FFAG R&D at Osaka University

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10th Nov. 2006, FFAG06 Kumatori

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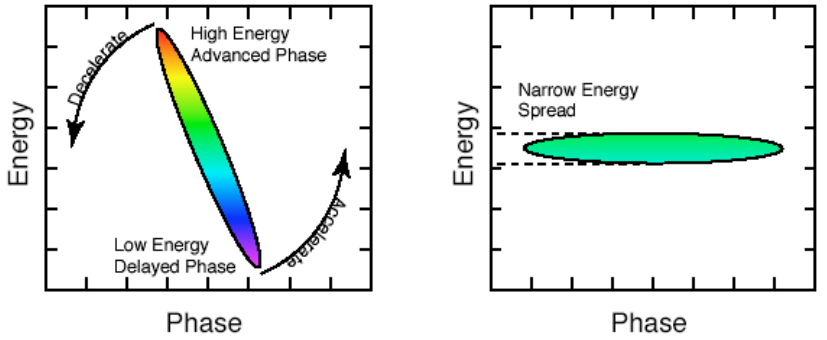
- ***FFAG ring cooler***
  - Lattice design
  - Super-fluid helium absorber

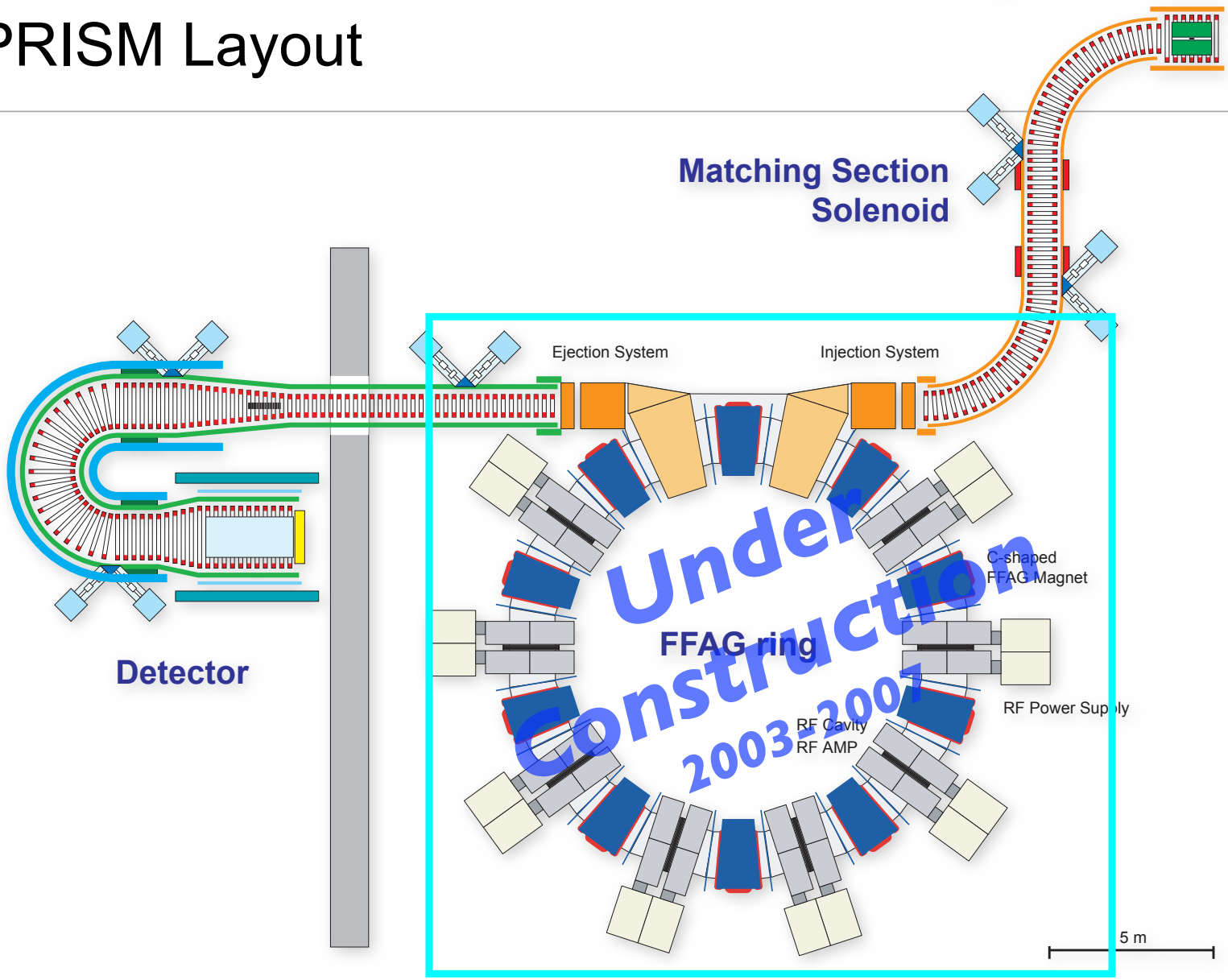
PRISM : Phase Rotated Intense Slow Muon source

- Goal : Search for Lepton Flavor Violation with B(μ-N→e-N)<10^{-18}
- We need a high intense and high quality muon beam, such as
  - ***High Intensity***
    - intensity : 10^{11}-10^{12}μ±/sec
    - beam repetition : 100-1000Hz
    - muon kinetic energy : 20 MeV (=68 MeV/c)
  - ***Narrow energy spread***
    - kinetic energy spread : ±0.5-1.0 MeV
  - ***Less beam contamination***
    - π contamination < 10^{-18}

phase rotation



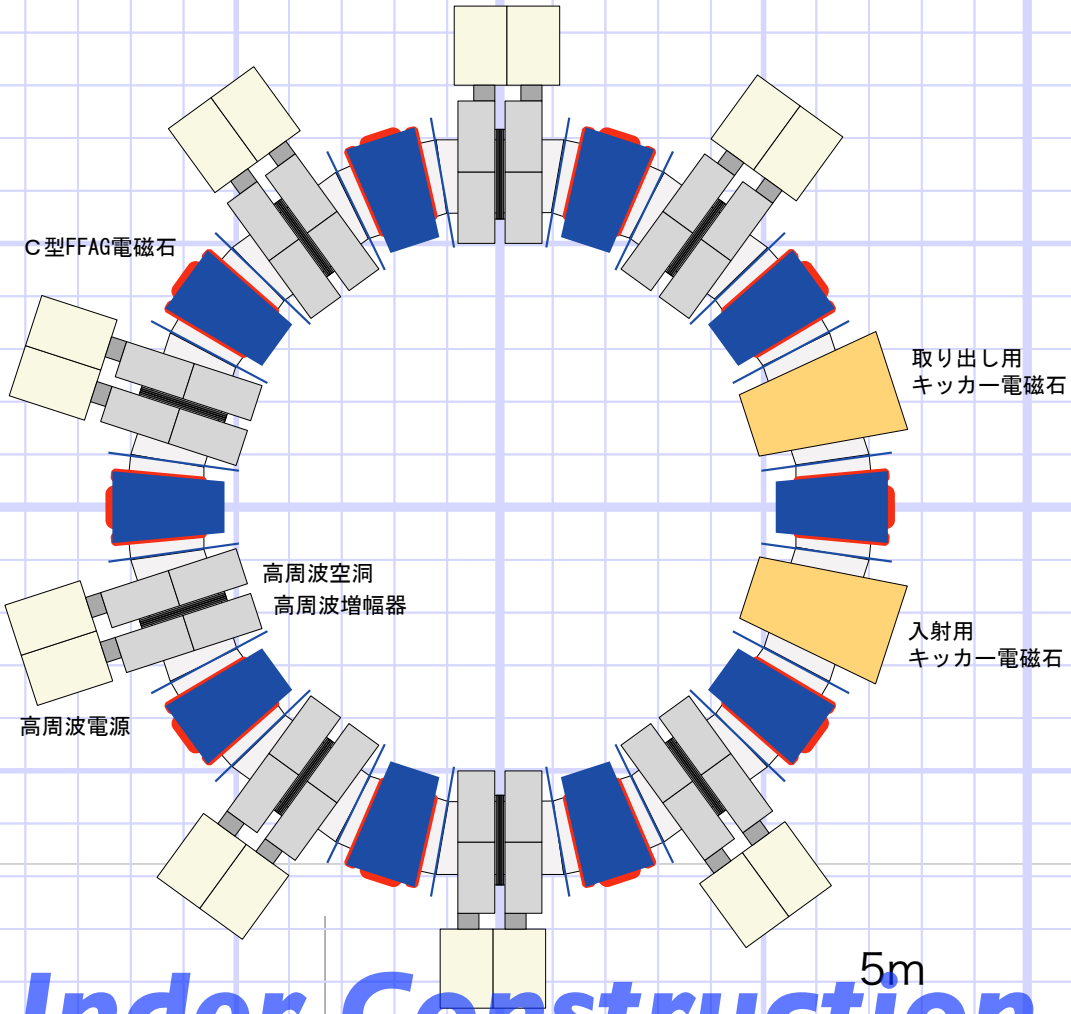
PRISM Layout



PRISM-FFAG

- 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

Phase Rotator



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%)

Goal of the PRISM-FFAG project

- Construct a full size FFAG ring to be used at the mu-e conv. experiment.
  - with Large transverse and Momentum acceptance
  - suitable for the phase rotator
- Develop a high-gradient RF system (-200kV/m)
- Demonstrate phase-rotation, which make narrower energy spread beam

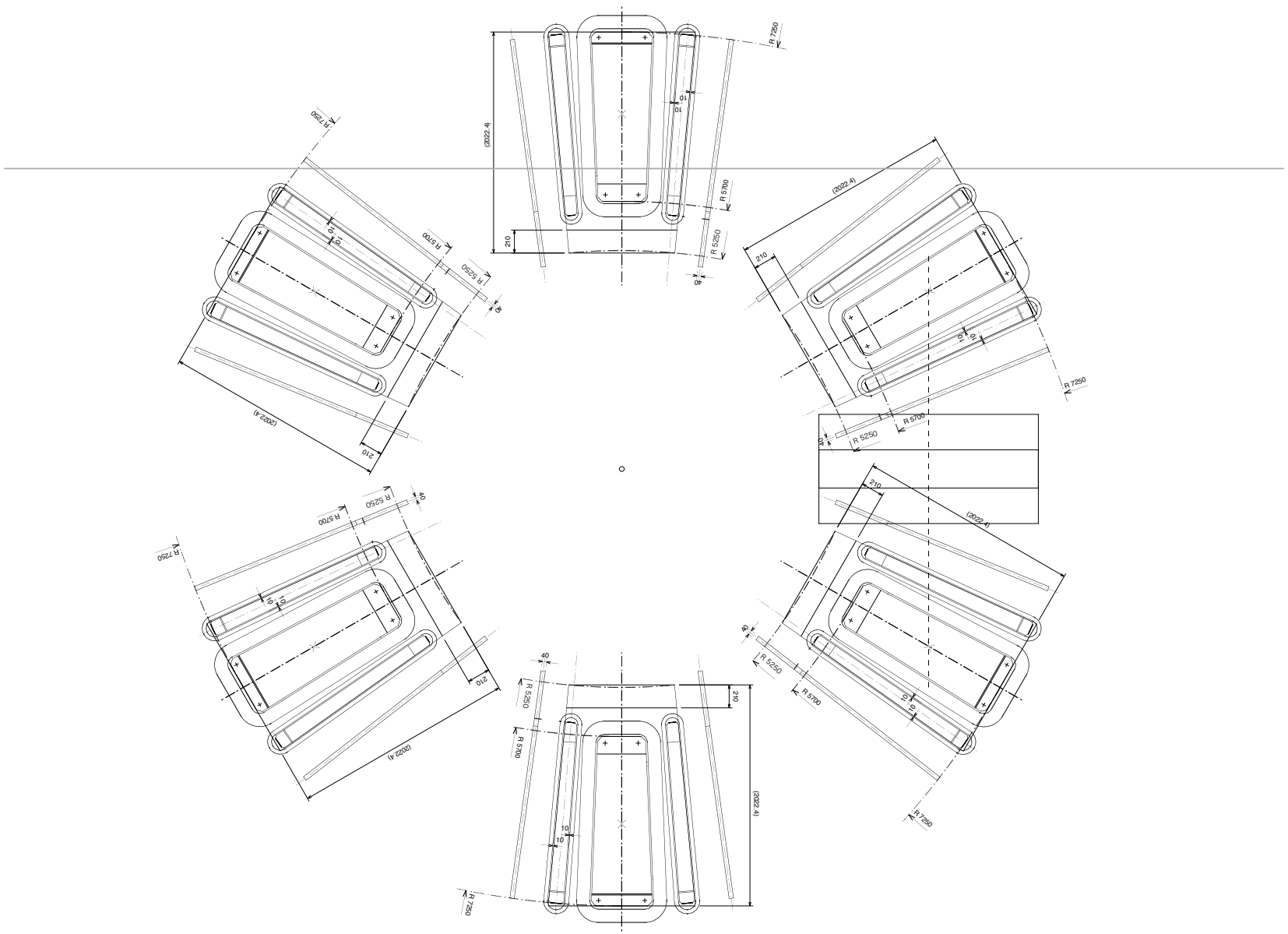
10-cell FFAG ring ----> 6-cell FFAG ring

Status and Schedule of PRISM-FFAG

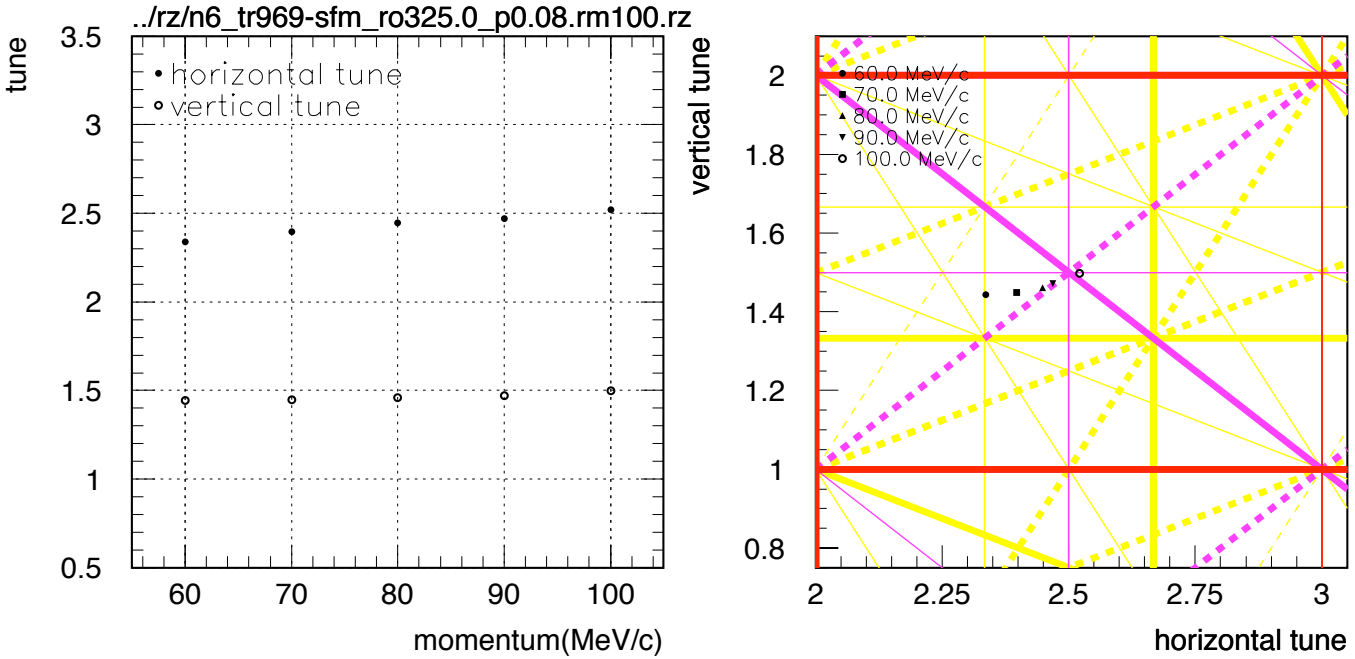
- Beam optics design : done
- RF R&D : done, 170kV/m with sinusoidal wave @ 5MHz is expected.
- Construction of magnets
  - -2006/03 : 3 magnets: done
  - -2007/05 : 3 magnets: coming soon
- Field measurement for the first 3 magnets : done and in analysis
- Beam dynamics study using 1 cell magnet : in preparation, will start from Feb.?
- R&D for high-gradient sawtooth RF : in progress
- Construction of FFAG-ring : 2007
- Demonstration of phase-rotation using 6-cell ring with alpha particles : 2007

Demonstration of Phase rotation using 6-cell FFAG ring

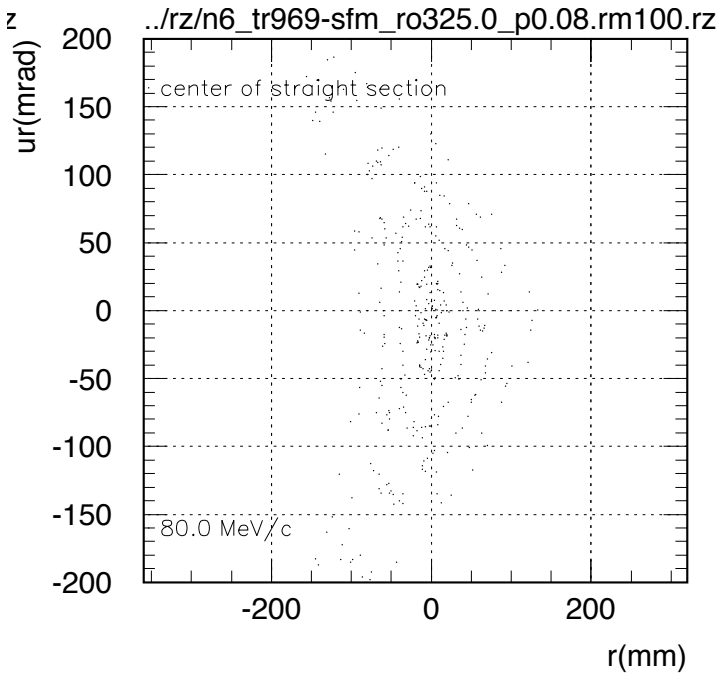
- use 6-cell ring instead of 10-cell full PRISM-FFAG ring.
- inject alpha particles to the ring
  - 241Am 5.48MeV(200MeV/c)
  - degraded to 80MeV/c
  - collimate for small eminence beam

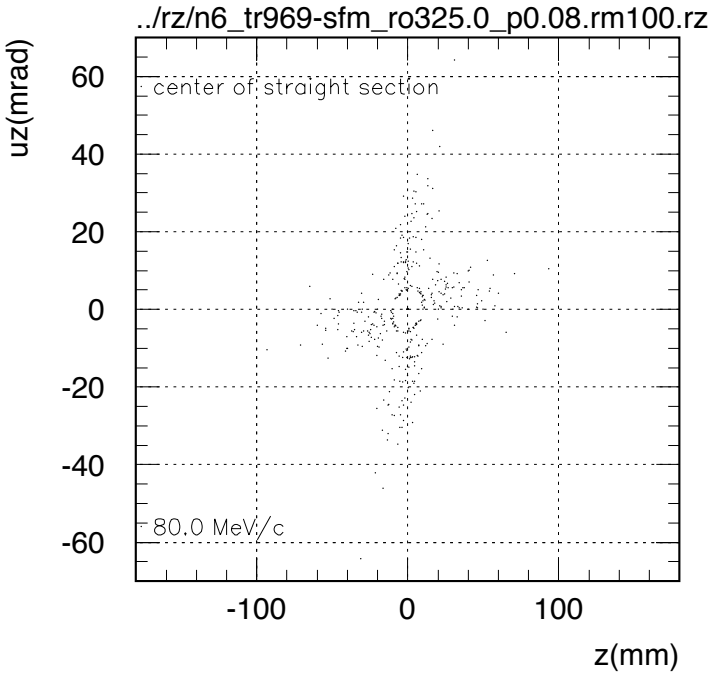

R 7250
(2022.4)
210
R 5700
R 5250
10
40
R 7250
(2022.4)
210
R 5700
R 5250
10
40
R 7250
(2022.4)
210
R 5700
R 5250
10
40
R 7250
(2022.4)
210
R 5700
R 5250
10
40
R 7250
(2022.4)
210
R 5700
R 5250
10
40

Tune Diagram of 6-cell FFAG



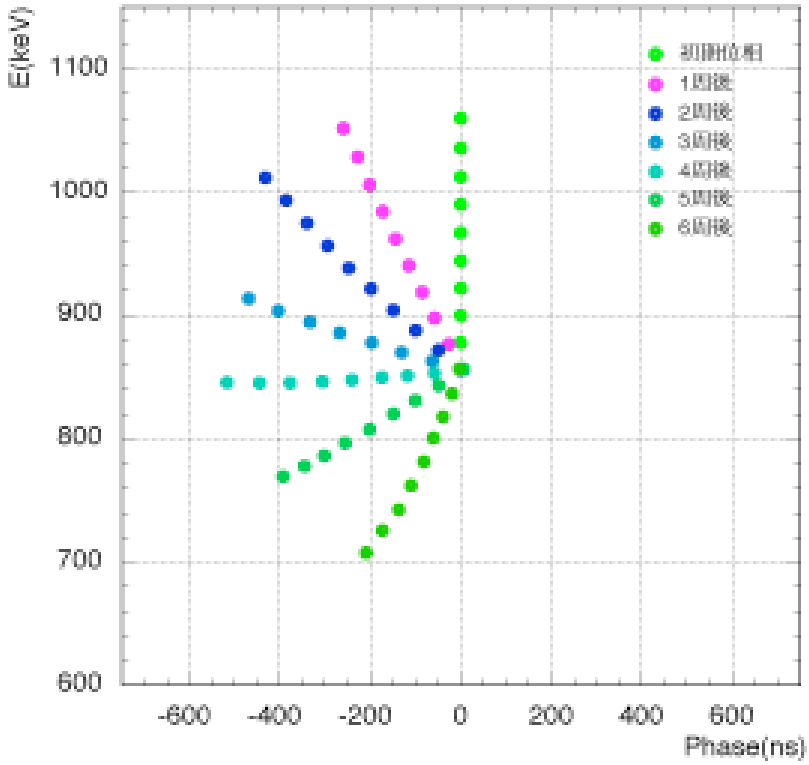
Phase Space of 6-cell FFAG



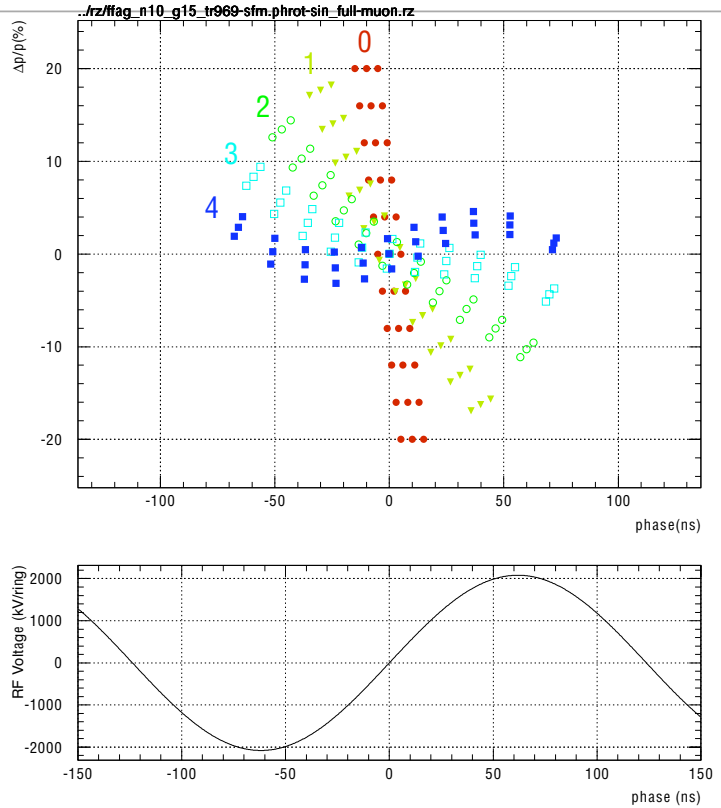


Requirements on RF for the study

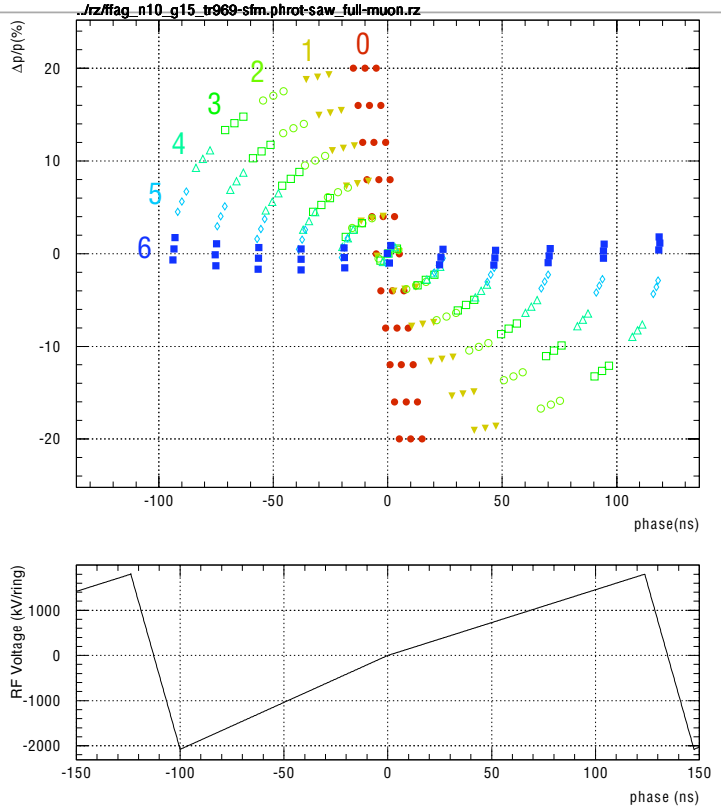
- Large aperture cavity
- Vpp=80kV at 1MHz (100kV/m)
- h=3 (Trevo.=3.18us for 80MeV/c alpha)
- sawtooth is better



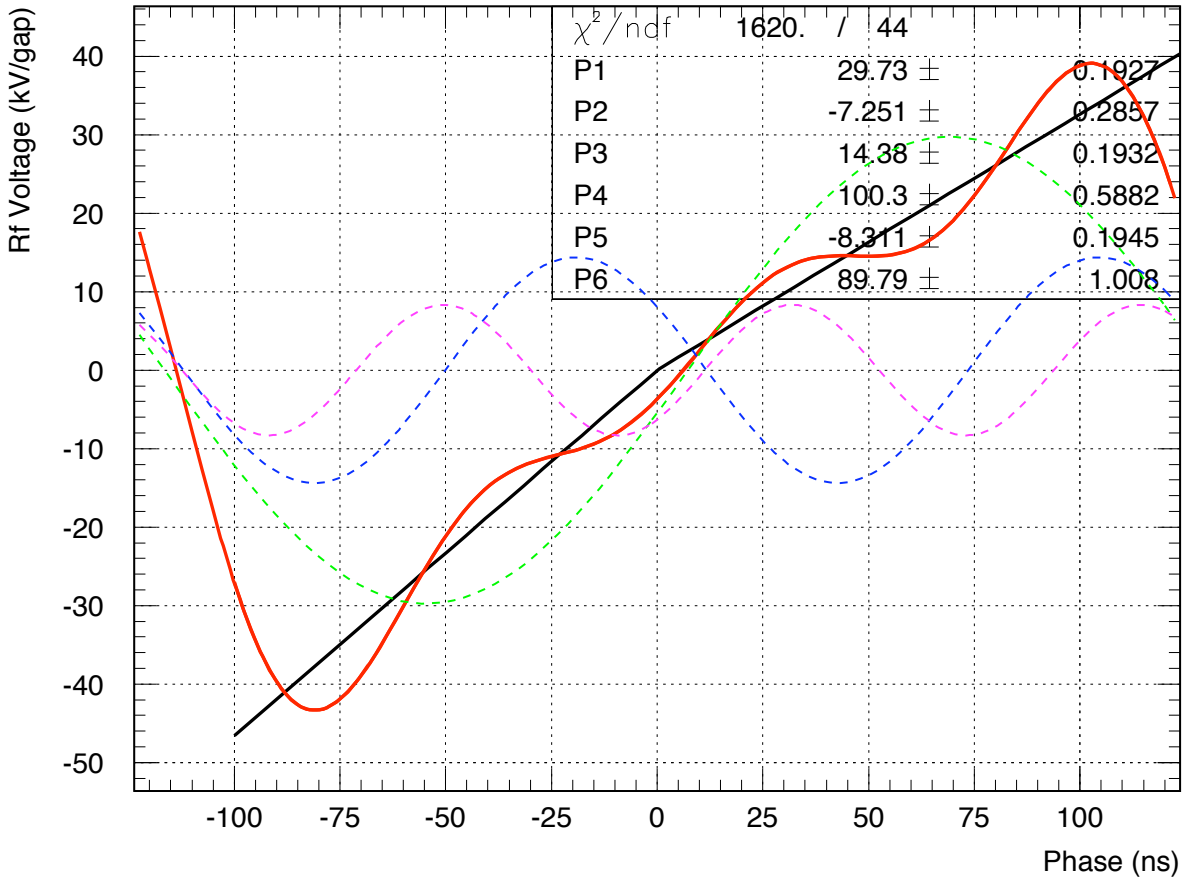
RF Wave Shape



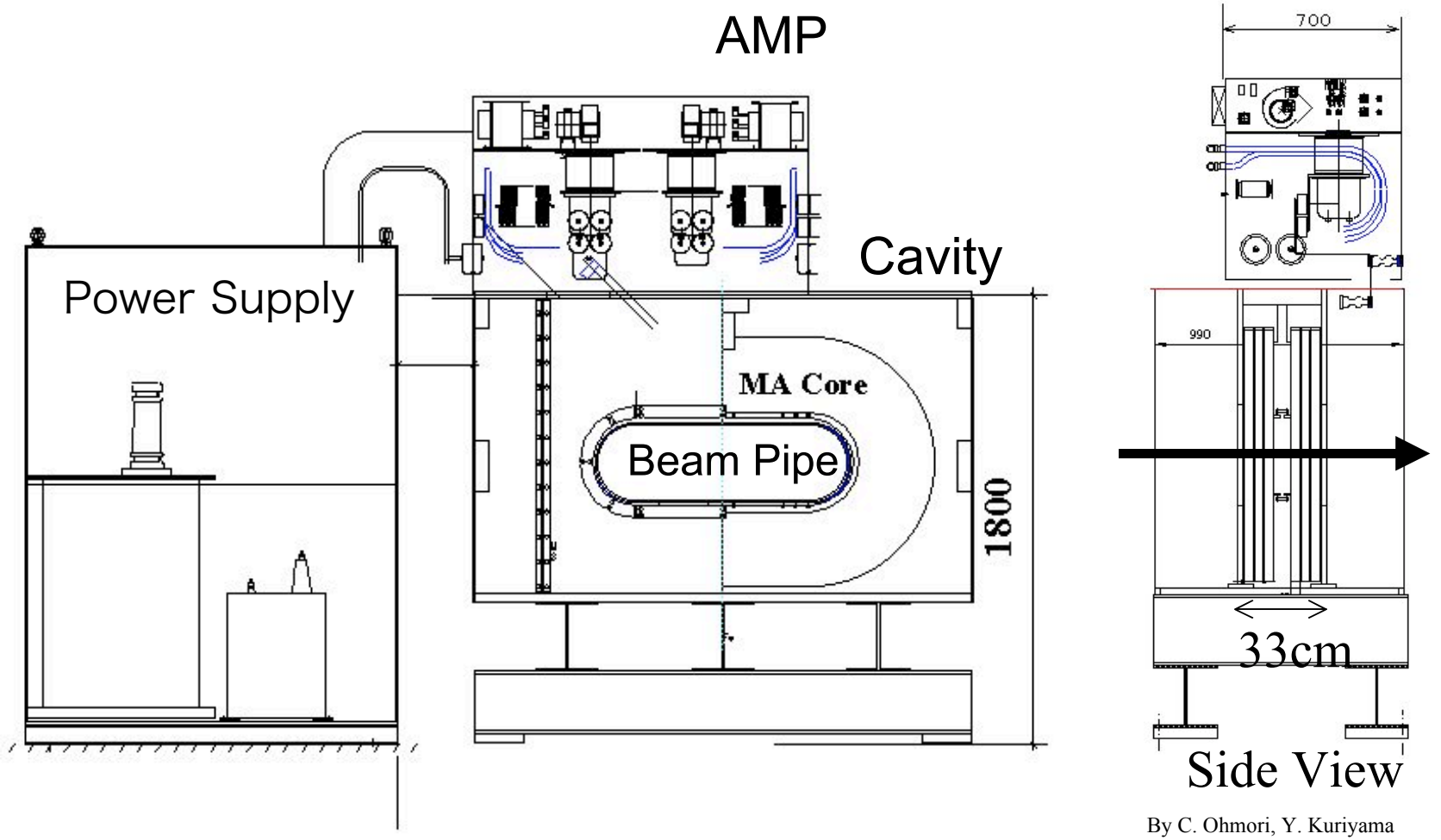
Δp /p　：4%
num. of turn：4
time：1.0μs
μ survival rate：68%



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

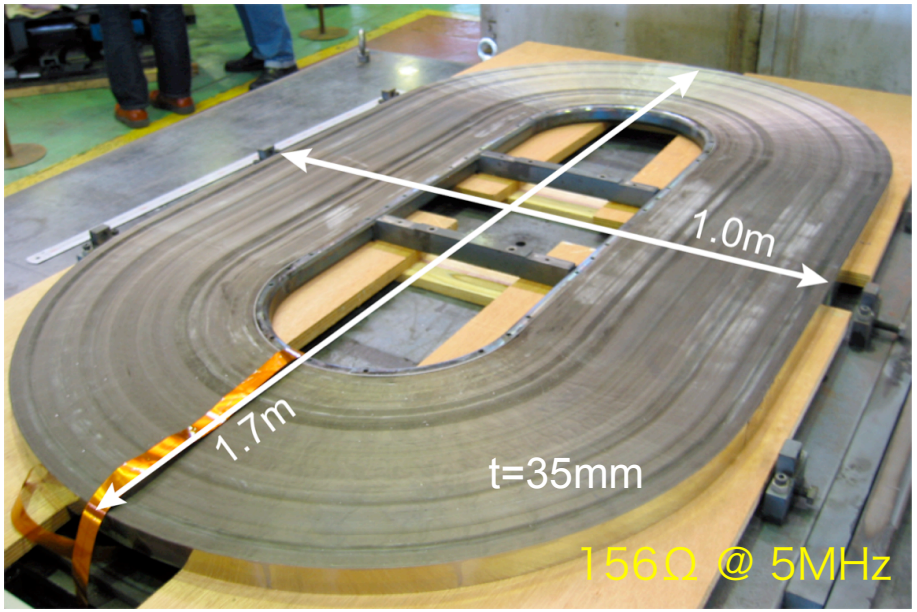

Rf Voltage (kV/gap)
Phase (ns)
χ²/ndf 1620. / 44
P1 29.73 ± 0.1927
P2 -7.251 ± 0.2857
P3 14.38 ± 0.1932
P4 100.3 ± 0.5882
P5 -8.311 ± 0.1945
P6 89.79 ± 1.008
40
30
20
10
0
-10
-20
-30
-40
-50
-100
-75
-50
-25
0
25
50
75
100

PRISM-RF System

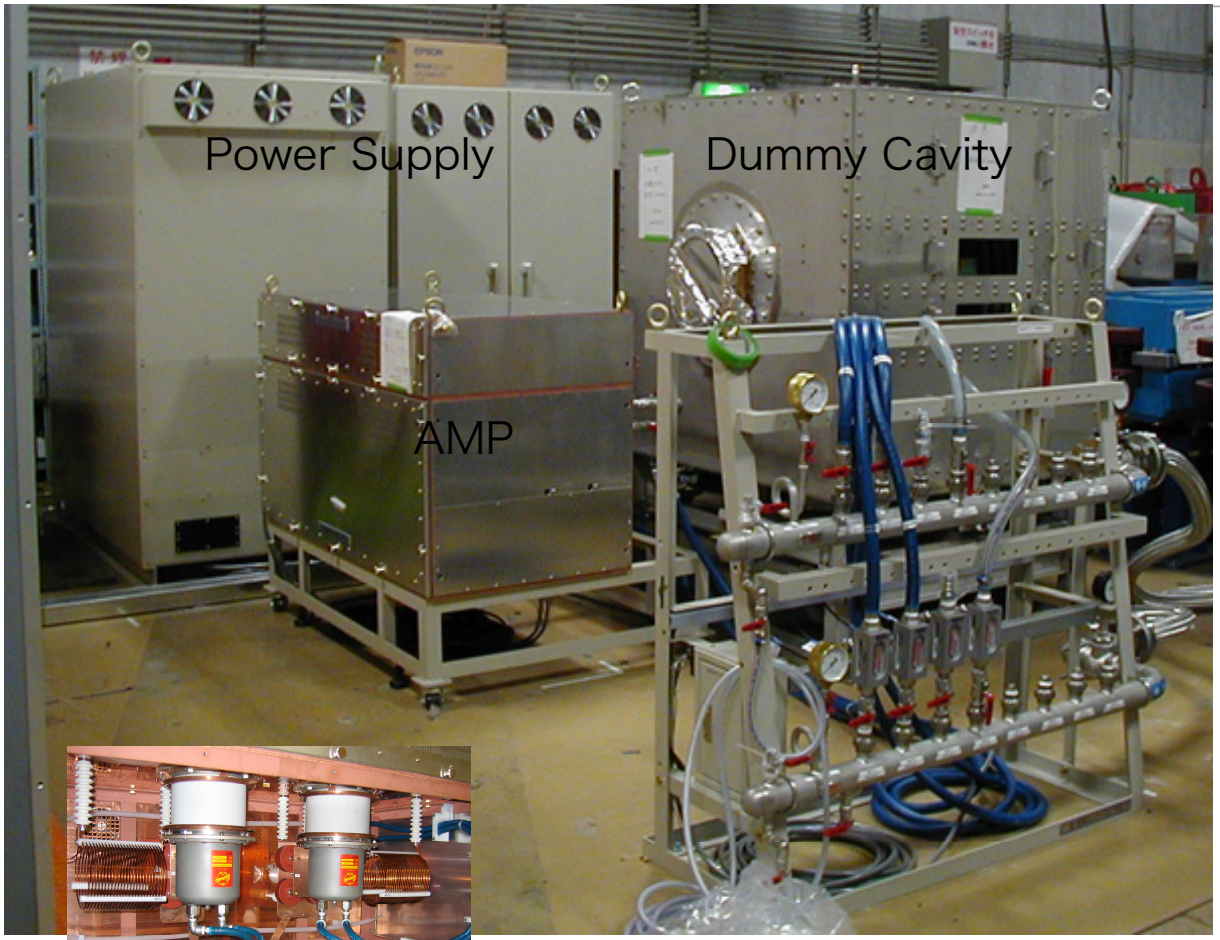


By C. Ohmori, Y. Kuriyama

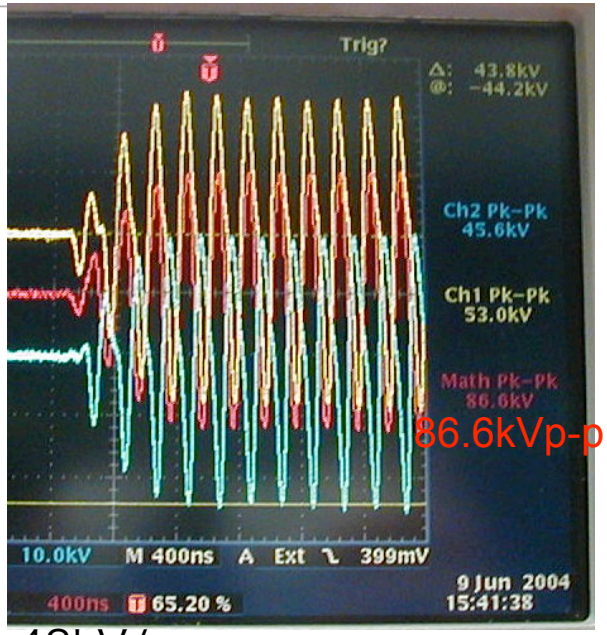
RF Cavity for PRISM-FFAG



RF AMP R&D



Tetrodes in AMP

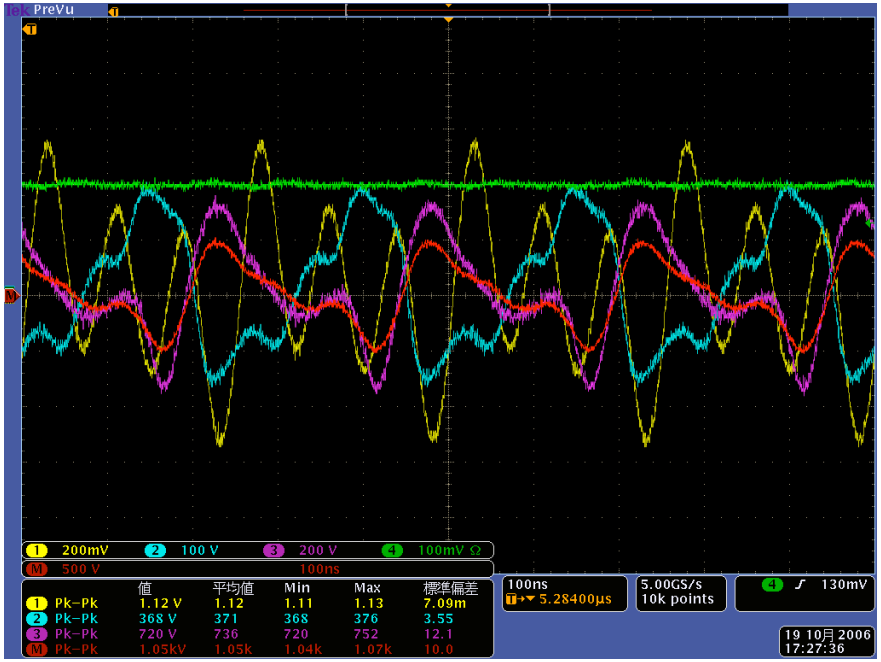


86.6kVp-p

43kV/gap
w/ 734Ω dummy cavity
@5MHz

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

Towards to the high voltage sawtooth



underway

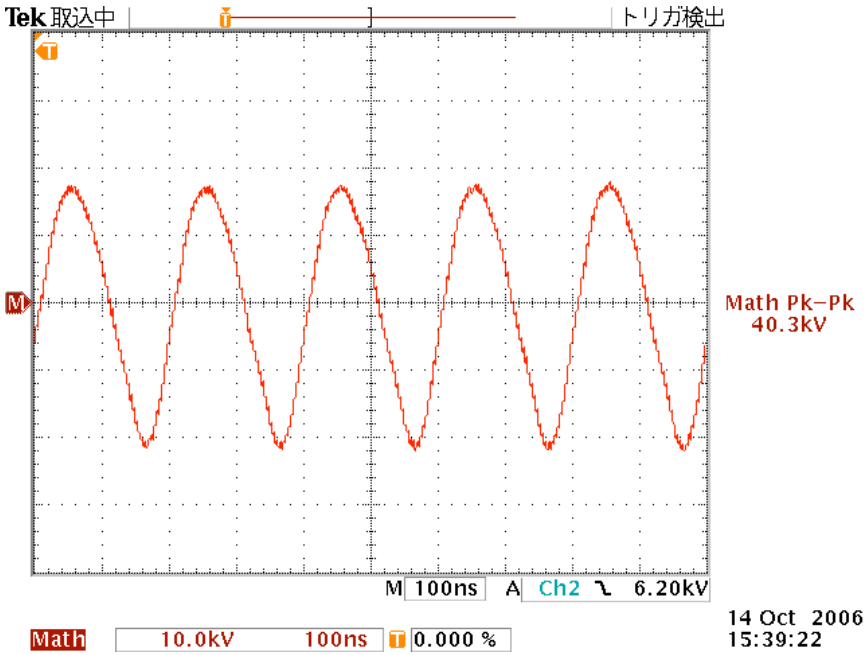


Figure 16: Image-16: Math(red)=gapB-gapA, wave=sawtooth01.csv with Atte.=8dB.

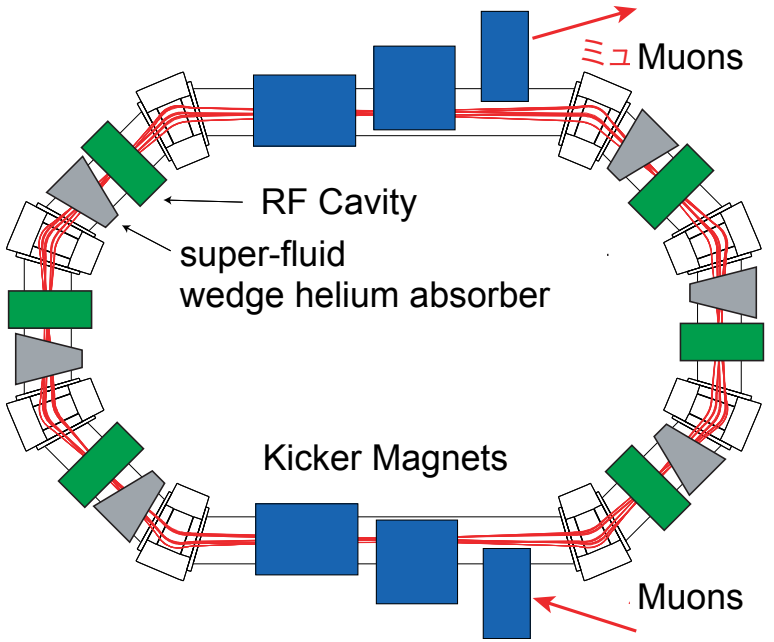
Ring Cooler R&D Plan

Ring Cooler R&D

- Design study of ring coolers for neutrino factory and muon collider.
- 2006JPY-2008JPY, Budget total ~ 150K$
- Osaka U., KEK, KURRI
  - A. Sato, S.Ishimoto, S.Suzuki, Y.Kuno, Y.Mori, K.Yoshimura, T.Itahashi, M.YOshida, and T.Oki
- ***Subjects in this project***
  - Design study of lattice and magnet
    - include injection/extraction scheme
    - FFAG ring cooler is one of the candidates
  - R&D of super-fluid helium absorber
    - construction cryostat
    - power test (heater)
    - beam test (if possible)

Ring Cooler Design Study

- to be solved
  - enough cooling power
  - injection/extraction
  - window issue of the absorbers
  - FFAG or solenoid ring



conceptional layout of the ring cooler

L-HeII Absorber

(super fluid helium absorber)

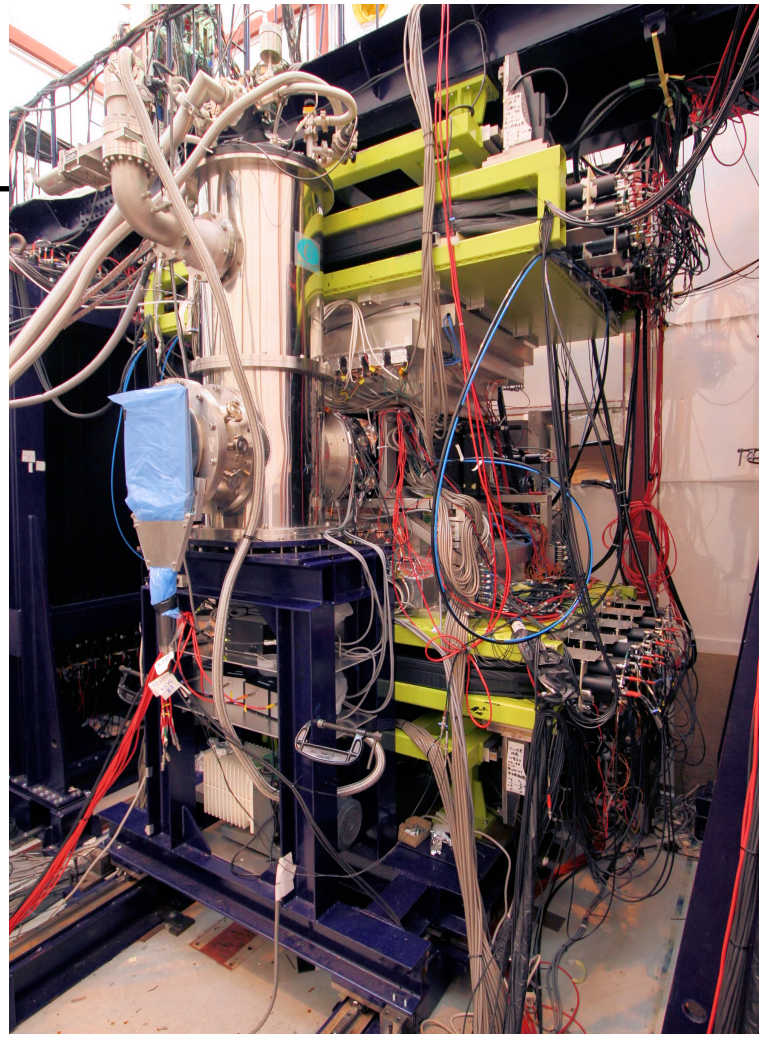
L-HeII Target for
KEK-PS E471/549/570

L-HeII (super fluid helium)

(1) Low Pressure → Thin Window

(2) Excellent heat transfer

L-HeII Absorber



2K L-HeII

1,000 W/cmK

2K Copper 2 W/cmK

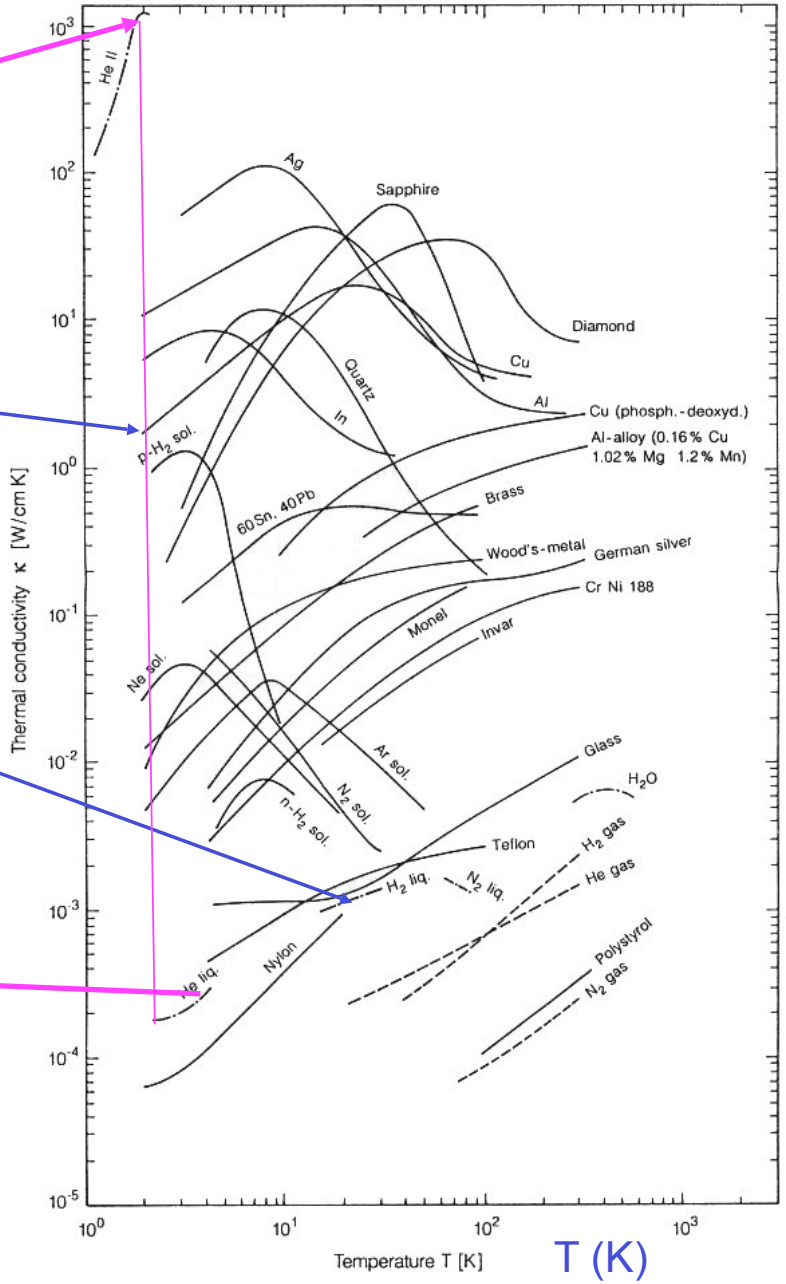
3 X 10^6

κ (W/cmK)

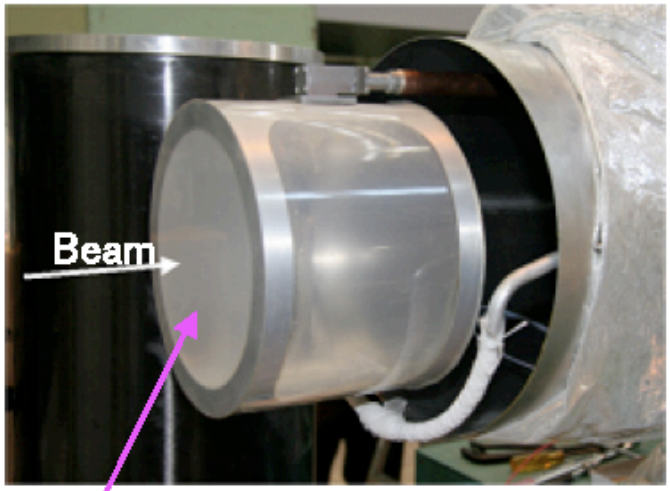
20K LH2 0.001 W/cmK

4.2K L-HeI

0.0003 W/cmK



L-HeII Target to L-HeII Absorber

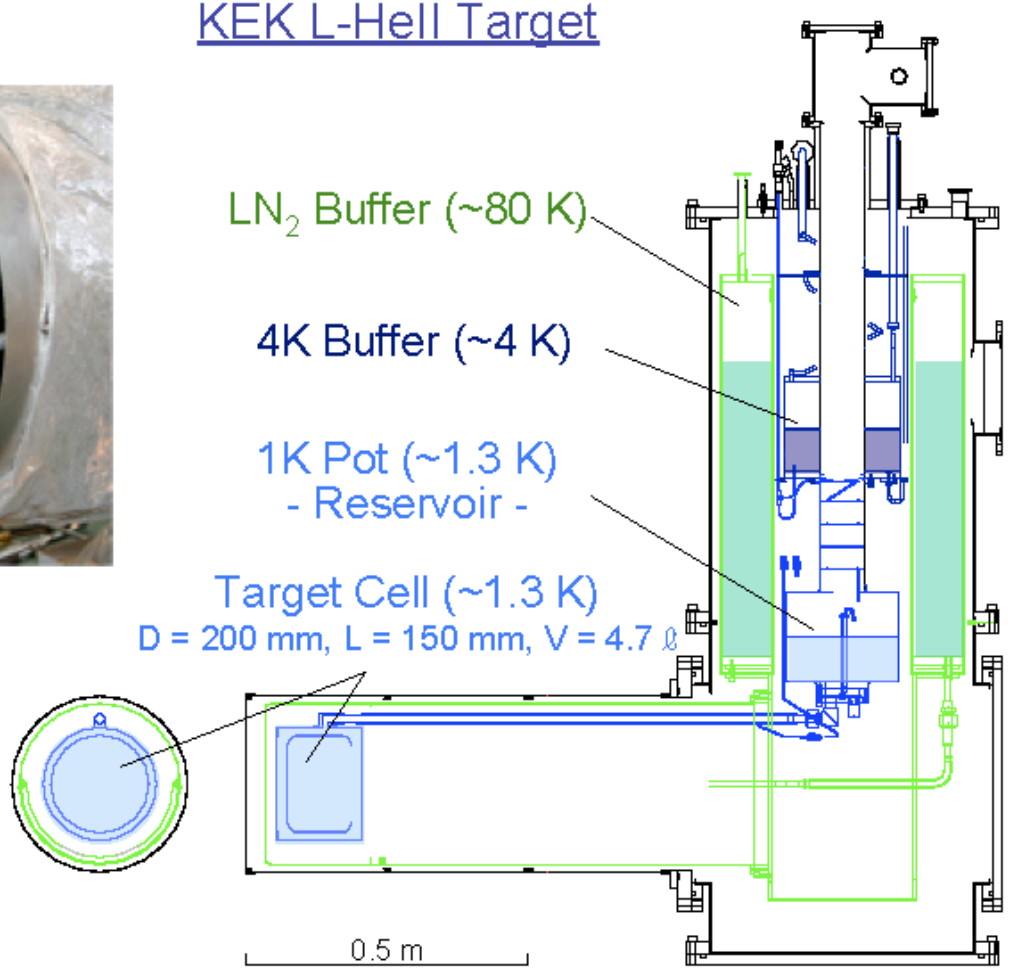


75μm ϕ200 Mylar Window

P_{op} ~ 1.2 Torr

P_{max} ~ 30 Torr

KEK L-HeII Target



L-HeII Absorber R&D

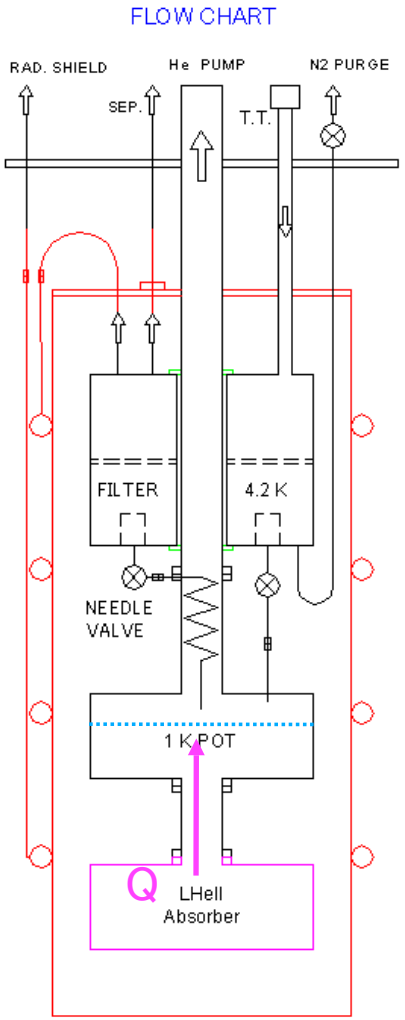
Osaka U.- KEK

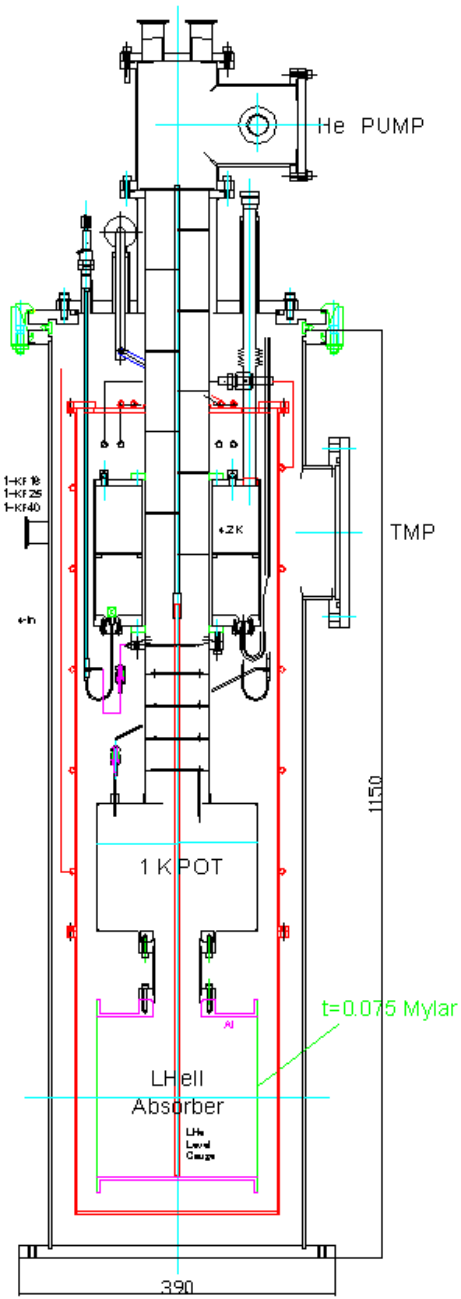
A. Sato, S. Ishimoto, Y. Kuno, M. Yoshida …

2006FY – 2008FY

Budget total ~ 150K$

Subjects
*Design of Ring Cooler
*R&D of L-HeII Absorber
- construction cryostat
- power test (heater)
- beam test



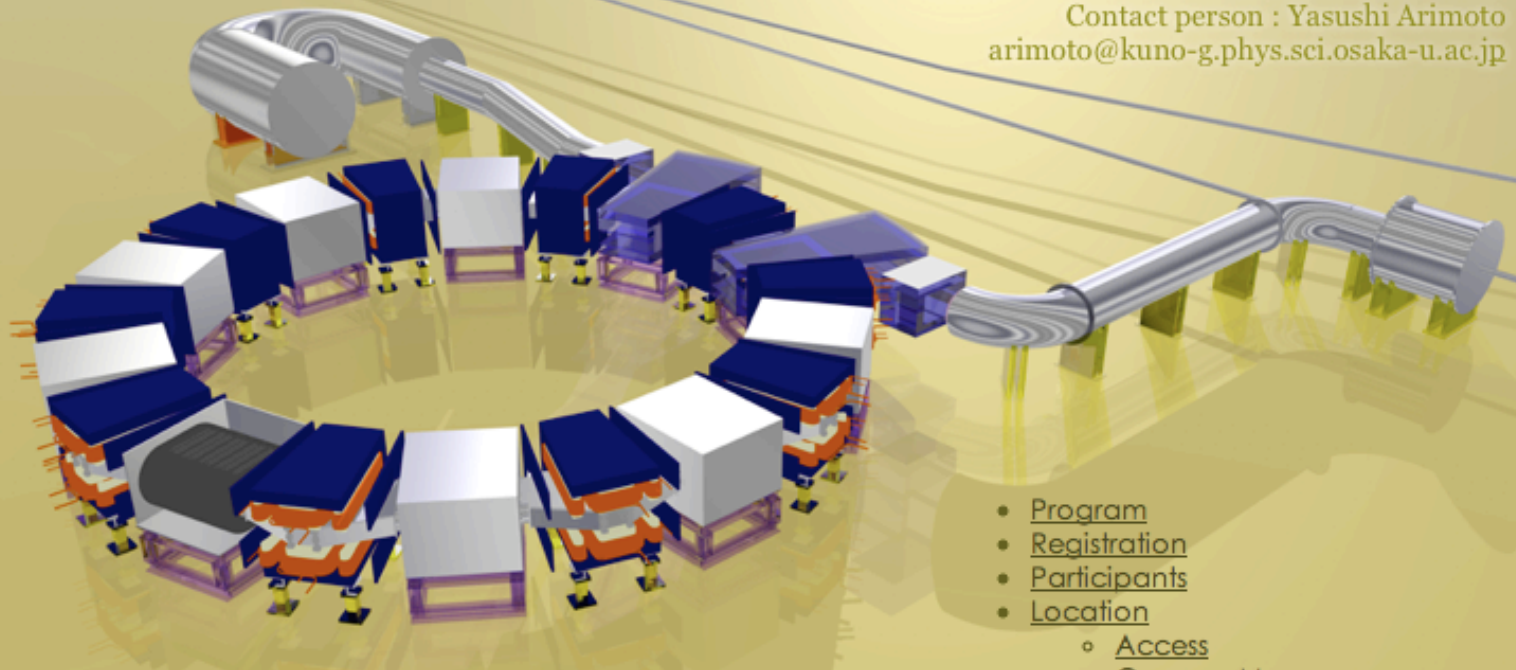


INTERNATIONAL PRISM WORKSHOP 2006

13-17, Nov. 2006, Osaka University

Meeting room: H701, graduate school of science, south block

Chair: Yoshitaka Kuno
Contact person : Yasushi Arimoto
arimoto@kuno-g.phys.sci.osaka-u.ac.jp



- Program
- Registration
- Participants
- Location
  - Access
  - Campus Map
- Accommodation
- Link
  - FFAG Workshop '06
  - PRISM Homepage
  - Kuno Laboratory Homepage