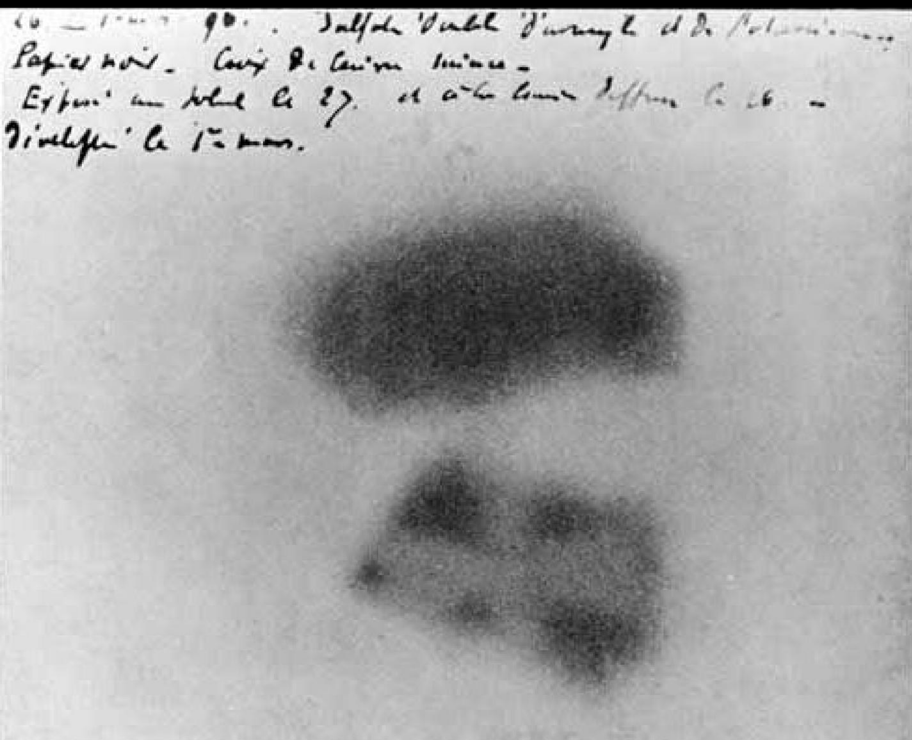
BECQUEREL PROJECT

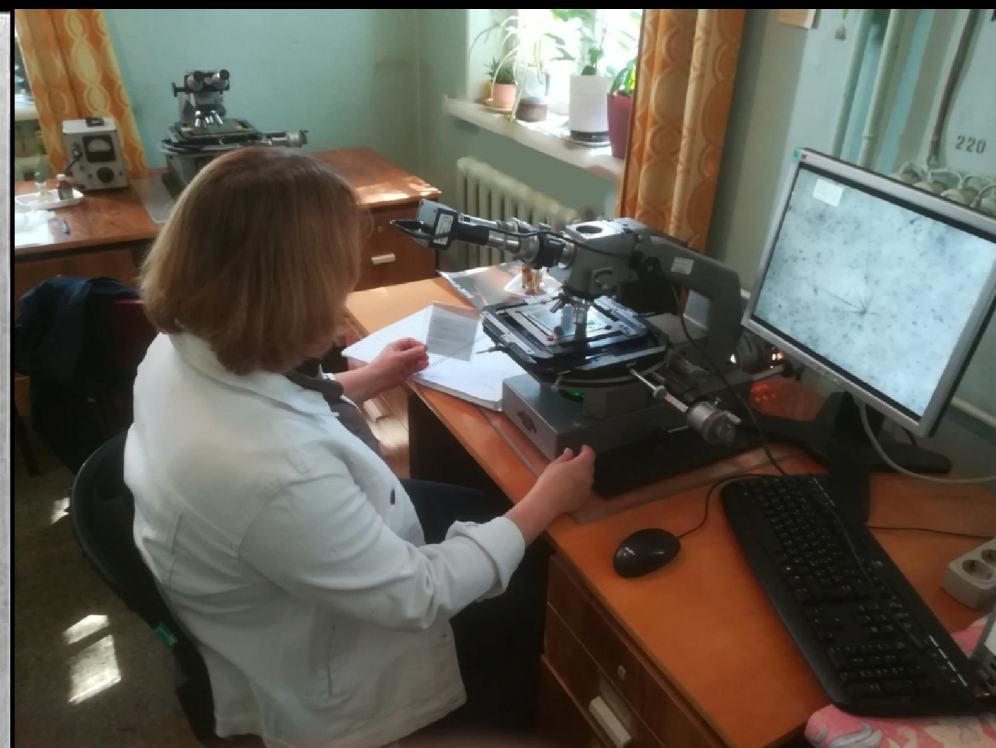
Проект БЕККЕРЕЛЬ

Beryllium (Boron) Clustering Quest in Relativistic Multifragmentation

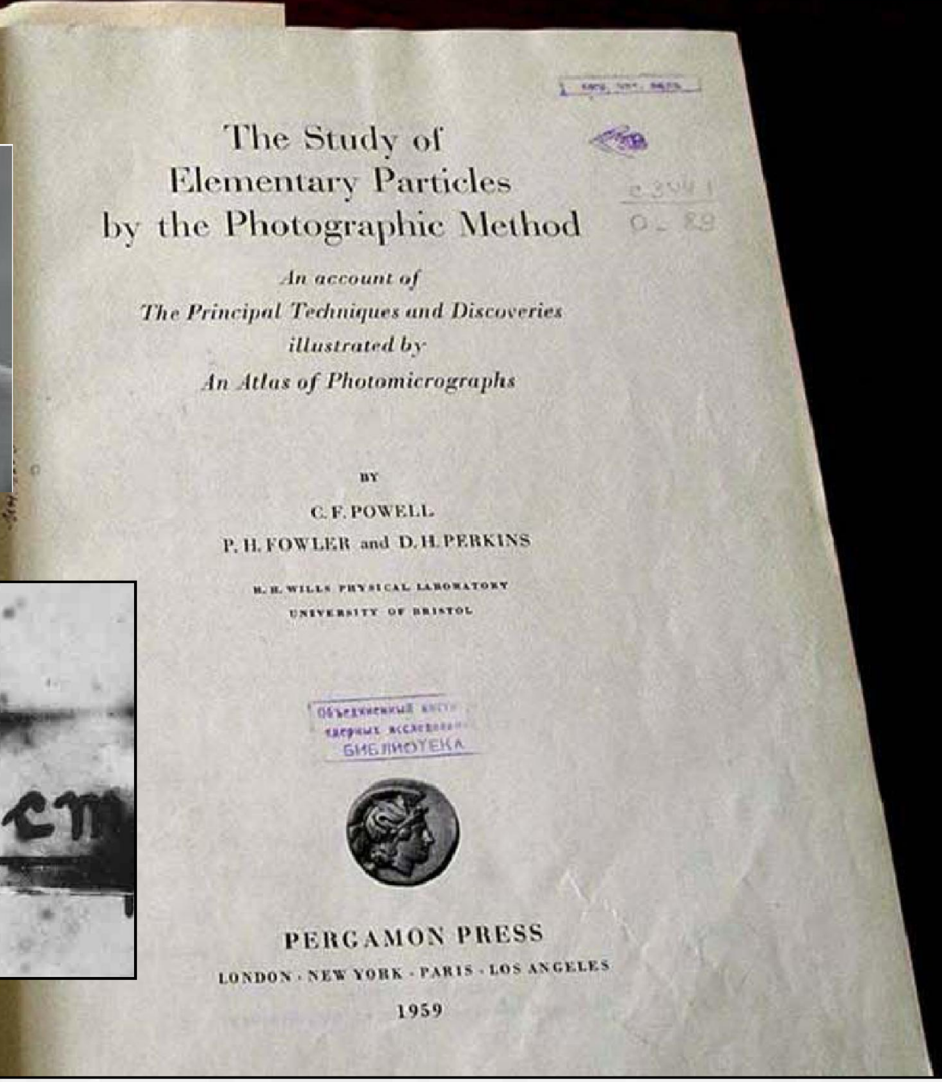
http://becquerel.jinr.ru

Pavel Zarubin “Observation of U and Cf fission in nuclear track emulsion (Status report)”





Veksler & Baldin Laboratory of High Energy Physics, JINR, Dubna, Russia



The Study of
Elementary Particles
by the Photographic Method

An account of
The Principal Techniques and Discoveries
illustrated by
An Atlas of Photomicrographs

BY
C. F. POWELL
P. H. FOWLER and D. H. PERKINS

H. H. WILLS PHYSICAL LABORATORY
UNIVERSITY OF BRISTOL

PERGAMON PRESS
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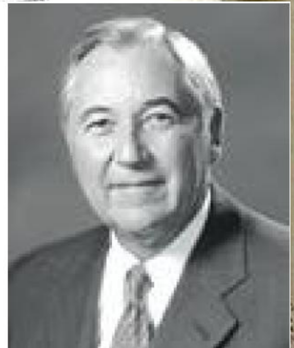
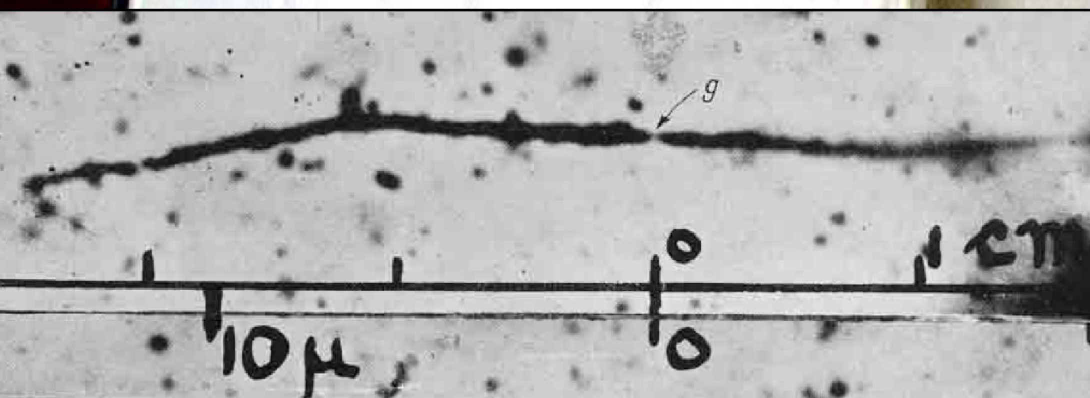
1959





Tracks due to the fission of uranium. A thin layer of a uranium salt was 'sandwiched' between two layers of emulsion so that the origin of the two fission fragments can be determined by the gap in the track (g), and the two ranges thus separately determined. The fragment on the left has collided with a nucleus in the emulsion to produce a forked track. The refinement of detail given by the very fine-grain emulsions produced by DEMERS is immediately apparent. The upper scale is divided to correspond approximately to the equivalent range in centimetres of air at N.T.P.

On the New Fission Processes of Uranium Nuclei

TSIEN SAN-TSIANG, HO ZAH-WEI, R. CHASTEL, AND L. VIGNERON
Laboratoire de Chimie Nucléaire du Collège de France, Paris, France
February 13, 1947

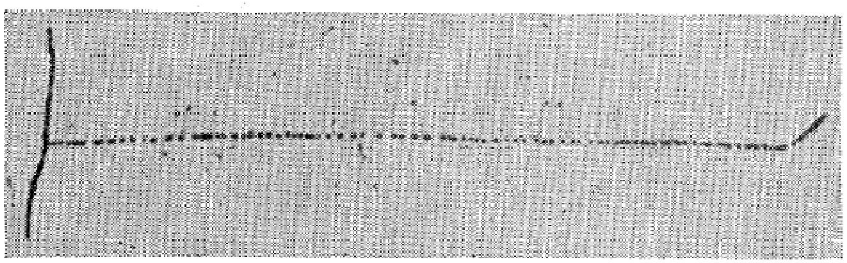


FIG. 1. Ternary fission: third fragment—mass≈9, range = 17 cm air equivalent.

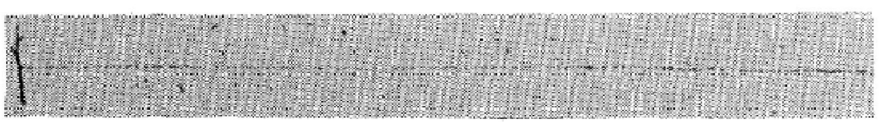


FIG. 2. Ternary fission: third fragment—mass≈6, range = 44 cm air equivalent. The two branches on one of the heavy fragments are caused by nuclear collisions.

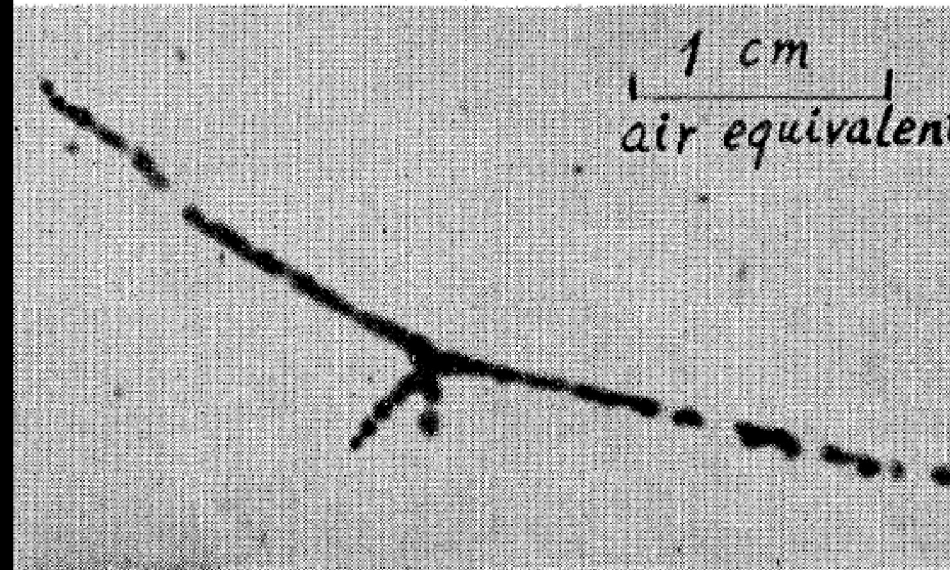


FIG. 4. Quaternary fission.

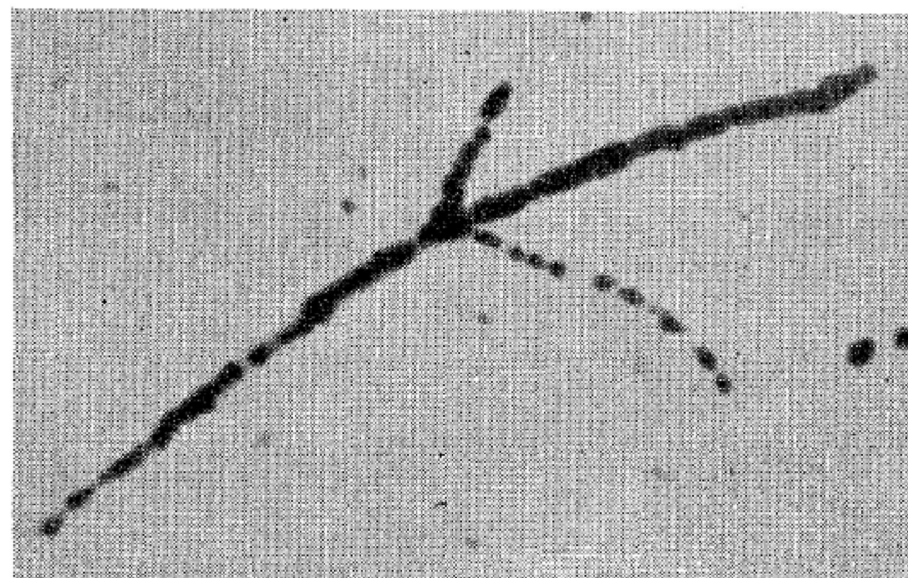
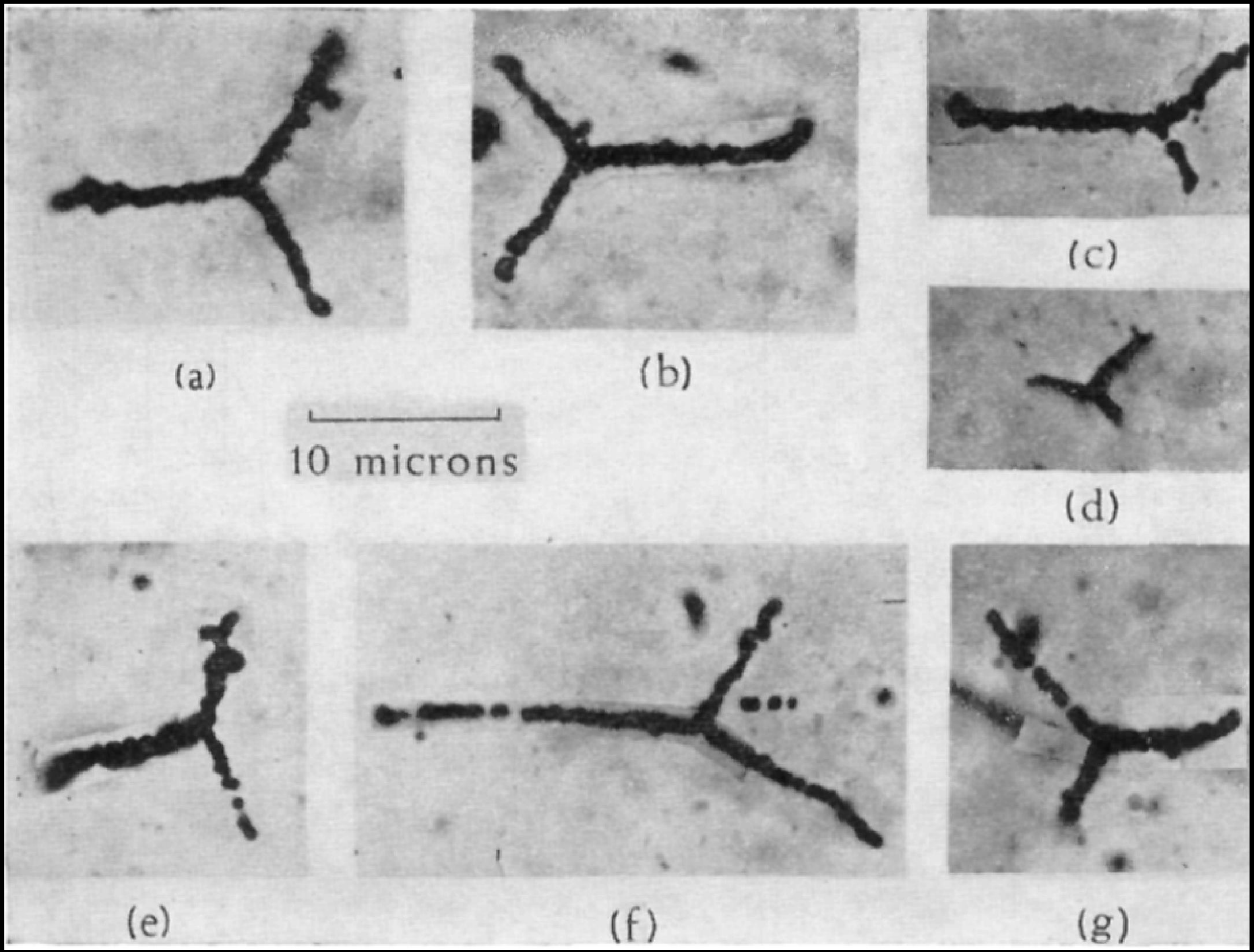


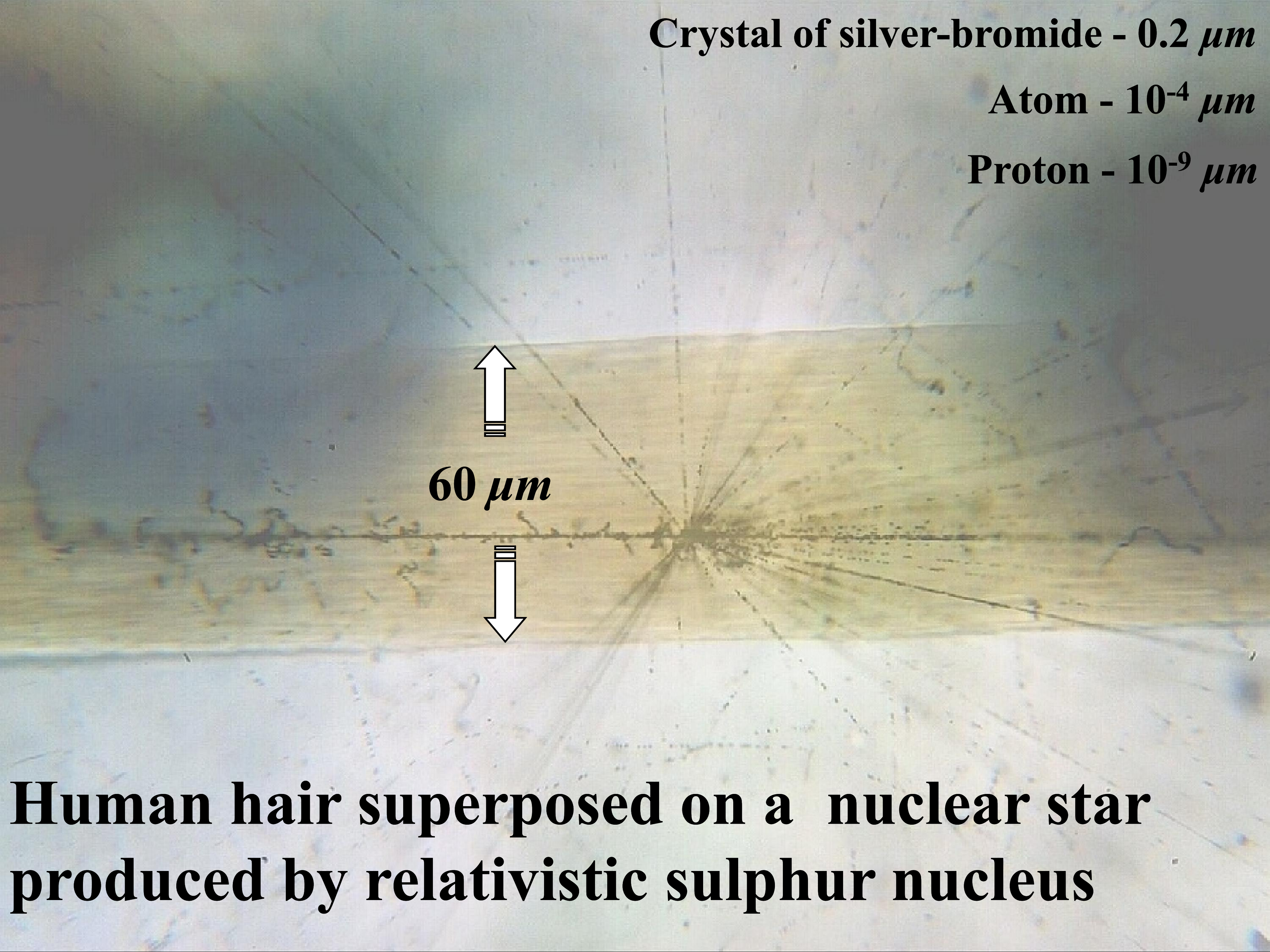
FIG. 5. Quaternary fission. (In same scale as Fig. 4.)

PHYSICAL REVIEW VOLUME 121, NUMBER 1 JANUARY 1, 1961

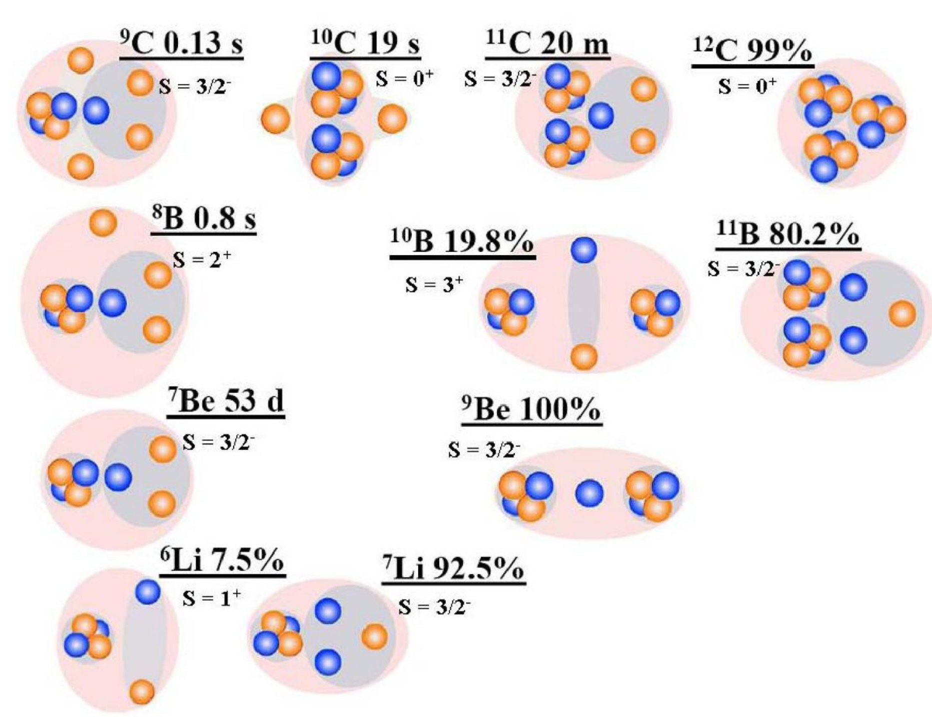
Tripartition in the Spontaneous-Fission Decay of Cf^{252}†

M. Luis Muga, Harry R. Bowman, and Stanley G. Thompson.
Lawrence Radiation Laboratory, University of California, Berkeley, California

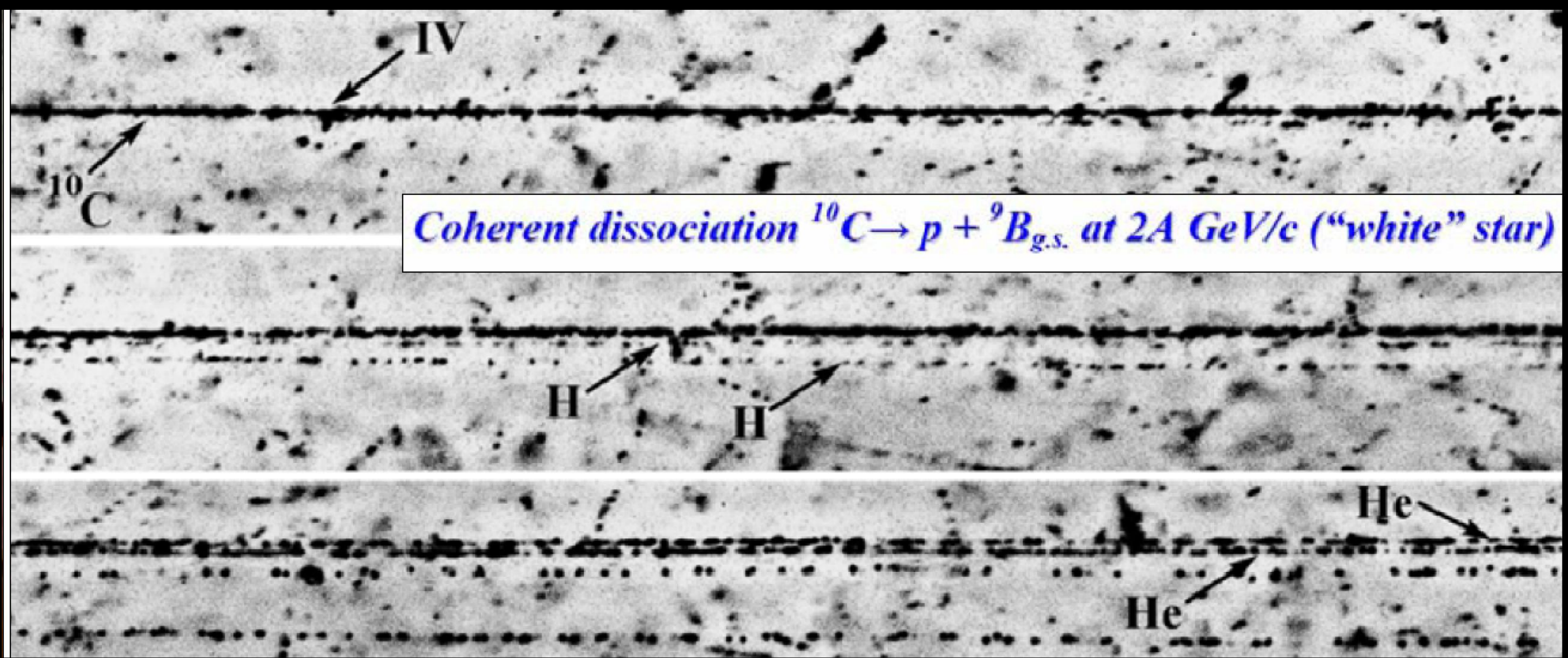




Human hair superposed on a nuclear star produced by relativistic sulphur nucleus

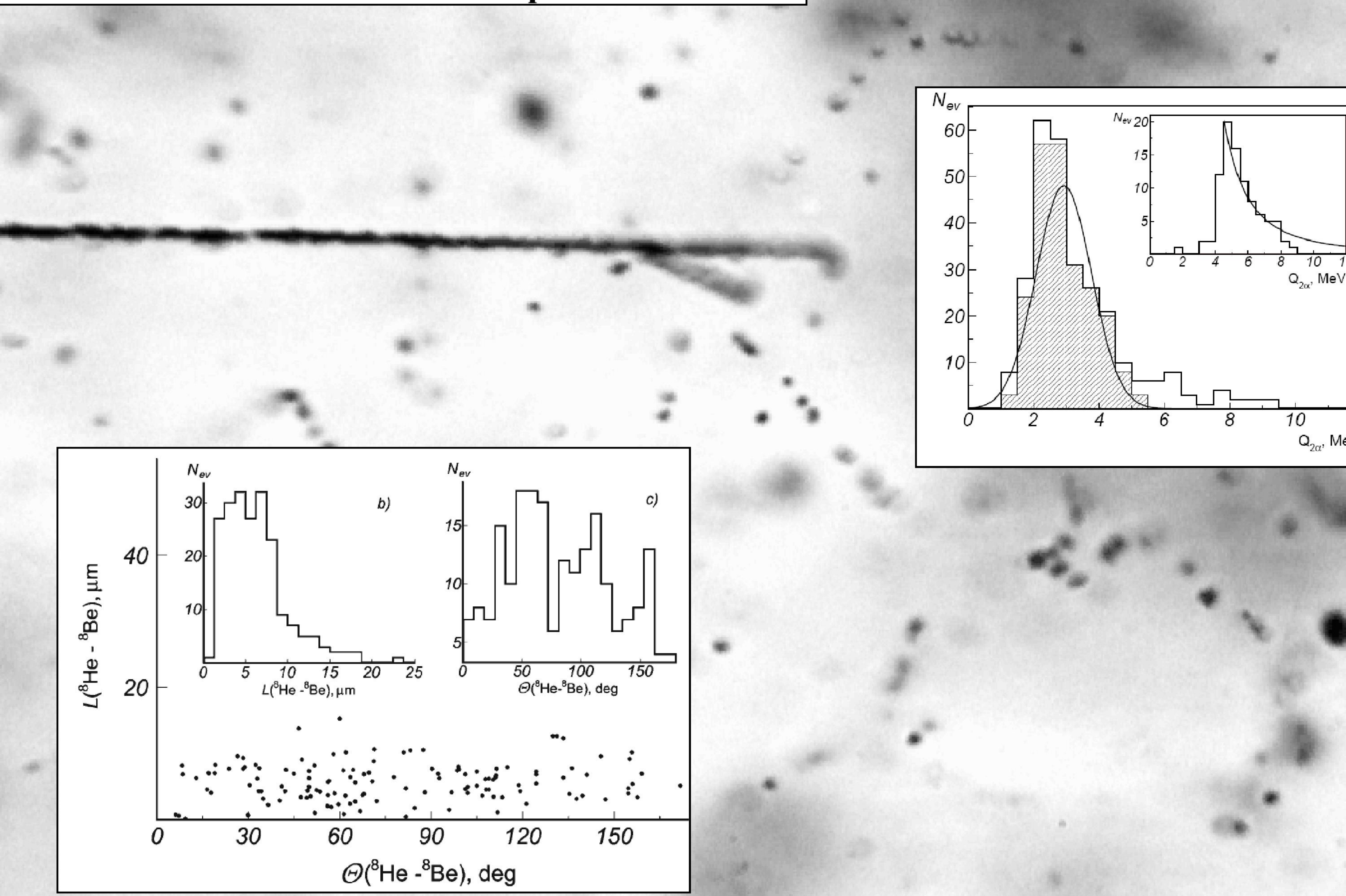


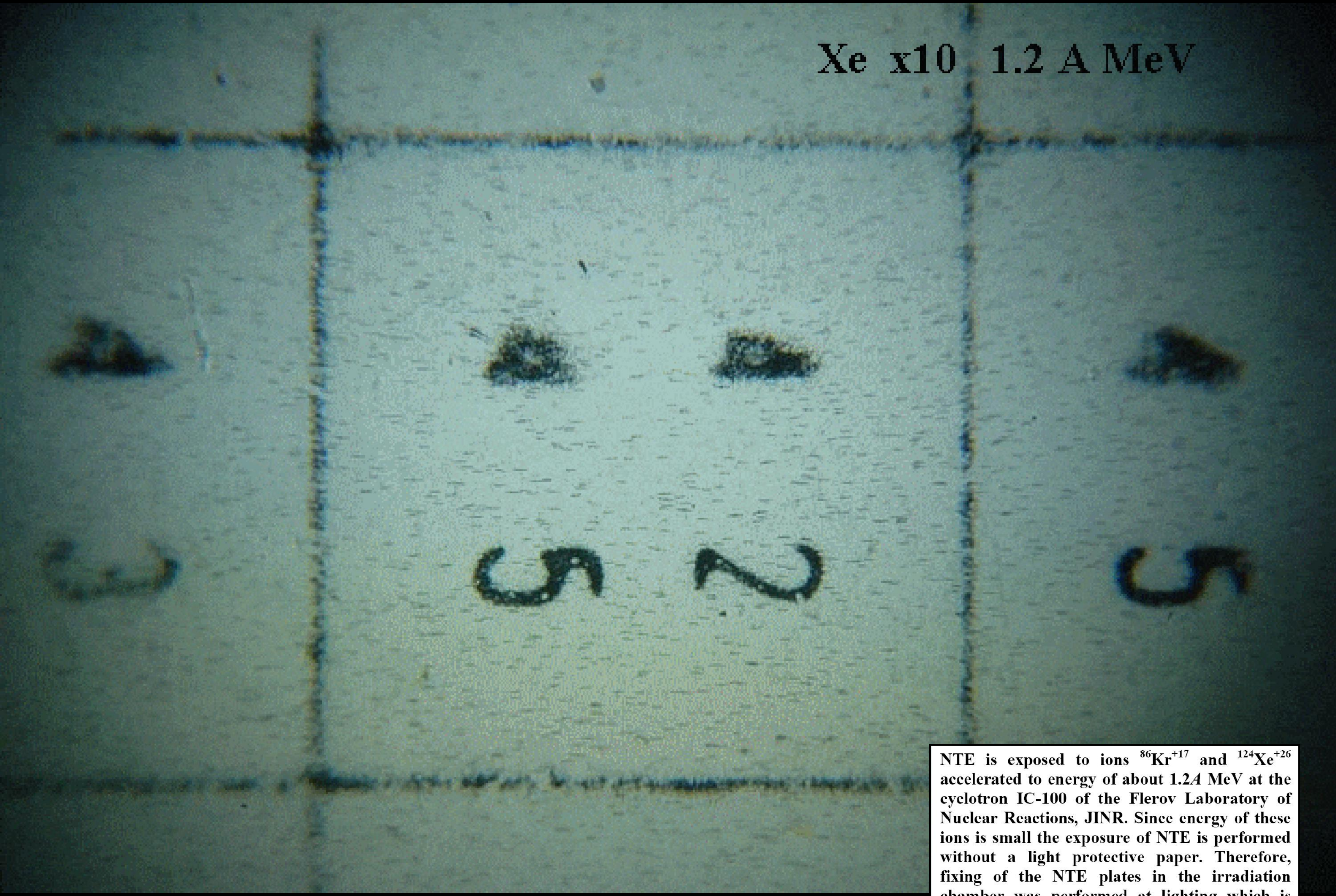
^{9}C 0.13 s
S = 3/2⁻
^{10}C 19 s
S = 0⁺
^{11}C 20 m
S = 3/2⁻
^{12}C 99%
S = 0⁺
^{8}B 0.8 s
S = 2⁺
^{10}B 19.8%
S = 3⁺
^{11}B 80.2%
S = 3/2⁻
^{7}Be 53 d
S = 3/2⁻
^{9}Be 100%
S = 3/2⁻
^{6}Li 7.5%
S = 1⁺
^{7}Li 92.5%
S = 3/2⁻



IV
^{10}C
Coherent dissociation $^{10}C \rightarrow p + {}^{9}B_{g.s.}$ at 2A GeV/c ("white" star)
H
H
He
He

Exposure of Nuclear Track Emulsion to ^{8}He Nuclei at the ACCULINNA Separator

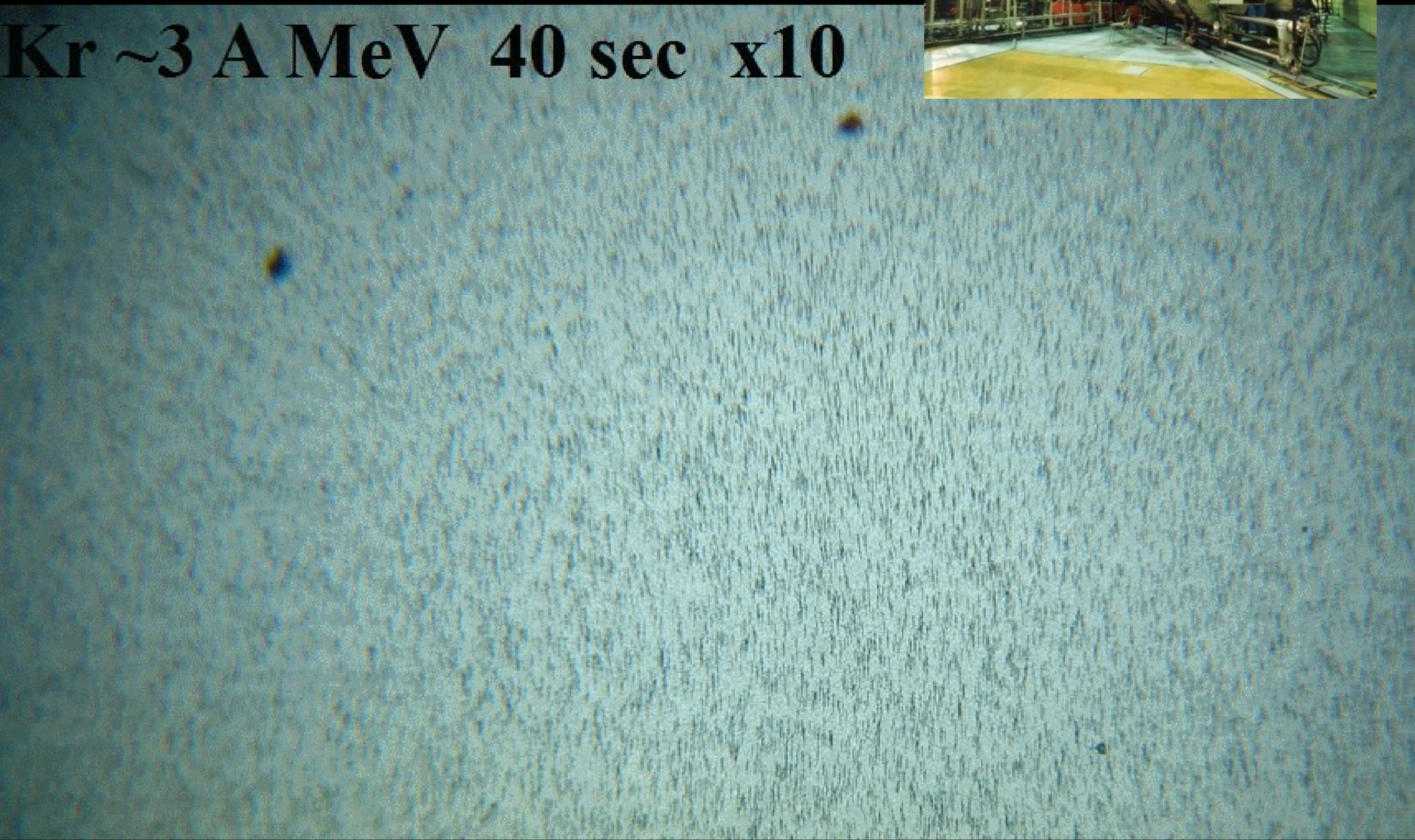




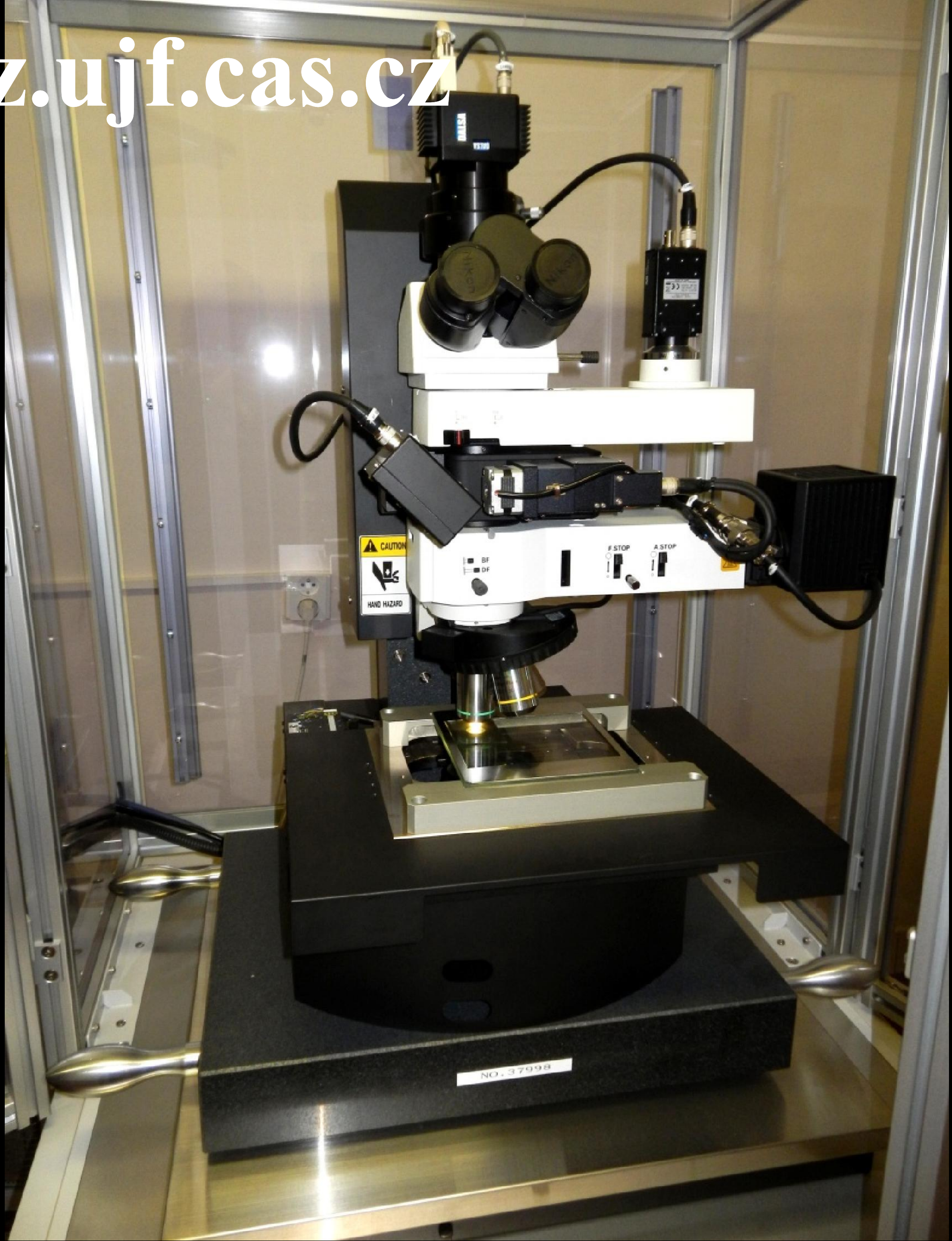
NTE is exposed to ions $^{86}Kr^{+17}$ and $^{124}Xe^{+26}$ accelerated to energy of about 1.2*A* MeV at the cyclotron IC-100 of the Flerov Laboratory of Nuclear Reactions, JINR. Since energy of these ions is small the exposure of NTE is performed without a light protective paper. Therefore, fixing of the NTE plates in the irradiation chamber was performed at lighting which is ordinary for a photographic laboratory. For 5 seconds of exposure the track density amounted to about 10^5 - 10^6 cm^{-2}.

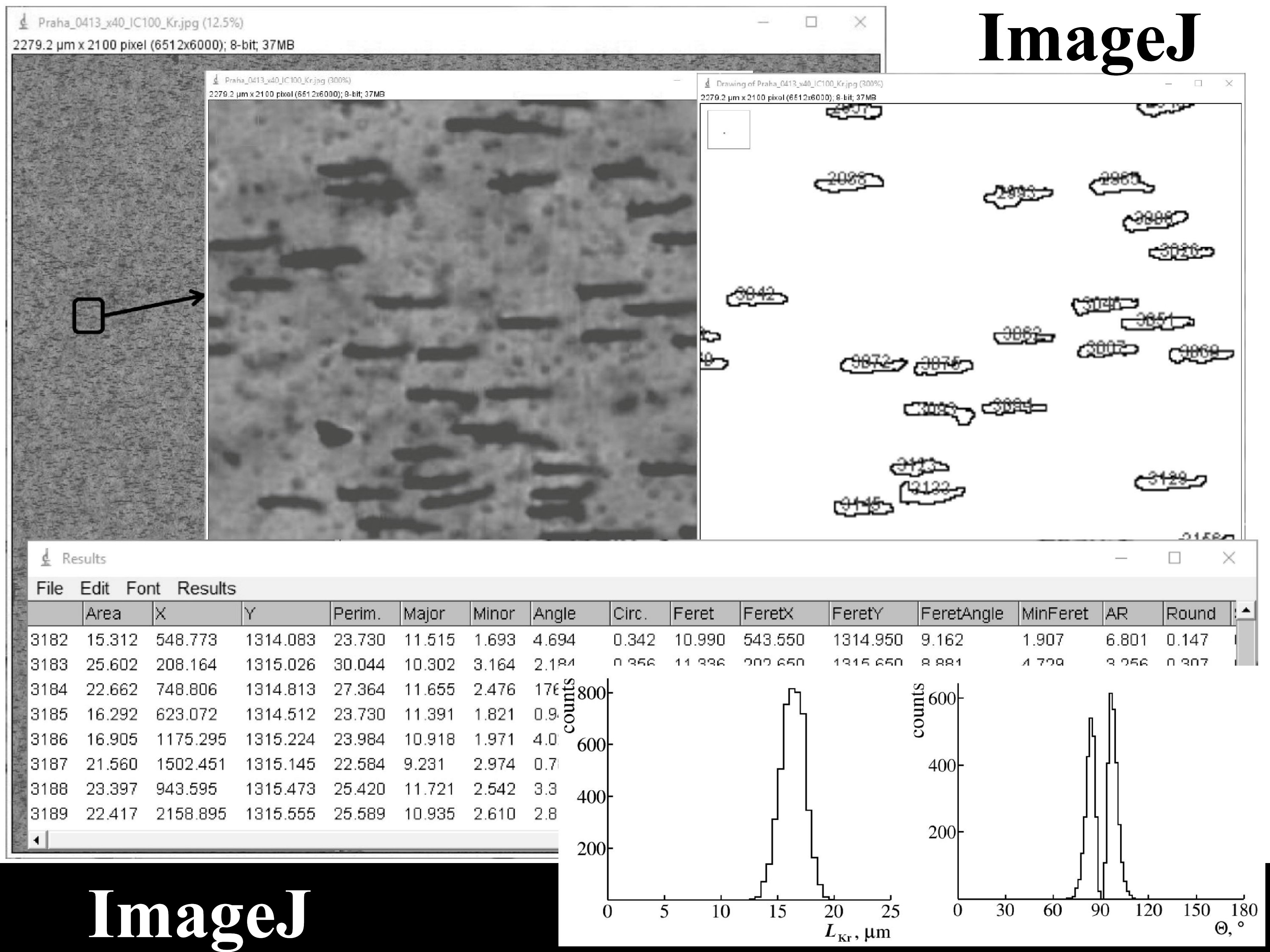
Flerov Laboratory

Kr ~3 A MeV 40 sec x10



www.odz.ujf.cas.cz




ImageJ
Praha_0413_x40_IC100_Kr.jpg (12.5%)
2279.2 µm x 2100 pixel (6512x6000); 8-bit; 37MB
Drawing of Praha_0413_x40_IC100_Kr.jpg (300%)
Results
File Edit Font Results
Area X Y Perim. Major Minor Angle Circ. Feret FeretX FeretY FeretAngle MinFeret AR Round
3182 15.312 548.773 1314.083 23.730 11.515 1.693 4.694 0.342 10.990 543.550 1314.950 9.162 1.907 6.801 0.147
3183 25.602 208.164 1315.026 30.044 10.302 3.164
3184 22.662 748.806 1314.813 27.364 11.655 2.476
3185 16.292 623.072 1314.512 23.730 11.391 1.821
3186 16.905 1175.295 1315.224 23.984 10.918 1.971
3187 21.560 1502.451 1315.145 22.584 9.231 2.974
3188 23.397 943.595 1315.473 25.420 11.721 2.542
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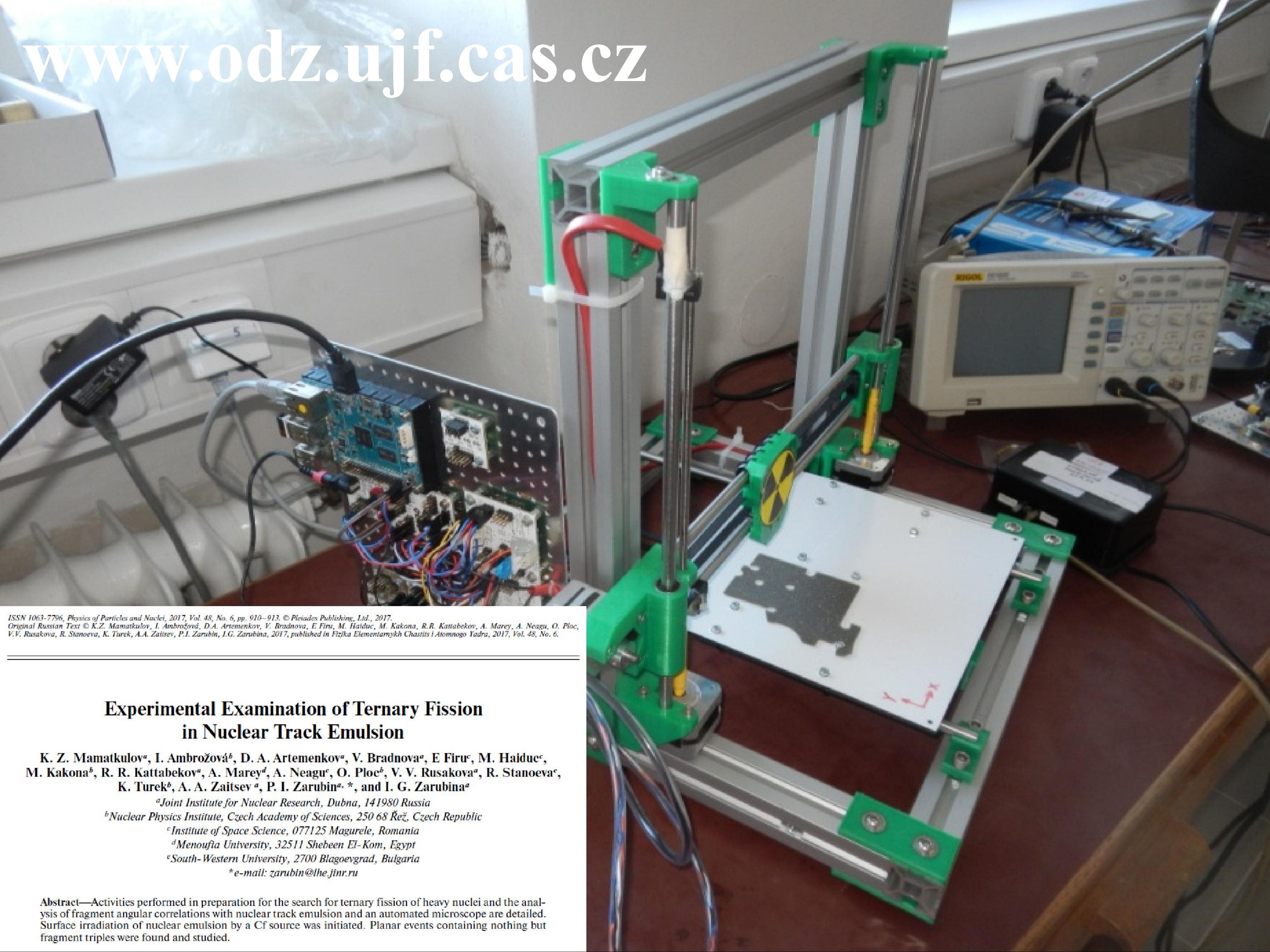
counts
L_{Kr}, µm
Θ, °
ImageJ



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Original Russian Text © K.Z. Mamatkulov, I. Ambrožová, D.A. Artemenkov, V. Bradnova, E Firu, M. Haiduc, M. Kakona, R.R. Kattabekov, A. Marey, A. Neagu, O. Ploc, V.V. Rusakova, R. Stanoeva, K. Turek, A.A. Zaitsev, P.I. Zarubin, I.G. Zarubina, 2017, published in Fizika Elementarnykh Chastits i Atomnogo Yadra, 2017, Vol. 48, No. 6.

Experimental Examination of Ternary Fission in Nuclear Track Emulsion

K. Z. Mamatkulov[a], I. Ambrožová[b], D. A. Artemenkov[a], V. Bradnova[a], E Firu[c], M. Haiduc[c], M. Kakona[b], R. R. Kattabekov[a], A. Marey[d], A. Neagu[c], O. Ploc[b], V. V. Rusakova[a], R. Stanoeva[e], K. Turek[b], A. A. Zaitsev [a], P. I. Zarubin[a, *], and I. G. Zarubina[a]

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[b]*Nuclear Physics Institute, Czech Academy of Sciences, 250 68 Řež, Czech Republic*
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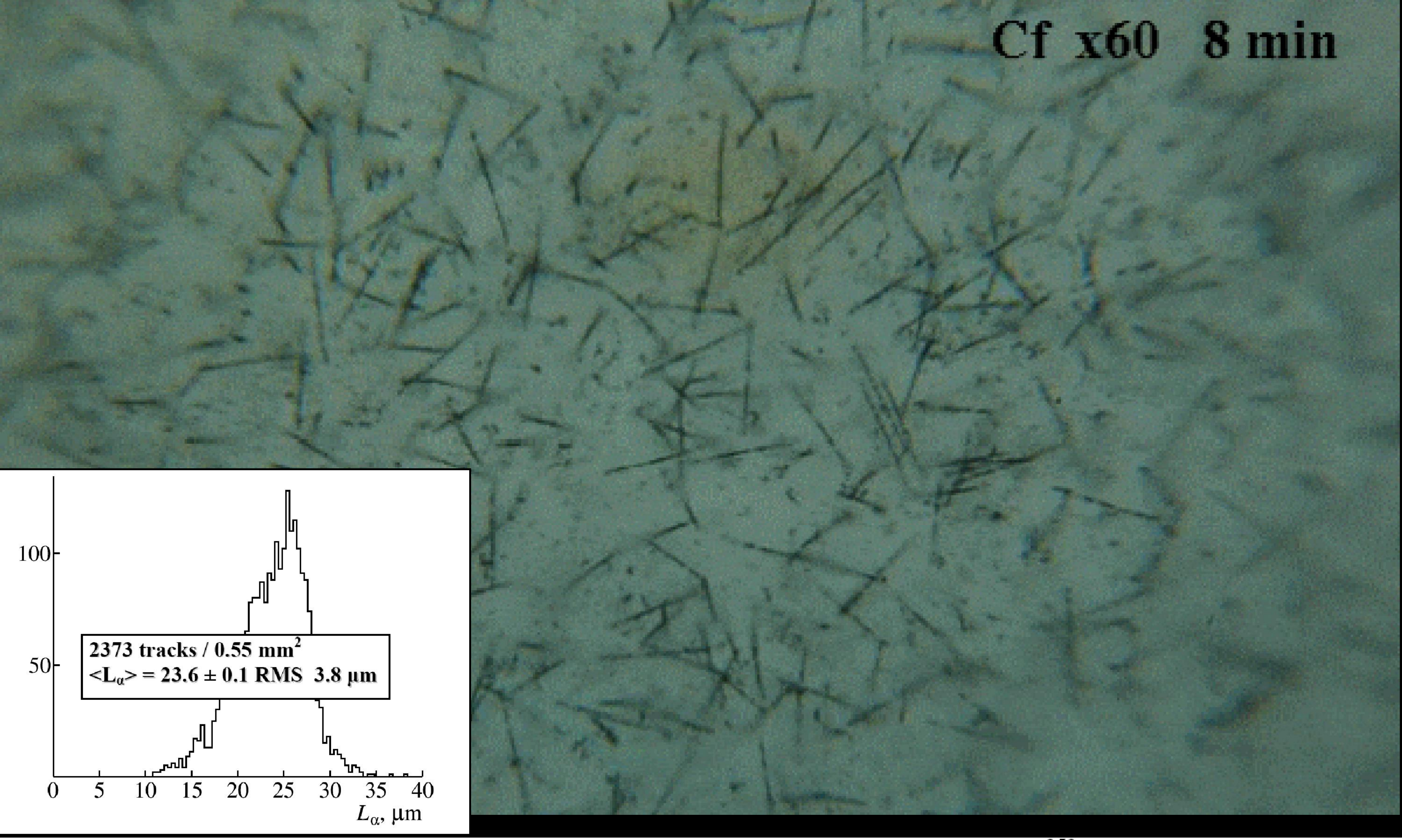
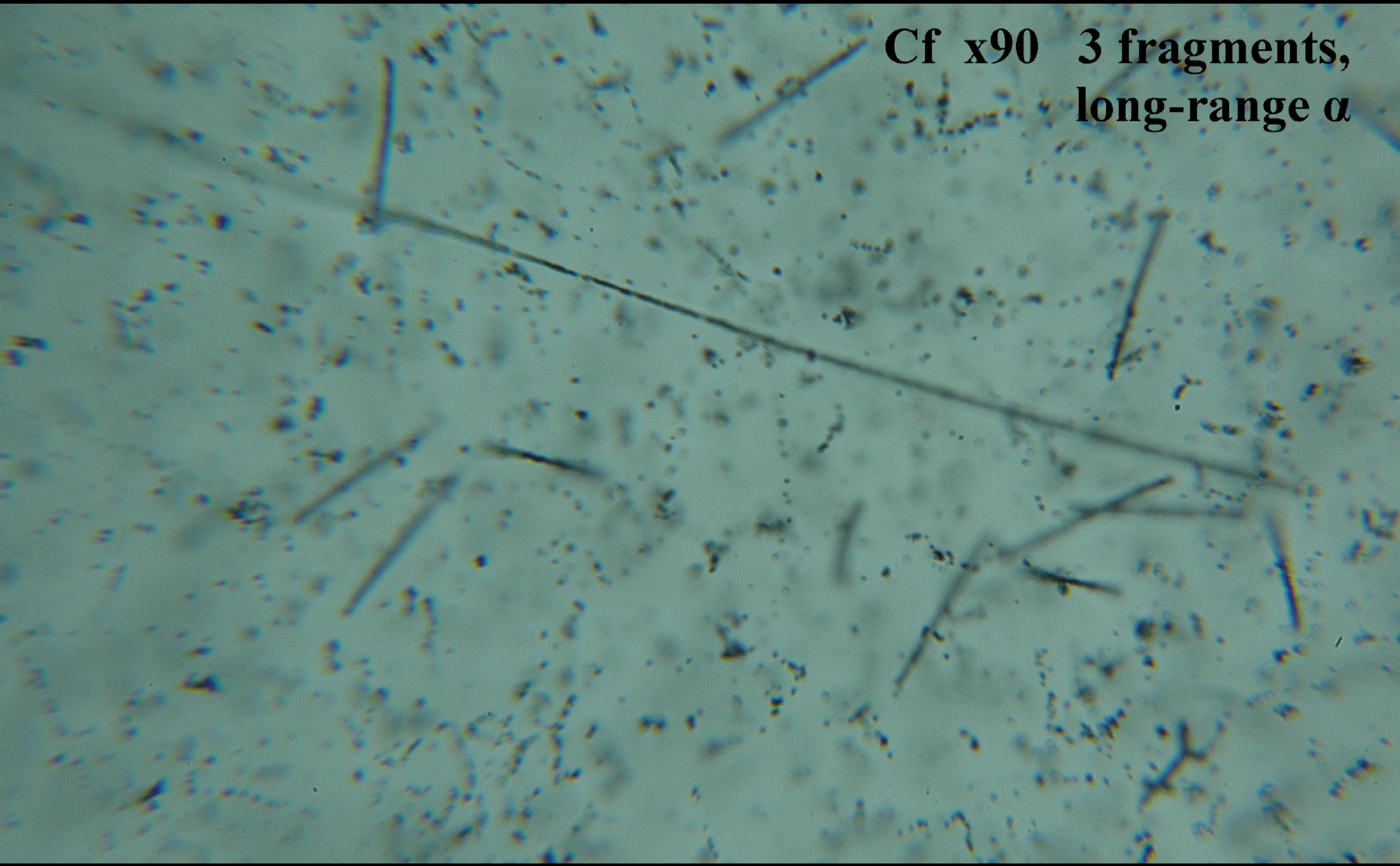
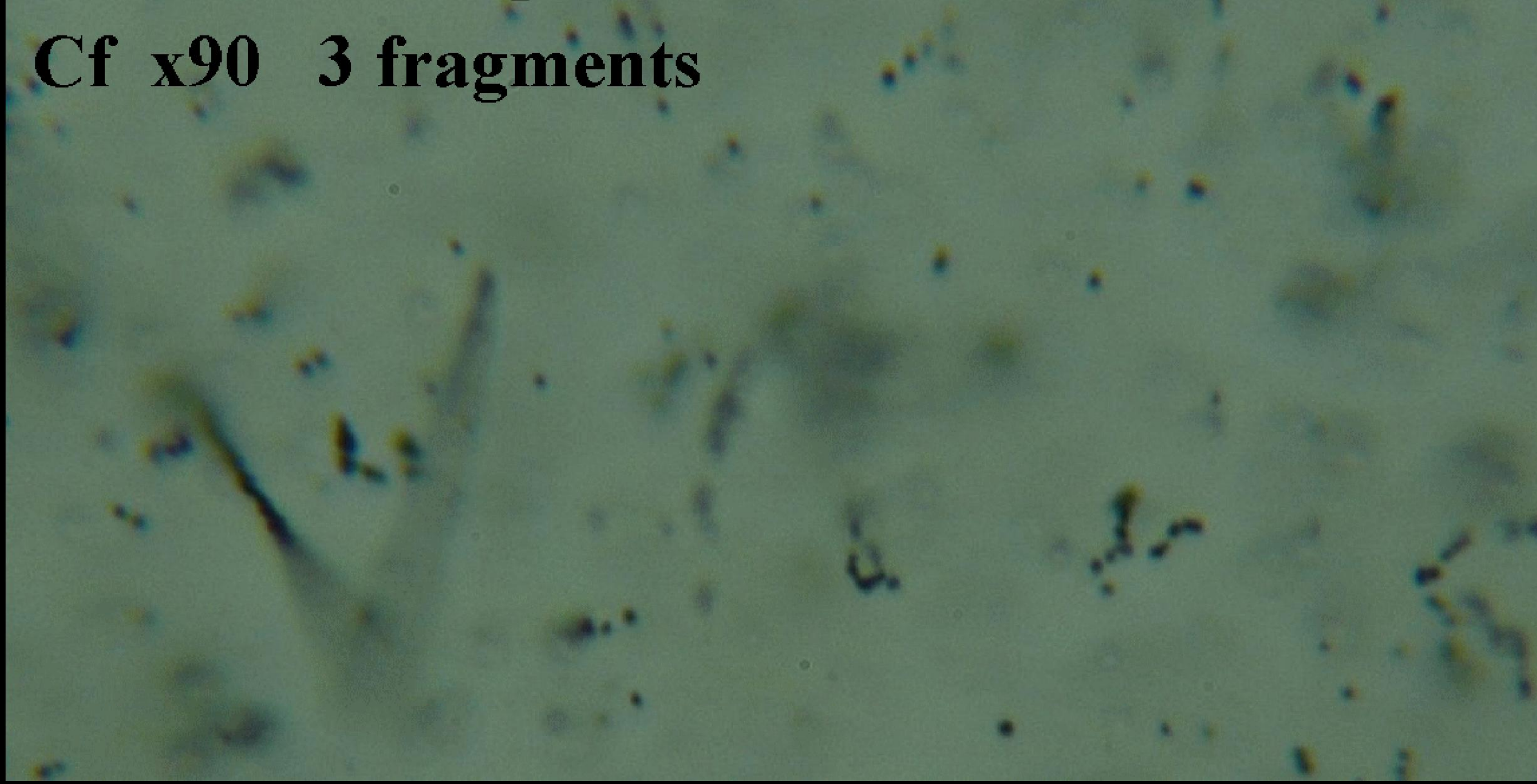
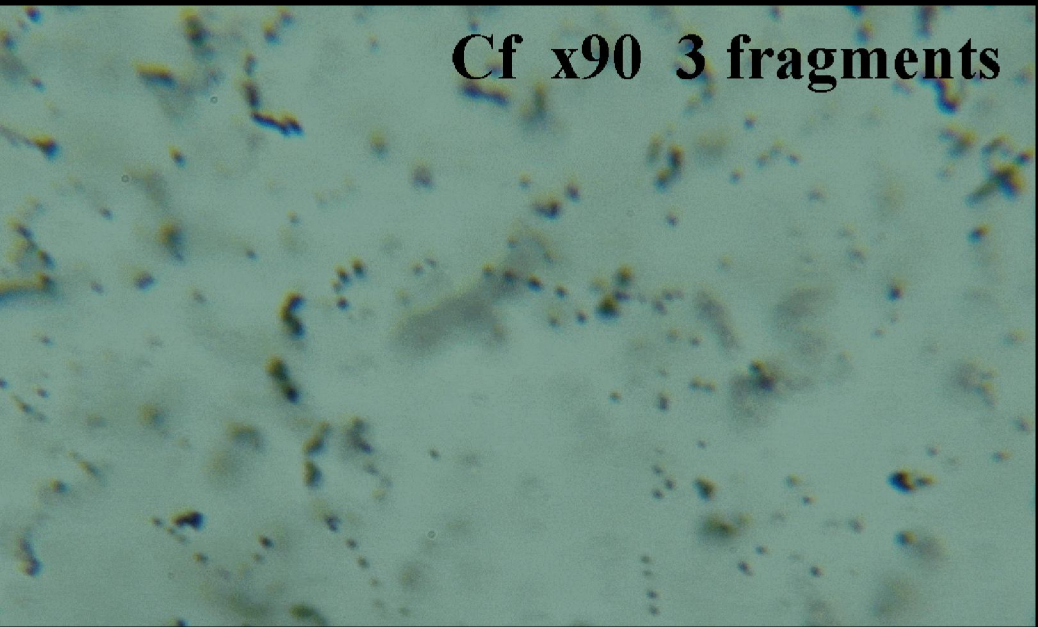
Abstract—Activities performed in preparation for the search for ternary fission of heavy nuclei and the analysis of fragment angular correlations with nuclear track emulsion and an automated microscope are detailed. Surface irradiation of nuclear emulsion by a Cf source was initiated. Planar events containing nothing but fragment triples were found and studied.

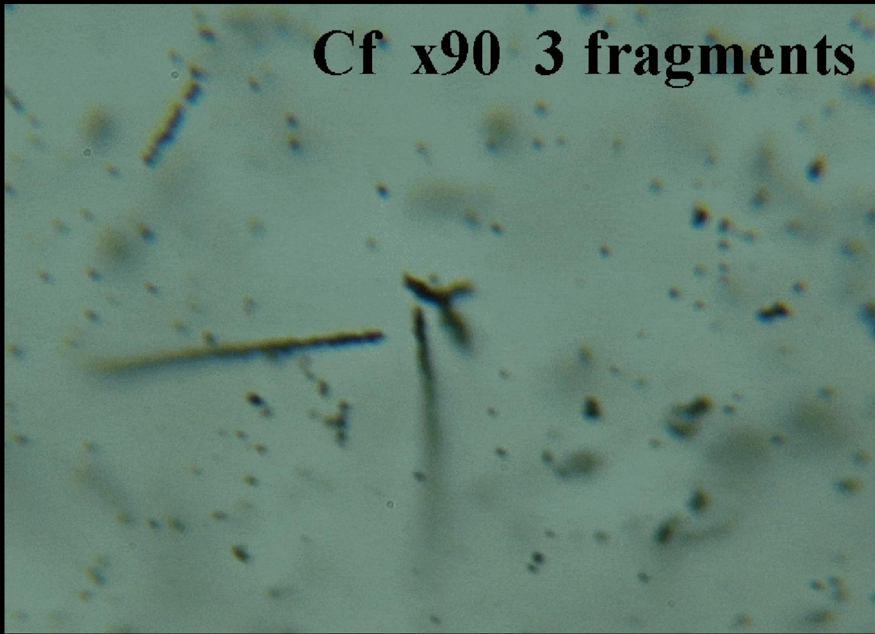


Surface exposures of NTE samples in DRD were performed by a manually moving ^{252}Cf source. Most likely, the ^{252}Cf isotope decays by emission of α-particles of energy of 5-6 MeV, the tracks of which mainly populate an exposed sample. This isotope also undergoes a spontaneous fission to a pair or even triple of fragments with probabilities of 3%, and about 0.1%, respectively. For comparison an NTE sample was exposed to a ^{241}Am source emitting only α-particles in the same energy range. Since the ranges of decay products are small the source exposures are performed without a light protective paper in a darkroom when illuminated with red light.


Cf x90 3 fragments,
long-range α


Cf x90 3 fragments


Cf x90 3 fragments


Cf x90 3 fragments

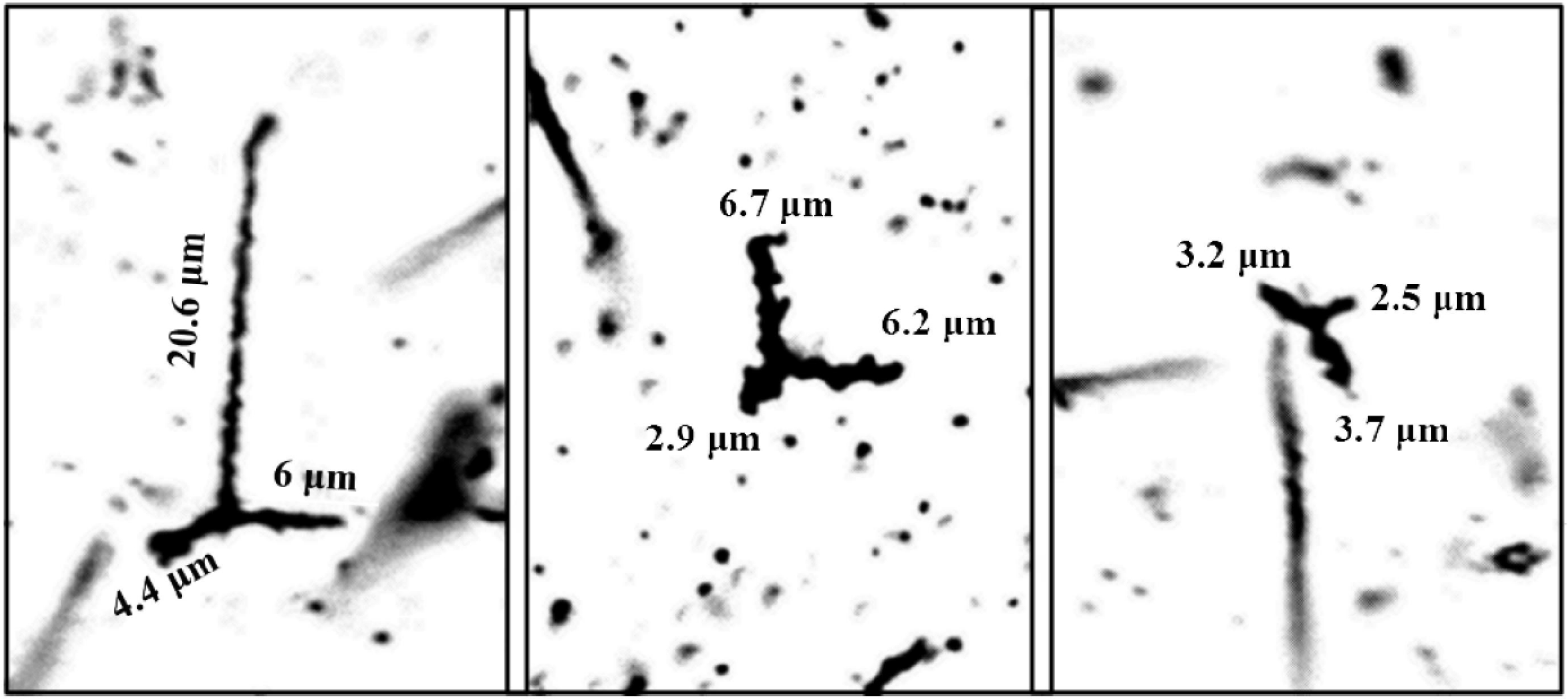


Figure 1. Examples of observed events of ternary fission; track lengths are specified. Left photo: long-range α-particle (long arrow), fragment (middle arrow). Mid and right photo: three fragment tracks.

96 planar events with fragment triples were also found during examination of the surface of NTE layers irradiated by the Cf source. The vertices of triples should be located deeper than the track diameter in order for the track triples to be observed fully.

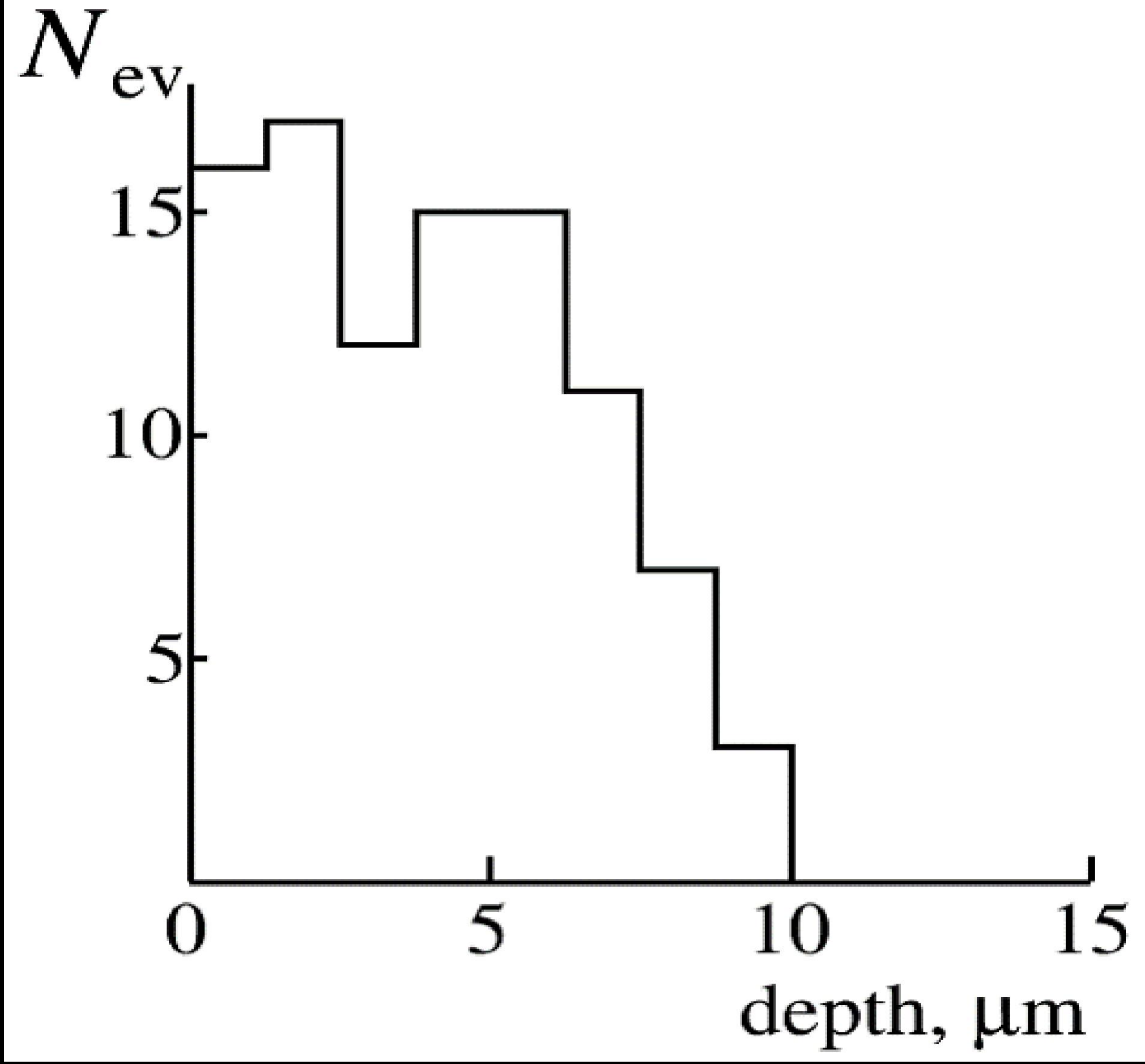
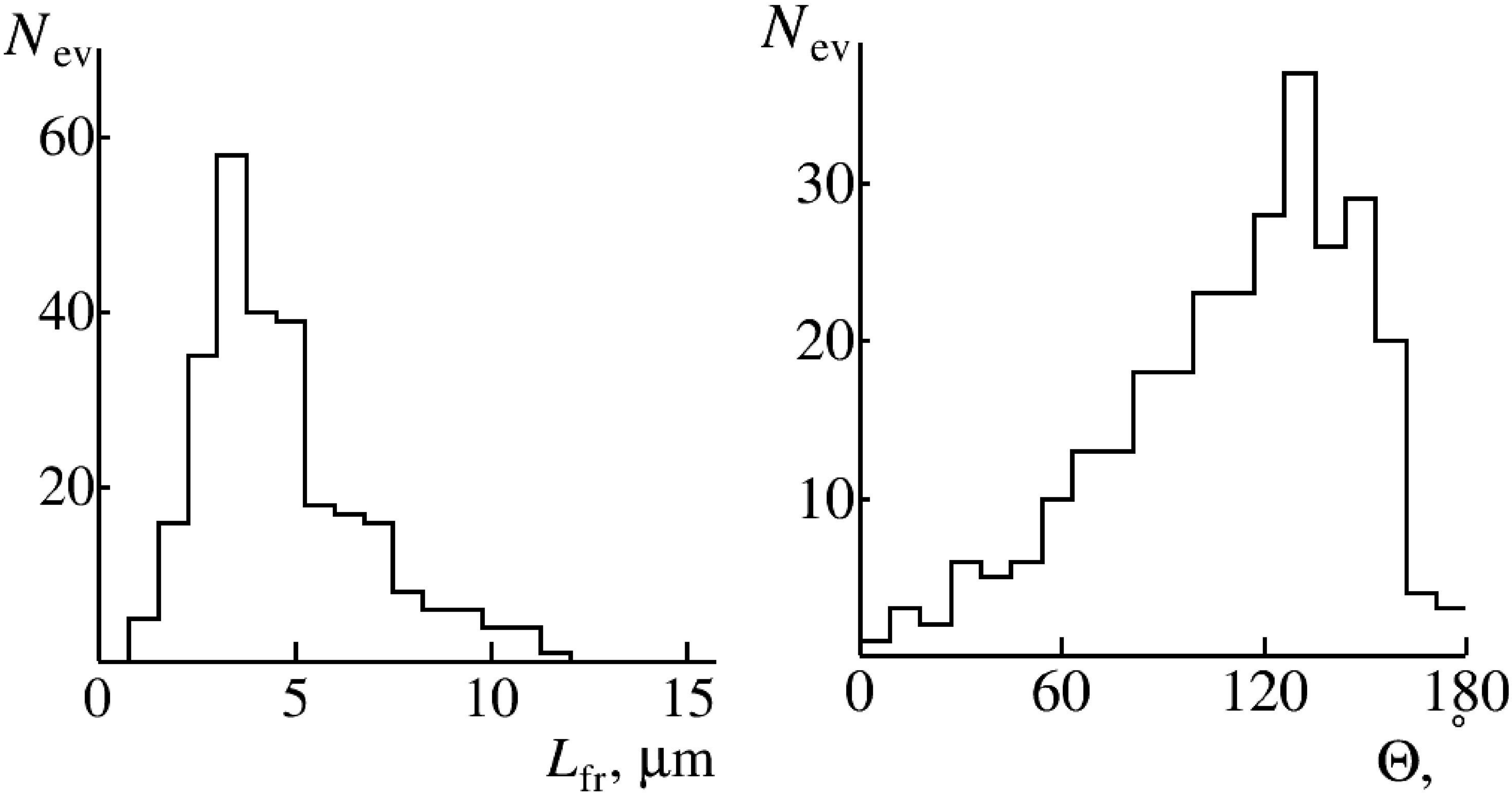
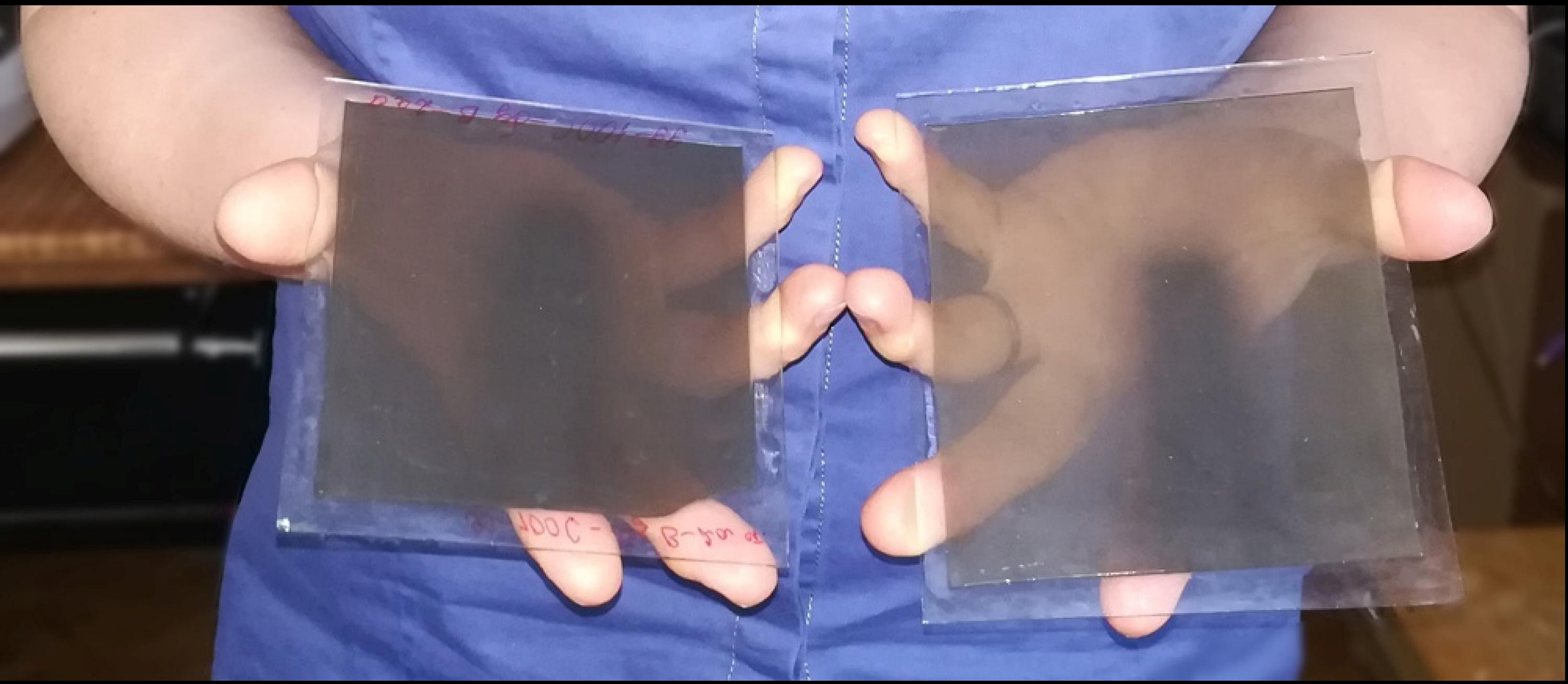


Figure shows the distribution of 96 vertices of Cf fission into three fragments over the NTE layer thickness. The mean value is 4.1 ± 0.2 μm (RMS 2.5 μm). This effect is probably associated with the binding of Cf atoms in microcrystals AgBr and their drift. The surface shielding of the source with the initial thickness of deposited gold of 50 μg/cm^2 (according to certificate) apparently did not prevent this penetration.

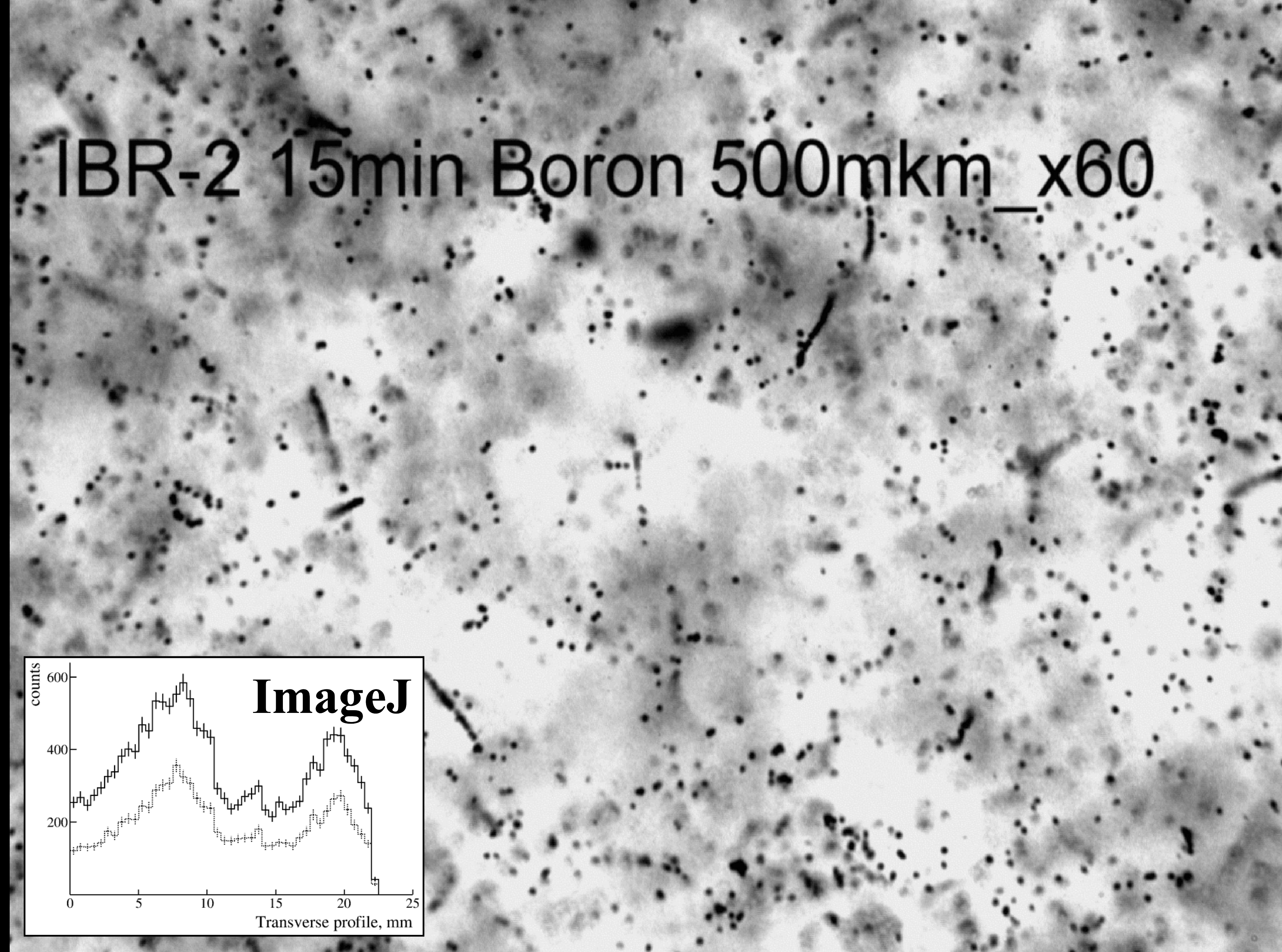


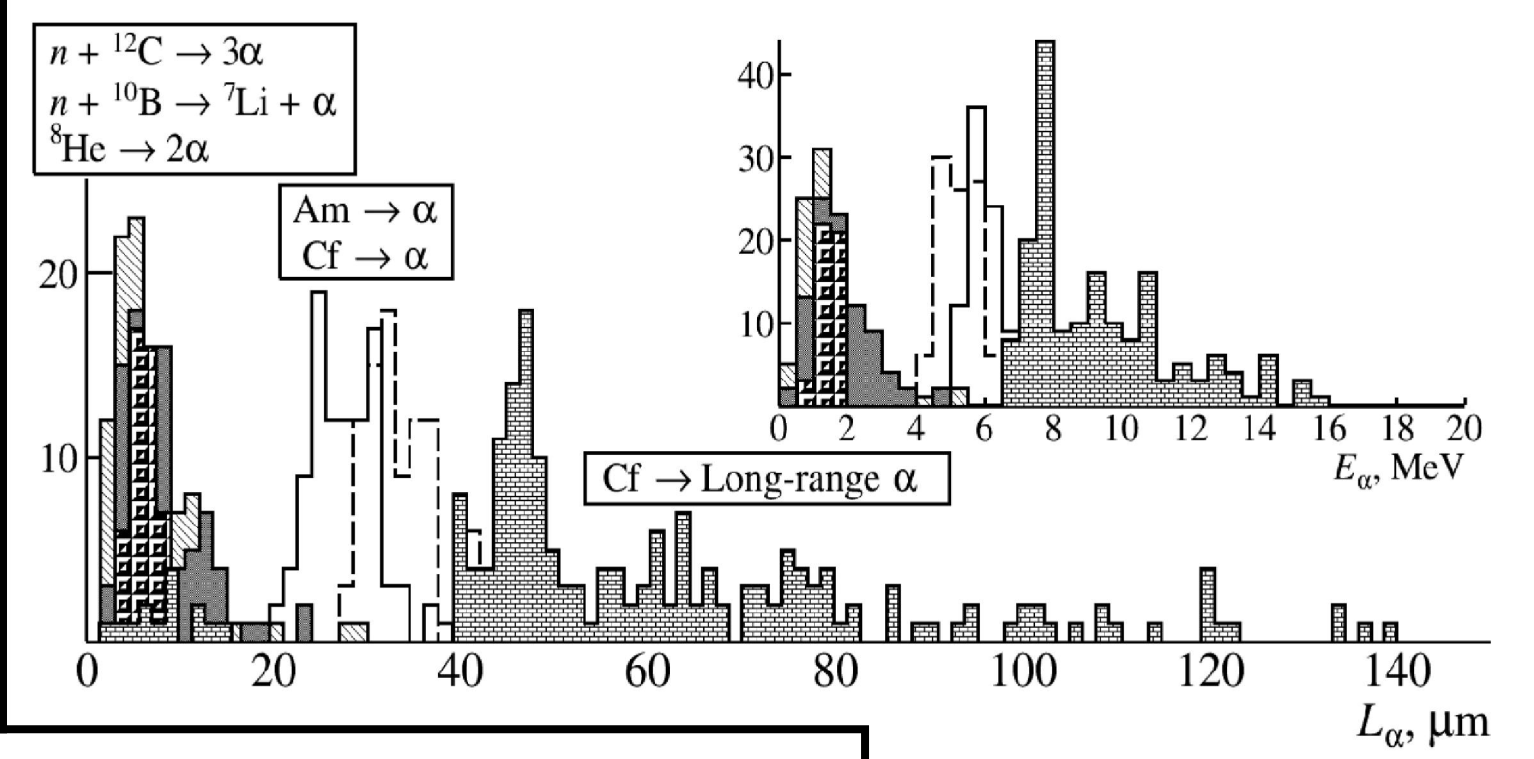
Track lengths L_{fr} of all fragments were measured in 96 found ternary fission events The mean value of L_{fr} is 4.6 ± 0.13 (RMS 2.1) μm, and a rough estimate of the average energy is 400 *A* keV

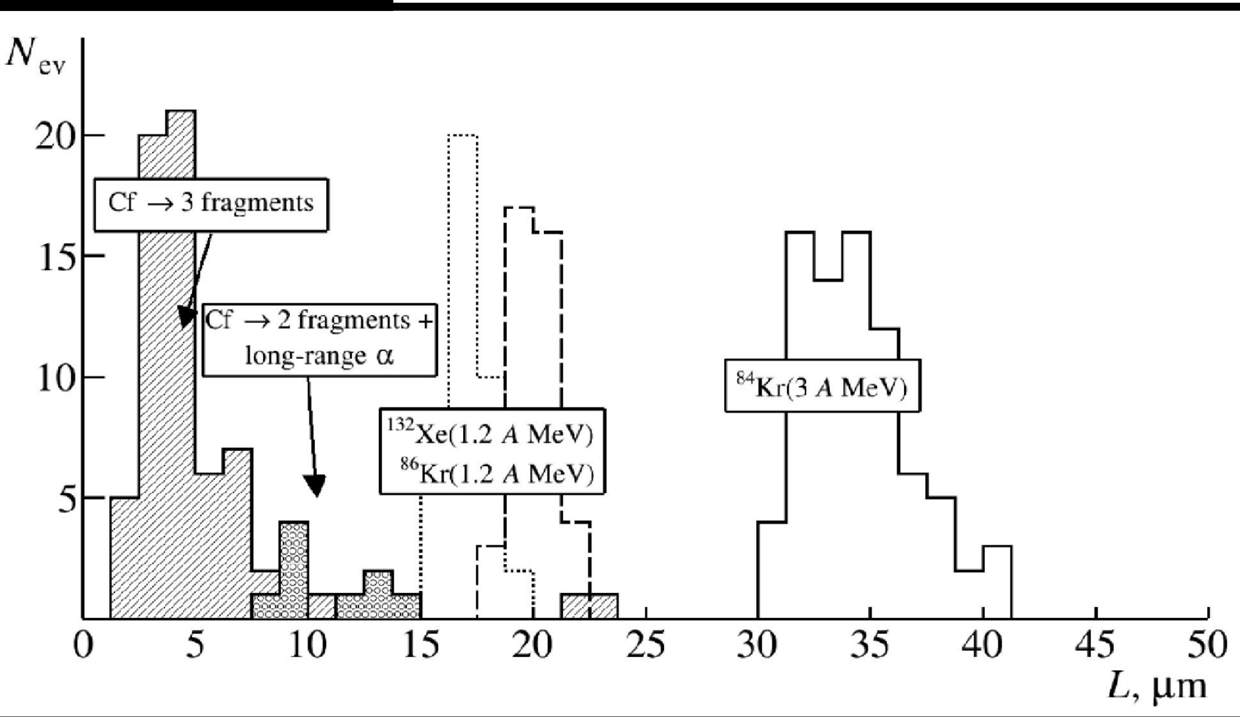
The opening angles of tracks of fragments were measured in these events. Their distribution has a mean value of 111 ± 2 (RMS 36)°.



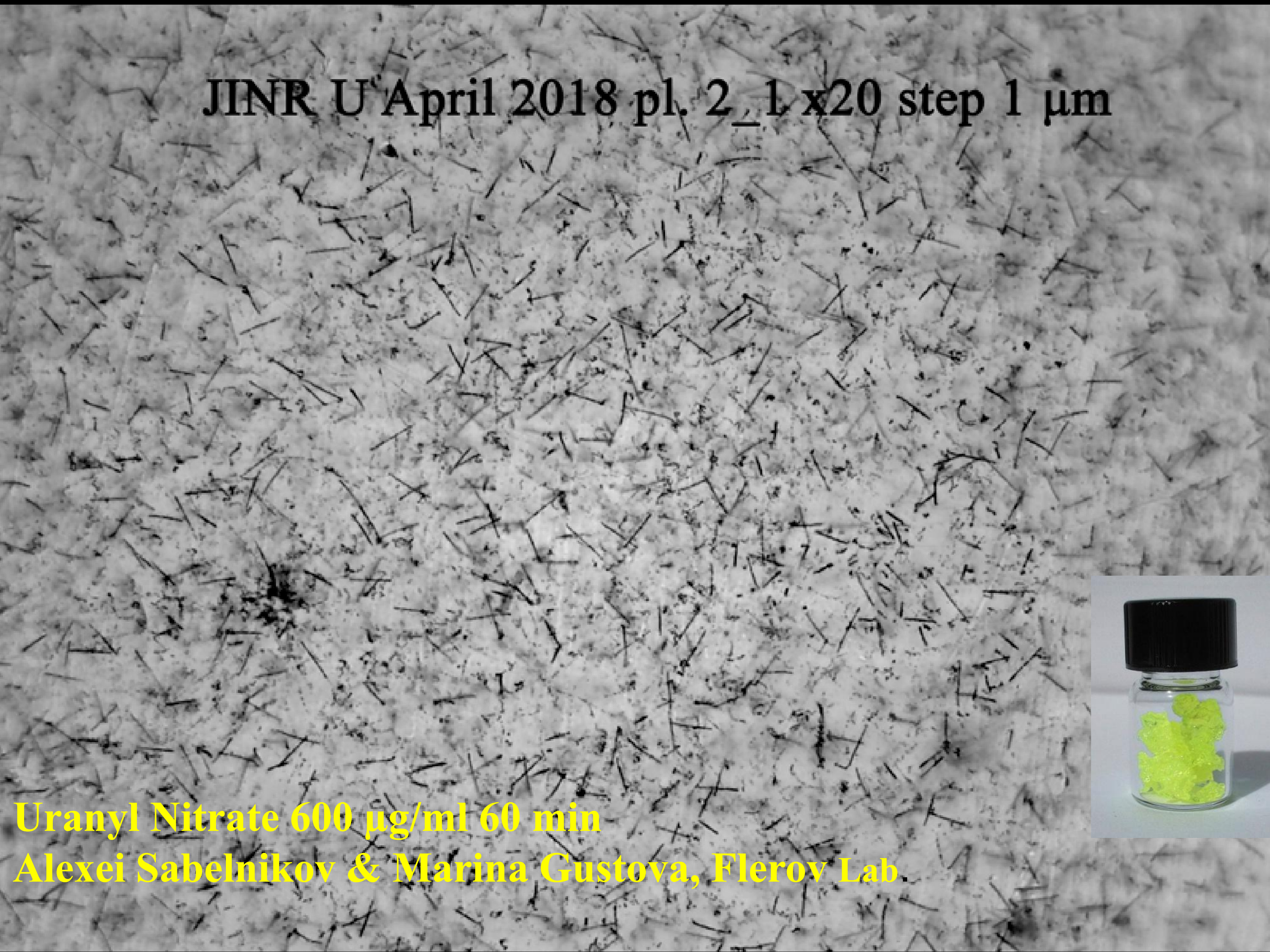
NTE samples enriched in boron (boric acid and borax) were irradiated for 30 min at the thermal neutron channel of the IBR-2 reactor JINR .

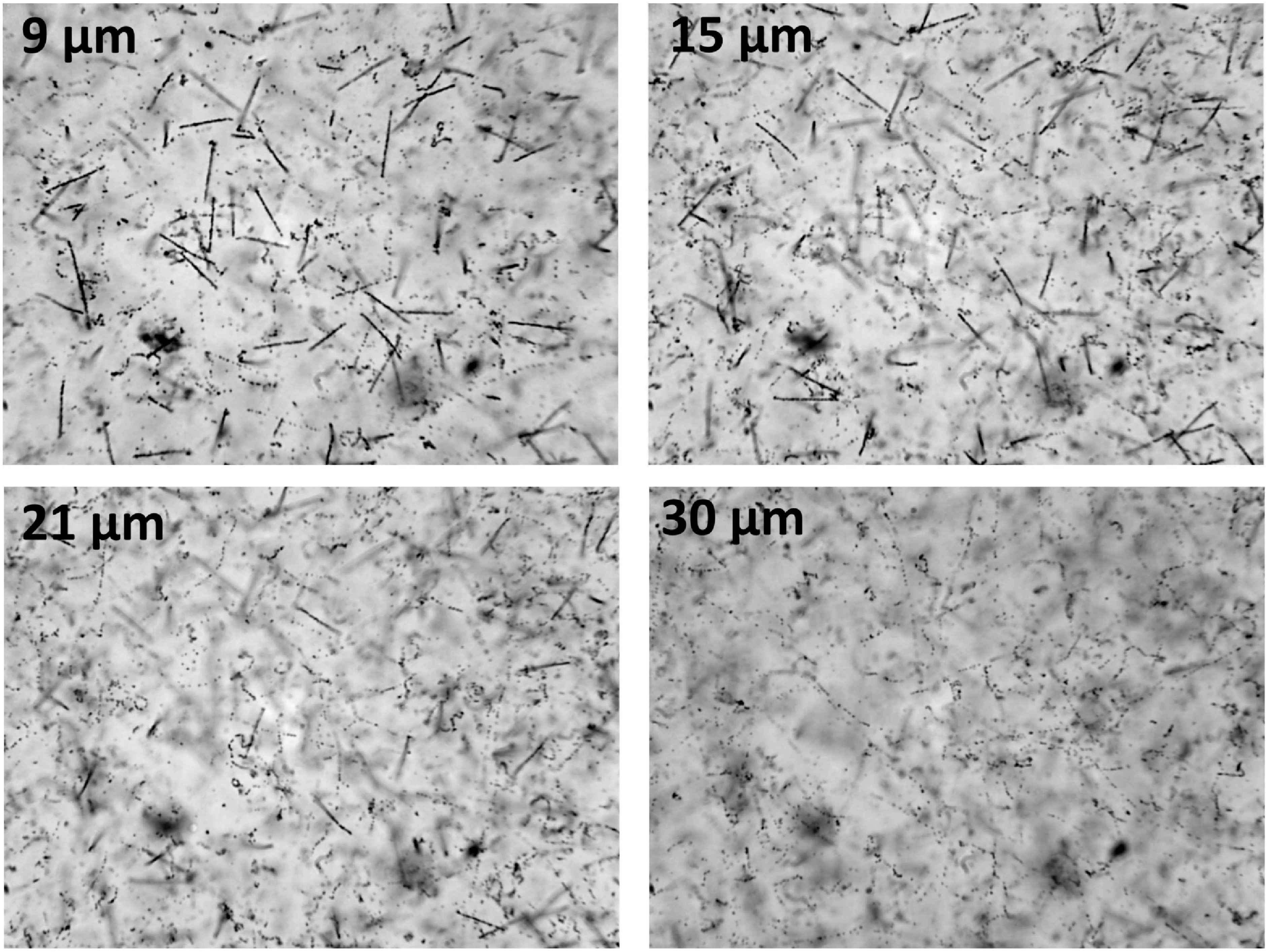

IBR-2 15min Boron 500mkm_x60
ImageJ
counts
600
400
200
0
5
10
15
20
25
Transverse profile, mm



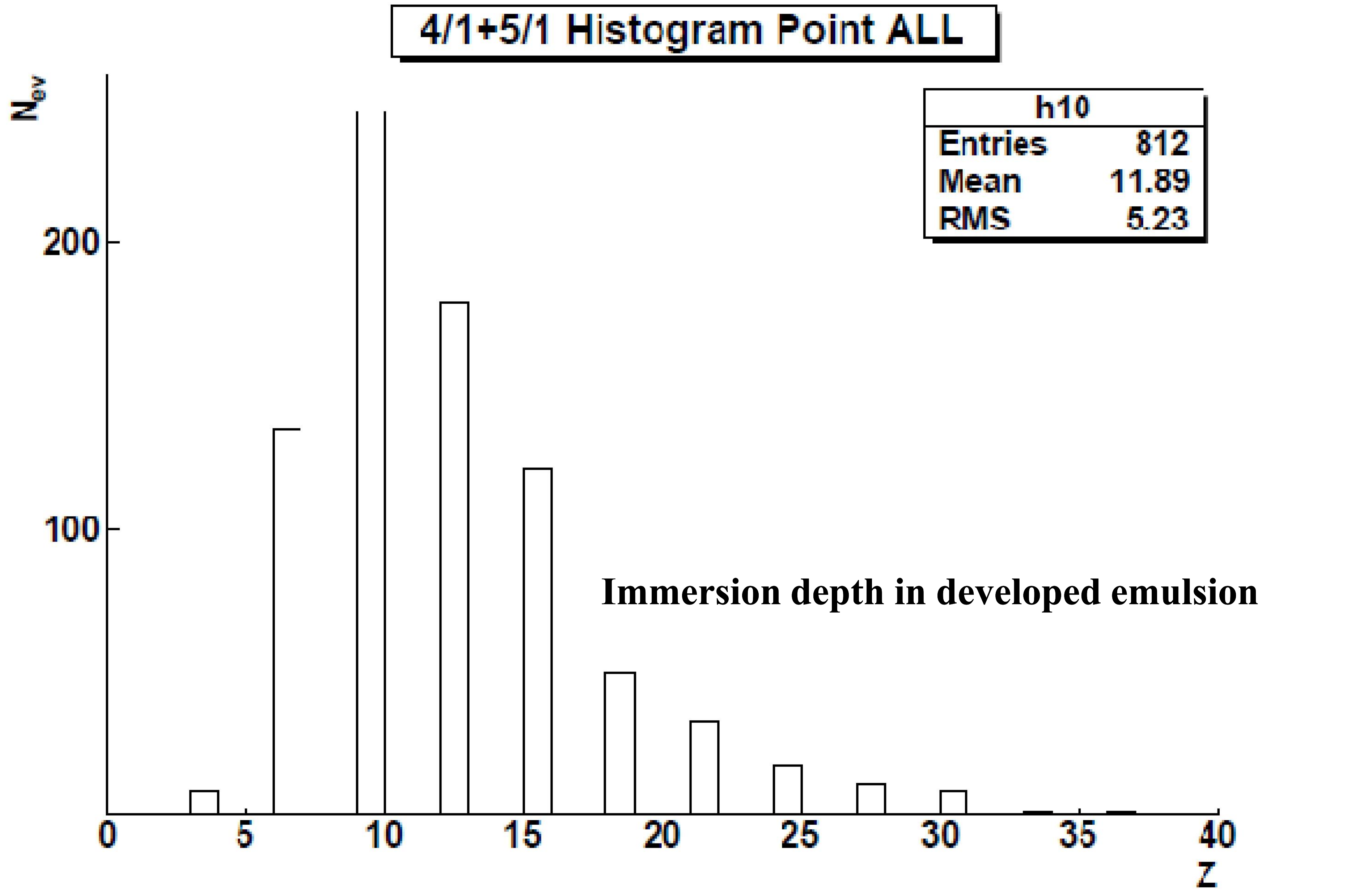


The ion range calibration of in NTE needs to be extended below 1 *A* MeV.


JINR U April 2018 pl. 2_1 x20 step 1 µm
Uranyl Nitrate 600 µg/ml 60 min
Alexei Sabelnikov & Marina Gustova, Flerov Lab.


9 µm
15 µm
21 µm
30 µm

Number of planar α-tracks per 1 μm in 50 μ emulsion on glass soaked in solution of uranyl nitrate

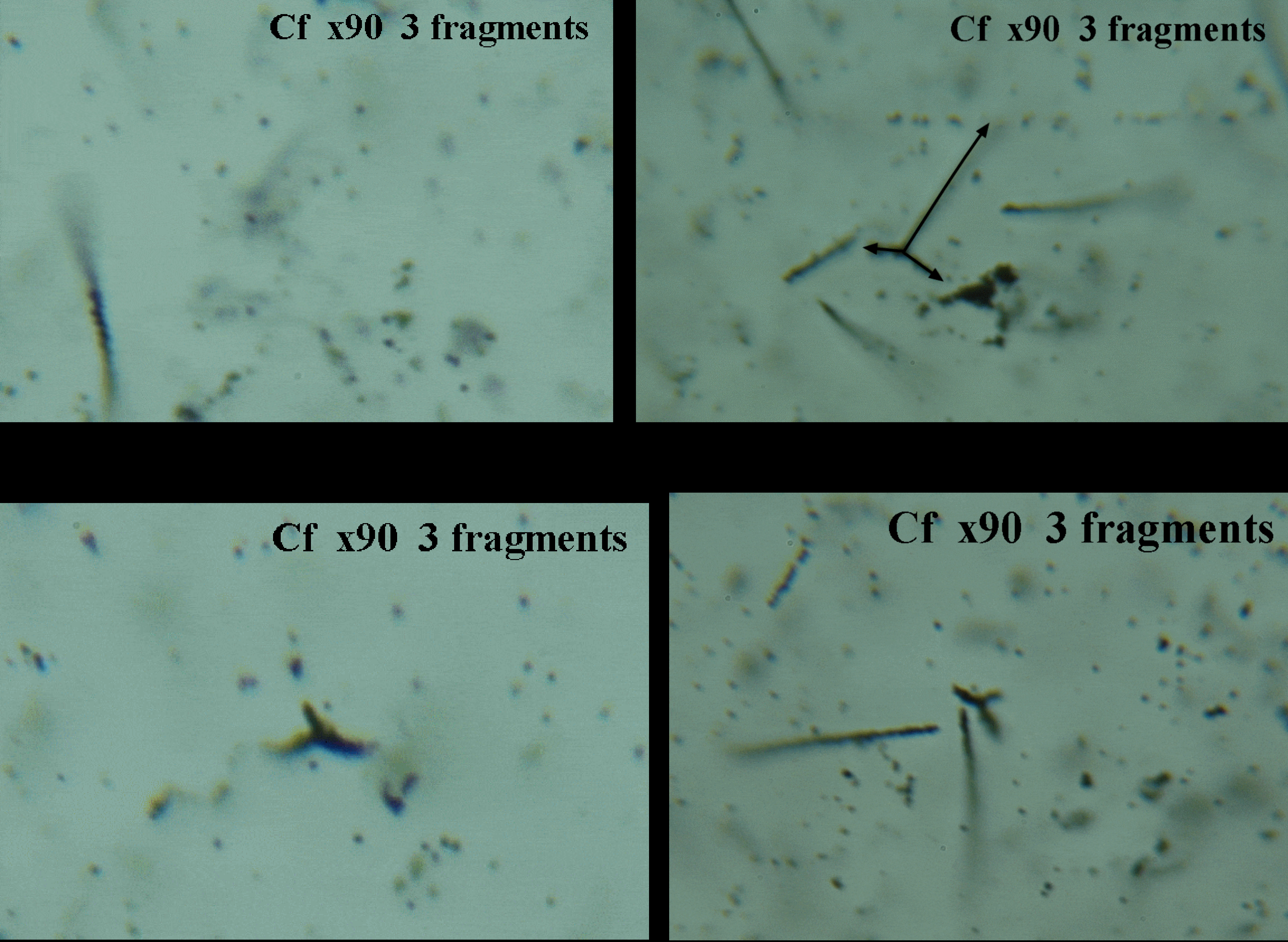


In general, the synergy of modern radioactive sources, NTE proven metrology and advanced microscopy seems to be a promising prospect for α-radioactivity and nuclear fission research.

Thus, the present study focused on the NTE return in practice of nuclear experiment will serve as a prototype of solution of an impressive variety of problems.

It can be assumed that ions of transfermium elements will be implanted in NTE. Their bright decays can be found as common vertices of few α-particle tracks and fission fragments. This perspective emphasizes the fundamental value of preservation and modernization of the NTE technique.

Macro photos of the discussed exposures and videos based on them are available on the BECQUEREL project website.


Cf x90 3 fragments
Cf x90 3 fragments
Cf x90 3 fragments
Cf x90 3 fragments