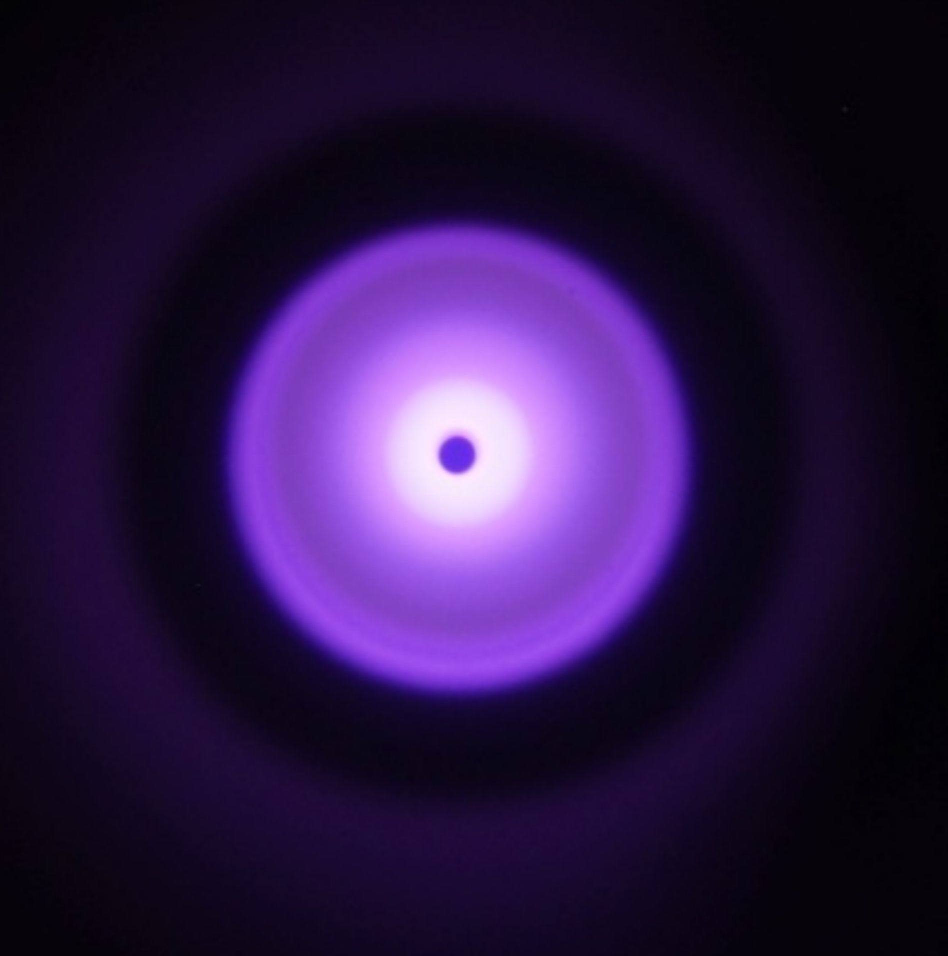
Optical Emission Spectroscopy
Residual Gas Analysis



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Lightwind OES RGA

The Lightwind L Series residual gas analyzers use optical emission rather than mass spectra used by traditional RGA's. Because the L series do not have filaments none of the failure modes seen with standard RGA's occur. This also makes them much more robust when exposed to aggressive chemistries.

The **L3** was the first Lightwind product and was introduced in 2001. It uses an inductively coupled plasma for optical emissions. Because of its design it is compatible with continuous exposure to a wide variety of gases seen in both etch (such as fluorine and chlorine) and deposition processes. The L3 has been used in 24x7 production manufacturing. It is designed to operate at mid vacuum pressures from 10- 2 to 3.0 Torr.

The **Lx** can replace the traditional RGA in most applications and operates at pressures from 10-7 to 10-2 Torr. It is not inductively coupled but uses an internal electrode, not a filament. As with the L3 the spectrometer is optically isolated from plasma exposure so recalibration is not normally required.

The L3 and Lx use standard Lightwind OES software which features both full spectral as well as selected channel data tracking and storage. Both systems can be used for troubleshooting, process monitoring, and leak test. Software will output a continuous data stream over an ethernet link, has recipe storage, and the ability to endpoint processes. A separate data viewer is included.

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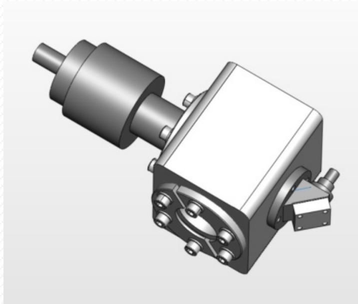
Lx and L3 System Configurations

Lx

10 – 7 to 10 – 2 Torr



DC Power Supply

L3

10 – 2 to 3.0 Torr

RF Supply

Spectrometer

Computer

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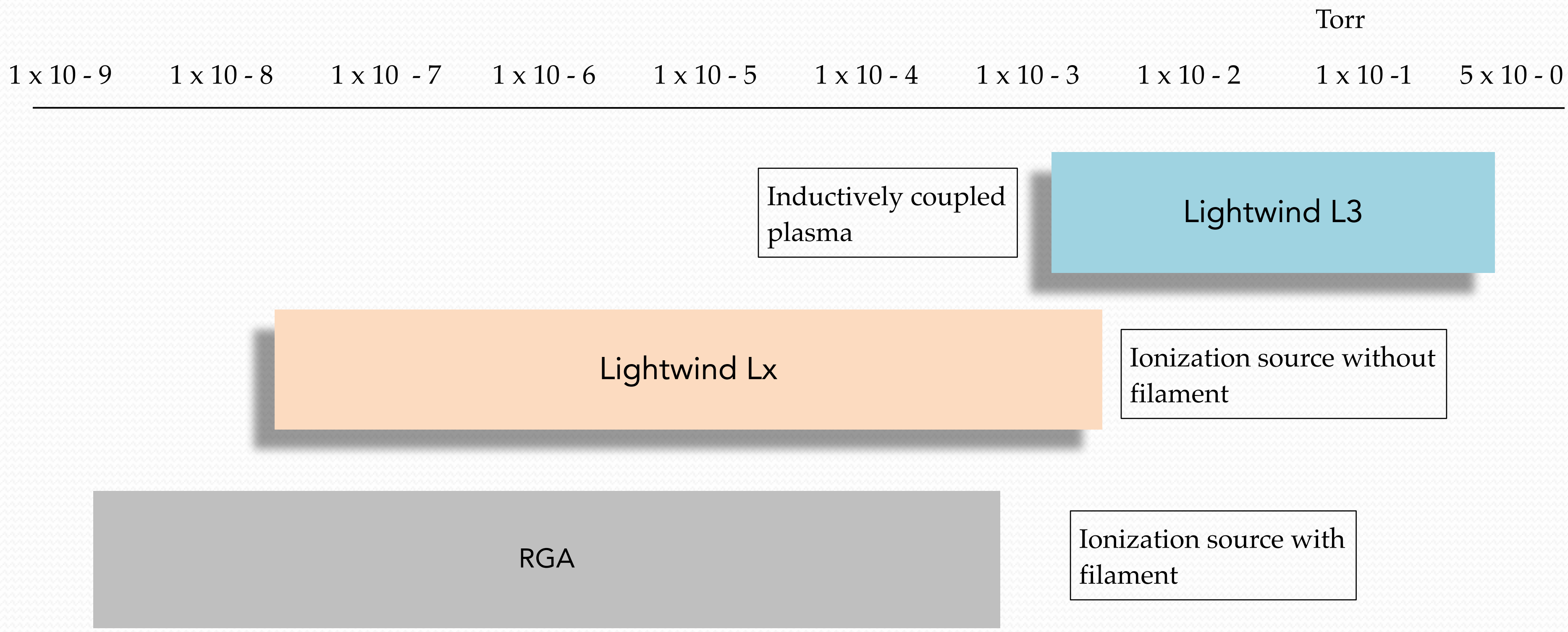
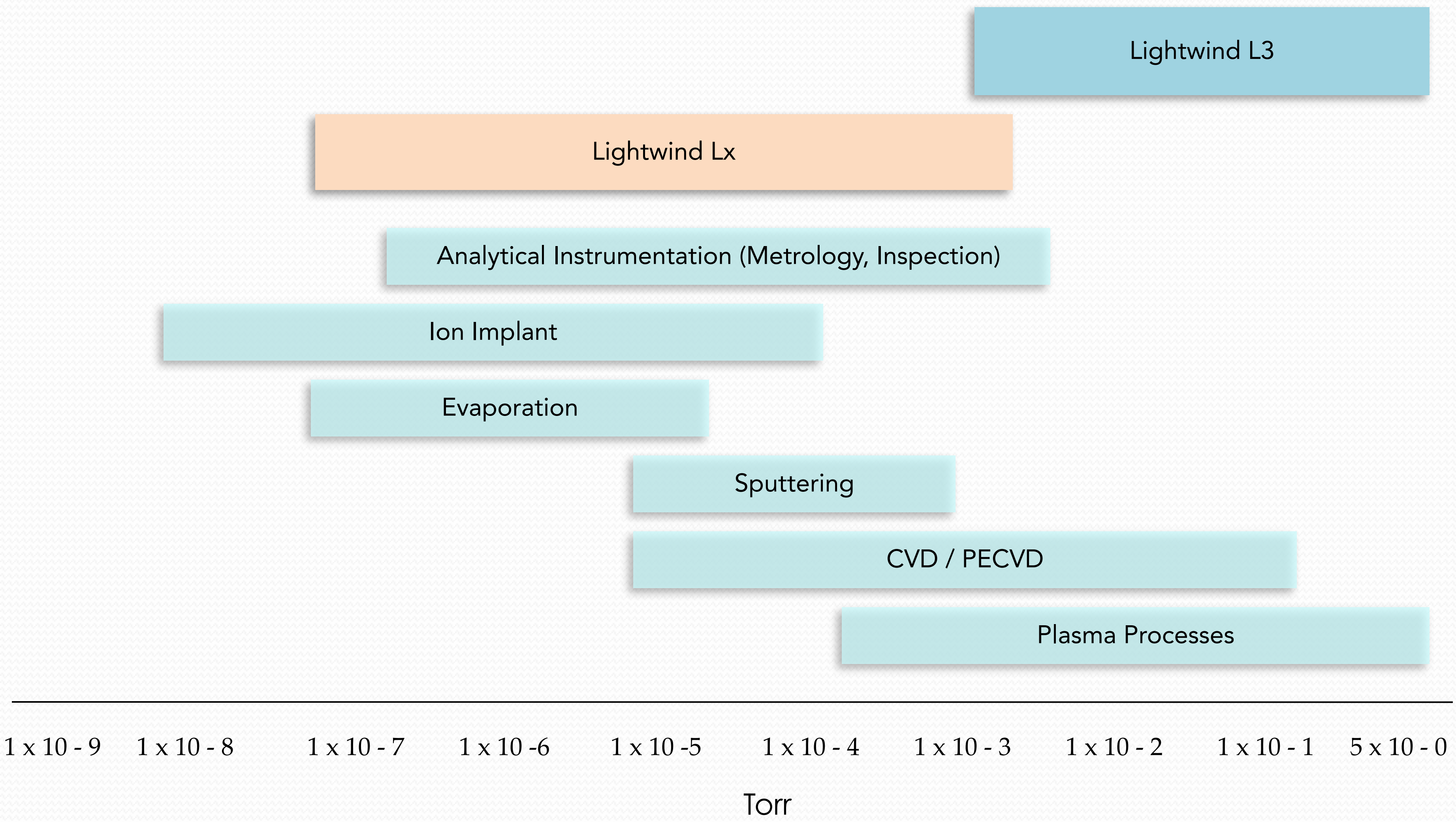
Lightwind OES Systems Pressure Ranges Compared to RGA *



*Standard pressure ranges for non differentially pumped systems. All the above can operate at higher pressures with differential pumping

Possible Applications Without Differential Pumping



L3 and Lx Compared to a Traditional RGA

	L3	LX OES RGA	RGA
Light source	Inductively coupled plasma	Ionization gauge	Filament gauge
Detector	CCD Array	CCD Array	Mass filter
Pressure range without differential pumping	1 x 10 – 3 to 5 Torr	1 x 10 – 7 to 1 x 10 -2	1 x 10 – 10 to 1 x 10 - 5
Pressure readout	No	Yes	Yes
Leak back measurement	No	Yes	Yes
Spectroscopy shows vacuum leaks	Yes	Yes	Yes
Material Sensitivity to reactive gases	No	Some processes << that Typical RGA	Yes
Detector protected by window	Yes	Yes	No

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Lx Integrated Sensor Assembly and Optional Hub

Lx Sensor assembly

1 Ionization source
2 Optical hub
3. Optical Output to Spectrometer
4. Vacuum Inlet

Vacuum ports use standard KF25 clamp mounting for input flexibility

Lx Hub

The hub can be adapted to many flange sizes. It is designed to integrate into existing cold cathode installations.

Preinstalled hubs enable walk up gas analysis without violating system vacuum.

Preinstalled Test Points With Existing Cold Cathode Gauges

Test point 1

Test point 2

Laptop and Spectrometer

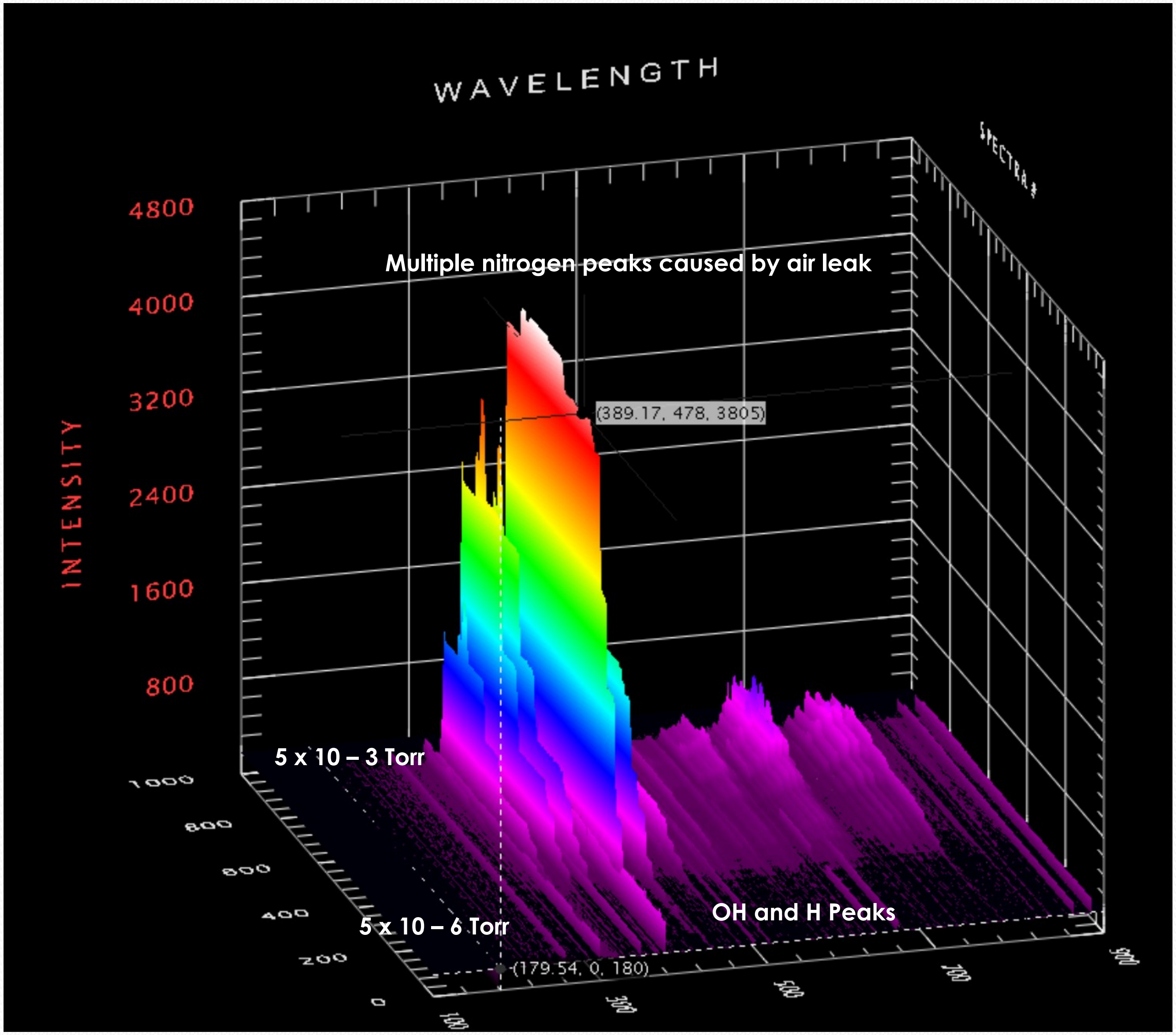
Test point 3

Attaching a fiber optic cable to
the spectrometer and the hub
is all that is necessary to directly
sample gases.
It is not necessary to break vacuum.

Pump Down With Air in Chamber

Shown is the change in gas composition from 10-3 to 10-6 Torr

Initially an air leak was introduced briefly. After the air leak the large N2 peaks (O2 peaks are smaller) start to disappear. At 10-6 the emission peaks are smaller because of the lower gas density. At the lower pressure the spectra reduces to a small CO peak, and relatively large OH and H peaks (alpha and beta) .



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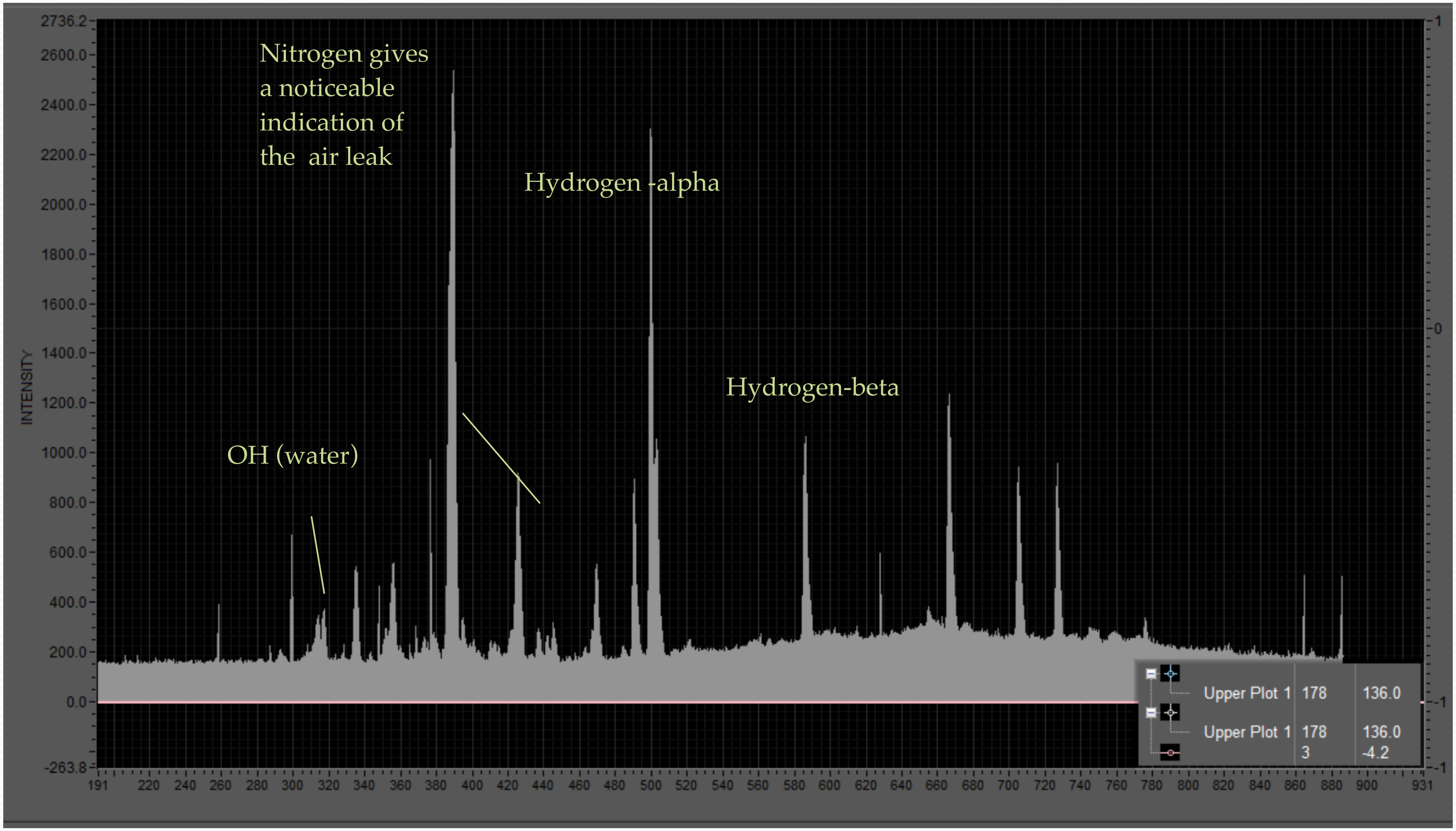
OES Spectra Shows Multiple Peaks for Nitrogen, Hydrogen, Water and Helium when a Small Air/He Mix is Leaked into the System *



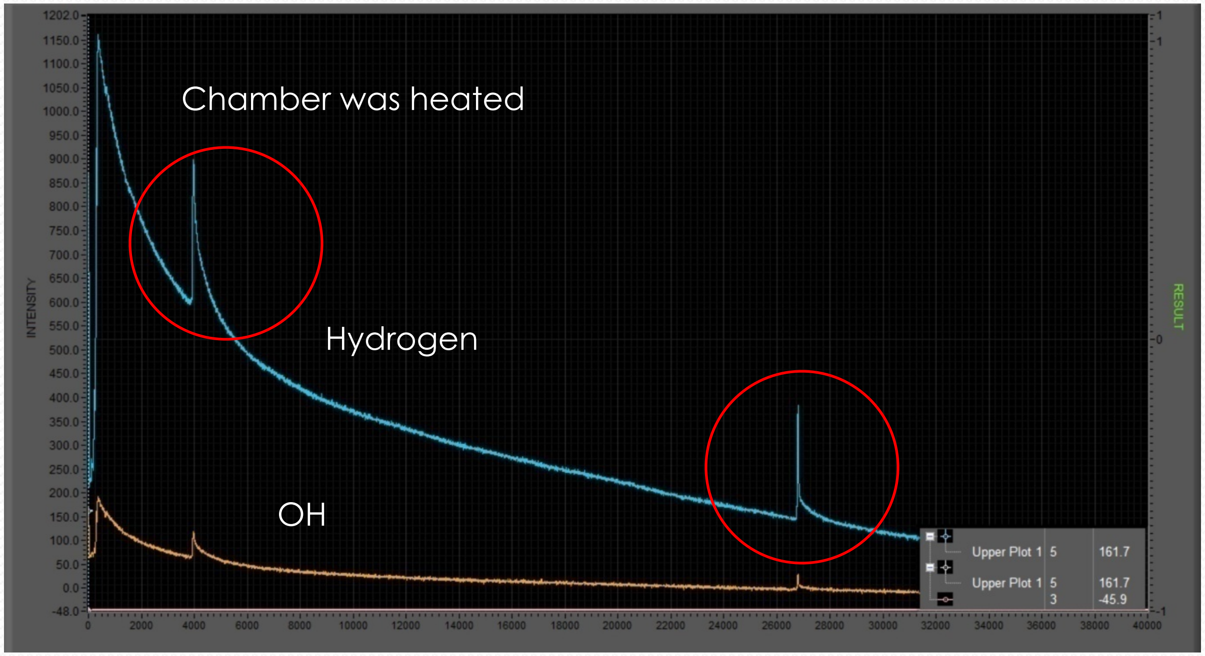
*Approximate Pressure ~ 1 x 10-4

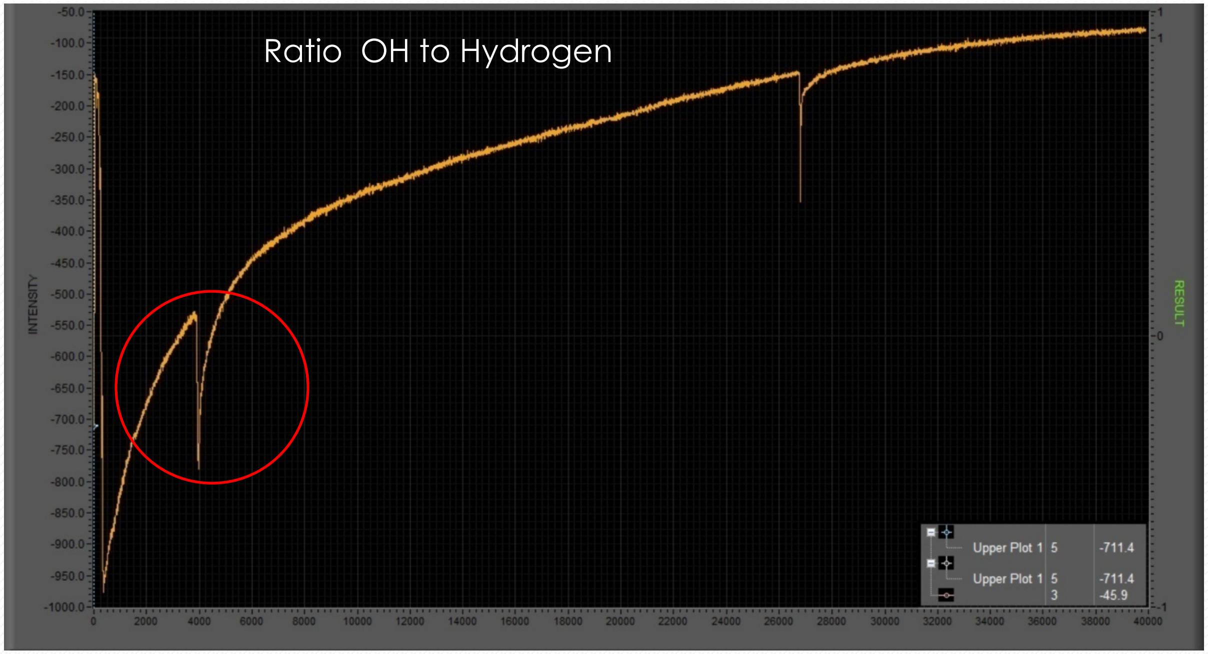
Pumpdown OH and H

Shown are OH and H peaks during vacuum chamber pump down.

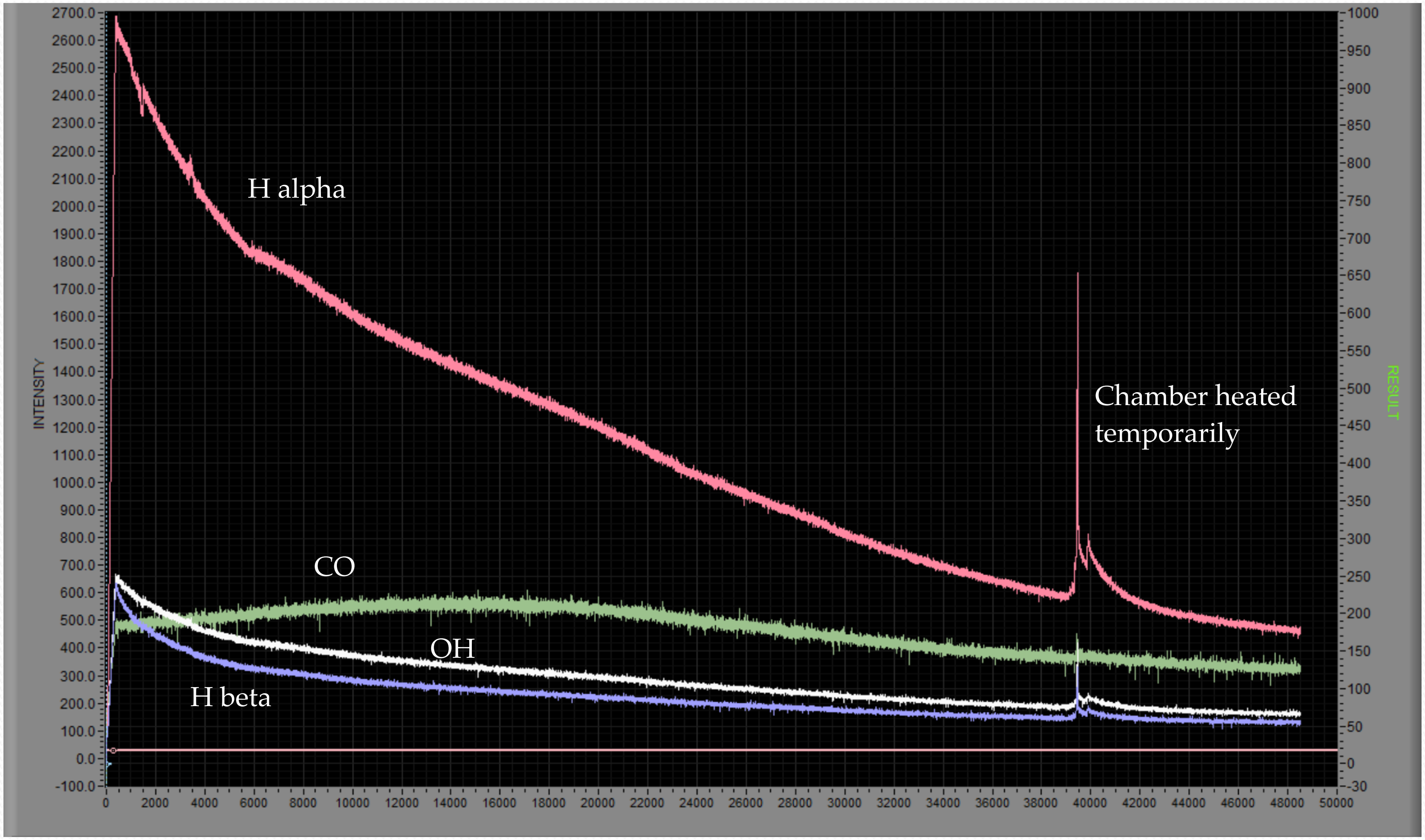
Parts of the chamber were heated to demonstrate the increase in out gassing as a function of chamber wall temperature. The peak increase matches the short heating cycle followed by cooling and return to ambient.

As can be seen in the second trace a comparison of an OH peak with a hydrogen peak illustrates that the hydrogen is removed faster than the OH…. i.e water OH groups are much harder to remove as would be expected.





Pump Down Showing OH, H, and CO with Heating



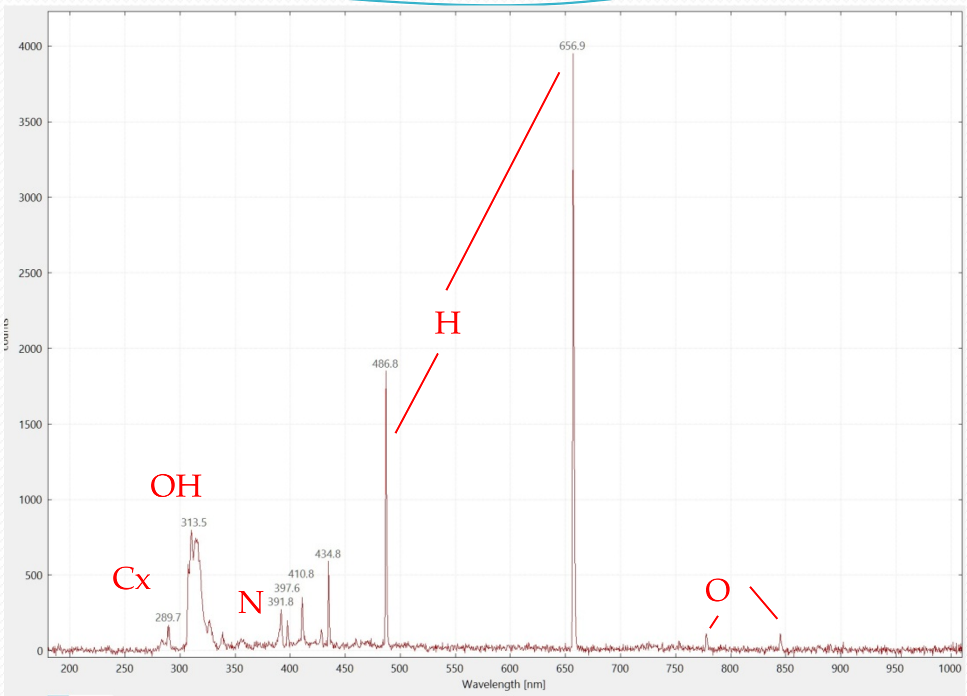
1x10 -3 Torr

9x10 -6 Torr

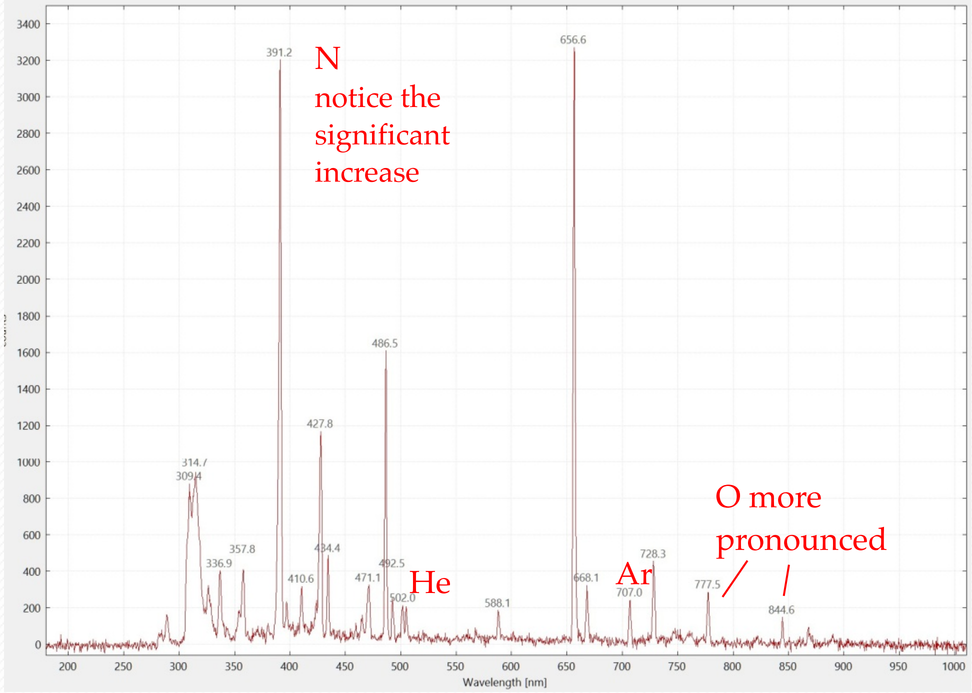
Shown is an extended pumpdown of a small vacuum chamber.
There are three points worth noting:
1 Chamber heating temporarily increased out gassing of all volatiles
2 The Hydrogen Alpha line (686) decreases faster than the Hydrogen Beta line (485)
3 There is an increase in CO out gassing down to 10-4 Torr where it begins to decrease

Typical Low Pressure Spectra

6.5 – 6 Torr
Showing very small air leak with Nitrogen and O2 peaks,



3.5 – 5 Torr
Larger air leak with small amount of Helium introduced. Notice the prominent N2 peaks. Small leaks create very large nitrogen peaks with 390 being prominent.



Lx Series Summary

- Full Spectral scan times range from 10 milliseconds to 5 seconds
- Non filament plasma source with higher operational pressure range than a mass RGA
- Not sensitive to presure inrushes
- Potentially lower cost of ownership
- Less complex and more reliable than alternatives
- More mobile than RGA's
- If using multiple optical hubs does not require violating system vacuum
- More robust when exposed to halogens

Lightwind   Lx System and Options

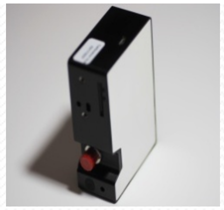
The standard system is comprised of the following   hardware.

Not shown is the power supply for the CC gauges

Options include:

- CC for high voltage environments
- Automation of CC turn on with a convection gauge
- Using end users's computer
- Using end user's CC gauge
- Optical hubs as sampling points
- Different fiber optic cable lengths

- Computer with Lightwind software



- Spectrometer
  200-800 nm.
  1.4 u resolution
  2048 or 3648 pixels
  integration times of 2milliseconds
  to 5 seconds

- Fiber optic cable 1 meter x 600 micron
  custom lengths are available.

- Sensor Head Includes
  Optical hub with optics
  Power supply
  Plasma head log voltage readout
  for pressure. Integration with convection
  gauge optional

- Optional Optical Hub Assembly for upgrade
  of preinstalled cold cathode gauges.
  Vacuum fittings for mounting existing
  cold cathode gauges need to be specified.

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For more information contact us: lightwindcorp.com

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Supplemental

Configuration Options

Detailed Comparison of Relative Strengths and Weaknesses of Optical vs Mass Spectra

Comparison of RGA Mass and OES Wavelengths During System Pumpdown

Comparison of Common RGA Mass and OES Wavelengths

Lx Configuration Options

Hardware	Standard System	Standard System with Auto Start	High Energy or Contaminating Environments	Upgrade to Existing Cold Cathode Gauge	Optical Hub Only
Ionization source	Type 1	Type 1	Type 2	Customer Provided	Customer Provided
Convection Source Trigger		Yes	Optional	Customer Provided	Customer Provided
Source Controller and Pressure readout	Separate Controller Not required No high pressure readout	Separate Controller not required Includes convection gauge for high pressure	Separate controller	No	No
Optical/Vacuum Hub Interface	Yes	Yes	Yes	Yes	Yes
Spectrometer Standard 200 – 850 ~1.2 nm Resolution 2048 Pixels Typical	Yes	Yes	Yes	Yes	No

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Standard RGA Vs Optical RGA Overview

Characteristic	Standard RGA	Lightwind Lx Optical RGA
Operating Principle	Electron impact ionization and mass filtering	Plasma discharge and optical emission spectra
Pressure Range	Typically 10-4 to 10 – 7 Torr	10-2 to 10 – 8 Torr, no filament
Startup Constraints	Cannot run above 10 – 4 filament must be protected	Starts immediately, no filament to burn out
Species Identification	Mass to charge, requires RSF and tuning	Discrete optical lines with fixed branching ratios
Calibration Sensitivity	Strongly dependent on filament age, ion source cleanliness, tuning	Stable overtime, optical lines are physics fixed
Contamination Sensitivity	High: filament poisoning, grid contamination, cracking patterns	Very Low: no filament, no grids, plasma can be self cleaning
Maintenance	Frequent filament changes, bakeouts, cleaning	Minimal since there is no filament
Response to Water/ Process	Water cracking complicates interpretation, corrosive gases shorten lifetime	Water produces clean OH/H lines not affected by corrosive gases
Leak Detection Behavior	Classic 28/32/40, requires stable tuning	Optical signatures appear instantly with not tuning drift
Pumpdown Monitoring	Cannot monitor early pumpdown	Full pump down visibility
Best Use Case	High vacuum diagnostics, contamination analysis UHV	Industrial Vacuum, pumpdown monitoring, process environments, 24/7
Weakness	Fragile, pressure limited, maintenance heavy	Cannot distinguish isotopes, some optical lines overlap

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Comparison of RGA and OES RGA Spectra During Pumpdown

Pump Down Stage (Torr)	RGA (AMU)	OES (Nm)	Interpretation
3 Torr to 10 -2	N2 14, 28 O2 16, 32 Ar 40 H20 16 , 17, 18 CO2 44 CO 12, 28 (with differential pumping)	Lightwind L3 OH 308 N2 337,357,389 Ar 696.5, 706.7, 750.4, 811.5 O 777, 844	Bright with strong N2, OH, and H lines6
10-2 to 10 -4	Hydrocarbons: 15, 29,43, 57 CO 12, 28 CO2 28, 44 H20 17,18	Lightwind Lx CH 431 C2 Swan bands 473- 563 H Balmer (486.1, 656.3 O 777 844 as well as all lines from the higher pressure regime	CH and C2 hydrocarbon contamination H water cracking hydrogen dominance emerging
10 – 5 and below	H2 2 H1 1 Very small traces of N2/CO if leak	H (beta) 656.3 (alpha) 486.1 OH band 306-309 N2 bands weaker	OH and H predominant

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Comparison of Common Mass Spectra Vs Optical Spectra

Species	Key RGA Mass (AMU)	Dominant OES Wavelengths (Nm)	Comment
CH4	14,15, 16	314 (C2), 388 (CN, 431 (CH)	Hydrocarbon fragments
C2H6/ C2Hx	26,27, 29, 30	388 (CN, 431 (CH), 470-480 (C2)	OES dominated by CH/C2
He	4	501, 587.6, 667.8	Clean bright peaks
Ne	20,22	585.2, 640.2, 703.2	Distinctive red/orange lines
H2	1, 2	434 .0 (H), 486 .1 (H), 656.3 (H)	Strong Balmer lines, extremely sensitive
H2O	16, 17, 18	306-308 (309) (OH), 486.1 (H), 656 (H), 777 (O), 844 (O)	No unique water line, fragmentation pattern
N2	14, 18	337.1 , 357.7, 380.5, 389	Bright molecular bands, excellent for leak detection
O2	16, 32	777.4, 844.6	Atomic discharge lines
Ar	40	686.5, 706.7, 738.4, 750.4, 811.5	Very bright, good for calibration
CO	12, 28	483 - 520	May be mixed with N2 lines
CO2	12, 16, 28, 44	288-289 (CO2), 315-350	Weak OE lines
Air mix	14,15,28, 32	308 (OH), 337 (N), 357 (N), 389 (N), 777 (O), 844 (O)	Classic peaks for water and air leak

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