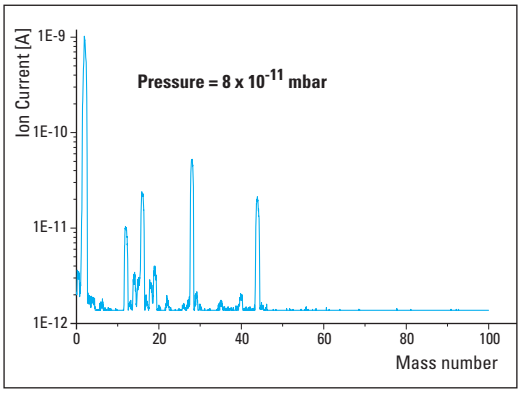
HiQuad QMG700

What does it take to serve your applications?
All you need is here!

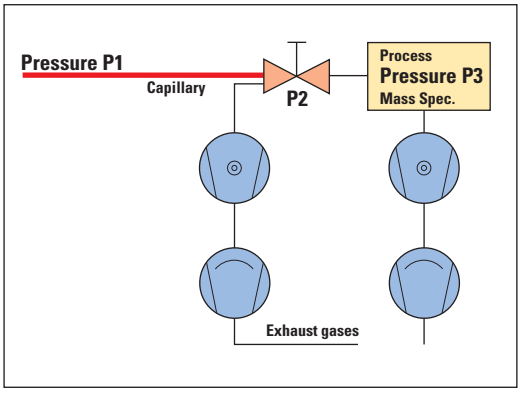
A modular Set of Mass Spectrometers, a Quality Vacuum and Pumping Systems and a well designed Gas Inlet System make a High Performance Gas Analysis System

We supply all the components and our specialists support your application!



Residual Gas Spectrum
Even at this low base pressure one can find some gases which may interfere with the sample to be measured! In this case it is H_2, CO and CO_2 and their fractions as the major components.
The contibution at mass number 16 and 19 may be oxygen and flourine ions which can show up as so called EID-Ions in the UHV.

For powerful mass spectrometry an excellent vacuum system is required.
Even at very low base pressure there is an influence of the vacuum system - residual gas composition - which may influence the detection limits of an analysis system.
The chamber material, surface treatment and the ideal pumping system is important.
The example shows an UHV residual gas spectrum, this becomes much worse if only a high vacuum system is used to perform gas analysis.
The components of the residual gas can interfere with the process gas and make trace analysis impossible.



Two stage non-discriminating gas inlet system for sampling at atmospheric pressure
The pressure is reduced in the laminar flow regime along the capillary from P1 to P2. No mass discrimination of the inlet gases can occur here. From P2 to P3 the pressure is reduced in the molecular flow, because the gas is pumped in the molecular flow in the process chamber. Both effects compensate and the gas inlet is non-discriminating. The residual gas composition in the process chamber is of vital importance for the performance of the whole analysis system, too. Some gases may condensate in the capillary. Therefore for some application a heated capillary has to be used. For trace analysis the valve has to be replaced by an orifice to avoid contamination of the sample by the valve itself. For other application the gas has to be introduced in a molecular beam inlet right through the ion source of the mass spectrometer. This is an example to show the principle of a two stage gas inlet, an ideal gas inlet system serving all applications doesn't exist.

For excellent analysis systems a quality gas inlet system is required.
The performance of an analysis system depends on the performance of the mass spectrometer, the vacuum system and the gas inlet system. To achieve the ultimate performance the gas inlet system has to be optimized for each individual application.

Our specialists can help to select the best inlet system for your application.

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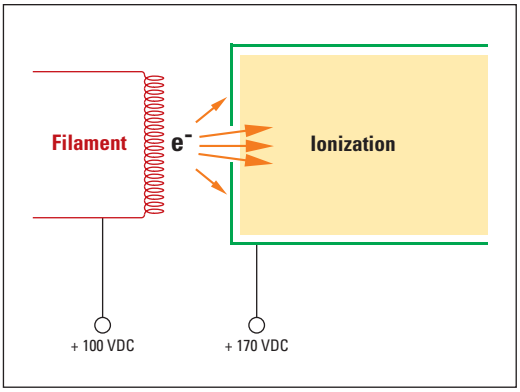
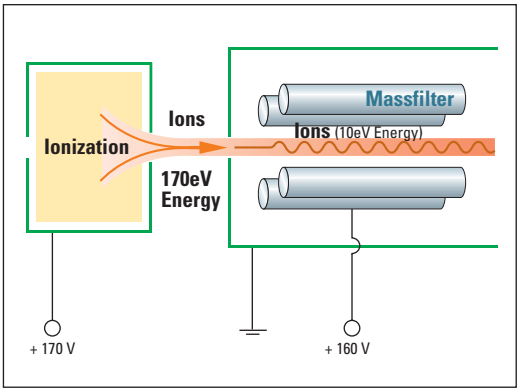
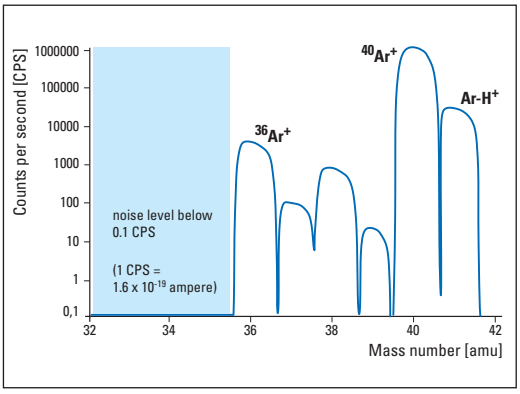
Design Advantages of the Pfeiffer Vacuum Mass Spectrometers



Biased Ionization Chamber
The electron emitting filament is positively biased by 100 - 150 VDC such that the electrons are strongly attraced to the anode. This way electron induced desorption of ions from other surfaces in the system like the chamber walls is avoided. This is the pre-condition to achieve an extreme low background signal.



Field-Axis-Technology
The ions generated in the ion source are accelerated to a high speed towards the mass filter. This allows them to cross the fringing fields with little interaction and thus they are injected with high efficiency and low mass discrimination into the massfilter.



Ions from a DC-Argon Plasma

SEM 90 degree off axis
In most of this instruments an SEM 90 degree off axis is used. Photons, electrons and high energetic neutrals can not reach the SEM and so do not contribute to the noise level. Due to the deflection of the ions a factor of about two is lost in sensitivity, on the other hand the noise level is suppressed by more than two orders of magnitude. The discrete dynode SEM is specially designed to show extremely low dark currents.
In combination with an appropriate ion counting electronics this extreme low noise level is achieved.
In the experiment shown here, Ar and Ar-Hydrogen ions generated in a plasma are detected.

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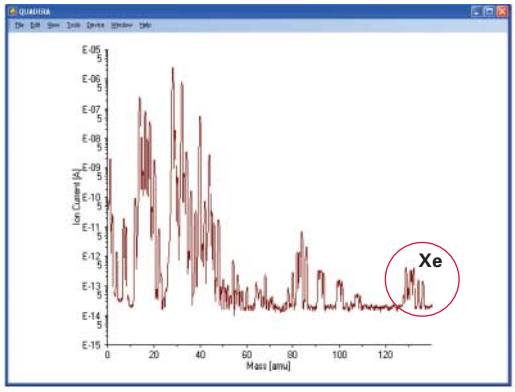
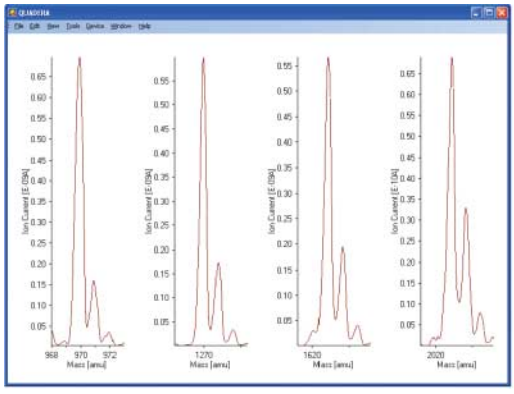
Outstanding Performance

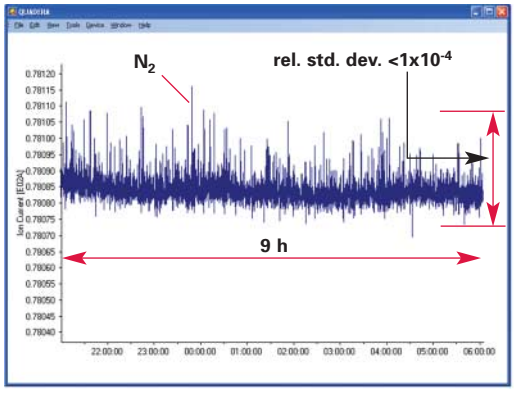
Sensitivity and dynamic range
136 Xe in air 7.8 ppb is detected orders of magnitude above the noise level.
A dynamic range of more than 10 decades is achieved.



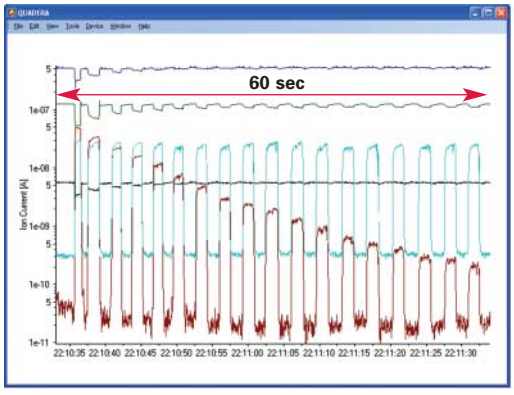
Excellent peak shape and resolution
QMA400 analyzer with 90 degree off axis SEM, Cross Beam Ion source with magnet.
Mass range 1 - 2048 amu.



Superb stability
Quantitative air analysis (normalized to 100%) shows excellent long term stability over many hours.

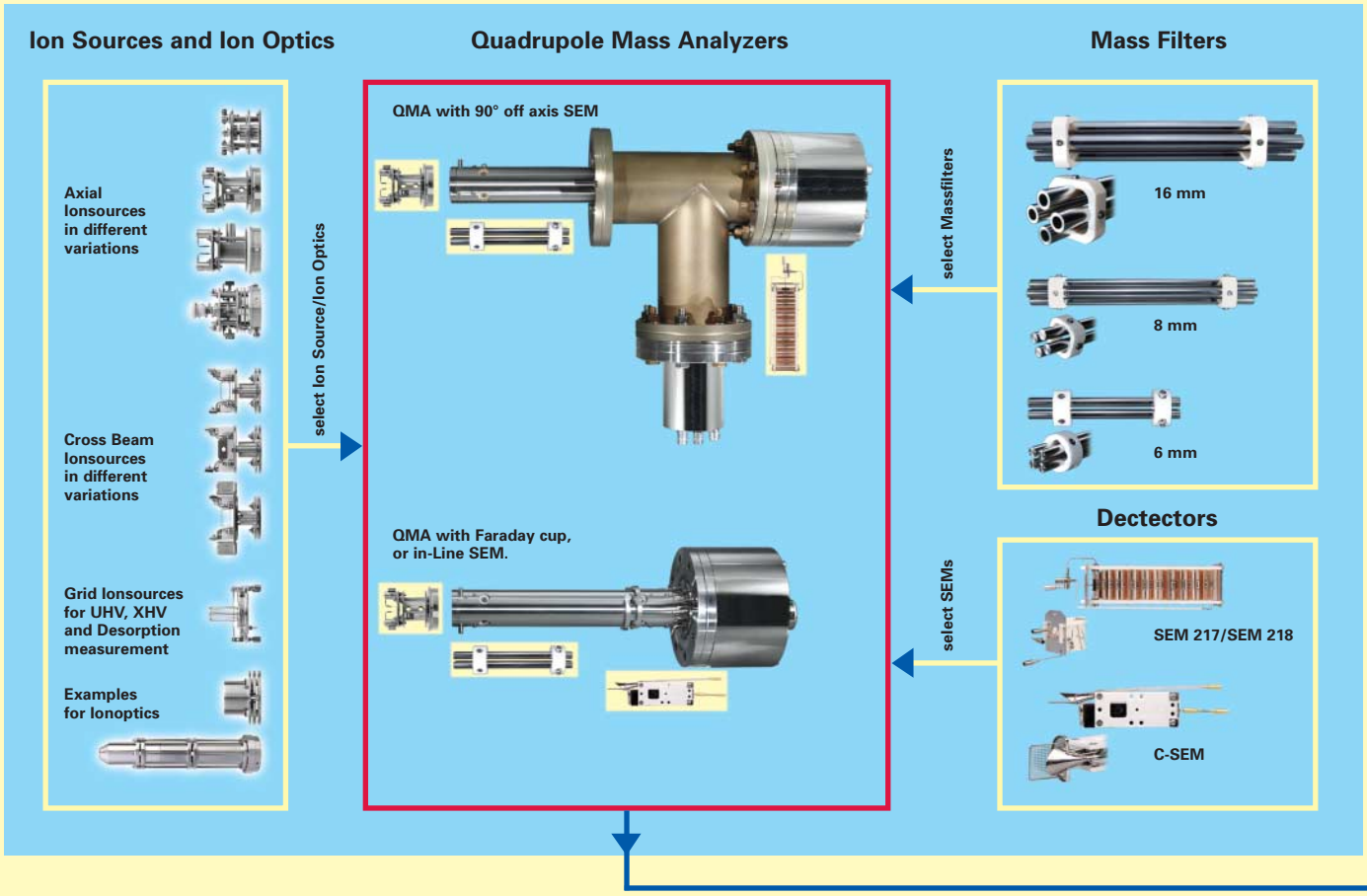


High measurement speed
Transient gas composition during respiration analysis. Nitrogen, Oxygen and Carbon-dioxide are the main components shown here.



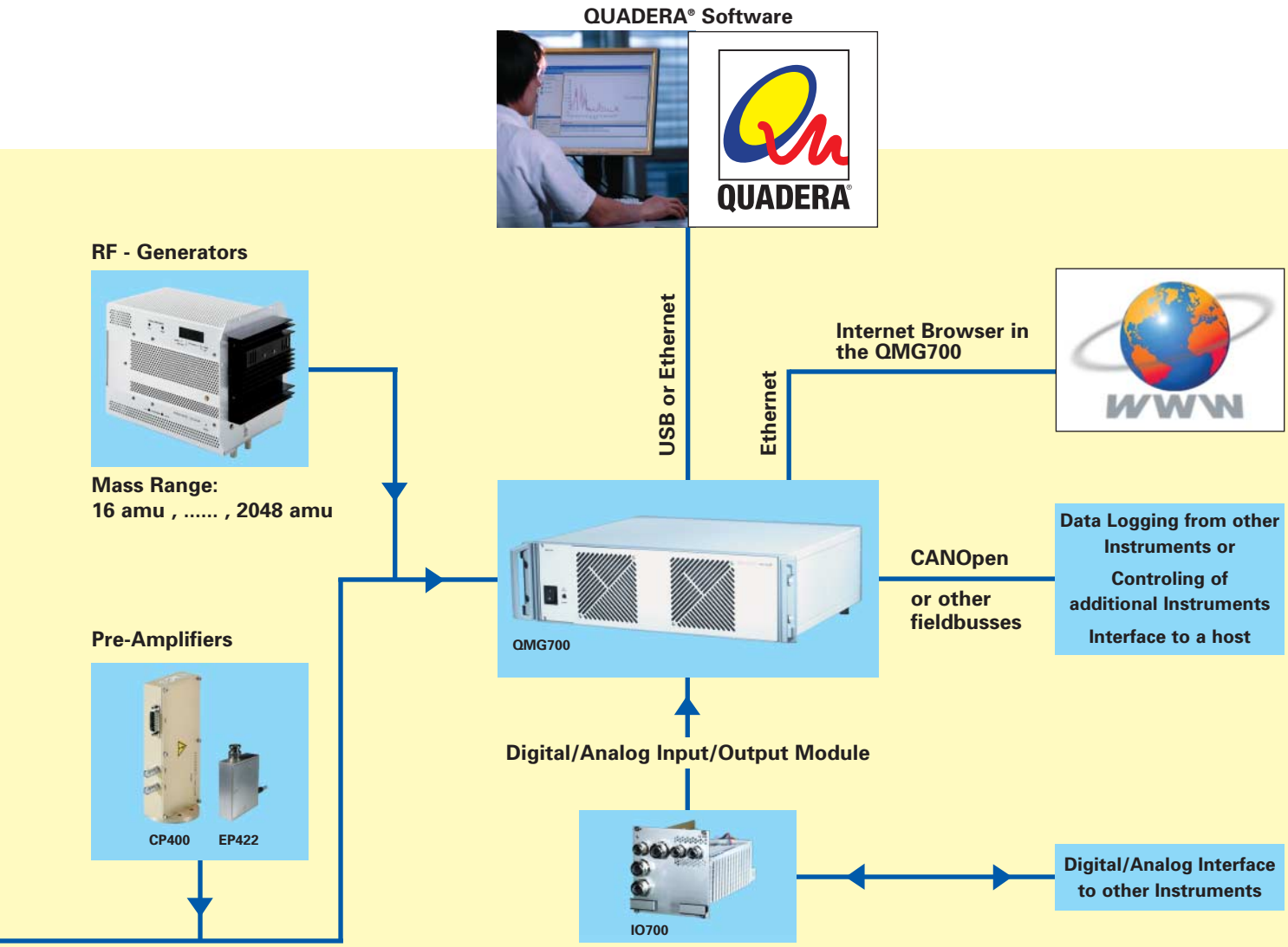
HiQuad QMG700 family

QMG700 Family of Modular High End Quadrupole Mass Spectrometers



Selection Rules and Description of the Units

The Ion Sources:
All Ion Sources shown here are for *electron impact ionization,* adaptation of other technologies and electron attachment on request.
In general the ion sources can be classified into two types: **Open Ion Sources** are used when the residual gas in a process chamber has to be measured and no further pressure reduction is required. **Closed Ion Sources** are applied to minimize the gas consumption in analytics and / or to increase the sensitivity due to a reduced background contribution of the vacuum system, these are used in conjunction with differentially pumped systems to analyze gases at higher pressures.
An **Axial Ion Source** is very robust, easy to maintain and is used in general residual gas analysis. **Cross Beam Ion Sources** are used among other applications for molecular beam applications where a vapor beam crosses the ion source with no contact with the surface of the ion source. Thus corrosive gases and trace gases down to the ppb-level may be analyzed. Cross Beam Ion Sources are available as open and closed versions and they also can be equipped with magnets to improve the sensitivity of the instrument by increasing the path length of the ionizing electrons.
The **Grid Ion Source** is used for residual gas analysis in the UHV, XHV and for desorption measurement. Because of it's extremely low surface area, this ion source is used for residual gas analysis in most accelerator experiments.
Filament Material:
Rhenium, Tungsten and Yttrium-Oxide are available. Rhenium (Rh) has a rather high vapor pressure and is mainly used in High Vacuum applications, Tungsten generally has a higher life time due to a lower vapor pressure than Rh, it is used in the UHV and XHV.
Yttrium-Oxide filaments are more resistant to oxygen, the temperature of a Yt-Oxide filament is much lower compared to the pure metal, the downside of this being a lower resistance to contamination of the ion source. Yt-Oxide replaced thorium oxide filaments which are no longer allowed to be manufactured and used in certain countries.
Ion optics and Inflection Units:
are used to guide ions already available from another process towards the mass spectrometer. Ion Optics and Inflection Units are used in instruments for plasma diagnostics (PPM) for Endpoint Detection (EPD). For applications such as SIMS, ICP or the like they are used to guide ions already available from other processes towards the mass spectrometer. There are two types shown here: a **two lens optics** and a **three lens optics.** The first is used if ions have to be transferred just over a short distance, the second is used to guide ions over a larger distance and is used as an energy filter in plasma diagnostics, too. Inflection units for angles between 0 and 90° are available too.
Quadrupole Mass Filters:
The larger the physical dimensions of a quadrupole rod system and the higher the quality of alignment and surface finish, the better the performance in resolution, peak shape and trans-



mission. 16 mm diameter Mo-rods for high resolution and high transmission are used for example in He/D2 separation.

SEMs

are used to increase the sensitivity of the instrument. For ultimate sensitivity. Discrete Secondary Electron Multipliers (SEMs) are available which show a longer lifetime and higher gain compared to many Continuous Dynode (C-SEMs). Further, by adding a conversion dynode, mass discrimination at the SEM is significantly decreased. Positive and negative ions (out of plasma and related experiments) can be detected with a combination of SEM and Ion Counter.

In-line or **90 degree off-axis** arrangement of the SEM is determined by the application in question. With an In-line configuration a high immersion depth into the process chamber is achieved. On the other hand , the 90 degree off axis arrangement results in a reduction in the signal background due to the lower chance of photons and high energetic neutrals being measured. For this reason most mass spectrometers used are 90 degree off axis type. This detector equipped with a direct **Ion Counter** results in the highest sensitivity possible.

If however the sensitivity achieved with a faraday cup is enough it is recommended to select this detector because the faraday detector has a more stable response.

RF-Generator: The lower the mass range selected (RF-generator) for a given mass filter the higher the transmission, the mass resolution and the stability. Select the lowest possible mass range for your instrument to achieve the highest performance. Due to the modular nature of the systems, replacing the RF-generator is all that is required to change the mass range for other applications.

Minimum configuration of the electronics for a **QMG700** is the **QC700** (quadrupole controller) in combination with a voltage supply for the ion source or the ion optics. Depending on the configuration selected and on the pre-amplifier a combination of the electronic boards results.

IO700 modules are available as options in the chassis of the QMG700 electronics. These modules provide digital and analog communication with other parts of the experiment or data systems.

Further communication to external units is possible via **Fieldbus** (CANOpen, DeviceNet, Profibus, Ethernet).

A **Web Browser** acts as the front panel of the instrument, no further special software except Microsoft Internet Explorer™ is required to operate this.

The various ion sources and ion optics require different supply voltages for their operation. Thus the analyzer chosen determines the configuration of the electronics (see next page).

HiQuad QMG700

Electronics and Boards

QMG700 Basic Unit

Basic unit with power supply USB and Ethernet Interface (a fieldbus interface is an option)

Typical data: for an 8 mm rod system

Stability: <0.1% variation over 8 hours (ratio 28/40 from air measured with Faraday, optimized vacuum system)

Stability: of the cracking pattern ± 1% (peaks of same order of magnitude)

Detection limits with SEM:
5 x 10^{-16} mbar with Ion Counter
2 x 10^{-15} mbar with Electrometer Pre-Amplifier

Measurement speed:
0.125 ms - 60 s per mass in MID mode
0.125 ms/amu - 60 s/amu in Scan mode

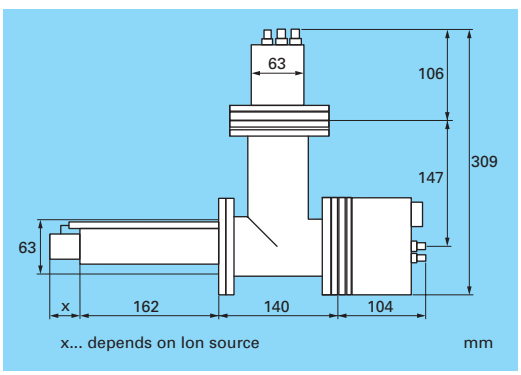
Resolution: contribution to the neighboring mass (40/41) < 0.1 ppm, 512 amu mass range

Partial pressure ratio: < 0.1 ppm with SEM

Transmission: 35 to 25 % for 512 amu mass range, 25 to 10 % for 1024 amu mass range

Variable Electron Energy : < 10 eV - 125 eV for Soft Ionization and Appearance Spectroscopy

Dimensions of a typical analyser



QC700

Control unit for the whole mass spectrometer, the RF-generator, the electrometer amplifier, the ion counter and the additional boards. Signal processing and communication with the computer.

IS716

provides the emission control for the filament and 9 additional voltages to operate the ion source and other ion optical elements.

IS700

provides the emission control for the filament and 3 voltages in addition to operate the ion source. Is used for rather simple ion sources.

IL700

provides 6 voltages either ± 150 VDC or ± 450 VDC in any combination. Is used for example when external generated ions are measured and no emission control is required. More than one IL700 can be installed in one chassis.

HV701 and HV702

HV701 provides the voltage for an SEM to measure positive ions.
HV702 provides the voltage for an SEM to measure positive and negative ions or to operate an SEM with a conversion dynode.

IO700

provides an digital / analog interface to other instruments. 32 DI/DO and 8 Analog In / Analog Out are contained in the IO700. The analog channels have 12 bit resolution and scale 0 - 10 VDC.

All this boards can be biased up to ± 1000 VDC.

EP422

Electrometer Pre-Amplifier with auto-ranging. Fast and highly sensitive measurement of the ion current or of the electron current of an SEM.

CP400

Ion Count processor with adjustable threshold used for signal processing in the single ion counting mode.