

Particle Swarm Optimization of Innovative Wide Angle Impedance Matching Metasurfaces

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Abstract

The design of innovative wide-angle impedance matching (*WAIM*) structures is proposed to mitigate reflection issues arising when scanning waveguide-fed planar phased arrays. The *WAIM* is based on a metasurface which is composed by several unit cells arranged according to a triangular lattice. A System-by-Design (*SbD*) approach is exploited to synthesize - by means of a customized particle swarm optimization (*PSO*)-based algorithm - the geometrical descriptors of such a metasurface in order to reduce the reflections when steering the main beam of the array. Numerical results are shown in order to verify the effectiveness as well as the potentialities of the developed design strategy.

1 GUIDA D'ONDA QUADRATA - LATTICE TRIANGOLARE (SbD approach)

Dielettrici considerati nelle seguenti analisi:

Dielettrico	ε	$\tan \delta$	d
tipo1=NY9208	2.08	0.0006	$0.508 \cdot 10^{-3}$
tipo2	2.08	0.6	$0.508 \cdot 10^{-3}$
tipo3	2.08	1	$0.508 \cdot 10^{-3}$
tipo4	2.08	1	$1.524 \cdot 10^{-3}$

Essendo ε la permittività elettrica, $\tan \delta$ fattore di dissipazione e d lo spessore.

Per il materiale NY9208 è stato scelto di usare lo spessore più sottile tra quelli disponibili per le simulazioni di partenza.

Nelle 3 simulazioni presentate di seguito, si va a modificare come unico parametro, solamente il fattore di dissipazione del materiale $\tan \delta$.

Nella simulazione 4 si va a modificare lo spessore del materiale.

1.1 FORMA: Croce “2” (5 croci) - DIELETTRICO: TIPO 1 = NY9208

Dielettrico:

- tipo: NY9208
- spessore: $0.508e-3$
- $\varepsilon = 2.08$
- $\delta = 0.0006$
- $\rho = 1000.0 [kg/m^3]$

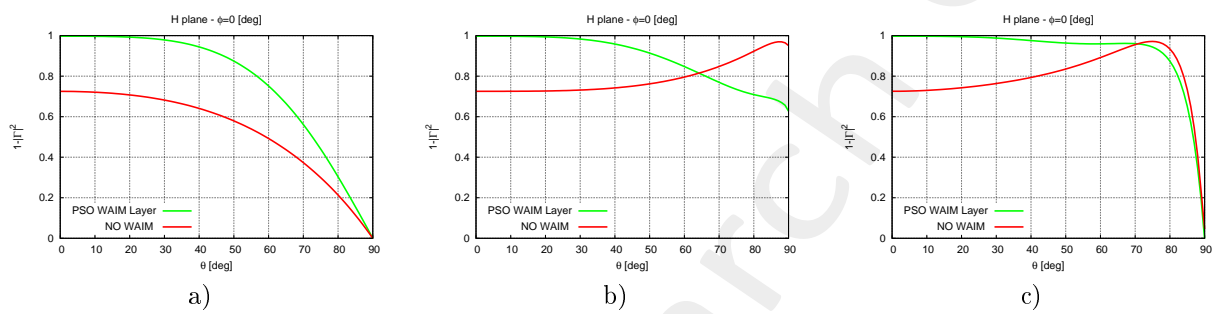


Figure 1: Coefficiente di Trasmissione, a) Piano H, b) Piano D, c) Piano E

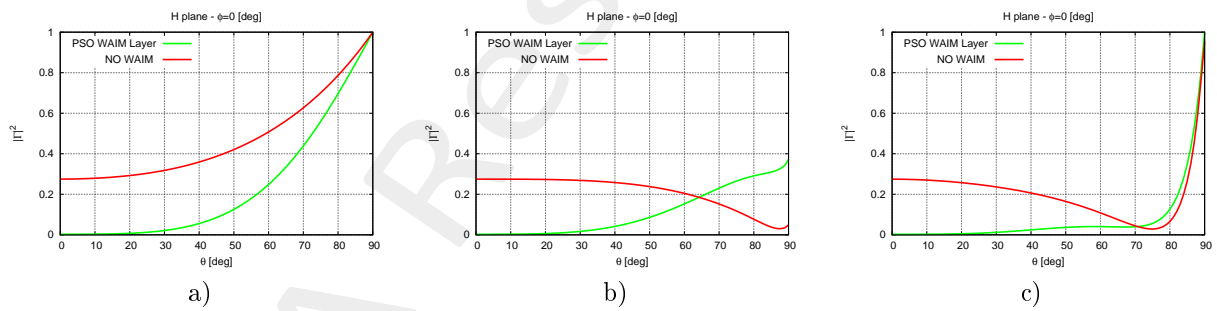


Figure 2: Coefficiente di Riflessione, a) Piano H, b) Piano D, c) Piano E

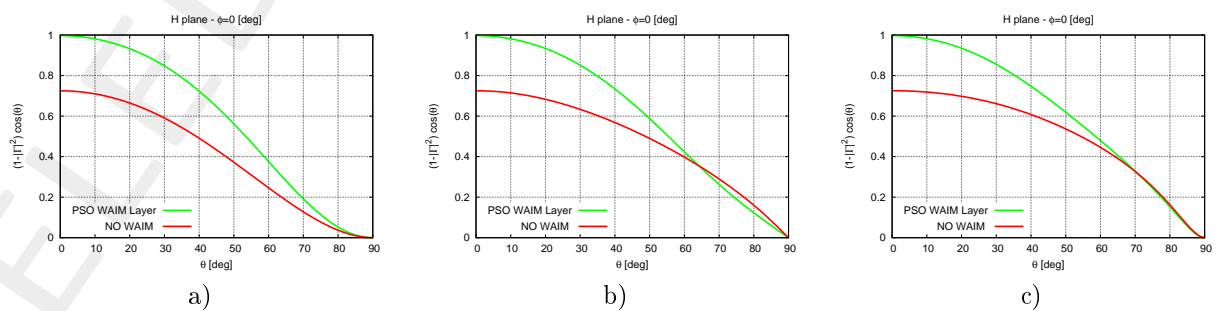


Figure 3: Coefficiente di Trasmissione $\cdot \cos(\theta)$, a) Piano H, b) Piano D, c) Piano E

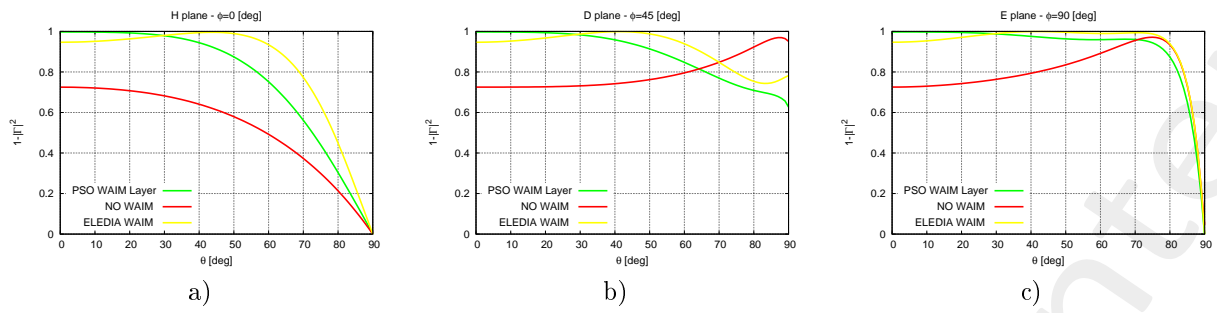


Figure 4: Coefficiente di Trasmissione , a) Piano H, b) Piano D, c) Piano E

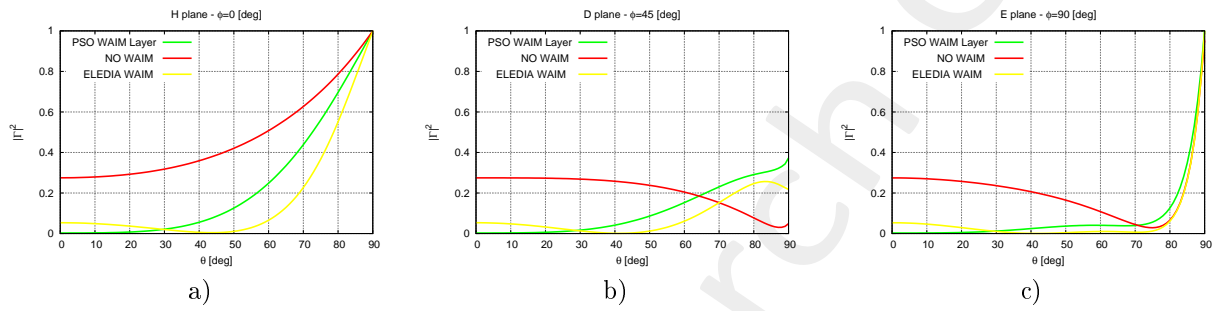


Figure 5: Coefficiente di Riflessione, a) Piano H, b) Piano D, c) Piano E

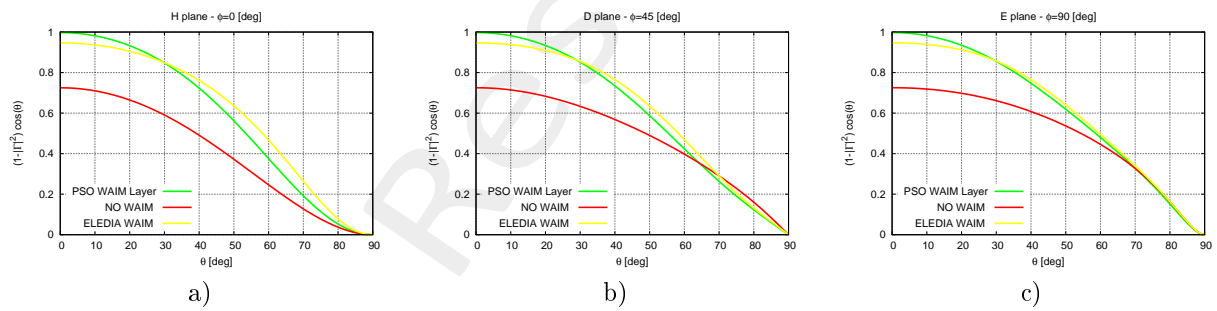


Figure 6: Coefficiente di Trasmissione $\cdot \cos(\theta)$, a) Piano H, b) Piano D, c) Piano E

Note:

- Utilizzando il dielettrico NY9208 si riesce ad ottenere le stesse performances della casistica senza dielettrico.

1.2 FORMA: Croce “2” (5 croci) - DIELETTRICO: TIPO 2

Dielettrico:

- tipo: 2
- spessore: $0.508e-3$
- $\varepsilon = 2.08$
- $\delta = 0.6$
- $\rho = 1000.0 [kg/m^3]$

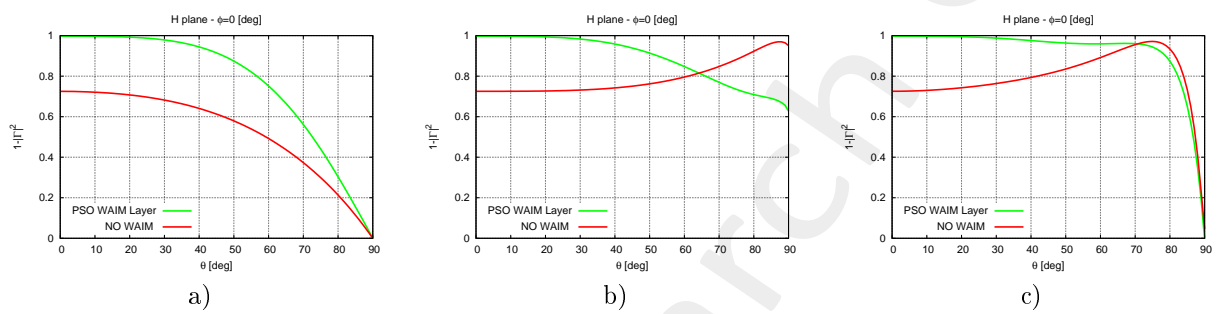


Figure 7: Coefficiente di Trasmissione, a) Piano H, b) Piano D, c) Piano E

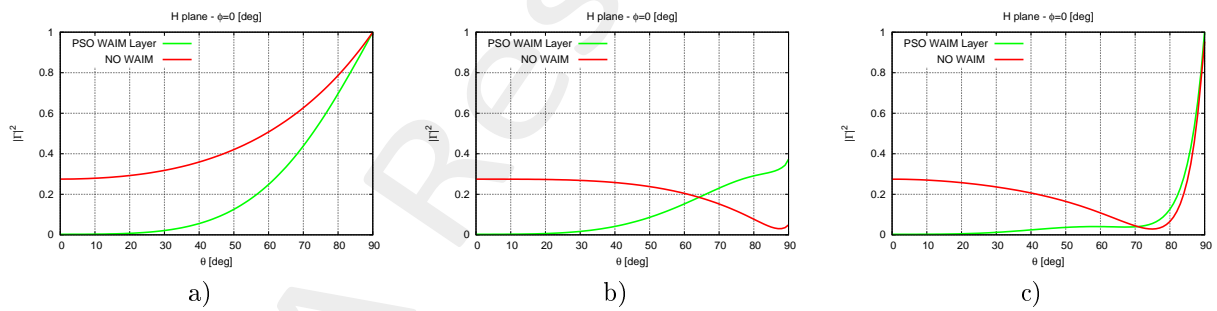


Figure 8: Coefficiente di Riflessione, a) Piano H, b) Piano D, c) Piano E

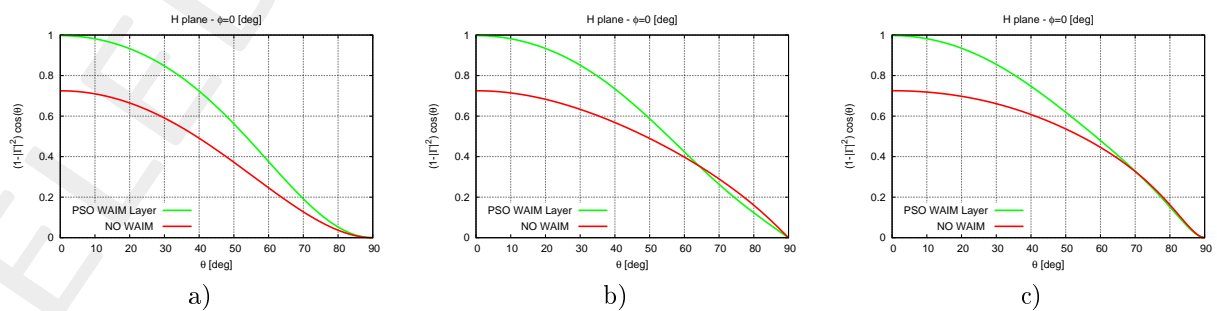


Figure 9: Coefficiente di Trasmissione $\cdot \cos(\theta)$, a) Piano H, b) Piano D, c) Piano E

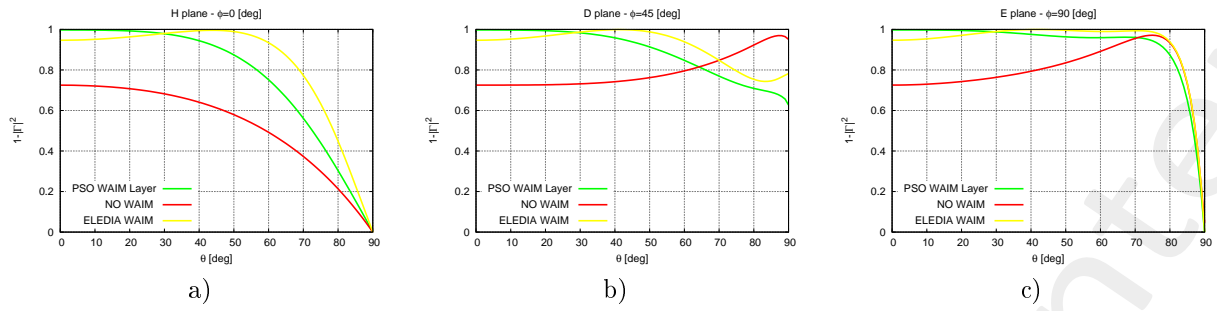


Figure 10: Coefficiente di Trasmissione , a) Piano H, b) Piano D, c) Piano E

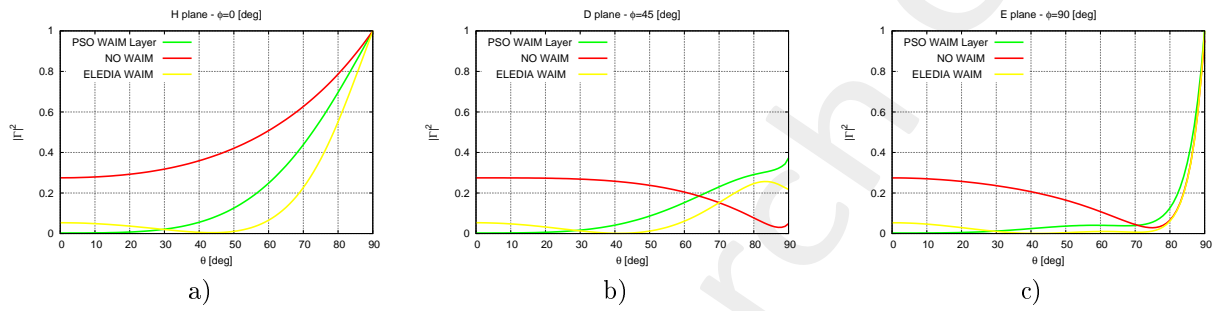


Figure 11: Coefficiente di Riflessione, a) Piano H, b) Piano D, c) Piano E

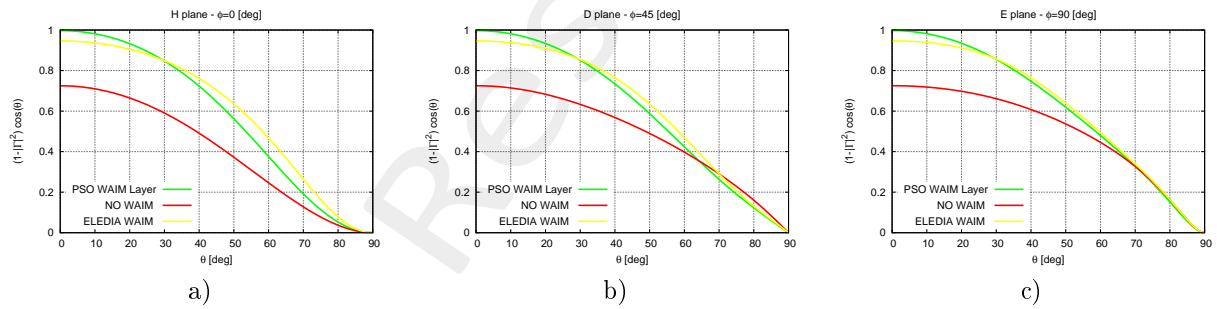


Figure 12: Coefficiente di Trasmissione $\cdot \cos(\theta)$, a) Piano H, b) Piano D, c) Piano E

Note:

- Per quanto riguarda la Fitness, si riesce a raggiungere lo stesso esatto valore del caso senza dielettrico: $3.4643 \cdot 10^{-2}$

1.3 FORMA: Croce “2” (5 croci) - DIELETTRICO: TIPO 3

Dielettrico:

- tipo: 3
- spessore: $0.508e-3$
- $\varepsilon = 2.08$
- $\delta = 1$
- $\rho = 1000.0 [kg/m^3]$

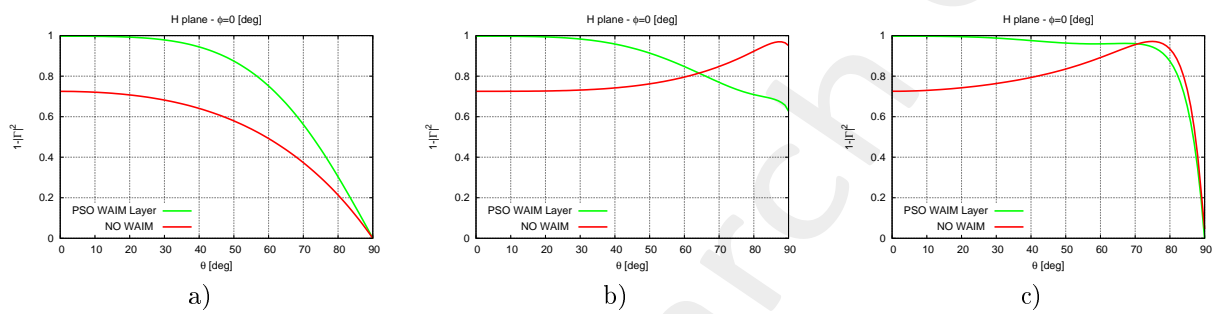


Figure 13: Coefficiente di Trasmissione, a) Piano H, b) Piano D, c) Piano E

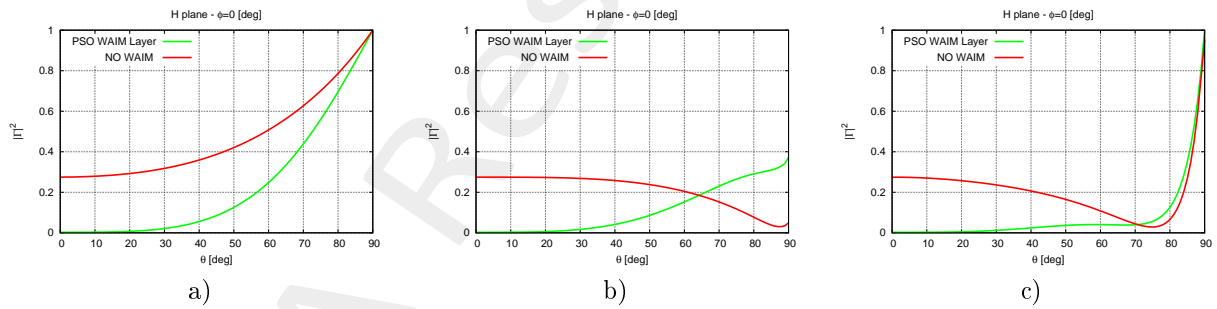


Figure 14: Coefficiente di Riflessione, a) Piano H, b) Piano D, c) Piano E

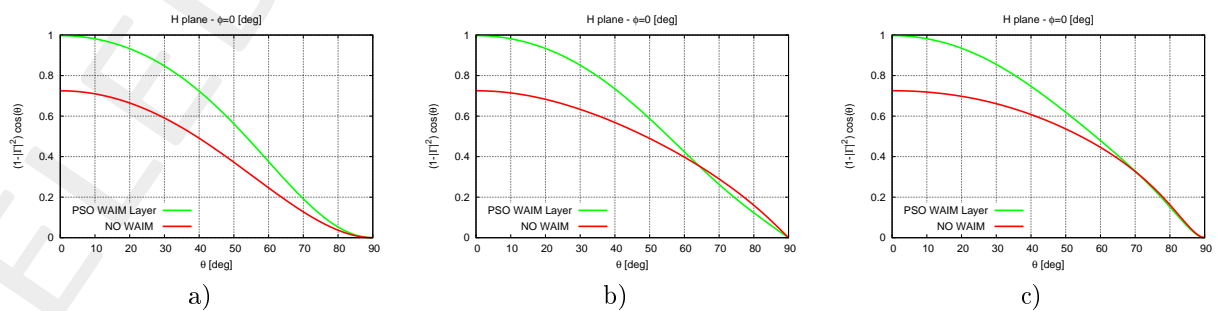


Figure 15: Coefficiente di Trasmissione $\cdot \cos(\theta)$, a) Piano H, b) Piano D, c) Piano E

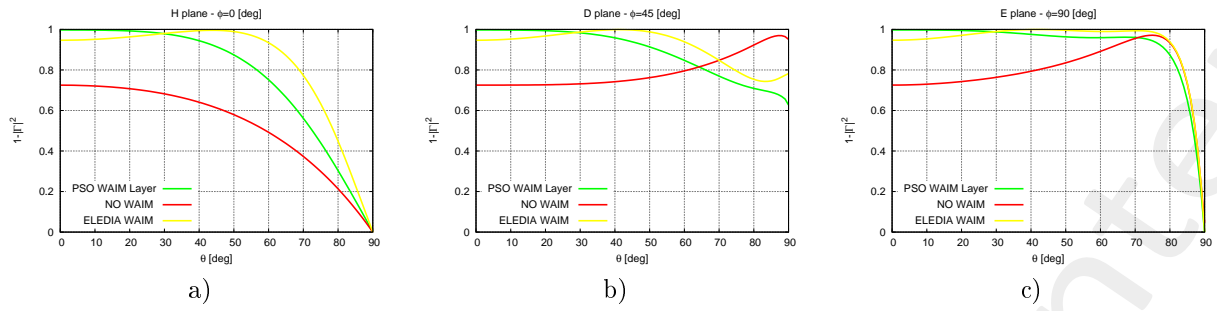


Figure 16: Coefficiente di Trasmissione , a) Piano H, b) Piano D, c) Piano E

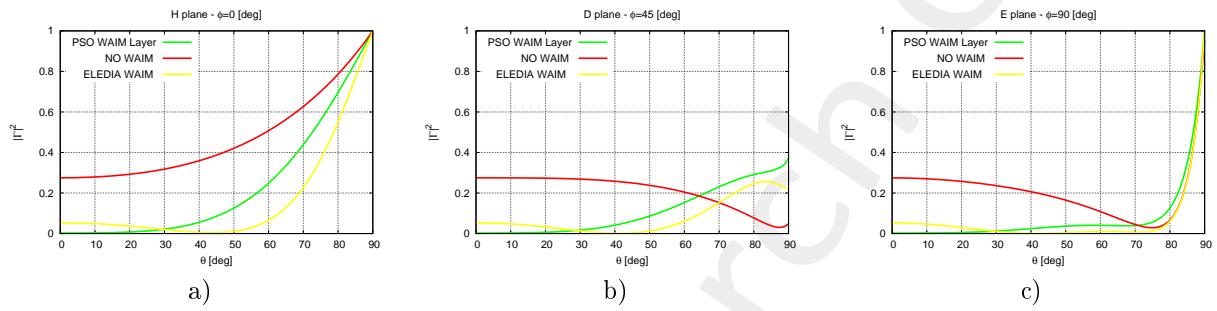


Figure 17: Coefficiente di Riflessione, a) Piano H, b) Piano D, c) Piano E

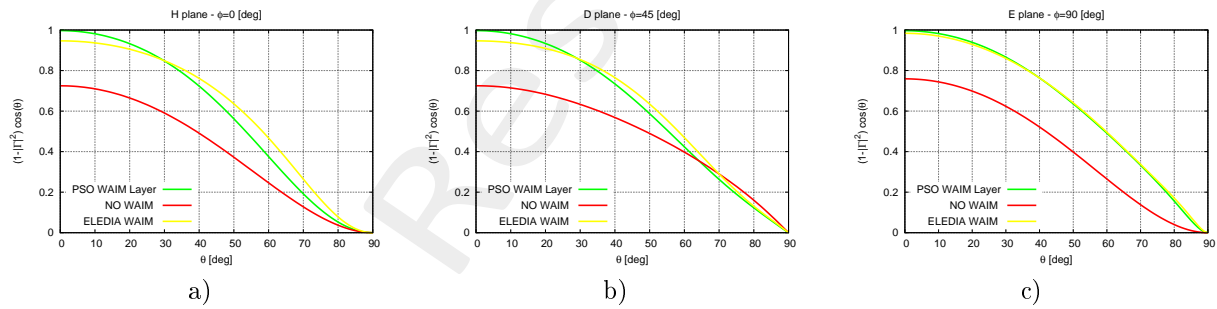


Figure 18: Coefficiente di Trasmissione $\cdot \cos(\theta)$, a) Piano H, b) Piano D, c) Piano E

Note:

- Non ci sono peggioramenti nelle prestazioni simulate, anche avendo usato un dielettrico con molte perdite.

1.4 FORMA: Croce “2” (5 croci) - DIELETTRICO: TIPO 4

Dielettrico:

- tipo: 4
- spessore: $1.524e-3$
- $\varepsilon = 2.08$
- $\delta = 1$
- $\rho = 1000.0 [kg/m^3]$

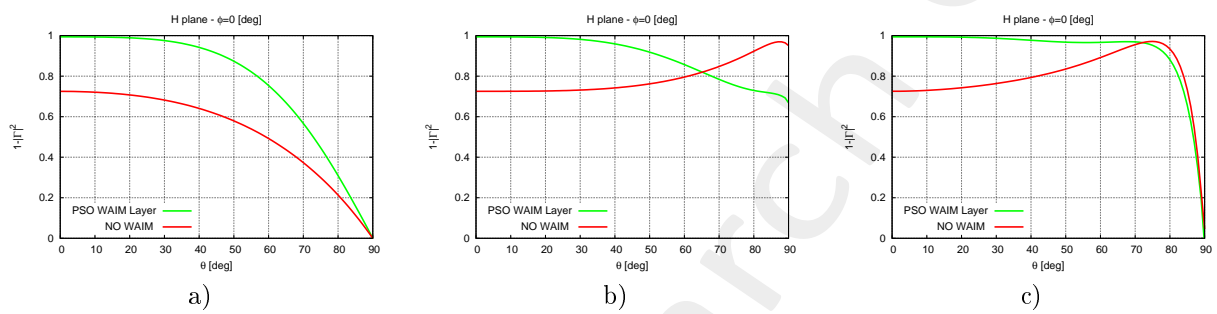


Figure 19: Coefficiente di Trasmissione, a) Piano H, b) Piano D, c) Piano E

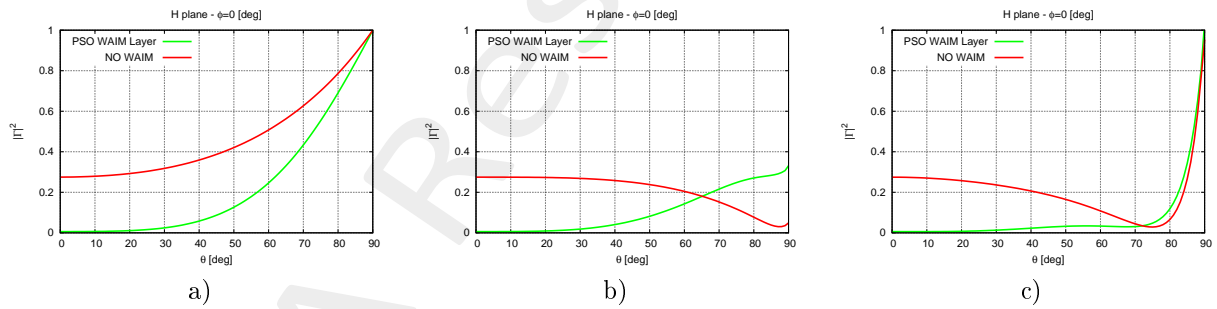


Figure 20: Coefficiente di Riflessione, a) Piano H, b) Piano D, c) Piano E

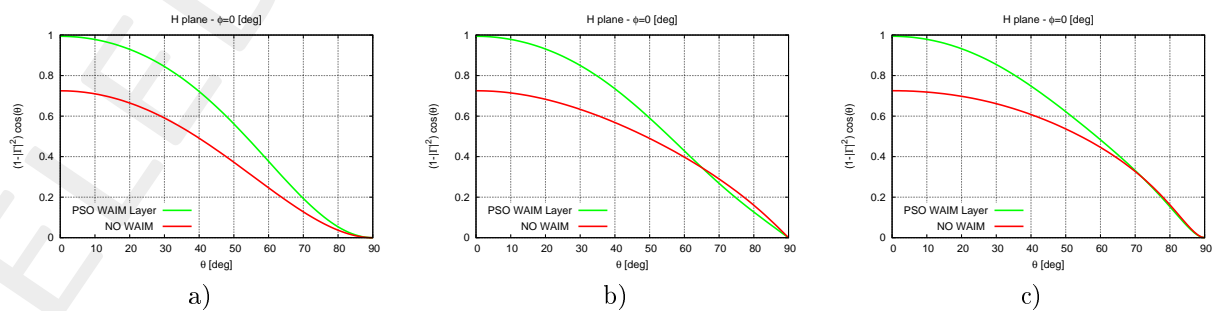


Figure 21: Coefficiente di Trasmissione $\cdot \cos(\theta)$, a) Piano H, b) Piano D, c) Piano E

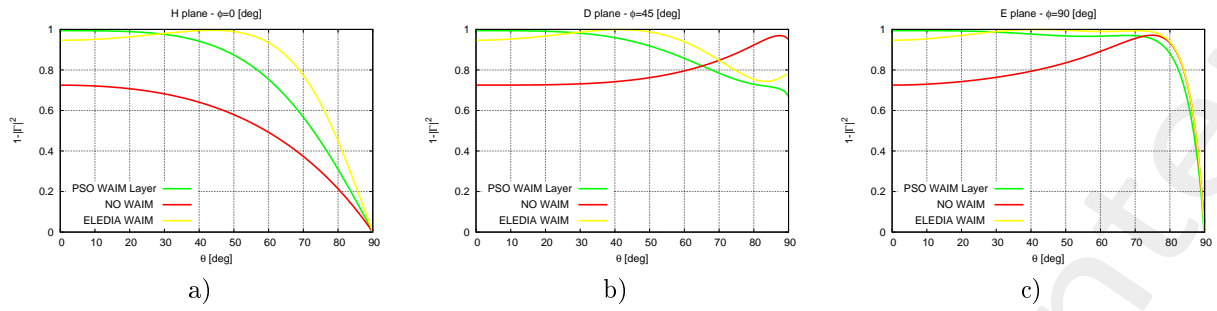


Figure 22: Coefficiente di Trasmissione, a) Piano H, b) Piano D, c) Piano E

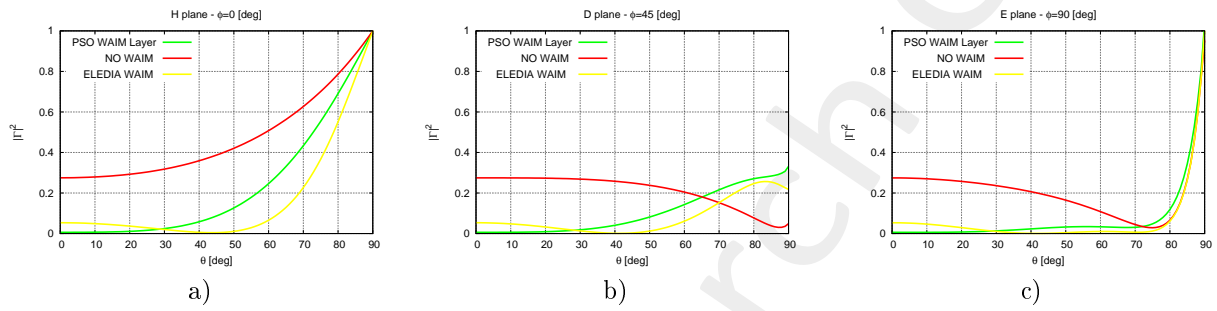


Figure 23: Coefficiente di Riflessione, a) Piano H, b) Piano D, c) Piano E

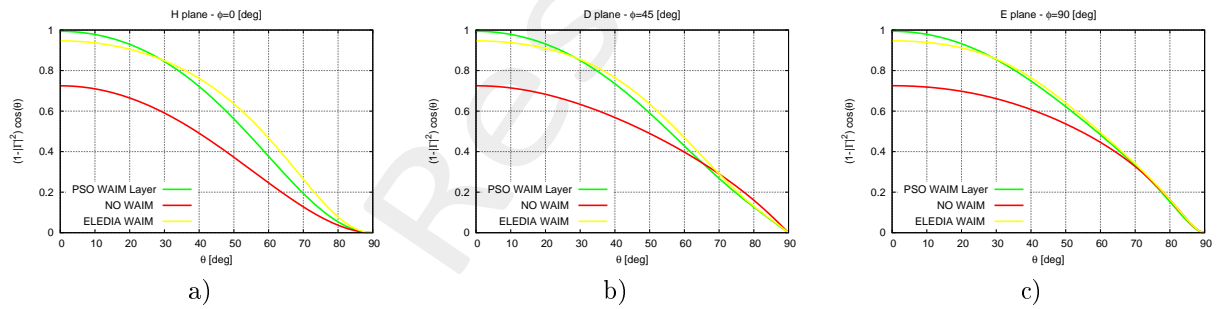


Figure 24: Coefficiente di Trasmissione $\cdot \cos(\theta)$, a) Piano H, b) Piano D, c) Piano E

Note:

- Non ci sono peggioramenti nelle prestazioni simulate, anche avendo usato un dielettrico con molte perdite.

1.5 Unit cell shape

Di seguito, le 4 celle elementari ottime che si sono ottenute nelle simulazioni con i diversi dielettrici.

	Dielettrico			
	Tipo 1	Tipo 2	Tipo 3	Tipo4
CrossLength	1.28799328E-03	1.23119843E-03	1.30000000E-03	1.30000000E-03
CrossWidth	6.38137513E-04	6.88320724E-04	7.01297307E-04	1.00000005E-03
TiltAngle	9.16968584E-01	1.59475899E+00	2.00000000E+00	1.90046072E-01

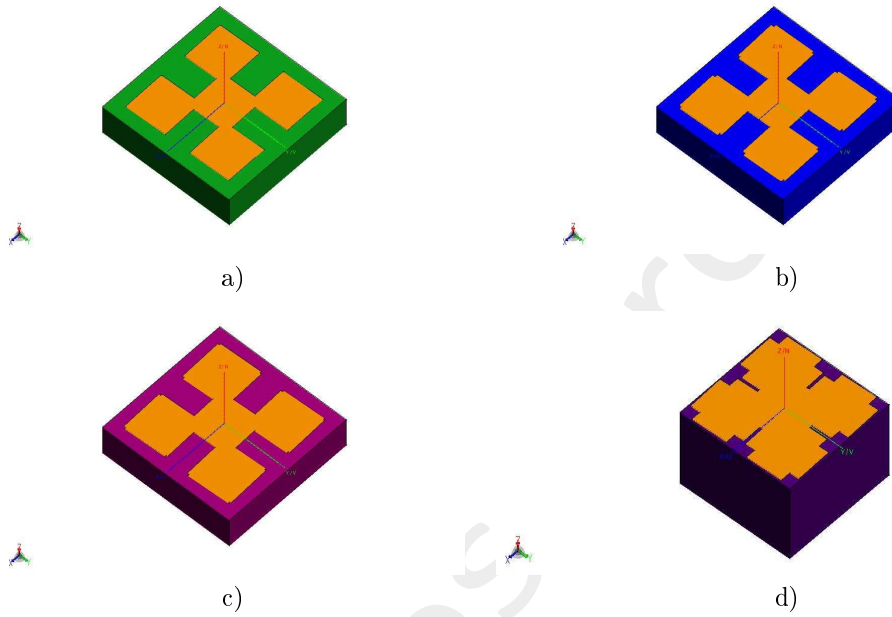


Table 1: Optimal Unit cells, a) using NY9208, b) lossy dielectric type2, c) lossy dielectric type3, d) lossy dielectric type4

- Note: Le celle ottime ottenute con dielettrico type4 nei diversi tipi di lattice, sono identiche.

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