IMPLANTATION OF ^{8}He NUCLEI IN NUCLEAR TRACK EMULSION

K.Z. MAMATKULOV

LHEP, JINR, Dubna, Russia.

DjPI, Uzbekistan.

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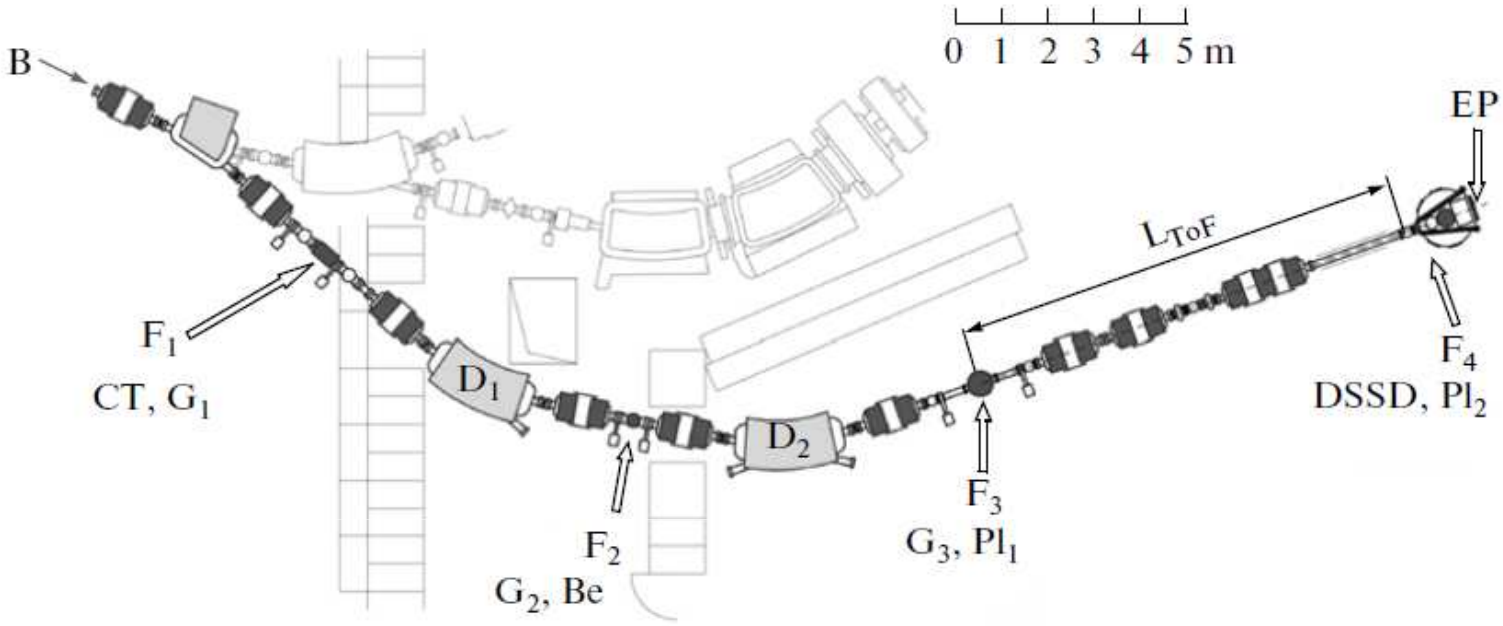
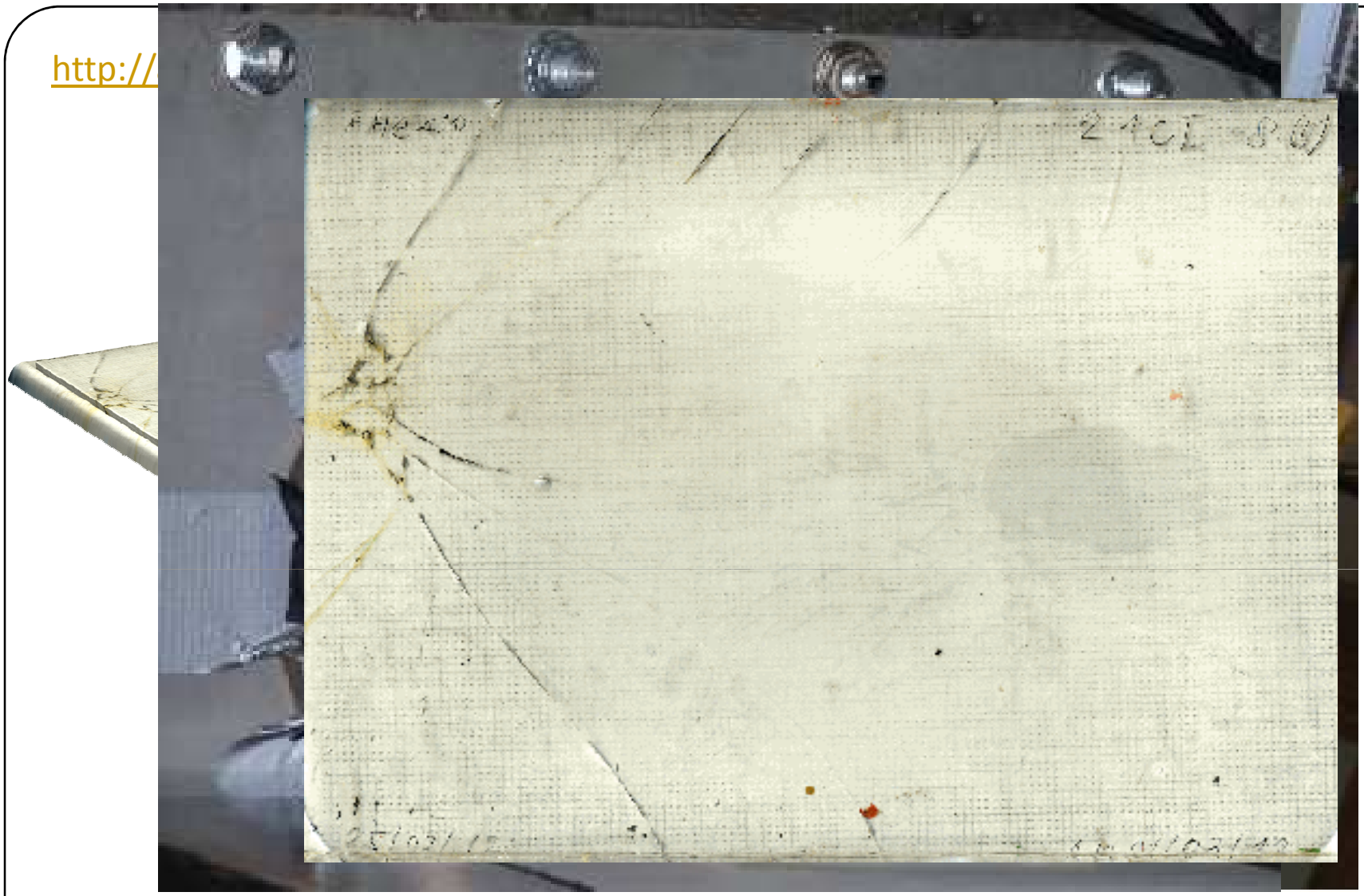
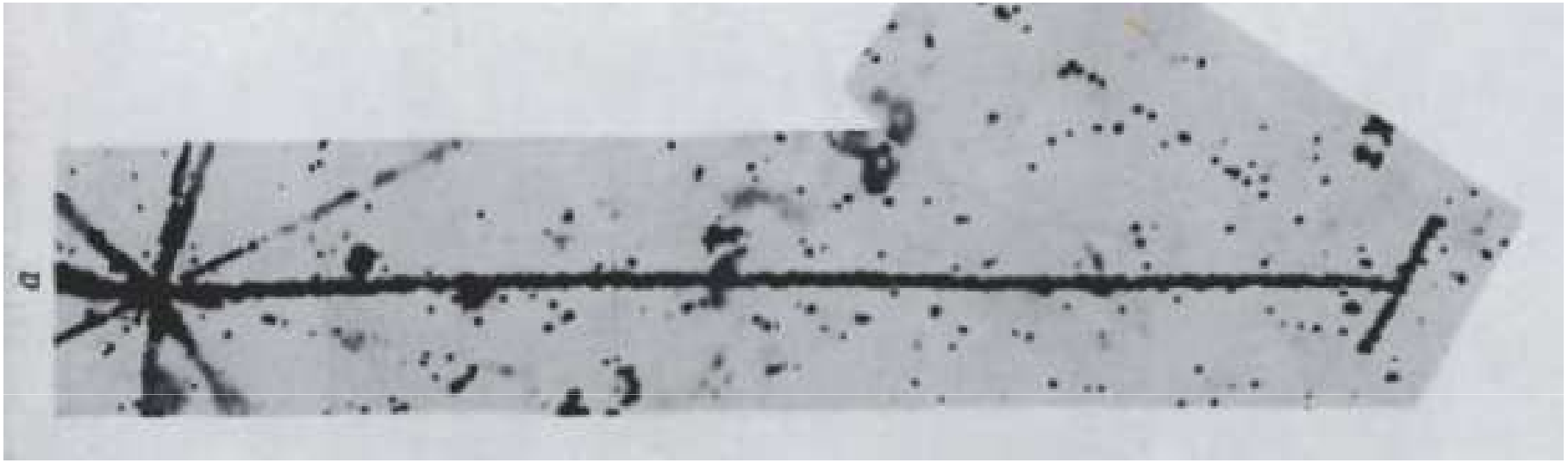


Scheme showing the production of the 60-MeV ^{8}He beam at the ACCULINNA separator and the location of the nuclear track emulsion pellicles in the focus F_4 during their exposure to ^{8}He nuclei. B is the direction of the primary beam extracted from the U400M accelerator; CT is the carbon target; $F_{1,2,3,4}$ are the focal planes; $G_{1,2,3}$ collimator gaps; Be is the beryllium wedge; $Pl_{1,2}$ are the plastic scintillator detectors; DSSD is the strip silicon detector; L_{ToF} is the time-of-flight measurement path; and EP is the emulsion pellicle exposure place.

http://

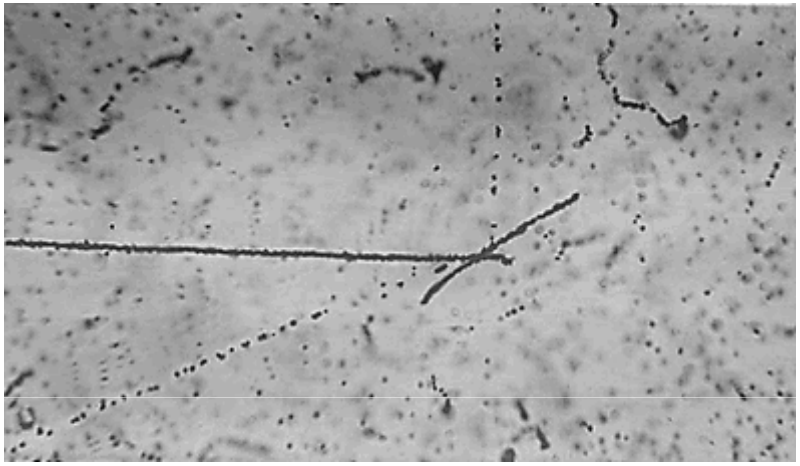


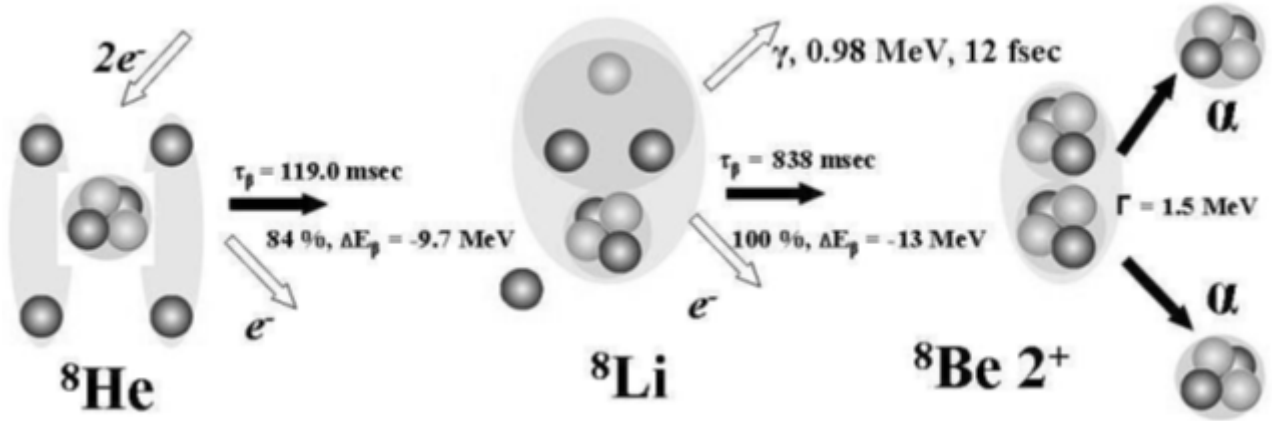
Emulsion layers with size (9 × 12) cm^2 and with ~100 µm thickness on a glass substrate with thickness ~2 mm, have placed at an angle 10^0 to the axis of the beam. The slope of the plate has provided an increase of braking of nuclei in emulsion. Irradiated layers were wrapped in two layers of black paper with a thickness of 100 µm to protect the emulsion from the daylight. With this have added additional braking.

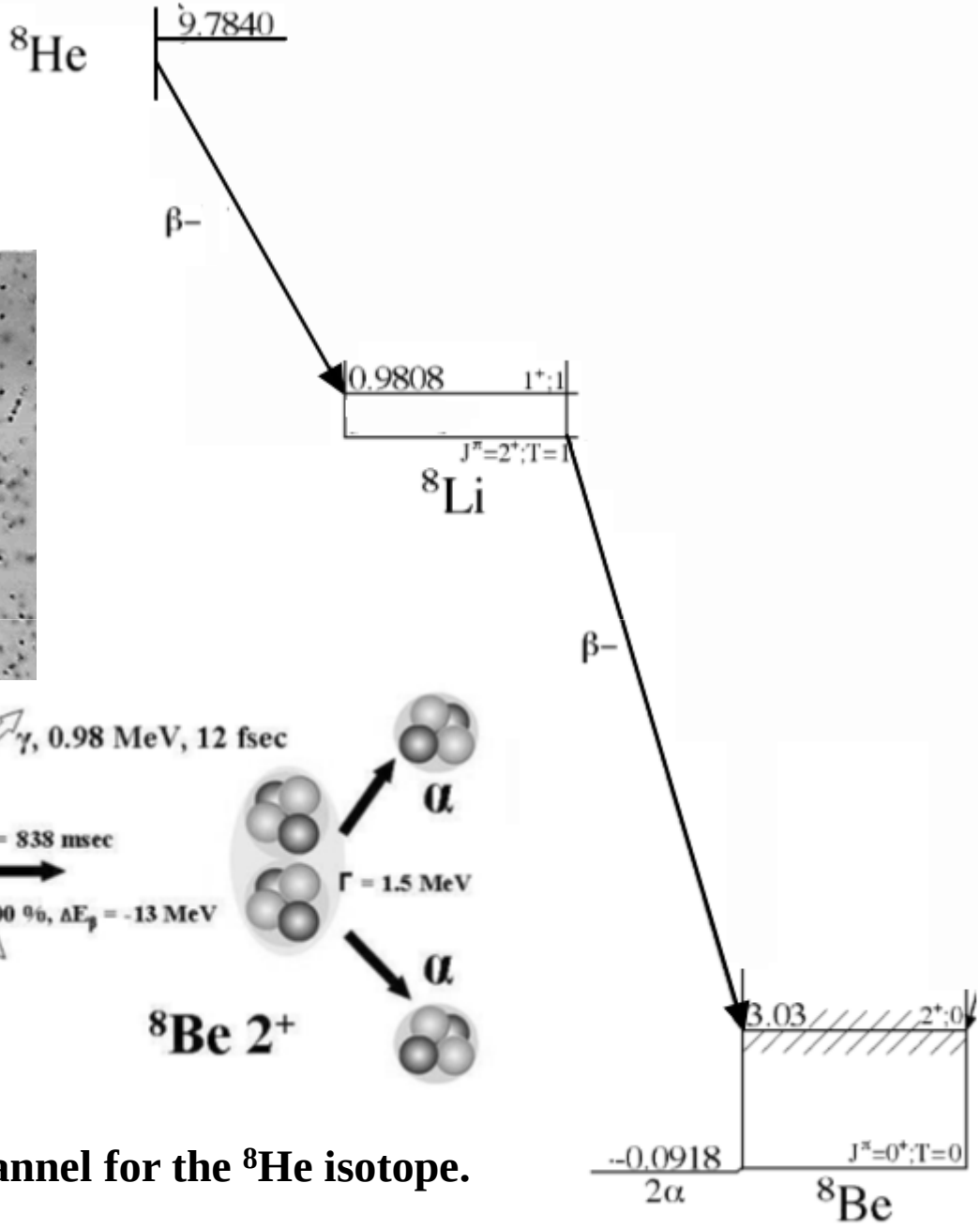


Microphotograph of "hammer“ tracks of the decay $^{8}Be \rightarrow 2\alpha$ from β-decays of stopped fragments ^{8}Li.

Energy levels

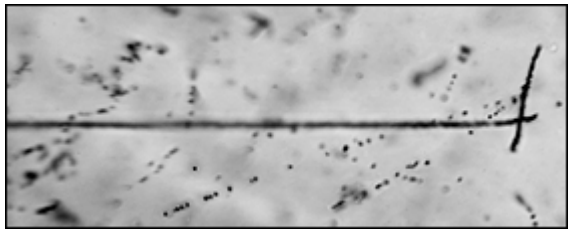


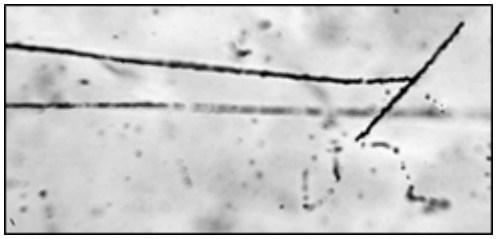


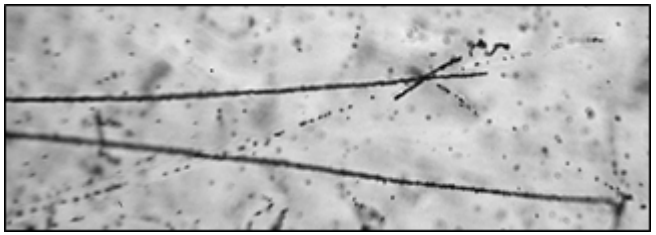


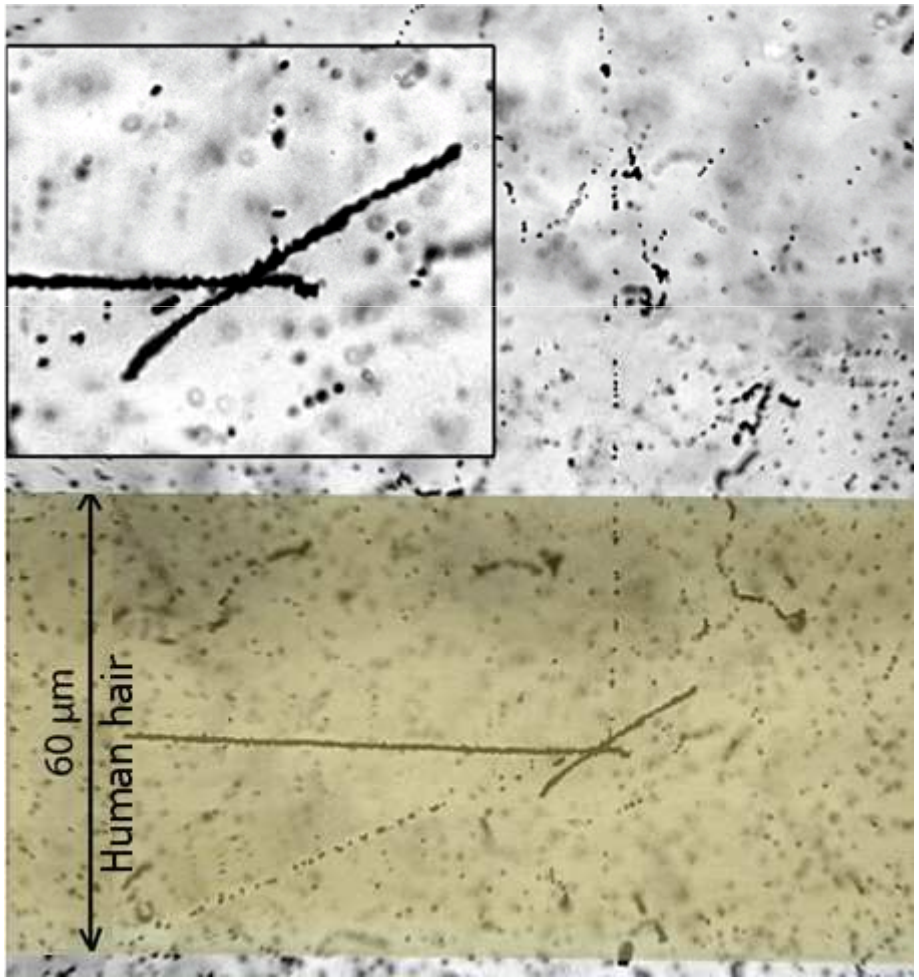
Scheme of the main cascade decay channel for the ^{8}He isotope.

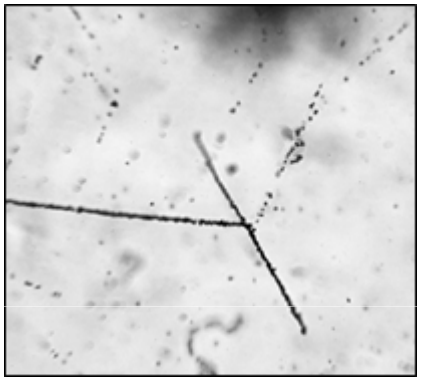
Microphotograph examples of “hummerlike” decays.

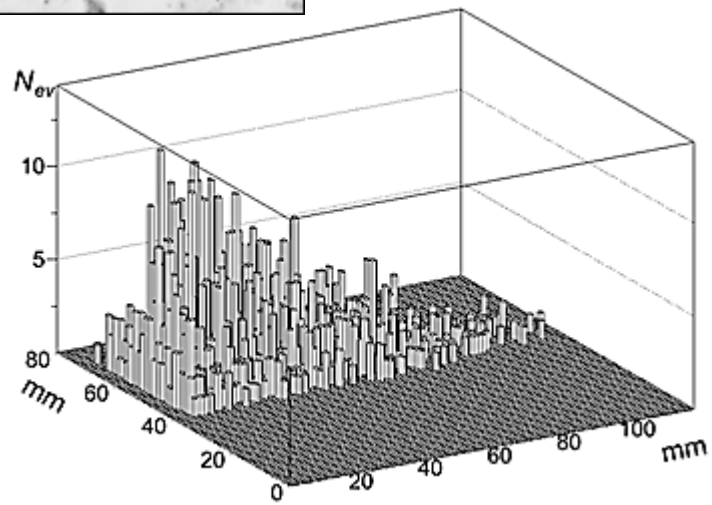




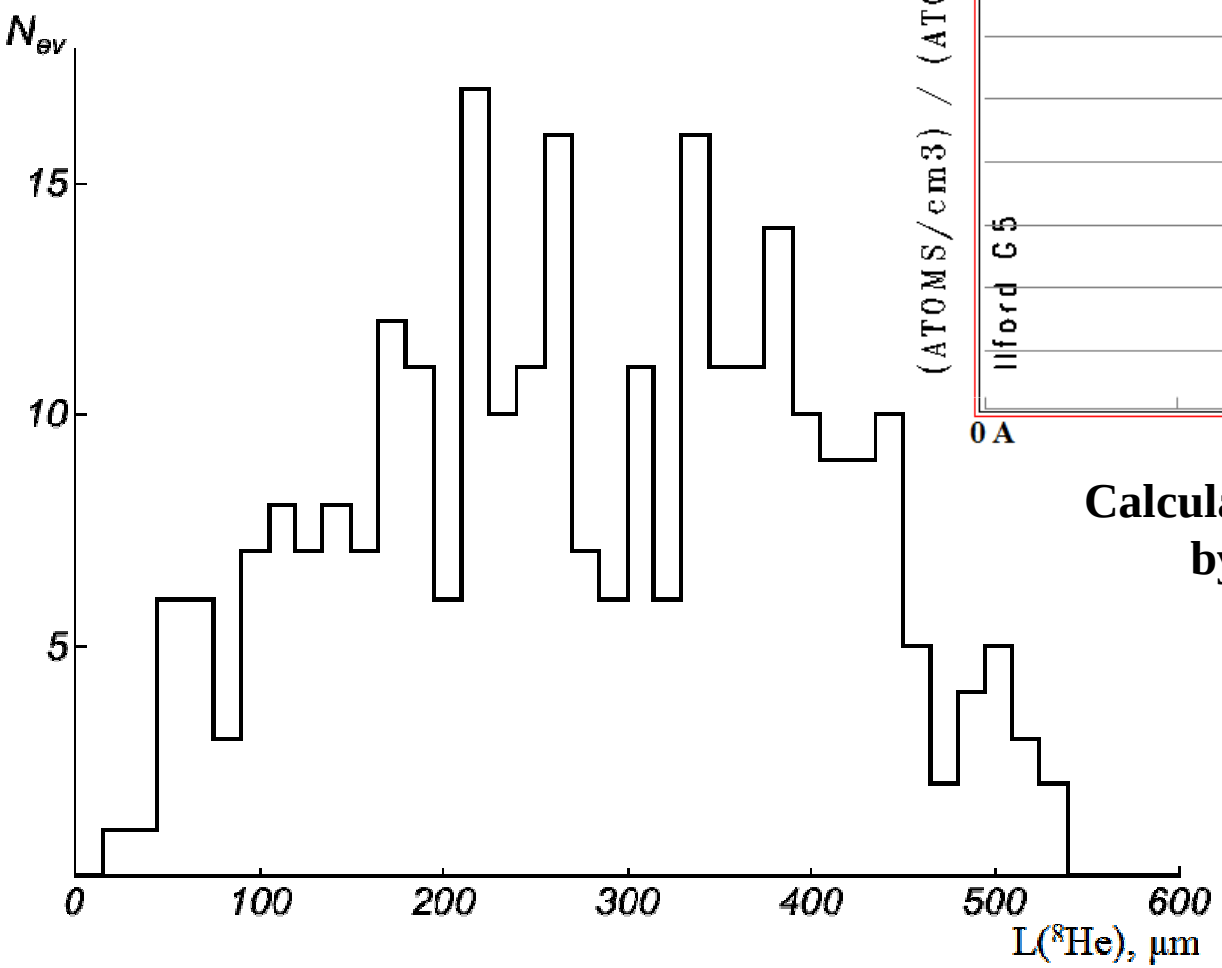


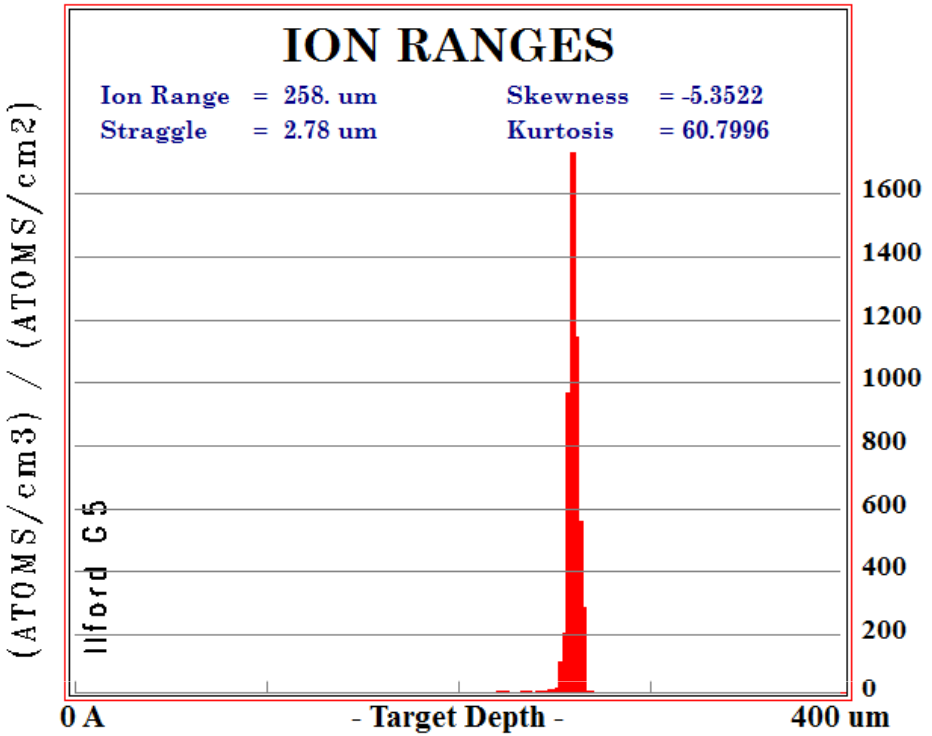






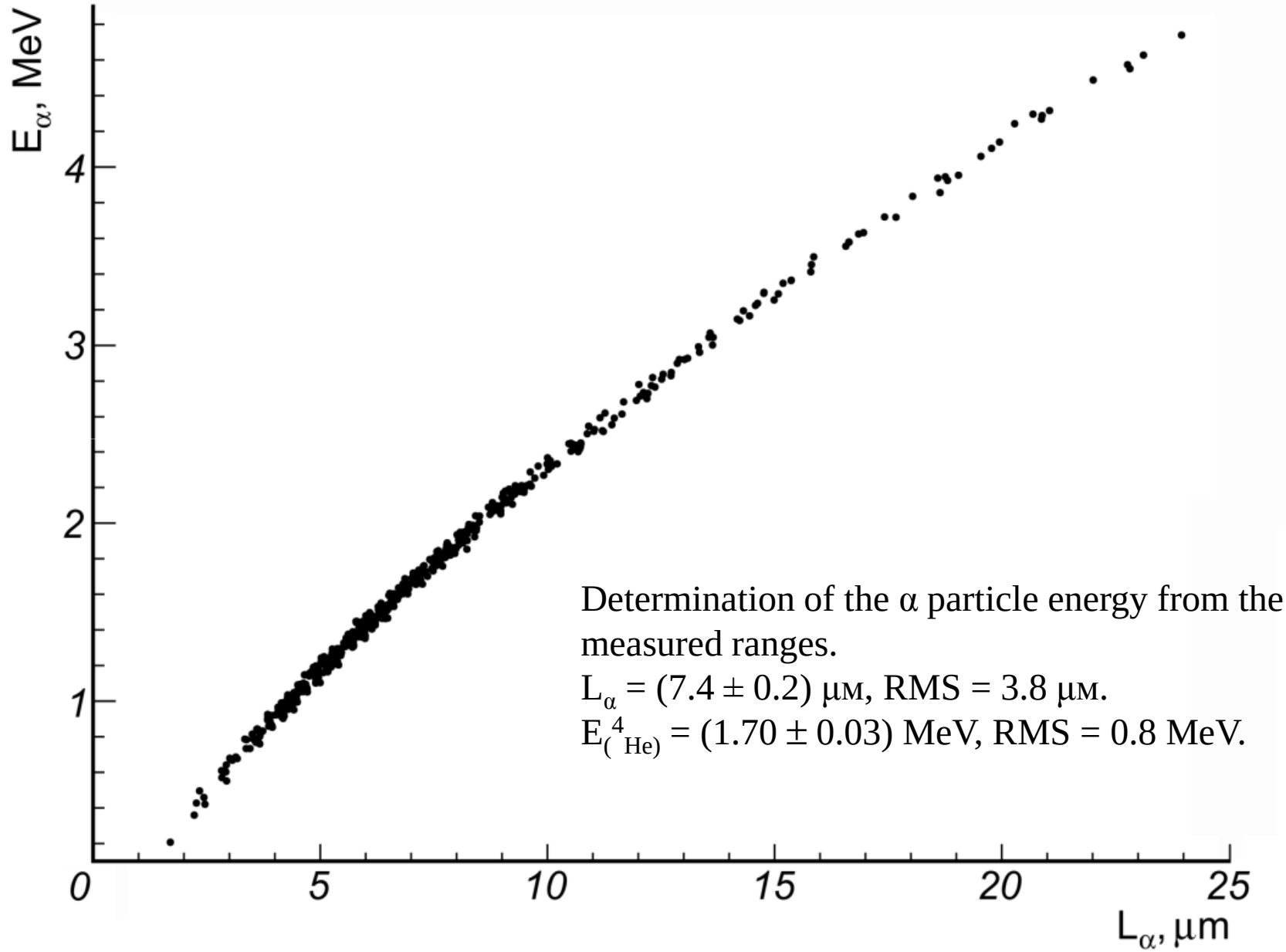
Beam profile in the hammerlike decays; the bin size is 1 × 1 mm.





Calculation range of nuclei ^{8}He by SRIM simulation.

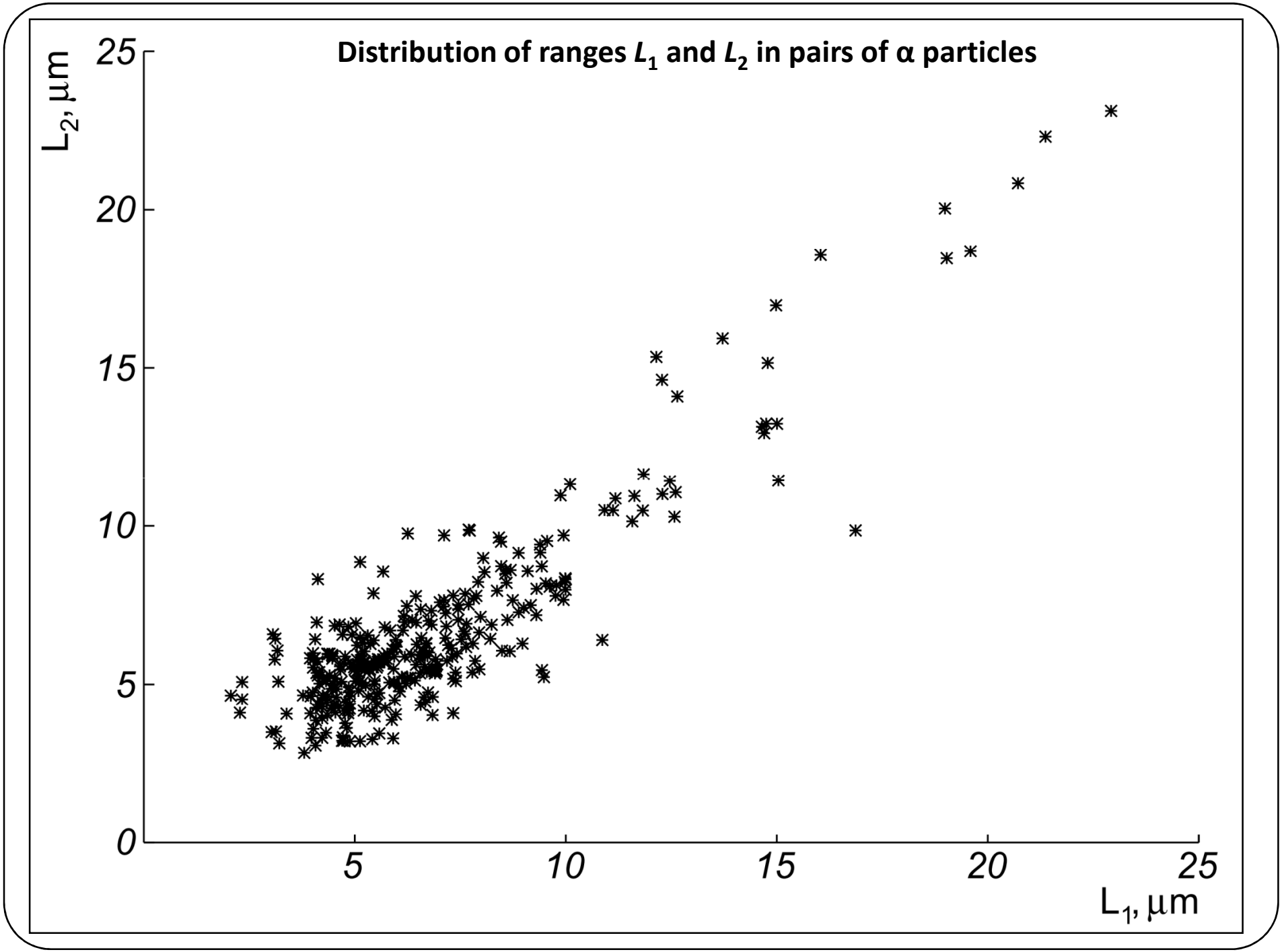
Range distribution of the ^{8}He tracks in the emulsion



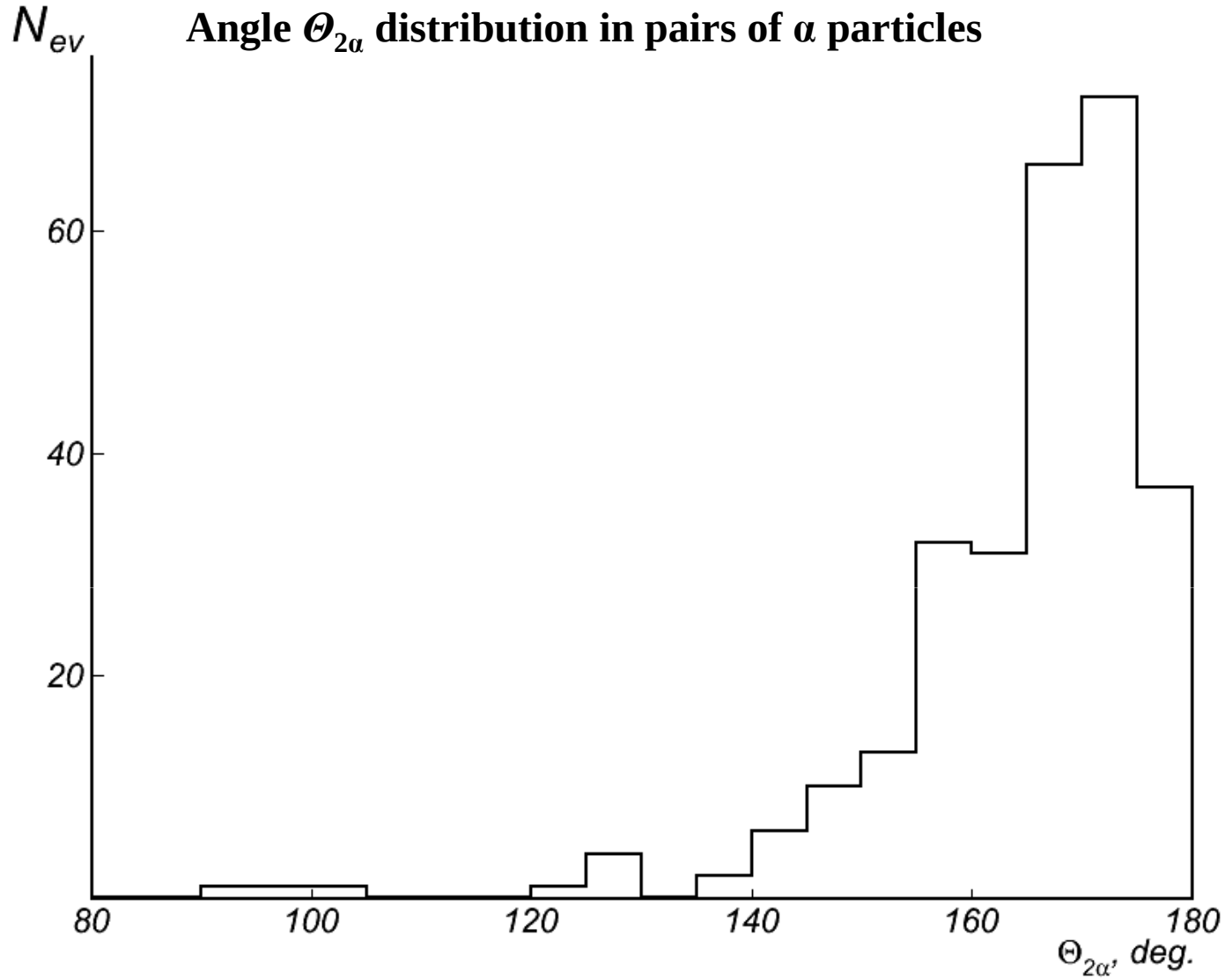
Determination of the α particle energy from the measured ranges.

L_α = (7.4 ± 0.2) μм, RMS = 3.8 μм.

$E_{(^4He)}$ = (1.70 ± 0.03) MeV, RMS = 0.8 MeV.


Distribution of ranges L_1 and L_2 in pairs of α particles
L_2, μm
25
20
15
10
5
0
5
10
15
20
25
L_1, μm

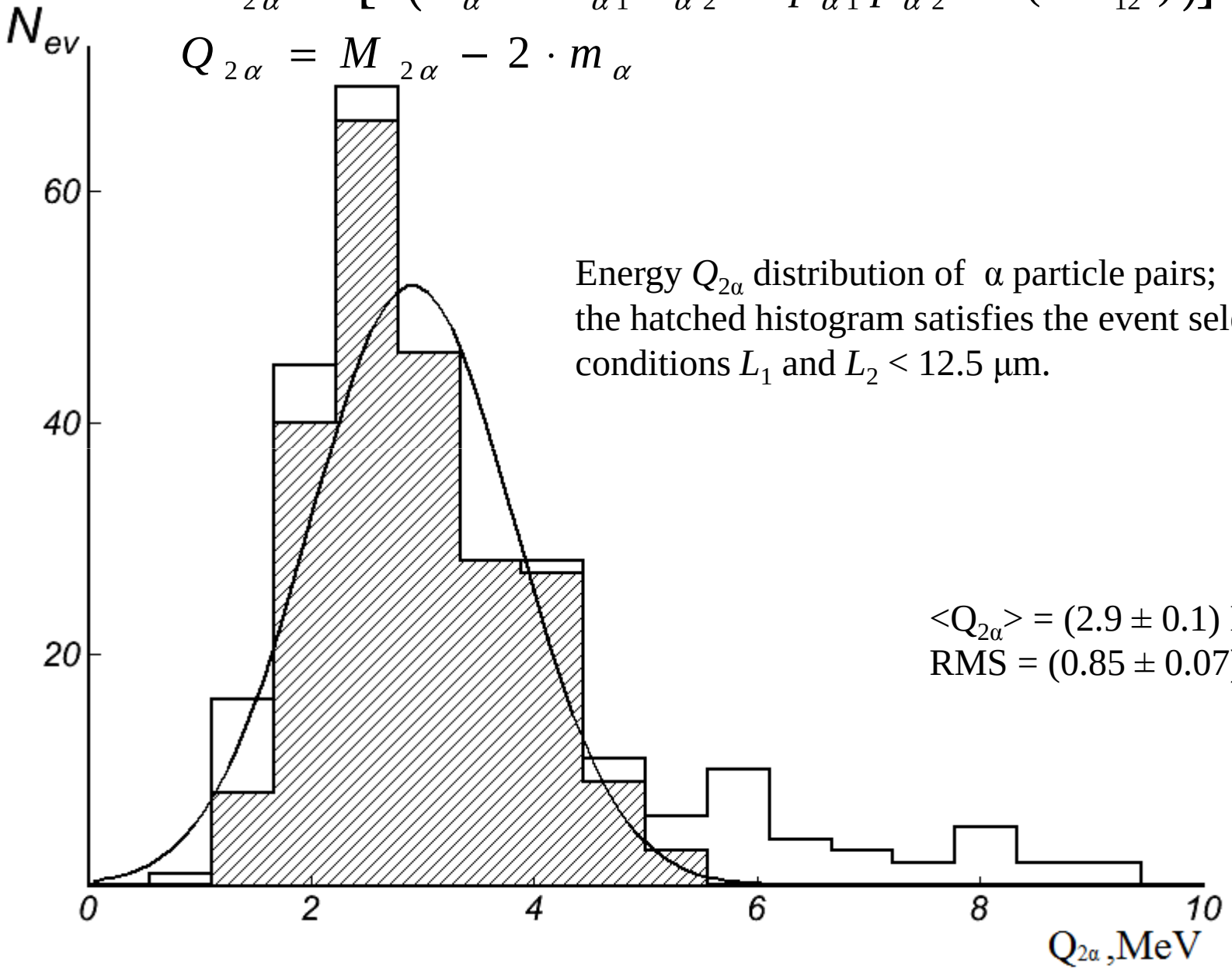
Angle $\Theta_{2\alpha}$ distribution in pairs of α particles



The average value of the angles is $< \Theta_{2\alpha} >$ = (164.9 ± 0.7)° at the RMS (116 ± 0.5)°.

$$M_{2\alpha} = \left[2\left(m_{\alpha}^{2} + E_{\alpha 1}E_{\alpha 2} - p_{\alpha 1}p_{\alpha 2}\cos(\Theta_{12})\right)\right]^{\frac{1}{2}}$$

$$Q_{2\alpha} = M_{2\alpha} - 2 \cdot m_{\alpha}$$



Energy $Q_{2\alpha}$ distribution of α particle pairs;
the hatched histogram satisfies the event selection conditions L_1 and L_2 < 12.5 μm.

$<Q_{2\alpha}>$ = (2.9 ± 0.1) MeV
RMS = (0.85 ± 0.07) MeV

Conclusions:

This work demonstrates the capabilities of the recently reproduced nuclear track emulsion exposed to a beam of ^{8}He nuclei. The test experiment allowed radioactive ^{8}He nuclei to be independently identified by their decays as they stopped in the emulsion, the possibility of carrying out the α spectrometry of these decays to be estimated, and the drift of thermalized ^{8}He atoms in matter to be observed for the first time.

The experiment proved the high purity of the beam of radioactive nuclei formed at the ACCULINNA facility with an energy ranging from 10 to 30 MeV/nucleon.

The analysis of 278 decays of ^{8}He nuclei can be a prototype for investigating decays of ^{8,9}Li, ^{8,12}B, ^{9}C, and ^{12}N nuclei in which the ^{8}Be nucleus serves as a marker. The nuclear track emulsion can be used for the diagnostics of beams of radioactive isotopes.

THANK YOU!