Results of axion searches at 34 μeV with RADES haloscope and prospects for searches in BabyIaxo

Sergio Arguedas Cuendis, on behalf of the RADES group and IAXO

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Measurement principle

- The RADES group uses the haloscope technique to search for axions at frequencies between 8 and 9 GHz.
- A figure of merit for our experiment is given by: $F \sim g_{a\gamma}^2 m_a^2 B^4 V^2 T_{sys}^{-2} G^4 Q$
- To resonate at these frequencies without decreasing in volume RADES employs rectangular cavities joined by irises.

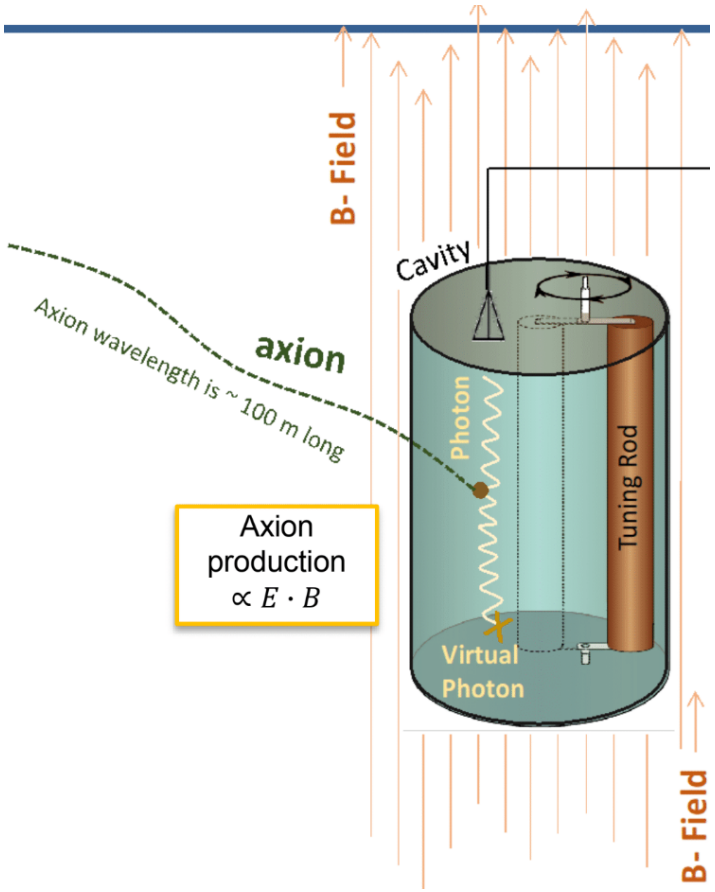

Figure 1: Scheme of a dark matter haloscope experiment [1].

RADES inductive irises prototype

- Consists of 5 sub-cavity structures joined by inductive irises.
- One can choose the working frequency by changing the dimension of the unit cell.
- Afterwards, the dimensions are optimized using simulations to achieve the best geometric factor.

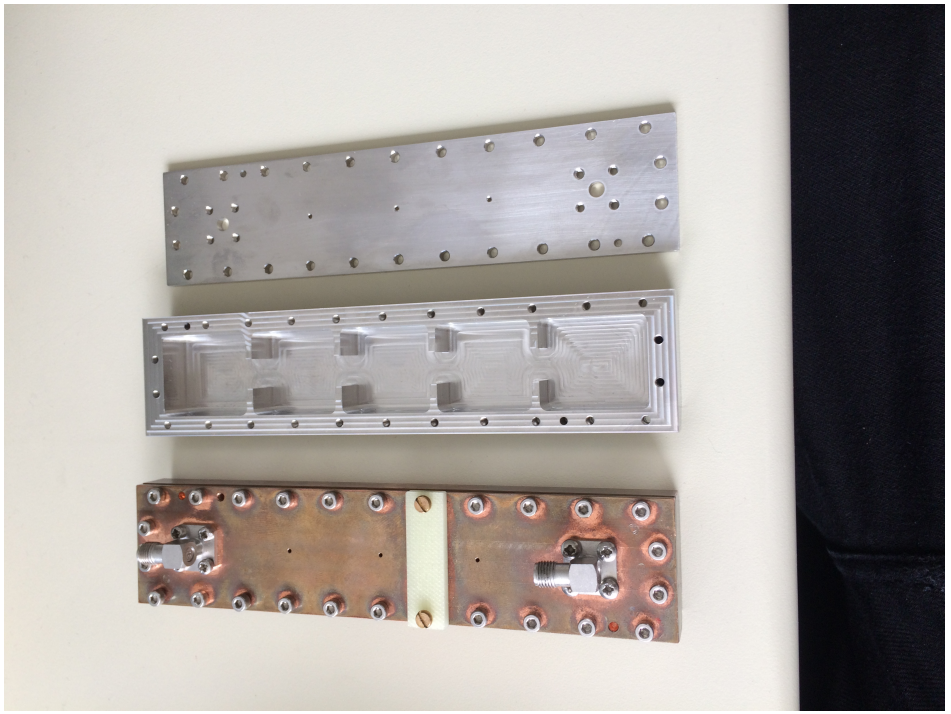

Figure 2: RADES first prototype [2].

Inductive irises prototype

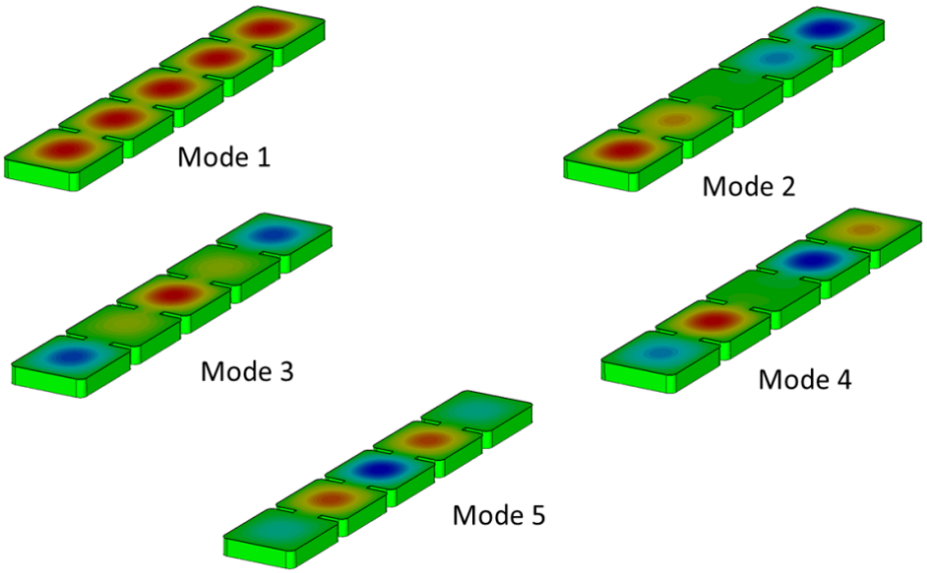

Figure 3: Electric field configuration of the 5 modes [2].

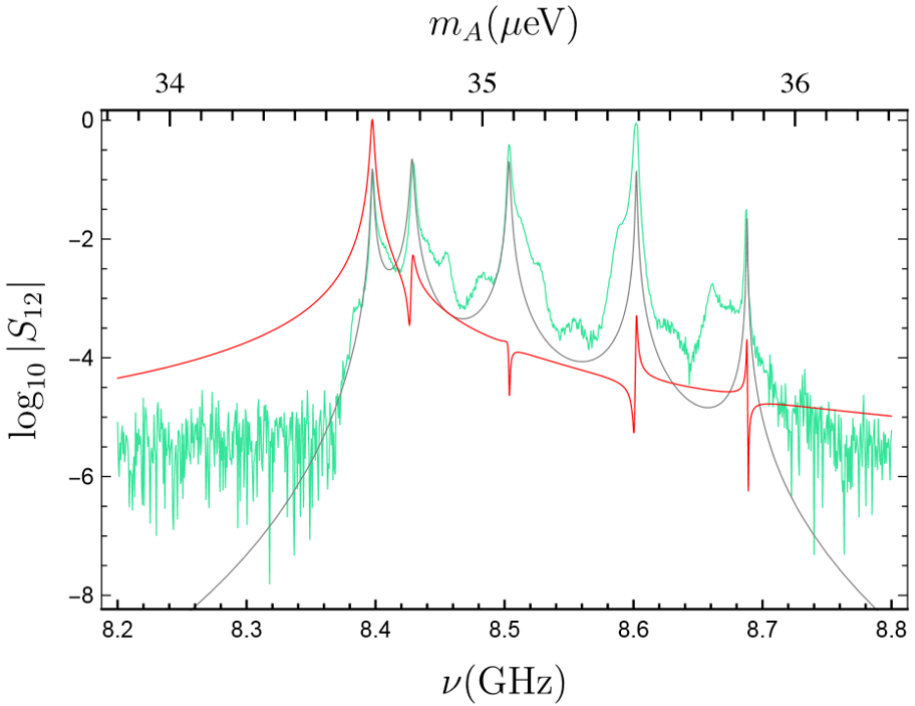

Figure 4: Transmission parameter: measurement (green) and theoretical model (gray). Red is axion coupling for the 5 modes [2].

RADES setup at CAST

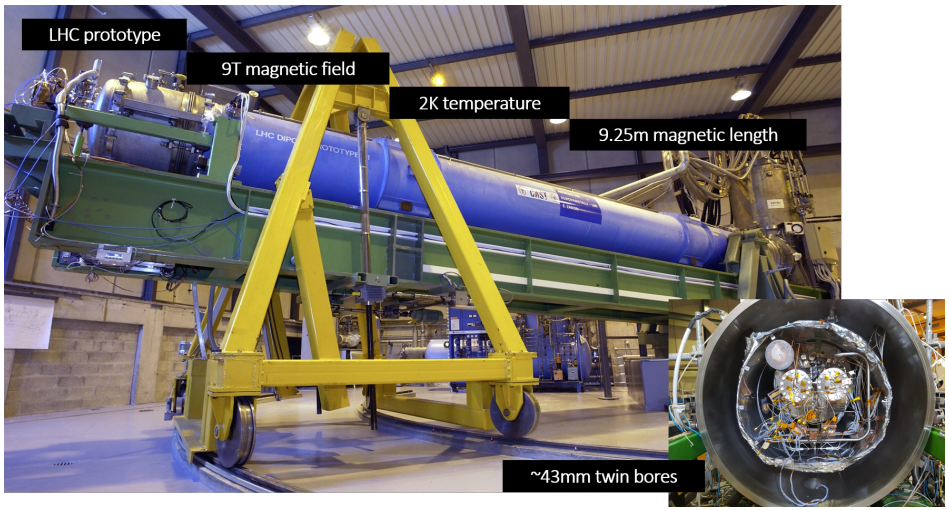

Figure 5: CAST magnet

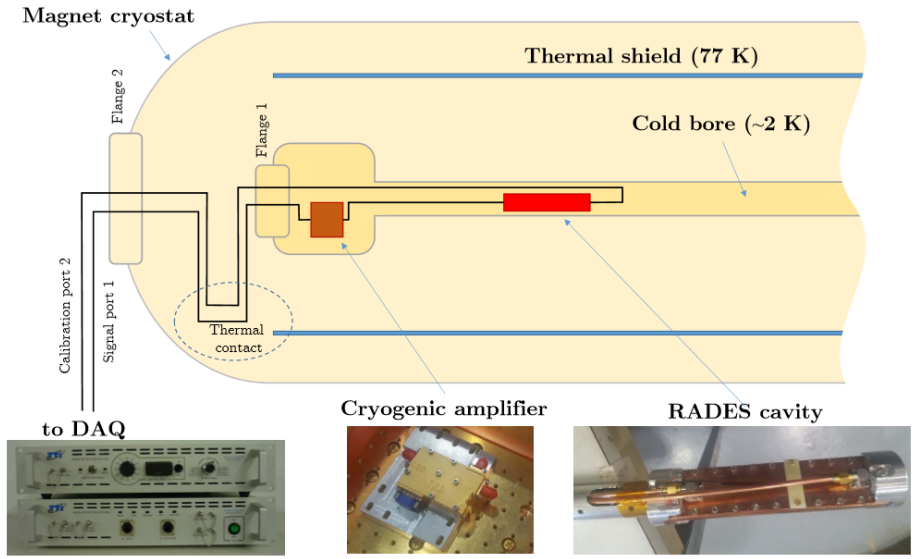

Figure 6: RADES setup at CAST [2].

RADES inductive irises prototype

- Approximately 103 hours of data were recorded in 2018.
- The characterization of the setup yielded the following values:
- $\beta = 0.50$.
- Q = 11009.
- T = 7.8 K
- $\Delta\nu = 4577$ Hz
- B = 8.8 T
- G = 0.65
- V = 0.03

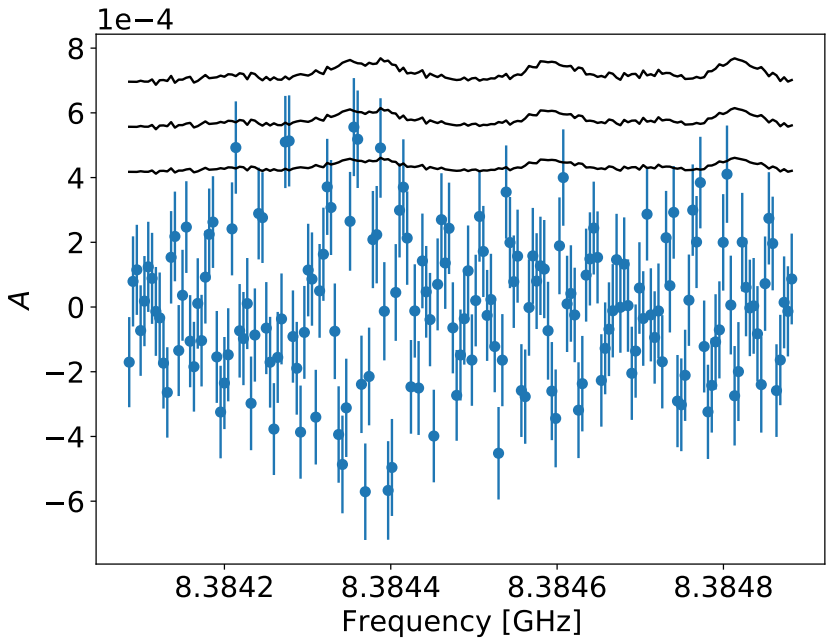

Figure 7: Amplitude of a fit for an axion signal.

First CAST-RADES axion search results

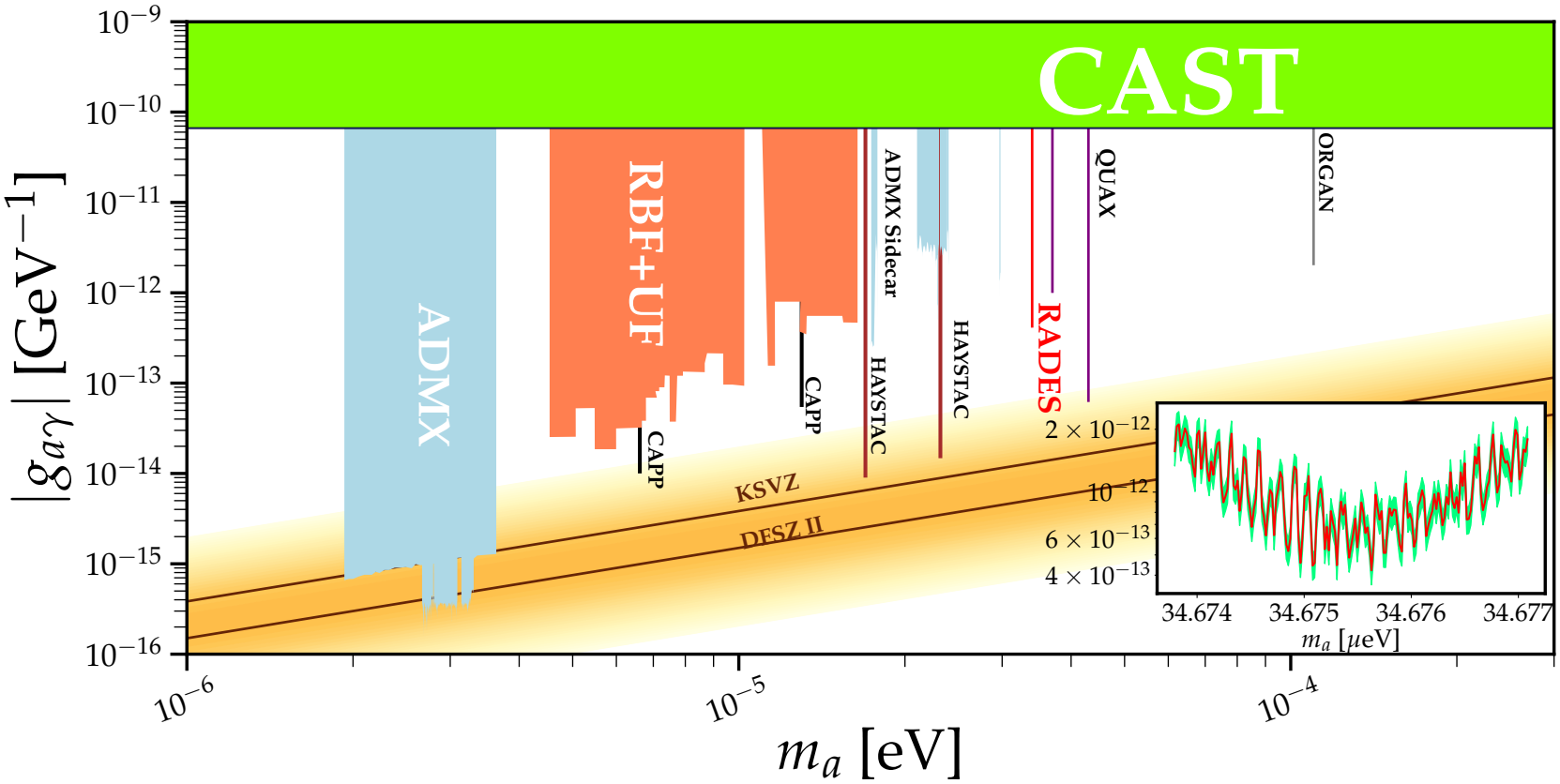

Figure 8: RADES exclusion limit. https://arxiv.org/abs/2104.13798

Cavity developments

- To grow in volume more sub-cavities were added to manufacture a new $\sim$ 1 m long cavity.

- For the BabyIAXO magnet, the height of the cavity can also be increased without affecting the resonance frequency.

Longer and taller cavities

Figure 9: 1 meter long cavity prototype [3].

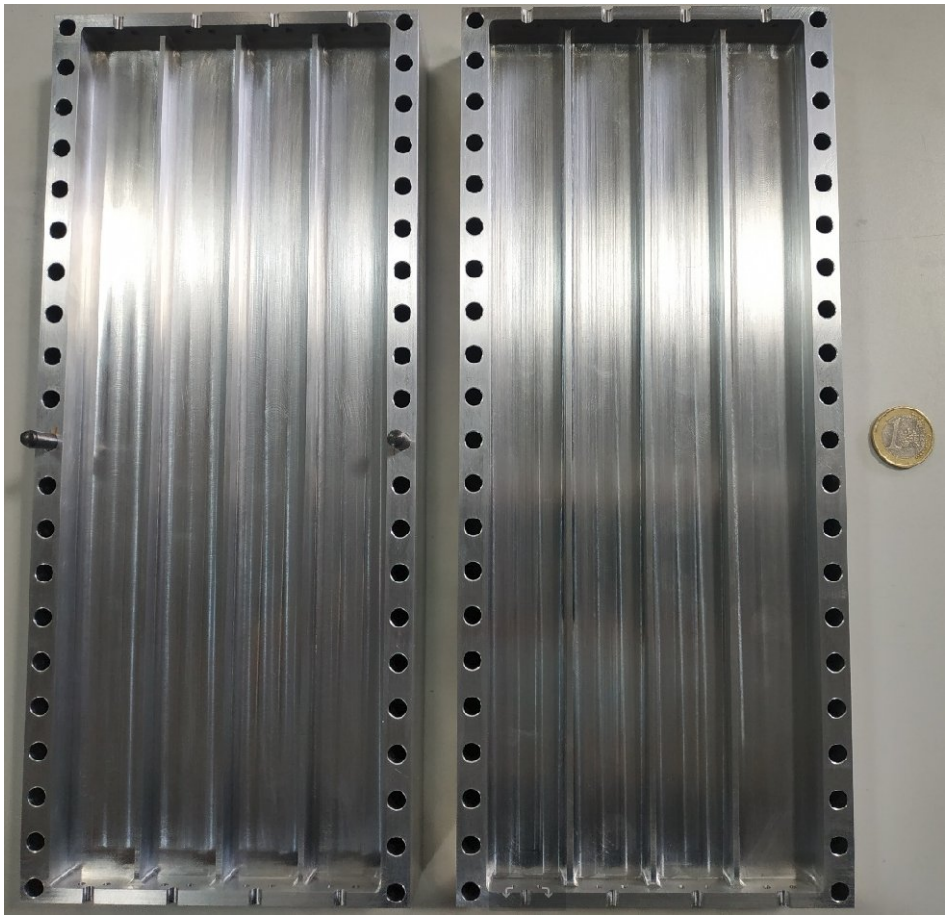

Figure 10: Tall cavity prototype. Photo made by J.M. García

Preliminary RADES prospects

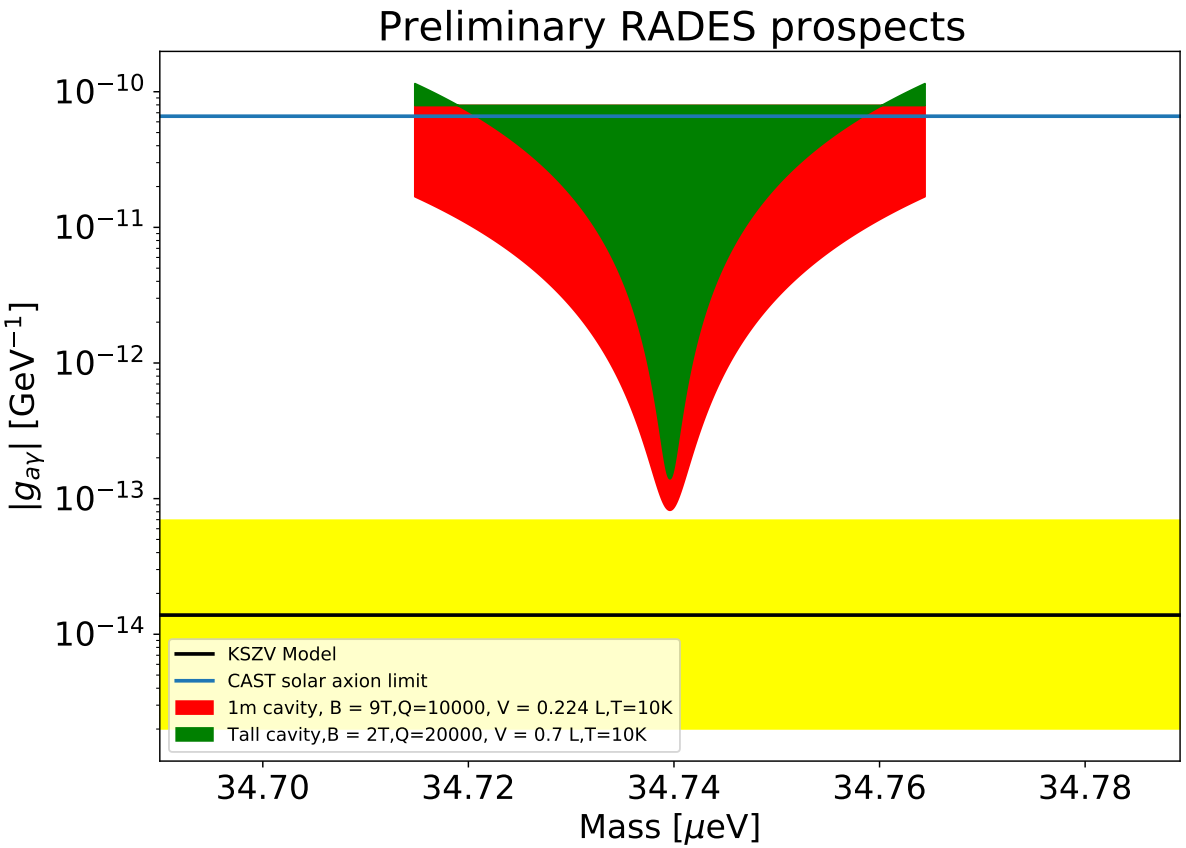

Figure 11: Preliminary RADES prospects for the long cavity at CAST (red) and the tall cavity at BabyIAXO (green) assuming 3 months of data.

Conclusion

- RADES is looking for a dark matter candidate called axions using RF cavities resonating at frequencies between 8 and 9 GHz.
- Data acquired with a 5-cavity pathfinding prototype in the CAST magnet provided first results at this frequency.
- The volume can be increased by adding more sub-cavities or increasing the height of the short prototype.
- RADES is also doing R&D toward tuning as well as using superconductive cavities.

References I

[1] Frank T. Avignone III.
Homing in on Axions?
APS Physics, 11:34, 2018.

[2] Alejandro Álvarez Melcón et al.
Axion Searches with Microwave Filters: the RADES project.
JCAP, 05:040, 2018.

[3] A. Álvarez Melcón et al.
Scalable haloscopes for axion dark matter detection in the 30μeV range with RADES.
JHEP, 07:084, 2020.