

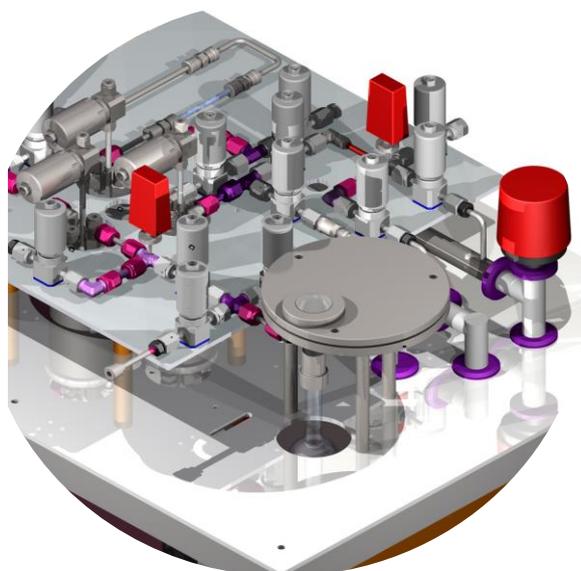
Isotope Batch Extraction System

IBEX

Introduction

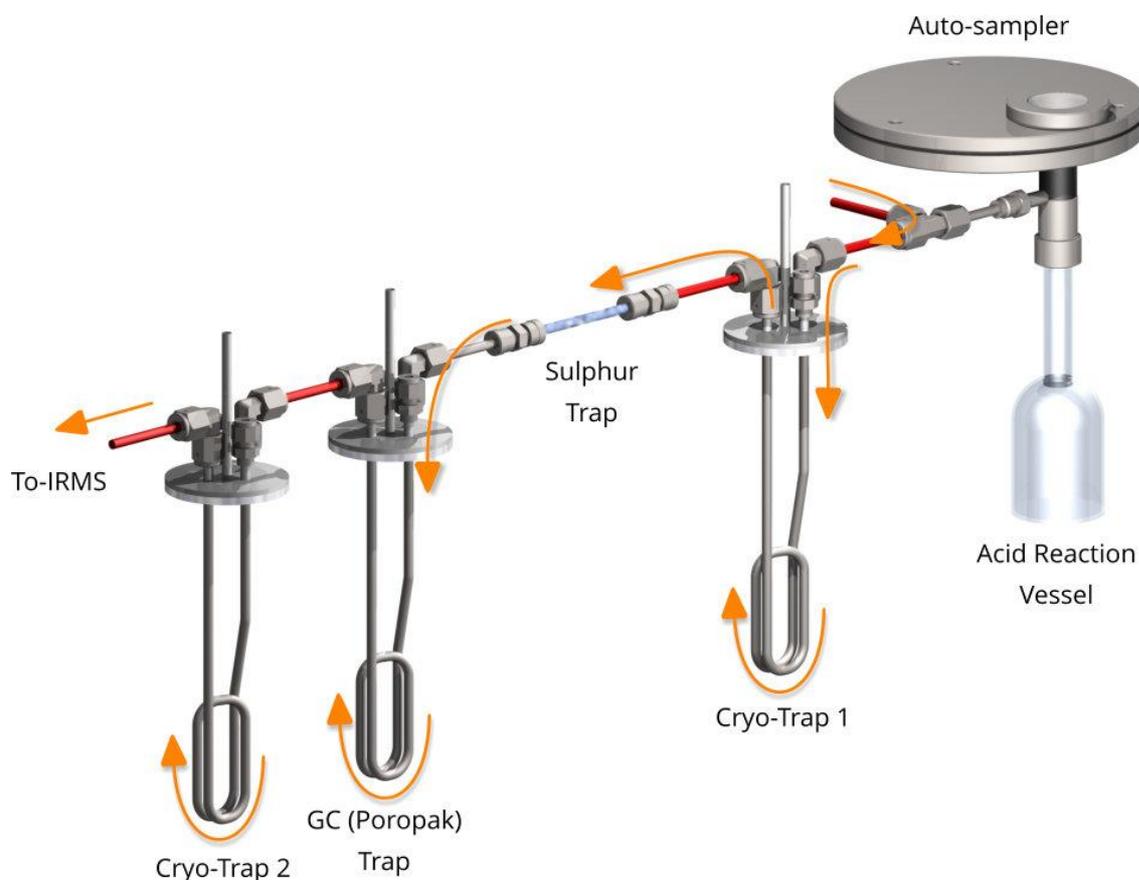
The IBEX is a fully automated system which prepares solid and gas samples for clumped isotope analysis. The system can process most carbonate materials, including calcite, dolomite, magnetite and siderites.

The IBEX can be integrated with most modern IRMS systems, including the Thermo 253 and 253+. Gas connections are made directly to the IRMS bellows and/or the inlet block. This allows the operator to analyse samples in either bellows or LIDI mode.



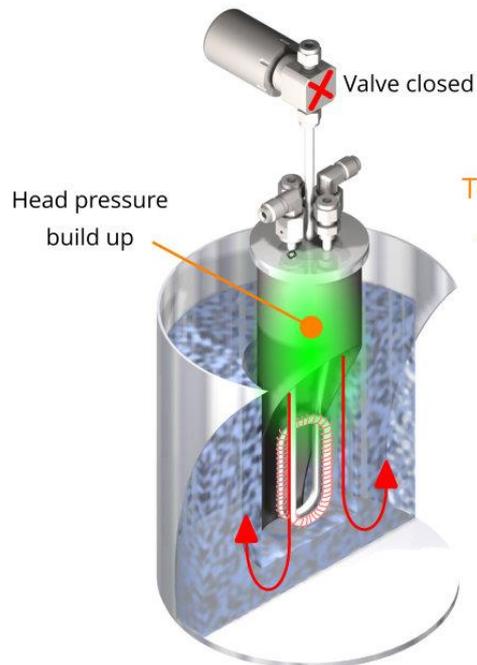
How the IBEX works

The IBEX uses a series of variable temperature cryo-traps and chemical purification processes to clean 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.

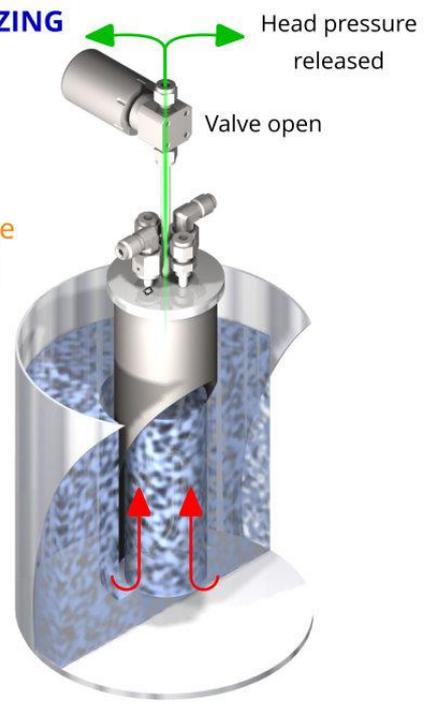
TRAP HEATING



LN₂ forced out of trap sheath by head pressure, exposing trap coil.

TRAP FREEZING

Temperature range
+250°C to -200°C



LN₂ covers trap due to release of head pressure.



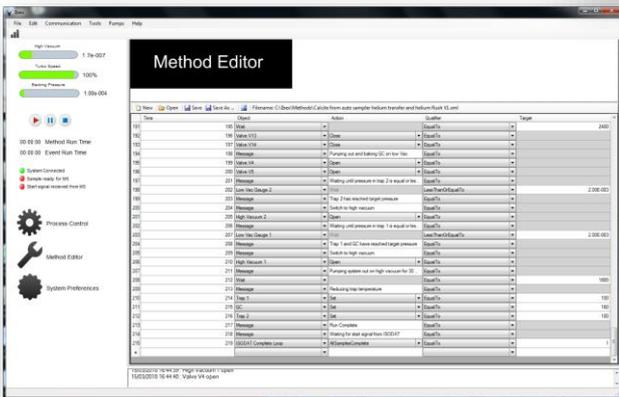
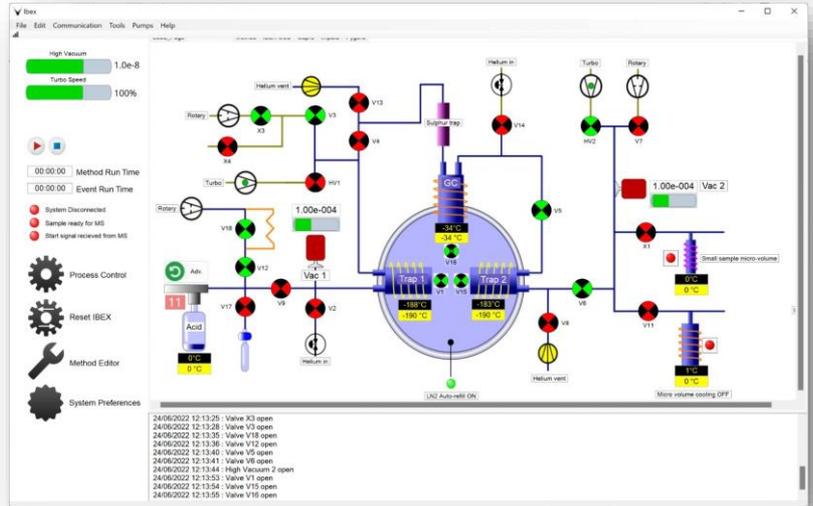
Once the sample has been cleaned, it is passed to the IBEX micro-volume for cryo-focusing and transferred to the mass spectrometer for analysis.

IBEX Control Centre Software

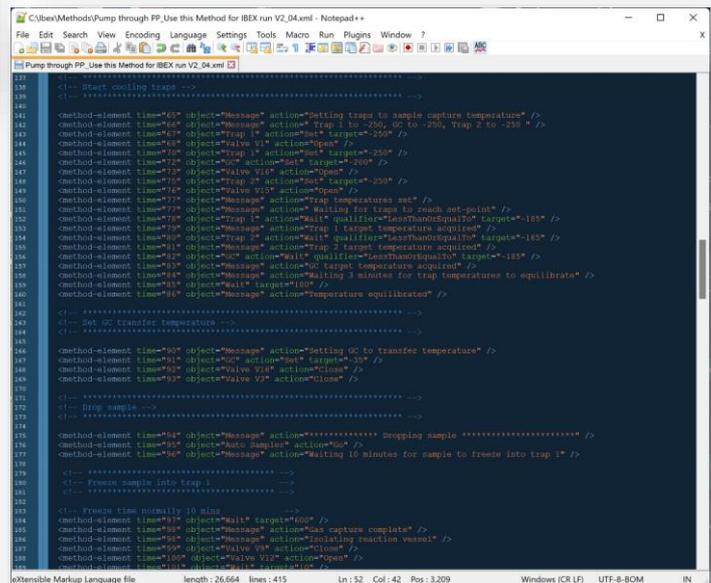
The IBEX Control Centre software (ICC) provides a fully integrated control and monitoring platform. Seamlessly linking with ISODAT sequence files, methods and scripting language.

Real-time control and readbacks of all functional objects are accessible in the main ICC screen, including valve state, trap temperatures and vacuum pressures.

The addition of custom controls and objects is also possible using the systems 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.

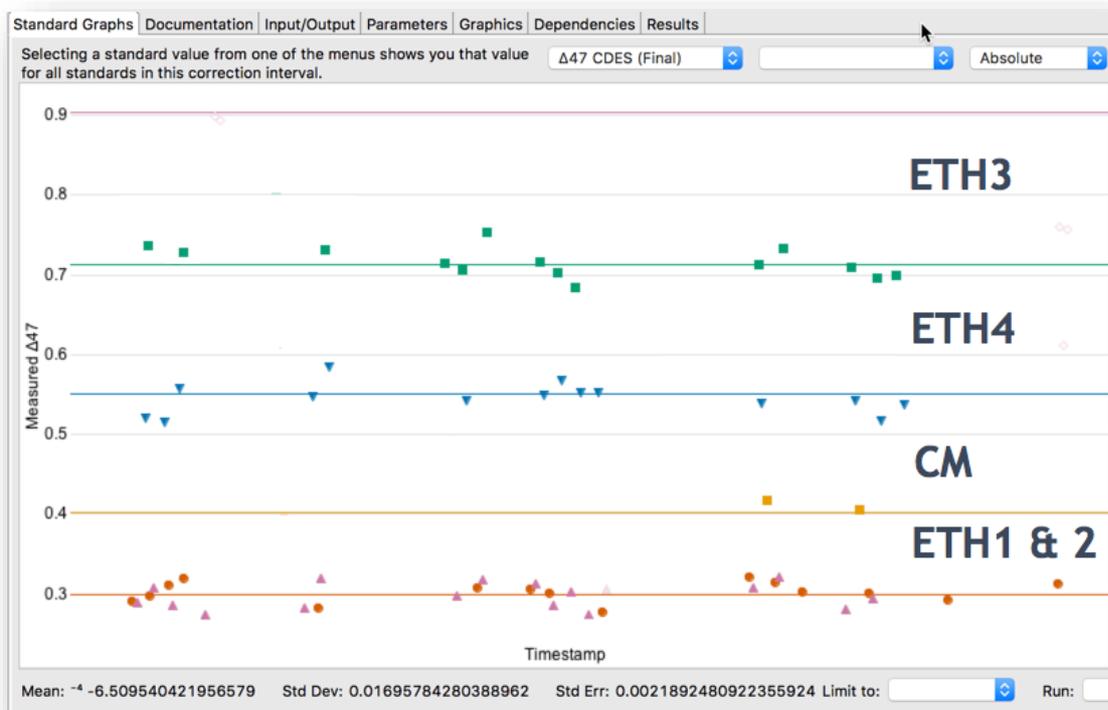


Existing methods can be edited with a few mouse clicks.

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. 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 8 acquisitions, each comprising of 8 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 pure carbonate sample from acidification to inlet to 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 CO ₂ release temperature -105 to -80°C Temperature increments 1°C PoraPlotQ trap Max Temp +220 °C Min Temp -197 °C CO ₂ 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 CO ₂ release temperature: Room temperature Volume 200 ml (can be altered on request).

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.

SULPHUR TRAP

Silver wool trap
Volume 3 ml

IBEX CONTROL CENTRE SOFTWARE

Compatible with ISODAT
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
2 x Edwards Pirani gauge
1 x Edwards TIC controller

Please note 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. Integrated acid stirrer and hot plate Heating collar are provided to enclose the acid reaction vessel. The heating collar temperature can be controlled independently.

Vacuum Fittings

All Vacuum joints and seals use VCR connections. All tubing is Ultron finished or equivalent



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