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X-BAND Velocity Bunching and Linearizer

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Outline

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X-BAND Velocity Bunching and Linearizer

Overview of WP3 contribution

Preliminary design of the TW structure for both devices →
- Single cell design
- Coupler tuning
- Power scaling curves

Next steps

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Contribution to WP3

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Task 3.1 - Gun Design => D3.1 M18 => D3.3 M36

a. S-Band Gun RF Design (**CNRS** + IASA+UAIAT-INFN+ALBA)
b. C-Band Gun RF Design (**INFN** +IASA+Sapienza)
c. X-Band Gun RF Design (**CSIC-IFIC** + UAIAT+ Sapienza)
d. DC Gun Design (**TU/e**)
e. Laser/Photocathode (**IASA**+CNRS+INFN)

Report

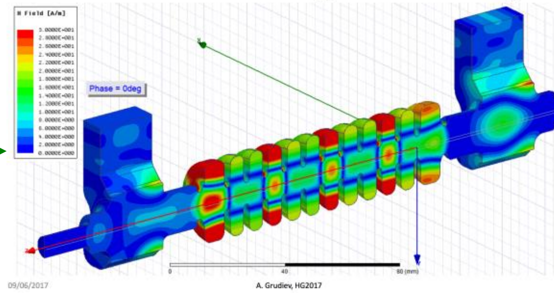
Task 3.2 - Compressor Design => D3.2 M18 => D3.3 M36

a. S-Band Velocity Bunching (**TU/e** + IASA+ALBA)
b. C-Band Velocity Bunching (**INFN** +IASA+TU/e)
c. X-Band Velocity Bunching (**Sapienza**+CERN+IASA+INFN)
d. Magnetic Compressor (**ST** + CERN+INFN+CNRS)

Task 3.3 – X-Band Transverse RF Deflector (Sapienza+IASA) => D3.3 M36

Review

DESY-PSI-CERN TDS

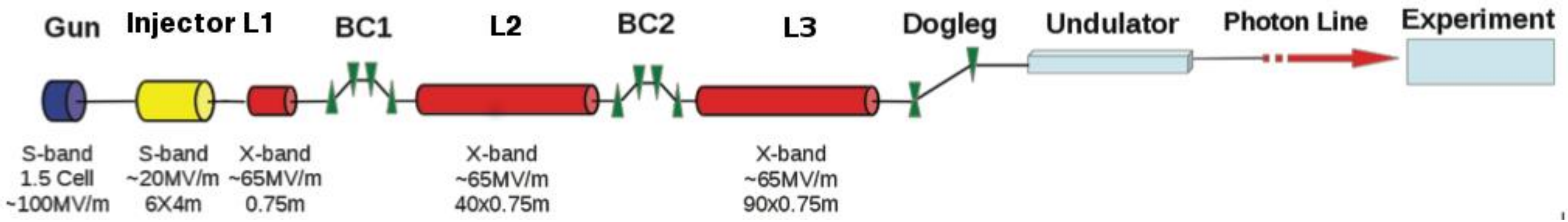


Task 3.4 - : RF Linearizer Design => D3.2 M18 => D3.3 M36

a. X-Band RF Linearizer Design (**Sapienza**)
b. K-Band RF Linearizer Design (**ULANC** +Sapienza)
c. Passive linearizer (**CNRS**)

Report

Reference parameters



XLS Hard X-Ray Case	After VB and/or BC1
Charge	100 pC
Beam Energy	300 MeV
Bunch repetition rate	100 to 1k Hz
RMS Bunch Length	35um (118fs)
RMS Energy Spread	<1%

Beam parameters after the injector

Beam parameters at the linearizer and VB compressor are under discussion → **General design of TW structures**

RF compressor and linearizer

Baseline design TW structure, Δϕ=2π/3 mode, Constant Impedance

Preliminary design strategy (iterations among steps required)

1. Single cell design — **Report**
2. Coupler tuning (5 cell) — **Report**
3. Full structure design and shunt impedance optimization — **?**
4. Modified Poynting vector analysis @ nominal gradient — **To be done**
5. Refined coupler analysis (RF heating, field distortion) — **To be done**
6. Wakefield analysis — **To be done**

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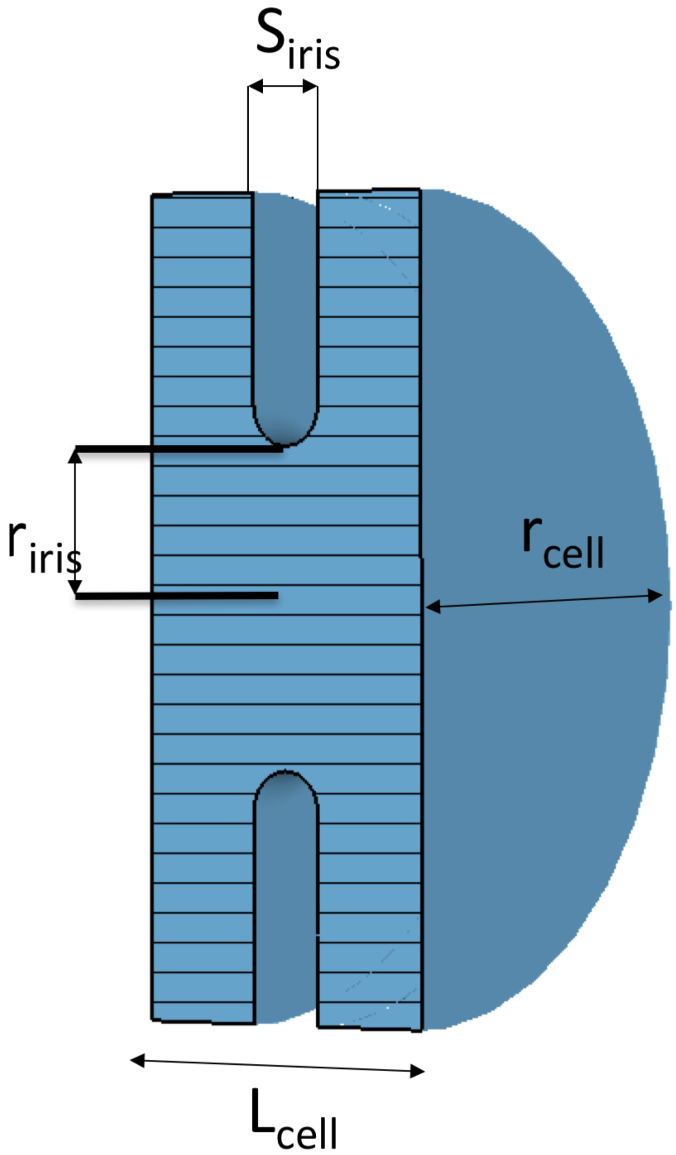
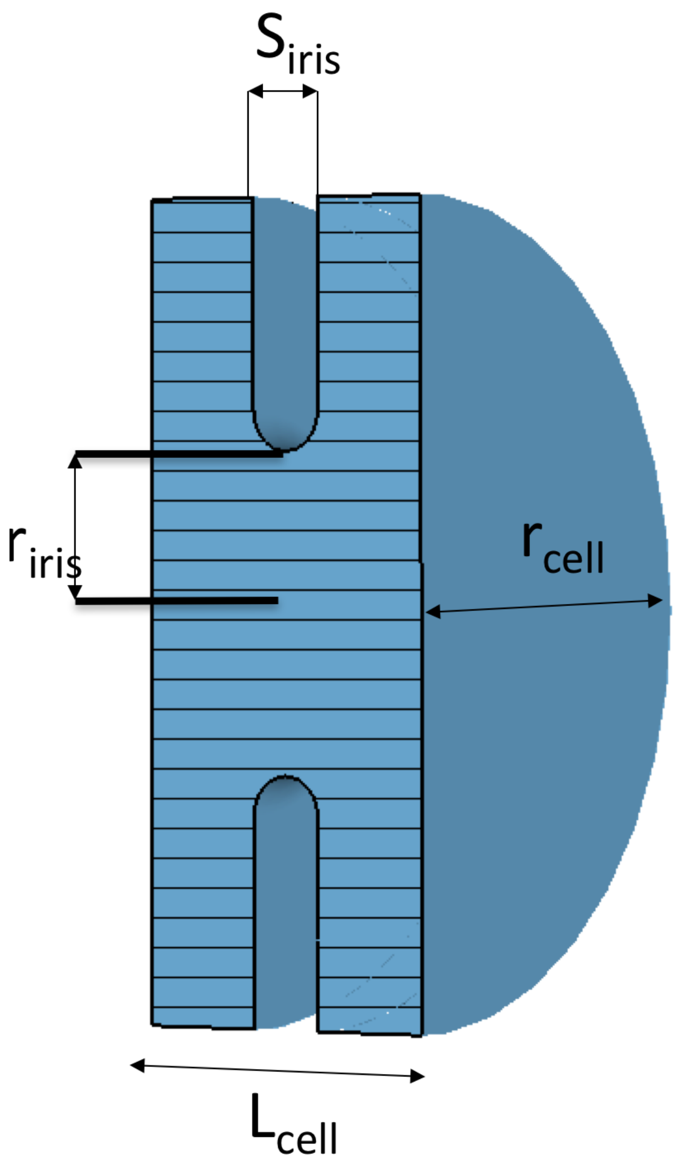
Single cell design

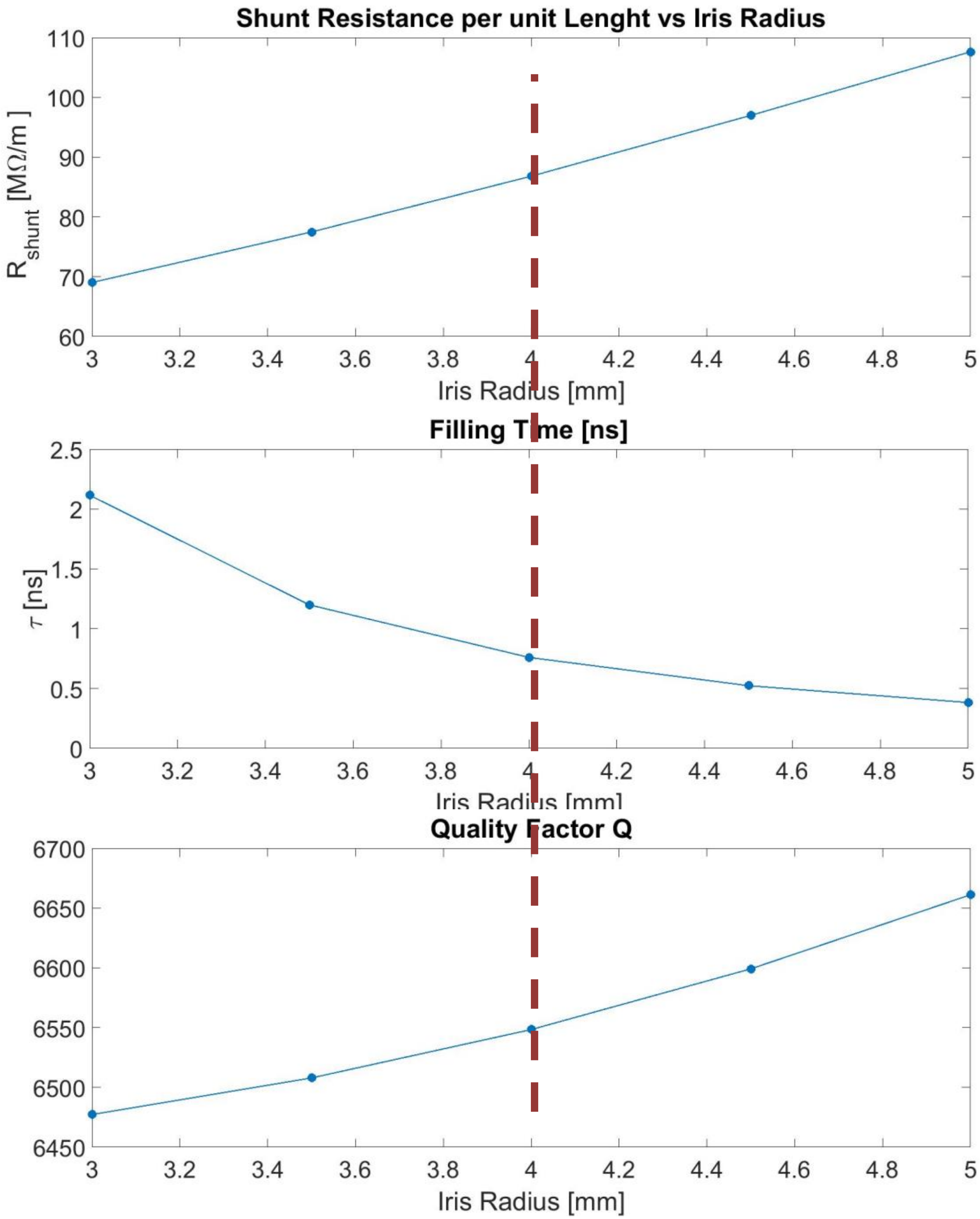


Freq. of 2π/3 mode [GHz]	11.9952
Average iris radius [mm]	4
Group velocity v_g/c [%]	3.7
Shunt Impedance R_s [MΩ/m]	87
Filling time [ns]	0.76
Quality factor Q_0	6550
Attenuation [1/m]	0.52
Cell length [mm]	8.4
Cell radius [mm]	10.3

- Cell length fixed by phase advance per cell
- Cell radius by operation frequency
- Iris depth by mechanical constraint (second order)
- Shunt Impedance strongly depends from aperture;

Single cell design: sensitivity



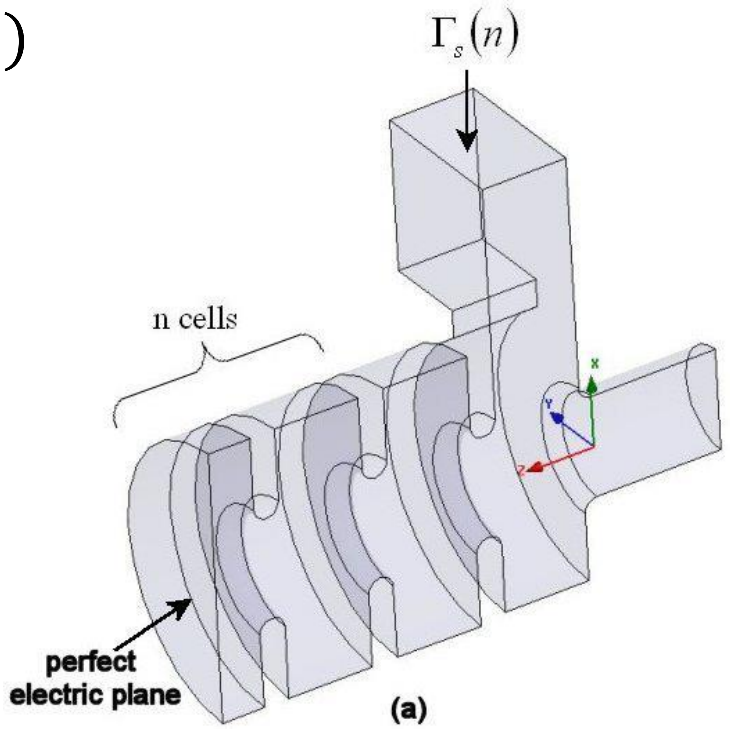


Coupler tuning: short circ. method

The Couplers must be designed in order to minimaze the reflection coefficient at the input port and to impose a phase advancement per cell of **Φ=120°**

$$S_{11} = 0 \Leftrightarrow \frac{\Gamma_s(n+2)}{\Gamma_s(n+1)} = \frac{\Gamma_s(n+1)}{\Gamma_s(n)} = exp(-j2\Phi)$$

$$(with\ |\Gamma_s(n)| = 1)$$



$S11$ is the reflection coefficient at the input port

Γs is the reflection coefficient at the coupler waveguide when the structure is short circuited (*n* is the position of the short circuited cell)

Φ is the phase advance per cell in the TW structure

D. Alesini et al., Design of couplers for traveling wave RF structures using 3D electromagnetic codes in the frequency domain, NIM-A (2007)

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Coupler tuning: simulations

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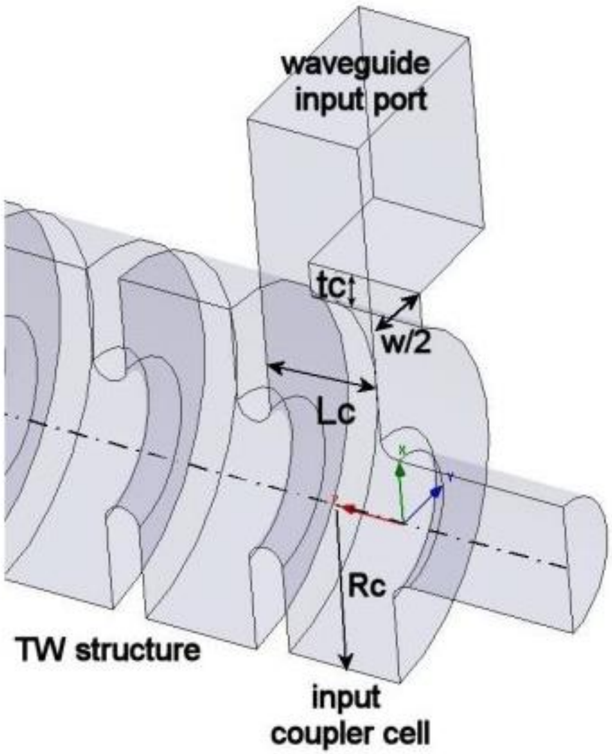
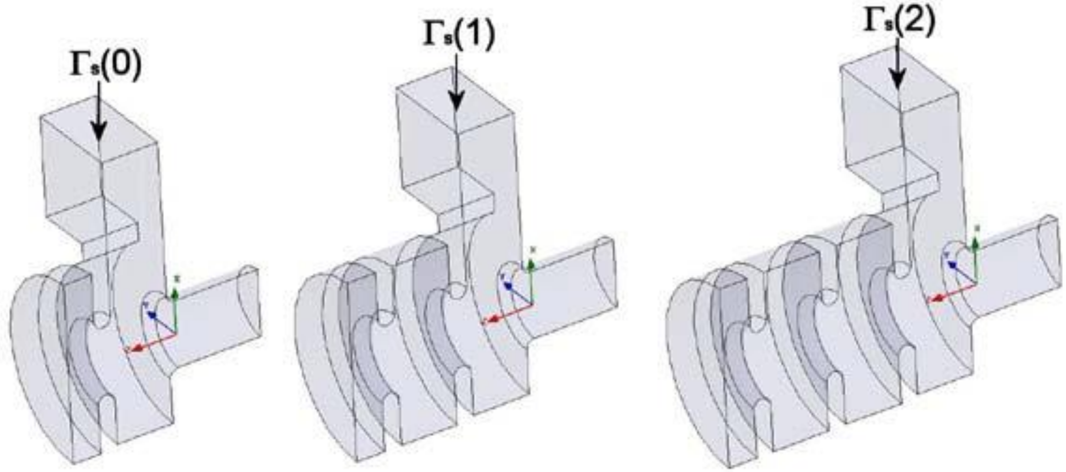
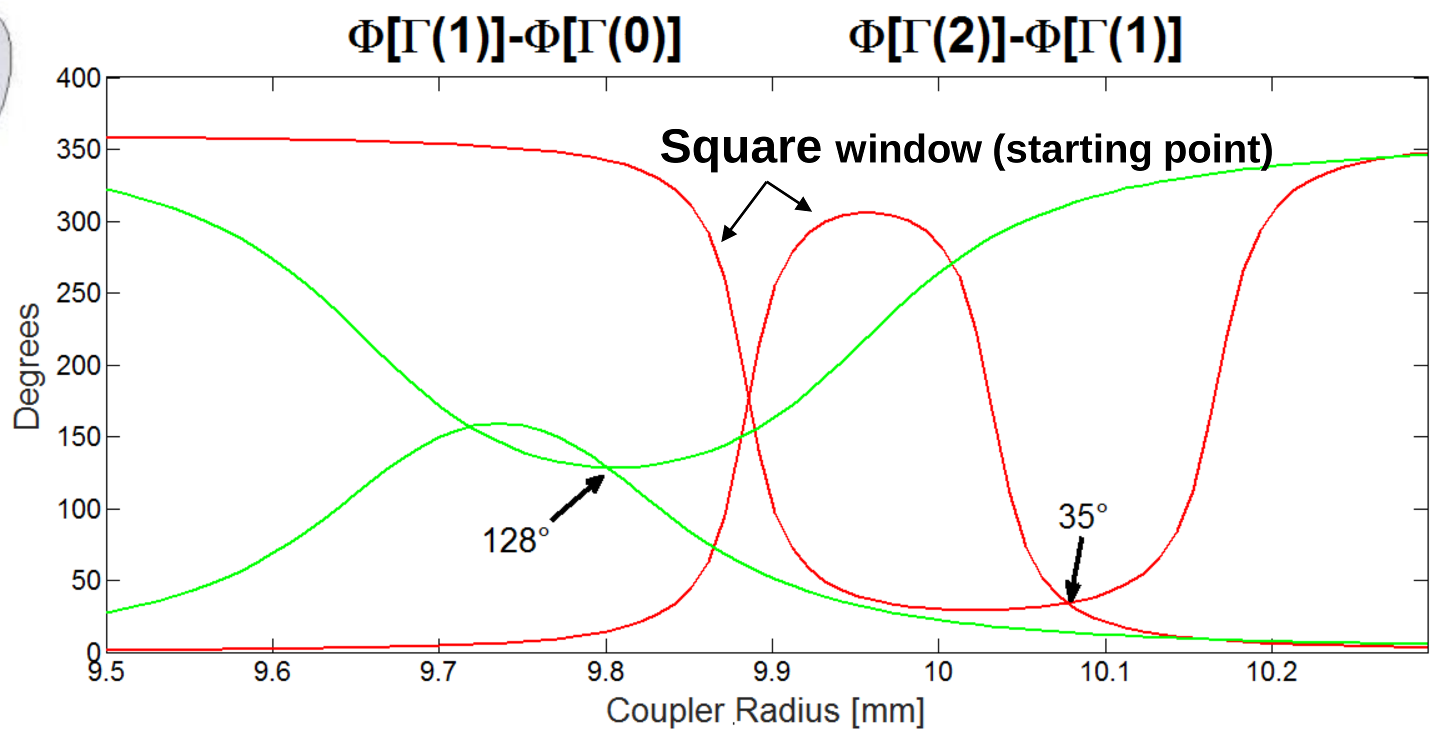


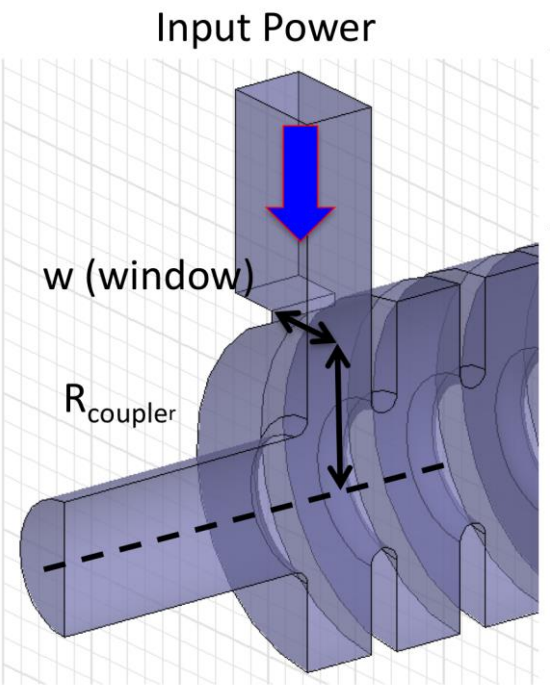


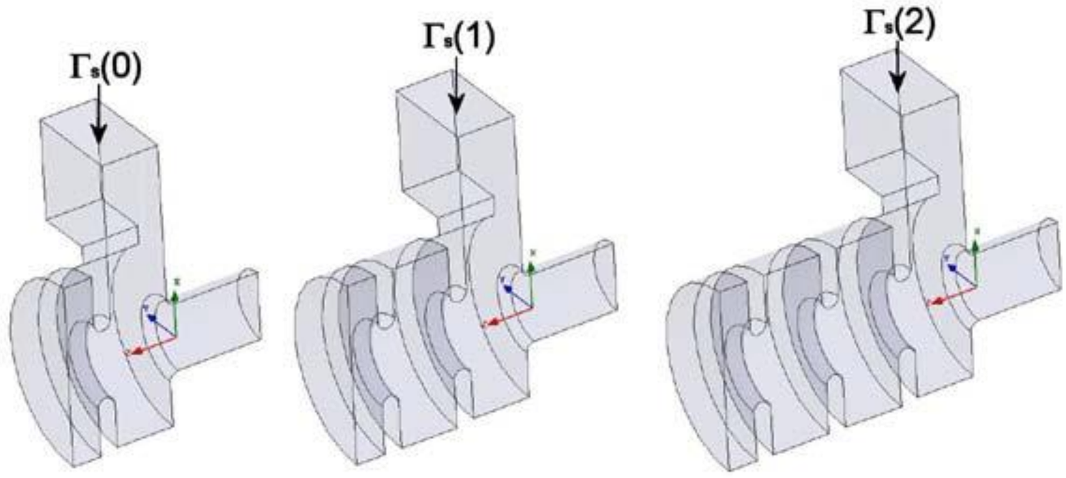


The most sensitive parameters are *w* and *Rc* while the cell length *Lc* and the thickness *tc* can be kept fixed.

D. Alesini et al., Design of couplers for traveling wave RF structures using 3D electromagnetic codes in the frequency domain, NIM-A (2007)

Coupler tuning: results

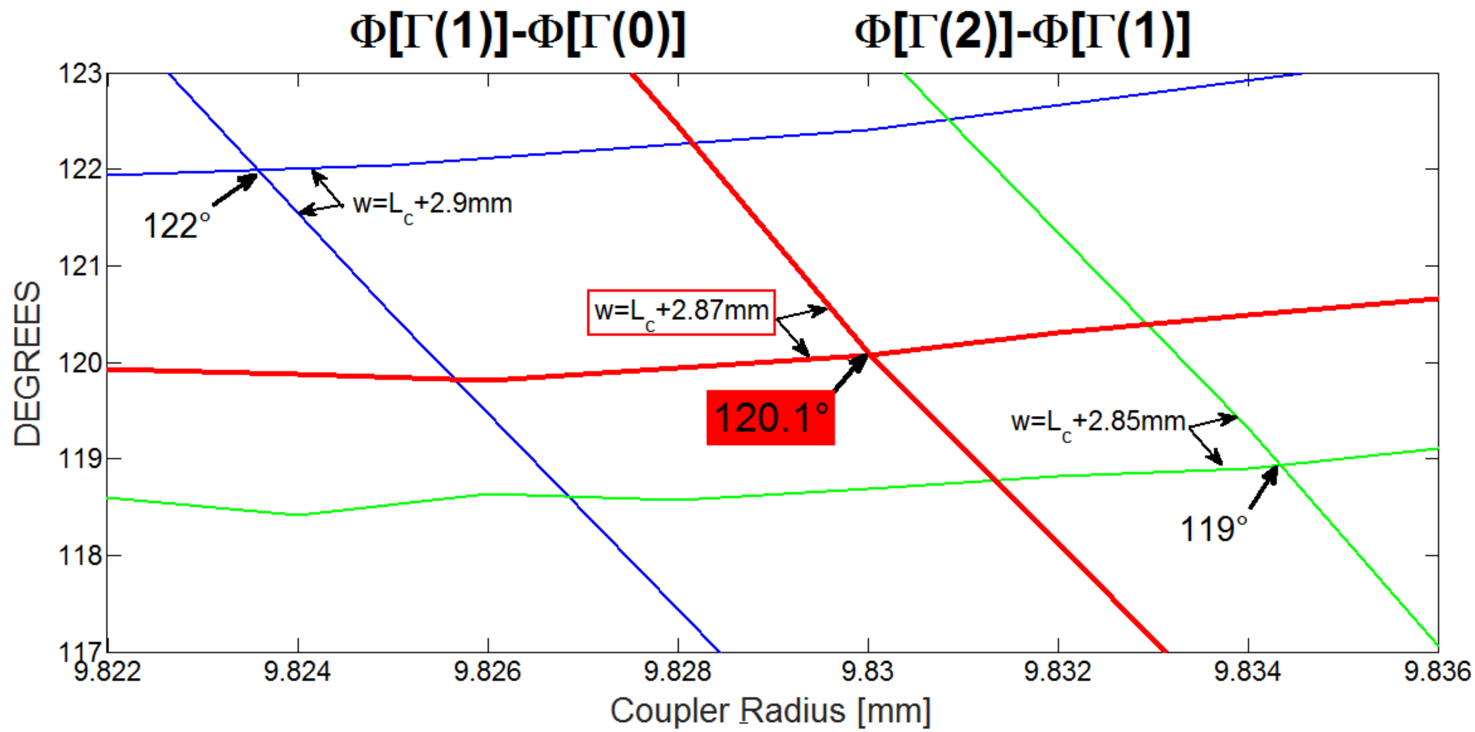




w=Lc+2.87 mm

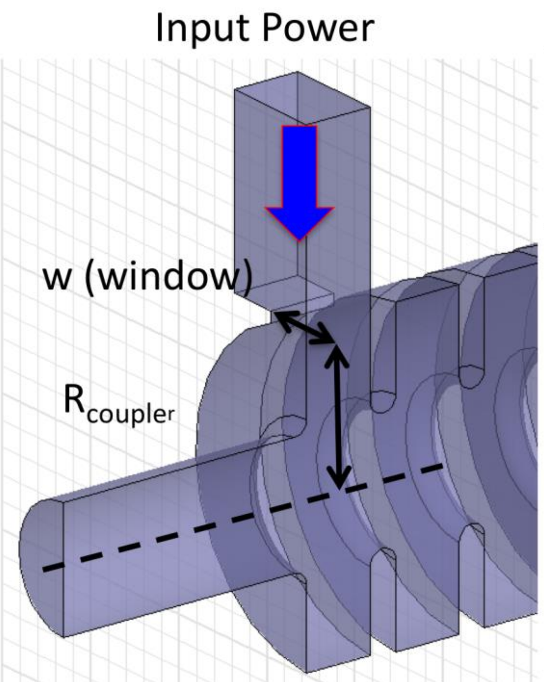
$\mathbf{R_{coupler}}$ =9.83 mm

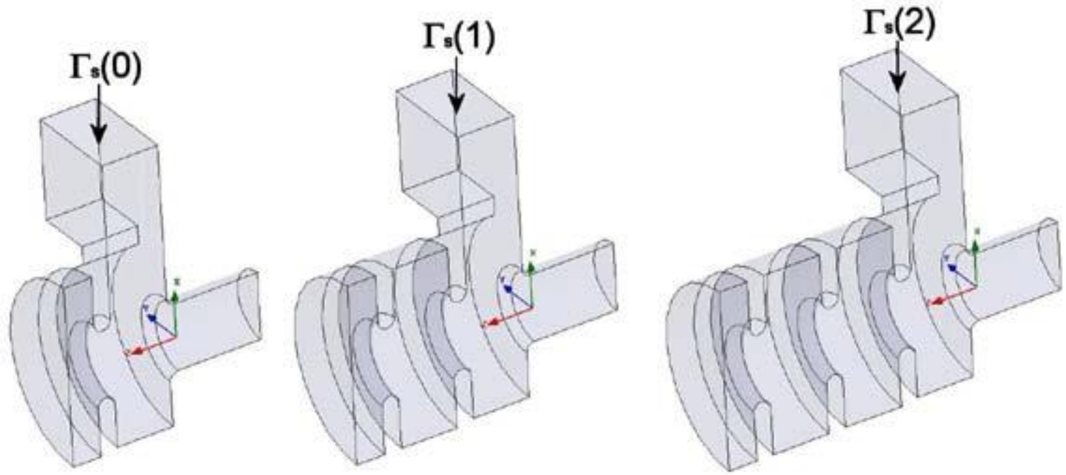
S11<30dB @ f=11.9952 GHz



D. Alesini et al., Design of couplers for traveling wave RF structures using 3D electromagnetic codes in the frequency domain, NIM-A (2007)

Coupler tuning: results





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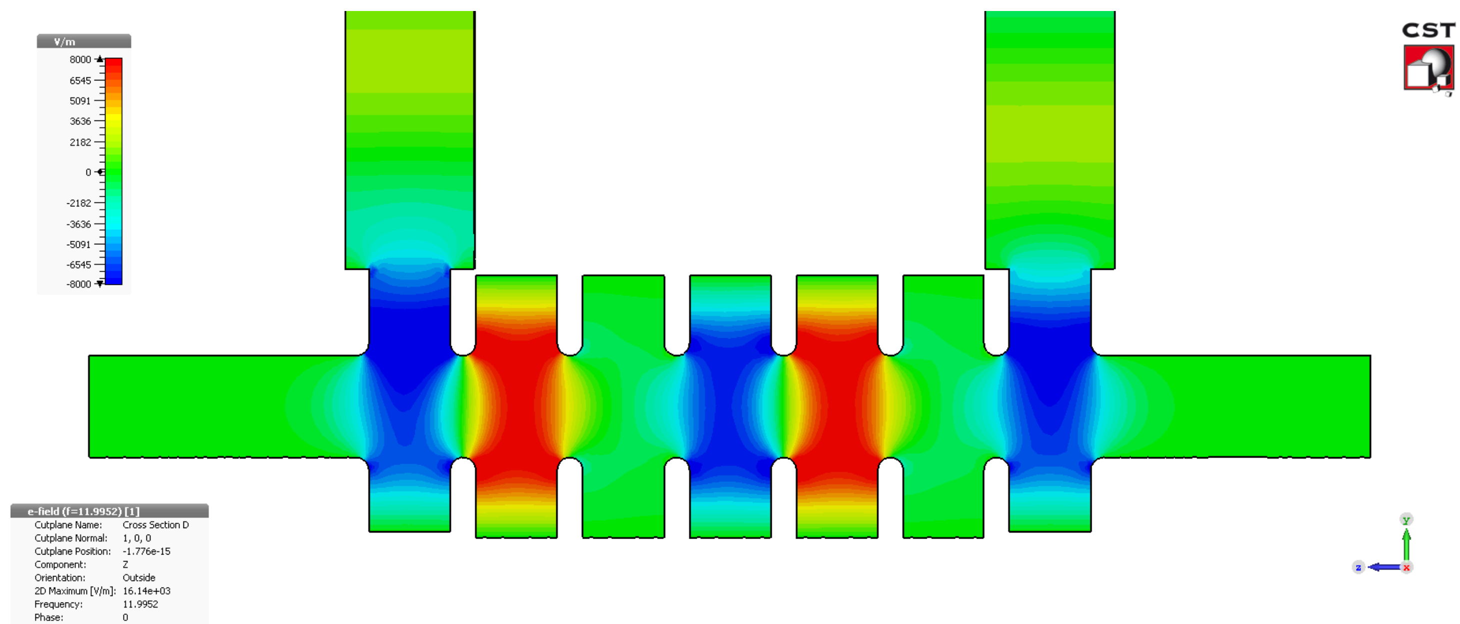
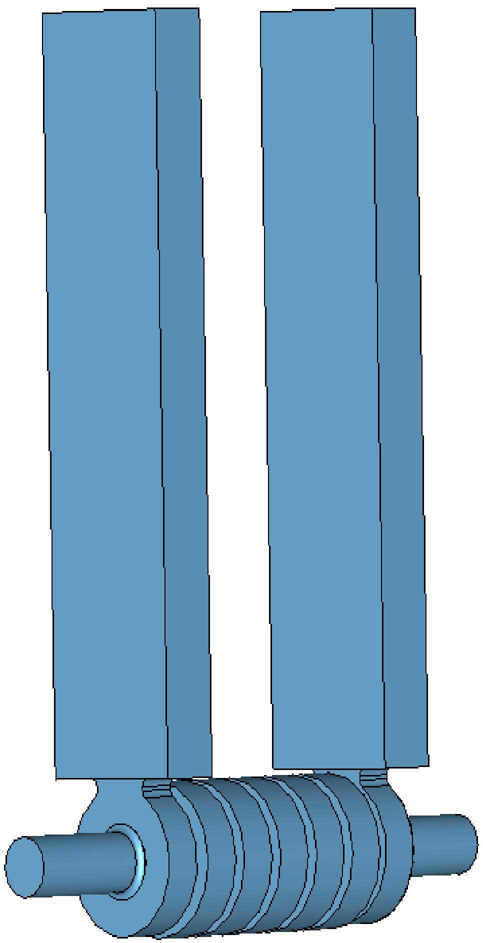
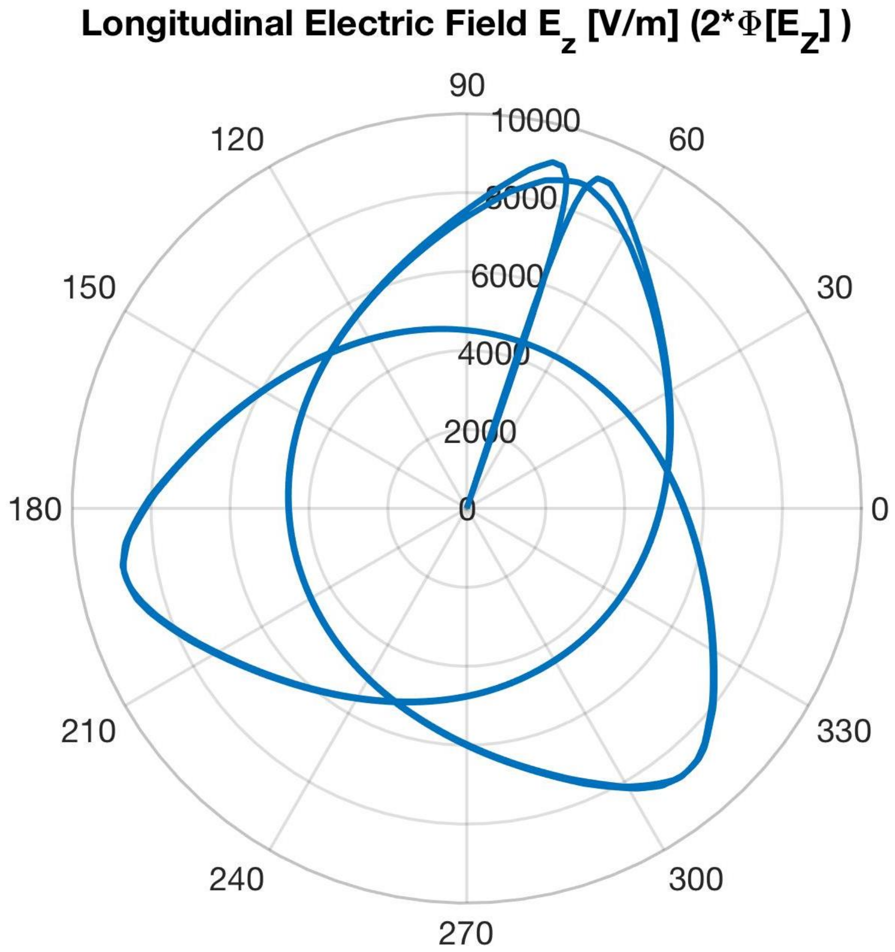
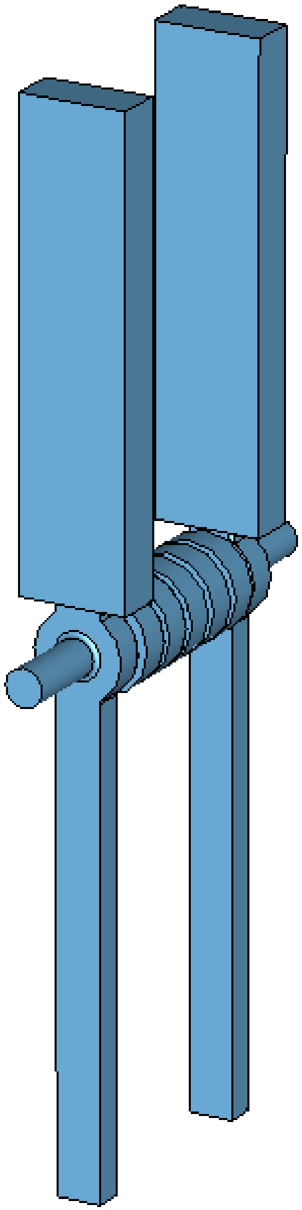


D. Alesini et al., Design of couplers for traveling wave RF structures using 3D electromagnetic codes in the frequency domain, NIM-A (2007)

Symmetric couplers

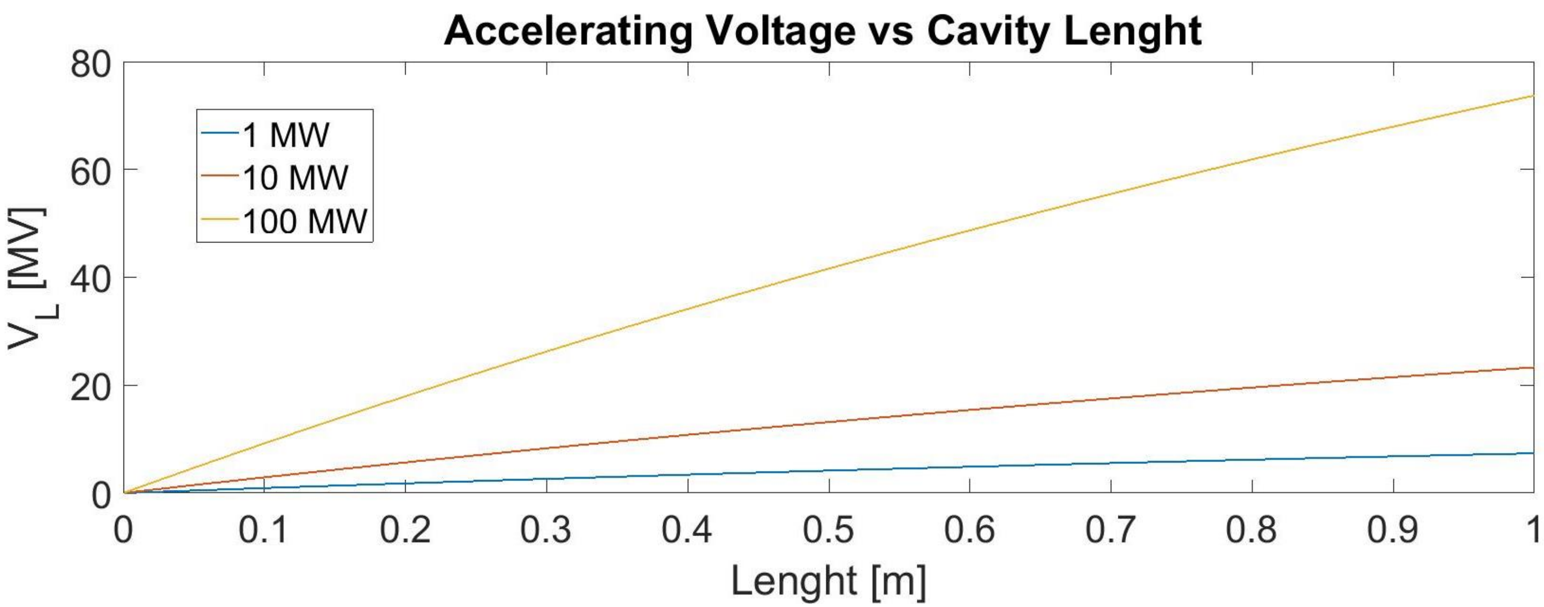




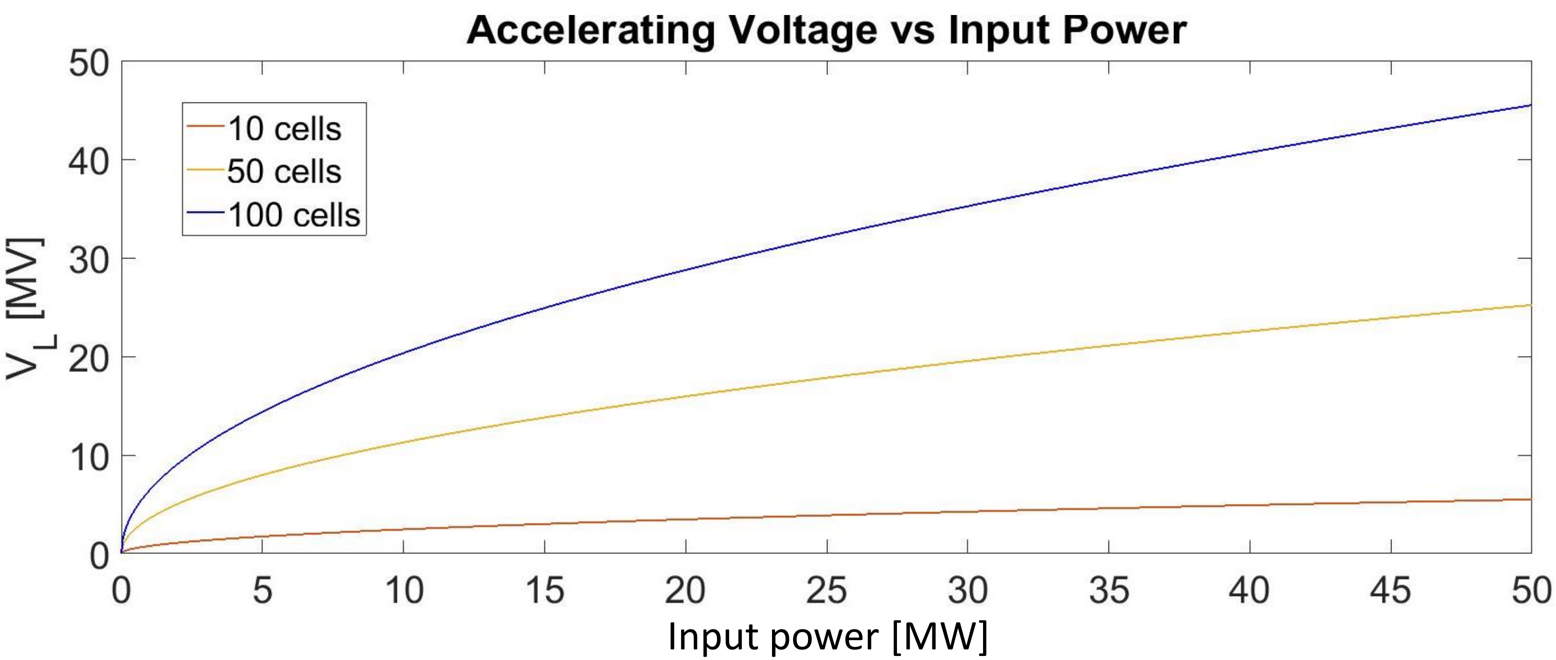


Full structure design: scaling laws

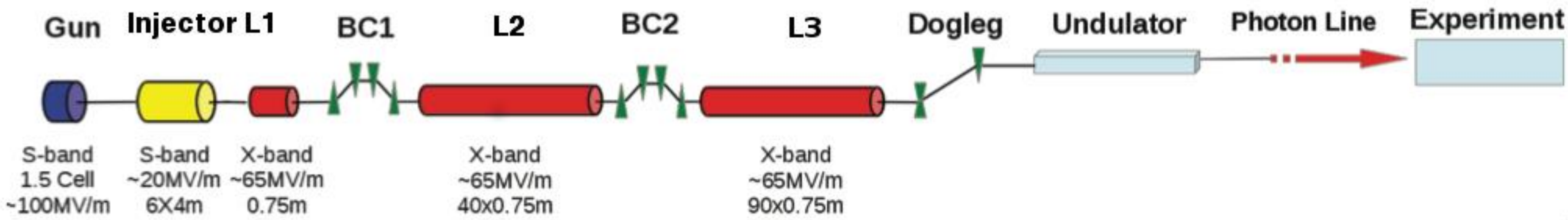
Average accelerating voltage vs effective length for different incident power



Average accelerating voltage vs incident power for different structure lengths



Next steps



0.75 m /Cell length = 89 cells

Incident Power = 58 MW

Total Filling Time = 89 * 0.76 ns = 68 ns

Next step → Expected value for the gradient

X-band RF compressor comes after the X-band gun

X-band linearizer useful for S-band, C-band solutions

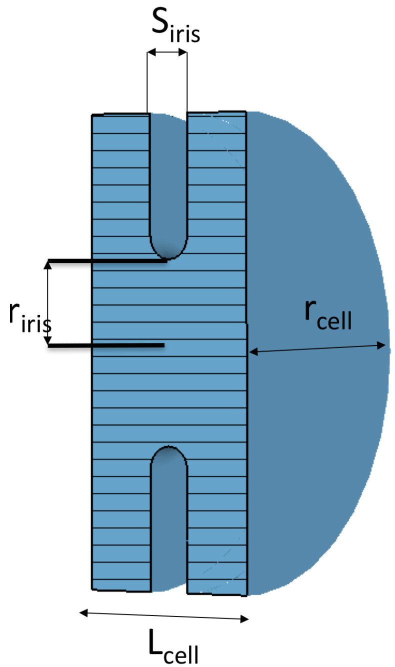
Define the beam dynamics and preliminary layout

Conclusions and outlook

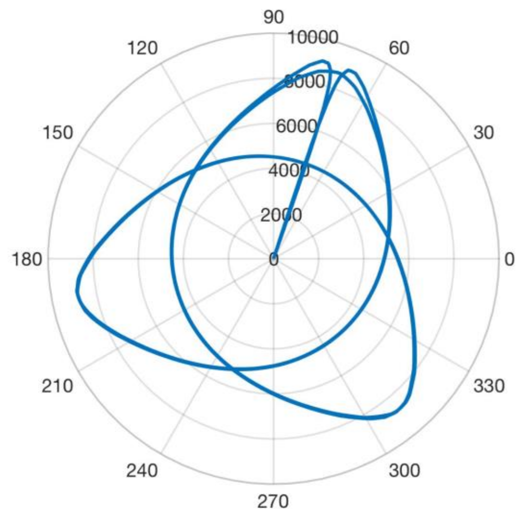
X-BAND Velocity Bunching and Linearizer

Baseline design TW structure, Δϕ=2π/3 mode, Constant Impedance

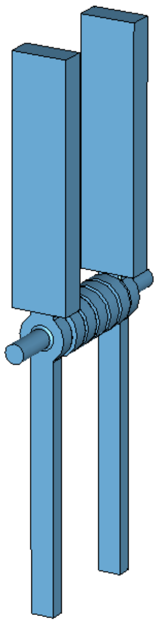
Single cell design



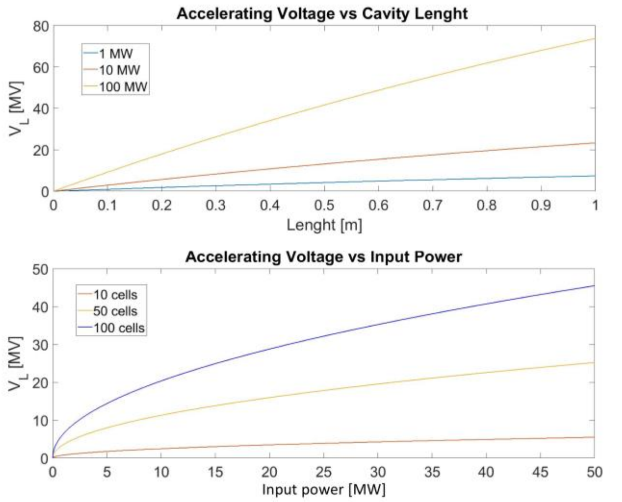
Coupler tuning



Improved couplers



Power scaling curves



Next step: define the expected value for the gradient according to beam dynamics and layout issues

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Thank you!

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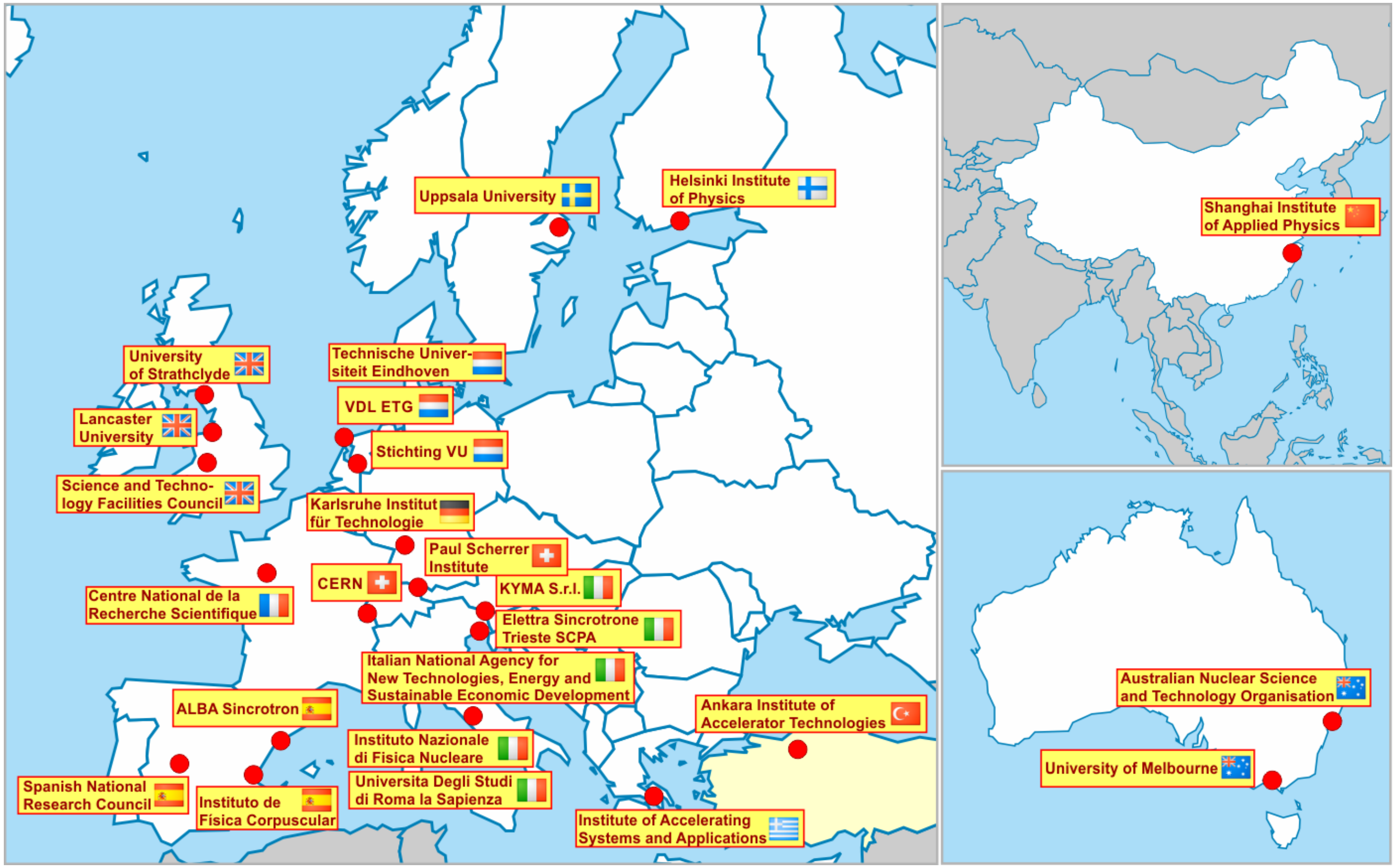

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