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Maxime Ardisson, Guillaume Bourcin, Jeremy Bourhill, David Spenato, David Dekadjevi, et al.. Generation of circulating cavity magnon polaritons in a compact geometry resonator. 21ème Colloque Louis Néel, Nov 2023, Sète, France. , 2023. hal-04295922

**HAL Id: hal-04295922**

**<https://hal.science/hal-04295922>**

Submitted on 21 Nov 2023

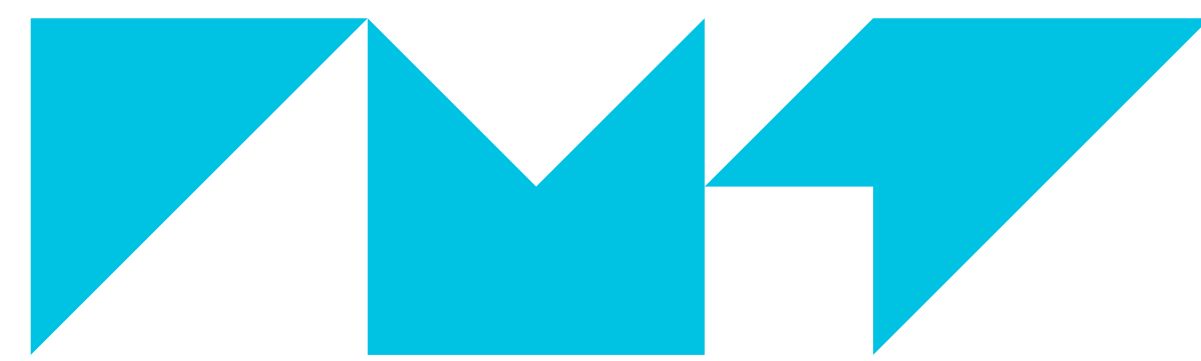
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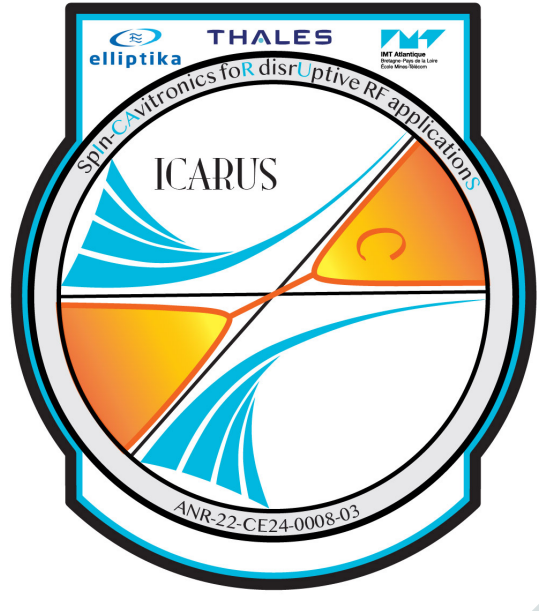
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# GENERATION OF CIRCULATING CAVITY MAGNON POLARITONS IN A COMPACT GEOMETRY RESONATOR



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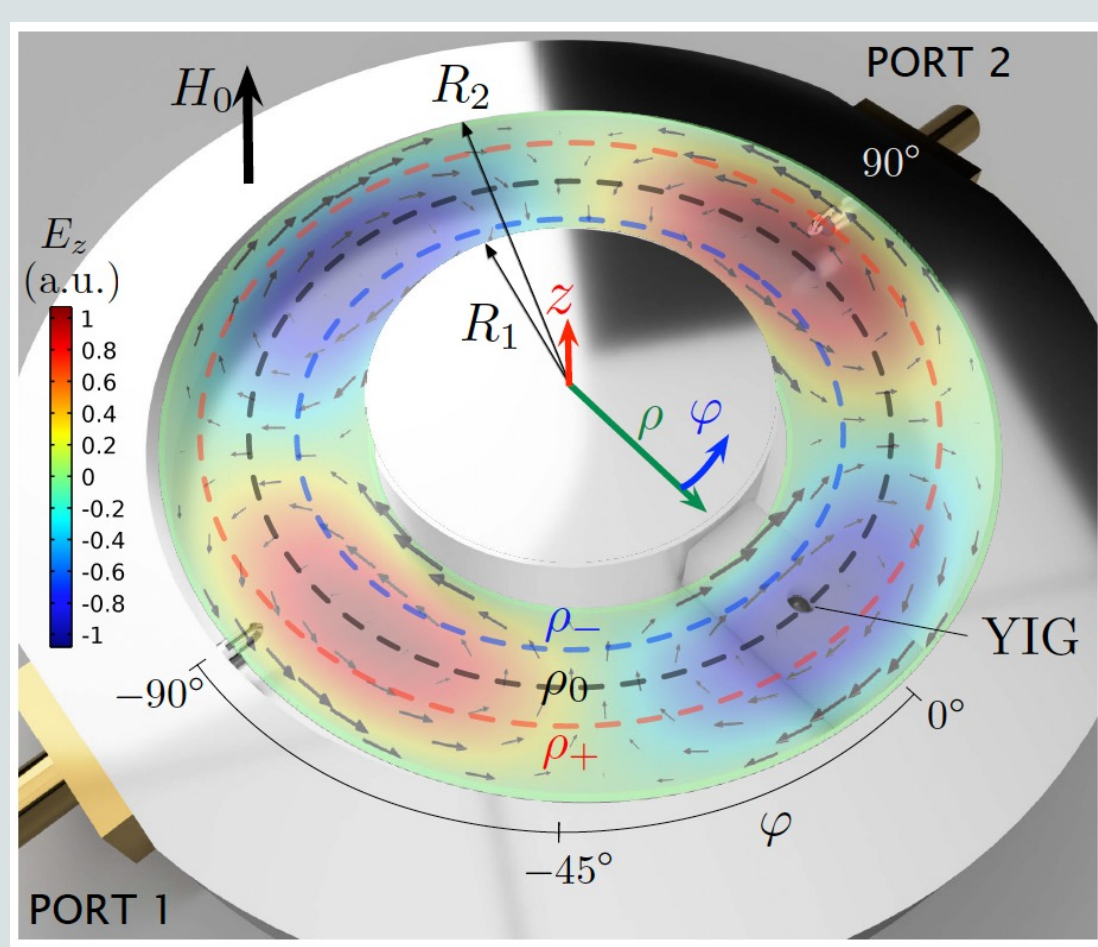
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## INTRODUCTION

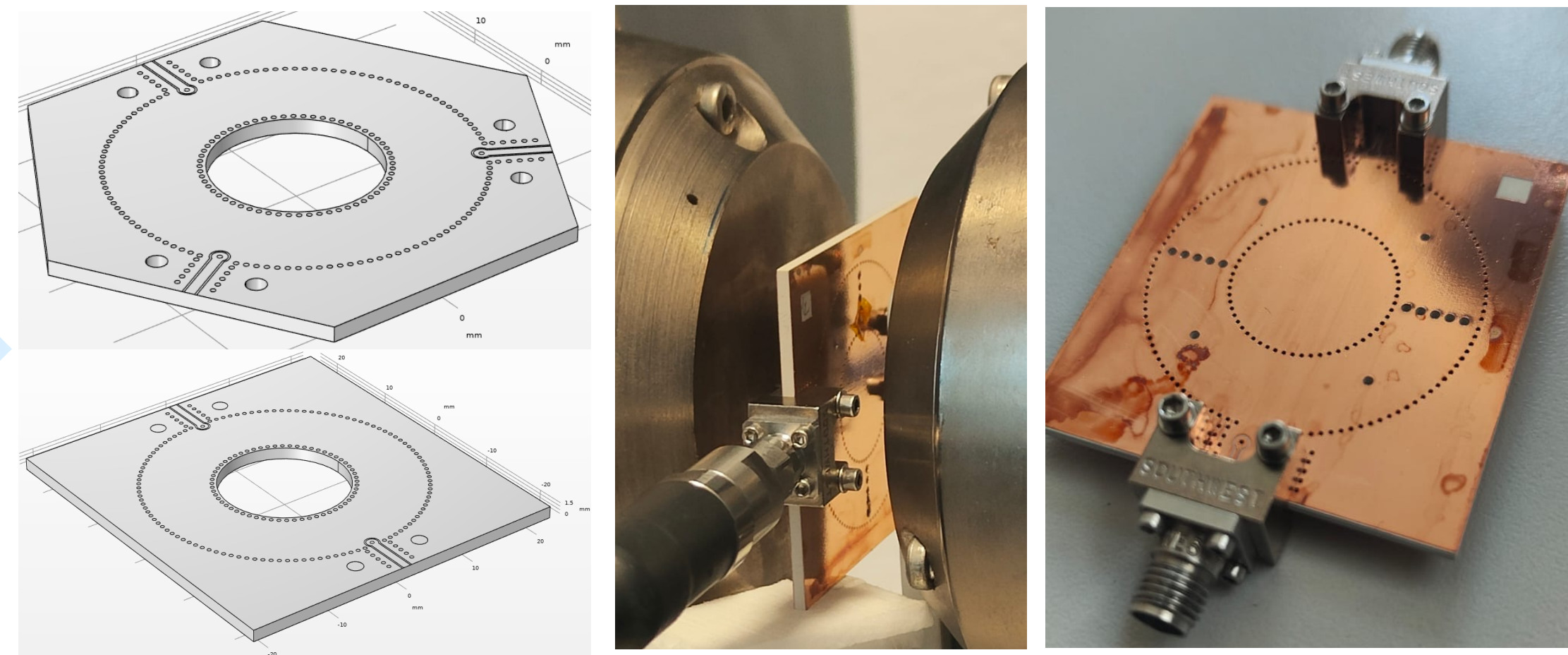
- **Generation** of circularly polarised unidirectional cavity magnon polaritons in a torus cavity [1]
- **Achieved** by the observation of a three-mode interaction picture when the magnetic resonance of a 1.8 mm YIG sphere and a cavity resonance were tuned coincident in frequency and the sphere is positioned at precise radial locations
- **Torus-shaped microwave cavity:**
  - Machined from high purity aluminium in two parts (lid and base)
  - The inner and outer radii R1 (15 mm) and R2 (30 mm) and the height h (6 mm)
  - 2 magnetic loops around the radial axis at  $\varphi = \pm 90^\circ$  that couple to  $H_\varphi$
  - Pure YIG sphere couples to a clockwise (cm,  $m > 0$ ) or counterclockwise (cew,  $m < 0$ ) photon
- **Multiple sphere setup:** How to demonstrate the generation of high-power unidirectional photon beam with high coherence and narrow bandwidth [2] in such big device?



## SIW CAVITY



SIW integration:  
Towards multiple YIG sphere setup



- Substrate Integrated Waveguide (SIW)
- Increasing the dielectric permittivity of the medium carrying the electromagnetic waves: reduction the device dimension
- From 60 to 36 mm for the external diameter
- Substrate: RO3003 (h=1.52 mm)

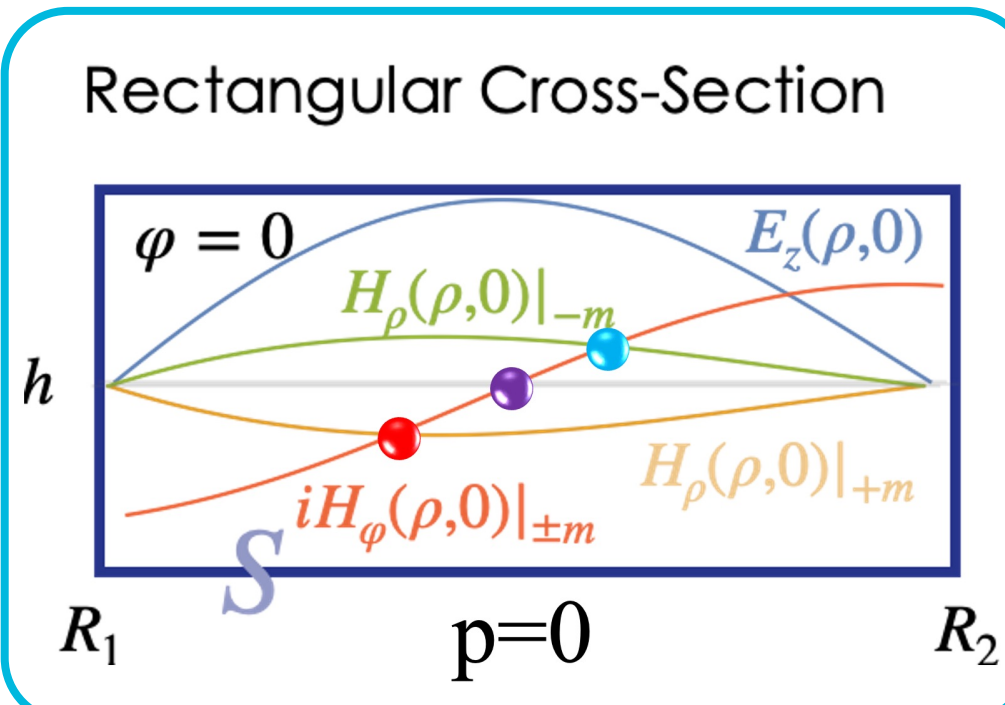
Microwave magnetic field of the TE modes is circularly polarized

$$H_z = 0 \text{ and } \partial_n E_z |_{s=0} = 0 \quad \text{TE mode}$$

$$E_z = \psi(\rho, \varphi) \cos\left(\frac{p\pi z}{h}\right), \quad p = 0, 1, 2, \dots$$

$$\psi(\rho, \varphi) = R_m(\rho) e^{im\varphi}, \quad m = 0, \pm 1, \pm 2, \dots$$

$$R_m(\rho) = J_m(\gamma_{p,m}\rho) + CN_m(\gamma_{p,m}\rho)$$



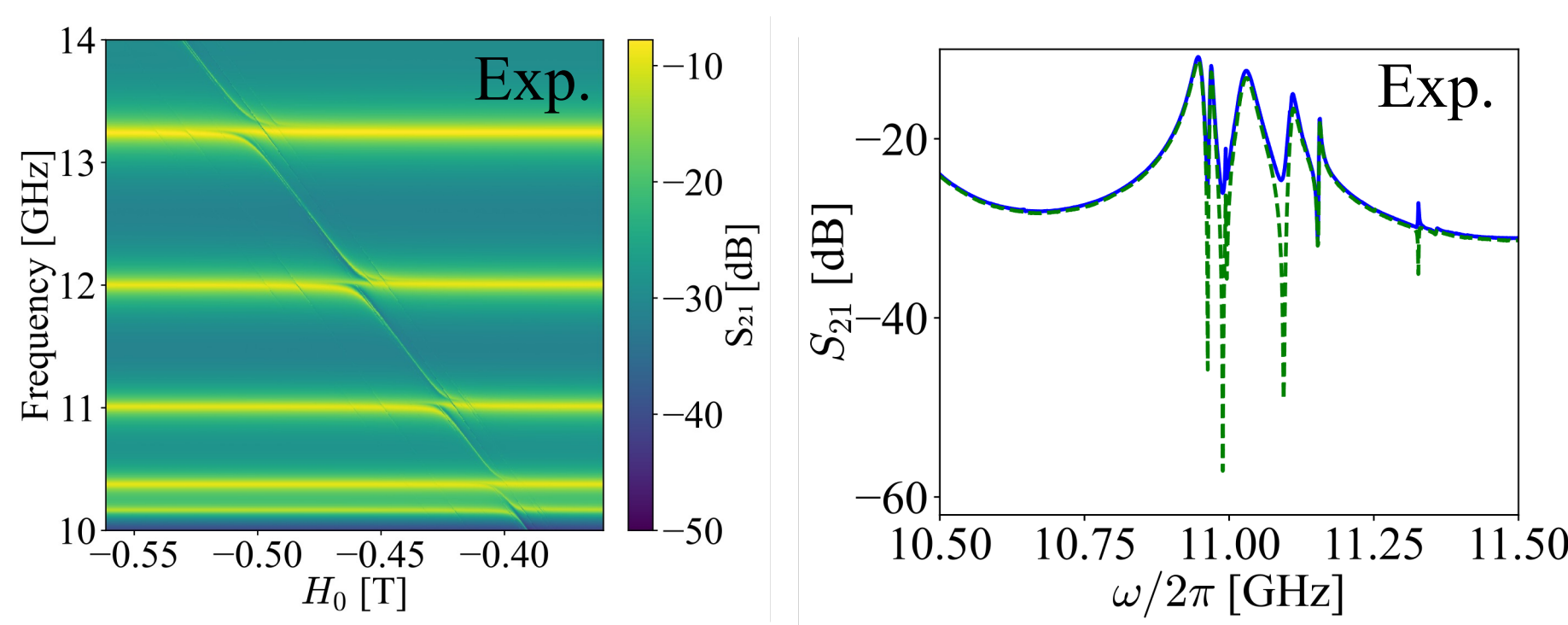
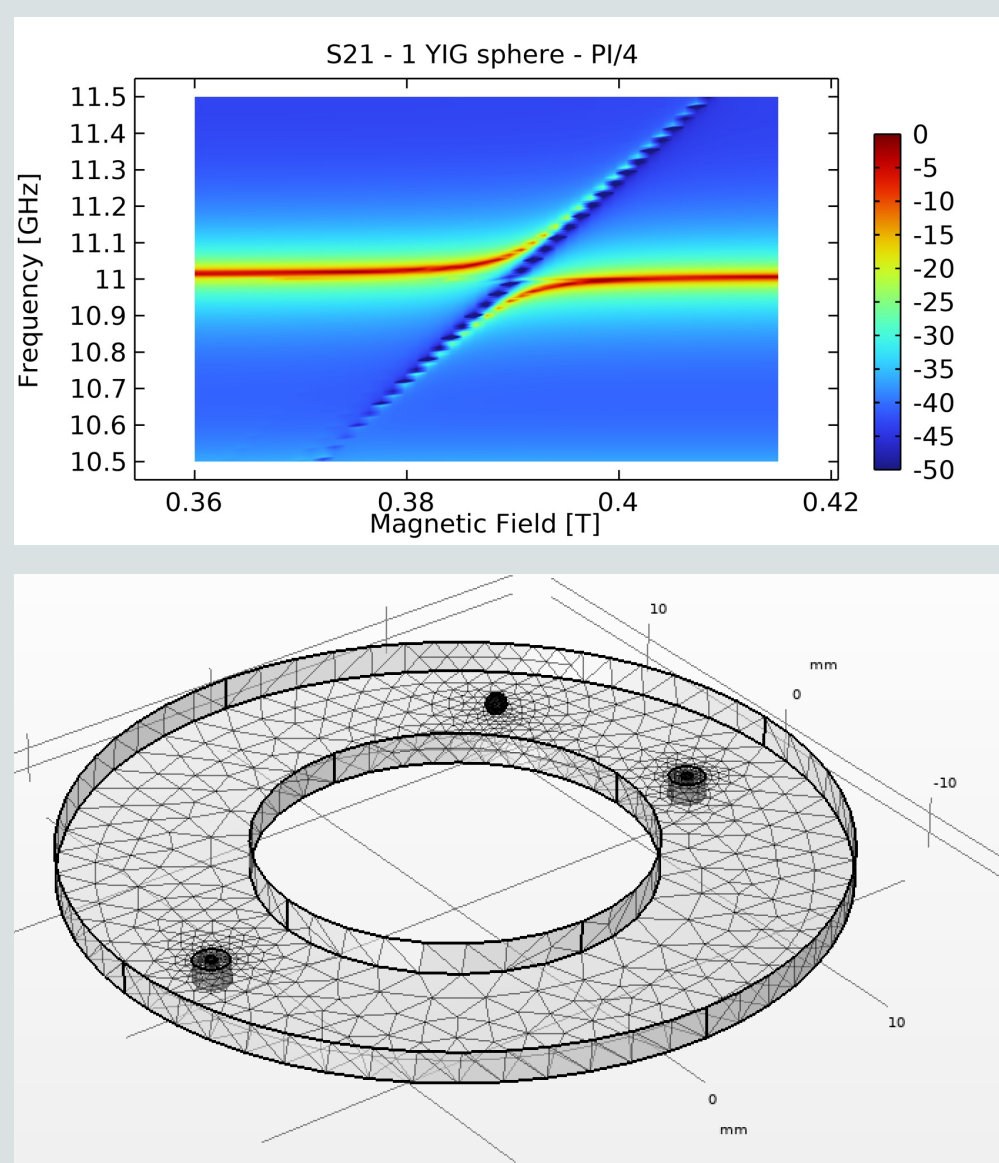
$$E_z(\rho, \varphi, z) = \left( J_m(\gamma_{p,m}\rho) - \frac{J_m(\gamma_{p,m}R_1)}{N_m(\gamma_{p,m}R_1)} N_m(\gamma_{p,m}\rho) \right) e^{im\varphi} \cos\left(\frac{p\pi z}{h}\right) \rho_{\pm}$$

	-m	+m
$\rho_+$	$H_\varphi = -iH_\rho$	$H_\varphi = iH_\rho$
$\rho_-$	$H_\varphi = iH_\rho$	$H_\varphi = -iH_\rho$
$\rho_0$	$H_\varphi = 0$	$H_\varphi = 0$

$$H_\rho(\rho, \varphi) = \frac{1}{\mu_0 \gamma_{p,m} c} \frac{m}{\rho} E_z$$

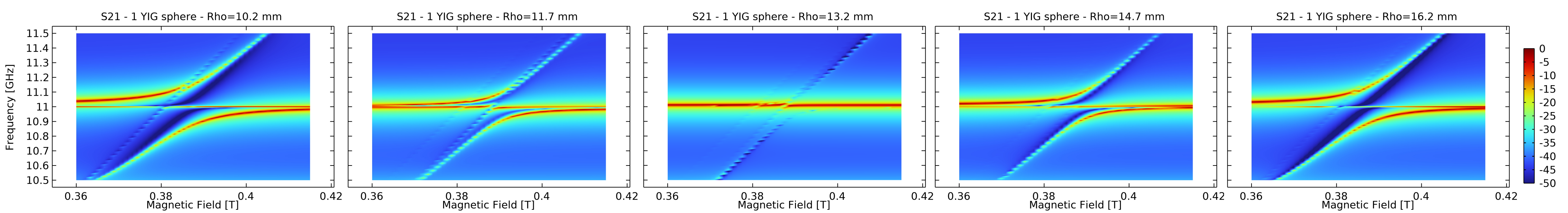
$$H_\varphi(\rho, \varphi) = -i \frac{1}{\mu_0 \gamma_{p,m} c} \frac{\partial E_z}{\partial \rho}$$

## SIMULATION & MEASUREMENT



**Simulation:**

- We calculate the microwave-induced dynamics of the Kittel mode by solving the coupled Maxwell and linearized Landau-Lifshitz-Gilbert (LLG) equation in the frequency domain in the macrospin by an electromagnetic FEM
- Simulated microwave transmission amplitudes for  $m = 2$  TE mode of the SIW chiral cavity as a function of the radial sphere position.



## CONCLUSION & PERSPECTIVES

- Simple sphere setup: 2 and 3 ports configuration, frequency and magnetic field dependence as function of the radial position
- The confirmation of predicted results [2] demonstrates the feasibility of a proposed multiple sphere setup, in which the magnets are placed along the same radial line and will coherently couple to one another
- New design configuration: low loss dielectric substrate and working frequency at 20, 30 and 40 GHz

## REFERENCES

[1] Jeremy Bourhill, Weichao Yu, Vincent Vlaminck, et al. Generation of Circulating Cavity Magnon Polaritons, Phys. Rev. Appl. 19, 014030 (1 2023)  
[2] Weichao Yu, Tao Yu, and Gerrit E. W. Bauer. Circulating cavity magnon polaritons. Phys. Rev. B 102, 064416 (6 2020)

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