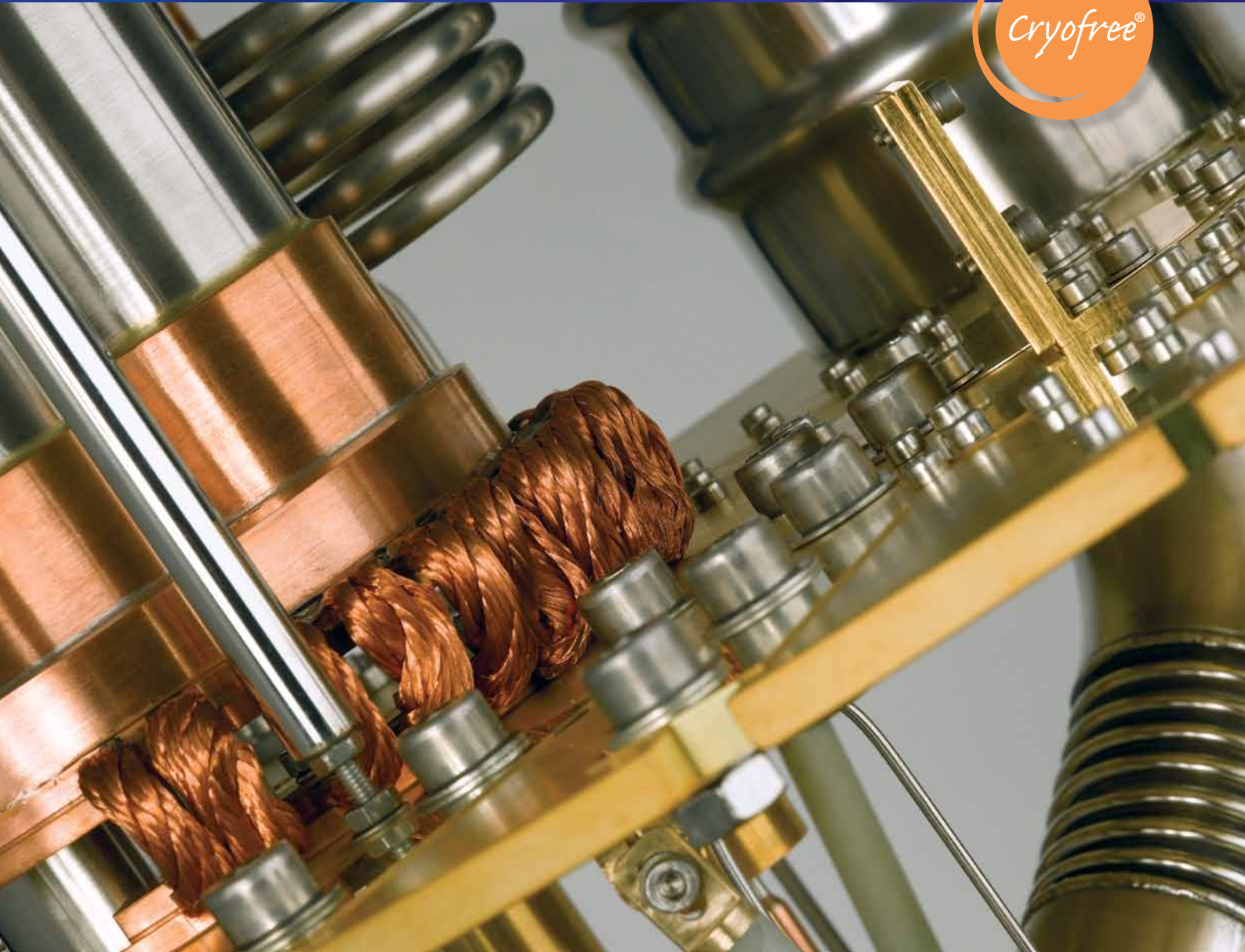


# TRITON

## Triton™ Product Family

Cryofree® dilution refrigerators



*The Business of Science®*



# Why is the **Triton** the right choice for you?

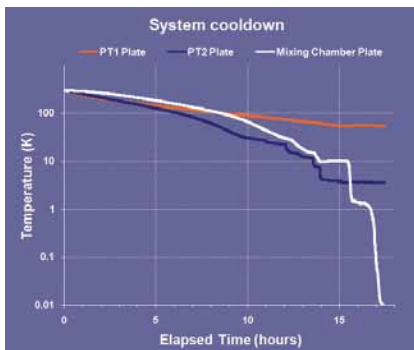


Figure 1: Triton cooldown time with 2 kg sample

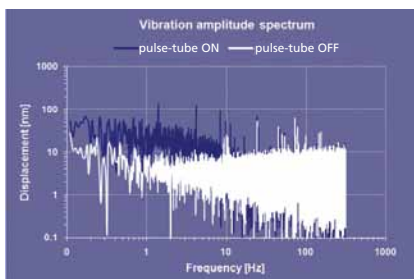


Figure 2: Vibration spectrum

## Cooldown times

**Triton** offers rapid turnaround times thanks to its unique and highly efficient pre-cool loop. Figure 1 shows a 2 kg sample mounted on the mixing chamber plate being cooled from room temperature to 10 mK in 17 h. Systems with an integrated 12 T superconducting magnet take typically 32 h to cool without using any liquid nitrogen.

## Vibration levels

The **Triton** concept offers an ultra-low vibration environment suitable for the most sensitive experiments. As shown in figure 2, absolute vibration amplitudes less than 100 nm across the spectra have been measured optically by one of our customers on a bottom loaded attocube stack mounted on the mixing chamber. Further measurements on an STM device showed tip to sample vibrations being less than 5 nm peak to peak.

Mechanical cooling has many benefits over conventional liquid cryogenics in terms of running costs, logistics, equipment complexity as well as health and safety concerns for inexperienced users. In recent years, the rapid improvement in performance and reliability of mechanical coolers, in particular Pulse Tube Refrigerators (PTRs) has enabled the development of Ultra Low Temperature platforms with low vibration characteristics.

## Mode of operation

In traditional low temperature inserts, condensation of the  $^3\text{He}$  or  $^3\text{He}/^4\text{He}$  mixture is achieved using a 1 K stage pumping on a  $^4\text{He}$  pot through a needle valve used to control the flow. Such a 1 K stage relies on a reservoir of liquid helium available within the cryogenic system. In moving away from the use of liquid cryogenics new condensation mechanisms are required. By driving condensation at higher pressures, higher condensation temperatures are possible, bringing these low temperature inserts within reach of the operating range of PTRs.

**Triton** Dilution Refrigerator condenses the returning  $^3\text{He}$  mixture using a Joule Thomson valve within the still pumping line for effective heat exchange.

- PTR technology enables low temperature instrumentation without liquid cryogenics
- Raising the condensing pressure allows condensation at temperatures well in excess of 1 K



**Triton200** with 10 x high frequency coax, 2 x fibre optics, 10 x flexible coax, 96 D.C leads. Temperature achieved < 10mk.

# TRITON

## Temperature control is critical for careful sample characterisation of any new material or device.

The inherent base temperature stability of the system without an active temperature control feedback loop can be seen in Figure 3 (a). The temperature measured was  $8.3 \pm 0.2$  mK. In separate experiments when over biasing the control sensor, the closed loop control of the system can be improved.

In the temperature range 20–300 mK control to better than  $10 \mu\text{K}$  has been achieved. Also shown in Figure 3 (b) is the measured mixing chamber temperature whilst controlling the temperature at 30 K and simultaneously ramping an integrated magnet from zero field to 12 T and back to zero at 0.3 T/min. The standard deviation of the temperature measurements was 3.5 mK and the maximum deviations were approximately  $\pm 7$  mK.

- $< 1$  mK open loop base temperature stability
- 4 decades of continuous temperature control

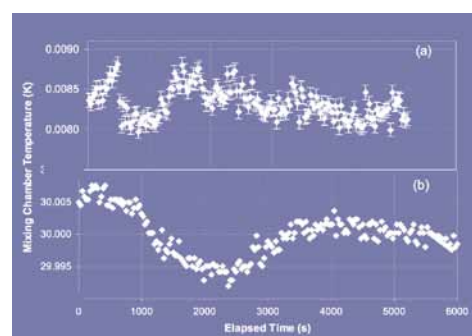


Figure 3: Temperature stability

## Why should you purchase your next Cryofree dilution refrigerator from Oxford Instruments?

- Cryofree dilution refrigerator and magnet from one supplier with guaranteed system performance
- Widest temperature range from 10 mK to 30 K in fields up to 18 T
- Modular design with no indium seal or exchange gas required
- The only Cryofree top-loading solution that achieves  $< 10$  mK at the sample position
- The largest installed base with over a hundred Triton systems sold worldwide
- Top and bottom sample loading

Oxford Instruments is the only supplier to offer:

- Local service support
- Comprehensive wiring options including low electron temperature high frequency wiring
- Most  $^3\text{He}$  efficient system on the market

## Triton control software

- TCP/IP Communication protocol
- Remote control access software for measurement scripting
- Auto-cool down and auto-run routines allow unattended operation
- System can be set up to allow remote diagnostics by our service team
- Fully integrated magnet control with safety features
- Free future upgrades
- Integrated routines for optional UPS, high-temperature operation and sample loading



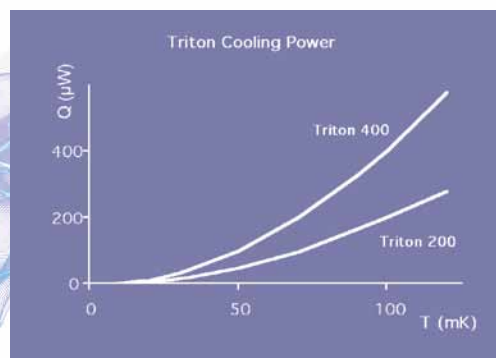
For more detailed information please see: Integration of superconducting magnets with cryogen-free dilution refrigerator systems Batey et al., *Cryogenics* 49 (2009) 727–734

# TRITON

## Triton Dilution Refrigerator

### 10 mK without the need for liquid helium!

- Low vibration pulse tube refrigerator technology
- 10 mK base temperature
- 200 and 400  $\mu\text{W}$  cooling power at 100 mK
- 3  $\mu\text{W}$  cooling power at 20 mK
- Fast cooldown times of less than 24 hours
- Excellent temperature stability from 10 mK to 30 K
- Automatic gas handling system
- Oil free circulation pumps
- Single common vacuum, no requirement for exchange gas
- 240 mm x 240 mm sample space enabling integration of complex experimental set-ups
- Built in cryogenic cold trap technology traps contaminants
- Central access for top loading
- Compatible with integrated superconducting magnet systems up to 18 T, wiring services or sample loadlock for a complete Cryofree solution



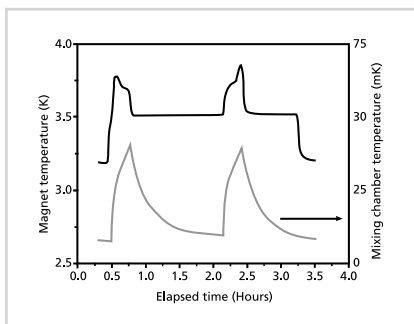
**Award  
winning  
product**

# Environment and sample handling

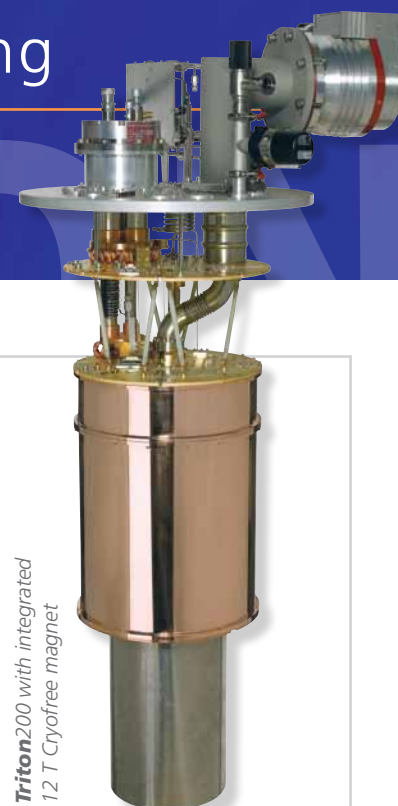
## Integrated superconducting magnets provide combined B/T environments cooled by a single PTR

A range of integrated superconducting magnets are available for the **Triton** range.

- 3, 5, 8, 12 and 15 T solenoids available as standard options
- **NEW Triton Ultra** offers magnet options up to 18 T
- HTS current leads for low heat dissipation between 50 K and 4 K
- Fast ramping capability using the latest high field, low loss Nb<sub>3</sub>Sn developed by Oxford Instruments
- 70 mm cold bore standard on NbTi coils, 57 mm cold bore standard on Nb<sub>3</sub>Sn coils
- 1 in 10<sup>3</sup> over 10 mm dsv homogeneity
- 1 in 10<sup>4</sup>/hr stability with persistent mode switch fitted
- Custom designs, split pairs and Vector Rotate coils available on request



Integrated magnet warming and cooling during 5 T field sweep, hold at field and sweep back to 0 T (sweep rate 0.31 T/min). Local eddy current heating at the mixing chamber also shown during field sweep with time to recover back to base temperature ~1 hour. 3  $\mu$ W cooling power available at 20 mK.



Triton200 with integrated 12 T Cryofree magnet



Triton top loading with sample carrier and loading probe

## Top and bottom loading loadlock for fast sample exchange

- Patented design
- 15 min sample exchange
- Cooldown time < 8 hrs
- Top-loading demountable sample carrier cooled to 10 mK
- All wiring efficiently heat sink on the dilution refrigerator



# Custom **Triton**

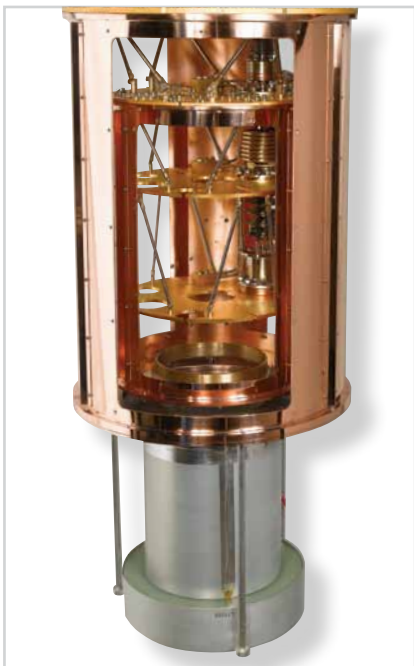
## Tailored to your needs

The modular **Triton** design offers extensive configuration possibilities and flexible sample environments. Some of the options include integrated or remote motor PTRs; large sample space; integrated superconducting magnets up to 18 T; top and bottom sample loading into vacuum; extensive wiring and service options as well as vacuum can tail sets to suit any applications.

Configurations proven popular for applications such as Quantum computing include optical windows, high frequency coaxial lines and extended sample space. We have considerable experience in the design of custom systems and would be delighted to discuss your specific requirements.

### Examples of customisation:

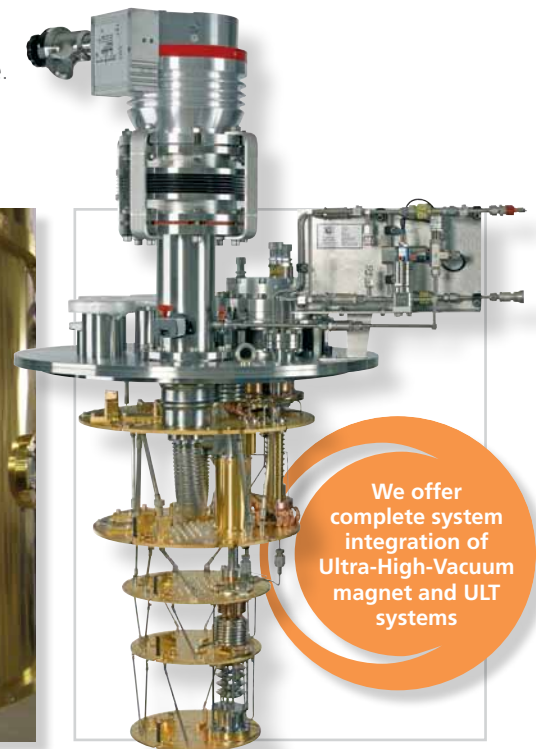
- Wide temperature range
- Reinforced for high mechanical load
- Side arm for detectors
- Open access radiation shield for easy access without demounting the magnet



- Optical windows

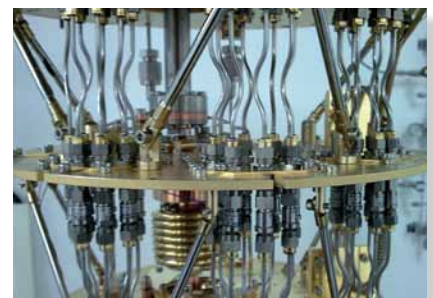
**This Triton insert (above) was fitted with 14 windows and achieved outstanding specifications:**

9 mK base temperature with all windows closed  
29 mK with all 14 windows open (with factory in darkness)



We offer complete system integration of Ultra-High-Vacuum magnet and ULT systems

- Ultra-High-Vacuum design



- High frequency coaxial lines

## Wiring and services

### Non-Line of Sight Services

The **Triton** product range has been designed with many customer accessible ports on the system top plate. In order to keep the 3 Line of Sight ports free for high frequency coaxial lines there are 3 Non-Line of Sight ports giving access for a variety of flexible wiring options.

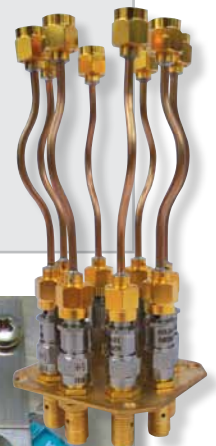
- 24 way DC looms – Constantan or Cu/NbTi twisted pairs
- S1 flexible coaxial lines – for use up to 500 MHz
- Thermal clamping at PT1, PT2, Still, 100 mK and Mixing Chamber
- Current leads for superconducting magnets
- Wiring to suit commercially available nano-positioning devices
- Custom services and optical fibres available



### Line of Sight Services

There are 3 Line of Sight ports for high frequency coaxial lines or other custom services. These ports can be configured as 2 off KF40 and 1 off KF50 vacuum fittings, fully terminated for high frequency applications or blanked for customer fittings. In addition a 65 mm central access LOS port is available for top loading sample access.

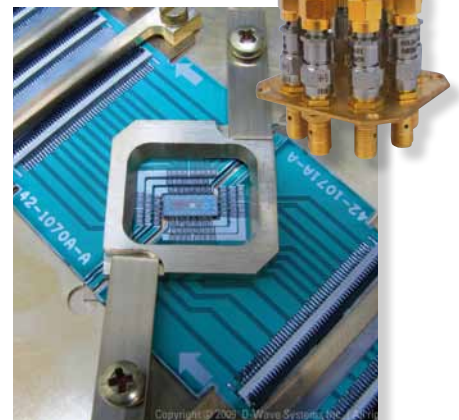
- UT85 semi-rigid coaxial lines
  - Stainless Steel inner/Stainless Steel outer conductor with PTFE insulation (UT85 SS SS)
  - Beryllium Copper inner/Stainless Steel outer conductor with PTFE insulation (UT85 B SS)
  - Niobium inner/Niobium outer conductor with PTFE insulation (UT85 Nb Nb) from Still to Mixing chamber
- Heatsinking at PT1, PT2, Still, 100 mK and Mixing Chamber
- SMA termination for frequencies up to 18 GHz
- SK termination for frequencies up to 40 GHz
- 20, 10, 6 dB attenuators at PT1, PT2 and Still plates available
- Optional Noise Thermometry
- Custom services and optical fibres available



### Weak phonon-electron interactions at low temperatures make electron system cooling in many applications problematic

Fast pulse sequences for signal control is necessary in many areas of modern physics with corresponding high bandwidth wiring required. When working in the GHz frequency range it is important to filter background blackbody radiation, also in the working GHz range, in the lines before it reaches the sample. Working with many of our customers we have developed extensive high frequency wiring options with signal attenuation and extensive heatsinking to minimise electron temperatures on the sample or device.

- Semi-rigid coaxial cables with frequency ranges up to 40 GHz
- Heatsinking of outer conductor at all thermal plates
- Heatsinking of inner conductor and filtering of blackbody radiation using attenuators



# TRITON

## Service<sup>®</sup> – ServiceWise

By choosing Oxford Instruments as the supplier of your next Cryofree system, not only are you getting a reliable product but also access to a service support team. This includes:

- Our team of more than ten expert service engineers have more than 100 years experience based on the successful installation of hundreds of magnet and low temperature systems
- Five people dedicated to helpdesk
- Local service support
- Bespoke Cryospares service

All of our products are supported by a twelve month warranty including parts, labour, on-site visits and third party items like pumps or electronics. Extended warranty is available on request.

### ServiceWise service contracts:

Cryofree systems use pulse tube refrigerators which require regular maintenance to ensure optimum performance. Oxford Instruments has support packages for complete peace of mind.



visit [www.oxford-instruments.com](http://www.oxford-instruments.com) for more information

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