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Comparison of electromagnetic parameters for the T4FASC-CSS-SPVSHC and T4FASC-CSS-CPVCHC configurations with the focusing lens

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Abstract

Numerical simulations are used to compare important electromagnetic parameters, such as the electric field enhancement and spot size reduction, at the second focus, for the T4FASC-CSS-SPVSHC and T4FASC-CSS-CPVCHC configurations with the focusing lens.

1 Introduction

The T4FASC-CSS-SPVSHC and T4FASC-CSS-CPVCHC designs were optimized in [1]. As mentioned in [1], the following dimensions are assumed as the default,

- SPVSHC:
  - feed arm + loft length, $l = 19.0$ cm,
  - height of the CSS, $H_{\text{css}} = 0.2$ cm,
  - radius of the pressure vessel, $r_{\text{pv}} = 2.0$ cm,
- CPVCHC: feed arm + loft length, $l = 19.0$ cm.

In this paper, the electromagnetic parameters, at the second focus, of the 4FA, T4FASC-CSS-SPVSHC and T4FASC-CSS-CPVCHC configurations are compared, in air and with the focusing lens, as in [2]. The focal waveforms and beam widths obtained with the focusing lens are examined to ensure that,

1. the shape of focal impulse waveform remains the same, i.e., it is not dispersed due to the small time-spread in the spherical wave originating from the first focal point [3, 4],
2. the electromagnetic parameters at the second focus are enhanced as predicted analytically,
3. the spot size is reduced by a factor of $\sqrt{\epsilon_{rt}} = 3.0$ (ϵ_{rt} is the relative permittivity of the target medium).

2 Setup

The setup for the T4FASC-CSS SPVSHC with the reflector and the focusing lens is shown in Fig. 2.1. The T4FASC-CSS SPVSHC and the reflector are identical to [3] while the focusing lens and slab design are identical to that in [2].

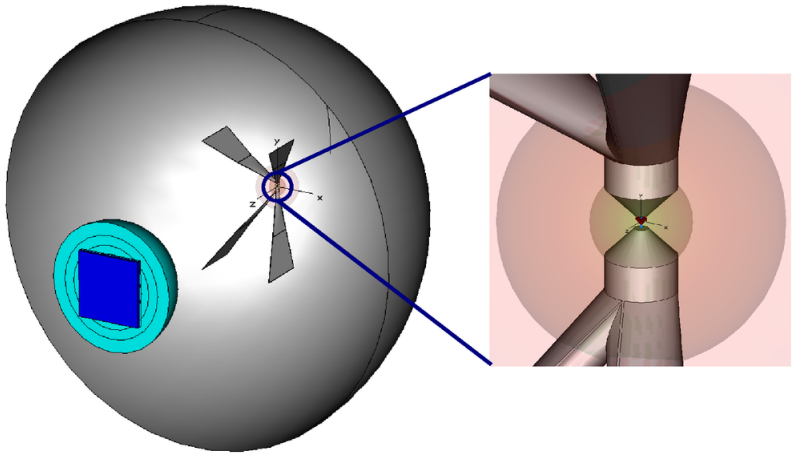


Figure 2.1: Perspective view of T4FASC-CSS-SPVSHC configuration with the reflector and focusing lens; "Zoomed-in" view showing SPVSHC and discrete port excitation..

The setup for the T4FASC-CSS CPVCHC with the reflector and the focusing lens is shown in Fig. 2.2. The T4FASC-CSS CPVCHC and the reflector are identical to [4] while the focusing lens and slab design are identical to that in [2].

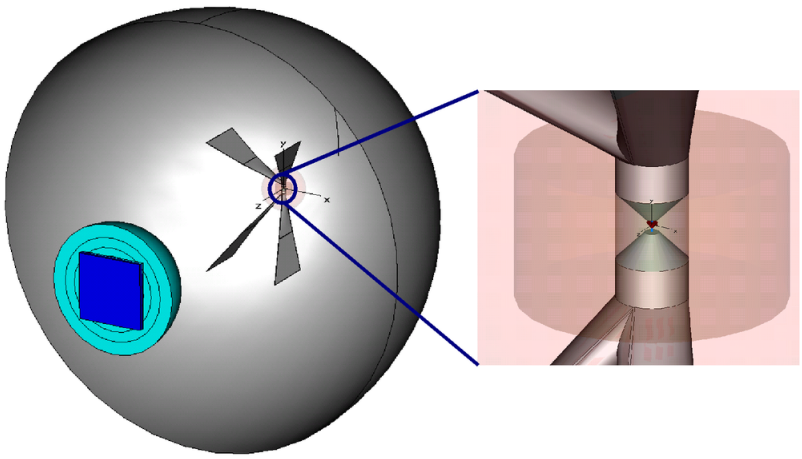


Figure 2.2: Perspective view of T4FASC-CSS-CPVCHC configuration with the reflector and focusing lens; "Zoomed-in" view showing CPVCHC and discrete port excitation..

3 CST parameters

- CST parameters and probe placements are identical to those in [5].
- In all simulations, a discrete port, 1 V, 100 ps, ramp rising step, excitation is applied between a 2 mm gap in the switch cones.

4 Results

Electric and magnetic field focal waveforms and spot sizes for the T4FASC-CSS-SPVSHC and T4FASC-CSS-CPVCHC configurations with the focusing lens are given in the appendix. As expected, the prepulse is dispersed, the electric field is amplified and the spot size is reduced. However, one notes the large amplitude of the post-pulse. For example, for the electric field focal waveforms in Fig. 5.1(a) and Fig. 5.2(a) the peak post-pulse amplitude is approximately 2/3 the peak amplitude of the impulse.

The electromagnetic parameters are compared with the 4FA configuration [2] in Table 1 and Table 2 respectively. One observes that,

- There is a slight decrease in the impedance without the focusing lens, Z_{NFL}, while the impedance with the focusing lens, Z_{WFL}, is almost the same for all configurations.
- There is $\lessapprox 10\%$ decrease in the electric enhancement and $\approx 9.5\%$ decrease in the magnetic enhancement.
- The spot diameters are, in general, $\lessapprox 4$ mm larger.

Table 1: Comparison of the electric and magnetic field information, for the 4FA, T4FASC-CSS-SPVSHC, T4FASC-CSS-CPVCHC configurations, at focal point, in air and with focusing lens (FL)

Field Information		Configuration		
		4FA	T4FASC-CSS-SPVSHC	T4FASC-CSS-CPVCHC
Peak E-Field No FL (V/m)	E_{max}^{NFL}	6.247	13.762	11.701
Peak H-Field No FL (A/m)	H_{max}^{NFL}	0.0151	0.03495	0.0297
Peak E-Field With FL (V/m)	E_{max}^{WFL}	10.725	21.864	18.637
Peak H-Field With FL (A/m)	H_{max}^{WFL}	0.0734	0.1537	0.1302
Impedance No FL (Ω)	$Z_{NFL} = E_{max}^{NFL}/H_{max}^{NFL}$	413.709	393.763	393.973
Impedance With FL (Ω)	$Z_{WFL} = E_{max}^{WFL}/H_{max}^{WFL}$	146.117	142.251	143.141
Electric enhancement	$E_{max}^{WFL}/E_{max}^{NFL}$	1.717	1.589	1.593
Magnetic enhancement	$H_{max}^{WFL}/H_{max}^{NFL}$	4.861	4.398	4.384

Table 2: Comparison of spot size for E and H field, for the 4FA, T4FASC-CSS-SPVSHC, T4FASC-CSS-CPVCHC configurations, with and without the focusing lens (FL)

Field Information		Configuration		
		4FA	T4FASC-CSS-SPVSHC	T4FASC-CSS-CPVCHC
E-Field Spot Size No FL (cm)	$EFSS^{NFL}$	3.6104	4.644	4.949
H-Field Spot Size No FL (cm)	$HFSS^{NFL}$	3.6502	4.937	5.232
E-Field Spot Size With FL (cm)	$EFSS^{WFL}$	1.187	1.448	1.537
H-Field Spot Size With FL (cm)	$HFSS^{WFL}$	1.1954	1.514	1.575
E-Field Spot Size reduction	$EFSS^{NFL}/EFSS^{WFL}$	3.042	3.207	3.220
H-Field Spot Size reduction	$HFSS^{NFL}/HFSS^{WFL}$	3.054	3.261	3.322

5 Conclusions

Compared to the 4FA, **there is over a 180% increase in the peak focal impulse electric fields with the focusing lens for the T4FASC-CSS-SPVSHC and T4FASC-CSS -CPVCHC configurations**. This amplification overshadows the corresponding small increase in spot size. Also, the electric and magnetic enhancements are not significantly affected.

References

[1] Prashanth Kumar, Carl E. Baum, Serhat Altunc, Christos G. Christodoulou and Edl Schamiloglu, "Optimization of the T4FASC-CSS-SPVSHC and T4FASC-CSS-CPVCHC configurations." EM Implosion Memo 45, May 2010.

[2] Prashanth Kumar, Carl E. Baum, Serhat Altunc, Christos G. Christodoulou and Edl Schamiloglu, "Numerical simulations of a 60 degree four-feed-arm PSIRA to determine the beam width inside a focusing lens." EM Implosion Memo 35, Oct. 2009.

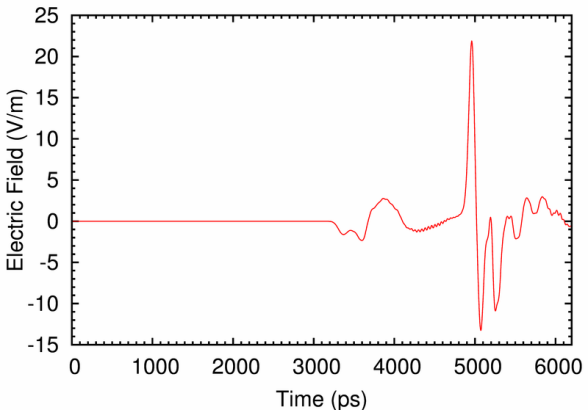
[3] Prashanth Kumar, Carl E. Baum, Serhat Altunc, Christos G. Christodoulou and Edl Schamiloglu, "The truncated four feed-arm configuration with switch cones (T4FASC) and a spherical pressure vessel." EM Implosion Memo 42, May 2010.

[4] Prashanth Kumar, Carl E. Baum, Serhat Altunc, Christos G. Christodoulou and Edl Schamiloglu, "The truncated four feed-arm configuration with switch cones (T4FASC) and a cylindrical pressure vessel." EM Implosion Memo 43, May 2010.

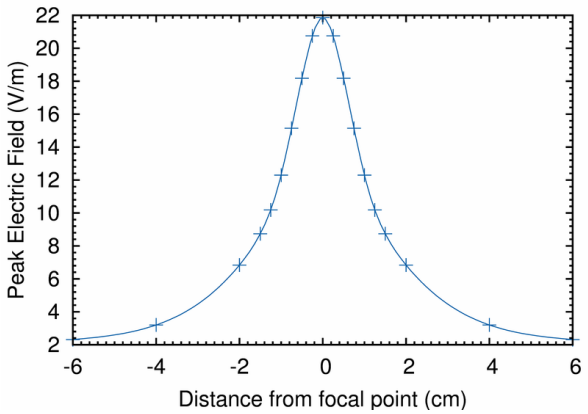
[5] Prashanth Kumar, Carl E. Baum, Serhat Altunc, Christos G. Christodoulou and Edl Schamiloglu, "Effect of the impedance of a bicone switch on the focal impulse amplitude and beam width." EM Implosion Memo 38, Feb. 2010.

Appendix

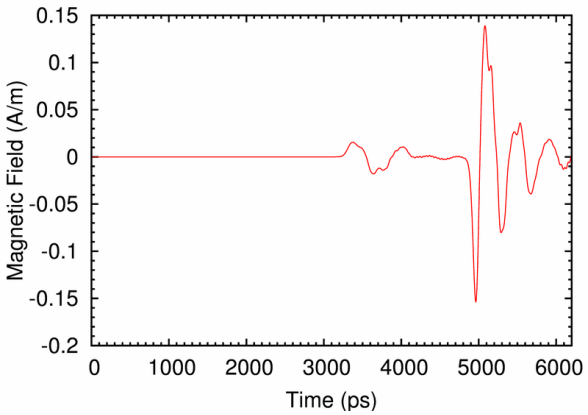
Electric and magnetic field focal impulse waveforms and beam widths for the T4FASC-CSS-SPVSHC and T4FASC-CSS-CPVCHC configurations with the focusing lens



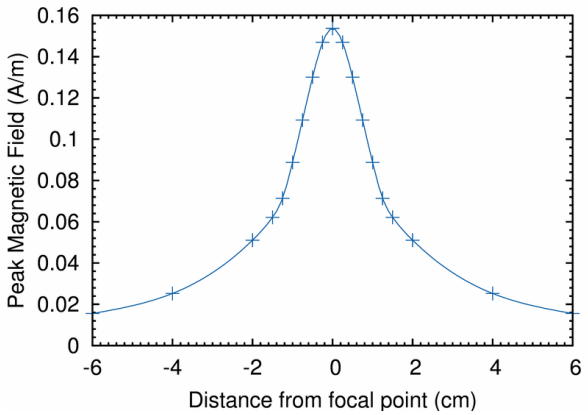
(a) Electric field: Focal waveform.



(b) Electric field: Beam width.

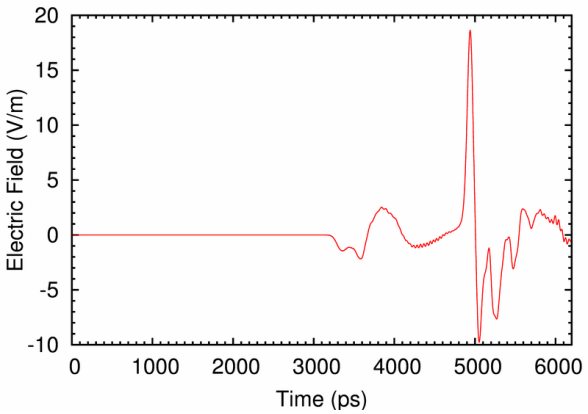


(c) Magnetic field: Focal waveform.

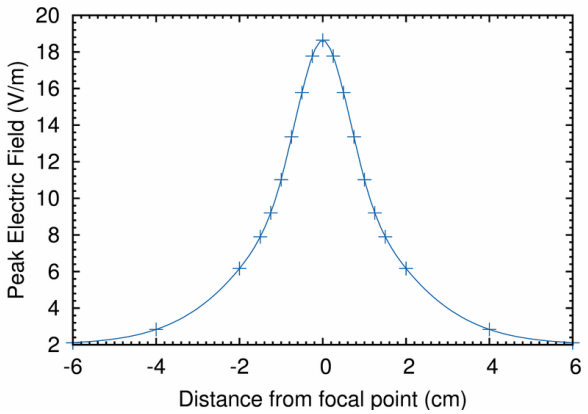


(d) Magnetic field: Beam width.

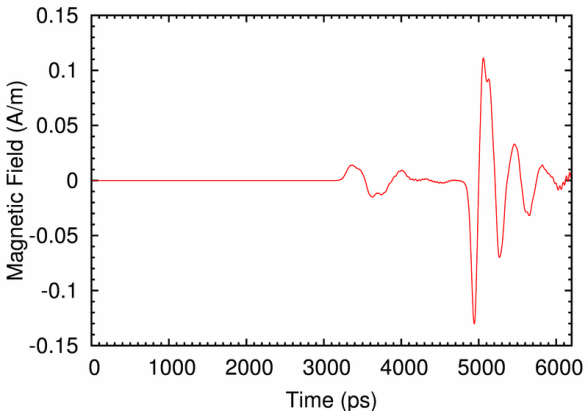
Figure 5.1: Electric and magnetic field focal impulse waveforms and beam widths for the T4FASC-CSS-SPVSHC configuration with the focusing lens.



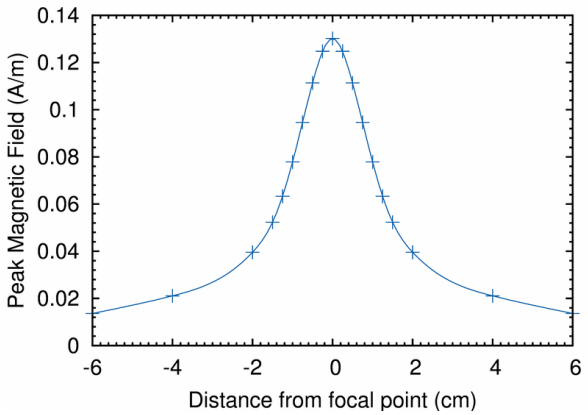
(a) Electric field: Focal waveform.



(b) Electric field: Beam width.



(c) Magnetic field: Focal waveform.



(d) Magnetic field: Beam width.

Figure 5.2: Electric and magnetic field focal impulse waveforms and beam widths for the t4fasc-cpvchc configuration with the focusing lens.