



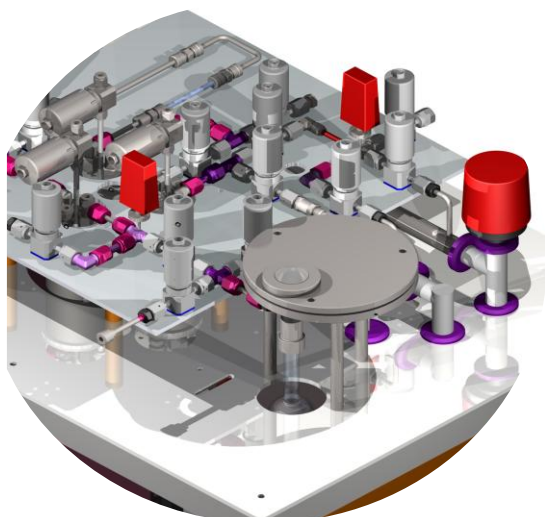
IBEX

Clumped Isotope sample preparation system V2.

Introduction

The IBEX is a fully automated system which prepares solid and gas samples for clumped isotope analysis. The system can process most carbonate materials, including calcite, dolomite, magnetite and siderite.

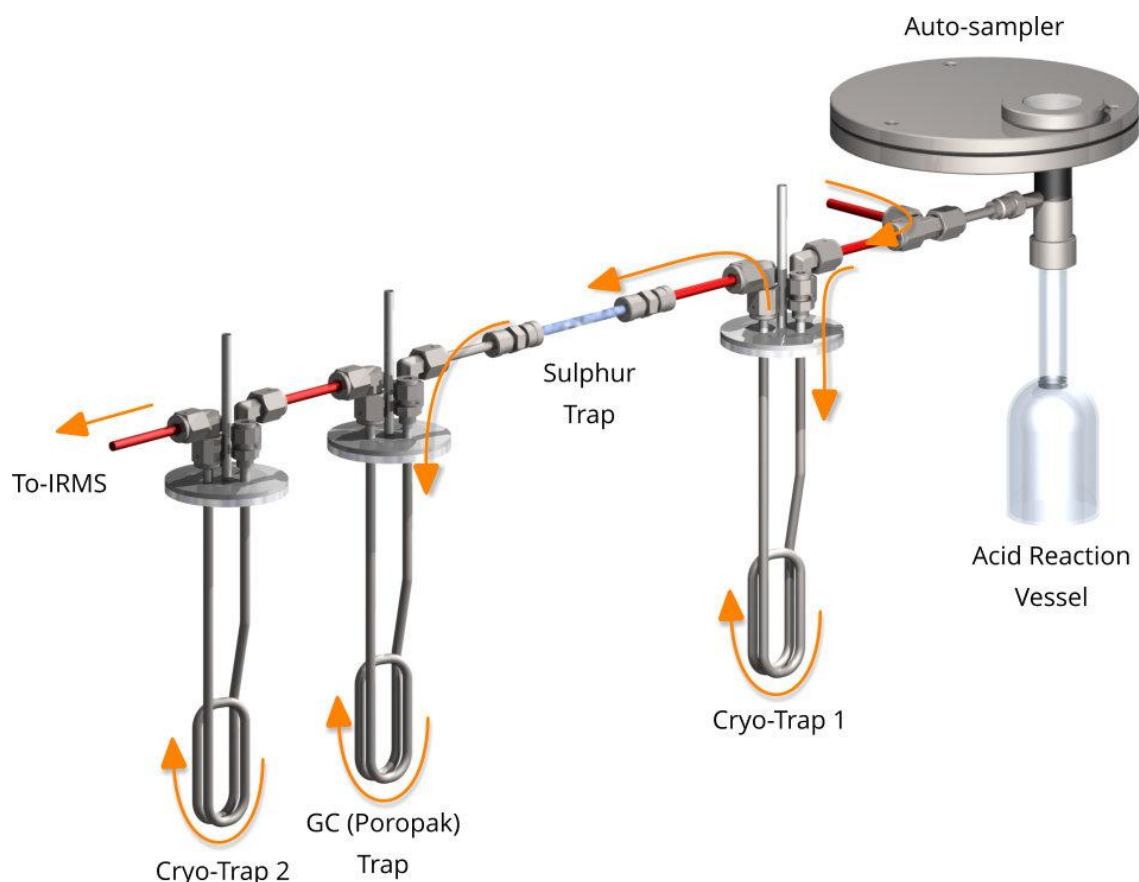
The IBEX can be integrated with most modern IRMS systems, including the Thermo 253 and 253+. The system is also compatible with the Aerodyne laser ratiometer.



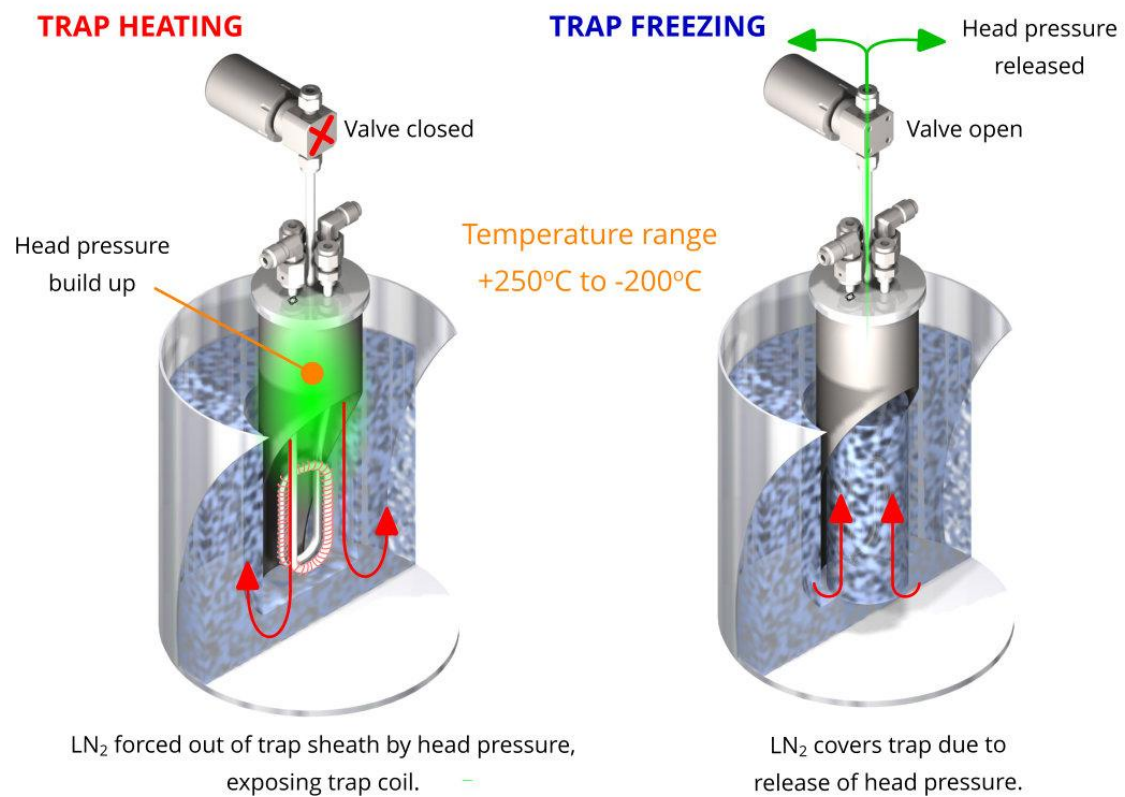
Gas connections are made directly to the IRMS bellows and/or the source inlet block. This allows the operator to analyse samples in either bellows or LIDI mode.

How the IBEX works

The IBEX utilises a series of variable-temperature cryo-traps and chemical purification processes to purify CO₂ from solid or gaseous sources.



The cryo-traps use a variable head-pressure system to raise and lower the liquid nitrogen level without physically moving the trap. This provides safe and accurate trap cooling and heating.



Once the sample has been cleaned, it is passed to the IBEX micro-volume for cryo-focusing and transferred to the mass spectrometer or laser for analysis.

Automated helium flow control

Helium flow through the system is regulated using high-precision mass flow controllers. This enables flow rates from 0 to 100 ml min⁻¹ (1 ml increments).

The flow rates are software-controlled and can be altered directly through the ICC software interface. Automated changes can also be added to the sample preparation method.

The ability to control flow rates in real time provides two benefits:

1. The use of variable-length Poraplot Q columns (typically 2m).
2. Bi-directional flow across the column, allowing back-flushing during the cleaning process.
3. The ability to place the IBEX in gas saver mode between sample preparations.



Optional gas inlet manifold



The IBEX comes with one standard gas inlet port.

This enables the preparation of heated gases. If required, a further eight ports can be added to the system, allowing the analysis of multiple gases.

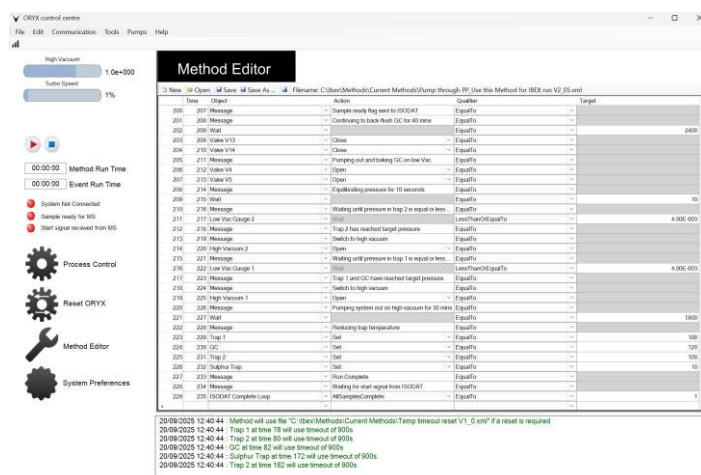
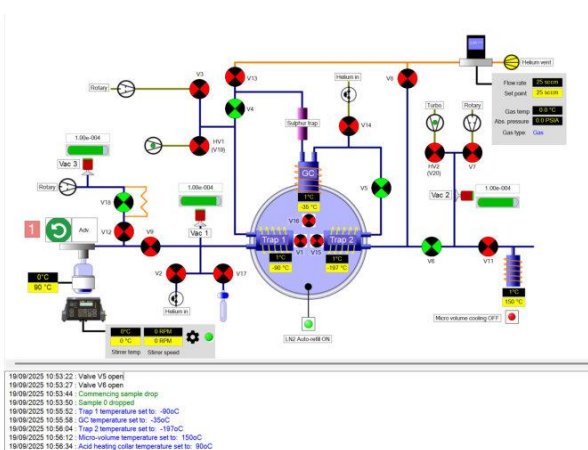


IBEX Control Centre Software

The IBEX Control Centre software (ICC) provides a fully integrated control and monitoring platform. Seamlessly linking with ISODAT and Qtegra.

Real-time control and readouts of all functional objects are accessible on the main ICC screen, including valve state, trap temperatures, helium flow rates, and vacuum pressures.

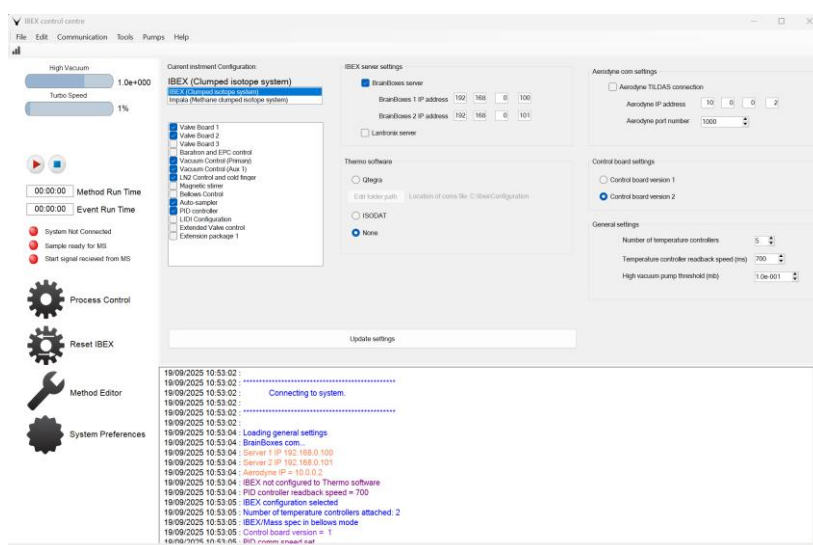
The addition of custom controls and objects is also possible using the system's plug-and-play options. This includes pressure gauges, valves and other bespoke equipment.



Custom analytical methods can be created using the ICC method editor. This requires no prior scripting or coding knowledge. New methods can be created and deployed in minutes.

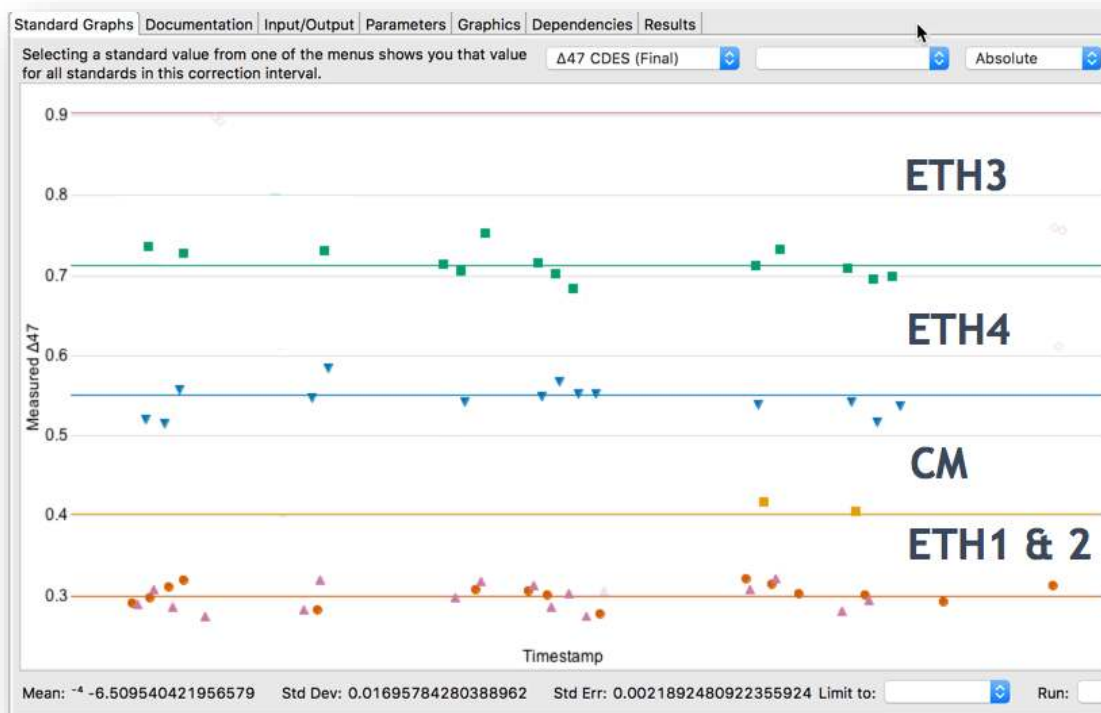
Existing methods can be edited with a few mouse clicks.

Advanced users can also edit and deploy methods using any XML editor.



IBEX functionality and specifications

An example of a typical IBEX reference frame (attached to a Thermo 253 mass spectrometer) can be seen below (containing 56 replicates of ETH standards and 2 Carrara Marble).



The overall reproducibility of this reference frame has a standard deviation of 0.017 (17 PPM)¹. The reproducibility of individual standards is reported in Table 1.

Table 1. An example of $\Delta 47$ reproducibilities observed when using the IBEX to prepare ETH standards.

Standard	n	sd
ETH1	15	0.012
ETH2	16	0.011
ETH3	12	0.014
ETH4	15	0.014
Carrara Marble	2	0.008

IBEX Specification

ANALYTICAL PRECISION
=< $\Delta 47$ 0.025 sd (25ppm) on 5 acquisitions of ETH1 & ETH2 ¹ .
SAMPLE SIZE
Bellows mode: 3.5 mg per analysis An “analysis” is defined as eight acquisitions, each comprising eight cycles (reference/sample cycles). The beam intensity during the acquisition is maintained at 15V on mass 44. LIDI mode: TBC
SAMPLE PREPARATION TIME
Preparation of a pure carbonate sample from acidification to the inlet of the Mass Spectrometer is approximately 45 minutes. Sample preparation times will vary depending on the size and purity of the sample and the configuration of the instrument.
CRYO TRAP PERFORMANCE
The system includes four cryo-traps (two water traps, one PoraPlotQ trap and one cold finger). Water traps Max Temp +250 °C Min Temp -197 °C CO₂ release temperature -105 to -65 °C Temperature increments 1°C PoraPlotQ trap Max Temp +220 °C Min Temp -197 °C CO₂ transfer temperature -60 to 30 °C Temperature increments 1°C Helium transfer flow rate 0 to 50 ml min⁻¹ IRMS cold finger Max Temp +130 °C Min Temp -197 °C CO₂ release temperature: Room temperature Volume 200 ml (can be altered on request).
MASS FLOW CONTROLLER
Helium flow rate control 0 to 100 ml min ⁻¹

¹ Performance of the IBEX is dependent upon adequate performance of the IRMS to which it is attached.

LIQUID NITROGEN CONSUMPTION
Approximately 45 litres per day. It is recommended that the customer provide a 90-litre (or larger) LN₂ storage vessel to supply the IBEX preparation system. Protium can supply LN₂ storage vessel if requested.
IBEX CONTROL CENTRE SOFTWARE
Compatible with ISODAT & Qtegra Requires Windows 7 or above
VACUUM SYSTEM
1 x DX85 Edwards turbo molecular pump 3 x RV5 Edwards rotary pumps 1 x Edwards Penning gauge 3 x Edwards Pirani gauge 1 x Edwards TIC controller 1 x Edwards gauge controller Please note that alternative components may be used if they provide better performance than those described above.
ACID TEMPERATURE CONTROL
Acid temperature can be controlled from room temperature to 110 °C. An integrated acid stirrer and hot plate Heating collar are provided to enclose the acid reaction vessel. The heating collar temperature can be controlled directly or via software control.
Vacuum Fittings
All Vacuum joints and seals use VCR connections. All tubing is Ultron finished or equivalent.



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