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NUMERICAL AND EXPERIMENTAL ASSESSMENT OF A PHASE RETRIEVAL TECHNIQUE APPLIED TO PLANAR NEAR FIELD DISTRIBUTIONS FOR WIDE BAND APPLICATIONS

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Saint-Louis - USA



Département de Recherche en Électromagnétisme
de Supélec et du L2S (UMR8506 / CNRS - Supélec - UPS)



CONTEXT

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Final purpose

- Experimental antenna far field pattern characterization
- Wide frequency range
- Pulsed sources

Measurement constraints

- Planar near field test setup
- Magnitude only measurements

APPROACH

Implementation of a phase retrieval algorithm

Assumptions on sources

- CW
- High directivity



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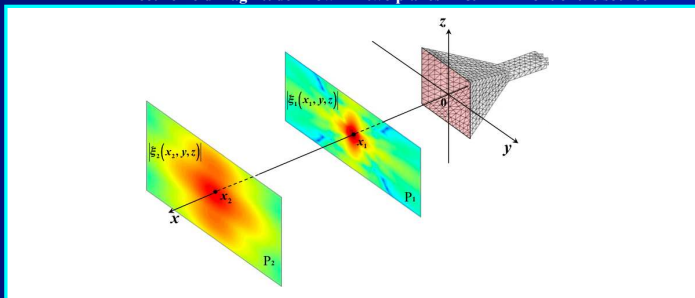
THE PHASE RETRIEVAL TECHNIQUE

HISTORICAL BACKGROUND

- ✓ Gerschberg-Saxton [1972] : electron microscopy (1 plane)
- ✓ « Misell » variant [1973] : electron microscopy (2 defocused planes)
- ✓ Anderson & Ali [1984] : microwave applications

PRINCIPLE

- ✓ Algorithm initialization :
 - Electric field magnitude known in two planes P_1 & P_2 in front of the source



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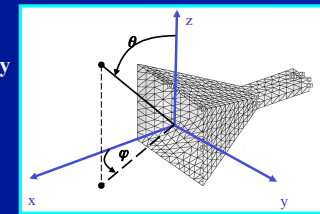
NUMERICAL ASSESMENTS (1/8)

Models

- ✓ MoM (Feko)
- ✓ Classical horn antenna (same used for experimental approach)
- ✓ Frequency: 8 GHz

Purposes

- ✓ Validation tool
 - Agreement Models/Measurements
 - Exact phase calculation
 - Exact far field calculation
- ✓ Sets of data for parametric study
 - $d_{\text{plane-source}}$ and $d_{\text{plane-plane}}$
 - Planes sampling
 - Planes sizes



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NUMERICAL ASSESMENTS (2/8)

◆ Parametric Study

✓ Criterion

$$\Delta_n^{cplx} = \frac{\sum_{i=1}^{N_x} \sum_{j=1}^{N_y} \|E_n(x_i, y_j, z_j) - \xi_n(x_i, y_j, z_j)\|^2}{\sum_{i=1}^{N_x} \sum_{j=1}^{N_y} \|\xi_n(x_i, y_j, z_j)\|^2}$$

✓ planes positions

- Fields calculated in magnitude and phase using Feko
- distances : 11 values [$x_l = 2\lambda, \dots, x_{l1} = 1 \text{ m}$]
- 55 phase reconstructions

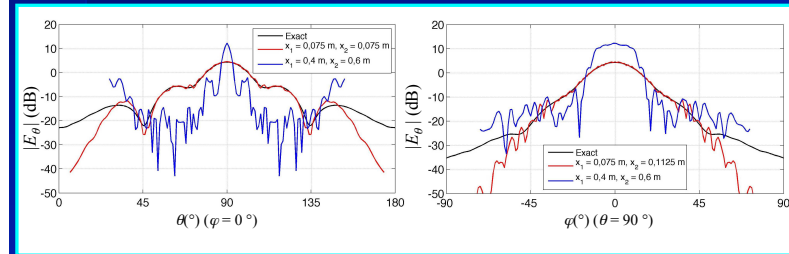


NUMERICAL ASSESMENTS (3/8)

◆ Planes positions parameter : x_1 and x_2

✓ Far field from using the reconstructed phase

- Worst case : $\Delta_n^{cplx} = 222.54 \%$
- Best case : $\Delta_n^{cplx} = 7.94 \%$

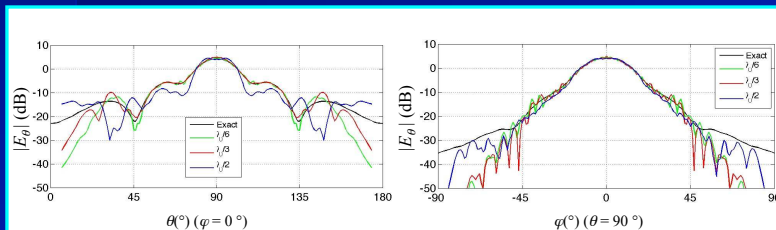


NUMERICAL ASSESMENTS (4/8)

◆ Sampling parameter : δ_x

✓ Far field from using the reconstructed phase

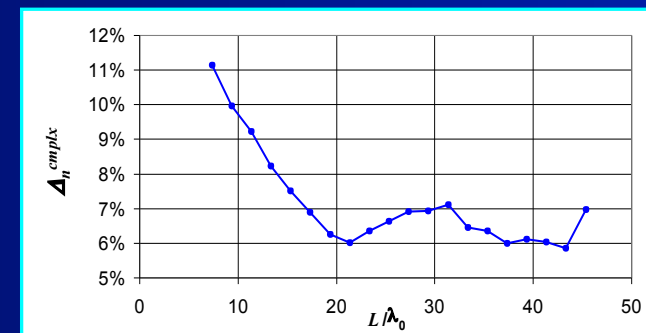
- $\delta_x = \lambda_0/6$ $\Delta_n^{cplx} = 7.94 \%$
- $\delta_x = \lambda_0/3$ $\Delta_n^{cplx} = 6.07 \%$
- $\delta_x = \lambda_0/2$ $\Delta_n^{cplx} = 29.53 \%$



NUMERICAL ASSESMENTS (5/8)

◆ Planes dimensions parameter : L

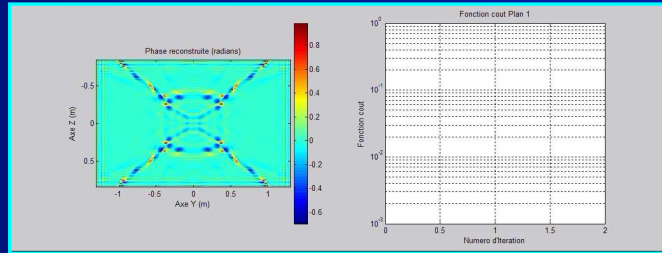
✓ $L_{min} = 20\lambda_0$



NUMERICAL ASSESMENTS (6/8)

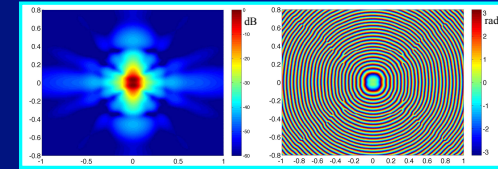
Phase reconstructions

- ✓ ~1000 to 10000 iterations
- ✓ Less than 1 or 2 hours on a standard PC

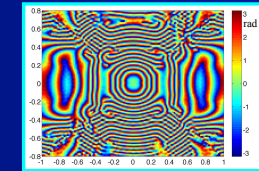


NUMERICAL ASSESMENTS (7/8)

Results at 8 GHz : phase on the first plane



Exact Field, $d = 2\lambda$, magnitude and phase (FEKO) and reconstructed phase

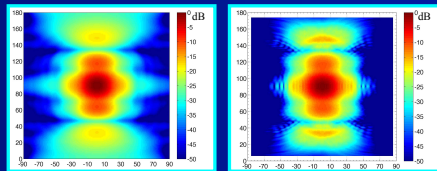


Reconstructed phase

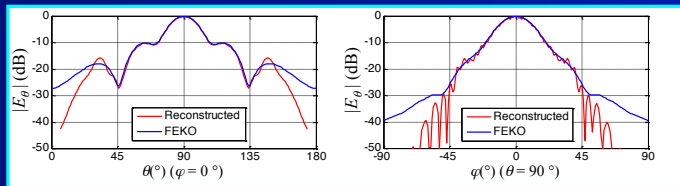


NUMERICAL ASSESMENTS (8/8)

Results at 8 GHz : reconstructed far field



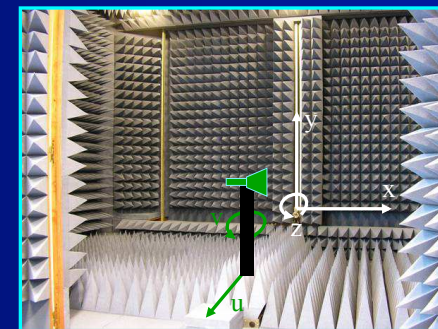
Exact and reconstructed far field



EXPERIMENTAL APPROACH

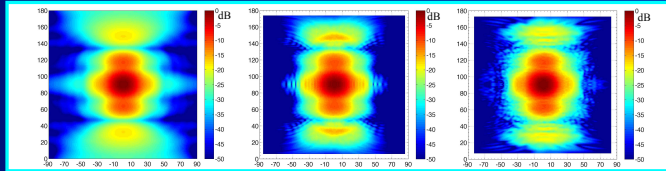
Experimental validation : planar near field measurement setup

- ✓ AUT = Horn, Probe = Dipole, open end waveguide
- ✓ Frequencies = 2 GHz, 8 GHz and 18 GHz
- ✓ Distance AUT/Probe : $2\lambda, 3\lambda, \dots 1m$

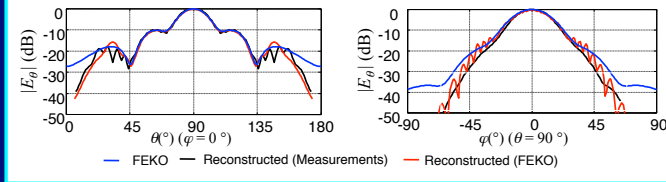


EXPERIMENTAL VALIDATION : $f = 8 \text{ GHz}$

Validation of reconstructed far field



Exact, reconstructed from simulated magnitudes and from measured magnitudes



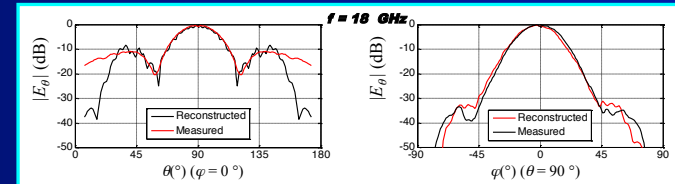
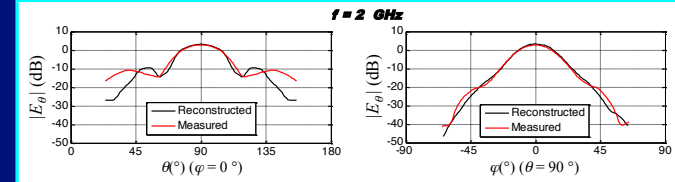
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EXPERIMENTAL VALIDATION : $f = 2 \text{ \& } 18 \text{ GHz}$

Validation of reconstructed far field



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CONCLUSION & FUTURE WORKS

Conclusions on the phase reconstruction algorithm

- ✓ Validation on numerical and experimental data
- ✓ Parametric study for optimal use
- ✓ Wide band validation

Future tasks

- ✓ Adding information to increase performances
- ✓ Expanding the parametric study
- ✓ Towards pulsed sources ...



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