RIA BEAM DYNAMICS: COMPARING TRACK TO IMPACT *

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Abstract

To benchmark the newly developed beam dynamics code TRACK we have performed comparisons with well established existing codes. This paper presents a detailed comparison of the beam dynamics simulation in the RIA driver linac between the codes TRACK and IMPACT. After updating the code IMPACT to support the special requirements of the RIA driver linac, a very good agreement was obtained which represents another validation of both codes.

INTRODUCTION

The new ray-tracing code TRACK was developed [1] to fulfill the special requirements of the RIA accelerator systems. During code development, codes like TRANSPORT, COSY, GIOS and RAYTRACE were used to check TRACK's implementation of the different beam line elements. To benchmark the end-to-end simulation of the RIA driver linac, the simulation of the low-energy part (from the ion source to the entrance of the SC linac) was compared with both DYNAMION [2] and PARMTEQ [3] simulations and found to agree reasonably well. For the SC linac, the code IMPACT [4] is used here to compare with TRACK simulations of the different linac sections.

After describing the lattice of the RIA driver linac, the important steps leading to a reasonable comparison of the two codes are presented. The results from both codes are then compared and discussed. Future steps of this work are discussed at the end.

RIA DRIVER LINAC

The RIA driver linac lattice consists of one or more ECR ion sources, a LEBT with a MHB and a RFQ serving as an injector to a SC linac. The linac is subdivided into three sections separated by two stripping stations with appropriate magnetic transport systems as sketched in Fig. 1. In the case of a uranium beam and to reach the desired beam power, two charge states (28^+,29^+) are accelerated simultaneously in the low energy section, five charge states (72^+,73^+,74^+,75^+,76^+) in the medium energy section and five charge states (86^+,87^+,88^+,89^+,90^+) in the high energy section.

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IMPORTANT STEPS TO SIMULATION

Updates to IMPACT

While TRACK has been heavily used to simulate the RIA accelerator systems [5], IMPACT had to be updated to meet the special requirements of the RIA driver linac. Features such as multiple charge state acceleration and stripper simulation has already been implemented and successfully tested. In this effort, IMPACT was modified to support new types of rf cavities such as the spoke cavities present in the ANL baseline design [6]. It was also modified to include fringe fields for all the elements and to add beam collimation using slits to clean the beam after a stripper.

Building the lattice and field files

Starting from the TRACK lattice of the ANL baseline design of the RIA driver linac, IMAPCT lattice was built section by section. The 3D field files for 10 different types of cavity were then converted into IMPACT mesh and format. For a better comparison the initial particle distribution generated by TRACK at the entrance of a given section was converted into IMPACT initial distribution to simulate the same section with exactly the same particle distribution.

COMPARISON: IMPACT VS. TRACK

For every section, simulations with both IMPACT and TRACK were performed first for the single charge state case and later for the multiple charge state case. In all cases 2.10^5 particles were used in the simulations. No errors were included. A very good agreement was obtained for all sections. In the first section, we noticed a slight discrepancy right after the injection into the SC linac (1st cryostat) which we isolated in Fig. 2. The injection part is known to be non linear and the difference may be explained by a difference in the phase settings in the two codes. This low-energy region is very sensitive due to the strong coupling between the longitudinal and transverse motions. A slight difference in the driven phase may result into a larger difference as the beam propagates. Despite this effect IMPACT and TRACK give very close results. For the rest of the first section a very good agreement was observed. Fig. 3 shows the comparison for the second linac section. A similar agreement was obtained for the third linac section.

SUMMARY AND FUTURE WORK

In this work we compared in detail TRACK and IMPACT simulations of the three sections of the RIA driver linac for which an excellent agreement was obtained. The next step is to build the IMPACT lattice for the chicane

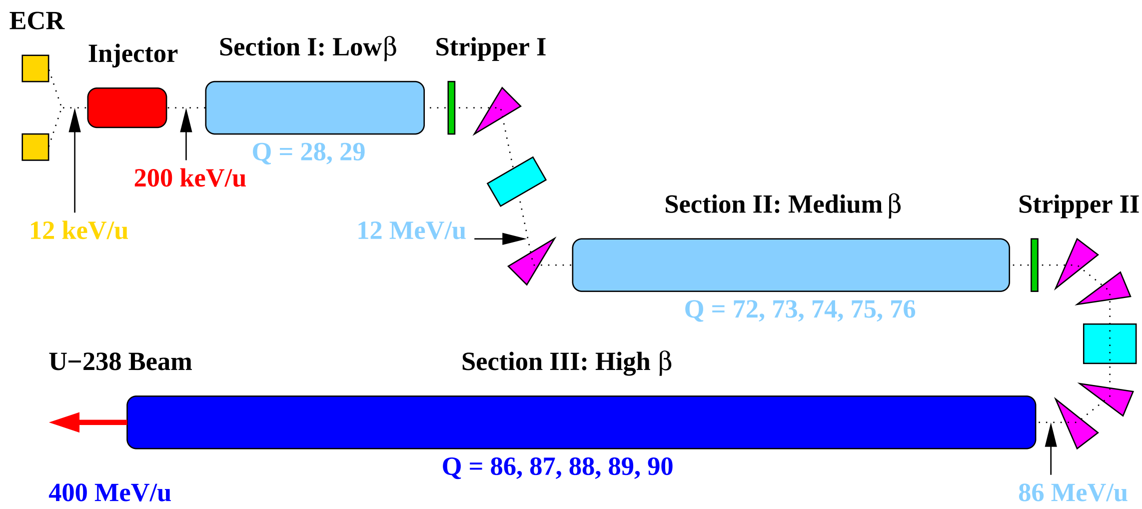

Figure 1: Schematic of the RIA driver linac.

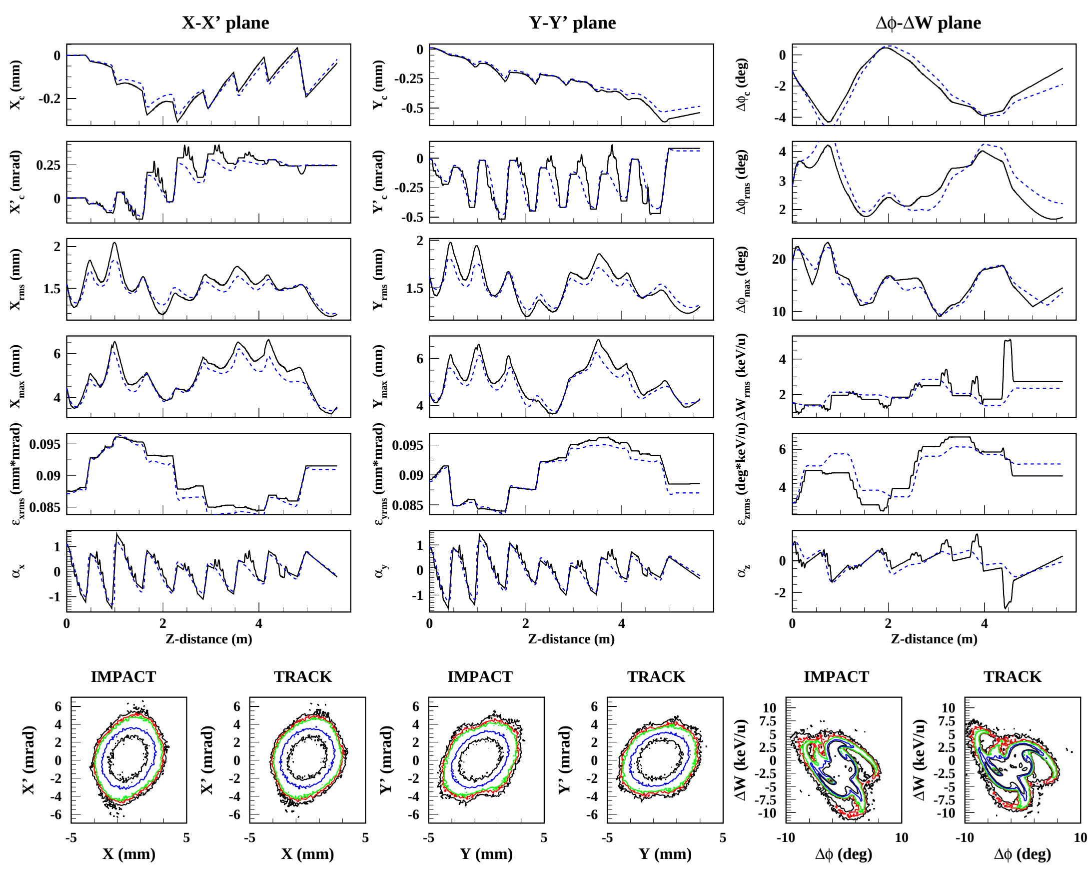

Figure 2: Comparison of IMPACT and TRACK simulations of the first cryostat of the first linac section for a dual charge state uranium beam (Q=28,29). The black solid curves corresponds to IMPACT and the blue dashed curves to TRACK. The top plots show the evolution of most important beam parameters as function of distance. The first column corresponds to the horizontal plane X-X' showing from top to bottom the beam centers X_c and X'_c, the RMS value X_{rms}, the beam envelope X_{max}, the beam RMS emittance ϵ_{xrms} and the Twiss parameter α_x. The second column is similar to the first but for the vertical plane Y-Y'. The third column corresponds to the longitudinal plane $\Delta\phi - \Delta W$, showing from top to bottom the beam central phase $\Delta\Phi_c$, the RMS value $\Delta\phi_{rms}$, the phase envelope $\Delta\phi_{max}$, the RMS value ΔW_{rms}, the beam RMS emittance ϵ_{zrms} the Twiss parameter α_z. The unit of the phase $\Delta\phi$ corresponds to the section's input frequency. The bottom plots compares particle coordinates in the three phase planes X-X', Y-Y' and $\Delta\phi - \Delta W$ at the exit of the section. The colored contours represent different levels of particle density.

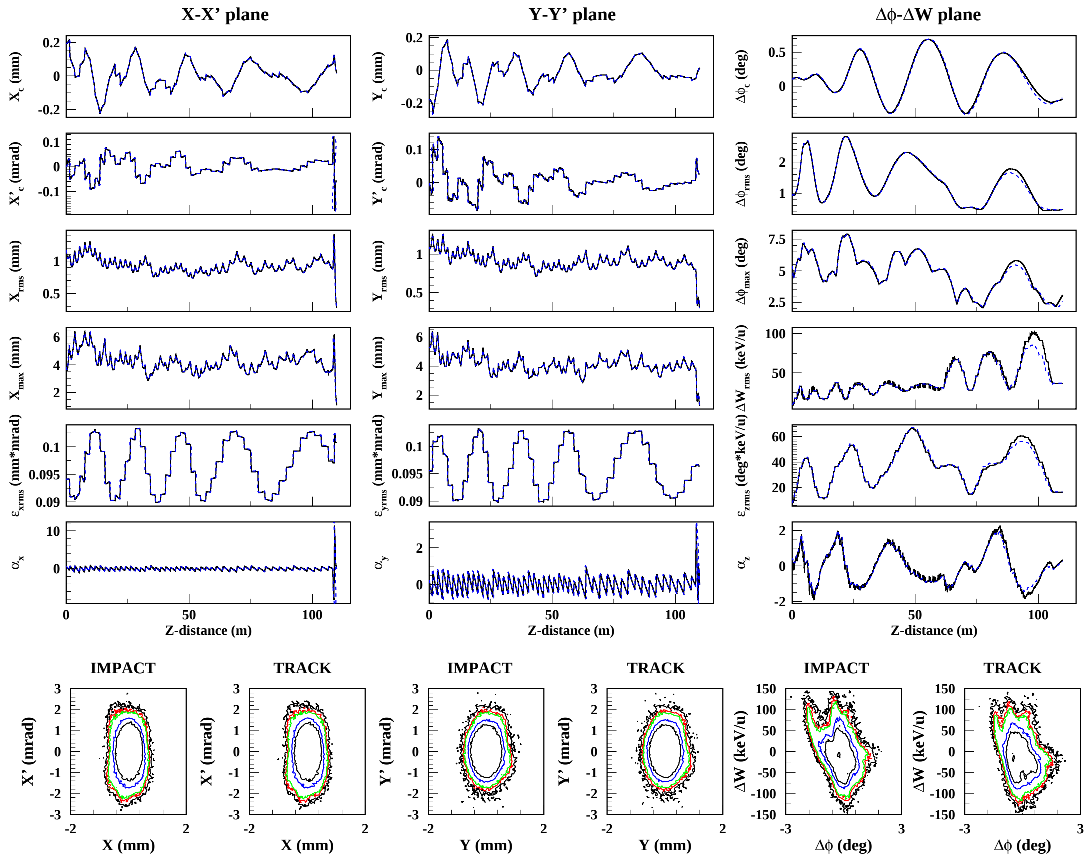

Figure 3: Comparison of IMPACT and TRACK simulations of the second linac section for a five charge state uranium beam (Q=72,73,74,75,76). The black solid curves corresponds to IMPACT and the blue dashed curves to TRACK, see Fig. 2 for more details.

areas following the two strippers and perform end-to-end simulations of the complete linac. Following this step IMPACT will be used to include error simulations and study beam losses to cross-check with TRACK results [5].

REFERENCES

[1] P.N. Ostroumov and K.W. Shepard. Phys. Rev. ST. Accel. Beams 11, 030101 (2001).

[2] A.A. Kolomiets et al, Proceedings of the Sixth European Part. Accel. Conf., Stockholm, Sweden, June 22-26, 1998, edited by S. Myers et al, p.1201.

[3] T. P. Wangler et al., " Advanced Beam-Dynamics Simulation Tools for RIA ", Proc. of LINAC 2004, Luebeck, Germany, 2004, p. 186.

[4] J. Qiang, R. D. Ryne, S. Habib, and V. Decyk, J. Comput. Phys. 163 (2000) 434.

[5] P.N. Ostroumov, V. N. Aseev, B. Mustapha. Phys. Rev. ST. Accel. Beams, Volume 7, 090101 (2004).

[6] P.N. Ostroumov, Phys. Rev. ST. Accel. Beams, Volume 5, 030101 (2002).

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