Gabor Lens- LhARA

This document specifies the dimensions of the first Prototype Gabor lens relevant to the LhARA project.

Design decisions:

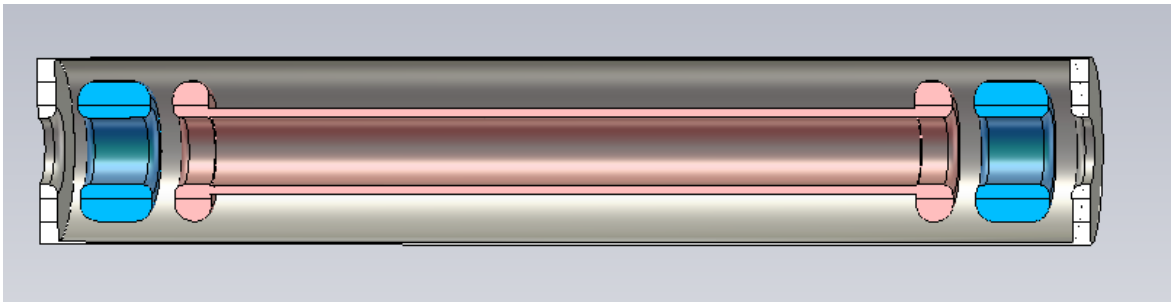
- Penning-Malmberg type particle trap – 2 cathodes one anode.
- All electrodes isolated from vacuum vessel – options to operate either grounded Anode or grounded Cathode.
- Magnetic field provided by array of 'pancake coil' magnets – this to allow access at selected axial positions for diagnostics.

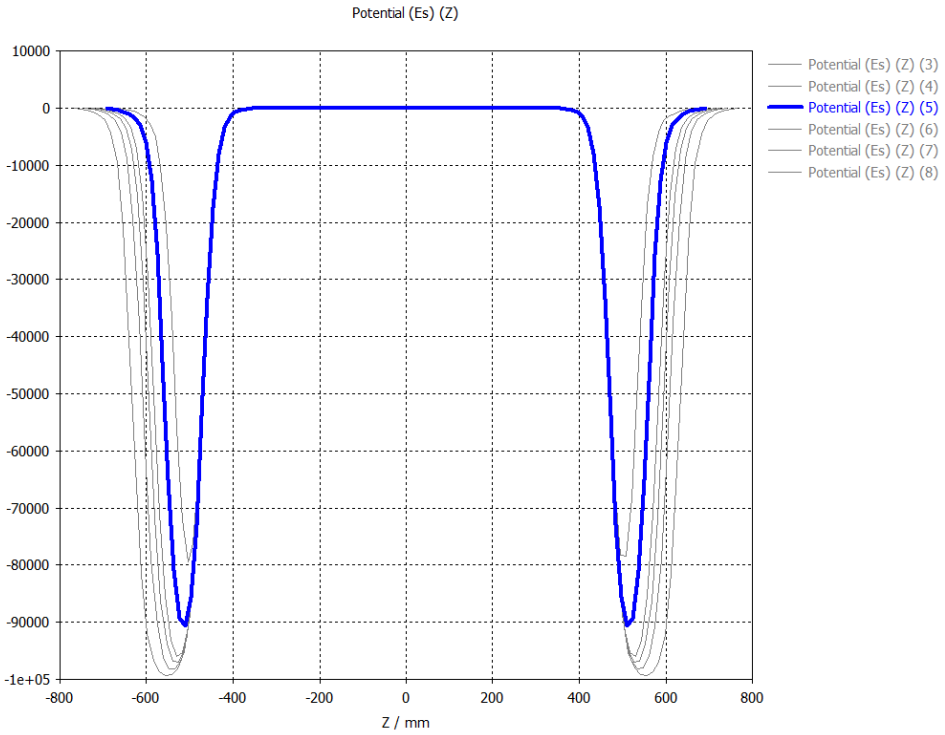
Dimensions taken from LhARA Pre-CDR report

Gabor lens length/alternate solenoid length	**1.157m**
Gabor lens effective length (anode length)	**0.857m**
Gabor lens clear bore diameter	**0.0365m**
Input beam divergence	50mrad
Beam radius at input of lens (2σ)	0.004m
Beam radius at output of second Gabor lens (2σ)	~0.03m
Equivalent solenoid maximum field	1.3T

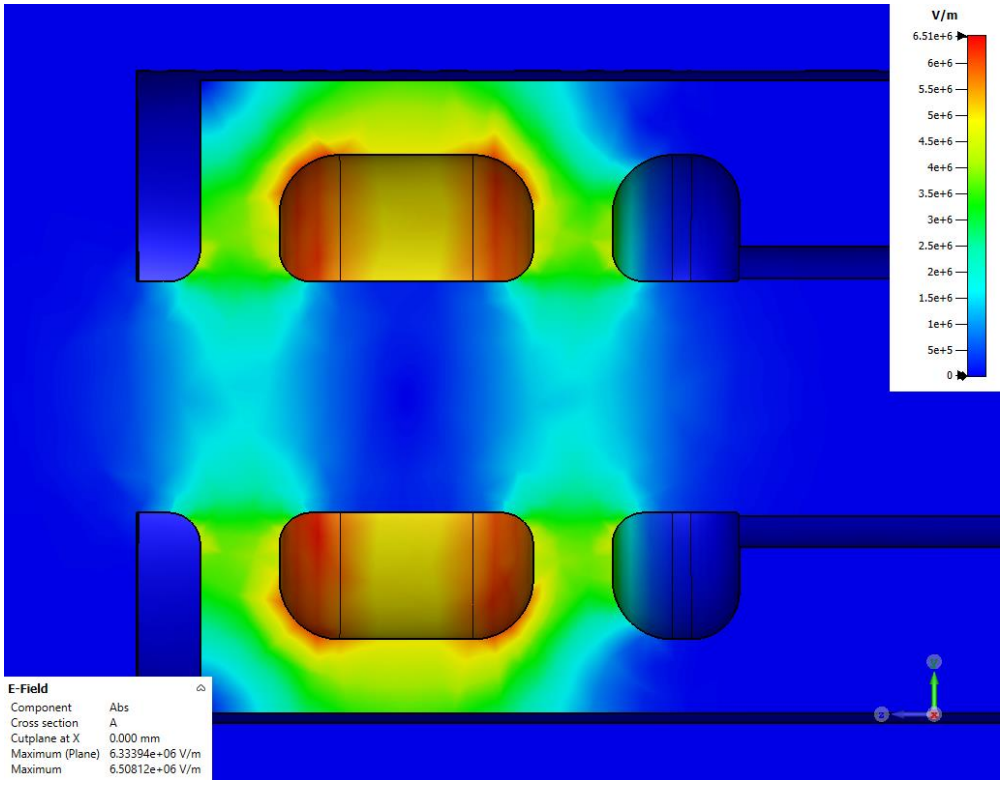
Parameters derived from focussing requirements as specified in LhARA Pre-CDR report

Gabor lens electron number density	**5×10^{15}**
Gabor lens magnetic field required - assuming 100% lens filling	30mT
Gabor Lens anode-cathode voltage required - assuming 100% lens filling	30kV
Gabor lens magnetic field design value	**50mT**
Gabor Lens anode-cathode voltage design value	**65kV**
Gabor Lens focal length f ~=	**2.5m**
Anode Cathode gap	0.025m
Vacuum vessel internal radius	0.10m





Grounded anode configuration – this configuration would be required for any experiment where we hoped to make a measurement of electron density using refractive index change. Graph above shows the calculated electric potential on-axis with varying length of cathode electrode. Profile highlighted in blue has cathode length = 65mm and provides 90% of total cathode voltage on axis to confine the electron cloud. Shorter cathodes provide lower percentage field on axis. To minimise the total cathode voltage required to confine a given electron density the cathode electrode length should be maximised within the space available – 80mm cathode length provides over 95% of total applied potential on axis while allowing an anode length of 0.857m.



Electric field map for 100kV cathode voltage. Max field strength <7MV/m. For 65kV confining field, allowing for up to 10% electric field loss on axis due to electrode configuration, the required max potential would be 72kV, giving a maximum field strength of 5MV/m. This seems reasonable given that conventional limits for DC fields in on well-prepared surfaces are 15Mv/m. Contour plot shows electric field is a maximum on the curved external surfaces of the anode with some enhancement at the start of the inside radius – this can be minimised by moving to a more gradual roll off of the profile.