



BROOKS AUTOMATION, INC.

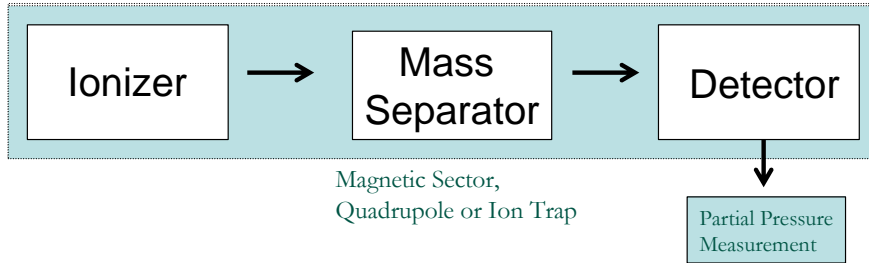
Autoresonant Ion Trap Mass Spectrometer The RGA Alternative

GRANVILLE-PHILLIPS®
A DIVISION OF BROOKS AUTOMATION
Advanced Vacuum Measurement Solutions

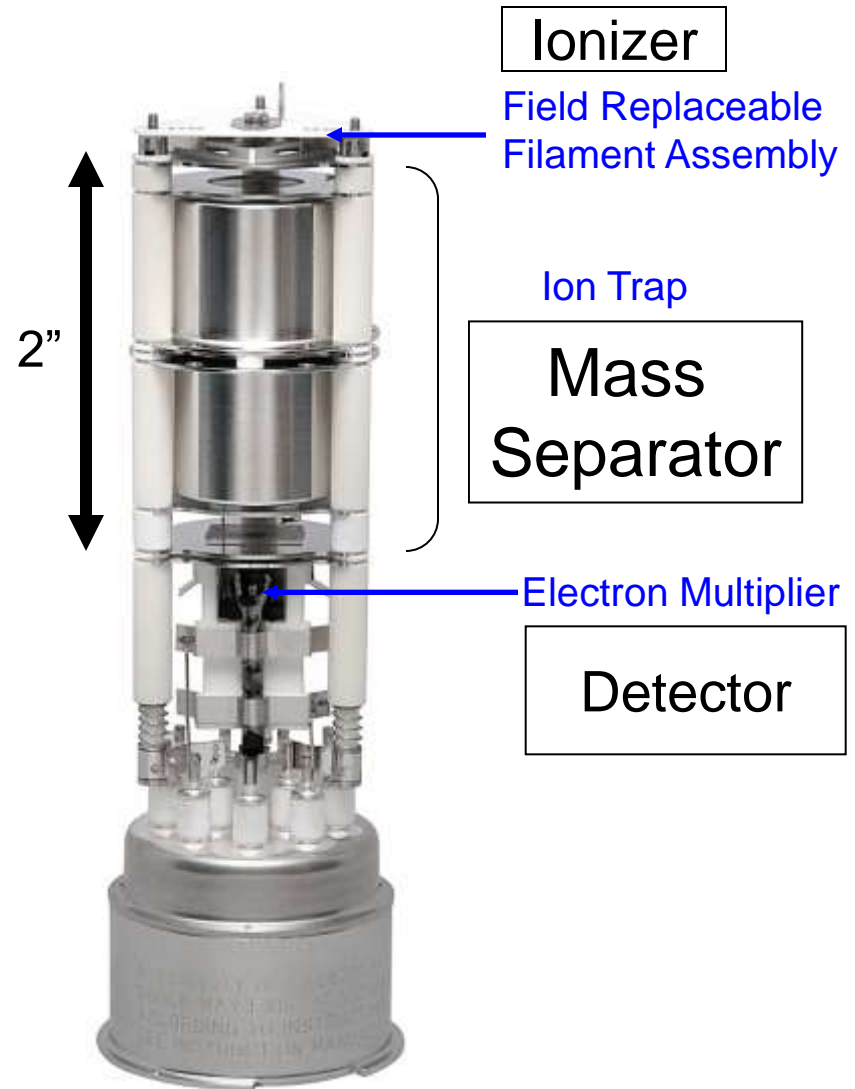


What is a Mass Spectrometer?

Mass Spectrometer



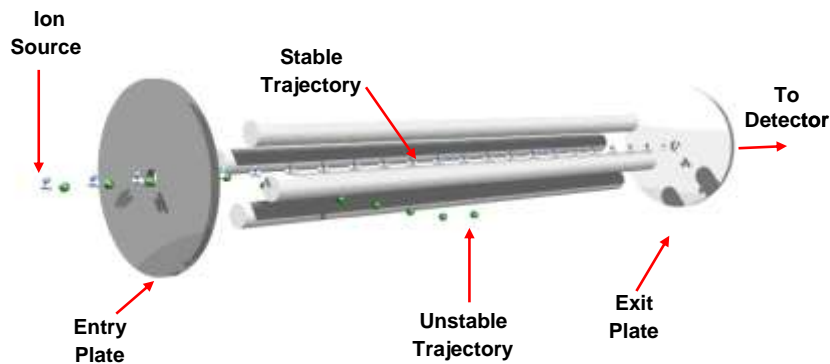
- Gas molecules are ionized (+ ions), and the resulting ions are separated, detected and measured according to their mass-to-charge ratios (m/z).



Mass Separator – Modern Trends

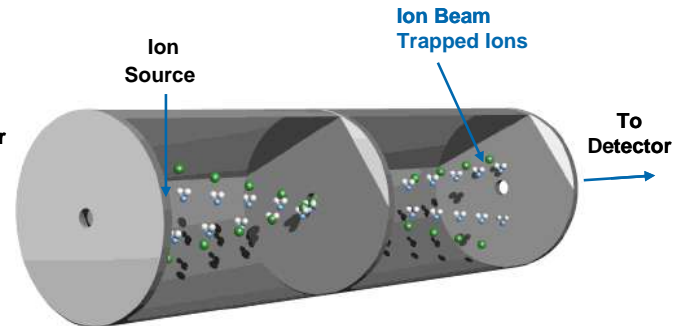
- Magnetic Sector and Quadrupoles are prevalent technologies
- The Electrostatic Ion Trap is the next generation of low mass separation technology

Quadrupole MS



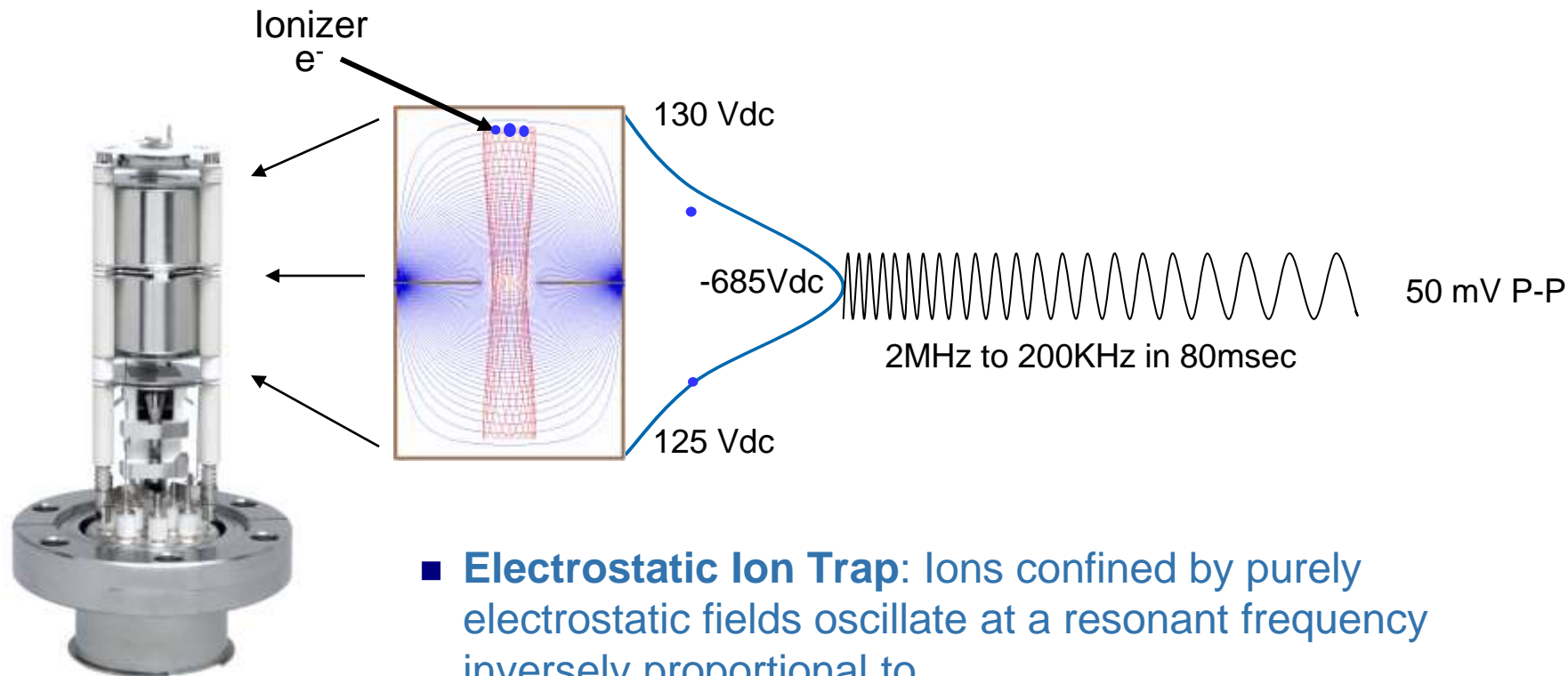
- Ionization is outside the mass separator
- Mass filter - one m/z at a time
- Poles get dirty
- Slow scanning

Ion Trap MS



- Ionization is inside the trap
- Trap - all ions stored together
- Clean
- Fast spectral output

Autoresonant Ion Trap Mass Separator



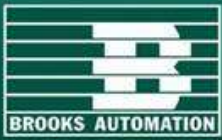
- **Electrostatic Ion Trap:** Ions confined by purely electrostatic fields oscillate at a resonant frequency inversely proportional to

$$\sqrt{m/z}$$

Where, m is mass, z is the total charge of the ion

- **Autoresonance:** RF scan pushes ions when scan frequency matches ion's resonant frequency

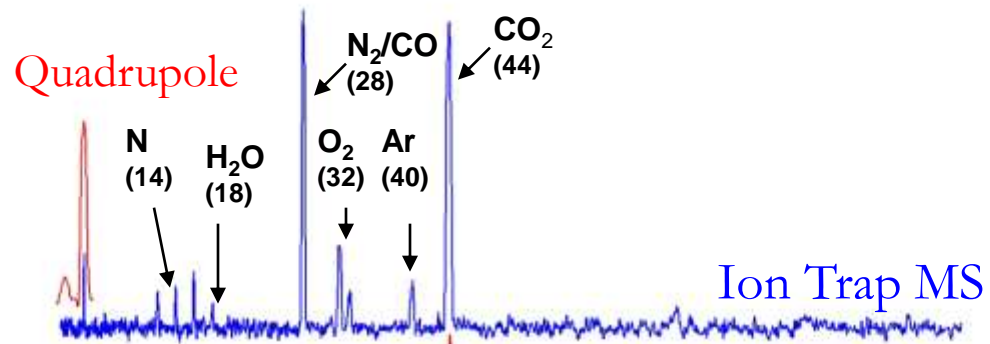
Electrostatic confinement = Ultra-low power requirements



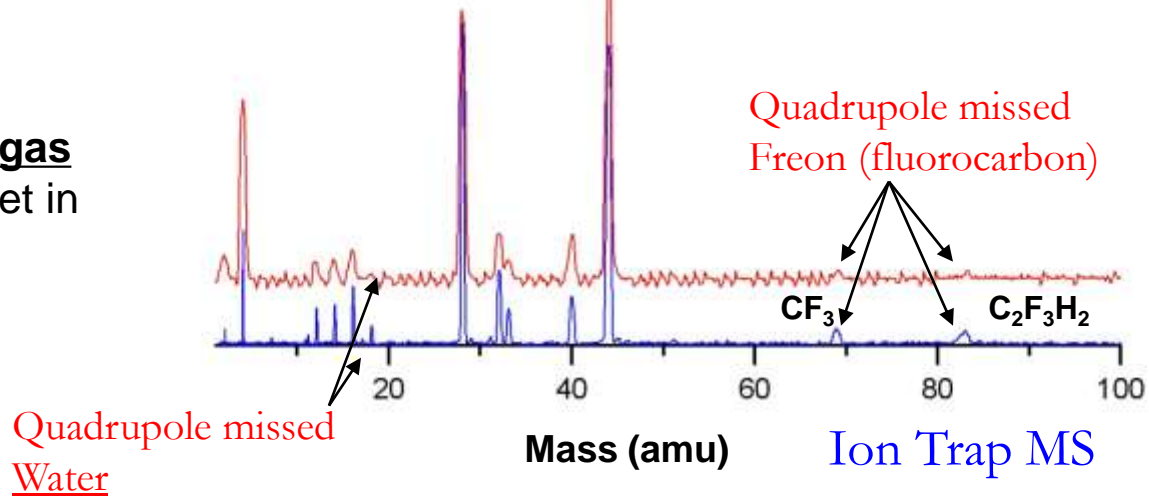
ART MS vs. Quadrupole RGA

Quad RGA = 1.5 sec, Ion Trap MS = 70 msec – 1-100 amu scan

How much **information** you get in a 70 msec scan

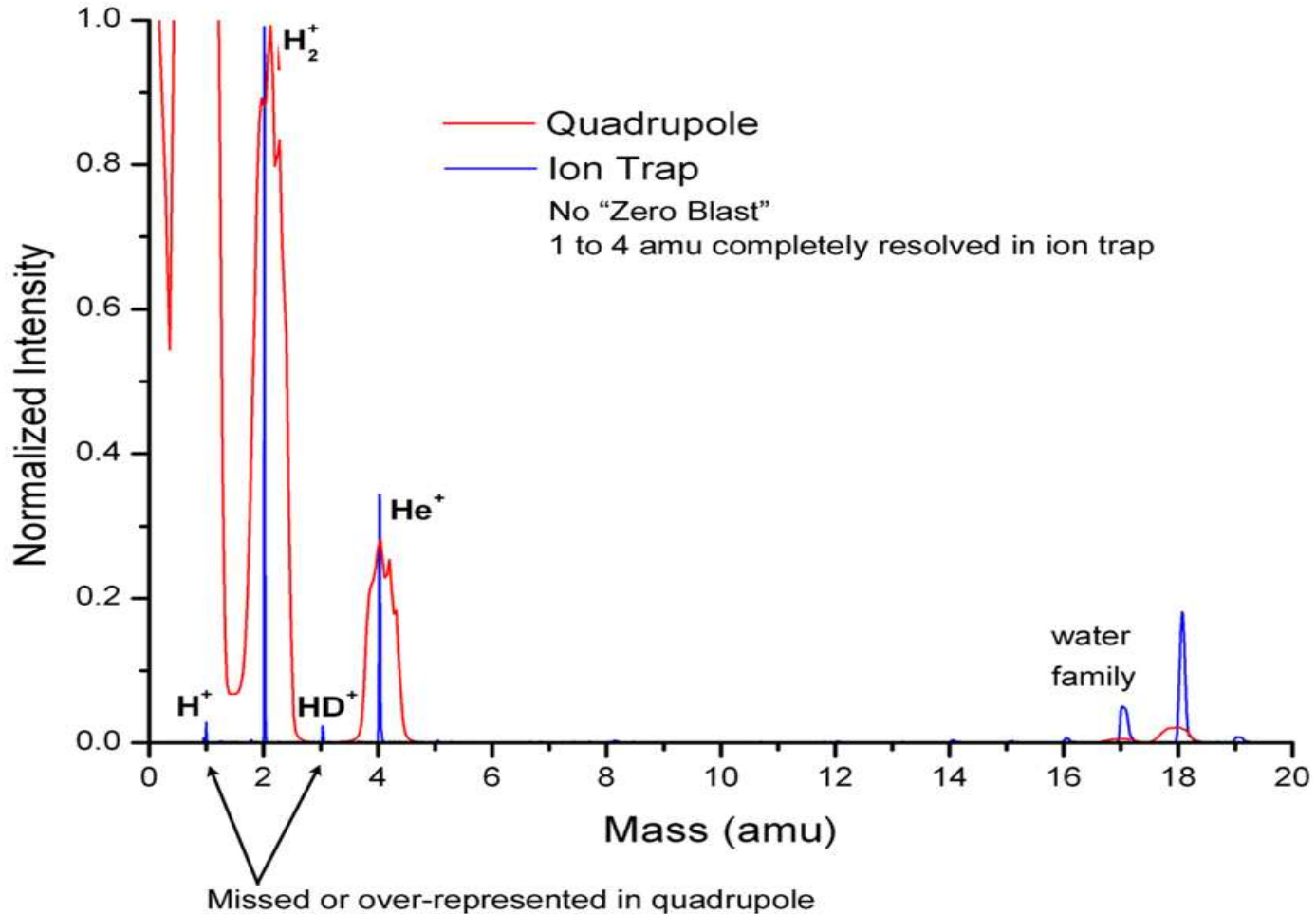


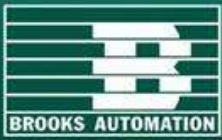
How much **resolution and gas detection** you get in 1.5 seconds



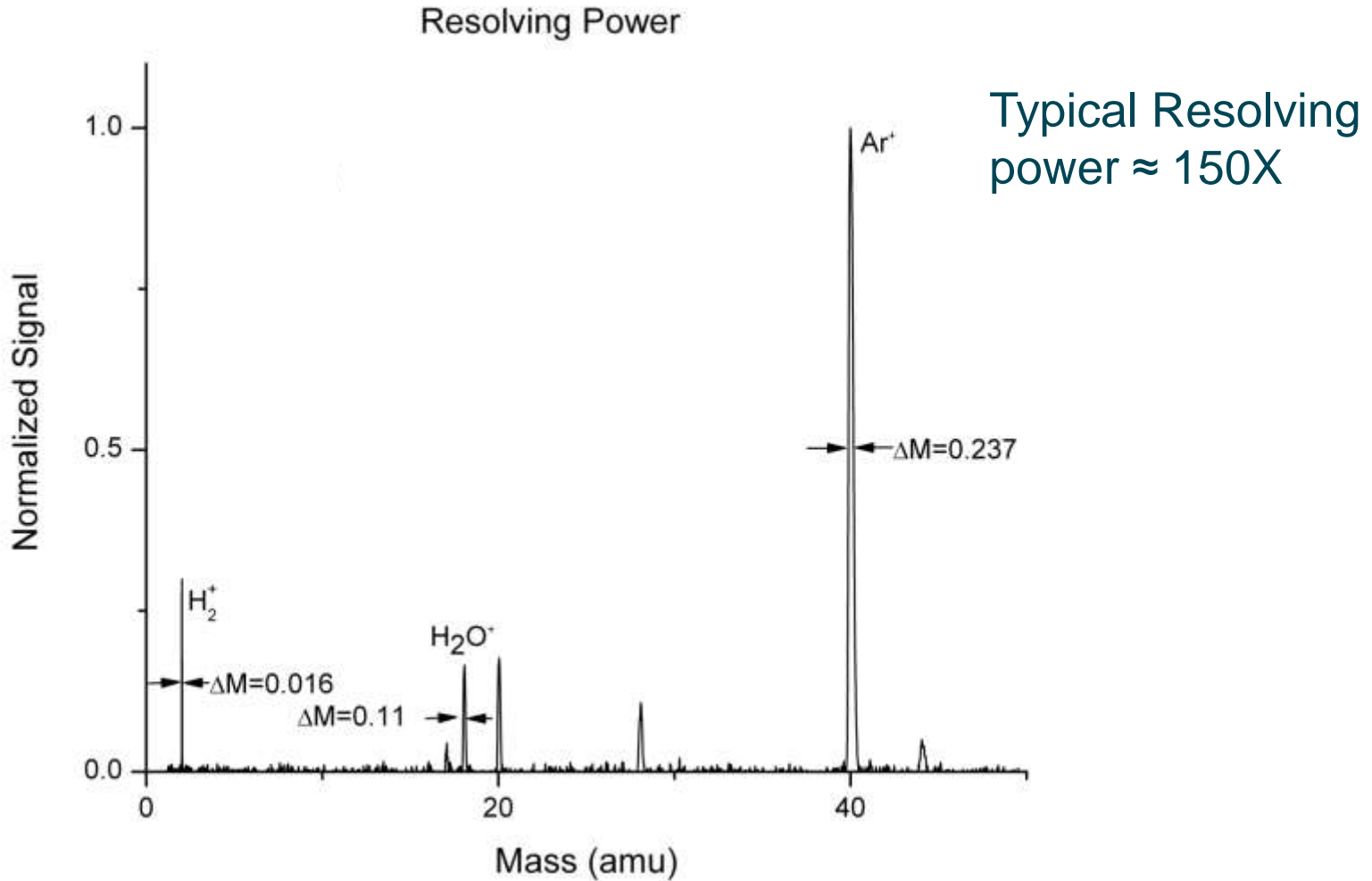
Low Mass Comparison

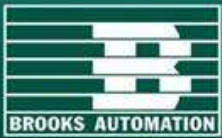
Low Mass Range Capability 830 VQM compared to Quadrupole





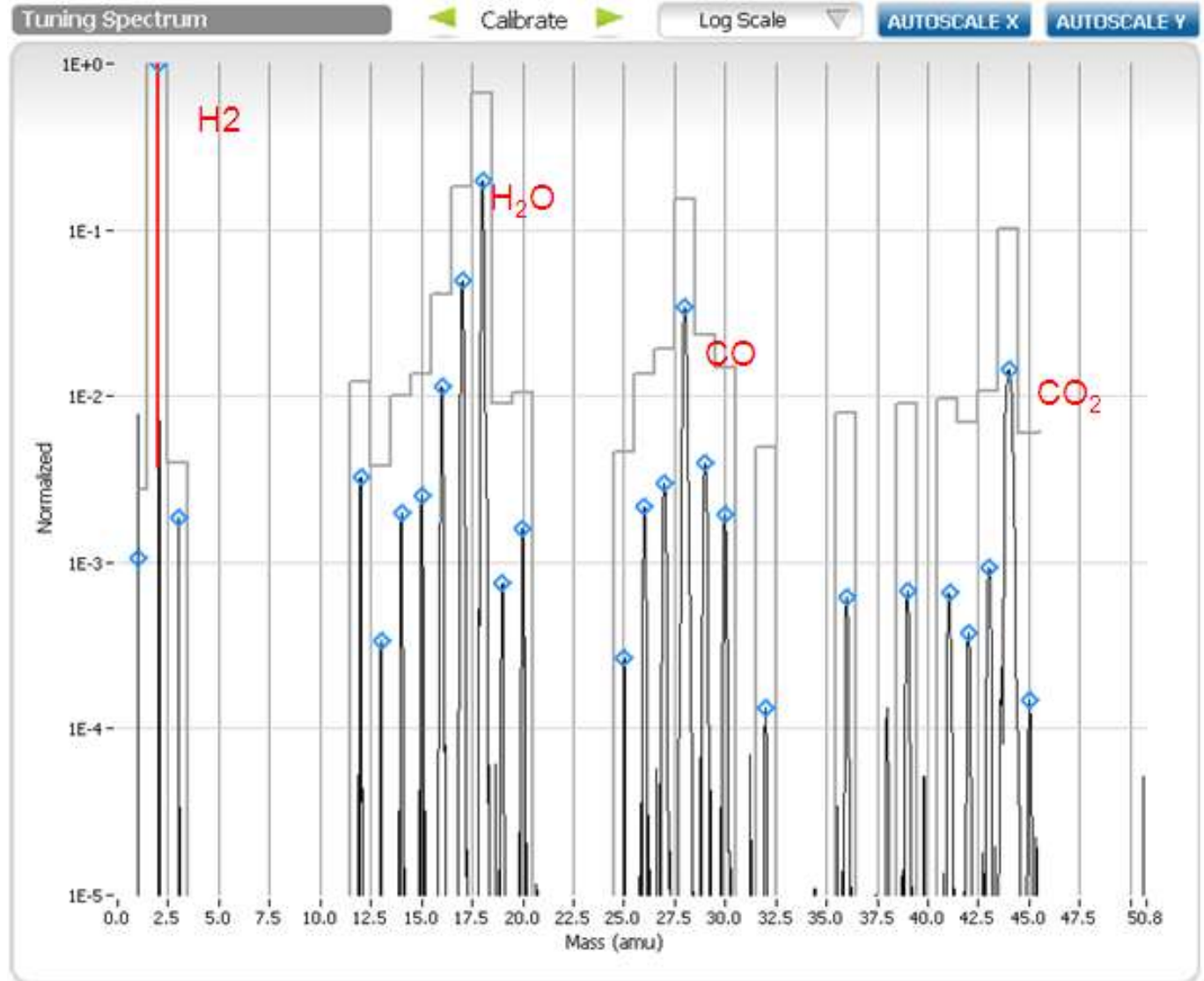
VQM Resolution





VQM Sensitivity / Dynamic Range

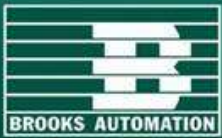
- Min detectable partial pressure is 2-3 decades below the max peak partial pressure
- 3 decades requires averaging
- Over 3 at UHV



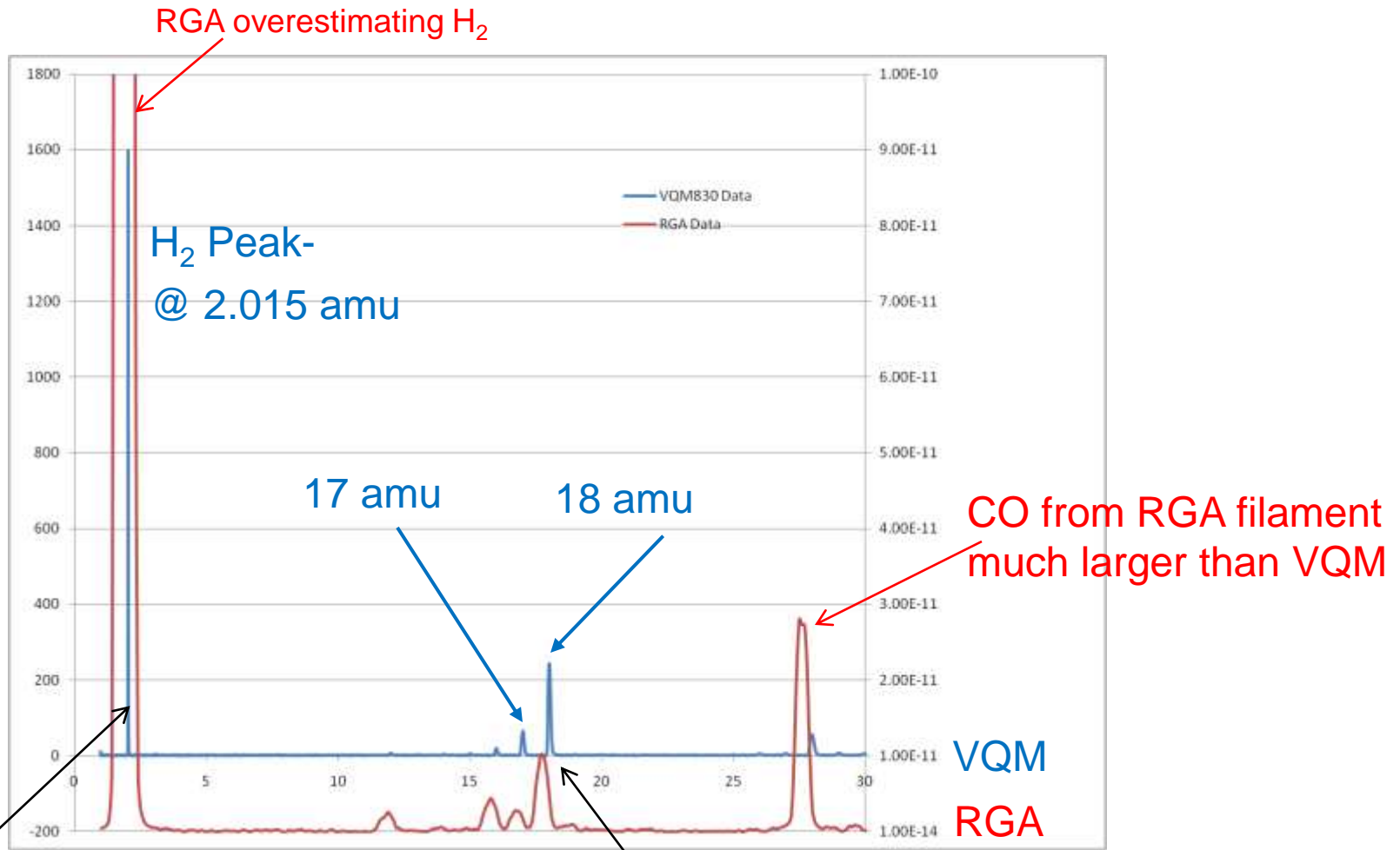


VQM Advantages at UHV

- Capable of running at extreme vacuum levels
 - Experiments run as low as $3\text{E}-13$ Torr
 - Can fill the trap at any pressure so performance does not degrade
- Does not over represent H_2
- Low CO and CO_2 outgassing
- No O_2 outgassing
- Can get up to 4 decades dynamic range
- Catches fast transients

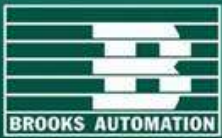


Waveform Comparison

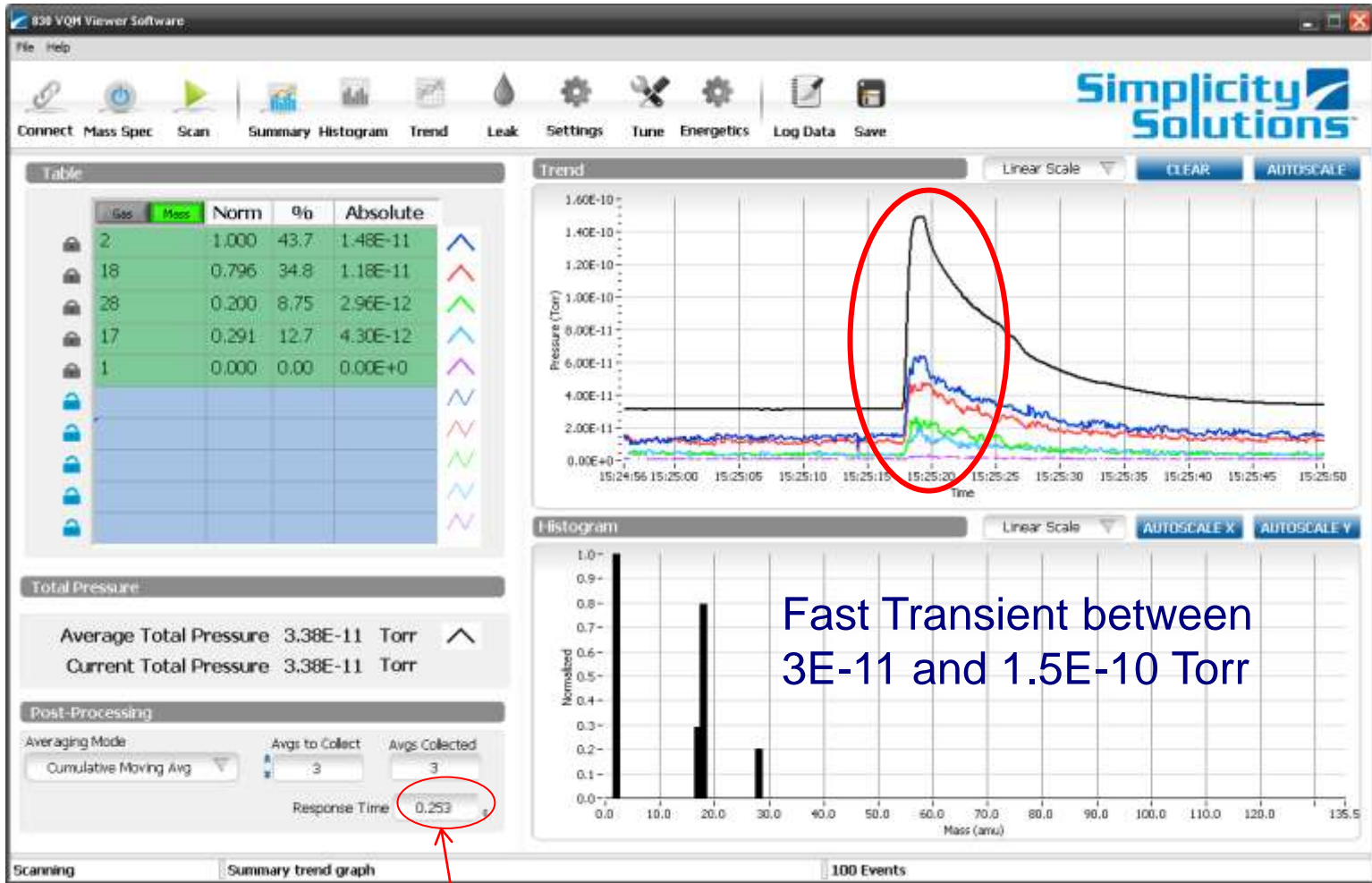


VQM resolution is much better

Waveforms are normalized to water peak

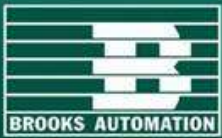


VQM Sees Fast Transients

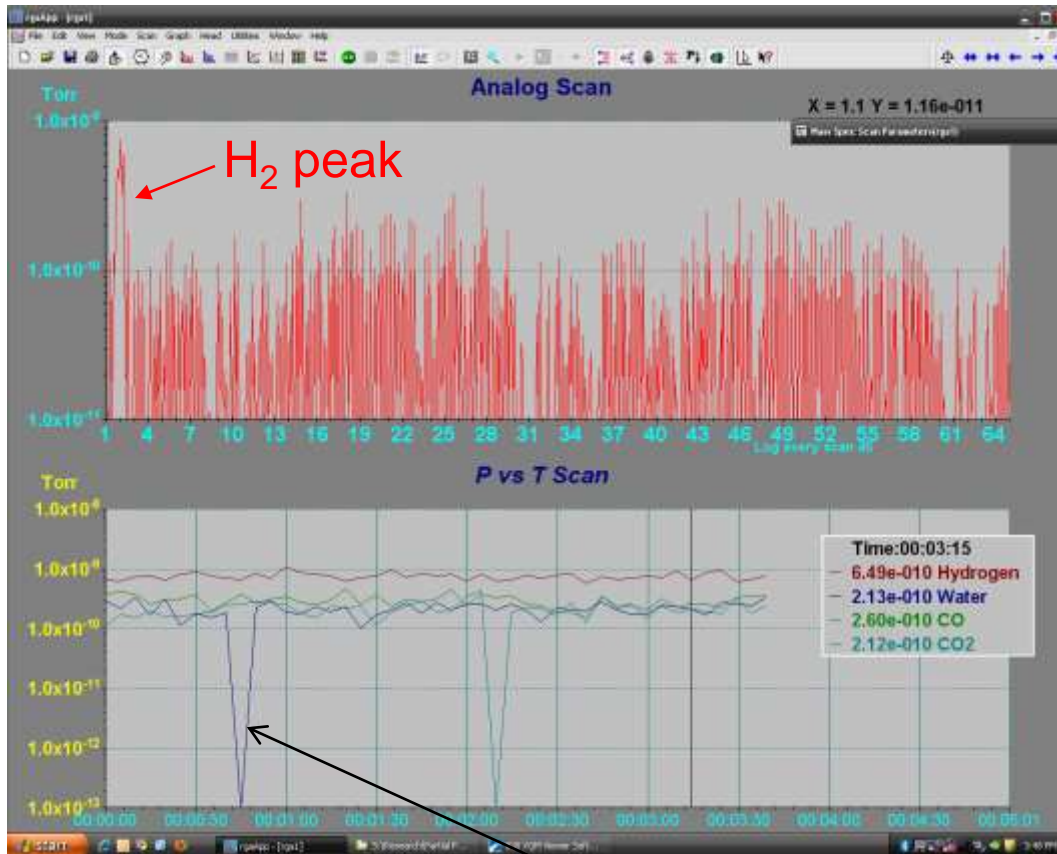


253 msec response time

Transient generated by turning Extractor Gauge filament on



RGA Misses Fast Transients



■ Transient is below noise level.

■ RGA not fast enough to see transient

SRS RGA:

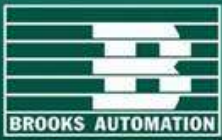
- SS=7
- 4 second scan (135 amu range)
- EM on; Gain:1000X

This is not the transient
➤ it's a dropout in the water waveform



Mass Spec Comparison

830	RGA	Feature	Comments
✓		Speed	Scan speed 85 ms vs. 1-3 seconds (for 1-135 amu)
✓		Power	15W vs. 60-70W Max
✓		Calibration	Single gas – very simple calibration
✓		Zero Blast	RGAs have don't filter accurately below 4 amu
✓		Match Controller to Gauge	Any controller can drive any gauge
✓		UHV Performance	VQM has better dynamic range and low outgassing
✓		Cleanliness	RGAs filter ions to poles; 830 clean after a year of use
	✓	Higher Pressures	RGAs with Faraday Cup detectors go up to 10^{-4} Torr
	✓	Dynamic Range	Can get 4-8 decades?



Introducing the 830 Vacuum Quality Monitoring System



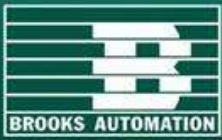
830 VQM Viewer

830 VQM Controller
830 VQM Gauge



Total Pressure Kit





830 VQM Features Summary

Highly Differentiated!

- Fast (Scan time 85ms)
- Full 1-135 amu measurement range
- Large Pressure Range UHV to 10^{-5} Torr
- Unprecedented low power requirements (8W)
- Single point mass axis calibration
- Comprehensive, easy to use viewer
- Small size
- Electronics remote from sensor
- Electronics not paired to the sensor