GTS gun
CST optimization

Sajini Wijethunga

12/4/2019

Goals

- Increase E_z at the cathode –by removing the pierce geometry and decreasing anode-cathode gap.
- Correct the beam deflection (vertical kick).
- Reduce the E field at the triple point junction (if we use a new shed).

Summary

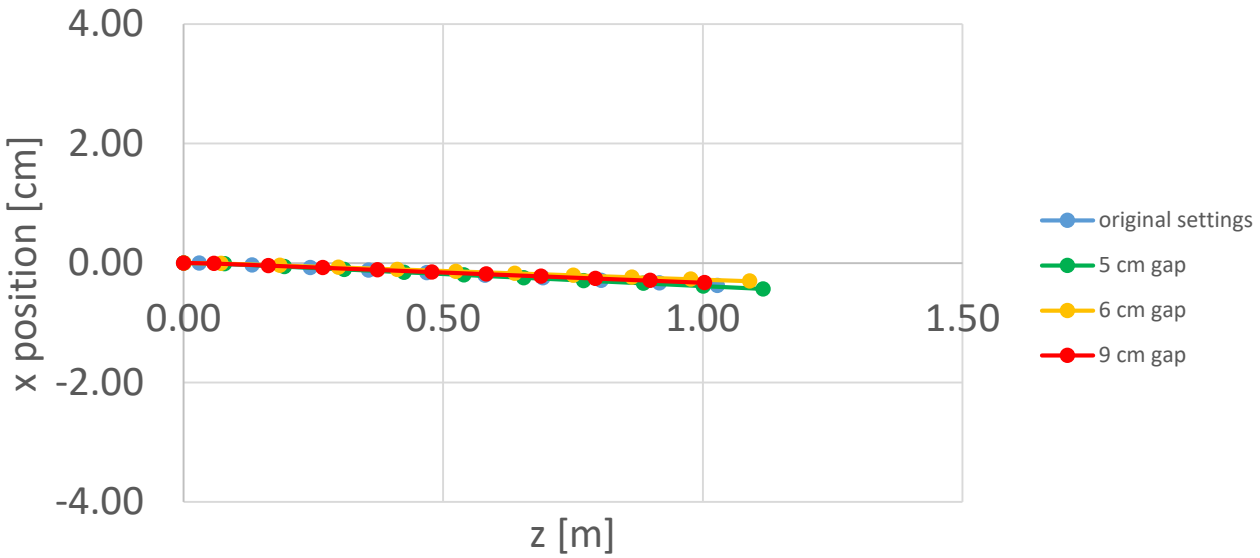
Gap	Pierce geometry	With NEGs and shed		No shed		No NEGs		No NEGs and shed	
		Ez cathode [MV/m]	E_{max} ball [MV/m]	Ez cathode [MV/m]	E_{max} ball [MV/m]	Ez cathode [MV/m]	E_{max} ball [MV/m]	Ez cathode [MV/m]	E_{max} ball [MV/m]
Original	With	-2.50	-11.5	-	-	-	-	-	-
5 cm	Without	-7.98	- 10.1	-8.05	-10.4	-7.93	-9.5	-8.00	-9.7
6 cm		-7.01	- 10.2	-7.11	-10.2	-6.93	-9.3	-7.03	-9.4
9 cm		-5.60	-10.2	-5.77	-10	-5.45	-9.1	-5.62	-9.6

* Ez at -350 kV

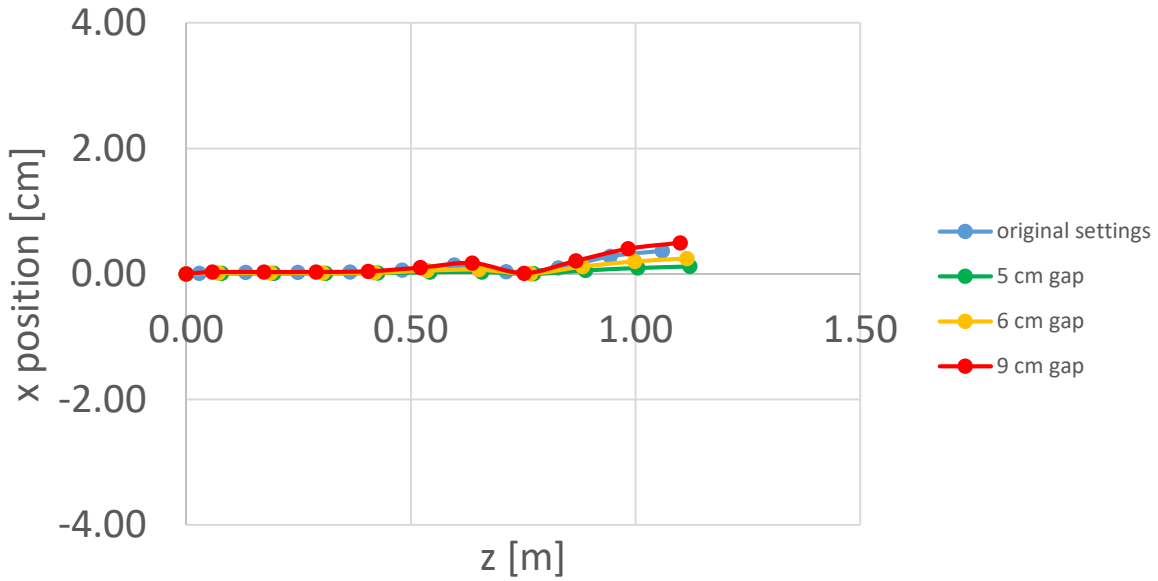
Beam position at ~0.5 m in cm (2 nC, -300 kV, 1 mm rms, 75 ps FWHM, sc on)

Gap	Pierce geometry	With NEGs and shed				No shed				No NEGs				No NEGs and shed			
		Non-magnetized		Magnetized (400 A)		Non-magnetized		Magnetized (400 A)		Non-magnetized		Magnetized (400 A)		Non-magnetized		Magnetized (400 A)	
		x	y	x	y	x	y	x	y	x	y	x	y	x	y	x	y
Original	With	-0.17	-1.4	0.07	-0.05	-	-	-	-	-	-	-	-	-	-	-	-
5 cm	Without	-0.2	-0.7	0.03	-0.04	-0.2	-0.13	0	-0.01	-0.17	-0.39	0.02	- 0.02	-0.17	-0.06	0	0
6 cm		-0.14	-0.74	0.05	-0.06	-0.13	-0.23	0.01	-0.03	-0.08	-0.60	0.05	-0.05	-0.08	-0.1	0	-0.01
9 cm		-0.15	-1.5	0.1	-0.10	-0.14	-0.53	0.03	-0.05	-0.02	-1.1	0.08	-0.07	-0.01	-0.2	0	-0.02

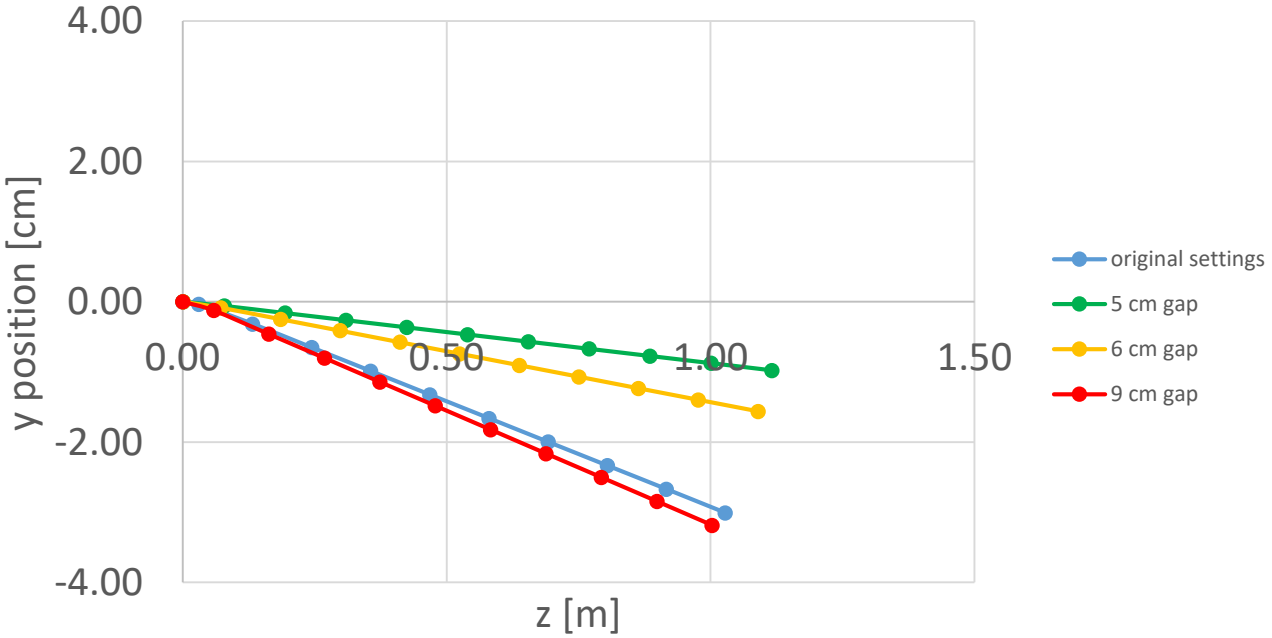
With shed and NEGs



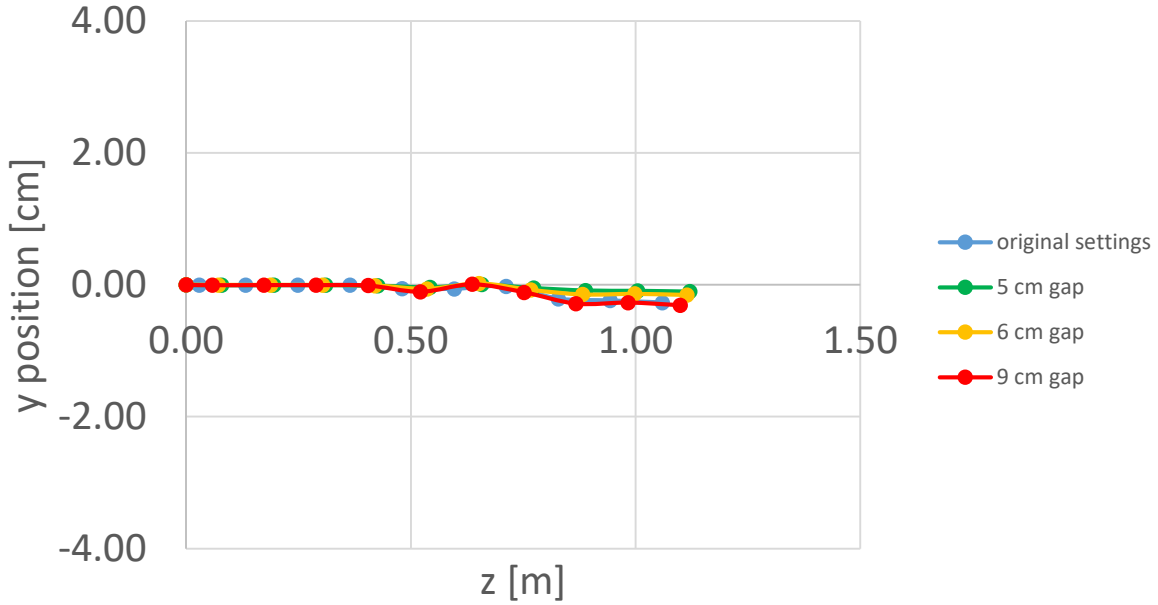
With shed and NEGs-Magnetized



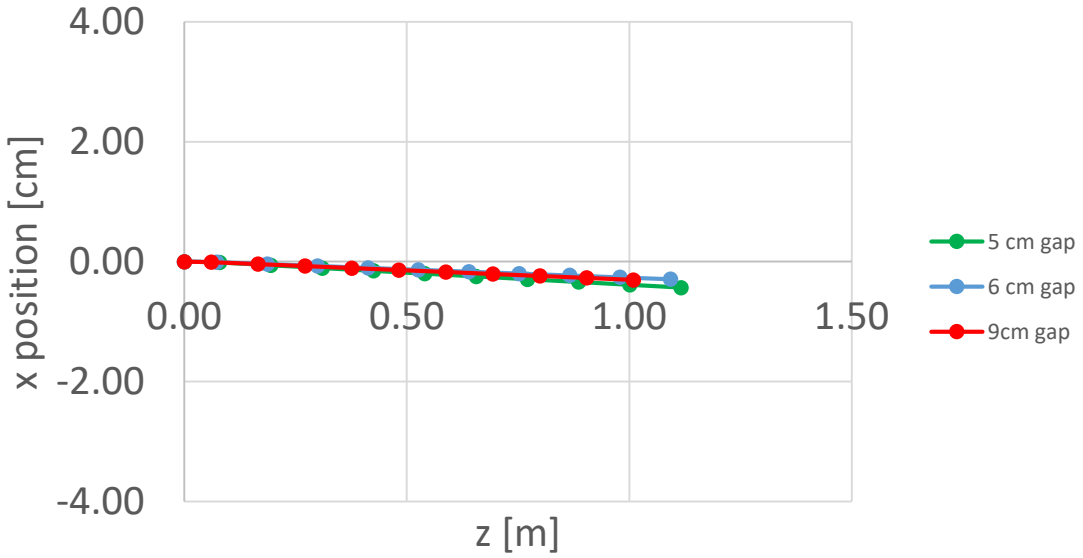
With shed and NEGs



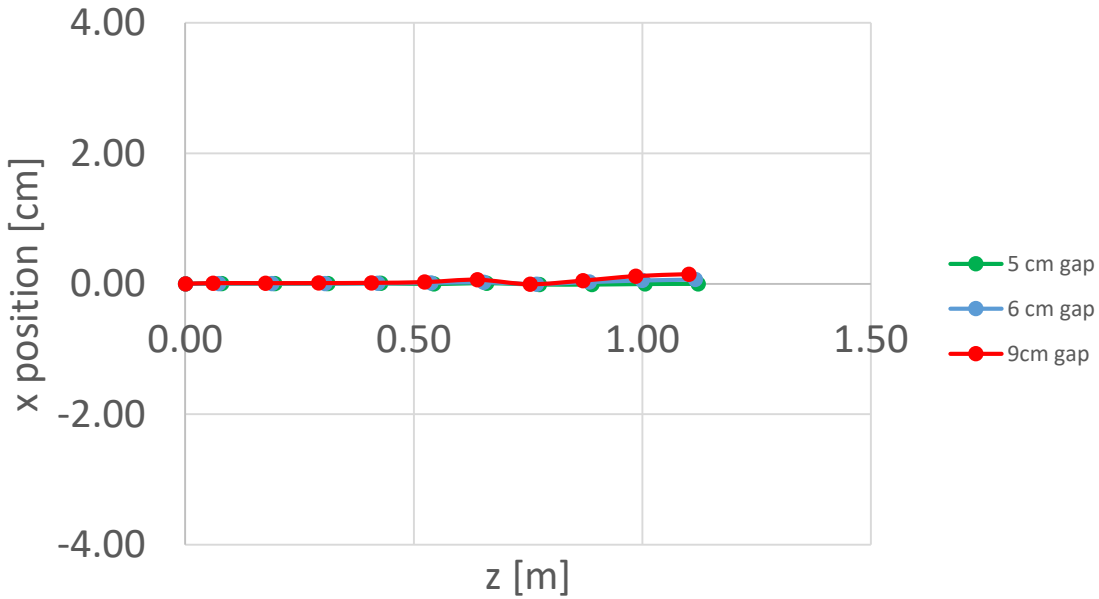
With shed and NEGs- Magnetized



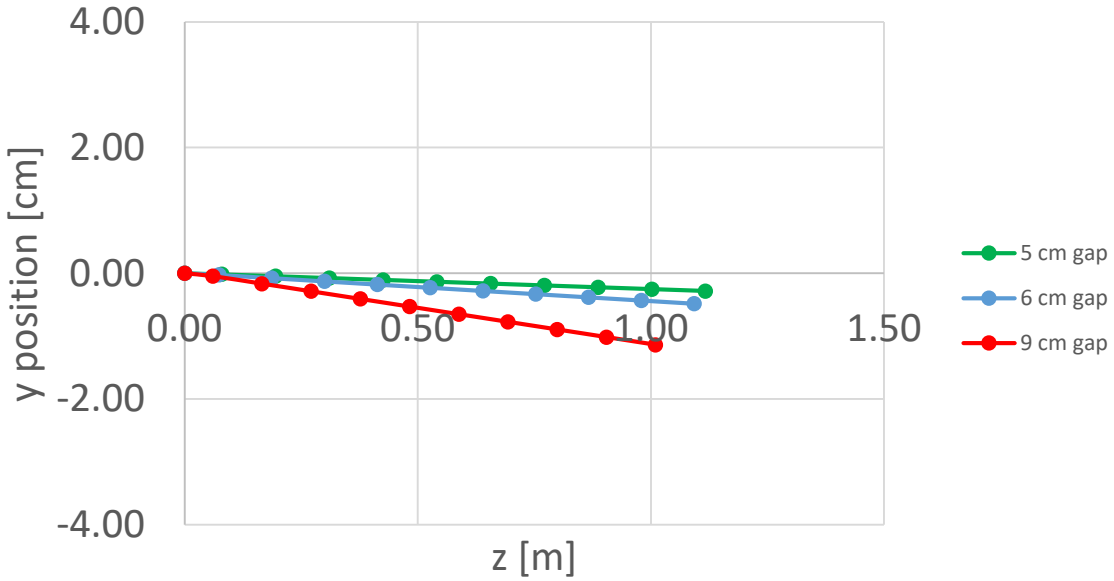
No shed



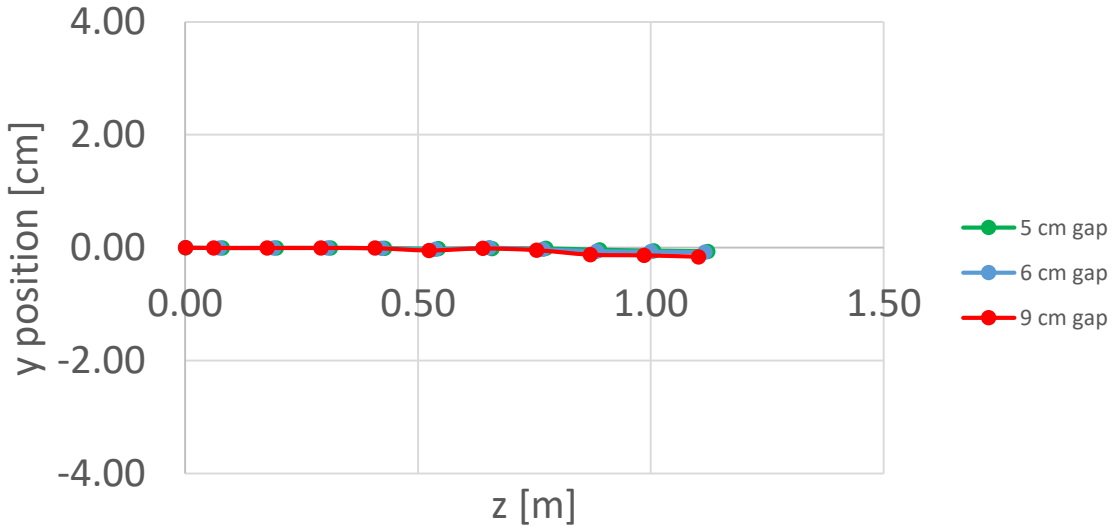
No shed- Magnetized



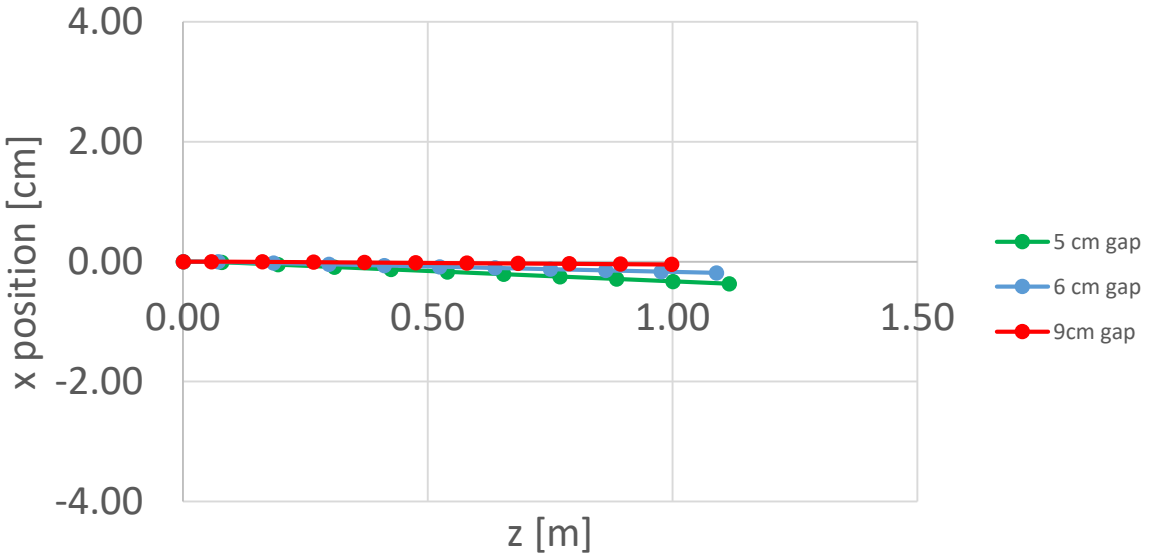
No shed



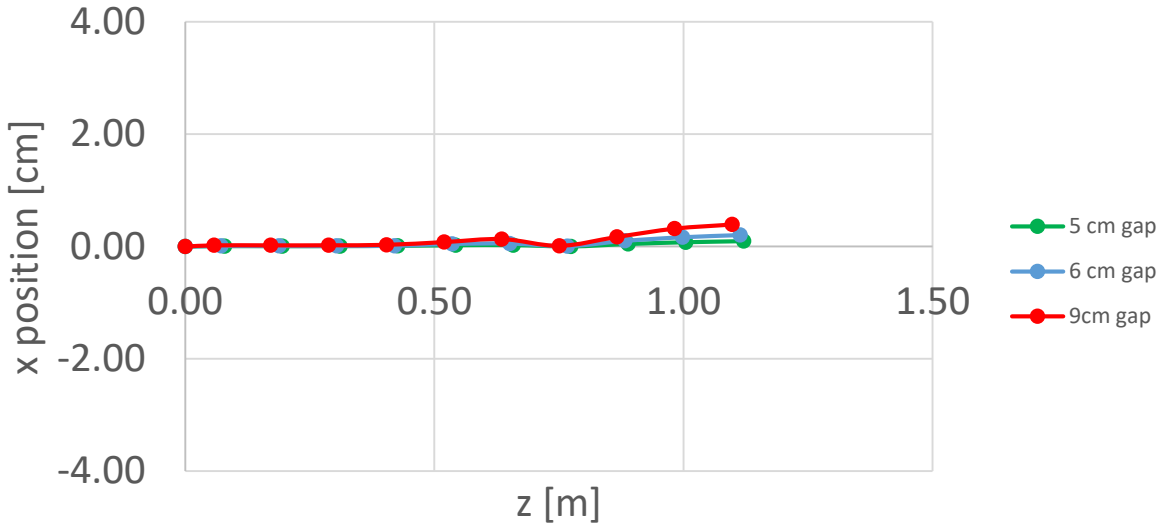
No shed-Magnetized



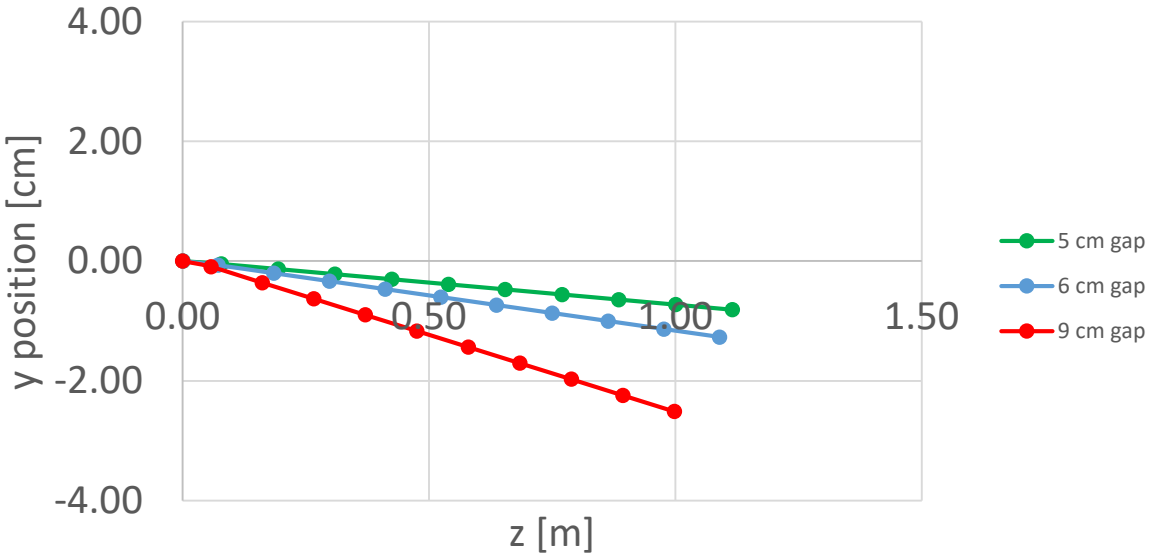
No NEGs



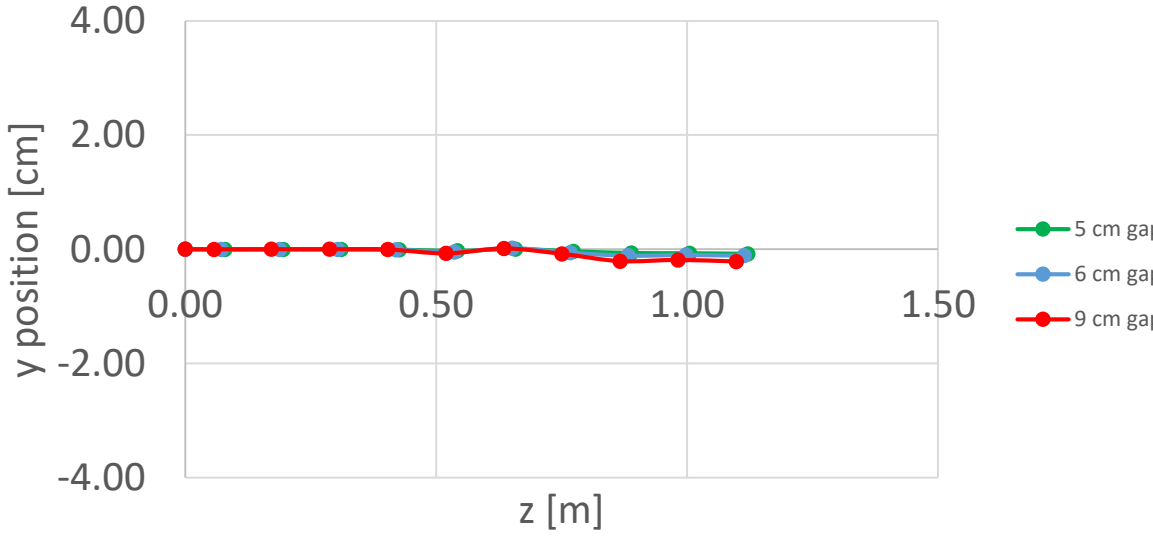
No NEGs- Magnetized



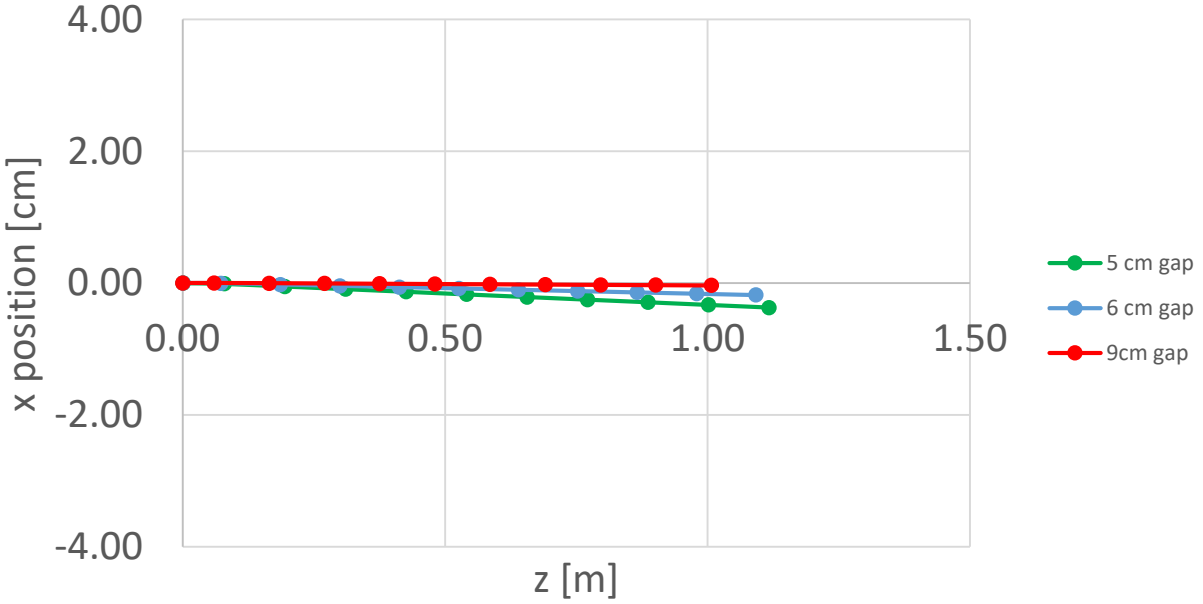
No NEGs



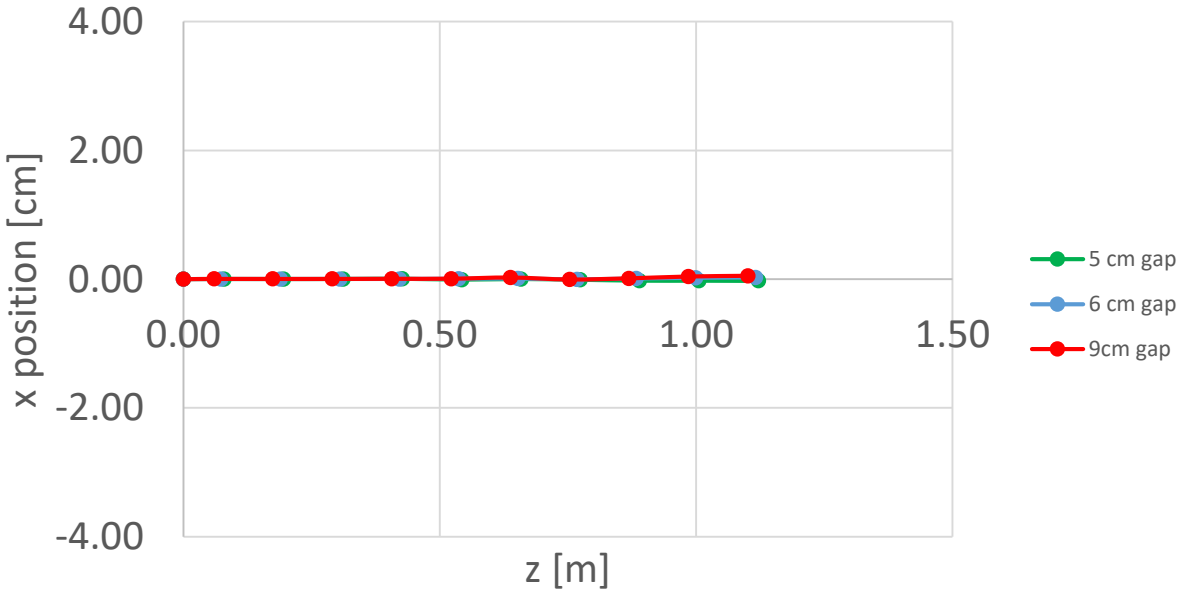
No NEGs-Magnetized



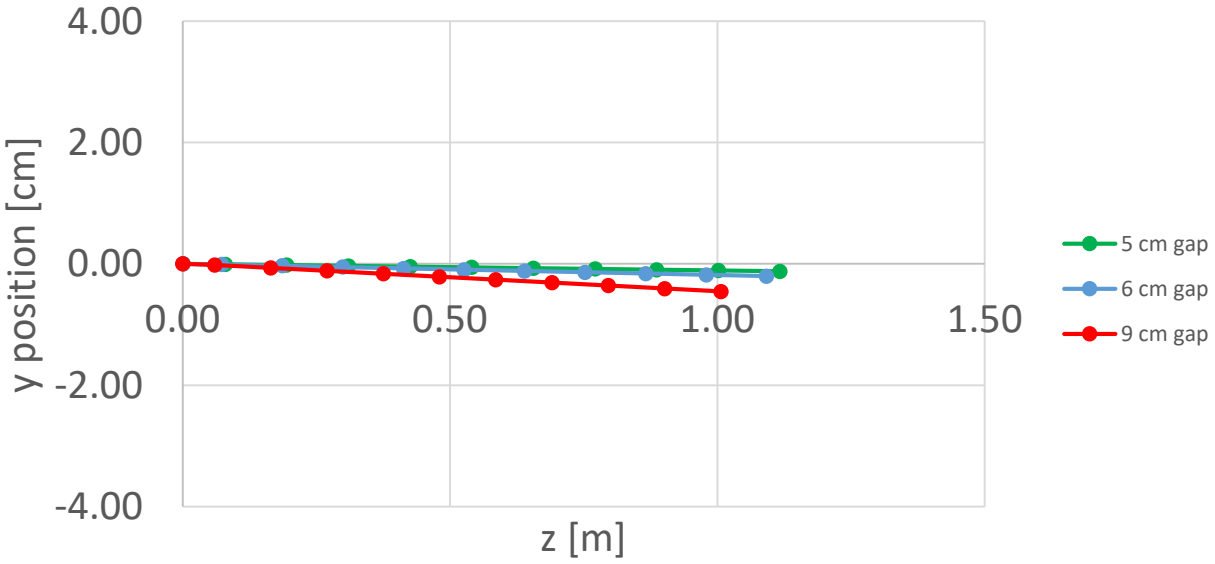
No shed no NEGs



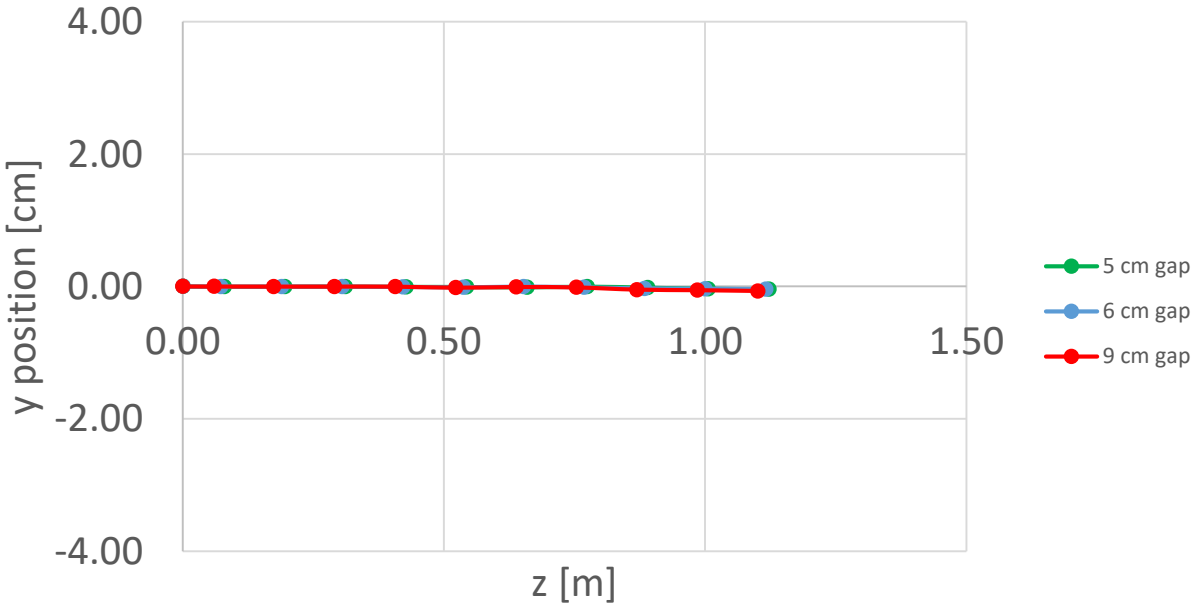
No shed no NEGs-Magnetized



No shed no NEGs

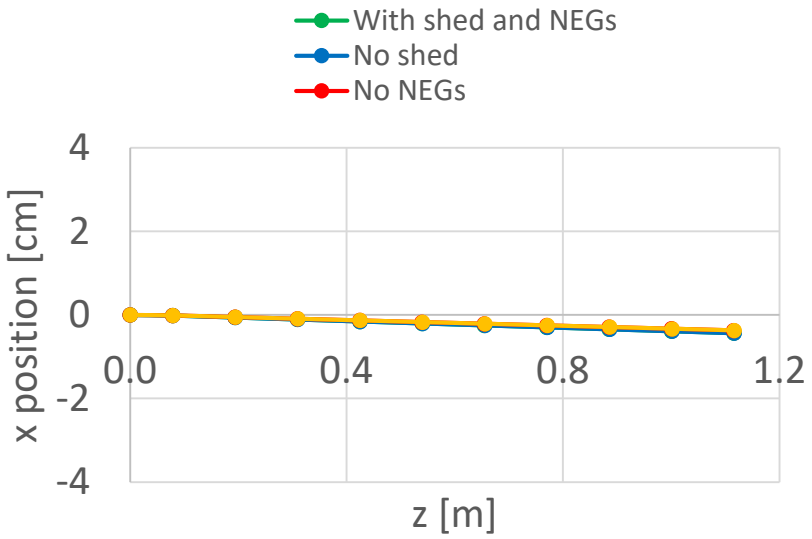


No shed no NEGs-Magnetized

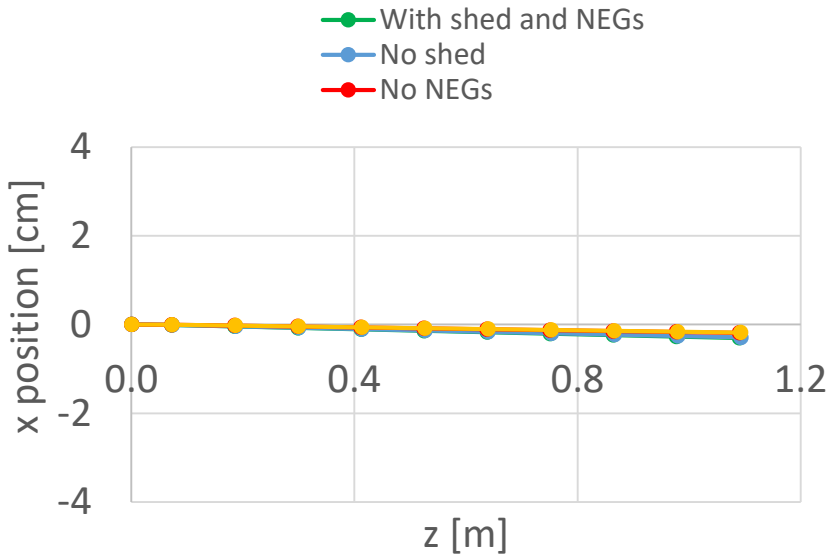


2 nC, -300 kV, 1 mm rms, 75 ps FWHM, sc on

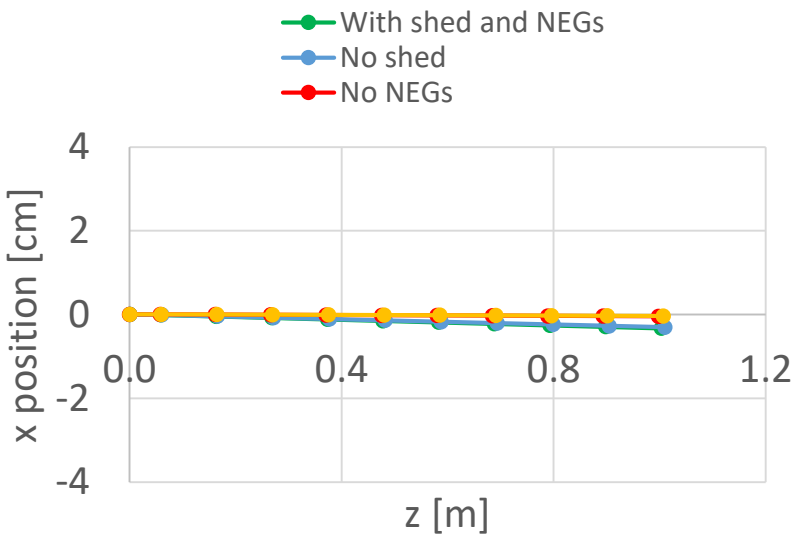
5 cm gap



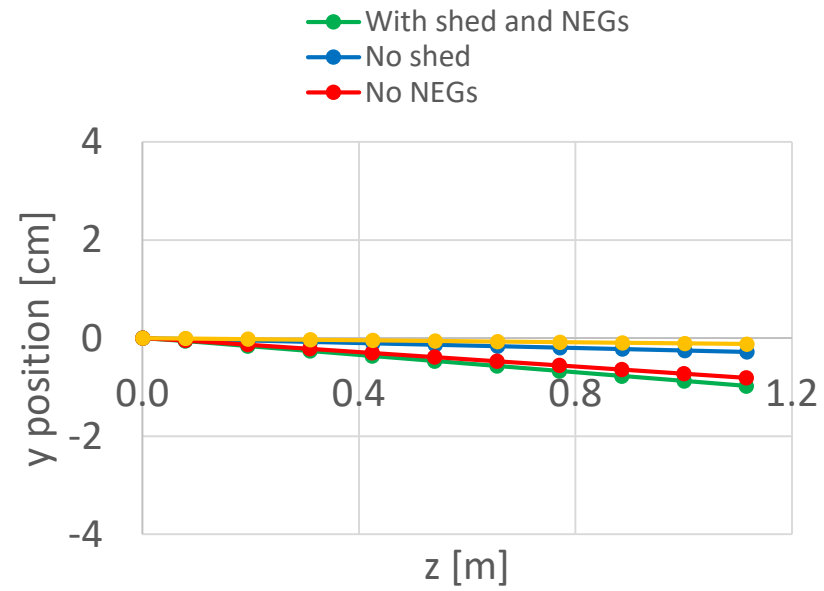
6 cm gap



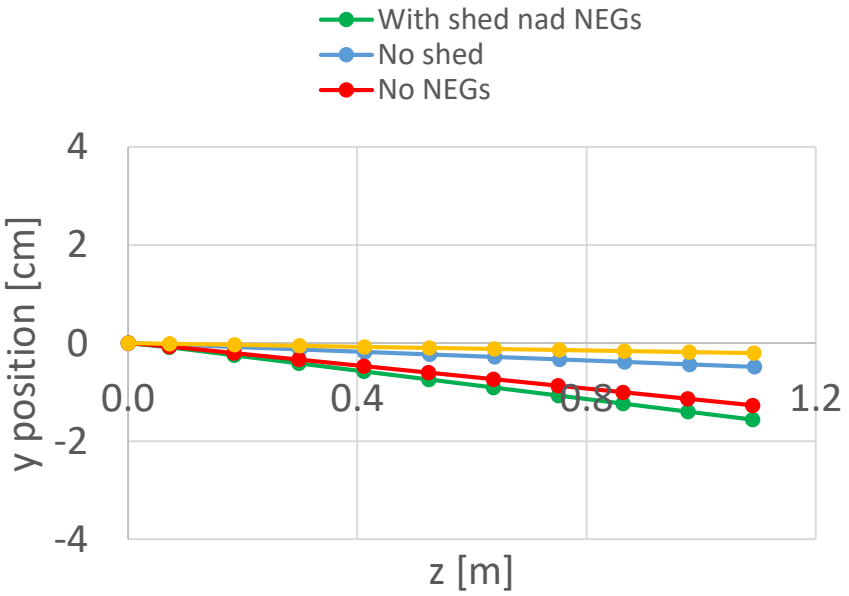
9 cm gap



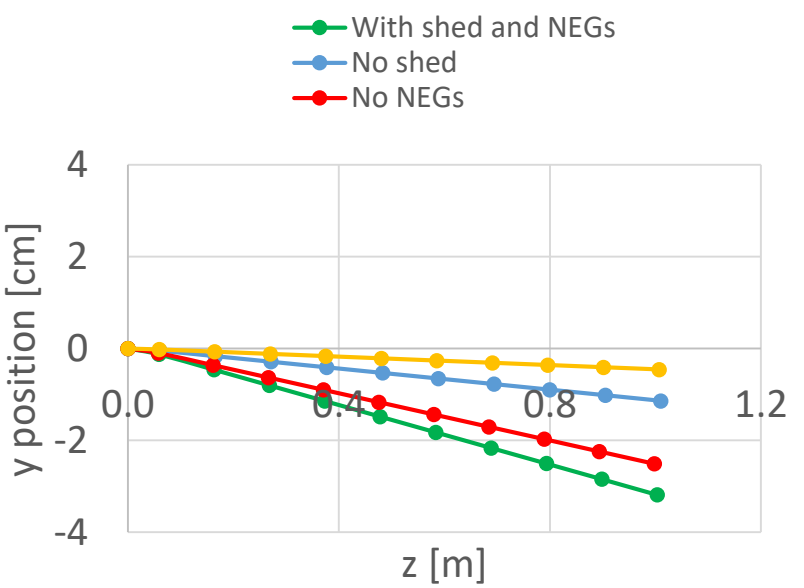
5 cm gap



6 cm gap



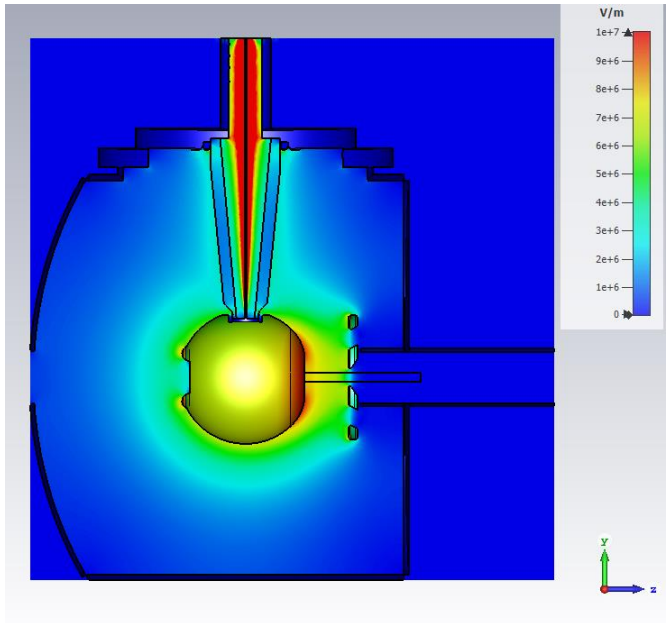
9 cm gap



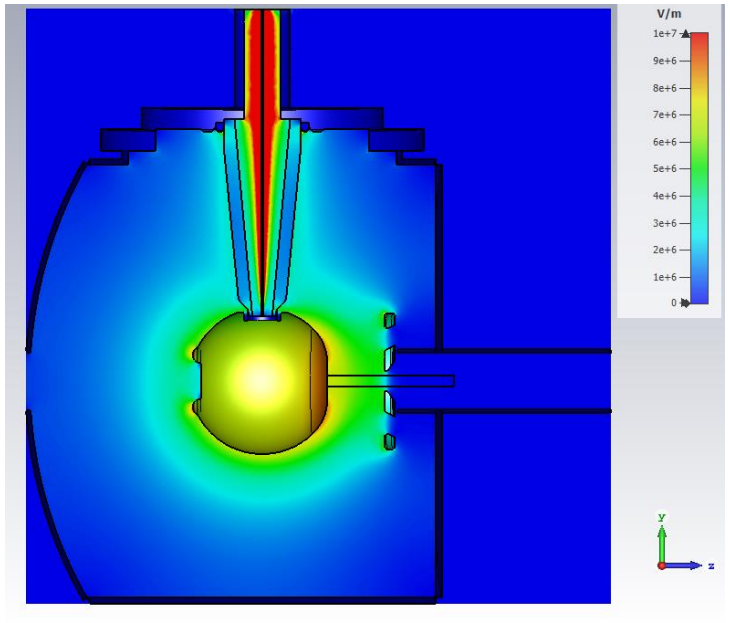
*Can see a small deflection in the x direction in all cases.

Flat cathode front and flat anode – no NEGs, no shed

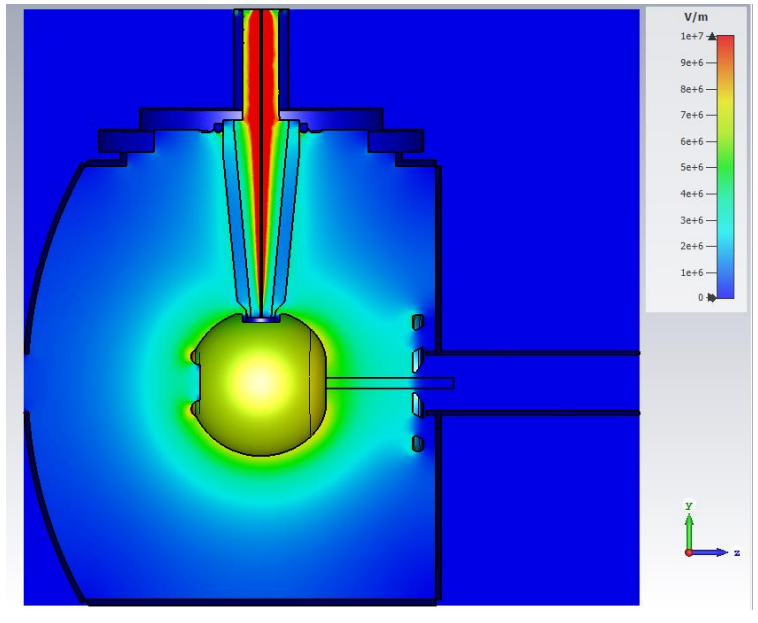
5 cm gap



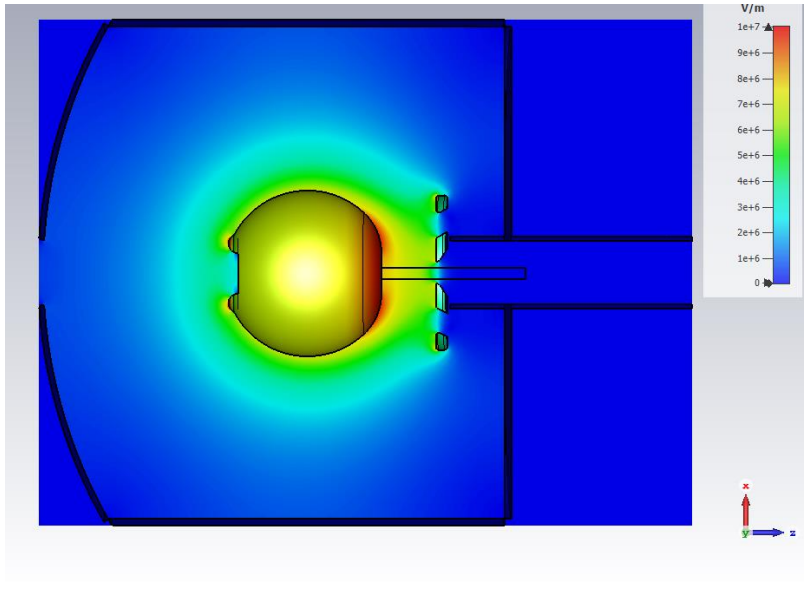
6 cm gap

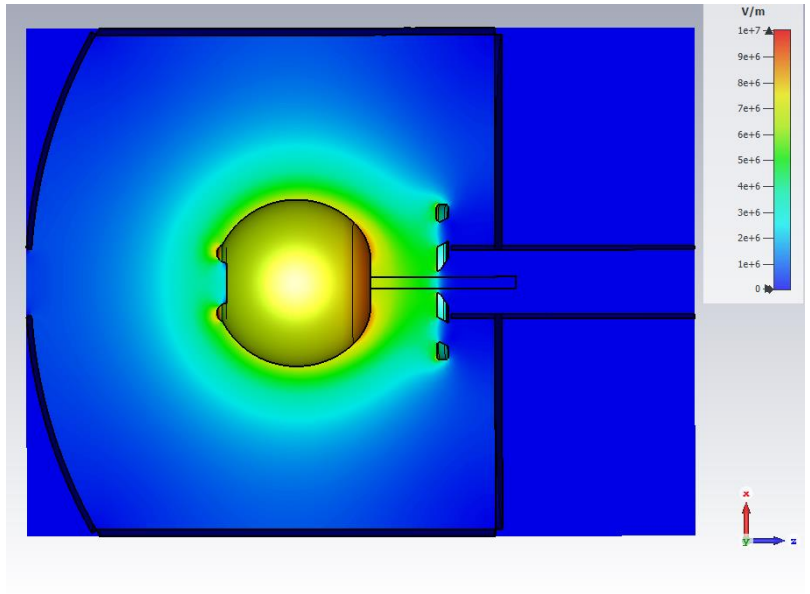


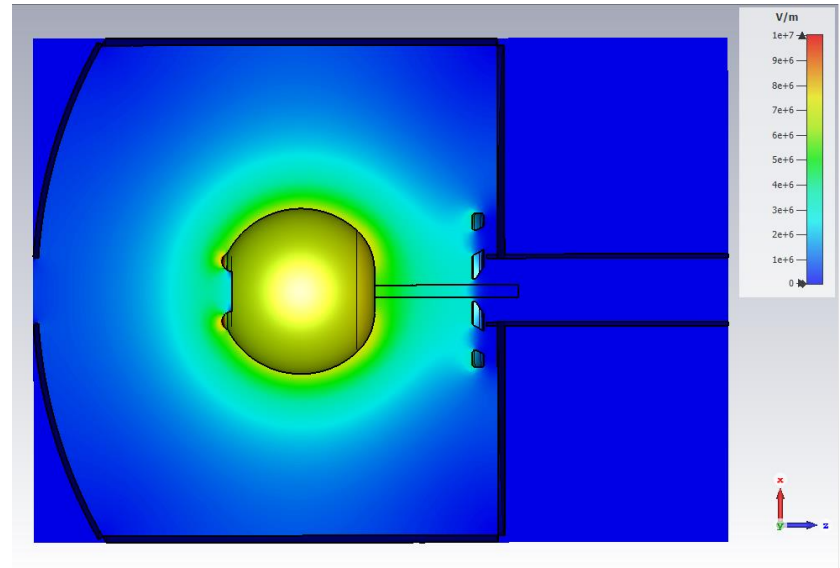
9 cm gap



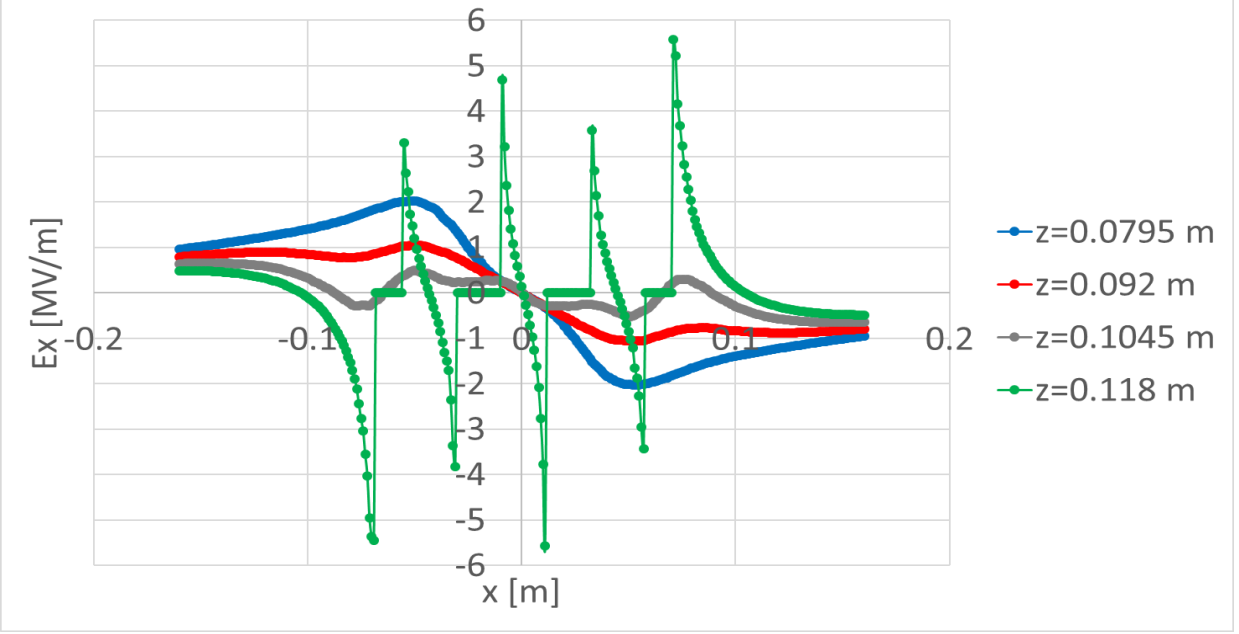
Top view



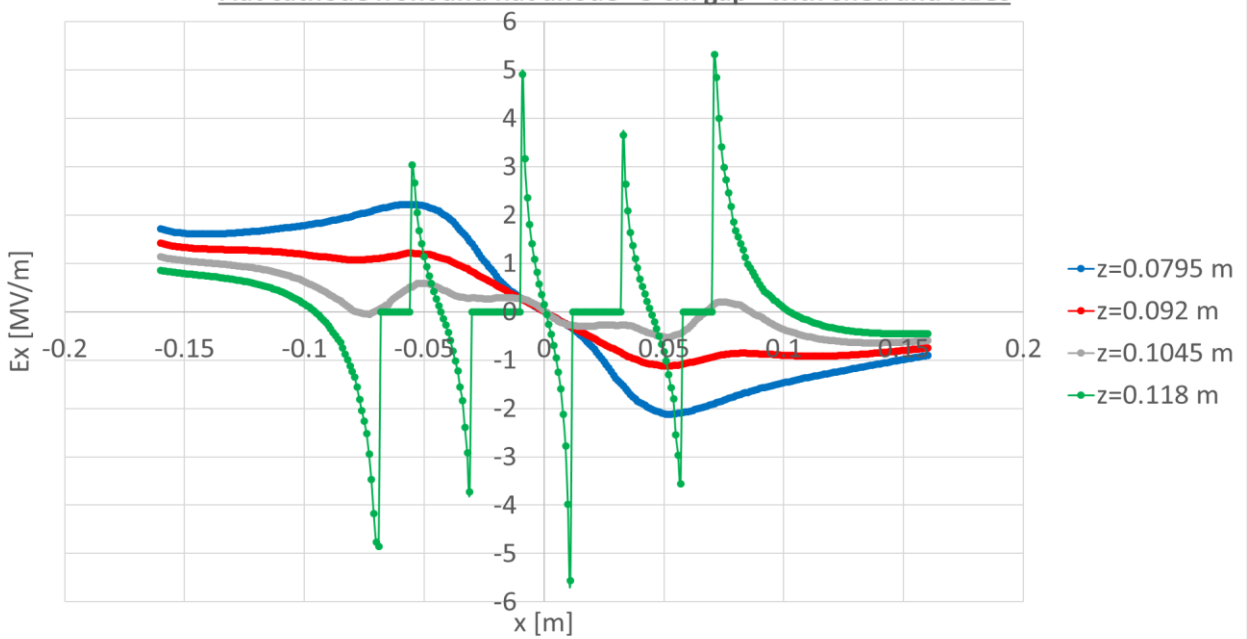




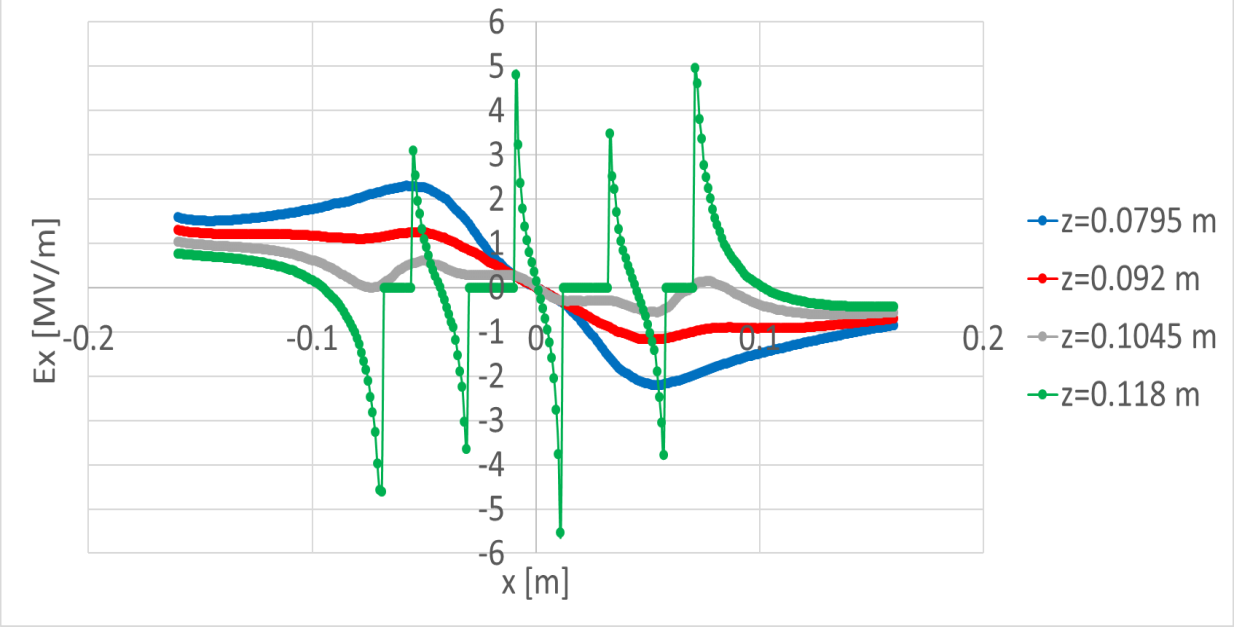
Flat cathode front and flat anode - 5 cm gap - no NEGs



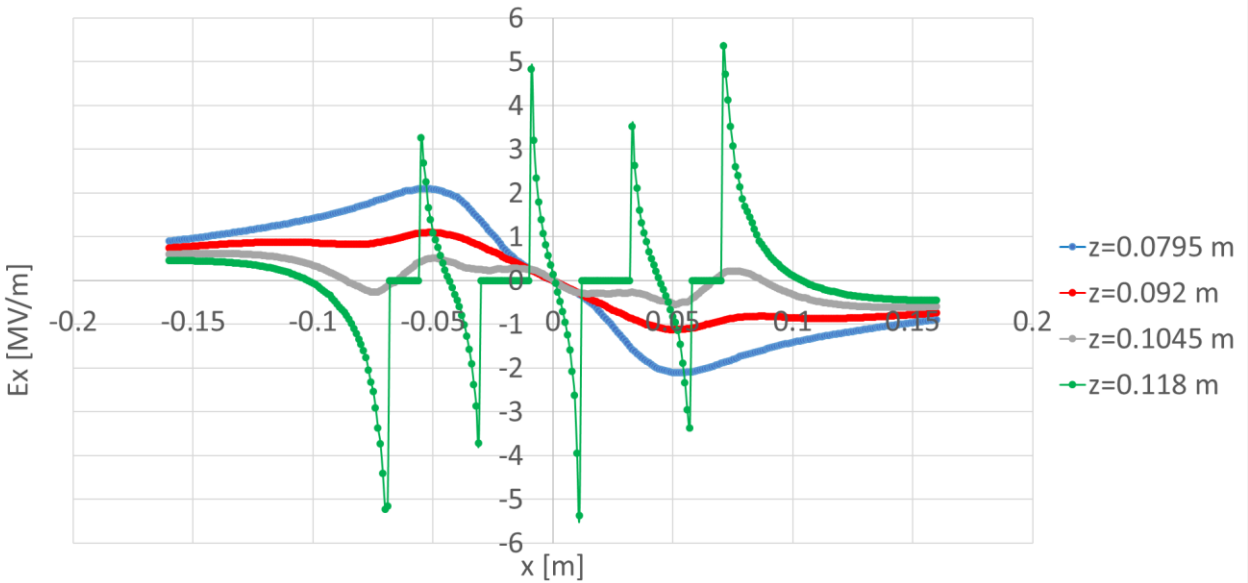
Flat cathode front and flat anode - 5 cm gap - with shed and NEGs

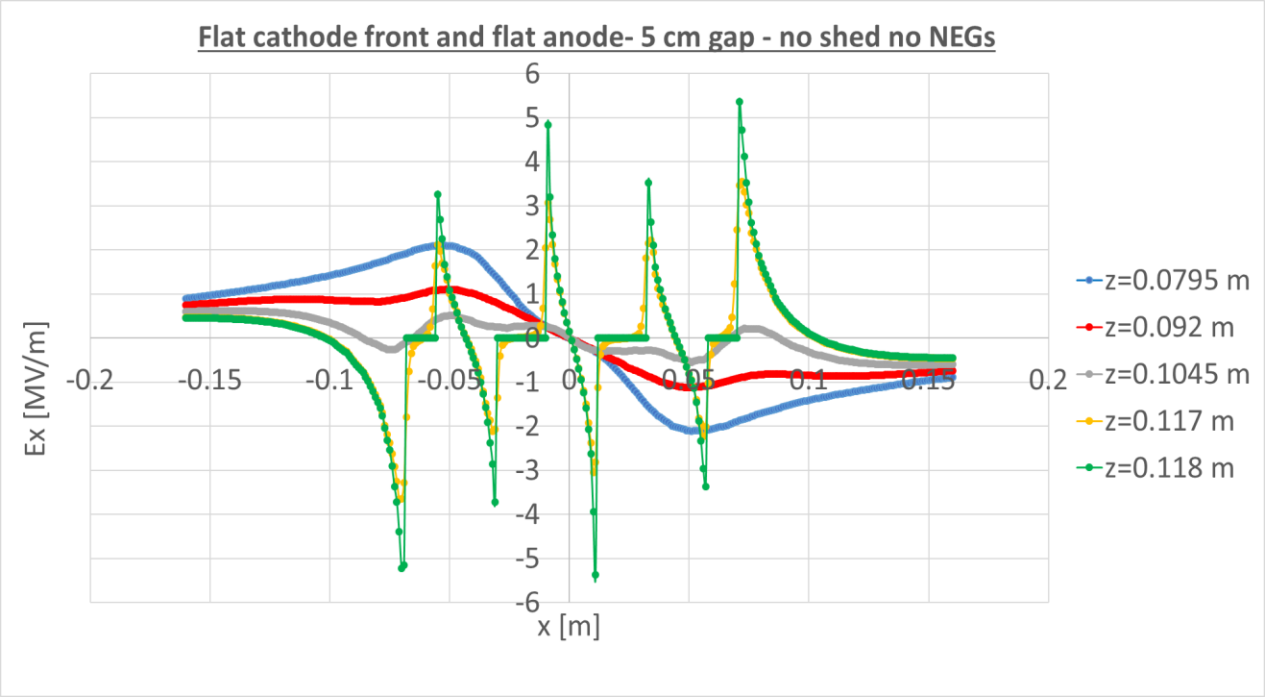


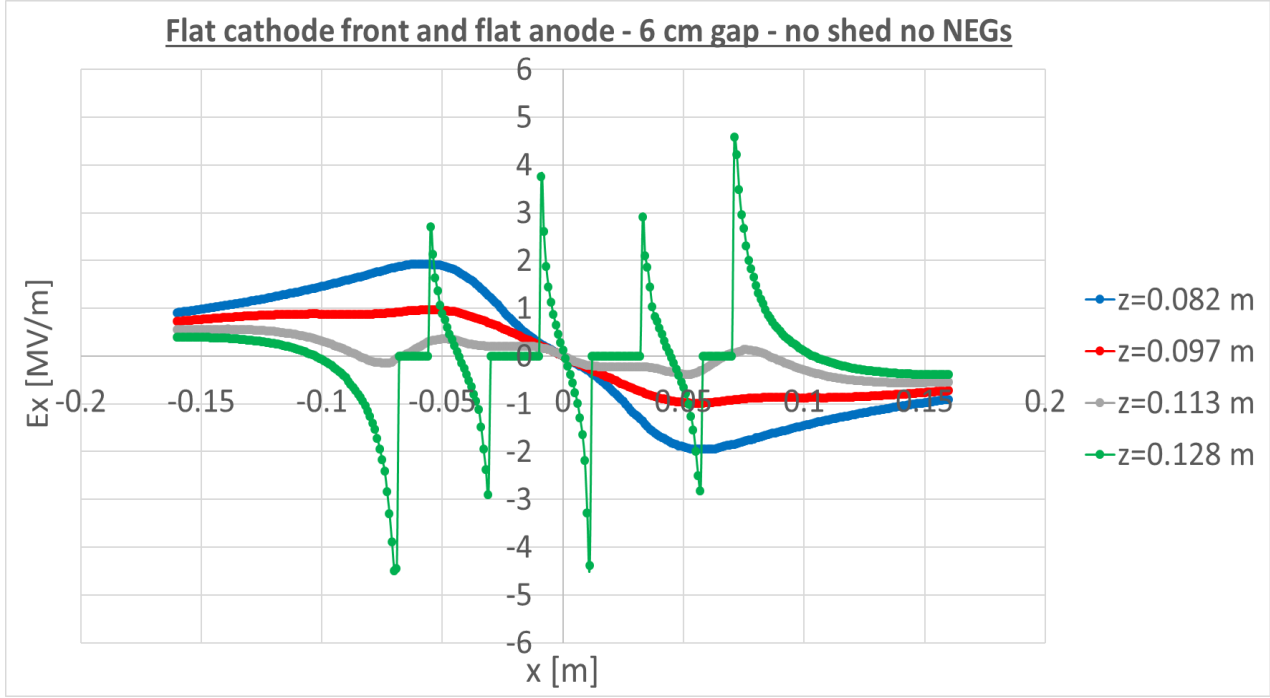
Flat cathode front and flat anode - 5 cm gap - no shed

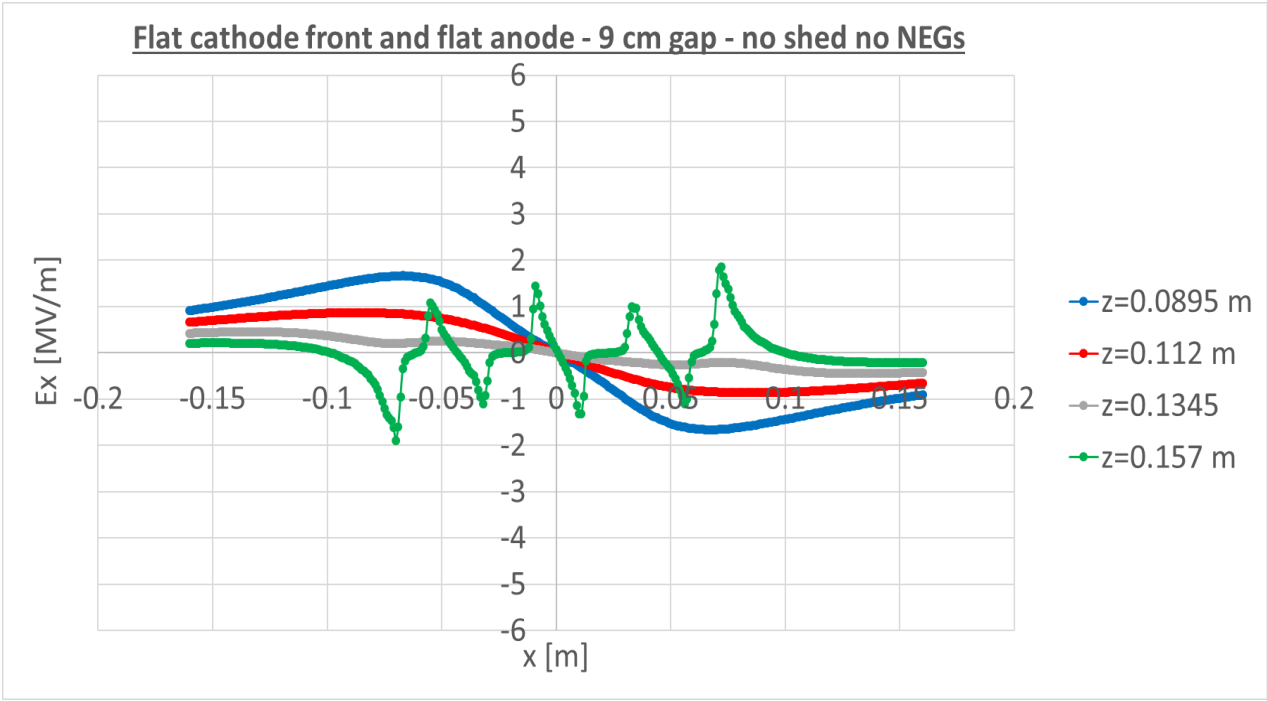


Flat cathode front and flat anode- 5 cm gap - no shed no NEGs



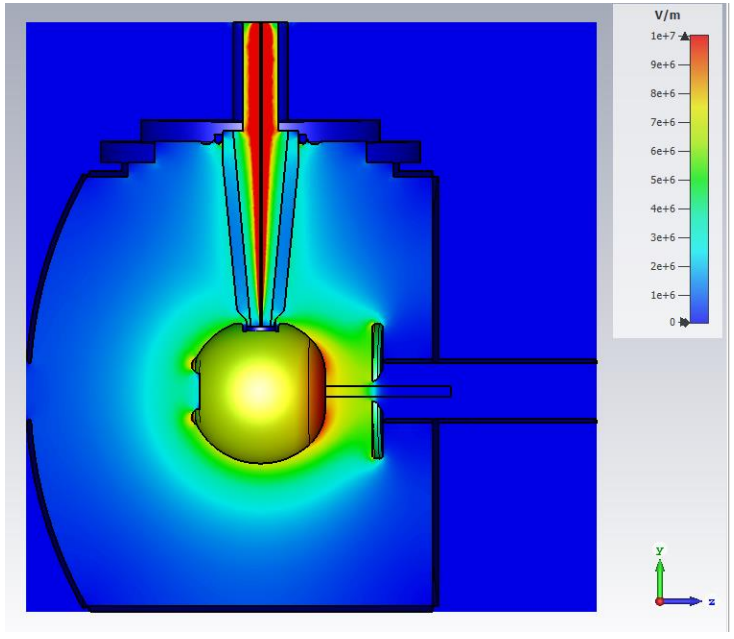

Flat cathode front and flat anode- 5 cm gap - no shed no NEGs
Ex [MV/m]
x [m]
z=0.0795 m
z=0.092 m
z=0.1045 m
z=0.117 m
z=0.118 m


Flat cathode front and flat anode - 6 cm gap - no shed no NEGs
Ex [MV/m]
x [m]
z=0.082 m
z=0.097 m
z=0.113 m
z=0.128 m

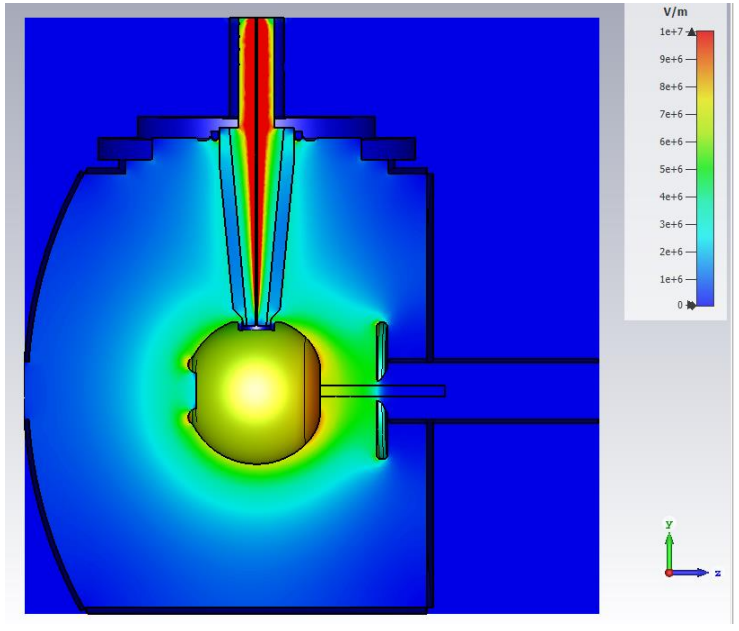

Flat cathode front and flat anode - 9 cm gap - no shed no NEGs
Ex [MV/m]
x [m]
z=0.0895 m
z=0.112 m
z=0.1345
z=0.157 m

Flat cathode front and flat anode – no NEGs, no shed - symmetric anode

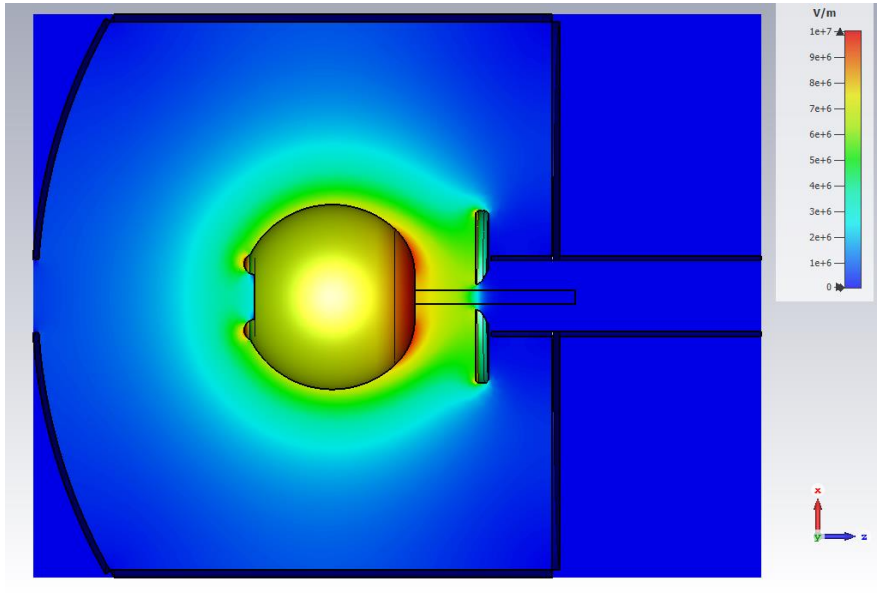
5 cm gap

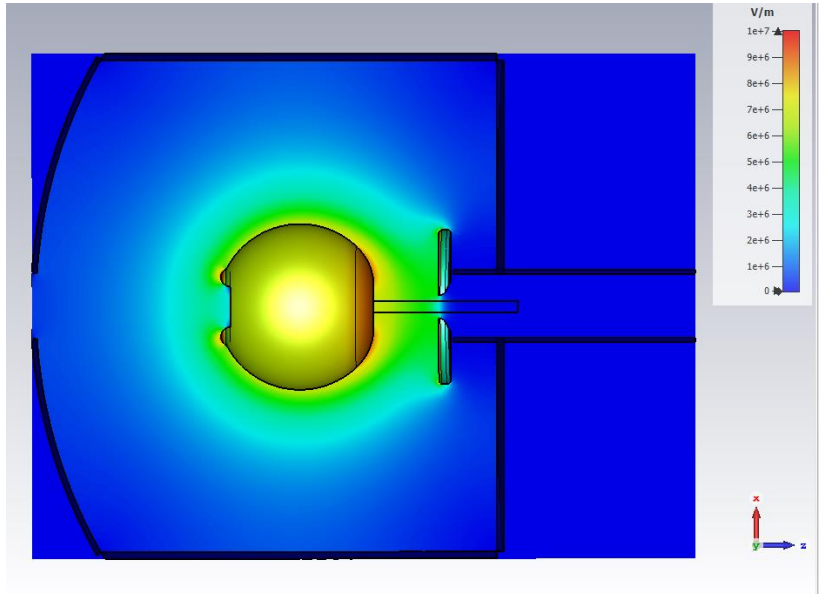


6 cm gap

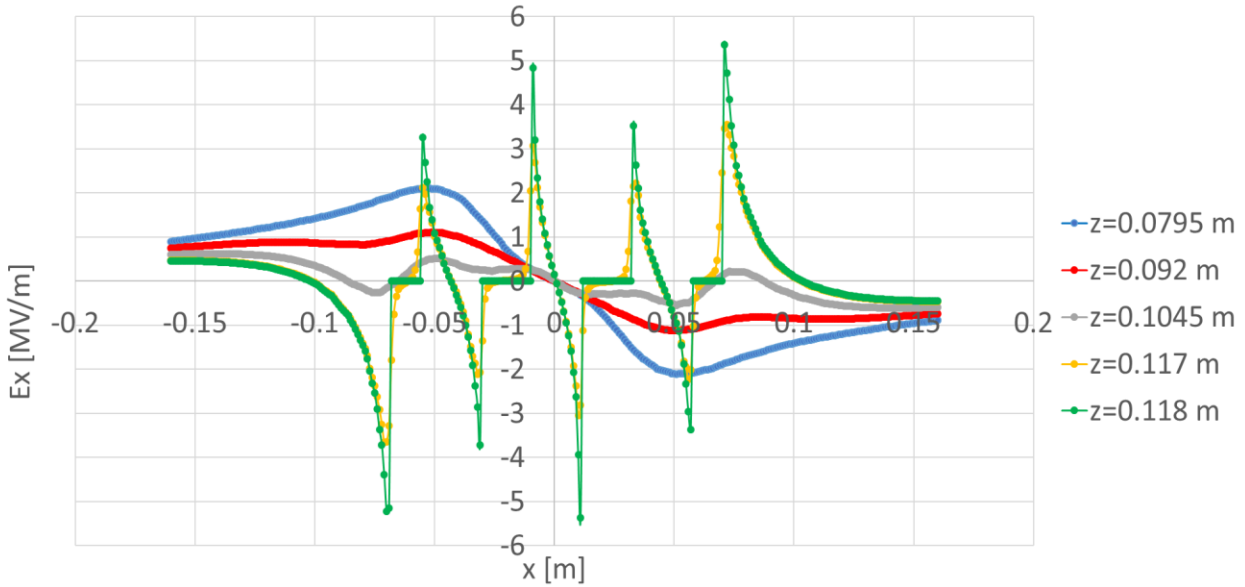


Top view

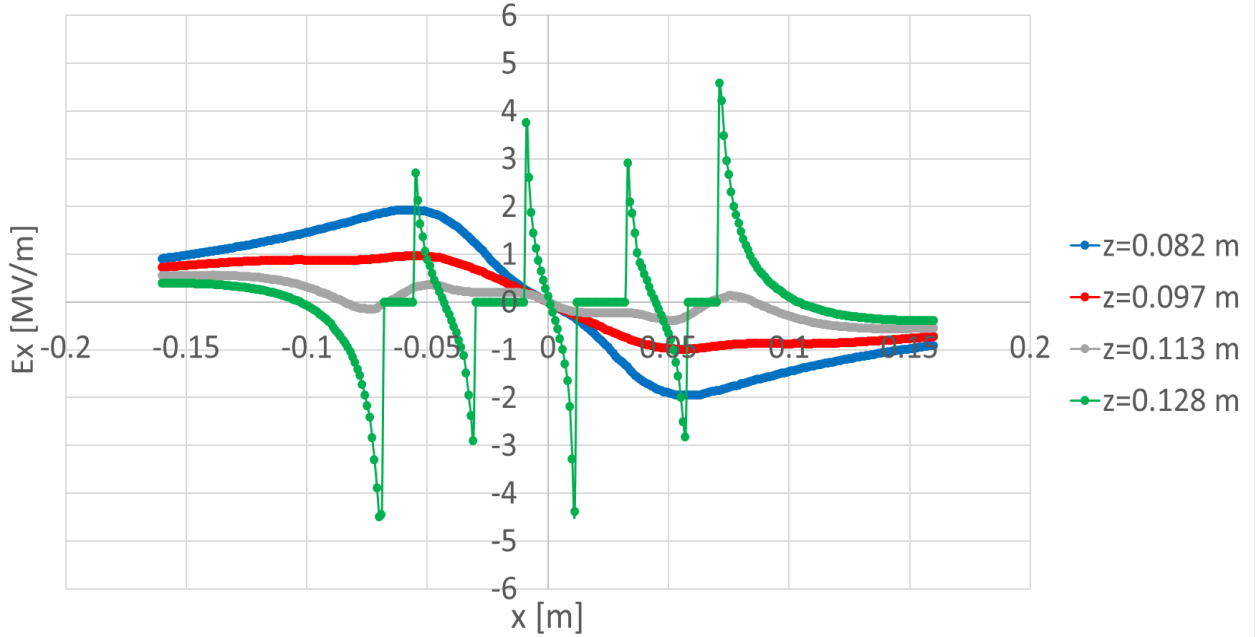




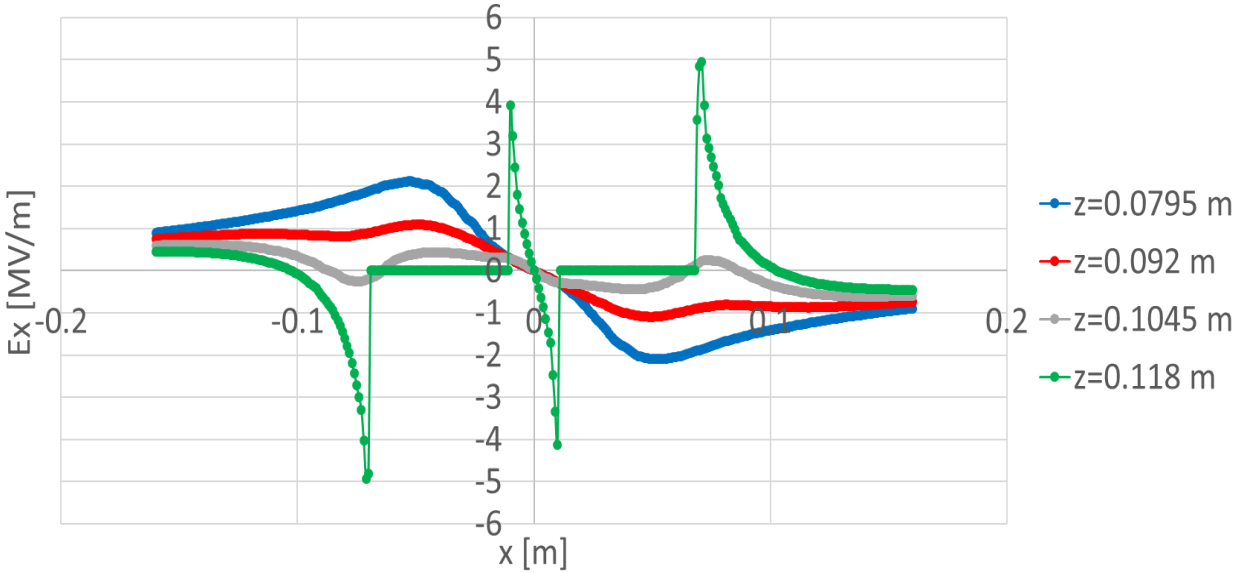
Flat cathode front and flat anode- 5 cm gap - no shed no NEGs



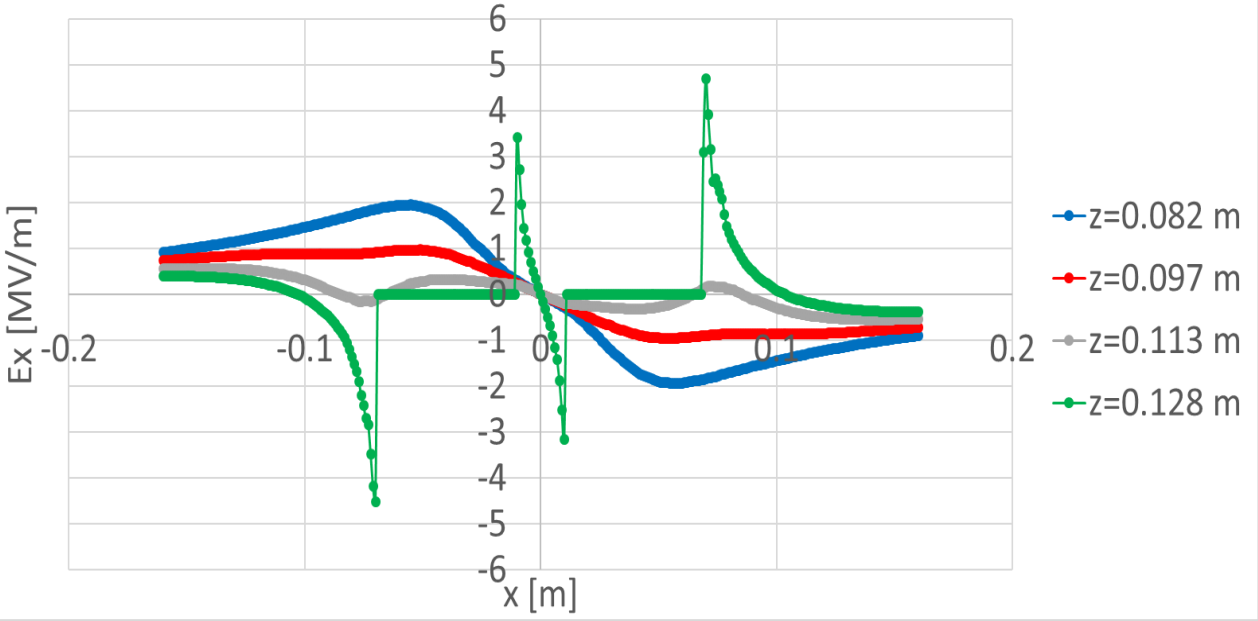
Flat cathode front and flat anode - 6 cm gap - no shed no NEGs



Flat cathode front and flat anode - 5 cm gap - no shed no NEGs- symmetric anode

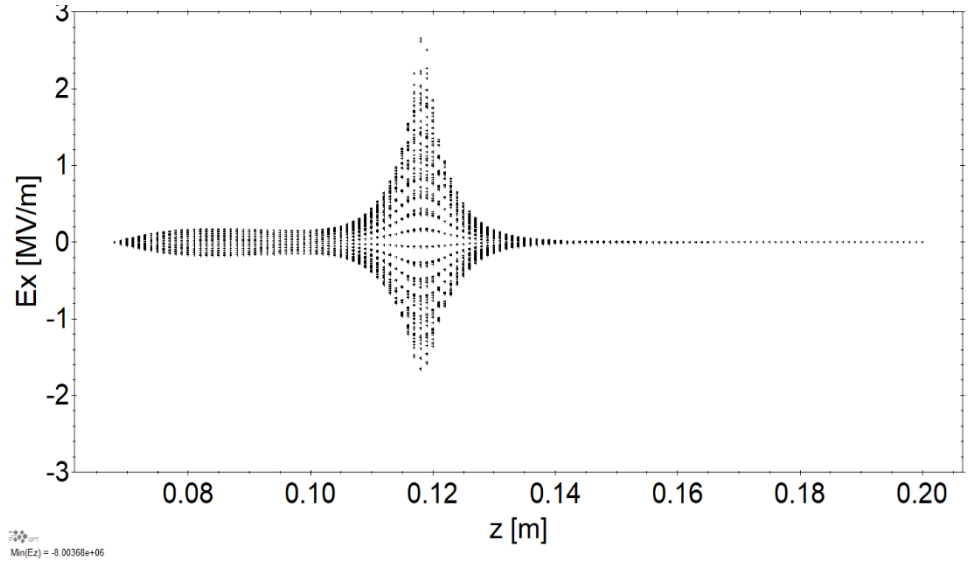


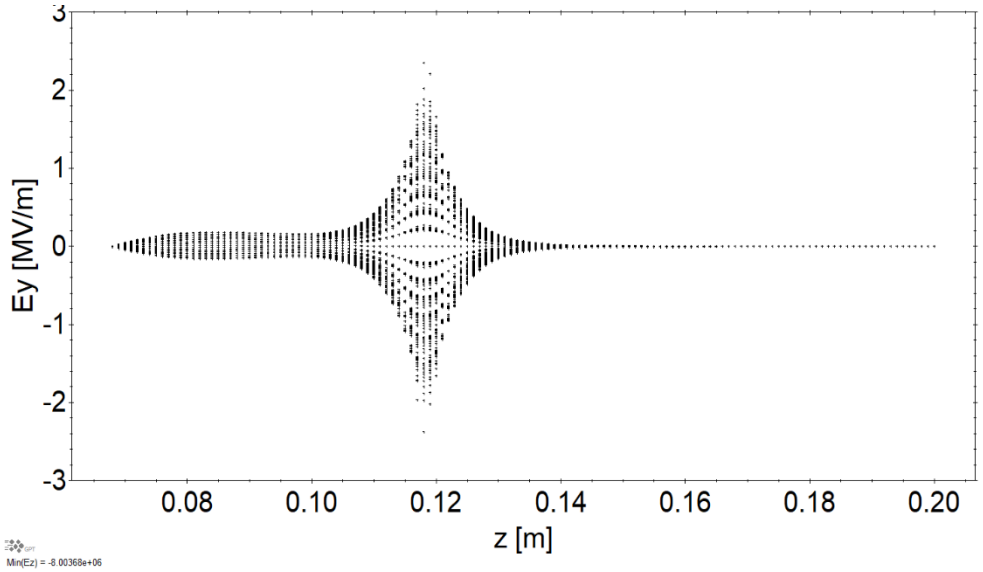
Flat cathode front and flat anode - 6 cm gap - no shed no NEGs- symmetric anode



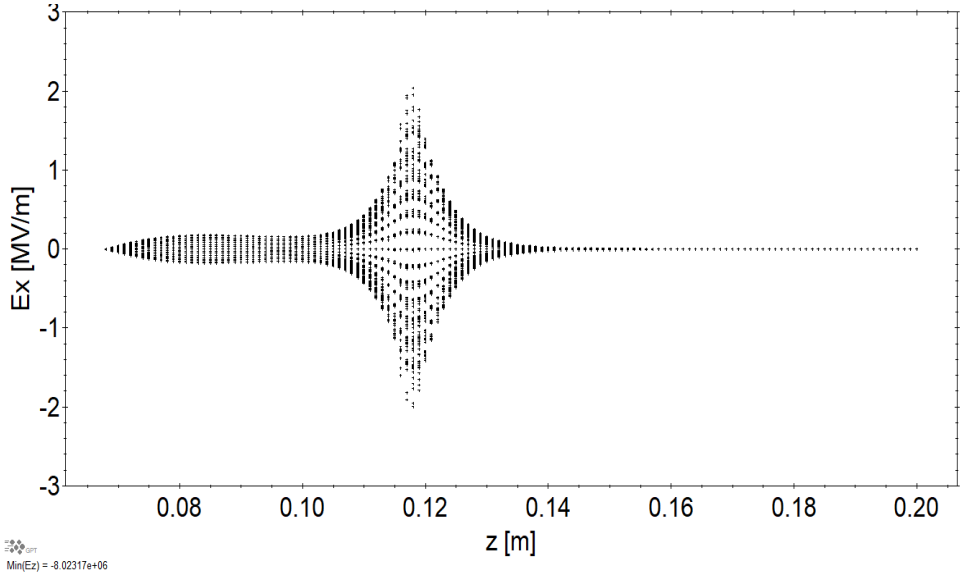
Flat cathode front and flat anode – no NEGs, no shed - cathode anode gap 5 cm

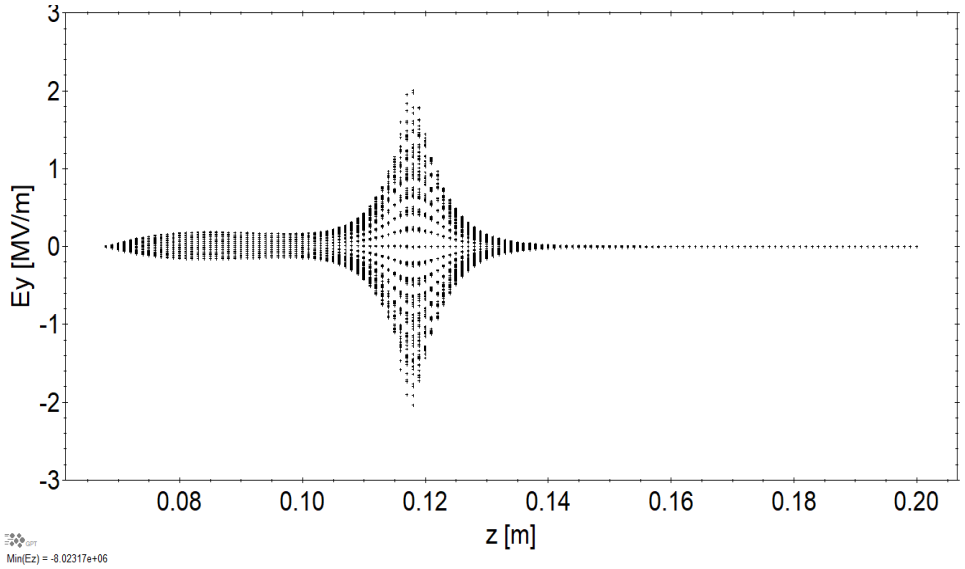
Asymmetric Anode





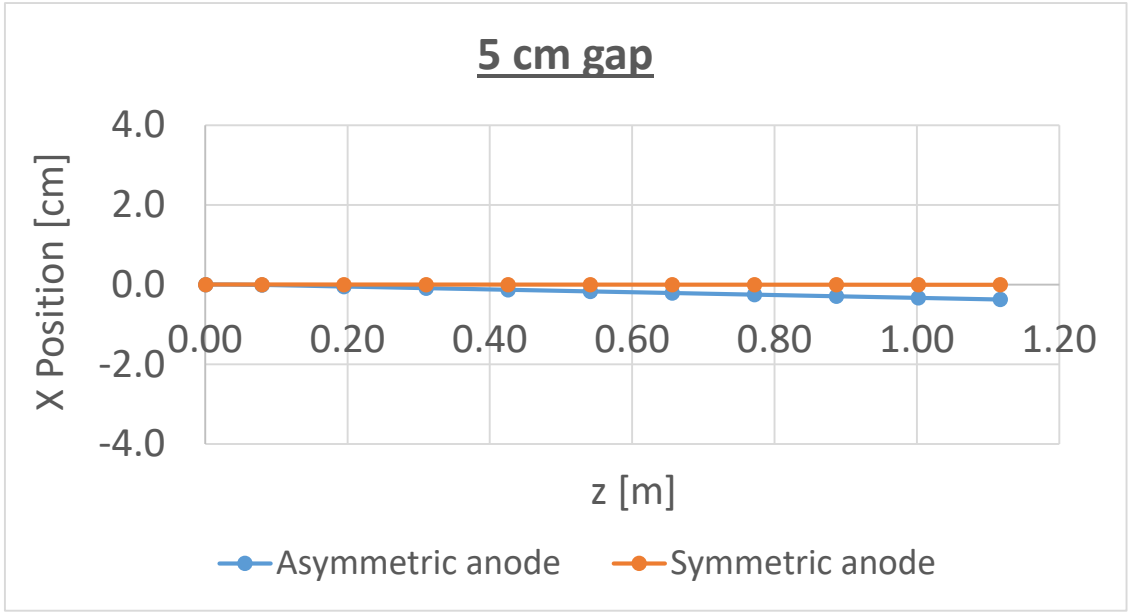
Symmetric Anode

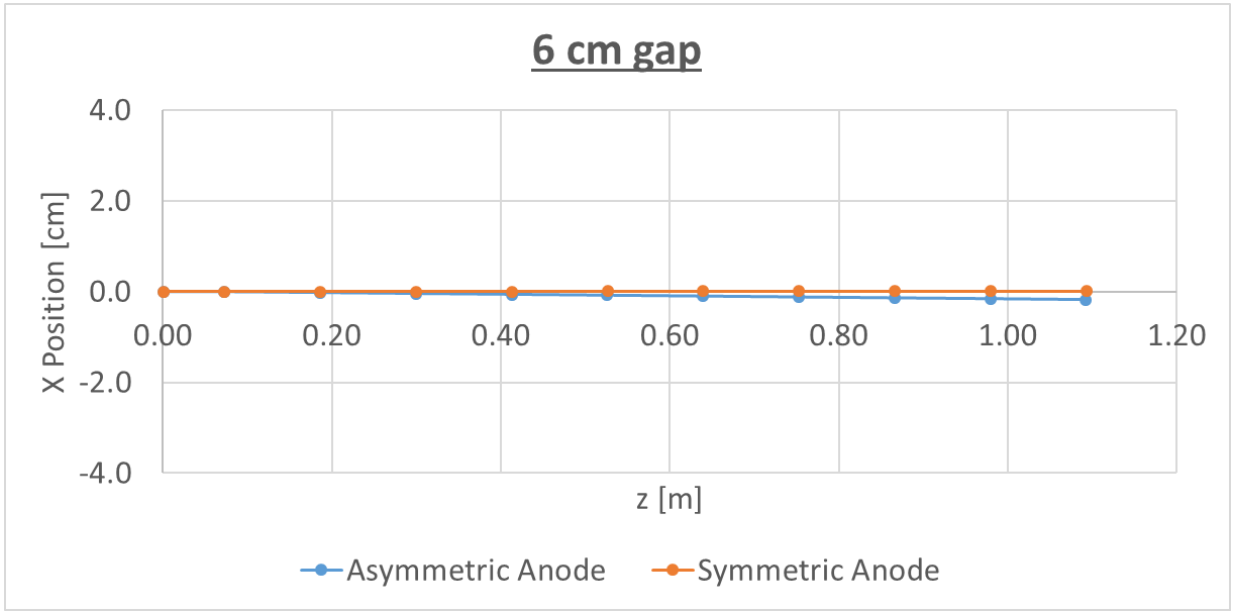


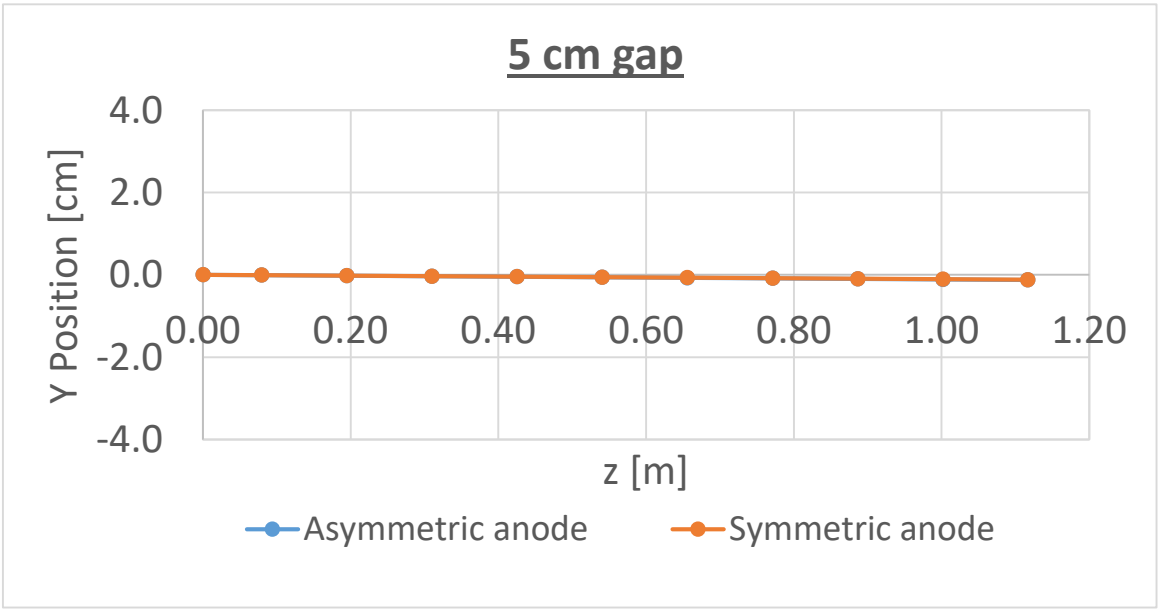


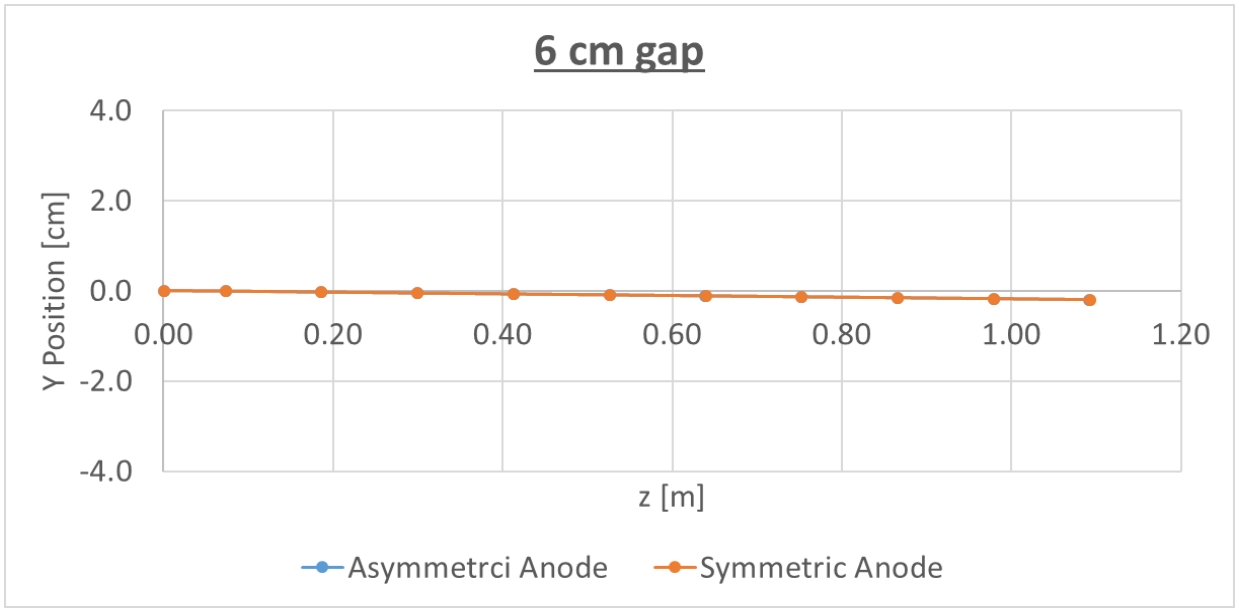
Flat cathode front and flat anode – no NEGs, no shed

2 nC, -300 kV, 1 mm rms, 75 ps FWHM, sc on

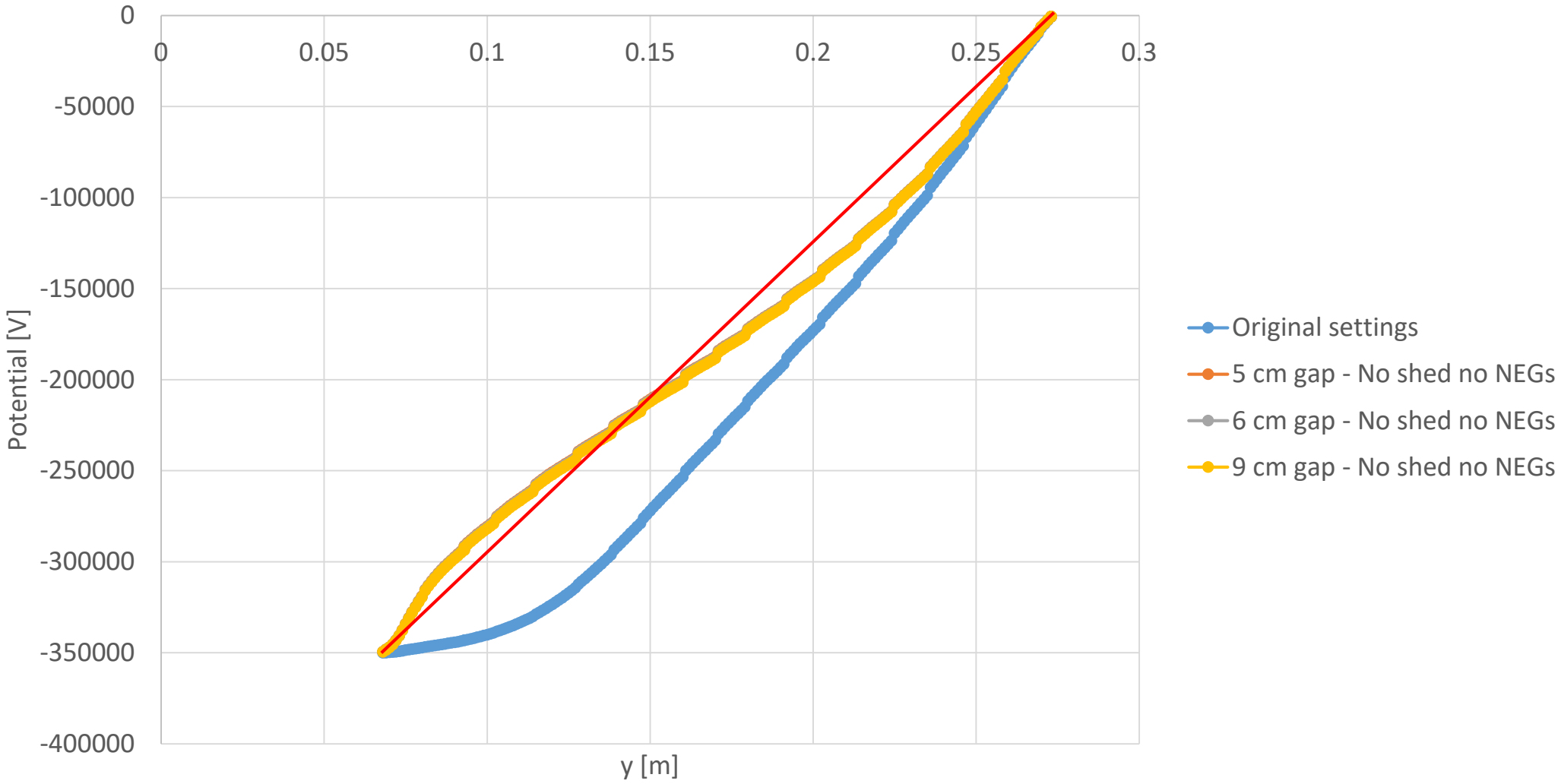


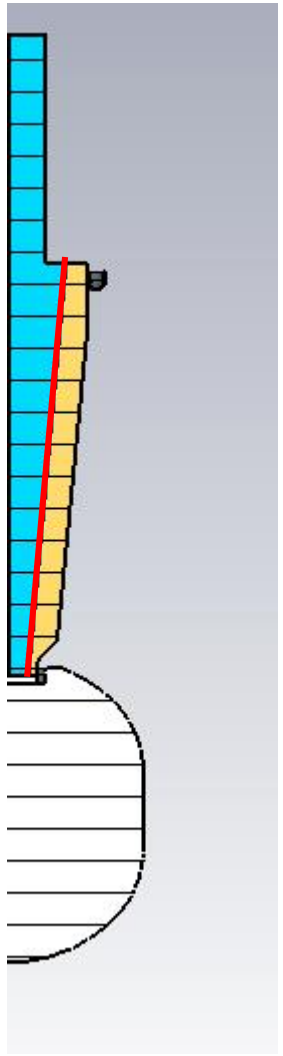






Potential variation along the rubber-insulator interface

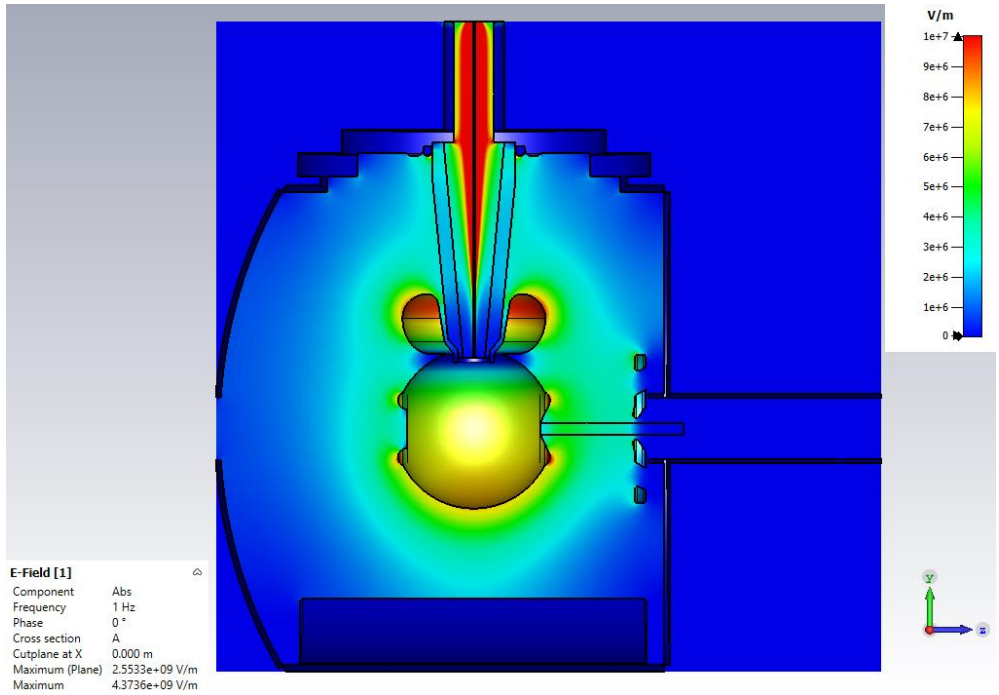




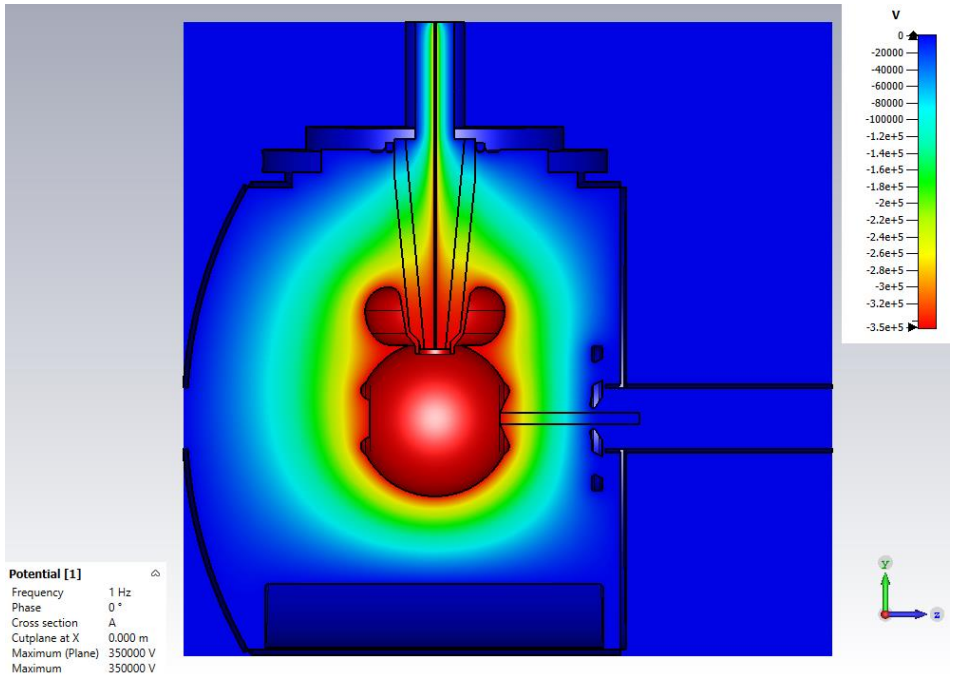
Original settings

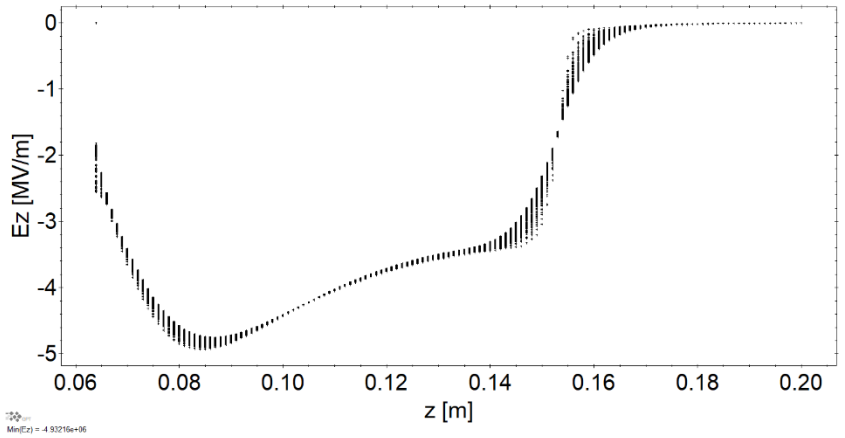
-350 kV at the cathode, 0 V at the anode

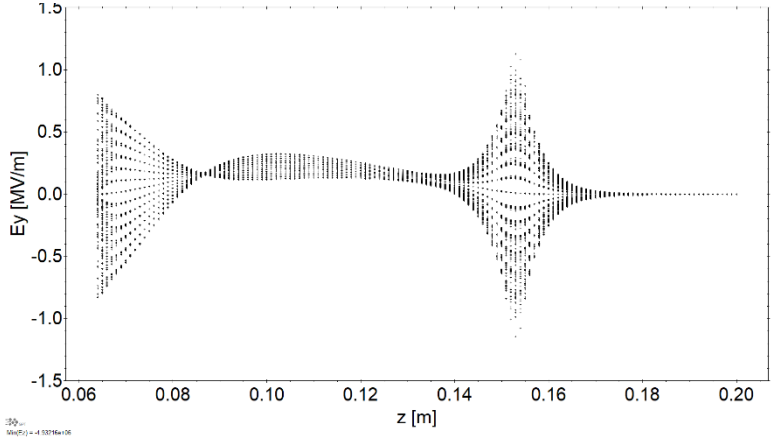
E field

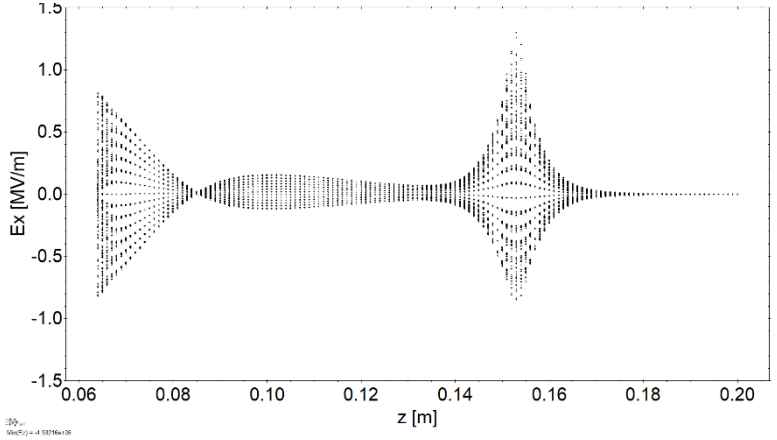


Potential





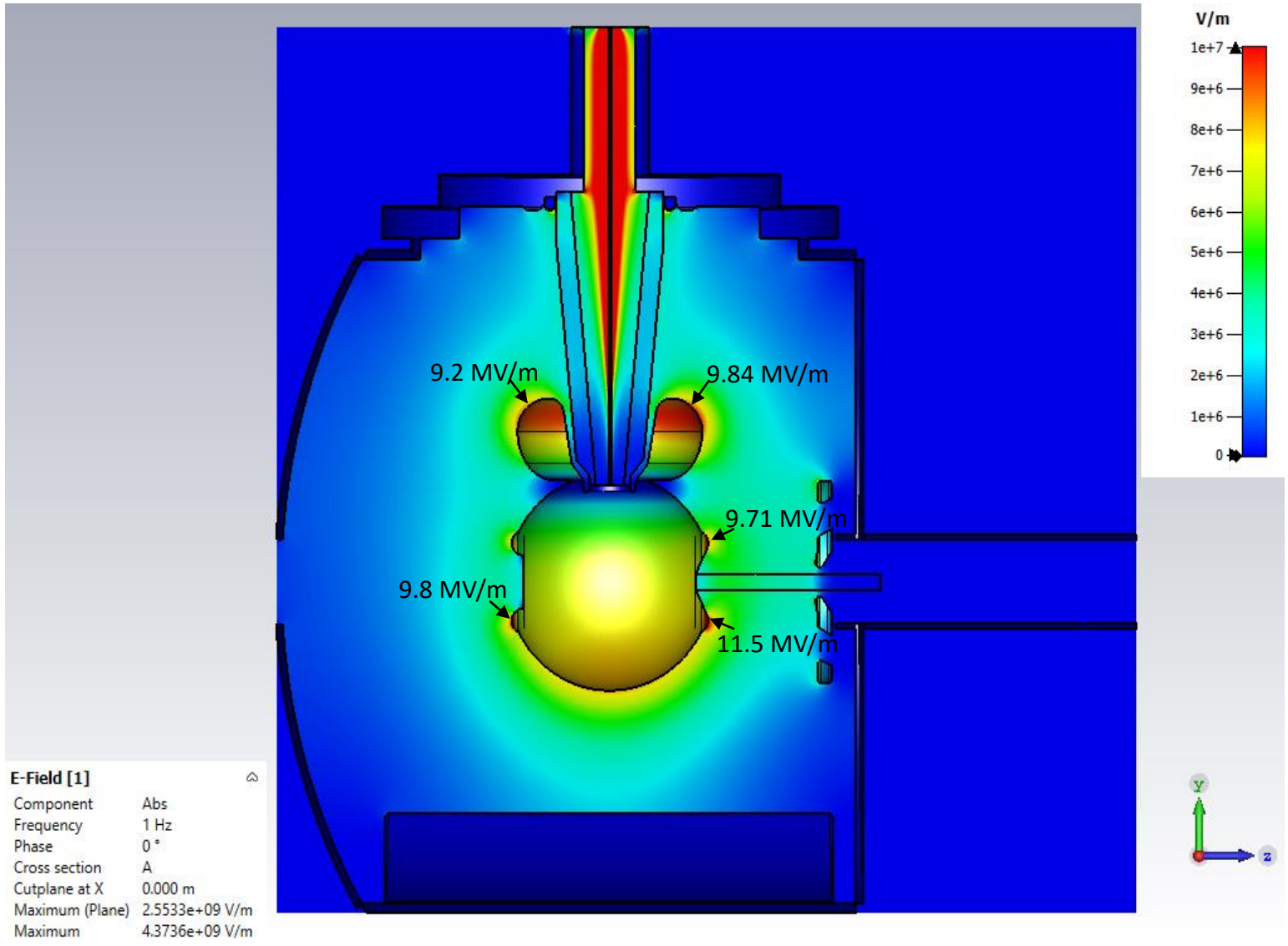




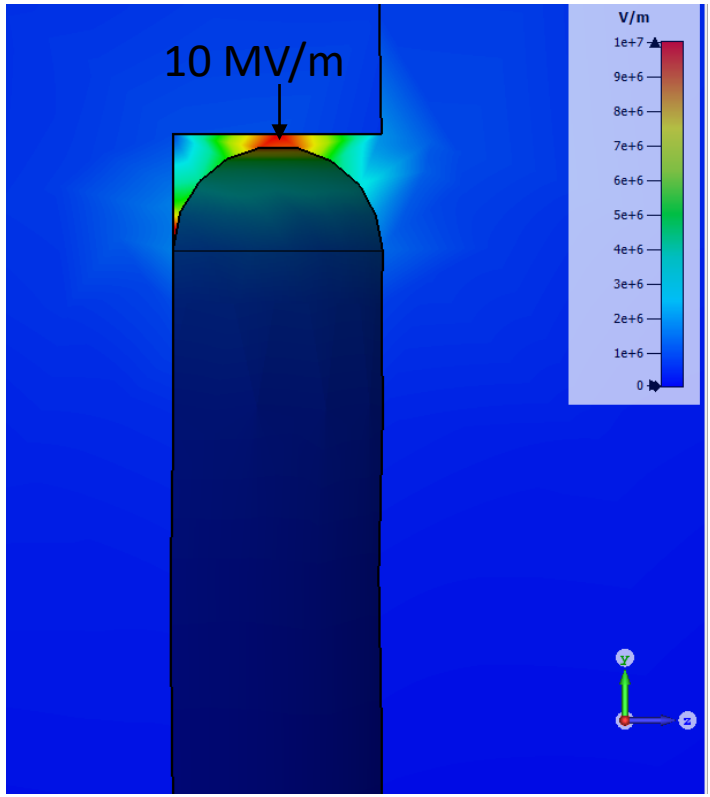
Original settings

-350 kV at the cathode, 0 V at the anode

E field



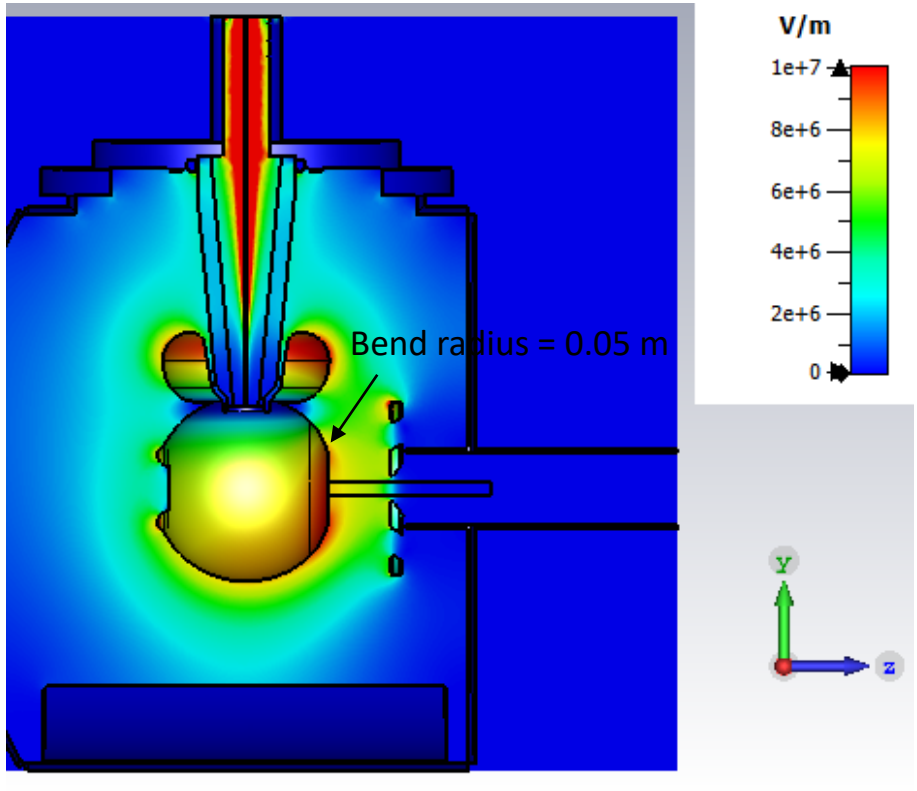
Triple point junction

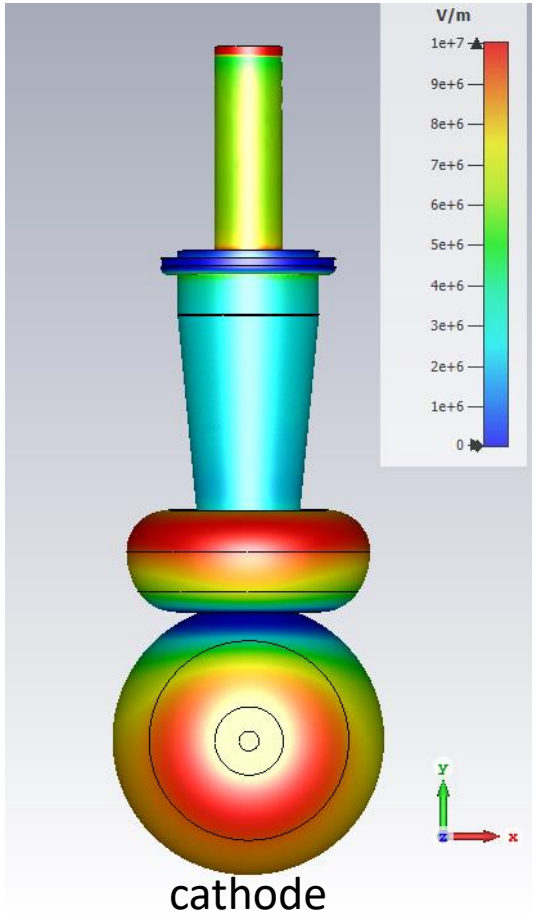


Flat cathode front and flat anode - cathode anode gap 5 cm

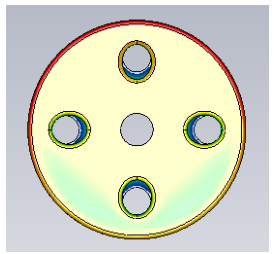
-350 kV at the cathode, 0 V at the anode

E field



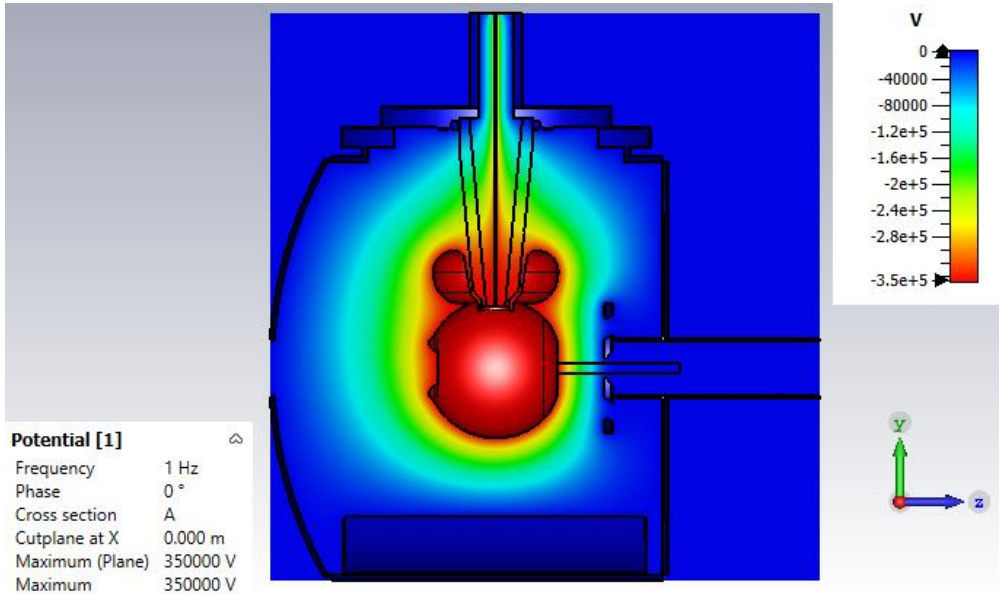


cathode



anode

Potential

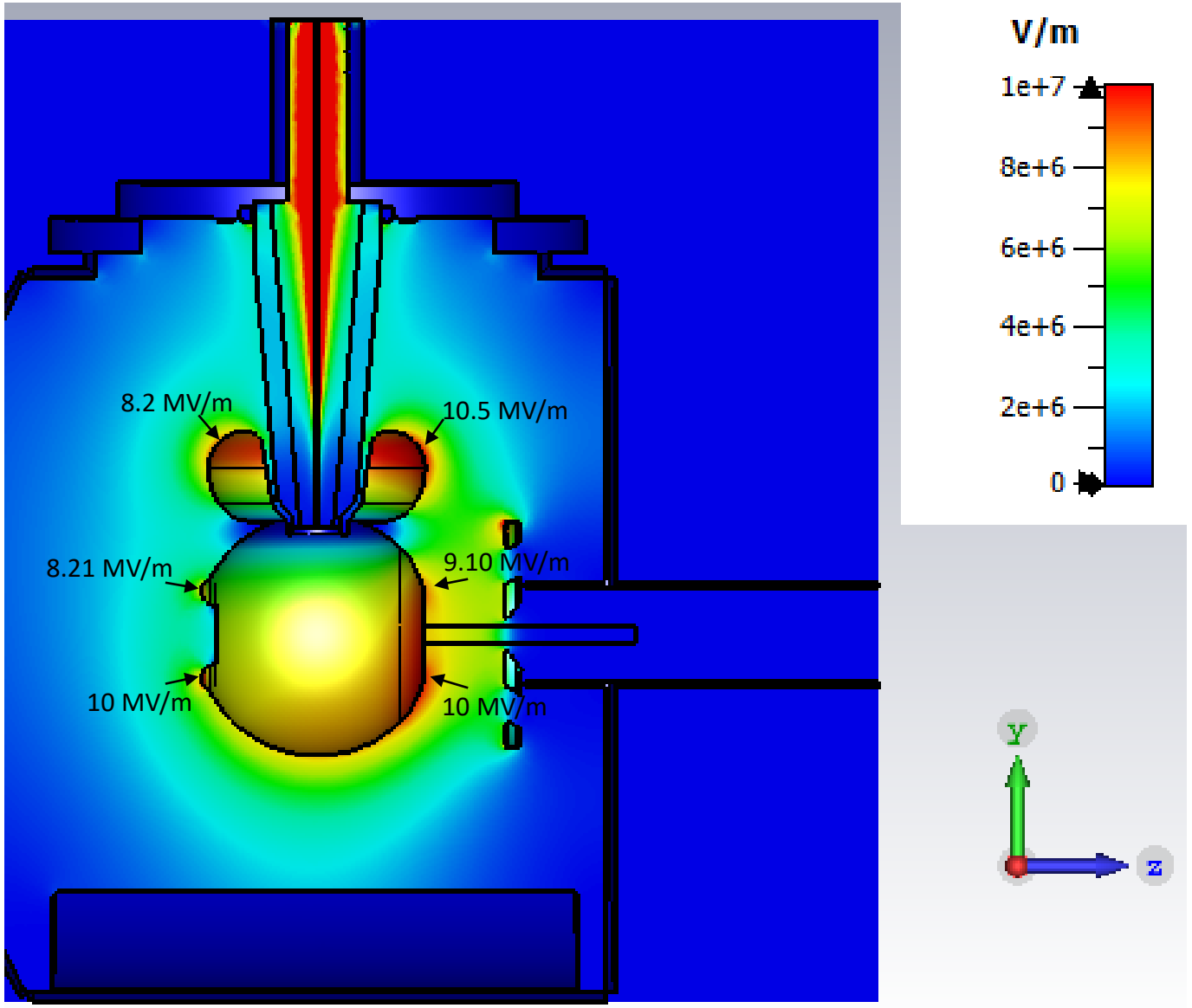


Potential [1]	
Frequency	1 Hz
Phase	0 °
Cross section	A
Cutplane at X	0.000 m
Maximum (Plane)	350000 V
Maximum	350000 V

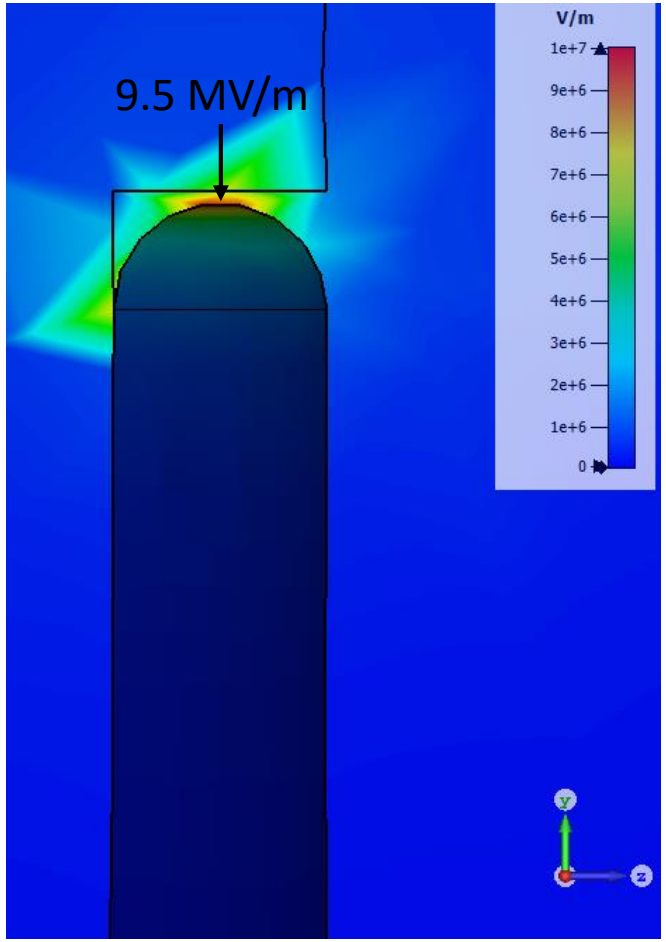
Flat cathode front and flat anode - cathode anode gap 5 cm

-350 kV at the cathode, 0 V at the anode

E field



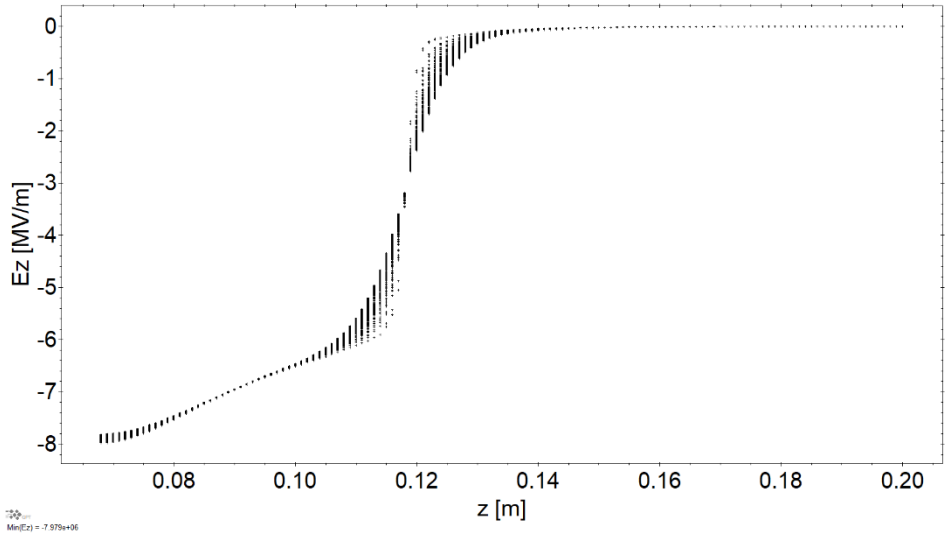
Triple point junction

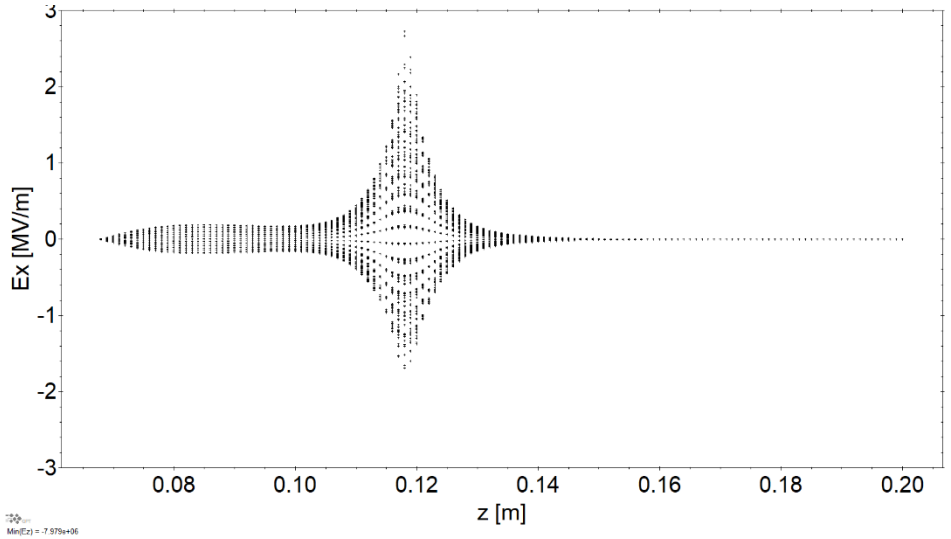


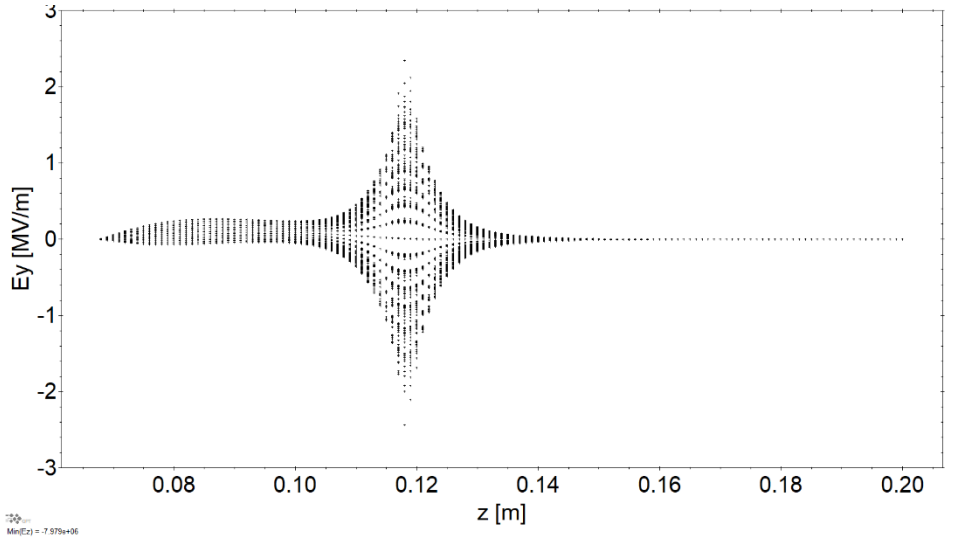
Flat cathode front and flat anode - cathode anode gap 5 cm

-350 kV at the cathode, 0 V at the anode

E fields



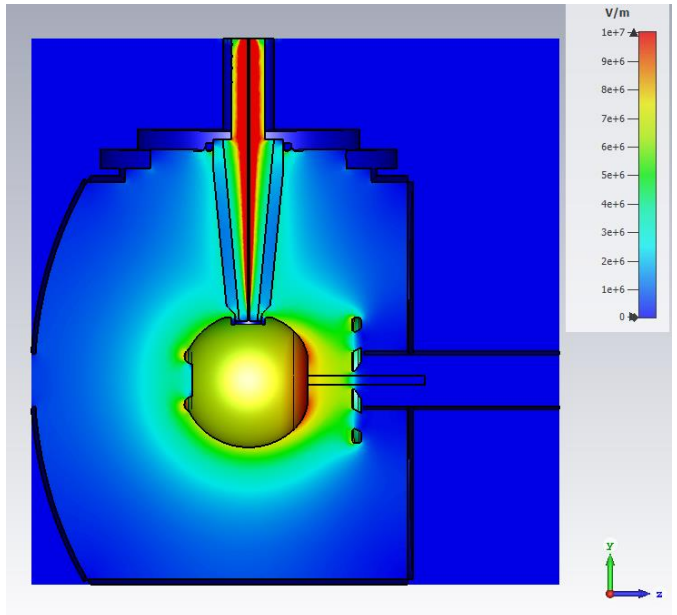


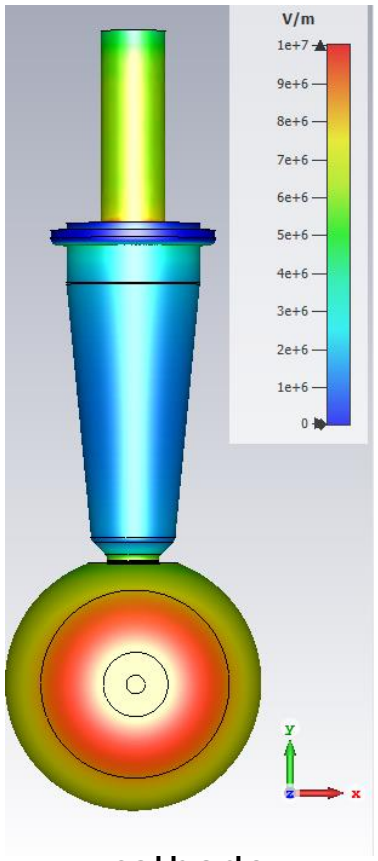


Flat cathode front and flat anode – no NEGs, no shed - cathode anode gap 5 cm

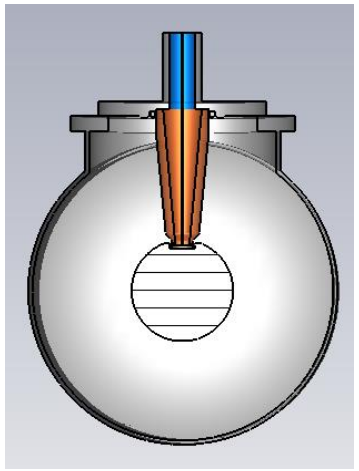
-350 kV at the cathode, 0 V at the anode

E field

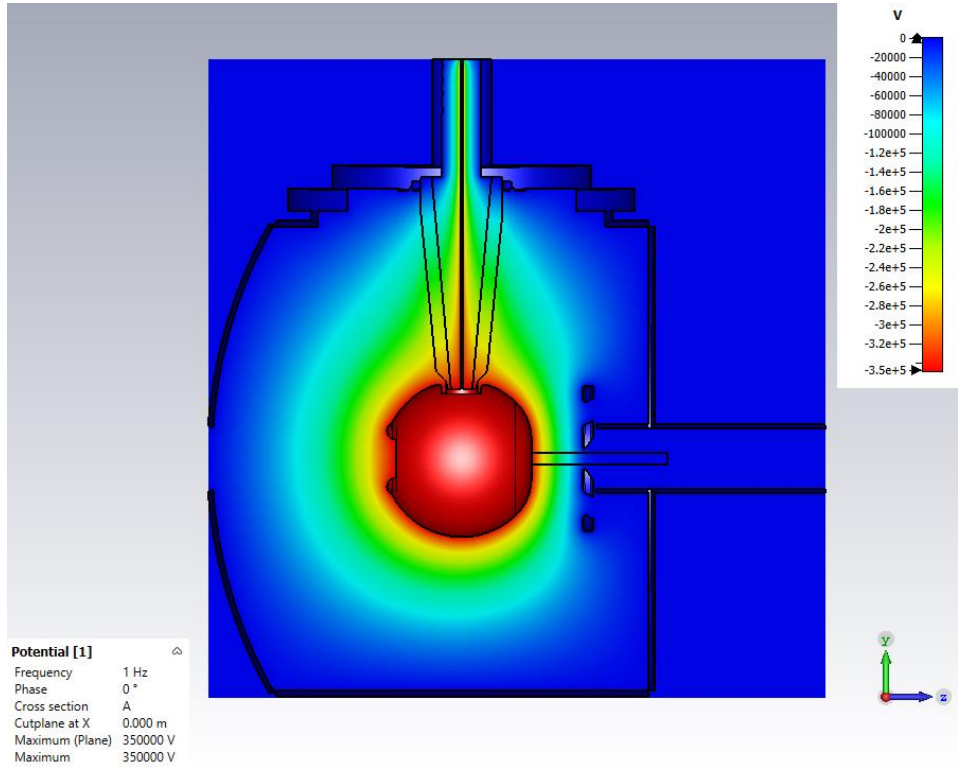




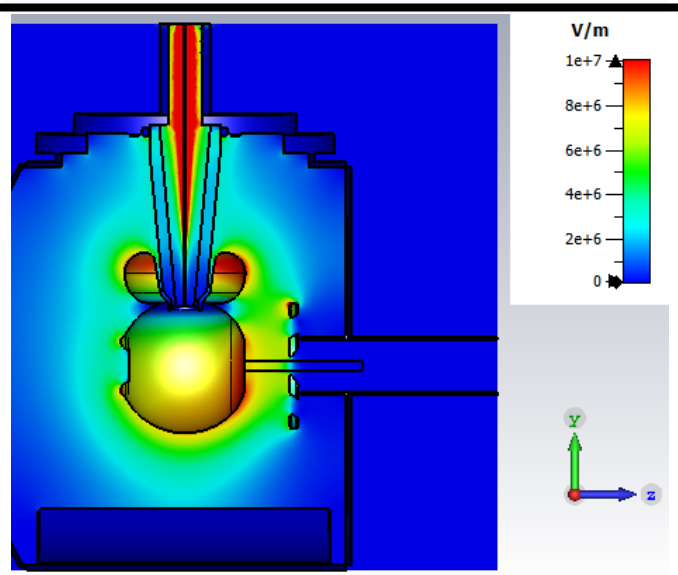
cathode

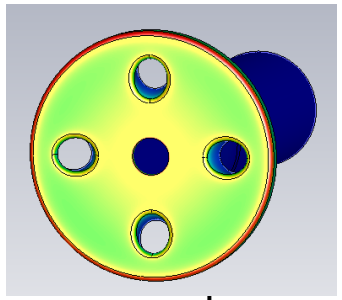


Potential



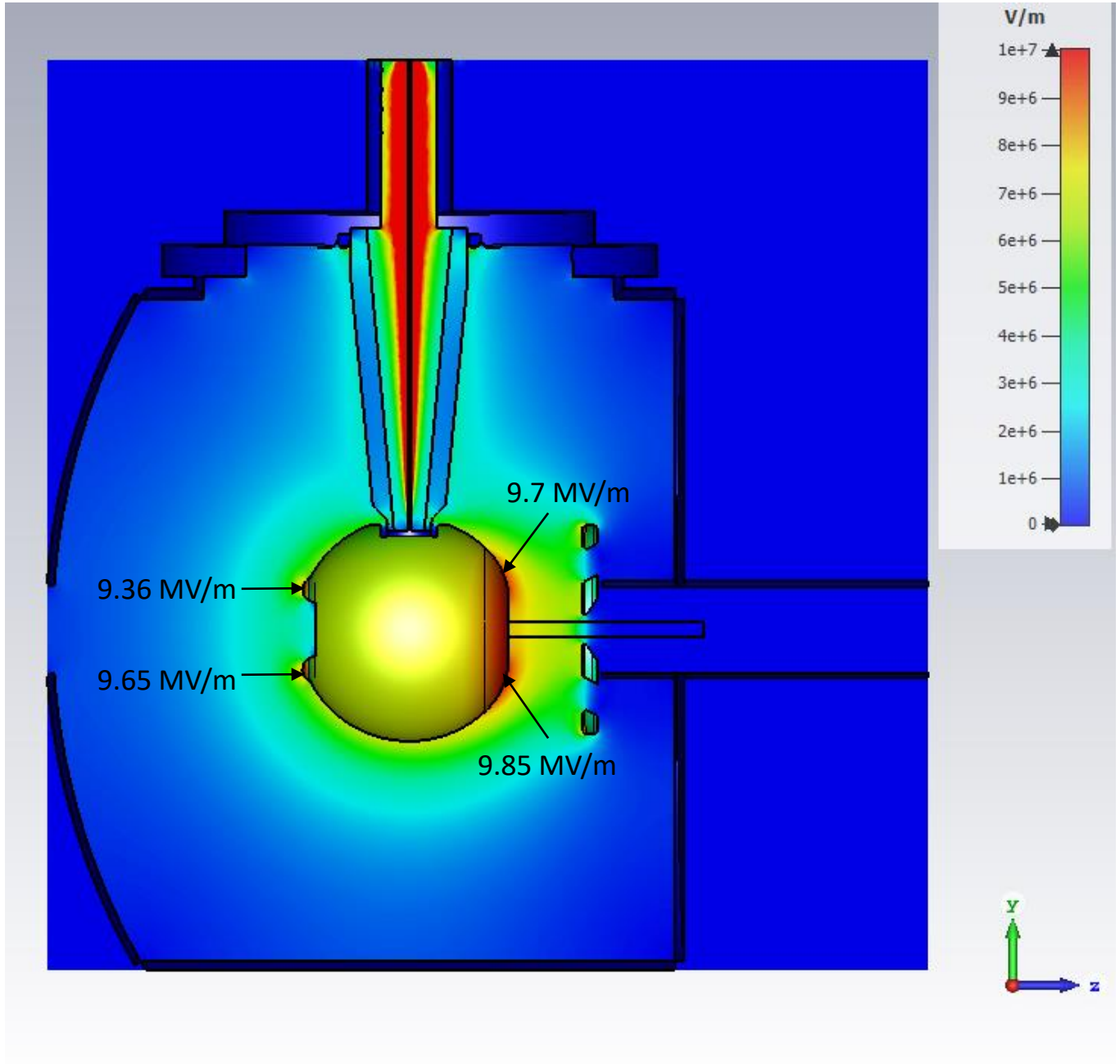
E field for with NEGs and shed

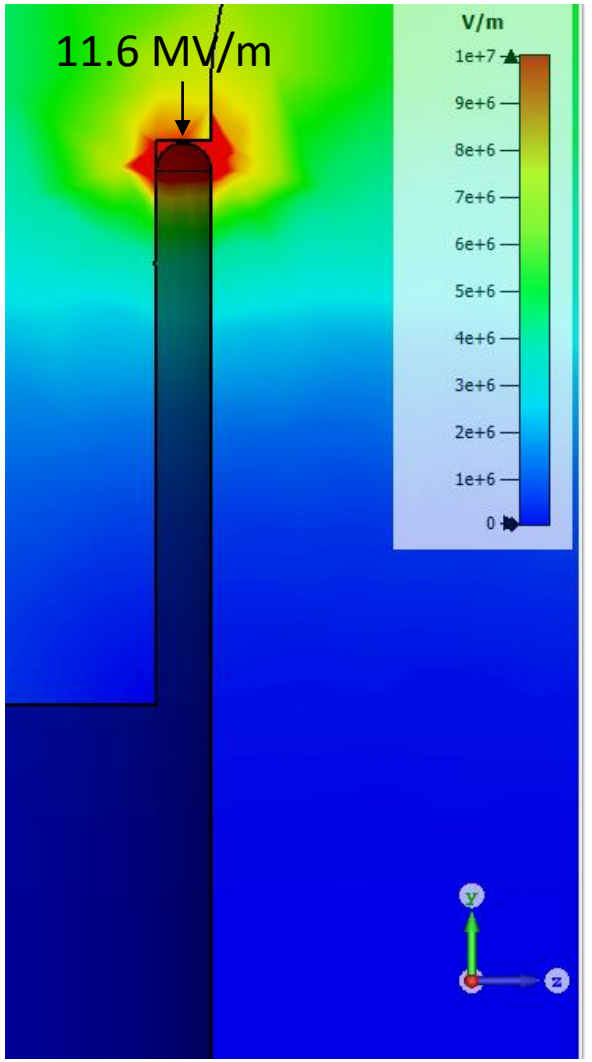




anode

Flat cathode front and flat anode – no NEGs, no shed - cathode anode gap 5 cm

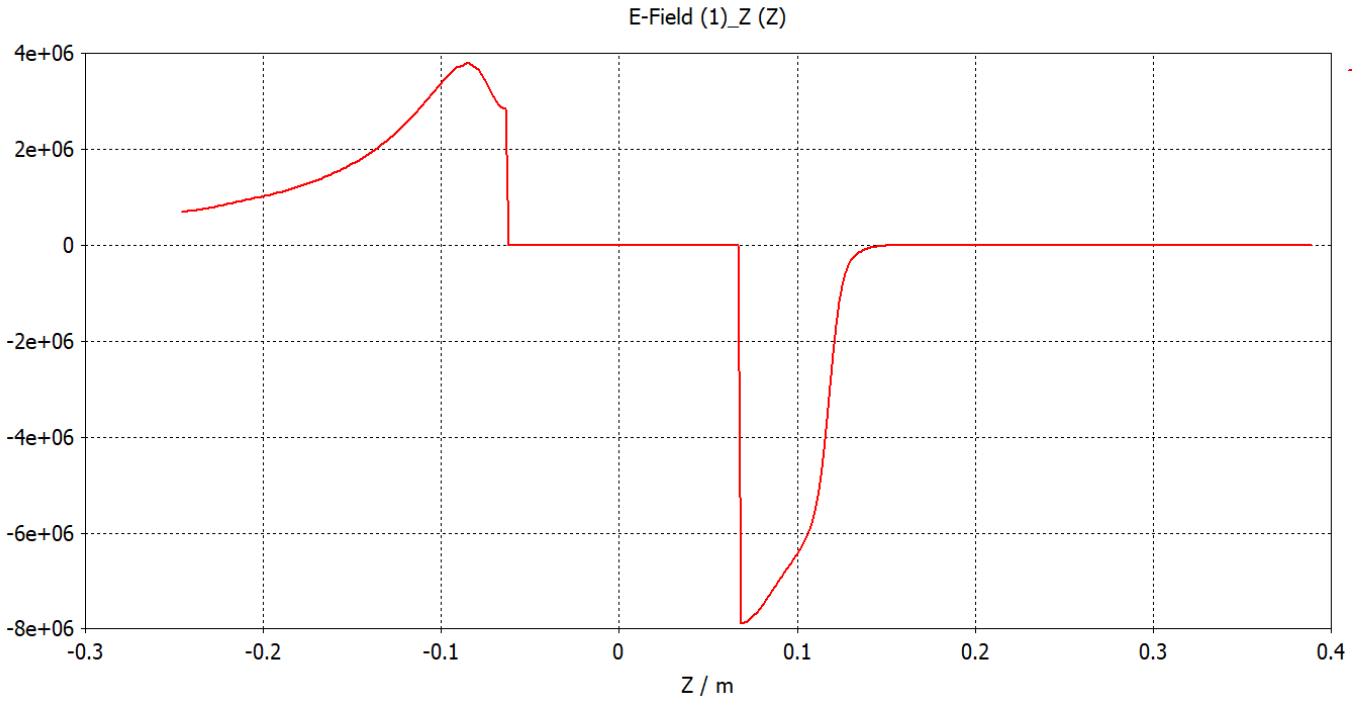


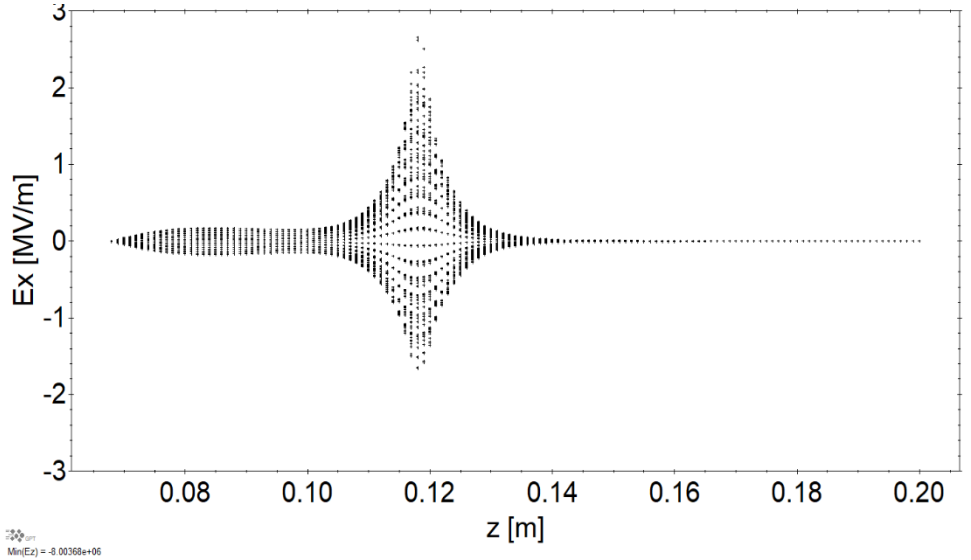


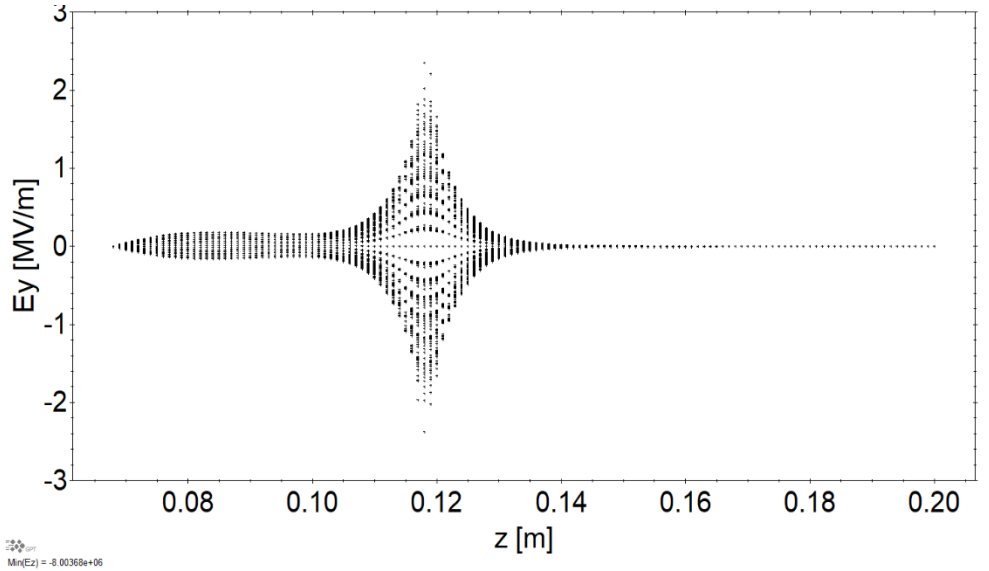
Flat cathode front and flat anode – no NEGs, no shed - cathode anode gap 5 cm

-350 kV at the cathode, 0 V at the anode

E fields





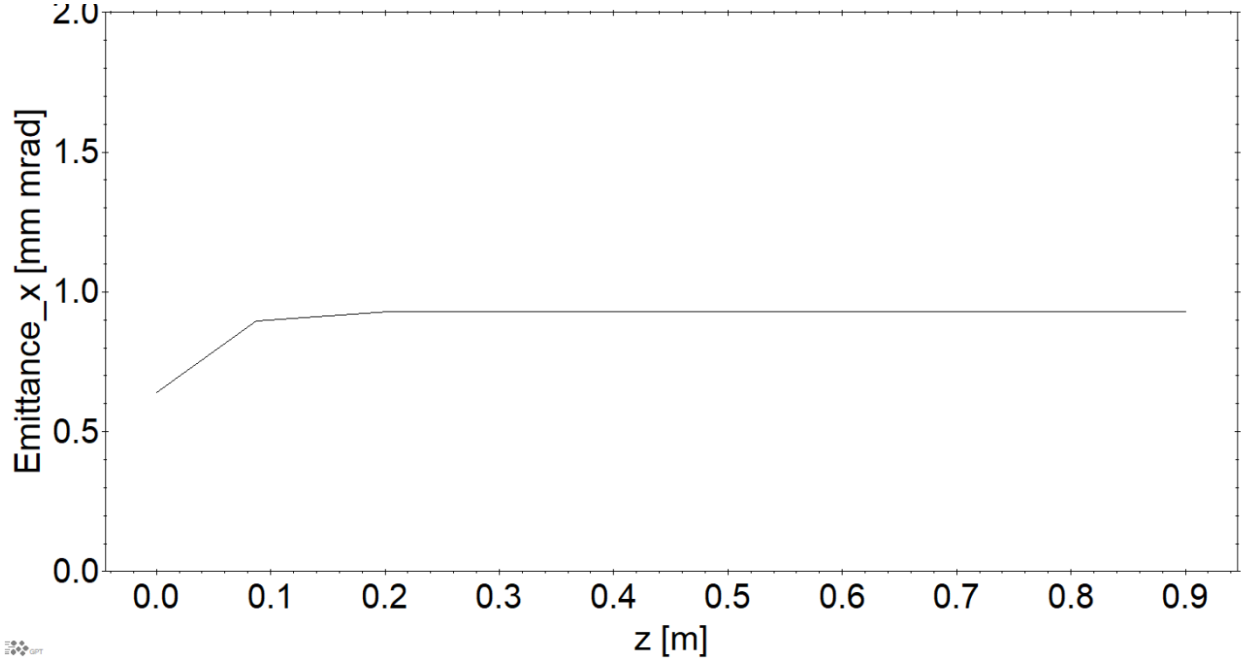


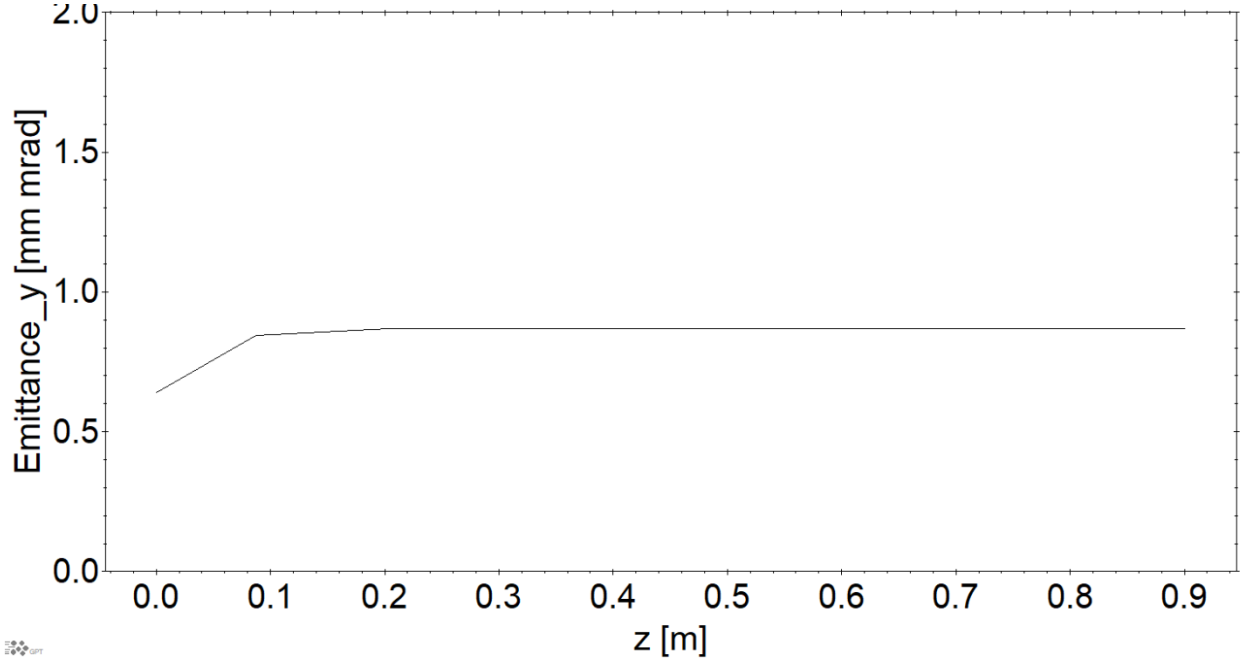
Ez at the cathode -8.00368 MV/m

Flat cathode front and flat anode – no NEGs, no shed - cathode anode gap 5 cm

-300 kV at the cathode, 0 V at the anode, no space charge

Emittance

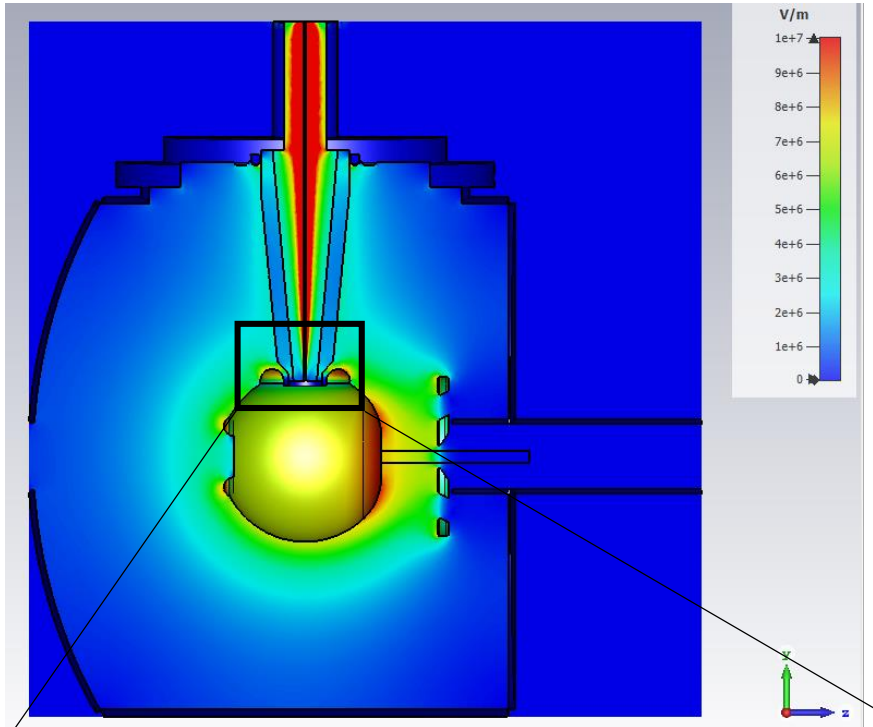


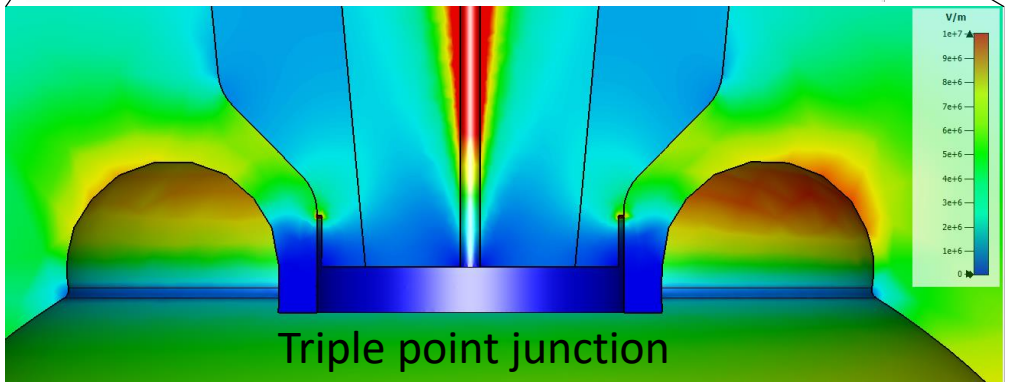


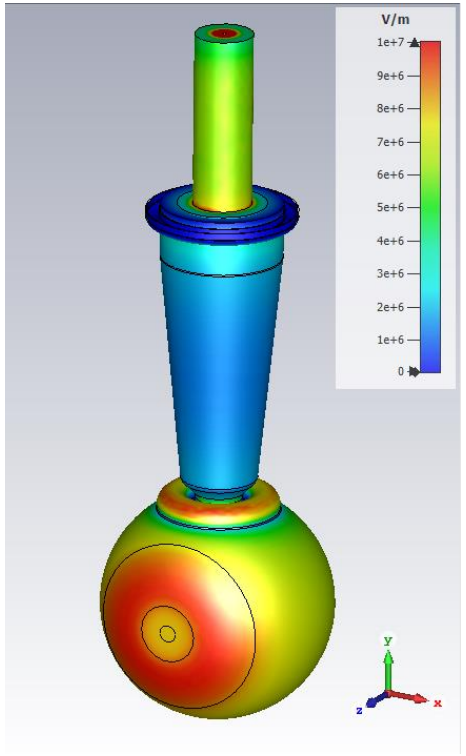
Flat cathode front and flat anode - cathode anode gap 5 cm - shed design 1

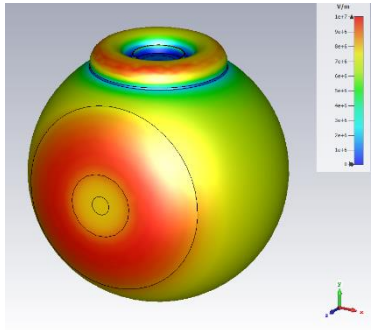
-350 kV at the cathode, 0 V at the anode

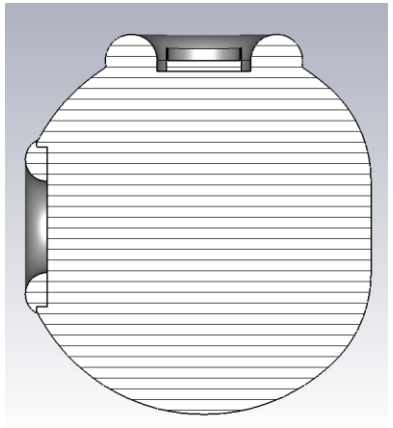
E field



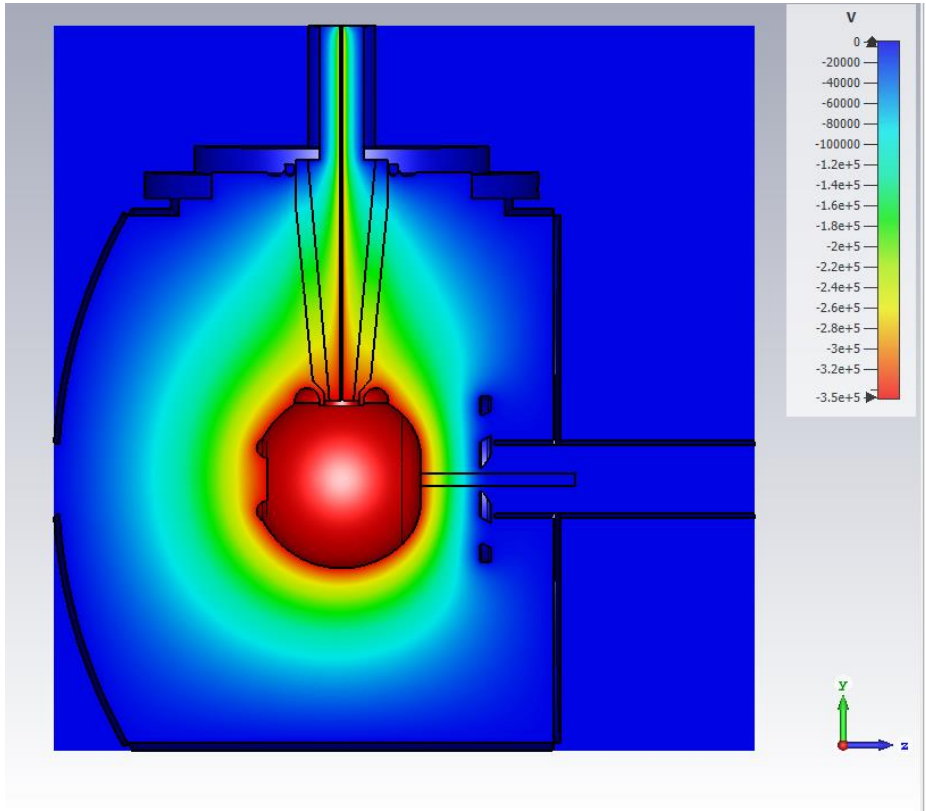




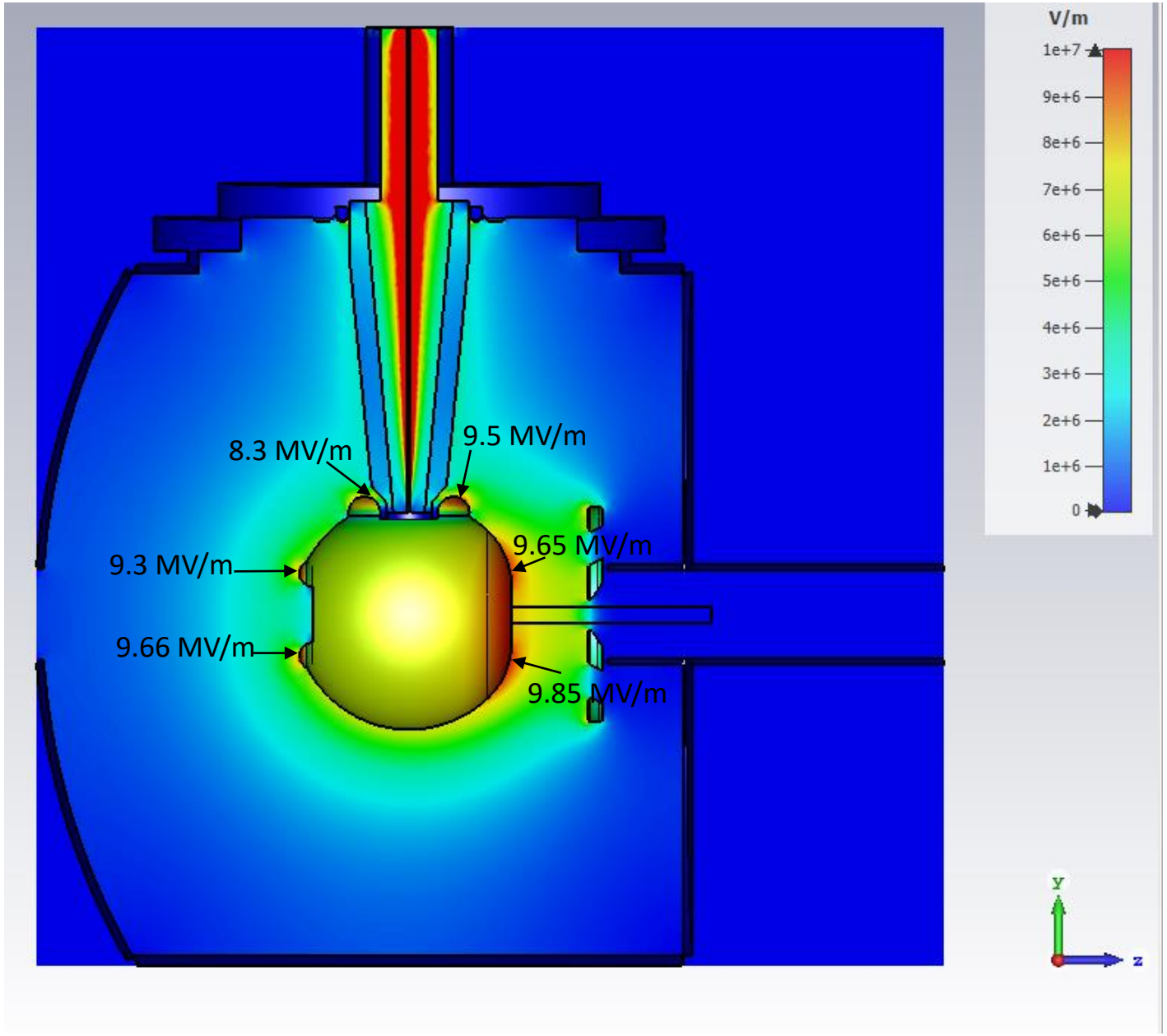


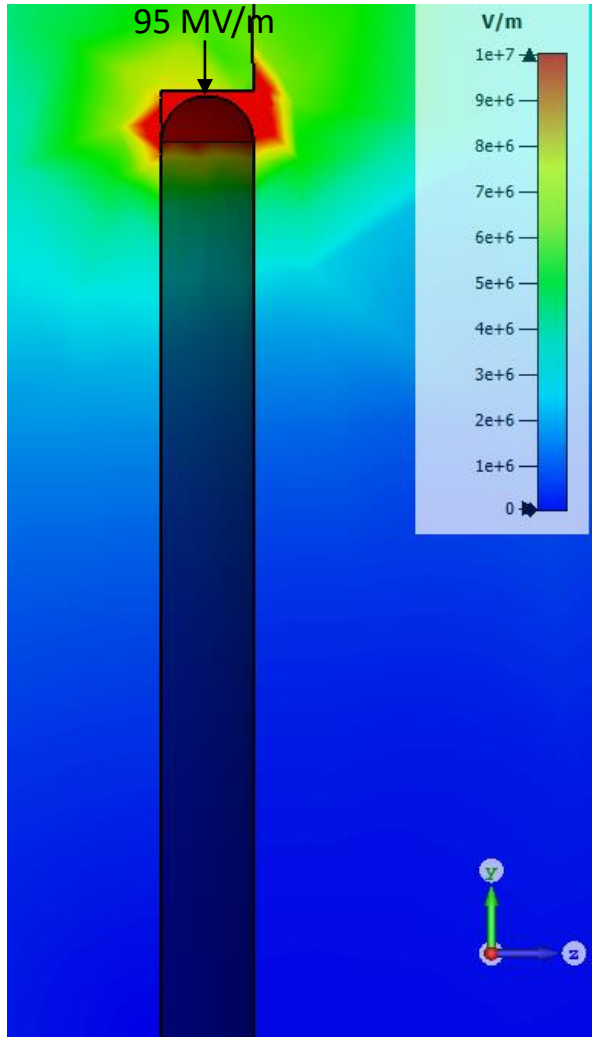


Potential



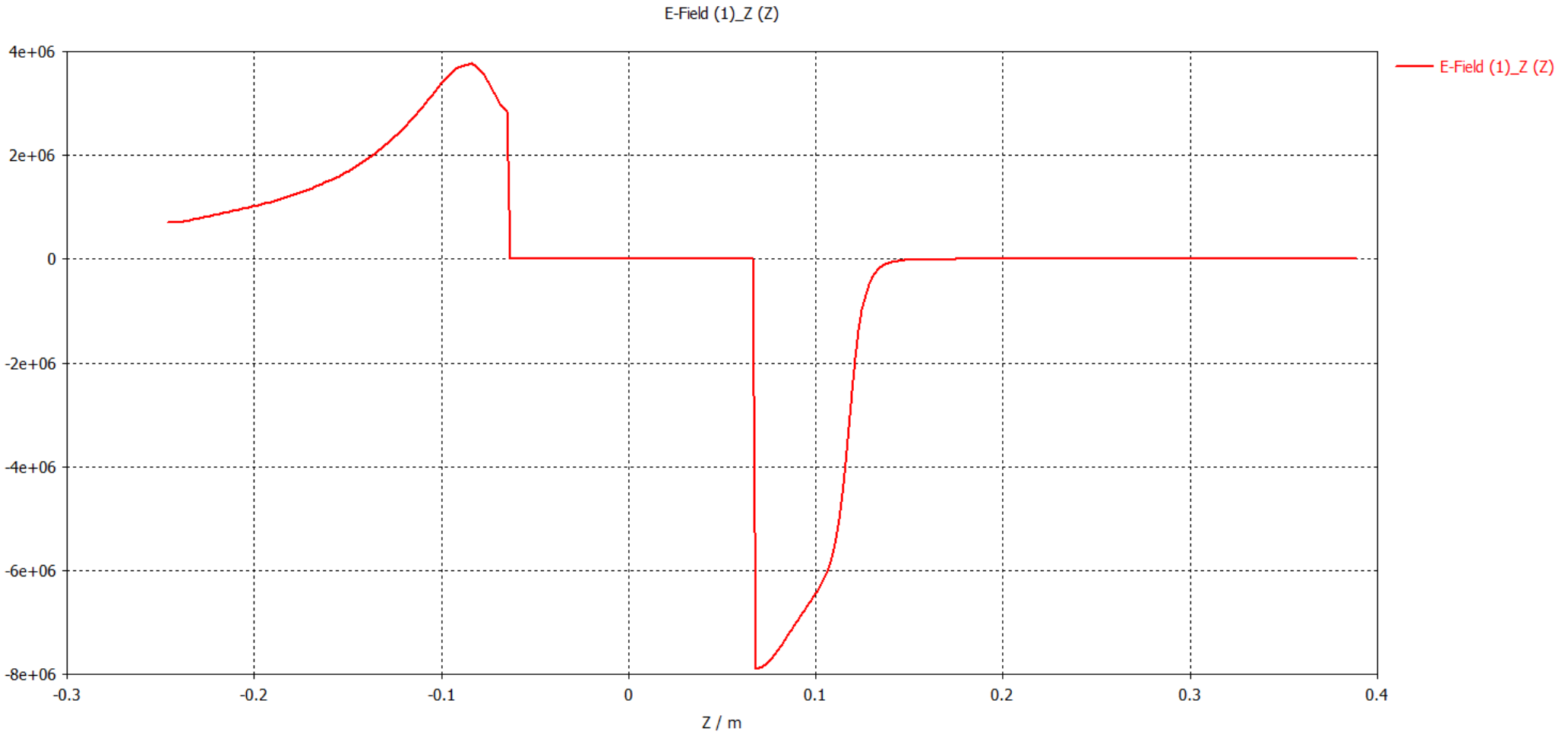
Flat cathode front and flat anode - cathode anode gap 5 cm - shed design 1





Flat cathode front and flat anode - cathode anode gap 5 cm - shed design 1

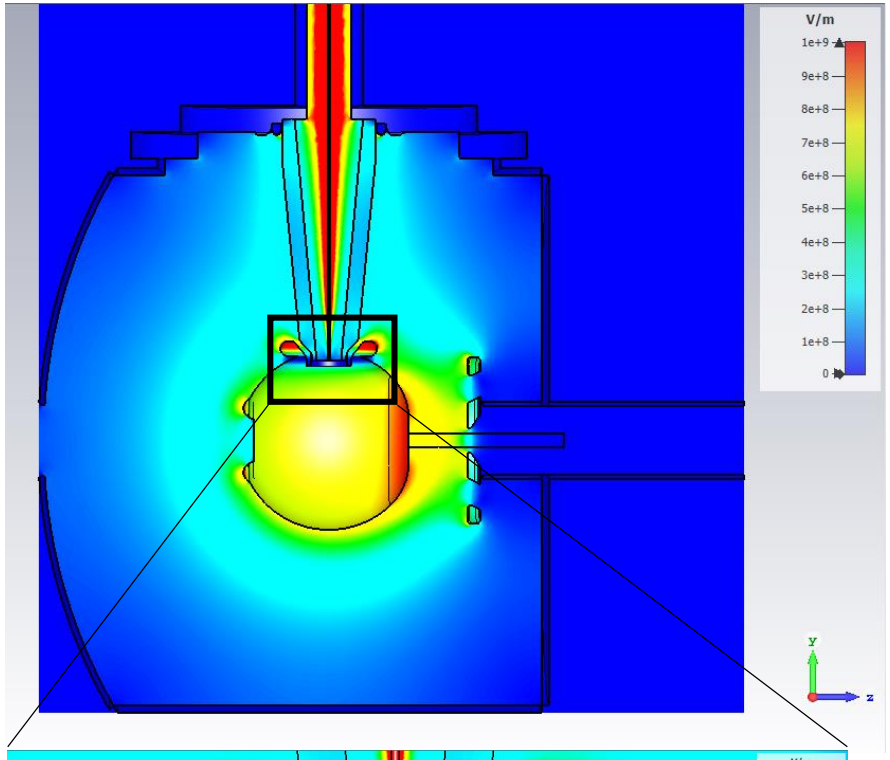
-350 kV at the cathode, 0 V at the anode

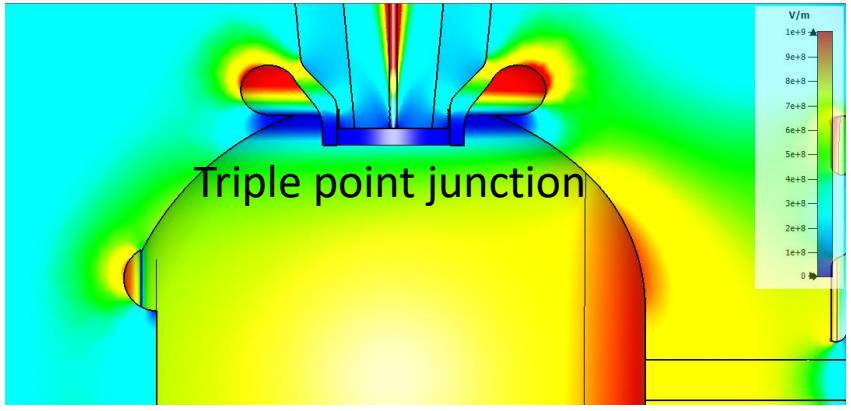


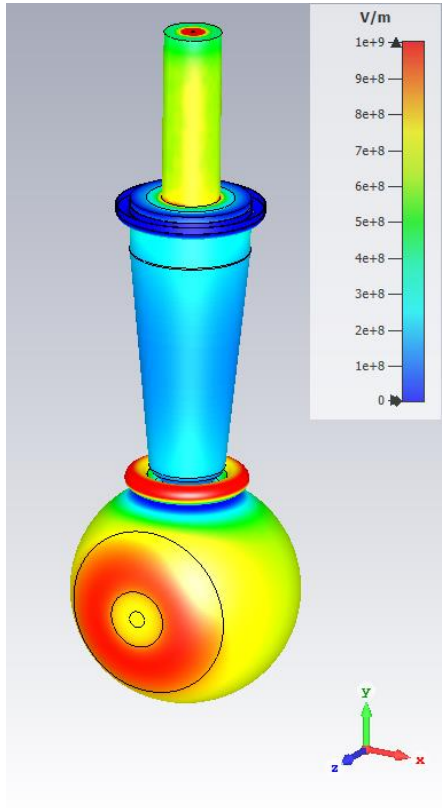
Flat cathode front and flat anode - cathode anode gap 5 cm - shed design 2

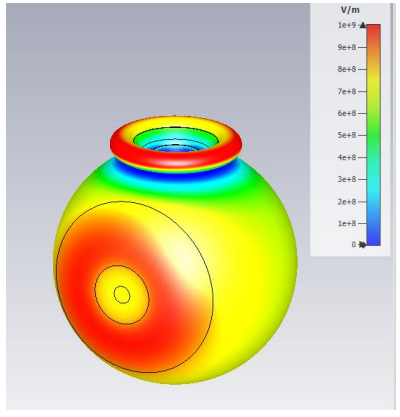
-350 kV at the cathode, 0 V at the anode

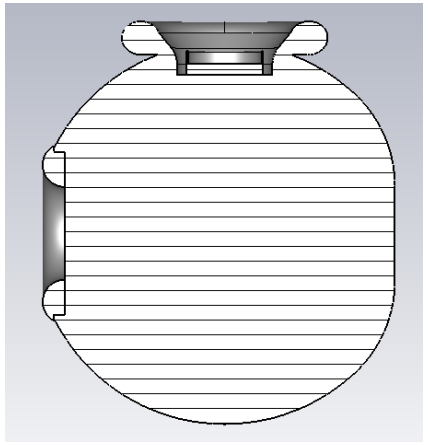
E field



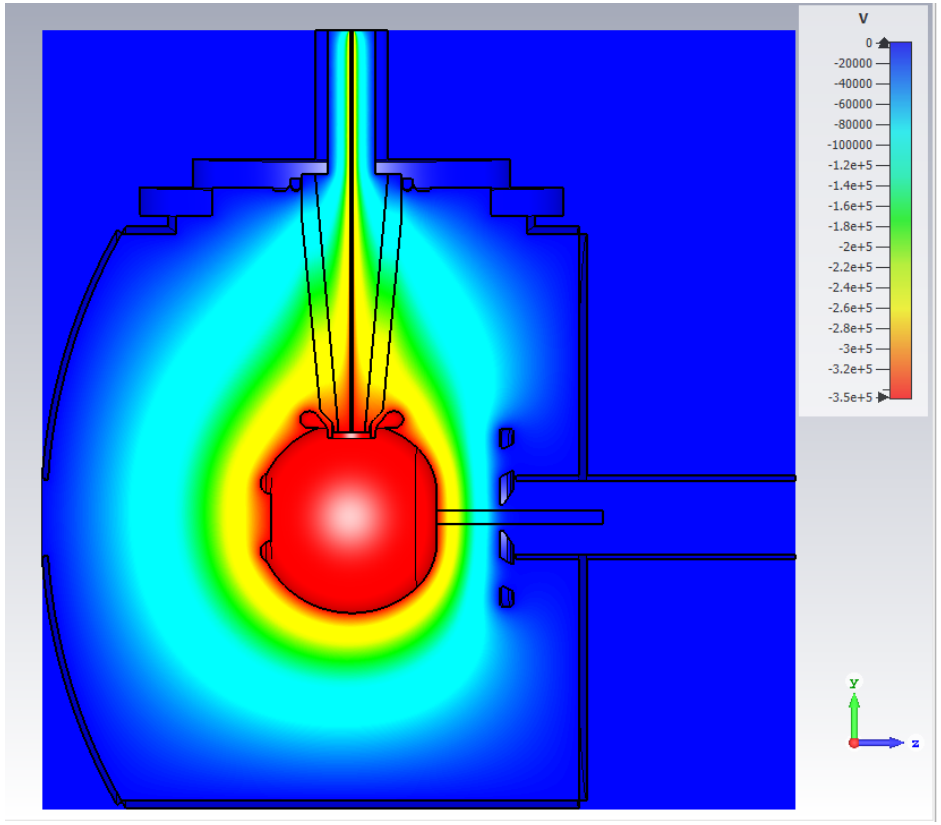




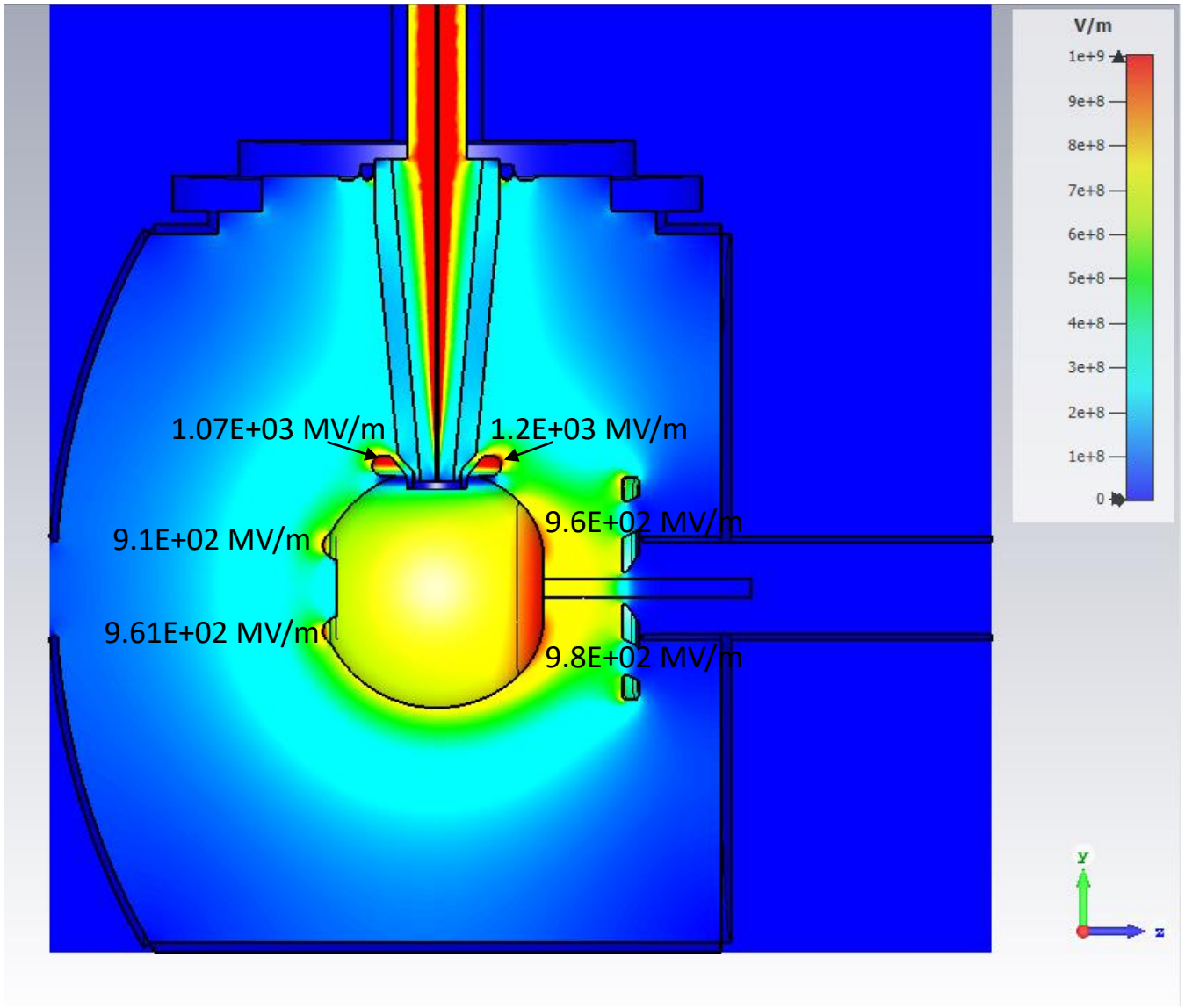


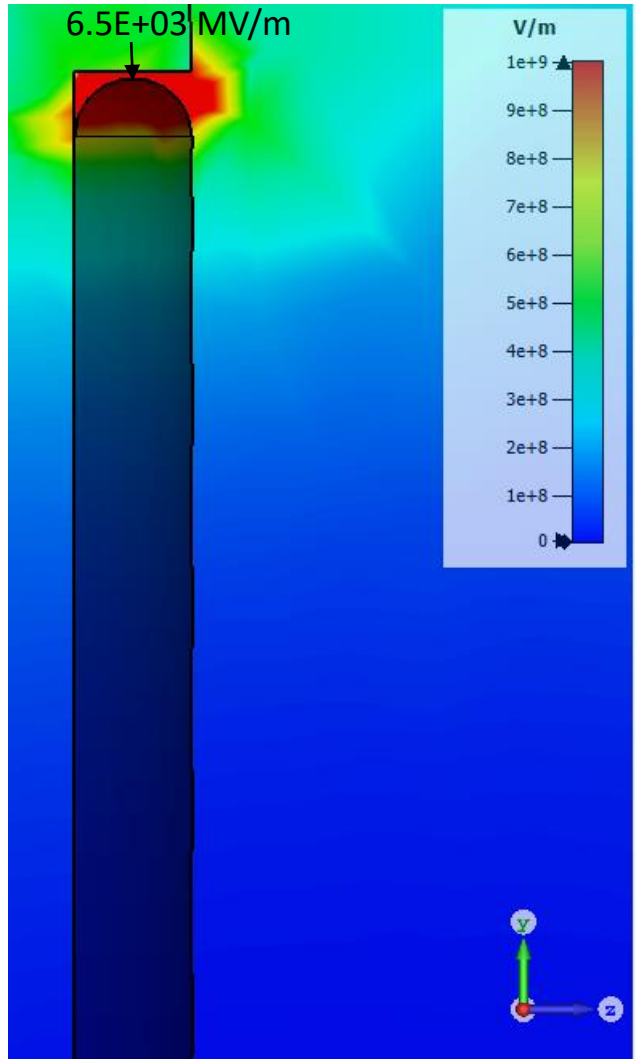


Potential



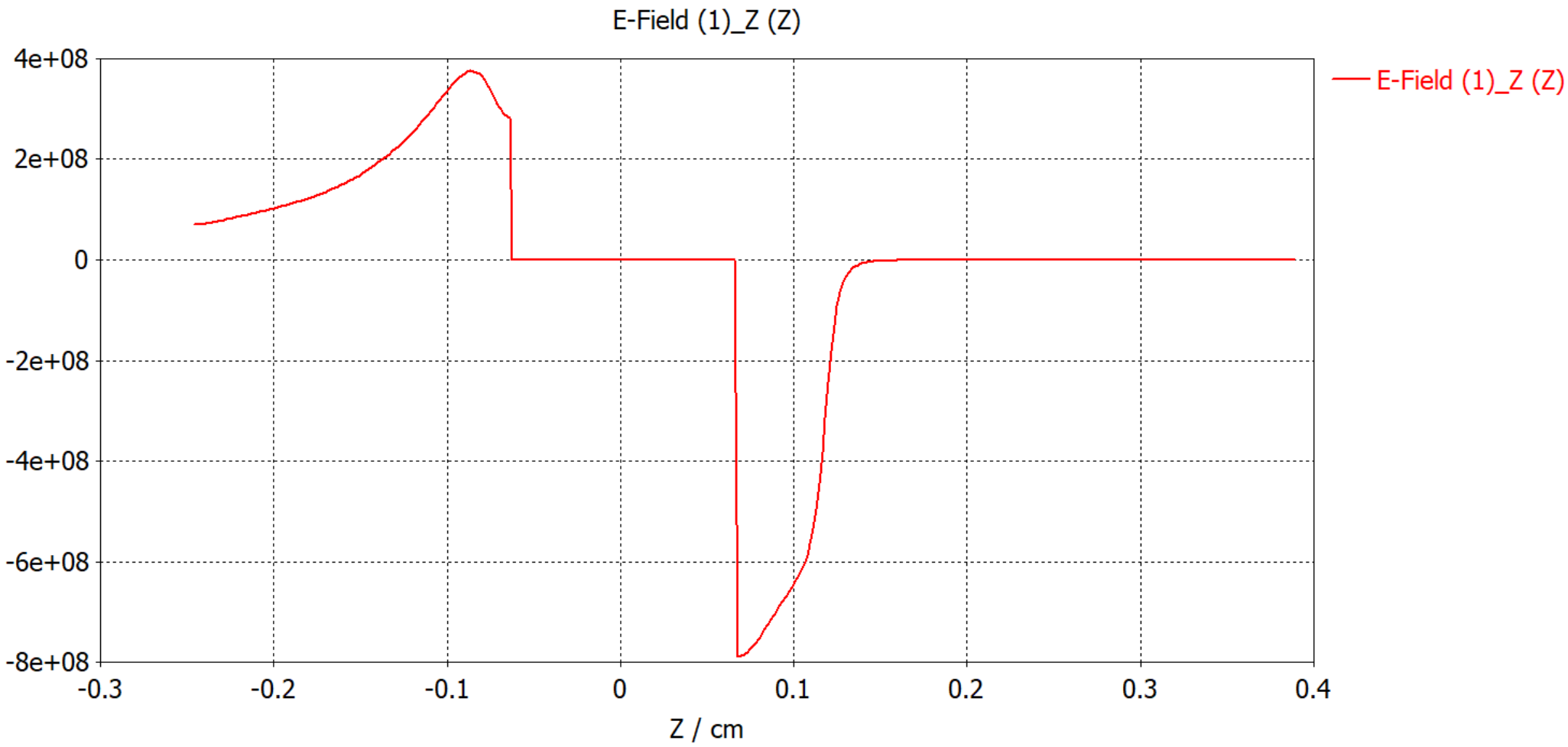
Flat cathode front and flat anode - cathode anode gap 5 cm - shed design 2





Flat cathode front and flat anode - cathode anode gap 5 cm - shed design 2

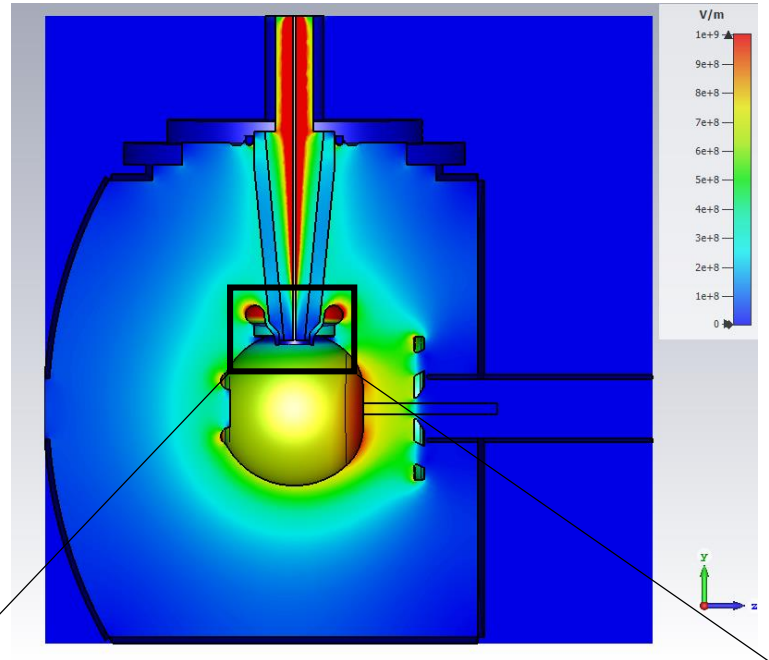
-350 kV at the cathode, 0 V at the anode

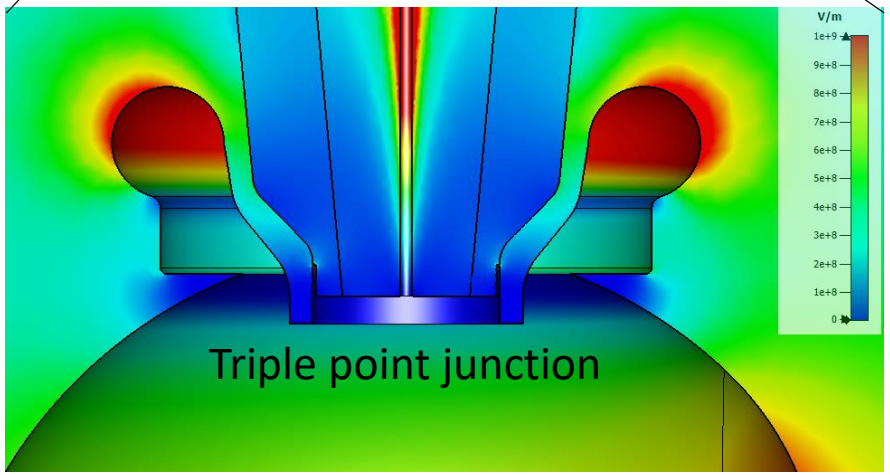


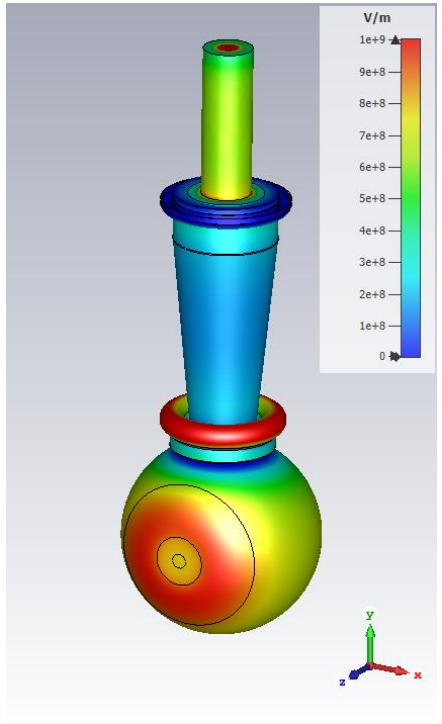
Flat cathode front and flat anode - cathode anode gap 5 cm - shed design 3

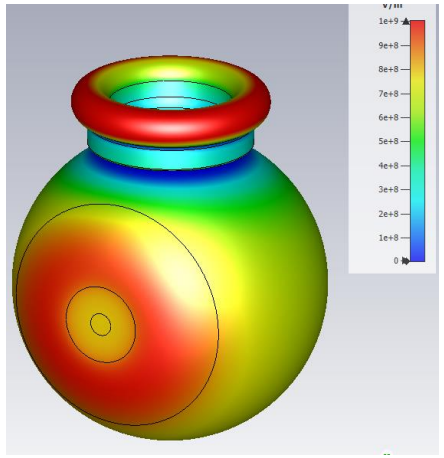
-350 kV at the cathode, 0 V at the anode

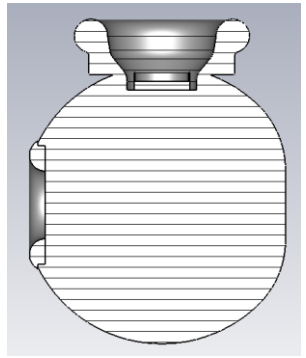
E field



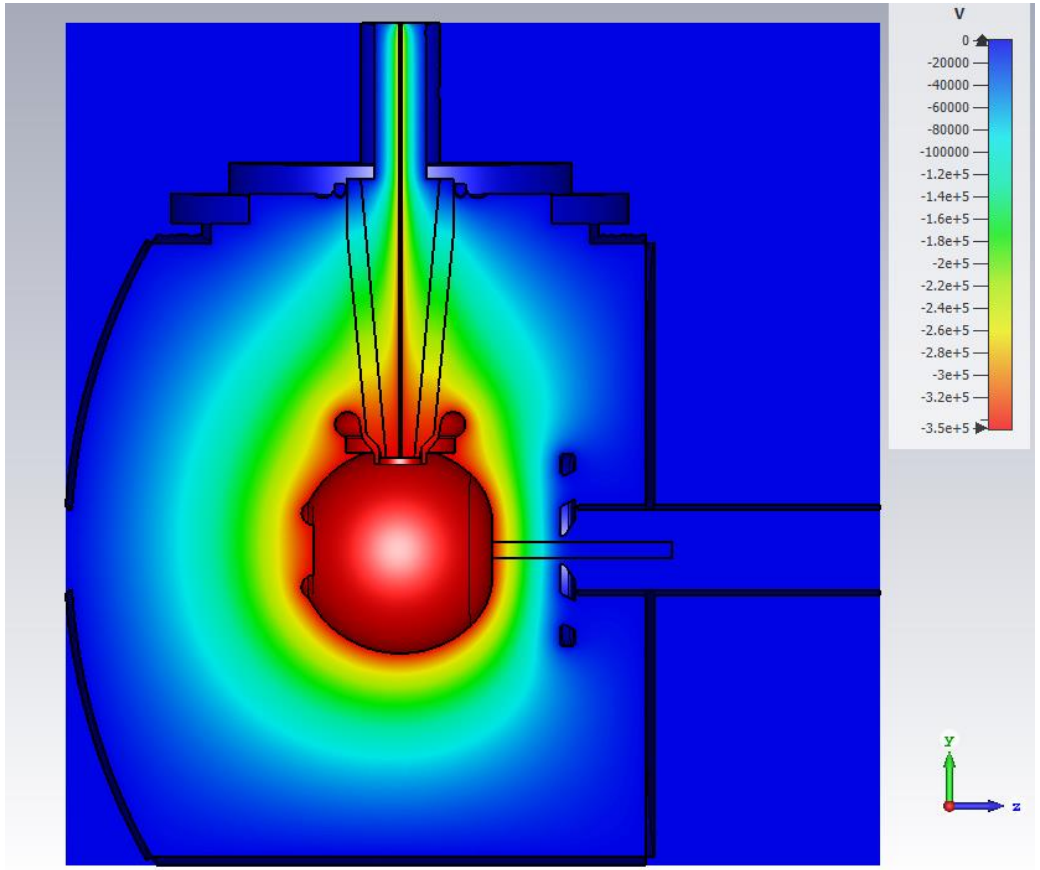




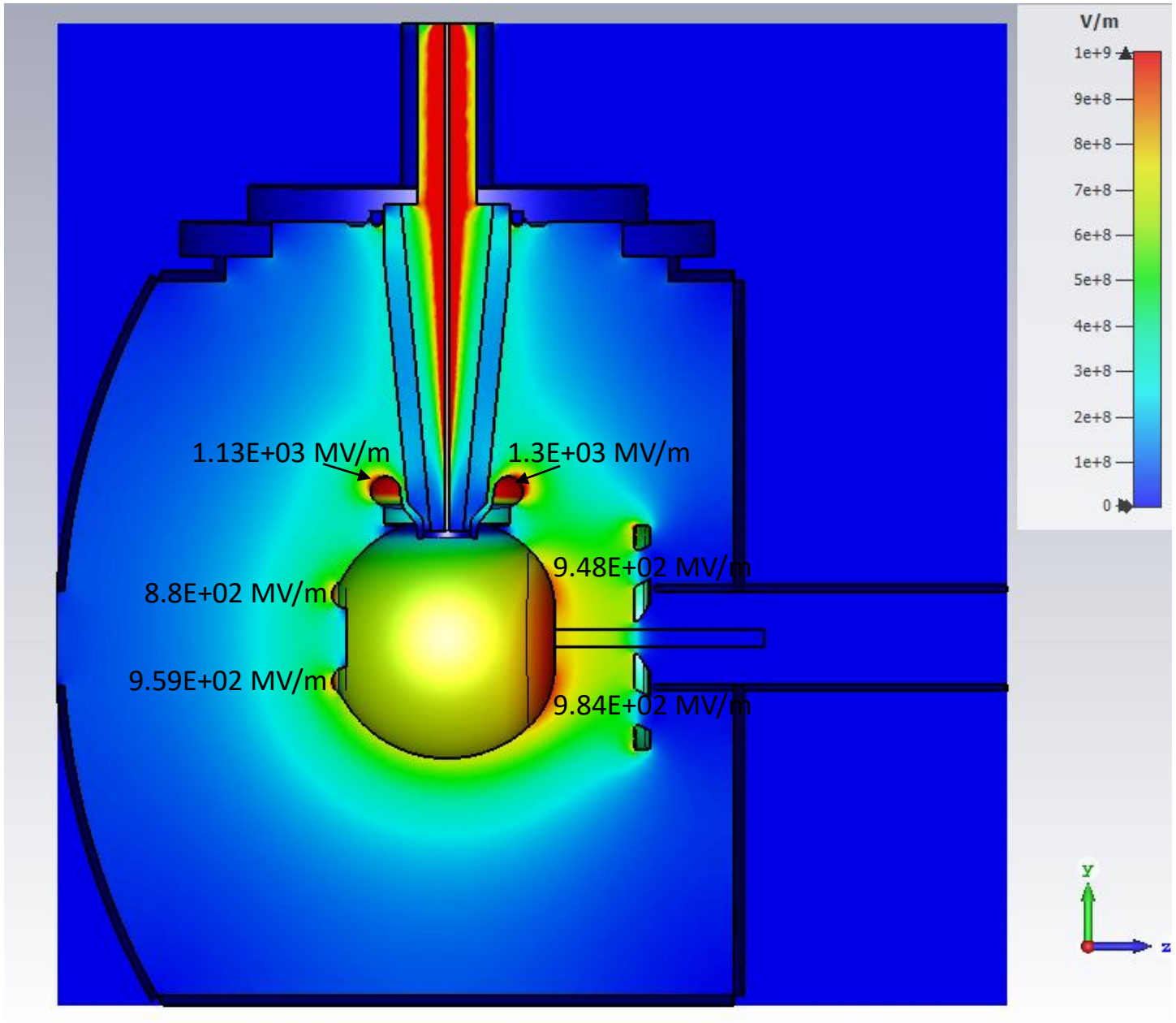


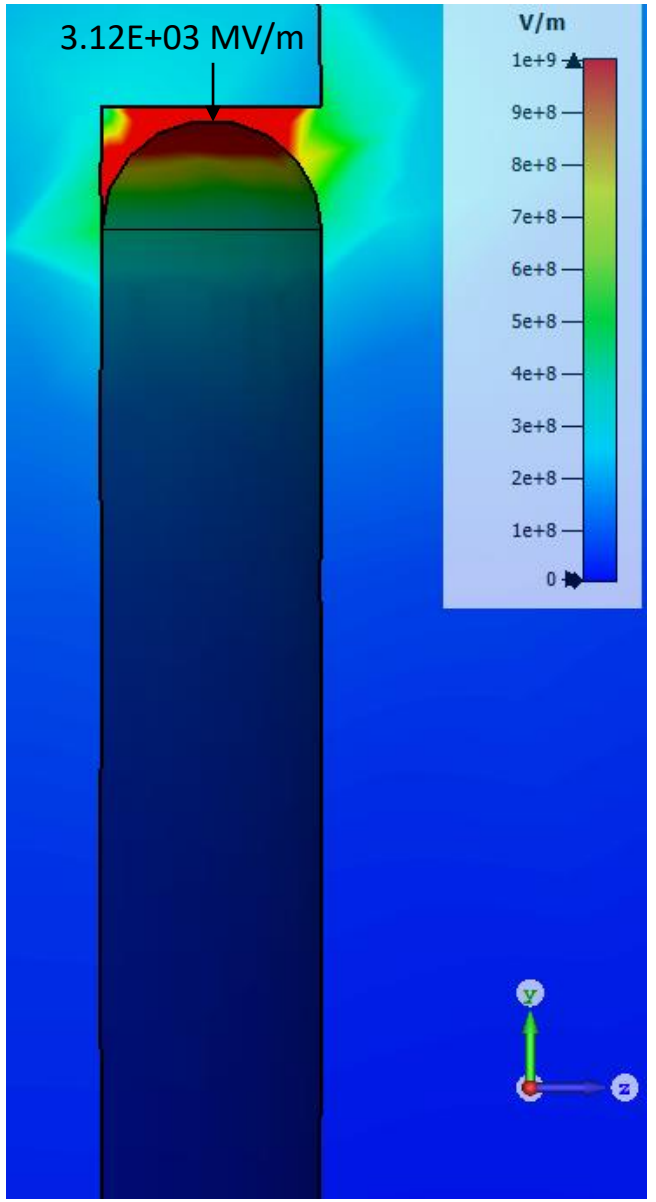


Potential



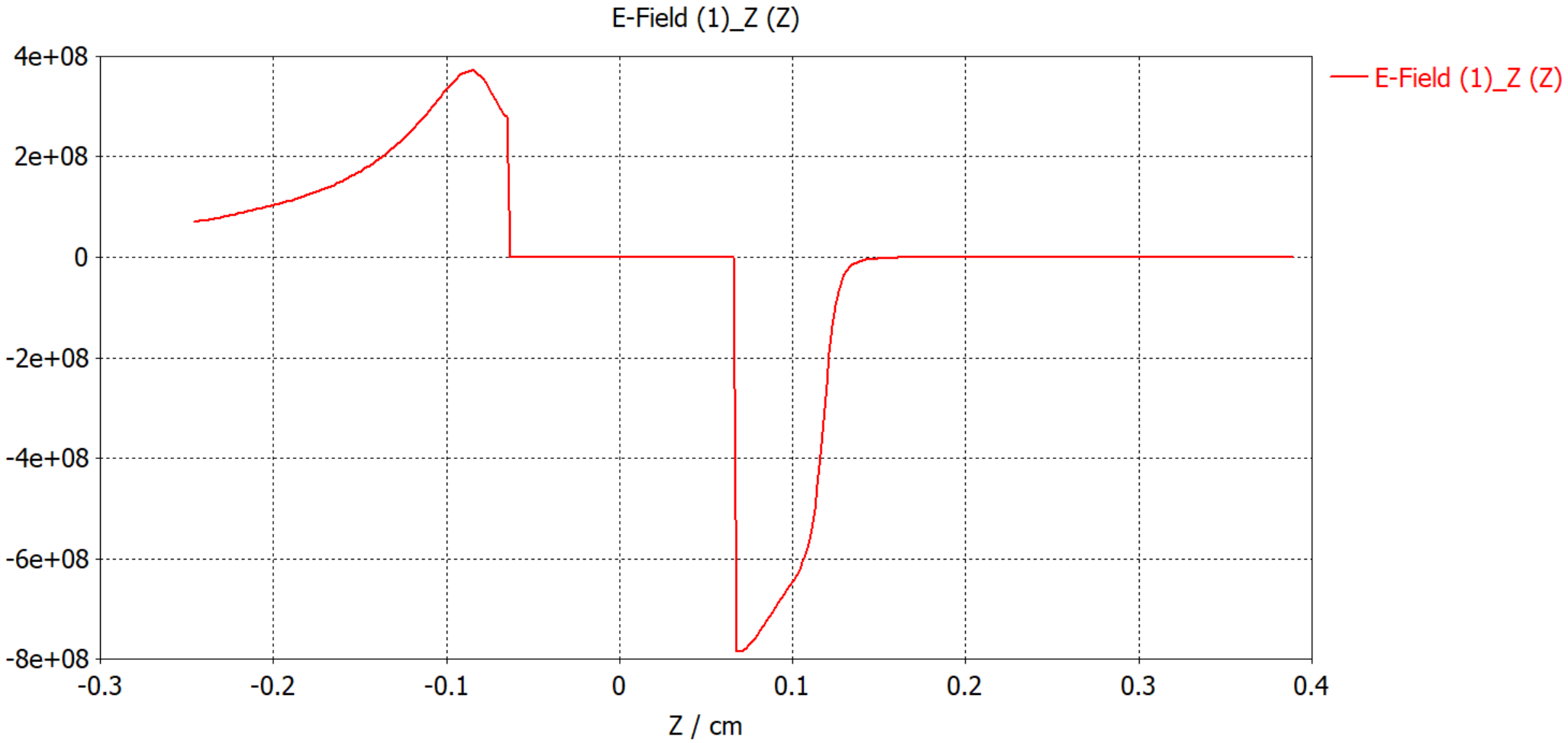
Flat cathode front and flat anode - cathode anode gap 5 cm - shed design 3





Flat cathode front and flat anode - cathode anode gap 5 cm - shed design 3

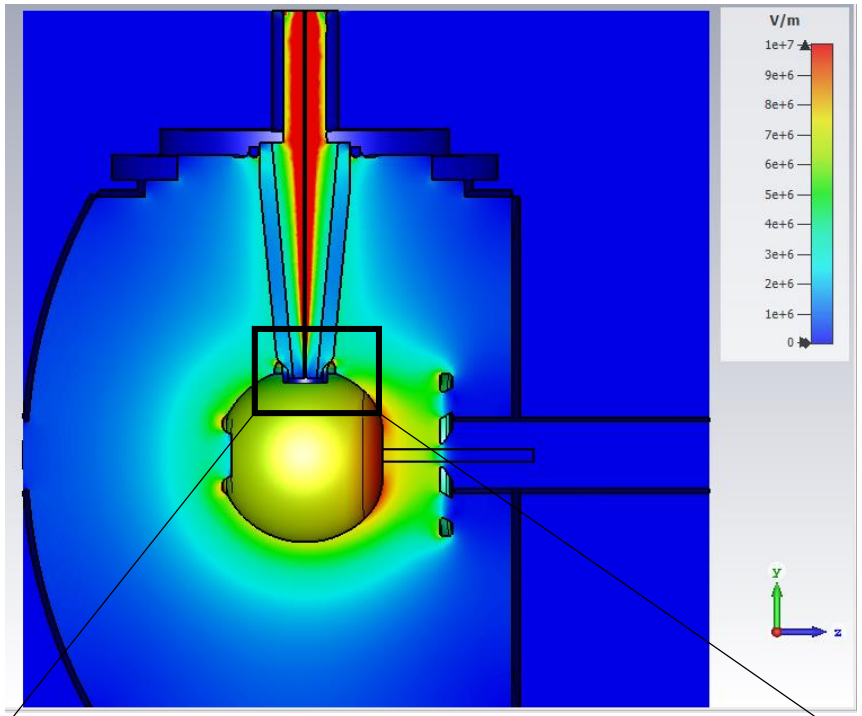
-350 kV at the cathode, 0 V at the anode

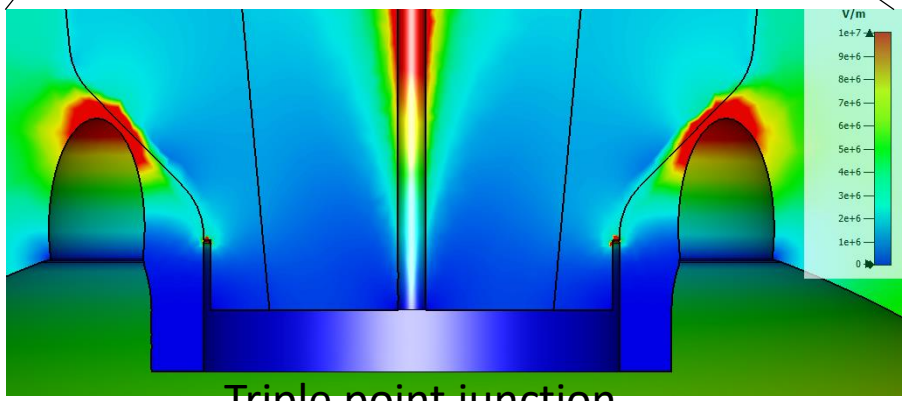


Flat cathode front and flat anode - cathode anode gap 5 cm - shed design 4

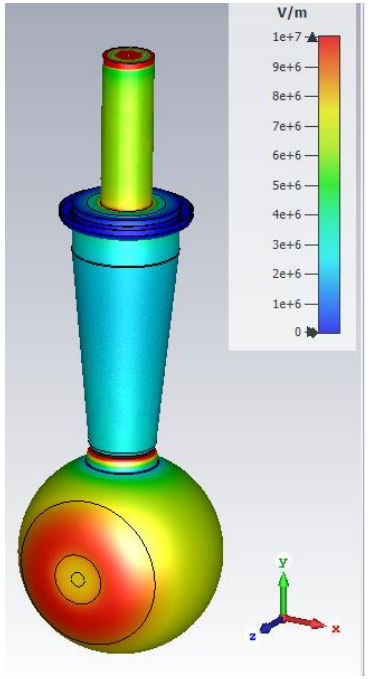
-350 kV at the cathode, 0 V at the anode

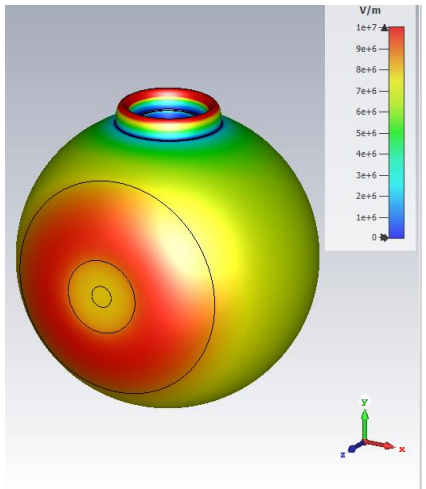
E field

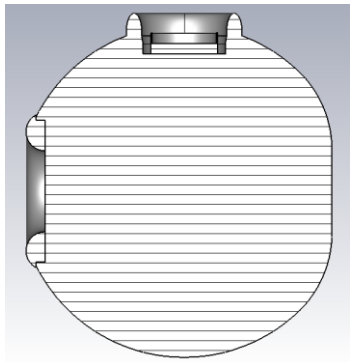




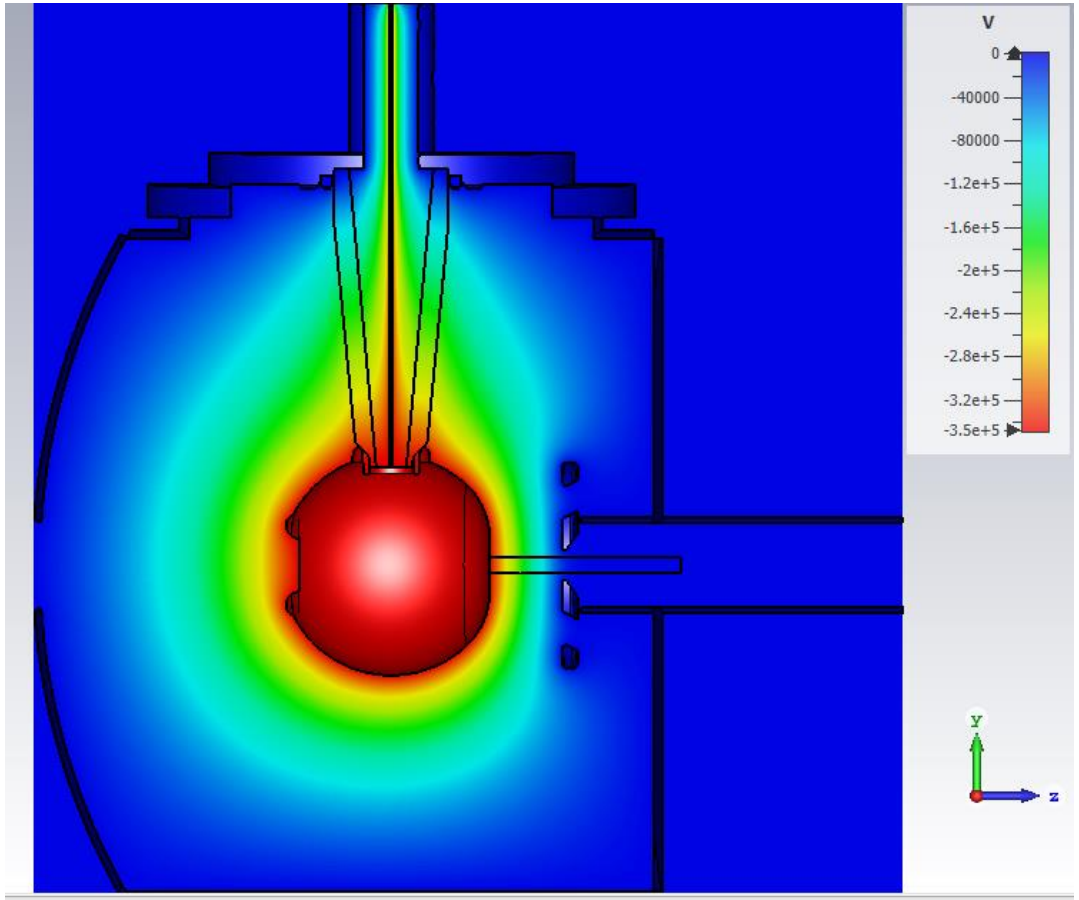
Triple point junction



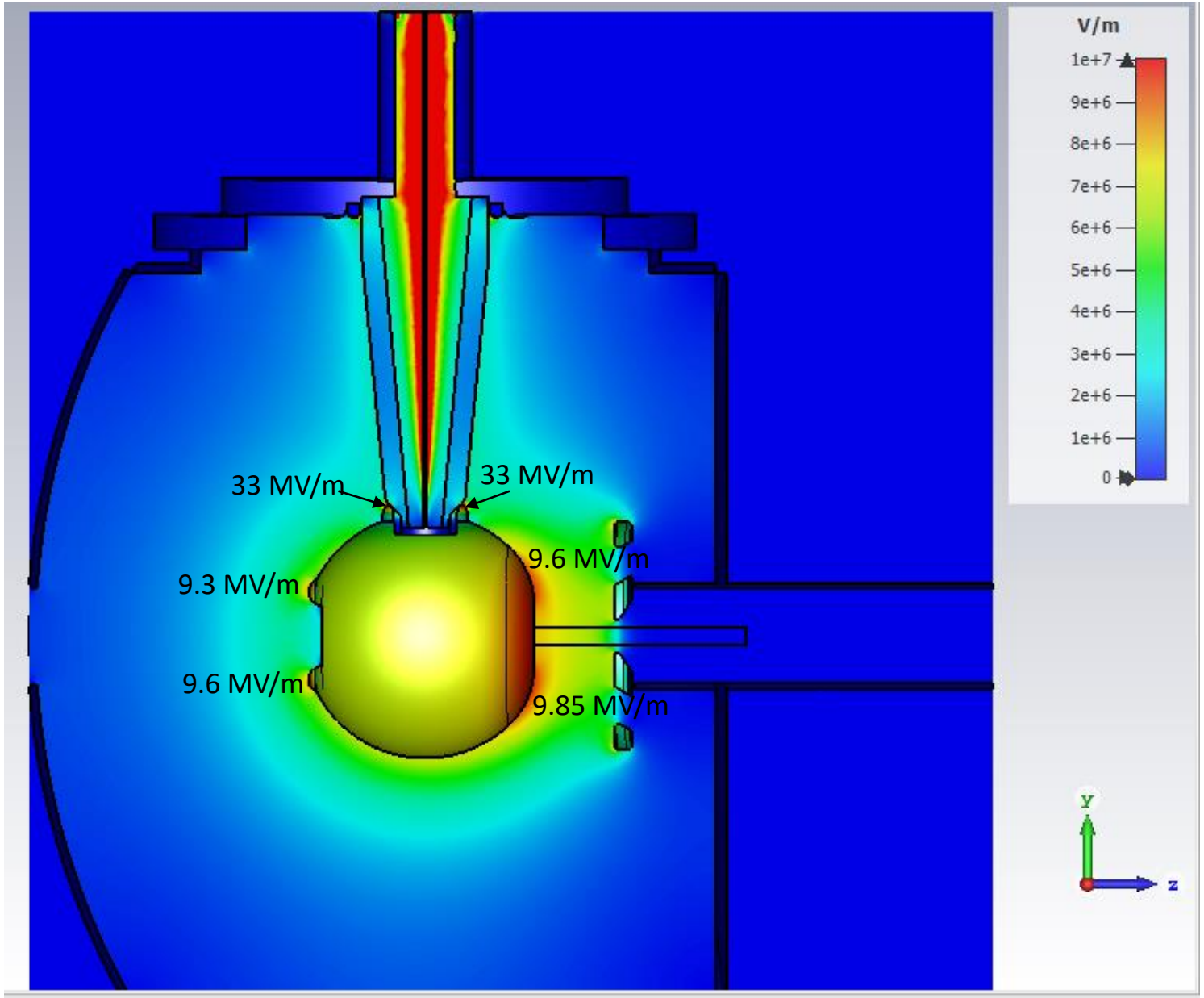


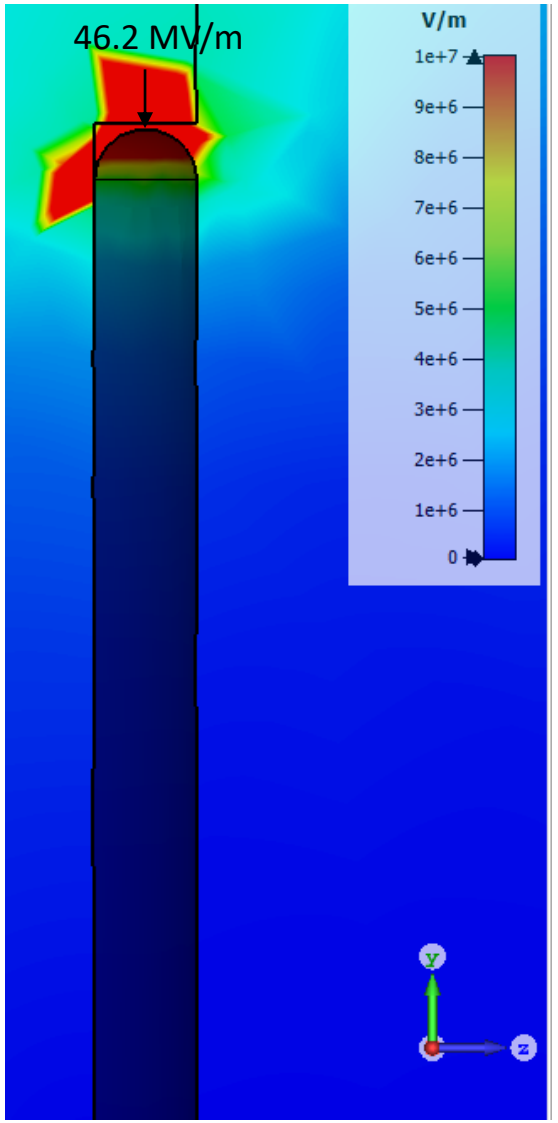


Potential



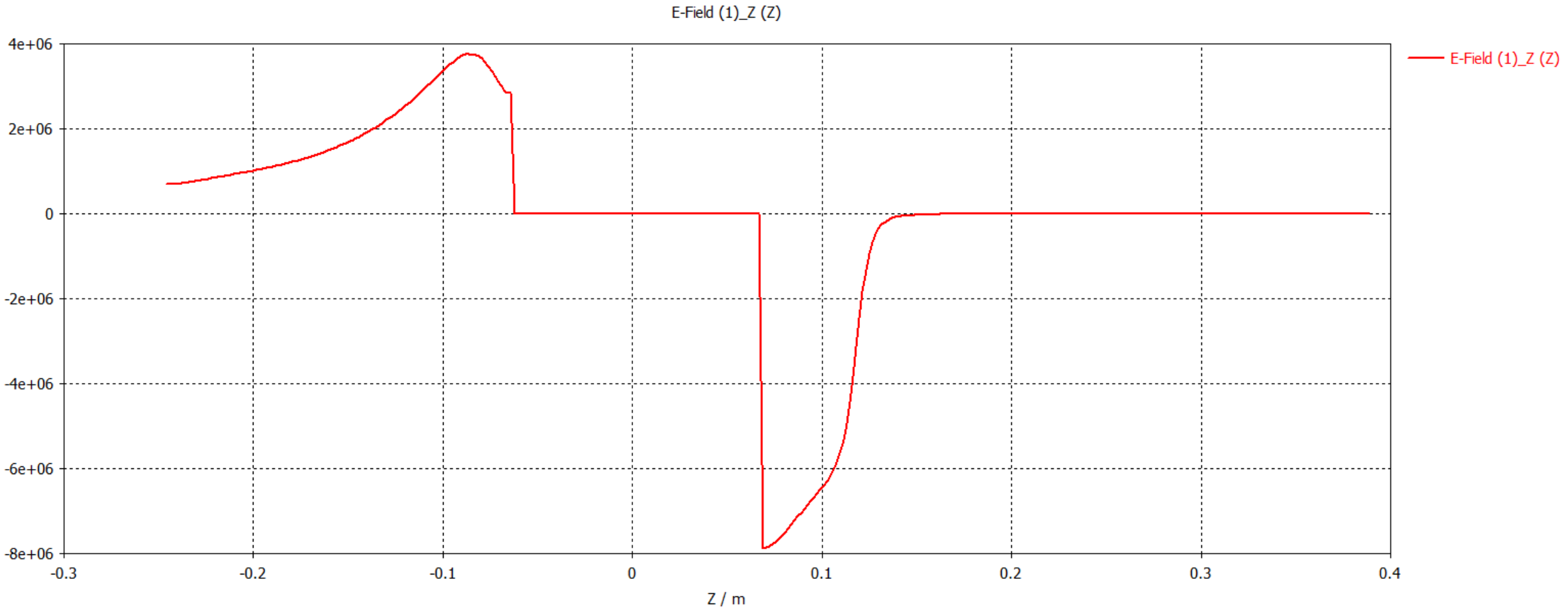
Flat cathode front and flat anode - cathode anode gap 5 cm - shed design 4





Flat cathode front and flat anode - cathode anode gap 5 cm - shed design 4

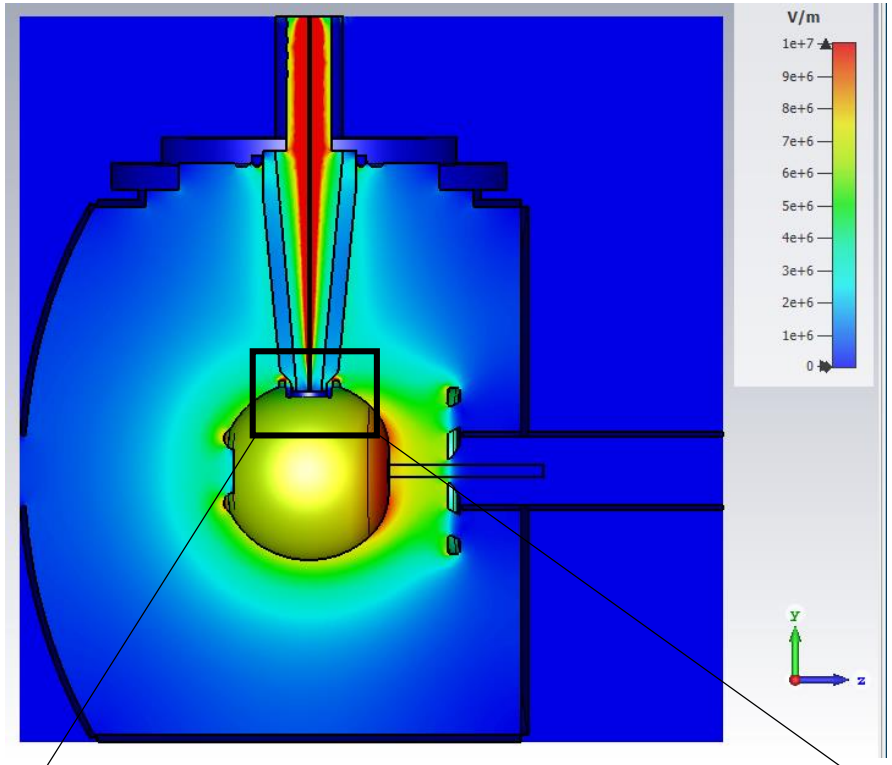
-350 kV at the cathode, 0 V at the anode

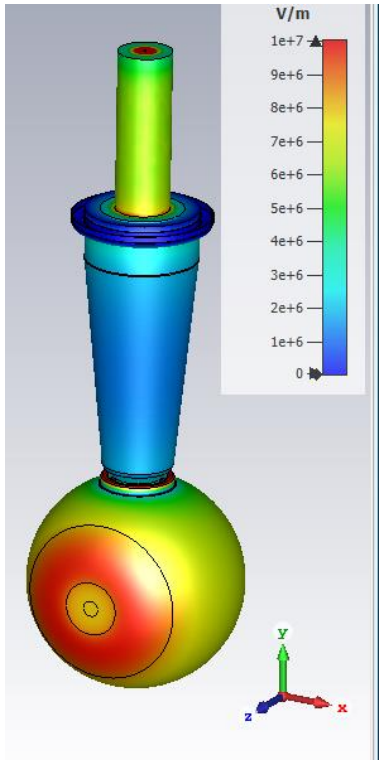


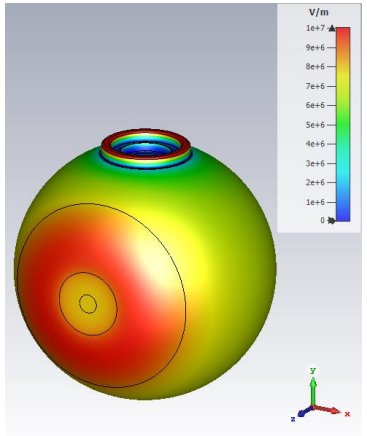
Flat cathode front and flat anode - cathode anode gap 5 cm - shed design 5

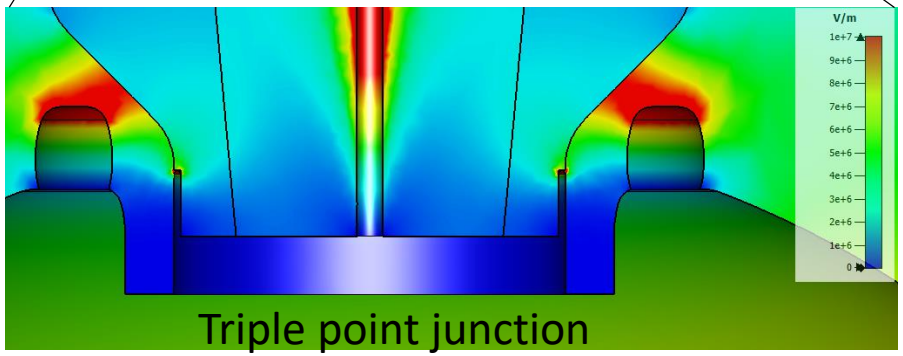
-350 kV at the cathode, 0 V at the anode

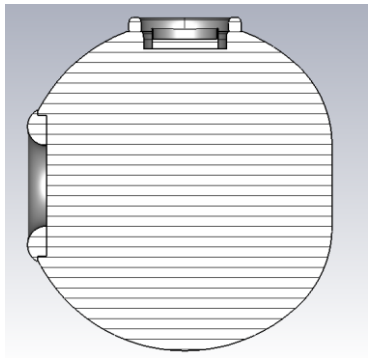
E field



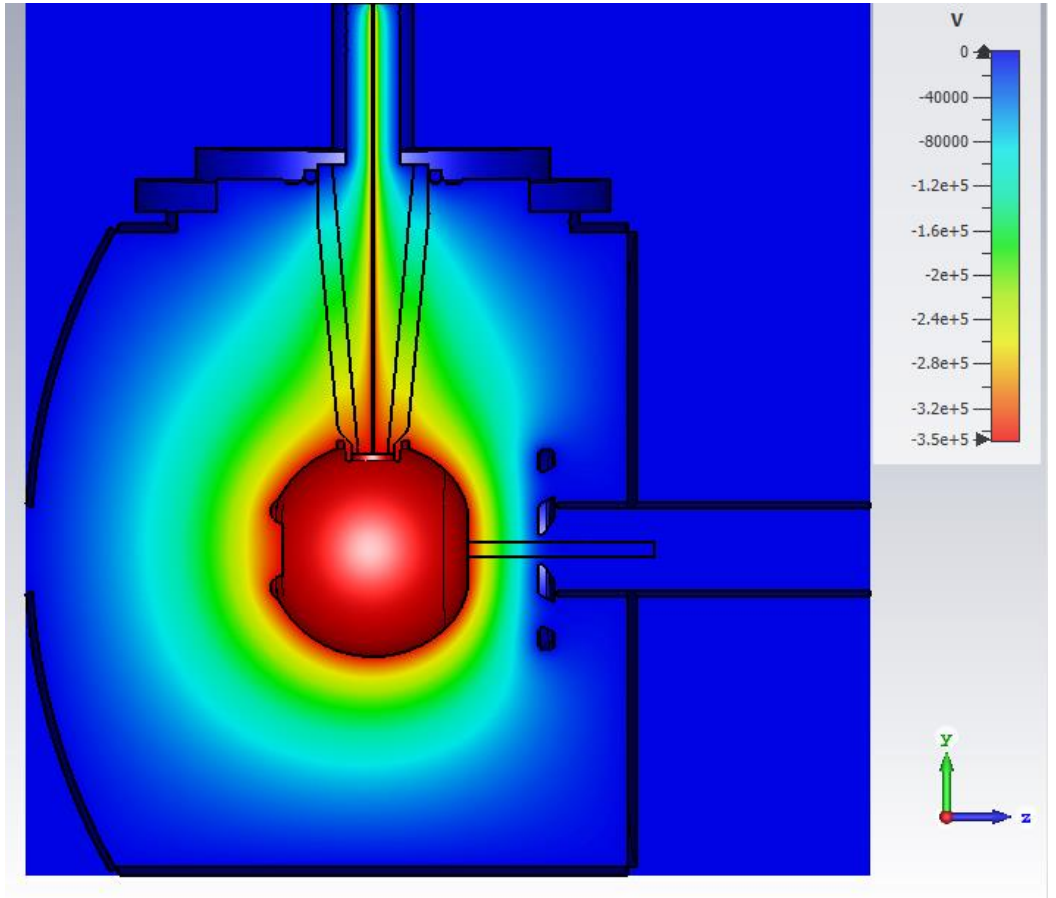




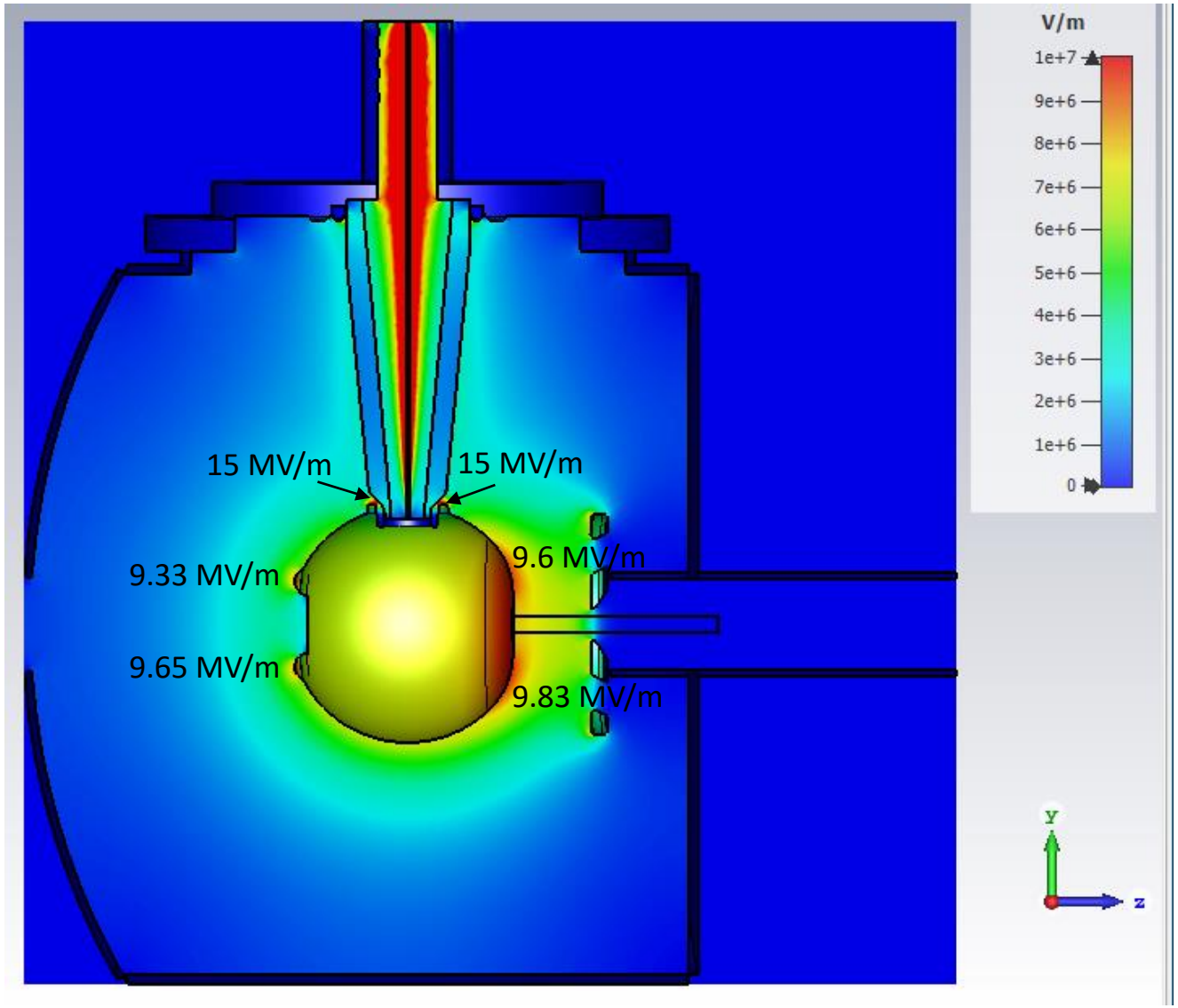


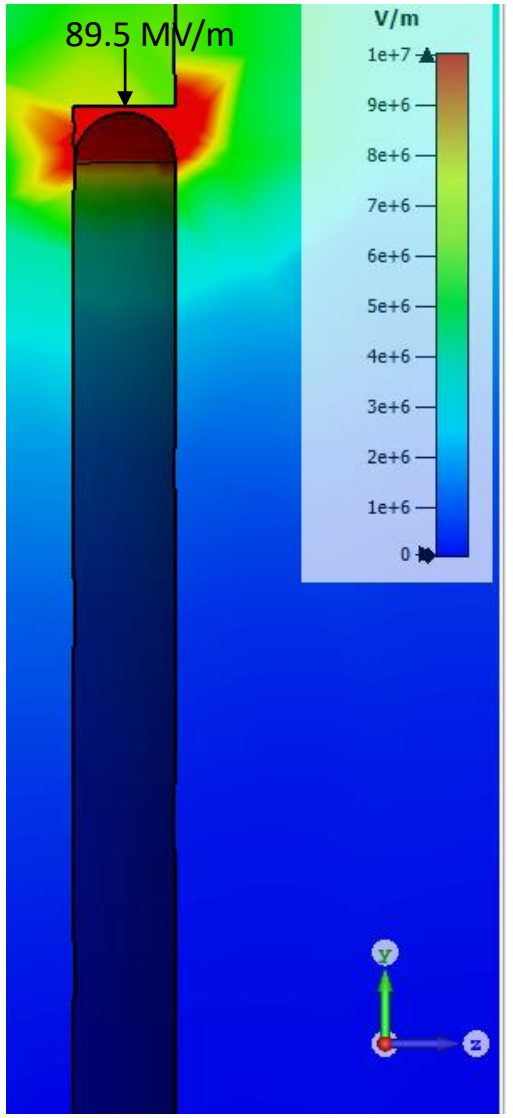


Potential



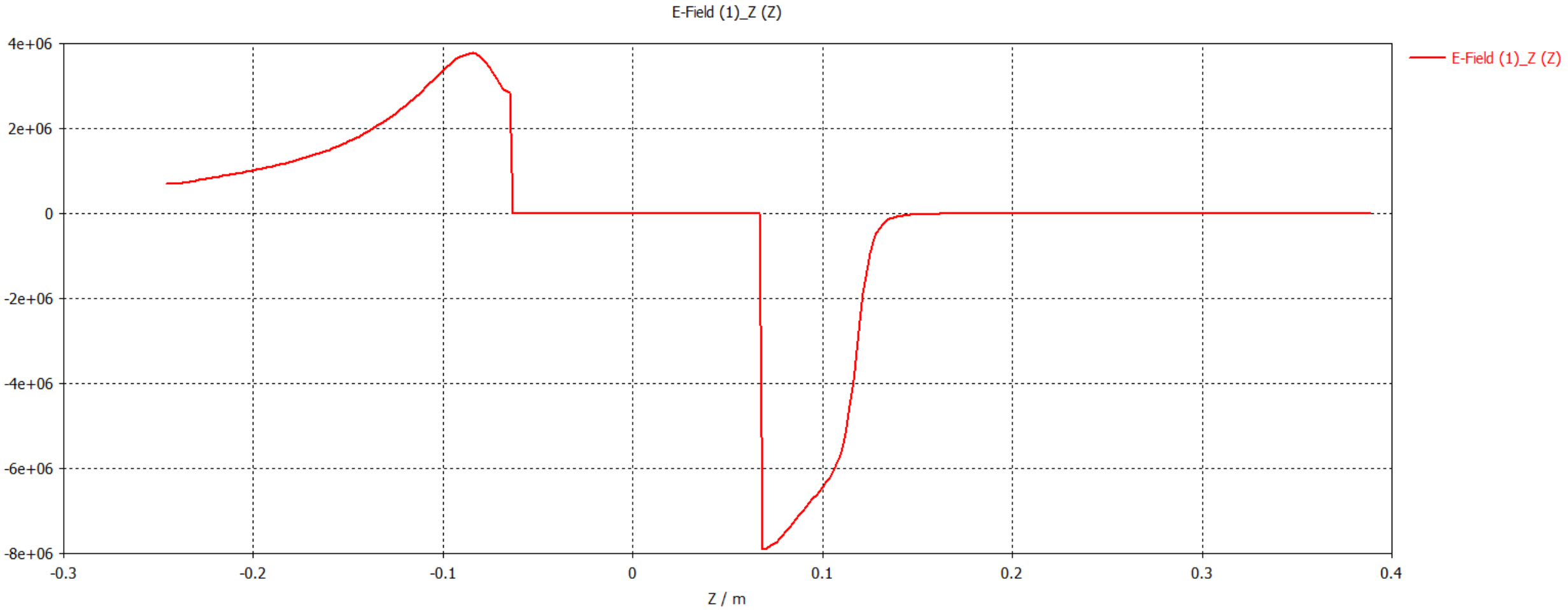
Flat cathode front and flat anode - cathode anode gap 5 cm - shed design 5





Flat cathode front and flat anode - cathode anode gap 5 cm - shed design 5

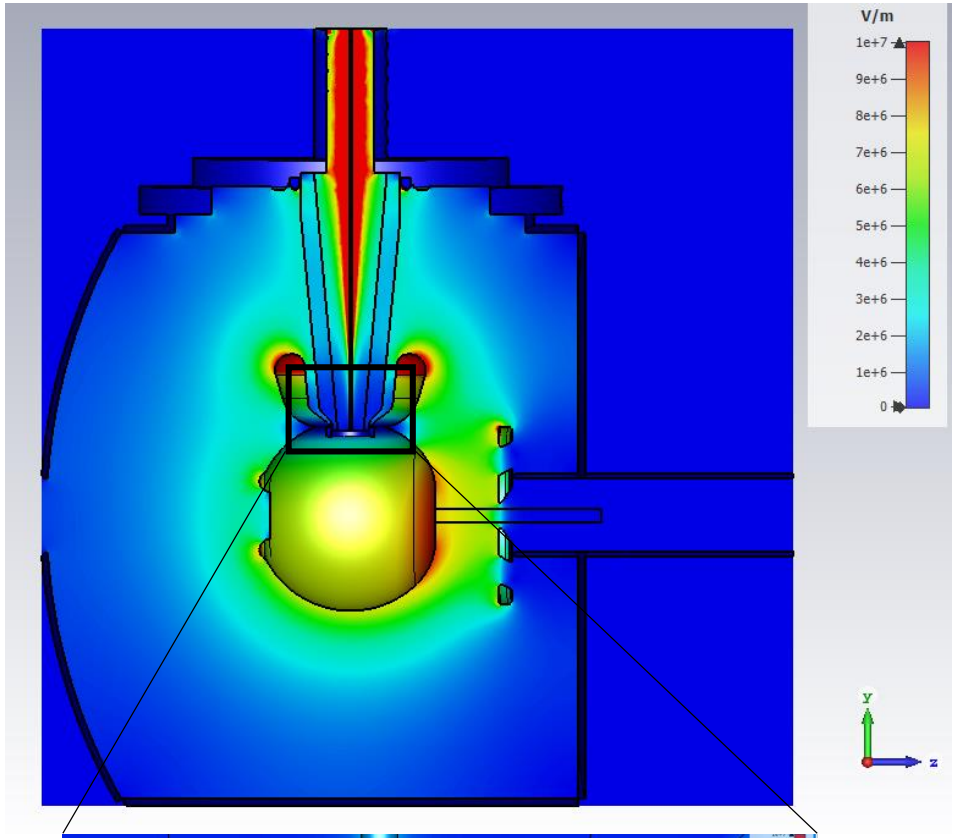
-350 kV at the cathode, 0 V at the anode

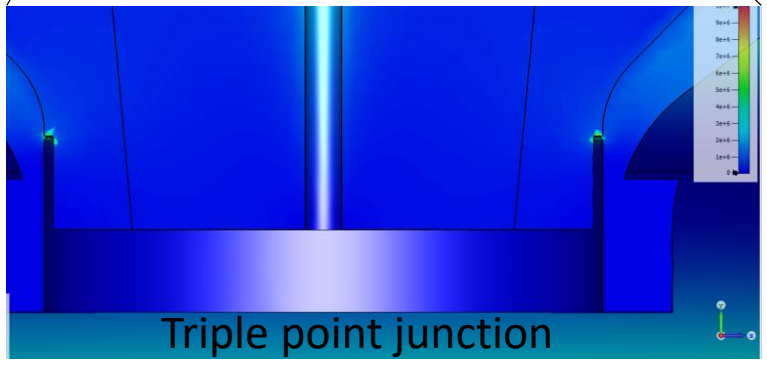


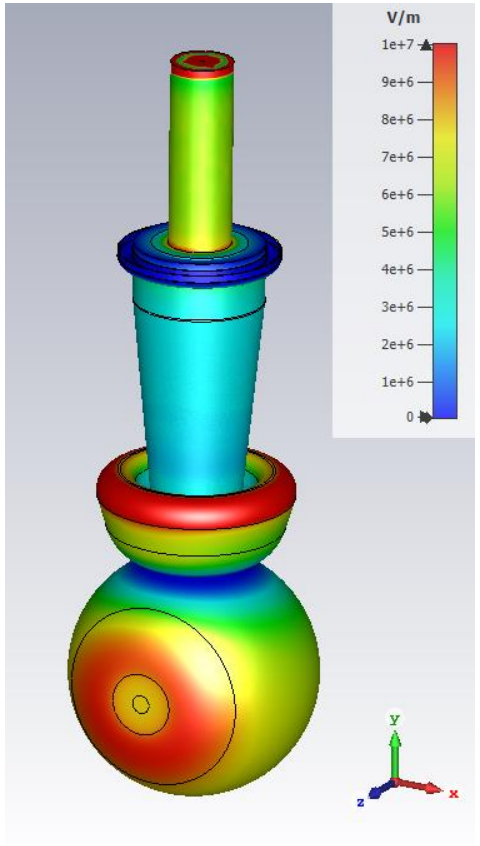
Flat cathode front and flat anode - cathode anode gap 5 cm - shed design 6

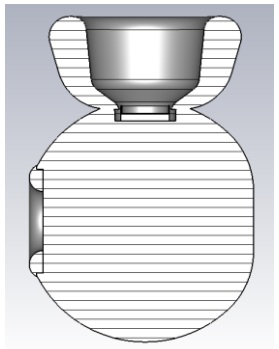
-350 kV at the cathode, 0 V at the anode

E field

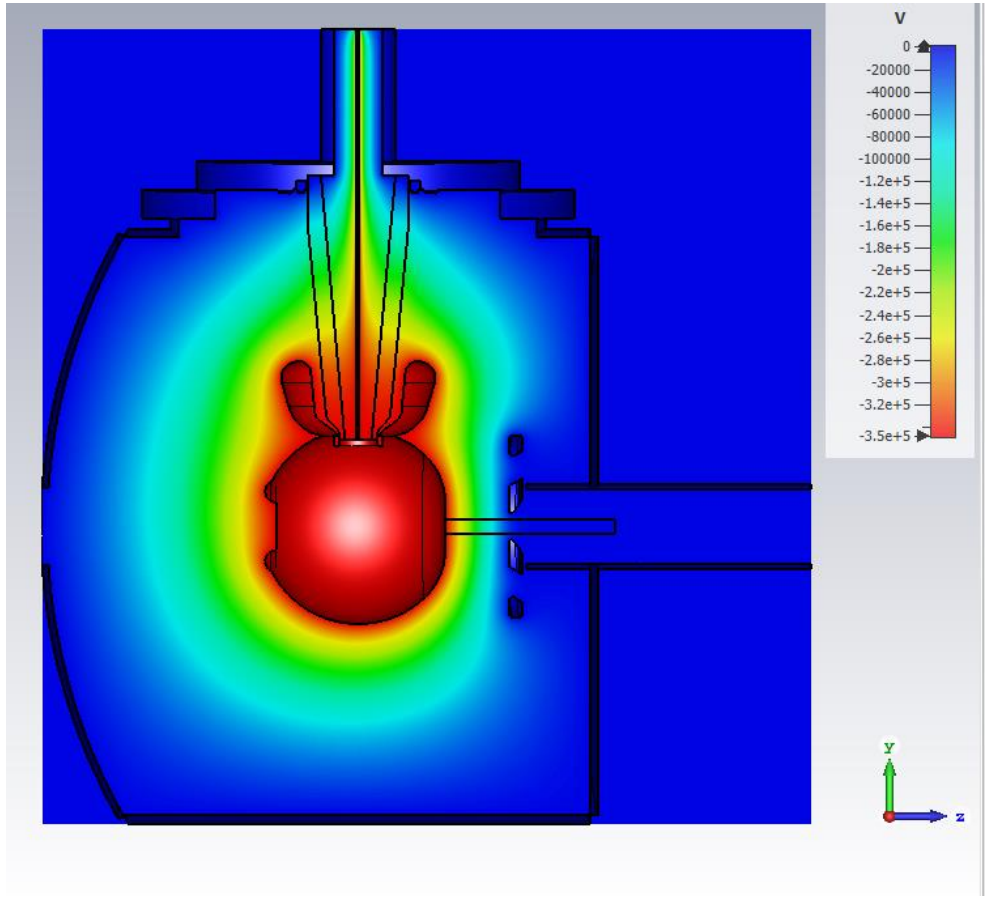




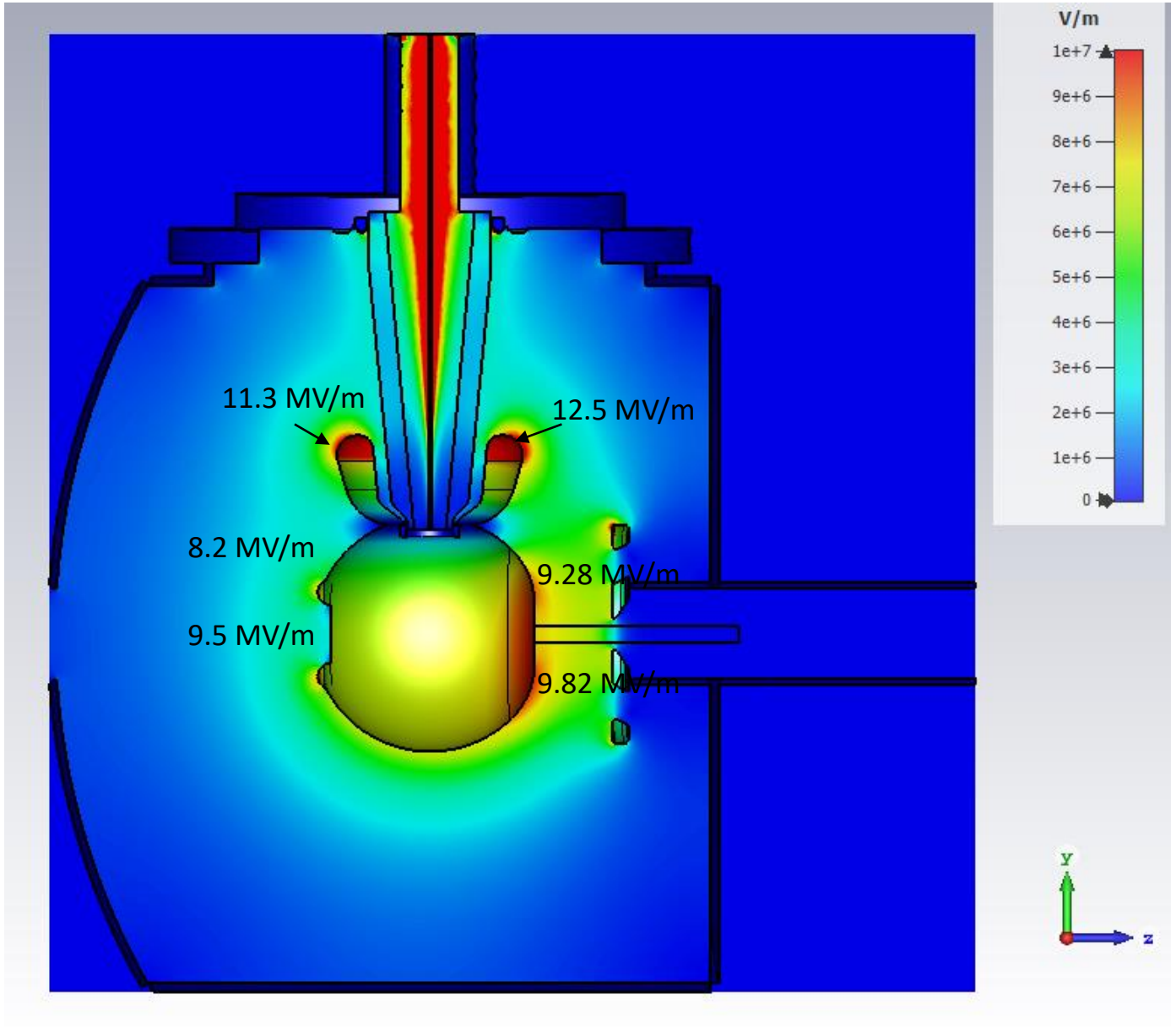


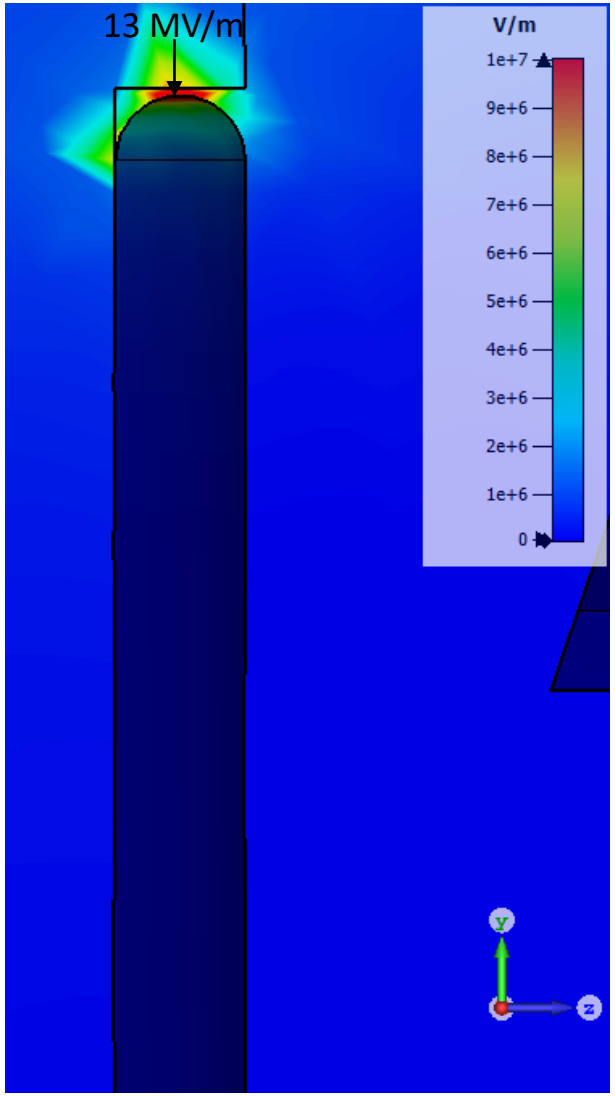


Potential



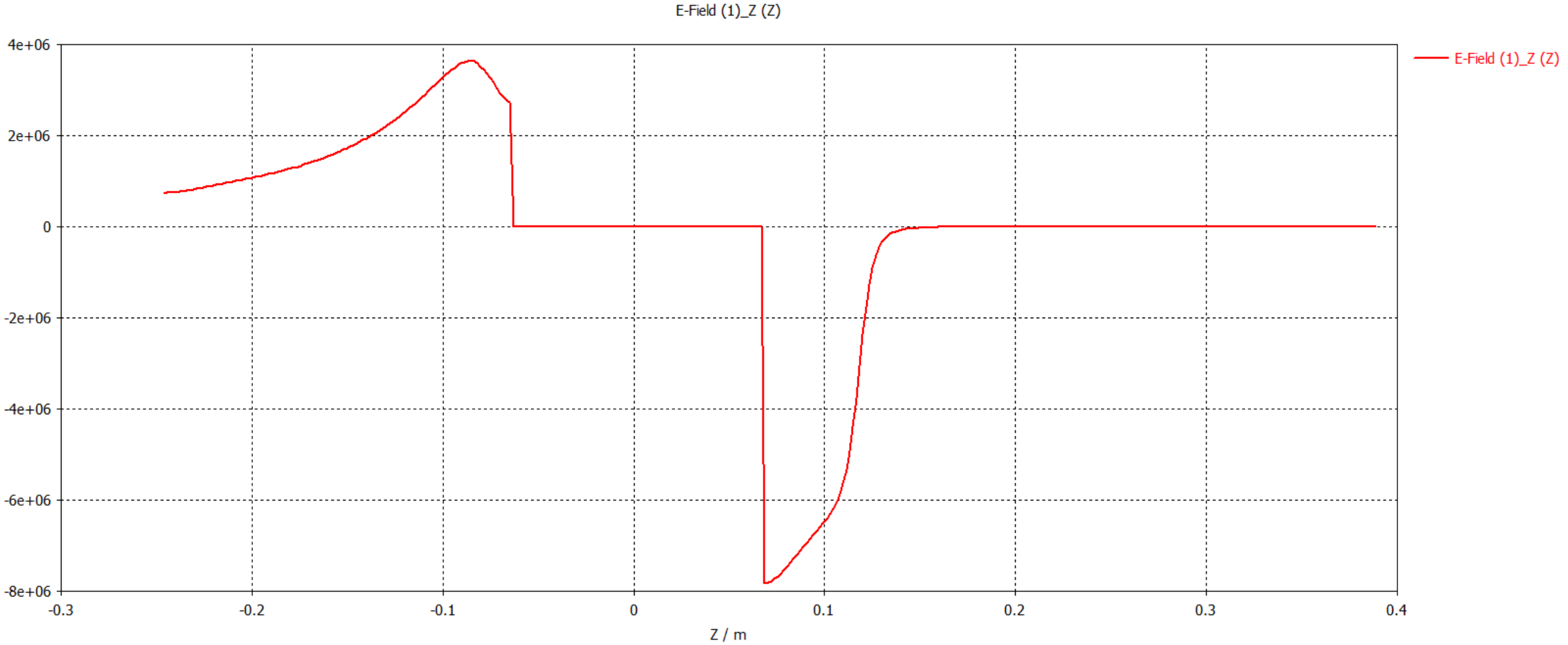
Flat cathode front and flat anode - cathode anode gap 5 cm - shed design 6





Flat cathode front and flat anode - cathode anode gap 5 cm - shed design 6

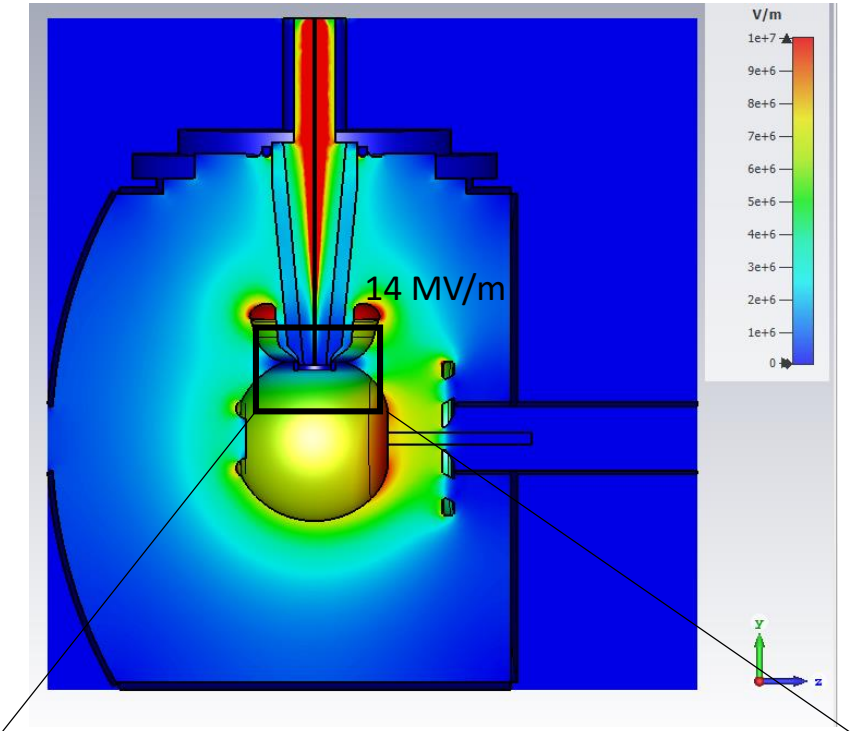
-350 kV at the cathode, 0 V at the anode

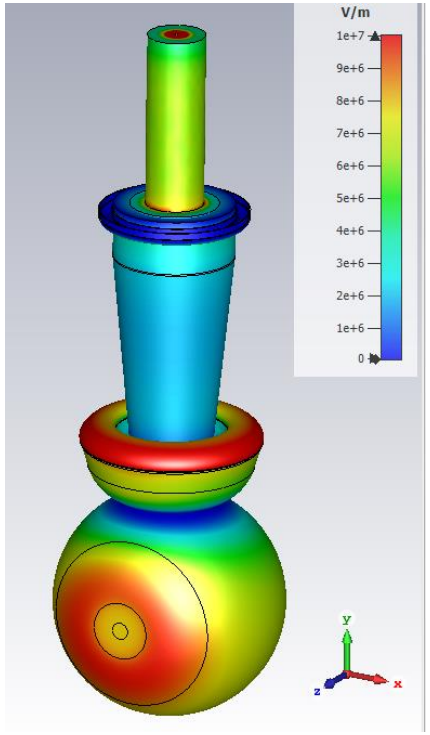


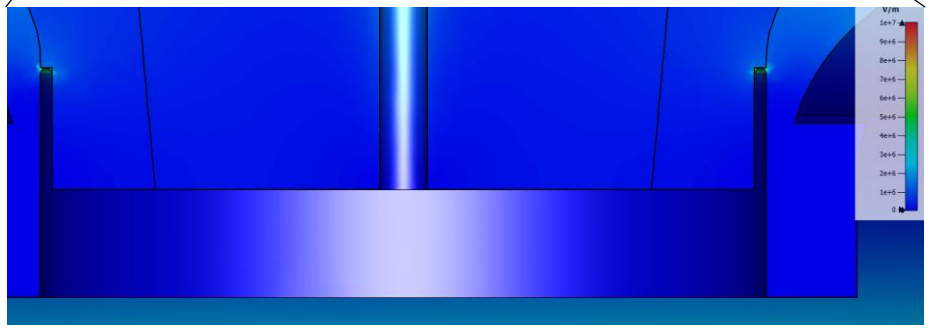
Flat cathode front and flat anode - cathode anode gap 5 cm - shed design 7

-350 kV at the cathode, 0 V at the anode

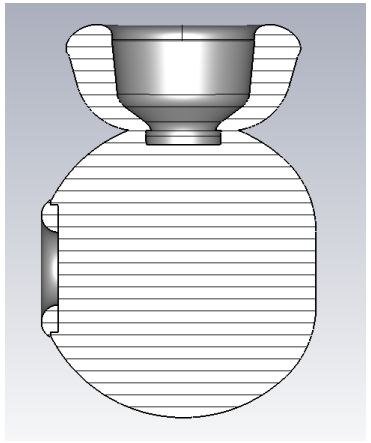
E field



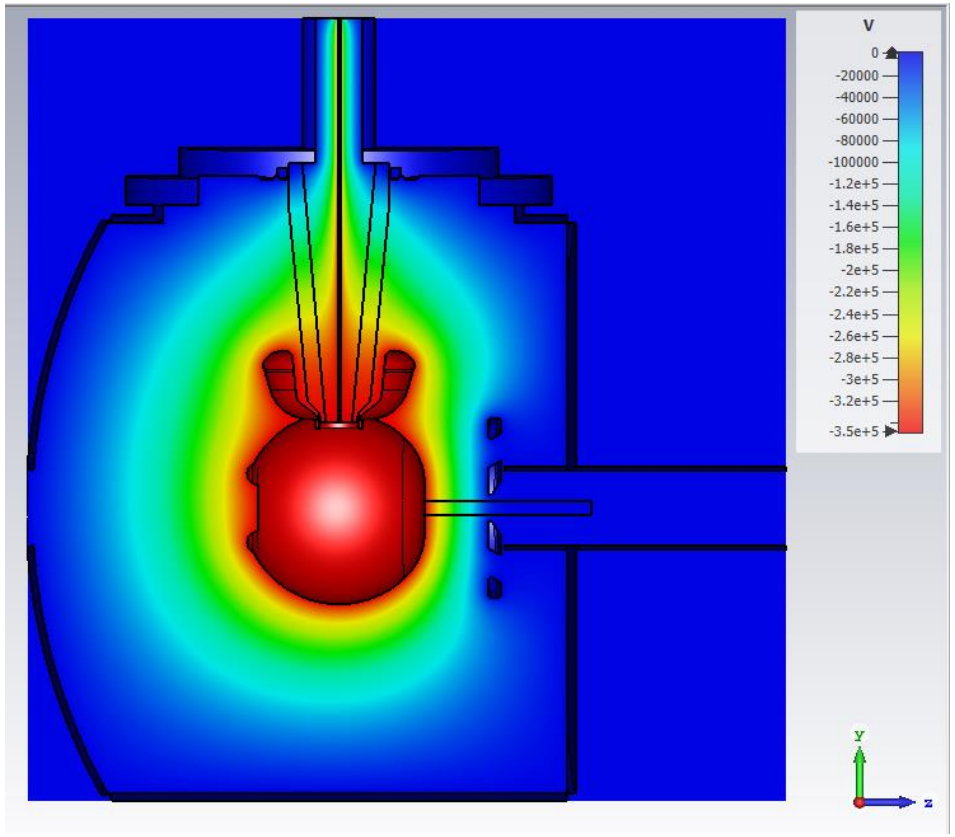




Triple point junction

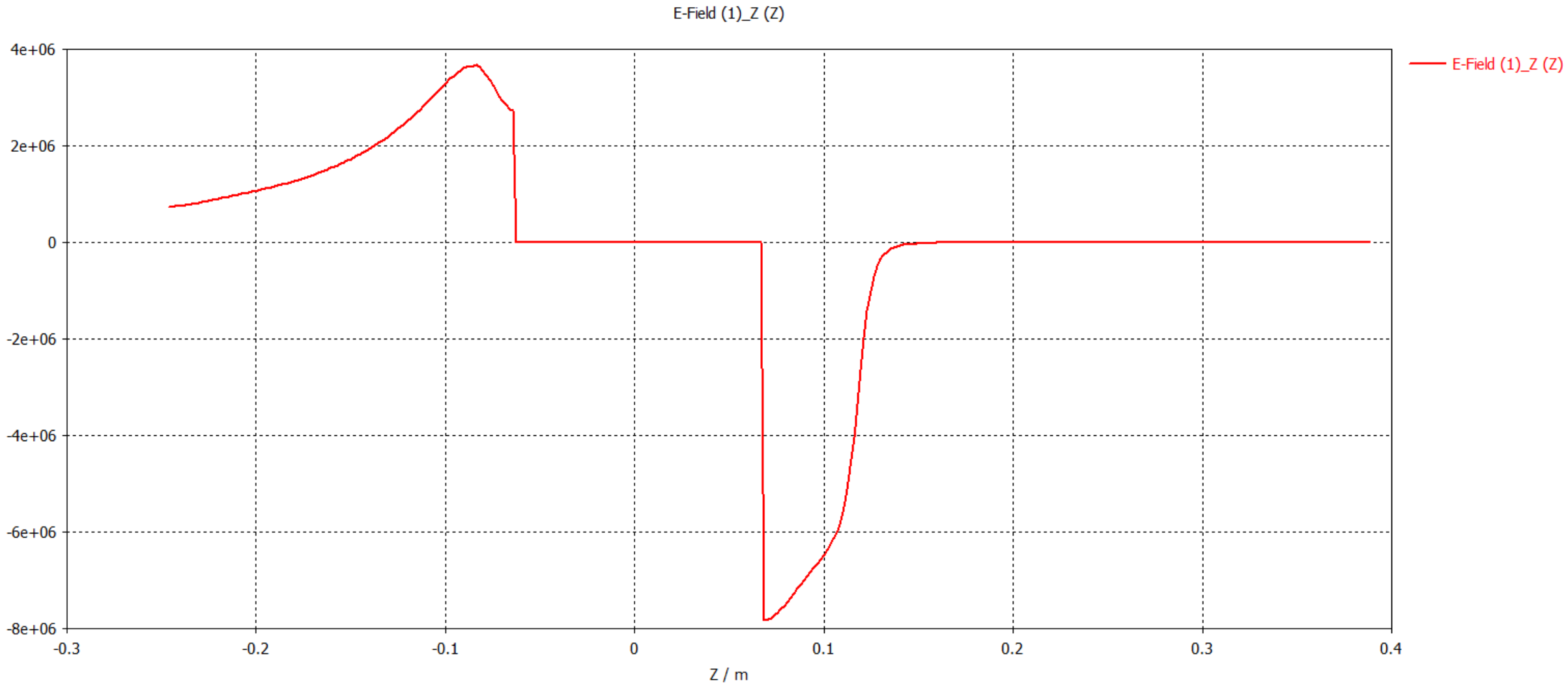


Potential



Flat cathode front and flat anode - cathode anode gap 5 cm - shed design 7

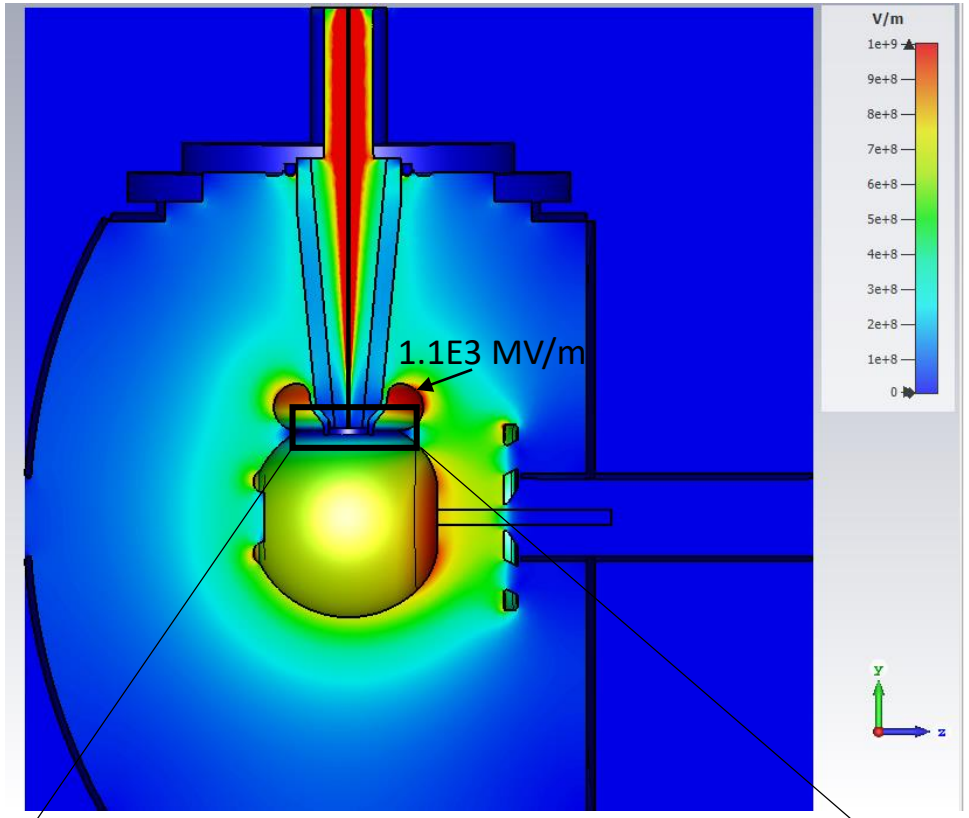
-350 kV at the cathode, 0 V at the anode

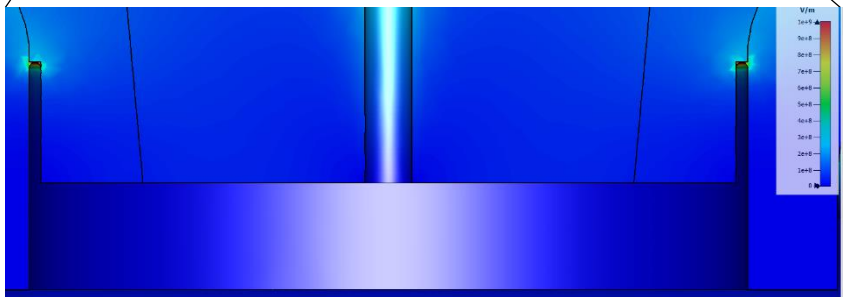


Flat cathode front and flat anode - cathode anode gap 5 cm - shed design 8

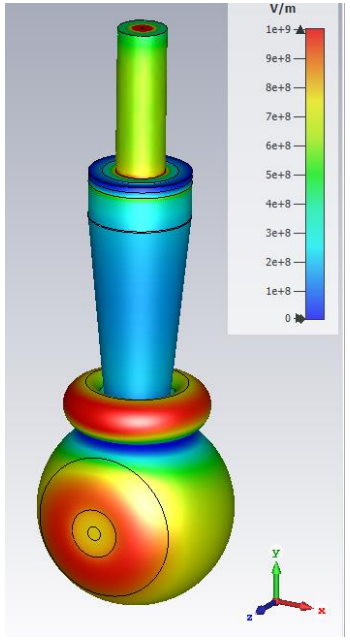
-350 kV at the cathode, 0 V at the anode

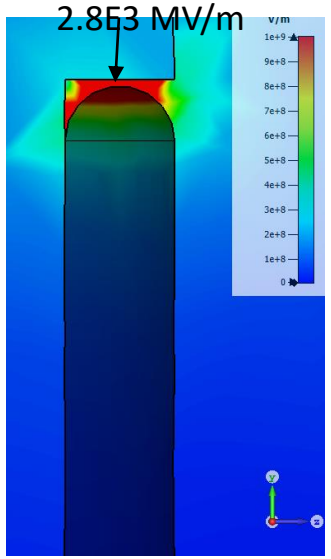
E field



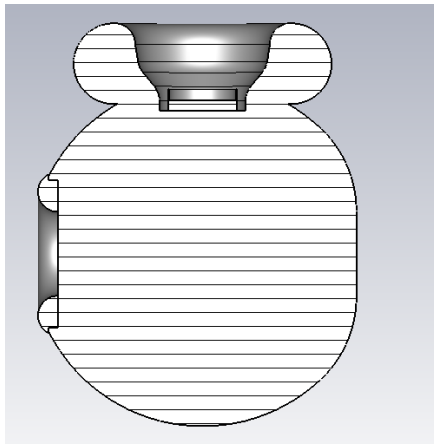


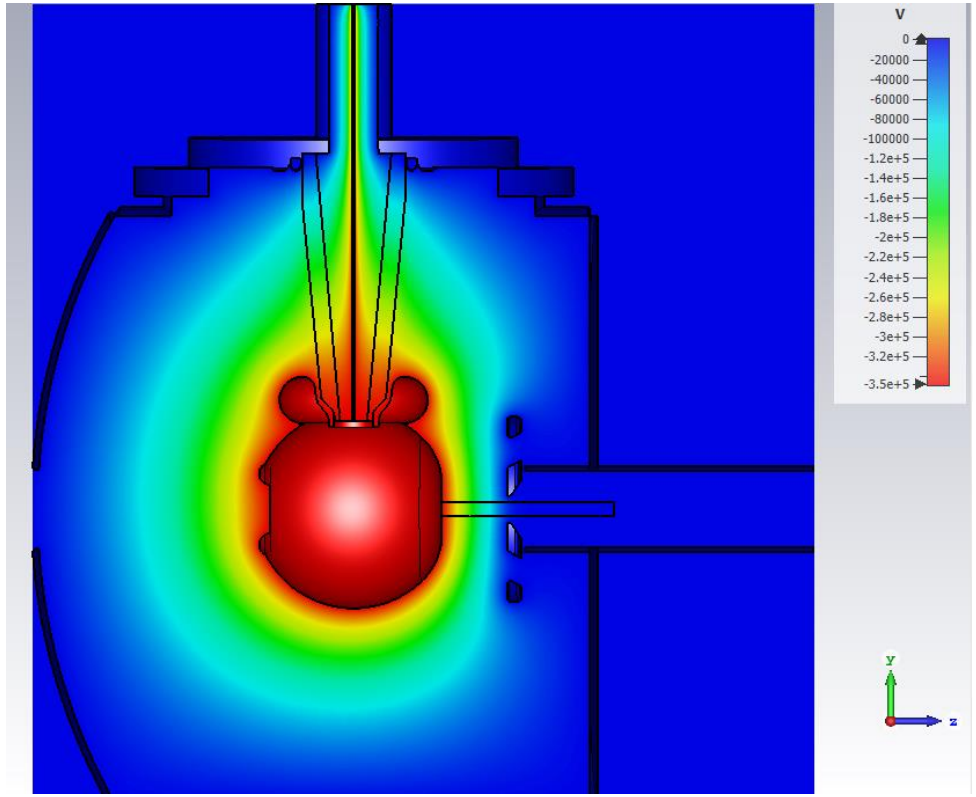
Triple point junction





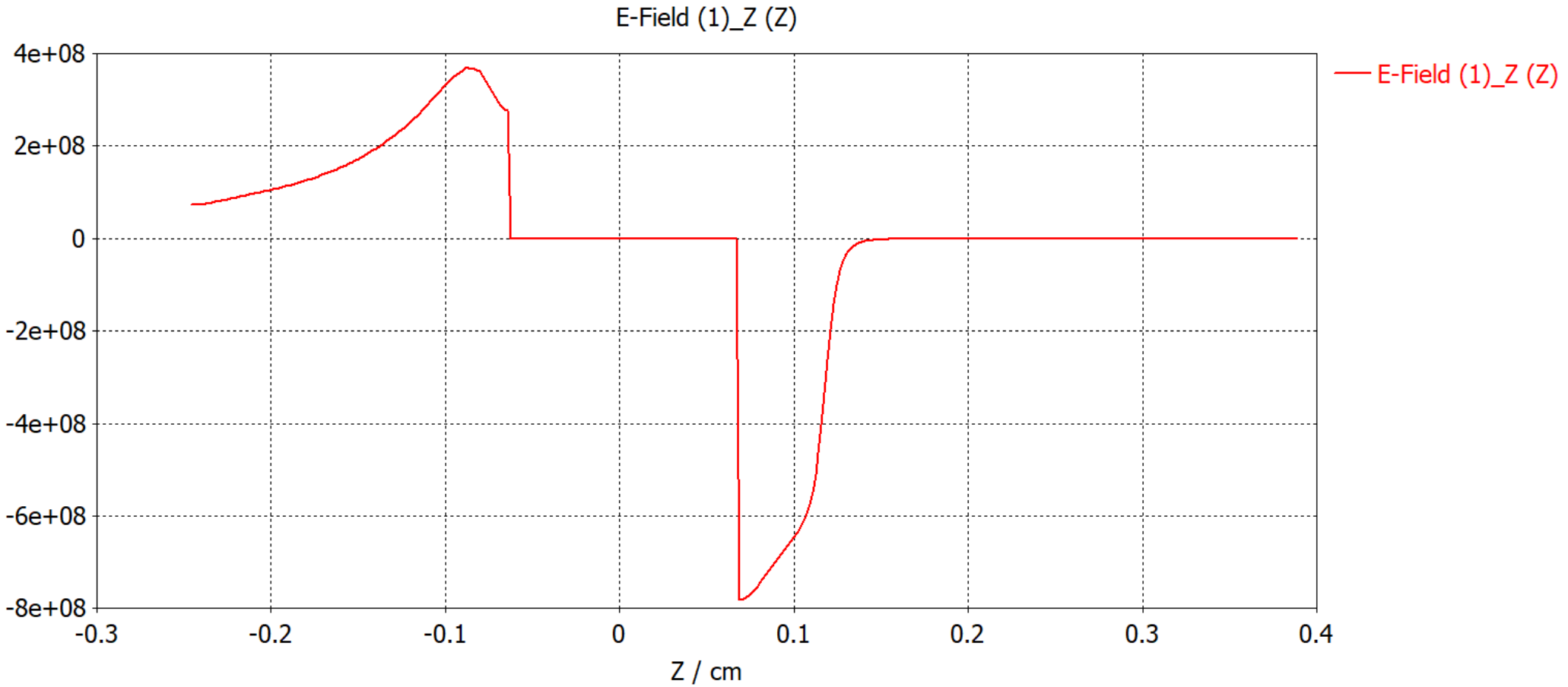
Potential





Flat cathode front and flat anode - cathode anode gap 5 cm - shed design 8

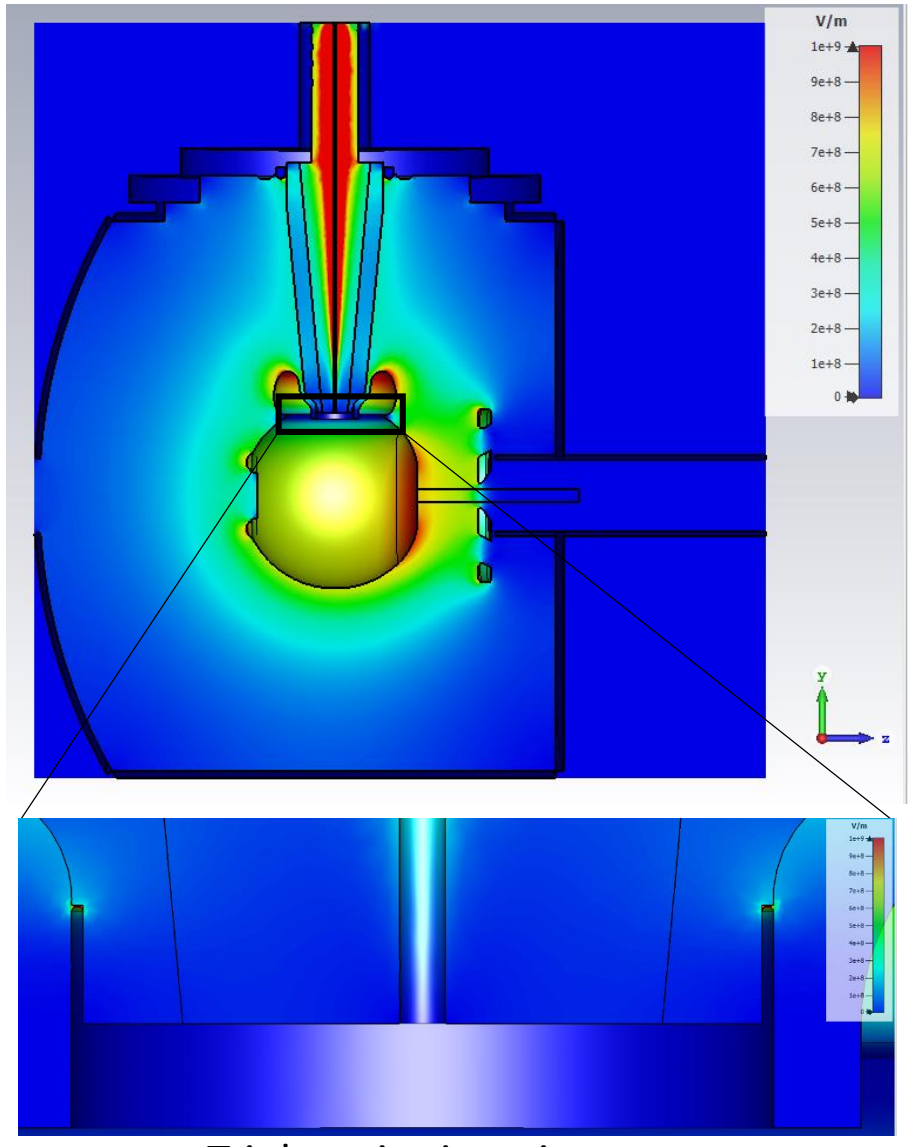
-350 kV at the cathode, 0 V at the anode



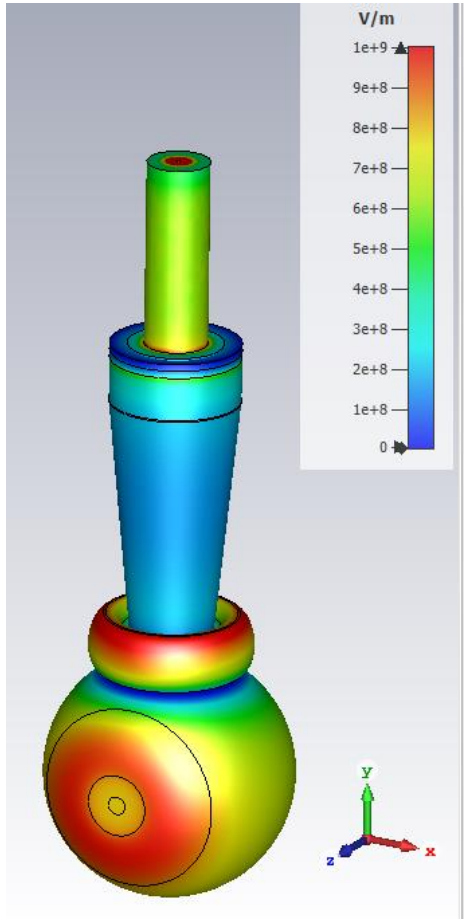
Flat cathode front and flat anode - cathode anode gap 5 cm - shed design 9

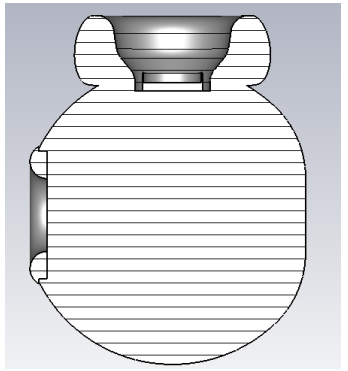
-350 kV at the cathode, 0 V at the anode

E field

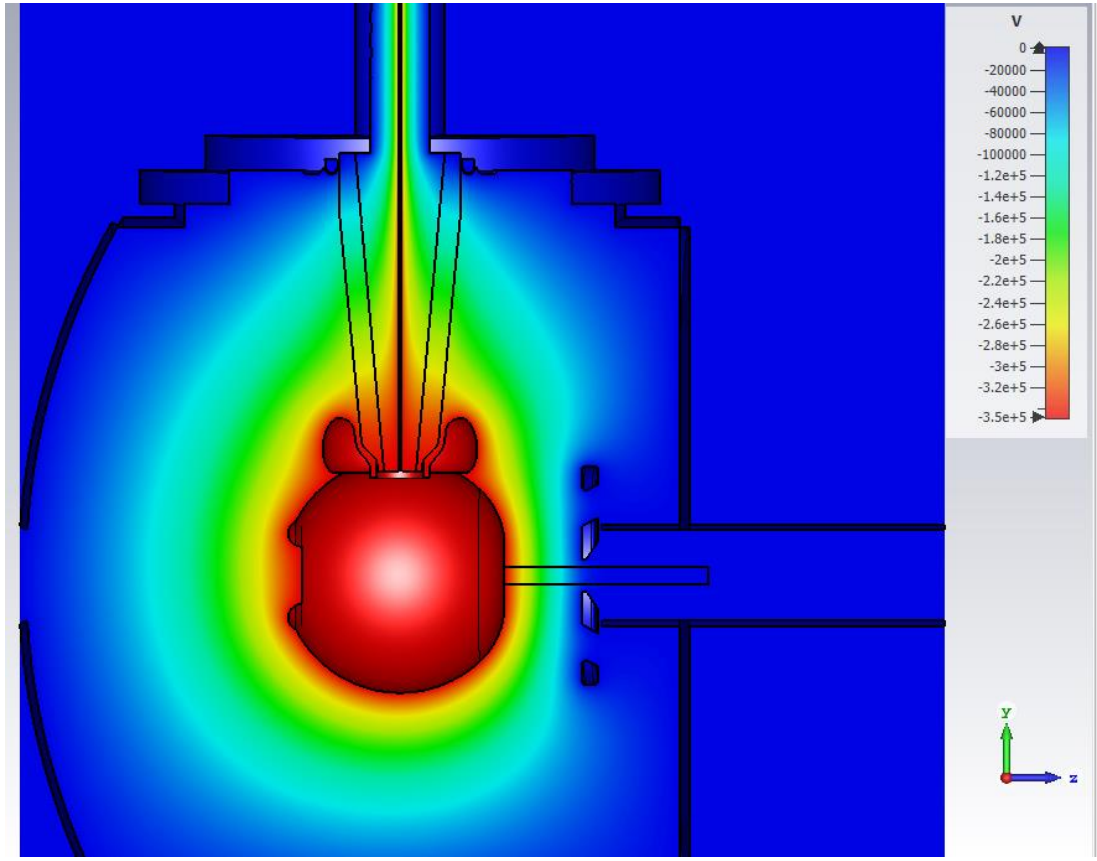


Triple point junction



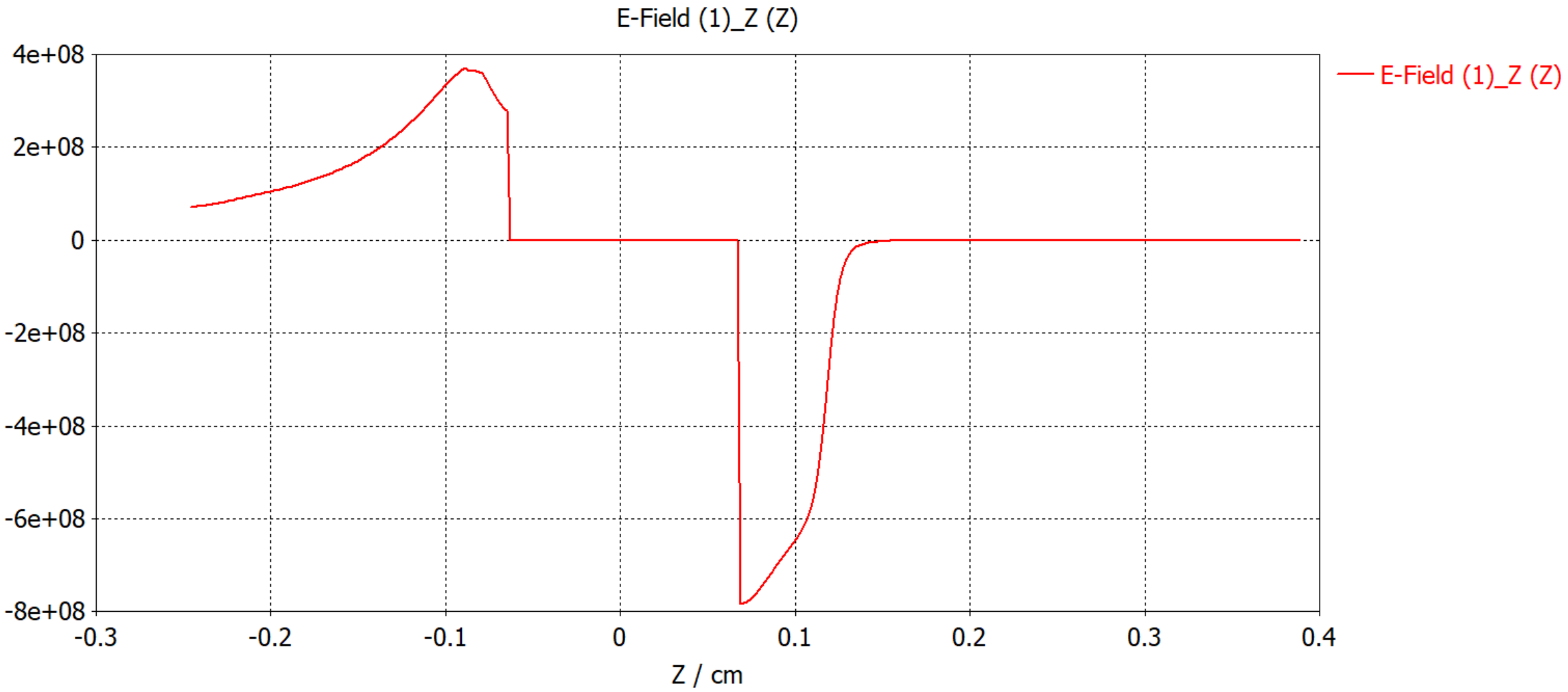


Potential

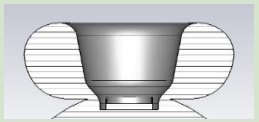
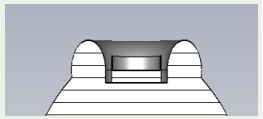
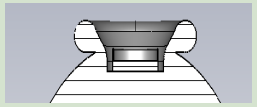
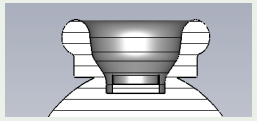
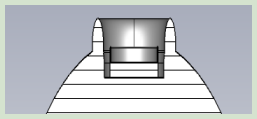
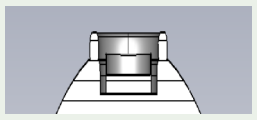


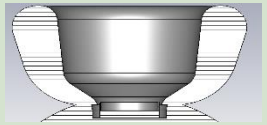
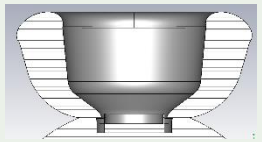
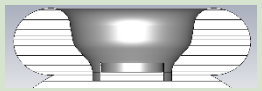
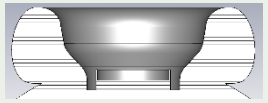
Flat cathode front and flat anode - cathode anode gap 5 cm - shed design 9

-350 kV at the cathode, 0 V at the anode

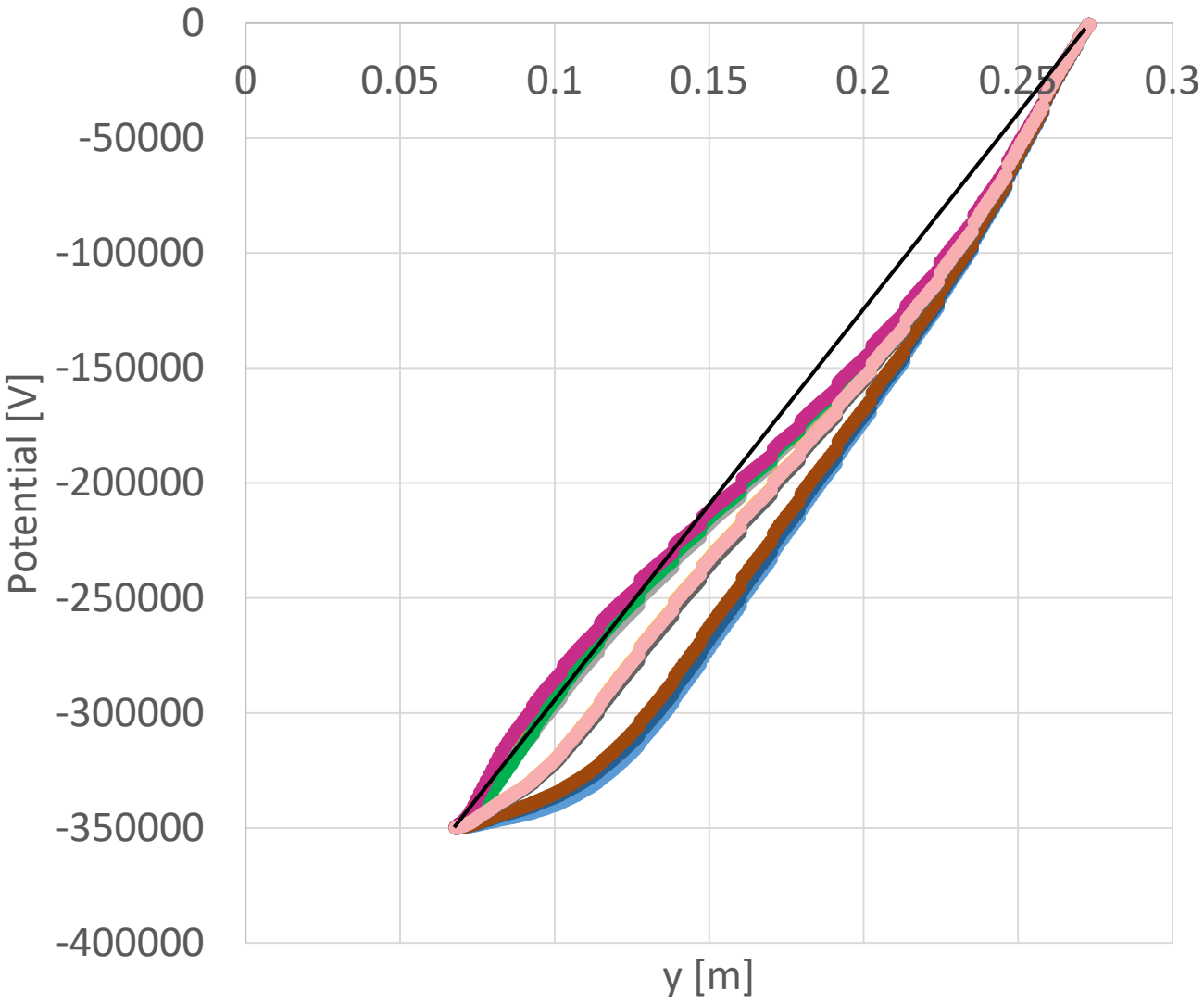


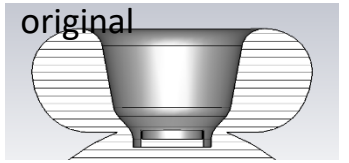
Summary of shed designs so far…

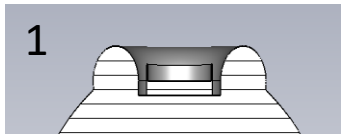
Design	Emax at cathode [MV/m]	Emax at the triple point junction [MV/m]	Emax ball [MV/m]	X position at 1m [cm]	Y position at 1m [cm]
original 	-2.50	-10	-11.5	-0.3797	-3.008
1 	-8	-95	-9.7	-0.332	-0.138
2 	-800	-6.5E3	-950		
3 	-800	-3.12E3	-9.8		
4 	-8	-46.2	-9.8	-0.331	-0.124
5 	-8	-89.5	-10	-0.332	-0.116

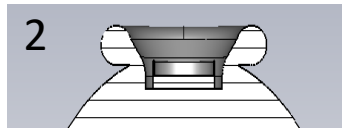
Design	Emax at cathode [MV/m]	Emax at the triple point junction [MV/m]	Emax ball [MV/m]	X position at 1m [cm]	Y position at 1m [cm]
6  Symmetric anode	-7.95	-12.5	-9.8	-5.87E-03	-0.49
7 	-7.96	-15.3	-9.8	-0.332	-0.49
8 	-800	-2.9E3	-960		
9 	-800	-3E3	-950		

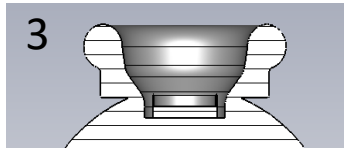
Potential variation along the rubber-insulator interface

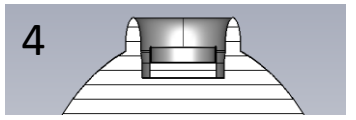


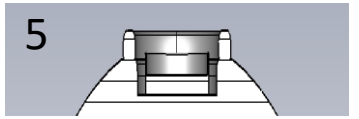


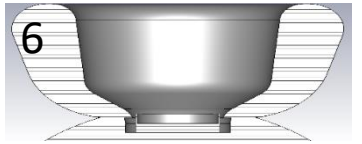


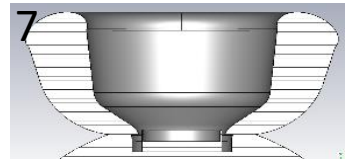


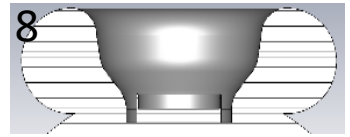


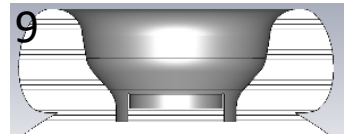




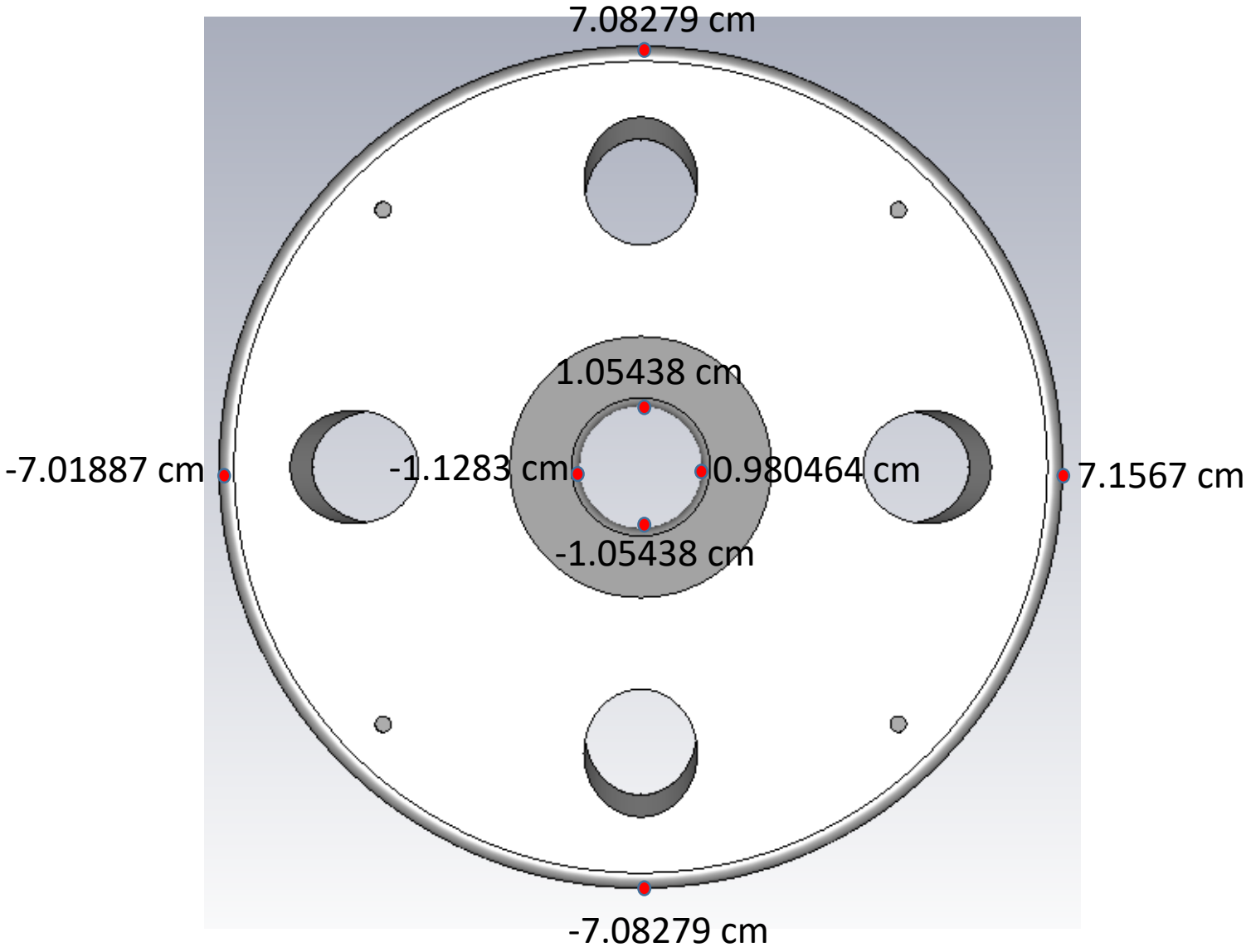








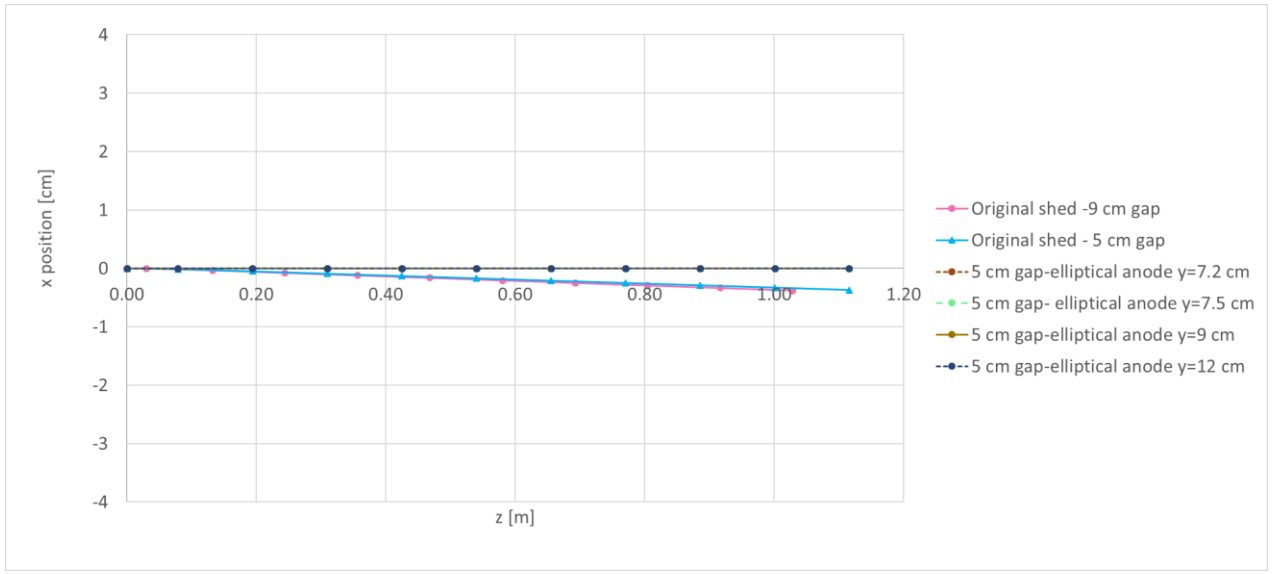
Original Anode

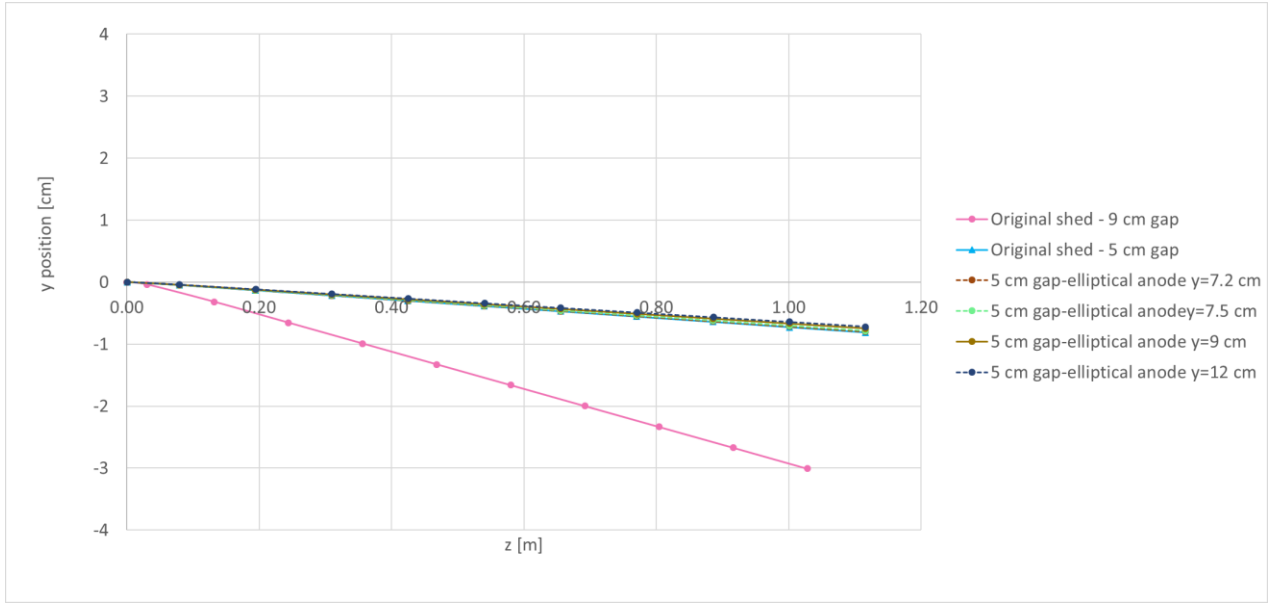


Elliptical anodes

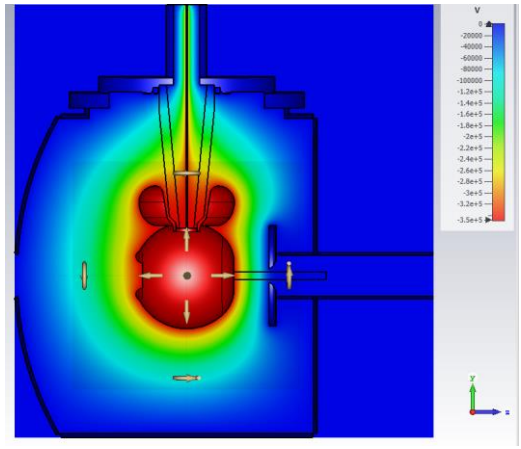
*Made the anodes elliptical to see whether it can compensate the kick from the shed.

*X=7.08 cm for all the cases

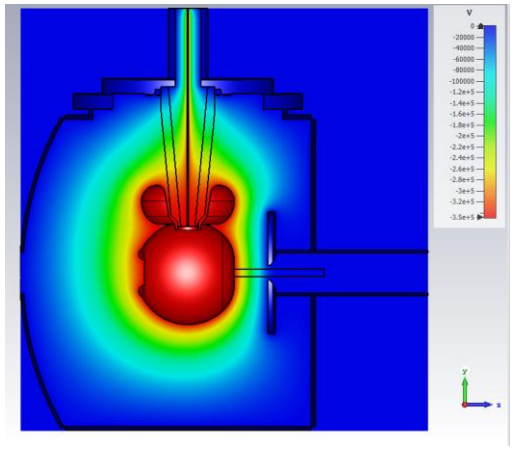




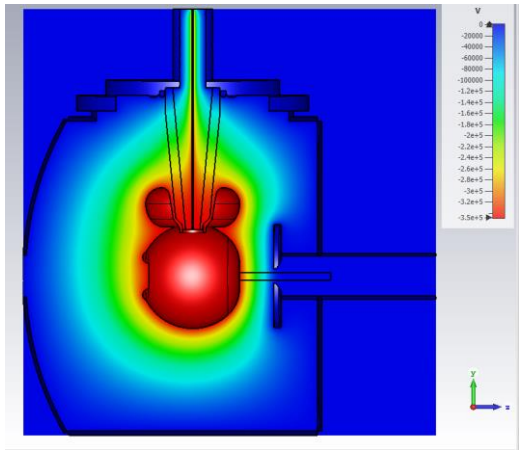
Y=7.2 cm



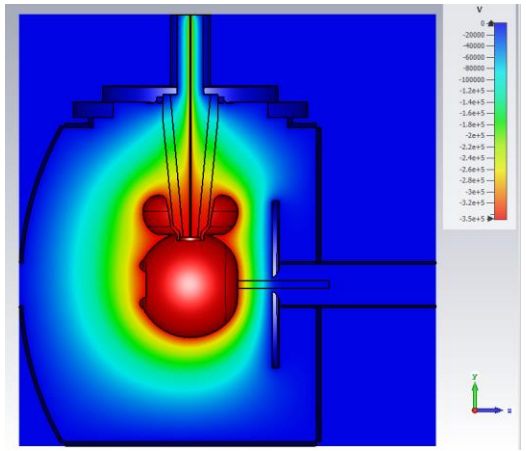
Y=9 cm



Y=7.5 cm



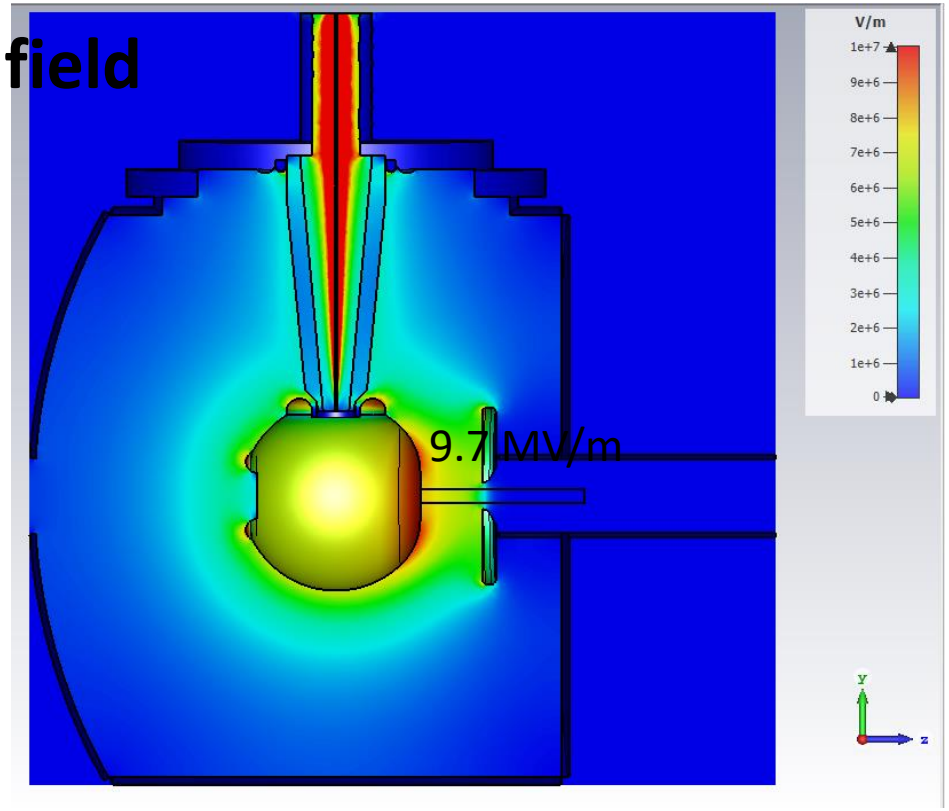
Y= 12 cm



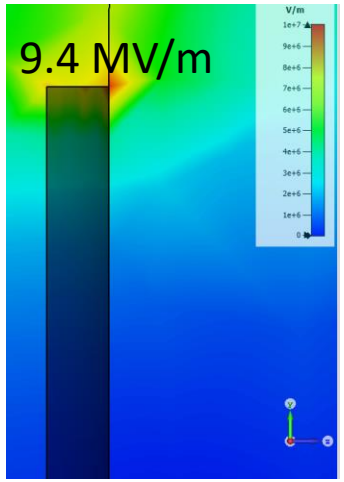
Flat cathode front and flat anode - cathode anode gap 5 cm - shed design 1

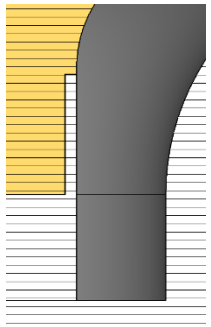
Symmetric anode – with actual triple point design

E field

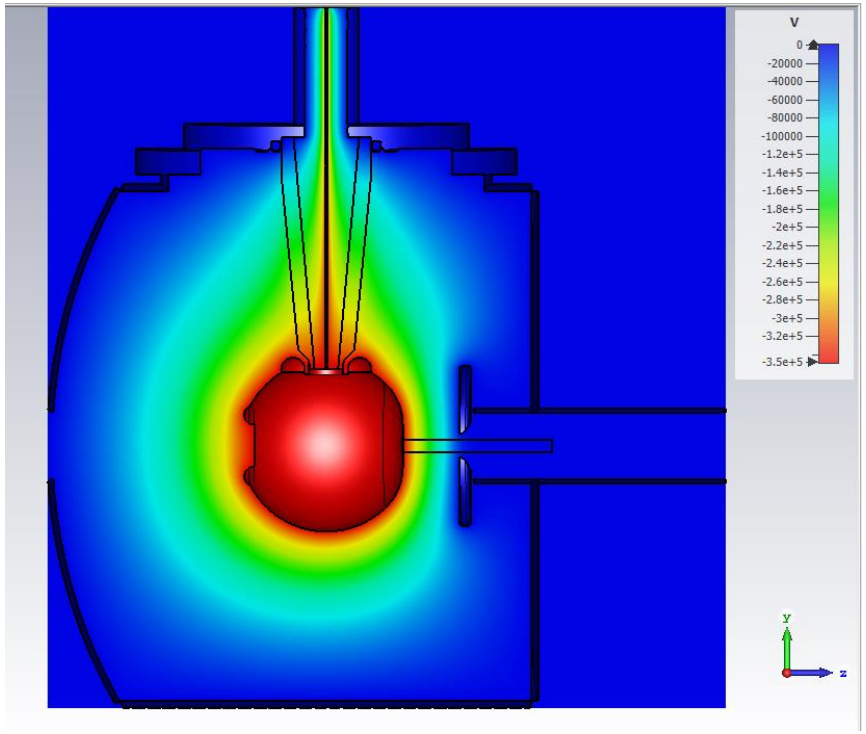


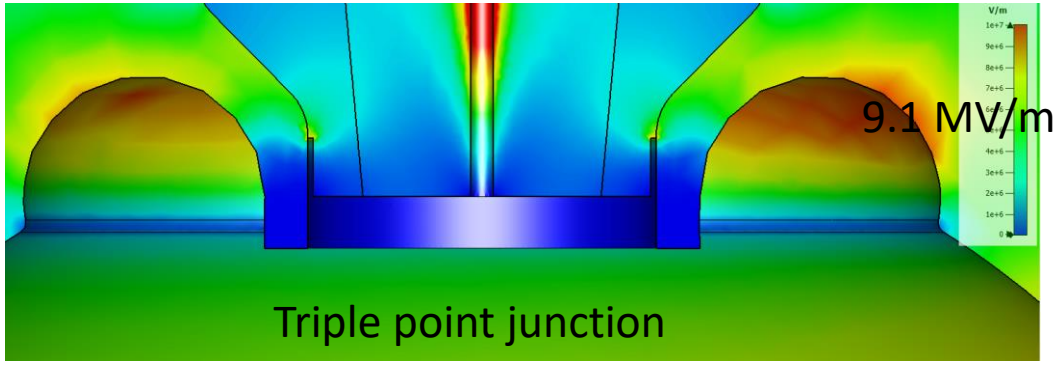
Actual design



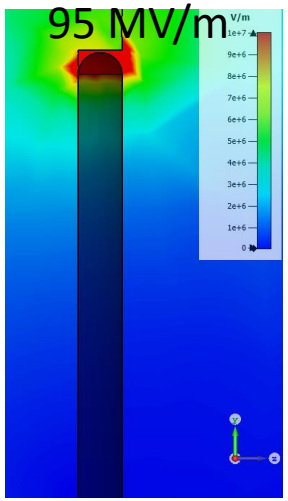


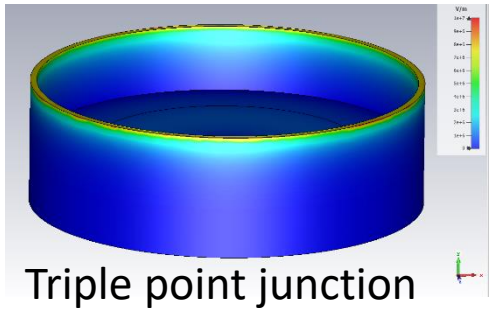
Potential





Original design

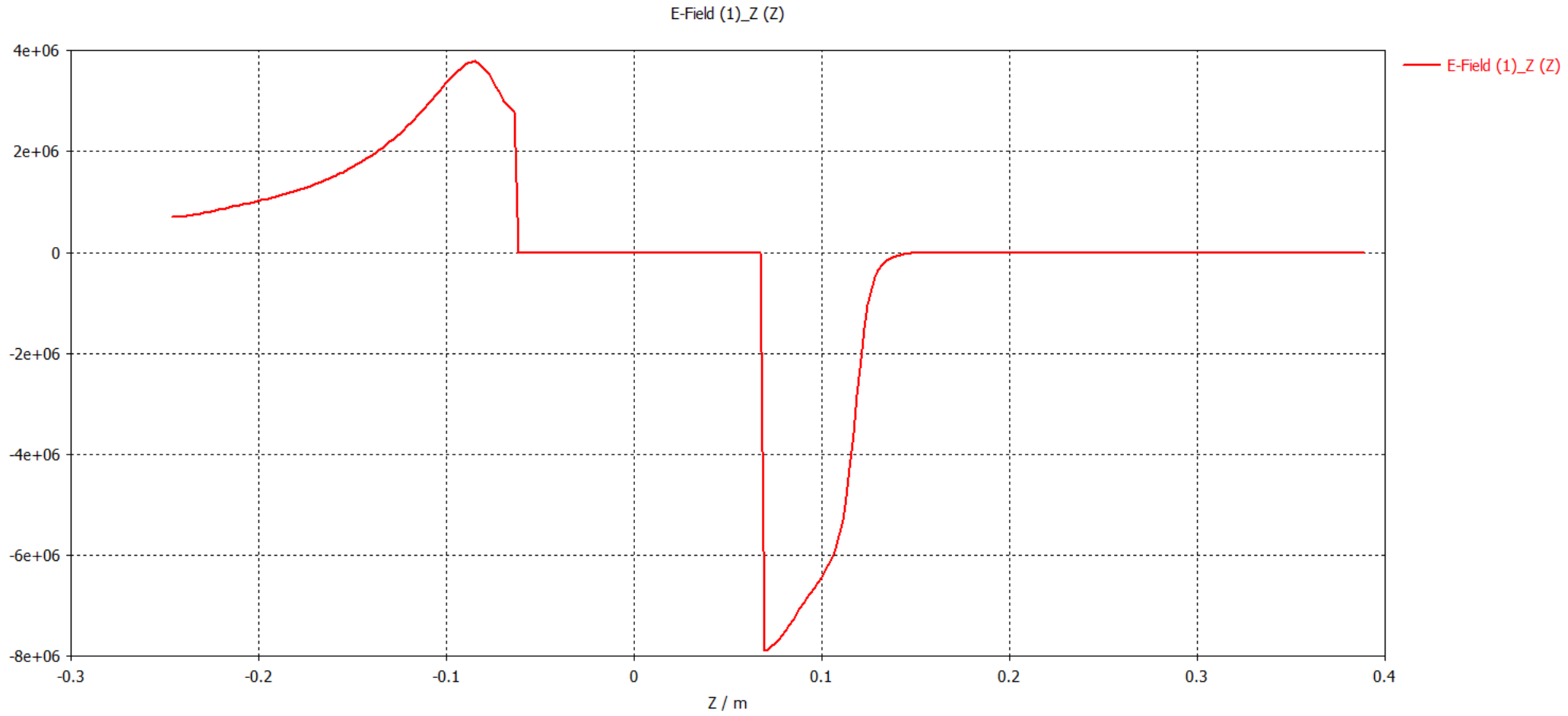


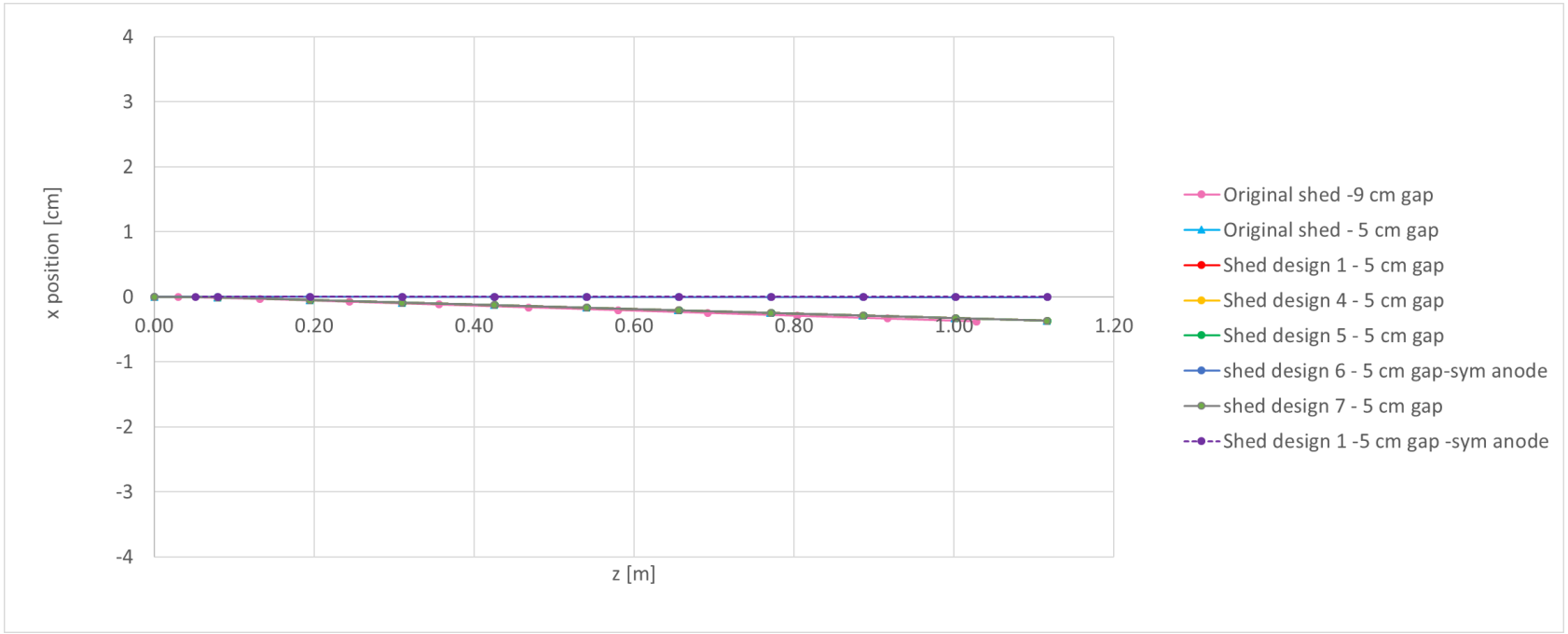


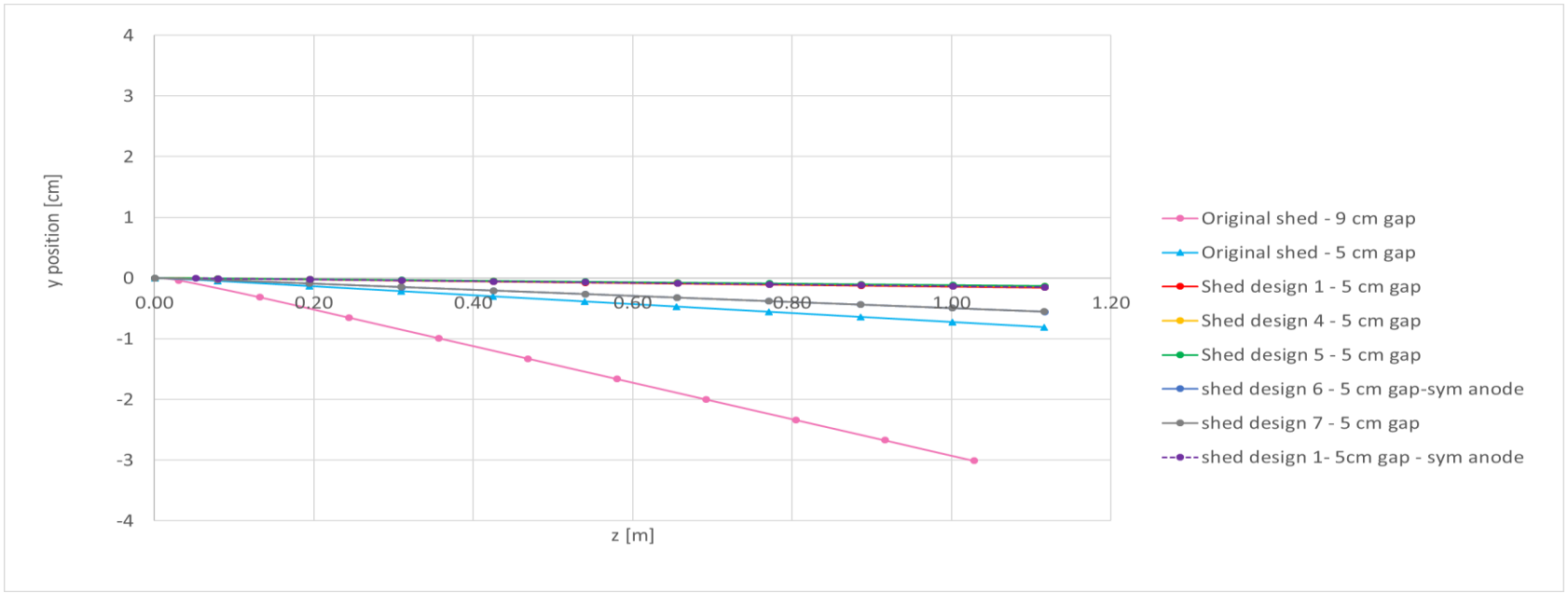
* This is the best shed design among all the above designs which reduces the E field at the triple point junction as well as the vertical kick.

Flat cathode front and flat anode - cathode anode gap 5 cm - shed design 1

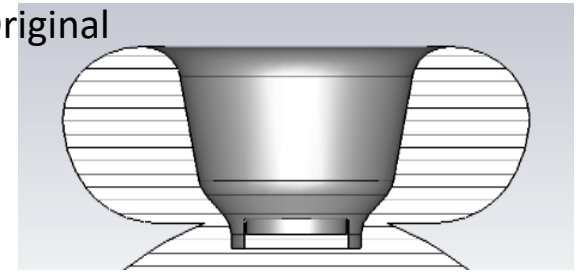
Symmetric anode – with actual triple point design







Original



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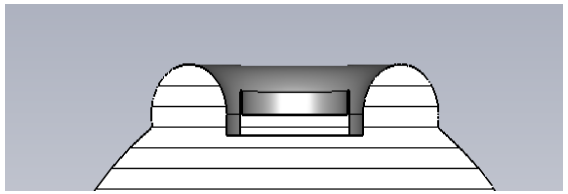

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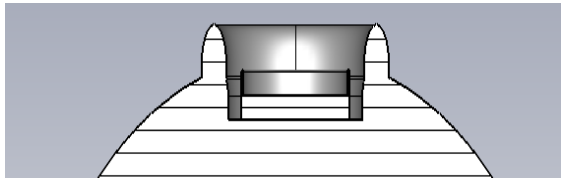

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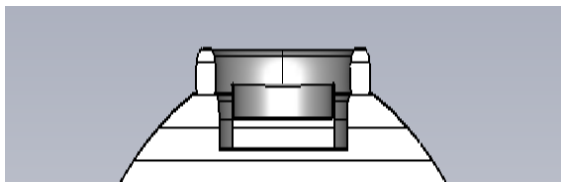

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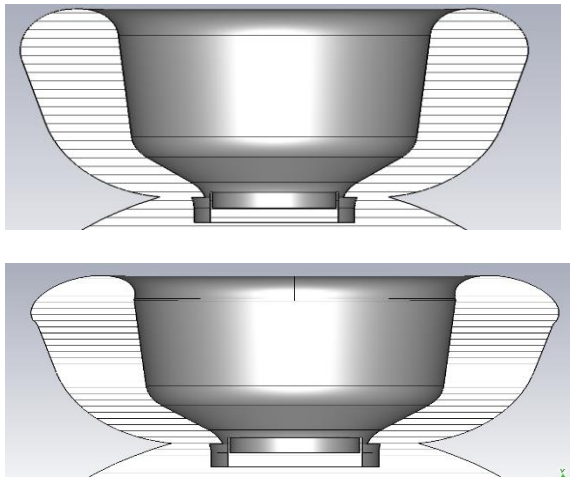
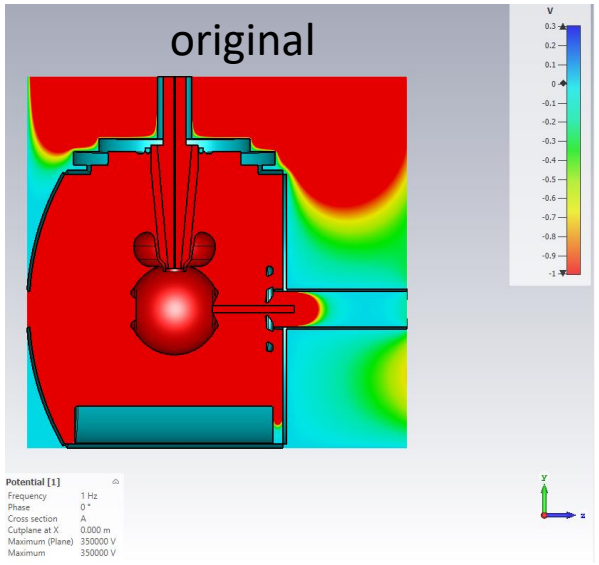


7

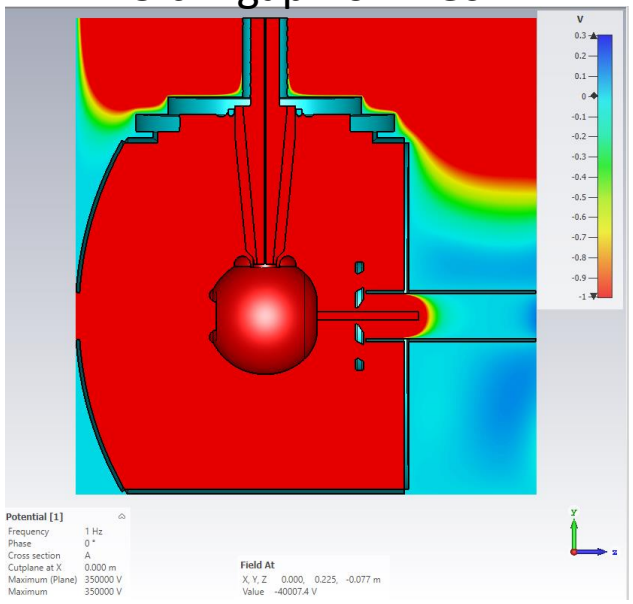
No NEGs for all the cases.

Potential

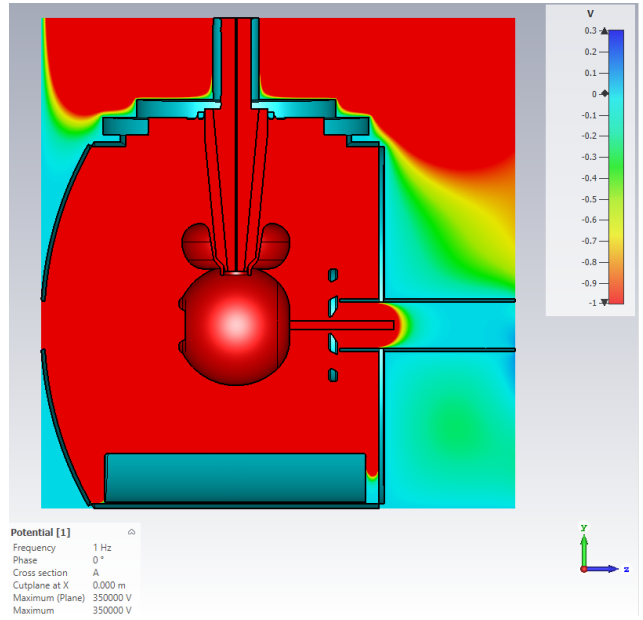
original



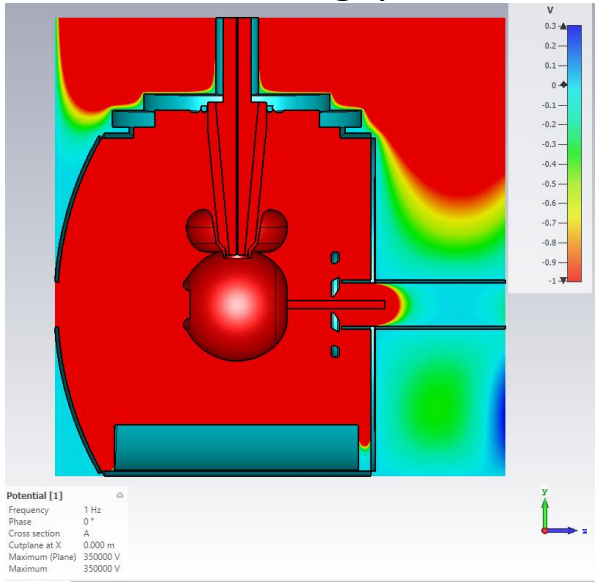
5 cm gap no NEGs



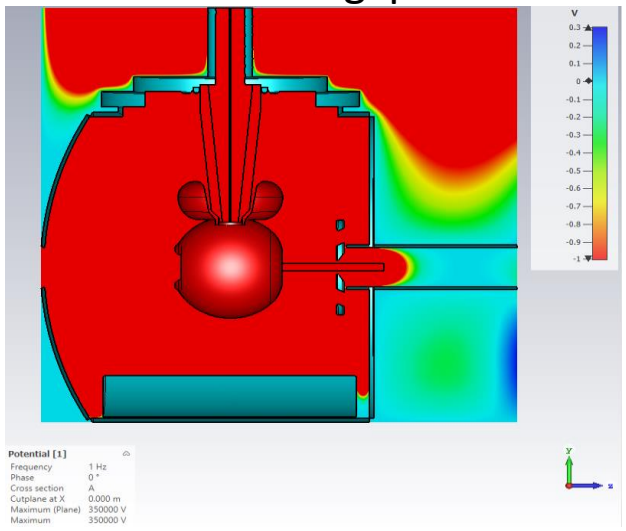
5 cm gap



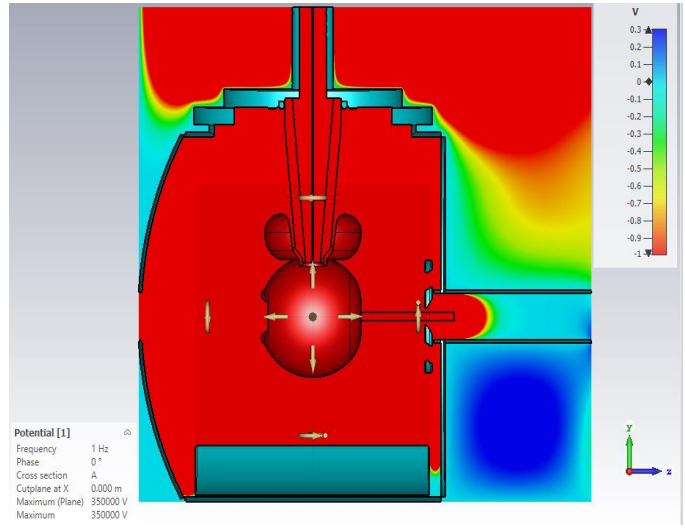
6 cm gap



7 cm gap



9 cm gap



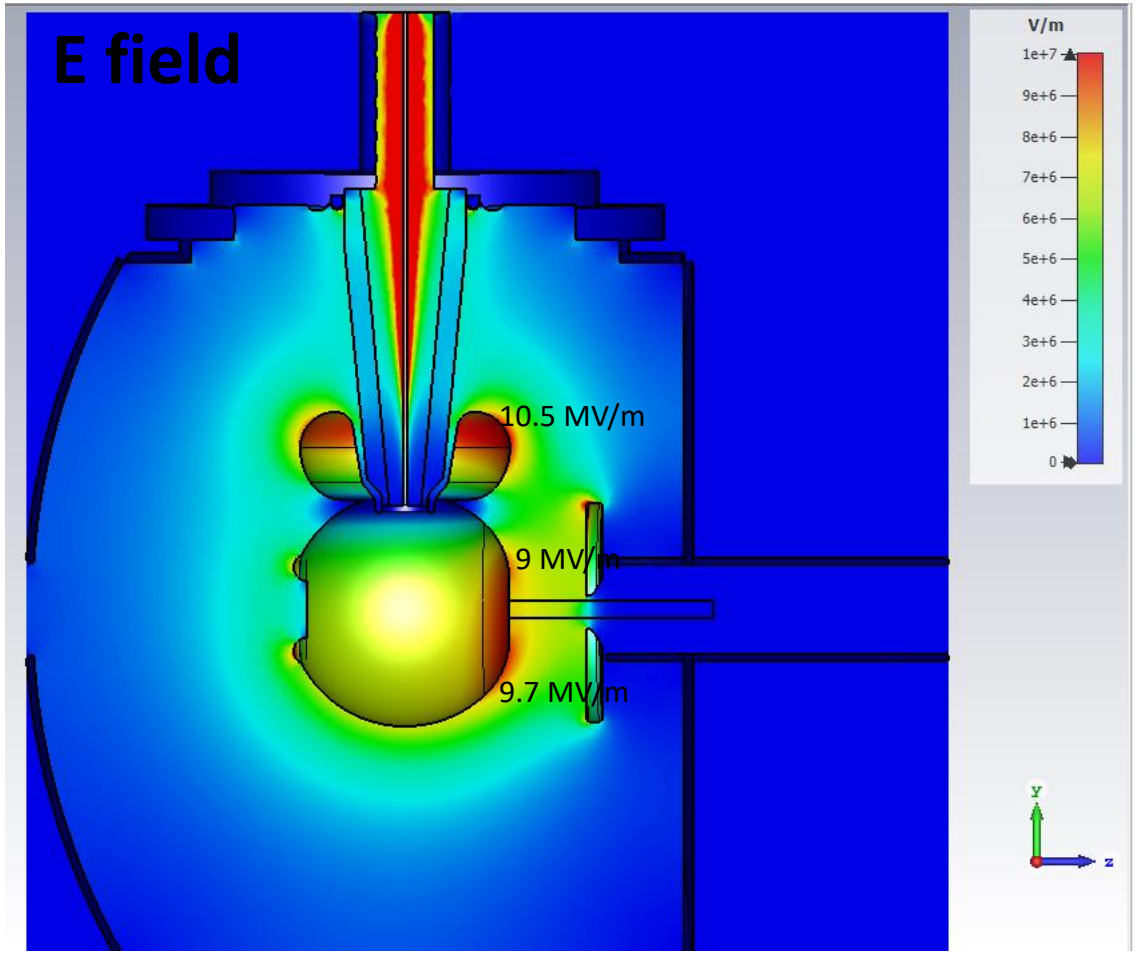
Shifted anode

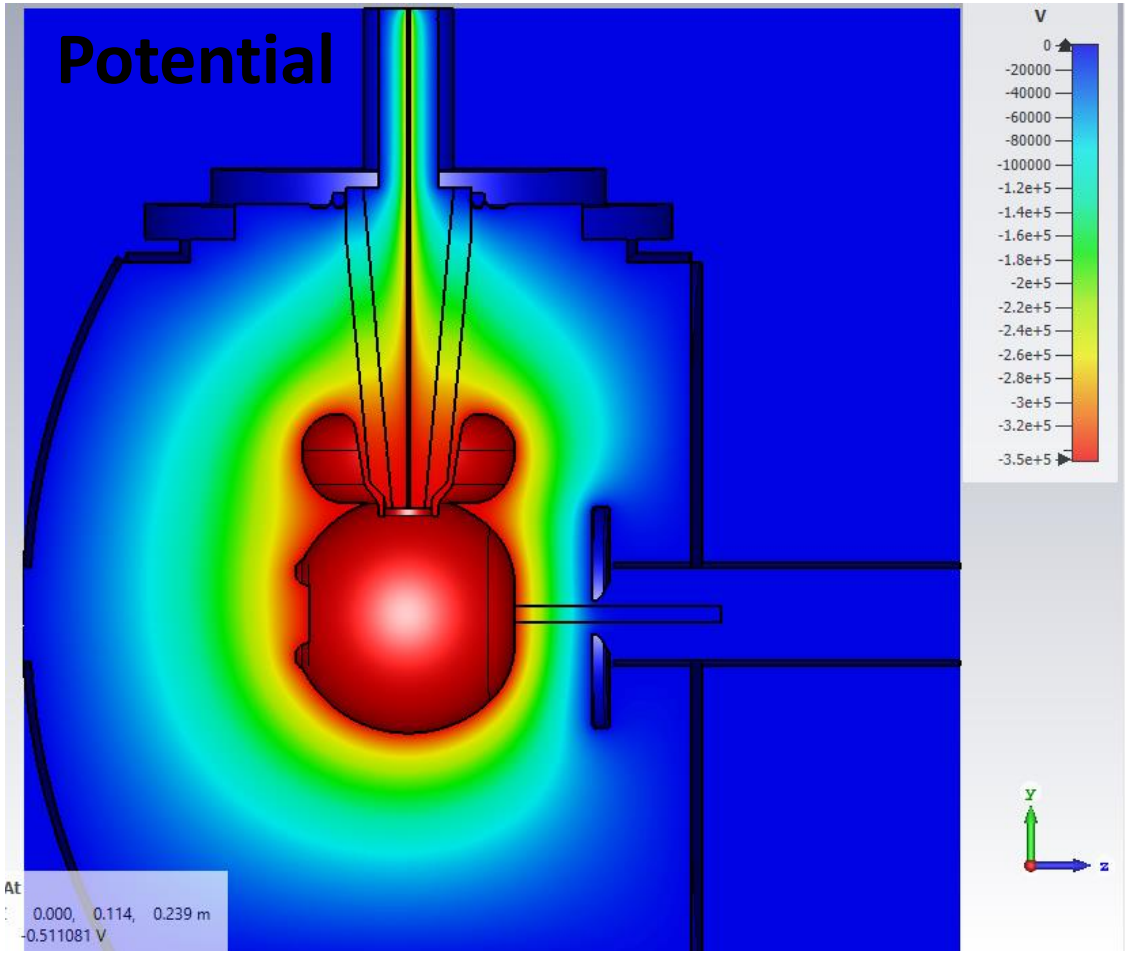
*Shifted the whole anode to see whether it can compensate the kick from the shed.

Flat cathode front and flat anode – no NEGs – cathode anode gap 5 cm - symmetric anode

-350 kV at the cathode, 0 V at the anode

Anode shifted -2 mm



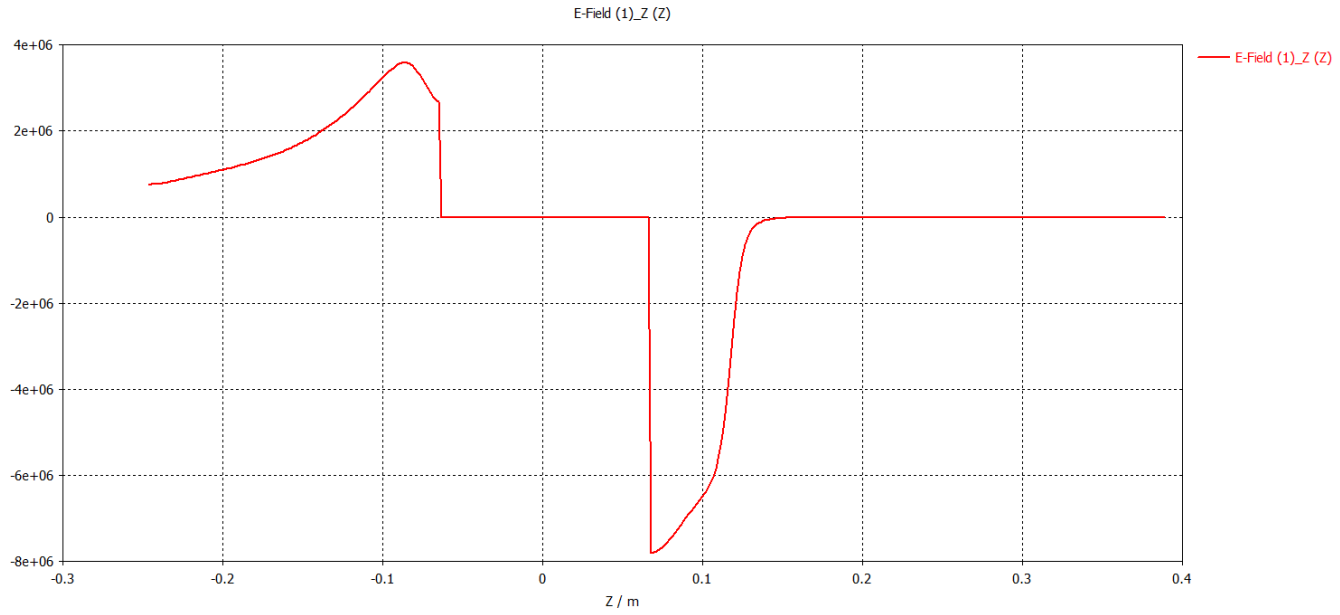


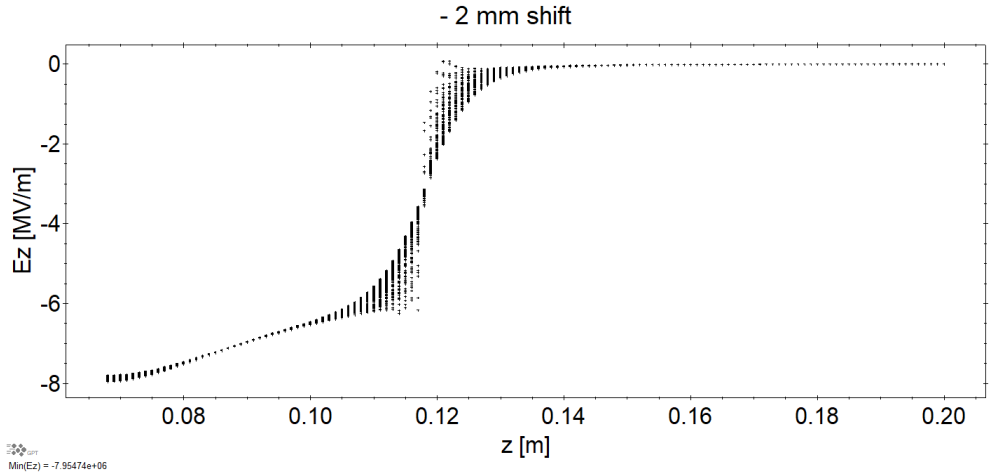
Shifted anode

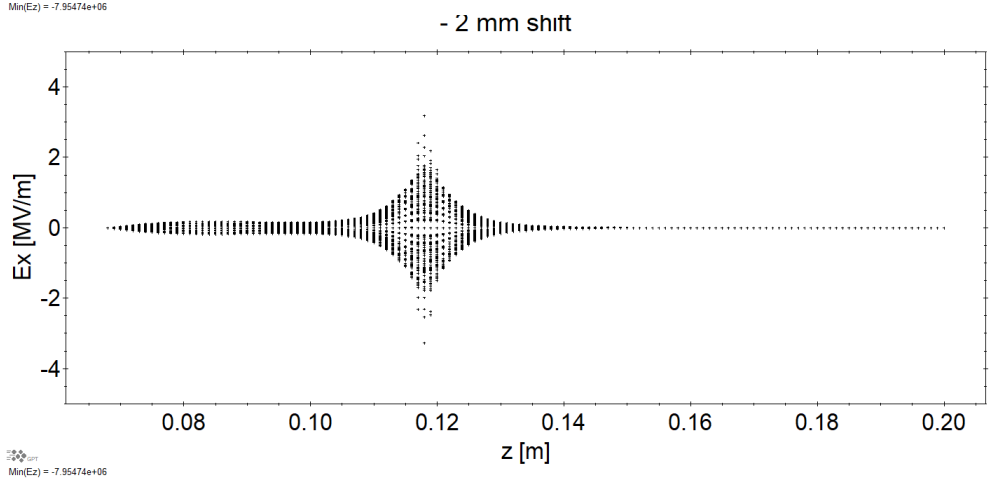
Flat cathode front and flat anode – no NEGs – cathode anode gap 5 cm - symmetric anode

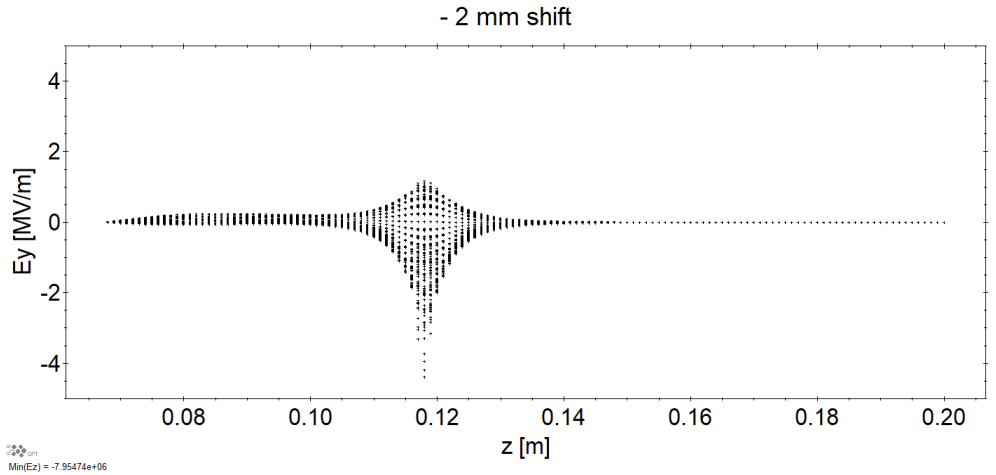
-350 kV at the cathode, 0 V at the anode

Anode shifted -2 mm







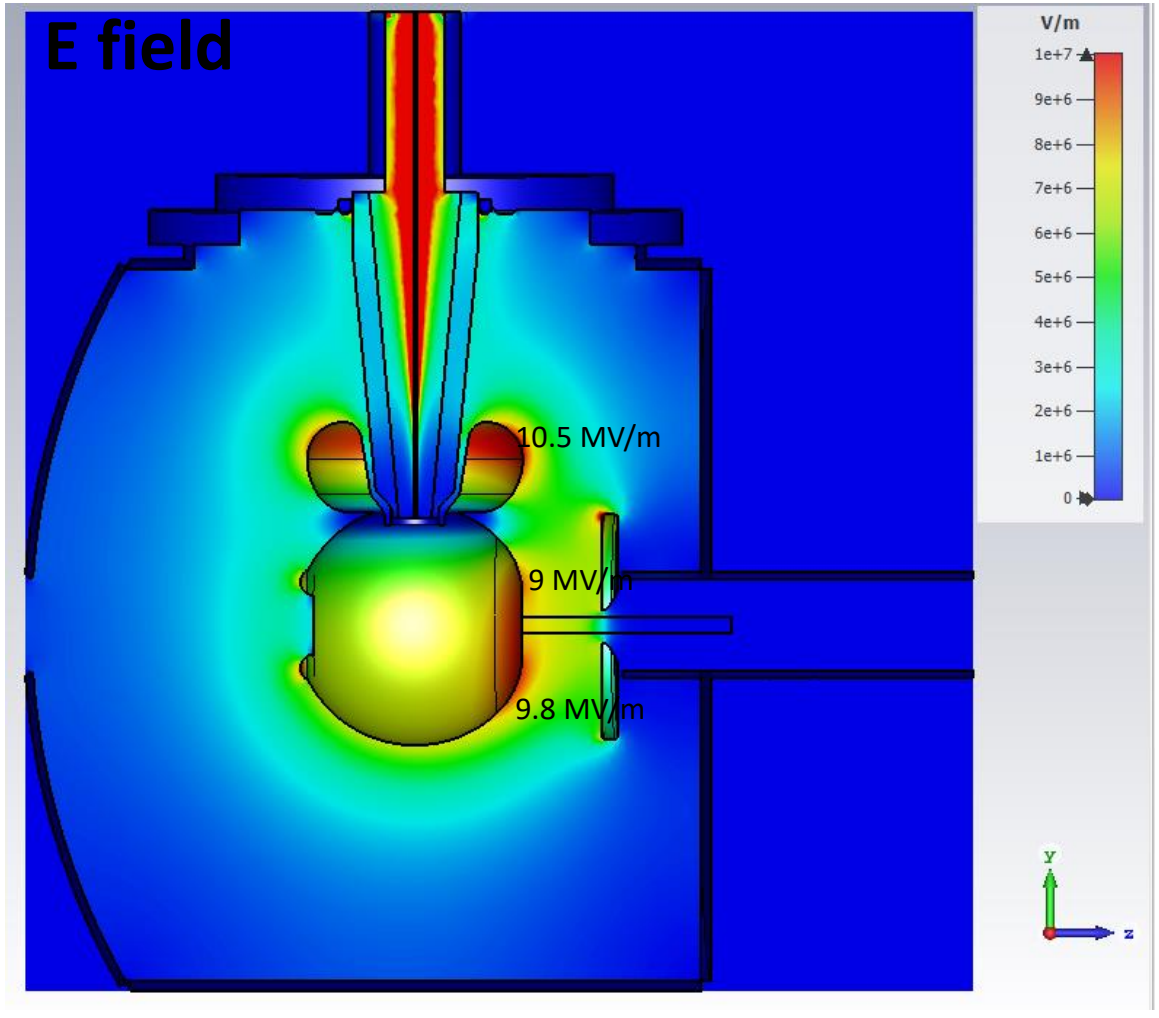


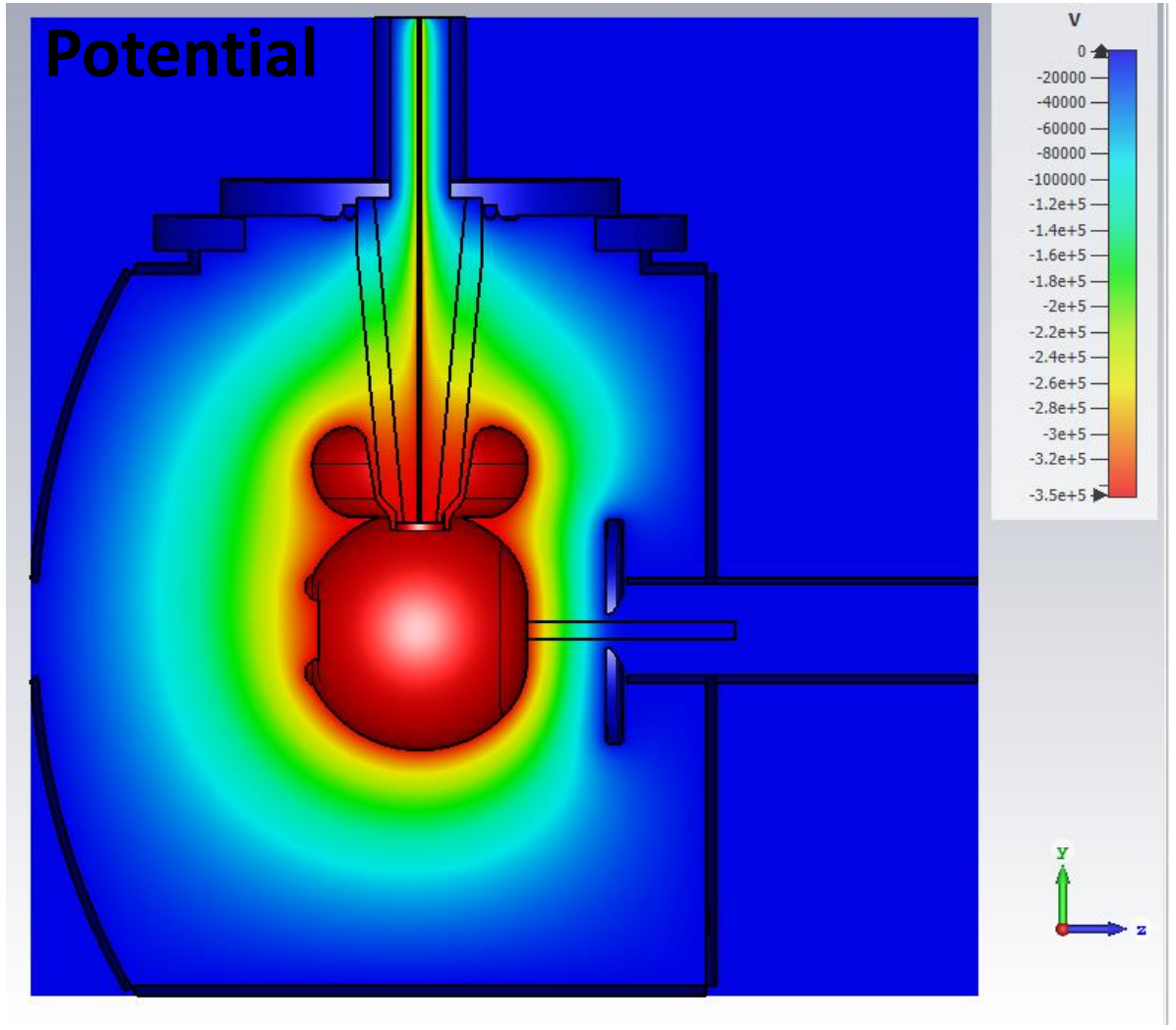
Shifted anode

Flat cathode front and flat anode – no NEGs – cathode anode gap 5 cm - symmetric anode

-350 kV at the cathode, 0 V at the anode

Anode shifted -1 mm





Shifted anode

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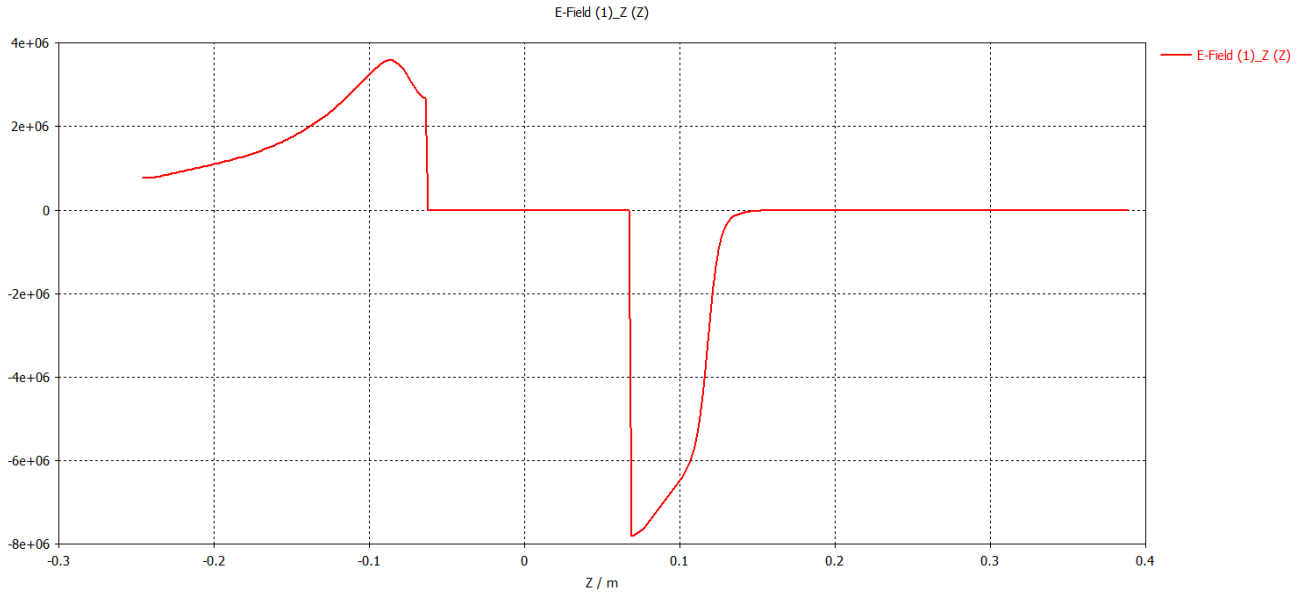
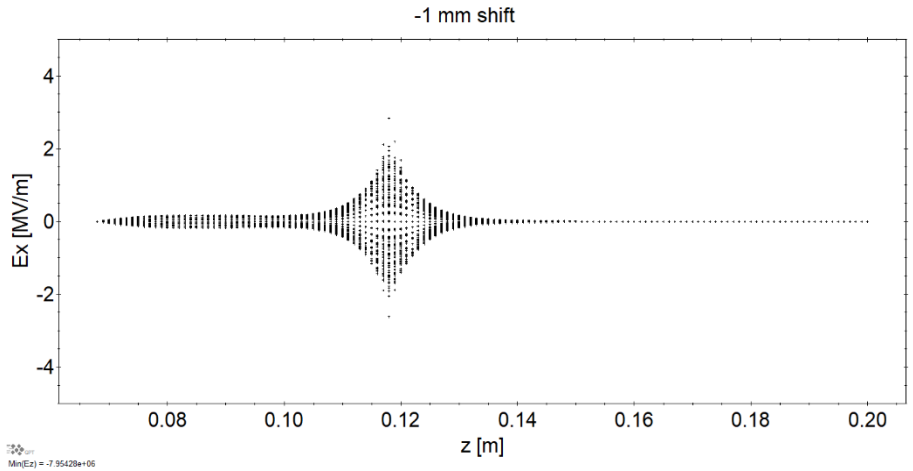
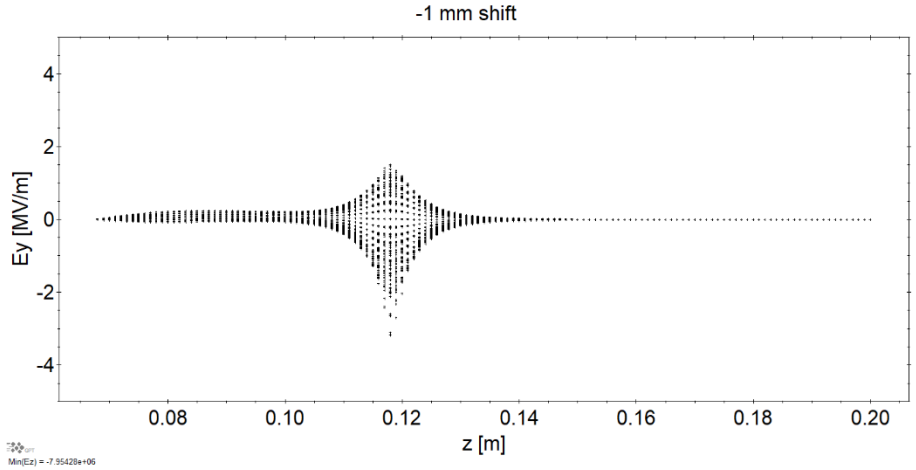
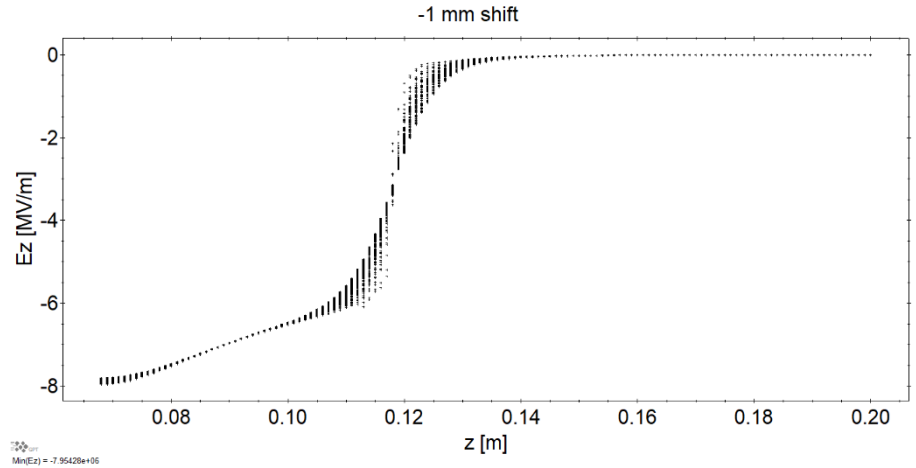
-350 kV at the cathode, 0 V at the anode

Anode shifted -1 mm







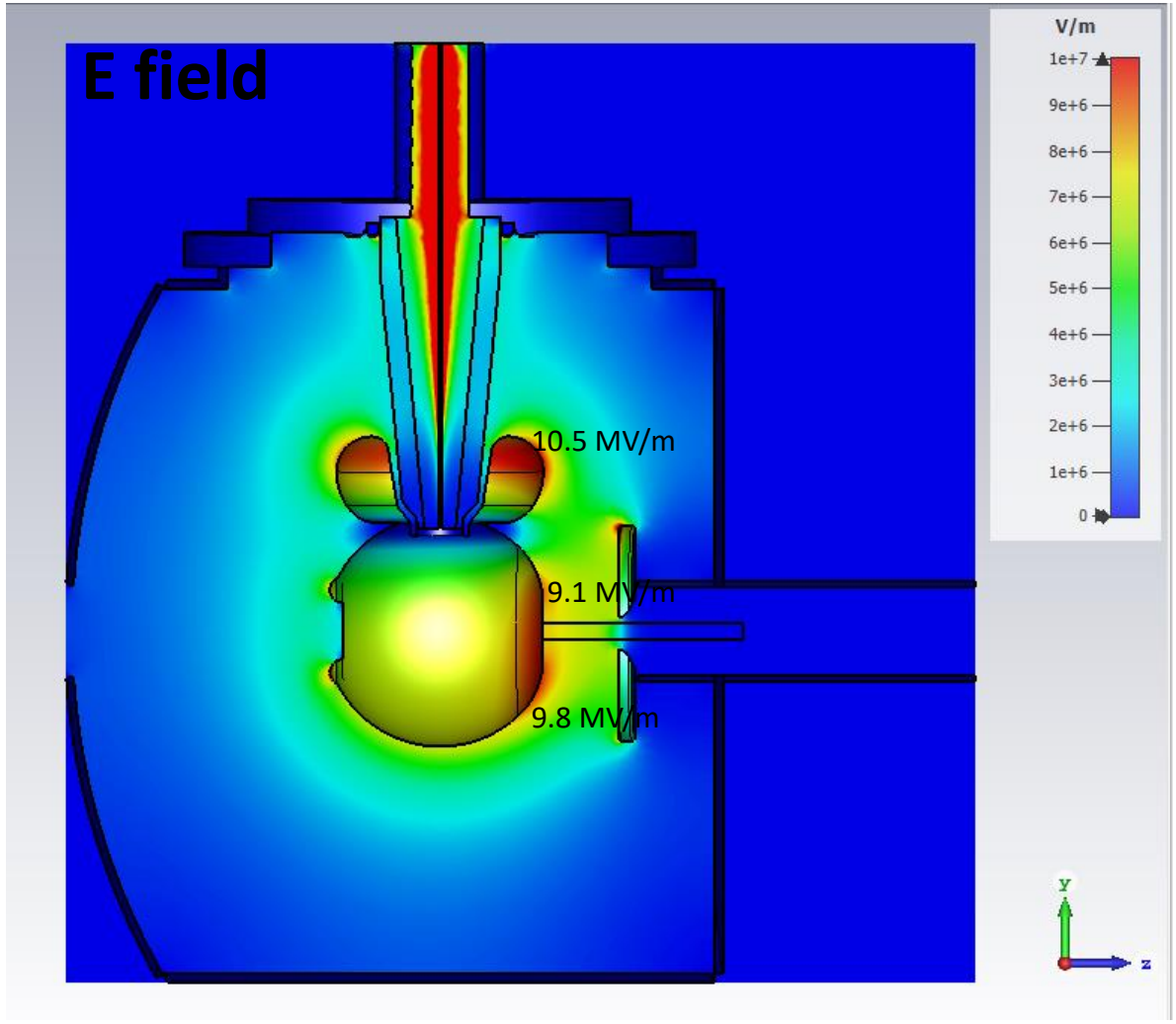


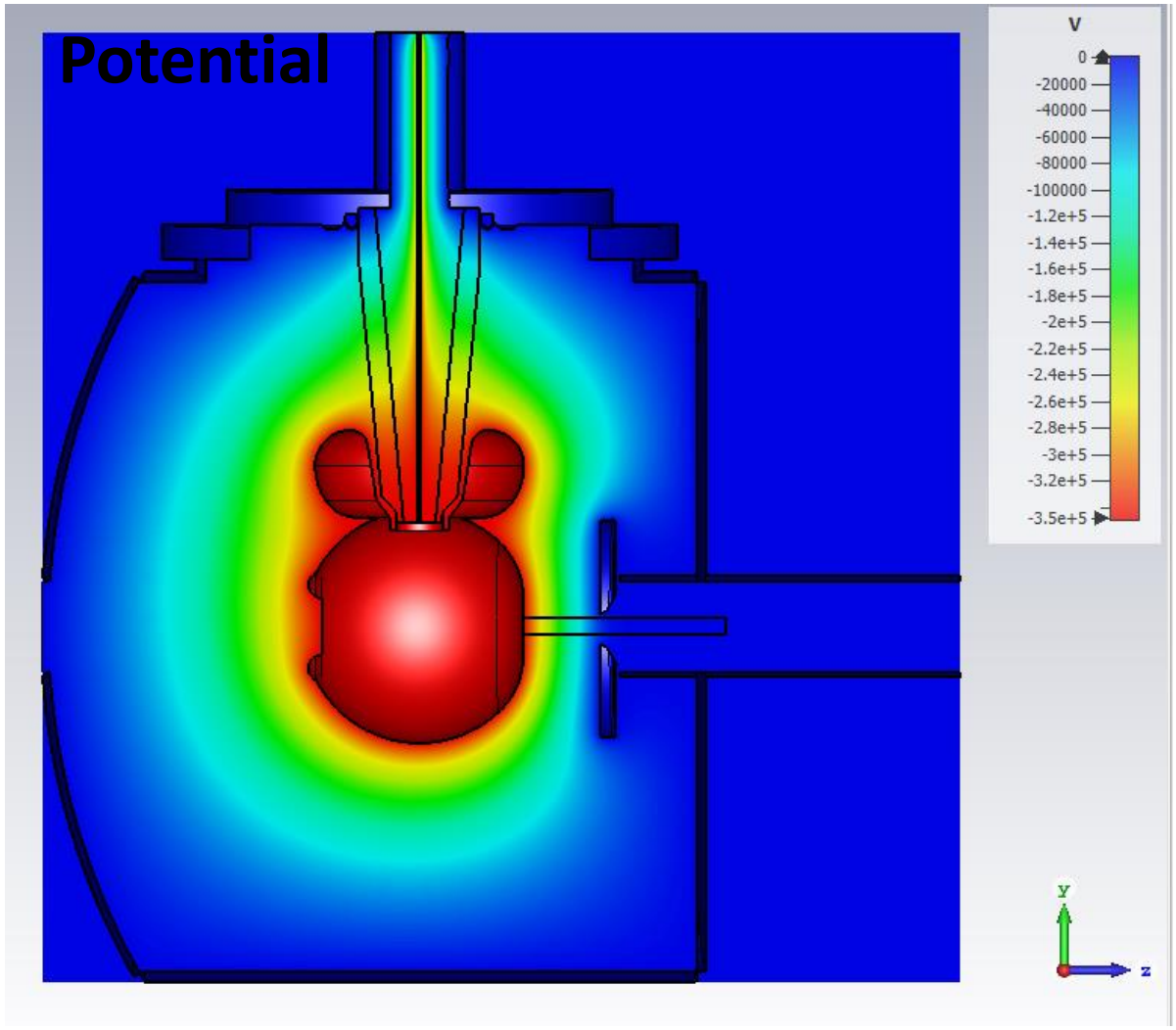
Shifted anode

Flat cathode front and flat anode – no NEGs – cathode anode gap 5 cm - symmetric anode

-350 kV at the cathode, 0 V at the anode

Anode shifted -1.5 mm



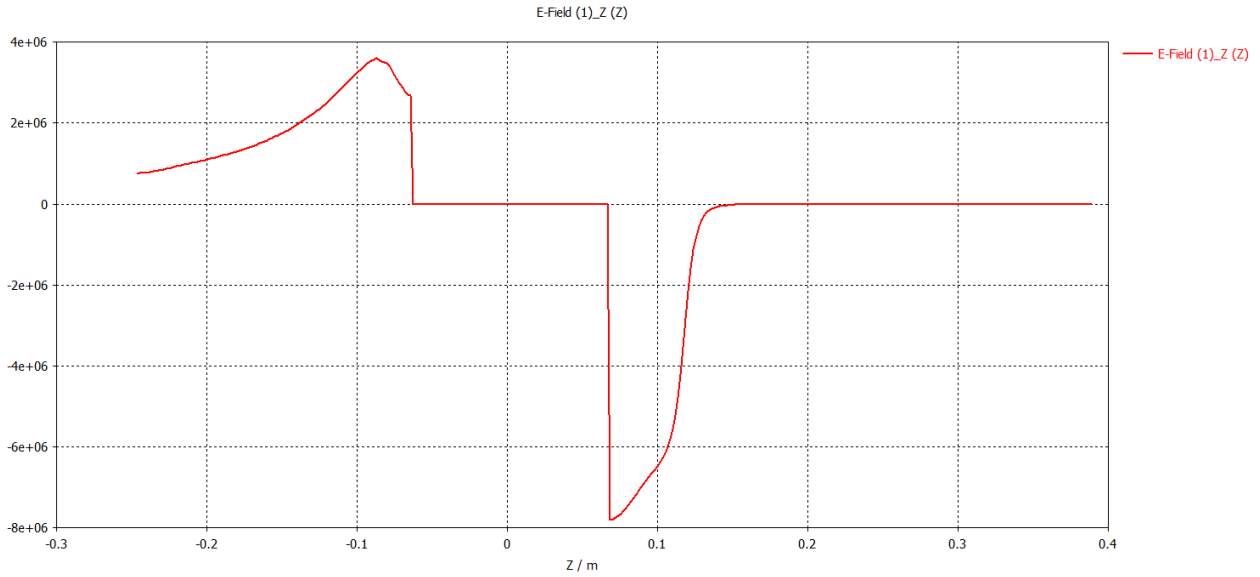


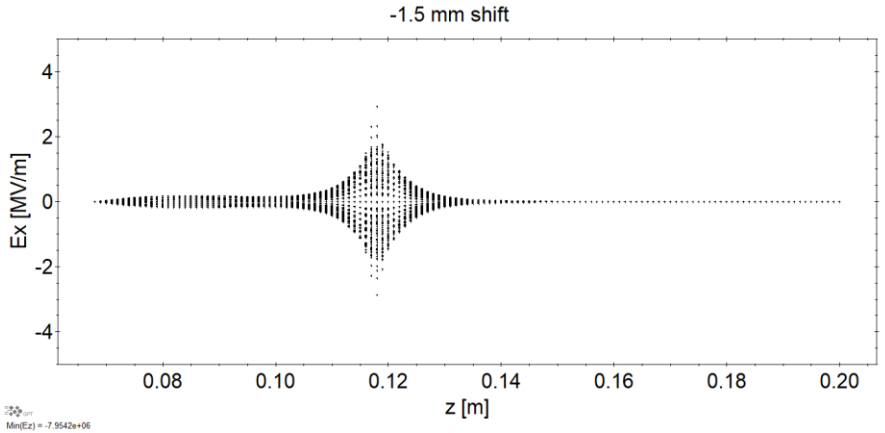
Shifted anode

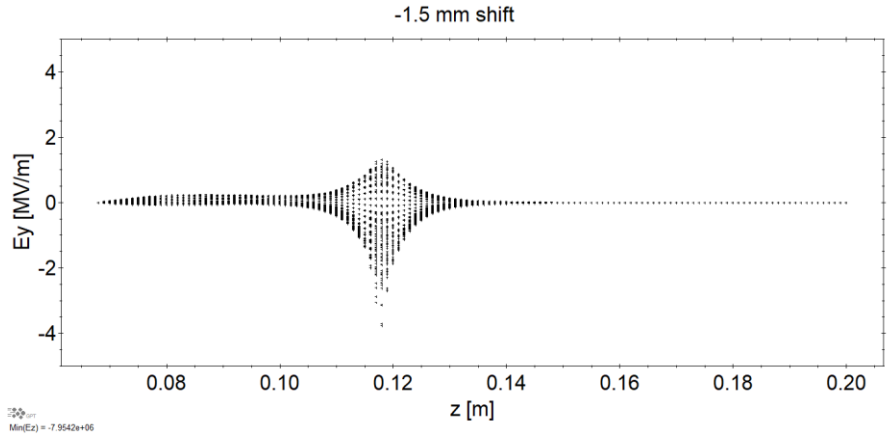
Flat cathode front and flat anode – no NEGs – cathode anode gap 5 cm - symmetric anode

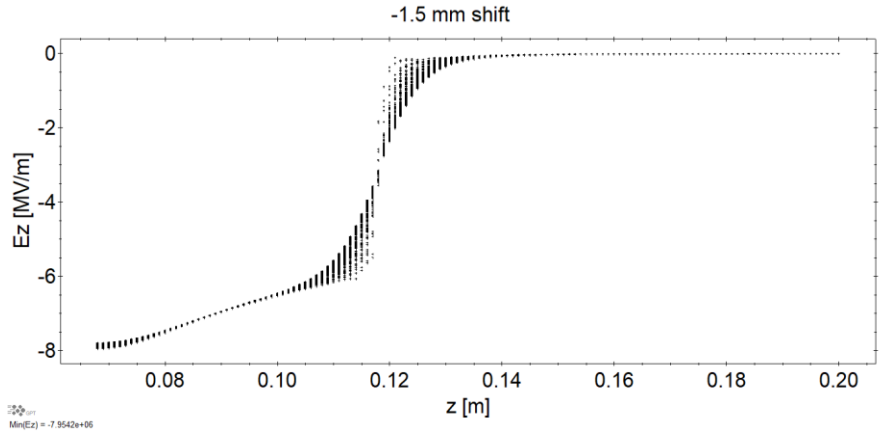
-350 kV at the cathode, 0 V at the anode

Anode shifted -1.5 mm



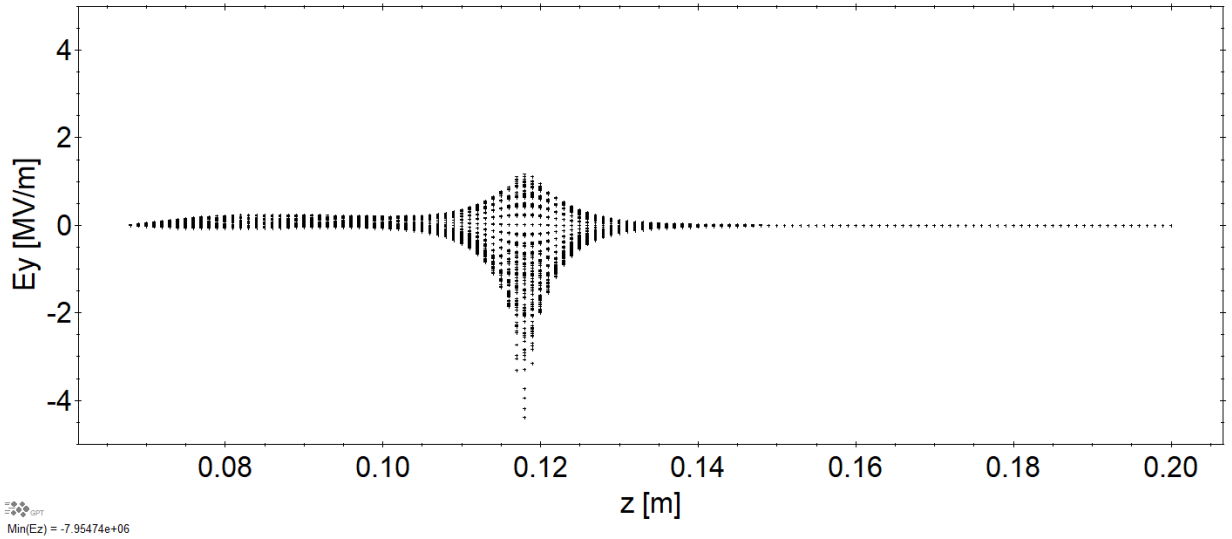






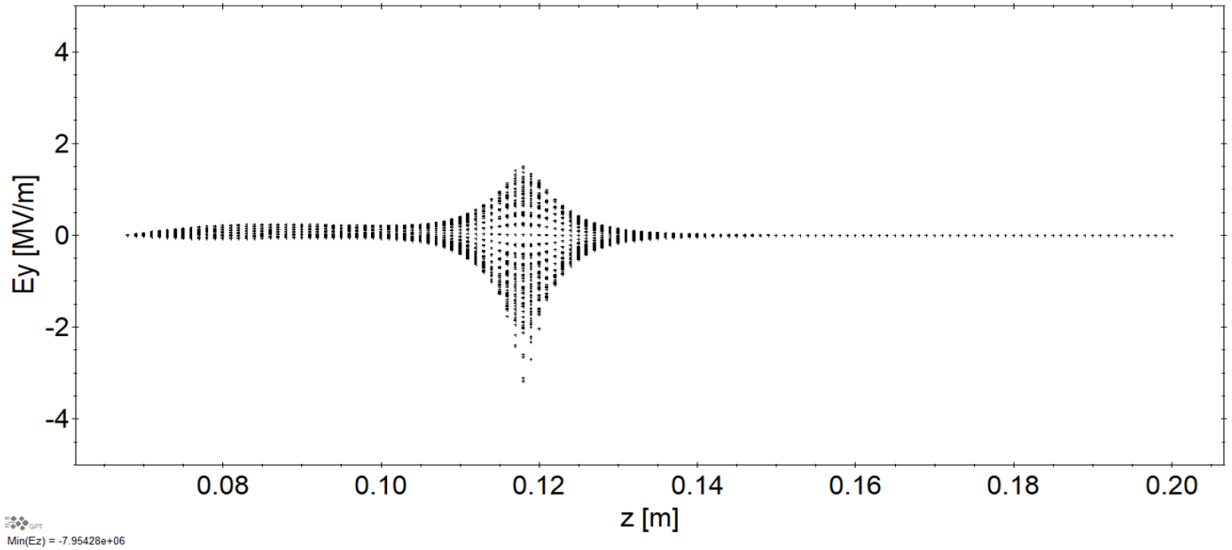
Comparison of Ey for different anode positions

- 2 mm shift



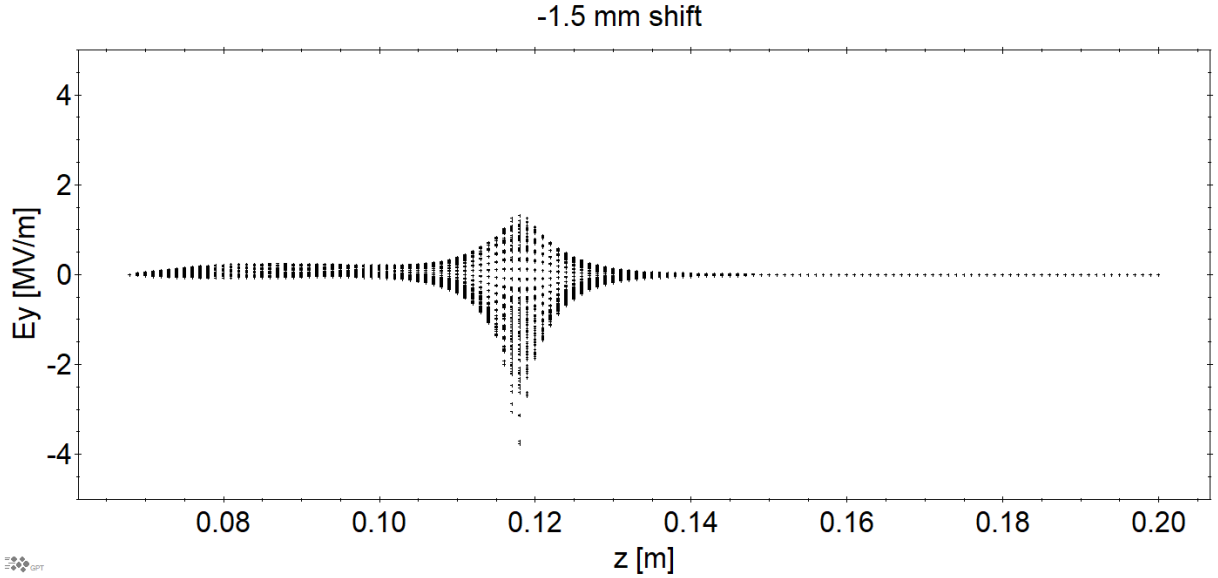
Min(Ez) = -7.95474e+06

-1 mm shift



Min(Ez) = -7.95428e+06

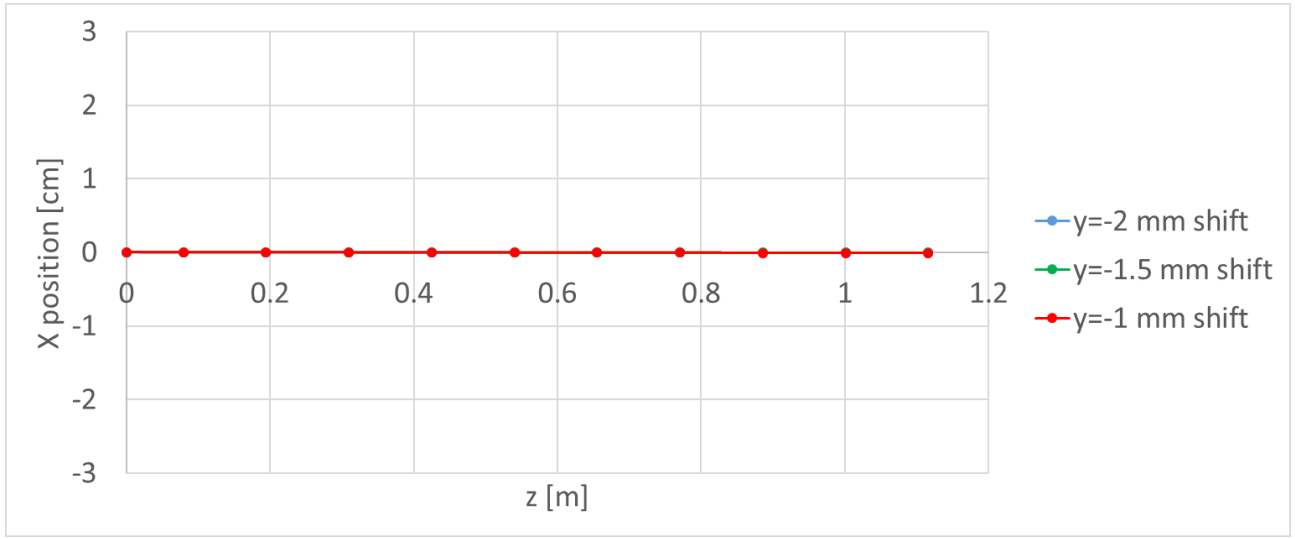
-1.5 mm shift

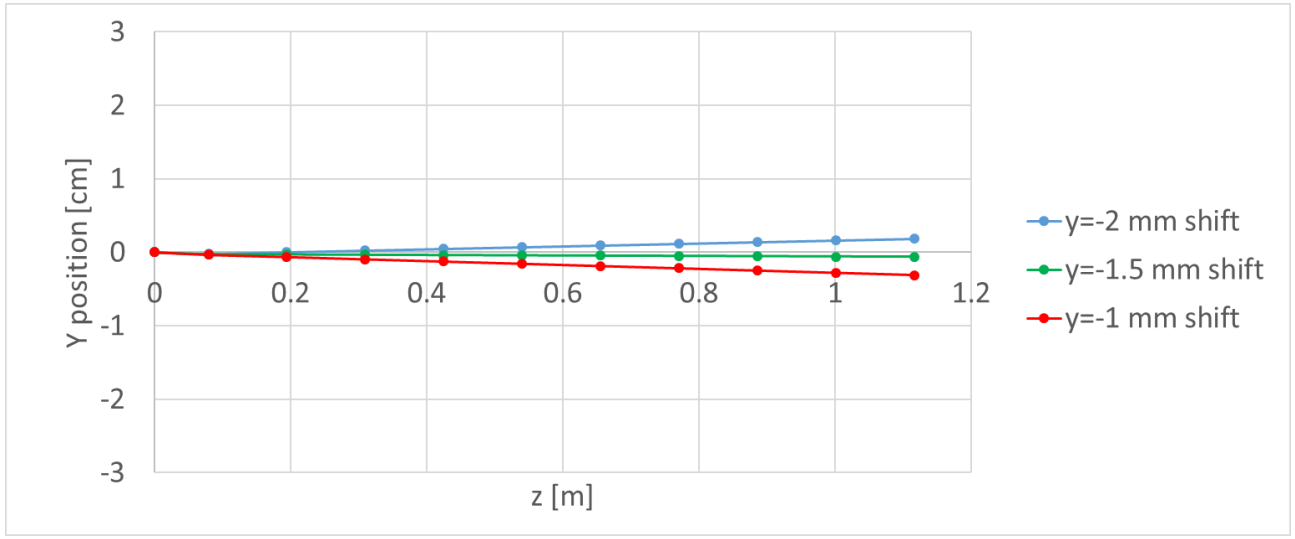


Min(Ez) = -7.9542e+06

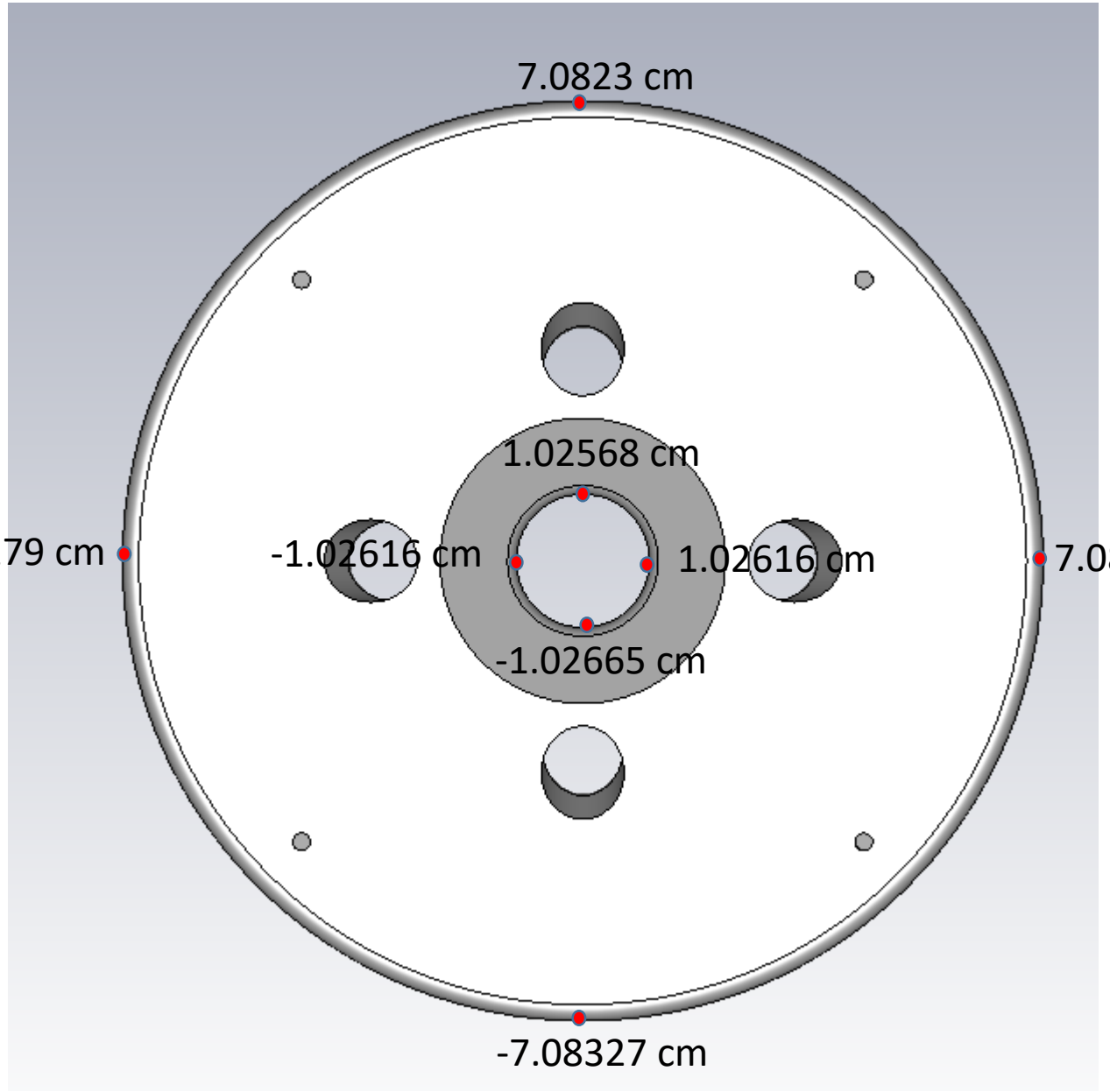
Shifted anode

Beam positions





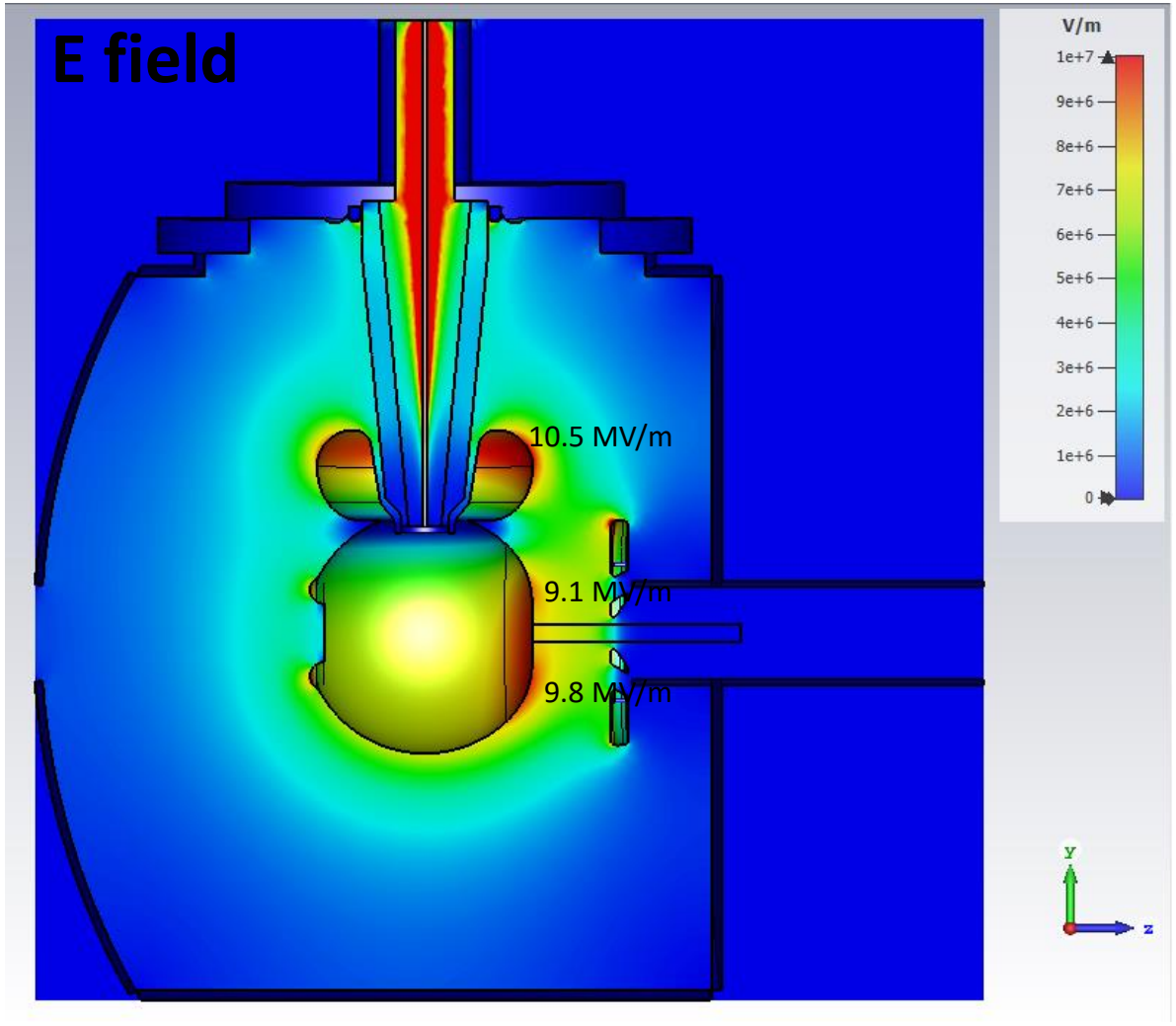
New Anode

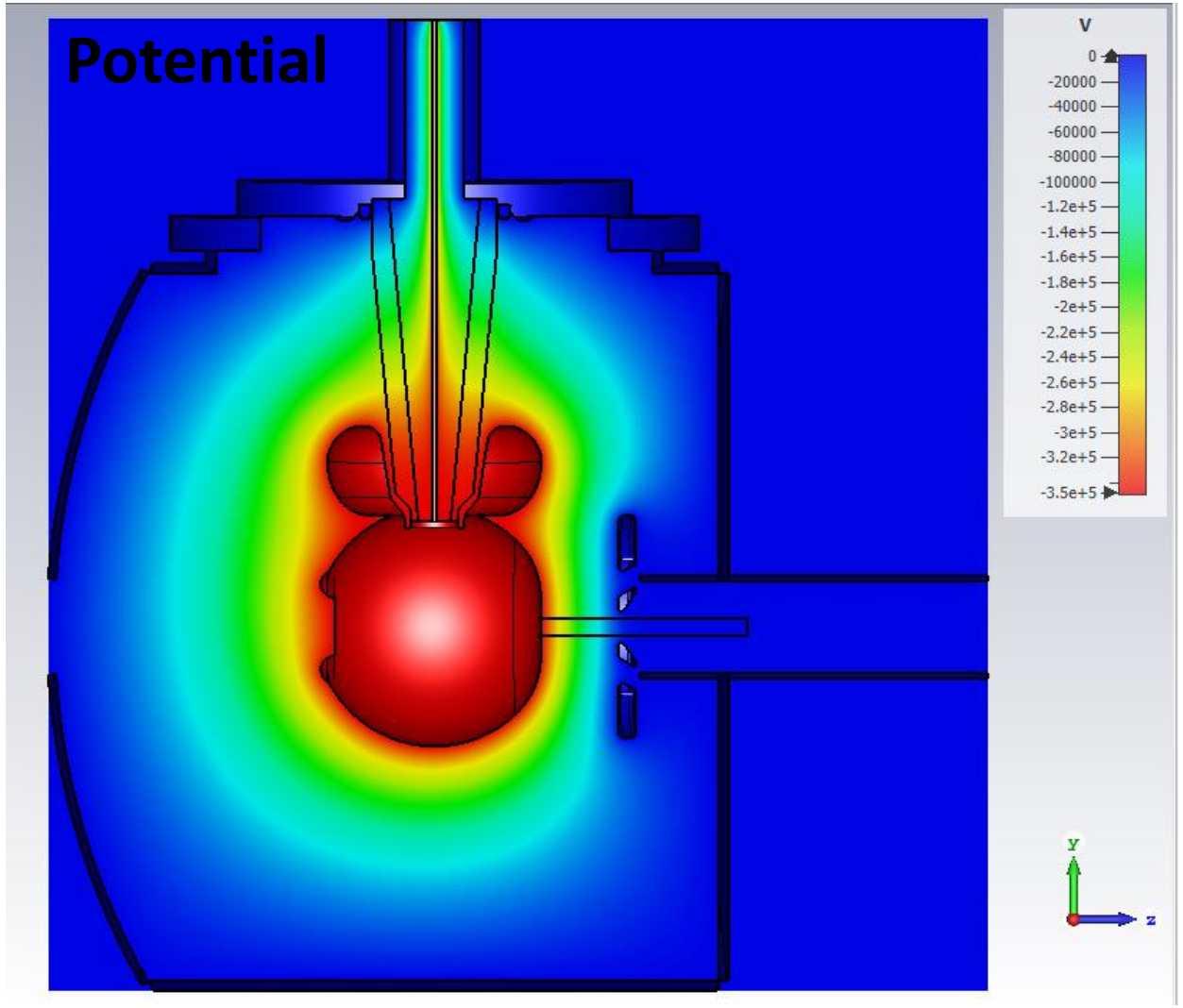

7.0823 cm
1.02568 cm
-7.08279 cm
-1.02616 cm
1.02616 cm
7.08279 cm
-1.02665 cm
-7.08327 cm

Flat cathode front and flat anode – no NEGs – cathode anode gap 5 cm

New anode – no shift

-350 kV at the cathode, 0 V at the anode

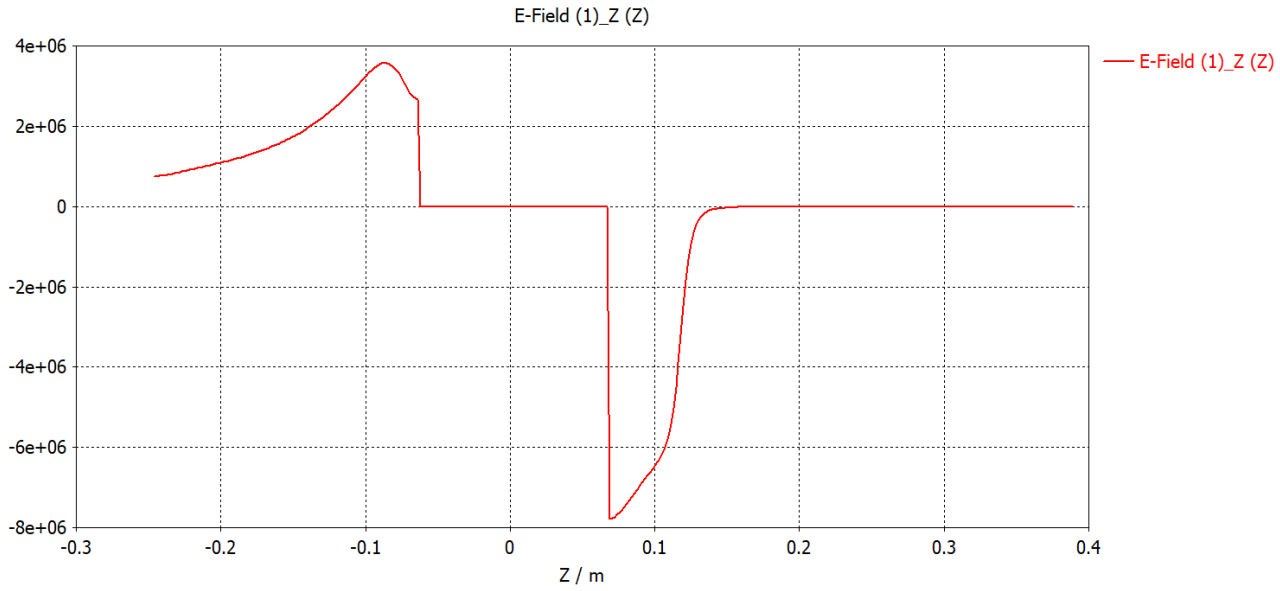


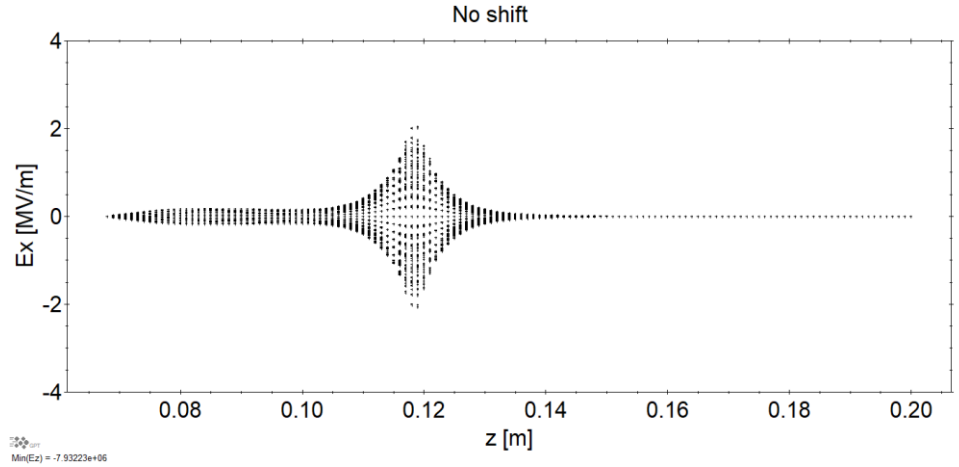


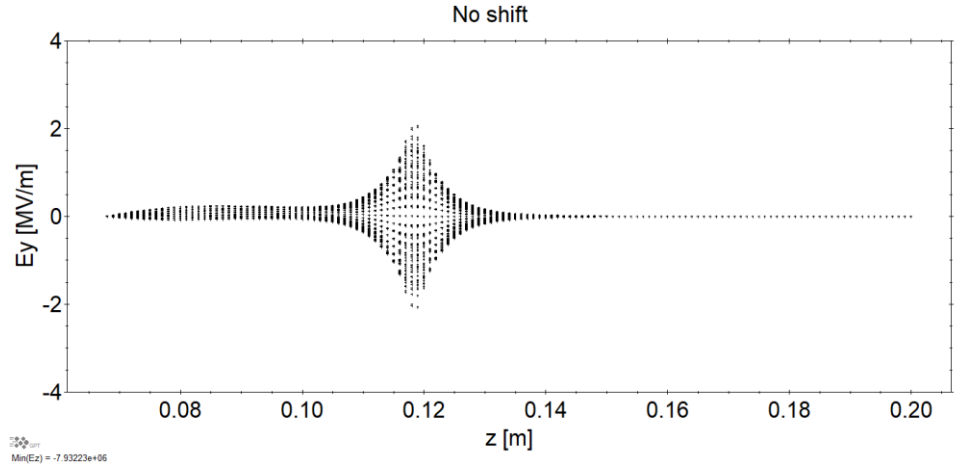
Flat cathode front and flat anode – no NEGs – cathode anode gap 5 cm

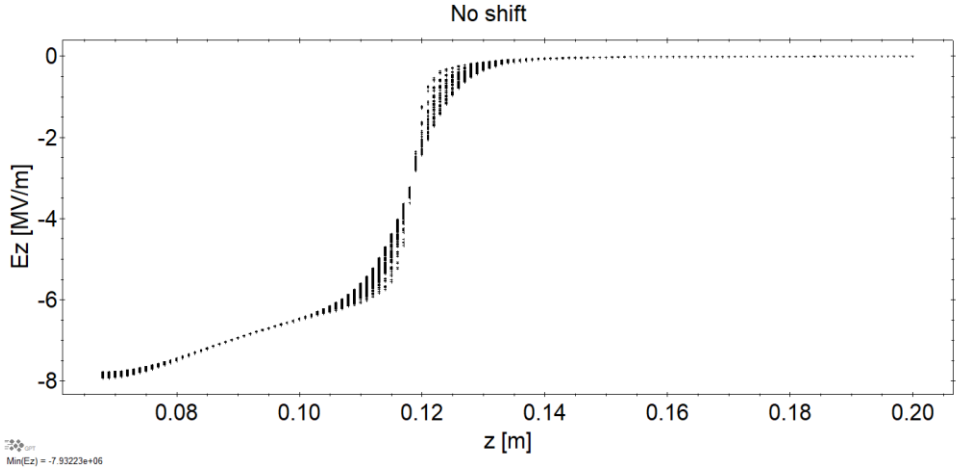
New anode – no shift

-350 kV at the cathode, 0 V at the anode





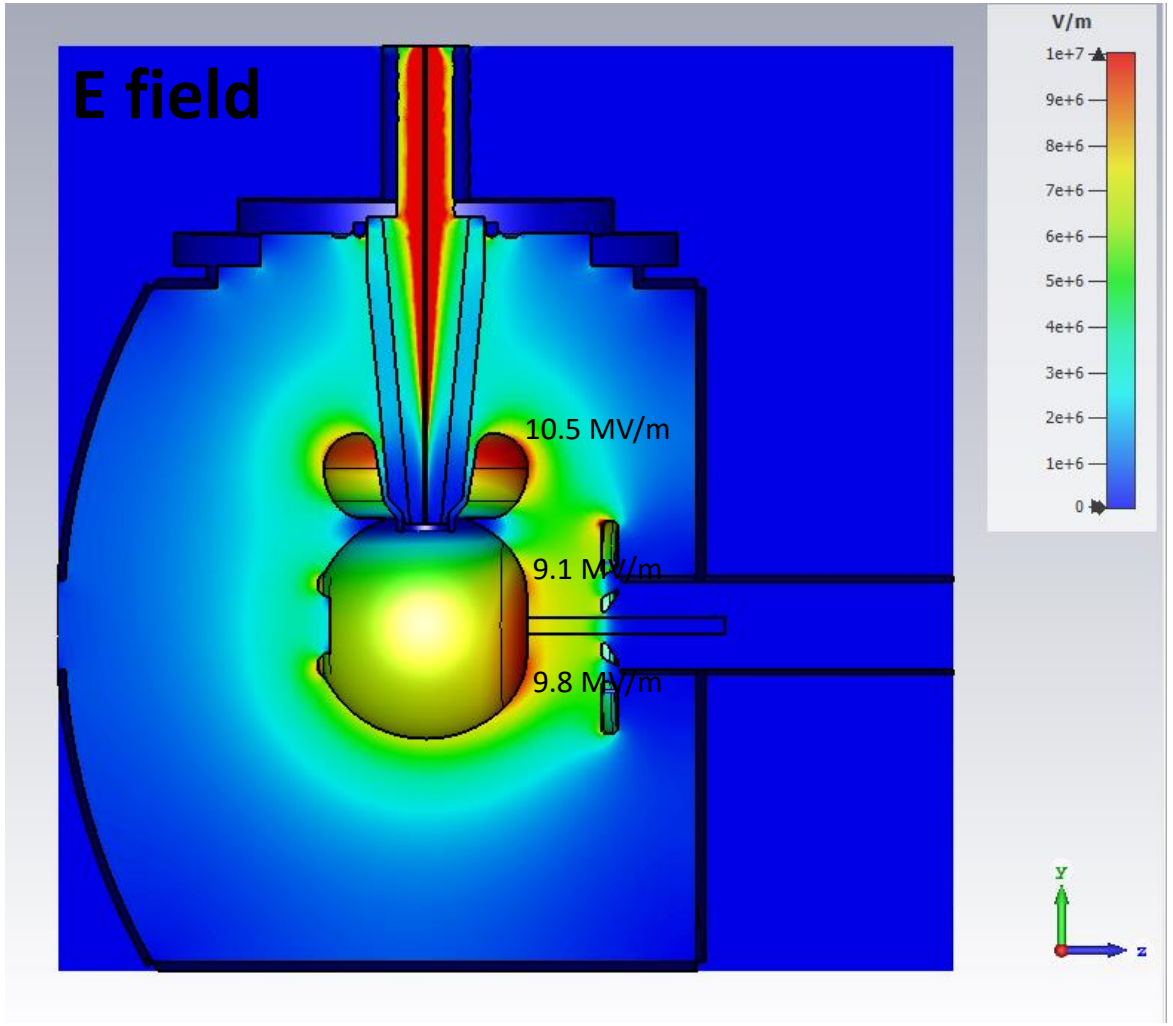


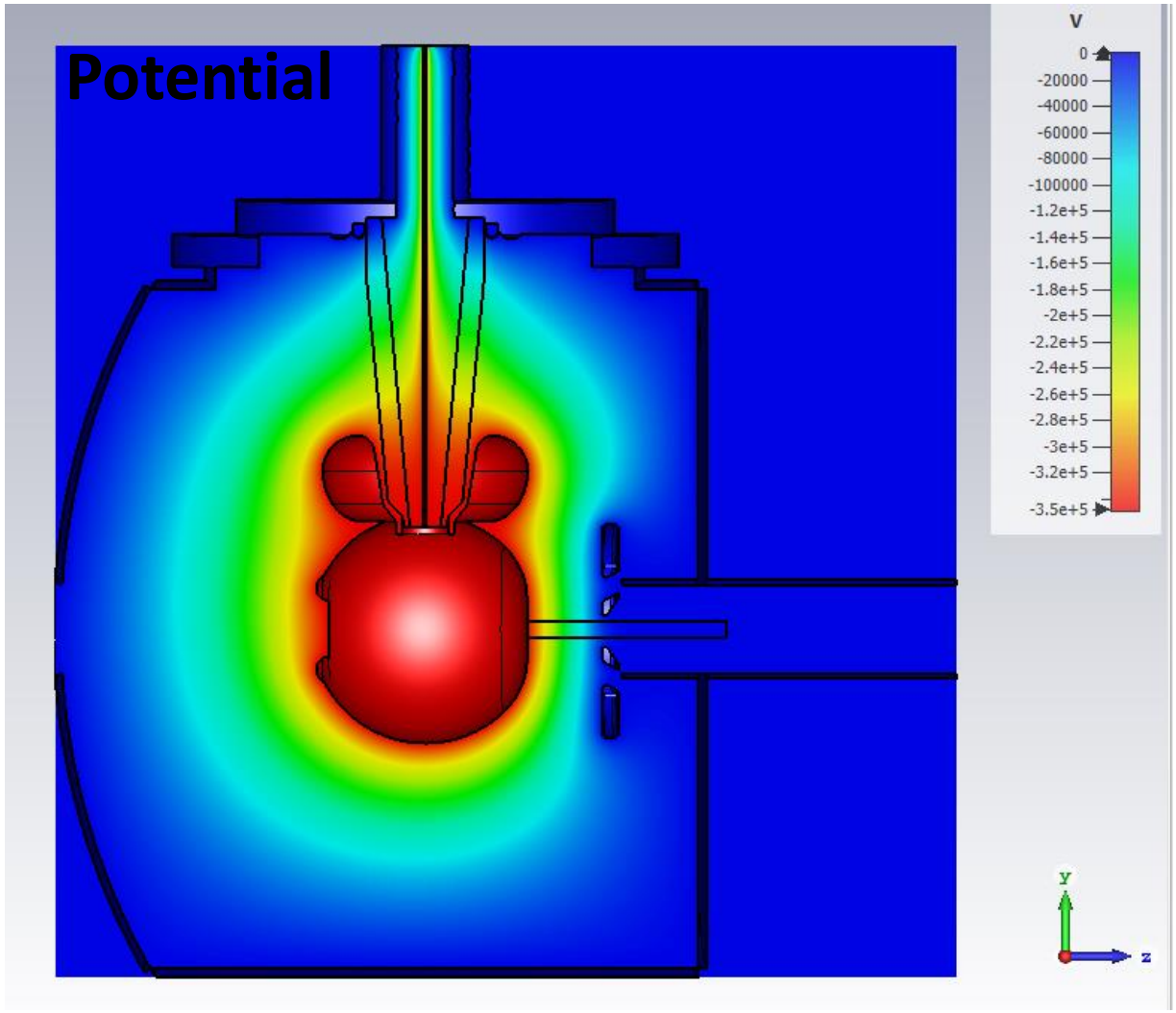


Flat cathode front and flat anode – no NEGs – cathode anode gap 5 cm

New anode -1.6 mm shift

-350 kV at the cathode, 0 V at the anode

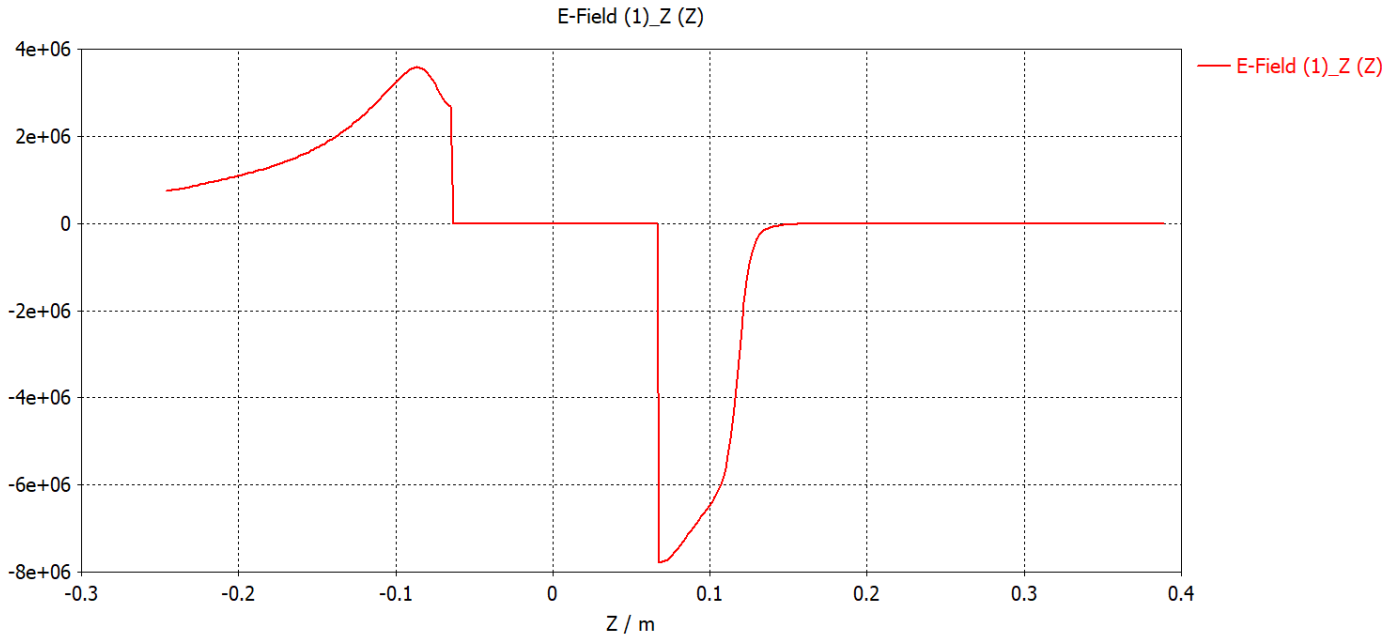


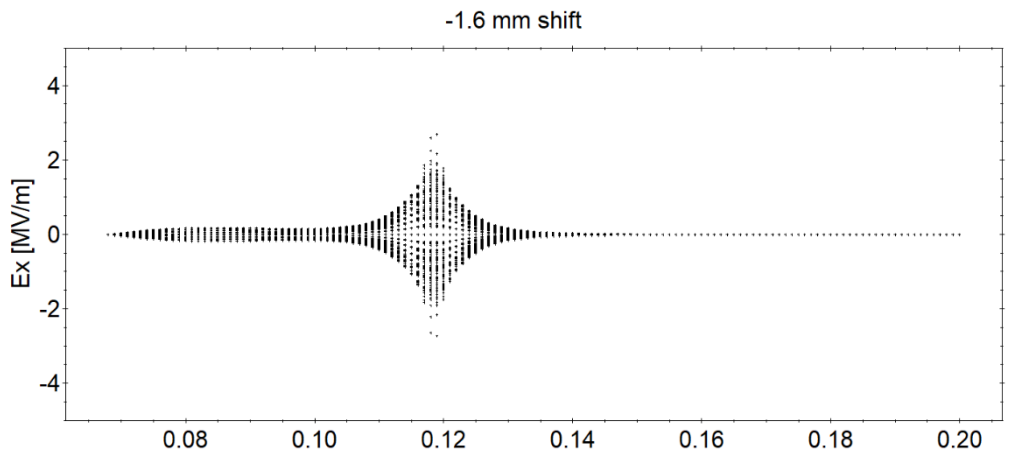


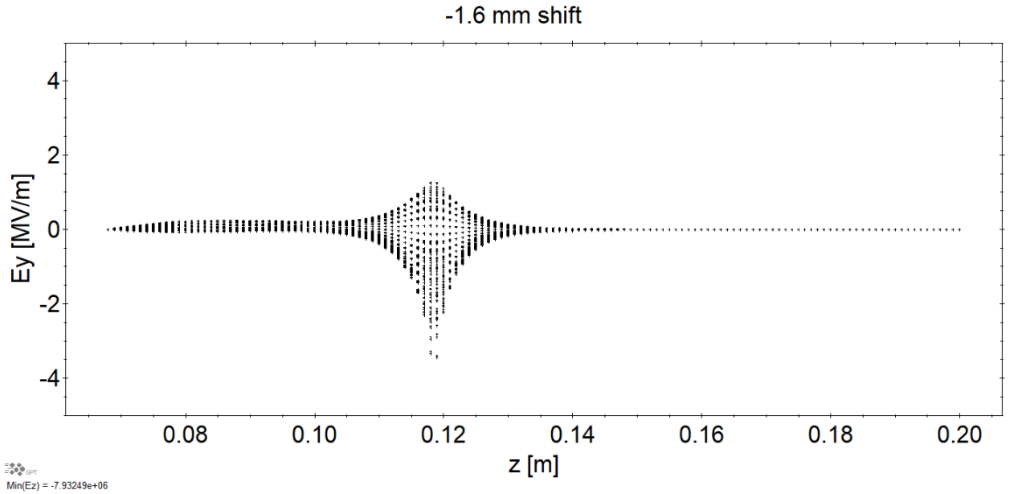
Flat cathode front and flat anode – no NEGs – cathode anode gap 5 cm

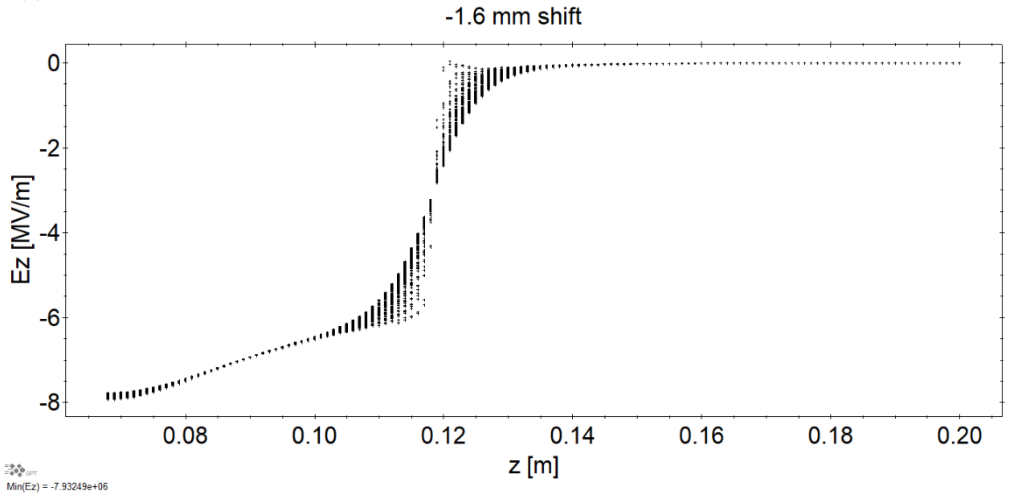
New anode -1.6 mm shift

-350 kV at the cathode, 0 V at the anode





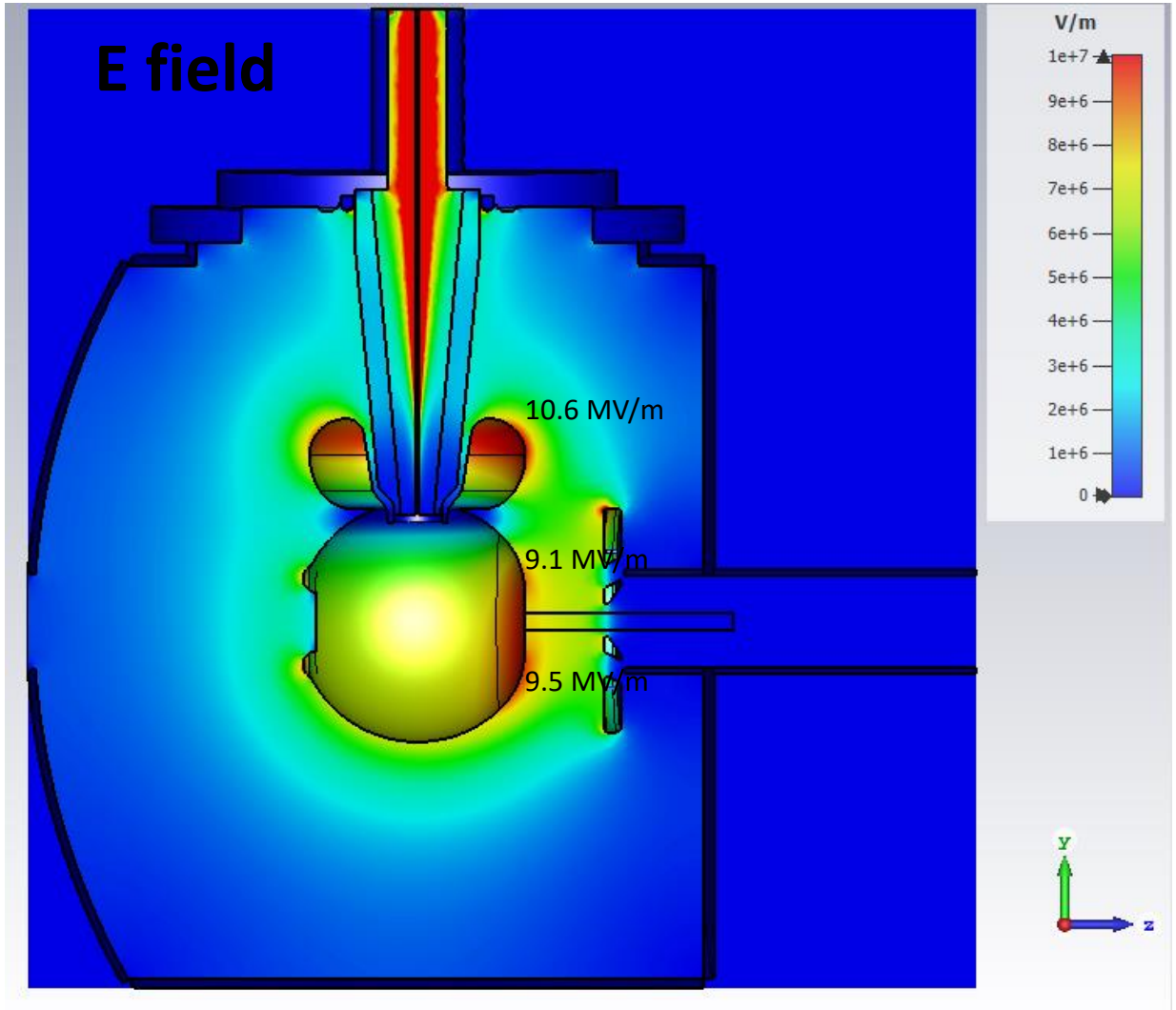


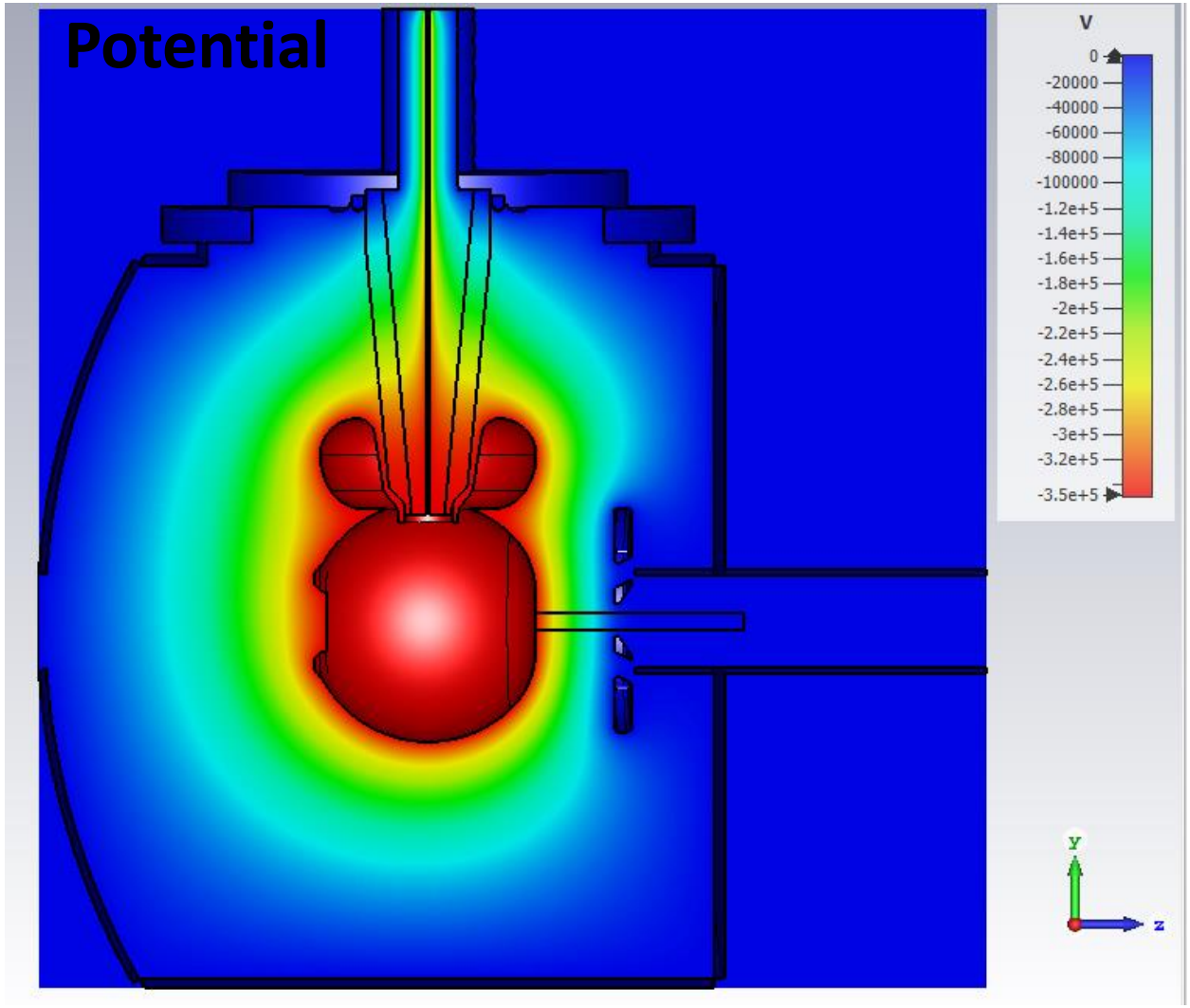


Flat cathode front and flat anode – no NEGs – cathode anode gap 5 cm

New anode +1 mm shift

-350 kV at the cathode, 0 V at the anode

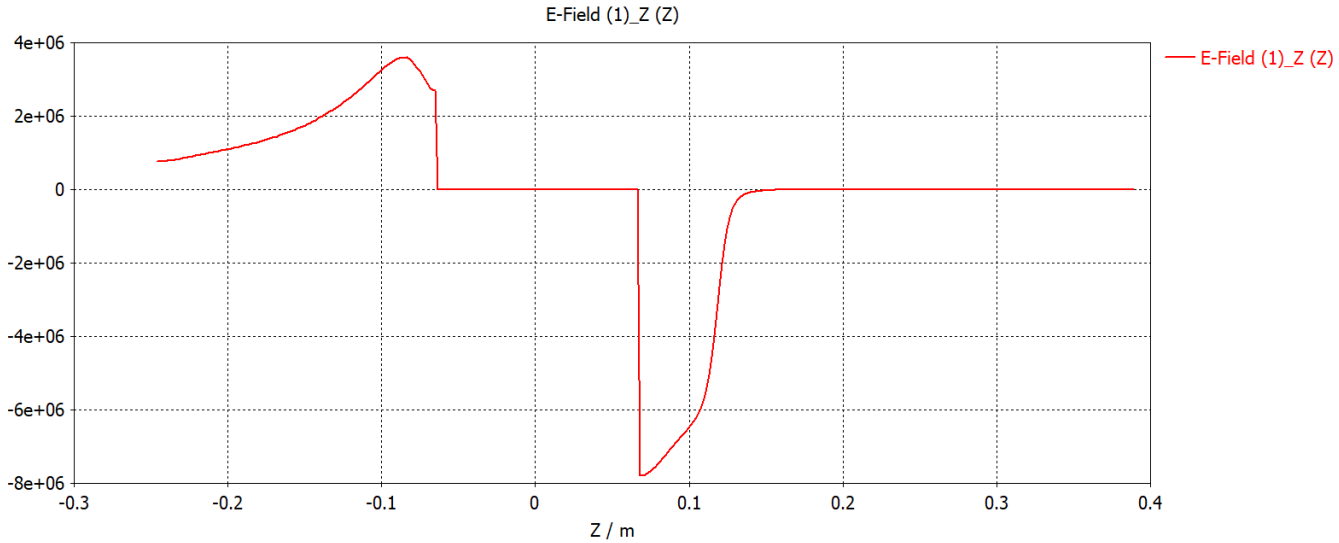


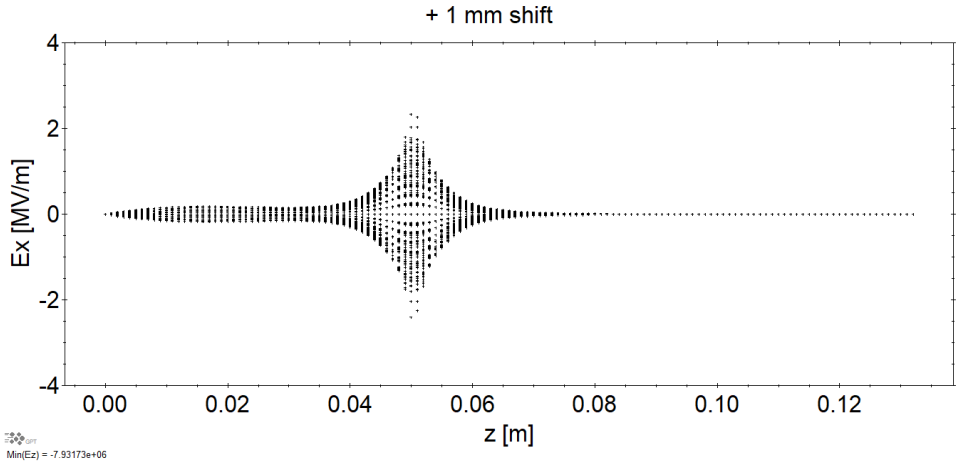


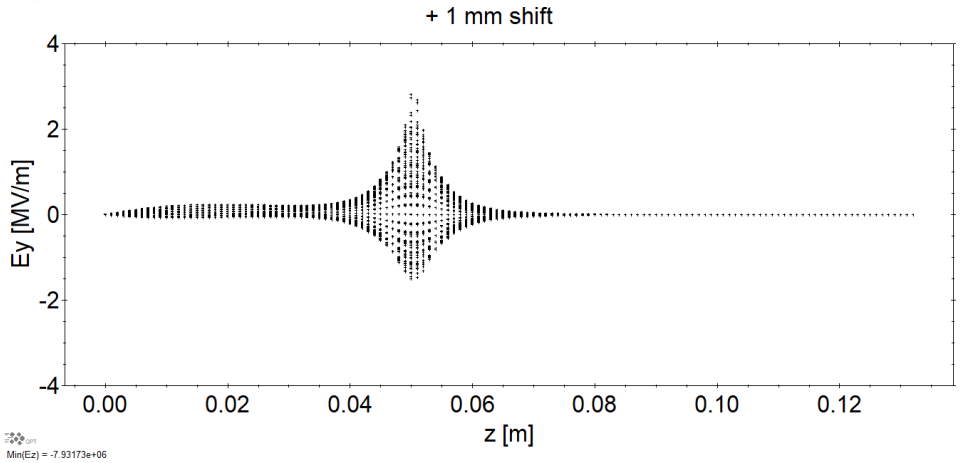
Flat cathode front and flat anode – no NEGs – cathode anode gap 5 cm

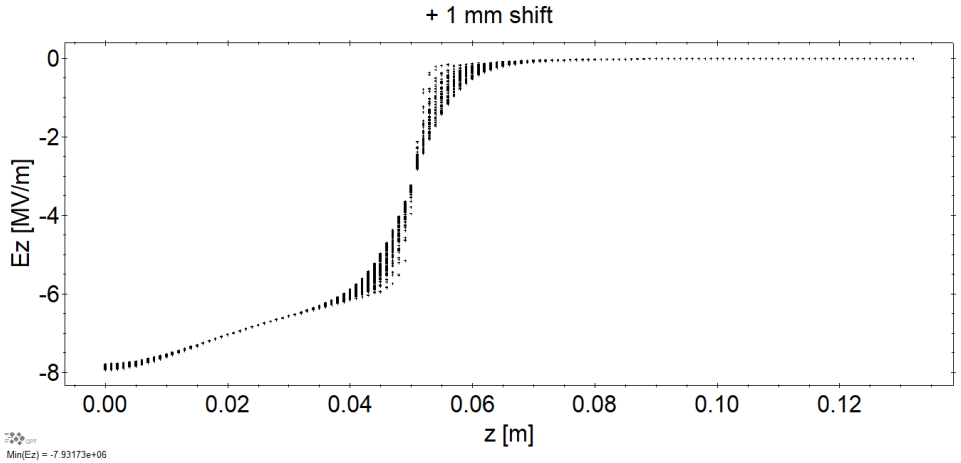
New anode +1 mm shift

-350 kV at the cathode, 0 V at the anode





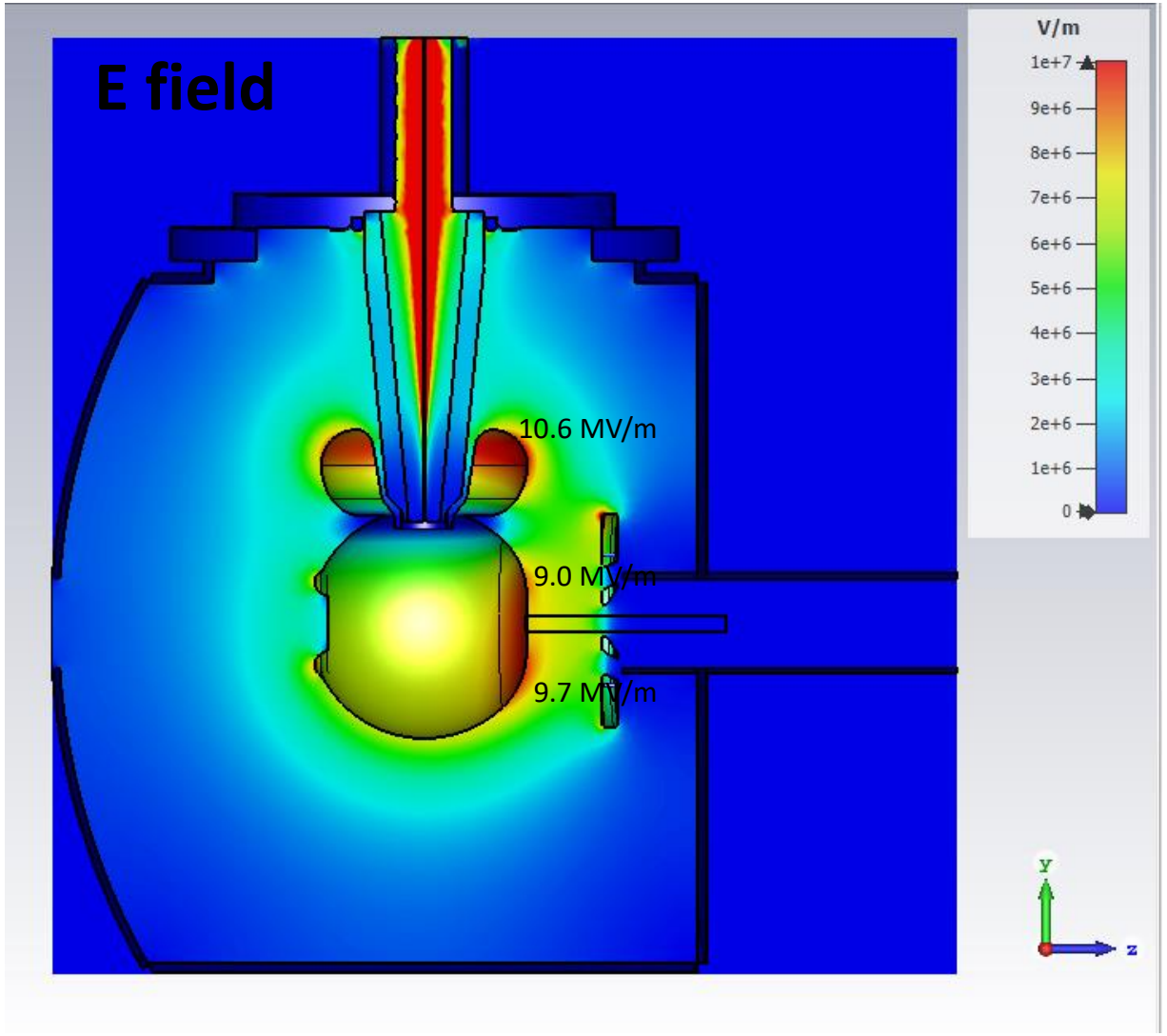


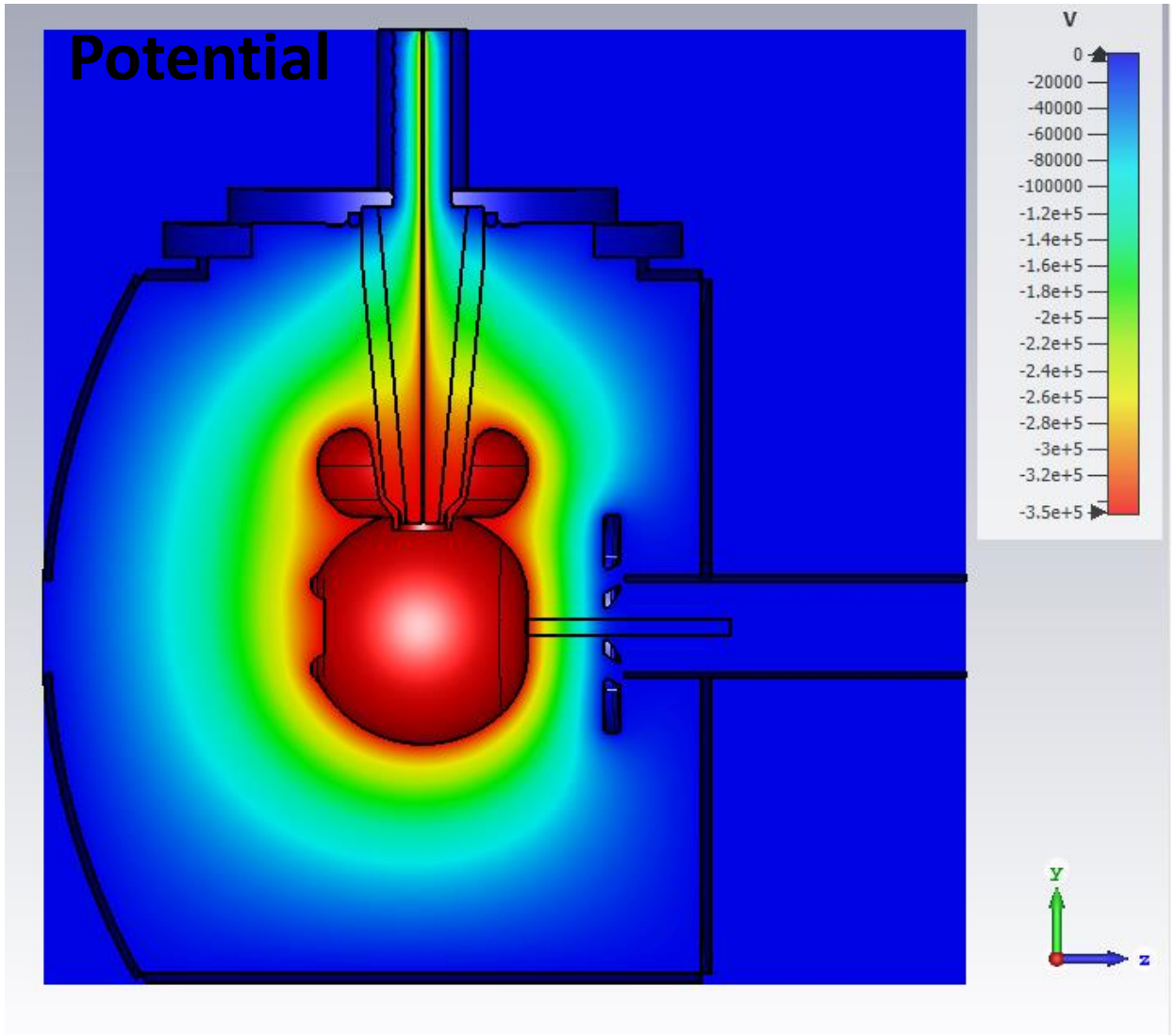


Flat cathode front and flat anode – no NEGs – cathode anode gap 5 cm

New anode +2 mm shift

-350 kV at the cathode, 0 V at the anode

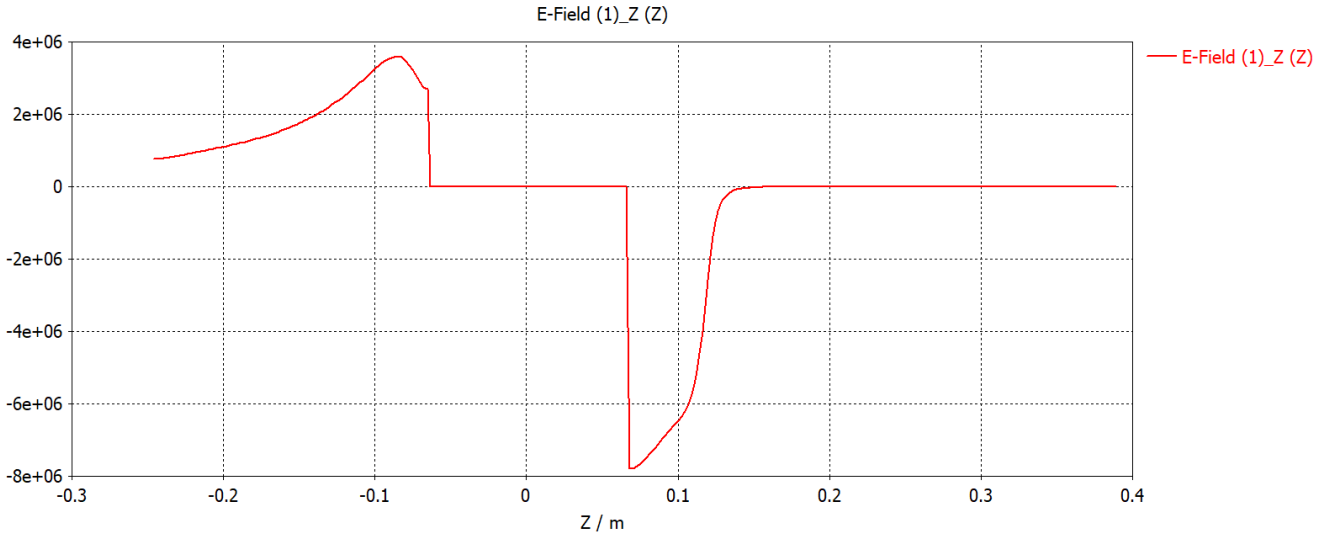


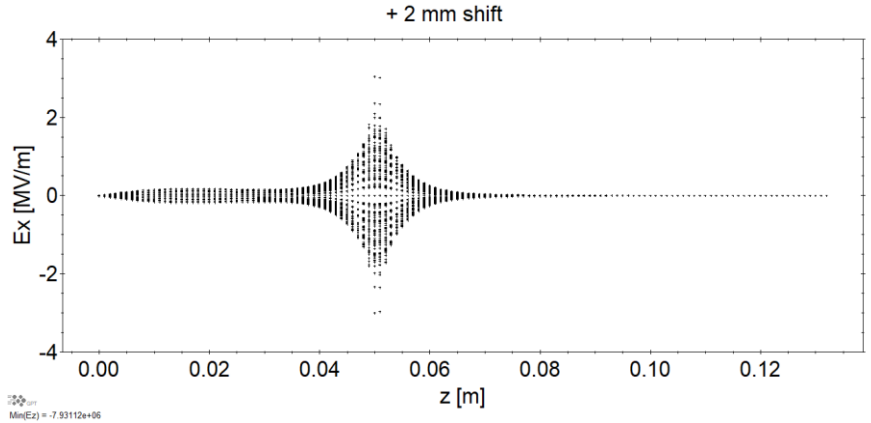


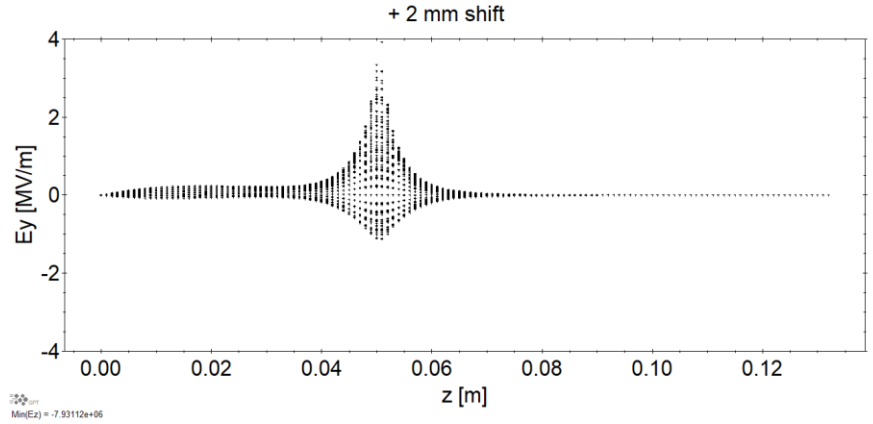
Flat cathode front and flat anode – no NEGs – cathode anode gap 5 cm

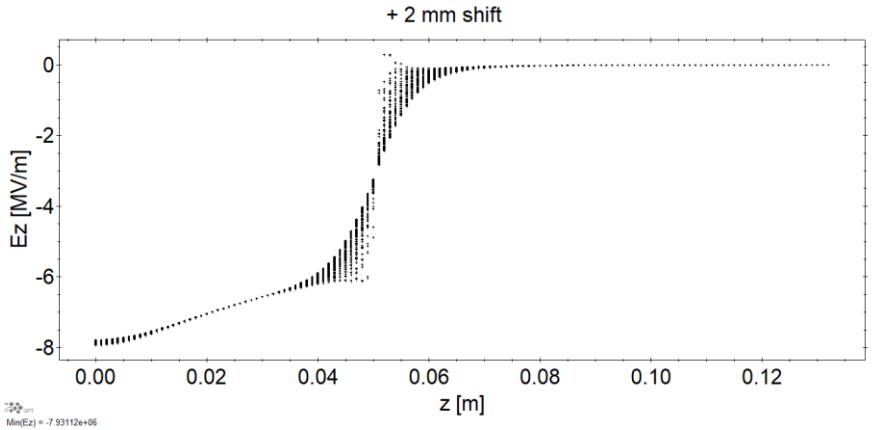
New anode +2 mm shift

-350 kV at the cathode, 0 V at the anode



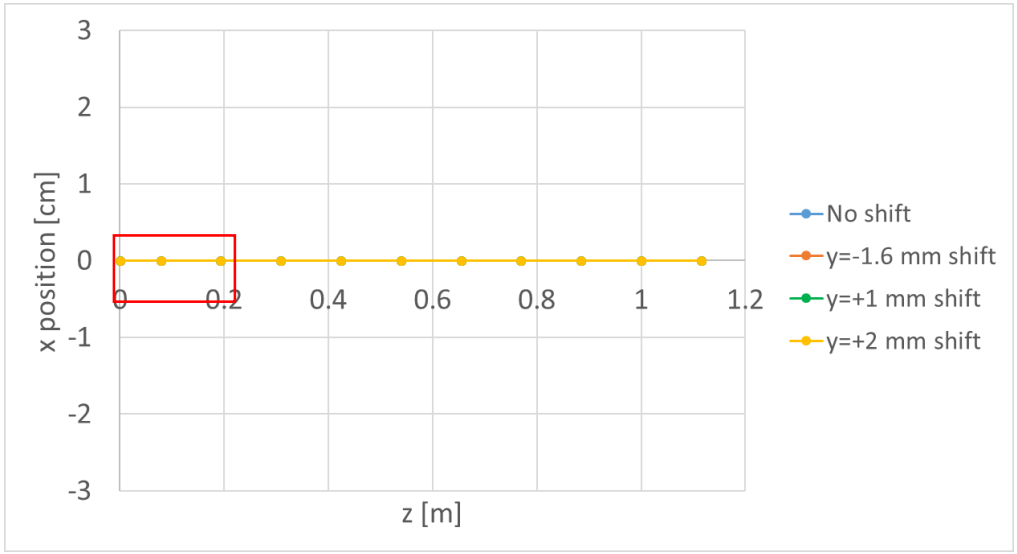


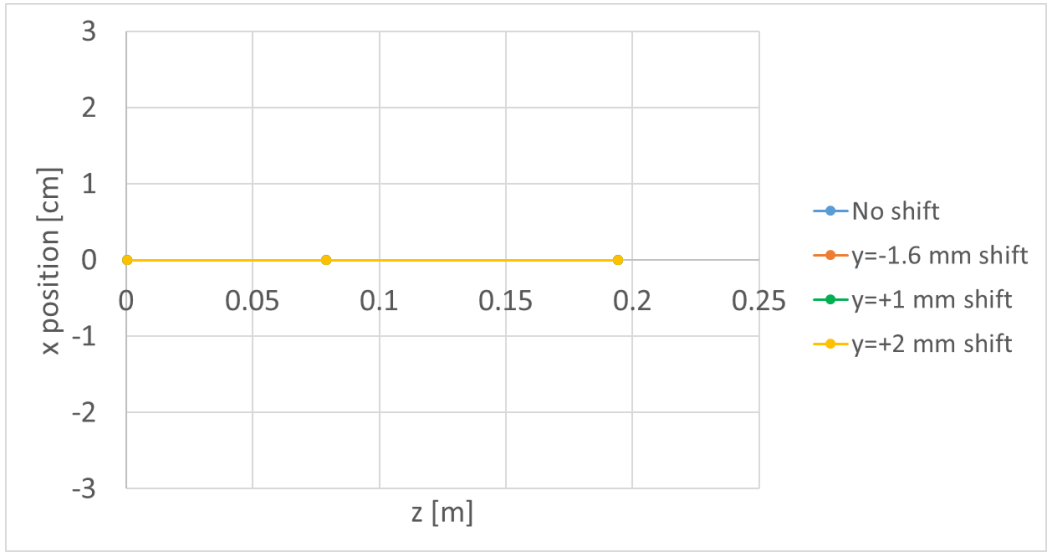


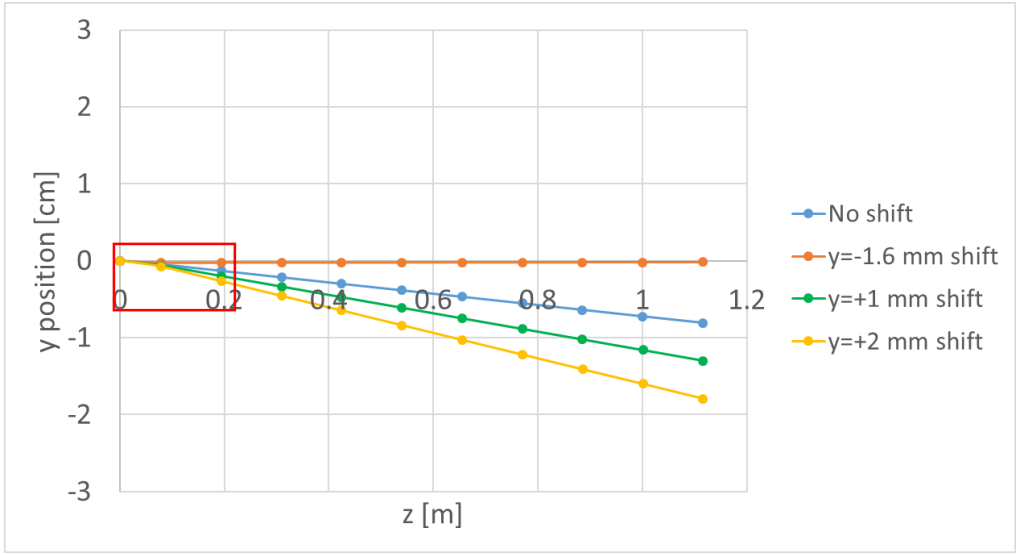


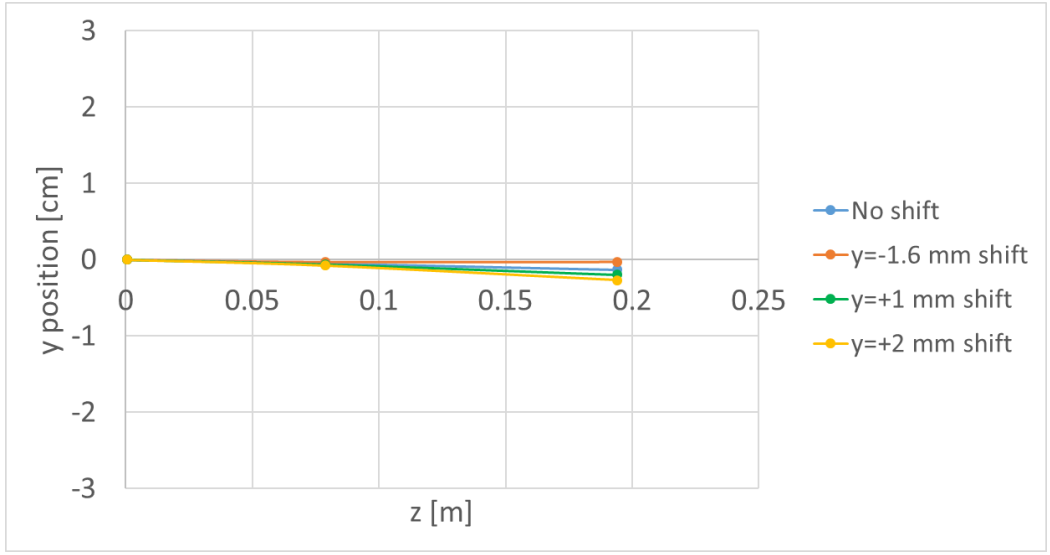
New anode

Beam positions





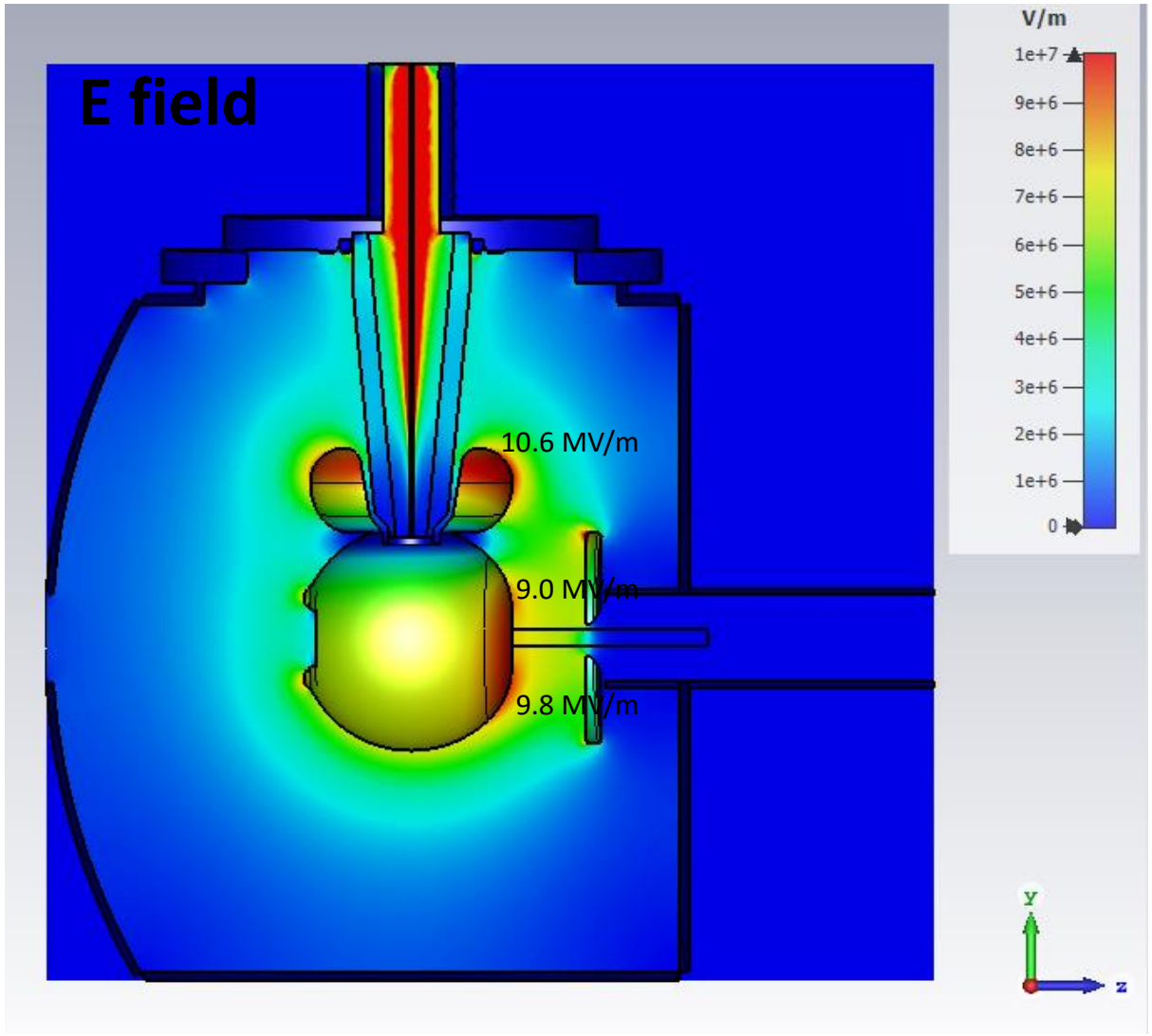


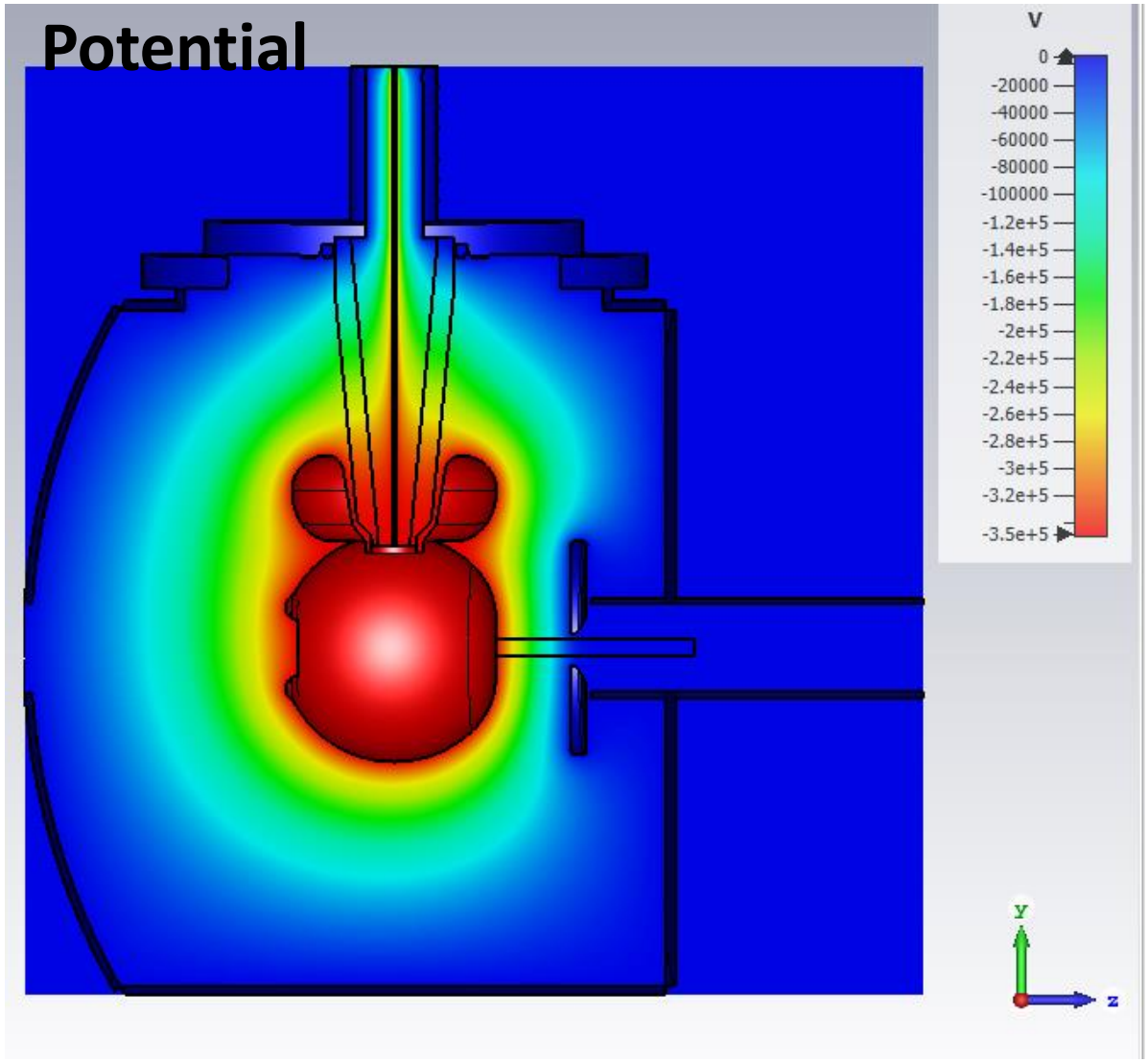


Flat cathode front and flat anode – no NEGs – cathode anode gap 5 cm

New anode - only anode hole shifted -1.6 mm

-350 kV at the cathode, 0 V at the anode





Flat cathode front and flat anode – no NEGs – cathode anode gap 5 cm

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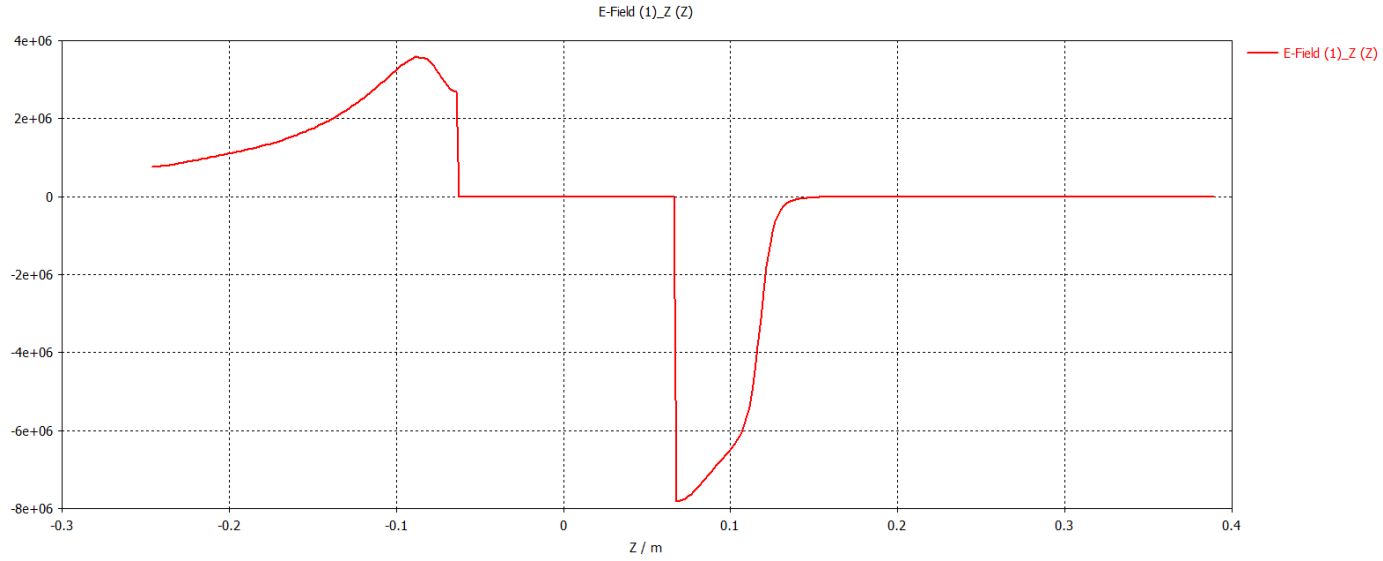
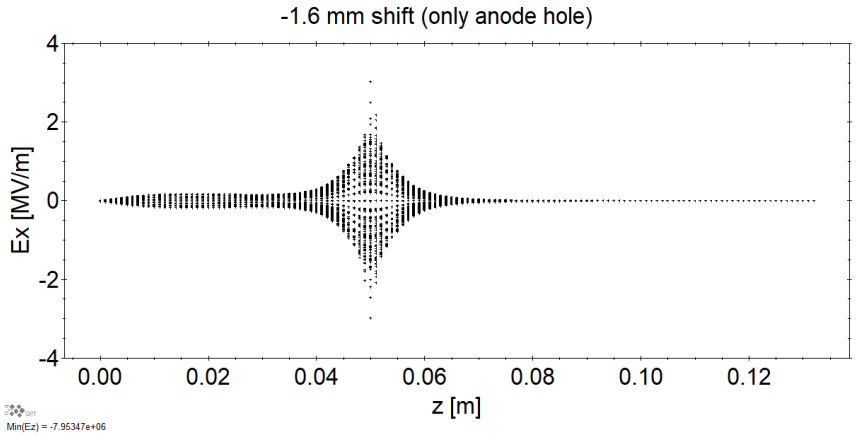
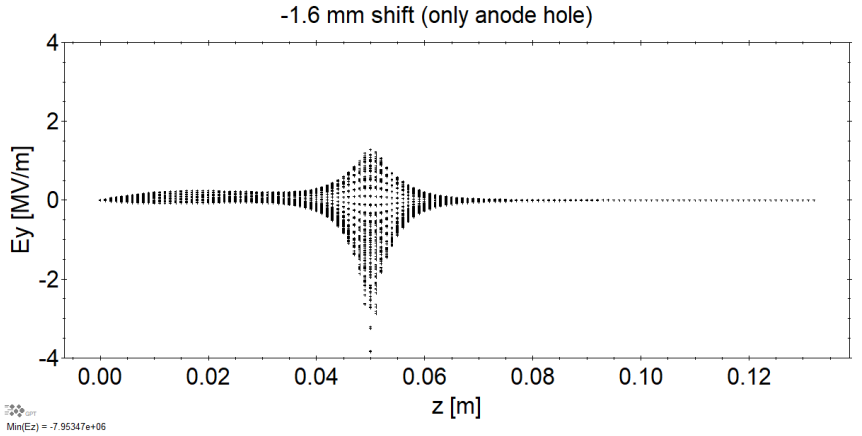
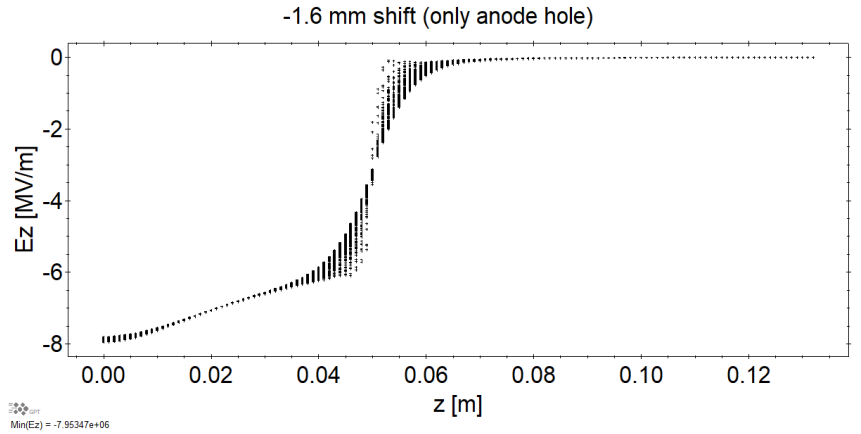
-350 kV at the cathode, 0 V at the anode

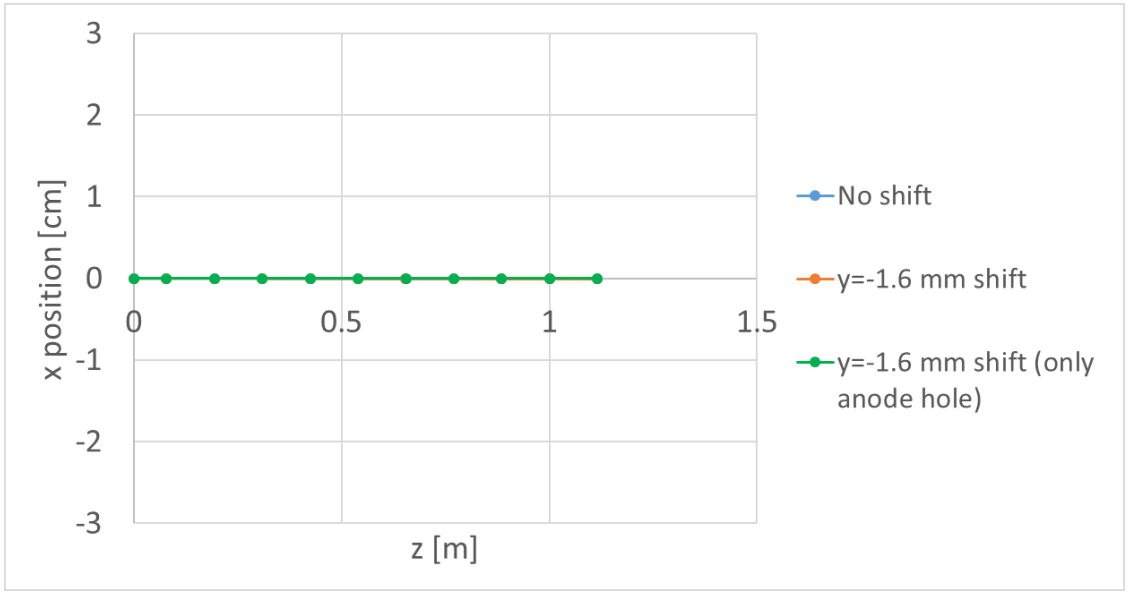


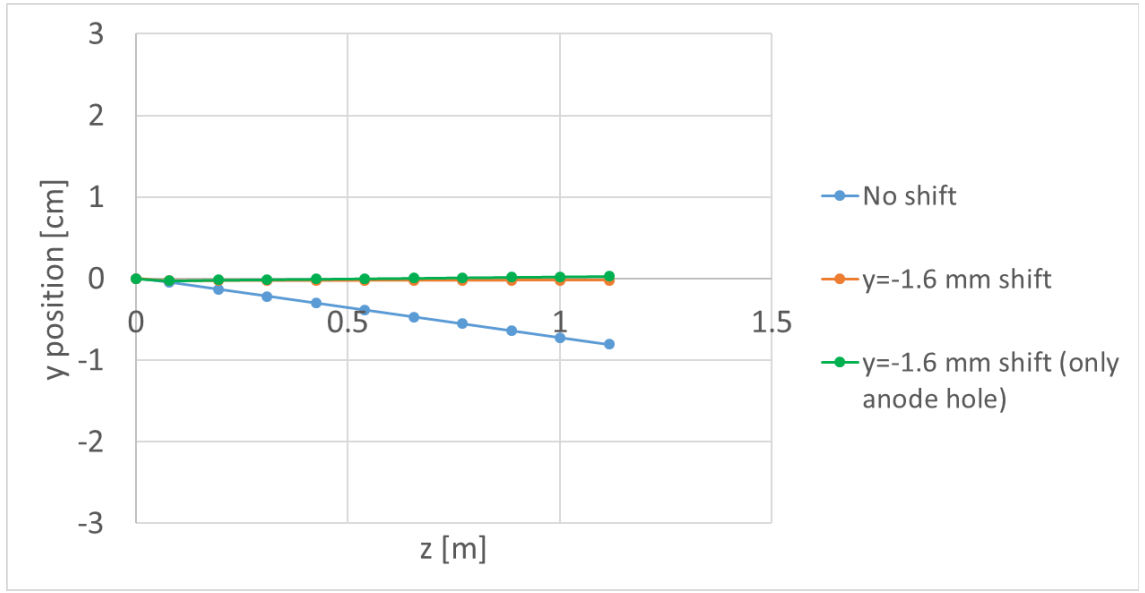




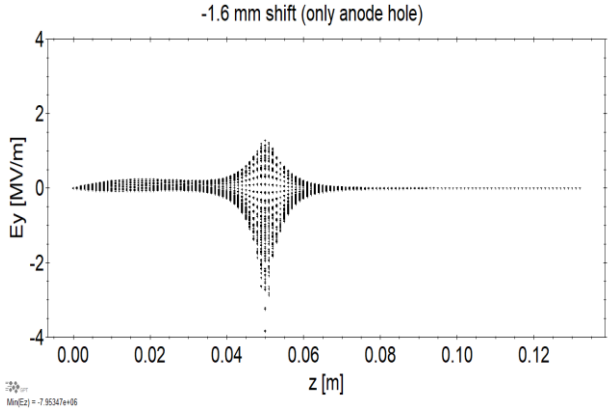


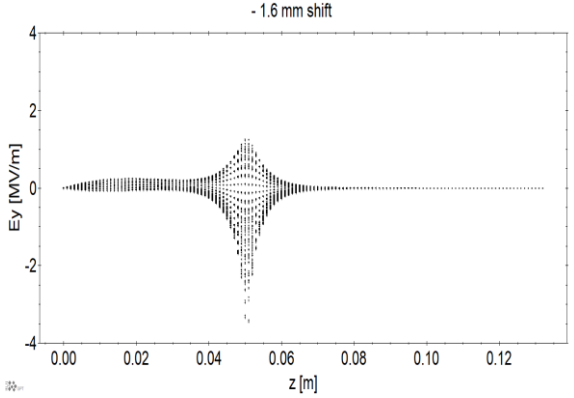
Anode shift vs anode hole shift

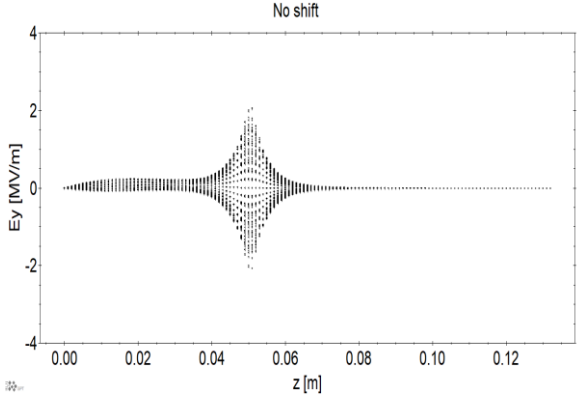


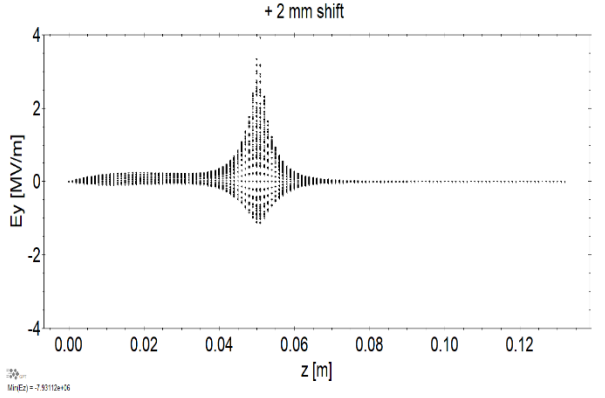


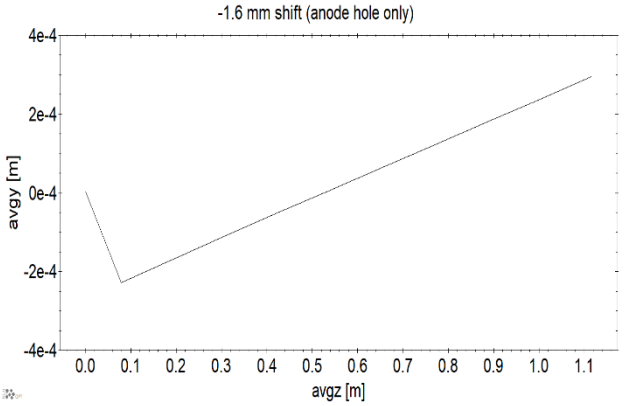
Ey and y beam position

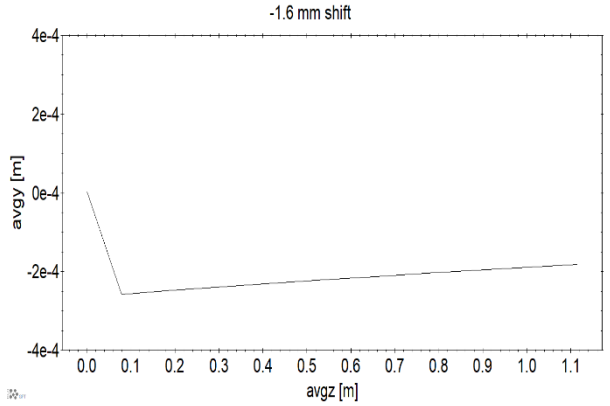


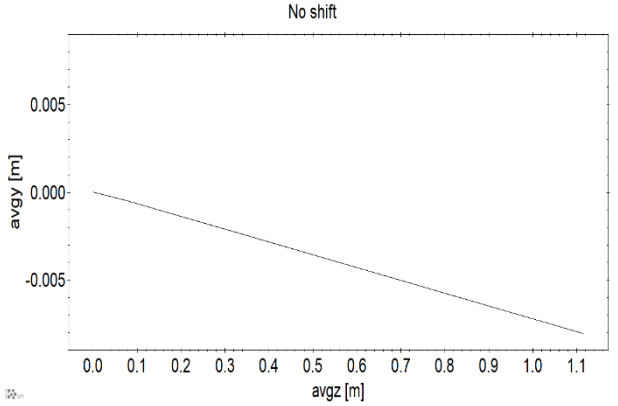


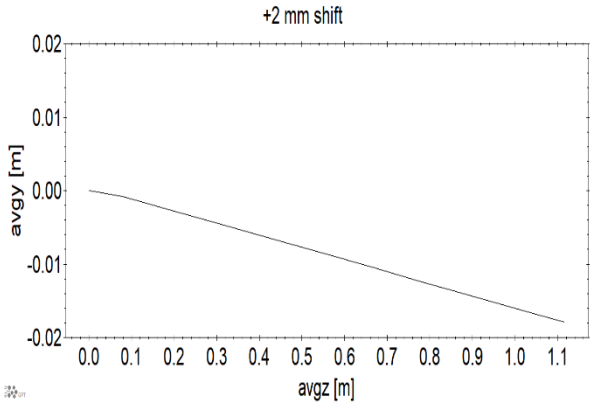




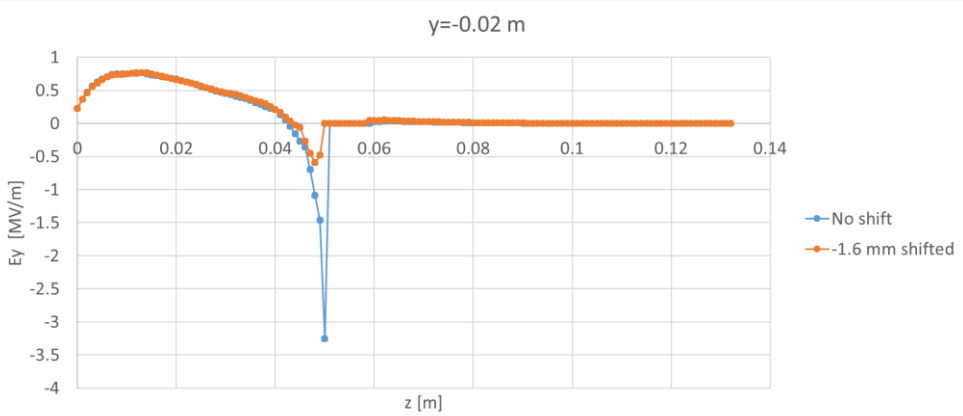


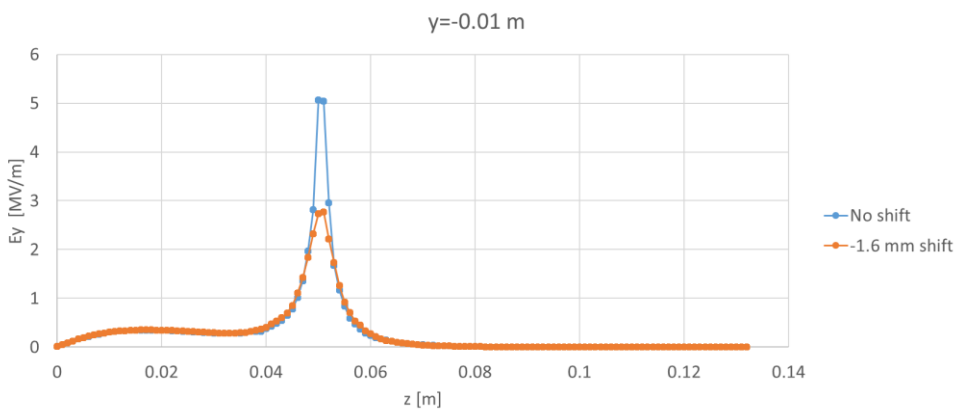


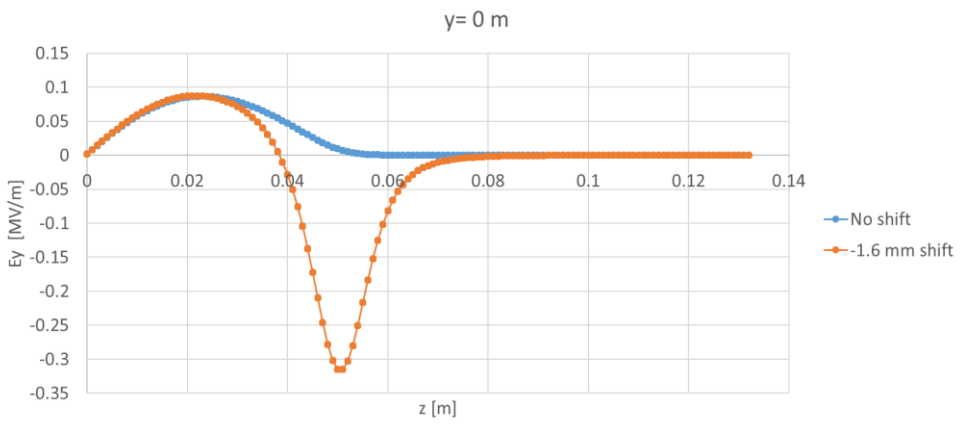


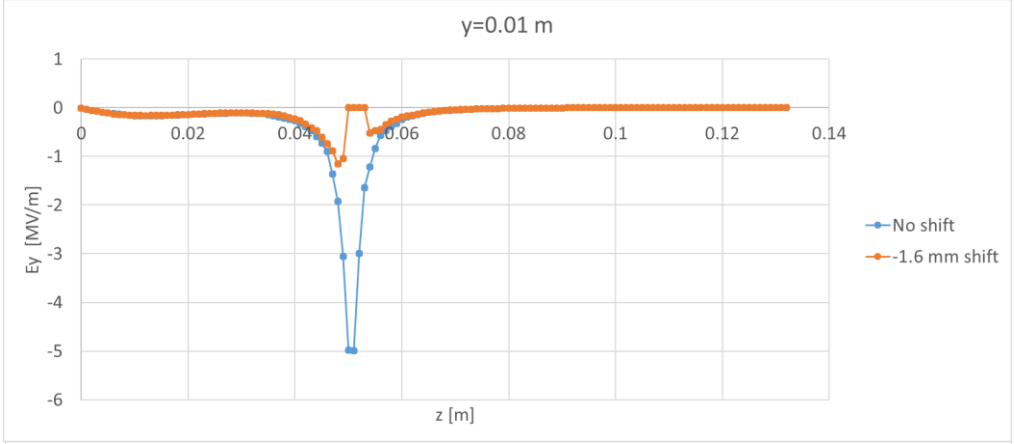


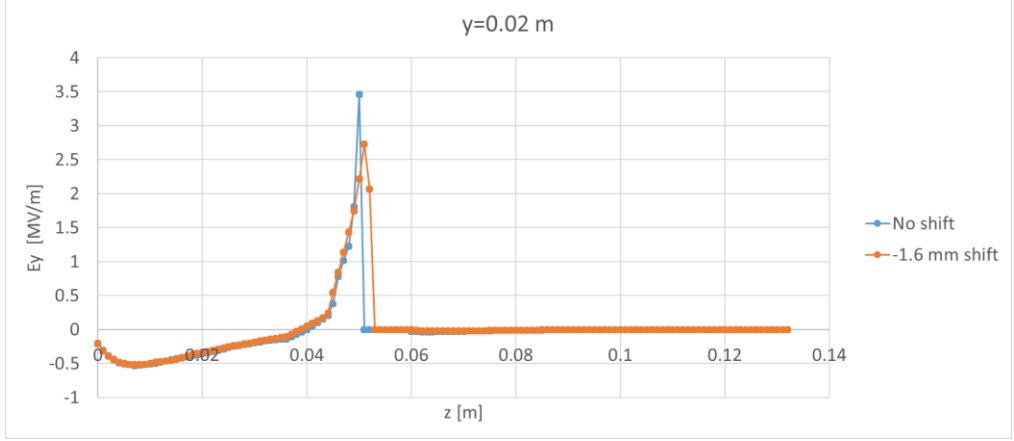
Ey vs z (at x=0)

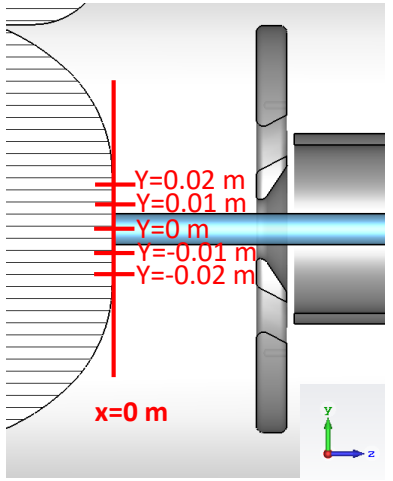

y=-0.02 m
Ey [MV/m]
z [m]
No shift
-1.6 mm shifted

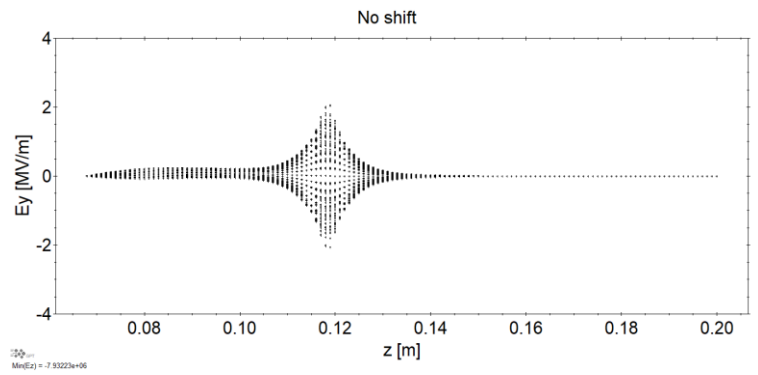

y=-0.01 m
Ey [MV/m]
z [m]
No shift
-1.6 mm shift

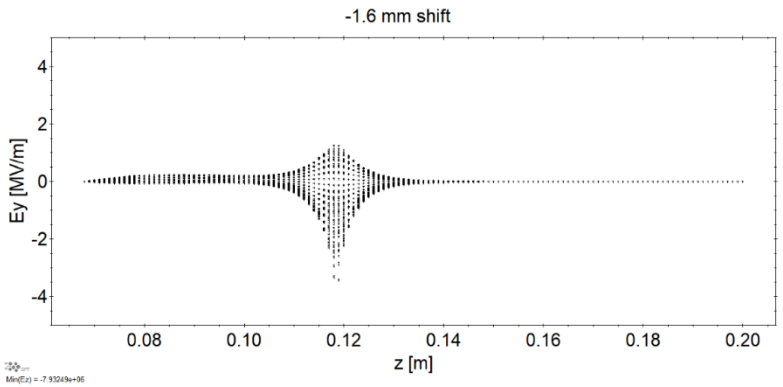

y= 0 m
Ey [MV/m]
z [m]
No shift
-1.6 mm shift

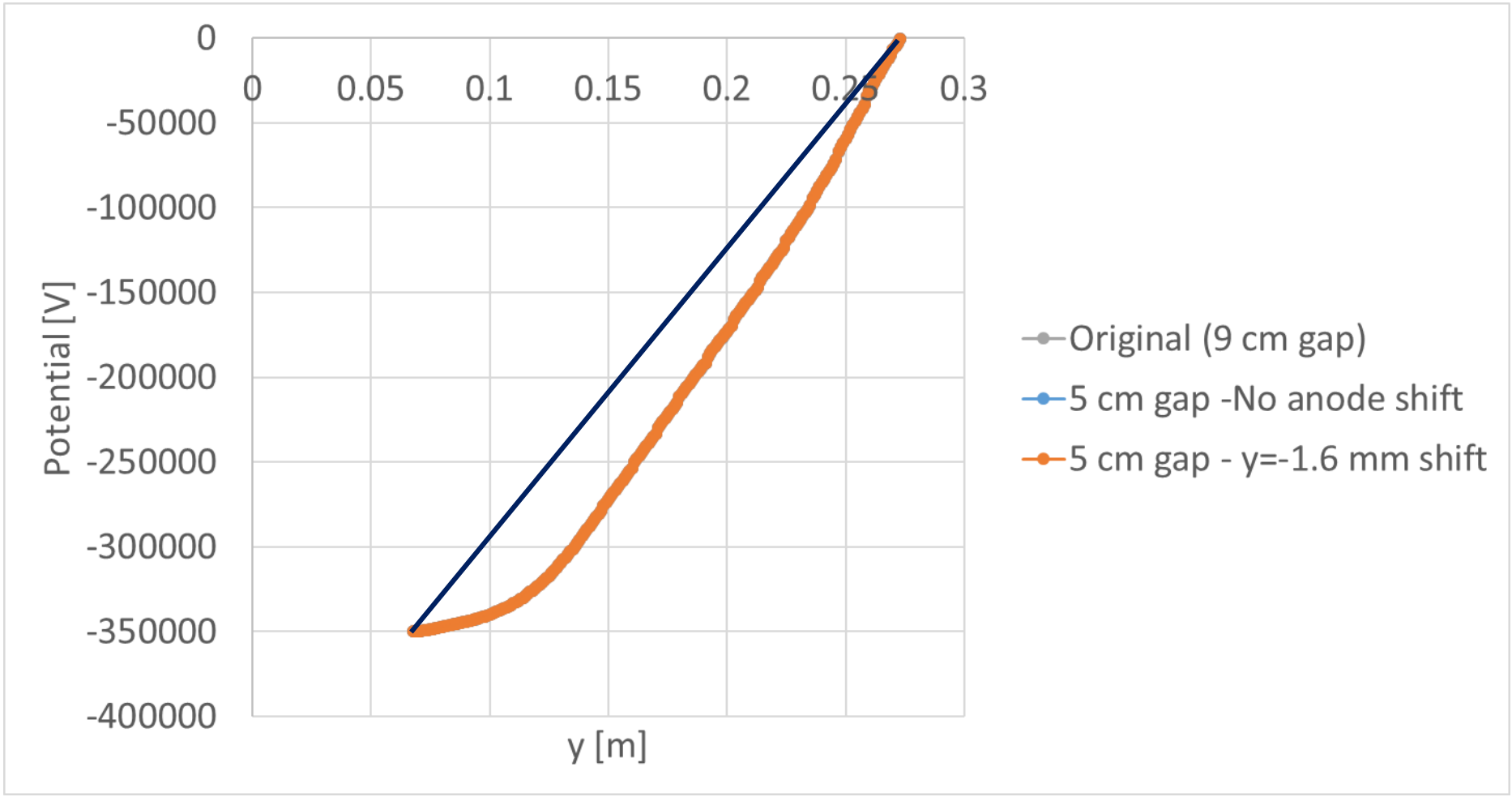
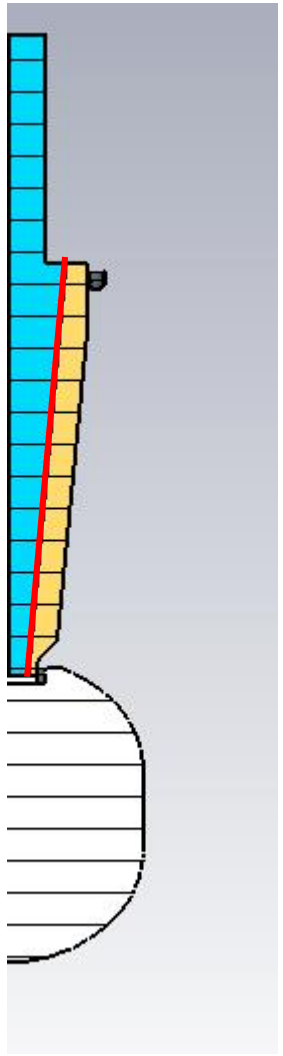

y=0.01 m
Ey [MV/m]
z [m]
No shift
-1.6 mm shift


y=0.02 m
Ey [MV/m]
z [m]
No shift
-1.6 mm shift


Y=0.02 m
Y=0.01 m
Y=0 m
Y=-0.01 m
Y=-0.02 m
x=0 m


No shift
Ey [MV/m]
z [m]


-1.6 mm shift
Ey [MV/m]
z [m]

Potential along the insulator-rubber interface

same shed