

Status of E-Gun and Electron Lens Design for GSI

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WP16 Meeting
10.04.2018

Objectives

Task 16.2. System Integration (GSI, IAP)

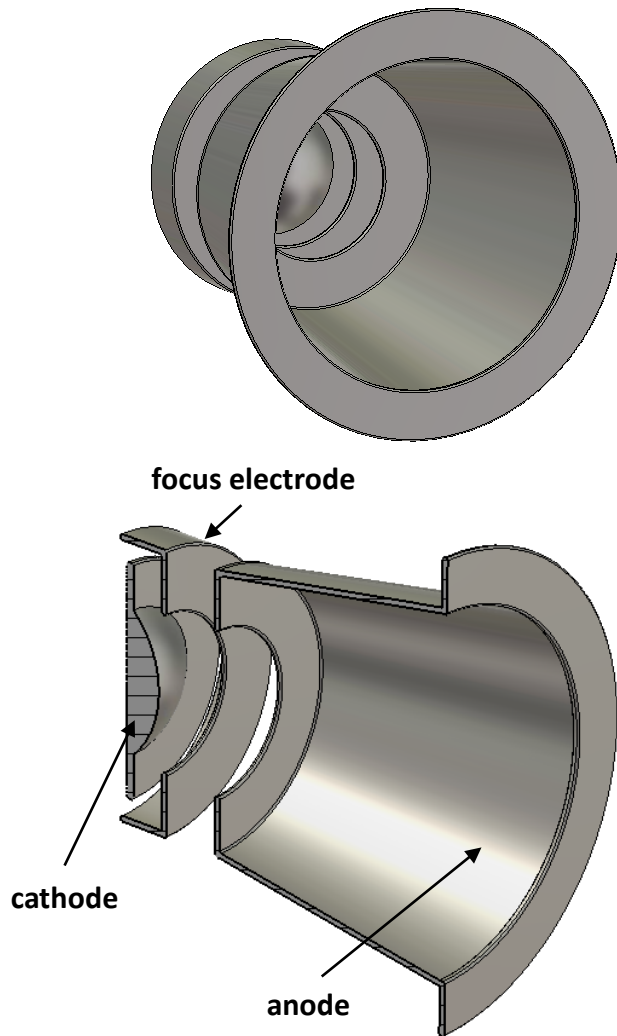
- First results of beam dynamics studies for e-lens setup

Task 16.3. Electron Gun and Power Modulator (IAP, RTU)

- Design status of gridded gun
 - transmission factor
 - required grid voltages
 - shaping of grid
 - forming of elliptical beam
 - test stands at IAP

Reminder: design status of e-gun in 2017

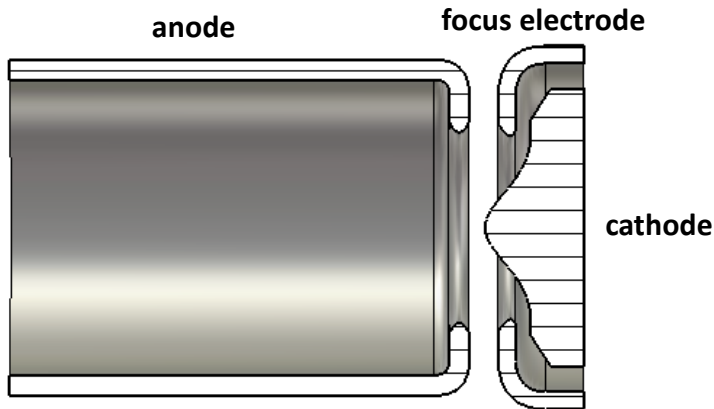
Round cathode



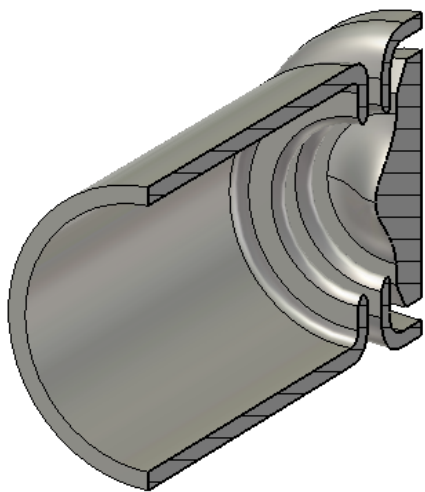
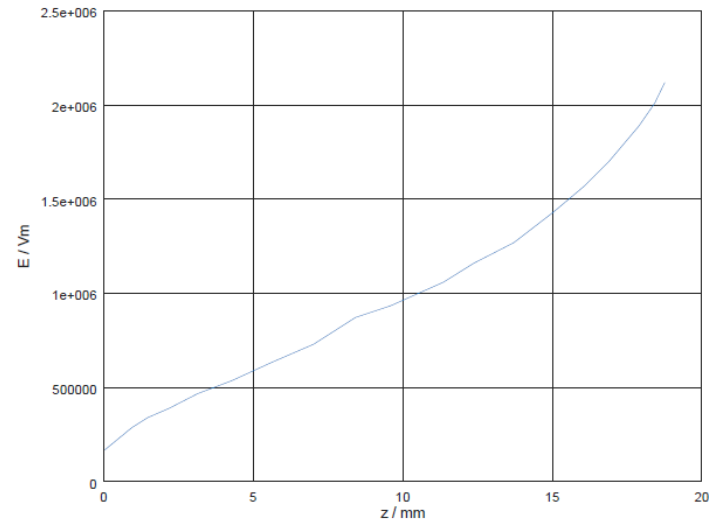
E-Gun Parameters	
Current I	10 A
Transverse beam profile σ	$2\sigma_x=35$ mm, $2\sigma_y=20$ mm
Cathode radius r_{gun}	35 mm
Magnetic field B_{gun}	>0.030 T
Minimum Extraction Voltage U_a	22.3 kV ($P=3 \cdot 10^{-6} A/V^{3/2}$)
Peak power P_{peak}	223 kW
Modulation frequency f	5 MHz
Grid voltage U_{cg}	500 V (grid distance of 3mm)
Dissipated Power $P_{diss} = C U_g^2 f$	≥ 100 W

Current design status of e-gun

Gaussian shaped cathode

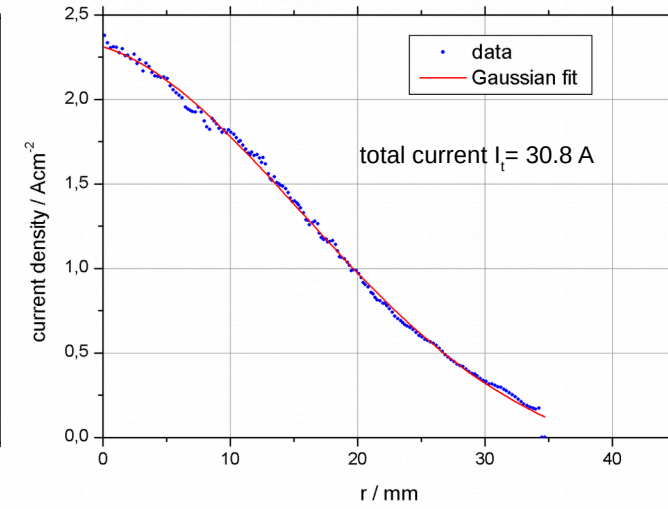
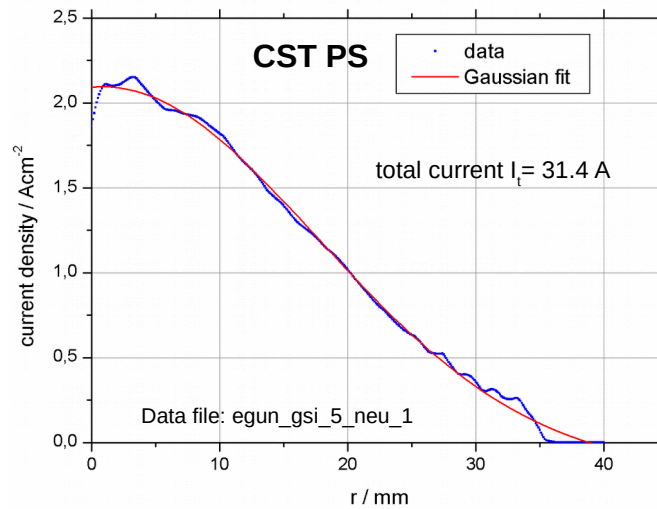


Electric field along cathode

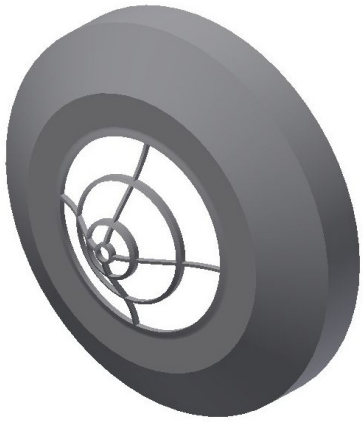


$P = 5.3 \cdot 10^{-6} \text{ A/V}^{3/2}$
 $U = 30 \text{ kV}$
 $I = 30.8 \text{ A}$
 $B_z = 0.2 \text{ T}$
 $J_e = 2.2 \text{ Acm}^{-2}$
 $r_c = 35 \text{ mm}$

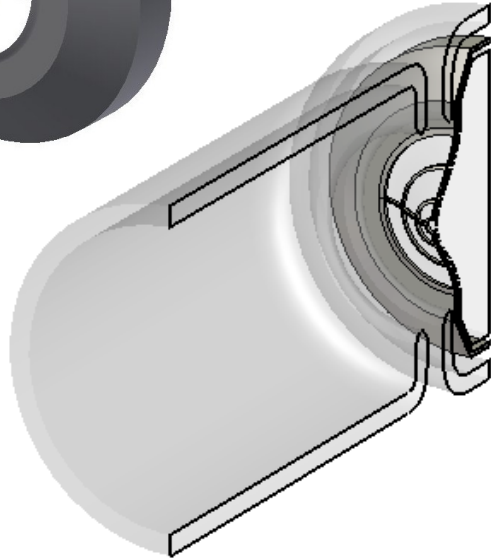
Transverse current density profile



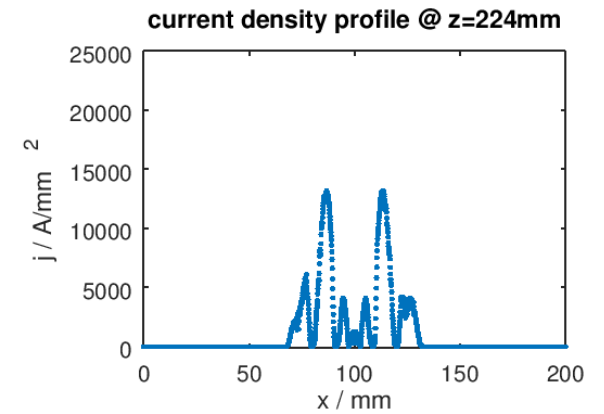
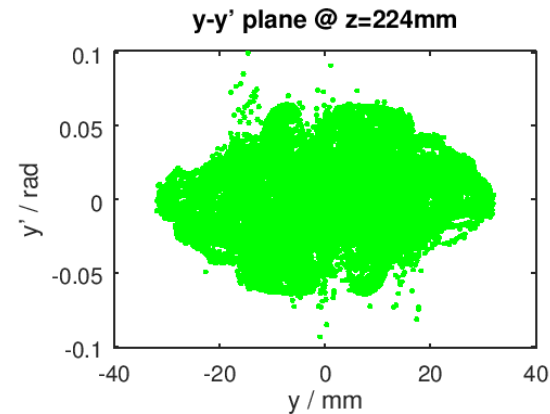
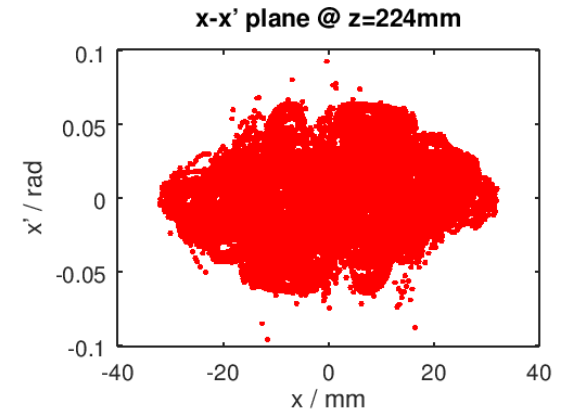
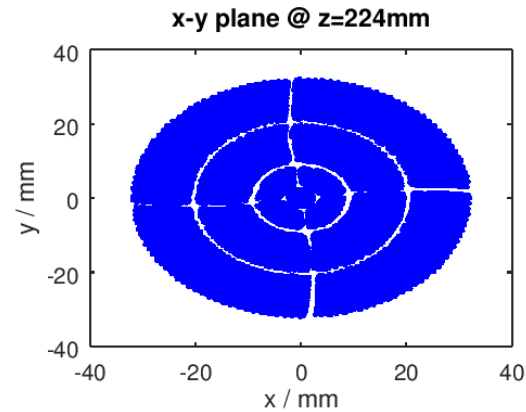
scaled design of BNL e-gun
by A. Pikin



Grid design 2



E-beam distribution in xy , xx' , yy' and current density profile in x



Gun parameters:

$$U_c = 0 \text{ V}$$

$$U_{ce} = 0 \text{ V}$$

$$U_a = 25 \text{ kV}$$

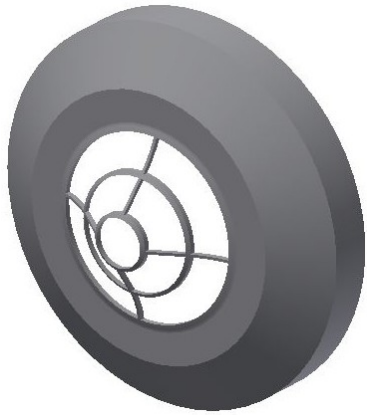
$$B_z = 0.2 \text{ T}$$

$$I_e = 10 \text{ A}$$

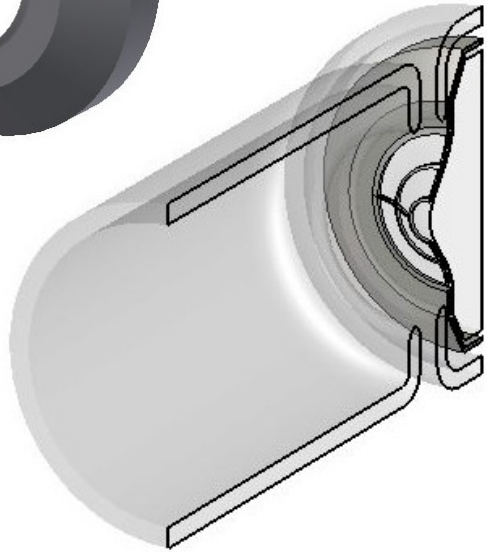
Grid parameters:

distance from cathode $d_{cg} = 2 \text{ mm}$

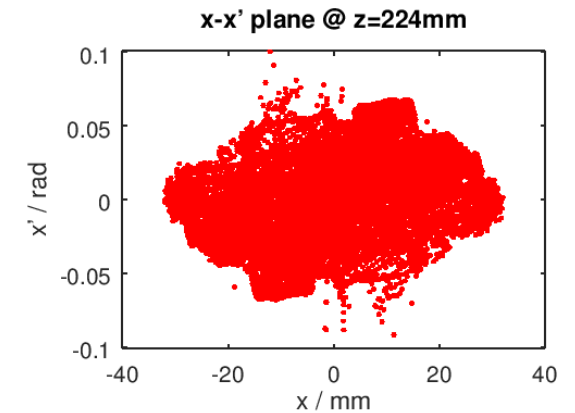
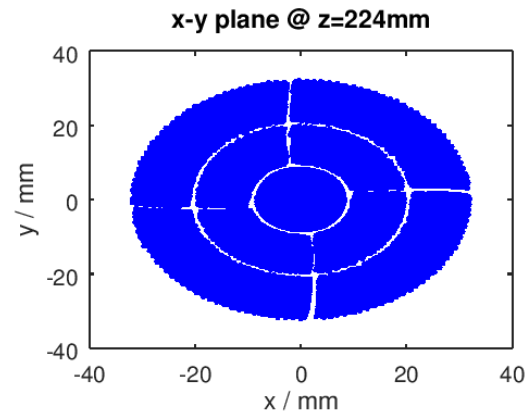
Transmission factor $f = 0.39$ \rightarrow to be validated



Grid design 1



E-beam distribution in xy , xx' , yy' and current density profile in x



Gun parameters:

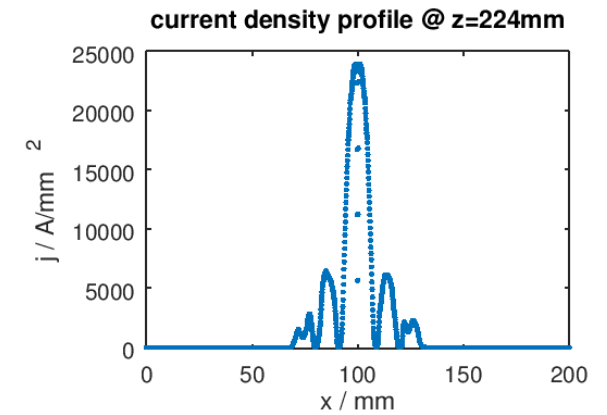
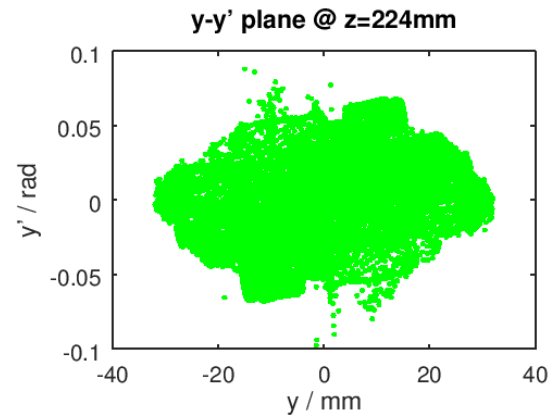
$$U_c = 0 \text{ V}$$

$$U_{ce} = 0 \text{ V}$$

$$U_a = 25 \text{ kV}$$

$$B_z = 0.2 \text{ T}$$

$$I_e = 12 \text{ A}$$



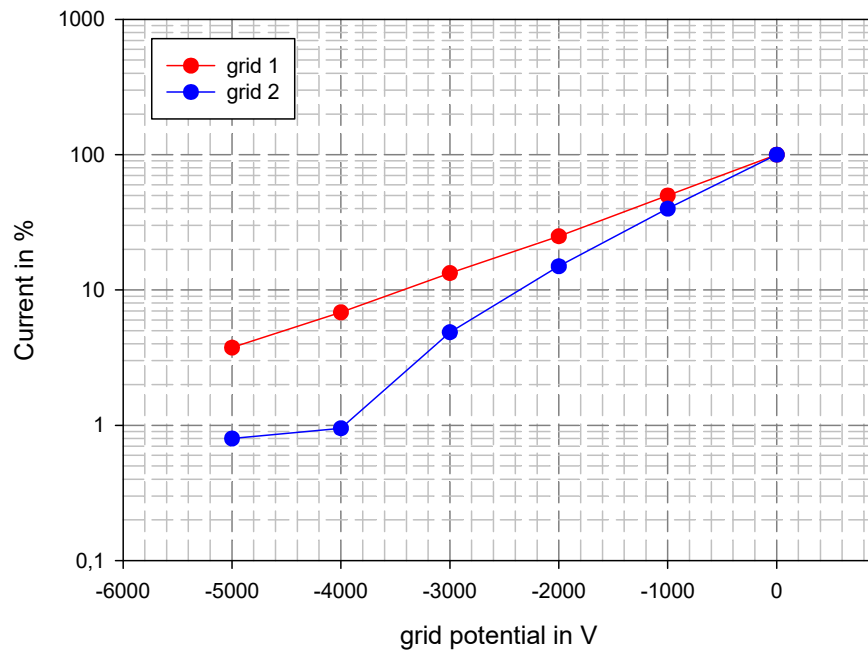
Grid parameters:

distance from cathode $d_{cg} = 2 \text{ mm}$

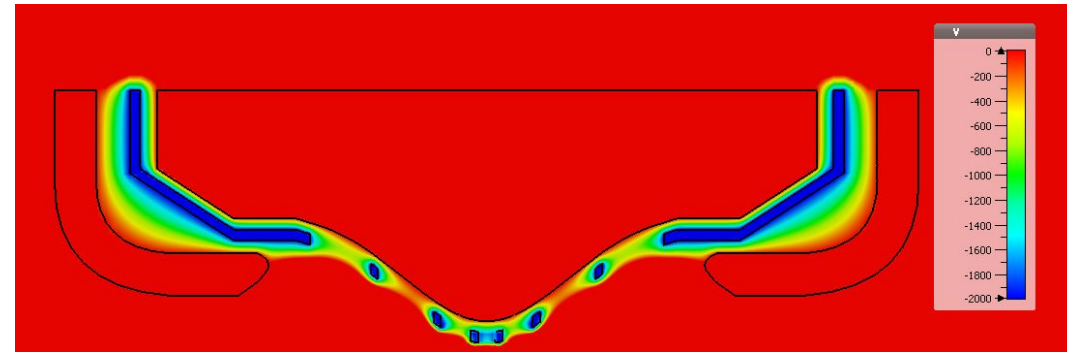
Transmission factor $f = 0.46$ \rightarrow to be validated

Current reduction by grid

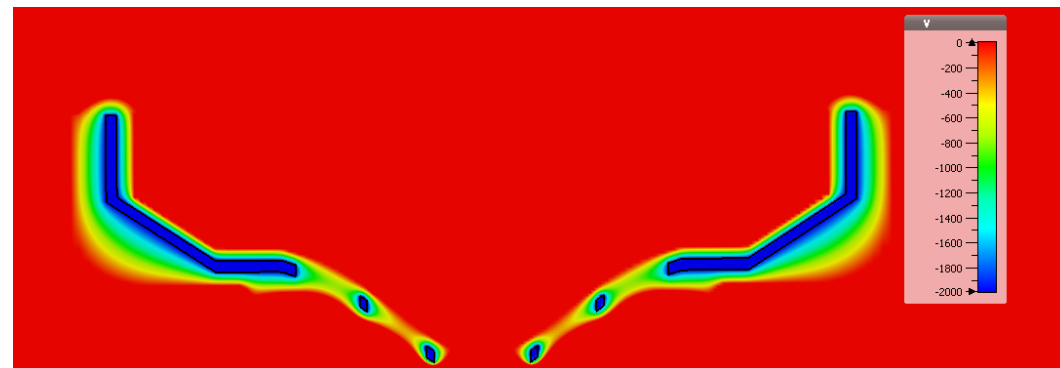
Emitted electron current as a function of grid potential



Grid 2 - Potential distribution

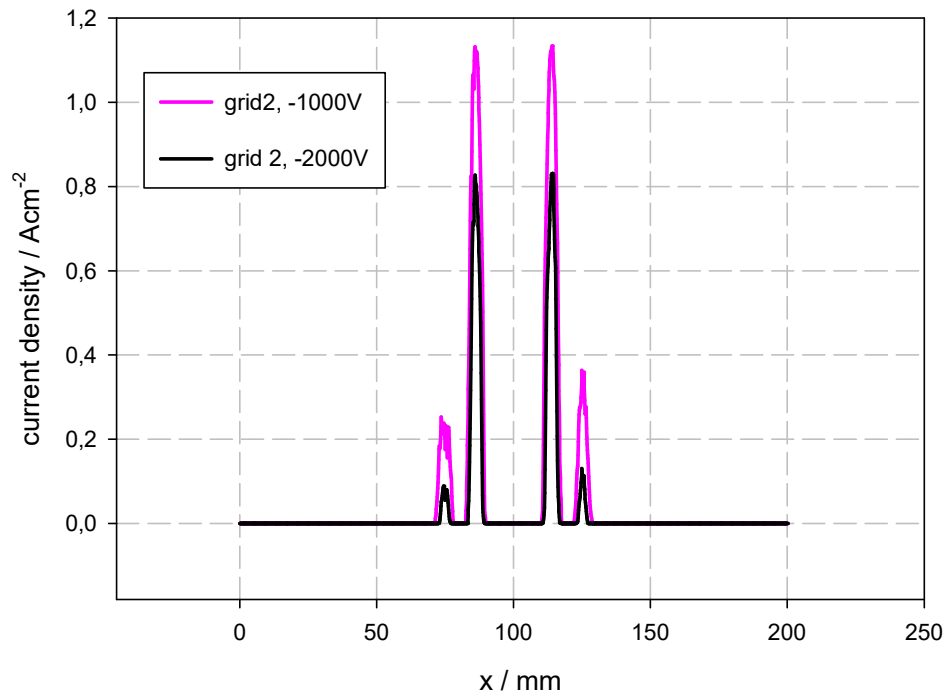


Grid 1 - Potential distribution

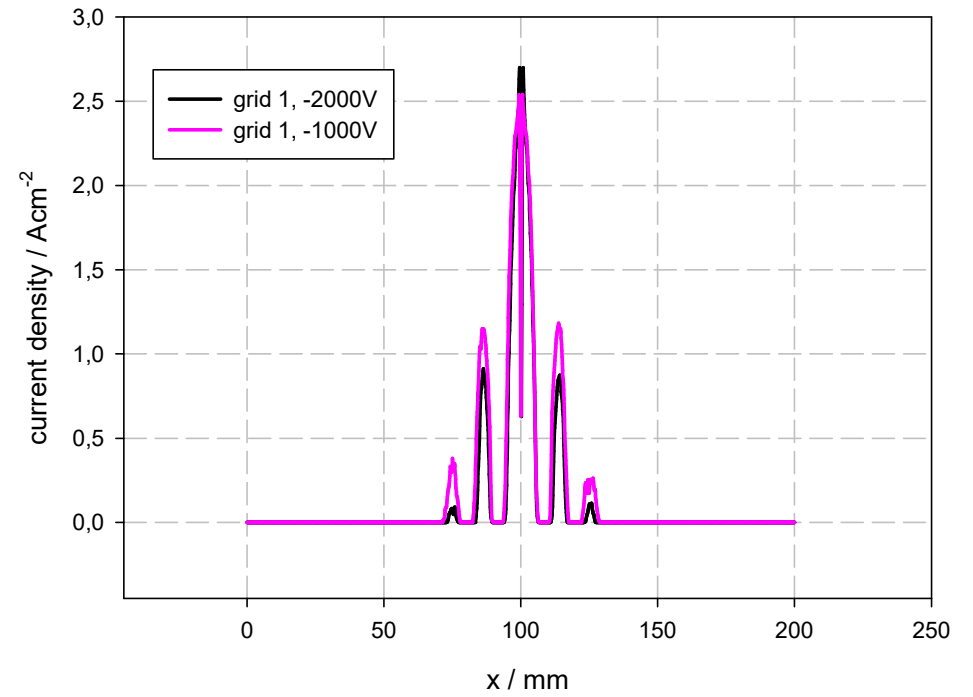


Current density profile

Grid 2

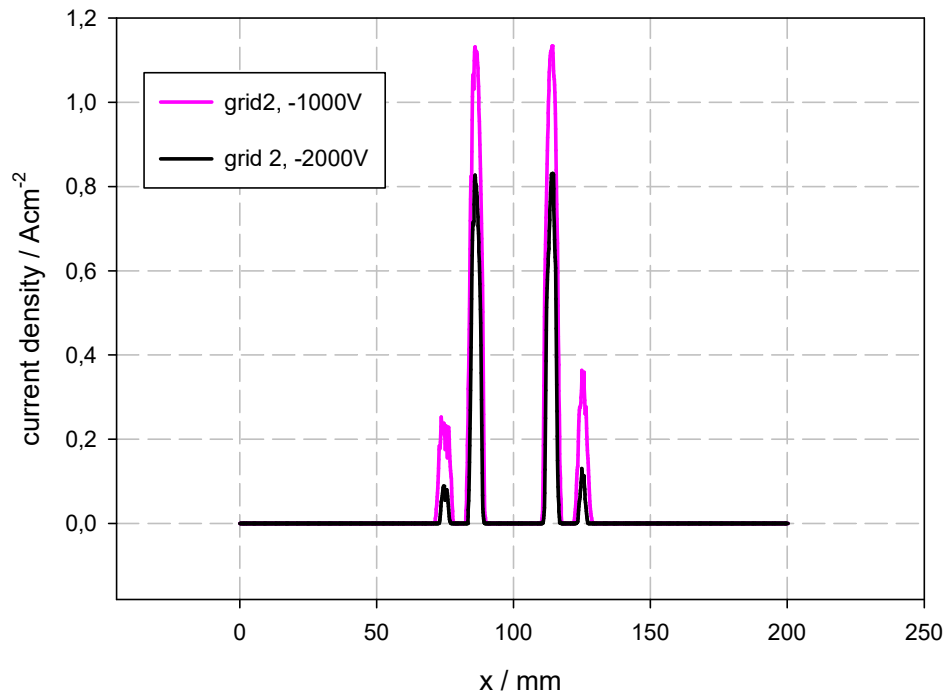


Grid 1

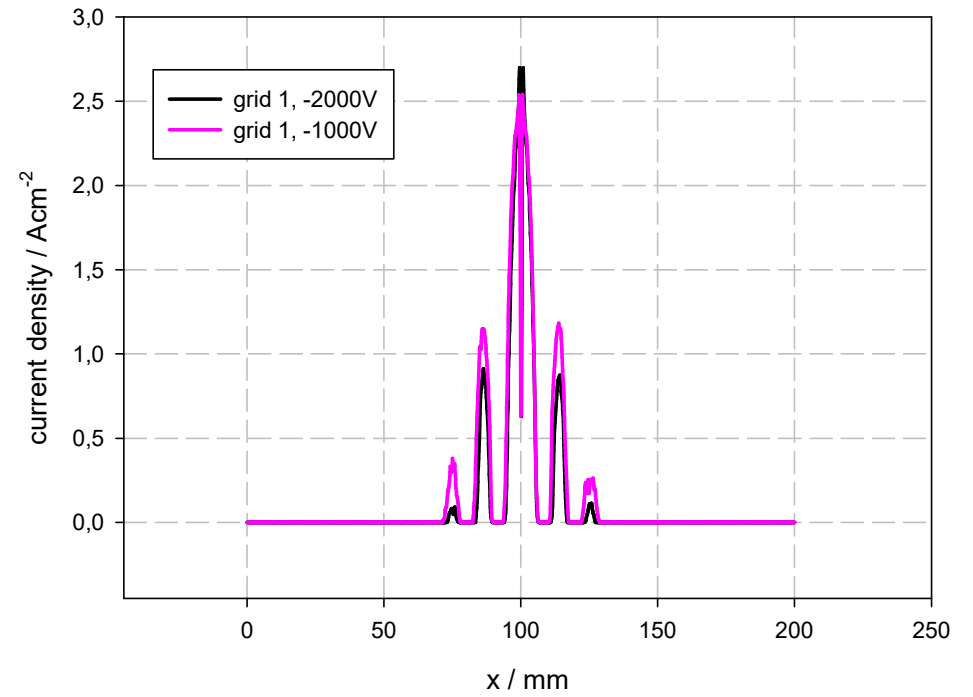


Current density profile

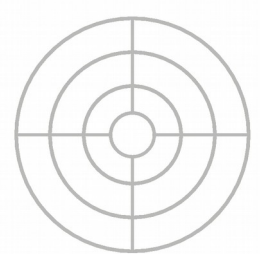
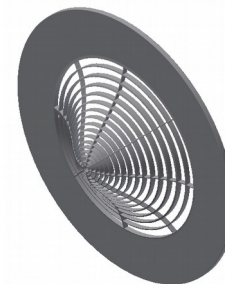
Grid 2



Grid 1

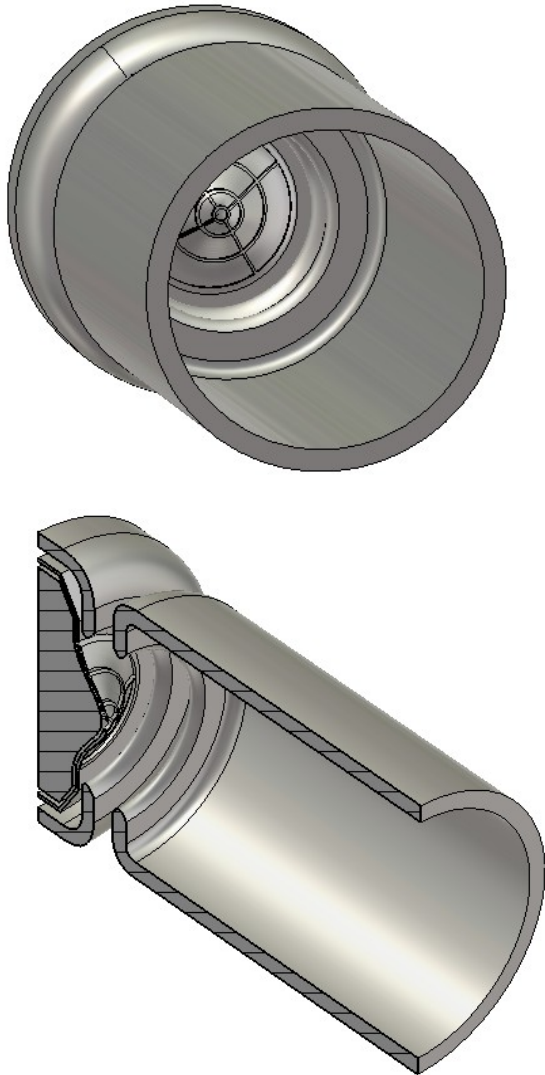


more detailed study of other grid geometries



Update of gun parameters

Gaussian shaped cathode



E-Gun Parameters	
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25 kV
 $P=5.3 \cdot 10^{-6} A/V^{3/2}$
250 kW

3000 V

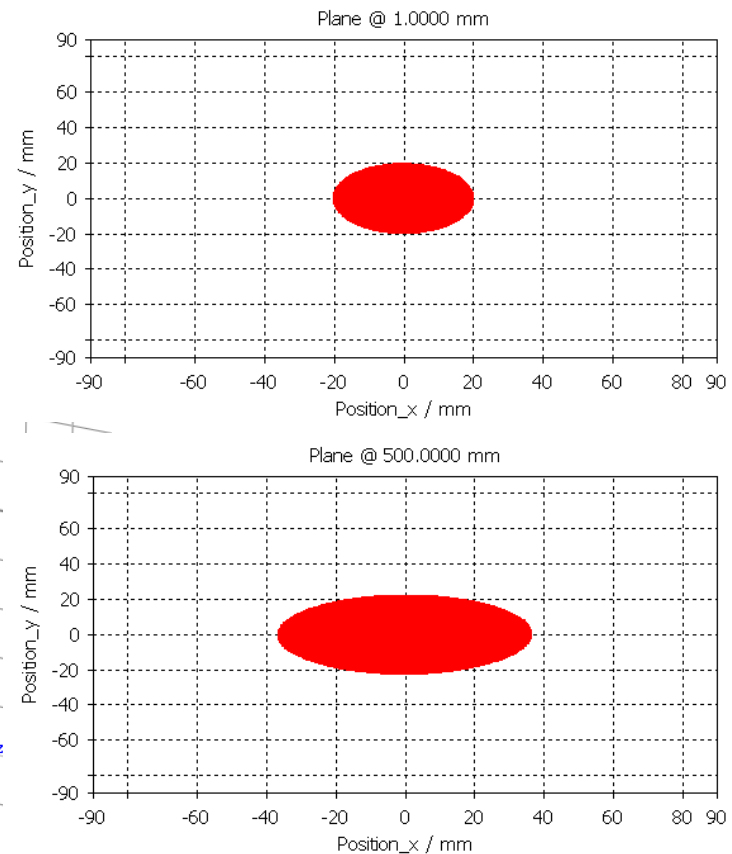
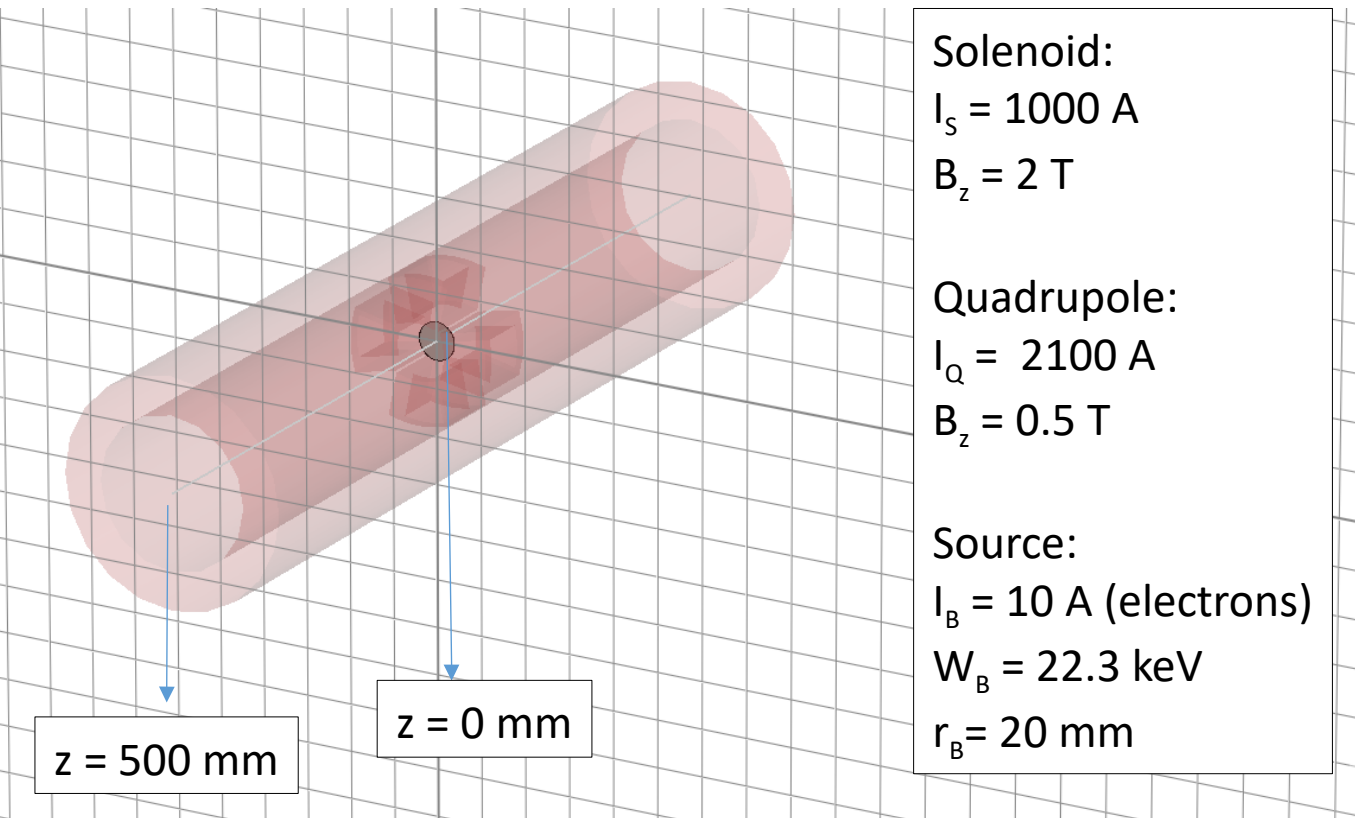
3375 W

75 pF

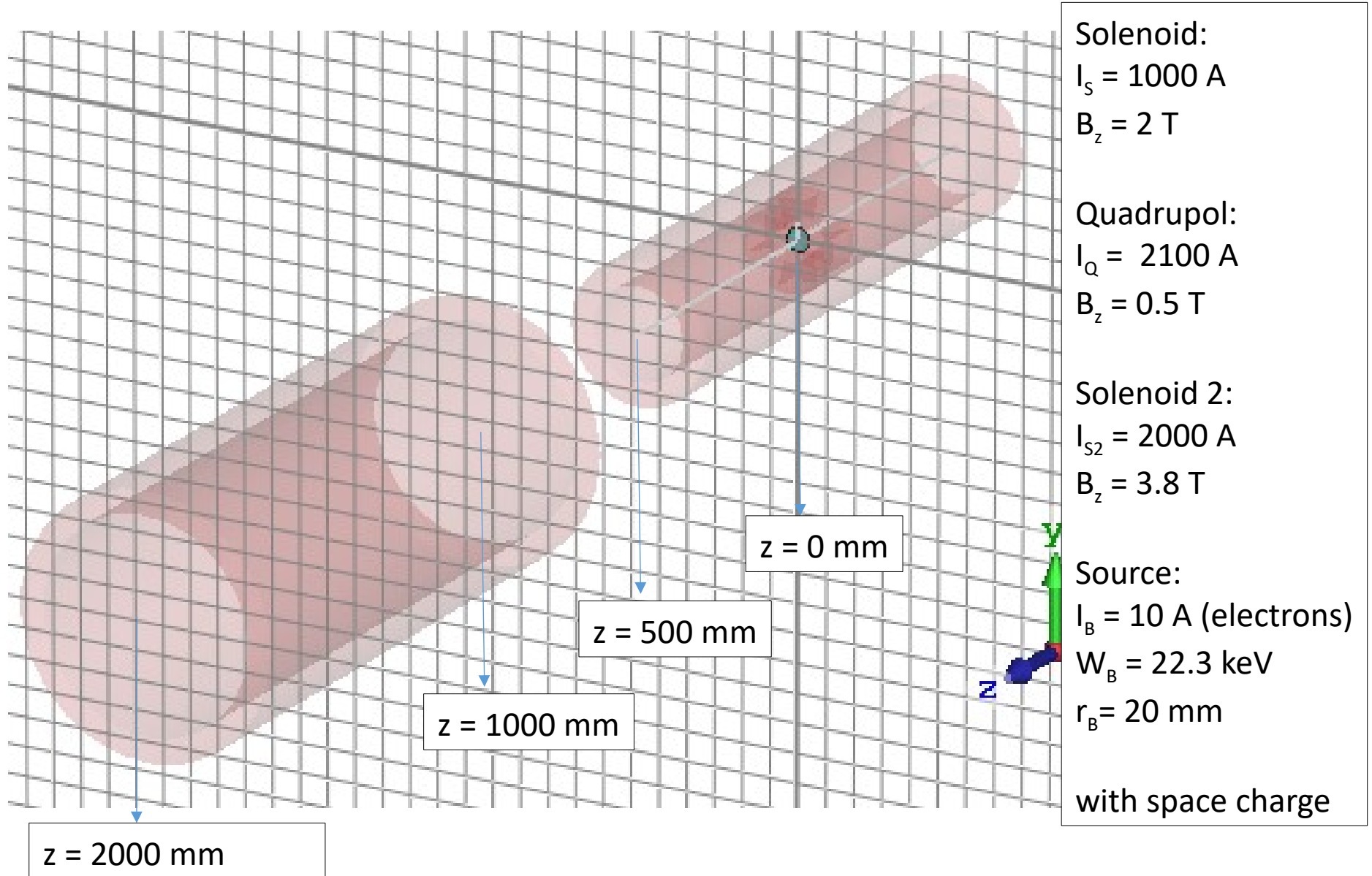
How to create an elliptical beam?

- Cathode shaping
- Beam pipe shaping
- Internal quadrupole field

Beam shape under the influence of space charge forces



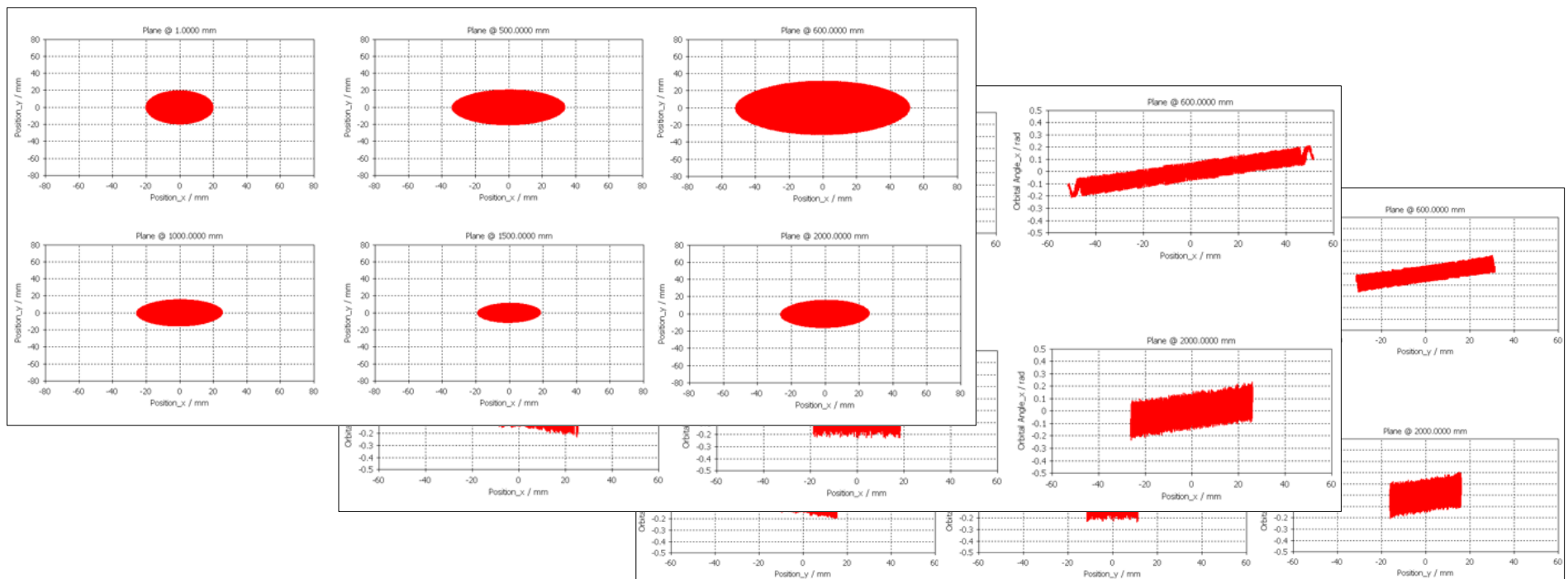
Beam dynamics of elliptical beam in main solenoid



Beam dynamics of elliptical beam in main solenoid

Expectation: the transverse rotation of e-beam after leaving the solenoid and the additional beams space charge would destroy the elliptical distribution.

Checking for xy -plane, xx' -plane and yy' -plane

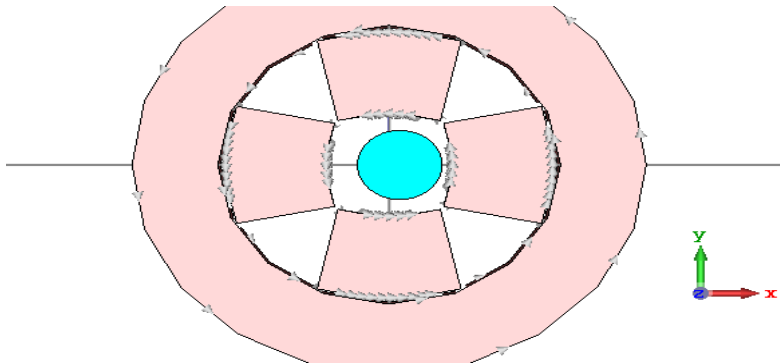


Result: no negative effect on elliptical distribution.

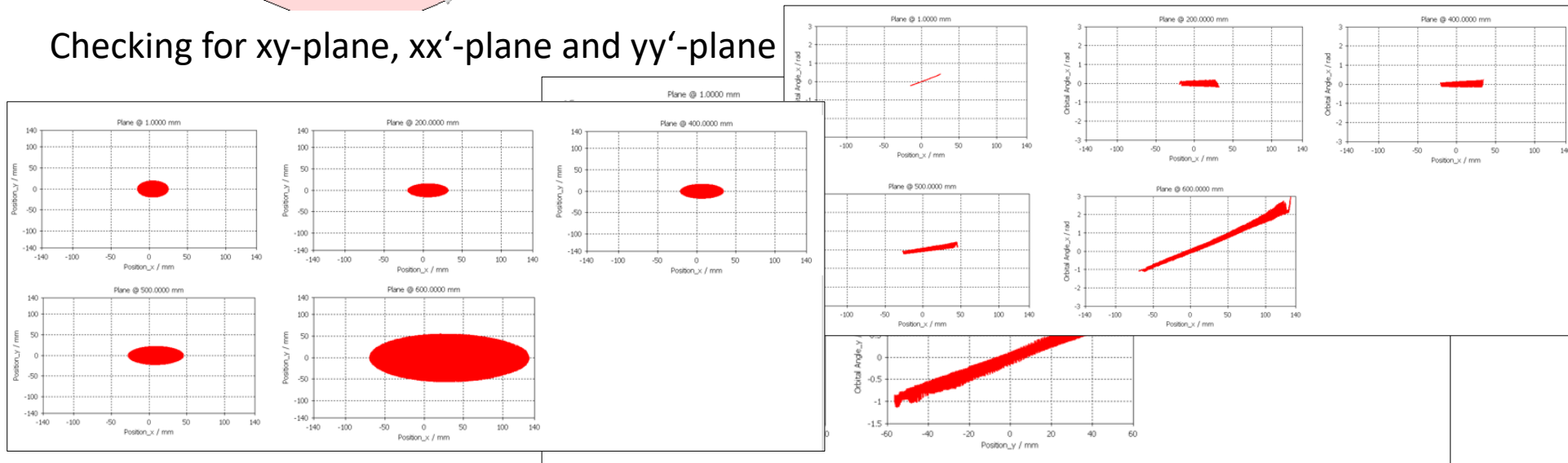
Possible explanation: coupling of magnetic fields \rightarrow further studies needed

Beam dynamics of shifted elliptical beam in main solenoid

Electron source in shifted 5mm in x direction



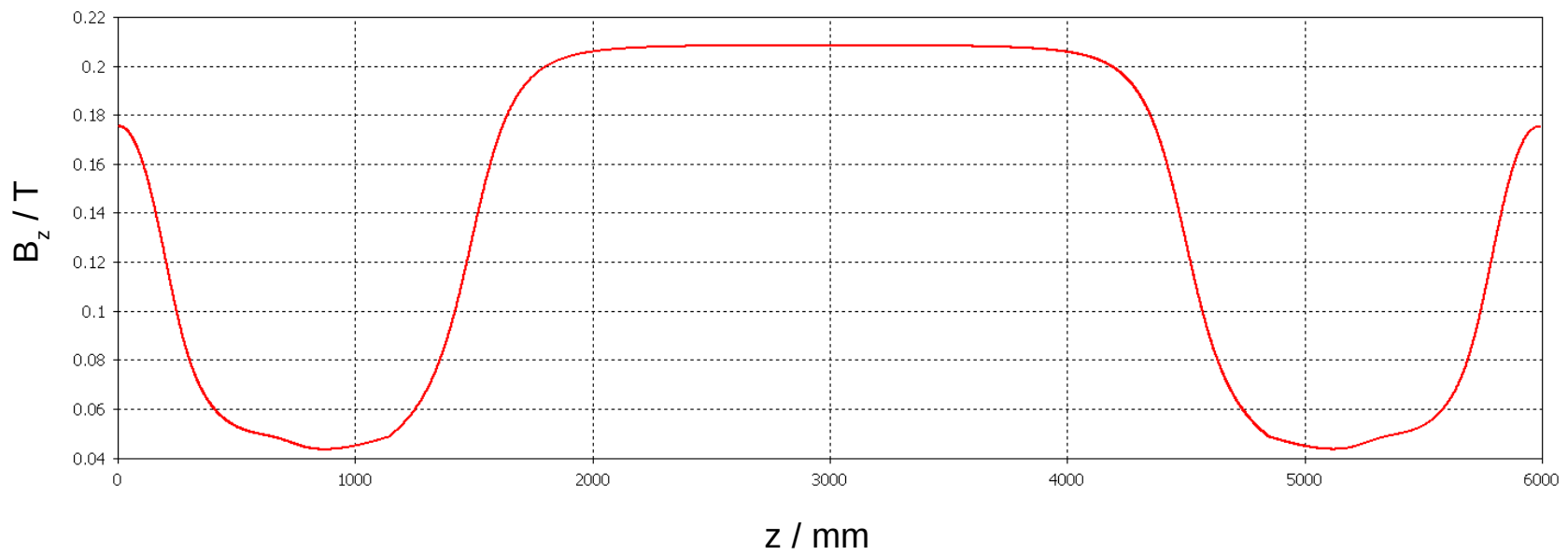
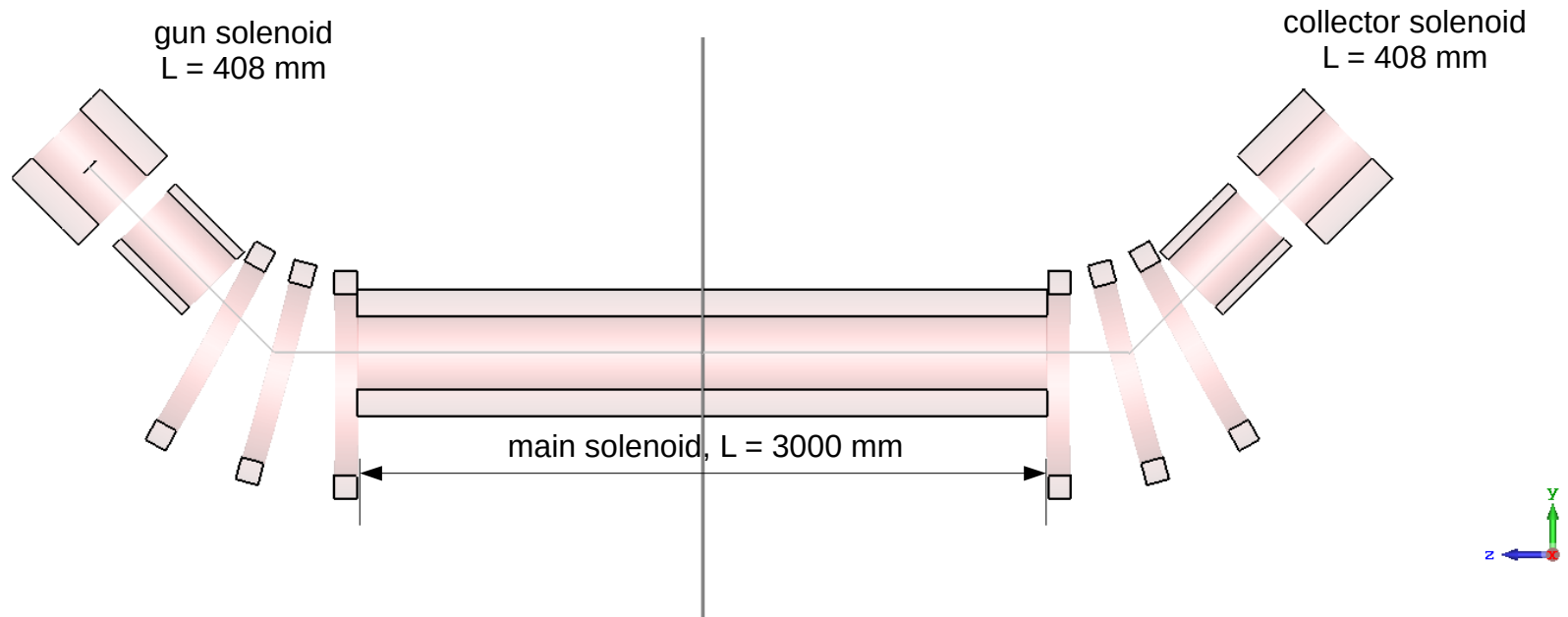
Checking for xy-plane, xx'-plane and yy'-plane



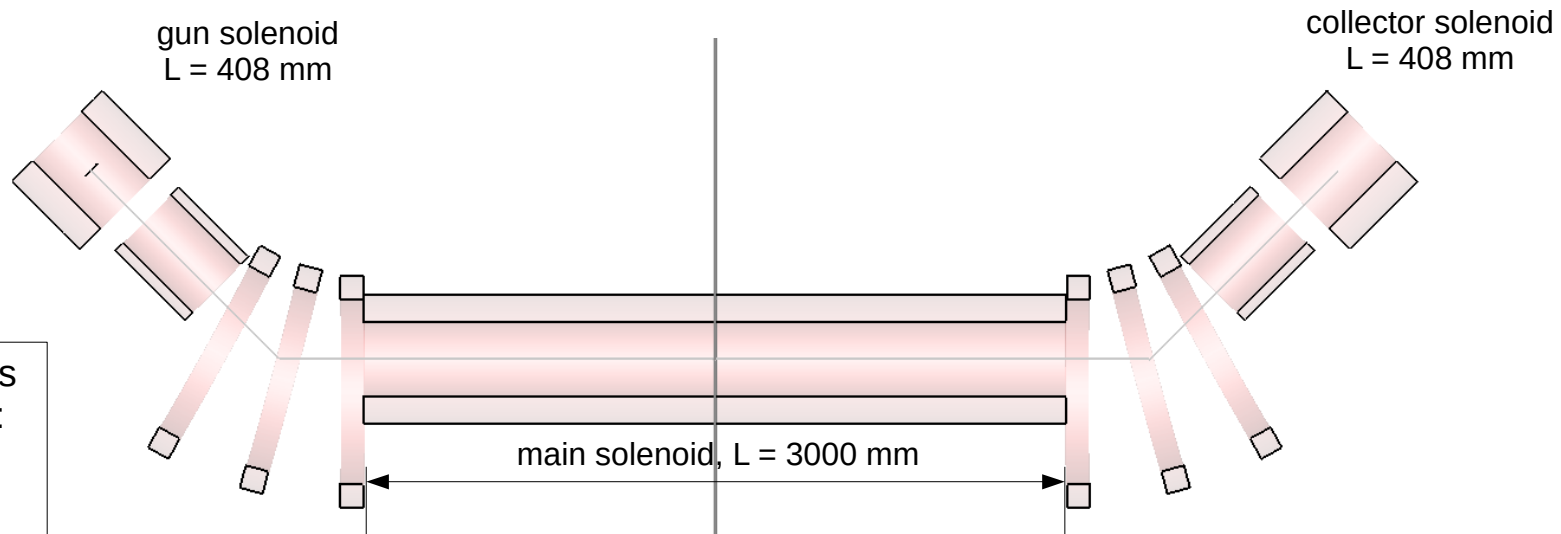
Result: no negative effect on elliptical distribution.

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E-Lens: beam dynamics and magnet design



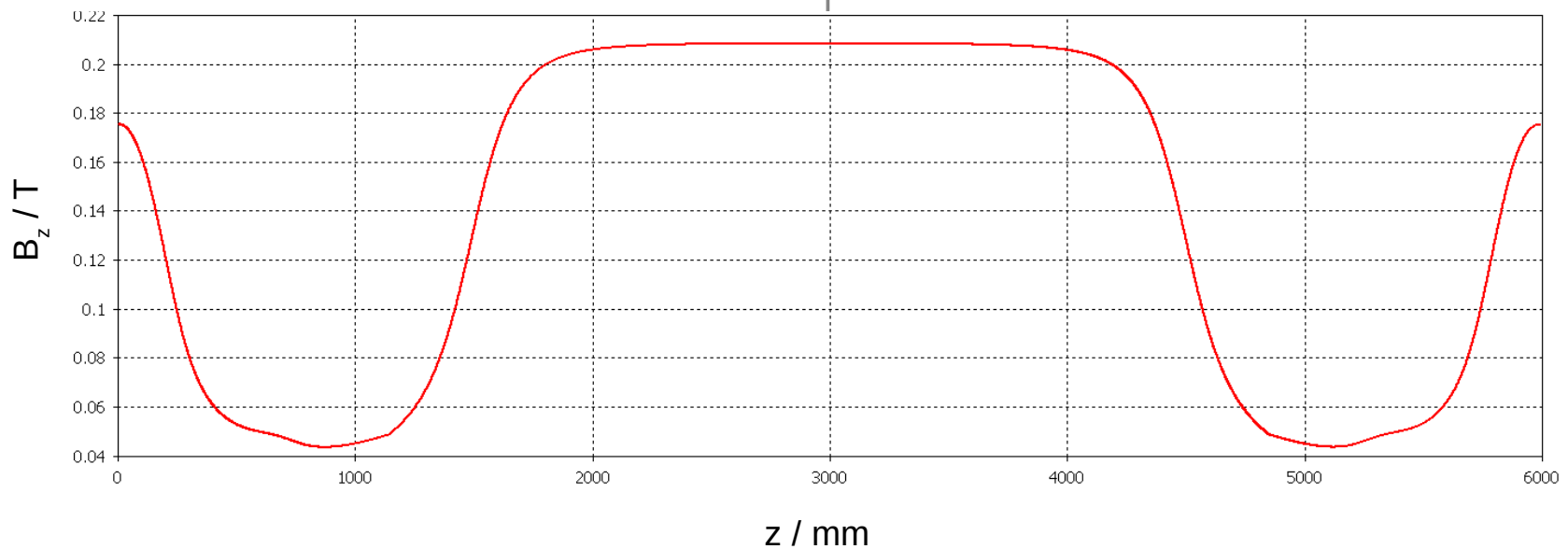
E-Lens: beam dynamics and magnet design



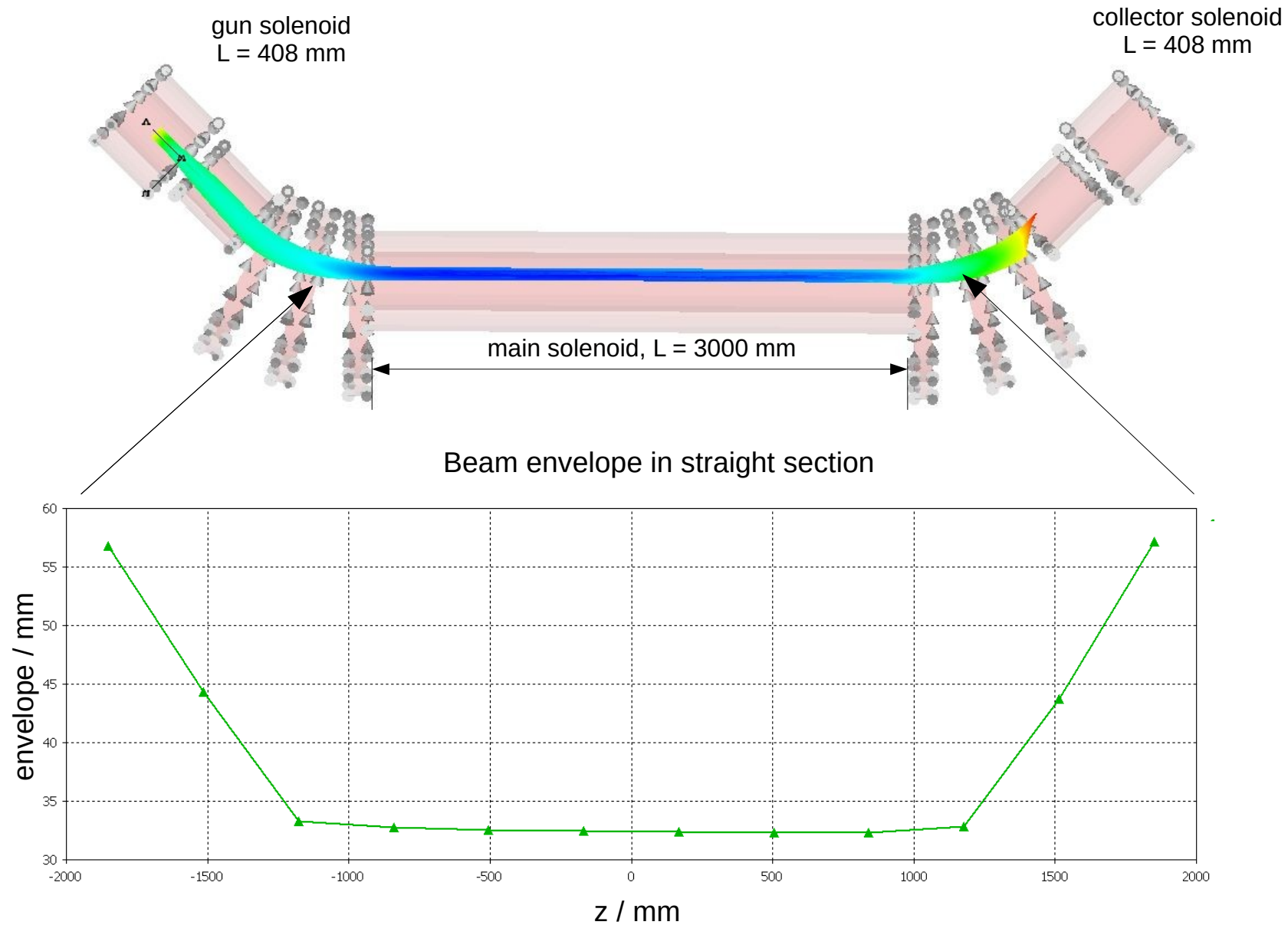
Magnetic settings
SIS18 e-cooler:

$$B_{\text{gun,max}} = 0.4 \text{ T}$$

$$B_{\text{main,max}} = 0.15 \text{ T}$$



E-Lens: beam dynamics and magnet design



Teststand at IAP

