Flow Cryostat - Optical Microscopy

The LT3-OM and LT3B OM (UHV) are designed for optical microscopy and nano-photonics with unique features not found in other cryostats. In addition to the slim 1.52” (LT3 OM) profile that allows it to fit on most microscope stages. The LT3/(3B)-OM have a continuously adjustable sample holder, enabling the user to fine tune the placement of the sample within the working distance of their microscopy system.

The LT3-OM vacuum shroud is constructed entirely of polished stainless steel for a clean (High Vacuum) sample environment. The smooth durable stainless steel finish limits the residual vapor pressure of water and reduces the probability of mono-layers of water from forming on the sample surface. The LT3B-OM has all conflat flanges for UHV sample environment when sample surface cleanliness is extremely important.

The LT3-OM is designed for low vibrations (in the sub nanometer level) and low long term mechanical and thermal drift. this allows a scientist to take data from a small feature such as a quantum dot for an extended period without having to make any adjustments.

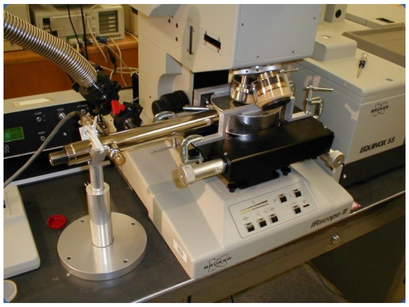
The above picture shows LT3OM Helitran®

Applications

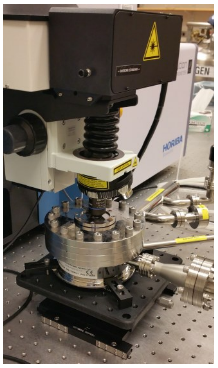
- Optical Microscopy and nanophotonics.
- Micro-Raman
- Quantum Dots
- Photoluminescence
- Micro-Photoluminescence
- Electro-Optical
- Magneto-Optical

Features

- Continuously adjustable sample height
- Slim profile
- Atomic level vibrations
- Liquid Helium or Nitrogen Flow
- Matrix Heat Exchanger for high cooling power at all temperatures.
- Co-Axial Shield Flow Transfer Line for low, stable flow.
- Sub 4K Operation (1.8K with pumping)
- 0.7 LL/hr liquid helium consumption (tip flow) at 4.2K
- Liquid Nitrogen Compatible (77K Operation)
- Precision Flow Control



The picture above shows LT3-OM Helitran® on a Bruker microscope.



The picture on the left shows an LT3B-OM for UHV sample environment installed on a Horiba Raman Spectrometer.

Typical Configuration

- Cold head LT3-OM (High Vacuum). Or LT3B-OM (Ultra High Vacuum)
- Coaxial Shield Flow Transfer Line
- Variable JT Valve at sample stage for sub 4K operation.
- High surface heat exchanger for capturing the cooling from the He. liquid and gas.
- Flow Meter Panel for Helium Flow Control and Optimization
- Sample Holder for Optical or electrical experiments. LCC, Flat Pack.

Options and Upgrades

- Two windows for transmission experiments.
- Magnet post option (to fit warm bore of a magnet)
- High Flow Transfer Line. For high cooling power.
- Custom temperature sensor configuration (please contact our sales staff
- Custom wiring configurations (please contact our sales staff)
- Sample holder upgrades (custom sample holders available)
- Window material and coating options.

Flow Cryostat - Optical Microscopy

Cooling Technology

LT3-OM	Open Cycle Cryocooler, Helitran
Refrigeration Type	Liquid Helium Flow
Liquid Cryogen Usage	Helium, Nitrogen Compatible

Temperature*

LT3 OM	< 4.2K - 350K (<2K with pumping)
With 800K Interface	(Base Temp + 2K) - 700K
With 450K Interface	Base Temp - 450K
Stability	0.1 K
*Based on bare cold head with a closed radiation shield, and no additional sources of experimental or parasitic heat load	

Sample Space

Diameter	19 mm (0.75 in). Options available.
Height	0-3 mm (0--0.12 in). Adjustable.
Vacuum Level	10^{-8} Torr.
Sample Holder	www.arscryo.com/Products/SampleHolders.html

LT3-OM Sample Vibrations (See Graphs below)

X-Axis	+/- 5-10 nm
Y-Axis	+/- 5-10 nm
Z-Axis	+/- 5-10 nm

Temperature Instrumentation and Control (Standard)

Heater	36 ohm wire wrapped Thermofoil Heater anchored to the coldtip
Control Sensor	Curve Matched Silicon Diode installed on the coldtip
Sample Sensor	Calibrated Silicon Diode with free length wires

Contact ARS for other options

Instrumentation Access

Instrumentation Skirt	Bolt On, Stainless Steel
Pump out Port	1 - NW 25
Instrumentation Ports	1
Instrumentation Wiring	Contact sales staff for options

Radiation Shield

Material	Nickel Plated OFHC Copper
Attachment	Bolt On
Optical Access	1 or 2

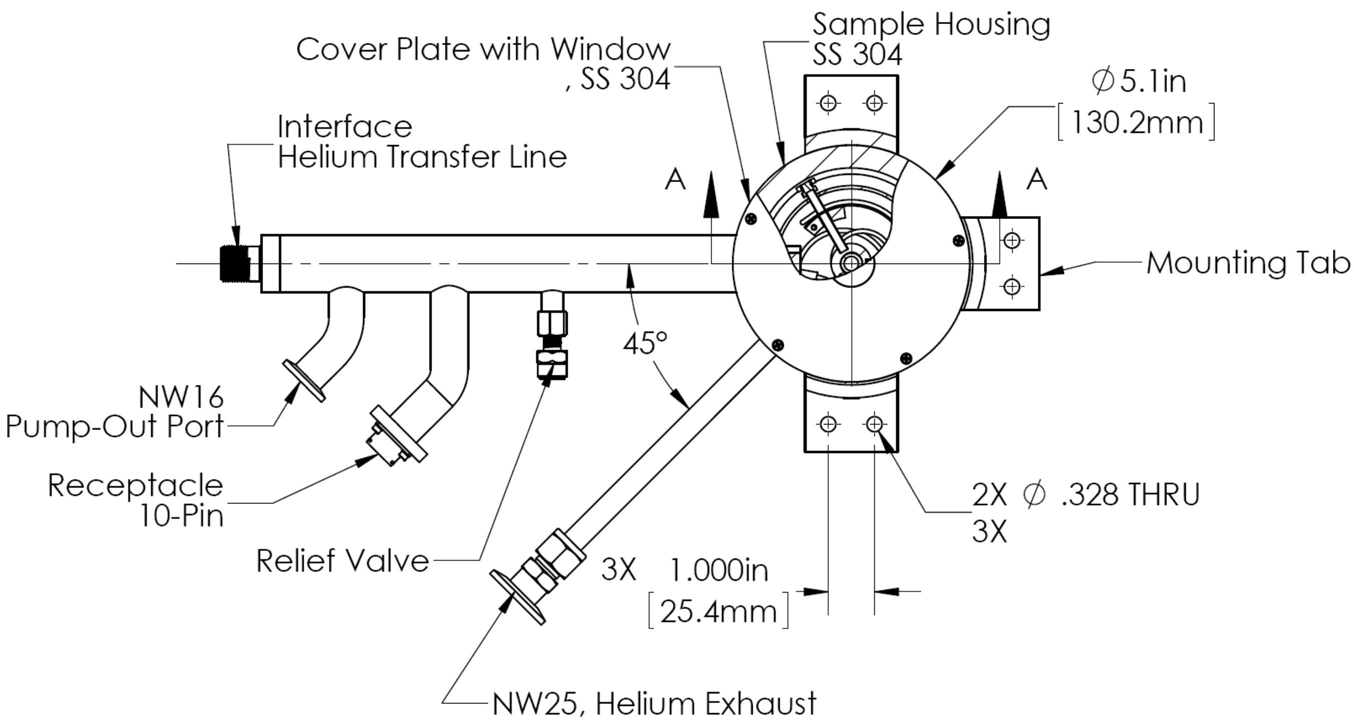
Cryostat Footprint

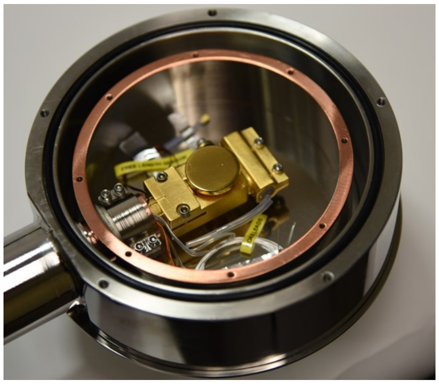
Overall Length	562 mm (22.12 in)

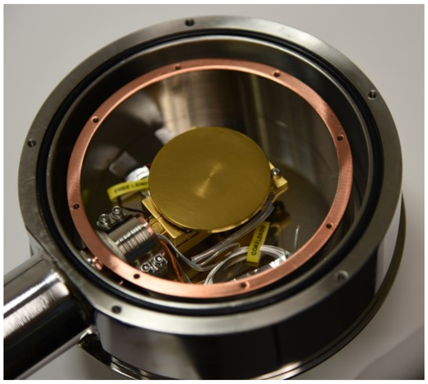
Cryostat Model	LT3-OM		
Cryogen	Liquid Helium		Liquid Nitrogen
Base Temperature	4.2K	<2K with Pumping	77K
Nominal Helium Consumption at 4.2K	0.7 LL/hr	-	
Cooling Capacity	0.7 LL/hr	2 LL/hr	
4.2K	0.5W	1.5W	
20K	3.0W	8.0W	
50K	7W	20W	
Maximum Temperature	450K with cold gas through transfer line		
Cooldown Time	20 min		
Weight	0.9 kg (2 lbs)		

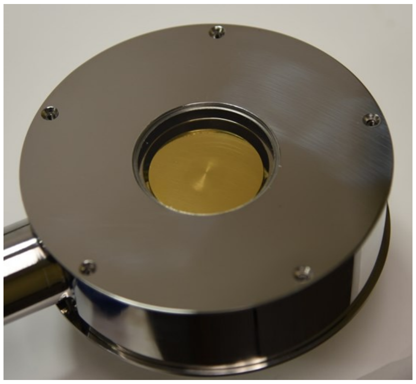
Flow Cryostat - Optical Microscopy

LT3-OM Outline Drawing









Left to Right. The LT3 OM is a Modular system with many sample holder options. All 4K components are gold plated (4-5μ layer of gold) for low temperature performance. Sample holders can be a variety of sizes, for reflection or transmission. The sample holder to window distance is continuously adjustable via a screw mechanism.

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Flow Cryostat - Optical Microscopy

Cooling Technology

LT3B-OM UHV	Helitran for extreme low drift.
Refrigeration Type	Liquid Helium Flow
Liquid Cryogen Usage	Helium, Nitrogen Compatible

Temperature*

LT3B-OM	< 2.8K with a 5 CFM mechanical pump.
Cooling power	2.25 Watts at 3.1K (5PSI setting in
Cooling power	4.5 Watts at 10K, 5PSI setting.
Stability	0.1 K
*Based on bare cold head with a closed radiation shield, and no additional sources of experimental or parasitic heat load	

Sample Space

Diameter	19 mm (0.75 in). Options available.
Height	0-3 mm (0--0.12 in). Adjustable.
Vacuum in sample space	10^{-11} Torr. Bakeable.
Sample Holder	www.arscryo.com/Products/SampleHolders.html

LT3B-OM Sample Vibrations (See Graphs on Page 3)

X-Axis	+/- 5-10 nm
Y-Axis	+/- 5-10 nm
Z-Axis	+/- 5-10 nm

Temperature Instrumentation and Control (Standard)

Heater	36 ohm wire wrapped Thermofoil Heater anchored to the coldtip
Control Sensor	Curve Matched Silicon Diode installed on the coldtip
Sample Sensor	Calibrated Silicon Diode with free length wires

Contact ARS for other options

Instrumentation Access

Cryostat Body	Stainless Steel, all conflat flanges.
Pump out Port	1.33 inch miniconflat
Instrumentation Ports	1
Instrumentation Wiring	Contact sales staff for options

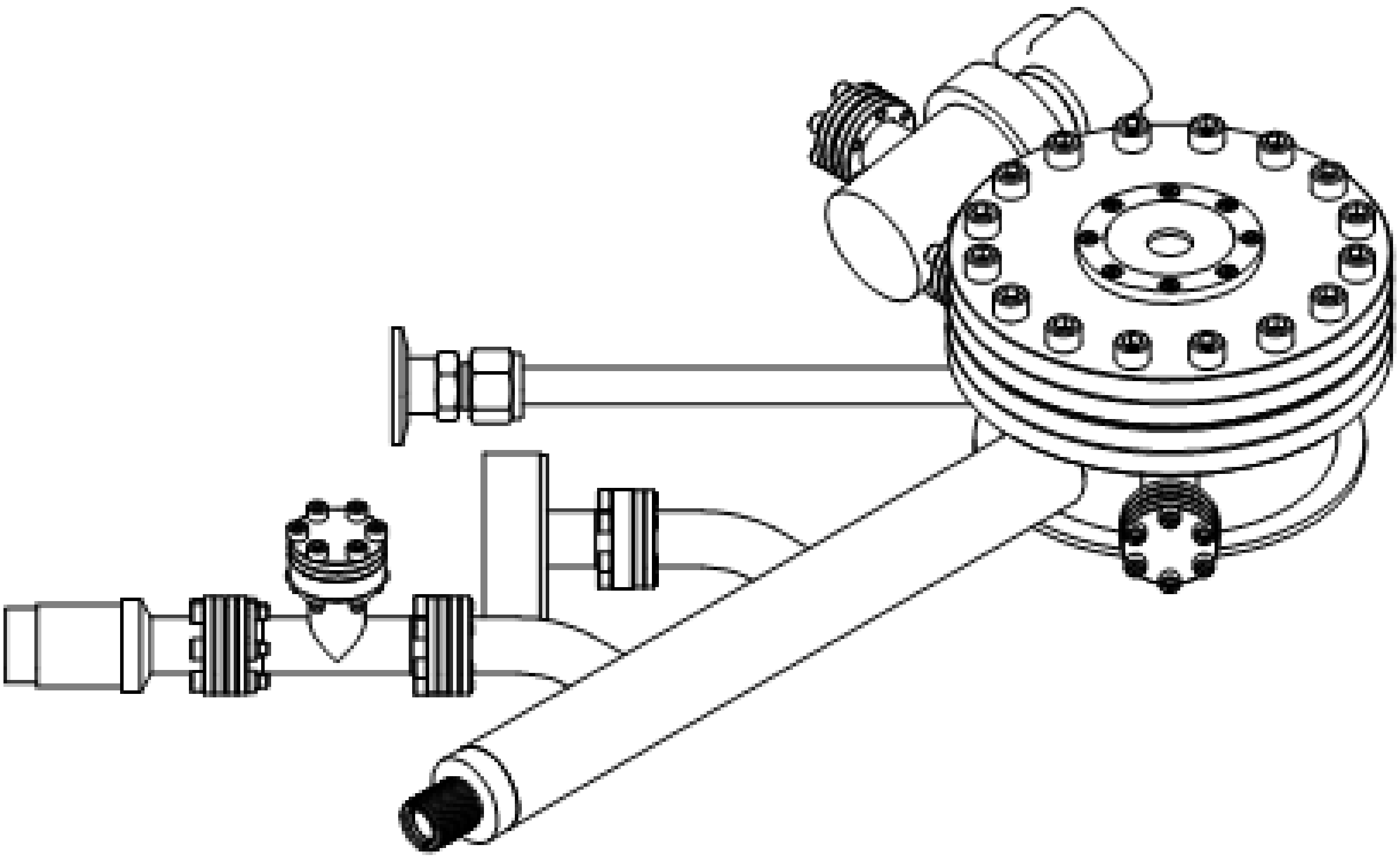
Radiation Shield

Material	Nickel Plated OFHC Copper or Gold.
Optical Access	1 or 2 (Transmission)

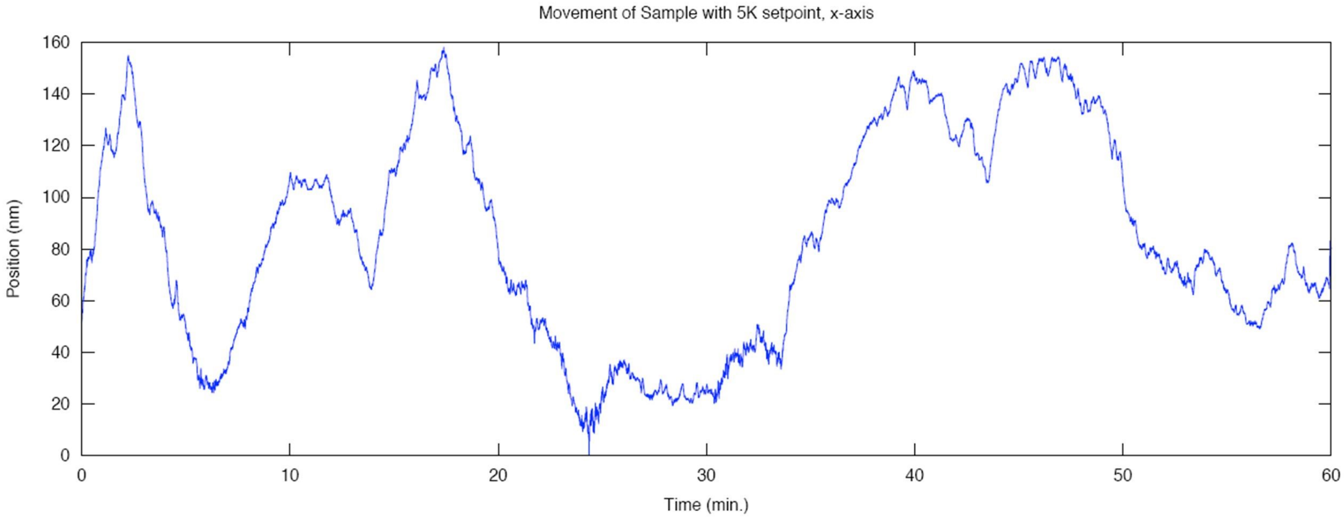
Cryostat Footprint

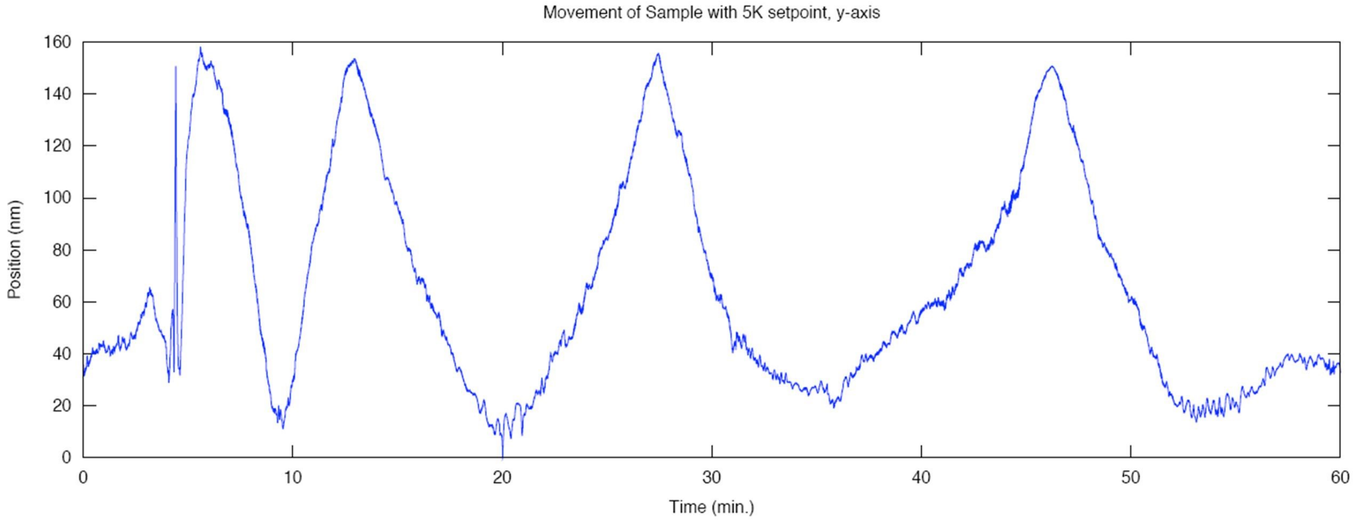
Overall Length	562 mm (22.12 in)

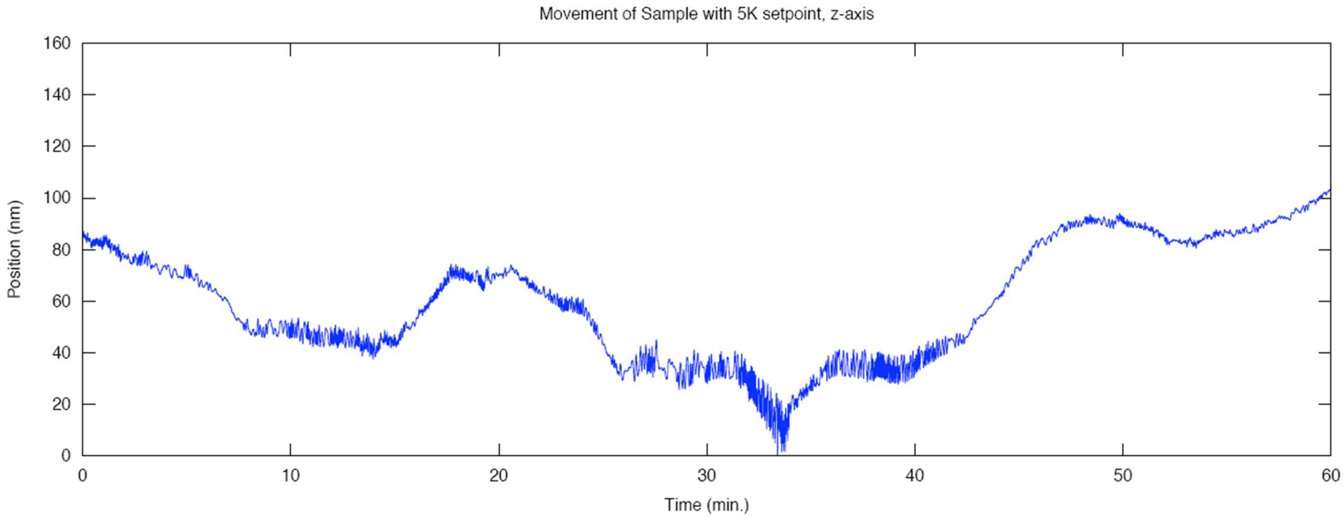
LT3B-OM Outline Drawing



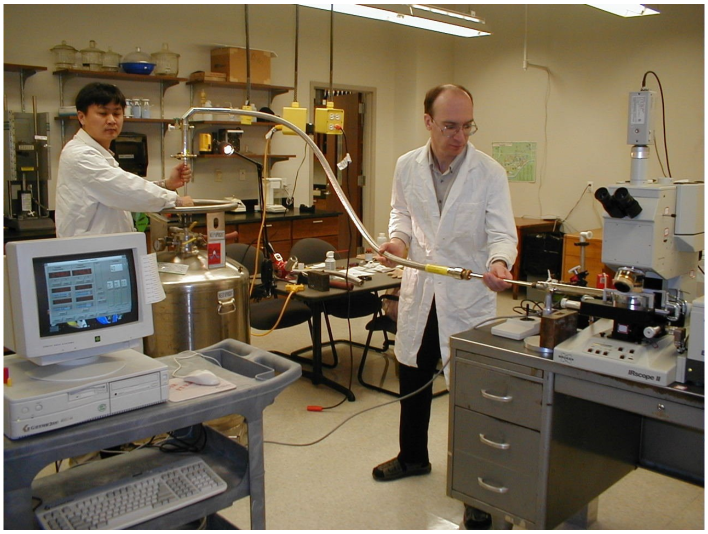
LT3-OM Drive and Vibration Levels (X, Y, & Z Axis)





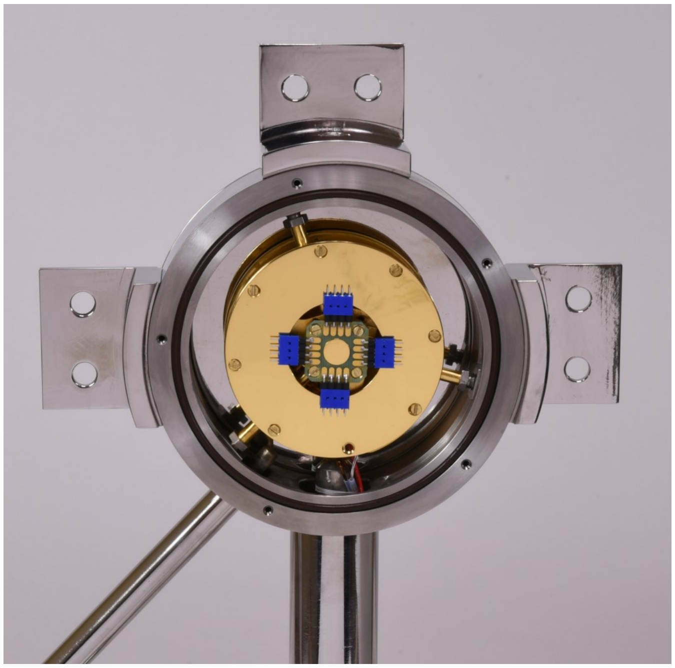


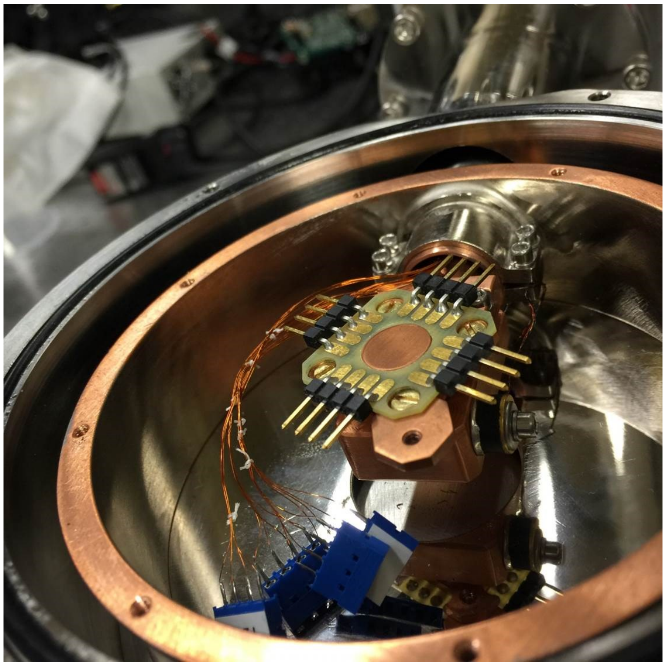
Flow Cryostat - Optical Microscopy



LT3 OM installed on a Spectrometer at the Musfeldt Lab, University of Tennessee.

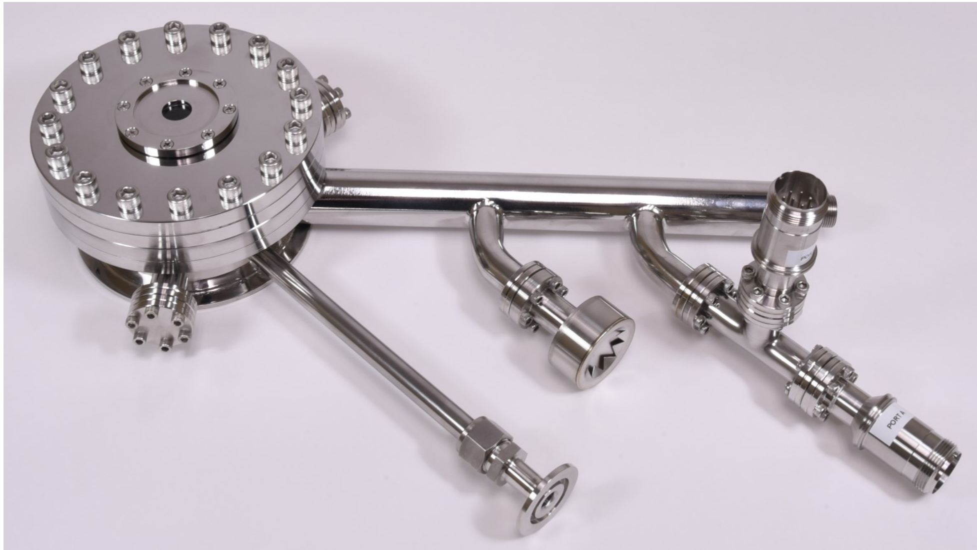
Courtesy Prof. Janice Musfeldt.

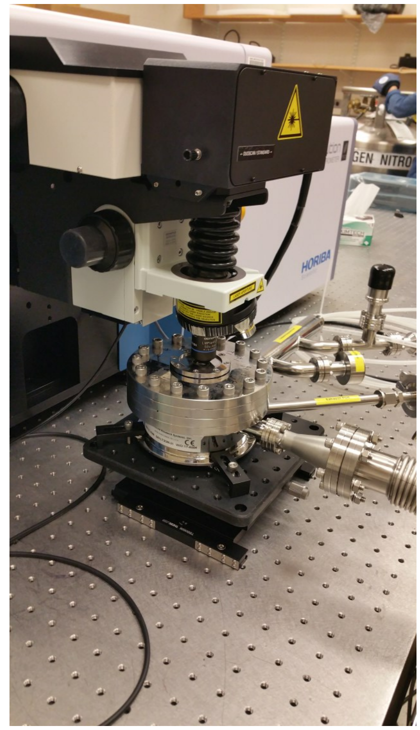




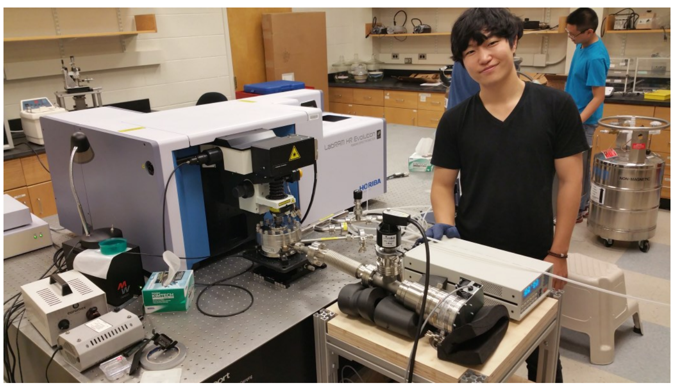
Sample Holder. Flat Pack, Circuit Board for device cooling.

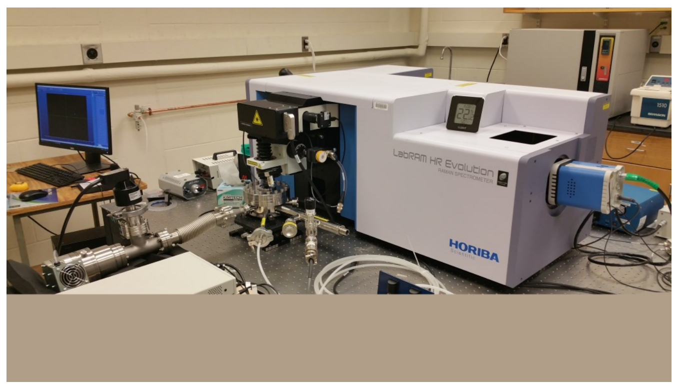
Flow Cryostat - Optical Microscopy





LT3 OM UHV is built for UHB and is bakeable to 150C. All Conflats flanges with copper gaskets. The window is specially designed to be field replaceable by the scientist.





LT3B OM installed in the Comin Lab at MIT. The cryostat is mounted on a two axis manipulator for sample to beam alignment.

Courtesy Prof. Riccardo Comin.

Flow Cryostat - Optical Microscopy

Advanced Features of LT3 Helitran®

The Helitran® has been designed for high performance with advanced features not normally found in traditional open cycle cryostats.

A detailed description of the **Matrix Heat Exchanger**, the **Adjustable Impedance Valve** and the **Coaxial Transfer Line** is presented in this paper.

Helium Consumption

Conventional Helium Flow Cryostats do not incorporate extended surface Heat Exchangers (at the sample mount) for cost reasons. The liquid helium is contained in a reservoir similar to a copper cup over the sample mount. As the helium boils and evaporates only the latent heat of vaporization is used to cool the sample mount, there is no provision to capture the enthalpy of the gas as it escapes from the cryostat at 4.2K regardless of the sample temperature. The cooling power of the gas is wasted. Enthalpy of Helium gas from 4.2 to 300K is substantial at 1542 Joules/gm.

The Helitran® incorporates an extended surface tip heat exchanger **(Matrix Heat Exchanger)** which provides efficient heat transfer between the helium and the sample mount. The Liquid helium flows through this heat exchanger and as the latent heat of vaporization cools the sample mount, the liquid evaporates, the gas continues to flow through the exchanger providing additional cooling (capturing the enthalpy of the gas) to the sample mount. If the flow is optimized the helium gas will exit the Matrix Heat Exchanger at a temperature equal to the sample temperature.

Helium usage is dramatically reduced as reported by J. B. Jacobs in Advances in Cryogenic Engineering, Volume 8, 1963, Page 529 as follows:

Amount of Cryogenic fluid required to cool metals (Liters/Kg.) to 4.2K.

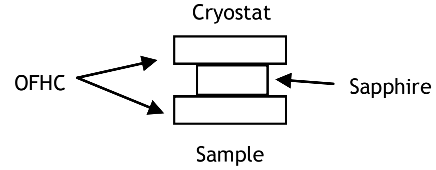
Cryogen	^{4}He	^{4}He
Initial Temperature of 1 Kg of Copper.	300K	77K
Final Temperature of 1 Kg of Copper,	4.2K	4.2K
Using the latent heat of vaporization only. **(Inefficient Heat Transfer)**	**31.1** Liters of Helium	2.16 Liters of Helium
Using the Enthalpy of Gas. (**Efficient Heat Transfer**)	**0.79** Liters of Helium	0.15 Liters of Helium

From this it is clear that for any sample size the consumption of He during initial cooldown is 40 times higher without an extended surface cryostat tip heat exchanger from 300K (room temperature) to 4.2K and 14 times higher when cooling from 77K to 4.2K.

Temperature Range

Sub 4.2K Operation: The temperature of helium drops to 1.8K when the pressure is reduced across an **Adjustable J T Valve (Impedance)**. Located inside the sample mount. In the Helitran® the vacuum pump connected to the exhaust drops the helium pressure in the sample chamber to sub atmospheric. Helium temperature is a function of pressure. this **Super-cooled helium** flows through the extended surface Matrix Heat Exchanger, The matrix heat exchanger and the conductively coupled sample mount are cooled to ~ 1.8K.

800K Operation: The high temperature can be achieved by incorporating a thermal switch, composed of a sapphire and OFHC copper arrangement as shown below. The unique property of sapphire is utilized, where its thermal conductivity is equal to that of copper from 4-300K but it becomes a thermal insulator above 300K. The high cooling power of the Matrix Heat exchanger protects the cryostat.



Temperature Stability

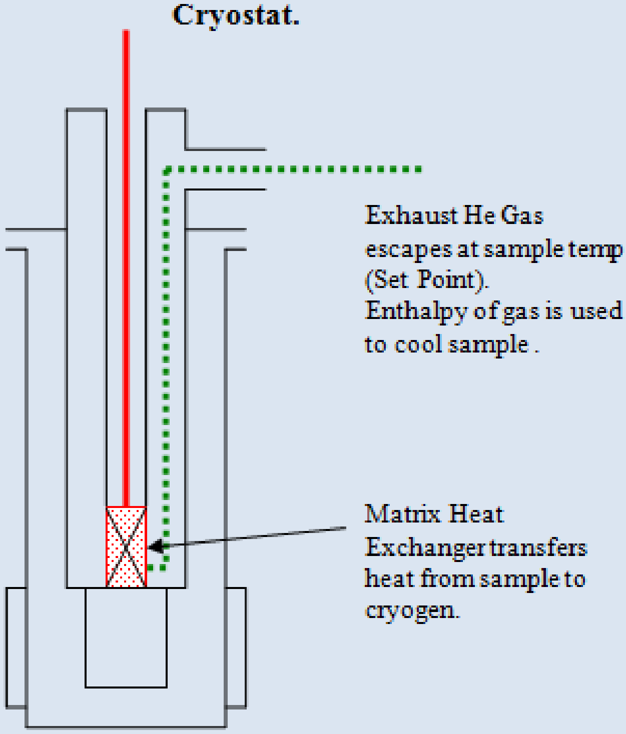
Conventional helium flow cryostats utilize a capillary tube in a vacuum jacket with superinsulation to reduce the radiant heat load. However as the helium absorbs radiant heat the liquid is vaporized and forms bubbles of gas which have a larger volume than the liquid thus forming a temporary block to the flow of the liquid called "vapor binding". At the delivery end of the transfer line this results in the liquid/gas mixture being delivered in spurts with accompanying pressure and temperature cycling.

The coaxial flow transfer line incorporates a shield flow (See figure) surrounding the tip flow for the entire length of the transfer line. The entrance to the coaxial shield flow tube is provided with a nozzle which results in a pressure and corresponding temperature drop in the shield flow which subcools the tip flow in the center tube. This subcooling prevents boiling and gas bubble formation in the helium, even at very low flow rates. The Helium is delivered at the sample end with the desired temperature stability and low vibrations.

Flow Cryostat - Optical Microscopy

Cryostat Design Features

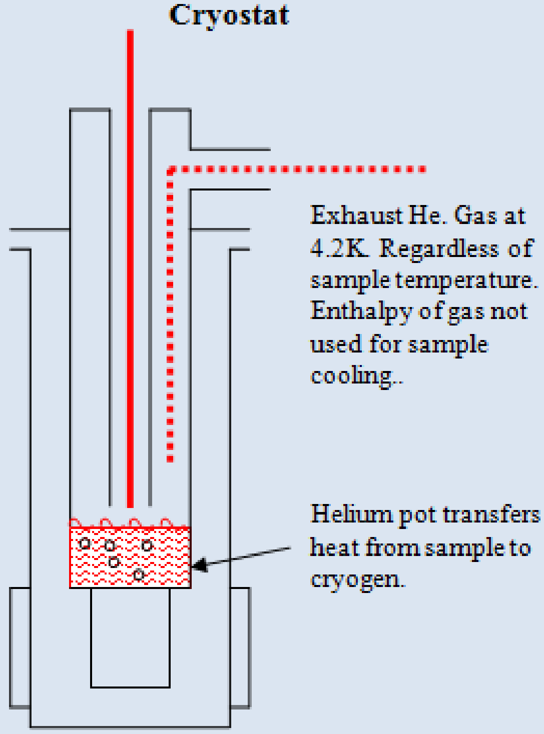
Helitran® Continuous Flow Cryostat.



Helitran® Features:

- Matrix Heat Exchanger for efficient heat transfer between sample mount and cryogen.
- Orientation independent.

Conventional Continuous Flow Cryostat

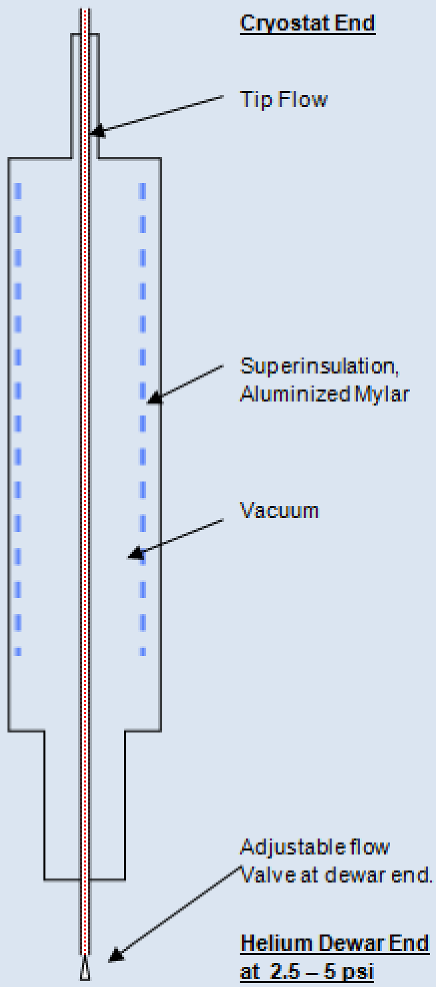


Conventional Helium Flow Cryostat Features:

- Helium reservoir exchanger results in helium boiling with resulting vibrations from the bubbling.
- Orientation dependent as helium is gravity contained.
- Gas escapes at 4.2K. No provision for heat transfer between sample mount and Helium gas from 4.2K to the sample temperature.

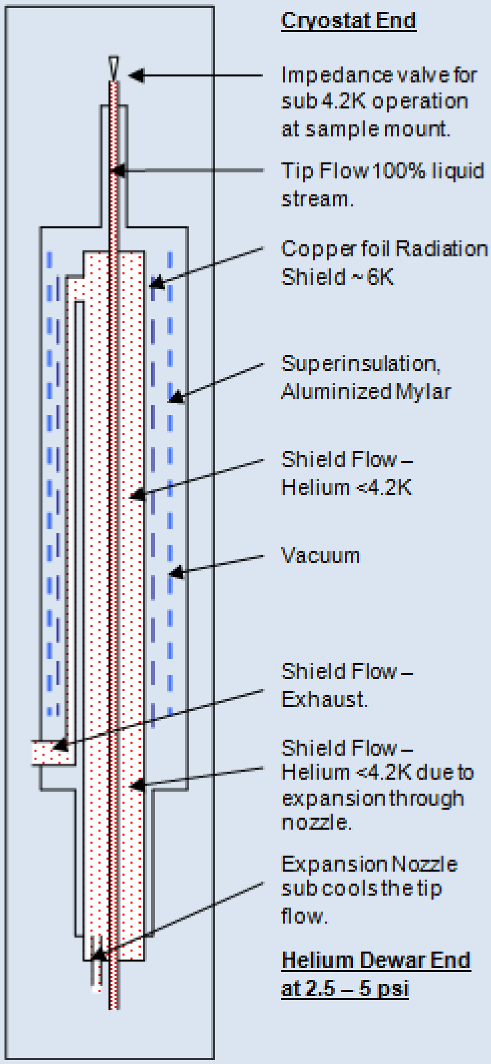
Flow Cryostat - Optical Microscopy

Helium Flow Transfer Line Features



Conventional – Superinsulated, vacuum-jacket Helium Transfer line, Features:

1. Simple inexpensive construction.
2. Flow control at dewar end.
3. Vacuum Jacket.
4. Superinsulation, Aluminized mylar. Provides insulation.
5. Percentage of liquid / gas mixture depends on helium flow rate.



High performance – Coaxial flow, Helium Transfer line, Features:

1. Flow control at cryostat end allows precise flow control (cooling power) at sample. Also permits lower temperature during sub 4.2K operation.
2. Shield flow enters the outer tube through an expansion nozzle, the resulting pressure and temperature drop sub cools the tip flow.
3. Shield flow is surrounded by copper foil radiation shield plus superinsulation in vacuum jacket.
4. Sub cooled tip flow is delivered as 100% liquid at very precise and low flow rate. No “Vapor Binding”.