ICP-MS measurements of enriched ^{82}Se samples for the LUCIFER experiment

presented by:

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Acknowledgements

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LNGS Chemistry Laboratory personal and the

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Thanks a lot!

It was a great experience!

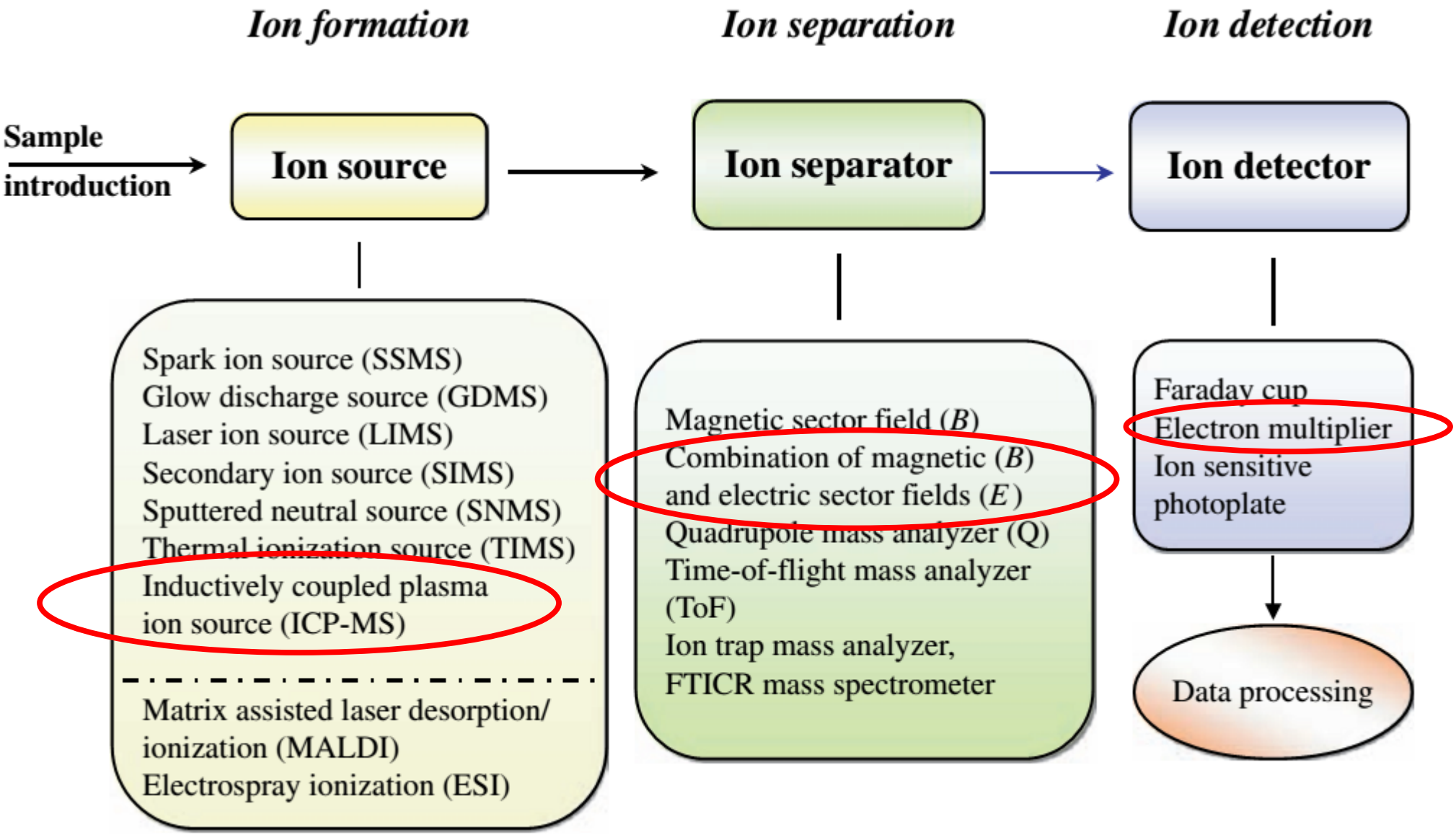
Project objective

LUCIFER – is an experiment for the search of neutrinoless double beta decay with the help of scintillating bolometers (e.g. ZnSe).

Two samples of enriched ^{82}Se material were sent to the LNGS Chemistry laboratory for **ICP-MS analysis of contamination** by the elements which are important for crystal growth and scintillation properties of the detectors.

Besides that we were able to check the **isotopic composition** of enriched and natural selenium.

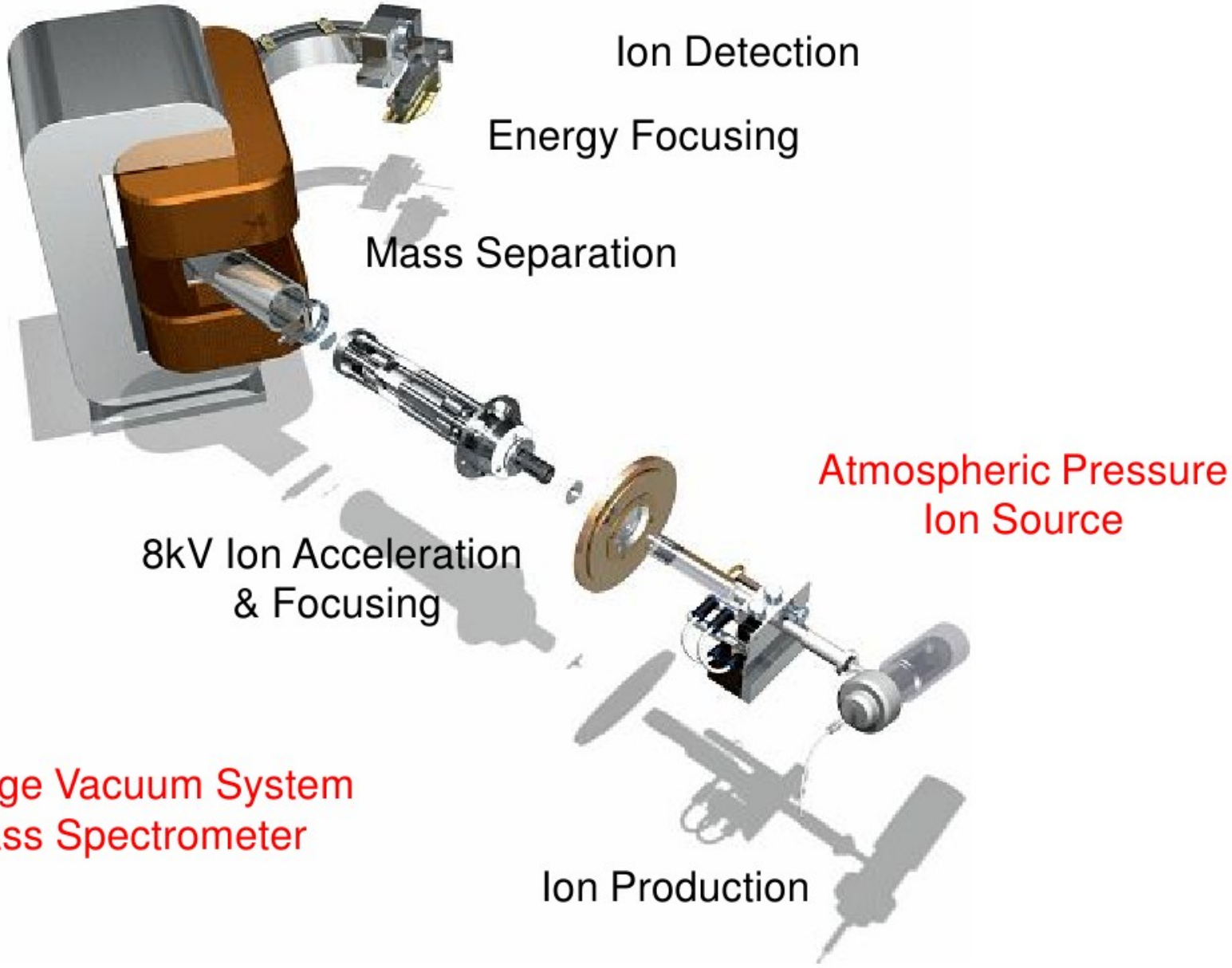
THERMO Finnigan ELEMENT2

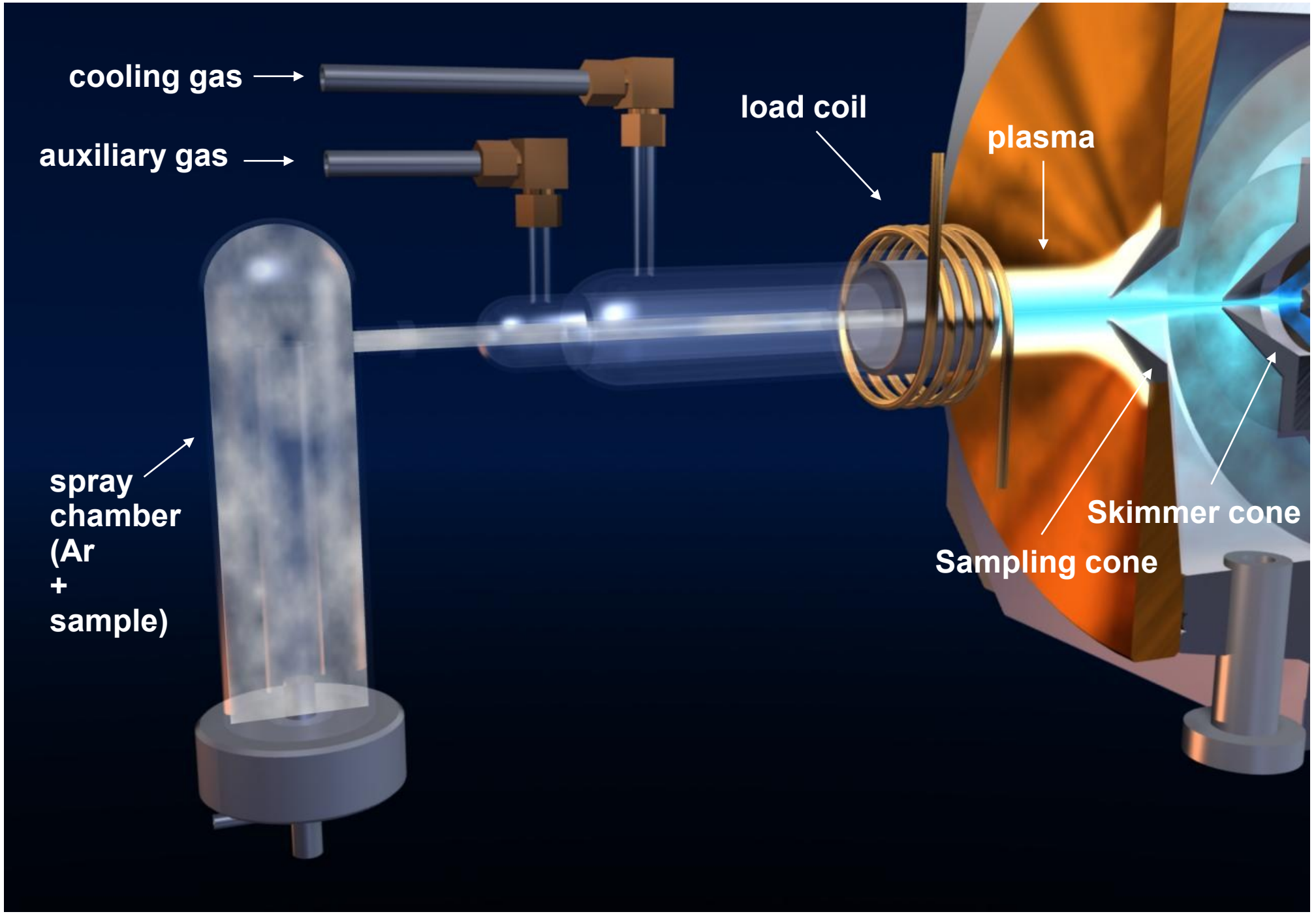


J. S. Becker, Inorganic mass spectrometry: principles and applications, Wiley, 2007

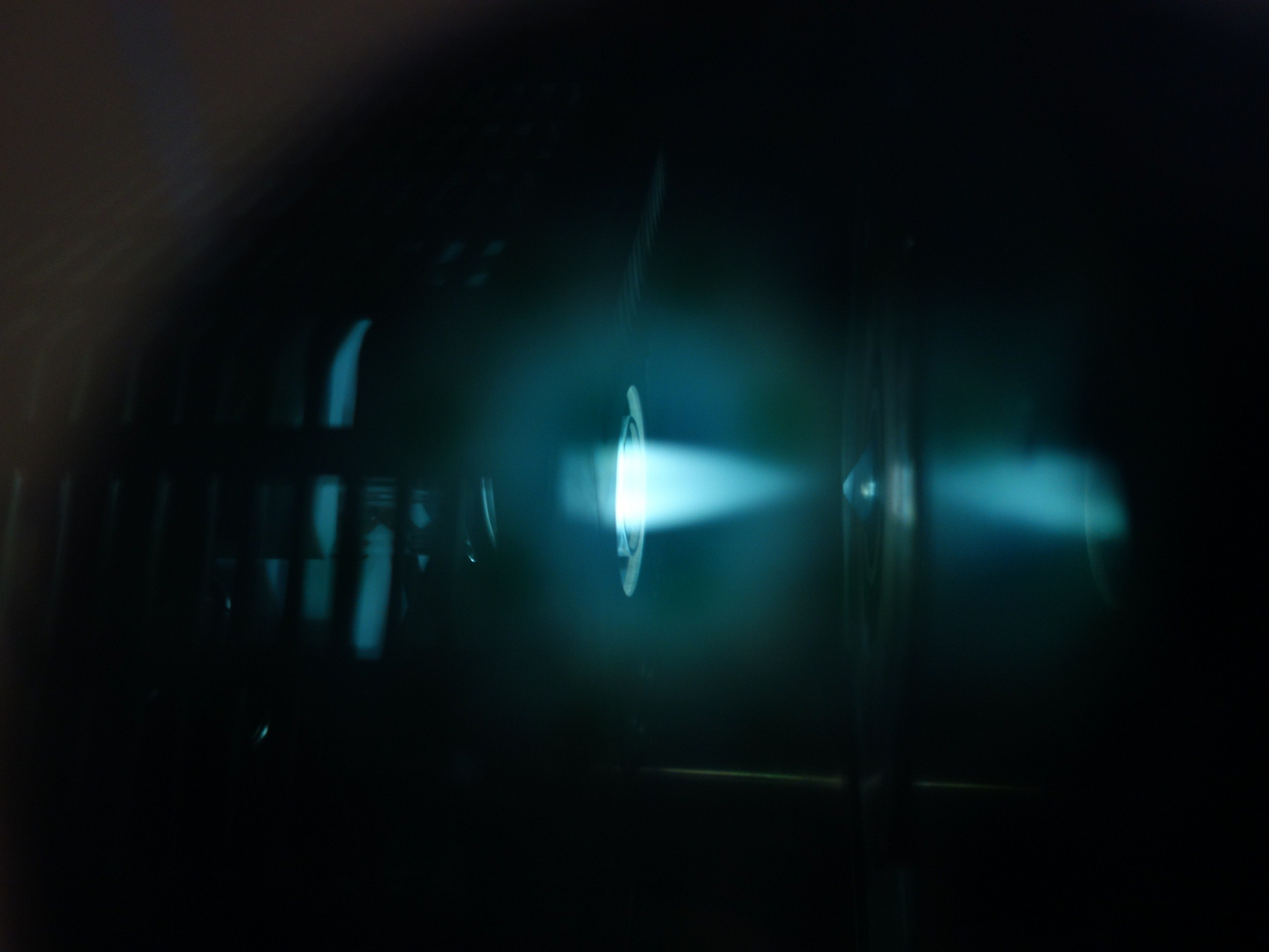
THERMO Finnigan ELEMENT2

Schematic of the ELEMENT2 ICP-MS




cooling gas
auxiliary gas
load coil
plasma
spray chamber (Ar + sample)
Skimmer cone
Sampling cone


ELEMENT 2



Interference

Interference is a masking of the peak of interest by another mono/polyatomic ions peak with close mass-to-charge ratio.

Solution: Resolution R = m / Δm (= const)

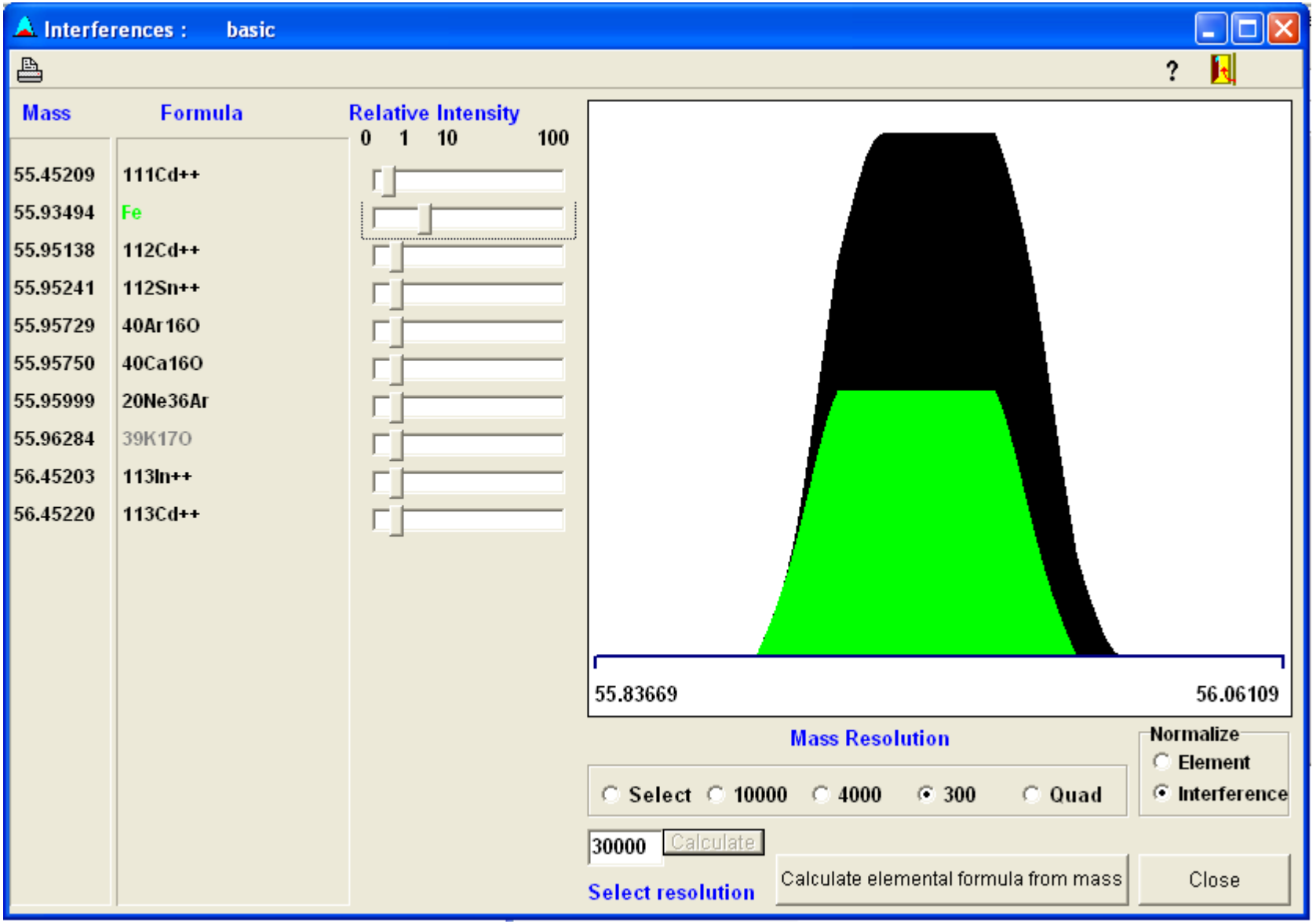
Δm = FW(5%)M

Low res: **R = 300**

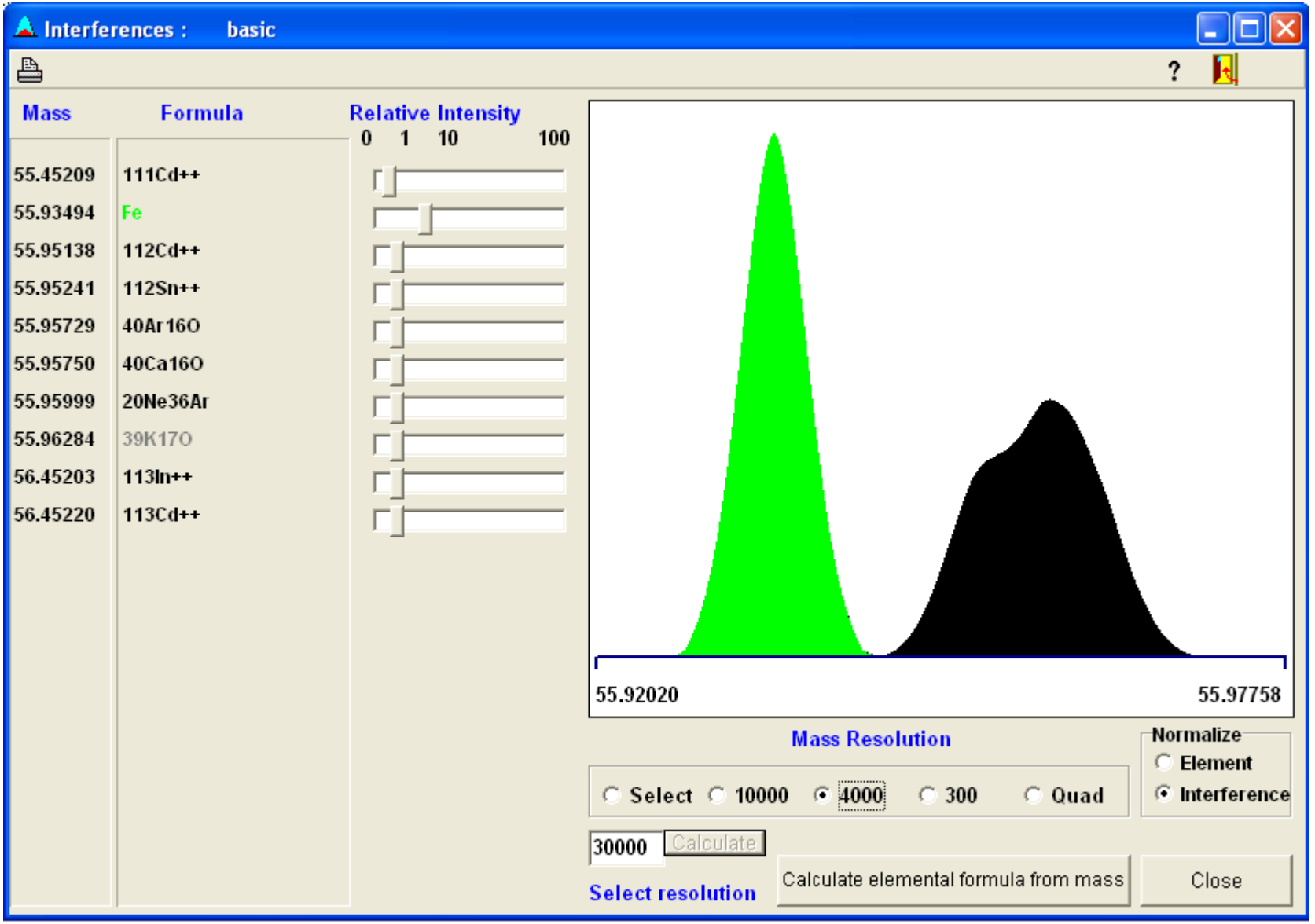
Medium res: **R = 4000**

High res: **R = 10000**

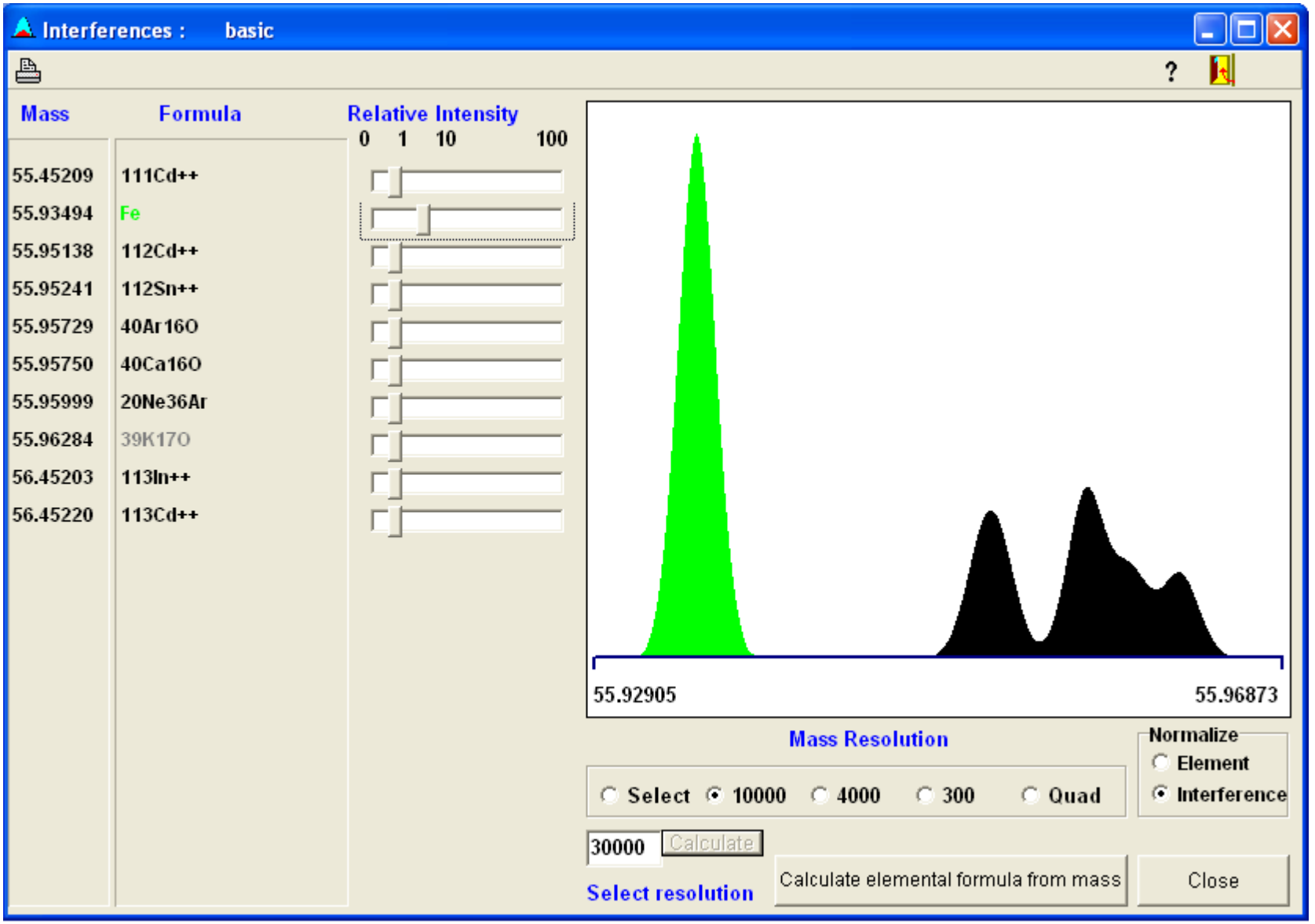
Low resolution (R=300)



Medium resolution (R=4000)

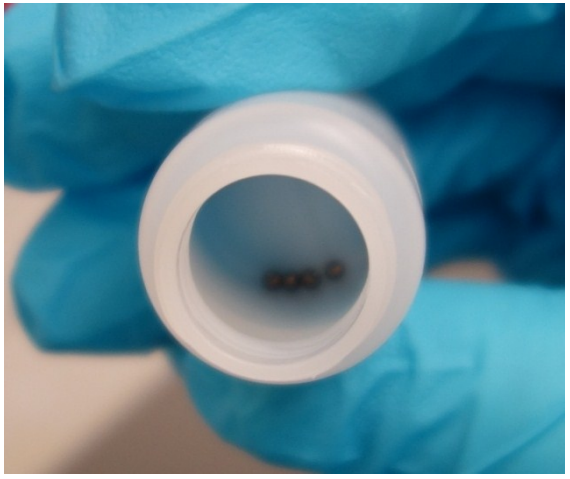


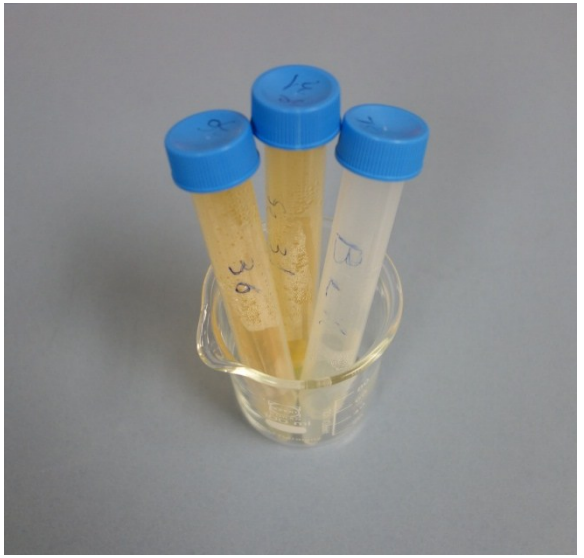
High resolution (R=10000)



Enriched ^{82}Se samples

Sample	Sample preparation	Dilution
Sample #1	m = 65 mg, dissolved in 1 ml HNO_3 up to 10 ml, diluted 12 times with UP water	1846
Sample #2	m = 99 mg, dissolved in 1 ml HNO_3 up to 10 ml, diluted 18 times with UP water	1818






ASX-520
AutoSampler
DELL

Contamination of samples

Isotope	Sample #1, *ppb*	Sample #2, *ppb*
Mg24(LR)	< 90	< 90
Mn55(LR)	< 20	< 20
Co59(LR)	< 20	< 20
Cu63(LR)	< 27	18
Cd110(LR)	< 20	< 20
W182(LR)	33	18
Pb206(LR)	< 40	< 40
Bi209(LR)	< 1	< 1
Th232(LR)	< 1	< 1
U238(LR)	< 2	< 2
Na23(LR)	< 1000	3300
Sb121(LR)	< 2	< 2
Hg202(LR)	< 2	< 3
Te125(LR)	3300	5400
Mo95(LR)	24	14
Sm152(LR)	< 2	< 2

Isotope	Sample #1, *ppb*	Sample #2, *ppb*
Al27(MR)	< 1800	< 1800
Ca44(MR)	< 7000	< 7000
Cr52(MR)	< 20	< 20
Fe56(MR)	< 500	< 500
Si28(MR)	14000	< 10000
V51(MR)	< 90	< 90
S32(MR)	185000	180000
Ni58(MR)	< 100	< 100
As75(MR)	< 90	< 50
Co59(MR)	< 10	< 10
K39(HR)	< 1800	< 1800

The concentrations refers to the solid samples; the uncertainty is about 5%.

Isotopic composition

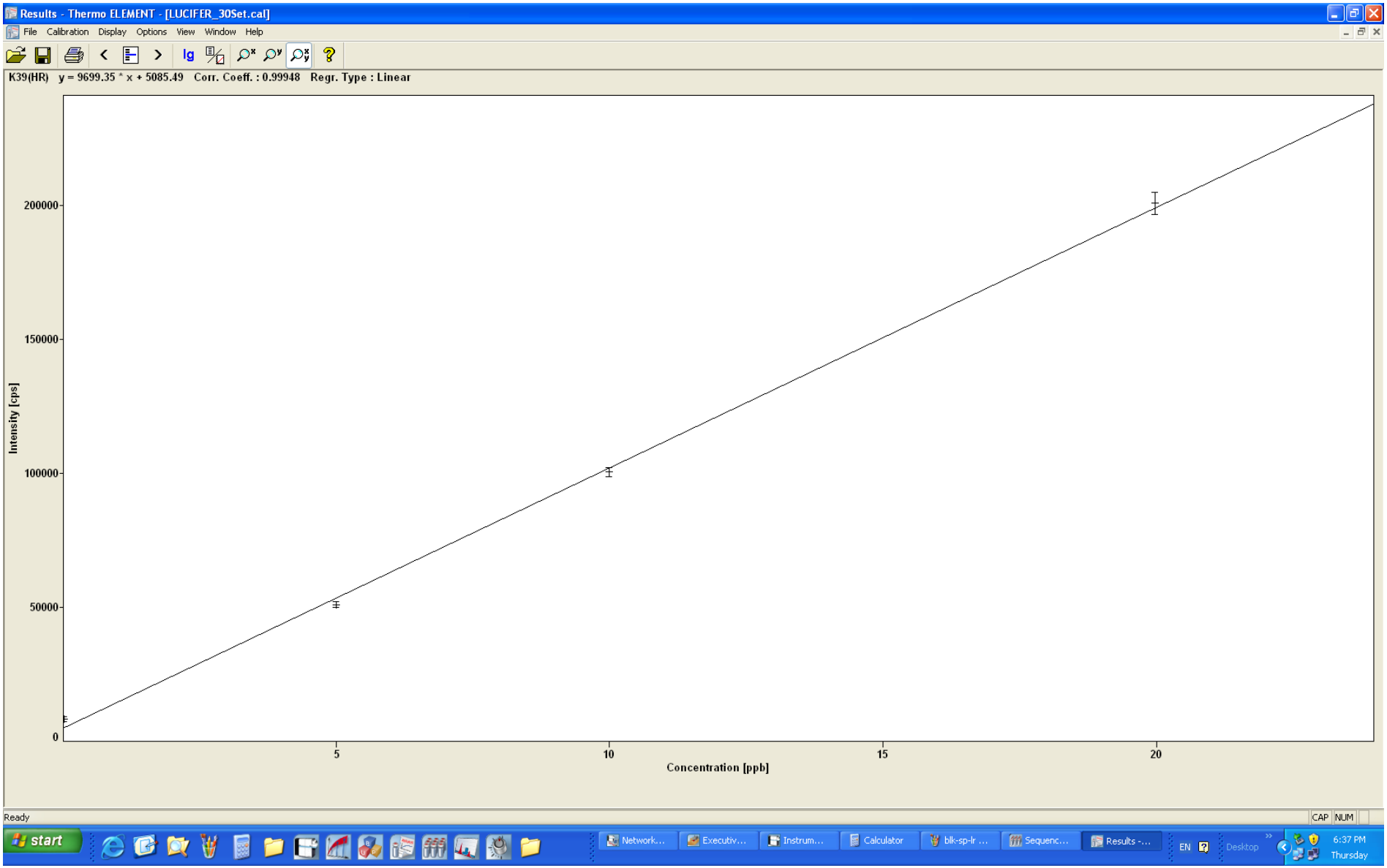
Se Isotope	Ref. Nat., %	Exp. Nat., %	Exp. Enr., %
74	0.89	0.72 ± 0.02	< 0.001
76	9.37	8.66 ± 0.26	< 0.08
77	7.63	6.74 ± 0.20	< 0.004
78	23.77	23.31 ± 0.70	< 0.02
80	49.61	50.94 ± 1.53	4.8 ± 1.4
82	8.72	9.63 ± 0.29	95.1 ± 2.9

Summary

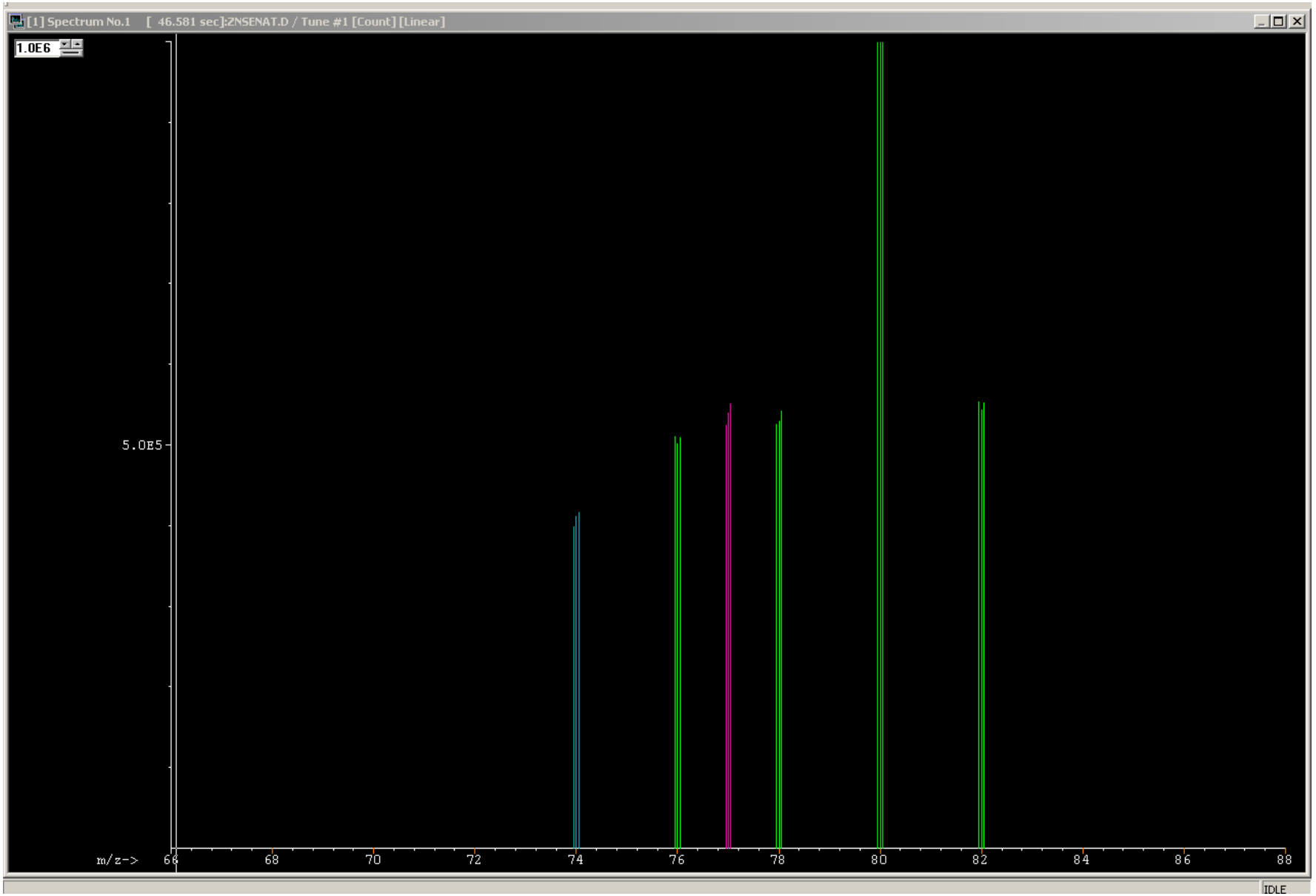
- Within this project I got in touch with ICP-MS and different chemical research tools
- The contamination of selenium samples was studied and results were sent to the LUCIFER collaboration
- Isotopic composition was measured and compared with natural selenium. The values are compatible with previous measurements.
- ICP-MS is often a necessary technique for low-background experiments and the knowledge I acquired I find very useful

BACKUP SLIDES

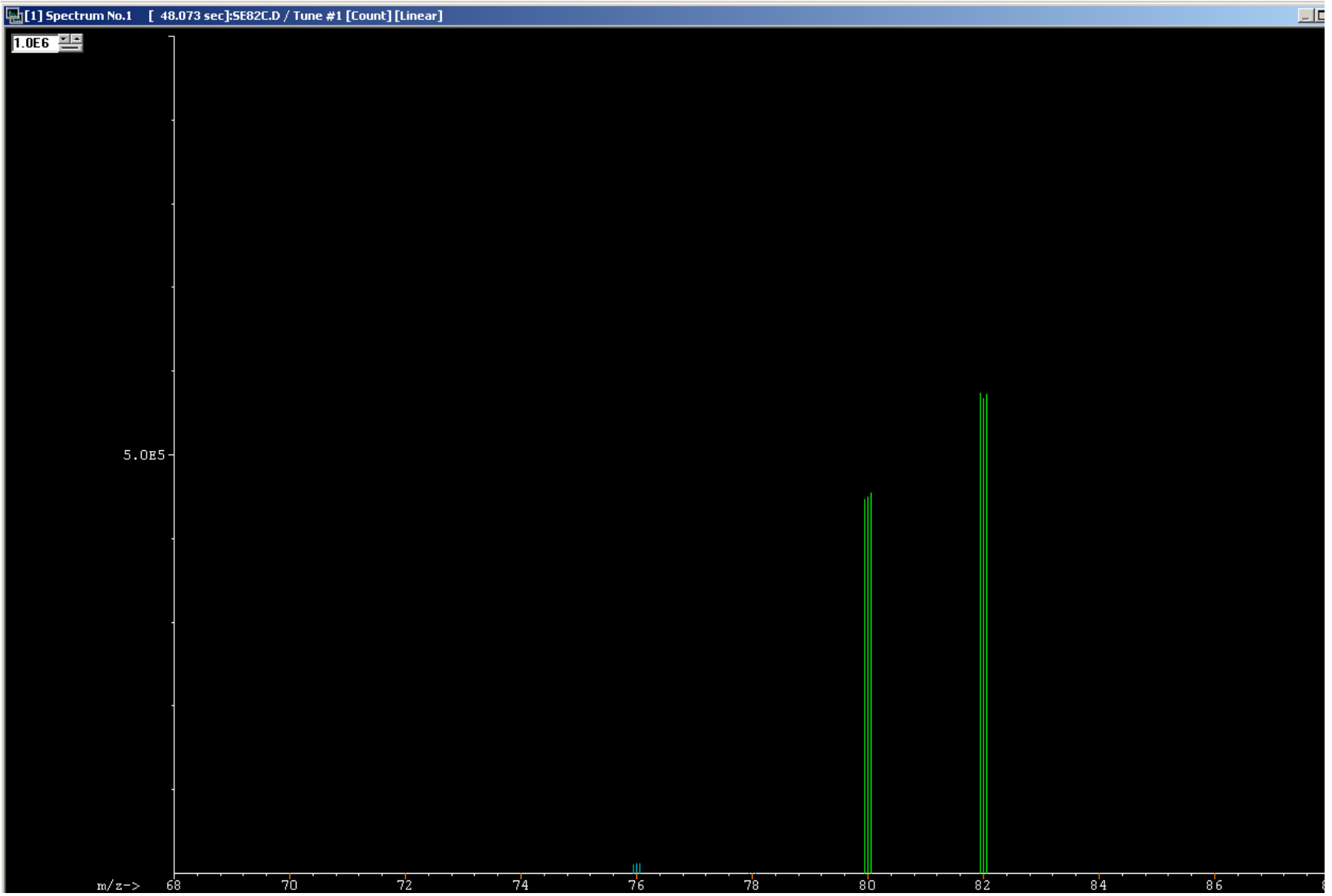
Calibration: ^{39}K (HR)

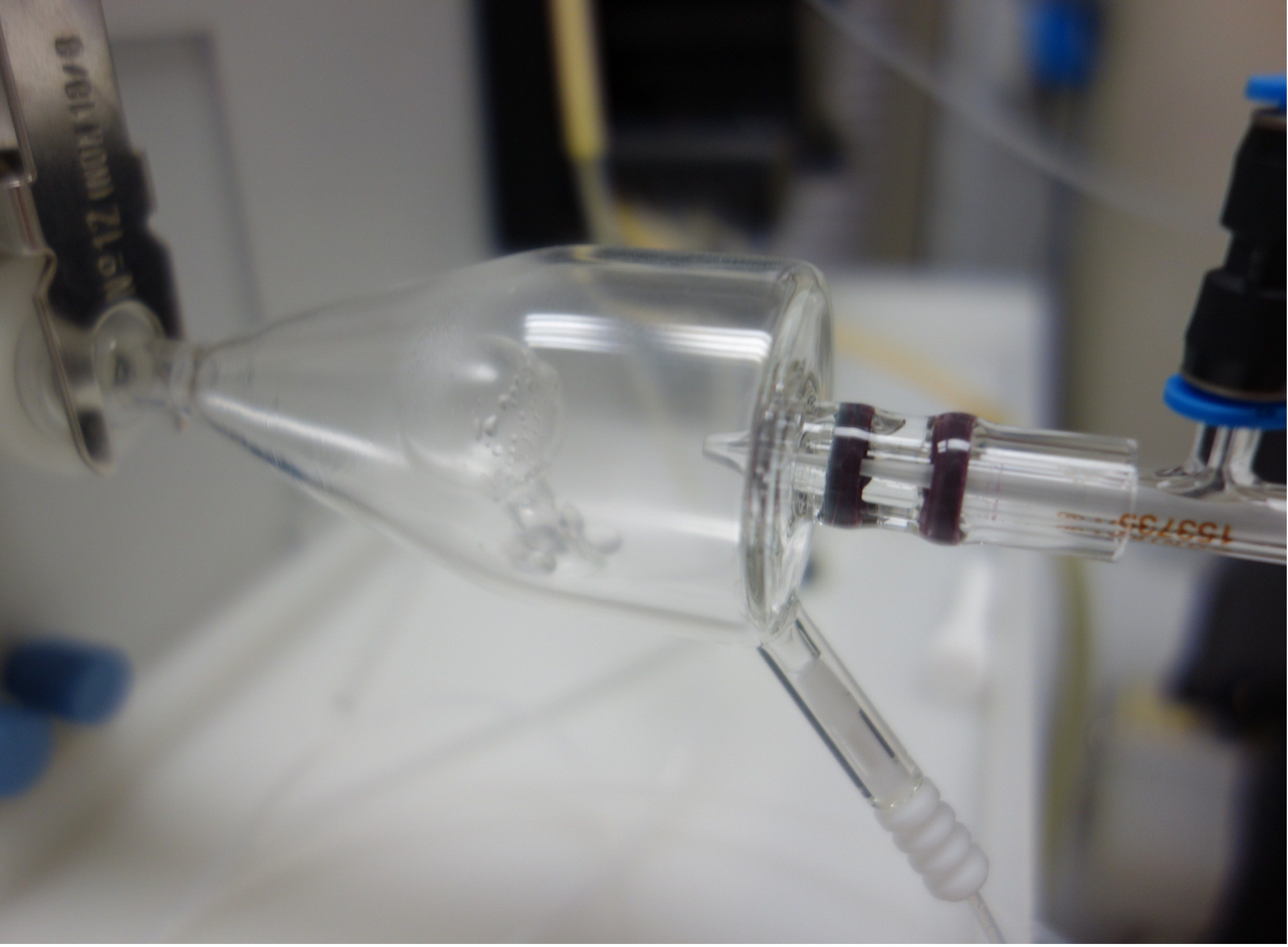


Natural Se sample



Enriched ^{82}Se sample

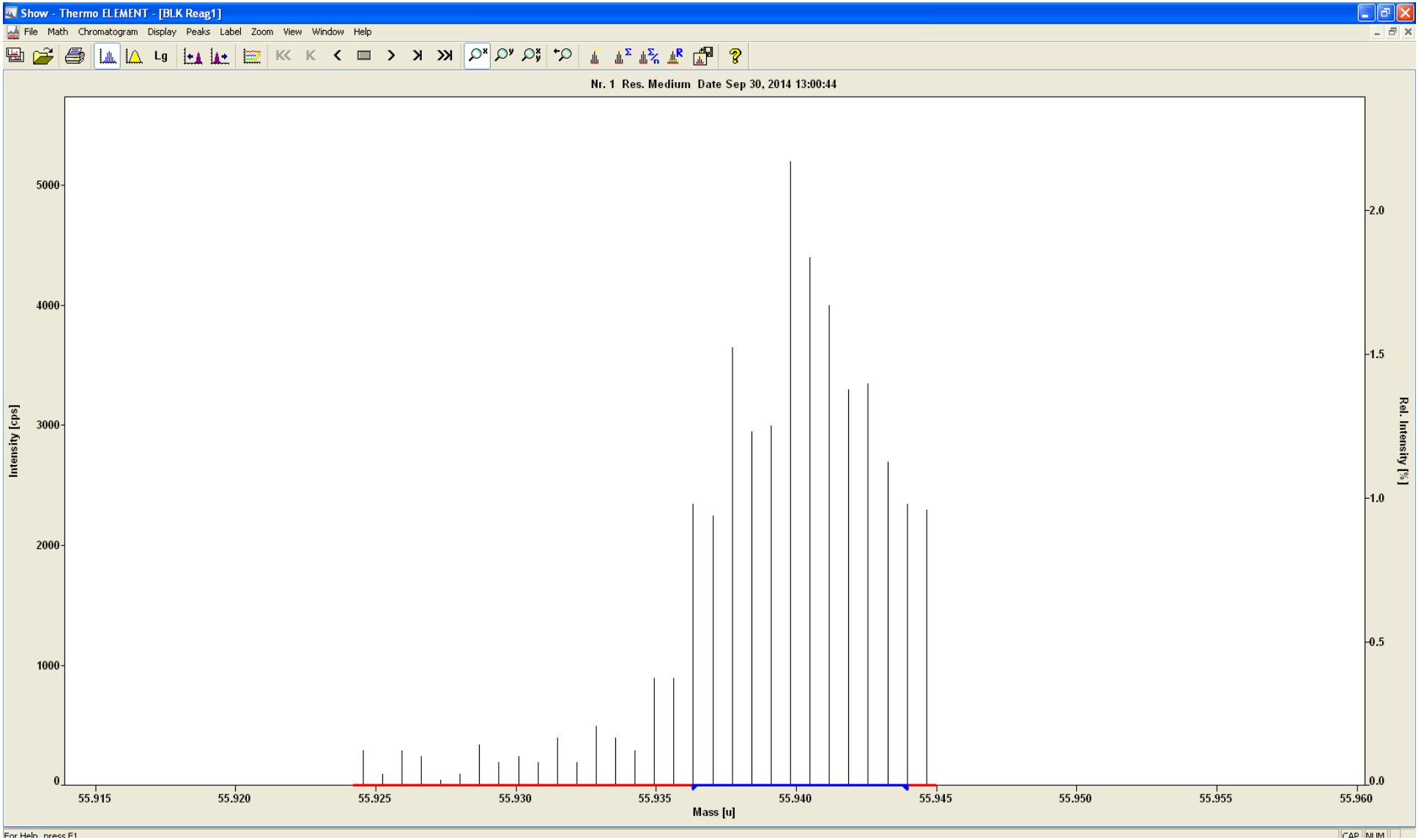




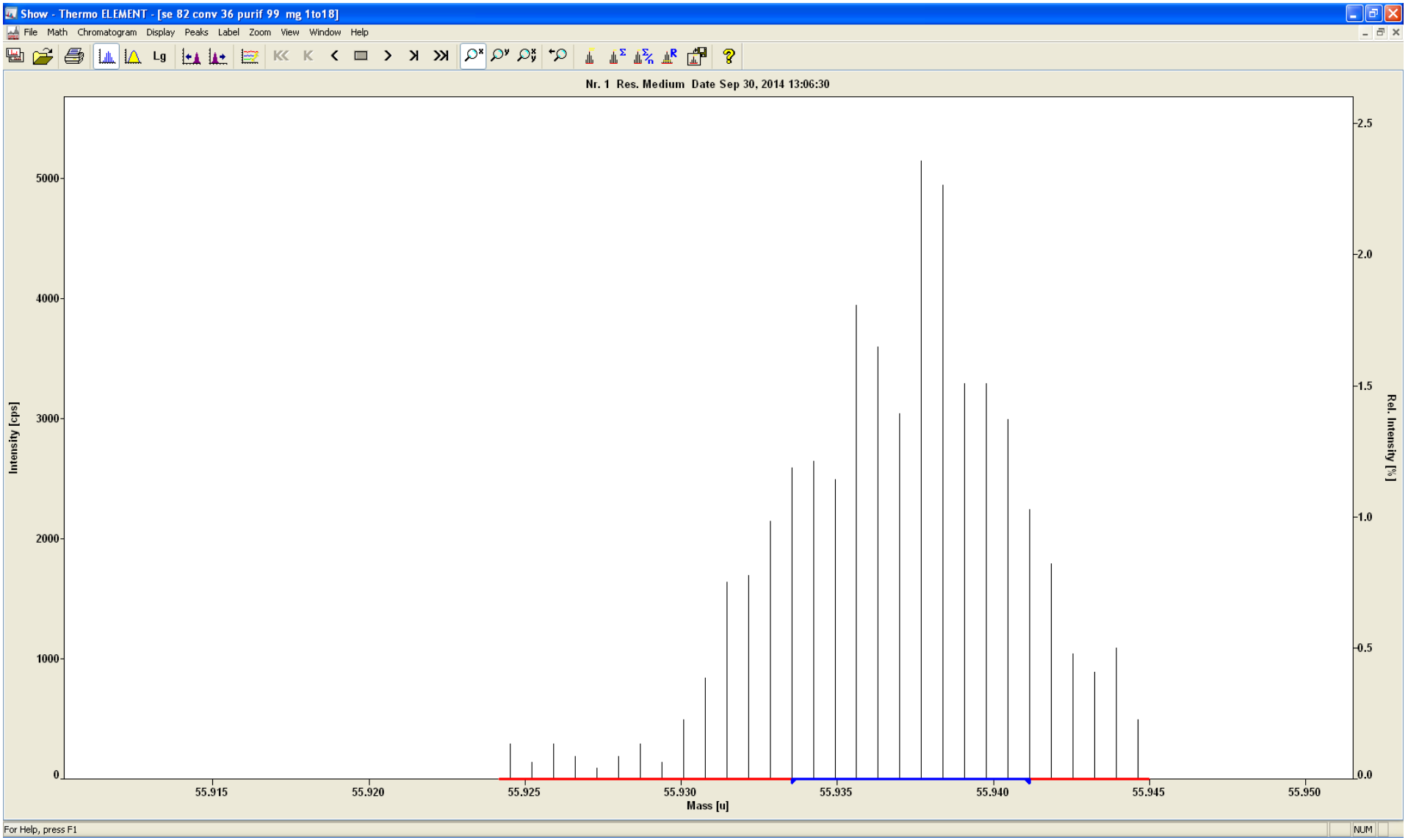
Challenge 2 - background

Presence of the isotope of interest in the blank sample

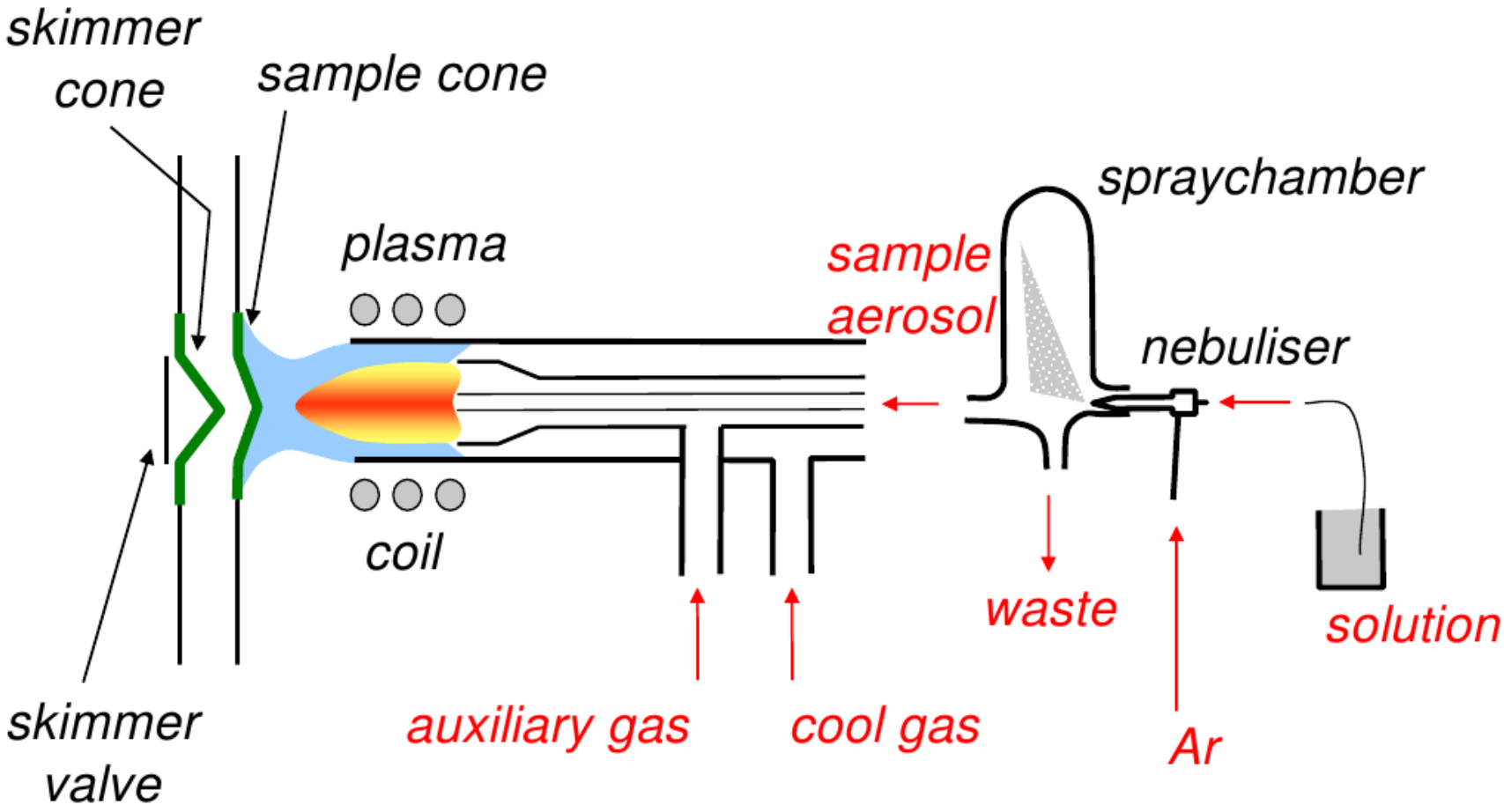
Blank sample spectrum: ^{56}Fe



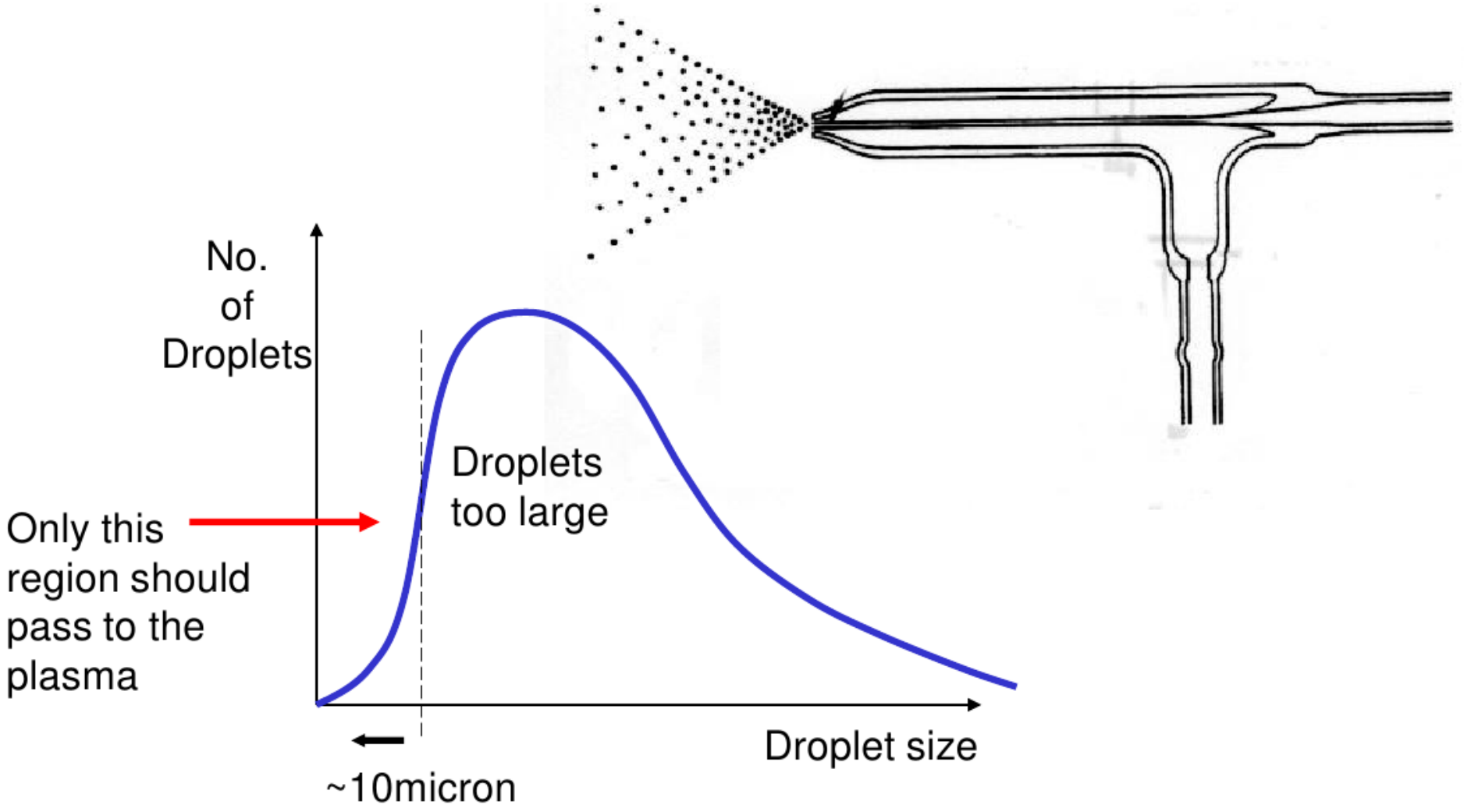
Test sample spectrum: ^{56}Fe



How to get a sample into the mass spectrometer?

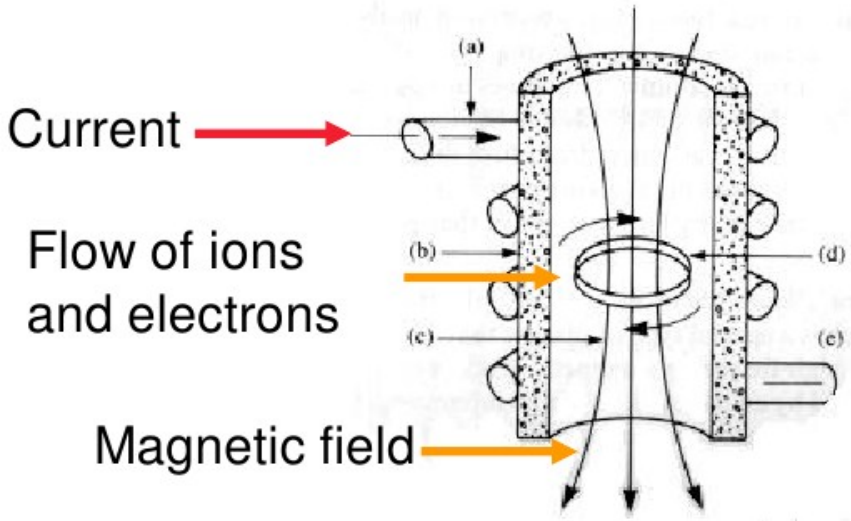


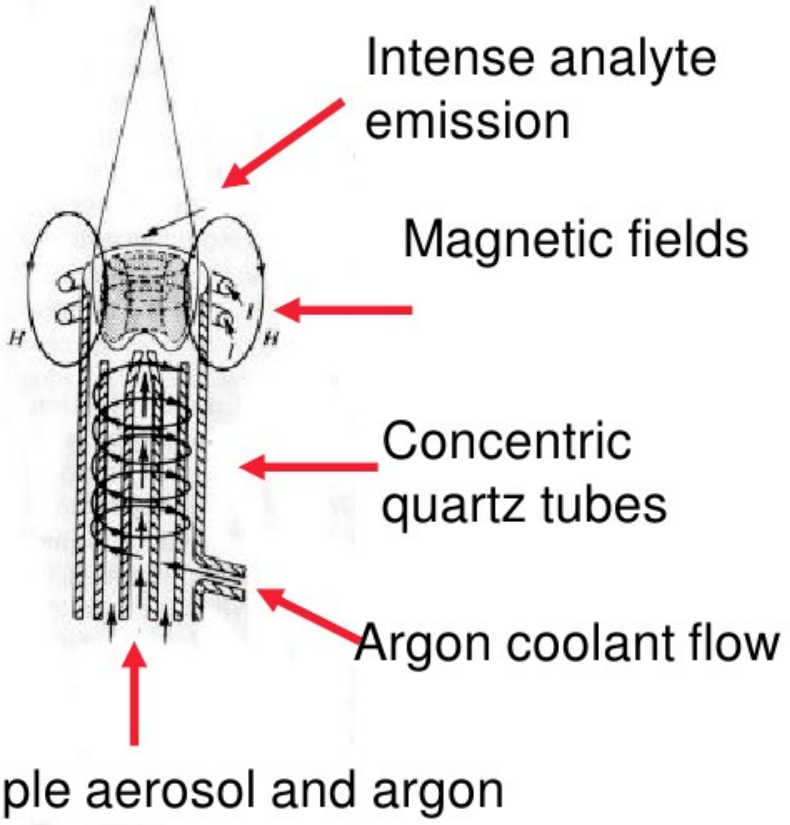
Liquid Sample Introduction – Droplet size



H. Willard, L. Merritt, J. Dean, F. Settle:
Instrumental Methods of Analysis; Wadsworth Publishing Company

Argon Plasma Formation





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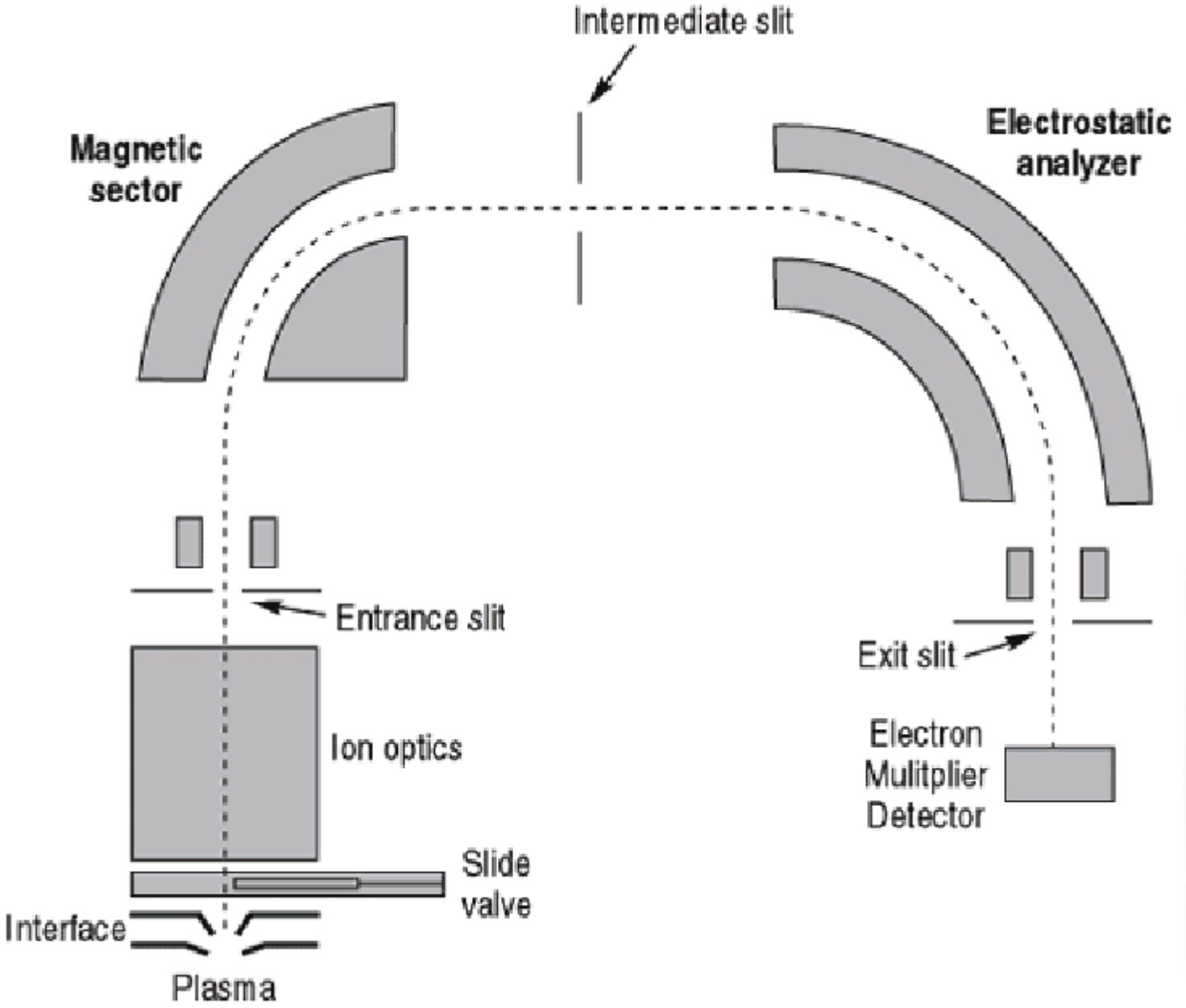
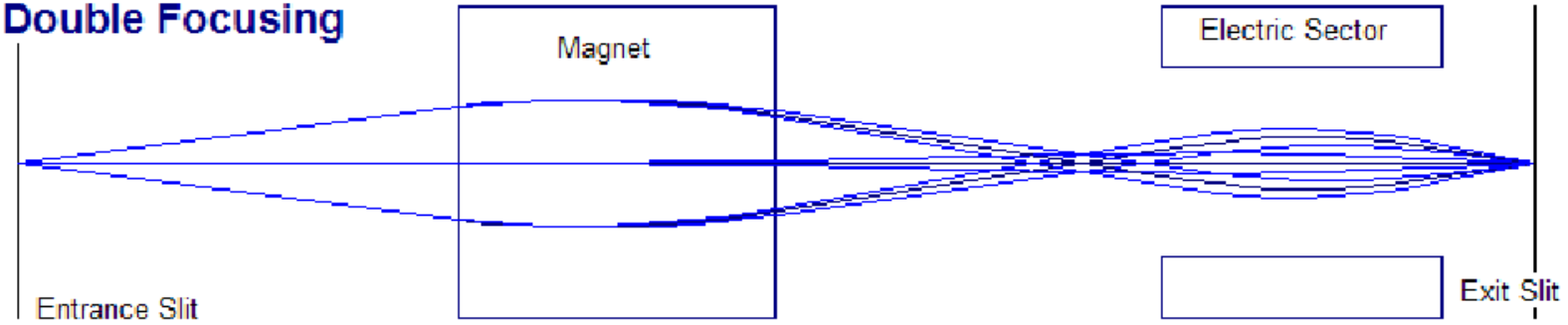
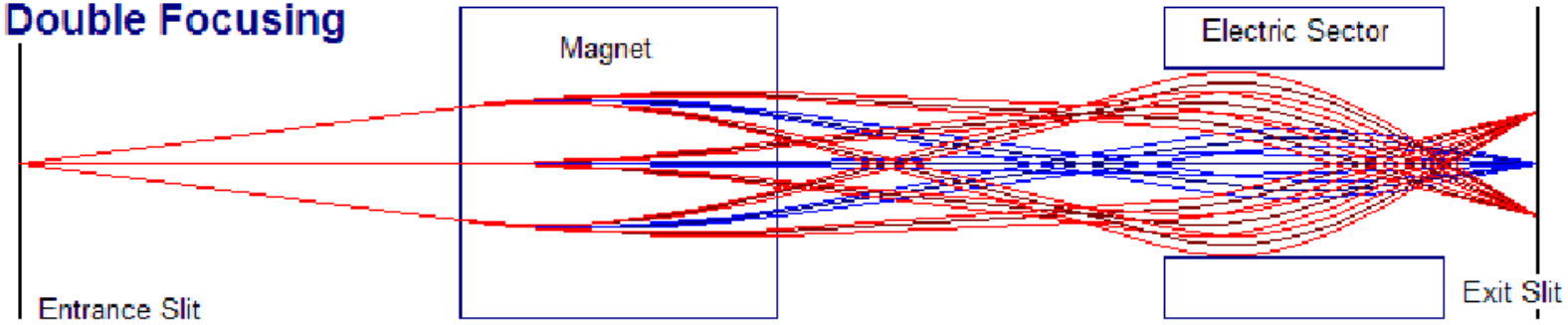

Intermediate slit
Magnetic sector
Electrostatic analyzer
Entrance slit
Exit slit
Ion optics
Electron Mulitplier Detector
Slide valve
Interface
Plasma

Double Focusing

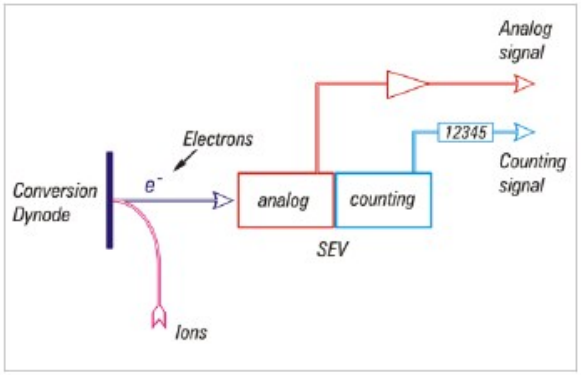


Double Focusing

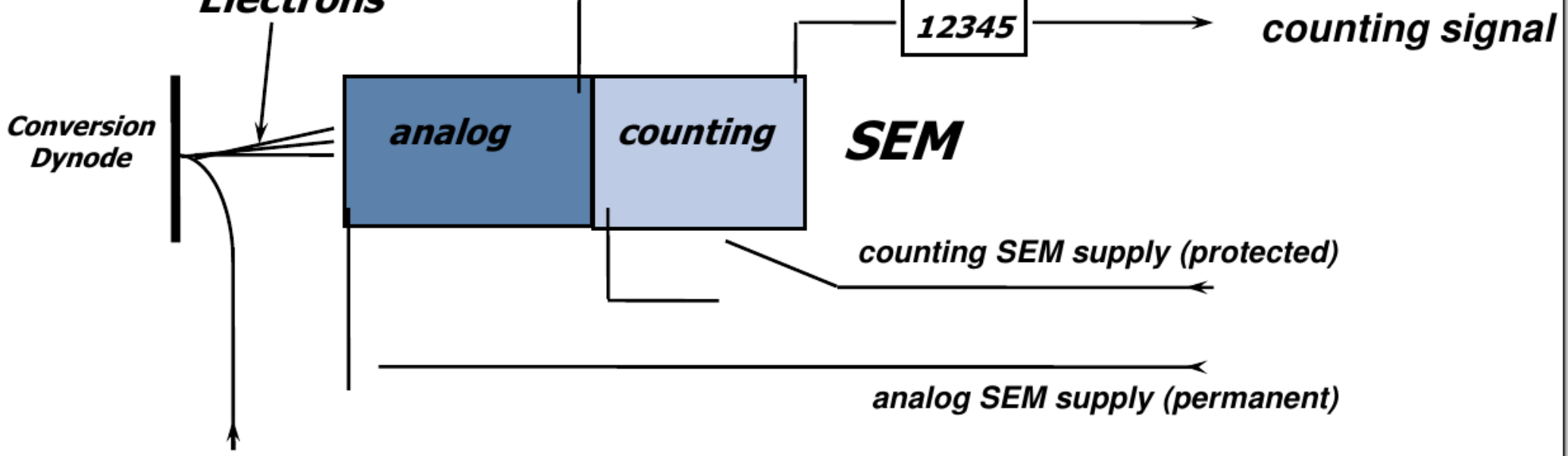


ESA

Ion Deflector
&
Conversion
Dynode



Secondary
Electron
Multiplier



* Simultaneous Registration of analog and counting signals
* No signal loss due to switching
* Automatic protection of the counting circuit
* Automatic 'on-the-fly' cross-calibration by the data system