XLS – Ka Band Linearizer

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WP3 – D3.4 working group,
Linearizer Updates- June 12th 2020.

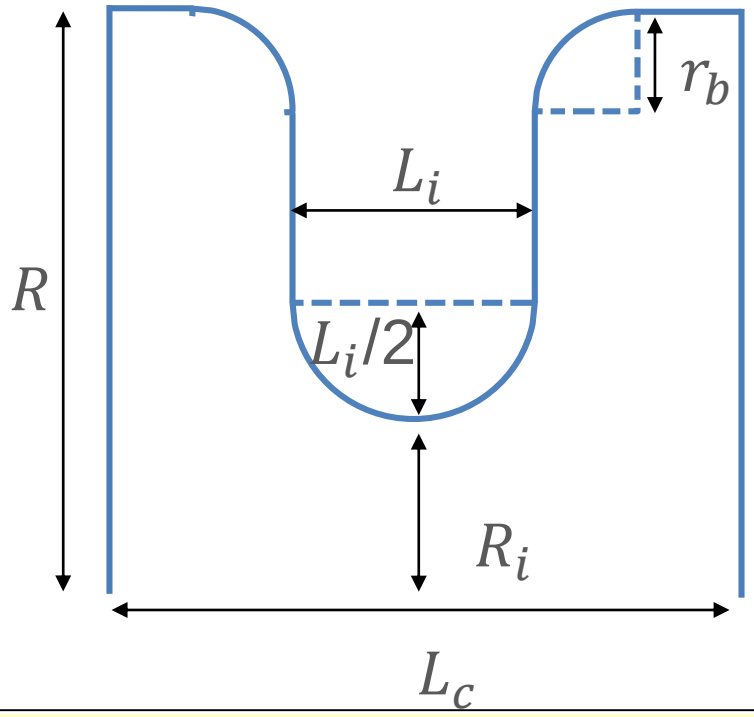
Single Cell Recap

Simple cell, constant impedance.

A geometry is proposed.

$H_p \approx 90$kA/m and $E_p \approx 65$MV/m @25MV/m.

$H_p \approx 226$kA/m and $E_p \approx 163$MV/m @63MV/m.



Parameter	Value	Units
Freq.	36	GHz
Q	4392	--
r_L	106	MΩ/m
v_g	0.12	c
α_0	0.7	m^{-1}
E_p^*	2.6	MV/m
R	3.96	mm
R_i	2.00	mm
L_c ($\varphi = {}^{2\pi}/_{3}$)	2.78	mm
L_i	0.60	mm
r_b	1.00	mm

*normalized to $E_z = 1\ MV/m$

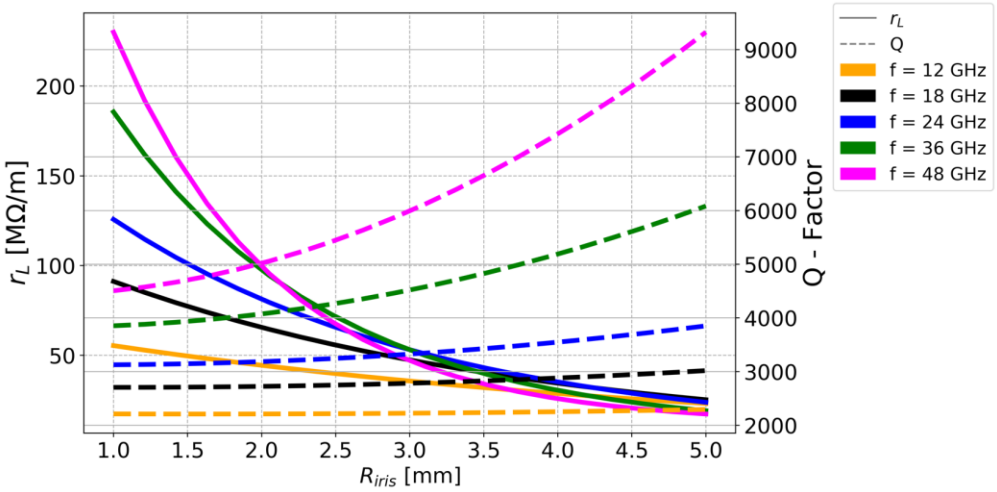
Options for a linearizer system @300 MeV

Freq. [GHz]	Iris aperture [mm]	Required voltage [MV]	Structure length [m]	Ave. gradient per cavity [MV/m]	Integrated voltage per cavity [MV/cavity]	Num. of structures [#]	Total available power [MW]
12	2.0	56.2	0.5	56.2	28.1	2	104 (2x 52)
18	2.0	25.0	0.3	83.3	25.0	1	52
24	2.0	14.1	0.2	70.5	14.1	1	44
36	2.0	6.2	0.1	62.0	6.2	1	23
48	2.5	3.5	0.1	35.0	3.5	1	14

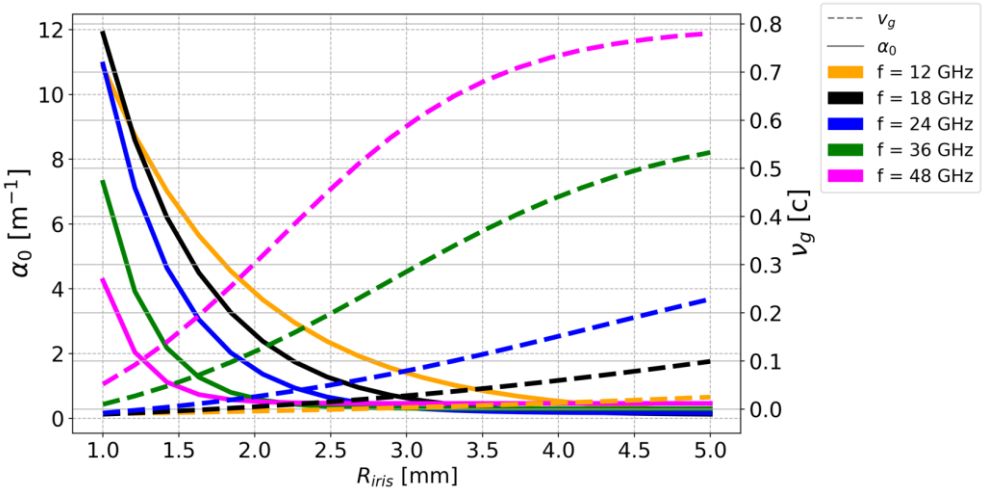
- Changing the frequency of the injection opens some room for comparison of different frequencies.
- Ka-band seems to be in a optimal point for either choice of the injector.
- Iteration with beam dynamics undergoing, to be confirmed soon!

Comparing options

Shunt Impedance and Q_0

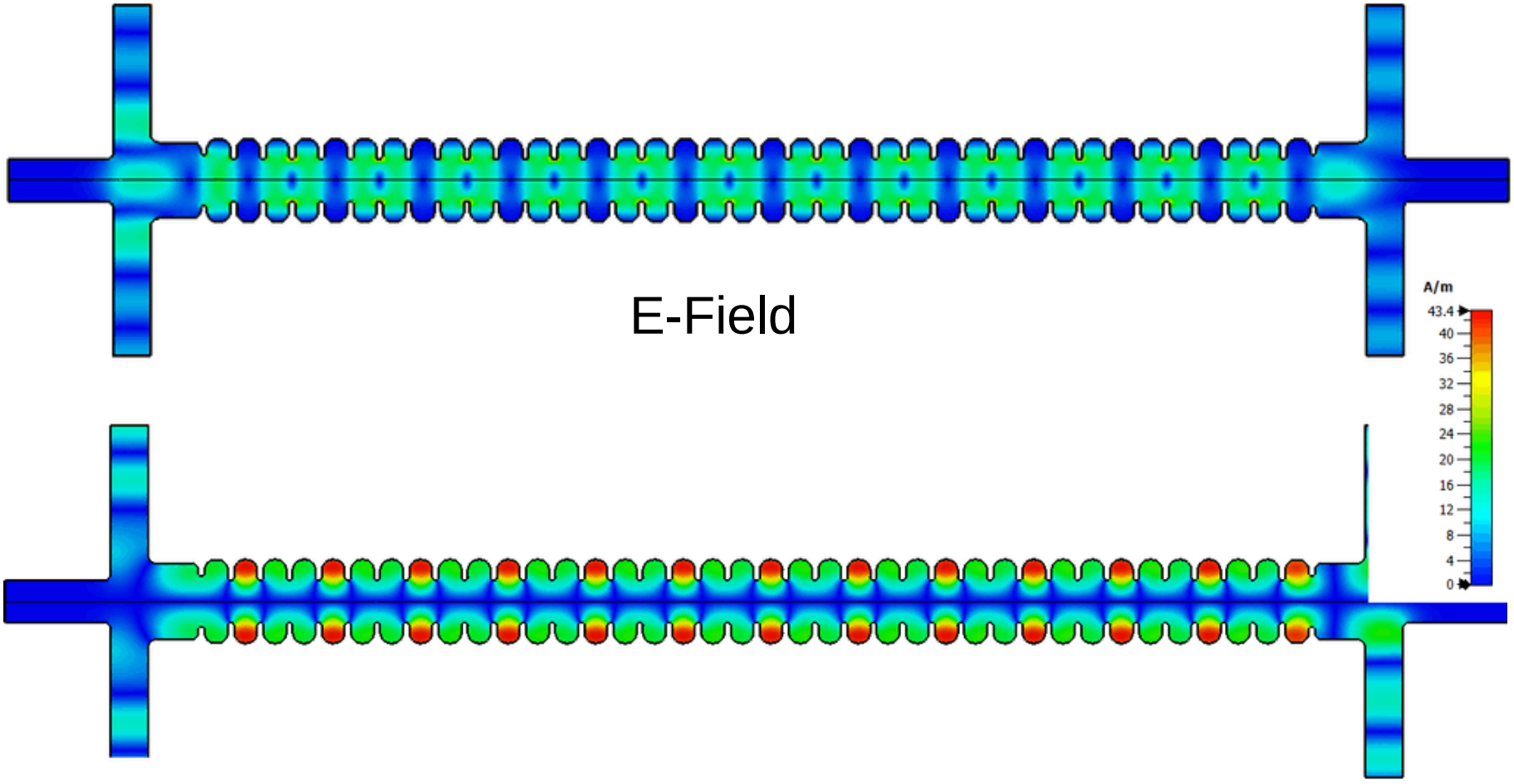


v_g and Attenuation Factor



- At low apertures (≤ 2.0mm) higher freqs. show more desirable numbers, as expected.
- At around 3.5mm, lower freqs. start to show better shunt impedance than the highest freqs.
- Higher freqs. maintain lower attenuation and higher group velocity along the range.

Full prototype in Ka-band

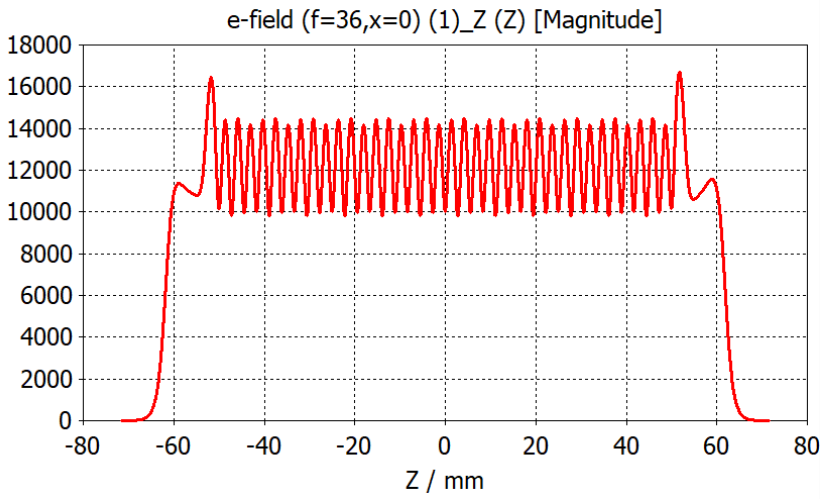


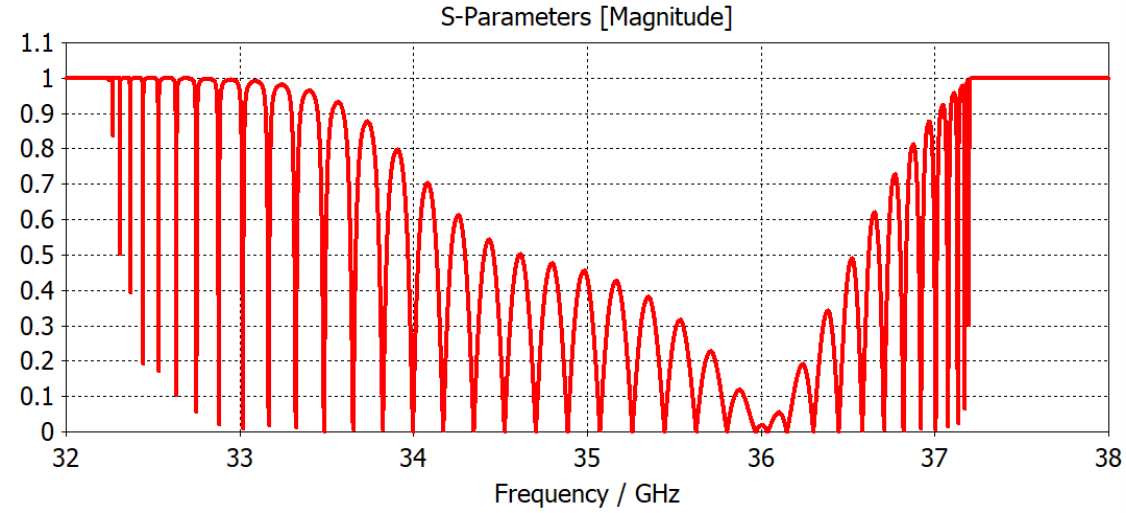
Full Structure

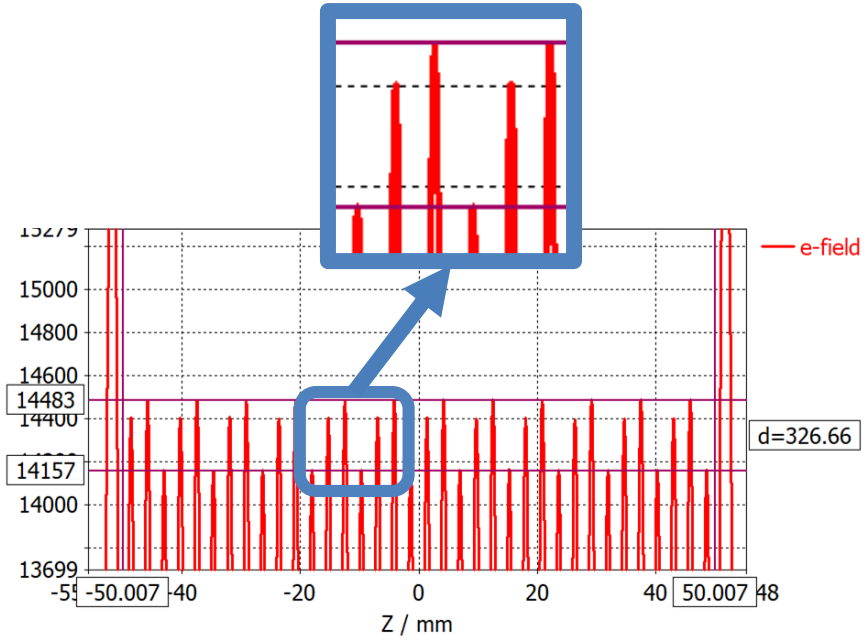
Decent matching.

There is still a small standing wave.

~2.5% and periodic every 3 cells (360deg).

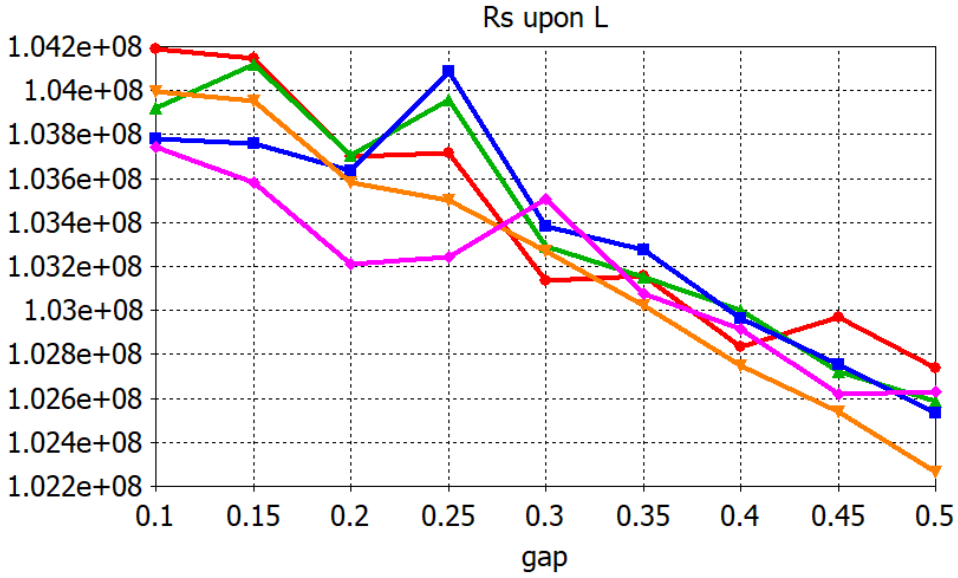


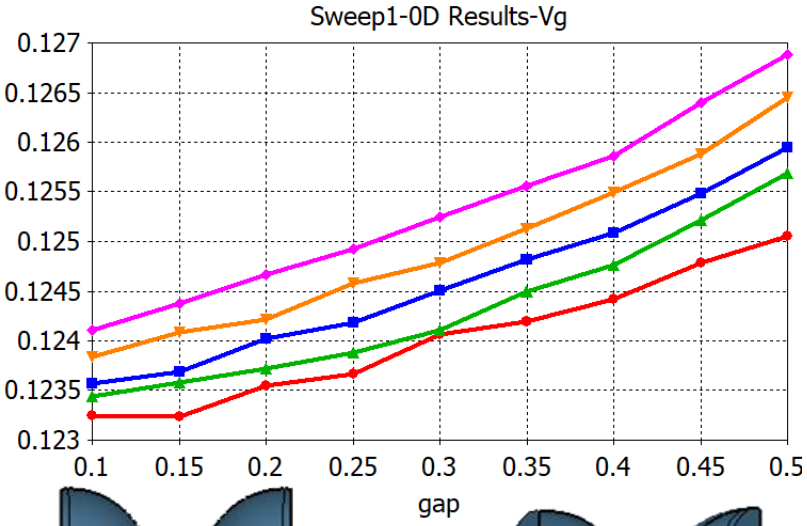


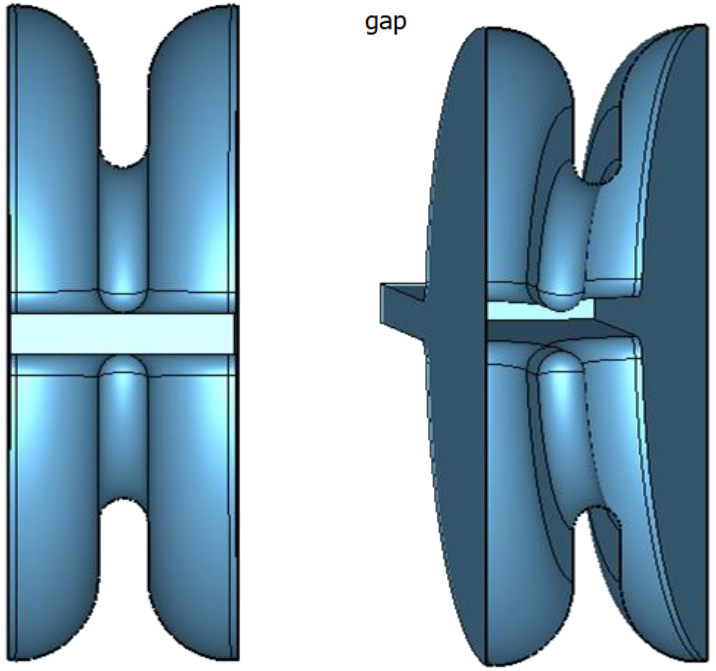


Open Structure

500 um gap seems manageable with slight detrimental effect on the performance.

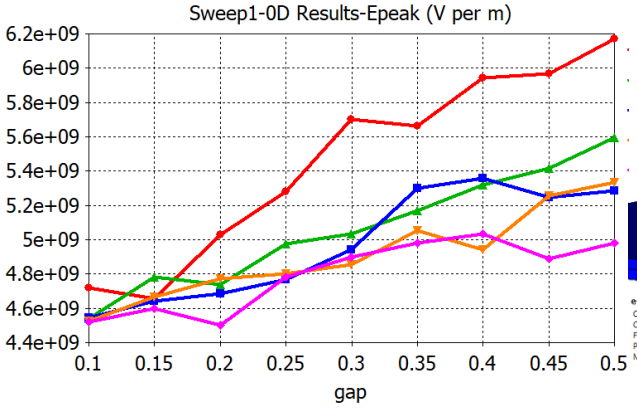


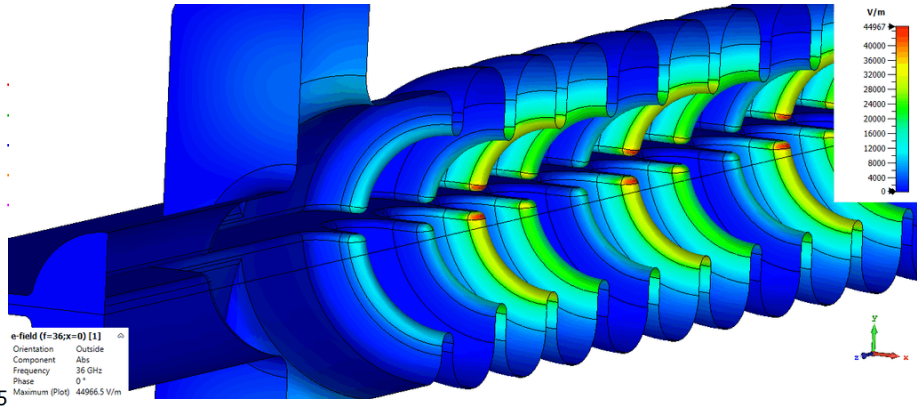




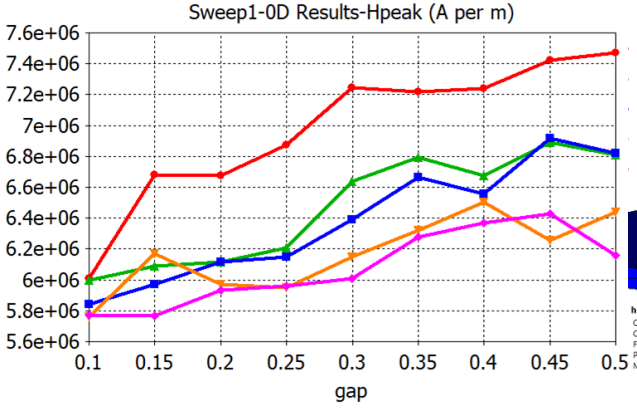
Full Open Structure

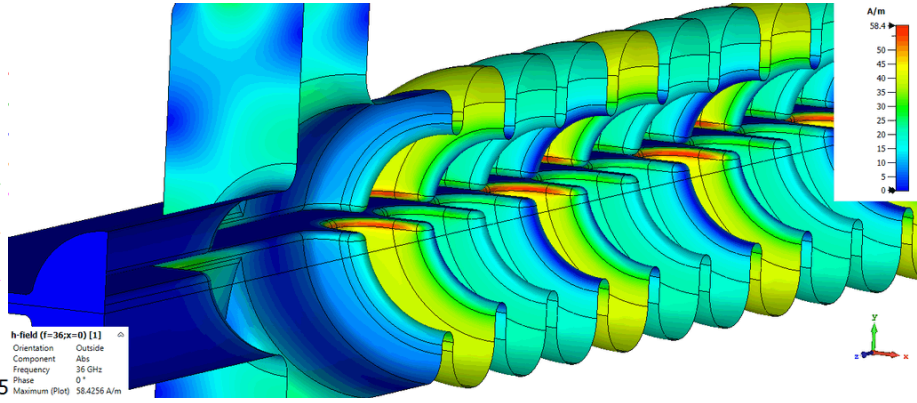
Highest peak E-field on the iris corner.





Highest peak H-field on the equator-gap edge.



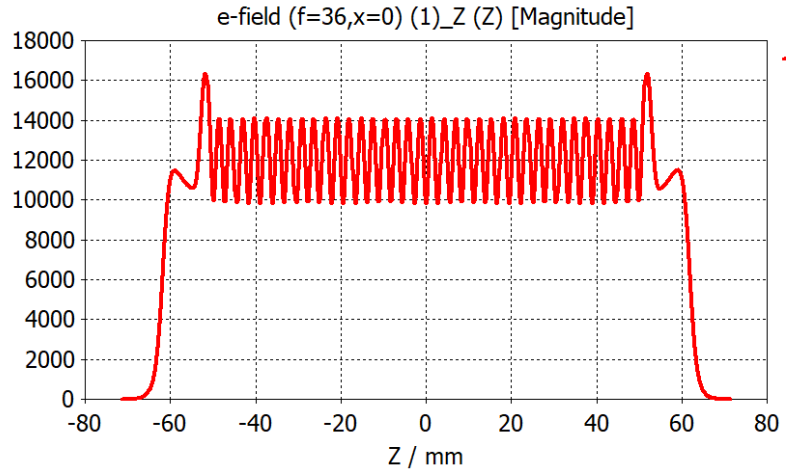


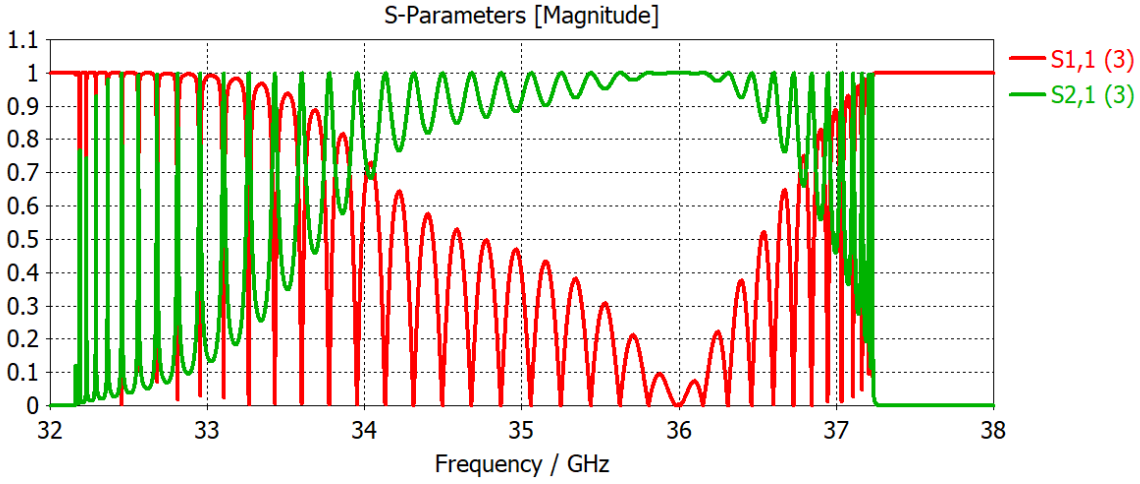
Full Open Structure

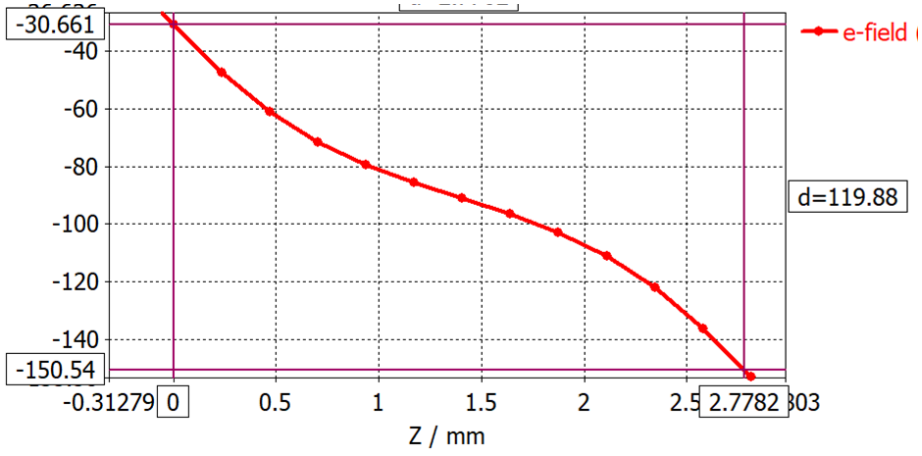
Still decent matching.

Proper phase advance.

<1% field flatness.







Simple vs Open

Simple

Parameter	Value	Units
Freq.	36	GHz
Q	4392	--
r_L	106	MΩ/m
v_g	0.123	c
α_0	0.7	m^{-1}
E_p^*	2.6	MV/m
R	3.96	mm
R_i	2.00	mm
L_c $(\varphi = {}^{2\pi}/_{3})$	2.78	mm
L_i	0.60	mm
r_b	1.00	mm

*normalized to $E_z = 1\ MV/m$

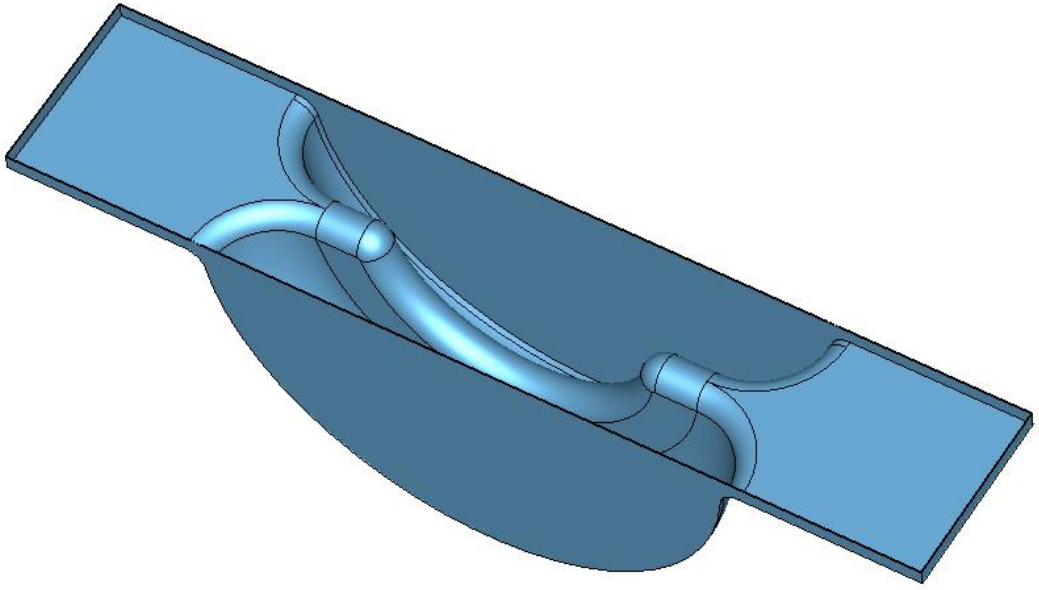
Open

Parameter	Value	Units
Freq.	36	GHz
Q	4344	--
r_L	102.5	MΩ/m
v_g	0.126	c
α_0	0.69	m^{-1}
E_p^*	3.6	MV/m
R	3.956	mm
R_i	2.00	mm
L_c $(\varphi = {}^{2\pi}/_{3})$	2.78	mm
L_i	0.60	mm
r_b	1.00	mm

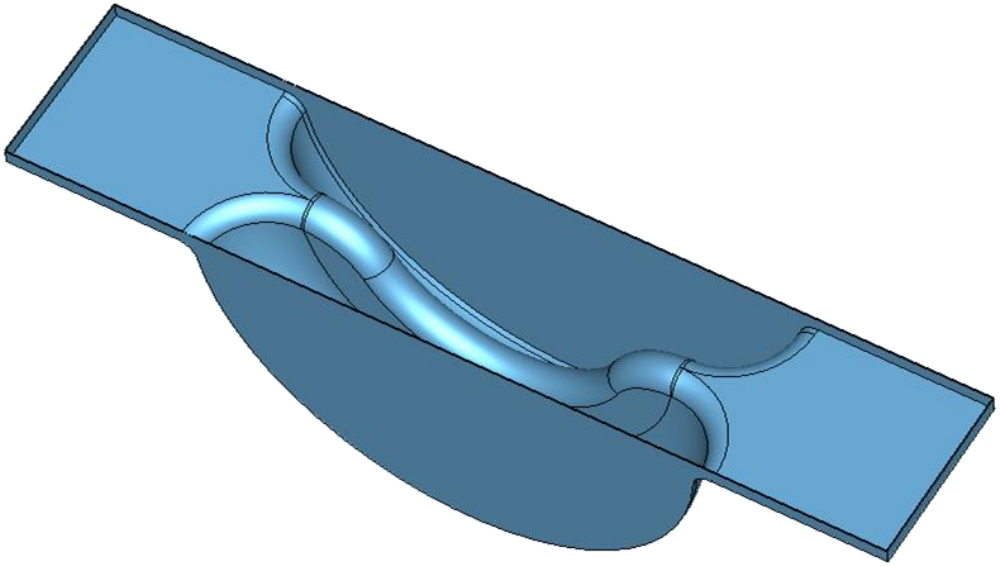
*normalized to $E_z = 1\ MV/m$

Another Go for the Open Structure

Original



Second Try



Single Vs Open 2

Simple

Parameter	Value	Units
Freq.	36	GHz
Q	4392	--
r_L	106	MΩ/m
v_g	0.123	c
α_0	0.7	m^{-1}
E_p^*	2.6	MV/m
R	3.96	mm
R_i	2.00	mm
L_c $(\varphi = {}^{2\pi}/_{3})$	2.78	mm
L_i	0.60	mm
r_b	1.00	mm

*normalized to $E_z = 1\ MV/m$

Open 2

Parameter	Value	Units
Freq.	36	GHz
Q	4357	--
r_L	101.0	MΩ/m
v_g	0.133	c
α_0	0.65	m^{-1}
E_p^*	3.3	MV/m
R	3.978	mm
R_i	2.00	mm
L_c $(\varphi = {}^{2\pi}/_{3})$	2.78	mm
L_i	0.60	mm
r_b	1.00	mm

*normalized to $E_z = 1\ MV/m$

Funded by the
European Union

Compact

Thank you!

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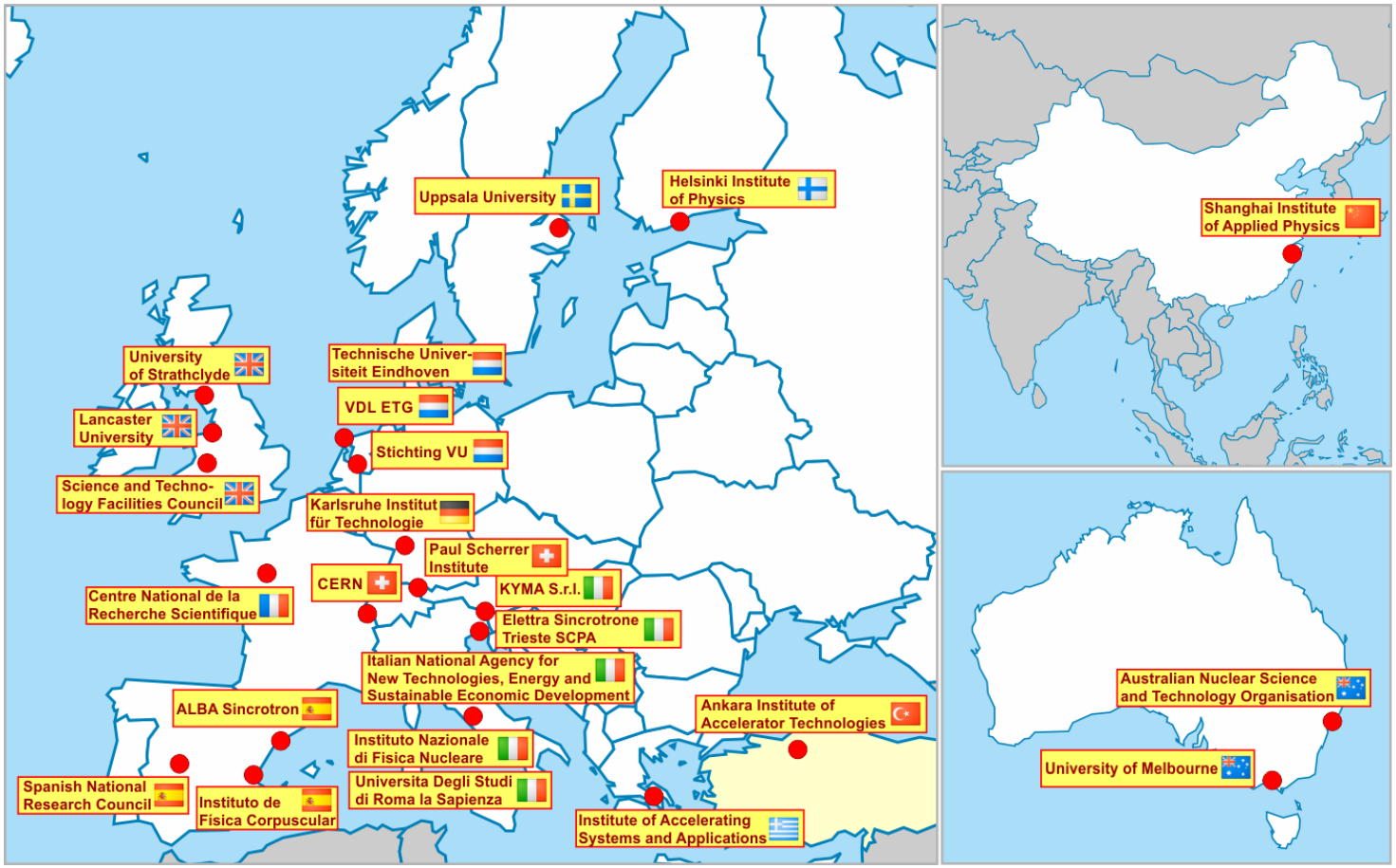
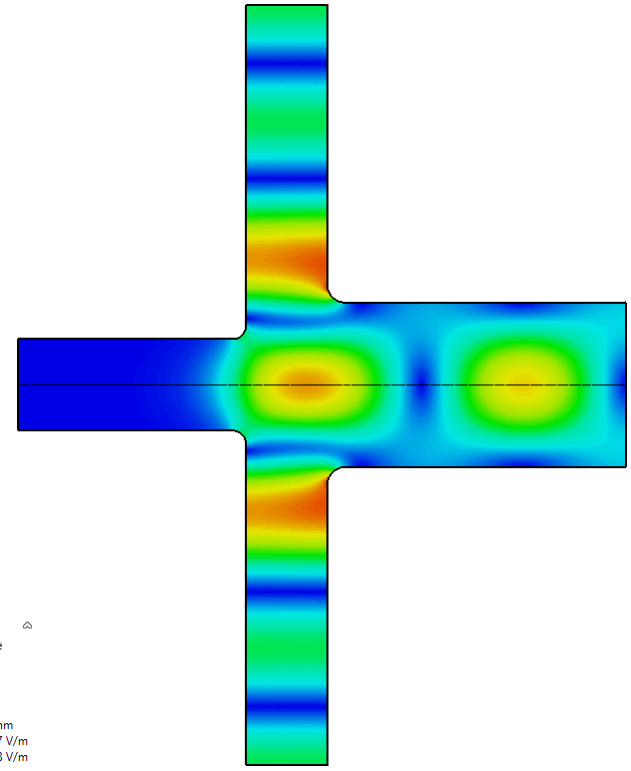
www.CompactLight.eu

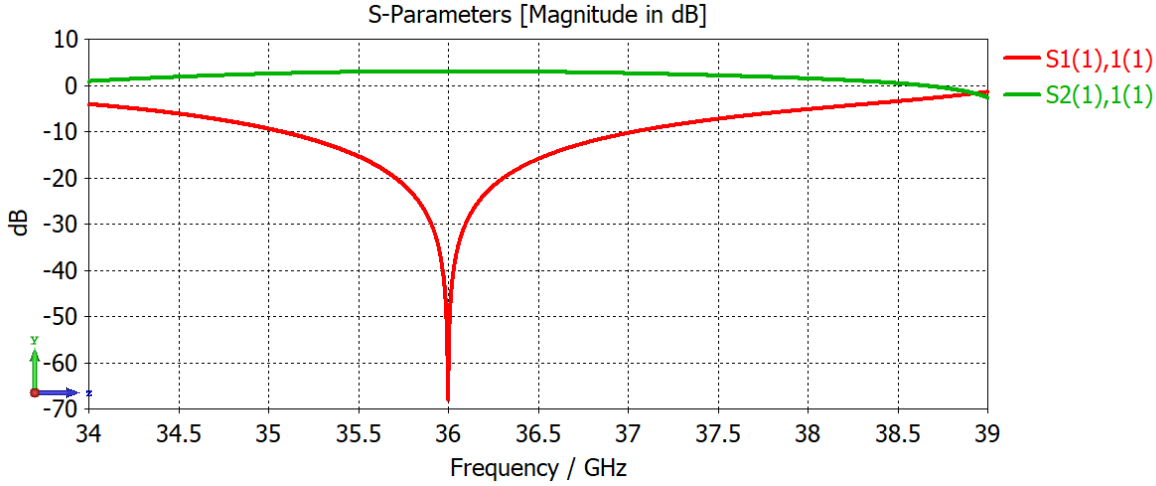


CompactLight is funded by the European Union's Horizon2020 research and innovation programme under Grant Agreement No. 777431.

Coupler design

- Is a low energy linearizing stage still on the table?
  - This has been brought up a couple of times, but seems to fall into the cracks every time.





Structure and power considerations for the options

- Ka-band seems to be in a optimal point for either choice of the injector.
- Iteration with beam dynamics undergoing, to be confirmed soon!

Freq. [GHz]	Vg [c]	Filling time [ns]	Source output [MW]	PC gain Klystron pulse width= 700 ns	PC gain Klystron pulse width= 1500 ns	Total Power for K.p.w. 700ns [MW]	Total Power for K.p.w. 1500ns [MW]
12	0.01	333.6, (166.8)	20, 50	1.85	3.54	37, (52), 92.5, (130)	70.8, 177
18	0.01	200.1, 100.1	12	2.68, 4.39	4.67, 5.89	32.1, 52.6	56, 70.6
24	0.025	53.4, 26.7	6.7	5.68, 6.62	6.76, 7.41	38, 44.3	45.2, 49.6
36	0.12	16.7, 8.3, 5.6	3	7.05, 7.47, 7.56	7.68, 7.94, 7.97	21.1, 22.4, 22.6	23, 23.8, 23.9
48	0.3	3.3, 2.2, 1.1	2	7.69, 7.62, 7.38	8.07, 7.96, 7.68	16.1, 15.9, 14.7	16.1, 15.9, 14.7