# Mass spectrometric measuring complex for the detection of signs of life in Europa's ice surface

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# For the detection of the signs of life on Europa, is proposed measuring complex, containing:

- Sample loading and processing system. It can obtain ice sample from 20 cm or deeper surface layer, then melt it and extract biomass from the ice surface water by filtration;
- Laser TOF MS for the measurements of element composition of the biomass;
- Gas TOF MS for the detection of:

  1) volatile components, generated at the heating of biomass sample (closed window mode);

  2) secondary ions, emitted from ice matrix by the influence of energetic magnetosphere ions (external ions registration mode or open window mode)

**Therefore, as a result of the experiment, 3 types of measurements will be performed:**

1. Measurements of element composition of the biomass sample.

   Different live cells have similar element composition. Amplitude values and mass peak ratios of carbon, oxygen, nitrogen, hydrogen can tell if the sample refers to microorganism.

   Ratio of potassium, calcium, phosphorus, and sulfur elements and some other microelements can serve as a marker, indicating the state of microorganism.

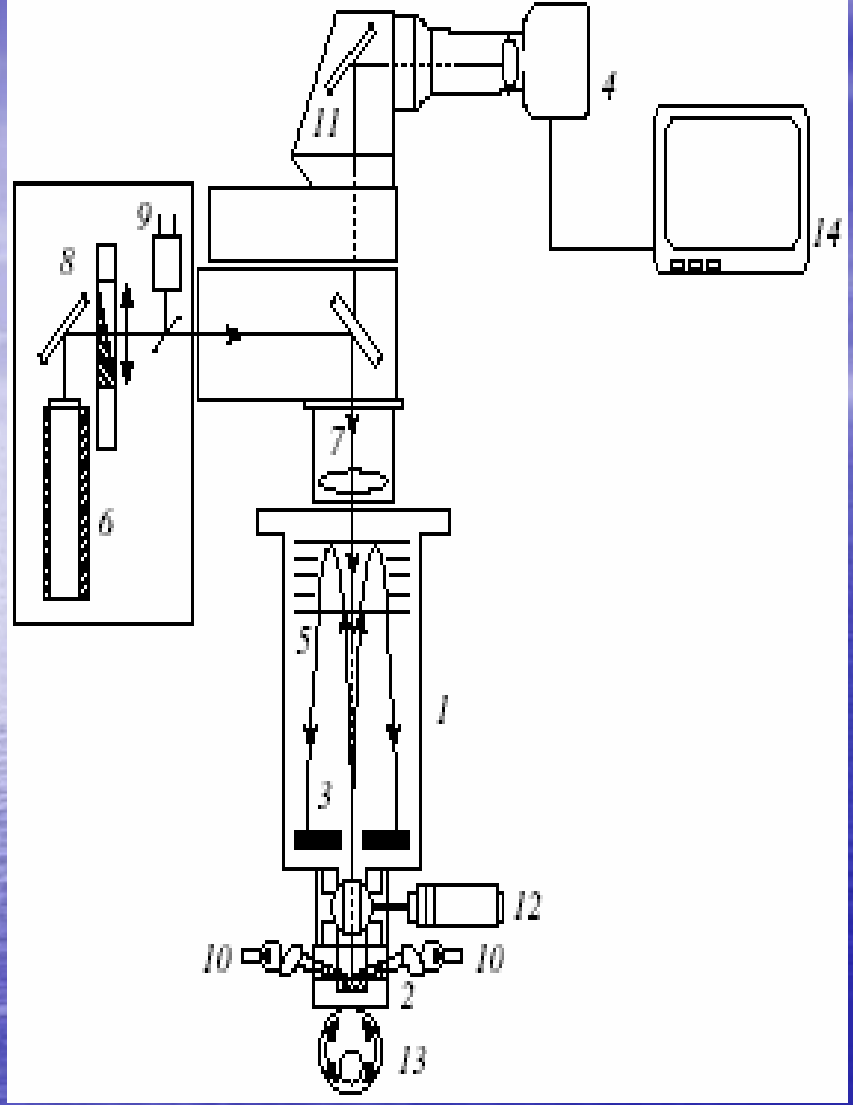
   The comparison of experimental data with the library of reference spectra of Earth microorganisms will provide information on their similarity.

2. Measurements of masses of molecular ions, obtained from the biomass sample after its thermal evaporation and ionization of the generated gas by electron shot.

This measurements will show the possibility of organic compounds presence in the ocean of Europa.

3. Measurements of molecular masses of secondary ions from ice matrix. These ions can be emitted by primary energetic magnetosphere particles in the process similar to fast atom bombardment. For the first time the possibility of OC ions emission was shown in the works of G. Tantsirev in 1980.

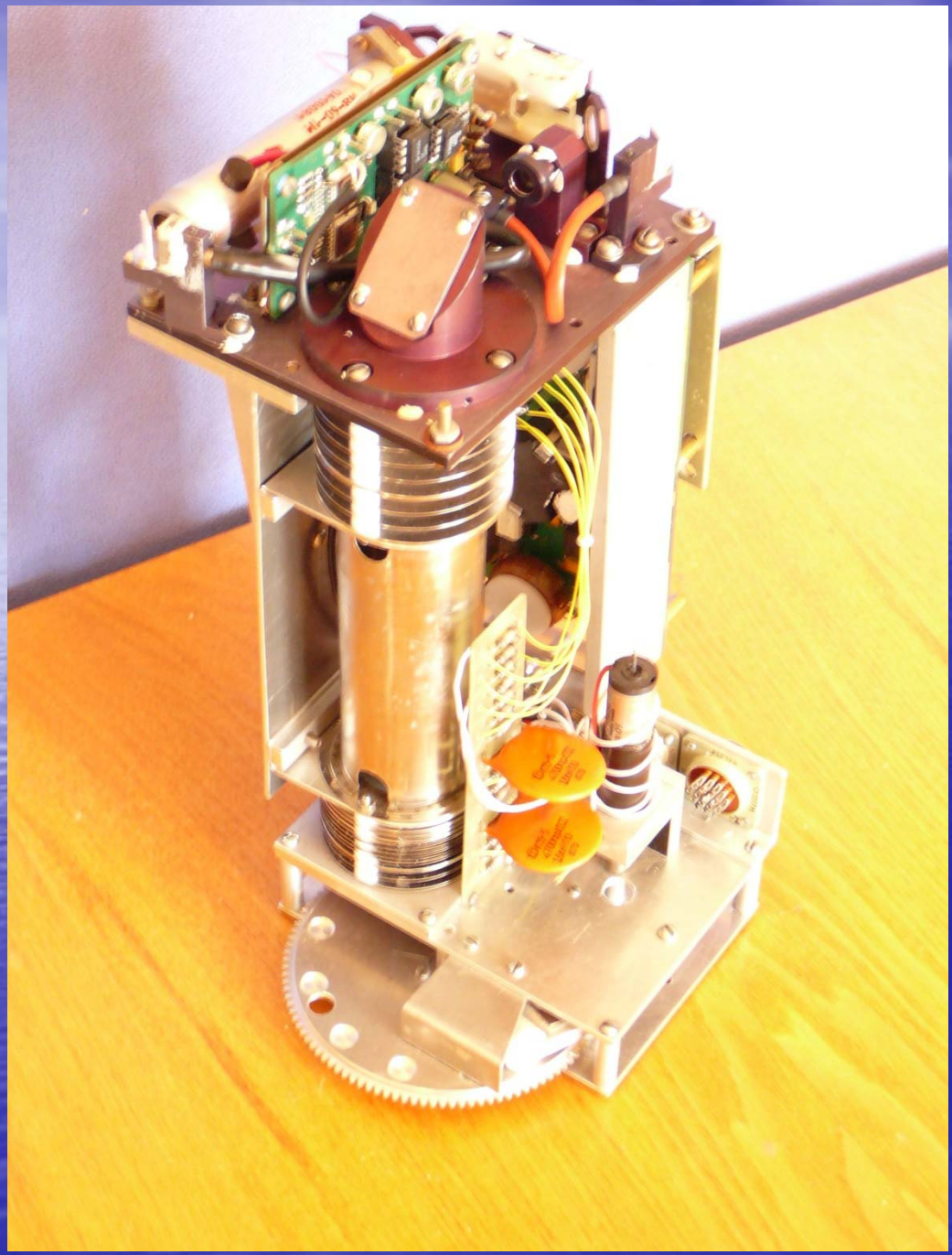
Detection of "heavy" molecular ions will indicate that ice matrix of Europa contains OC. Due to low temperature and high radiation formation of OC on the surface of Europa is unlikely, therefore it is more probable that they are present in the ice matrix and so in the subsurface ocean.




**A scheme of the laser TOF MS:**

**1—vacuum chamber,**
**2—interchangeable carriage with sample,**
**3—detector,**
**4—TV camera,**
**5—reflector,**
**6—laser,**
**7—focusing lenses,**
**8—neutral filter,**
**9—radiation power meter,**
**10—target illuminator,**
**11—microscope,**
**12—motorized vacuum valve,**
**13—carriage adjusting system,**
**14—monitor.**

Laser source with a focusing system concentrates energy into spot diameter of 50 microns on the target surface. Ions emitted as a result of Q-switch laser irradiation are reflected in the field of the electrostatic reflector and directed to the detector where they form narrow mass peaks. The amount of ions in mass peaks is proportional to the concentration of ionized materials in a sample. High reproducibility of data is provided through axis symmetrical configuration.

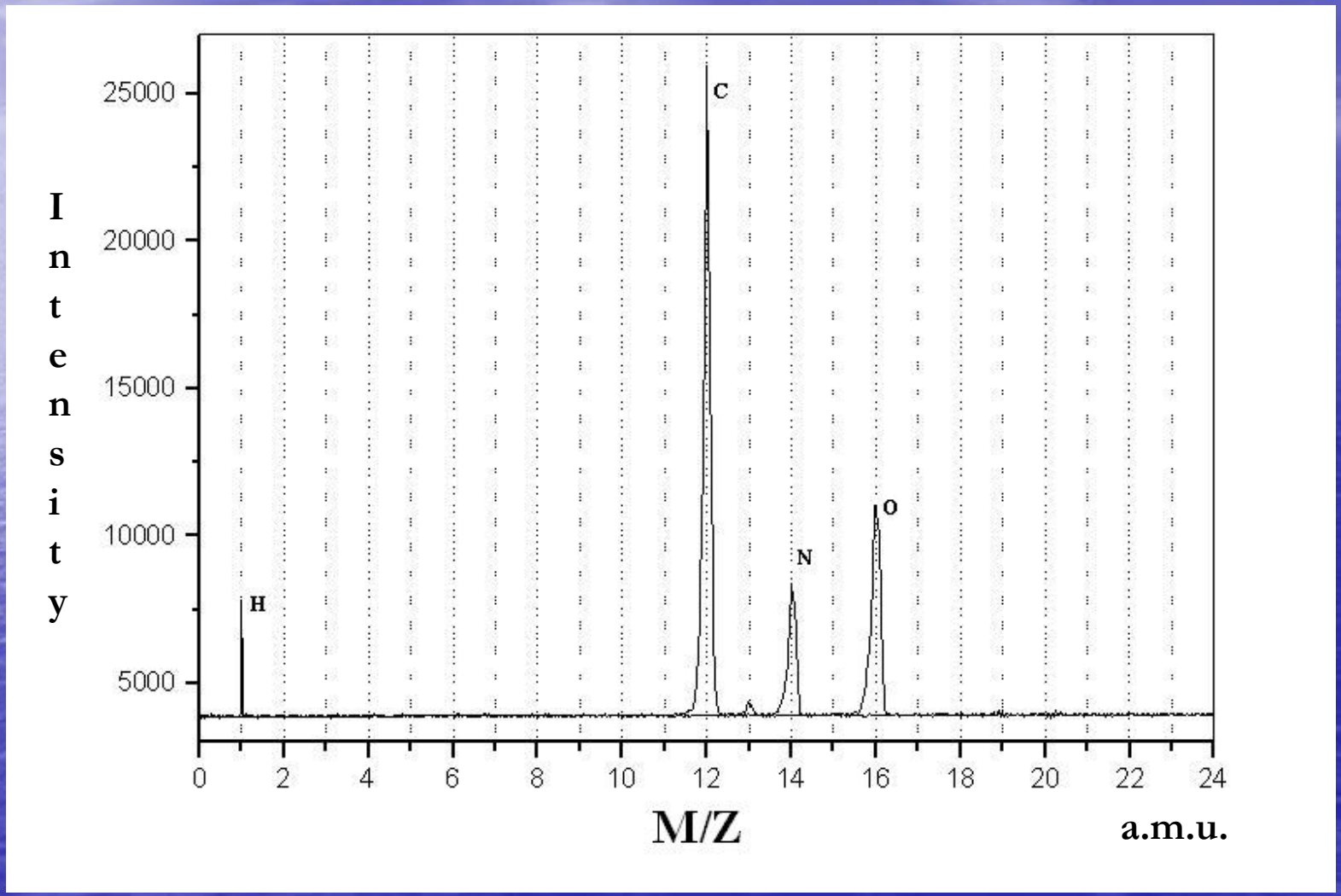


**Engineering mock-up of the analytical part of onboard laser TOF MS LASMA**

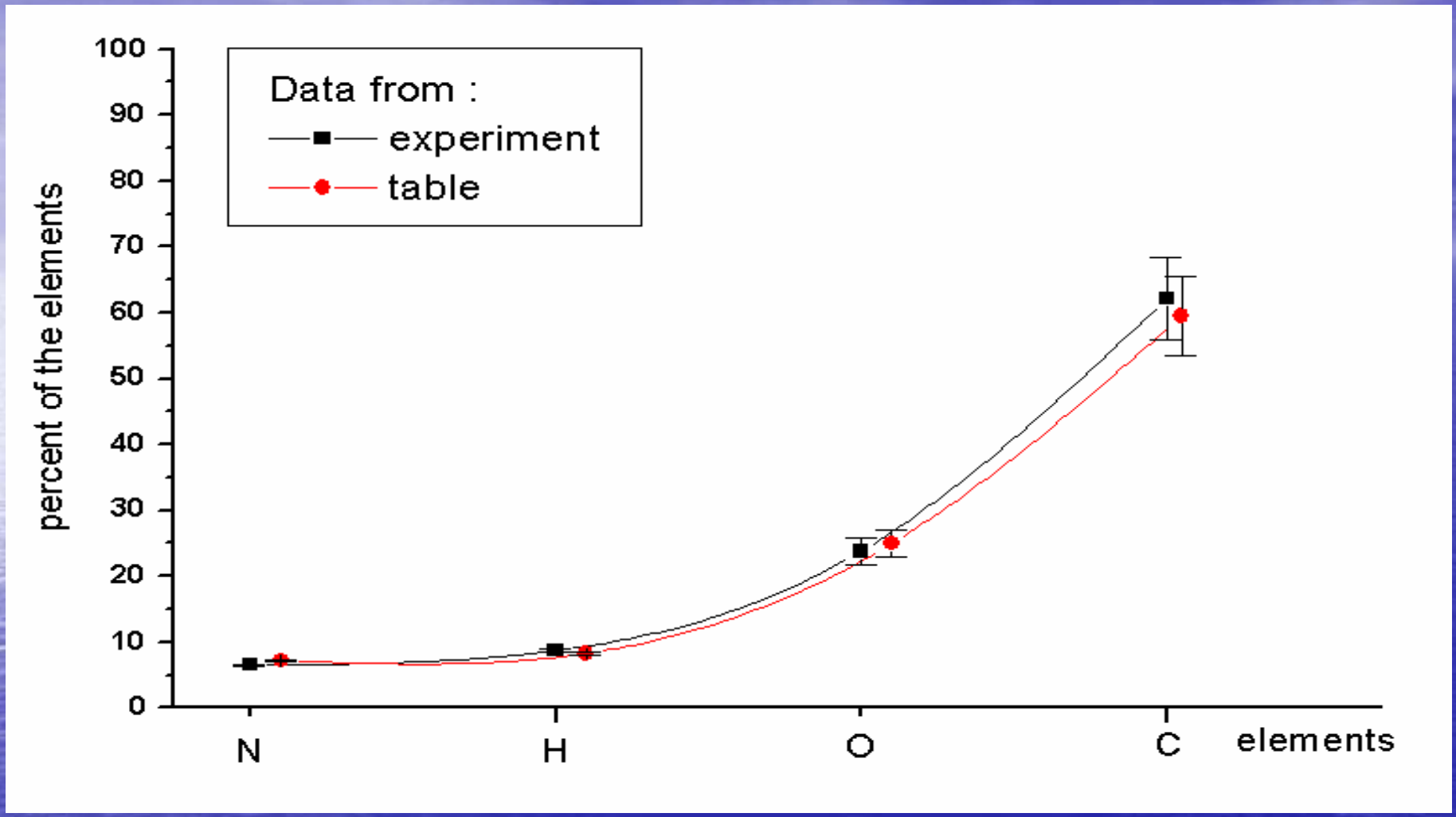
## Main analytical characteristics of LASMA instrument

| | |
|---|---|
| • Mass range | 1-250 a.m.u. |
| • Mass resolution | 300-600 |
| • Relative sensitivity in 1 spectrum | $10^{-5}$ |
| • Absolute detection level in 1 analysis | $5 \cdot 10^{-13}$ g |
| • Instrument speed at 1 a.m.u. | 200 ns |
| • Dynamic diapason | $10^{5}$ |
| • Sampling rate | 10 ns |
| • Accuracy | 10% |
| • Mass | ~2 kg |
| • Average power consumption | 5 W |
| • Overall dimensions | 262 x 110 x 225 mm |

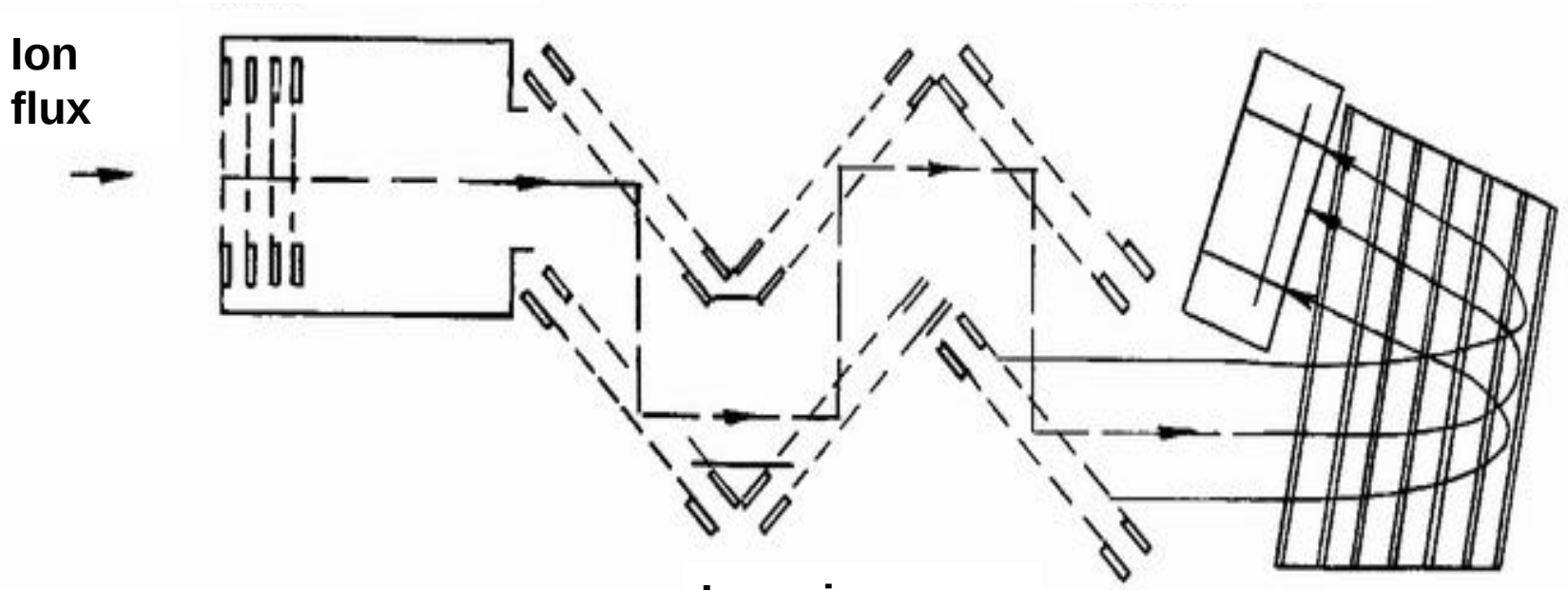
# Preliminary experiments with yeast sample on the TOF MS LASMA



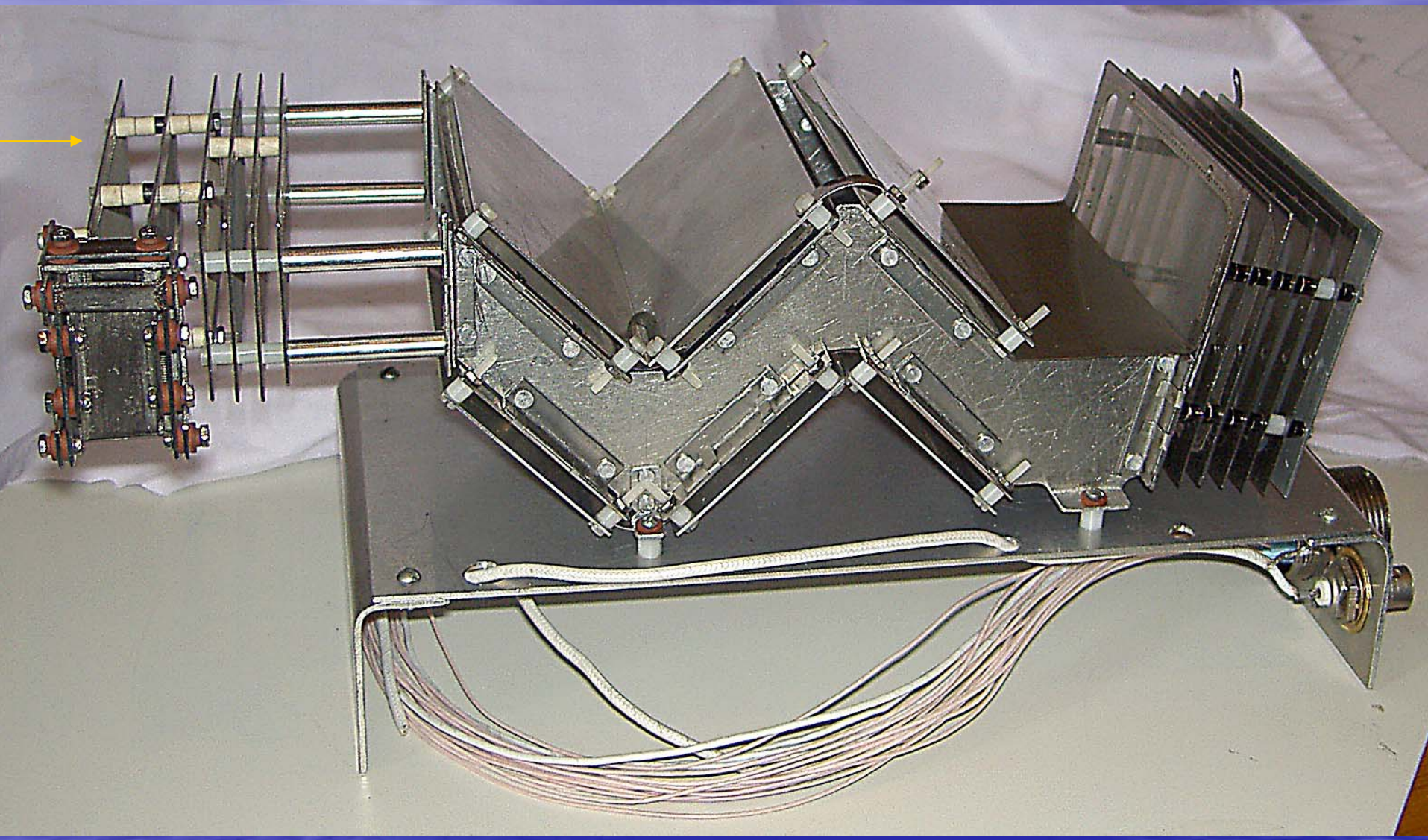

Mass spectrum of yeast sample obtain at single laser shot.



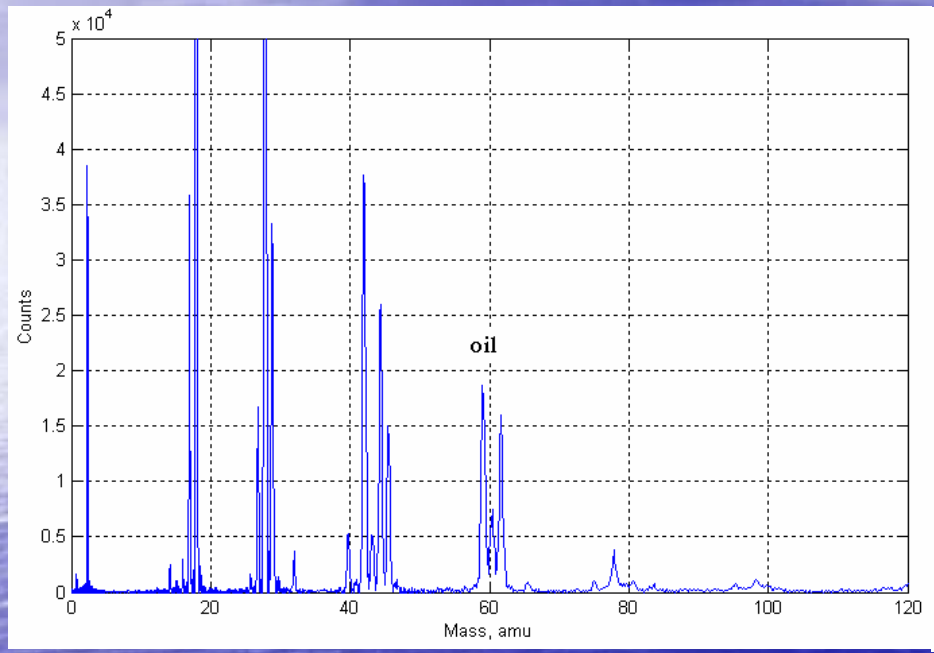

Percent concentration of matrix elements in the yeast sample.
Black: experimental data;
red: averaged concentration according to reference data.

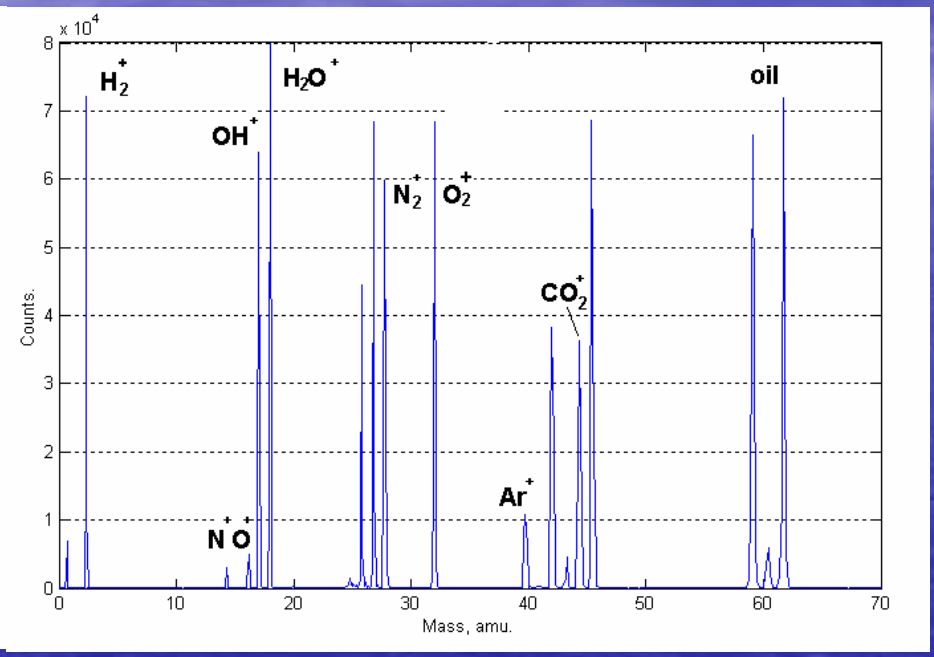



Ion-optical scheme of gas TOF MS MANAGA.
External ion registration mode: normally closed electrostatic window prevents entering of external ions into the analytical part. Window opens with 1000-10000 Hz frequency for 10 ns, admitting external secondary ions from the environment. After additional acceleration ion packs are reaching TOF area. In the reflection field happens spatio-temporal focusing of ions, which allows to form narrow mass peaks when reaching detector. System of ion mirrors provides weakening of background intensity.



Gas TOF MS MANAGA with the electron gun

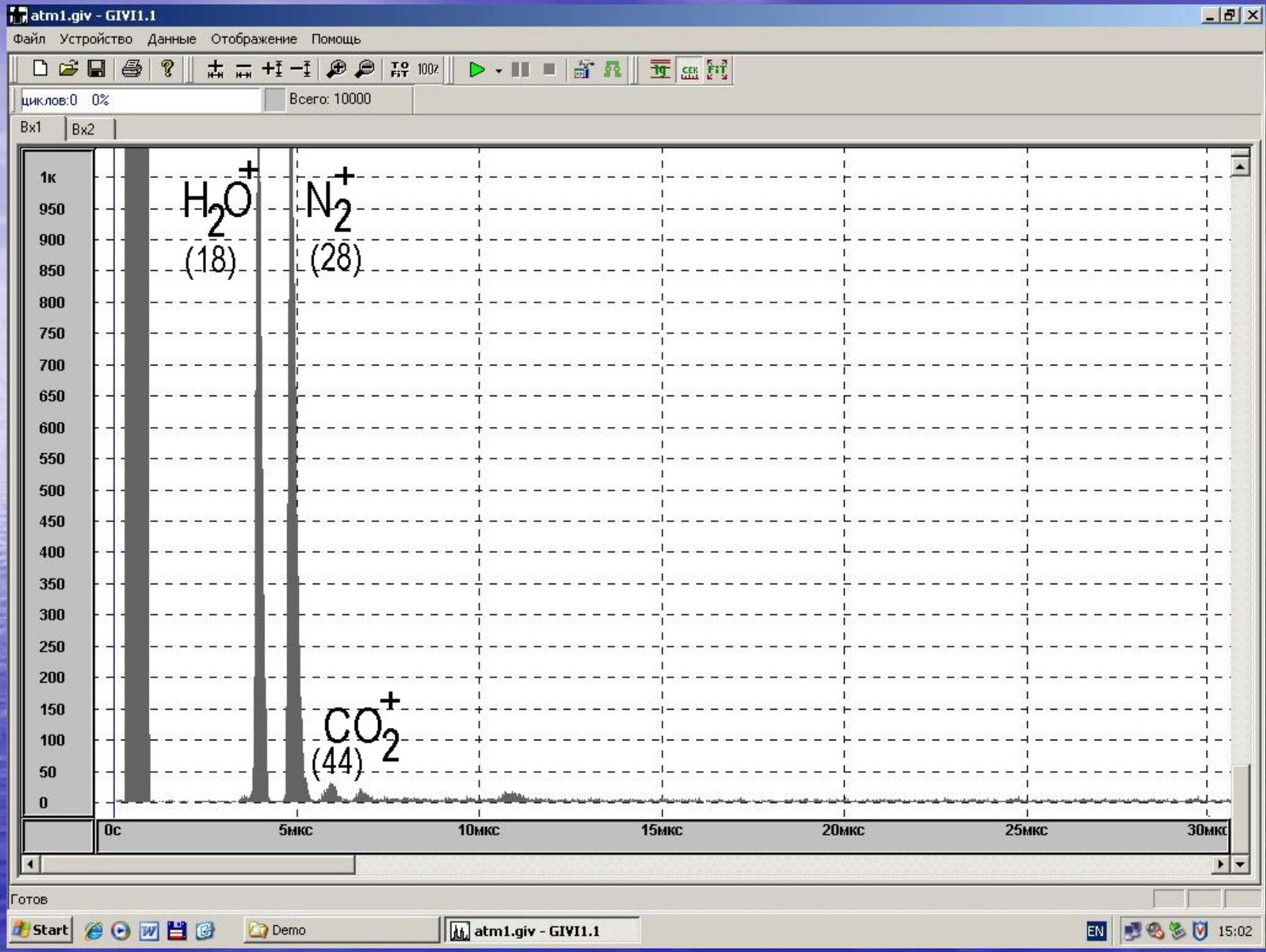


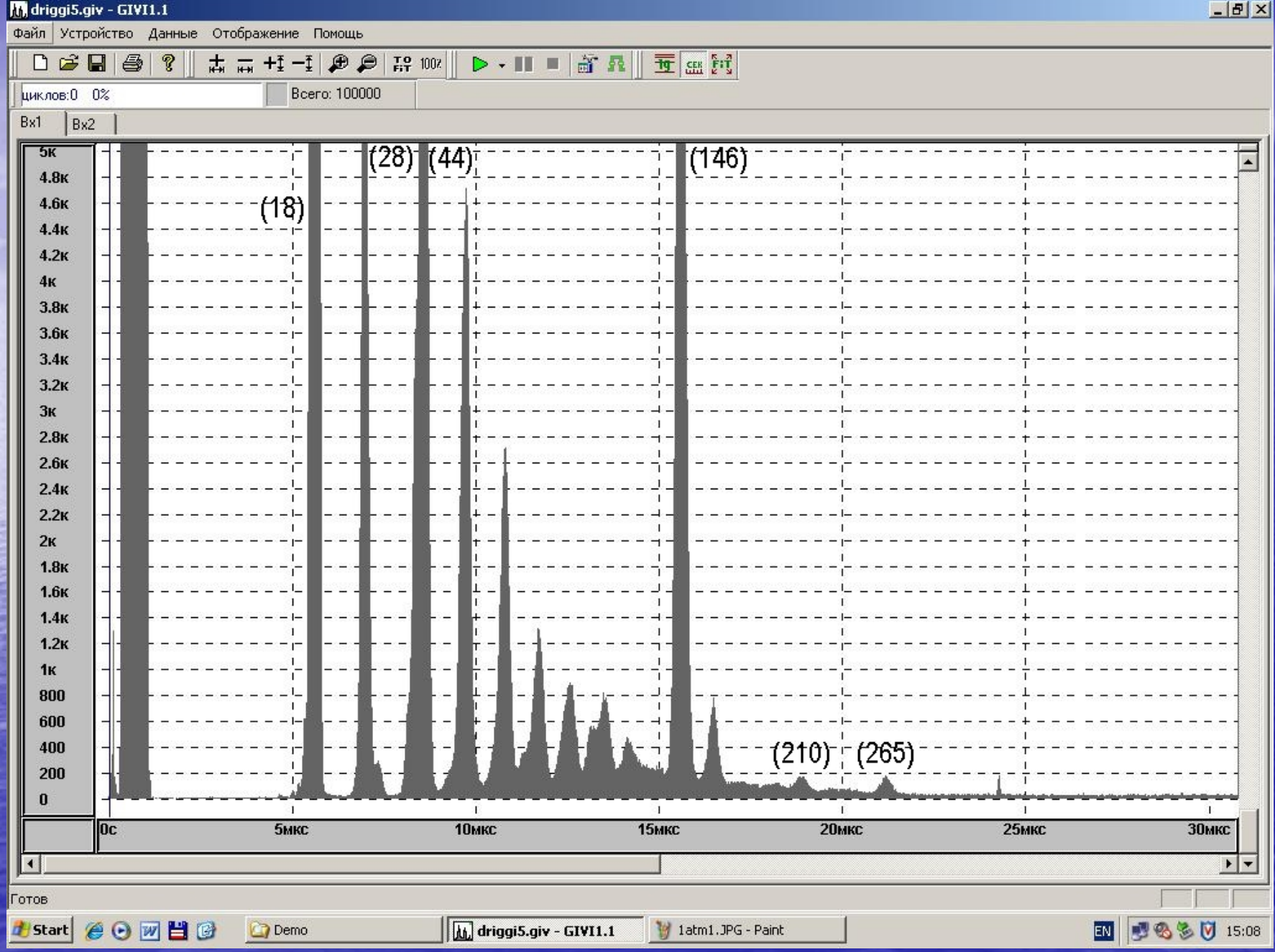

**Mass spectrum of residual gas in vacuum chamber, demonstrating mass resolution of the mock-up of an on-board gas TOF MS MANAGA.**

# MANAGA instrument characteristics

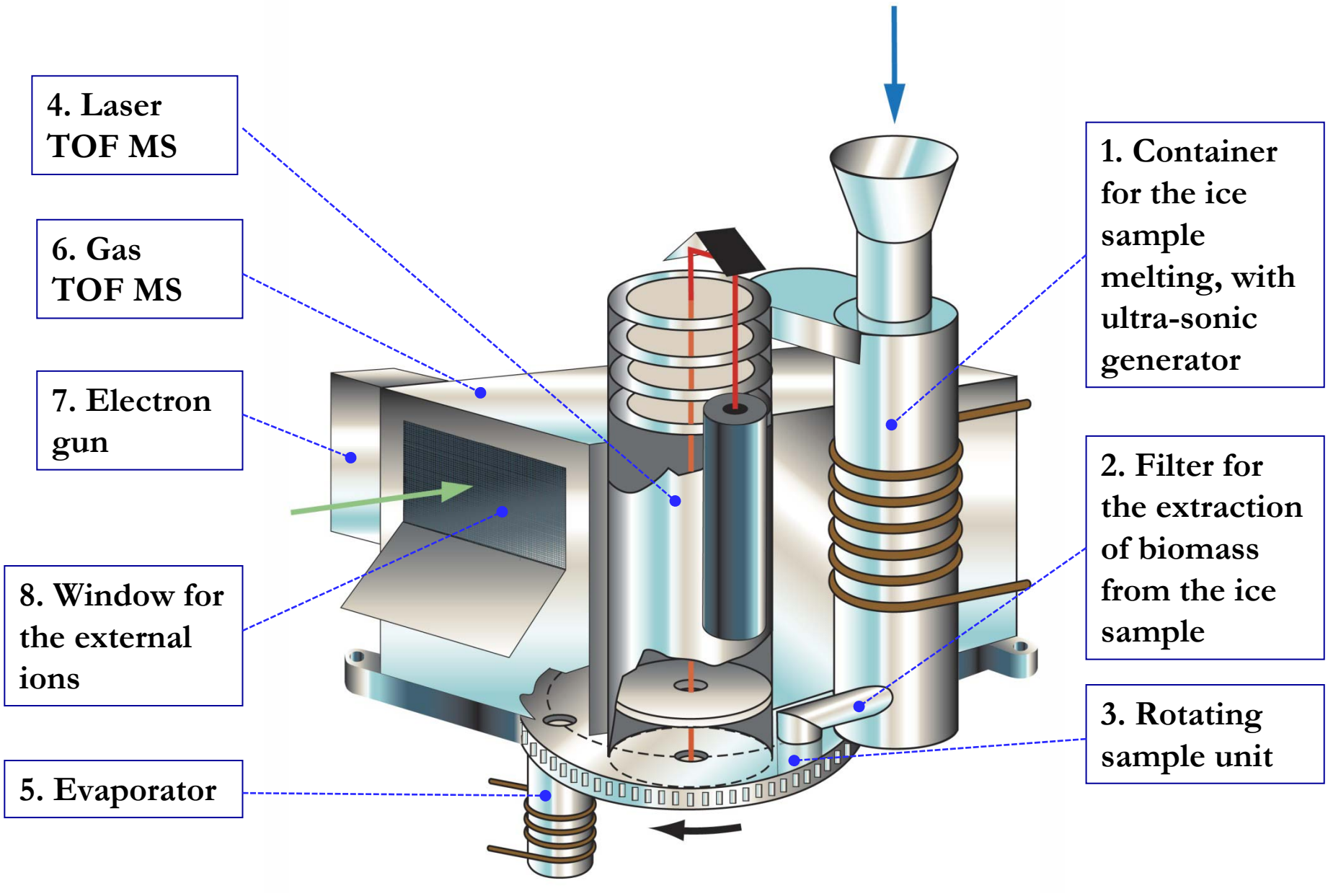
| | |
|---|---|
| Mass range | 1…1000 a.m.u. |
| Mass resolution at 50%, not lower than | ≥200 |
| Absolute detection level for 1 second (for neutral component) | $\geq 10^5$ cm$^{-3}$ |
| Absolute detection level for 1 second (for ion component) | $10^{-5}$ cm$^{-3}$ |
| Relative sensitivity | 1 ppm |
| Dynamical diapason | $10^6$ |
| Frequency of spectrum output for 1 s | $10^4$ |
| Area of entrance window | 15.43 cm$^2$ |
| Field of view | $60^0$ x $40^0$ |
| Quantity of quantification intervals (channels) | 2048* |
| Duration of quantification intervals | 20 ns |
| Duration of 1 spectrum measuring | 40,96 ms** |
| | |
| *- Nominal. Can vary from 512 to 65 536. | |
| | |




**Residual gas spectrum obtained by gas TOF MS MANAGA.**




**Spectrum of yeast sample. Obtained by gas TOF MS MANAGA at the thermal desorption of the sample.**




Tentative draft of the measuring MS complex with the sample processing system

# Conclusion

- The joint comparative analysis of the results of our and other experiments of the mission will help to make a conclusion on the presence of signs of life on the Europa and in case the living forms will be discovered, to compare them with the Earth forms.

- The MS complex for Europa mission will require considerable modernization of the onboard LASMA and MANAGA MS. Onboard system of sample processing will be created for the first time.