AGS MODEL IN ZGOUBI RHIC RUN 13 POLARIZATION MODELING STATUS*

F. Méot, L. Ahrens, K. Brown, Y. Dutheil, J. Glenn, C. Harper, H. Huang, V. Ranjbar, T. Roser, V. Schoefer, N. Tsoupas, Collider-Accelerator Department, BNL, Upton, NY 11973, USA

Abstract

This paper gives a status of the AGS model in the ray-tracing code Zgoubi and its operation via the "AgsZgoubiModel" and the "AgsModelViewer" applications available from the controls system application launcher, "StartUp". Examples of typical uses and studies performed using these are included, as optics controls, spin matching to RHIC, etc. A companion paper (MOPWA085) gives additional details, regarding especially spin dynamics and polarization studies aimed at determining optimal AGS settings for polarization during RHIC Run 13. This work is an additional step towards further combination with the already existing RHIC spin tracking model in Zgoubi, and AGS's Booster model in Zgoubi, a promising suite for detailed beam and spin dynamics studies and optimizations.

INTRODUCTION

The modeling of the Alternating Gradient Synchrotron lattice, including optics and spin dynamics, is based on stepwise ray-tracing methods using Zgoubi [1]. Optics account for two Siberian snakes simulated using their 3-D OPERA field maps, and possibly uses the 240 2-D field maps of the main magnets, as described in detail in earlier publications [2]-[7]. Recent studies aimed at determining optimal AGS settings for polarization during RHIC Run 13 are further detailed in a companion paper [8]. The present paper gives a status of this work, and examples of various possible applications.

Table 1: "ZgoubiFromSnaprampCmd"

At an arbitrary timing, or series of timings, in a cycle,

(i) ZgoubiFromSnaprampCmd" reads magnet settings from an AGS "snapramp" : a snapramp is a photo of an AGS cycle, i.e., (a folder that houses) a series of files containing magnet currents vs. timing over that cycle, as well as orbit radius and other bumps.

(ii) It then builds a "zgoubi.dat" input data file to Zgoubi, from an existing template.

(iii) This "zgoubi.dat" problem is run, so producing outputs as closed orbits, optical functions, periodic spin $\vec{n}_0$ vector, and possibly plots.

ZGOUBI MODEL FROM SNAPRAMPS

The model of the AGS in the ray-tracing code Zgoubi is now operational and used in optical and polarization studies in the present RHIC Run 13. Not just an AGS operation tool however, it is in addition a research tool, as addressed below.

The model can be launched from any shell terminal under linux/unix, via the command "ZgoubiFromSnaprampCmd", see Table 1. Like the existing command "MadxFromSnaprampCmd", the former produces "twiss" type of output files, formatted in exactly the same way as MADX ones, so making existing interfaces operational for both engines with minor additional work.

In addition, two interfaces have been developed, as described hereafter, that both essentially execute "ZgoubiFromSnaprampCmd".

"AGSZGOUBIMODEL"

This interface stands as an application in the AGS operation "StartUp" menu. It is an R&D tool, in continuous development. Its goal is to make user's life easier in sophisticated manipulations of the AGS Zgoubi model. Two examples for illustration, amongst other possibilities :

Example 1. When producing a model of the AGS at particular timing(s) during a cycle, tunes (and chromaticities as well) will fall at some distance from measured tunes during that very cycle. The reason for that may be attributed to a lack of knowledge of the main magnets, due for instance to evolutions in shape and alignment over the years, or to eddy currents during the ramp (this is still to be investigated). However it is necessary for betatron resonance studies, or spin dynamics studies, for instance, to have tight agreement between the model and the live machine. The way this is dealt with is by matching, varying the K1F and K1D gradient indices in the respectively focusing and defocusing main magnet families. This variation is very small, within $\pm 10^{-3}$, relative, whatever the timing. "AgsZgoubiModel" will establish the required (file-)links between measured (tunes, chromaticities) and "ZgoubiFromSnaprampCmd", so that this operation of matching is automatic. This results in a "zgoubi.dat" file matched to the live AGS, ready for further dynamics studies. A typical outcome of such a manipulation is shown in Fig. 1. Similar consideration of automation holds for orbit, dispersion, and measurements and their modeling.

* Work supported by Brookhaven Science Associates, LLC under Contract No. DE-AC02-98CH10886 with the U.S. Department of Energy.

ISBN 978-3-95450-122-9

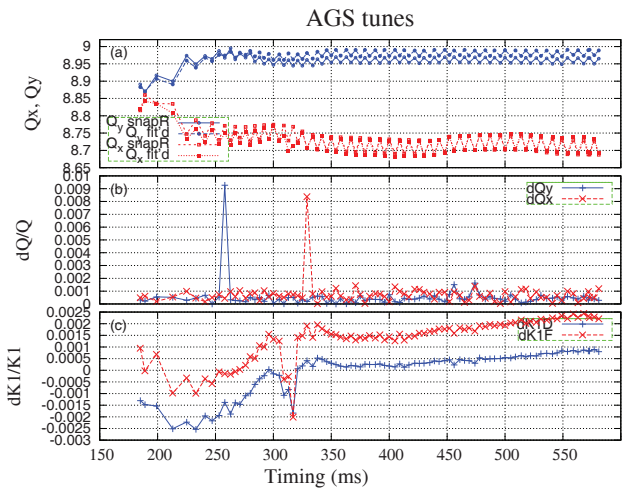

Figure 1: Tune measurements and modeling during the ramp, in presence of polarization tune jump quadrupoles. The top plot shows tunes along the cycle, before and after matching of the K1F and K1D families to measured AGS data. The accuracy of the agreement between measured and computed tunes is controlled via a "penalty" function in Zgoubi's fitting procedure. It takes of the order of a minute to complete - quite compatible with operation imperatives. The middle plot shows the difference between measured tunes and their values from the model prior to matching - usually small. Bottom plot : the amount that K1F and K1D families need be varied in order to have measured and model tunes agree. The dip in the 310 ms region results from the transition quads not being powered in this particular simulation.

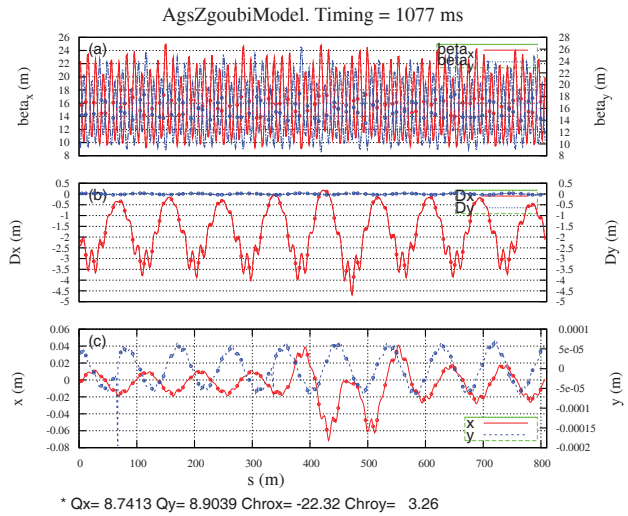

Figure 2: AGS extraction optics (1077 ms after injection, $G\gamma = 45.5$), in presence of the "G10" kicker and "H10" septum orbit bumps - this is for instance the configuration required for determining the periodic spin precession vector $\vec{n}_0$ at H10 in view of its transport to the collider RHIC via the AGS to RHIC beam line, see Fig. 4. Bottom plot : first the H and V closed orbits are searched for (the vertical orbit is normally very small in the model since an artificial orbit bump is maintained at both sakes - they are sources of H and V orbit, decreasing in strength with increasing momentum). Middle plot : then the dispersions are computed. Top plot : eventually the optical functions are computed from ray-tracing as well, with these very H and V closed orbits as Serret-Frenet frame reference.

Example 2. Periodic extraction conditions - beam and spin - need be transported to RHIC. A first step is, getting the former, which includes orbit and related feed-downs from the main magnets, tuning quadrupoles and chromaticity sextupoles. Simulation of the bump optics at 1077 ms in nominal working conditions (orbit bump is switched on around 680 ms, zero-ed at 1100 ms, extraction occurs at 1077 ms) is schemed and commented in Fig. 2.

"AGSMODELVIEWER"

The AgsModelViewer is a thin client graphical interface application written in C++ that makes use of a local user interface library developed on top of OSF/Motif®widgets and the commercial XRT™(from Quest Software) graphics plotting package. It interfaces to the AGSModelServer, which exists in two instances, one for a MADX model of the AGS and one for the Zgoubi model of the AGS. The servers are generic CDEV servers that collect live or archived data of the machine settings or readbacks and build the instances for the respective model engines. In the case of Zgoubi, the same ZgoubiFromSnapRampCmd infrastructure is used. The model servers are designed to publish model results to any requesting client including command line requests using the cdevCommand interface [9].

The AgsModelViewer is designed to display all the data relevant to the online model, see example in Fig. 3. Once a given set of data is requested, whether from live settings or from an archive of the settings, the viewer will display the magnet currents and other machine settings, and the model output data in terms of Courant-Snyder parameters, generated either from the MADX or Zgoubi server. The viewer can access both. It also contains a simple longitudinal model, with the intent of connecting the longitudinal and transverse models of the accelerators together. This would provide, for example, the momentum compaction factor to the longitudinal model for a more accurate prediction of the synchrotron frequency as a function of time. This feature is still under development. The viewer is also designed to make comparisons of the model predictions to measurements, so it is capable of reading data logged from instrumentation, such as tune measurements, as a function of time.

SPIN OPTICS

As mentioned earlier, "ZgoubiFromSnaprampCmd" and its interface "AgsZgoubiModel" are also R&D tools. They can be used for spin studies, this is the example displayed in Fig. 4 which shows the transport of the periodic $\vec{n}_0$ pre-

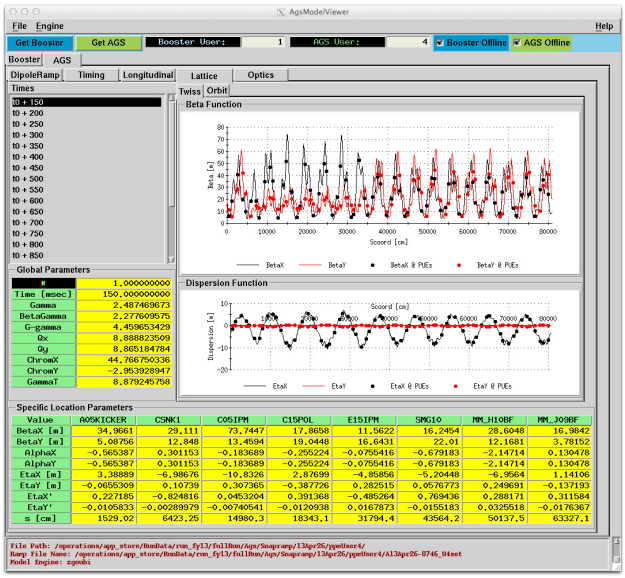

Figure 3: The AGS "lattice" page of AgsModelViewer, at an early timing. MADX and Zgoubi engines give very similar results. They differ essentially at low energy, where the effect of the snakes on the optics is strongest - MADX uses first order matrices to simulate the snakes, whereas Zgoubi ray-traces.

cession vector at the extraction septum H10 in the AGS, via the AtR (AGS to RHIC beam line), to the downstream end of the injection kickers in the "RHIC Blue" and "RHIC Yellow" rings. The exercise in that example consists in a series of steps, as follows:

(i) get the the periodic optics in AGS in presence of the extraction bumps at G10 and H10,
(ii) get the periodic spin $\vec{n}_0$ at H10,
(iii) transport $\vec{n}_0$ along the AtR,
(iv) bring $\vec{n}_0$ through RHIC-X and RHIC-Y injection sections down to Blue and Yellow kicker ends.

Phases (iii), (iv) require getting the AtR and RHIC injection sections settings in Zgoubi's AtR model, the process of automatizing that and incorporating it in ZgoubiFromSnaprampCmd is on-going.

CONCLUSION

A powerful AGS modeling tool is now in operation for RHIC Run 13, after 3 years of development. It is based on stepwise ray-tracing methods and allows detailed and sophisticated simulations and studies of beam and spin optics in RHIC's injector, AGS. Combined with the already existing RHIC model in Zgoubi, that has proved a powerful tool for spin dynamics simulations [10], and with the existing Booster model, used at present for the simulation of polarized helion transport to RHIC [11], the Zgoubi engine method appears a promising tool for the modeling of RHIC collider and its injectors complex.

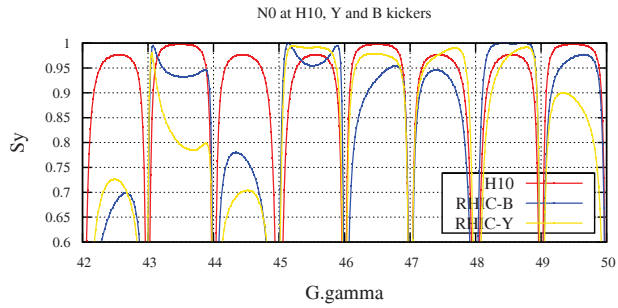

Figure 4: Red curve: vertical component of the periodic $\vec{n}_0$ precession vector as observed at septum H10 in AGS, as a function of beam energy (in units of $G\gamma$). Blue and Yellow curves: resulting vertical component at RHIC-Blue and RHIC-Yellow injection kickers. The ideal case is when S_y is closest to 1 in both Blue and Yellow since RHIC's $\vec{n}_0$ *is* vertical. It can be observed that RHIC Run 13 injection $G\gamma = 45.5$ is a reasonable compromise in that respect.

REFERENCES

[1] Zgoubi Users' Guide, F. Méot, Report BNL-98726-2012-IR, https://www.bnl.gov/isd/documents/79375.pdf.

[2] Spin Dynamics Simulations at AGS, H. Huang et al., Procs IPAC 2010 Conf., Kyoto.

[3] Modelling of the AGS using Zgoubi - status, F. Méot et al., Procs IPAC 2011 Conf., San Sebastian.

[4] Development of a stepwise ray-tracing based, on-line model of the AGS, F. Méot et al., Procs PAC 2011 Conf., New York.

[5] Modelling of the AGS using Zgoubi - status, F. Méot et al., Procs PAC 2012 Conf., New Orleans ;
A Model of the AGS Based on Stepwise Ray-Tracing Through the Measured Field Maps of the Main Magnets Y. Dutheil et al., Procs PAC 2012 Conf., New Orleans.

[6] Spin tracking simulations in AGS based on ray-tracing methods - bare lattice, no snakes, F. Méot et al., Note C-AD/AP/452 (Feb. 2012).

[7] Zgoubi-ing AGS spin motion with snakes and jump-quads, $G\gamma = 43.5$ through $G\gamma = 46.5$ and beyond, F. Méot et al., Note C-AD/AP/453 (Feb. 2012).

[8] Spin Dynamics Simulations and Horizontal Intrinsic Resonance Studies in the AGS using the Zgoubi Code, Y. Dutheil et al., MOPWA085, these proceedings.

[9] J. Chen et al., Cdev: An object-oriented class library for developing device control applications, Procs 1995 Int. Conf. on Accelerator and Large Experimental Physics Controls Systems, (Chicago), p. 97, 1995.

[10] Spin code benchmarking at RHIC, F. Méot et al., Procs IPAC 2011 Conf., San Sebastian.
Polarization transmission at RHIC, numerical simulations, F. Méot et al., Procs PAC 2012 Conf., New Orleans.

[11] Transport of polarized ^3He in Booster and AGS, F. Méot, Workshop on Opportunities for Polarized He-3 in RHIC and EIC, BNL, Sept. 2011.

ISBN 978-3-95450-122-9