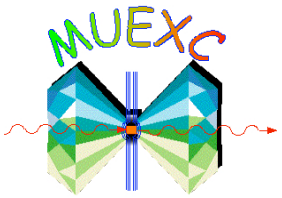


Materials Under EXtreme Conditions
(LNF & Sez.Firenze)

M. Cestelli Guidi (Art. 23), G. Della Ventura (Ass.), **D. Di Gioacchino (Resp. Naz.)**, L. Gambicorti (Ass.), A. Marcelli, A. Mottana (Ass.), E. Pace (Ass.), P. Postorino (Ass.), A. Puri (Ass.), N. Saini (Ass.), F. Tabacchioni (Tech.), R. Sorchetti (Tech.)

- **MUEXC** is a project, developed at the LNF in the framework of the Vth committee, that will finish to developed the **'PRESS-MAG-O' instrumentation.**

- an unique device [2006 *Activity Highlights of the 'INFN TECHNOLOGY RESEARCH (Vth Committee)*]

✓**concurrent IR spectroscopy and a.c. multi-harmonic magnetic susceptibility experiments**

with a control of the

✓**pressure**
✓**magnetic field**
✓**temperature**

- to investigate new materials under extreme conditions such as **materials for INFN technological applications,**

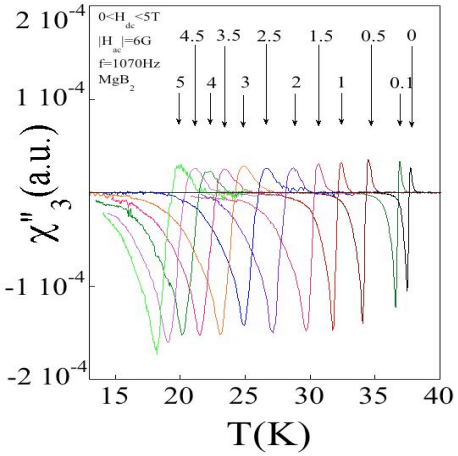
✓high performance superconductors for magnets
✓Detectors
✓sensors materials (for accelerator & space applications)

- **new quantum phenomena under extreme conditions**

Why PRESS-MAG-O/MUEXC device

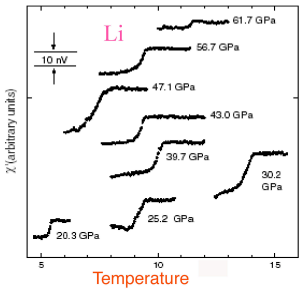
Experiments of the magneto-dynamic-optics versus High Pressure/ Low Temperature

Why magneto-dynamics ?

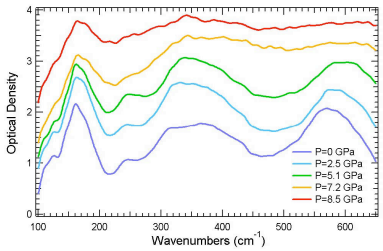


MgB_2 sample - χ''_3 third harmonic magnetic susceptibility imaginary part versus H_{dc}:
Superconducting flux-pinning studies

Why the pressure?

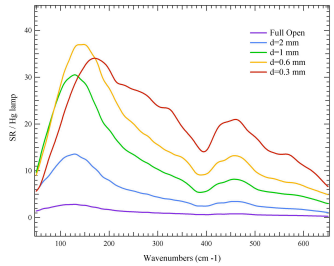


Litium becames superconductor in pressure: T_c=14K , P=30 GPascal



Study of the IR active modes (phonons) as a function of the pressure in $La_{0.8}Ca_{0.2}MnO_{3-\delta}$:
MIT transitions phase

Why IR synchrotron radiation?

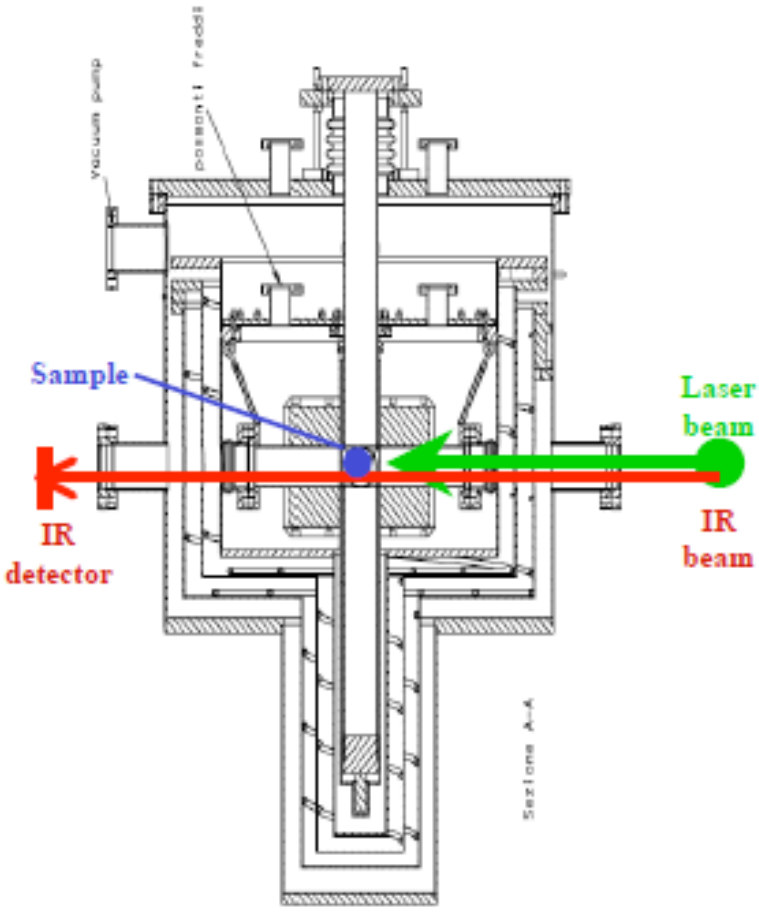


Gain>>10!

PRESS-MAG-O/MUEXC cryostat

High pressure (up to 20 GPa),
high magnetic field (up to 8 T)
in a wide temperature range (4.2 - 300 K)

Goal: concurrent a.c. magnetic susceptibility measurements and
IR/Raman spectroscopy.



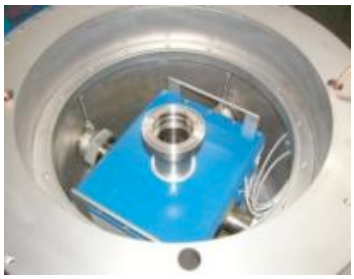
D. Di Gioacchino, P. Tripodi, A. Marcelli, M. Cestelli Guidi, M. Piccinini, P. Postorino, D. Di Castro, E. Arcangeletti, Journal of Physics and Chemistry of Solid 69 (2008) 2213-2216

PRESS-MAG-O/MUEXC cryostat know-how

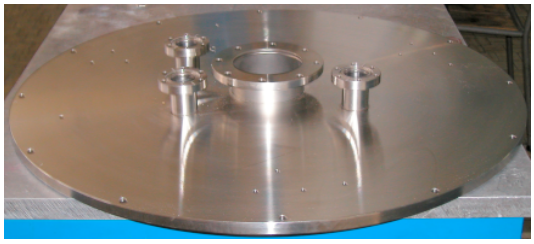
8 T superconducting split coil magnet

LHe reservoir around the magnet

Four optical access ports for transmission experiments with visible light and IR radiation.

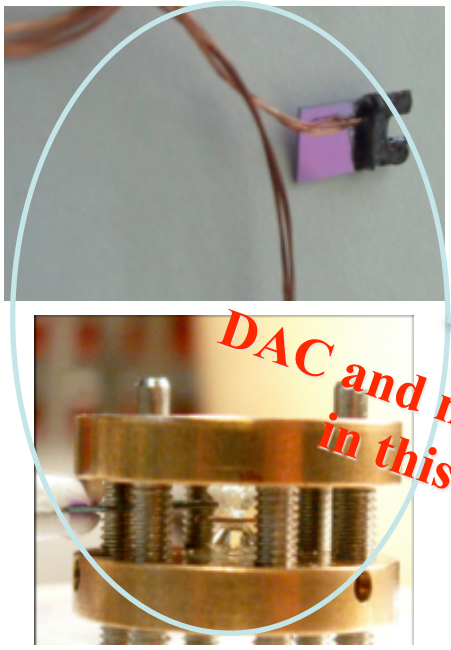


Top cover with a load-lock port for the "sample insert"

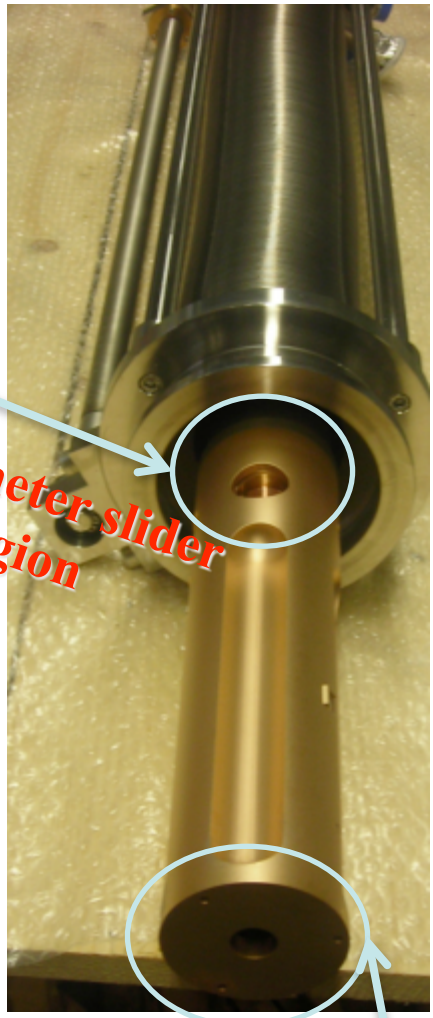


D. Di Gioacchino, A. Marcelli, M. Cestelli Guidi, A. Puri, P. Postorino, E. Pace, A. De Sio and L. Gambicorti, High Pressure Research, 31, No.1, (2011), 91-97

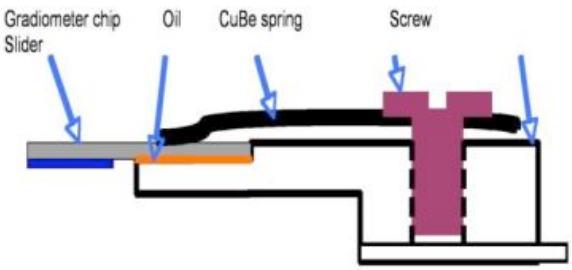
PRESS-MAG-O/MUEXC know how sample insert



DAC and magnetometer slider in this insert region

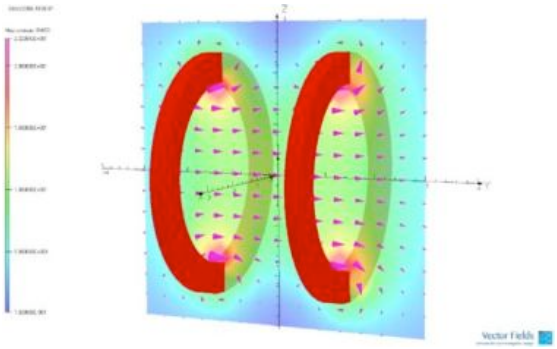


Superconducting gradiometer

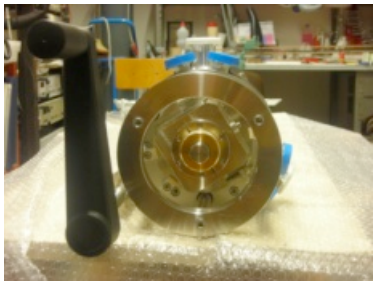


SQUID and shield fixed on the bottom of the insert inside the cold finger

PRESS-MAG-O/MUEXC know how sample insert



a.c.magnetic field study of the exciting coil on the DAC.



The upper part contains the X-Y-Θ control with micrometer accuracy to align the sample inside the DAC.

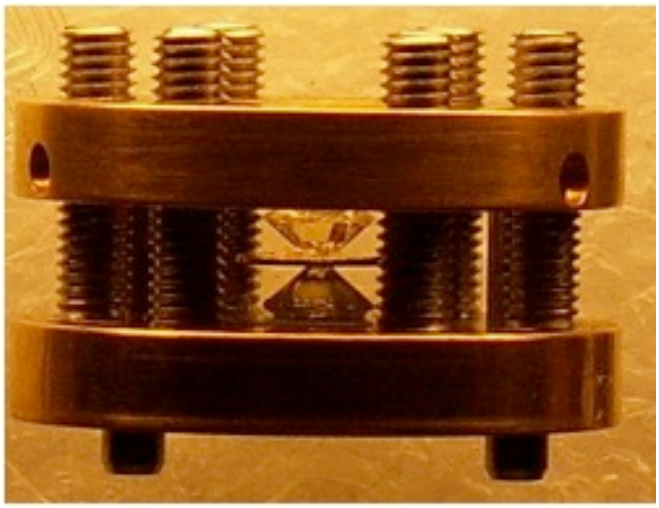
The lower section contains the Cu-Be/sapphire sample-holder, Cu-Be springs for thermal contact, DAC, a.c. exciting coil (10G), magnetometer slider.

PRESS-MAG-O/MUEXC know how sample insert

The non-magnetic 2% CuBe alloy miniature DAC to apply pressure

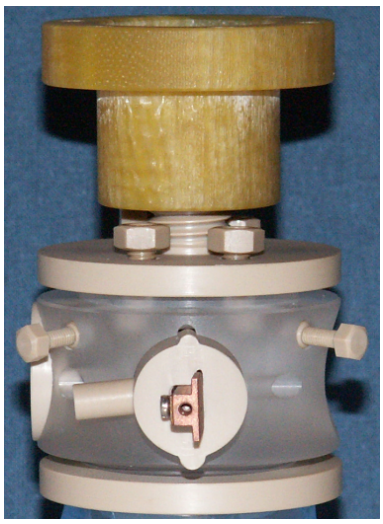
Two brilliant cut IIa type diamonds

Two SiC-δ moissanite cylinders with a 400 μm conic hole to press the anvils

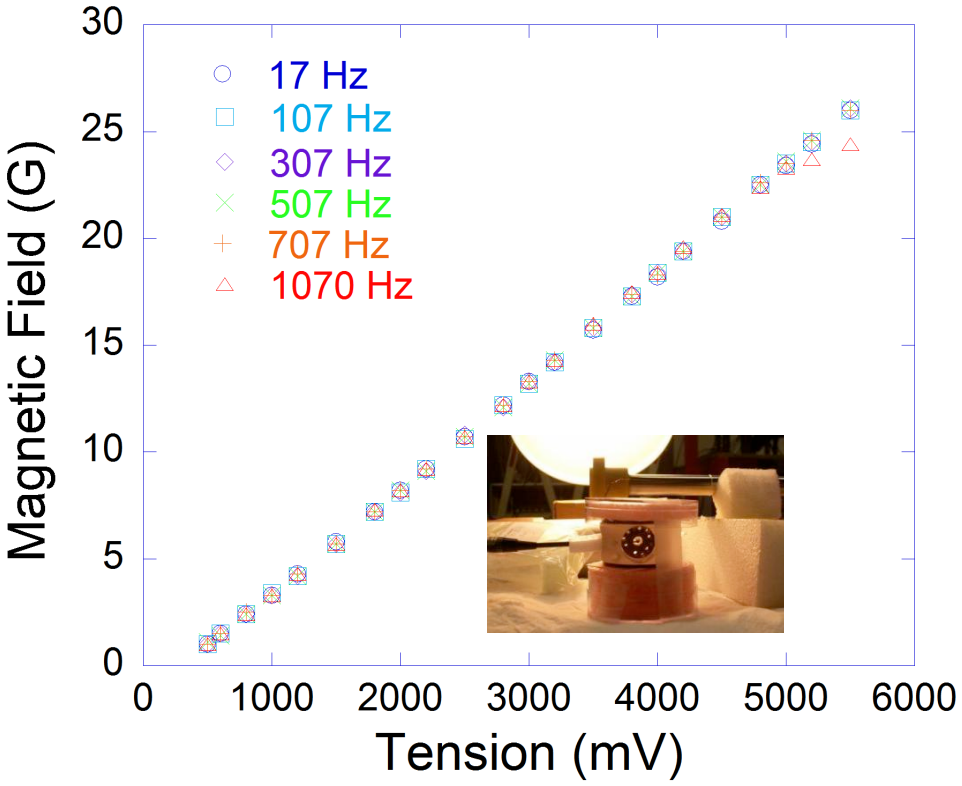


PRESS-MAG-O/MUEXC know how sample insert

the sapphire sample holder



Magnetic field inside the sample holder



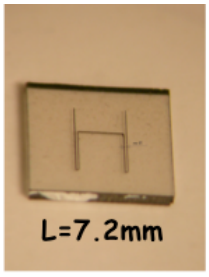
The generator may work in the range 200-5500 mV at 17-1070 Hz.

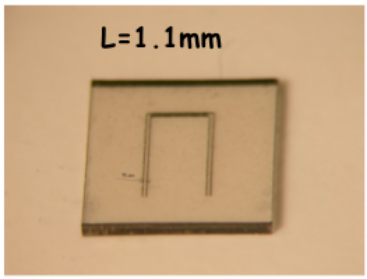
A linear trend of the magnetic field vs. V has been observed inside the DAC in the range ~1-20 Gauss vs. frequency.

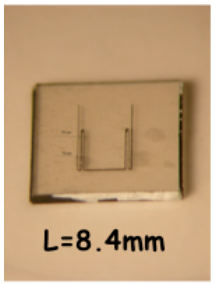
D. Di Gioacchino, A. Marcelli, M. Cestelli Guidi, M.Piccinini, A. Puri, P. Postorino, E. Pace, A. De Sio, L. Gambicorti, J. Phys. Chem. Solids 71, 1042-1045 (2010).

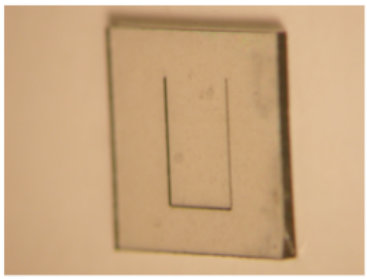
PRESS-MAG-O/MUEXC know how sample insert

DAC - R&D of an anvil integrated heater system





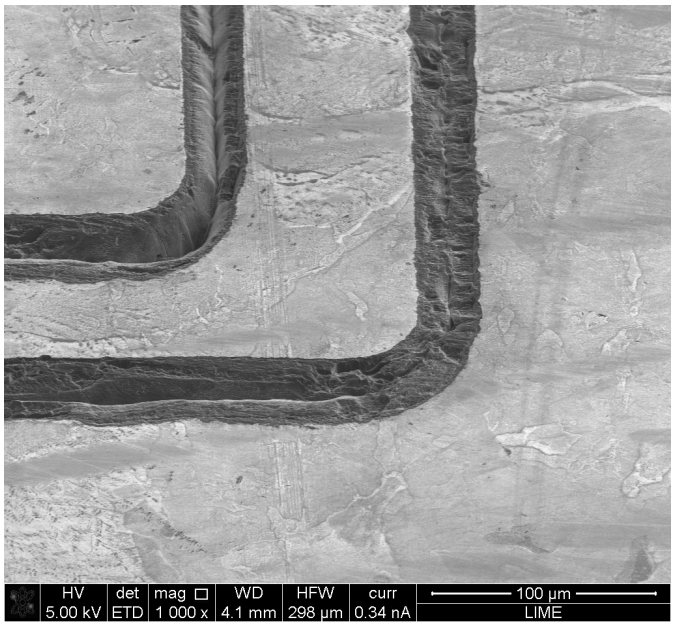


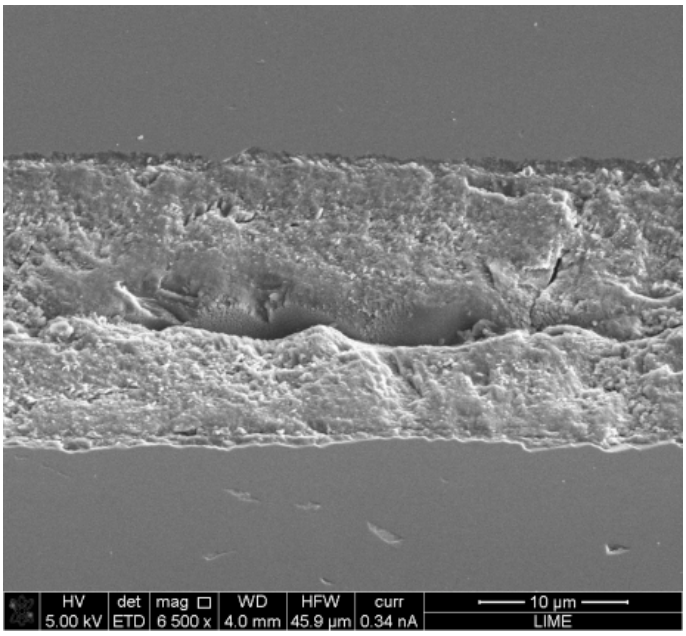


First layout of resistive line on diamond slabs

Line width= 17 μm to 42 μm, ρ=10 Ωmm

Collaboration Fi-INFN &Diamond material GmbH



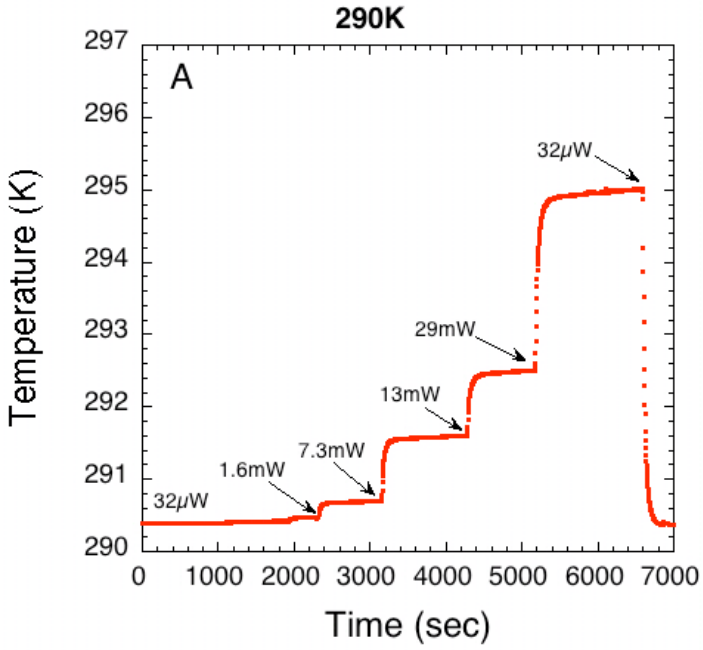


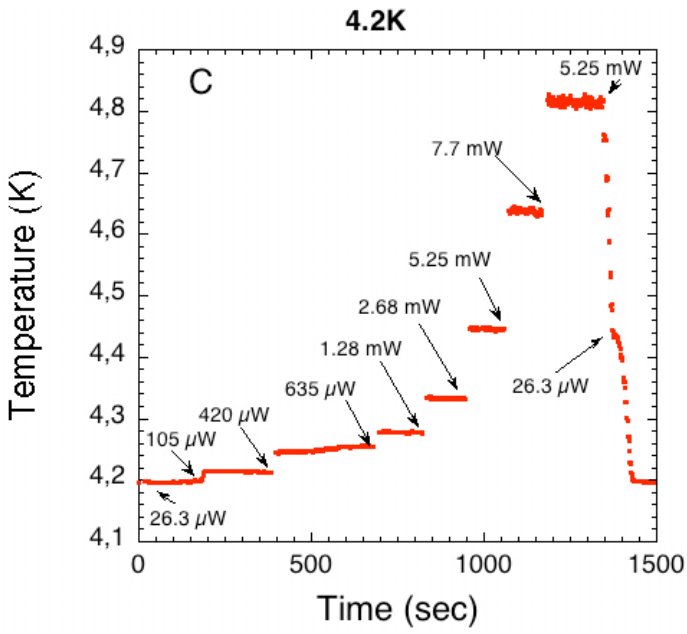
Characterization is under way using the Focused Ion Beam (FIB) of the LIME laboratory of the University of Roma Tre

PRESS-MAG-O/MUEXC know how sample insert

DAC - R&D of an anvil integrated heater system

Heating control tests inside the cryostat are done at the LNF

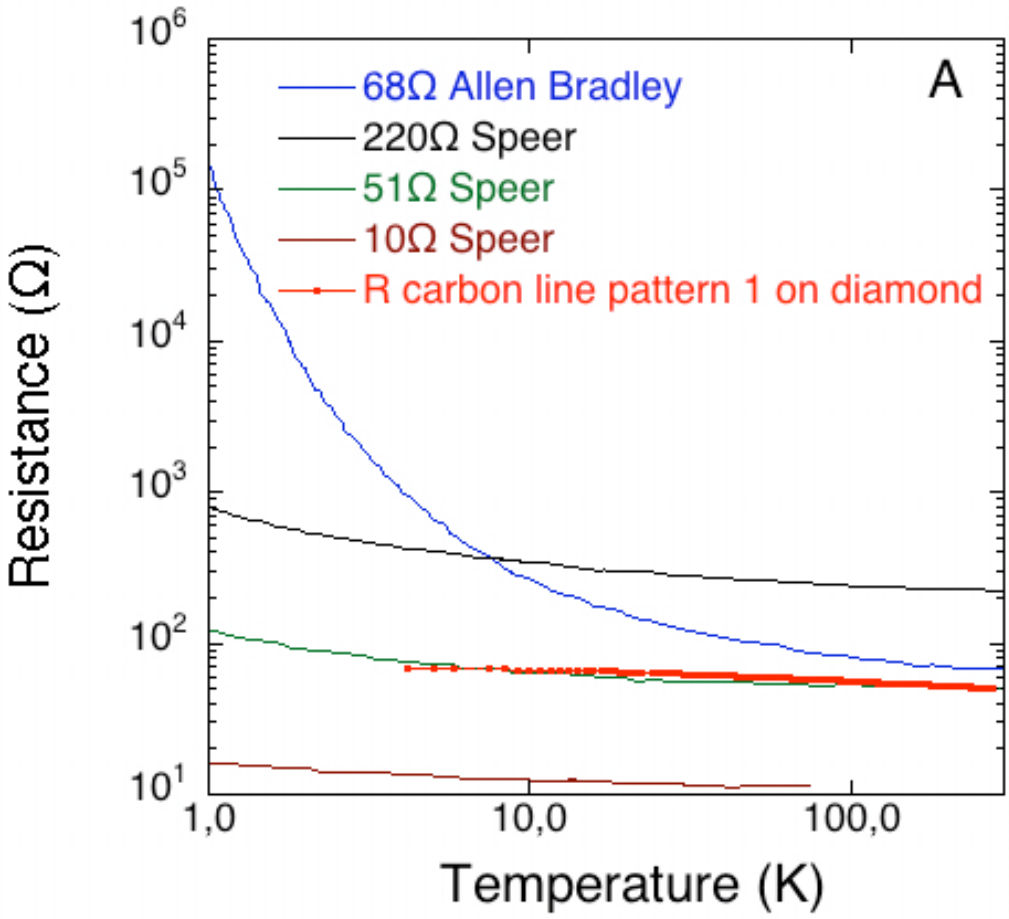




Experimental tests at room temperature and at low temperature point out that these lines can be used to design a micro-heater

PRESS-MAG-O/MUEXC know how sample insert

DAC - R&D of an anvil integrated heater system



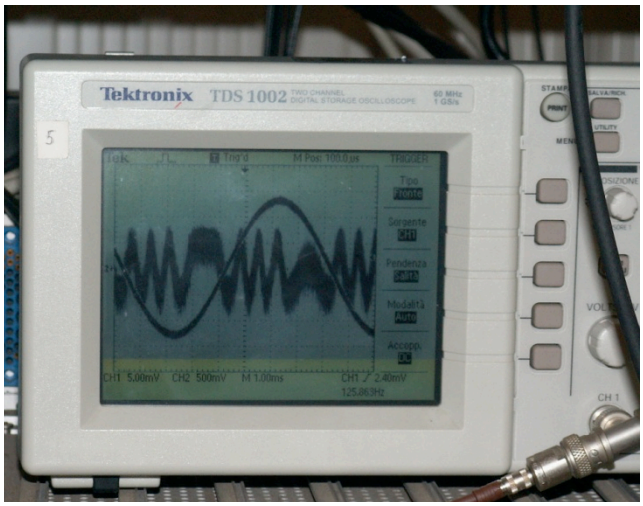
The same device may be also used as a thermometer. Indeed, we measured on the same pattern a resistance vs. temperature behavior similar to that of a 51 Ω Speer CGR

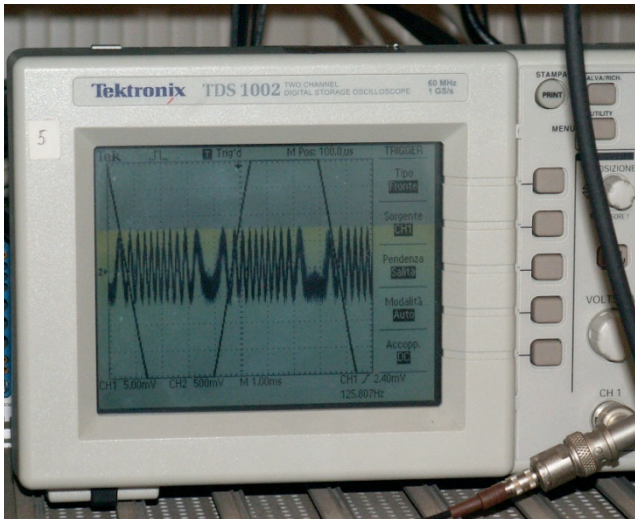
A. Puri, A. Marcelli, M. Cestelli Guidi, P. Postorino, E. Pace, A. De Sio, L. Gambicorti, G. Della Ventura, A. Notargiacomo, D. Di Gioacchino, Internal note LNF- 11/ 19 (NT) (2011)

PRESS-MAG-O/MUEXC know how sample insert

Test experiments on the SQUID gradiometer

Test on the system at 4.2 K with YBCO loaded in the DAC cell mounted on the PRESS-MAG-O insert to check the proper SQUID gradiometer operation



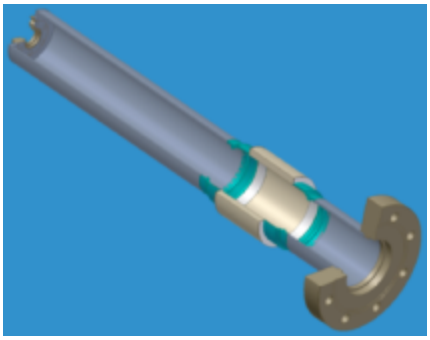


AC field of 22.7 Hz in the mGauss amplitude range generated by the exiting coil of the insert .

The persistent current in the gradiometer coils produces flux in SQUID whose amplitude depends on the exiting field.

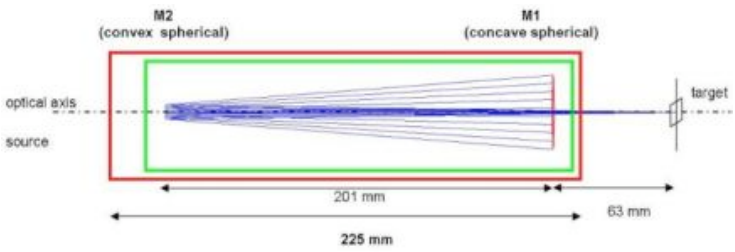
The test confirmed that the SQUID was working properly.

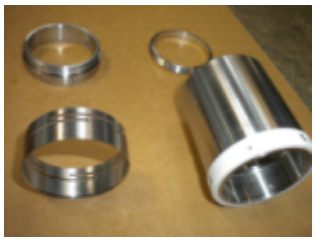
PRESS-MAG-O/MUEXC know how Optics lines cryostat

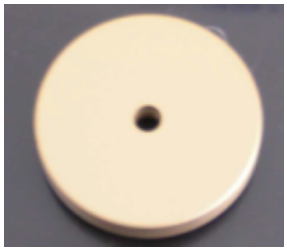


Two optical windows on the cryostat allow the transmission of IR and visible light.

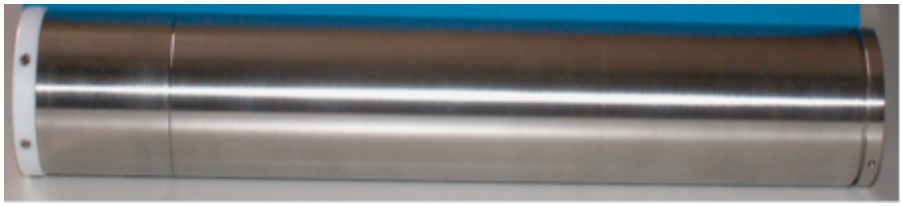
A Cassegrain concentrator designed to focus the light in a small spot inside the DAC (the diameter of the Airy disk is ~200 μm at the shortest wavelength).

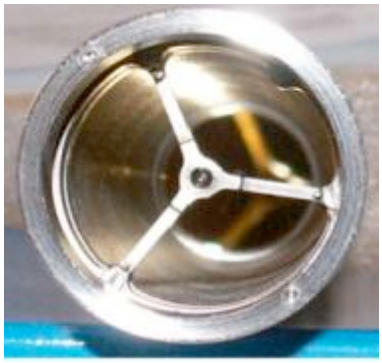






IR Wavelength range (micron)	2.5-50
Source beam diameter (mm)	30
Window thickness (micron)	500
Distance window-target (mm)	39
Optical Tube dimension (mm)	225/325





The optics has been designed and built in cooperation with CNR-INOA (Firenze).