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► **To cite this version:**

Nicolas Ribière-Tharaud, Aronne Casagrande, Marc Lambert, François Jouvie. Numerical and experimental assessment of a phase retrieval technique applied to planar near field distribution for wide band application. ICONIC'07, Jun 2007, Saint-Louis, United States. hal-01107471

**HAL Id: hal-01107471**

**<https://centralesupelec.hal.science/hal-01107471v1>**

Submitted on 20 Jan 2015

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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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ICONIC 2007 – June 28, 2007  
Saint-Louis - USA



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## 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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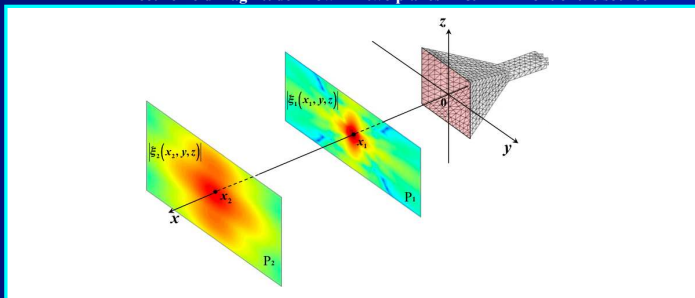
## THE PHASE RETRIEVAL TECHNIQUE

### 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

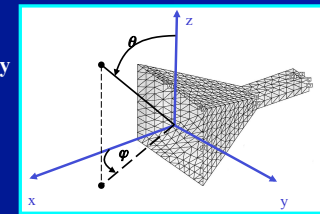
### Purposes

#### 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

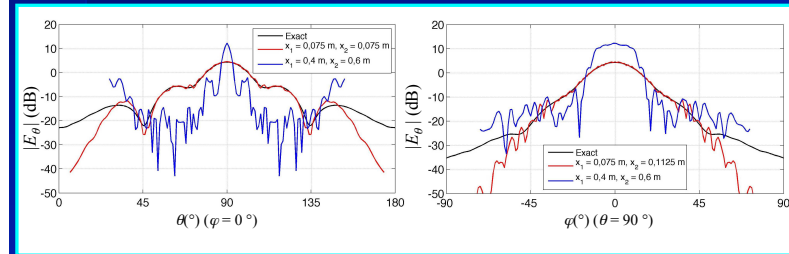


## NUMERICAL ASSESMENTS (3/8)

### ◆ Planes positions parameter : $x_1$ and $x_2$

#### ✓ Far field from using the reconstructed phase

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

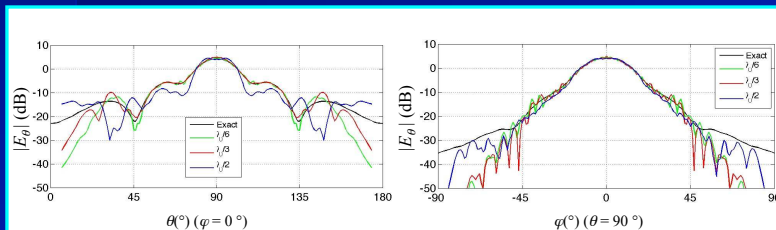


## NUMERICAL ASSESMENTS (4/8)

### ◆ Sampling parameter : $\delta_x$

#### ✓ Far field from using the reconstructed phase

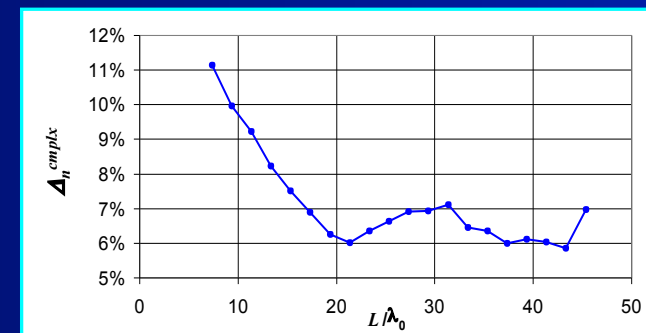
- $\delta_x = \lambda_0/6$   $\Delta_n^{cplx} = 7.94 \%$
- $\delta_x = \lambda_0/3$   $\Delta_n^{cplx} = 6.07 \%$
- $\delta_x = \lambda_0/2$   $\Delta_n^{cplx} = 29.53 \%$



## NUMERICAL ASSESMENTS (5/8)

### ◆ Planes dimensions parameter : $L$

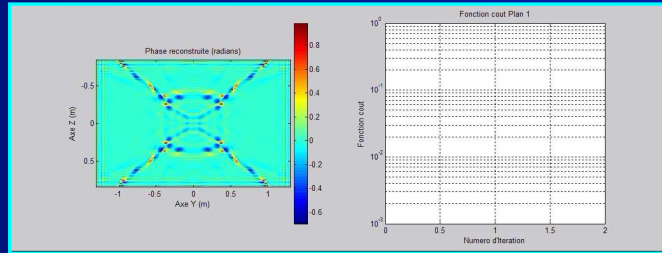
#### ✓ $L_{min} = 20\lambda_0$



## NUMERICAL ASSESMENTS (6/8)

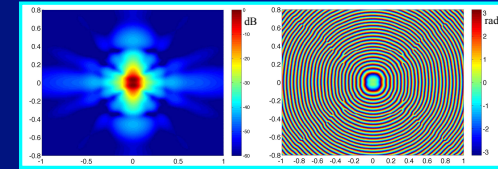
### Phase reconstructions

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

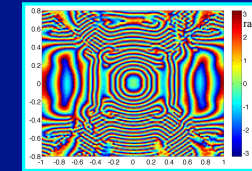


## NUMERICAL ASSESMENTS (7/8)

### Results at 8 GHz : phase on the first plane



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

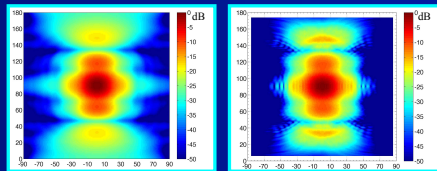


Reconstructed phase

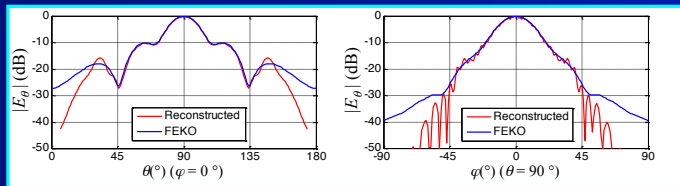


## NUMERICAL ASSESMENTS (8/8)

### Results at 8 GHz : reconstructed far field



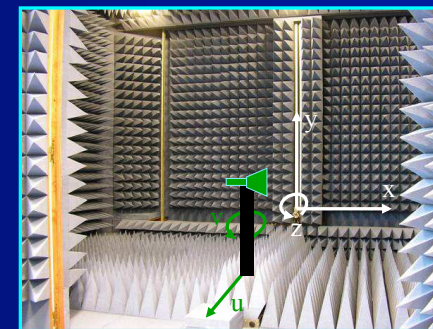
Exact and reconstructed far field



## EXPERIMENTAL APPROACH

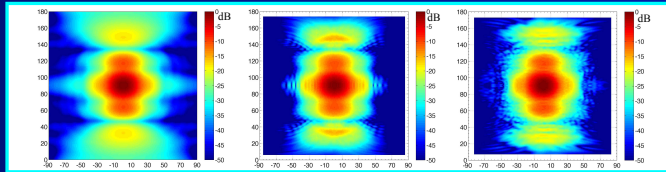
### Experimental validation : planar near field measurement setup

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

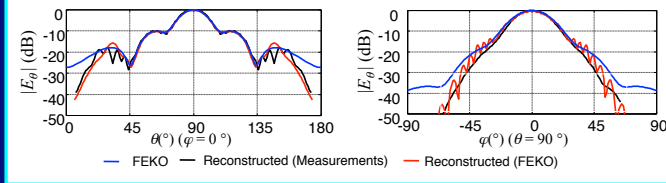


## EXPERIMENTAL VALIDATION : $f = 8 \text{ GHz}$

### Validation of reconstructed far field



Exact, reconstructed from simulated magnitudes and from measured magnitudes



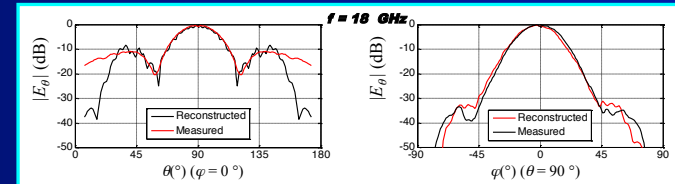
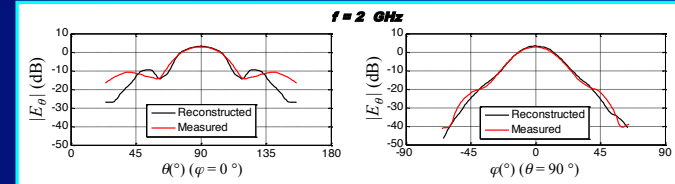
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## EXPERIMENTAL VALIDATION : $f = 2 \text{ \& } 18 \text{ GHz}$

### 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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