# Design Study of PRISM

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# PRISM Overview

- Phase Rotation Intense Slow Muon source
- a **dedicated** secondary muon beam channel with
  - High Intensity
  - Narrow Energy Spread
  - High Purity

for stopped muon experiments.

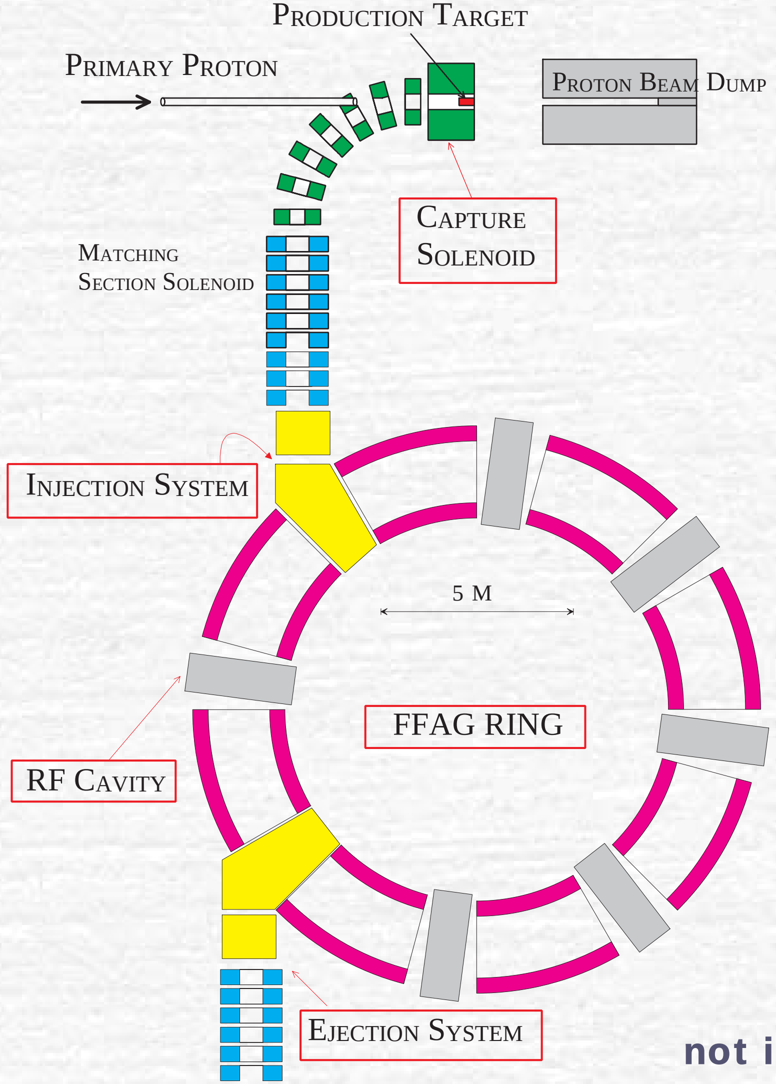
> **High Field Pion Capture**
>
> **Phase Rotation**

# PRISM Beam Characteristics

- intensity : $10^{11}$-$10^{12}$ $\mu^{\pm}$/sec
- muon kinetic energy : 20 MeV (=68 MeV/c)
  - range = about 3 g
- kinetic energy spread : ±0.5-1.0 MeV
  - ±a few 100 mg range width
- beam repetition : about 100Hz

# PRISM layout

- Pion capture section
- Decay section
- Phase rotation section




## FFAG Based

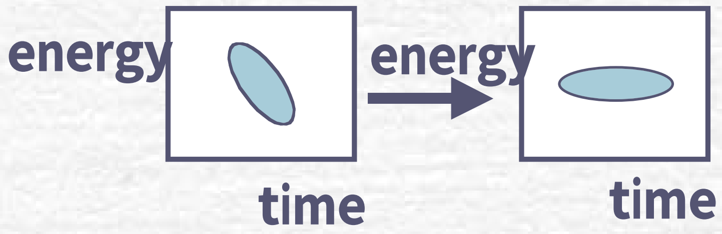
a ring instead of linear systems

- reduction of # of rf cavities
- reduction of rf power consumption
- compact

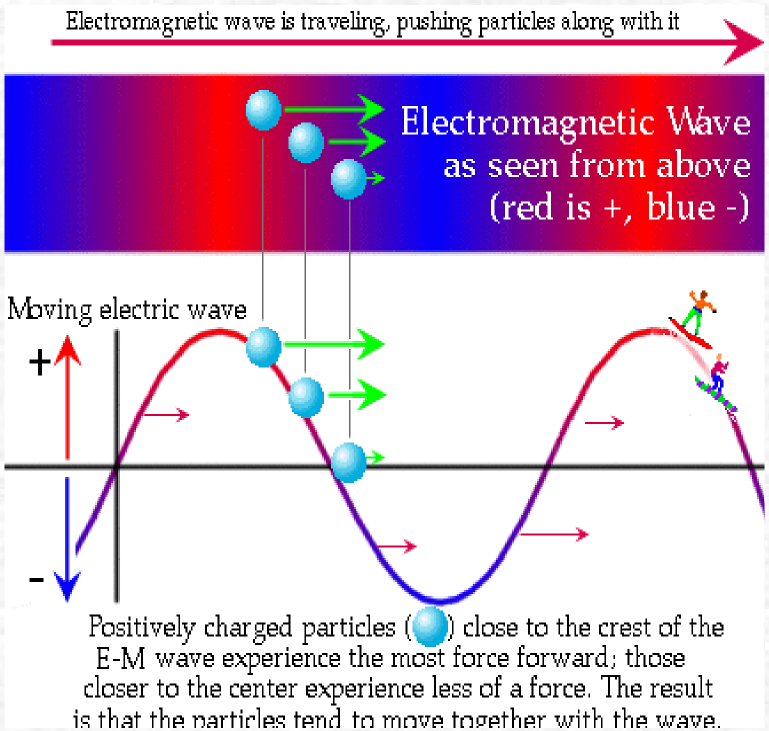
not in scale

# Phase Rotation

- **Phase Rotation** = decelerate particles with high energy and accelerate particle with low energy by high-field RF




- **A narrow pulse structure (<1 nsec) of proton beam is needed** to ensure that high-energy particles come early and low-energy one come late.



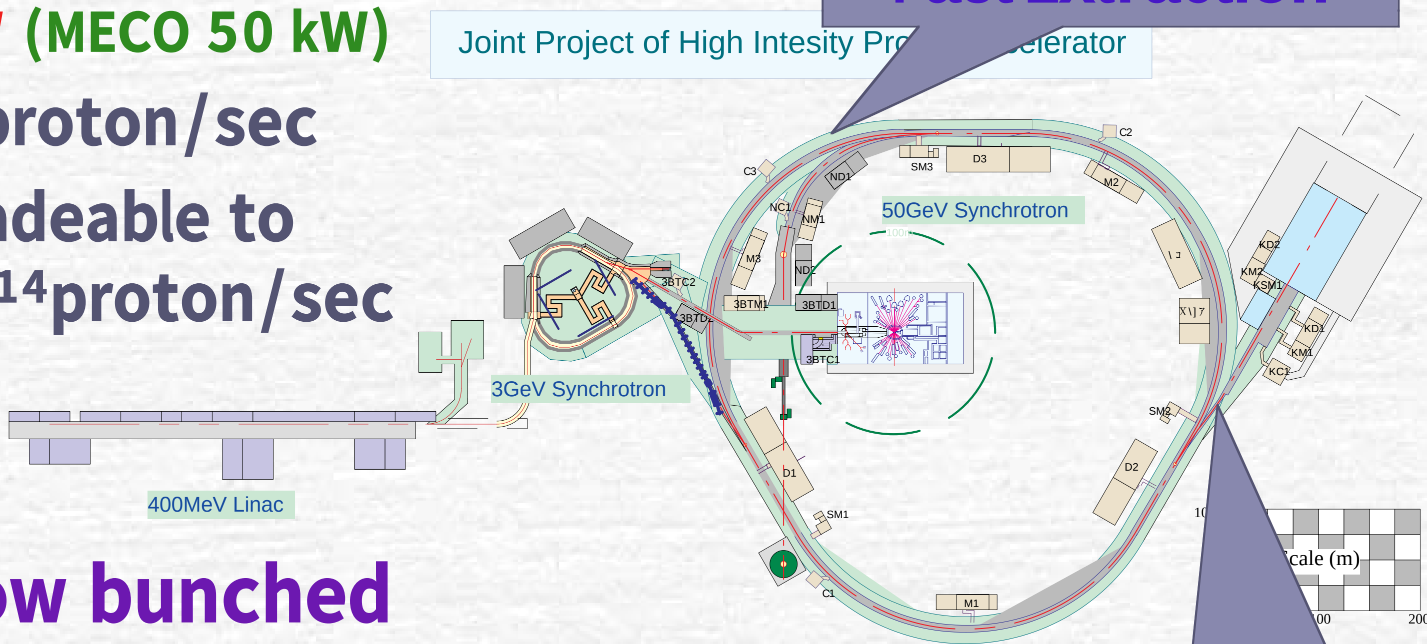
# How to realize PRISM

- Proton driver
  - High intensity
  - Bunched Beam
- Pion capture
  - High field solenoid
  - High Radiation
  - High heat load
- Phase rotator
  - FFAG

# Proton Driver - 50GeV PS

- High intensity
  - 0.75 MW (MECO 50 kW)
    - $10^{14}$proton/sec
    - Upgradeable to $4\times10^{14}$proton/sec
- A narrow bunched

Fast Extraction



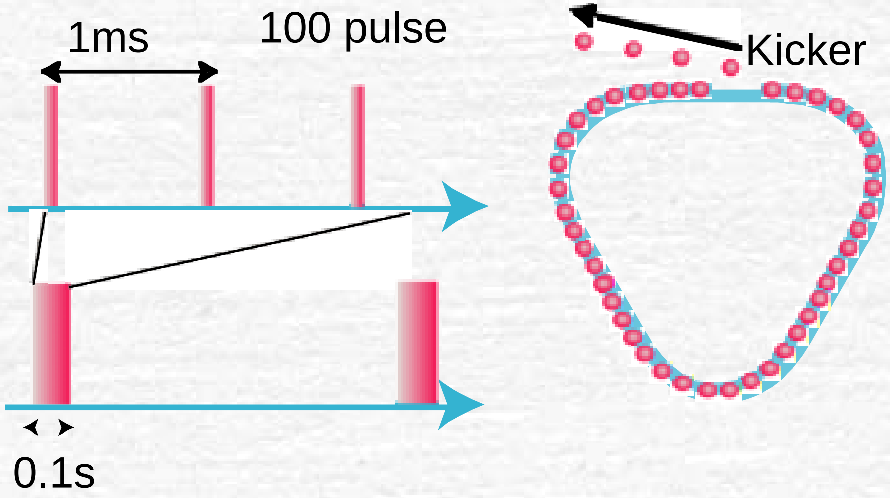

Slow Extraction



PRISM Phase-Rotation Intense Slow Muon
High-Intensity Low-Energy μ Source

# Fast extraction scheme

- Fast Extraction
  - 100Hz is feasible
    - Cf. ~ 1MHz(MECO)




Event Rate Huge!

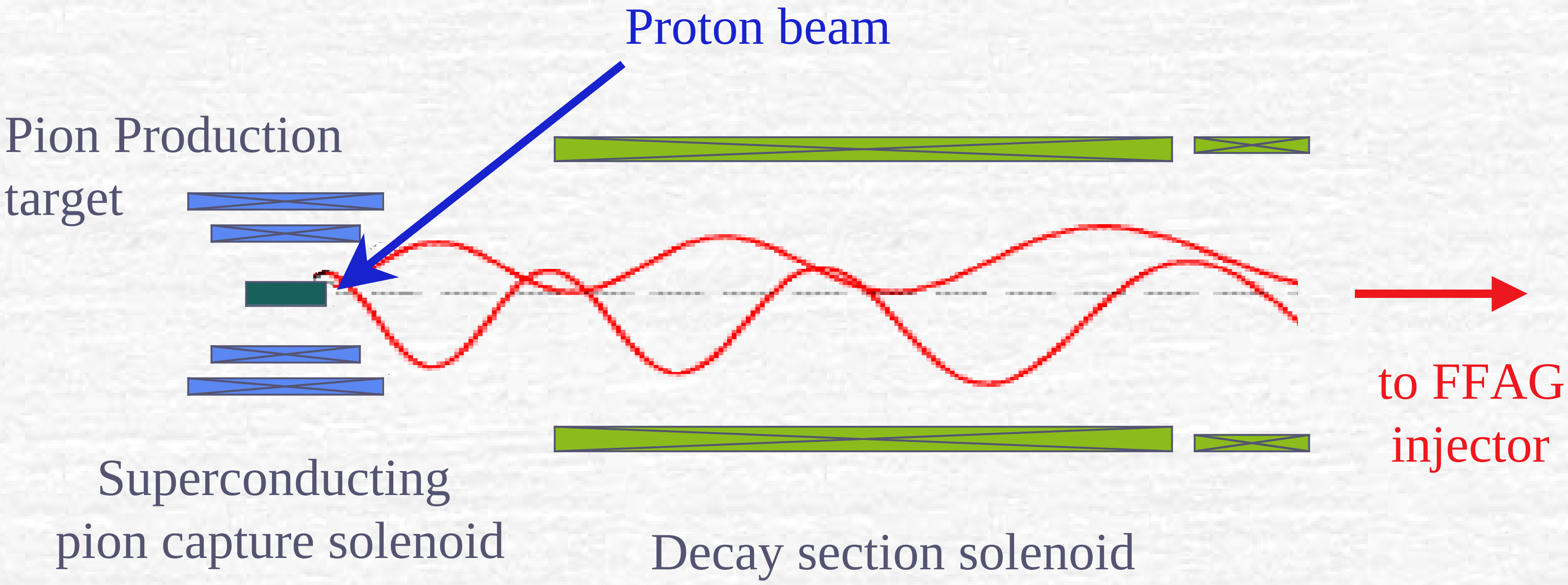
# Experimental Hall -PRISM-



PRISM Phase-Rotation Intense Slow Muon
High-Intensity Low-Energy μ Source

# Capture & Decay Section
## - solenoid scheme

- **Solenoid field beam line with superconducting solenoid magnet**



# Pion Capture Yield

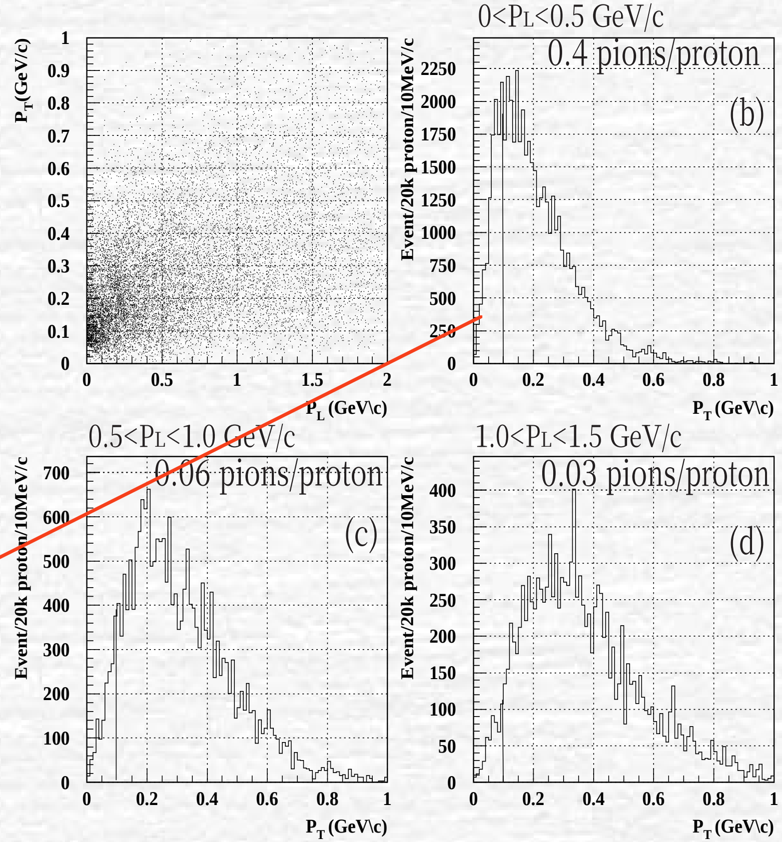
- maximum transverse momentum

$$P_T(MeV/c) = 0.3 \times H(kG) \times \left(\frac{R}{2}\right)(cm)$$

  - $R$ : inner radius of magnet
  - ex: $H$=120kG(=12T), $R$=5cm
    - $P_T$ < 90 MeV/c

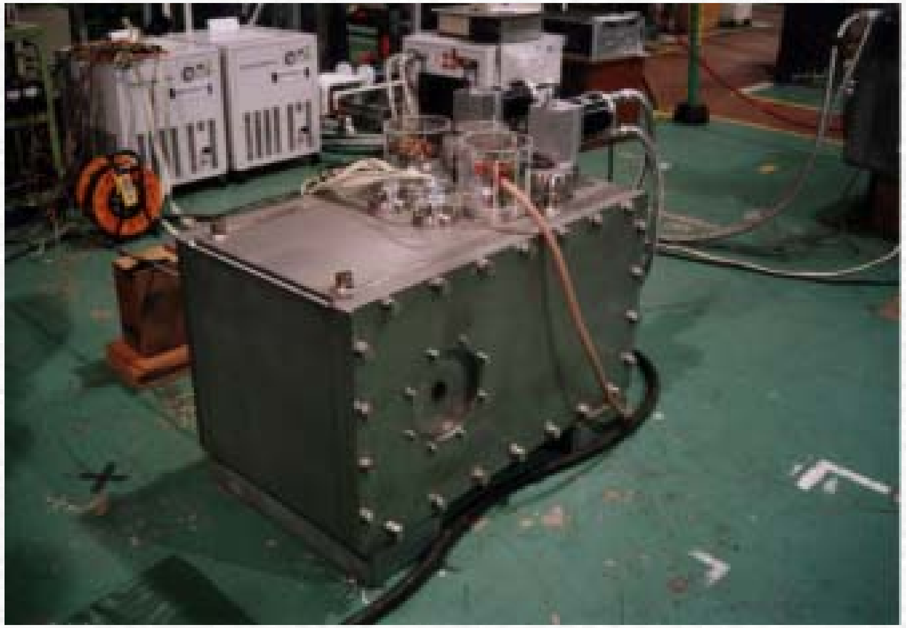
4x10^13 $\pi^-$/sec

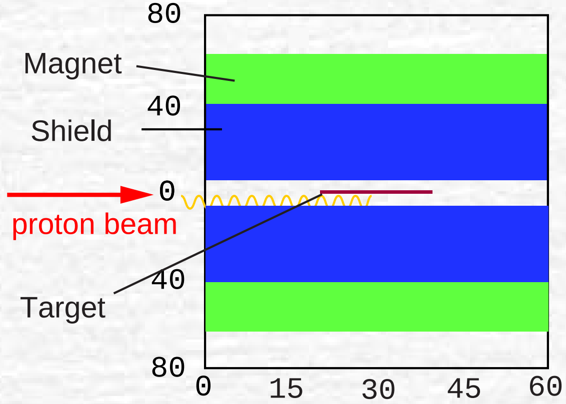
50GeV PS with 10^14 protons/sec

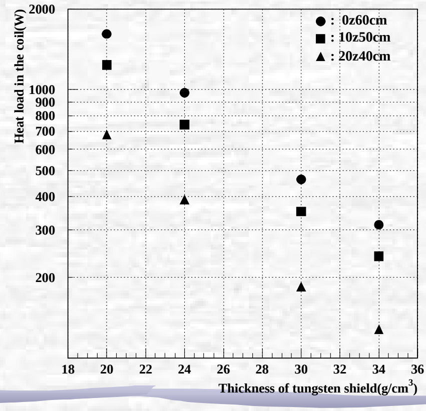


# Solenoid R&D

- High field superconducting solenoid magnet
  - a test magnet
  - 11T hybrid magnet ($Nb_3Sn$, NbTi)

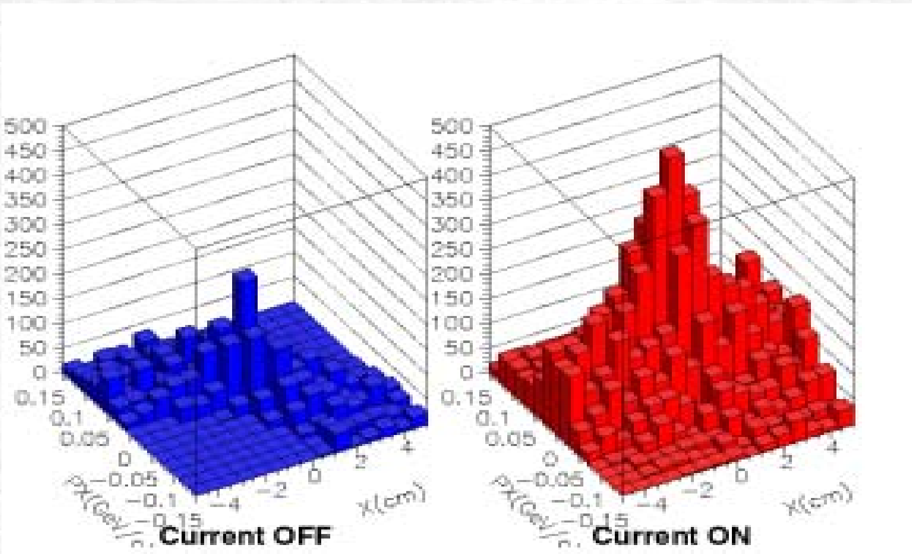


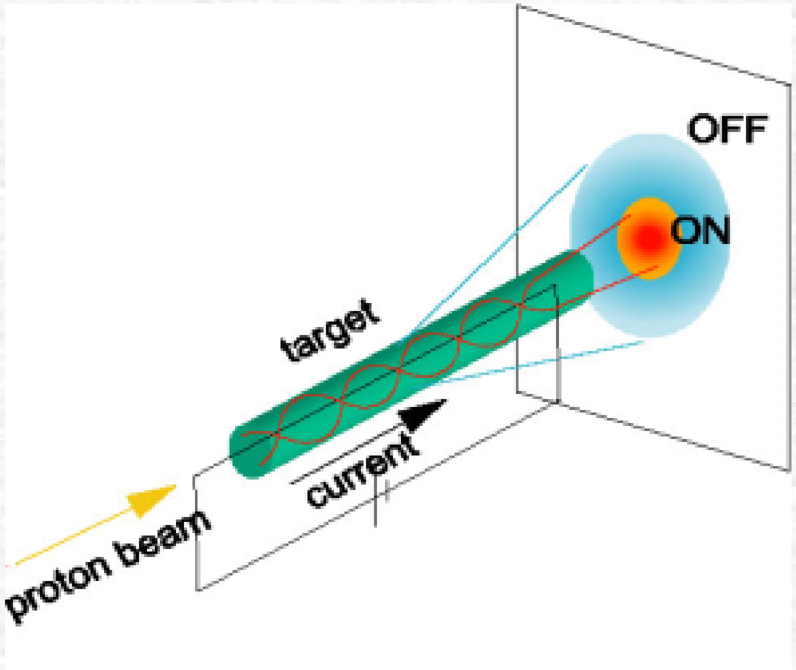


# Conducting Target

- Small emittance pion beam



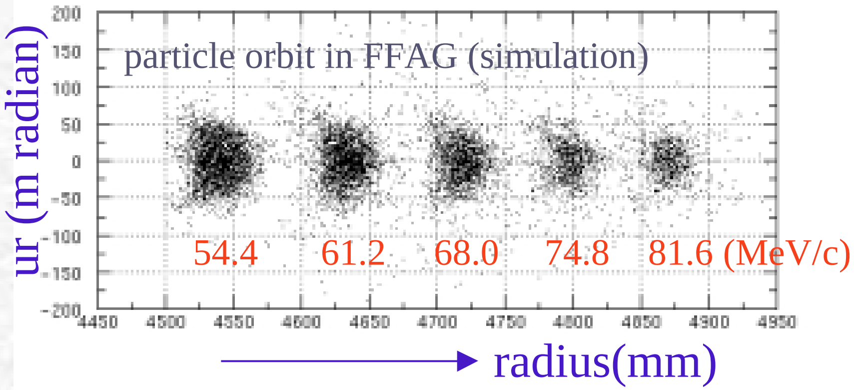
# FFAG for Phase Rotation

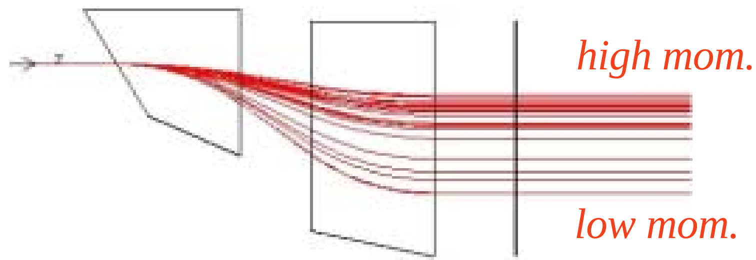
*Fixed Field Alternating Gradient Synchrotron*

- synchrotron oscillation for phase rotation
  - not cyclotron (isochronous)
- large momentum acceptance
  - larger than synchrotron
  - ± several 10 % is aimed
- large transverse acceptance
  - strong focusing
  - large horizontal emittance
  - reasonable vertical emittance at low energy

# Injector to FFAG Ring

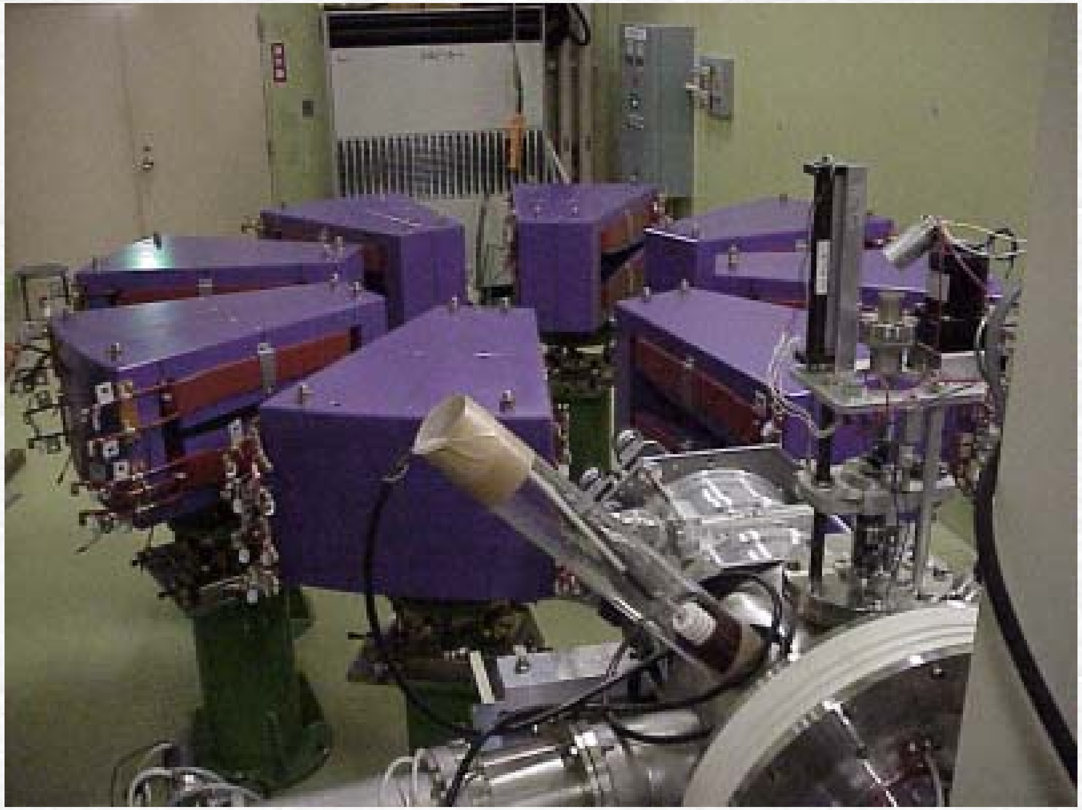
- **FFAG has large momentum acc.**
  - Outer region :
    - High mom. particle
  - Inner region :
    - Low mom. particle
- **Dispersion matching is required**




Double bend magnets injector

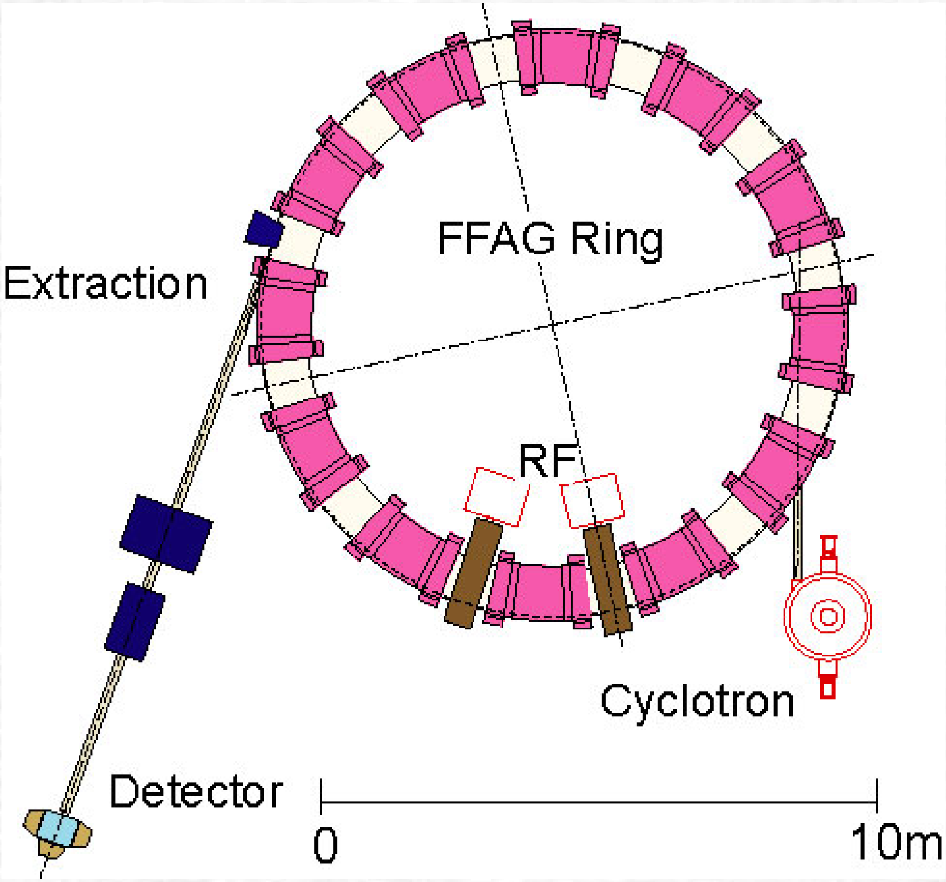
# FFAG R&D (1)



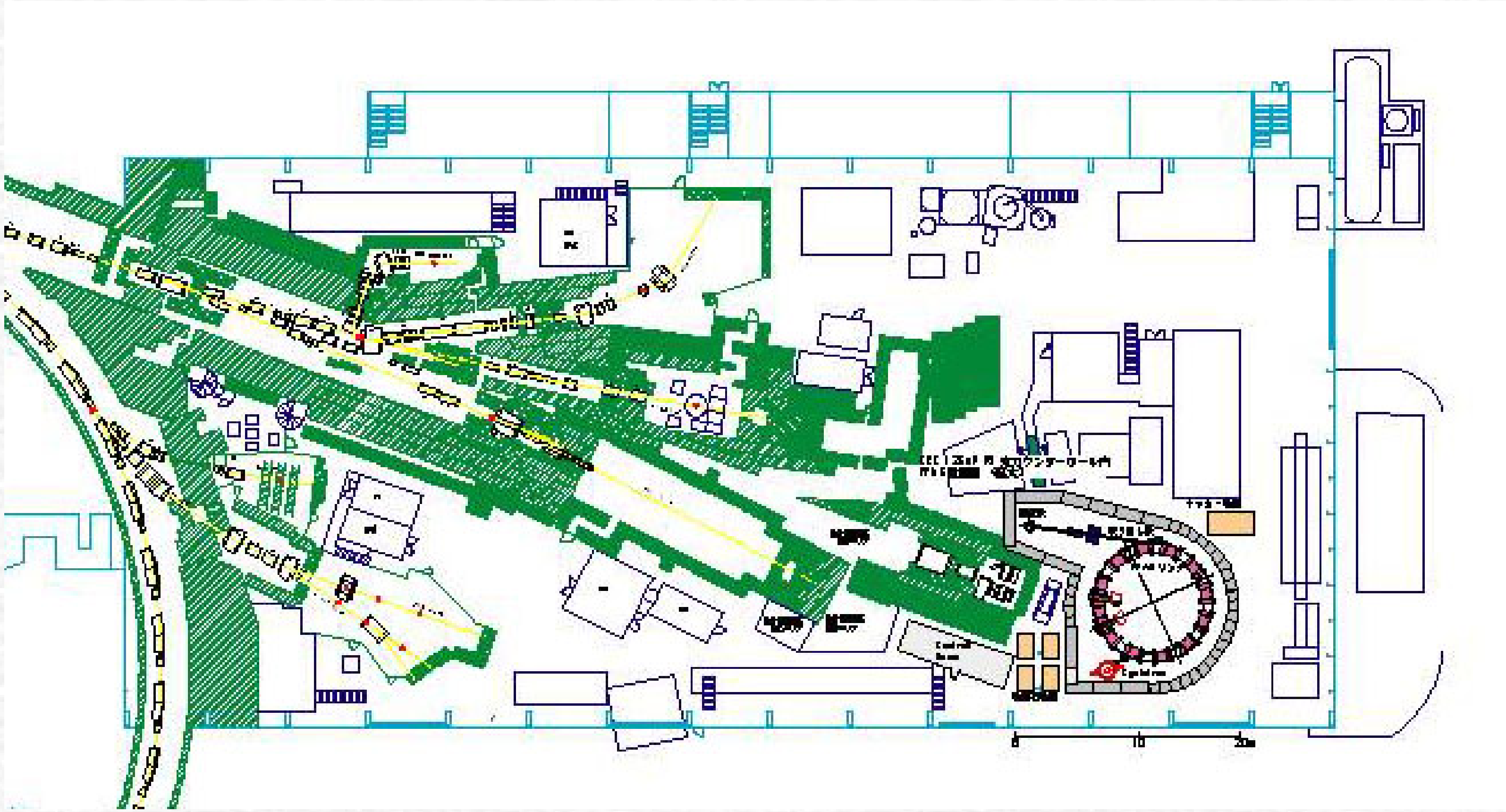
- Proton FFAG POP Machine
  - the first proton FFAG in the world
  - 500 keV acceleration

# FFAG R&D (2)

- **Proton FFAG Machine in construction**
  - 150 MeV acceleration
  - R&D for injection and extraction

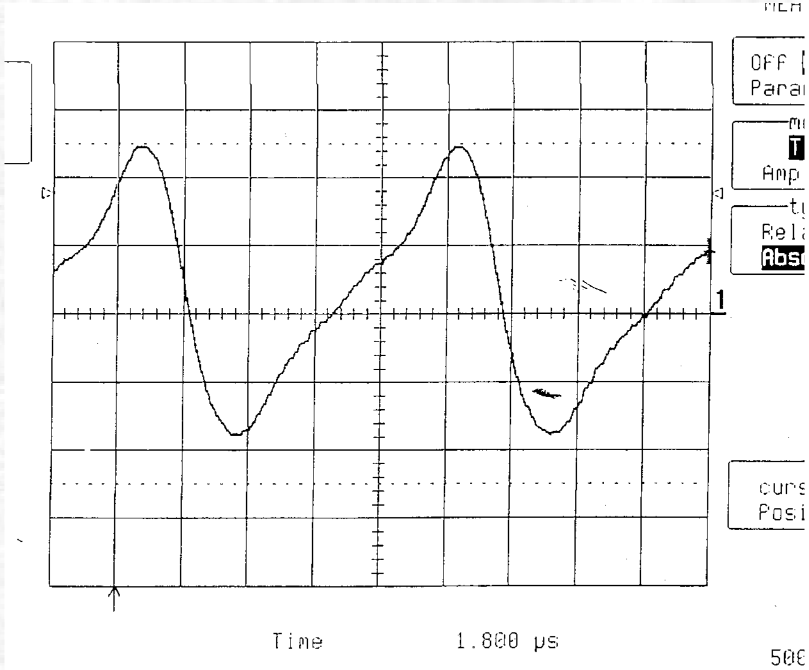


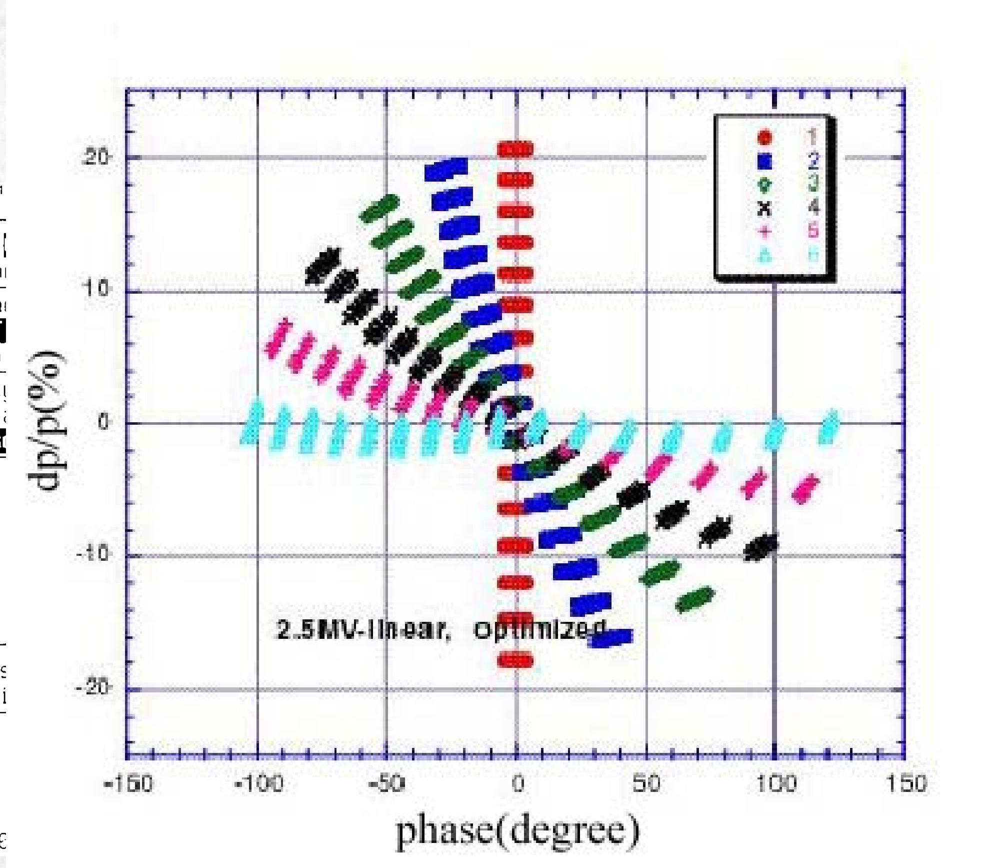
# 150MeV FFAG at E-Hall



# Phase Rotation Simulation

- in case of saw-tooth wave rf



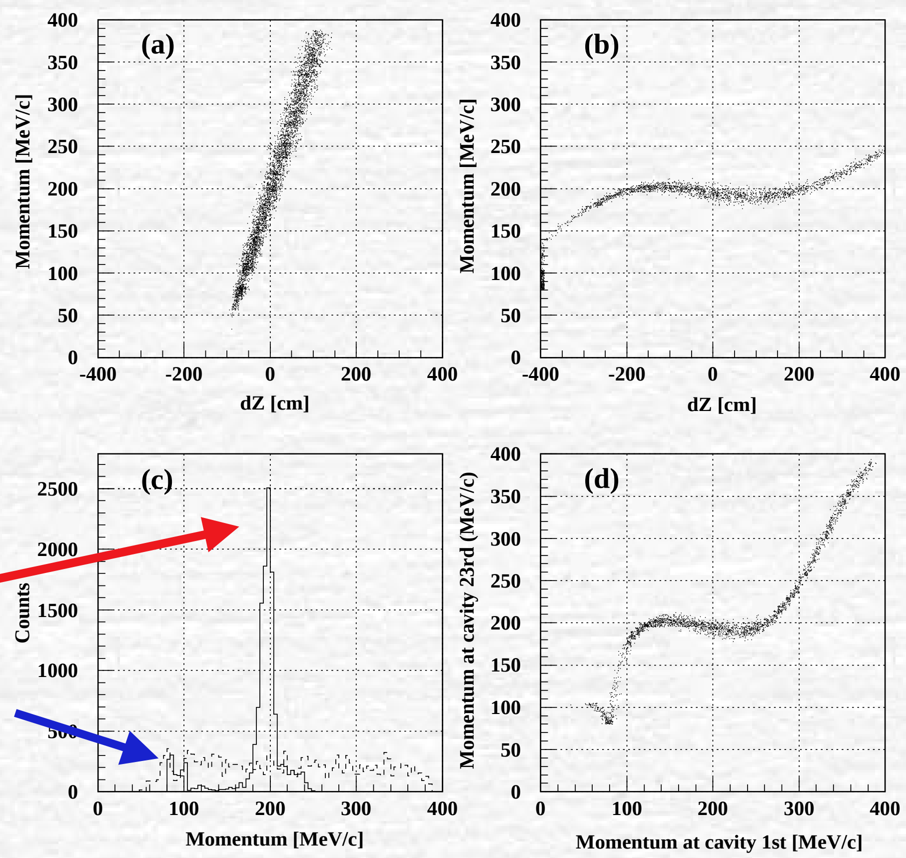



# Phase Rotation Simulation

- Phase rotation realize the narrow energy spread muon beam

after phase rotation

before phase rotation



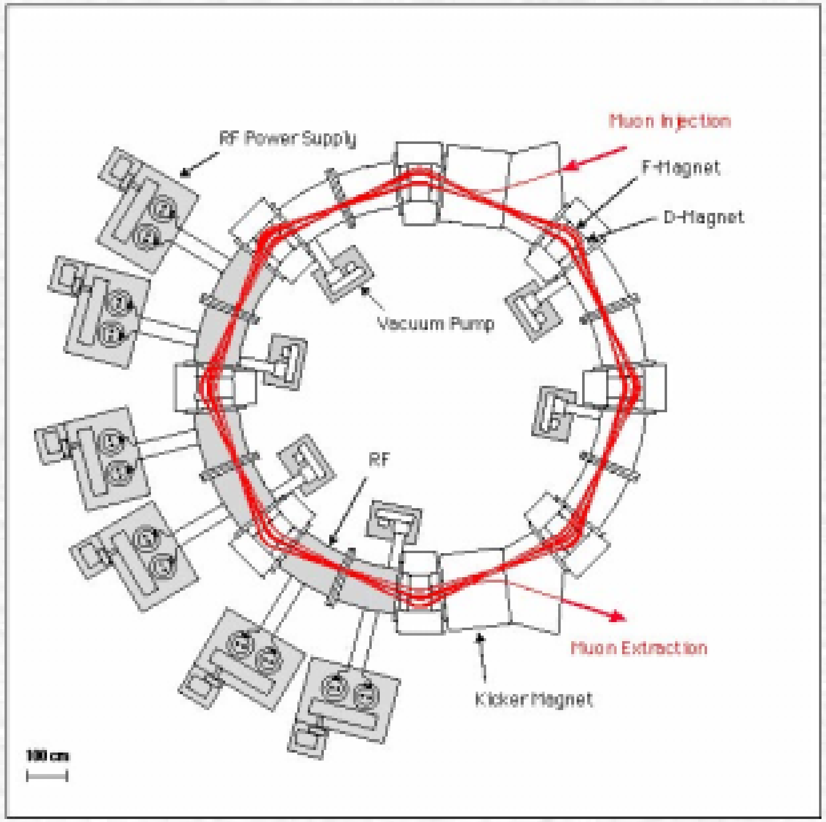
# PRISM Phase Rotator

- 3D tracking simulation is studied to get realistic layout
- Applied budget to a funding agency with 6RFs
- 2002-2006

Construction Full Scale Prototype and Study

- Acceptance
- Phase rotation

⇨ **PRISM Phase Rotator**




Layout of the prototype phase rotator

# Muon Yield Estimation

- **muon yield**

  **0.005 - 0.01$\mu^{\pm}$/proton**

  in 20 MeV±(0.5-1.0)MeV range

  **$10^{14}$ proton/sec**

  **at the 50-GeV PS**

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

- **$P_T$<90 MeV/c**

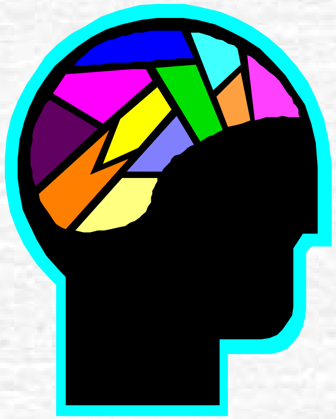
(12T 5cm radius) at pion capture

- **10000π mm・mrad**
- Horizontal acceptance
- **3000π mm・mrad**

vertical acceptance of FFAG

# Application List with PRISM

- Particle, Nuclear Physics
  - Lepton flavor violation
    - **$\mu e$ conversion**,
    - $\mu^+ \mu^-$ conversion
  - $\mu$ life time
  - g-2
- Material Science
  - Muonic X-ray, $\mu$ sR
- Archeology
- Life science
  - Living cell
  - Brain scan



# Summary

- **PRISM** is a high-intensity low energy muon source with narrow energy spread and less contamination.
- Many simulation and R&D are studying to get realistic design…

  toward to construct PRISM in 2007!