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# MODELING MICROWAVE CHIRAL MATERIAL BASED ON CRANKS RESONATOR ARRAY USING COMSOL MULTIPHYSICS

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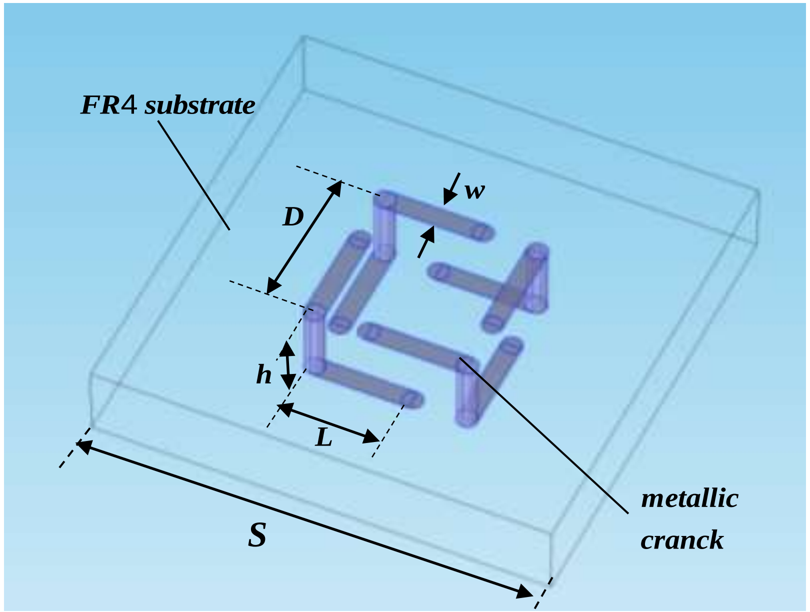
# OVERVIEW

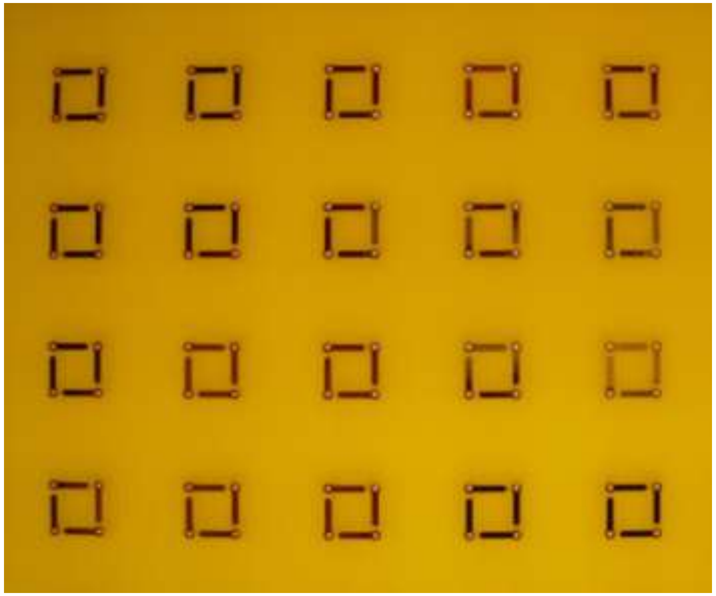
- Chiral media
  - Electric and magnetic coupling
  - Electromagnetic rotatory dispersion and circular dichroism
  - Negative refractive index (metamaterial), but does not require simultaneously negative permittivity and permeability
  - Only one resonant structure
- Free-wave X-band experimental and simulated characterization of the material
- Use of COMSOL (RF module):
  - Frequency domain
  - Double Floquet Periodic Boundary Conditions
  - Setting up linearly and circularly polarized waves
  - Sampling Electric Field

# MODELING A CHIRAL STRUCTURE

*(The unit cell)*

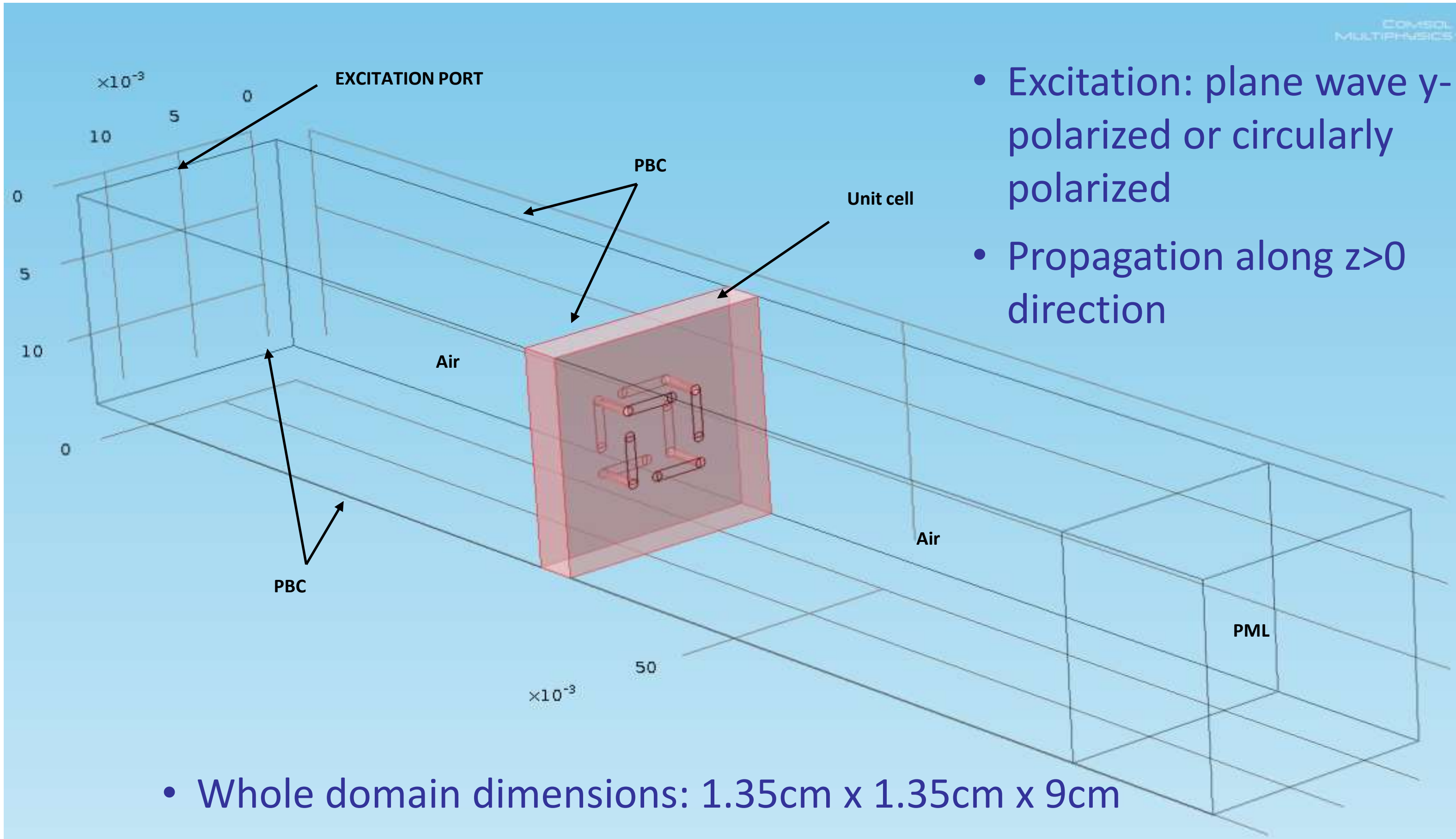



*(The experimental sample)*



- Periodical two-dimensional array of four metallic cranks
- Copper metallization 30 μm thick, patterned on a FR4 dielectric board both sides and connected via posts
- S=13.5 mm, h=2.4 mm
- Uniaxial chirality for normal incident TEM wave

# BUILDING THE MODEL




- Excitation: plane wave y-polarized or circularly polarized
- Propagation along z>0 direction

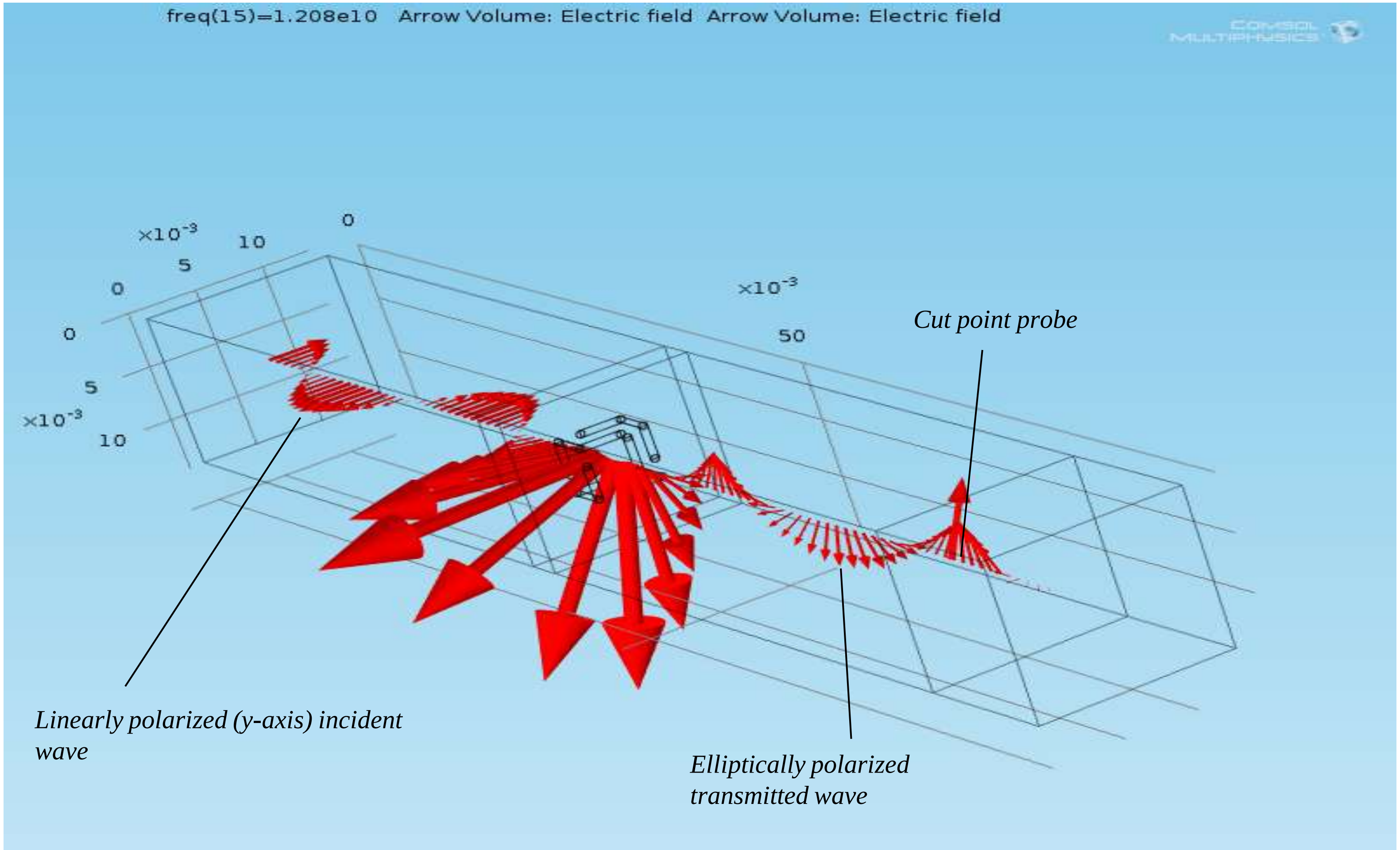
- Whole domain dimensions: 1.35cm x 1.35cm x 9cm
- PML: Perfect Matched Load: 1.35cm x 1.35cm x 1cm
- PBC: Periodic Boundary Condition

# MESHING AND SOLVING

- Finer mesh
- Copy mesh: same triangular mesh on periodic boundaries
- Remaining:  Free tetrahedral

- Frequency domain
- Parametric solver: 41 frequency points in the range [8-17 GHz]
- Stationary
- DIRECT enabled
- PARDISO
- Time: about 2 h (PC with a 64-bit Microsoft Windows Operating System, with a 3.20 GHz-processor and 30 GB of RAM)

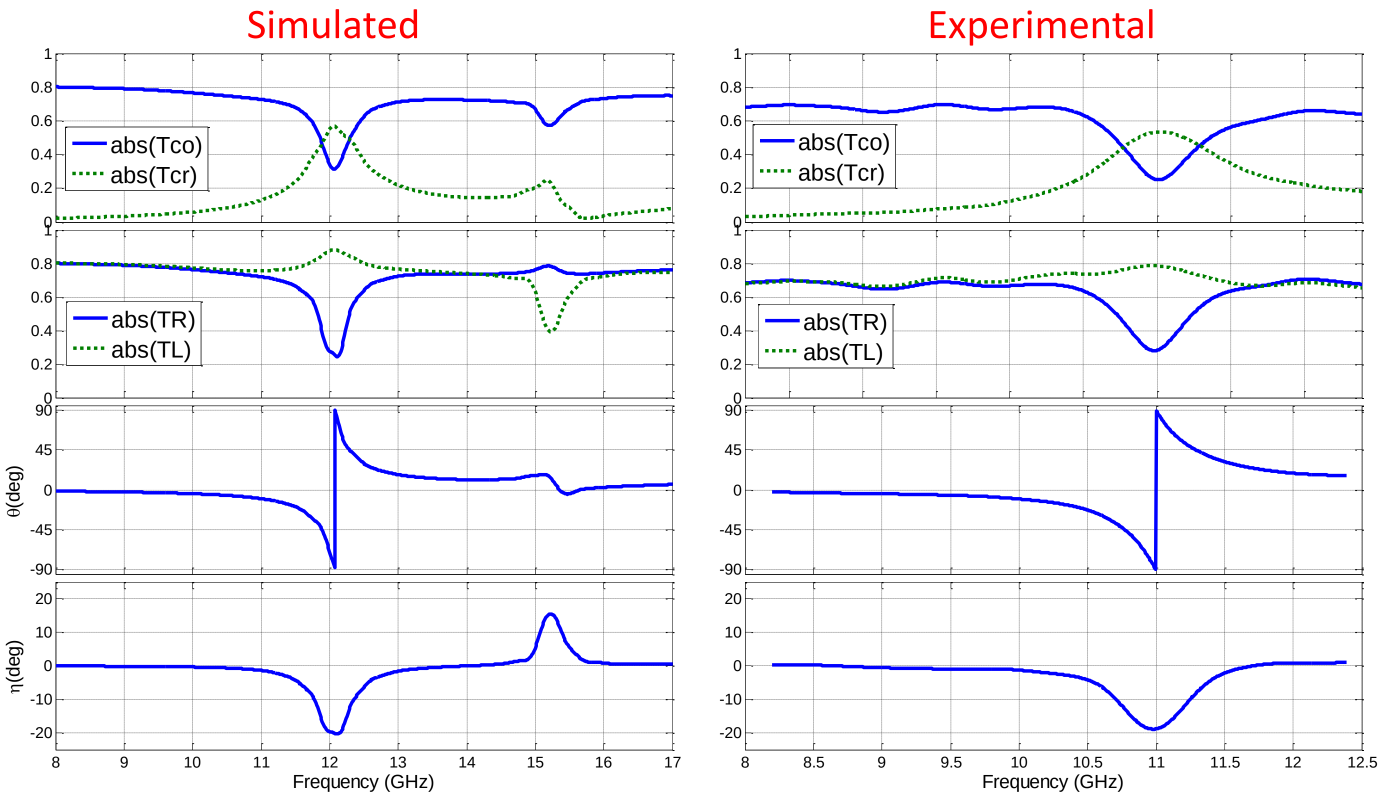
# SIMULATION RESULTS: LINEARLY POLARIZED WAVE




- Arrows volume distribution of E-field along propagation direction
- Resonant frequency ($f_0$=12.04 Ghz, 0.5 GHz bandwidth)

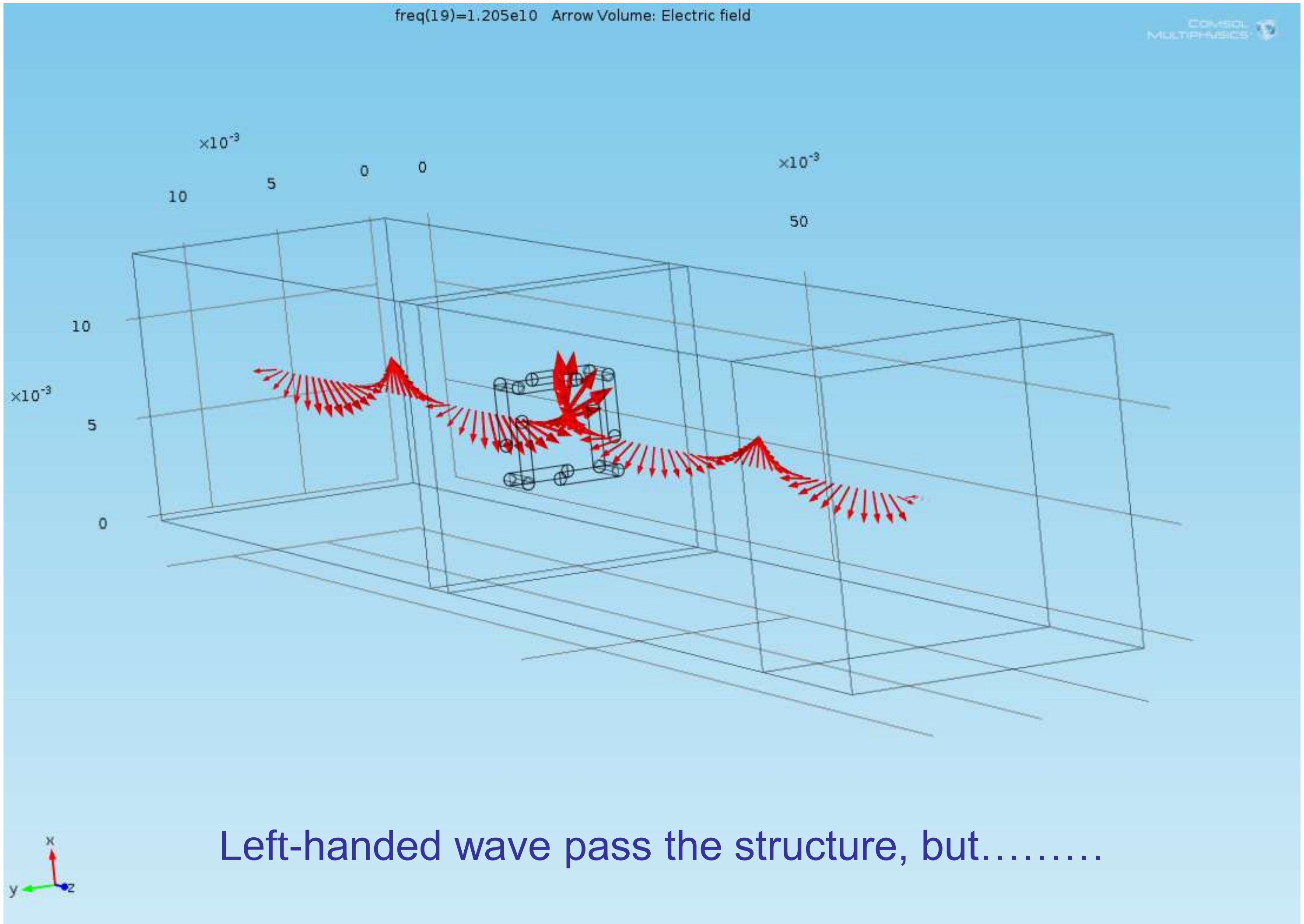
# COMPARING WITH EXPERIMENTAL RESULTS

Sampling co- and cross-polar components of the transmitted field:



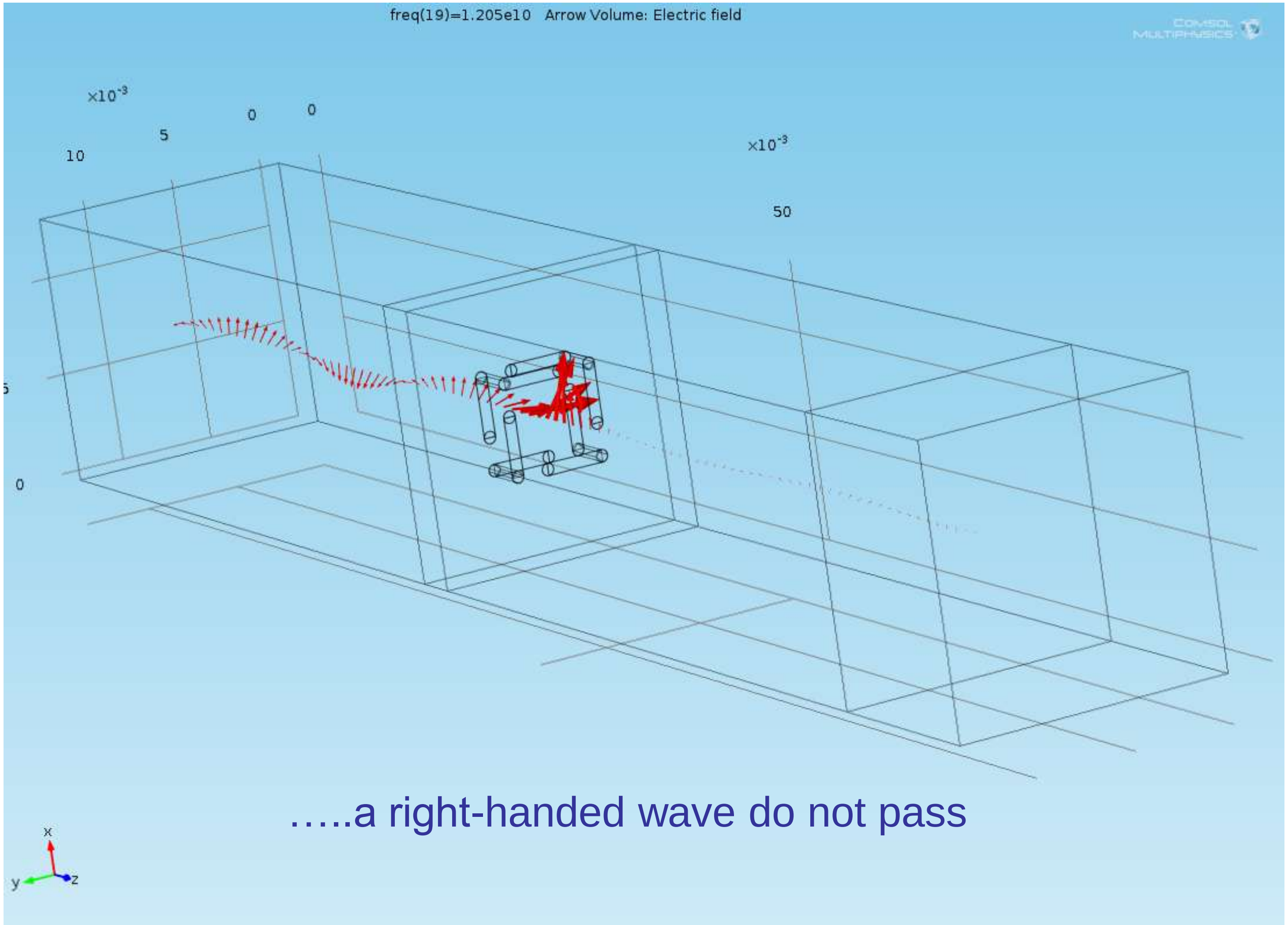

Good agreement with experimental results except for 1 GHz-shift of the resonant frequency

# SIMULATION RESULTS: CIRCULARLY POLARIZED WAVE




Left-handed wave pass the structure, but………

# RESULTS: CIRCULARLY POLARIZED WAVE




…..a right-handed wave do not pass

# RETRIEVING CONSTITUTIVE PARAMETERS

- Requires reflection and transmission coefficients computation → two additional models:
  - All domains set to air → incident field reference
  - Short-circuit plate → reference plane for reflection

- Retrieval algorithm* → $\varepsilon_{eff}$ , $\mu_{eff}$ , $n_{eff}$

(*) J. Margineda et al.
*Electromagnetic Characterization of Chiral Media, in Electromagnetic Waves*
Ahmed Kishk (Ed.), ISBN: 980-953-307-527-8, InTech (2012).

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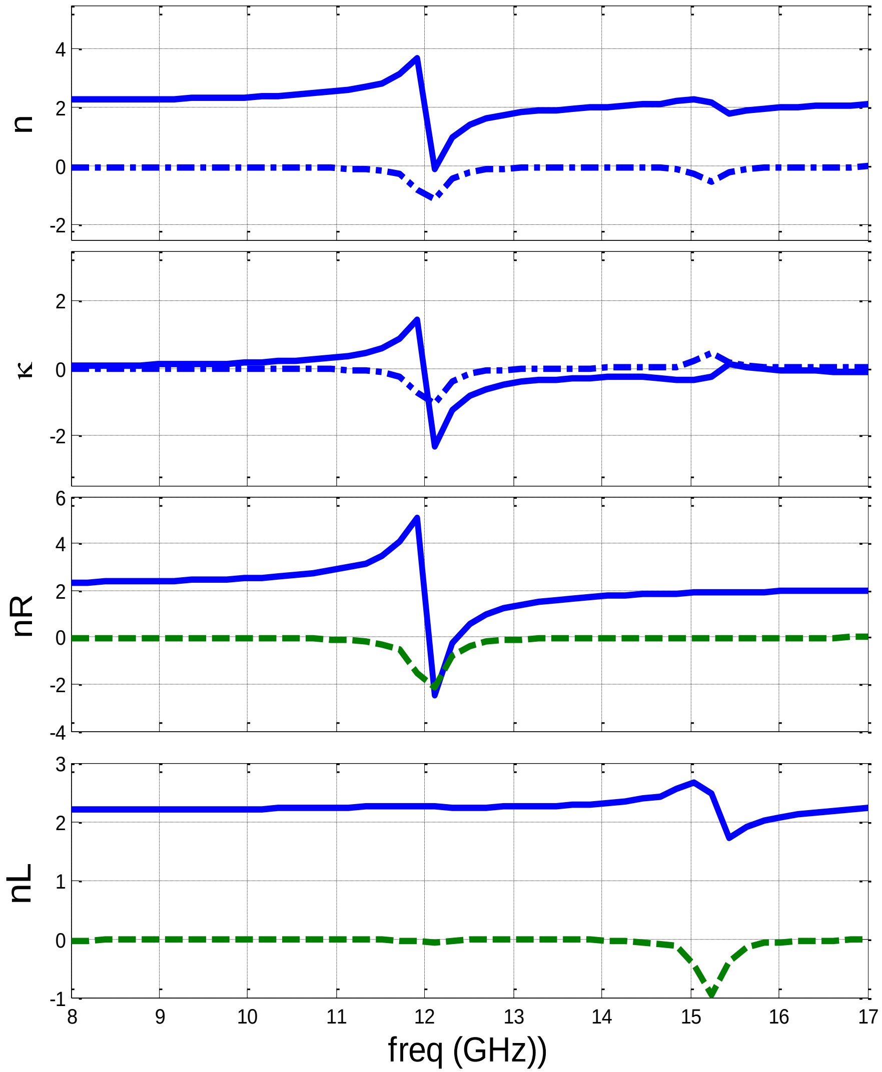


***THAN YOU VERY MUCH***