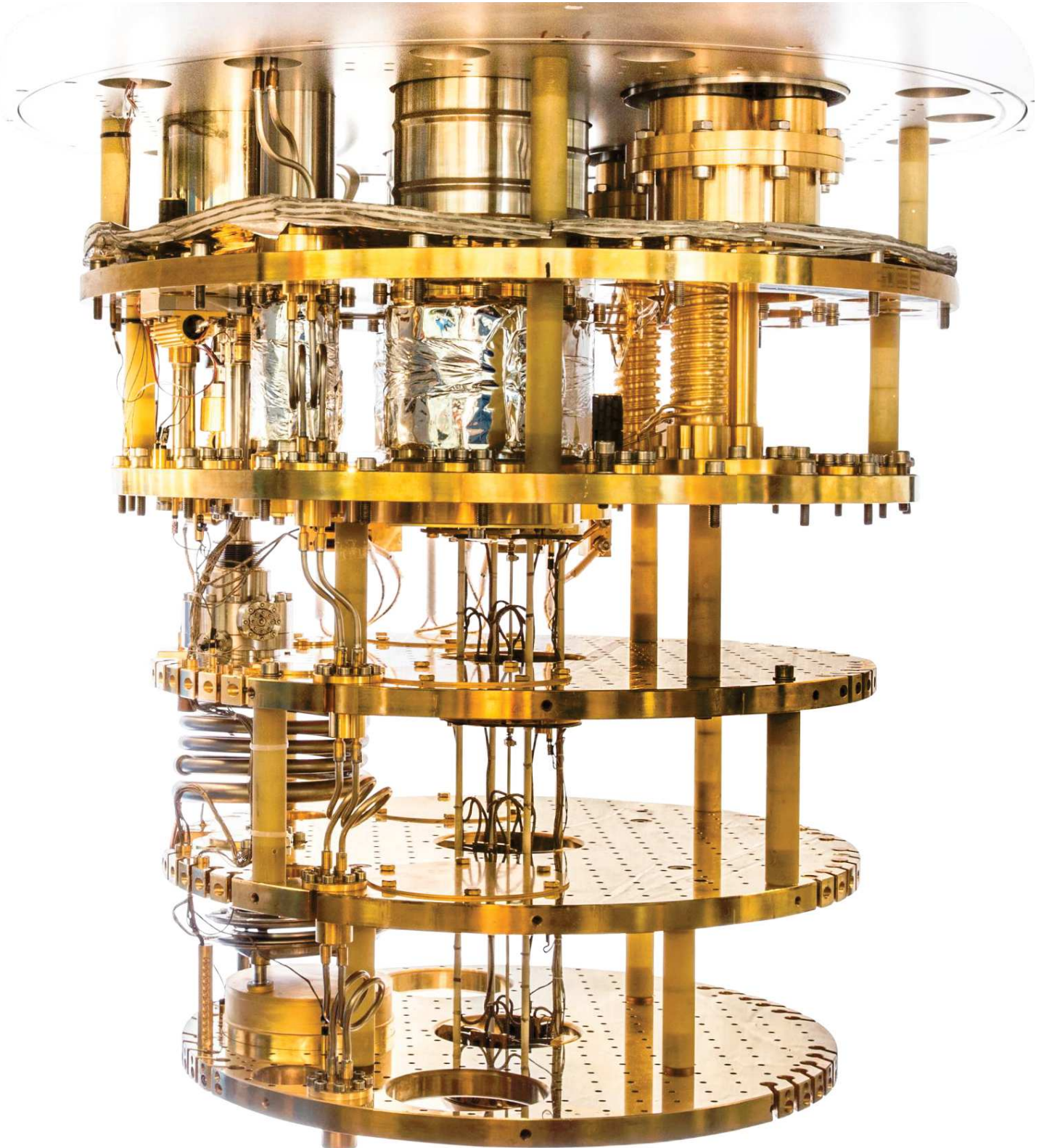


[WWW.LEIDENCRYOGENICS.COM](http://WWW.LEIDENCRYOGENICS.COM)

# LEIDEN CRYOGENICS BV

*Leader in Low Temperature Techniques*





# Cryogen-free models

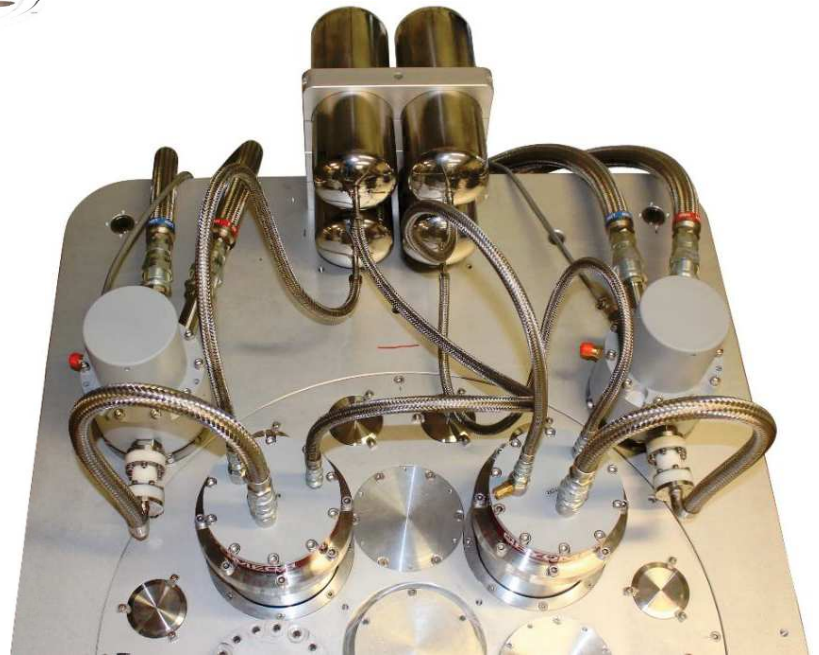
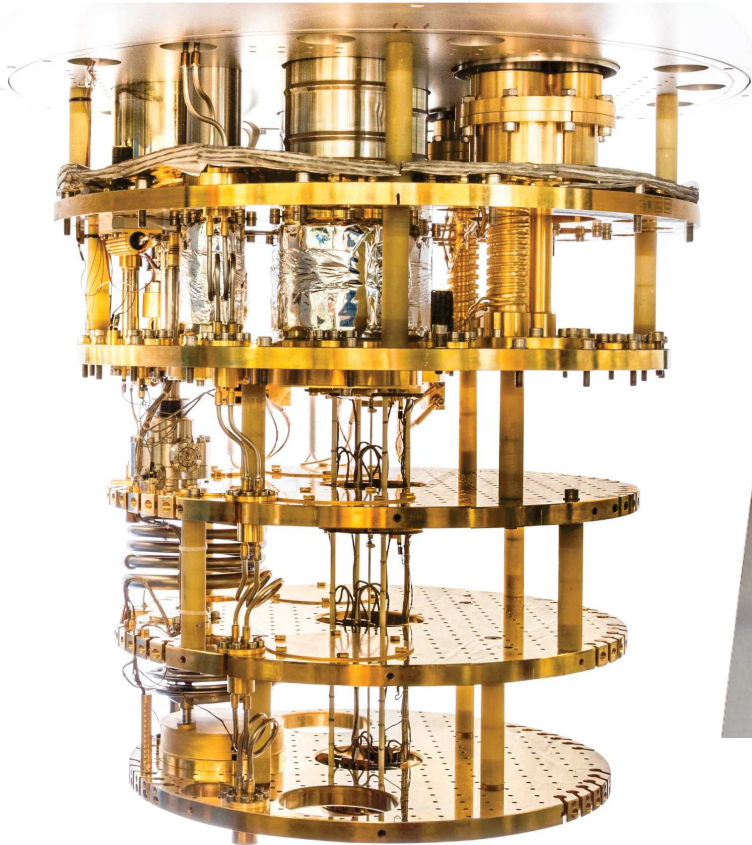
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- CF CS110 – single or twin pulse tube system
- CF CS81 – single pulse tube system
- CF CS50 – single pulse tube system



# The CF CS110-2PT model



Two pulse tube coolers for the CF-CS110 system

## Technical specifications of our latest line of cryogen-free models – the CF-CS110 series

- **2 Pulse Tube coolers** => Room temperature to base temperature ~ 24 hours with liquid nitrogen pre-cooling
- DR unit with 490mm diameter mixing chamber plate => Possibility of multiple simultaneous experiments
- Optional top-loading cold-insertable probes (see later) for quick sample change (110mm or 50mm sample space) -> 8 hours from room temperature to base temperature. Warm-insertable semi-probes also available
- Up to four 110mm and two 50mm clear shot tubes possible down to the 3K plate (one 110mm and one 50mm being standard) => Multiple parallel experimental probes possible
- Possibility of inserting the probe into a magnet attached to the Still shield (up to 10T) or the 3K shield (up to 14 Tesla). Vector magnets (either YZ or XYZ) are also available
- Pt and/or RuO resistance thermometers on all stages. Calibrated resistance thermometer on the mixing chamber plate. Optional CMN mutual inductance and/or SQUID noise thermometers also available
- Automatic lifting table for easy mounting of the shields
- Robust design => High stability and low vibration amplitudes
- Optional Halcyonics active damping system

CF-DR Models	Tmin (mK)	Q@100mK (μW)	Q @120mK (μW)
CF-2500 Maglev*	< 8	1800	2500
CF-2000 Maglev	< 8	1400	2000
CF-1400 Maglev	< 8	1000	1400
CF-1000 Maglev	< 8	700	1000

\*in development



# The CF-CS81 model

## Technical specifications of the CF-CS81 Models CF-300/600/1000/1400/2000

- Single pulse tube cooler. Room temperature to base temperature  $\sim$  36 hours using liquid nitrogen pre-cooling
- DR unit with 408mm mixing chamber plate
- Up to two 81mm and two 50mm clear shot tubes down to the 3K plate (one 81mm and one 50mm being standard)
- Optional top-loading probes for quick sample change (81mm or 50mm sample space) ) -> 8 hours from room temperature to base temperature
- System mounted on automatic lifting table
- Magnets, thermometers and active vibration damping options similar to the CS110 system

CF-DR Models	Tmin (mK)	Q@100mK ( $\mu$ W)	Q @120mK ( $\mu$ W)
CF-2000 Maglev	<8	1400	2000
CF-1400 Maglev	<8	1000	1400
CF-1000 Maglev	<8	700	1000
CF-600	<9	430	600
CF-300	<12	200	380



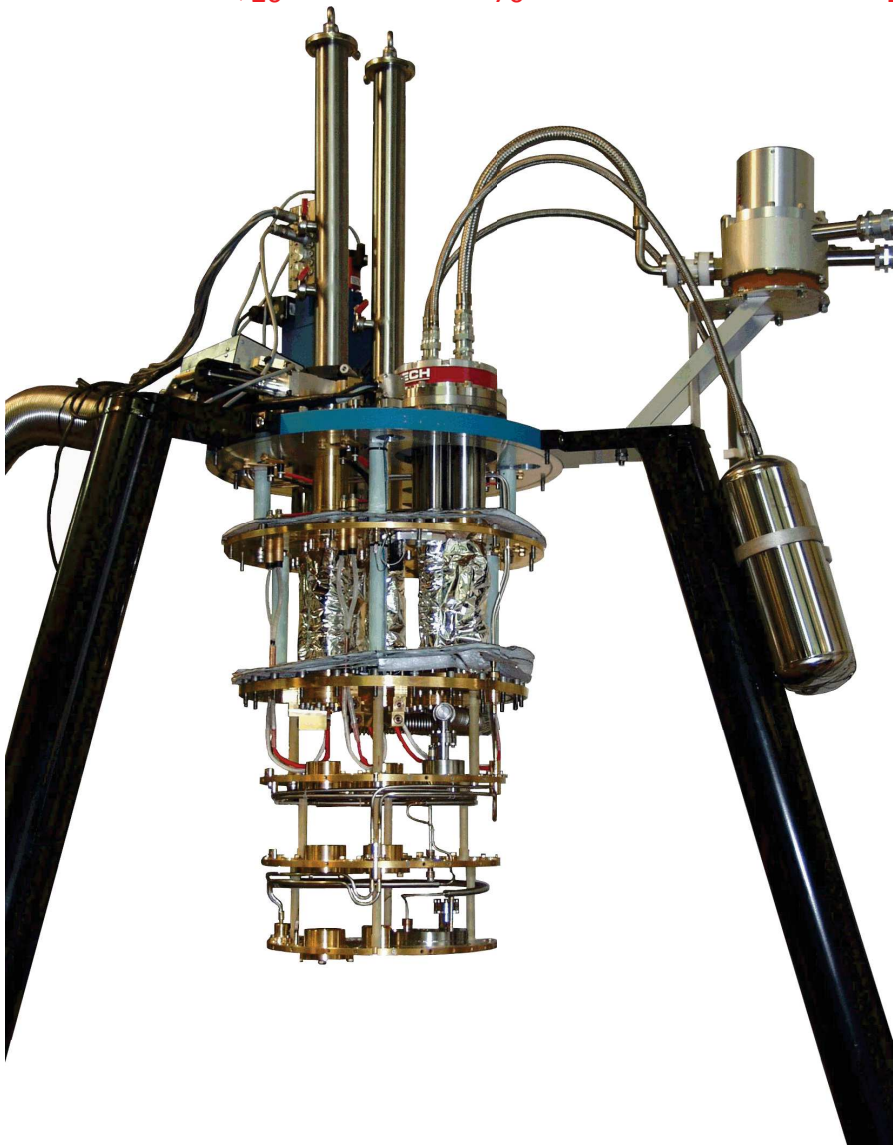


# The CF-CS50 model

## Technical specifications of the CF Models CF-100/200/500/800/1000/1400

- Single pulse tube cooler. Cool-down time ~ 20 hours with liquid nitrogen pre-cooling
- DR unit with 340mm mixing chamber plate
- Up to three 50mm clear shot tubes down to the 3K plate, with the central one being standard.
- Optional top-loading probes for quick sample change (50mm sample space) ) -> 8 hours from room temperature to base temperature
- Choice between automatic lifting table or tripod mounting
- Magnets, thermometers, lifting table and active vibration damping options similar to the CS110 system

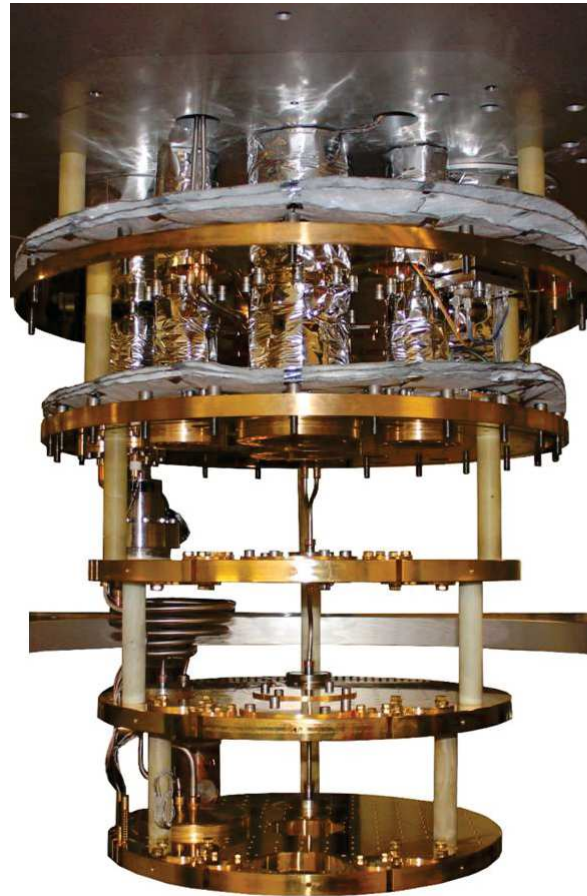
CF-DR Models	Tmin (mK)	Q @120mK ( $\mu$ W)	Q @120mK ( $\mu$ W)
CF-1400	< 8	1000	1400
CF-1000	< 8	700	1000
CF-800	< 8	580	800
CF-500	< 12	350	500
CF-250	< 15	150	200
CF-100	< 20	70	100



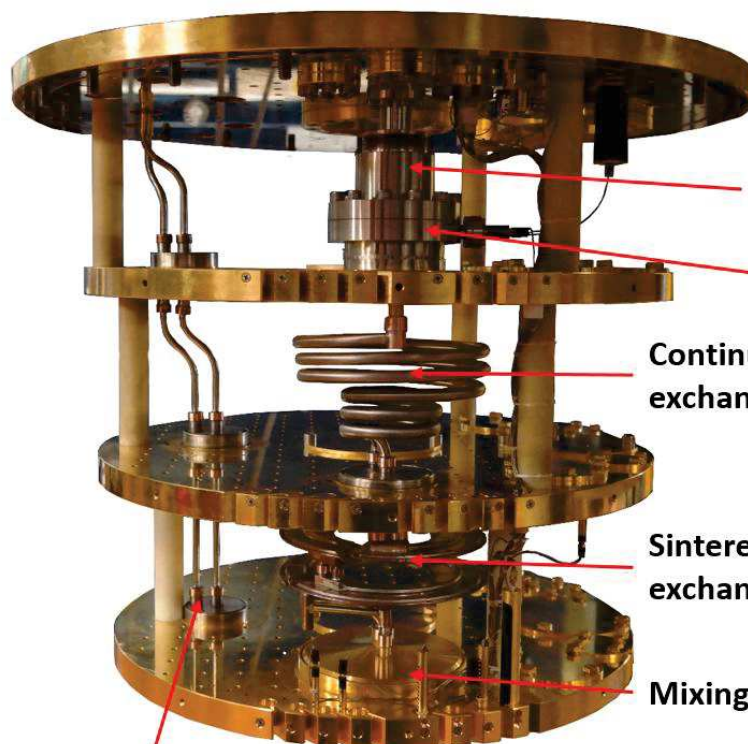


# CF models – more details

- 20 mm thick gold-plated Copper plates – fabricated in-house
- 120 mm spacing between plates - rigidly bolted via G10 rods
- PT and dilution fridge inserts couple to the plates off-centre
- LN2 circuit couples to every stage
- To each plate is a can attached – act as radiation shields
- OVC (Outer Vacuum Can at 300K) and IVC (Inner Vacuum Can at 4K) are vacuum sealed forming two separate vacuum spaces
- 3 stages of heat exchangers – two of them with Silver sinter
- Thermometer and level gauge immersed in the Still liquid
- Two independently tunable primary flow impedances providing insurance against blockage
- 100 W heaters on the 4K and 50K plates for overnight warm-up
- Mechanical safety valve on the Still pumping line for recovery of mixture in the event of power failure and UPS failure



- 50K plate – 1<sup>st</sup> PT stage
- 4K plate – 2<sup>nd</sup> PT stage
- Still plate – at around 800 mK
- 50mK plate
- MC plate



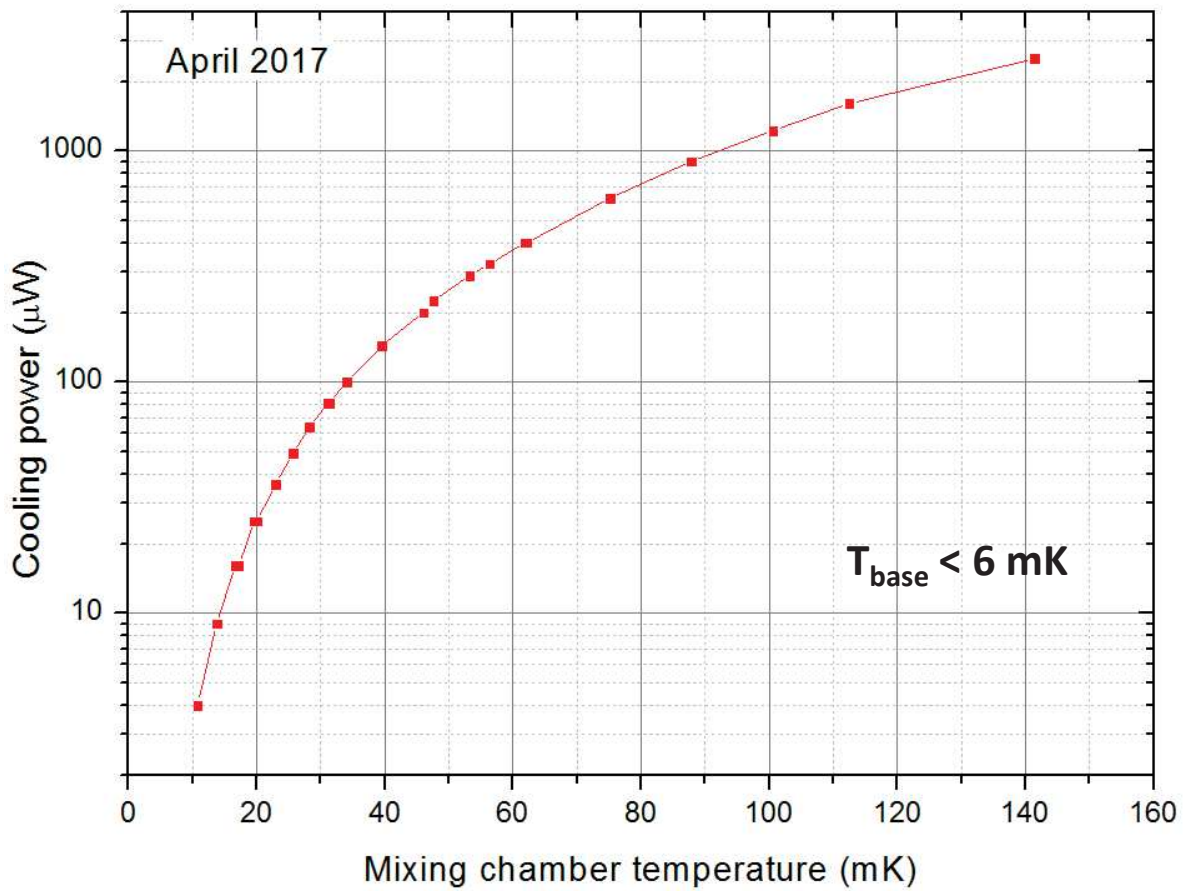
- J-T heat exchanger
- Still
- Continuous heat exchanger
- Sintered heat exchanger
- Mixing Chamber

LN2 circuit

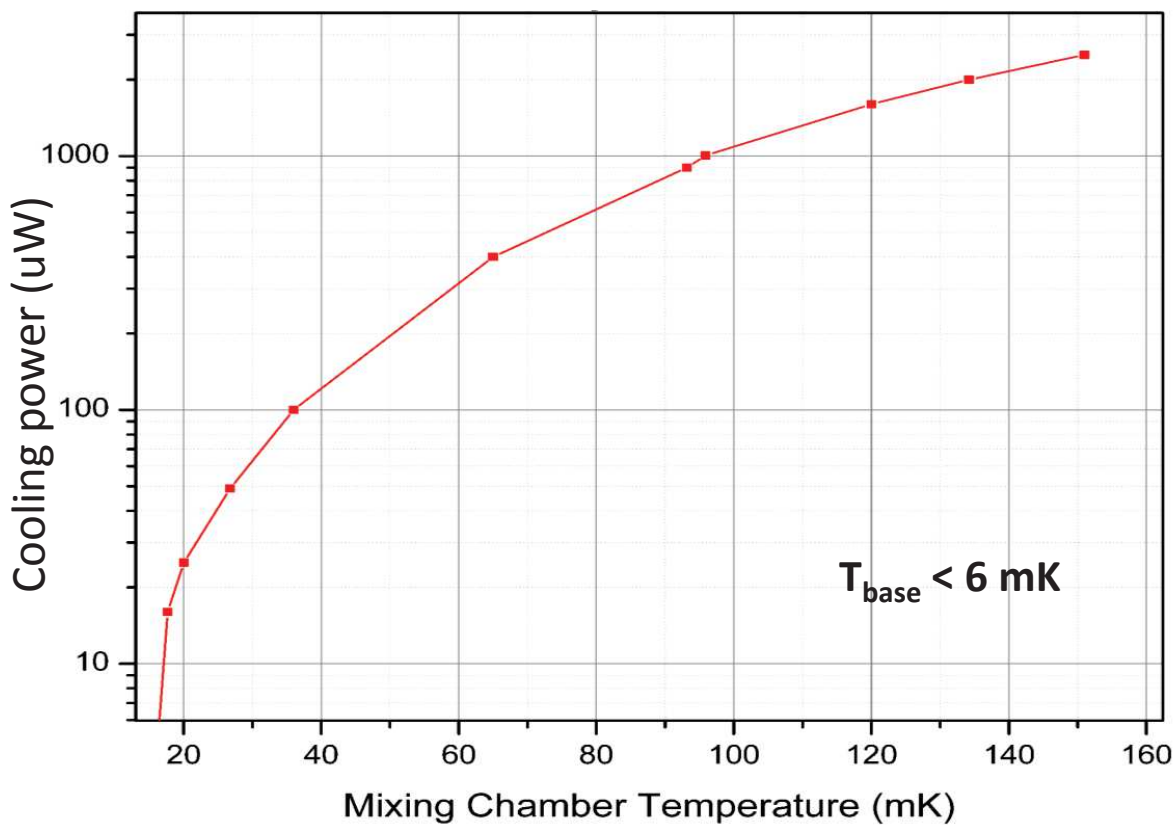


# Performance of the CF Models

Performance of the CS110 model



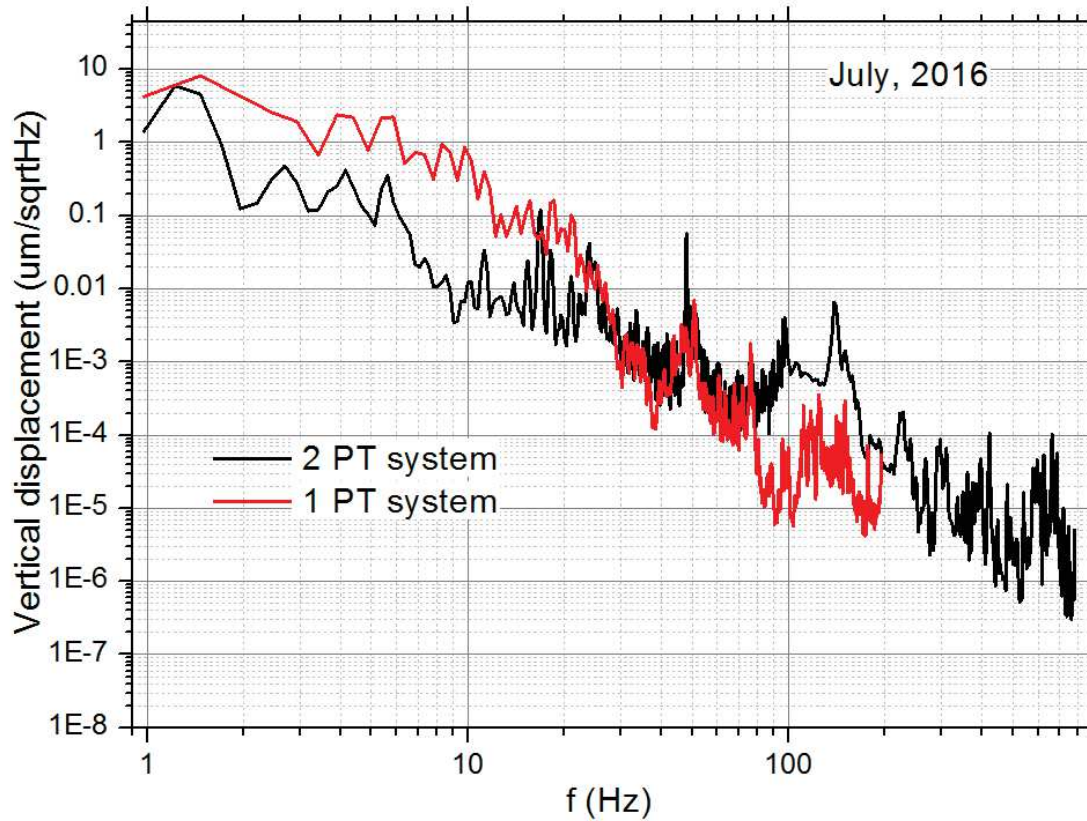
Performance of the CF-CS81-1600



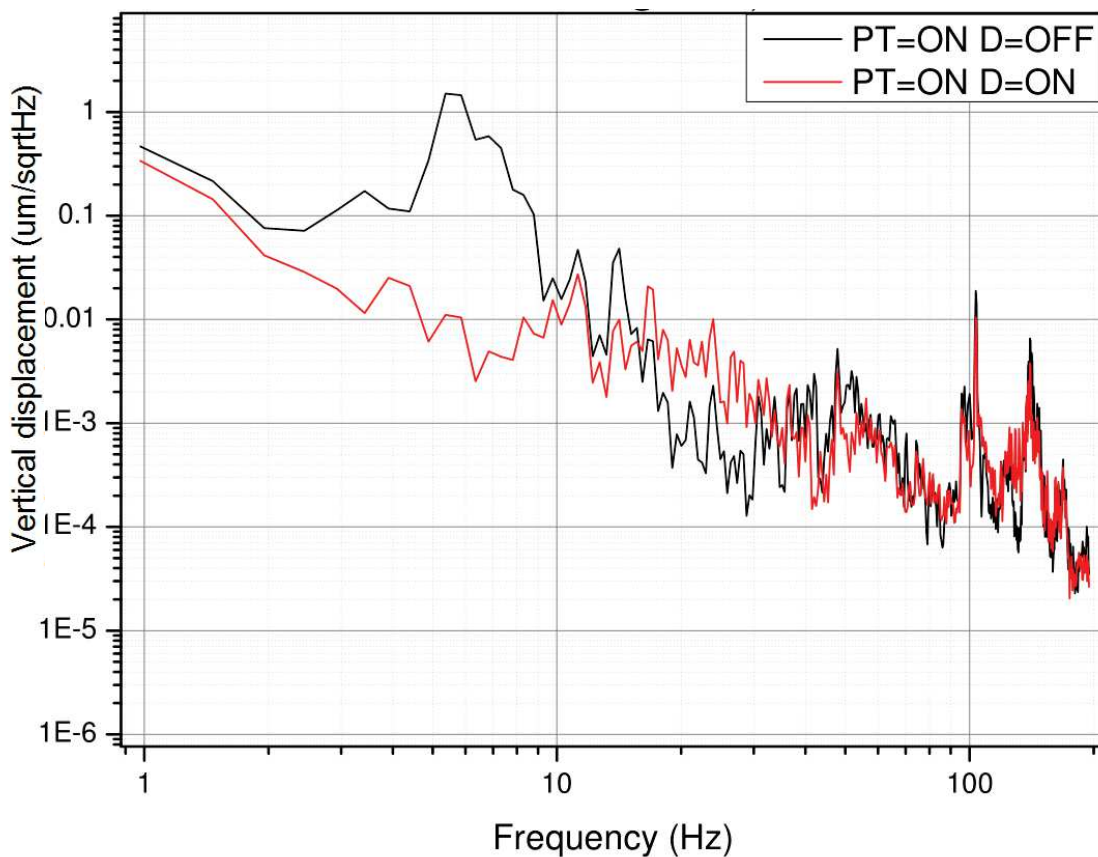


# Vibrations in the CF models

Vertical displacement measurements (using a Geophone) at the mixing chamber –  
the 2 pulse tube system has a lower amplitude at lower frequencies



Vertical displacement measurements (using a Geophone) at the mixing chamber –  
effect of active vibration damping

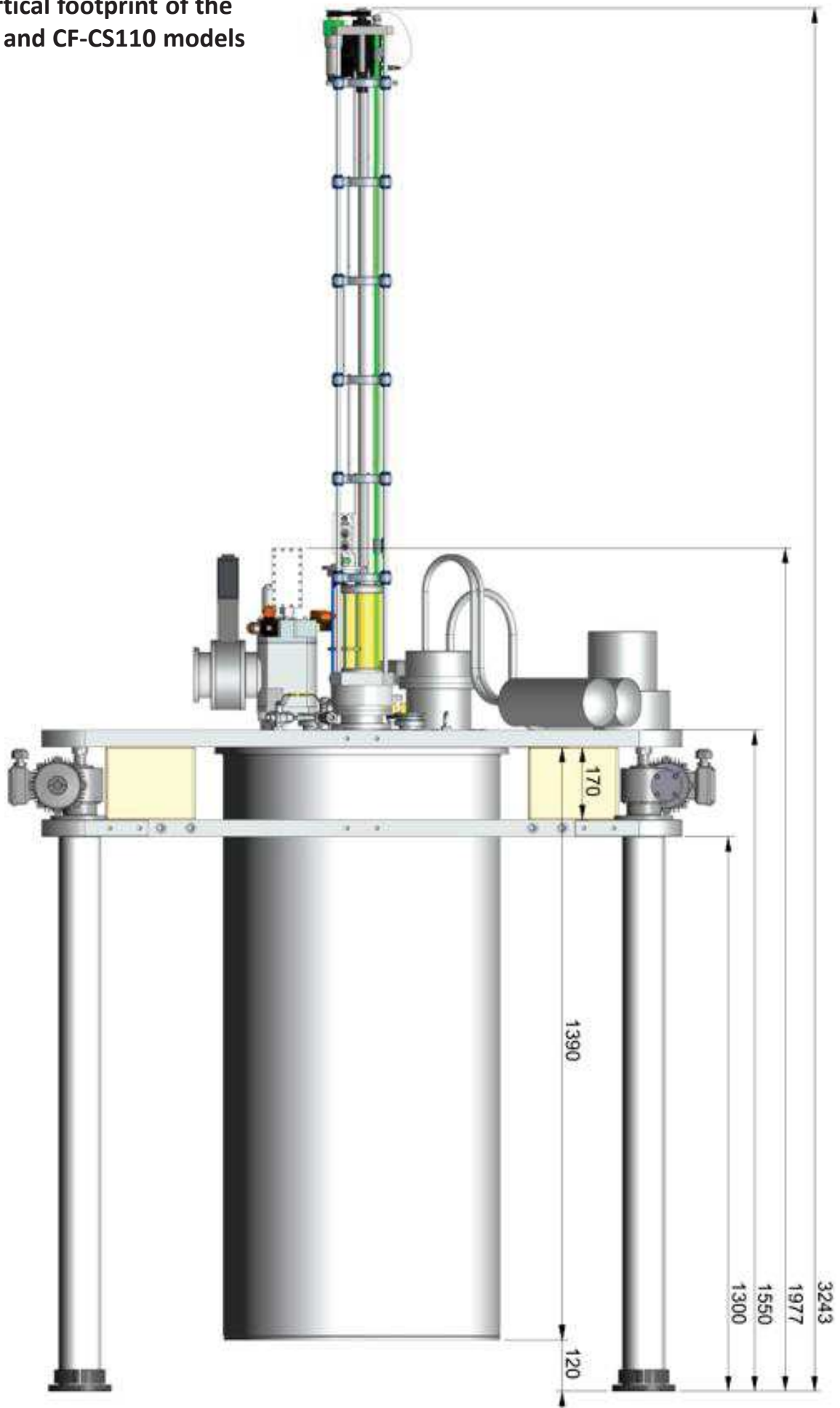






# CF models - Vertical Footprint

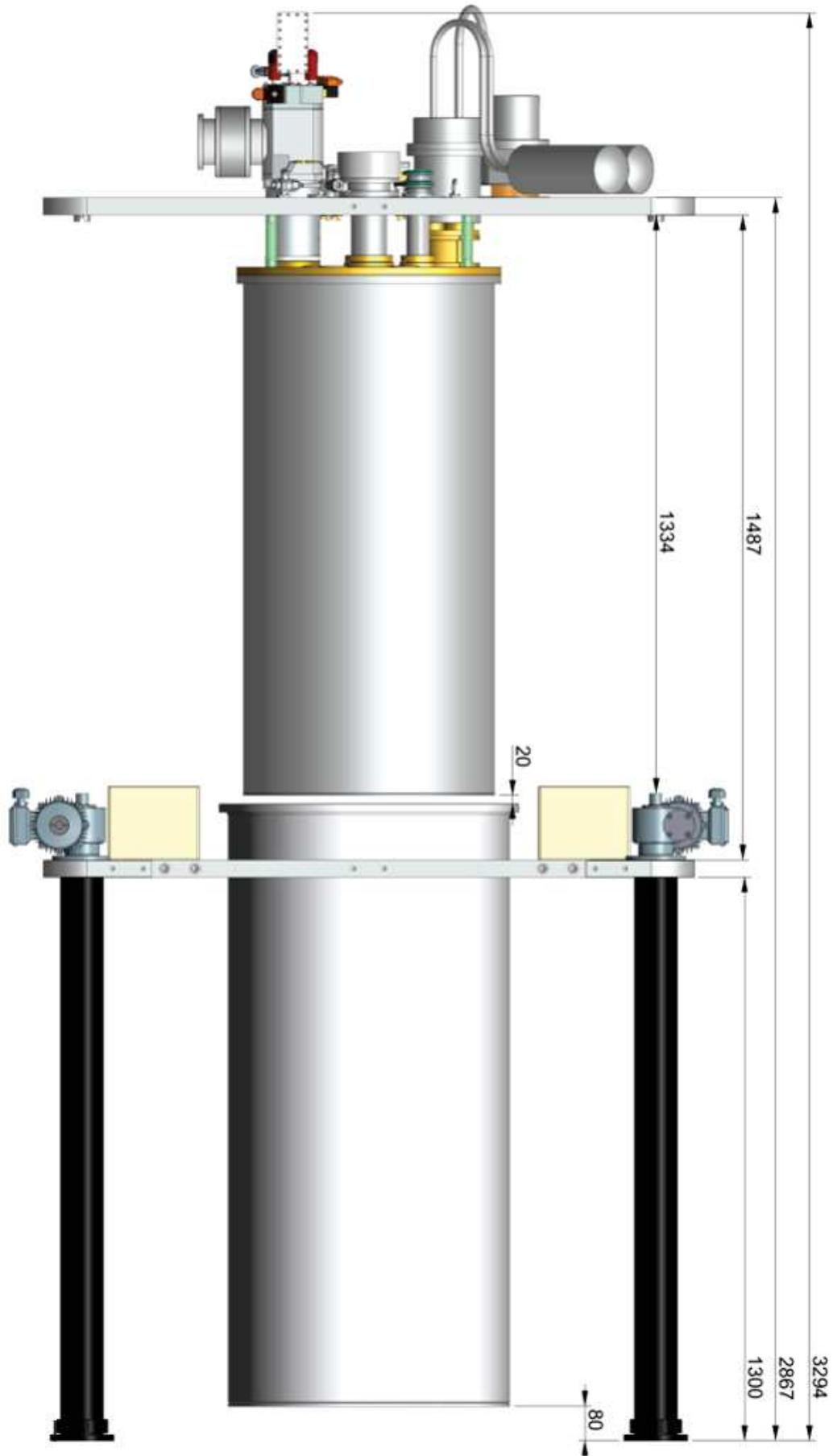
The vertical footprint of the  
CF-CS81 and CF-CS110 models





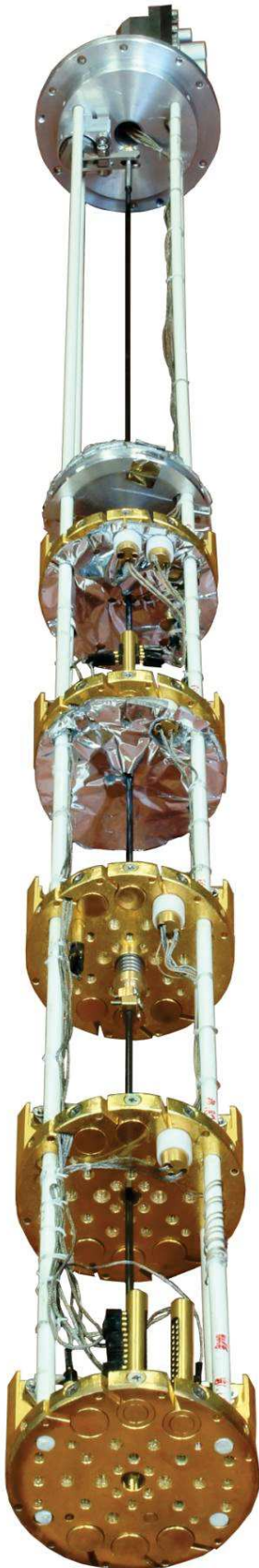
# CF models - Vertical Footprint

The vertical footprint of the  
CF-CS81 and CF-CS110 models





# Cold Insertable Probes



The 81mm cold - insertable probe



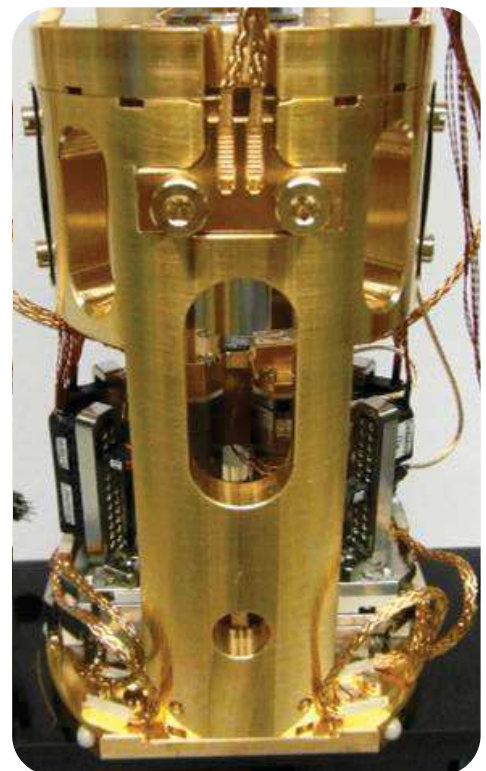
The 81mm probe-lift

## Cold insertable probe

The cold insertable probe is loaded in to the dilution refrigerator fully automatically. The arms of the probe are pushed against the plates of the DR unit using a pneumatic actuator. An edge welded bellow is used as load-lock, thus avoiding possibly leaky sliding seals. The probe shown on the right has a single spindle and 4 guiding rods. The larger 110 mm probe has 2 spindles and 2 guiding rods.

## Atomic force and confocal microscopy at 38 mK in a cold-insertable probe!!

The low vibrations in our fridge and excellent probe alignment enabled us to perform AFM and CFM at an unprecedented 38 mK at the microscope in a vector magnet of 5-1-1 T. The vibration level was < 5nm RMS even at 5T. This project was in association with Attocube. Such microscopy attachments are now commercially available





# Cold Insertable probes



Wiring chamber attached to the MC plate

Cold-insertable probe with a clicking cold finger with mechanical guides



Cold-insertable probe can be combined with a unique cold-finger that “clicks onto” existing wired connectors on the MC plate on the fridge providing excellent thermal contact for the samples to the lowest temperatures



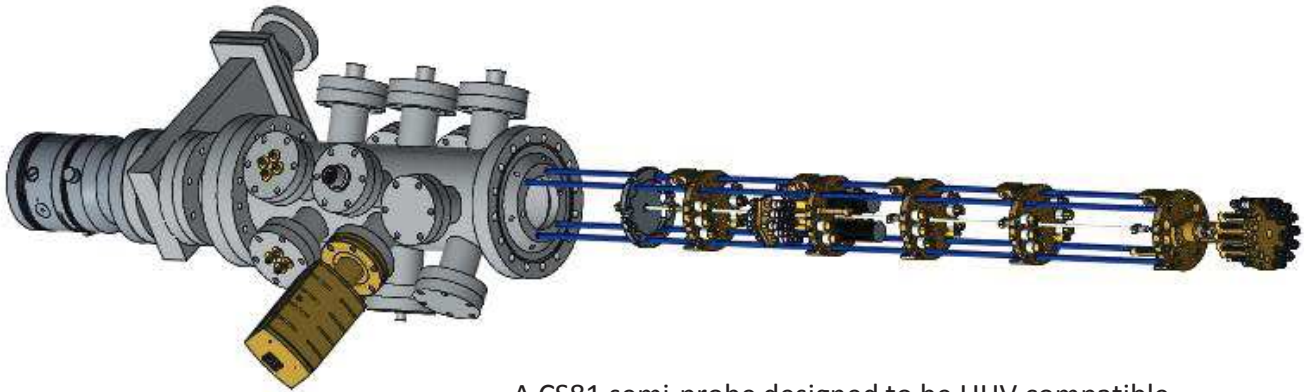
# Semi-probes (warm-insertable)

## Warm insertable semi-probes

Can be thermally clamped to the fridge by tightening a nut at the bottom, hence can only be done when the system is warm and open. However, it offers the advantage of having an insert that can be worked upon on the work table. It also provides an easy way for the customer to introduce wiring. Since it is clamped when the system is warm, the thermal contact is very good



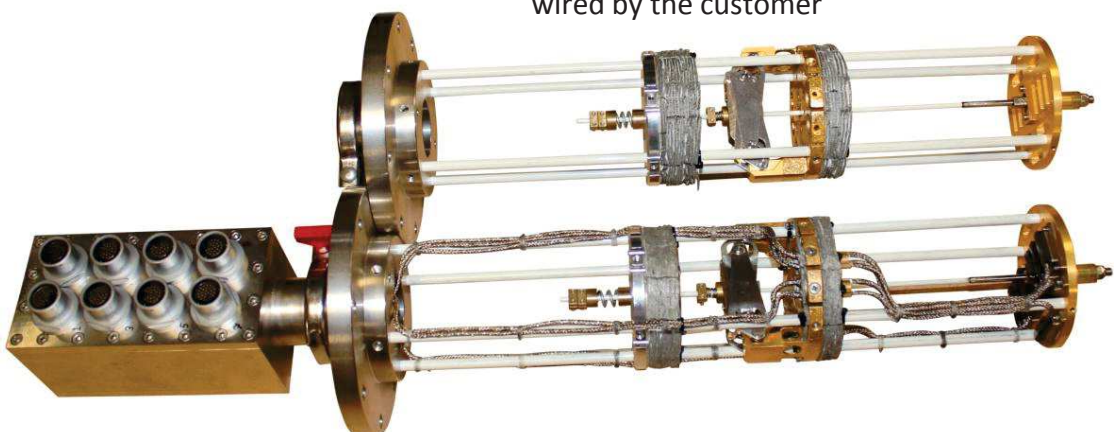
A CS50 semi-probe

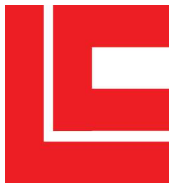


A CS81 semi-probe designed to be UHV compatible



CS81 semi-probes, one wired and the other to be wired by the customer





# Wet refrigerators

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**DRS series**



**MNK series**



**MCK series**



## Technical specifications of the DRS Models 1000/2000/4000

- Dilution refrigerator insert  $\phi$  220 mm with  $\phi$  200 mm IVC and  $\phi$  174 mm gold-plated copper bottom mixing chamber
- Central 50 mm clear shot access to outside the mixing chamber
- Three 25 mm ID clear shot tubes to the Helium bath, one extends into the IVC. If required the other two can also be extended to the IVC
- Capacitance level gauge inside the still
- Thermometry and thermometry options similar to the CF models
- 1 K pot bypass valve and twin impedance mixture condensing circuit
- Radiation shields for all stages
- Dewar, Helium bath level gauge and controller, transfer lines, coaxial magnet insert
- Coaxial magnet insert
- Can be fitted on to a motorized automatic lifting table if necessary

### DRS Models

$T_{\min}$  (mK)

Q @120mK ( $\mu$ W)

DRS4000

<5

4000

DRS2000

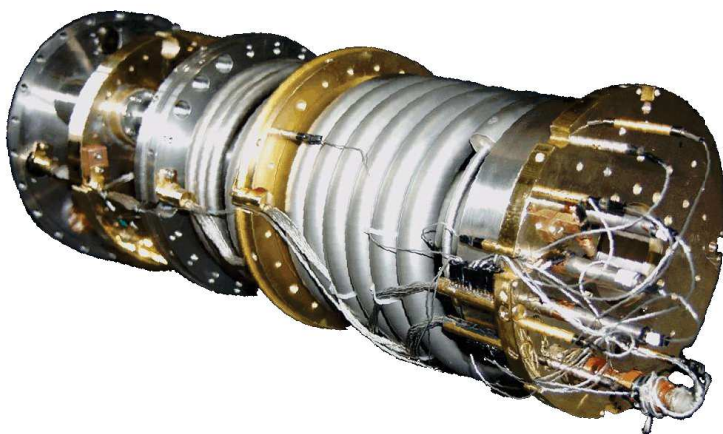
5

2500

DRS1000

6

1300





## Technical specifications of MNK models

- Dilution refrigerator insert  $\phi$  126 mm with  $\phi$  109 mm IVC and  $\phi$  94 mm gold-plated copper bottom mixing chamber
- Three 17 mm ID clear shot tubes to the Helium bath, one extends into the IVC. If required the other two can also be extended to the IVC
- Capacitance level gauge inside the still
- Thermometry and thermometry options similar to the CF models
- 1 K pot bypass valve and twin impedance mixture condensing circuit
- Radiation shields for all stages
- Dewar, Helium bath level gauge and controller, transfer lines, coaxial magnet insert
- Coaxial magnet insert
- Can be fitted on to a motorized automatic lifting table if necessary

MNK Models	Tmin (mK)	Q @120mK ( $\mu$ W)
MNK126-650	< 6	650
MNK126-500	< 7	500
MNK126-250	< 15	250
MNK126-100	< 18	100







## Technical Specifications

- Plastic dilution unit => absence of Eddy currents in a magnetic field: A novel option for ultra-low temperatures measurements in very high magnetic fields
- Dilution refrigerator insert outer  $\phi = 50/76$  mm with 50 /76 mm OD IVC including 1K pot
- $\phi 24$  mm x 40 mm length useful internal space
- Greased conical plug for access to the liquid inside the mixing chamber. For measurements outside the mixing chamber an optional conical plug with cold finger is used
- Three  $\phi 10$ mm clear-shot tubes to IVC
- Still capacitance level gauge
- Available as an insert for a Cryogen-free system too (also in combination with a Cryogenic Limited magnet cryostat)

### MCK Models

### Tmin (mK)

### Q @120mK ( $\mu$ W) (inside the MC)

MCK76-400

<25

400

MCK50-400

<25

400

MCK50-100

<25

100

CF-MCK76-400

<25

400

CF-MCK50-400

<25

400

CF-MCK50-100

<25

100





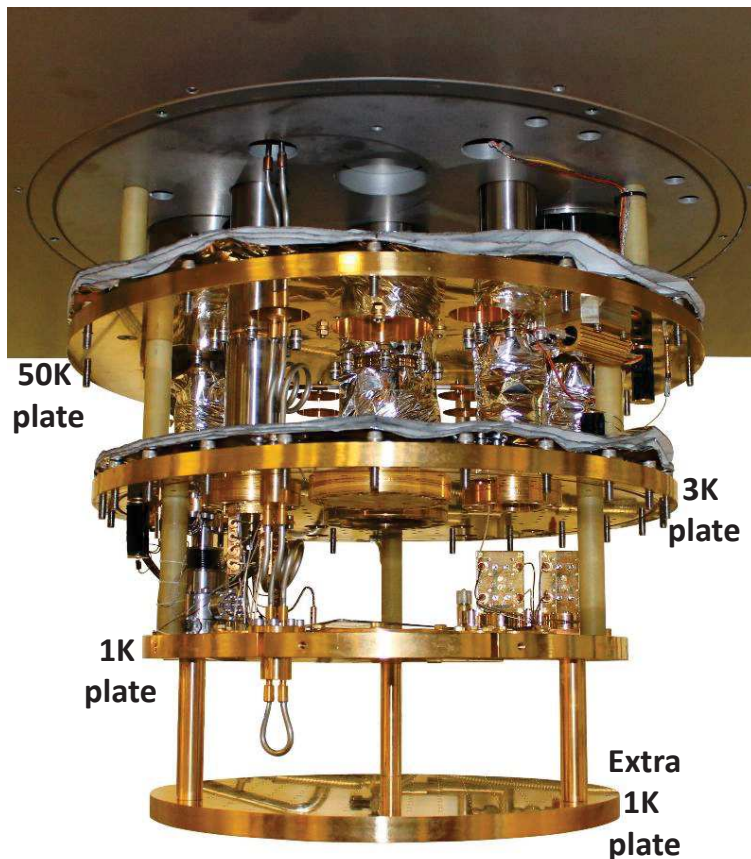
# Other models

## Nuclear Demagnetisation refrigerators

- Nuclear Demagnetisation Stages can be suspended from the mixing chamber of a wet Dilution Refrigerator coaxially with a demagnetization magnet insert like shown on the right
- A lowest temperature of lower than 40  $\mu\text{K}$  was achieved in Nuclear demagnetization refrigerators

## Cryogen-free 1K refrigerators

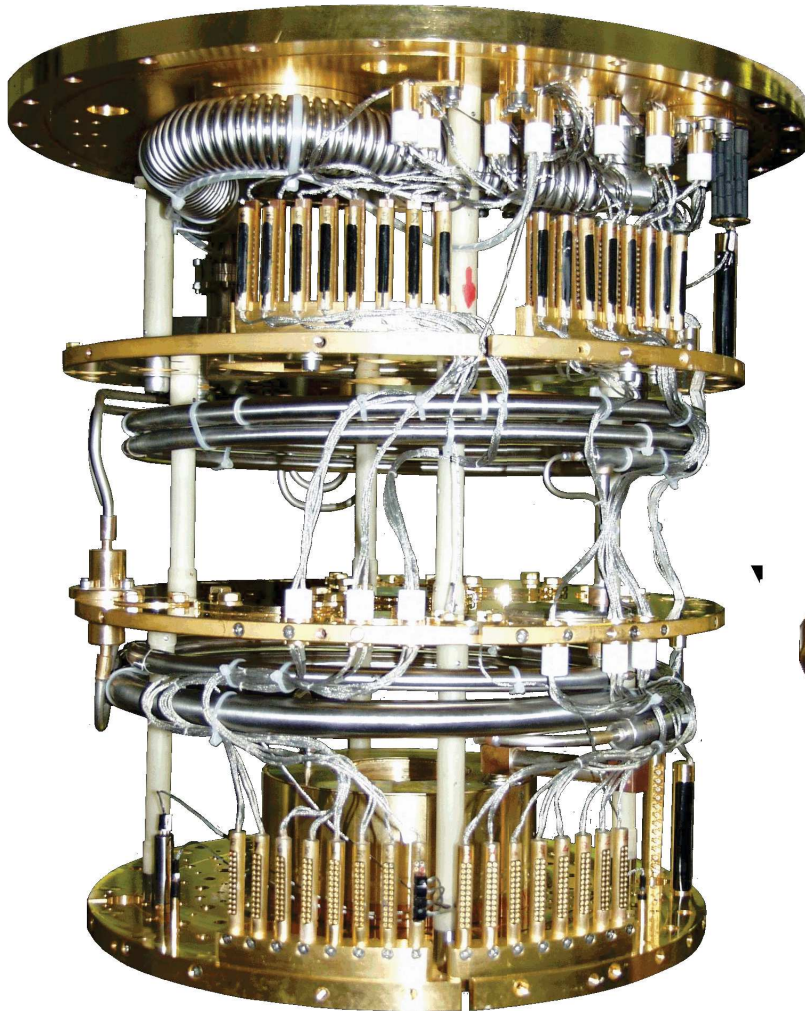
- Truncated dilution refrigerators at the 1K stage act as continuously operatable 1K refrigerators with a base temperature of around 0.8 K
- These are available as CS50, CS81 and CS110
- Shown below is an example of a CS81 system combined with detectors from Single Quantum BV





# Some customised systems

## High Cooling Power Systems



**Left:**

CF-CS50-2500 at MIT Lincoln Laboratory (Will Oliver)

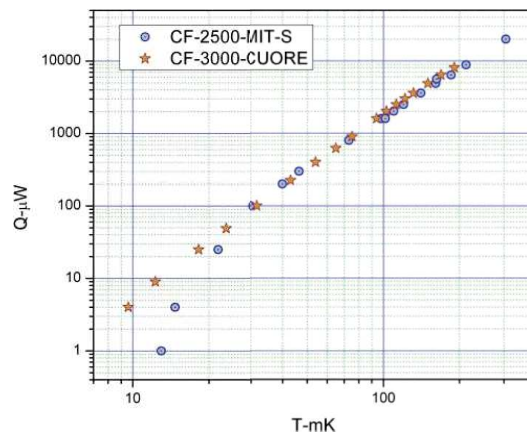
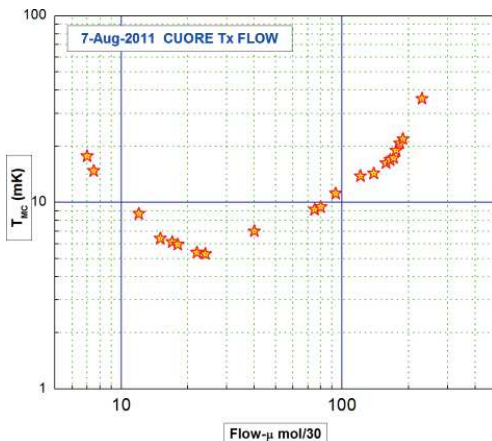
$T_{min} = 4.6 \text{ mK}$   
1.6 mW @ 100 mK  
2.5 mW @ 120 mK



**Right:**

CF-3000 for CUORE  
(Laboratori Nazionali del Gran Sasso)

$T_{min} = 5.26 \text{ mK}$   
2 mW @ 100 mK  
3 mW @ 123 mK



The CUORE (Cryogenic Underground Observatory for Rare Events) experiment consists of 988 crystals of TeO 2 with a total mass of 750 kg, which are presently being cooled down to 8mK. The incoming mixture of the dilution refrigerator is pre-cooled by two PT415 pulse tube coolers (CRYOMECH), three others are used to pre-cool the shields.

<http://crio.mib.infn.it/wig/Cuorepage/CUORE>



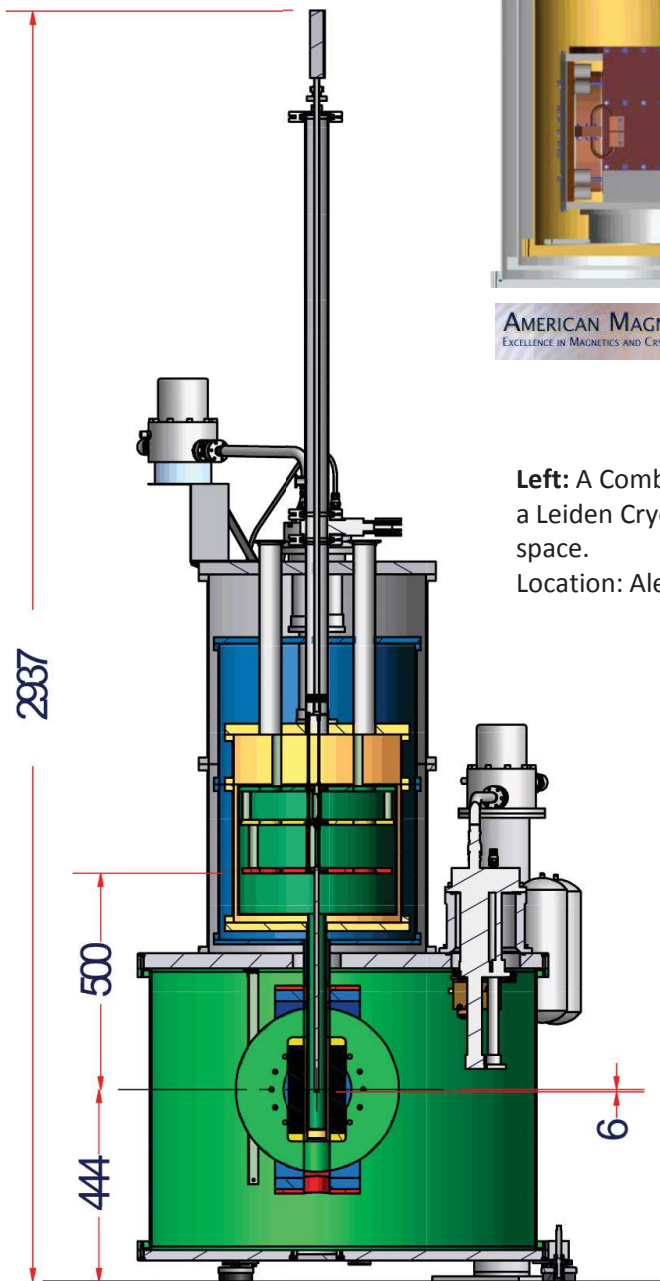


# Some customised systems

## Special CF Systems

### CF 3K 2-axis Vector Magnet 9-3T (AMI)

The CF vector magnet is fitted inside the IVC using exchange gas. The system can be used with a top-loading MCK50-CF dilution refrigerator or a cold insertable probe at 3K.



**Left:** A Combination of a Cryogenic Limited High Field vector magnet with a Leiden Cryogenics CF-450 dilution refrigerator, using a common vacuum space.

Location: Alex Hamilton, University of Sydney, Australia



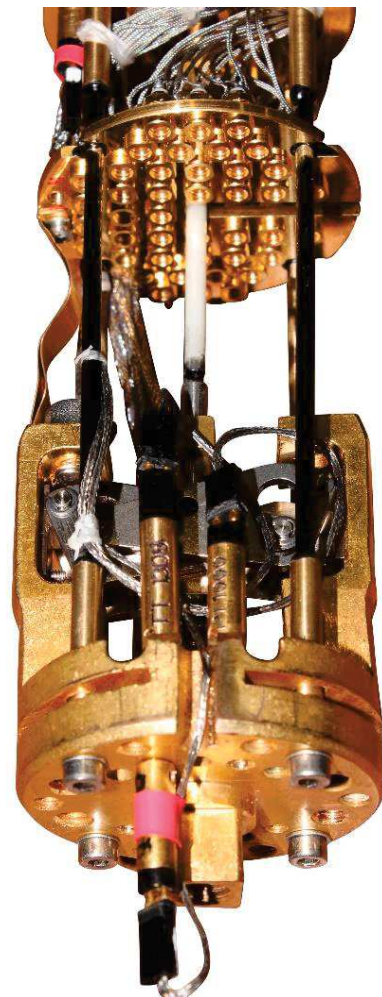
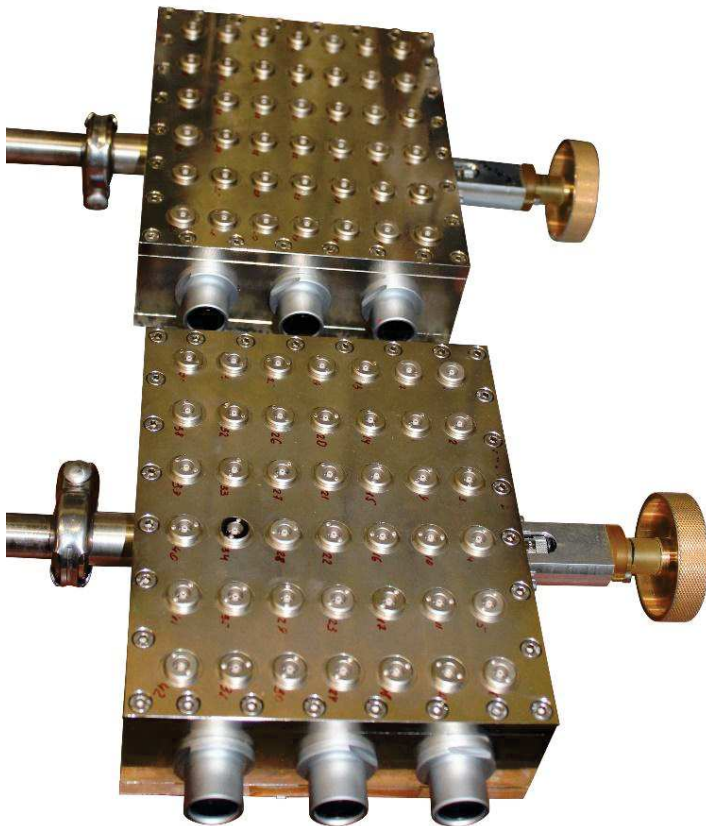
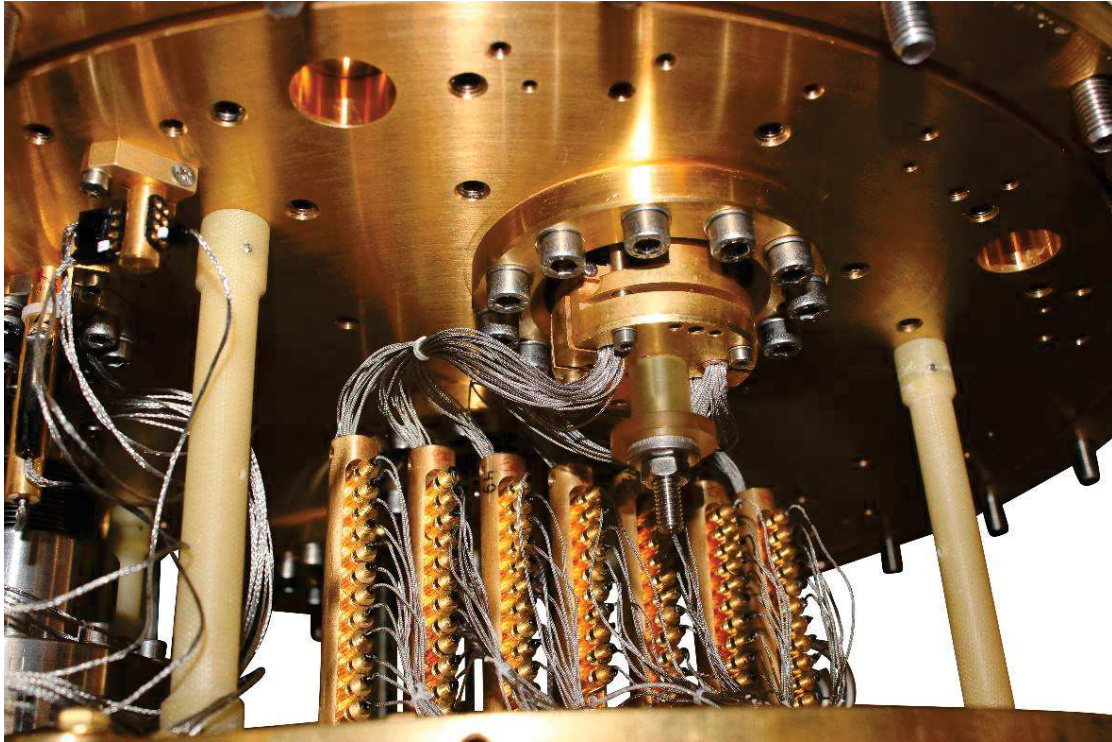
### CF-450 9-5-2 Vector Magnet (Cryogenic Limited, UK)

The 3-axis magnet is bolted down to the bottom of the IVC. The center of magnet can be reached by using the cold insertable probe extended with a cold finger.

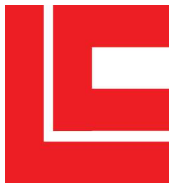




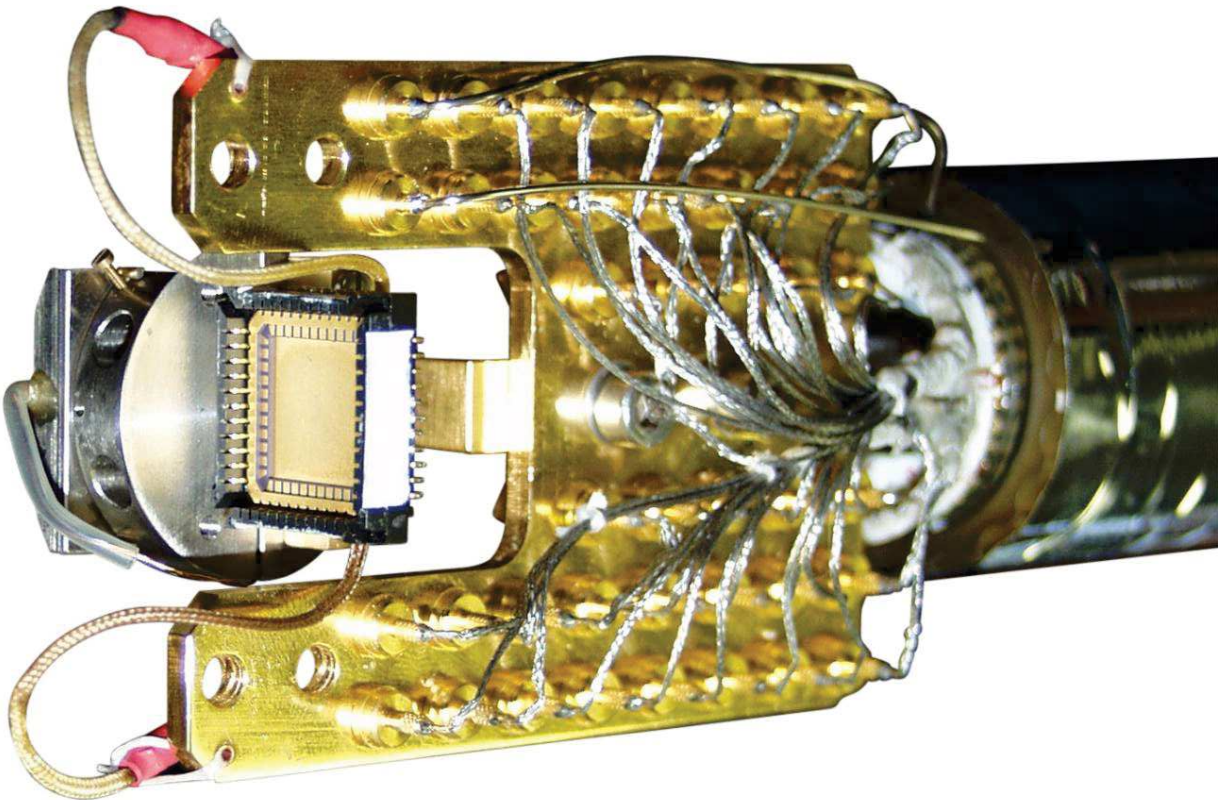
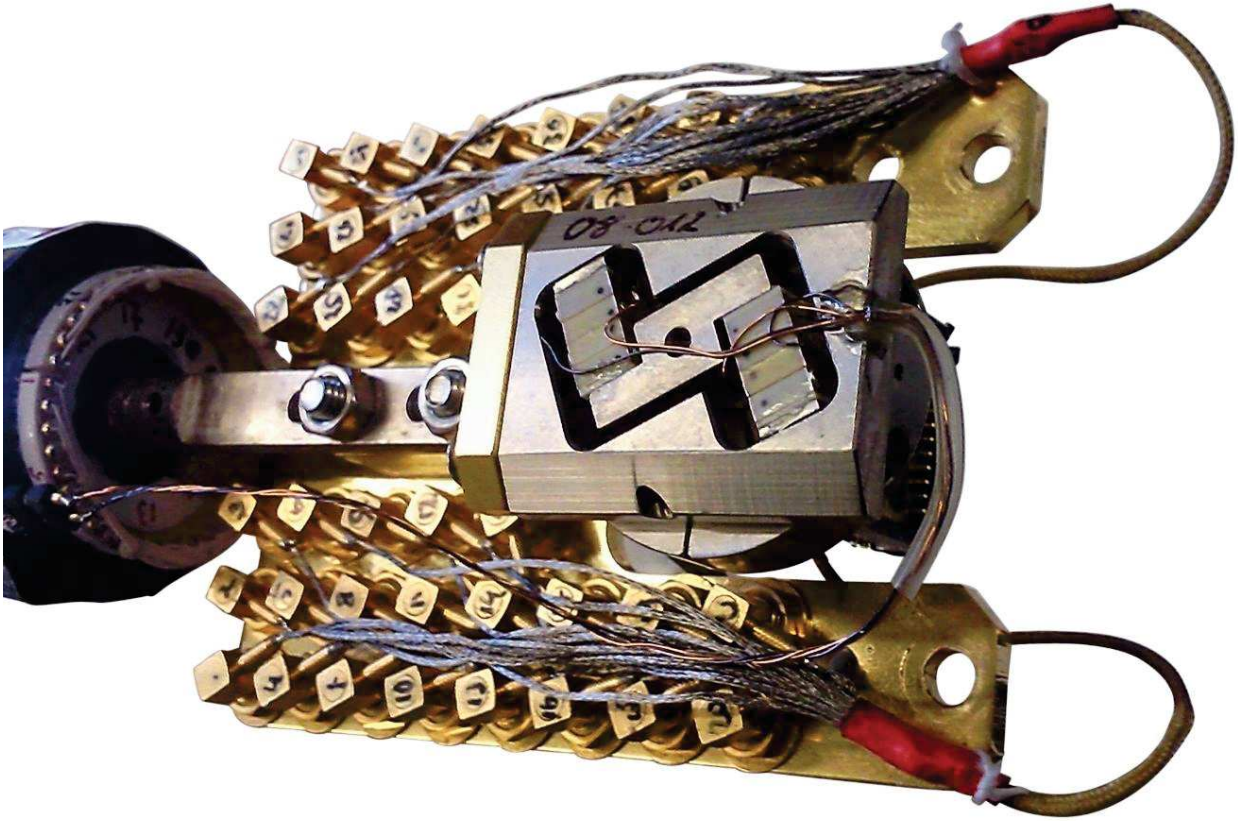
# Custom wiring examples



Custom made wiring in the CF-CS50 and on the 50 mm cold-insertable proge.  
(David Goldhaber-Gordon, Stanford)



# Custom wiring examples



40 flexible coaxes ending in mmcx connectors, extending to a chip holder on a Attocube rotator (Groningen, The Netherlands)



# Gas Handling System



## Technical specifications of our Gas Handling Systems

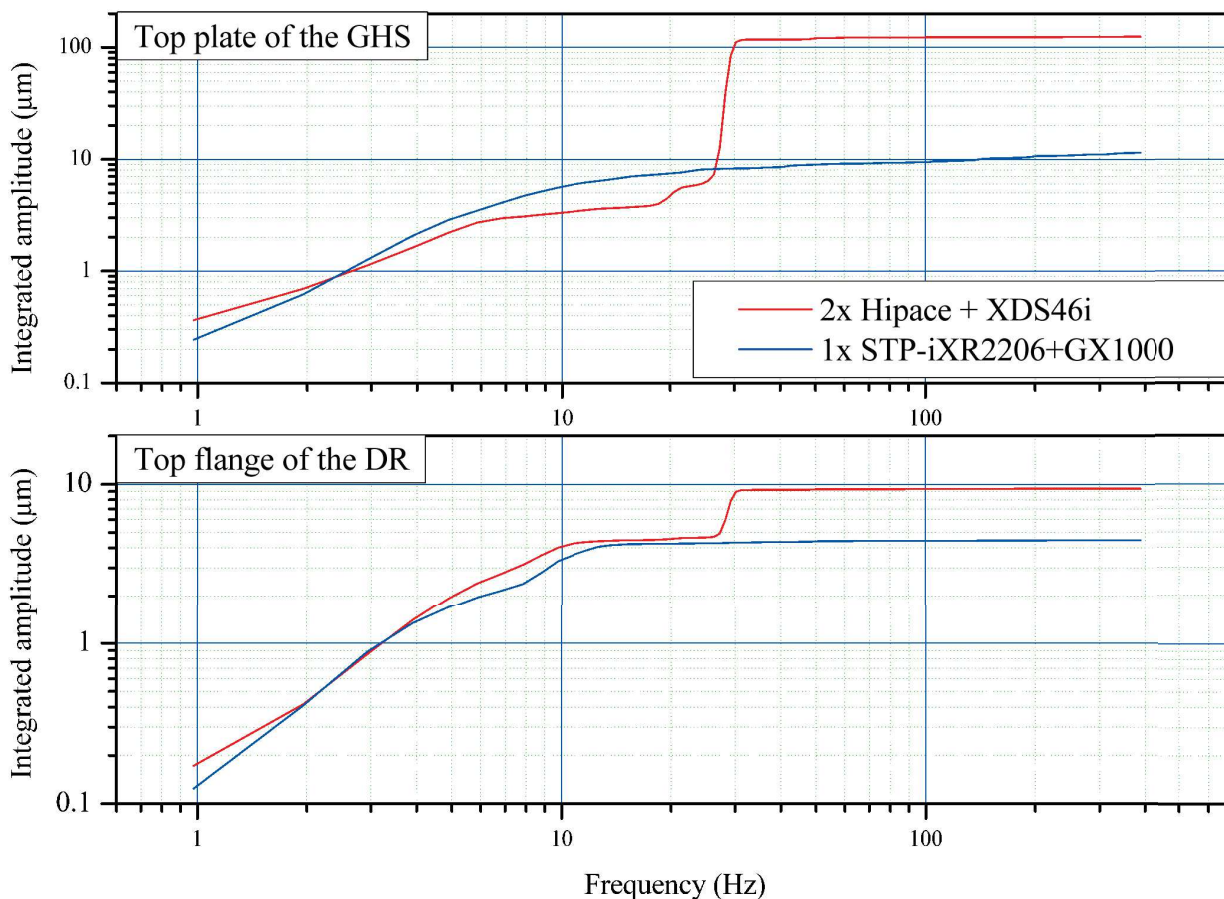
- All our GHSs are oil-free
- The system is designed such that the control panel, valve board, pumps and compressor are all housed in a Stainless Steel cabinet on wheels
- The helium gas mixture is stored inside of the frame of the cabinet itself. This design allows for a compact arrangement for even the most powerful systems



# Gas Handling System

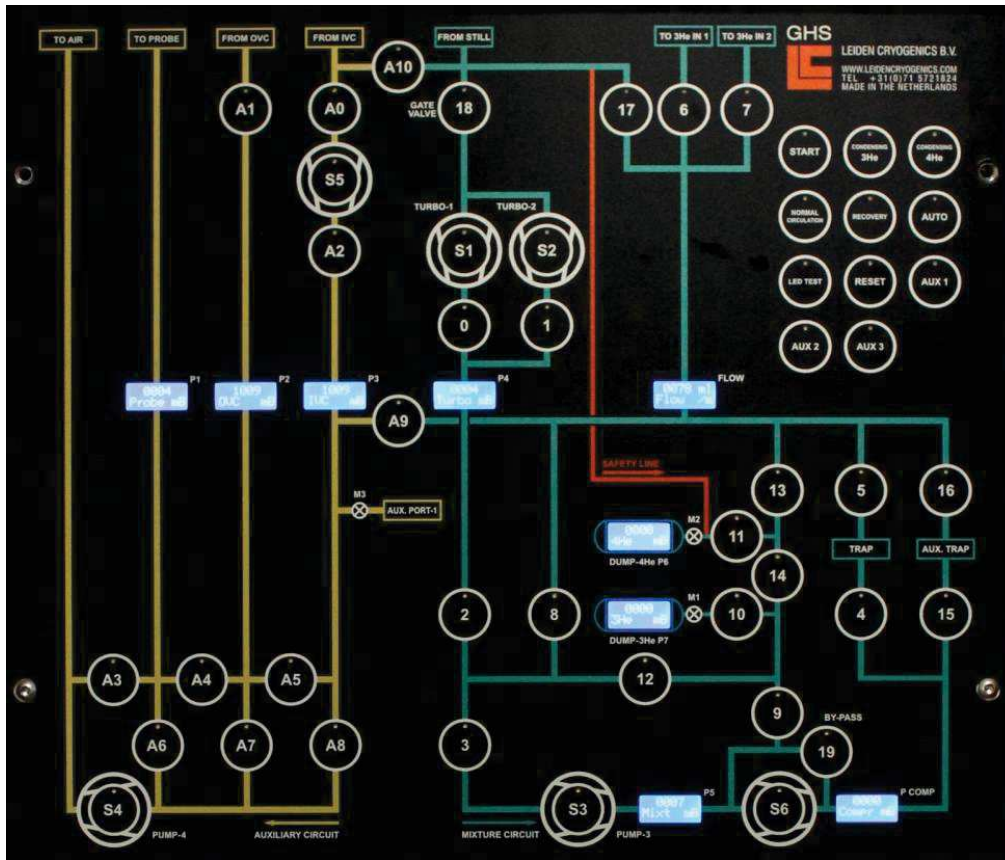
## Features of our Gas Handling Systems

- Turbo pumps with magnetically levitating rotor which has low wear and tear
- Multi-claw roots pump for backing the turbos (typically GX series from Edwards)
- The above two choices make our GHSs much quieter and the circulation circuit maintenance free
- Double membrane mixture compressor for the cryogen-free systems
- An extra scroll pump for general vacuum (in CF systems) and 1K pot pumping (in wet systems)
- Flowmeter
- Two charcoal traps including liquid nitrogen dewar
- Quad Current Source power supply for low power heating of refrigerator stages
- Microprocessor controlled pneumatic valves and relays
- UPS for safe recovery in case of power failure
- High power heater power supply to power the heaters in the fridge for overnight warm-up



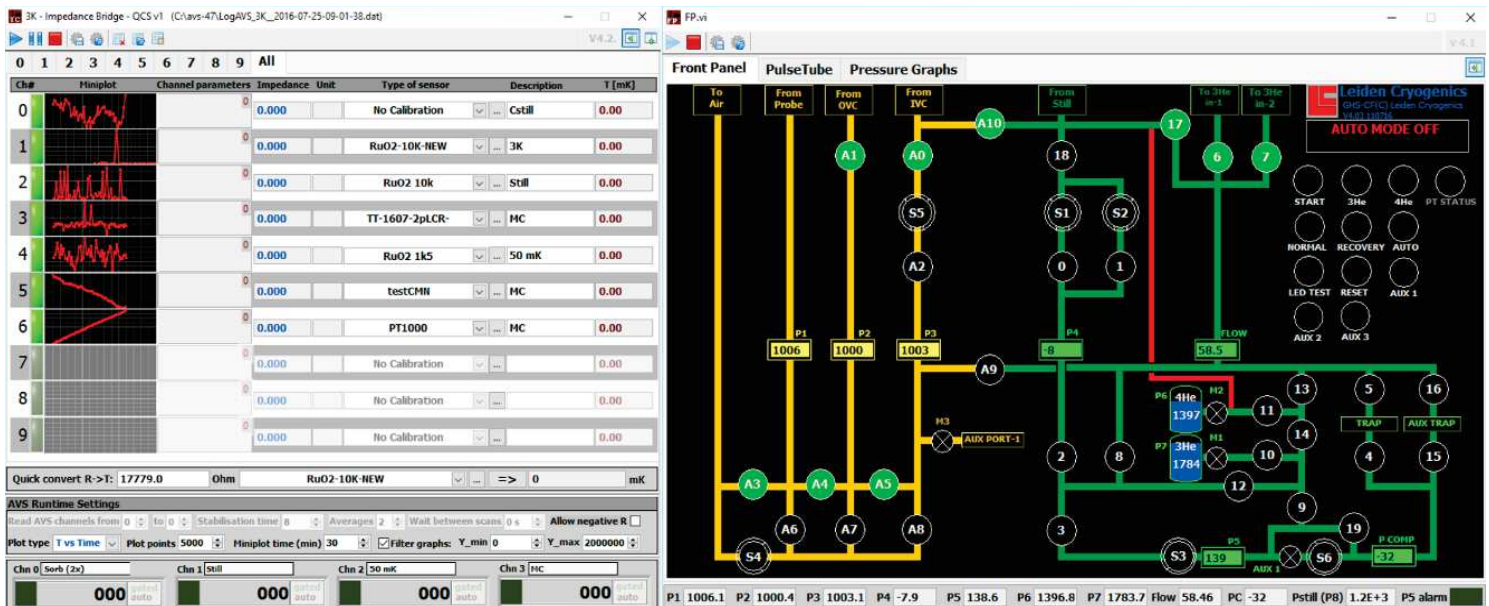
Vibration level of the Maglev GHS when compared to the traditional choice of pumps





- The front panel of the GHS (shown above) has access to all the valves and automation controls via piezoelectric switches. It also contains displays for the pressure gauges and flowmeter readouts

- A **laptop computer** with (labview based) software to remotely operate the system (valves, pumps, gauges, automation programs, cold-insertable probe-lift operation, PT compressors, thermometry and heating) is provided. The interface of the programs looks like shown below





# THE COMPANY



Founded in January 1992 by Prof. Giorgio Frossati and Alex Kamper

Three locations in Leiden:  
**Kenauweg** (Fabrication, assembly, cryogenic tests and administration)  
**Ananasweg** (Fabrication)

22 employees (+ interns):  
4 - Physicists  
1 - Electronics engineer  
3 - Office and support  
Rest - instrument-makers

A strong tradition of innovation and openness to challenges!



## Prof. Giorgio Frossati

Our founder, Prof. Frossati has pioneered innovations in dilution refrigerators since 1970 having introduced silver powder heat exchangers. His dilution fridges have reached record low temperatures, one of which reached a continuously maintained temperature of 1.85 mK and a record cooling power of 25 micro-Watt at 10 mK. In 1980 he became a Professor of Physics at the University of Leiden where he researched quantum fluids and solids, ultra-low temperature techniques and gravitational wave detection. He now devotes all his time to Leiden Cryogenics





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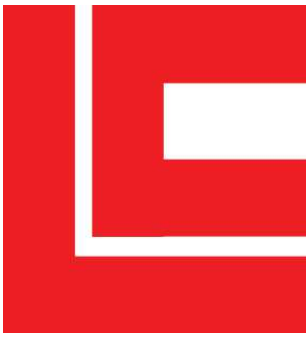
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