Gridded lens for the RHIC EBIS LEBT

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1. Introduction

The gridded lens at the entrance into LEBT right after accelerating tube is used to control the angle of the accelerated ion beam to get the required conditions at the magnet lens located at the entrance into RFQ. It was found that to transmit ions He^{2+} in LEBT this lens needs to be focusing, and heavier ions like Au^{32+} require defocusing to have similar conditions at the entrance into the magnetic lens. A good choice for this lens would be a gridded lens, since it can be easily transformed into focusing or defocusing mode by changing the polarity of the central grid (with grounded guarding electrodes). This lens is not intended to be used as a final focusing element into RFQ where very low aberrations are required; rather it is used as an angle-correcting element with relatively small overall effect on the ion beam. A schematic of this lens is presented on Fig. 1.

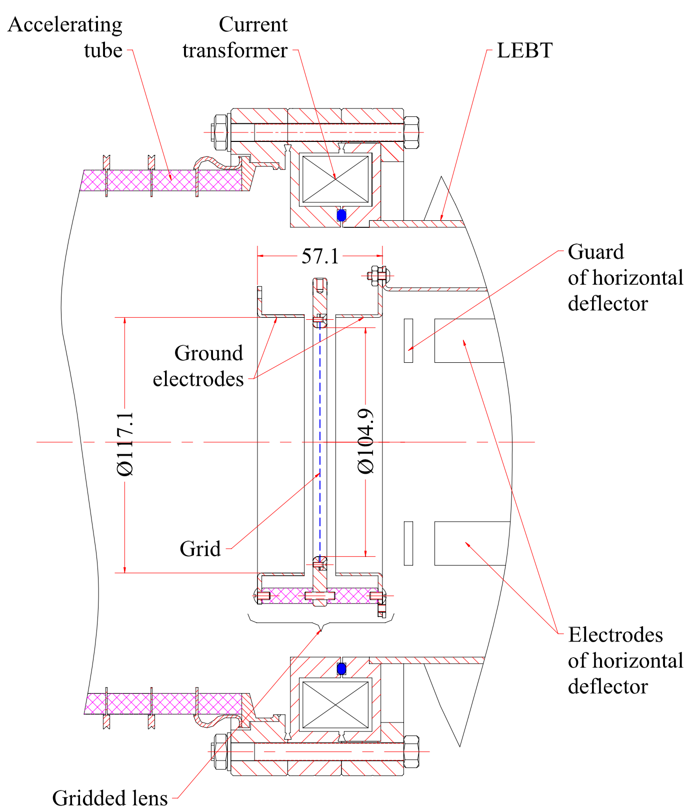

Fig.1 Schematic of the gridded lens at the entrance into LEBT.

The legitimate concern is the effect of the gridded lens on the emittance of ion beam because of non-homogeneous electrostatic field in a plane of the mesh caused by the structure of the grid.

2. Simulations of the effect of the gridded lens on the emittance of the ion beam.

An actual geometry of electrodes has been used for simulations with 2-D program TRAK assuming cylindrical symmetry. This means that the grid was represented as a concentric structure of wires with equal radial distance between adjacent wires.

Two models of the grid have been used for simulations:

1. Dimensionless wires located in one plane and radially separated by 1 mm.
2. Wires with square cross-section 0.1x0.1 mm separated by 1 mm radially.

The boundary condition on the left (entrance) plane, which corresponds to an equipotential surface close to the plane geometry, is 11110 V and was found from the previous simulations of the ion beam transmission in LEBT. The length of the problem is 136 mm with distance from the entrance plane to the grid 84 mm and from the grid to the exit plane 52 mm. The output ion beam emittance is an emittance at the exit plane. The parameters of Au^{32+} ion beam with current 8 mA at the entrance plane of this problem were obtained also from the previous simulations of ion beam in LEBT (500 trajectories) and the ion beam had initial normalized X RMS emittance at this plane ε_{RMS_norm}=0.1176 mm.mrad. An example of trajectory simulations with square wires with grid voltage U_{grid}=5.5 kV is presented on Fig. 2.

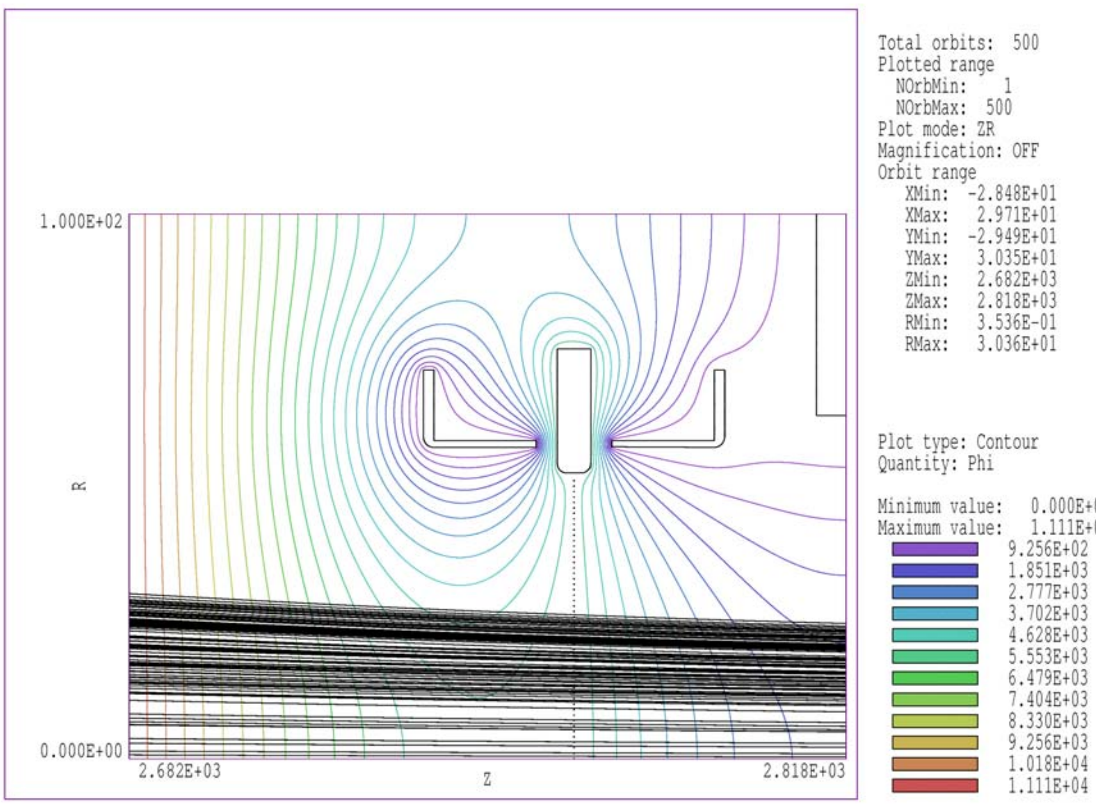

Fig.2 Simulated ion beam transmission through the gridded lens (model of square wires). I_ion=8 mA, U_grid=5.5 kV (defocusing).

A detailed view on the electrostatic field distribution in the grid area is presented on Fig. 3.

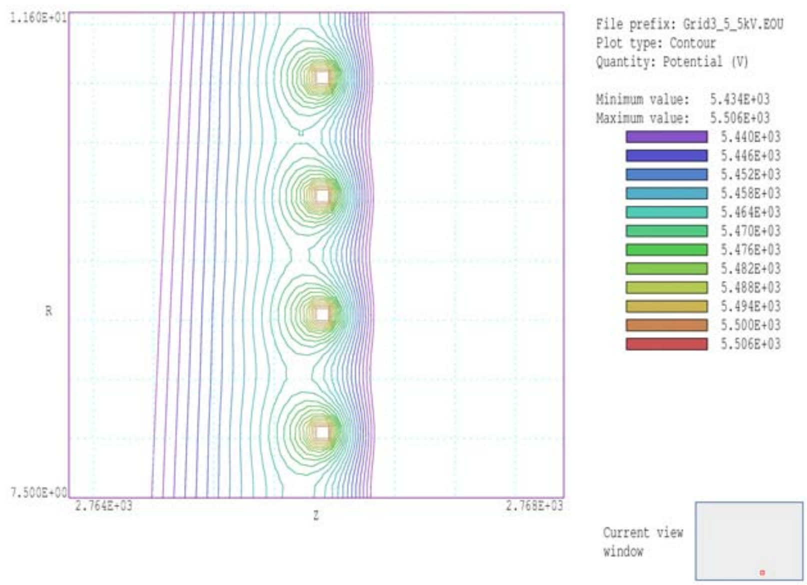

Fig.3 A structure of the electrostatic field in the grid region with potential on the grid U_{grid}= 5.5 kV.

The results of these simulations are summarized in Fig.4 presenting dependence of the ion beam emittance at the exit plane after the grid on the grid voltage.

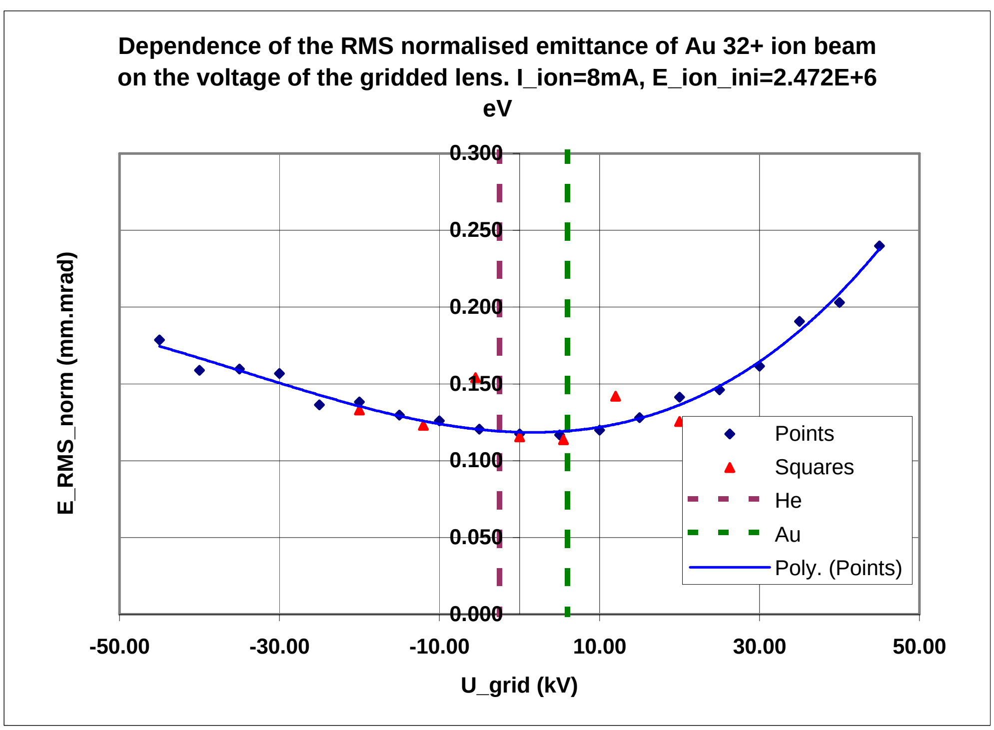

Fig. 4. Simulated dependence of the emittance of the ion beam at the exit plane on the grid voltage for models of dimensionless wires (points) and square wires 0.1x0.1mm.

3. Results.

- As one can see from the Fig.4 the output ion beam emittance can be doubled by the effect of the gridded lens at approximately +40 kV (defocusing lens) on the grid. With negative voltage on the grid (focusing lens) the effect of the lens on the ion beam emittance is somewhat smaller.
- For optimal He^{2+} ion beam transmission the required voltage on the grid is U_{grid_He}=-3 kV (brown vertical line on Fig.4), and for Au^{32+} beam this voltage is U_{grid_Au}=+6 kV (green vertical line on Fig.4). The effect of the lens on the output ion beam emittance within this range of grid voltages does not exceed 5%.