Cryostation® xp100

Ultra-low Temperature, Closed-Cycle Optical Cryostat

KEY FEATURES:

- Reach critical transitions and reduce thermal noise with temperatures from 1.7K - 350K
- Fully automated operation with push-button cooling and temperature control via an embedded user interface touchscreen
- Leverage existing optical setups & maximize collection efficiency with direct, free-space high NA access
- Test components quickly with an overnight cycle time prior to long & expensive cooldowns in mili-Kelvin (dilution refrigerator) systems
- Exchange samples without warming up the entire system via unique vacuum barrier separation technology

The Cryostation xp100 platform integrates liquid helium cooling technology with the benefits of an automated, closed-cycle cryostat. The system offers full variable temperature control from 1.7 - 350K.

The “off-table” design reduces energy transfer to the experimental setup by moving the cold head off the table while still maintaining superior sample and optical access on the platform.

Cryostat Features

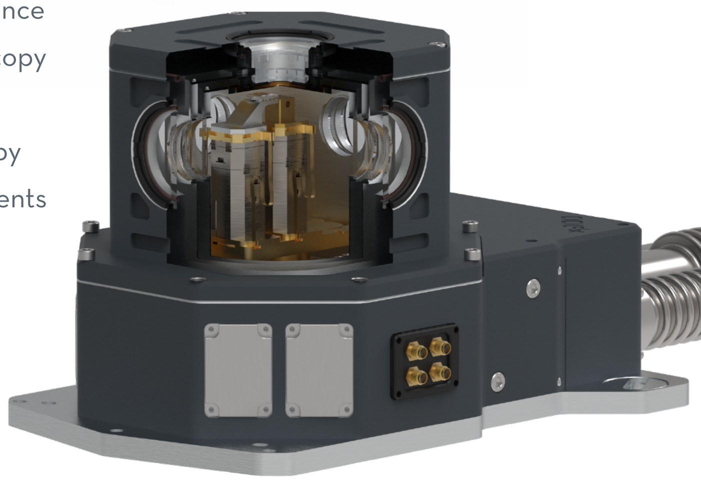
Based on the user-friendly design of Montana Instrument’s proven base platforms, the xp100 offers:

- Low cost, helium-free operation
- Fully-automated control
- Versatile & flexible tabletop sample chamber access
- Optimized temperature performance & thermal stability
- Unobstructed sample & optical access
- Multiple access ports for universal feedthrough options

Applications

The xp100 is ideal for experiments which would benefit from lower temperatures while maintaining high collection efficiency, including:

- Quantum Information Science
- Single Molecule Spectroscopy
- Single Photon Sources
- Quantum Dot Spectroscopy
- Cavity Enhanced Experiments



Specifications and other information subject to change without notice.

Crossover Premium "xp" Cooling Technology

Thermal Performance

Superior Thermomechanical Stability

The crossover design of the xp100 makes it easier than ever to reach and maintain temperatures of <1.7K for increased experimental flexibility. A closed-cycle cryocooler with a proprietary liquid helium (LHe) generation and recirculation method delivers pumped (low pressure) LHe to the sample chamber platform.

Figure 1 shows a typical cooling cycle of the xp100. The system contains two helium reservoirs: one in the cooler and the second below the sample platform. In the first cooldown of the system, the cooler reservoir fills with LHe (orange curve). During a sample cooldown, this LHe supply is transferred to the platform reservoir (blue curve). A proprietary sample exchange barrier provides thermal and vacuum separation of the two reservoirs, allowing the cooler to remain cold while the sample platform is cooled and warmed up independently, enabling quicker sample exchange cycles.

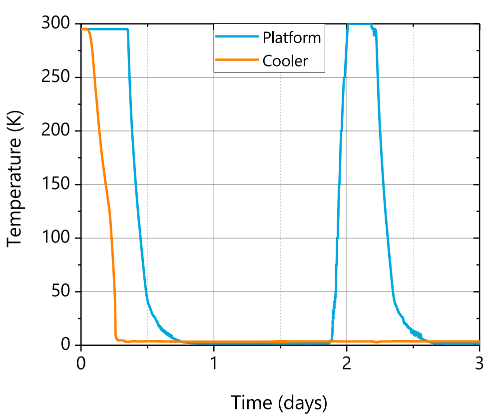


Figure 1: Initial system cooldown and sample platform warmup & cooldown cycle

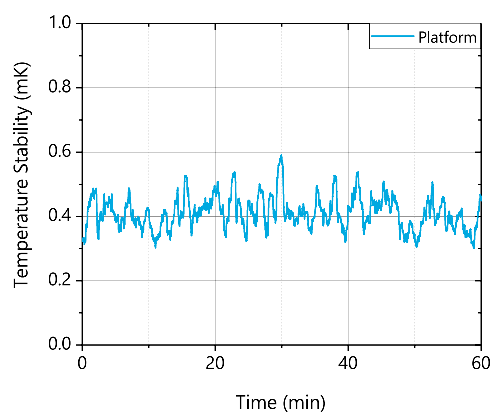


Figure 2: Peak to peak temperature stability of the platform

Figure 2 shows the temperature stability of the platform at base temperature over a one hour period. The excellent (<1mK) temperature stability is the result of the high heat capacity of LHe, closed-circuit pumped LHe platform cooling, and a dual radiation shield design which greatly reduces radiative heat loads in the sample space.

Cooling Power

Improved Experimental Flexibility

High cooling power compensates for experimental heat loads which would typically impact base temperature, such as thermal or radiative loads from user wiring, laser input, or optical windows.

The optimized cooling power in the xp100 is achieved by careful thermal design and proprietary mass flow control. The thermal performance of the xp100 is further enhanced with heat exchangers at each radiation shield which pull additional thermal energy out of the sample chamber and thermal lagging (wiring) locations, so no cooling power is wasted.

This design reduces the cryogenic expertise required for operation while increasing configuration flexibility and improving sample access.

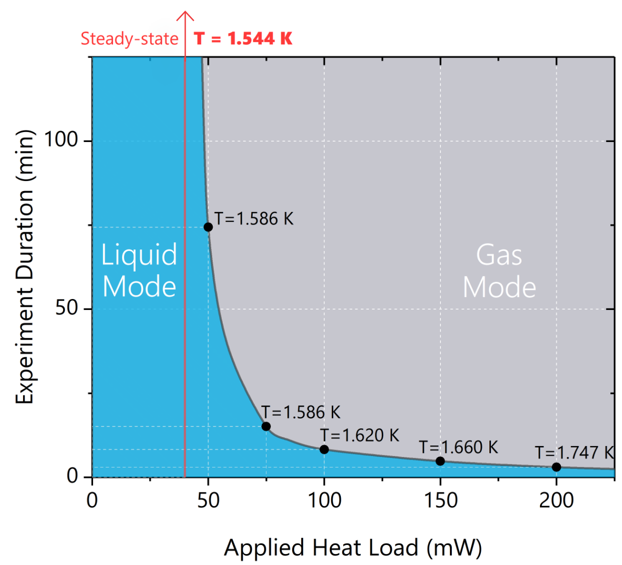


Figure 3: Applied heat loads with corresponding platform temperature over time

Single Shot Experiments

Figure 3 shows the hold time and platform temperature for user applied heat loads. The baseline xp100 configuration (2 RF coax lines, 25 DC wires, 3 optical windows) can accommodate an ***additional*** 40mW of heat load and remain at base temperature ***indefinitely*** (red line). For users who need to apply larger heat loads, the xp100 allows "single shot" measurements for limited amounts of time. A heat load of greater than 40mW will eventually deplete the sample platform LHe reservoir, resulting in a finite experimental duration (Figure 3). To return to an optimal cooling state after the liquid "boils off" to gas (grey area), the reservoir can be regenerated in less than 12 minutes by removing the active heat load.

Mechanical Performance

Platform Positional Stability

The crossover technology separates the GM cryocooler from the optical table by isolating the cooling architecture to an adjacent, free-standing cabinet. The vibration inducing components inside this system are further isolated with tuned dampers. This combined approach greatly reduces the baseline vibrations without the need for complex external supports or dedicated tables.

Minimized Experimental Energy Transfer

The vibration isolation system has been designed to damp all major optical table and component resonant modes to ensure the end user's optical table remains optimized for the most sensitive experiments.

Figure 4 shows a frequency comparison of the optical table energy for three different systems. Many basic cryostat designs rigidly mount the cold head to the optical table (red line), whereas the standard on-table Cryostation platforms leverage patented vibration damping to isolate this energy transfer (grey line). The xp100 architecture (blue line) represents even further reductions in table energy by removing the cold head from the optical table completely.

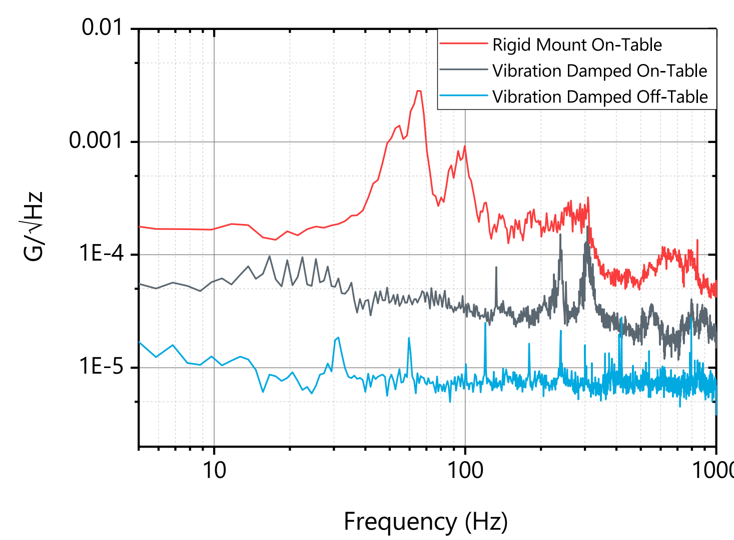


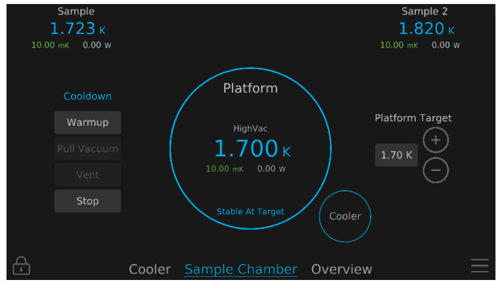
Figure 4: Optical table acceleration comparison (measured in Z axis)

USER CONTROL

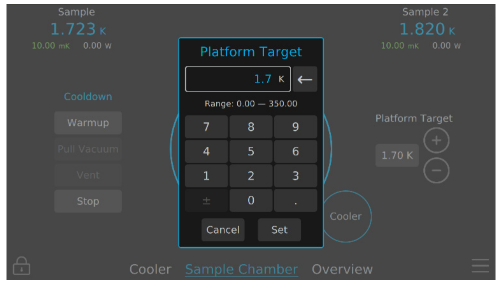
Measurement Throughput

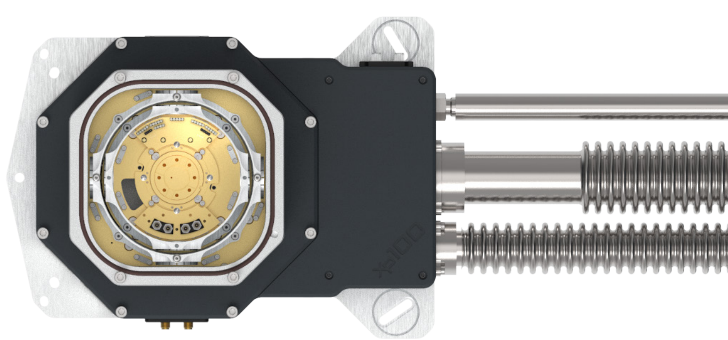
- Access & exchange samples while maintaining alignment of all components by simply lifting off the cryogenic housing and radiation shields
- Input, monitor & change the sample temperature on a single touchscreen interface (shown below)
- Warmup & cooldown the sample chamber while keeping the rest of the system cold for maximum efficiency

TEMPERATURE READOUT SCREEN



TEMPERATURE INPUT SCREEN





Specifications

Last Updated: February 22, 2019

Baseline system includes: 2 RF coax lines, 25 DC connections & 3 optical windows

	Cryostation xp100	Notes
PERFORMANCE DATA		
Temperature Range	1.7 K - 350 K	
Temperature Stability	<2 mK <200 mK <50 mK	peak to peak at base T (1.7K) 1.7K - 15K 15K - 350K
Vibrational Stability	<20 nm	peak to peak (measured on platform in x-axis)
Cooling Power @ Base T	>20 mW	in addition to baseline configuration above
Sample Cooldown Time to Base T	~12 hrs	using vacuum barrier
Sample Warmup Time	~2 hrs	
Vacuum Pressure	<5.5 x 10^{-8} torr	measured in sample space (at base T)
OPTICAL PROPERTIES		
Optical Access	3 optical ports	2 radial + 1 overhead (4 radial available)
Acceptance Angle	30° full angle 80° full angle 120° full angle	Sample at center of sample space Sample located near cold window Sample located near warm window
INTERFACING		
Electrical Access	25 user connections	Feedthroughs to DC connectors pre-lagged to the platform
Interface Side Panels	one three	quad RF feedthrough (2 coax routed standard, 2 more available) blank for additional RF, DC, gas & fiber options
Thermal Lagging	6 locations	To radiation shield
Temperature Sensors	2 Calibrated Cernox™	Corresponding to platform and sample temperature Location for 1 additional user thermometer available
DIMENSIONS		
Sample Space (diameter x height)	ø 92 mm x 92 mm	Inner radiation shield
Beam Height	147 mm	Options available to modify
OPTIONS		
Sample Mounting	User specified	Standard (fixed, adjustable, electrical) & custom alternatives available
Sample Motion	Optional piezo stage integration	Stages mounted on platform

Note: Unless noted otherwise, product specifications are on a baseline system; various options, configurations, and/or custom modifications may cause slight differences. Specifications above are based on a Beta testing of the system and are subject to change in the final design.

Power Consumption

Maximized Efficiency

The entire system is powered by a closed-cycle GM cryocooler which runs off a single-phase, air cooled compressor. This cooling architecture minimizes the infrastructure demands and overall energy requirements of the system. The smaller cold head optimizes performance by generating less overall mechanical noise compared to larger cryocoolers, enabling users to maintain a focus on their measurements rather than the cryogenic equipment.