DARK PHOTONS & AXION LIKE PARTICLES INTERFEROMETER

DALI

Status and prospects of the DALI Experiment

Javier De Miguel on behalf of the DALI Collaboration

19th Patras Workshop on Axions WIMPs and WISPs

PROSPECTS

VOLUME 51, NUMBER 16 PHYSICAL REVIEW LETTERS 17 OCTOBER 1983

Experimental Tests of the "Invisible" Axion

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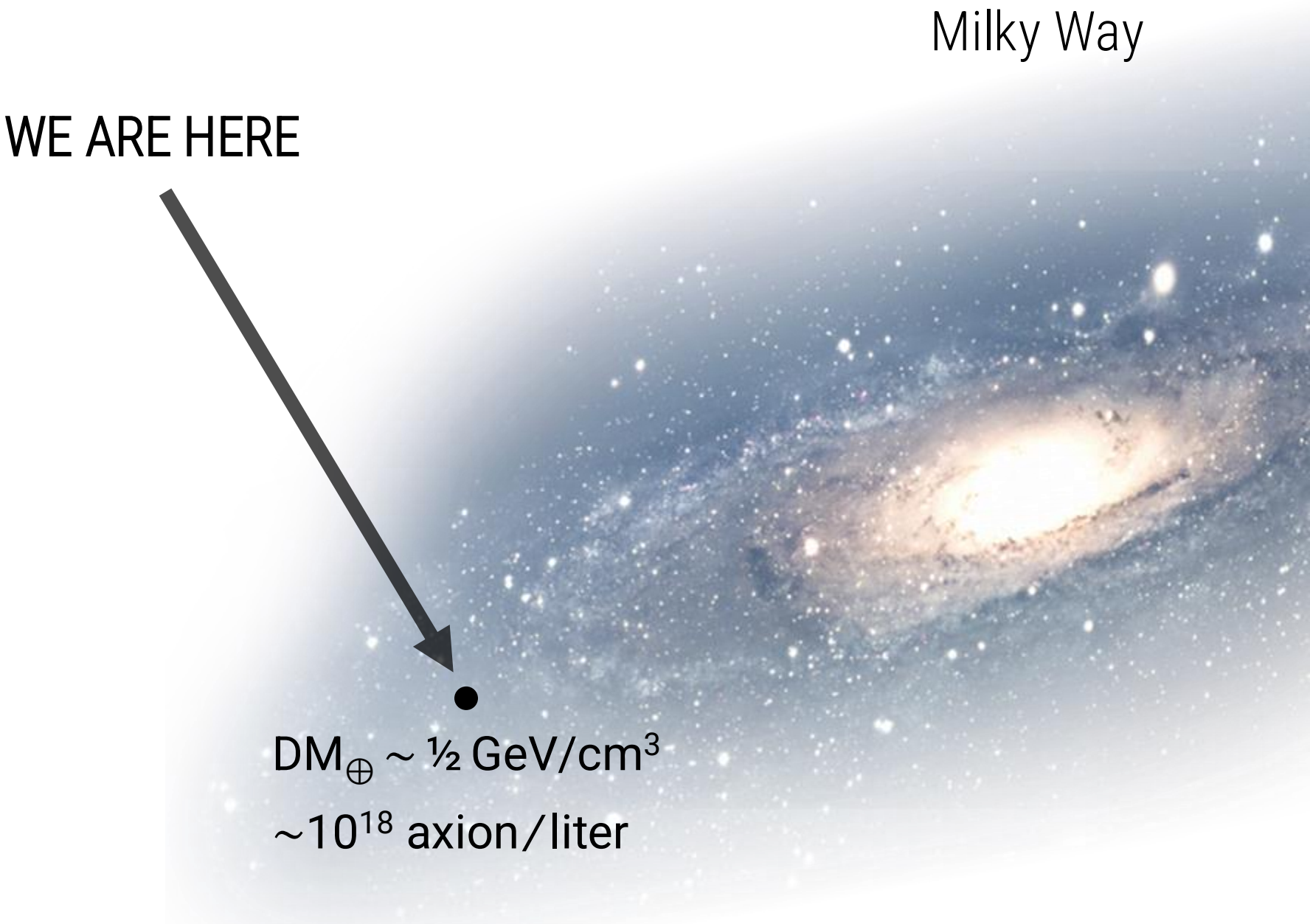
Physics Department, University of Florida, Gainesville, Florida 32611
(Received 13 July 1983)

Experiments are proposed which address the question of the existence of the "invisible" axion for the whole allowed range of the axion decay constant. These experiments exploit the coupling of the axion to the electromagnetic field, axion emission by the sun, and/or the cosmological abundance and presumed clustering of axions in the halo of our galaxy.


Milky Way
WE ARE HERE
$DM_{\oplus} \sim ½$ GeV/cm^3
$\sim 10^{18}$ axion/liter

DARK PHOTONS & AXION LIKE PARTICLES INTERFEROMETER

DALI

DARK PHOTONS & AXION LIKE PARTICLES INTERFEROMETER DALI

RIKEN

(SENDAI, JAPAN)

DARK PHOTONS & AXION LIKE PARTICLES INTERFEROMETER

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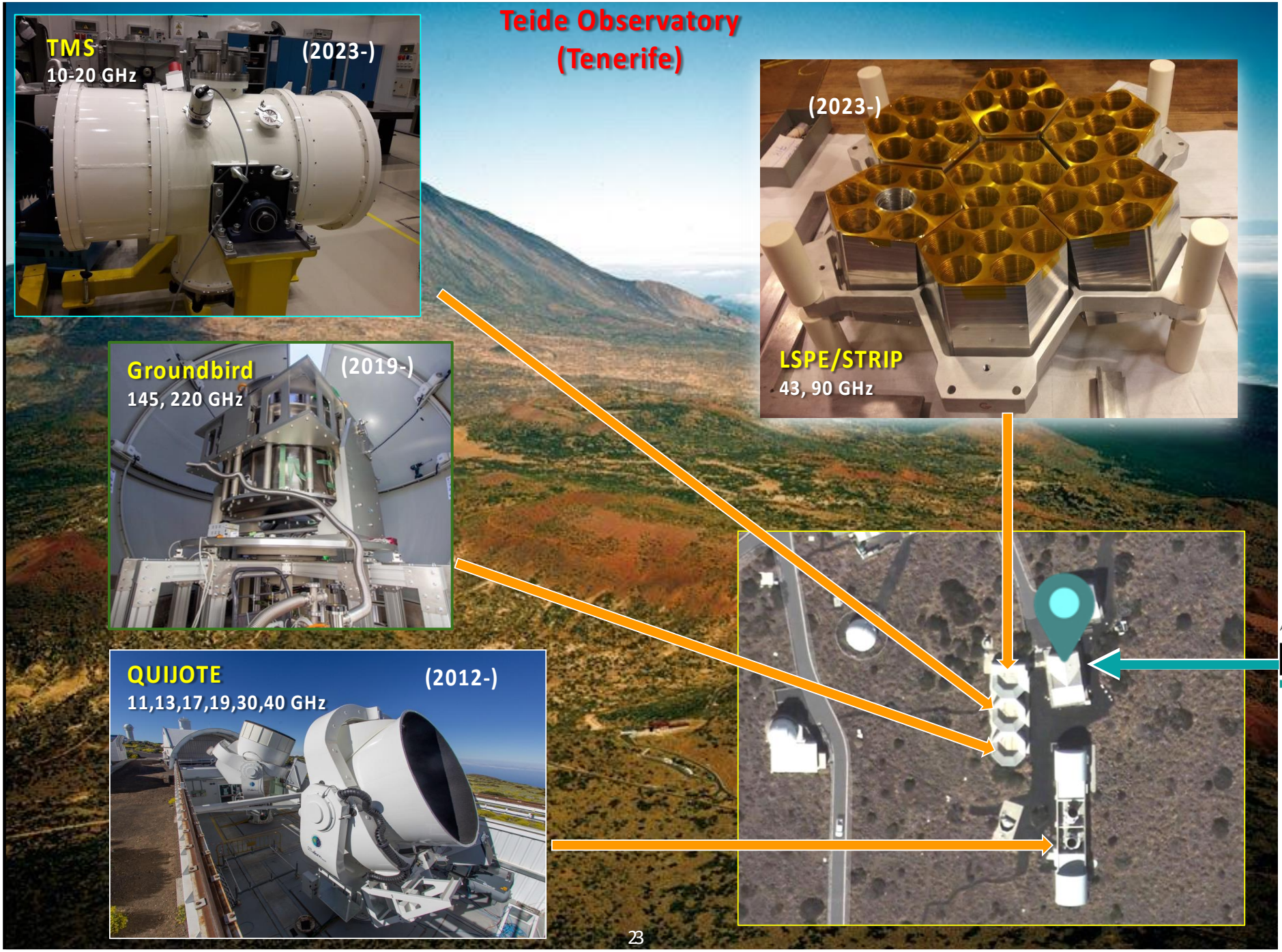

Teide Observatory
(Tenerife)
TMS
10-20 GHz
(2023-)
(2023-)
LSPE/STRIP
43, 90 GHz
Groundbird
145, 220 GHz
(2019-)
QUIJOTE
11,13,17,19,30,40 GHz
(2012-)

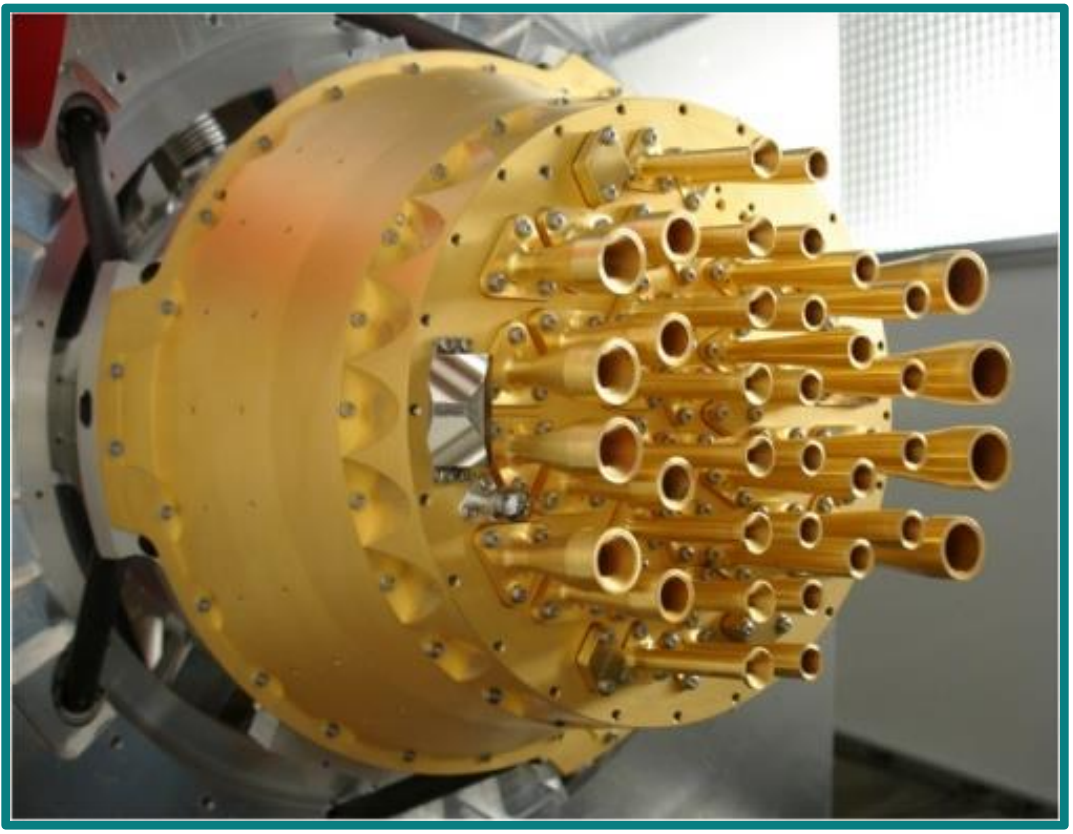
CMB

"PHASED ARRAY" TELESCOPES

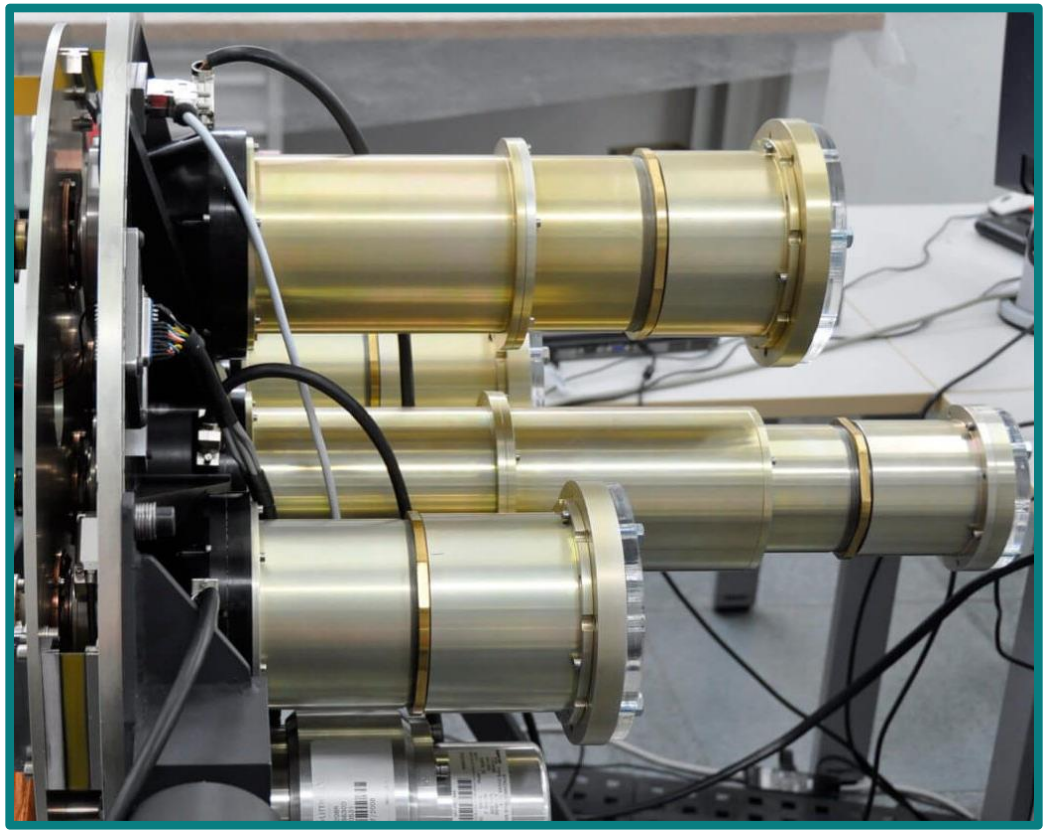
→

Dark Matter

MAGNETIZED "PHASED ARRAY" HALOSCOPE

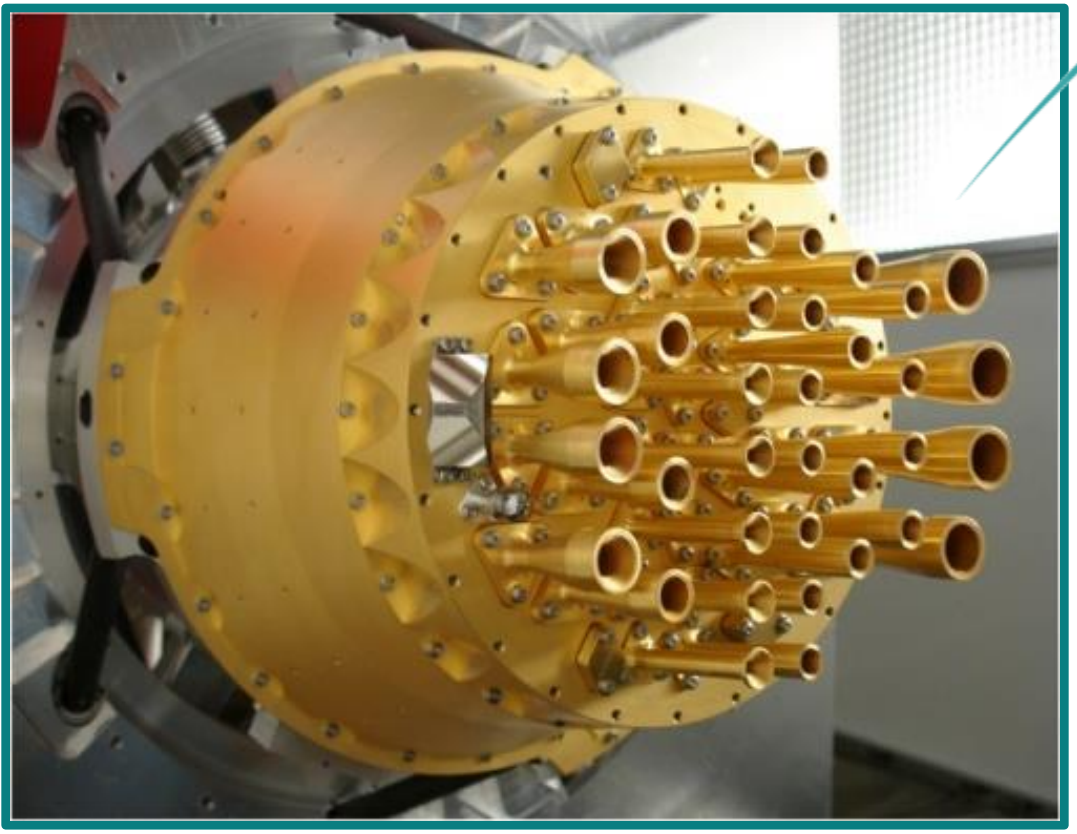


Planck LFI (27-77 GHz)

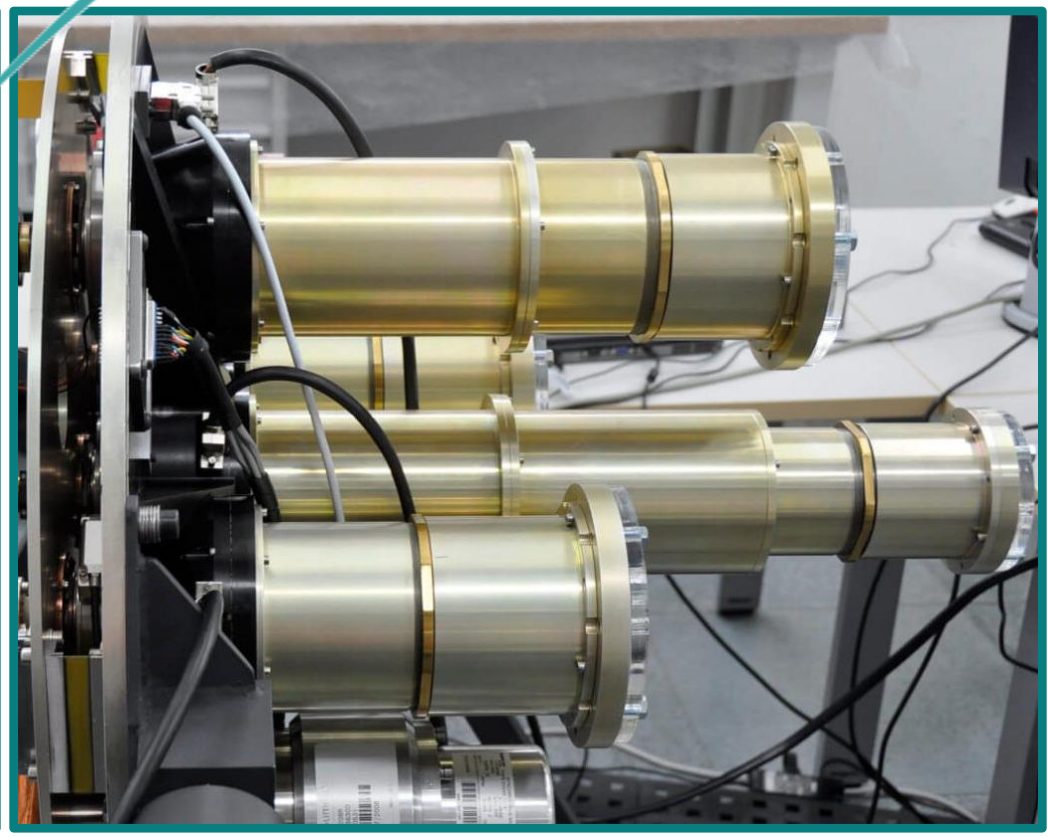


QUIJOTE-CMB MFI (10-42 GHz)

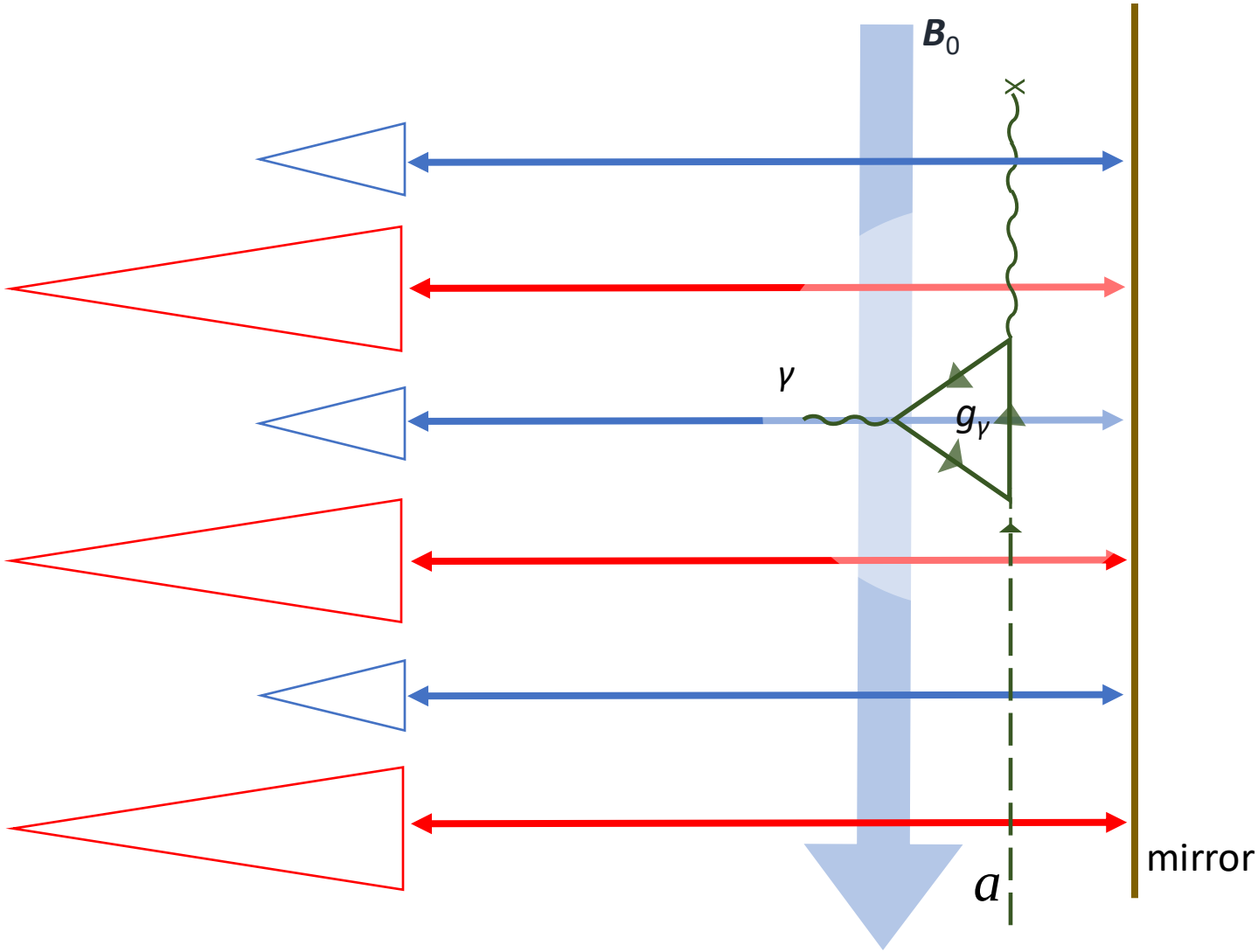
DALI



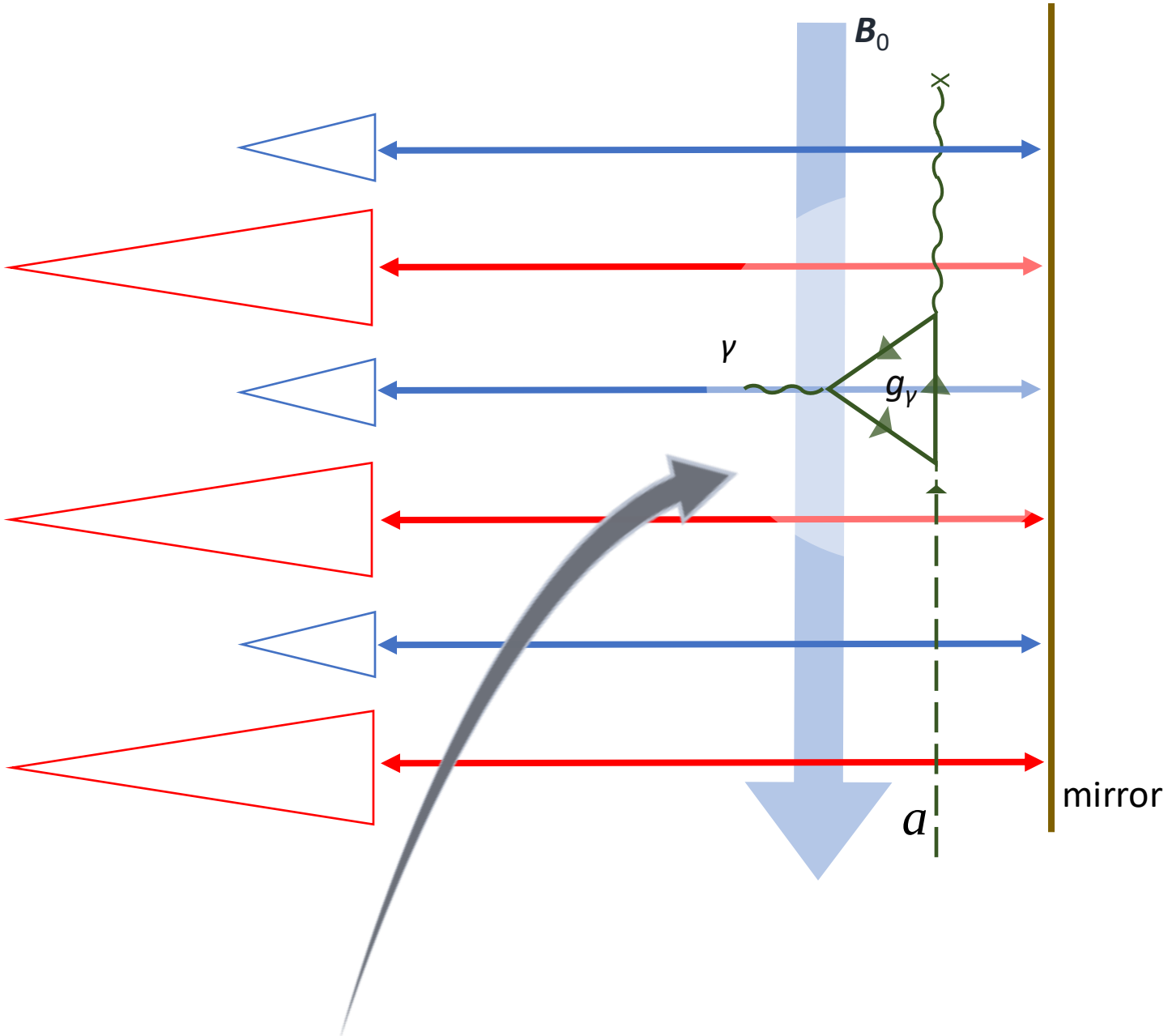
Planck LFI (27-77 GHz)



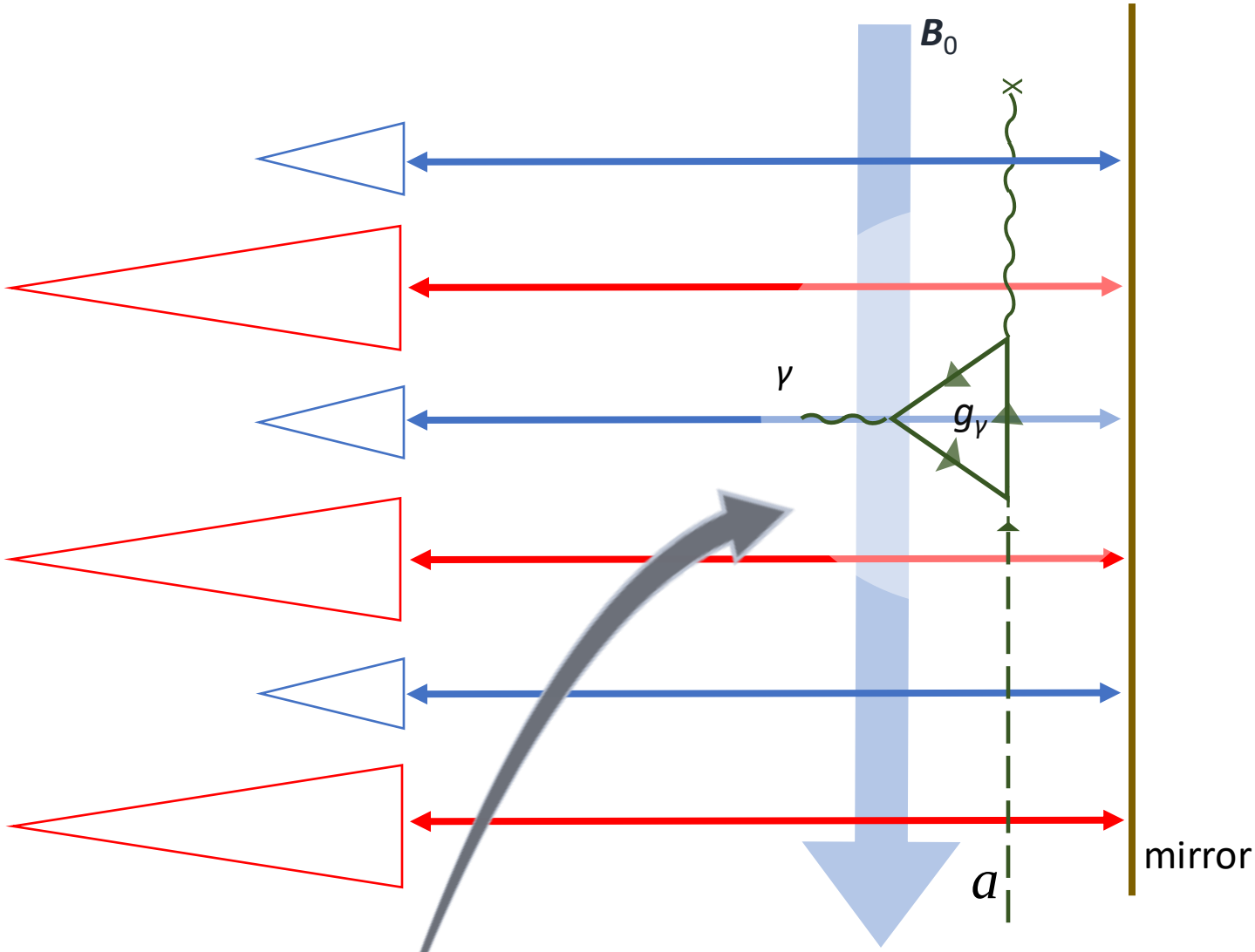
QUIJOTE-CMB MFI (10-42 GHz)



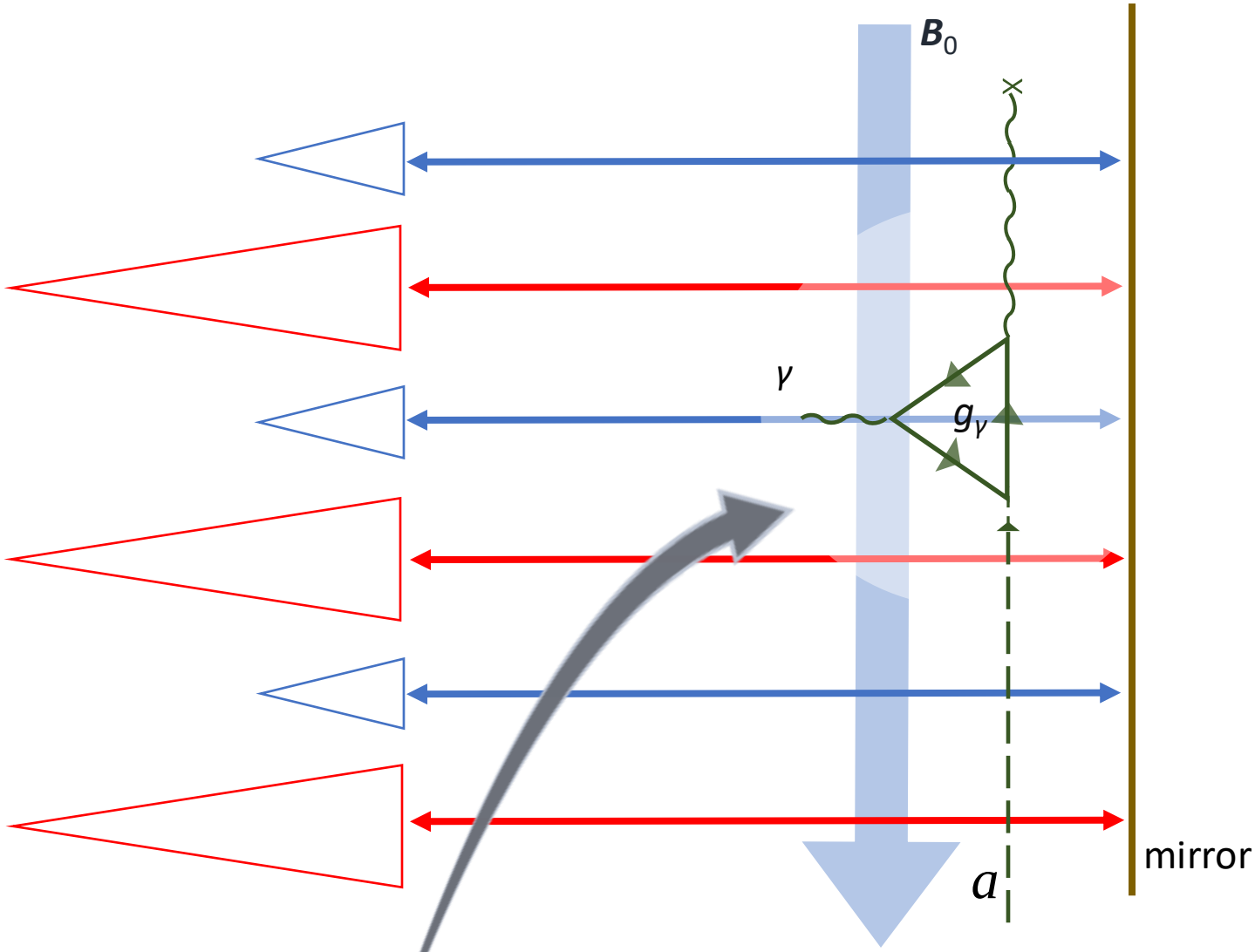
Magnetized phased array (MPA) haloscope



MPA + Resonator

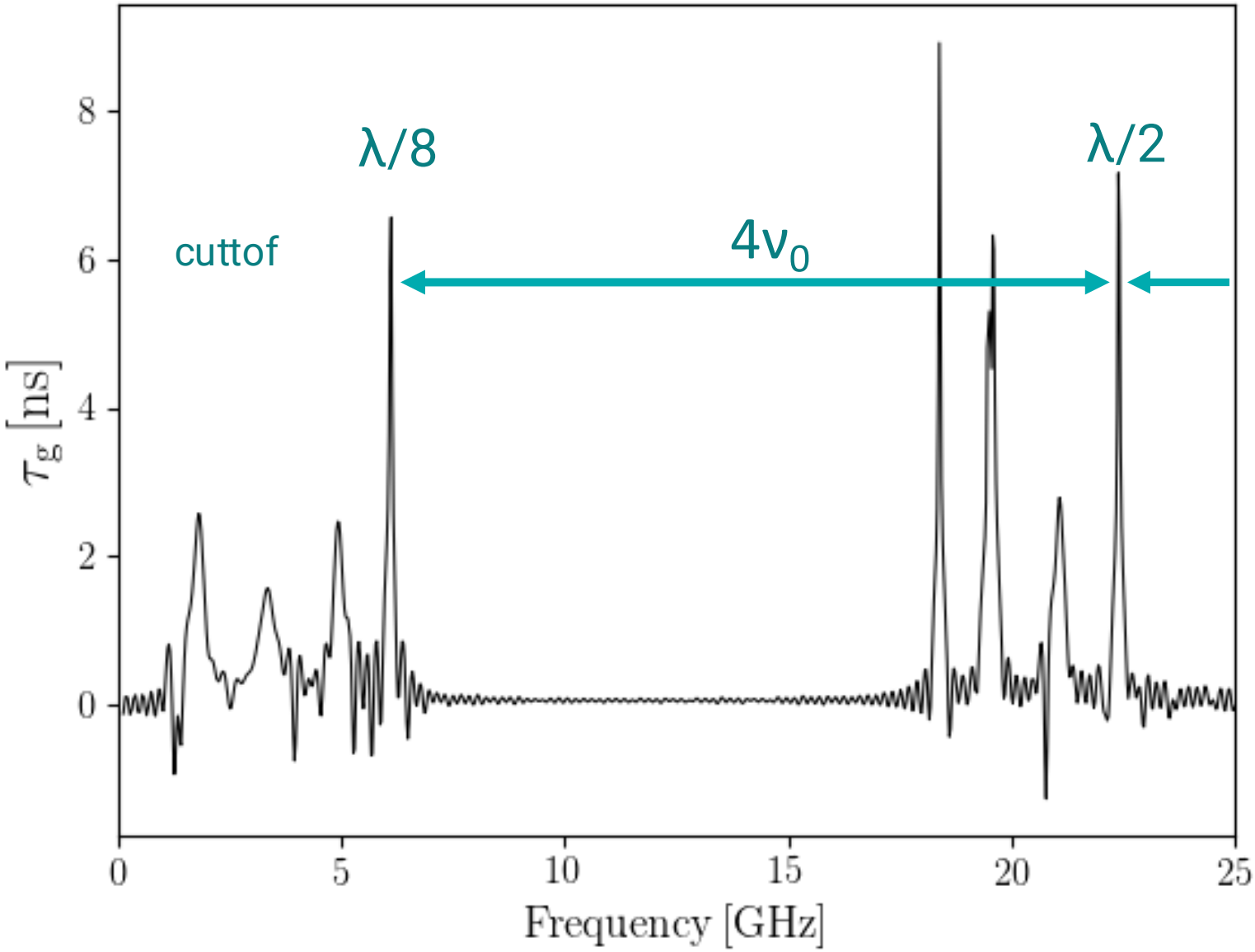


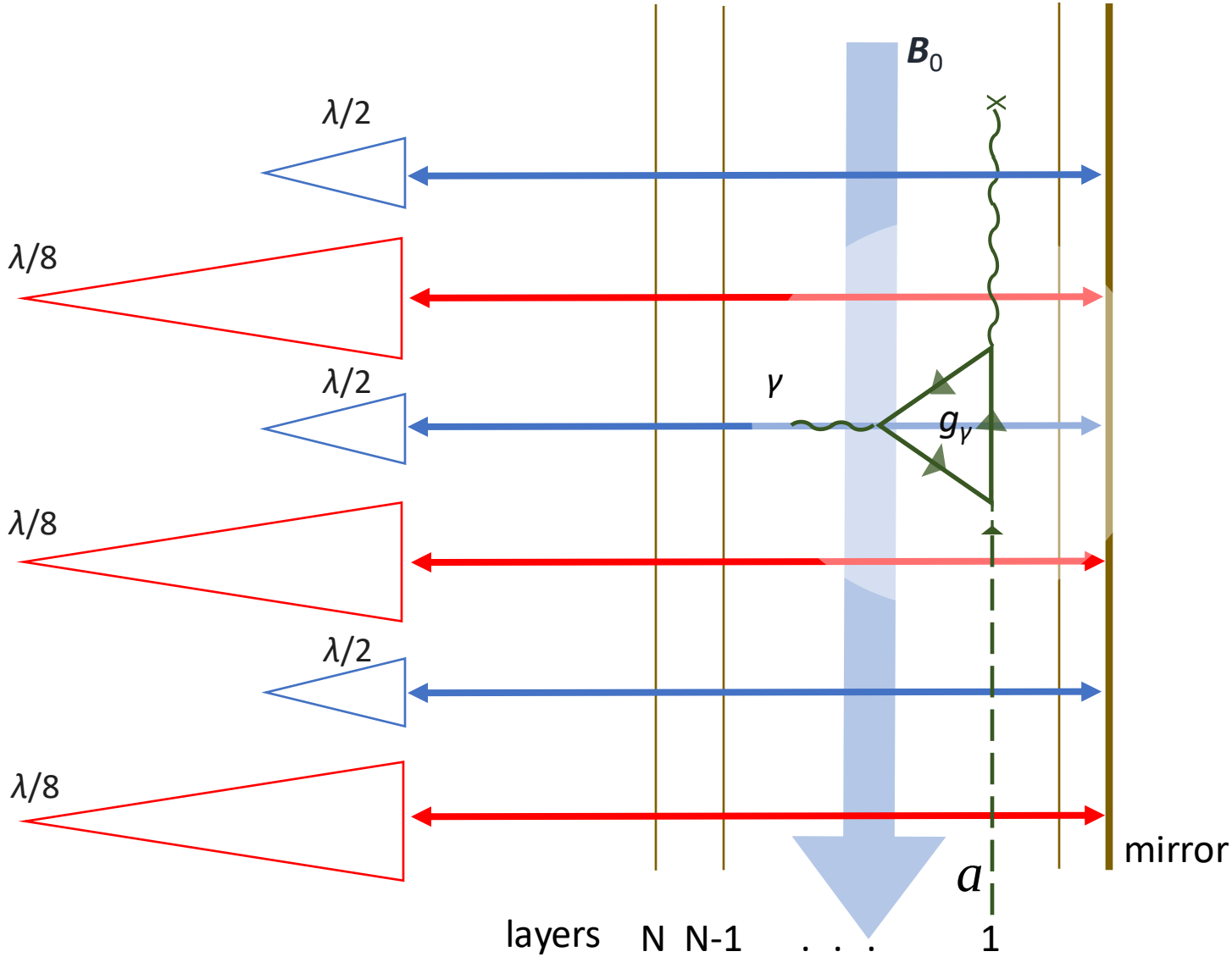
MPA + Resonator
- Cavities
- Fabry-Pérot (FP)
- Metamaterials



MPA + Resonator
- Cavities
- Fabry-Pérot (FP)
- Metamaterials

Fabry-Pérot





MPA + Resonator
- Cavities
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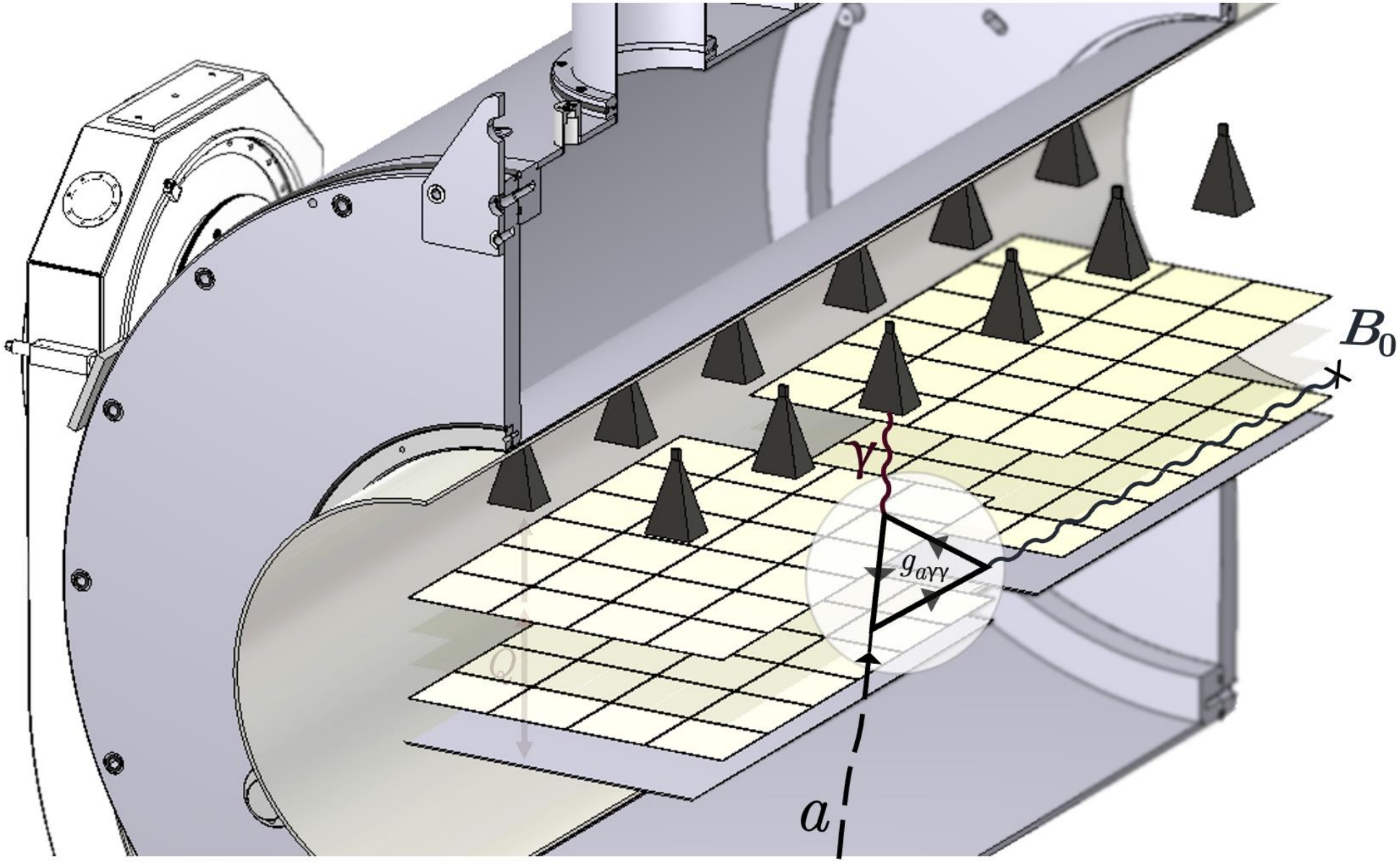
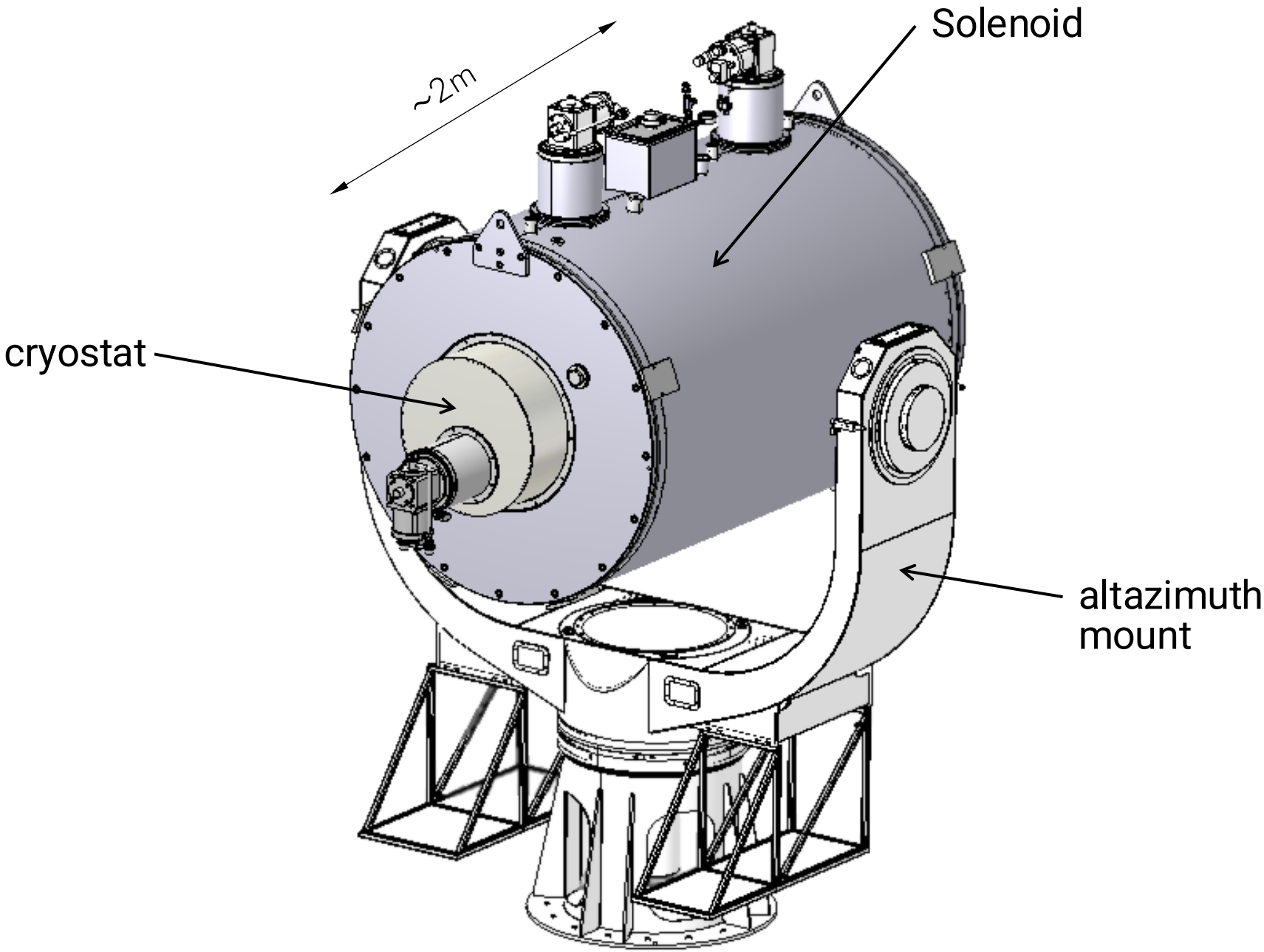
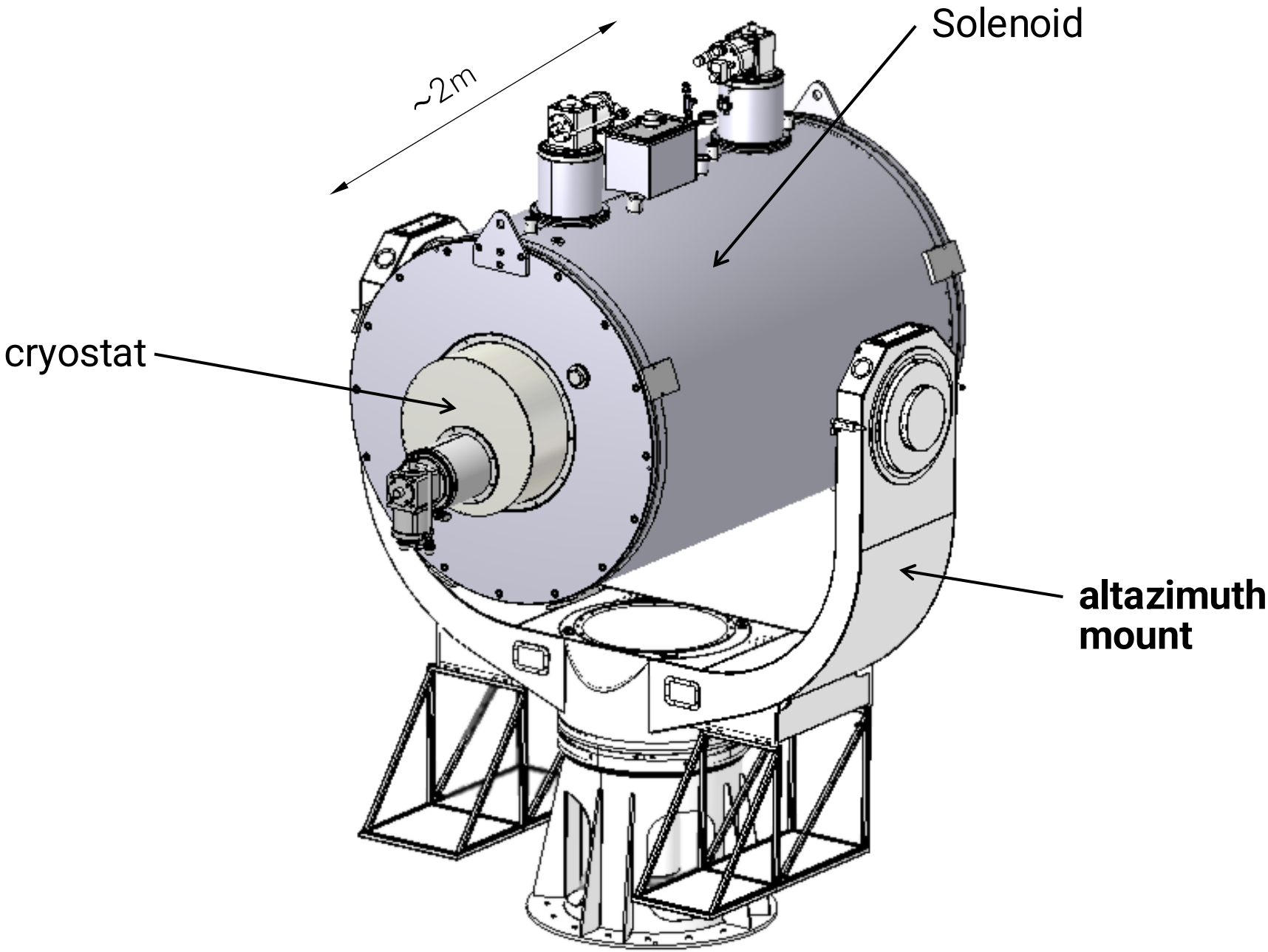
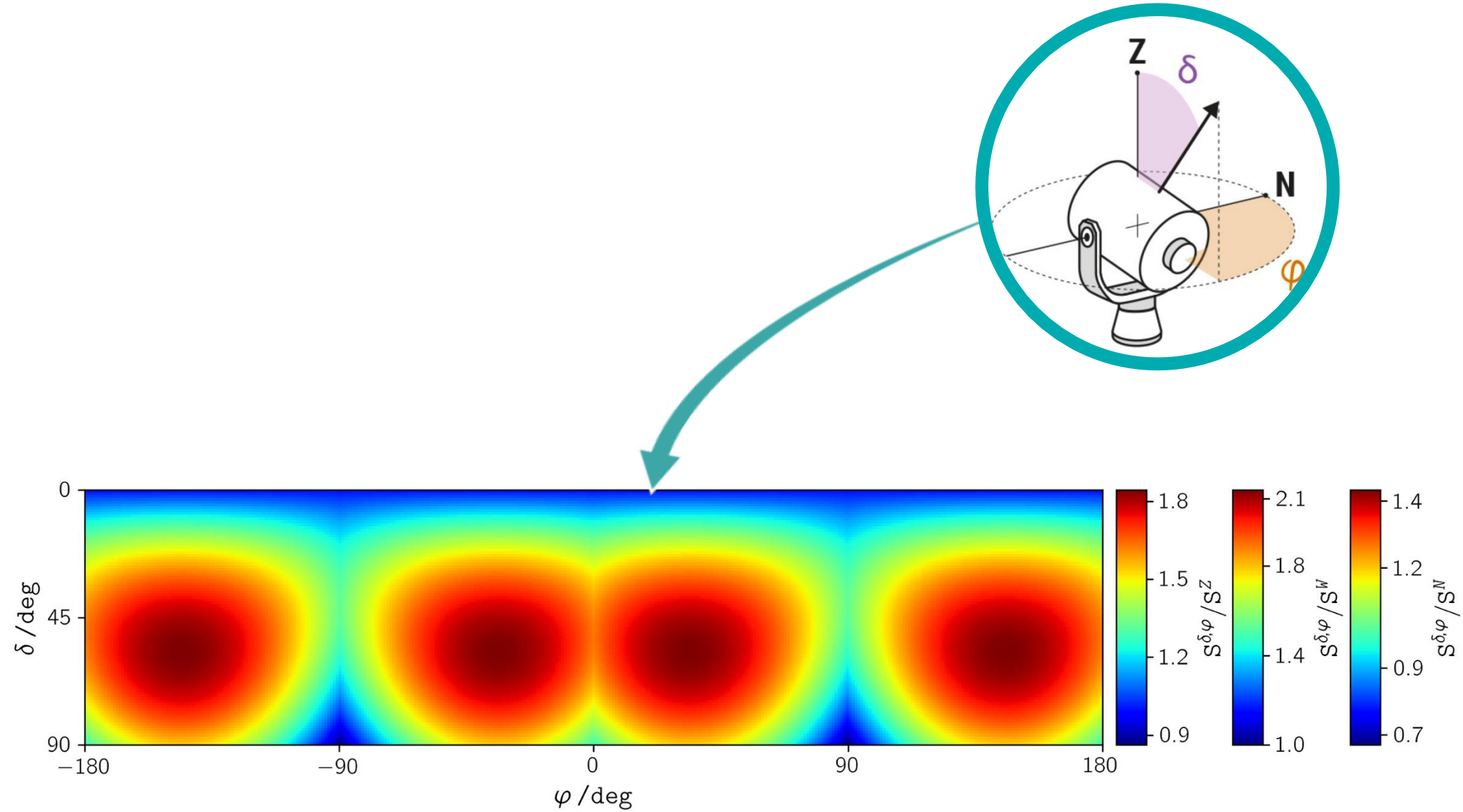
- Metamaterials

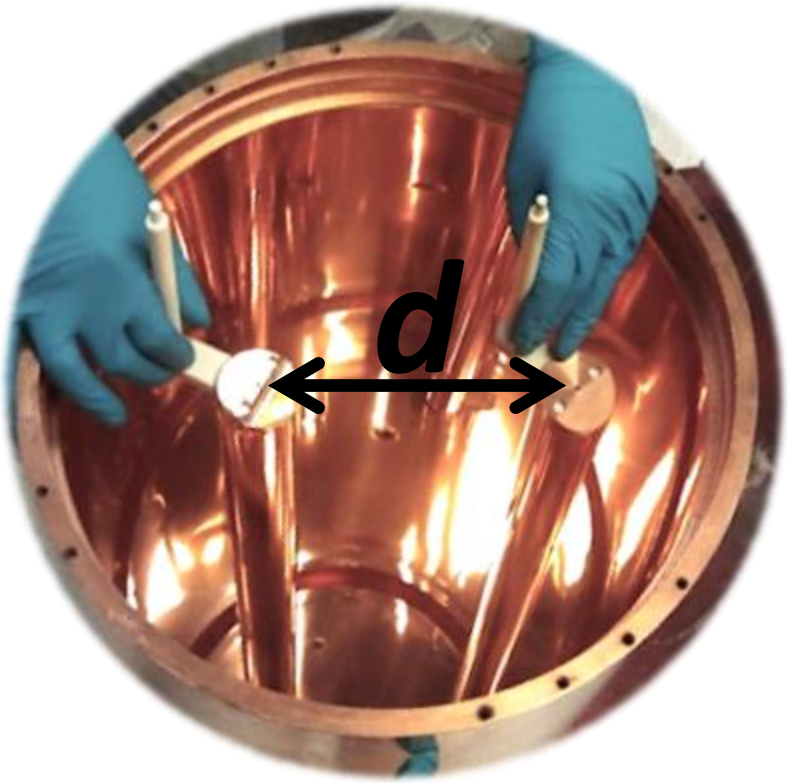

B_0
γ
$g_{a\gamma\gamma}$
a


~2m
Solenoid
cryostat
altazimuth mount


~2m
Solenoid
cryostat
altazimuth mount


Z
δ
N
φ
0
45
90
δ /deg
−180
−90
0
90
180
φ /deg
1.8
1.5
1.2
0.9
$S^{\delta,\varphi}/S^{Z}$
2.1
1.8
1.4
1.0
$S^{\delta,\varphi}/S^{M}$
1.4
1.2
0.9
0.7
$S^{\delta,\varphi}/S^{N}$

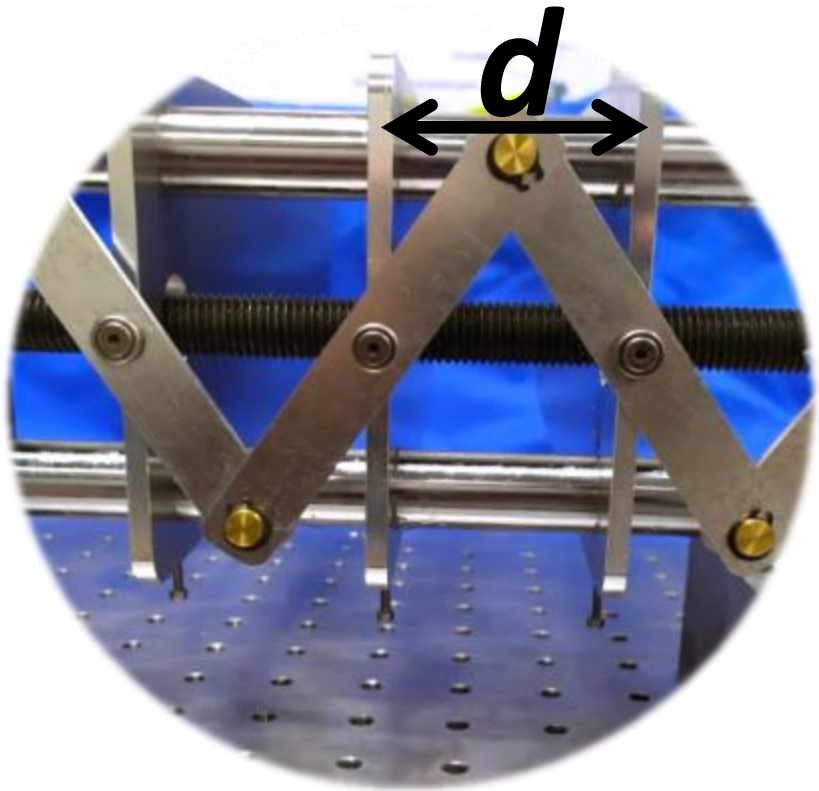
Resonant cavity (ADMX)



$d \sim \lambda$

Power $\propto \lambda^2$

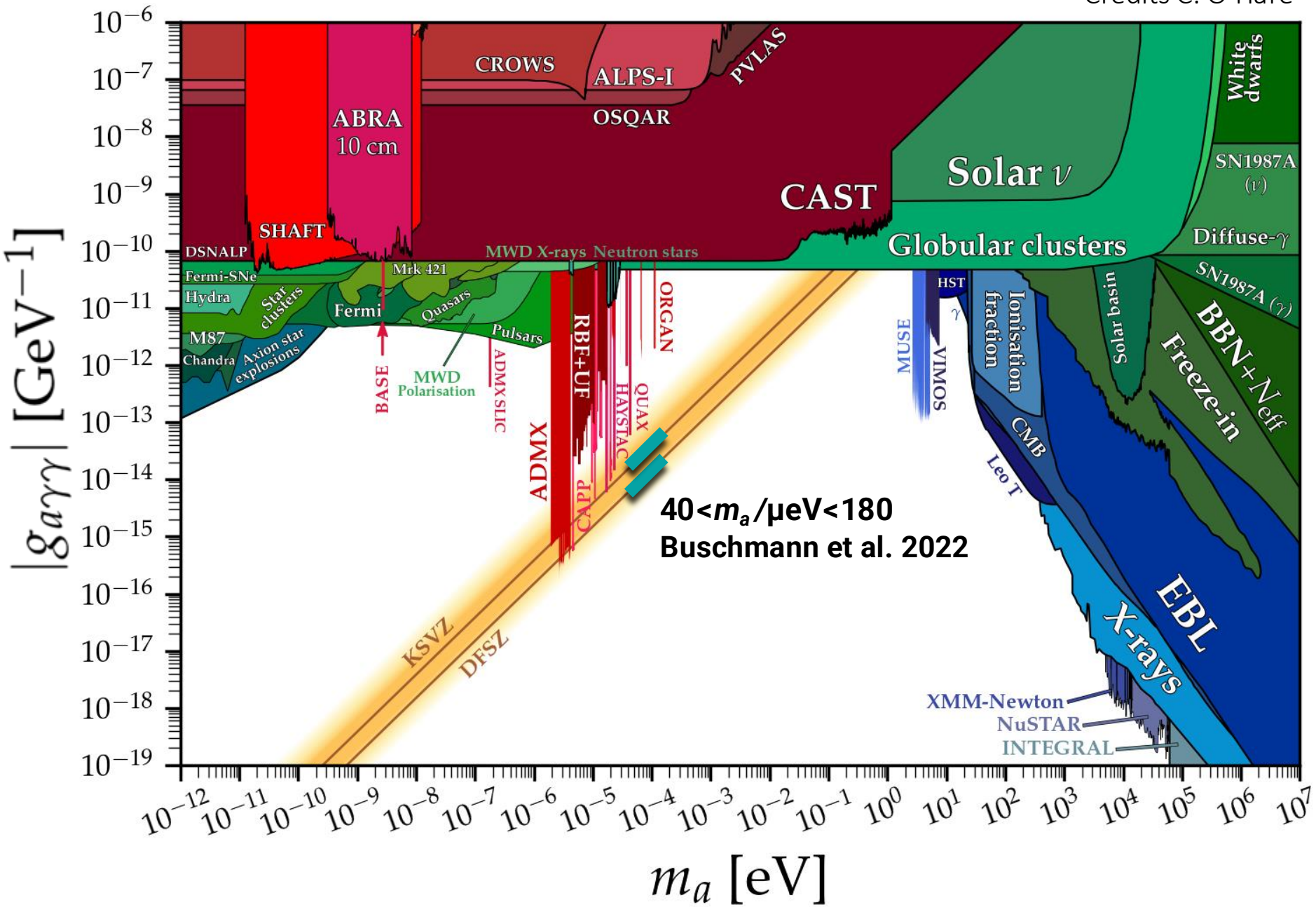
Fabry-Pérot (DALI)

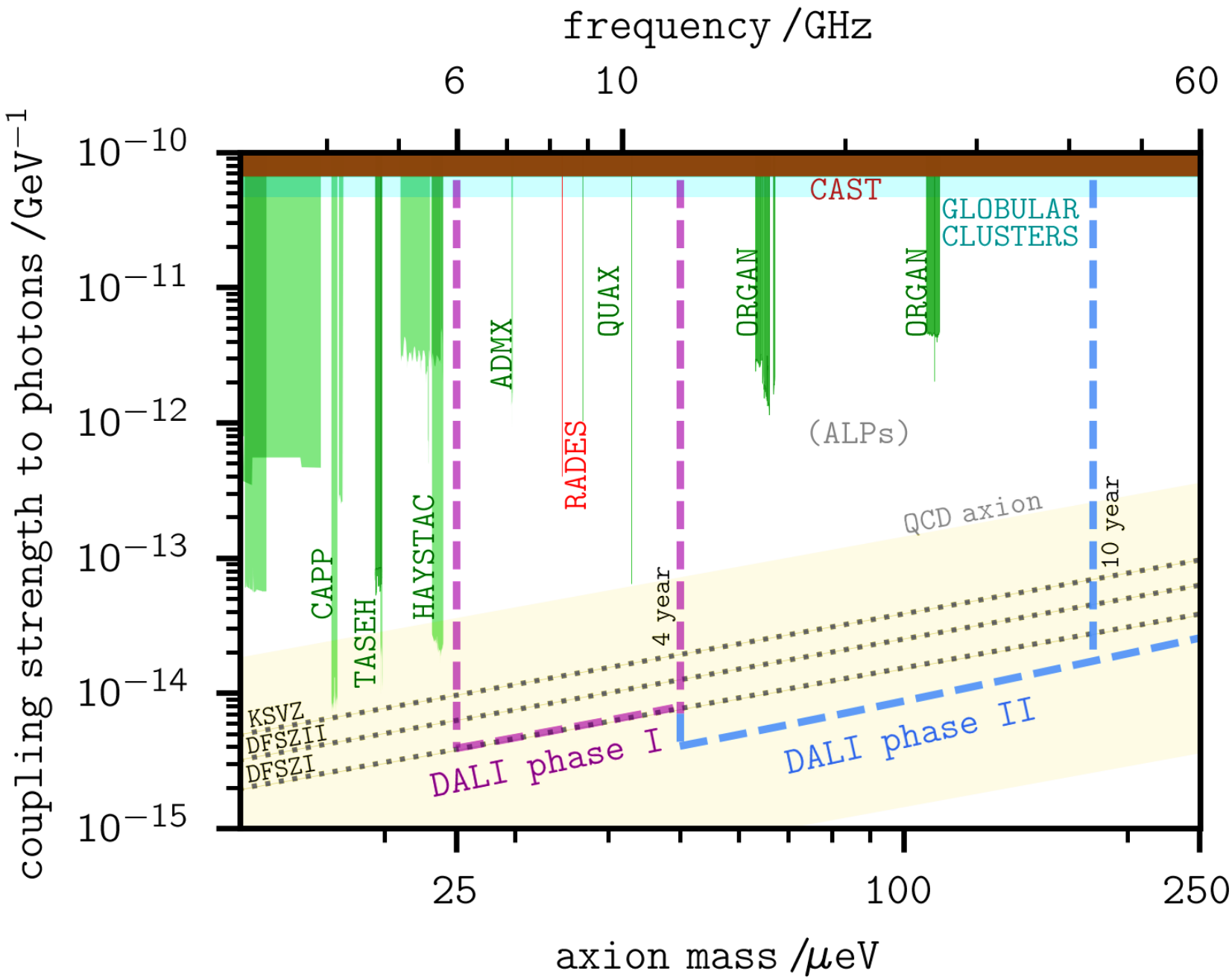


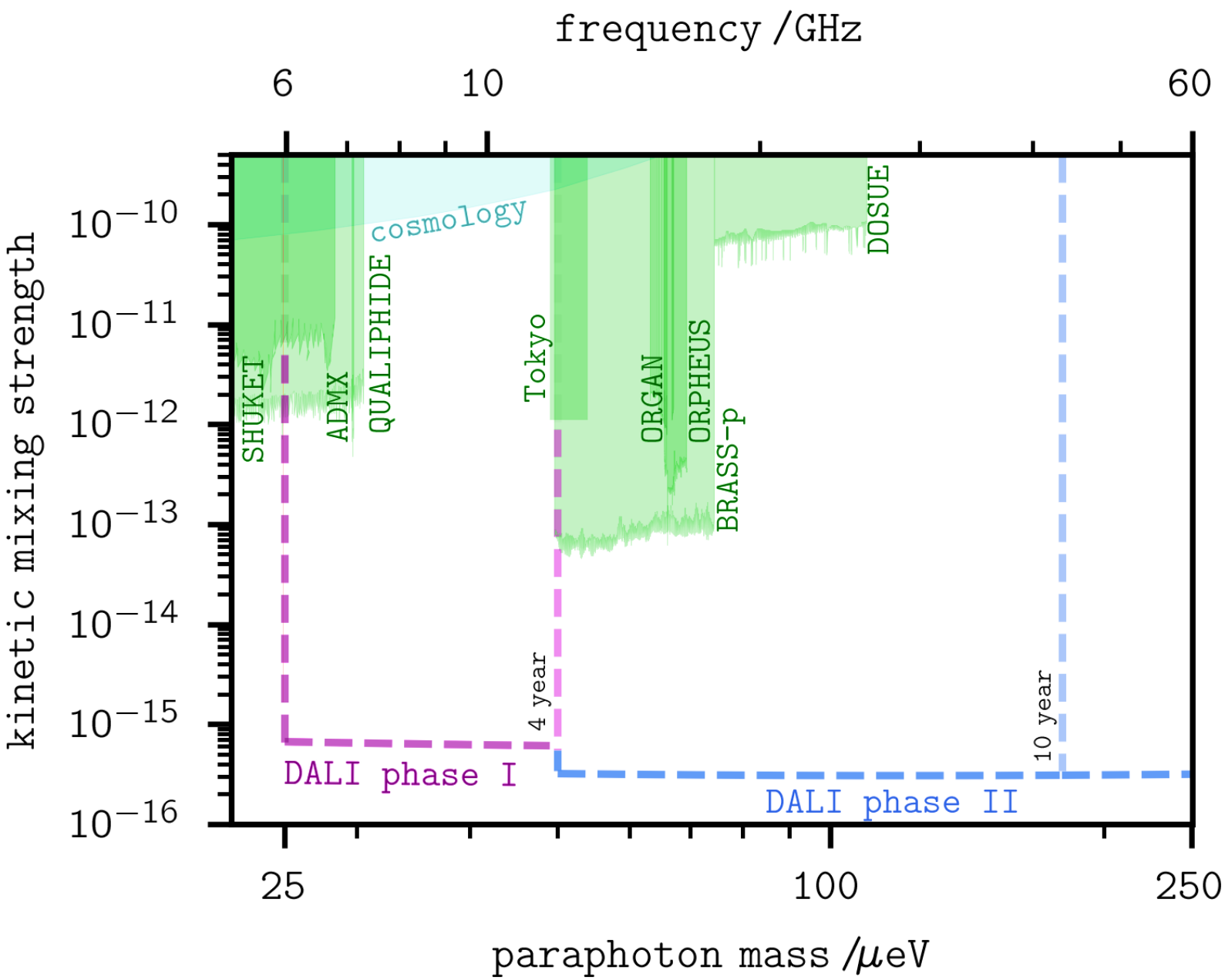
$d \sim \lambda$

Power $\propto$ Area

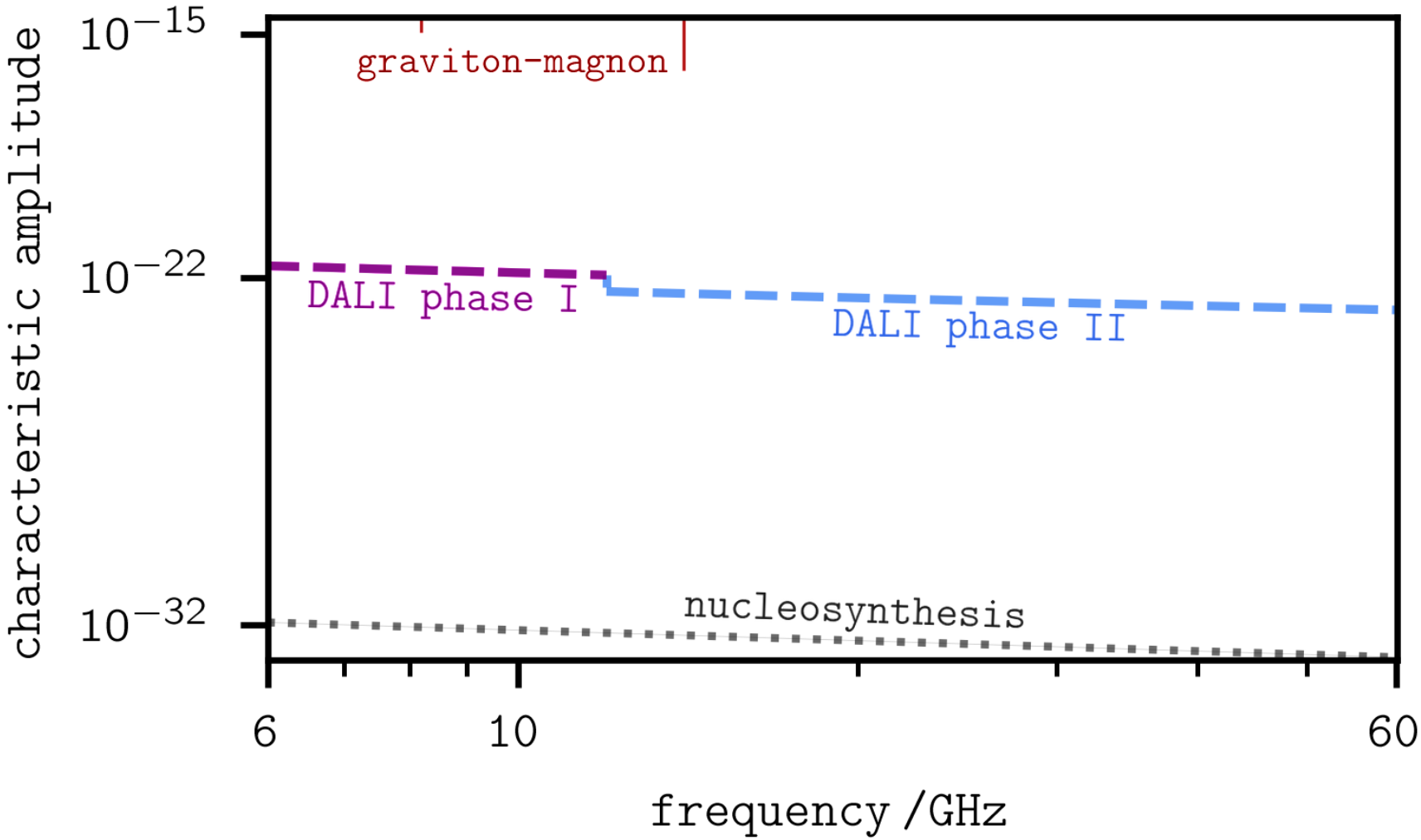
Credits C. O'Hare



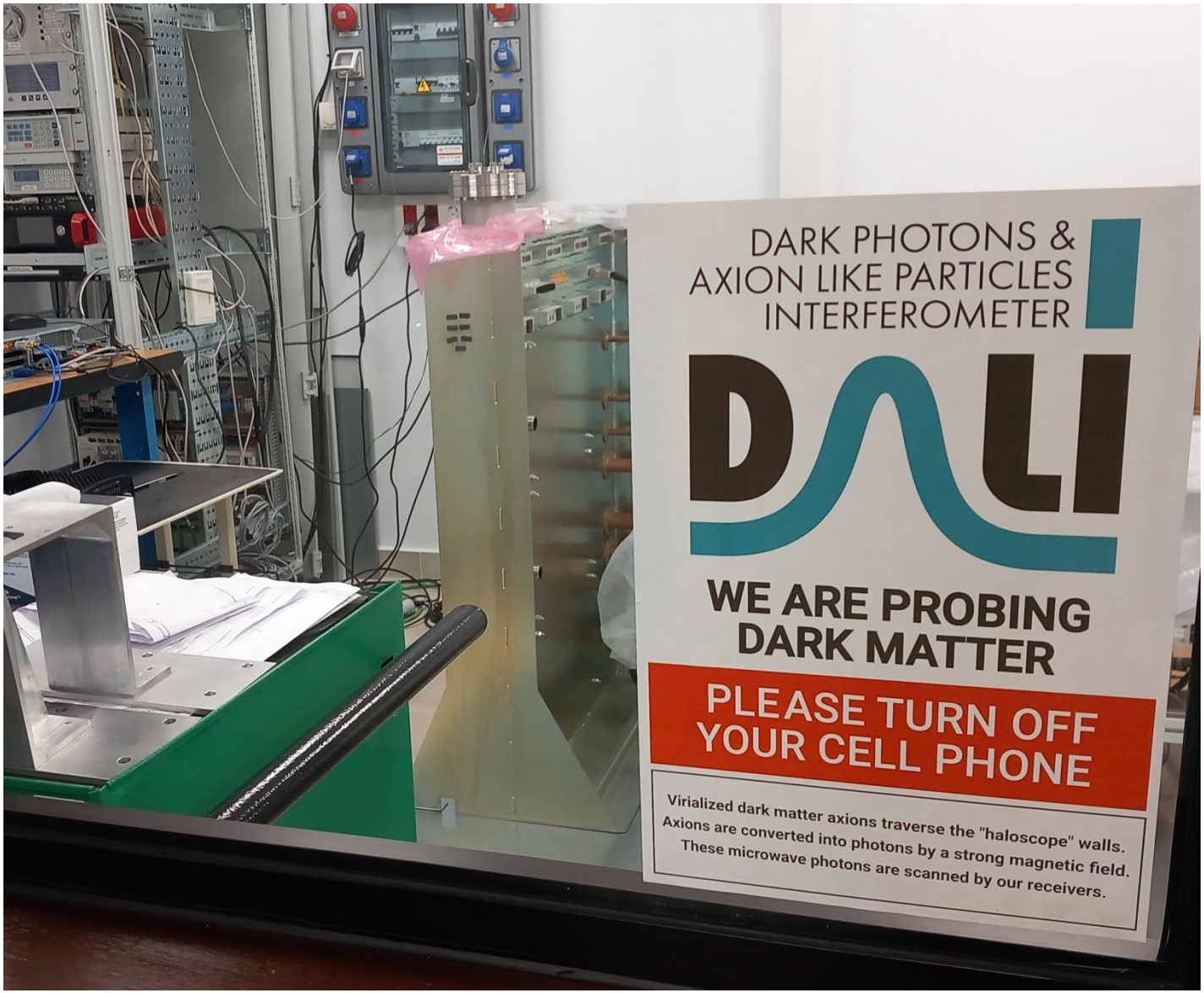

frequency /GHz
6
10
60
coupling strength to photons /GeV^{-1}
10^{-10}
10^{-11}
10^{-12}
10^{-13}
10^{-14}
10^{-15}
CAST
GLOBULAR CLUSTERS
ORGAN
ORGAN
QUAX
ADMX
RADES
HAYSTAC
TASEH
CAPP
(ALPs)
QCD axion
10 year
4 year
KSVZ
DFSZII
DFSZI
DALI phase I
DALI phase II
25
100
250
axion mass /μeV


frequency /GHz
6
10
60
kinetic mixing strength
10^{-10}
10^{-11}
10^{-12}
10^{-13}
10^{-14}
10^{-15}
10^{-16}
cosmology
SHUKET
ADMX
QUALIPHIDE
Tokyo
ORGAN
ORPHEUS
BRASS-p
DOSUE
4 year
10 year
DALI phase I
DALI phase II
25
100
250
paraphoton mass /μeV

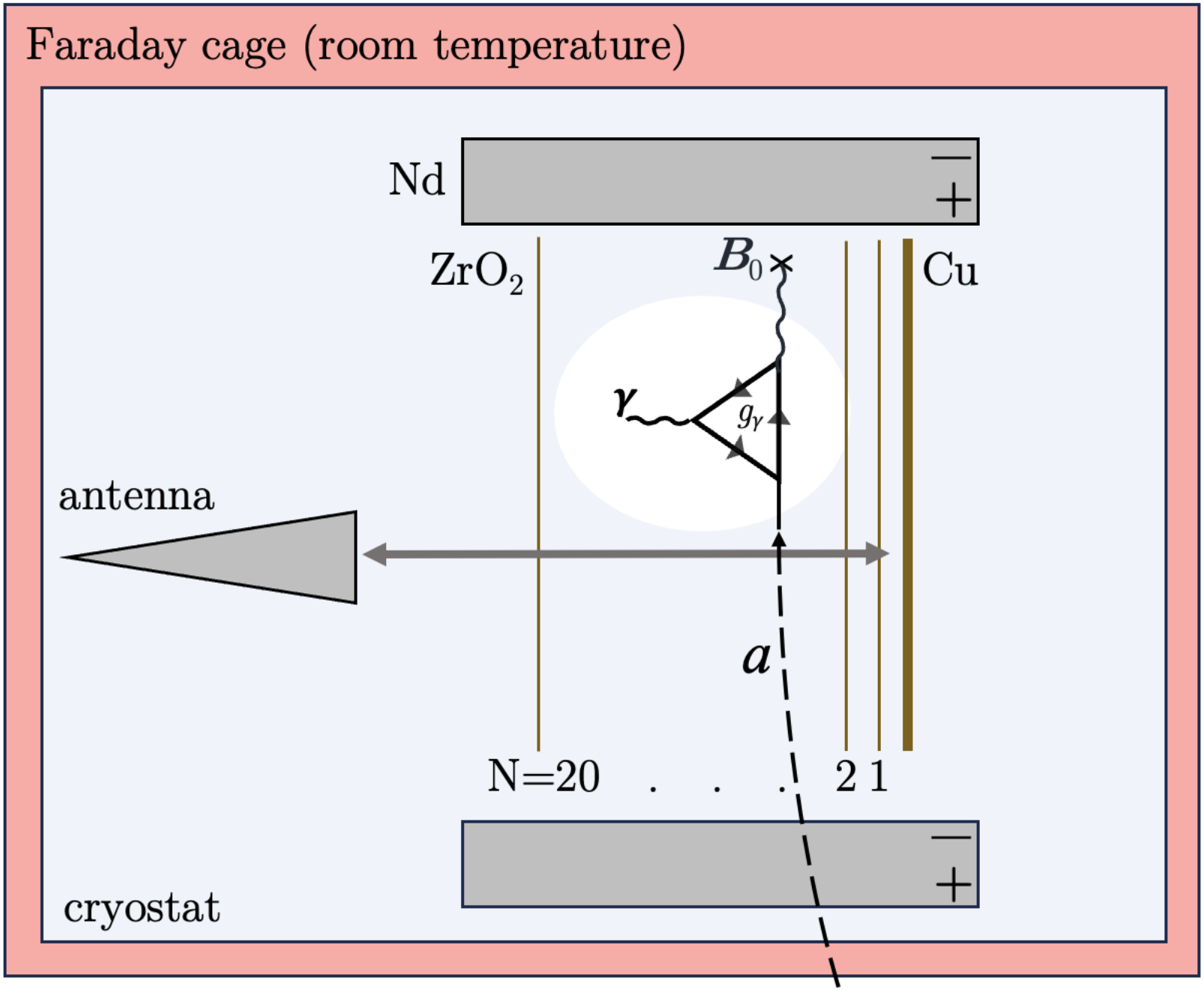
$$\mathcal{L}_{g\gamma}^{\text{int}} = -\frac{1}{2}\kappa \underbrace{h_{\mu\nu}}_{\text{graviton}} \mathrm{B}^{\mu}\,\mathrm{B}^{\nu}$$

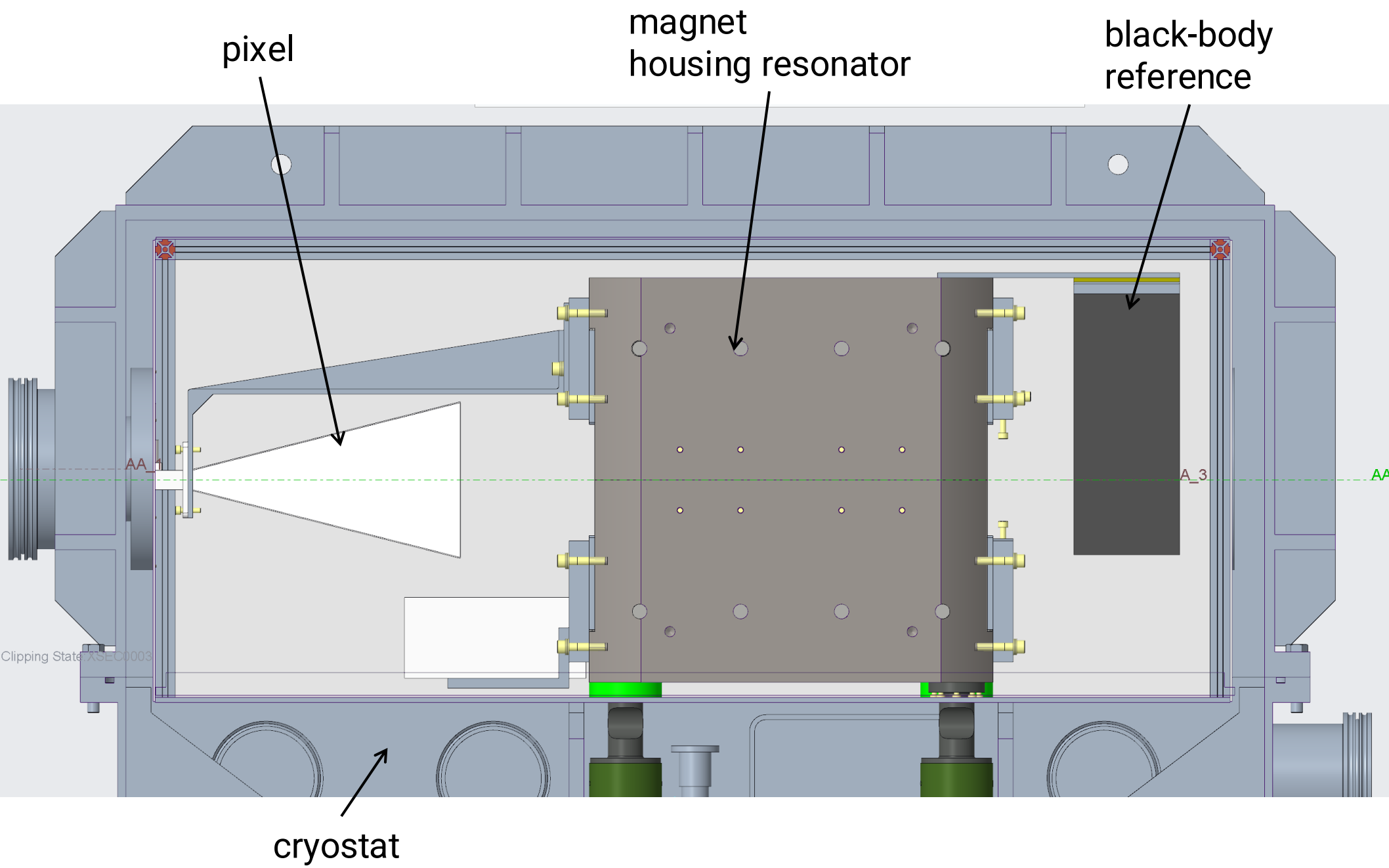

characteristic amplitude
10^{-15}
10^{-22}
10^{-32}
graviton-magnon
DALI phase I
DALI phase II
nucleosynthesis
6
10
60
frequency /GHz

STATUS


DARK PHOTONS &
AXION LIKE PARTICLES
INTERFEROMETER
DALI
WE ARE PROBING
DARK MATTER
PLEASE TURN OFF
YOUR CELL PHONE
Virialized dark matter axions traverse the "haloscope" walls.
Axions are converted into photons by a strong magnetic field.
These microwave photons are scanned by our receivers.

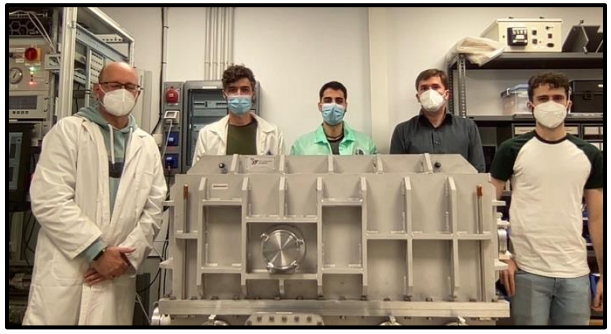
~1:10 DALI prototype

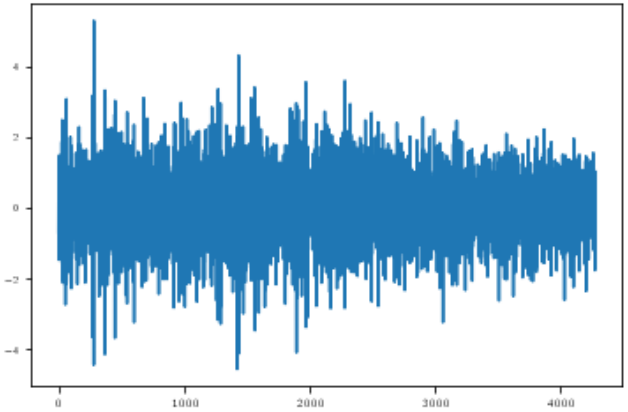



pixel
magnet
housing resonator
black-body
reference
AA_1
A_3
AA
Clipping State:XSEC0003
cryostat

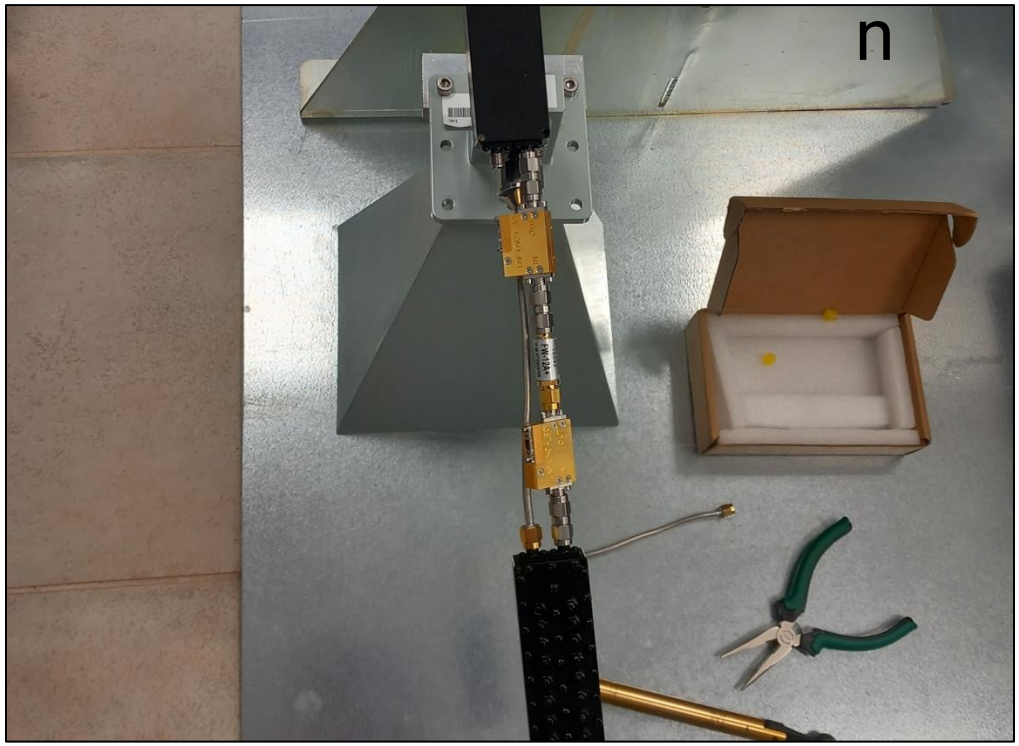

the vacuum
projects

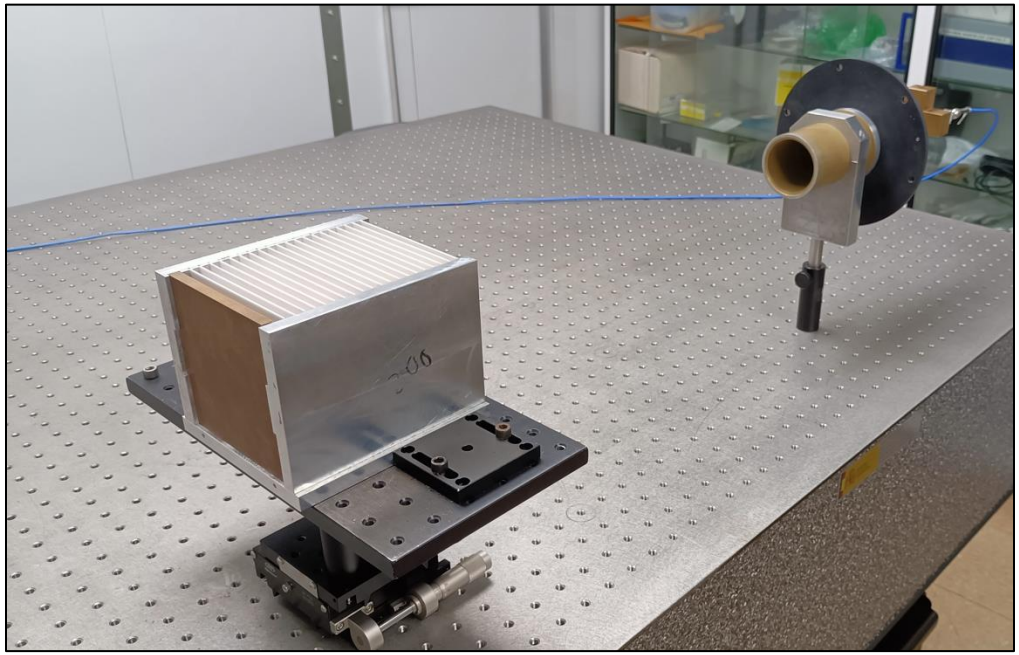
Cryogenics & Data Acquisition

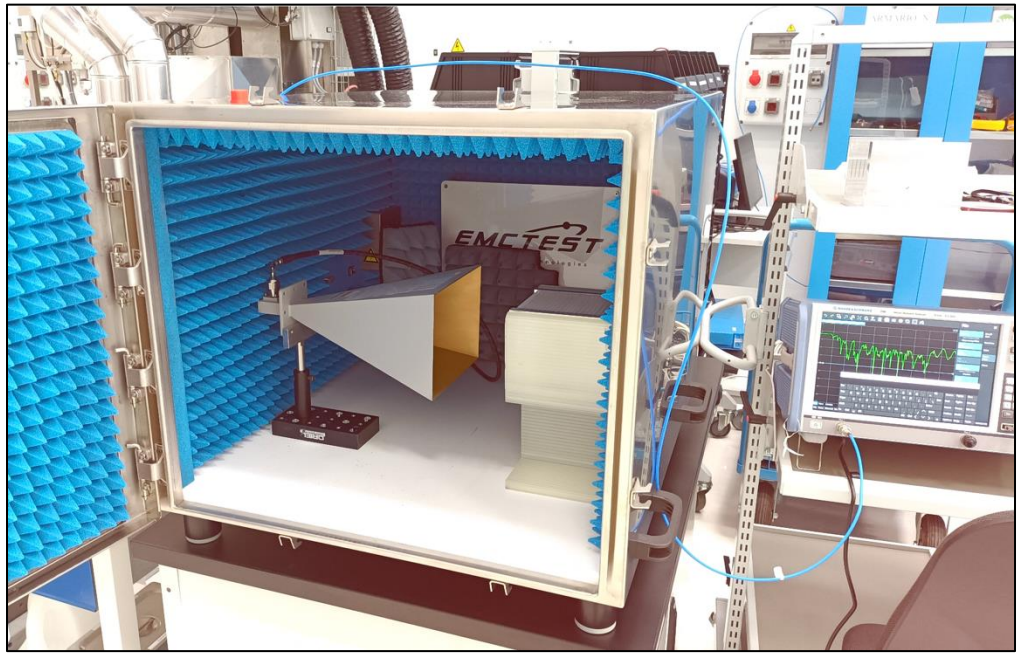




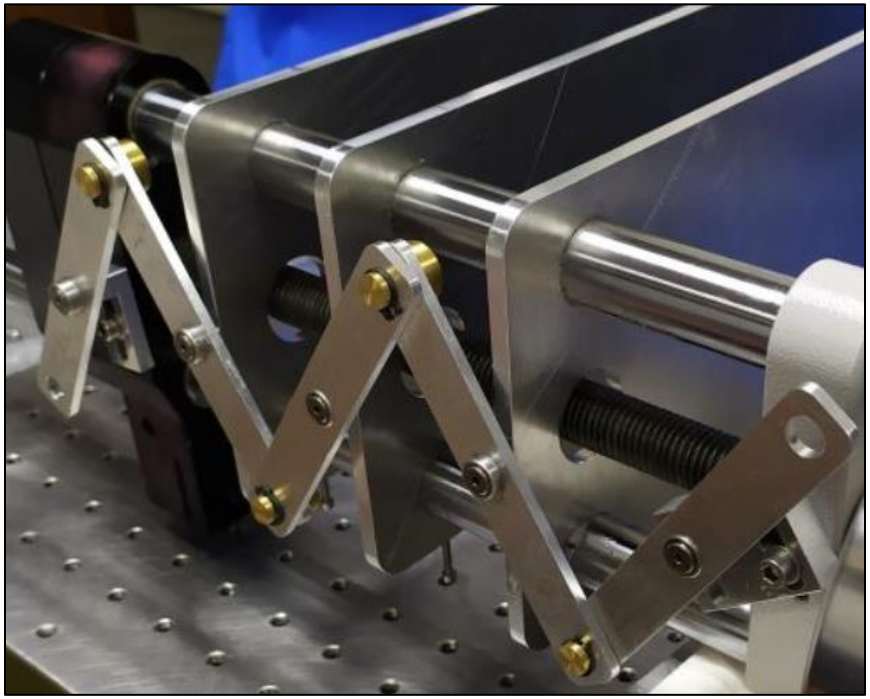
Calibration



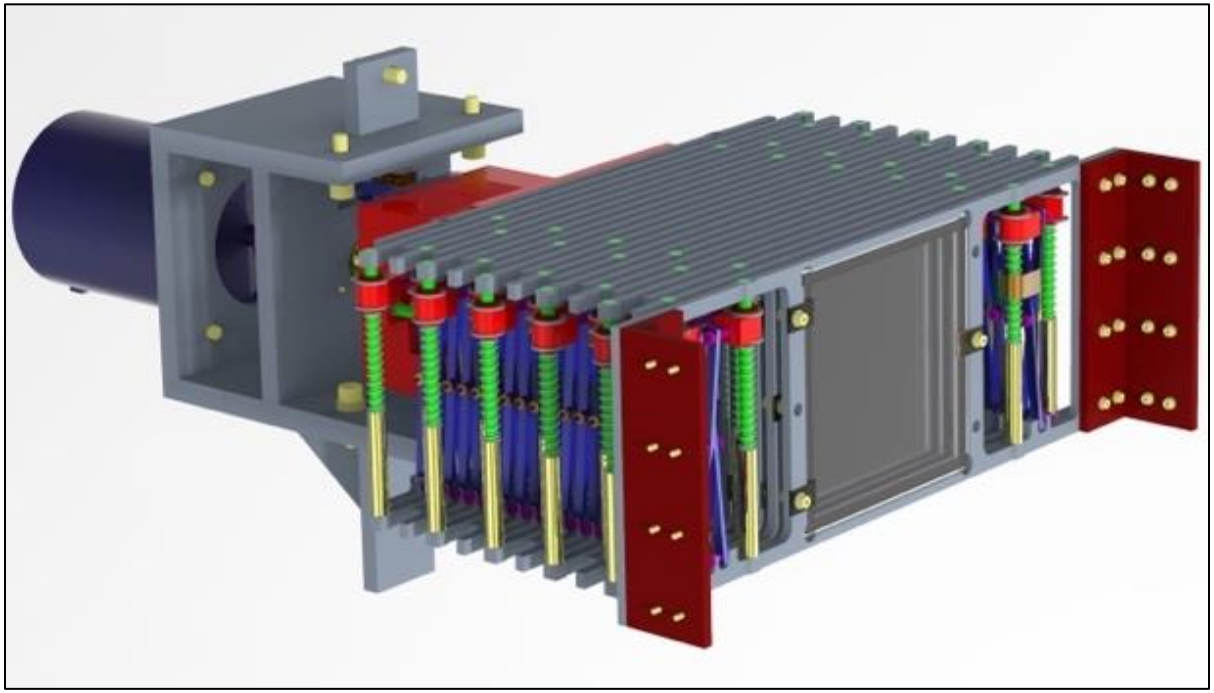




Frequency Tuner

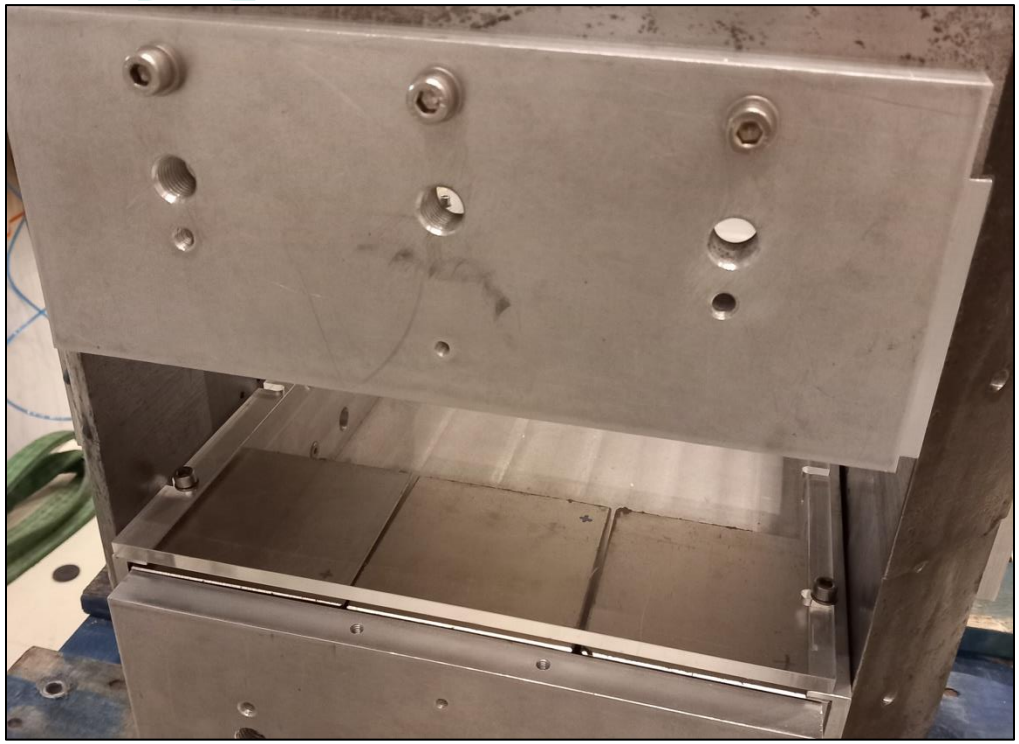


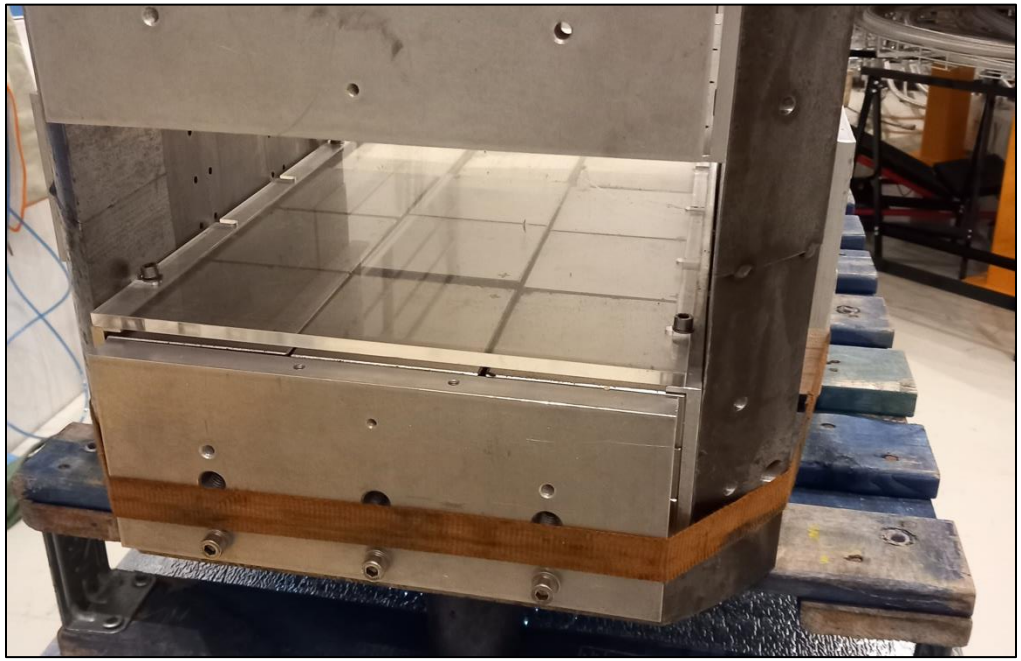
3-layer (proof-of-concept) prototype

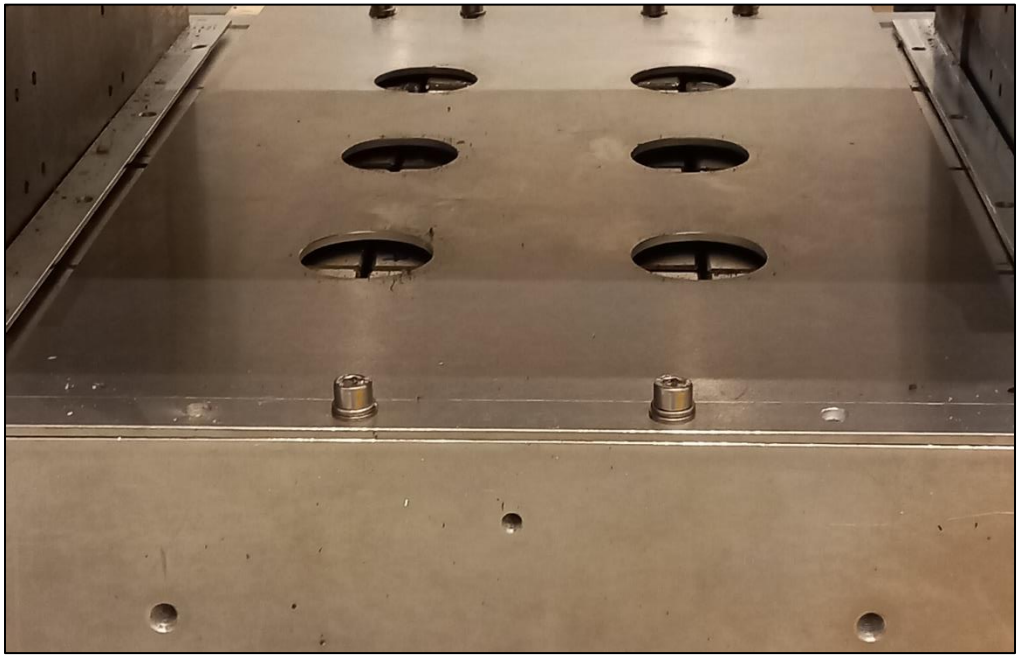


20-layer prototype (manufacturing)

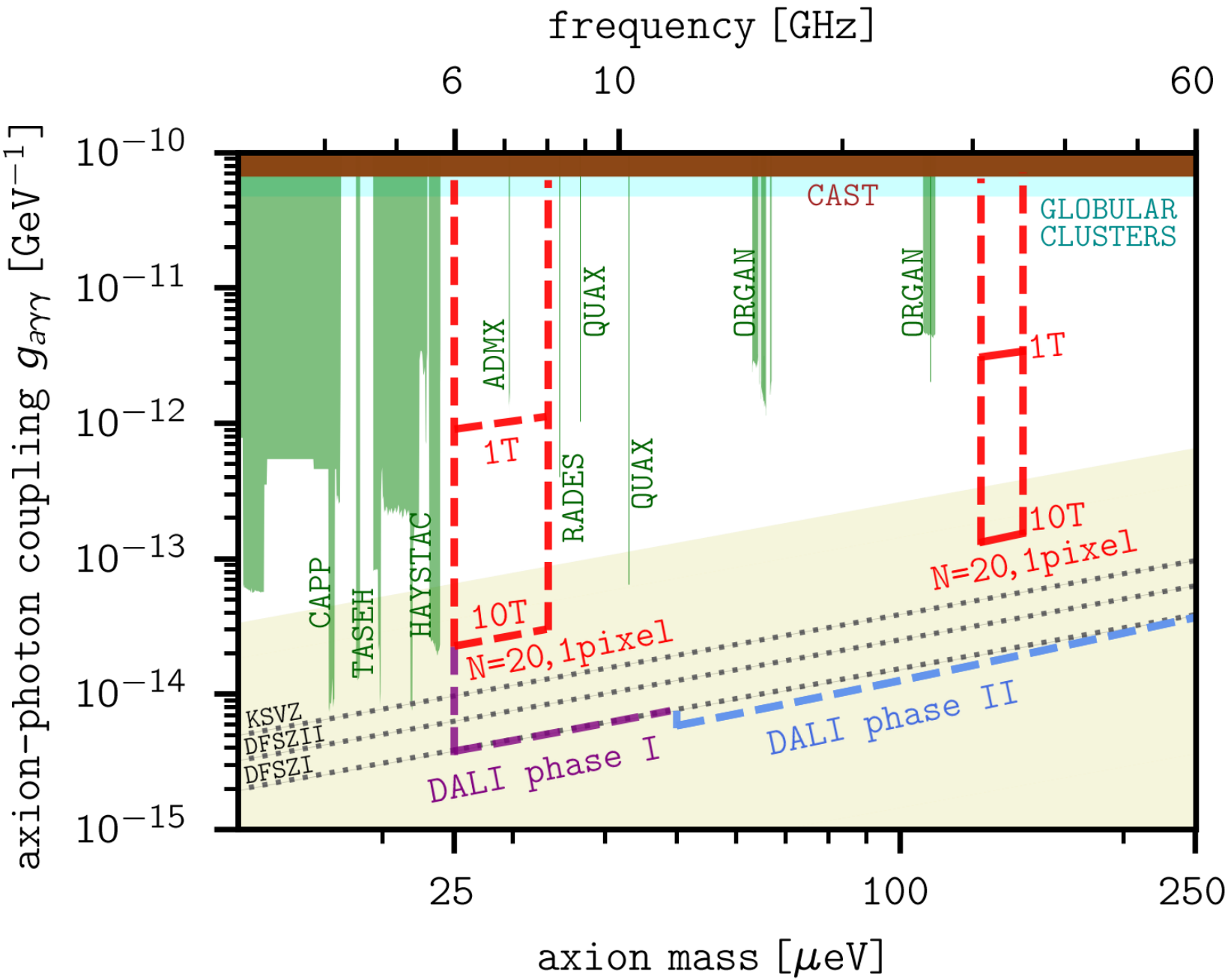
Magnet







Forecast (red lines)



RECAP

1. DALI new haloscope: **MPA + FP**
2. λ/8 & λ/2 **simultaneous frequencies** → faster scan
3. **only available equipment** (e.g. solenoid) → **DFSZ sensitivity at >40 μeV**
4. **Alt-az mount** → background modulation
5. ~**1:10 prototype** is being commissioned

References

1. J. De Miguel. “A dark matter telescope probing the 6 to 60 GHz band”. (2020) arXiv:2003.06874 [physics.ins-det]

2. J. De Miguel et al. “Discovery prospects with the Dark-photons & Axion-Like particles Interferometer”. (2023) arXiv:2303.03997 [hep-ph]

3. J. Hernández-Cabrera et al. “A forecast of the sensitivity of the DALI Experiment to Galactic axion dark matter”. (2023) arXiv: 2310.20437 [hep-ph]

4. J. Hernández-Cabrera et al. “Experimental measurement of the quality factor of a Fabry-Pérot open-cavity axion haloscope”. (2023) arXiv: 2310.16013 [hep-ph]

5. J. Hernández-Cabrera et al. “Echo-free quality factor of a multilayer axion haloscope”. (2024) arXiv: 2405.01096 [hep-ex]

PRE-ANNOUNCEMENT OF HIRING

POSTDOC (EXPERIMENTAL)

EMAIL FOR THOSE INTERESTED:

javier.miguelhernandez@riken.jp

DARK PHOTONS &
AXION LIKE PARTICLES
INTERFEROMETER

DALI

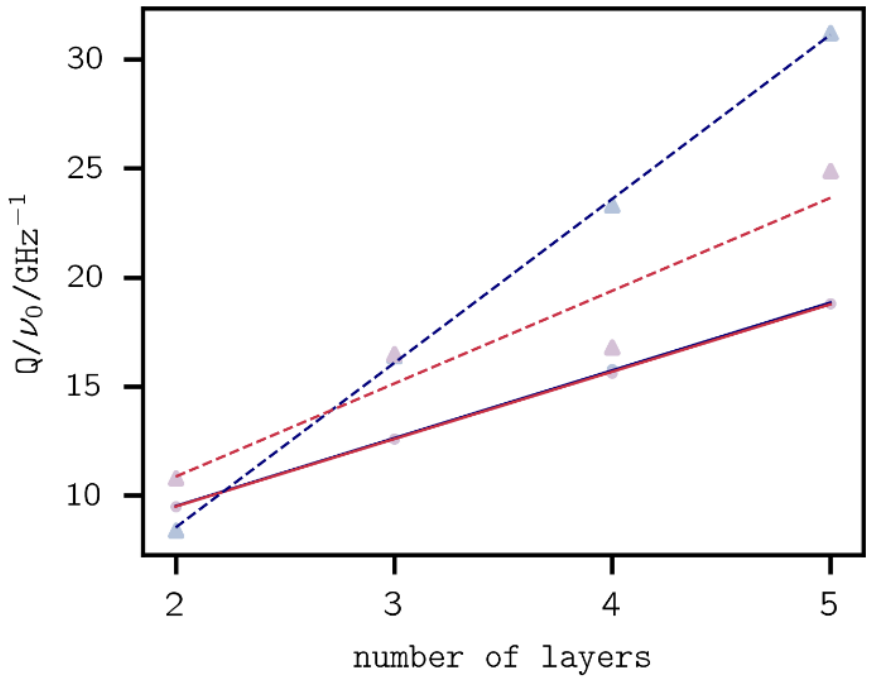


FIG. S3. Experimental measurements of the quality factor for a stack of N plates of 3 mol% yttria stabilized tetragonal zirconia of 100x100x1 mm each. Two twin fixed-plate resonators were fabricated and tested with a frequency shift between them. The results for DUT 1 are shown in blue and those of DUT 2 in red. The circular points were taken at low frequency (∼7 GHz) and the triangular points are at high frequency (∼33 GHz) At high and low frequency, where diffraction can play a role since the plate size is of the order of the wavelength, different equipment is used. We normalize the observed quality factor to the resonant frequency to evidence the one-eight wavelength concept. The lines are the least squares fits.