Effective Integration of BCS with the IMSA to Enhance the Microwave Imaging of Sparse Objects Under the Born Approximation

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Abstract

In this work, the microwave imaging of sparse scatterers under the first order Born approximation is dealt with. Towards this end, an innovative Bayesian compressive sensing (*BCS*) methodology is derived and implemented in order to combine the well-known regularization capabilities of *CS* solvers with the progressively acquired information about the imaged scenario through the iterative multi-scaling approach (*IMSA*).
Selected numerical results are presented in order to verify the effectiveness of the proposed *IMSA-BCS* technique, as well as to compare it against competitive state-of-the-art approaches.

1 Numerical Results

1.1 E-shaped Object, $\ell = 1.5\lambda$

Test Case Description

Direct solver:

- Side of the investigation domain: $L = 6.0\lambda$
- Cubic domain divided in $\sqrt{D} \times \sqrt{D}$ cells
- Number of cells for the direct solver: $D = 1600$ (discretization $= \lambda/10$)

Investigation domain:

- Cubic domain divided in $\sqrt{N} \times \sqrt{N}$ cells
- Number of cells for the inversion:
  - First Step IMSA: $N^{(1)} = 100$ (discretization $= \lambda/10$)
  - Following Steps IMSA: $N^{(i)}$ not fixed, defined according to the estimated RoI $\mathcal{D}^{(i)}$

Measurement domain:

- Total number of measurements: $M = 60$
- Measurement points placed on circles of radius $\rho = 4.5\lambda$

Sources:

- Plane waves
- Number of views: $V = 60$; $\theta_{inc}^{v} = 0^\circ + (v-1) \times (360/V)$
- Amplitude: $A = 1.0$
- Frequency: $F = 300$ MHz ($\lambda = 1$)

Background:

- $\varepsilon_r = 1.0$
- $\sigma = 0$ [S/m]

Scatterer

- E-shaped object, $\ell = 1.5\lambda$
- $\varepsilon_r \in \{1.01, 1.02, 1.04, 1.05, 1.06, 1.08, 1.10, 1.15, 1.20\}$
- $\sigma = 0$ [S/m]

1.1.1 E-shaped Object, $\ell = 1.5\lambda$, $\tau = 0.02$ - $IMSA-BCS$ vs. $TVCS$ vs. BP reconstructed profiles

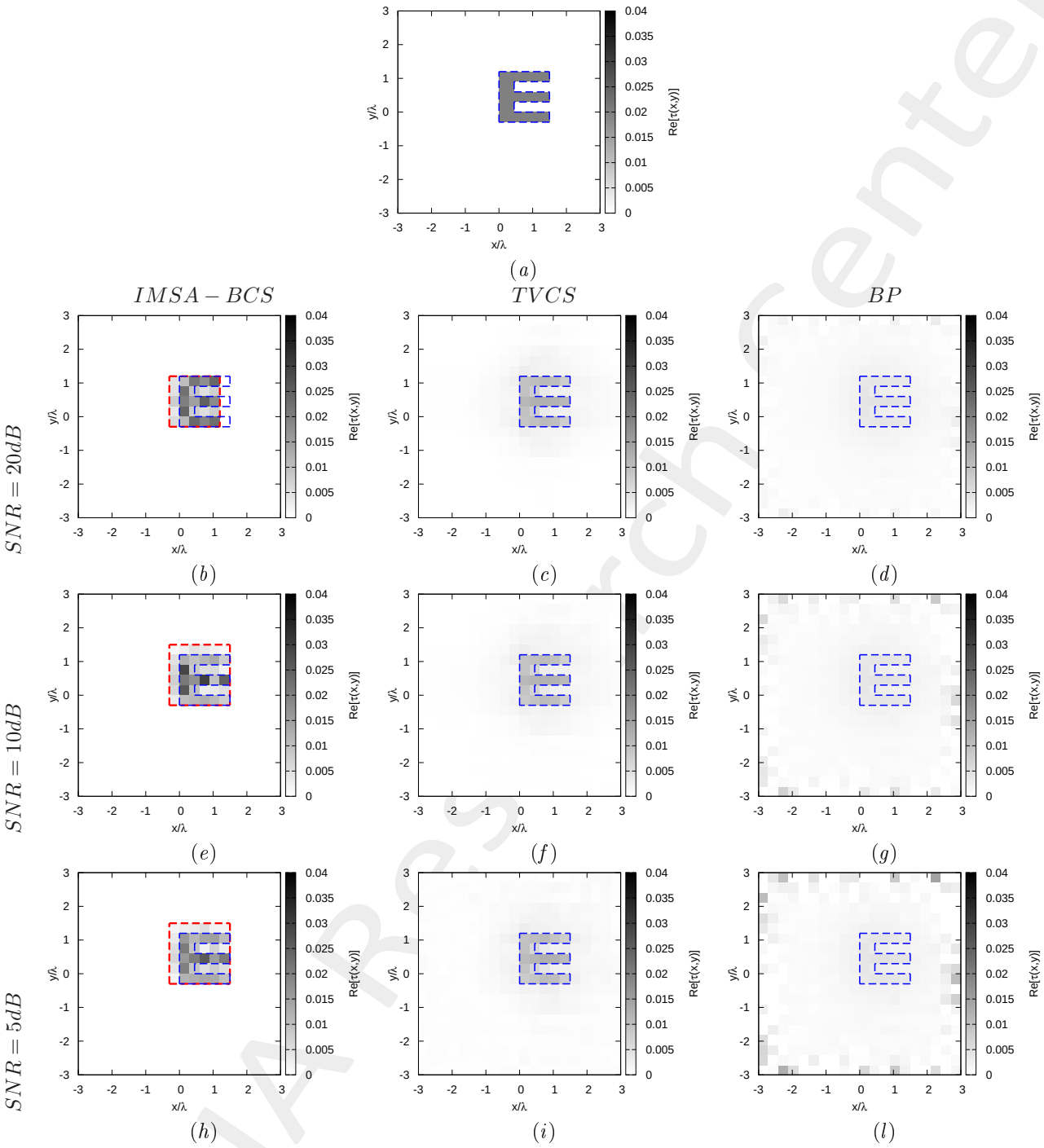

Figure 1: *E-shaped Object*, $\ell = 1.5\lambda$, $\tau = 0.02$ - *IMSA-BCS vs. TVCS vs. BP* - (a) Actual profile, $(b)(e)(h)$ $IMSA-BCS$, $(c)(f)(i)$ $TVCS$ and $(d)(g)(l)$ BP reconstructed profiles for $(b)(c)(d)$ $SNR = 20$ [dB], $(e)(f)(g)$ $SNR = 10$ [dB] and $(h)(i)(l)$ $SNR = 5$ [dB].

	$SNR = 50dB$		
	$IMSA-BCS$	$TVCS$	BP
ξ_{tot}	5.12×10^{-4}	9.10×10^{-4}	1.53×10^{-3}
ξ_{int}	7.76×10^{-3}	9.71×10^{-3}	1.57×10^{-2}
ξ_{ext}	1.71×10^{-4}	4.95×10^{-4}	8.64×10^{-4}
	$SNR = 20dB$		
	$IMSA-BCS$	$TVCS$	BP
ξ_{tot}	4.53×10^{-4}	9.17×10^{-4}	1.65×10^{-3}
ξ_{int}	6.70×10^{-3}	9.64×10^{-3}	1.57×10^{-2}
ξ_{ext}	1.56×10^{-4}	5.06×10^{-4}	9.27×10^{-4}
	$SNR = 10dB$		
	$IMSA-BCS$	$TVCS$	BP
ξ_{tot}	5.53×10^{-4}	1.00×10^{-3}	2.14×10^{-3}
ξ_{int}	8.04×10^{-3}	9.94×10^{-3}	1.57×10^{-2}
ξ_{ext}	1.99×10^{-4}	5.81×10^{-4}	1.25×10^{-3}
	$SNR = 5dB$		
	$IMSA-BCS$	$TVCS$	BP
ξ_{tot}	4.37×10^{-4}	1.18×10^{-3}	2.74×10^{-3}
ξ_{int}	5.40×10^{-3}	9.96×10^{-3}	1.57×10^{-2}
ξ_{ext}	2.01×10^{-4}	7.69×10^{-4}	1.68×10^{-3}

Table I: *E-shaped Object*, $\ell = 1.5\lambda$, $\tau = 0.02$ - *IMSA-BCS vs. TVCS vs. BP* - Reconstruction errors: total (ξ_{tot}), internal (ξ_{int}) and external (ξ_{ext}) errors.

1.1.2 E-shaped Object, $\ell = 1.5\lambda$, $\tau = 0.05$ - $IMSA-BCS$ vs. $TVCS$ vs. BP reconstructed profiles

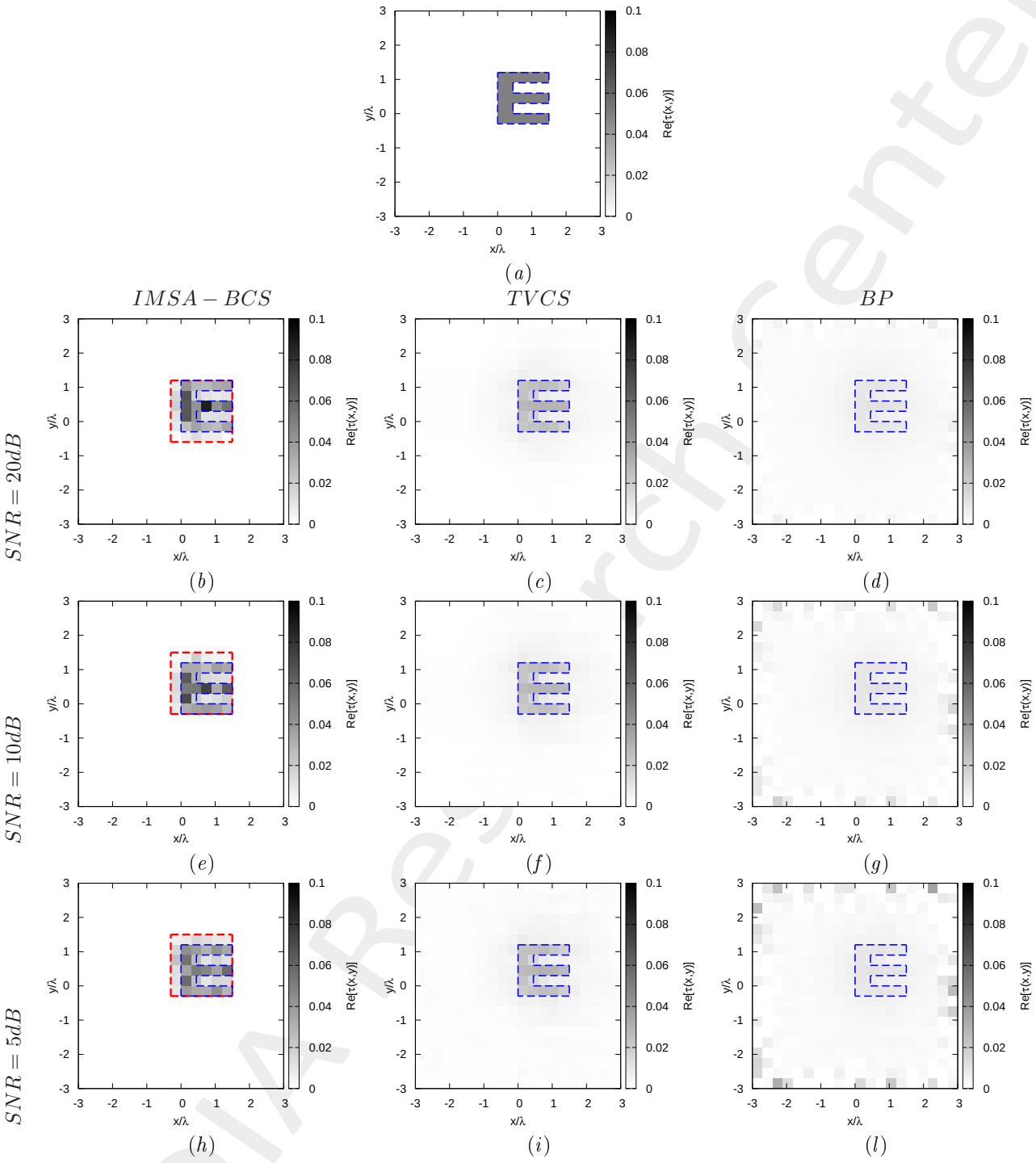

Figure 2: *E-shaped Object*, $\ell = 1.5\lambda$, $\tau = 0.05$ - *IMSA-BCS vs. TVCS vs. BP* - (a) Actual profile, $(b)(e)(h)$ $IMSA-BCS$, $(c)(f)(i)$ $TVCS$ and $(d)(g)(l)$ BP reconstructed profiles for $(b)(c)(d)$ $SNR = 20$ [dB], $(e)(f)(g)$ $SNR = 10$ [dB] and $(h)(i)(l)$ $SNR = 5$ [dB].

	$SNR = 50dB$		
	$IMSA-BCS$	$TVCS$	BP
ξ_{tot}	1.18×10^{-3}	2.29×10^{-3}	3.78×10^{-3}
ξ_{int}	1.54×10^{-2}	2.38×10^{-2}	3.82×10^{-2}
ξ_{ext}	4.92×10^{-4}	1.27×10^{-3}	2.15×10^{-3}
	$SNR = 20dB$		
	$IMSA-BCS$	$TVCS$	BP
ξ_{tot}	1.25×10^{-3}	2.30×10^{-3}	4.09×10^{-3}
ξ_{int}	1.64×10^{-2}	2.41×10^{-2}	3.82×10^{-2}
ξ_{ext}	5.15×10^{-4}	1.27×10^{-3}	2.31×10^{-3}
	$SNR = 10dB$		
	$IMSA-BCS$	$TVCS$	BP
ξ_{tot}	1.20×10^{-3}	2.55×10^{-3}	5.29×10^{-3}
ξ_{int}	1.52×10^{-2}	2.49×10^{-2}	3.82×10^{-2}
ξ_{ext}	5.25×10^{-4}	1.50×10^{-3}	3.12×10^{-3}
	$SNR = 5dB$		
	$IMSA-BCS$	$TVCS$	BP
ξ_{tot}	1.14×10^{-3}	2.91×10^{-3}	6.80×10^{-3}
ξ_{int}	1.10×10^{-2}	2.46×10^{-2}	3.83×10^{-2}
ξ_{ext}	6.34×10^{-4}	1.88×10^{-3}	4.18×10^{-3}

Table II: *E-shaped Object*, $\ell = 1.5\lambda$, $\tau = 0.05$ - *IMSA-BCS vs. TVCS vs. BP* - Reconstruction errors: total (ξ_{tot}), internal (ξ_{int}) and external (ξ_{ext}) errors.

1.1.3 E-shaped Object, $\ell = 1.5\lambda$, $\tau = 0.15$ - $IMSA-BCS$ vs. $TVCS$ vs. BP reconstructed profiles

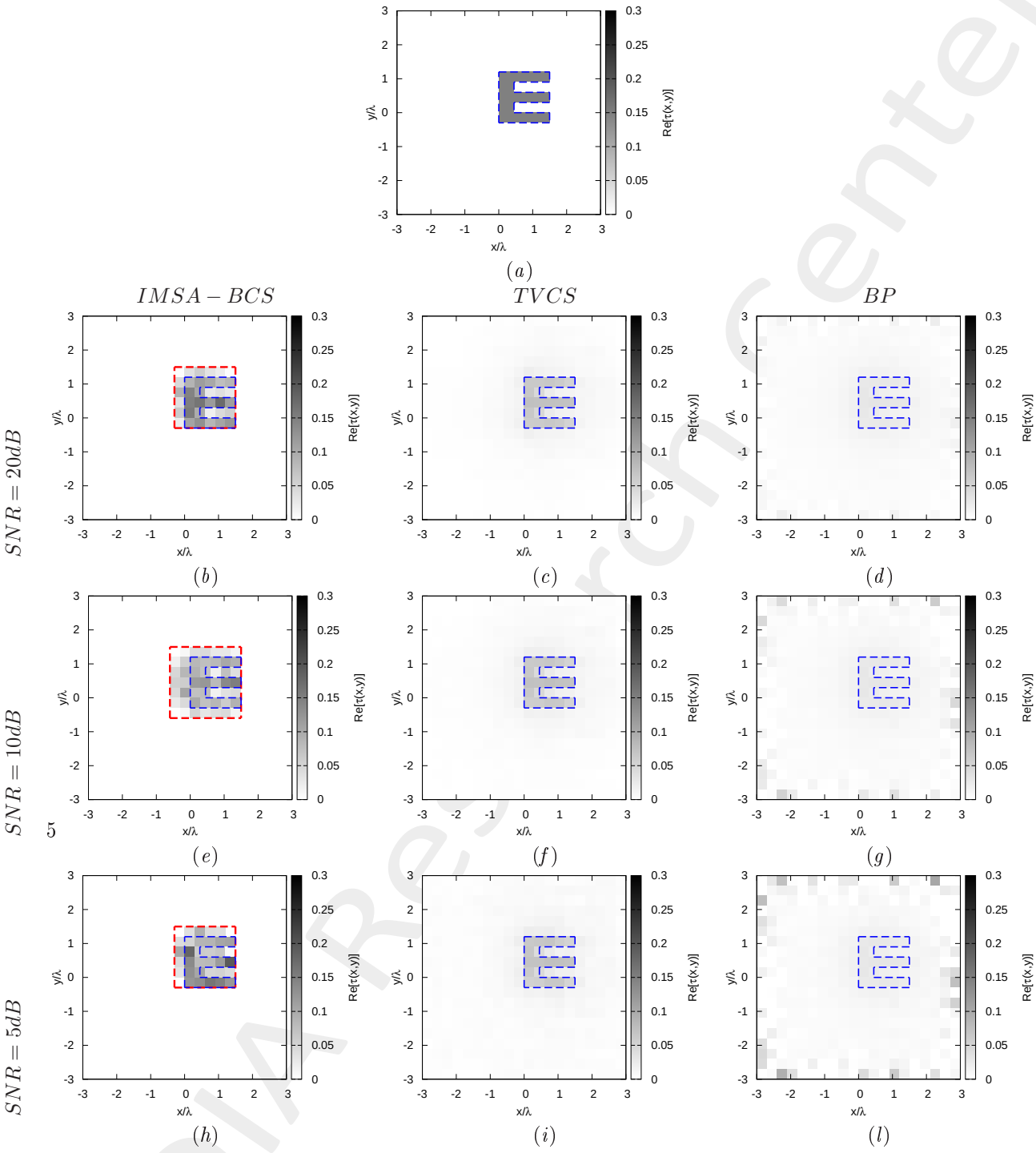

Figure 3: *E-shaped Object*, $\ell = 1.5\lambda$, $\tau = 0.15$ - *IMSA-BCS vs. TVCS vs. BP* - (a) Actual profile, $(b)(e)(h)$ $IMSA-BCS$, $(c)(f)(i)$ $TVCS$ and $(d)(g)(l)$ BP reconstructed profiles for $(b)(c)(d)$ $SNR = 20$ [dB], $(e)(f)(g)$ $SNR = 10$ [dB] and $(h)(i)(l)$ $SNR = 5$ [dB].

	$SNR = 50dB$		
	$IMSA-BCS$	$TVCS$	BP
ξ_{tot}	4.03×10^{-3}	7.41×10^{-3}	1.09×10^{-2}
ξ_{int}	4.09×10^{-2}	7.25×10^{-2}	1.06×10^{-1}
ξ_{ext}	1.78×10^{-3}	4.34×10^{-3}	6.24×10^{-3}
	$SNR = 20dB$		
	$IMSA-BCS$	$TVCS$	BP
ξ_{tot}	3.80×10^{-3}	7.50×10^{-3}	1.18×10^{-2}
ξ_{int}	3.13×10^{-2}	7.48×10^{-2}	1.06×10^{-1}
ξ_{ext}	1.89×10^{-3}	4.33×10^{-3}	6.70×10^{-3}
	$SNR = 10dB$		
	$IMSA-BCS$	$TVCS$	BP
ξ_{tot}	5.61×10^{-3}	8.12×10^{-3}	1.53×10^{-2}
ξ_{int}	4.88×10^{-2}	7.52×10^{-2}	1.06×10^{-1}
ξ_{ext}	3.11×10^{-3}	4.96×10^{-3}	9.09×10^{-3}
	$SNR = 5dB$		
	$IMSA-BCS$	$TVCS$	BP
ξ_{tot}	4.67×10^{-3}	9.24×10^{-3}	1.97×10^{-2}
ξ_{int}	3.57×10^{-2}	7.55×10^{-2}	1.06×10^{-1}
ξ_{ext}	2.18×10^{-3}	6.11×10^{-3}	1.21×10^{-2}

Table III: *E-shaped Object*, $\ell = 1.5\lambda$, $\tau = 0.15$ - *IMSA-BCS vs. TVCS vs. BP* - Reconstruction errors: total (ξ_{tot}), internal (ξ_{int}) and external (ξ_{ext}) errors.

1.1.4 E-shaped Object, $\ell = 1.5\lambda$, $\tau = 0.20$ - $IMSA-BCS$ vs. $TVCS$ vs. BP reconstructed profiles

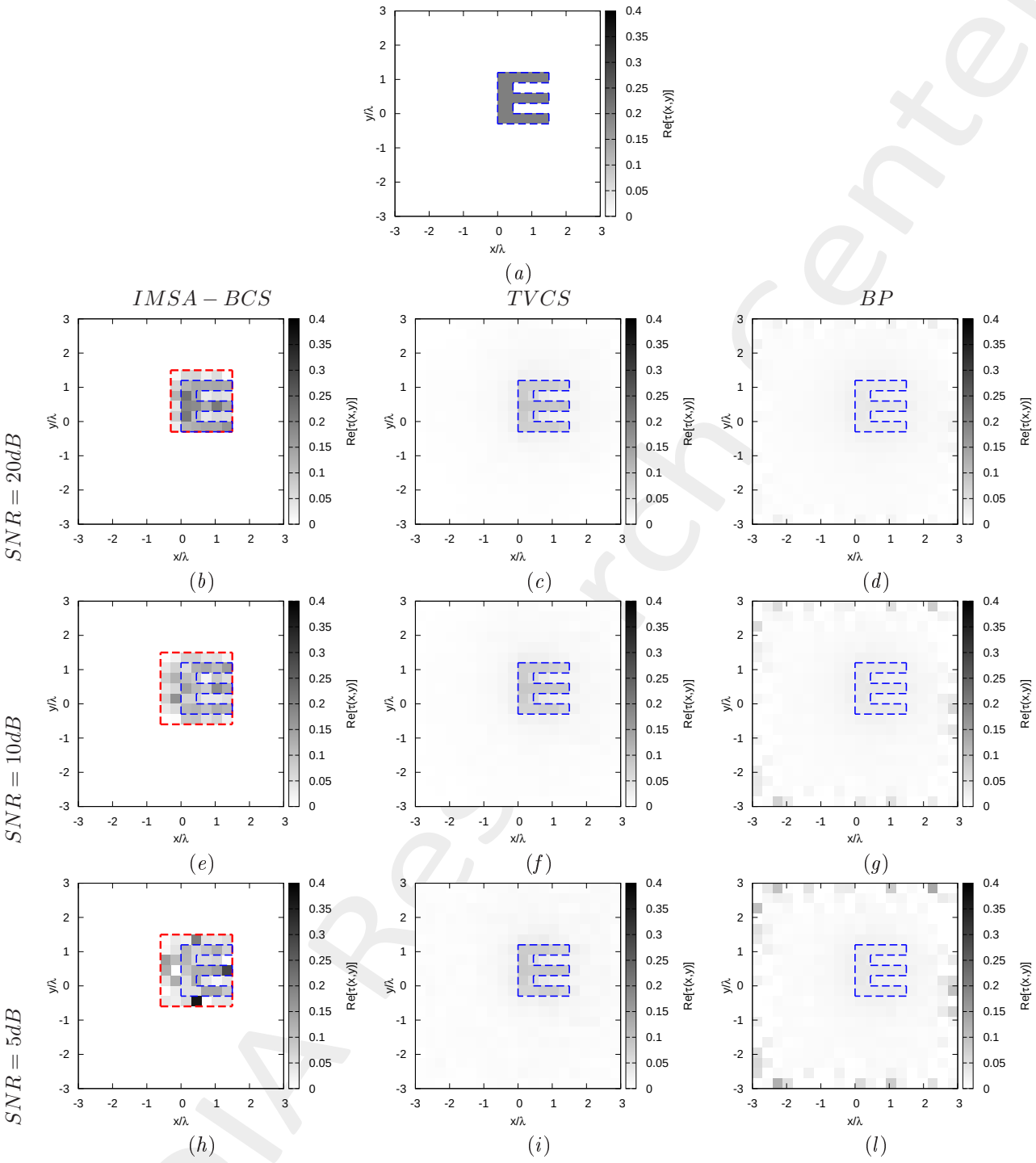

Figure 4: *E-shaped Object*, $\ell = 1.5\lambda$, $\tau = 0.20$ - *IMSA-BCS vs. TVCS vs. BP* - (a) Actual profile, $(b)(e)(h)$ $IMSA-BCS$, $(c)(f)(i)$ $TVCS$ and $(d)(g)(l)$ BP reconstructed profiles for $(b)(c)(d)$ $SNR = 20$ [dB], $(e)(f)(g)$ $SNR = 10$ [dB] and $(h)(i)(l)$ $SNR = 5$ [dB].

	$SNR = 50dB$		
	$IMSA-BCS$	$TVCS$	BP
ξ_{tot}	5.14×10^{-3}	1.02×10^{-2}	1.43×10^{-2}
ξ_{int}	4.33×10^{-2}	1.01×10^{-1}	1.37×10^{-1}
ξ_{ext}	2.23×10^{-3}	5.96×10^{-3}	8.07×10^{-3}
	$SNR = 20dB$		
	$IMSA-BCS$	$TVCS$	BP
ξ_{tot}	5.42×10^{-3}	1.04×10^{-2}	1.54×10^{-2}
ξ_{int}	4.39×10^{-2}	1.01×10^{-1}	1.37×10^{-1}
ξ_{ext}	2.52×10^{-3}	6.11×10^{-3}	8.69×10^{-3}
	$SNR = 10dB$		
	$IMSA-BCS$	$TVCS$	BP
ξ_{tot}	8.31×10^{-3}	1.12×10^{-2}	2.00×10^{-2}
ξ_{int}	7.27×10^{-2}	1.03×10^{-1}	1.37×10^{-1}
ξ_{ext}	4.44×10^{-3}	6.89×10^{-3}	1.18×10^{-2}
	$SNR = 5dB$		
	$IMSA-BCS$	$TVCS$	BP
ξ_{tot}	1.15×10^{-2}	1.27×10^{-2}	2.58×10^{-2}
ξ_{int}	8.38×10^{-2}	1.03×10^{-1}	1.37×10^{-1}
ξ_{ext}	5.40×10^{-3}	8.46×10^{-3}	1.59×10^{-2}

Table IV: *E-shaped Object*, $\ell = 1.5\lambda$, $\tau = 0.20$ - *IMSA-BCS vs. TVCS vs. BP* - Reconstruction errors: total (ξ_{tot}), internal (ξ_{int}) and external (ξ_{ext}) errors.

1.1.5 E-shaped Object, $\ell = 1.5\lambda$ - $IMSA-BCS$ vs. $TVCS$ vs. BP errors resume vs. τ

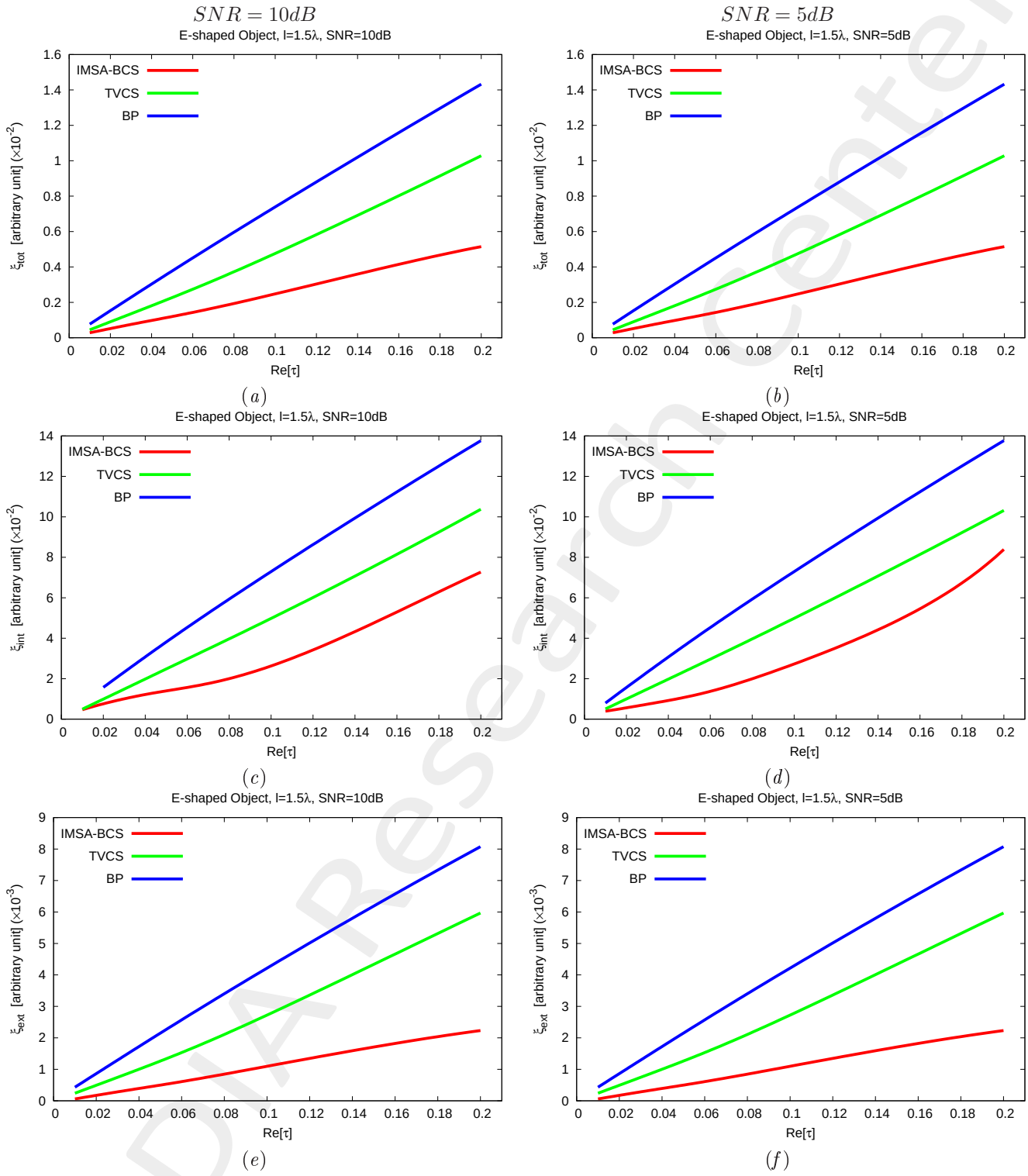

Figure 5: *E-shaped Object*, $\ell = 1.5\lambda$ - Reconstruction errors vs. τ: (a) total error, (b) internal error and (c) external error. Reconstruction errors vs. τ: $(a)(b)$ total error, $(c)(d)$ internal error and $(e)(f)$ external error for $(a)(c)(e)$ $SNR = 10dB$ and $(b)(d)(f)$ $SNR = 5dB$.

1.2 Rhombus, $D = 1.5\lambda$

Test Case Description

Direct solver:

- Side of the investigation domain: $L = 6.0\lambda$
- Cubic domain divided in $\sqrt{D} \times \sqrt{D}$ cells
- Number of cells for the direct solver: $D = 1600$ (discretization = $\lambda/10$)

Investigation domain:

- Cubic domain divided in $\sqrt{N} \times \sqrt{N}$ cells
- Number of cells for the inversion:
  - First Step IMSA: $N^{(1)} = 100$ (discretization = $\lambda/10$)
  - Following Steps IMSA: $N^{(i)}$ not fixed, defined according to the estimated RoI $\mathcal{D}^{(i)}$

Measurement domain:

- Total number of measurements: $M = 60$
- Measurement points placed on circles of radius $\rho = 4.5\lambda$

Sources:

- Plane waves
- Number of views: $V = 60$; $\theta_{inc}^{v} = 0^\circ + (v-1) \times (360/V)$
- Amplitude: $A = 1.0$
- Frequency: $F = 300$ MHz ($\lambda = 1$)

Background:

- $\varepsilon_r = 1.0$
- $\sigma = 0$ [S/m]

Scatterer

- Rhombus, $D = 1.5\lambda$
- $\varepsilon_r \in \{1.01,\ 1.02,\ 1.04, 1.05,\ 1.06,\ 1.08,\ 1.10,\ 1.15,\ 1.20\}$
- $\sigma = 0$ [S/m]

1.2.1 Rhombus, $D = 1.5\lambda$, $\tau = 0.02$ - $IMSA-BCS$ vs. $TVCS$ vs. BP reconstructed profiles

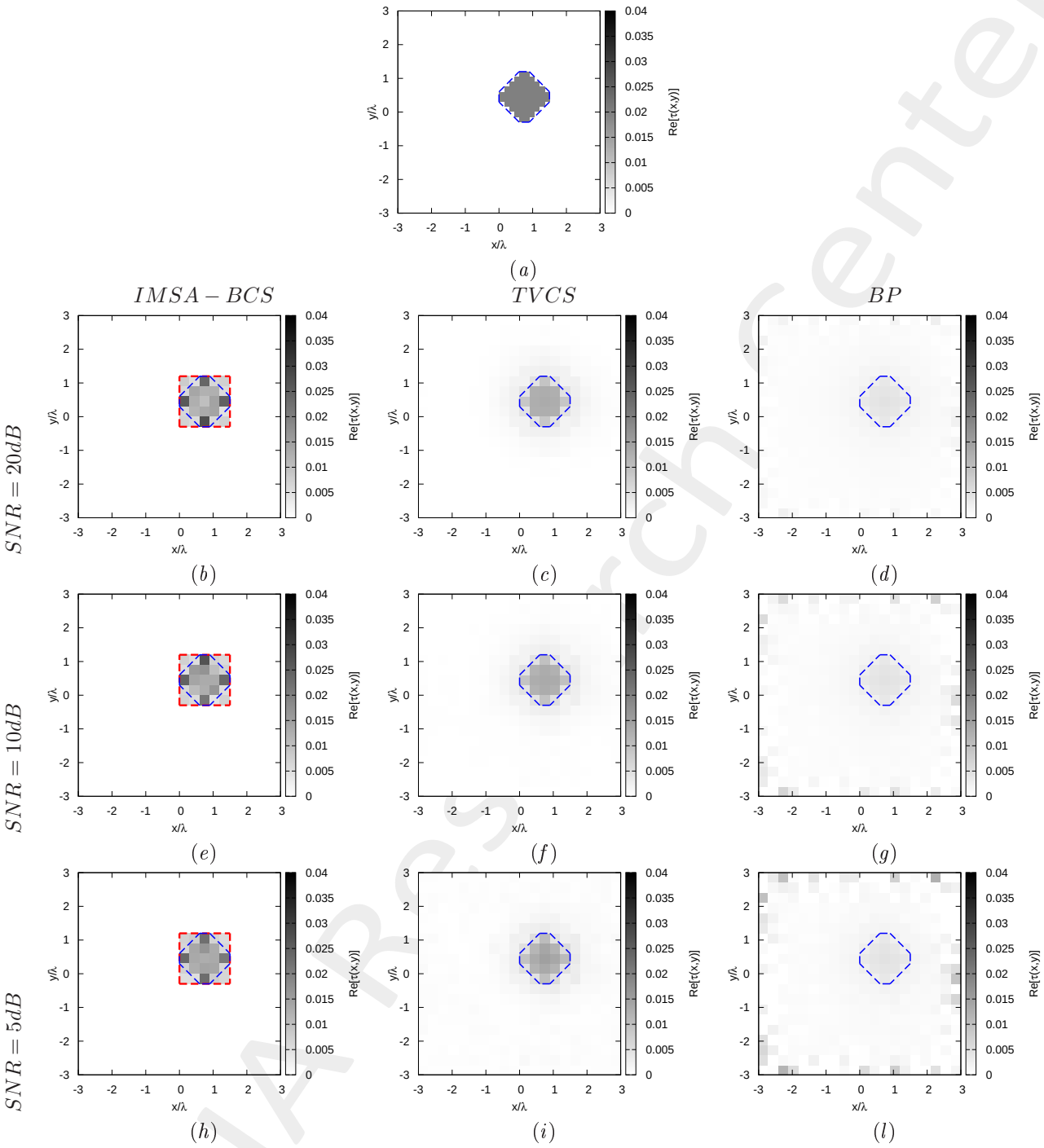

Figure 6: *Rhombus*, $D = 1.5\lambda$, $\tau = 0.02$ - *IMSA-BCS vs. TVCS vs. BP* - (a) Actual profile, $(b)(e)(h)$ $IMSA-BCS$, $(c)(f)(i)$ $TVCS$ and $(d)(g)(l)$ BP reconstructed profiles for $(b)(c)(d)$ $SNR = 20$ [dB], $(e)(f)(g)$ $SNR = 10$ [dB] and $(h)(i)(l)$ $SNR = 5$ [dB].

	$SNR = 50dB$		
	$IMSA-BCS$	$TVCS$	BP
ξ_{tot}	4.48×10^{-4}	7.59×10^{-4}	1.28×10^{-3}
ξ_{int}	7.80×10^{-3}	9.47×10^{-3}	1.58×10^{-2}
ξ_{ext}	1.62×10^{-4}	4.19×10^{-4}	7.20×10^{-4}
	$SNR = 20dB$		
	$IMSA-BCS$	$TVCS$	BP
ξ_{tot}	4.44×10^{-4}	7.59×10^{-4}	1.40×10^{-3}
ξ_{int}	7.59×10^{-3}	9.17×10^{-3}	1.58×10^{-2}
ξ_{ext}	1.66×10^{-4}	4.31×10^{-4}	7.82×10^{-4}
	$SNR = 10dB$		
	$IMSA-BCS$	$TVCS$	BP
ξ_{tot}	4.04×10^{-4}	8.36×10^{-4}	1.85×10^{-3}
ξ_{int}	6.67×10^{-3}	9.00×10^{-3}	1.58×10^{-2}
ξ_{ext}	1.59×10^{-4}	5.18×10^{-4}	1.09×10^{-3}
	$SNR = 5dB$		
	$IMSA-BCS$	$TVCS$	BP
ξ_{tot}	3.88×10^{-4}	9.70×10^{-4}	2.42×10^{-3}
ξ_{int}	6.03×10^{-3}	8.61×10^{-3}	1.58×10^{-2}
ξ_{ext}	1.67×10^{-4}	6.72×10^{-4}	1.48×10^{-3}

Table V: *Rhombus*, $D = 1.5\lambda$, $\tau = 0.02$ - *IMSA-BCS vs. TVCS vs. BP* - Reconstruction errors: total (ξ_{tot}), internal (ξ_{int}) and external (ξ_{ext}) errors.

1.2.2 Rhombus, $D = 1.5\lambda$, $\tau = 0.05$ - $IMSA-BCS$ vs. $TVCS$ vs. BP reconstructed profiles

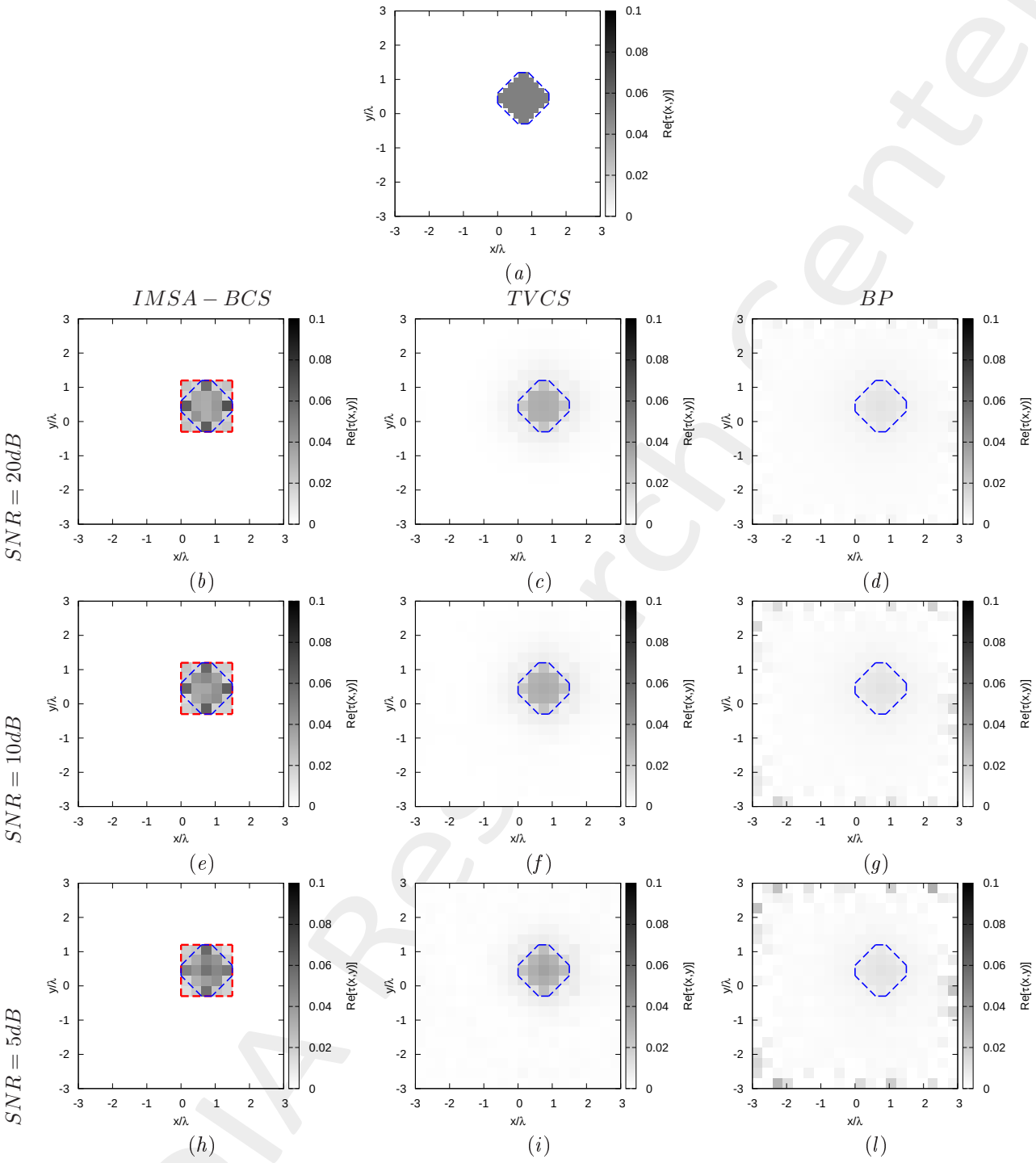

Figure 7: *Rhombus*, $D = 1.5\lambda$, $\tau = 0.05$ - *IMSA-BCS vs. TVCS vs. BP* - (a) Actual profile, $(b)(e)(h)$ $IMSA-BCS$, $(c)(f)(i)$ $TVCS$ and $(d)(g)(l)$ BP reconstructed profiles for $(b)(c)(d)$ $SNR = 20$ [dB], $(e)(f)(g)$ $SNR = 10$ [dB] and $(h)(i)(l)$ $SNR = 5$ [dB].

	$SNR = 50dB$		
	$IMSA-BCS$	$TVCS$	BP
ξ_{tot}	1.12×10^{-3}	1.91×10^{-3}	2.55×10^{-3}
ξ_{int}	1.65×10^{-2}	2.28×10^{-2}	3.11×10^{-2}
ξ_{ext}	5.13×10^{-4}	1.09×10^{-3}	1.43×10^{-3}
	$SNR = 20dB$		
	$IMSA-BCS$	$TVCS$	BP
ξ_{tot}	1.09×10^{-3}	1.91×10^{-3}	2.79×10^{-3}
ξ_{int}	1.53×10^{-2}	2.25×10^{-2}	3.11×10^{-2}
ξ_{ext}	5.27×10^{-4}	1.10×10^{-3}	1.56×10^{-3}
	$SNR = 10dB$		
	$IMSA-BCS$	$TVCS$	BP
ξ_{tot}	9.67×10^{-4}	2.12×10^{-3}	3.69×10^{-3}
ξ_{int}	1.30×10^{-2}	2.26×10^{-2}	3.11×10^{-2}
ξ_{ext}	4.81×10^{-4}	1.32×10^{-3}	2.17×10^{-3}
	$SNR = 5dB$		
	$IMSA-BCS$	$TVCS$	BP
ξ_{tot}	8.71×10^{-4}	2.44×10^{-3}	4.81×10^{-3}
ξ_{int}	1.01×10^{-2}	2.16×10^{-2}	3.11×10^{-2}
ξ_{ext}	4.74×10^{-4}	1.69×10^{-3}	2.96×10^{-3}

Table VI: *Rhombus*, $D = 1.5\lambda$, $\tau = 0.05$ - *IMSA-BCS vs. TVCS vs. BP* - Reconstruction errors: total (ξ_{tot}), internal (ξ_{int}) and external (ξ_{ext}) errors.

1.2.3 Rhombus, $D = 1.5\lambda$, $\tau = 0.10$ - $IMSA - BCS$ vs. $TVCS$ vs. BP reconstructed profiles

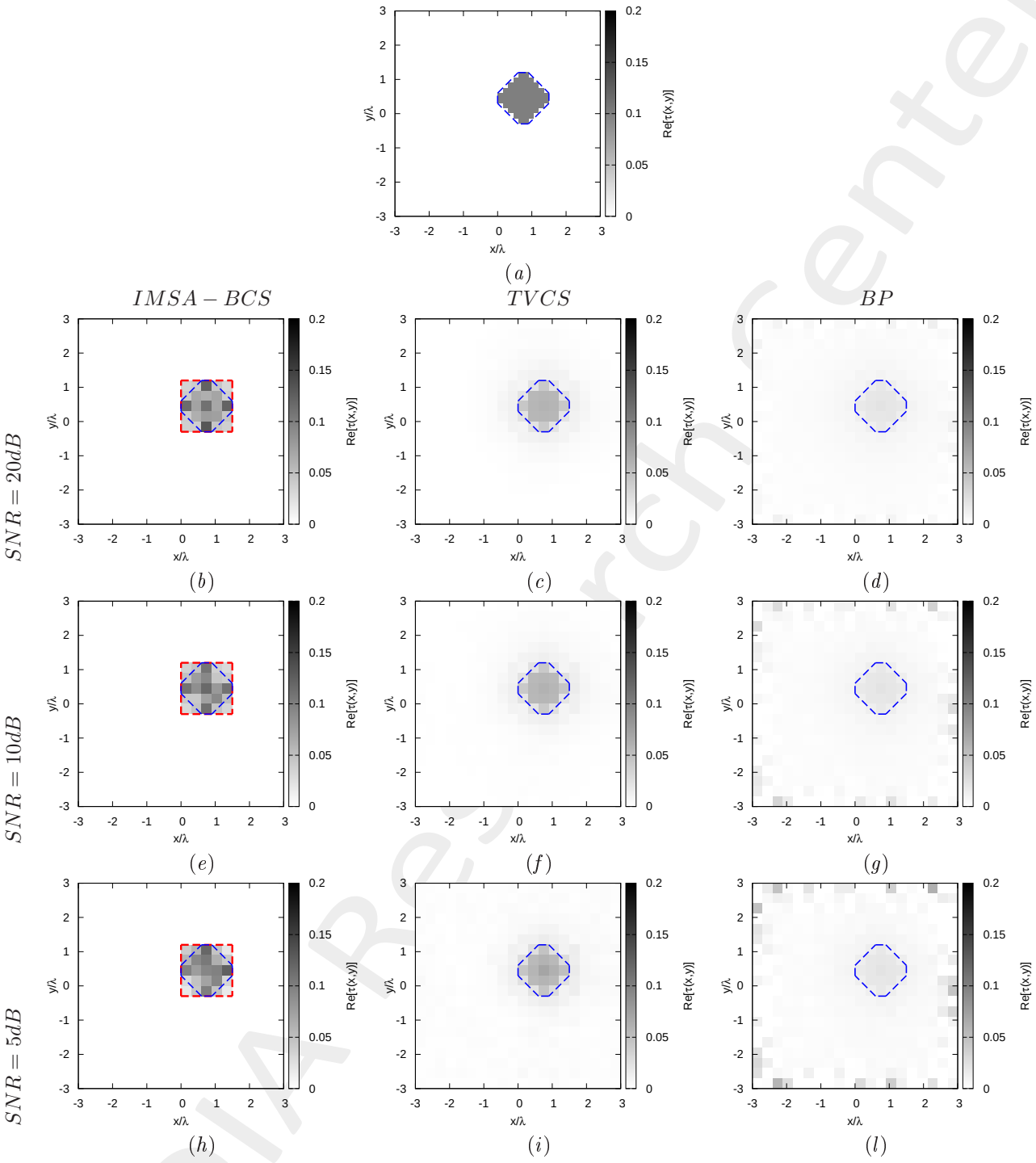

Figure 8: *Rhombus*, $D = 1.5\lambda$, $\tau = 0.02$ - *IMSA-BCS vs. TVCS vs. BP* - (a) Actual profile, $(b)(e)(h)$ $IMSA-BCS$, $(c)(f)(i)$ $TVCS$ and $(d)(g)(l)$ BP reconstructed profiles for $(b)(c)(d)$ $SNR = 20$ [dB], $(e)(f)(g)$ $SNR = 10$ [dB] and $(h)(i)(l)$ $SNR = 5$ [dB].

	$SNR = 50dB$		
	$IMSA-BCS$	$TVCS$	BP
ξ_{tot}	2.10×10^{-3}	3.89×10^{-3}	6.23×10^{-3}
ξ_{int}	2.72×10^{-2}	4.62×10^{-2}	7.40×10^{-2}
ξ_{ext}	9.86×10^{-4}	2.24×10^{-3}	3.53×10^{-3}
	$SNR = 20dB$		
	$IMSA-BCS$	$TVCS$	BP
ξ_{tot}	2.18×10^{-3}	3.96×10^{-3}	6.82×10^{-3}
ξ_{int}	2.81×10^{-2}	4.66×10^{-2}	7.40×10^{-2}
ξ_{ext}	1.01×10^{-3}	2.29×10^{-3}	3.84×10^{-3}
	$SNR = 10dB$		
	$IMSA-BCS$	$TVCS$	BP
ξ_{tot}	2.05×10^{-3}	4.34×10^{-3}	9.04×10^{-3}
ξ_{int}	2.29×10^{-2}	4.67×10^{-2}	7.40×10^{-2}
ξ_{ext}	1.02×10^{-3}	2.69×10^{-3}	5.37×10^{-3}
	$SNR = 5dB$		
	$IMSA-BCS$	$TVCS$	BP
ξ_{tot}	1.88×10^{-3}	5.01×10^{-3}	1.18×10^{-2}
ξ_{int}	1.95×10^{-2}	4.43×10^{-2}	7.40×10^{-2}
ξ_{ext}	9.40×10^{-4}	3.48×10^{-3}	7.32×10^{-3}

Table VII: *Rhombus*, $D = 1.5\lambda$, $\tau = 0.10$ - *IMSA-BCS vs. TVCS vs. BP* - Reconstruction errors: total (ξ_{tot}), internal (ξ_{int}) and external (ξ_{ext}) errors.

1.2.4 Rhombus, $D = 1.5\lambda$, $\tau = 0.15$ - $IMSA-BCS$ vs. $TVCS$ vs. BP reconstructed profiles

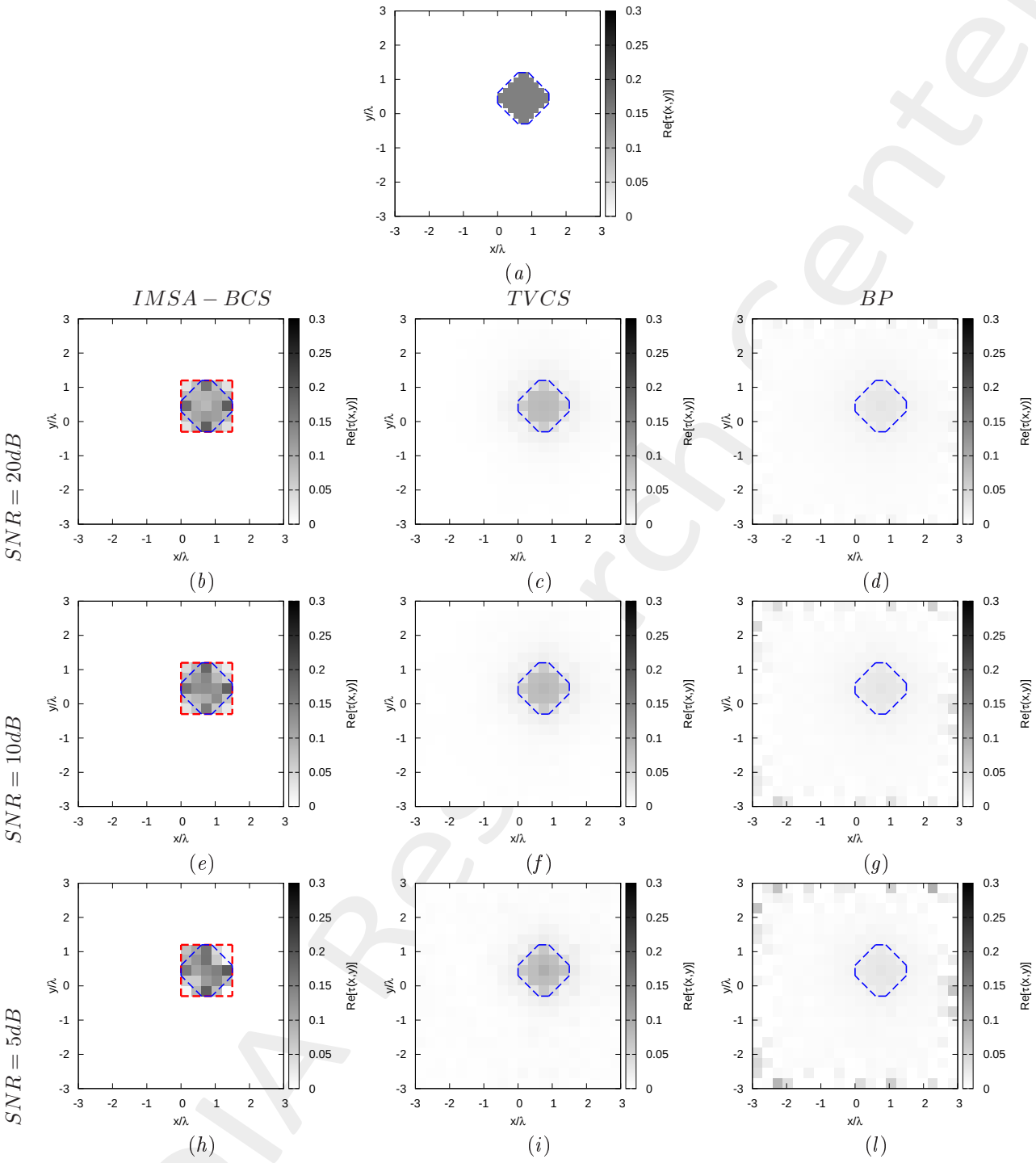

Figure 9: *Rhombus*, $D = 1.5\lambda$, $\tau = 0.15$ - *IMSA-BCS vs. TVCS vs. BP* - (a) Actual profile, $(b)(e)(h)$ $IMSA-BCS$, $(c)(f)(i)$ $TVCS$ and $(d)(g)(l)$ BP reconstructed profiles for $(b)(c)(d)$ $SNR = 20$ [dB], $(e)(f)(g)$ $SNR = 10$ [dB] and $(h)(i)(l)$ $SNR = 5$ [dB].

	$SNR = 50dB$		
	$IMSA-BCS$	$TVCS$	BP
ξ_{tot}	3.51×10^{-3}	6.20×10^{-3}	9.17×10^{-3}
ξ_{int}	4.27×10^{-2}	7.17×10^{-2}	1.07×10^{-1}
ξ_{ext}	1.52×10^{-3}	3.64×10^{-3}	5.18×10^{-3}
	$SNR = 20dB$		
	$IMSA-BCS$	$TVCS$	BP
ξ_{tot}	3.53×10^{-3}	6.28×10^{-3}	1.00×10^{-2}
ξ_{int}	4.09×10^{-2}	7.20×10^{-2}	1.07×10^{-1}
ξ_{ext}	1.62×10^{-3}	3.71×10^{-3}	5.65×10^{-3}
	$SNR = 10dB$		
	$IMSA-BCS$	$TVCS$	BP
ξ_{tot}	3.06×10^{-3}	6.76×10^{-3}	1.33×10^{-2}
ξ_{int}	3.18×10^{-2}	7.19×10^{-2}	1.07×10^{-1}
ξ_{ext}	1.38×10^{-3}	4.22×10^{-3}	7.91×10^{-3}
	$SNR = 5dB$		
	$IMSA-BCS$	$TVCS$	BP
ξ_{tot}	3.39×10^{-3}	7.73×10^{-3}	1.74×10^{-2}
ξ_{int}	3.40×10^{-2}	6.94×10^{-2}	1.07×10^{-1}
ξ_{ext}	1.32×10^{-3}	5.33×10^{-3}	1.08×10^{-2}

Table VIII: *Rhombus*, $D = 1.5\lambda$, $\tau = 0.15$ - *IMSA-BCS vs. TVCS vs. BP* - Reconstruction errors: total (ξ_{tot}), internal (ξ_{int}) and external (ξ_{ext}) errors.

1.2.5 Rhombus, $D = 1.5\lambda$, $\tau = 0.20$ - $IMSA-BCS$ vs. $TVCS$ vs. BP reconstructed profiles

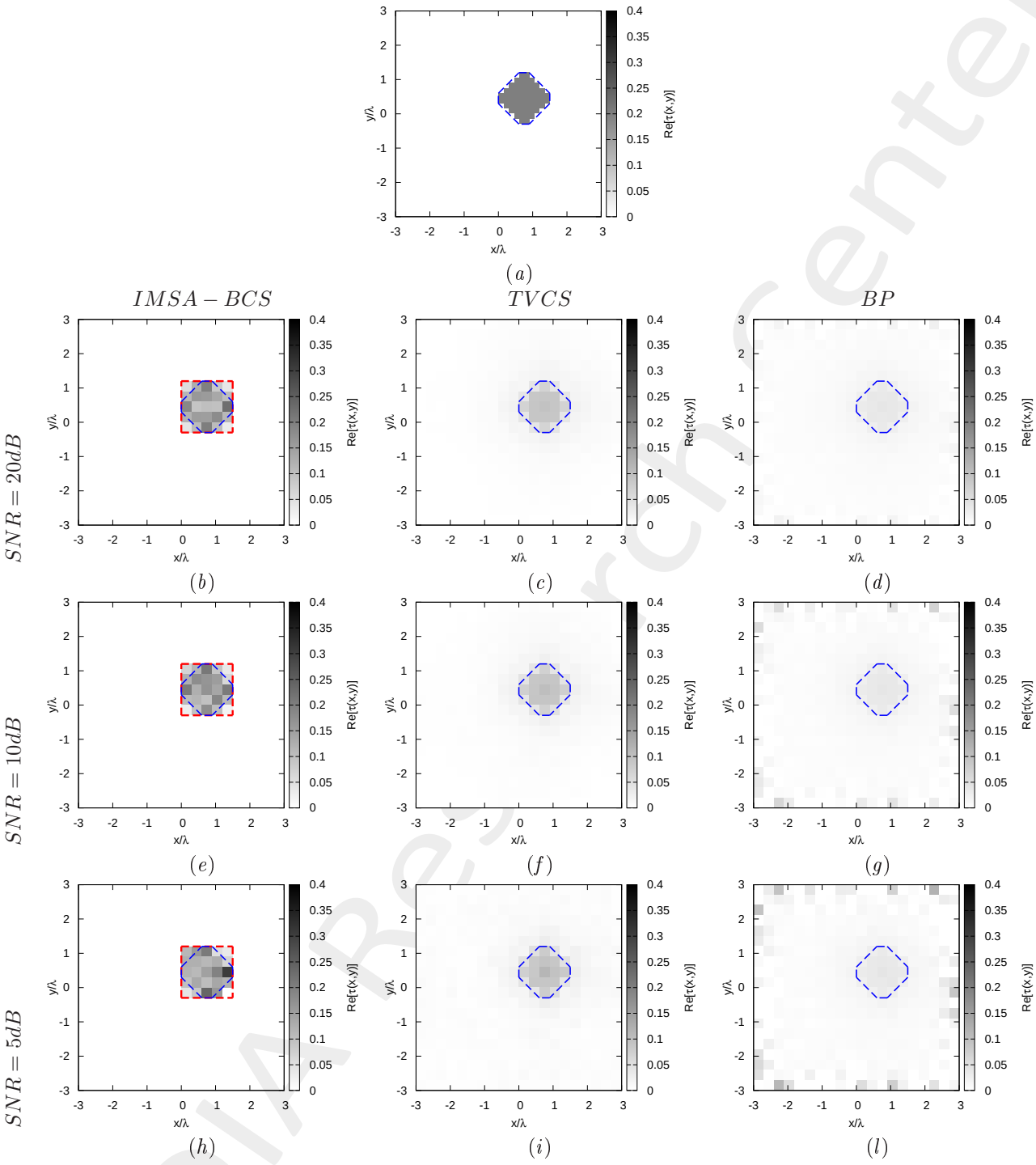

Figure 10: *Rhombus*, $D = 1.5\lambda$, $\tau = 0.20$ - *IMSA-BCS vs. TVCS vs. BP* - (a) Actual profile, $(b)(e)(h)$ $IMSA-BCS$, $(c)(f)(i)$ $TVCS$ and $(d)(g)(l)$ BP reconstructed profiles for $(b)(c)(d)$ $SNR = 20$ [dB], $(e)(f)(g)$ $SNR = 10$ [dB] and $(h)(i)(l)$ $SNR = 5$ [dB].

	$SNR = 50dB$		
	$IMSA-BCS$	$TVCS$	BP
ξ_{tot}	4.83×10^{-3}	8.84×10^{-3}	1.19×10^{-2}
ξ_{int}	4.18×10^{-2}	1.01×10^{-1}	1.38×10^{-1}
ξ_{ext}	2.16×10^{-3}	5.25×10^{-3}	6.69×10^{-3}
	$SNR = 20dB$		
	$IMSA-BCS$	$TVCS$	BP
ξ_{tot}	4.86×10^{-3}	8.86×10^{-3}	1.31×10^{-2}
ξ_{int}	4.42×10^{-2}	1.01×10^{-1}	1.38×10^{-1}
ξ_{ext}	2.13×10^{-3}	5.25×10^{-3}	7.31×10^{-3}
	$SNR = 10dB$		
	$IMSA-BCS$	$TVCS$	BP
ξ_{tot}	4.56×10^{-3}	9.40×10^{-3}	1.74×10^{-2}
ξ_{int}	3.97×10^{-2}	9.96×10^{-2}	1.38×10^{-1}
ξ_{ext}	1.95×10^{-3}	5.89×10^{-3}	1.03×10^{-2}
	$SNR = 5dB$		
	$IMSA-BCS$	$TVCS$	BP
ξ_{tot}	5.47×10^{-3}	1.07×10^{-2}	2.28×10^{-2}
ξ_{int}	5.71×10^{-2}	9.75×10^{-2}	1.38×10^{-1}
ξ_{ext}	2.22×10^{-3}	7.34×10^{-3}	1.41×10^{-2}

Table IX: *Rhombus*, $D = 1.5\lambda$, $\tau = 0.20$ - *IMSA-BCS vs. TVCS vs. BP* - Reconstruction errors: total (ξ_{tot}), internal (ξ_{int}) and external (ξ_{ext}) errors.

1.2.6 Rhombus, $D = 1.5\lambda$ - $IMSA - BCS$ vs. $TVCS$ vs. BP errors resume vs. τ

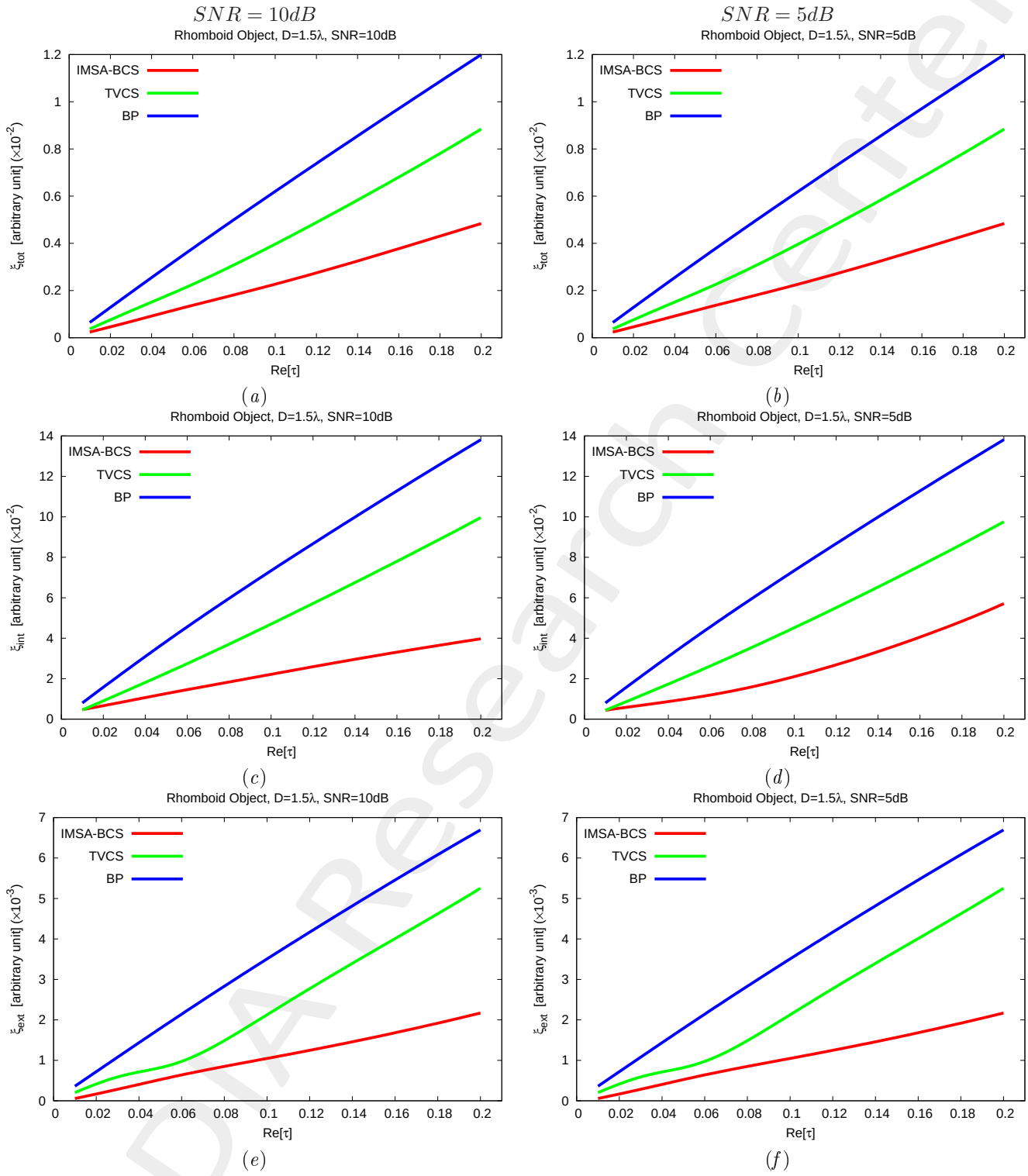

Figure 11: *Rhombus*, $D = 1.5\lambda$ - Reconstruction errors vs. τ: (a) total error, (b) internal error and (c) external error. Reconstruction errors vs. τ: $(a)(b)$ total error, $(c)(d)$ internal error and $(e)(f)$ external error for $(a)(c)(e)$ $SNR = 10dB$ and $(b)(d)(f)$ $SNR = 5dB$.

More information on the topics of this document can be found in the following list of references.

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