MASS SPECTROMETRY

Thermo Scientific DELTA V Advantage DELTA V Plus

The Next Generation Isotope Ratio MS

Part of Thermo Fisher Scientific

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Thermo Scientific
DELTA V Advantage | DELTA V Plus

The Next Generation Isotope Ratio MS

Thermo Scientific DELTA V isotope ratio mass spectrometers are characterized by combining highest sensitivity with excellent linearity and stability.

Features of the new DELTA V generation

- Sensitivity
  - The most sensitive DELTA Isotope Ratio MS ever
- Versatility
  - Up to 10 detectors
  - Widest range of collector configurations
  - Larger mass range
  - On-line H_2 capability
  - Upgrade from DELTA V Advantage to DELTA V Plus
- Robustness and reliability
  - Monolithic analyzer with intrinsic alignment of all ion optical components
  - Integrated signal amplifiers and digitizers
  - All ion optics in place: no alignments during installation or maintenance
  - Optimized pumping strategy
  - Comprehensive set of automated diagnostics
- Compact and user-friendly design
  - Small footprint
  - Space for on-line peripheral on top
  - Dual inlet, µ-Volume and Multiport inside
  - Activation of continuous flow interfaces on front panel
  - All pumps inside
  - Low noise design

The Most Sensitive DELTA Isotope Ratio MS Ever

The Next Generation Isotope Ratio MS

More than 50 years of Isotope Ratio MS experience have been incorporated into the design of a new generation of Isotope Ratio MS, the Thermo Scientific DELTA V. With more than 1300 DELTA instruments installed in over 70 countries, the DELTA instruments are the most widely used Isotope Ratio MS.

Building and expanding on this tradition, the new DELTA V is more sensitive while delivering excellent linearity and stability. The DELTA V is also more versatile and more rugged than its predecessors. Special emphasis has been placed on ease of use and automation.

The two new models, DELTA V Advantage and DELTA V Plus, are built on the same platform and offer all standard applications, including H_2 analysis under helium carrier gas load. The DELTA V Plus delivers additional functionality for a wider scope of applications. There is full upgradeability from the DELTA V Advantage to the DELTA V Plus.

Inside the small-footprint design is a novel monolithic analyzer with fixed alignment of all ion optical components, including the electro magnet. This unique concept is a major step forward for achieving unprecedented reliability and robustness.

The DELTA V is guaranteed to deliver rapid startup and sustained superior performance.

Thermo Scientific DELTA V Advantage and DELTA V Plus share the revolutionary ion optical and functional design of the DELTA V platform ...

Thermo Scientific DELTA V Advantage

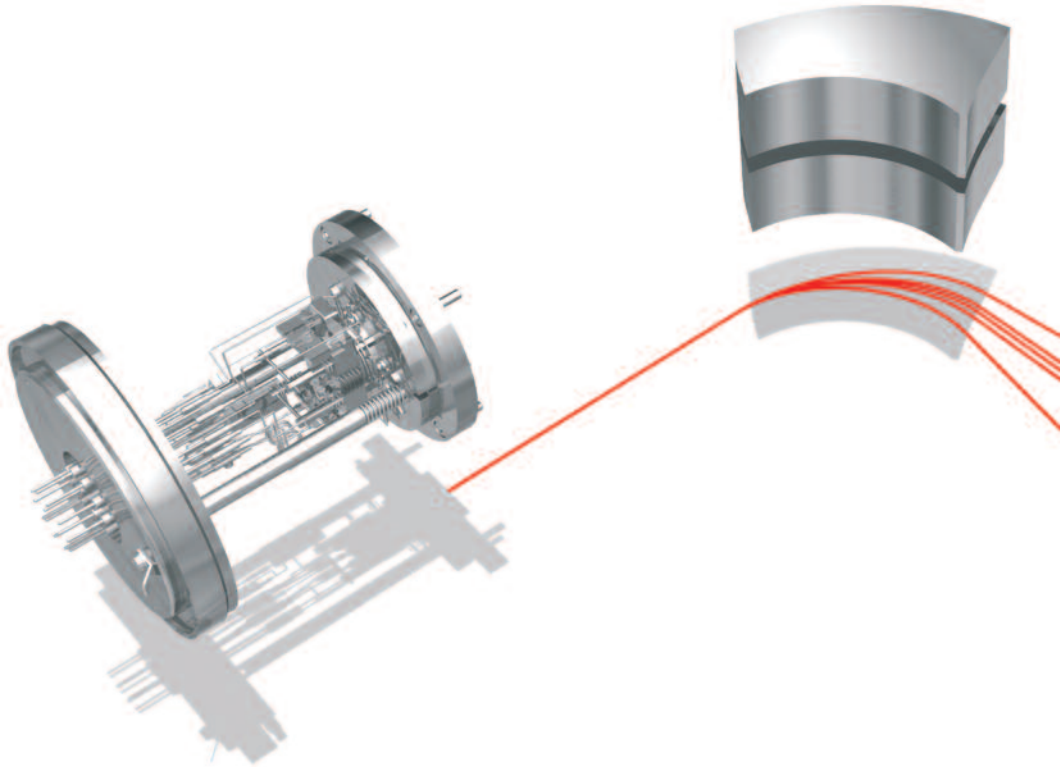
The DELTA V Advantage exceeds the performance of the Thermo Scientific DELTA^{plus} XP in virtually all aspects. Its sensitivity for CO_2 in Dual Inlet mode is better than 1200 molecules per ion. The standard collector configuration is the Universal Triple Collector. H_2 collectors with on-line hydrogen capability are optional. The DELTA V Advantage delivers high performance in Dual Inlet and Continuous Flow mode. Excellent linearity is guaranteed with or without helium carrier gas flow.

If the analytical needs of the laboratory change, the DELTA V Advantage is prepared for a field upgrade to the DELTA V Plus.

Thermo Scientific DELTA V Plus

The DELTA V Plus is the highest performance DELTA ever. Its sensitivity is second only to the MAT 253, recognized as the top-of-the-line Isotope Ratio MS. The ion optics have been refined, resulting in the highest possible ion transmission. This leads to a sensitivity of 800 molecules per CO_2 ion in the Dual Inlet mode and, more importantly, 1100 molecules per ion in the Continuous Flow mode, which is the preferred operating condition for all continuous flow applications.

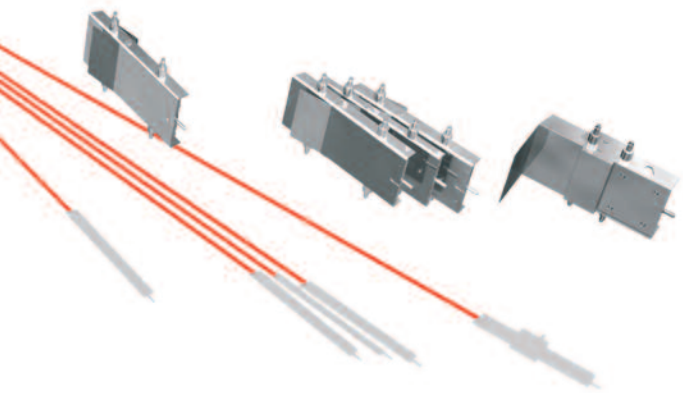
The DELTA V Plus can accommodate up to 10 collectors, ensuring flexibility to cover all isotope ratio MS applications in the mass range up to m/z 96. Its versatility puts virtually no instrumental limit to your research.

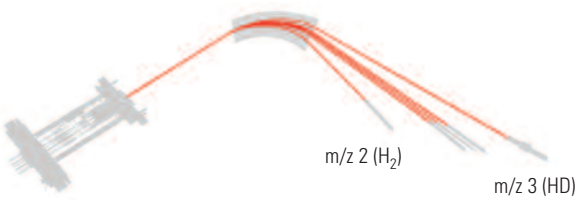


... and all the proven Isotope Ratio MS technology available only from Thermo Fisher Scientific.

- Full sensitivity for all masses
  -Full acceleration voltage for all gas species
- Extended user defineable range
  -Amplifiers register to 50 V
  -Computer switchable amplifier gains
- Full flexibility for a wide range of isotope, elemental and molecular ratios
  -Simultaneous mass range of ± 25 %, e.g. m/z 28 - 46 or m/z 2 - 3
- Three or more isotope ratios in a single sample injection
  -Fast switching magnetic analyzer
  -Simultaneous static multicollection of up to 10 signals
- Ultimate Dual Inlet performance
  -Monolithic, all-metal valves with gold gaskets
- "Fast bellows" system
  -Enhanced speed of Dual Inlet measurements
- Fiber optics signal transmission
  -No ground loops or other sources of electronic noise
- Seamless integration of software and hardware
  -Full Isodat integration
  -Full automation from sample introduction to reporting
- Computer controlled ion source potentials and parameters
  -Manual and automatic tuning with storage and recall of parameters
- Easy and flexible connection of peripherals
  -"Plug and measure" peripheral recognition
  -The DELTA V provides power and control to all peripheral units

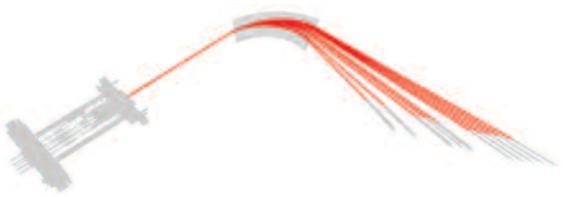
One Concept - Two Isotope Ratio Engines





5 Collector System

m/z 44, 45, 46
m/z 28, 29, 30
m/z 32, 33, 34
m/z 64, 66



10 Collector System

m/z 28, 29
m/z 32, 33, 34
m/z 36, 40
m/z 44, 45, 46

The conversion of any type of organic or inorganic compound into simple gases is the basic principle for isotope ratio mass spectrometry. A wide range of Thermo Scientific sample preparation devices and interfaces are available as inlets to the DELTA V series. We offer complete analytical solutions with GC, HPLC and elemental analyzers for fully automated isotope ratio analyses on a wide range of samples for practically every application.

Elemental Analyzers

The Thermo Scientific **ConFlo IV Universal Interface**, with an installed base of over 900 units, is the most widely used interface for coupling elemental analyzers with isotope ratio mass spectrometers. It allows the connection of a wide variety of elemental analyzers to Thermo Scientific DELTA V including: Dumas combustion elemental analyzers for $^{13}C/^{12}C$, $^{15}N/^{14}N$ and $^{34}S/^{32}S$, quantitative high temperature carbon reduction elemental analyzers for D/H and $^{18}O/^{16}O$ (Thermo Scientific **TC/EA** and **Flash 2000 HT**), the **GC-Box** for analysis of components of gas mixtures, as well as custom made peripherals e.g. DOC analyzers, laser ablation devices. The automated dilution system of the ConFlo IV together with the 50 Volt amplification range of the DELTA V allow dual element analysis of C and N or H and O with a dynamic range > 1:1000.

Liquid Chromatography

The Thermo Scientific **LC IsoLink** opens the world of HPLC separations to $^{13}C/^{12}C$ isotope ratio applications. Its sensitivity, precision and accuracy enable, for the first time, the compound specific isotope analysis of bioactive compounds with high polarity and high molecular weight. It offers full automation and maintenance-free operation. In addition, the LC IsoLink comes with a fully automated bulk µ-Elemental Analyzer mode for ^{13}C-analysis of DOC, dissolved organic carbon.

Gas Chromatography

The Thermo Scientific **GC IsoLink** with combustion and high temperature pyrolysis is used for compound specific isotope analysis of complex mixtures separated on a capillary GC column. Determination of D/H, $^{13}C/^{12}C$, $^{15}N/^{14}N$ and $^{18}O/^{16}O$ isotope ratios is possible for all mixtures accessible by the GC technique. The GC IsoLink couples to the ConFlo IV universal interface, leveraging its benefits for isotope ratio monitoring GC/MS. More than 800 GC-IRMS systems are installed and being used in a very large range of application.

Positive identification of compounds can be achieved by simultaneous determination of isotope ratios and acquisition of full scan EI/CI spectra, with a hybrid GC-MS/IRMS system.

Loop Injection of Gases

The Thermo Scientific **GasBench II** is a flexible continuous flow preparation device and inlet system with Repetitive Loop Injection of gases. It has proven its versatility and performance in more than 200 installations. Supported by a robotic autosampler and using septum-sealed sample vials, a wide variety of applications is accessible for high precision on-line measurements. The GasBench II connected to a Thermo Scientific DELTA V offers precision compareable to dual inlet methods for H_2 and CO_2 water equilibration, phosphorolysis of carbonates, CO_2 from air, and dissolved inorganic carbon but with the enhanced productivity and ease-of-operation of Continuous Flow Isotope Ratio MS.

Trace Gas Analysis

The Thermo Scientific **PreCon** trace gas pre-concentrator can be connected to the GC IsoLink or the GasBench II for atmospheric trace-gas research in the ppm and ppb range.

Complete Analytical Solutions

Dual Inlet Analysis

The Thermo Scientific **Dual Inlet** system delivers ultimate precision and accuracy by close comparison of clean sample and reference gases under viscous flow conditions.

The Dual Inlet system uses monolithic, all-metal valve blocks with gold-sealed and gold-seated valves. The changeover valve is mounted directly to the ion source housing, a design with minimal dead volume and minimum gas path length.

The variable bellows can be adjusted between 3 and 40 mL volume. Each bellows has a built-in pressure transducer to enable exact sample-standard pressure balancing to ensure the highest level of performance. The "Fast Bellows" drive allows more rapid adjustment, leading to optimal sample utilization. The waste line is pumped by a built-in turbomolecular pump.

The Dual Inlet system, including the capillaries, has integrated heating in order to minimize memory.

The system can be expanded with a **µ-Volume** inlet and up to two 10 sample Multiports with optional tube crackers. The **Multiport** has built-in pressure transducers; intelligent software allows extreme flexibility in sample inlet.

Sample preparation systems which can be connected to the Dual Inlet system include the unique Thermo Scientific **KIEL IV Carbonate Device** automated carbonate preparation device, the gold standard for isotope analysis of foraminifera, the **H/Device** for ultra-high precision chromium reduction of sub-µL water samples, and the automated **HDO** water equilibration device.

Operation of the Thermo Scientific DELTA V is straightforward and intuitive enabling high-throughput routine and flexible research applications.

Productive, Reliable and Easy to Use

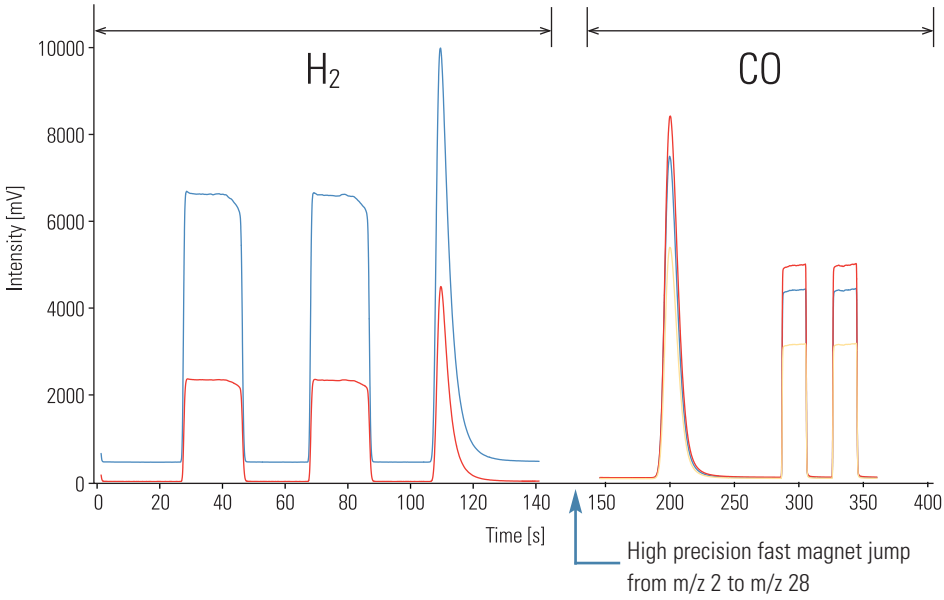
The ion source is computer controlled, supporting manual and automatic tuning, including a push-button option for periodic fine-tuning. Tune parameters are stored and can be linked directly to specific applications.

The new magnet is designed for fast mass switching, which is further supported by an intelligent "fast jump" control. Therefore, consecutive measurements of multiple gases within one run are made easier and faster, e.g. H_2 to CO, N_2 to CO_2, resulting in less sample preparation and higher throughput.

The amplifiers register ion beams up to 50 V, increasing the dynamic range accessible within one experiment by a factor of 5 over traditional 10 V amplifiers. The dynamic range can be further extended by switching between two feedback resistors – a technology built into all amplifiers of the Thermo Scientific DELTA V platform, enabling optimal resistor combinations for all gases and applications.

Peripheral devices are recognized automatically through a unique plug-and-measure philosophy.

The DELTA V series and its wide range of original peripherals and preparation systems are under full control of the Isodat software suite, ensuring high throughput unattended 24/7 operation and the flexibility required for design and execution of the most demanding experiments.



Quickly go from samples to results.

Thermo Scientific Isodat Software Suite

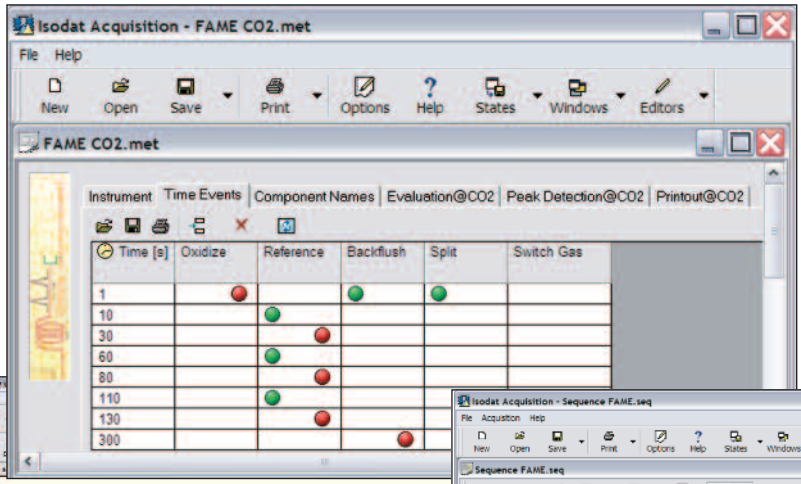
The Isodat software suite fully combines the divergent requirements for easy, unattended productivity and flexible support of demanding research. It is a seamlessly integrated part of the Thermo Scientific DELTA V and its peripheral devices controlling and automating the complete analysis from sample preparation to data reporting.

Automated analysis is enabled by a straightforward method and sequence set-up, automated user-tailored reporting and flexible data export, including all network capabilities.

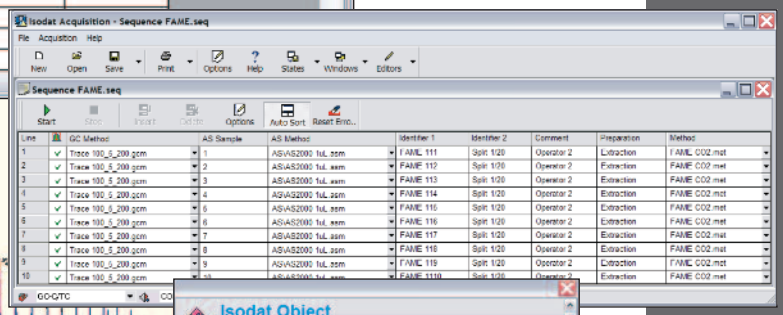
Complex experiments are supported by full control of operation parameters and, more importantly by "ISL", the integrated script language which enables the experienced scientist to take complete control of all aspects of the Isotope Ratio MS, including standard peripherals and home-build preparation and inlet devices.

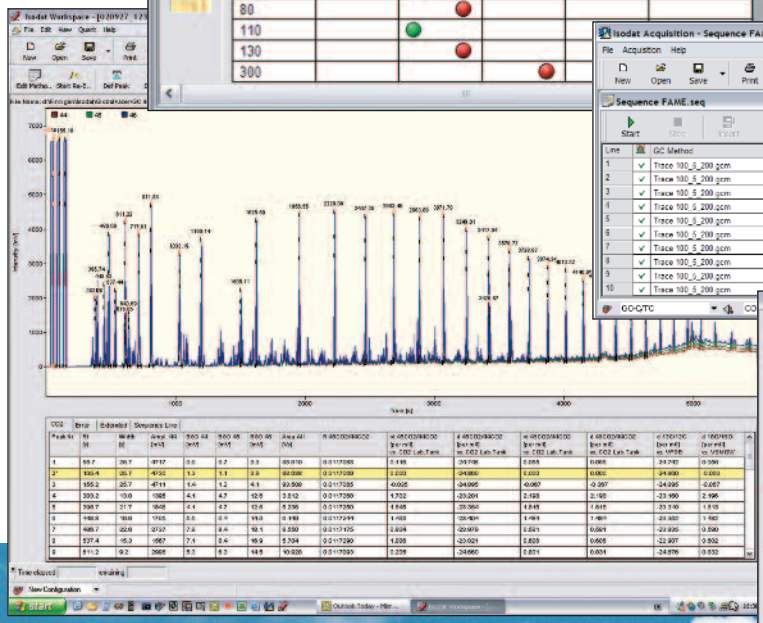
The quality of analyses, leading to confidence and defensible results, is assured by a unique package of diagnostic functions, checking all important aspects of the mass spectrometer. Rest assured that you can depend on the DELTA V and its analytical results.

Intuitive Method Creation

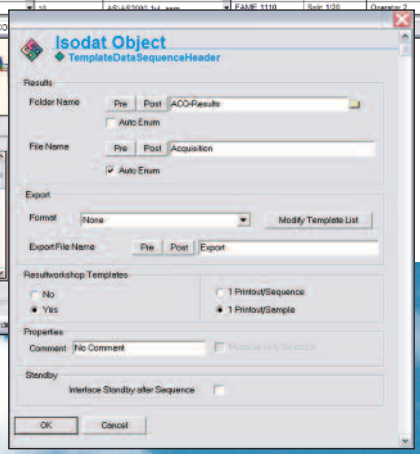


Clearly Structured Sequence





Comprehensive Display of Results



Powerful Acquisition Launcher

Flexible & Powerful
Straightforward & Easy

Thermo Scientific DELTA V Advantage is prepared for a field upgrade to the full performance of the DELTA V Plus.

Analyzer

The DELTA V uses a weld-free monolithic analyzer, with the ion source housing, flight tube, collector housing and amplifier housing precision machined from one single block. No component can move and no alignment is necessary during installation or maintanance.

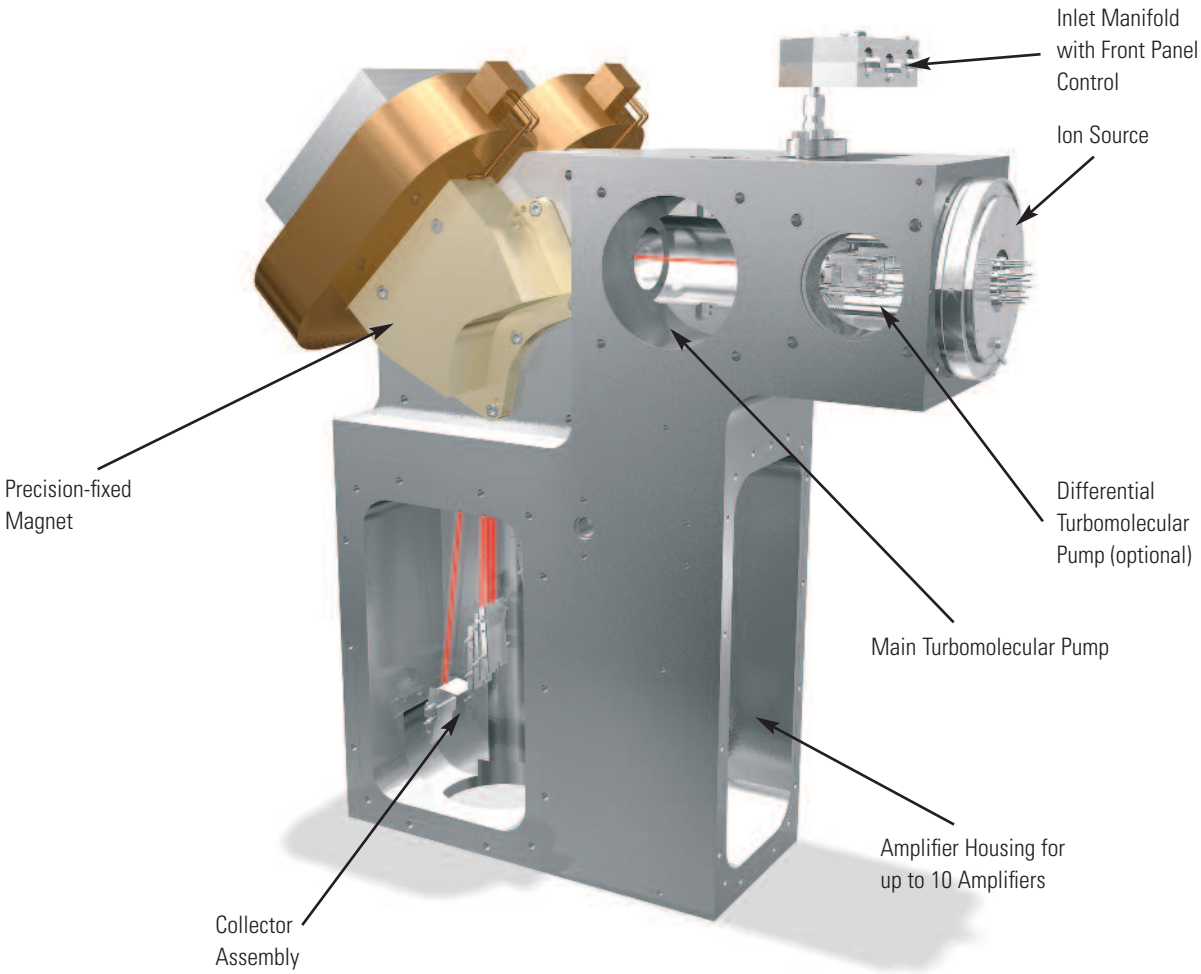
The magnet is precision-mounted into the monolithic analyzer with intrinsic alignment, its pole faces determining the free flight space for the ions, thus eliminating the traditional flight tube. The gain in ion beam height directly translates into increased sensitivity.

The vertical orientation of the analyzer gives direct access to the plug in ion source making ion source maintenance easy and straight forward.

The novel analyzer design enables very effective pumping. The vacuum system has been completely redesigned, enabling single-stage turbo-pumping for all normal continuous flow applications. Differential pumping is available for the most demanding applications.

Integration of the signal amplifier and digitizer housing into the analyzer block ensures short connections, identical thermal conditions and the absence of any noise-pickup. Evacuation of the amplifier housing eliminates signal spikes due to cosmic rays.

A Breakthrough Analyzer Concept



The ion optics of the Thermo Scientific DELTA V provide higher sensitivity and a larger mass dispersion.

Ion Source

The electron impact ion source is self-aligning and plugs into the front flange of the analyzer block.

The proven design combines very high sensitivity with excellent linearity for all Dual Inlet and He carrier gas Continuous Flow applications.

The same filament is used for all gas species, no exchange is needed for H_2. Ion source parameters are controlled by the data system and can be stored and retrieved. Tuning is manual or automatic. Automatic fine-tuning (e.g. re-tuning) is activated by push-button action.

The sample gas is introduced at ground potential, eliminating the need for insulation of the flow path, ensuring 100 % transfer into the ion source. The weld-free design, together with radiant heating of all surfaces in the ion source, virtually eliminates memory and background.

Ion Optics

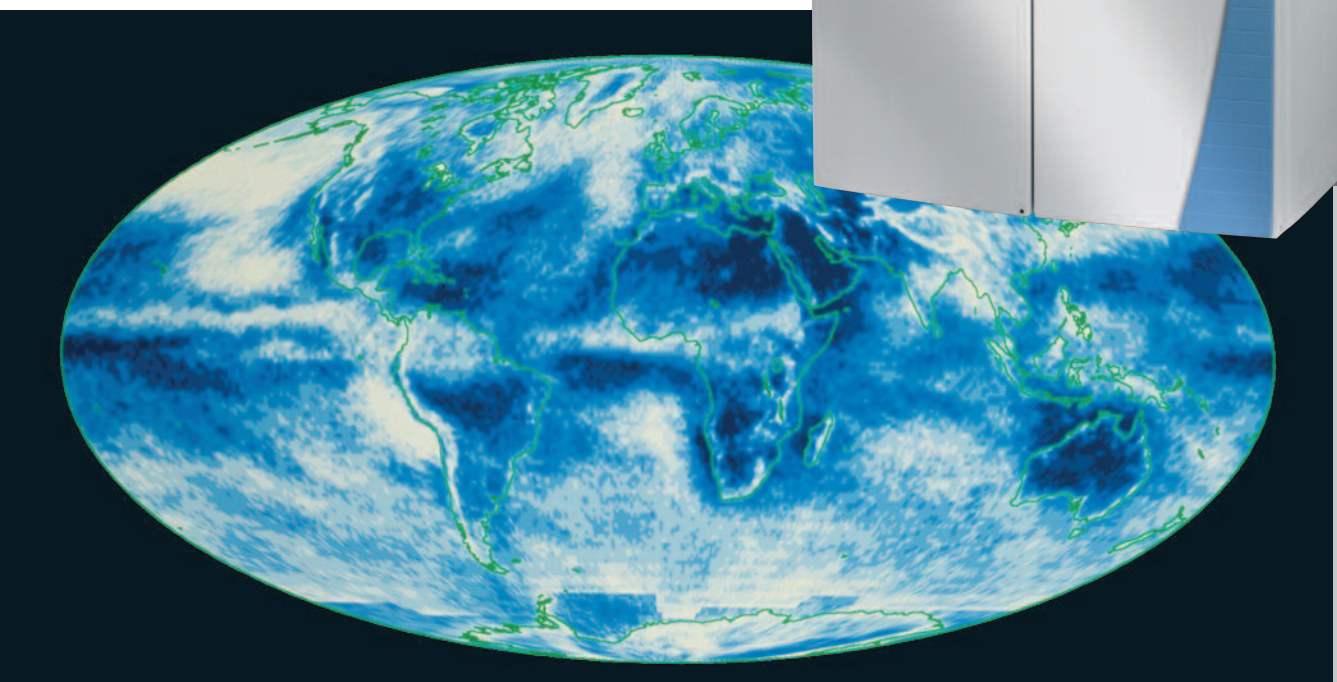
The ion optics of the DELTA V have been thoroughly refined, achieving higher sensitivity and a larger mass dispersion. Mass dispersion is about twice that of bench-top isotope ratio MS. The new ion optics are image error corrected and designed to accept an extremely wide angular ion distribution.

The new ion optics and the wider magnet gap lead to extremely high ion transmission from the ion source to the collectors, which directly translates into sensitivity.

In addition, the mass range at full acceleration voltage has been increased to m/z 96 at a mass resolution of better 110, extending the range of applications.

With the new ion optics the specifications of the DELTA V Advantage exceed those for the prior highest performance DELTA, the DELTA^{plus} XP.

Due to further refined ion optics, the DELTA V Plus is able to accept an extremely wide angular ion distribution while still accurately focusing all ion beams in the wide image plane. The refined ion optics lead to even higher sensitivity and flexibility in collector configurations which allow unique cup configurations at higher masses.



The Widest Possible Range ...

Universal Triple Collector

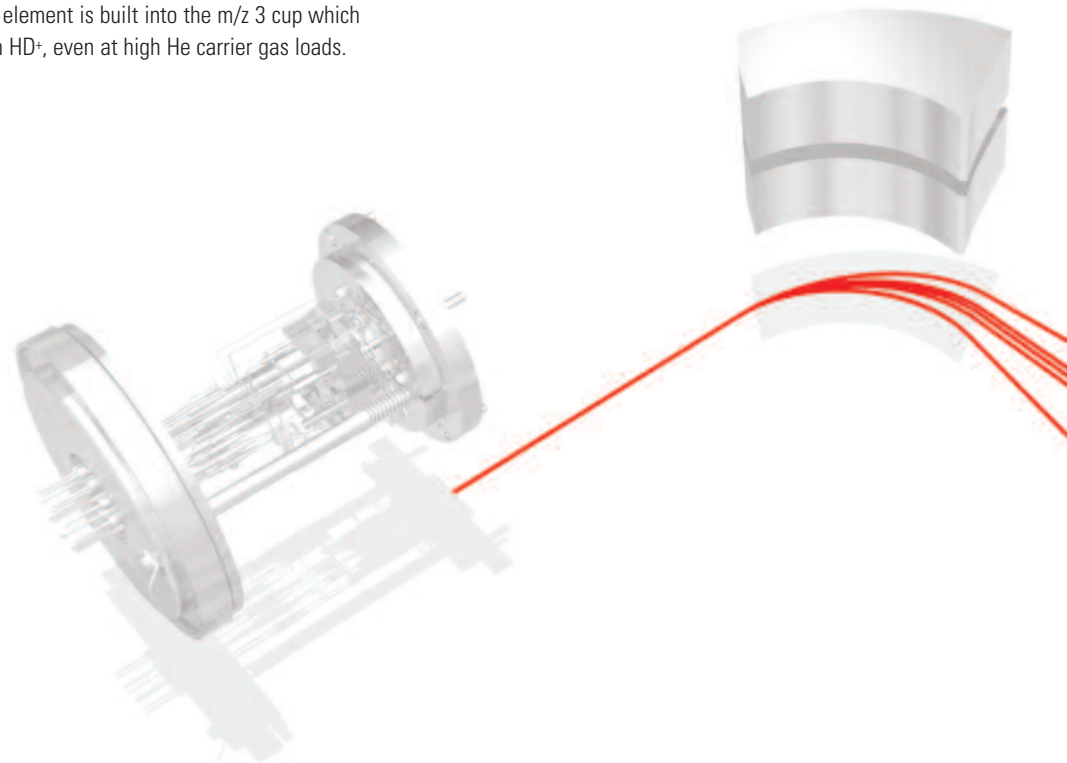
The universal triple collector is standard on the Thermo Scientific DELTA V platform and is suitable for all standard applications involving N_2, CO, NO, O_2, CO_2, N_2O and SO_2.

D/H Collector

A H_2 collector with two additional Faraday cups for m/z 2 and 3 is optional for both the DELTA V Advantage and the DELTA V Plus. Because measurement of D/H in Continuous Flow mode requires complete removal of low energy $^4He^+$ ions from the HD^+ ion beam at m/z 3, a unique ion optical element is built into the m/z 3 cup which removes all ions other than HD^+, even at high He carrier gas loads.

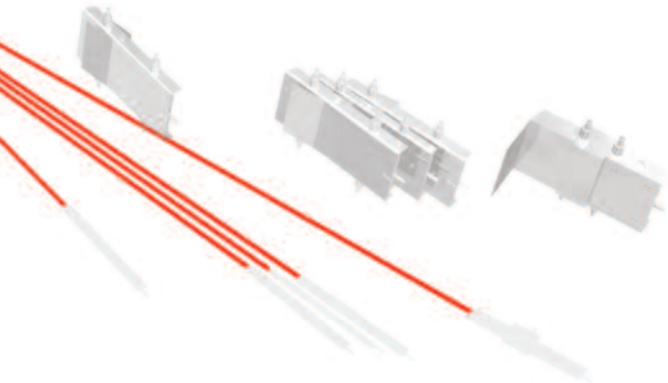
Individual Collector Arrangements

The DELTA V Plus collector array is prepared for up to 10 collectors with deep individually shielded long-life Faraday cups. It offers the choice of several collector widths for optimal tailored solutions combining specific and standard cup systems within the same collector array. Configurations include e.g. m/z 28 to 46 for all major gases and isotopes in air; N_2^+ - NO^+ - N_2O^+ for N_2O isotopomers; simultaneous CO^+ - CO_2^+ experiments; m/z 48 to 66 for SO^+-SO_2^+ for ^{18}O-corrected SO_2 measurements.



The Thermo Scientific DELTA V platform offers the widest range of collector configurations from the standard arrangement on the DELTA V Advantage to individual arrangements on the DELTA V Plus.

Gas	Collector Arrangements for Masses (m/z)									
H_2	2									3
N_2			28	29	30					
CO			28	29	30					
NO			30	31	32					
O_2			32	33	34					
CO_2			44	45	46					
N_2O			44	45	46					
SO_2			64	66						
DELTA V Plus - Additional Collector Arrangements										
Air	28	29	32	33	34	36	40	44	45	46
N_2O	28	29	30	31	32			44	45	46
CO, CO_2	28	29	30					44	45	46
N_2, CO_2	28	29	30					44	45	46
SO_2								64	65	66
SO, SO_2					48	49	50	64	65	66
CH_3Cl					50	51	52	53		
CH_3Br									94	96
Ne	20	21	22							
Ar					36	38	40			
Kr						78	80	82	84	86



... Available on Isotope Ratio MS

Thermo Scientific DELTA V System Performance

Standard performance data of the DELTA V Plus and the DELTA V Advantage:

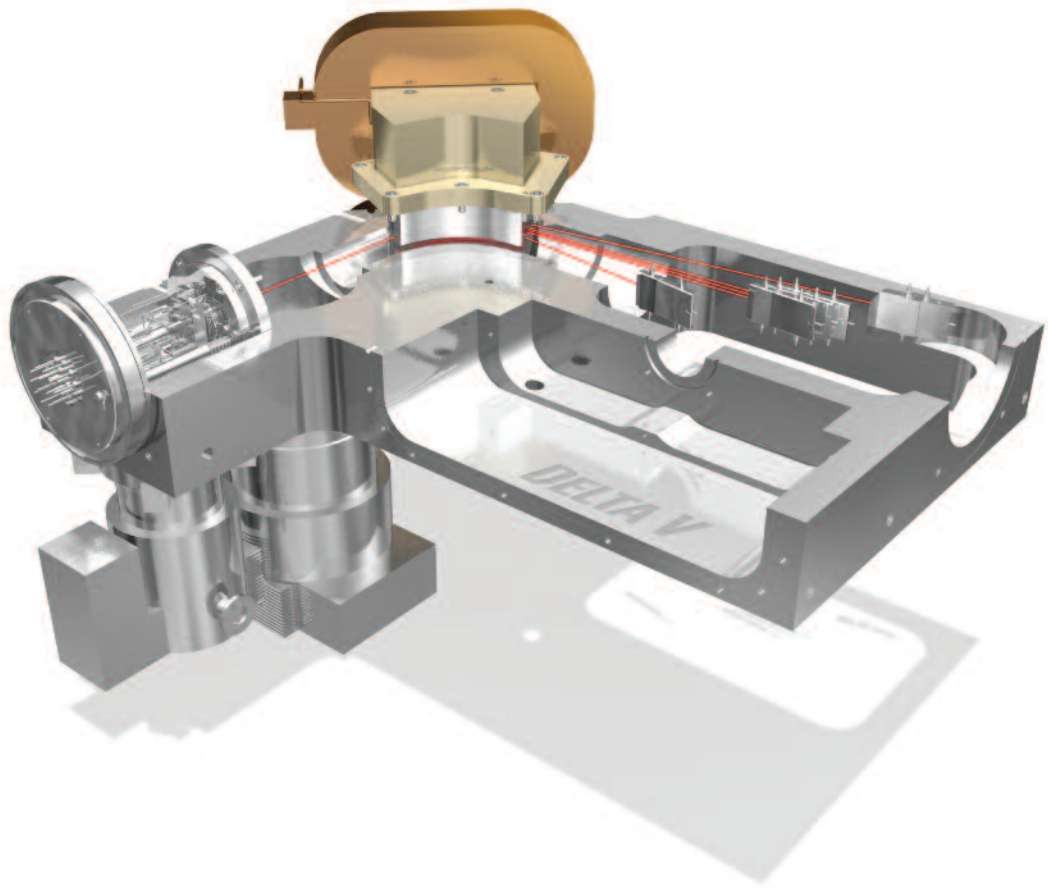
	DELTA V Plus	DELTA V Advantage
Sensitivity Dual Inlet mode Molecules CO_2 / mass 44 ion translates to Sample Consumption for 5 nA signal at mass 44	800 M/I 0.04 nmol/s	1200 M/I 0.06 nmol/s
Sensitivity Continuous Flow mode Molecules CO_2 / mass 44 ion with Isotope Ratio Linearity*	1100 M/I 0.02 ‰ / nA	1500 M/I
Mass Range at 3 kV	1 – 96 Dalton	1 – 80 Dalton
Mass Resolution m/Δm (10 % valley)	110	
Effective Magnetic Deflection Radius	191 mm	
System Stability	< 10 ppm	
H_3^+ Factor	< 10 ppm / nA	
H_3^+ Factor Stability	< 0.03 ppm / nA / h	
Noise Level	< 50 dB(A)	

*Known as Ion Source Linearity

Thermo Scientific DELTA V isotope ratio mass spectrometers are characterized by highest sensitivity with excellent linearity and stability. The sensitivity of the DELTA V is guaranteed for both Dual Inlet mode and Continuous Flow mode.

Outstanding

Breakthrough New Analyzer Concept for Outstanding System Performance.



Dual Inlet Performance

Standard performance data of the Delta V by viscous flow gas introduction using the Dual Inlet system and changeover valve:

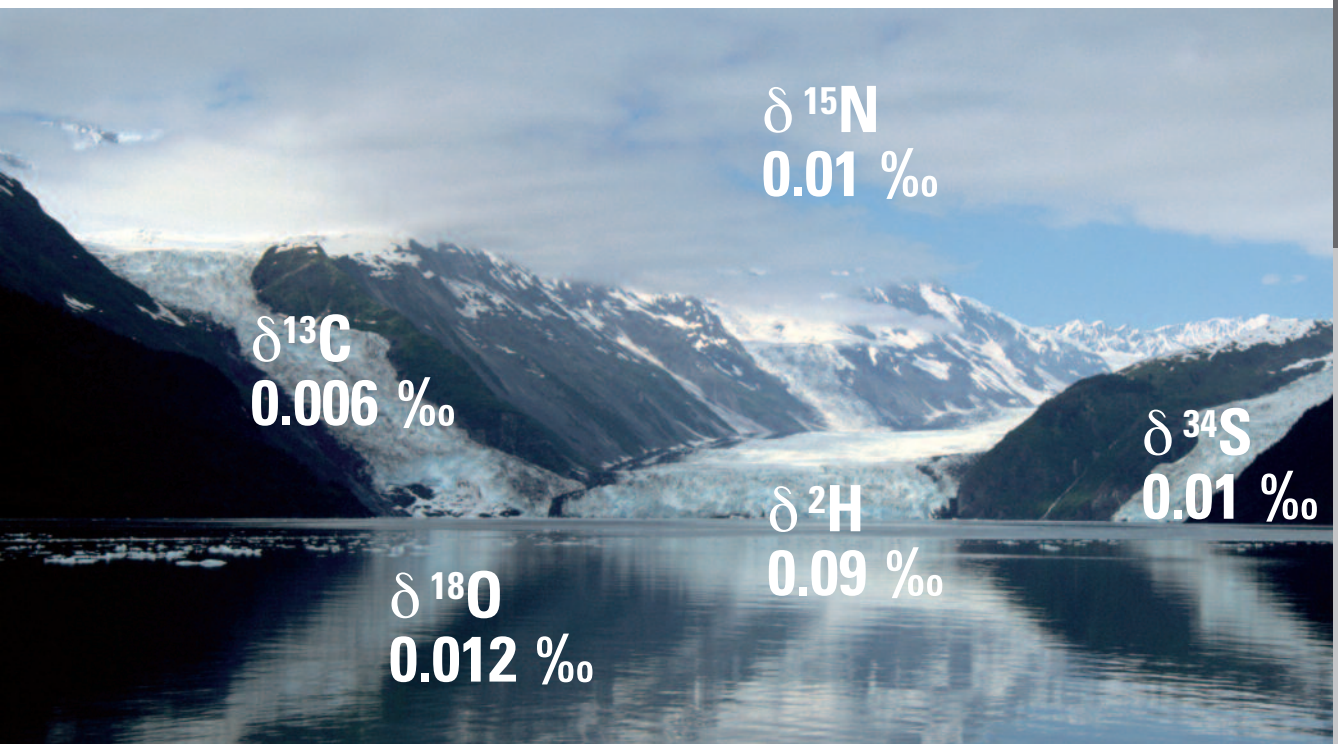
GAS	MINOR ISOTOPE	INTERNAL PRECISION ($2\sigma_{mean}$)	SAMPLE SIZE bar µL
CO_2	^{13}C	0.006 ‰	> 100
		0.02 ‰	> 50
	^{18}O	0.012 ‰	> 100
		0.04 ‰	> 50
N_2	^{15}N	0.01 ‰	> 100
		0.05 ‰	> 50
SO_2	^{34}S	0.01 ‰	> 100
H_2	^{2}H	0.09 ‰	> 200

Continuous Flow Performance

Standard performance data of the DELTA V by continuous flow gas introduction. 10 pulses of reference gas at an amplitude of 5 nA (1.5 V, for H_2 5 V):

GAS	MINOR ISOTOPE	PRECISION (1σ)	LINEARITY
CO_2	^{13}C	0.06 ‰	0.02 ‰ / nA
	^{18}O	0.08 ‰	0.02 ‰ / nA
N_2	^{15}N	0.06 ‰	0.02 ‰ / nA
O_2	^{18}O	0.08 ‰	0.03 ‰ / nA
	^{17}O	0.20 ‰	0.04 ‰ / nA
CO	^{18}O	0.15 ‰	0.04 ‰ / nA
H_2	^{2}H	0.40 ‰	0.20 ‰ / nA
SO_2	^{34}S	0.10 ‰	0.03 ‰ / nA

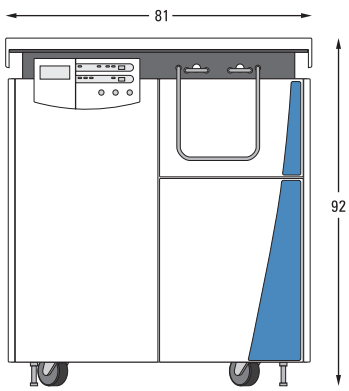
System Performance

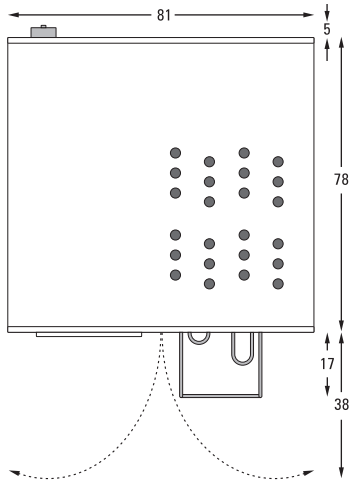


Installation Requirements

THERMO SCIENTIFIC DELTA V	
Environment	Heat output 1.5 kW during normal operation, 2.0 kW during bakeout (basic system). Ambient temperature must be 18 - 28 °C with a relative humidity of 20 - 70 %
Power	3 -phase 230/400 V -10 % + 6%, fused 16 A / phase (single-phase optional), 50/60 Hz, dedicated line voltage must be free of spikes. Maximum permissible voltage between ground and neutral lines < 400 mV
Compressed air	> 400 Kpa (> 50 psi)
Dimensions	Mass spectrometer system: 81 cm (width) x 78 cm (depth) x 92 cm (height) 31.9 inch x 30.7 inch x 36.2 inch
Weight	300 kg (660 lb.), basic system

Thermo Scientific DELTA V Dimensions (in cm)





Laboratory Solutions Backed by Worldwide Service and Support

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