Fragmentation of relativistic nuclei ^{10}C in a nuclear track emulsion

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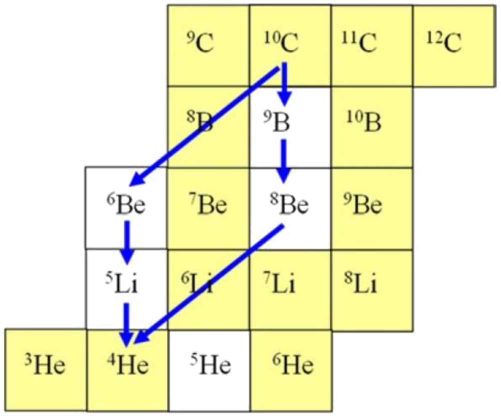
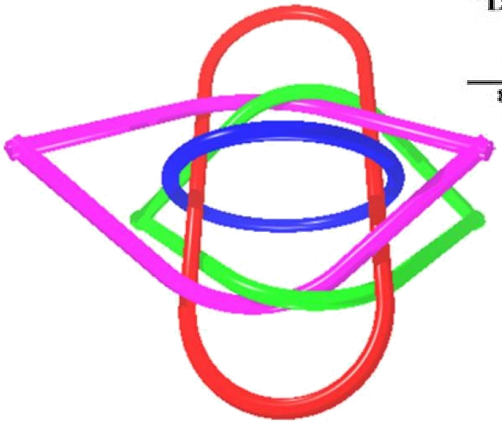
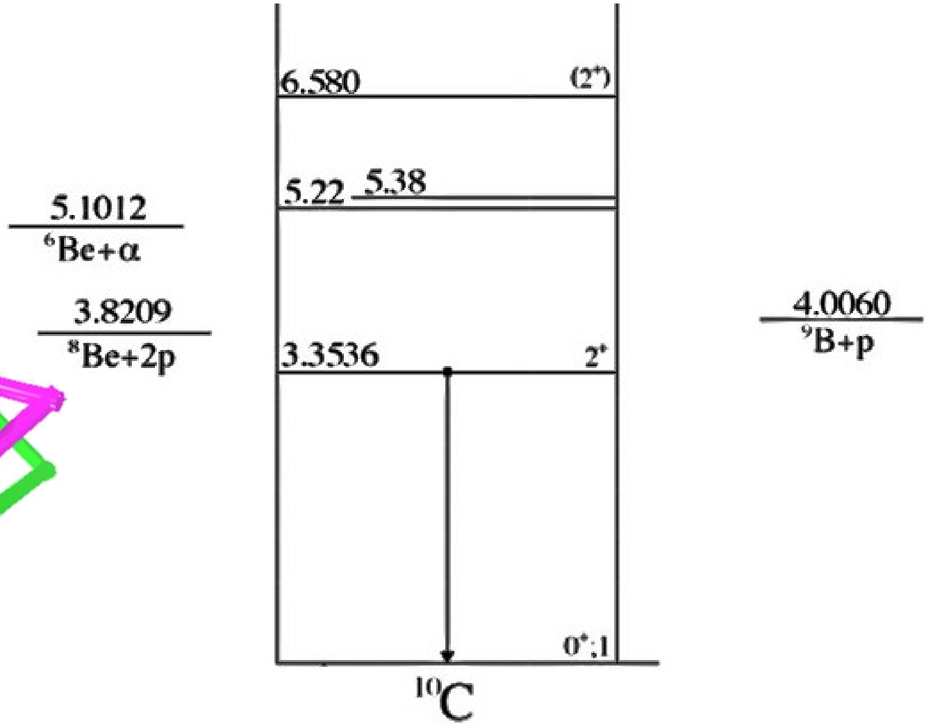
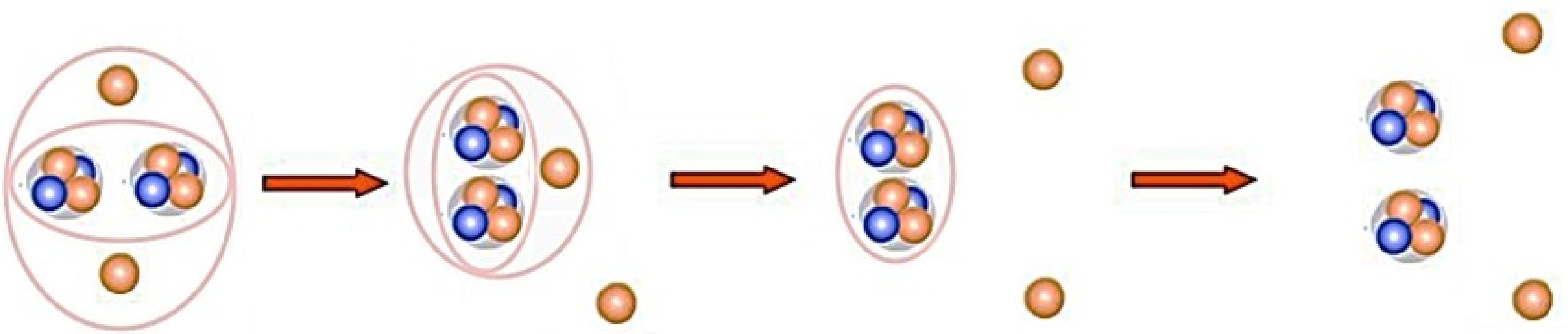
Energy levels of ^{10}C



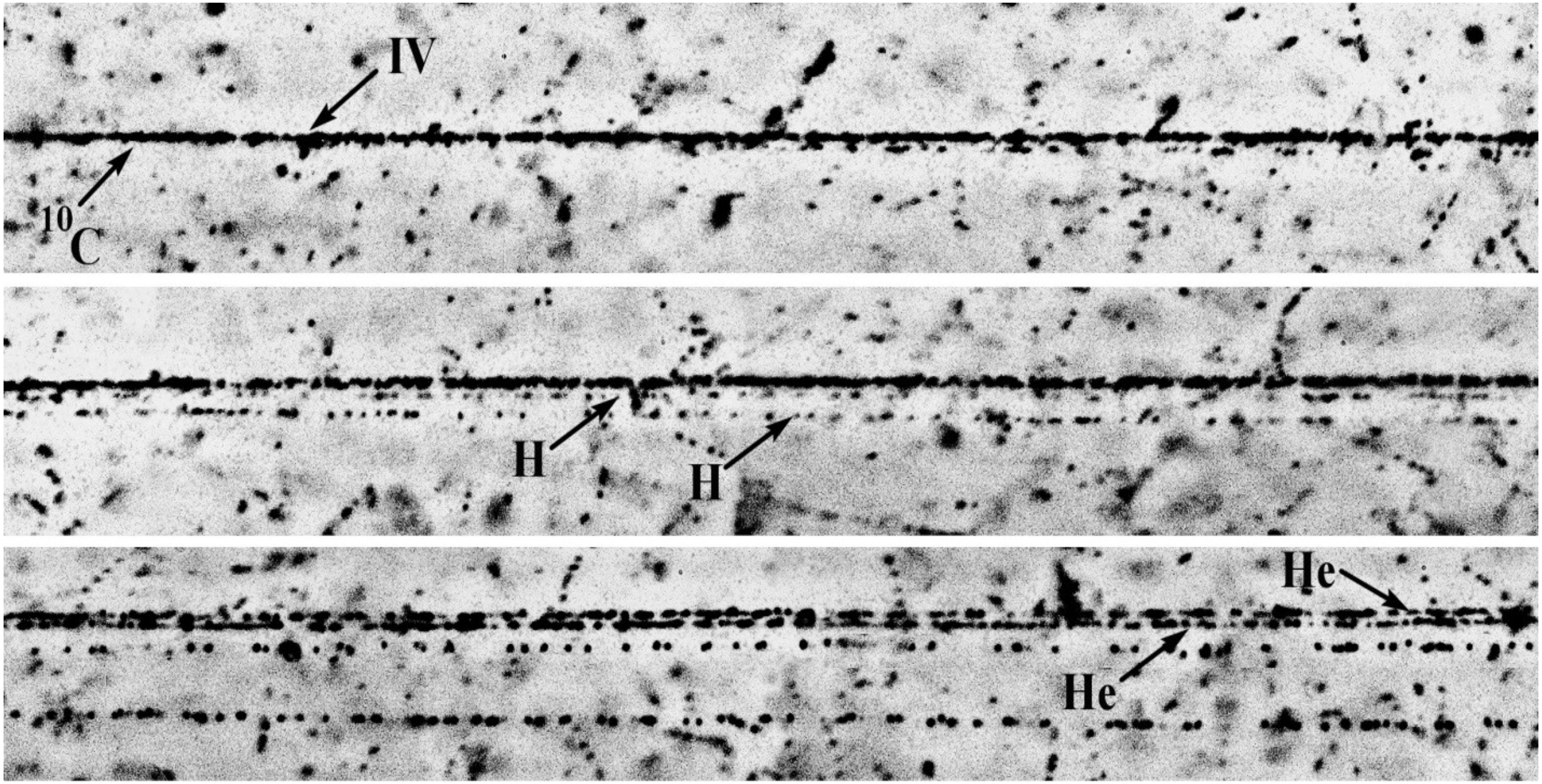




$$^{10}C \longrightarrow {}^{9}B + p \longrightarrow {}^{8}Be + 2p \longrightarrow 2\alpha + 2p$$

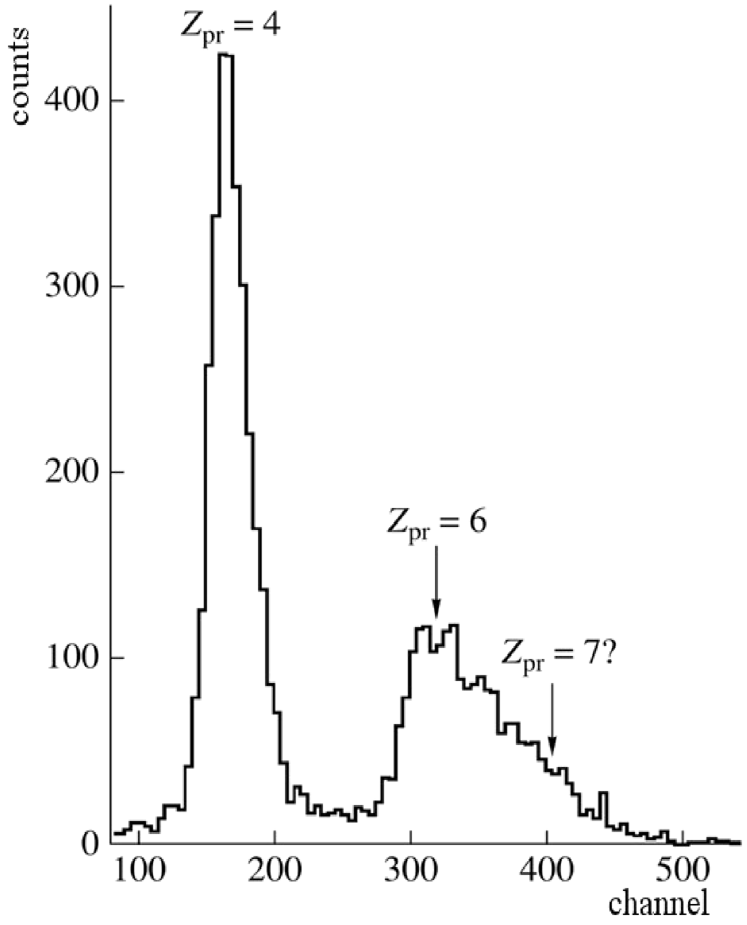


http://veksler.jinr.ru/becquerel/



A micrograph one of the events of the nuclear fragmentations
in the channel $^{10}C \rightarrow 2He + 2H$.

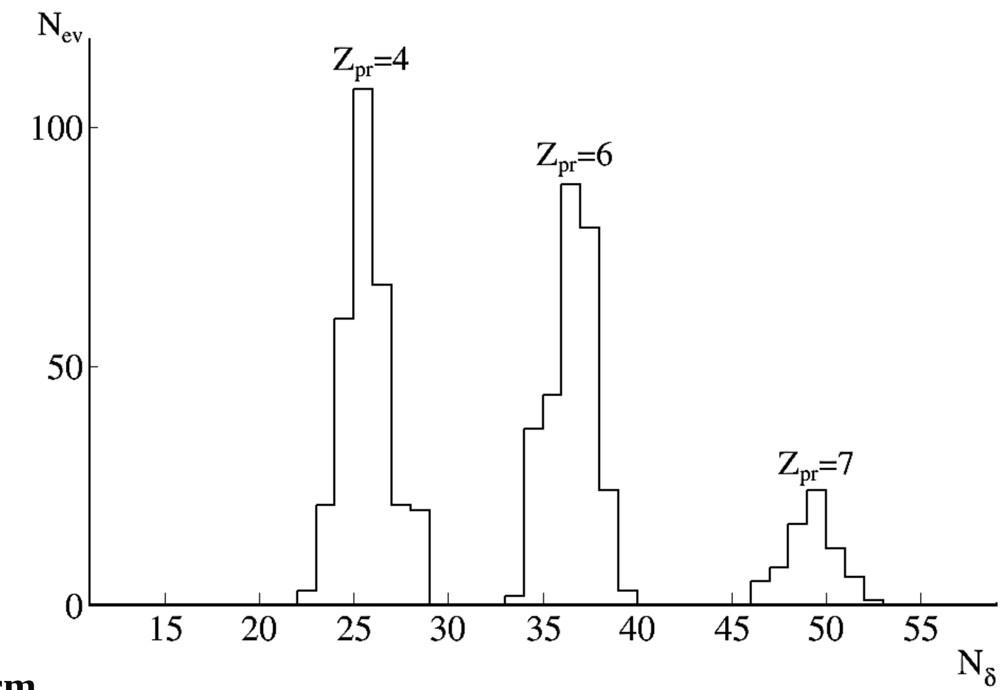
Irradiation of the emulsion in the beam nuclei Be, C and N with energy 1.2 *A* GeV



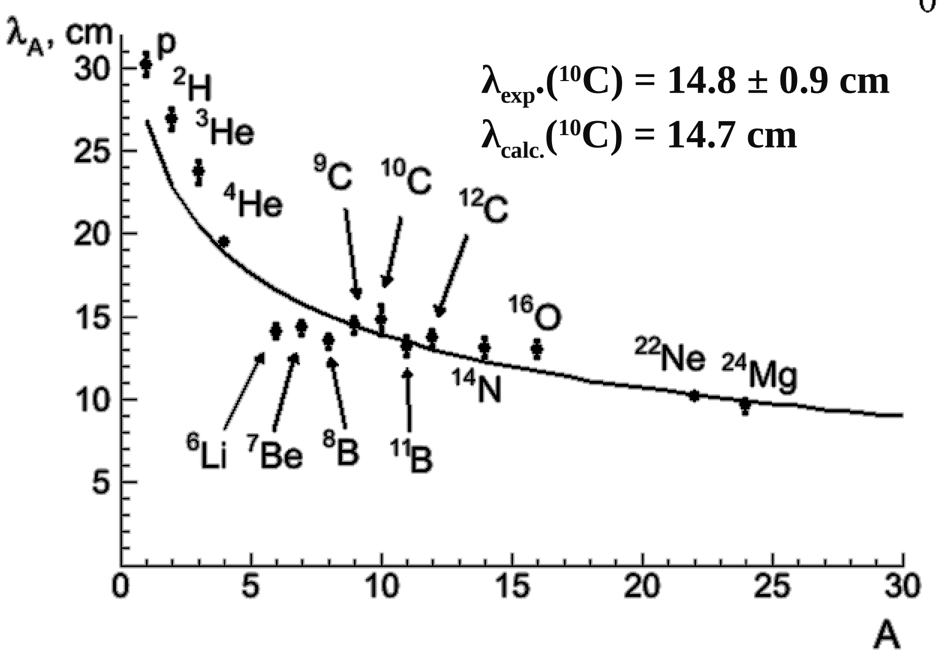
Amplitude spectrum from a scintillation counter, shows the positions of the peaks for nuclei with charges **Z_{pr} = 4, 6 and 7**

Determination of charge and mean-free path of beam particles in the emulsion

- Viewed plates – 12 pcs.
- The total length of viewing of primary tracks – 1088.1 m.
- Number of total events – 7241
- Number of events ("white stars“) – 608



Distribution of tracks beam nuclei by the number of δ-electrons N_δ per 1 mm length of the tracks.

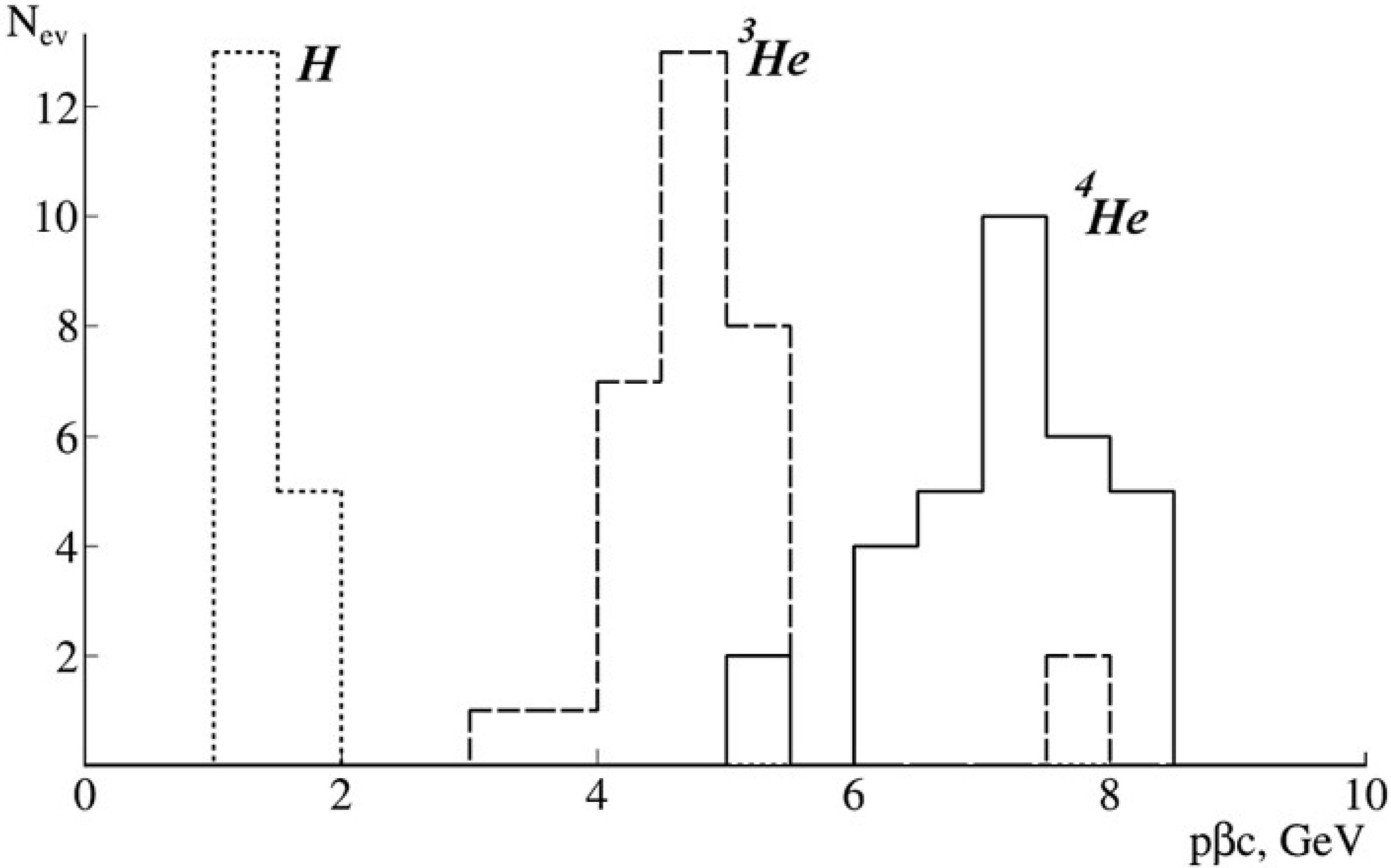


The average range λ(A) for inelastic interactions depending on the mass of the projectile nuclei A; the curve - calculation by the ratio of Bradta Peters.

The observed fragmentation channels ^{10}C nuclei ("White stars")

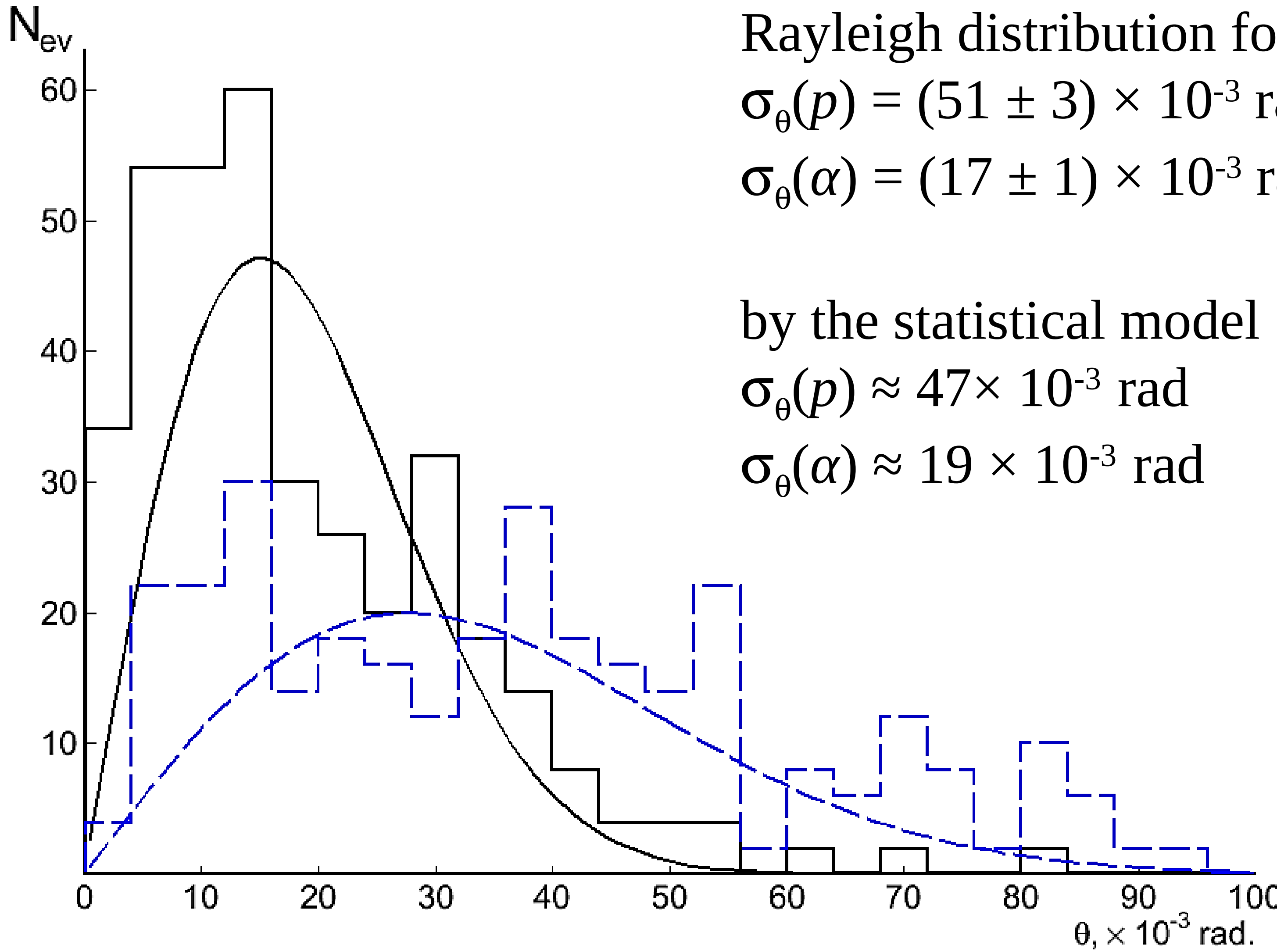
Channels (^{10}C)	**N_{ws}=227**	**100%**	**N_{tf}=627**	**100%**
2He+2H	**186**	**81.9**	361	57.6
He+4H	12	5.3	160	25.5
3He (2^{3}He + ^{4}He)	12	5.3	15	2.4
6H	9	4.0	30	4.8
Be + He	6	2.6	17	2.7
B+H	1	0.4	12	1.9
Li+3H	1	0.4	2	0.3
^{9}C+n	-	-	30	4.8

Identification of the isotopic composition of the fragments H and He



b)

Distribution of the fragments by value pβc of the "white" stars $^{10}C \rightarrow 2He + 2H$.
^{3}He fragments from events of fragmentation $^{9}C \rightarrow 3\,^{3}He$ at 1.2 *A* GeV.



Rayleigh distribution for p and α

$\sigma_\theta(p) = (51 \pm 3) \times 10^{-3}$ rad

$\sigma_\theta(\alpha) = (17 \pm 1) \times 10^{-3}$ rad

by the statistical model

$\sigma_\theta(p) \approx 47\times 10^{-3}$ rad

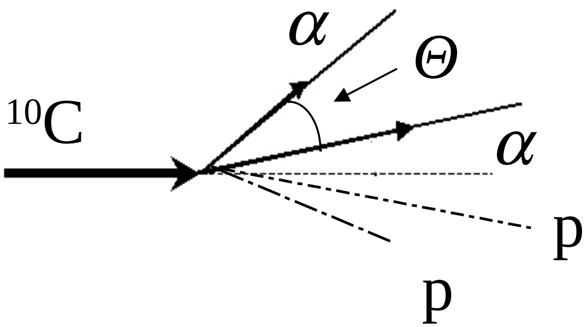
$\sigma_\theta(\alpha) \approx 19 \times 10^{-3}$ rad

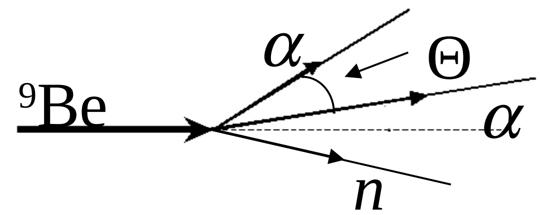
Distribution of the fragments of the polar of emission angle formed in the "white stars" $^{10}C \rightarrow 2\alpha + 2p$. (dotted line - p, solid line - α fragments, curve - the Rayleigh distribution)

Distribution of opening angles of α fragments

$^{10}C \rightarrow 2\alpha + 2p$

$^{9}Be \rightarrow 2\alpha + n$



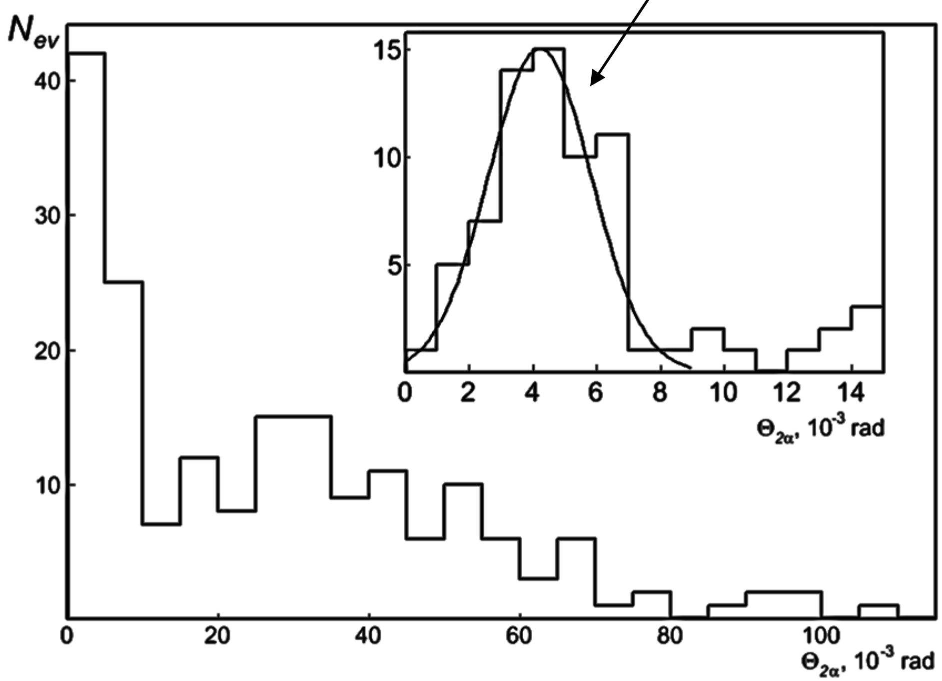


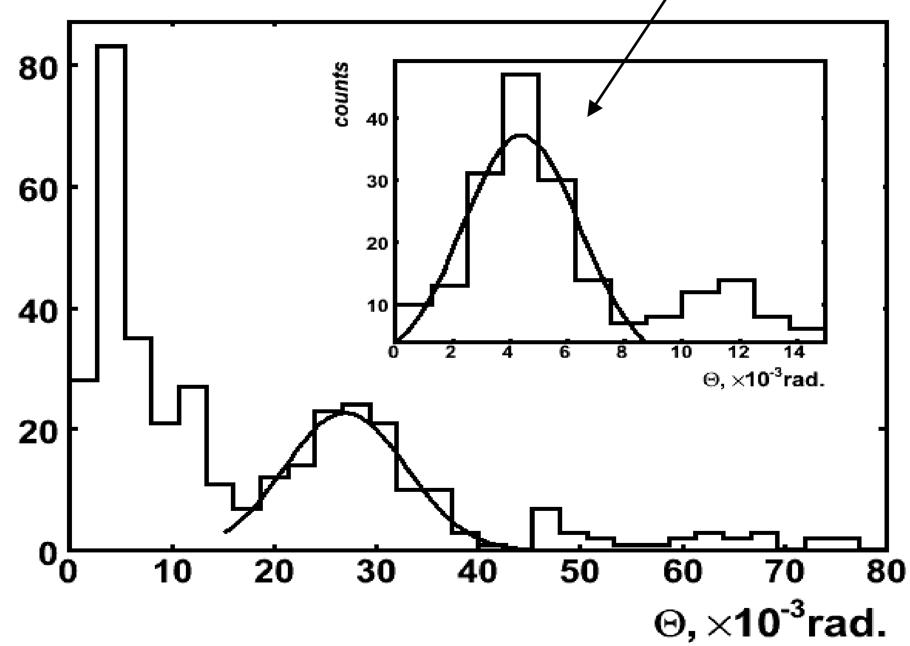
<Θ>4.2±0.2 мрад

σ_Θ=1.6±0.1 мрад

<Θ>4.4±0.2 мрад

σ_Θ=2.1±0.2 мрад





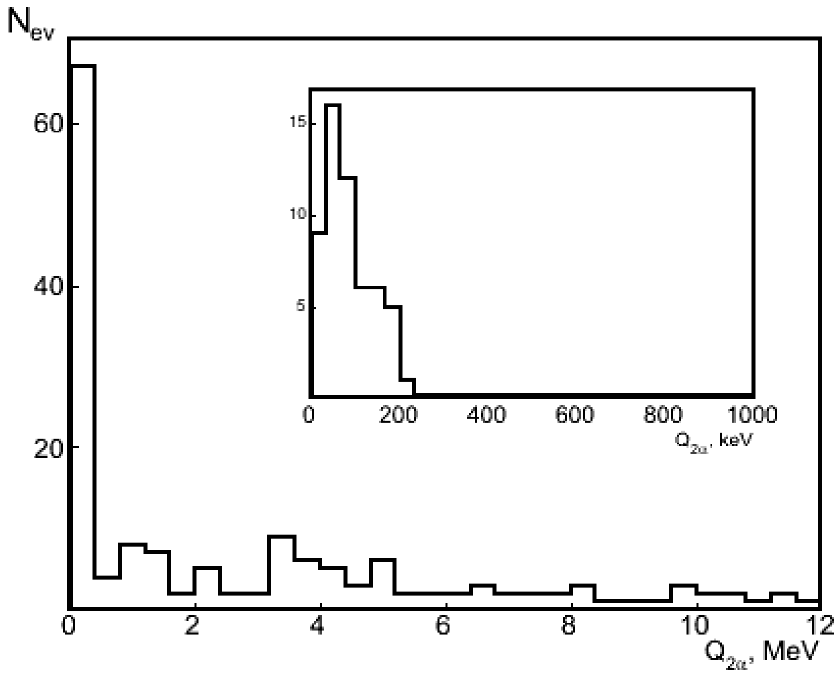
Distribution of excitation energy ($Q_{2\alpha}$) defined for α pairs from events $^{10}C \to 2\alpha+2p$

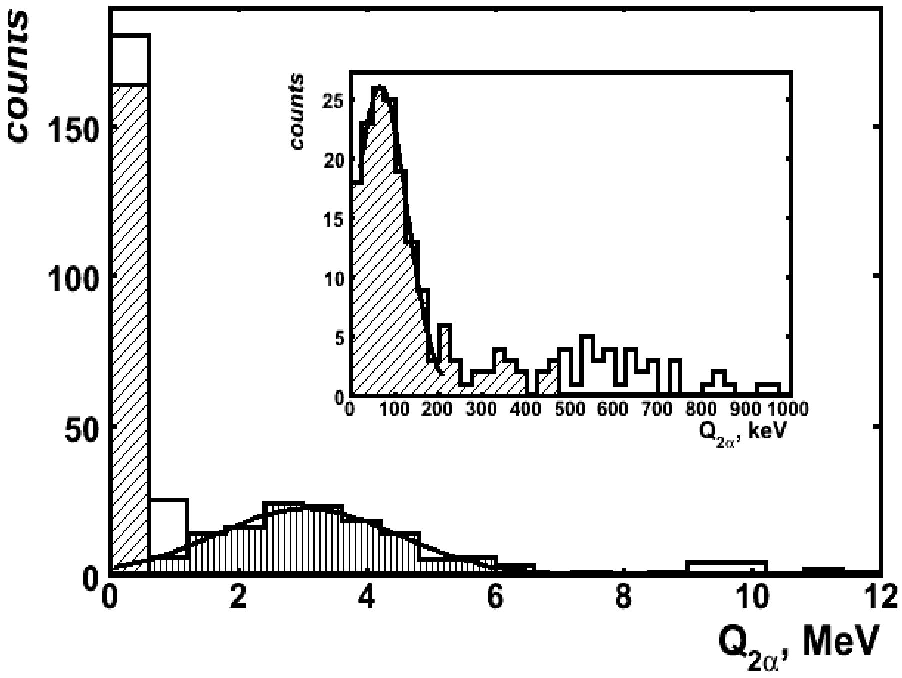
$$M_{2\alpha} = \left[2\left(m_\alpha^2 + E_{\alpha 1}E_{\alpha 2} - p_{\alpha 1}p_{\alpha 2}\cos(\Theta_{12})\right)\right]^{\frac{1}{2}}$$

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

$^{10}C \to 2\alpha+2p$

$^{9}Be \to 2\alpha + n$





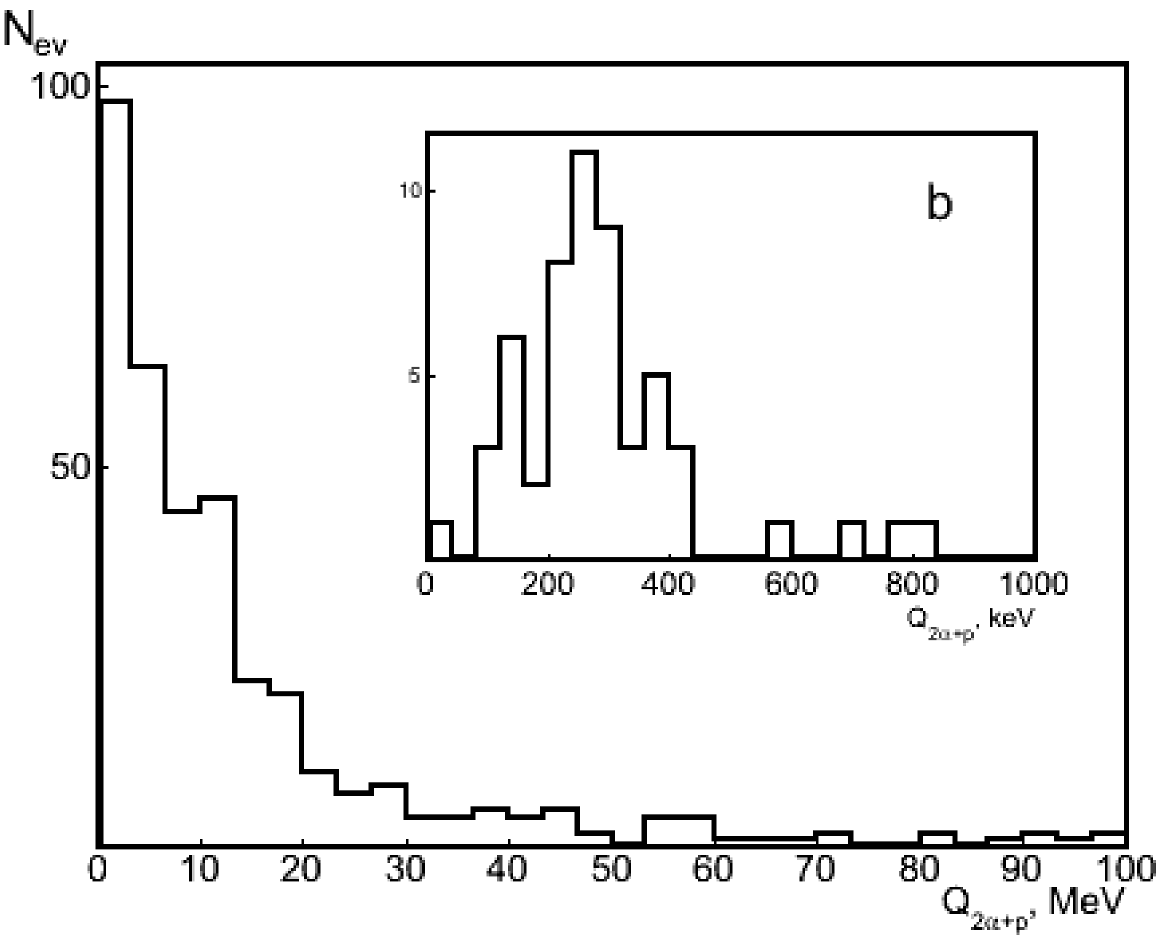
Distribution of excitation energy ($Q_{2\alpha+p}$) defined for triples $2\alpha + p$ from events $^{10}C \rightarrow 2\alpha + 2p$

$^{10}C \rightarrow 2\alpha + 2p$ provided that He=^{4}He, H=^{1}H

$$M(^9B) - 2 \cdot M(^4He) - M(^1H) = 280\, кэB$$

$$M^2_{2\alpha+p} = -\left[\sum P_i\right]^2$$

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



$^{10}C \rightarrow {}^9B + p \rightarrow {}^8Be + 2p \rightarrow 2\alpha + 2p$

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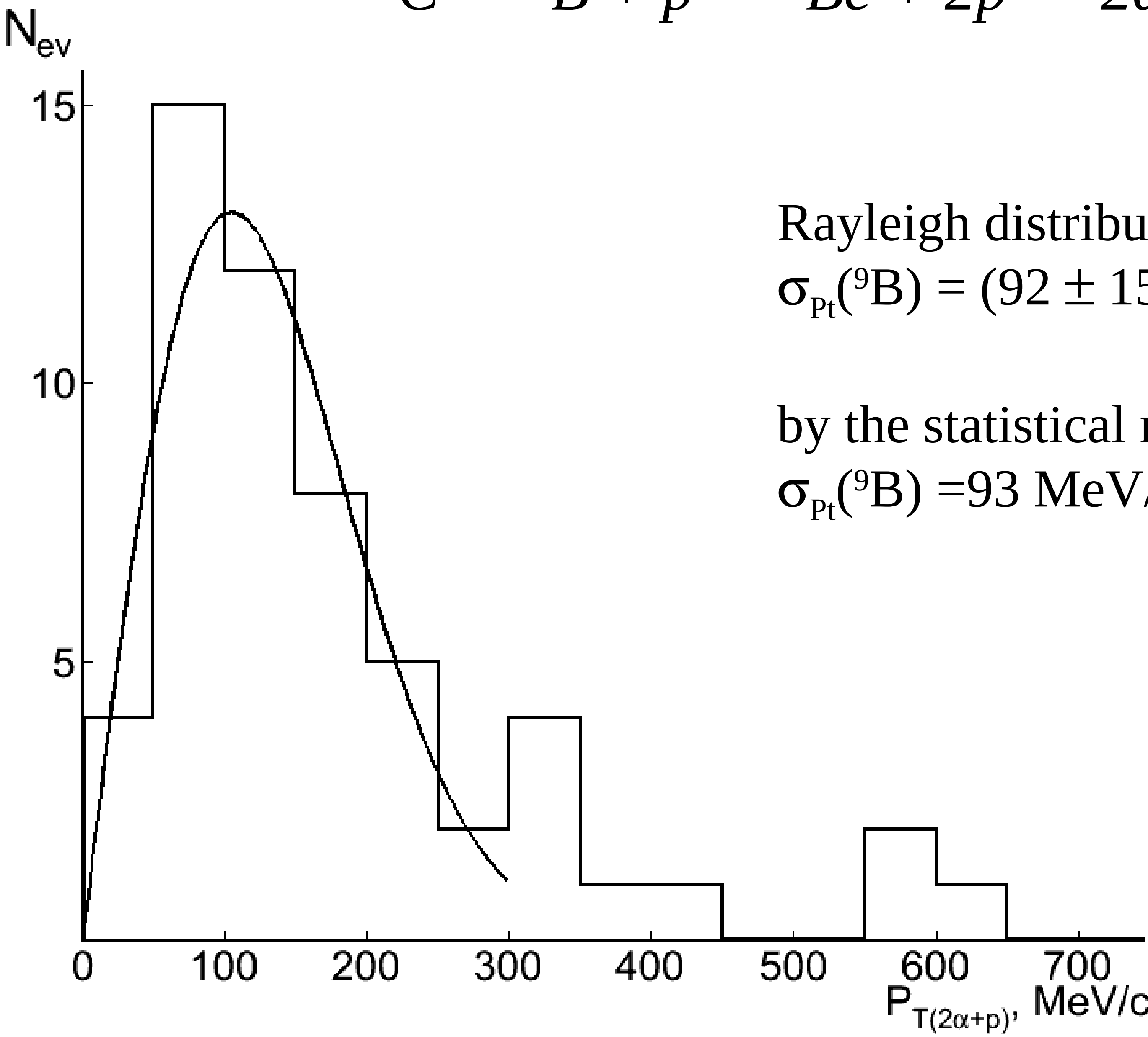
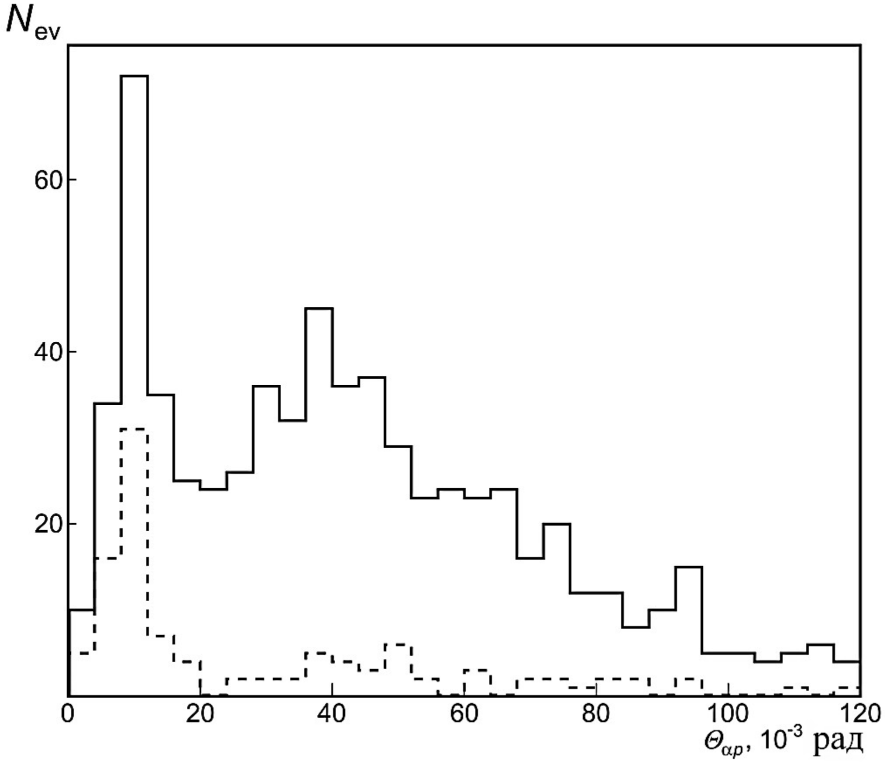
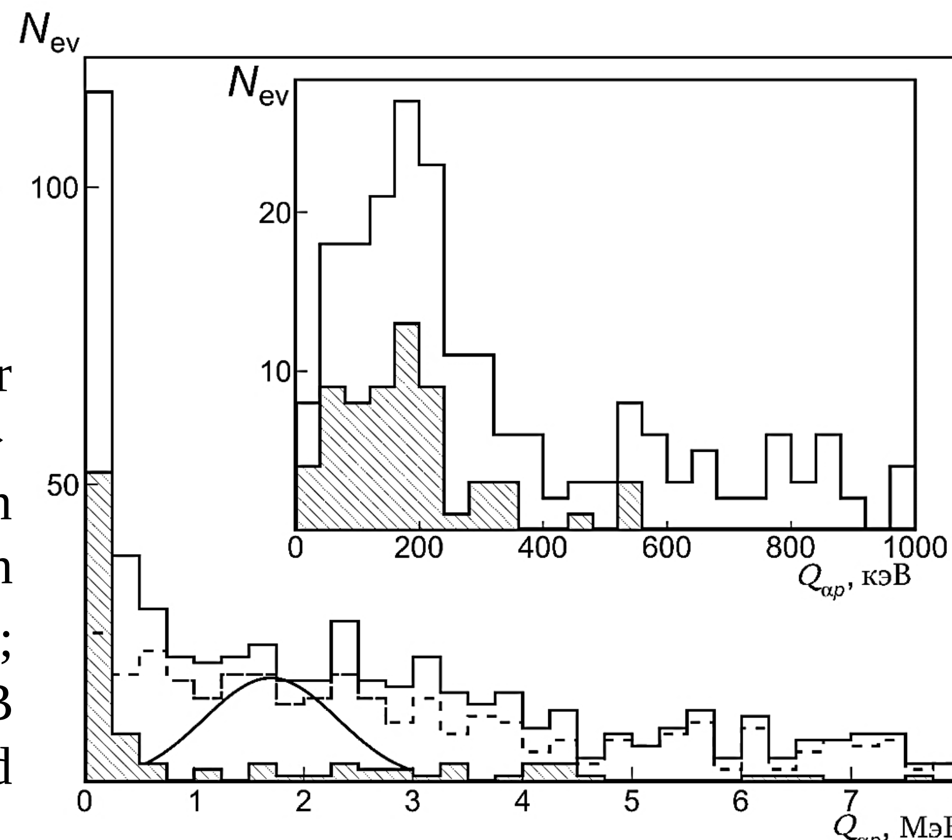


Rayleigh distribution
$\sigma_{Pt}(^{9}B) = (92 \pm 15)$ MeV/c

by the statistical model
$\sigma_{Pt}(^{9}B) = 93$ MeV/c



Distribution of the opening angles between the fragments $\Theta_{\alpha p}$; dashed histogram - distribution $\Theta_{\alpha p}$ with the formation ^{9}B and ^{8}Be.



Distribution of excitation energy of pair fragments α and *p* in «white stars» ^{10}C → 2α + 2*p*. Solid histogram - the distribution of all combinations $Q_{\alpha p}$; dashed - in events without formation ^{9}B and ^{8}Be; shaded – in events with the formation ^{9}B and ^{8}Be; with line shown the expected position of the resonance ^{5}Li;

Conclusions

- First time was studied fragmentation of nuclei ^{10}C with energy 1.2 A GeV in a nuclear track emulsion, derived at the Nuclotron, JINR.

- On the total length of viewing of primary traces of 1088.1 m was found 7241 inelastic interactions, including 608 "white" stars. The average range of nuclei ^{10}C was equal to $\lambda_C = 14.8 \pm 0.9$ sm.

- The main feature of the distribution by charge topology is that its main share, about ~ 82% accounts for channel $2\alpha + 2p$, as expected for the isotope ^{10}C.

- Identified the isotopic composition of fragments H and He for the leading channel. It is shown that the dominance of the isotopes ^{1}H and ^{4}He confirms the correctness of the formation of a beam of isotope ^{10}C.

- The process of fragmentation of nuclei $^{10}C \rightarrow 2\alpha + 2p$ in case (≈ 30%) have a cascade character $^{10}C \rightarrow {}^{9}B \rightarrow {}^{8}Be$ by analogy with the nucleus ^{9}Be.

Thank you for attention!