Investigations of galactic nuclei tracks in olivine crystals from meteorites

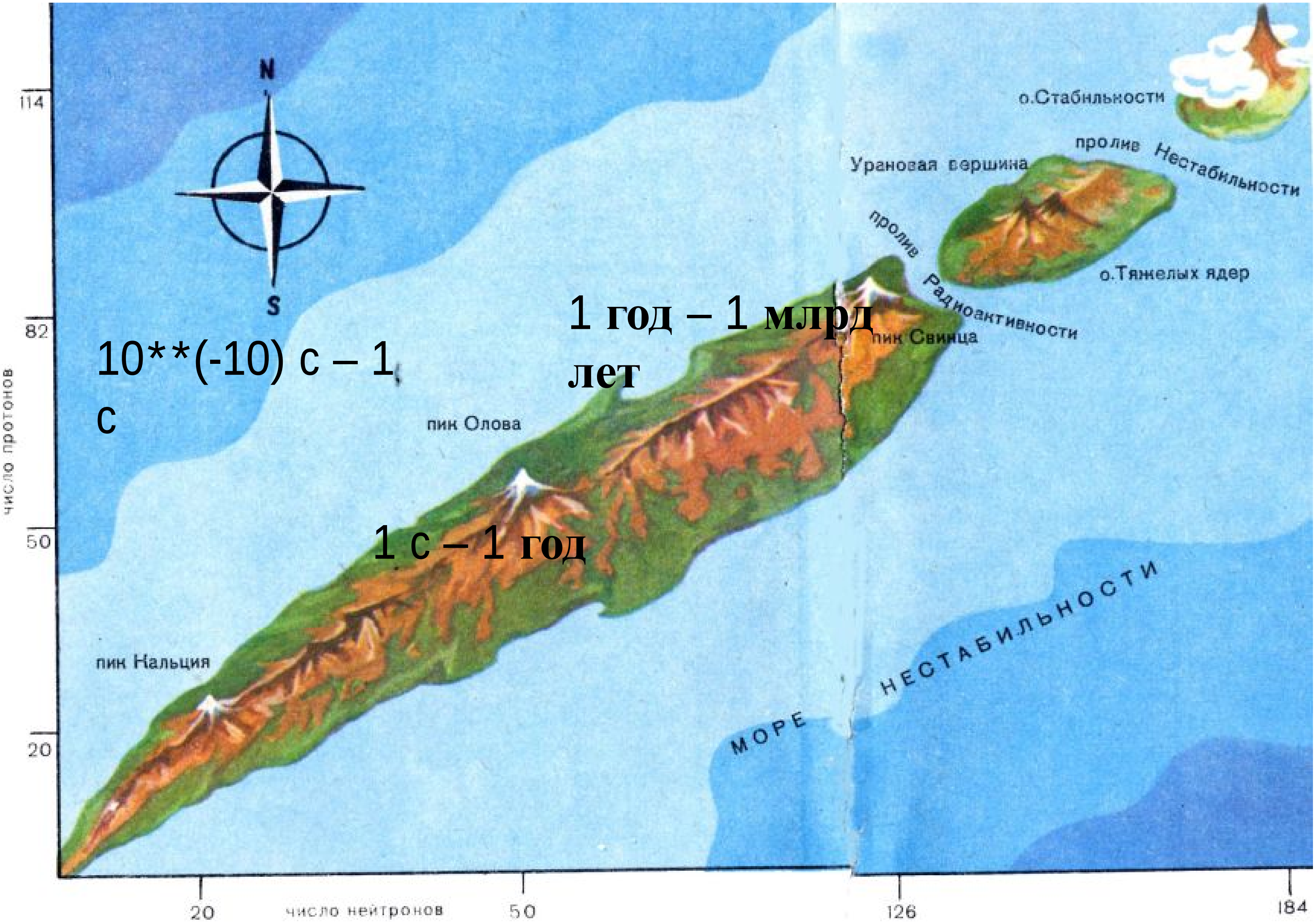
Aleksandrov A. B., Bagulya A. V., Vladimirov M.S., Goncharova L. A., Konovalova N. S., Okateva N.M.1, Polukhina N. G., Roussetski A. S., Starkov N. I.

(Lebedev Physical Institute of RAS)

Ivliev A. I., Kalinina G.V., Kashkarov L. L.

(Vernadsky Institute of Geochemistry and Analytical Chemistry of RAS)

May 31, 2012



10**(-10) с – 1 с

1 год – 1 млрд лет

1 с – 1 год

In 1869 г. – 63 elements, in 2010 - 118

(238)	(239)	(239)	(243)	(247)	(247)	(252)	(251)	(257)	(258)	(259)	(260)
92 U	93 Np	94 Pu	95 Am	96 Cm	97 Bk	98 Cf	99 Es	100 Fm	101 Md	102 No	103 Lr
$5f^36d^17s^2$	$5f^46d^17s^2$	$5f^67s^2$	$5f^77s^2$	$5f^76d^17s^2$	$5f^97s^2$	$5f^{10}7s^2$	$5f^{11}7s^2$	$5f^{12}7s^2$	$5f^{13}7s^2$	$5f^{14}7s^2$	$5f^{14}6d^17s^2$
1132	639	641	996	1340	1050	900	860	-	-	-	-
3818	3902	3340	2607	3110	2630	1227	-	-	-	-	-
~1.2/1.2	1.22/1.2	1.2/1.2	~1.1/1.2	1.2/1.2	~1.1/1.2	1.2/1.2	1.3/-	1.3/1.2	1.2/1.2	1.3/-	1.3/-
Uranium Уран	Neptunium Нептуний	Plutonium Плутоний	Americium Америций	Curium Кюрий	Berkelium Берклий	Californium Калифорний	Einsteinium Эйнштейний	Fermium Фермий	Mendelevium Менделевий	Nobelium Нобелий	Lawrencium Лоуренсий

104 Rf	105 Db	106 Sg	107 Bh	108 Hs	109 Mt	110 Uun	111 Uuu	112 Uub	113 Unt	114 Uuq
$5f^{14}6d^27s^2$	$5f^{14}6d^37s^2$	$5f^{14}6d^47s^2$	$5f^{14}6d^57s^2$	$5f^{14}6d^67s^2$	$5f^{14}6d^77s^2$	$5f^{14}6d^87s^2$	$5f^{14}6d^97s^2$	$5f^{14}6d^{10}7s^2$	$5f^{14}6d^{10}7s^27p^1$	$5f^{14}6d^{10}7s^27p$
Rutherfordium Резерфордий	Dubnium Дубний	Seaborgium Сиборгий	Bohrium Борий	Hassium Хассий	Meitnerium Мейтнерий	Ununnilium Унуннилий	Unununium Унуунуний	Ununbium Унунбий	Ununtrium Унунтрий	Ununquadium Унунквадий

JINR synthetic elements production:
Flerov:
102, 103, 104, 105 (dubnii), 106
Oganessyan:
112, 113, 114 (flerovii), 115,
116 (livermorii), 117, 118.

Pu-239
Production of synthetic elements in the world growed from billion part of gramme up to many kilograms, even tonnes.

The meteorites are natural “detectors” which have many millions years of exposition time.

The use of the factor of long-time exposure of meteorites in space leads to a great advantage of the method for the search of superheavy elements in crystals of olivine from meteorites as compared with methods based on the use of various satellite and aerostat detectors.

G.Flerov evaluated that in consideration of great meteorite ages ivestigation of 1 cubic centimetre olivine from meteorites is equal results of space experiment with 1 tonne of emulsion during 1 year.

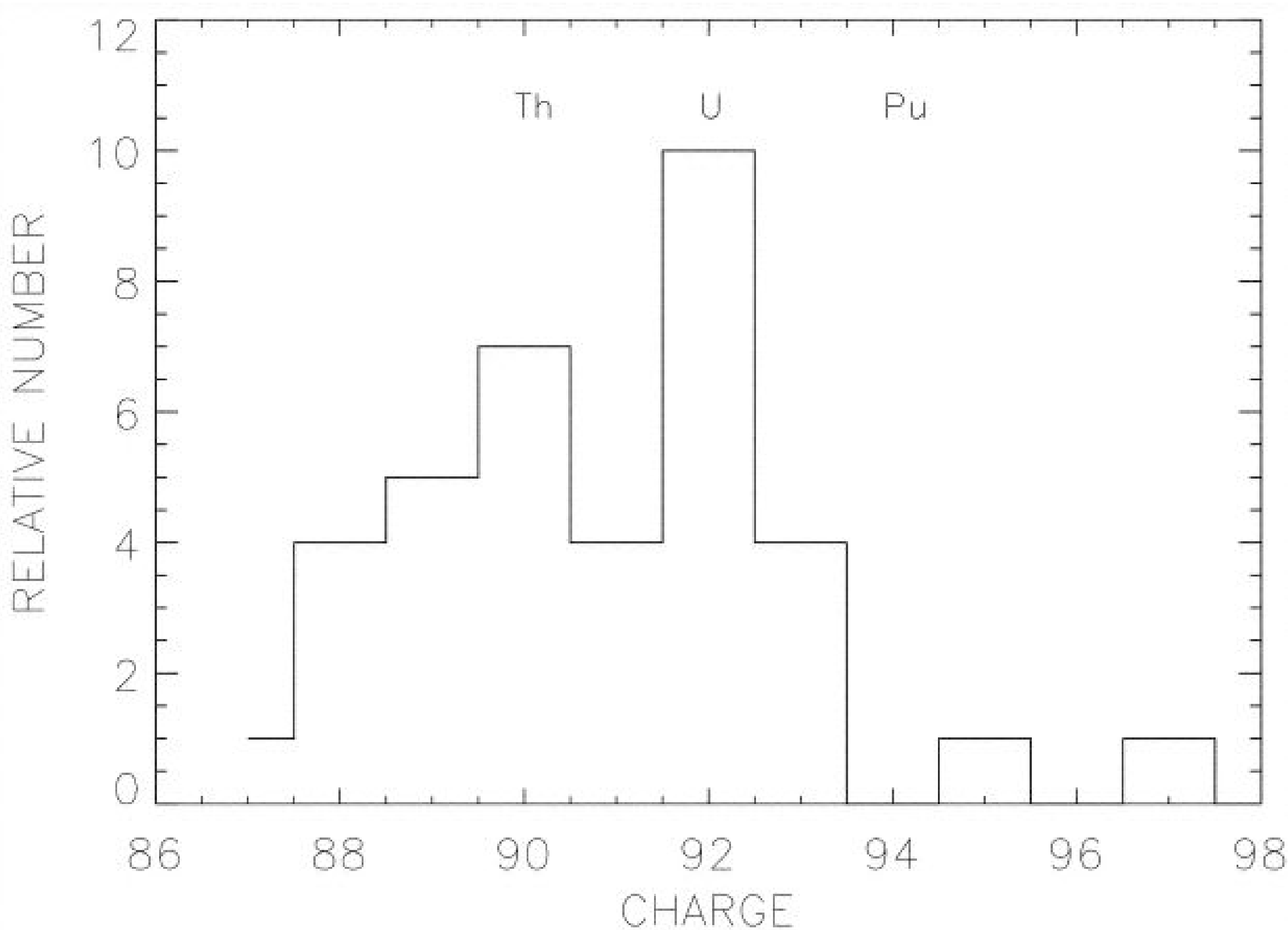
First investigation of very heavy nuclei (Z~26) were carried out by Maurette et al. (1964)

More heavy: Fleischer et al. (1967)

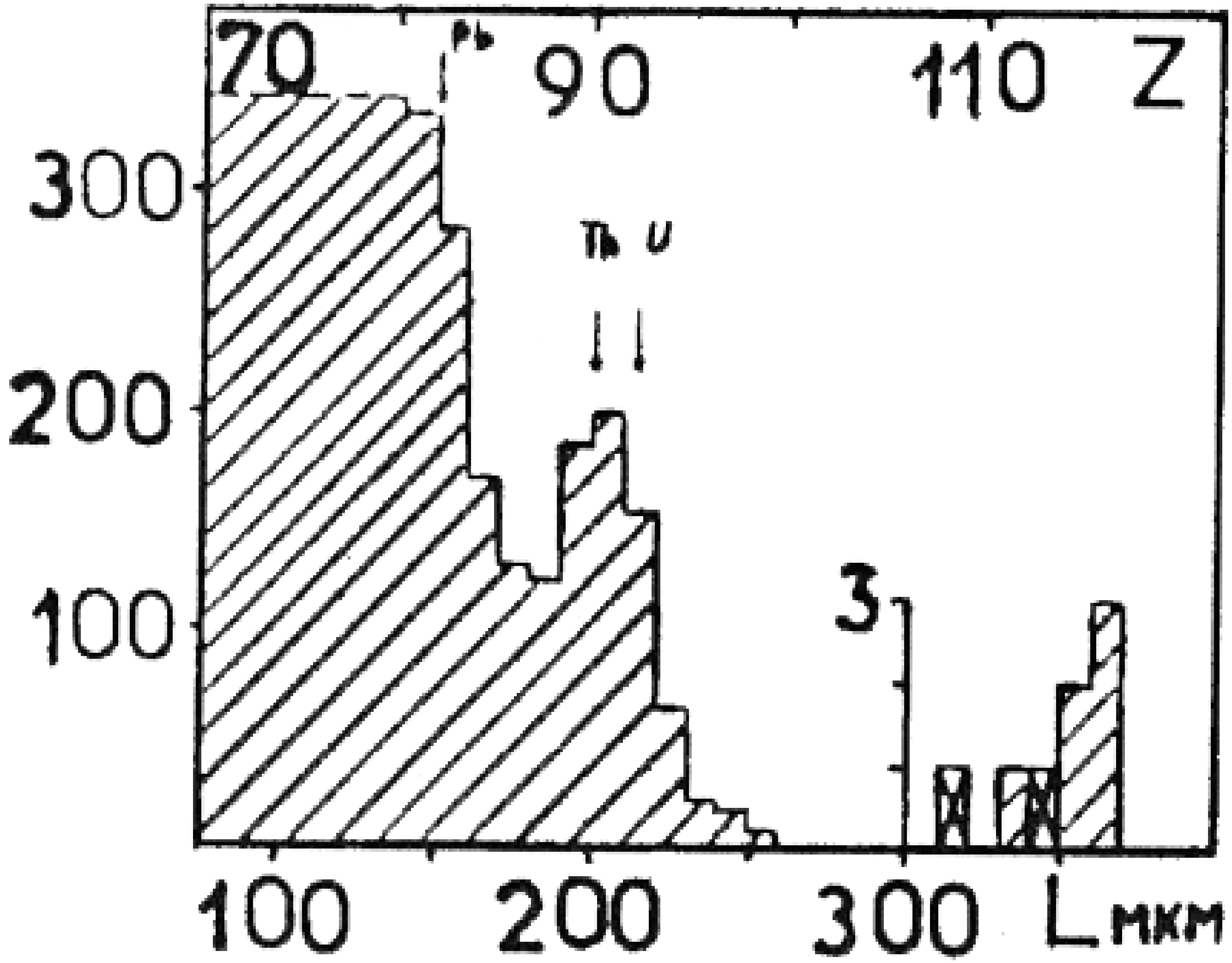
The most detailed – Perelygin V. et al.(1975-2003, Dubna)

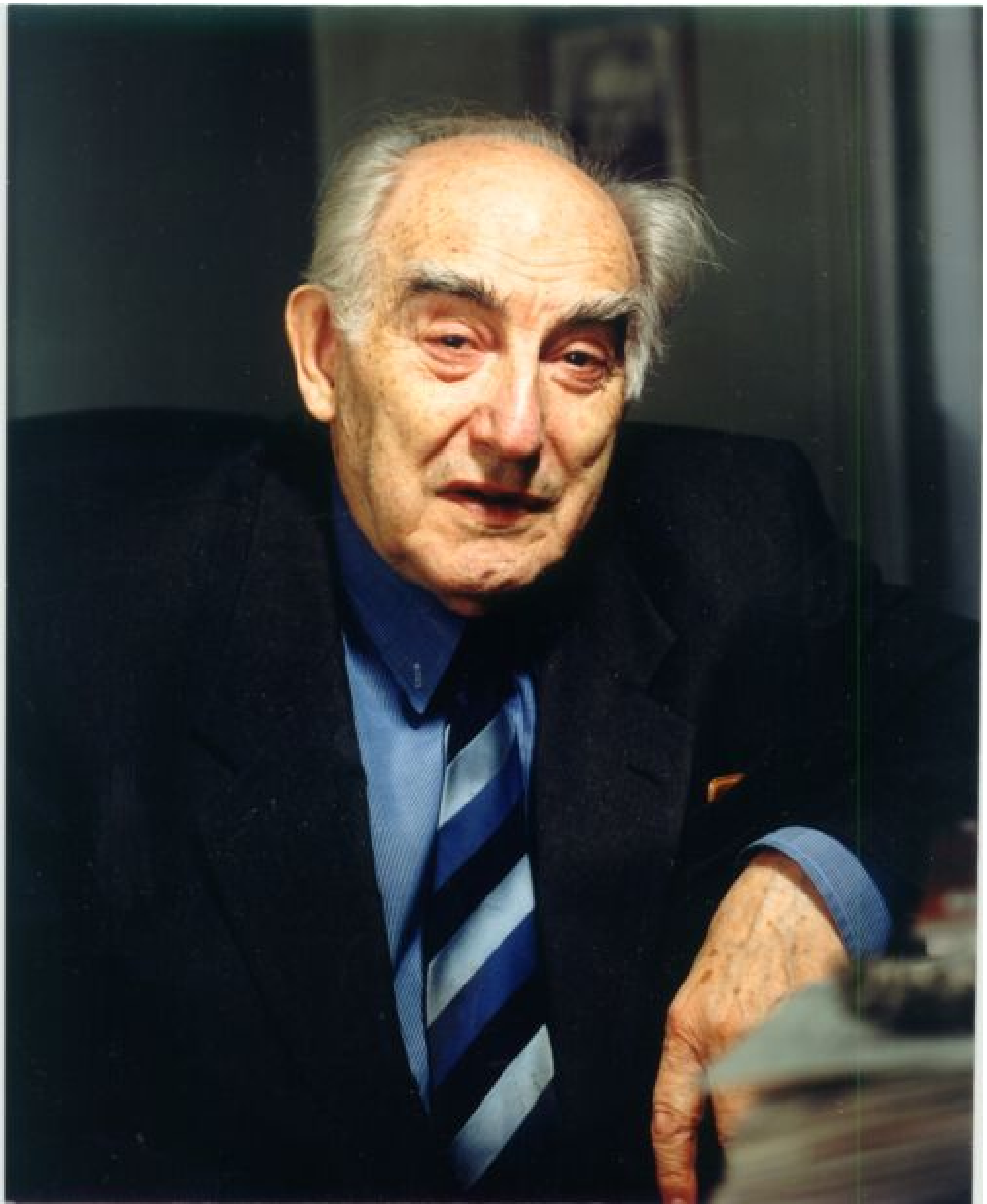
H. Tsao, et al., Astrophysical Journal, 549, 320-324, 2001

Domingo et al. (1995), Westphal et al. (1998), Donelli et al. (1999)



The most detailed – Perelygin V. et al. (1985)





Prof. V.L.Ginzburg considered problem of superheavy nuclei search (investigation of existence of stability element islands) as one of the most important problems in the modern physics.

Prof. V.L.Ginzburg included it to his famous list of first priority physical tasks.

From 2005 the investigations of galactic cosmic ray nuclei are carried out at Lebedev Physical Institute of RAS.

Doklady Physics, Vol. 50, No. 6, 2005, pp. 283–285. Translated from Doklady Akademii Nauk, Vol. 402, No. 4, 2005, pp. 472–474.

PHYSICS

Problems and Horizons of the Search for Tracks of Heavy and Superheavy Nuclei in Olivine Crystals from Meteorites (OLIMPIYA Project)

Academician **V. L. Ginzburg**, Academician **E. L. Feĭnberg, N. G. Polukhina, N. I. Starkov, and V. A. Tsarev**

Received February 1, 2005

In this paper, we consider the nuclear-physical and astrophysical aspects of investigations associated with the search for heavy and superheavy nuclei in the composition of cosmic rays. We also discuss the potentiality of searching for tracks of these nuclei in the olivine crystals found in meteorites with the use of the completely automated PAVICOM setup, which was designed for the scanning and processing of tracks of particles.

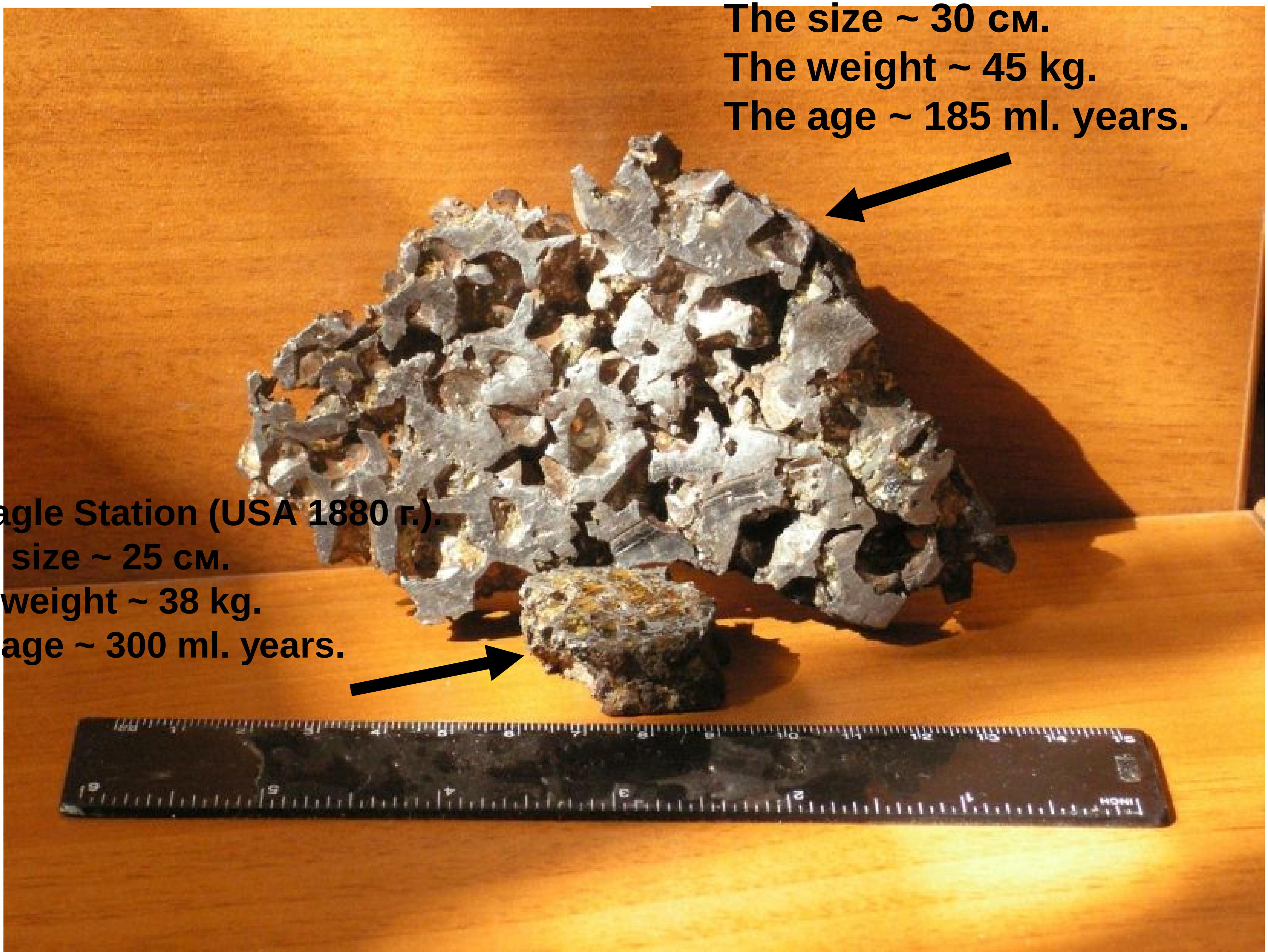
tinue to hold for very large values of *N* and *Z*, the existence of stability islands for even heavier nuclei must not be ruled out.

Verification of the existence of unusual stable forms of nuclear matter containing, for example, strange [4] or other even heavier quarks [5] would also be of obvious interest.

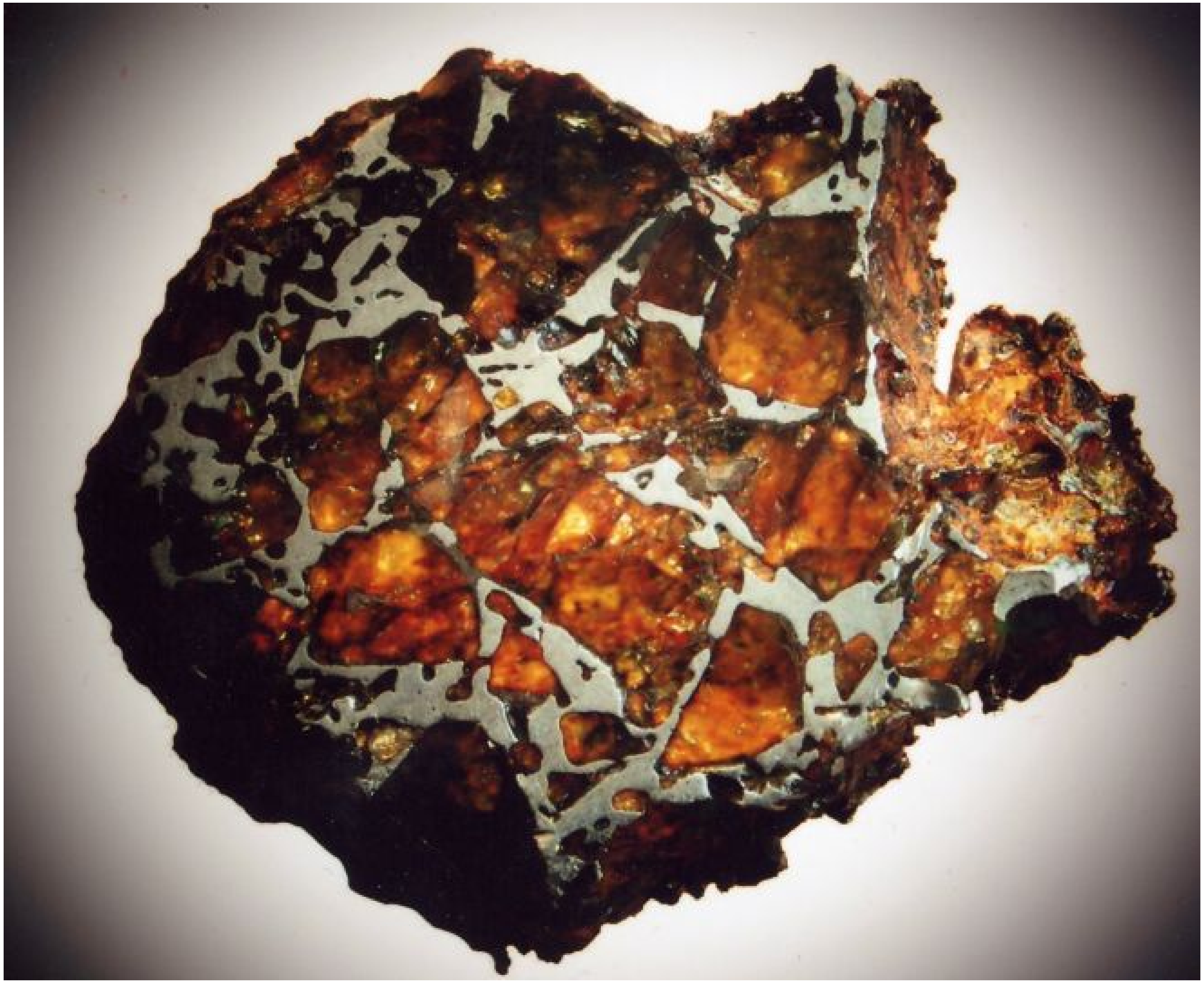
2. The measurement of fluxes and of the spectra of heavy and superheavy nuclei composing cosmic rays is

Completely Automated Measuring Facility PAVICOM

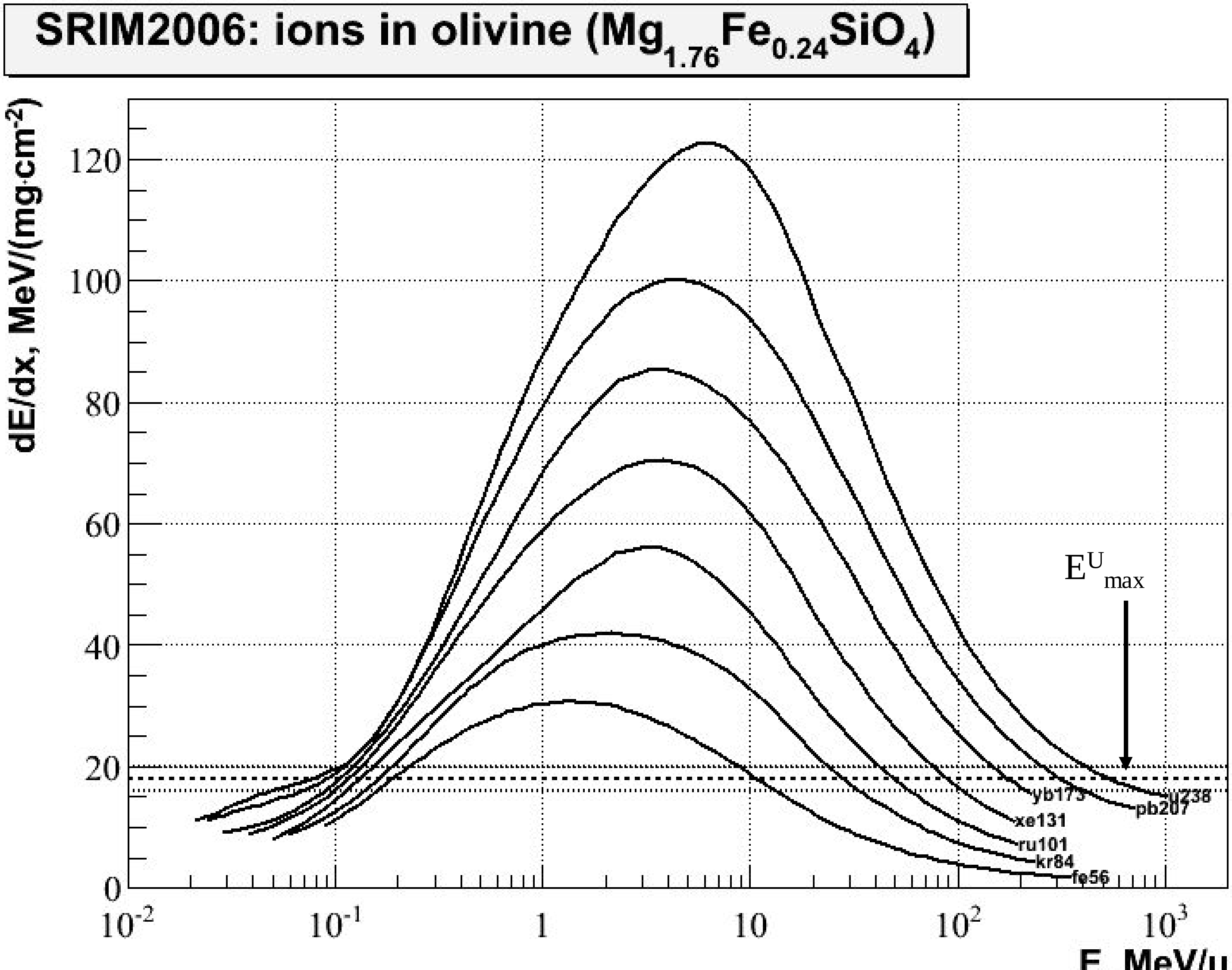
1. Marjalahty (Finland, 1902 г.).
The size ~ 30 см.
The weight ~ 45 kg.
The age ~ 185 ml. years.



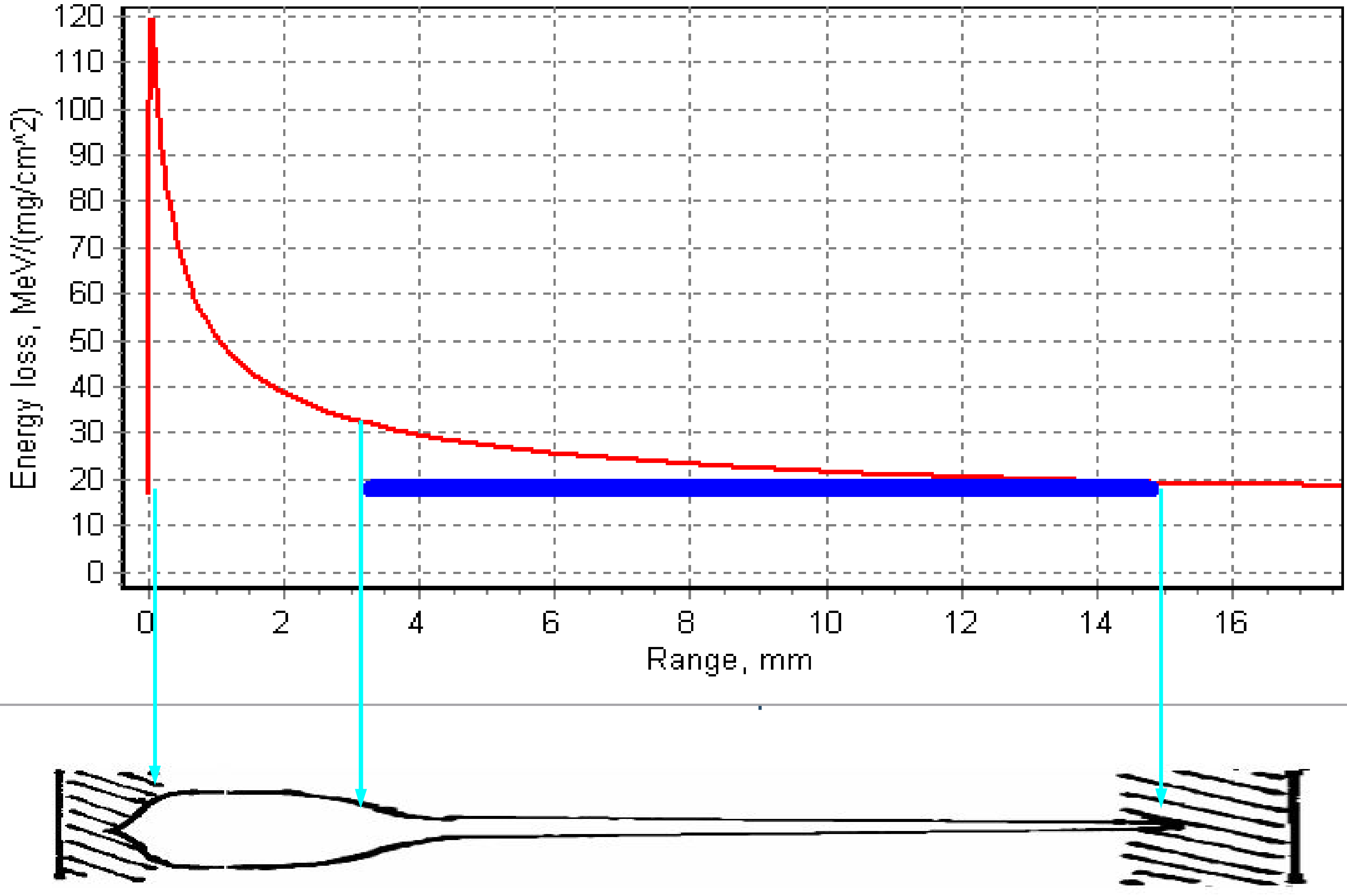
2. Eagle Station (USA 1880 г.).
The size ~ 25 см.
The weight ~ 38 kg.
The age ~ 300 ml. years.

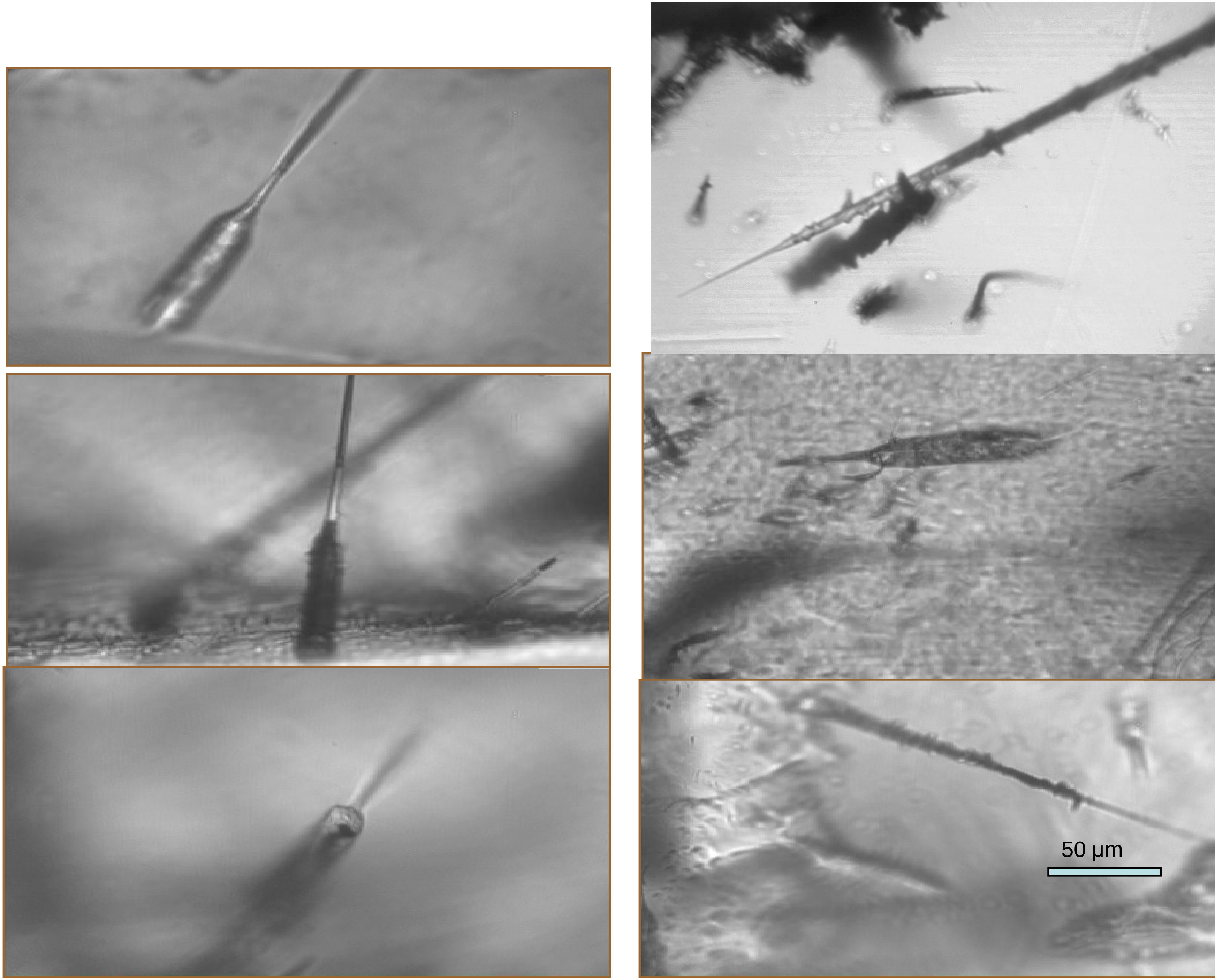


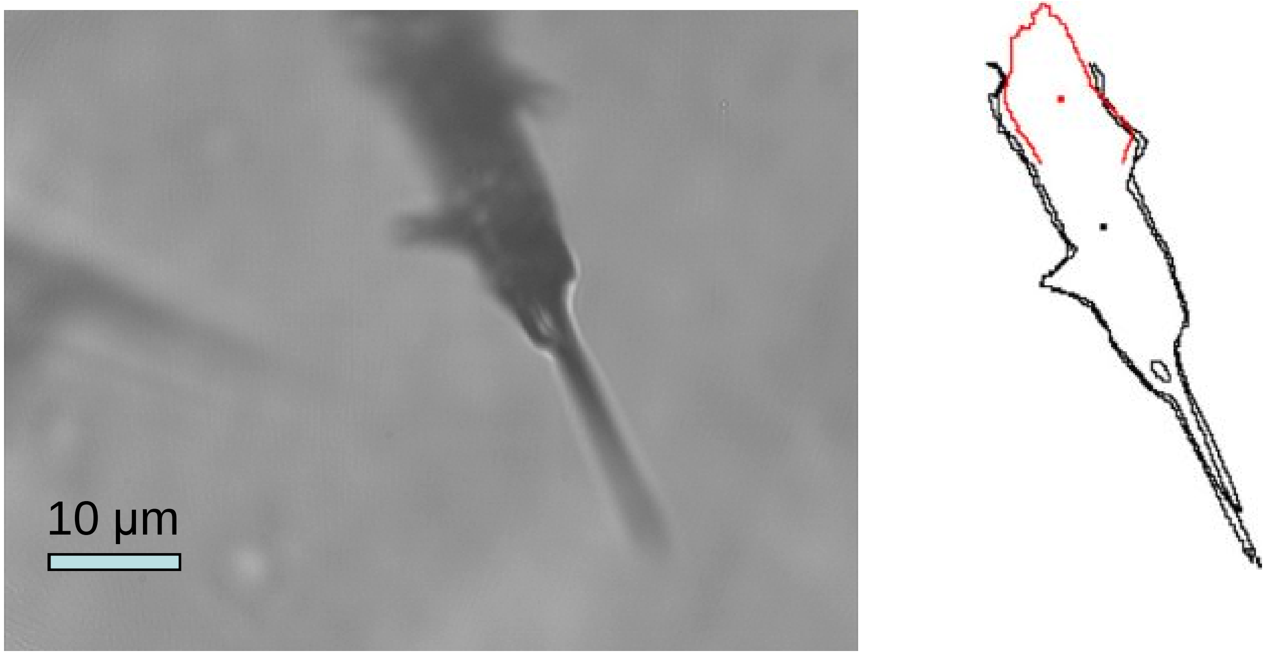
The curves illustrate the method of the full etching track length determination in olivine for a number of nuclei from ${}^{56}_{26}Fe$ up to ${}^{238}_{92}U$

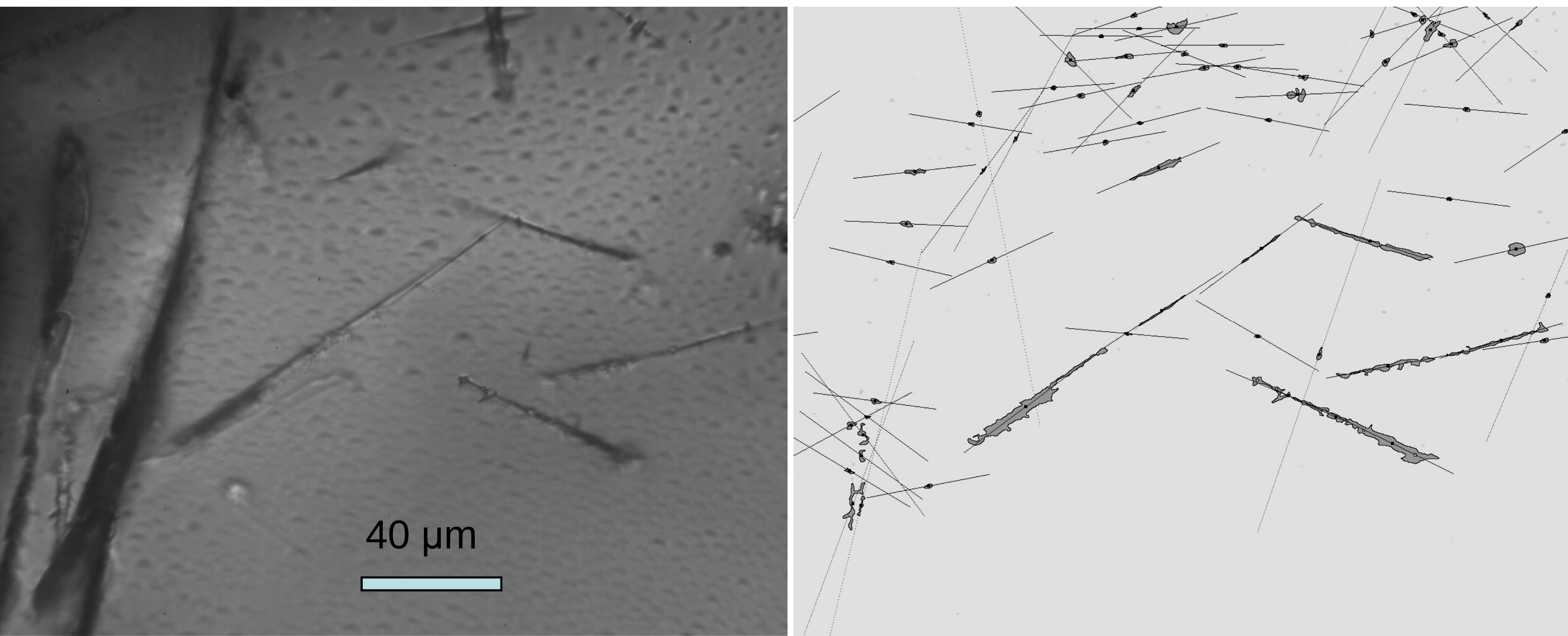


The scheme of etching track formation in olivine

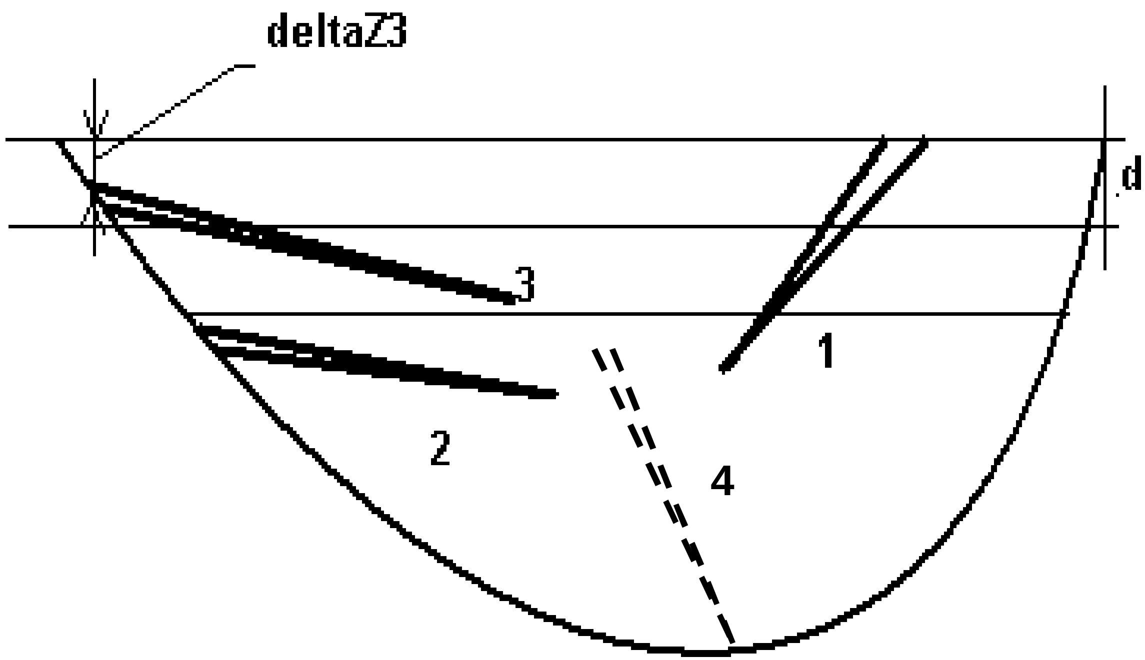



50 μm


10 µm


40 µm

The method of stepwise cut and etching is used



The thickness of cut layer is ***d*** = 30 – 100 µm

The charge identification method

The main problem:

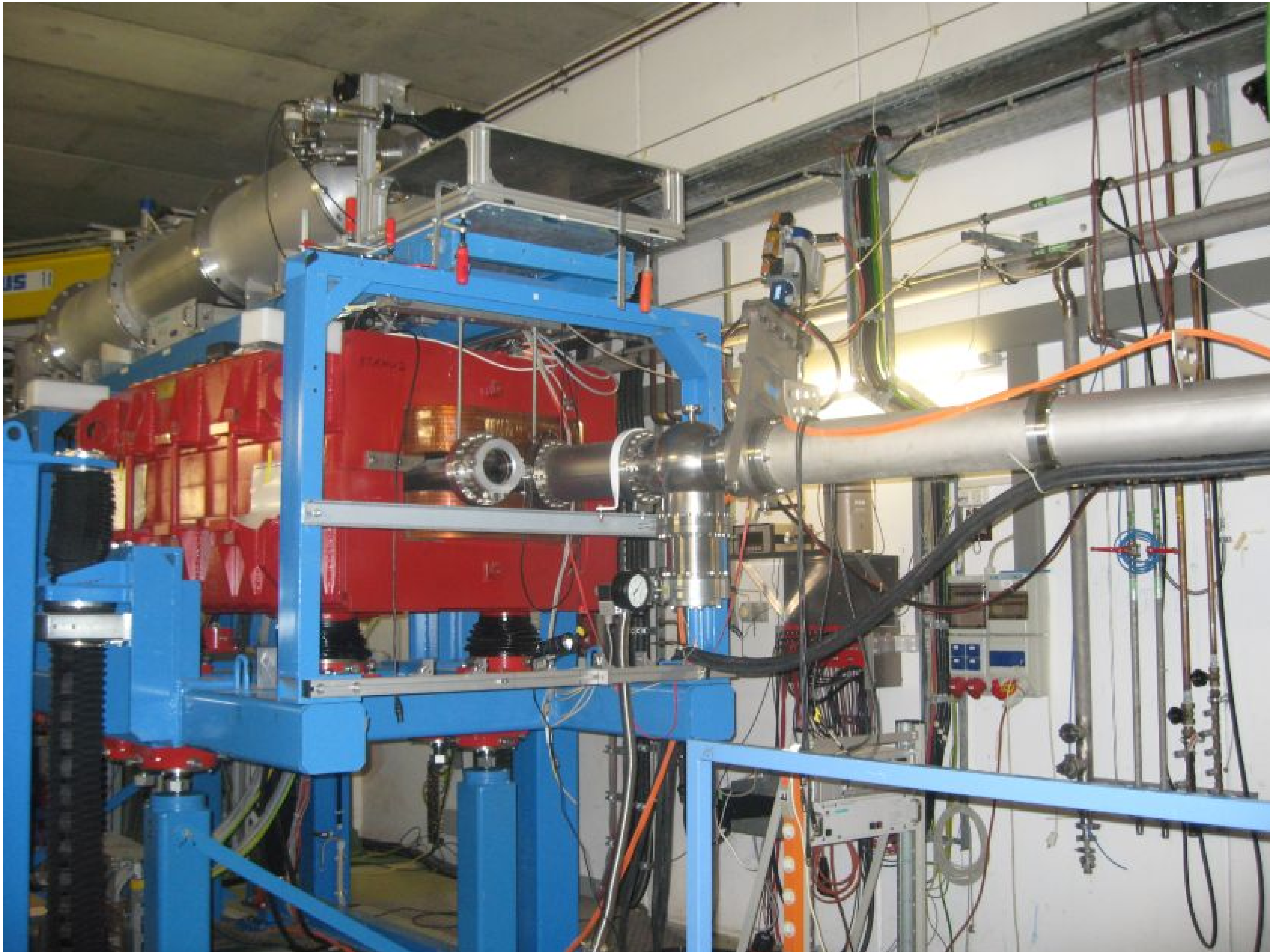
the size of the using olivine pieces is less as compared with total etched length.

=>   The measurement only track length is not enough

Characteristics :

1. The length of etched track.
2. The etching rate.
3. The etched channel width.

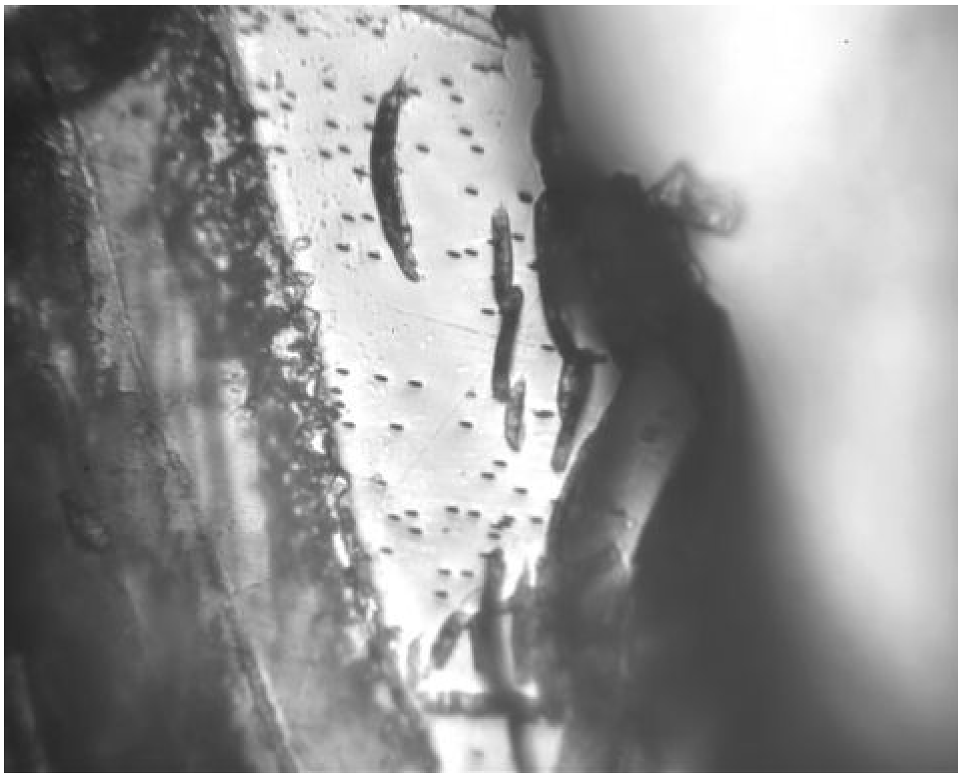
=> It is necessary to have calibration experiments



Xe nuclei tracks (E=11,4 MeV/n)

Size field of view ~ 500×700 microns

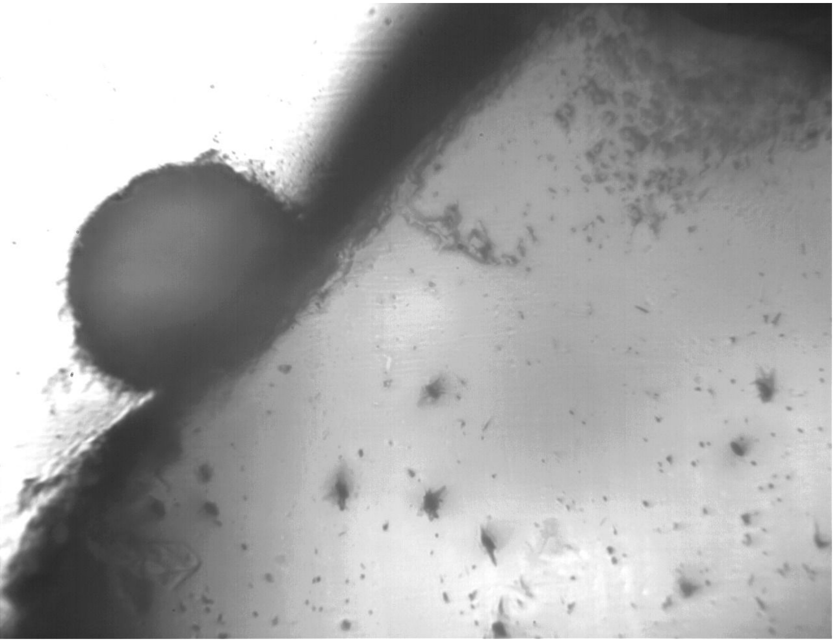
Flux density (4-10)10**5 nuclei/cm**2 - 30-80 tracks/crystal



Length of tracks 57±6 мкм (by the calculation ~ 65 мкм)

Etch rate (E=11.4 MeV/nucl) ≈ 10-14 micron/hour

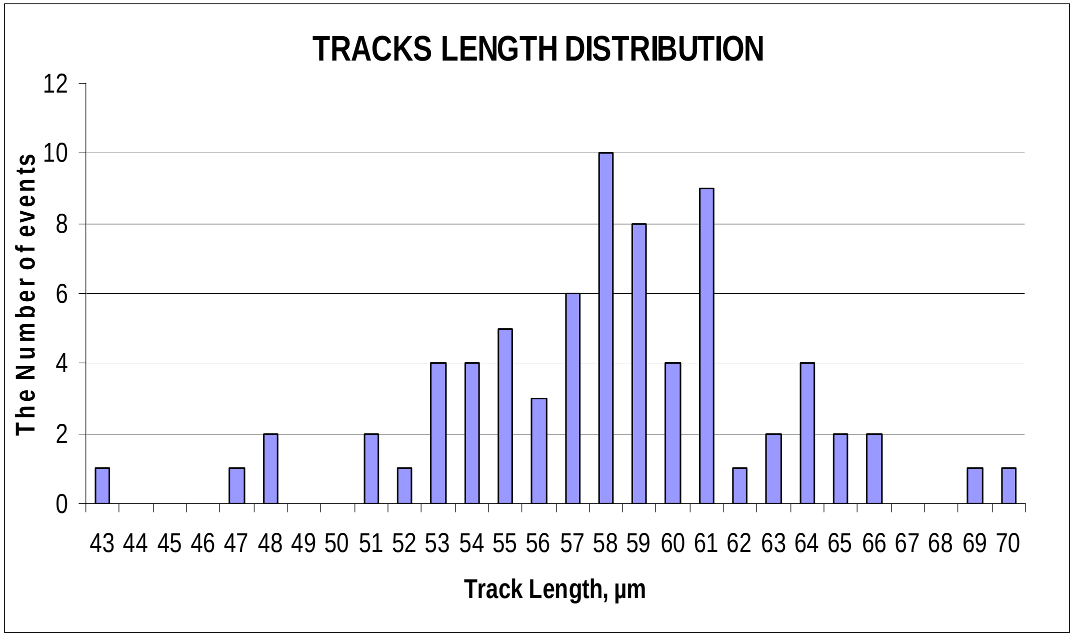
Darmschtadt, GSI, 2009 г., Au, 11.4 MeV/n



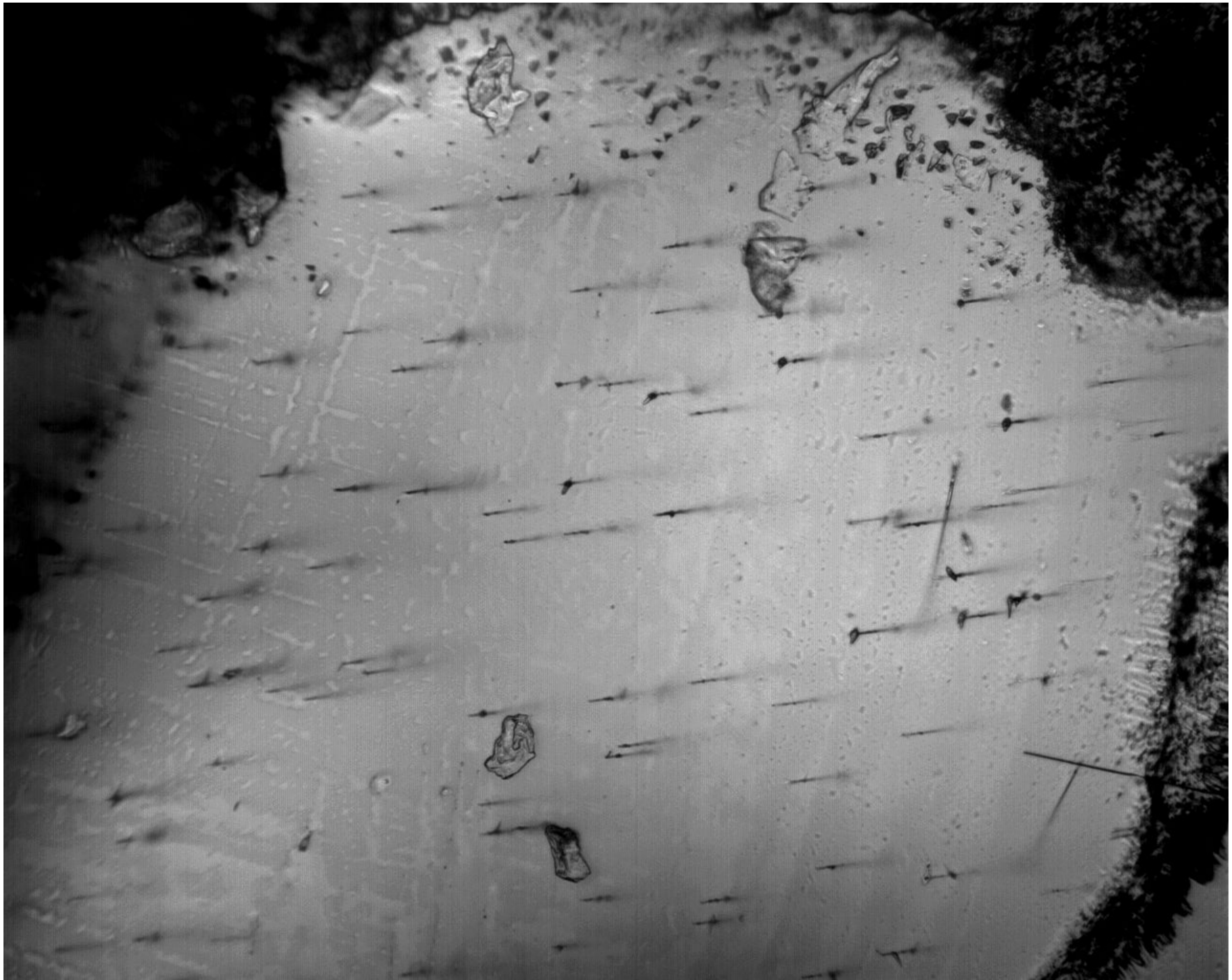
Calculation: (77 ± 5) microns

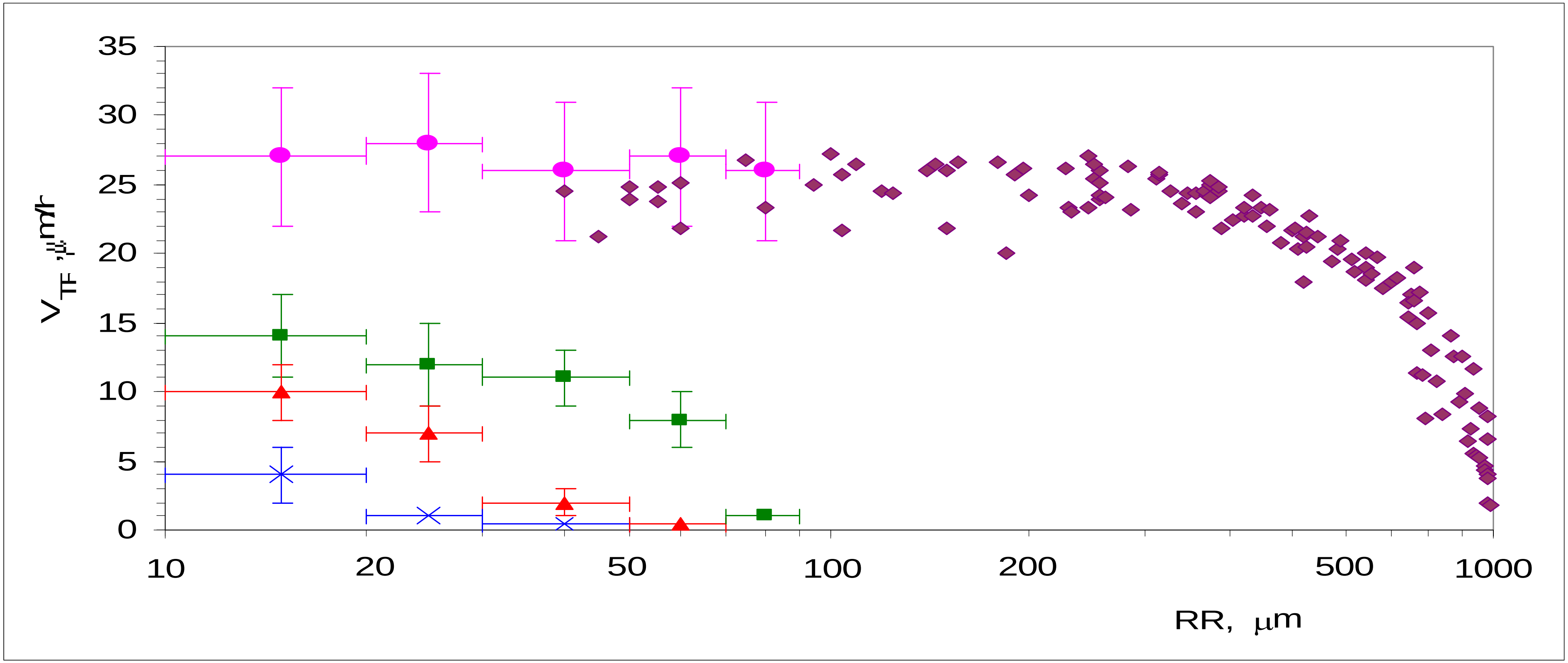
Experiment: (69 ± 6) microns

Etch rate 16 micron/hour



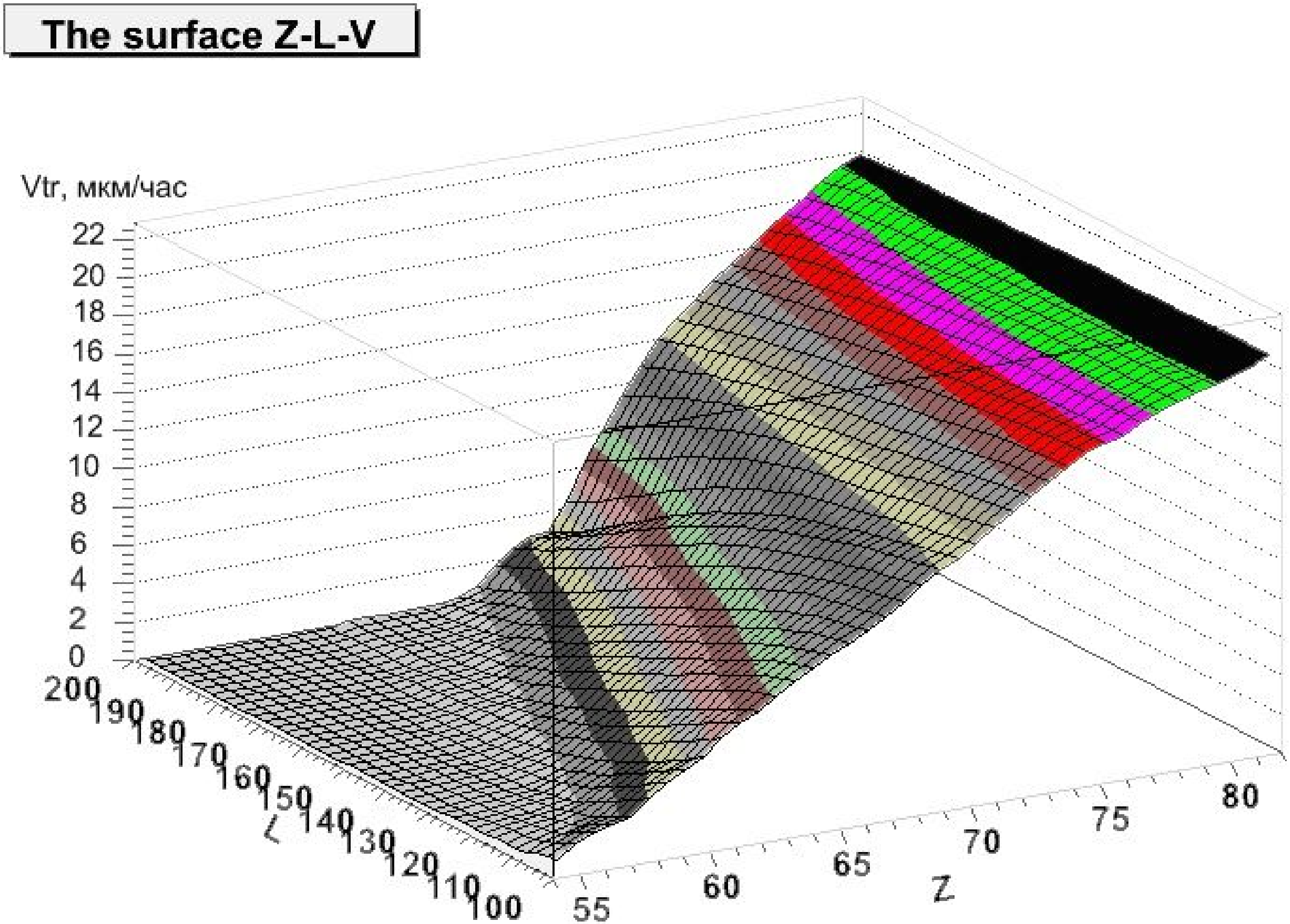
Darmschtadt, GSI, 2010 г., U, E= 150 МэВ/н





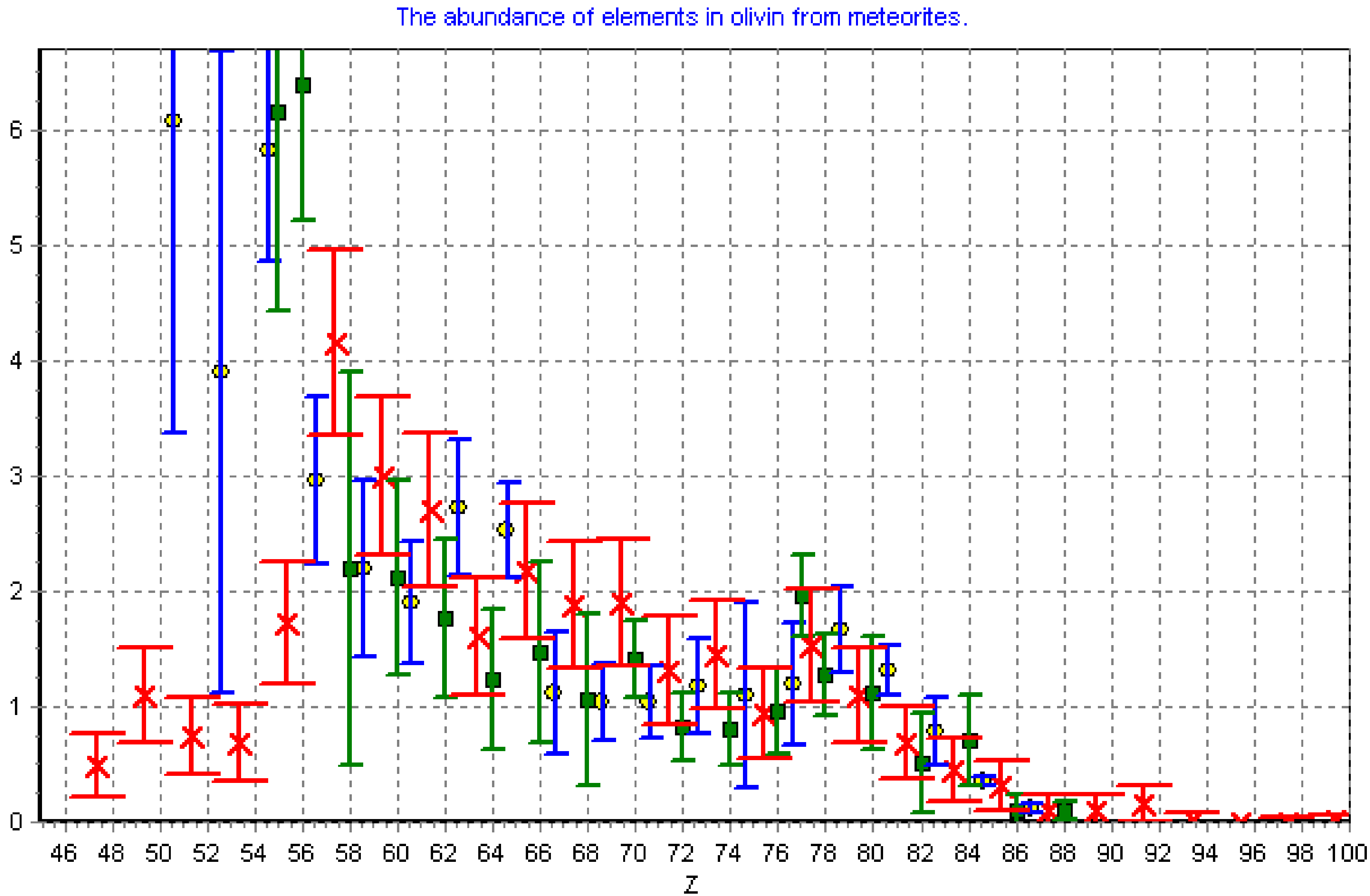
Measured VTR values at the certain residual range (RR) of accelerated Kr, Xe and U ions and Fe nuclei in olivine crystals from the Marjalahti pallasite.

Charge – Length – Etching Rate dependence (UFN, v. 180, № 8, p.839-842, 2010).



The galactic nuclei abundance A (A_{Fe}= 10^6)

(■ - HEAO; o – Ariel; x – our results)



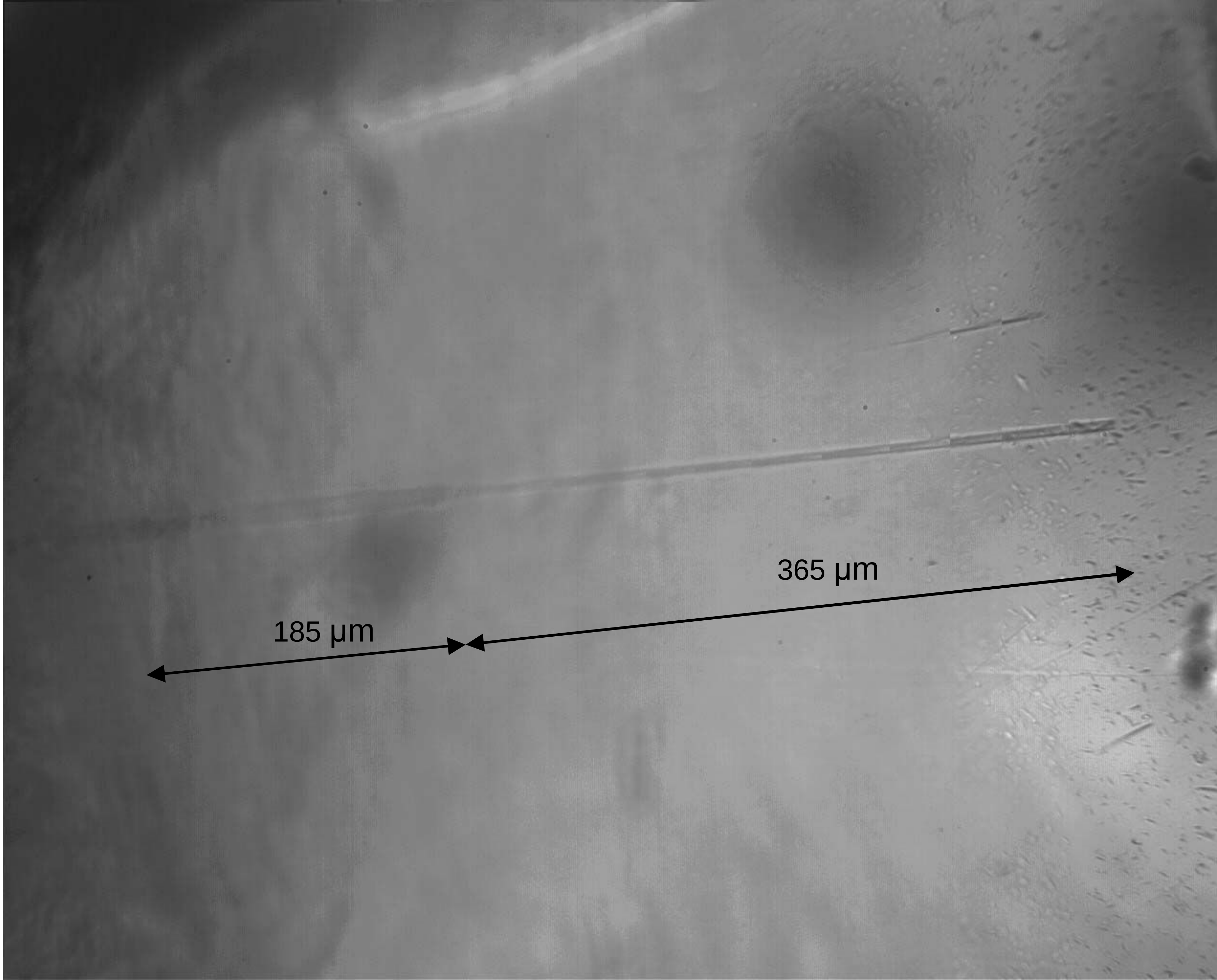
Superheavy nuclei

Besides the distributions of galactic nuclei we observed three events having very large charges (our estimations are Z>105).

Their lengths are large (700-900 μm) but their minimal etching rates are more then

35 μm/h.

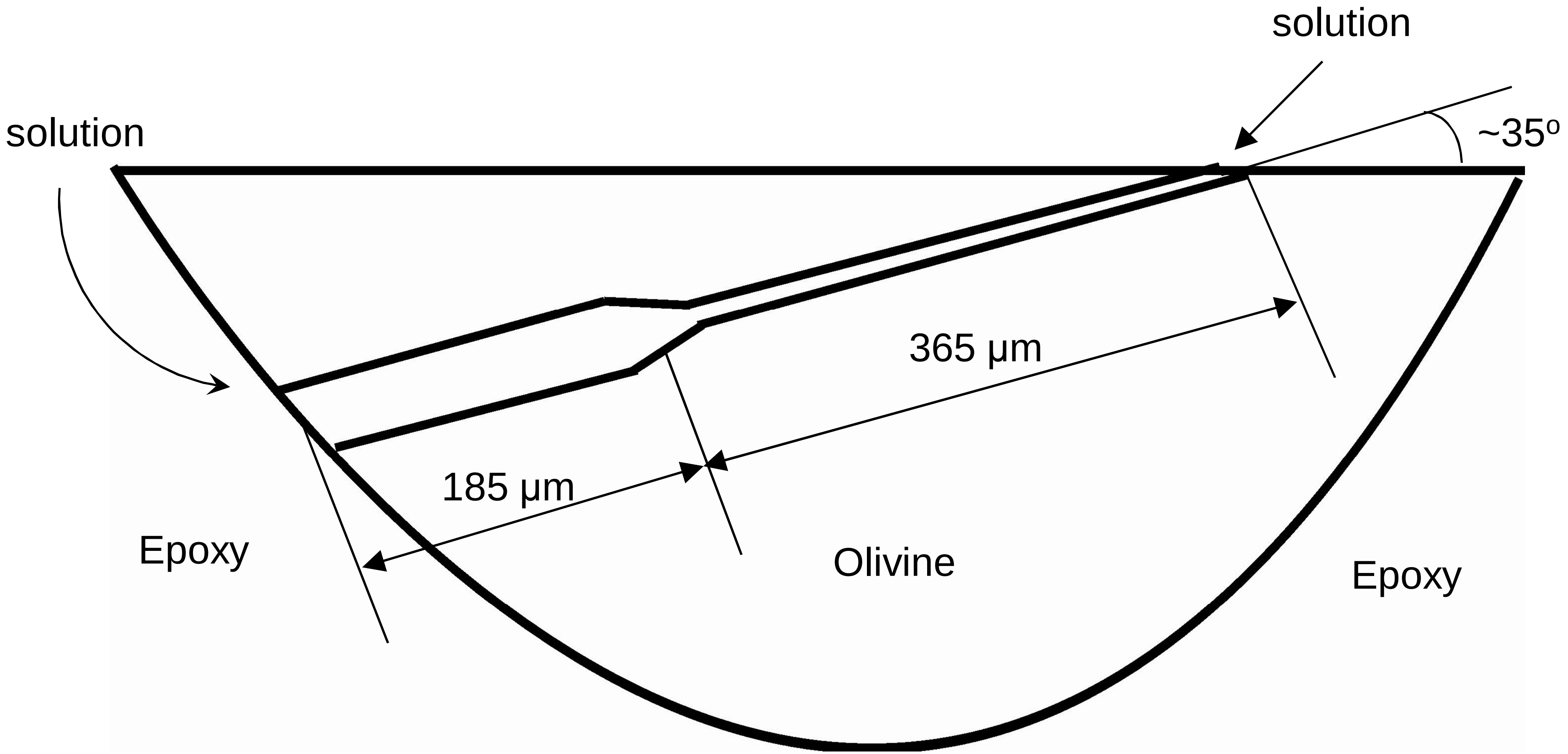
It is very large as compared with the uranium maximum etching rate (25 μm/h).


365 µm
185 µm

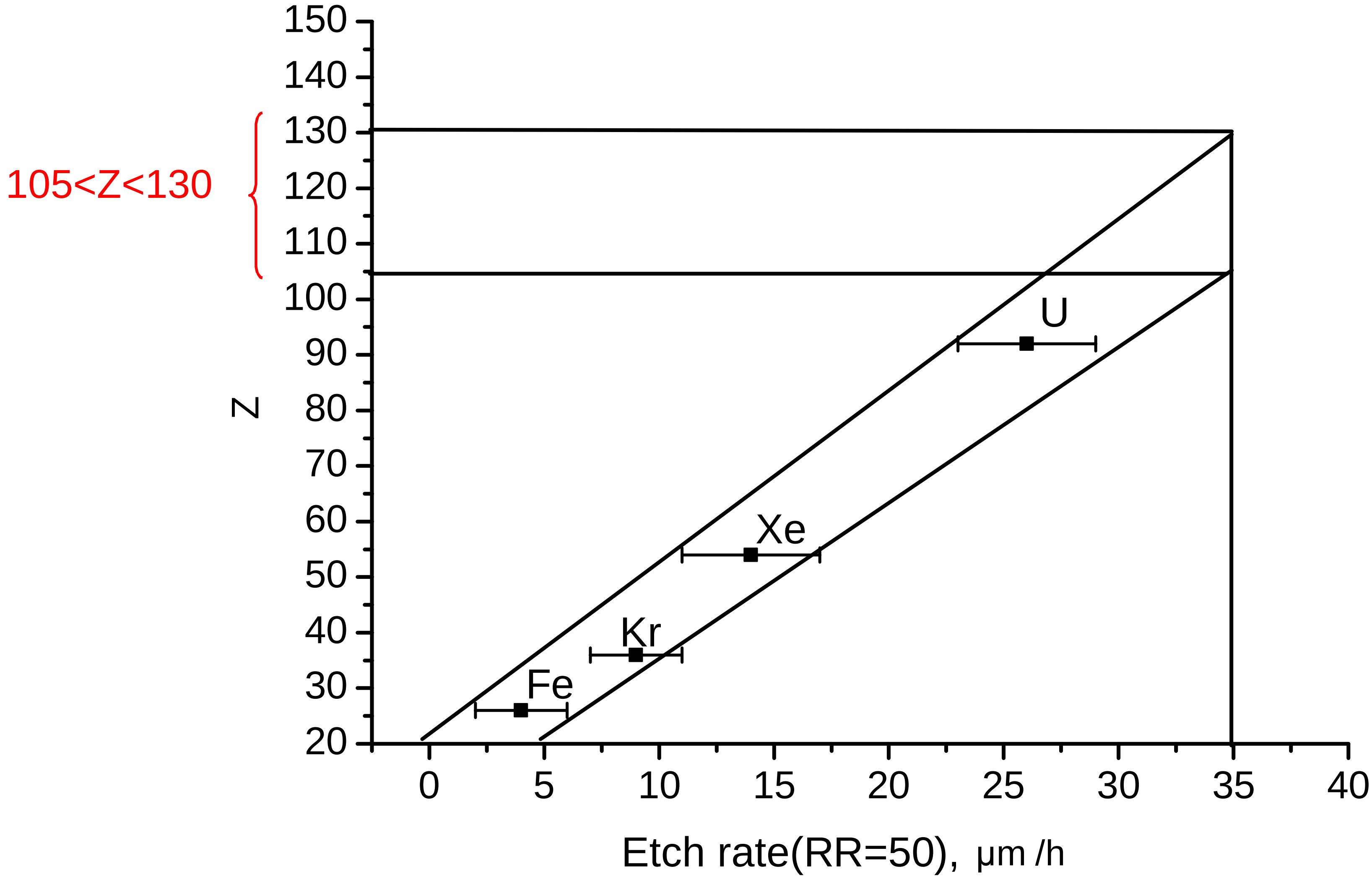
The total track length in olivine is ~550 μm.   The etching time is 8 hours.

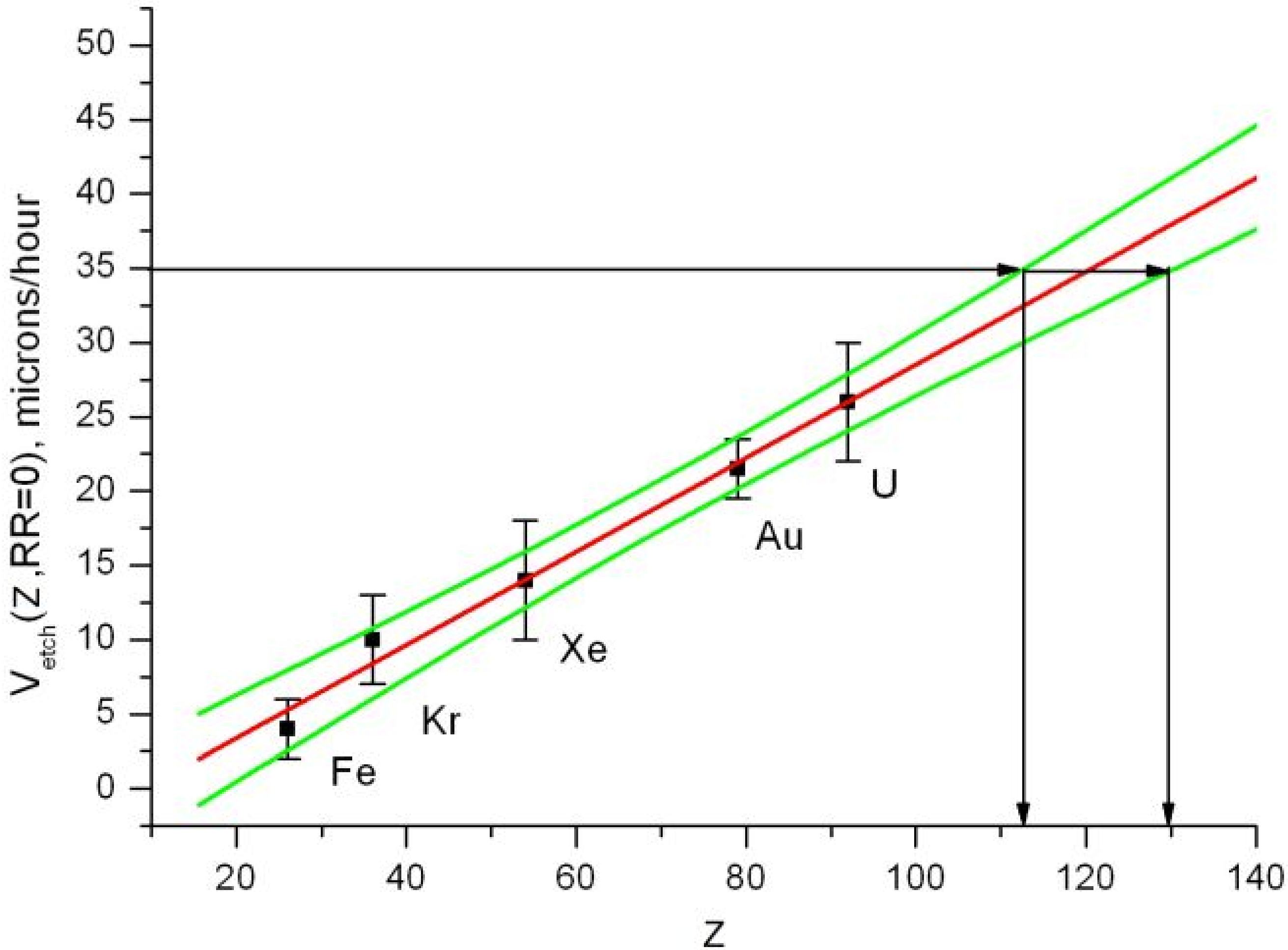
but the etch solution can reach to track from both sides.

=>   The minimum etching rate is about 35 μm/h.



The extrapolation of the residual range dependence $Z(RR,V_{etch})$ to superheavy nuclei.





Regression analysis: at the confidence level 95% nucleus charge with etching rate about 35 micron/hour is **Z=119(+10,-6).**

On the plot: red line – approximation for experimental data by straight line, green lines – error corridor at the confidence level 95%. Vertical lines mark out possible charge interval at the confidence level 95% at etching rate near stopping point 35 micron/hour.

Conclusions.

1. We derived the charge distribution of 6000 galactic nuclei whose charges are more 55.

2. We observed three events whose charges are estimated $105<Z<130$ (one of them - $Z=119(+10,-6)$).

3. So we derived additional indication of existence in nature (galactic cosmic ray) of the elements near stability island.