FFAG projects status and overview: PRISM

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PRISM Project

- PRISM = Phase Rotated Intense Slow Muon source
- Search for Lepton Flavor Violation
 - N + μ⁻ -> N + e⁻
 - Signal sensitivity : ~10⁻¹⁸
- Muon beam intensity: $10^{11} \sim 10^{12} \mu^{-1}/sec$
- Energy spread : ±2 %





PRISM-FFAG Lattice

- Scaling FFAG
- Radial sector DFD triplet
- Number of cells : 10
- Field index (k value) : 4.6
- Bending (Focus/Defocus) ratio : 6.0
- Momentum : 68 MeV/c ± 20 %
- Equilibrium radius : 6.5 m



Property of PRISM-FFAG

- Transverse acceptance:
 - 38000 pi mm mrad
 - 5700 pi mm mrad
- Momentum acceptance:
 - 68 MeV/c +- 20 %
- Field gradient of RF cavity:
 - ~200 kV/m (2 MV/turn)
- Phase Rotation is finished in 5~6 turn



/home/arimoto/tosca/run/rz/ffag_n10_g15_tr969-fm.4daf.0.0000ezarimoto/tosca/run/rz/ffag_n10_g

Goal of PRISM-FFAG project

- Construct a full size FFAG ring to be used at the mu-e conversion experiment.
 - with Large transverse and Momentum acceptance
 - suitable for the phase rotator
- Develop a high-gradient RF system (~200 kV/m)
- Demonstration of Phase Rotation
 - 10 cell ring ----> 6 cell ring

Status and Schedule

- Development of RF amp system : done.
- Magnet production:
 - 5 magnets produced : done
 - I magnet : summer of this year
- Field measurement and magnetic field analysis: done for 3 magnets and analysis is in progress
- Demonstration of phase rotation with 6 cell ring : 2007
 - RF development for 6 cell ring : 2006-Aug.2007
 - R&D of alpha-ray detector: May. 2007
 - Design and production of injection system: Aug. 2007
 - Design and production of vacuum chamber: Aug, 2007
 - Construction of 6 cell ring : start at Sep. 2007?
- Beam dynamics study using I cell magnet : in progress, finish in Sep. 2007

R&D status



RF AMP R&D



RF acceleration test

- Measurement of energy modulation of alpha particle passed I RF gap
 - PRISM RF amp system
 - Dummy cavity with MA cores
- Purpose
 - Pilot study of 6 cell phase rotation
 - R&D of detector near RF noise
 - R&D of kicker injector
 - Generation of Sawtooth wave form



R&D of alpha particle detector

- Detector : Solid State Detector (SSD)
- Study effect of noise from RF Field to SSD.
- Energy resolution of ~50 keV is required while RF power is turned on.



Energy resolution of detector



• Energy resolution of 38 keV is achieved with RF on.

This energy resolution is sufficiently good.

In 6 cell experiment, detector will be located farther away from RF cavity than this experiment. The energy resolution become smaller than this value.

RF cavity for 6 cell ring

- To test bunch rotation using alpha beam
 - Low energy, low RF frequency (I MHz)
 - Band width : 3 MHz for saw-tooth (3rd harmonics)
 - ~40 kV is required to observe bunch motion
- Problems
 - Low impedance: 88 $\Omega \times 4 = 352 \Omega$, uncut core
 - Expected voltage: $352 \Omega \times 60 A = 21 kV$
- Solution : use 2 RF amps to drive one cavity.
 - Expected voltage: $352 \times 120 \text{ A} = 42 \text{ kV}$



RF cavity development plan

- Alpha particle acceleration test
 - measurement of Energy vs TOF
 - test of electrostatic kicker
- Generation of sawtooth RF field
 - until 3rd order higher harmonics
- Increase of duty factor : air cooling system
- Long term operation (a few days)
- Generation of RF with PRISM-FFAG MA core

PRISM-FFAG Magnet

- Five magnets have been produced.
- one magnet will be constructed in 2007
- Magnet
 measurements for
 three magnets have
 been finished.



Measured Result



Beam dynamics study with I cell magnet

- Purpose : experimental beam dynamics study at large amplitude = study of nonlinear behavior
- Method : determine transfer map from measured phase space of alpha particle at inlet of a magnet and at that of outlet.

$$x_{i} = \sum_{j=1}^{2} R_{ij} x_{j}(0) + \sum_{j=1}^{2} \sum_{k=j}^{2} T_{ijk} x_{j}(0) x_{k}(0) + \sum_{j=1}^{2} \sum_{k=j}^{2} \sum_{l=k}^{2} U_{ijkl} x_{j}(0) x_{k}(0) x_{l}(0) + \cdots$$



Injector and Detector

- Injector : (x_0, x'_0)
 - Alpha particle emitted from RI(241Am) and degraded by a foil.
 - Angle and position is determined by collimator which is downstream setup to degrader
 - Incident angle and position are changed by stepping-motor-control stages.
- Detector: (x_1, x'_1)
 - Position of alpha particle is measured by position sensitive detector and stepping-motorcontrol linear stage
 - Angle is determined from measured position difference when detector position is changed in direction of beam axis.



Selecton of Degrader

- Energy of alpha particle should be degraded from 5,436 keV to 2,481 keV with thin foil.
- Energy spread greatly change with surface roughness.
- Energy spread has been measured with several material to select good surface material



Picture of Apparatus





Injector collimator



6 cell ring study

Demonstration of Phase Rotation

- Construction of 6 cell ring will be start at autumn of 2007
- Alpha-ray from ²⁴¹Am
- Phase rotation of alpha particle is done with one RF cavity
- Pulsed alpha beam is necessary





 α beam incident to SSD after a few turn, energy and time of Flight is measured by SSD.

Alpha-ray injector to 6 cell ring

• Pulsed beam is required to observe phase rotation Kicker electrode Kicker off Median plane Pulsed beam Kicker or with electrostatic kicker • Kicker Electrode will be install to **RF** acceleration test Electrostatic Deflector apparatus Vertical injection Side view of injection kicker Degrader Alpha-ray souce 241 Am under design

Power supply for electric kicker

 \bullet Out put voltage : - 10 kVp \bullet Pulse width :> 0.1 mS (FWHM) \bullet Repetition rate : 5 KHz (5kpps) \bullet Droop : < 3 %</td> \bullet Rise time : 25 nsec (design) \bullet Fall time : 50 nsec (design) \bullet Flat : 60 nsec

•EIMAC (CPI)

Assumed capacity is 10pF or more



- Test electrode is produced.
- Pulse power supply is prepared.
- Will be installed into acceleration test cavity

Summary

- We are planning to demonstration of phase rotation with 6 cell ring
 - Construction of 5 ffag magnet are finished.
 - RF development for 6 cell ring is underway
 - Investigation of Injection system is underway
 - Construction of Ring will start at Sep. 2007
- Beam dynamics study is progress with I cell FFAG magnet.