Mass Spectrometers for Residual Gas Analysis - RGA

For Applications in a Vacuum Environment

Quadrupole Mass Spectrometers

- Mass range options to 5000 amu
- Single and Triple filter options
- 6, 9 or 20 mm diameter rods
- Networking interface
- Ioniser options including

  Cross beam, Platinum, Vacuum Fired

Applications Include:

- RGA
- Gas Analysis
- Plasma Characterisation
- UHV Surface Science
- SIMS

RGA Overview

The Hiden Quadrupole Mass Spectrometer for Residual Gas Analysis is suitable for vacuum print analysis, leak detection and trend analysis.

Features include:

- High sensitivity helium leak detection, mass selectable for alternative search gases
- Advanced analysis capability for complex gas interpretation
- Data presentation as mass peak ratios for highest stability and accuracy
- Twin burnout-resistant oxide coated iridium filaments
- User-programmable multi-tasking firmware for creation of process-specific control and data acquisition functions
- Industry best 3-year warranty and lifetime service support

RGA Applications

The Hiden Residual Gas Analyser can be used for a wide variety of applications, including:

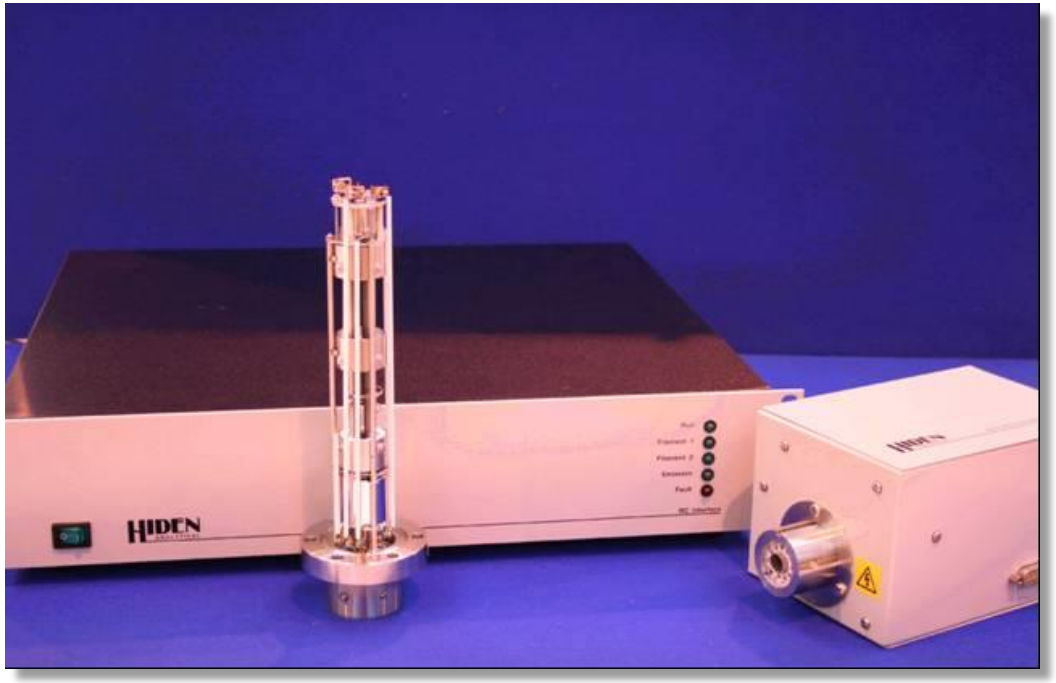
- Vacuum Diagnostics
- Leak detection
- Contamination analysis
- Semiconductor production
- Vacuum process analysis
- Reactive sputtering closed loop control
- Vacuum furnace monitoring
- Molecular beam studies, MBE
- UHV/XHV surface science
- UHV TPD

Specification Levels

HALO: Single filter mass spectrometer for multi-purpose HV/UHV applications

3F: Triple filter mass spectrometer for precise analytical capability

3F-PIC: Triple filter mass spectrometer with pulse ion counting detector for fast event studies



Hiden RGA-HALO Features

- Interchangeable gauge heads and control modules reduce operational and aftersales support costs.
- Mass range options 100, 200 and 300 amu.
- Dual Faraday / Electron Multiplier detector with partial pressure range 10^{-4} mbar to 10^{-13} mbar.
- DN-35-CF (2¾"/70mm O.D. Conflat-type).
- Insertion length: 204mm
- RF Head Dimensions: Height – 117mm, Width - 104mm, Depth - 195mm.
- Fast speed – up to 500 measurements per second (but through 1 decade only).

Electron Multiplier Detector

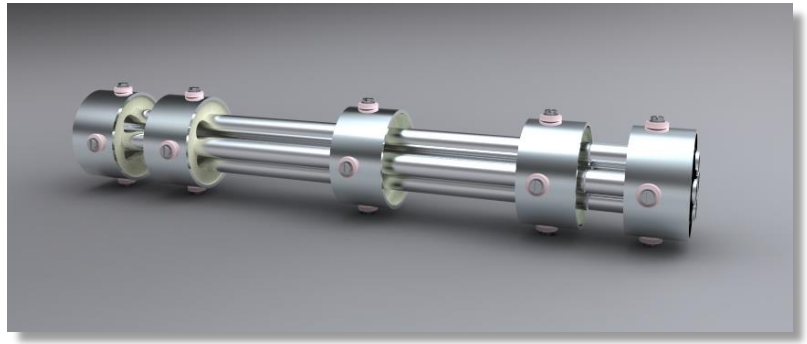
3F - Triple Filter Mass Spectrometer

Why have a triple filter?

Two main advantages:

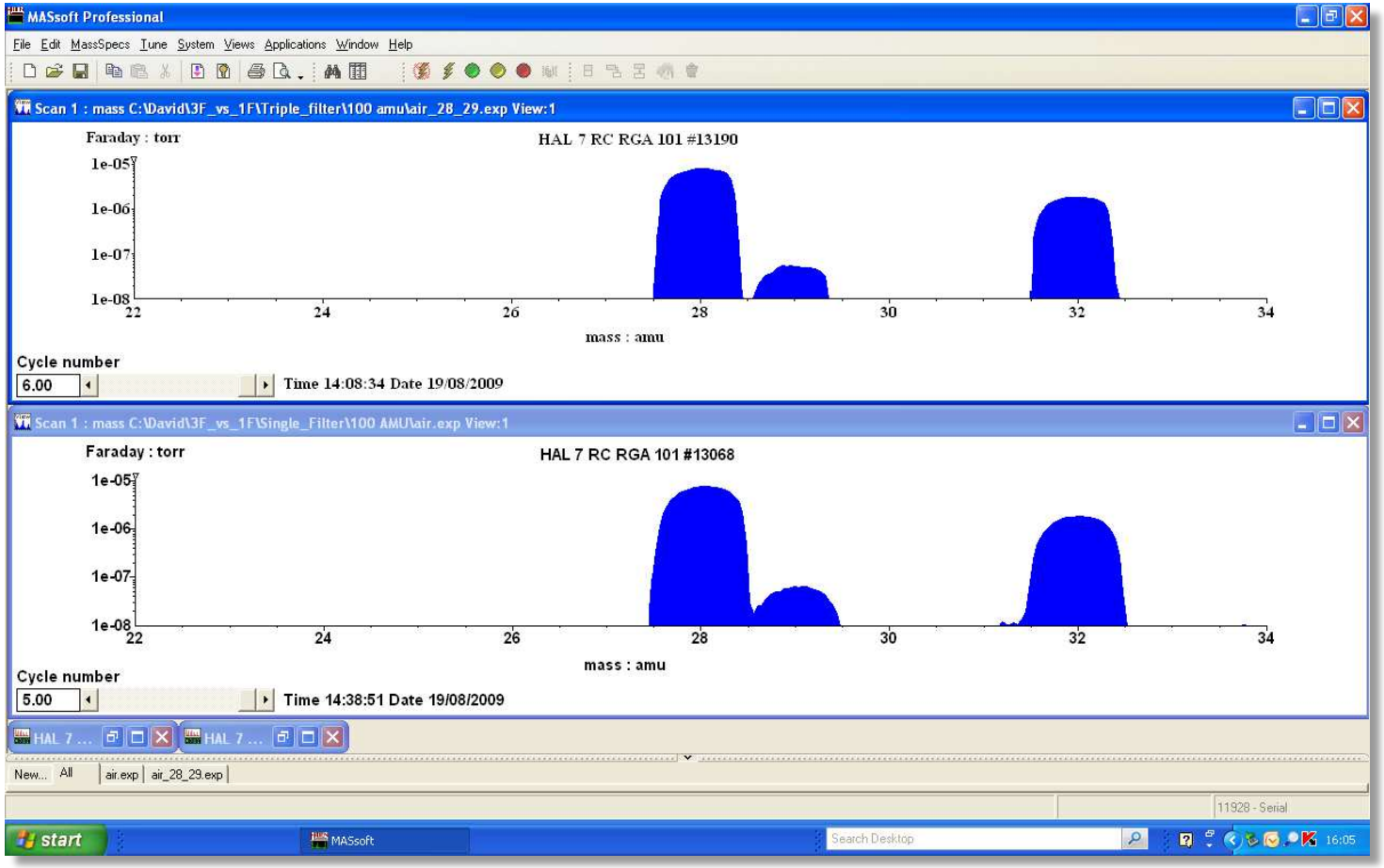
1. Strict control over the quadrupole entrance and exit fields provides enhanced sensitivity for high mass transmission and increased abundance sensitivity

2. Enhanced long-term stability. The bulk of the deselected ions from the quadrupole ioniser deposit harmlessly on the RF-only pre-filter stage, minimising contamination on the mass selective primary filter.



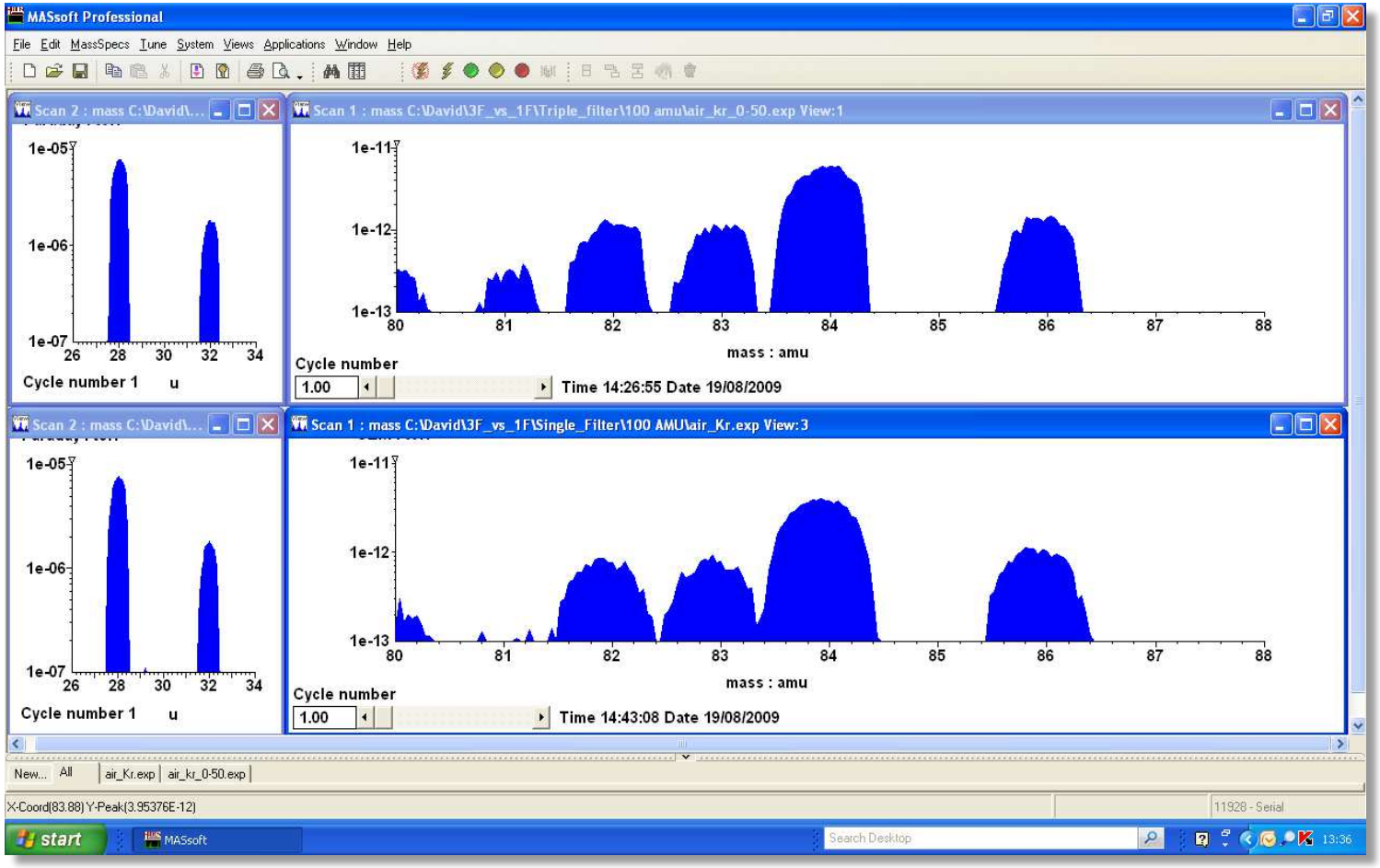
Triple Filter – Enhanced Resolution

- For applications where you wish to measure a low intensity peak next to a high intensity peak.



Triple Filter – Enhanced Sensitivity

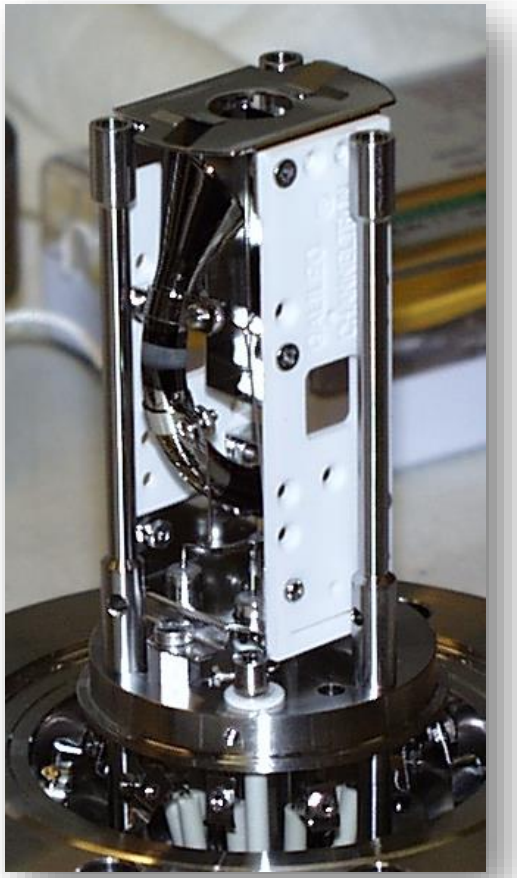
- Triple filter system will also give an increase in sensitivity with increasing mass.



Hiden RGA-HAL 3F Features

- Interchangeable gauge heads and control modules reduce operational and aftersales support costs.
- Mass range options 100, 200, 300 and **500** amu.
- Dual Faraday / Electron Multiplier detector with partial pressure range 10^{-4} mbar to **10^{-14}** mbar.
- **DN-63-CF** (4½"/114mm O.D. Conflat-type).
- Insertion length: **308mm**
- RF Head Dimensions: Height – **137mm**, Width - **335mm**, Depth - **216mm**.
- Fast speed – up to 500 measurements per second (but through 1 decade only).

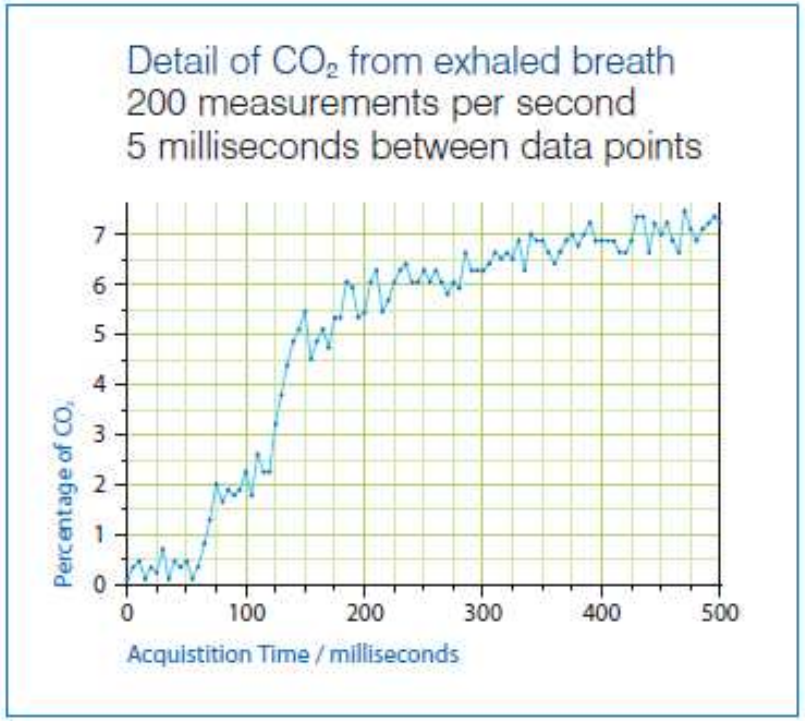
Pulse Ion Counting (PIC) Detector



- 7 decade continuous dynamic range.
- 24 bit counter for 1c /s resolution.
- Faraday Cup option for higher pressure measurements.
- Signal gating with 1 μs resolution energy & mass distributions vs time.
- Data export options.

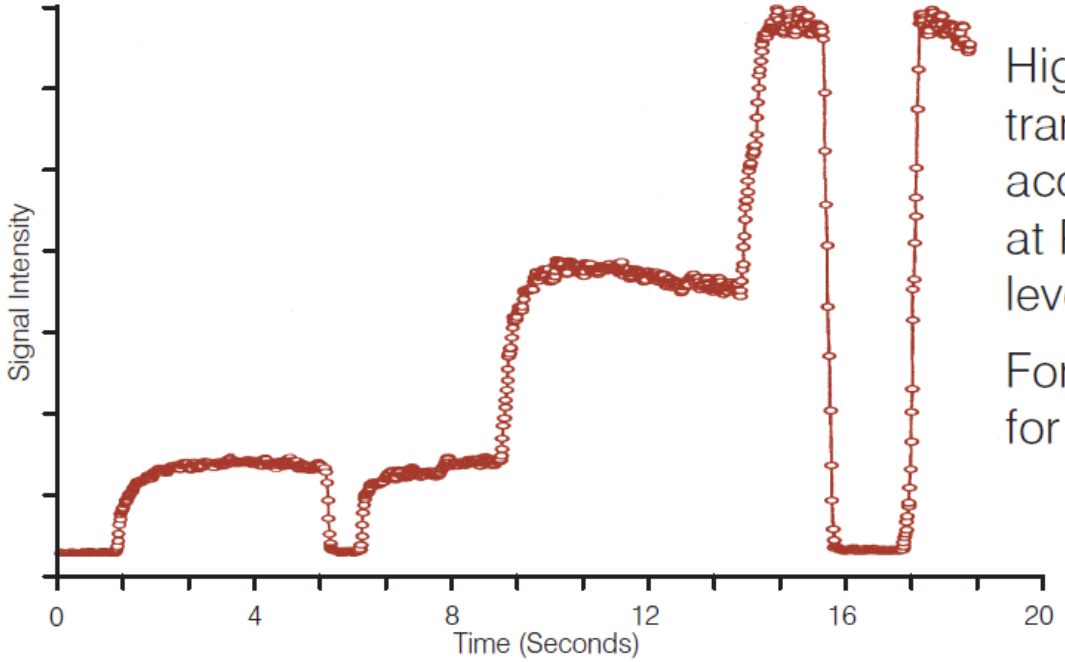
Hiden RGA-HAL 3F PIC Features

- Interchangeable gauge heads and control modules reduce operational and aftersales support costs.
- Mass range options 100, 200, 300 and 500 amu.
- Typically PIC detector only
  (Faraday detector is an option)
  PIC with partial pressure range
  $5x10^{-6}$ mbar to $5x10^{-15}$ mbar.
- DN-63-CF (4½"/114mm O.D. Conflat-type).
- Insertion length: 308mm
- RF Head Dimensions: Height – 137mm, Width - 335mm, Depth - 216mm.
- Fast speed – up to 500 measurement per second (through 7 decades).



Application Specific Performance

3F PIC Trend Analysis - up to 500 measurements per second



High quality transient data acquisition at PPM/PPB levels.

For UHV/TPD for example.

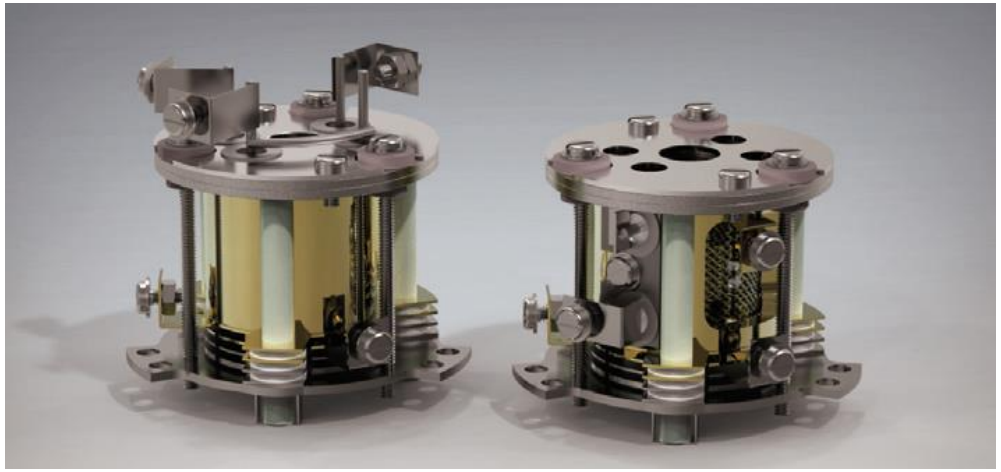
- Fast pulse ion counting detector with continuous 7 decade measurement from 1 cs^{-1} to 10^7 cs^{-1}
- Minimum detectable partial pressure 5 x 10^{-15} mbar

Hiden RGA Configuration Options

Product Title	Mass range (amu)	Detector	Maximum Operating Pressure	Minimum Detectable Partial Pressure	Application
HALO 100	100	Faraday	1×10^{-4} mbar	1×10^{-11} mbar	RGA
HALO 201	200, 300	Channelplate	1×10^{-4} mbar	2×10^{-13} mbar	RGA
HAL 200	200	Faraday	1×10^{-4} mbar	5×10^{-12} mbar	RGA
HAL 201	100, 200, 300	Channeltron	1×10^{-4} mbar	2×10^{-14} mbar	RGA
HAL 3F RC	50, 200, 300, 500	Channeltron	1×10^{-4} mbar	2×10^{-14} mbar	RGA
HAL 3F PIC	50, 200, 300, 500	Pulse Ion Counter	5×10^{-6} mbar *(1×10^{-4} mbar with Faraday)*	5×10^{-15} mbar	UHV-TPD
HAL 1001-9 RC (9mm)	50, 300, 500, 1000	Channeltron	1×10^{-4} mbar	2×10^{-14} mbar	High mass or high resolution
HMT 100	100	Faraday	5×10^{-3} mbar	2×10^{-11} mbar	RGA
HMT 101	100	Channelplate	5×10^{-3} mbar	2×10^{-13} mbar	RGA

Ion Source Options

- Standard RGA – A radially symmetric configuration for general applications.
- UHV Low Profile – Optimised for UHV TPD studies enabling closer proximity of the ion source to the evolution surface.
- Closed Source – For high pressure studies with direct gas input used in conjunction with a differential pumping stage for the analyser.
- Platinum Ion Source - Configured for improved operation in reactive atmospheres.
- Gold Plated Ion Source - Configured to minimise the effects of source outgassing.
- Basic Cross Beam Source.
- XBS Cross Beam Source – Configured specially for MBE deposition rate monitoring and control.
- Laser Cross Beam Source.
- 4 Lens Ion Optics with Integral Ioniser

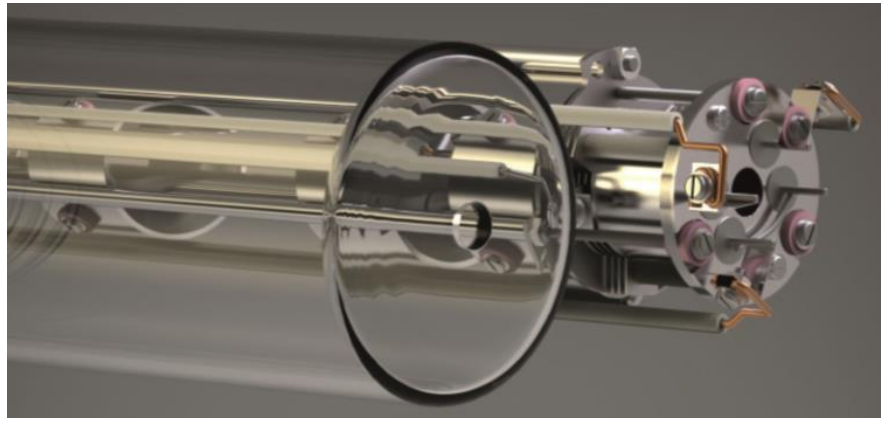


Ion Source Options – PIC specific

UHV compatible mass filter shrouds

UHV Low Profile – Optimised for UHV TPD studies enabling closer proximity of the ion source to the evolution surface.

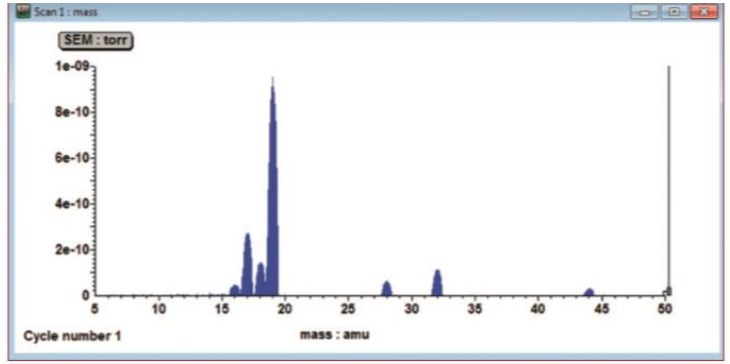
Range of Shrouds



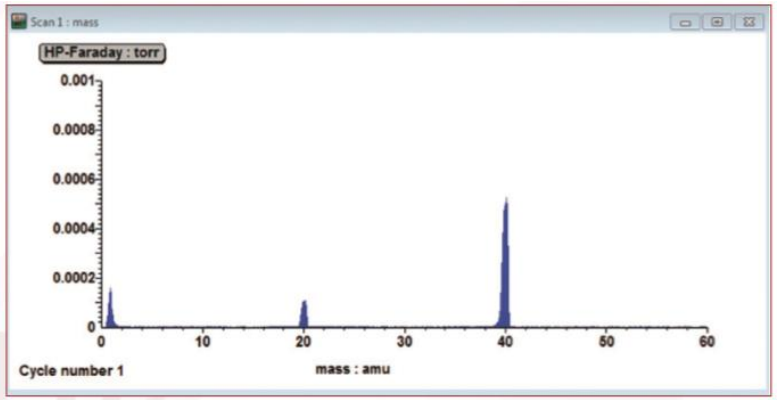
HAL 3F-PIC and quartz shroud

Special Hiden RGA Configurations
HMT – High Pressure RGA

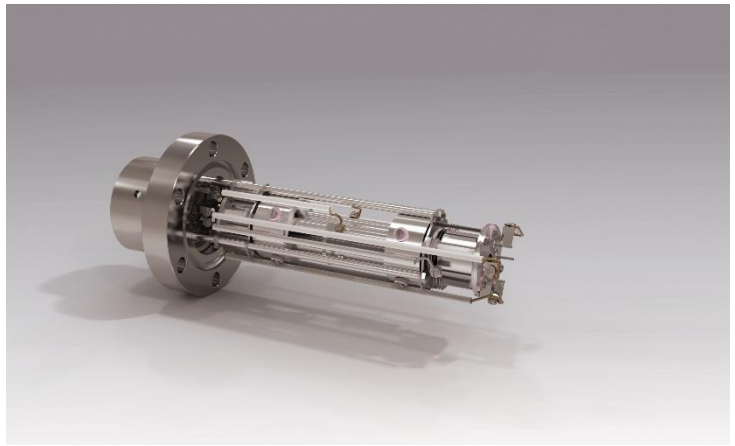
- HMT mode for high pressure operation to $4x10^{-3}$ mbar
- RGA mode for high sensitivity operation to 10^{-13} mbar
- Stability better than ±1% over 24 hours
- Fast access mixed mode scanning
- Real time background subtraction
- 100 amu



Profile mass scanning in RGA high sensitivity mode



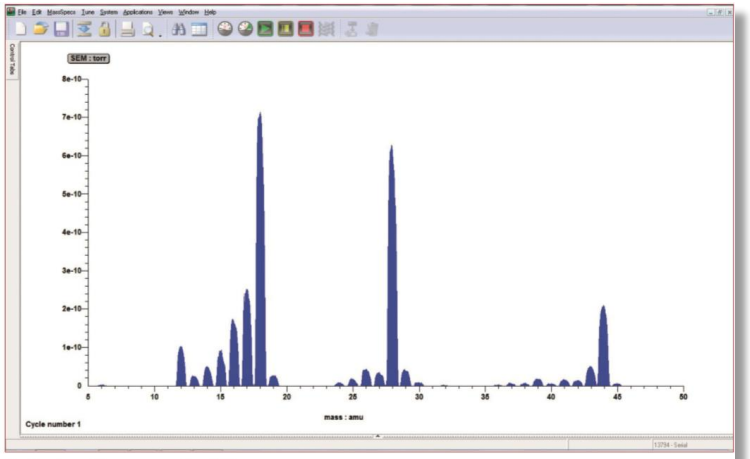
Profile mass scanning in high pressure HMT mode



Special Hiden RGA Configurations
RGA For UHV: HAL 201 RC

- Minimum detectable partial pressure of 5 x 10^{-14} mbar
- Vacuum fired ion sources to minimise source outgassing
- EPICS is the standard instrument control software and Hiden HAL system is fully compatible with EPICS software driver.
- Based on the RGA supplied to the Brookhaven National Laboratory in the USA (over 70 of these types of RGA system supplied) and CERN in Europe (over 30 of these types of RGA system supplied)
- Suitable for use with:

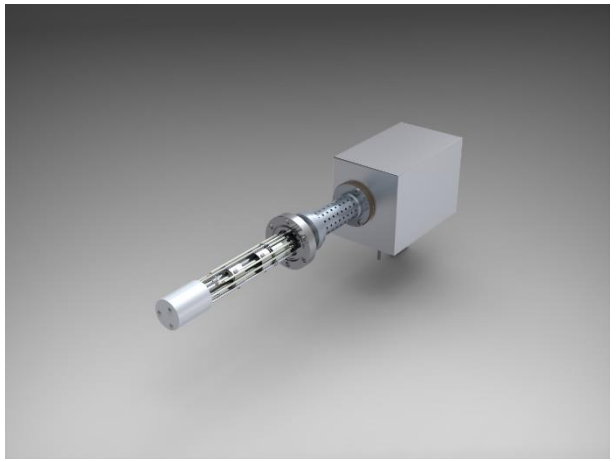
  - Tokamaks/Torus Facilities
  - Beam Lines
  - Particle Accelerators
  - Synchrotrons
  - UHV Chambers



Typical profile spectra for HAL system

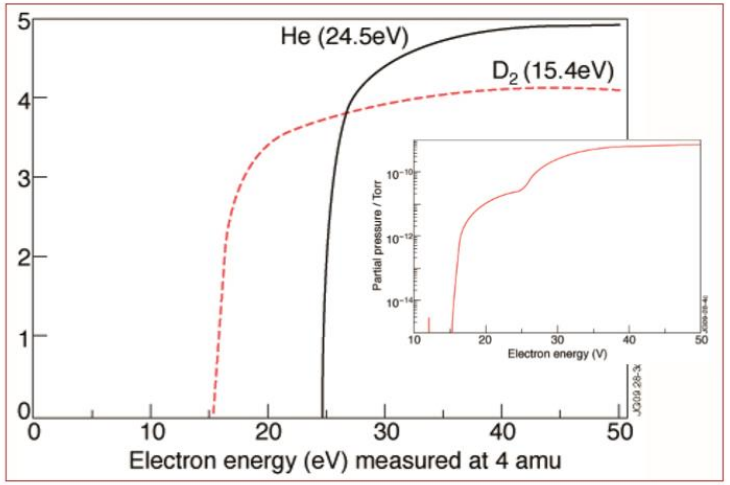
Special Hiden RGA Configurations
RGA for MBE: HALO 201 MBE

- Constructed from compatible materials and designed for prolonged use in MBE environments.
- Includes molybdenum wiring in place of copper and a contamination resistant ion source shroud.
- Applications include semiconductors, solar cells, oxides, etc.
- Also the option of a thermal extender for RGA operation during bakeout

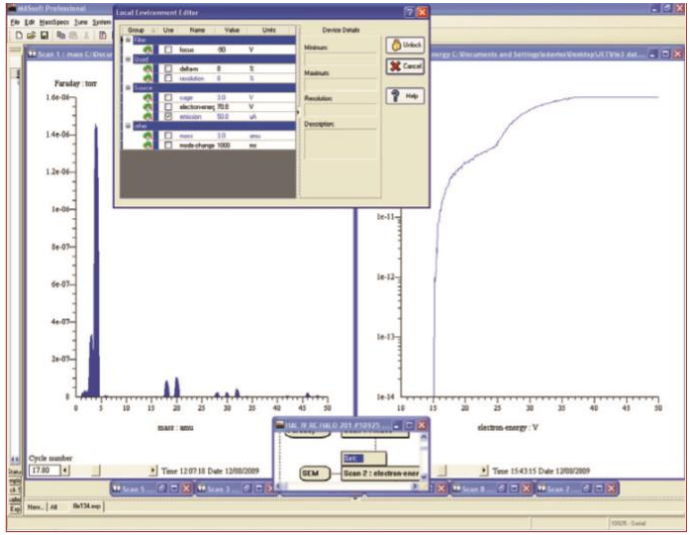


Special Hiden RGA Configurations DLS-1 for Advanced Research

- For Tokamak/Torus Fusion Research Facilities
- Threshold Ionisation Mass Spectrometry allows close mass peak separation
- Low cost multi unit solution with radiation and magnetic shielding solutions



DLS-1, real time TIMS data taken at JET, UK. $^{2}D_2$ and ^{4}He are easily separated and quantifiable



DLS-1, real time TIMS data taken at JET, UK. Spectra shows scans at 3amu, separating ^{3}He from $^{1}H^{2}D$. Mass separation: 0.0058 amu

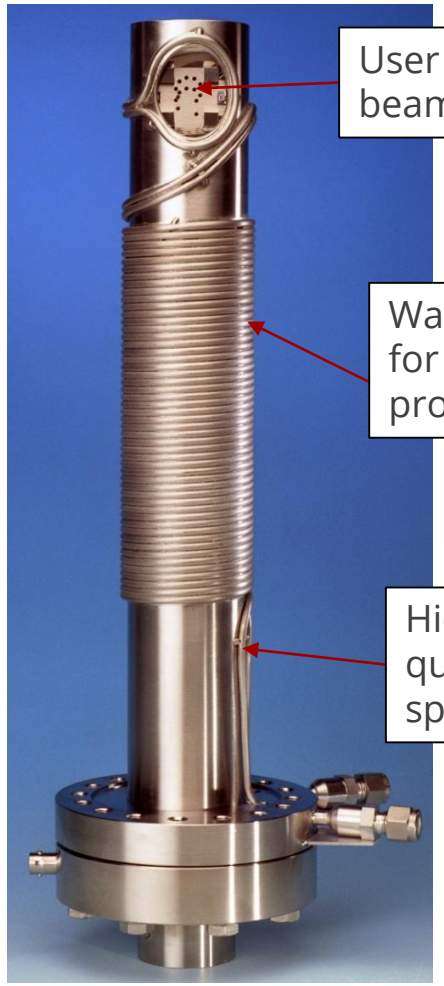
Special Hiden RGA Configurations XBS Deposition Rate Monitor

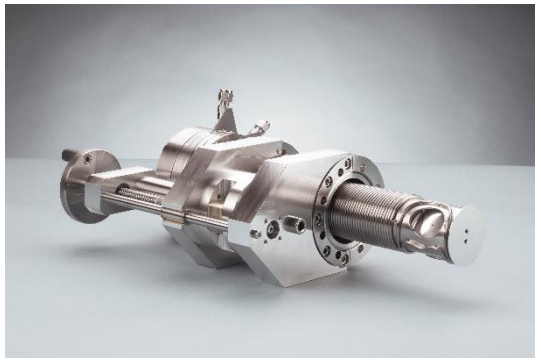
A quadrupole mass spectrometer designed for monitoring multiple sources simultaneously. Suitable for:

- Monitor and control in MBE processes
- Molecular beam studies
- Multiple beam source analysis
- Photoionisation studies
- Desorption/outgassing studies
- Monitor and diagnostics of contaminants in the process chamber

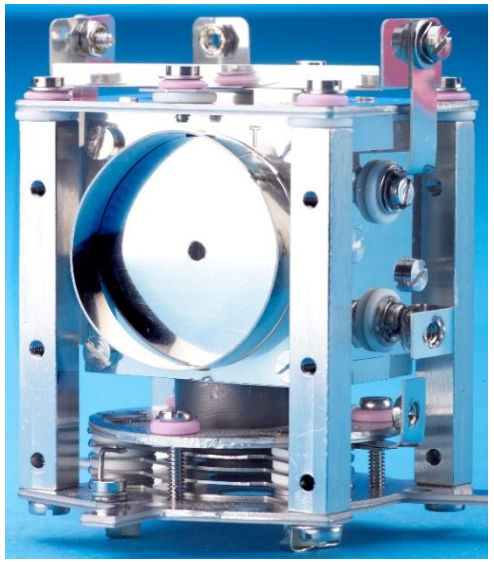
It also doubles as a high performance RGA with high-sensitivity helium leak check mode for vacuum quality verification.

Special Hiden RGA Configurations
XBS Deposition Rate Monitor





With z-shift drive for insertion/extraction



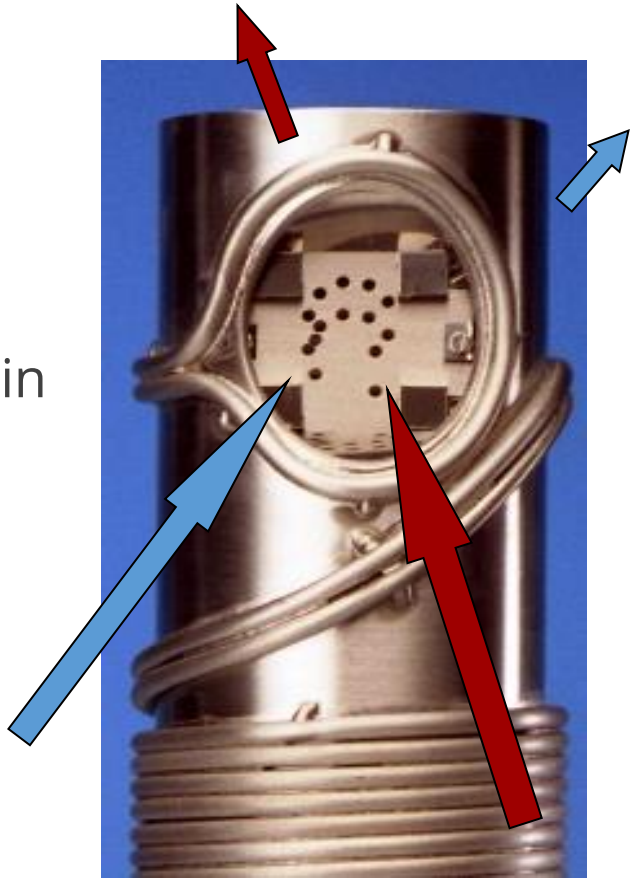
Integral Ion Source:

- Shroud to inhibit contamination
- No direct beam contact with internal probe structures

Special Hiden RGA Configurations
XBS Deposition Rate Monitor

- 320 or 500 amu mass range
- Dual Faraday or Channeltron Electron Multiplier ion detector
- 10^{-4} to 2.5×10^{-14} mbar partial pressure range
- Typical growth rate determination of <0.01 Å s-1
- Beam acceptance apertures are configured for each specific process chamber source position made as replaceable plug-in elements.

XBS Probe Tip + Beam Apertures

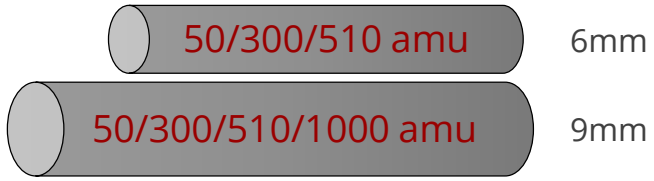


Special Hiden RGA Configurations
3F Series / 1000 Series RGA

- Multiple ion source options
- Configured with 6mm or 9mm pole diameters

What pole diameter do I need?

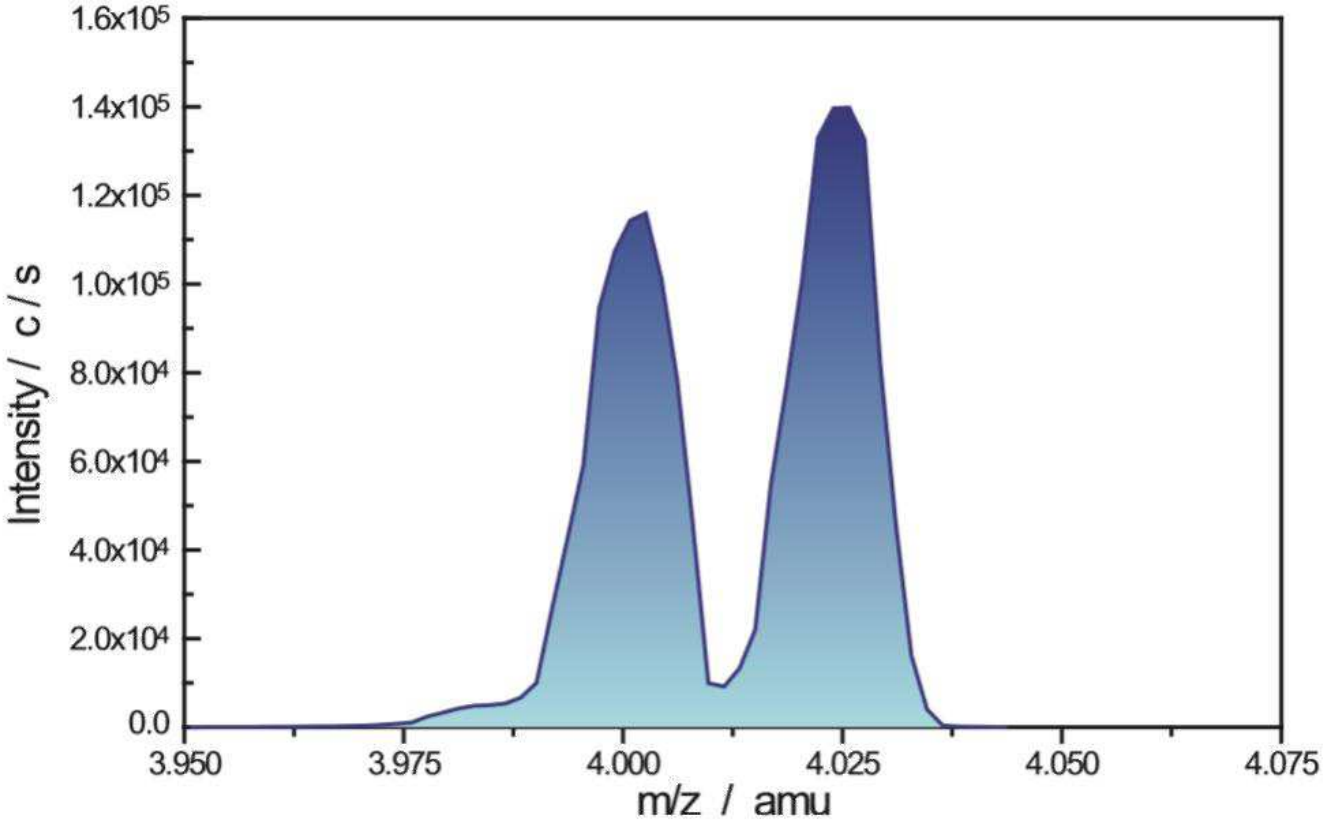
- Total RF output power is fixed for a given generator
- Power demand increases dramatically with increasing RF frequency ($\propto \nu^5$)
- For given mass, performance improves with increasing frequency
- For given tolerances, transmission and mass separation improve with increasing pole diameter
- Overall size and cost increase with increasing pole diameter
- Enlarging pole diameter increases assembly capacitance and limits RF range (increases power losses)



Special Hiden RGA Configurations 3F Series / 1000 Series RGA

- Designed for gas analysis in high precision scientific and process applications.
- Pre and post filter in combination with longer mass filter and wider rod diameter of 9mm or 12 mm results in increased:
  - mass resolution
  - ion sensitivity
  - stability for precision/ratio measurements
  - high mass transmission
- Available with SEM or PIC detector or dual Faraday/SEM or Faraday/PIC models

Special Hiden RGA Configurations
3F Series / 1000 Series RGA

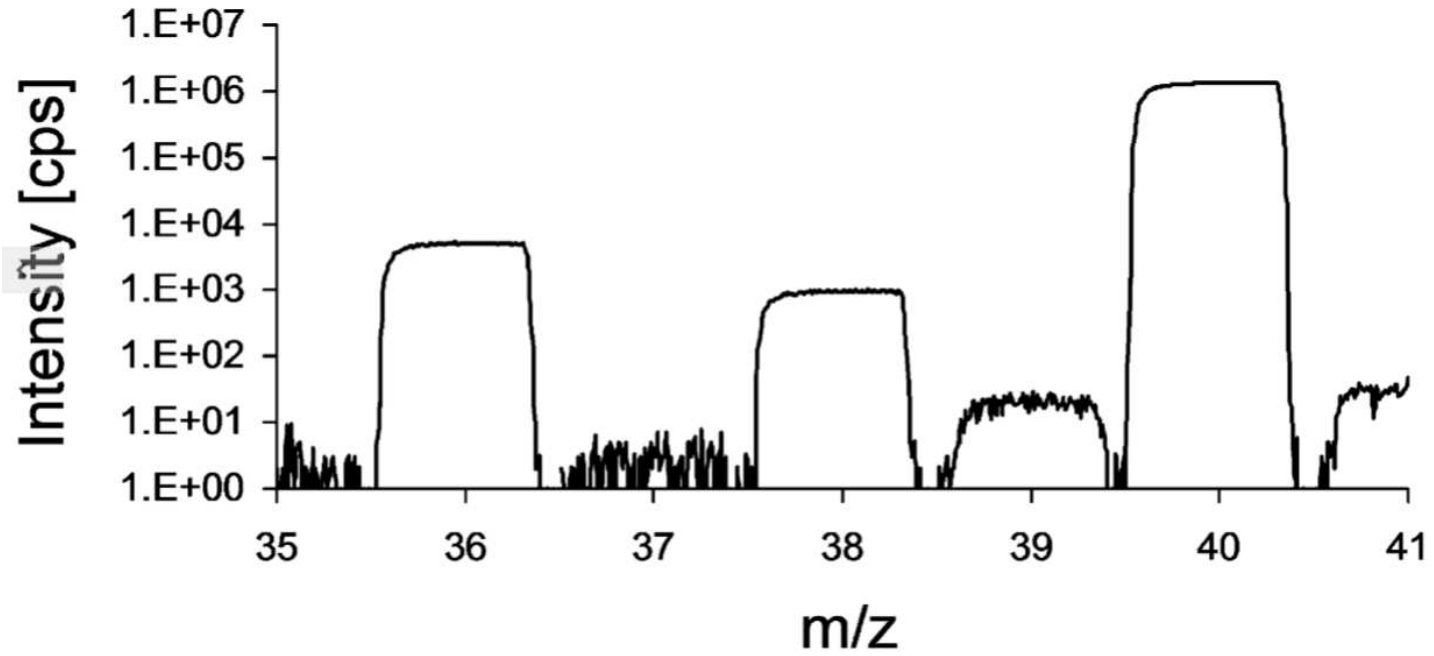


Ultra high resolution of the 3F system, 9mm pole diameter - 50 amu mass range system. Separation of the helium and deuterium peaks with a difference of only 0.0256.

Special Hiden RGA Configurations
3F Series / 1000 Series RGA

"Over two years the position of the flat peak measurement did not move significantly"

"The stability of the Hiden QMS compares favourably"



High stability for precision isotope ratio measurement: $^{40}Ar/^{39}Ar$ geochronology research. Data taken by B Schneider et al.[1]

Hiden RGA Users

- Los Alamos National Lab
- Samsung
- NASA
- Intel Corporation, USA
- CERN
- Carl Zeiss, Germany
- California Institute of Technology
- Brookhaven National Laboratory
- Corning
- CCFE (JET)
- Durham University
- National Physical Laboratory
- Jozef Stephan Institut
- Max Planck Institut
- Bern University
- Rutherford Appleton Laboratory
- SLAC National Accelerator Laboratory
- University of Sao Paulo
- Aarhus University

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