

MATCHING OF A C^{6+} ION BEAM FROM A LASER ION SOURCE TO A RFQ

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Abstract

A laser ion source, driven by a Nd-YAG laser can provide more than 100 mA of C^{6+} ions for a duration of about 1 μ s, which is well matching the task of single-turn injection into synchrotrons for hadron tumor therapy with light ions. The “direct” injection scheme has been improved by providing a design, which reduces the surface field strength to less than 30 kV/cm on all critical parts on relative negative potential. The new design keeps the advantage of divergent ion emission and acceleration, which seems to be the only way to keep the surface fields in limits, but includes a decelerating electrostatic lens on birth potential of the ions to refocus the emerging ion beam to the RFQ entrance. The whole design is very compact and allows for electrostatic steering between the ion source and the RFQ.

INTRODUCTION

The direct injection scheme of ions from a laser ions source (LIS) to a RFQ [1] has resulted in a low transmission in the RFQ. This was mainly due to the divergent shape of the electric field lines between the outlet of ions (called “slit”) and the RFQ electrodes of the radial matching section. In order to still keep the whole system as compact as possible, a decelerating electrostatic lens has been designed, which is operated at the source potential and connected internally, thus avoiding an extra power supply as well as an extra high voltage feedthrough.

MATCHING CALCULATIONS

A new feature has been added to IGUN [2,3,4], a positive ion extraction simulation tool, which allows to take into account the rf-focusing of the RFQ electrodes as a reduction of beam spreading, as caused by space charge [5]. In the present case, this has been essential to mathematically treat correctly the overlap of electrostatic and rf-fields in the radial matching section of a RFQ for the direct injection scheme.

At first it has been tried, to improve the electrostatic ion focusing by proper shaping of the outlet aperture for the laser induced ion beam pulse (see Fig. 1). However, the increase of focusing at low velocities (Fig. 1 b,c) inevitably leads to a divergent beam at the end of the radial matching section. Therefore a more classical approach has been optimised, to use an electrostatic lens between the ion outlet aperture and the radial matching

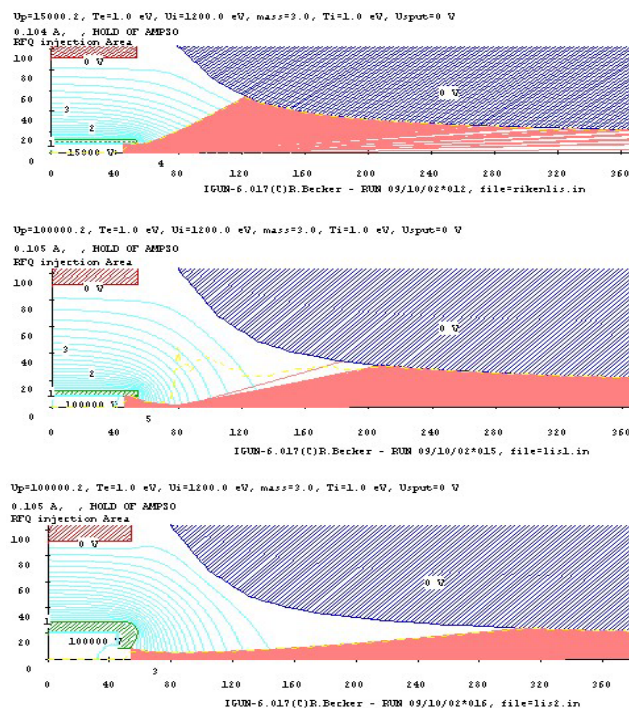


Figure 1: The direct injections scheme (upper panel) and small improvements by shaping the emitter part (middle and lower panel) The beam still enters divergent into the RFQ, which will cause extreme loss of particles

section in order to transform the inherently divergent beam into a convergent one, necessary for matching. The result is seen in Fig. 2 for the simulations and in Fig. 3 for details of construction. The accelerating electrode may be split into 4 sections for steering the ion beam with low voltages of less than 10 kV.

References

- [1] M. Okamura et al. Rev. Sci. Instrum. **73**, 761 (2002)
- [2] R.Becker and W.B.Herrmannsfeldt, Rev. Sci. Instrum. **63**, 2756 (1992)
- [3] R.Becker, Proc. EPAC-98, Stockholm, <http://accelconf.web.cern.ch/AccelConf/e98/PAPERS/THP44G.PDF>
- [4] www.egun-igun.com
- [5] R. Becker and R.A.Jameson, Simulation of rf-focusing in the RFQ matching section by IGUN, ICAP-2004, 29 June-2 July 2004, St. Petersburg

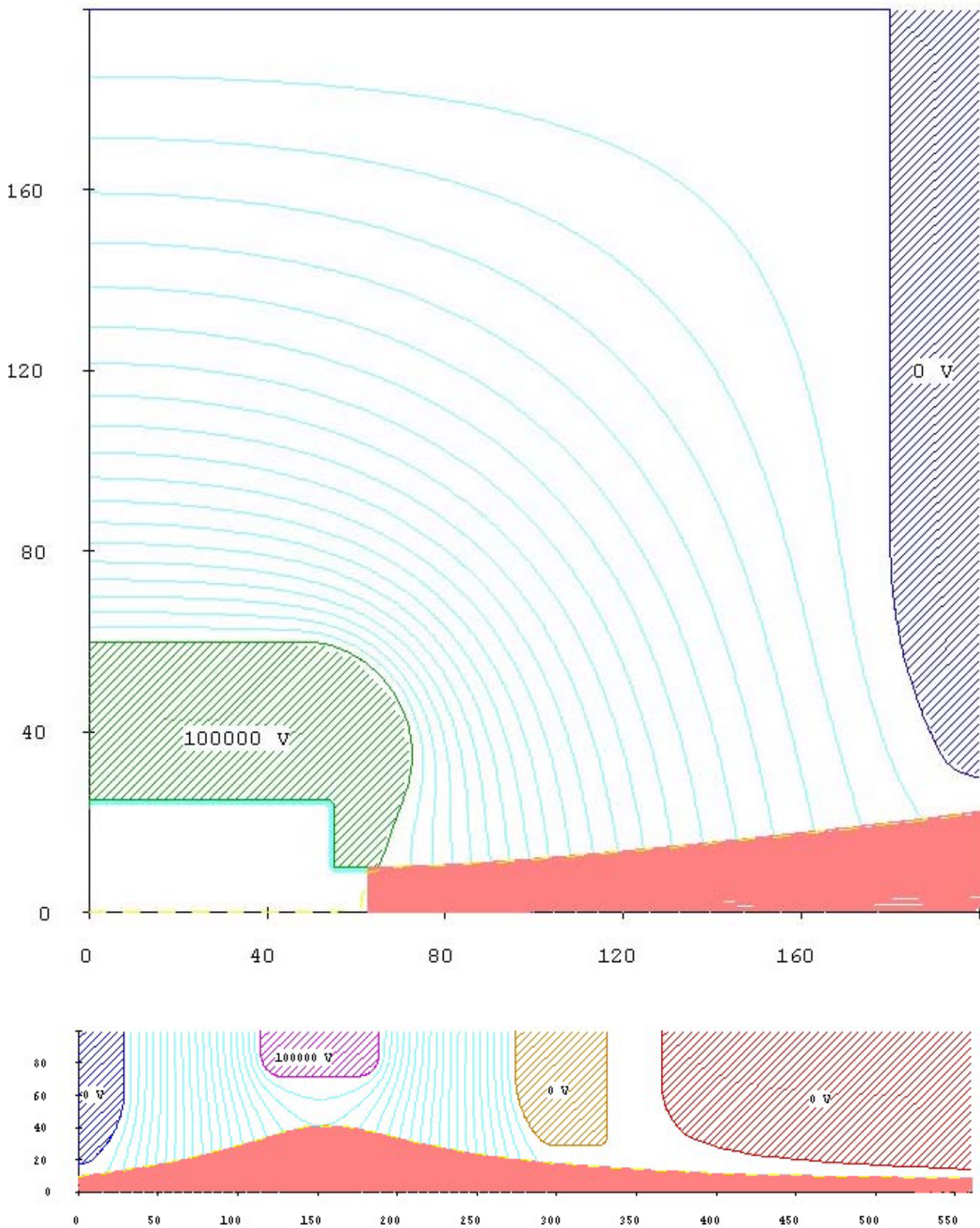


Figure 2: Separation of the simulation into ion gun (with high mesh resolution) (upper panel) and the focusing section (lower panel) with concatenation of trajectories obtained at the end of the ion gun

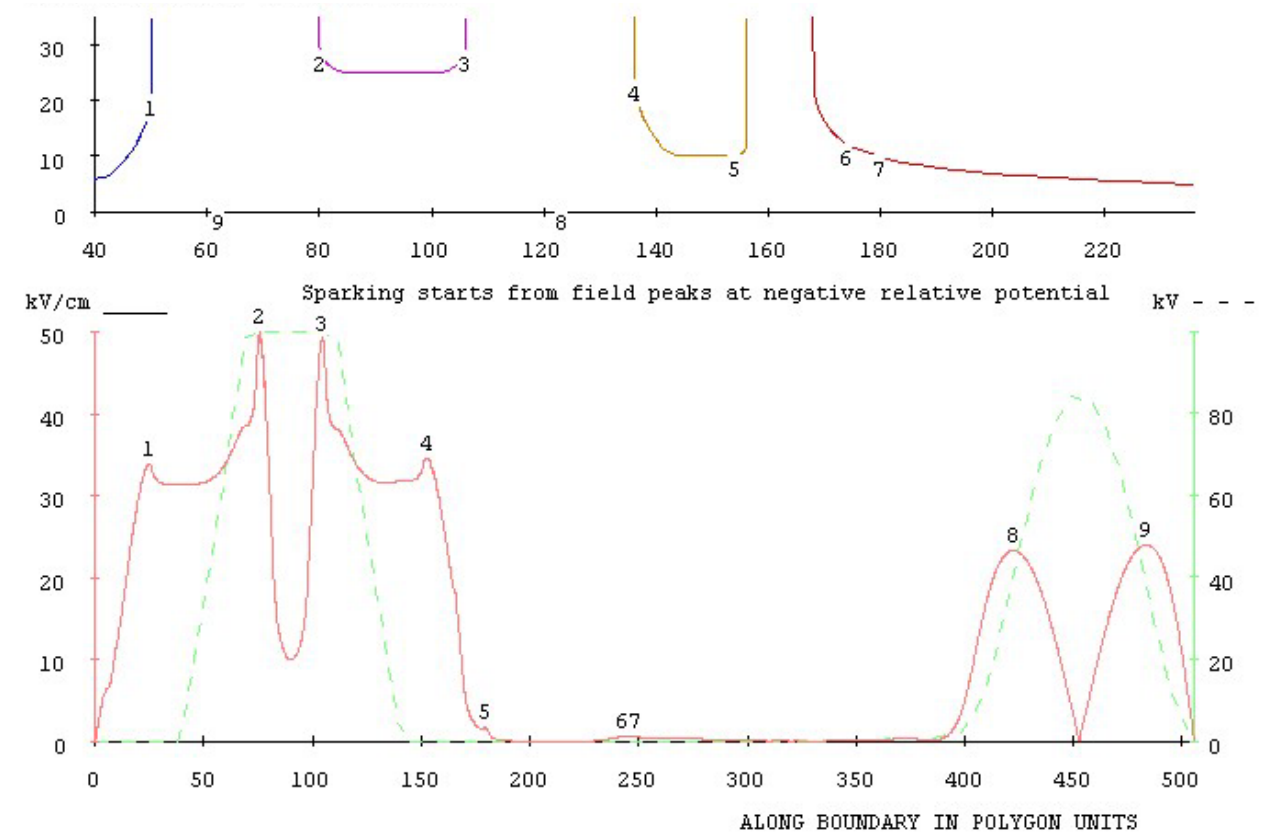


Figure 3: Compact matching system between a laser ion source and a RFQ, using the ion source potential on a decelerating electrostatic lens. Distances and sizes are optimised for surface fields < 35 kV/cm on relative negative potential - see field maxima 1 and 4 in the upper panel