

FCC
— **RF** —
Considerations

FCC-RF-Working Group

S. Aull, O. Brunner, A. Butterworth, N. Schwerg, M. Therasse

parameter	FCC-ee crab waist (2 IPs)			
	Z	W	H	t
E_{beam} [GeV]	45.5	80	120	175
current [mA]	1450	152	30	6.6
$P_{\text{SR,tot}}$ [MW]	100	100	100	100
no. bunches	90300	5162	770	78
N_b [10^{11}]	0.33	0.6	0.8	1.7
e_x [nm]	0.09	0.27	0.61	1.3
e_y [pm]	1.0	1.0	1.2	2.5

towards a new FCC-ee
parameter baseline – v2

Frank Zimmermann
based on input from many colleagues
FCC-ee design meeting
9 December 2015

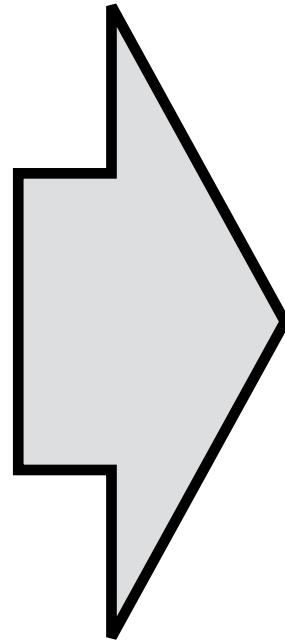
Input

Machine Parameters

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towards a new FCC-ee
parameter baseline – v2

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	V_tot	n_bunch	I_beam	E_turnloss
Z	0.08	90300	1450	0.034
W	0.8	5162	152	0.33
H	5.5	770	30	1.67
t	10	78	6.6	7.55

Input

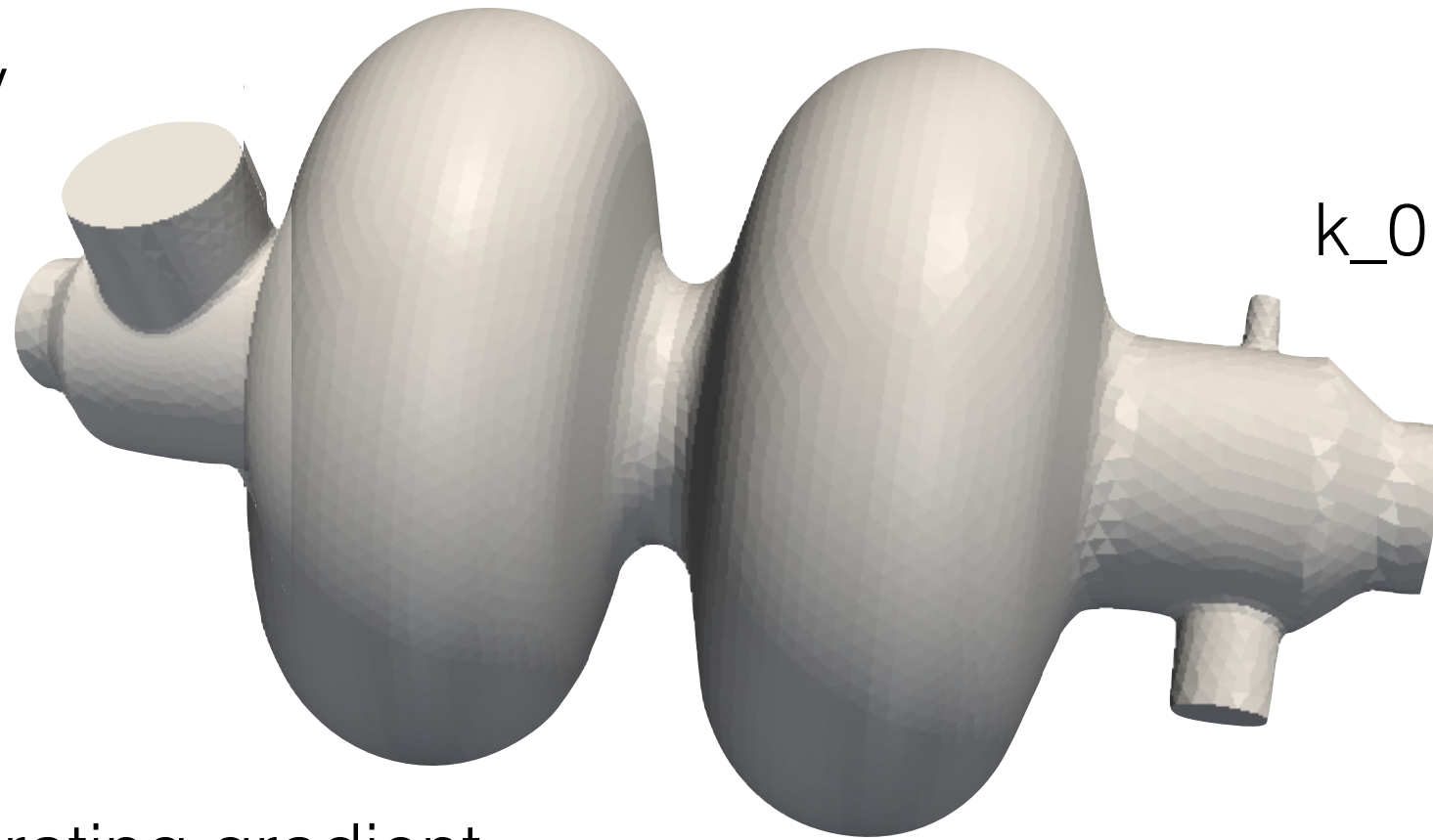
Machine Parameters

G : Geometry factor

R_s : Surface Resistivity

f : Frequency

k_0 : Loss factor



E_{acc} : Accelerating gradient

n_{cells} : Number of cells

Design and Technology

Choices

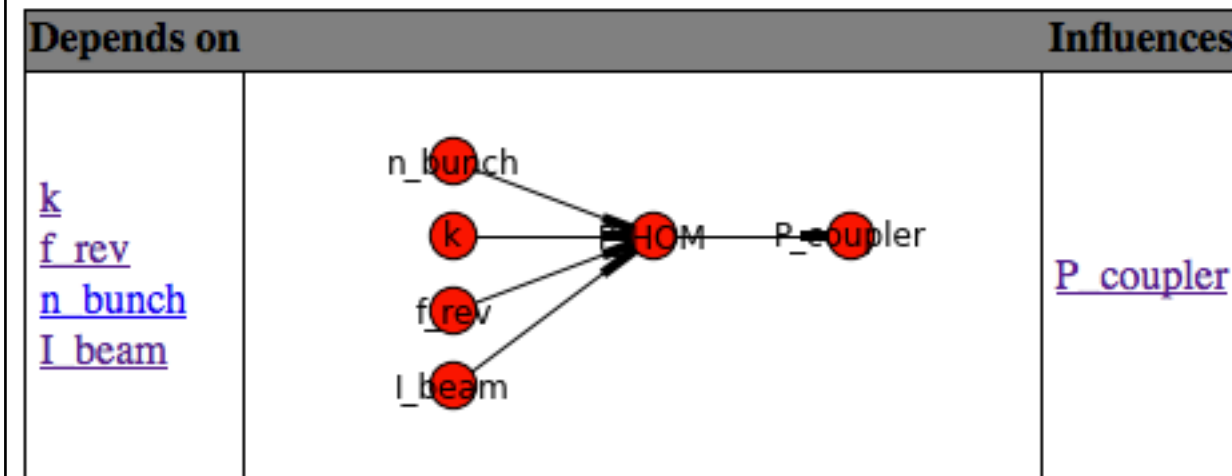
P_HOM : Beam loss per accelerating cell

$$P_HOM = (I_beam/1000)**2 * (k*1e12) / (f_rev*1000) / n_bunch / 1000$$

Value : 0.194805194805 kW

Limits : None ----> 4 kW

Dependency :



Interrelationships

and
Limits

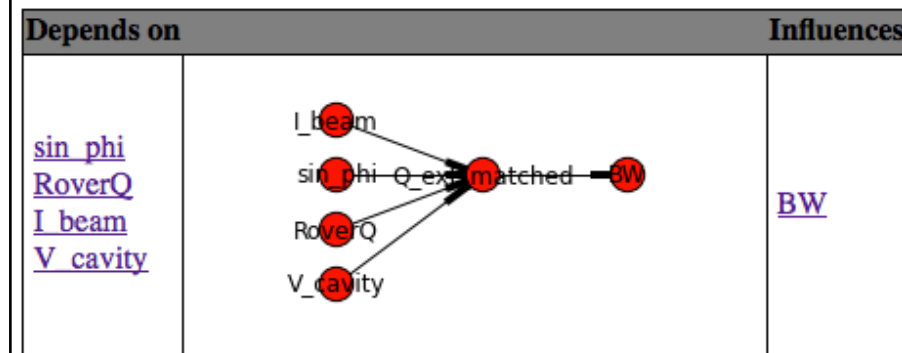
Q_ext_matched : External q-factor

$$Q_ext_matched = V_cavity * 1e6 / (2 * RoverQ * I_beam / 1000 * \sin_phi)$$

Value : 2742612.30705 -

Limits : 10000.0 - ----> 5000000.0 -

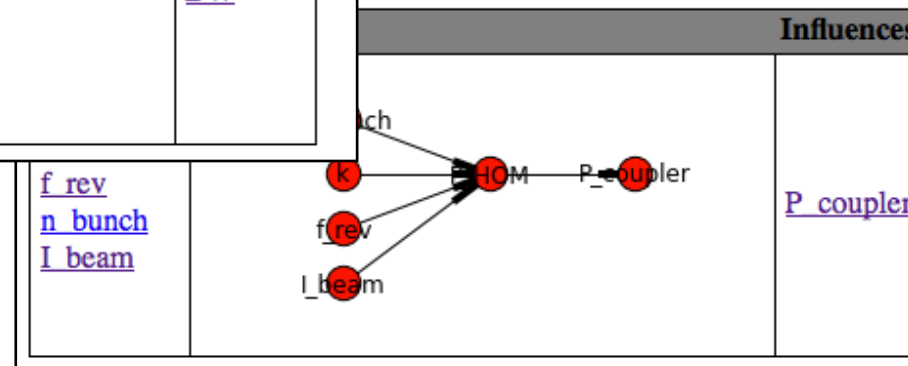
Dependency :



loss per accelerating cell

$$**2 * (k * 1e12) / (f_rev * 1000) / n_bunch / 1000$$

W



Interrelationships

Collection of Quantities

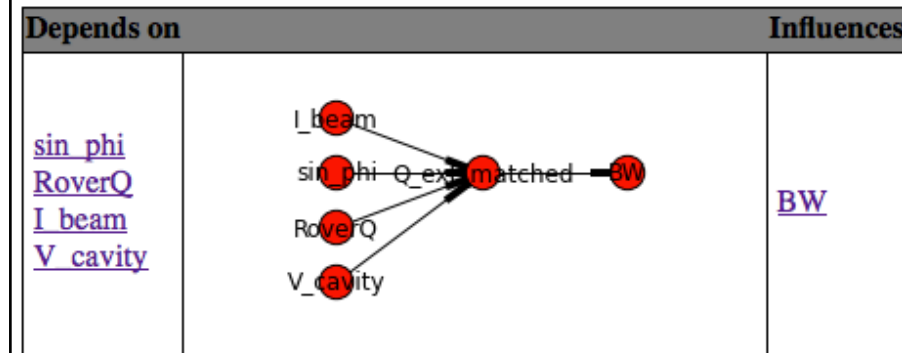
Q_ext_matched : External q-factor

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Dependency :



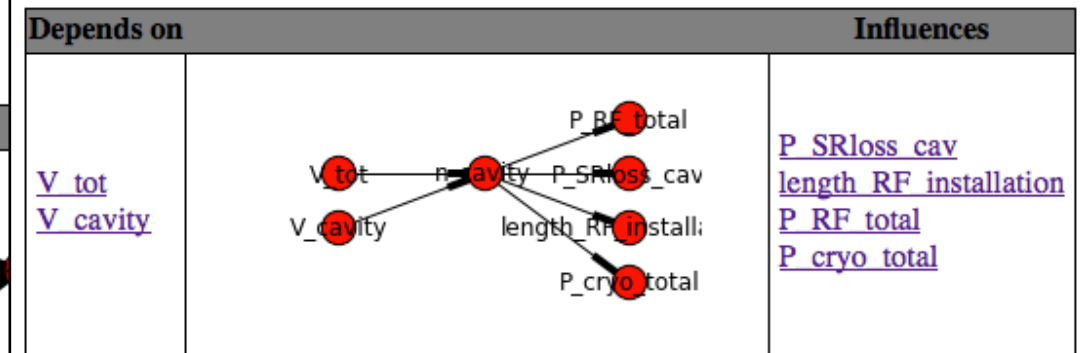
n_cavity : Total number of accelerating cavities

$$n_{cavity} = (V_{tot} * 1000) / V_{cavity}$$

Value : 1223.06834906 -

Limits : 1 - ----> 10000 -

Dependency :



[f_rev](#)
[n_bunch](#)
[I_beam](#)

k
 f_rev
 I_beam

Interrelationships

Collection of Quantities

Q_ext_matched : External q-factor

$$Q_{ext_matched} = V_{cavity} * 1e6 / (2 * R_{overQ} * I_{beam} / 1000 * \sin_phi)$$

Value : 2742612.30705 -

Limits : 10000.0 - ----> 5000000.0 -

Dependency :

Depends on	Influences
sin_phi	I_beam

loss p

**2 * (k*

W

n_cavity : Total number of accelerating cavities

$$n_{cavity} = (V_{tot} * 1000) / V_{cavity}$$

Value : 1223.06834906 -

Limits : 1 - ----> 10000 -

Dependency :

Depends on	Influences
V_tot V_cavity	P_RF total P_SRloss_cav length RF installation P_RF total P_cryo total

V_cavity : Accelerating voltage per cavity

$$V_{cavity} = E_{acc} * (l_{cell} / 100) * n_{cell}$$

Value : 4.49688687 MV

Limits : None ----> None

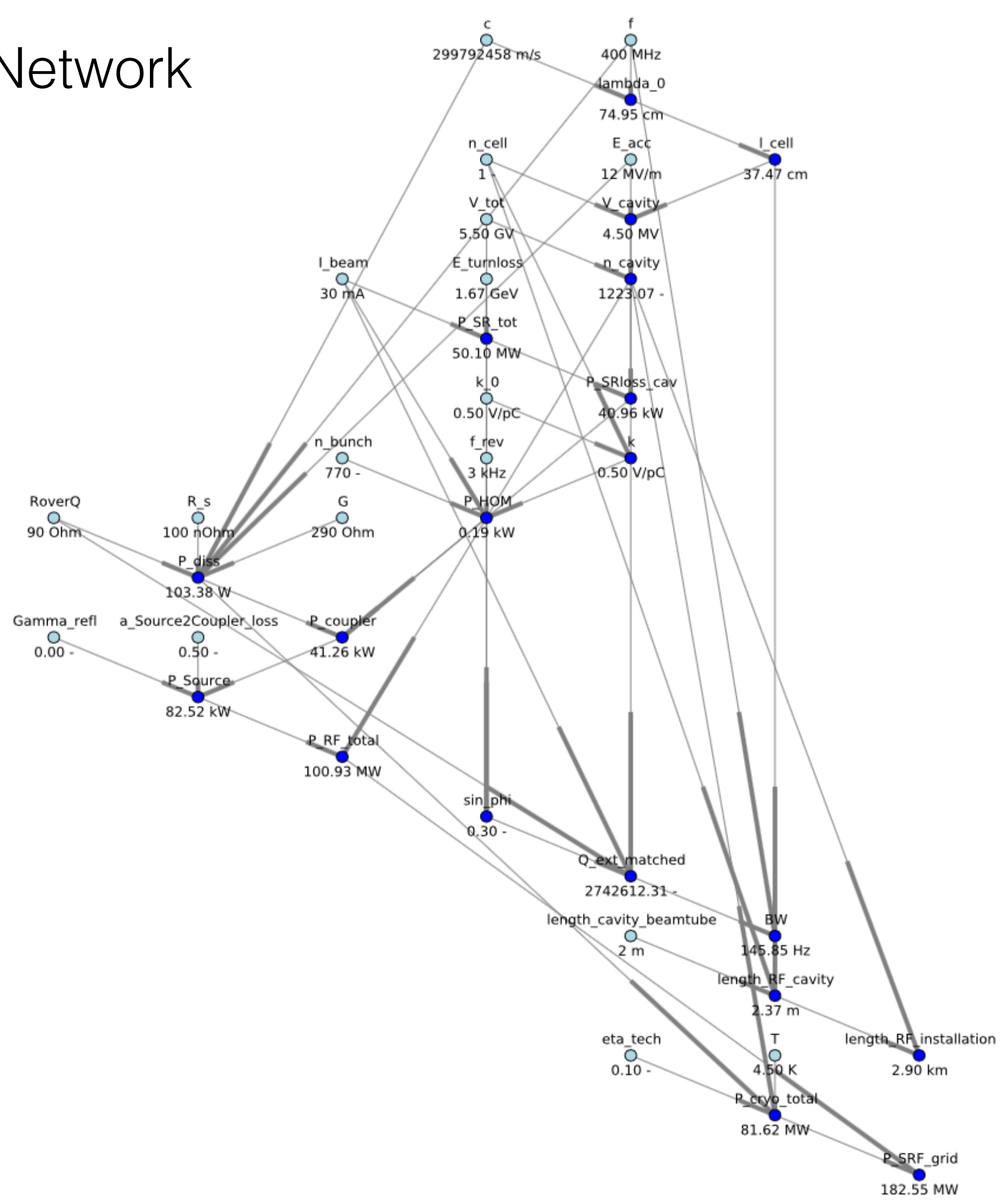
Dependency :

Depends on	Influences
l_cell E_acc n_cell	Q_ext_matched n_cavity

Interrelationships

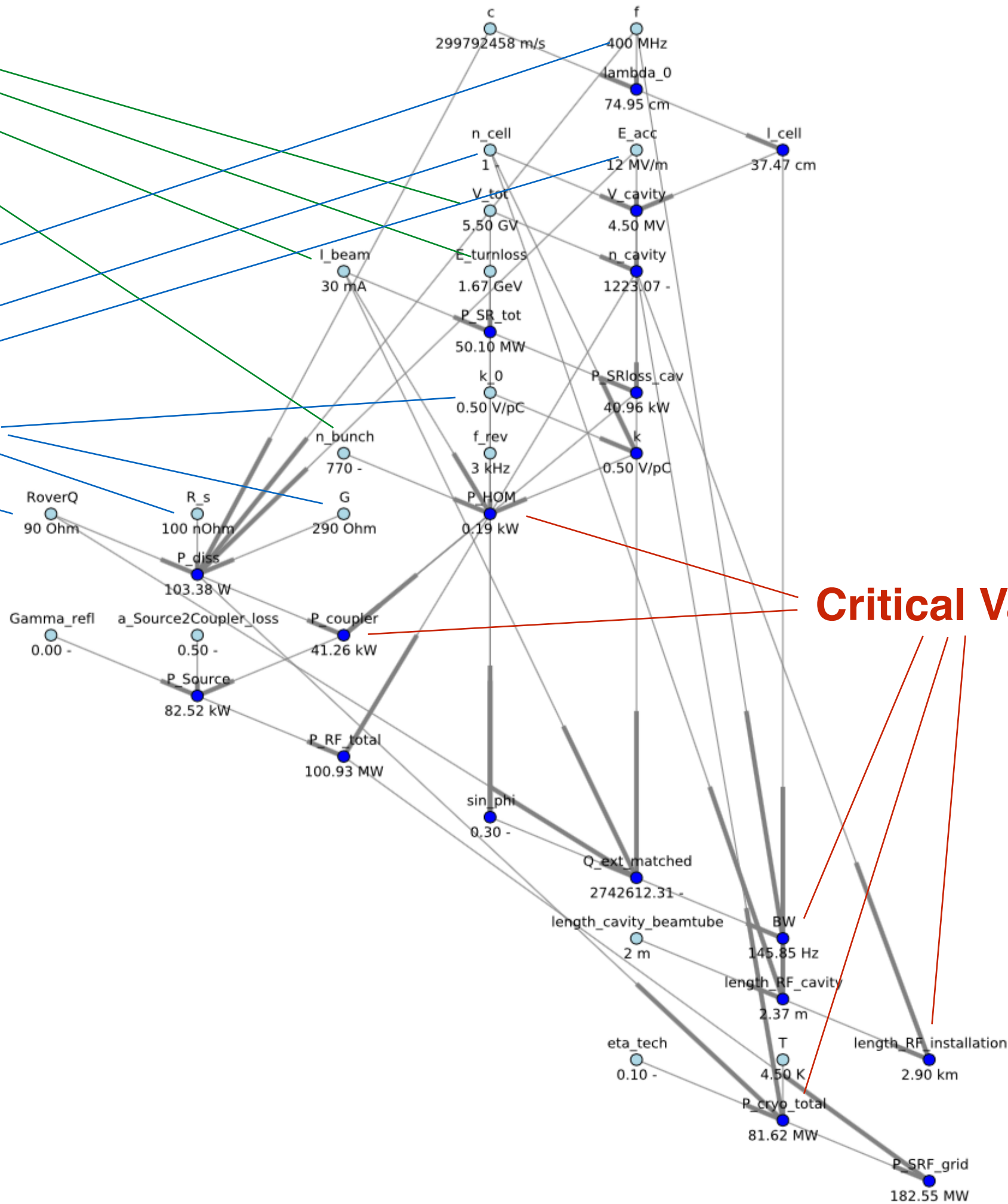
Collection of Quantities

Interrelationship Network

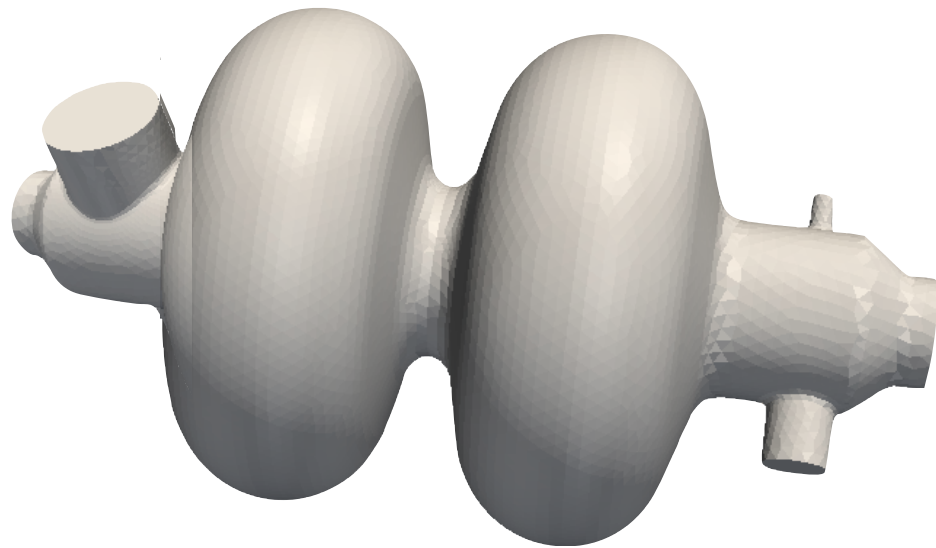


Machine Related

Design and Technology Choices



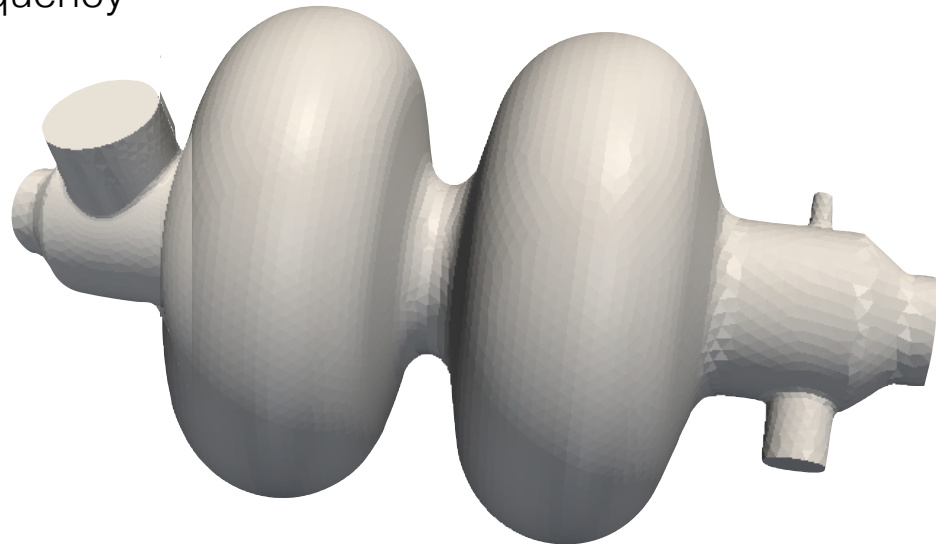
Critical Values



Design and Technology

Parameter Variation

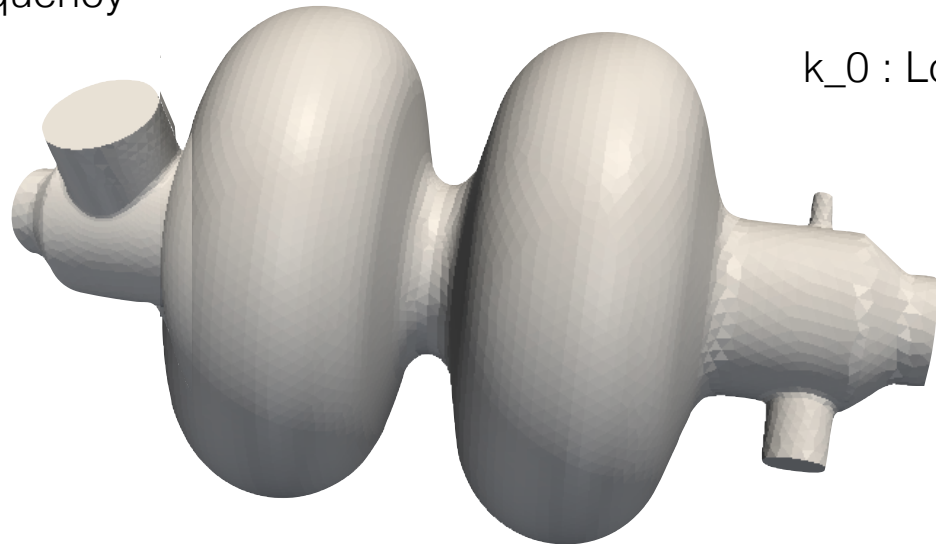
f : Frequency



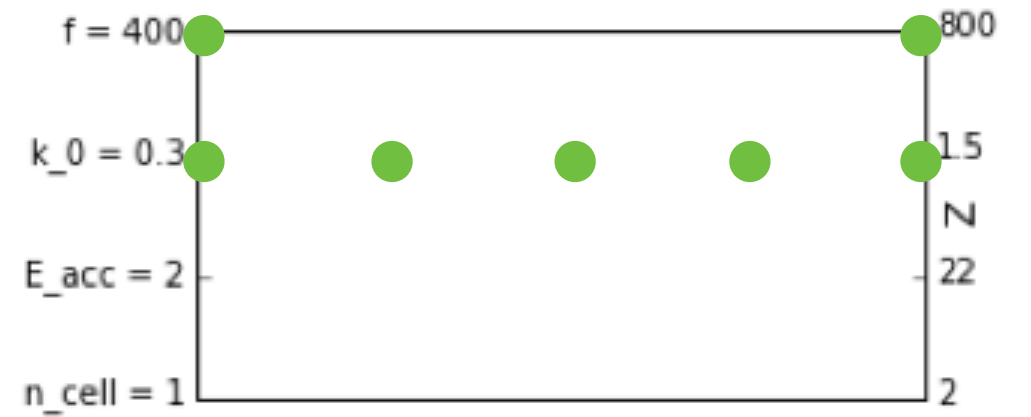
Design and Technology

Parameter Variation

f : Frequency



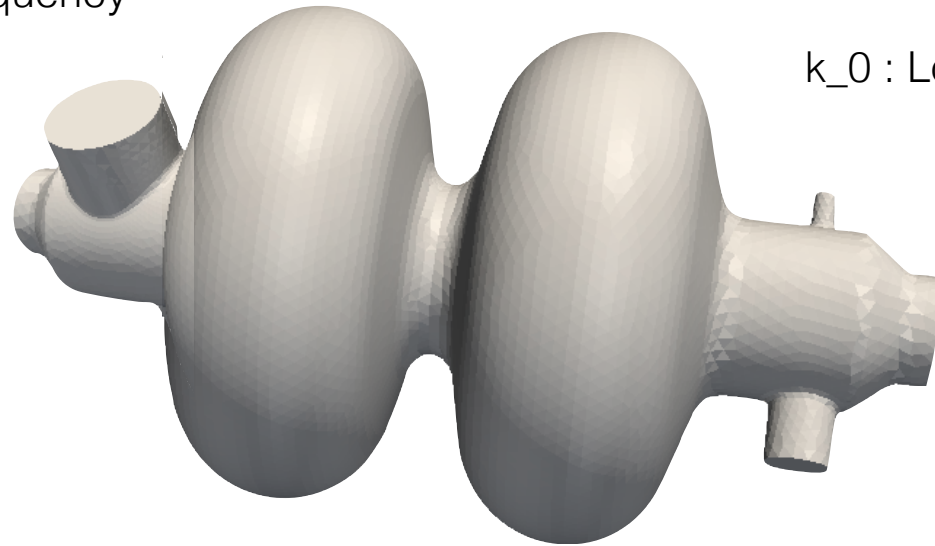
k_0 : Loss factor



Design and Technology

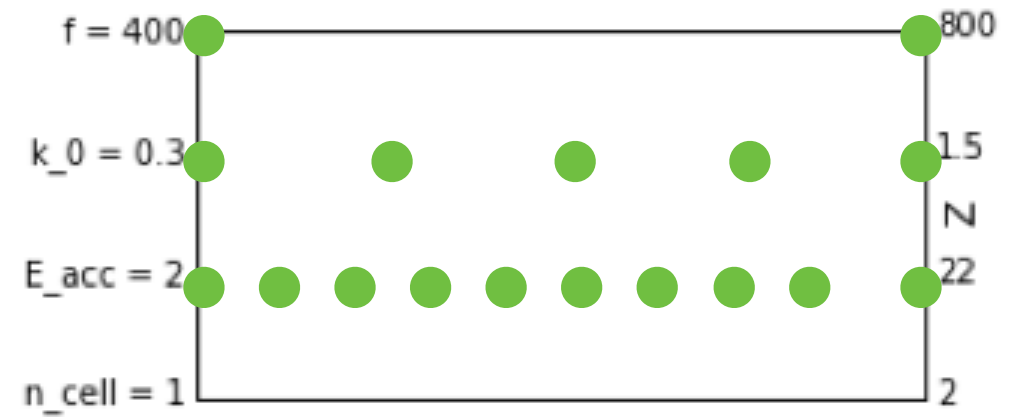
Parameter Variation

f : Frequency



k_0 : Loss factor

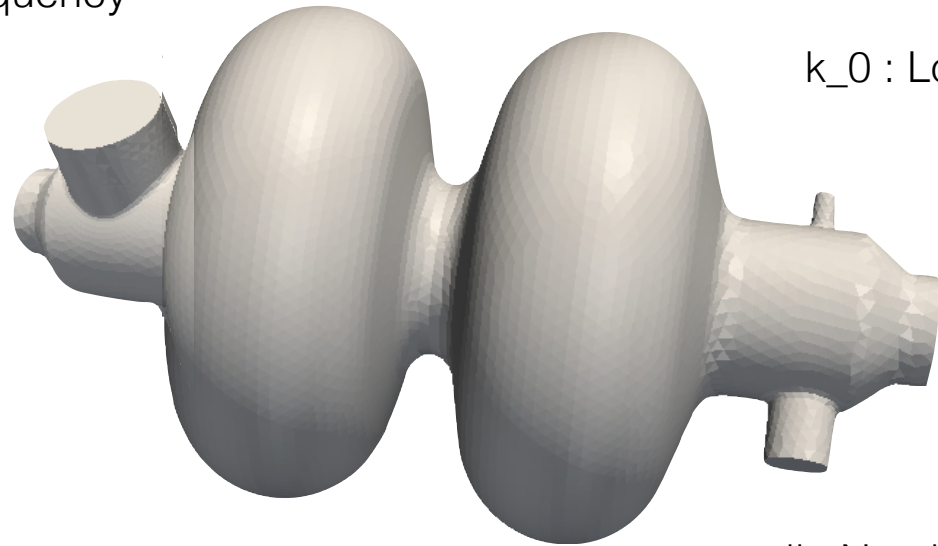
E_acc : Accelerating gradient



Design and Technology

Parameter Variation

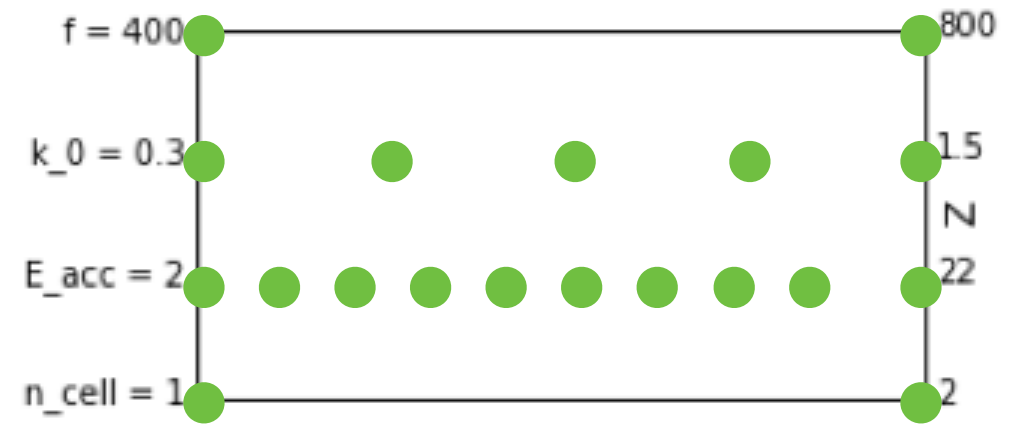
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k_0 : Loss factor

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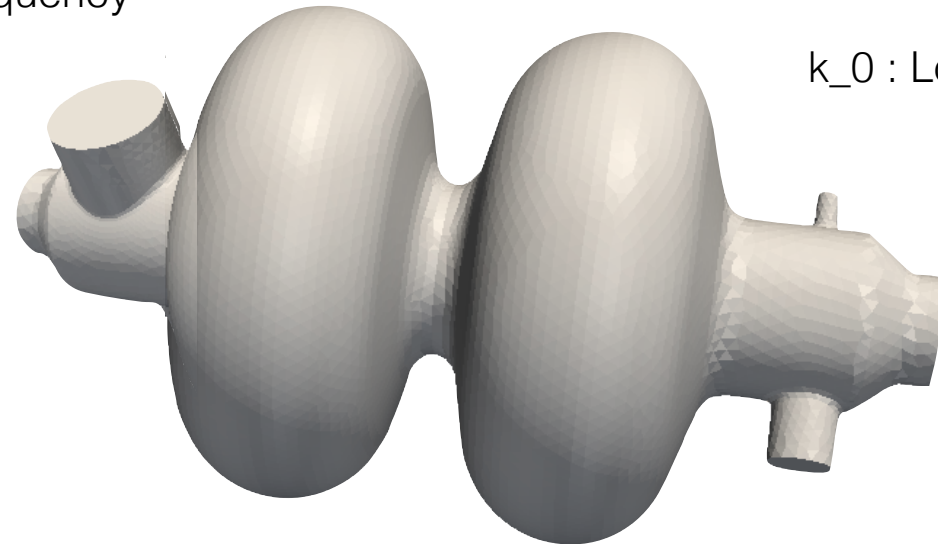
n_cell : Number of cells



Design and Technology

Parameter Variation

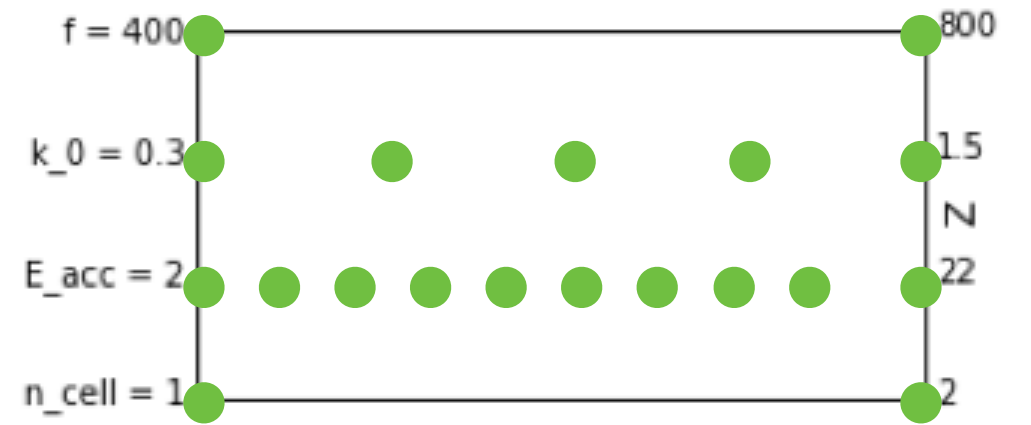
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Test all possible combinations

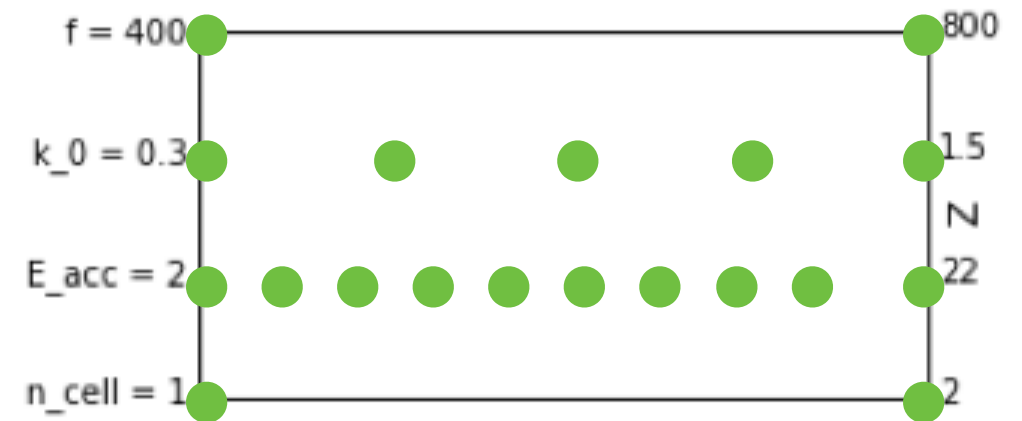
Design and Technology

Parameter Variation

Machine Parameters

	V_tot	n_bunch	I_beam	E_turnloss
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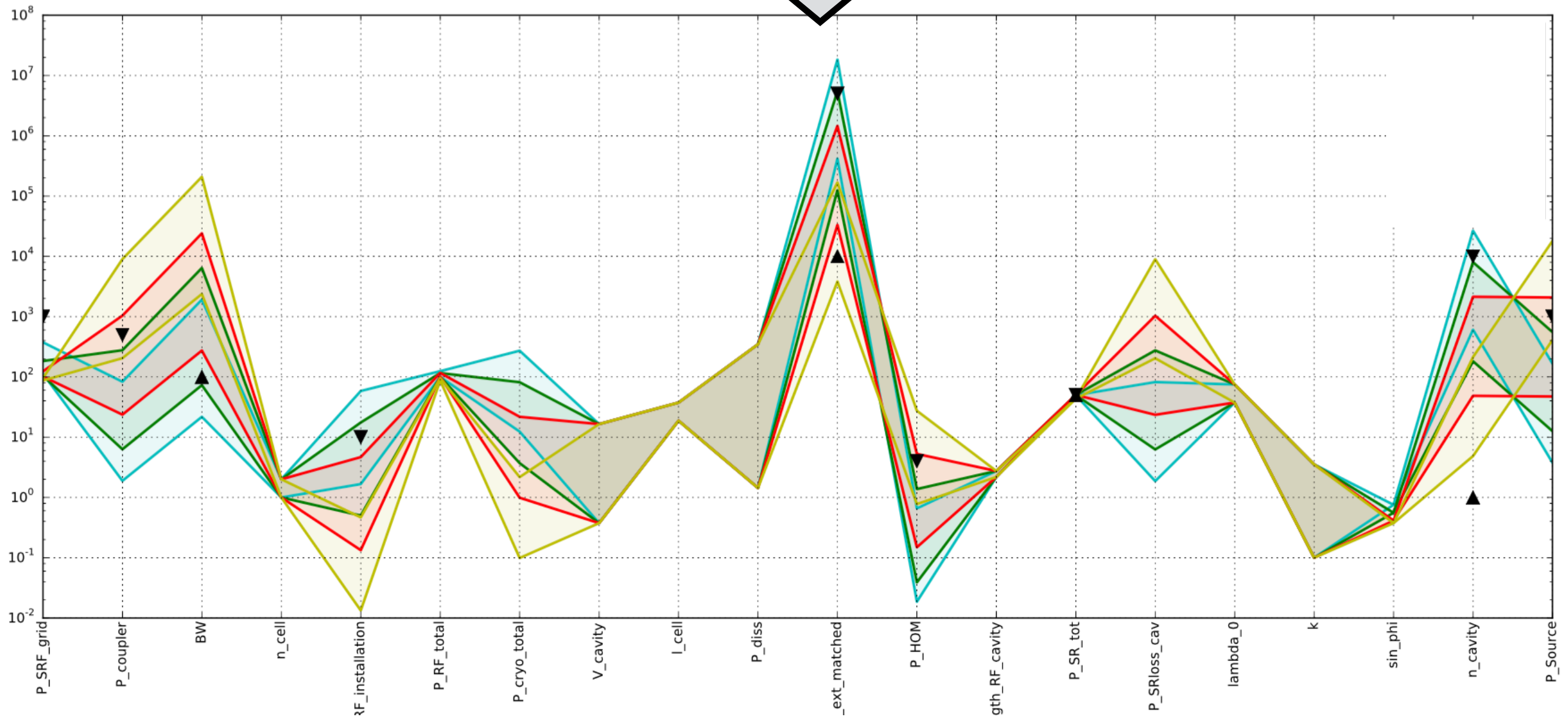
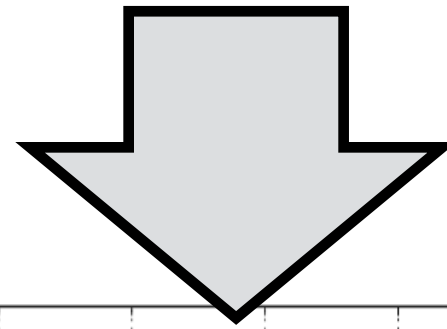
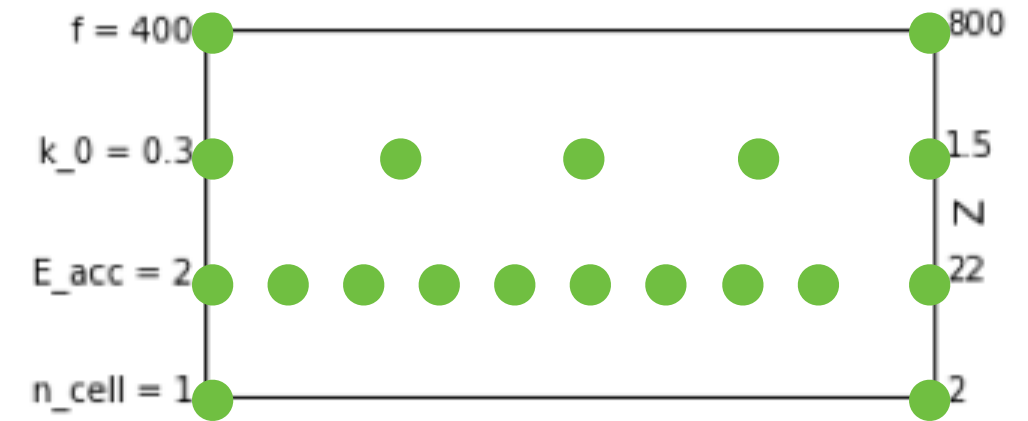
Design and Technology Choices



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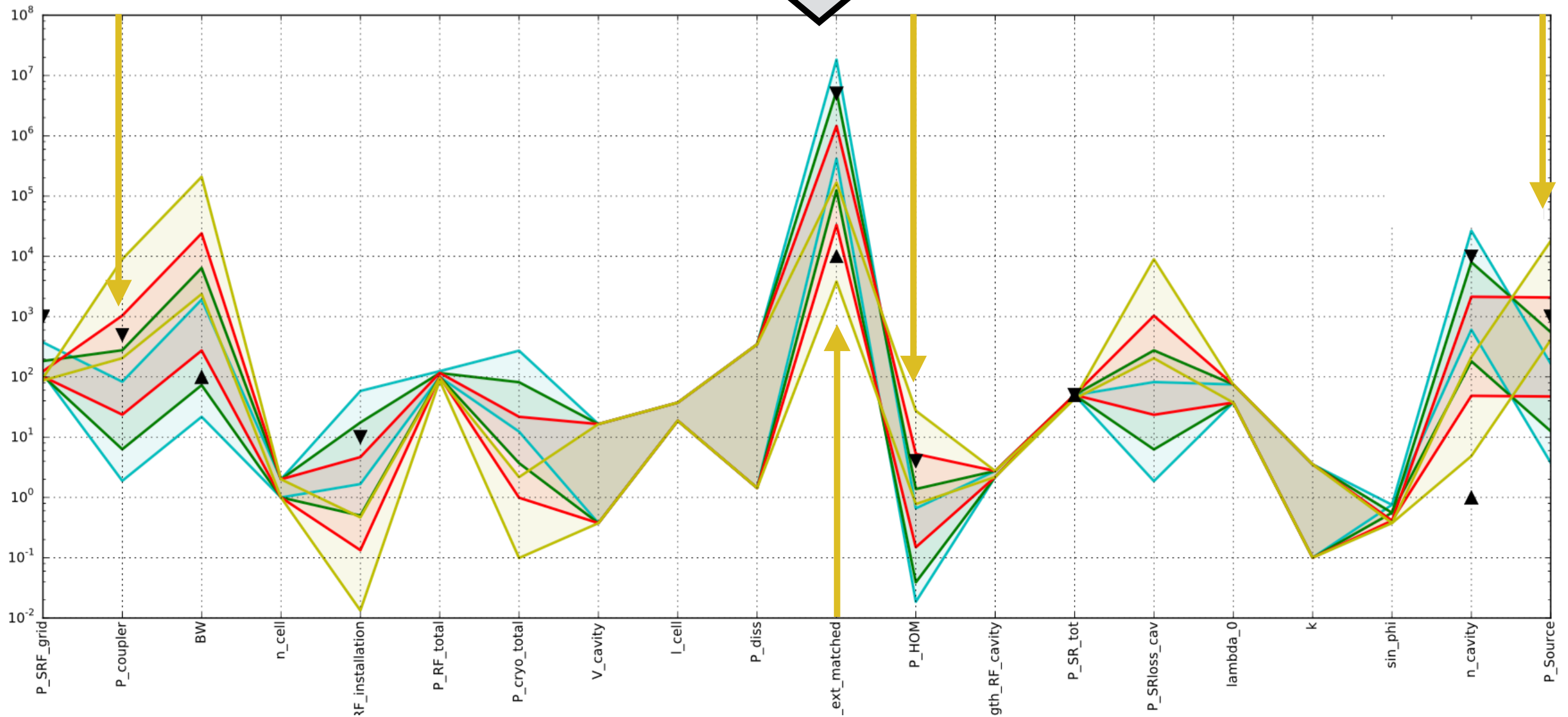
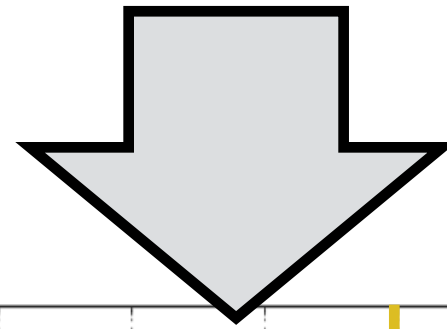
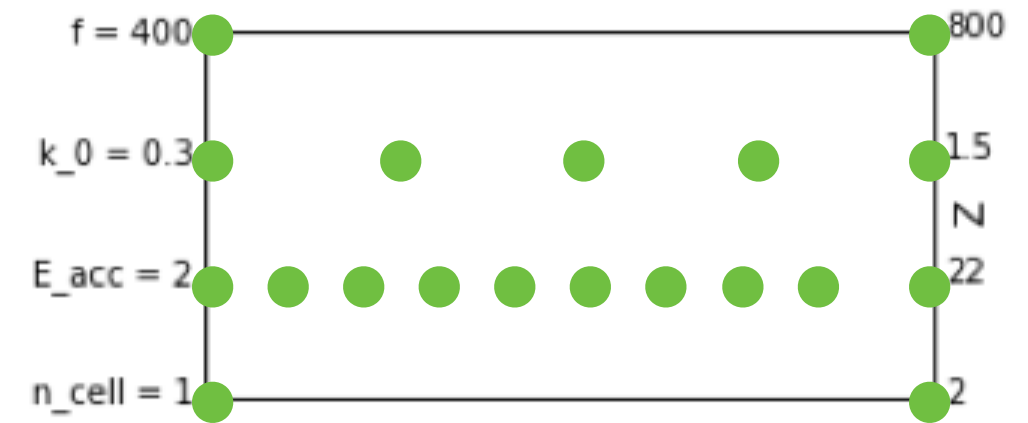
Design and Technology Choices



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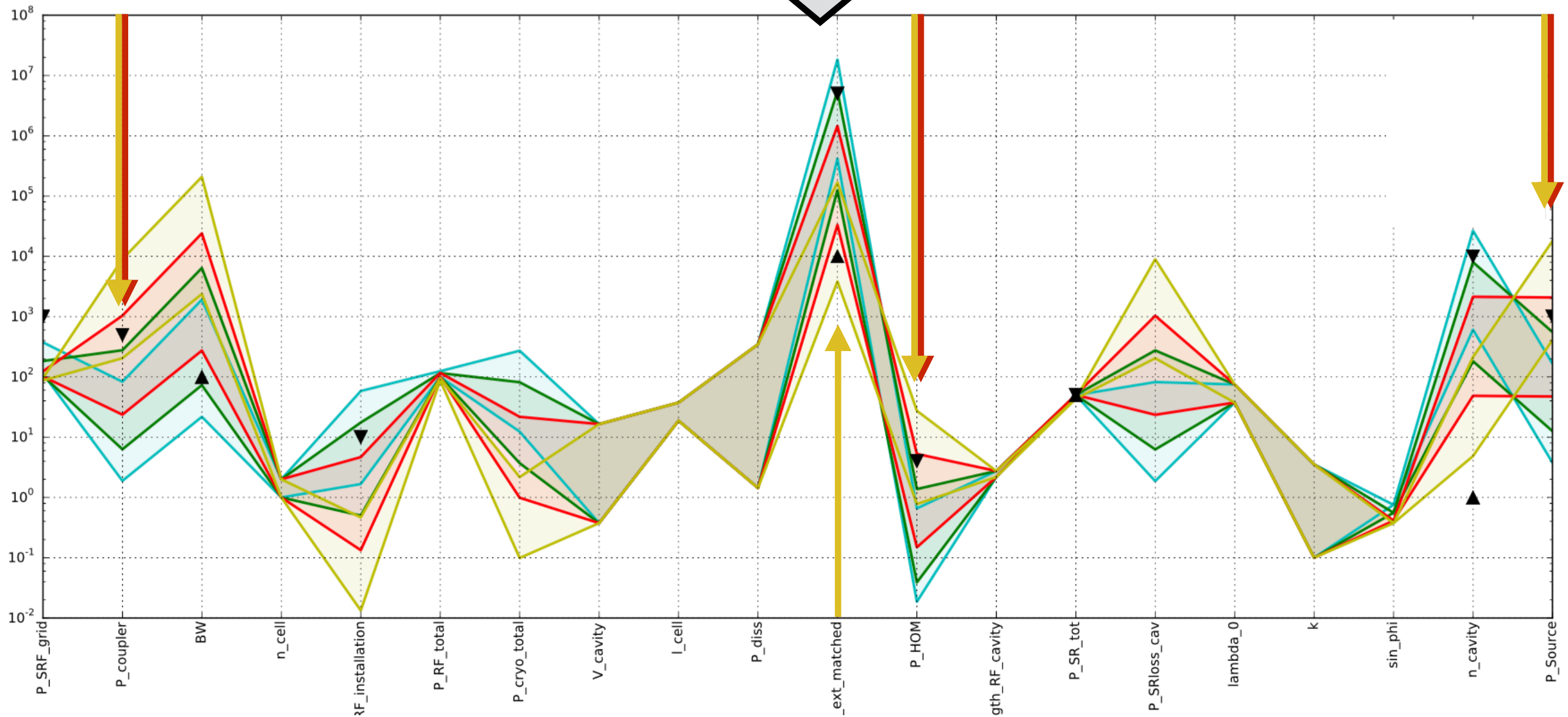
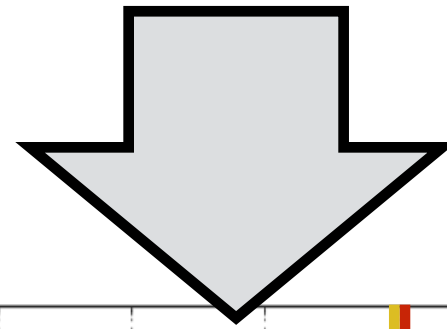
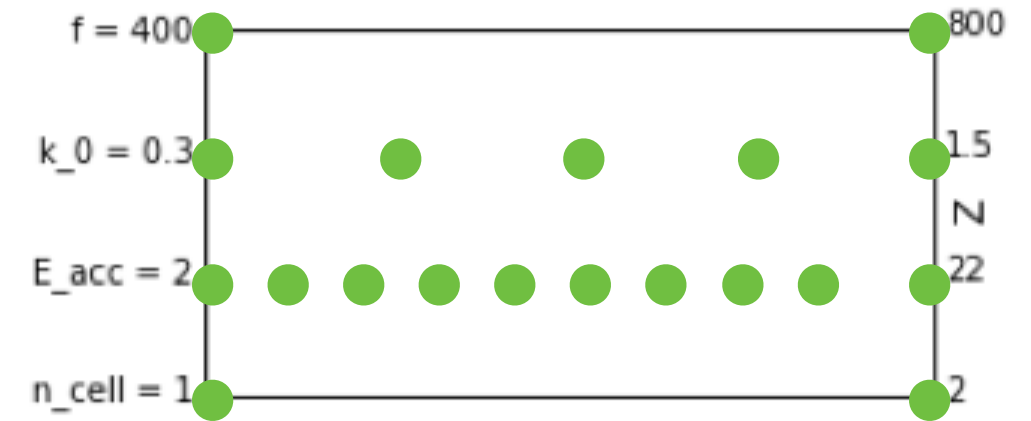
Design and Technology Choices



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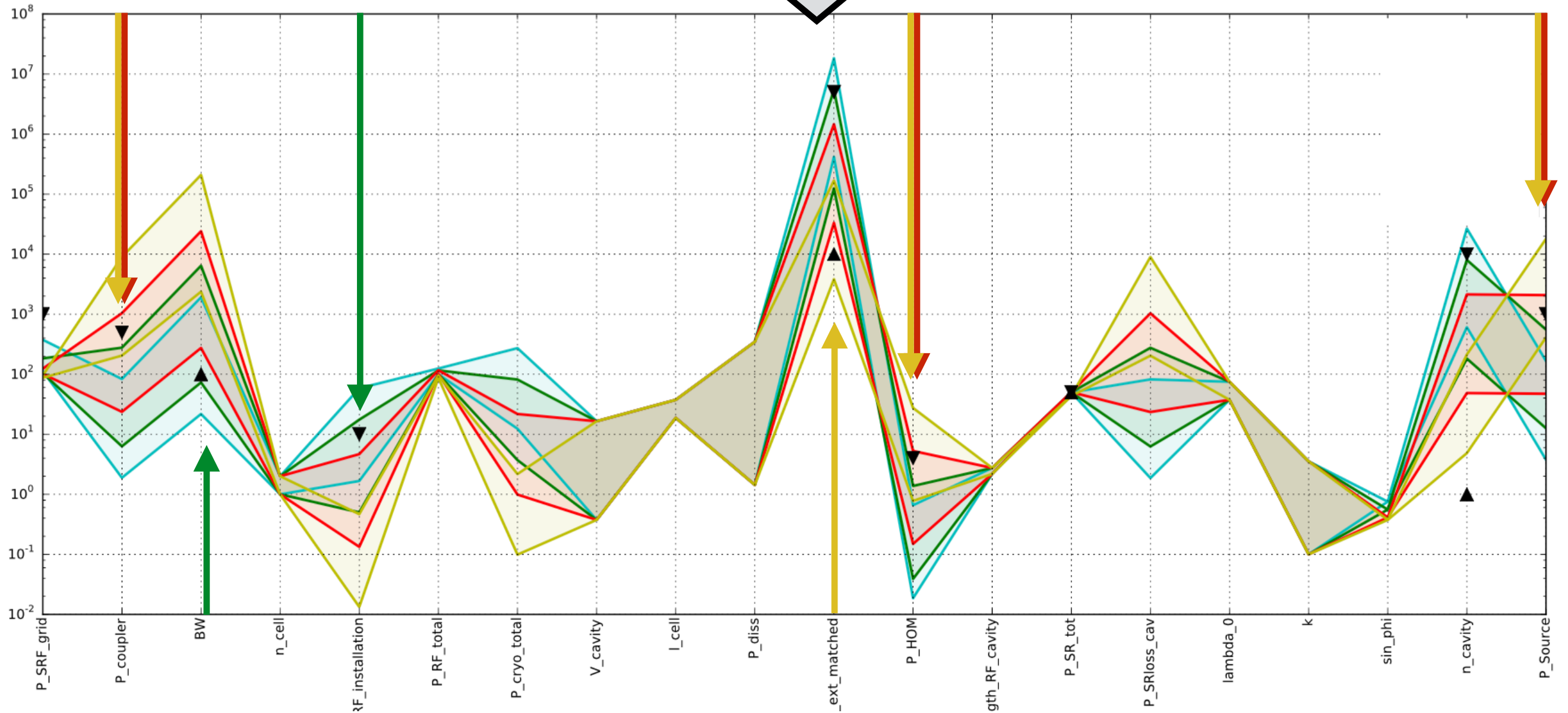
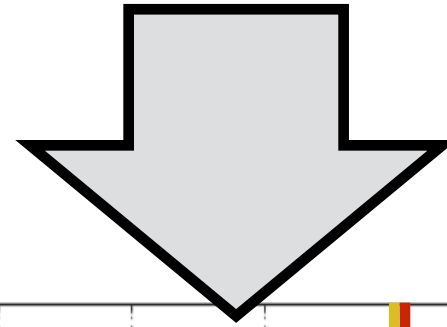
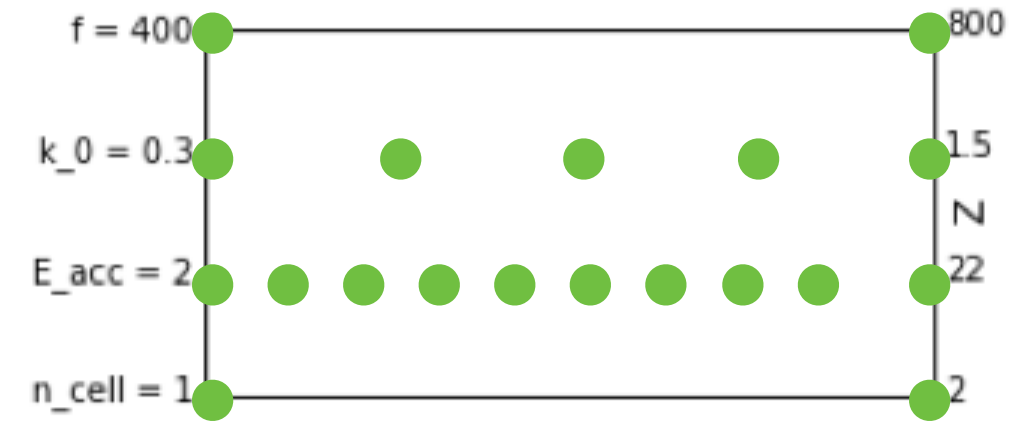
Design and Technology Choices



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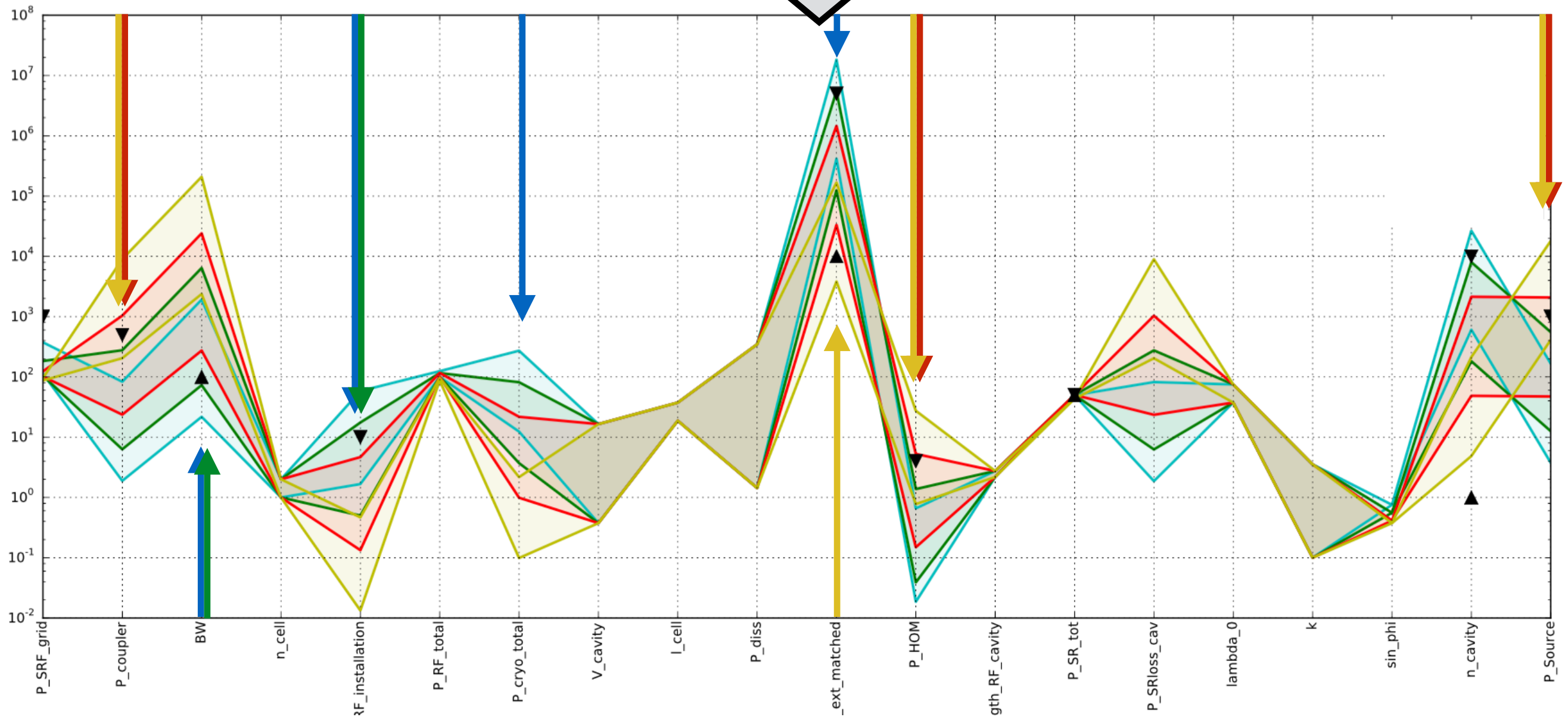
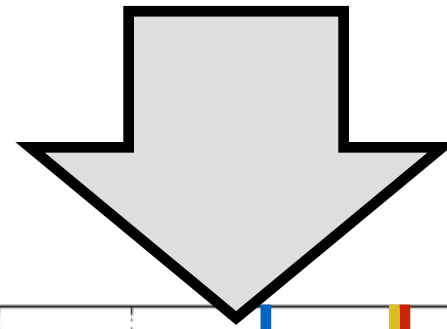
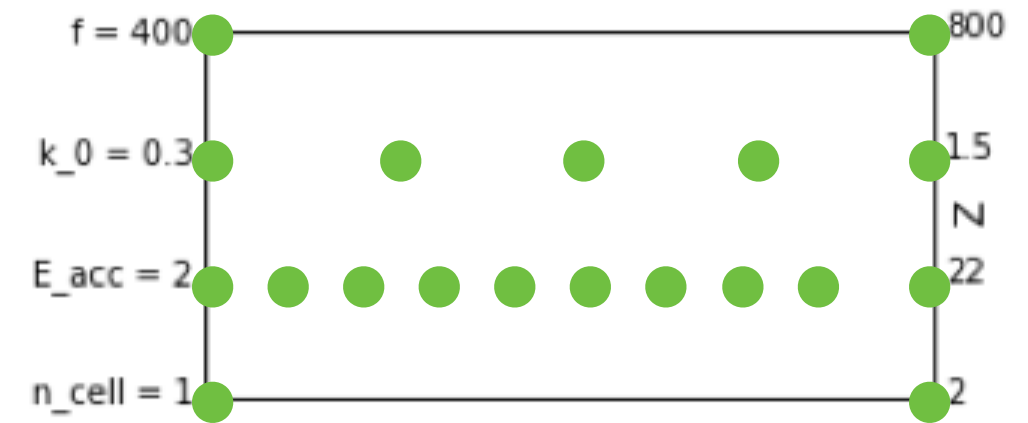
Design and Technology Choices

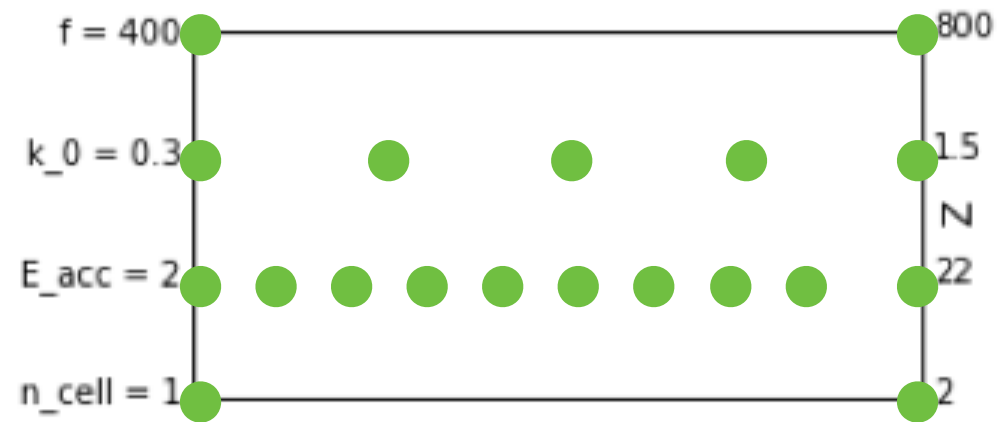


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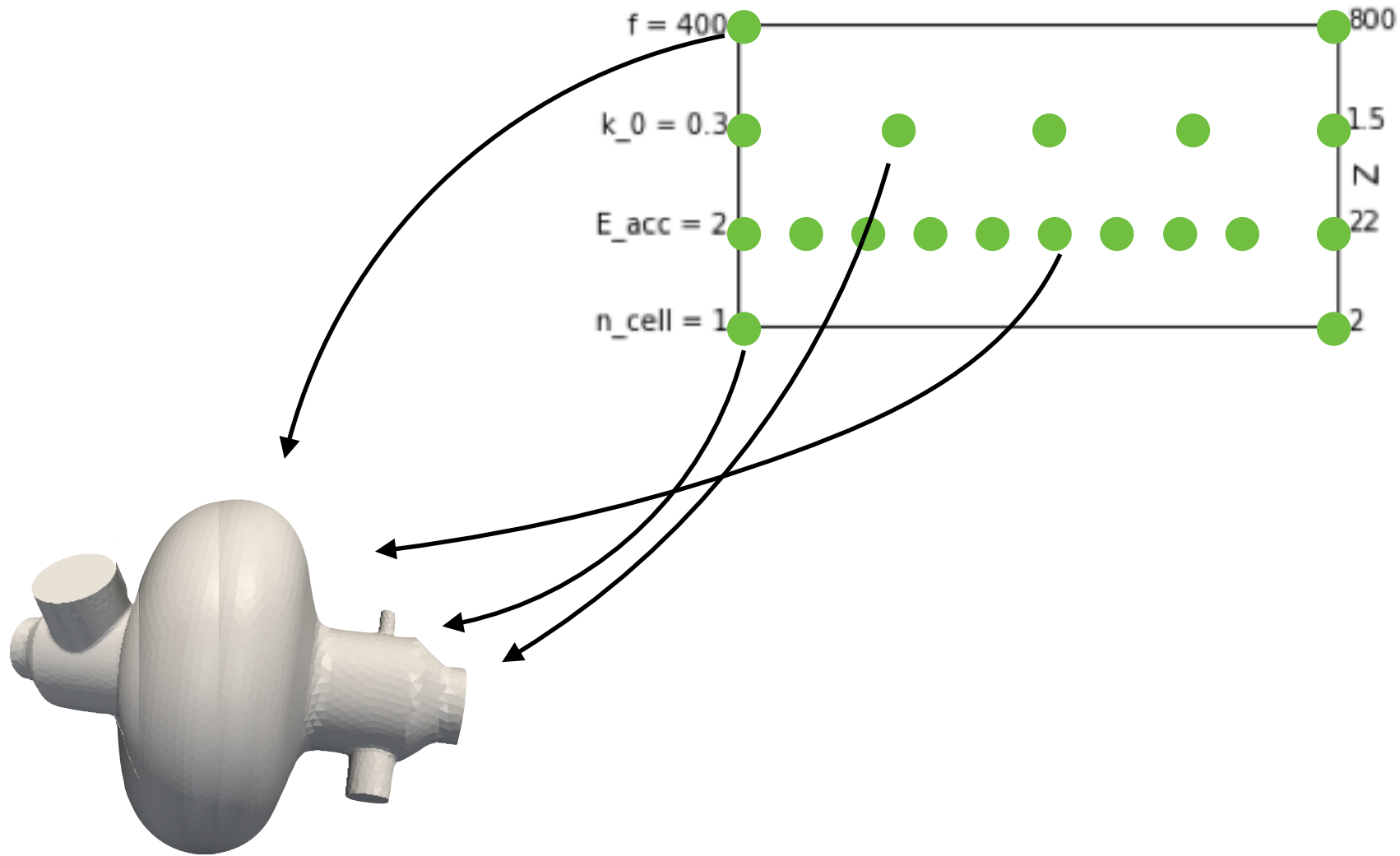
Design and Technology Choices





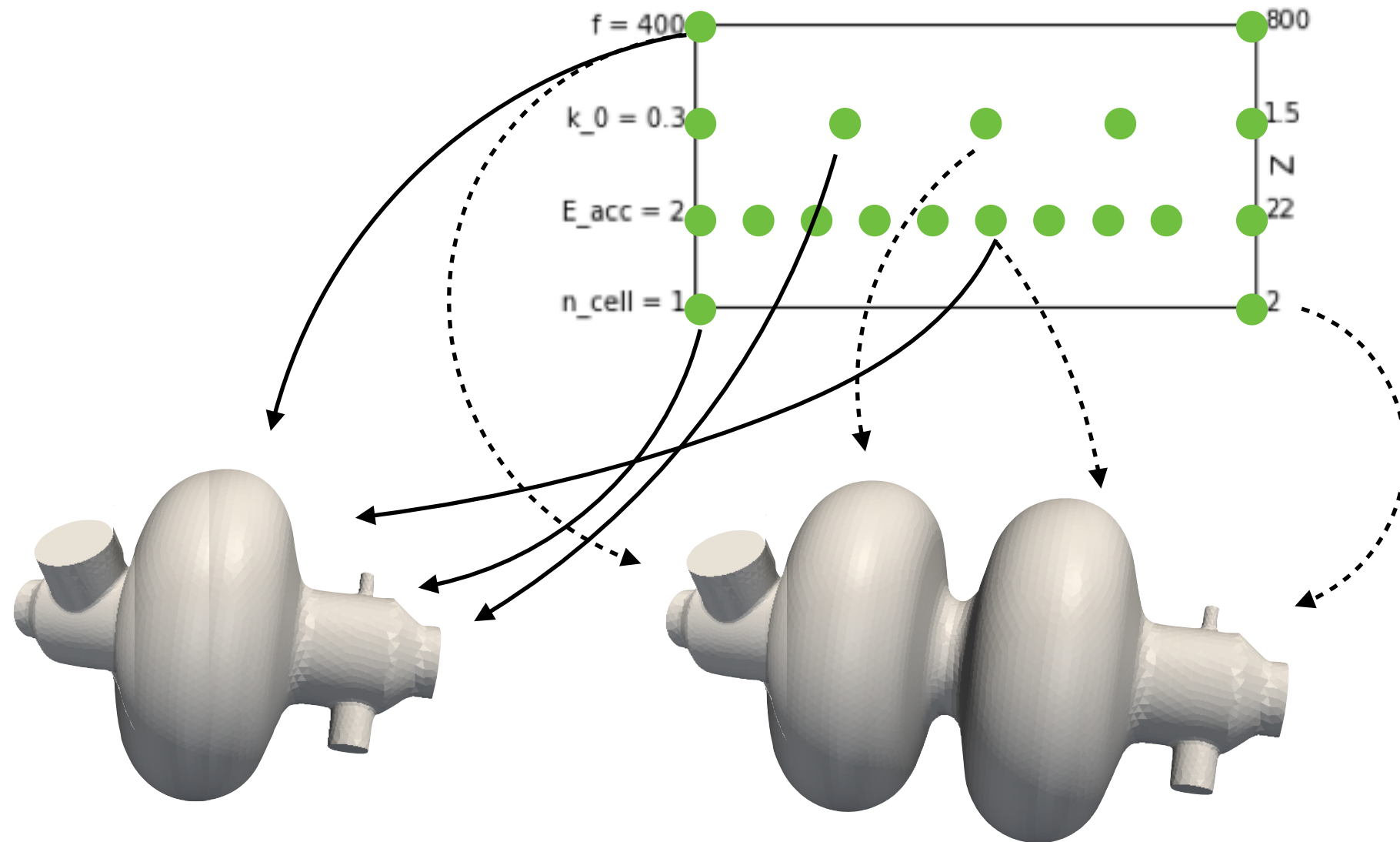
Design and Technology

Testing 3 Different Designs



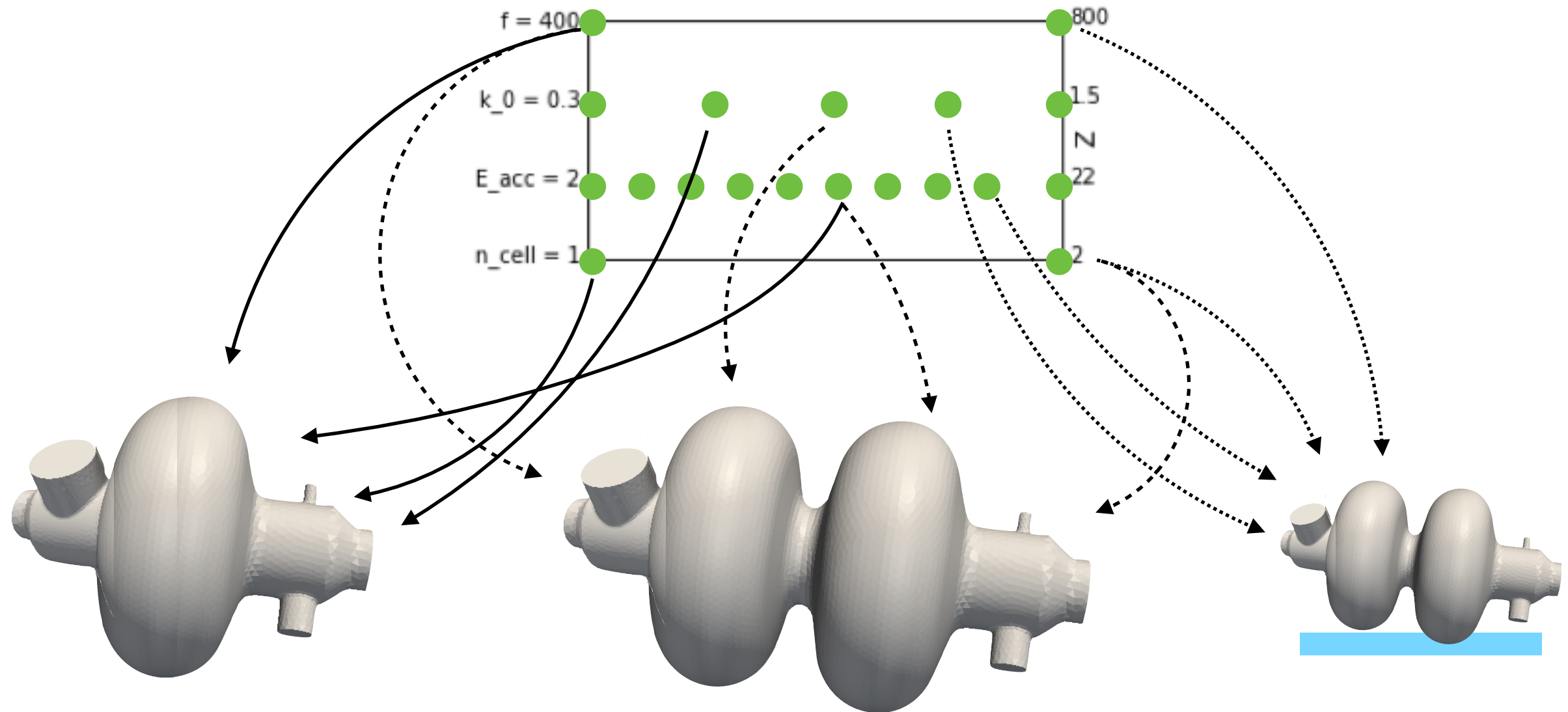
Design and Technology

Testing 3 Different Designs



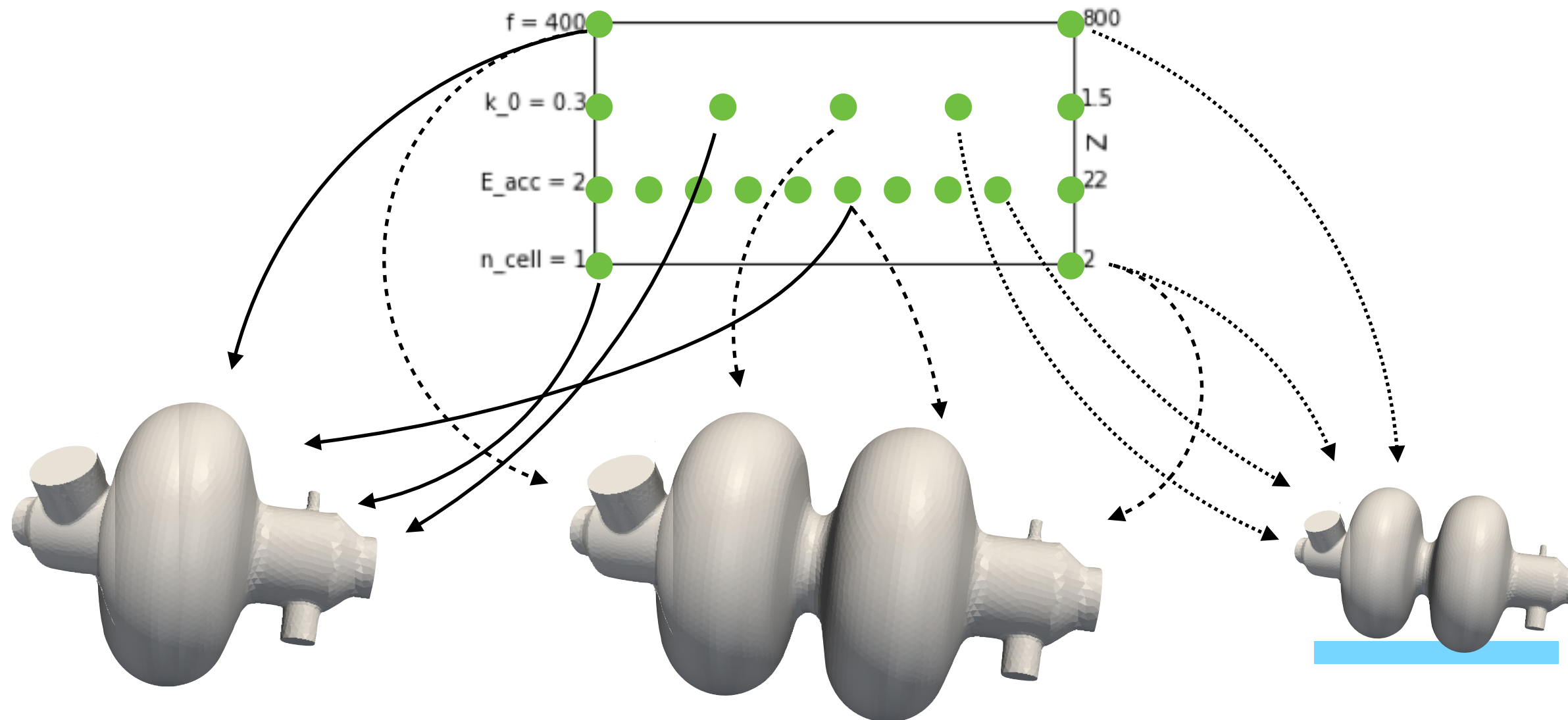
Design and Technology

Testing 3 Different Designs



Design and Technology

Testing 3 Different Designs



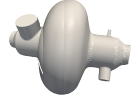
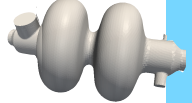

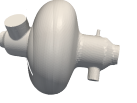
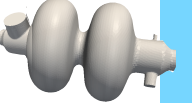

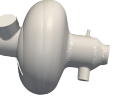
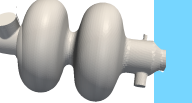
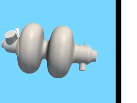

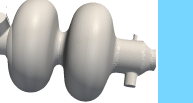
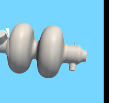
	f [MHz]	# cells	Vcell [MV/m]	R/Q [Ohm]	G [Ohm]	k// [V/pC]	Rs [nOhm]	Operating T [K]	Pmax/FPC [kW]
1 cell, 400MHz	400	1	10.0	90	290	0.50	100	4.5	500
2 cells, 400MHz	400	2	10.0	90	290	0.70	100	4.5	500
2 cells, 800MHz	800	2	20.0	90	290	1.00	80	2.0	400

Design and Technology

Testing 3 Different Designs

Design and Technology

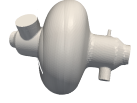
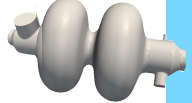

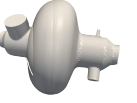
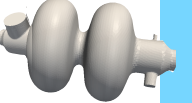

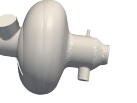
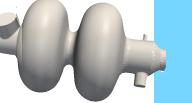
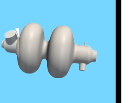

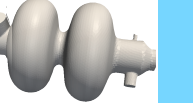
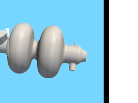
3 Different Designs 4 Machines

	Z			W			H			t		
Technology&design												
cavity choice	cell, 400MH	cells, 400MH	cells, 800MH	cell, 400MH	cells, 400MH	cells, 800MH	cell, 400MH	cells, 400MH	cells, 800MH	cell, 400MH	cells, 400MH	cells, 800MH
frequency [MHz]	400	400	800	400	400	800	400	400	800	400	400	800
Nb cells/cavity	1	2	2	1	2	2	1	2	2	1	2	2
Eacc [MV/m]	2.1	1.05	1.65	10.0	10.0	20.0	10.0	10.0	20.0	10.0	10.0	20.0
R/Q [Ohm]	90	90	90	90	90	90	90	90	90	90	90	90
k// [V/pC]	0.50	0.70	1.00	0.50	0.70	1.00	0.50	0.70	1.00	0.50	0.70	1.00
Pfpc max [kW]	0.50	0.70	1.00	0.50	0.70	1.00	0.50	0.70	1.00	0.50	0.70	1.00
G [Ohm]	290	290	290	290	290	290	290	290	290	290	290	290
Rs [nOhm]	100	100	80	100	100	80	100	100	80	100	100	80
Operating Temp [K]	4.5	4.5	2.0	4.5	4.5	2.0	4.5	4.5	2.0	4.5	4.5	2.0
RF system parameters												
Cell length [m]	0.375	0.375	0.1875	0.375	0.375	0.1875	0.375	0.375	0.1875	0.375	0.375	0.1875
Active length/cavity [m]	0.375	0.75	0.375	0.375	0.75	0.375	0.375	0.75	0.375	0.375	0.75	0.375
Vcell [MV]	0.79	0.39	0.31	3.75	3.75	3.75	3.75	3.75	3.75	3.75	3.75	3.75
Pbeam loss [MW]	49.3	49.3	49.3	50.16	50.16	50.16	50.1	50.1	50.1	49.83	49.83	49.83
Qext matched	7.1E+03	7.1E+03	5.6E+03	3.3E+05	6.6E+05	6.6E+05	2.3E+06	4.6E+06	4.6E+06	4.2E+06	8.4E+06	8.4E+06
BW	56343	56343	143418	1204	602	1204	175	87	175	96	48	96
Nb cells	102	203	259	213	213	213	1467	1467	1467	2667	2667	2667
Nb cavities	102	102	129	213	107	107	1467	733	733	1333	667	667
Pdiss/cav [W]	3	1	1	72	72	115	72	72	115	72	72	115
RF system active length	38	76	48	80	80	40	550	550	275	500	500	250
RF system length [m]	180	218	165	379	229	136	2603	1577	935	1183	717	850
Pcryo tot [MW]	0	0	0	10	5	18	68	34	123	62	31	112
PRF/cell [kW]	485	485	381	235	470	470	34	68	68	37	75	75
Phom [kW]	3.9	5.4	7.8	0.7	1.0	1.5	0.2	0.3	0.4	0.1	0.1	0.2
max "allowable" k// [V/g]	0.52			2.68			10.27			21.49		

both beams

Design and Technology

3 Different Designs 4 Machines

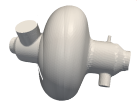
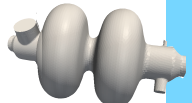

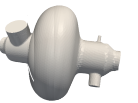
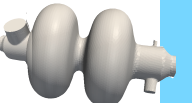
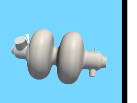
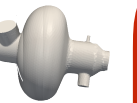
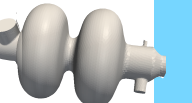
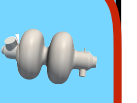

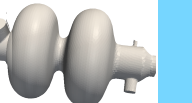
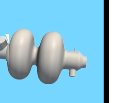
	Z			W			H			t		
Technology&design												
cavity choice	cell, 400MH	cells, 400MH	cells, 800MH	cell, 400MH	cells, 400MH	cells, 800MH	cell, 400MH	cells, 400MH	cells, 800MH	cell, 400MH	cells, 400MH	cells, 800MH
frequency [MHz]	400	400	800	400	400	800	400	400	800	400	400	800
Nb cells/cavity	1	2	2	1	2	2	1	2	2	1	2	2
Eacc [MV/m]	2.1	1.05	1.65	10.0	10.0	20.0	10.0	10.0	20.0	10.0	10.0	20.0
R/Q [Ohm]	90	90	90	90	90	90	90	90	90	90	90	90
k// [V/pC]	0.50	0.70	1.00	0.50	0.70	1.00	0.50	0.70	1.00	0.50	0.70	1.00
Pfpc max [kW]	0.50	0.70	1.00	0.50	0.70	1.00	0.50	0.70	1.00	0.50	0.70	1.00
G [Ohm]	290	290	290	290	290	290	290	290	290	290	290	290
Rs [nOhm]	100	100	80	100	100	80	100	100	80	100	100	80
Operating Temp [K]	4.5	4.5	2.0	4.5	4.5	2.0	4.5	4.5	2.0	4.5	4.5	2.0
RF system parameters												
Cell length [m]	0.375	0.375	0.1875	0.375	0.375	0.1875	0.375	0.375	0.1875	0.375	0.375	0.1875
Active length/cavity [m]	0.375	0.75	0.375	0.375	0.75	0.375	0.375	0.75	0.375	0.375	0.75	0.375
Vcell [MV]	0.79	0.39	0.31	3.75	3.75	3.75	3.75	3.75	3.75	3.75	3.75	3.75
Pbeam loss [MW]	49.3	49.3	49.3	50.16	50.16	50.16	50.1	50.1	50.1	49.83	49.83	49.83
Qext matched	7.1E+03	7.1E+03	5.6E+03	3.3E+05	6.6E+05	6.6E+05	2.3E+06	4.6E+06	4.6E+06	4.2E+06	8.4E+06	8.4E+06
BW	56343	56343	143418	1204	602	1204	175	87	175	96	48	96
Nb cells	102	203	259	213	213	213	1467	1467	1467	2667	2667	2667
Nb cavities	102	102	129	213	107	107	1467	733	733	1333	667	667
Pdiss/cav [W]	3	1	1	72	72	115	72	72	115	72	72	115
RF system active length	38	76	48	80	80	40	550	550	275	500	500	250
RF system length [m]	180	218	165	379	229	136	2603	1577	935	1183	717	850
Pcryo tot [MW]	0	0	0	10	5	18	68	34	123	62	31	112
PRF/cell [kW]	485	485	381	235	470	470	34	68	68	37	75	75
Phom [kW]	3.9	5.4	7.8	0.7	1.0	1.5	0.2	0.3	0.4	0.1	0.1	0.2
max "allowable" k// [V/pC]	0.52			2.68			10.27			21.49		

both beams

Design and Technology

3 Different Designs

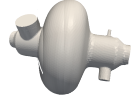
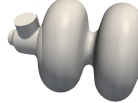

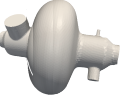
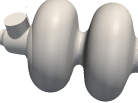

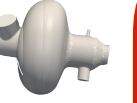
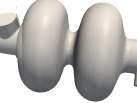


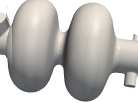

4 Machines

	Z			W			H			t		
Technology&design												
cavity choice	cell, 400MH	cells, 400MH	cells, 800MH	cell, 400MH	cells, 400MH	cells, 800MH	cell, 400MH	cells, 400MH	cells, 800MH	cell, 400MH	cells, 400MH	cells, 800MH
frequency [MHz]	400	400	800	400	400	800	400	400	800	400	400	800
Nb cells/cavity	1	2	2	1	2	2	1	2	2	1	2	2
Eacc [MV/m]	2.1	1.05	1.65	10.0	10.0	20.0	10.0	10.0	20.0	10.0	10.0	20.0
R/Q [Ohm]	90	90	90	90	90	90	90	90	90	90	90	90
k// [V/pC]	0.50	0.70	1.00	0.50	0.70	1.00	0.50	0.70	1.00	0.50	0.70	1.00
Pfpc max [kW]	0.50	0.70	1.00	0.50	0.70	1.00	0.50	0.70	1.00	0.50	0.70	1.00
G [Ohm]	290	290	290	290	290	290	290	290	290	290	290	290
Rs [nOhm]	100	100	80	100	100	80	100	100	80	100	100	80
Operating Temp [K]	4.5	4.5	2.0	4.5	4.5	2.0	4.5	4.5	2.0	4.5	4.5	2.0
RF system parameters												
Cell length [m]	0.375	0.375	0.1875	0.375	0.375	0.1875	0.375	0.375	0.1875	0.375	0.375	0.1875
Active length/cavity [m]	0.375	0.75	0.375	0.375	0.75	0.375	0.375	0.75	0.375	0.375	0.75	0.375
Vcell [MV]	0.79	0.39	0.31	3.75	3.75	3.75	3.75	3.75	3.75	3.75	3.75	3.75
Pbeam loss [MW]	49.3	49.3	49.3	50.16	50.16	50.16	50.1	50.1	50.1	49.83	49.83	49.83
Qext matched	7.1E+03	7.1E+03	5.6E+03	3.3E+05	6.6E+05	6.6E+05	2.3E+06	4.6E+06	4.6E+06	4.2E+06	8.4E+06	8.4E+06
BW	56343	56343	143418	1204	602	1204	175	87	175	96	48	96
Nb cells	102	203	259	213	213	213	1467	1467	1467	2667	2667	2667
Nb cavities	102	102	129	213	107	107	1467	733	733	1333	667	667
Pdiss/cav [W]	3	1	1	72	72	115	72	72	115	72	72	115
RF system active length	38	76	48	80	80	40	550	550	275	500	500	250
RF system length [m]	180	218	165	379	229	136	2603	1577	935	1183	717	850
Pcryo tot [MW]	0	0	0	10	5	18	68	34	123	62	31	112
PRF/cell [kW]	485	485	381	235	470	470	34	68	68	37	75	75
Phom [kW]	3.9	5.4	7.8	0.7	1.0	1.5	0.2	0.3	0.4	0.1	0.1	0.2
max "allowable" k// [V/pC]	0.52			2.68			10.27			21.49		

both beams

Design and Technology

3 Different Designs 4 Machines

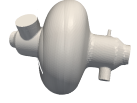
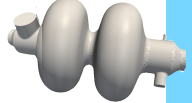

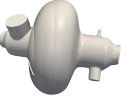
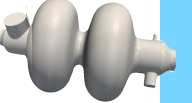

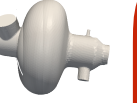
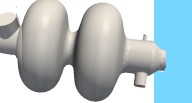
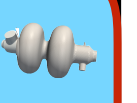

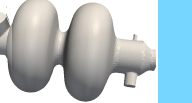
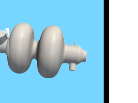
	Z			W			H			t		
Technology&design												
cavity choice	cell, 400MH	cells, 400MH	cells, 800MH	cell, 400MH	cells, 400MH	cells, 800MH	cell, 400MH	cells, 400MH	cells, 800MH	cell, 400MH	cells, 400MH	cells, 800MH
frequency [MHz]	400	400	800	400	400	800	400	400	800	400	400	800
Nb cells/cavity	1	2	2	1	2	2	1	2	2	1	2	2
Eacc [MV/m]	2.1	1.05	1.65	10.0	10.0	20.0	10.0	10.0	20.0	10.0	10.0	20.0
R/Q [Ohm]	90	90	90	90	90	90	90	90	90	90	90	90
k// [V/pC]	0.50	0.70	1.00	0.50	0.70	1.00	0.50	0.70	1.00	0.50	0.70	1.00
Pfpc max [kW]	0.50	0.70	1.00	0.50	0.70	1.00	0.50	0.70	1.00	0.50	0.70	1.00
G [Ohm]	290	290	290	290	290	290	290	290	290	290	290	290
Rs [nOhm]	100	100	80	100	100	80	100	100	80	100	100	80
Operating Temp [K]	4.5	4.5	2.0	4.5	4.5	2.0	4.5	4.5	2.0	4.5	4.5	2.0
RF system parameters	→											
Cell length [m]	0.375	0.375	0.1875	0.375	0.375	0.1875	0.375	0.375	0.1875	0.375	0.375	0.1875
Active length/cavity [m]	0.375	0.75	0.375	0.375	0.75	0.375	0.375	0.75	0.375	0.375	0.75	0.375
Vcell [MV]	0.79	0.39	0.31	3.75	3.75	3.75	3.75	3.75	3.75	3.75	3.75	3.75
Pbeam loss [MW]	49.3	49.3	49.3	50.16	50.16	50.16	50.1	50.1	50.1	49.83	49.83	49.83
Qext matched	7.1E+03	7.1E+03	5.6E+03	3.3E+05	6.6E+05	6.6E+05	2.3E+06	4.6E+06	4.6E+06	4.2E+06	8.4E+06	8.4E+06
BW	56343	56343	143418	1204	602	1204	175	87	175	96	48	96
Nb cells	102	203	259	213	213	213	1467	1467	1467	2667	2667	2667
Nb cavities	102	102	129	213	107	107	1467	733	733	1333	667	667
Pdiss/cav [W]	3	1	1	72	72	115	72	72	115	72	72	115
RF system active length	38	76	48	80	80	40	550	550	275	500	500	250
RF system length [m]	180	218	165	379	229	136	2603	1577	935	1183	717	850
Pcryo tot [MW]	0	0	0	10	5	18	68	34	123	62	31	112
PRF/cell [kW]	485	485	381	235	470	470	34	68	68	37	75	75
Phom [kW]	3.9	5.4	7.8	0.7	1.0	1.5	0.2	0.3	0.4	0.1	0.1	0.2
max "allowable" k// [V/pC]	0.52			2.68			10.27			21.49		

both beams

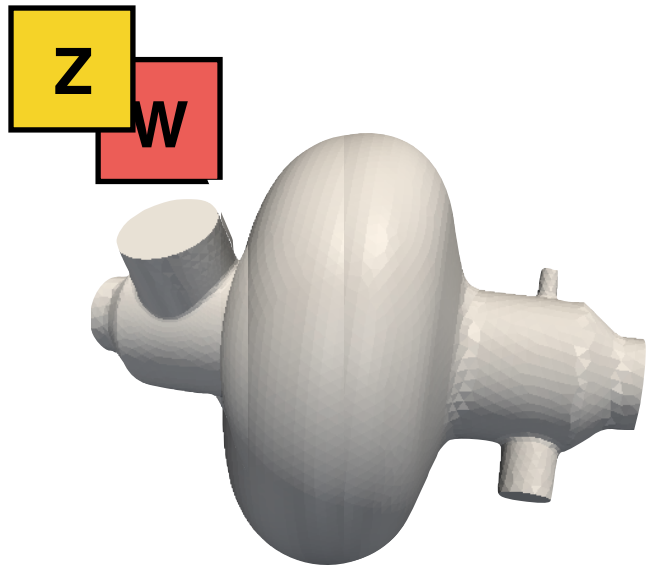
Design and Technology

3 Different Designs

4 Machines

	Z			W			H			t		
Technology&design												
cavity choice	cell, 400MH	cells, 400MH	cells, 800MH	cell, 400MH	cells, 400MH	cells, 800MH	cell, 400MH	cells, 400MH	cells, 800MH	cell, 400MH	cells, 400MH	cells, 800MH
frequency [MHz]	400	400	800	400	400	800	400	400	800	400	400	800
Nb cells/cavity	1	2	2	1	2	2	1	2	2	1	2	2
Eacc [MV/m]	2.1	1.05	1.65	10.0	10.0	20.0	10.0	10.0	20.0	10.0	10.0	20.0
R/Q [Ohm]	90	90	90	90	90	90	90	90	90	90	90	90
k// [V/pC]	0.50	0.70	1.00	0.50	0.70	1.00	0.50	0.70	1.00	0.50	0.70	1.00
Pfpc max [kW]	0.50	0.70	1.00	0.50	0.70	1.00	0.50	0.70	1.00	0.50	0.70	1.00
G [Ohm]	290	290	290	290	290	290	290	290	290	290	290	290
Rs [nOhm]	100	100	80	100	100	80	100	100	80	100	100	80
Operating Temp [K]	4.5	4.5	2.0	4.5	4.5	2.0	4.5	4.5	2.0	4.5	4.5	2.0
RF system parameters	→									→		
Cell length [m]	0.375	0.375	0.1875	0.375	0.375	0.1875	0.375	0.375	0.1875	0.375	0.375	0.1875
Active length/cavity [m]	0.375	0.75	0.375	0.375	0.75	0.375	0.375	0.75	0.375	0.375	0.75	0.375
Vcell [MV]	0.79	0.39	0.31	3.75	3.75	3.75	3.75	3.75	3.75	3.75	3.75	3.75
Pbeam loss [MW]	49.3	49.3	49.3	50.16	50.16	50.16	50.1	50.1	50.1	49.83	49.83	49.83
Qext matched	7.1E+03	7.1E+03	5.6E+03	3.3E+05	6.6E+05	6.6E+05	2.3E+06	4.6E+06	4.6E+06	4.2E+06	8.4E+06	8.4E+06
BW	56343	56343	143418	1204	602	1204	175	87	175	96	48	96
Nb cells	102	203	259	213	213	213	1467	1467	1467	2667	2667	2667
Nb cavities	102	102	129	213	107	107	1467	733	733	1333	667	667
Pdiss/cav [W]	3	1	1	72	72	115	72	72	115	72	72	115
RF system active length	38	76	48	80	80	40	550	550	275	500	500	250
RF system length [m]	180	218	165	379	229	136	2603	1577	935	1183	717	850
Pcryo tot [MW]	0	0	0	10	5	18	68	34	123	62	31	112
PRF/cell [kW]	485	485	381	235	470	470	34	68	68	37	75	75
Phom [kW]	3.9	5.4	7.8	0.7	1.0	1.5	0.2	0.3	0.4	0.1	0.1	0.2
max "allowable" k// [V/pC]	0.52			2.68			10.27			21.49		

both beams

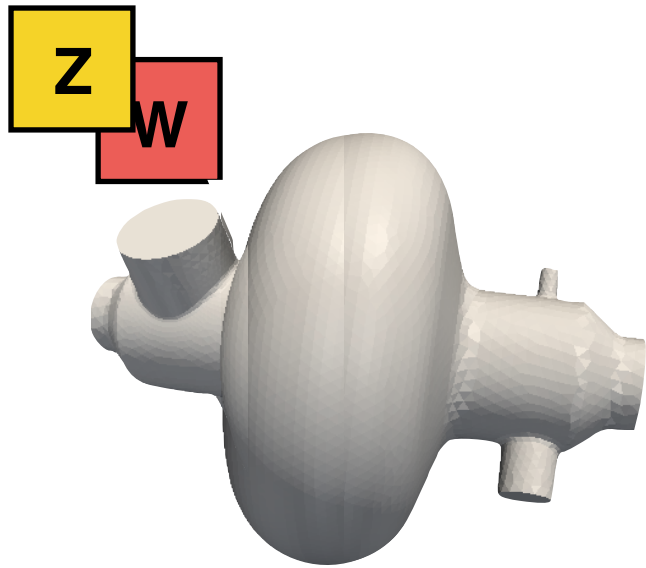


400 MHz (1 cell) x 90

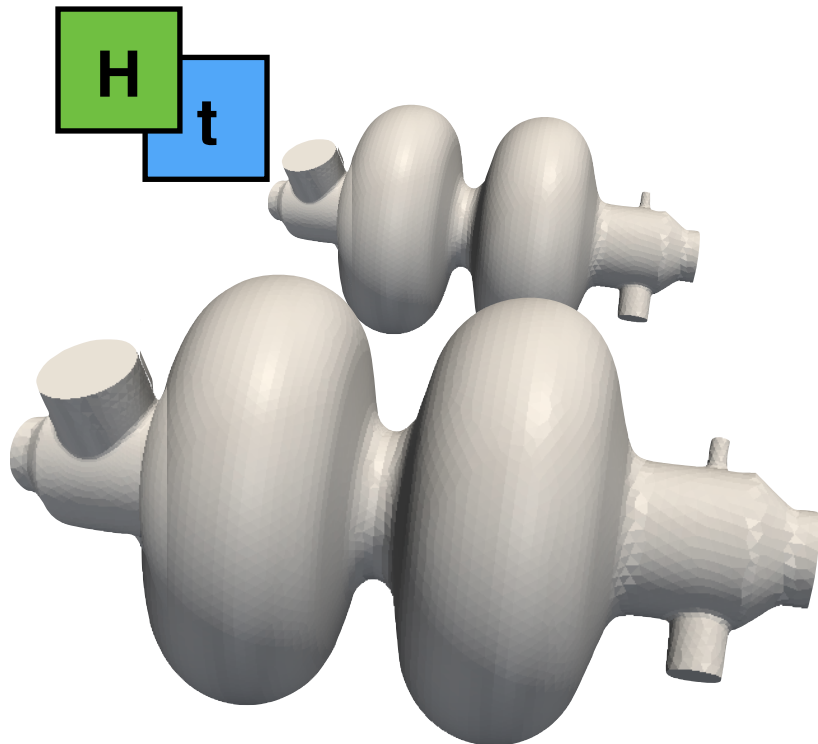
RF Power up to 500 kW

HOM Power up to 4 kW

Niobium on Copper @ 4.5 K

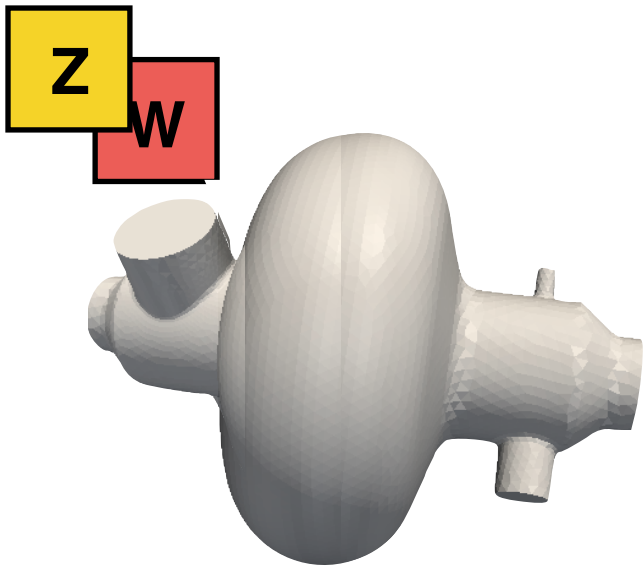


400 MHz (1 cell) x 90
RF Power up to 500 kW
HOM Power up to 4 kW
Niobium on Copper @ 4.5 K



400/800 MHz (2 cells) x 700
RF Power below 80 kW
Cryo Losses 170 kW
Niobium on Copper @ 4.5 K
Bulk Niobium @ 2 K

R'n'D Topics

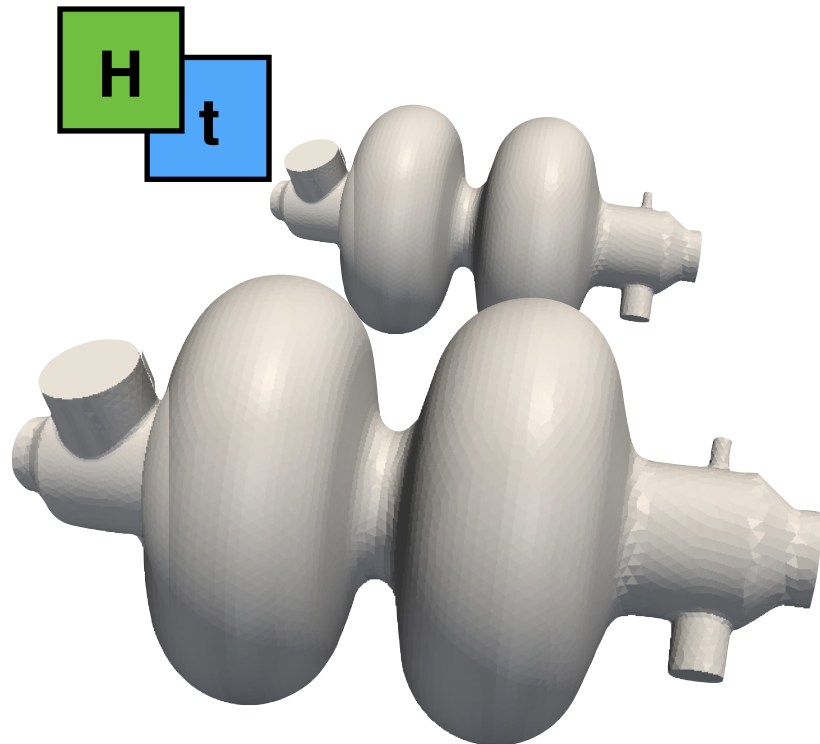


400 MHz (1 cell) x 90
RF Power up to 500 kW
HOM Power up to 4 kW
Niobium on Copper @ 4.5 K

Fundamental Power Coupler

Loss factor

HOM Damping



400/800 MHz (2 cells) x 700
RF Power below 80 kW
Cryo Losses 170 kW
Niobium on Copper @ 4.5 K
Bulk Niobium @ 2 K

Solid-State Amplifier

R_s and E_{acc}

End

— Discussion and Comments —

Interrelationship Table

NAME	TITLE	MATH	VALUE	UNIT	LOWER_LI MIT	UPPER_LIMI T	SOURCE
f	frequency	-	400	MHz	-	-	-
c	speed of light	-	299792458	m/s	-	-	https://en.wikipedia.org/wiki/Speed_of_light
lambda_0	wave length	$c/(f*1e6) * 100$	74.95	cm	-	-	-
l_cell	RF cell length	$lambda_0/2$	37.47	cm	-	-	-
E_acc	maximum accelerating gradient	-	12	MV/m	-	-	-
n_cell	number of cells per cavity	-	1	-	-	-	-
V_cavity	accelerating voltage per cavity	$E_acc * (l_cell/100) * n_cell$	4.50	MV	-	-	-
V_tot	total RF voltage for the machine	-	5.50	GV	-	-	Machine type specific
n_cavity	total number of accelerating cavities	$(V_tot * 1000) / V_cavity$	1223.07	-	1	10000	-
E_turnloss	synchrotron loss per turn OR WHAT EVER	-	1.67	GeV	-	-	-
I_beam	beam current	-	30	mA	-	-	-
P_SR_tot	power loss due to synchrotron radiation	$(E_turnloss * 1e9) * (I_beam / 1000) / 1e6$	50.10	MW	49.50	50.50	-
P_SRloss_cav	beam loss per accelerating cavity	$P_SR_tot / n_cavity * 1000$	40.96	kW	-	-	-
k_0	HOM loss factor constant	-	0.50	V/pC	-	-	Plot by Rama Calaga
k	HOM loss factor	$k_0 * n_cell^{**}0.5$	0.50	V/pC	-	-	Plot by Rama Calaga
f_rev	revolution frequency	-	3	kHz	-	-	-
n_bunch	number of bunches	-	770	-	-	-	-
P_HOM	beam loss per accelerating cell	$(I_beam/1000)^{**}2 * (k*1e12) / (f_rev*1000) / n_bunch / 1000$	0.19	kW	-	4	-
G	Geometry factor	-	290	Ohm	-	-	[Padamsee, pp. XX]
R_s	surface resistance	-	100	nOhm	-	-	[Padamsee und Sarah, pp. XX]
RoverQ	R upon Q	-	90	Ohm	-	-	LHC standard
P_diss	dissipated power per cell	$(E_acc*1e6)^{**}2 * c * (R_s*1e-9) / ((4 * f*1e6) * G * RoverQ)$	103.38	W	-	-	[Padamsee, pp. XX]
P_coupler	total RF power per cavity going through the power coupler FPC	$P_HOM + P_SRloss_cav + P_diss/1000$	41.26	kW	-	500	-