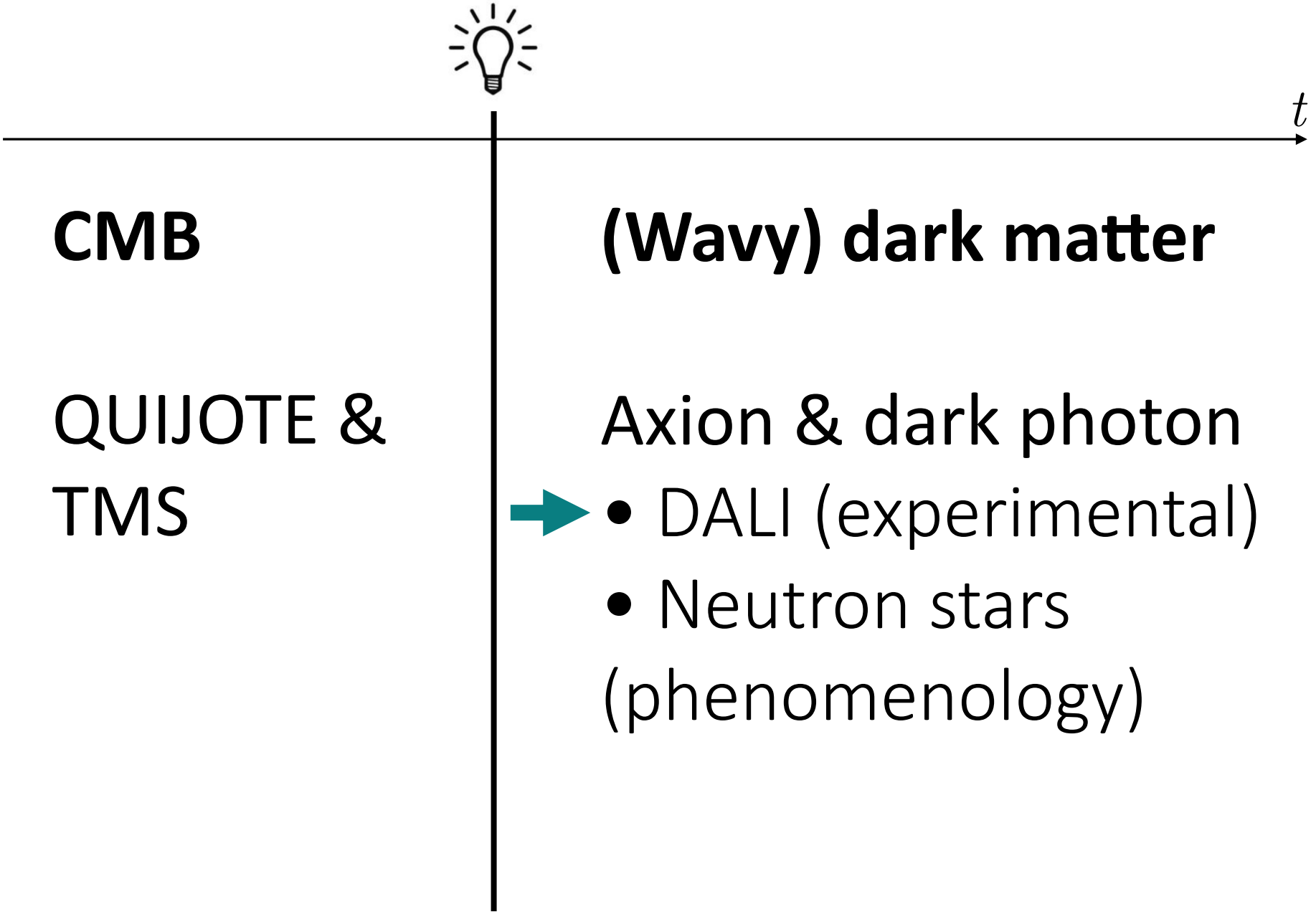
DARK PHOTONS & AXION LIKE PARTICLES INTERFEROMETER

International Workshop on Multi-probe approach to wavy dark matters

Korea University Seoul 2023

Javier De Miguel (on behalf of the DALI Collaboration) RIKEN (Japan), IAC (Spain)



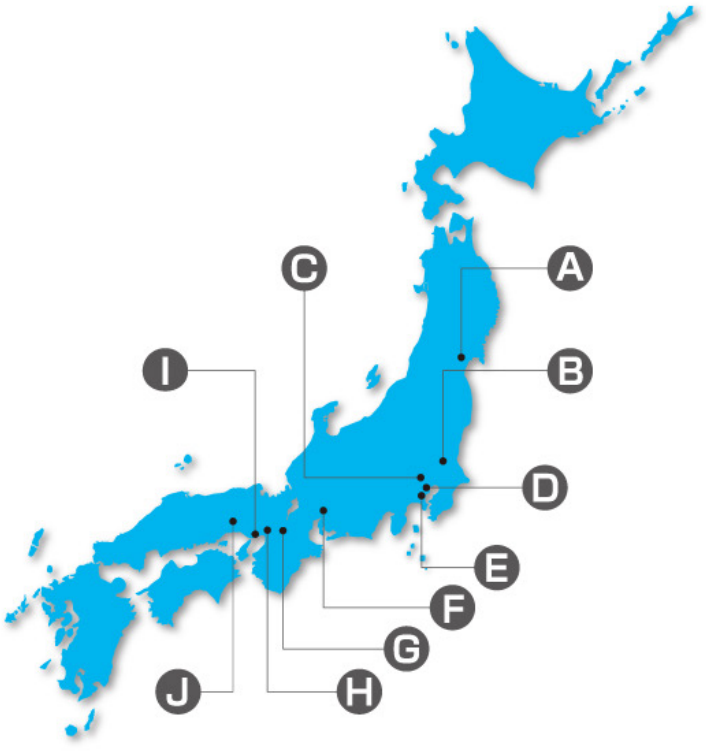
CMB

QUIJOTE & TMS

(Wavy) dark matter

Axion & dark photon

- DALI (experimental)
- Neutron stars (phenomenology)



RIKEN (Sendai city)

GTC

MAGIC

CTA

QUIJOTE

References

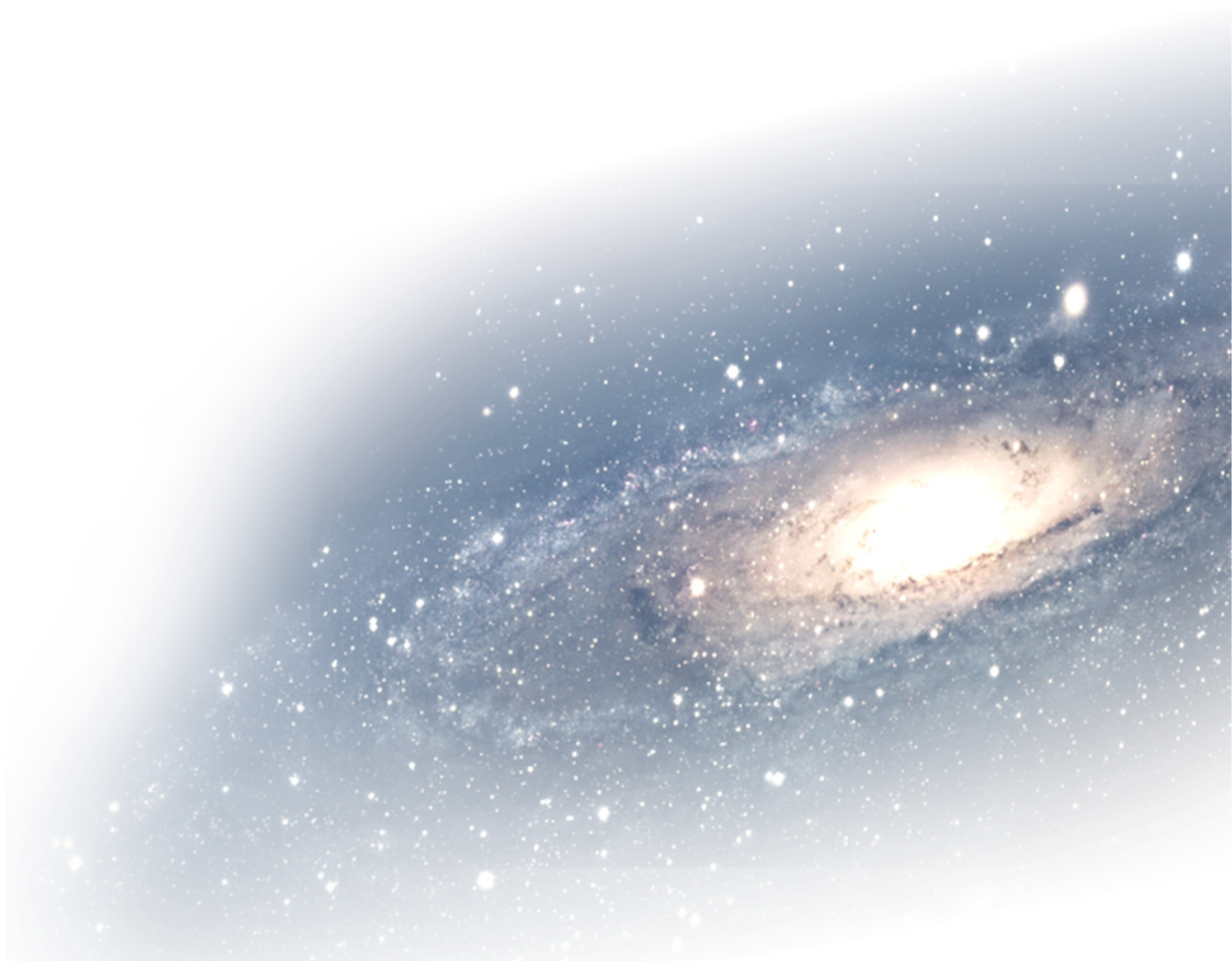
J. De Miguel. “A dark matter telescope probing the 6 to 60 GHz band”. (2020) arXiv:2003.06874 [physics.ins-det]

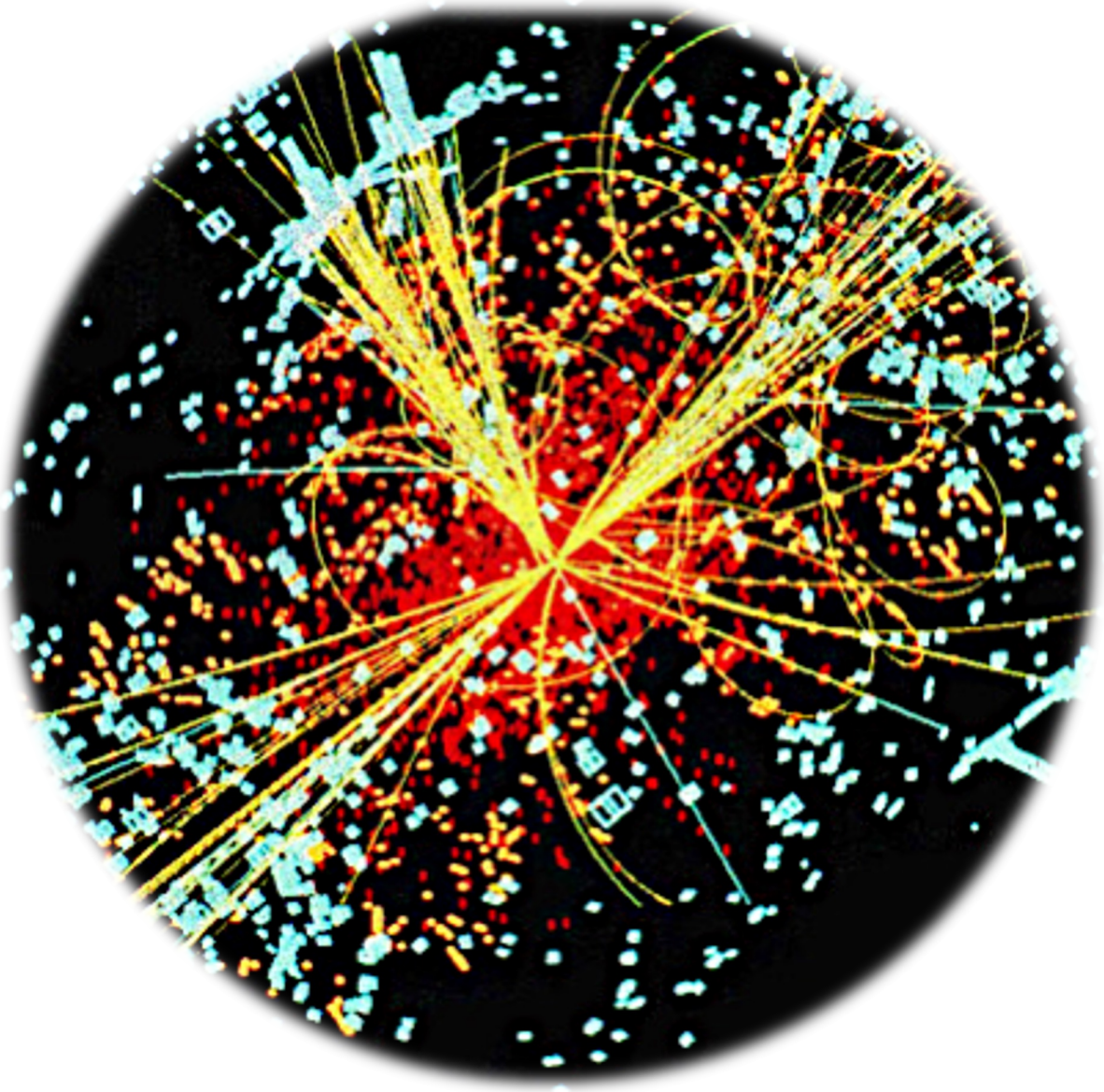
J. De Miguel et al. “Discovery prospects with the Dark-photons & Axion-Like particles Interferometer”. (2023) arXiv:2303.03997 [hep-ph]

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]

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]

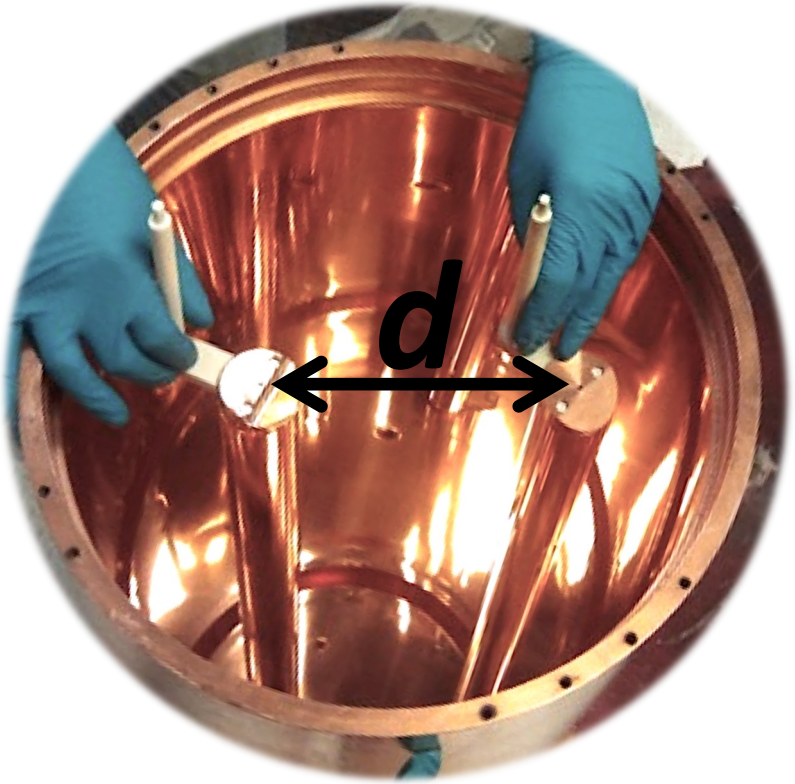
PREFACE





Higgs boson production. Credits CMS/LHC

Resonant cavity (ADMX)

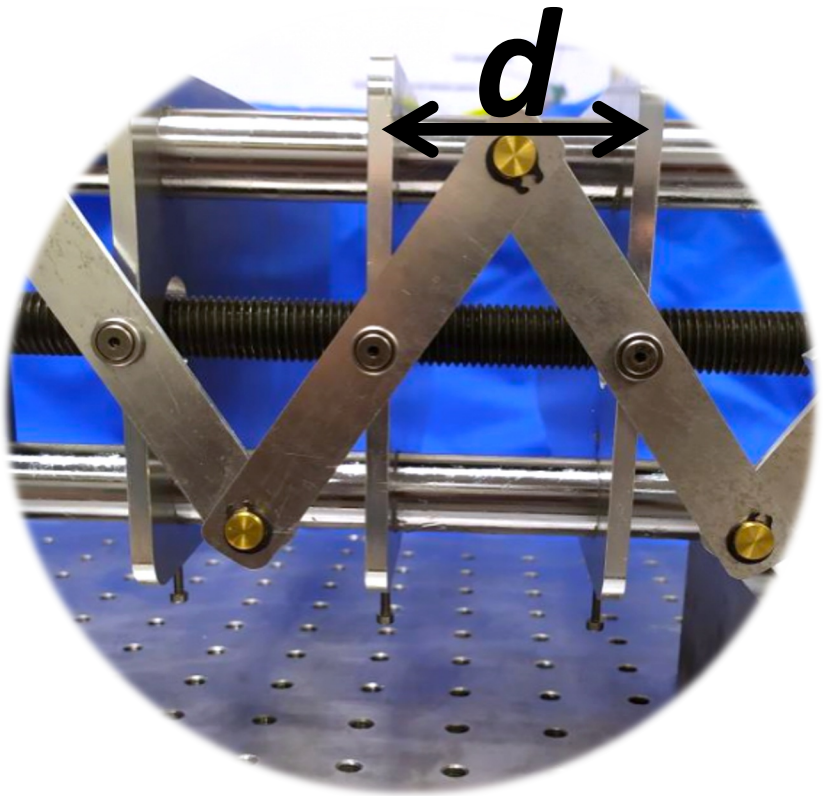


$d \sim \lambda$

$V \sim \pi \times d^2 \times \text{height}$

$P \propto \mathbf{V} \times Q$

Fabry-Pérot (DALI)



$d \sim \lambda/2$

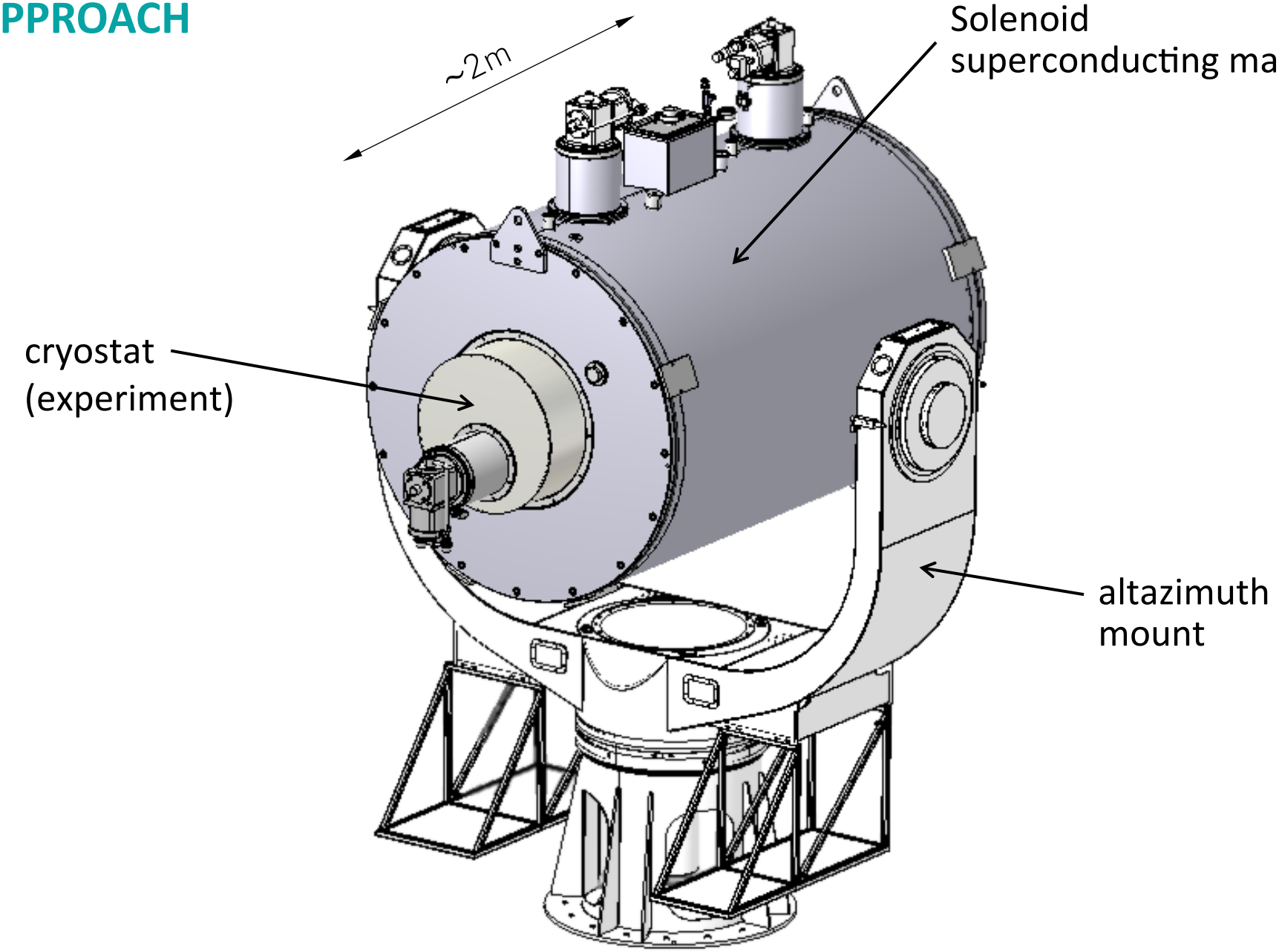
$V \sim \underbrace{\text{length} \times \text{height}}_{=A} \times \text{width}$

$P \propto \mathbf{A} \times Q$

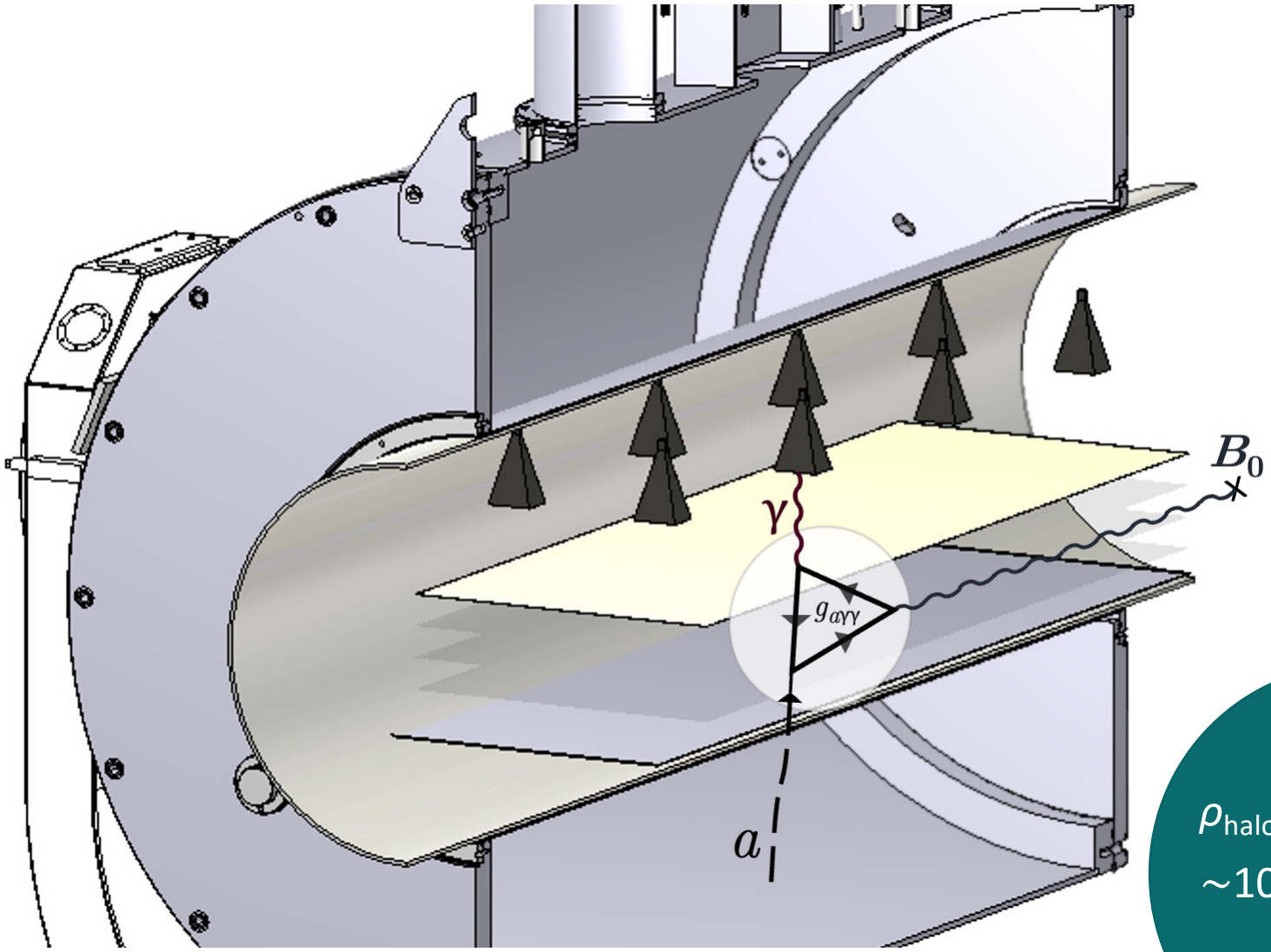
Project	Experimental approach	Range [μeV]	Sensitivity [DFSZ > KSVZ]
ADMX G2	Cavity haloscope	25–?	>KSVZ (?)
CAPP			
ORGAN			
QUAX			
ALPHA	Plasma haloscope	40–	DFSZ
ALPS II	Light shining through a wall	$\lesssim$100	<KSVZ
BRASS	Dish antenna haloscope	40–4000	<KSVZ
DALI	**Fabry-Pérot haloscope**	**25–250**	**DFSZ**
IAXO*	Helioscope	$<10^3$	<KSVZ
		$\sim 10^4$	DFSZ
MADMAX	Dielectric haloscope	40–	DFSZ
Orpheus	Fabry-Pérot (SC) haloscope	40–	DFSZ
RADES	Cavity filter halos.	25–	KSVZ (?)

*BabyIAXO is ~1/10 scale.

EXPERIMENTAL APPROACH



EXPERIMENTAL APPROACH

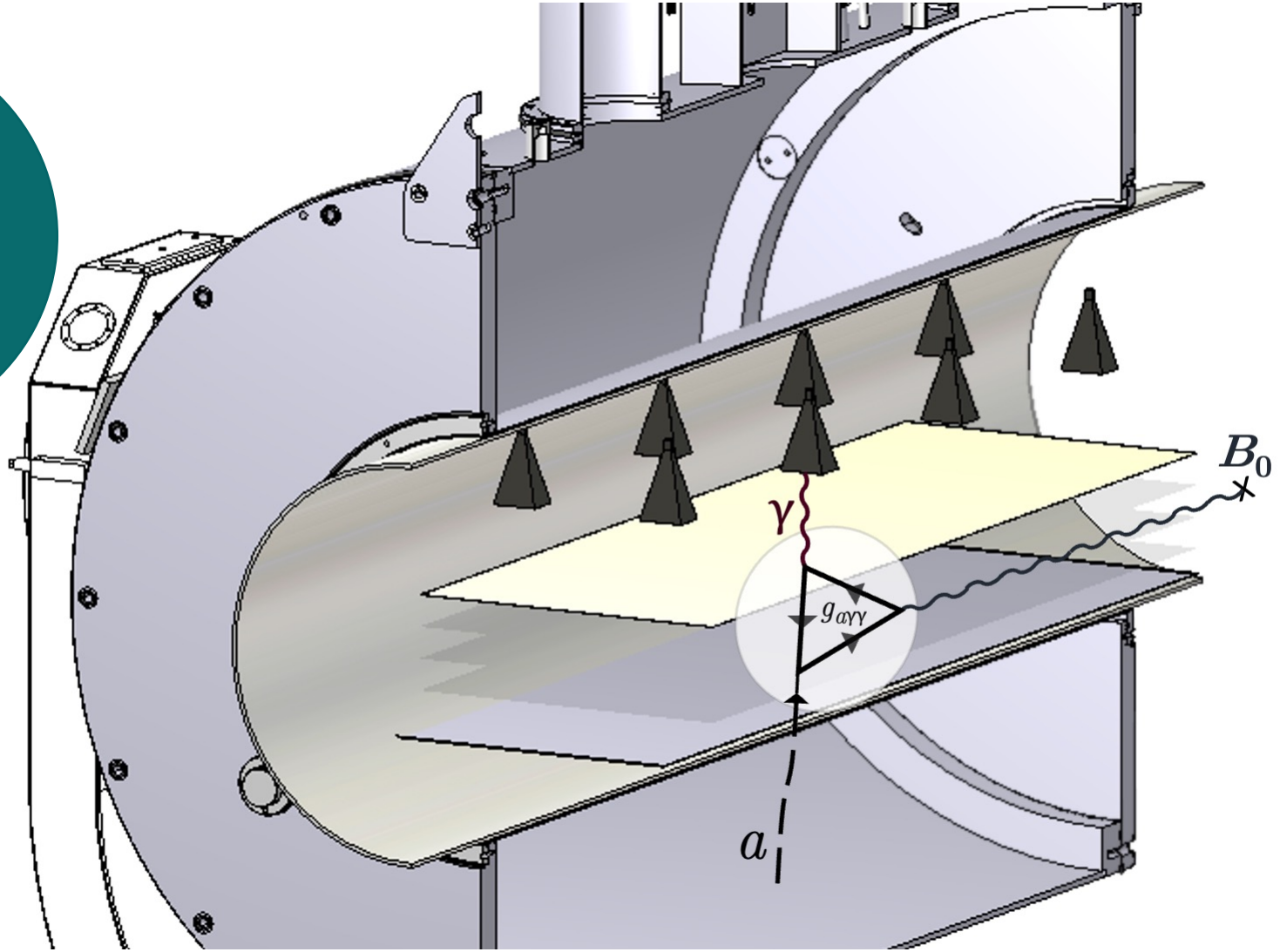


$\rho_{halo} \sim ½$ GeVcm^{-3}

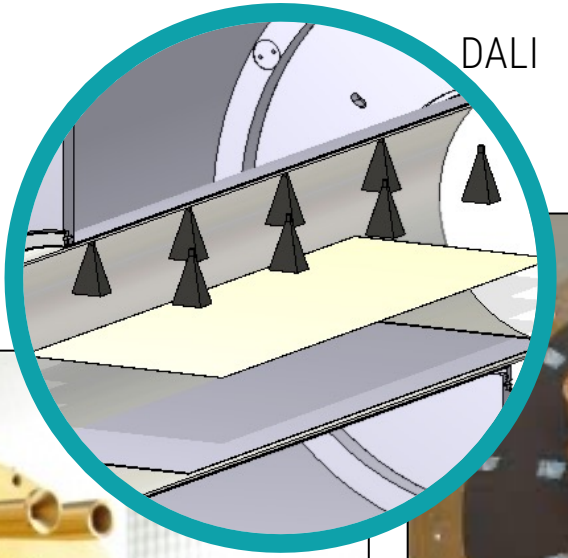
$\sim 10^{18}$ axion/liter

EXPERIMENTAL APPROACH

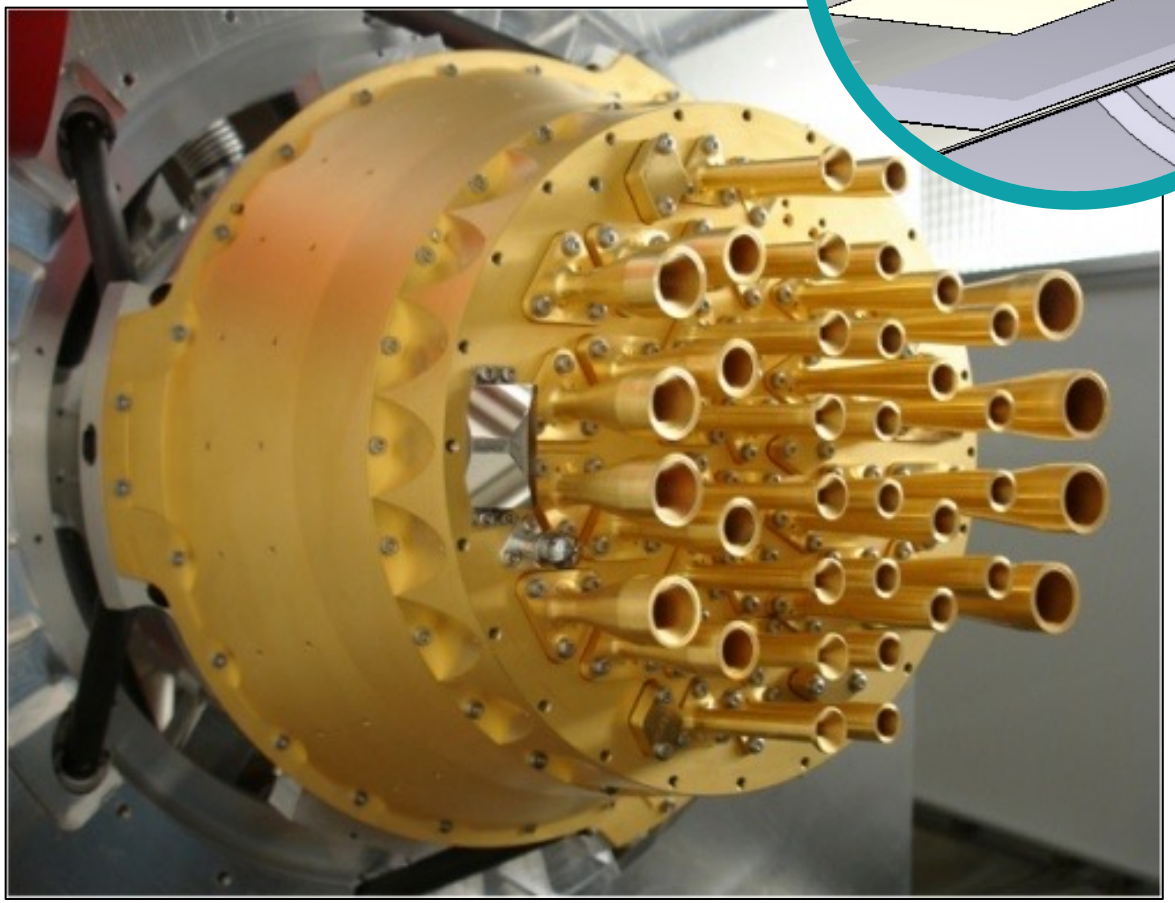
$a + B_0 \rightarrow \gamma$
on antennas



EXPERIMENTAL APPROACH



DALI

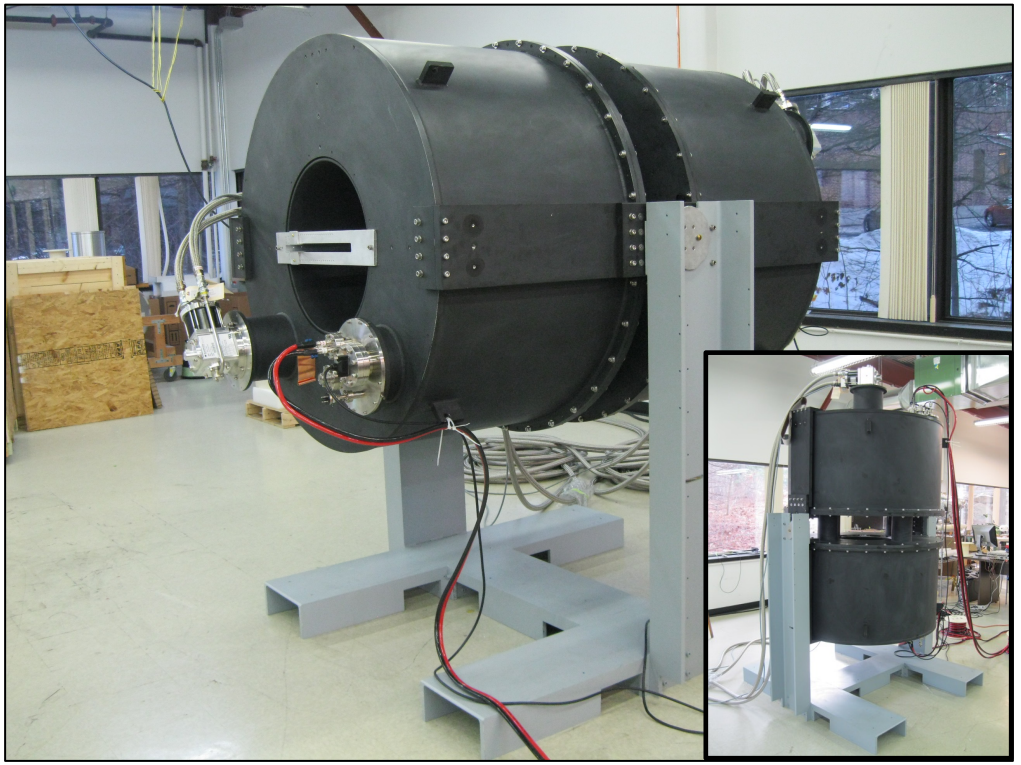


Planck

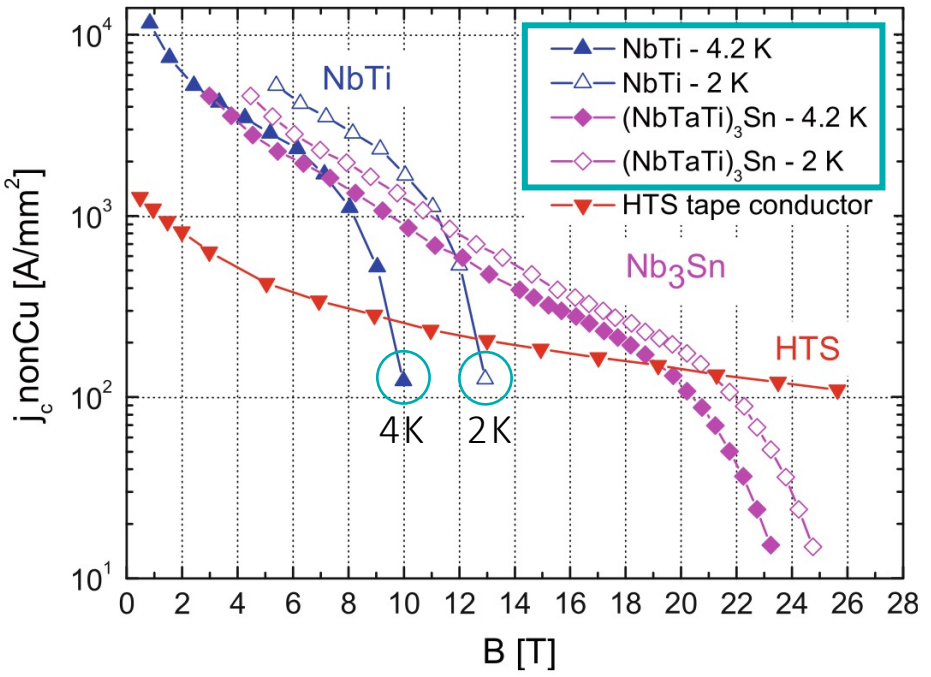
BICEP

QUaD

EXPERIMENTAL APPROACH

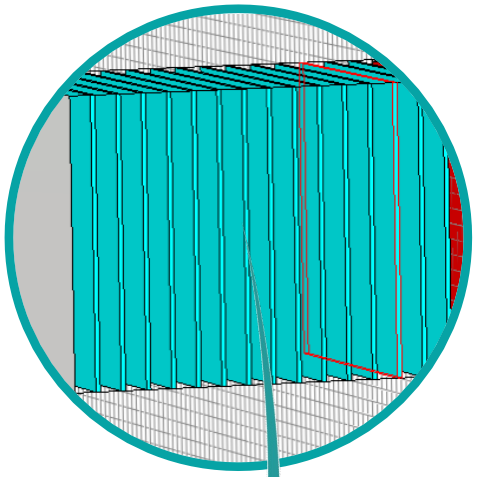


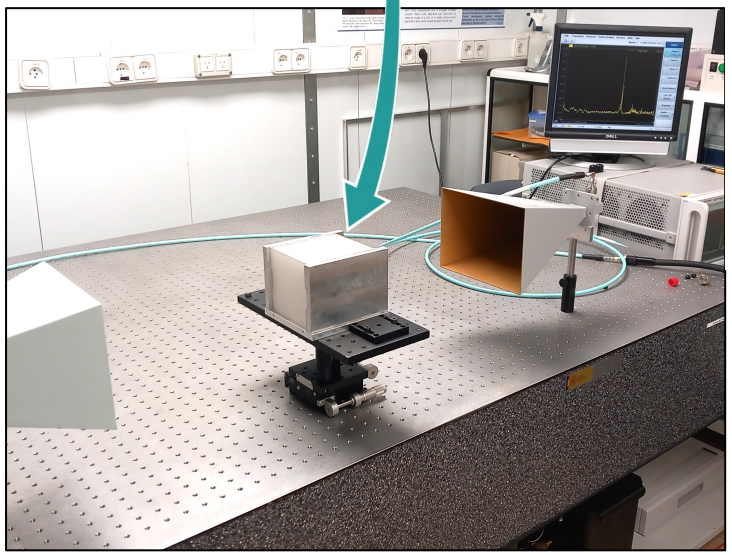
H. Liebel 2011

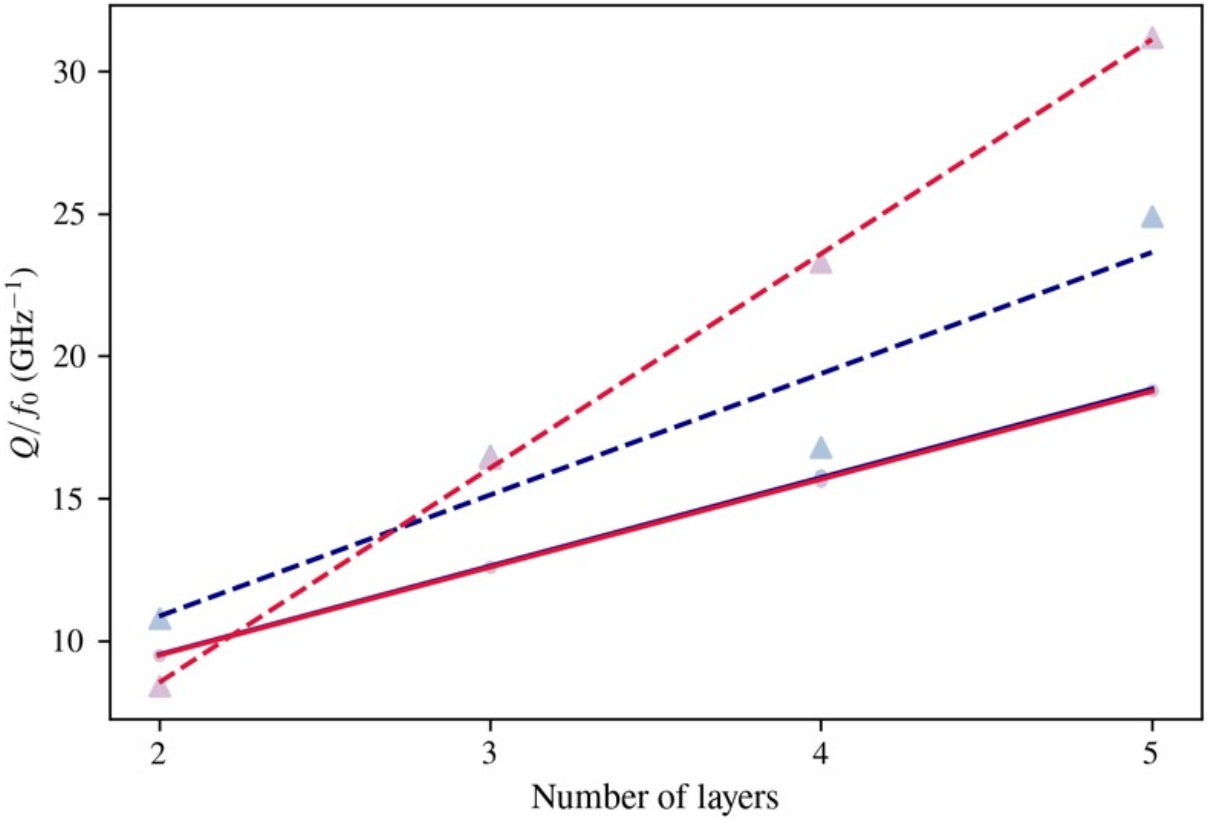


EXPERIMENTAL APPROACH

[2310.16013]



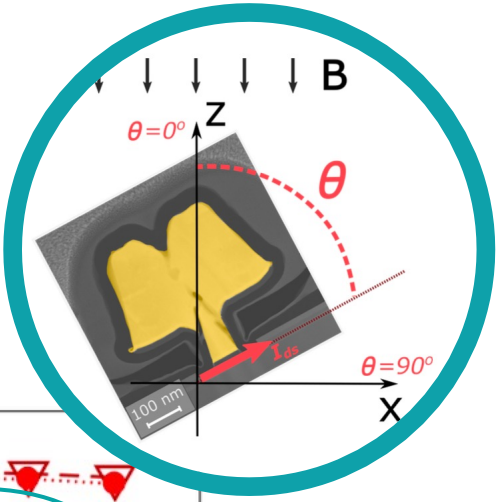




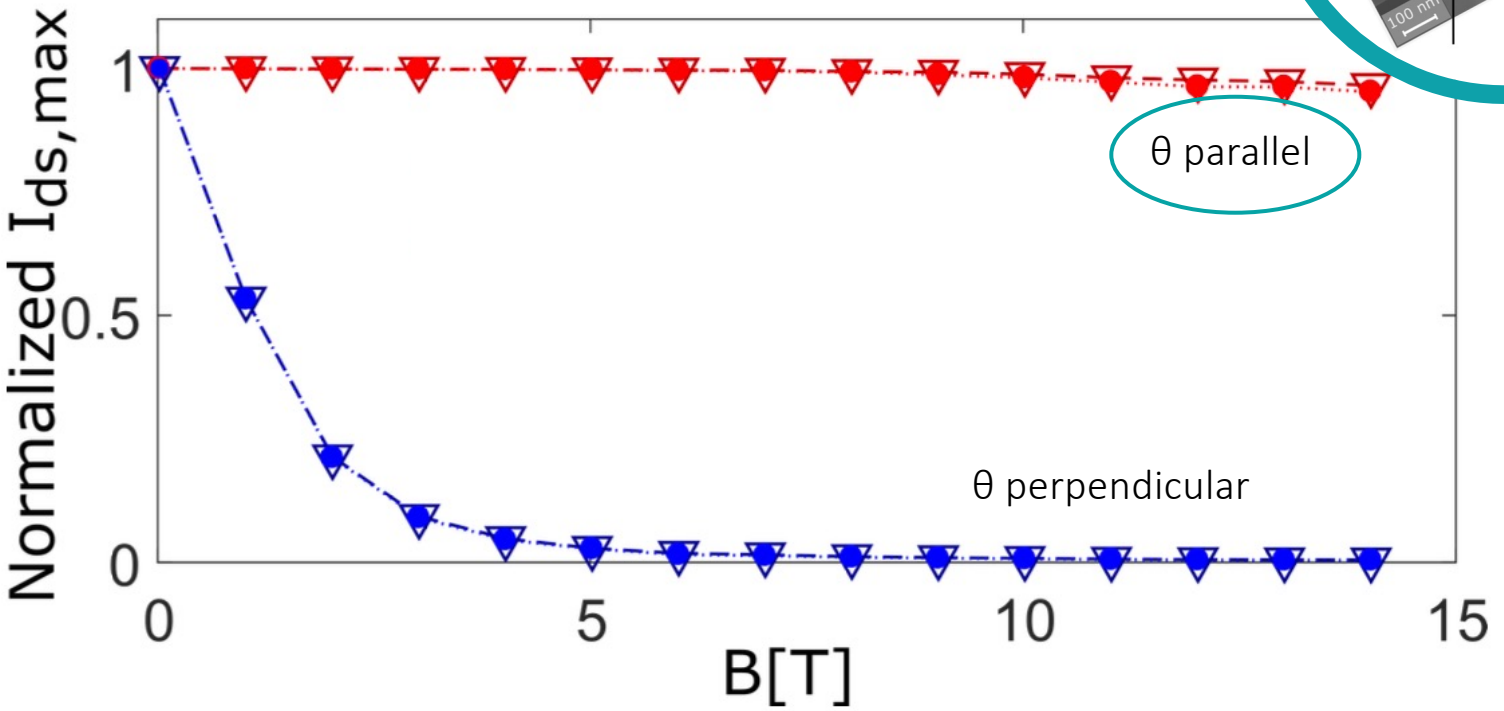
$Q = \omega \times$ group delay $\sim 10^4$

N = number of layers ~ 50

EXPERIMENTAL APPROACH

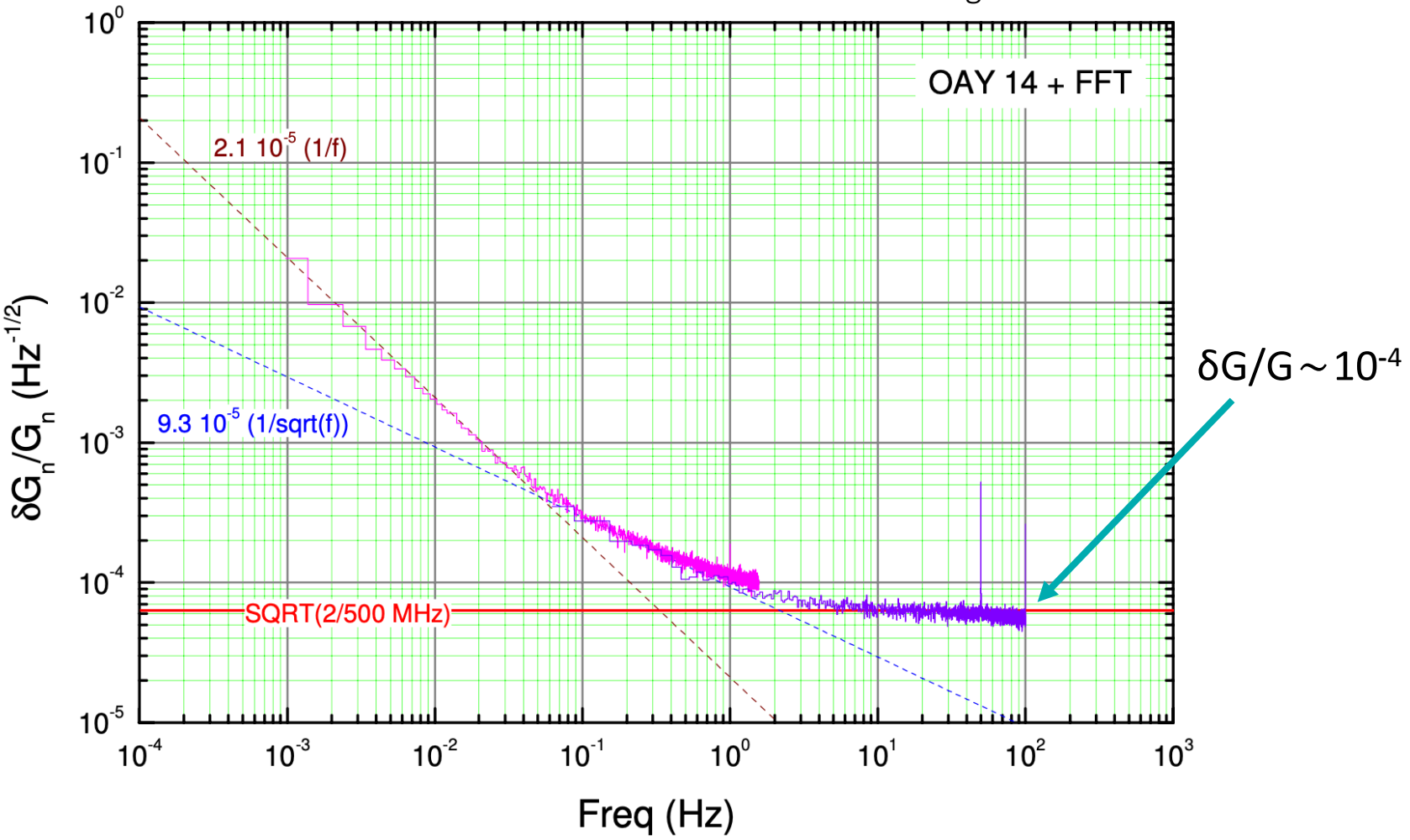


Rodrigues et al. 2019



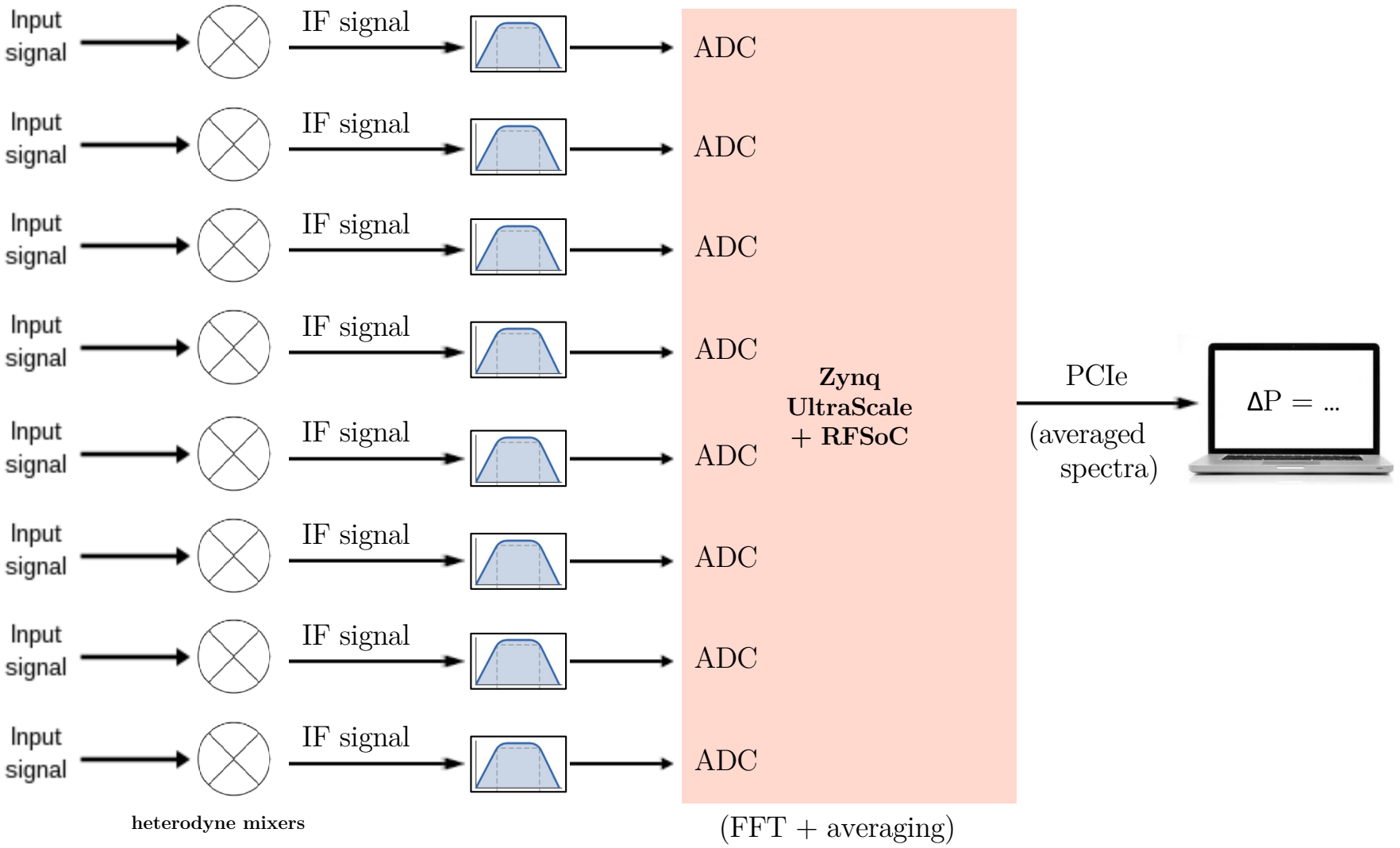
EXPERIMENTAL APPROACH

Gallego et al. 2004



$$\delta G/G << (\delta \nu_a \, x \, t)^{-½} \rightarrow t < 10 \text{ ms}$$

EXPERIMENTAL APPROACH

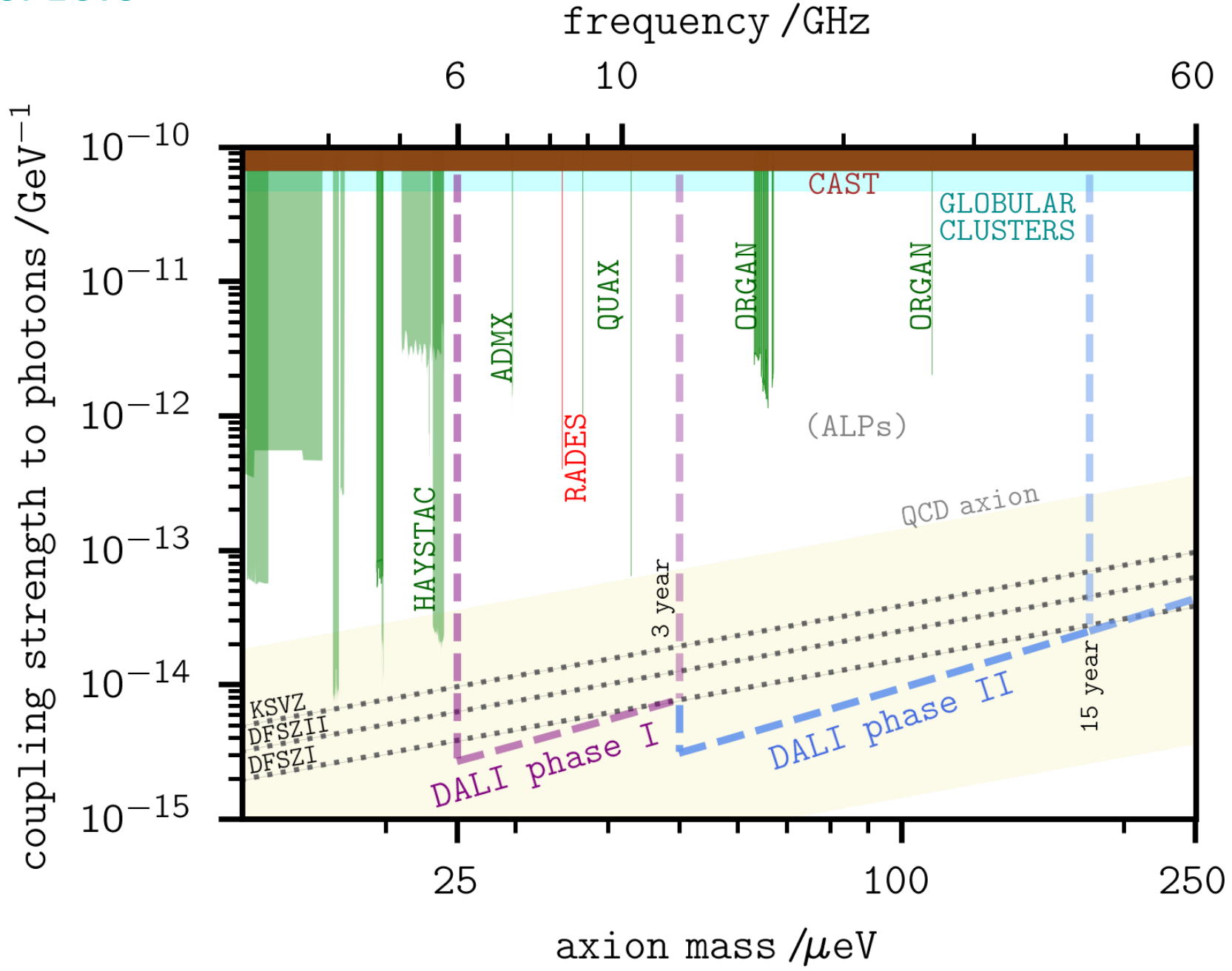


$$g_{a\gamma} \propto T_{sys}^{\frac{1}{2}}\, A^{-\frac{1}{2}}\, Q^{-\frac{1}{2}}\, eff_{sys}^{-\frac{1}{2}}\, t_{tot}^{-\frac{1}{4}}\, B_0^{-1}$$

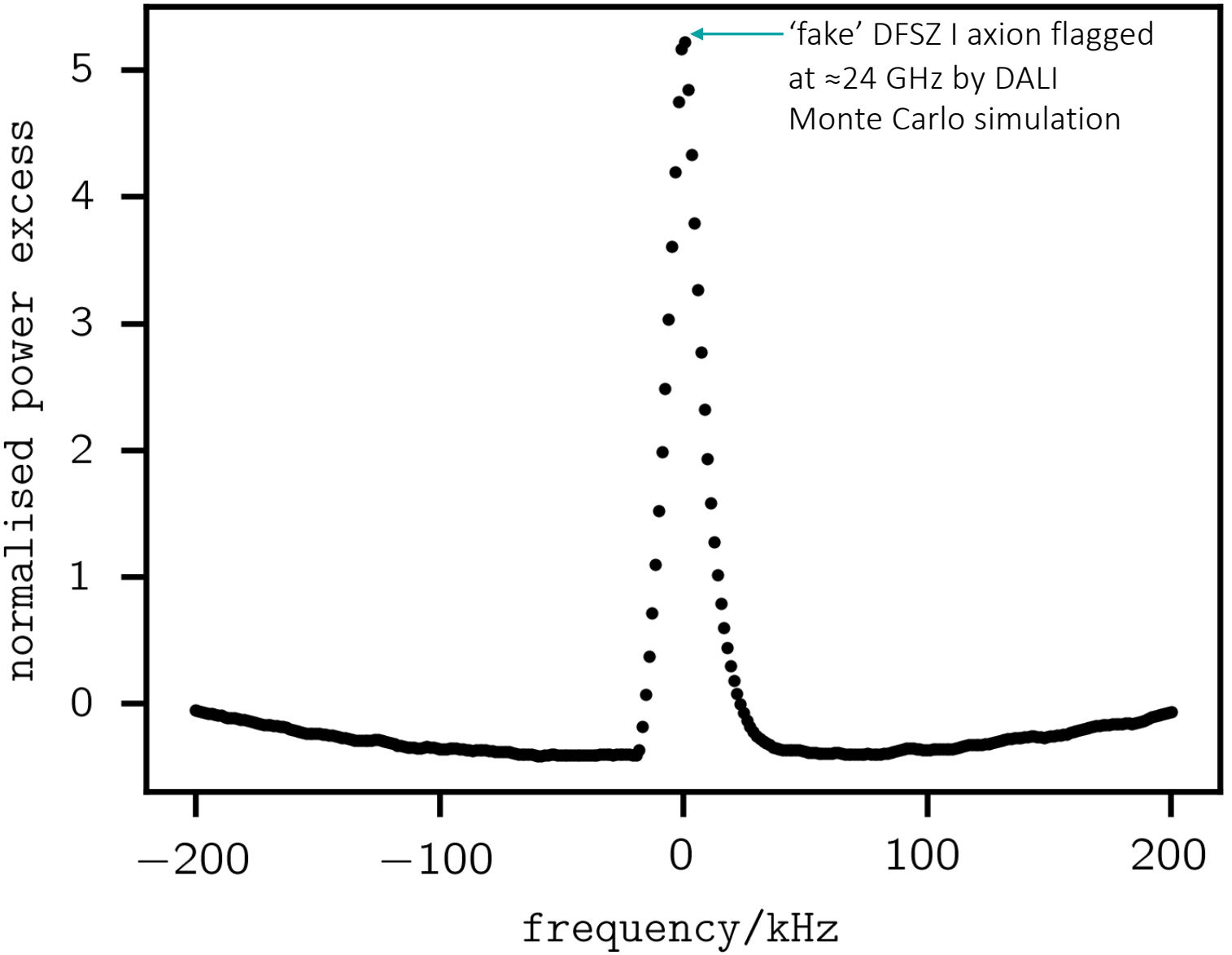
- $T_{sys} \sim T_{LNA}$ + 3 x quantum noise (< 10 K at 60 GHz)
- $A \sim 1\ m^2$
- $Q \sim 10^4$ (40–50 layers ZrO_2, $\delta\nu \sim 50$ MHz)
- $eff_{sys} > 80\ \%$
- $t_{tot} \sim$ day ($t \sim 1$ ms)
- $B_0 \sim 10$ T

DISCOVERY PROSPECTS

Sensitivity to Halo AXION dark matter

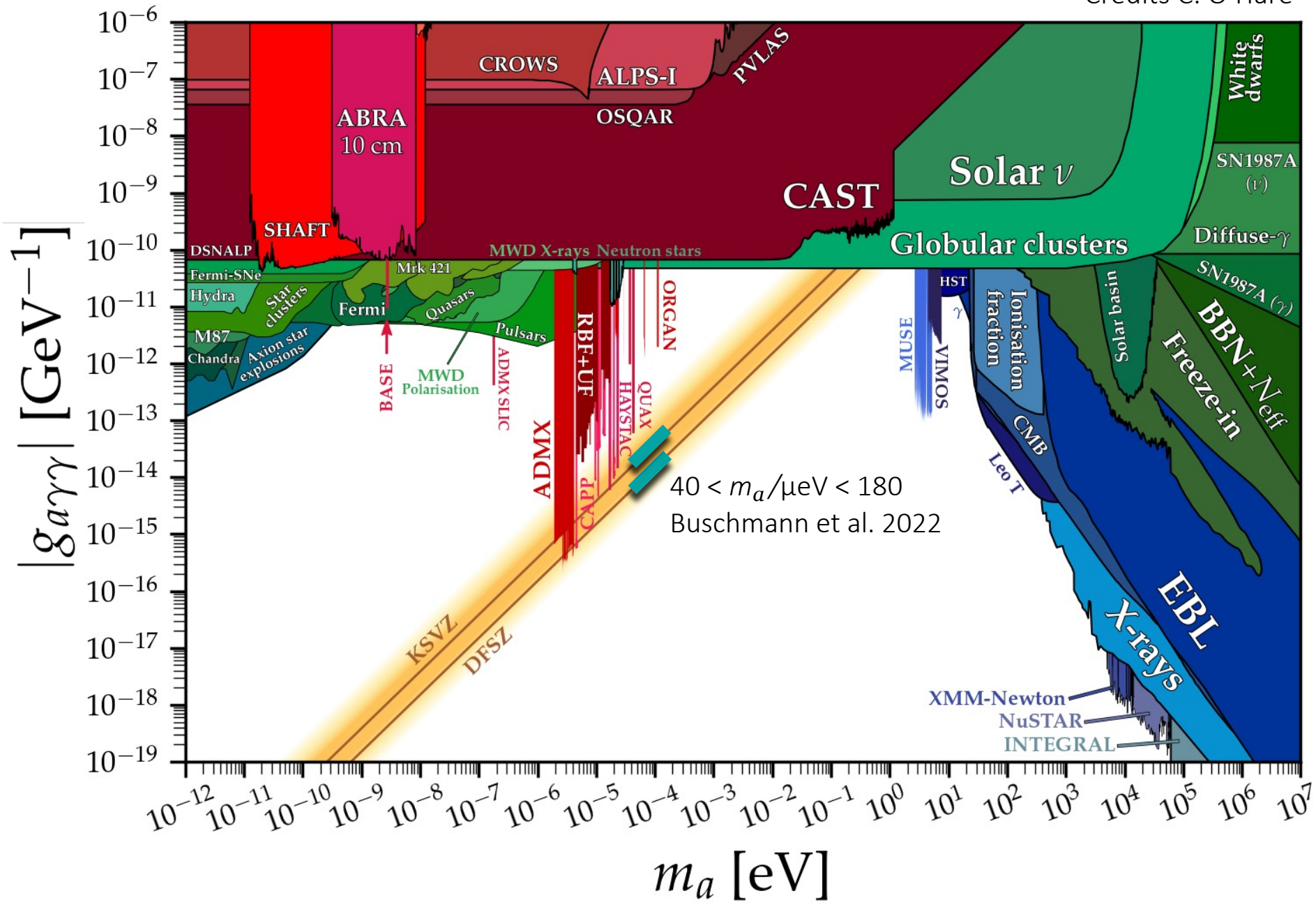


[2310.20437]


'fake' DFSZ I axion flagged
at ≈24 GHz by DALI
Monte Carlo simulation
normalised power excess
0
1
2
3
4
5
−200
−100
0
100
200
frequency/kHz

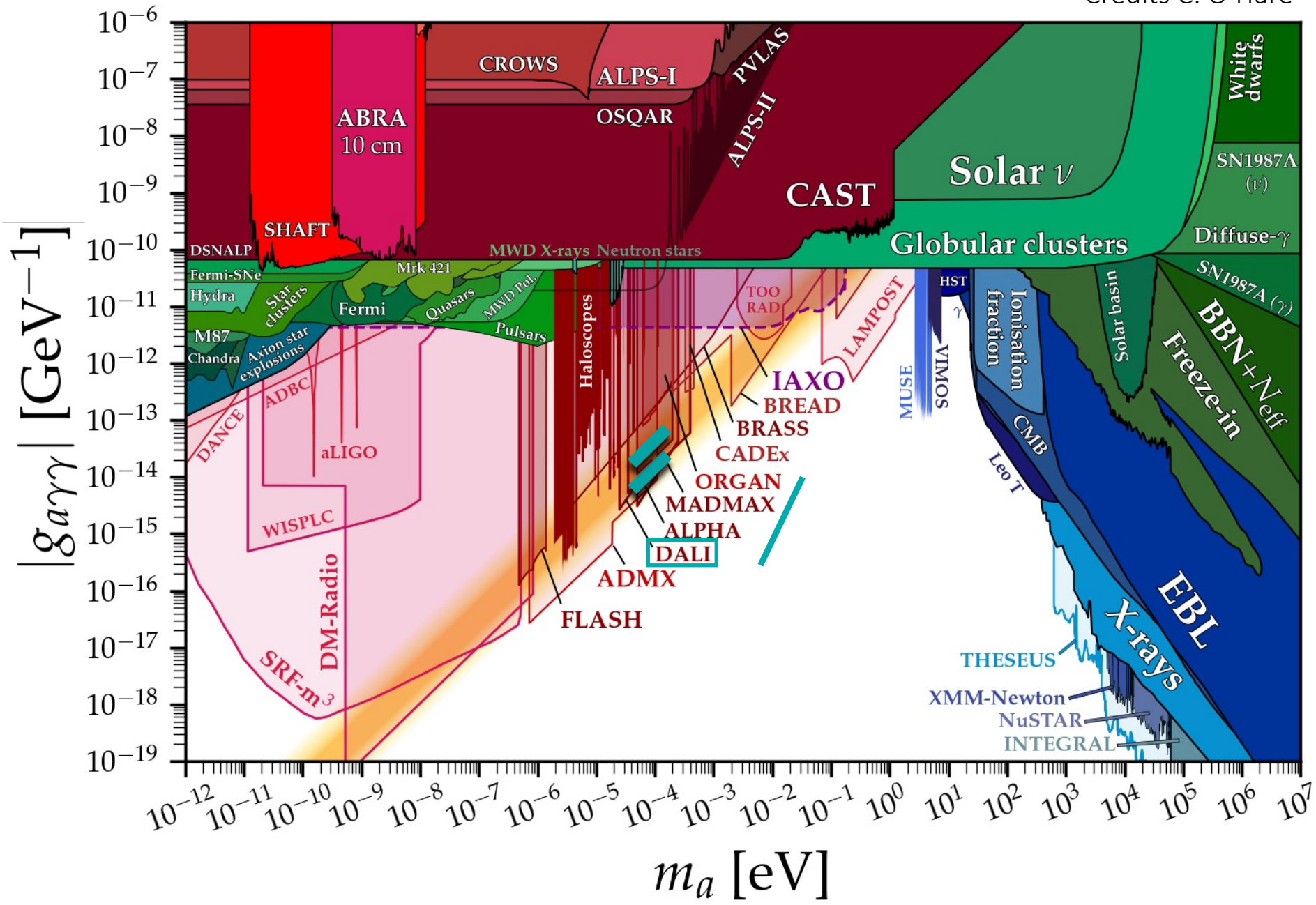
DISCOVERY PROSPECTS

Credits C. O'Hare

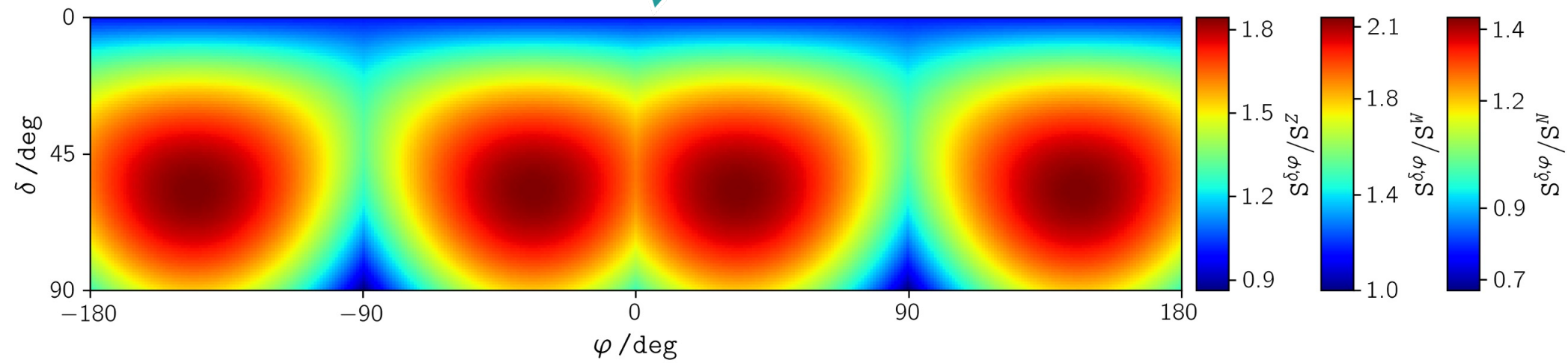


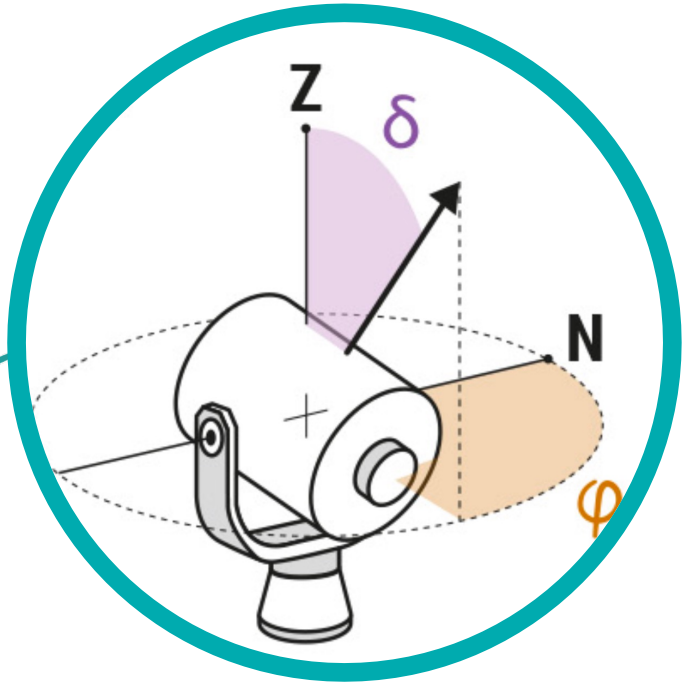
DISCOVERY PROSPECTS

Credits C. O'Hare



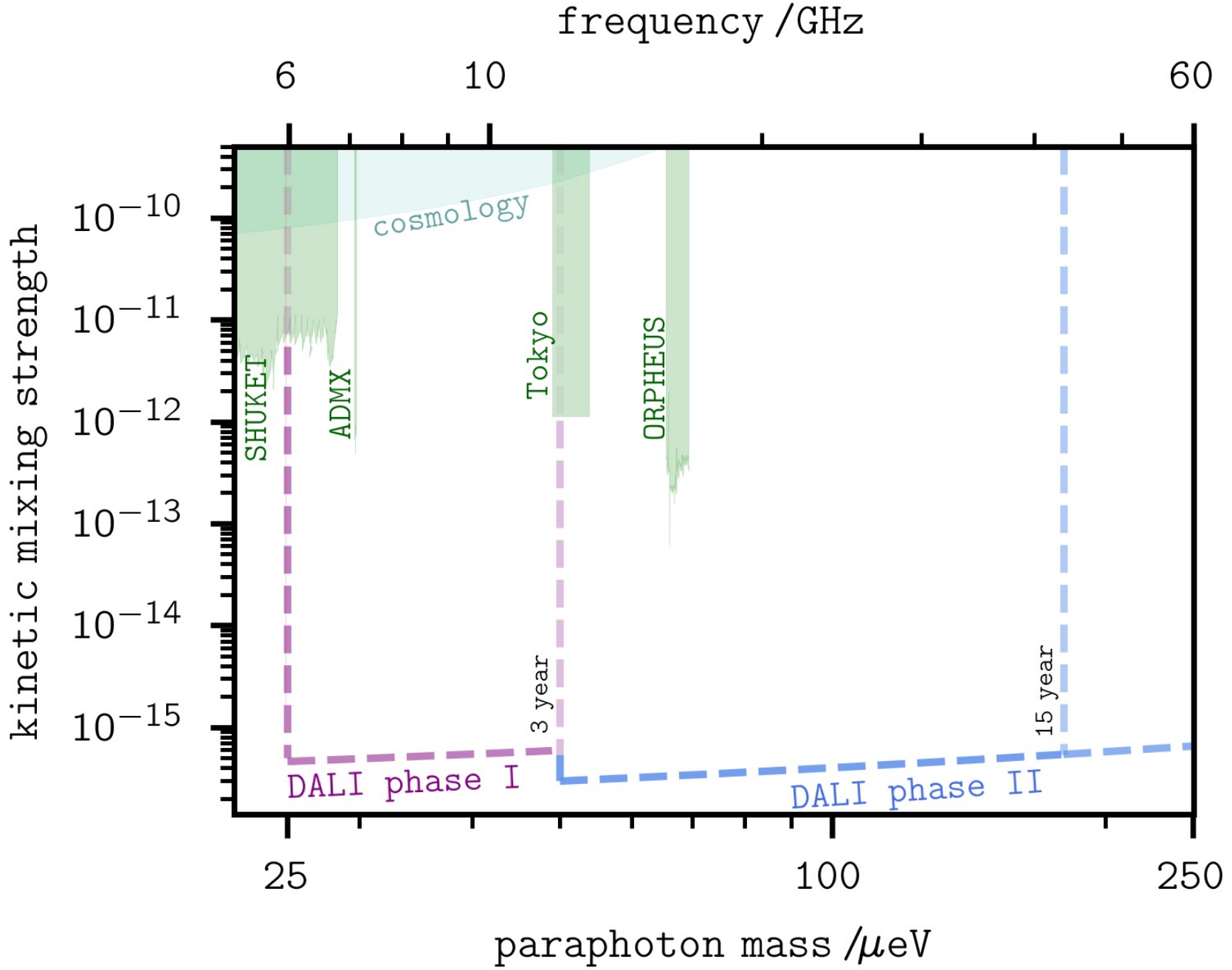
DISCOVERY PROSPECTS





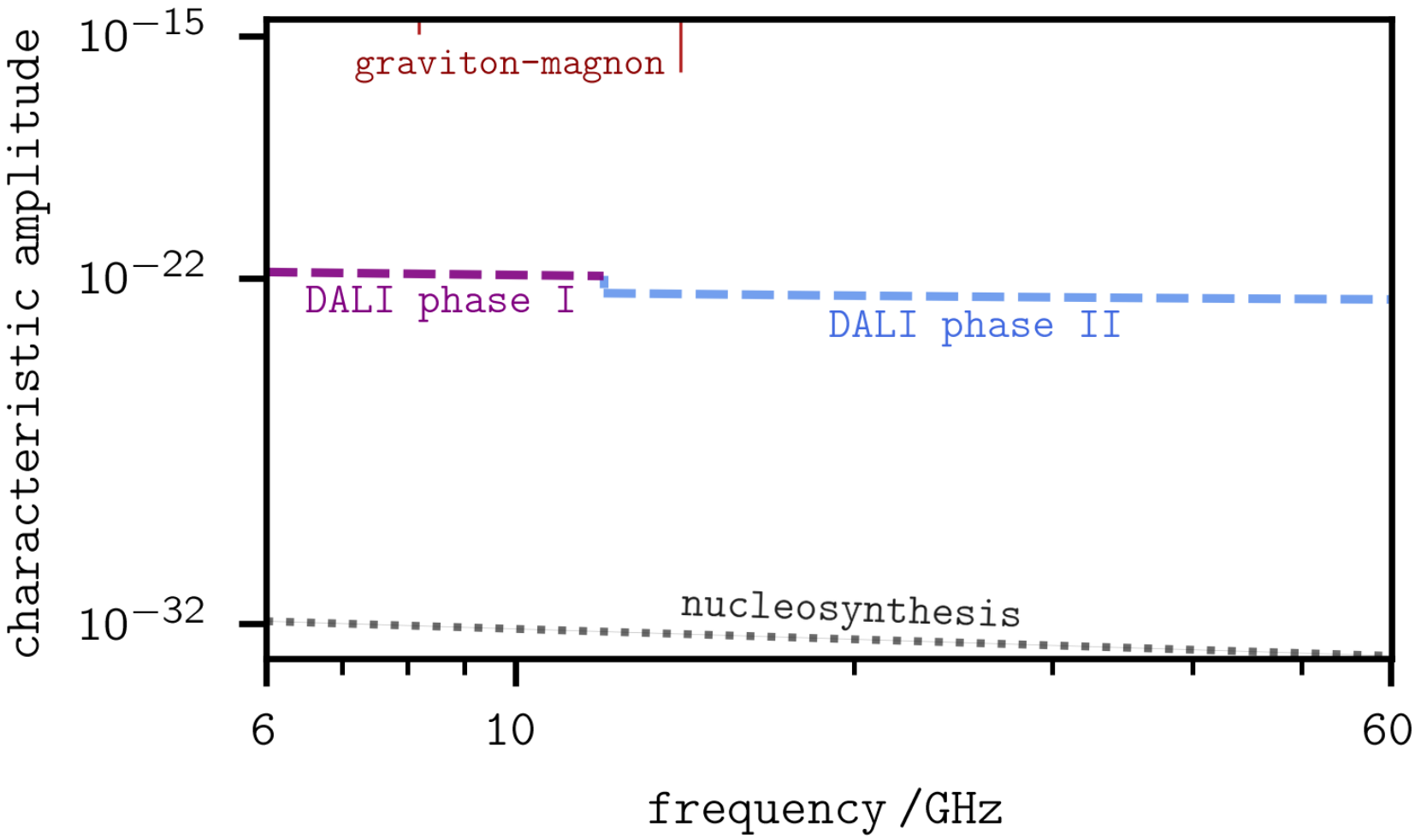
DISCOVERY PROSPECTS

Sensitivity to Halo DARK-PHOTON dark matter



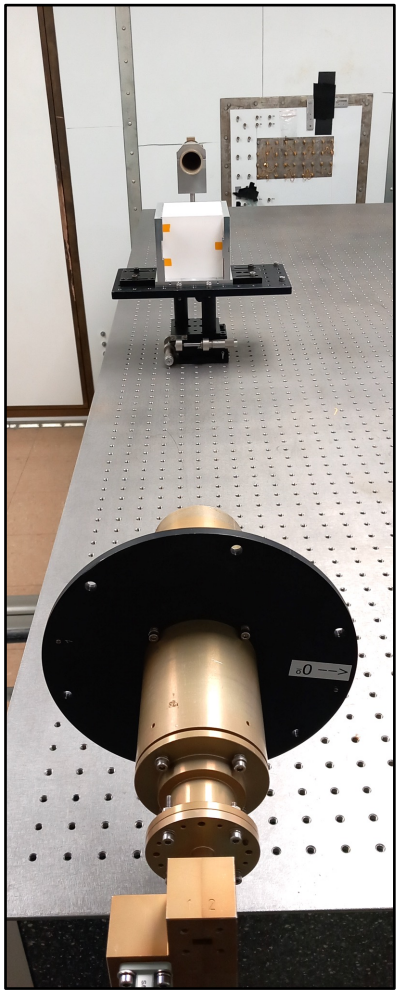
DISCOVERY PROSPECTS

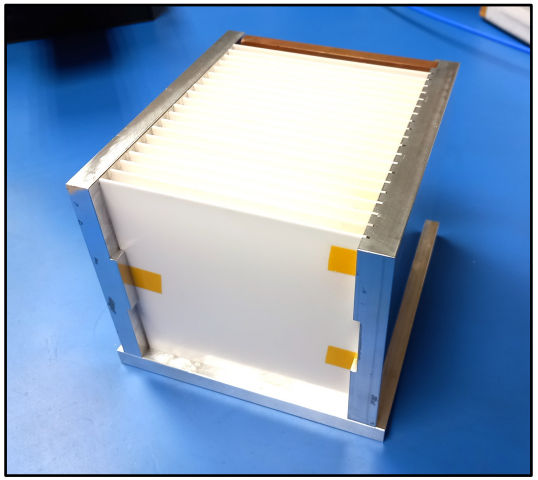
Sensitivity to GRAVITATIONAL WAVE BACKGROUND

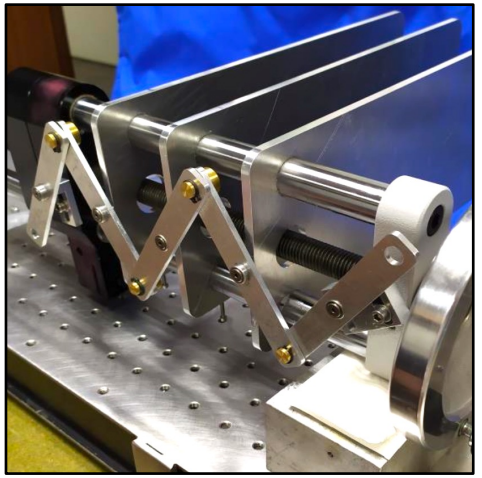


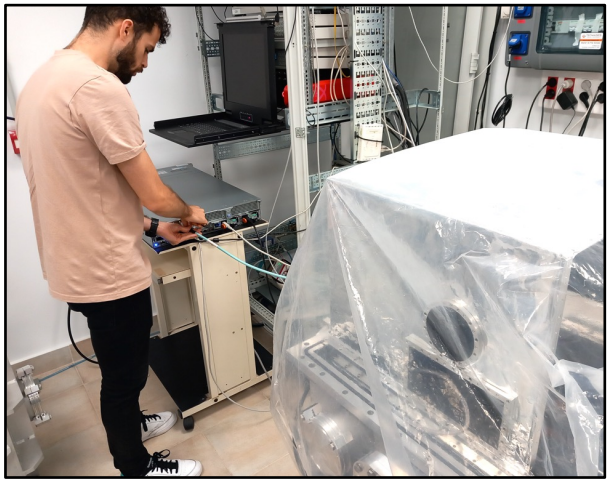
PRELIMINARY

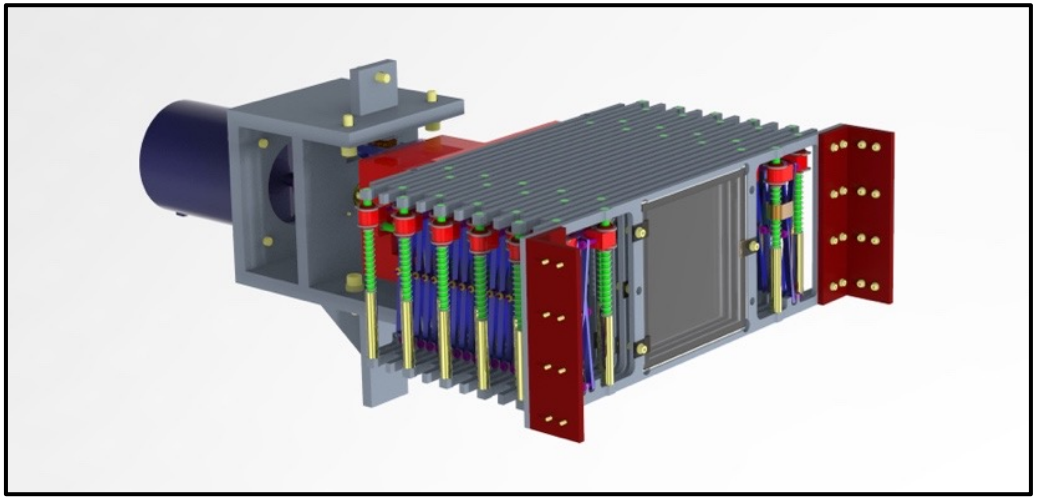
Proof-of-concept run in preparation

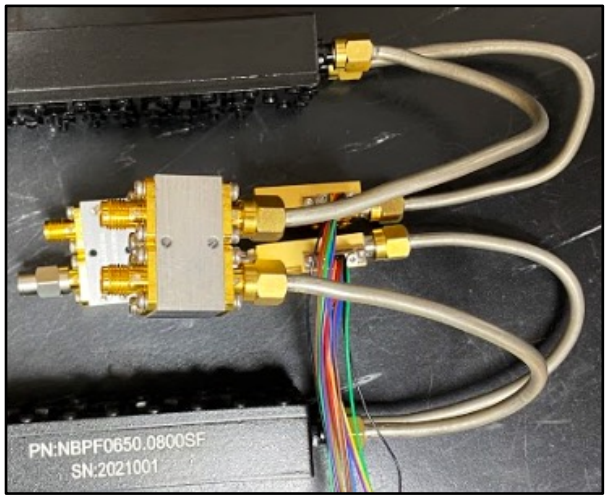




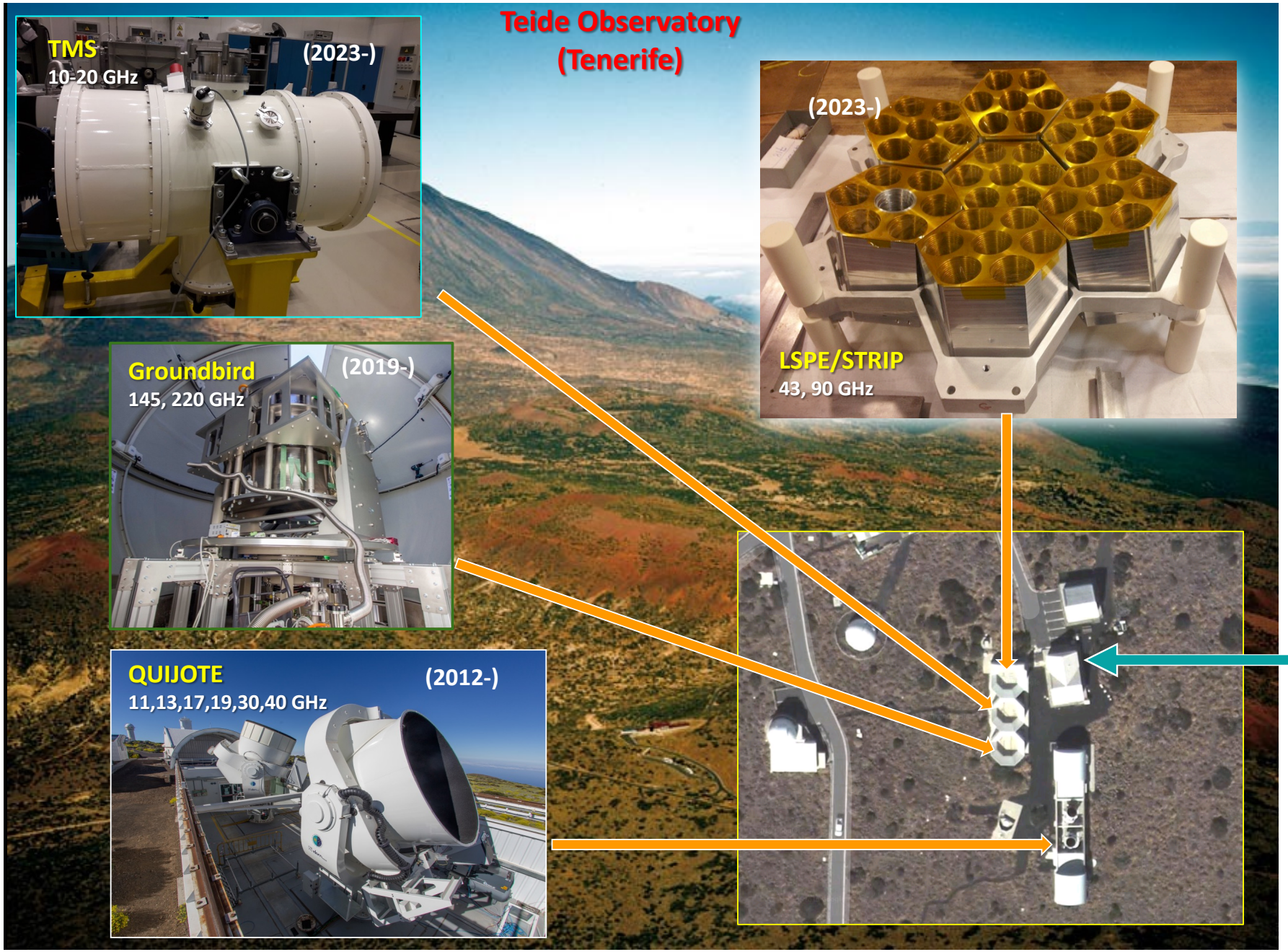








STATUS


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-)
DARK PHOTONS & AXION LIKE PARTICLES INTERFEROMETER
DALI

DARK PHOTONS & AXION LIKE PARTICLES INTERFEROMETER

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