



**PRESS-MAG-O: status of the commissioning and
of the associated R&D**

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Abstract

PRESS-MAG-O is a unique innovative apparatus under commissioning at the Laboratori Nazionali di Frascati of the Istituto Nazionale di Fisica Nucleare (INFN), designed to perform experiments on materials under extreme conditions. The instrument will allow concurrent magnetic and spectroscopic experiments under high pressure and high DC magnetic field in a wide temperature range. A highly sensitive SQUID gradiometer designed to fit inside a diamagnetic DAC cell and cooled inside the cryostat hosting a 8 T superconducting magnet is the heart of the instrument. The cryostat has been designed with four access ports two of them equipped with special windows and optical lenses to focus and collect radiation down to the IR region to perform spectroscopic experiments on the sample loaded in the DAC. In this report we summarize the technical characteristics of the system and the status of test and commissioning at the end of 2011.

1 INTRODUCTION

Press-Mag-O is a new instrument designed by INFN to investigate materials under extreme conditions¹⁾. The apparatus has been completely developed in the framework of a project funded by the Vth National Committee of the INFN²⁾. Materials of technological interest for the next generation of micro-devices for charged particles/neutron detectors, Terahertz spectroscopy or beamline diagnostic, based on ferroelectrics or superconducting systems, phenomena like magnetic transitions, or new condensed matter phases received a considerable attention^{3,4)}. All the above materials and phenomena can be usefully investigated with a device specifically designed to perform concurrent magnetic and optical experiments such as Press-Mag-O. Actually, the latter instrument once completed and commissioned will allow performing high harmonic ac magnetic susceptibility measurements and magneto-optic experiments on a sample under high pressure using a diamond anvil cell (DAC), with a variable DC magnetic field, in a wide temperature range performing in a concurrent way optical spectroscopic experiments thanks to windows transmitting radiation down to the IR region. In this way it will be possible to investigate the magnetic properties and to collect detailed vibrational information on bonding properties of crystals, glass, and melts undergone to a high pressure.

The design of the system has been particularly optimized to work at SINBAD, the IR synchrotron radiation beamline operational since 2001 at DAΦNE (Double Annular Φ -factory for Nice Experiments), the storage ring of the INFN Frascati National Laboratory (LNF)⁵⁾. The optical layout is also compatible for Raman and other spectroscopic experiments (e.g., x-ray spectroscopies) in large infrastructures where suitable light sources will be available. Using IR spectroscopy techniques it is possible to investigate phonons, collective modes, pseudo-gap, superconducting gap. At the same time the high harmonic ac susceptibility technique allows to distinguish the linear and non-linear electronic transport processes occurring in the same material vs. $T(K)$, $H(T)$ and $J(A/m^2)$. The frequency of the H_{ac} field sets also the window of these processes. While for IR experiments an interferometer has to be coupled to the device, for the magneto-dynamic experiments an original SQUID magnetometer operating in the 10 Hz – 2 KHz frequency range has been designed, manufactured and tested. The pressure will be applied to the sample with a Cu–Be DAC so that, in principle, the device will be able to collect FTIR spectra and high harmonic ac susceptibility data in a dc magnetic field up to 8 T in a wide temperature range (4.2 – 200 K) up to about 20 GPa for a typical sample using standard gaskets.

As will be described in the next, the apparatus is the result of a significant R&D in different areas. Several technical advancements, the availability of new materials and high quality technological processes allowed the construction of the cryostat, its components and many of the ancillaries associated experimental parts.

In the next we will describe the system, the main components and the status of the commissioning of the different parts of the PRESS-MAG-O device.

2 THE INSTRUMENT

The key issues of this original device are: a reasonably compact a-magnetic steel cryostat built around a 8T superconducting split magnet with four radial ports placed on the equatorial plane. Two of them are equipped with optical systems going through two low temperature LN₂ shields that focus the radiation making them suitable for spectroscopy experiments. To load inside the cryostat the DAC cell necessary to apply the pressure, a long vertical ‘sample-holder insert’ with a x-y-z- Θ micro-position movements has been designed. The latter ends with a complex sapphire sample-holder where in addition to the DAC a superconducting miniaturized micro-SQUID gradiometer is hosted.



Figure 1: Photographs of cryostat (left), LN₂ shields, LHe vessel (center) and of the 8 T superconducting magnet (right) with the radial ports and the cold finger on the bottom.

2.1 Cryostat e magnet

The cryostat (Fig.1, left) has been designed in cooperation with the DG-Technology Service (Parma, Italy). It is a compact device made by an a-magnetic stainless steel cylindrical vacuum vessel of radius ~ 40 cm and ~ 1 m high with a nose at the bottom. Inside there are two shields working at the liquid nitrogen temperature with four access ports for optical experiments (Fig.1, center). In the core an internal liquid helium (LHe) reservoir (Fig. 1 center) hosts the 8 T superconducting split coil magnet (Fig.1, right) manufactured by American Magnetics Inc. (AMI). The characteristics of the magnet are: a) maximum field 8T, b) axial clear bore 68.6 mm, radial clear bore 53.3 mm. The vessel (Fig. 2) has four radial and one vertical flange sealed by indium wires. An internal top cover on the LHe core separates the latter region from the vacuum (Fig. 3). We show in Fig. 3 also the electrical leadthrough of the magnet with controls and temperature contacts. A vertical port is also necessary to insert the ‘sample-holder’ device with the DAC and the magnetometer. It is designed to perform a static sample cooling via a cold finger placed on its bottom. The insert is loaded through a load-lock port (Fig. 4) on the top cover of the cryostat (Fig. 5).

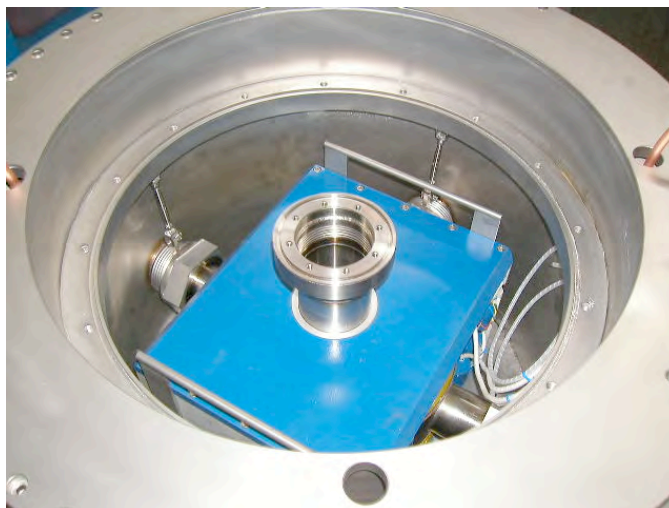


Figure 2: Photograph of the magnet sets inside the cryostat.



Figure 3: internal top cover to separated LHe vessel from vacuum zone

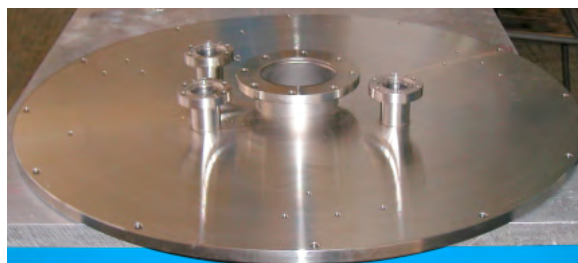


Figure 4: external load lock insert and valve. **Figure 5:** top cover with the load-lock flange.

The cryostat may allow concurrent magneto-optics experiments thanks to two thin-wedged diamond windows of 15 mm of diameter set along the light path, transmitting light from the visible down to the far-IR range. The system is designed with the magnetic field perpendicular to the light propagation vector (Voigt geometry) (Fig. 6).

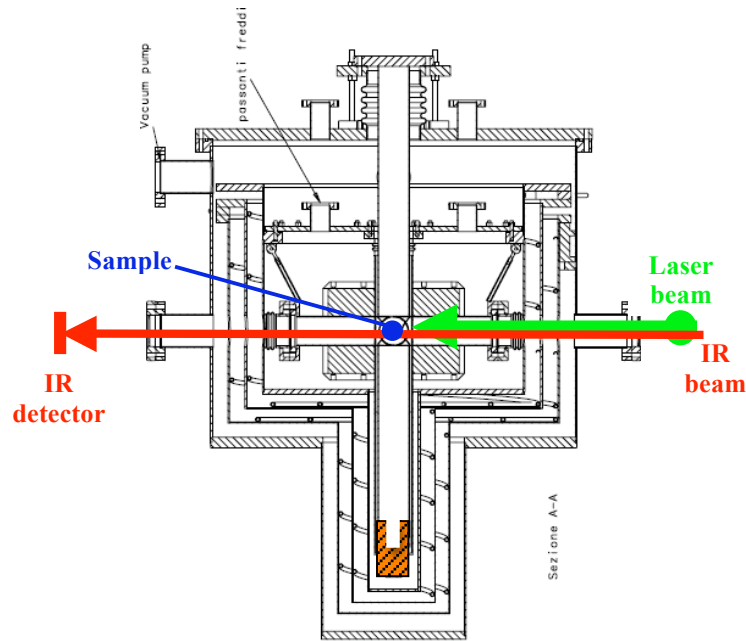


Figure 6: Layout of the central section of the cryostat with the two main optical ports. The red arrow indicates the IR light path. The system can be used also for Raman experiments (green path).

The cryostat cooling exhibits a large thermal inertia. Experimental tests indicate that in stable conditions the system may remain at low temperature for more than five days without He refilling. Performances are fully compatible with the requirements of magnetic and IR optical experiments with IRSR at the SINBAD beamline at DAΦNE.

2.2 Sample insert

The sample holder insert, showed disassembled in Fig. 7 (left panel), is the heart of the PRESS-MAG-O system. It can be divided in two main sections: an upper movable part that enters a fixed lower part, both containing important components. A load-lock system installed with a vacuum flange on the upper cover of the cryostat (Fig. 4, 5) allows safely inserting and extracting the system inside the cryostat. The valve guarantees the vacuum of the vessel during the sample loading procedure (Fig. 4 and 6 central panel).



Figure 7: Photographs of the insert disassembled. The two main components (left), the long bellow for the vertical motion (central) and the X-Y- Θ stage (right).



Figure 8: Photographs of the internal sample-holder with the DAC (left), the spring crown for the cold contact (left) and the external fixed part (right).

The upper part of the holder with its X-Y- Θ control (Fig. 7 right panel) with its micrometer accuracy will be used to align the radiation path to the sample loaded inside the DAC. The sample is actually loaded inside a gasket with a maximum internal hole diameter of $\sim 400 \mu\text{m}$ that has to be set at the best at the center of the DC magnetic field of the superconducting magnet. The sample holder with the DAC is fixed with screws at the bottom of the upper part insert (Fig. 8 left and Fig. 9 left). Specially designed Cu-Be springs (Fig. 8 left and Fig. 9 left) will guarantee the cold contact with the external fixed part via the cold finger at the bottom of the cryostat (Fig. 6, bottom in orange color).

2.3 Sample-holder

The sample-holder is shaped with some breaks and contains:

- 1) DAC and the slider to insert the micro-gradiometer coils inside the DAC as close as possible to the diamond anvils (Fig. 9 left);
- 2) the excitation coils (Fig. 9 right) placed on top and on the bottom of the holder.



Figure 9: Photographs of the Cu-Be sample holder, the cold contact spring crown, the DAC and the slider (left) and the excitation coil (right)

The gradiometer, connected by a flexible superconducting wire to the SQUID, is in thermal contact with the external fixed part of the insert and the ac drive coil placed around the DAC. Thanks to a magnetic Nb_3Sn shield cylinder, the external fixed part of the insert has been designed to host the SQUID in a region of low magnetic field (100 G) at the bottom section. The read-out of the ac signals from the SQUID electronics will be performed by a multi-harmonic lock-in.

After technical evaluations and tests with the ac magnetic field produced by the excitation coils, the original Cu-Be sample-holder has been manufactured from a unique sapphire crystal. This material exhibits a high thermal conductivity but is an electrical insulator. This new DAC holder (Fig. 10) allows minimizing the ‘Foucault current’ losses inside the bulk Cu-Be material still maintaining a good thermal contact. In fact, although it was designed with a particular shape, due to Foucault losses the previous Cu-Be system dissipated about 80% of the magnetic signal. The final solution is much more efficient, and during tests we performed the intensity values of the sinusoidal field in this new holder goes from 1 to 20 Gauss at the sample position inside the DAC cell (Fig. 11).



Figure 10: Lateral views of the sapphire sample-holder showing the DAC break (left) and the slider break (central). Top view on the right.

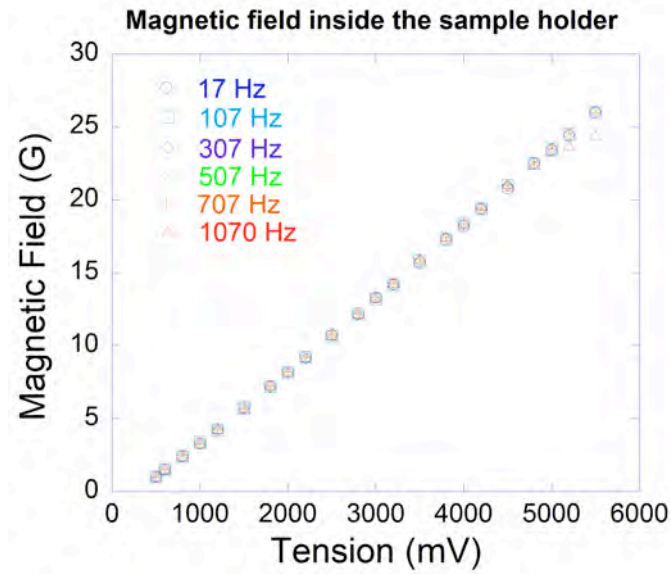


Figure 11: The magnetic field inside the sapphire sample-holder vs. the applied voltage.

We also manufactured several PEEK parts properly shaped to fix the DAC and match the breaks with the slider and with other components of the sample-holder (Fig. 12). Moreover they are also used to fix the holder at the end of the upper part of the insert (Fig. 8 right).

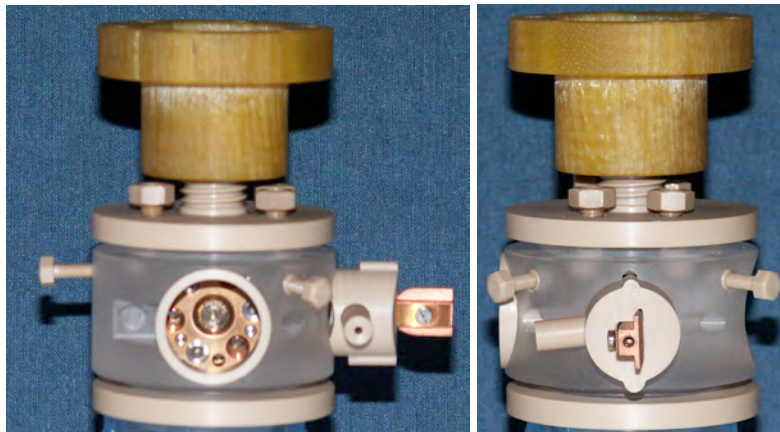


Figure 12: Side views of the sapphire DAC-holder with all PEEK components: the DAC (left) and the slider side (right).

Furthermore, we also manufactured a PEEK made DAC-holder (Fig. 13 right) to be used with a different first derivative gradiometer (Fig. 13 left) working at higher temperature. Tests are in progress and the first results are very promising.



Figure 13: The first derivative PEEK gradiometer prototype (left); Different views of the PEEK DAC-holder (right).

2.4 DAC cell

To apply pressure to the sample we also manufactured a compact DAC cell⁶⁾. To reduce unwanted magnetic contribution capable to mask the response of the small samples under investigation pressed between the anvils, the cell has been manufactured using a non-magnetic 2% Be–Cu alloy⁷⁾ and other a-magnetic materials. In more details, it is composed by two Cu–Be disks and titanium screws allowing to work to pressures in the GPa range (Fig. 14 left), two brilliant cut diamonds of type IIa necessary to perform experiments in the IR range⁸⁾ (Fig. 14, centre) and two SiC- δ cylinders with a manufactured 400 μm conic hole in the centre (Fig. 14, right). This latter material, named moissanite⁹⁾ is very hard (Mohs = 9,25) but less than the diamond (Mohs = 10) and it is characterized by a low magnetic response. The moissanite is set between the Cu–Be disks and the anvils (Fig.14, right). A complete DAC mounted is shown in Figure 15.



Figure 14: The Cu–Be disks of the DAC with its Ti screws (left), the two diamonds (centre), a moissanite (SiC- δ) cylinder with its 400 μm conic hole (right).

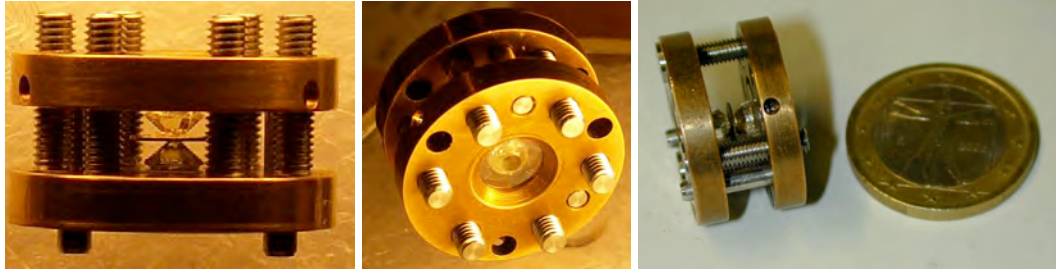


Figure 15: Three different views of a-magnetic Cu-Be DAC cell with the loaded sample.

2.5 Ac exciting coil and V-I Modulator

The ac exciting coil Helmholtz like (Fig. 9 right) has been designed for the specific geometric break of the sample-holder to give on the loaded sample inside the DAC an exciting sinusoidal magnetic field of amplitude from 1 to 20 Gauss in the frequency range 10 Hz -1 KHz. The Cu wire used has a thickness of 0.315 mm. The magnetic amplitude and the configuration have been studied using the OPERA 3D simulation (Fig. 16 left and center).

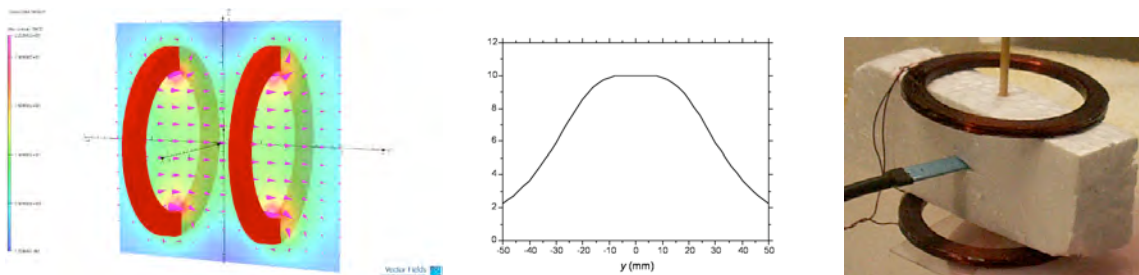


Figure 16: The magnetic field configuration on the y-axis (left); the amplitude homogeneity at the centre of the sample holder (center) and the exciting coil realized under magnetic test with Hall probe (right).

We performed tests measuring with a Hall probe the magnetic field amplitude generated by the exciting coil (Fig. 16 right) supplied by a V-I modulator realized by the LNF electronic service. The latter converts the sinusoidal signal from a pulse generator into a sinusoidal current. The modulator has two power supplies ± 15 V in switching technology, the input signal with a maximum amplitude 10 V / 50 Ω . The maximum working frequency is 1 KHz and the maximum loaded current is 1.8 A.

2.6 The ac-gradiometer and the SQUID

A challenging issue of any magnetic measurement inside a DAC is the extremely small sample volume (10^{-5} - 10^{-7} cm³) with very poor filling factors of the detection coils¹⁰. To improve the magnetic sample response respect to background signal, an original high sensitive micro-gradiometer coupled to the SQUID¹¹) (Fig. 17) has been designed from SUPRACON (Jena, Germany). The geometrical configuration developed it has been optimized to match the DAC to be as near as possible to the gasket pressed by the two diamonds. In this way the sample loaded in the DAC is set between the two pick-up coils.

The micro-gradiometer sensor is made by two Nb-Ti thin coils in a Cu matrix (0.05 mm of diameter), realized by a photolithography technique on a mono-crystal silicon wafer. Each

coil of the gradiometer has 8 turns with an external diameter of 2 mm and an internal of 1.6 mm. The wires to the pickup coil are twisted and embedded in a bundle of five Cu wires (0.1 mm of diameter). The pickup coils and the Cu wires are glued to the Si chip patterned as a fork (Fig.17 left) to insert them between the two anvils (Fig.15 left).

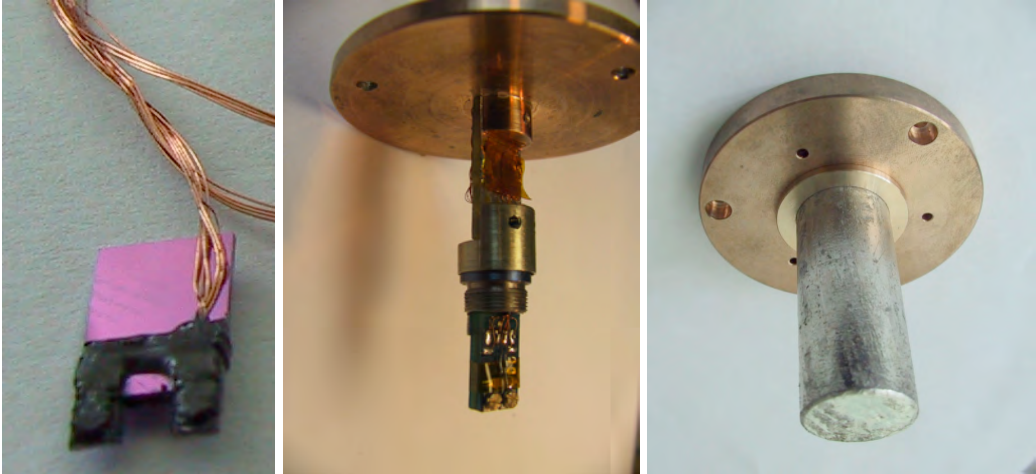


Figure 17: The micro-gradiometers (left), the SQUID system (center) and the Nb₃Sn shield (right).

The chip with a thickness of 0.35 mm is coated by a SiN film ~ 0.8 μm thick (necessary to produce a lithographic etching). The Stycast 2850 FT glue with some special additives was used to glue components. The Cu wires ensuring the good thermal contact of the NbTi wires with the He bath, are soldered to the PCB SQUID holder (Fig.18).

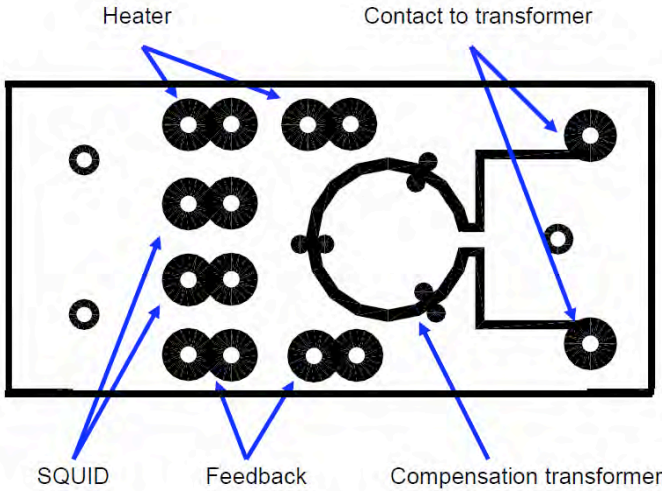


Figure 18: The layout of the PCB SQUID holder

Besides that, in the middle of the bundle a loop guarantees the thermal contact with the cold finger. The Cu wires have no electrical contact with the pickup circuit. The current sensor SQUID (Model CE1blue) is mounted on the PCB holder inside the set of the superconducting shields. The SQUID has an equivalent input noise level better than 1.5 pA/sqrt (Hz). It has

also integrated feedback coils on the chip. On the PCB holder there are contact pads to solder wires to the SQUID and to a compensation transformer. Due to a non-perfect gradiometer balance, the latter is supposed to be used to compensate the parasitic signal in the pickup circuit. The transformer has one turn in Cu wire covered by Pb-Sn solders and two turns of a Nb-Ti wire connected in series with the pickup coils.

The SQUID leads and compensation transformer are made by twisted pairs of Cu wires. The wires are soldered to the PCB and to the plate and fixed with a thin glue layer to the insert to have a good heat sink, in order to ensure the constant low temperature maintenance of the SQUID system. A scheme of the heat sink and its mounting on the insert is shown in Figure 19.

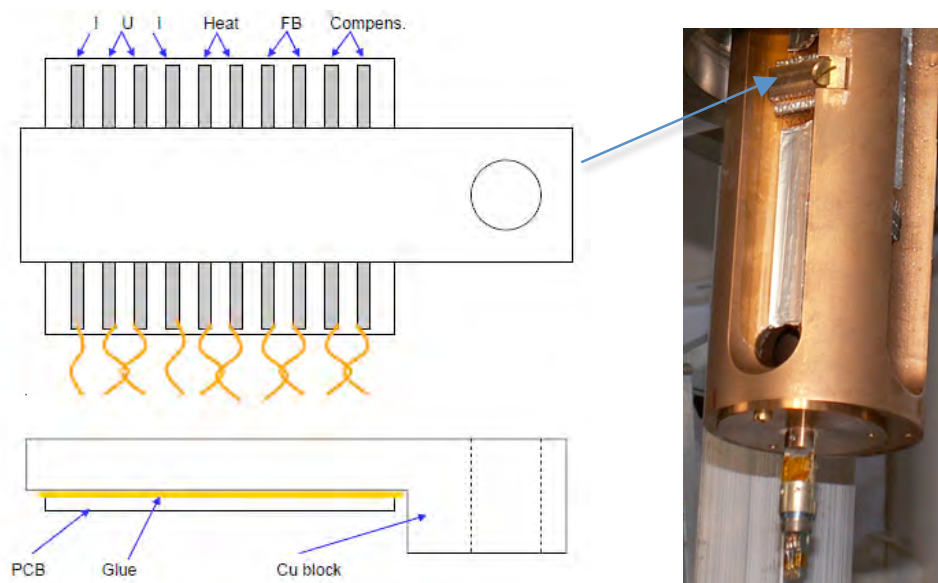


Figure 19: Layout of the heat sink of the SQUID system (left), the mounting on the insert (right).

Moreover the SQUID system (Fig. 17 center) has a Nb_3Sn shield (Fig. 17 right) to reduce to less than 100 Gauss, the background magnetic field (>1 T) when the superconducting magnet is at 8 T, its maximum value. This complex Nb- Nb_3Sn shield has three layers. Its performance has been measured with a superconducting solenoid in liquid He. For tests a current sensor SQUID was mounted inside the shield and the SQUID flux-voltage characteristics were monitored while the magnetic field increased at the rate of ~ 0.5 T/min. No change in the SQUID characteristics was detected up to 850 mT.

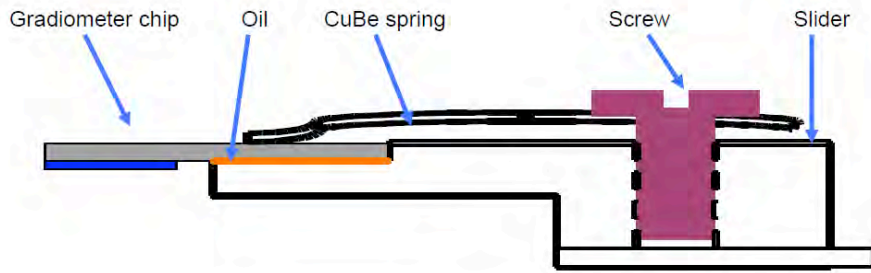


Figure 20: Gradiometer chip assembled on the slider

The gradiometer works inside the DAC, near the anvils, and it is driven to the position by a slider through a break manufactured on the sample holder (Fig. 12, right). An example of the gradiometer coil assembly on the slider is shown in Fig. 20.

3 EXPERIMENTAL TESTS ON THE SQUID GRADIOMETER

We also test the SQUID gradiometer operation. Several measurements have been performed on the system at 4.2 K with a superconductor sample (i.e. an YBCO sample of dimension $\sim 0,16 \text{ mm}^3$) loaded in the DAC cell mounted on the insert as in a real situation. To remove unwanted noises caused by interferences of RF signals we have to shield all cables with Al foils and use standard ferrite RF filters.

Using the exciting coil of the insert we generated an AC field at the frequency of 22.7 Hz in the mGauss amplitude range. The persistent current in the gradiometer coils induces a flux in the SQUID whose amplitude depends by the exciting field. Tests confirmed the proper SQUID operation. As an example, in Fig. 21 we show the SQUID response in the RESET mode for two different amplitudes of the exciting field (0.26 Gauss and 0.78 Gauss).

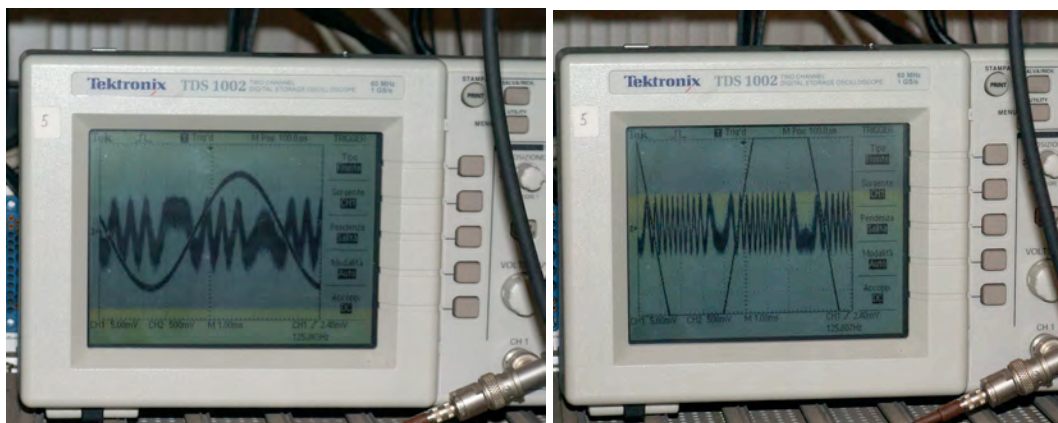


Figure 21: (left image) the generator at 26 mV (0.26 Gauss) induces 4 flux quanta while (right image) at 78 mV (0.78 Gauss) we measure 11 flux quanta.

4 SAMPLE TEMPERATURE CONTROL TESTS

To control and tune accurately the sample temperature inside the DAC, we considered two possible configurations. In the first an external laser beam¹²⁾ coupled to an optical waveguide has been set up. The results of the tests performed on the DAC cell at liquid nitrogen temperature using the cold finger (Fig. 22), confirm the feasibility of an *in situ* heating procedure with a commercial laser of 3 W ($\lambda = 532$ nm). Figure 22 shows that the temperature at the sample position measured by the thermometer 1 changes while the temperature of the gradiometer is almost constant thanks to the thermal shield made by Teflon and to a thermal short through a copper sock with the cold finger [see the behavior of the thermometer 2].

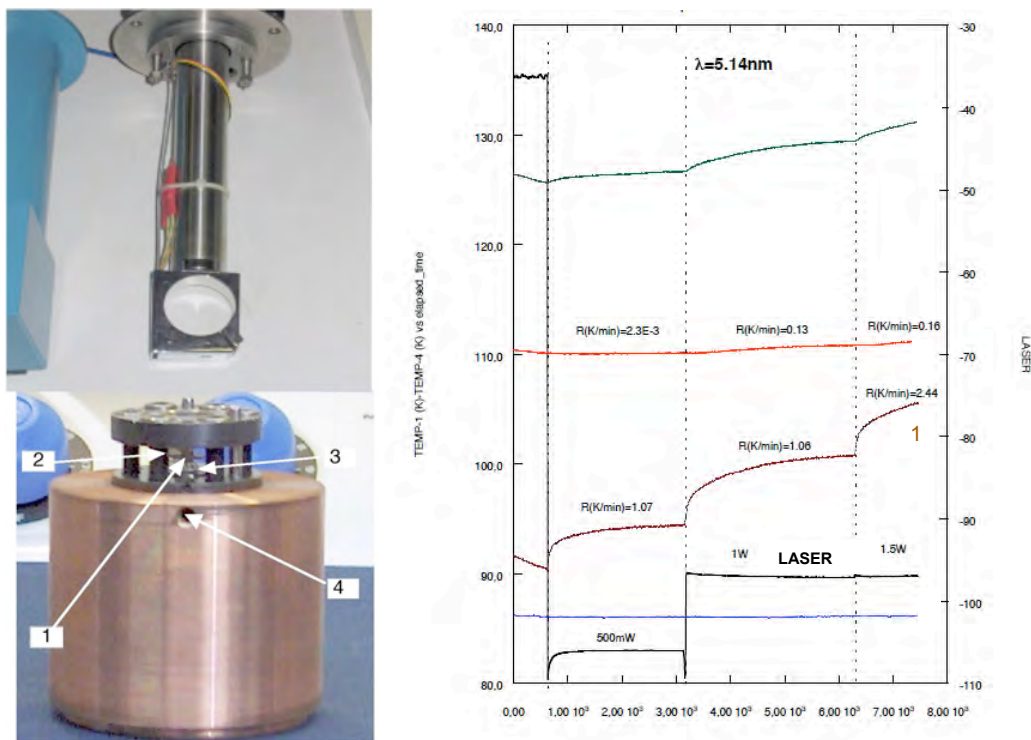


Figure 22: Photos of the cold finger and of the temperature control (left). The experimental temperature behavior vs. time (right). The thermometers inside the DAC cell are located on the diamond near the sample (1), on the DAC gasket (at the gradiometer position) (2), on the anvil table (3) and on the cold finger (4).

In the second set-up, we are developing in cooperation with the INFN section of Florence and the Diamond material GmbH, an anvil integrated heating system based on resistive lines¹³⁾ directly patterned on the diamond anvils. At present, to characterize the properties of these micro-devices we patterned lines on diamond slabs as showed in Fig. 23. A full morphological and structural characterization of resistive lines (for more details see Fig. 24) is under way using the Focused Ion Beam (FIB) of the LIME laboratory of the University of Roma Tre. Preliminary results regarding the morphology of these resistive lines obtained using a laser source are extremely positive and indicate that micro-devices compatible with the geometry of the diamond anvils can be realized. To identify the materials patterned on the diamond slabs (Fig. 23D), micro-Raman measurements on the resistive lines have been performed at the

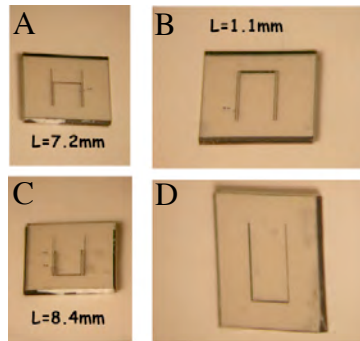


Figure 23: Some simple layouts of resistive patterns realized on CVD diamond slabs.

The area probed by the system was $\sim 1 \mu\text{m}^2$ with an estimated thickness $< 20 \mu\text{m}$. We measured different points around one corner of one of the patterns showed in Fig. 23D while in Fig. 24 we present two magnified images with details characteristics of these amorphous carbon based patterns. The comparison among Raman spectra, showed in Figure 25, clearly points out the presence of both a carbon glass phase and a nano-crystalline diamond phase¹⁴⁾.

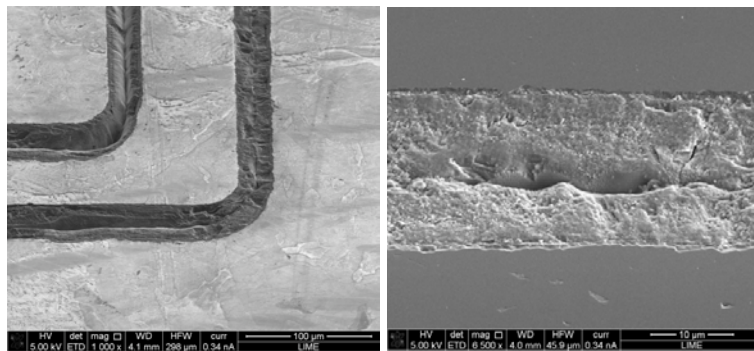


Figure 24: FIB/SEM images of the laser patterned lines on a diamond slab. View of two corners of resistive lines (left); a detail at higher magnification of one line (right).

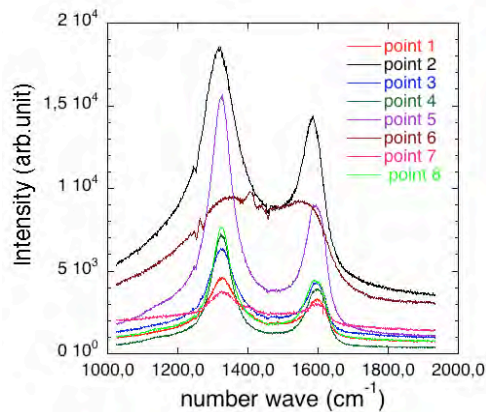


Figure 25: Comparison of Raman spectra collected on different points around one of the corner showed in Fig. 23D and 24.

In particular, it has been verified the heating with of the tests of the resistive patterns using a four contacts technique, by a Cu sample-holder inserted in a liquid helium cryostat, these experiments have been performed at the LNF. Either experimental test at room temperature and at low temperature point out that with a proper pattern these lines can be used to design a micro-heater. We show in Fig. 26 the result obtained by a resistive pattern exhibiting a stable temperature plateau at each successive increase of the applied power.

In principle, the same device could 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 CGR¹⁵⁾ (Fig. 27). Further work is in progress to manufacture a reliable thermal device based on these patterns. At the same time is in progress an attempt to manufacture more accurate patterns realized with the FIB source of the LIME laboratory at the University of Roma Tre instead of the laser. This approach appears more suitable to achieve more accurate pattern design.

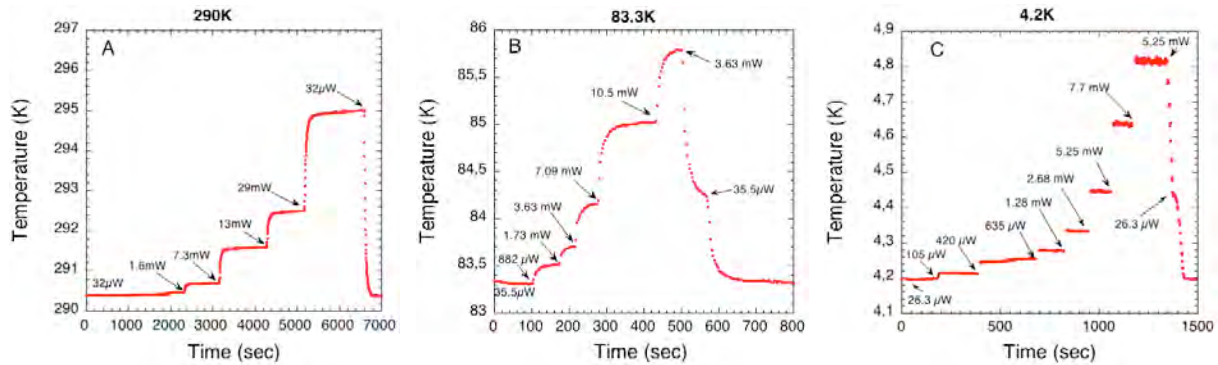


Figure 26: The temperature dependence of one of the amorphous carbon line measured in a thermal bath at 290 K (A), 83.3 K (B) and 4.2 K (C) vs. the applied power.

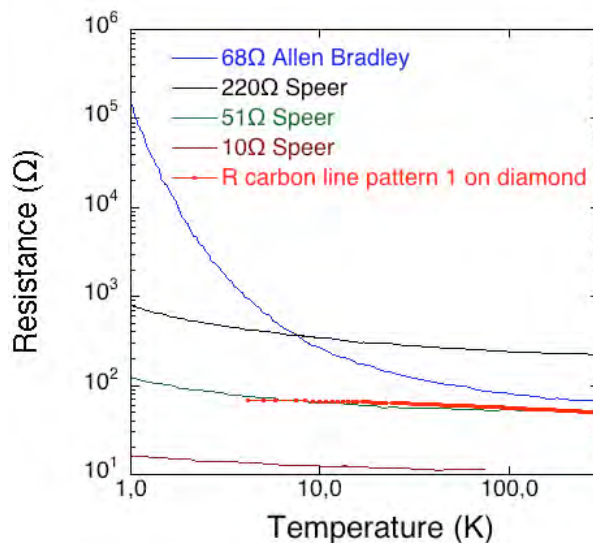


Figure 27: Comparison of the R-T curve of the amorphous carbon line showed in fig. 23D with those of commercial thermometers.

5 PRESS-MAG-O OPTICS

As outlined in the introduction PRESS-MAG-O has been designed to perform also optical experiments such as FTIR spectroscopy in transmission or reflection modes and Raman spectroscopy. This instrument, one time commissioned, could be installed at SINBAD (Synchrotron Infrared Beamline At DAΦNE), the first Italian IR beamline operational at the INFN, National Laboratories of Frascati, since 2001³⁾. A brilliant IR synchrotron radiation source such as SINBAD is ideal to perform high-pressure experiments on small samples inside a DAC. This is particularly true at DAΦNE (Double Annular Φ -factory for Nice Experiments), the Frascati electron-positron collider working in topping up mode at an energy of 0.51 GeV per beam with a maximum beam current $> 2 \text{ A}$ ¹⁶⁾. SINBAD has been designed to work at IR wavelengths from about 10 up to 10000 cm^{-1} and operates with a customized BRUKER Equinox 55 interferometer working in vacuum coupled to a BRUKER Hyperion 3000 microscope. In more detail, at SINBAD the collimated beam coming out from the interferometer will match the PRESS-MAG-O setup thanks to a focusing optical system designed to for the DAC dimension. The radiation will hit the loaded sample going trough one of the four lateral ports equipped with optical transmitting windows. Different windows can be installed in the system: a CVD diamond window with ~ 1 deg of wedge is the option selected to cover the widest IR range down to the far-IR domain⁸⁾.

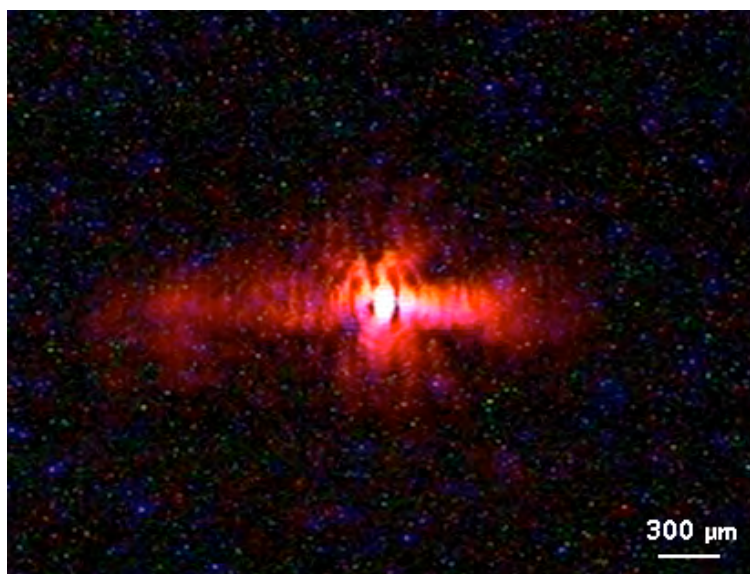


Figure 28: Image test of the focal spot produced by the Cassegrain optical system using a horizontal collimated illumination. A similar image is obtained for the vertical focus. The observed spot has a diameter $< 300 \mu\text{m}$.

To match the geometrical conditions of the cryostat and fit inside the small dimension of the DAC in cooperation with the CNR-INOA (Florence) we designed and built a Cassegrain concentrator to focus the synchrotron radiation¹⁷⁾ (Fig. 28).

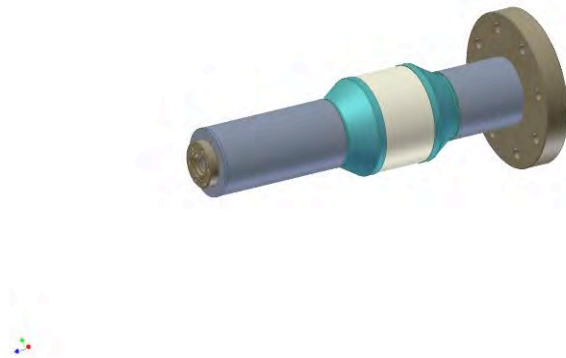


Figure 29: 3D-view of the steel tube and the ceramic break necessary to the cryogenic system.

The diameter of the Airy disk of the focal spot of this optical system is $\sim 200 \mu\text{m}$ at the shortest wavelength. Actually, the wavelength range of this mirrors based collector goes from the visible down to $\sim 50 \mu\text{m}$. The entrance beam diameter is $\sim 30 \text{ mm}$ and the entire optical system, i.e., 2 mirrors, is placed inside a stainless steel tube (Fig. 29, 30), with the optical axis coincident with the axis of the tube. At the end of the tube an optical window 16 mm of diameter is present.



Figure 30: View of the different mechanical components of one of the two concentrators.

The ray-tracing analysis of this Cassegrain telescope with a 3.8% central obstruction is showed in Fig. 31. The opto-mechanical parameters of the system are summarized in Tab. 1 and Tab. 2.

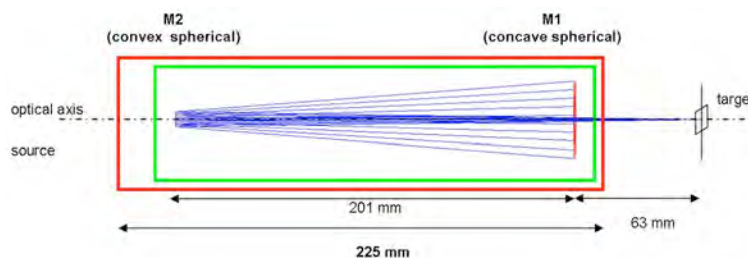


Figure 30: Layout of the Cassegrain optics designed for the optical line of the cryostat.

The efficiency of this optics is determined by its performances, i.e., the mirrors reflectivity ($R = 0.95$) and the obstruction coefficient that reduces the source area only by 3.8 %. For IR transmission experiments, the beam will exit through a second window placed on the opposite lateral port and then will be focused to the detector position by a symmetrical Cassegrain lens.

Table 1: The main parameters of the optical systems

Wavelength range (micron)	2.5-50
Source collimated max diameter (mm)	40
System length available (mm)	225/325
Window thickness (micron)	500
Window clear aperture diameter (mm)	15
Distance window-target (mm)	39
Optical Tube dimension (mm)	225/325

For Raman experiments always using a DAC cell³⁾ or measurements performed in the reflection geometry, as in a microscope optical layout, the beam will be collected by half of the Cassegrain optics used for the incoming beam in the transmission geometry.

Table 2: Optical parameter to match the system requirements

f /#	33.7
Diameter Mirror M1 (mm)	40
Thickness Mirror M1 (mm)	6.7
Curvature radius concave M1(mm)	500
Diameter Mirror M2 (mm)	7.8
Thickness Mirror M2 (mm)	1.3
Curvature radius convex M2(mm)	119.94
Distance Window-M2 (mm)	5
Distance Center M1-M2 (mm)	201
Distance Center M2-target (mm)	264.8
Obstruction factor (R_2^2/R_1^2) %	3.8
Diameter Mirror M1 (mm)	40
Global efficiency (collector) %	86.5

6 CONCLUSIONS

When commissioned, PRESS-MAG-O, will represent a unique device equipped with an ultra-sensitive AC micro-gradiometer capable to probe the magnetic response of small samples such those contained inside a Cu-Be DAC. This extremely versatile instrument will cover a wide range of dc magnetic field (≤ 8 T), temperature (4.2 – 200 K) and pressure (0 – 20 GPa), allowing concurrent or simultaneous spectroscopic experiments (FTIR or Raman) and ac magnetic multi-harmonic susceptibility measurements (10 Hz – 20 KHz). Both magneto-optical experiments vs. pressure and vs. magnetic field in a dc magnetic field will be possible using the IR synchrotron radiation available at SINBAD, the beamline operational at Frascati or eventually at other large infrastructures where a device of this dimensions can also operate.

An instrument like PRESS-MAG-O could be extremely useful also to characterize materials for technological applications such as superconductor wires and tapes for applications in high-energy accelerators. Indeed, recently have been introduced the cold high pressure

densification (CHPD) method, a new approach to enhance the critical current density of *in situ* MgB₂ wires at 4.2 and 20 K at fields between 5 and 14 T¹⁸). The development of optimized wires and tapes for industrial and demanding research applications is certainly one of the major issue of the next years.

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