AREAL RF Gun Model Refinement by Beam Trajectory Response

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Problem description

In most cases of result comparison for simulations and measurements there is discrepancy in main characteristics.

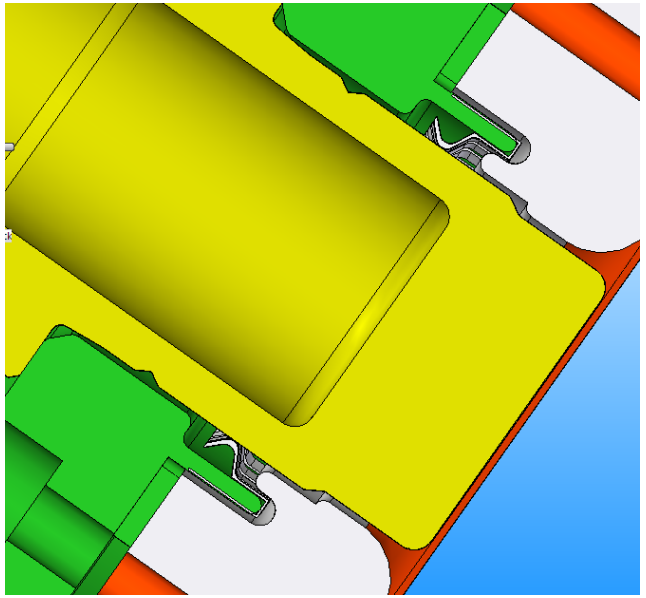
Possible reasons:

- **Gun focusing effect (plug, cell deformation)**
- **Solenoid focusing**
- Beam energy, beam charge
- Beamline ASTRA model & real coordinates
- …

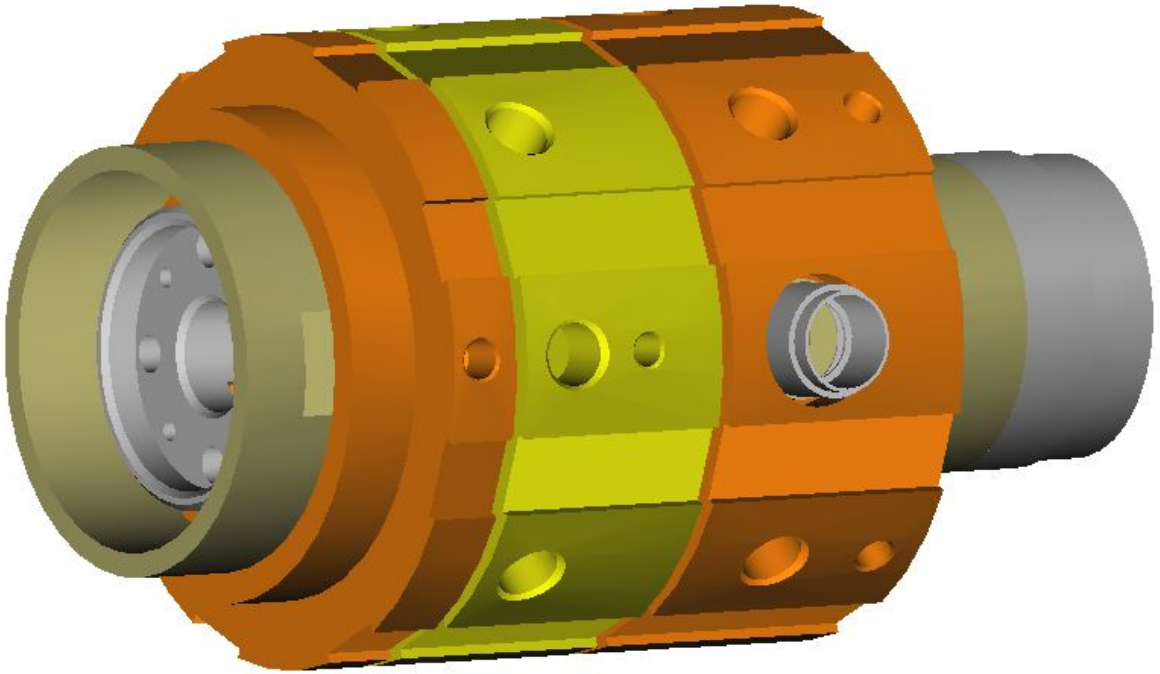
Goal – Refine gun model and minimize discrepancy between simulation and measurement

Gun focusing effect

- Change of plug location can correspondingly cause change of electromagnetic field on the cathode surface, hence gun focusing effect on the beam



- Gun cell deformation analogically causes field balance disturbance and change of gun focusing of the beam



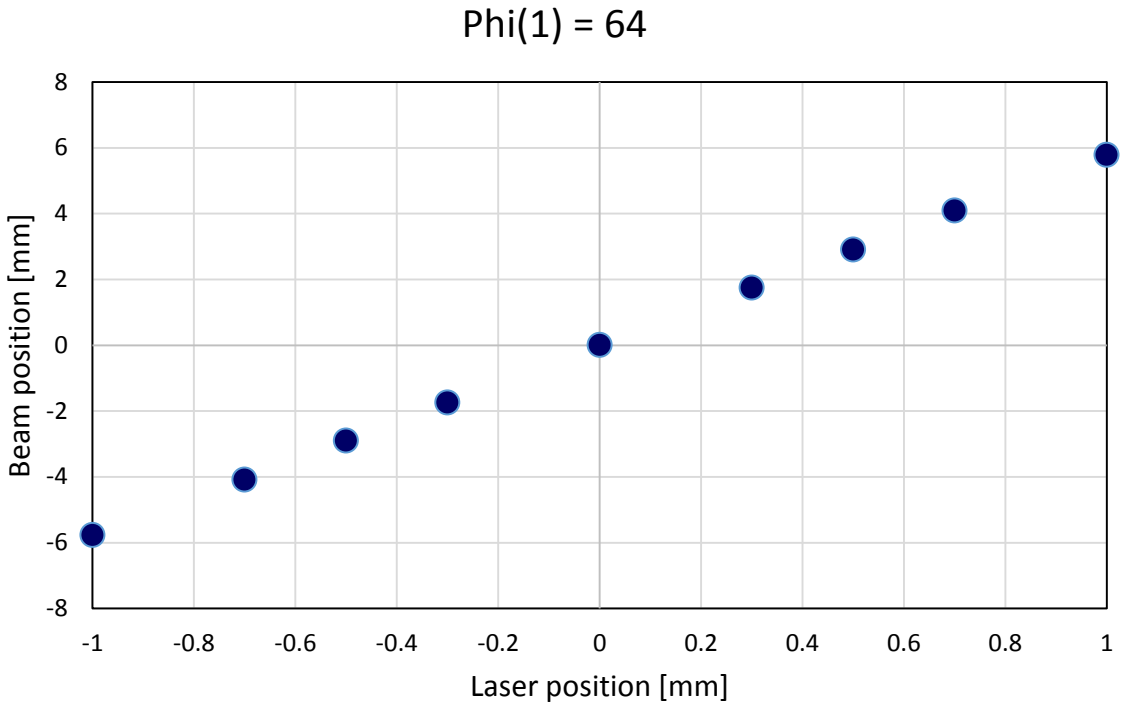
Method

$$\begin{bmatrix} X \\ X' \end{bmatrix}_{Screen} = \begin{bmatrix} M_{11} & M_{12} \\ M_{21} & M_{22} \end{bmatrix} \begin{bmatrix} X \\ X' \end{bmatrix}_{Cathode}$$

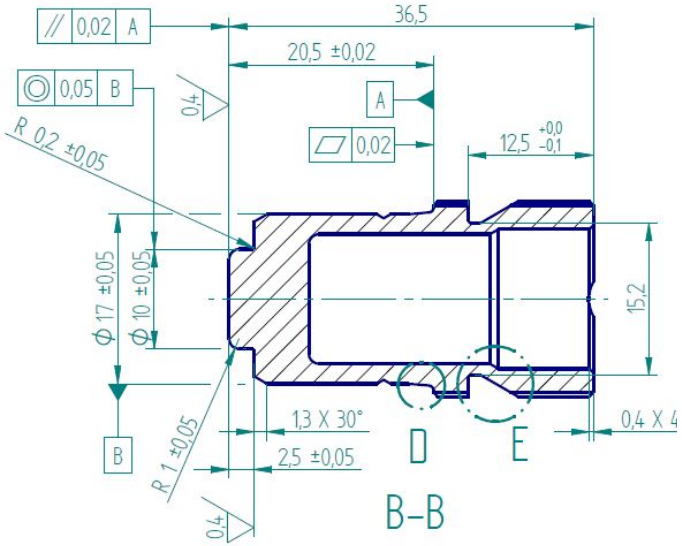
$$\frac{\partial X_S}{\partial X_C} = M_{11}$$

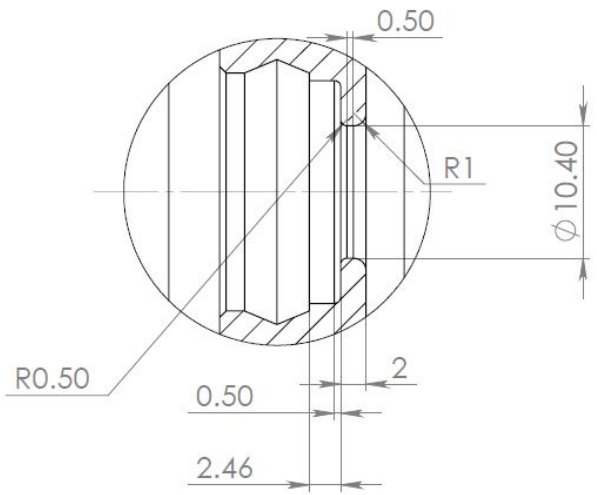
simulation

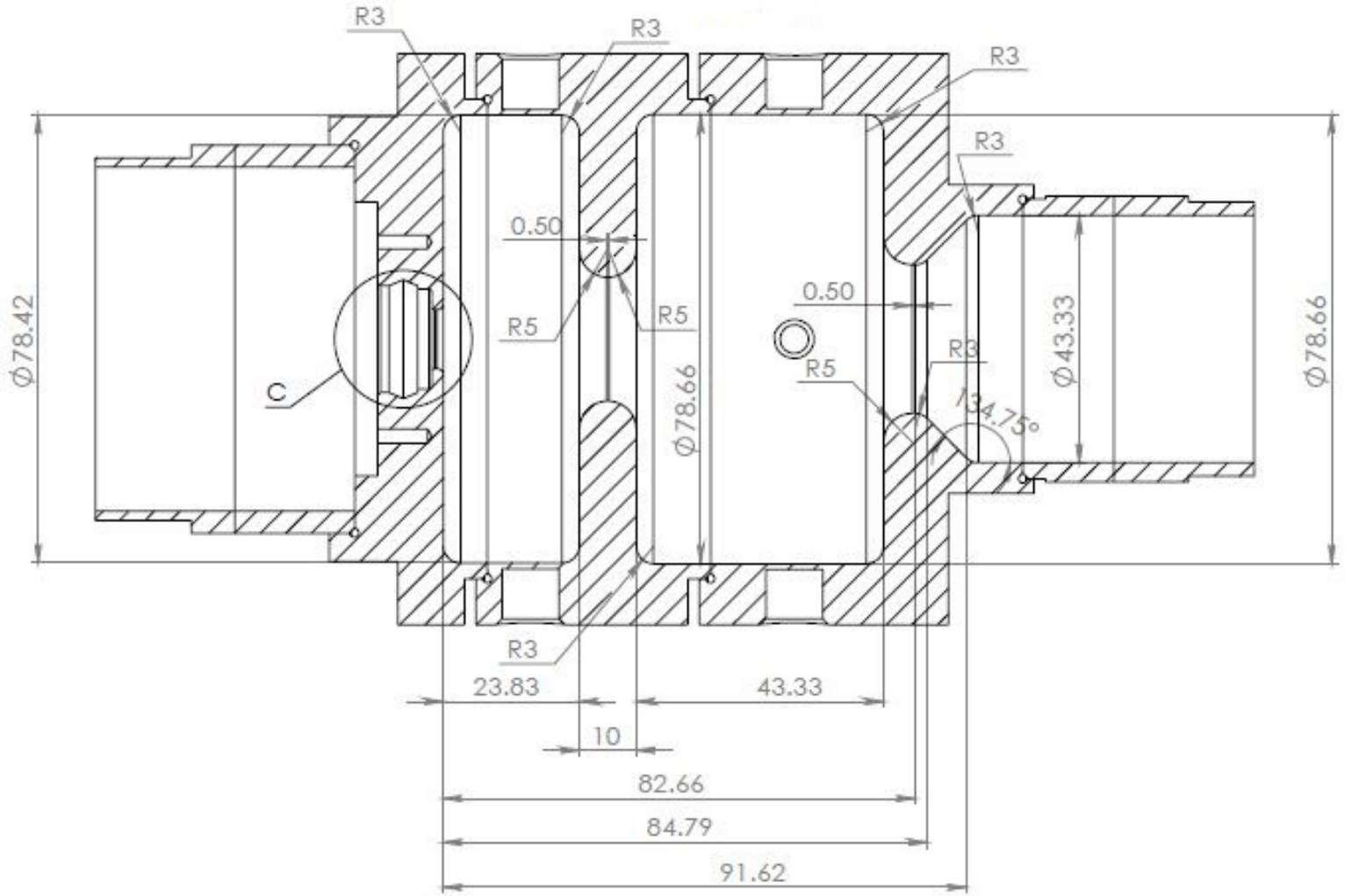
measurement



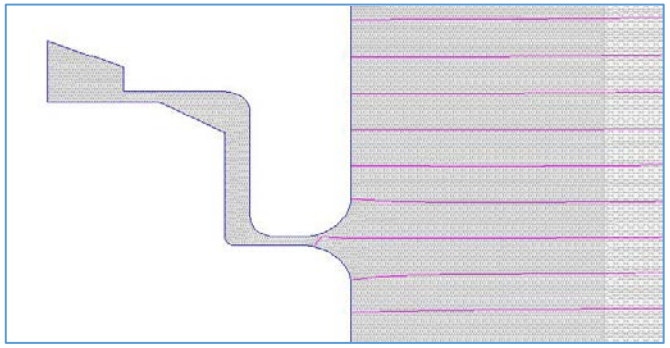
Geometries of Gun and cathode



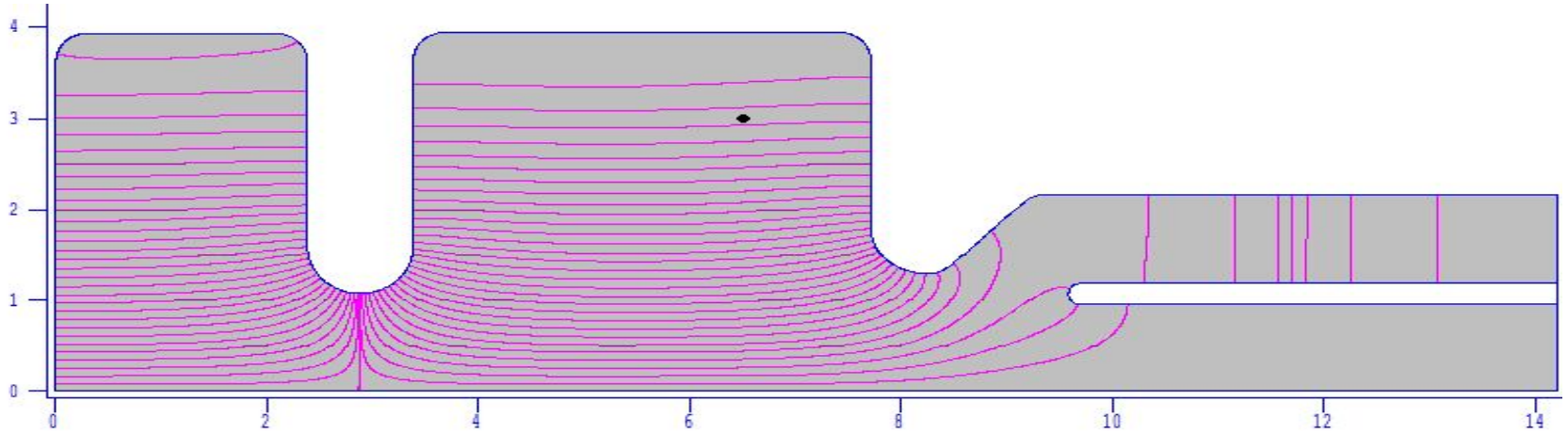


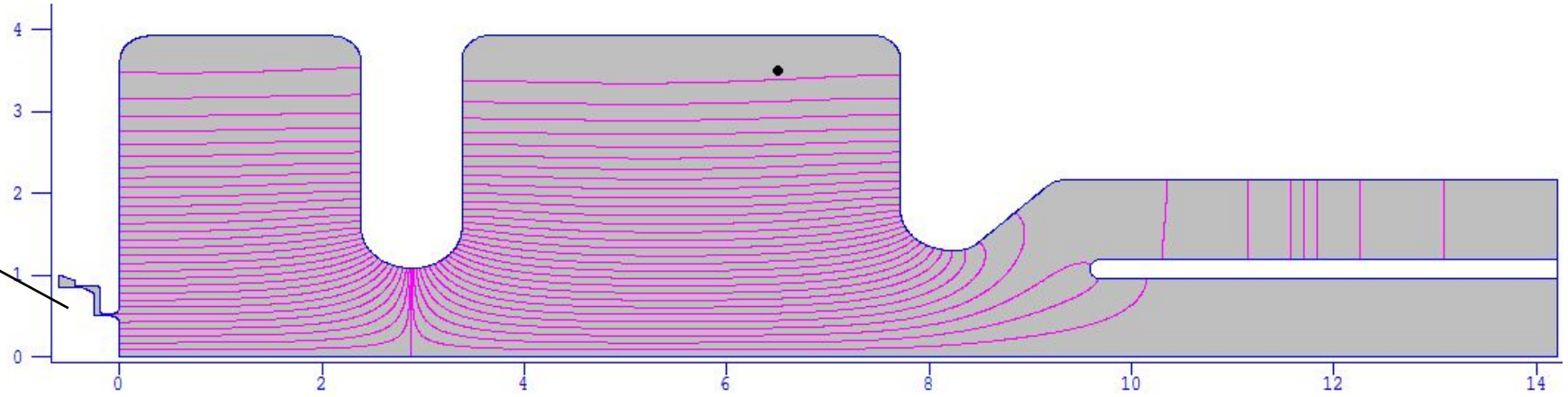


SUPERFISH simulation results



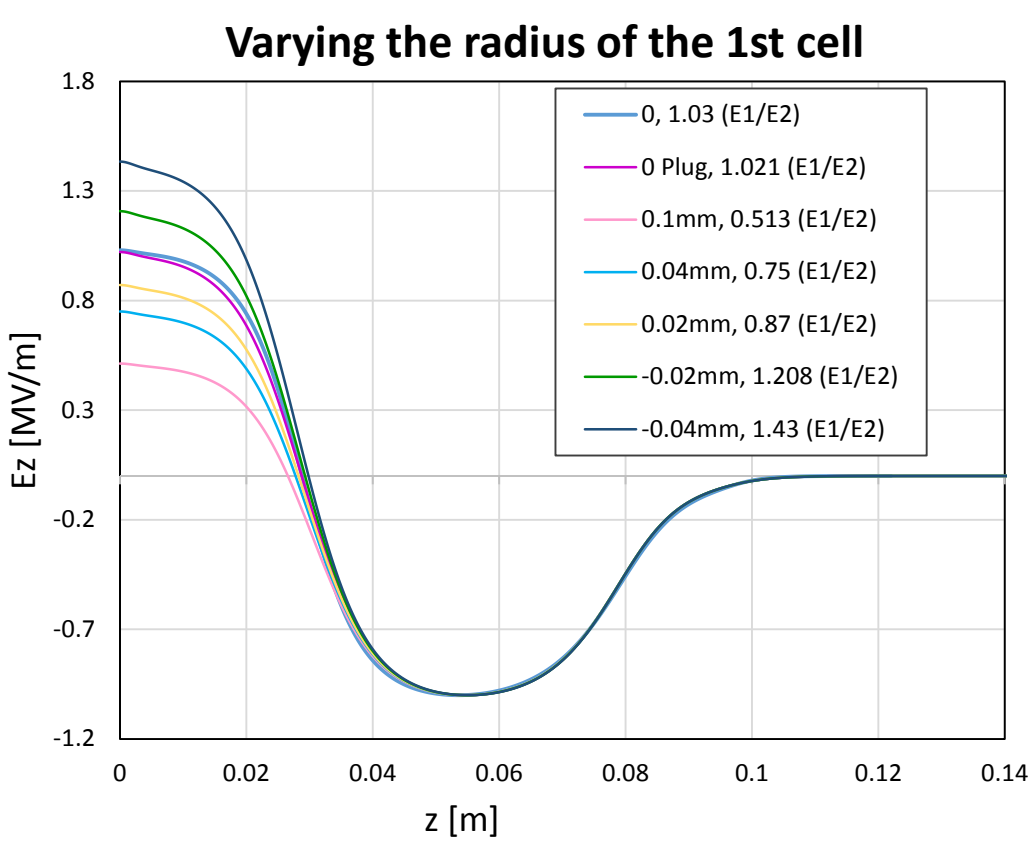
Local finer meshes were used

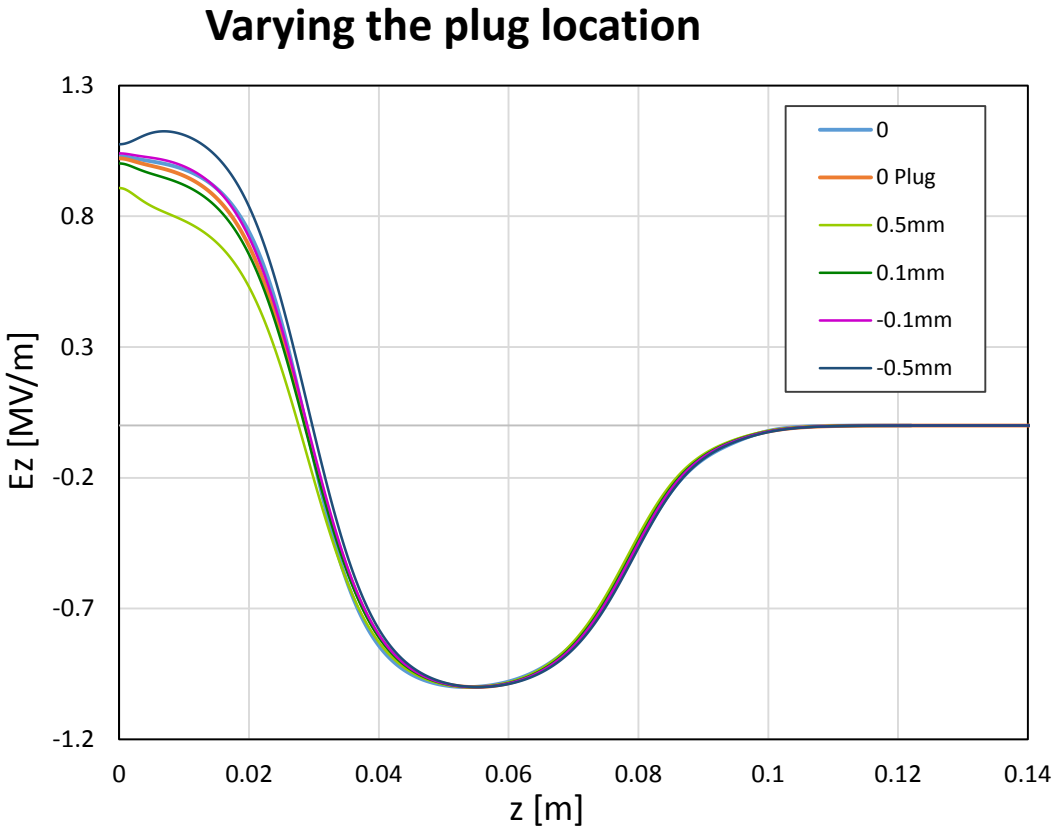




Gun field maps for different geometrical changes

SUPERFISH results of gun field maps





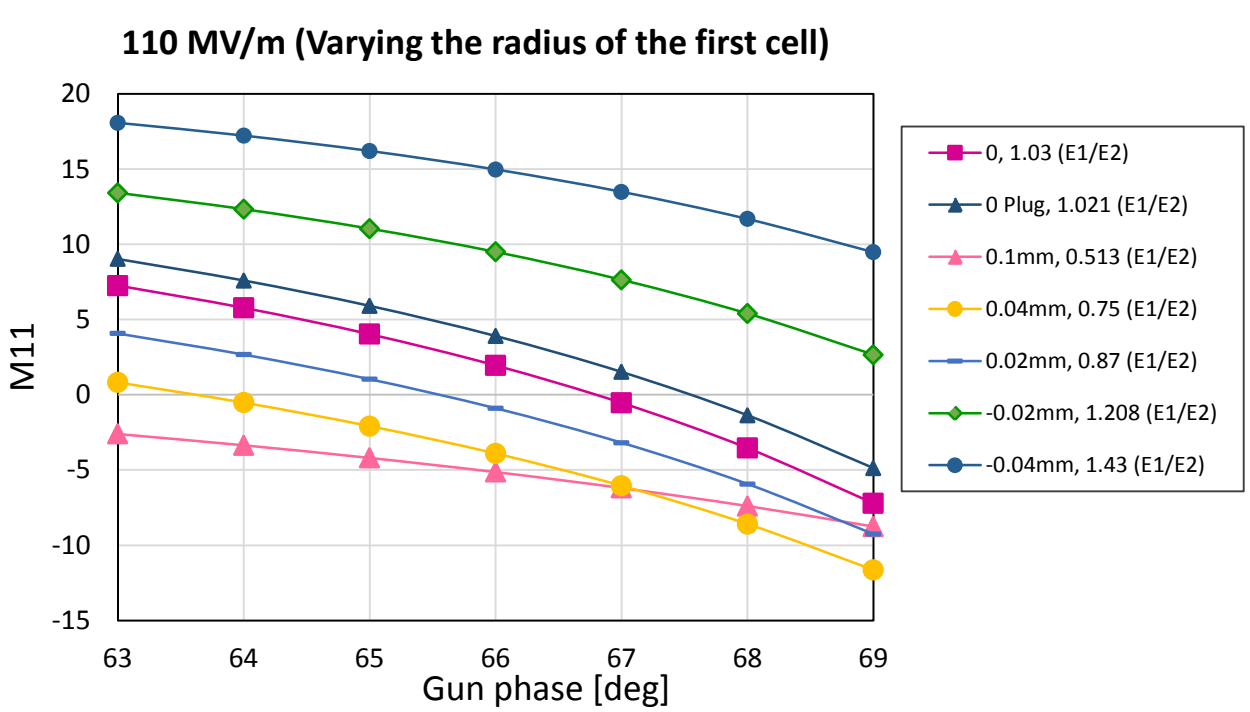
Energy gain change due to field balance disturbance.

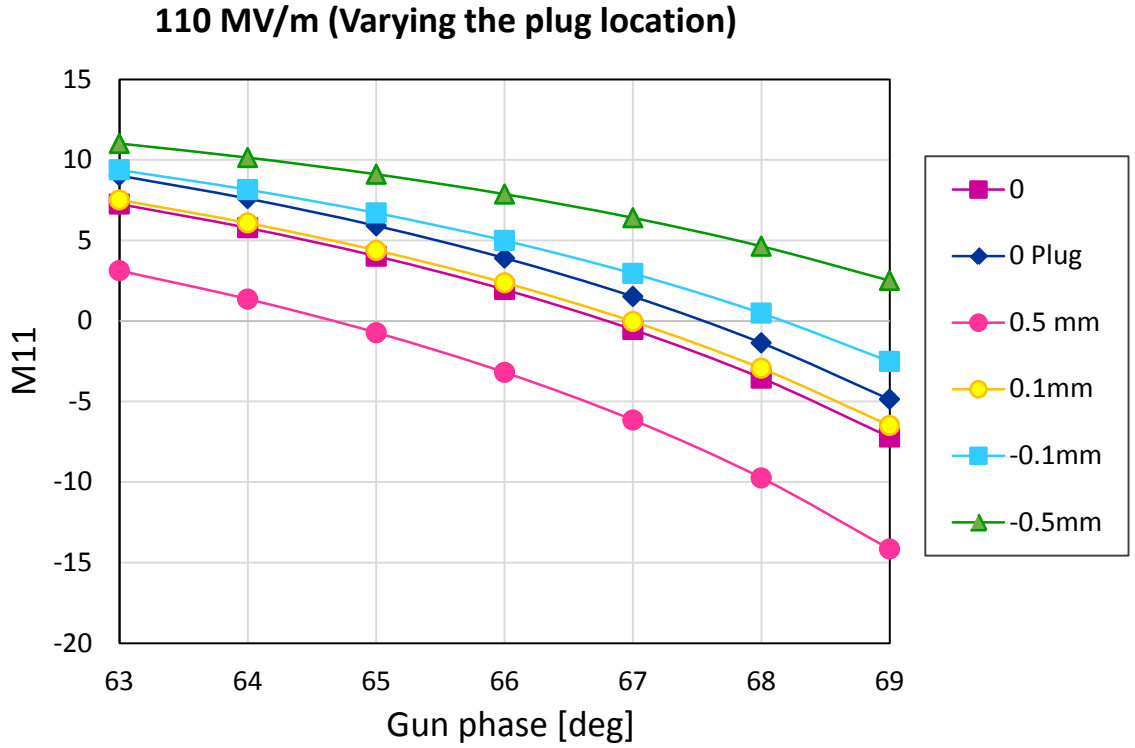
Radius of the 1st cell (mm)	E1/E2	Max Energy gain MeV
0 .1	0.5127287135	4.47047353
0.04	0.7502934719	5.01460796
0.02	0.8710634993	5.28607501
0 (original)	1.0296691059	5.55893566
0	1.0216281467	5.51232951
-0.02	1.207928531	5.06743079
-0.04	1.4340937192	4.68386696

Plug position (mm)	E1/E2	Max Energy gain MeV
0.5	0.9082500665	5.21210612
0.1	1.0021641954	5.5284844
0 (original)	1.0296691059	5.55893566
0	1.0216281467	5.51232951
-0.1	1.0406096425	5.50183975
-0.5	1.075249721	5.37400512

Astra simulation results

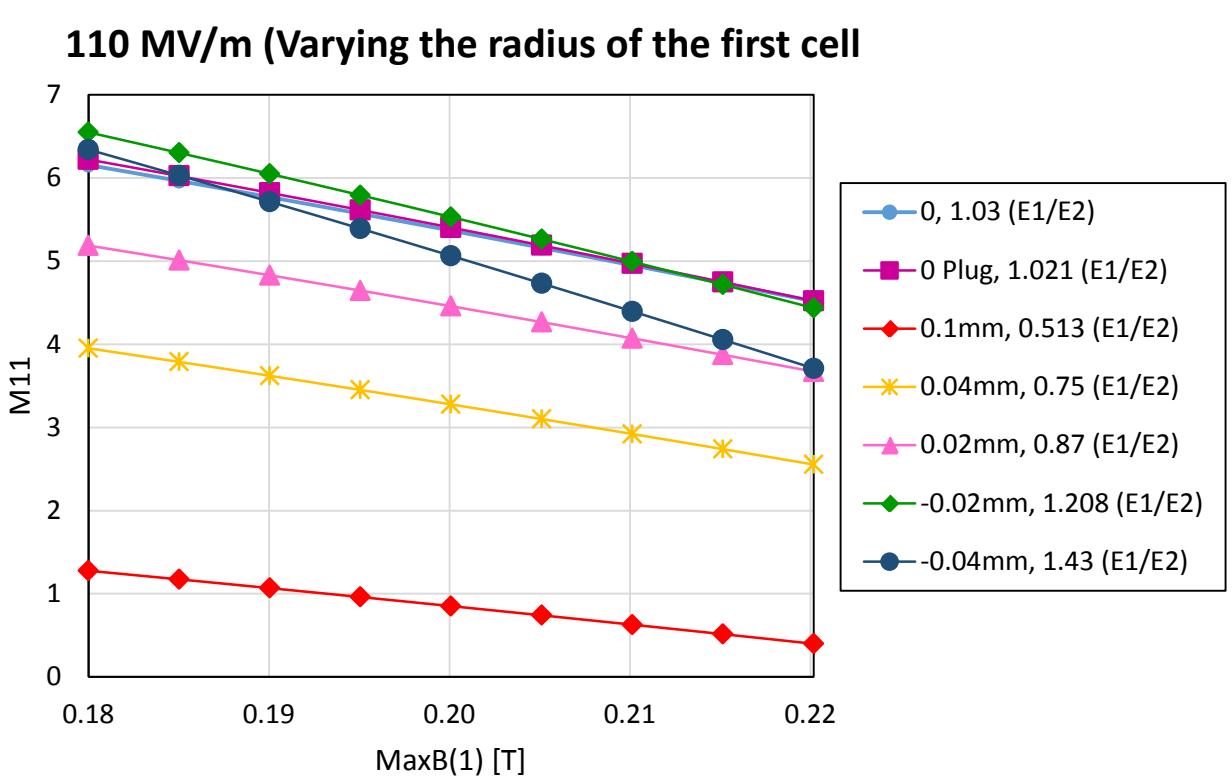
Solenoid field is OFF

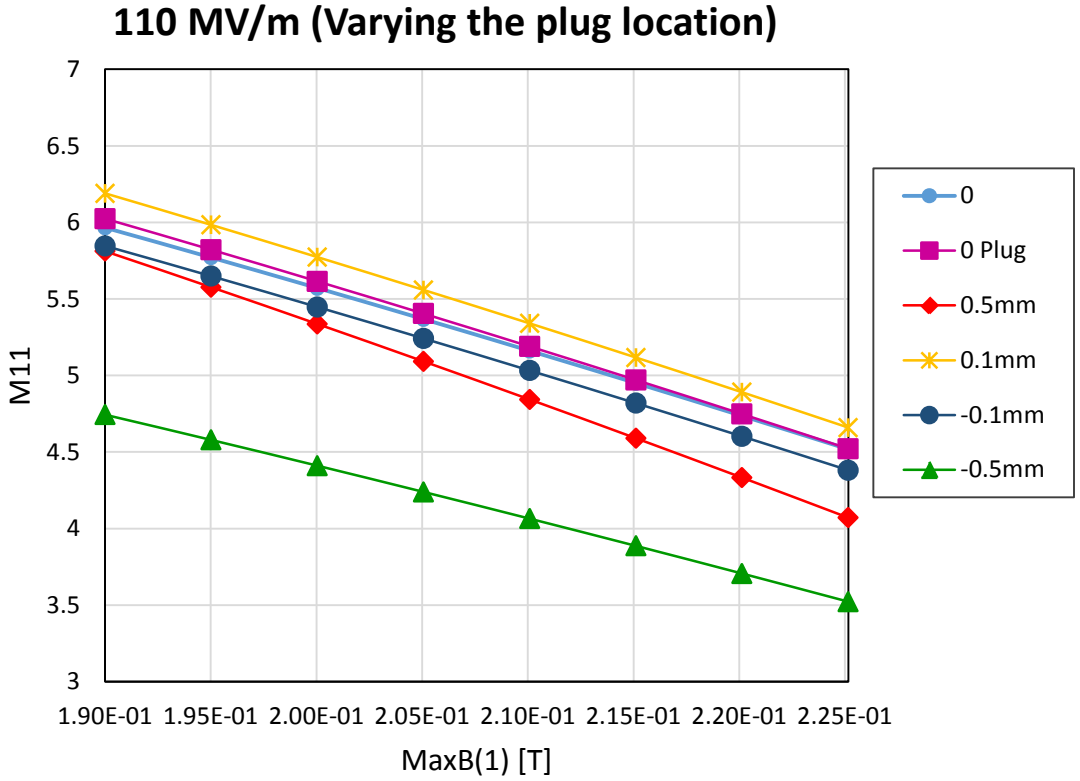




- The field balance (for M11=0) is changed by 15.5% when the phase of the gun is shifted by 1.5 degree due to cell deformation.
- The plug location (for M11=0) is changed by 0.02 mm when the phase of the gun is shifted by 1.5 degree.

Astra simulation results Sol on

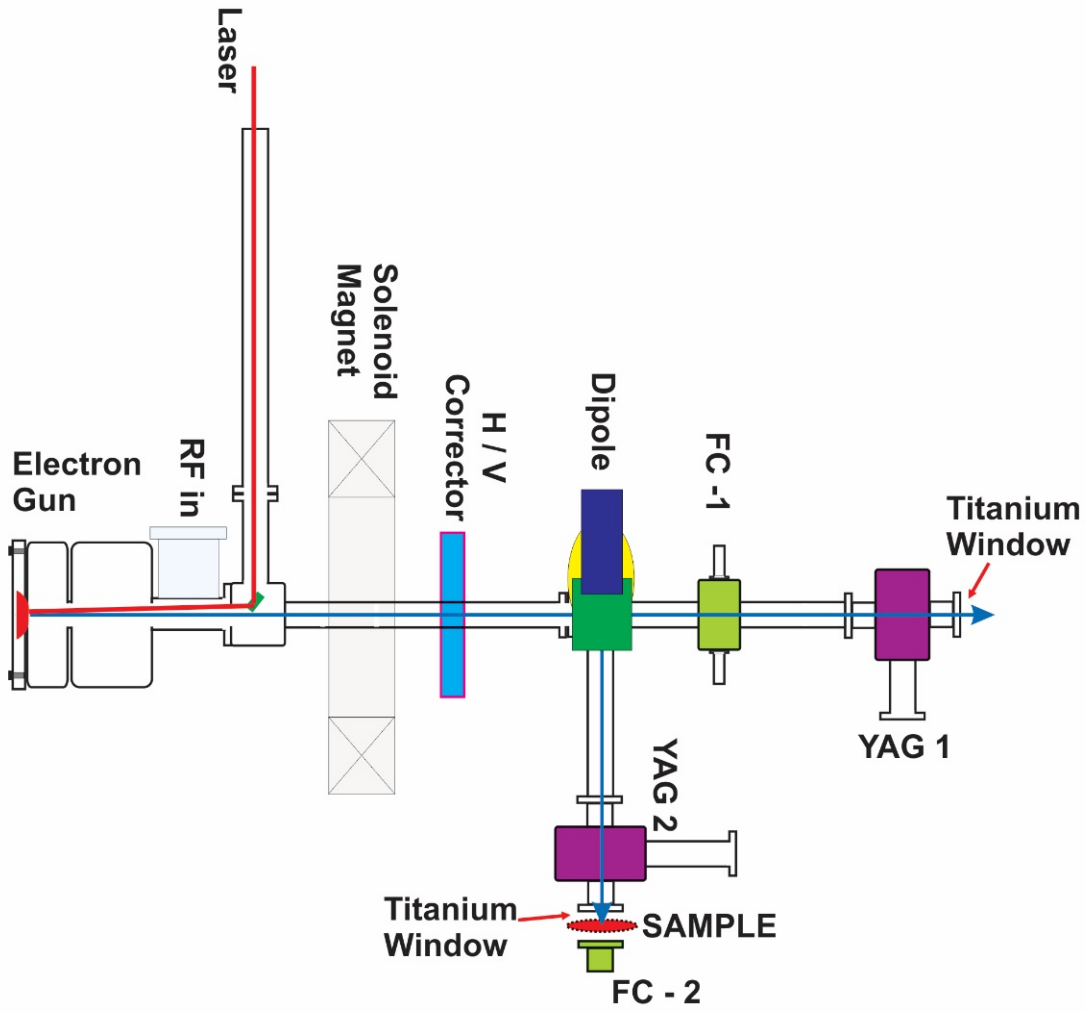




- The field balance (M11=5) is changed by 40% when the MaxB(1) of the solenoid is shifted by 0.01 T (4.4%)

- The plug location (for M11=5) is changed by 0.5 mm when the MaxB(1) of the solenoid is shifted by 0.008 T (3.5%).

Experimental setup



- Gun field amplitude: 110 MV/m
- Solenoid on, check MMMG phase
- Solenoid off, find the gun focusing phase
- Scan laser position on cathode, measure beam centroid movement on screen
- Using different gun field maps, fit simulation to experiment
  - ➢by tuning cathode plug insertion in gun
  - ➢by changing the field balance between 1st and 2nd cells

Summary

- SUPERFISH simulations for different plug locations and gun cell deformations, with cathode plug geometry included
- ASTRA simulations of beam trajectory response with different gun field maps for both Solenoid ON and OFF
- Trajectory response with solenoid ON is more sensitive to gun geometry changes (plug location, field balance)

Next steps

- To do measurements for trajectory response around gun focusing phases for both cases
- Fine adjustment of simulation model to experimental results

Thank you for attention