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STATUS OF AC DIPOLE PROJECT AT RHIC INJECTORS FOR POLARIZED ^{3}He, UPDATE

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Abstract

An ac dipole will be used for the efficient transport of polarized ^{3}He in the AGS Booster as it is accelerated to $|G\gamma| = 10.5$. The ac dipole produces coherent vertical beam oscillation for preservation of polarization by full spin flipping through the two intrinsic resonances: $|G\gamma| = 12 - \nu_y$ and $|G\gamma| = 6 + \nu_y$. The AGS Booster ac dipole will be tested with protons crossing the $|G\gamma| = 0 + \nu_y$ intrinsic resonance, which has ac dipole requirements similar to polarized ^{3}He crossing the $|G\gamma| = 12 - \nu_y$ resonance and provides a convenient proof of principle. Beam dynamics studies are planned for late 2019 and polarized proton experiments in early 2020. Part of this upgrade include magnets that will also be used by the vertical and horizontal tune kickers, providing higher kicker strength for tune measurements at higher rigidities. This paper gives a status of the project.

INTRODUCTION

Polarized ^{3}He collisions are a part of future physics programs for RHIC and the EIC. Due to the higher anomolous magnetic moment of ^{3}He in comparison with protons, ^{3}He will cross several intrinsic resonances in the AGS Booster as it is accelerated to $|G\gamma| = 10.5$ [1–3]. To preserve polarization through these resonances, an ac dipole has been designed for installation in July 2019. An ac dipole preserves polarization through intrinsic resonances by driving large amplitude betatron oscillations in phase with the betatron motion, which causes all particles to sample the strong horizontal quadrupole fields [4]. As a results, spin of all particles is flipped and polarization is preserved.

The increased length of the horizontal kick magnet will provide a kick strength 1.7 times stronger than the previous magnet. The increased length of the vertical kicker will provide a kick at 4 times the strength. The vertical kick magnet will be shared between the ac dipole system and the vertical tune kicker system, the mode will be controlled by relays. This will allow tune measurements at the maximum rigidity of the booster, 17.5 T · m. A cross section of the vacuum assembly is shown in Fig. 1.

PROJECT STATUS

The installation is planned during the RHIC maintenance period of 2019. Beam dynamics studies will occur in the fall of 2019 with ions from EBIS [3]. Polarized protons will be available from LINAC in late 2019 to allow spin studies. These studies include: measuring the coherent motion of the bunch, scanning the resonance proximity parameter, spin flipping protons through the $|G\gamma| = 0 + \nu_y$ resonance.

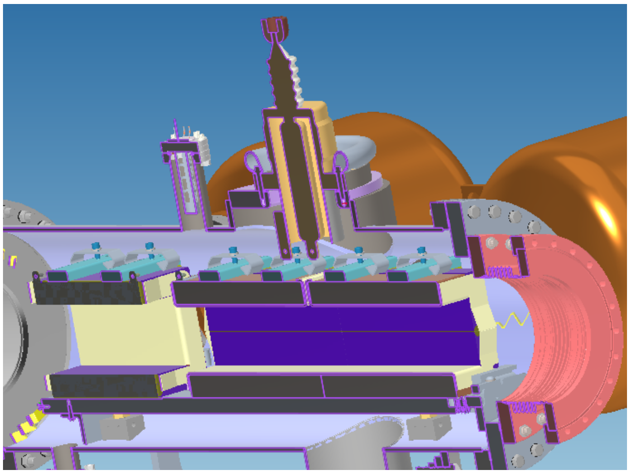

Figure 1: Cross section of the vacuum assembly design.

The completed magnets have been assembled, shown in Fig. 2. The ac dipole magnet's measured inductance is L=661 nH with a quality factor, Q=125. It's designed to deliver a 25 G · m kick at 322 A. At 250 kHz the reactive power is 53.9 kVAR yielding an instantaneous power of 431W (for Q=125). During polarized ^{3}He operation the ac dipole will be triggered twice (for the two resonant crossing) for four AGS booster cycles over a four second super cycle, yielding a 0.72% duty cycle. At this duty cycle the average magnet losses in the vacuum will be 3 W. Initial worst case calculations, that assumed all losses in the vacuum, were done for Q=27; the resulting 14 W loss raised concerns over possible ferrite outgassing due to heating. As a result of the much lower expected magnet losses, vacuum spoiling due to ferrite outgassing is no longer a concern. Since the magnet inductance is so very low, the total ac dipole inductance and losses will be largely determined by the stray inductance and ac resistance of the interconnections of the vacuum feedthrough and termination box. These will be measured once the termination box is assembled.

The Booster Gauss clock will be used to trigger the ac dipole, the raw signal shown in Fig. 3. The Booster Gauss clock can broadcasts events during various points of the AGS Booster main magnet cycle that are available for all systems to use as a trigger. Future ac dipole firmware will allow it to trigger at target frequency points of the RF ramp derived from the RF revolution tick frequency (f_{rev}) signal. These triggers will be internal to the ac dipole controller.

Beam position monitor (BPM) electronics have been updated for the horizontal and vertical BPMs that will be used for the ac dipole and tune kicker. This BPM hardware is a

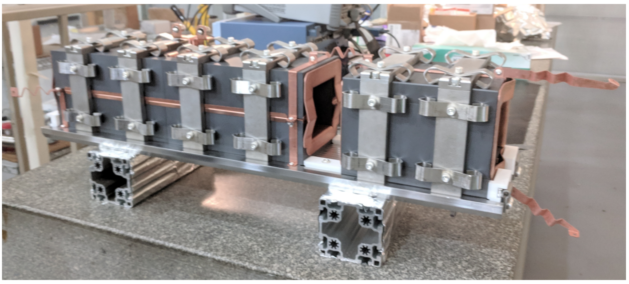

Figure 2: The completed vertical and horizontal magnets prior to being installed in the vacuum chamber.

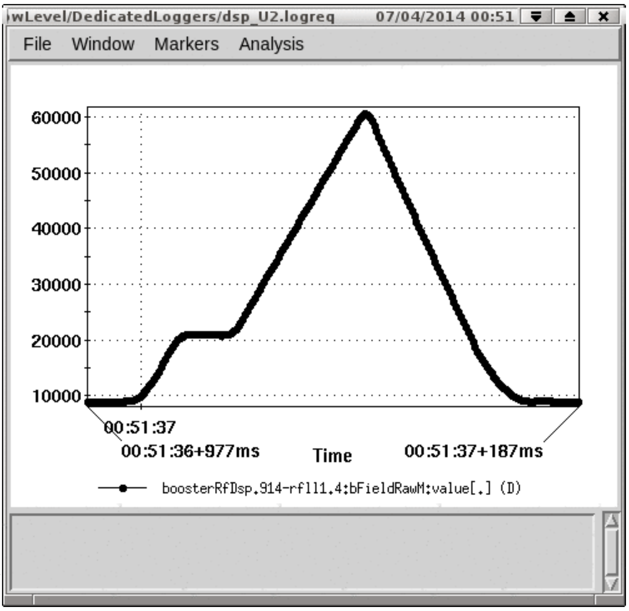

Figure 3: Raw Booster Gauss clock signal from ^{3}He Booster cycle during RHIC in 2014.

Zynq based system capable of a 5 MHz acquisition rate [5]. The bandwidth is sufficient for turn-by-turn and bunch-by-bunch monitoring at the maximum revolution frequency with four bunches.

CONCLUSION

The ac dipole project is near installation, which will allow studies to commence. Several outstanding issues are now resolved including: determination of in vacuum ac dipole magnet losses, implementation of new BPM electronics, and design of termination boxes. The resolution of these items will improve the performance of the ac dipole.

ACKNOWLEDGEMENTS

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