A MUON COOLING RING WITH CURVED LITHIUM LENSES

Yasuo Fukui[#], David Cline, Alper Garren, Physics and Astronomy Dept., UCLA, California, USA
Harold Kirk, BNL, Brookheaven, New York, U.S.A.

Abstract

We design a muon cooling ring with curved Lithium lenses for the 6 dimensional muon phase space cooling. The cooling ring can be the final muon phase space cooling ring for a Higgs Factory, a low energy muon collider.Tracking simulation shows promising muon cooling with simplified magneti element models.

INTRODUCTION

We have designed a muon phase space cooling ring with straight Lithium lenses and bending sections with edge focusing dipole magnets.[1] Figure 1 shows a schematic diagram of a muon coolin ring with straight Lithium lenses and beta function and dispersion as a function of z in a half ring. The circumference of the ring is 42 m, and the length of the one Lithium lenses is 34.5 cm which includes the matching Lithium lens section. The minimum β in the Lithium lenses is 1.0 cm.

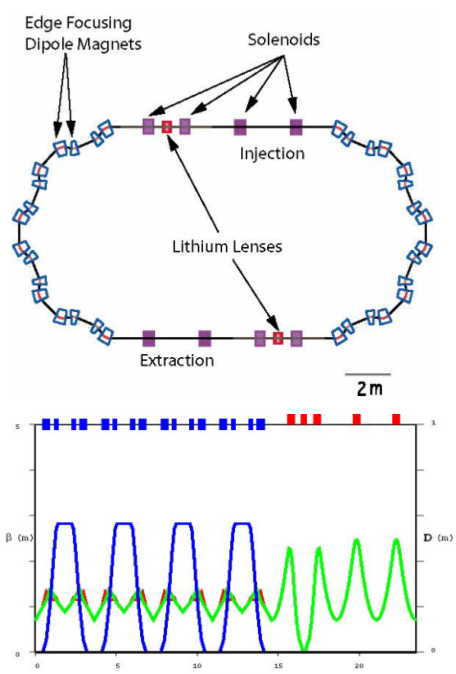

Figure 1: A schematic diagram of a muon cooling ring with straight Lithium lenses and beta function and dispersion as a function of z in a half ring.

In tracking simulation with ICOOL code, we demonstrated the equilibrium normalized transverse emittance around 300 mm*mrad. But there was no mechanism to stop the growth of the normalized longitudinal emittance.

Figure 2 shows normalized transverse emittance (top) and transmission (bottom) as a function of z. Figure 3 shows normalized longitudinal emittance, ΔP/P, and Δz as a function of z.

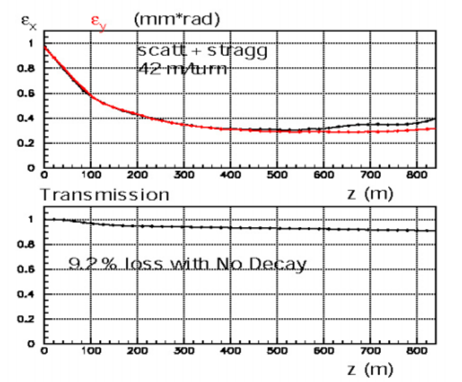

Figure 2: normalized transverse emittance (top) and transmission (bottom) as a function of z

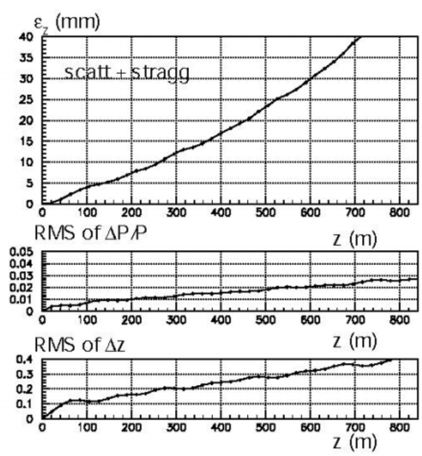

Figure 3: normalized longitudinal emittance, ΔP/P, and Δz as a function of z.

CURVED LITHIUM LENS RING

In order to realize the emittance exchange between longitudinal and transverse emittance, we developed a toy model of curved Lithium lenses without realistic RF gaps to restore the energy loss of muons going through liquid Lithium, which is an energy absorber.

Figure 4 shows a schematic diagram of a toy muon ring cooler which is made of curved Lithium lens with a diameter of 2 cm. The ring circumference is 1.0 m. Muons are kicked in going through four gaps which simulates the function of RF cavities. The average enrgy loss through each quarter of the Curved Lithium ring is compensated through the gaps.

[#]fukui@slac.stanford.edu

 0-7803-8859-3/05/$20.00 ©2005 IEEE

This toy model should function as a 6 dimensional muon phase space cooling ring for it has the low beta function through the ring, dispersion due to the ring structure, and the energy compensation through the gaps. 250 MeV/c muons are used in this tracking simulation.

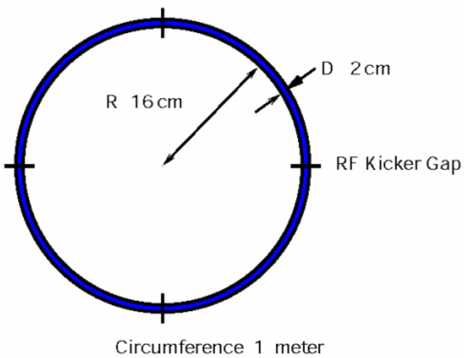

Figure 4: A curved Lithium lens ring

Figure 5 shows the horizontal(top) and vertical(bottom) normalized emittance as a function of z. At z=0 the muon beam is cold, the phase space is zero in 6 dimension. The normalized enittance developed to reach 100 mm*mrad in horizontal, and around 80 mm*mrad in vertical. There exists slight dependence of the equilibrium emittance on the RF cavity frequencies, as shown in the figure.

Figure 6 shows the transmission (top) and longitudinal normalized emittance(bottom) as a function of z. Transmission without decay is as high as around 99% which is expected with the simple toy model of the curved Lithium lenses. Growth of the normalized longitudinal emittance is not as fast as that with the Straight Lithium lend ring cooler which is shown in Figure 3.

Figure 7 shows the ΔP/P and RMS of Δz as a function of z in the curved Lithium ring. With the RF frequency at 10 MHz, the beam Δz seems to grow, which causes larger growth of longitudinal emittance, as shown in the bottom figure of Figure 6.

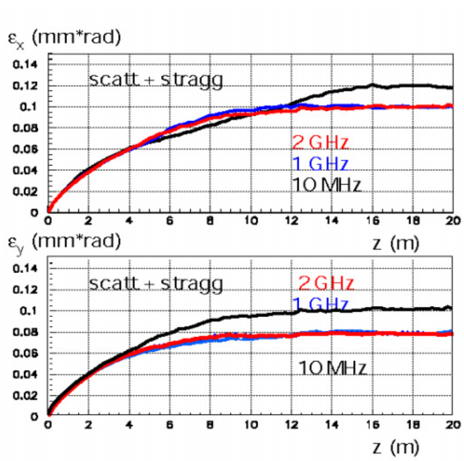

Figure 5: Horizontal(top) and vertical(bottom) normalized emittance as a function of z.

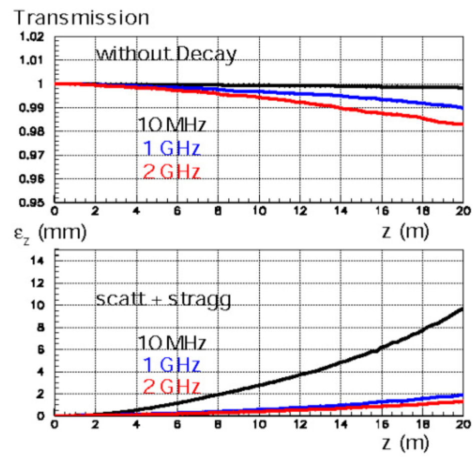

Figure 6: Transmission (top) and longitudinal normalized emittance(bottom) as a function of z.

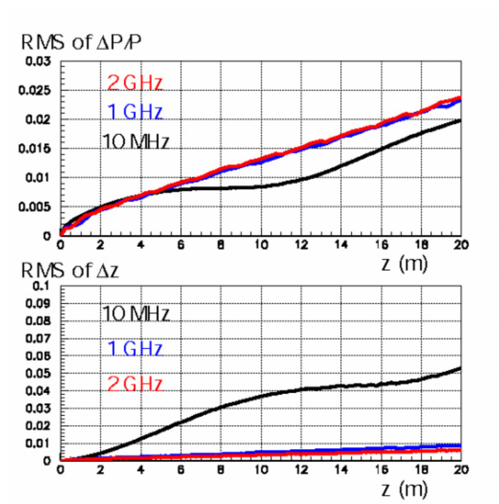

Figure 7: ΔP/P and RMS of Δz as a function of z

Tracking simulation is going to be performed with the initial muon phase space larger than those normalized equilibrium emittance in order to demonstrate the 6 dimensional muon phase space cooling. The RF cavity gaps which gives p_z kick to muons must be expanded to a set of matching solenoid coils, RF cavities and drift spaces, in order to make the cooling ring with curved Lithium lenses more realistic.

CONCLUSION

We designed a toy model of a curved Lithium lens ring for the 6 dimensional muon phase space cooling. The horizontal normalized equilibrium emittance is around 100 mm*mrad, and the vertival normalized equilibrium emittance is around 80 mm*mrad, which is expected by the balance of heating, due to multiple Coulomb scattering, and the ionization transverse cooling. The longitudinal normalized emittance grows up to 0.5 mm after 10 turns, but the growth is much smaller than that in the muon cooling ring with straight Lithium lenses where it grows up to 15 mm after 10 turns.

We need design the more realistic model of the muon cooling ring with curved Lithium lenses by adding matching solenoid sections, RF cavities and drift spaces.

REFERENCES

[1] Y. Fukui, “Progress in Designing a Muon Cooling Ring with Lithium Lenses,”
Proceedings of the 2003 Particle Accelerator Conference, Portland, Oregon, May ,2003.

 0-7803-8859-3/05/$20.00 ©2005 IEEE