

SPECTRO MS

Fully Simultaneous ICP-Mass Spectrometer



SPECTRO MS

The commercial use of analytical instruments with an inductively coupled plasma (ICP) as the excitation source began in 1974 with the first ICP emission spectrometer. ICP mass spectrometers were introduced beginning in 1983; they established themselves on the market quickly. Improvements in the sensitivity and reduction of the interferences have led to more precise analytical results. Today, the detection limits for many elements are so low that they can only be achieved in clean rooms and are, in practice, frequently limited by natural impurities.

With its new SPECTRO MS ICP mass spectrometer SPECTRO demonstrates that even with the high level of technology today, quantum leaps in development are possible; bringing measurable advantages to users everywhere. The SPECTRO MS is the only commercially available ICP mass spectrometer to offer fully simultaneous measurement of the complete, inorganically relevant, mass range from ^6Li to ^{238}U . The capacities of ICP mass spectrometry reach new standards with this fundamental step from sequential to simultaneous measurement. Not only have precision and accuracy been improved, but the measuring time per sample has also been greatly reduced.

The heart of this unique, revolutionary technology is the combination of a double focusing Mattauch-Herzog sector field mass spectrometer with a novel detector that is able to simultaneously record the complete ion beam. This detector using the "Direct Charge Detection" principle has 4800 channels and can simultaneously cover all of the relevant isotopes. With this simultaneous mode of operation, the required masses are no longer viewed in sequence as in conventional ICP mass spectrometers. Instead, the entire mass spectrum is always recorded "at a single glance" and then stored. In this way, all of the information for the evaluation of all relevant elements of the periodic table is available for every measurement – that information which is interesting at the time is extracted and processed.

Every single component of the SPECTRO MS has been optimized in view of extraordinary analytical performance and simple operation. With the maintenance-friendly housing, robust systems for vacuum and cooling, a flexible sample introduction system, matrix tolerant interface, an unusually efficient ion optic and simplest routine operation the SPECTRO MS offers users many unique possibilities.





Applications

Superior performance, drastically reduced measuring times and comprehensive possibilities for the connection of accessories and automatic equipment for unattended operation; the SPECTRO MS has been engineered for the most demanding analytical applications. Typical areas of use can be found, for example, in academic and industrial research laboratories, in geology, in the mining and metal industries as well as in agriculture and nutrition. Additionally, there are other classical tasks for ICP mass spectrometry in the environmental sector, in companies in the chemical, petrochemical and nuclear industries, in clinical, biological and pharmaceutical facilities and during the manufacture of semiconductors. New fields of application are being continuously developed especially in light of the rapid advancements in the coupling of various separation techniques. The SPECTRO MS is the optimal solution for many of these.



- **Double focusing sector field mass spectrometer with newly developed ion optic and pioneering detector technology**
- **Simultaneous measurement of the complete inorganic mass spectrum for improved sensitivity and precision as well as highest sample throughput**
- **Robust dry vacuum system and zero-maintenance, free-running, generator**
- **Rapid fingerprinting, real-time internal standardization and measurement of transient signals, isotope ratios and isotope dilution**
- **ICAL system logic for continuous optimal operation**
- **Compatible with EPA, FDA, CLP and 21 CFR Part 11 as well as other standards and guidelines**



Highest analytical performance, fast access to the spacious sample chamber, simple operation and maintenance: Application and operator were paramount during the development of the SPECTRO MS.

Housing and Vacuum System

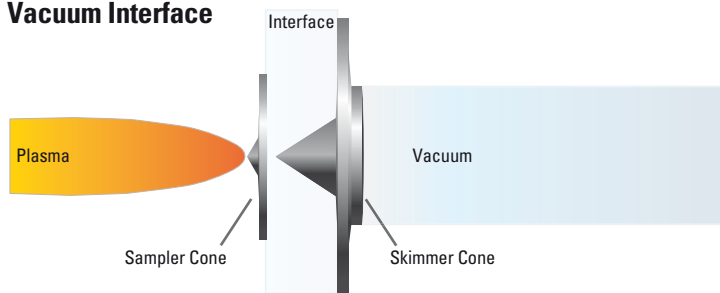
The well thought-out SPECTRO MS housing bears the trademark of experienced industrial designers and supports simple installation, operation and maintenance. Dimensions and weight have been kept to a minimum. The instrument is mounted on stable rollers so that it can be moved with no trouble if this should become necessary. This is, however, not required for normal maintenance as sampler, skimmer, sample introduction system, torch and other components that must be replaced for analytical reasons, or that must be taken out for service, are accessible from the front and can be exchanged with little effort.

The powerful, low-maintenance vacuum system consists of two turbomolecular pumps and an internal rotary pump. The system provides efficient evacuation of the interface (approx. 2-4 mbar), ion optic (approx. 10^{-3} to 10^{-5} mbar) and mass spectrometer (10^{-6} mbar and lower). Completely automatic control and monitoring of the entire vacuum system as well as other instrument components enables safe unattended operation without extensive user input. The standby mode reduces the pump speed when not in use; reducing wear and energy consumption.

While the SPECTRO MS RF generator uses air cooling, the vacuum interface requires an active cooling. A cooling system or external heat exchanger can be connected to the SPECTRO MS for this. The necessary connections for gas and power, as well as the main switch, are easily accessible on the right side of the instrument.



Vacuum Interface

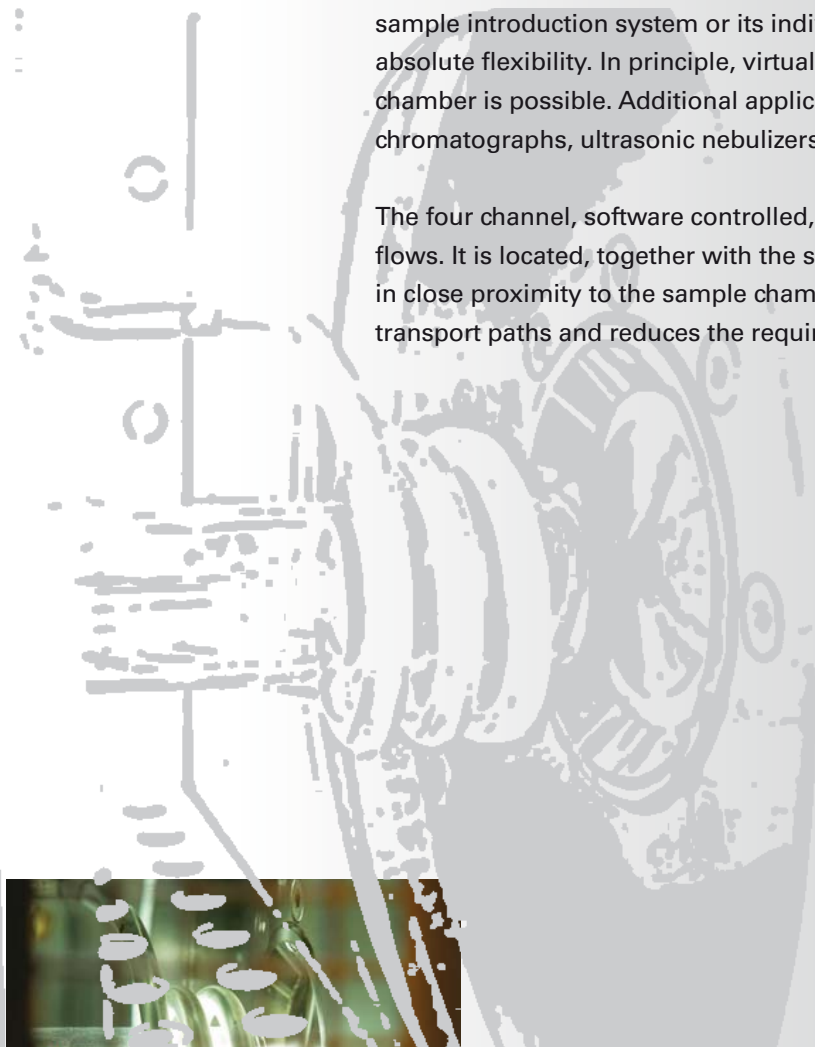




Sample Introduction

The SPECTRO MS sample chamber can be accessed by sliding the front cover to the side. It is spacious and enables simple and rapid exchange of the entire sample introduction system or its individual components. The SPECTRO MS offers absolute flexibility. In principle, virtually every combination of nebulizer and spray chamber is possible. Additional application fields are easily developed by attaching chromatographs, ultrasonic nebulizers or laser ablation systems.

The four channel, software controlled, peristaltic pump enables exact sample flows. It is located, together with the sample shelf, on the left side of the instrument in close proximity to the sample chamber. This arrangement minimizes sample transport paths and reduces the required flush times.



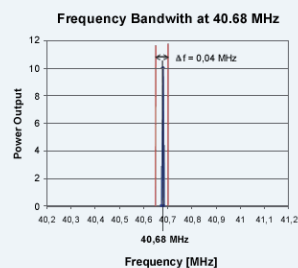
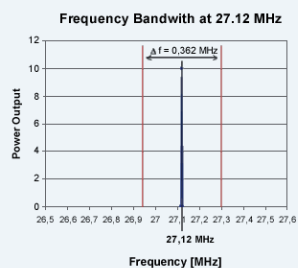
Excitation

Like the high-end SPECTRO ARCOS ICP-OES, the SPECTRO MS utilizes a compact, maintenance-free generator with high efficiency (> 70 %) and high power stability (> 99.9 %). This is a free-running 27 MHz system with air cooling, integrated semiconductor power supply and fully automatic control. With immediate adjustment of the resonance frequency for varying loads, it guarantees utterly stable plasma conditions even for the most difficult excitation conditions – an absolute must for excellent analytical results.

The SPECTRO generator requires neither moveable parts nor complex electronics making the construction very robust; the reliability is, figuratively speaking, built in. The 27 MHz generator has a wider regulated band width than the 40.68 MHz generator, enabling it to compensate for much larger load fluctuations. With an output power of up to 1.7 kW the generator has more than enough reserves for all ICP mass spectrometer applications – even the most difficult organic solutions.

Control and continuous monitoring of the generator is performed by the instrument software. The settings for given sample types are stored with the respective method.

A motor is used to optimize the torch position along all three axes for best possible alignment of the ion stream from the plasma into the interface. These settings are stored, together with the generator settings, with the rest of the method parameters.





Interface

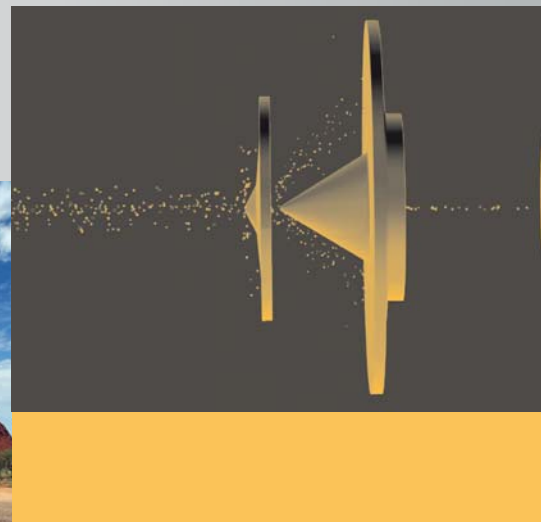
The interface for transport of the ions from the plasma into the high vacuum system consists of two cone-shaped metal nozzles ("cones") aligned in succession: The sampler and the skimmer. Both have a small orifice in the middle onto which the plasma region with the highest portion of single charged ions is exactly aligned using the torch positioning.

The sampler causes the plasma gas to expand in the form of a super sonic beam into the interface vacuum. The gas temperature and pressure are rapidly reduced and the ions generated in the plasma are efficiently transported into the vacuum system without collisions. The skimmer, which completes the interface vacuum, peels off the outer gas stream; allowing the analyte ions to enter the next vacuum stage.

The cones are manufactured out of nickel or – especially for use with organic solutions or highly concentrated acids and hydrofluoric acid – platinum. Due to the proximity to the plasma and with it the extremely high temperatures, water cooling is required. Because the cones are subject to a corrosive and chemically aggressive environment, they are cleaned regularly and replaced when they display extreme wear. The maintenance work required for this is quickly and easily conducted on the SPECTRO MS.

With an open sample chamber, visual examination of the cones can be easily conducted. If necessary, the entire component block can be brought, with a mouse click, into the service position so that cones or extractor lens can be serviced.

Efficient transport of plasma generated ions into the mass spectrometer by the newly designed vacuum interface.





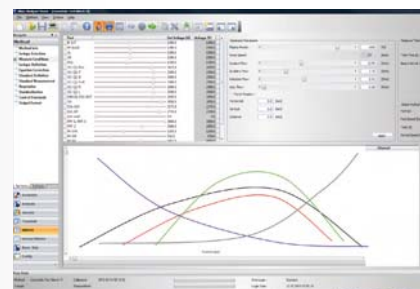
Ion Optic

The ion optic in the SPECTRO MS is a completely new development. Its components separate disturbing electrons, photons and neutral particles with extreme efficiency from the analyte ions; transporting the latter optimally into the mass spectrometer.

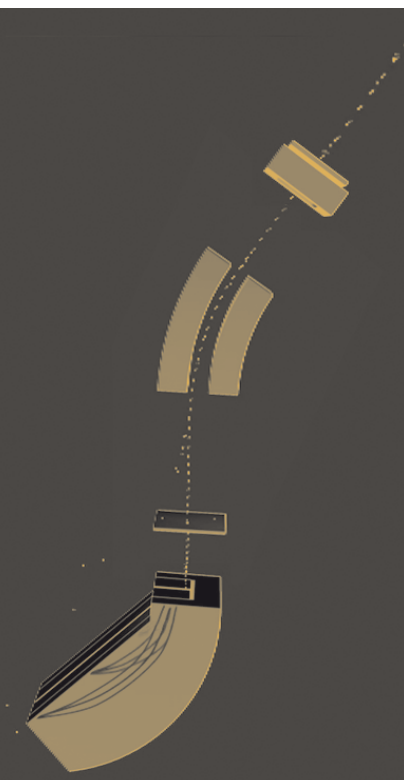
At first, the interface extractor lens removes the electrons from the gas beam formed by the skimmer of the vacuum interface. The now positively charged ion beam is then focused in the next step, the pre-filter. The interface extractor lens can also be easily removed and cleaned without breaking the high vacuum.

In the following pre-filter, a 127° electrostatic sector field, the ions follow the circular path defined by the field while photons and other non-charged particles fly in a straight path separated from the ions. After passing through the pre-filter, the ion beam continues through the beam forming optic consisting of an Einzel lens and an electrostatic quadrupole doublet. The ion beam is converted from being round to rectangular, attuned to the entrance slit form. This enables efficient beam transport into the subsequent Mattauch-Herzog mass spectrometer.

Control of the entire ion optic is performed intuitively using the instrument software. The settings are stored in the method, ensuring simple operation.



The newly designed ion optic is virtually drift-free due to the ICAL system logic.

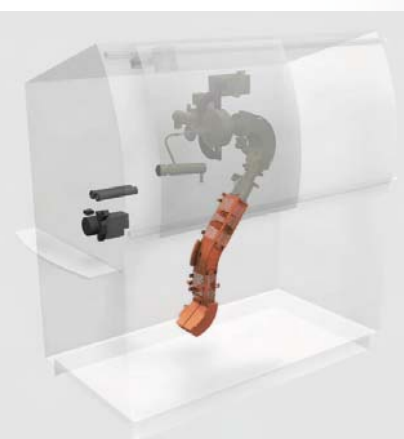


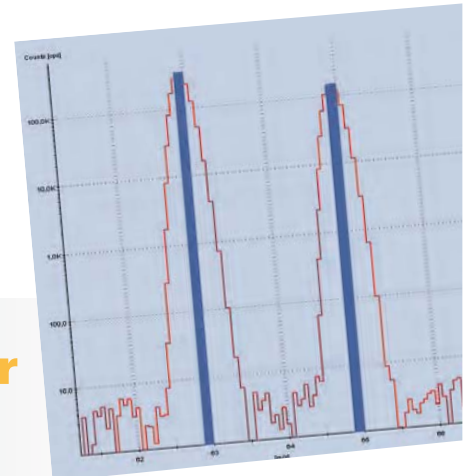
Simultaneous measurement of the entire spectrum is enabled by the combination of double focusing sector field mass spectrometer and a novel planar detector.

Mass Spectrometer

A double focusing sector field mass spectrometer in a Mattauch-Herzog geometry is utilized in the SPECTRO MS. It is composed of an entrance slit, an electrostatic analyzer (ESA), an energy slit and a magnetic sector field with the subsequent detector attached.

The ion beam energy band width is reduced in the electrostatic energy analyzer (ESA) in order to achieve high resolution for the following mass separation in the magnetic field. The special characteristic of the Mattauch-Herzog geometry is that all ion masses are focused on one focal plane; enabling the use of a flat surface detector and simultaneous measurement of the entire spectrum. The time consuming sequential scanning used in other spectrometers is not necessary. At the same time, with the high sensitivity and minimum background disturbance, even complex matrices can be measured with extraordinarily low detection limits.



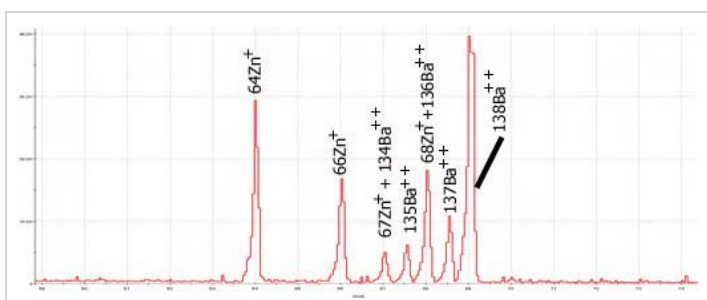


Detector

The Direct Charge Detector (DCD) used in the SPECTRO MS is a completely new semiconductor detector with 4800 channels and a high readout rate. It simultaneously covers the entire mass spectrum. Every channel is made up of an array with a low and a high amplification pixel (dual stage design). In this way, every channel can directly process a wide range of signals.

The dynamic measuring range can be further increased by adjusting the integration time. It is automatically set for every single channel during the measurement and is adjusted when necessary. This enables an optimum signal to noise ratio with maximum measurement dynamics. The high readout frequency makes it possible to easily record transient signals.

With the SPECTRO MS it is possible to separate doubly charged ions with uneven masses (e.g., 137Ba^{++} with 68.5) from neighboring analyte masses (e.g., 69Ga and 68Zn).



Sophisticated master methods have been provided to simplify method development. Assistants lead the user through all of the steps of the development process and help the operator in all respects. Interferences in semi-quantitative analyses are automatically detected and corrected.

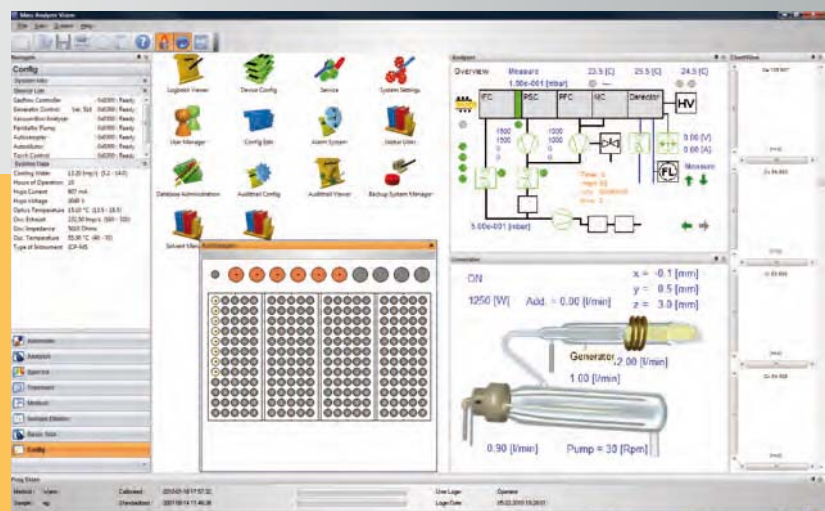
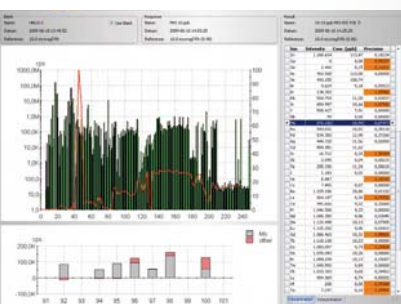
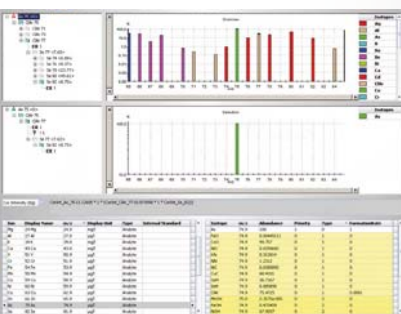
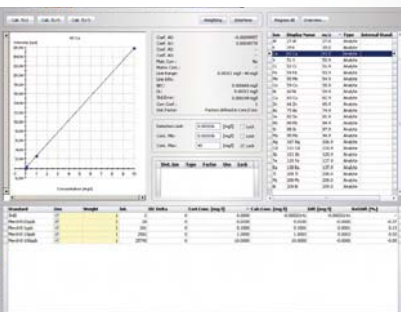
Software

The SPECTRO MASS ANALYZER VISION software package is characterized by its intuitive user interface and very easy operation. Frequently repeated measurement tasks can be conducted with just a few mouse clicks. Rapid semi-quantitative screening analyses over the entire spectrum are easily performed without extensive calibrations. Functions for evaluation, print-out, storage and transfer of the measurement results are available. Unique functions for post processing of the results are enabled by the fact that all of the raw data is stored for every analysis and can be re-evaluated and interpreted as required.

SPECTRO MASS ANALYZER VISION offers comprehensive possibilities for fully automatic, unattended operation. The software is also well prepared for the coupling and connection of external accessory instruments – from sample introduction systems, autosamplers and autodilutors to complex online solutions. Further applications are easily developed using the software modules for isotope ratio and isotope dilution analyses.

The SPECTRO MS instrument state is continuously monitored and documented by the ICAL system logic functions for automatic system monitoring and control. This means that the instrument is always in an optimum state of operation. Automatic normalization of the methods is conducted with a single sample.

SPECTRO MASS ANALYZER VISION is compatible with EPA, FDA, CLP as well as other standards and guidelines and offers a 21 CFR Part 11-conforming user and data management system.



By storing the complete spectrum with each measurement, SPECTRO MS delivers exciting new levels of flexibility. For the first time it offers the simultaneous isotope ratio analysis for the complete mass spectrum. Outstanding productivity results from best-of-class sample throughput, reliability and ease-of-use. The revolutionary detector and read-out electronics make new benchmarks for precision and accuracy possible.

SPECTRO MS

Technical Data

RF-Generator

- Free running type, Frequency: 27.12 MHz
- RF power output: 0.7 to 1.7 kW
- Power efficiency: >70%, power stability <0.1%
- Automatic plasma ignition
- Stand-by mode (low power, low argon)
- Fully computer controlled
- Air cooled (no external cooling required)
- Solid state power supply fully integrated in cabinet

Mass Spectrometer

- Double-focusing magnetic sector field mass spectrometer in Mattauch-Herzog geometry
- "Solid state design": Permanent spectrometer magnet (no solenoid), no scanning required
- Continuous separation of the ion beam into mass spectrometer's focal plane:
 - 100% duty cycle
 - no signal loss from pulsing ions onto the analyzer
- Fully simultaneous capture of the entire mass range from ~5 to 240 amu

Detector

- Semiconductor Direct Charge Detector mounted in mass spectrometer focal plane
- 4800 dual stage channels cover the complete mass range from ~5 to 240 amu
- >9 orders of magnitude dynamic range possible
- Channel-individual signal-dependent automatic optimum integration time setting
- Non-destructive read-out

Dimensions and Weight

- Spectrometer (HxVxD) 1604 x 1673 x 892 mm (63 x 66 x 35 inch)
- Footprint (WxD) 1470 x 779 mm, (58 x 31 inch)
- Weight approx. 675 kg, (1490 lbs)

Environmental Conditions

- Room temperature: 18-25°C
- Relative Humidity: <80% non-condensing
- Atmosphere: free of corrosive vapors and high dust pollution

Exhaust System Requirements

- Plasma: 2 x 250 m³ per h (>150 cft/min) separately adjustable between zero and maximum

Argon Supply Requirements

- Quality 4.8, Argon for Spectrometry, pressure 7.5-10 bar (109-145 psi)

Water Cooling

- Pressure 4 bar
- Flow rate min. 1.8 L/min at 18°C

Electrical Requirements

- 230V +/- 5%, 50/60 Hz
- Approx. 6.5 kVA power consumption
- 32A line protection (slow-blow fuse)



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