Finanziato dall'Unione europea NextGenerationEU
Ministero dell'Università e della Ricerca
Italiadomani
Università degli Studi di Napoli Federico II

National Quantum Science and Technology Institute
Missione 4, Componente 2, Investimento 1.3 – Spoke 5
Codice progetto MUR PE00000023 – CUP UNINA E63C22002190007

Università degli Studi di Napoli Federico II - Dipartimento di Fisica "Ettore Pancini"

OPEN PROCEDURE WITH APPLICATION OF THE CRITERION OF THE MOST ECONOMICALLY ADVANTAGEOUS OFFER IDENTIFIED ON THE BASIS OF THE BEST QUALITY/PRICE RATIO, PURSUANT TO ARTICLES 71 AND 108 OF LEGISLATIVE DECREE NO. 36/2023 AND SUCH AMENDMENTS, IN TWO LOTS HAVING AS ITS OBJECT THE SUPPLY OF CRYOSTASTS FOR THE CHARACTERISATION OF SUPERCONDUCTING QUANTUM DEVICES FOR THE NQSTI PROJECT IN THE UNIVERSITY CAMPUS OF MONTE SANT'ANGELO, NAPLES

TECHNICAL SPECIFICATIONS RELATING TO THE COMPETITION IN TWO LOTS FOR THE AWARDING OF A CONTRACT HAVING AS ITS OBJECT THE SUPPLY OF CRYOSTATS FOR THE CHARACTERISATION OF SUPERCONDUCTING QUANTUM DEVICES FOR THE NQSTI PROJECT

Premise

The intervention in question concerns the purchase of high-tech scientific equipment that will be part of the equipment of the quantum computation and characterization of quantum superconductive devices laboratory of the Department of Physics "Ettore Pancini" of the University of Naples Federico II, and will be used for the cooling of superconducting quantum bits and their characterization at cryogenic temperatures.

This document, attached to the purchase request by the referents for the definition of the technical characteristics, is intended to define the technical-functional characteristics suitable for satisfying the needs of the Department.

The instrumentation and materials to be supplied must be free of defects, new and original in all their parts and/or components, of the latest generation, complete with all the accessories necessary for the correct functioning of the equipment, as detailed below for each lot.

Used instruments, even in "refurbished" or ex-demo conditions, cannot be offered in the tender.

The elements described represent the minimum required configuration of the Object to which the Offeror must comply in its offer. The listed characteristics must be present simultaneously for the requested configuration. Failure to comply with one or more parameters will lead to the exclusion of the offer from the tender. The required characteristics must be demonstrated in a technical report, produced by the economic operator, which must also contain the detailed description of the offered instrumentation.

LOT n. 1

Lot No. 1 concerns the purchase of a dilution cryostat with a base temperature of approximately 10 mK and a cooling power of approximately 400 microW at around 100 mK, to ensure the cooling and operation of superconducting quantum bits, briefly defined as "Dilution cryostat with a base temperature of approximately 10 mK and a cooling power of 400 microW at a temperature of 100 mK".

The following services must be an integral part of the requested supply:

- Transport, delivery, installation, commissioning of the instrument and verification of conformity.
- Warranty service, assistance and a preventive maintenance plan included in the standard 36-month warranty period.
- Training of personnel in the use of the acquired instrumentation for a minimum duration of 2 days.

Technical and functional characteristics of lot no. 1: Dilution cryostat

Specifications:

Dilution refrigerator (DR) insert. Cryogen-free dilution refrigerator system, including 1x pulse tube cryocooler PTR, bellows dampening and integrated nitrogen heat pipes for fast cool down.

Base temperature <10 mK for basic system;
Cooling power > 10 μW at 20 mK;
Cooling power > 400 μW at 100 mK;
Cooling power > 550 μW at 120 mK;
Data measured on experimental flange away from mixing chamber;
Full cool-down time from room temperature to base temperature < 36 hours.

Sample space (bottom of the MXC Flange): experimental space beneath the Mixing Chamber Flange without a magnet at least of 280 mm in diameter and 500 mm in height.

System Voltage: Control Unit with temperature readout and control electronics 220 V, 50 Hz. Single phase power for Gas Handling System and Control Unit. Standalone Control Unit. Pulse Tube Cryocooler PTR Voltage: 380/415V 50Hz.

Helium gas monitoring system (Gas Handling System), vacuum tubes and interconnected pumping lines (built according to the layout of the quantum computing laboratory).

18 liters Helium-3, Helium-3–helium-4 mixture for optimal cryostat performance.

Standard frame: System support frame adapted to dilution refrigerator

3-section Vacuum Can: Vacuum enclosure and radiation shield assembly. Lightweight radiation shields and vacuum enclosure easy to handle by maximum two persons without any lifting tools or a crane.

Pulse Tube Cryocooler with compressors
The Pulse Tube Cryocooler with a remote motor should provide the cryogenic cooling power of the dilution refrigerator measurement system without the need for liquid cryogens. Specifically, it should pre-cools components of the dilution refrigerator insert to ~50 kelvin and ~3 kelvin through integrated

heat switches, it should cool down the radiation shields of the cryostat during operation, provide two stages of pre-cooling for the circulated helium-3 gas as it returns to the cryostat, and should provide additional cooling power to heat sink experimental wiring. Although the Pulse Tube Cryocooler must be in good thermal contact with the cryostat and radiation shields, it is requested that the Pulse Tube Cryocooler must also be mechanically well decoupled from them to make sure low vibration levels. Mechanical isolation of Pulse Tube Cold Heads: the motors of the compressors pulse tubes should be mounted remotely from the Cold Head to reduce mechanical vibrations and electromagnetic interference.

Pumps:
All pumps and the mixture compressor in the Gas Handling System should be oil-free to prevent the mixture contamination. The compressor for the mixture circulation shouldn't be of membrane-type, so there is no risk of rupture leading to mixture loss or contamination and should be only in use during condensation of the mixture.

Circulation of the mixture: Scroll Pump, 580 l/min 1-phase, 0.6 kW (approx.), air cooled; **2x Turbo Pumps in parallel, together 1500 l/s** 1-phase, 0.5 kW (approx.) per pump, water cooled: 1.7 LPM at 15–30°C, per pump. **Scroll Pump, 60 l/min (outlet > 2 bar, acts as compressor),** 1-phase, 0.25 kW (approx.), air cooled

Evacuating the cryostat: Scroll Pump, 120 l/min, 1-phase, 0.3 kW (approx.), air cooled; **Turbo Pump, 67 l/s**, 1-phase, 0.11 kW (approx.), air cooled. The turbo pump should be dedicated to the vacuum pumping.

Pulse tube: 1x PT415-RM or PT420-RM, 3-phase, 15 kW (max.), water-cooled with max. 20 LPM at 15–30°C.

It is requested to integrate the following features:
- Heat pipe for fast cool-down;
- Edge-welded bellow assembly for mounting pulse tube for reduced vibration amplitudes;
- Temperature Controller;
- 1x 4K Heater Kit: resistive heater at the 4K flange for faster warm-up, 40 W (10 Ohm, 2A max), all cabling and heat sinking, integrated with system control software;
- Cold traps: Long-life cold trap, additional internal cold trap;
- Frame Sound Isolation, which should enclose the top of the cryostat frame;
- Lab Layout Design Single installation layout design for 1 dilution cryostat system;
- MXC Shield, Au-plated Cylindrical shield for attaching to the MXC flange. Material: Au-plated copper;
- Packing ready for AIR/ROAD export;
- Variety of access ports between the Room Temperature and the Mixing Chamber Flange (MXC Flange), at least six line-of-sight (LOS) ports available for experimental wiring, while other ports are requested for system diagnostic wiring, for pumping the vacuum can, for accessing the helium-3 condensing line. At least four KF40 not LOS ports available for experimental wiring;
- It is requested that the Dilution Unit can be replaced without removing any of the experimental plates. It is requested the absence of soft solder joint in the dilution refrigerator cooling unit. It is requested that the Pulse Tube Cryocooler can be easily replaced without removing the Dilution Unit or any of the experimental plates;

- The cryostat should be electrically isolated from the pumping system by electrically insulating spacers, clamps, and centering rings inserted into a break in each pumping line close to the Gas Handling System;
- Commissioning: installation and first testing, including leak tests, full cool-down and a demonstration of the base temperature and cooling powers specified in the test report (typical temperatures 20 mK and 100 mK);
- Delivery according to delivery terms, including insurance.

Fully automated system:

- Cooldown from room to base temperature should be fully automated;
- It is requested that the system can be operated and controlled fully remotely. Also, complete manual operation and control of the system should be possible without a computer connection;
- It is requested automatic recovery to safe mode operation after power failure without the control computer. The system should be in a safe mode following a loss of power. In case of a long power failure, it is requested that the mixture naturally returns to the helium tanks through the system of overpressure valves.

Lifetime remote technical support.

System service and maintenance free for the first 3 years.

Experimental wiring

2x DC Installation Set:

- Set 1 KF40 flange 1x Fischer installed, RT breakout with 1x fischer connector;
- Set 2 KF40 flange 1x Fischer installed, RT breakout with 1x fischer connector.

DC Wiring:

- Shielded 12x low-ohmic twisted pairs from RT to MXC installed in KF40 port. Twisted pair experimental wiring (35 AWG copper) from room temperature connector box (24-pin FISCHER) to 4K flange. Twisted pair experimental wiring (NbTi/CuNi) from 4K flange to MXC flange (Micro-D). Electromagnetic shielding included. Additional anchoring to pulse tube and intermediate break-out at 4K and at the cold plate (100 mK) included.

Amplifier Wiring installed in port KF40: wiring for powering up to 4 Low Noise Amplifiers, including mounting parts

- 4x TWP wiring (35 AWG copper) from RT connector box (24-pin FISCHER) to 4K flange (nano-D)
- Bias cable for 1-4 Low Noise Amplifiers
- Nano-D Clamp 4 AU
- 2x mounting beam 80 mm AU
- 2x mounting bracket 86 mm AU
- 8x adapter AU
- 8x SMA-SMA coaxial assembly 50 Ohm Cu 2.19, 300mm

4x Isolator mounting bracket: isolators and circulators mounting parts

- 1x mounting beam 80mm AU 18
- 1x mounting bracket 86 mm AU
- 4x adapter AU
- 4x SMA-SMA coaxial assembly 500 Ohm Cu 2.19, 300mm

3x RF Installation Set for a total of 49x coaxial microwave lines SMA RT-4K. Installation set for 49x SMA lines from RT to 4K; vacuum flange with 49x hermetic SMA feed-throughs plus 3x aluminum and 3x gold thermal anchoring flanges with F/F SMA bulkheads for 50K and 4K stages.

3x RF Installation for a total of 49x coaxial microwave lines SMA 4K-MXC. Installation set for 49x SMA lines from 4K to MXC; gold plated copper thermal anchoring flanges with F/F SMA bulkheads for Still, Cold Plate and MXC.

19x Semi-rigid Coaxial Lines (18 GHz) installed on different LOS (line-of-sight):

- RT-4K: 0.86 mm SCuNi-CuNi (SMA)
- 4K-MXC: 0.86 mm NbTi-NbTi (SMA)
- Attenuator Value at 50 K = 0 dB, Attenuator Value at 4 K= 20 dB, Attenuator Value at Still = 0 dB, Attenuator Value at CP = 0 dB, Attenuator Value at MXC = 0 dB.

23x Semi-rigid Coaxial Lines (18 GHz) installed on different LOS (line-of-sight):

- RT-4K: 0.86 mm SCuNi-CuNi (SMA)
- 4K-MXC: 0.86 mm SCuNi-CuNi (SMA)
- Attenuator Value at 50 K = 0 dB, Attenuator Value at 4 K= 20 dB, Attenuator Value at Still = 0 dB, Attenuator Value at CP = 20 dB, Attenuator Value at MXC = 20 dB.

3x Semi-rigid Coaxial Lines (18 GHz) installed in one port KF40:

- RT-4K: 0.86 mm SCuNi-CuNi (SMA)
- 4K-MXC: 0.86 mm SCuNi-CuNi (SMA)
- Attenuator Value at 50 K = 0 dB, Attenuator Value at 4K= 20 dB, Attenuator Value at Still = 0 dB, Attenuator Value at CP = 0 dB, Attenuator Value at MXC = 20 dB.

4x Semi-rigid Coaxial Lines (18 GHz) installed in one port KF40:

- RT-4K: 2.19 mm SCuNi-CuNi (SMA)
- 4K-MXC: 0.86 mm SCuNi-CuNi (SMA)
- Attenuator Value at 50 K = 0 dB, Attenuator Value at 4 K= 20 dB, Attenuator Value at Still = 0 dB, Attenuator Value at CP = 20 dB, Attenuator Value at MXC = 20 dB.

Optical Fiber Installation Set installed in one port KF40. Optical fiber installation set comprising:

- RT break-out box
- Thermalization flanges at 50 K, 4 K, Still, CP and MXC stages
- MXC break-out.

M10 body FC/PC Hermetic feedthrough with Thorlab GIF50E installed in one port KF40

- Narrow key.
- Key aligned to slow axis.

M10 body FC/PC Hermetic feedthrough with Thorlab 780HP installed in one port KF40

- Narrow key.
- Key aligned to slow axis.

2x M10 body FC/PC Hermetic feedthrough with SMF28 installed in one port KF40

- Narrow key.
- Key aligned to slow axis.

Thorlab GIF50E fiber patchcord FC/PC-FC/PC- one strain relief. Lg: 1.5 m installed in one port KF40

- GIF50E fiber patchcord
- FC/PC-FC/PC
- One strain relief
- Length from RT - MXC: Lg = 150 cm (± 3 cm)
- Hytrel 900 µm jacket.
- Strain relief at MXC end

2x SMF28 singlemode fiber patchcord FC/PC-FC/PC- one strain relief. Lg: 1.5 m installed in one port KF40

- SM28 single mode fiber patchcord
- FC/PC-FC/PC
- One strain relief
- Length from RT - MXC: Lg = 150 cm (± 3 cm)
- Hytrel 900 µm jacket
- Strain relief at MXC end

Lead time: 7 months after order confirmation.

LOT n. 2

Lot no. 2 concerns the purchase of an evaporation cryostat with a base temperature of approximately 300 mK and a cooling power of approximately 50 microW at around 350 mK, to ensure the cooling and operation of superconducting devices, briefly defined as "Evaporation cryostat with a base temperature of approximately 300 mK and a cooling power of 50 microW at a temperature of 350 mK".

The following services must be an integral part of the requested supply:

- Transport, delivery, installation, commissioning of the instrument and verification of conformity.
- Warranty service, assistance and a preventive maintenance plan included in the standard 36-month warranty period.
- Training of personnel in the use of the acquired instrumentation for a minimum duration of 2 days.

Technical and functional characteristics of lot no. 2: Evaporation cryostat

Specifications:

Evaporation insert. Cryogen-free evaporation refrigerator system, including 1x pulse tube cryocooler PTR.
Base temperature ≤300 mK for more than 30 hours with no applied heat load;
Cooling power: ≤ 350 mK for more than 5 hours with 50 μW applied;
Temperature range: 300 mK to 300 K
Temperature stability: +/- 3 mK at 1.2 K; +/- 0.1 K above 1.2K

Sample space (bottom of the He3-pot plate): experimental space beneath the He3-pot at least of 30 mm in diameter and 250 mm in height. Insert diameter of at least 40 mm.

System Voltage: Control Unit with temperature readout and control electronics 220 V, 50 Hz. Single phase power for Manual Gas Handling System. Pulse Tube Cryocooler PTR Voltage: 380/415V 50Hz.

Gas management system and interconnected pumping lines (built according to the layout of the quantum computing laboratory)
Temperature controller for evaporation insert:

- Control of sample temperature from base temperature to 300 K
- Monitors all temperature sensors on independent channels
- Mains power cable
- Diagnostic connecting cables
- Removable rack mounting ears

3 liters Helium-3, for optimal cryostat performance with the following specifications:

- Chemical purity > 99.99 %
- Isotopic enrichment > 99.9 %

Pulse Tube Cryocooler with compressors
The Pulse Tube Cryocooler with a remote motor should provide the cryogenic cooling power of the refrigerator measurement system without the need for liquid cryogens. Although the Pulse Tube Cryocooler must be in good thermal contact with the cryostat and radiation shields, it is requested that the Pulse Tube Cryocooler must also be mechanically well decoupled from them to make sure low

vibration levels. Mechanical isolation of Pulse Tube Cold Heads: the motors of the compressor pulse tubes should be mounted remotely from the Cold Head to reduce mechanical vibrations and electromagnetic interference. Nominal second stage cooling power of 1.0 W at 4.2 K. Diagnostic thermometry: Cold head equipped with sensor on both the first and second stage.

Pulse tube: 3-phase, 15 kW (max.), water cooled with maximum 15 LPM at 15–30 °C.
Pumps: Manual gas handling system for the closed-loop cooling circuit, including:

- Manually operated valves,
- 10 m^3/hour oil-free circulation pump,
- helium gas storage tank with mechanical pressure gauge (tank supplied with helium charge),
- zeolite trap with integrated heater for regeneration.
- Pump and flush kit including scroll pump
- OVC-PUMP

Experimental wiring: Line of sight port configured with 24-way loom

- 12 off twisted pairs of constantan wired to the helium-3 pot
- 24 way Fischer connector at room temperature
- Mating Fischer connector
- Flying leads at helium-3 pot

It is requested to integrate the following features:

- Diagnostic wiring, at room temperature with 2 off 16 way Fischer connectors temperature sensors
- Calibrated Cernox thermometer on the helium-3 pot
- Calibrated Ruthenium Oxide sensor
- Basic system spares kit and toolbox
- Lab Layout Design - Single installation layout design for 1 evaporation cryostat system;
- Packing ready for AIR/ROAD export;
- The cryostat should be electrically isolated from the pumping system by electrically insulating spacers, clamps, and centering rings inserted into a break in each pumping line close to the Gas Handling System;
- Commissioning: installation and first testing, including leak tests, full cool-down and a demonstration of the base temperature and cooling powers specified in the test report;
- Delivery according to the delivery terms, including insurance.

Fully automated system:

- Cooldown from room to base temperature should be fully automated;
- It is requested that the system can be operated and controlled fully remotely. Remote control and monitoring software should be available for download. Also, complete manual operation and control of the system should be possible without a computer connection. Operators manuals

Lifetime remote technical support.

System service and maintenance free for the first 3 years.

Lead time: 7 months after order confirmation.