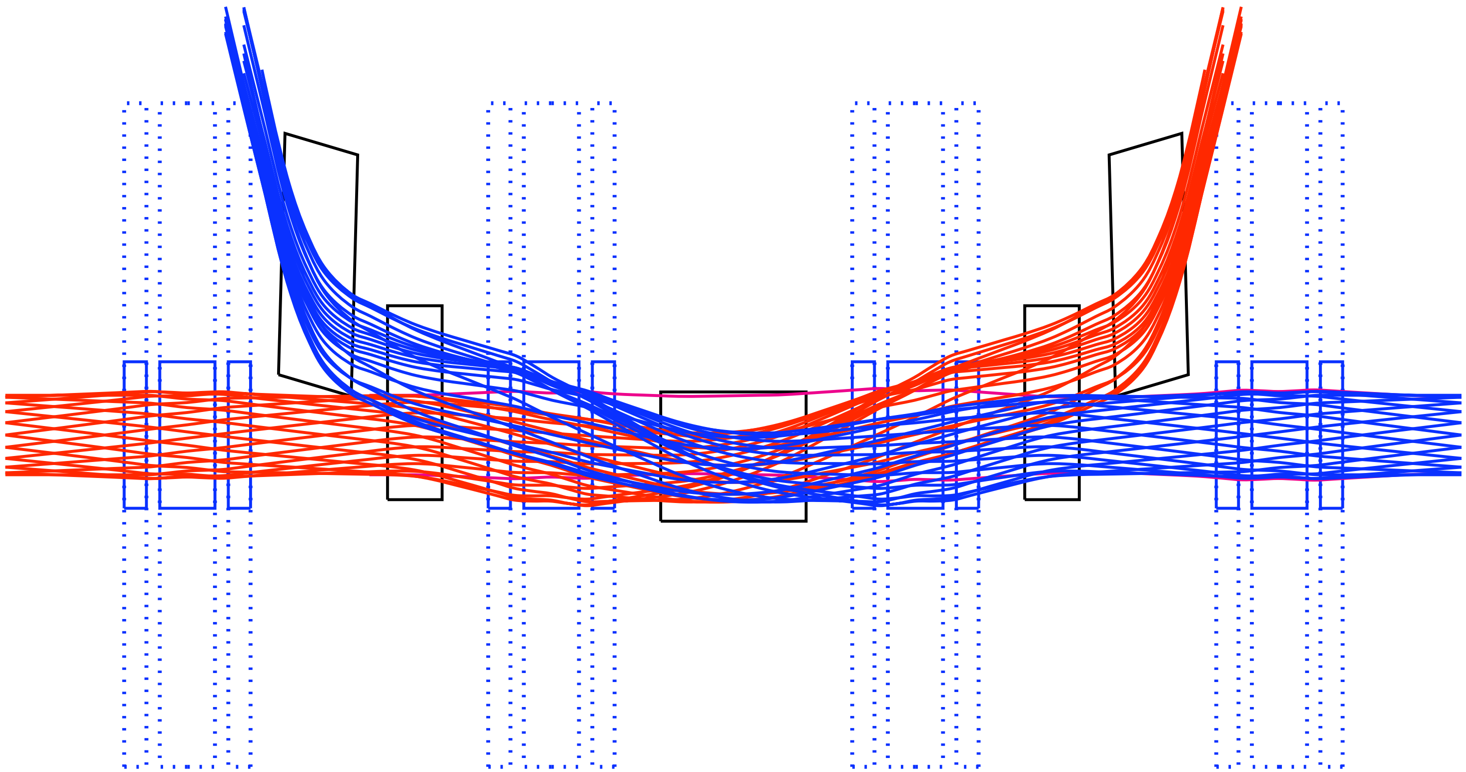




- (FFAG)/(FFAG-Kicker) = 64%

preliminary

Vertical Injection/Extraction



R.B.Palmer @ FFAG04

Vertical Injection/Extraction kicker parameters

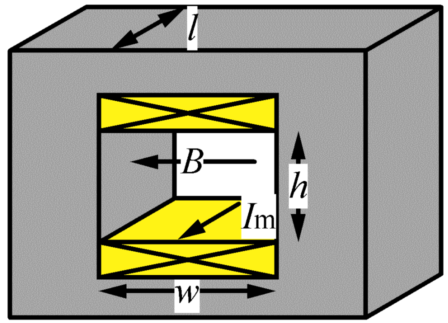
		dz	len	ht	wid	tilt	B	Grad	V_o	U
		m	m	m	m	deg	G	G/m	kV	J
1	Kicker	0.51	0.61	0.45	0.95	0	-167	-78	92	29
2	Kicker	0.00	1.63	0.30	0.95	0	147	64	144	40
3	Kicker	-.51	0.61	0.45	0.95	0	206	98	114	44
4	Septum	0.61	0.82	0.56	0.95	4	1710	930		
Max	(Total)								144	(113)
Horiz		0	1.22	.34	1.2		1080		3160	2038

Optimizing now

B.Palmer's results

PRISM-FFAG Kicker System

- V_0 < 40kV, Im ~ 6kA
- τ < 50nsec, τs ~ 25nsec
- L ~ 0.5μH



$$I_m = \frac{w\,B}{\mu_0},\ L = \mu_0 \frac{h\,l}{w}$$

To reduce the voltage swing: R < V_0 / Im ~ 5Ω

To realize fast rise time: L < R (τ – τs) ~ 0.125μH

The kicker Magnet should be divided (3 ~ 5units), and each unit should be driven separately.

Power = Im^2 R × unit number × duty (R = 5Ω, duty 0.02%)

#1 kicker (0.363 μH , 3units):108kW (6kA)

#2 kicker (0.647 μH , 5units): 61kW (3.5kA)

#3 kicker (0.363 μH , 3units):164kW (7.4kA)

Total 334kW for Extraction

T. Oki

Engineering design is to start.

Summary

- PRISM-FFAG is under construction at Osaka-Univ.. Commissioning will be started in 2007.
- High field gradient RF system has been successfully developed. ~170kV/m
- Developing the vertical injection/extraction system.
- Study of commissioning scheme is underway.