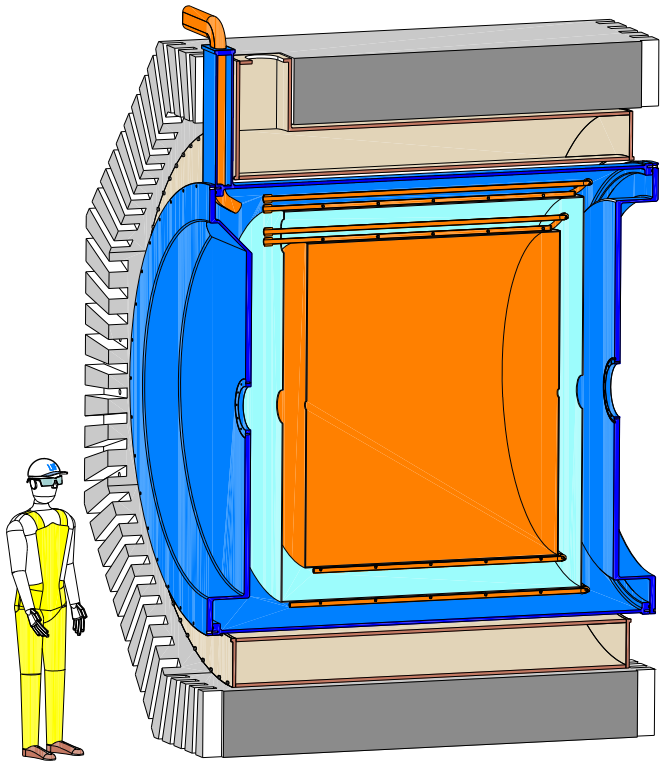
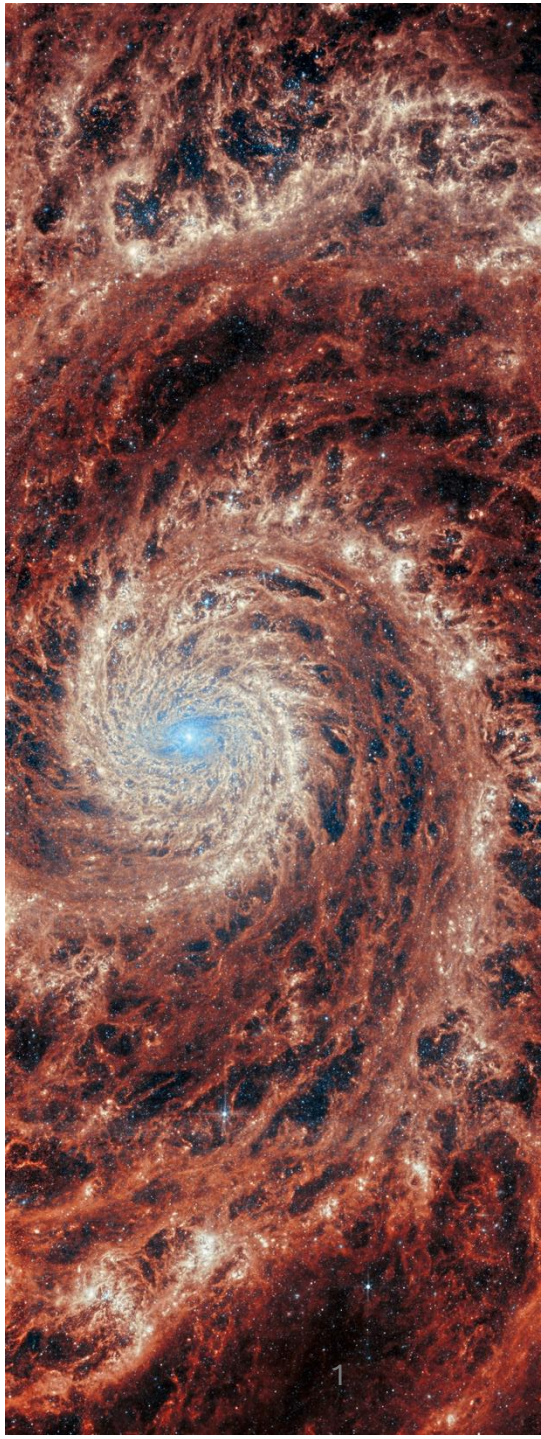
FLASH
Finuda magnet for Light Axion Search Haloscope



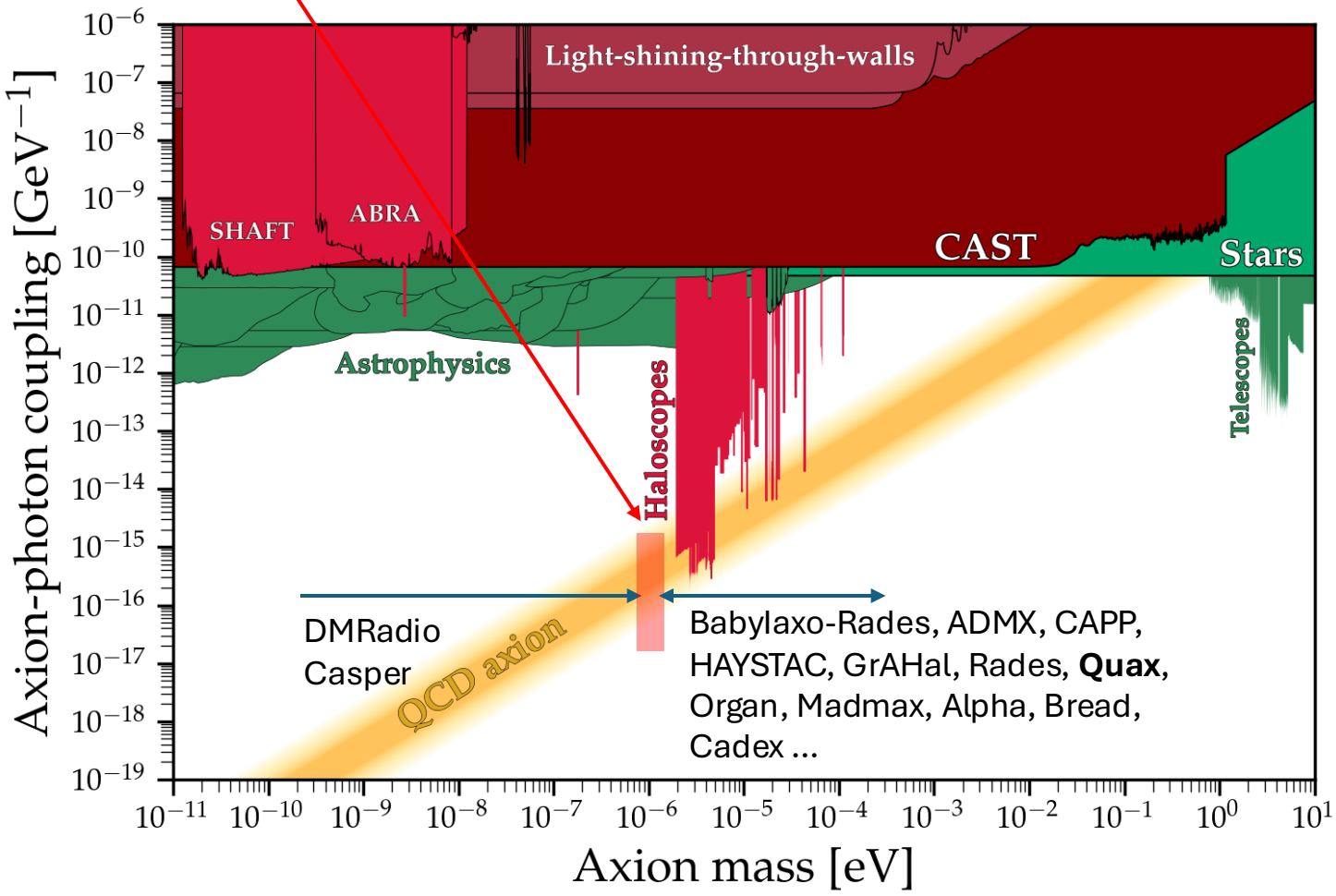
Claudio Gatti LNF – INFN

Kick Off Meeting 26/11/2024



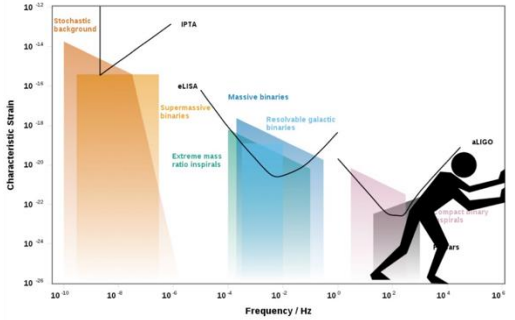
FLASH aims to probe the region between 0.5 and 1.5 μeV

$1\mu eV = 250\ MHz \rightarrow \lambda = 1.2m$ → cavity with O(m) diameter



Main Goals

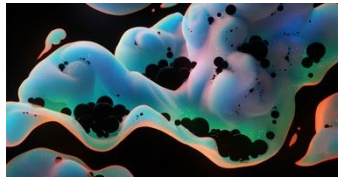
- Search of galactic axions at 100 MHz (0.5-1.5 μeV)
- Probe several light DM models: scalar, pseduscalar and vector DM.
- Extend the gravitational wave search region to higher (MHz-GHz) frequencies



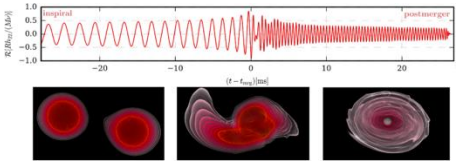
https://www.ctc.cam.ac.uk/activities/UHF-GW.php

https://cajohare.github.io/AxionLimits/

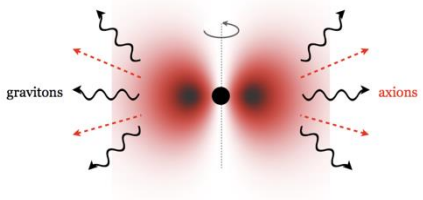
High Frequency Gravitational Waves



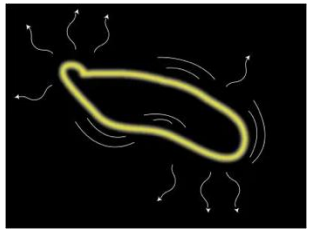
Primordial BH



Boson stars mergers

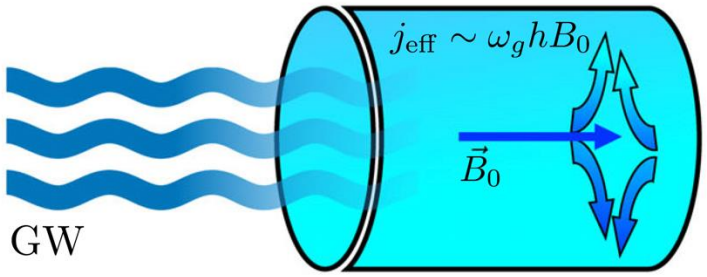


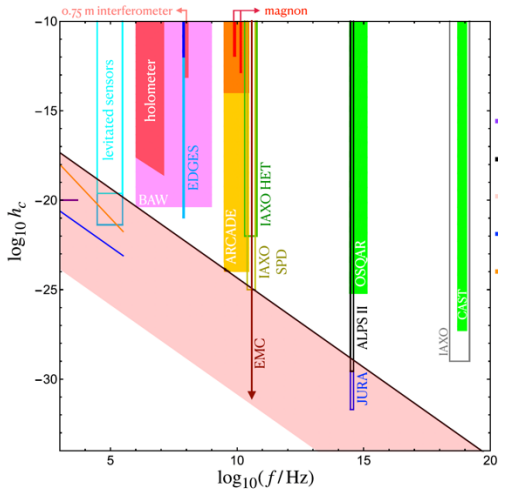
BH superradiance



Cosmic strings

- The landscape of gravitational waves in the ultra-high frequency regime, above the kHz, is beyond the sensitivities of the present terrestrial experiments.
- HFGW could potentially be sourced by a collection of exotic physical phenomena originating both in the early and late Universe.
- Possibility to probe particle physics at energy scales many orders of magnitude beyond the reach of future particle colliders.

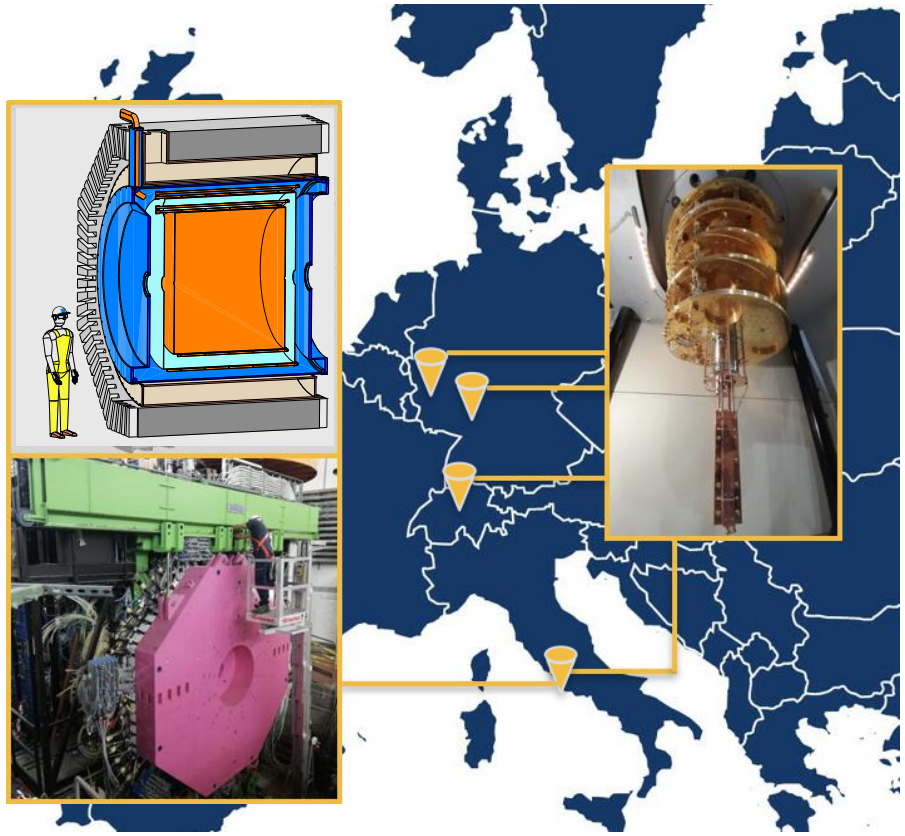




Aggarwal et al. Challenges and opportunities of gravitational-wave searches at MHz to GHz frequencies. Living Rev Relativ 24, 4 (2021).

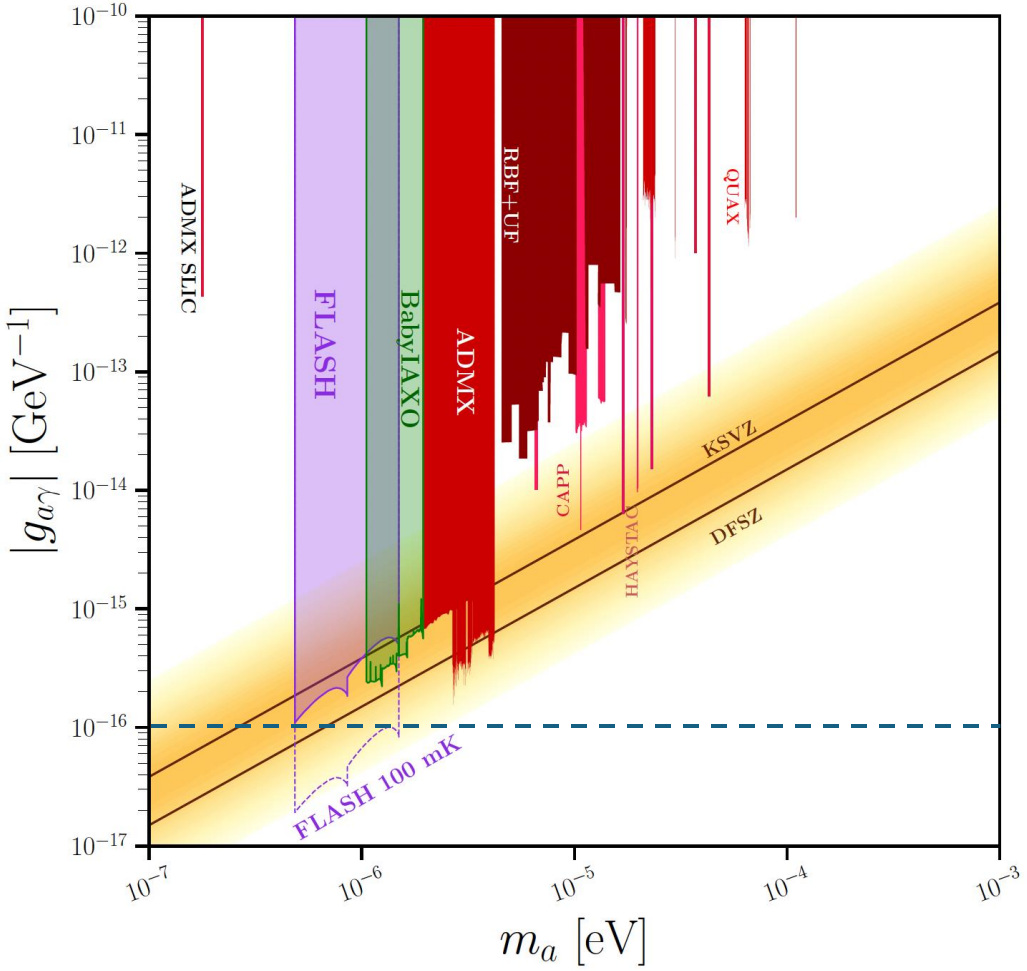
GravNet: A Global Network for the Search for High Frequency Gravitational Waves

ERC Synergy funded with 10 Meuro



European Research Council
Established by the European Commission

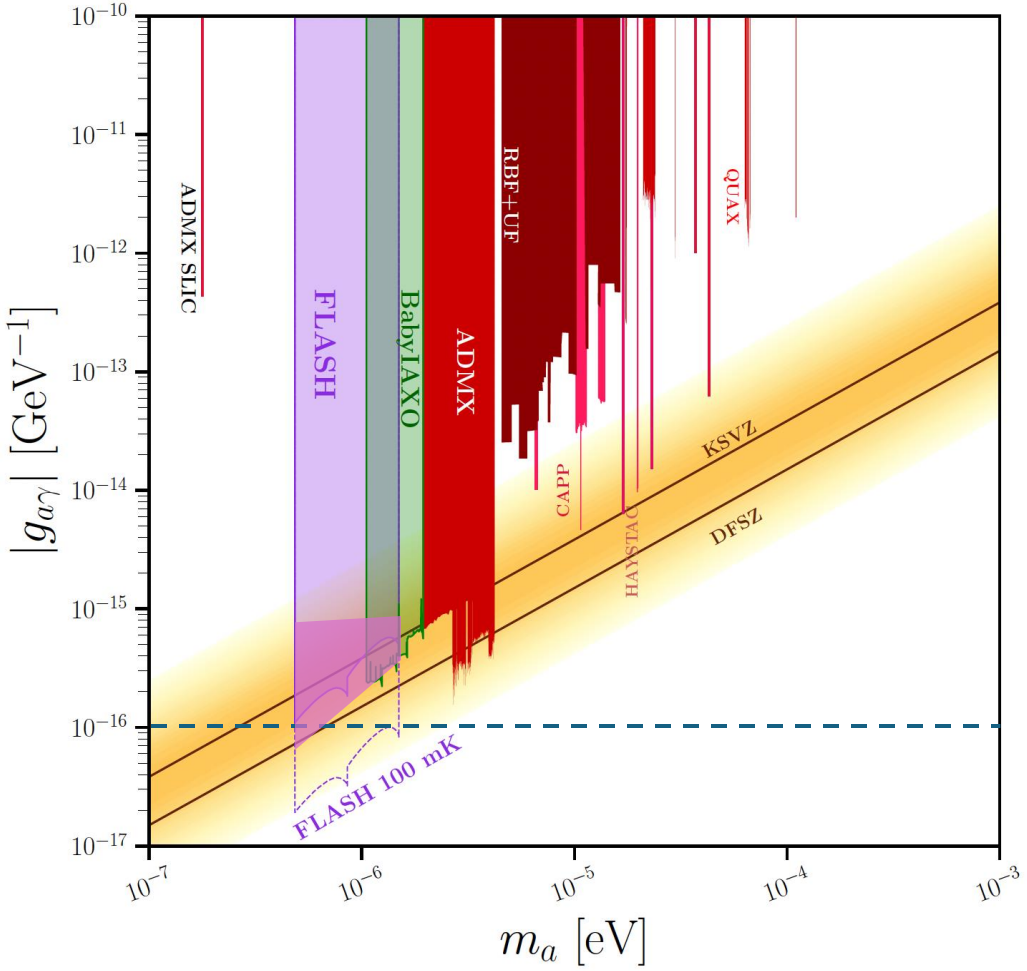
FLASH Physics Reach



With Cu cavity at 4.5 K

Parameter	Value
ν_c [MHz]	150
m_a [μeV]	0.62
$g_{a\gamma\gamma}^{\mathrm{KSVZ}}$ [GeV^{-1}]	2.45×10^{-16}
Q_L	1.4×10^5
C_{010}	0.53
B_{max} [T]	1.1
β	2
τ [min]	5
T_{sys} [K]	4.9
P_{sig} [W]	0.9×10^{-22}
Scan rate [Hz s^{-1}]	8
m_a [μeV]	0.49 - 1.49
$g_{a\gamma\gamma}$ 90% c.l. [GeV^{-1}]	$(1.25 - 6.06) \times 10^{-16}$

FLASH Physics Reach



With Cu cavity at 1.9 K

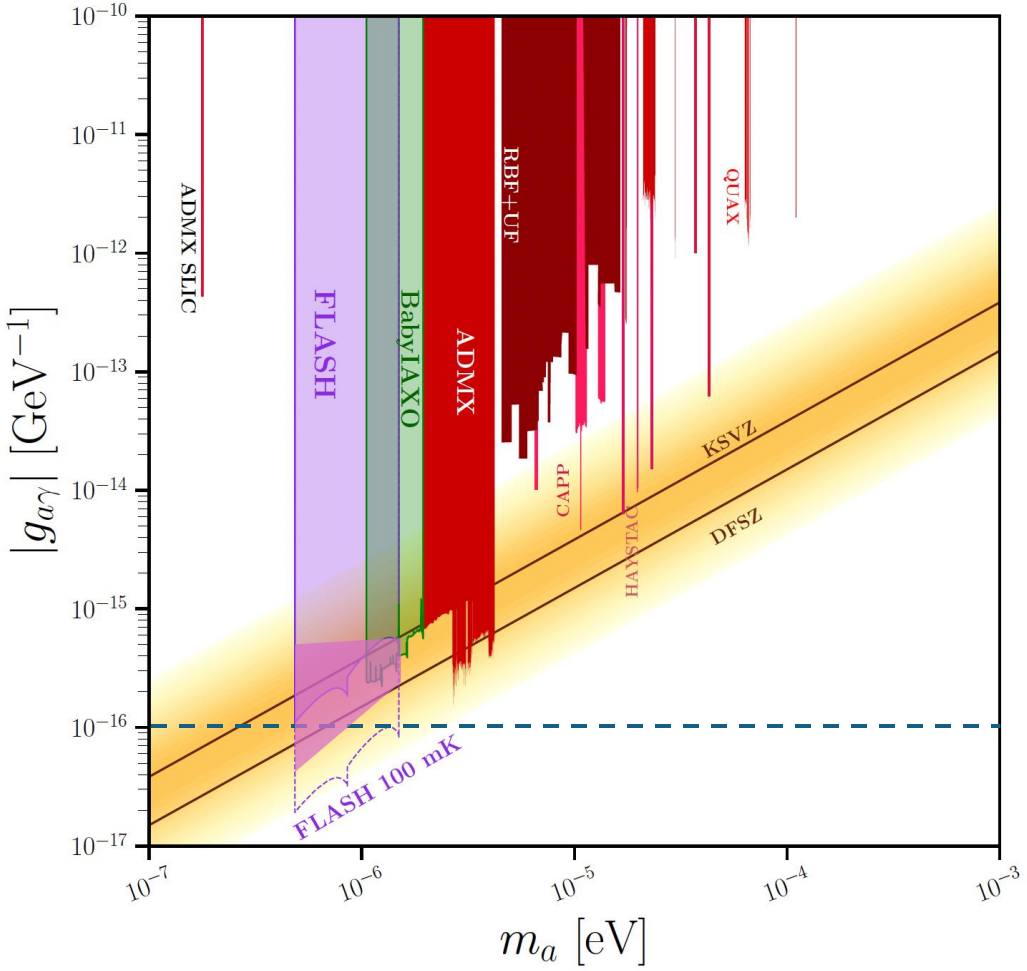
Parameter	Value
ν_c [MHz]	150
m_a [μeV]	0.62
$g_{a\gamma\gamma}^{\mathrm{KSVZ}}$ [GeV^{-1}]	2.45×10^{-16}
Q_L	1.4×10^5
C_{010}	0.53
$B_{\max}$ [T]	1.1
β	2
τ [min]	5
T_{sys} [K]	4.9
P_{sig} [W]	0.9×10^{-22}
Scan rate [Hz s^{-1}]	8
m_a [μeV]	0.49 - 1.49
$g_{a\gamma\gamma}$ 90% c.l. [GeV^{-1}]	(0.8- 3.96) $\times 10^{-16}$

FLASH Physics Reach

SuperMAD

Superconducting RF **M**aterials for **A**xion **D**etectors

With NbTi cavity at 1.9 K

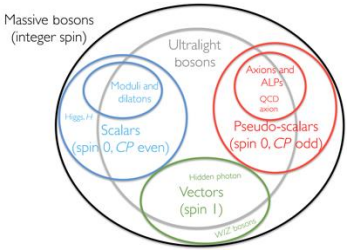


Parameter	Value
ν_c [MHz]	150
m_a [μeV]	0.62
$g_{a\gamma\gamma}^{\mathrm{KSVZ}}$ [GeV^{-1}]	2.45×10^{-16}
Q_L	6.7 $\times 10^5$
C_{010}	0.53
$B_{\max}$ [T]	1.1
β	2
τ [min]	5
T_{sys} [K]	4.9
P_{sig} [W]	0.9×10^{-22}
Scan rate [Hz s^{-1}]	8
m_a [μeV]	0.49 - 1.49
$g_{a\gamma\gamma}$ 90% c.l. [GeV^{-1}]	(0.37- 1.8) $\times 10^{-16}$

Design Study and R&D for the TDR

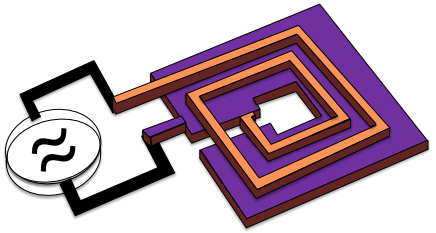
Approved by INFN in September 2024
Goal: TDR ready for Summer 2026

Visinelli (TDLI), Mescia (LNF)



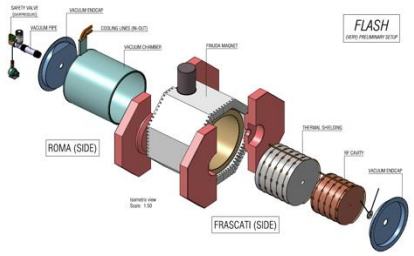
WP1 Physics Reach

Falferi (TIFPA), Lamanna (INFN Pisa)



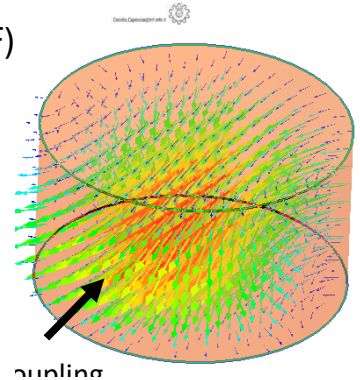
WP4 Signal Amplification and DAQ

Ligi (LNF)

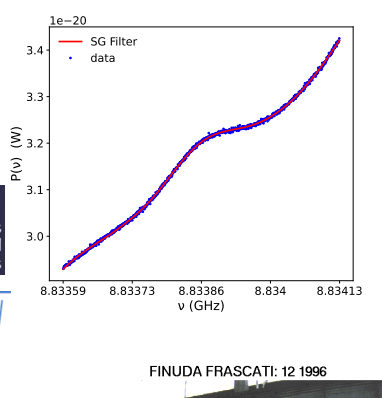


WP2 Mechanical Design and Cryogenics

Diaz (UPCT), Tocci (LNF)



WP3 RF Cavity



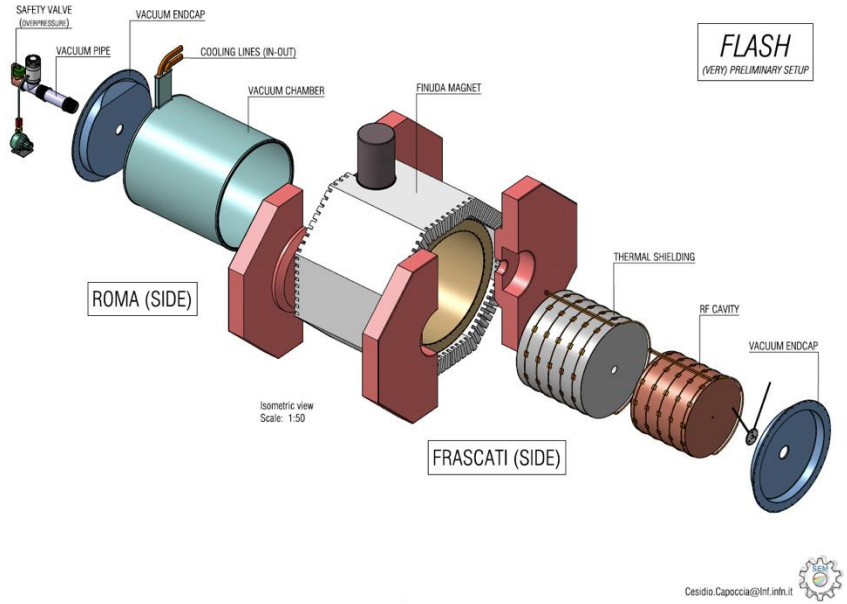
Schmieden (Mainz), Schott (Bonn)

WP5 Data Analysis and Computing

Gazzana (LNF)

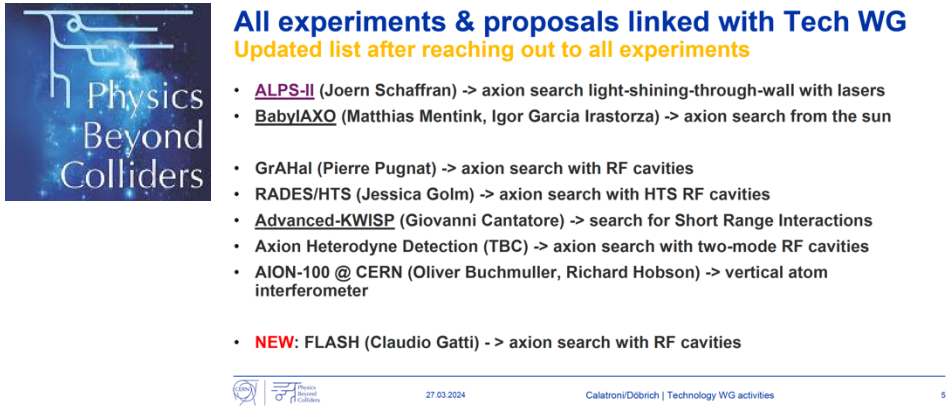
WP6 Decommissioning of FINUDA and FLASH Commissioning

WP2 - Mechanical Design and Cryogenics



Design by the Crygenic Service and the *Engineering and Mechanical Service of LNF (SEM)*

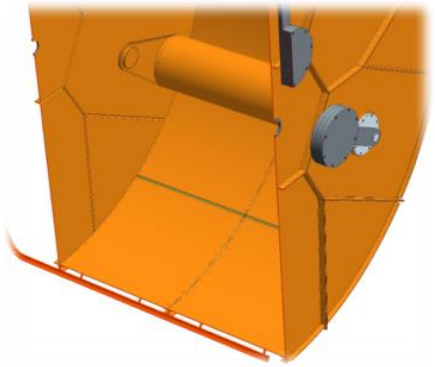
and by the Department of Mechanical Engineering of Unimarconi with 1 Professor and 1 PhD student,



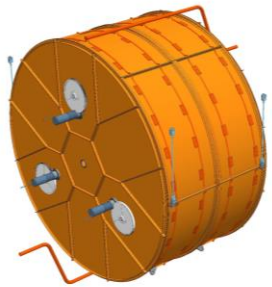
with the technical consultancy from Engineering and Mechanical Support Section at CERN, Cryogenics Group, Technology Dept.

https://indico.cern.ch/event/1369776/timetable/#20240325.detailed

WP3 – RF Cavity

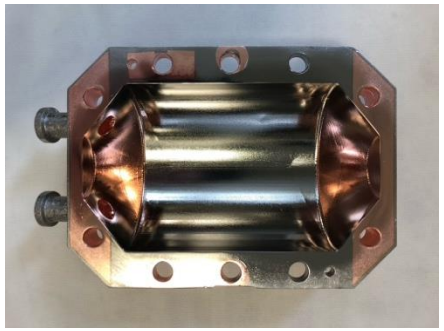


Design and simulation of RF cavity made by UPCT IFIC-UV and LNF



500 MHz Prototype:

- Fabrication at the mechanical workshop in Uni Bonn
- Test in LHe at LNF

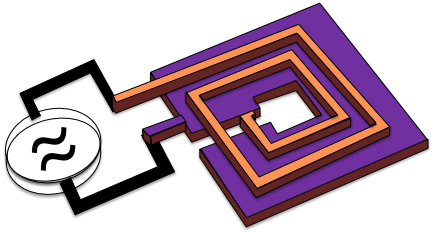


Assess the feasibility of SC coatings for large low-frequency copper cavities within SuperMAD project in CSN5.

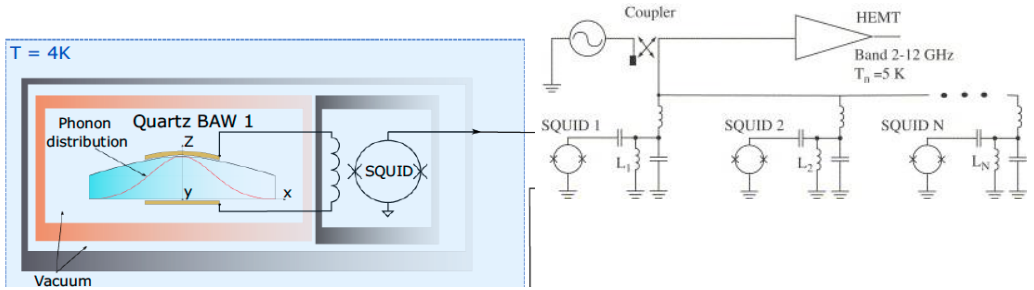
SuperMAD

Superconducting RF Materials for Axion Detectors

WP4 – Signal Amplification and DAQ
WP5 – Data Analysis and Computing

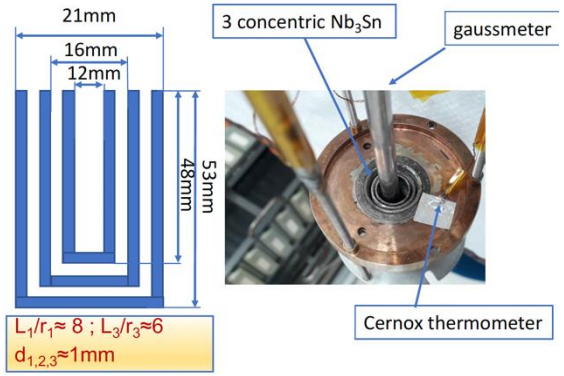


MSA characterization

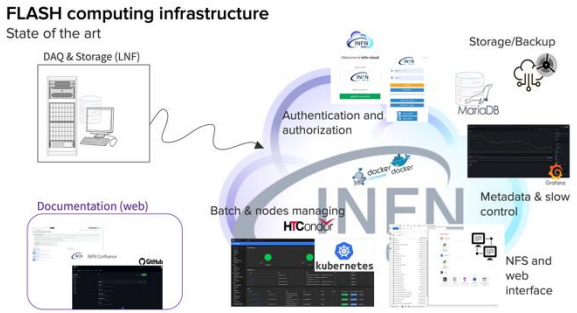


Signal multiplexing and DAQ test with multimode BAW

Synergy with MiB
BAUSCIA project



Characterization in
B field of shielded MSA



Computing

Synergy with QUAX

Timeline

Year	2024	2025				2026	
Quarter	IV	I	II	III	IV	I	II
WP1 - Physics Reach		Modes & Frequencies				TDR Section on Physics Reach	
WP2 - Mechanical Design and Cryogenics	Envelope volume for RF cavity		Define MSA Position in Cryostat and Probe	Prototype Mechanical Design		Cryostat Design	TDR section on Mechanical Design
WP3 - RF Cavity			Cavity RF Design	Prototype RF Design	Fabrication of Cavity Prototype	Cryogenic Test of Cavity Protoype	TDR Section on RF Cavity
WP4 - Amplification and Acquisition		Gain and Noise Characterization of MSA	Test of Shielding in Magnetic Field	DAQ	Multiplexing Prototype Circuit	Full Chain Test with BAW resonator	TDR Section on Amplification & DAQ
WP5 - Data Analysis and Computing					Computing Cloud Model validated	TDR Section on Analysis & Computing	
WP6 - Decommissioning & Commissioning				Tools for FINUDA Decommissioning		TDR Section on Decommissioning &	
WP7 - Management	Periodic Meeting	Periodic Meeting	Periodic Meeting	Periodic Meeting	Periodic Meeting	TDR writing	Technical Design Report

TDR in summer 2026

Organization

1. Steering Committee composed by the Group/Institution leaders and key figures/persons
   a) Define collaboration organization: rules and roles
   b) Arrive at the TDR with a formal collaboration proposal
   c) Connection to GravNet and funding agencies (INFN, …)

2. Technical Board: provisionally chosen by me, then by the SC, composed of technical experts (infrastructure, detector, computing, …) that review and follow the evolution of the TDR preparation. Interacts with LNF services.
3. Project WPs and Taks leaders