OPTIMIZATION OF AGS POLARIZED PROTON OPERATION WITH THE WARM HELICAL SNAKE*

J. Takano#, M. Okamura, RIKEN, Saitama, Japan
L. Ahrens, M. Bai, K. A. Brown, C. J. Gardner, J. W. Glenn, H. Huang, A. U. Luccio, W. W. MacKay, T. Roser, S. Tepikian, N. Tsoupas, BNL, Upton, NY 11973, U.S.A.
T. Hattori, TITech, Tokyo, Japan

Abstract

The normal conducting helical dipole partial Siberian snake (warm snake) has been installed in the AGS at BNL. The polarized proton threw the warm snake but it is not perfectly because the warm snake has some hardware error which cause beam offset and deflection angle. This paper reports the measured proton beam orbit in the AGS with the warm snake.

INTRODUCTION

The polarized proton has been accelerated without depolarizing in the RHIC with operating full two Siberian snakes in each ring for overcoming all depolarizing resonances. However the AGS is bottle neck of the polarization because there is not enough length of straight section for the full Siberian snakes. The 5% (9 degrees) solenoidal partial Siberian snake had been used for overcoming the all imperfection resonances, but this solenoidal magnetic field causes the transverse coupling resonances [1]. The warm snake was designed as same snake strength (5%) but the structure is helical dipole for not causing the transverse coupling resonances [2]. The polarization at the extraction energy of the AGS has been improved from 40% to 50% with using the warm snake instead of the solenoidal snake. The warm snake in the AGS and the pole face of the warm snake are shown in Fig. 1 and 2.

Figure 1: Warm snake in the AGS.

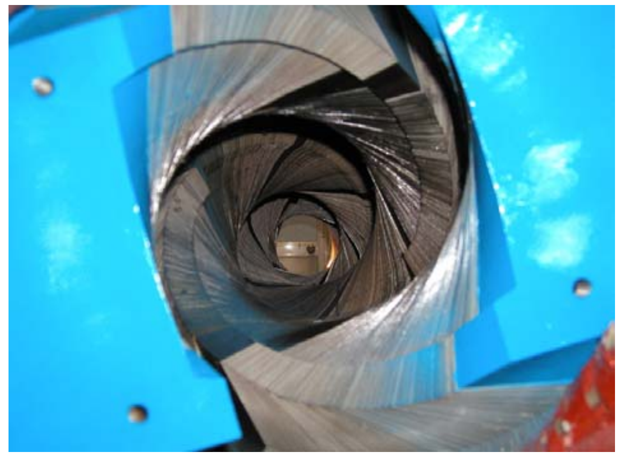

Figure 2: Helical dipole structure.

DESIGN AND HARDWARE ERROR

The warm snake had been designed with simulating the magnetic field by using OPERA-3D/TOSCA [3]. The design of the warm snake is based on the AGS cold snake [4]. The warm snake has double helical pitch structure as rapid pitch section in both end regions and slow pitch section in center region. These lengths and pitches are optimized as the proton beam having no deflection angle and offset at the extraction of the warm snake. The length of the rapid pitch regions are 39cm and the pitches are 90cm/rev. The length of the slow pitch is 132cm and the pitch is 185cm/rev. The simulation model of the warm snake is shown in Fig. 3.

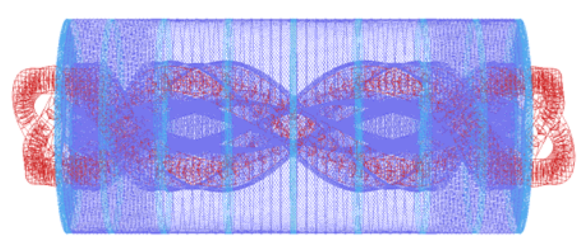

Figure 3: Simulation model of the warm snake

The operating current had been optimized too as 2671A. The calculated proton trajectory which was optimized is shown in Fig.4.

*Work supported by U. S. DOE and RIKEN Japan
#magnet@riken.jp

0-7803-8859-3/05/$20.00 ©2005 IEEE

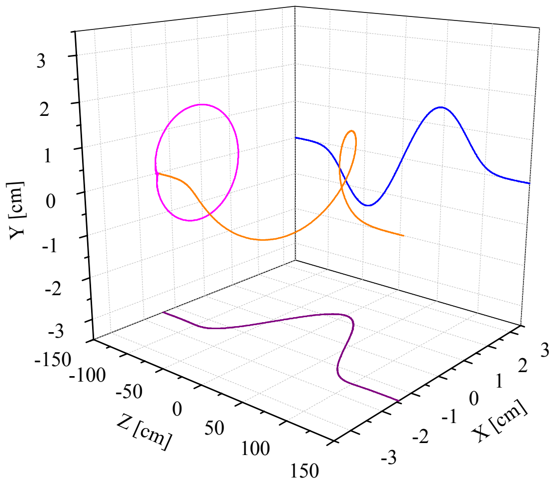

Figure 4: Trajectory of the 2GeV proton beam in the calculated magnetic field of the warm snake.

However the warm snake has some hardware errors which are the end pole plates are bending outer and the packing factor of the lamination steels are reduced by the bending. The beam orbit had been calculated with adjusting the operating current and putting shims on each end plate as the error estimated simulation model [#]. The proton beam could through the warm snake with the operating current as between 2640A and 2700A.

BEAM MEASUREMENTS

The proton beam orbits had been taken with turning the warm snake on as 2700A and off. The differences of the warm snake as "on – off" are plotted to find out the effect of the warm snake to the beam orbit. The plots are shown in Fig. 5 and 6. The location of the warm snake is the straight section between E20 and F1 AGS main dipole magnets.

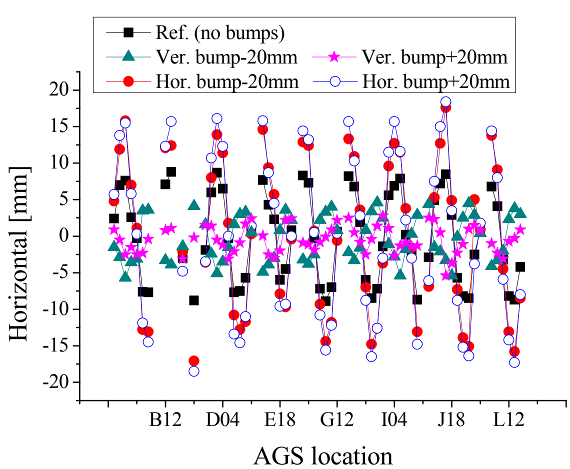

Figure 5: Horizontal orbit in the AGS with horizontal and vertical bumping.

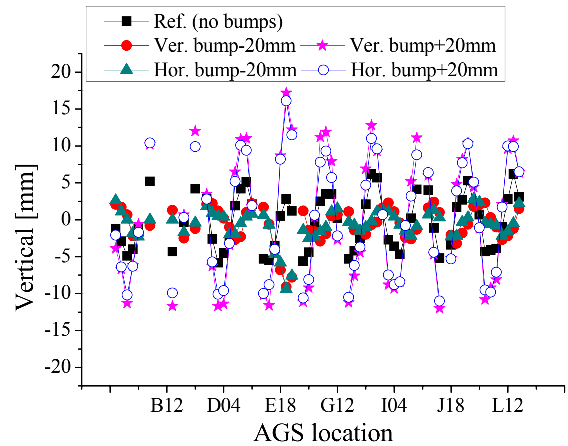

Figure 6: Vertical orbit in the AGS with horizontal and vertical bumping.

The ideal condition for the AGS beam orbit is no difference with warm snake on and off but only tilting the spin axis. However the Fig. 5 and 6 show that there are some differences of beam position with the warm snake on and off. It means the warm snake has some deflection angle and offset. The income beam position at injection of the warm snake is adjusted from -20 mm to 20 mm for reducing the differences and the plots are also shown in Fig.5 and 6.

Fig. 5 says that both of positive and negative vertical bumping is good for horizontal orbit but in other hand the both of positive and negative horizontal bumping makes the horizontal beam orbit worse. Fig. 6 means the horizontal and vertical negative bumping makes the vertical beam orbit better.

We took some measurement data of current dependence of the beam orbit. The plots are shown in Fig. 7 and 8.

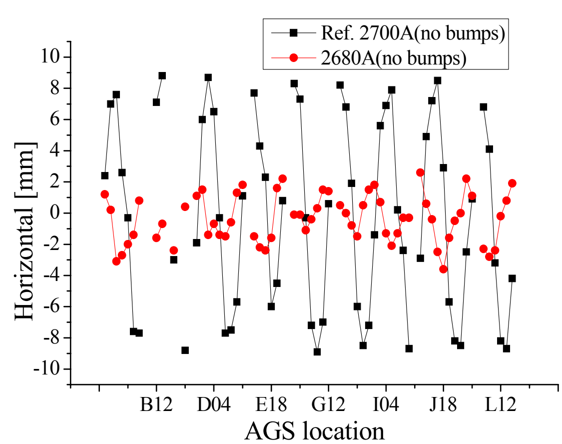

Figure 7: Current dependence of the horizontal orbit.

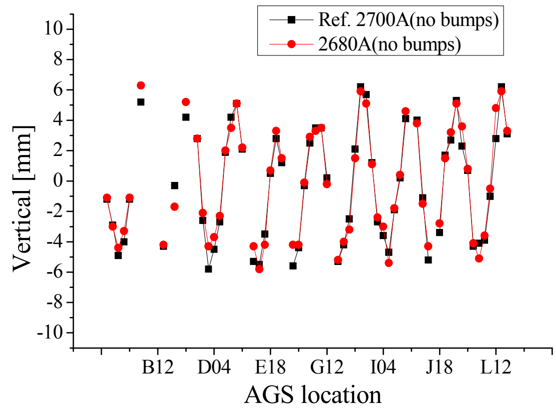

Figure 8: Current dependence of the vertical orbit.

The horizontal orbit is sensitive to the operating current and the orbit is better with lower current. The vertical orbit is not so sensitive and the orbit is little worse. Fig.6 and 8 mean that the adjusting the beam orbit with handling the bumping is more effective for vertical orbit.

The beam orbit data with 2680A and vertical bumping to negative are shown in Fig. 9 and 10.

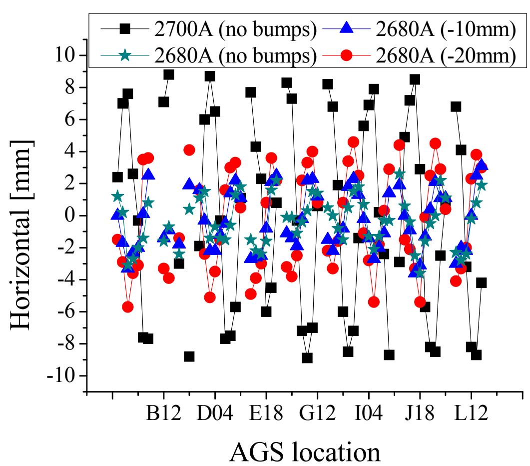

Figure 9: Horizontal beam orbit with 2680A and vertical bumping (Reference orbit is 2700A and no bumps).

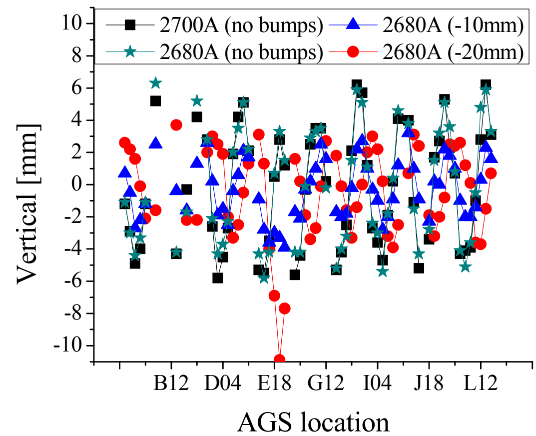

Figure 10: Vertical beam orbit with 2680A and vertical bumping (Reference orbit is 2700A and no bumps).

The both of horizontal and vertical beam orbit are minimized as between +-4mm with same condition as 2680A and -10mm vertical bumping.

CONCLUSION

Some AGS beam orbits with warm snake on and off had been taken and analyzed. The operating current and income beam offset make the warm snake effect to the orbit reduced. This RUN5 study made the orbit better than RUN4 because the warm snake had been operated as 2700A and no bumping in RUN4. This study would be helpful for the new AGS superconducting cold snake which has been installed in the AGS [5]. This cold snake has 2 trim coils inner the helical coil for correcting the beam orbit. The effect of the cold snake to the beam orbit should be smaller than the warm snake. The AGS has commissioning to operate the cold snake with the warm snake in this RUN5 for getting higher polarization at extraction of the AGS and the spin mismatch at injection and extraction of the AGS would be reduced with operating the warm snake and the cold snake [6].

REFERENCES

[1] W. W. MacKay, et al., “Spin dynamics in AGS and RHIC”, Proc. PAC03 (2003) 405
[2] J. Takano, et al., “Field measurement in the AGS warm snake”, Proc. EPAC2004 (2004) 2116.
[3] Vector Fields Inc.
[4] M. Okamura, et al., “Design study of a partial snake for the AGS”, Proc. EPAC2002 (2002), 2421.
[5] H. Huang, et al., “Acceleration of Polarized Protons in the AGS with Two Helical Partial Snakes”, FPAE014, these proceedings.
[6] T. Roser, et al., “Acceleration of Polarized beams using multiple strong partial Siberian snakes”, Proc. EPAC2004, (2004) 1577

0-7803-8859-3/05/$20.00 ©2005 IEEE