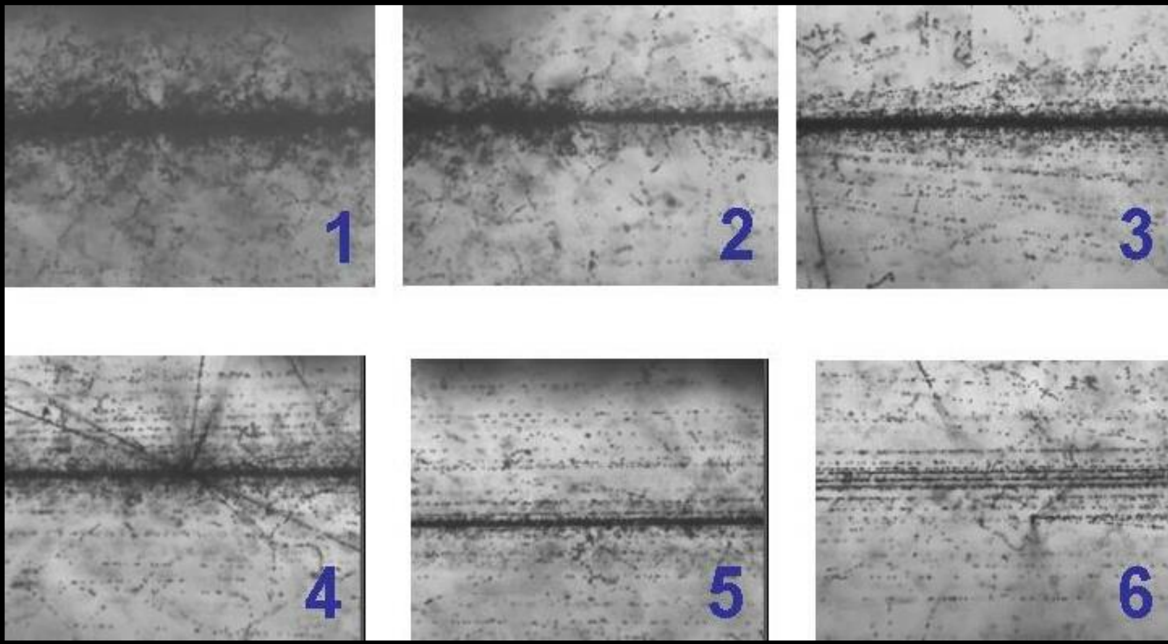
BECQUEREL PROJECT

Проект БЕККЕРЕЛЬ

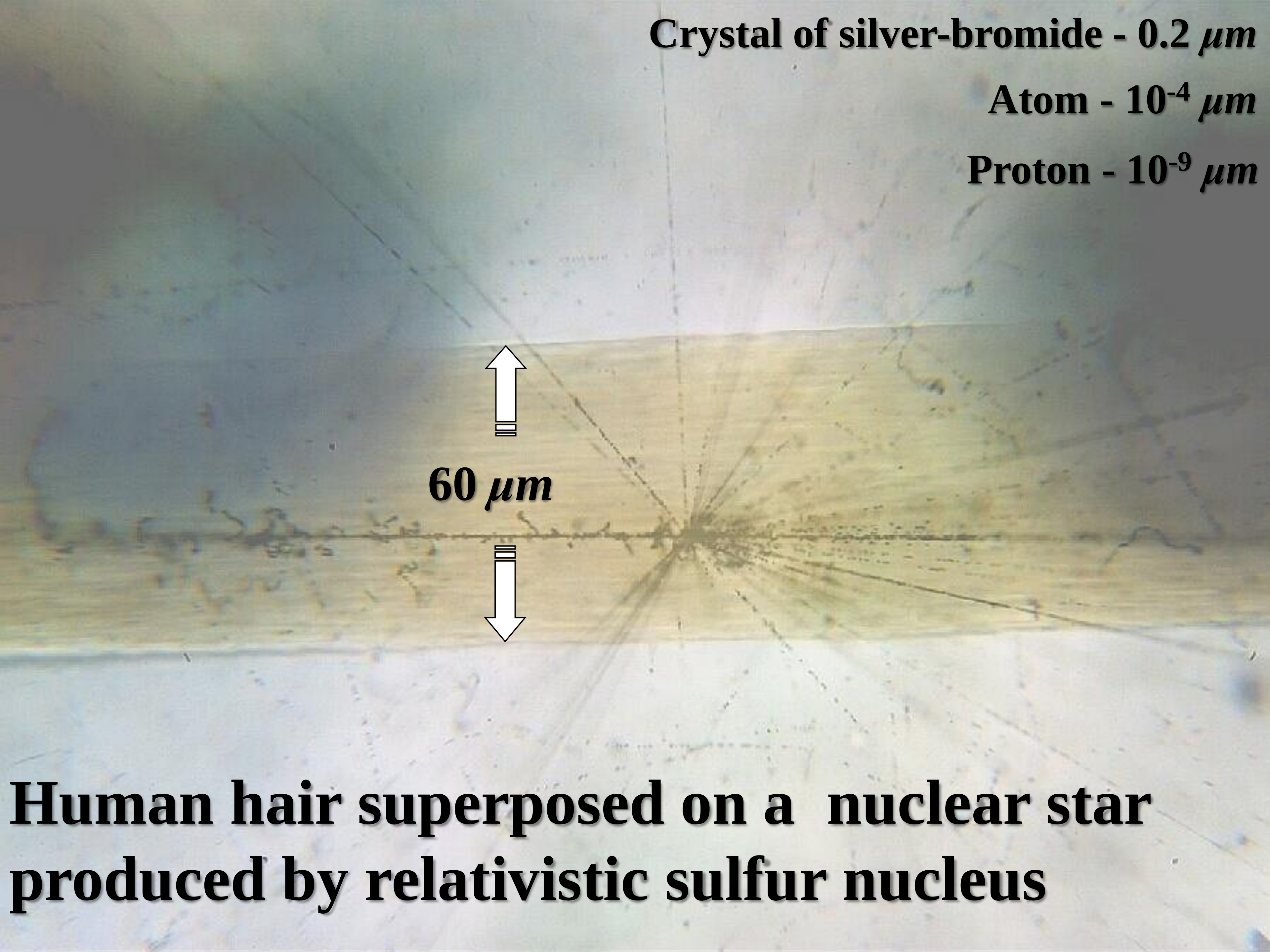
Beryllium (Boron) Clustering Quest in Relativistic Multifragmentation

http://becquerel.jinr.ru

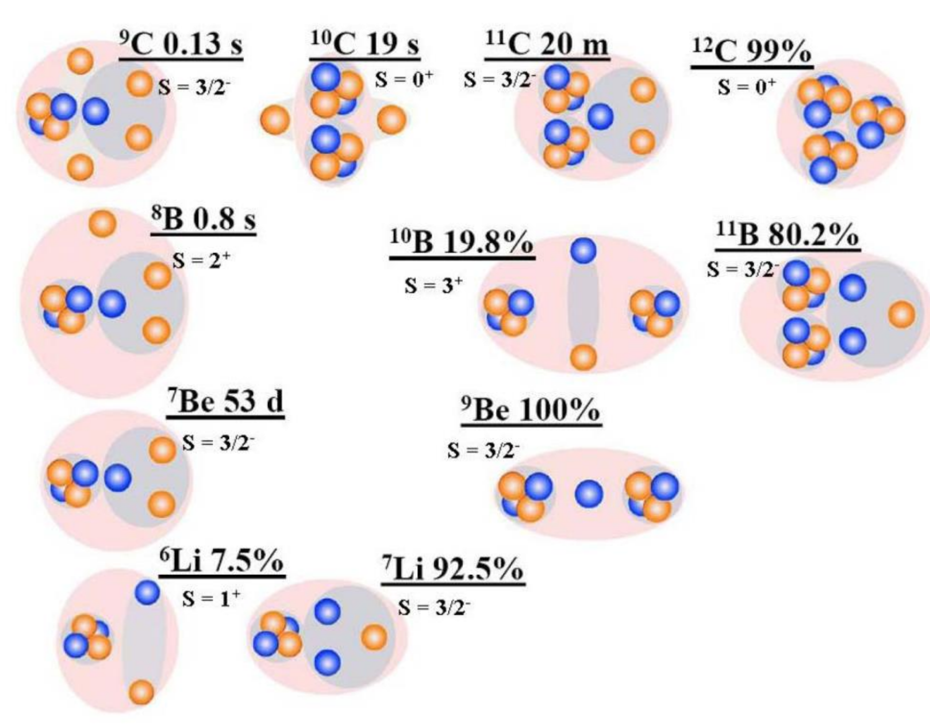
Irina Zarubina "Imaging of few-body nuclear systems in nuclear track emulsion "



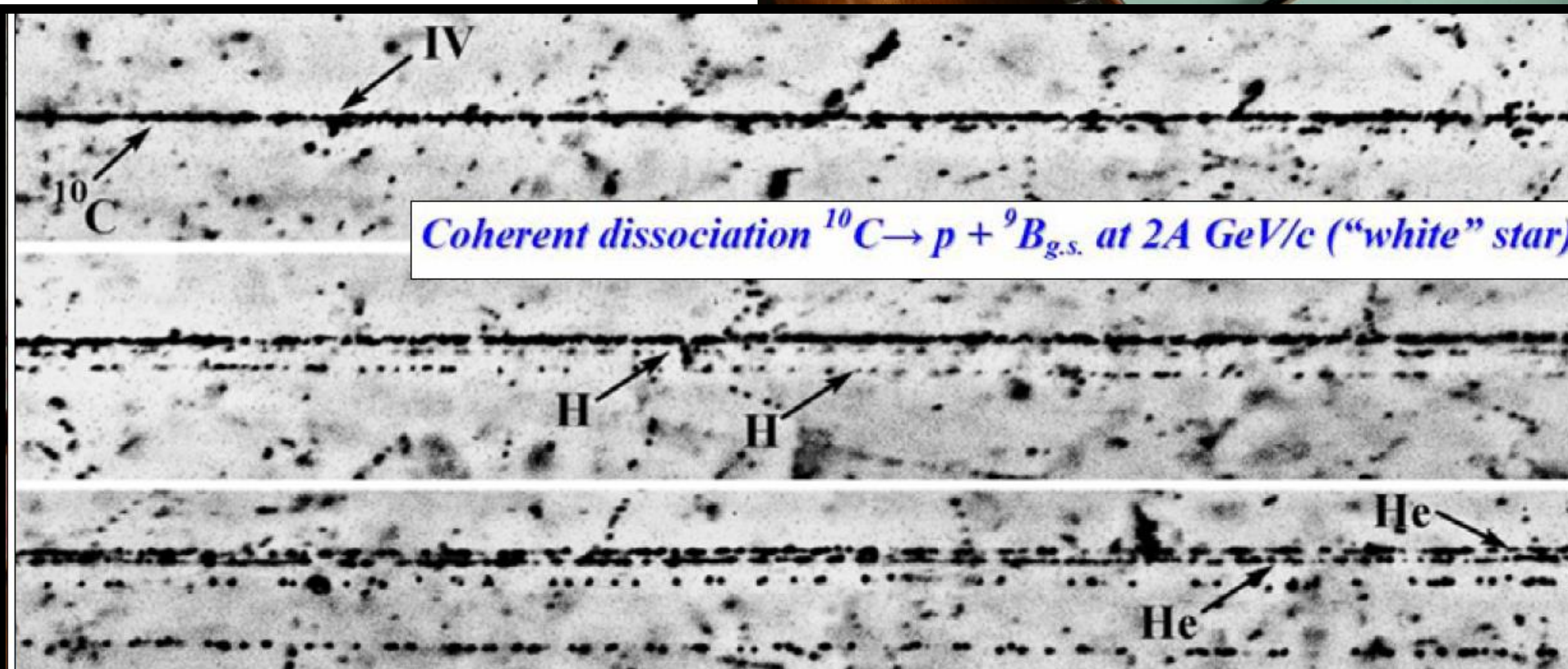
Veksler & Baldin Laboratory of High Energy Physics, JINR, Dubna, Russia



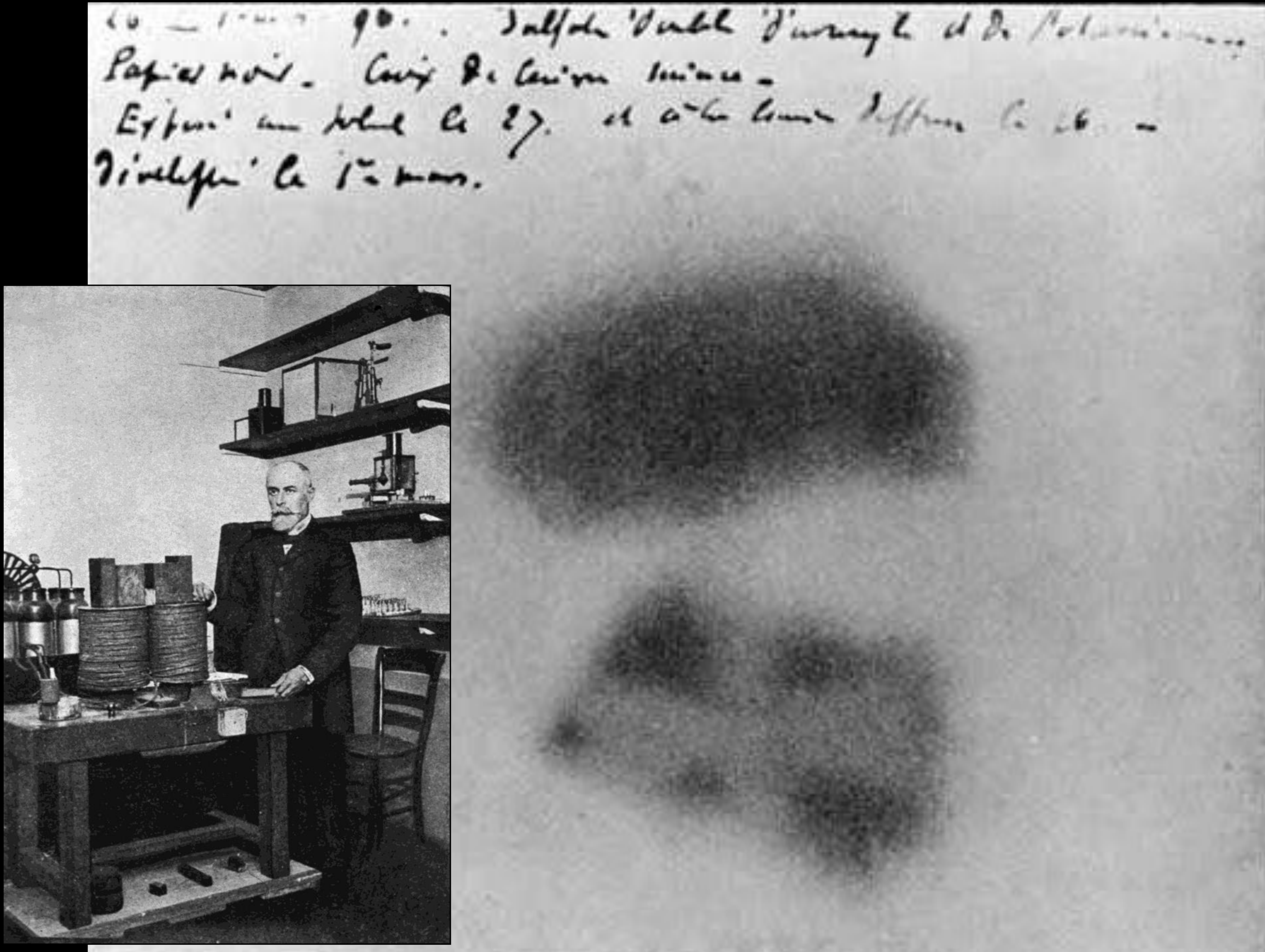
Human hair superposed on a nuclear star produced by relativistic sulfur nucleus

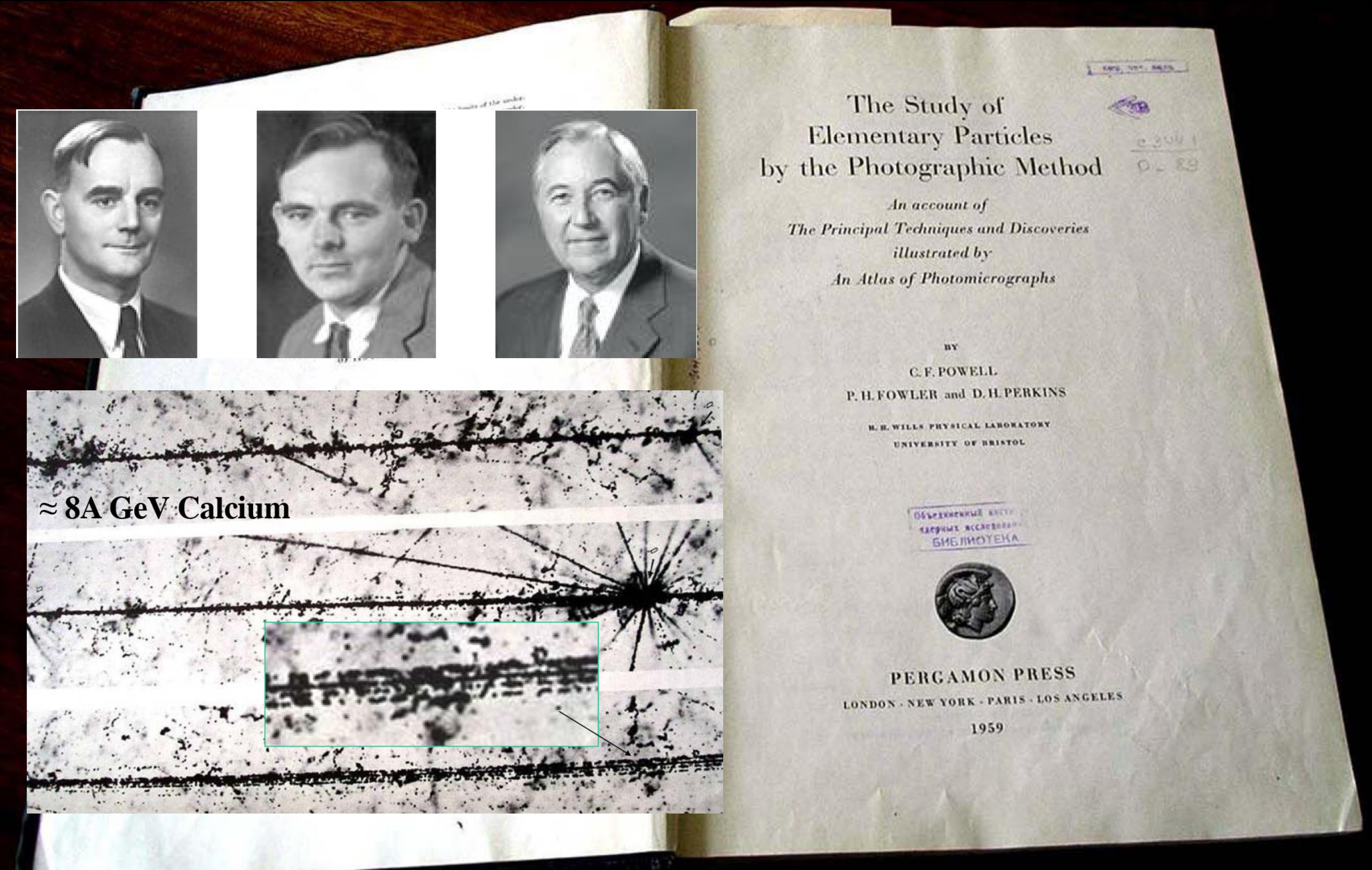


⁹C 0.13 s
S = 3/2⁻
¹⁰C 19 s
S = 0⁺
¹¹C 20 m
S = 3/2⁻
¹²C 99%
S = 0⁺
⁸B 0.8 s
S = 2⁺
¹⁰B 19.8%
S = 3⁺
¹¹B 80.2%
S = 3/2⁻
⁷Be 53 d
S = 3/2⁻
⁹Be 100%
S = 3/2⁻
⁶Li 7.5%
S = 1⁺
⁷Li 92.5%
S = 3/2⁻

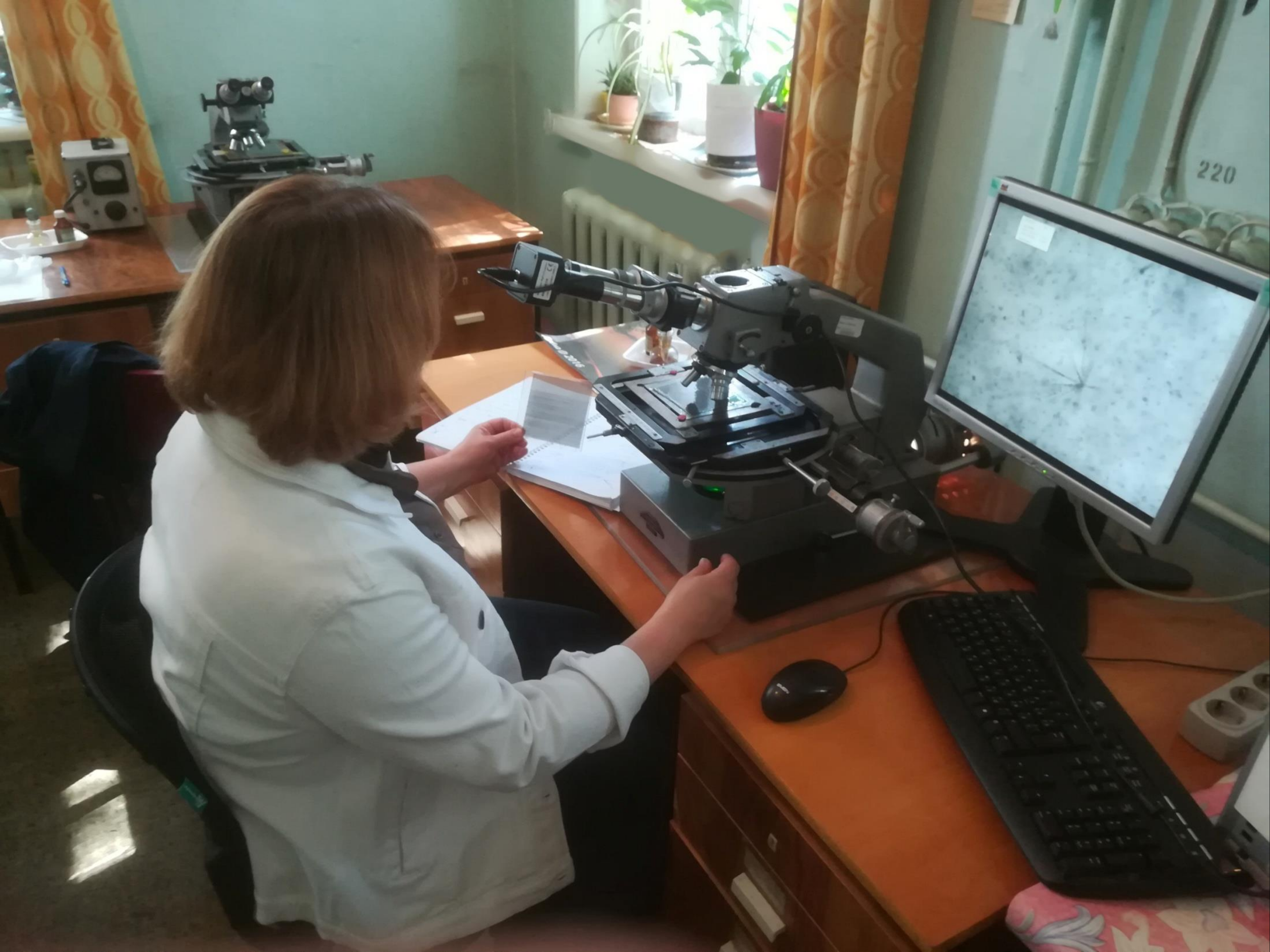


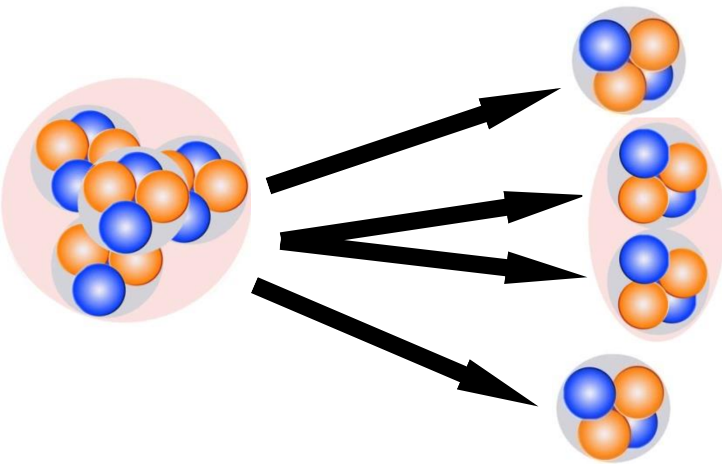
IV
¹⁰C
Coherent dissociation ¹⁰C→ p + ⁹B g.s. at 2A GeV/c ("white" star)
H
H
He
He



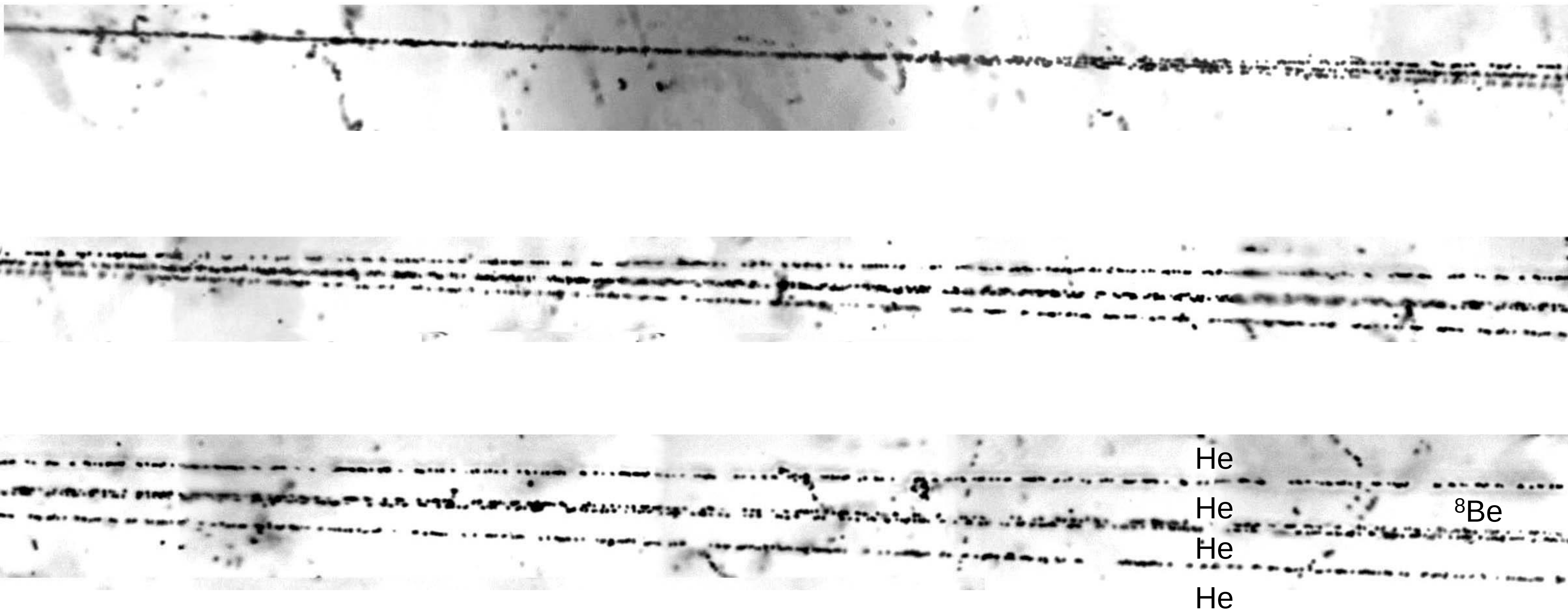


Events of multiple fragmentation of relativistic nuclei were observed as early as the 40s in the NTE exposed to cosmic rays in the stratosphere. Their photographs presented in the classic book by C. H. Powell, P. H. Fowler and D. H. Perkins, among other fundamental observations can serve as a model of clarity in our time. Our research is implemented in keeping with this tradition.


220



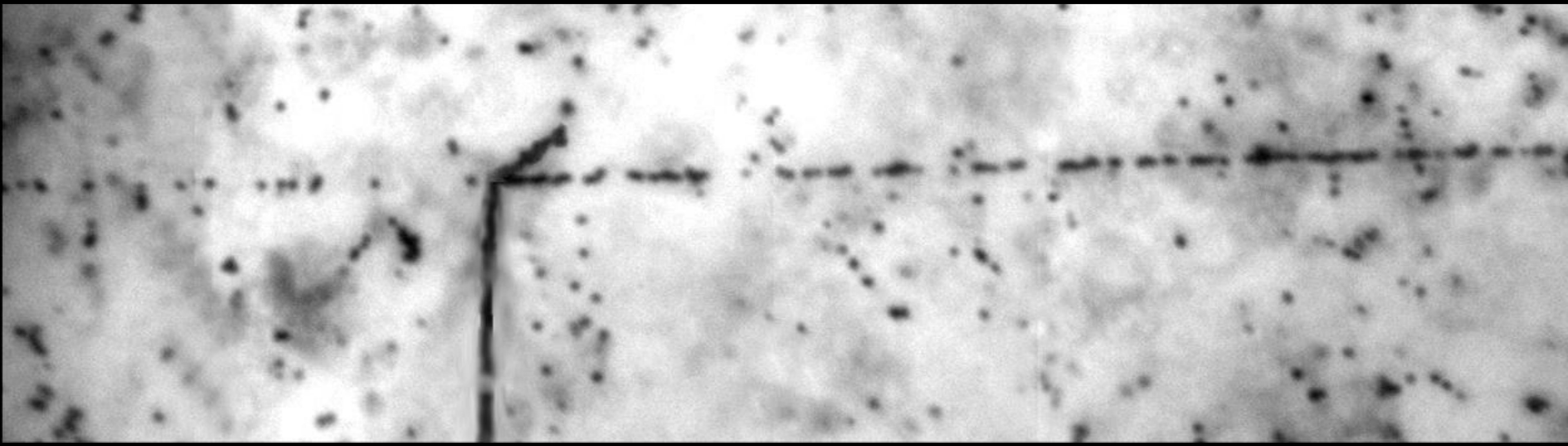
4.5 *A* GeV/*c* ^{16}O
JINR SPhT 80-ies



4.5 *A* GeV/*c* ^{24}Mg JINR SPhT 80-ies

2.7 A GeV/c ^{3}H

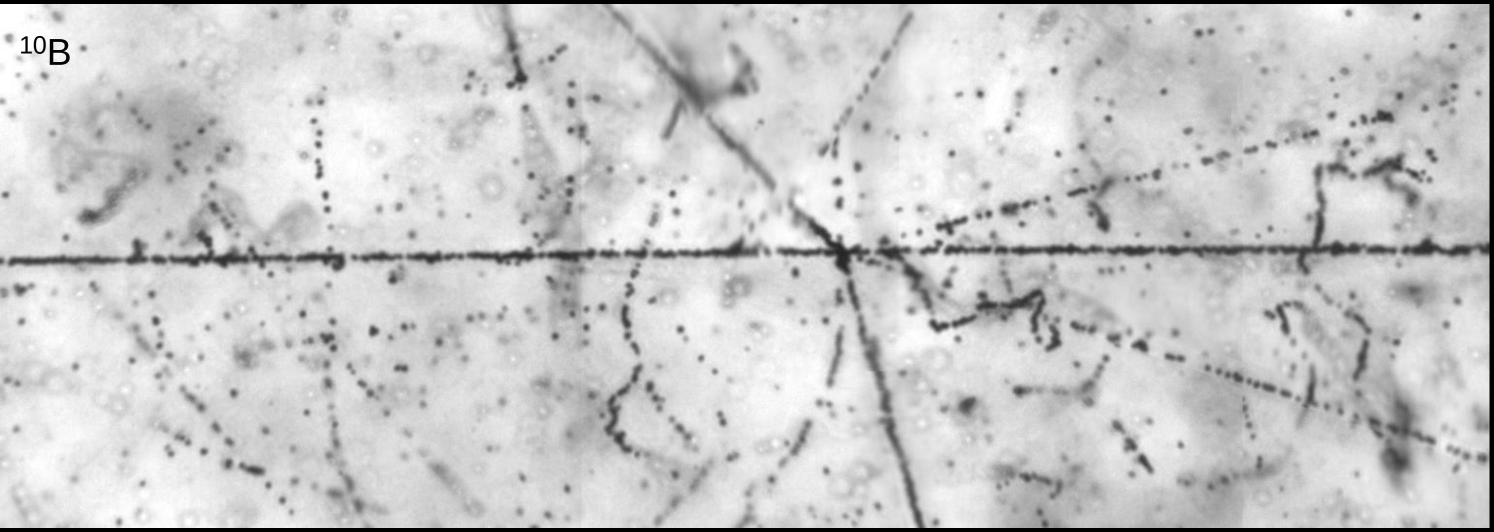
JINR SPhT late 90-ies

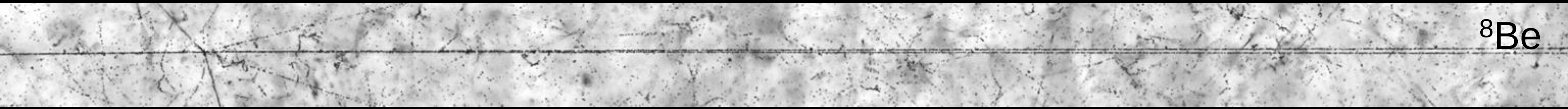


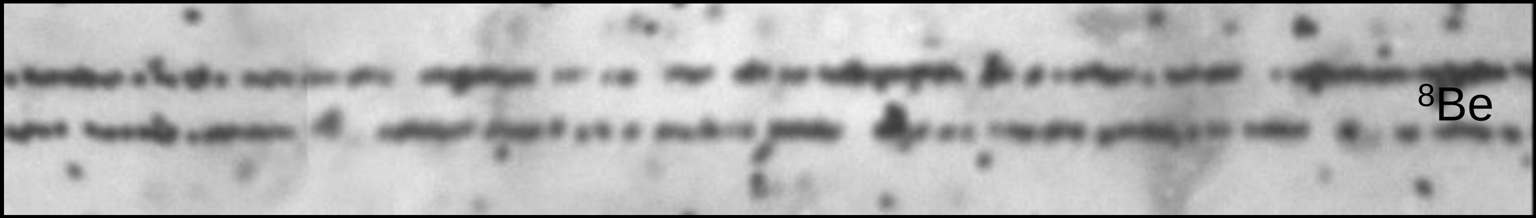
$$^3H \rightarrow {}^3He + 2b$$

2.0 *A* GeV/*c* ^{9}Be → ^{8}Be(→2He) +2*b* +2*g*

JINR Nuclotron mid 2000-ies

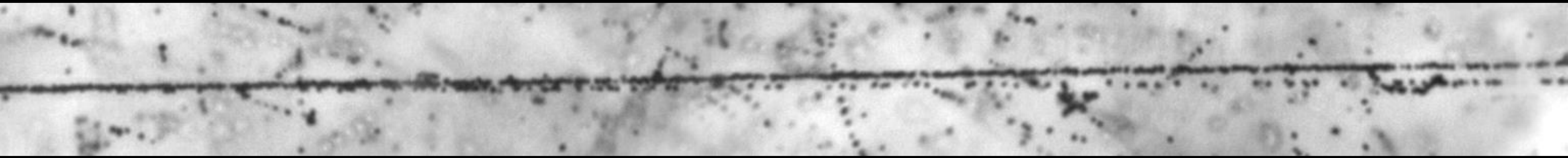


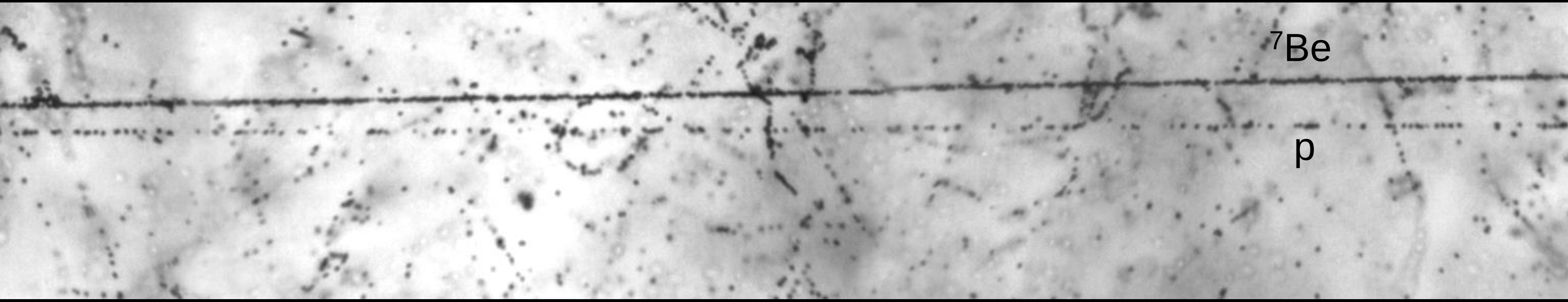


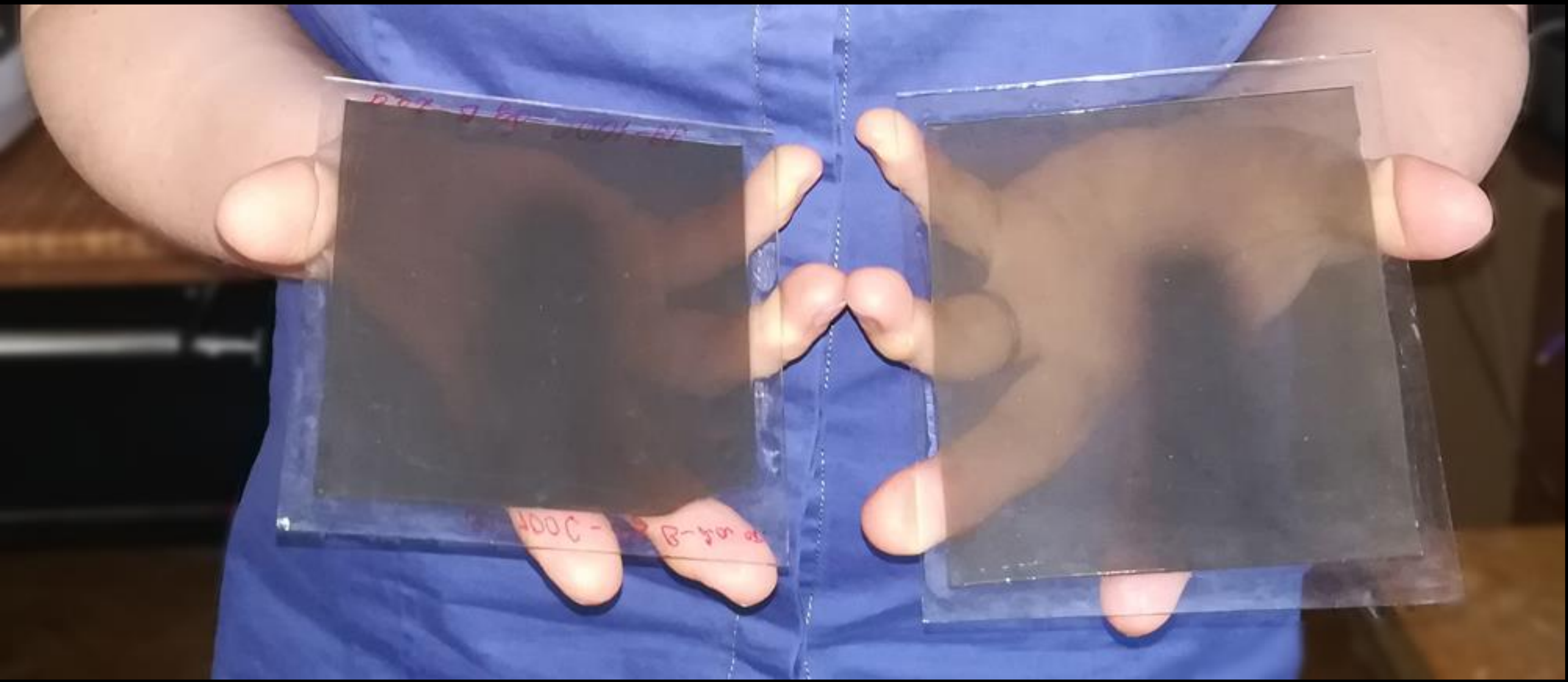


2.0 *A* GeV/*c* ^{8}B → ^{7}Be + *p* "white" star

JINR Nuclotron mid 2000-ies

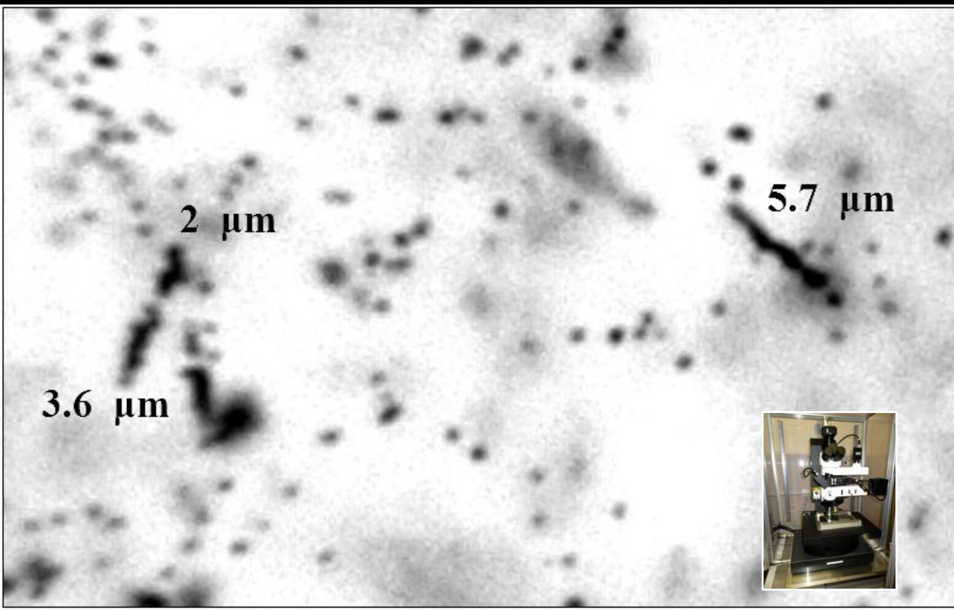


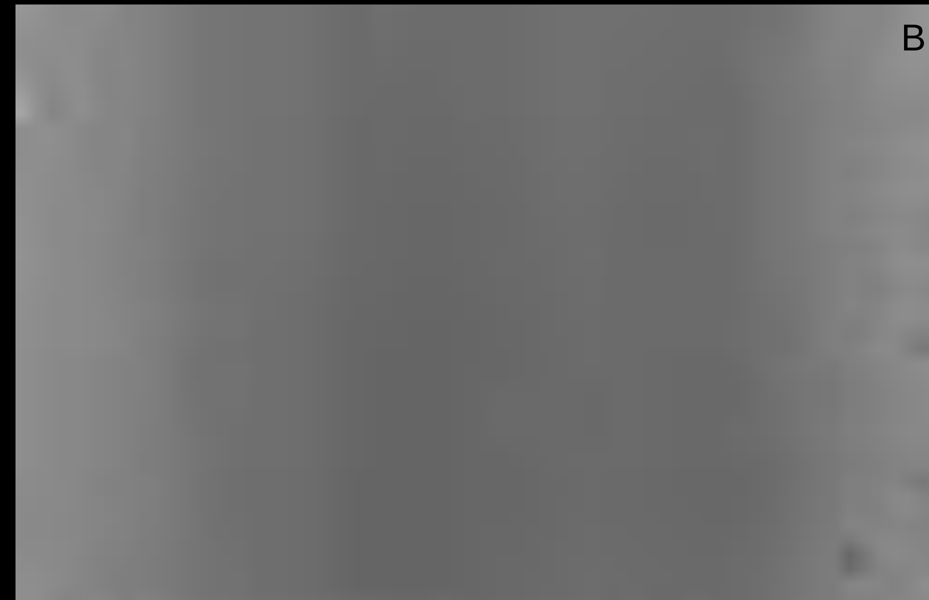




Boron-enriched samples of NTE (boric acid and borax), were irradiated for 30 minutes at the thermal neutron channel of the IBR-2 reactor JINR .

The presence of boron in NTE allows one to observe tracks of ^{7}Li and ^{4}He





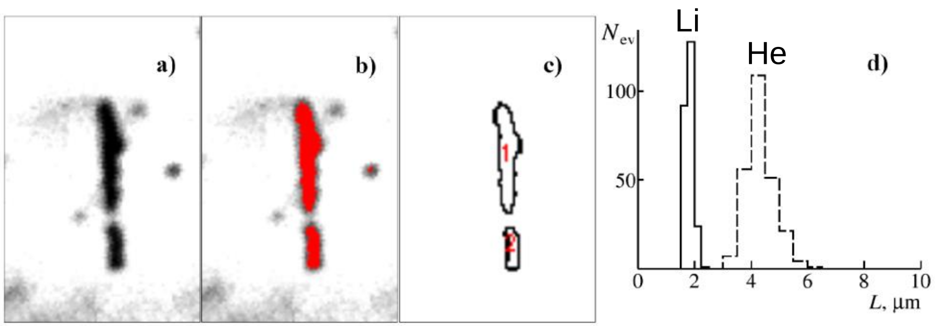
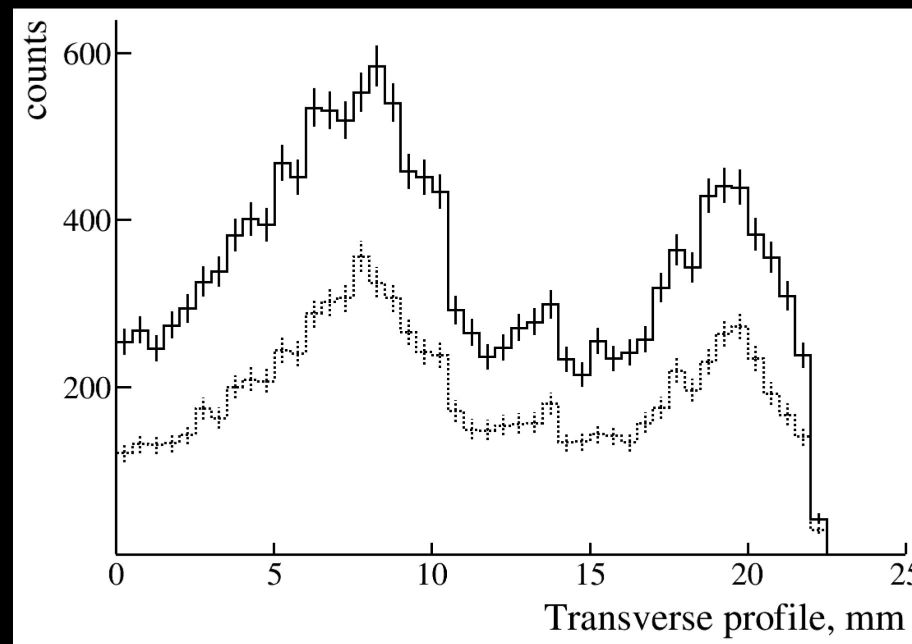
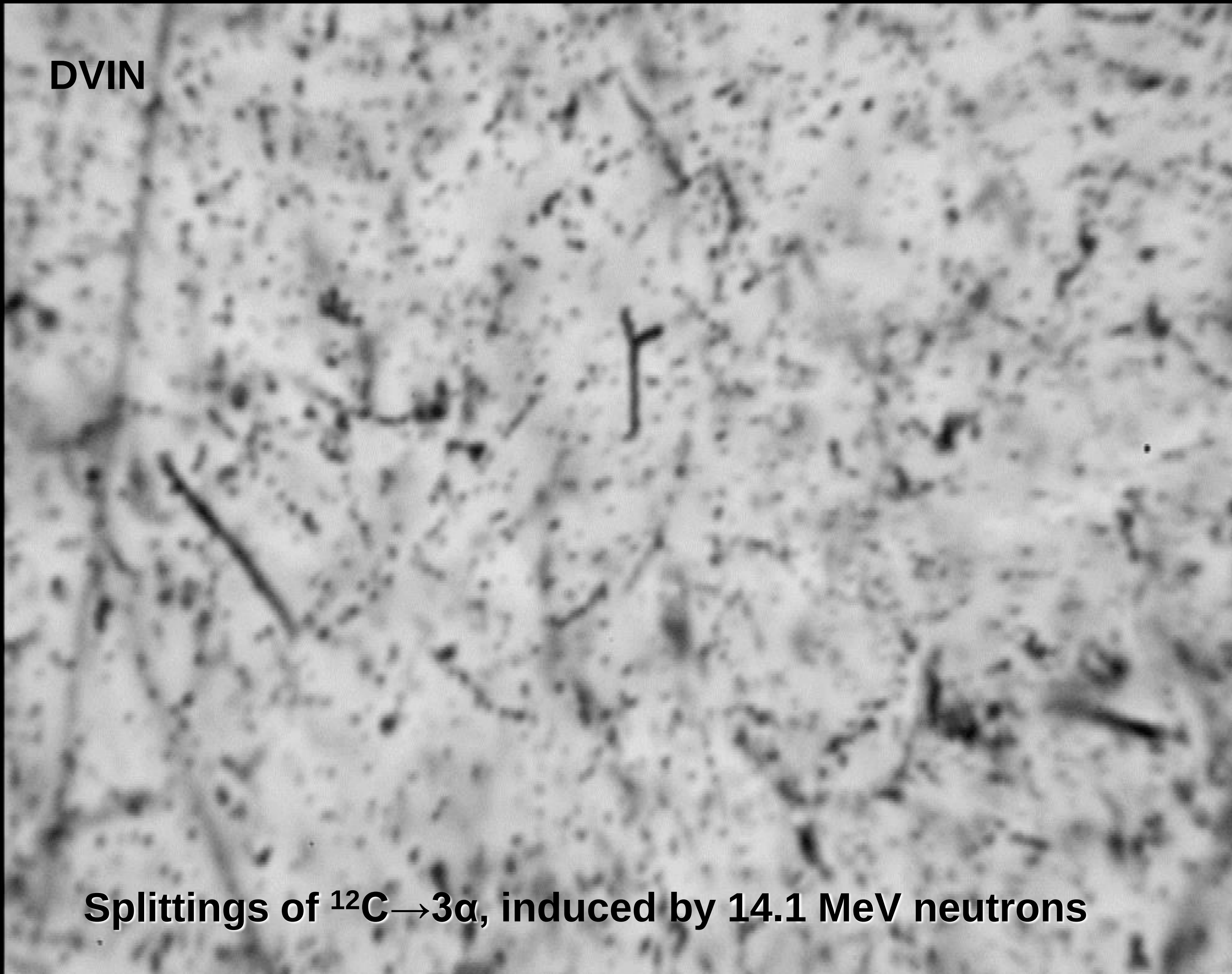
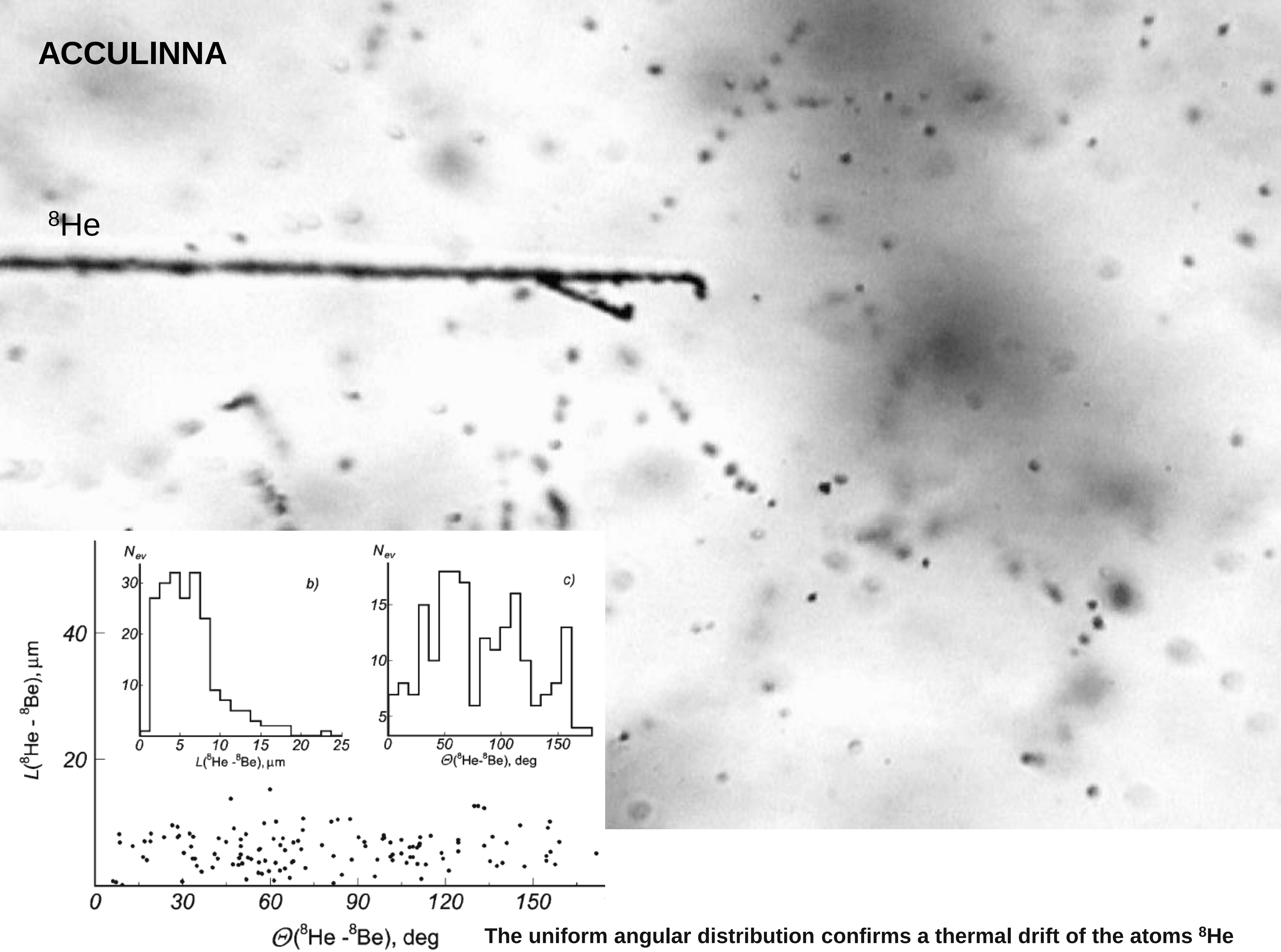


Figure 3. Example of disintegration of boron nucleus by thermal neutron to the Li and He n_{th} (a) and steps of image recognition via the ImageJ program (a-c). Distribution of mean range of Li (solid line) and He (dotted line) (d).




DVIN
Splittings of ¹²C→3α, induced by 14.1 MeV neutrons

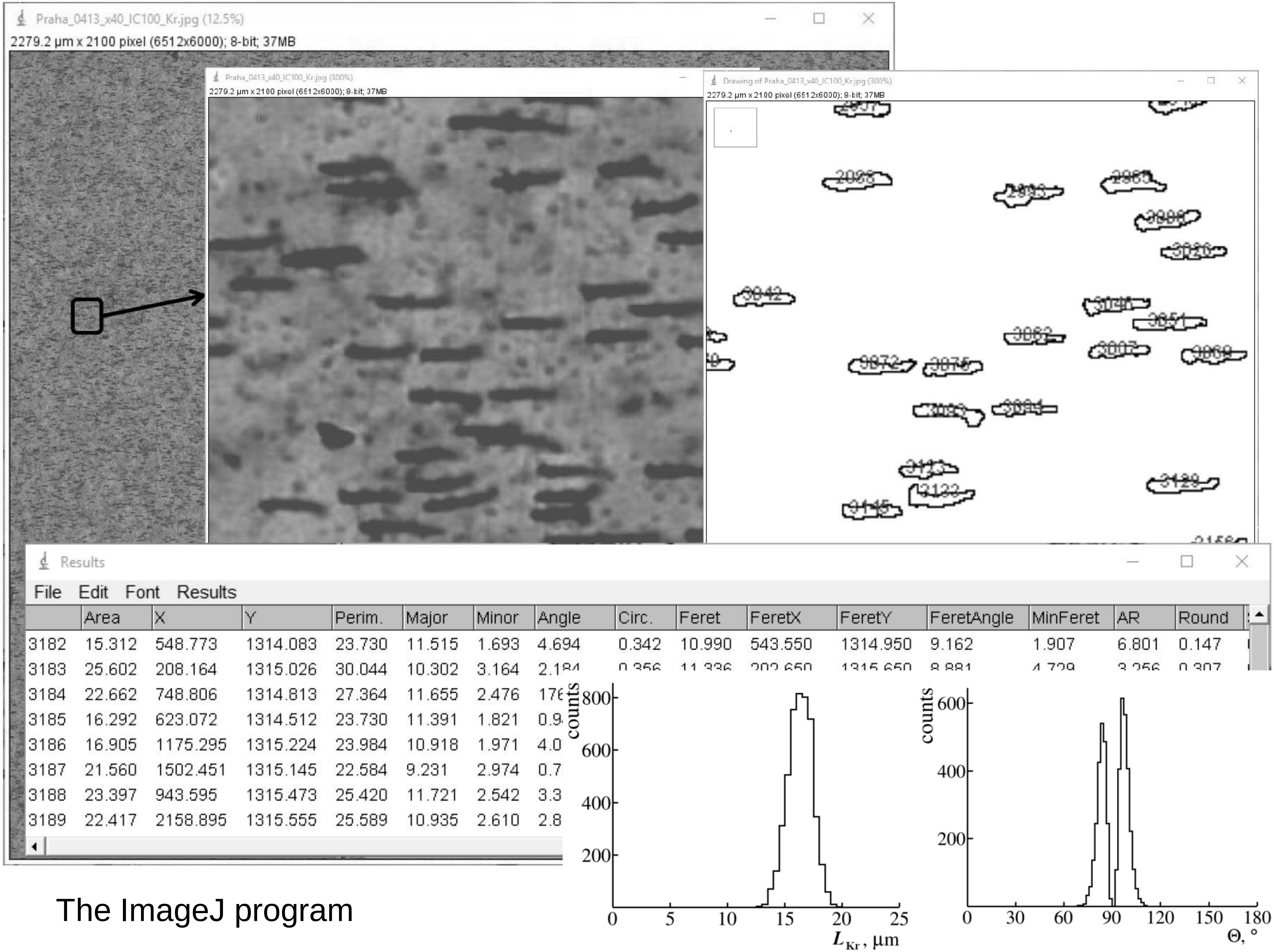
ACCULINNA



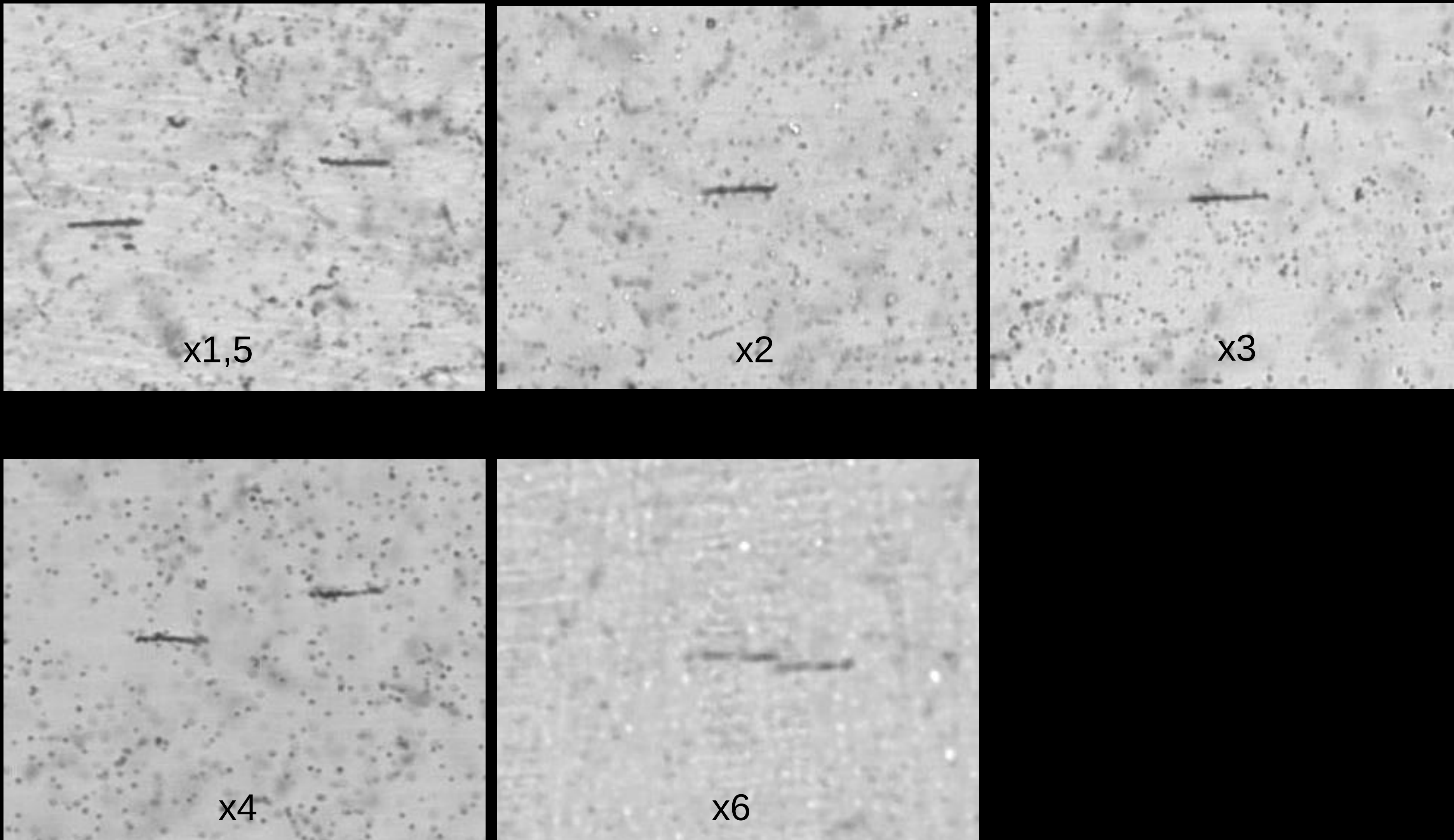
The uniform angular distribution confirms a thermal drift of the atoms ^{8}He

IC-100 cyclotron

Implantation of 1.2 *A* MeV Kr and Xe ions



The ImageJ program



Diluted emulsion exposed to Xe ions

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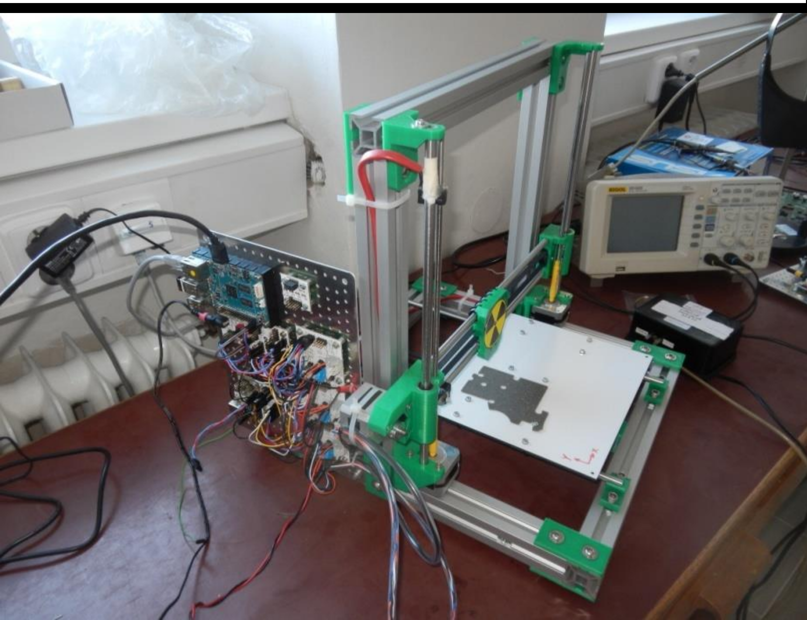
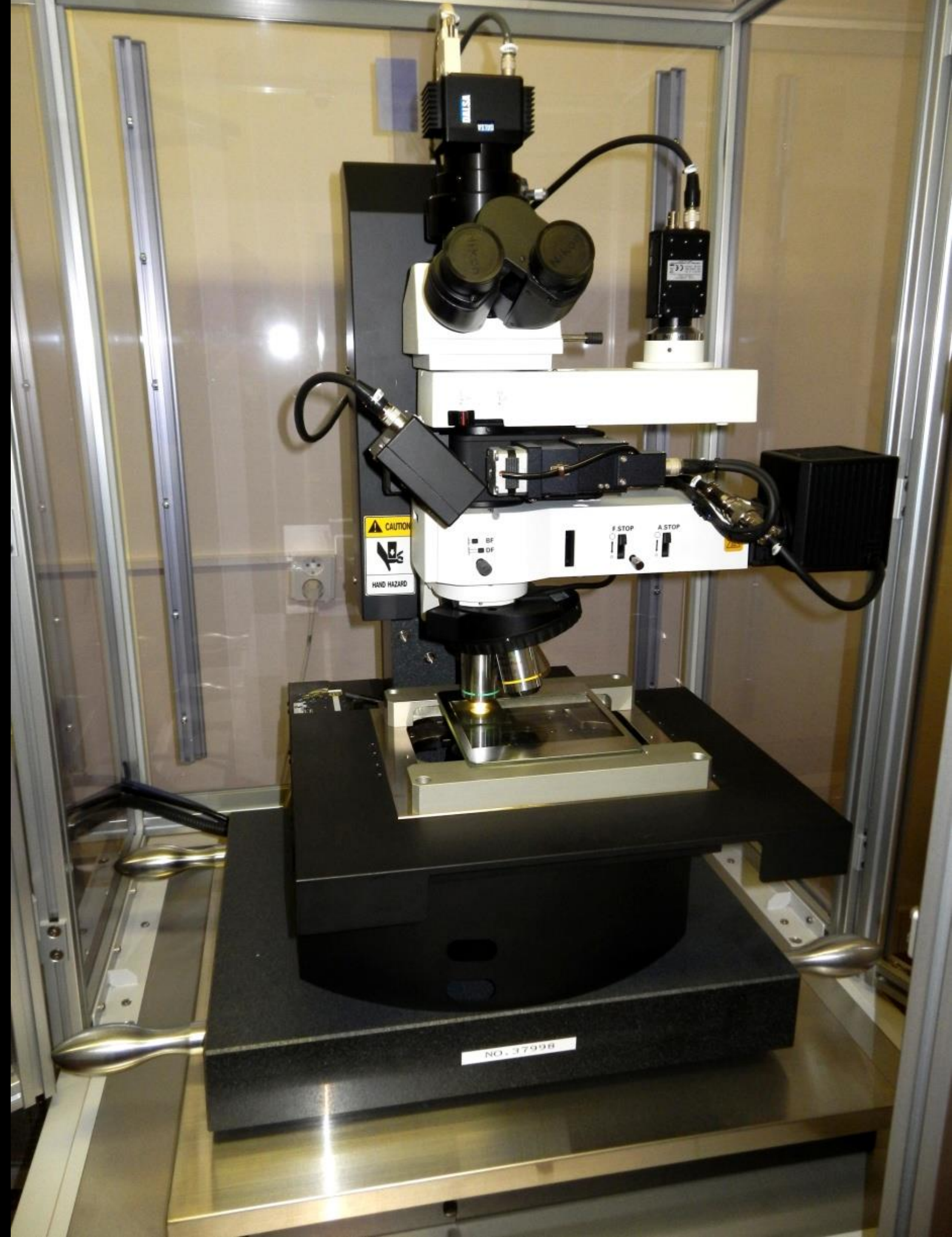
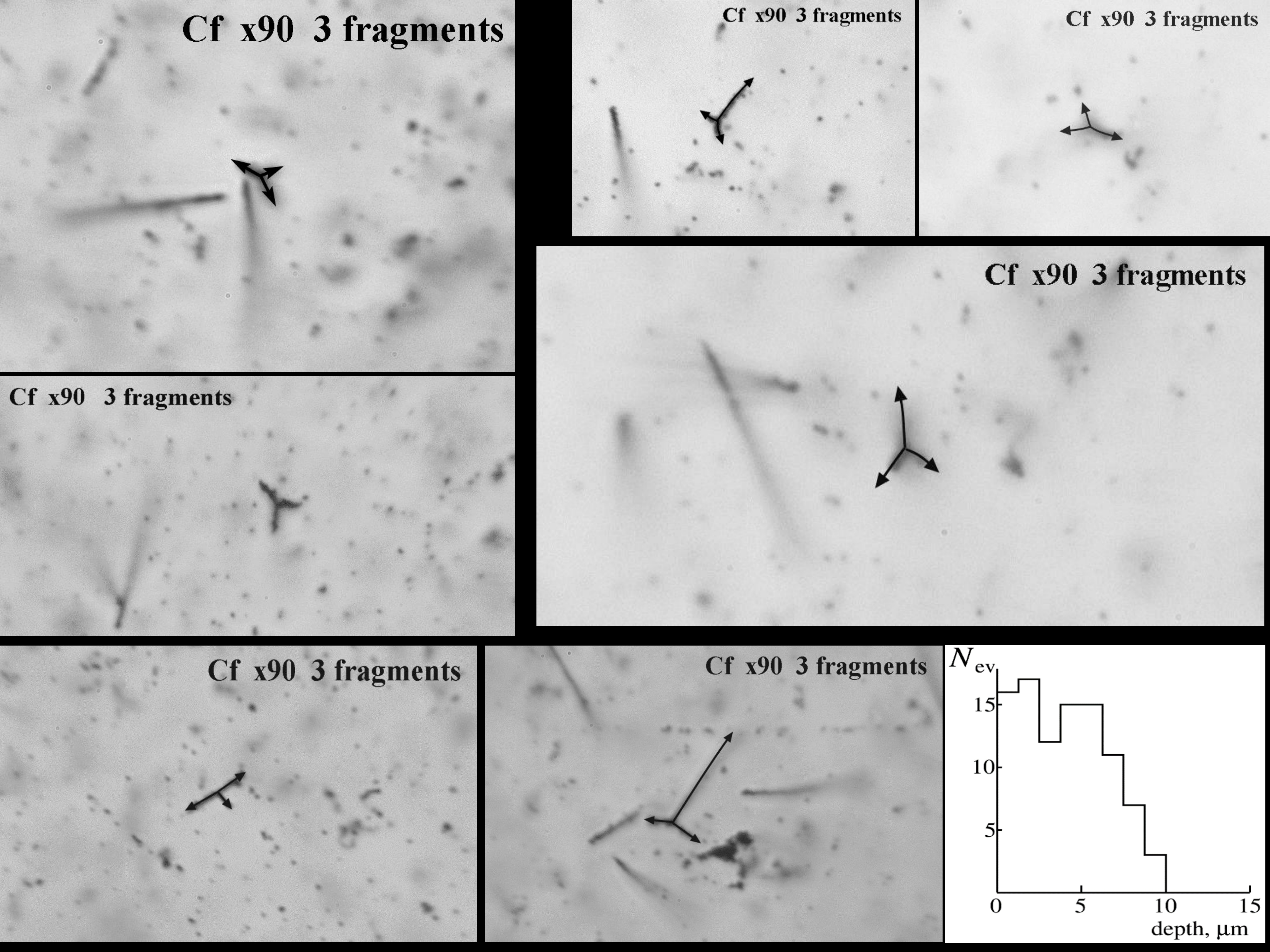
A large-scale NTE scanning is suggested to be performed on the microscope HSP-1000 of the Department of radiation dosimetry (DRD) of Nuclear Physics Institute of the Academy of Czech Republic. The use of the NTE resolution will be full if the microscope will be adapted to operate with lenses of the highest magnification. Development of algorithms for automatic search and analysis of short tracks of heavy ions in NTE will be required. On the experimental side, ion ranges in NTE must be calibrated in the α-decay and fission energy scale. Progress of the preparatory phase of the proposed study is summarized below.






Cf x90 3 fragments
Cf x90 3 fragments
Cf x90 3 fragments
Cf x90 3 fragments
Cf x90 3 fragments
Cf x90 3 fragments
Cf x90 3 fragments
N_{ev}
15
10
5
0
5
10
15
depth, μm

Nuclear education with nuclear track emulsion

Despite of the fact that half a century has passed since its development, the nuclear track emulsion retains the status of a universal and inexpensive detector. Due to the record spatial resolution (about 0.5μm), this method provides a complete observation of tracks, beginning with fragments of fission and up to relativistic particles.

The method of nuclear emulsion deserves further application in fundamental and applied research of modern accelerators and reactors and sources of radioactivity, including natural ones. Application of NTE is especially justified in those pioneering experiments in which tracks of nuclear particles cannot be reconstructed by electronic detectors in http://becquerel.jinr.ru/

We have created an extensive collection of macrophotos and videos about the interactions of relativistic nuclei and in low-energy physics.

Our goal is to draw attention to the ever-growing collection. Our materials can be easily accessed and used to develop intuition, to inspire new researches and pedagogical work.

Despite of the fact that half a century has passed since its development, the nuclear track emulsion retains the status of a universal and inexpensive detector. Due to the record spatial resolution (about 0.5μm), this method provides a complete observation of tracks, beginning with fragments of fission and up to relativistic particles. The method of nuclear emulsion deserves further application in fundamental and applied research of modern accelerators and reactors and sources of radioactivity, including natural ones. Application of NTE is especially justified in those pioneering experiments in which tracks of nuclear particles cannot be reconstructed by electronic detectors.

The NTE technique is still based on intelligence, vision and performance of researchers using traditional microscopes.

Despite wide interest, its labor consumption causes limited sampling of hundreds of measured tracks, which present, as a rule, only tiny fractions of the available statistics.

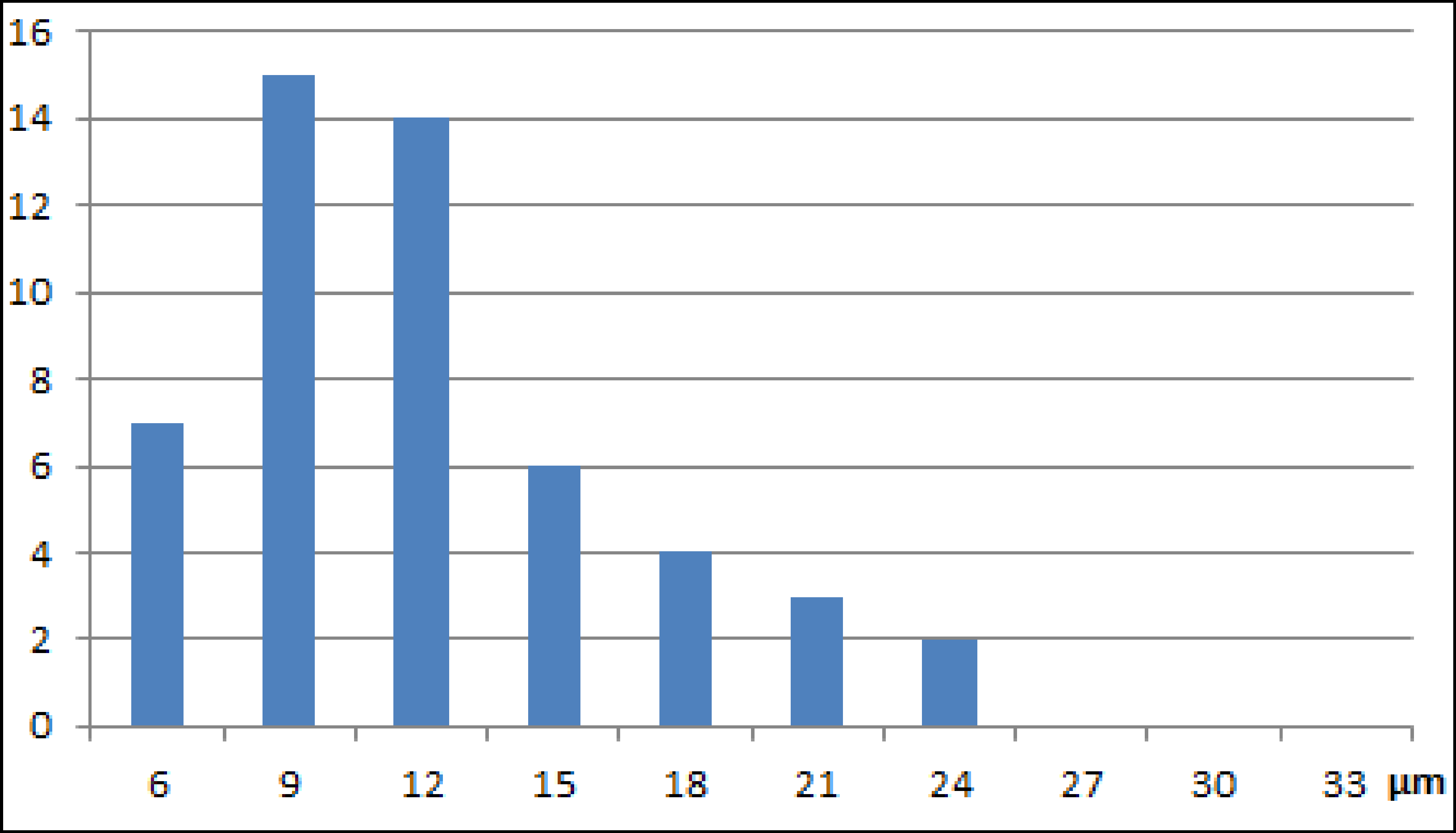
Application of computerized and fully automated microscopes in NTE analysis allows one to bridge this gap.

These are complicated and expensive devices of collective or even remote use, which allow us to describe the record statistics of short nuclear tracks.

To make such a development purposeful, it is necessary to focus on such topical problems in nuclear physics, the solution of which can be reduced to simple tasks of recognition and measurement of tracks in NTE, which will be solved with the help of already developed programs.

JINR U April 2018 pl. 2_1 x20 step 1 μm

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



Immersion depth in developed emulsion


CERN Muons May 2017 vi3_4
x20