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PROPOSED HADRON INJECTION INTO THE FUTURE eRHIC COLLIDER*

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Abstract

The future electron Relativistic Heavy Ion Collider (eRHIC) [1,2] will collide polarized electrons at energies 5, 10, and 18 GeV with 250 GeV polarized protons, 210 GeV/u polarized ^{3}He ions and other heavy ion species which are already produced by the ion sources of the RHIC accelerator. To increase the luminosity during electron hadron collisions at the interaction points the number of circulating hadron bunches will increase to 330 and this requires a modification of the injection system for the RHIC accelerator. This paper describes one of the hadron injection scheme into the "Yellow" ring of the RHIC collider.

INTRODUCTION

During the RHIC operations the AtR line [3] is being used to transfer the hadron ions from the AGS to the Blue and Yellow rings which circulate the hadron ions clockwise and counterclockwise respectively. Figure 1 is a schematic diagram of the AtR line with the AGS ring at the bottom of the figure and the RHIC rings at the top. The switching magnet of the AtR line (Fig. 1) deflects the beam into either the X-line for Blue-ring-injection or the Y-line for Yellow-ring-injection. The eRHIC collider utilizes only the Yellow ring which at present can accept only 116 bunches. This limitation in the number of injected bunches comes from the ~90 nsec rise-time injection kicker of the beam injection system [4, 5]. The eRHIC collider will be injected with 330 hadron beam bunches into the Yellow ring therefore a kicker with ~18 nsec rise time is needed. To overcome the limitation of the present kicker's large rise time it has been suggested that the Y-line of the AtR line injects the beam into the section of the Blue ring which will transport the hadron bunch and inject it to the Yellow ring at the IP4 point at the center of the 4 o' clock straight section as shown in the right picture of Fig. 1.

THE Y-INJECTION SYSTEM OF RHIC

Currently the hadron ions are injected into the Yellow ring from the Y-Line of the AtR beam-transfer line using a ~38 mrad Labertsons septum magnet as shown in Fig. 2. Upstream of the Lamberton magnet a 3 mrad vertically bending magnet which bends the beam downwards is followed by six RHIC quadrupoles which match the AtR beam parameters to the beam parameters of the Yellow ring at the location of the 1.7 mrad vertically bending Y-Kicker whose location is shown in Fig. 2.

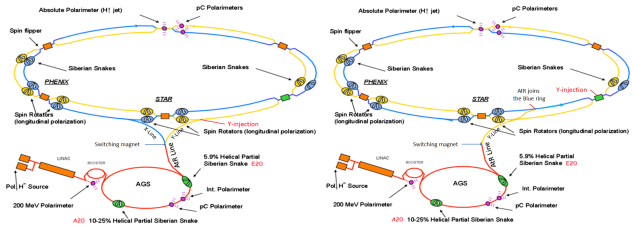

Figure 1: Schematic diagram of the RHIC collider. (left) The AGS to RHIC (AtR) transfer line is located between the AGS and RHIC rings. The switching magnet of the AtR line deflects the beam into either the X-line for Blue ring injection or the Y-line for Yellow ring injection. (right) the Y-line will be extended to join the Blue ring which will transport and inject the beam at IP4 point of the Yellow ring. The X-line which is now part of the AtR line will be eliminated.

A closeup view of Fig. 2 is Fig. 3 which shows the survey points at the location of the 4m long, 38 mrad of bend Lambertson septum magnet. If the Lamberton septum magnet is off the beam from the Y-line will hit the cryostat of the Y-arc. Figure 4 is an expanded view of Fig. 3 which shows the survey coordinates of devices upstream of the Lambertson septum magnet.

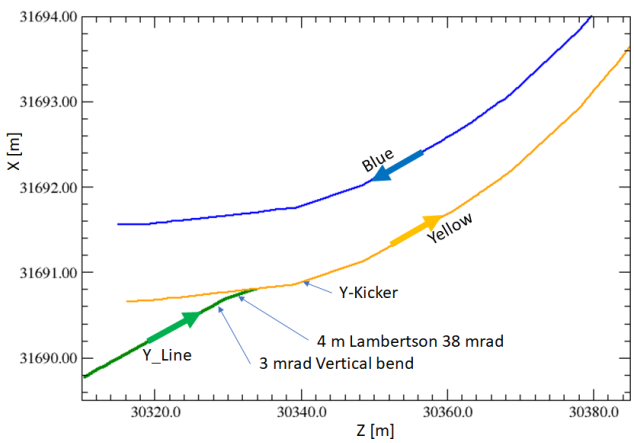

Figure 2: The green, yellow, and blue, traces are the "RHIC survey coordinates" at the entrance and exit of the elements which comprise the Y-Line (green), part of the Yellow ring (yellow) and part of the Blue ring (blue). The location of the 3 mread vertical bend, the Labmertson septum magnet, and the1.7 mrad vertically bending Y-kicker is shown on the figure.

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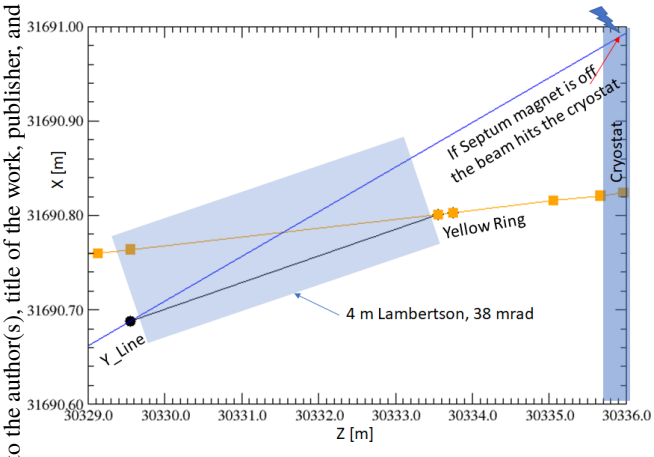

Figure 3: Same as Fig. 2 above but a closeup view showing the survey coordinates at the location of the Lambertson septum magnet.

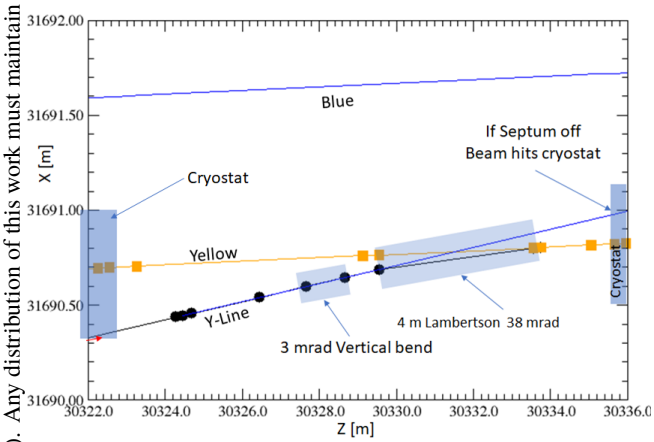

Figure 4: An expanded view of Fig. 3 showing the survey coordinates of devices upstream of the Lambertson septum magnet. The picture on the left of the figure shows that the vacuum pipe of the Y-line is gouging the cryostat of the Yellow arc.

Modification of the Y-line Beam-Injection-System

Curently the maximum number of injected hadron bunches into the either Blue or Yellow rings is limited to 112 bunches. The eRHIC accelerator will be injecting 330 hadron bunches into the Yellow ring therefore a system of kickers with ~18 nsec rise time is needed but the available space in the current location of the Y-Kickers is not large enough to accommodate kickers with such a fast rise time.

To overcome this limitation a new scheme of injecting into the Yellow ring is proposing to use part of the arc of the Blue ring starting from the present Y-line Injection region and ending at the IP4 point of the 4 o'clock straight section. Figure 5 is a guide to help visualize the steps required which are also listed below, to make the proposed modification.

a) Remove the 3 mrad Vertical dipole and the 38 mrad Lambertson septum magnet. This step will direct the beam of the AtR-line on to the cryostat of the Yellow arc, but also the beam trajectory will never meet the Blue arc, as it is shown by the cyan line in Figure 5. This problem is resolved by step d) below.

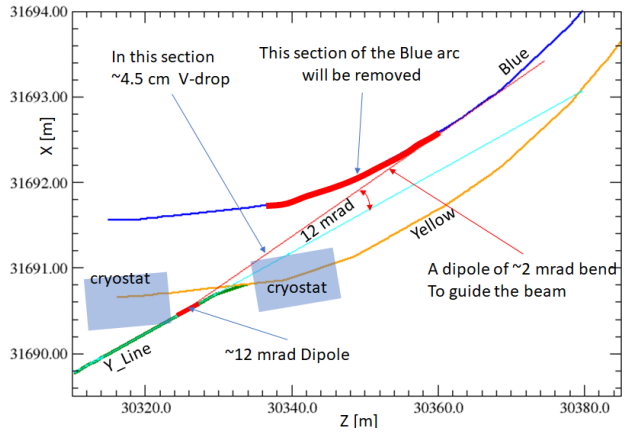

Figure 5: A schematic diagram of the Y-line injection region which helps visualize the steps required for the modification of the beam lines in this region as described in the text.

b) Just after the last horizontaly bending dipole of the Y-AtR tranfer line (see Fig. 6) a vertically bending dipole will be placed to bend the beam ~40 cm above the level of the Yellow line.

c) Part of the Blue line will be removed as it is indicated by the red arc in Fig. 5.

d) Another vertical dipole will be placed near the Yellow line (see Fig. 6) to level the beam horizontallly and keep the line at ~40 cm above the Yellow ring. A horizontally bending dipole is placed at the 40 cm elevated part of the beam line. This dipole will aim the beam towards the Blue arc as shown in Fig. 6.

e) Two consecutve verically bending dipoles will bring the beam direction at the same level with the Blue arc as shown in Fig. 6.

f) Following the last verticaly bending dipole are few quadrupoles and a 2 mrad dipole magnet to guide the beam into the Blue ring.

Figure 6 is a schematic diagram of the elements required for the extension of the Y-line.

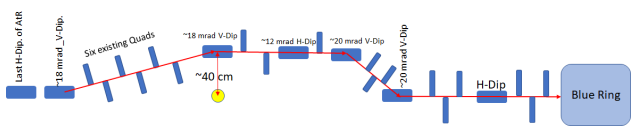

Figure 6: A schematic diagram of the extension of the Y-AtR beam-line as described in the steps a) to f) in this subsection "modification item #2". The yellow circle represents the cross section of the yellow ring.

Table 1 list the number and some of the parameters of the magnetic elements which appear in Fig. 6.

The part of the Blue ring which is of interest in this modification is the section defined from the Y-injection Lambertson magnet to the 4 o'clock Interaction Point #4 (IP4). The beam parameters of this section of the Blue arc are plotted in Fig. 7

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Table 1: The Magnetic Elements of the Extension of the Y-line as They Appear in Fig. 6. Only the elements which have to be built appear in this table.

Element	number	Length [m]	Gap/Radius [cm]	Bend-angle [mrad]	K1 m^{-2}
V- Dipole	2	1.25	4	18.0	NA
V- Dipole	2	1.50	4	20.0	NA
H-Dipole	1	0.75	4	12.0	NA
H-Dipole	1	0.5	4	2.0	NA
Quad	11	0.5	3	NA	0.2

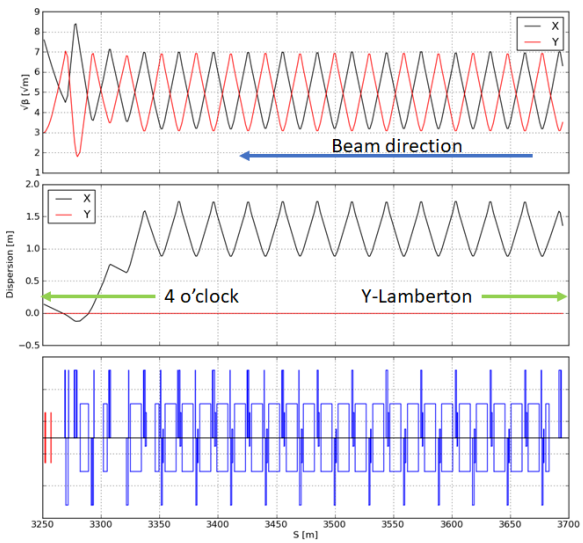

Figure 7: Beam optics of the Blue ring section from the Lamberton magnet to the 4 o'clock IP. From top to bottom plotted are the beta ($\beta_{x,y}$), eta ($\eta_{x,y}$) functions and the location of the elements along the Blue ring.

and the location of the magnetic elements are shown in the bottom part of the figure.

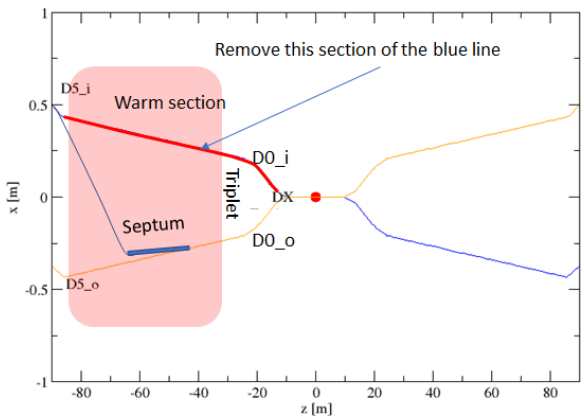

Figure 8: (left) Schematic diagram of the beam injection scheme for the 4 o'clock region. A dipole magnet following the D5-i magnet will guide the beam into an ijection septum magnet. The right picture is a rather accurate layout of two possible arrangements of the dipole and septum magnet.

After the hadron bunches are transported by this section of the Blue ring will be injected in the Yellow ring at the IP4 straight section. A scematic diagram of the injection at the IP4 is shown in Fig. 8. Part of the elements upstream of the D5-i magnet included, will be removed and replaced with warm magnets which will guide the beam towards the yellow ring where the injection septum magnet is located, and also much the injected beam to that of the circulating in the yellow ring.

Figure 9 shows the beam optics of the 4 o'clock region. The layout of the beam elements is shown in the bottom picture of Fig. 9 with the highlighted region being the proposed injection region where the dipole and and the injection septum will be placed, as discussed earlier in the text.

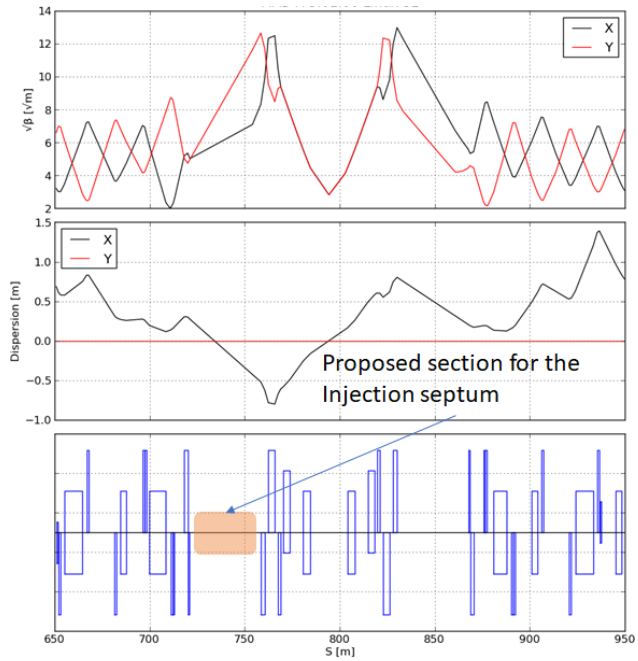

Figure 9: The beta $\beta_{x,y}$ and the dispersion $\eta_{x,y}$ functions (top plots) and the placement of the elements at the 4 o'clock region. The highlighted region being the proposed injection region where the dipole and and the injection septum magnet will be placed as discussed earlier in the text.

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