

Simple X-band RF valve

Sergey Kazakov

**2nd Collaboration Meeting on X-band Accelerator
Structure Design and Test-Program**

15 May, 2008

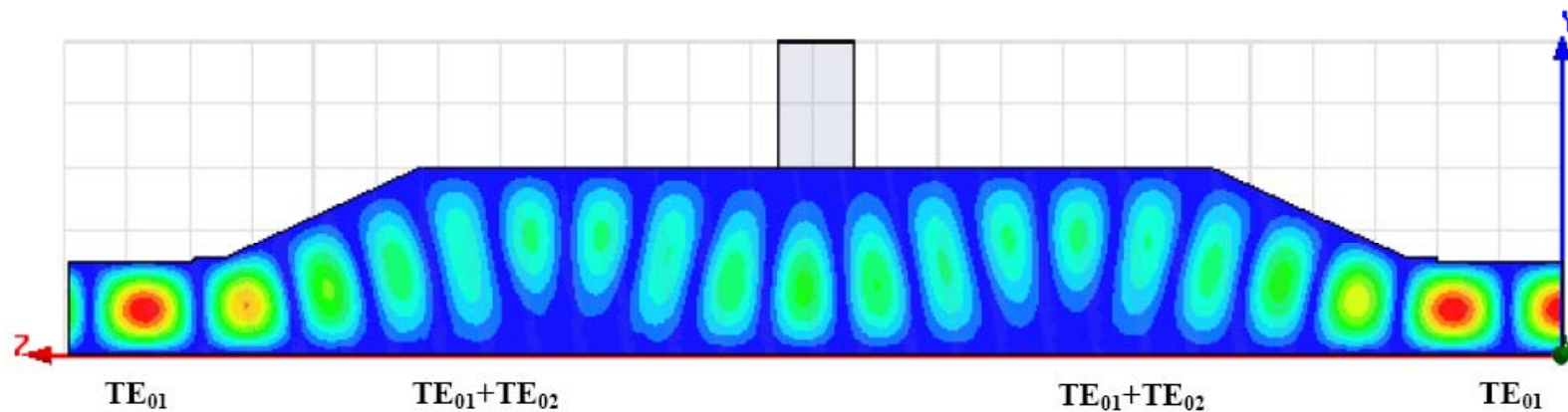
Work is inspired by idea of Alexsey Grudiev to use combination of TE₀₁-TE₀₂ modes in RF valve:

Proceedings of EPAC 2006, Edinburgh, Scotland

TUPCH142

DEVELOPMENT OF A NOVEL RF WAVEGUIDE VACUUM VALVE

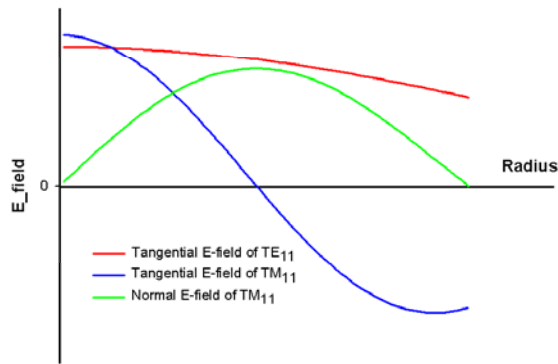
A. Grudiev, CERN, Geneva, Switzerland



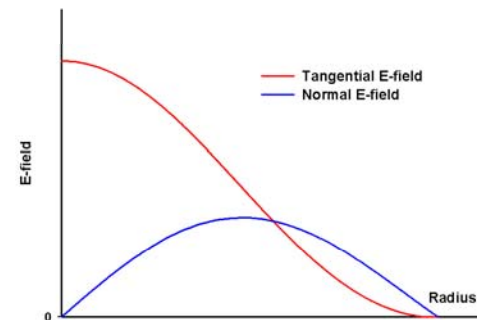
In our design we decided to use the similar approach but different modes combination. In our case we are using combination TE₁₁+TM₁₁. In this case we do not need TE₁₀-TE₀₁ mode converters. In some cases it can be convenient.

We used before the TE₁₁+TM₁₁ combination in Mixed-Mode RF window to decrease fields at brazing area:

X-band TW mixed-mode window

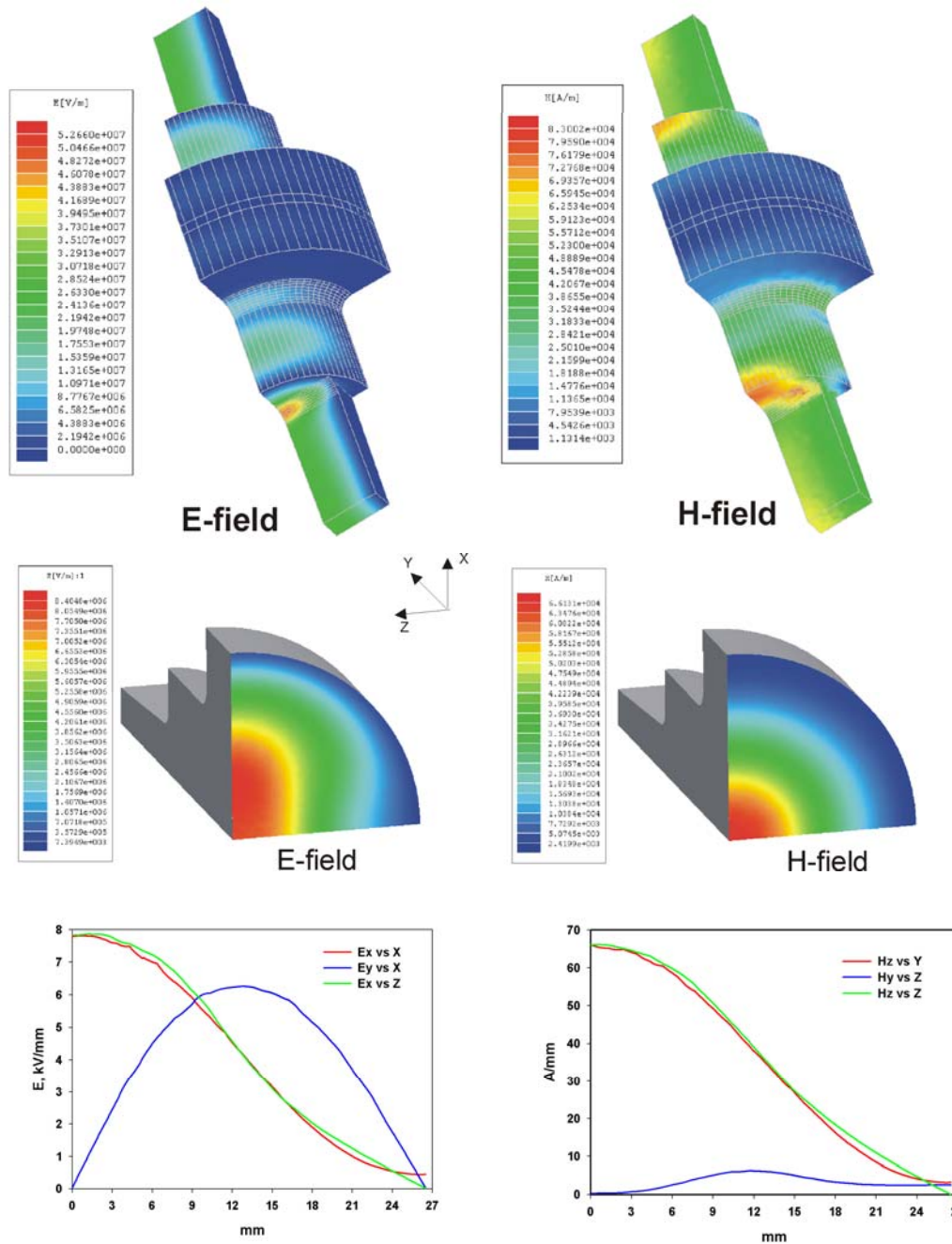


Electric fields of TE₁₁ and TM₁₁ modes in the circular waveguide



Electric fields of summation of TE₁₁ and TM₁₁ modes in the circular waveguide

X-band TW mixed-mode window



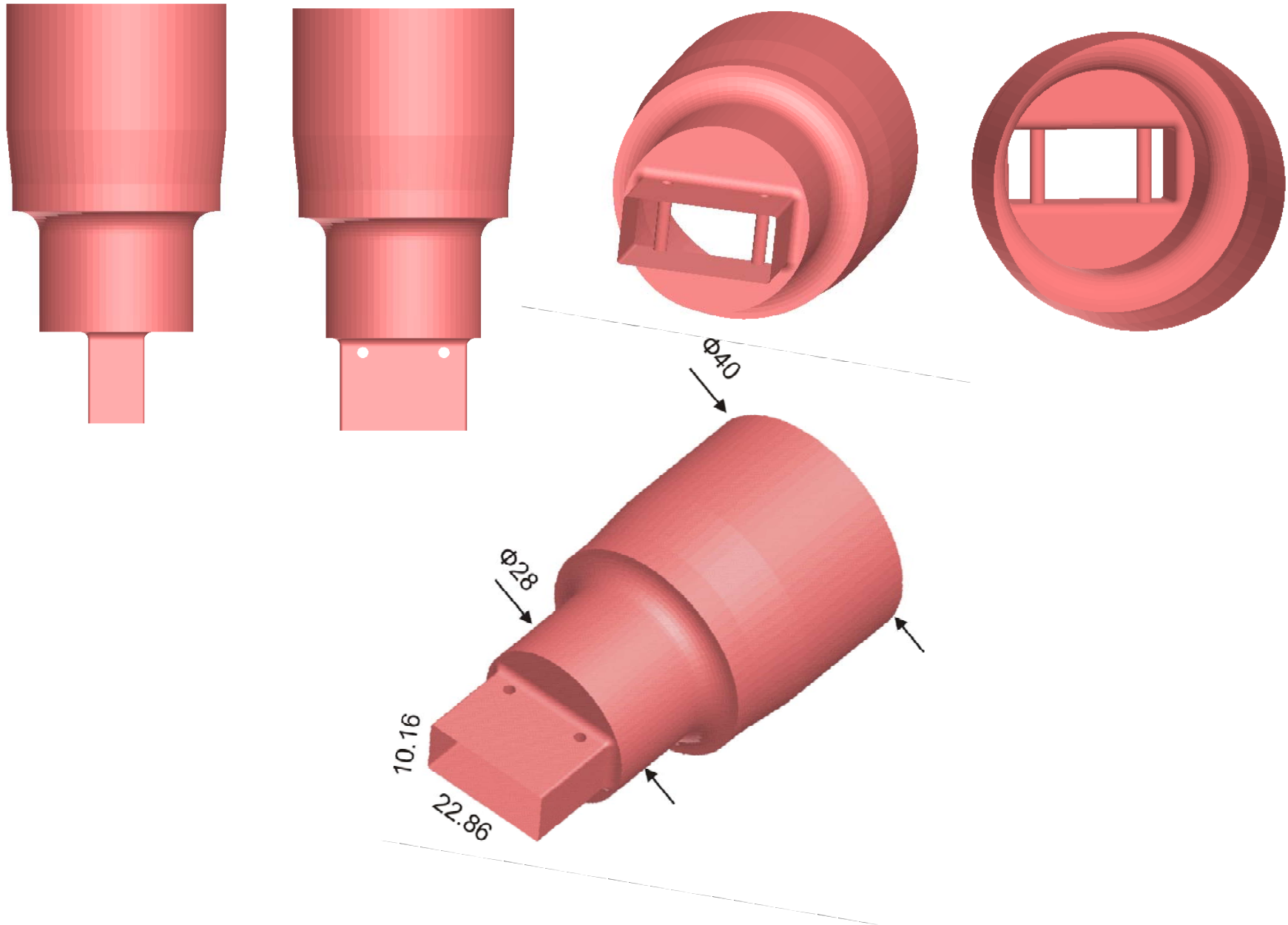
Ideal case – to eliminate all field at the wall. But we can not do it with these two mode only. But we can eliminate H_ϕ at some point ! In this case the combination of modes becomes similar to TE01 mode and we can make a slot without radiation.

The circular waveguide with 40mm diameter was chosen for 11.424 GHz.
Reasons: cutoff for TE12; there are commercial Φ 40mm valves.

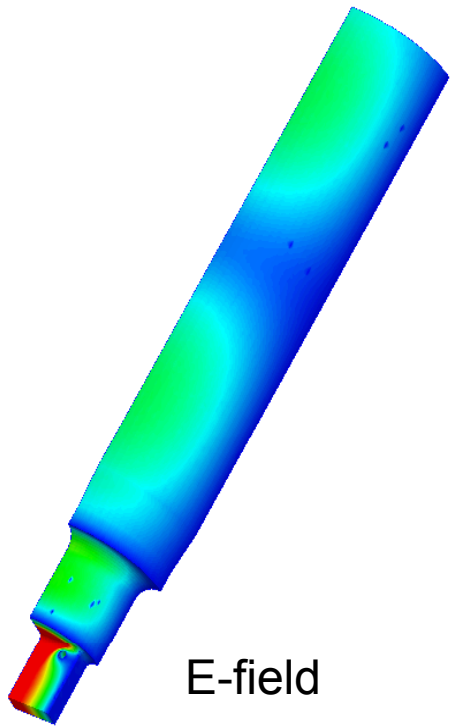
For Φ 40mm waveguide the TM11 / TE11 amplitude ratio have to be 0.48 to provide

$$H_\phi = 0$$

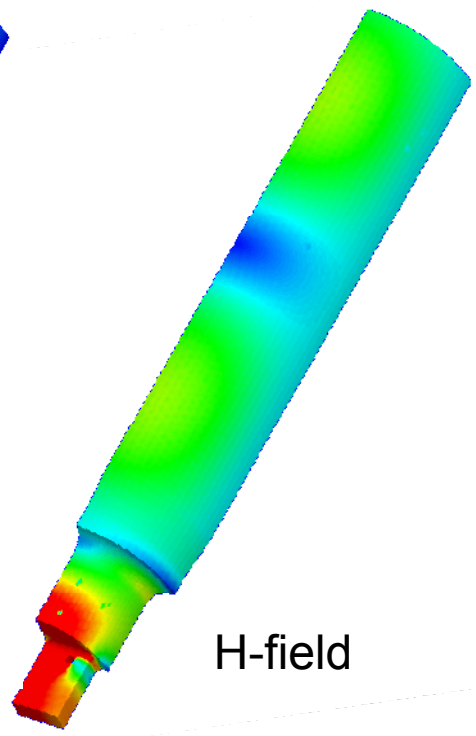
TE11+TM11 Launcher



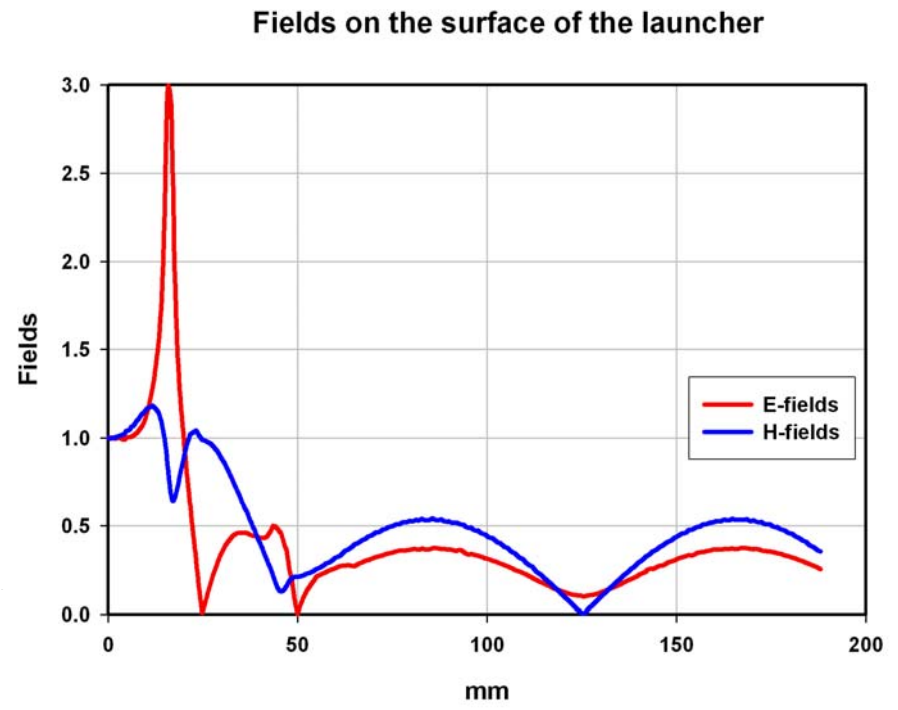
	port1:m1	port2:m1	port2:m2	port2:m3
port1:m1	(0.00519, -68.847)	(0.90069, -18.172)	(0.43442, 79.895)	(0.00120, 141.055)
port2:m1	(0.90069, -18.172)	(0.18886, -60.019)	(0.39125, -140.377)	(0.00111, 172.141)
port2:m2	(0.43442, 79.895)	(0.39125, -140.377)	(0.81130, 137.323)	(0.00045, -82.089)
port2:m3	(0.00120, 141.055)	(0.00111, 172.141)	(0.00045, -82.089)	(1.00000, 152.726)



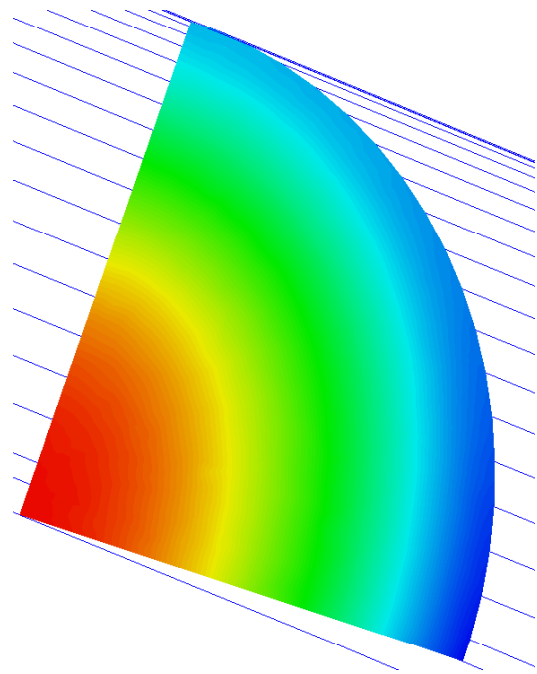
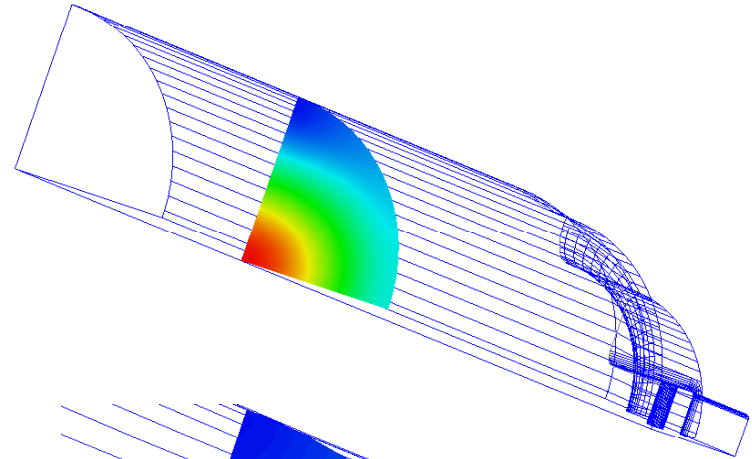
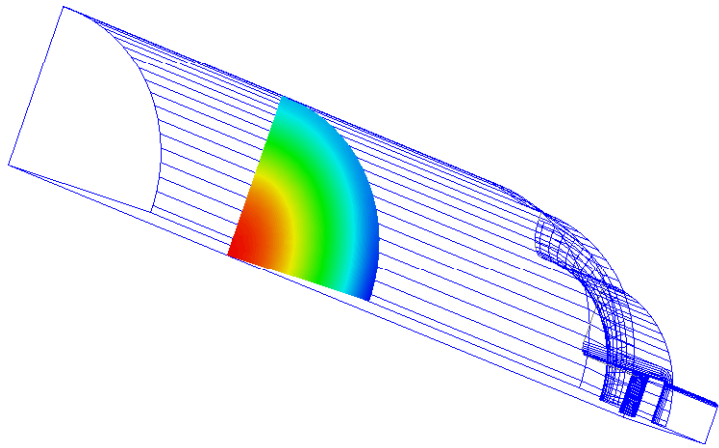
E-field



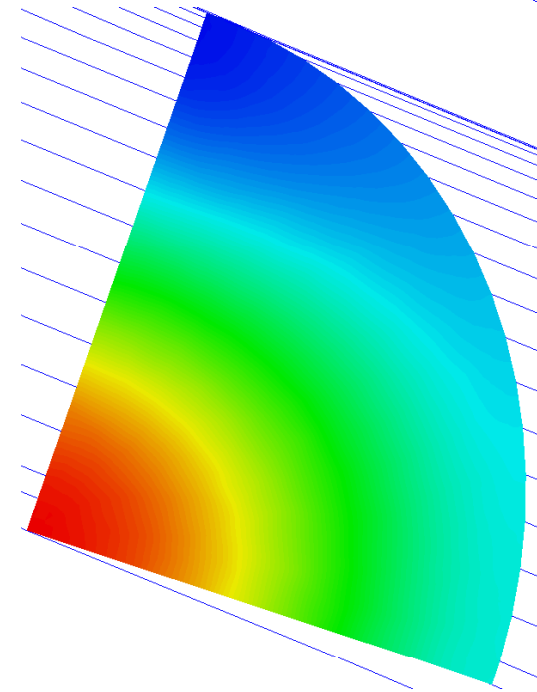
H-field



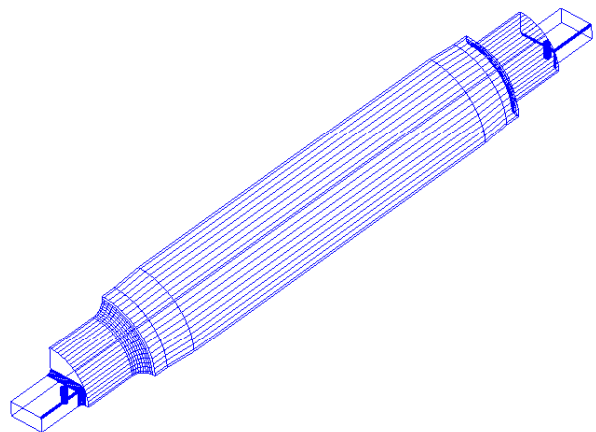
Field in cross-section, where $H_\varphi = 0$



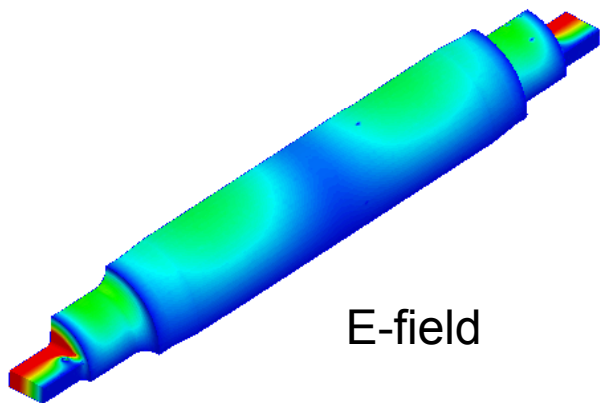
E-field



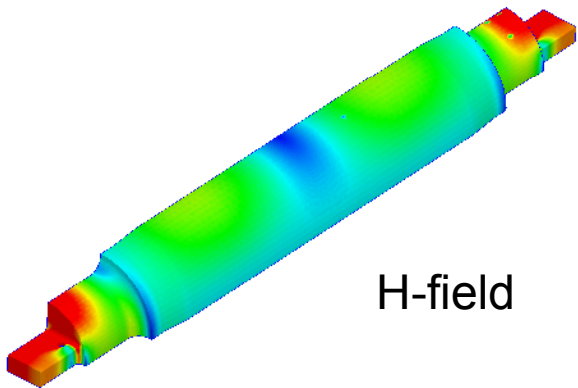
H-field



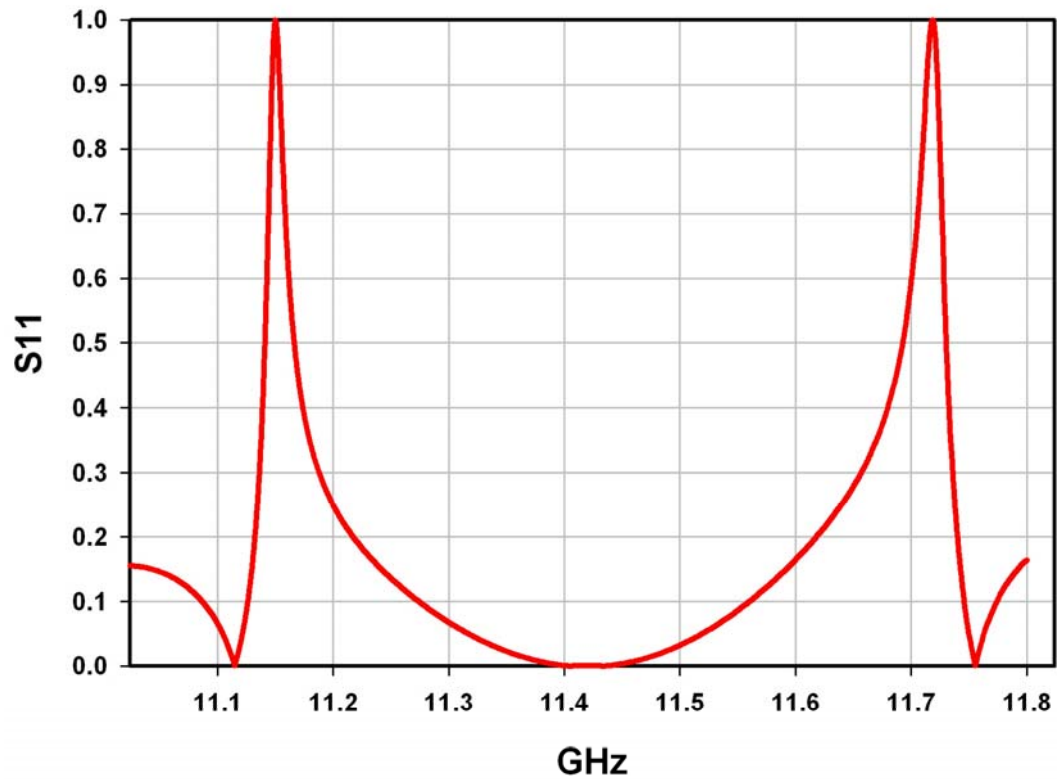
	port1:ml	port2:ml
port1:ml	(0.00048, -164.498)	(1.00000, 114.232)
port2:ml	(1.00000, 114.232)	(0.00048, -147.038)

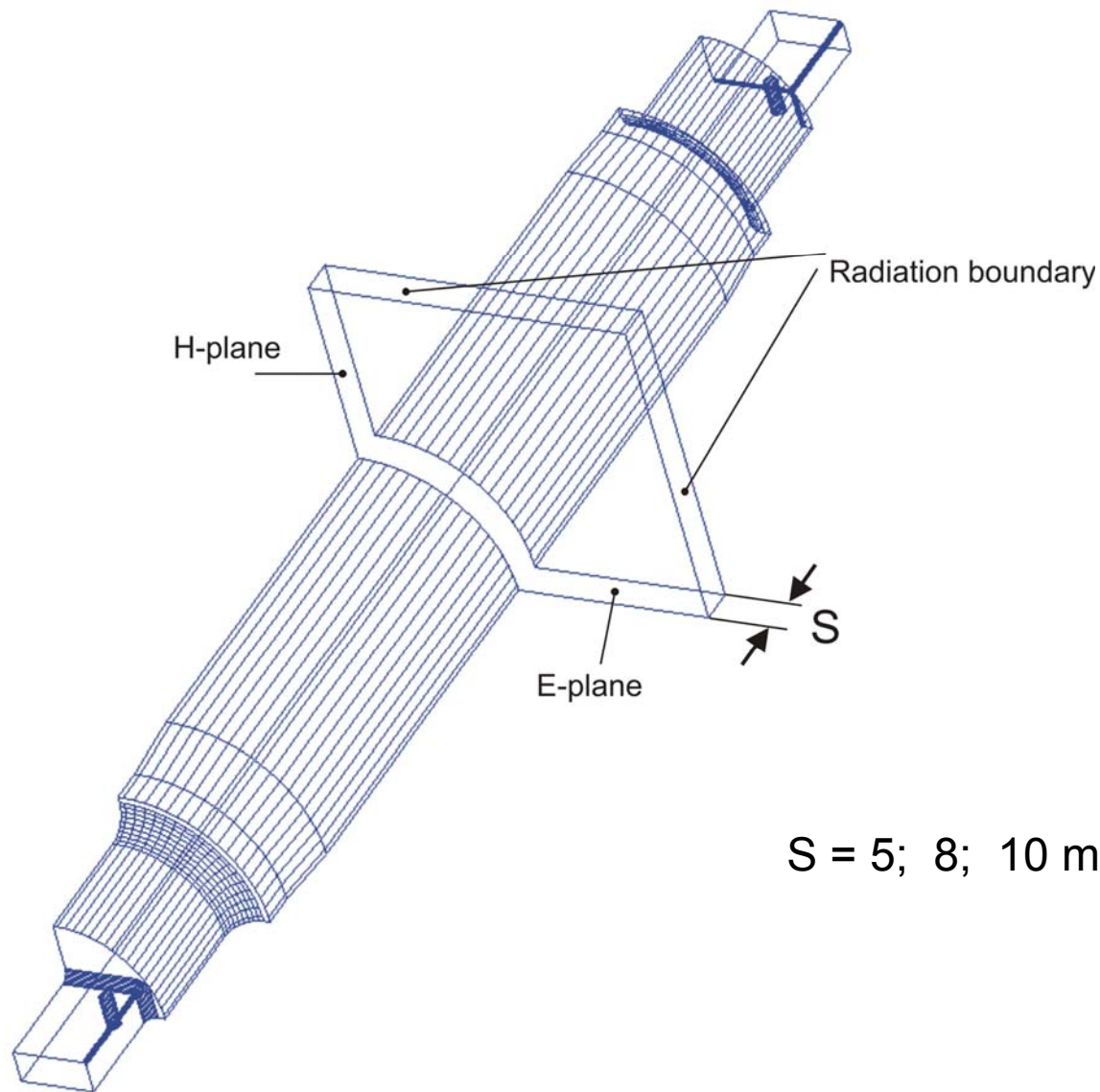


E-field



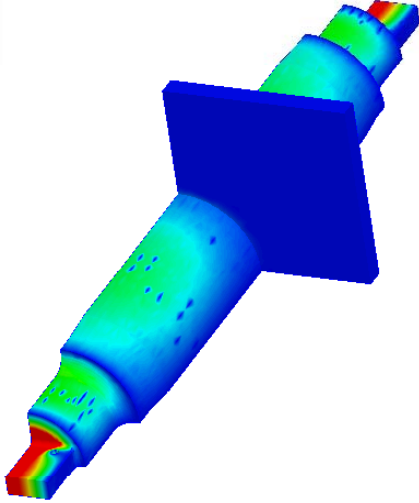
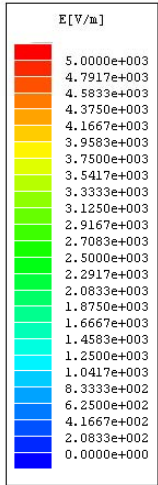
H-field



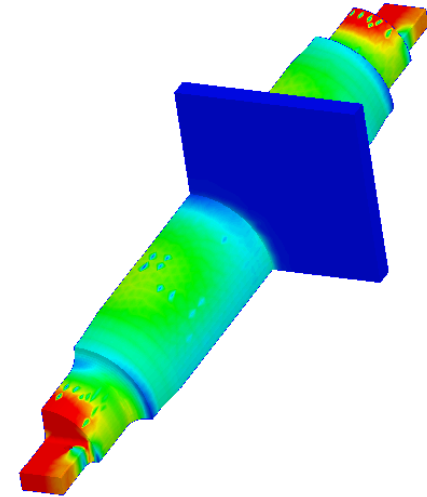
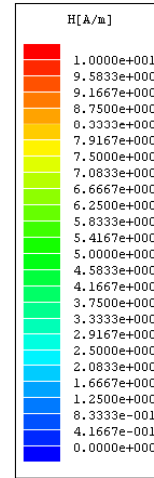


$S = 5; 8; 10 \text{ mm};$

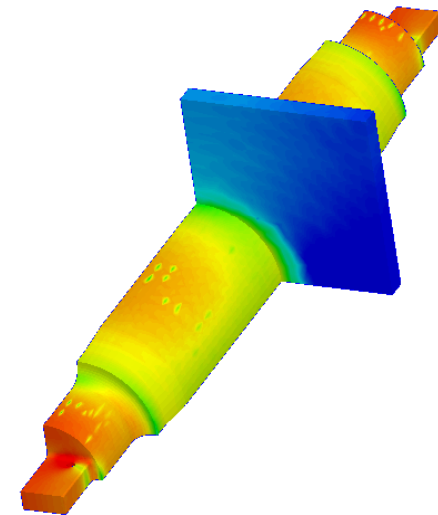
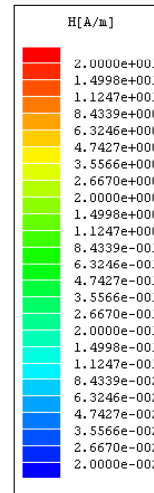
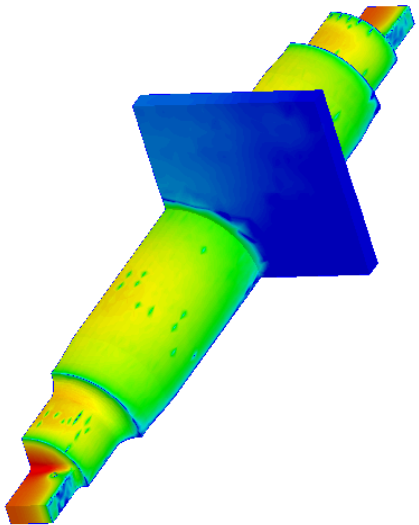
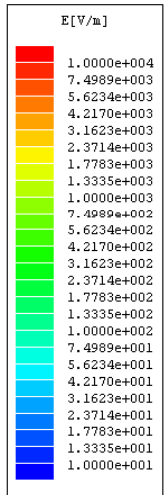
Slot 5mm



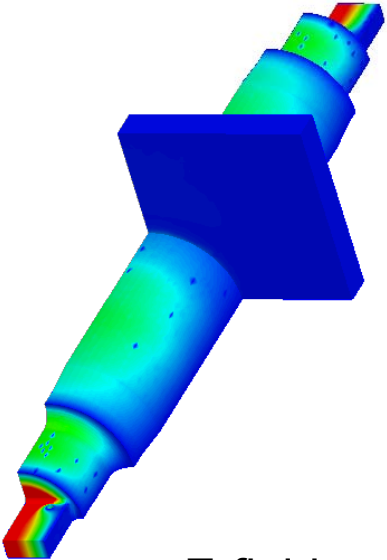
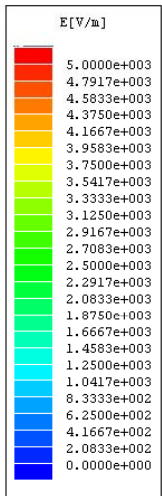
E -field



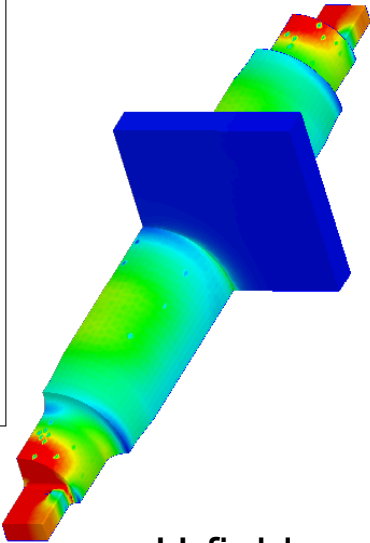
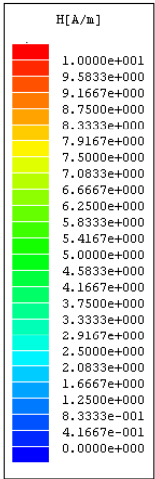
H-field



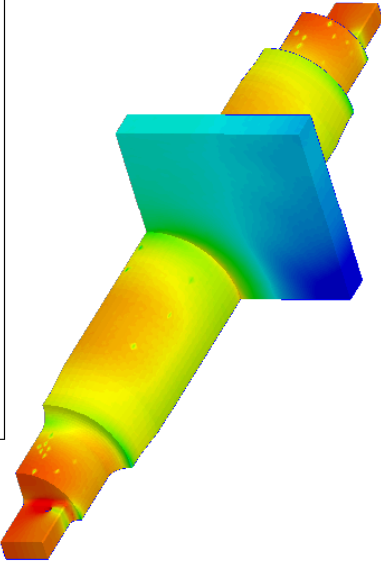
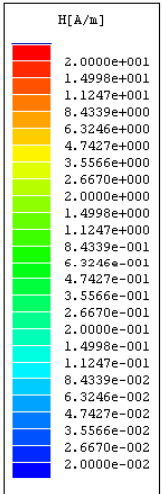
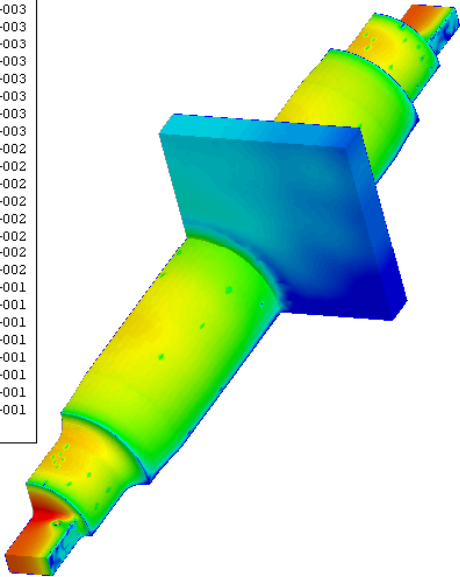
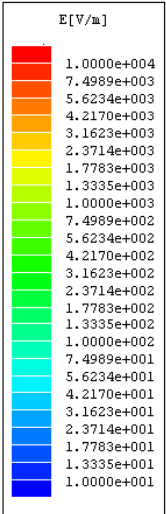
Slot 8mm



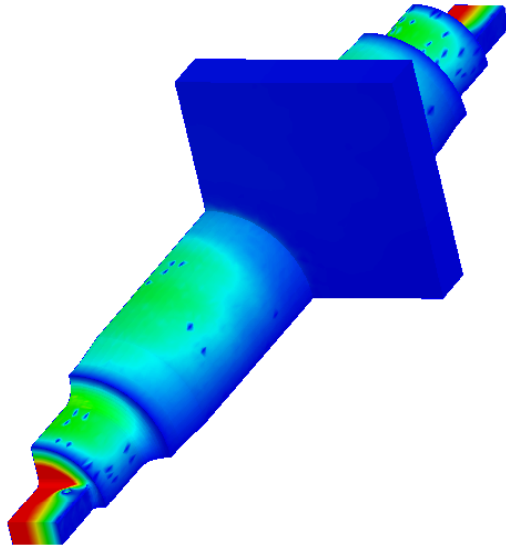
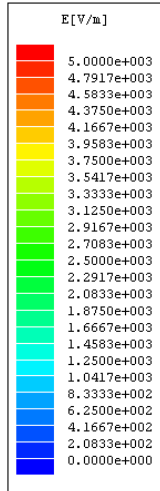
E-field



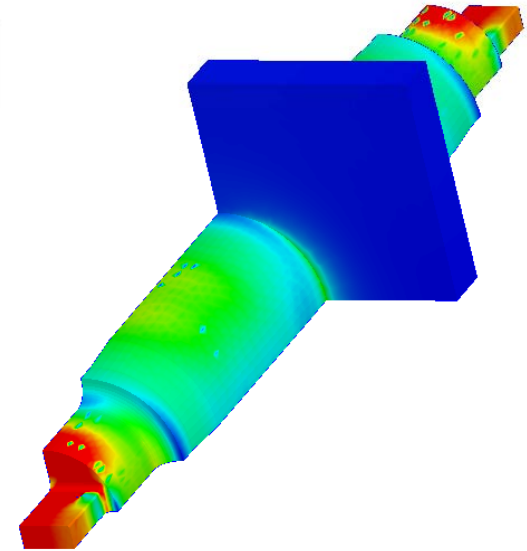
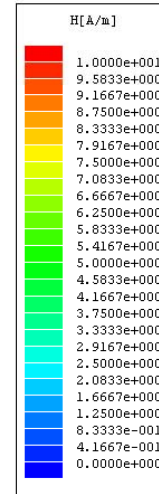
H-field



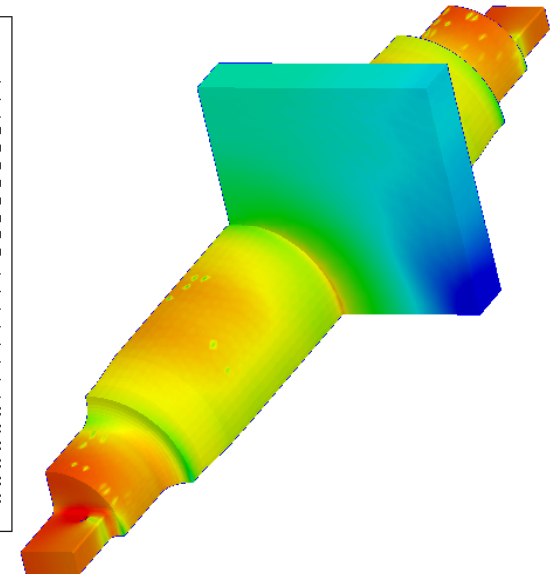
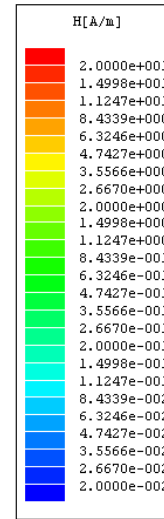
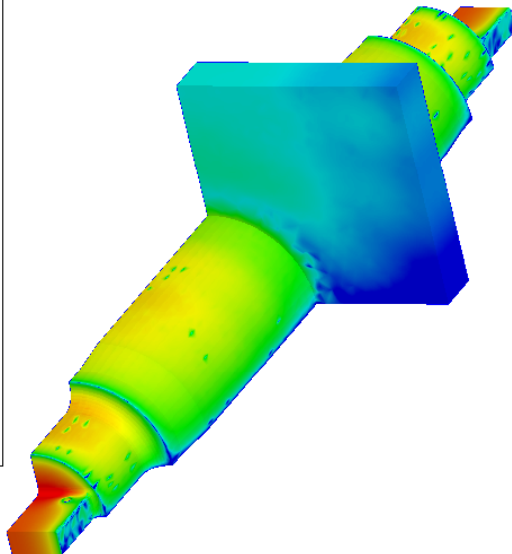
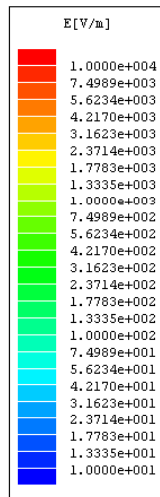
Slot 10mm



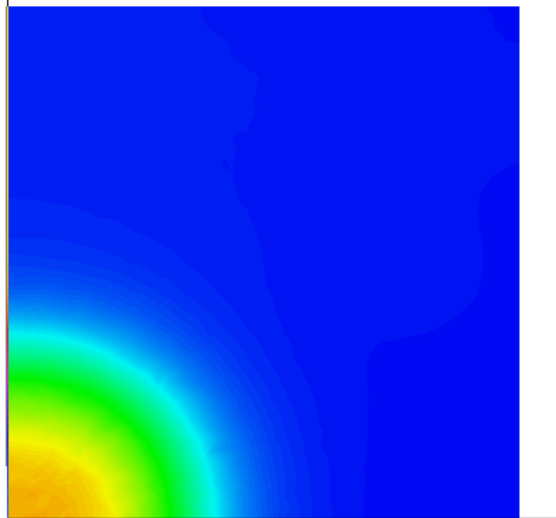
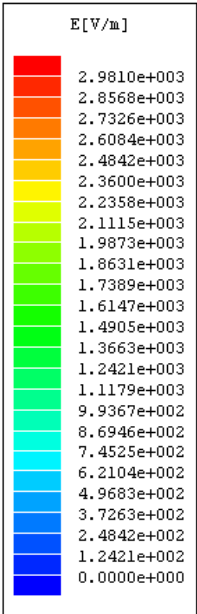
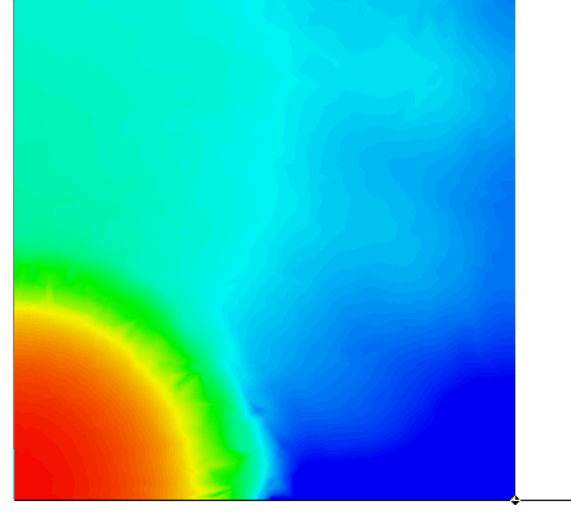
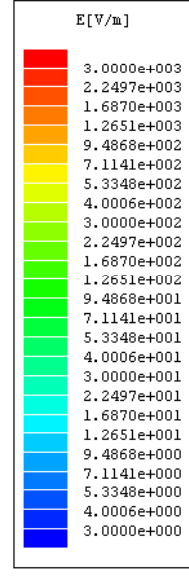
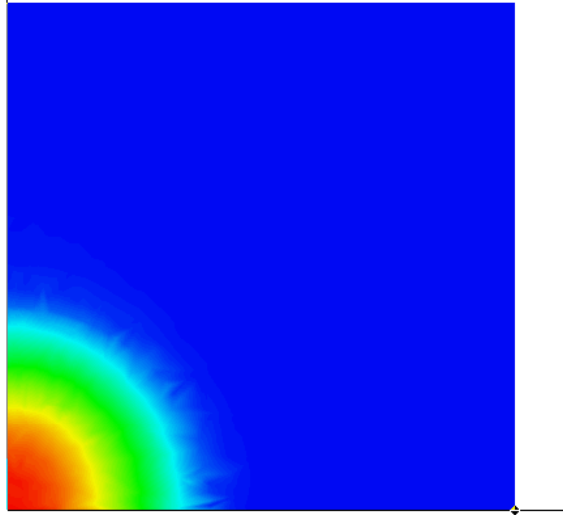
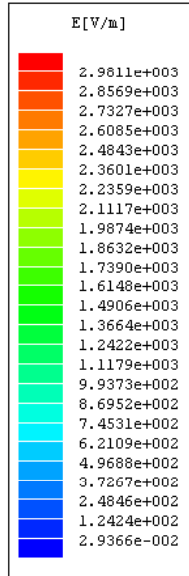
E-field



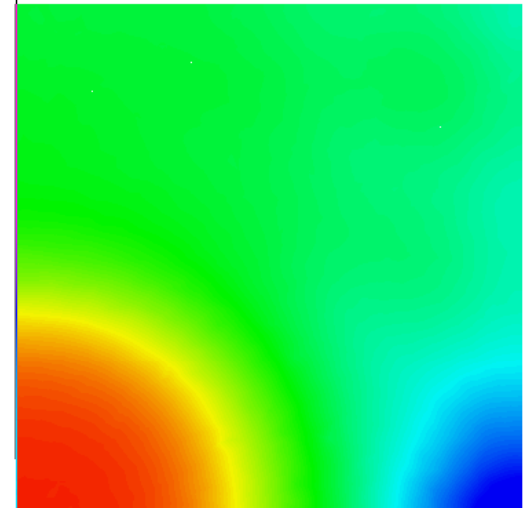
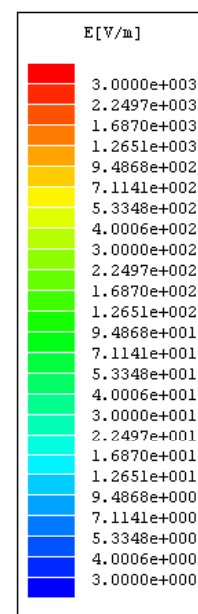
H-field

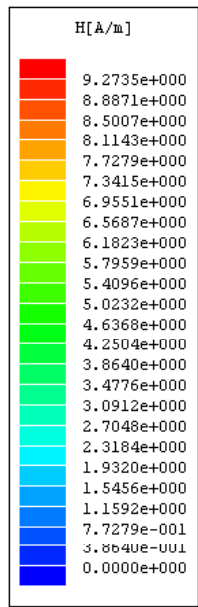


E-field

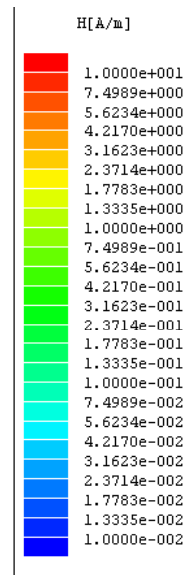


10 mm

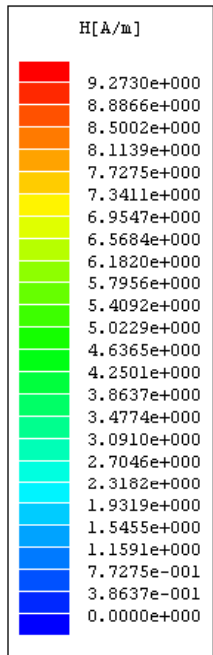
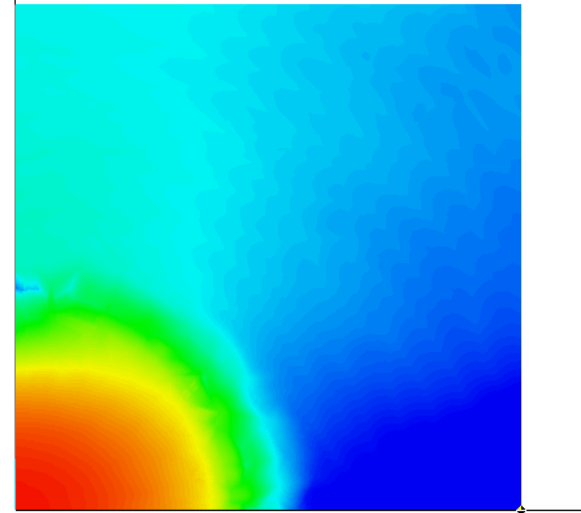




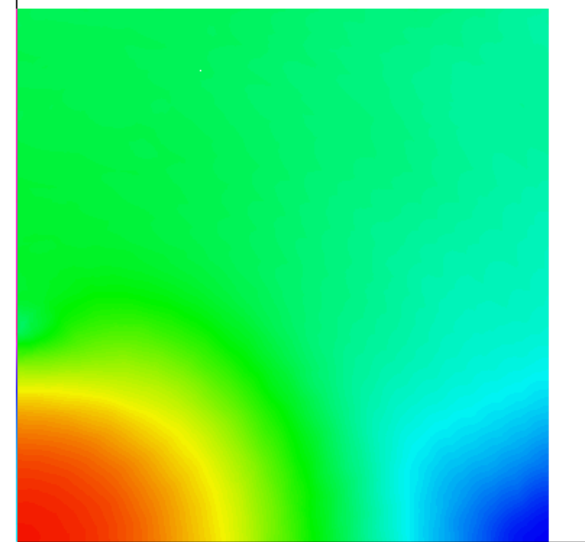
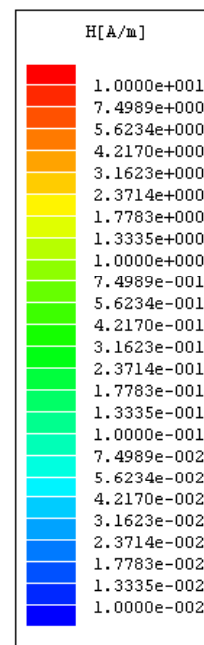
H-field



5mm

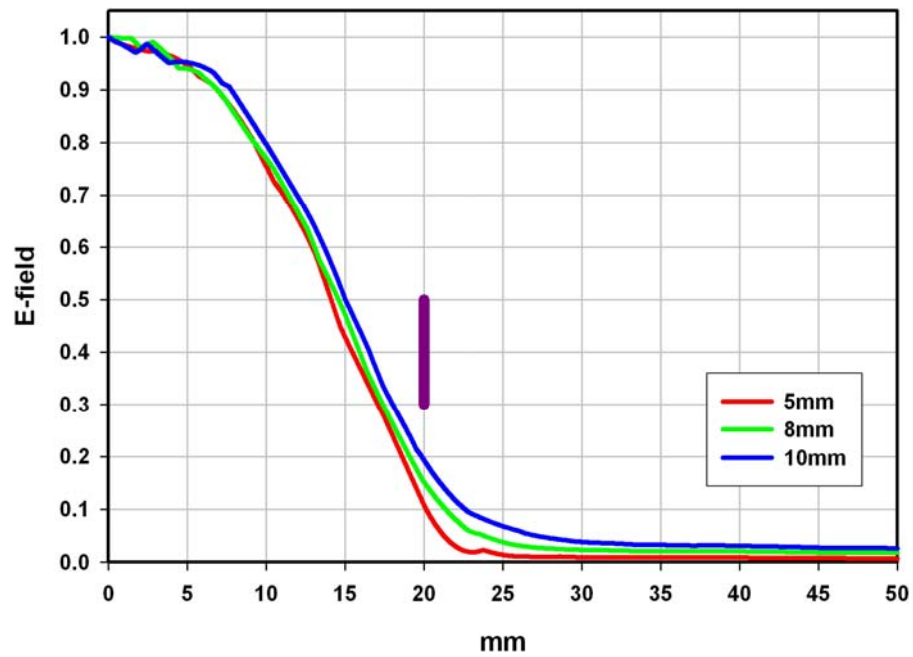


10mm

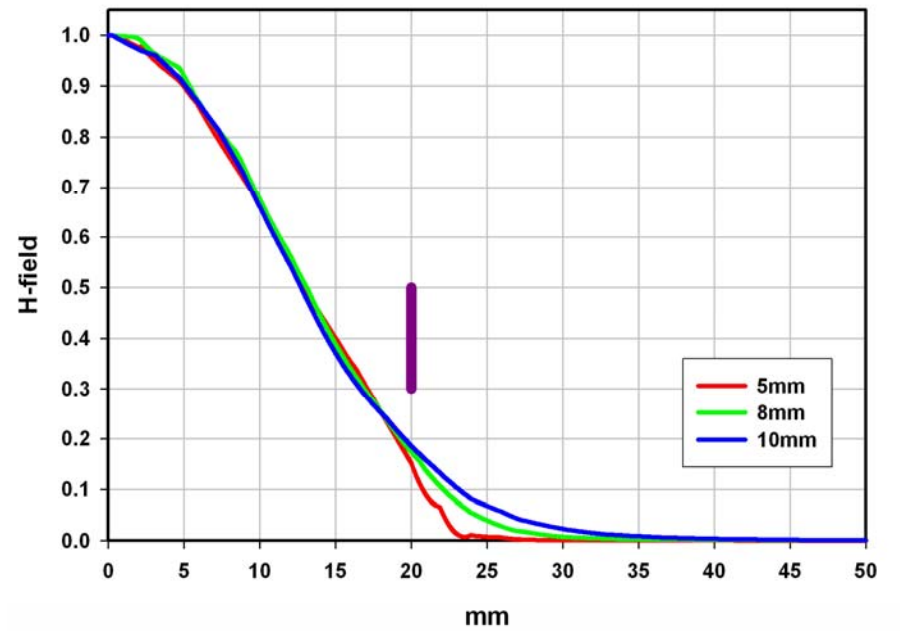


Fields decay in the slots

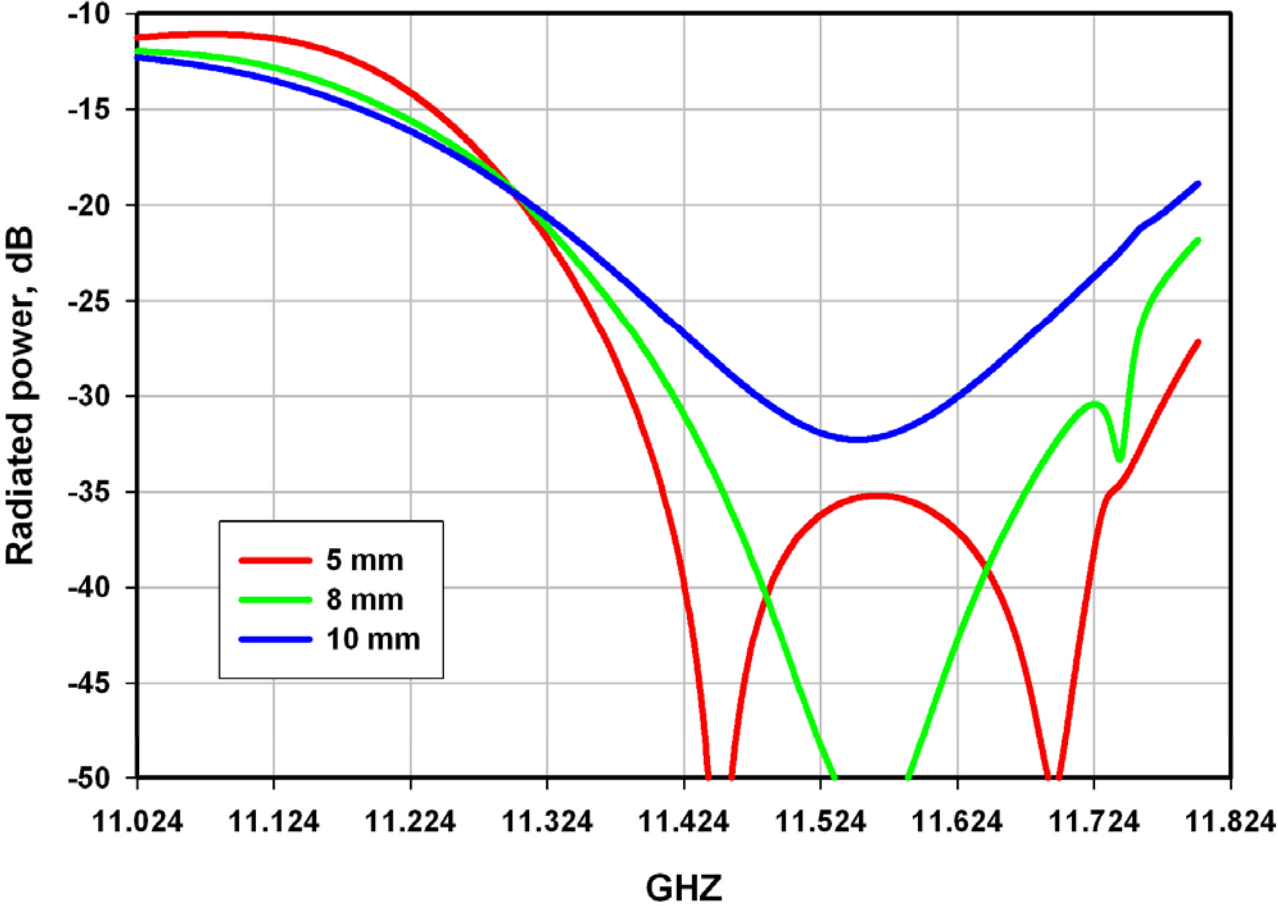
Decay of electric field



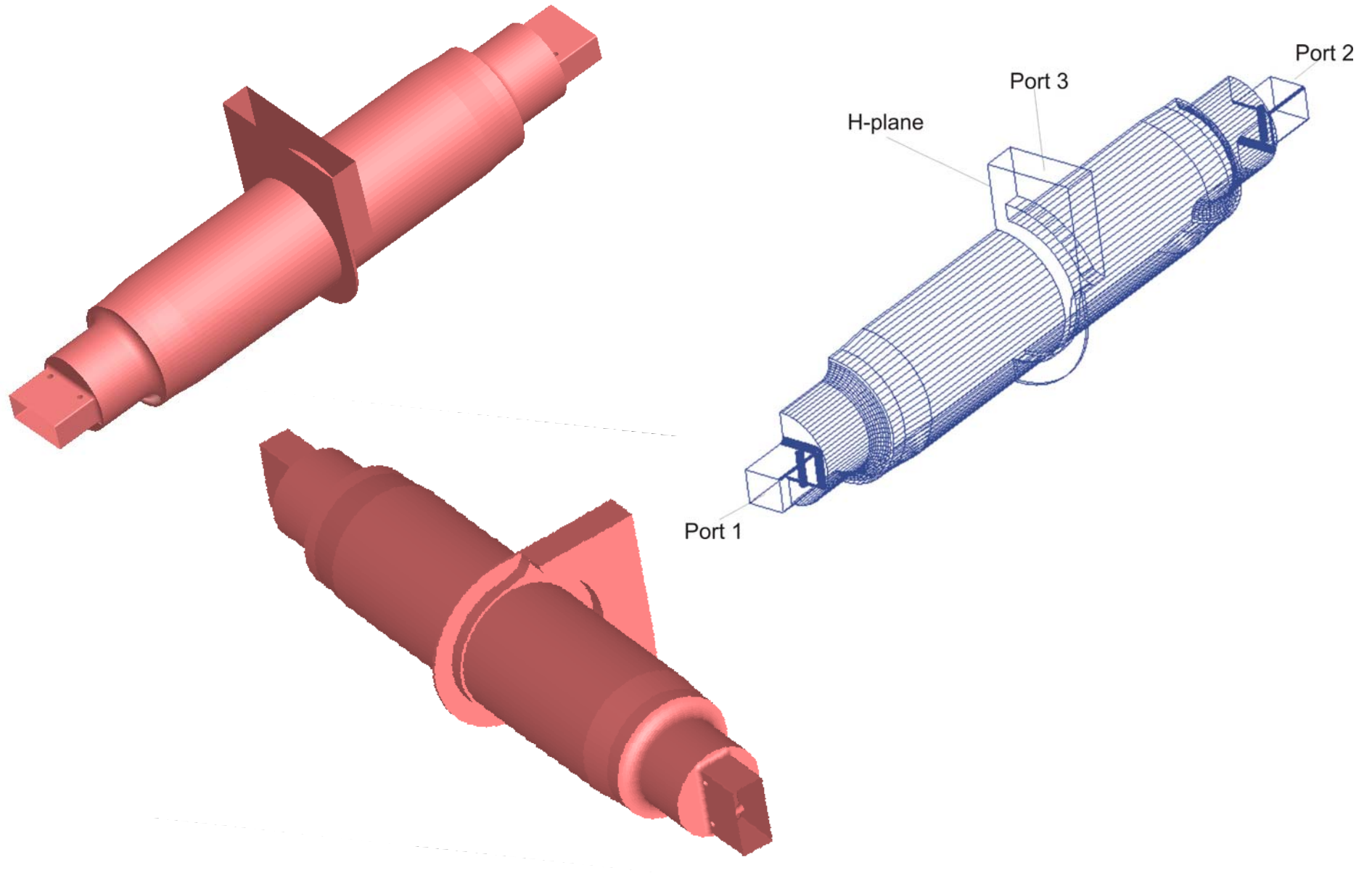
Decay of magnetic field

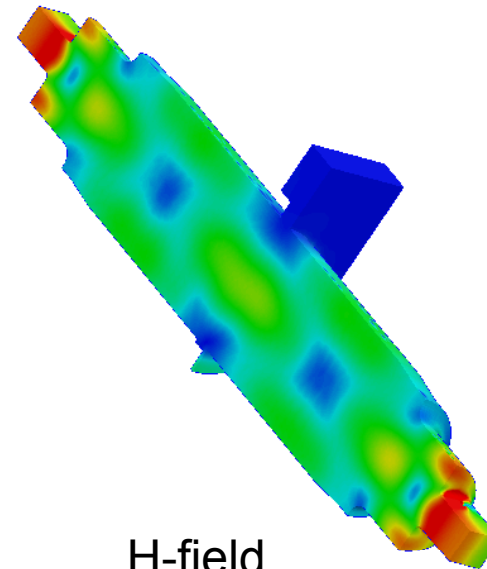
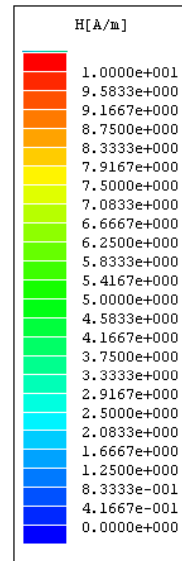
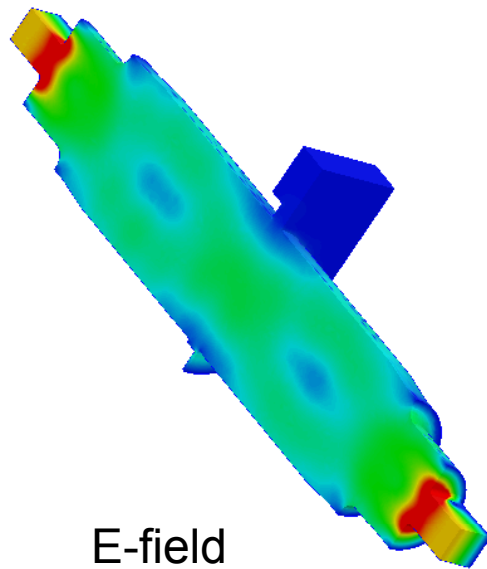
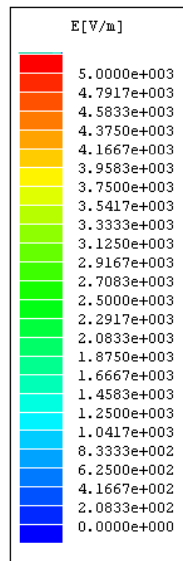


Radiated power through slots

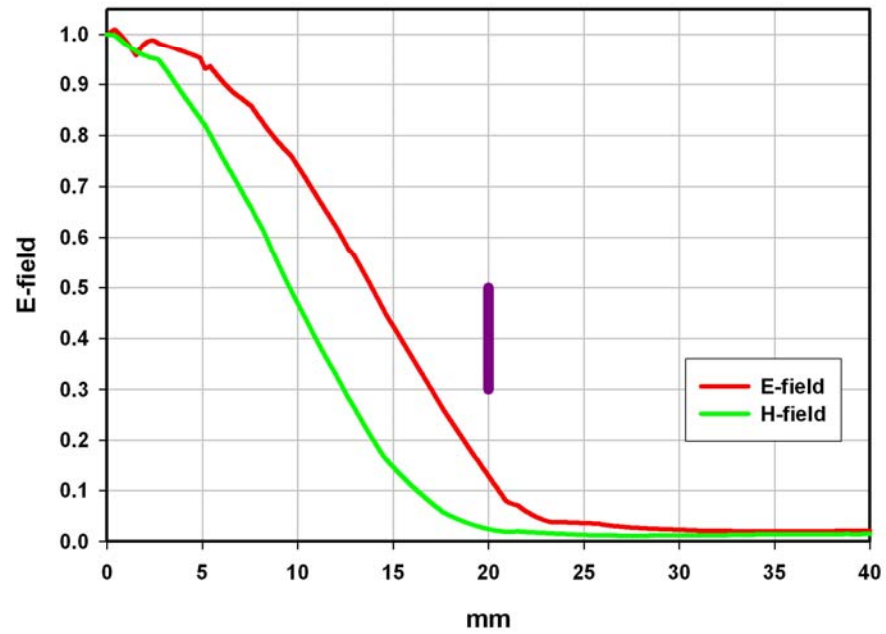


Simulations of geometry close to commercial valve

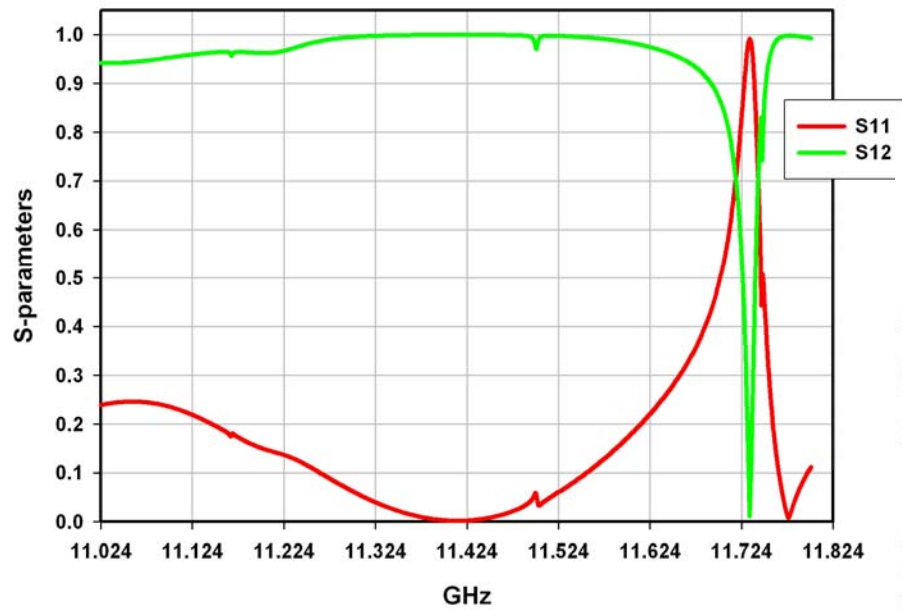




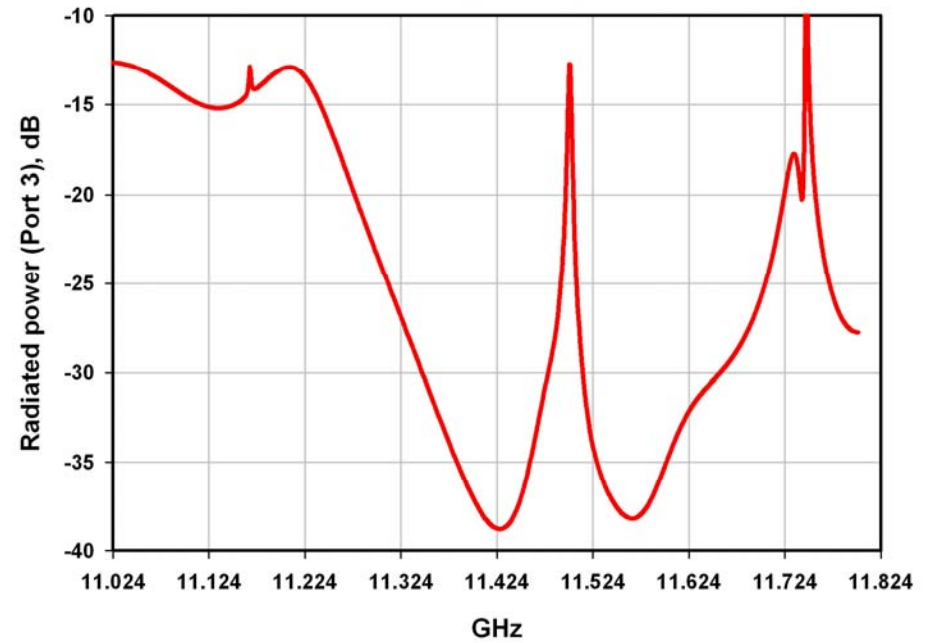
Decay of fields



S-parameters,
Real geometry

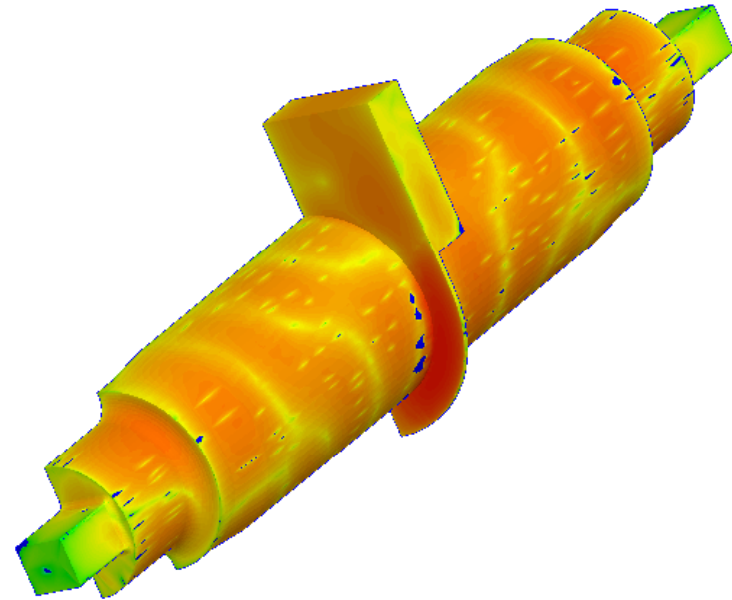
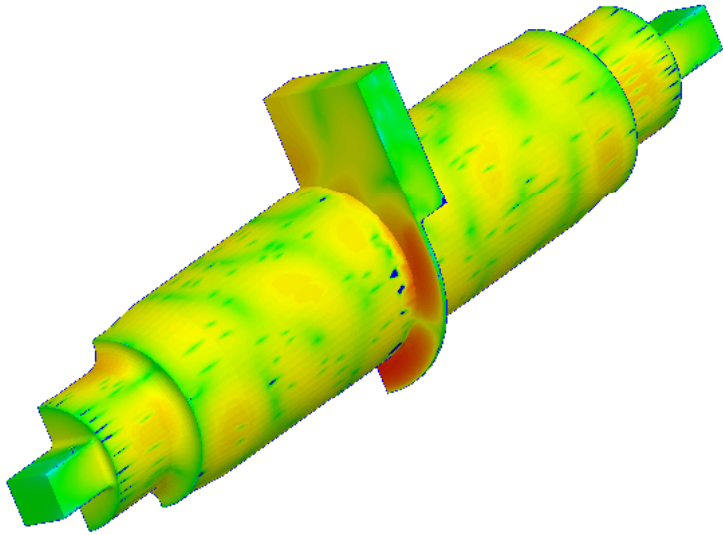


Radiated power,
Real geometry



	port1:m1	port2:m1	port3:m1	port3:m2
port1:m1	(0.00258, 7.582)	(0.99993, 112.639)	(0.00778, -177.320)	(0.00853, -176.106)
port2:m1	(0.99993, 112.639)	(0.00267, 35.851)	(0.00684, -139.180)	(0.00927, -99.063)
port3:m1	(0.00778, -177.320)	(0.00684, -139.180)	(0.95378, 90.838)	(0.30033, -155.142)
port3:m2	(0.00853, -176.106)	(0.00927, -99.063)	(0.30033, -155.142)	(0.95375, 138.854)

Resonances



	Frequency (GHz)	Q
Mode 1	(1.14749e+001, 2.34429e-002)	2.44742e+002
Mode 2	(1.15011e+001, 3.25326e-003)	1.76763e+003
Mode 3	(1.15987e+001, 4.27042e-001)	1.35895e+001
Mode 4	(1.16137e+001, 6.22086e-002)	9.33460e+001
Mode 5	(1.17376e+001, 9.84511e-003)	5.96111e+002

	Frequency (GHz)	Q
Mode 1	(1.13169e+001, 1.07606e-005)	5.25852e+005
Mode 2	(1.14915e+001, 7.79883e-003)	7.36747e+002
Mode 3	(1.16120e+001, 2.04656e-002)	2.83696e+002
Mode 4	(1.16178e+001, 3.71971e-005)	1.56165e+005
Mode 5	(1.17559e+001, 2.41866e-004)	2.43025e+004

Parameters:

Max. E-field (100MW)	855 kV/cm
Max. E-field (50MW)	605 kV/cm
Max. H-field (100MW)	234 kA/m
Max. H-field (50MW)	165 kA/m
Pulse heating (100MW x 10 ⁻⁶ s)	22°
Pulse heating (50MW x 10 ⁻⁶ s)	11°
Length	~230mm