Development of Ultra-High Field Gradient RF System for PRISM

Y. Kuriyama[a], M. Aoki[a], Y. Arimoto[a], Y. Kuno[a], A. Sato[a], M. Yoshida[a], S. Ninomiya[b], Y. Iwashita[c], C. Ohmori[d] and Y. Mori[d]

[a]*School of Science, Osaka University, Toyonaka, Osaka, 560-0043, Japan*

[b]*Research Center for Nuclear Physics (RCNP), Osaka University, Ibaraki, Osaka 567-0047, Japan*

[b]*NSRF, ICR, Kyoto University, Uji, Kyoto 611-0011, Japan*

[b]*KEK, Oho 1-1, Tsukuba 305-0801, Japan*

Muon is a key particle for elementary particle physics. Lepton flavor violation has been observed in neutral section, namely ν oscillation, but charged lepton flavor violation, such as μe conversion, has not been observed yet. Improving the experimental sensitivity to the muon lepton flavor violation process by a few orders of magnitude would reveal the physics beyond the standard model[1].

PRISM, which stands for Phase Rotated Intense Slow Muon source, is a project to construct a highly intense muon source based on a novel idea of phase rotation in a FFAG synchrotron[2]. It would provide a muon beam having an intensity of about $10^{11\sim12}\mu^{\pm}$/sec, with a narrow momentum width of a few % and no pion contamination. The energy of PRISM muon beam is relatively low (20MeV in kinetic energy), since it is aimed to be used for stopped muon beam experiment in general. Figure 1 shows a schematic diagram of the PRISM. The PRISM consists of (a) a high power pulsed proton driver, (b) a solenoid pion capture system with large acceptance and solenoid magnet transport line, (c) a FFAG ring for phase rotation. A key component of PRISM project is a Fixed-Field Alternating Gradient(FFAG) phase-rotation ring. In the ring, injected muon beam with momentum spread of ±20% will be phase rotated, and the momentum spread will be decreased down to ±2% after $\pi/2$ of synchrotron oscillation. Since the muon is unstable particle (τ=2.2μsec), it is important to phase-rotate as quick as possible in order to save the loss of muon from its decay. Thus, a radio frequency (RF) system is very important for PRISM project. The current design requires RF voltage of 200kV/m, which is almost one order of magnitude higher than that of ordinary synchrotron RF.

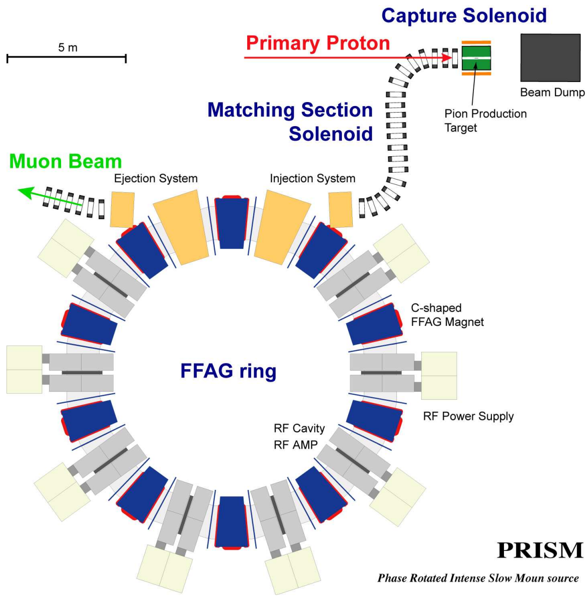

Figure 1: PRISM Layout

PRISM RF was designed to have magnetic alloy (MA) cavity, wide band resonance, tetrode tube, which can be used at the high DC voltage of 40kV[3]. To achieve a high field gradient, the cavity was also designed to have a thin gap, which is 33cm/gap. Parameters of the RF system are summarized in Table 1. Each gap will be driven by push-pull amplifiers using tetrode tubes, 4CW150,000E. The tube can be used at the high DC voltage of 40kV and RF current of 60A is possible to generate. In case of 1kΩ cavity impedance, 60kV will be available as a gap voltage. Tetrode amplifiers are installed either on-the-top of or underneath the cavity to secure the total cavity length being less than 175cm. A low duty factor enables the tubes to generate the maximum RF

Table 1: Parameters of PRISM RF system

Number of gap per cavity	5
Length of cavity	1.75m
Number of core per gap	6
Core material	Magnetic Alloy
Core shape	Racetrack
Core size	1.7m x 1.0m x 3.5cm
Shunt impedance	0.9kΩ/gap @5MHz
RF frequency	∼5MHz
Flux density in core	300 Gauss
Duty	≤0.1%

Table 2: Parameters of PRISM RF Amp

Operating mode of tube	Push-pull
Number of tubes per Amp.	2
Size of Amp.	1.35m x 0.8m x 0.7m
Tetrode	4CW150,000E
Max. RF current	60A
Max. cathode current	50A
Max. plate voltage	40kV
Max. RF power	1.8MW

power of 1.8MW. Parameters of the amplifier system are summarized in Table 2.

A prototype of PRISM RF system, which consists of an amplifier and an anode power supply and an auxiliary power supply, was built and installed in M experimental hall, RCNP, Osaka University. A test cavity and a driver amplifier were provided by JAERI for initial test of the RF system. This cavity consists of ten finemet cut cores whose radius is 900mm and has 8cm gap. The picture of this prototype of the RF system is shown in Figure 2, and the RF amplifier is shown in Figure 3.

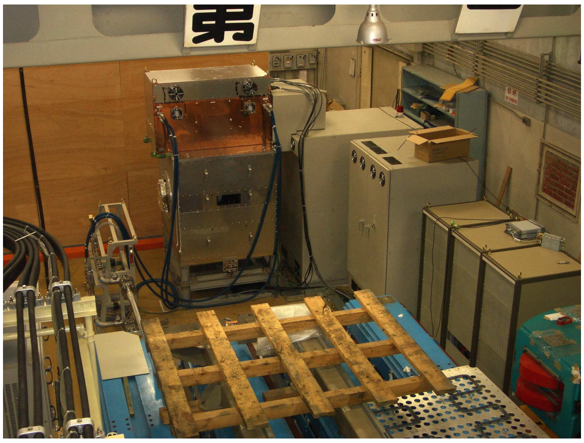

Figure 2: M experimental hall, RCNP, Osaka University

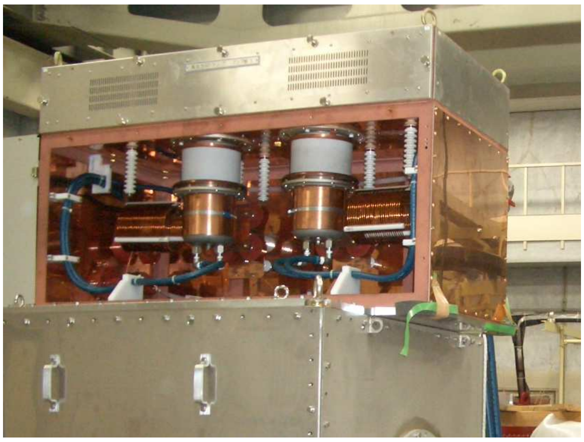

Figure 3: PRISM RF Amp.

A series of tests for the RF amplifier system with the test cavity had started in the spring of 2004. We obtained over 40kV gap voltage at 5MHz frequency with 700Ω cavity impedance. Figure 4 is an oscilloscope picture at the time when we obtained 43kV gap voltage. We also made a endurance test with 100Hz pulse operation (30μsec burst length), and verified its stable performance over 12 hours. An ultra-thin PRISM RF test cavity had been designed and now under construction. This cavity includes a single gap and consists of six MA cores, and whose size along the beam direction is 33cm. Figure 5 shows a design of this cavity. The overall system test with this realistic cavity will be performed in the spring of 2005.

References

[1] Letter of Intent for J-PARC, An Experimental Search for the $\mu^- - e^-$ Conversion Process at an Ultimate Sensitivity of the Order of 10^{-18} with PRISM, contact person Y. Mori, K. Yoshimura, N. Sasao.

[2] Letter of Intent for J-PARC, The PRISM Project - A Muon Source of the World-Highest Brightness by Phase Rotation -, contact person Y. Mori, K. Yoshimura, N. Sasao, Y. Kuno.

[3] C. Ohmori et al., Ultra-High Field Gradient RF System for PRISM-MUON Bunch Rotation, proceedings of SAST03.

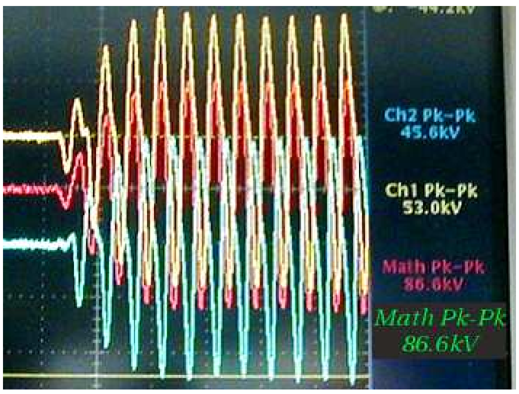

Figure 4: Osiloscope picture at RF amplifier test

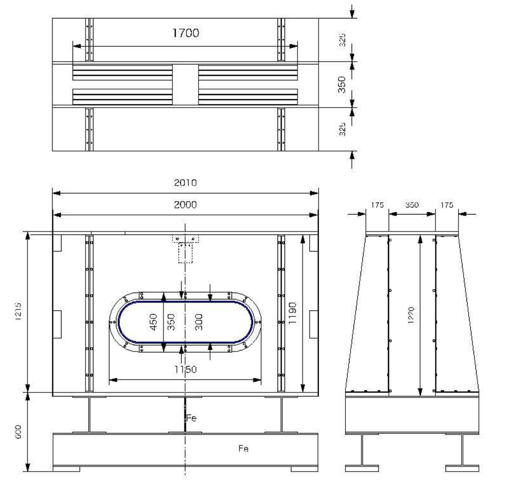

Figure 5: Ultra-thin PRISM RF Test Cavity