

**DELTA V Advantage
DELTA V Plus**



The Next Generation Isotope Ratio MS

DELTA V Advantage | DELTA V Plus

The Next Generation Isotope Ratio MS

The 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 H₂ capability
 - Upgrade from the DELTA V Advantage to the 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 DELTA V. With more than 900 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 H₂ 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.



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

DELTA V Advantage

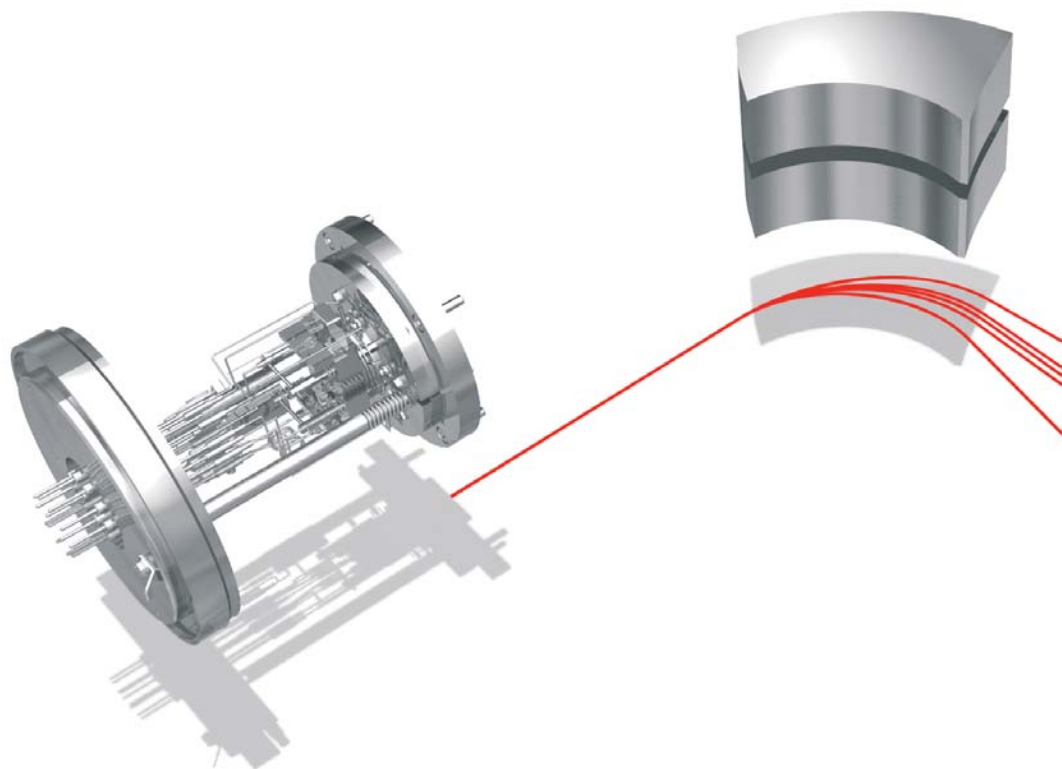
The DELTA V Advantage exceeds the performance of the DELTA^{plus} XP in virtually all aspects. Its sensitivity for CO₂ in Dual Inlet mode is better than 1200 molecules per ion. The standard collector configuration is the Universal Triple Collector. H₂ collectors with on-line hydrogen capability are optional. 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.

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 CO₂ 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.

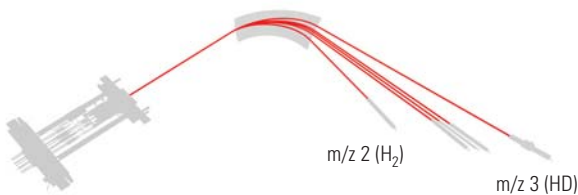
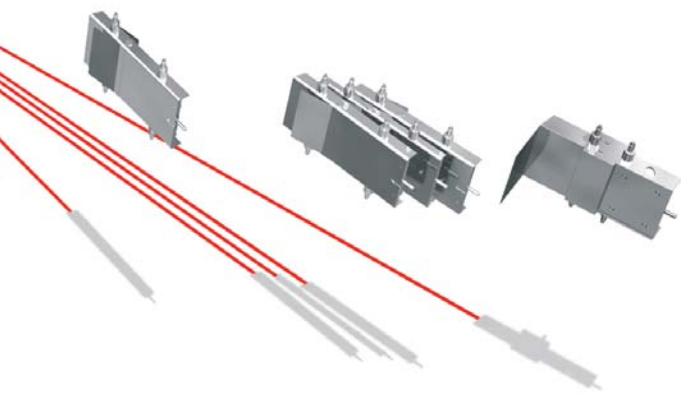
The DELTA V Plus can accommodate up to 10 collectors, ensuring flexibility to cover all isotope ratio MS applications in the mass range up to m/z 96. Its versatility puts virtually no instrumental limit to your research.



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

- 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 $\pm 25\%$, 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 sample preparation devices and interfaces are available as inlets to the DELTA V series. Thermo offers 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 ConFlo, with an installed base of over 600 units, is the most widely used interface for coupling elemental analyzers with isotope ratio mass spectrometers. The **ConFlo III Universal Interface** allows the connection of a wide variety of elemental analyzers to the DELTA V including: Dumas combustion elemental analyzers for $^{13}\text{C}/^{12}\text{C}$, $^{15}\text{N}/^{14}\text{N}$ and $^{34}\text{S}/^{32}\text{S}$, quantitative high temperature carbon reduction elemental analyzers for D/H and $^{18}\text{O}/^{16}\text{O}$ (**TC/EA** and **Flash EA 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 III 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 **LC IsoLink** opens the world of HPLC separations to $^{13}\text{C}/^{12}\text{C}$ 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 **GC-C/TC III** 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, $^{13}\text{C}/^{12}\text{C}$, $^{15}\text{N}/^{14}\text{N}$ and $^{18}\text{O}/^{16}\text{O}$ isotope ratios is possible for all mixtures accessible by the GC technique. More than 600 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 **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 DELTA V offers precision comparable to dual inlet methods for H₂ and CO₂ water equilibration, phosphorolysis of carbonates, CO₂ 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 **PreCon** trace gas pre-concentrator can be connected to the GC-C/TC III or the GasBench II for atmospheric trace-gas research in the ppm and ppb range.

Complete Analytical Solutions

Dual Inlet Analysis

The **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 **Kiel Carbonate IV** 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 DELTA V is straightforward and intuitive enabling high-throughput routine and flexible research applications.

Productive, Reliable and Easy to Use

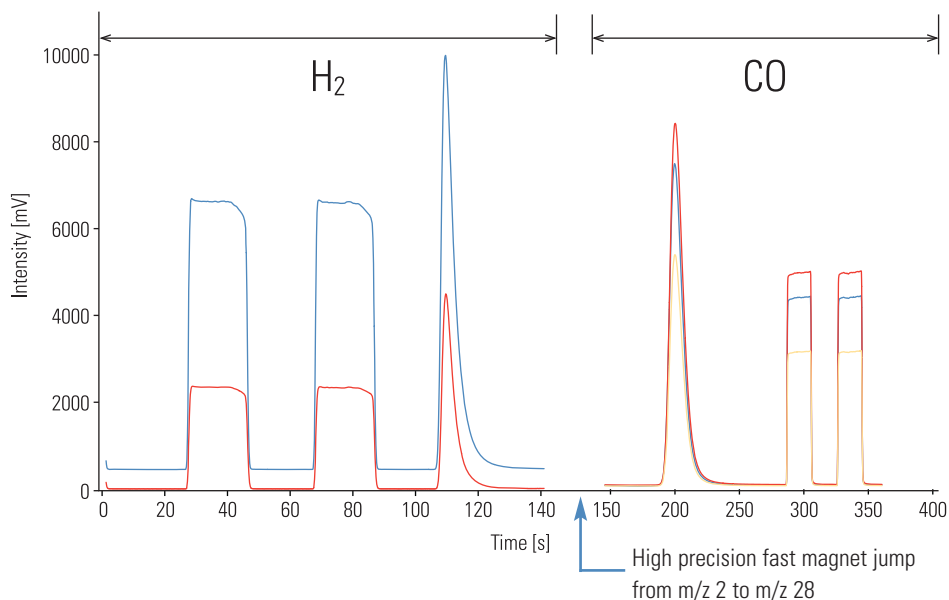
The ion source is computer controlled, supporting manual and automatic tuning, including a push-button option for periodic fine-tuning. Tune parameters are stored and can be linked directly to specific applications.

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. H₂ to CO, N₂ to CO₂, 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 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.

Isodat Software Suite

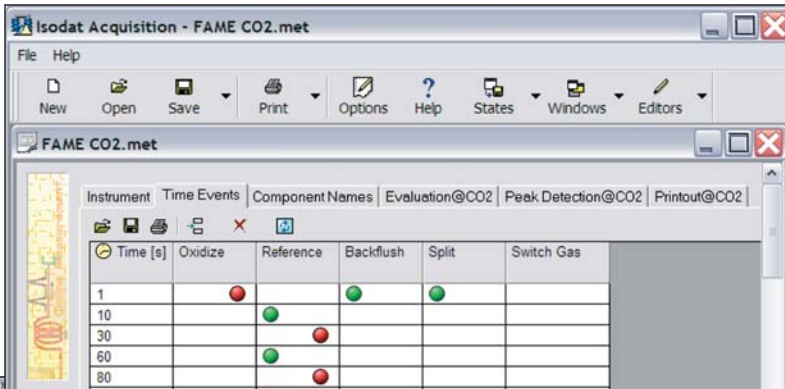
The Isodat software suite fully combines the divergent requirements for easy, unattended productivity and flexible support of demanding research. It is a seamlessly integrated part of the DELTA V and its peripheral devices controlling and automating the complete analysis from sample preparation to data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

Line	OC Method	AS Sample	AS Method	Identif. 1	Identif. 2	Comment	Preparation	Method
1	Trace 100_0_200 ppm	AS:AS2000 tol_asm	AS:AS2000 tol_asm	FAME 111	Split 1/20	Operator 2	Extraction	FAME CO2.met
2	Trace 100_0_200 ppm	AS:AS2000 tol_asm	AS:AS2000 tol_asm	FAME 112	Split 1/20	Operator 2	Extraction	FAME CO2.met
3	Trace 100_0_200 ppm	AS:AS2000 tol_asm	AS:AS2000 tol_asm	FAME 113	Split 1/20	Operator 2	Extraction	FAME CO2.met
4	Trace 100_0_200 ppm	AS:AS2000 tol_asm	AS:AS2000 tol_asm	FAME 114	Split 1/20	Operator 2	Extraction	FAME CO2.met
5	Trace 100_0_200 ppm	AS:AS2000 tol_asm	AS:AS2000 tol_asm	FAME 115	Split 1/20	Operator 2	Extraction	FAME CO2.met
6	Trace 100_0_200 ppm	AS:AS2000 tol_asm	AS:AS2000 tol_asm	FAME 116	Split 1/20	Operator 2	Extraction	FAME CO2.met
7	Trace 100_0_200 ppm	AS:AS2000 tol_asm	AS:AS2000 tol_asm	FAME 117	Split 1/20	Operator 2	Extraction	FAME CO2.met
8	Trace 100_0_200 ppm	AS:AS2000 tol_asm	AS:AS2000 tol_asm	FAME 118	Split 1/20	Operator 2	Extraction	FAME CO2.met
9	Trace 100_0_200 ppm	AS:AS2000 tol_asm	AS:AS2000 tol_asm	FAME 119	Split 1/20	Operator 2	Extraction	FAME CO2.met
10	Trace 100_0_200 ppm	AS:AS2000 tol_asm	AS:AS2000 tol_asm	FAME 1110	Split 1/20	Operator 2	Extraction	FAME CO2.met

Powerful Acquisition Launcher

Flexible & Powerful Straightforward & Easy

The 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 maintenance.

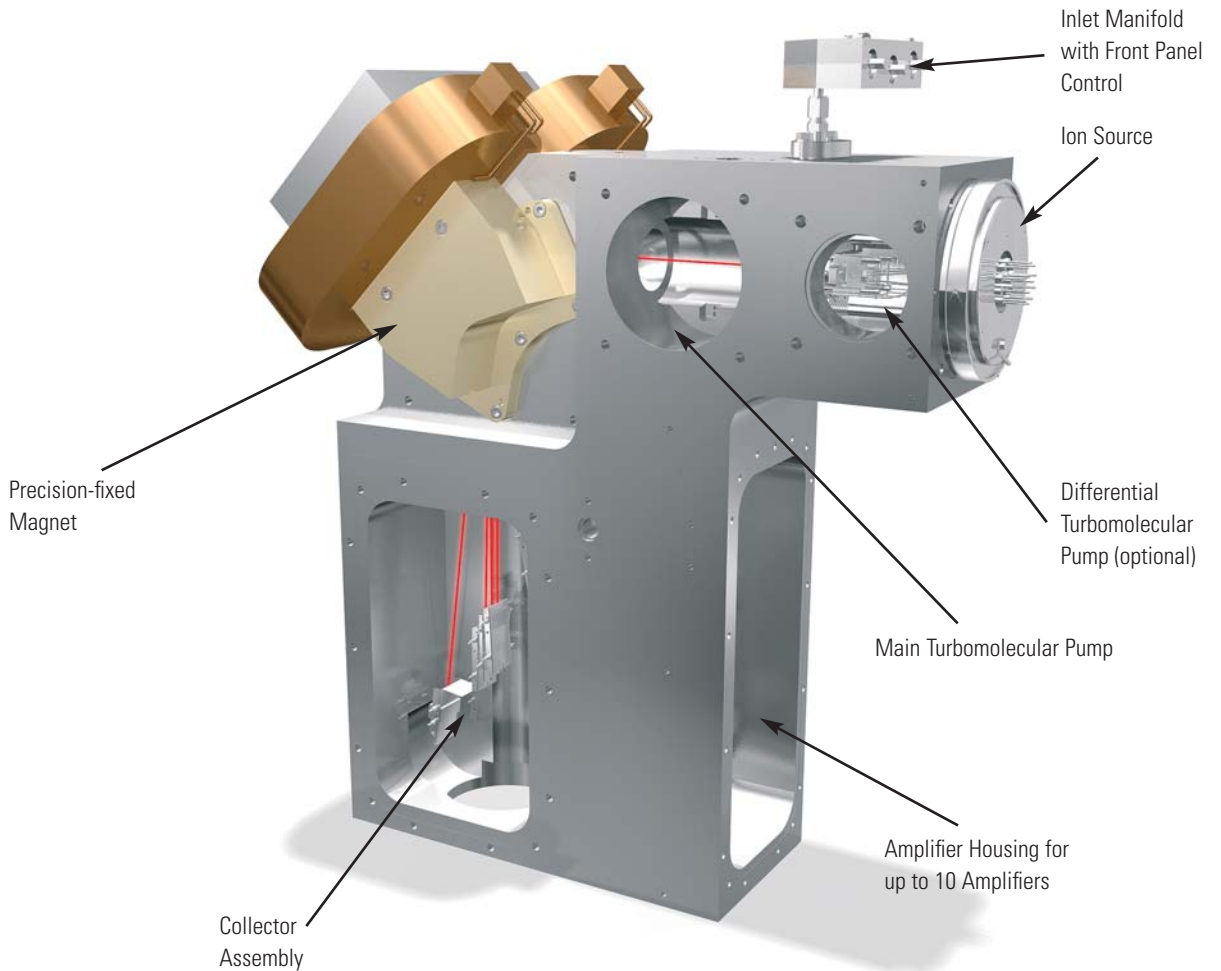
The magnet is precision-mounted into the monolithic analyzer with intrinsic alignment, its pole faces determining the free flight space for the ions, thus eliminating the traditional flight tube. The gain in ion beam height directly translates into increased sensitivity.

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 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 H₂. 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

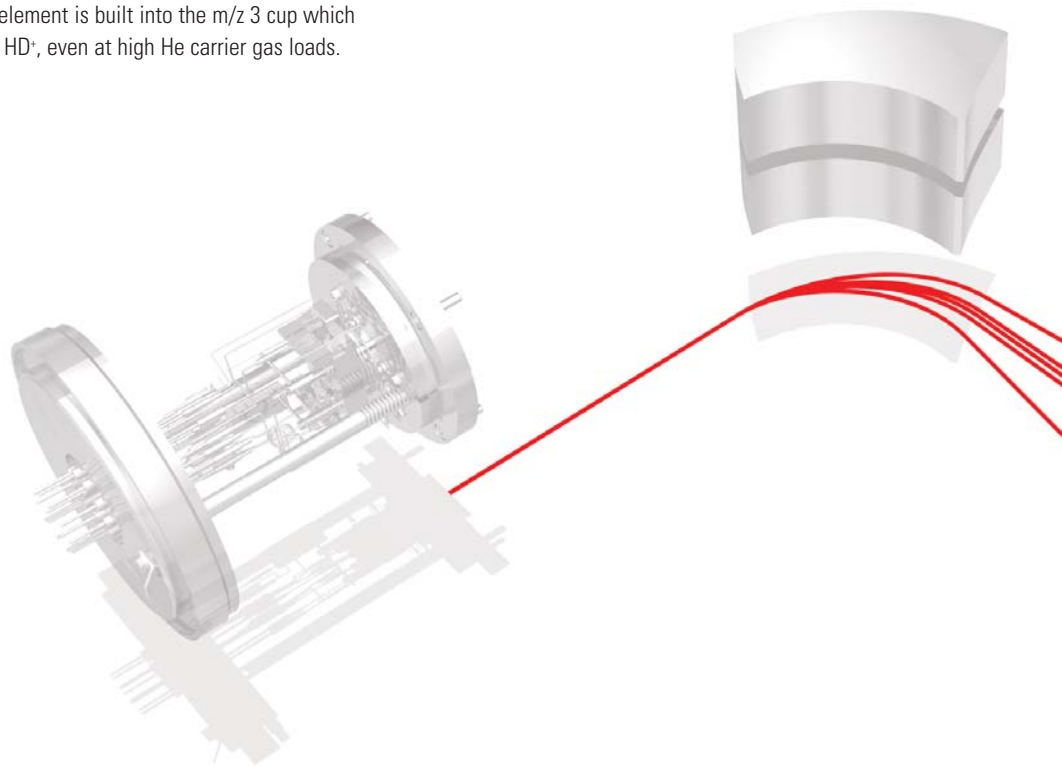
The universal triple collector is standard on the DELTA V platform and is suitable for all standard applications involving N_2 , CO, NO , O_2 , CO_2 , N_2O and SO_2 .

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 He^+ 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.

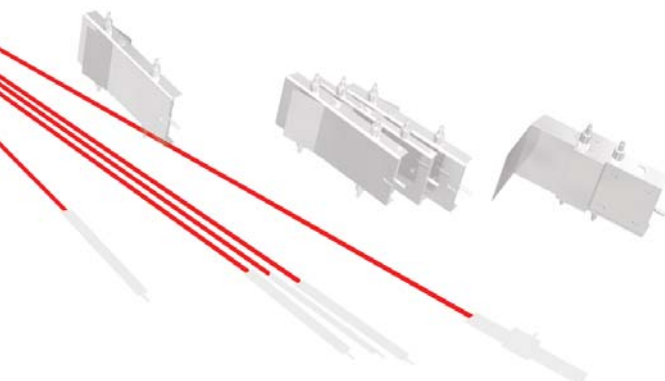
Individual Collector Arrangements

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 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 ₂ O			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 ₂ O	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 ₂ Cl					50	51	52	53			
CH ₃ Br								94	96		
Ne	20	21	22								
Ar				36	38	40					
Kr						78	80	82	84	86	



... Available on
Isotope Ratio MS

DELTA V System Performance

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

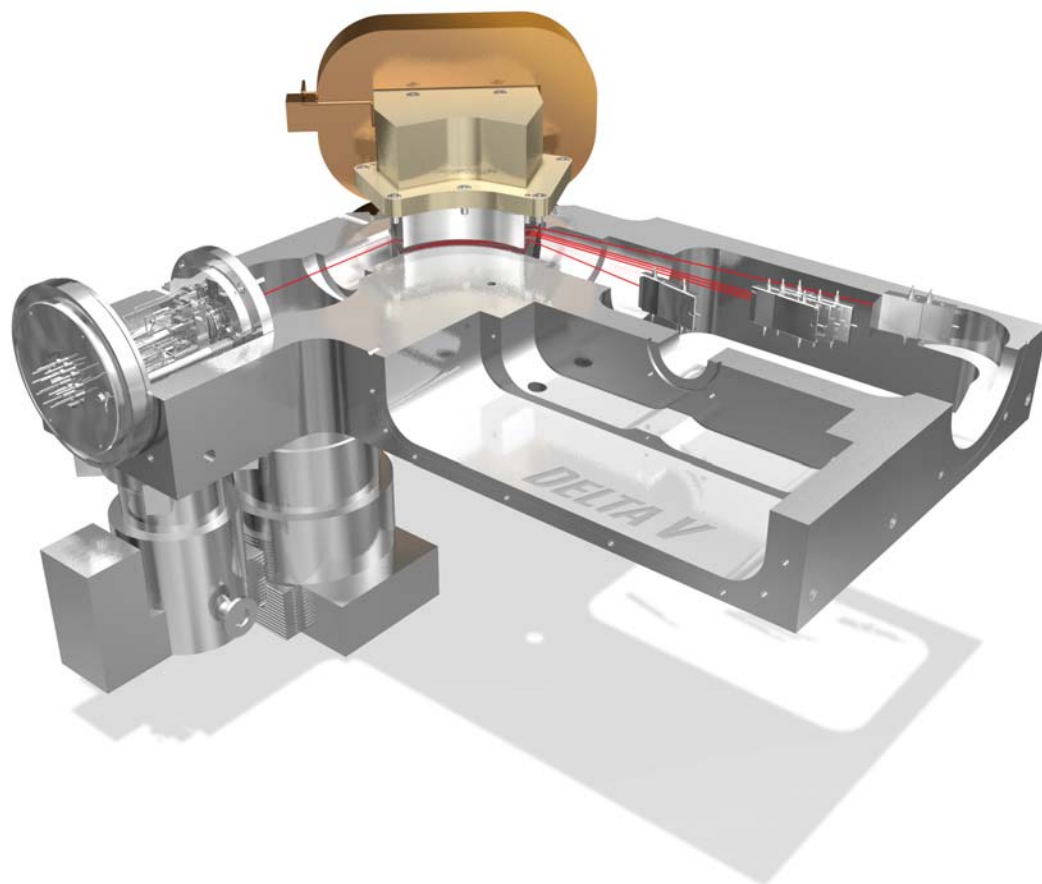
	DELTA V Plus	DELTA V Advantage
Sensitivity Dual Inlet mode Molecules CO ₂ / mass 44 ion translates to	800 M/l	1200 M/l
Sample Consumption for 5 nA signal at mass 44	0.04 nmol/s	0.06 nmol/s
Sensitivity Continuous Flow mode Molecules CO ₂ / mass 44 ion with	1100 M/l	1500 M/l
Isotope Ratio Linearity*	0.02 ‰ / nA	
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

The 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:

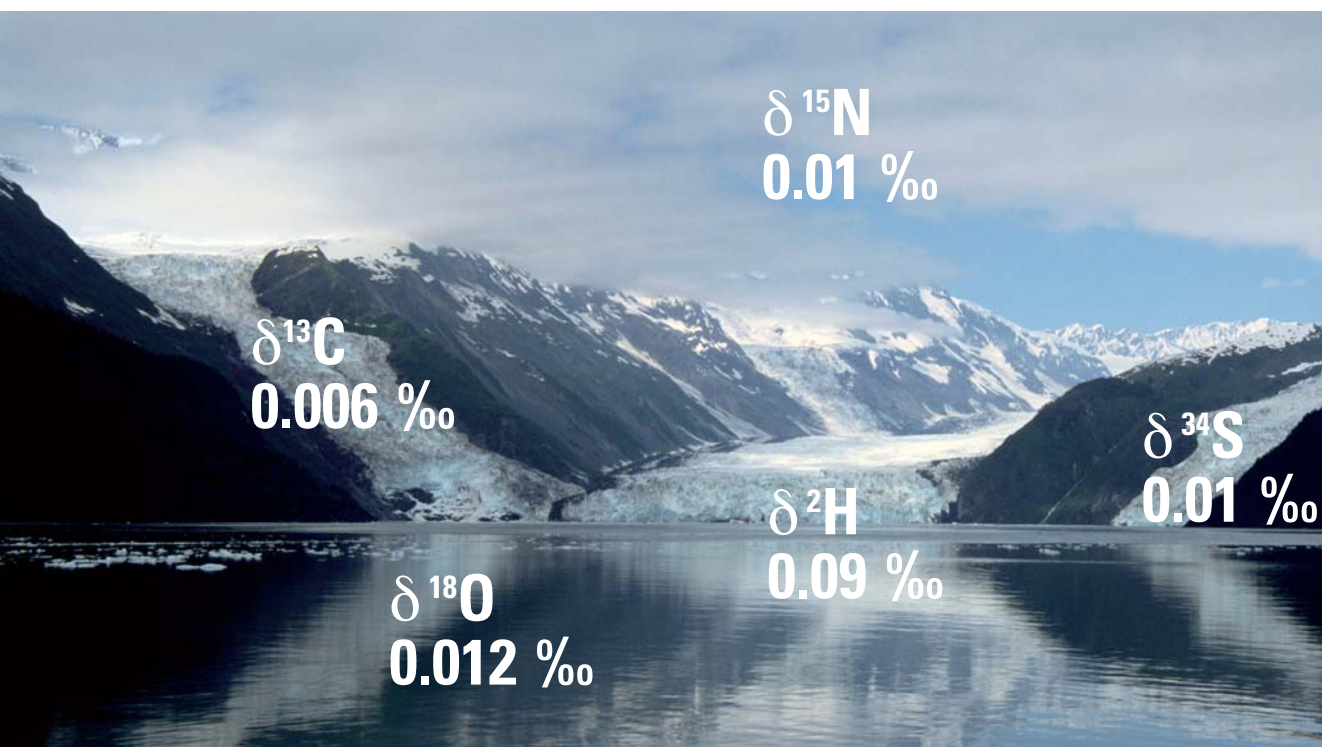
GAS	MINOR ISOTOPE	INTERNAL PRECISION ($2\sigma_{\text{mean}}$)	SAMPLE SIZE bar μL
CO ₂	¹³ C	0.006 ‰	> 100
		0.02 ‰	> 50
	¹⁸ O	0.012 ‰	> 100
		0.04 ‰	> 50
N ₂	¹⁵ N	0.01 ‰	> 100
		0.05 ‰	> 50
SO ₂	³⁴ S	0.01 ‰	> 100
H ₂	² H	0.09 ‰	> 200

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 H₂ 5 V):

GAS	MINOR ISOTOPE	PRECISION (1 σ)	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

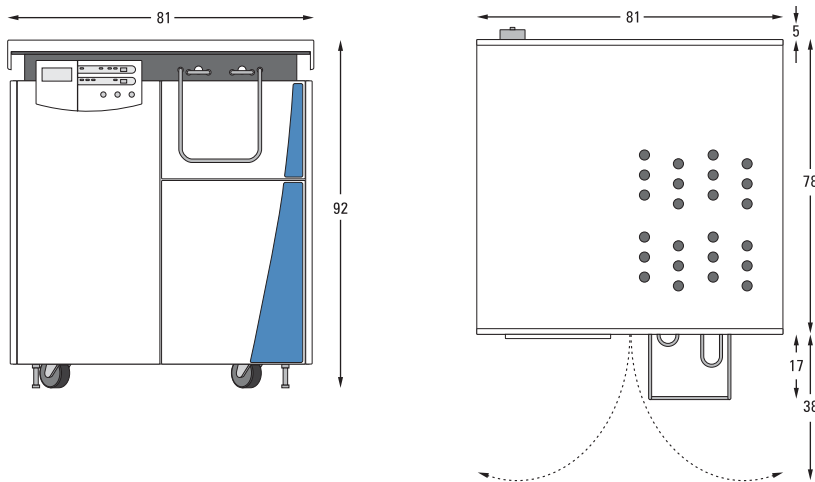


Installation Requirements

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

DELTA V Footprint and Dimensions (in cm)



Laboratory Solutions Backed by Worldwide Service and Support

Tap our expertise throughout the life of your instrument. As an industry leader in analytical instruments, Thermo extends its support throughout our worldwide network of Thermo-trained and certified engineers who are experts in laboratory technologies and applications. Put our team of experts to work for you in a range of disciplines, from system installation, training and technical support, to complete asset management and regulatory compliance consulting. Improve your productivity and lower the cost of instrument ownership through our product support services. Maximize uptime while eliminating the uncontrollable cost of unplanned maintenance and repairs. When it's time to enhance your systems, Thermo also offers certified parts and a range of accessories and consumables suited to your application.

To learn more about our products and comprehensive service offerings, visit our Web site at www.thermo.com.

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