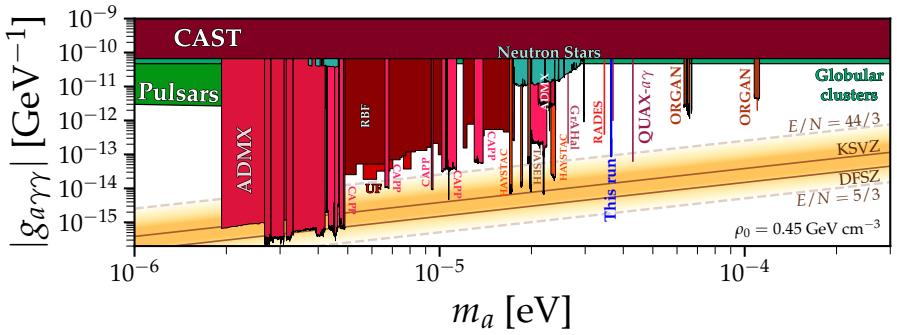
QUAX: QUest for AXions (2025)

Ricerca di assioni Dark Matter (m_a=30-60 μeV)

QUAX Collaboration
Padova (Resp. Naz. G. Carugno)
LNL
LNF
TIFPA
Salerno

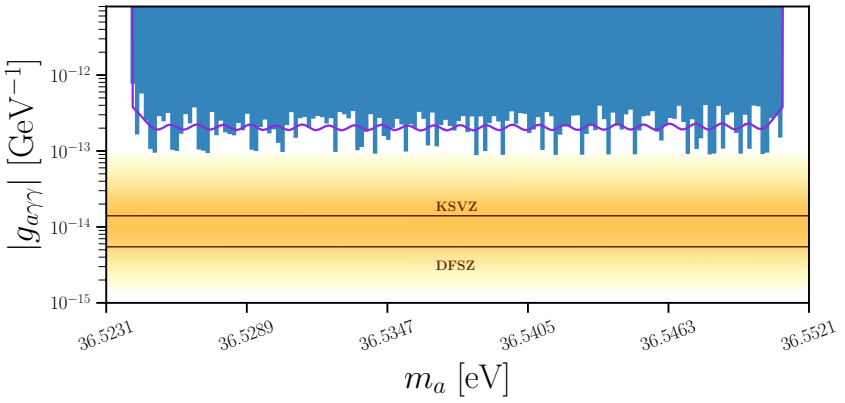
Risultati QUAX@LNF 2023-2024:

- Primi risultati pubblicati su PRD con l'aloscopio di LNF arXiv:2404.19063
- Primi risultati cavità YBCO
- Test amplificatore quantum JPA del NIST

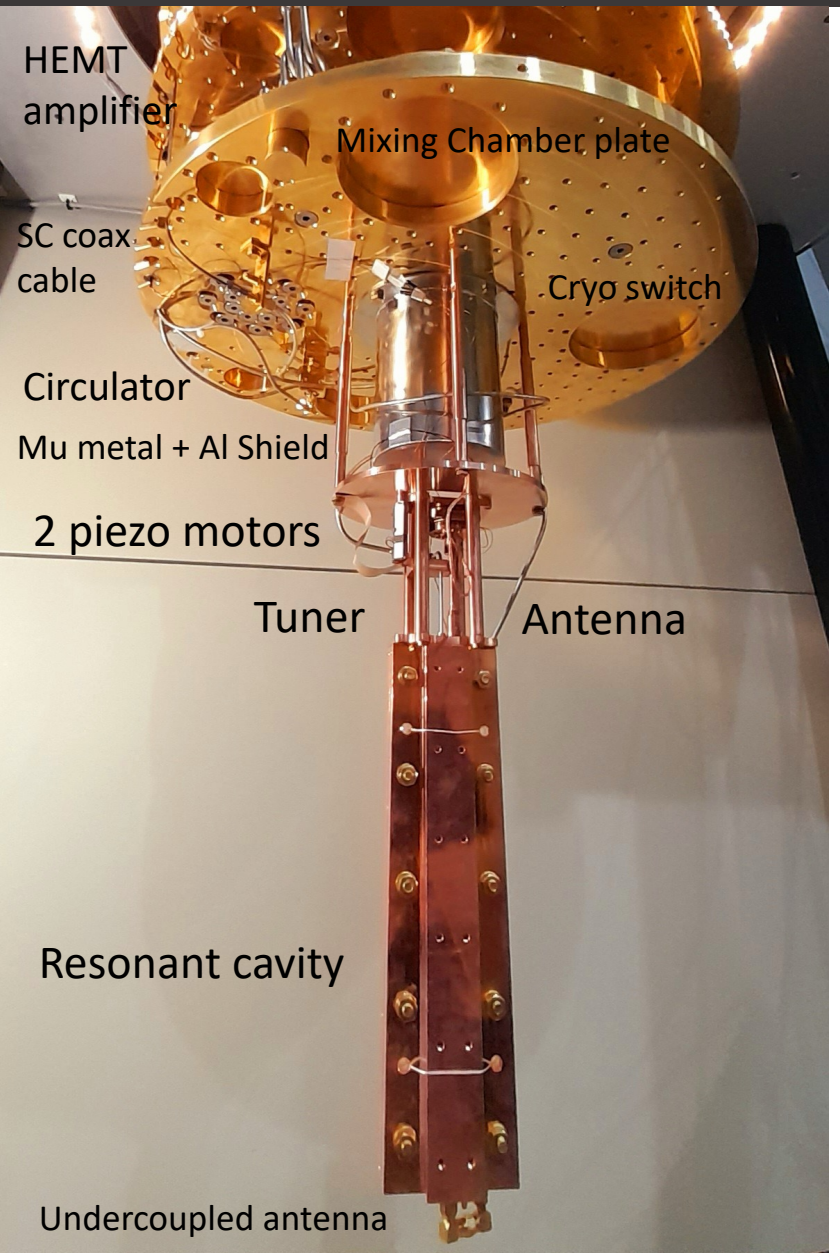


Obiettivi/Milestone QUAX@LNF 2025:

- Ricerca Assioni scan 50-100 MHz intorno a 9 GHz
- Completamento automazione apparati
- Completamento computing QUAX su Cloud INFN
- Migliorie nel DAQ usando FPGA
- Sviluppo sorgente termica calibrata criogenica
- Cavità YBCO
- Test detezione assioni con photon counter sviluppato in progetto QubIT (CSNV)

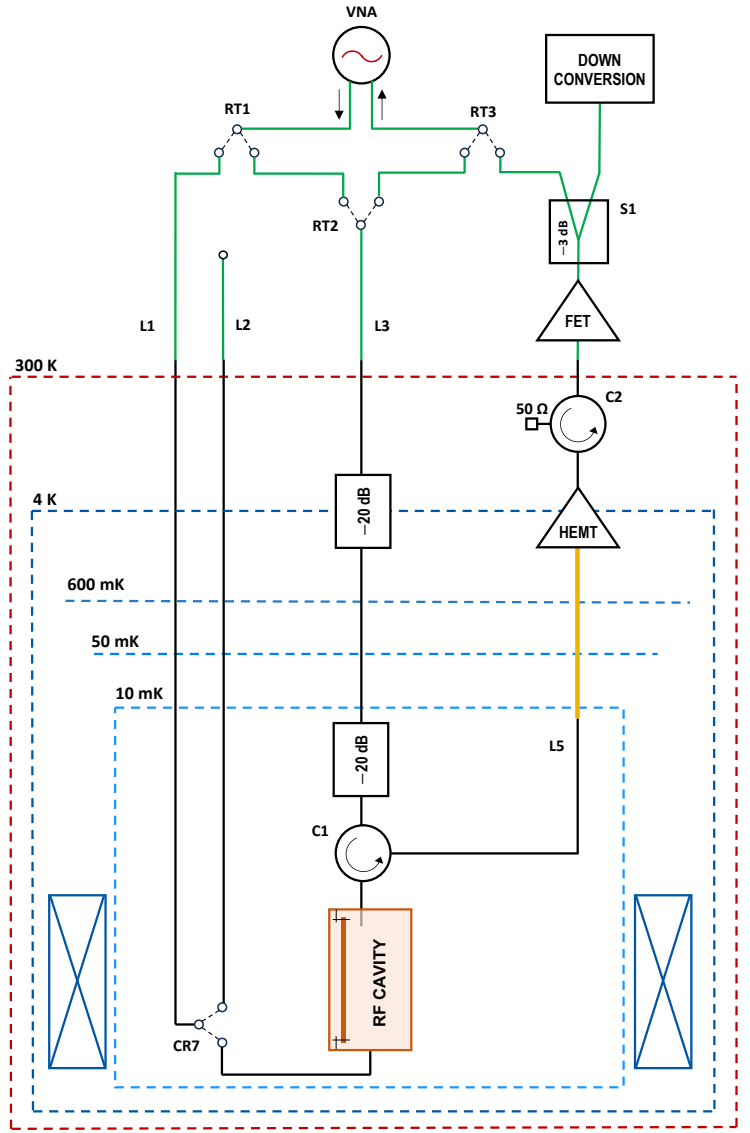


QUAX@LNF: The LNF Axion Haloscope

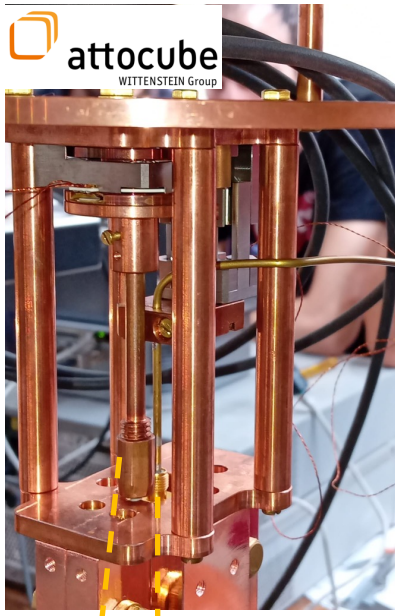


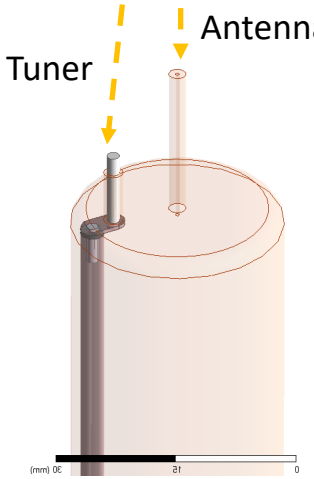
December 2023 Run

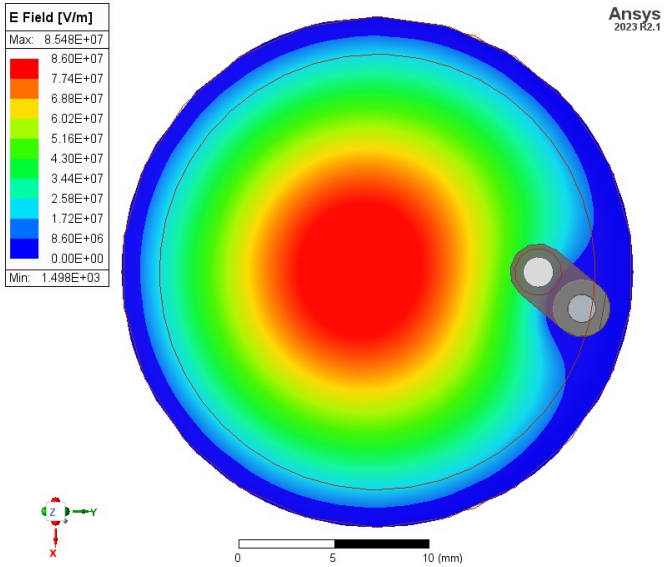
- Cavity temperature 30 mK
- Magnetic Field B=8 T
- Frequency 8.8 GHz
- Copper cavity Q_0=50,000 with tuner
- HEMT amplifier
- Tnoise 4K
- 2 weeks data taking
- 6 MHz scan



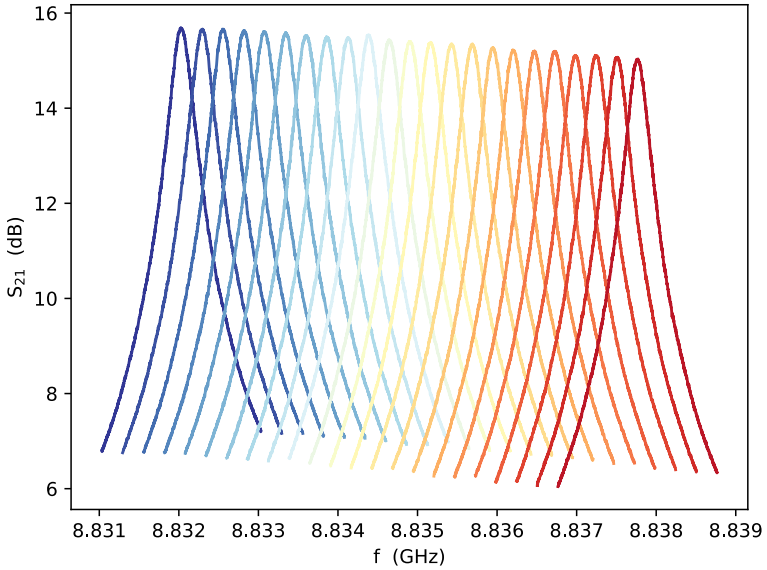
Cavity Tuning

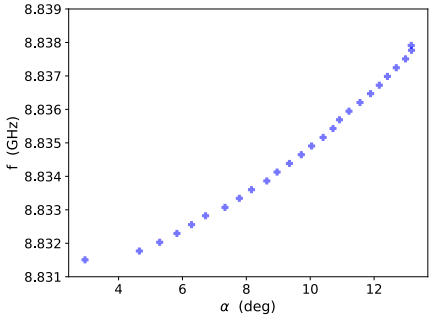


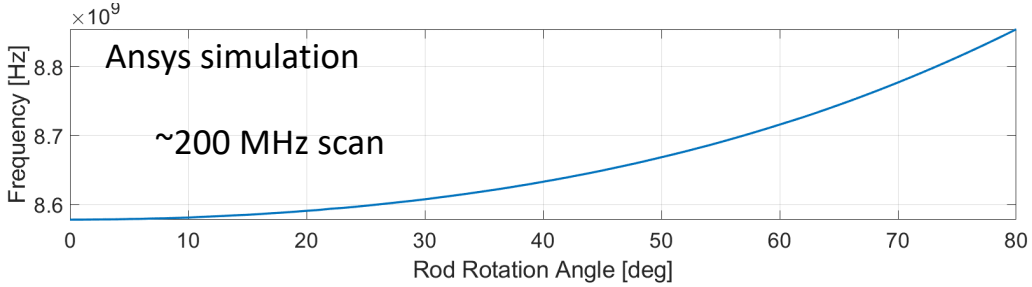




6 MHz of frequency scan







QUAX: QUest for AXions (2025)

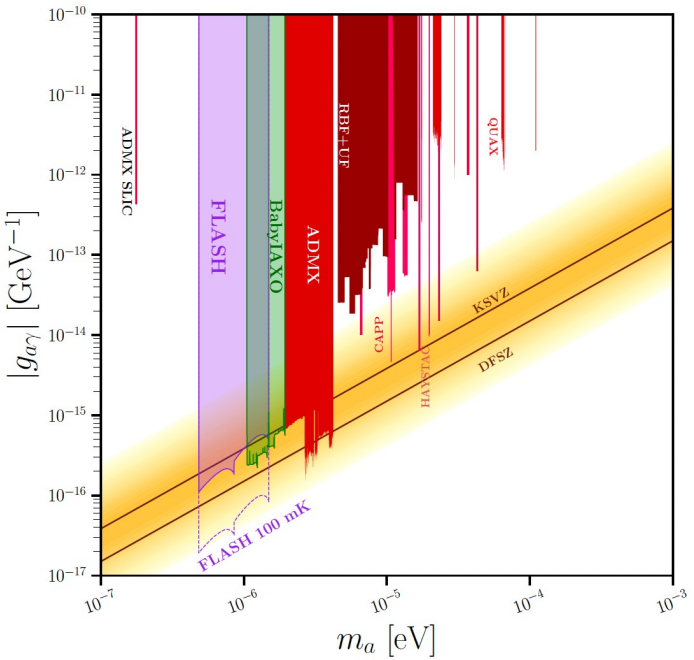
QUAX@LNF (PRIN – IRONMOON)

- **FTE**: LNF 4.25 (3,1 + 1.15) - C. Gatti (20%+5%, Resp. Loc.), D. Alesini (20%), D. Babusci (40%), D. Di Gioacchino (40%), C. Ligi (30%+10%), G. Maccarrone (40%), A. Piedju (100%), A. Rettaroli (100%), J Rezvani (UniCam)(20%).
- **Attività a carico LNF**: Completamento automazione, acquisizione e trasferimento dati su Cloud; Ricerca di assioni a 9 GHz per almeno 50 MHz di banda. Sviluppo cavità YBCO: Sorgente termica; Test con photon counter QubIT.
- **Richieste LNF a CSNII 2025**: Inventario (10 k€), Apparato e Manutenzione (10 k€), Consumi Trasporti (10+2 k€), Missioni (5k€)
- **Richieste a LNF 2025**: 2 mu tecnico meccanico; 2 mu tecnico elettronico; 2 mu progettazione meccanica; 2 mu progettazione elettronica; Officina Meccanica per fabbricazione cavità 9 GHz.
- **Fondi Esterni**: PRIN-IRONMOON, SQMS

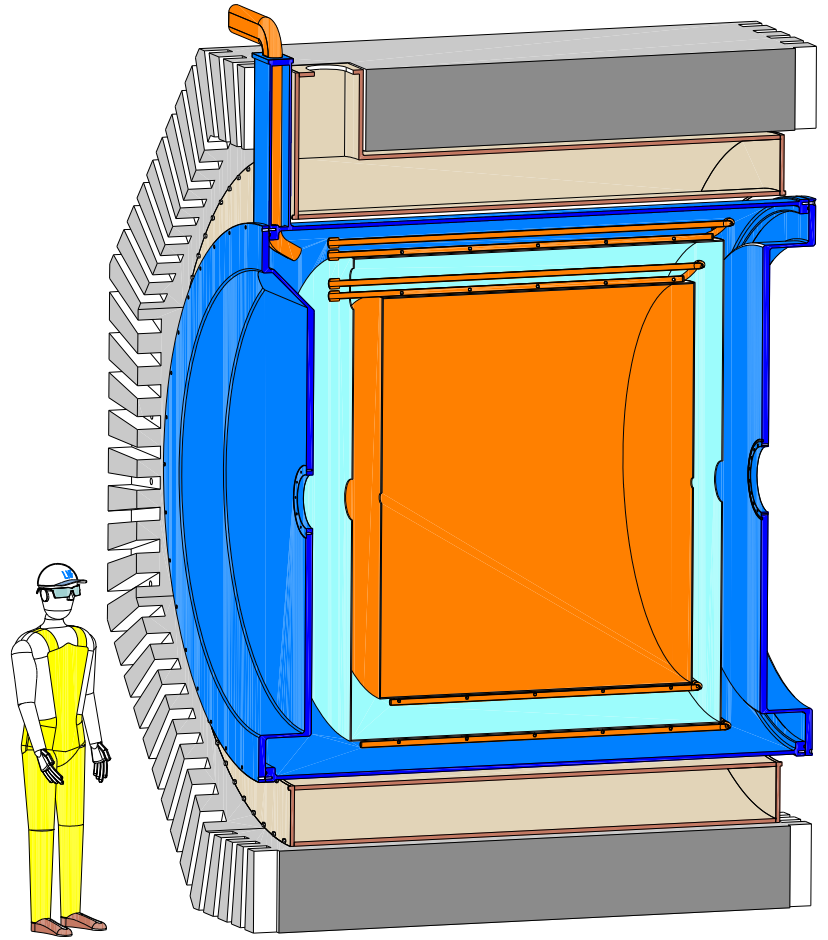
FLASH – Proposta TDR (2025)

- Ricerca di assioni Dark Matter (m_a=1 μeV)

Obiettivi/Milestone FLASH-TDR 2025:
- Scrittura FLASH TDR entro estate 2026
- R&D cavità, amplifcazione, DAQ, computing



FLASH Collaboration
LNF (Resp. Naz. C. Gatti)
Uni Pisa and INFN
Uni Camerino (ass. LNF)
TIFPA
University of Bonn and of Mainz
University of Valencia
Technical University of Cartagena
IFAE-ICREA (Theory)
University of Liverpool
TDLI Shangai (Theory)
University of Zaragoza (Theory)



FLASH – Proposta TDR (2025)

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

Table 8: R&D forseen during the FLASH-TDR phase.

R&D	Description	Initial TRL	Final TRL
RF Cavity	500 MHz cavity prototype	TRL4	TRL7
Superconductive Cavity	Feasibility of a FLASH SC cavity	TRL4	TRL5
SQUID Amplifier	MSA at 2 and 4 K and B field	TRL6	TRL9
SQUID Amplifier	Signal Multiplexing	TRL3	TRL7
DAQ	Test of the full amplification and DAQ chain	TRL4	TRL9
Computing	Validation of the Cloud Computing model	TRL7	TRL9

Table 9: WPs

WP1	Physics Reach
WP2	Mechanical Design and cryogenics
WP3	RF Cavity
WP4	Signal Amplification and Acquisition
WP5	Data Analysis and Computing
WP6	FINUDA Decommissioning and FLASH Commissioning
WP7	Project Management

FLASH – Proposta TDR (2025)

- FTE: LNF 3.3 - C Gatti (30%, Resp. Naz.), C Ligi (40%), S Gazzana (20%), G Di Pirro (20%), A. Vannozzi (10%), P Ciambrone (20%), F Bossi (40%), D Babusci (30%), P Gianotti (20%), D Di Gioacchino(30%), J Rezvani (UniCam) (0.4), B Gianfelici (UniCam, PhD) (0.3) + Theory Group (F Mescia 0%, E Nardi 0%) + (COLD team).

- Attività a carico LNF: Progettazione meccanica e RF; Test squid in B field (UniCam); Test prototipo cavità 500 MHz in LHe; Analysis strategy (QUAX); Cloud Computing (QUAX); DAQ (QUAX); Controlli; Theory and Physics Reach; Decommissioning FINUDA and Commissioning FLASH;

- Richieste LNF a CSNII 2025: Inventario (20 k€), Consumi (28 k€), LHe (10k€), Missioni (25k€).

- Richieste a LNF 2025: Progettazione criostato SEM (12 mp), Officina Meccanica (1 mp), Servizio Elettronica (1 mp), Criogenia (2 mp).