

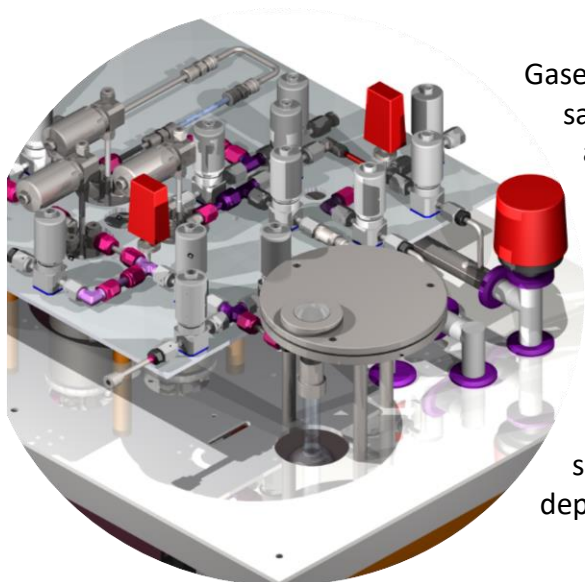


Isotope Batch Extraction System

IBEX

Introduction

The IBEX is a fully functioning automated system for the preparation and inlet of carbonates and gases for clumped isotope analysis. The system can process most carbonate materials including calcite, dolomite and siderites.



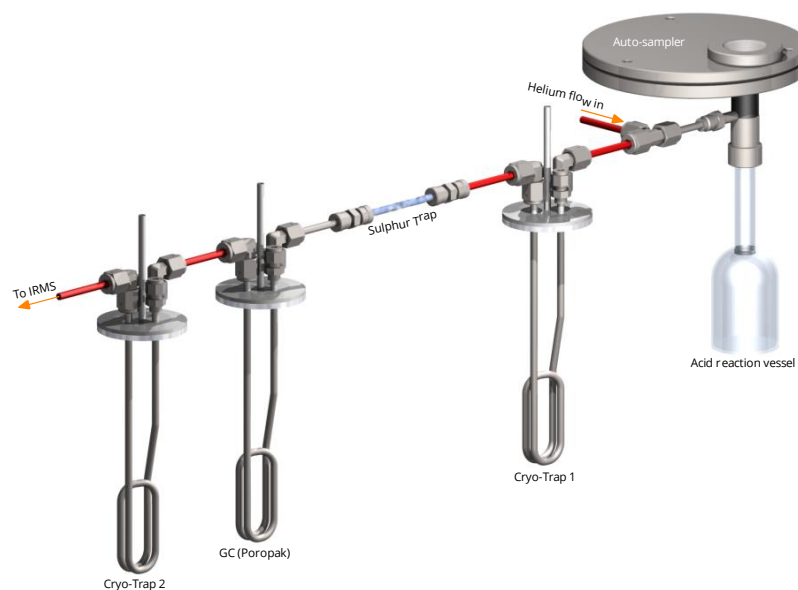
Gaseous samples can also be processed in the same manner as solid samples (excluding acidification); allowing system calibration via heated gases.

The IBEX can be integrated with most modern IRMS systems; including the Thermo 253 and 253+. Connections can be made directly to the IRMS bellows or to the inlet block. This allows the operator to analyse samples in either 'Bellows' or 'LIDI' mode depending on user requirements.

The IBEX also provides the operator with the option of transferring sample gases 'passively' (freezing the sample from one trap to another) or 'actively' by flushing the sample through the IBEX with a helium carrier gas.

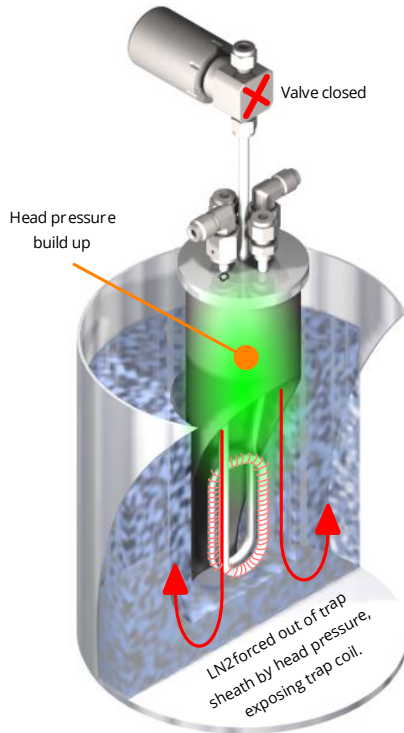
How the IBEX works

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



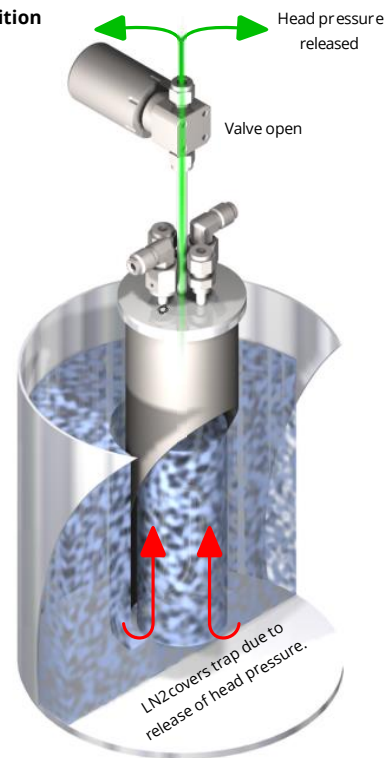
The cryo-traps uses a variable head-pressure system to raise and lower the level of liquid nitrogen without physically moving the trap. This provides safe and accurate trap cooling and heating.

a) Trap heat position



Temperature range +250°C to -200°C

b) Trap freeze position



Temperature range +250°C to -200°C



Once the sample has been cleaned; it is transferred to the IBEX micro-volume. This focuses the CO₂ into a small volume ensuring maximum sample transfer to the IRMS bellows or source block (depending on the chosen analytical method).

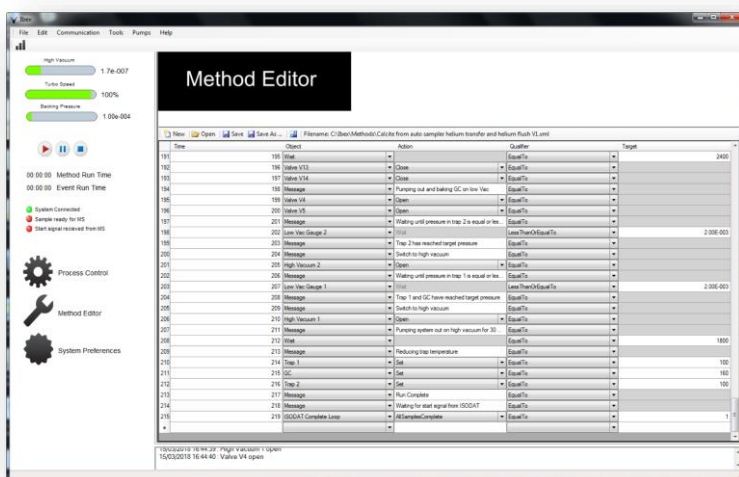
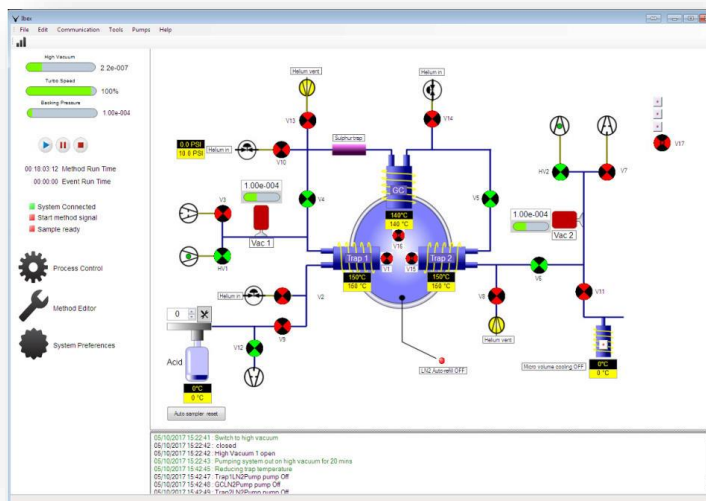
The volume of the final trap can be modified on request.

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 operational 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 may include pressure gauges, valves or other bespoke equipment.



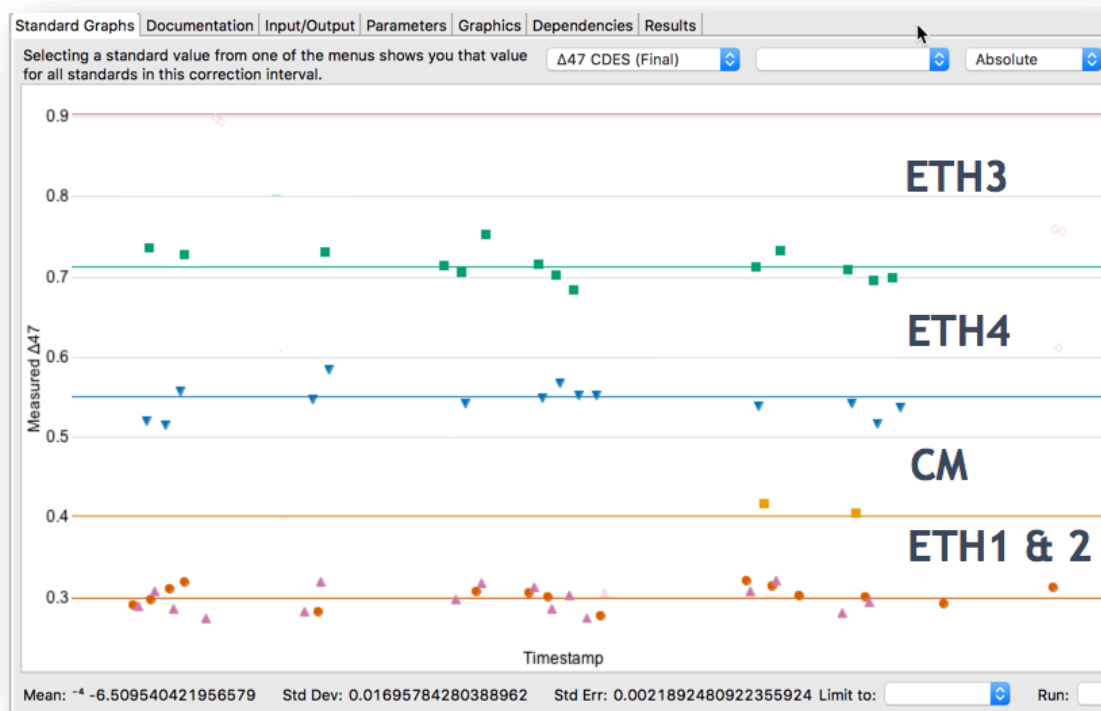
Custom analytical methods can be created using the ICC method editor. This requires no prior scripting or coding knowledge. New methods can be created and deployed in minutes.

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 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). The reproducibility of individual standards is reported in Table 1.

Table 1. Example of typical $\Delta 47$ reproducibility observed when using the IBEX to preparing ETH standards.

Standard	n	sd
ETH1	15	0.012
ETH2	16	0.016
ETH3	12	0.018
ETH4	15	0.021
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 size and purity of sample and configuration of 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).
LIQUID NITROGEN CONSUMPTION

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

Approximately 30 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 is provided to enclose acid reaction vessel. Heating collar temperature can be controlled independently.

Vacuum Fittings

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



Protium MS Ltd.
The Innovation Centre
Sci-Tech Daresbury
Keckwick Lane Daresbury
WA 4 4FS
www.protiumms.com



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