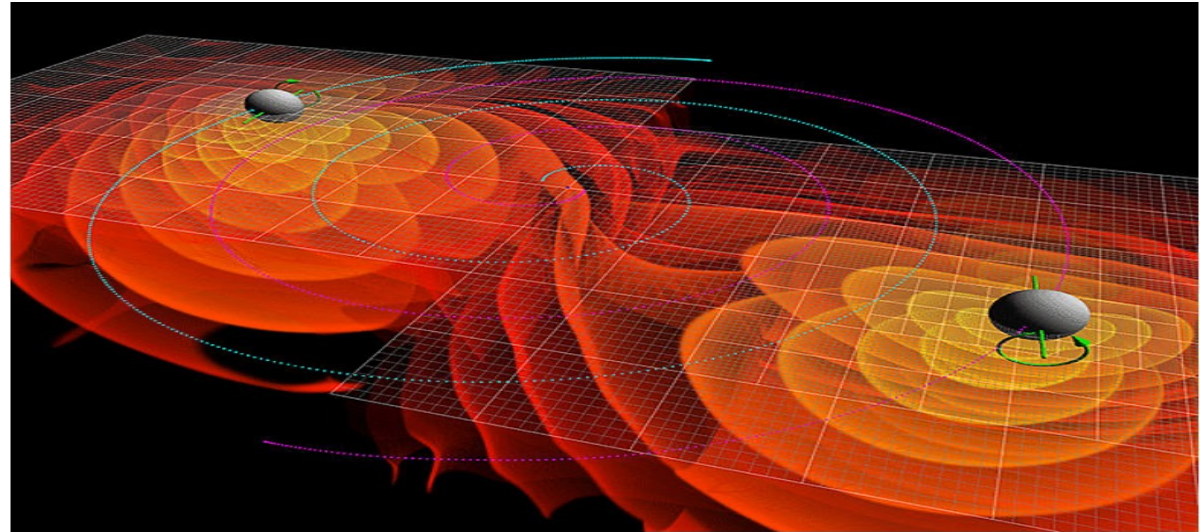


# Gravitational wave searches at high frequencies

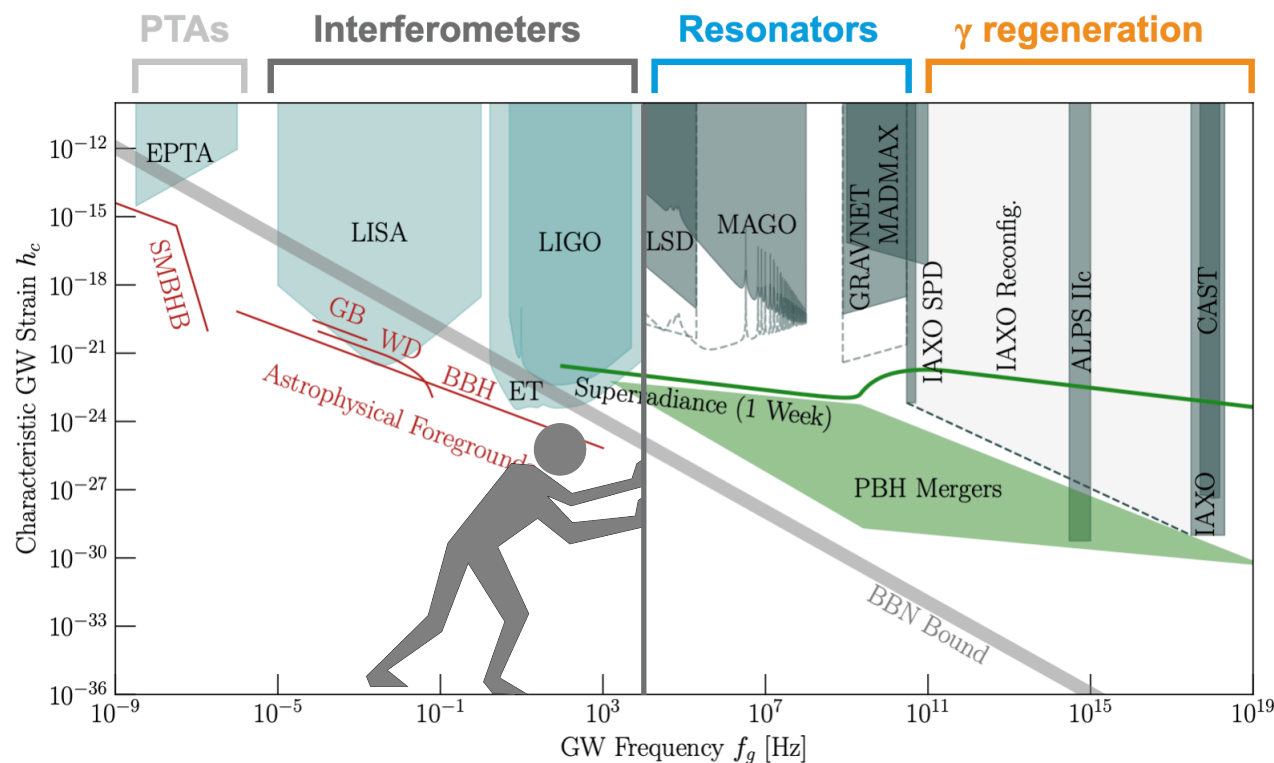


Christoph Reinhardt, Axel Lindner, Krisztian Peters

FH Retreat, 20 Juni 2025

# Opportunity to push the boundary on GWs

## Gravitational Waves at Higher Frequencies

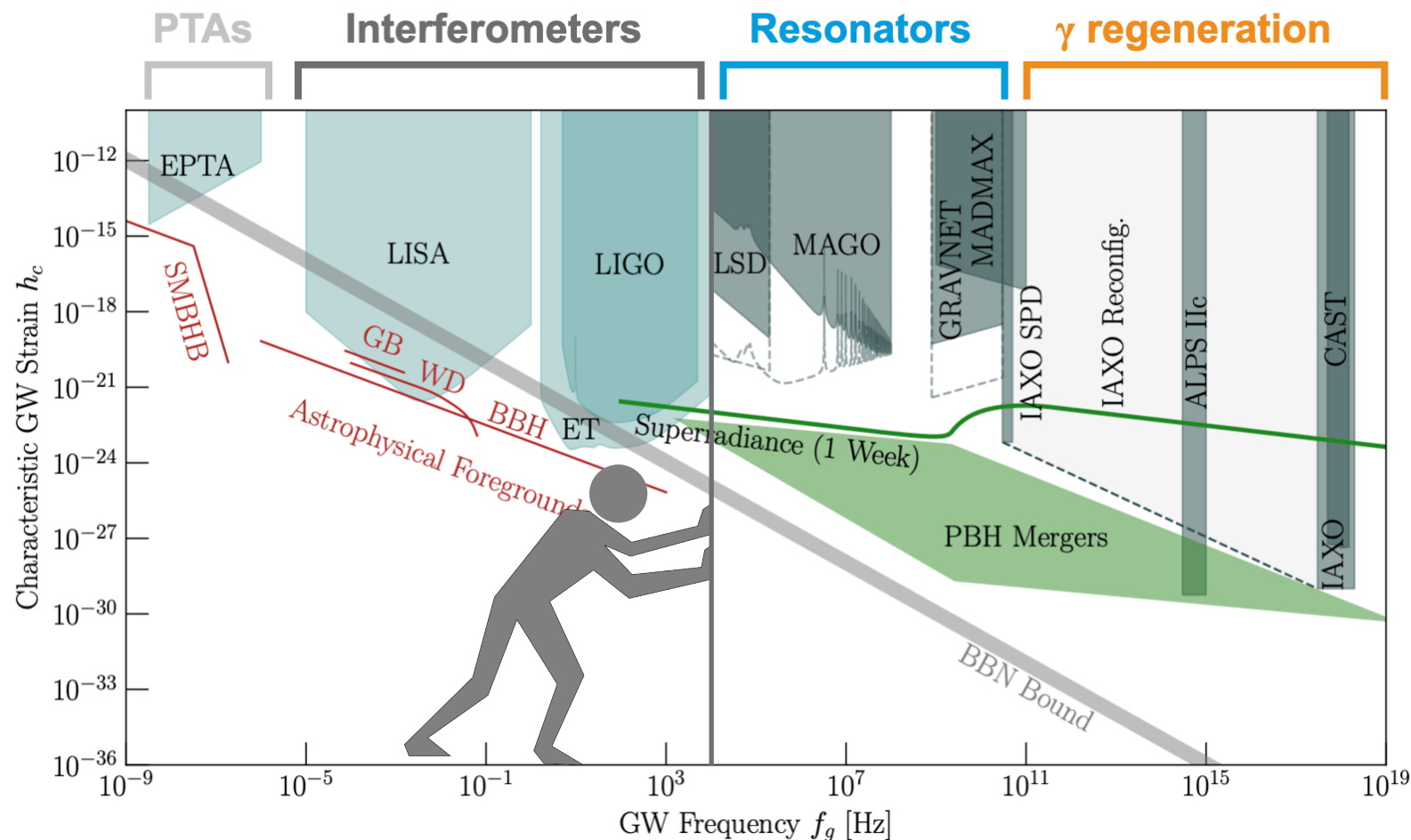


**Universe expected to be populated by GWs over many decades in frequency** (cf. to EM radiation)

- Extend to high frequency, complementary to LIGO/ET
- No known astrophysical objects over O(kHz): if detected, points to BSM physics
- High risk, high return!
- Long term goal: measure CGMB over entire frequency range

# Current developments and opportunities at DESY

Mechanical resonators (kHz - GHz) and axion infrastructure (above GHz)



Ongoing R&D projects at DESY to establish technologies and assess feasibility

- SRF cavities (MAGO)
- Levitated sensor detector
- Axion infrastructure (ALPS, IAXO, MADMAX)

# SRF cavities

## Revival of the MAGO proposal

Cavities **de-tuned by GW**, an effect that could be detected with appropriate instrumentation

R&D at **DESY/UHH** in collaboration with **Fermilab** with the MAGO cavity (on loan from INFN)



**Short term goal:** proof-of-principle measurement

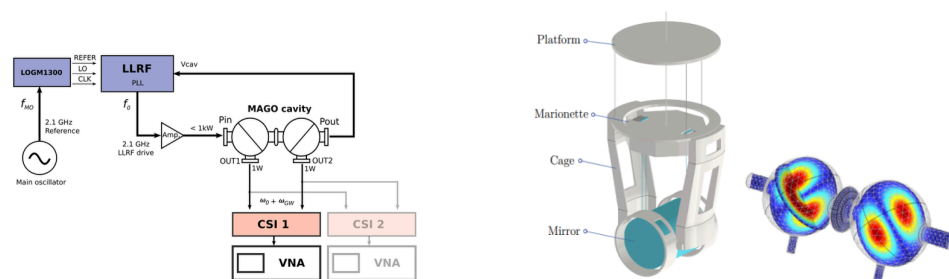


# SRF cavities

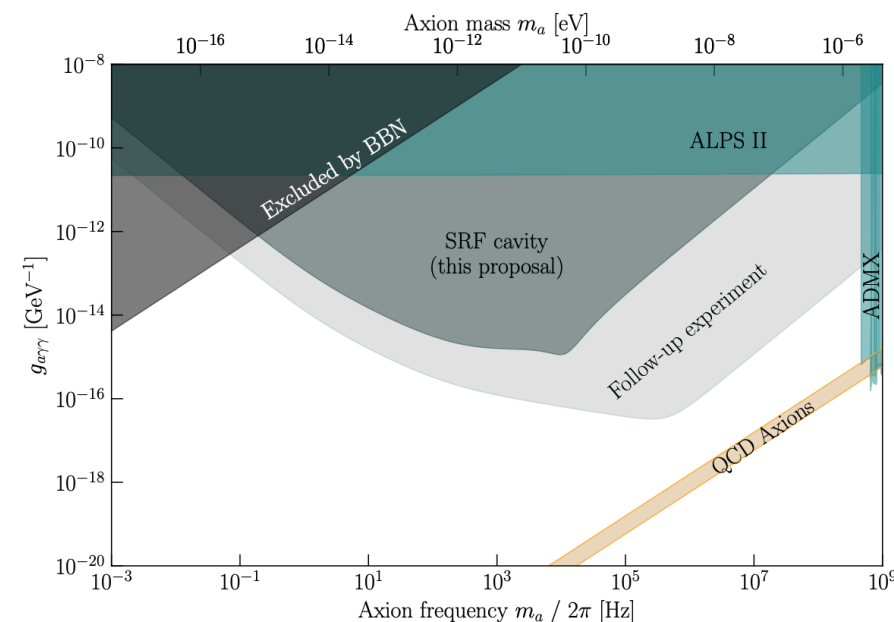
## Revival of the MAGO proposal

### Goals for the coming 5 years (2026-2031):

- Improve cavity control & readout, and mitigate environmental noise



- Physics runs in an existing DESY cryostat with cavities optimized for HFGW and DM axion search
- Ongoing funding applications, funds also from QU++ expected



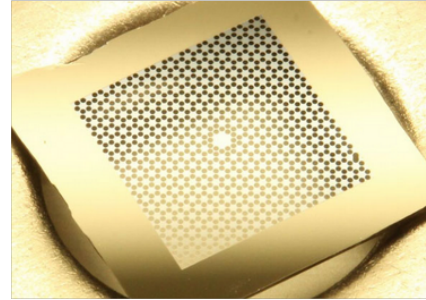
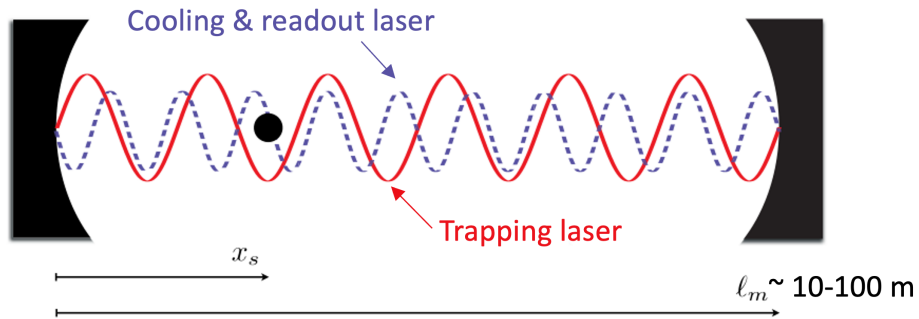
### Goals beyond (2032+):

- Dedicated cryostat housed in the cryoplatfrom for further noise suppression and larger cavities
- Explore beyond SQL readout



# Levitated sensor detector

Dielectric particle optically-levitated inside cavity

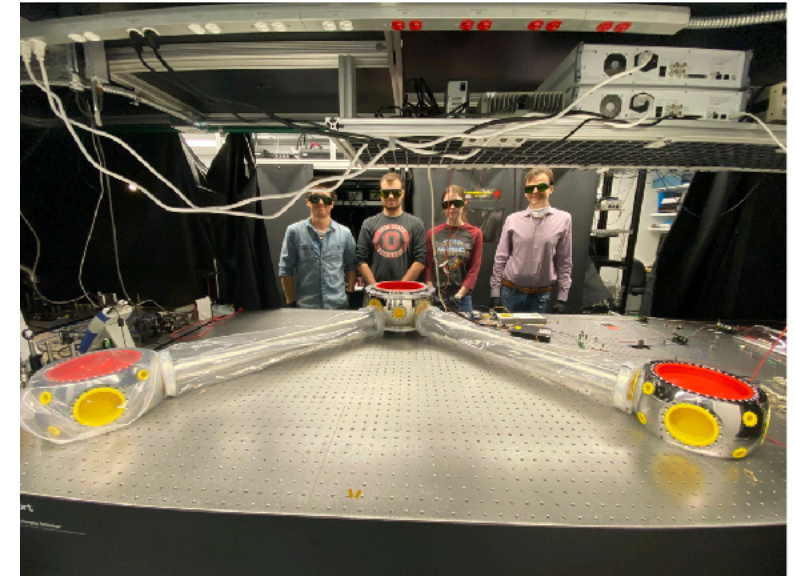


R&D at DESY to use instead an **optically-trapped membrane** (which has also further applications)

Ongoing funding applications to build a **table-top prototype** detector (and physics run) by 2030

With the **ALPS II** and **cryoplatfrom** infrastructure a **full-scale experiment** could be aimed beyond PoF V

1m prototype at Northwestern University



# Axion search infrastructure

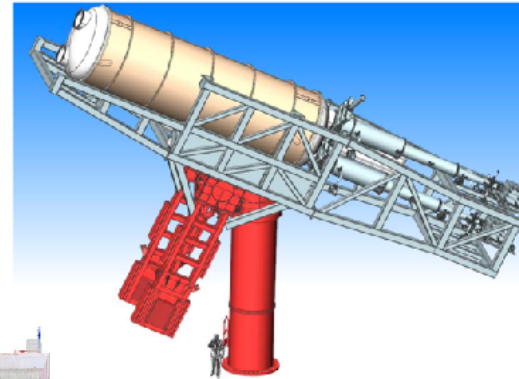
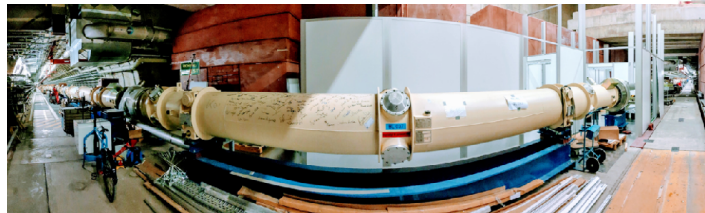
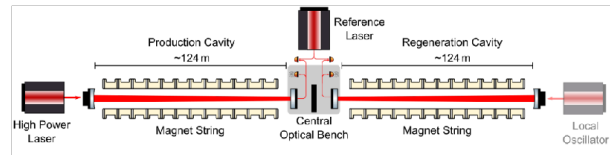
Detect GW to photon conversion in a static magnetic field

Current axion search bounds **can be translated into (weak) constraints on HFGW amplitudes**

Significant potential for dedicated improvements to **enhance sensitivity on GW detection**

Possible **HFGW runs**: ALPS II 2030, BabyIAXO and MADMAX towards end/beyond PoF V

## ALPS



## MADMAX

# Conclusions

GW signals above the LIGO/ET band are a **smoking gun for BSM physics** and current experimental attempts are **still moderate in size and cost**

**Emerging field of science** with growing interest in the particle physics community

HFGW searches have **important synergies** with **axion searches** and **complement science with the ET**

In addition, with the necessary **expertise and infrastructure (e.g. cryoplatform)** on-site, **DESY** would be an **ideal place** to develop and host some of these experiments

