Study and Optimization of 5.1 PITZ RF Gun for the DESY Photo-Injector Test Facility

By:

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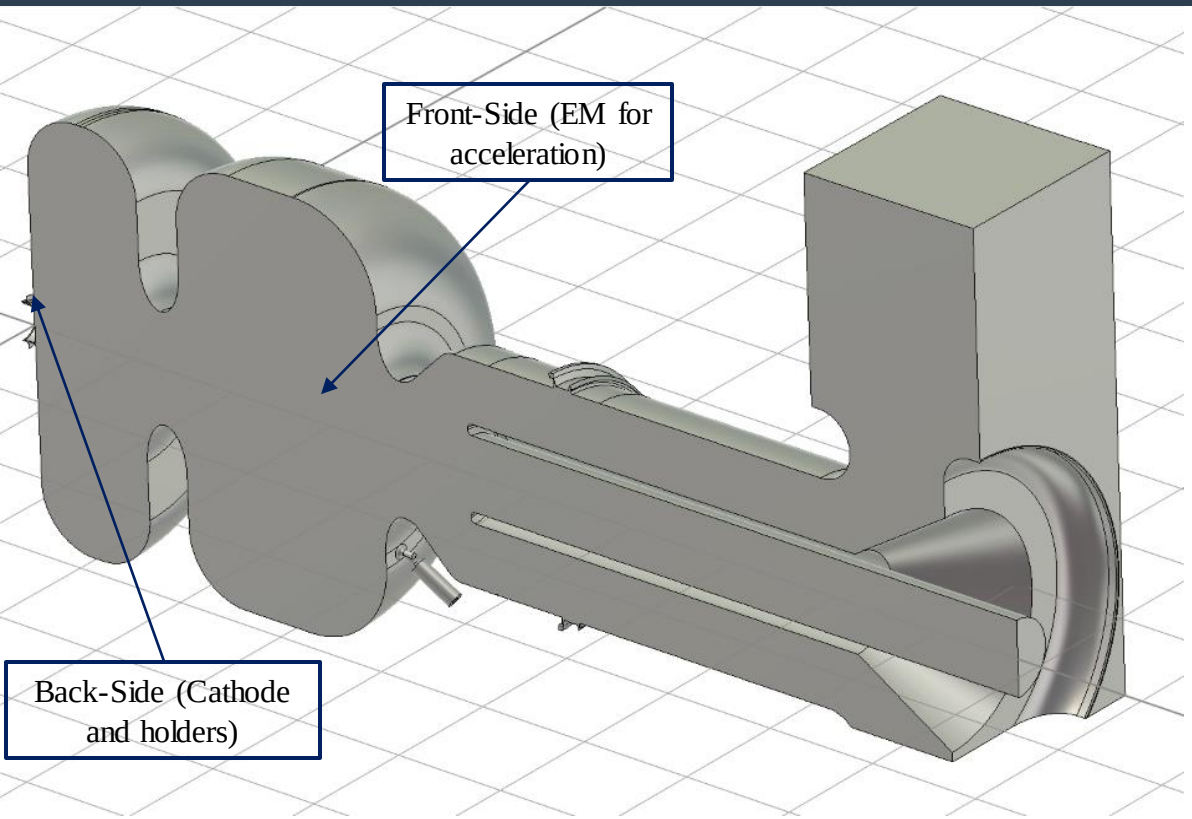
Contents

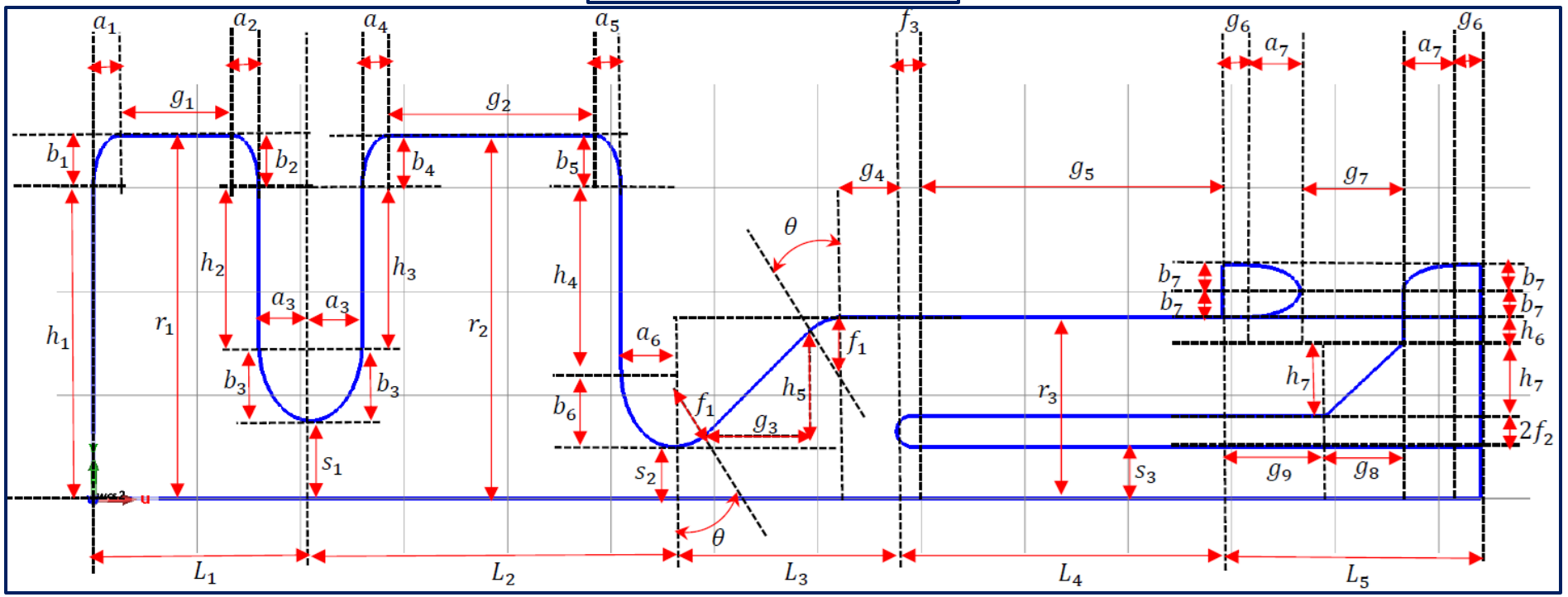
1.1 Gun Main Characteristics



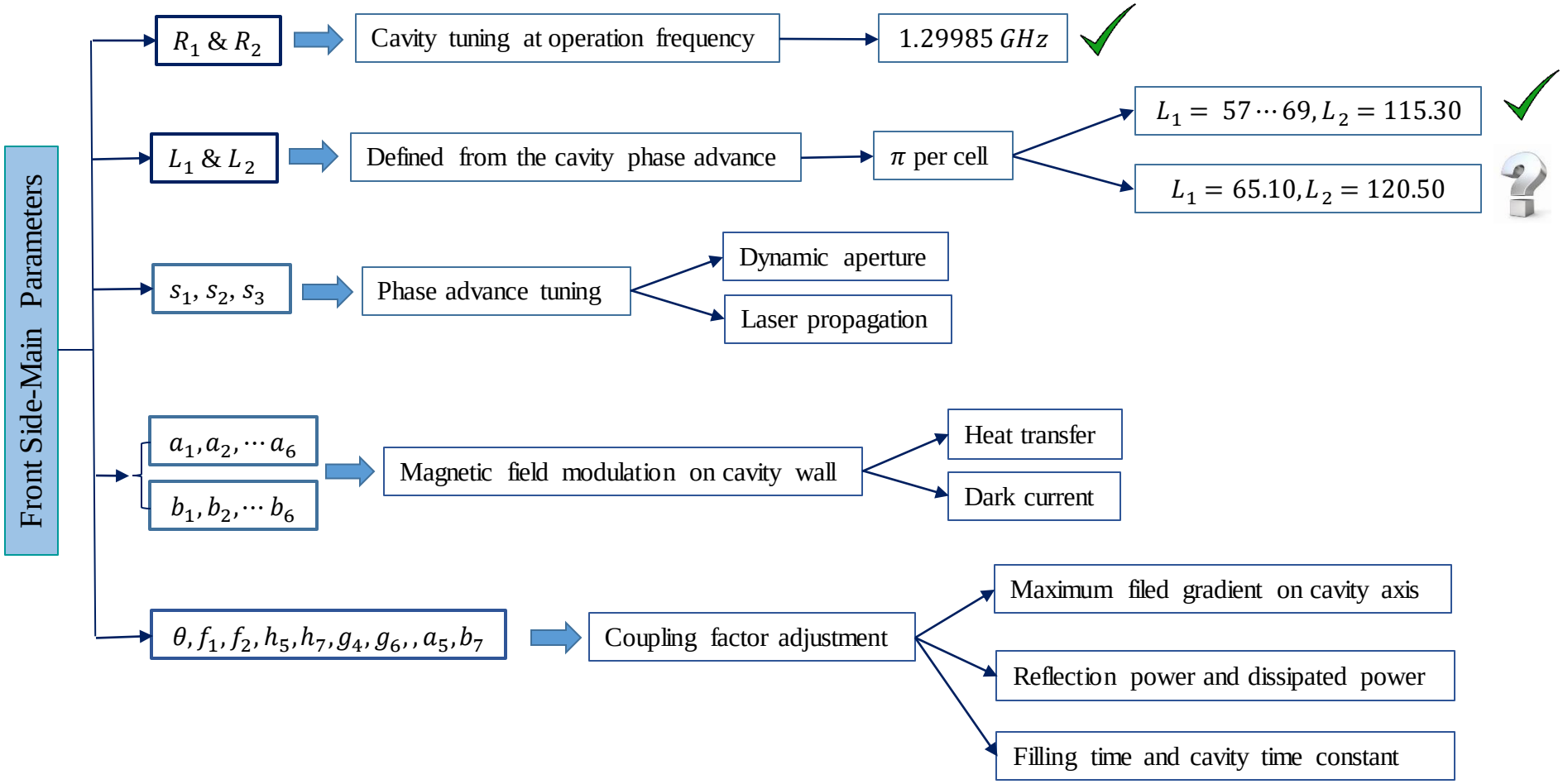
Characteristic	Value
Generation	5.1
Cell Number	1.6
Frequency	1.3 GHz-L Band
Type (Material-Wave)	NC-SW
Operation Mode	π
Max Input Power	8 MW
Wave Guide	Coaxial-WR650

1.2 Front Side Geometry

Front Side-Geometry



1.2 Front Side Geometry

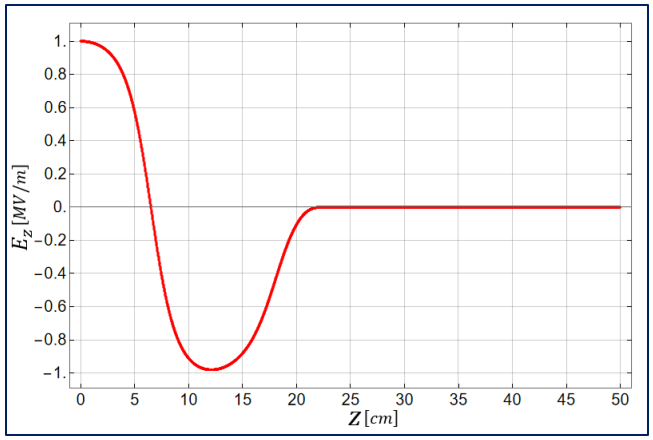


1.2 Front Side Geometry

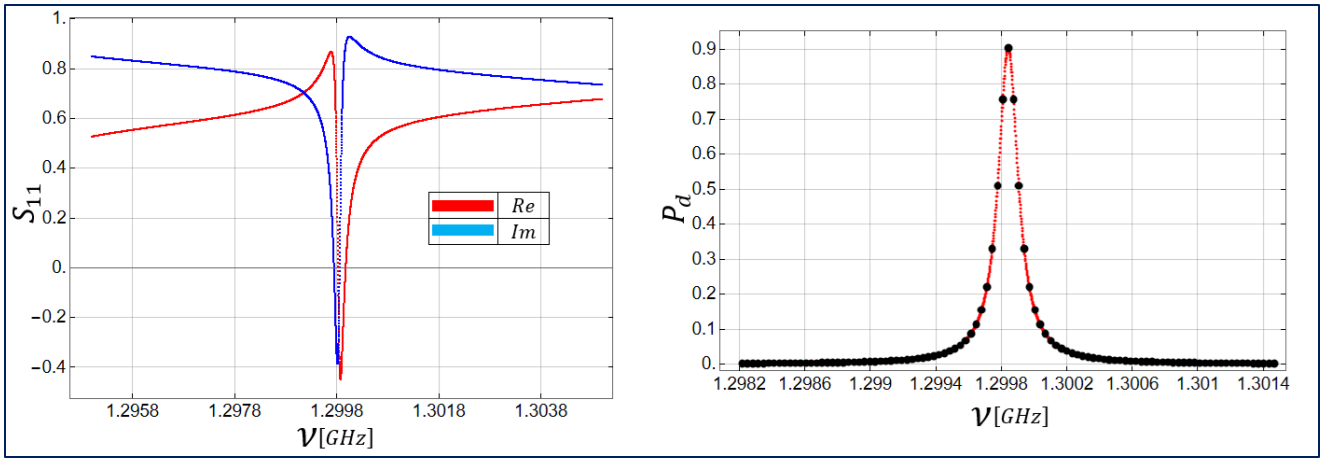
Front Side-Geometrical Parameters

Parameter	Value	Parameter	Value	Parameter	Value	Parameter	Value
a_1	25.5	b_5	40	g_7	31.95	L_2	120.5
a_2	25.5	b_6	19	g_8	35	L_3	31.38
a_3	10	b_7	15	g_9	18.95	L_4	173.25
a_4	27.5	f_1	6.5	h_1	69.87	L_5	82.55
a_5	40	f_2	2.5	h_2	25.87	r_1	95.37
a_6	10	g_1	4.1	h_3	23.87	r_2	95.37
a_7	22	g_2	33	h_4	5.87	r_3	50
b_1	25.5	g_3	15.69	h_5	15.69	s_1	25
b_2	25.5	g_4	10	h_6	0.01	s_2	30.5
b_3	19	g_5	170.75	h_7	28.24	s_3	16.75
b_4	27.5	g_6	3.3	L_1	65.1	θ	45

1.3 Main RF Characteristics

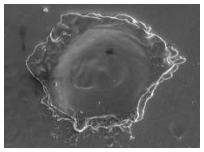


Parameter	Value	Parameter	Value
ν_c	1.29985 GHz	R_{sh}	$7.2M\Omega$
Q_c	25544	τ_f	4.3 μs
β_c	1.9	$V_{acc}(1MW)$	2.5 MV

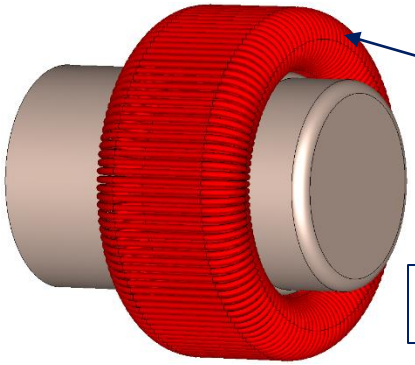


$$P_d = \frac{\frac{4\beta_c}{(1+\beta_c)^2}}{1+\left(\frac{2Q_c}{1+\beta_c}\left(\frac{\nu-\nu_c}{\nu_c}\right)\right)^2}$$

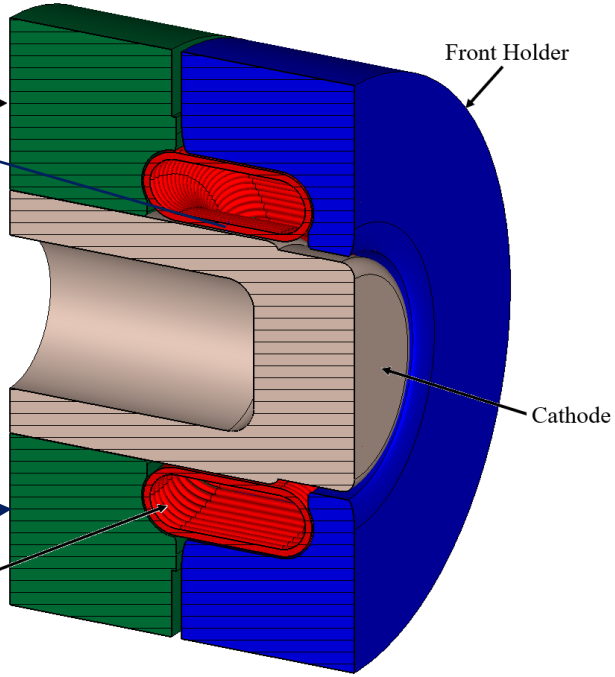
2.1 Current Structure-Back Side Geometry

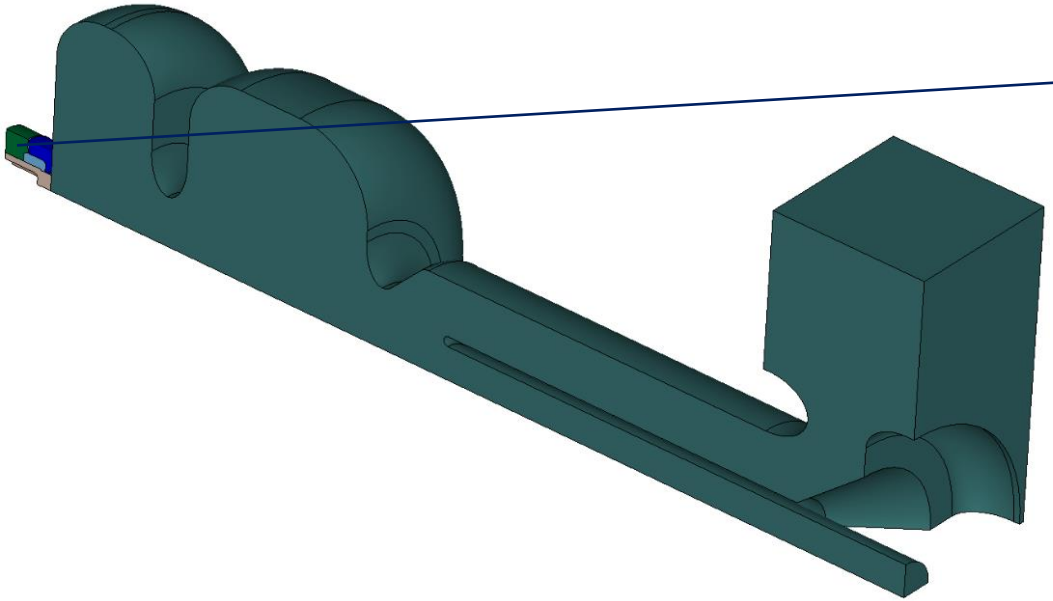


RF Breakdown



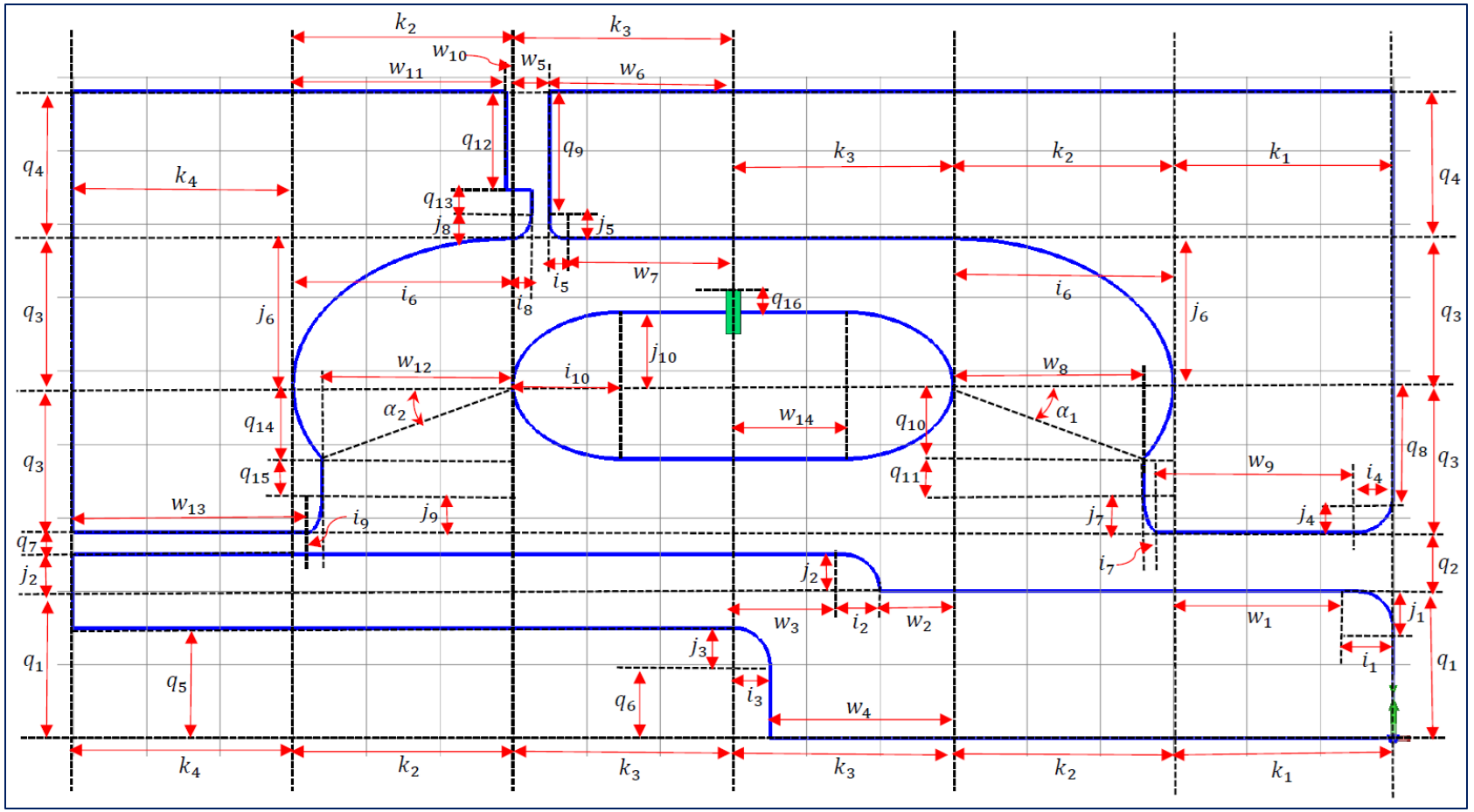
60 race track shape windings of 0.6mm thickness





2.1 Current Structure-Back Side Geometry

Back Side-Geometry



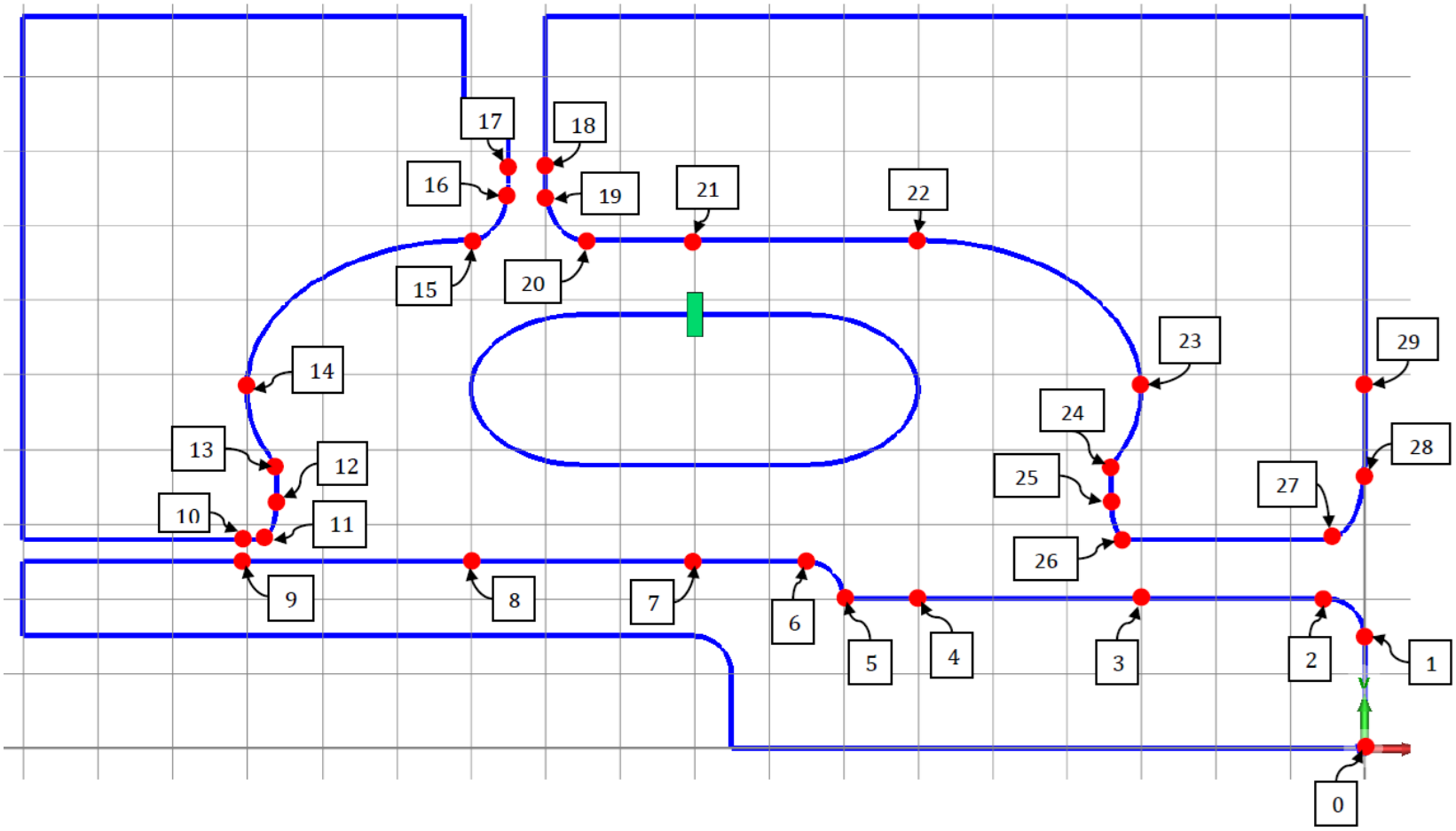
2.1 Current Structure-Back Side Geometry

Back Side-Geometrical Parameters

Parameter	Value	Parameter	Value	Parameter	Value	Parameter	Value
i_1	1	j_5	2.33	q_5	5.33	w_3	2.8
i_2	1	j_6	2.5	q_6	3.33	w_4	2
i_3	2	j_7	0.3	q_7	0.02	w_5	0.5
i_4	0.5	j_8	1.17	q_8	0.5	w_6	3.5
i_5	0.5	j_9	0.3	q_9	4.66	w_7	3
i_6	2.5	j_{10}	2.2	q_{10}	1.36	w_8	2.1
i_7	0.3	k_1	3.1	q_{11}	0.83	w_9	2.7
i_8	0.125	k_2	2.5	q_{12}	4.67	w_{10}	0.25
i_9	0.3	k_3	4	q_{13}	1.17	w_{11}	2.25
i_{10}	2.25	k_4	10	q_{14}	1.36	w_{12}	2.1
j_1	1	q_1	8	q_{15}	0.84	w_{13}	10.1
j_2	0.48	q_2	0.5	q_{16}	0.25	w_{14}	3.97
j_3	2	q_3	2.5	w_1	2.1	$\alpha_1 = \alpha_2$	33
j_4	2	q_4	7	w_2	0.2	δ	0.025

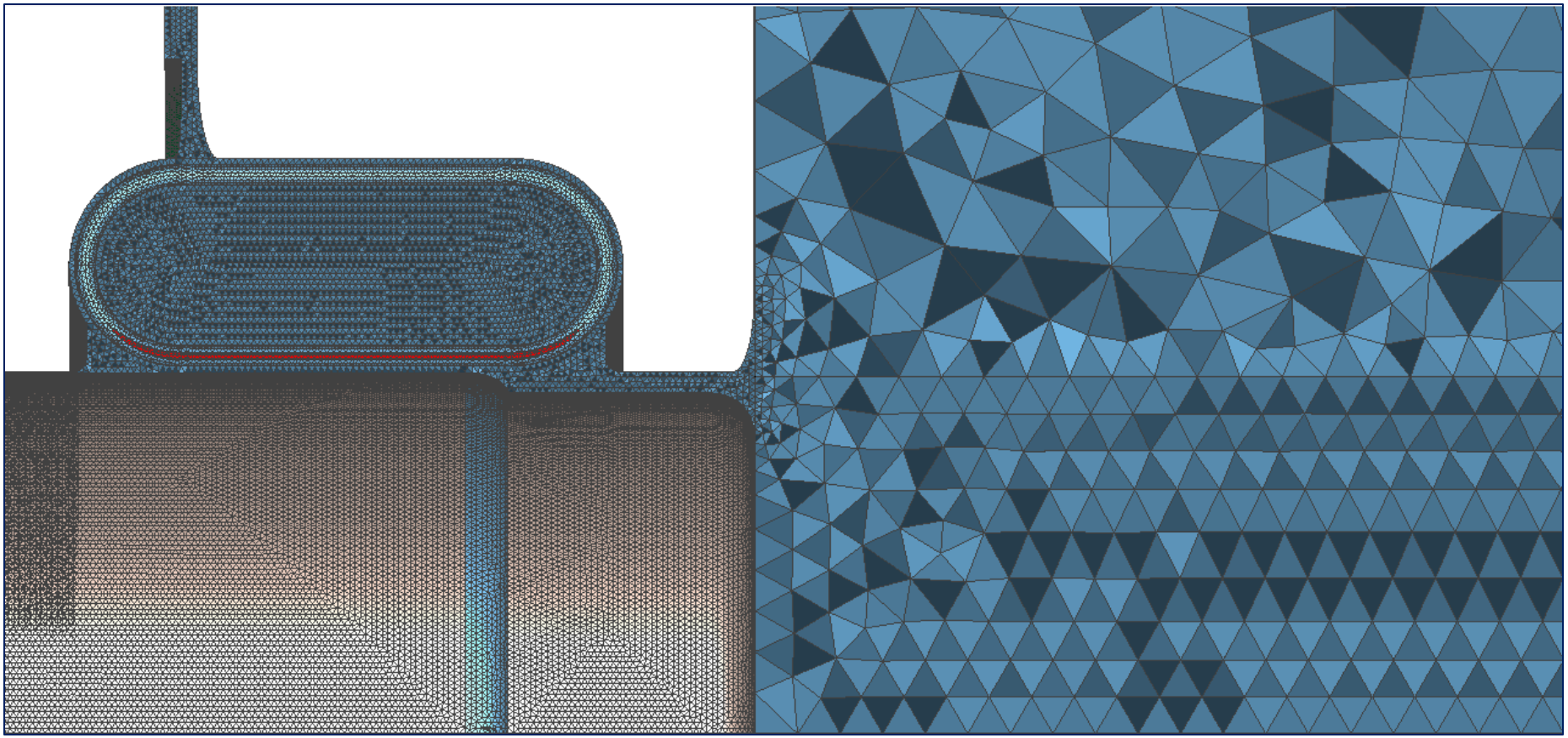
2.1 Current Structure-Back Side Geometry

Critical Points from EM View



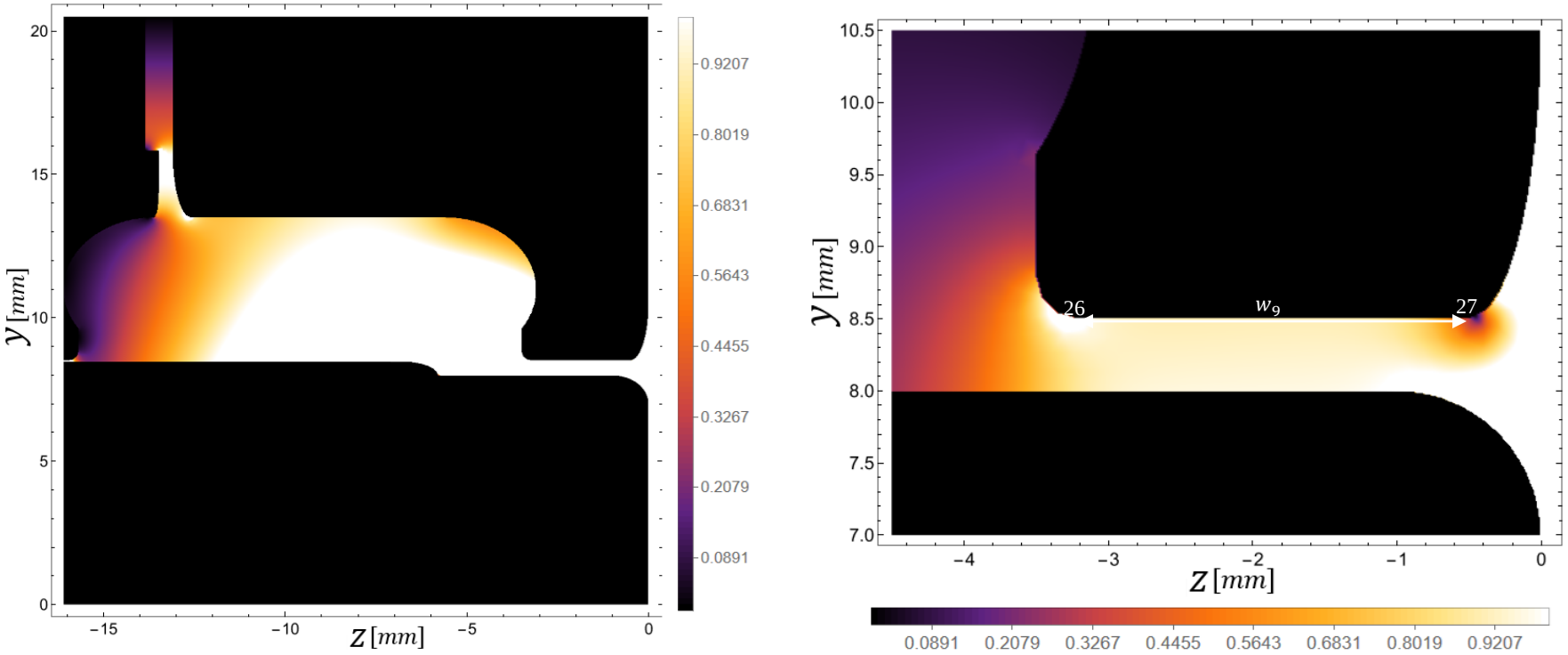
2.1 Current Structure-Back Side Geometry

Mesh Structure



2.2 Optimization Against RF Breakdown

Filed Distribution-without Spring



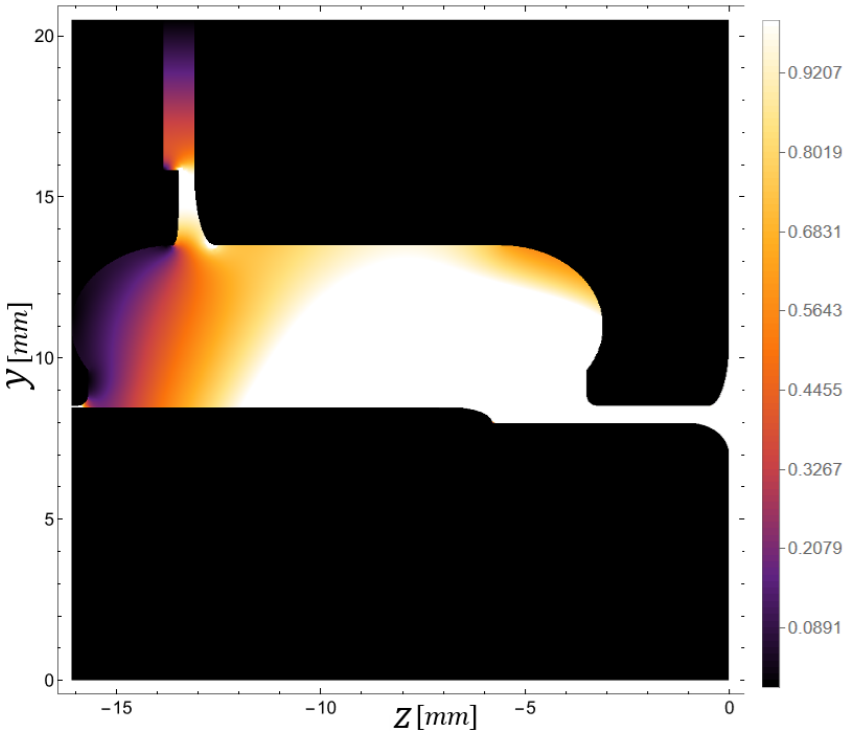
Absolute value of electric filed for $1MV/m$ maximum field gradient

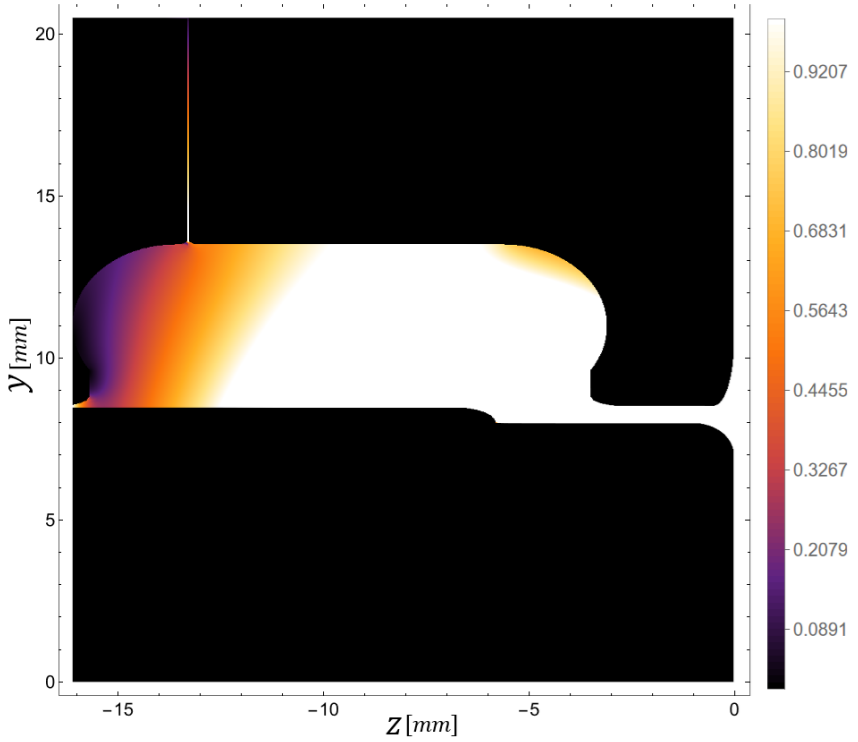
2.2 Optimization Against RF Breakdown

1. Close the gap in between the front and the back holders through as much as possible decreasing the value of $w_5 - i_8$.
2. To avoid of creating any sharp edges which in turns increases the probability of breakdown, we must symmetrize the joint between the holders i.e. points 15 and 20 in figure 7 through letting i_8 and j_8 take the values of i_5 and j_5, respectively.
3. The circular corner at point 26 should be modified to an elliptic form might with relatively large ratio between its radii for having larger curvature. This can be done for instance by selecting i_7 to be 3 time j_7 ($i_7 = 3j_7$) that already was in the form of $i_7 = j_7$.
4. Make the cathode corner in between the point 1-2 elliptical and probably for keeping symmetry let it to be exactly similar to the corner in between the points 28-29.
5. Enlarge the gap length in between the cathode and the front holder by increasing the value of parameter w_9 in Fig.6.

2.2 Optimization Against RF Breakdown

Field Distribution-Without Spring

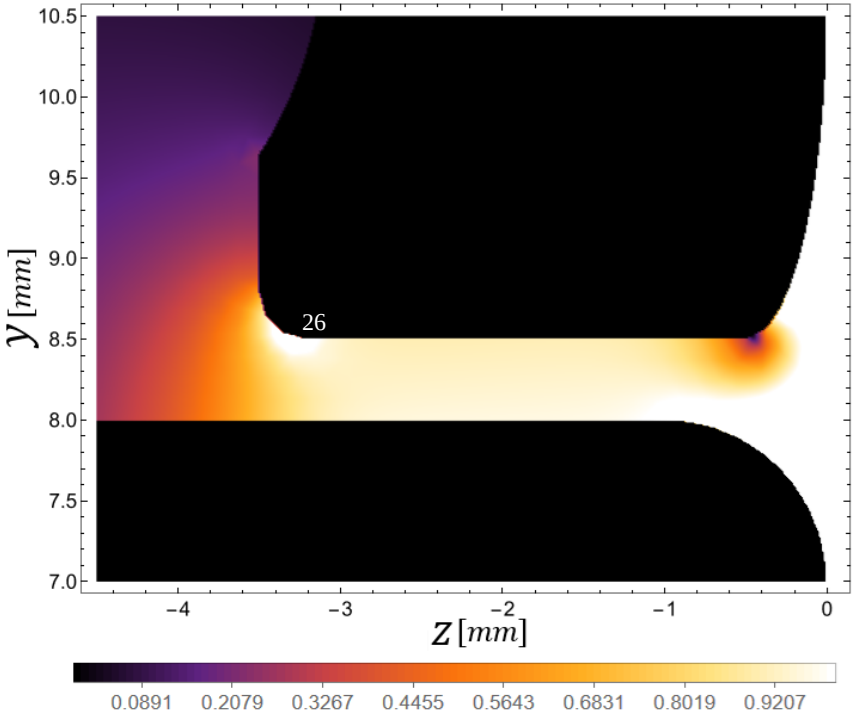


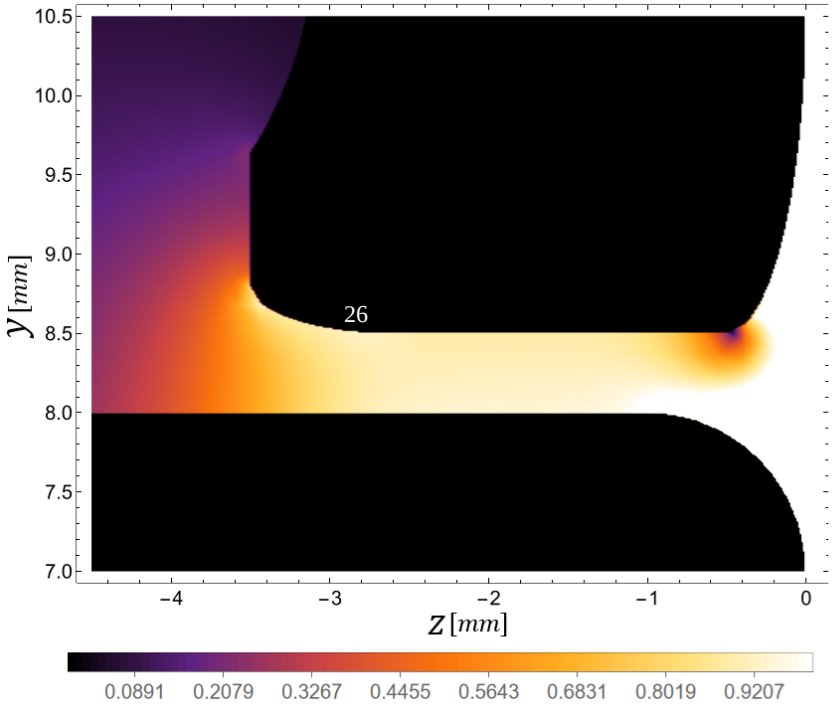


Closing the gap between the holders and making the corners (except for the cathode) elliptic

2.2 Optimization Against RF Breakdown

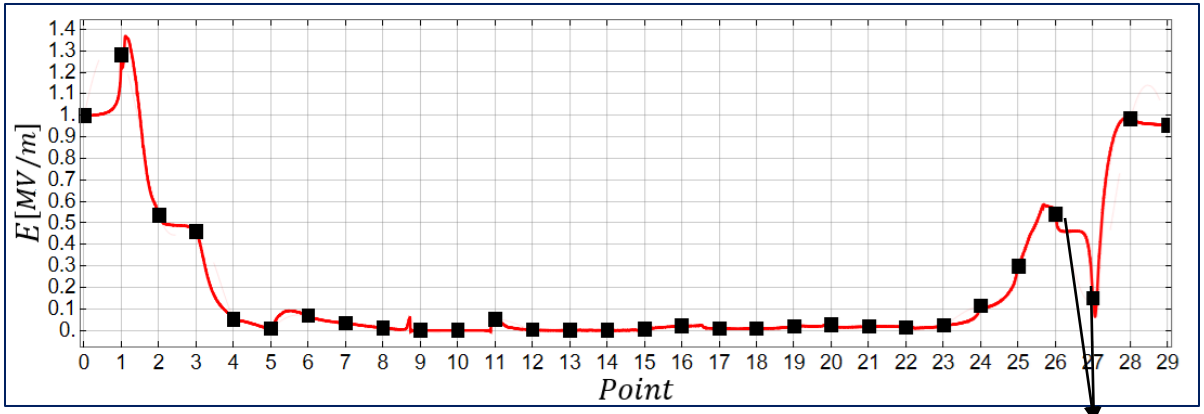
Field Distribution-without Spring



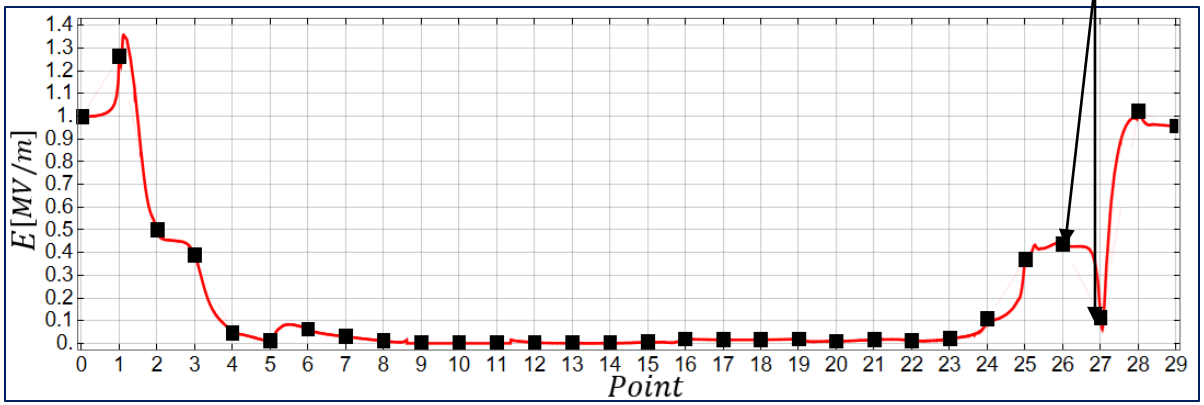


2.2 Optimization Against RF Breakdown

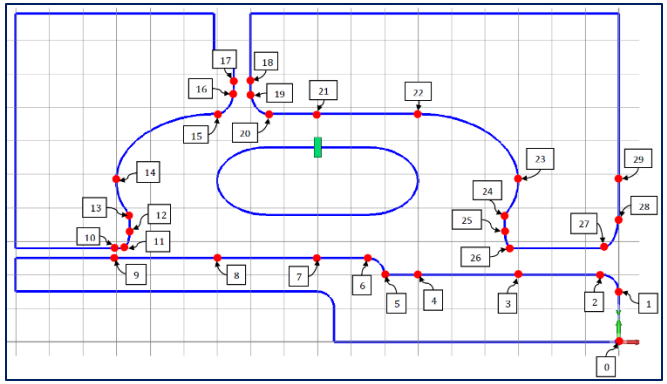
$1MV/m$ maximum field gradient on the cavity axis



%20 deacrease

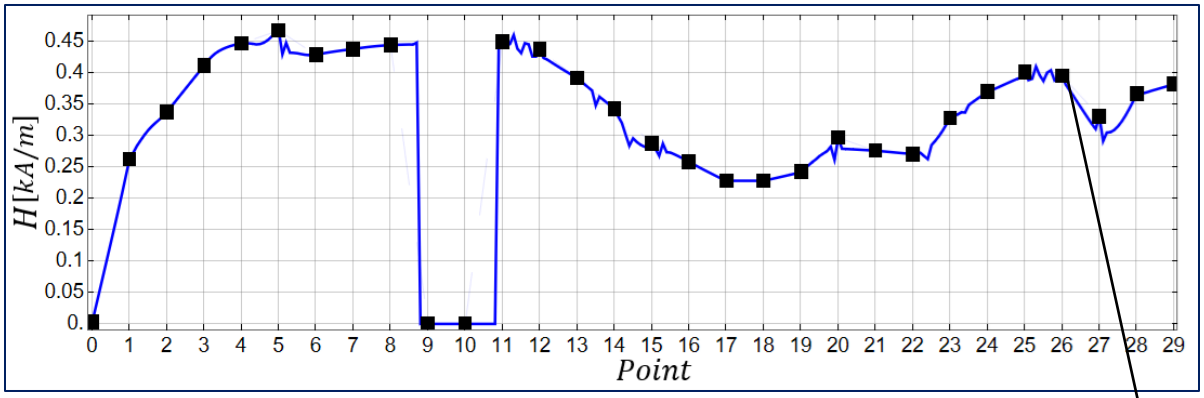


Electric Filed on the Wall-without Spring



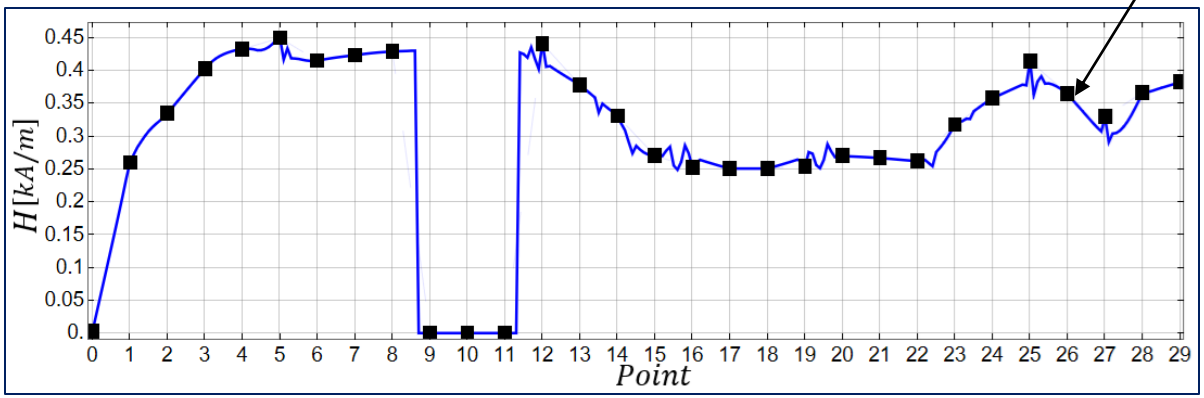
2.2 Optimization Against RF Breakdown

$1MV/m$ maximum field gradient on the cavity axis

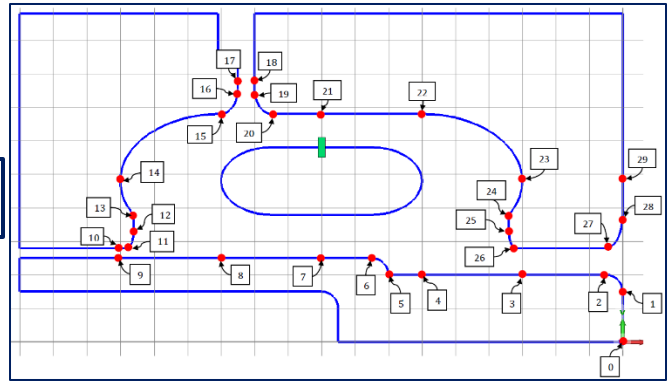


$H = J_s$

%10 deacrease



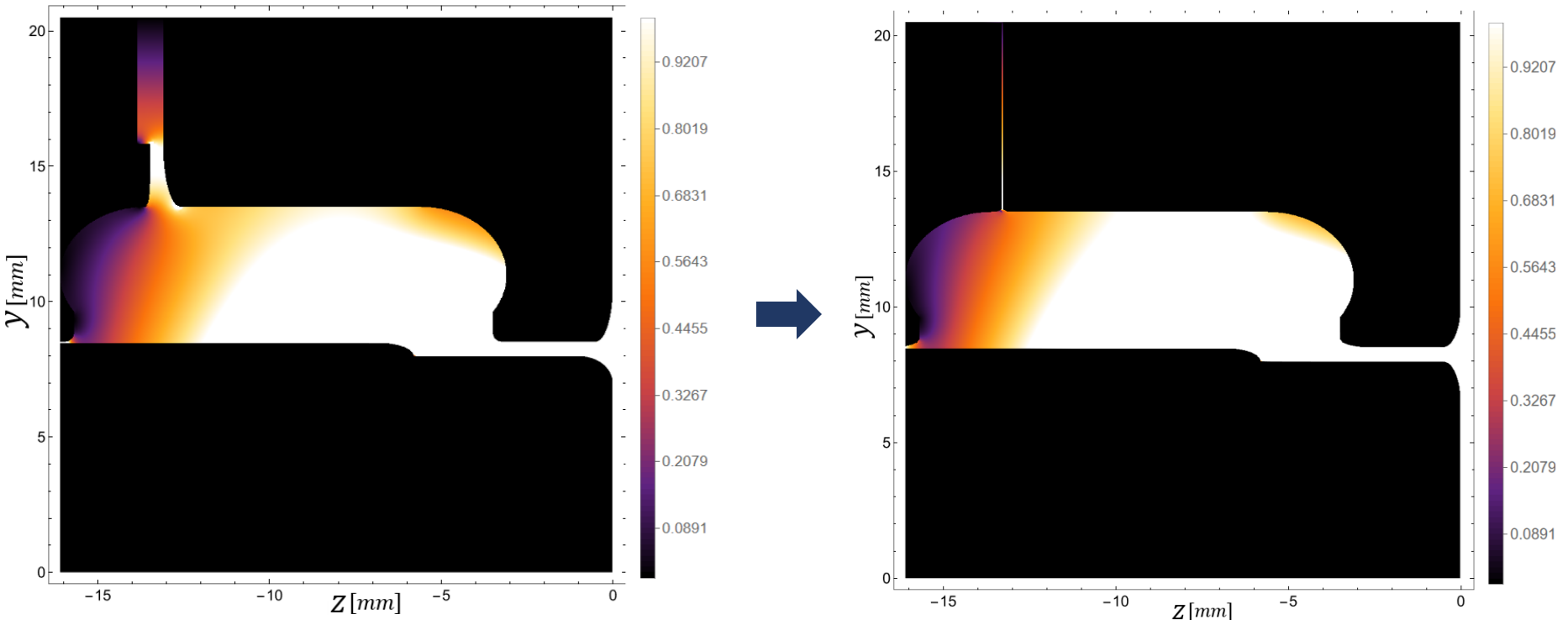
Magnetic Filed on the Wall-without Spring



Large surface current on the order of $0.5A/mm$

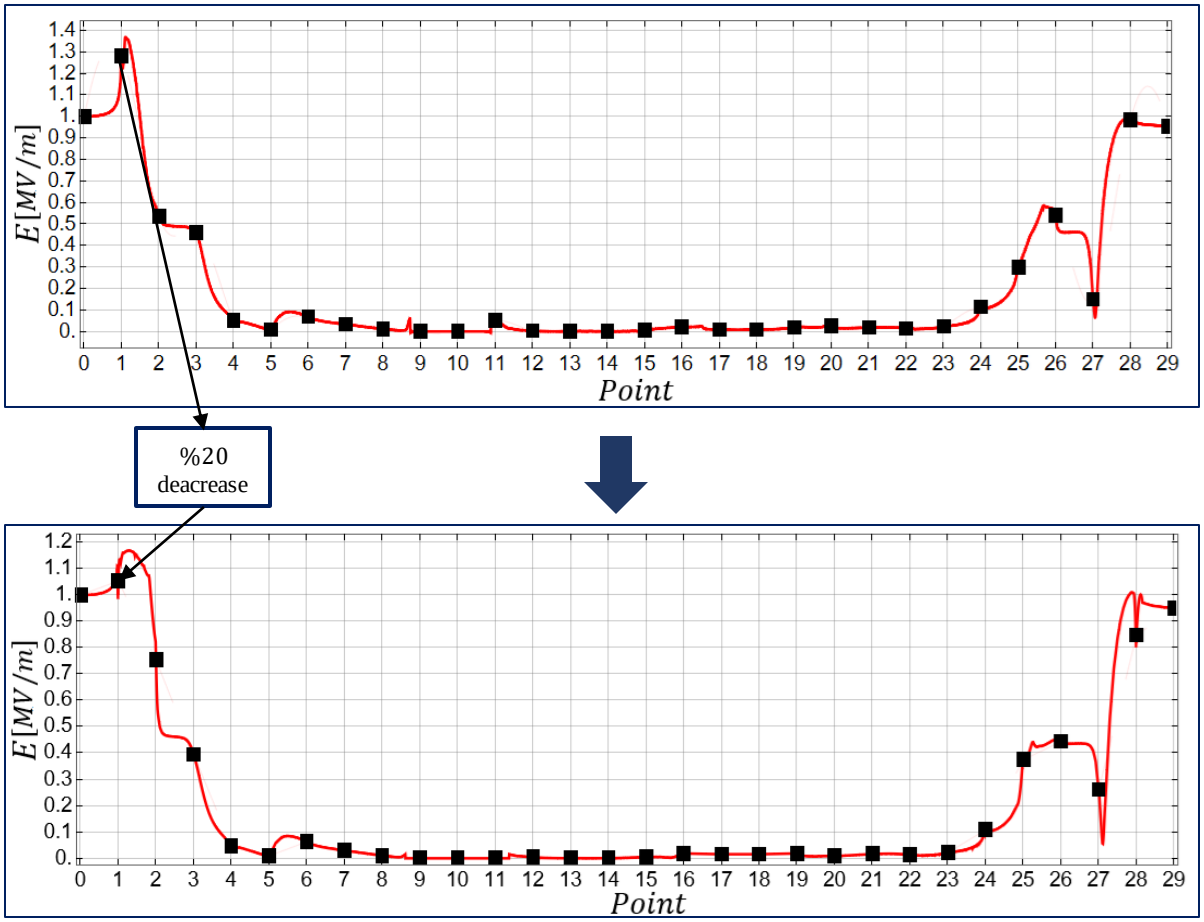
2.2 Optimization Against RF Breakdown

Field Distribution-without Spring

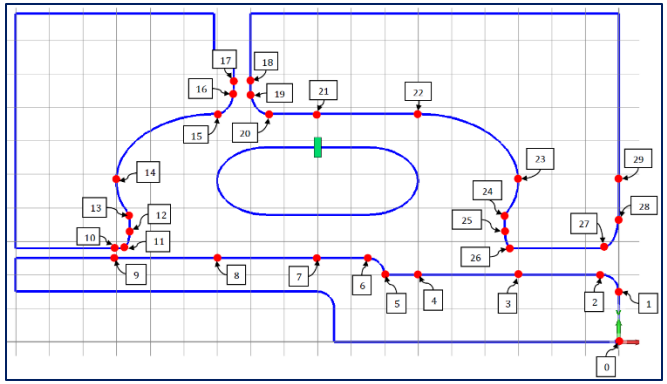


Making cathode corner symmetrically elliptic

2.2 Optimization Against RF Breakdown



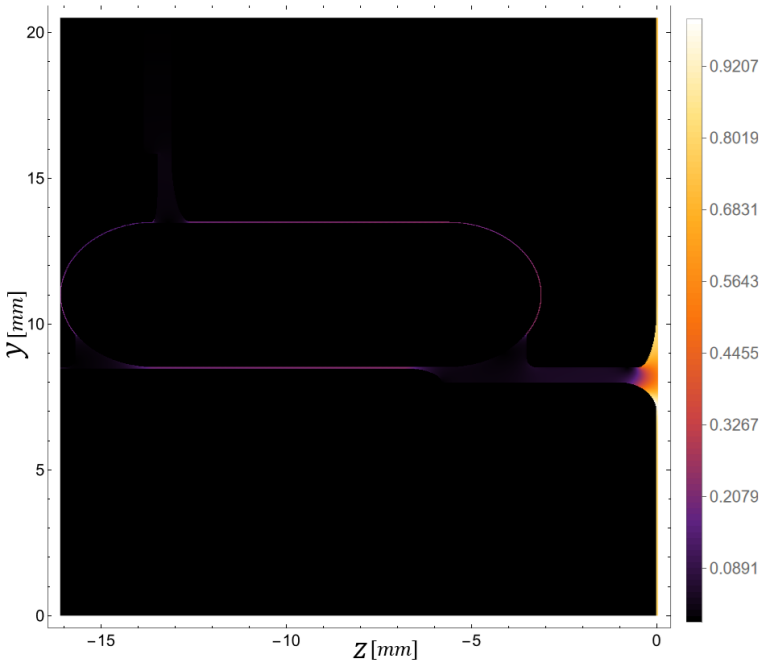
Electric Filed on the Wall-without Spring



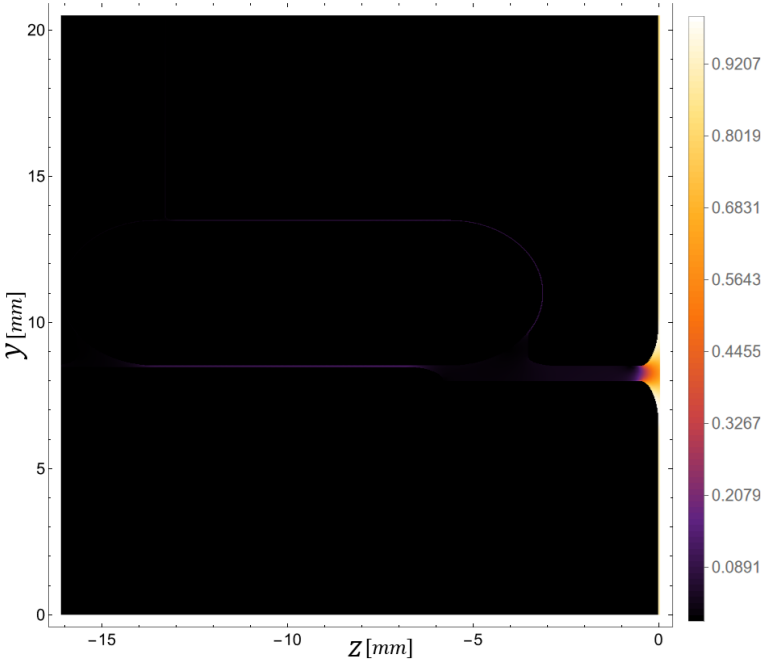
2.2 Optimization Against RF Breakdown

Field Distribution-with Spring

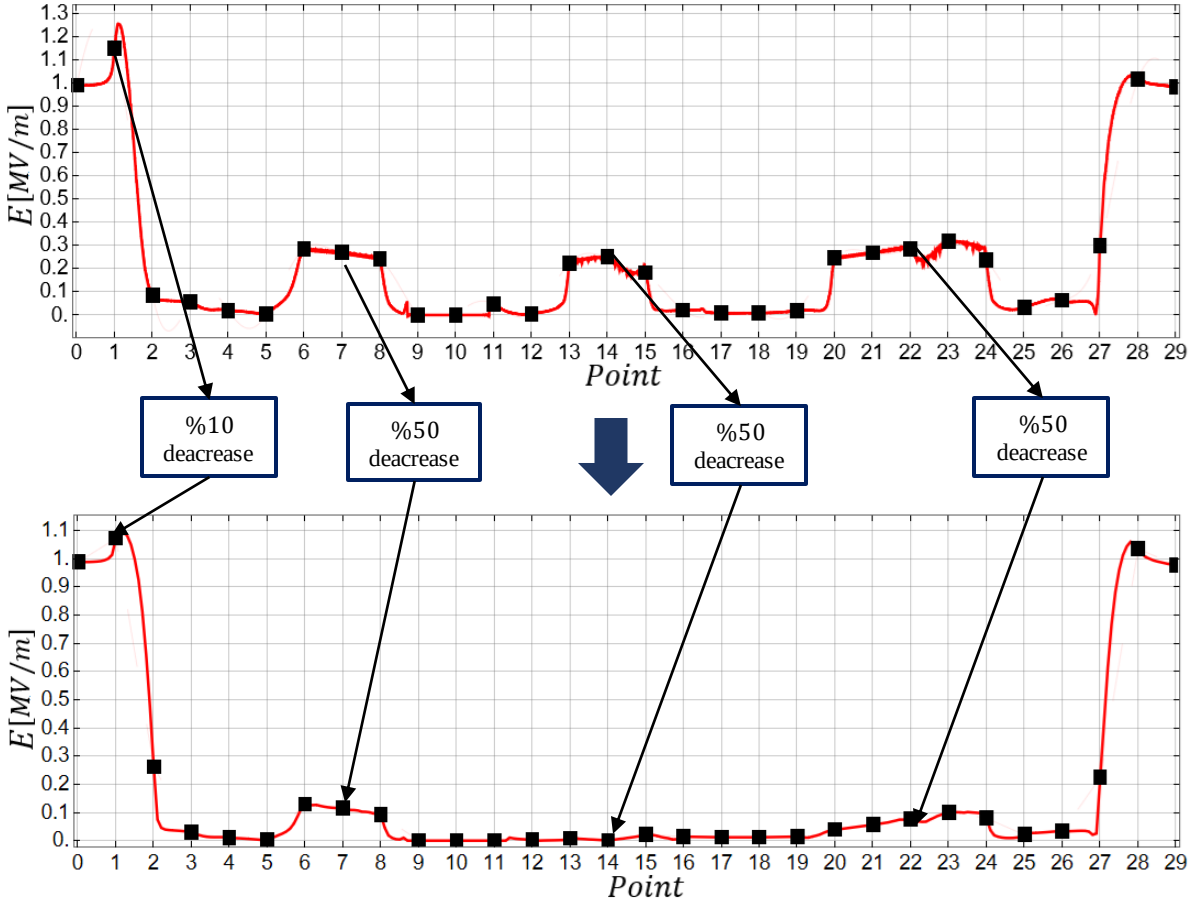
Current Structure



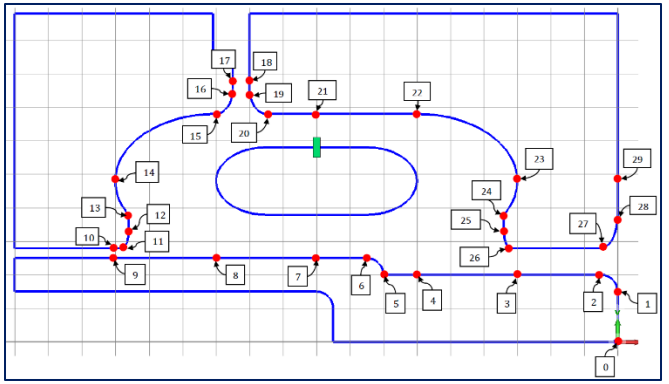
Optimized Structure



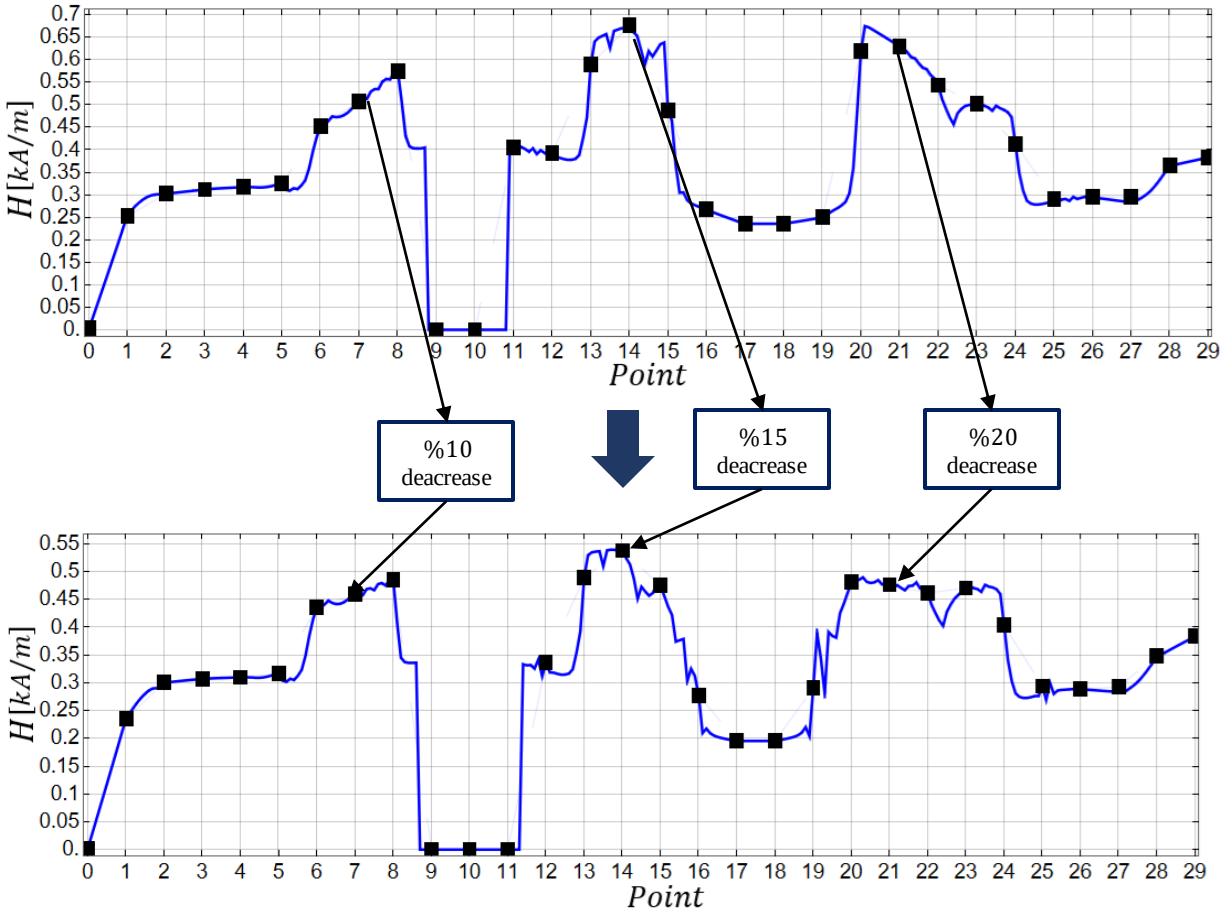
2.2 Optimization Against RF Breakdown



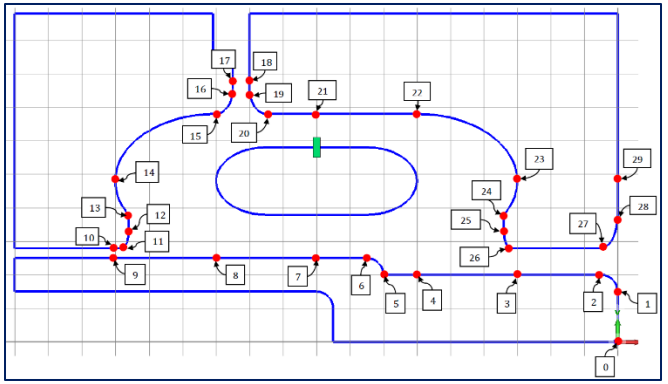
Electric Filed on the Wall-with Spring



2.2 Optimization Against RF Breakdown



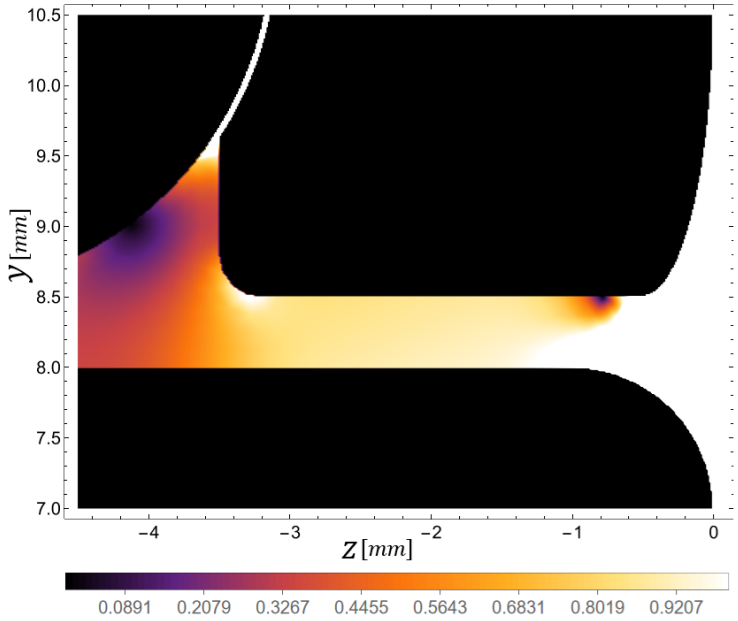
Magnetic Filed on the Wall-with Spring



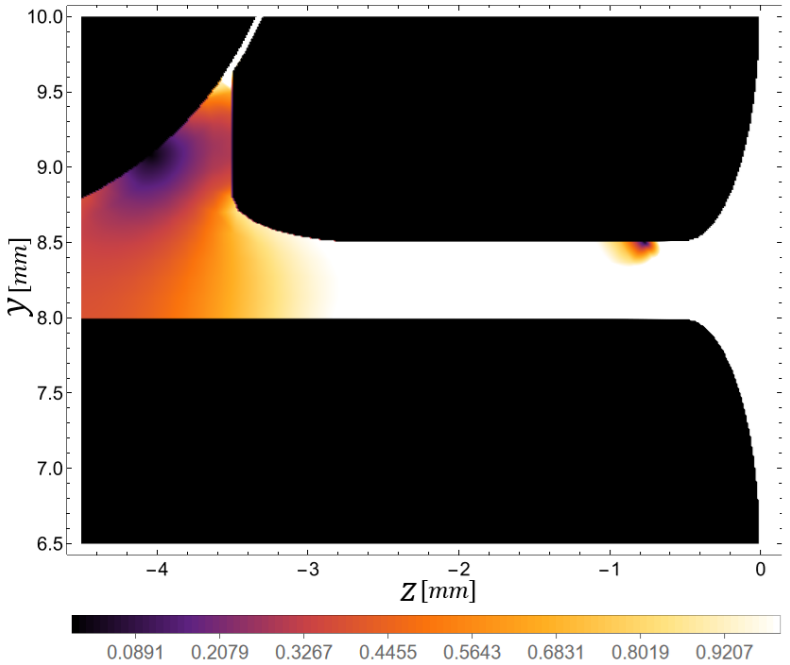
2.2 Optimization Against RF Breakdown

Field Distribution Around the Cathode -with Spring

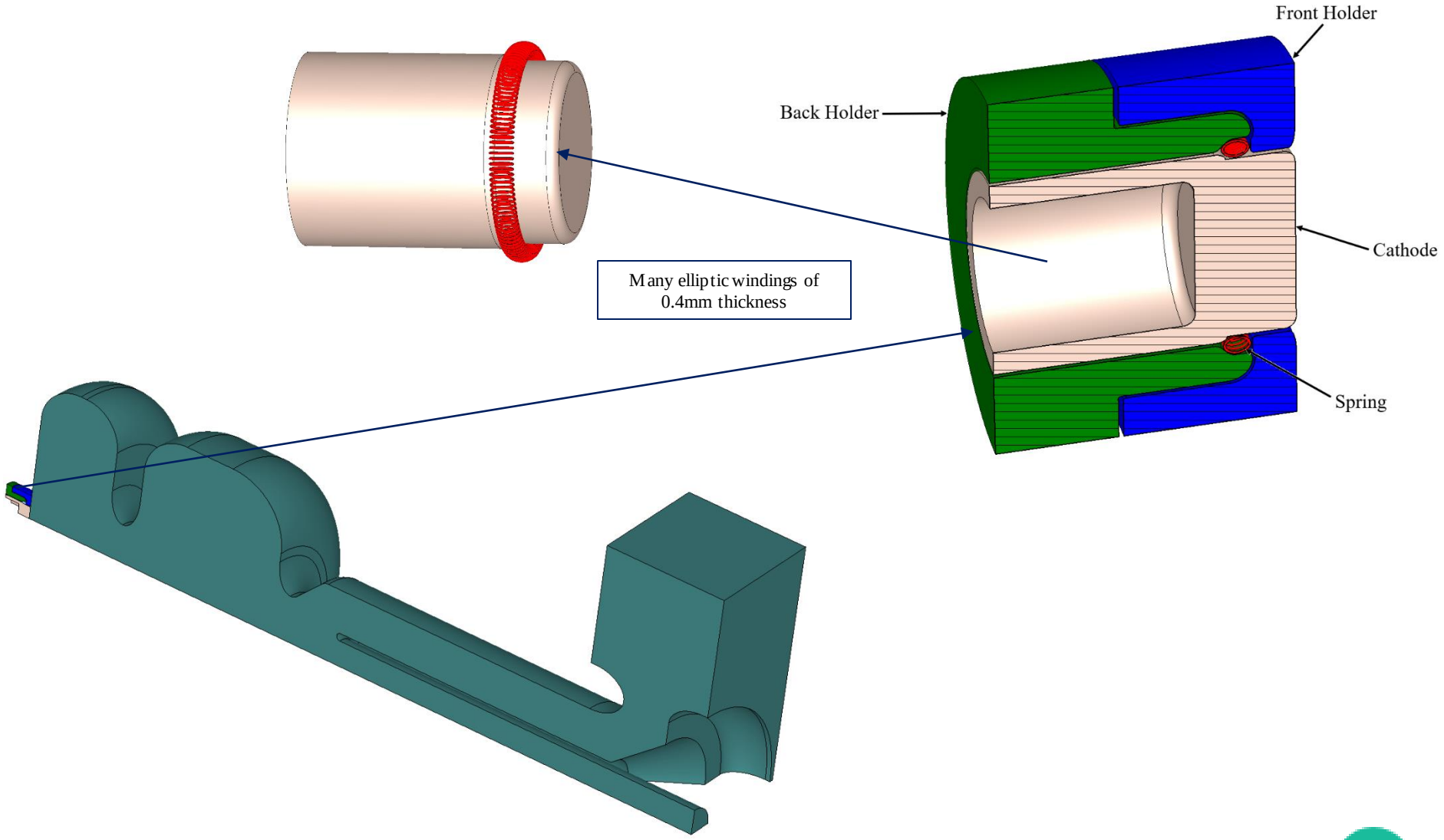
Current Structure



Optimized Structure

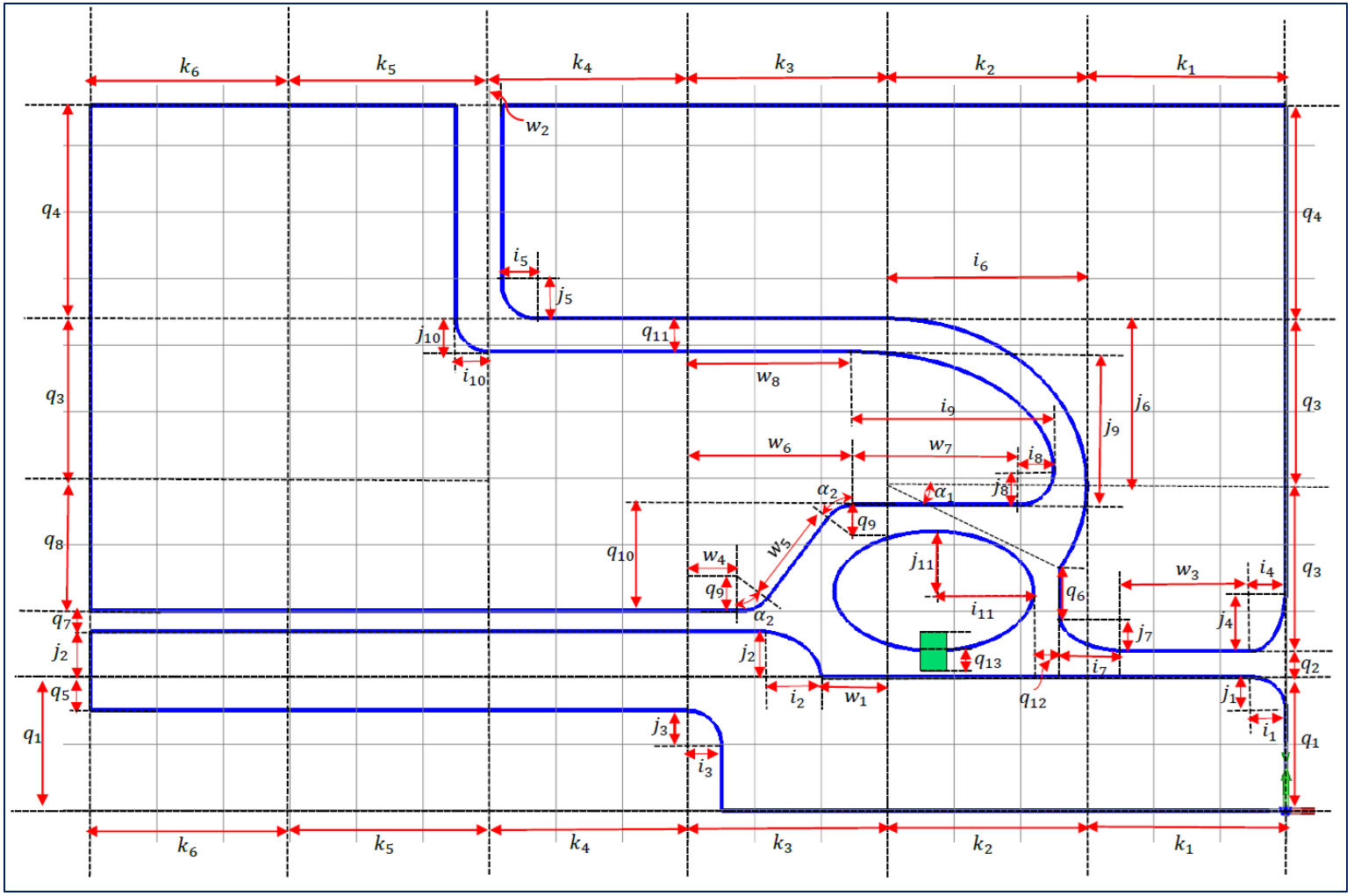


4.1 New Structure-Back Side Geometry



4.1 New Structure-Back Side Geometry

Back Side-Geometry



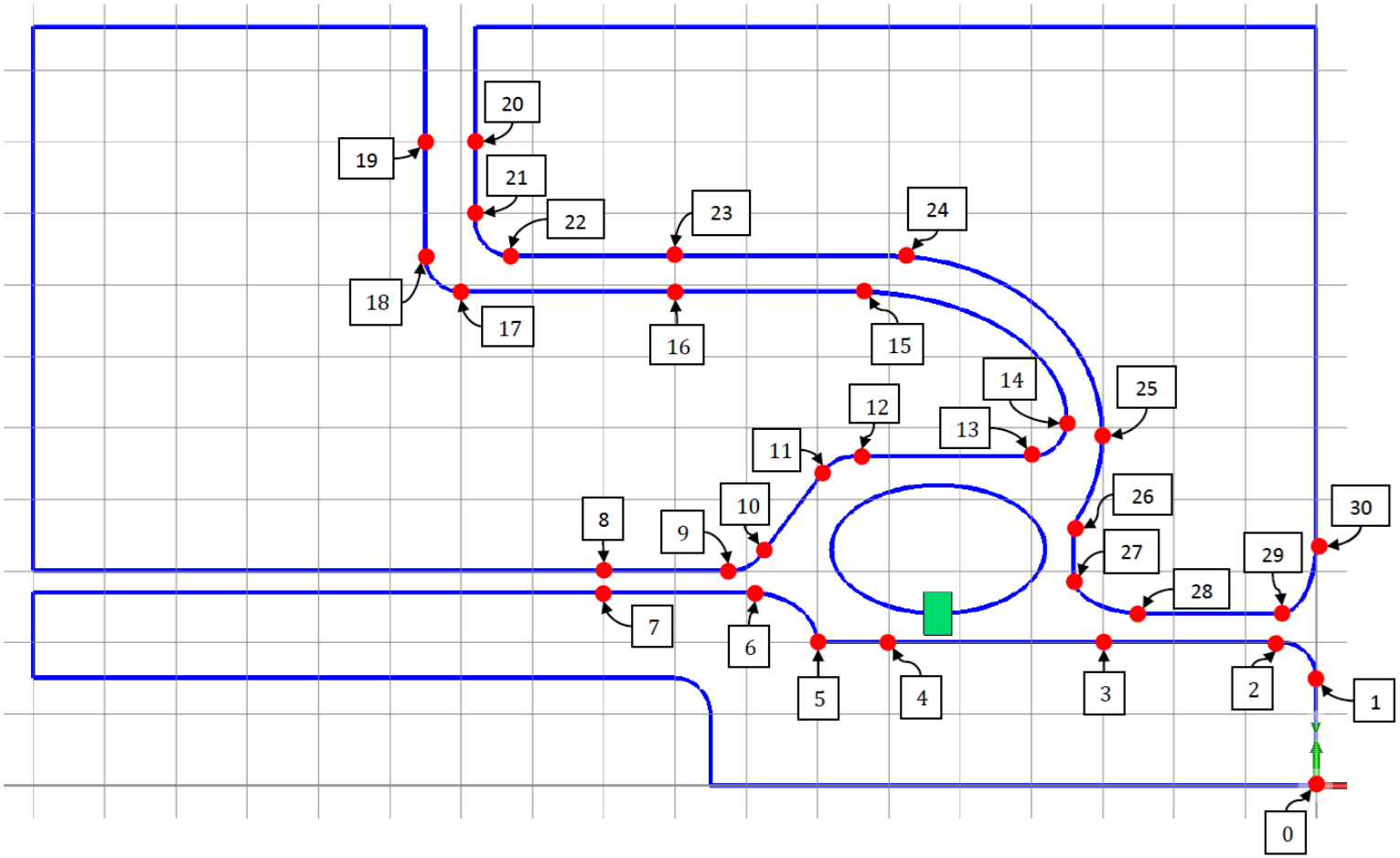
4.1 New Structure-Back Side Geometry

Back Side-Geometrical Parameters

Parameter	Value	Parameter	Value	Parameter	Value	Parameter	Value
i_1	0.95	j_3	1.0	k_4	5.0	q_{11}	0.2
i_2	0.87	j_2	0.5	k_5	2.0	q_{12}	0.2
i_3	1.0	j_4	1.9	k_6	2.0	q_{13}	0.2
i_4	0.5	j_5	0.1	q_1	8	w_1	0.2
i_5	0.1	j_6	2.5	q_2	0.5	w_2	0.1
i_6	2.0	j_7	0.3	q_3	2.5	w_3	2.7
i_7	0.3	j_8	0.52	q_4	5.0	w_4	2.26
i_8	0.5	j_9	1.82	q_5	1.5	w_5	0.59
i_9	2.0	j_{10}	0.2	q_6	0.82	w_6	4.09
i_{10}	0.1	j_{11}	0.67	q_7	0.25	w_7	0.78
i_{11}	1.0	k_1	3.3	q_8	1.55	w_8	3.37
j_1	1.0	k_2	2.0	q_9	1.0	α_1	26
j_2	0.5	k_3	3.7	q_{10}	1.0	α_2	45

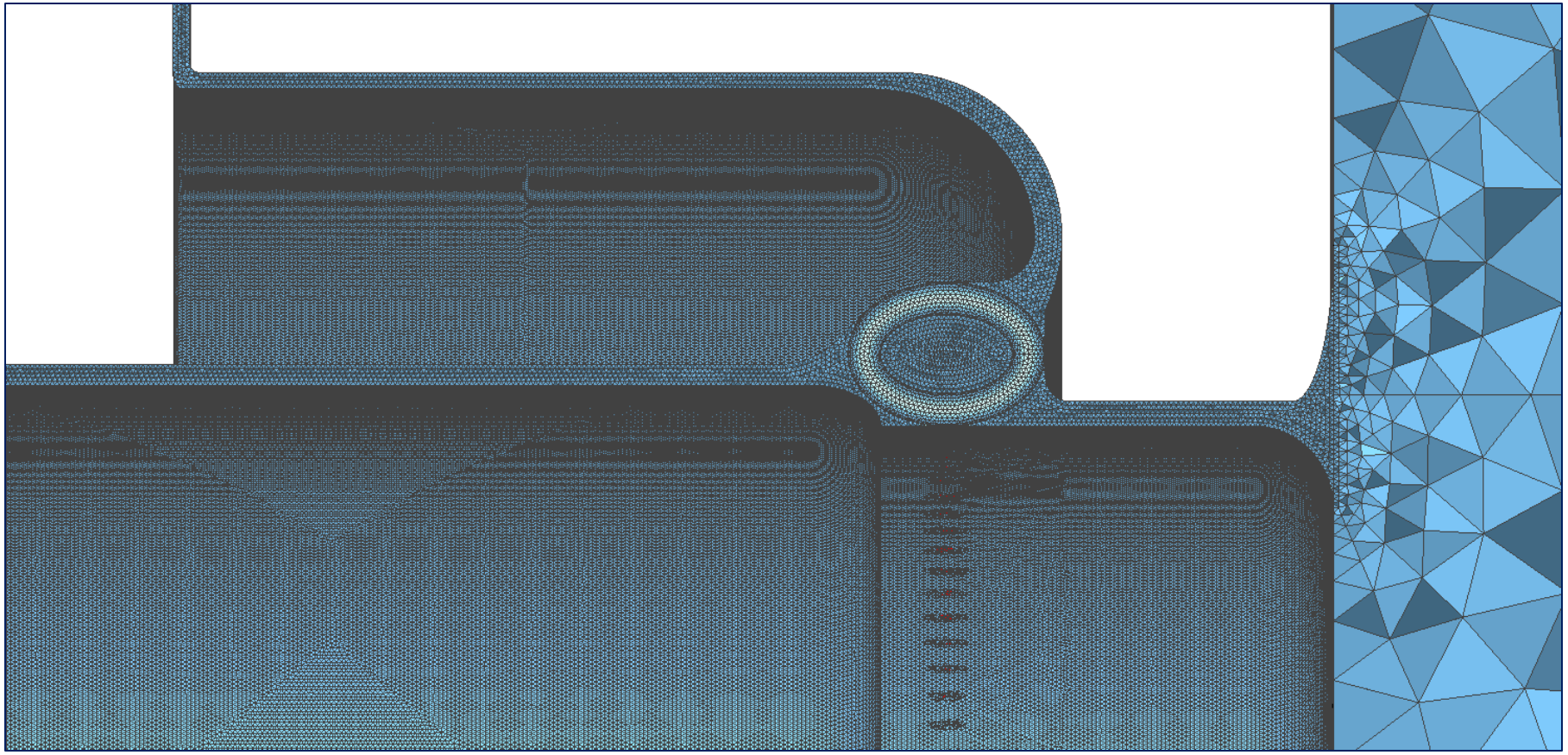
4.1 New Structure-Back Side Geometry

Critical Points from EM View



4.1 New Structure-Back Side Geometry

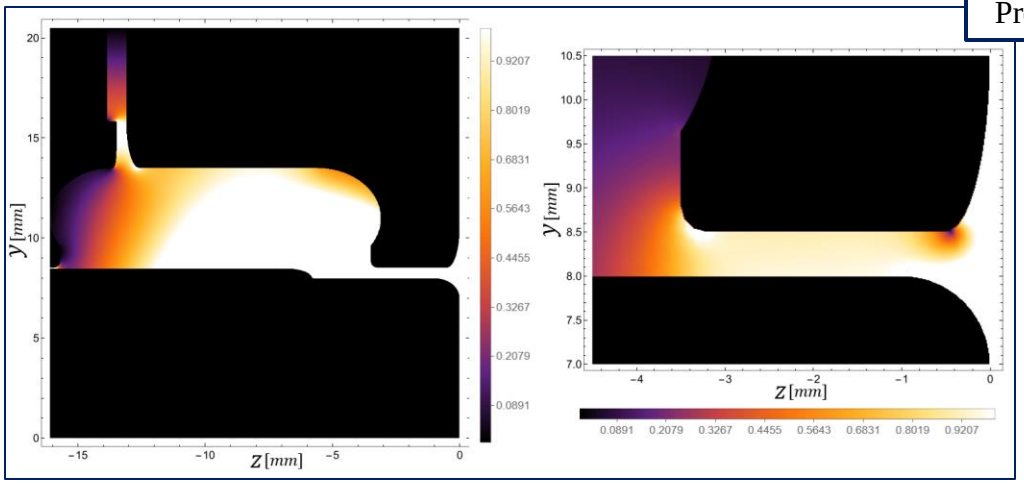
Mesh Structure



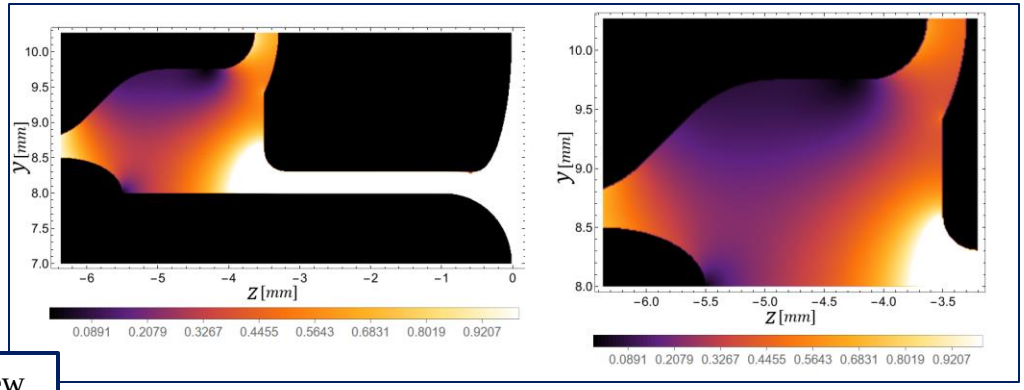
4.2 New Structure-RF Simulations

Filed Distribution-without Spring

Previous

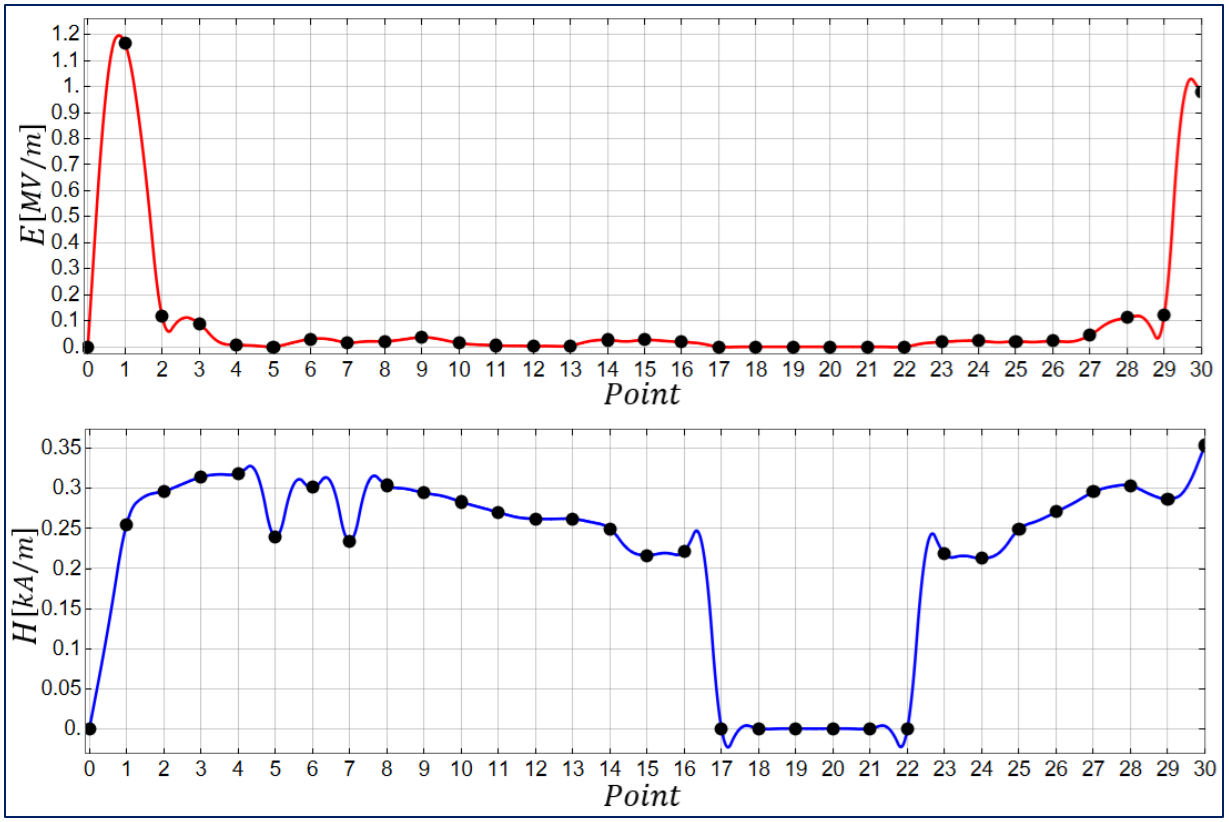


New

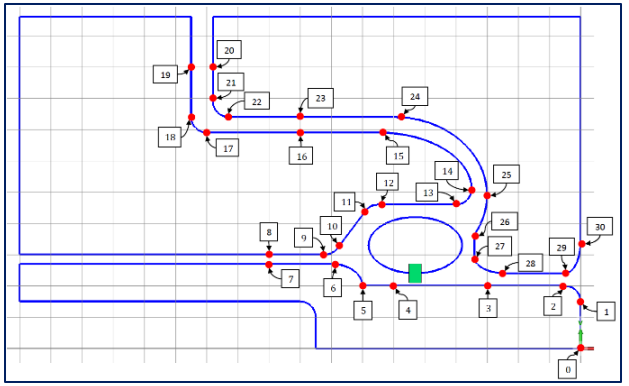


Significant decrees in the filed strength

4.2 New Structure-RF Simulations



Field Profiles on the Wall-without Spring

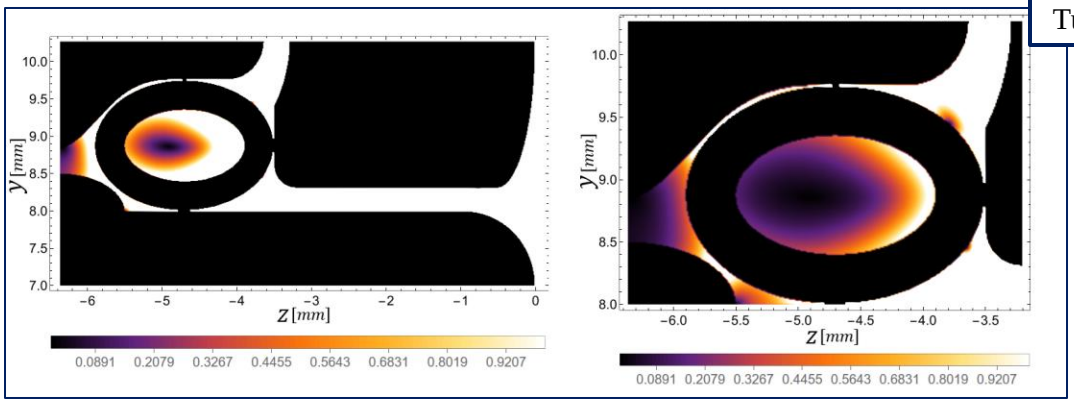


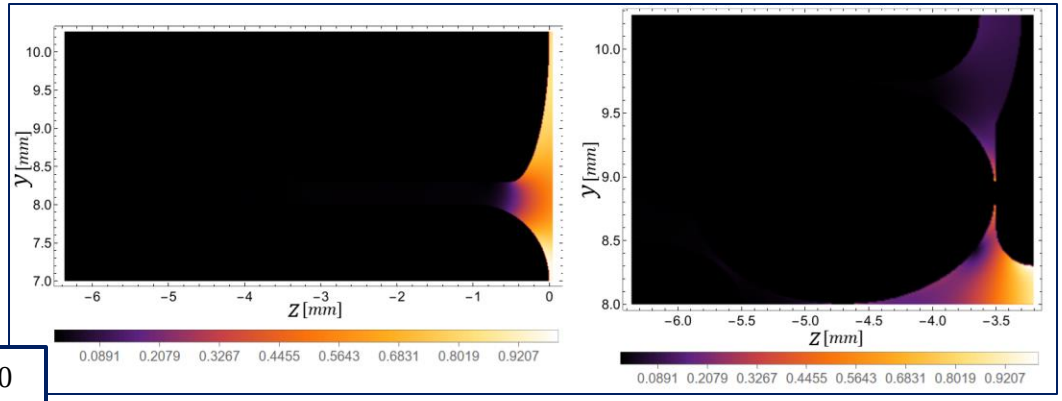
Much more smooth behavior and overall 30% decreases in the surface current

4.2 New Structure-RF Simulations

Filed Distribution-with Spring

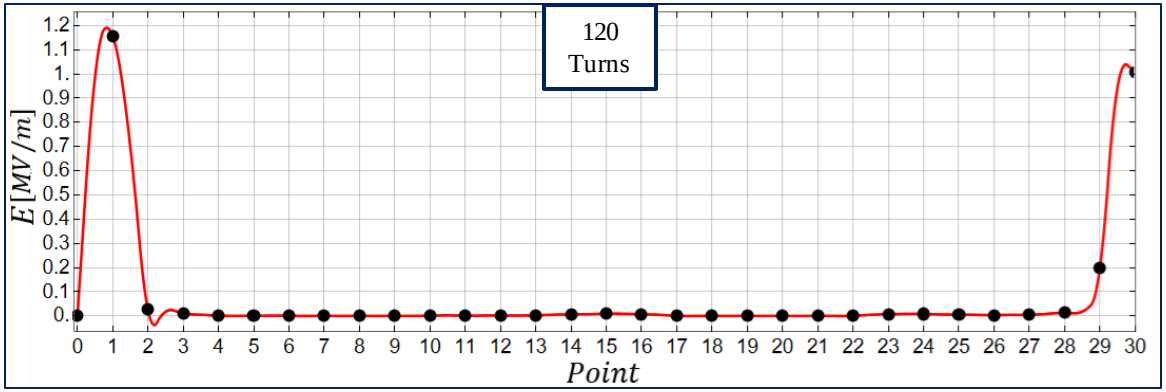
120 Turns

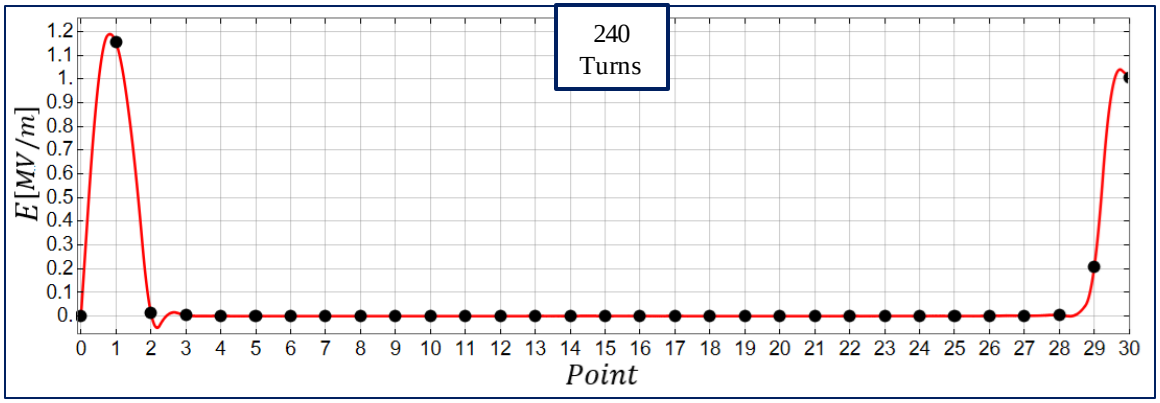




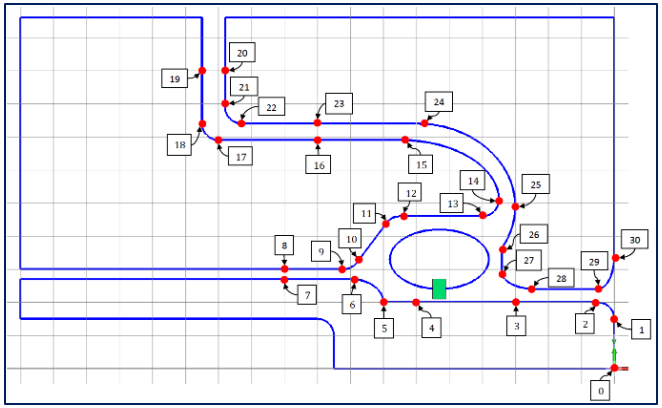
240 Turns

4.2 New Structure-RF Simulations

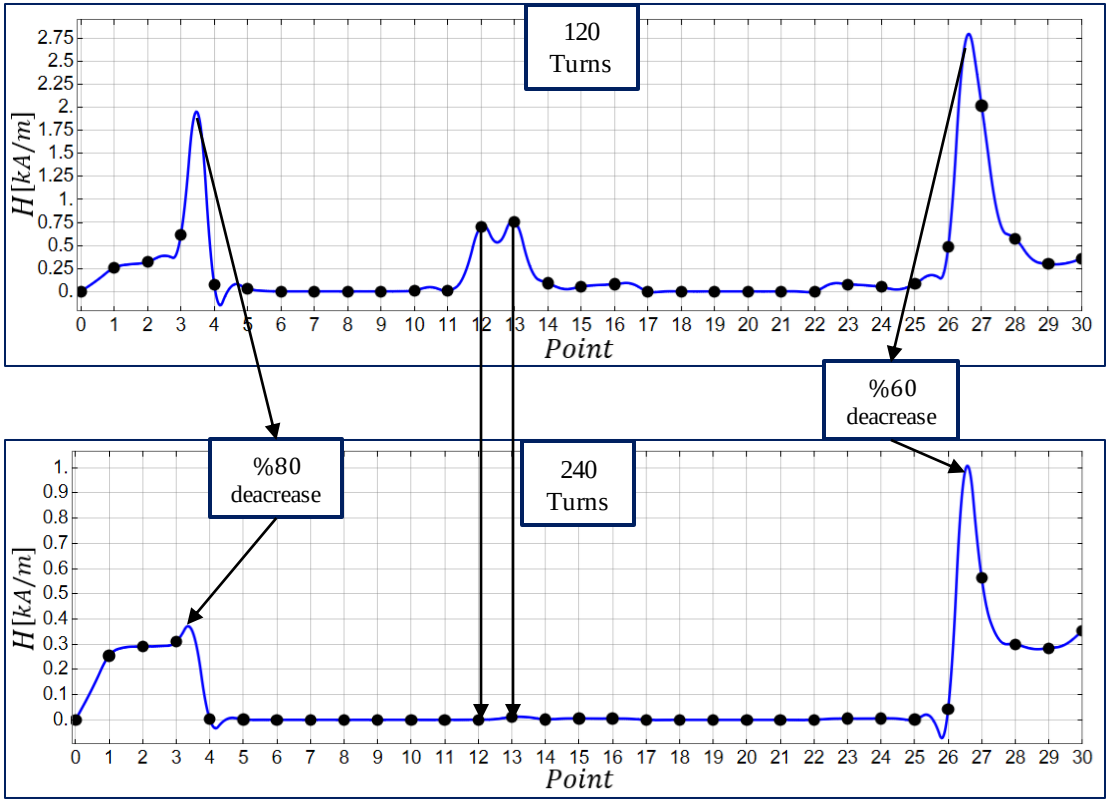




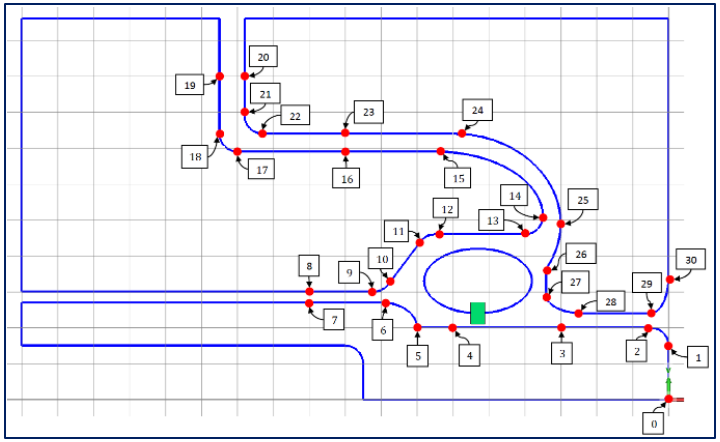
Filed Profile on the Wall-With Spring



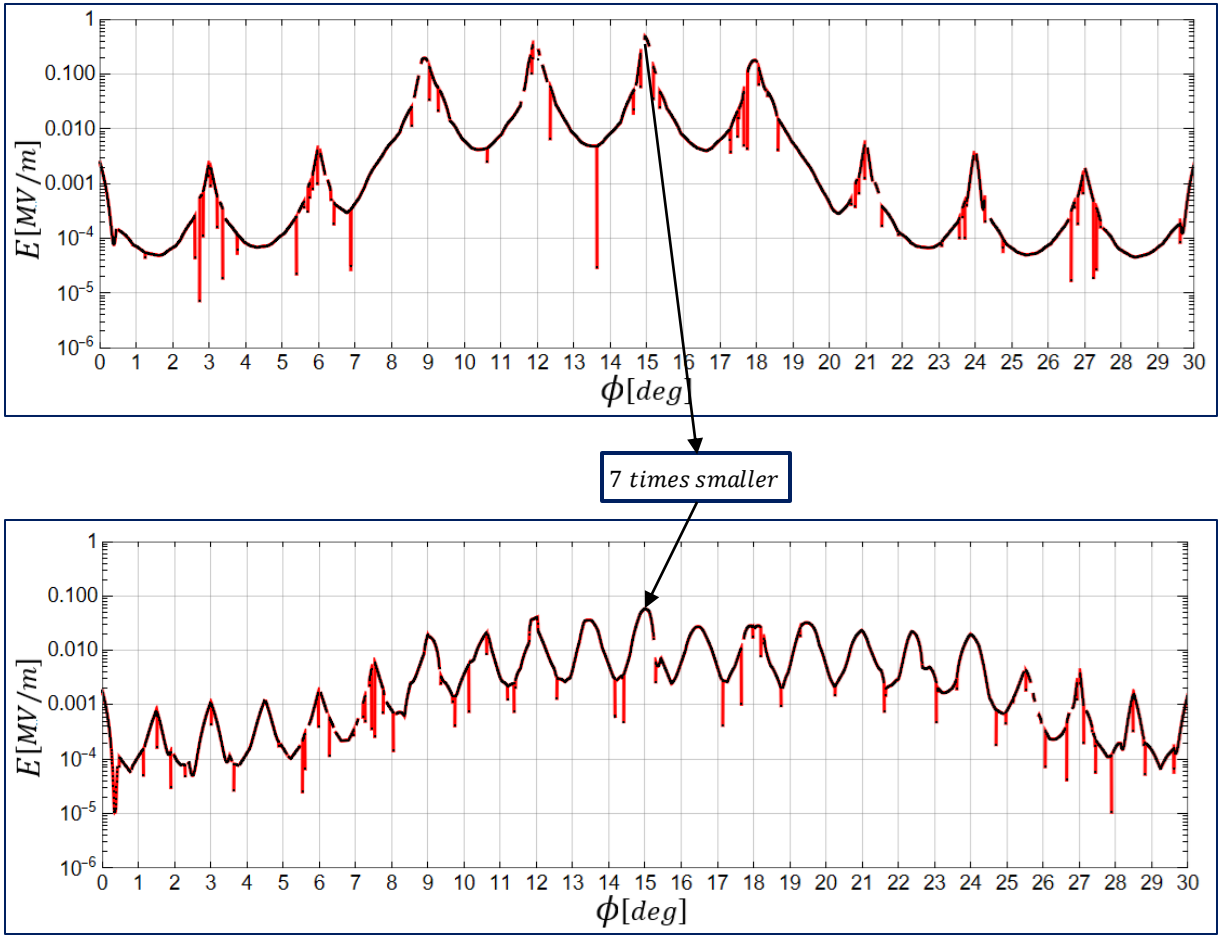
4.2 New Structure-RF Simulations



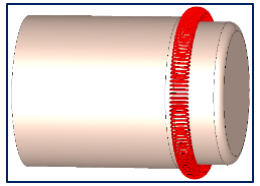
Filed Profile on the Wall-with Spring



4.2 New Structure-RF Simulations



Filed Profile on the Cathode-Spring Contact



Thanks for Attention