**Low Energy Ion Beam Line for TwinEBIS**

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### Introduction

The TwinEBIS setup is being developed at CERN as a test bench for new types of electron guns and novel Electron Beam Ion Source (EBIS) concepts [1]. The primary goal is to improve the performance of EBISs as charge breeders for radioactive beam facilities like ISOLDE. Presently, TwinEBIS is featuring MEDeGUN, a Brillioun electron gun designed for applications in hadron therapy [2].

In order to extend the capabilities of the test bench an ion beam line is going to be installed at TwinEBIS, serving the following purposes:

- Extraction of highly charged ions into an accelerating radio frequency quadrupole (RFQ)
- Injection of ions from an external source
- Ion beam diagnostic

In order to ensure an efficient injection into the small acceptance of a Brillioun electron beam inside the EBIS, and the extraction into the RFQ, the beam line was optimised to minimise the emittance growth.

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### General layout

**Deflector design**

The electric field in the centre of the deflectors needs to be homogeneous to minimise aberrations. This is difficult to achieve for large apertures with flat electrodes, since the ground potential is leaking in from the vacuum chamber.

→ Electrodes are shaped to compensate for this effect.

For the presented shape the electric field imperfections within a 20 mm radius around centre are: (2D simulation):

- **Horizontal field strength deviation**: \( \frac{E_x}{E_0} < 0.2\% \)
- **Residual vertical field strength**: \( \frac{E_y}{E_0} < 0.2\% \)

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### Main beam optics components

- **Acceleration tube**
  - Multiple ring electrodes acting as potential dividers

- **Set of three lenses for matching into the RFQ**
  - Two gridded lenses (4) as main focusing elements
  - Small aberrations, ability to defocus
  - Slightly reduced transmission (∼90%) due to grid
  - Einzel lens for intermediate focusing

- **Adapter ring electrode**
  - Between the EBIS ion extractor and the acceleration tube
  - Focusing strength adjustment

- **Two sets of horizontal and vertical deflectors** in the RFQ direction:
  - Electrode shape carefully adjusted to homogenise electric field
  - First horizontal deflector is used as a +/- 20° kicker for the switchyard

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### Kicker design

The design of the switchyard kicker is based on the deflector geometry. The kicker is tapered in order to grant enough space for the beam while limiting the effective gap size, which reduces the required voltages. Front and back shields are used to mitigate fringe fields.

3D simulations in CST Particle Studio [6] indicate that the emittance growth in this kicker is insignificant (< 5%) even for moderate beam displacements (< 10 mm).

At this point, the investigations are still ongoing and other designs are studied, e.g. diagonally segmented cylinder or flat electrodes.

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### References

5. [http://www.fieldsp.com](http://www.fieldsp.com)
6. [http://www.cst.com](http://www.cst.com)

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### Beam Diagnostic Tool

**Beam Line Design**

**Ion Beam Simulations**

**Injection simulation**

Ion tracking from the diagnostic chamber (where the beam parameters will be measurable in practice) into the electron beam. For efficient injection (\( A/q = 0.5 \)) within the electron beam radius the normalised acceptance is only 0.011 mm mrad.

→ Need to prevent growth of injection emittance.

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