

Centro Nazionale HPC, Big Data e Quantum Computing

Missione 4, Componente 2, Investimento 1.4

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UNIVERSITÀ DEGLI STUDI DI NAPOLI FEDERICO II - DIPARTIMENTO DI

FISICA "ETTORE PANCINI"

Dilution cryostat

Specifications:

Dilution refrigerator (DR) insert. Cryogen-free dilution refrigerator system, including 2x pulse tube cryocooler, bellows dampening and integrated nitrogen heat pipes for fast cool down.

Base temperature <10 mK (7 mK expected) for basic system;

Cooling power > 30 μ W at 20mK;

Cooling power > 1000 μ W at 100mK;

Cooling power > 1400 μ W at 120 mK;

Data measured on experimental flange away from mixing chamber;

Full cool-down time from room temperature to base temperature < 48 hours.

Sample space (bottom of the MXC Flange): experimental space beneath the Mixing Chamber Flange without a magnet of about 500 mm in diameter and at least 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 or vacuum Gas Handling System and interconnecting pumping lines (custom rigid still pumping line made according to customer lab layout)

40 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 cryogenes. Specifically, it should pre-cools components of the dilution refrigerator insert to \sim 50 kelvin and \sim 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; **3x 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: 2x PT420-RM or PT425-RM, 3-phase, 15 kW (max.) per unit, water cooled: 9 LPM at 15–30°C, per pump.

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;
- Upgrade to PT420-RM for 2 Cryocoolers;
- 2x 4K Heater Kit: resistive heater at the 4K flange for faster warm-up, 40W (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 side-loading 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. Side loading should allow fast exchange of experimental wiring, greatly reducing room temperature idle time;
- 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);
- Shipping Cost: 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. 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 technical support.

System service and maintenance free for the first 3 years.

Experimental wiring

3x DC Installation Set:

- Set 1 KF40 flange 1x Fischer installed, RT breakout with 1x fischer connector;
- Set 2 WireBox 2x Fischer installed in KF40 port, RT break-out box with 2x fischer connectors.
- Set 3 WireBox 2x Fischer installed in KF40 port, RT break-out box with 2x fischer connectors.

DC Wiring:

- 12x phosphorbronze twisted pairs from RT to MXC with break-out at 4K installed in KF40 port. Twisted pair experimental wiring (36 AWG Phosphor Bronze) from room temperature connector box (24- pin FISCHER) to MXC flange. Intermediate Micro-D break-out at the 4K flange. Termination with MicroD break-out at the MXC flange. Shielding for 12 twisted wire pairs installed in port KF40, EM shielding included
- 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 included.

- 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 included.

3x RF Installation Set Side Loading 32x SMA RT-4K installed in port Side Loading. Installation set for 32x SMA lines from RT to 4K; vacuum flange with 32x hermetic SMA feed-throughs plus 1x aluminium and 1x gold thermal anchoring flanges with F/F SMA bulkheads for 50K and 4K stages.

3x RF Installation Set Side Loading 32x SMA 4K-MXC installed in port Side Loading. Installation set for 32x SMA lines from 4K to MXC; gold plated copper thermal anchoring flanges with F/F SMA bulkheads for Still, Cold Plate and MXC.

32x Semi-rigid Coaxial Lines (18 GHz) installed in port Side Loading:

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

32x Semi-rigid Coaxial Lines (18 GHz) installed in port Side Loading:

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

8x Semi-rigid Coaxial Lines (18 GHz) installed in port Side Loading:

- RT-4K: 0.86mm SCuNi-CuNi (SMA)
- 4K-MXC: 0.86mm SCuNi-CuNi (SMA)
- Attenuator Value at 50K = 0dB, Attenuator Value at 4K= 20dB, Attenuator Value at Still = 0dB, Attenuator Value at CP = 10dB, Attenuator Value at MXC = 0dB.

16x Semi-rigid Coaxial Lines (18 GHz) installed in port Side Loading:

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

8x Semi-rigid Coaxial Lines (18 GHz) installed in port Side Loading:

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

Amplifier Wiring installed in port KF40: wiring for powering up to 8 Low Noise Amplifiers, including mounting parts

- 12x TWP wiring (35 AWG copper) from RT connector box (24-pin FISCHER) to 4K flange (nano-D)
- Bias cable for 1-8 Low Noise Amplifiers
- Nano-D Clamp 4 AU
- 4x mounting beam 80 mm AU
- 4x mounting bracket 86 mm AU
- 16x adapter AU
- 16x SMA-SMA coaxial assembly 50 Ohm Cu 2.19, 300mm

8x Isolator mounting bracket: isolators and circulators mounting parts

- 2x mounting beam 80mm AU 18
- 2x mounting bracket 86 mm AU
- 8x adapter AU
- 8x SMA-SMA coaxial assembly 500 Ohm Cu 2.19, 300mm

Lead time: 8 months after order confirmation.