CAS tutorial on RGA
Interpretation of RGA spectra

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CAS on Vacuum for Particle Accelerators

Why are we interested in RGA spectra?

- Identify **which gas species are present** in vacuum systems; for accelerators, 10^{-9} mbar of H_2 are not equivalent to 10^{-9} mbar of oxygen or pump oil vapour.

- **Monitor processes**; for example thin film deposition.

- **Validate manufacturing and surface treatments**; virtual leaks, remaining contaminations, residual cleaning agents…

Content

1. Mass of molecules
2. Spectra of single and simple molecules: fragmentation
3. Mixing different gas molecules
4. Case studies
5. Guidelines for diagnosis.

The periodic table of the elements

In UHV system for accelerators

- Always present
- Frequently detected
- Only in specific applications
- Contaminants

hydrogen 1 H 1.0079																		helium 2 He 4.0026
lithium 3 Li 6.941	beryllium 4 Be 9.0122												boron 5 B 10.811	carbon 6 C 12.011	nitrogen 7 N 14.007	oxygen 8 O 15.999	fluorine 9 F 18.998	neon 10 Ne 20.180
sodium 11 Na 22.990	magnesium 12 Mg 24.305												aluminium 13 Al 26.982	silicon 14 Si 28.086	phosphorus 15 P 30.974	sulfur 16 S 32.065	chlorine 17 Cl 35.453	argon 18 Ar 39.948
potassium 19 K 39.098	calcium 20 Ca 40.078		scandium 21 Sc 44.956	titanium 22 Ti 47.867	vanadium 23 V 50.942	chromium 24 Cr 51.996	manganese 25 Mn 54.938	iron 26 Fe 55.845	cobalt 27 Co 58.933	nickel 28 Ni 58.693	copper 29 Cu 63.546	zinc 30 Zn 65.39	gallium 31 Ga 69.723	germanium 32 Ge 72.61	arsenic 33 As 74.922	selenium 34 Se 78.96	bromine 35 Br 79.904	krypton 36 Kr 83.80
rubidium 37 Rb 85.468	strontium 38 Sr 87.62		yttrium 39 Y 88.906	zirconium 40 Zr 91.224	niobium 41 Nb 92.906	molybdenum 42 Mo 95.94	technetium 43 Tc [98]	ruthenium 44 Ru 101.07	rhodium 45 Rh 102.91	palladium 46 Pd 106.42	silver 47 Ag 107.87	cadmium 48 Cd 112.41	indium 49 In 114.82	tin 50 Sn 118.71	antimony 51 Sb 121.76	tellurium 52 Te 127.60	iodine 53 I 126.90	xenon 54 Xe 131.29
caesium 55 Cs 132.91	barium 56 Ba 137.33	57-70 *	lutetium 71 Lu 174.97	hafnium 72 Hf 178.49	tantalum 73 Ta 180.95	tungsten 74 W 183.84	rhenium 75 Re 186.21	osmium 76 Os 190.23	iridium 77 Ir 192.22	platinum 78 Pt 195.08	gold 79 Au 196.97	mercury 80 Hg 200.59	thallium 81 Tl 204.38	lead 82 Pb 207.2	bismuth 83 Bi 208.98	polonium 84 Po [209]	astatine 85 At [210]	radon 86 Rn [222]
francium 87 Fr [223]	radium 88 Ra [226]	89-102 * *	lawrencium 103 Lr [262]	rutherfordium 104 Rf [261]	dubnium 105 Db [262]	seaborgium 106 Sg [266]	bohrium 107 Bh [264]	hassium 108 Hs [269]	meitnerium 109 Mt [268]	ununnilium 110 Uun [271]	unununium 111 Uuu [272]	ununbium 112 Uub [277]		ununquadium 114 Uuq [289]				

*Lanthanide series	lanthanum 57 La 138.91	cerium 58 Ce 140.12	praseodymium 59 Pr 140.91	neodymium 60 Nd 144.24	promethium 61 Pm [145]	samarium 62 Sm 150.36	europium 63 Eu 151.96	gadolinium 64 Gd 157.25	terbium 65 Tb 158.93	dysprosium 66 Dy 162.50	holmium 67 Ho 164.93	erbium 68 Er 167.26	thulium 69 Tm 168.93	ytterbium 70 Yb 173.04
**Actinide series	actinium 89 Ac [227]	thorium 90 Th 232.04	protactinium 91 Pa 231.04	uranium 92 U 238.03	neptunium 93 Np [237]	plutonium 94 Pu [244]	americium 95 Am [243]	curium 96 Cm [247]	berkelium 97 Bk [247]	californium 98 Cf [251]	einsteinium 99 Es [252]	fermium 100 Fm [257]	mendelevium 101 Md [258]	nobelium 102 No [259]

What is the relative mass of a molecule?

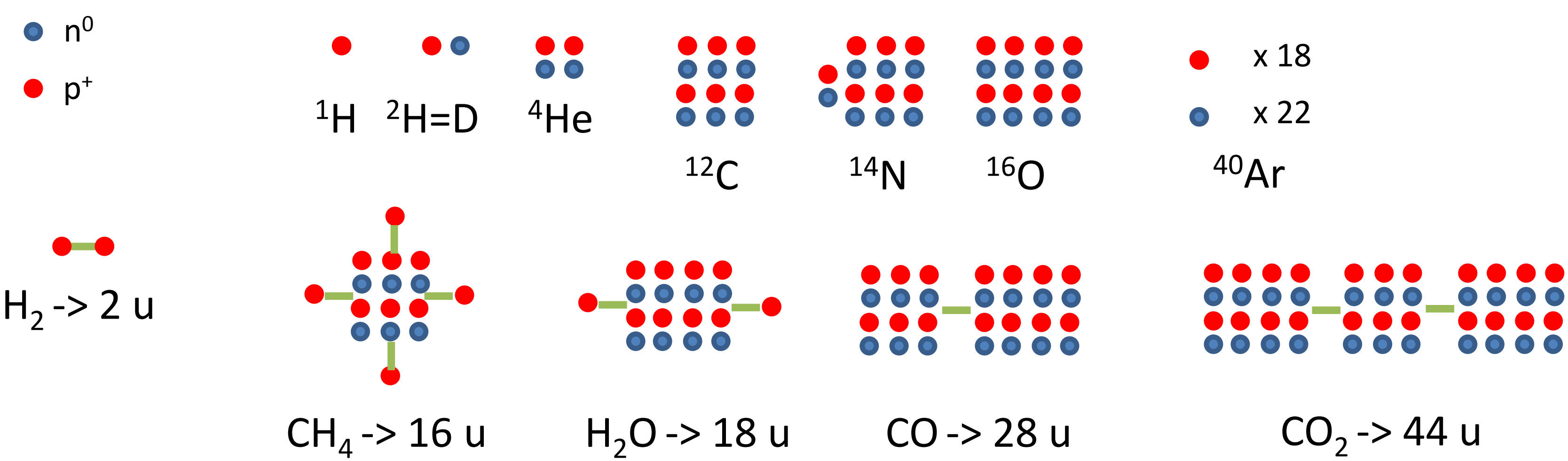
- Relative molecular masses are measured in ‘unified atomic mass units’ (‘u’ or Dalton, Da).

- One atomic mass unit is defined as one twelfth of the rest mass of a carbon-12 atom in its ground state.

$$1\ \text{u} = 1/12\ (^{12}\text{C mass}) = 1.66\ldots \times 10^{-27}\ \text{Kg}$$

- One unit is roughly equal to the mass of 1 proton or 1 neutron

- In first approximation the atomic mass unit of a molecule can be evaluated counting its number of protons and neutrons.



Molecule	Symbol	Rel. mass of main isotope	Z = Number of protons	N = Number of neutrons
Hydrogen	H	**1**	1	
Helium	He	**4**	2	2
Carbon	C	**12**	6	6
Nitrogen	N	**14**	7	7
Oxygen	O	**16**	8	8
Fluorine	F	**19**	9	10
Neon	Ne	**20**	10	10
Chlorine	Cl	**35**	17	18
Sulfur	S	**32**	16	16
Argon	Ar	**40**	18	22
Krypton	Kr	**84**	36	48

Isotopes

Z	N	M	Rel. abundance
1 H	1	1	≈1
	2	2	10^{-4}
2 He	2	4	≈1
	1	3	10^{-4}
6 C	6	12	0.989
	5	13	0.011
7 N	7	14	≈1
	8	15	3.6×10^{-3}
8 O	8	16	0.998
	9	17	3.8×10^{-4}
	10	18	2.05×10^{-3}
10 Ne	10	20	0.905
	11	21	3×10^{-3}
	12	22	0.092

Z	N	M	Rel. abundance
17 Cl	18	35	0.7576
	20	37	0.2424
18 Ar	18	36	0.003336
	20	38	6.3×10^{-4}
	22	40	0.99
36 Kr	42	78	0.0035
	44	80	0.0229
	46	82	0.1159
	47	83	0.1150
	48	84	0.5699
	50	86	0.1728

Interpretation of Mass Spectra

- In general in **UHV**, we have a **limited number of molecules** which are **very light** and easy to identify singularly.

H_2, He, Ne, CH_4, H_2O, F, C_2H_6, CO, C_2H_5-OH, O_2, Ar, C_3H_8, CO_2, Kr …

- However, in the common practise, the gas species of the **residual gas are mixed** and cannot be separated easily and quickly. We do not have a separation equipment in front of the gas analyser as it is the case in analytical chemistry, for example in chromatography.

- The whole set of molecules arrives simultaneously to the quadrupole and the **output signal is the superposition of the single molecule contributions**.

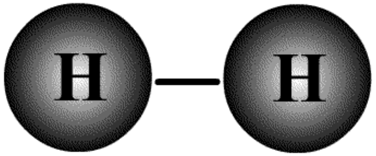
- How can we unbundle the signal and obtain the contribution of each gas in the vacuum system?

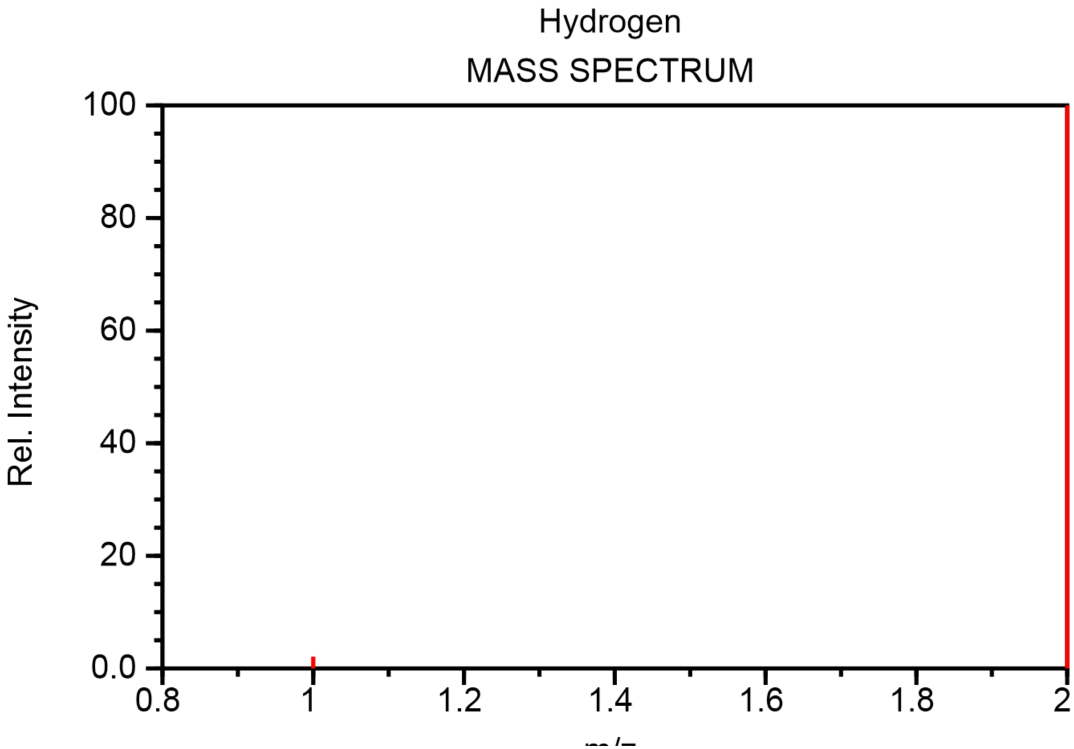
- Thanks to the **fragmentation pattern**…

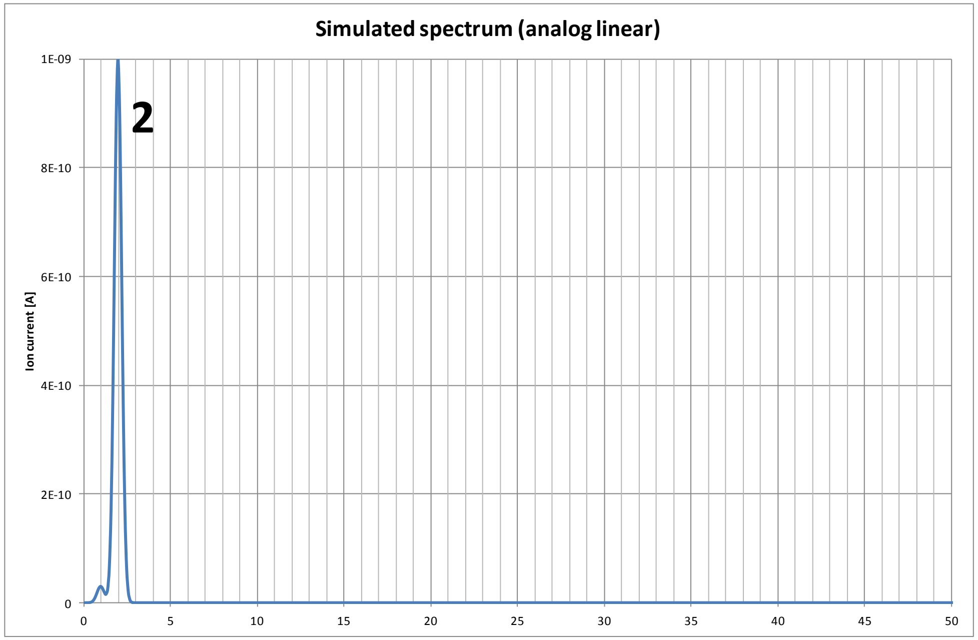
NIST Chemistry WebBook (http://webbook.nist.gov/chemistry)

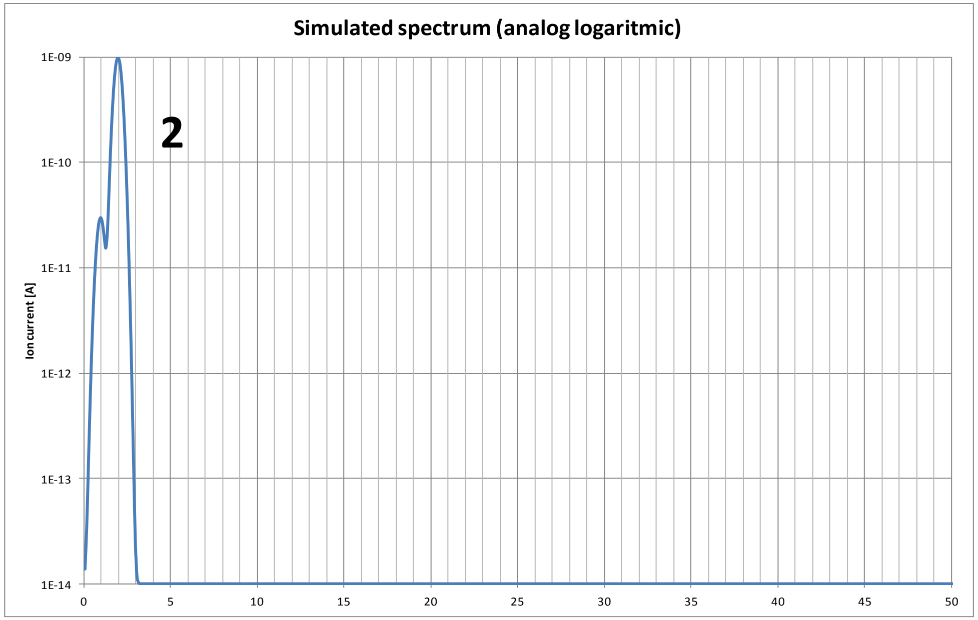
Hydrogen

ions	M	Rel. int.
H_2	2	100
H	1	2.1



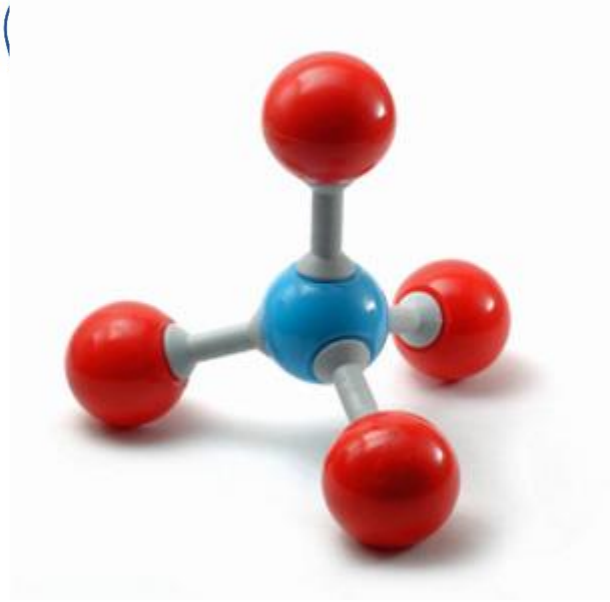



Simulated spectrum (analog linear)
Ion current [A]
1E-09
8E-10
6E-10
4E-10
2E-10
0
0
5
10
15
20
25
30
35
40
45
50
2

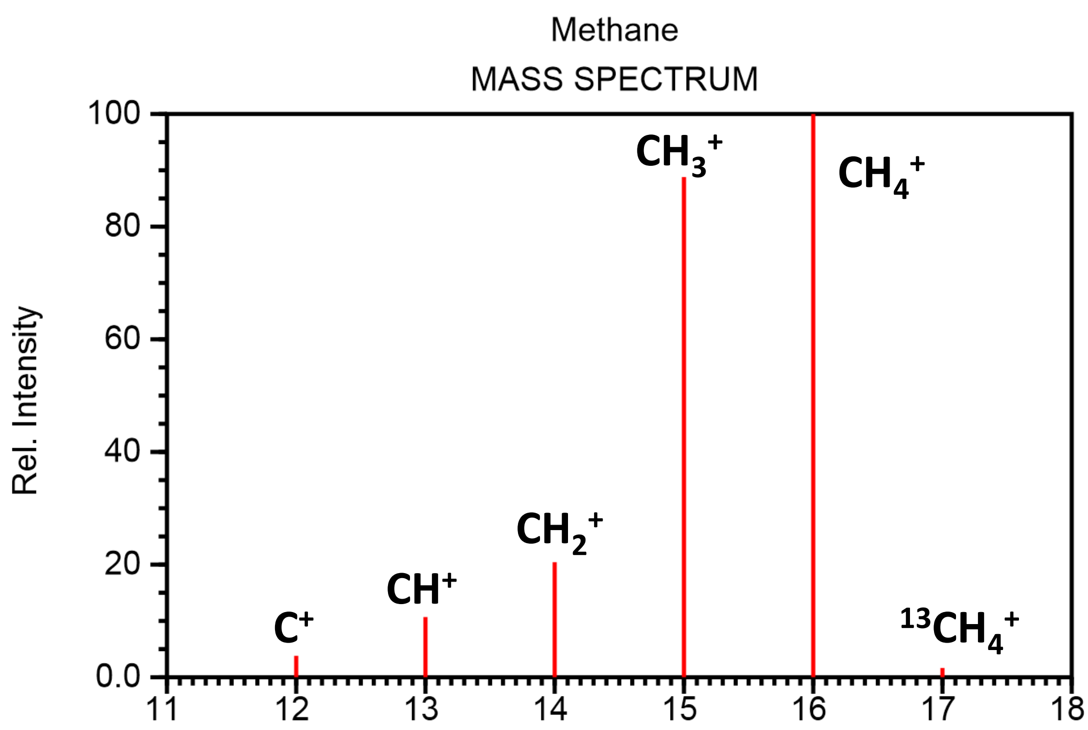

Simulated spectrum (analog logaritmic)
Ion current [A]
1E-09
1E-10
1E-11
1E-12
1E-13
1E-14
0
5
10
15
20
25
30
35
40
45
50
2

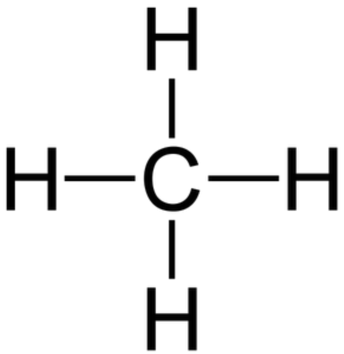
Molecules

Methane



ions	M	Rel. int.
CH_4	16	100
CH_3	15	85
CH_2	14	20.5
CH	13	10.7
C	12	3.8
$^{13}CH_4$	17	1.1





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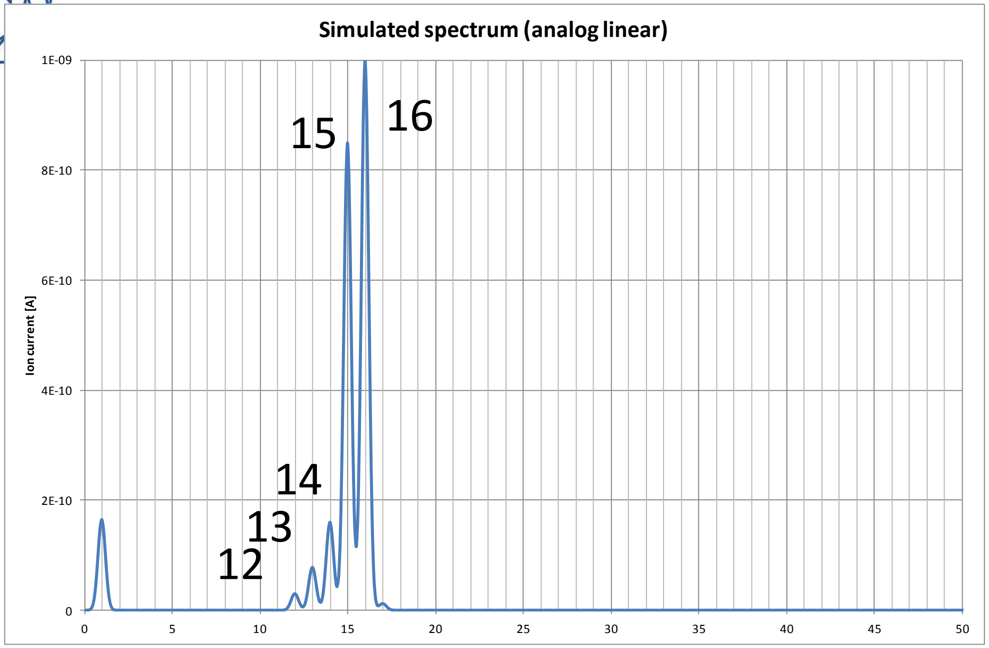
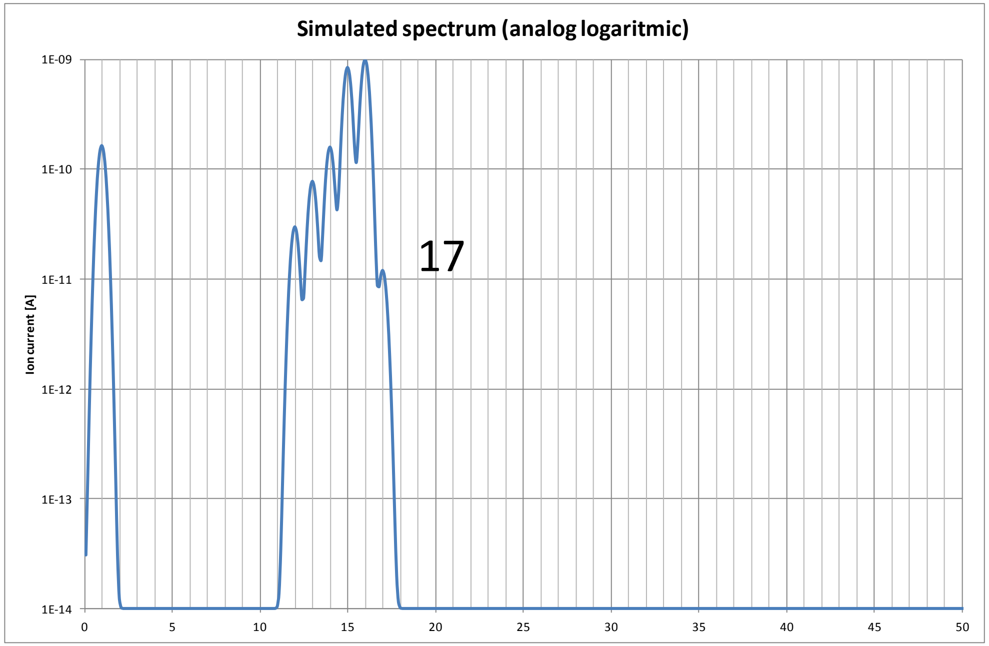
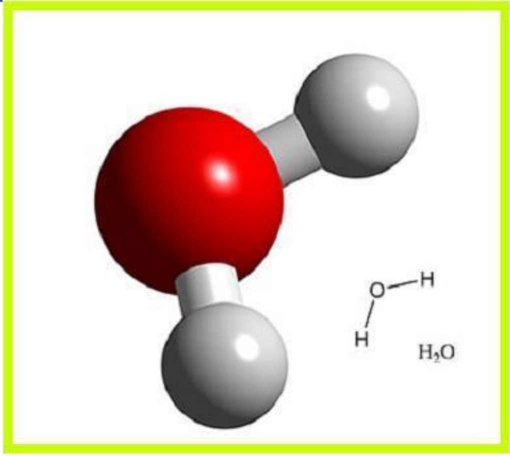




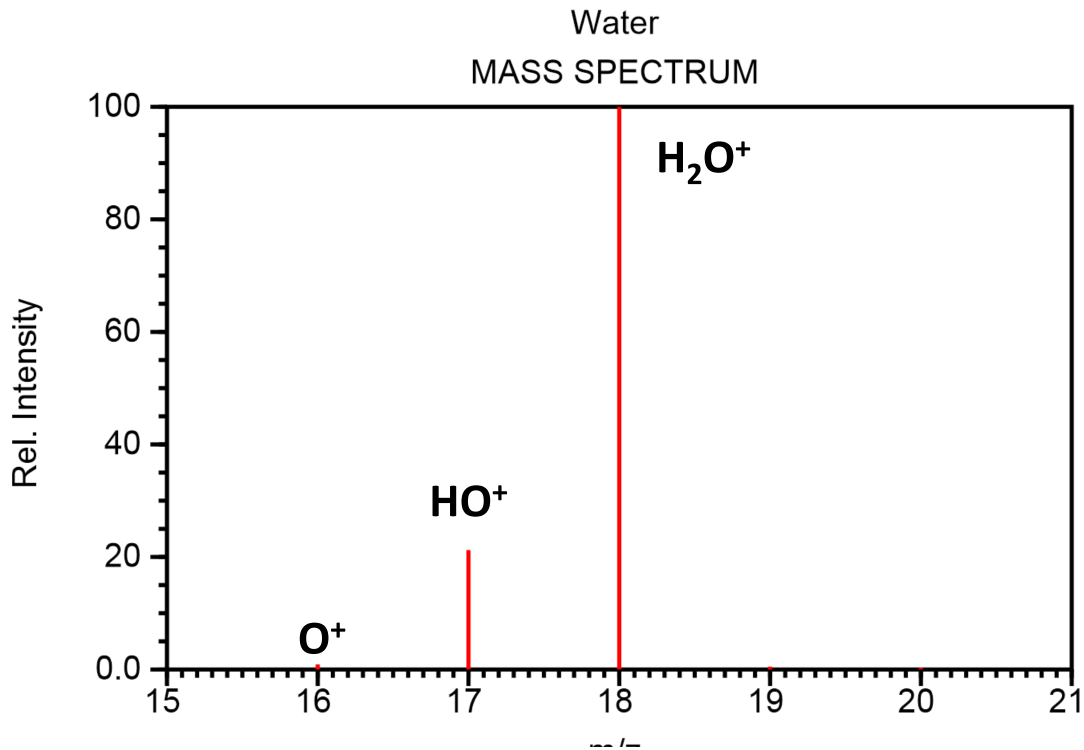
For pure methane:

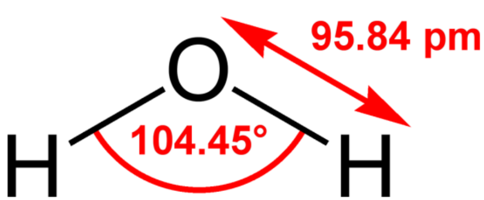
- <15> is very close to <16>
- <14> is lower than <15>
- <12> is lower than <13>

Water



ions	M	Rel. int.
H_2O	18	100
HO	17	21
O	16	1
$H_2{}^{17}O$	19	0.06
$H_2{}^{18}O$	20	0.2





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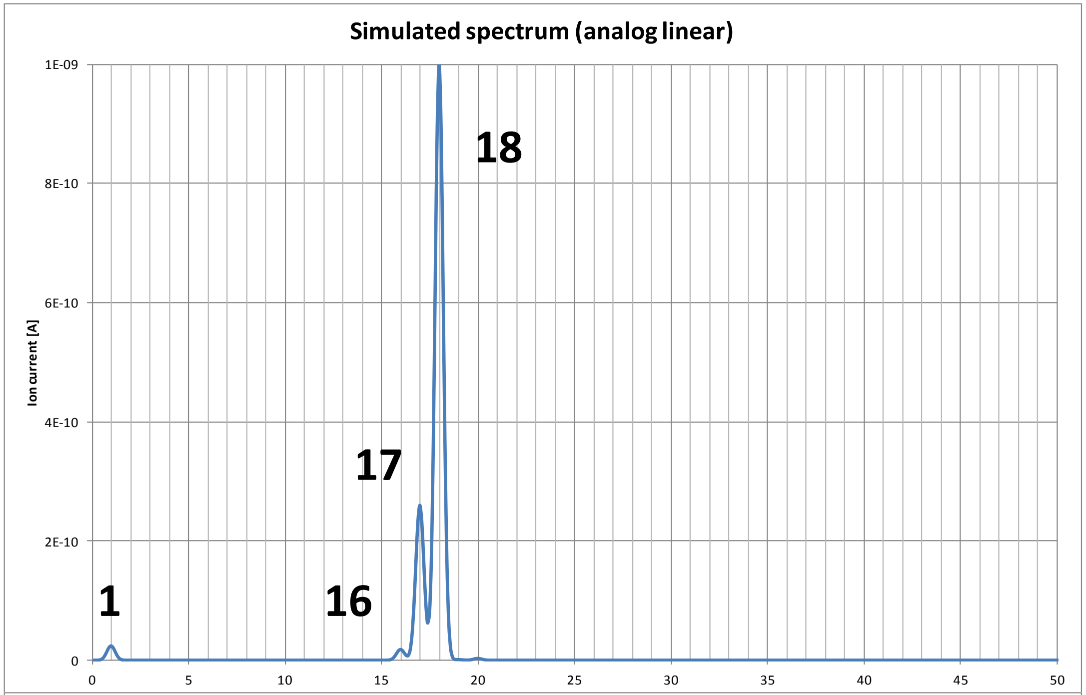
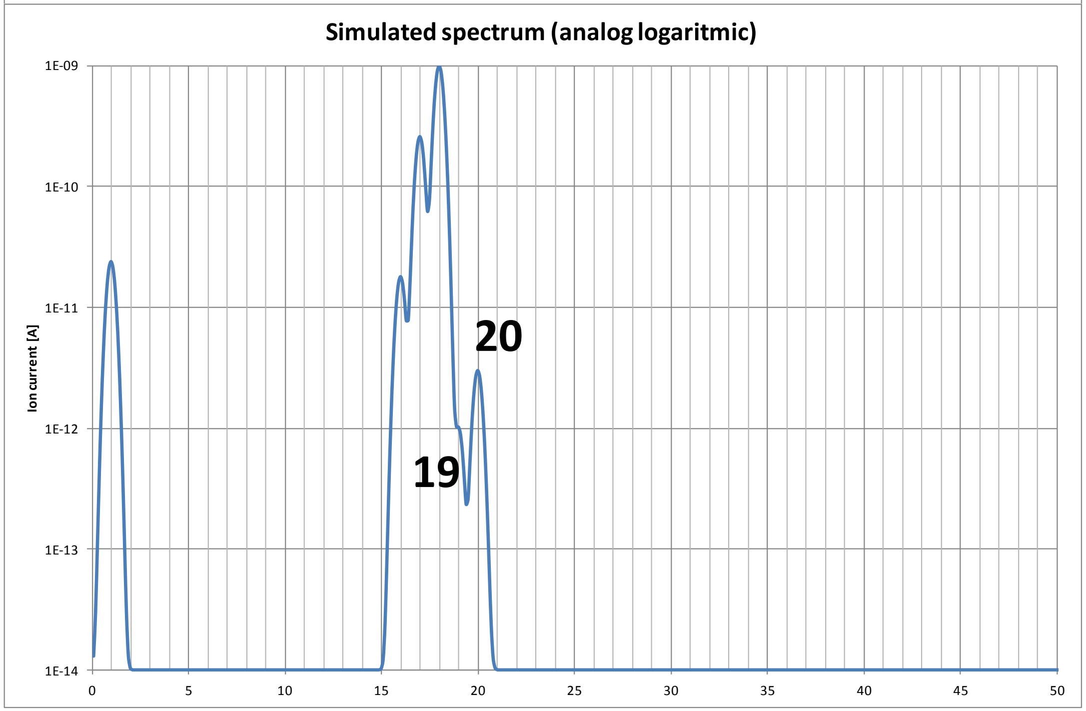
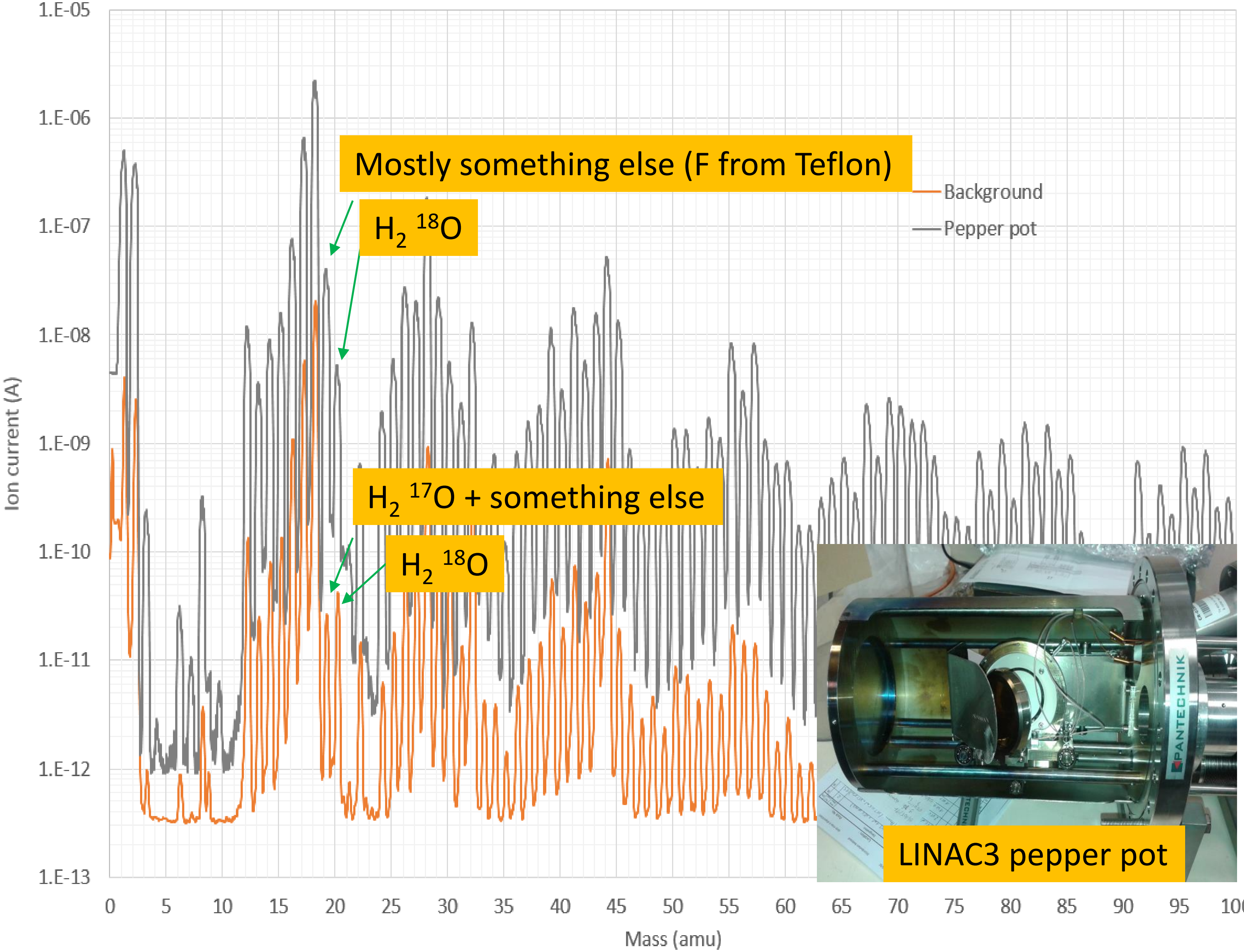




When water peaks are high, <19> and <20> may be detected even w/o F and Ne (or Ar) traces.

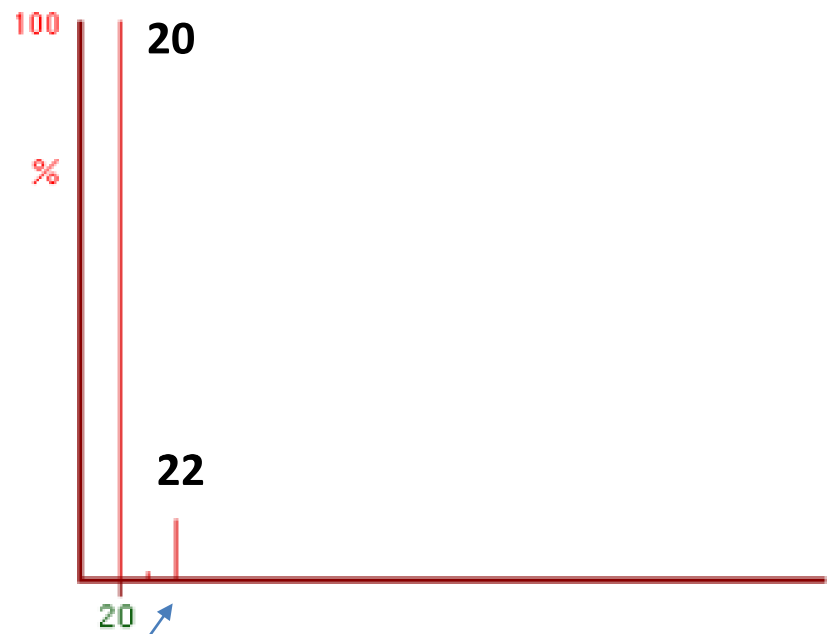


Mostly something else (F from Teflon)
H_2 ^{18}O
H_2 ^{17}O + something else
H_2 ^{18}O
Background
Pepper pot
LINAC3 pepper pot
PANTECHNIK
Ion current (A)
Mass (amu)
1.E-05
1.E-06
1.E-07
1.E-08
1.E-09
1.E-10
1.E-11
1.E-12
1.E-13
0
5
10
15
20
25
30
35
40
45
50
55
60
65
70
75
80
85
90
95
100

‘Molecules’

Neon

ions	M	Rel. int.
^{20}Ne	20	100
^{22}Ne	22	10.2



Useful for leak detection in unbaked systems in high helium background

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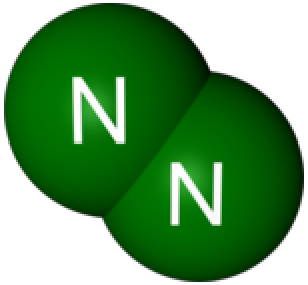
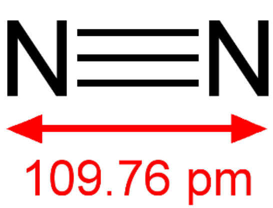
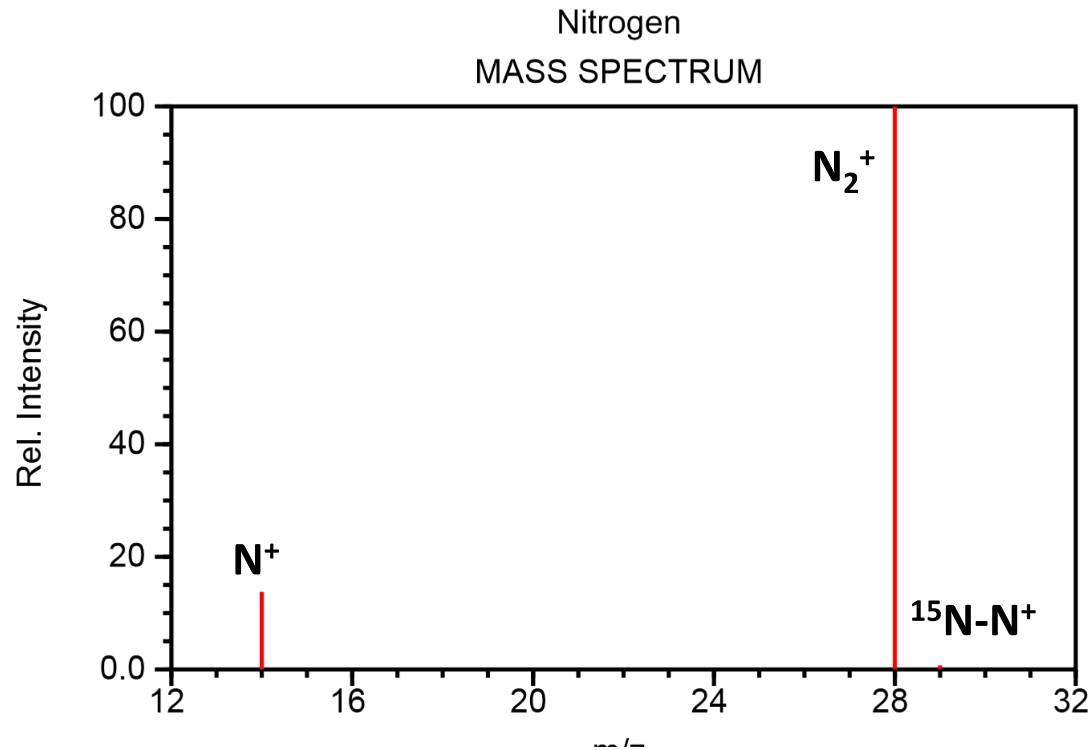
Molecules

Nitrogen



ions	M	Rel. int.
N_2	28	100
N	14	14
^{15}N-^{14}N	29	0.7





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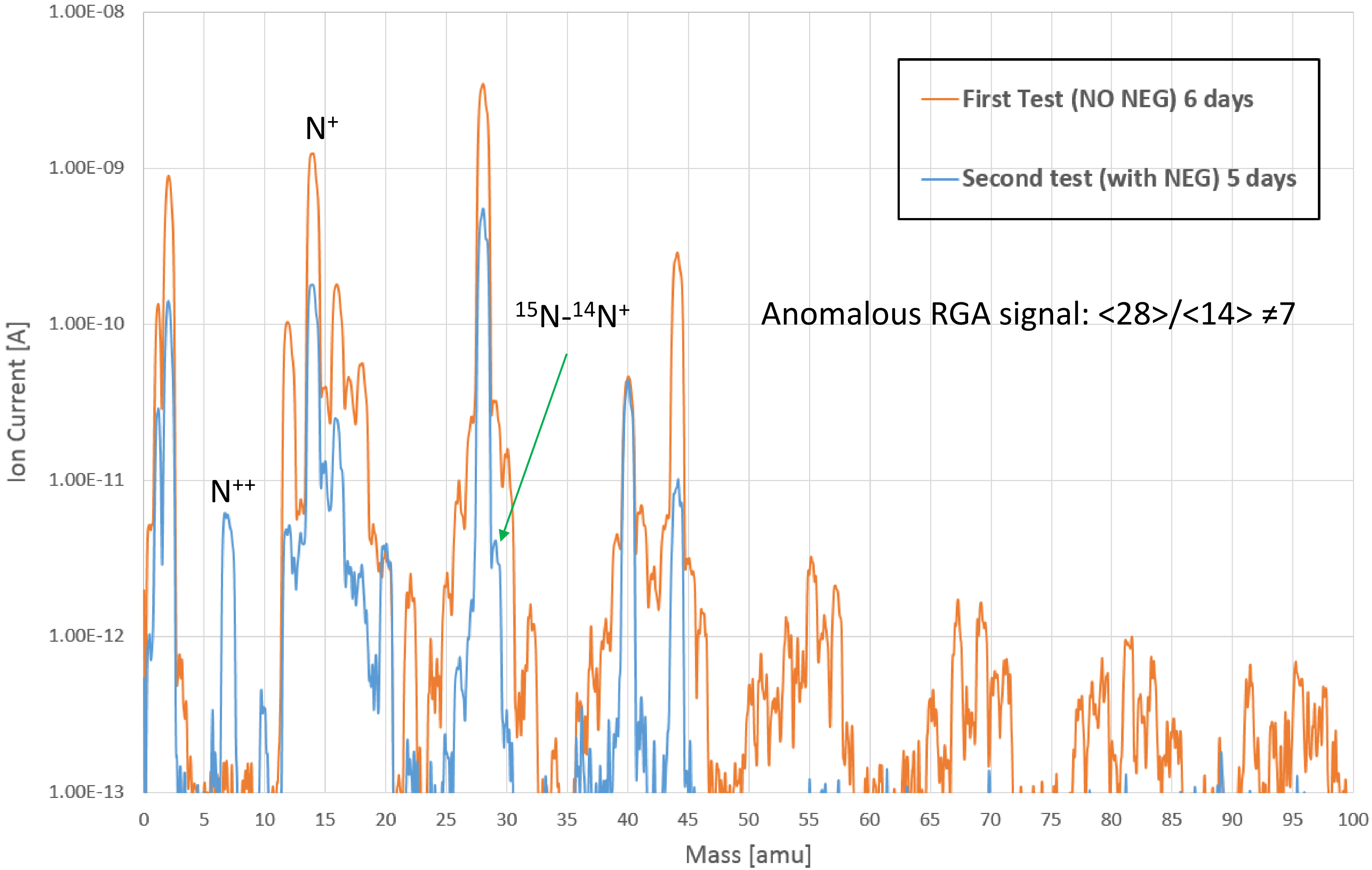
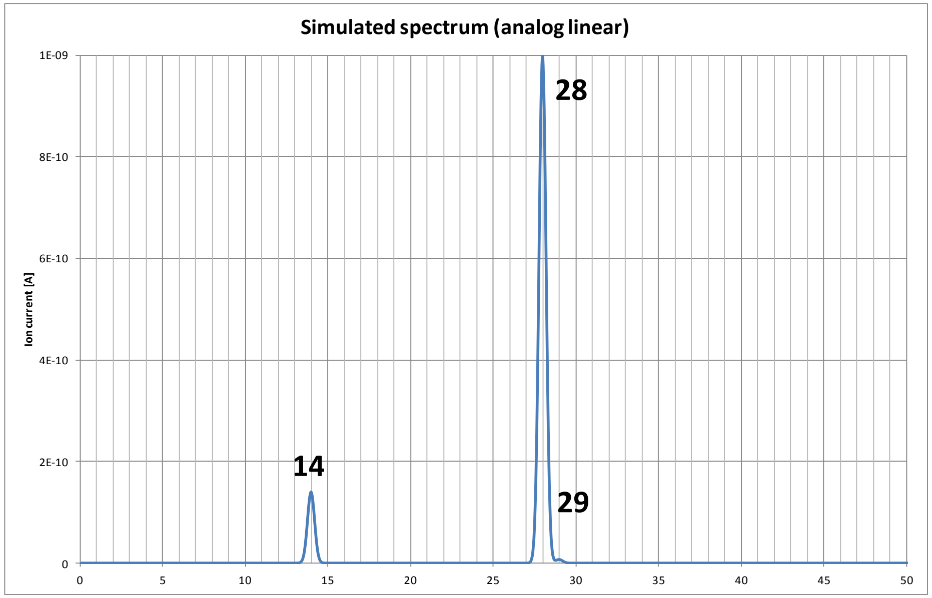
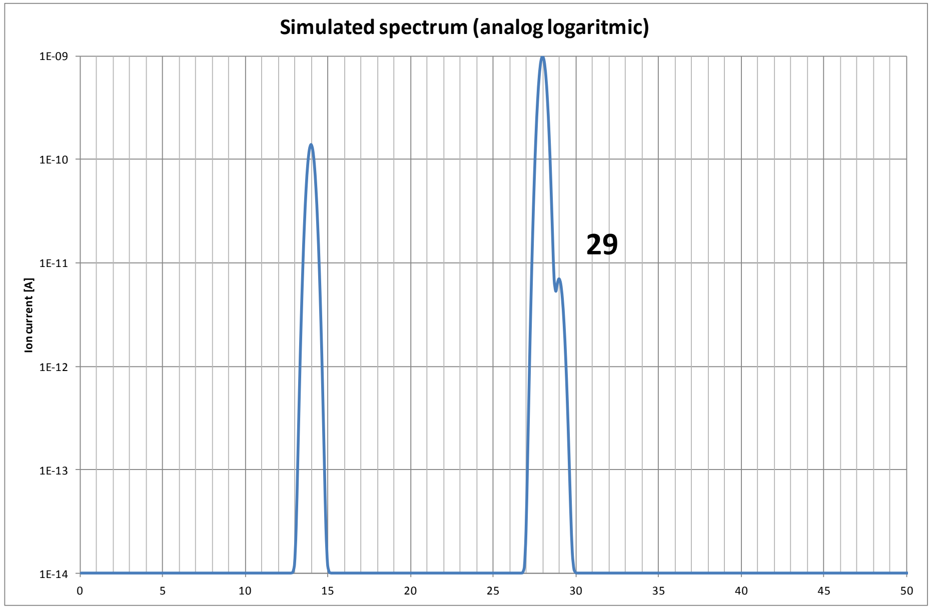
TCSPM prototype collimator

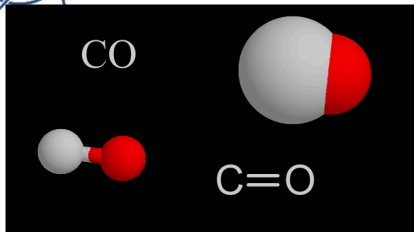


Courtesy of Giuseppe Bregliozzi

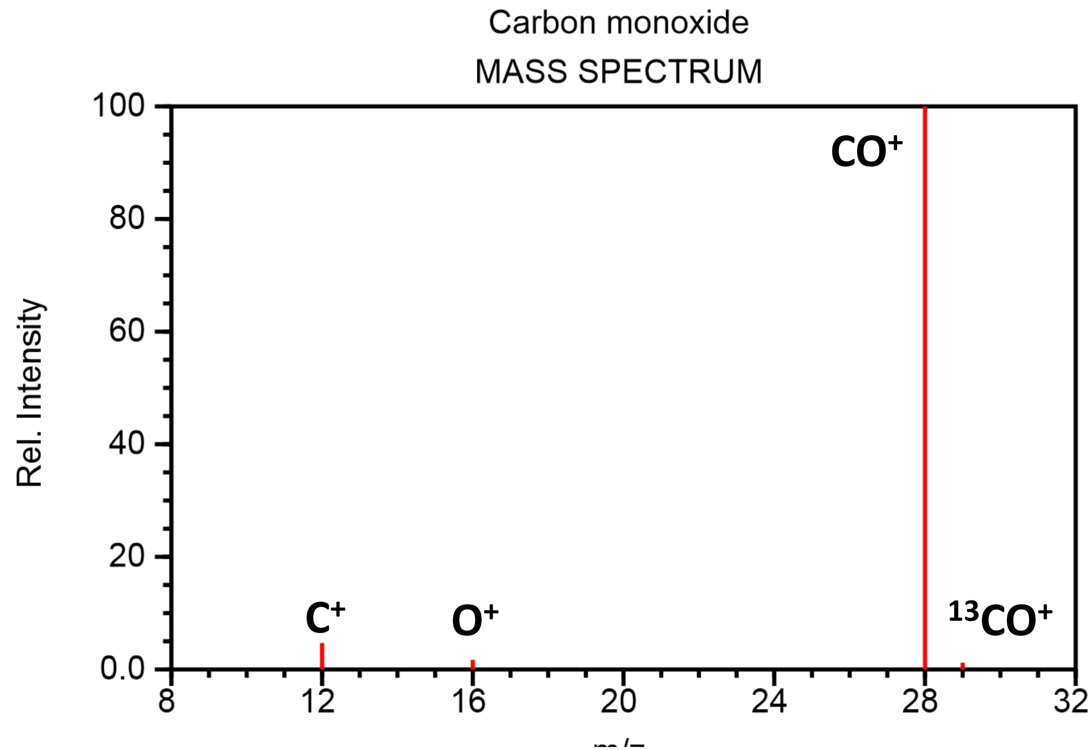

Simulated spectrum (analog linear)
Ion current [A]
1E-09
8E-10
6E-10
4E-10
2E-10
0
0
5
10
15
20
25
30
35
40
45
50
14
28
29


Simulated spectrum (analog logaritmic)
Ion current [A]
1E-09
1E-10
1E-11
1E-12
1E-13
1E-14
0
5
10
15
20
25
30
35
40
45
50
29

Carbon monoxide



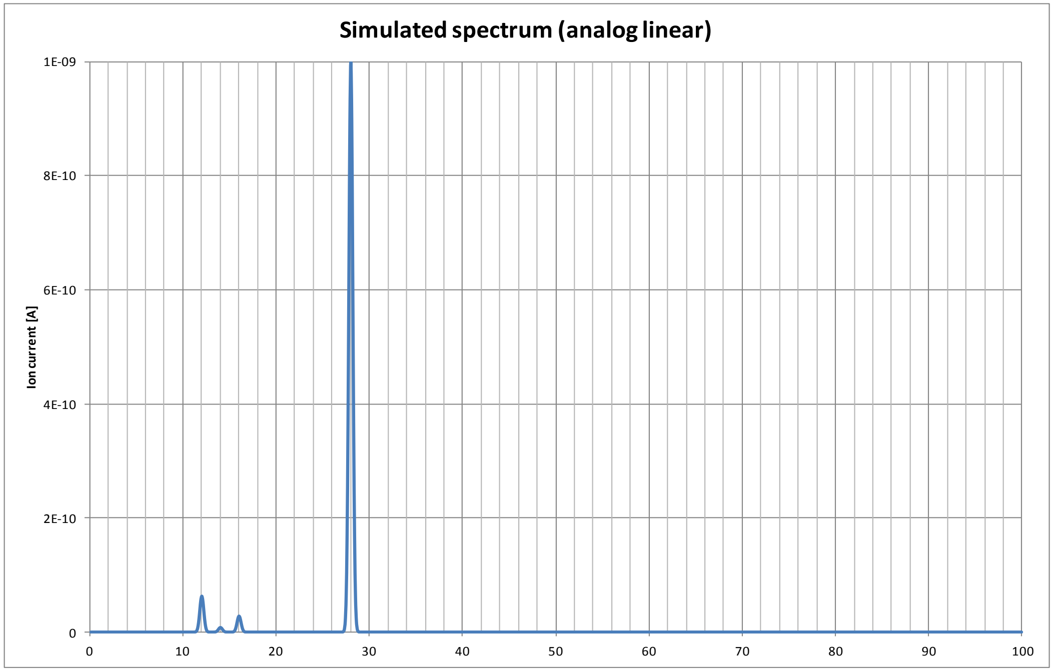
ions	M	Rel. int.
CO	28	100
O	16	1.7
C	12	4.7
^{13}CO	29	1.2

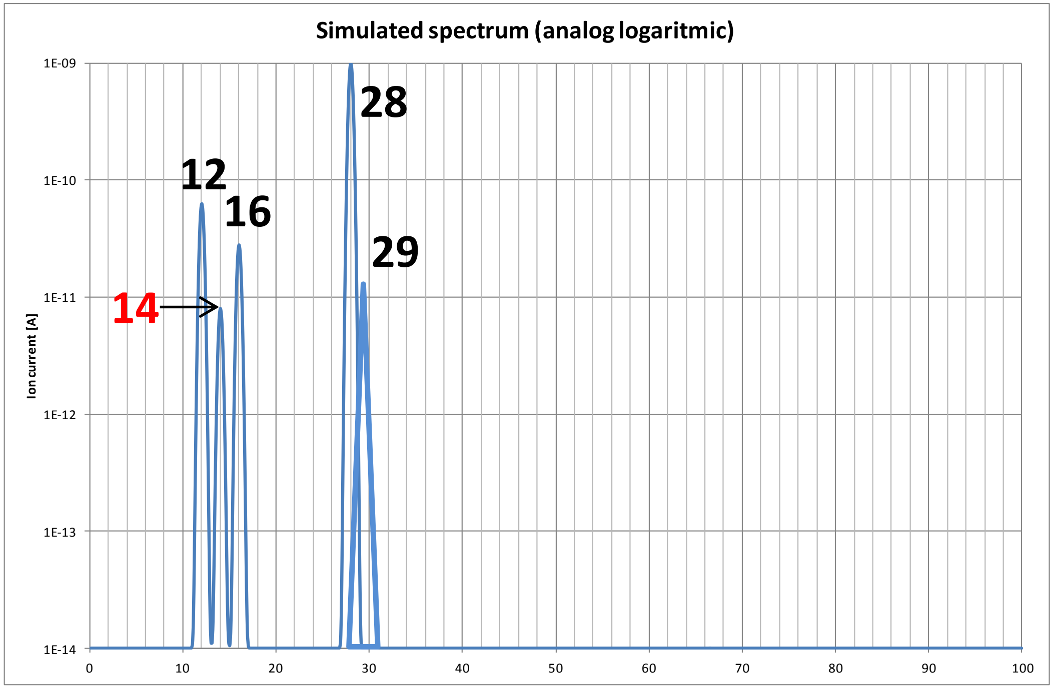


NIST Chemistry WebBook (http://webbook.nist.gov/chemistry)

C — O

The minimum resolution to separate CO^+ from N_2^+ would be 28/0.011 = 2522 ☹





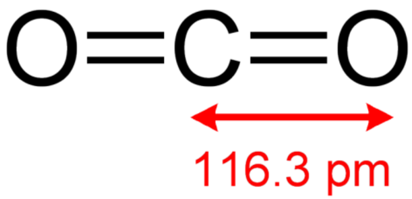
Peak at 14:

CO^{++}

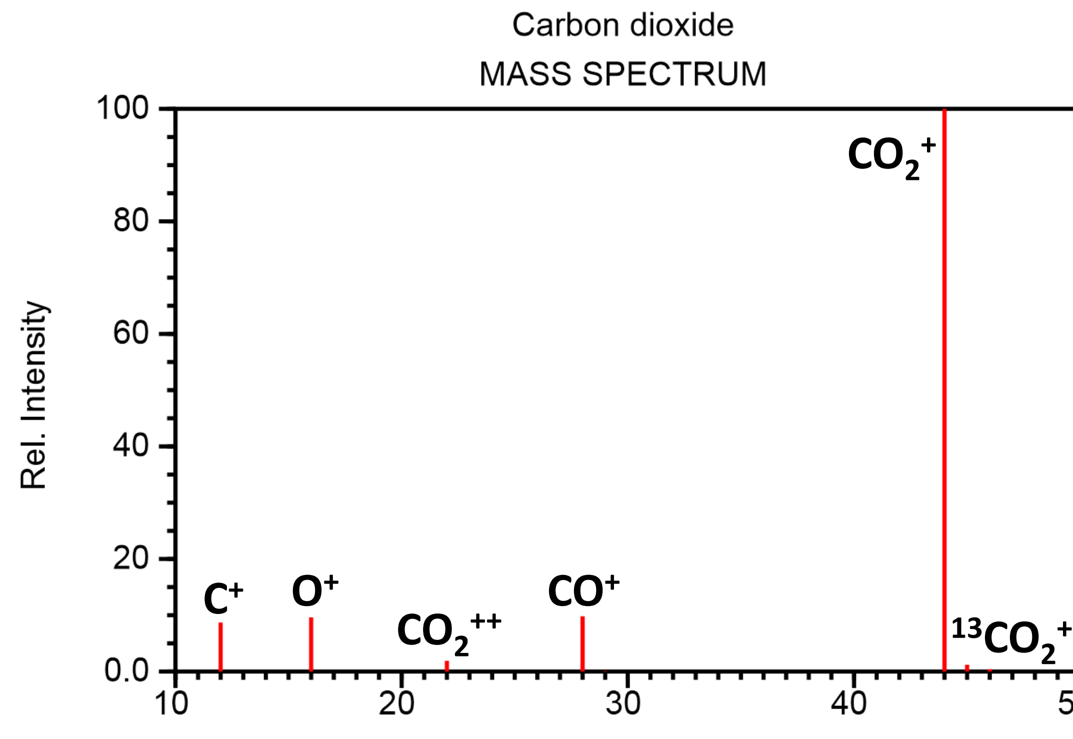
$$I \approx \frac{\langle 28 \rangle}{100}$$

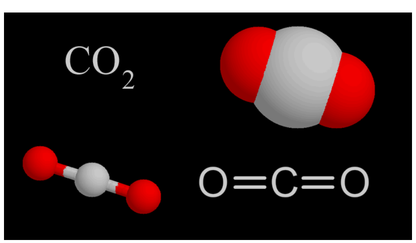
Molecules

Carbon dioxide

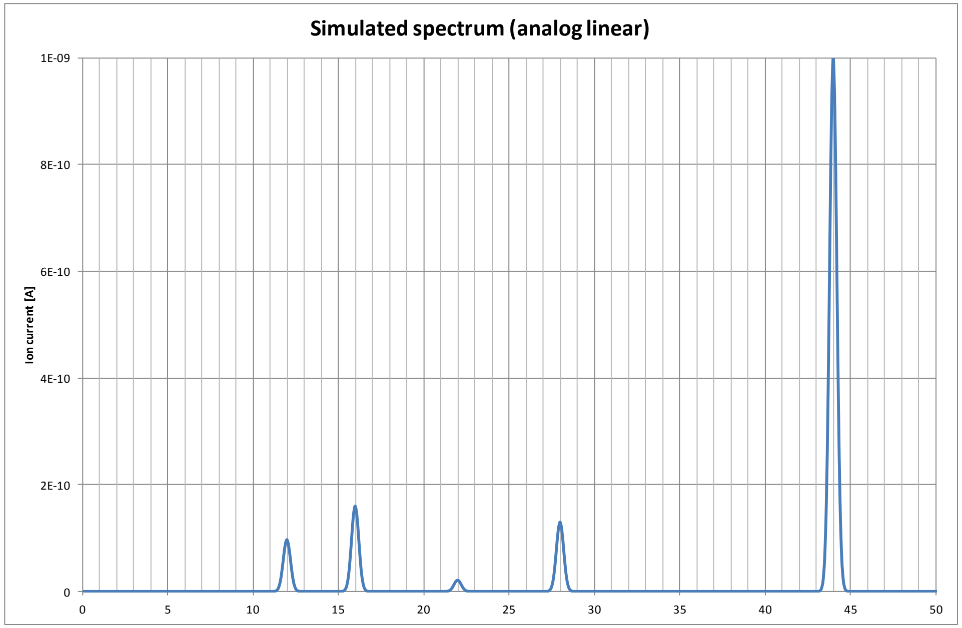


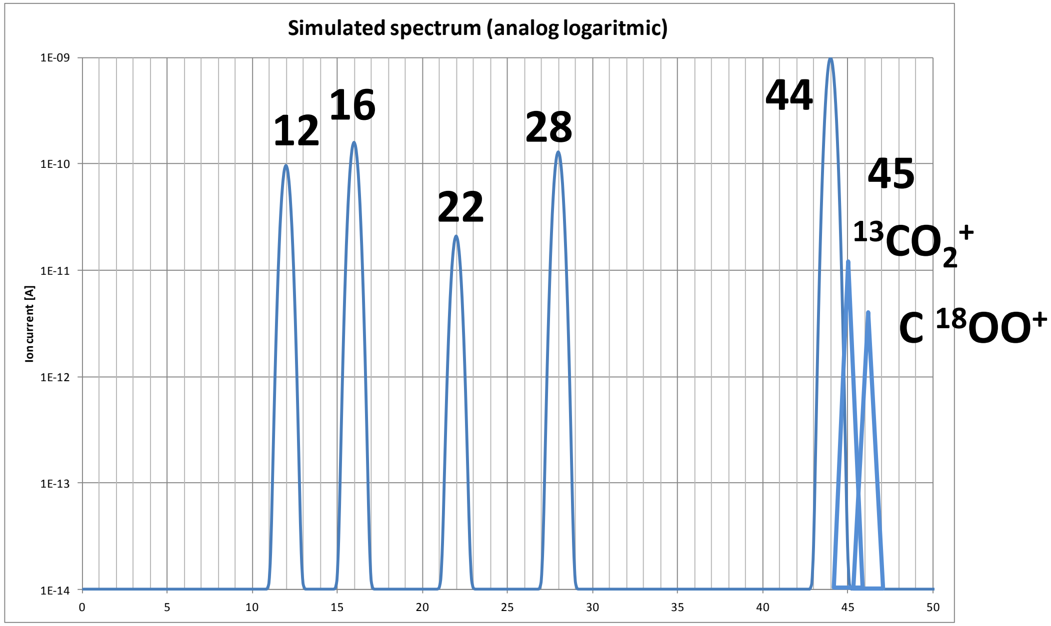
ions	M	Rel. int.
CO_2	44	100
CO	28	10*
O	16	10
C	12	8.7
$^{13}CO_2$	45	1.1
$C^{18}O$-O	46	0.4
CO_2^{++}	**22**	**1.9**



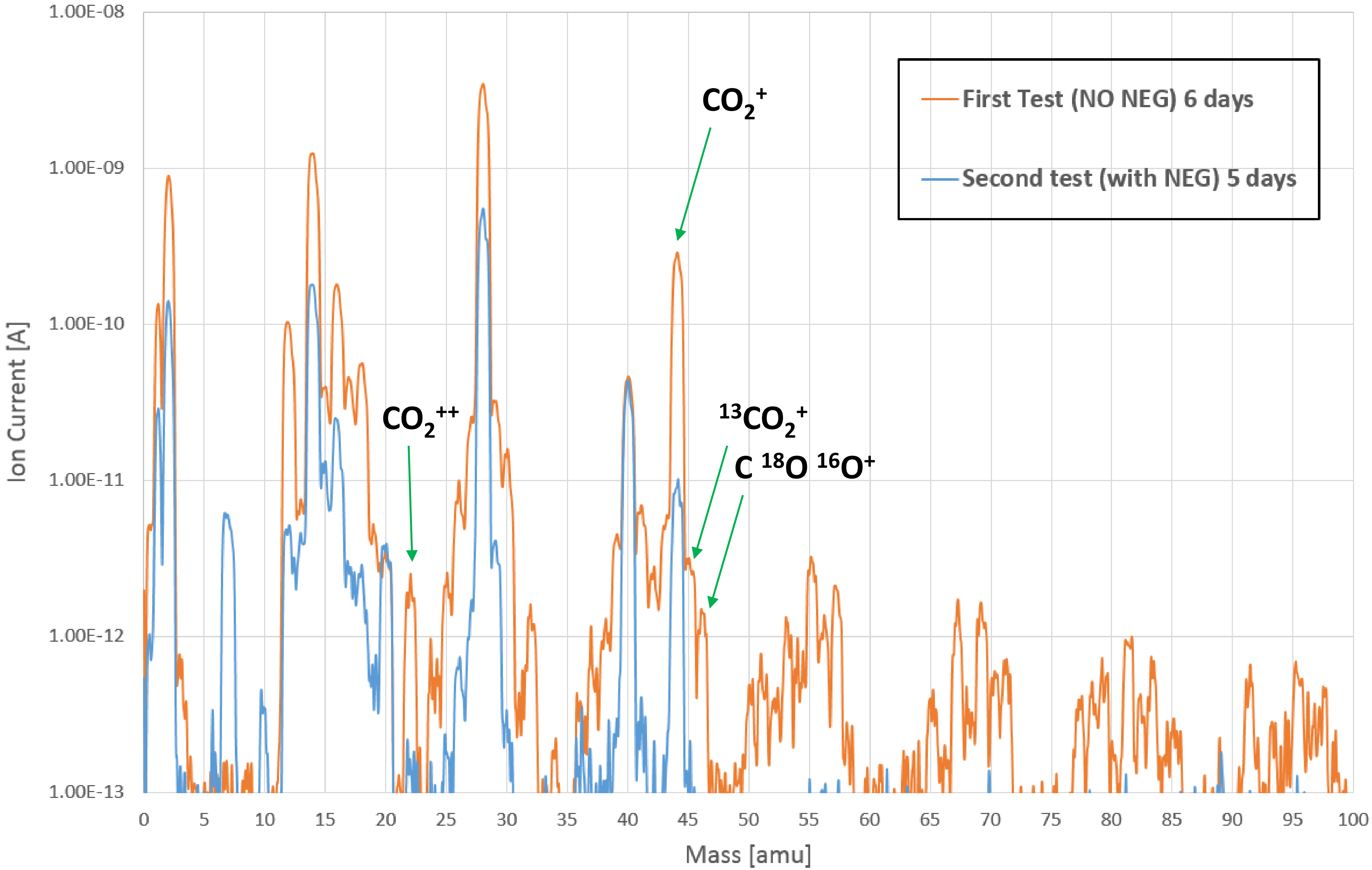


WARNING: (*) strongly system dependent


Simulated spectrum (analog linear)
Ion current [A]
1E-09
8E-10
6E-10
4E-10
2E-10
0
0
5
10
15
20
25
30
35
40
45
50

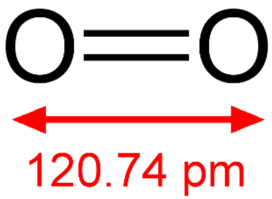

Simulated spectrum (analog logaritmic)
Ion current [A]
1E-09
1E-10
1E-11
1E-12
1E-13
1E-14
0
5
10
15
20
25
30
35
40
45
50
12
16
22
28
44
45
$^{13}CO_2^+$
$C\ ^{18}OO^+$

TCSPM prototype collimator

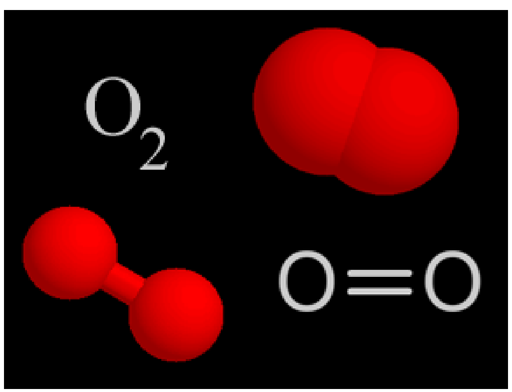


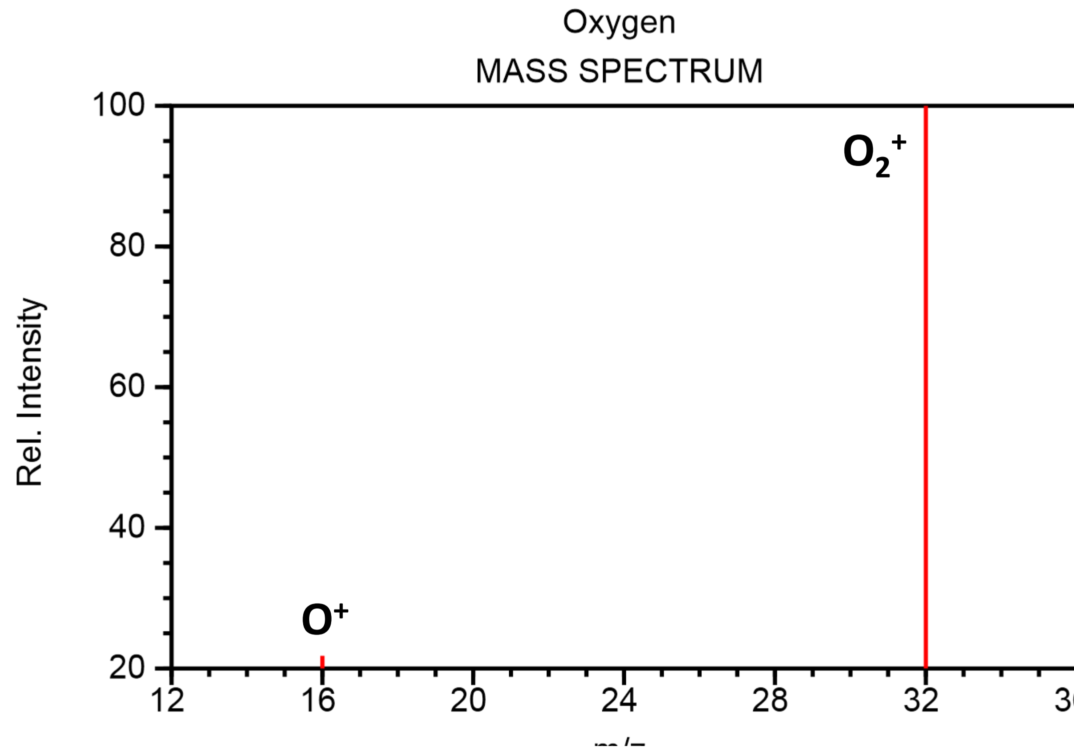
Courtesy of Giuseppe Bregliozzi

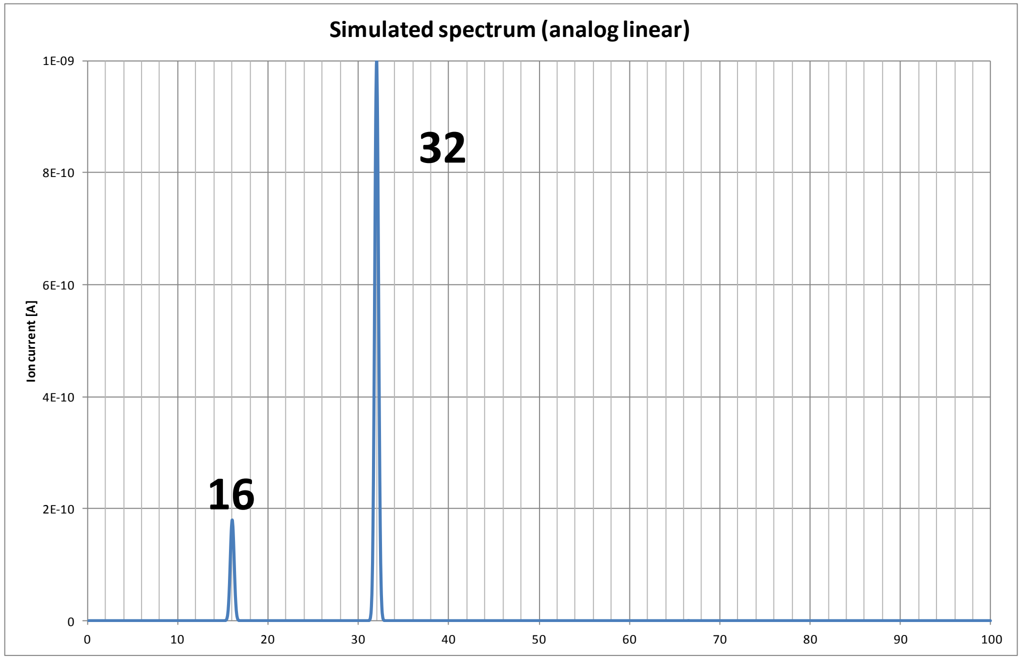
Oxygen

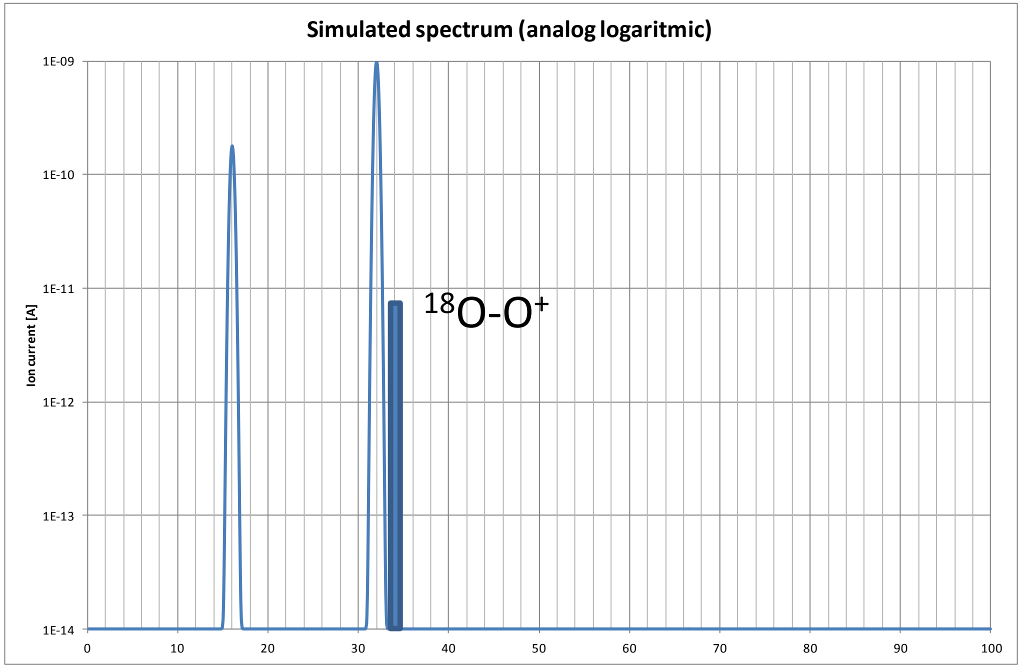


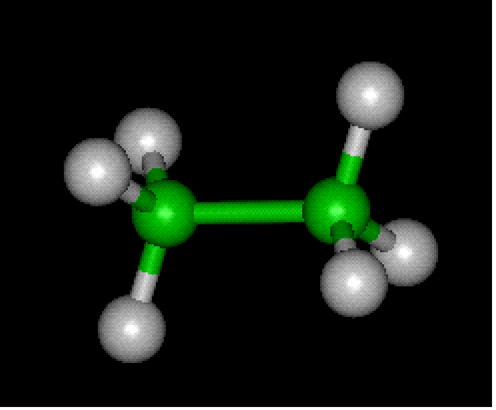
ions	M	Rel. int.
O_2	32	100
O	16	22
^{18}O-O	34	0.7






Simulated spectrum (analog linear)
Ion current [A]
1E-09
8E-10
6E-10
4E-10
2E-10
0
0 10 20 30 40 50 60 70 80 90 100
32
16

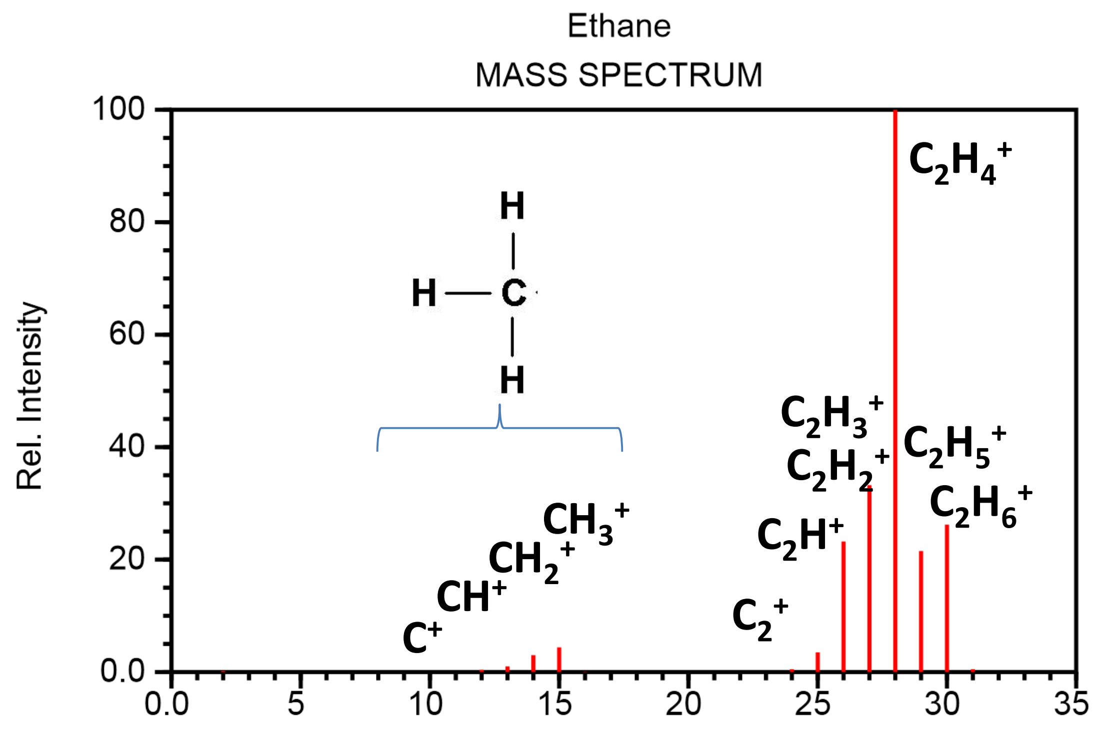

Simulated spectrum (analog logaritmic)
Ion current [A]
1E-09
1E-10
1E-11
1E-12
1E-13
1E-14
0 10 20 30 40 50 60 70 80 90 100
18O-O+

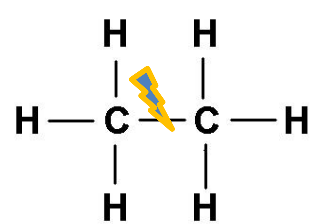


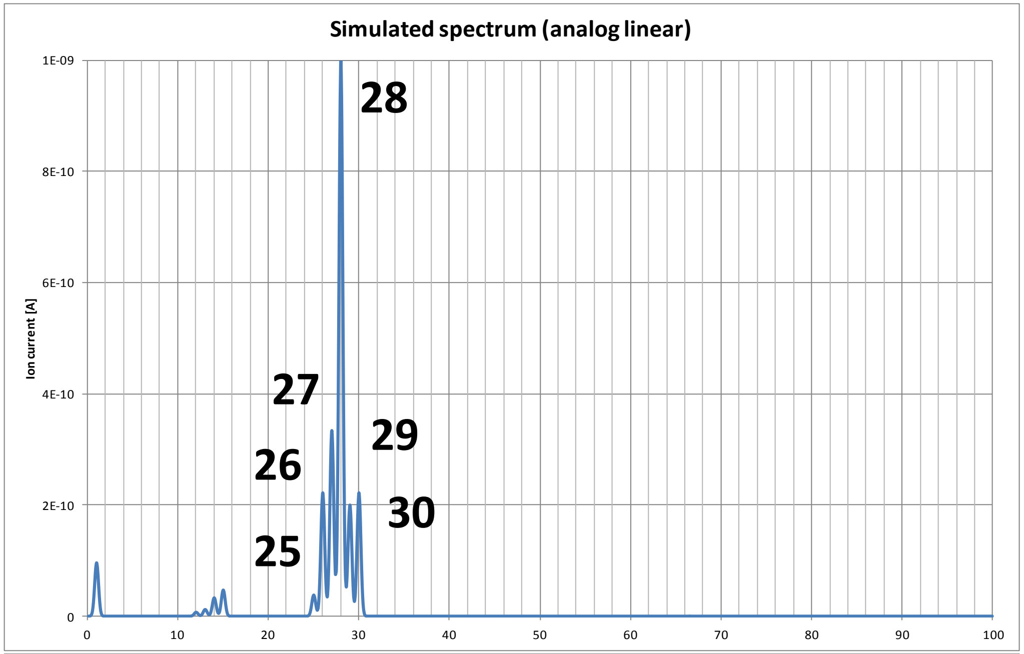
Molecules

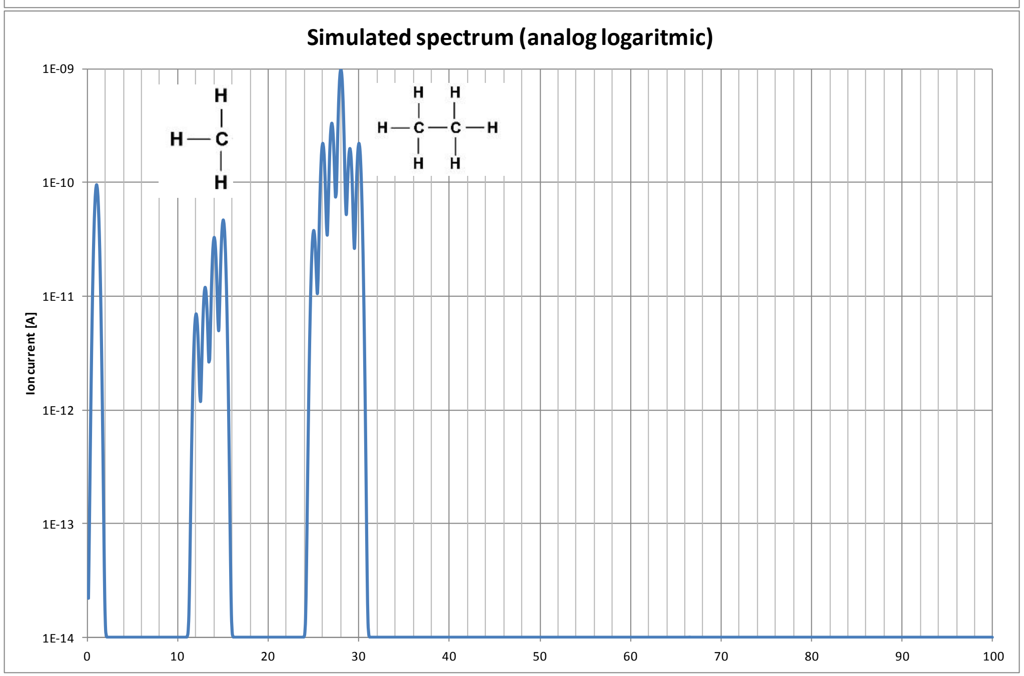
Ethane

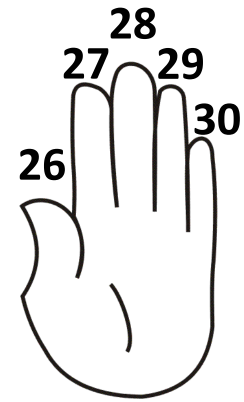
ions	M	Rel. int.
C_2H_6	30	26
C_2H_5	29	22
C_2H_4	28	100
C_2H_3	27	33
C_2H_2	26	23
C_2H	25	3.5
C_2	24	0.5
CH_3	15	4.4
CH_2	14	3
CH	13	1
C	12	0.4
$^{13}C\text{-}CH_6$	31	0.5






Simulated spectrum (analog linear)
Ion current [A]
1E-09
8E-10
6E-10
4E-10
2E-10
0
0 10 20 30 40 50 60 70 80 90 100
28
27
26
25
29
30

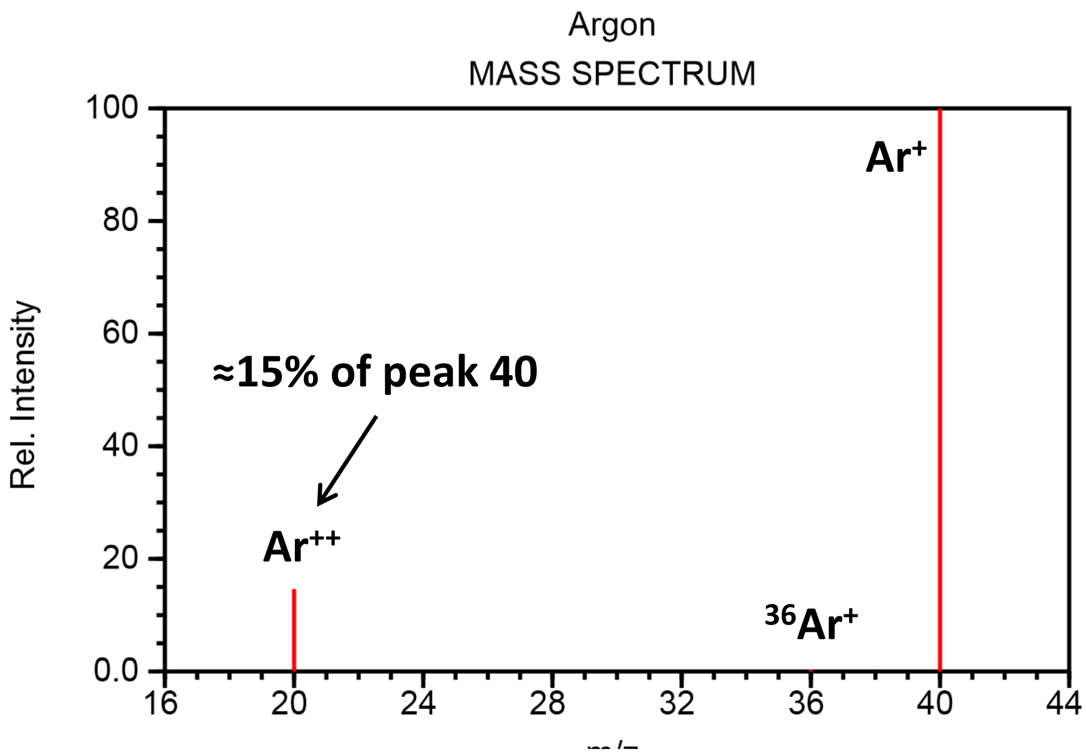

Simulated spectrum (analog logaritmic)
Ion current [A]
1E-09
1E-10
1E-11
1E-12
1E-13
1E-14
0 10 20 30 40 50 60 70 80 90 100
H
H — C
H
H H
H — C — C — H
H H

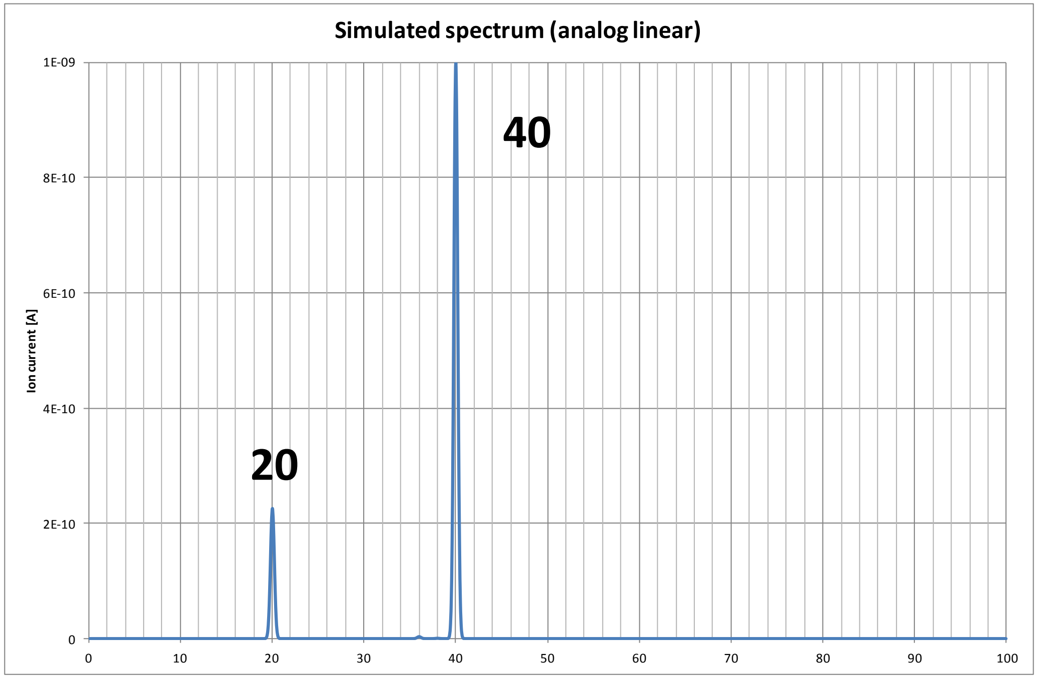

28
27
29
30
26

'Molecules'

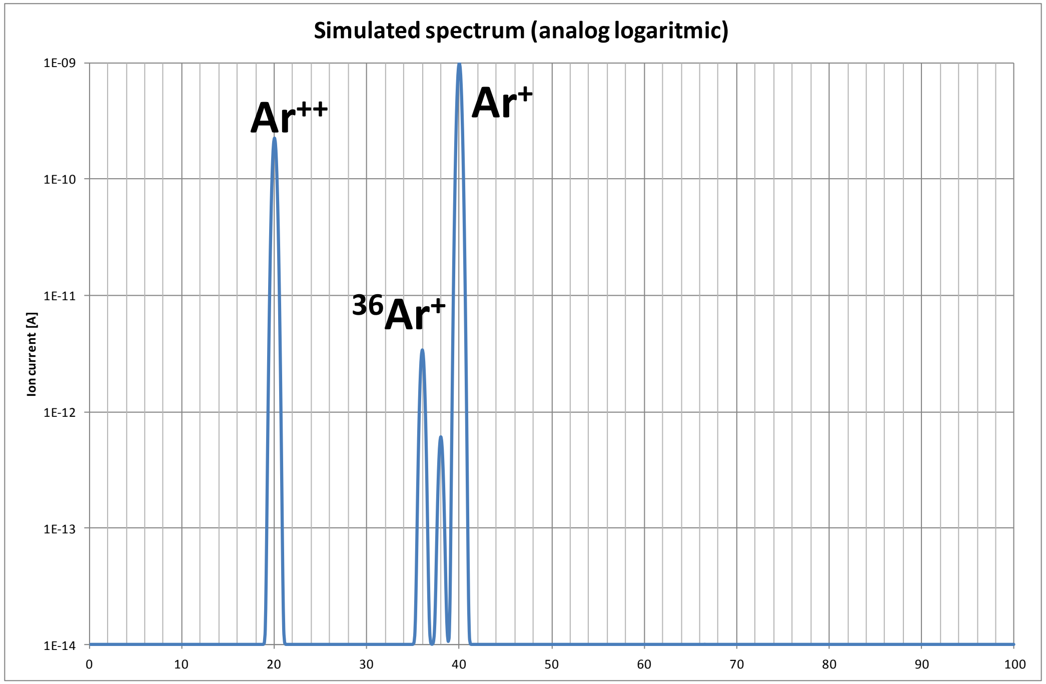
Argon

ions	M	Rel. int.
Ar	40	100
^{36}Ar	36	0.3
^{38}Ar	38	0.05
Ar^{++}	20	14.6





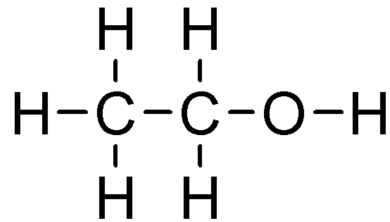
Simulated spectrum (analog linear)
Ion current [A]
1E-09
8E-10
6E-10
4E-10
2E-10
0
20
40
0 10 20 30 40 50 60 70 80 90 100



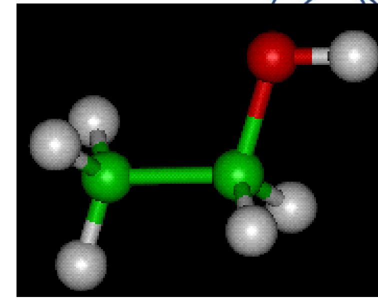
Simulated spectrum (analog logaritmic)
Ion current [A]
1E-09
1E-10
1E-11
1E-12
1E-13
1E-14
Ar++
Ar+
36Ar+
0 10 20 30 40 50 60 70 80 90 100

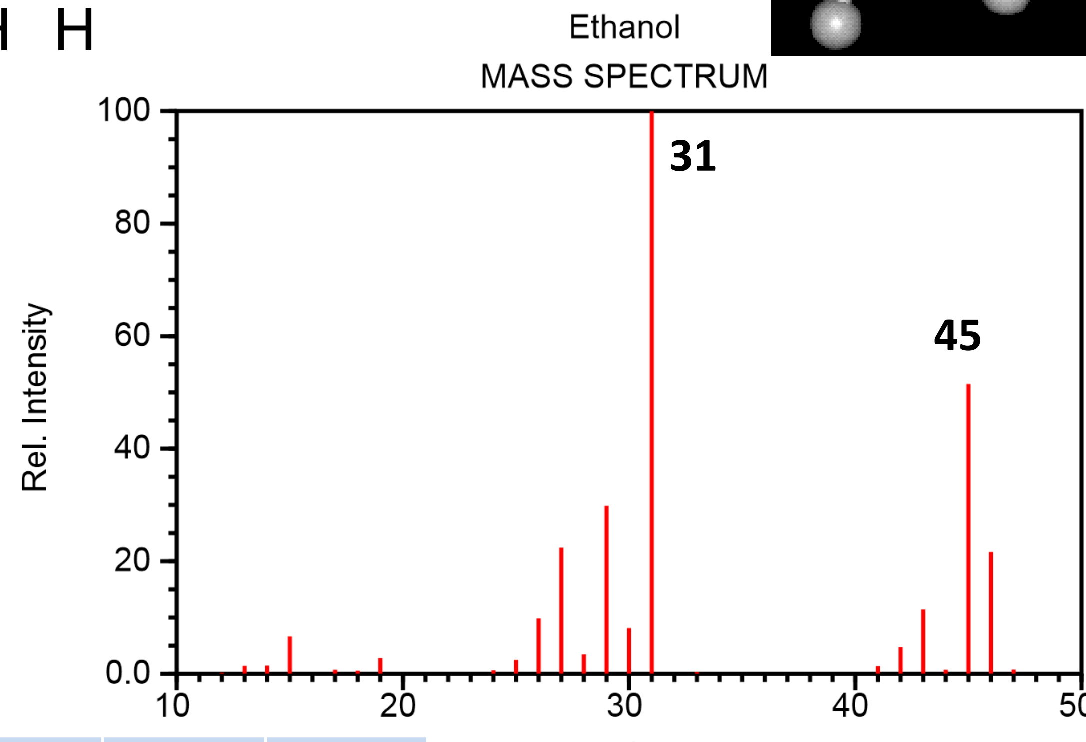
ions	M	Rel. int.
C_2H_5OH	46	21.5
C_2H_4OH	45	51.5
C_2H_3OH	44	0.7
C_2H_2OH	43	11.4
C_2HOH	42	4.7
C_2OH	41	1.3
CH_2OH	31	100
CHOH	30	8
COH, C_2H_5	29	29.7
CO, C_2H_4	28	3.4
C_2H_3	27	22.4
C_2H_2	26	9.8
C_2H	25	2.4
C_2	24	0.6
H_3O	19	2.8
H_2O	18	0.55

Molecules



Ethanol





OH	17	0.7
CH_3	15	6.6
CH_2	14	1.5
CH	13	1.4
C	12	0.2

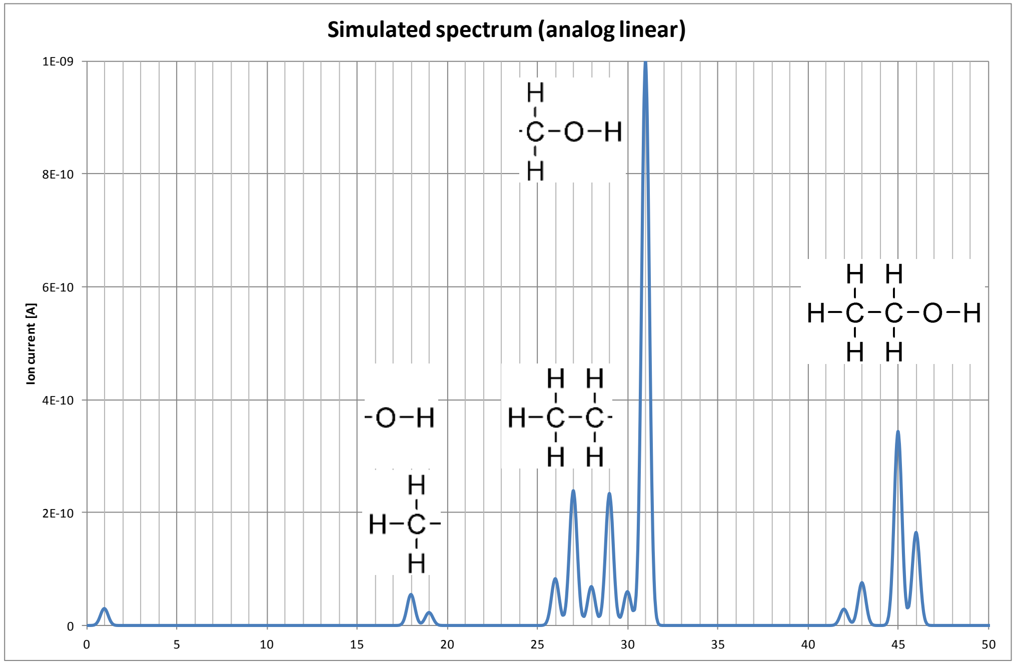
46 M^+ Parent ion

45 M - H

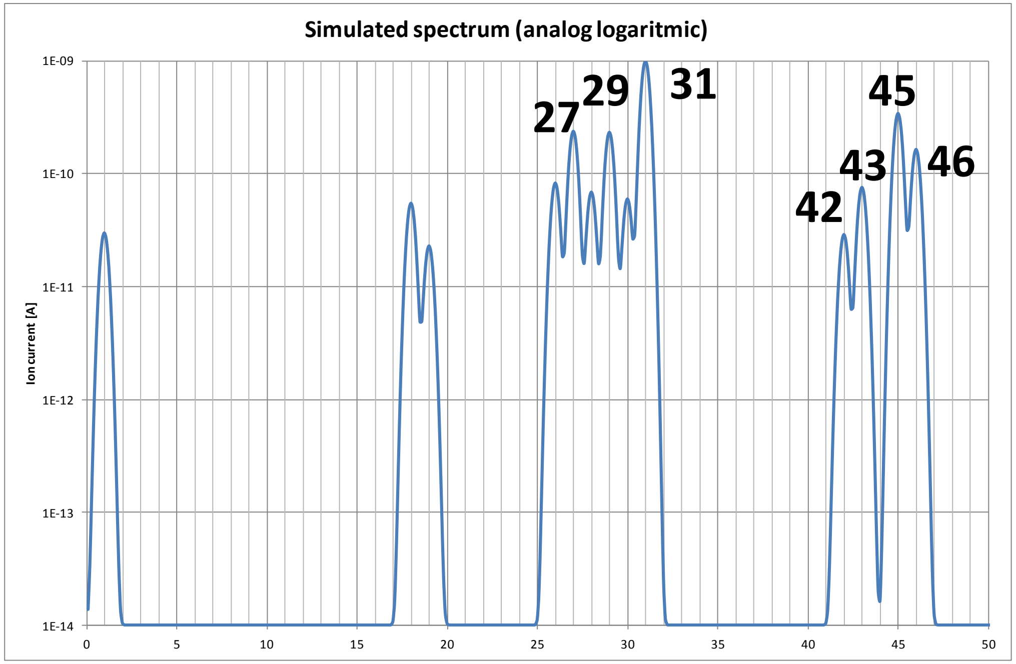
31 M - CH_3, CH_2OH^+

29 M - OH, $CH_3CH_2^+$

28 M - HHO



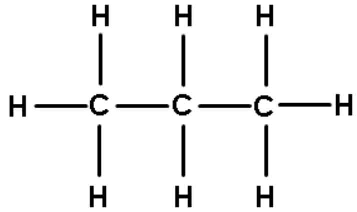
Simulated spectrum (analog linear)
Ion current [A]
1E-09
8E-10
6E-10
4E-10
2E-10
0
0
5
10
15
20
25
30
35
40
45
50



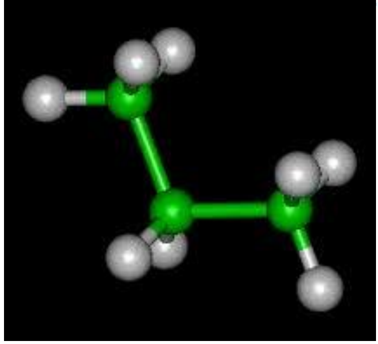
Simulated spectrum (analog logaritmic)
Ion current [A]
1E-09
1E-10
1E-11
1E-12
1E-13
1E-14
27
29
31
42
43
45
46
0
5
10
15
20
25
30
35
40
45
50

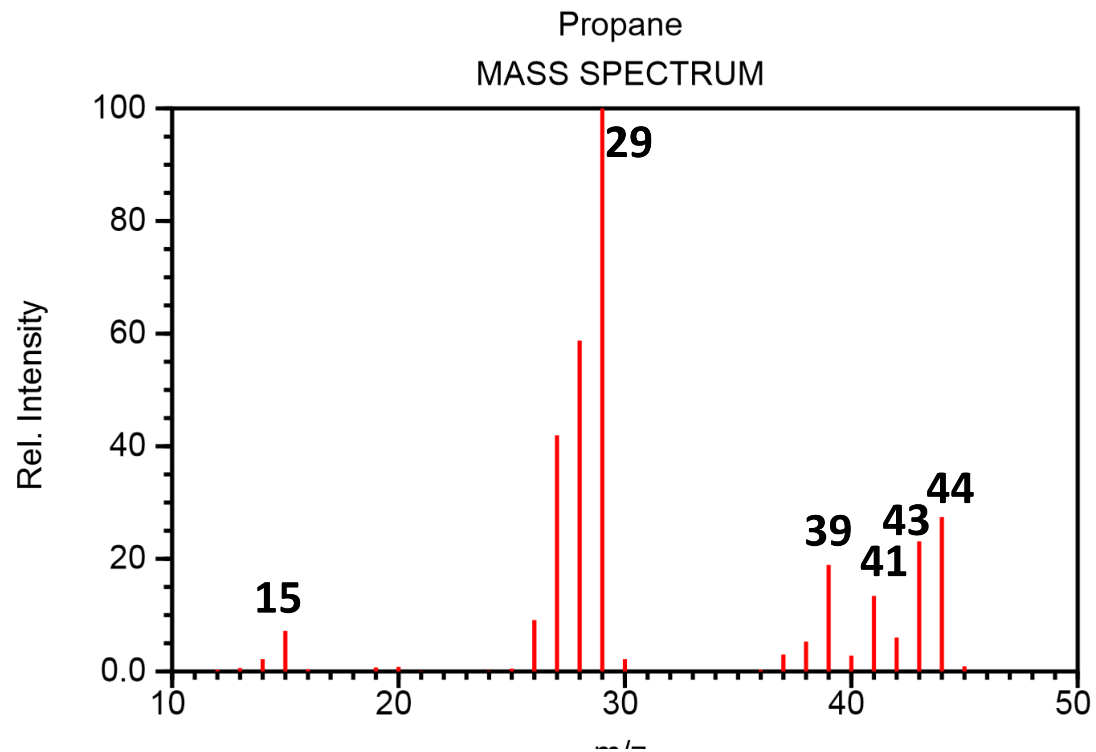
Molecules

ions	M	Rel. int.
$^{13}C\text{-}C_2H_8$	45	0.9
C_3H_8	44	27.5
C_3H_7	43	23
C_3H_6	42	6
C_3H_5	41	13.4
C_3H_4	40	2.8
C_3H_3	39	18.9
C_2H_5	29	100
C_2H_4	28	58.9
C_2H_3	27	42
C_2H_2	26	9
CH_3	15	7.2



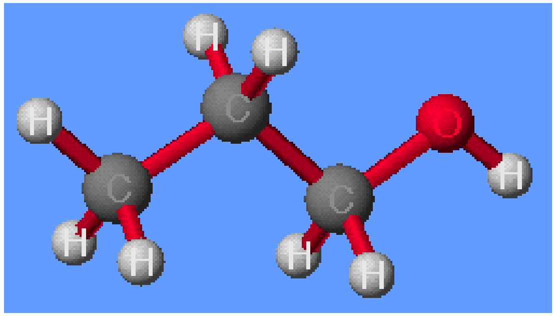
Propane



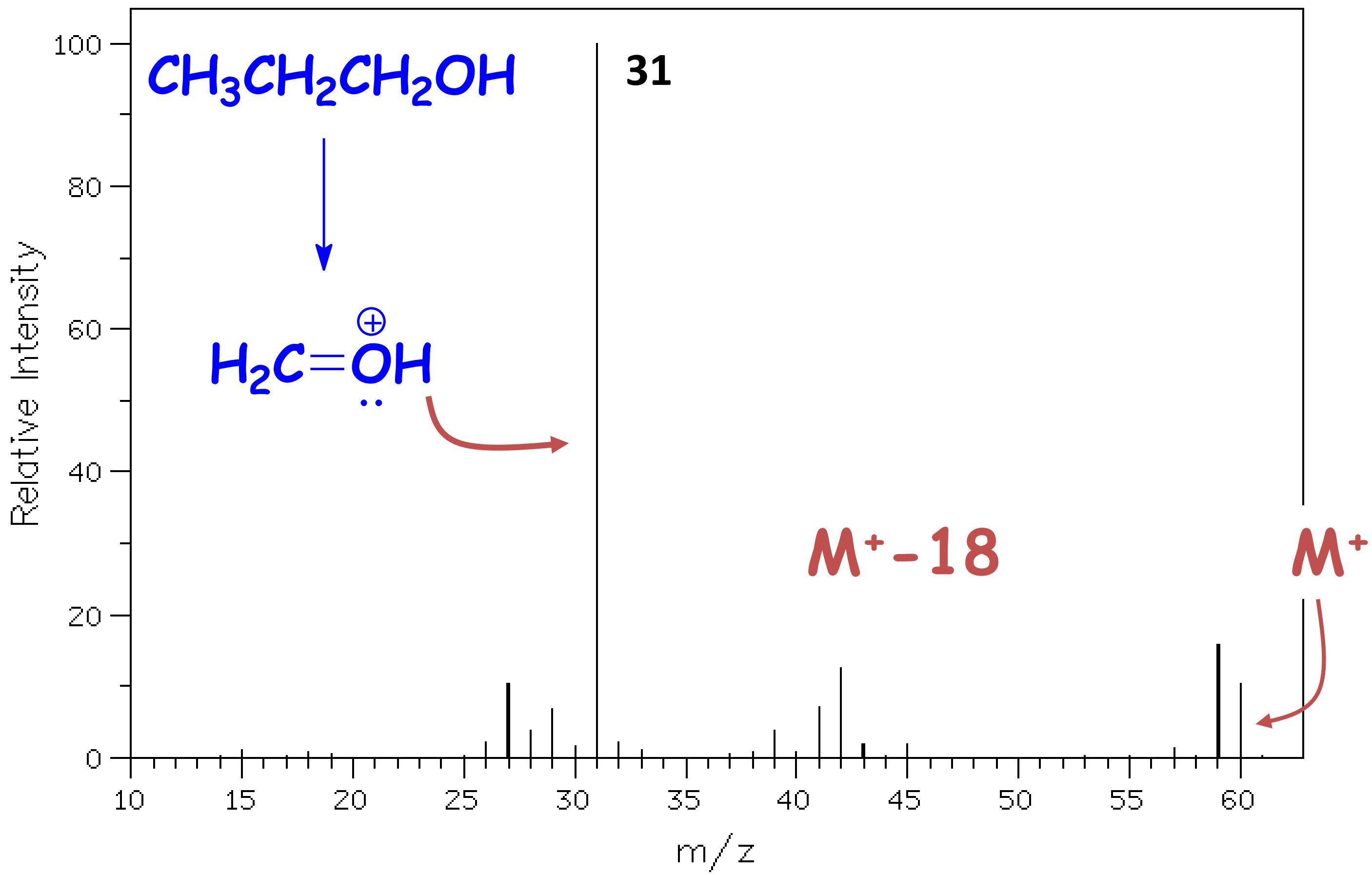


$$\frac{\langle 41\rangle}{\langle 40\rangle} = 4.8 \quad \frac{\langle 39\rangle}{\langle 40\rangle} = 6.7 \quad \frac{\langle 39\rangle}{\langle 41\rangle} = 1.6$$

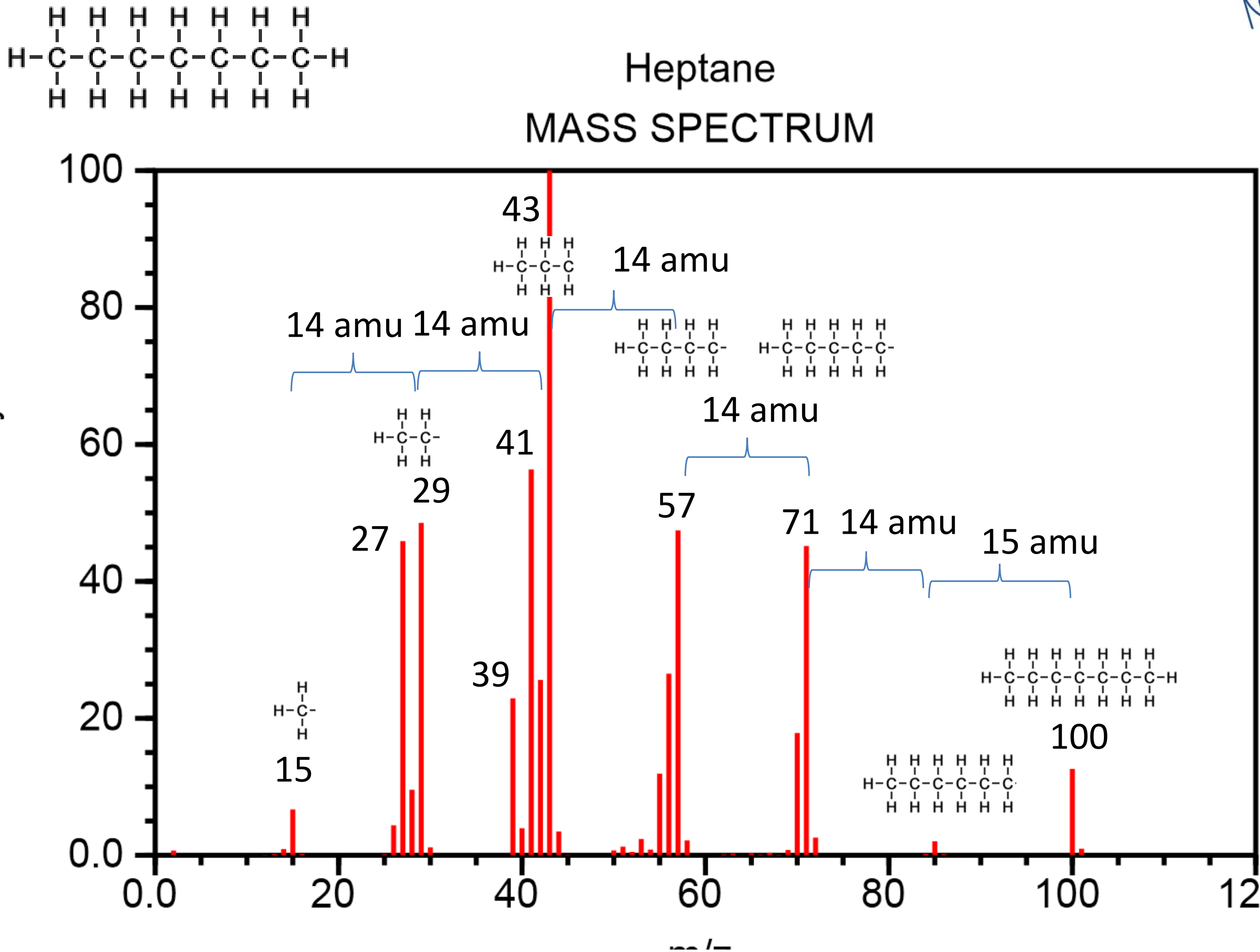
The ratios $\frac{\langle 41\rangle}{\langle 40\rangle}$ and $\frac{\langle 39\rangle}{\langle 40\rangle}$ are important to identify Ar and, as a consequence, air.



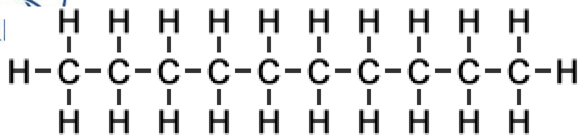
Propanol

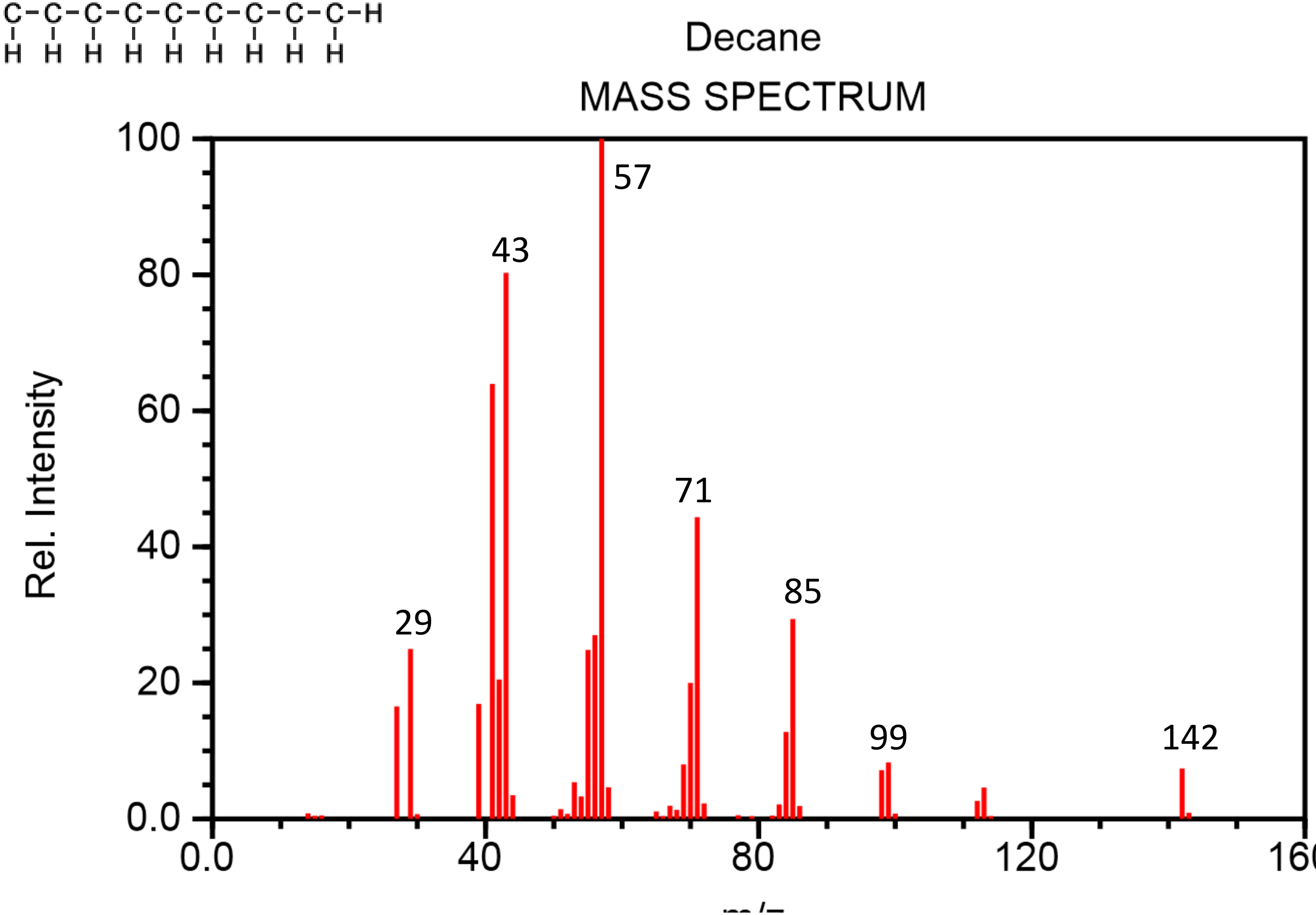


$CH_3CH_2CH_2OH$
$H_2C=\overset{\oplus}{\ddot{O}}H$
31
M^+-18
M^+
Relative Intensity
100
80
60
40
20
0
10
15
20
25
30
35
40
45
50
55
60
m/z



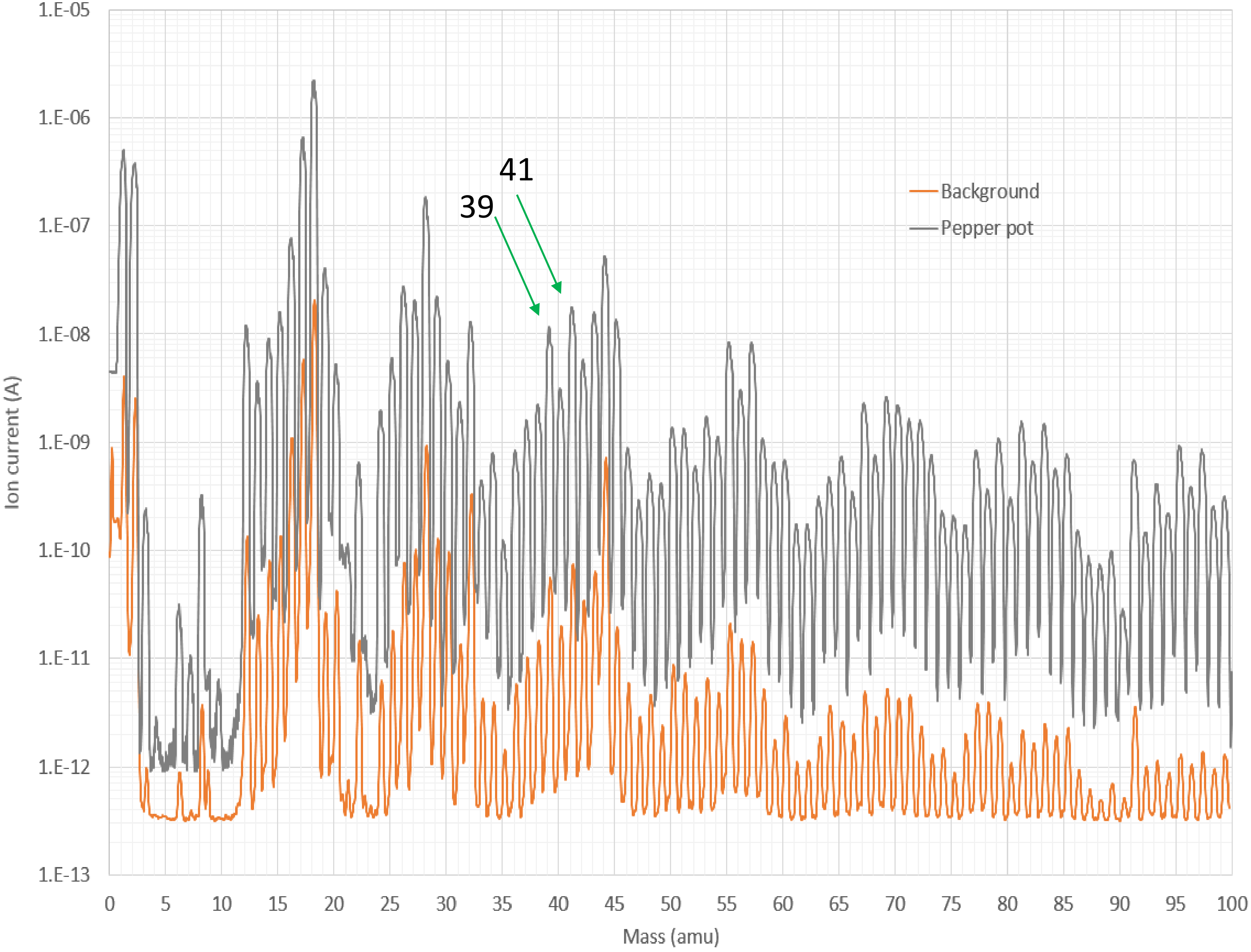
$$\frac{\langle 41\rangle}{\langle 40\rangle} = 14.1 \quad \frac{\langle 39\rangle}{\langle 40\rangle} = 5.75 \quad \frac{\langle 39\rangle}{\langle 41\rangle} = 0.41$$



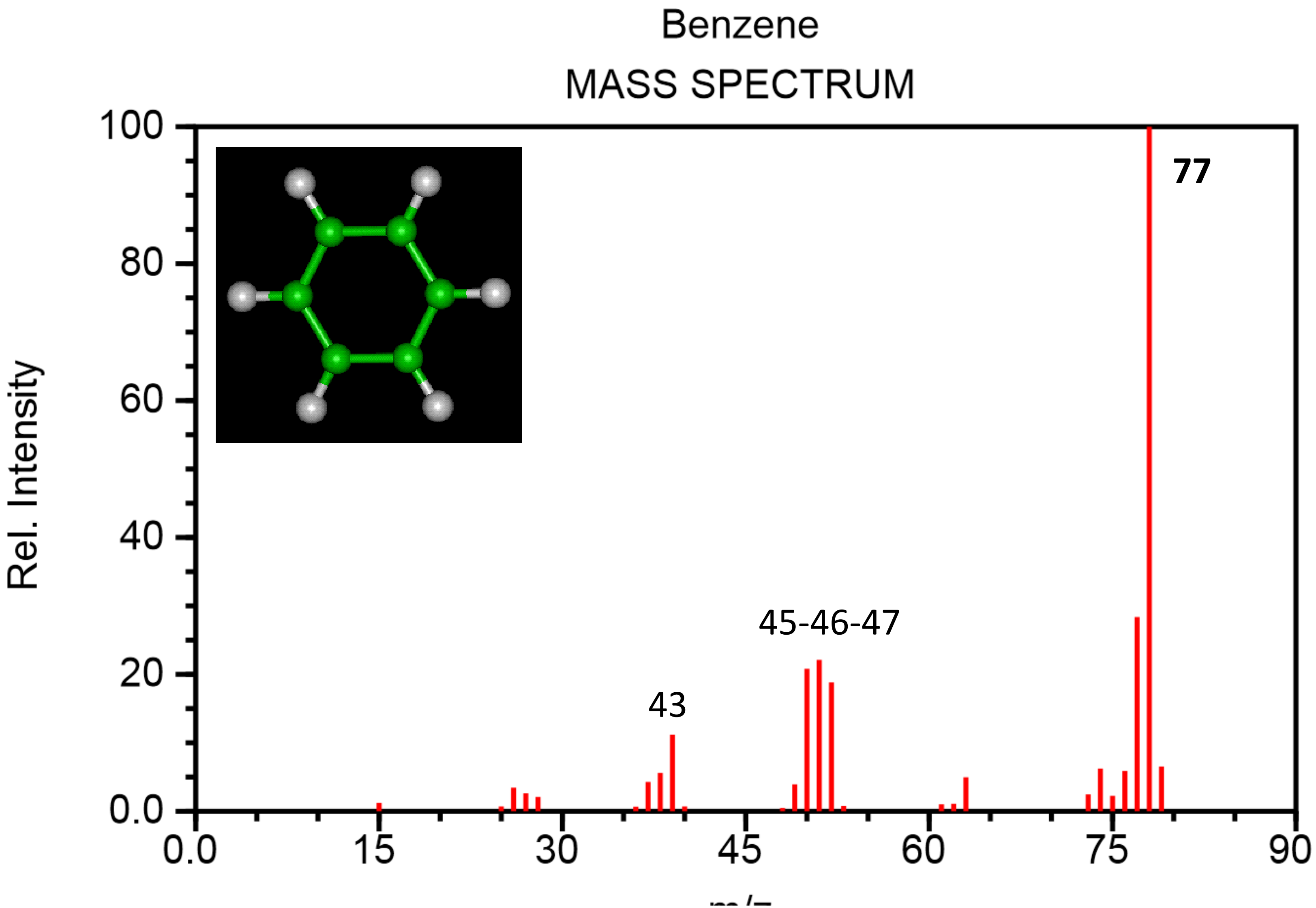


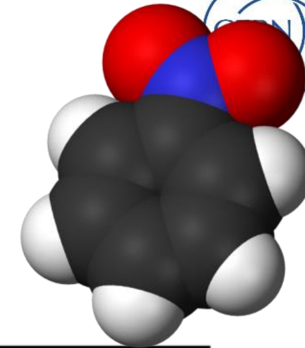
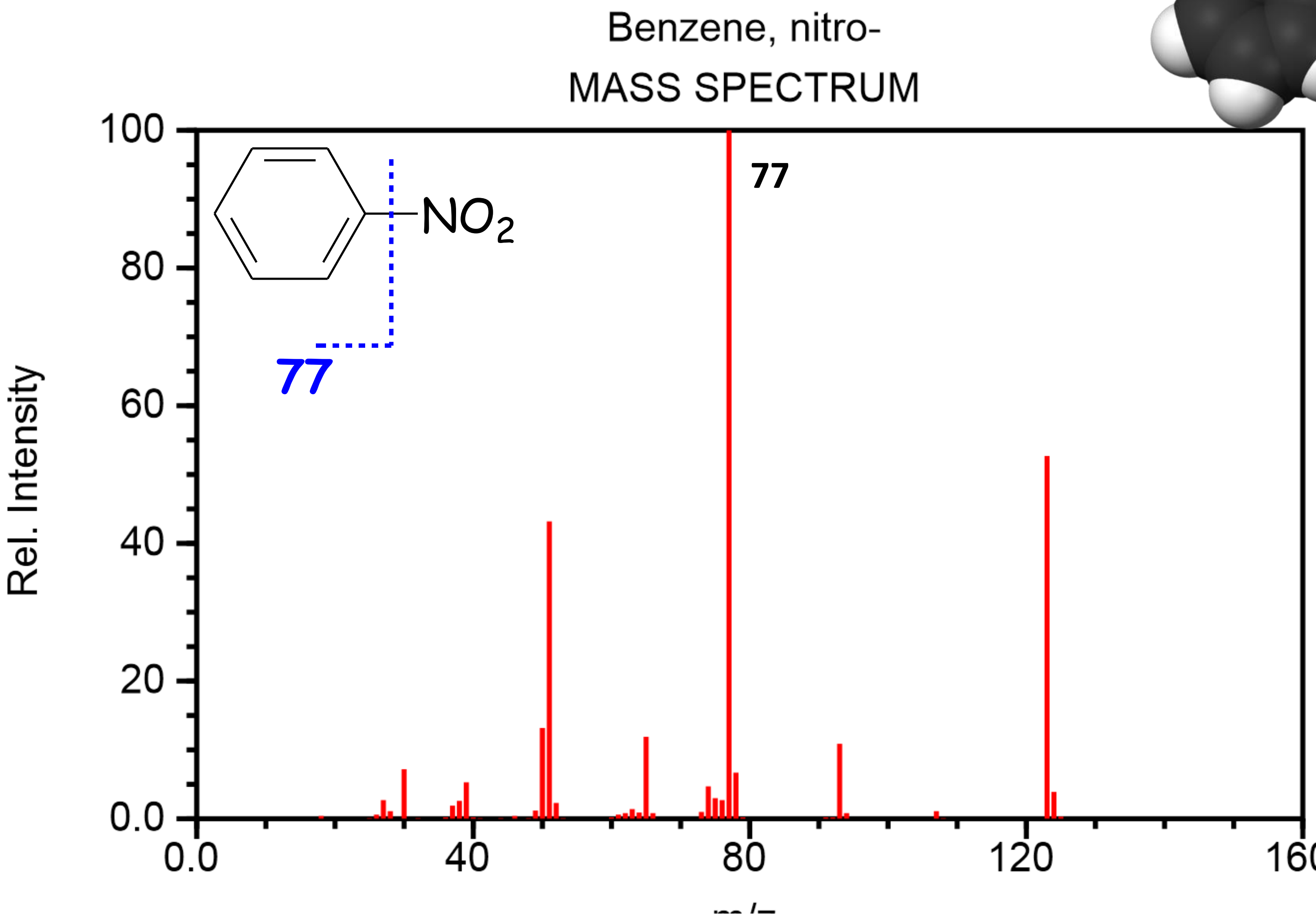
$\frac{\langle 41 \rangle}{\langle 40 \rangle} = ?$ $\frac{\langle 39 \rangle}{\langle 40 \rangle} = ?$ $\frac{\langle 39 \rangle}{\langle 41 \rangle} = 0.26$

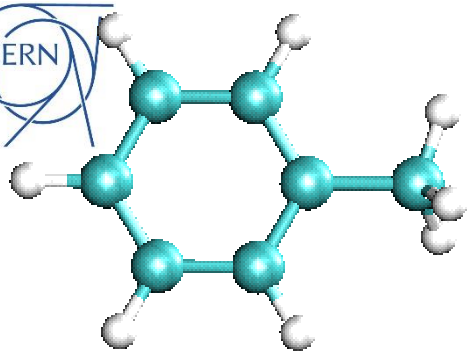
Heavier the alkane molecule, lower the ratio $\frac{\langle 39 \rangle}{\langle 41 \rangle}$



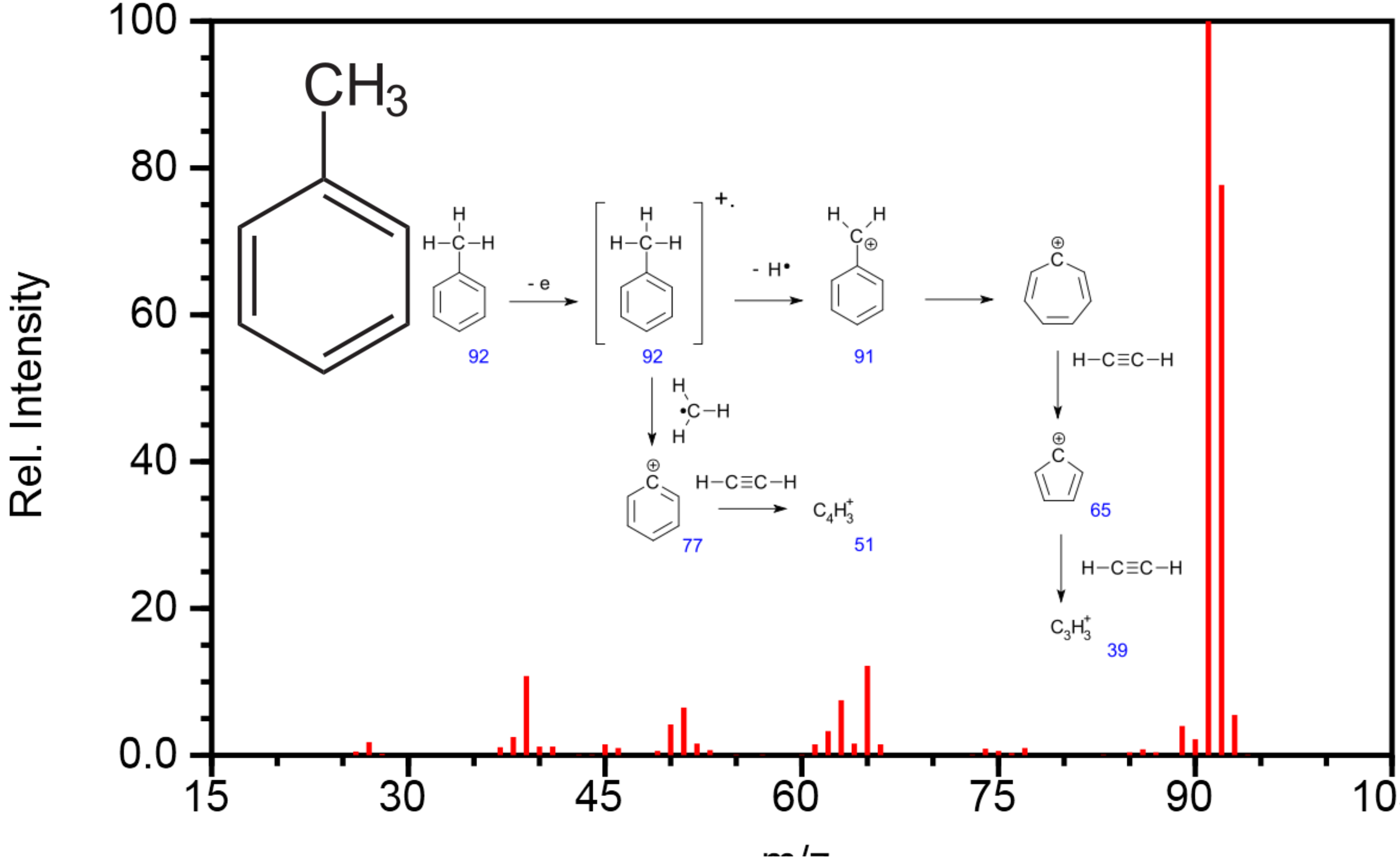
1.E-05
1.E-06
1.E-07
1.E-08
1.E-09
1.E-10
1.E-11
1.E-12
1.E-13
Ion current (A)
0
5
10
15
20
25
30
35
40
45
50
55
60
65
70
75
80
85
90
95
100
Mass (amu)
Background
Pepper pot
39
41


Benzene
MASS SPECTRUM
Rel. Intensity
100
80
60
40
20
0.0
0.0
15
30
45
60
75
90
77
45-46-47
43



Benzene, nitro-
MASS SPECTRUM
Rel. Intensity
100
80
60
40
20
0.0
0.0
40
80
120
NO2
77
77



Toluene
MASS SPECTRUM



Pump Oil Contamination

A **mineral oil** is any of various colorless, odorless, light mixtures of alkanes in the C15 to C40 range from a non-vegetable (mineral) source, particularly a distillate of petroleum

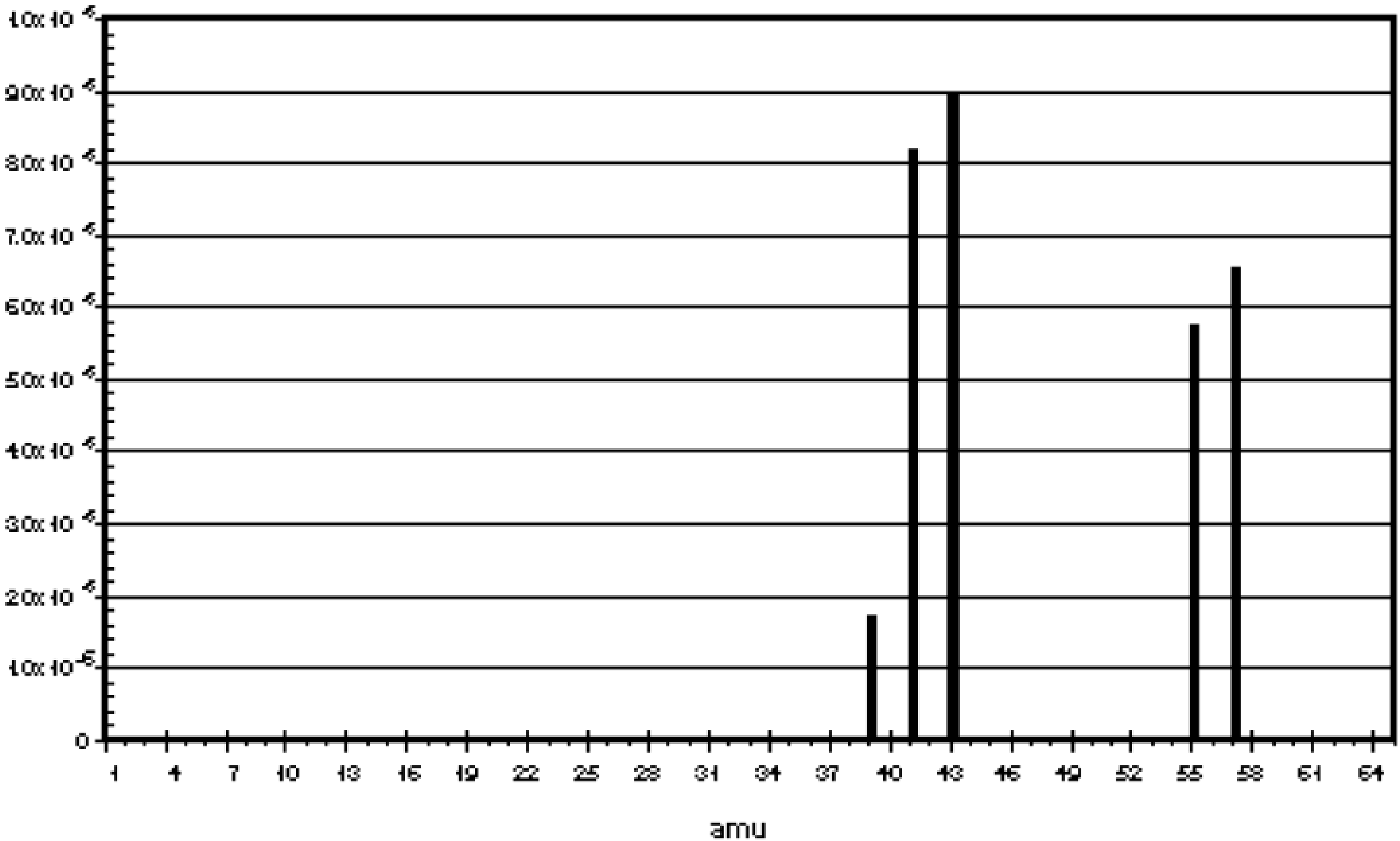
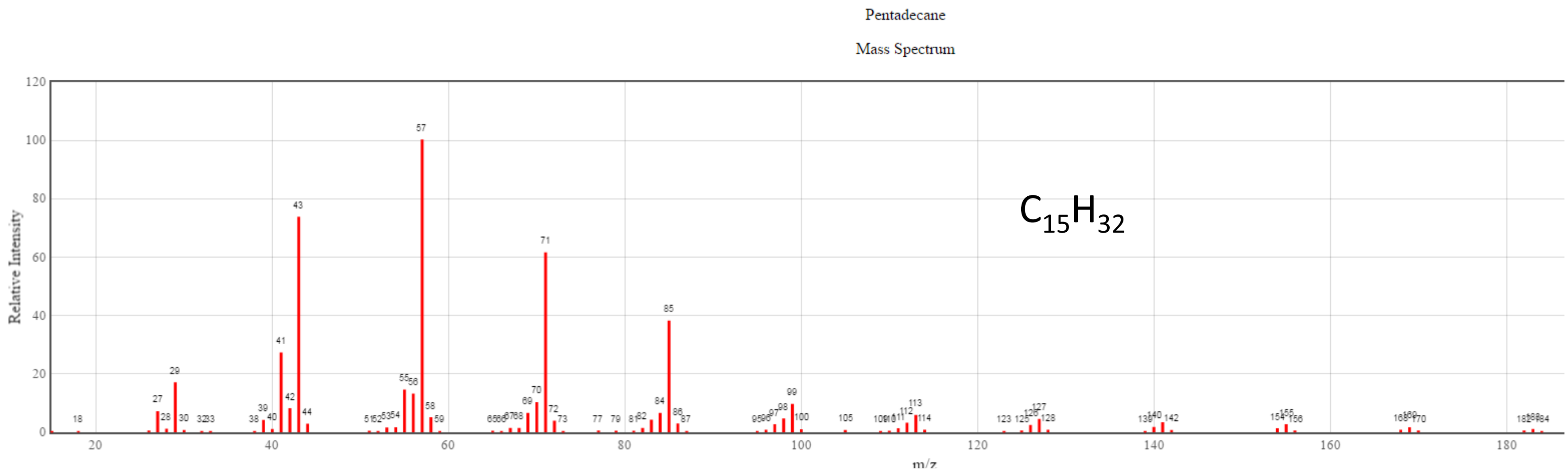
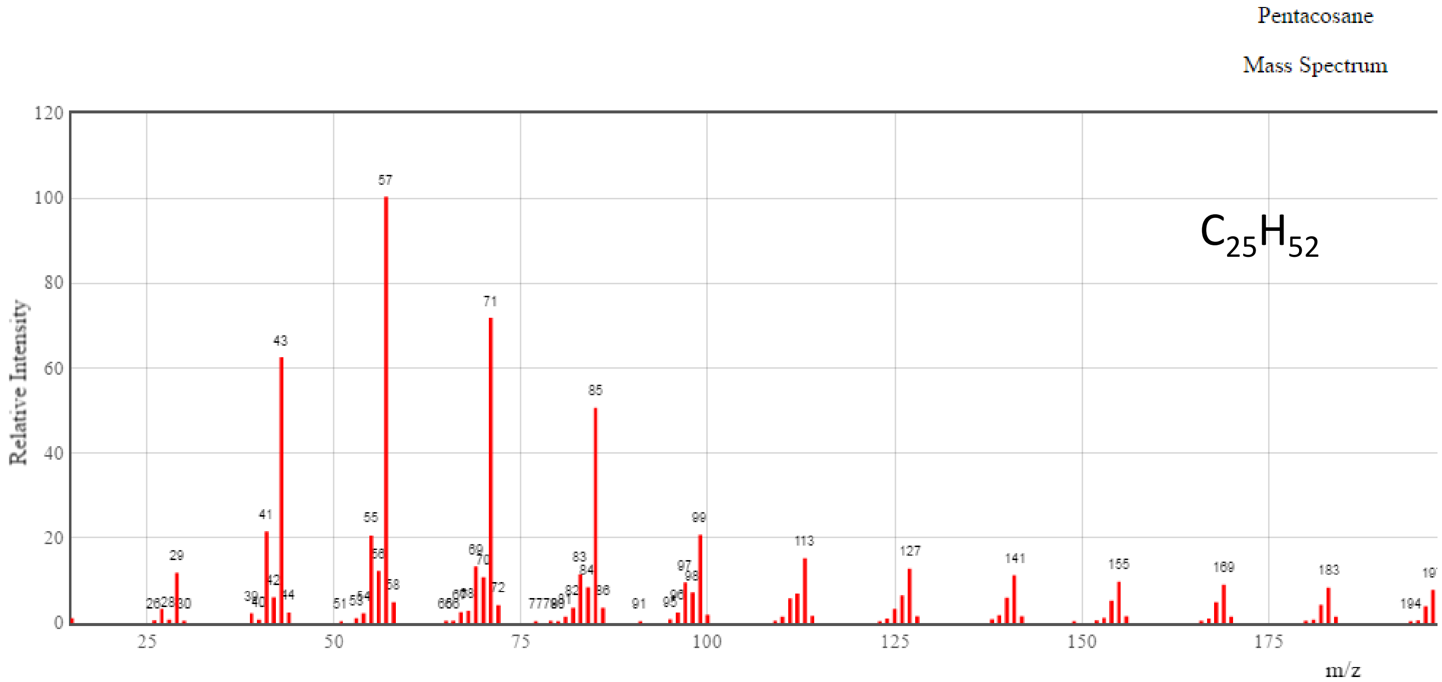


Figure 2b: Library Pump Oil Data





To have <57>/<55> ≈1 We need other molecules than those of alkanes

A=2.945 B=-44094 C=1.3677 D=0

$$\log(p\,/atm) = A + B\,/T + C^{*}\log(T) + D\,/T_{3}$$

Tungsten isotopes:

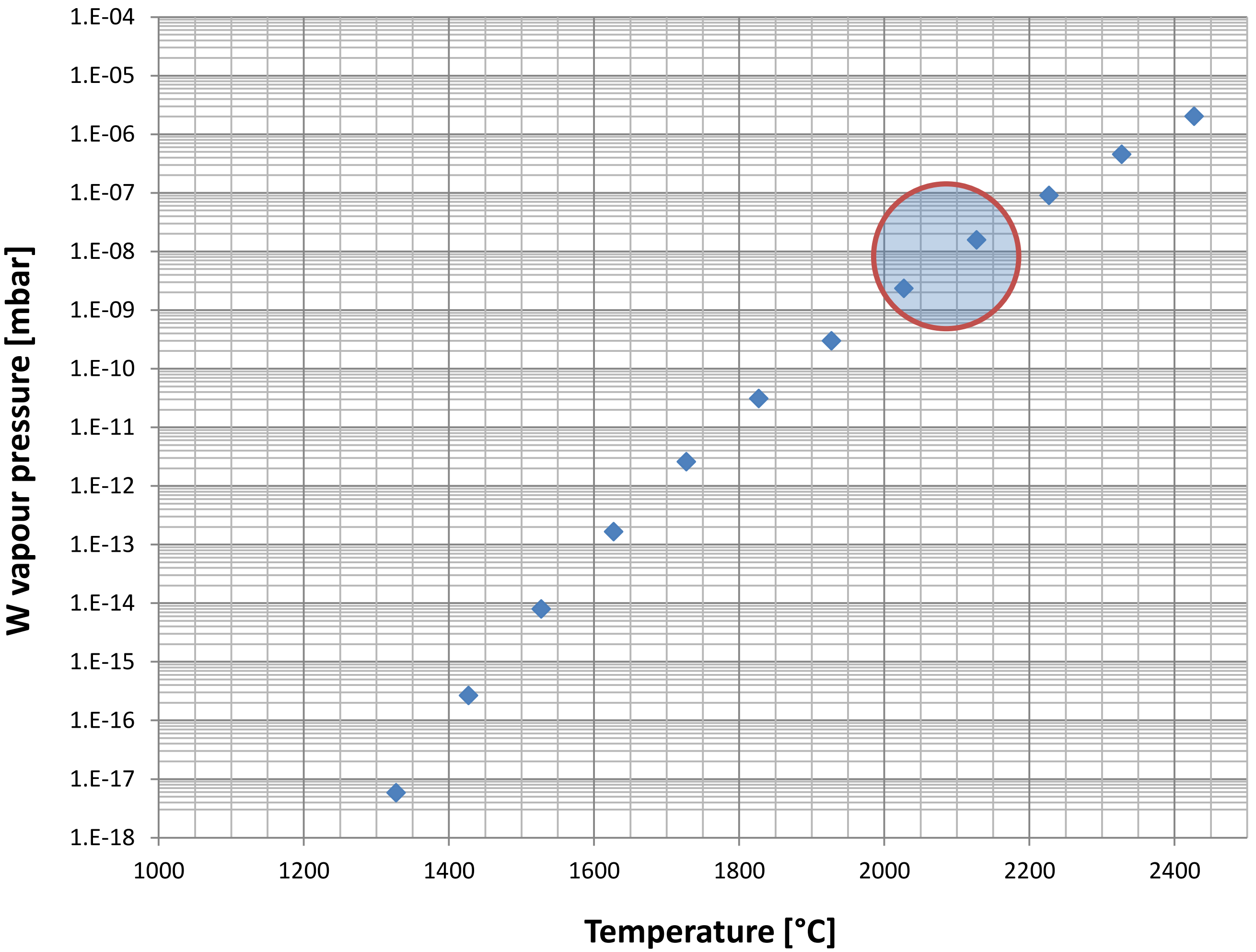
^{182}W 26.5% → $^{182}W^{++}$ 91 amu

^{183}W 14.3% → $^{183}W^{++}$ 91.5 amu

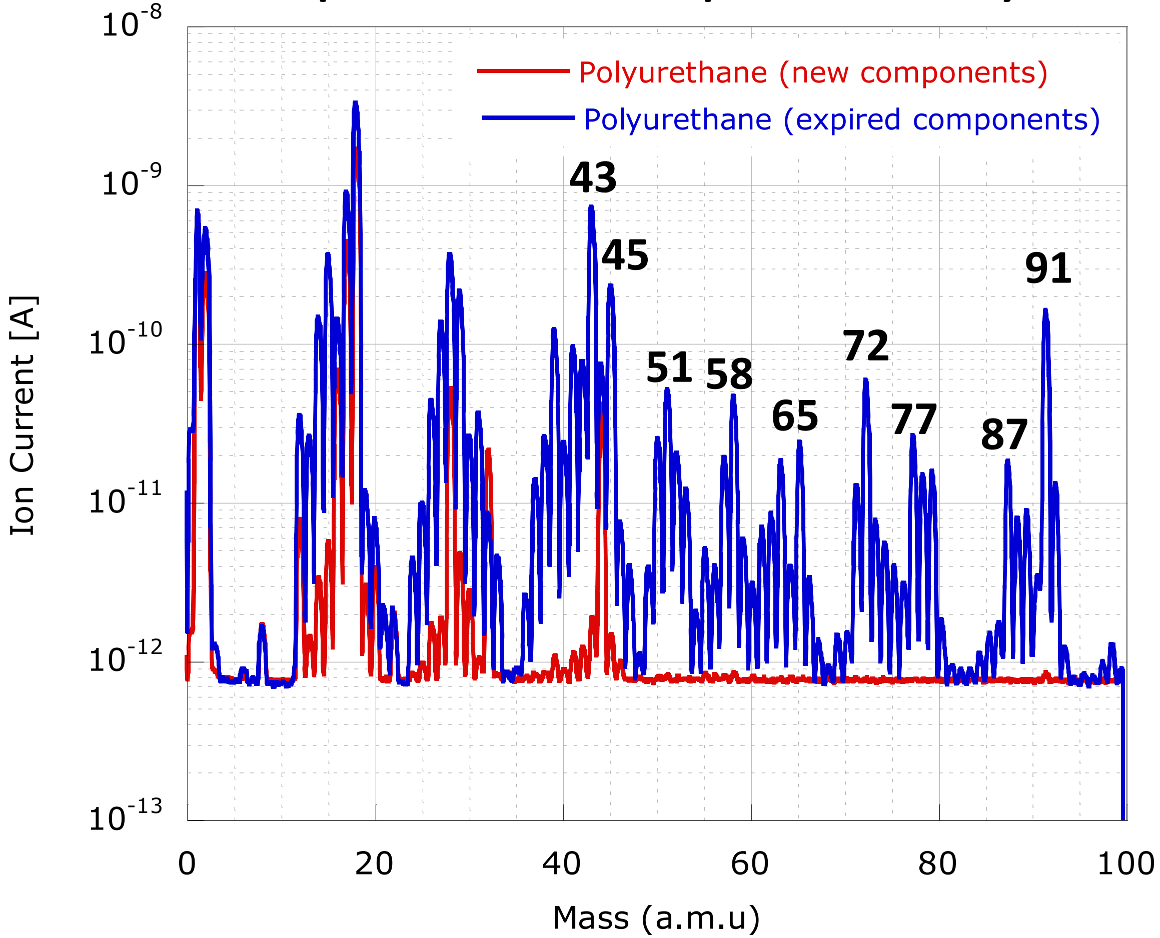
^{184}W 30.6% → $^{182}W^{++}$ 92 amu

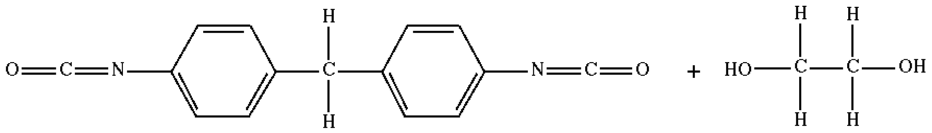
^{186}W 28.4% → $^{182}W^{++}$ 93 amu

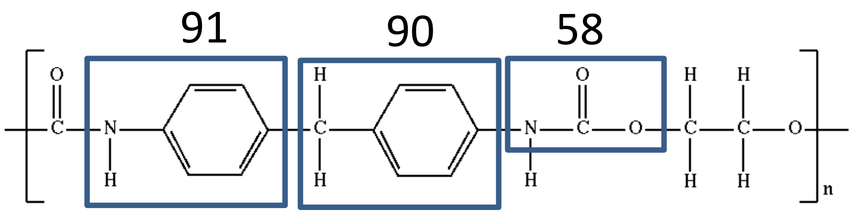
Several peaks superposed in the RGA spectrum



Interpretation of Mass Spectra: not easy

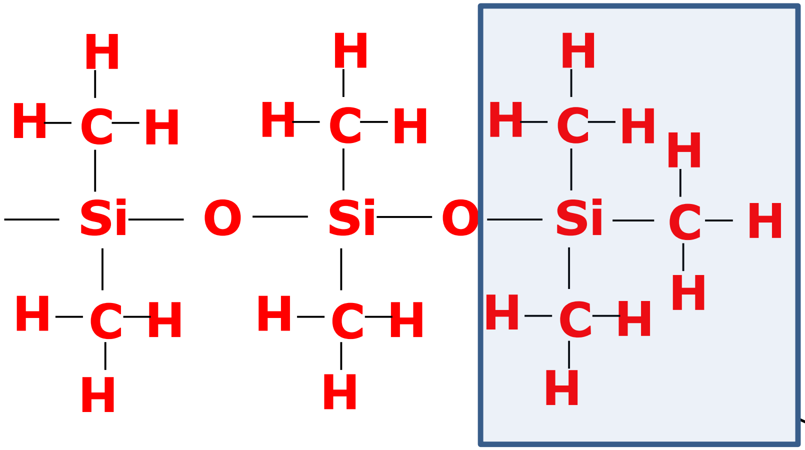


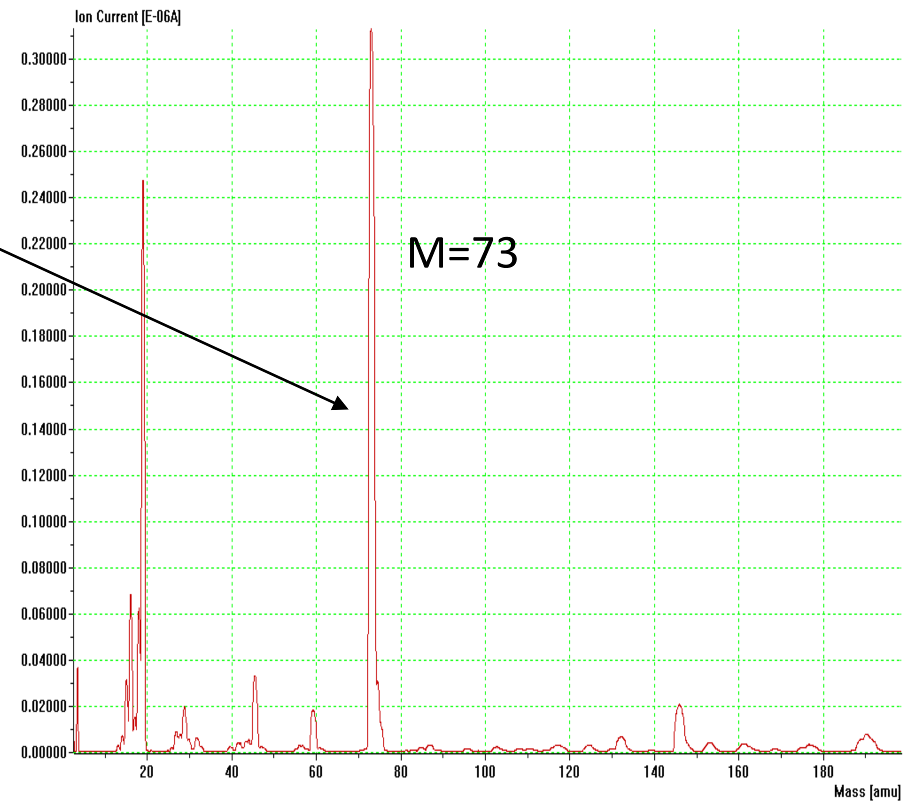




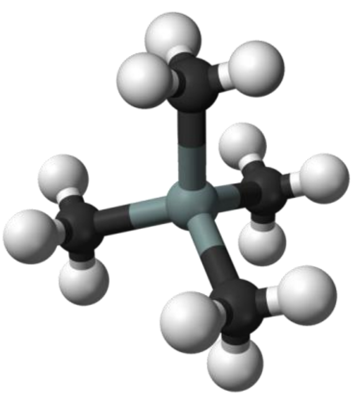
https://en.wikipedia.org/wiki /Polyurethane →

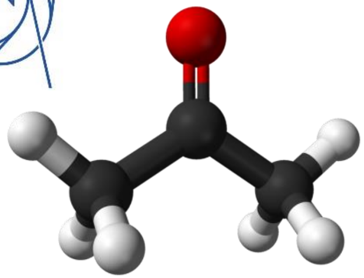
Interpretation of Mass Spectra: silicone glue

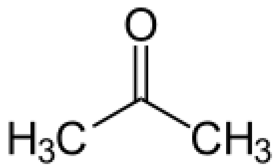


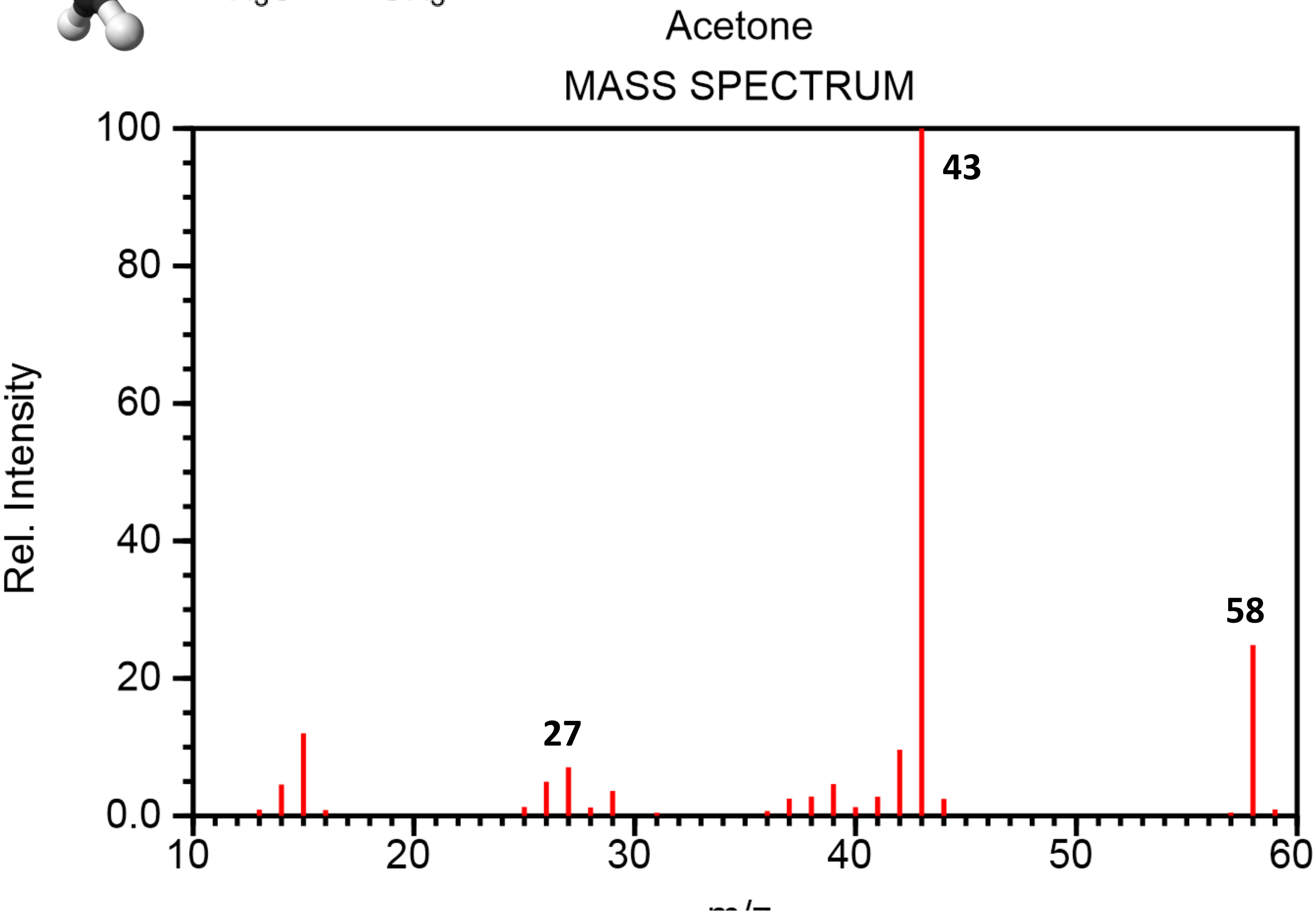


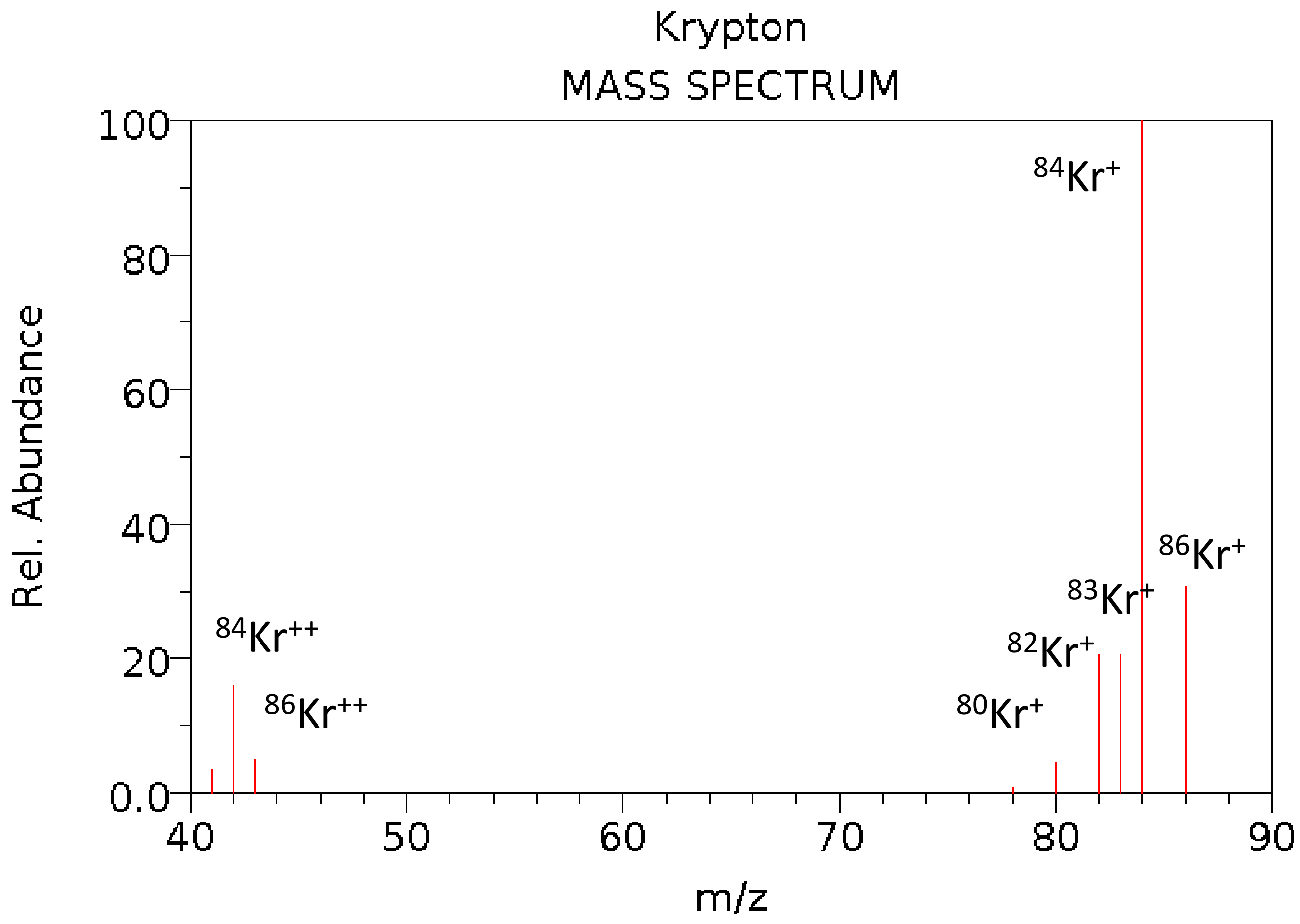
Tetramethylsilane






O
H3C
CH3


Acetone
MASS SPECTRUM
Rel. Intensity
100
80
60
40
20
0.0
10
20
30
40
50
60
43
58
27

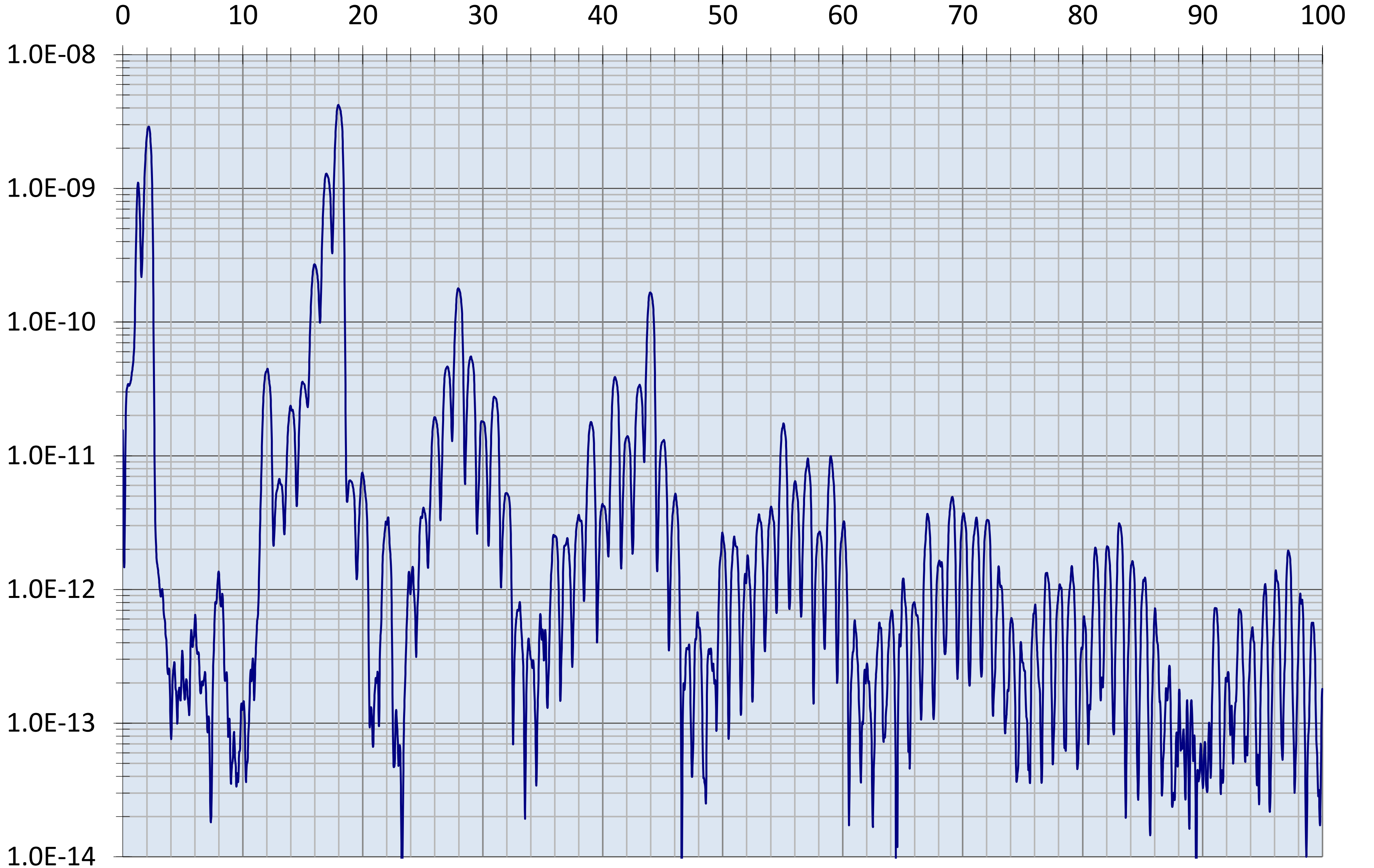

Krypton
MASS SPECTRUM
100
80
60
40
20
0.0
40
50
60
70
80
90
Rel. Abundance
m/z
84Kr+
86Kr+
83Kr+
82Kr+
80Kr+
84Kr++
86Kr++

How can we identify an air-leak by RGA

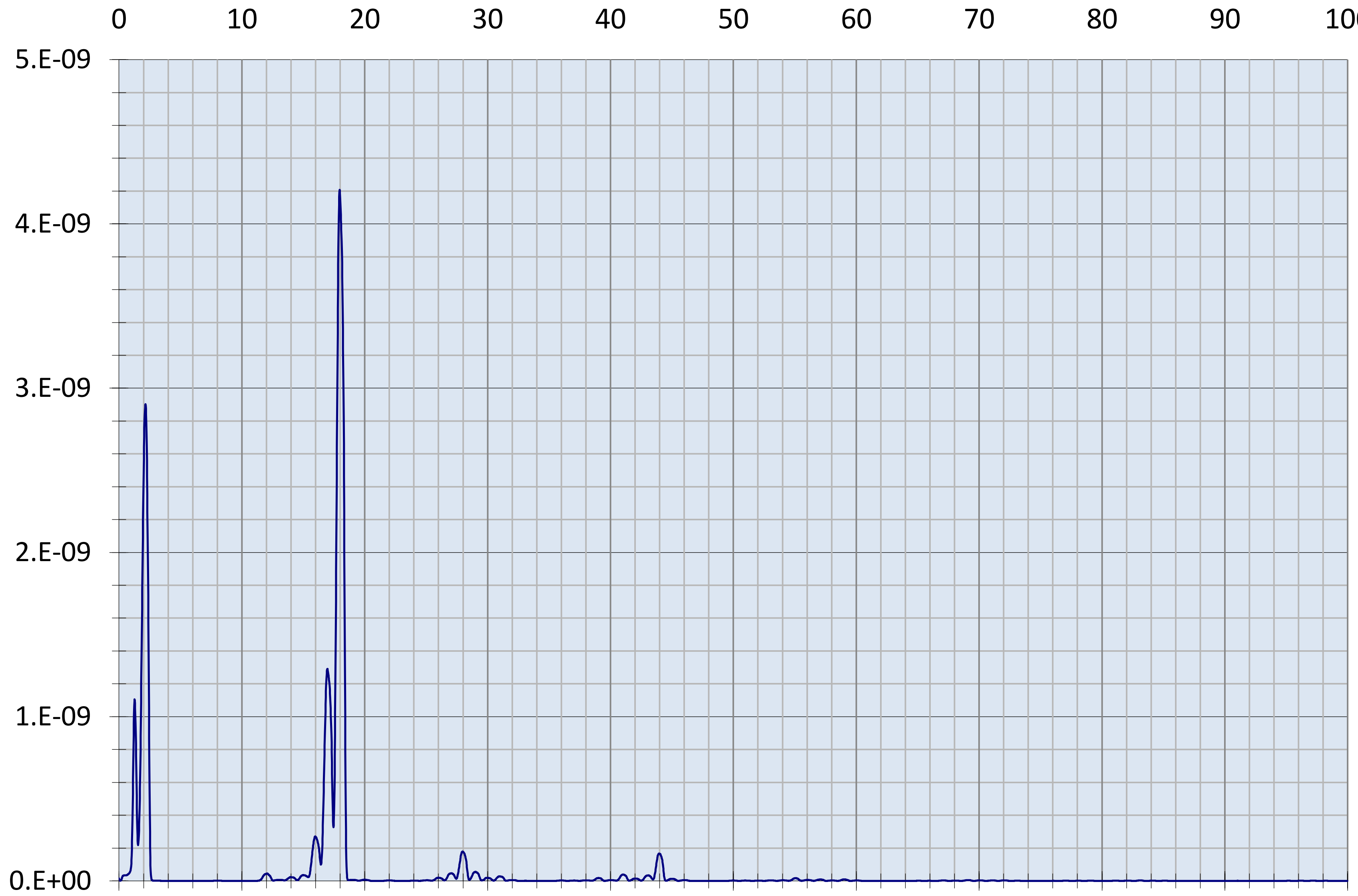
- **Large leaks in unbaked systems**:
  - High 28 - 32 - 40 in the typical ratio for air N_2/O_2 = 78/21= 3.7 and N_2/Ar 78/1=78.

- **Small leaks:**
  - Look at mass 14 and 15; **if the ratio <15>/<14> is lower than 4**, a **leak is not excluded**.
  - If there is a **peak at 20 and not at 22**, Ar could be present.
  - If the ratio **<39>/<40> is lower than 3**, Ar could be present.
  - In baked system, the **absence of peak 32** does not imply the absence of leaks; **baked stainless steel walls adsorb oxygen**.

Interpretation of Mass Spectra: Unbaked System 4x10^{-9} mbar



Interpretation of Mass Spectra: Unbaked System $4x10^{-9}$ mbar



Interpretation of Mass Spectra: Artefacts

➢ Artefacts:

- The cracking pattern depends on the RGA electrical setting (in particular the energy of the electrons);

- Misalignment could have a role.

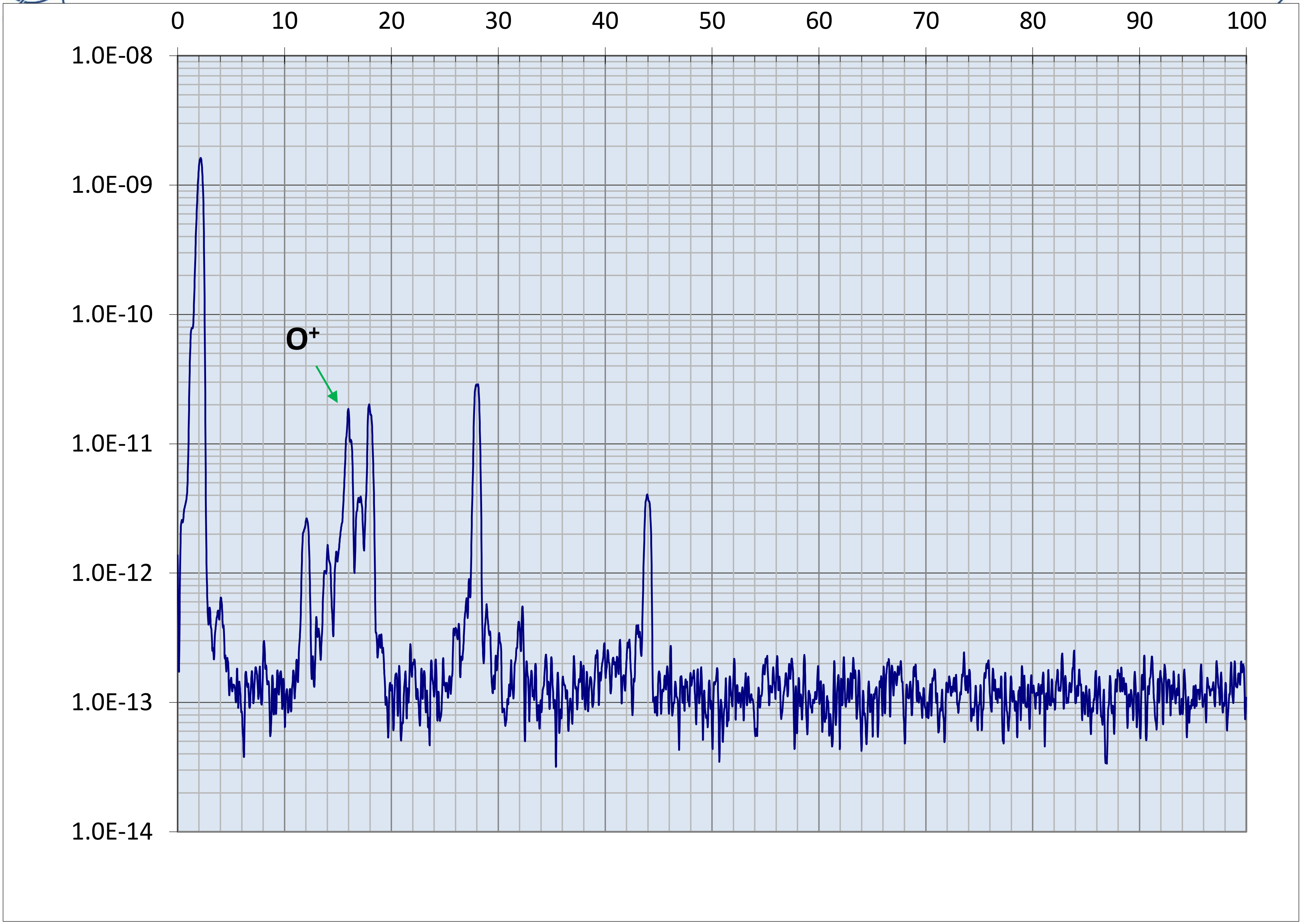
- The RGA fragmentation pattern is **indirectly modified by the vacuum system**. For example assume that:
  - CO_2 is the only gas injected in the system
  - the system is equipped with ion pumps and ionization gauges

→ CO is generated and the measured 28/44 ratio increases.

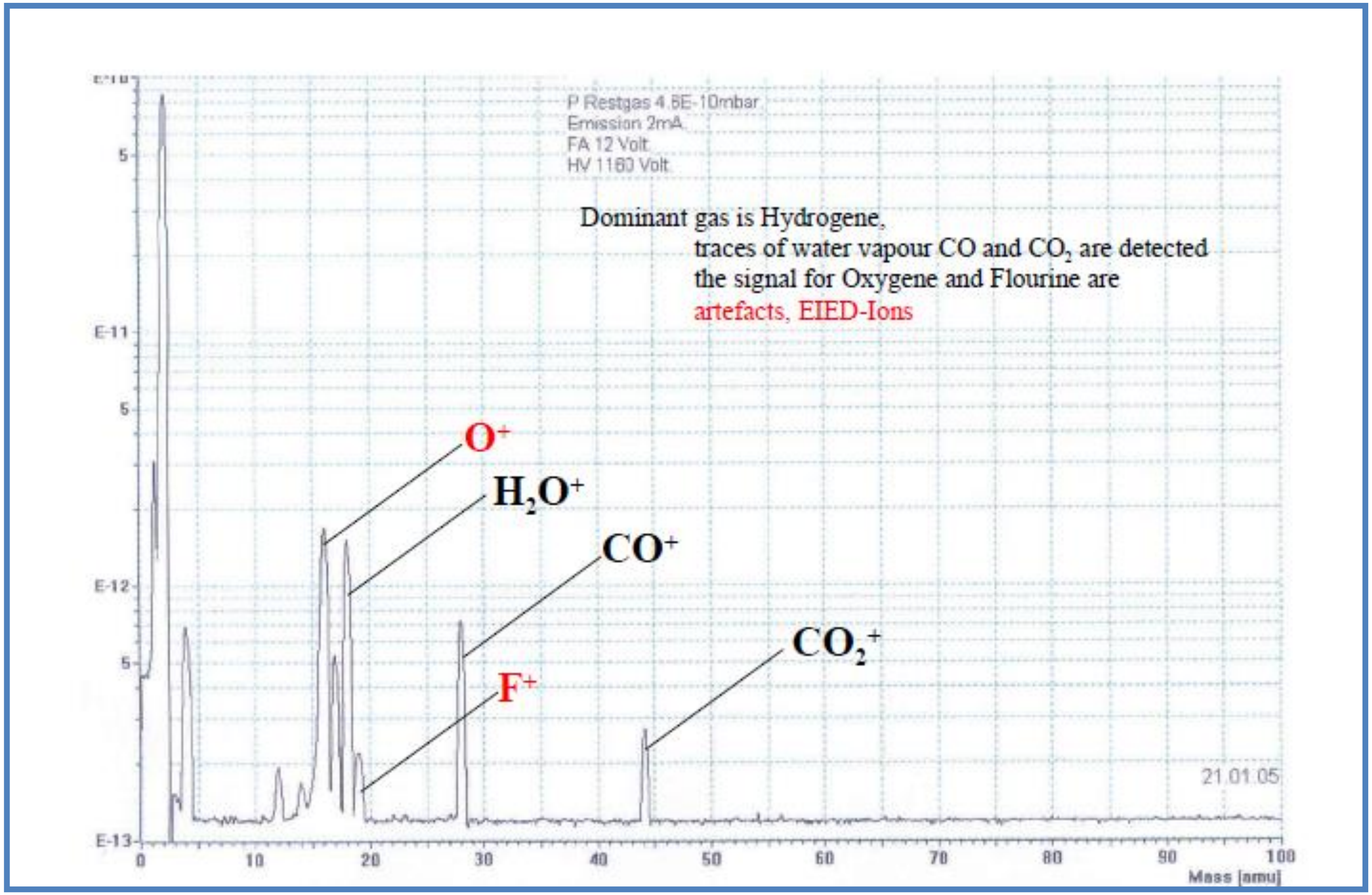
- Some peaks not related to gas molecules may appear in the UHV range: **ESD** of gas adsorbed on the grid **may lead to spurious peak** in the mass spectrum. The most common ESD peaks are:

	Mass (m/e)	Component
–	1	H+
–	16	O+
–	19	F+
–	23	Na+
–	28	CO+
–	35,37	Cl+
–	39	K+

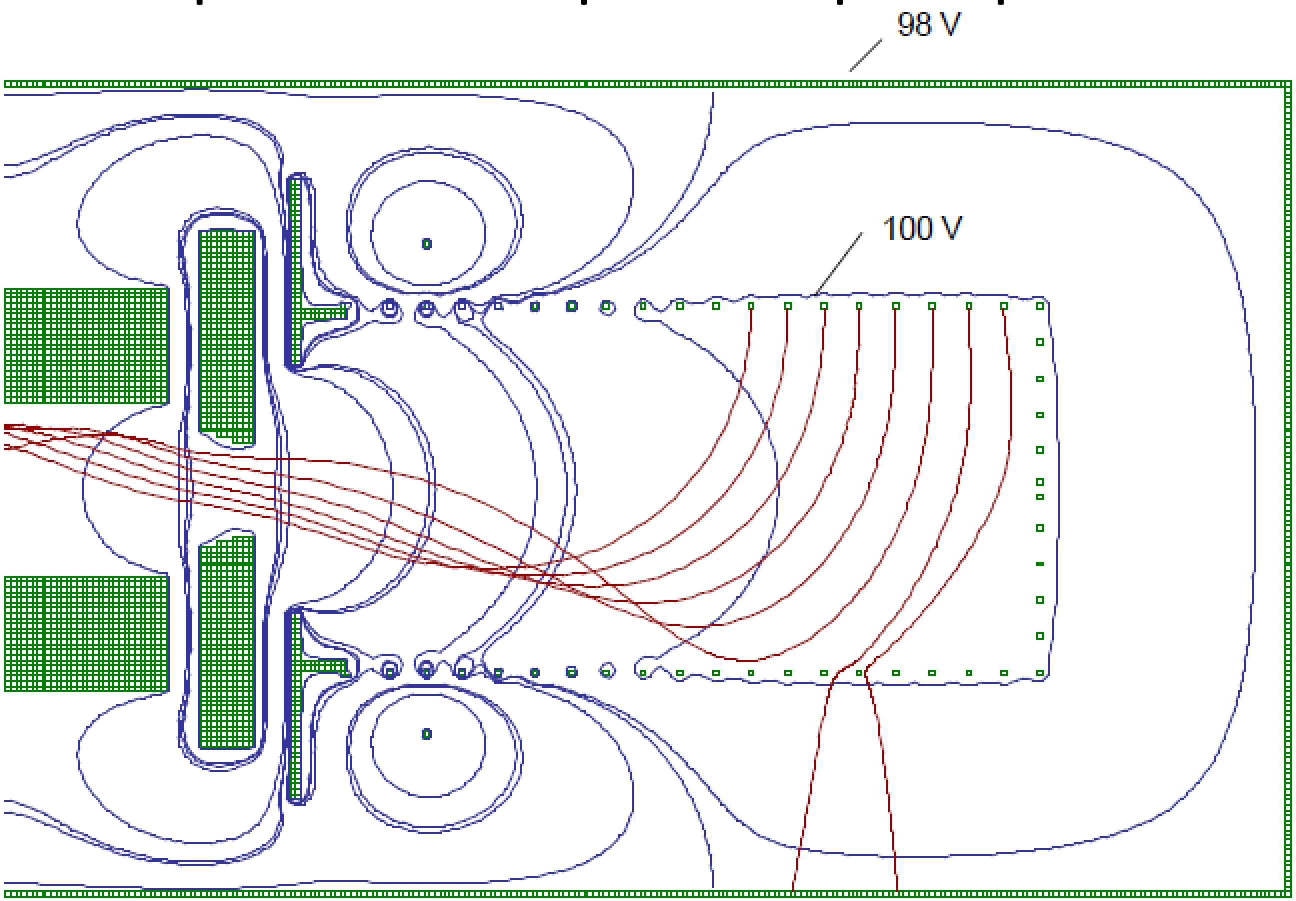
Interpretation of Mass Spectra: Baked System 4×10^{-11} mbar



Interpretation of Mass Spectra: ESD spurious peak

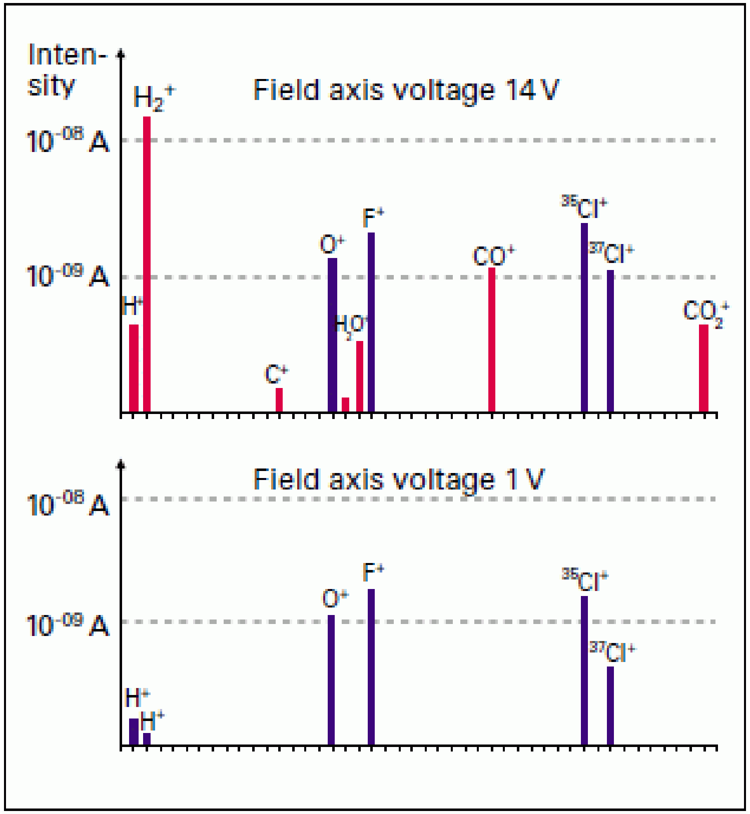


Interpretation of Mass Spectra: ESD spurious peak

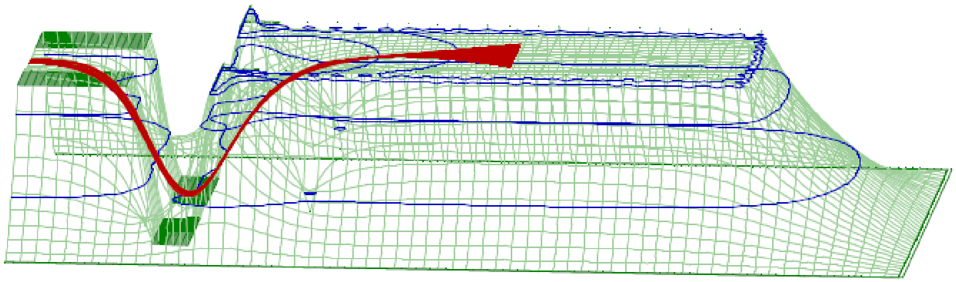


ESD ions acquire a kinetic energy of the order of 1 eV as a result of the electron collision. So, **they move much faster than the gas ion of the same mass** (in average 0.025 eV).

Interpretation of Mass Spectra: ESD spurious peak



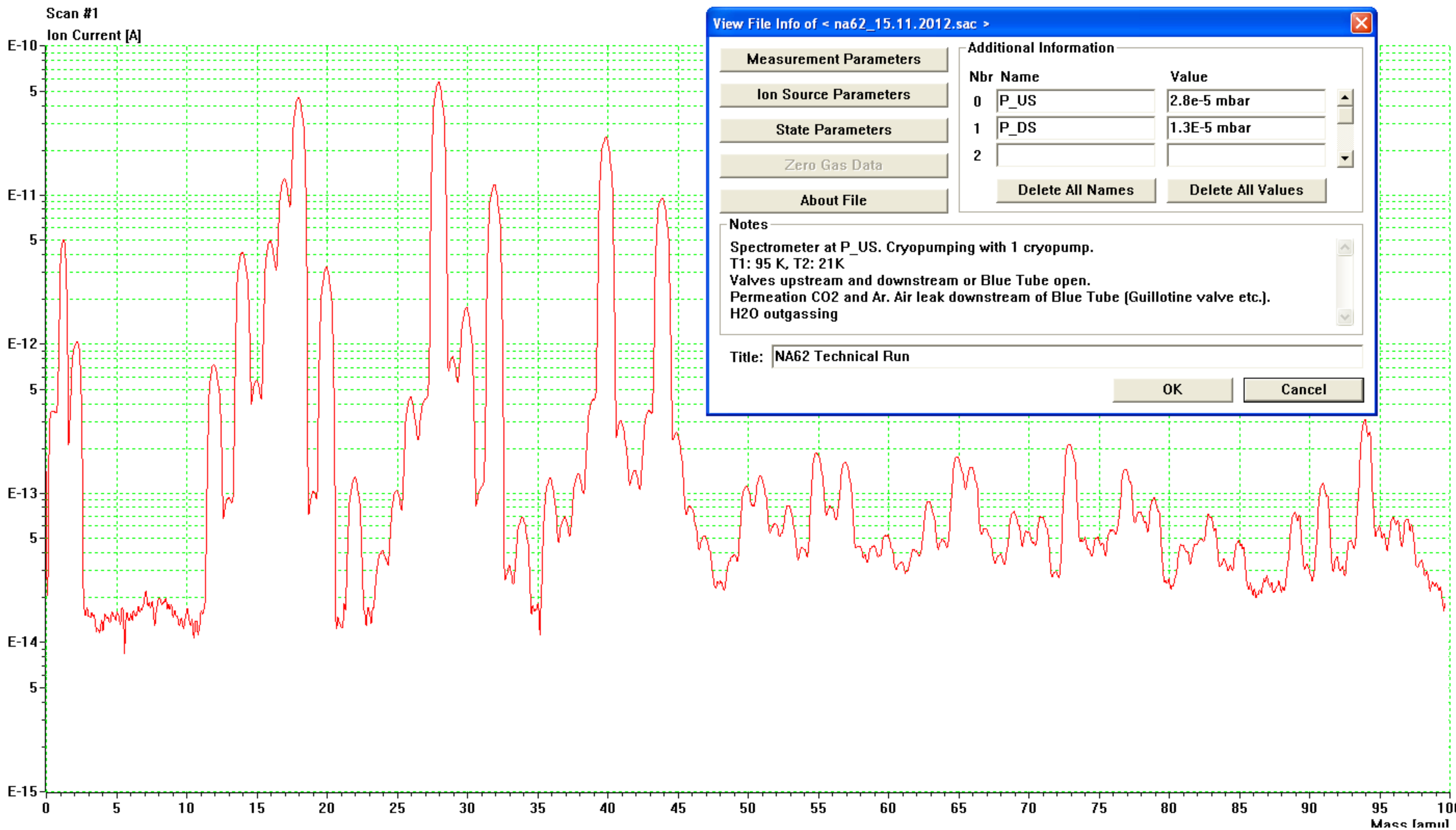
➢ Because they have higher energy than gas ions, they can fly directly into the quadrupole even with a small field axis voltage.



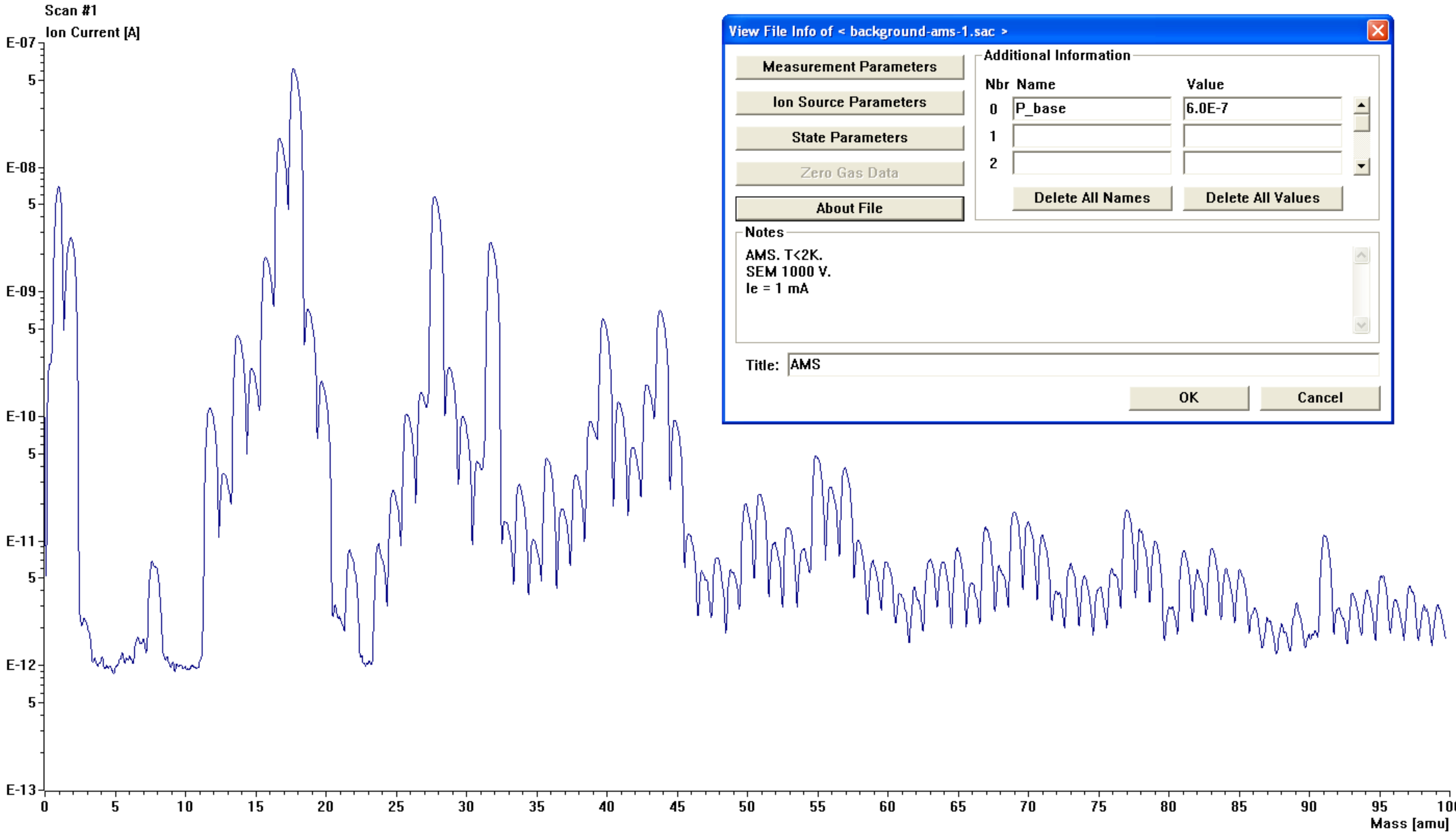
➢ **Reducing the field axis voltage leads to the suppression of the gas ions**; in this way, only the **ESD spurious peaks are detected**.

SOME EXAMPLES

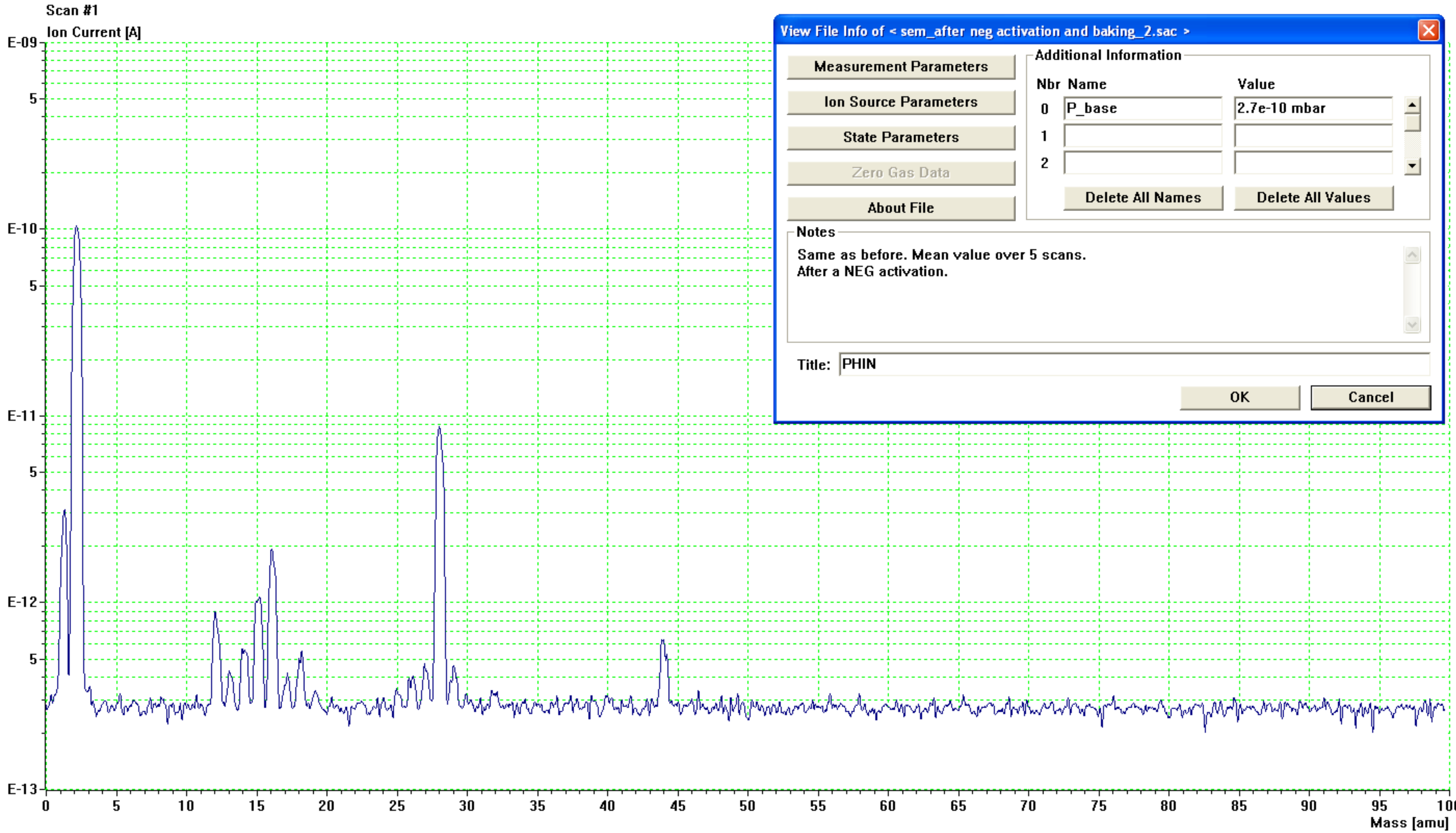
Measured Spectrum NA62 (16.11.2012)



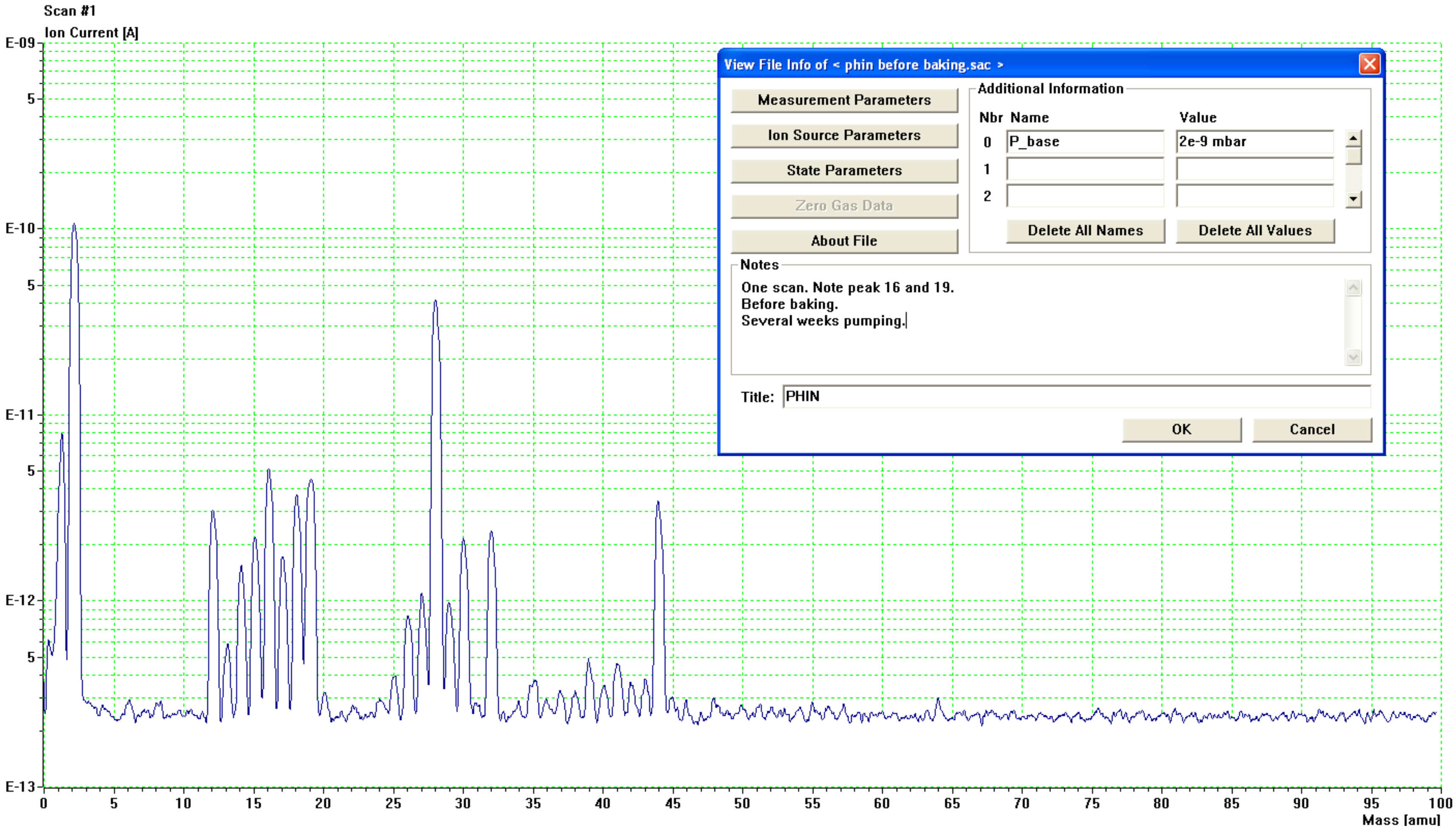
AMS background

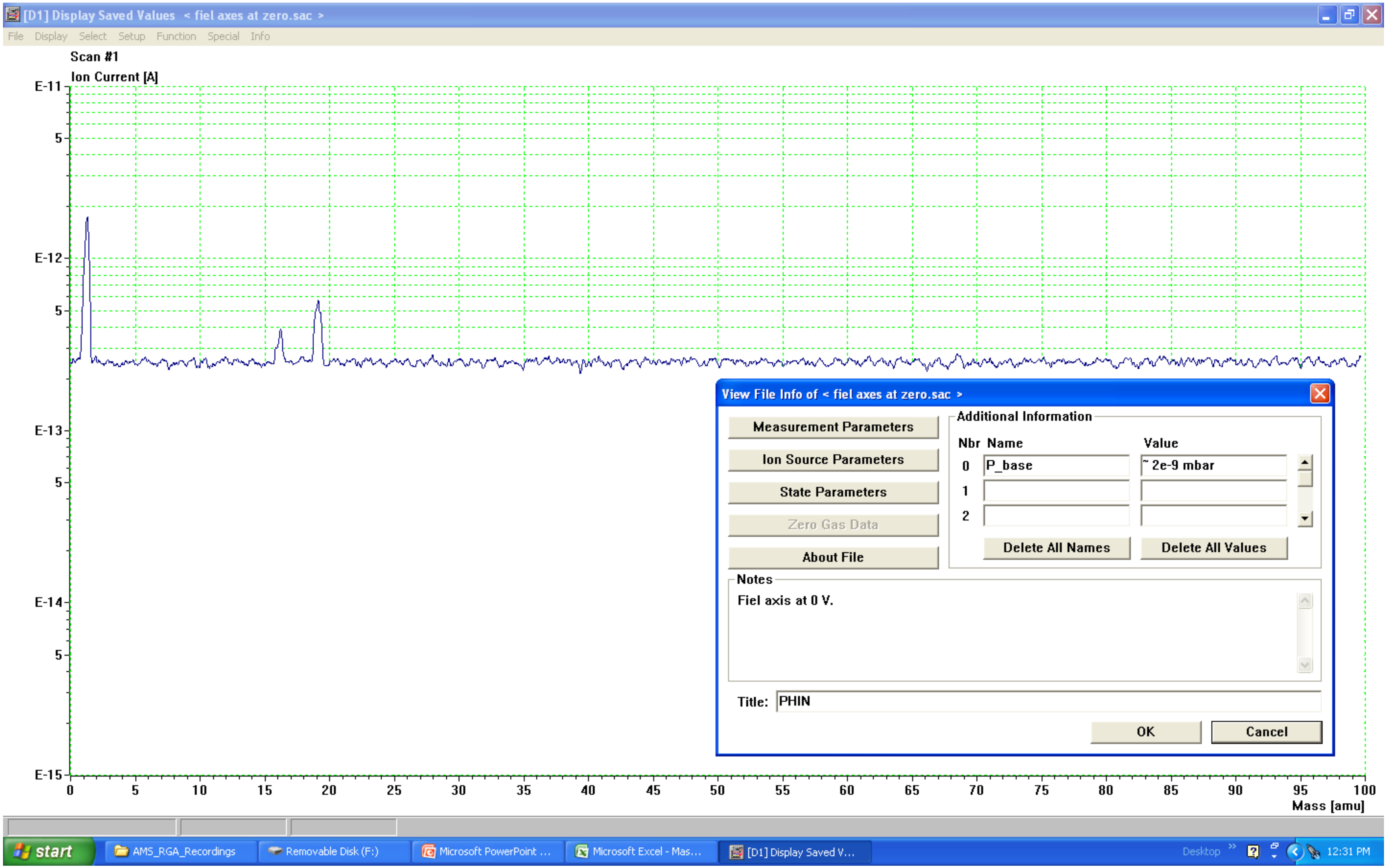


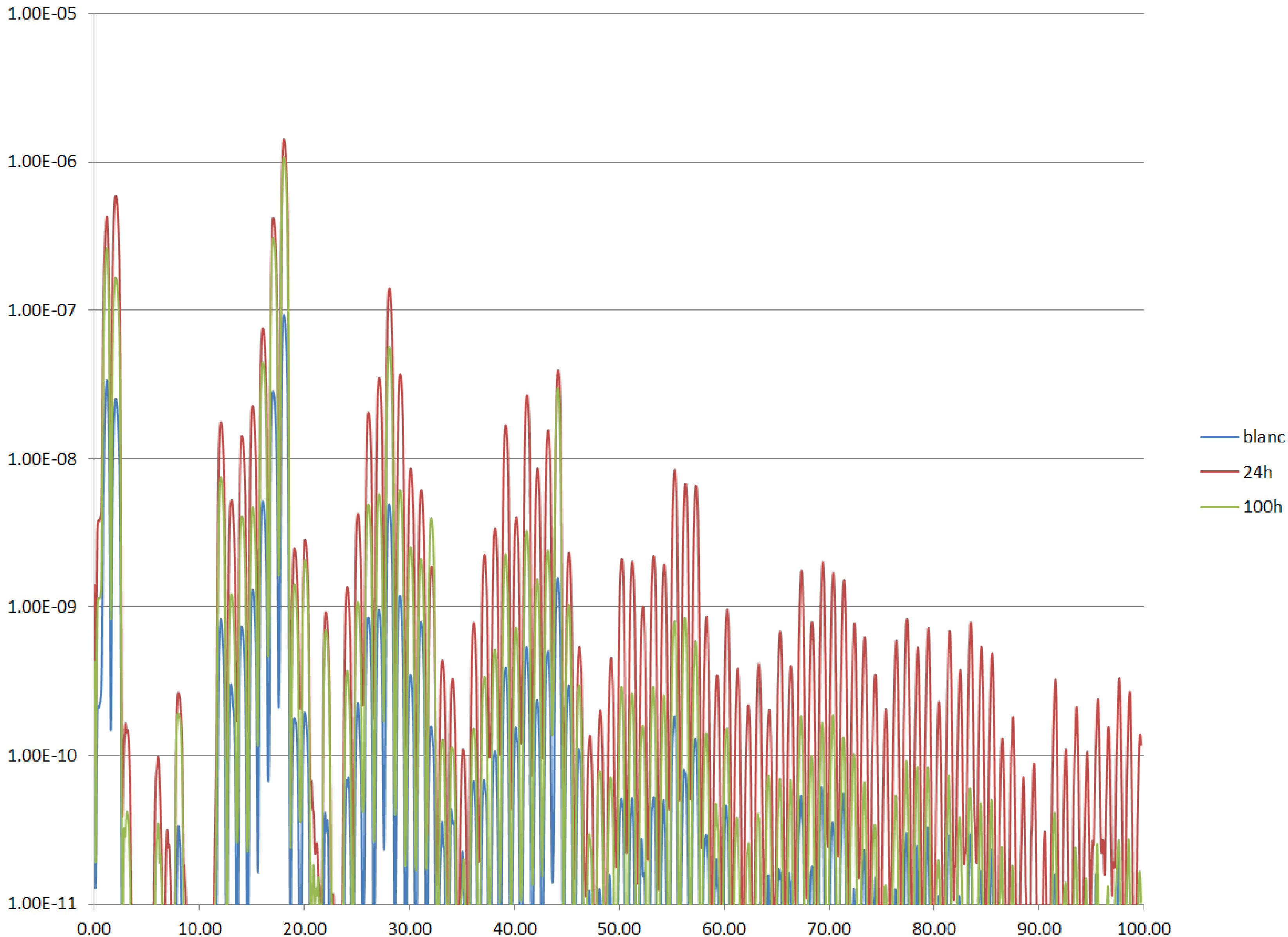
CTF-PHIN


Scan #1
Ion Current [A]
E-09
5
E-10
5
E-11
5
E-12
5
E-13
0 5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85 90 95 100
Mass [amu]
View File Info of < sem_after neg activation and baking_2.sac >
Measurement Parameters
Ion Source Parameters
State Parameters
Zero Gas Data
About File
Additional Information
Nbr Name
Value
0 P_base
2.7e-10 mbar
1
2
Delete All Names
Delete All Values
Notes
Same as before. Mean value over 5 scans.
After a NEG activation.
Title: PHIN
OK
Cancel

CTF-PHIN


Scan #1
Ion Current [A]
E-09
5
E-10
5
E-11
5
E-12
5
E-13
0
5
10
15
20
25
30
35
40
45
50
55
60
65
70
75
80
85
90
95
100
Mass [amu]
View File Info of < phin before baking.sac >
Measurement Parameters
Ion Source Parameters
State Parameters
Zero Gas Data
About File
Additional Information
Nbr
Name
Value
0
P_base
2e-9 mbar
1
2
Delete All Names
Delete All Values
Notes
One scan. Note peak 16 and 19.
Before baking.
Several weeks pumping.
Title:
PHIN
OK
Cancel


[D1] Display Saved Values < fiel axes at zero.sac >
File Display Select Setup Function Special Info
Scan #1
Ion Current [A]
E-11
5
E-12
5
E-13
5
E-14
5
E-15
0 5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85 90 95 100
Mass [amu]
View File Info of < fiel axes at zero.sac >
Measurement Parameters
Ion Source Parameters
State Parameters
Zero Gas Data
About File
Additional Information
Nbr Name Value
0 P_base ~ 2e-9 mbar
1
2
Delete All Names
Delete All Values
Notes
Fiel axis at 0 V.
Title: PHIN
OK
Cancel
start
AMS_RGA_Recordings
Removable Disk (F:)
Microsoft PowerPoint ...
Microsoft Excel - Mas...
[D1] Display Saved V...
Desktop
12:31 PM


1.00E-05
1.00E-06
1.00E-07
1.00E-08
1.00E-09
1.00E-10
1.00E-11
0.00
10.00
20.00
30.00
40.00
50.00
60.00
70.00
80.00
90.00
100.00
blanc
24h
100h

- The calibration of a RGA consists in measuring the **sensitivity [A/Torr] and the cracking pattern** for a set of gases.

- The calibration of RGA is a frustrating activity because the **sensitivities** can change quickly and depends on so many parameters that are in most of the cases impossible to keep under control. In particular, gas mixtures affects the sensitivity of a single gas component (**matrix effect**). Pre-exposure to a reactive gas modifies sensitivities of single gases. The time stability is also an issue, in particular when SEM are used.

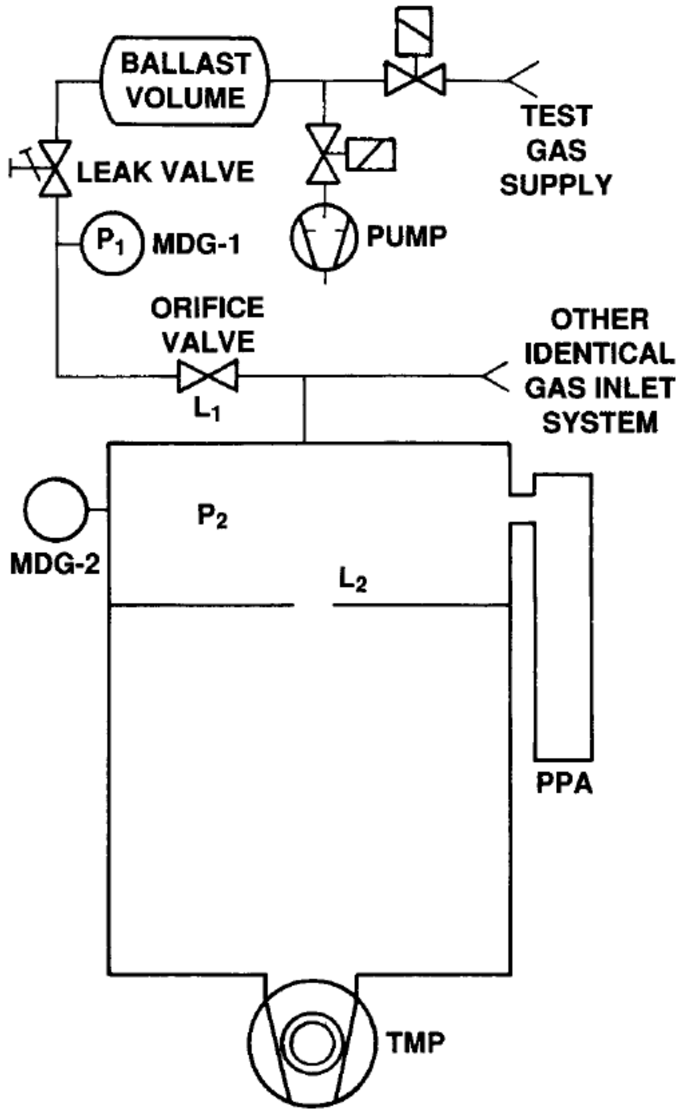
- For these reasons, **RGA are not calibrated against primary standard**.

- The simplest calibration method is to **compare its signal to that of an ionization gauge**. The sensitivity for the gas 'i' is:

$$S_i = \frac{I_{RGA} - I_0}{P_i - P_0}$$

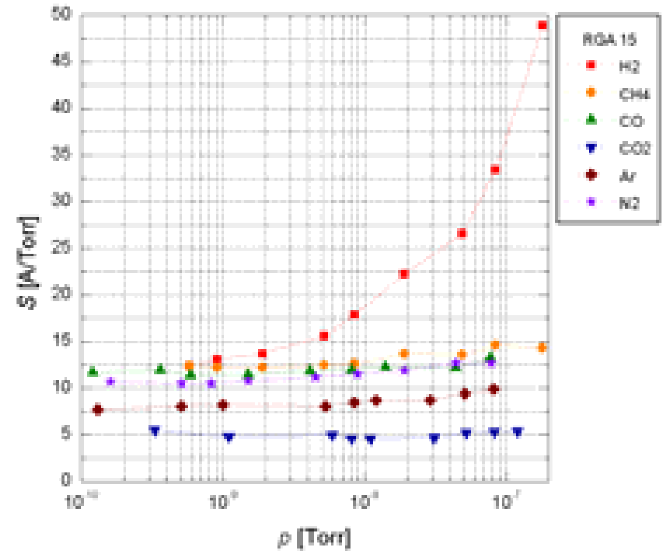
- **The relative sensitivity** is the ratio of the absolute sensitivity for a given gas to the absolute sensitivity for a **reference gas**.

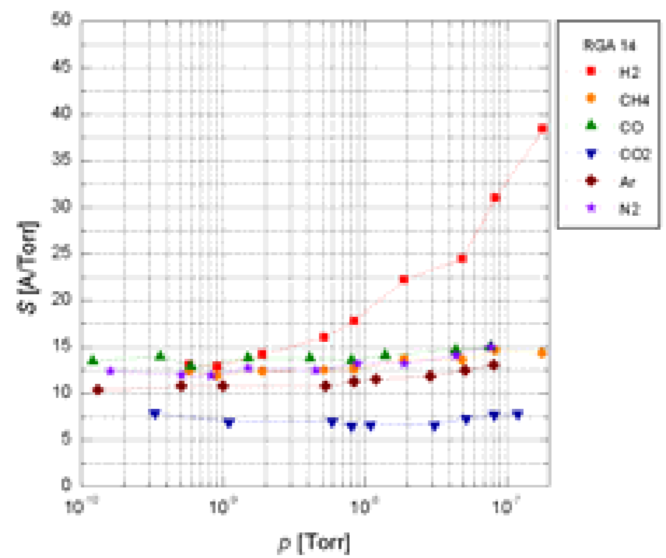
Calibration of Quadrupole Mass Analyzers



Lieszkovszky et al. , JVST-A, 8(1990)3838

QMA 125, SEM 1600, Ie= 2 mA, ***Courtesy of E. Mahner***



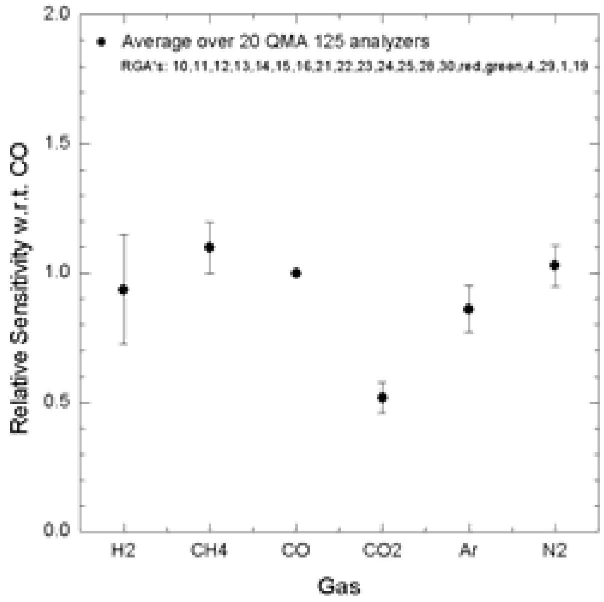


Calibration of Quadrupole Mass Analyzers

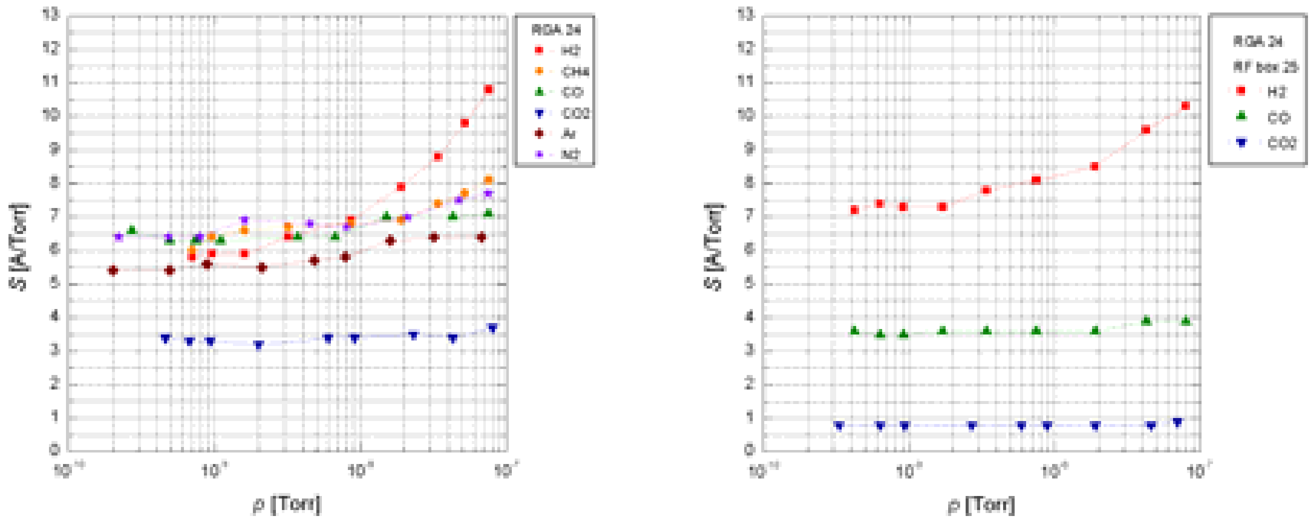
➢If quantitative measurement are necessary**, the RGA has to be recalibrated as frequently as reasonable in situ**. Fortunately the calibration for the full set of gas is not necessary because **the relative sensitivities do not change too much** (E. Mahner data: ±10%, except for H_2 23%) despite the usual drift of the absolute sensitivity. It is then enough to measure in situ the sensitivity for an 'heavy' gas (Ar or N_2) and hydrogen (the gas with the largest spreading in sensitivity).

➢ As a general rule, when a RGA is used for quantitative measurements, there should be the possibility of gas injection and total pressure reading.

➢ Another possibility consists in using calibrate leaks, for example for H_2 and N_2.

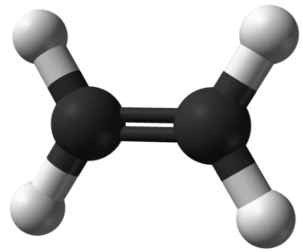


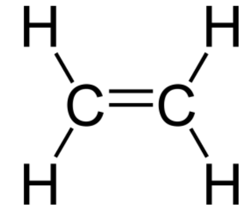
Calibration of Quadrupole Mass Analyzers



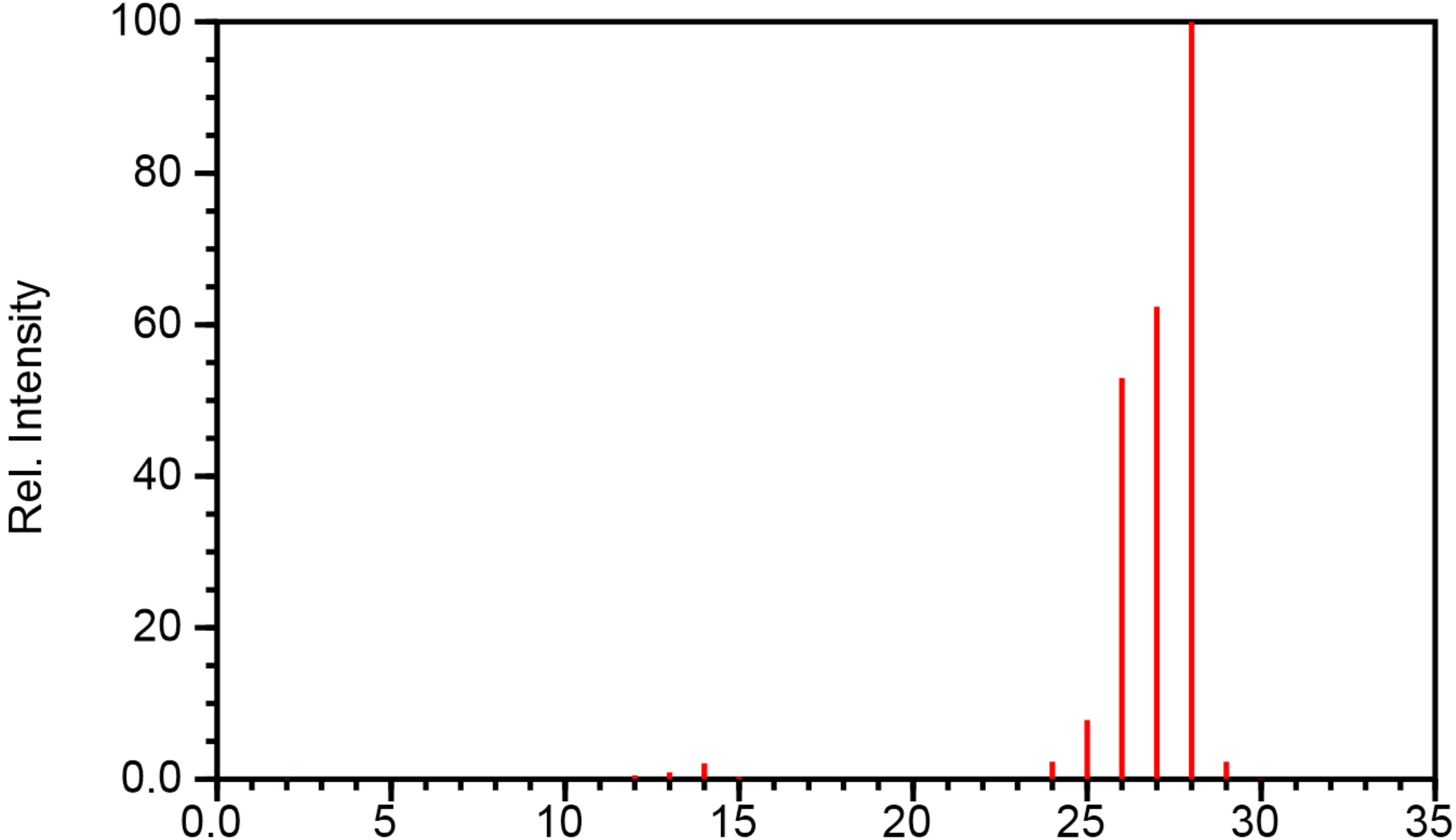
Experience at CERN (E. Mahner) indicates that ‘a change of the RF supply can strongly influence the sensitivity of the head. The Pfeiffer’s **QMA 125 head and the QME 125 RF box are tuned assemblies**’.

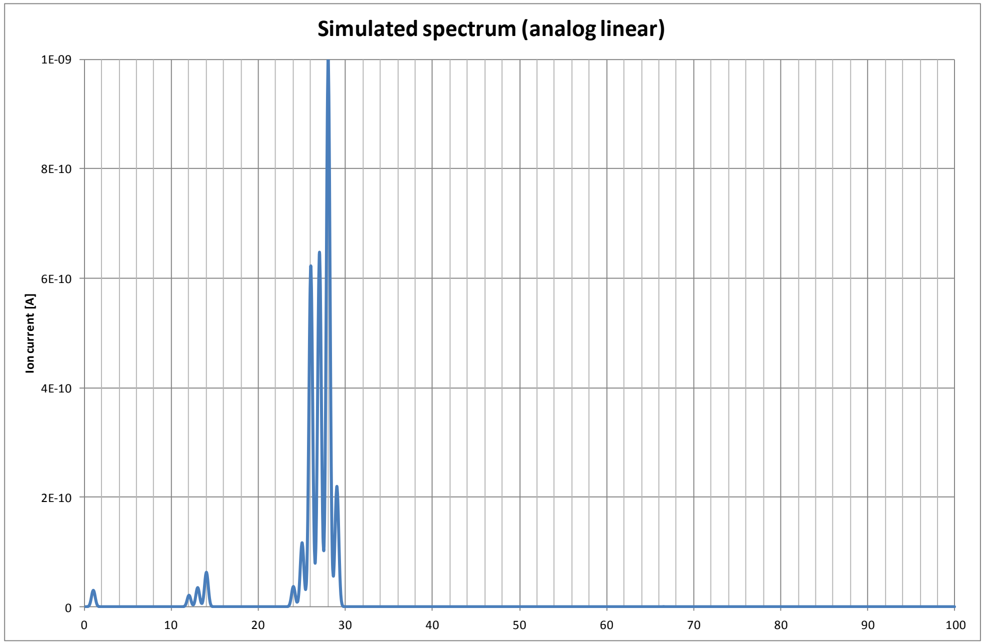
And now let’s put into practise…



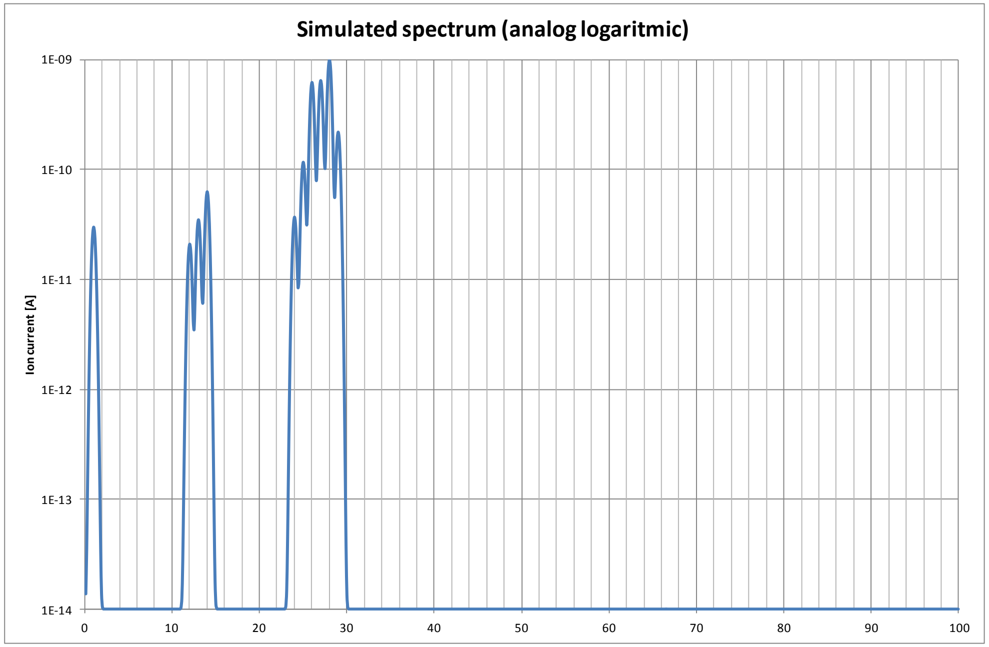


Ethylene
MASS SPECTRUM

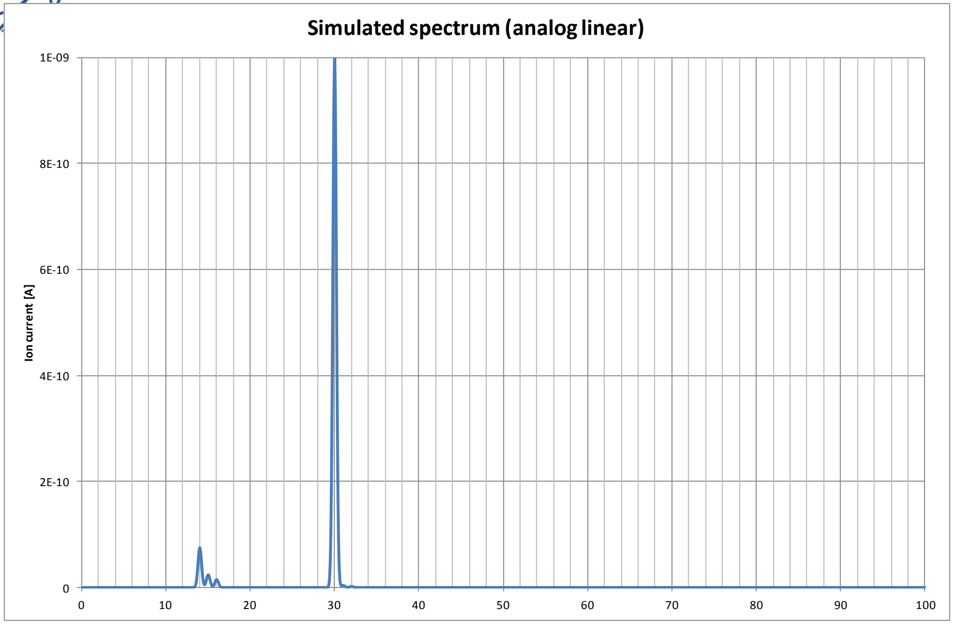


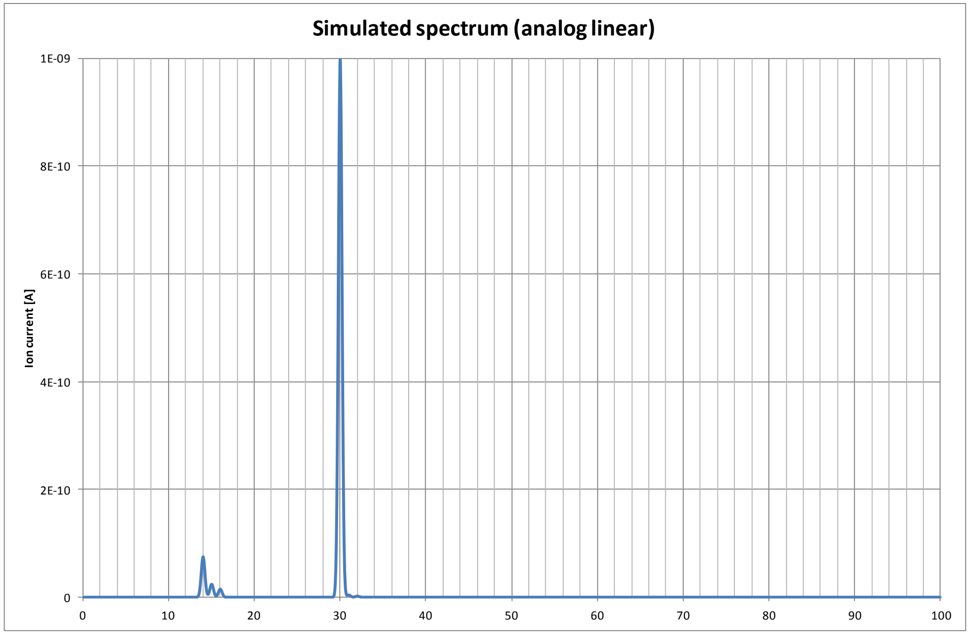


Simulated spectrum (analog linear)
Ion current [A]
1E-09
8E-10
6E-10
4E-10
2E-10
0
0
10
20
30
40
50
60
70
80
90
100



Simulated spectrum (analog logaritmic)
Ion current [A]
1E-09
1E-10
1E-11
1E-12
1E-13
1E-14
0
10
20
30
40
50
60
70
80
90
100


Simulated spectrum (analog linear)
Ion current [A]
1E-09
8E-10
6E-10
4E-10
2E-10
0
0
10
20
30
40
50
60
70
80
90
100


Simulated spectrum (analog linear)
Ion current [A]
1E-09
8E-10
6E-10
4E-10
2E-10
0
0
10
20
30
40
50
60
70
80
90
100

NO