DARK PHOTONS & AXION LIKE PARTICLES INTERFEROMETER

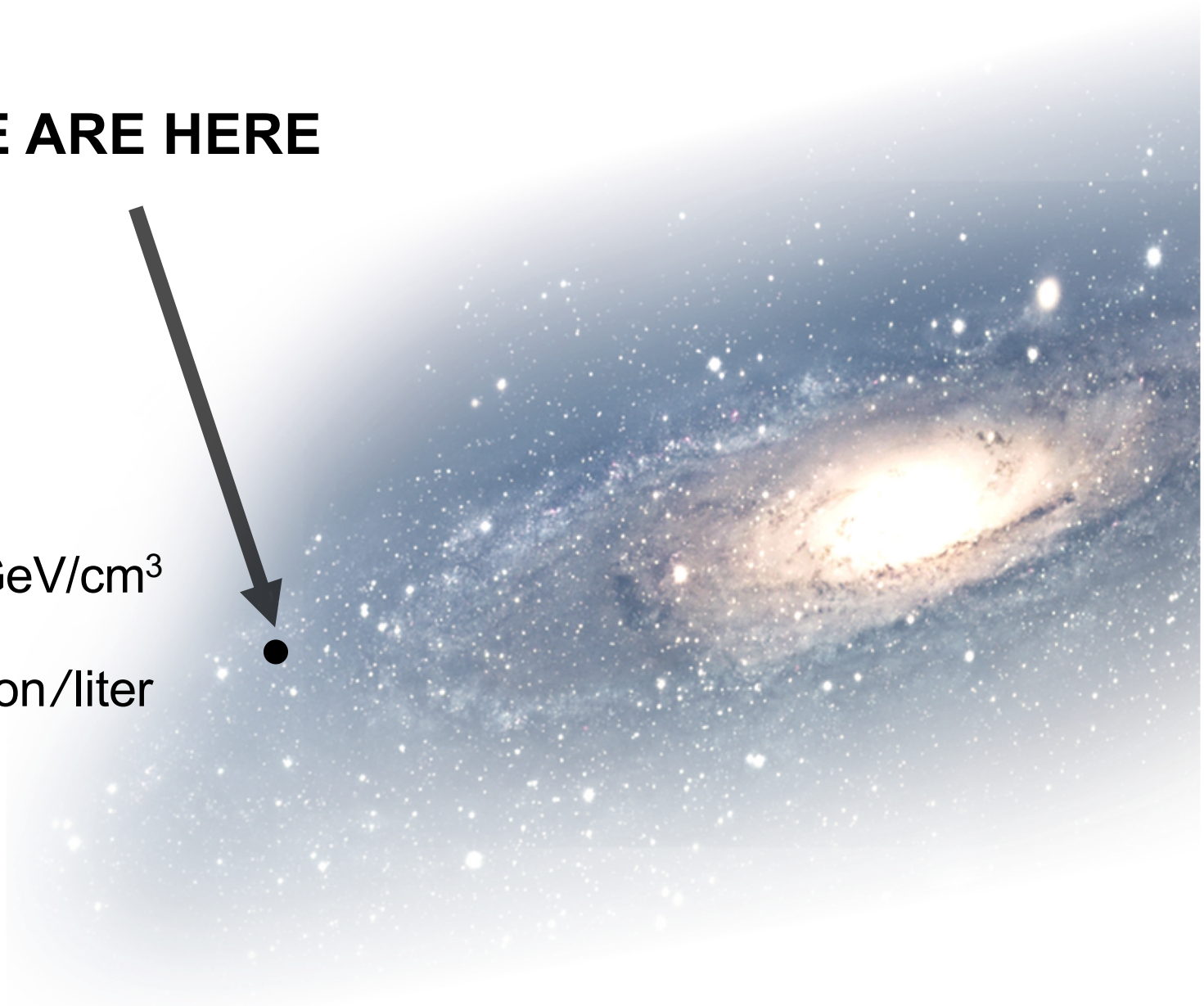
Javier De Miguel

2024/11/21

COST COSMIC WISPers

HALOSCOPES

WE ARE HERE



$\rho_{DM} \sim ½\,\mathrm{GeV/cm^3}$

$\sim 10^{18}$ axion/liter

VOLUME 51, NUMBER 16 PHYSICAL REVIEW LETTERS 17 OCTOBER 1983

Experimental Tests of the "Invisible" Axion

P. Sikivie
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.

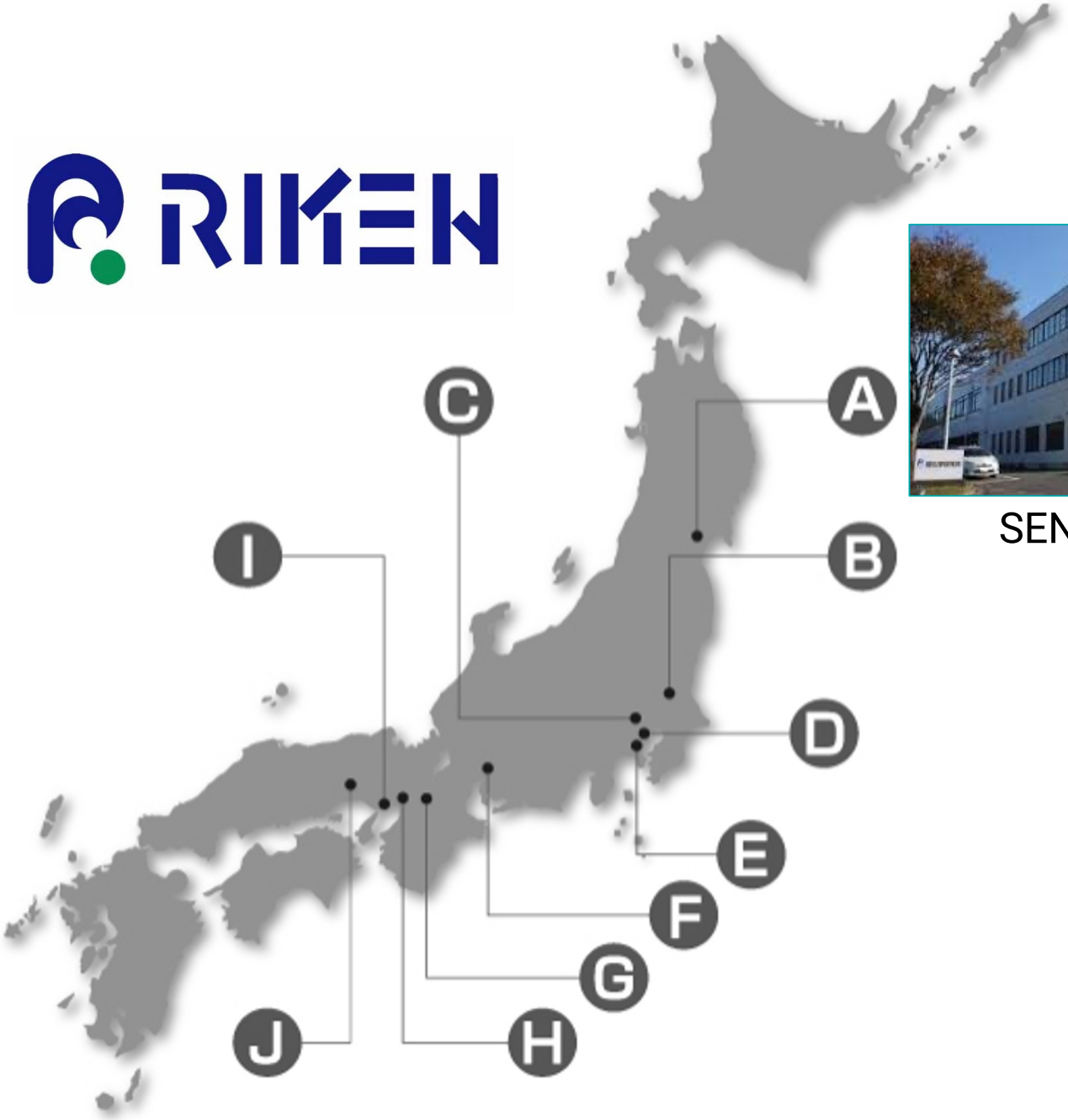
$$a + B(\gamma_{\text{virt}}) \leftrightarrow \gamma$$

$$m_a \sim \omega$$

DALI
COLLABORATION

DARK PHOTONS & AXION LIKE PARTICLES INTERFEROMETER DALI

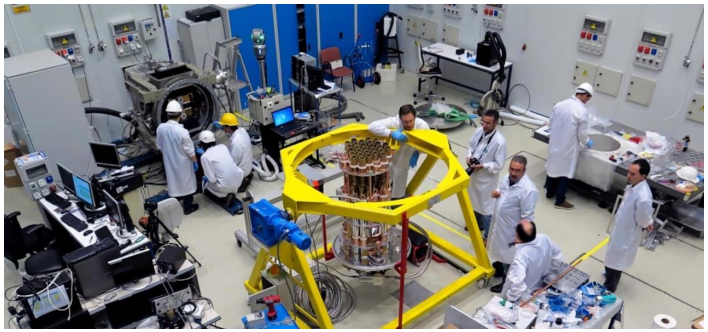
RIKEN



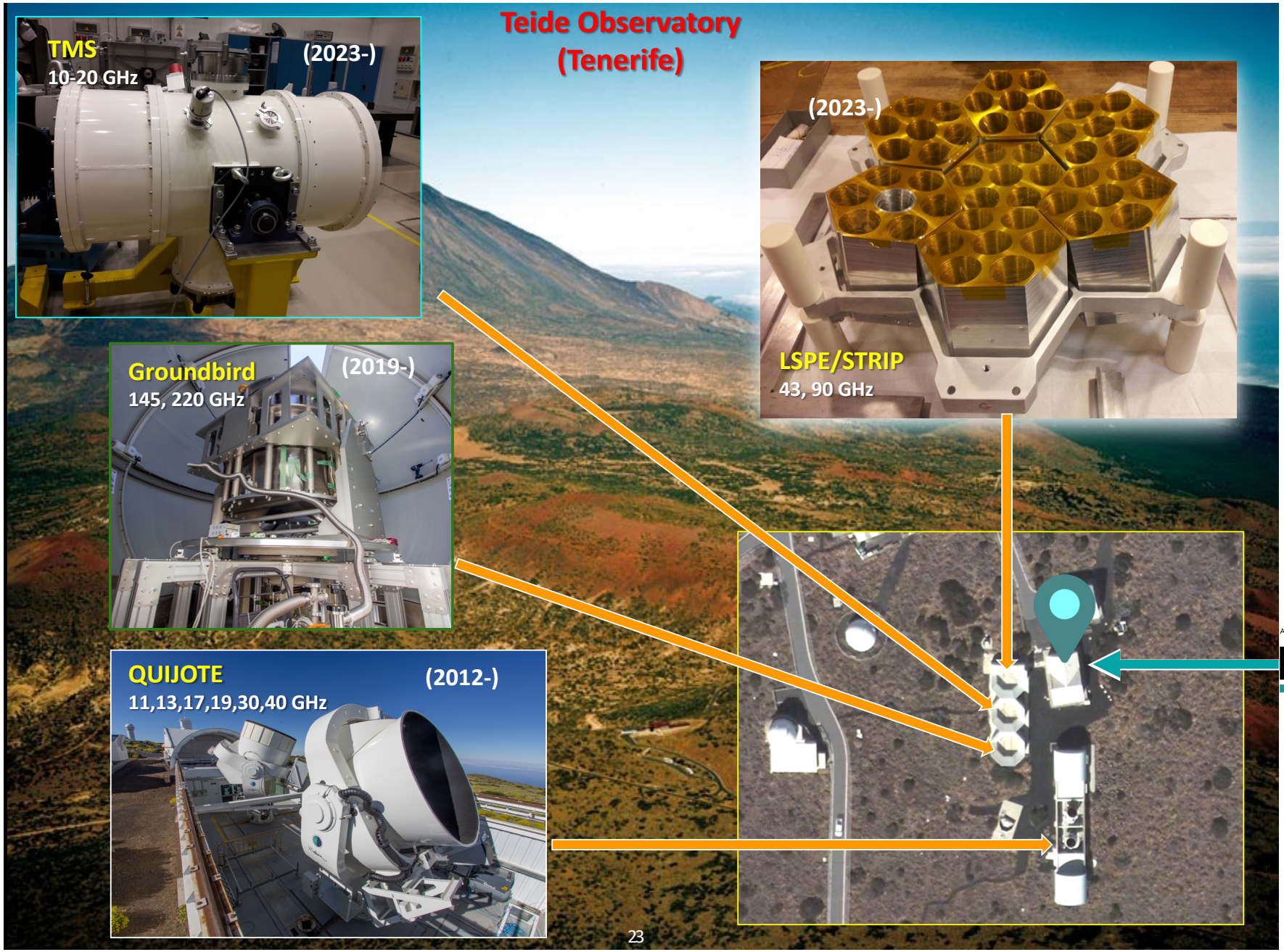
SENDAI, JAPAN

DARK PHOTONS & AXION LIKE PARTICLES INTERFEROMETER

DALI



CMBLab

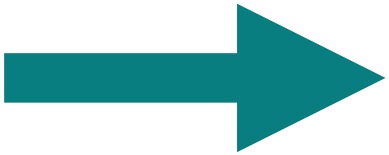

Teide Observatory
(Tenerife)
TMS
10-20 GHz
(2023-)
(2023-)
LSPE/STRIP
43, 90 GHz
Groundbird
145, 220 GHz
(2019-)
QUIJOTE
11,13,17,19,30,40 GHz
(2012-)

DALI
CONCEPT

DARK PHOTONS & AXION LIKE PARTICLES INTERFEROMETER DALI

CMB

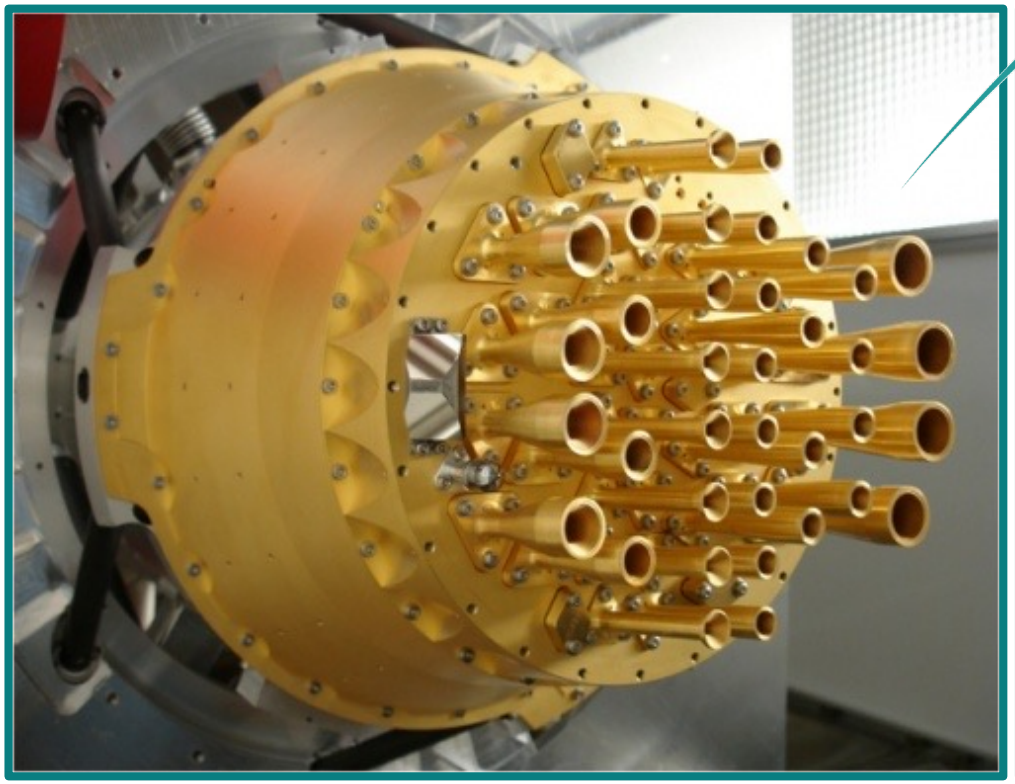
“PHASED ARRAY” RADIO TELESCOPE

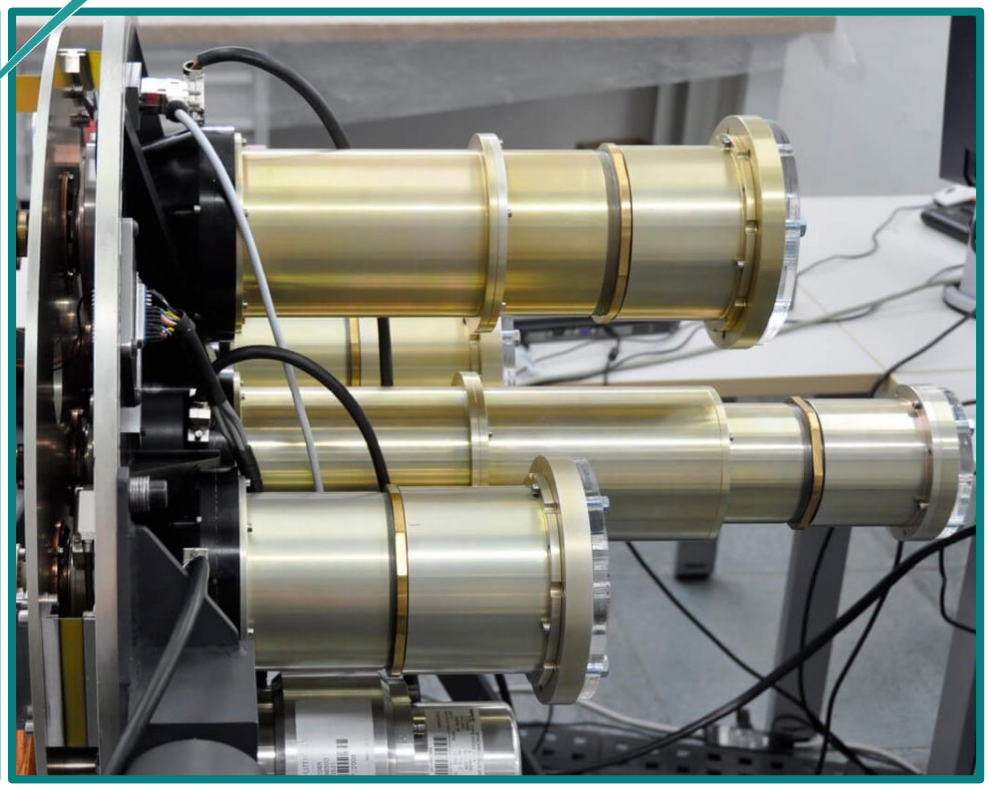


Dark Matter

“MAGNETIZED PHASED ARRAY” HALOSCOPE

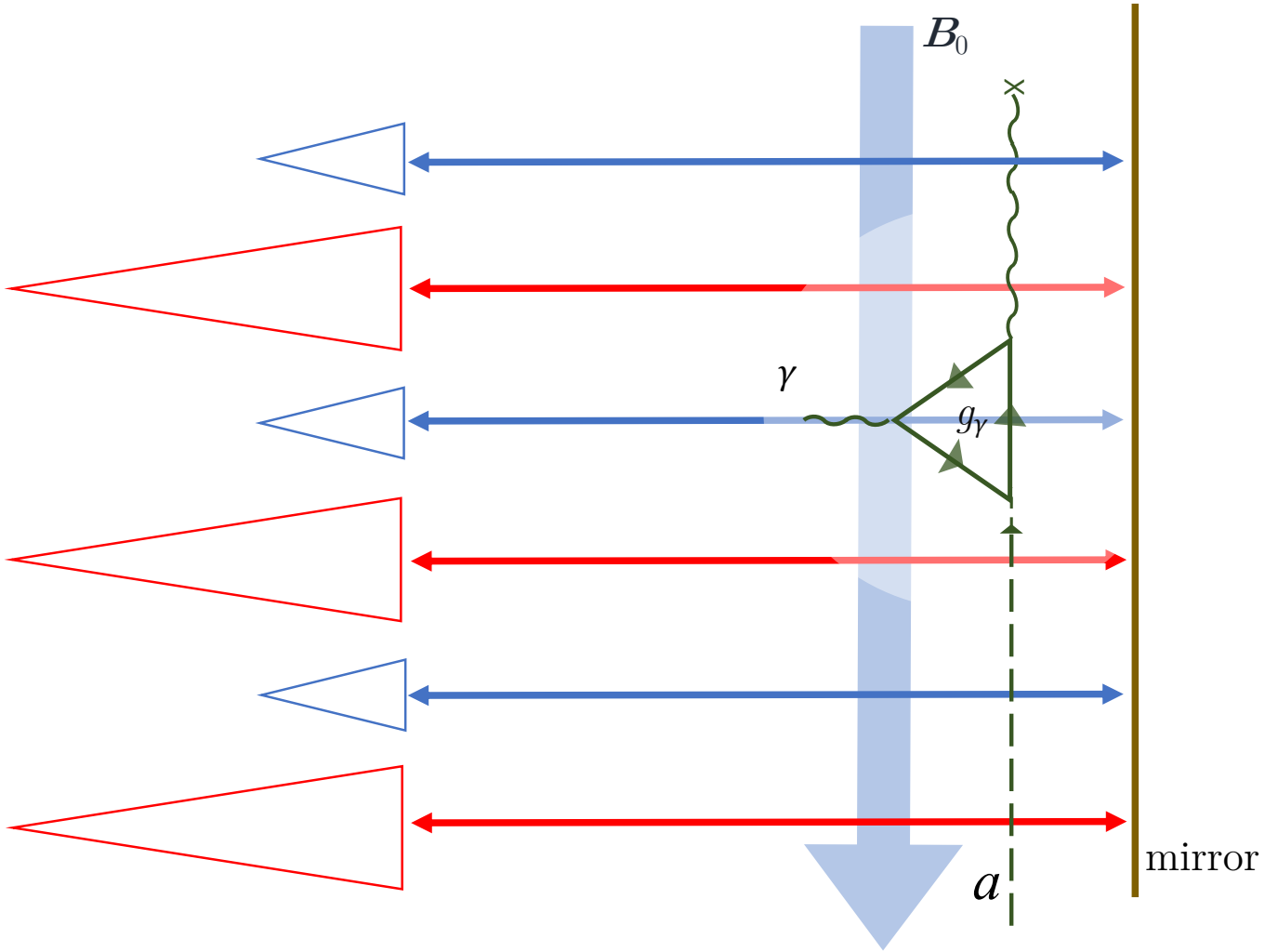
DALI



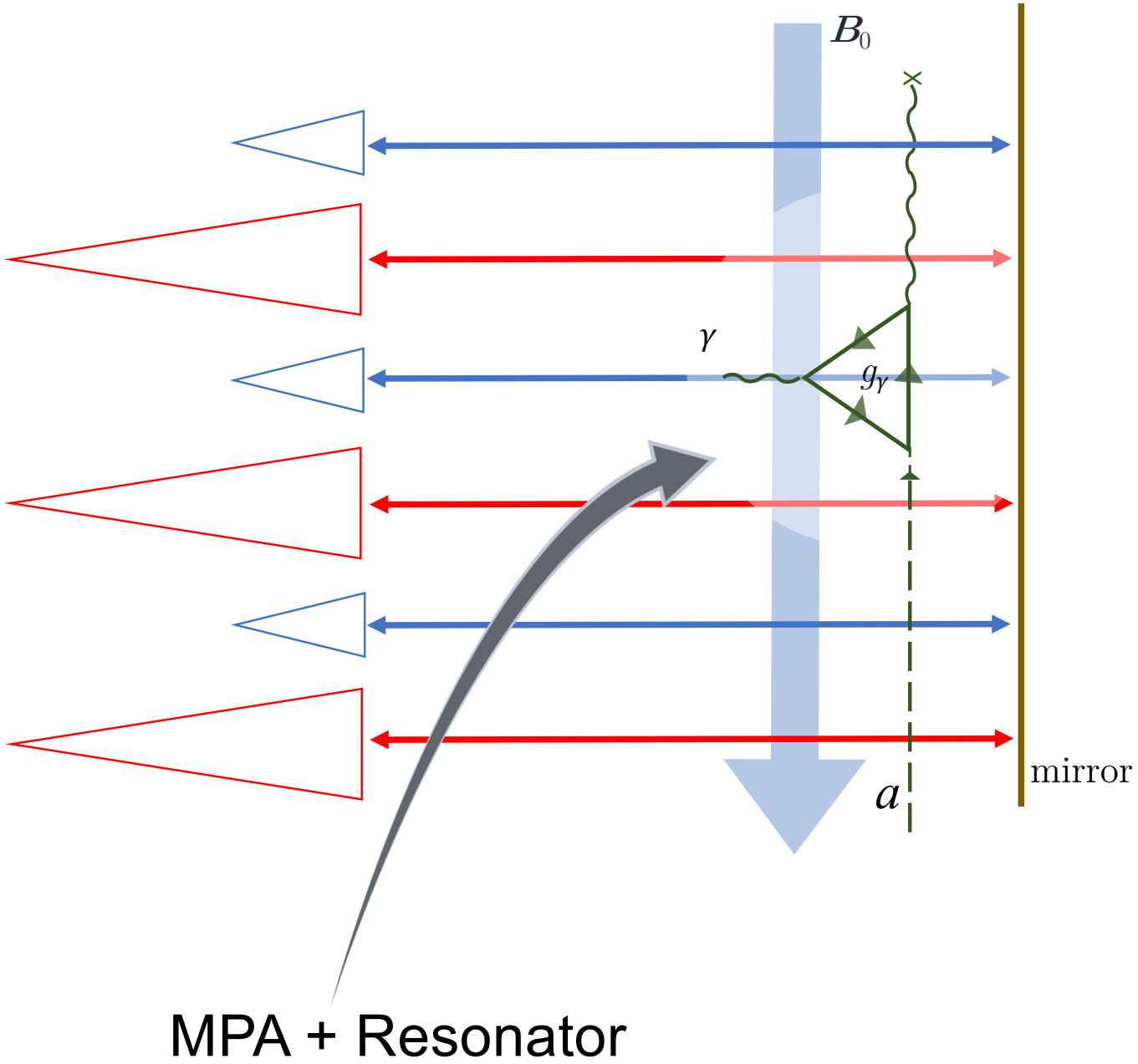


Planck LFI (27-77 GHz)

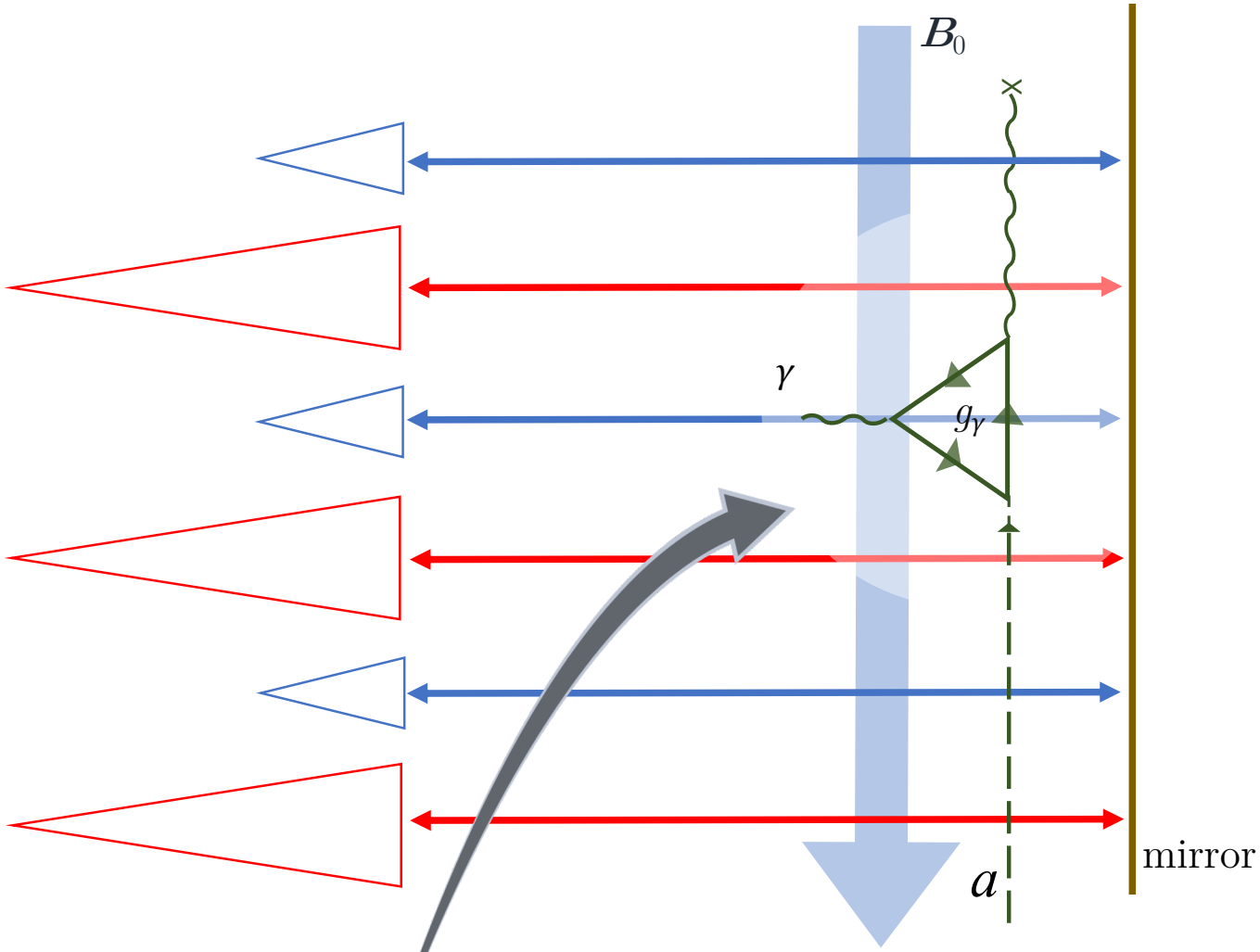
QUIJOTE-CMB MFI (10-42 GHz)



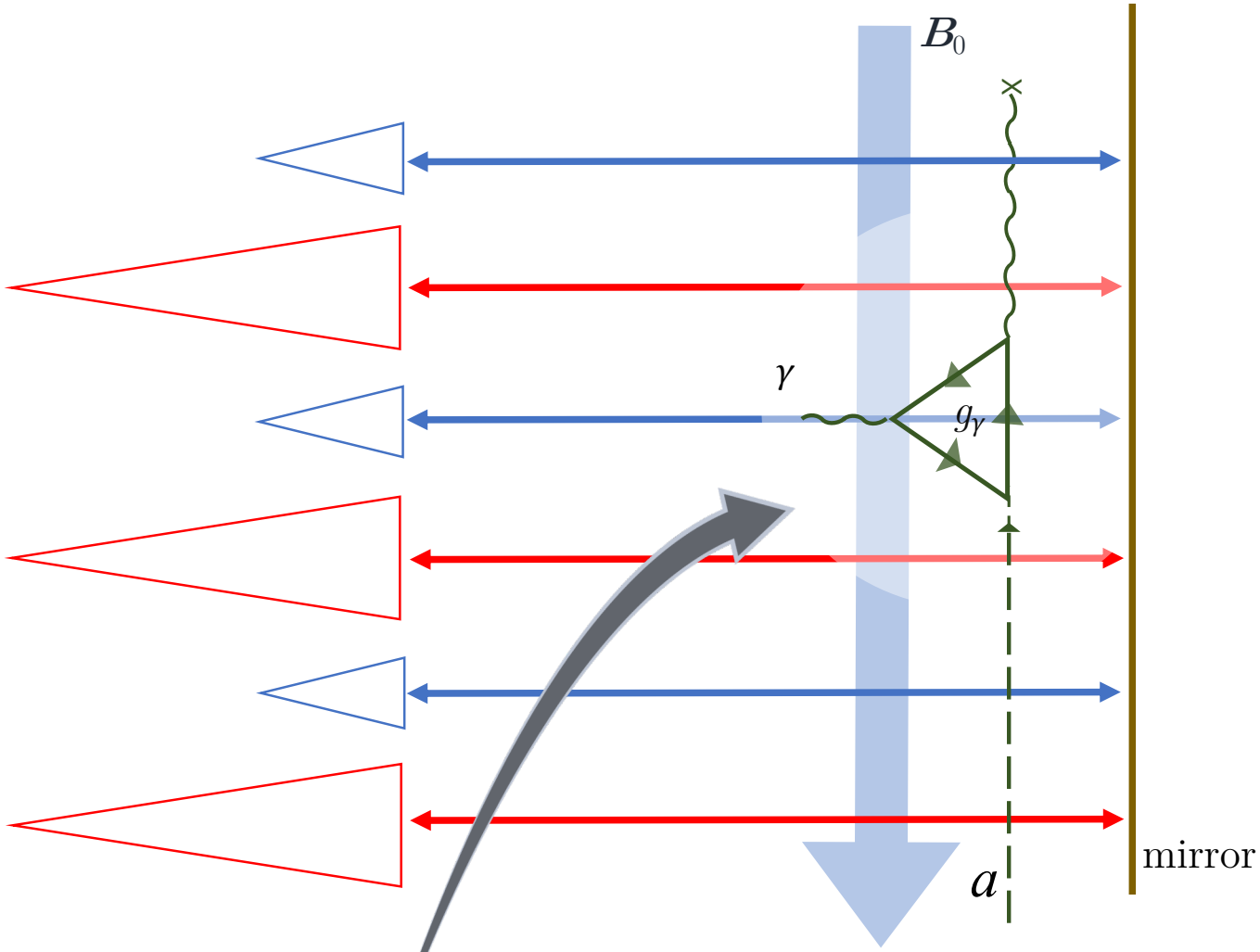
Magnetized phased array (MPA) haloscope



MPA + Resonator

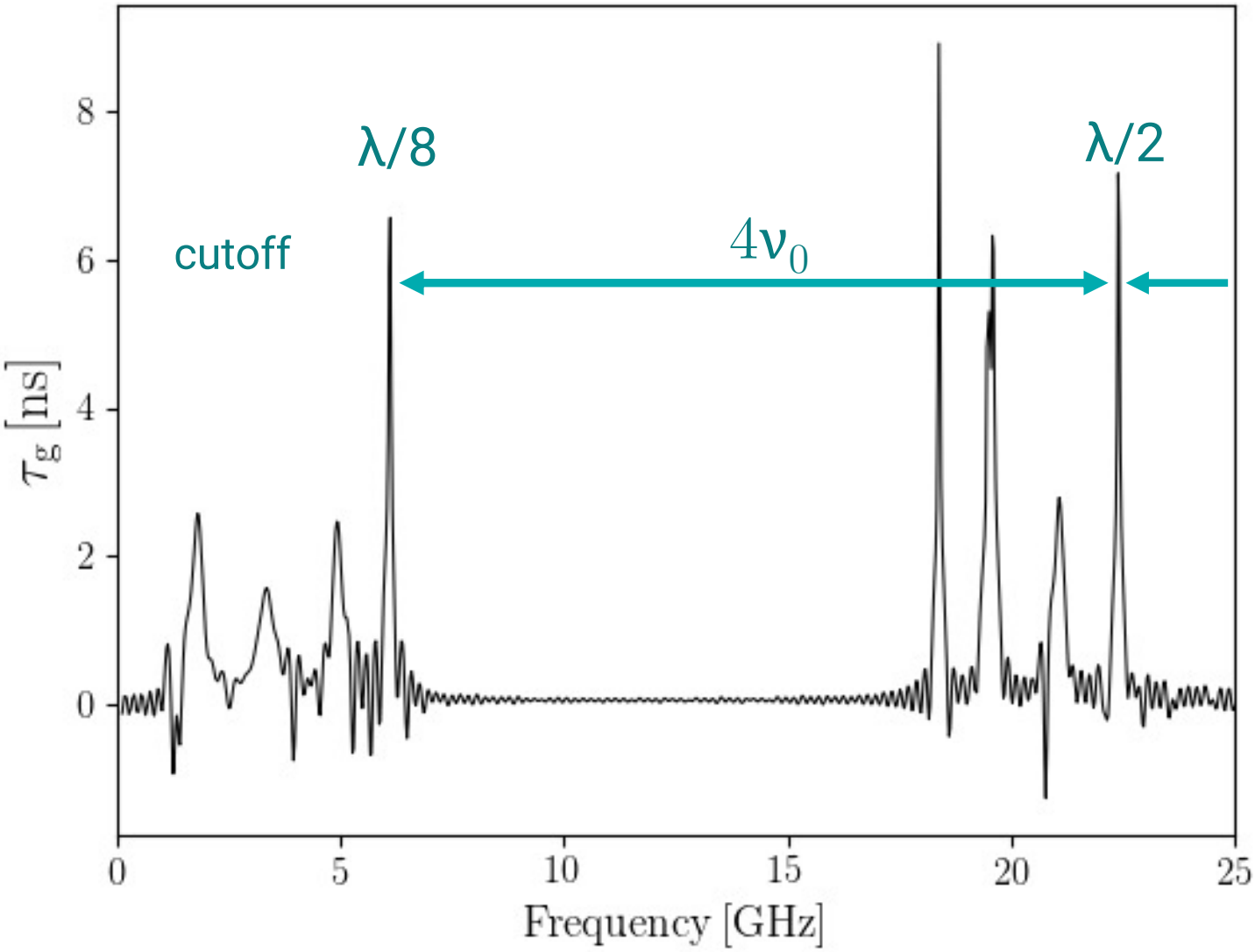


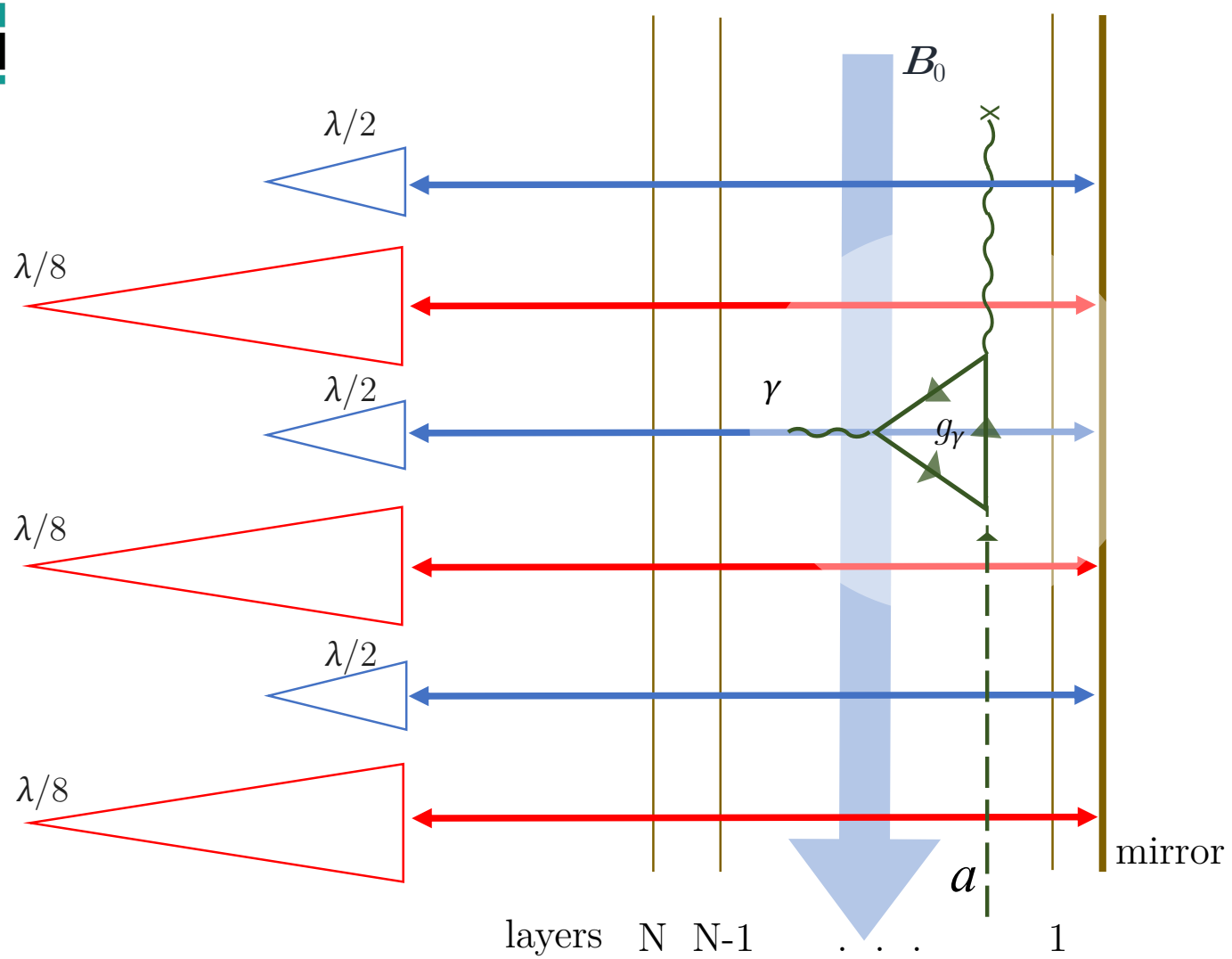
MPA + Resonator
- Cavities
- Fabry-Pérot (FP)
- Metamaterials



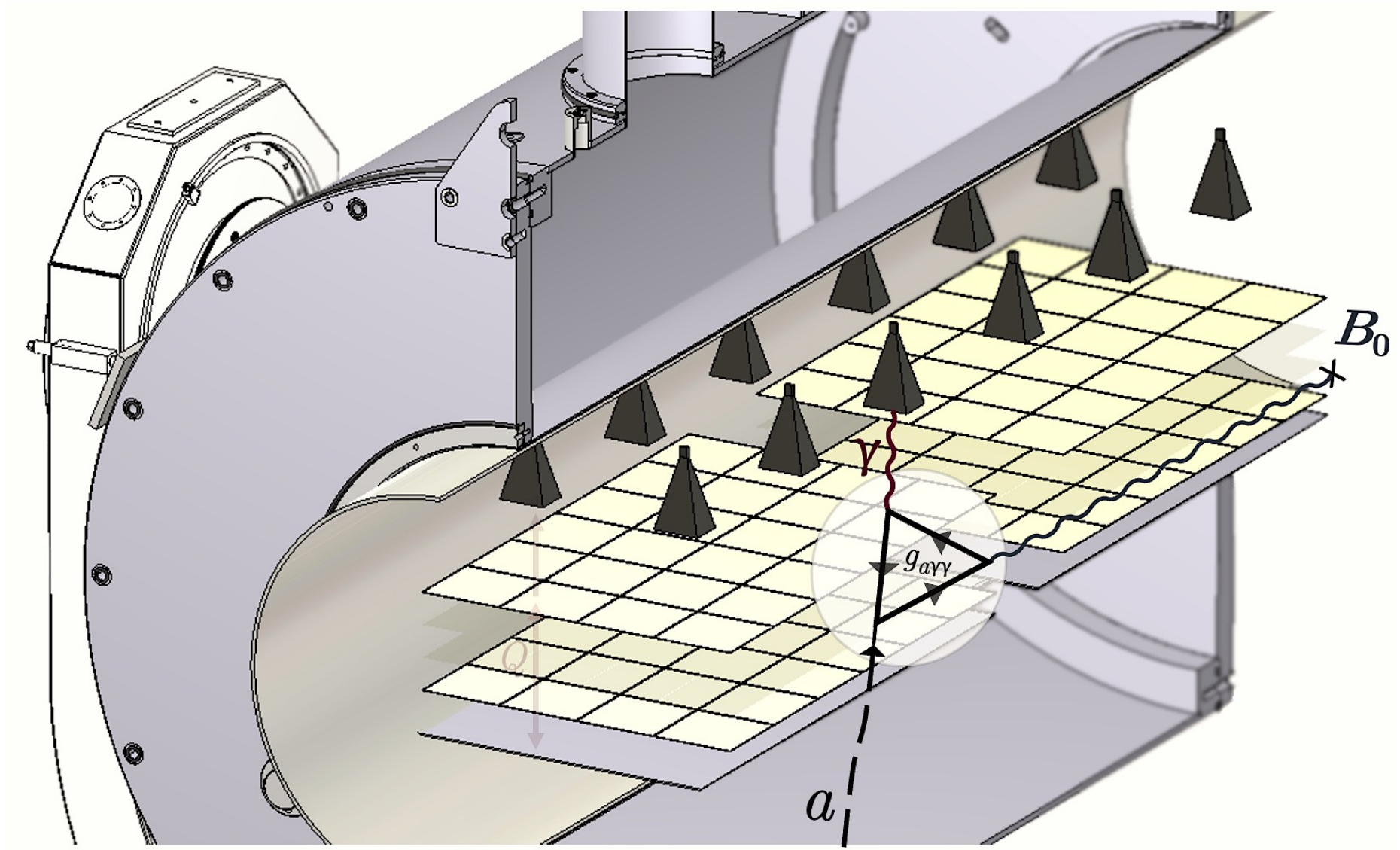
MPA + Resonator
- Cavities
- Fabry-Pérot (FP)
- Metamaterials

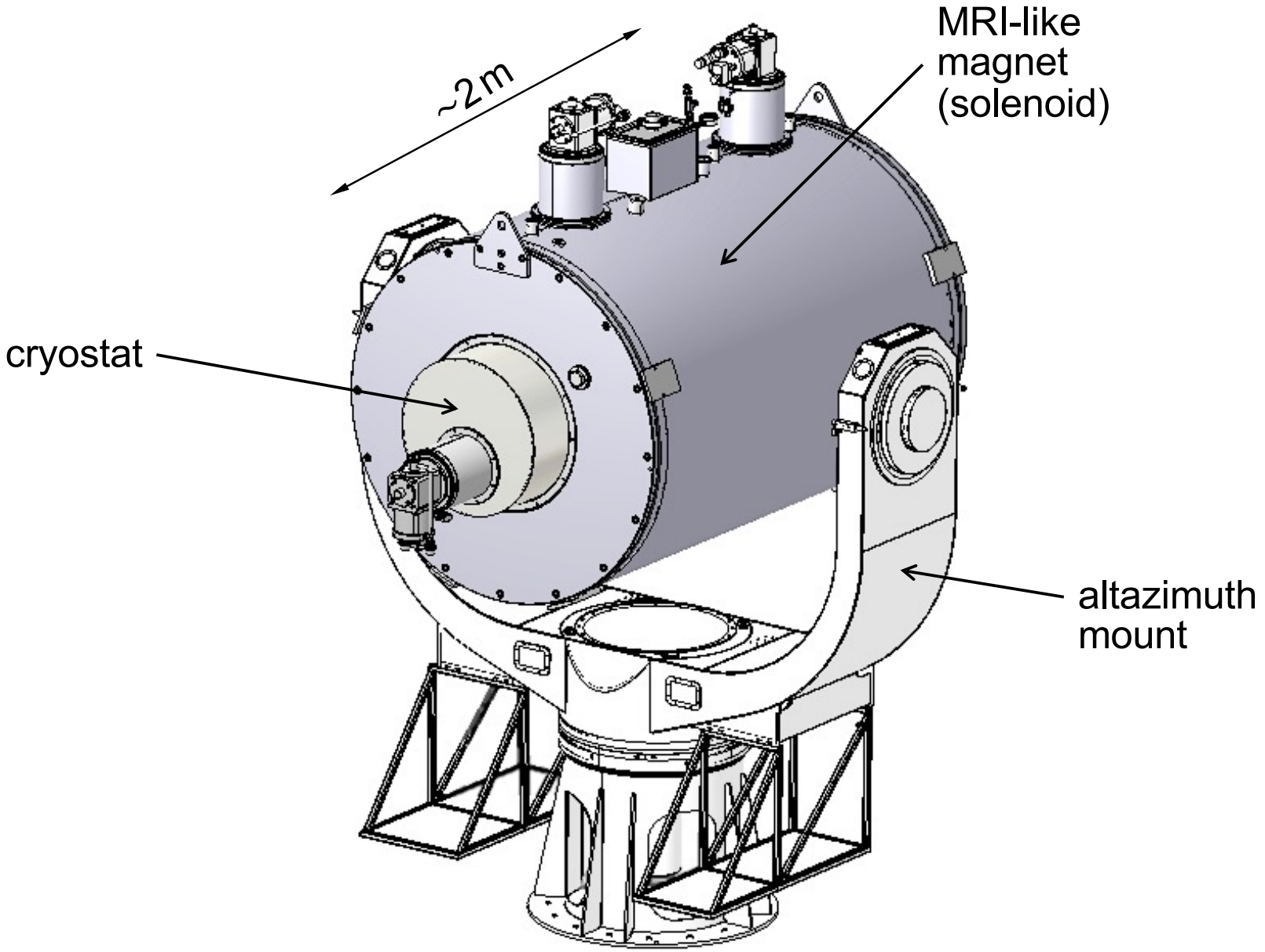
Fabry-Pérot ($Q=\omega \times \tau_g$)





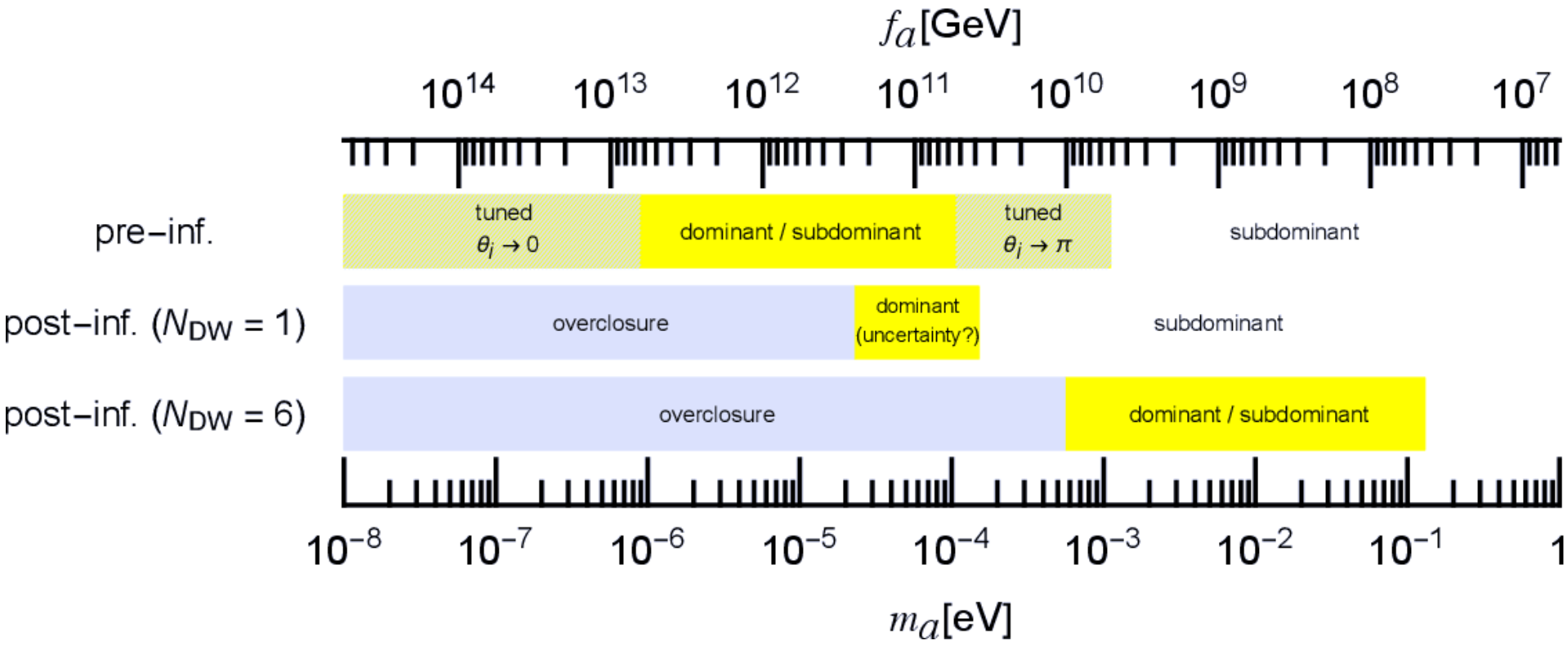
MPA + Resonator
- Cavities
- Fabry-Pérot (FP)
- Metamaterials


B_0
x
γ
$g_{a\gamma\gamma}$
Q
a

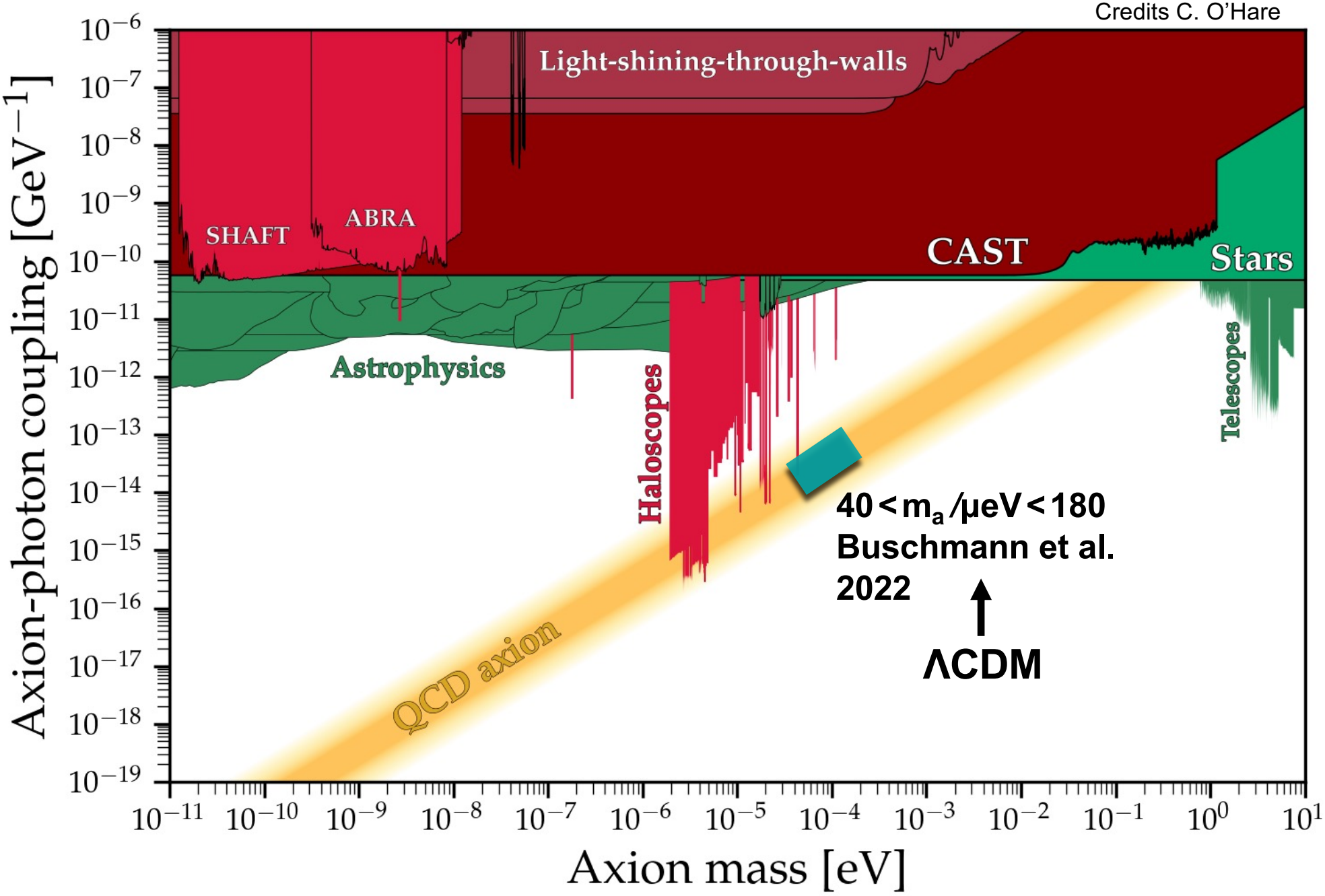

~2 m
MRI-like magnet (solenoid)
cryostat
altazimuth mount

DISCOVERY PROSPECTS

Saikawa 2017

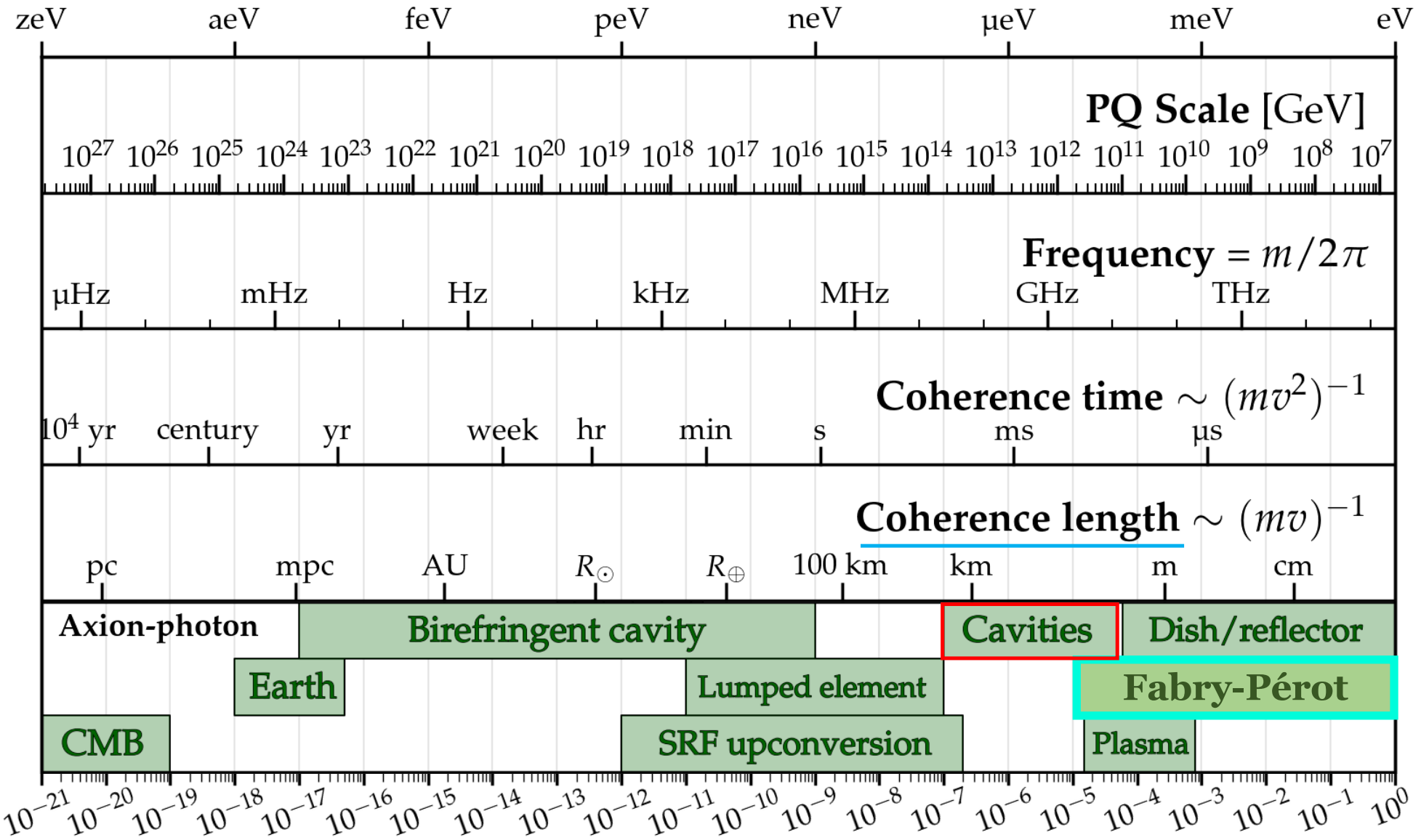


Credits C. O'Hare

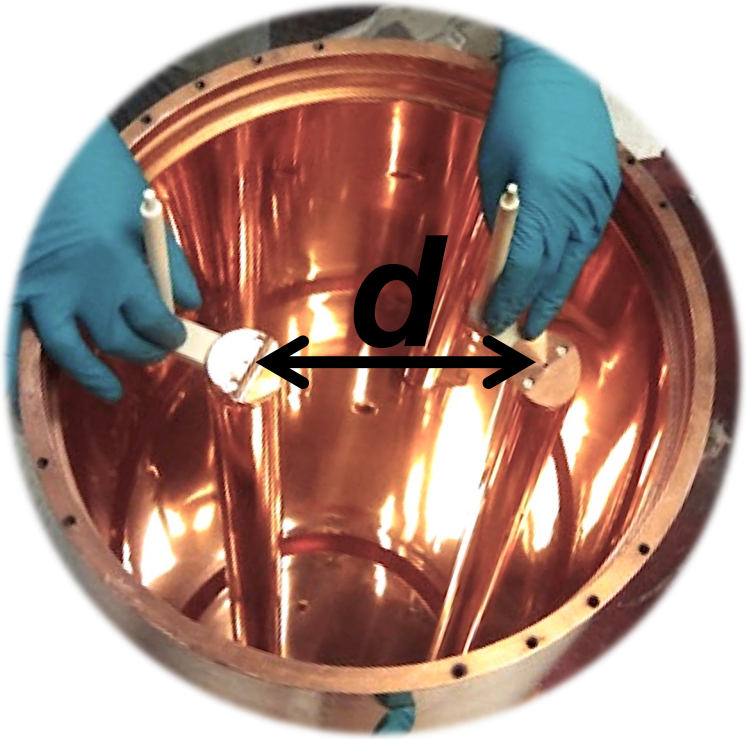


Dark matter mass

Credits C. O'Hare



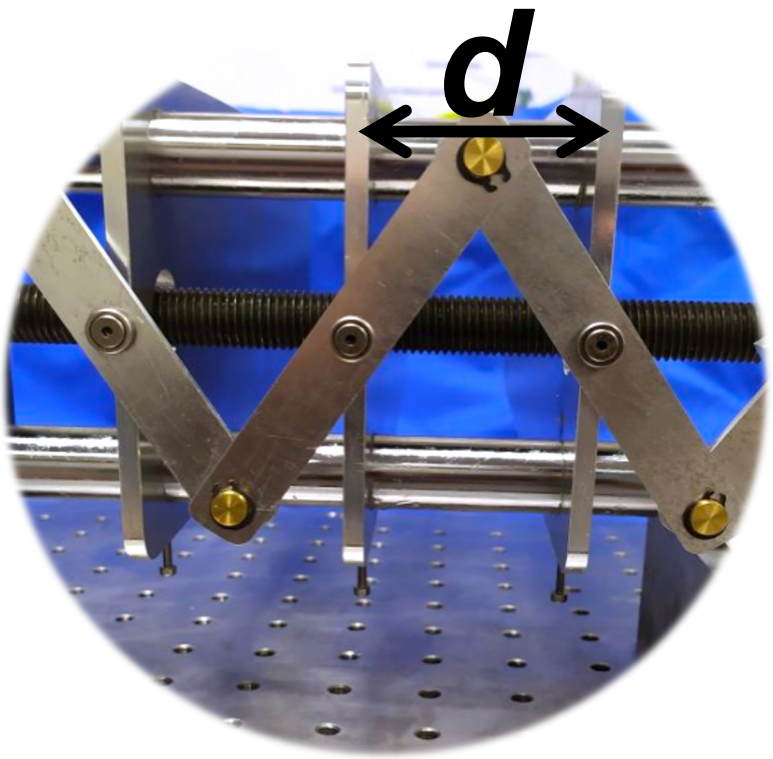
Resonant cavity (ADMX)



$d \sim \lambda$

Power $\propto V \propto \lambda^2$

Fabry-Pérot (DALI)



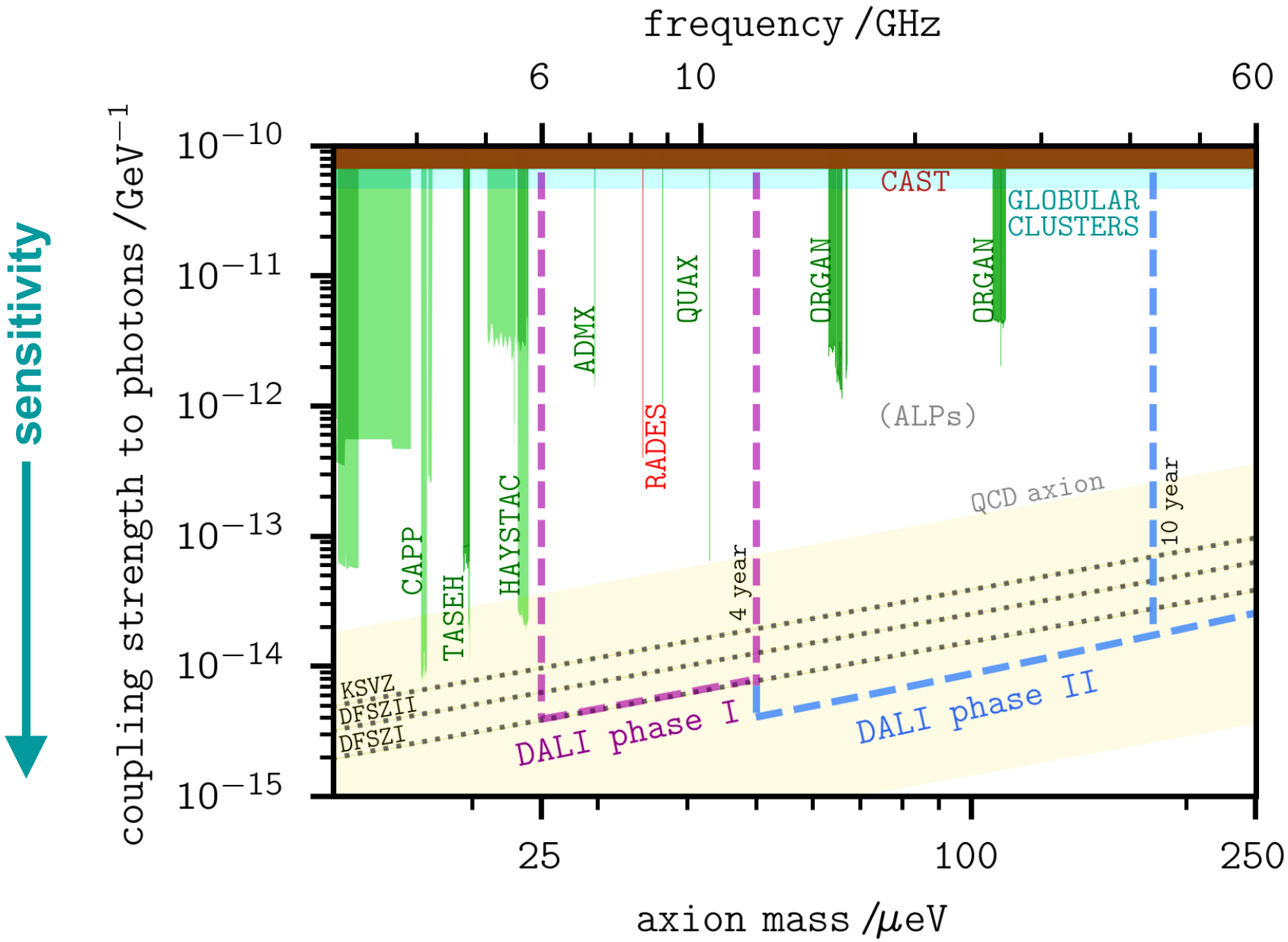
$d \sim \lambda$

Power $\propto A \not\propto \lambda$

STANDARD HALO

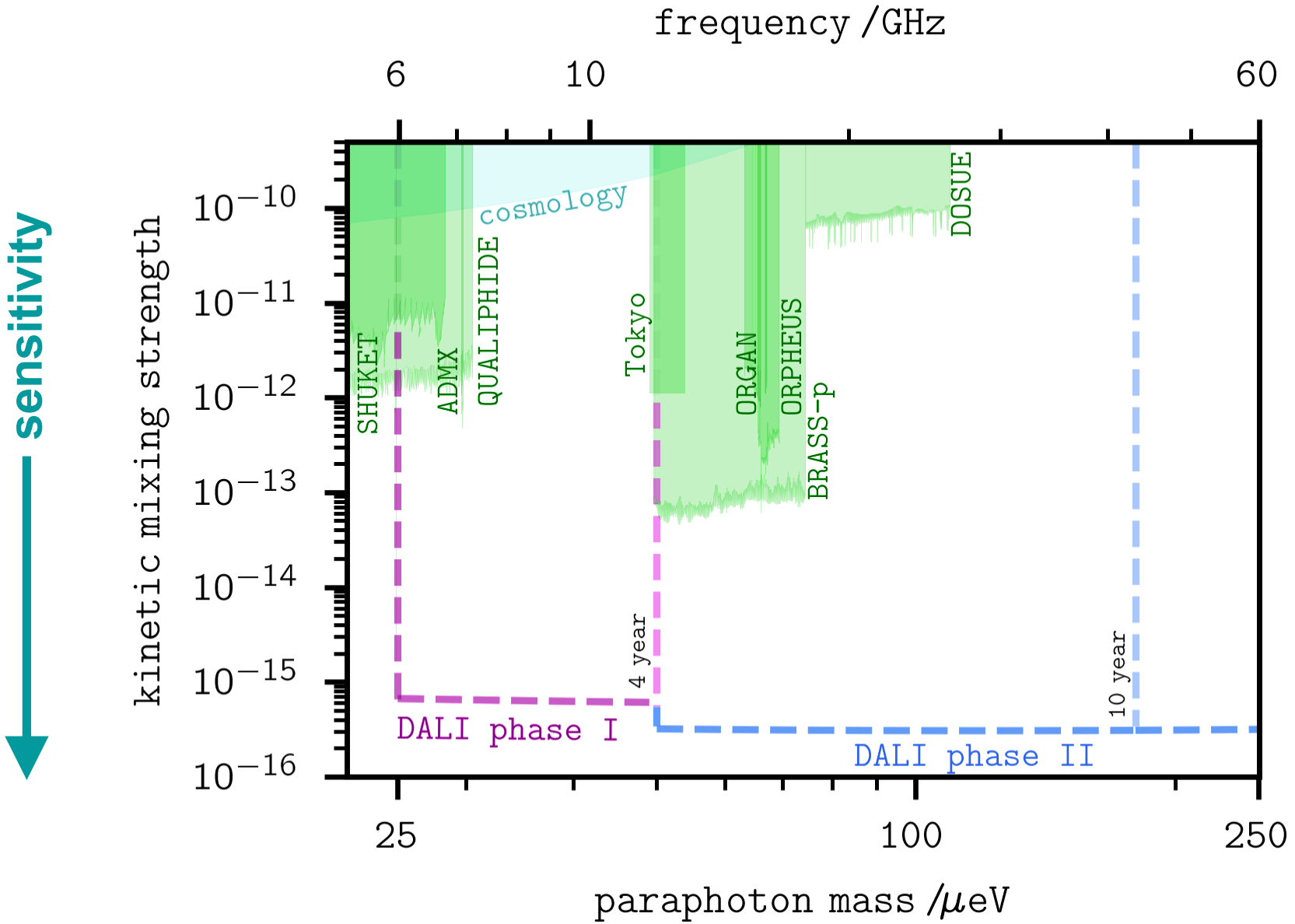
DARK PHOTONS & AXION LIKE PARTICLES INTERFEROMETER DALI

arXiv:2303.03997

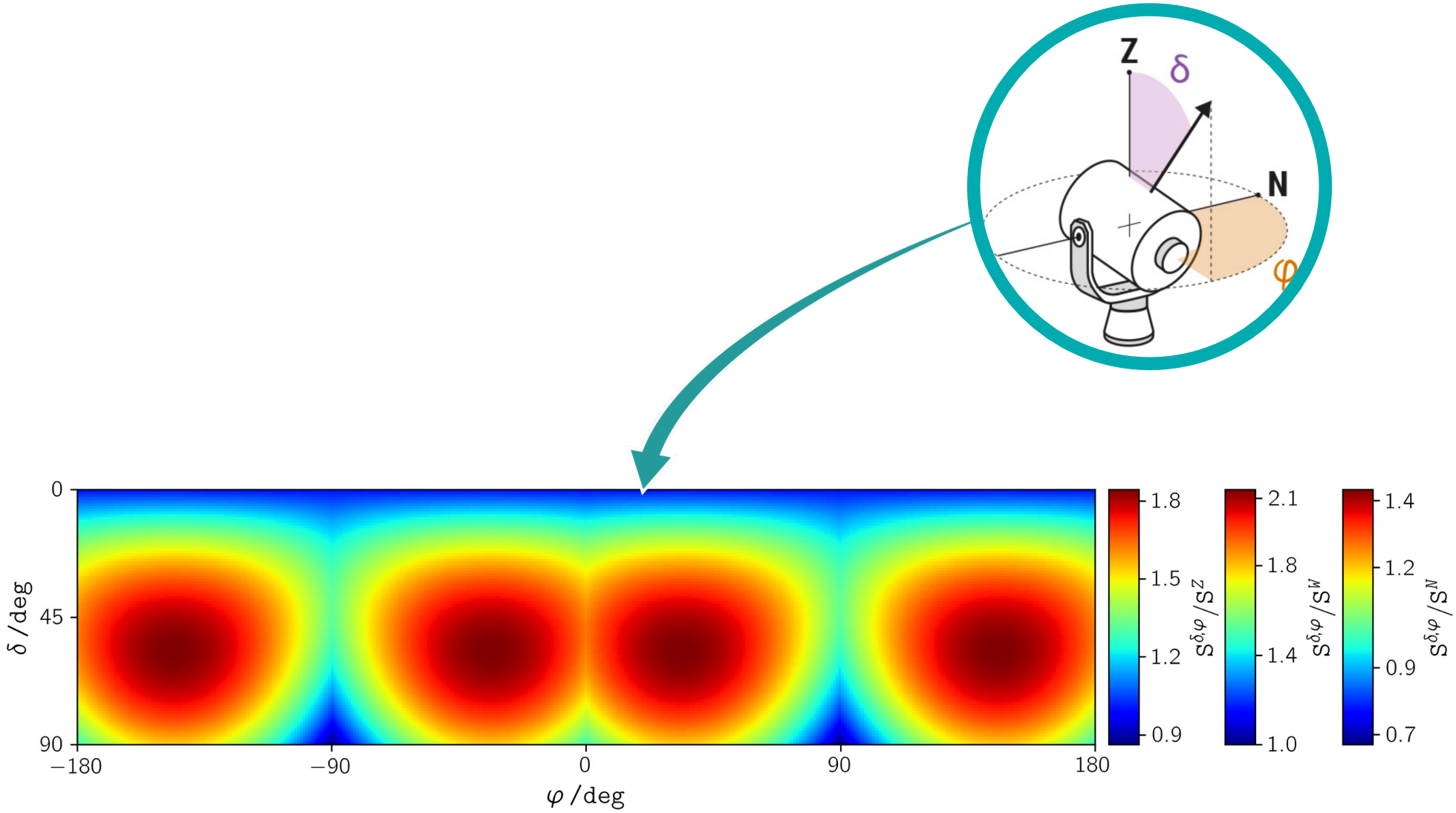


DARK PHOTONS & AXION LIKE PARTICLES INTERFEROMETER DALI

arXiv:2303.03997

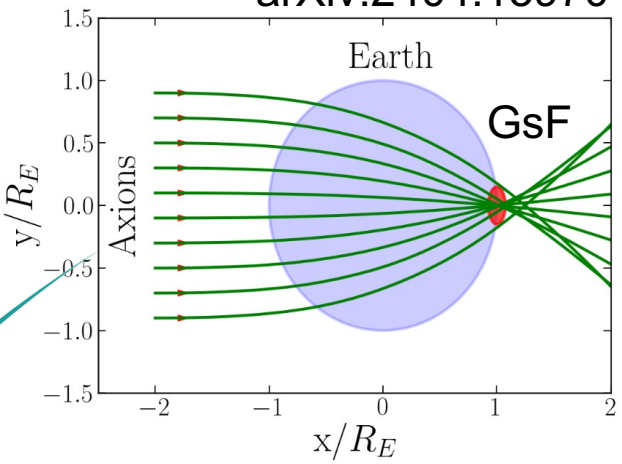


STREAMS I


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
$S^{\delta,\varphi}/S^{W}$
1.4
1.2
0.9
0.7
$S^{\delta,\varphi}/S^{N}$

STREAMS II

arXiv:2404.13970



arXiv:2210.07367,
Vogelsberger et al.

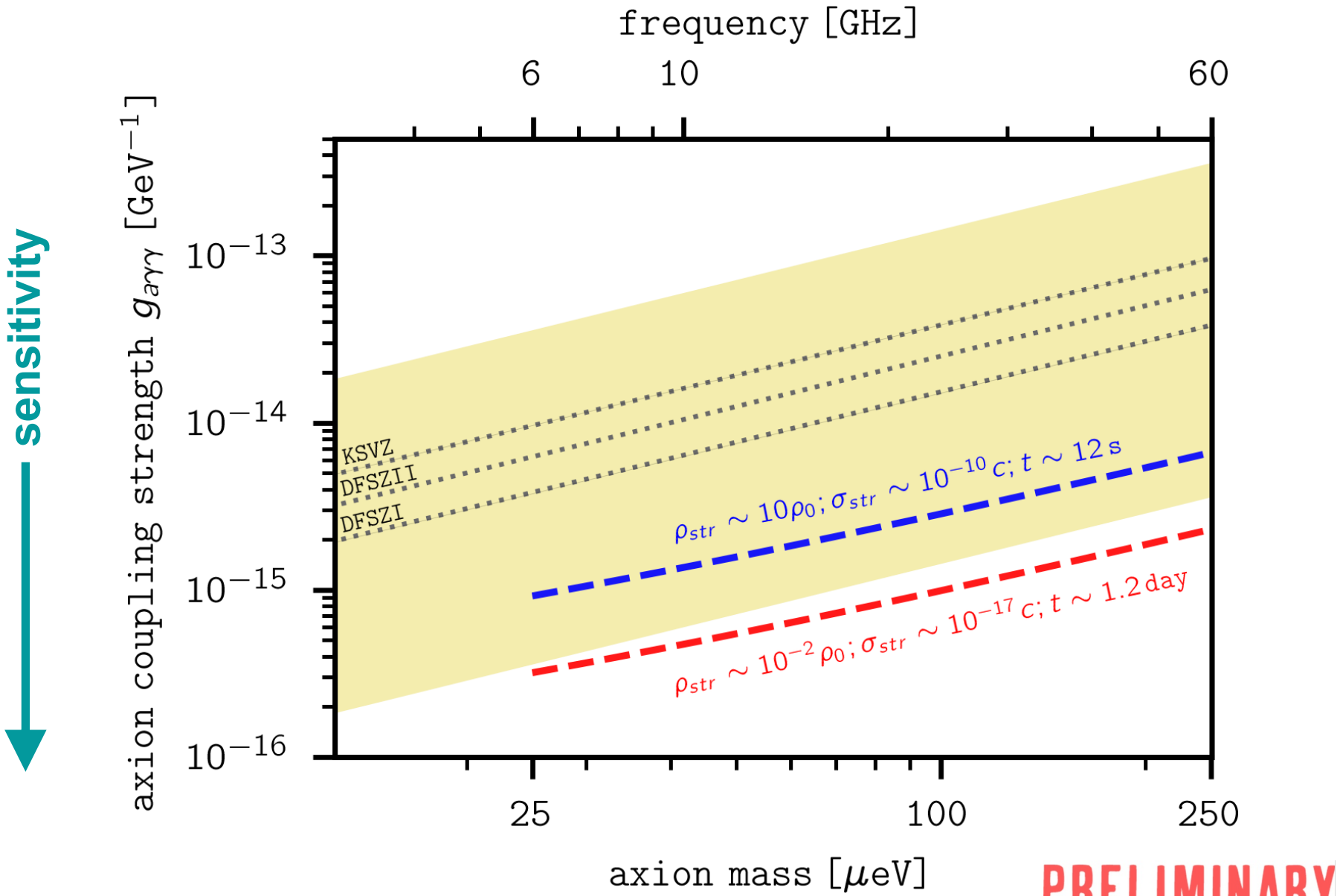
TABLE I. Stream information before and after gravitational self-focusing (GsF) by the Earth.

Stream density $[\rho_0]$	Stream count	GsF density[a] $[\rho_0]$	P_{day}[b] (GsF encounter)
10^{-2}	1	10^6	2.4×10^{-10}
10^{-3}	10	10^5	1.2×10^{-8}
10^{-4}	500	10^4	6.0×10^{-7}
10^{-5}	2×10^4	10^3	2.4×10^{-5}
10^{-6}	4×10^5	10^2	5.0×10^{-4}
10^{-7}	2×10^6	10	6.0×10^{-3}

~2 year^{-1}

[a] The expected density for the specific stream measured in units of ρ_0, resulting from flux amplification caused by the GsF.
[b] The probability that during one day an experiment on Earth will intersect this specific gravitationally focused region.

DARK PHOTONS & AXION LIKE PARTICLES INTERFEROMETER DALI



PRELIMINARY

arXiv:2404.13970

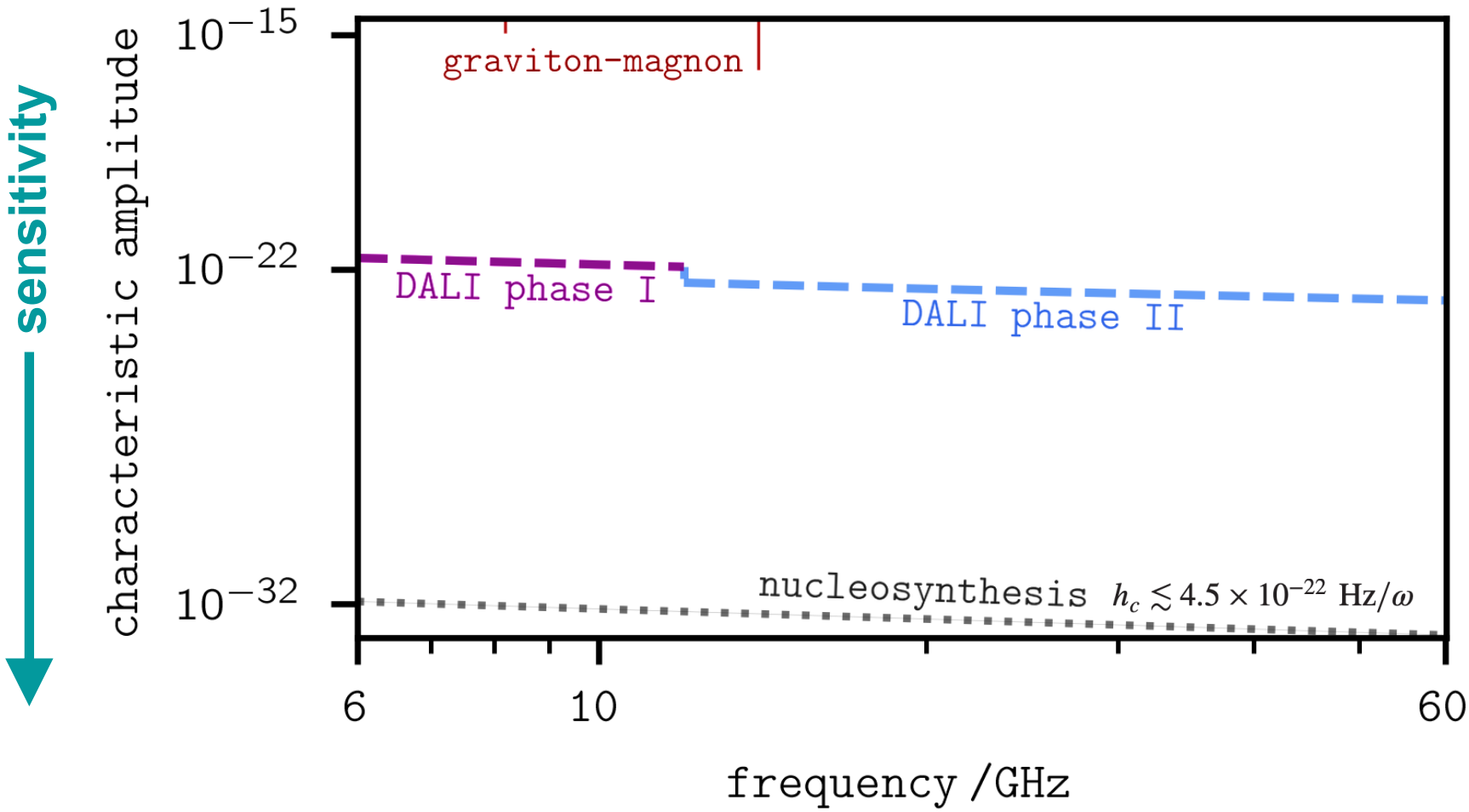
PHYSICAL REVIEW D VOLUME 37, NUMBER 5 1 MARCH 1988

Mixing of the photon with low-mass particles

Georg Raffelt
Astronomy Department, University of California, Berkeley, California 94720
and Institute for Geophysics and Planetary Physics, Lawrence Livermore National Laboratory, Livermore, California 94550

Leo Stodolsky
Max-Planck-Institut für Physik und Astrophysik, Postfach 401212, 8000 München 40,
Federal Republic of Germany
(Received 21 August 1987)

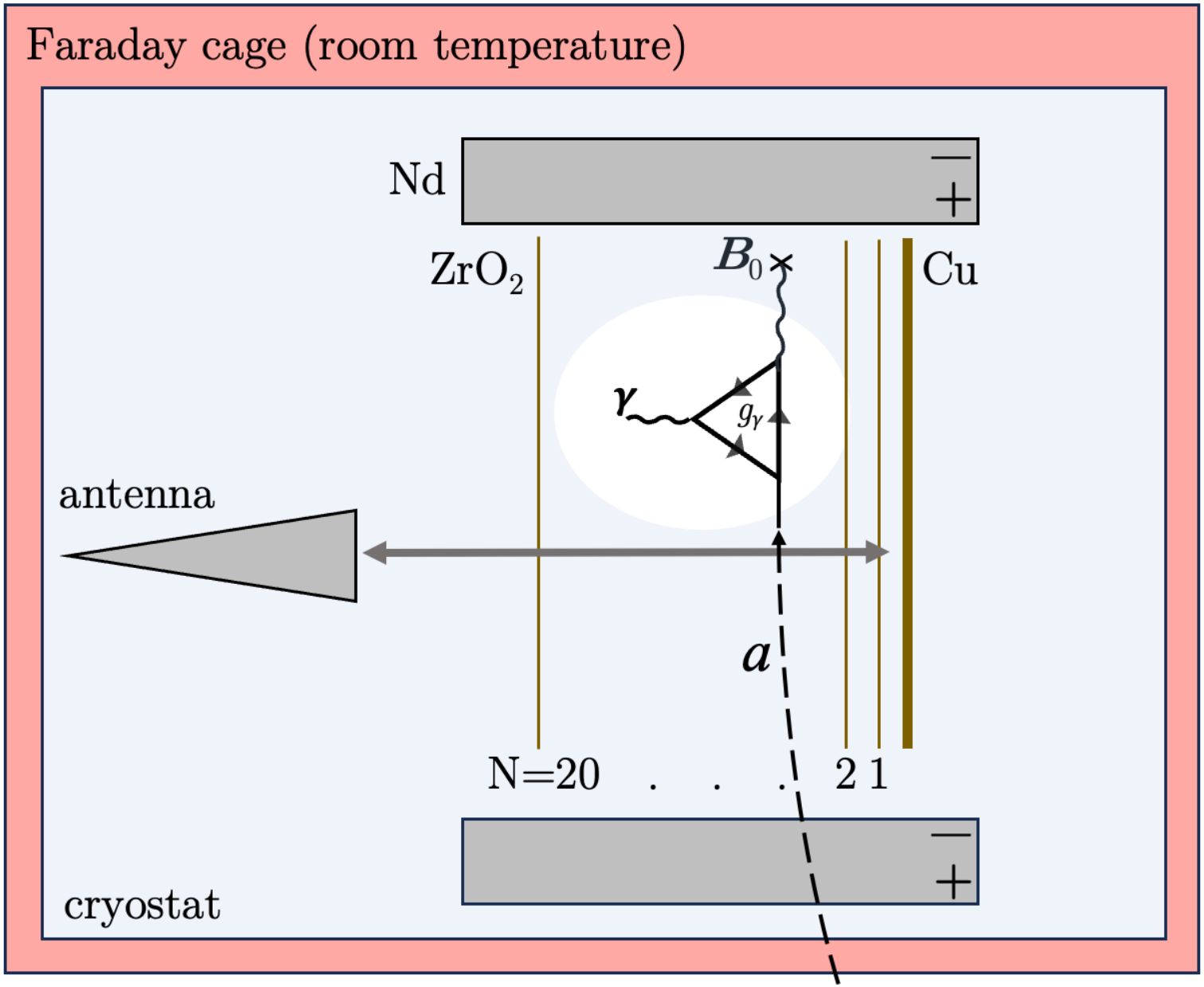
arXiv:2303.03997

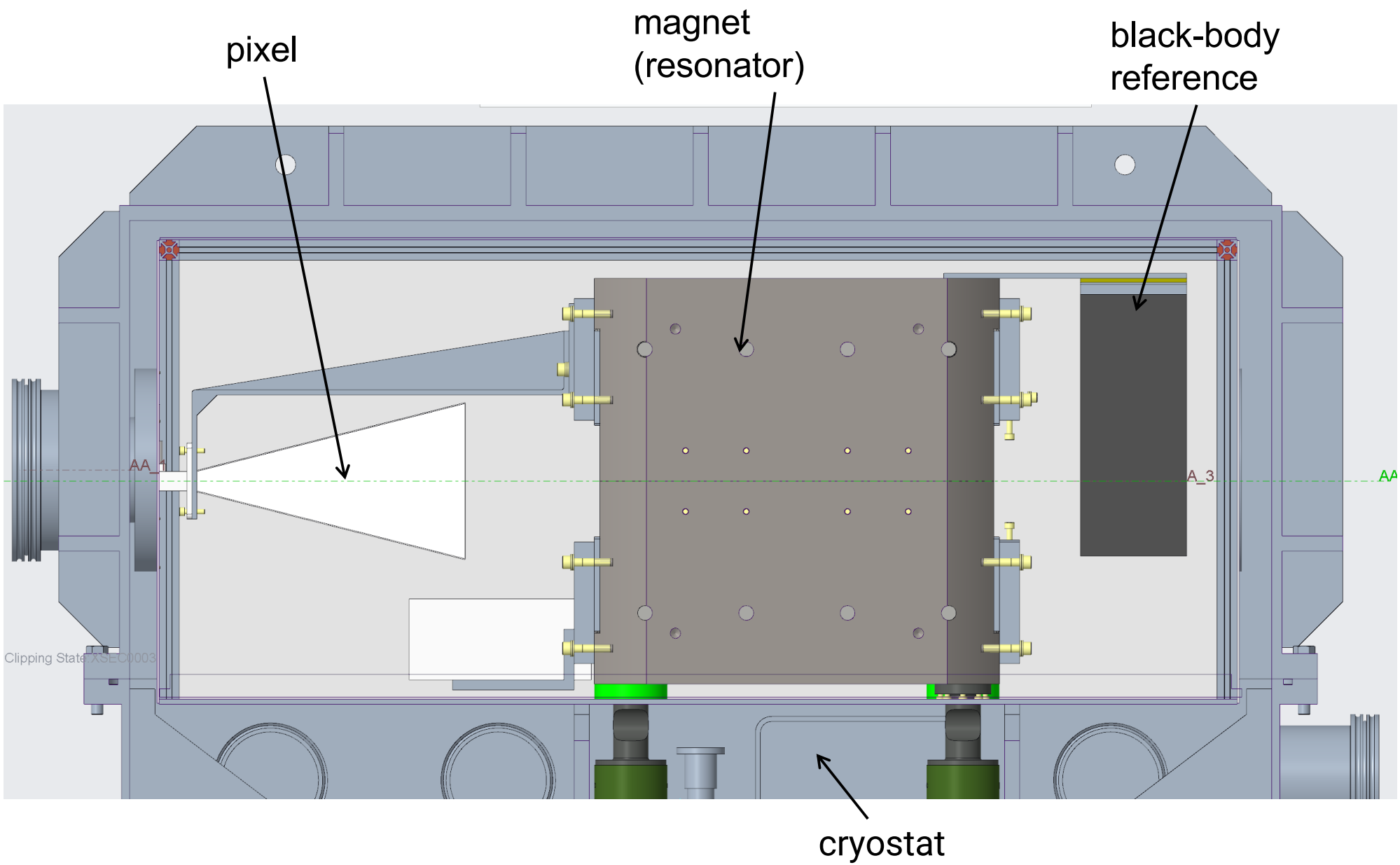


STATUS


DARK PHOTONS &
AXION LIKE PARTICLES
INTERFEROMETER
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.

Scaled-down DALI prototype

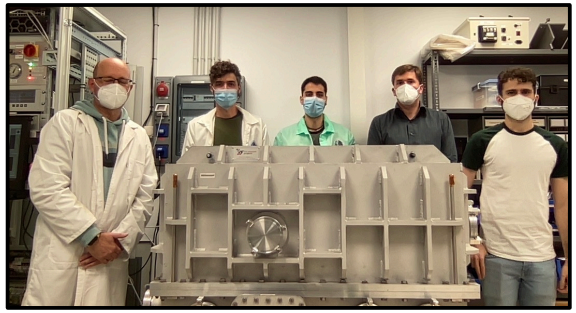


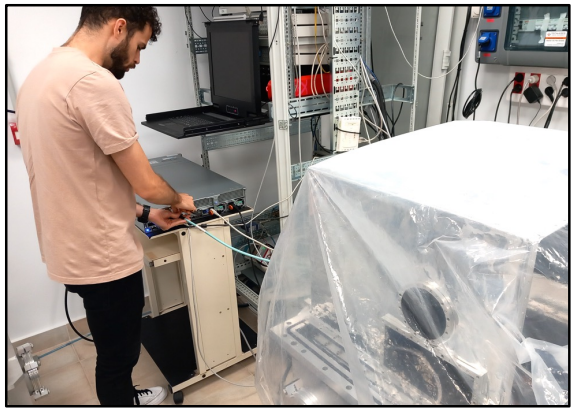

pixel
magnet
(resonator)
black-body
reference
cryostat

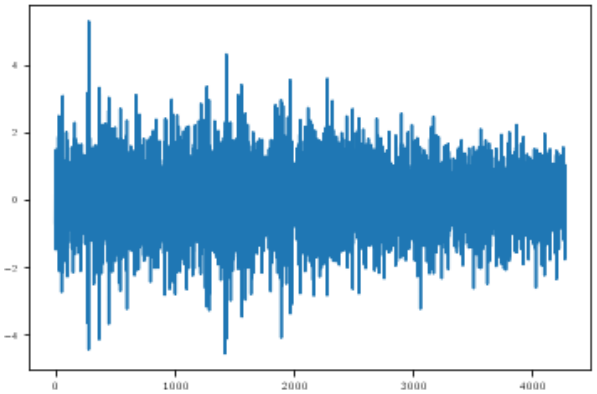
DARK PHOTONS & AXION LIKE PARTICLES INTERFEROMETER DALI

DARK PHOTONS & AXION LIKE PARTICLES INTERFEROMETER DALI

Cryogenics & Data Acquisition

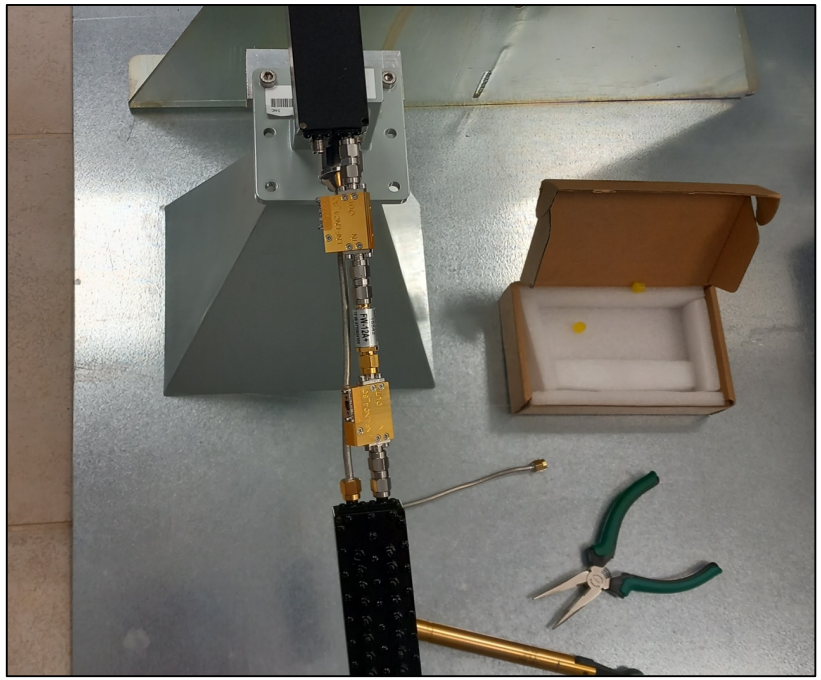


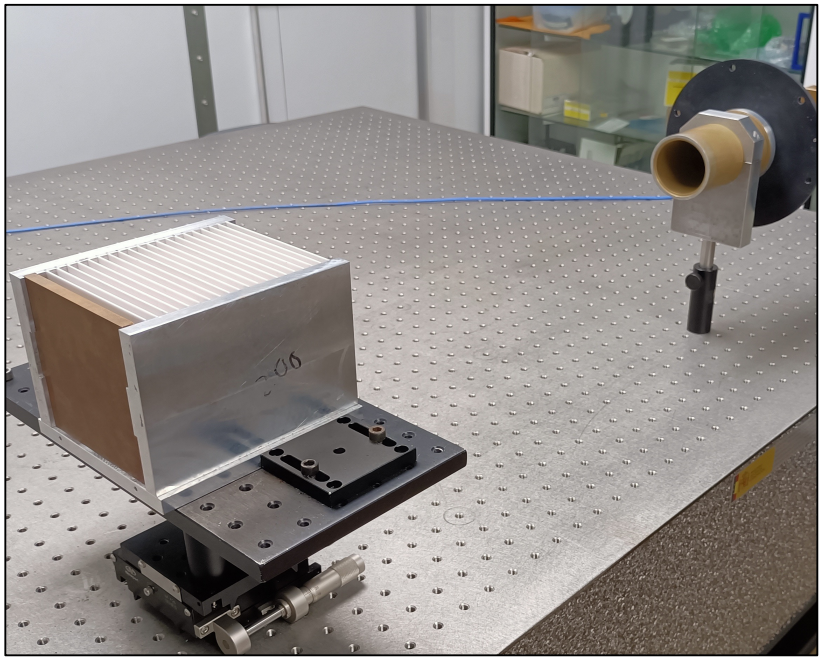


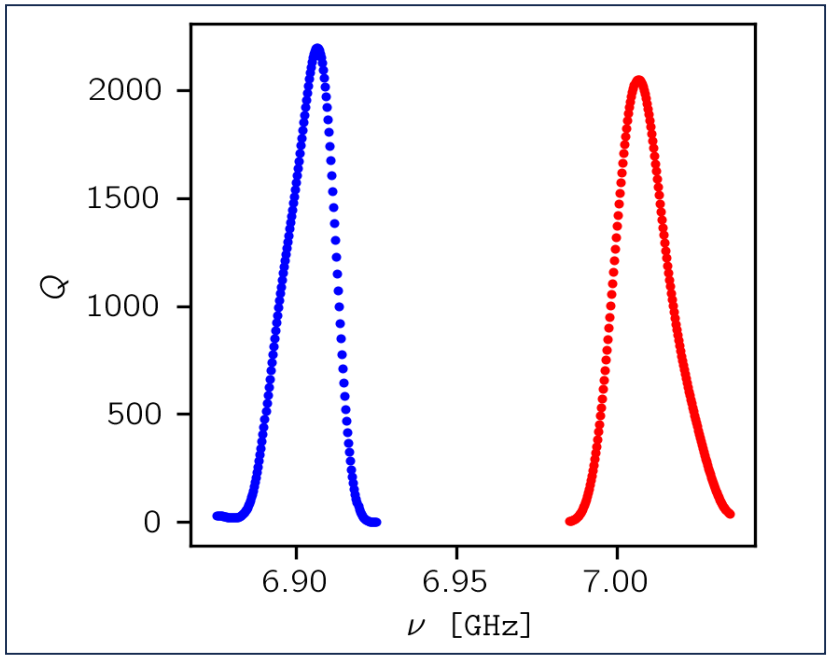


DARK PHOTONS & AXION LIKE PARTICLES INTERFEROMETER DALI

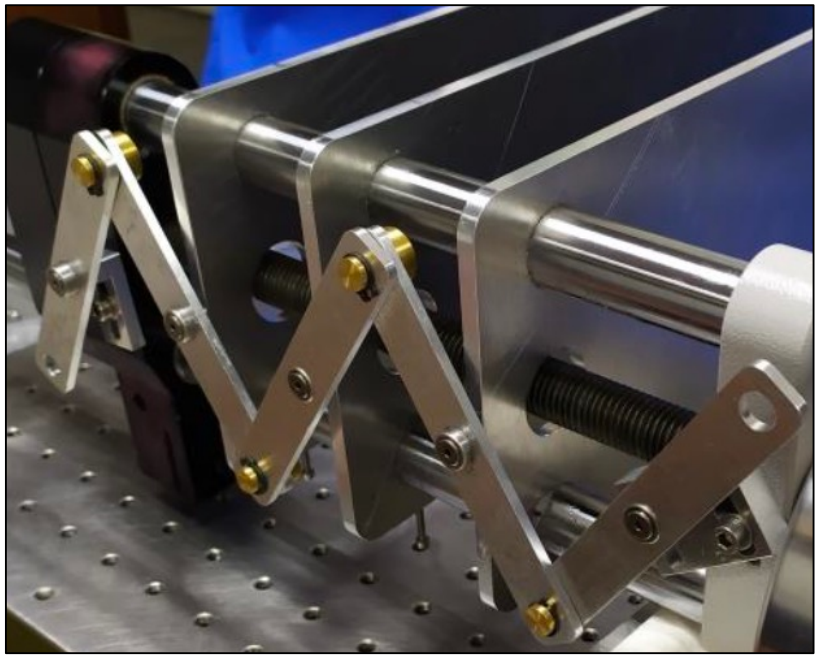
Calibration



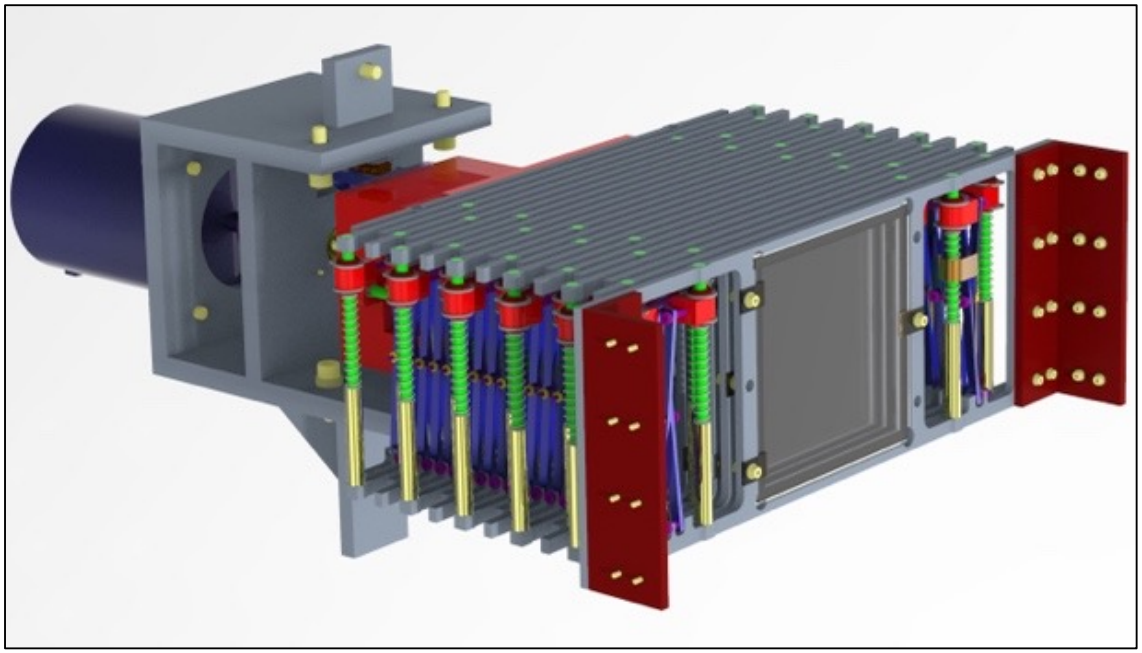




Frequency Tuner



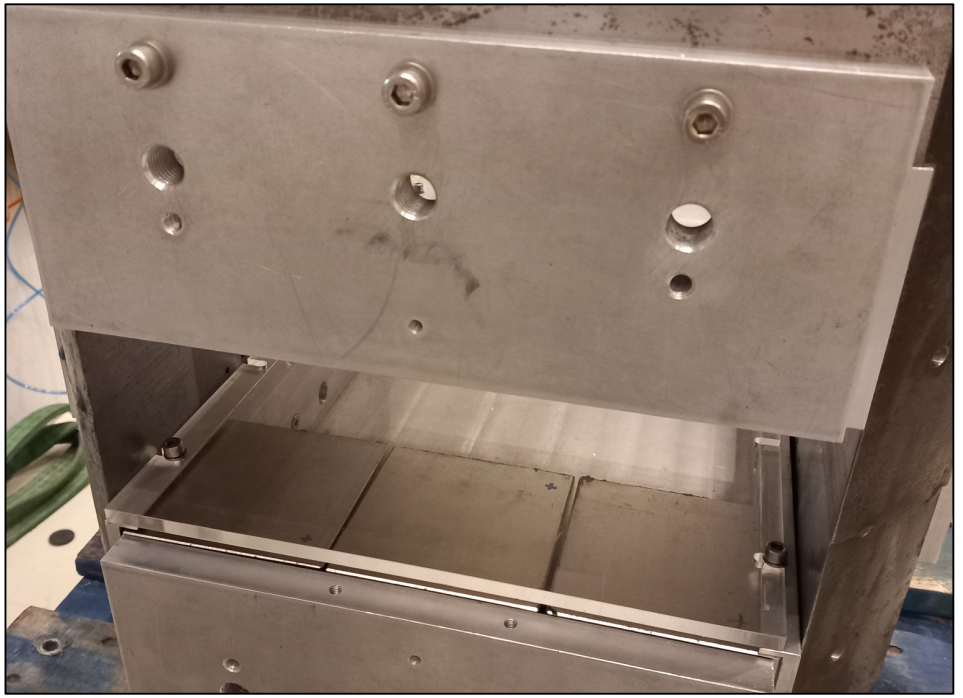
3-layer (proof-of-concept) prototype

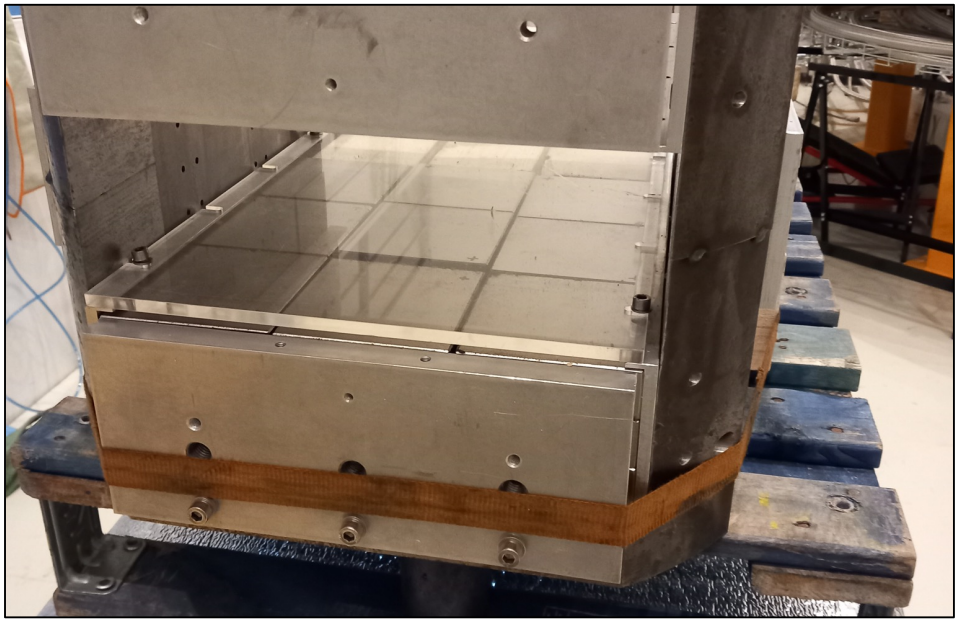


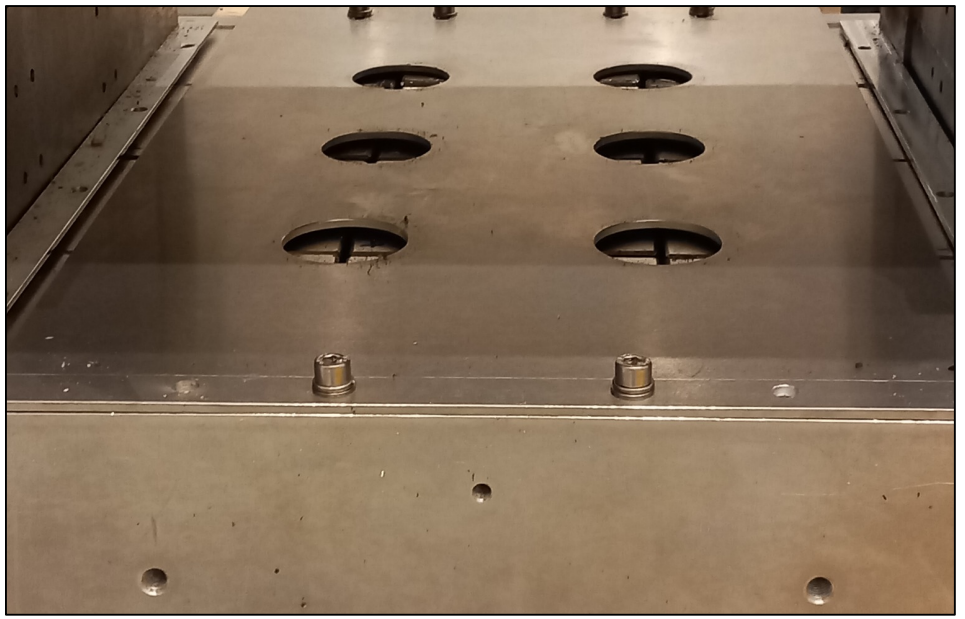
20-layer prototype (manufacturing)

DARK PHOTONS & AXION LIKE PARTICLES INTERFEROMETER DALI

Magnet







DARK PHOTONS & AXION LIKE PARTICLES INTERFEROMETER DALI

DALI prototype	B_0 [T]	Area [m^2]	Range [GHz]	T_{sys} [K]	Q	Sensitivity in t~1 day g_γ [GeV^{-1}]
Scaled-down	~1	1/100	6-8 31-35	~30 K	~2,000 ~8,000	~10^{-11}
full-scale Phase I	9.4	1/2	6-60	2-10 K	~50,000	~5×10^{-15}
full-scale Phase II	11.7	3/2	~10-100	2-10 K	~70,000	~10^{-15}

DARK PHOTONS & AXION LIKE PARTICLES INTERFEROMETER DALI

Key Takeaways:

1. DALI, new haloscope: **MPA + FP**
2. $\lambda/8$ & $\lambda/2$ (…) **simultaneous resonance** → faster scan
3. **only available equipment** (e.g. MRI solenoid) → **DFSZ sensitivity at >40 μeV**
4. **Alt-azimuth mount** & **streams, HF-GWs,** …
5. Scaled-down **prototype** science for Q1 2025

DARK PHOTONS & AXION LIKE PARTICLES INTERFEROMETER DALI

References

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

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

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

5. De Miguel et al. “DALI sensitivity to streaming axion dark matter”. (2024) arXiv:2404.13970 [hep-ph]

DARK PHOTONS & AXION LIKE PARTICLES INTERFEROMETER DALI

Postdoc position (experimental):

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