FFAG construction for PRISM

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PRISM
Phase Rotated Intense Slow Muon source

- secondary muon beam channel with high intensity
  - Superconducting Solenoid Magnet
  - narrow energy spread
  - High purity
  - Phase rotation
dedicated for the stopped muon experiments.

- intensity: $10^{11}-10^{12}/\text{sec}$
- 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 advantages:

- synchrotron oscillation
  - necessary to do phase rotation
- large momentum acceptance
  - necessary to accept large momentum distribution at the beginning to do phase rotation
- large transverse acceptance
  - muon beam is broad in space

A budget for the PRISM-FFAG has been approved!
FY2003-FY2007
Construction of the PRISM-FFAG
We will construct a full size PRISM-FFAG

Only 1 RF cavity and 1 kicker will be constructed. Future budget -> Other RFs and kicker to upgrade to the full spec.

- To demonstrate
  - Phase rotation
  - Muon acceleration
  - (Muon ionization cooling)

- R&D components
  - RF with high
    - 5MHz, 250kV/m
  - Large aperture Magnet
    - multi coil
Proton Synchrotron RF System

PRISM Cavity

J-PARC Cavities
(High Duty)
Ferrite Cavities

Field Gradient (kV/m)

Frequency (MHz)
MA (Magnetic Alloy) Cavity
for high field gradient (~300kV/m) at 5MHz

- MA will be used for J-PARC synchrotron RF cavities
- Characteristics of MA
  - Thin Tape, 18 μm
  - High Field Gradient
    - Voltage limit: Brf < Bsatz (1T) and Voltage per layer < 5 V
  - High Curie Temperature
  - Large core, Rectangular Shape
  - Large permeability (about 2000 at 5MHz)
  - Original Q value is small (0.6)
  - High Q is possible by cut core configuration
  - Thickness -35mm (50mm in future)
High Gradient Cavity

Ferrites

Magnetic Alloys

B = V/\[S\] = 25kV/2pX5MHzX5cmX40cm = 400 Gauss

250kV/m 4gap 5MHz
MA Cavity using Cut Core

- Low Q=large inductance
  vs. Resonant frequency = 5MHz
  vs. RF power for 250kV/m
  - Resonant capacitance > 50-100 pF by structure
  - Large inductance in case of no cut MA (not good).
    - Can be reduced by using cut core

- Solution
  - Q=1 at 5MHz with Cut Core (1.5mm gap)
    - C=100pF and Rp=500 W/gap
    - Or C=50 pF and Rp=1 kW/gap
    - To obtain 40kV/gap, 800kW is necessary.

Measured using a core for J-PARC cavity
Need a model cavity to confirm.
Sinusoidal or Saw-tooth

- RF: 5MHz, 128kV/m
  $\Delta E/E = 20\text{MeV} + 12\%-10\%$

- RF: 5MHz, 250kV/m
  $\Delta E/E = 20\text{MeV} + 4\%-5\%$
# PRISM RF plan

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>Power tube</td>
<td>EIMAC 4CW150K DC35-40kV900-kW(peak)</td>
</tr>
<tr>
<td>Field gradient</td>
<td>62.5- kV/cavity 250- kV/m</td>
</tr>
<tr>
<td>Gaps/cavity</td>
<td>1 gaps, 31.25-kV/gap, 25cm</td>
</tr>
<tr>
<td>Impedance</td>
<td>1k Q/gap 以上</td>
</tr>
<tr>
<td># of cores</td>
<td>4 cores /gap (2.5- 3 cm core)</td>
</tr>
<tr>
<td>Cooling</td>
<td>Air cooling</td>
</tr>
</tbody>
</table>

The image includes a circuit diagram with labels such as drive AMP, Anode PS Clover, and Heater SG. The text references a PRISM RF plan, discussing power tube specifications, field gradient, gap/cavity details, impedance, number of cores, and cooling method.
MA core

MA core for 150MeV FFAG
1.7m x 0.985m x 30mm
**PRISM-FFAG Magnet**

**Pole shape type**
- **merit**
  - Established scheme
  - Easy to design
- **demerit**
  - Has small Gap
    - Acceptance is limited by gap size
  - k-value unchangeable

**Multi coil type**
- **merit**
  - Flat gap, large gap
    - Large acceptance
  - k-value changeable
- **demerit**
  - Not easy to design
  - Needs current control

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**PoP 150-MeV**

**New**

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2003/6/10  
NuFact03@Colombia University
Magnet design is undergoing.
Acceptance Simulations

Horizontal
More than 20,000pi mm-mrad.

vertical
\(~ 3,000\text{pi mm-mrad}\).
Schedule of the PRISM-FFAG construction

- FY2003
  - Lattice design, Magnet design
  - RF R&D

- FY2004
  - RFx1gap construction & test
  - Magnetx1 construction & field meas.

- FY2005
  - RFx4gap tuning
  - Magnetx7 construction
  - FFAG-ring construction

- FY2006
  - Commissioning
  - Phase rotation

- FY2007
  - Muon acceleration
  - (Ionization cooling)

Important first step to Neutrino Factory