NbTi THIN FILM SRF CAVITIES FOR DARK MATTER SEARCH

QUANTUM TECHNOLOGIES FOR FUNDAMENTAL PHYSICS
Erice, 01-07 September 2023

INFN LNL

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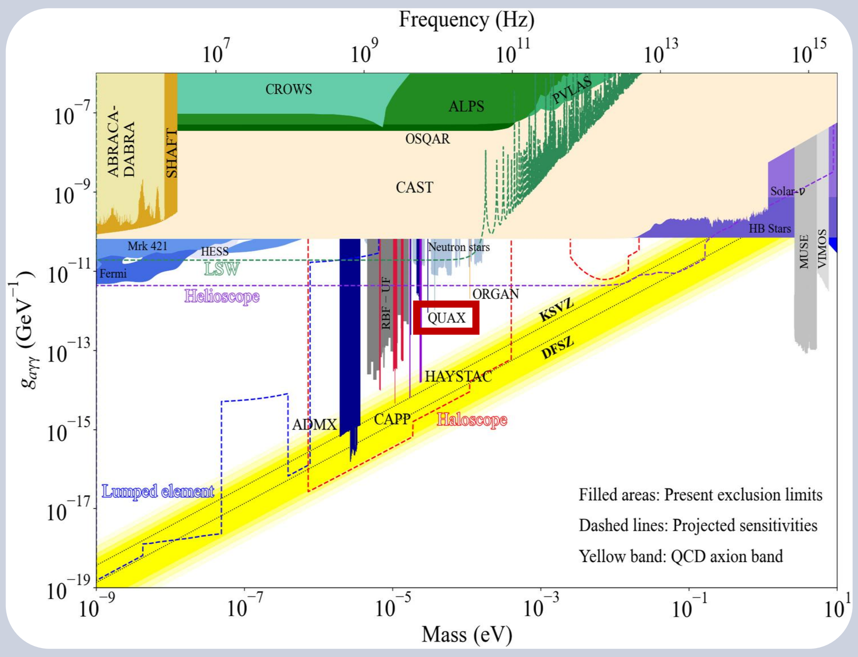
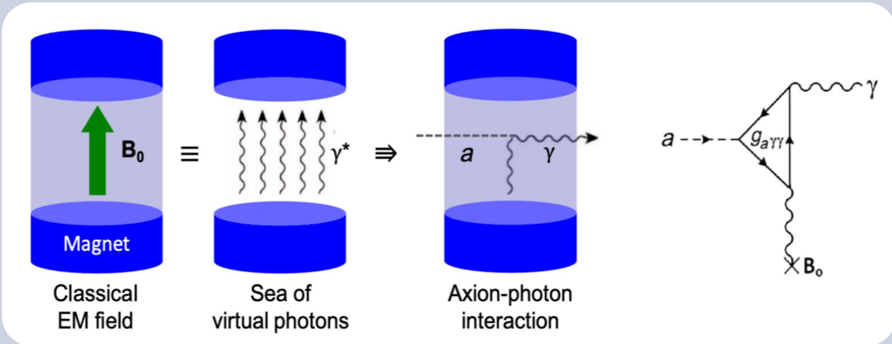
QUAX (QUerere AXion)

AXION → PHOTON

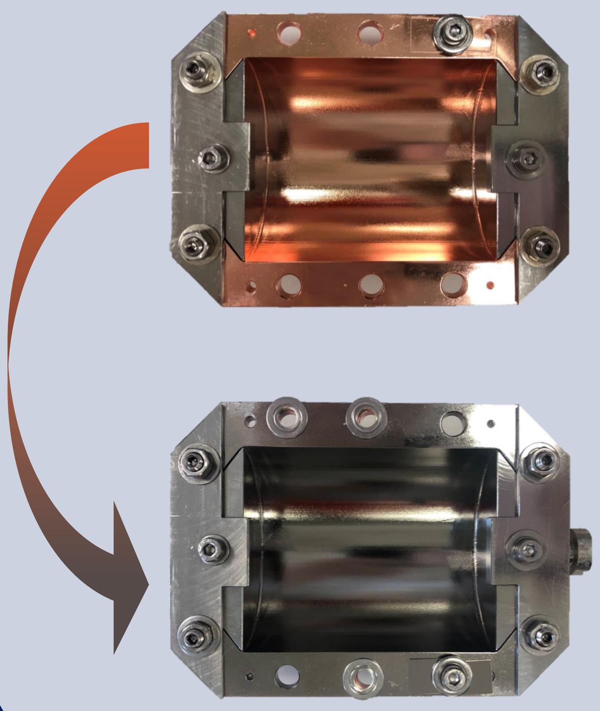


Y. K. Semertzidis e S. Youn, *Science Advances*, vol. 8, fasc. 8, p. eabm9928, feb. 2022



When the frequency of the axion-induced photon matches the frequency of the cavity eigenmode the conversion power is resonantly enhanced by orders of magnitude given by the cavity Q factor

CAVITY PREPARATION



Cu substrate preparation:

- Ultrasonic bath
- Electropolishing
- SUBU
- HPR

Coating process:

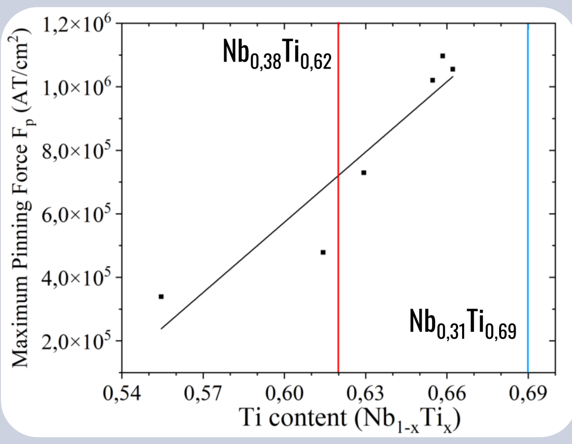
- Single target DCMS
- Ar pressure $6 \cdot 10^{-3}$ mbar
- T substrate 500°C
- Film thickness 2,5 µm

PINNING in NbTi

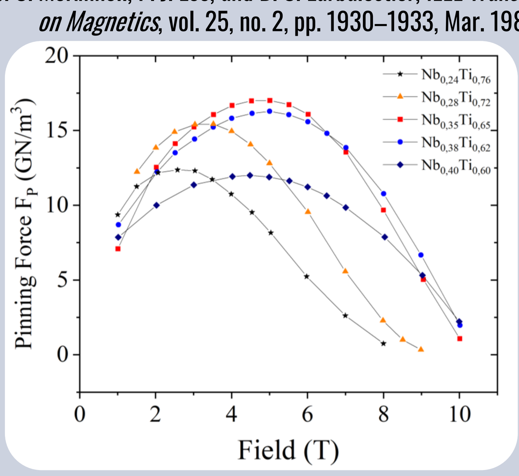
α-Ti ribbons as pinning centers

J. F. Li *et al.*, *Physica C: Superconductivity*, vol. 468, fasc. 15, pp. 1840–1842, set. 2008

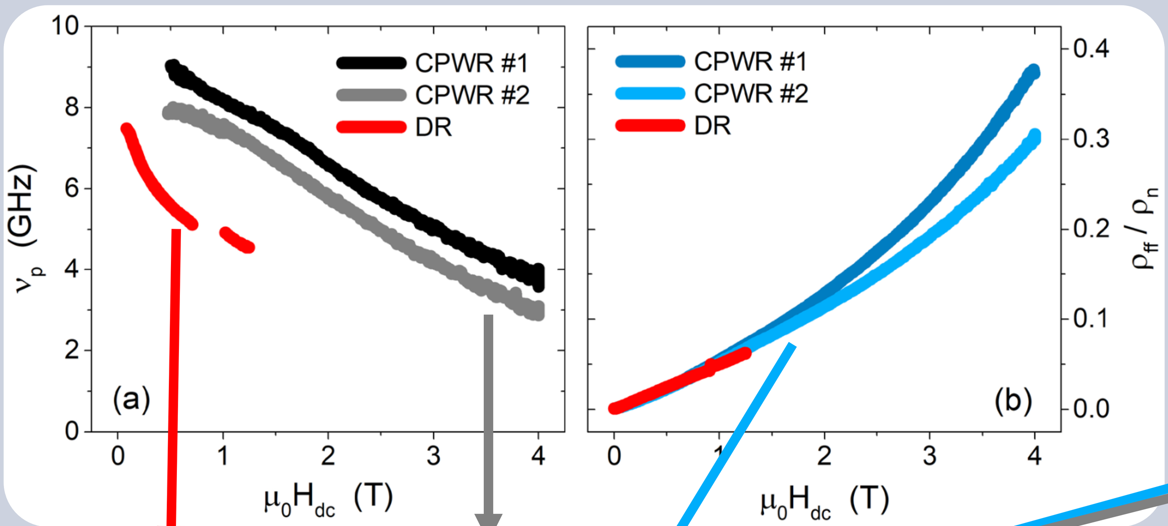
H. Hillmann and K. Best, *IEEE Transactions on Magnetics*, vol. 13, no. 5, pp. 1568–1570, Sep. 1977



J. C. McKinnell, P. J. Lee, and D. C. Larbalestier, *IEEE Transactions on Magnetics*, vol. 25, no. 2, pp. 1930–1933, Mar. 1989



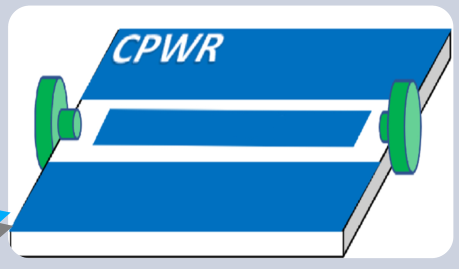
NbTi CHARACTERIZATION

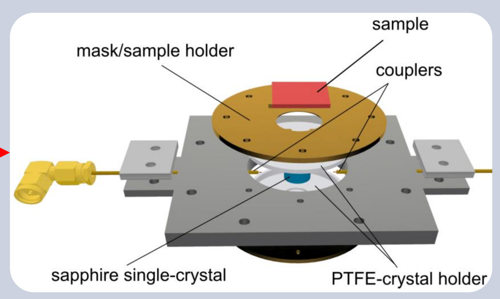


$Nb_{0,38}Ti_{0,62}$ $Nb_{0,31}Ti_{0,69}$

G. Ghigo *et al.*, *Sci Rep*, vol. 13, no. 1, Art. no. 1, Jun. 2023

G. Ghigo *et al.*, *Materials*, vol. 15, no. 3, Art. no. 3, Jan. 2022



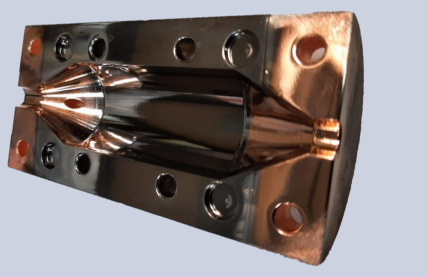


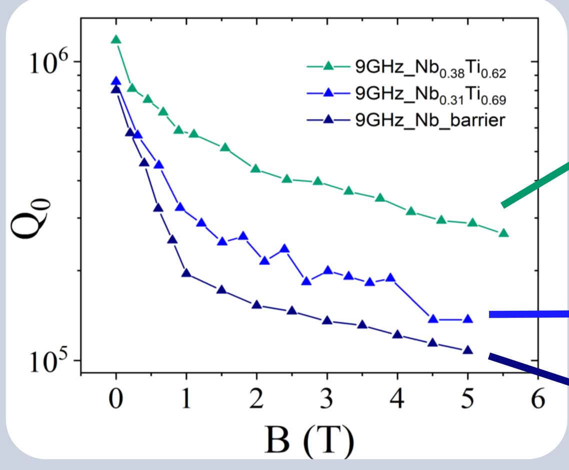
A. Alimenti *et al.*, *Sensors*, vol. 23, no. 1, Art. no. 1, Jan. 2023

While maintaining the same scaling of the flux flow resistivity normalized to the normal state resistivity, the $Nb_{0,38}Ti_{0,62}$ samples show lower depinning frequency but still comparable with $Nb_{0,31}Ti_{0,69}$

CAVITY CHARACTERIZATION

9 GHz HALOSCOPE





$Nb_{0,38}Ti_{0,62}$

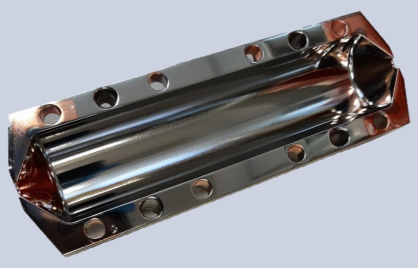
D. Di Gioacchino *et al.*, *IEEE Transactions on Applied Superconductivity*, vol. 29, fasc. 5, pp. 1–5, ago. 2019

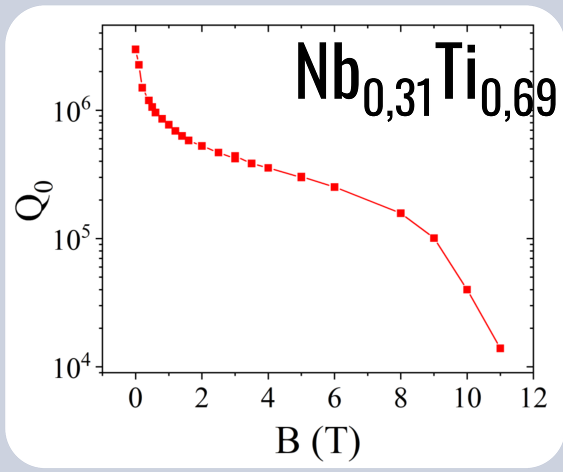
$Nb_{0,31}Ti_{0,69}$

$Nb + Nb_{0,31}Ti_{0,69}$

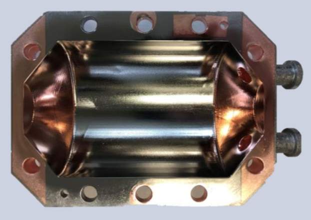
Nb barrier layer brings no visible improvement !

7 GHz HALOSCOPE



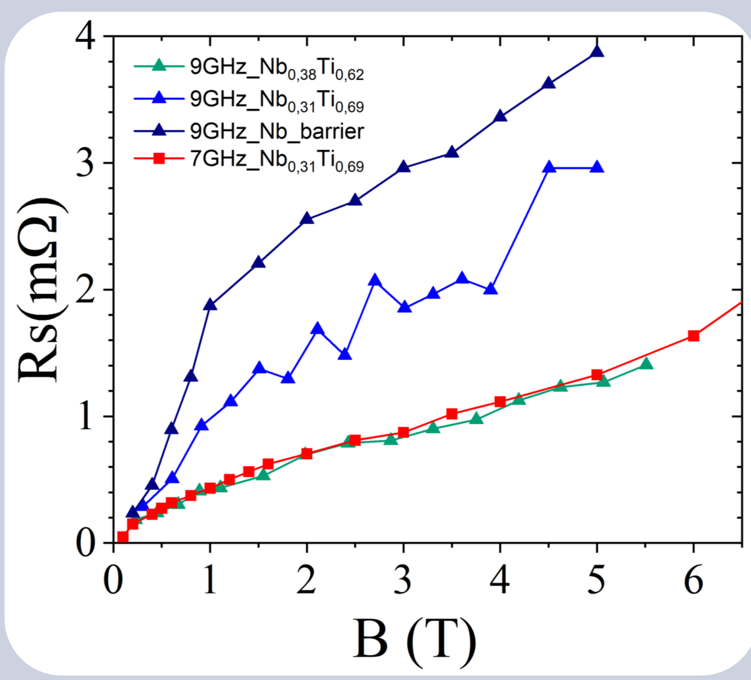


3.9 GHz HALOSCOPE

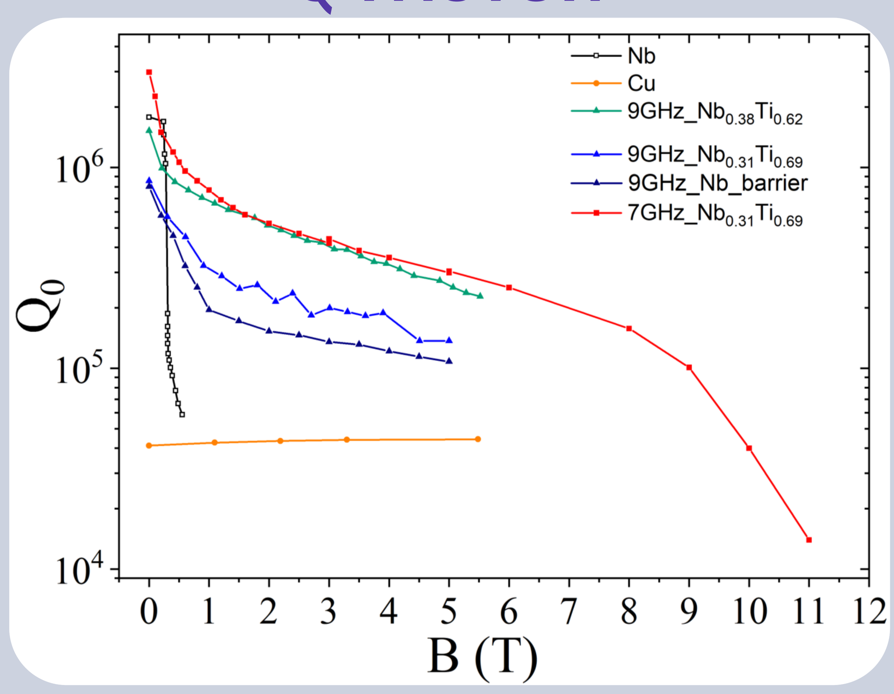


To be characterized

SURFACE RESISTANCE



Q FACTOR



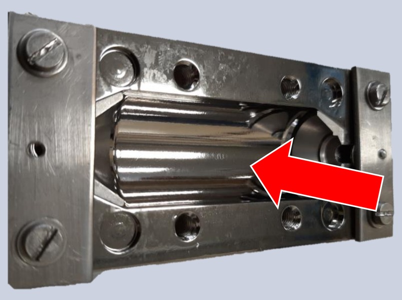
Looking at R_s we see worse performances for the 9GHz $Nb_{0,31}Ti_{0,69}$ cavities, but the same material recovers the previous R_s in the 7 GHz cavity

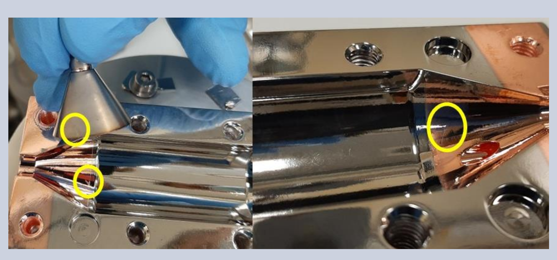
? Possible damage on the 9GHz cavity surface between the depositions

? Possible sputtering of superconducting material on the cones' surface

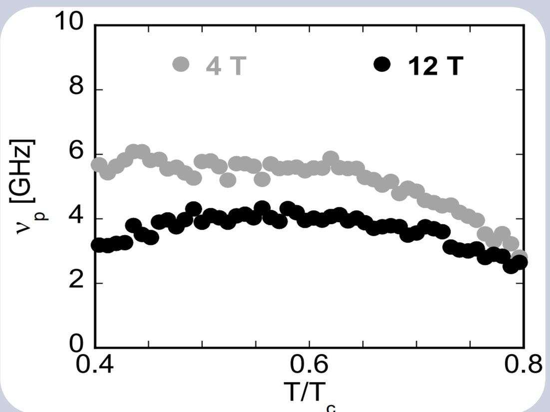
⇩

Enhanced dissipation due to flux vortexes





Nb_3Sn DEVELOPMENT



Higher H_{c2}

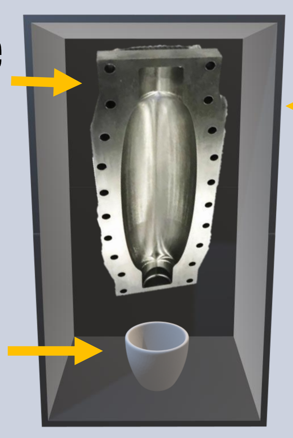
Higher depinning frequency than NbTi at same magnetic field

	NbTi	Nb_3Sn
H_{c2}	~13 T	~25 T
v_p @ 4 T	~4 GHz	~6 GHz

A. Alimenti *et al.*, *IEEE Trans. Appl. Supercond.*, vol. 29, no. 5, pp. 1–4, Aug. 2019

Fermilab Vapour tin diffusion VS Magnetron sputtering INFN

Courtesy of S. Posen

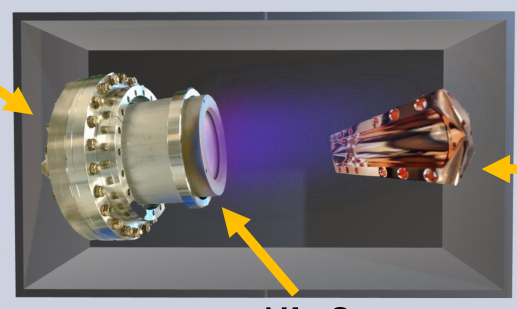


Nb substrate

UHV chamber ~1100°C

Sn crucible ~1200°C

- State of the art for SRF Nb_3Sn cavities



Magnetron

UHV chamber ~600°C

Cu or almost **any** substrate

Nb_3Sn target

- Smaller grains -> more pinning in Nb_3Sn
- Possibility to use masks
- Deposition on Cu -> cheaper -> better thermal conductor

SQMS SUPERCONDUCTING QUANTUM MATERIALS & SYSTEMS CENTER

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Italiadomani

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