The Performance Characteristics of a Newly Available ICP Time-of-Flight Mass Spectrometer

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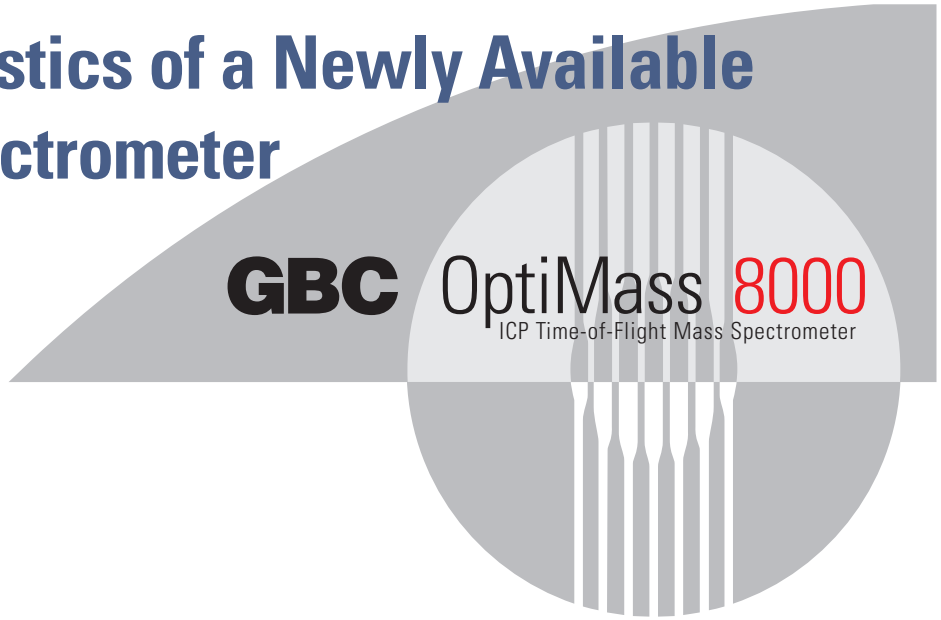

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Objectives

To evaluate the performance characteristics of a newly-available commercial ICP Time-of-Flight MS, the GBC OptiMass 8000, in terms of :

- **Resolution**
- **Dynamic Range**
- **Detection Limits**
- **Effectiveness of Ion Blanking**
- **Mass Response**
- **Oxide and Doubly Charged Species Ratios**
- **Ratio Precision**

GBC OptiMass 8000 ICP-TOFMS

Description of the OptiMass 8000

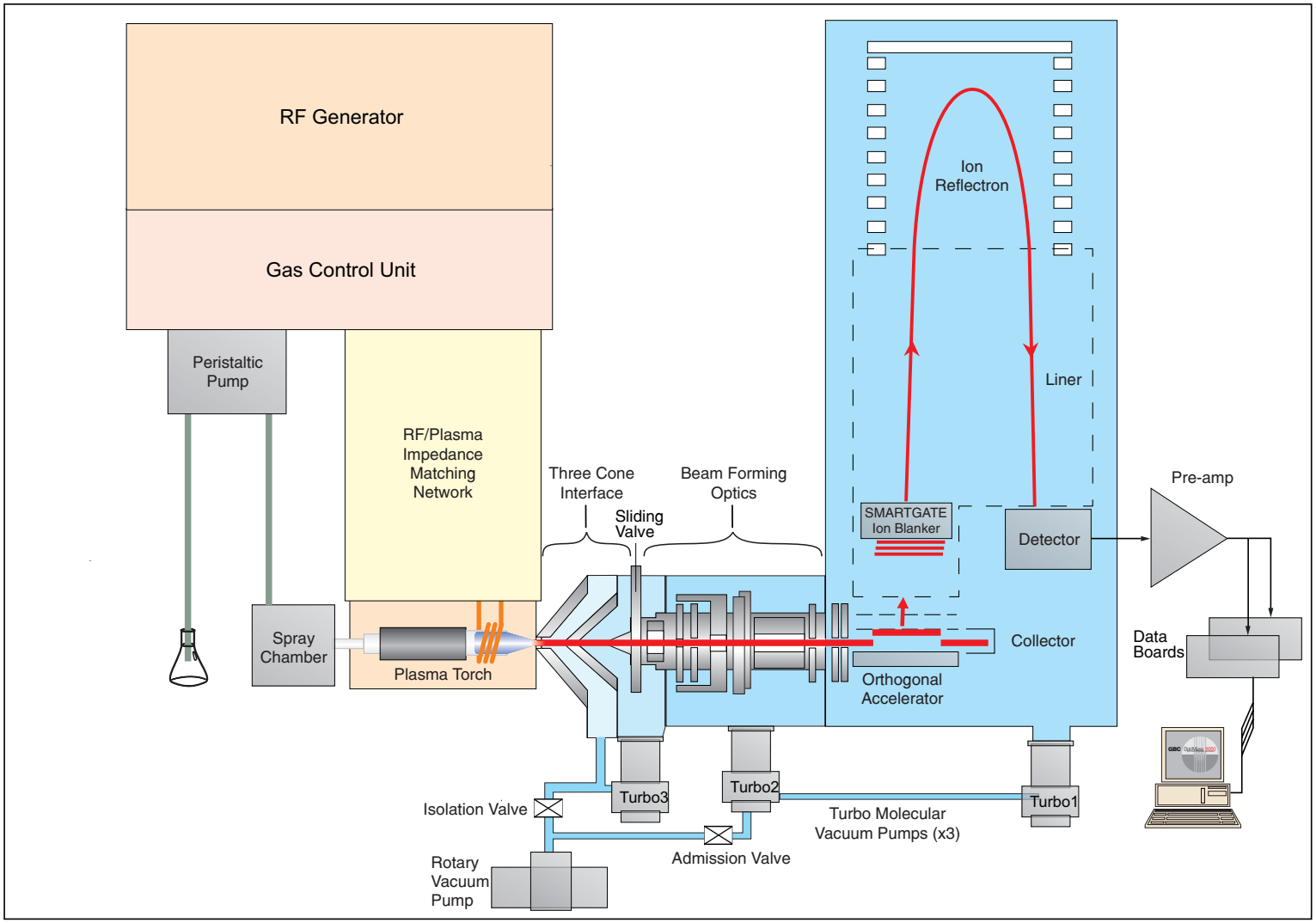
Solid state 27.12 MHz RF generator.

Coventional three cone, water cooled interface with differential pumping.

Orthogonal acceleration time-of-flight mass spectrometer.

- 30,000 full spectra per second ion extraction speed.
- SMARTGATE ion blanker.
- Discrete dynode multiplier detector.
- 400 MHz detection system sampling rate.
- Dual TDC/TR detection system.

Schematic of the OptiMass 8000



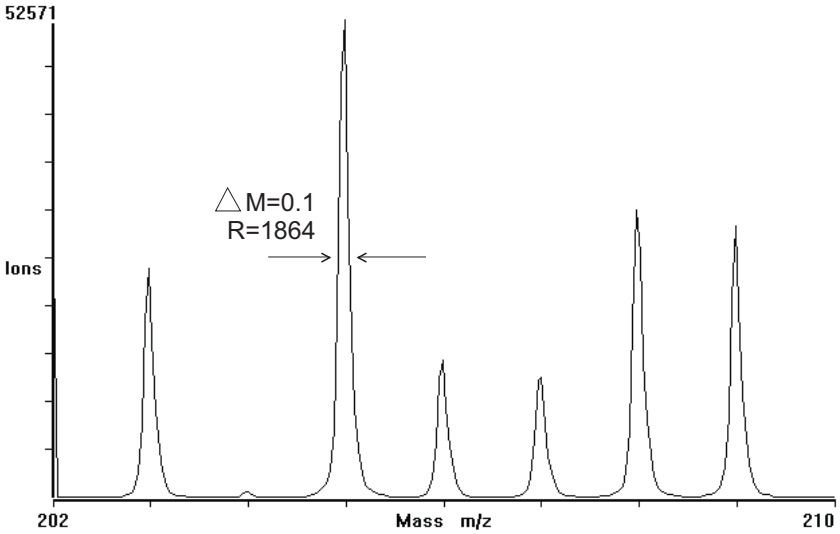
Evaluating Resolution

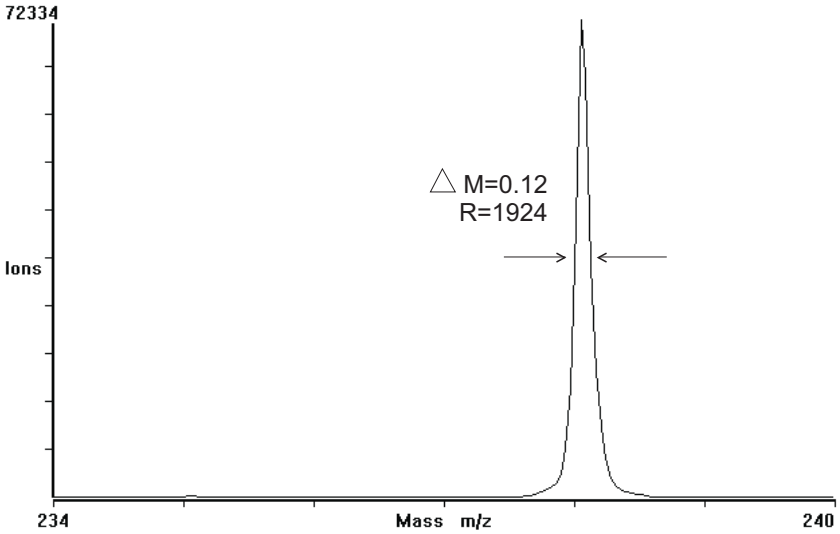
- Resolution in TOF MS is defined as
  $R = M/\Delta M = T/(2\Delta T)$,
  where T is time of flight.

As T=Const. X $\sqrt{M}$, resolution depends on mass

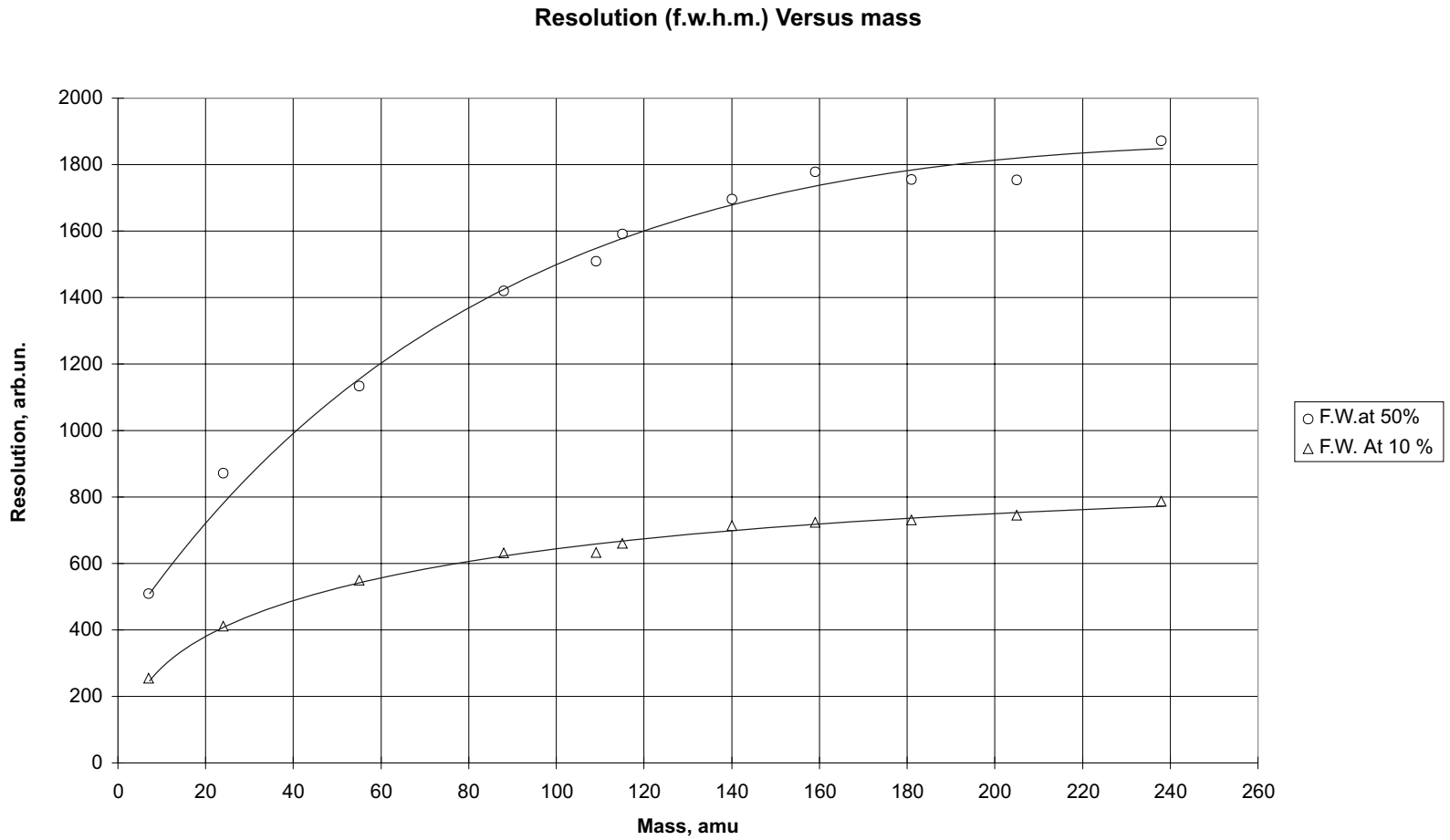
- Resolution of OPTIMASS was evaluated for different masses by 7 x 18 s TDC measurements (intetgral of 557,056 OA extractions for each measurement) of 10 ppb mult-ielement RO water solution

Typical Resolution





Resolution vs. mass



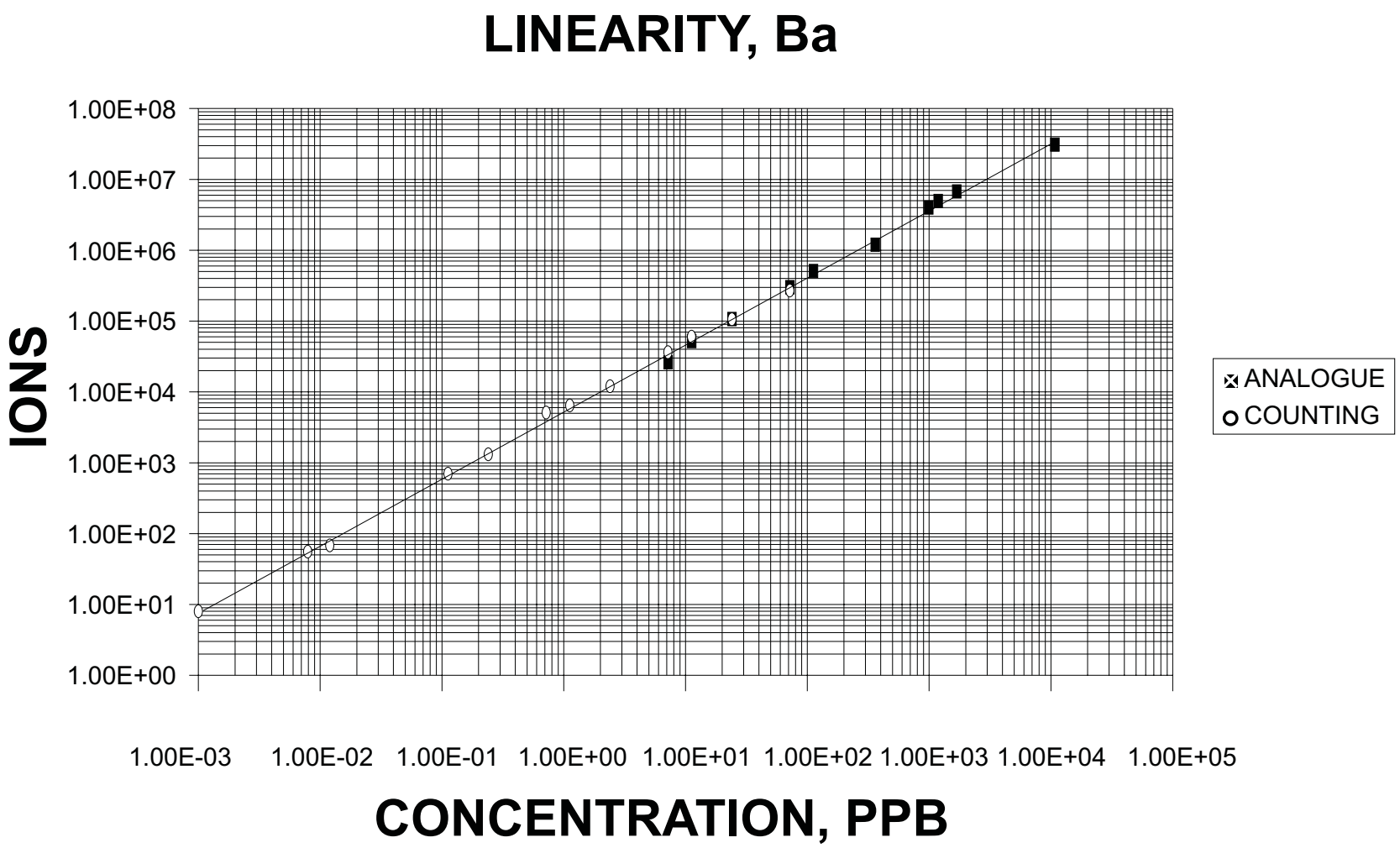
M, amu		7	24	55	88	109	115	140	159	181	205	238
ΔM, amu	at 10%	0.03	0.06	0.1	0.14	0.17	0.17	0.2	0.22	0.25	0.28	0.3

Dynamic range evaluation

- Dynamic range was evaluated by measuring responses (peak areas) for Ba130, Ba135, Ba137, Ba138 in RO water solutions at 10, 100, 1000 and 15,000 ppb, 3 x 10 s acquisitions (integral of 311,296 OA extractions). At low concentrations Xe130 interference was accounted for (Ba130 = Counts(130)-0.155*Counts(129))

- Correlation factors with linear fit obtained were :
  Corr.(TDC) = 0.991
  Corr. (TR) = 0.995

Linear Dynamic Range



Detection Limits

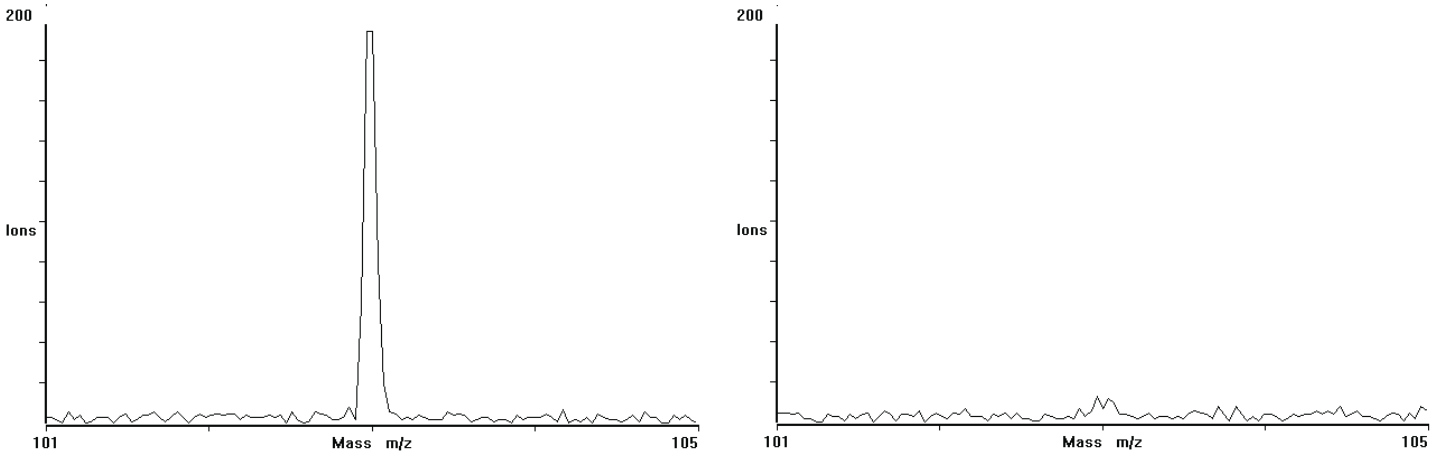
3-σ detection limits were determined from the sequence of 10 x 10 s sample-blank acquisitions. Sample: 50 ppt multi-element solution; Blank: RO water blank

Element	Detection Limit (ng/L)
V, Mn, Co, Rb, Sr, Y, Zr, Nb, Rh, Ag, In, Sc, Ba, Ce, Tb, Ho, Ta, Pb, Bi, U	<1ng/L
Li, Mg, Al, Ti, Cu, Ga, Mo, Pr, Nd, Re, Pt, Au	<10ng/L

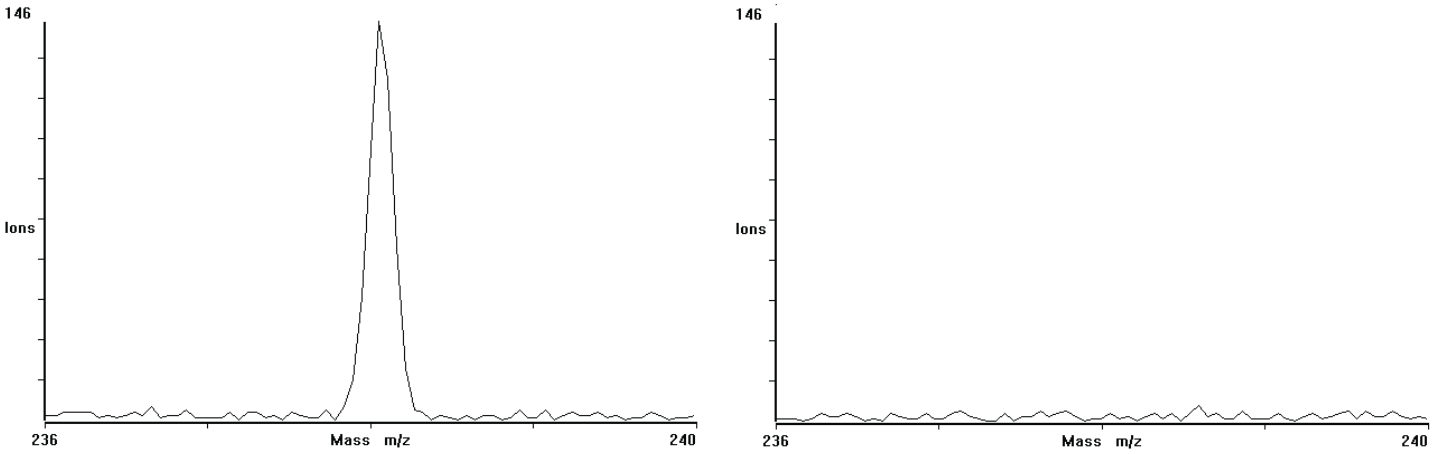
Table 1: Typical DLs for 10 s acquisition with the OptiMass 8000.

Detection Limits

Rh at 50 ppt Instrument 3σ DL 1 ppt



U at 50 ppt Instrument 3σ DL 0.5 ppt ppt



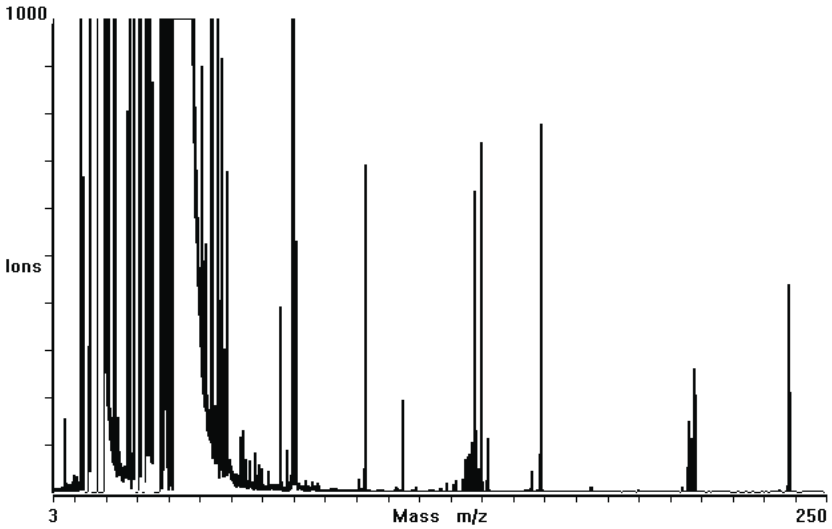
Ion Blanking

As a time-of-flight analyzer allows all ions into the analyzer, a mechanism is required for preventing highly abundant ions such as Ar^+ from reaching the detector.

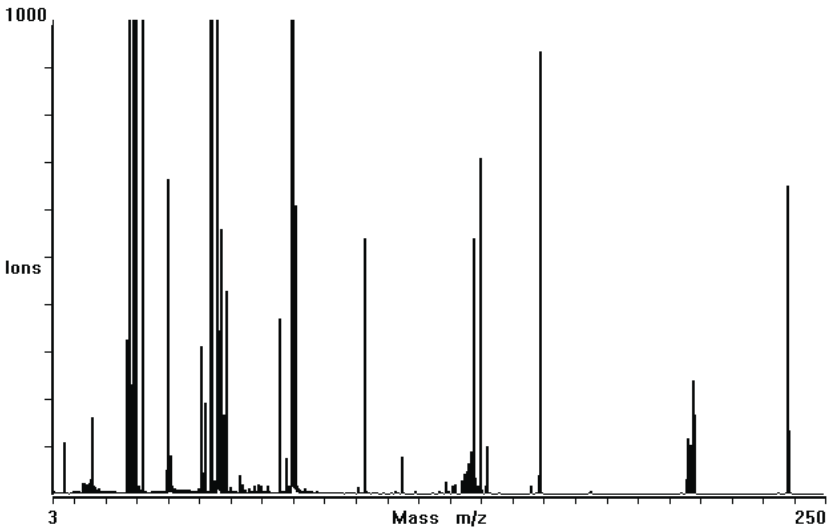
OptiMass 8000 SMARTGATE Ion Blanker

- **effectiveness 100,000 (adjustable)**
- **multiple mass blanking rate 10 MHz**
- **resolution 25 nS**

Effectiveness of SMARTGATE Ion Blanker

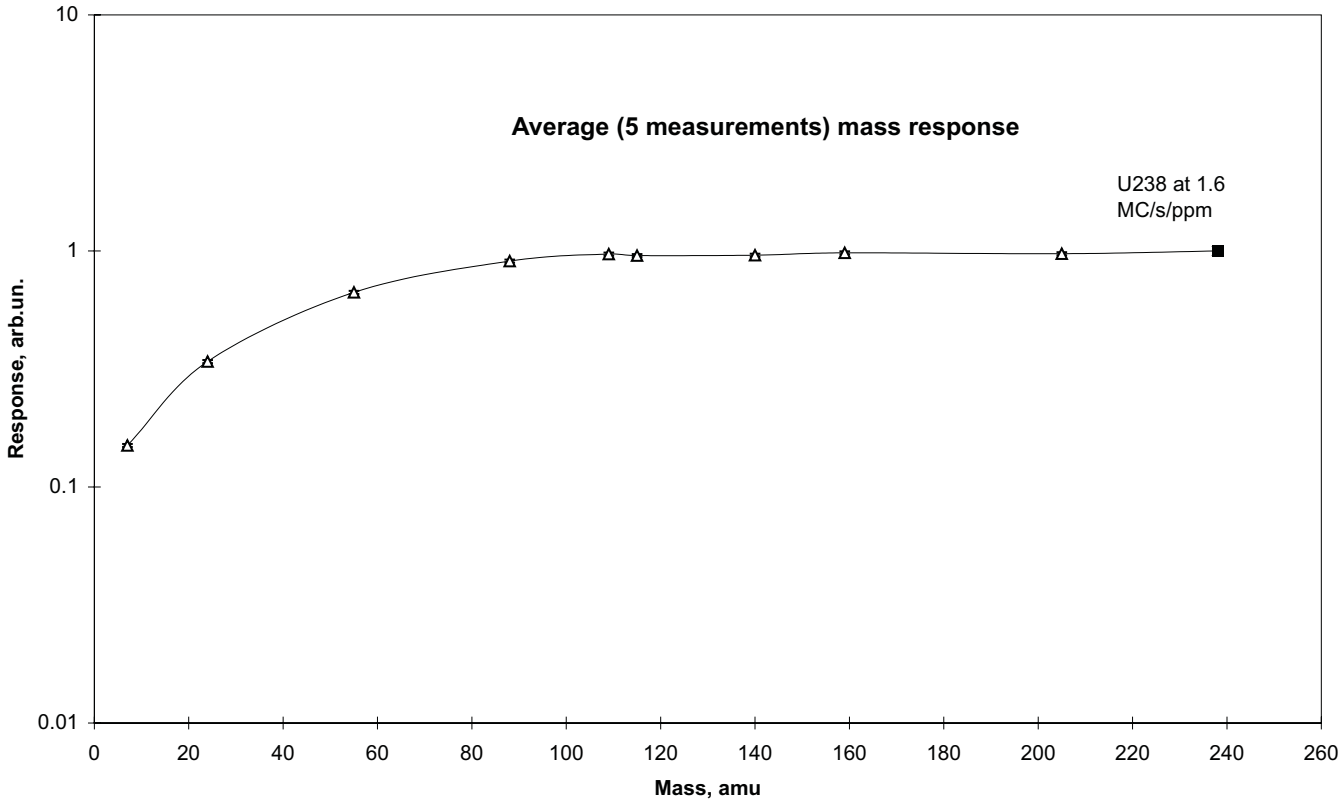


SMARTGATE: Off
Multiplier voltage: 2.4 kV



SMARTGATE: On
Multiplier voltage: 2.4 kV
Ar eliminated to < 2 ppb conc.

Evaluating Mass Response Curve



Mass response curve was measured using 10-element solution at 10 ppb in RO water. Natural abundances and equilibrium degrees of first and second ionization were accounted for.

MO/M and M^{++}/M^{+} Ratios

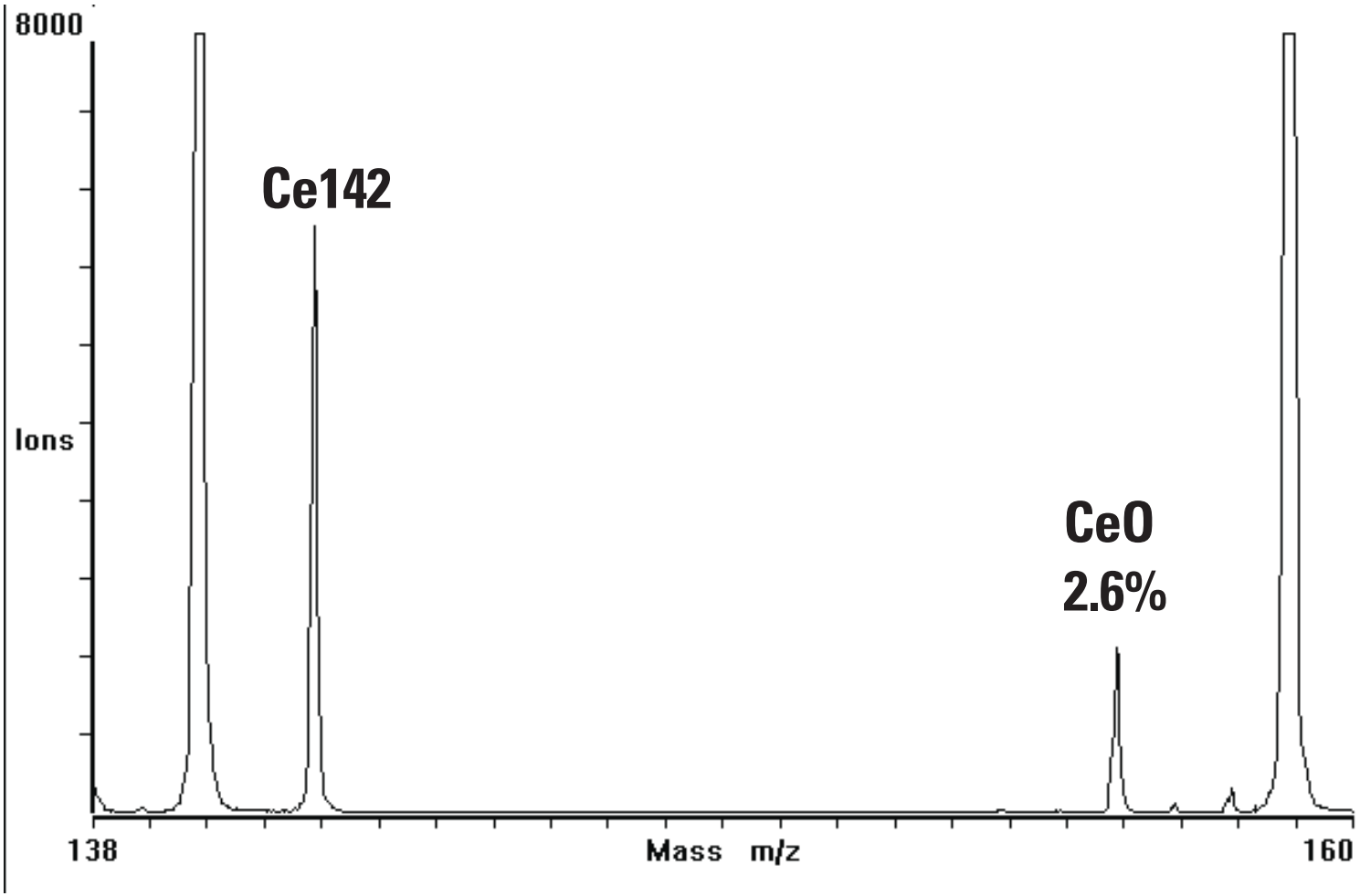
Oxide and double charged ions of Ce and Ba maximal values were defined for 7 x 15 s acquisitions under normal operating conditions.

The maximal measured values were :

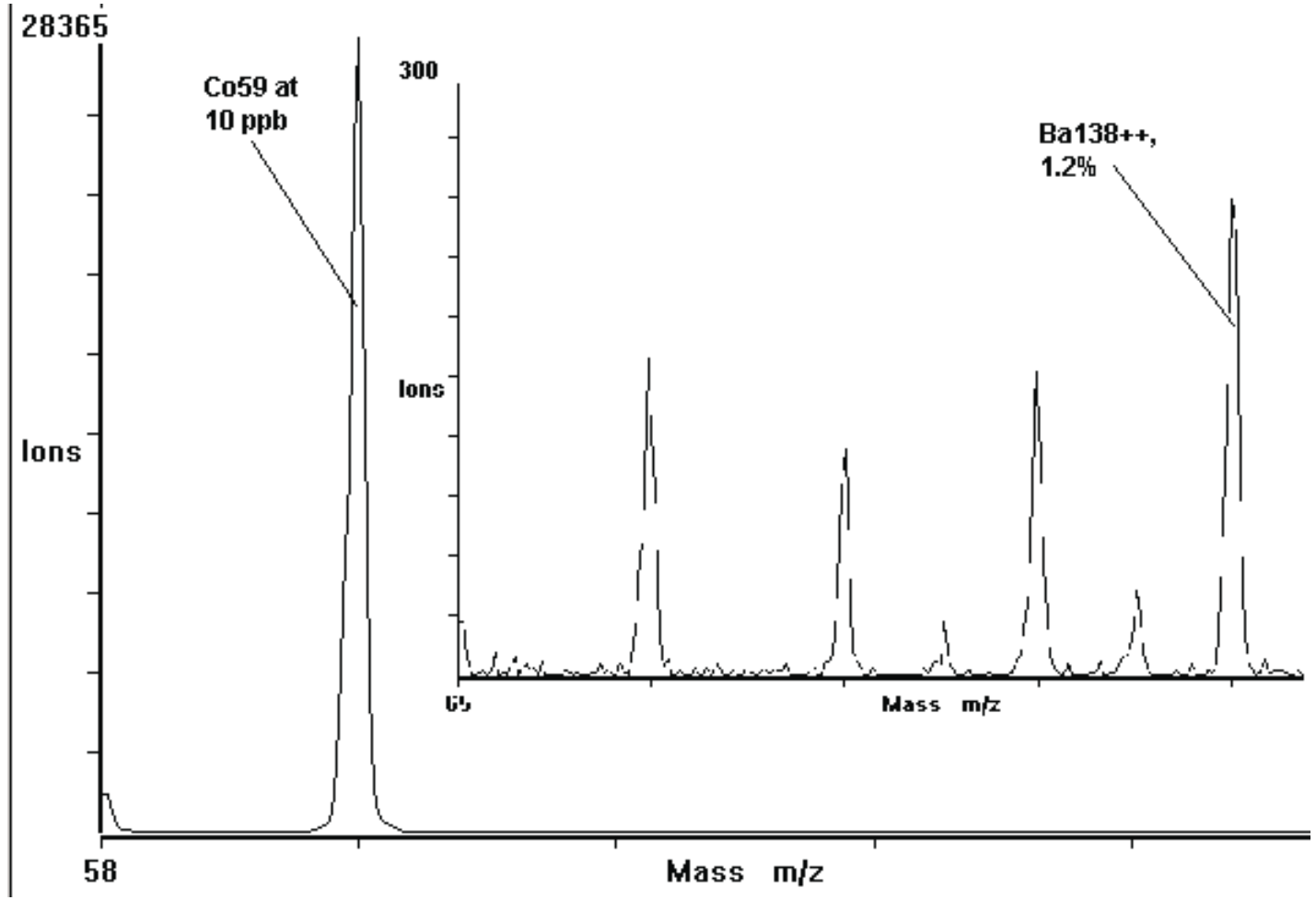
$BaO^{+}/Ba^{+} < CeO^{+}/Ce^{+} < 0.03$

$Ce^{++}/Ce^{+} < Ba^{++}/Ba^{+} < 0.02$

CeO/Ce Ratio



Ba^{++}/Ba ratio



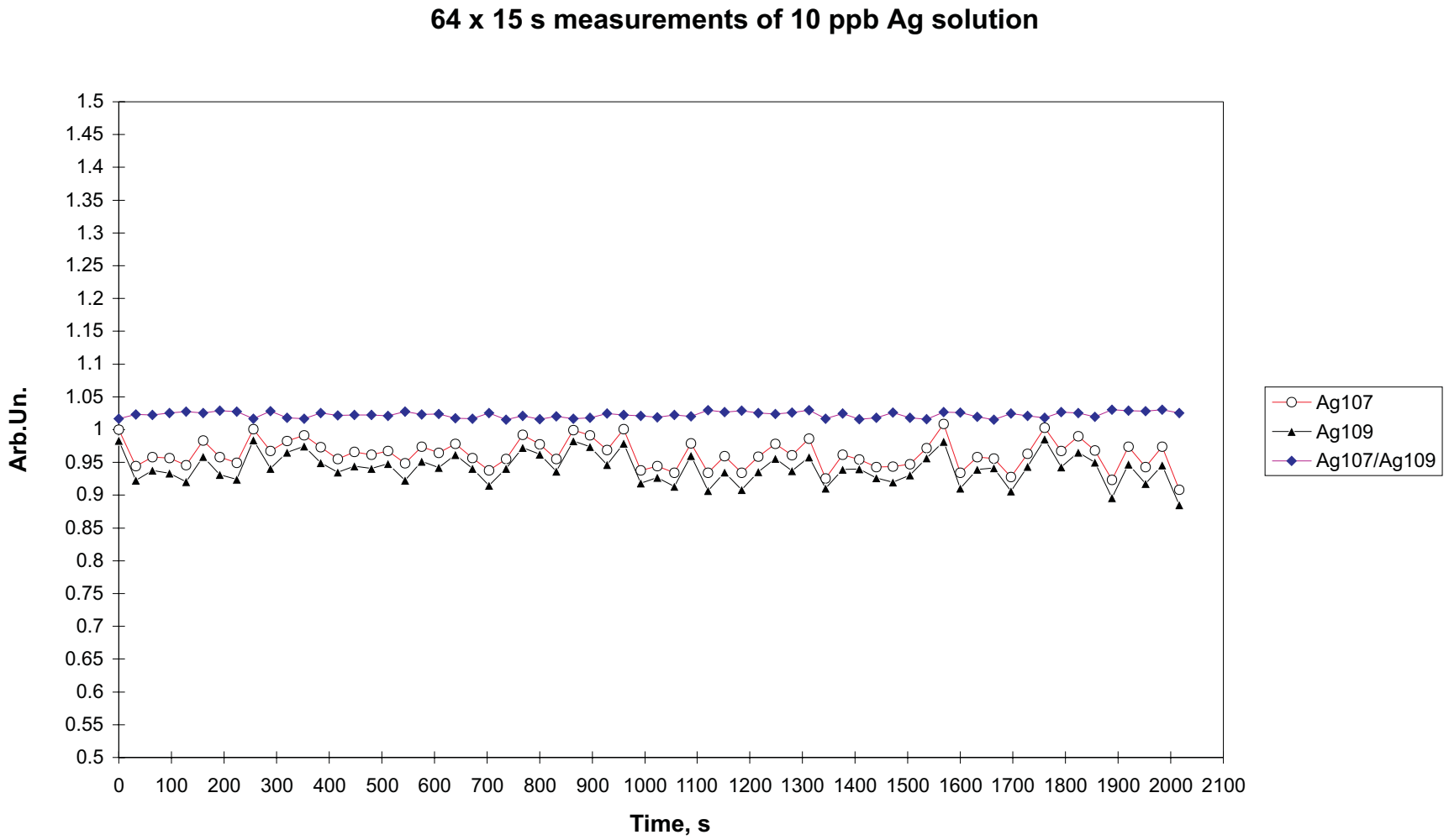
Ratio Precision

Ag107/Ag109 ratio precision was evaluated from full mass range measurements using 15 s TDC scans of a 10 ppb solution.

- **15 s acquisitions:**
  - **Ag107 — 93,050 counts with 2.3 % RSD;**
  - **Ag109 — 90,906 counts with 2.2 % RSD;**

- **Integrals for 10 consecutive points:**
  - **Ag107 — average 931,327 counts at 0.62% RSD;**
  - **Ag109 — average 911,110 counts at 0.73 % RSD;**
  - **Ratio RSD — 0.174 %, Statistical limit 0.147% .**

Ratio Precision



Conclusions

OptiMass 8000 under standard operating conditions displays the following performance characteristics:

- **Resolution > 1800 (f.w.h.m.); 0.03–0.3 a.m.u. At 10 %**
- **Dynamic range 10^7**
- **Detection limits 1–10 ppt for 10 s acquisition**
- **Ar elimination efficiency of >100,000:1**
- **Flat mass response for 80–250 a.m.u. Mass range**
- **MO/M < 3%; M^{++}/M^{+} < 2%**
- **Ratio Precision is Approaching Statistical Limit**