FIRST RADIOCARBON MEASUREMENTS AT BINP AMS

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BINP AMS facility purpose

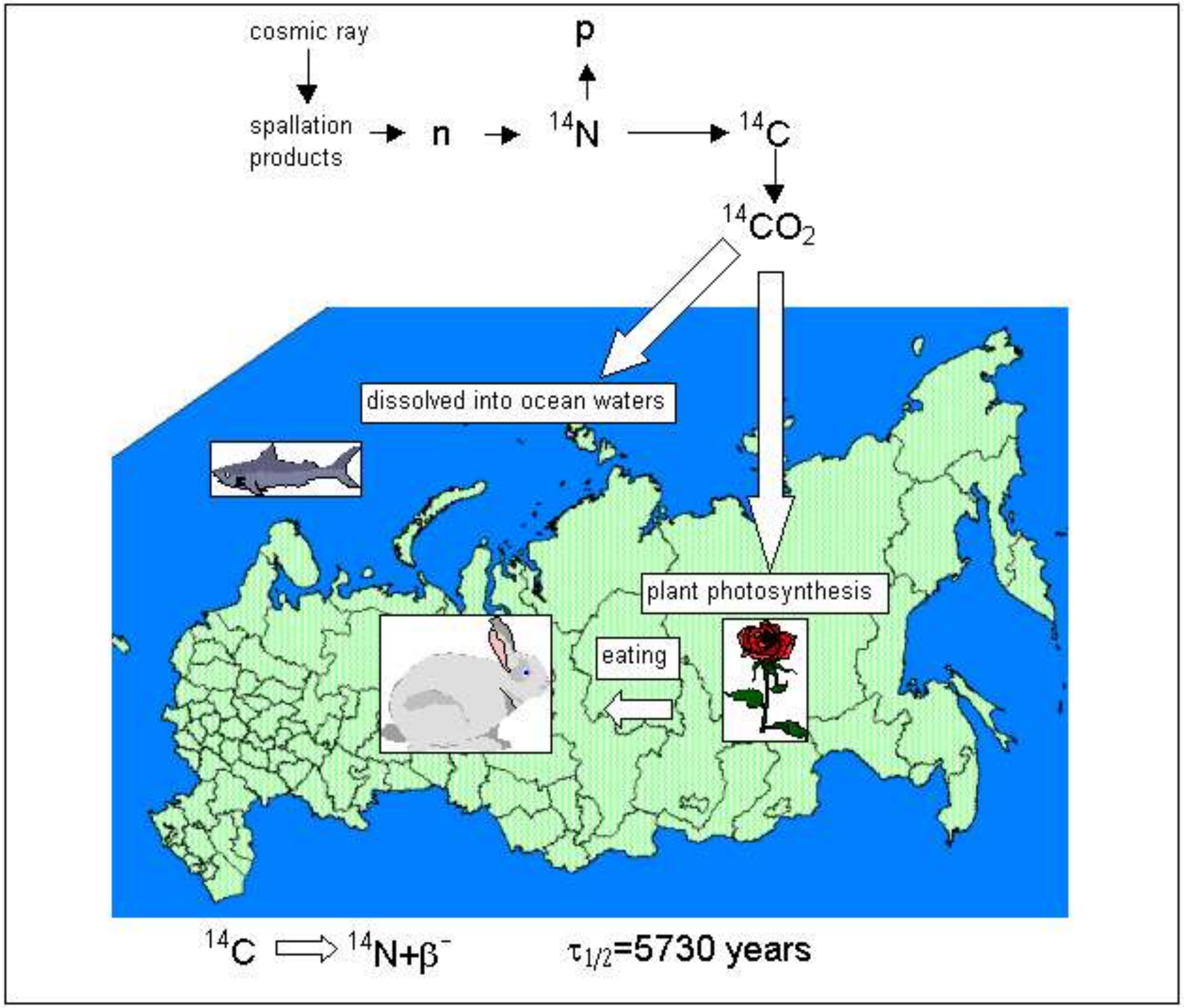
The AMS is mainly dedicated for dating of archaeological and geological samples

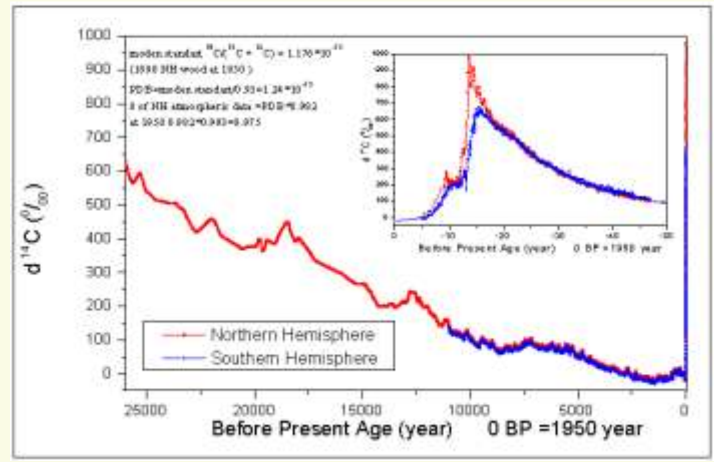
by measurements

of the ratio between carbon isotopes.

AMS can be used for many others applications.

Radiocarbon abundance





The ratio $^{14}C/^{12}C$ in atmosphere is about $1.2 \cdot 10^{-12}$

Isotope composition of modern carbon

1 mg modern carbon ⇒ 0.8 decay/hour

$6*10^7$

radiocarbon atoms

1 uA carbon ion current ⇒ 27000/hour

radiocarbon ions

The statistical uncertainty is 1% for 10000 counts

AMS method

is based on the direct rare isotope counting

- The ion extraction from the sample
- The rejection of the primary isotopes
- The beam acceleration
- The rejection of the isobaric ions
- The rare isotope counting

Atomic and molecular isobars of *radiocarbon*

- ^{14}N m/dm=84000
- ^{13}CH, $^{12}CH^{2}$ m/dm ~1000

(About 10^8 molecular isobars
for each negative radiocarbon ion)

AMS facility solve isobar problems

- negative ^{14}N ions not stable
- stripping destroys molecules

RESIDUAL BACKGROUND

Electrostatic filter → E/q

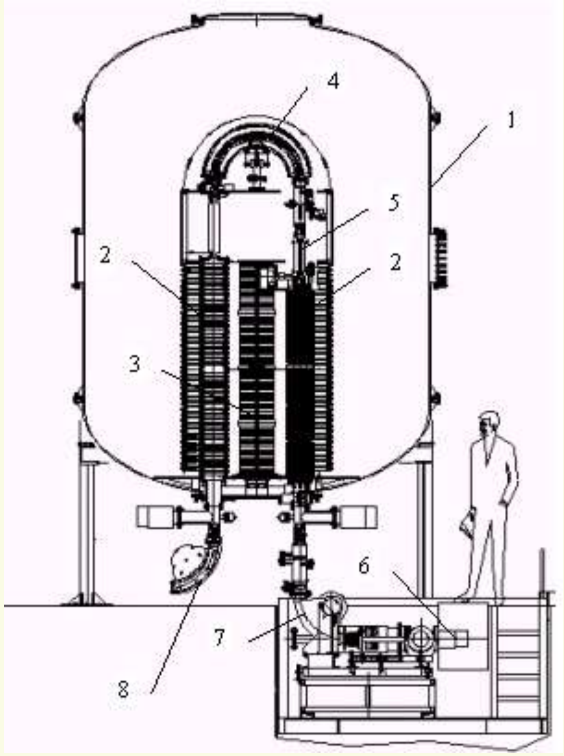
→ M/q

Magnetic filter → ME/q^2

Problems:

The scattering and charge exchange processes allow the unwanted particles to pass through electrostatic and magnetic filters. The ions can interact with molecules of residual gas and parts of vacuum chamber.

Basic features of BINP AMS facility

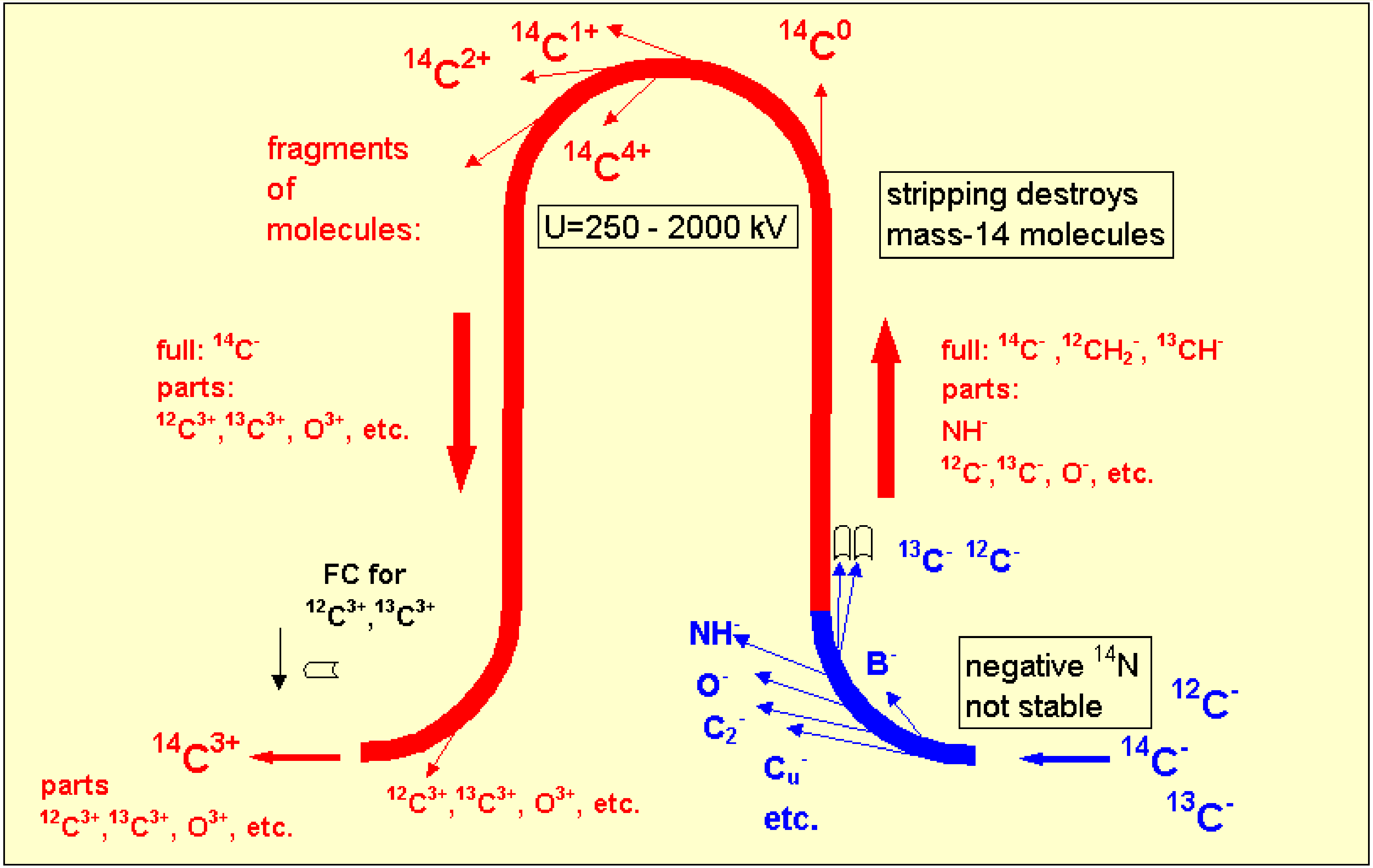


1 - pressure tank,
2 - accelerator tube,
3 - cascade generator,
4 - middle energy electrostatic filter,
5 - magnesium vapors stripper,
6 - ion source,
7 - low-energy magnetic analyzer,

8- high-energy magnetic analyzer

- The ion energy selection just after molecular destruction → **effective filtration of the molecular fragments**, because energy of fragments always less then ion energy (at this moment).
- The magnesium vapor target as a molecule destroyer → **localized molecular destruction**
- 2D time of flight detector → **accurate recognition of each ion**

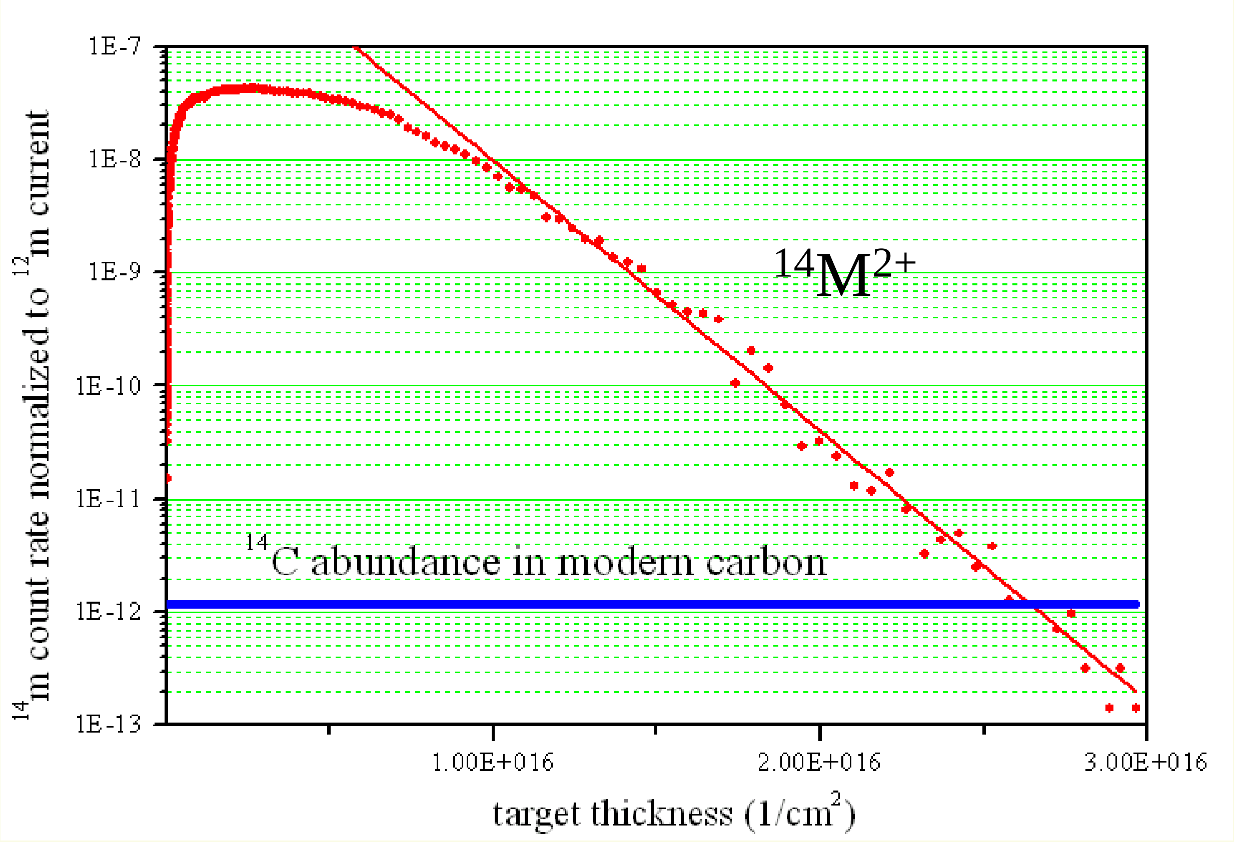
BINP AMS facility

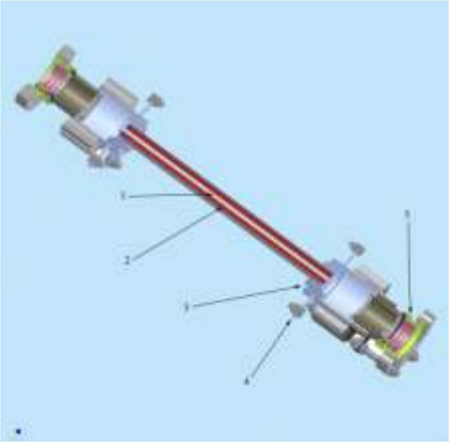


Molecular background suppression

with magnesium target

The molecular background can be suppressed by many orders of magnitude by the stripping process.





magnesium target

The magnesium vapors stripper had no the observable influence on vacuum condition

BINP AMS summary from RuPAC 2008

SUMMARY

The main parts of AMS facility have been installed and tested at BINP.
The ion background was enough removed from radiocarbon beam.
The first experiments for radiocarbon detection was carry out for low

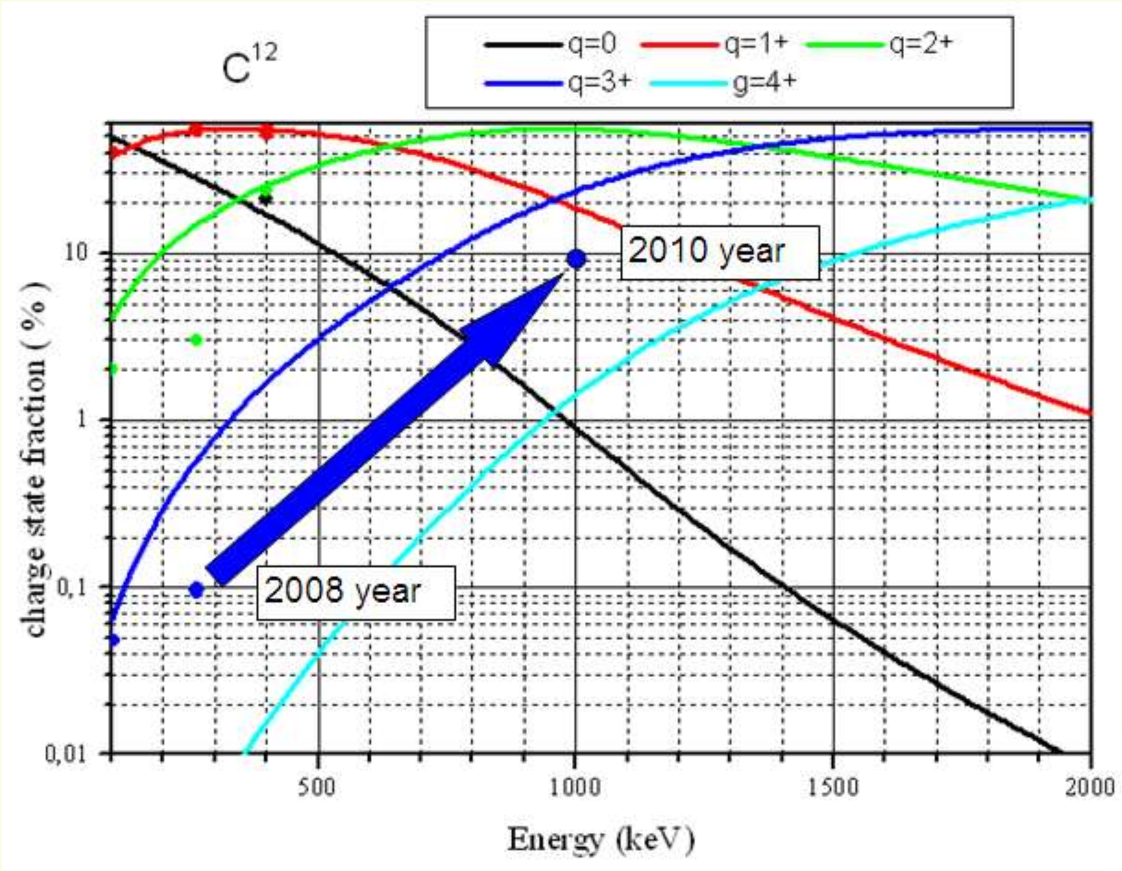
beam energy at 250 kV tandem accelerator voltage.

The assembling of the AMS complex in specialized building for AMS (Dating Center) has begun this year.

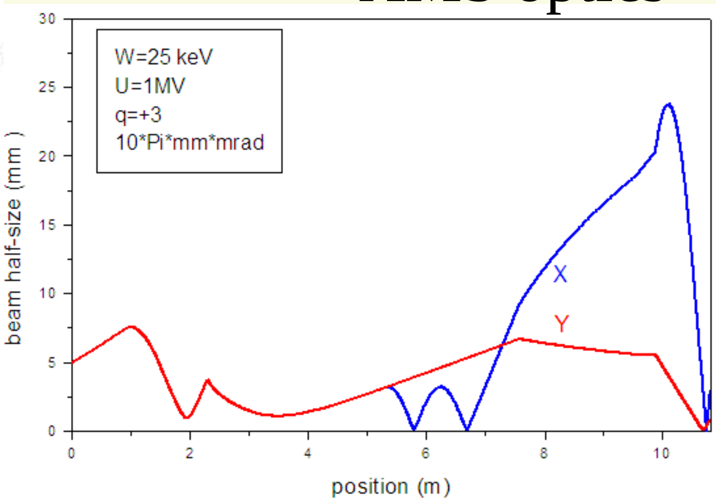
We plan to use ~ 2MV tandem voltage for optimum 3+ charge state transmission in this Center equipped with radiation shielding.
(3+ transmission: 0.05% (250keV) ---> 25-50% (2MeV))

Now the BINP AMS facility was installed at CCU “Geochronology of the Cenozoic era”

1 MV regime



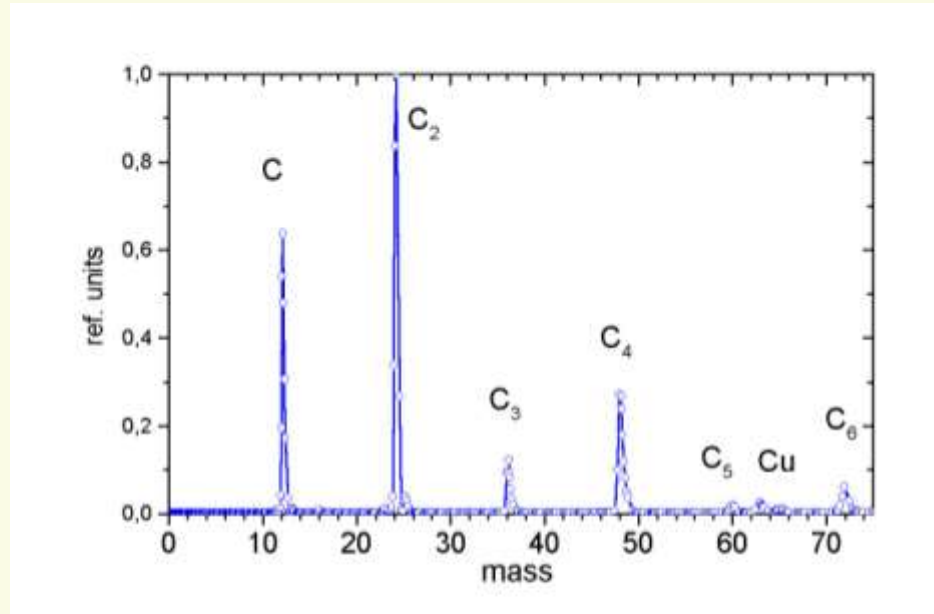
AMS optics



Recently, 1 MV terminal voltage was achieved by using low cost air-gas mixture: Air $+N_2+4$ kg of SF_6

Multi-cathode sputter ion source

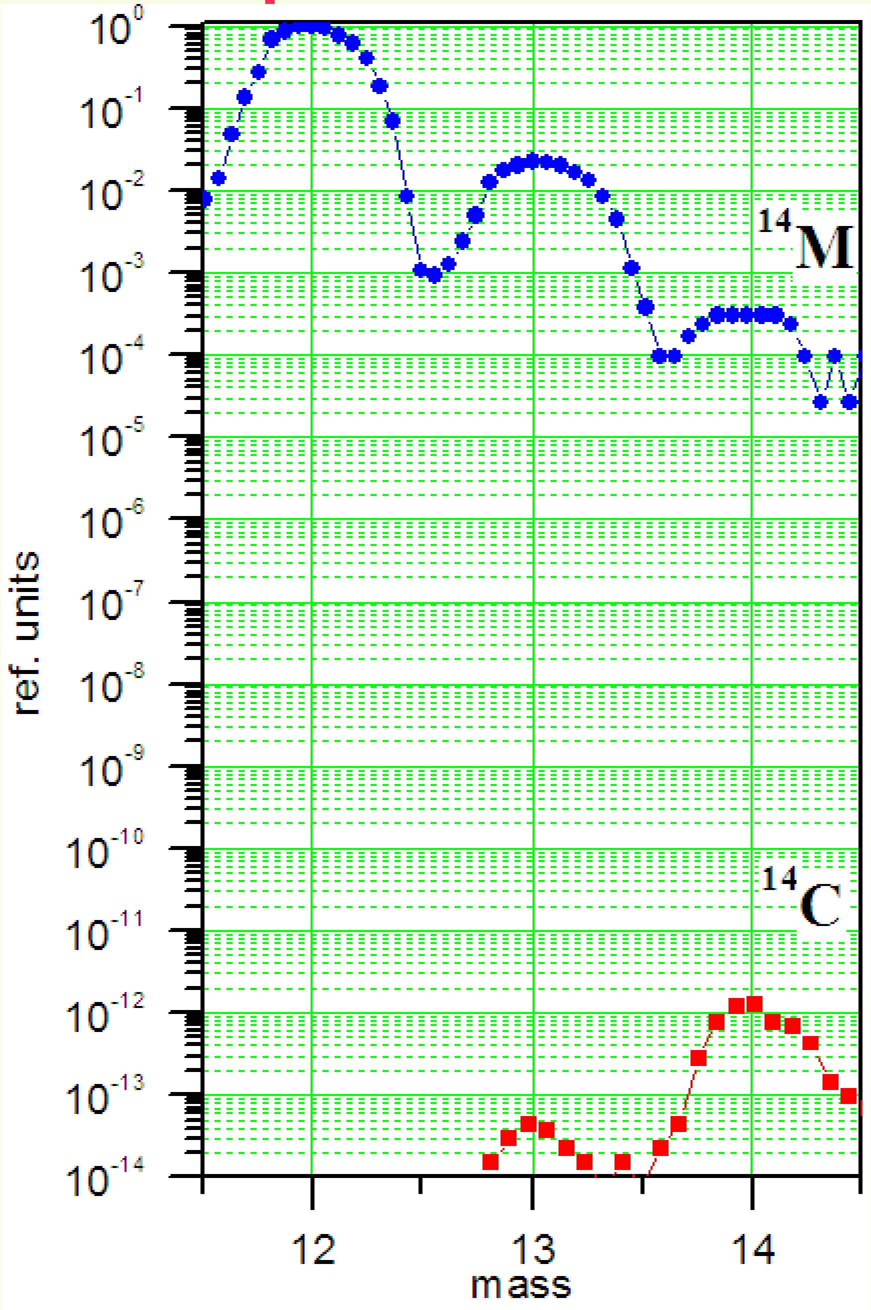
Sample wheel



Low energy mass spectrum

The multi-cathode (for 23 samples) sputter ion source has been recently manufactured and installed.

Mass spectrum of the modern sample

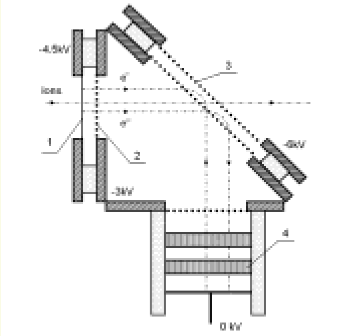


low energy spectrum

8 orders of magnitude

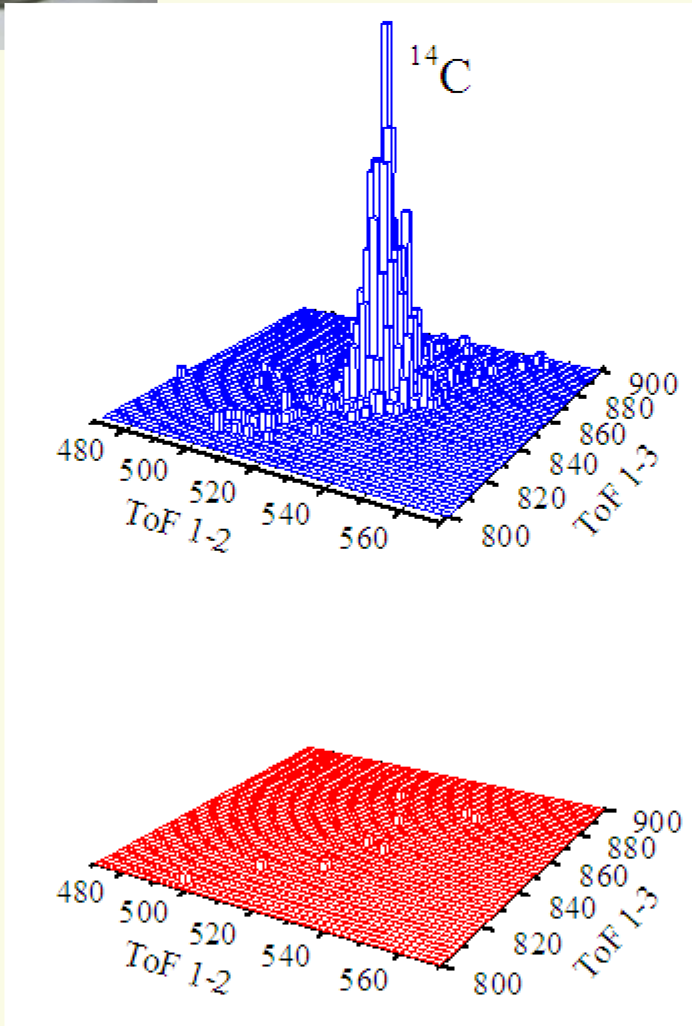
at the exit of AMS facility

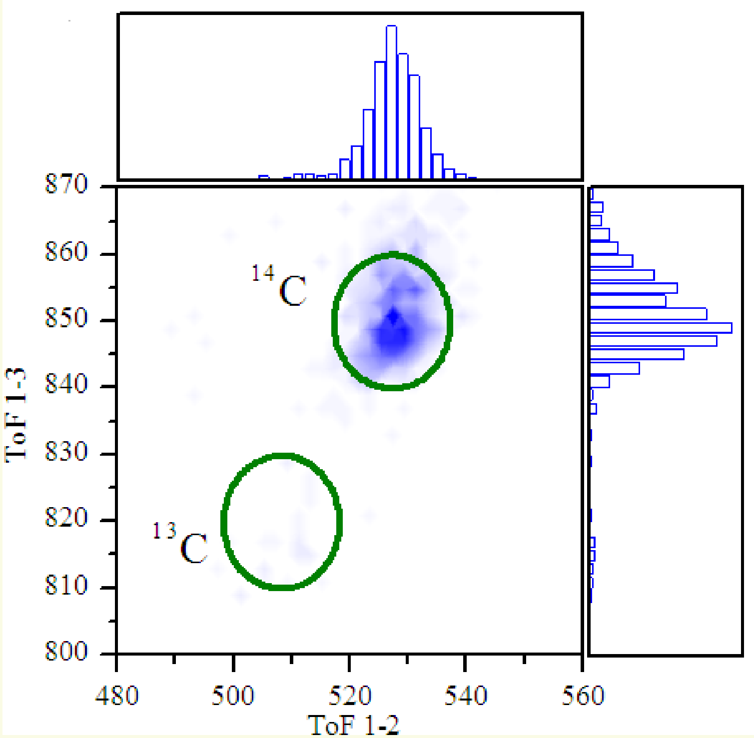
2D TOF spectrum



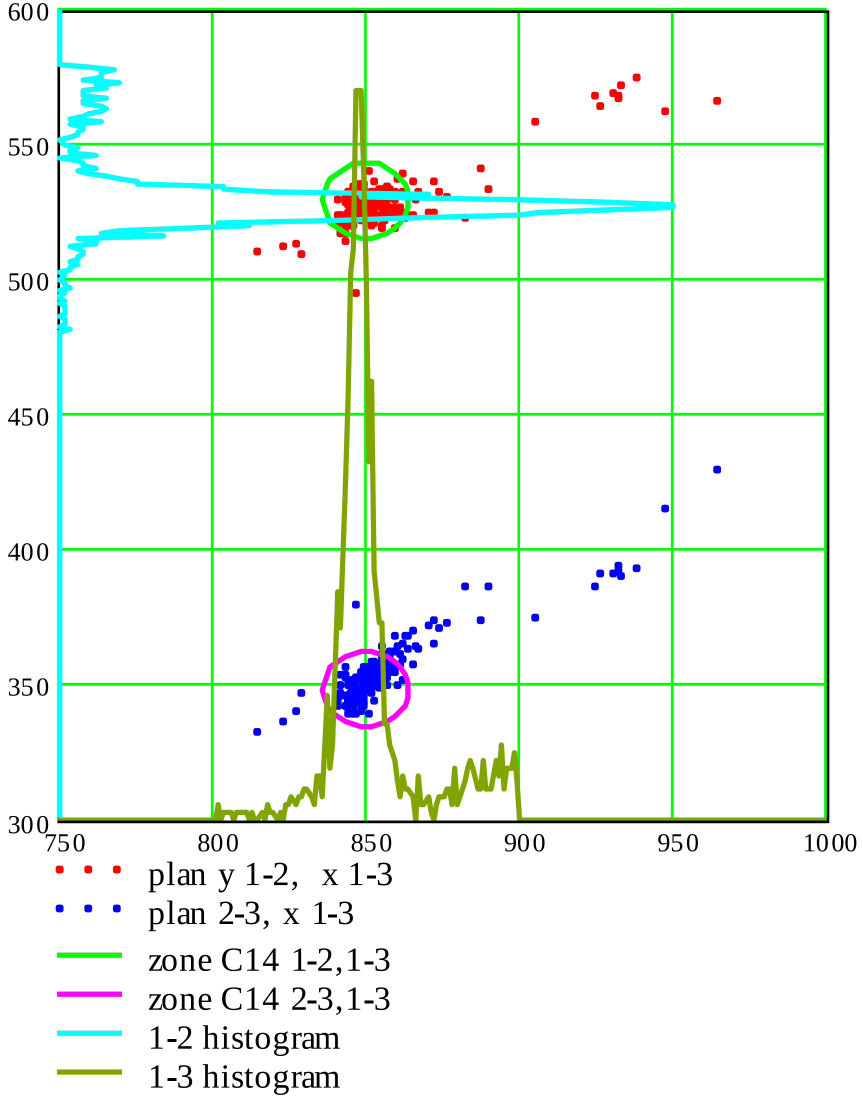
Modern sample

"dead" sample

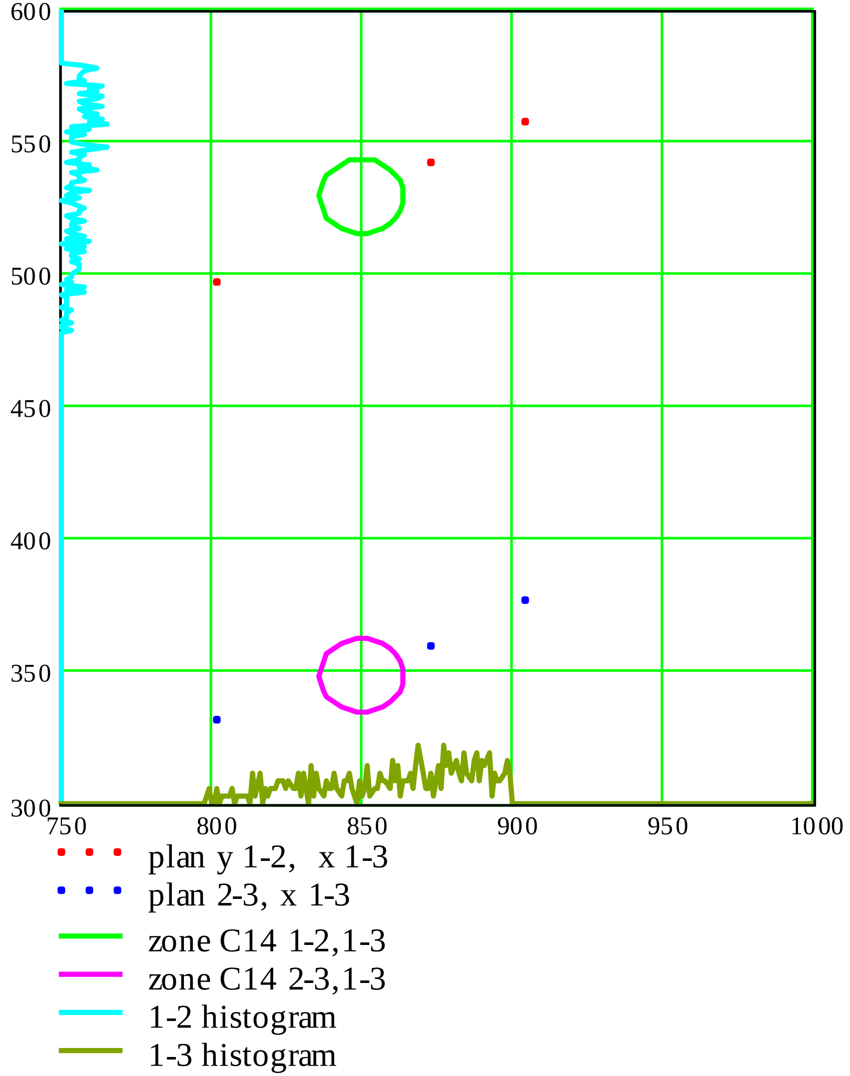




2D TOF spectrum

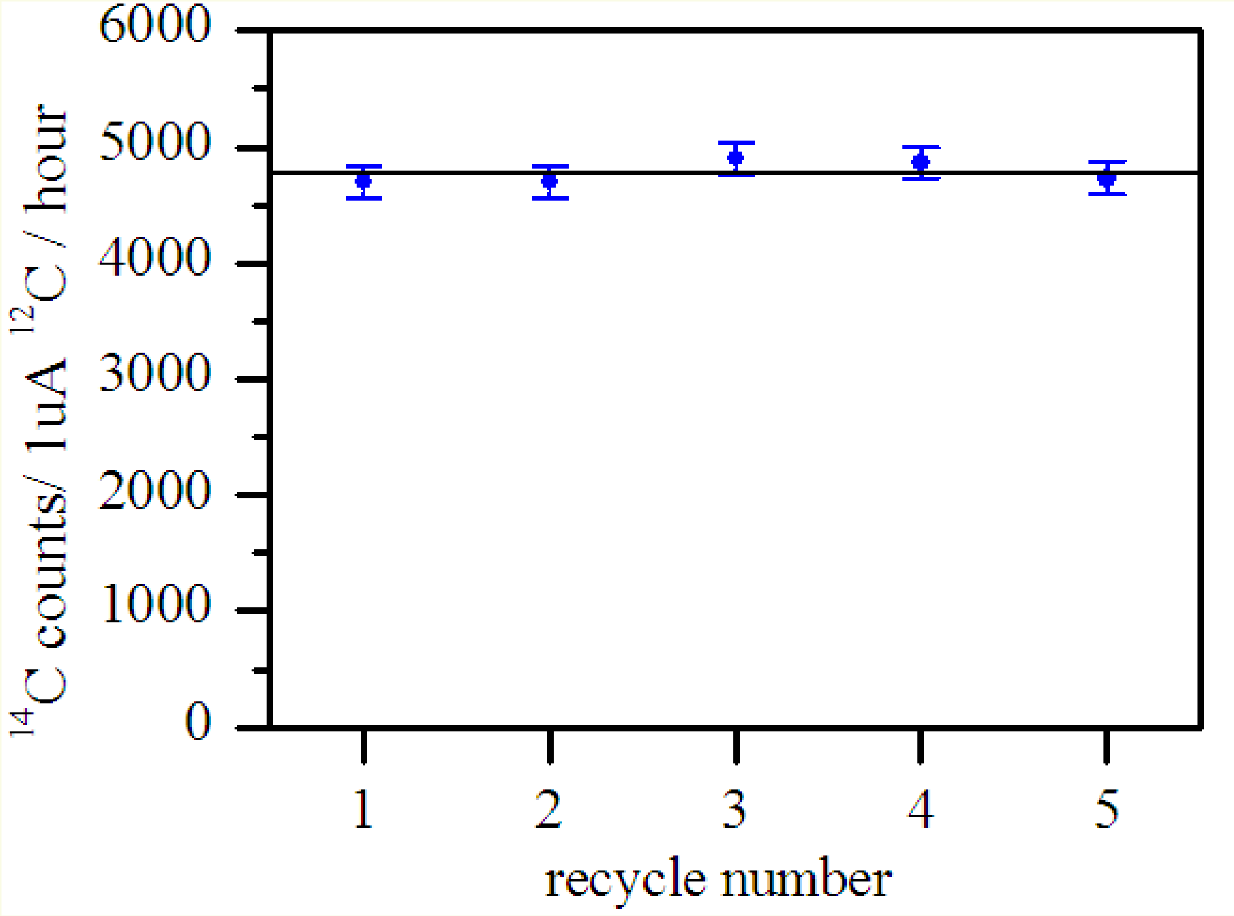


Modern sample



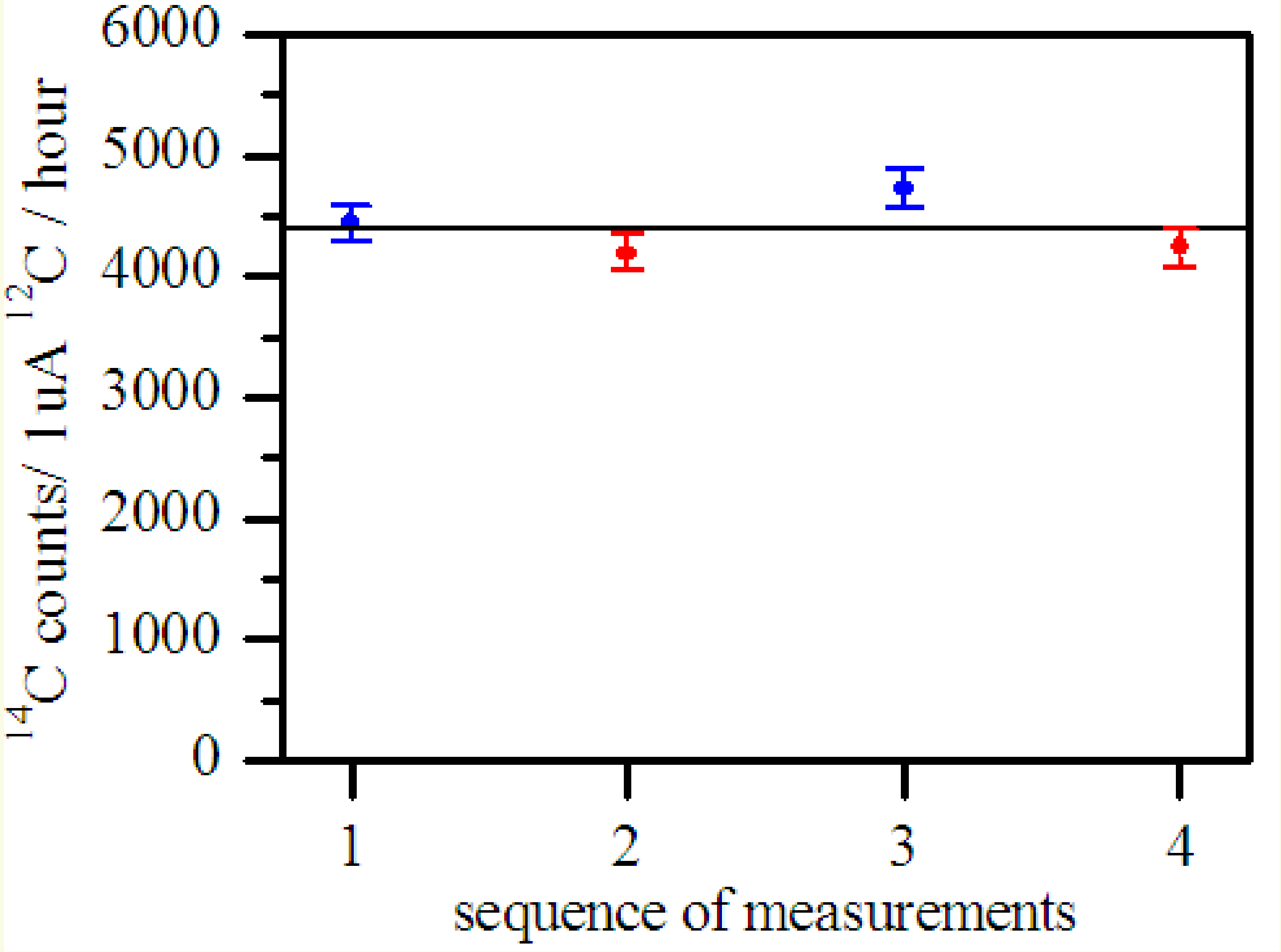
“dead” sample

Reproducibility of measurements



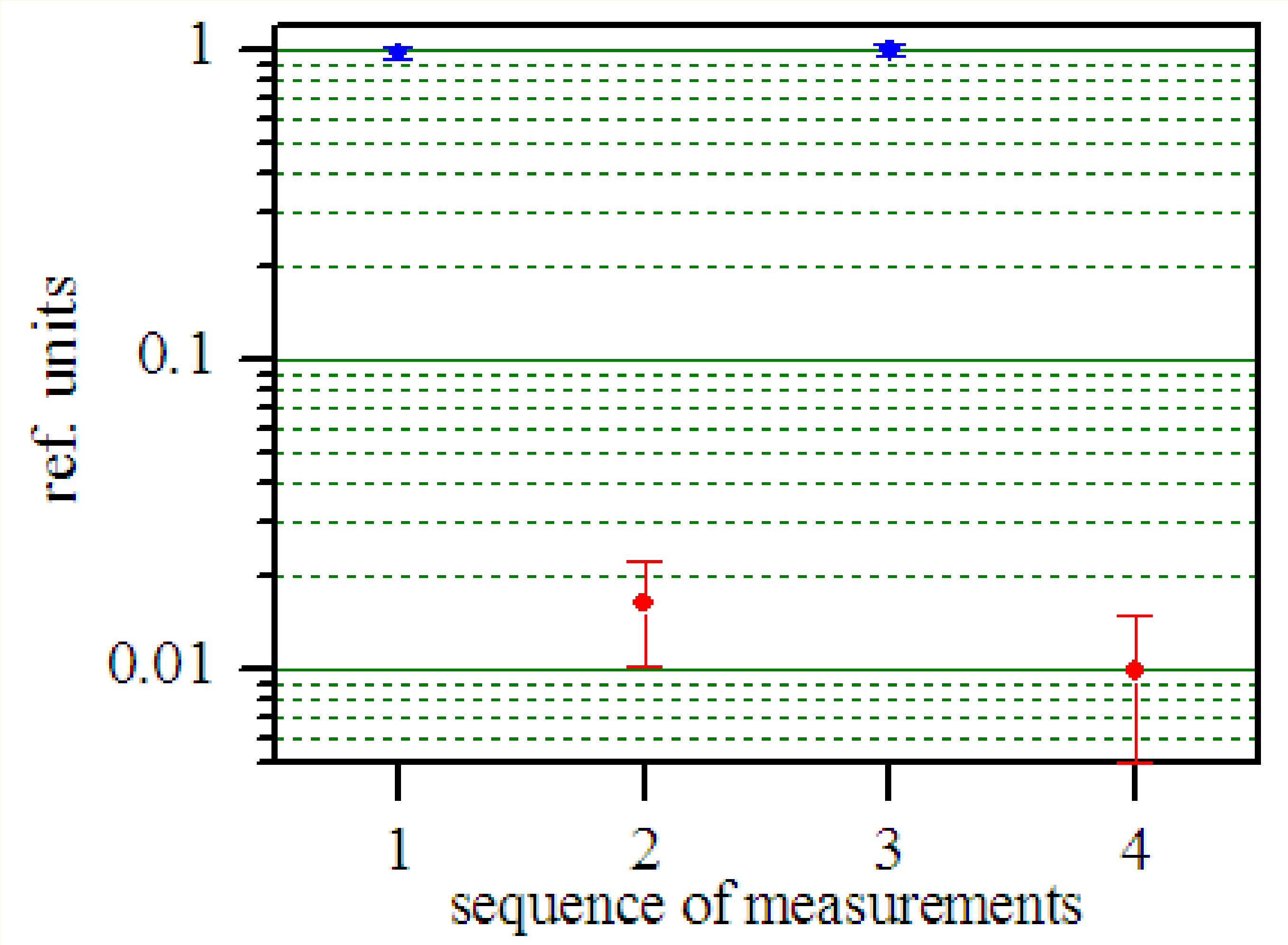
Radiocarbon concentration in modern sample.
The sample was measured five times

Reproducibility of measurements after sample wheel turning



Radiocarbon concentration in two modern samples (measured alternately).

Background estimation



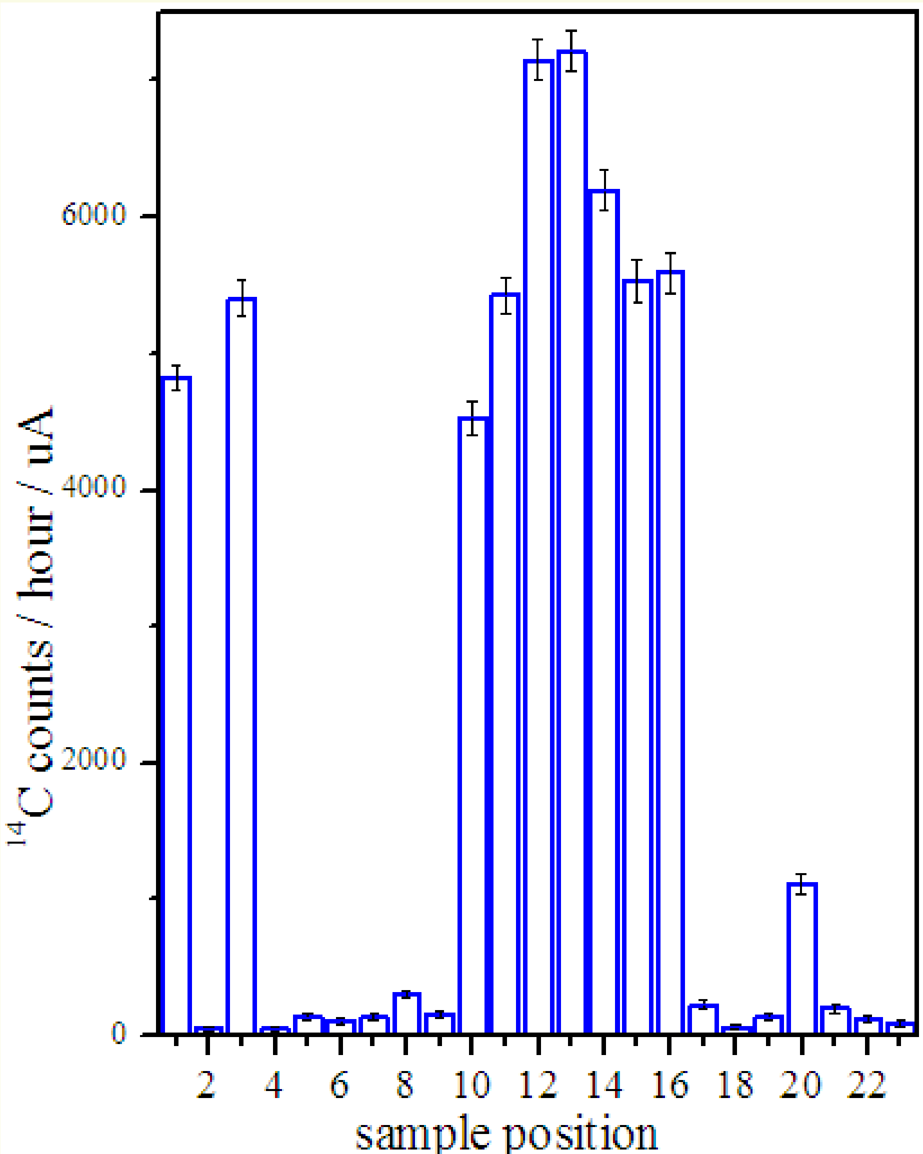
Radiocarbon concentration in the modern and “dead” samples (measured alternately).

Sample preparation

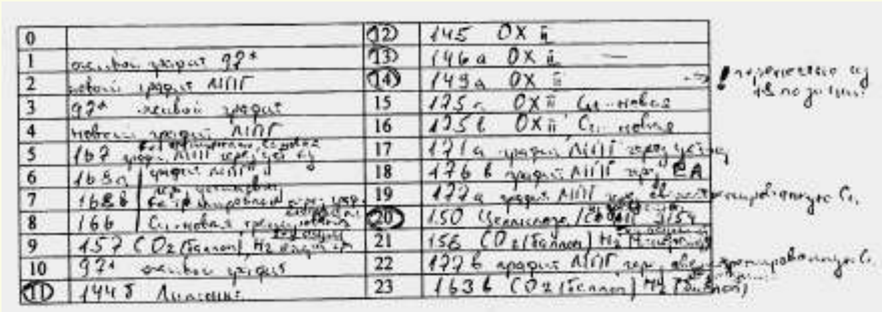
Sample preparation line of CCU “Geochronology of the Cenozoic era”

For radiocarbon analysis, the samples with large content of carbon were used. The sample preparation is needed for transformation of natural objects to such samples by combustion and graphitization.

Radiocarbon measurements of the prepared samples



full wheel of carbon targets
(23 samples)



SUMMARY

- The accelerator complex demonstrated sustained performance on 1MV running.
- The reproducibility of first radiocarbon concentration measurements is about 3%.
- The measured radiocarbon concentration in “dead” sample is about 1% of the modern sample concentration