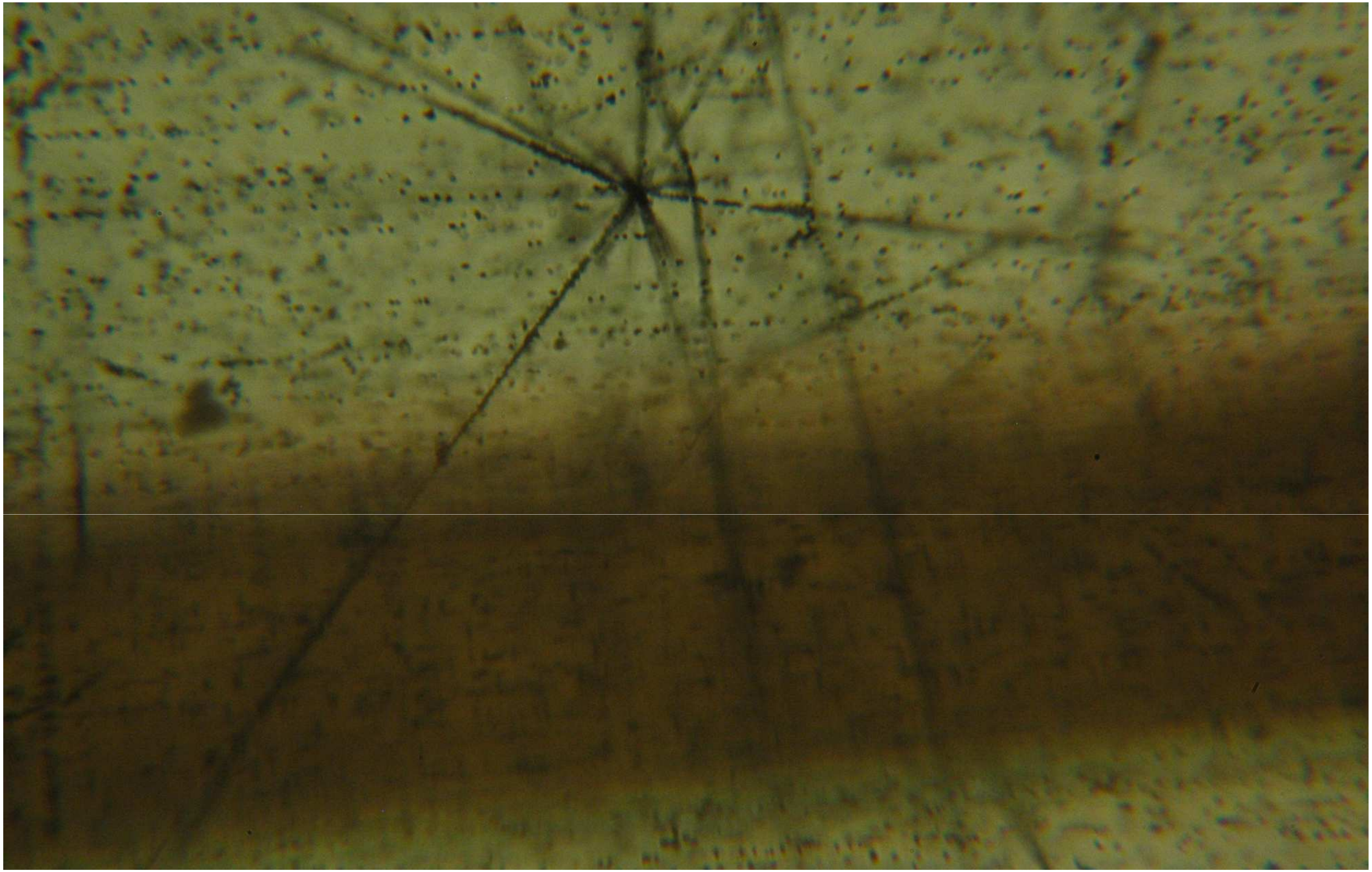
"Tomography" of nuclear structure in dissociation of relativistic nuclei

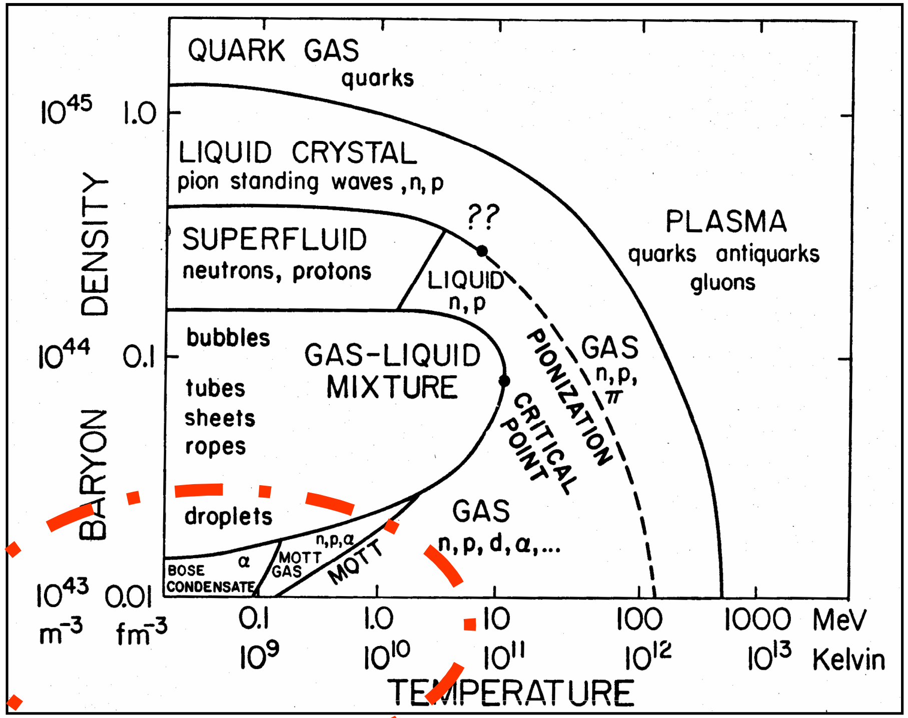
P. I. Zarubin

V. I. Veksler and A. M. Baldin Laboratory of High Energy Physics
Joint Institute for Nuclear Research, Dubna, Russia

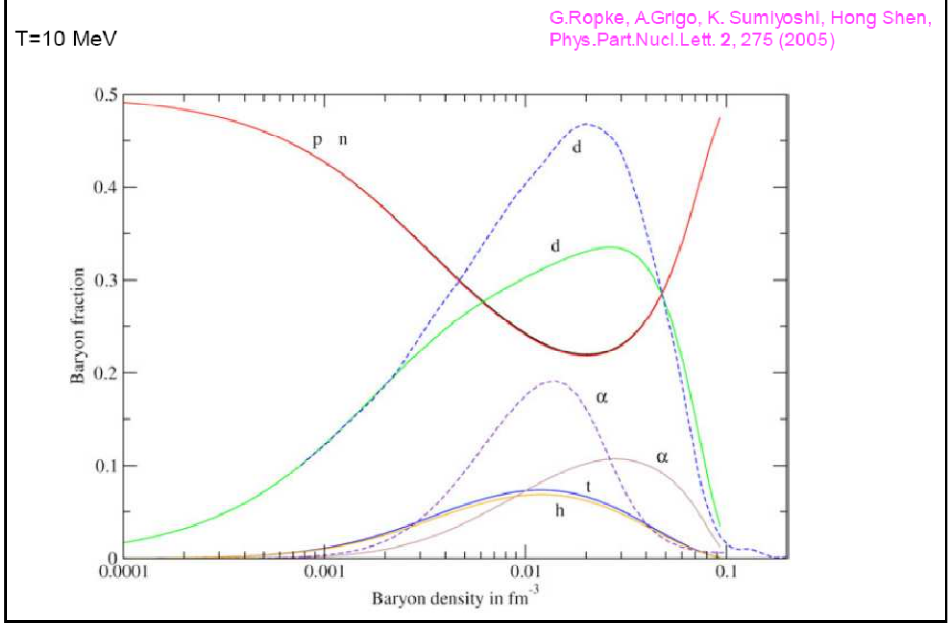
The use of accelerated nuclei, including radioactive ones, qualitatively diversifies the spectroscopy of cluster systems. Configuration overlap of a fragmenting nucleus and finite cluster states manifests in the dissociation at the periphery of the target nucleus. The definition of interactions as peripheral ones is simplified at energy above 1A GeV due to the collimation of the incident nucleus fragments. The detection thresholds disappear and energy lose in detector material are minimal.



Close up of a nuclear star in nuclear track emulsion, exposed to the secondary particle beam (IHEP, Protvino). The beam is mainly represented by 5 GeV pions. The photo is taken with a 90-fold increase in the microscope lens. Tracks of minimum ionizing particles, giving grains of about 0.5 microns, can be seen clearly. For comparison, a hair is introduced in the vision field (about 30-40 microns).



Composition of symmetric nuclear matter



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Multifragmentation reactions and properties of stellar matter at subnuclear densities

A. S. Botvina[1] and I. N. Mishustin[2,3]

[1]*Institute for Nuclear Research, Russian Academy of Sciences, RU-117312 Moscow, Russia*
[2]*Frankfurt Institute for Advanced Studies, J.W. Goethe University, D-60438 Frankfurt am Main, Germany*
[3]*Kurchatov Institute, Russian Research Center, RU-123182 Moscow, Russia*

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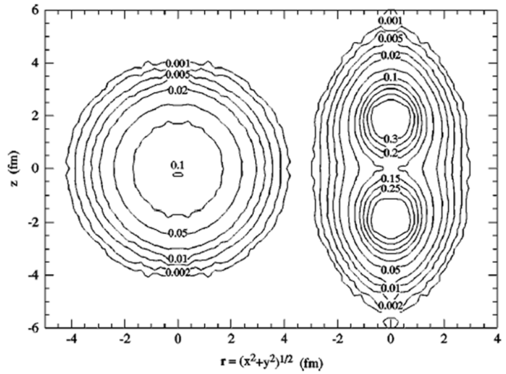
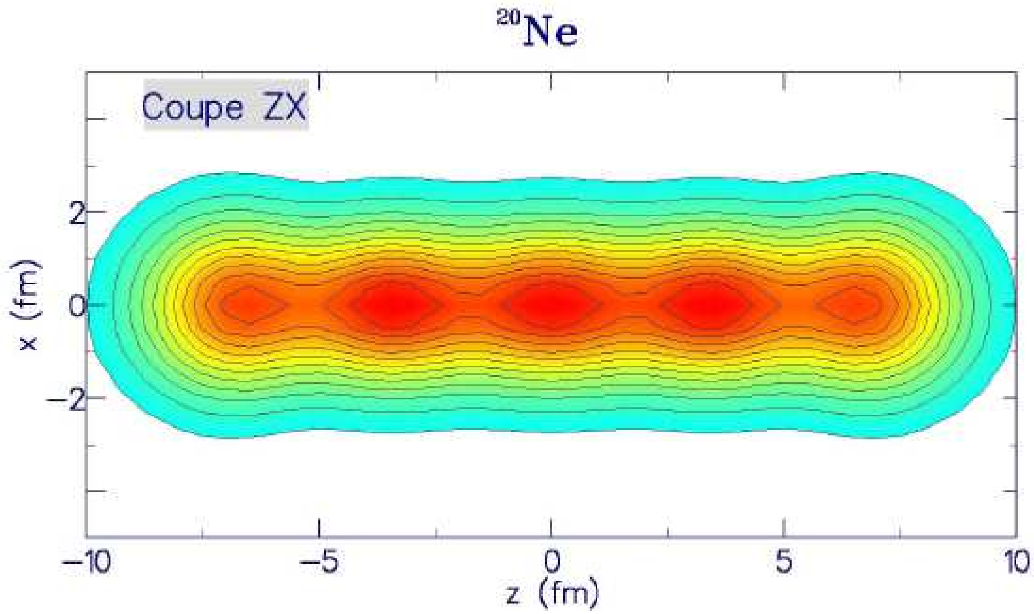
We point out the similarity of thermodynamic conditions reached in nuclear multifragmentation and in supernova explosions. We show that a statistical approach previously applied for nuclear multifragmentation reactions can also be used to describe the electroneutral stellar matter. Then properties of hot unstable nuclei extracted from the analysis of multifragmentation data can be used to determine a realistic nuclear composition of hot supernova matter.

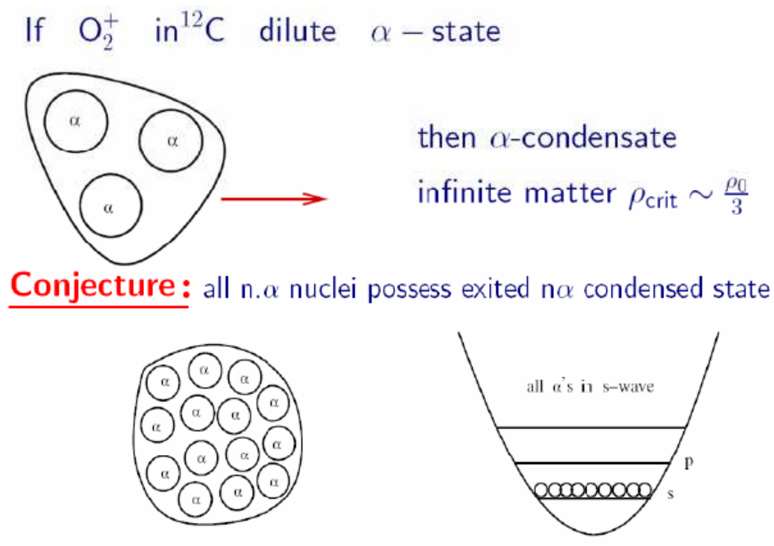
Alpha-Clusters in Nuclear Systems

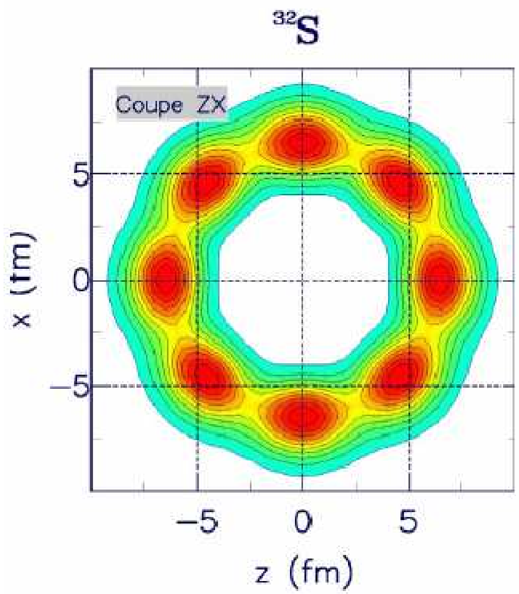
P. Schuck

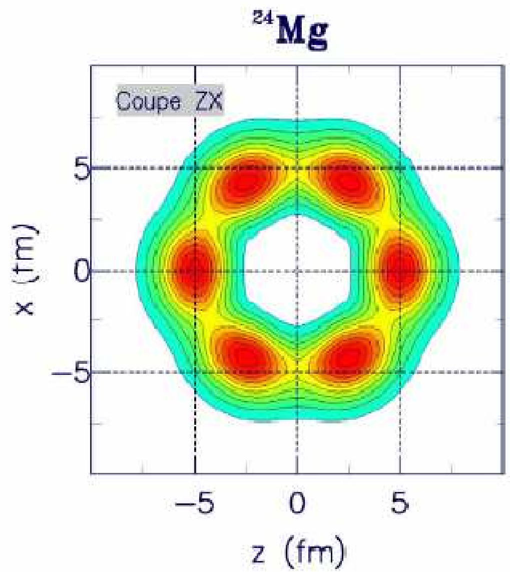
**Y. Funaki, H. Horiuchi, G. Röpke,
A. Tohsaki , W. von Oertzen and T. Yamada**

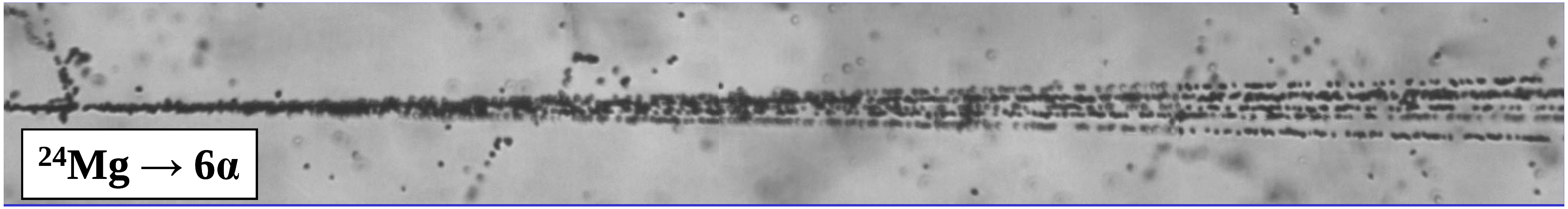


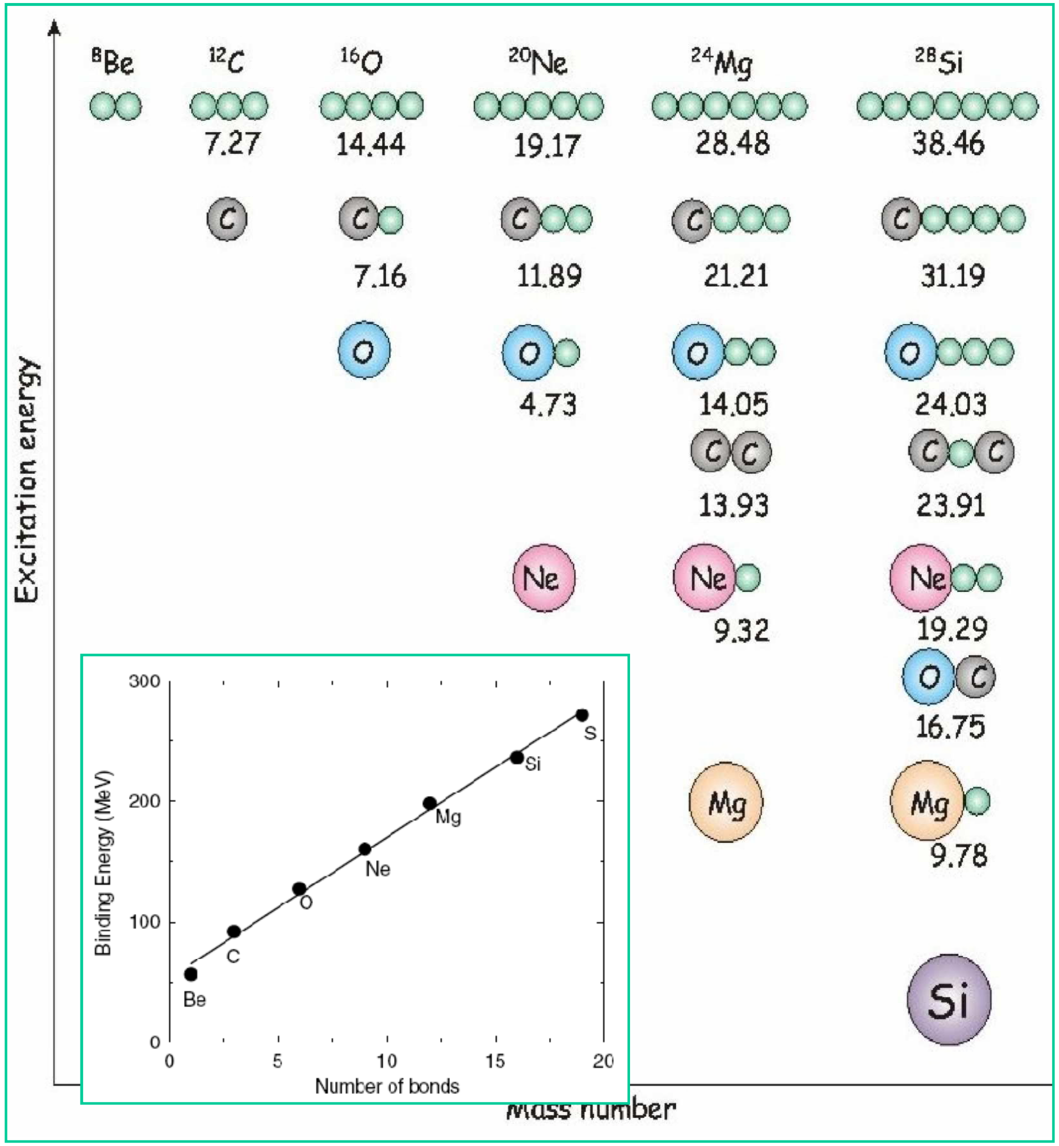


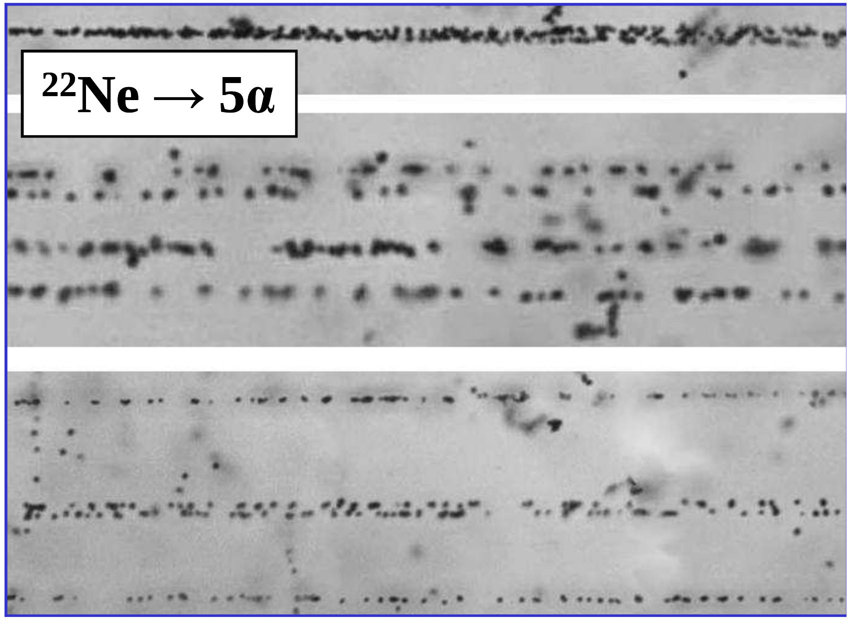


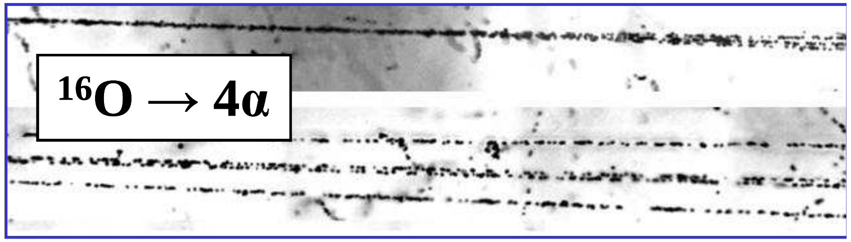


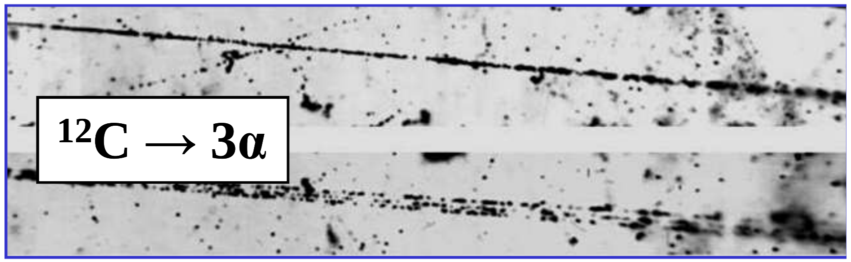


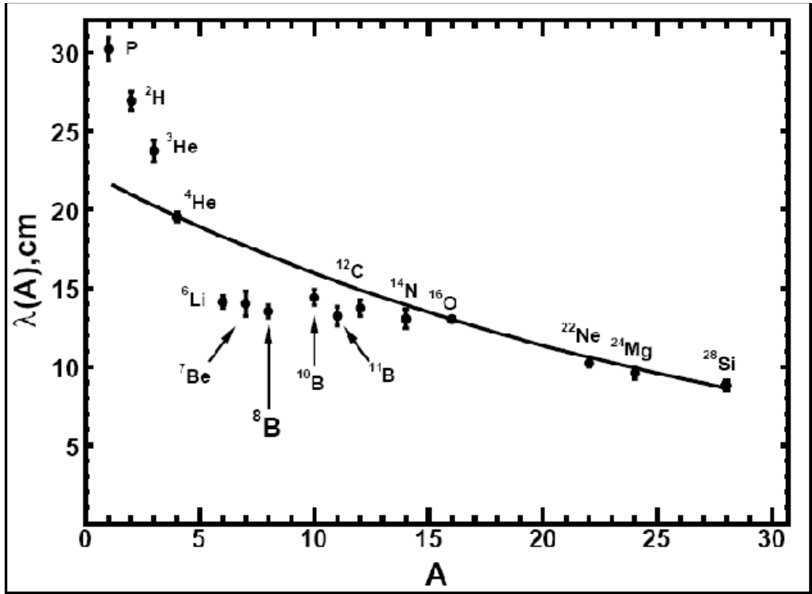

$^{24}Mg \rightarrow 6\alpha$


Excitation energy
Mass number
^{8}Be
^{12}C
^{16}O
^{20}Ne
^{24}Mg
^{28}Si
7.27
14.44
19.17
28.48
38.46
7.16
11.89
21.21
31.19
4.73
14.05
24.03
13.93
23.91
9.32
19.29
16.75
9.78
Binding Energy (MeV)
Number of bonds
Be
C
O
Ne
Mg
Si
S

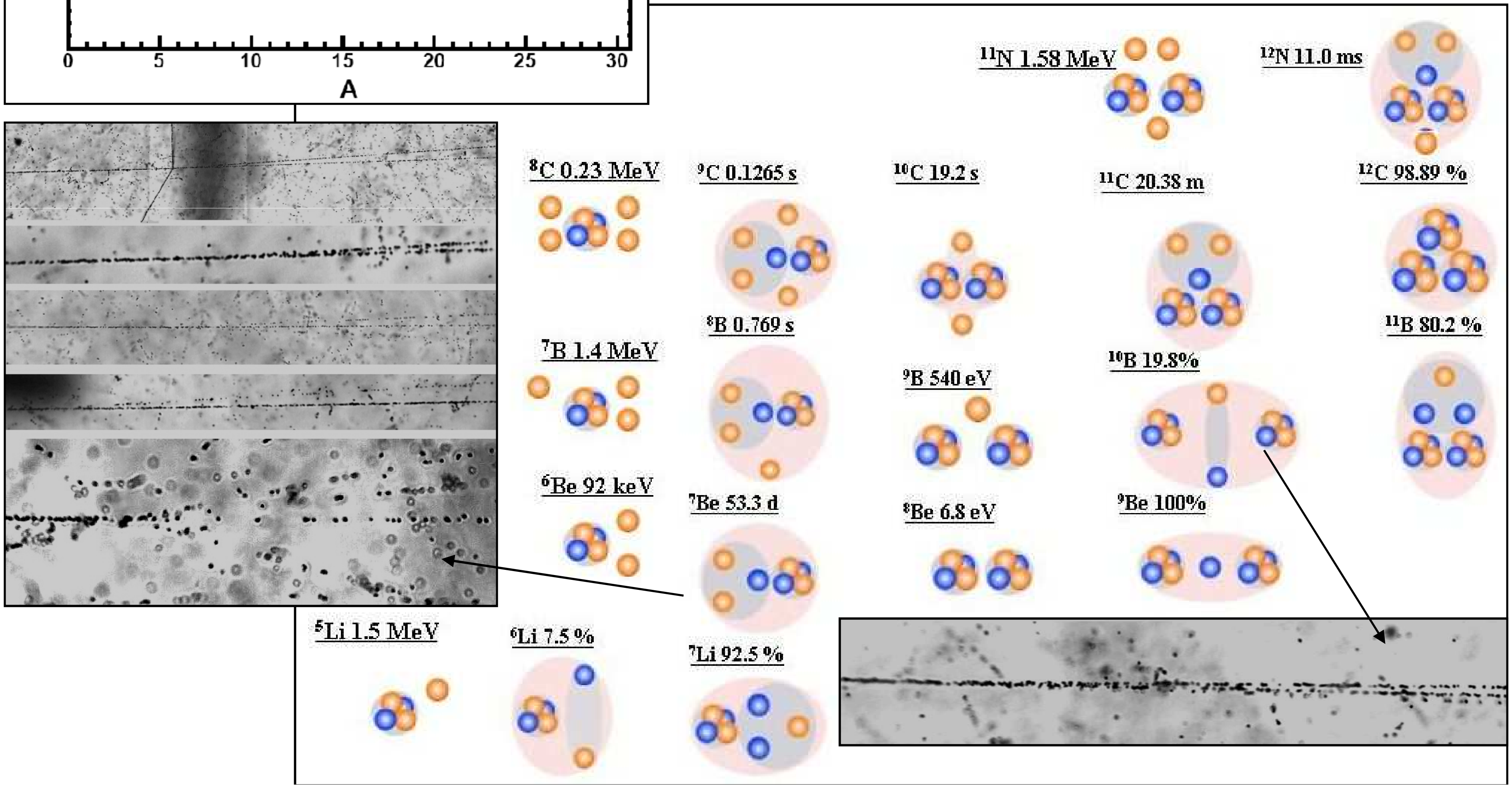

$^{22}Ne \rightarrow 5\alpha$

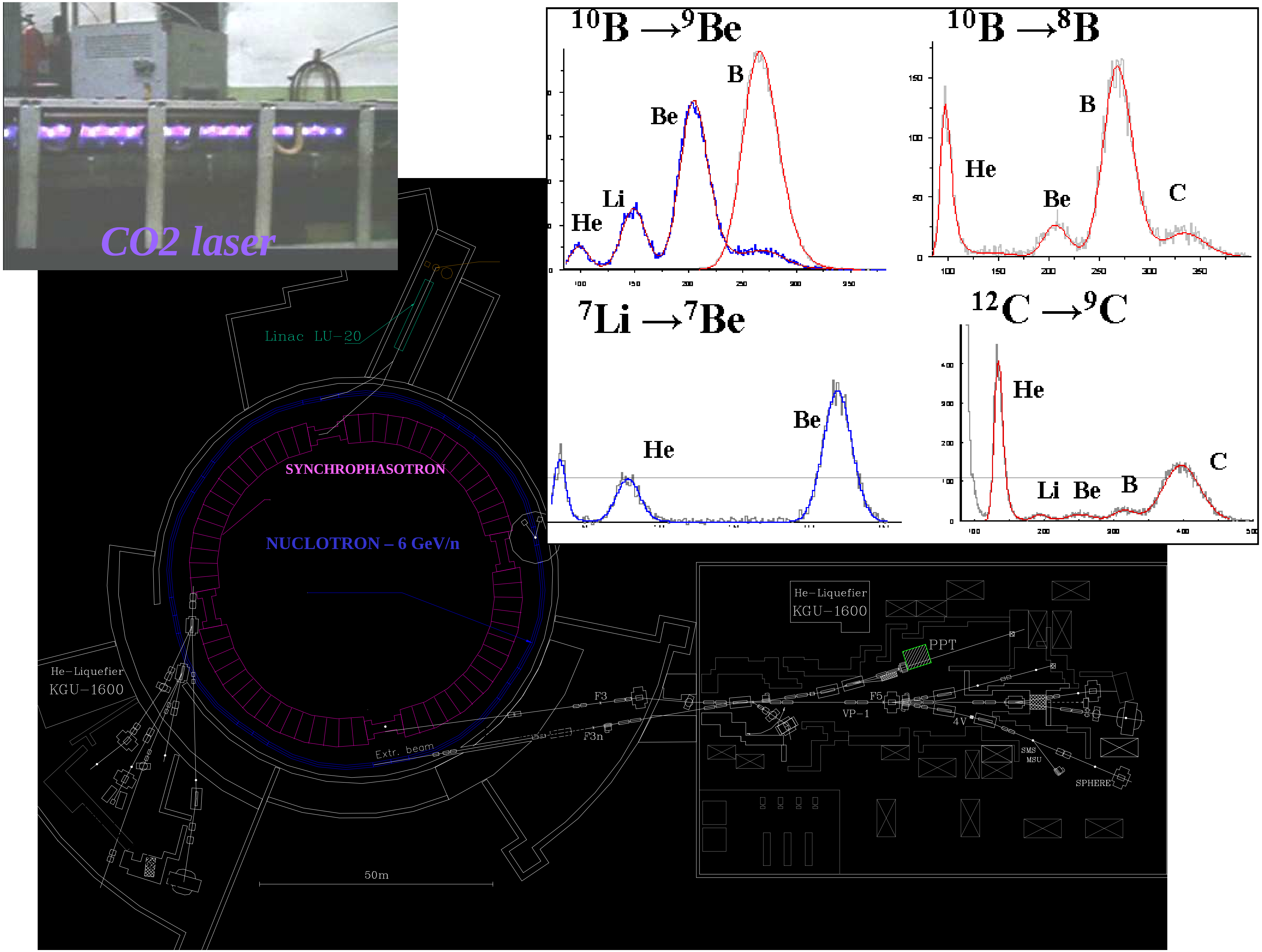

$^{16}O \rightarrow 4\alpha$


$^{12}C \rightarrow 3\alpha$

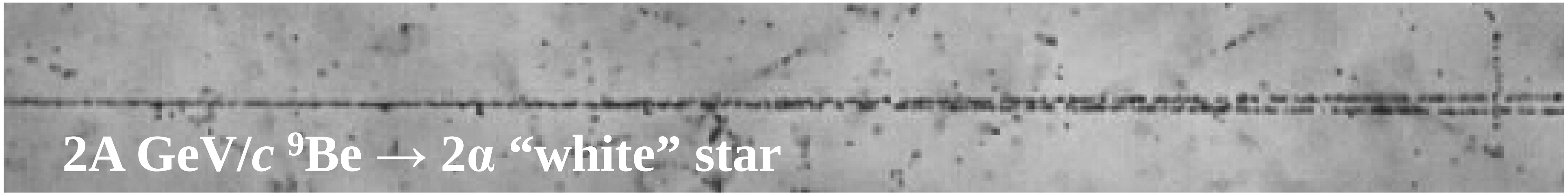


The use of accelerated nuclei, including radioactive ones, qualitatively diversifies the cluster spectroscopy. Configuration overlap of a fragmenting nucleus and final cluster states manifests in the dissociation at the periphery of the target nucleus. The definition of interactions as peripheral ones is simplified at energy above 1A GeV due to the collimation of the fragments. The detection thresholds disappear and energy lose in detector material are minimal. These statements are particularly true for the light nuclei with an excess of protons.

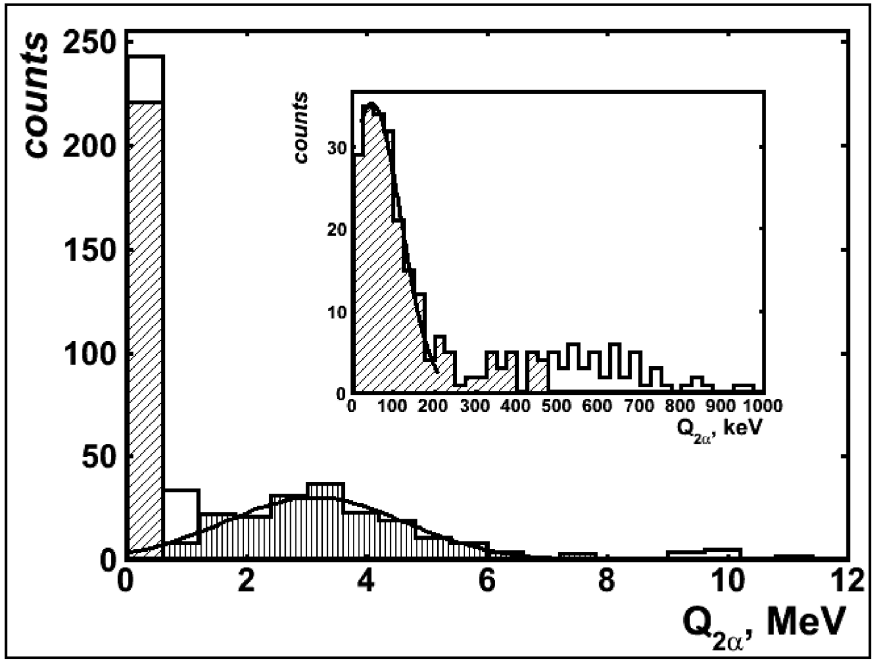


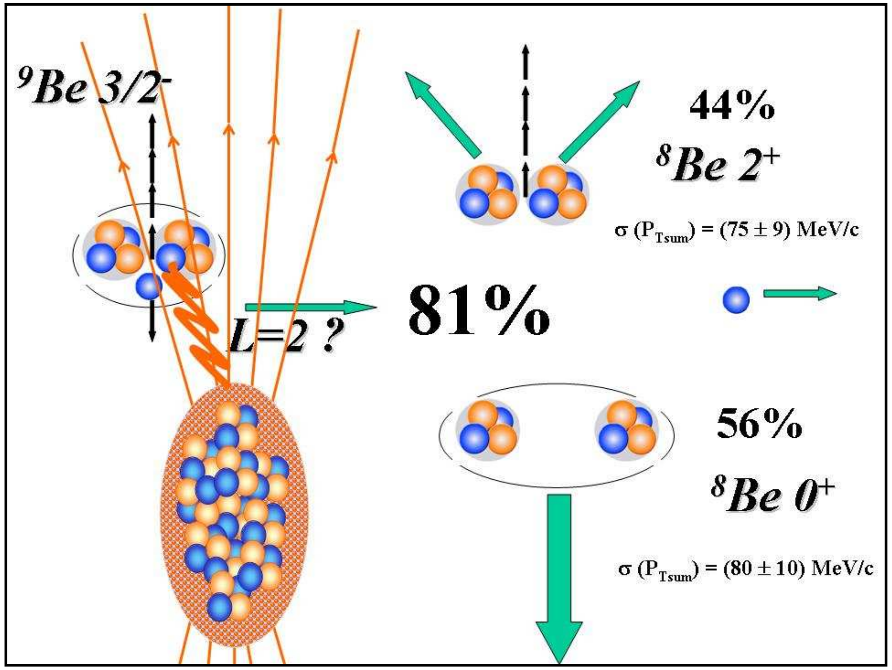

CO2 laser
Linac LU-20
SYNCHROPHASOTRON
NUCLOTRON – 6 GeV/n
He-Liquefier
KGU-1600
He-Liquefier
KGU-1600
PPT
F3
F3n
F5
VP-1
4V
SMS
MSU
SPHERE
Extr. beam
50m
$^{10}B \rightarrow ^{9}Be$
He
Li
Be
B
$^{10}B \rightarrow ^{8}B$
He
Be
B
C
$^{7}Li \rightarrow ^{7}Be$
He
Be
$^{12}C \rightarrow ^{9}C$
He
Li
Be
B
C

2A GeV/c ^{9}Be → 2α “white” star

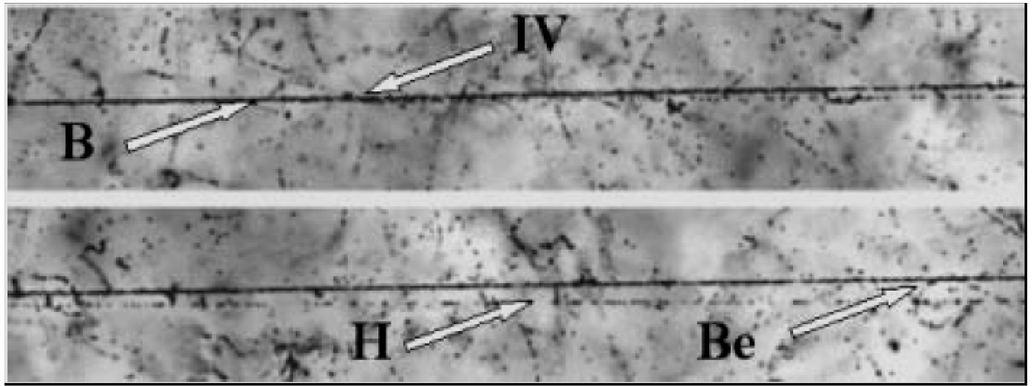


The secondary ^{9}Be beam was obtained by fragmentation of accelerated ^{10}B nuclei. When scanning the exposed emulsion 500 events ^{9}Be → 2α in a fragmentation cone of 0.1 rad have been found. About 81% α-pairs form roughly equal groups on $\Theta_{2\alpha}$: “narrow" ($0 < \Theta_n < 10.5$ mrad) and “wide” ($15.0 < \Theta_w < 45.0$ mrad) ones. The Θ_n pairs are consistent with ^{8}Be decays from the ground state 0^+, and pairs Θ_w - from the first excited state 2^+. The Θ_n and Θ_w fractions are equal to 0.56 ± 0.04 and 0.44 ± 0.04. These values are well corresponding to the weights of the ^{8}Be 0^+ and 2^+ states $\omega_{0+} = 0.54$ and $\omega_{2+} = 0.47$ in the two-body model n - ^{8}Be, used to calculate the magnetic moment of the ^{9}Be nucleus.



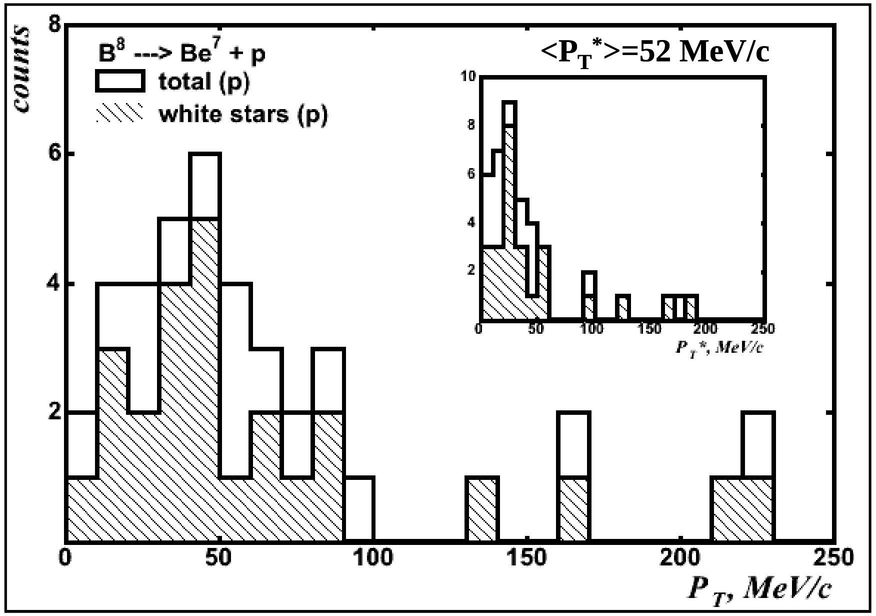


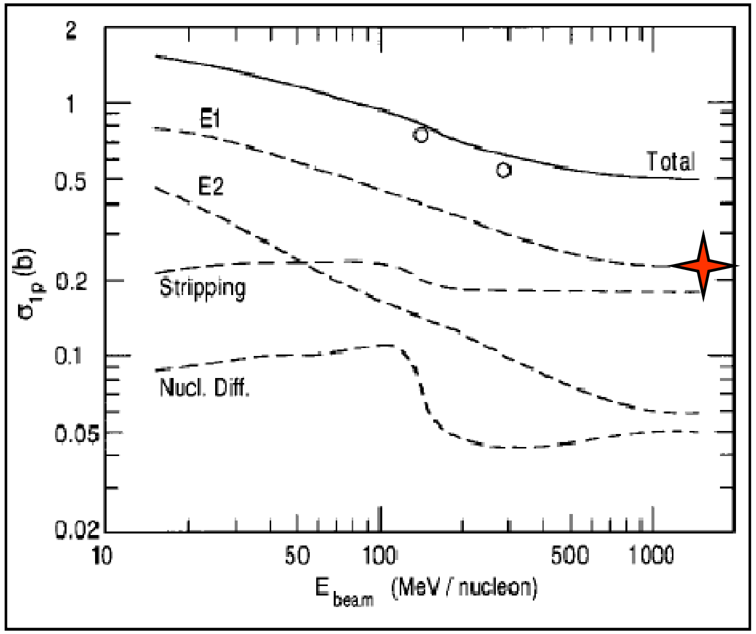
For the coherent dissociation ^{9}Be → 2α + n, the average value of the total α-pair transverse momentum is equal to $\langle P_{Tsum} \rangle \approx 80$ MeV/c in correspondence with the Goldhaber statistical model. So, it can be assigned to the average transverse momentum carried away by neutrons. For the ^{9}Be coherent dissociation through the ^{8}Be 0^+ and 2^+ states there is no differences in the values $\langle P_{Tsum} \rangle$, which points to a “cold fragmentation” mechanism. The whole complex of these observations may serve as an evidence of the simultaneous presence of the ^{8}Be 0^+ and 2^+ states with similar weights in the ground state of the nucleus ^{9}Be.

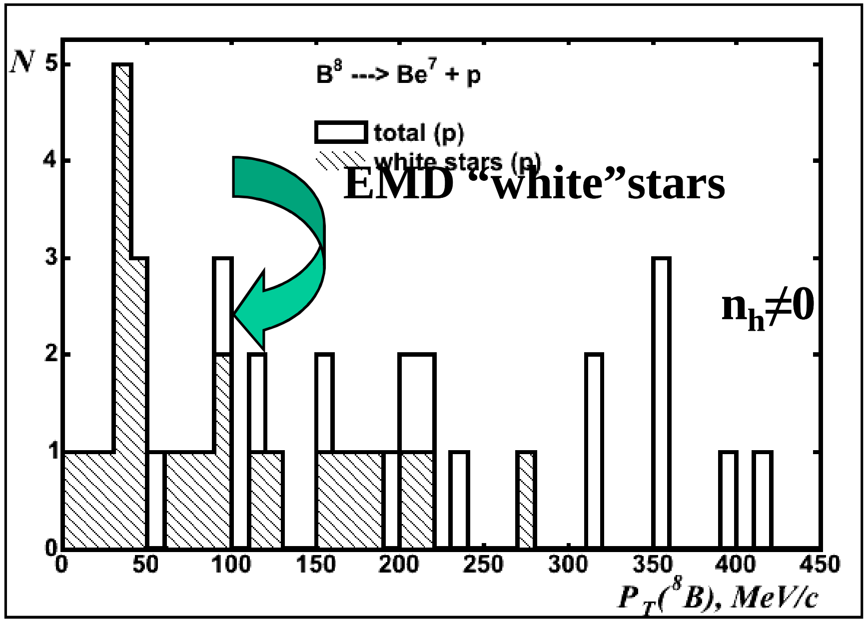


$^{8}B \rightarrow {}^{7}Be + p$

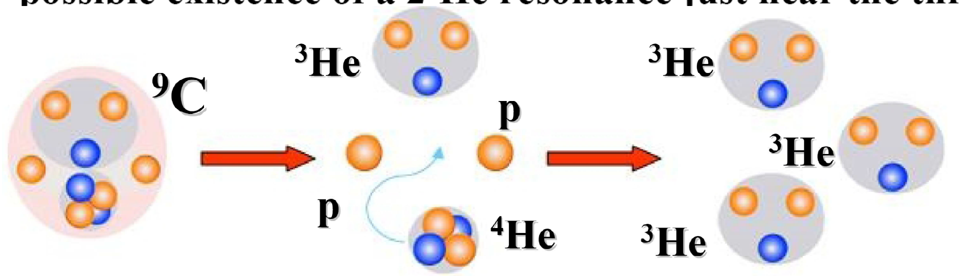
	Q_{min} (^{10}B), МэВ	N_{ws} (^{10}B)	% (^{10}B)	Q_{min} (^{8}B), МэВ	N_{ws} (^{8}B)	% (^{8}B)
2He+H	6.0	30	73	1.724	14	27
He+3H	25	5	12	8.6	12	23
Be+H	6.6	1	2	0.138	25	48
B		-	-		1	2
Li+He	4.5	5	13	3.7	-	-

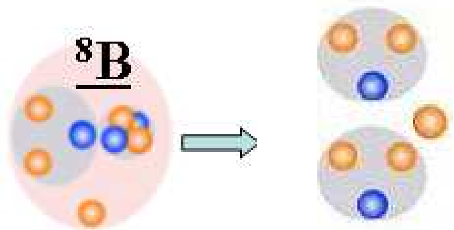


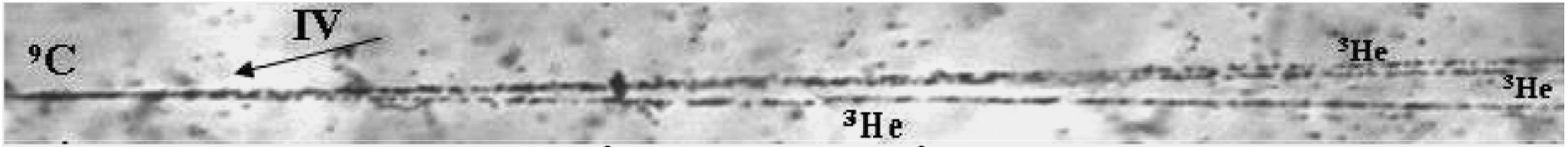




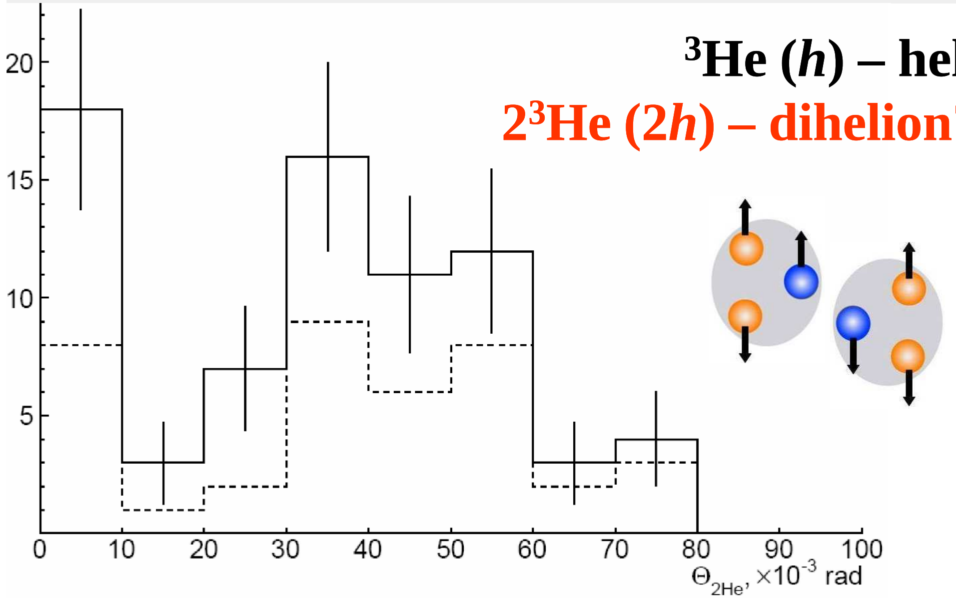
In the study of 2A GeV/c ^{9}C interactions it is found that the probability of the $3^{3}He$ coherent dissociation is roughly coincides with the values for the channels with the separation of one or a pair of nucleons. Due to a significant probability of the channel $^{9}C \rightarrow 3^{3}He$, $2^{3}He$ pairs with opening angles up to 10^{-2} rad are found as well as for ^{8}B interactions with the neutron knock out. This observation indicates the possible existence of a $2^{3}He$ resonance just near the threshold.







Macro photo of “white” star of ^{9}C dissociation to 3 ^{3}He nuclei in nuclear track emulsion; the interaction vertex IV is shown by the arrow.



^{3}He (*h*) – helion

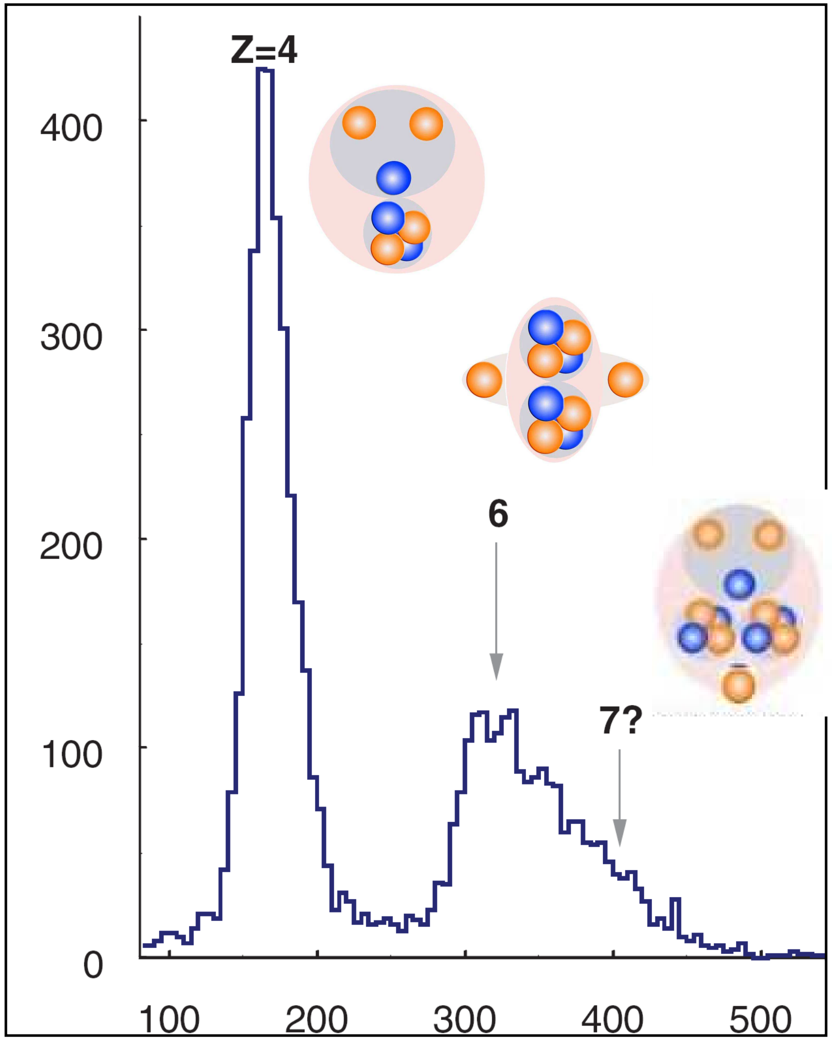
$2^{3}He$ (2*h*) – dihelion?!...

Distribution of "white" stars N_{ws} to the charge configurations $\Sigma Z_{fr} = 6$

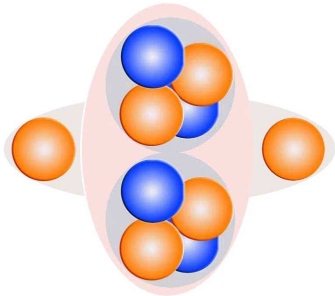
Z_{fr}						N_{ws}
6	5	4	3	2	1	
-	1	-	-	-	1	15
-	-	1	-	-	2	16
-	-	-	-	3	-	16
-	-	-	1	-	3	2
-	-	-	-	1	4	28
-	-	-	-	2	2	24
-	-	-	-	-	6	6

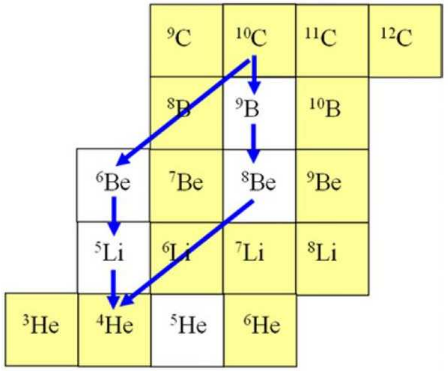
Exposure of emulsion to a mixed beam of relativistic ^{12}N, ^{10}C, and ^{7}Be nuclei

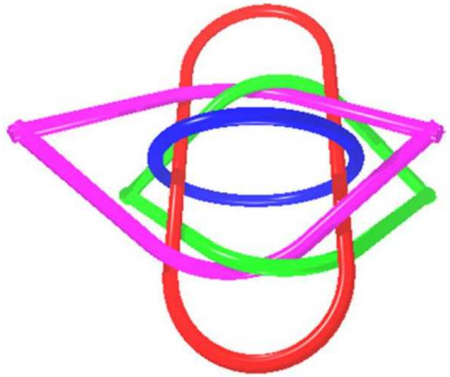
Generation of ^{12}N and ^{10}C nuclei is possible in charge exchange and fragmentation reactions of accelerated ^{12}C nuclei [3]. The charge to weight ratio Z_{pr}/A_{pr} differs by only 3% for these nuclei, while the momentum acceptance of the separating channel is 2 - 3%. Therefore, their separation is not possible, and the ^{12}N and ^{10}C nuclei are simultaneously present in the secondary beam, forming a so-called beam "cocktail". The contribution of ^{12}N nuclei is small in respect to ^{10}C ones in accordance with the cross sections for charge transfer and fragmentation reactions. Also, the beam contains ^{7}Be nuclei, differing by Z_{pr}/A_{pr} from ^{12}N nuclei only by 2%.



Nuclear track emulsion is exposed to a mixed beam of ^{12}N, ^{10}C and ^{7}Be nuclei formed by means of primary 1.2A GeV ^{12}C nucleus beam. The initial scanning phase consisted in visual search of beam tracks with charges Z_{pr} = 1, 2 and $Z_{pr} > 2$. The ratio of beam tracks with charges Z_{pr} = 1, 2 and $Z_{pr} > 2$ is found to be equal ≈ 1 : 3 : 18. Thus, the contribution of ^{3}He nuclei dramatically decreased compared with the ^{9}C irradiation, which radically raised the event search efficiency. The scanning along the total length of primary tracks in emulsion layers that was equal to 924.7 m revealed 6144 inelastic interactions, including 516 "white" stars.







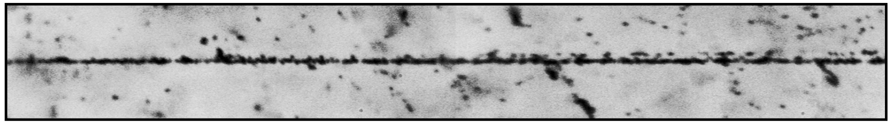
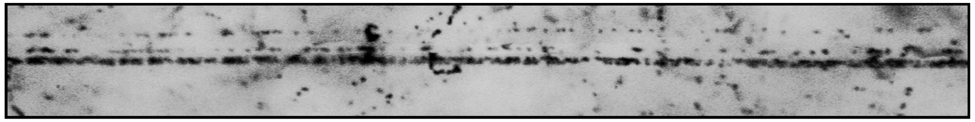
The ^{10}C nucleus is the only example of the system, which has the "super-boromean" properties, since the removal of one of the four clusters in the 2α + 2p structure leads to an unbound state.

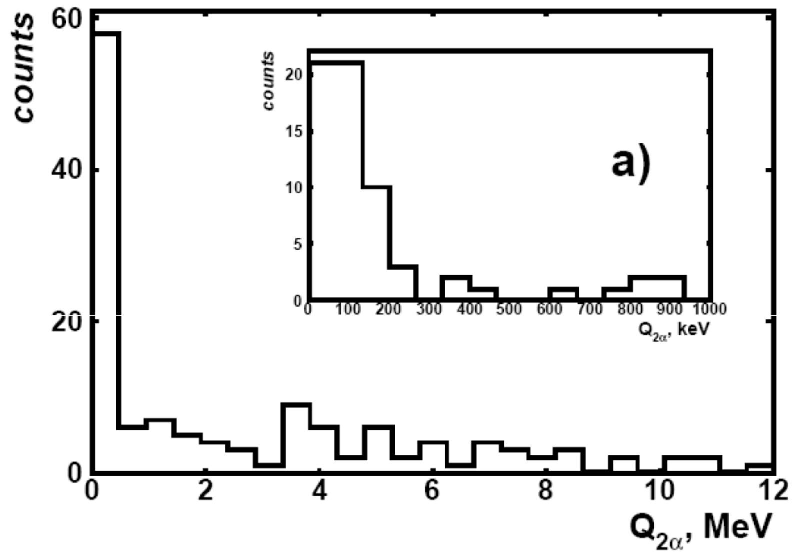
Distribution of the number of "white" stars, N_{ws}, and the number of events involving the production of target fragments, N_{tf}, with respect to $\sum Z_{fr}$ = 6 channels

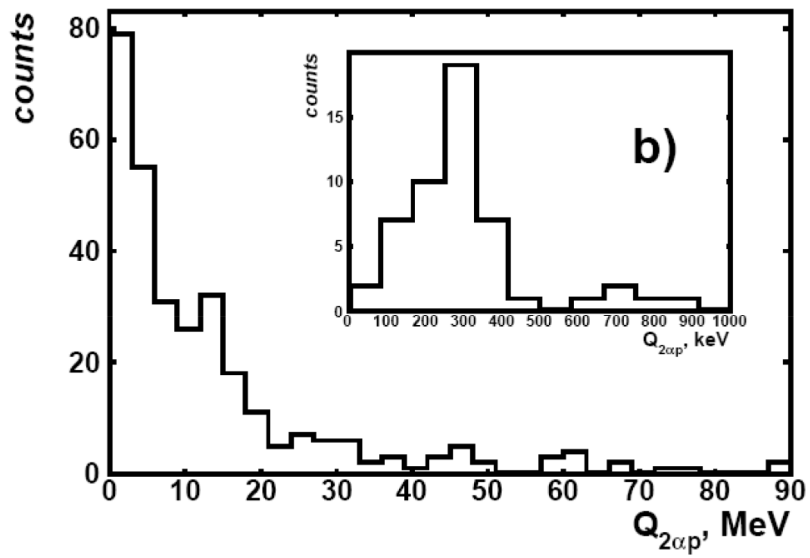
Канал	C	2He + 2H	He+4H	6H	3He	Be+He
N_{ws}	-	165	16	8	9	8
N_{tf}	27 (^{9}C)	211	76	16	8	9

For "white" stars N_{ws} with charge topology $\sum Z_{fr}$ = 6 the most probable channel is represented by events 2He + 2H, which might be expected for the isotope ^{10}C. The channel He + 4H is found to be suppressed, as in the ^{10}C case it is required to overcome the high threshold of the α-cluster break up. Besides, events are observed in the channel ^{10}C $\rightarrow$ 3He.

Production of ^{8}Be and ^{9}B nuclei in ^{10}C dissociation

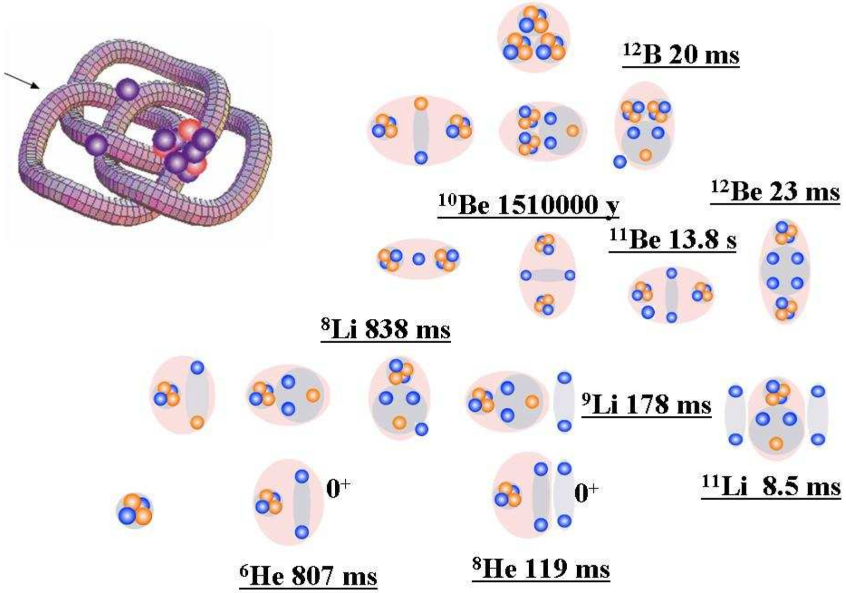







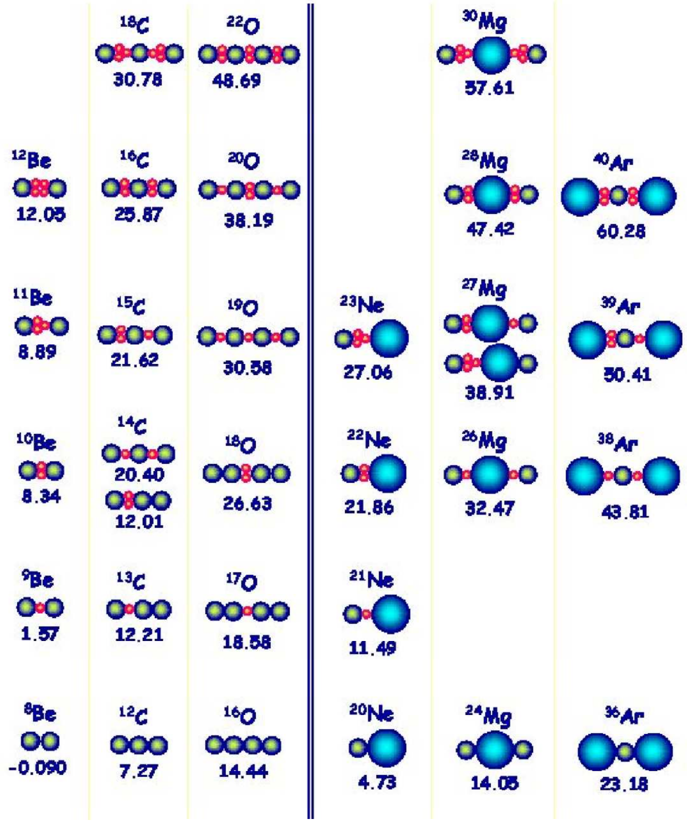
a) Distribution of the number of "white" stars 2α + 2*p* versus excitation energy $Q_{2\alpha}$ of the α-pairs. In the inset a zoom over the $Q_{2\alpha}$ distribution is shown. b) Distribution of the number of "white" stars 2α + 2*p* versus excitation energy $Q_{2\alpha p}$ of triples 2α + *p*. In the inset a zoom over the $Q_{2\alpha p}$ distribution is shown.

In 63 events the $Q_{2\alpha}$ value does not exceed 500 keV (inset a)). For them, the average value is $\langle Q_{2\alpha}\rangle \approx 110 \pm 20$ keV and the mean-square scattering σ = 40 keV, which well corresponds to the decays of the ^{8}Be 0^{+} ground state. The unbound ^{9}B nucleus can be another major product of the ^{10}C coherent dissociation. The $Q_{2\alpha p}$ values for one of two possible 2α + p triples do not exceed 500 keV in 58 events (inset b)). The average value for these triples is $\langle Q_{2\alpha p}\rangle = 250 \pm 15$ keV with rms σ = 74 keV.

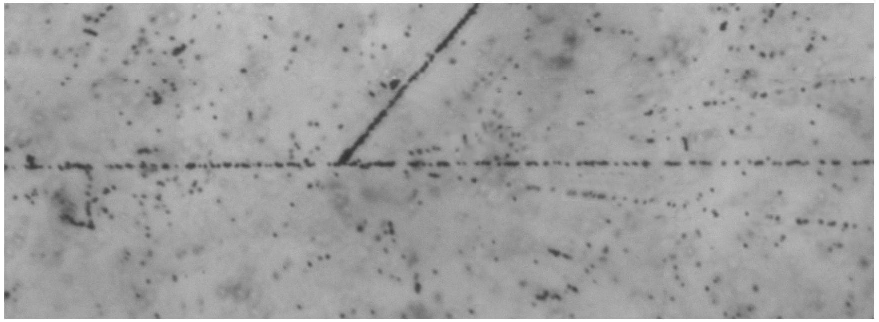


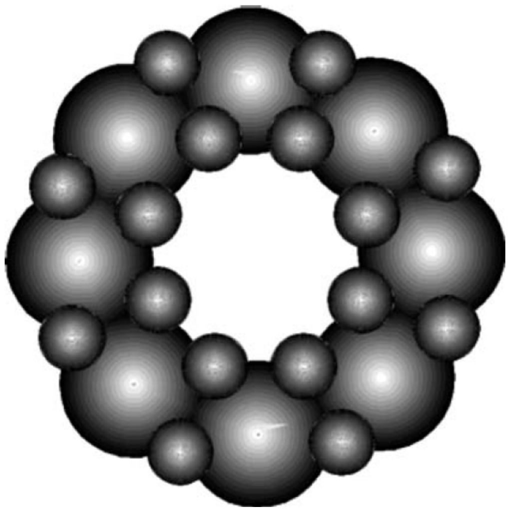
^{12}B 20 ms
^{10}Be 1510000 y
^{12}Be 23 ms
^{11}Be 13.8 s
^{8}Li 838 ms
^{9}Li 178 ms
^{11}Li 8.5 ms
0^{+}
0^{+}
^{6}He 807 ms
^{8}He 119 ms

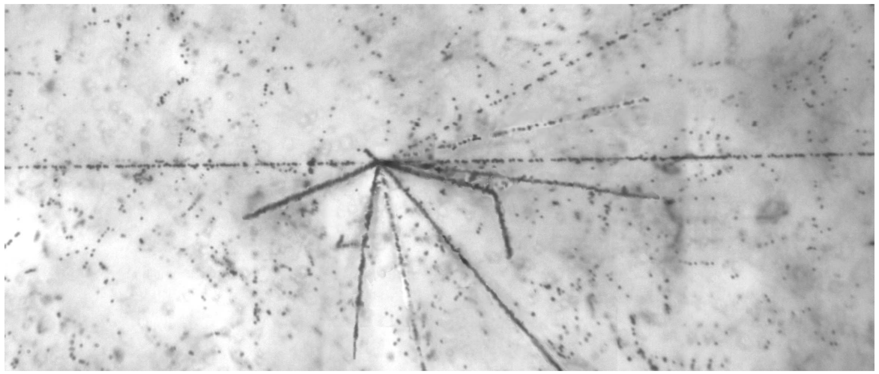
von Oertzen

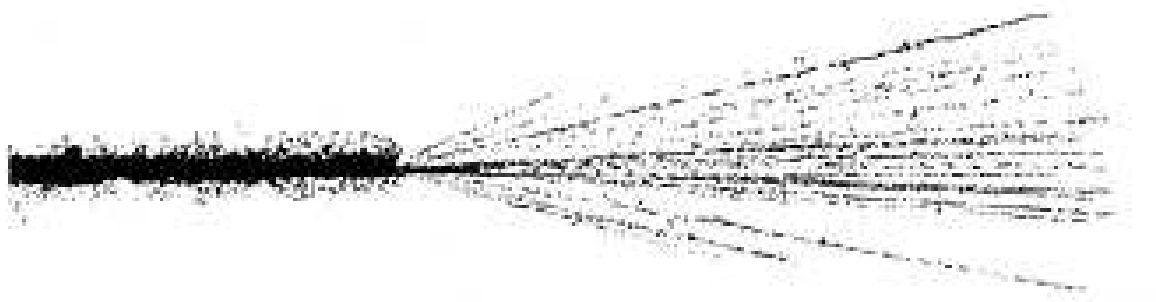


^{18}C 30.78
^{22}O 48.69
^{30}Mg 57.61
^{12}Be 12.05
^{16}C 25.87
^{20}O 38.19
^{28}Mg 47.42
^{40}Ar 60.28
^{11}Be 8.89
^{15}C 21.62
^{19}O 30.58
^{23}Ne 27.06
^{27}Mg 38.91
^{39}Ar 50.41
^{10}Be 8.34
^{14}C 20.40 12.01
^{18}O 26.63
^{22}Ne 21.86
^{26}Mg 32.47
^{38}Ar 43.81
^{9}Be 1.57
^{13}C 12.21
^{17}O 18.58
^{21}Ne 11.49
^{8}Be -0.090
^{12}C 7.27
^{16}O 14.44
^{20}Ne 4.73
^{24}Mg 14.05
^{36}Ar 23.18

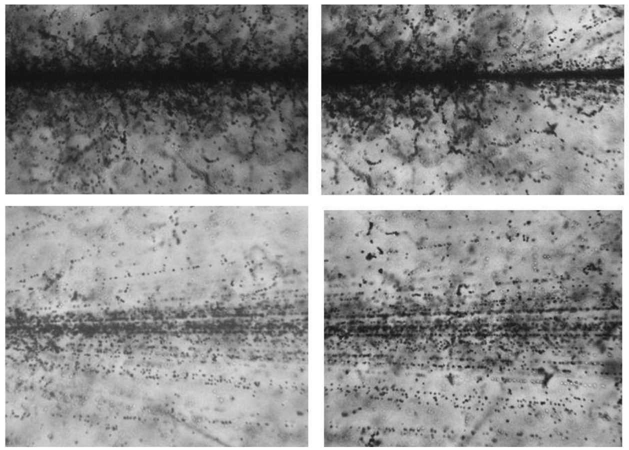




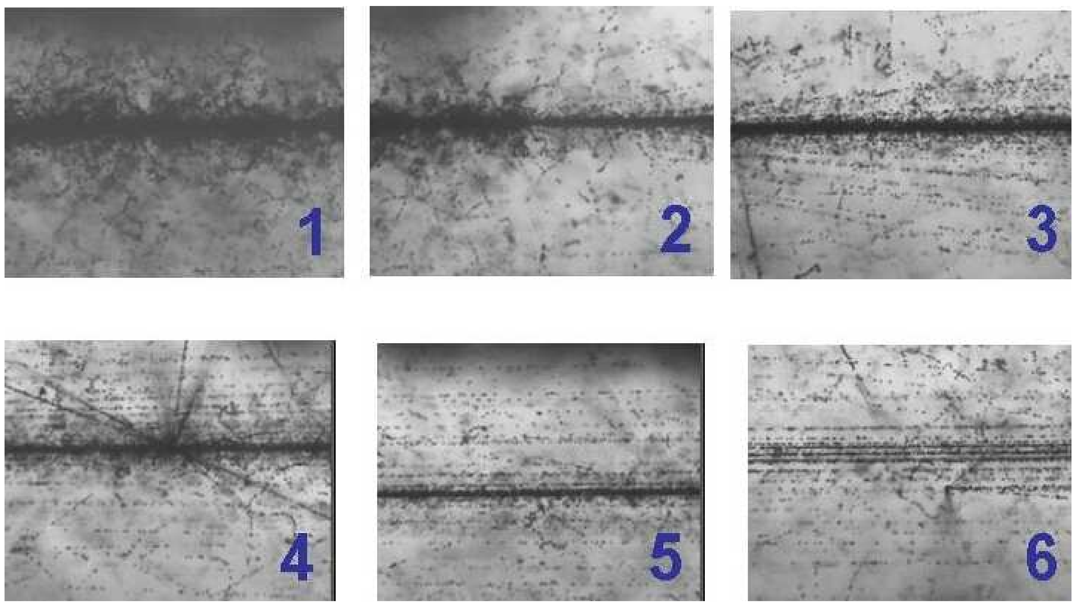




1A GeV U

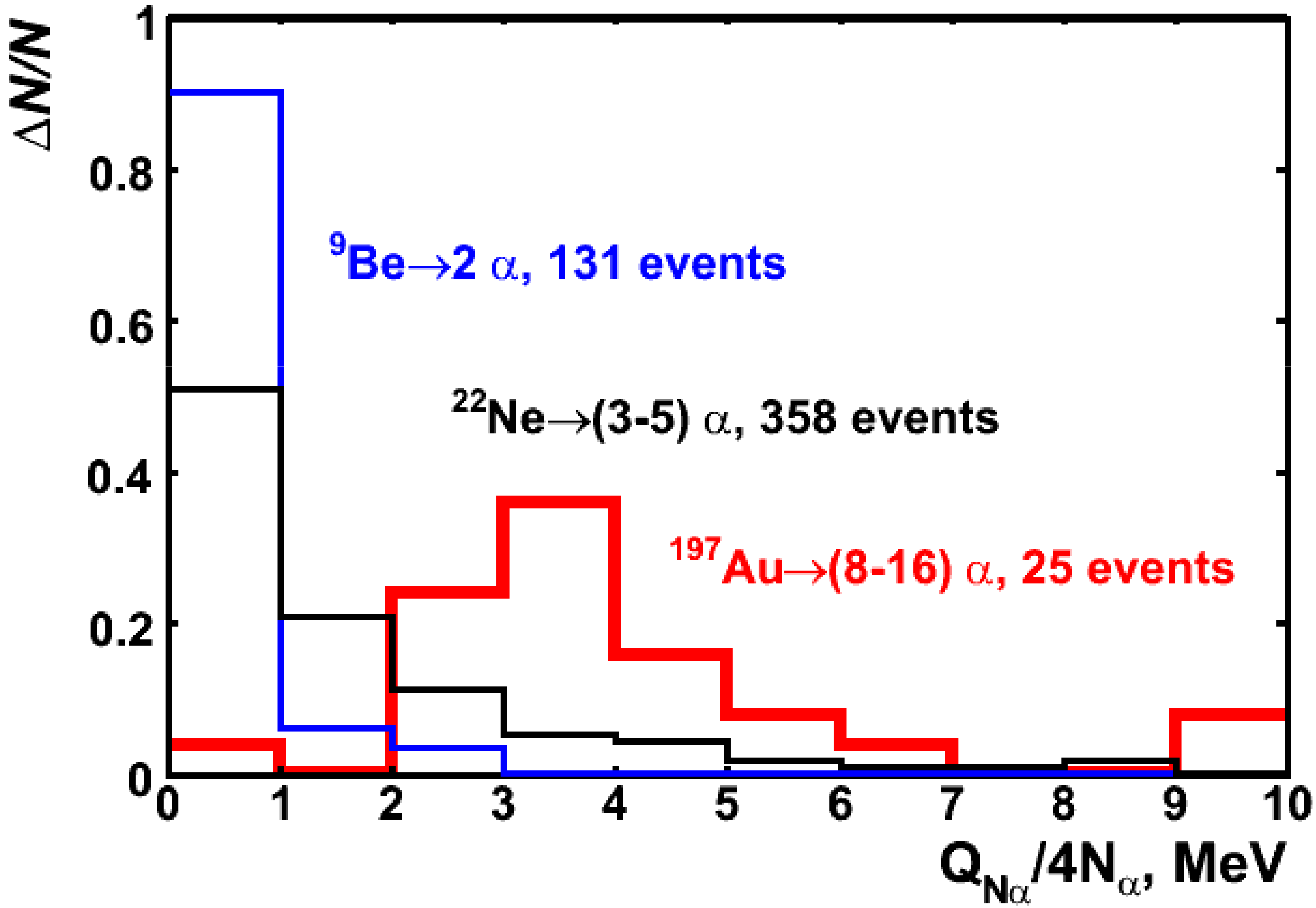


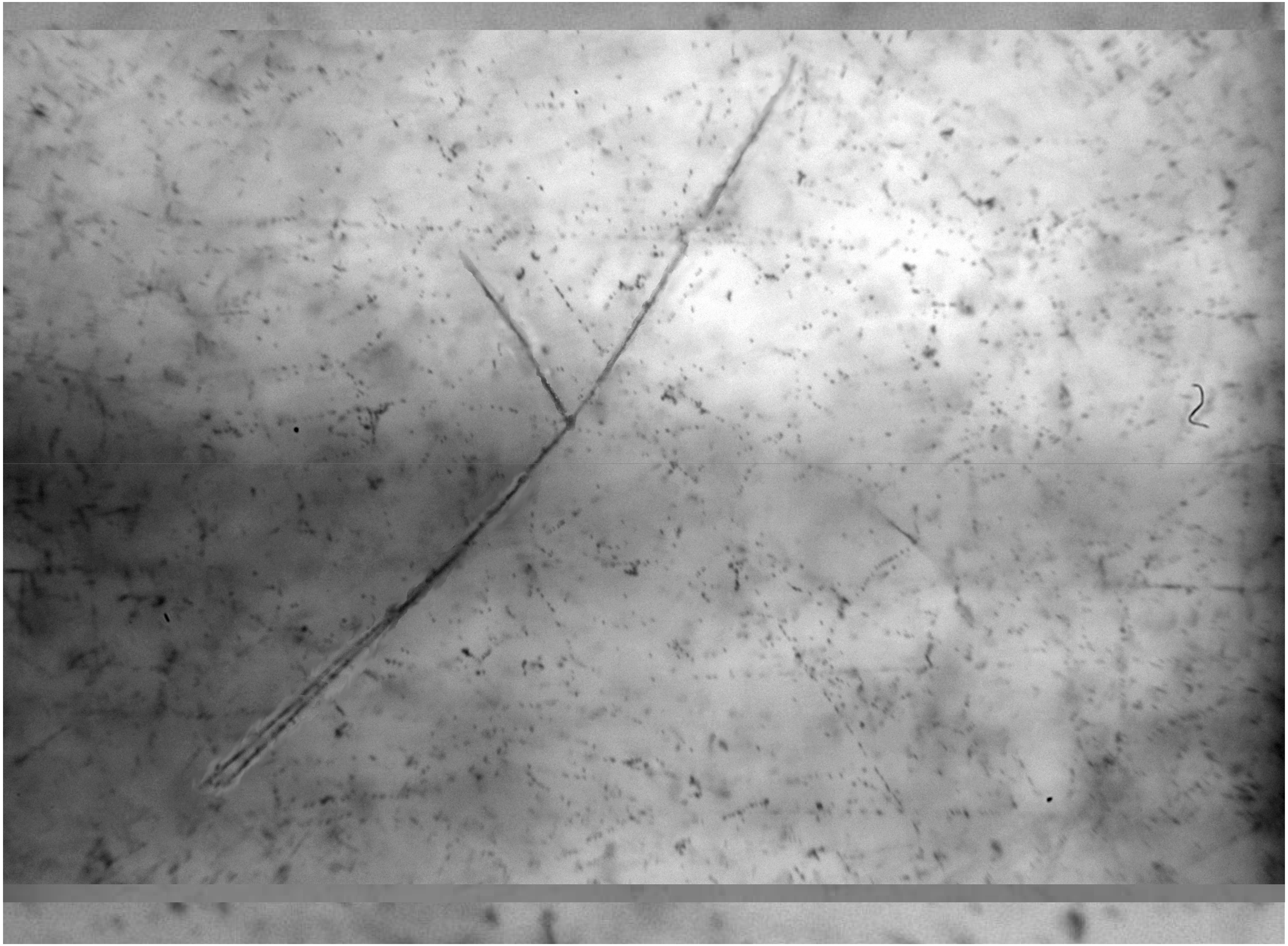
10A GeV Au



160A GeV Pb

1.2A GeV ^{9}Be **3.22A GeV ^{22}Ne** **10.7A GeV ^{197}Au**

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Electromagnetic dissociation of relativistic heavy ions

W. J. Llope and P. Braun-Munzinger
Department of Physics, State University of New York at Stony Brook, Stony Brook, New York 11794

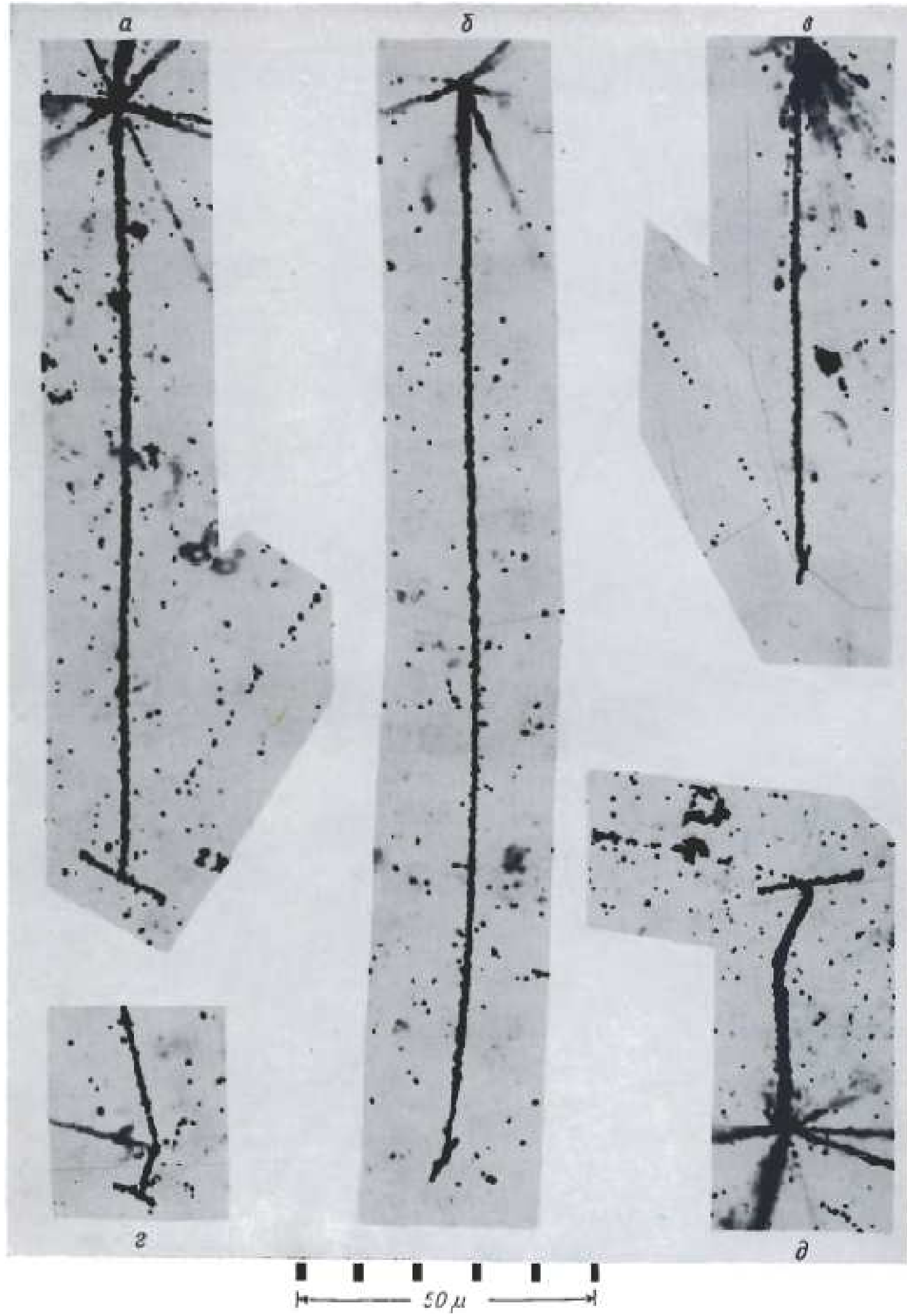
In particular, electromagnetic excitation of modes based on the nuclear giant dipole resonance (GDR) may lead to very exotic final states[1,2] in which neutrons oscillate against protons with a very large amplitude. The existence and decay mechanisms of such states is unknown at present. However, this electromagnetic process efficiently excites collective states so that little or no temperature is produced during the very short time scale (of order 1 fm/c) of the collision. One may thus hope to use this type of reaction to search for fragile, weakly bound exotic states such as multineutron clusters which might be formed in the decay of the possibly strongly excited multi-GDR states.

Request for irradiation to a high-energy muon beam

- **Until now, a high-energy muon exposure has not been conducted, which is a notable omission in survey observations of high-energy particle interactions.**
- **Meanwhile, the use of the muon, which is an electromagnetic probe, facilitates the interpretation of the phenomenon of nuclear multiple fragmentation.**
- **Moreover, the unexplored effects of multiphoton exchange may occur in the formation of muon stars associated with the destruction of heavy nuclei of emulsion.**
- **In addition to the nuclear dynamics, the muon interactions associated with the electron-positron pair formation in strong electromagnetic fields of heavy nuclei can be studied.**
- **It is also important that the images of the investigated events will complement the nuclear photo collection begun in the classic book by Powell, Fowler and Perkins.**
- **In terms of applications the received material will be very valuable for the development of systems of automatic search for nuclear interactions, as well as for university education**.

Hammer tracks in cosmic ray events:

^{8}Be produced in β-delayed decay of stopped ^{8}B and ^{8}Li



Beta Decay of a C^9 Nucleus*

M. S. Swami, J. Schneps, and W. F. Fry
Department of Physics, University of Wisconsin, Madison, Wisconsin

(Received June 29, 1956)

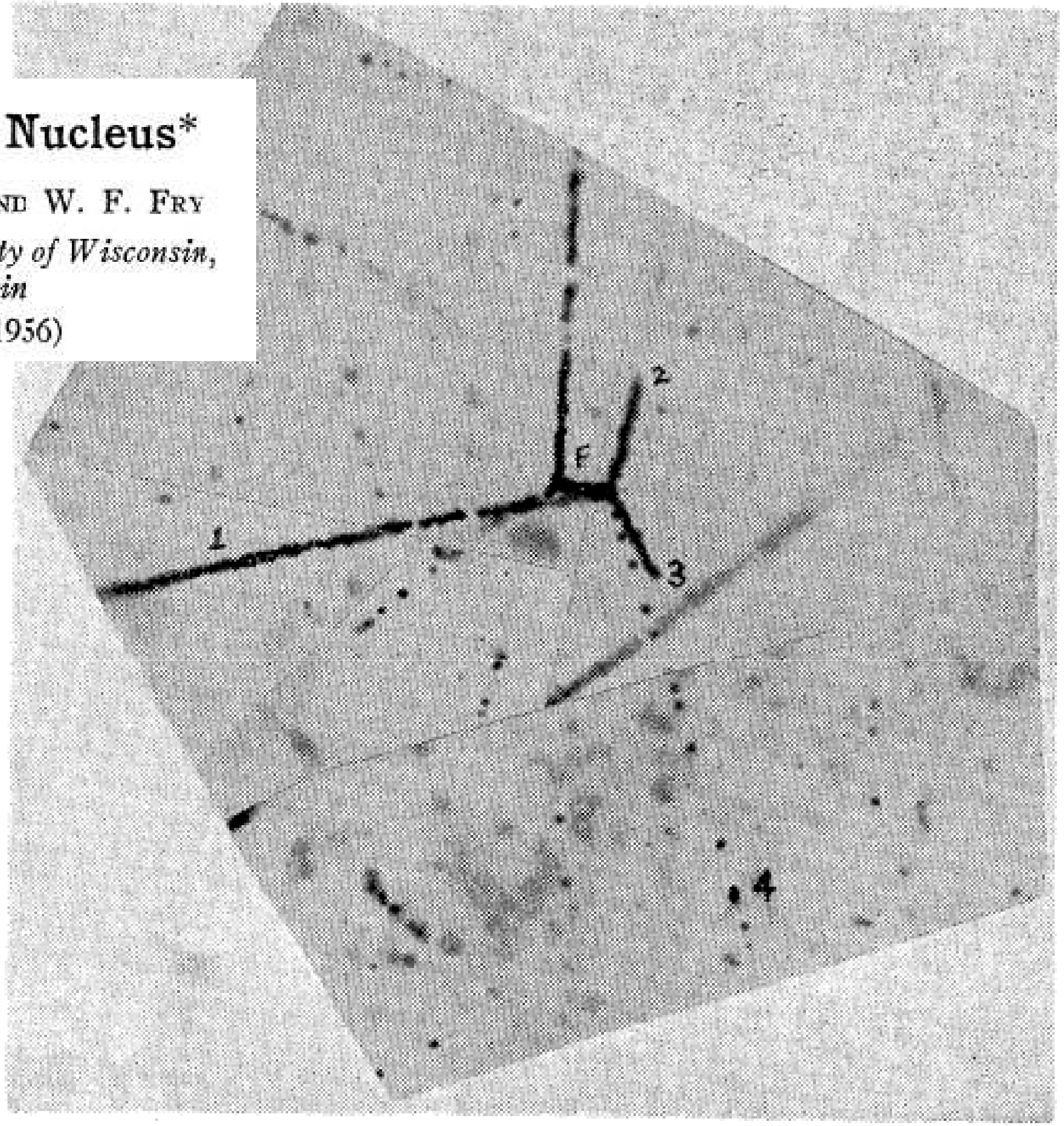


Fig. 1. A photograph of an event interpreted as the beta decay of C^9. The C^9 nucleus (track *F*) was produced in star (*A*) and disintegrated into a proton, two alpha particles, and a positron (tracks 1, 2, 3, and 4, respectively).

The automated microscope set PAVICOM-2 (LPI RAS, Moscow) based on the MPE-11 microscope with a controlled table, a video camera and capture card; on the screen - the image of the exposed area of a film emulsion

Conclusions

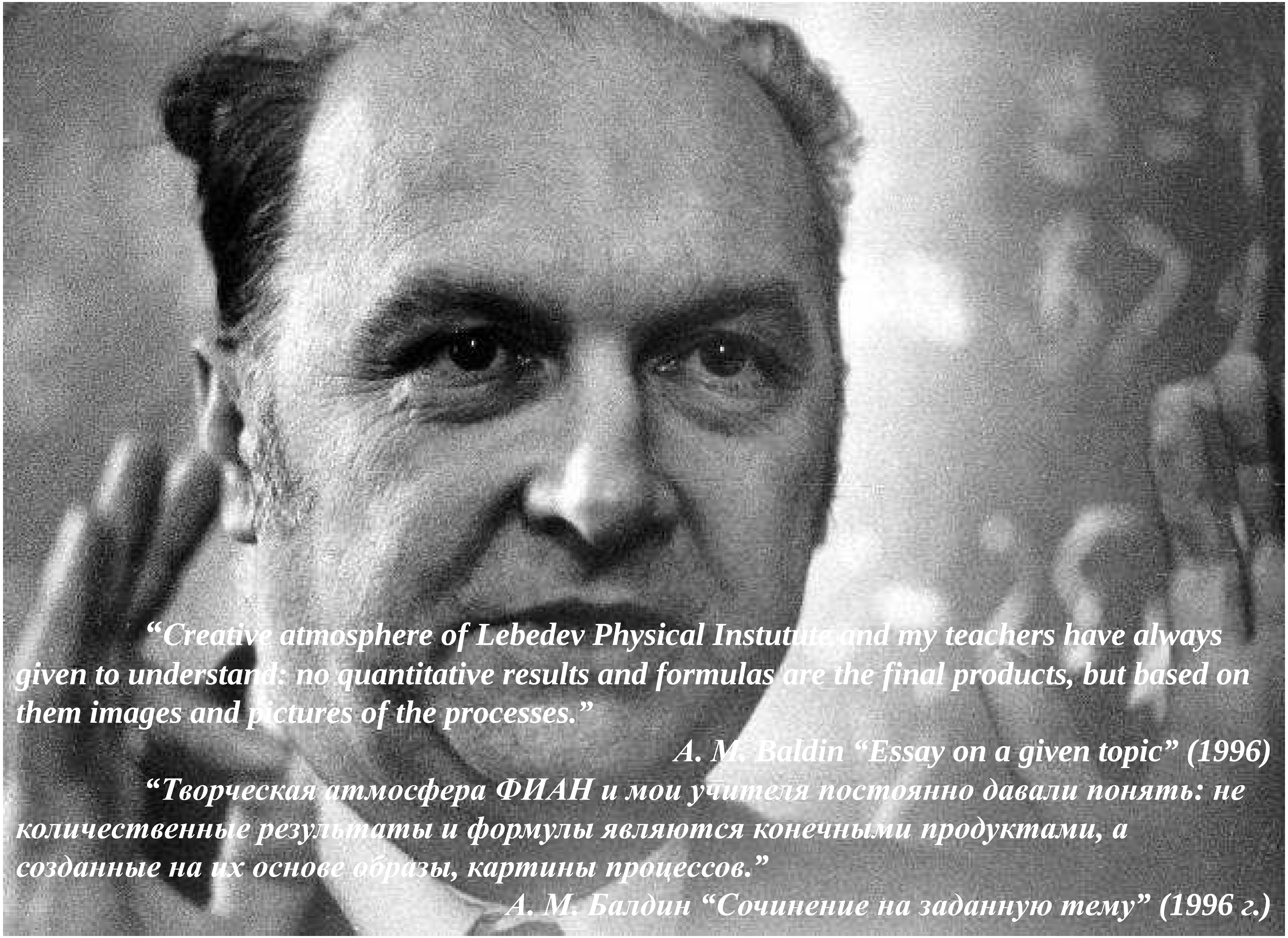
The presented observations serve as an illustration of prospects of the Nuclotron for nuclear physics and astrophysics researches. The relativistic energy scale does not impede investigations of nuclear interactions down to energy scale relevant for nuclear astrophysics, but on the contrary gives advantages for investigation of multi-particle systems.

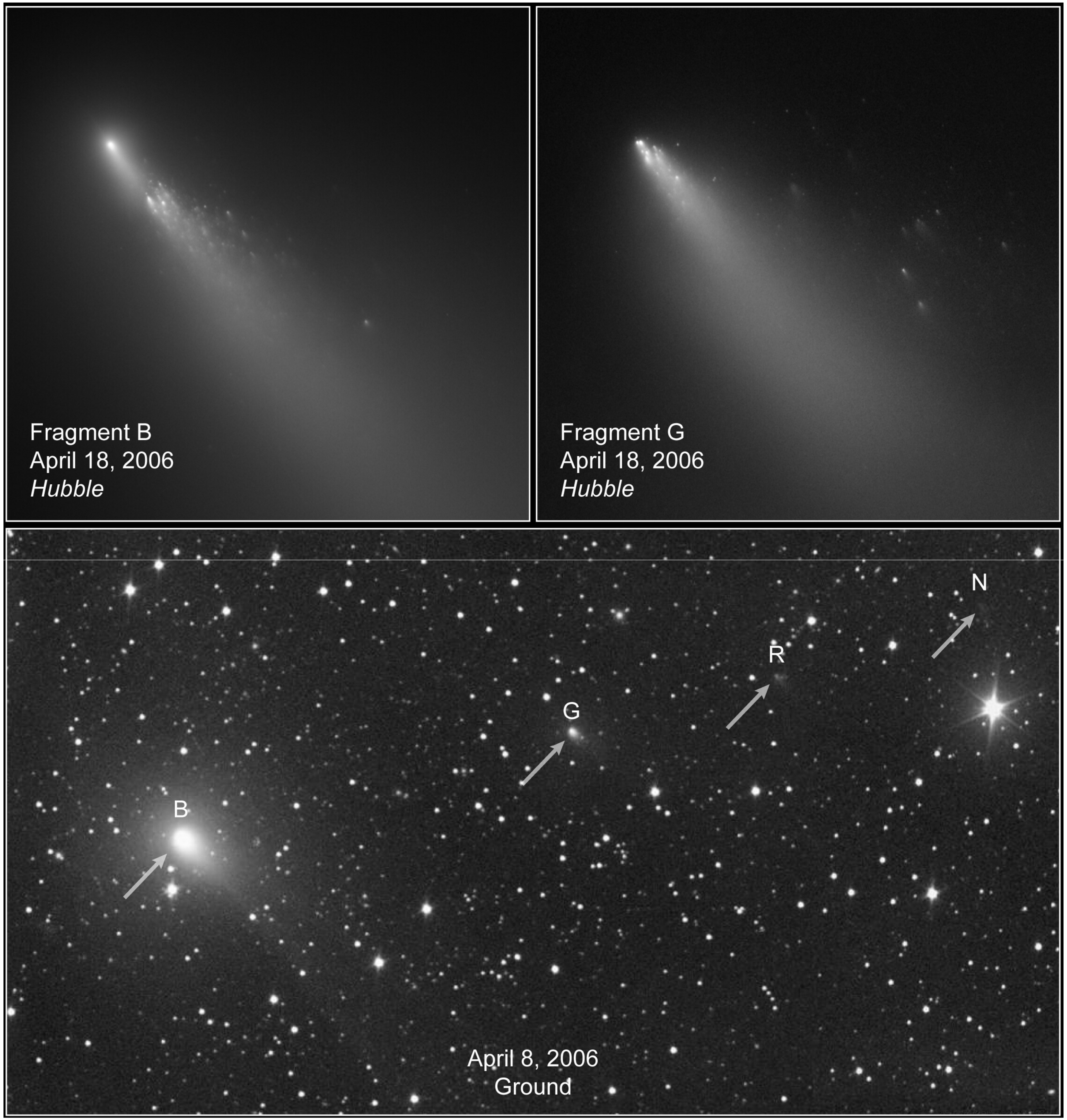
Due to a record space resolution the emulsion technique provides unique entirety in studying of light nuclei, especially, neutron-deficient ones. Providing the 3D observation of narrow dissociation vertices this classical technique gives novel possibilities of moving toward more and more complicated nuclear systems.

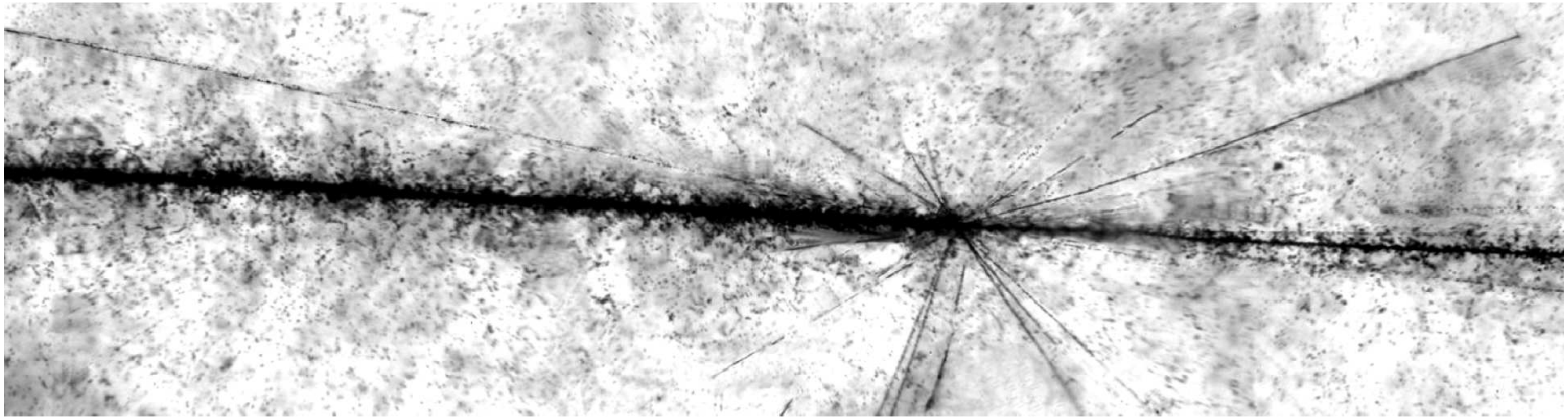
The results of the light nucleus study lead to the conclusion that their structure dominates in very peripheral dissociations while some unknown features are clearly observed

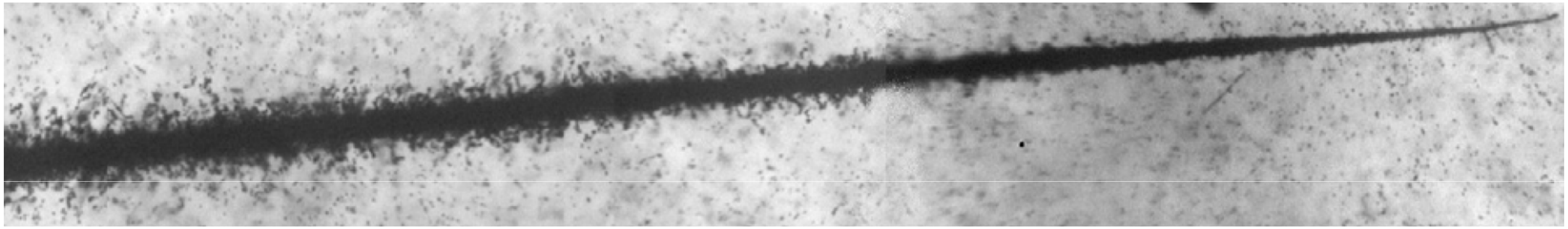
The investigations with light nuclei provide a basis for challenging studies of increasingly complicated systems *He – H - n* produced via complete fragmentation of heaviest relativistic nuclei.

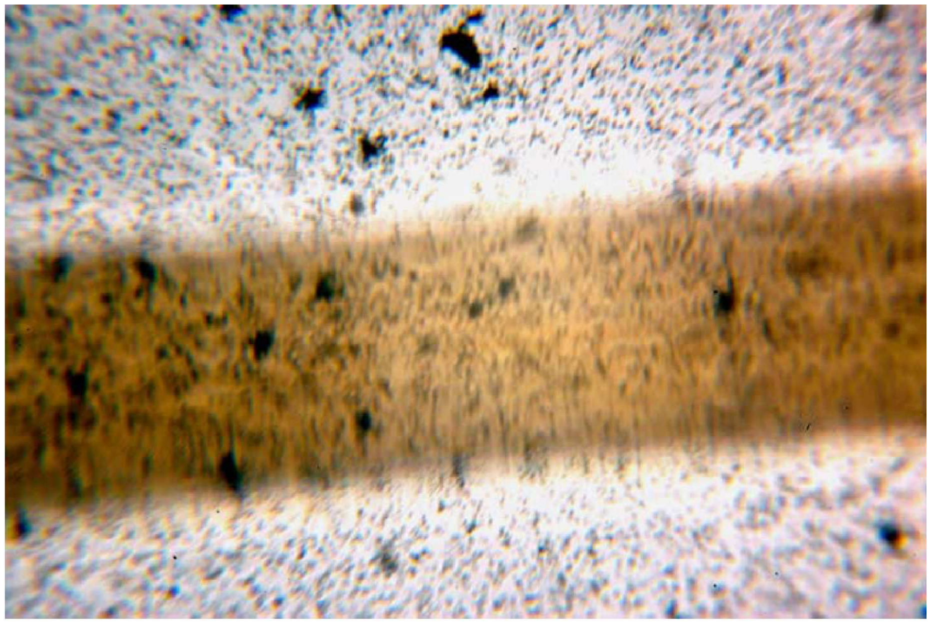
Long and bright road is ahead for nuclear researches using HEP techniques. Nuclear imaging continue to inspire our imagination.

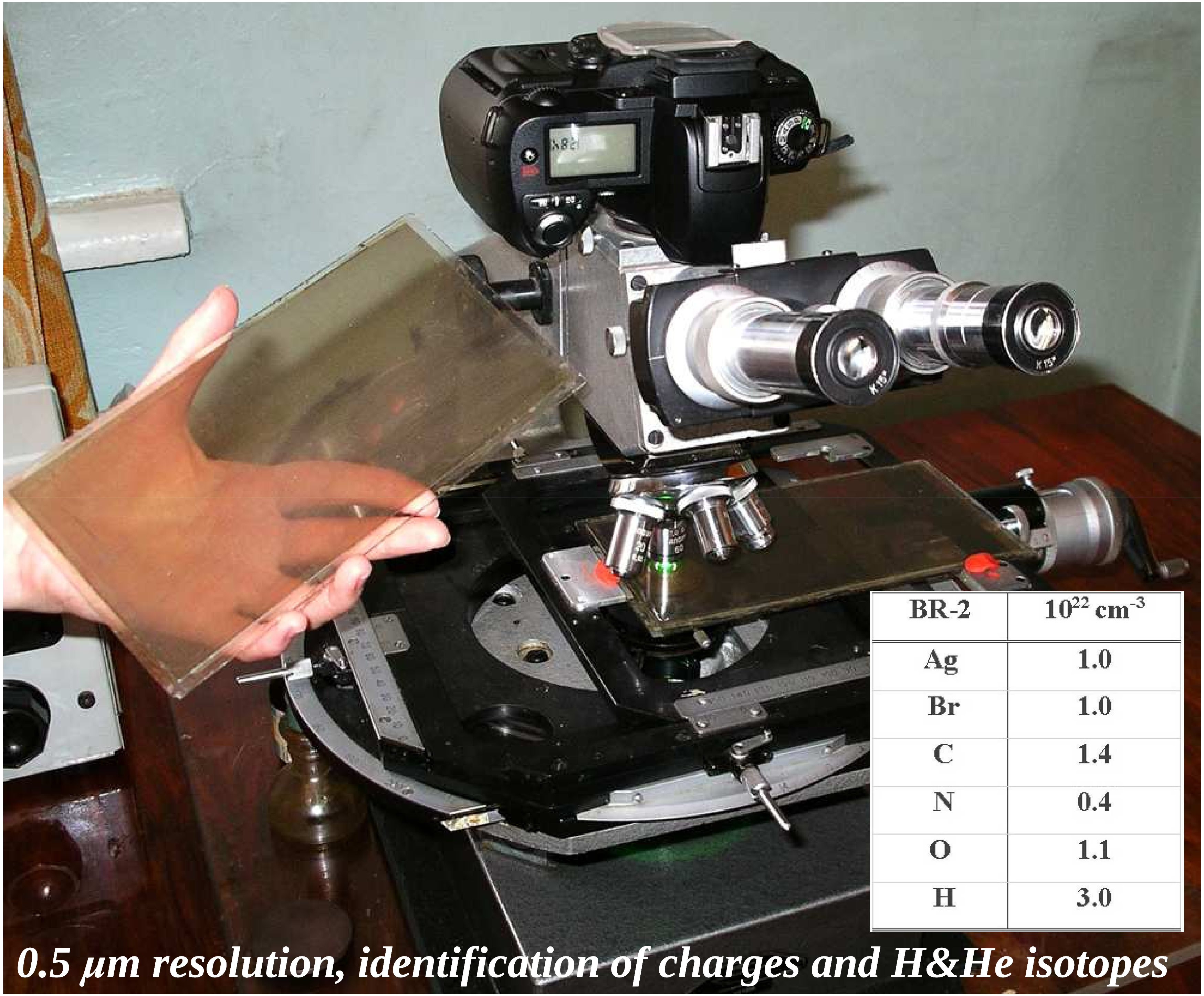

“Creative atmosphere of Lebedev Physical Institute and my teachers have always given to understand: no quantitative results and formulas are the final products, but based on them images and pictures of the processes.”
A. M. Baldin “Essay on a given topic” (1996)
“Творческая атмосфера ФИАН и мои учителя постоянно давали понять: не количественные результаты и формулы являются конечными продуктами, а созданные на их основе образы, картины процессов.”
А. М. Балдин “Сочинение на заданную тему” (1996 г.)


Fragment B
April 18, 2006
Hubble
Fragment G
April 18, 2006
Hubble
N
R
G
B
April 8, 2006
Ground



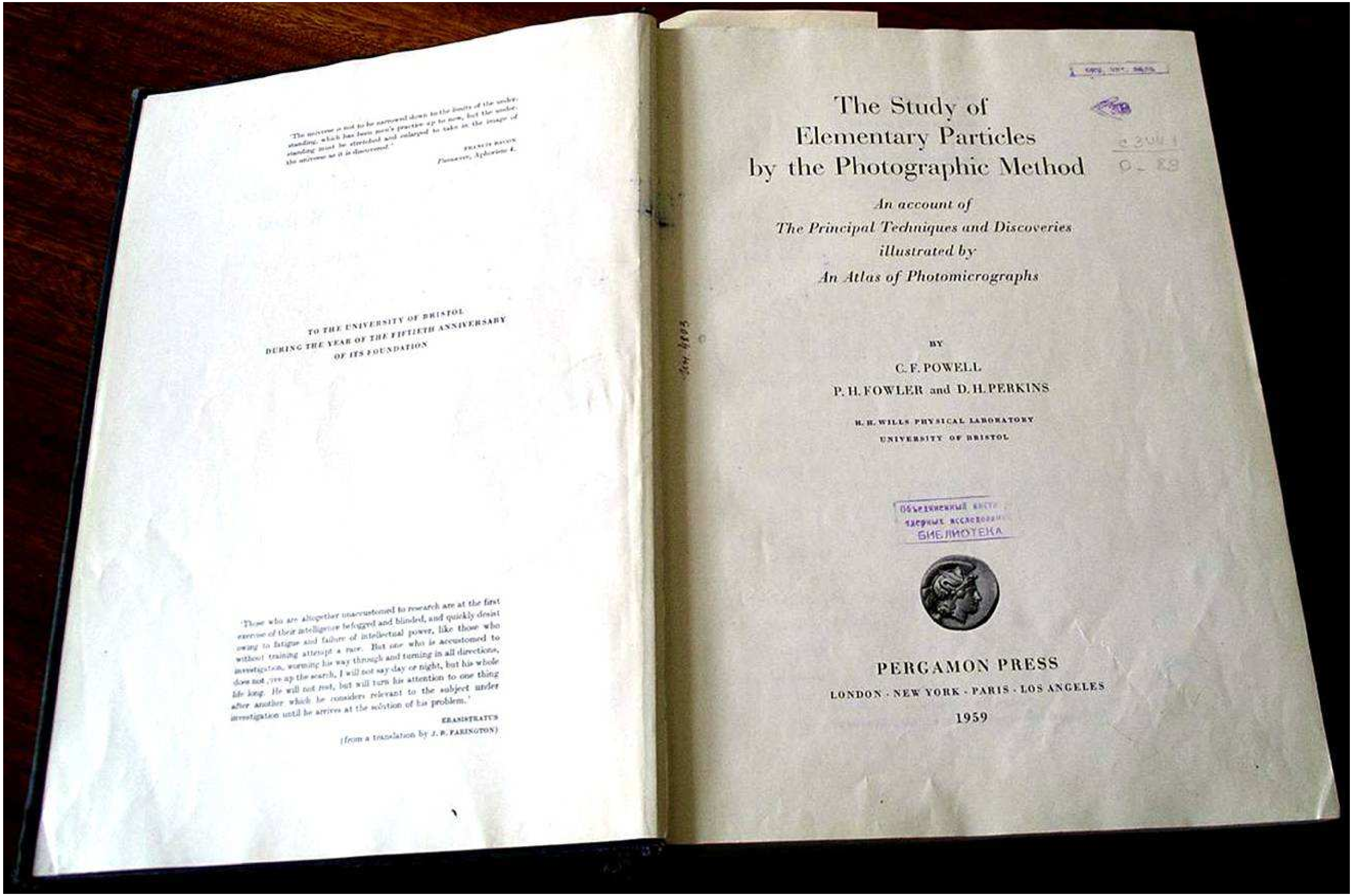






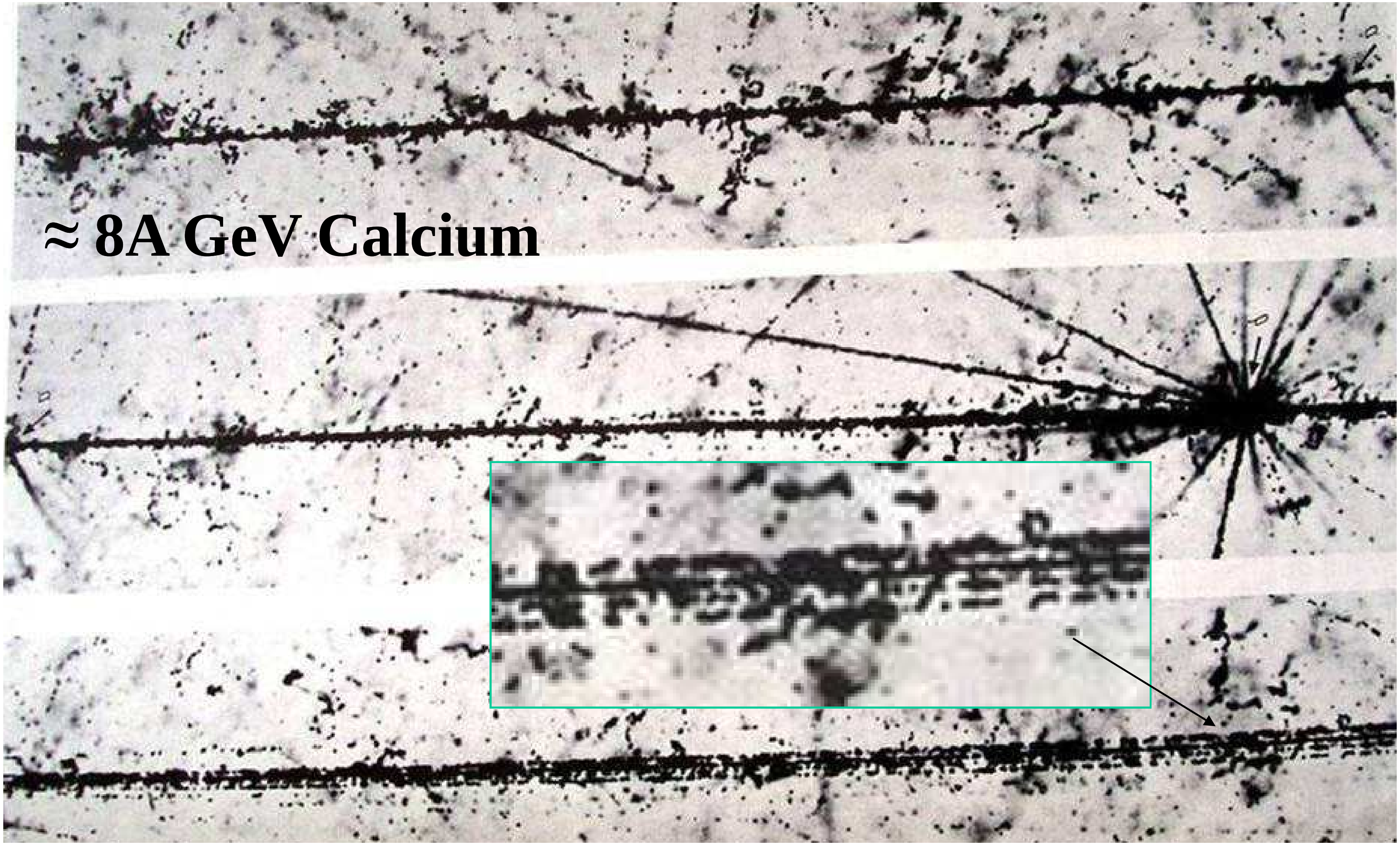
BR-2	10^{22} cm^{-3}
Ag	1.0
Br	1.0
C	1.4
N	0.4
O	1.1
H	3.0

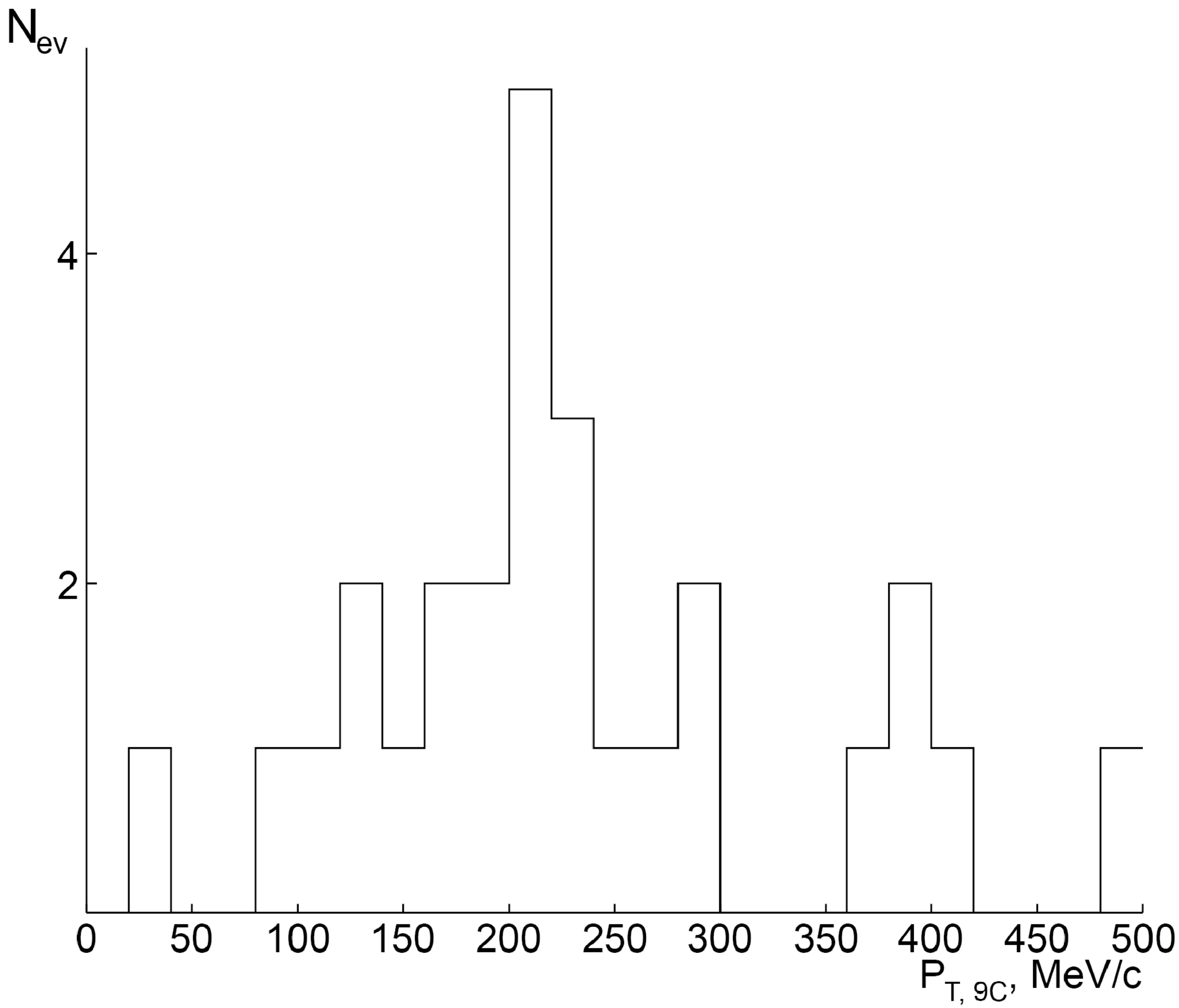
0.5 μm resolution, identification of charges and H&He isotopes

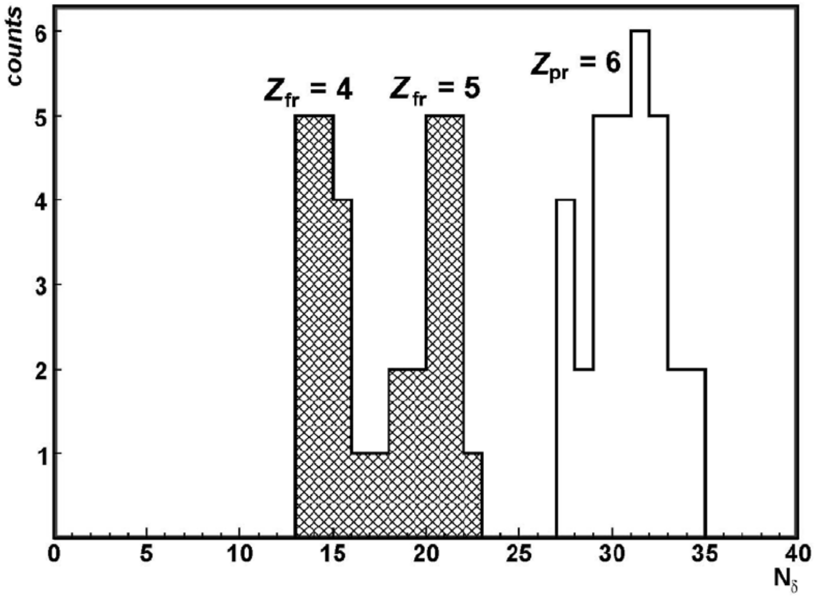


The unique collection of images in the "Emulsion Bible" by Powell, Fowler, and Perkins.

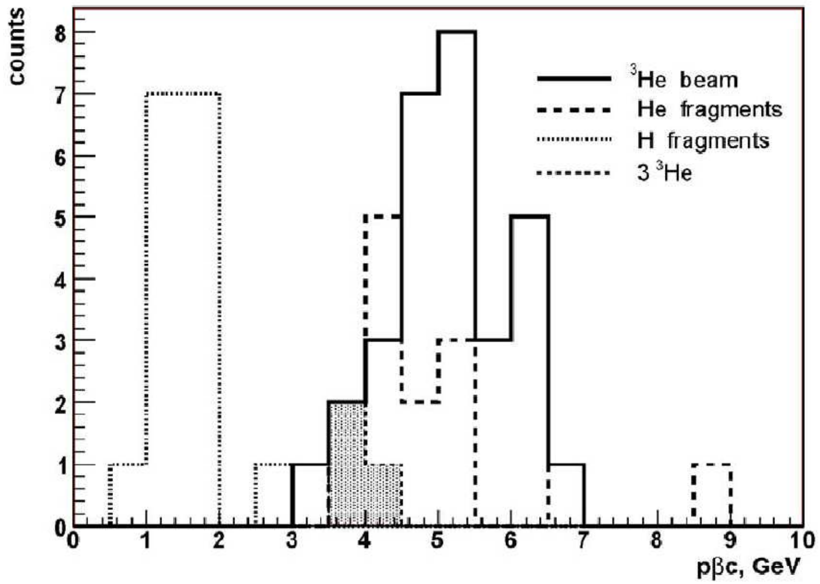
Interactions of relativistic nuclei of galactic origin



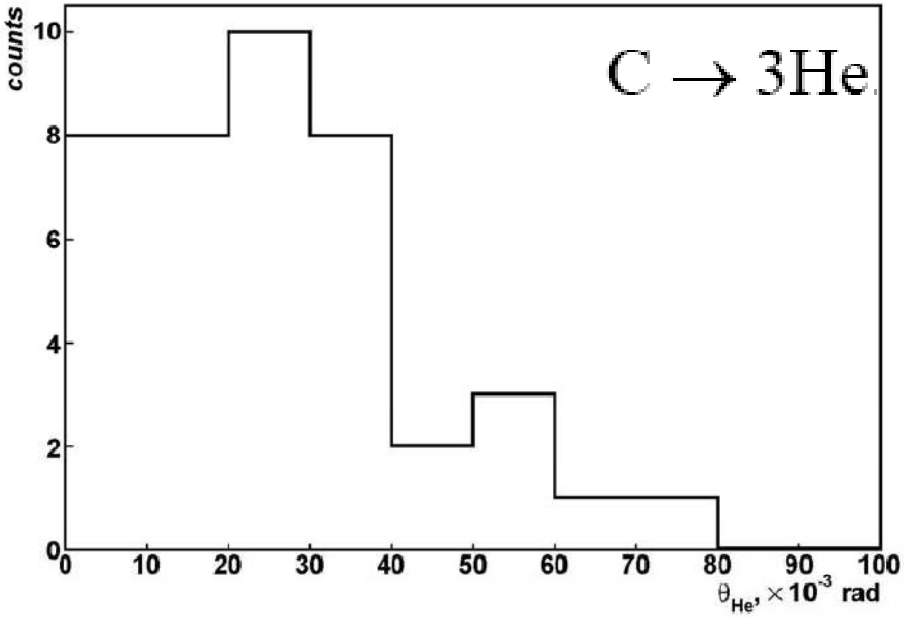

N_ev
4
2
0
50
100
150
200
250
300
350
400
450
500
P_T, 9C, MeV/c



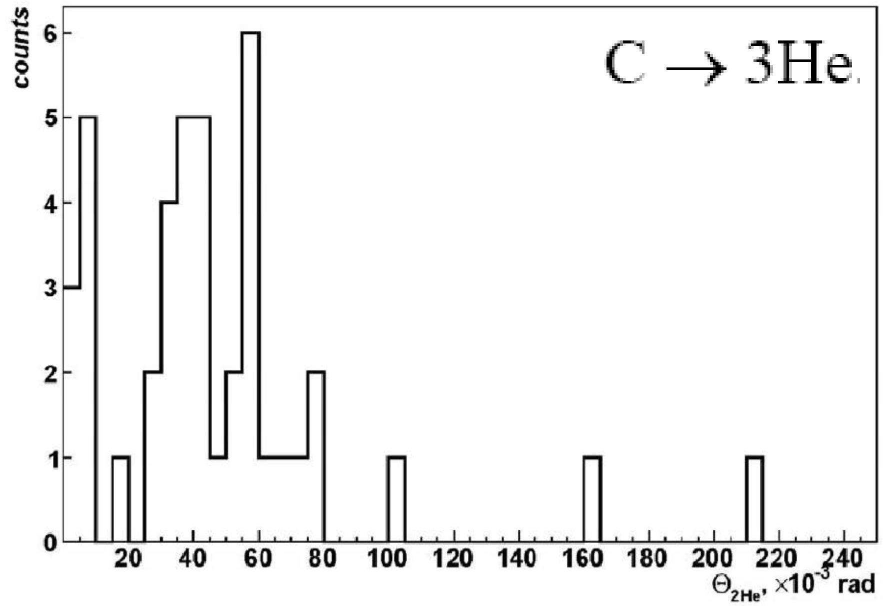
δ -electrons density for beam particles and relativistic fragments with charges $Z_{fr} > 2$ from "white" stars $\sum Z_{fr} = 5 + 1$ and $4 + 1 + 1$



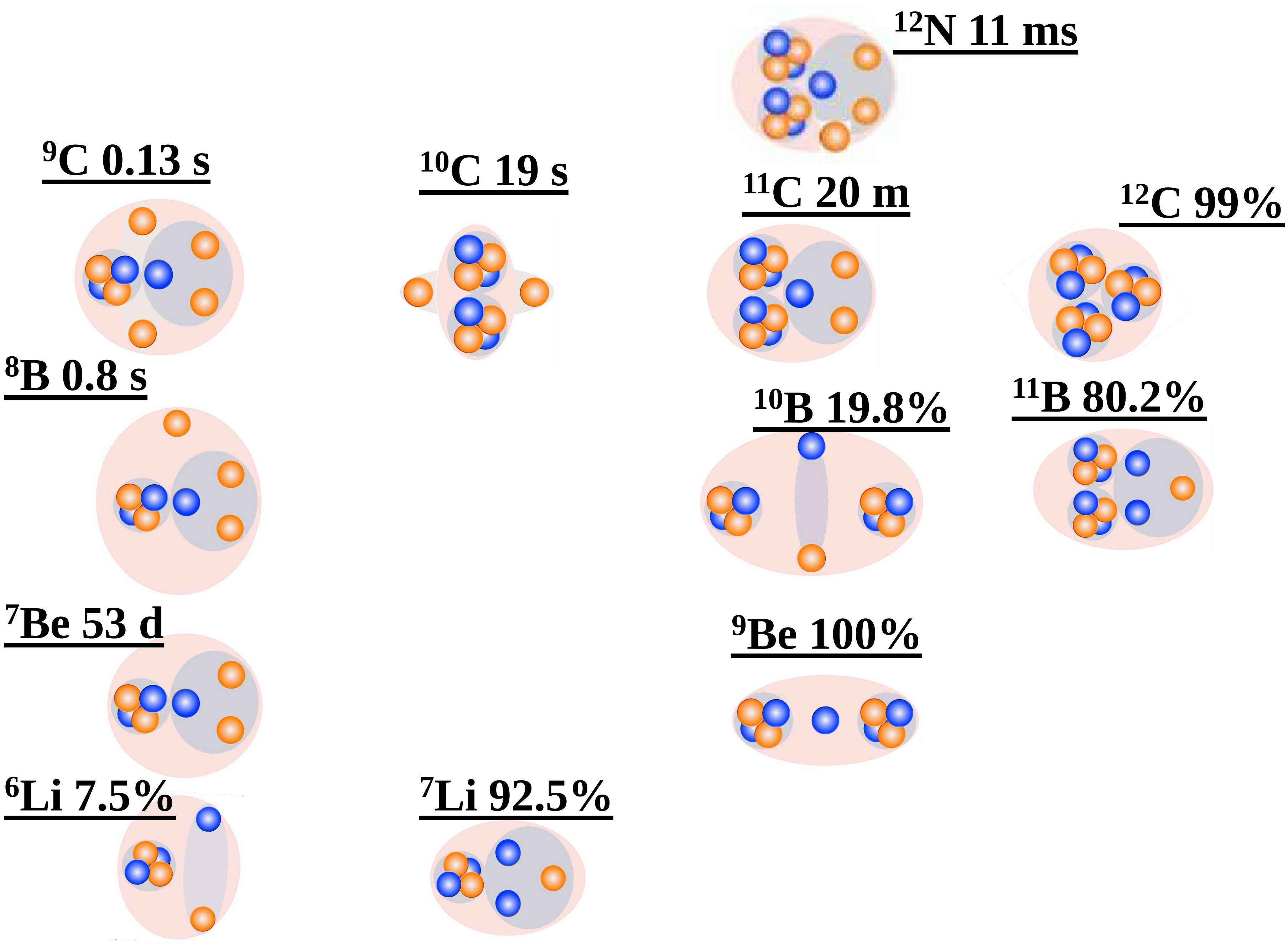
pβ*c* for beam ^{3}He nuclei, H fragments of the "white" stars $\sum Z_{fr} = 5 + 1$ and $4 + 1 + 1$, He fragments of the "white" stars 3He and from the 3^3He event



Polar angles θ for doubly charged fragments in the "white" stars C → 3He



Opening angles Θ_{2He} between fragments in the "white" stars C → 3He

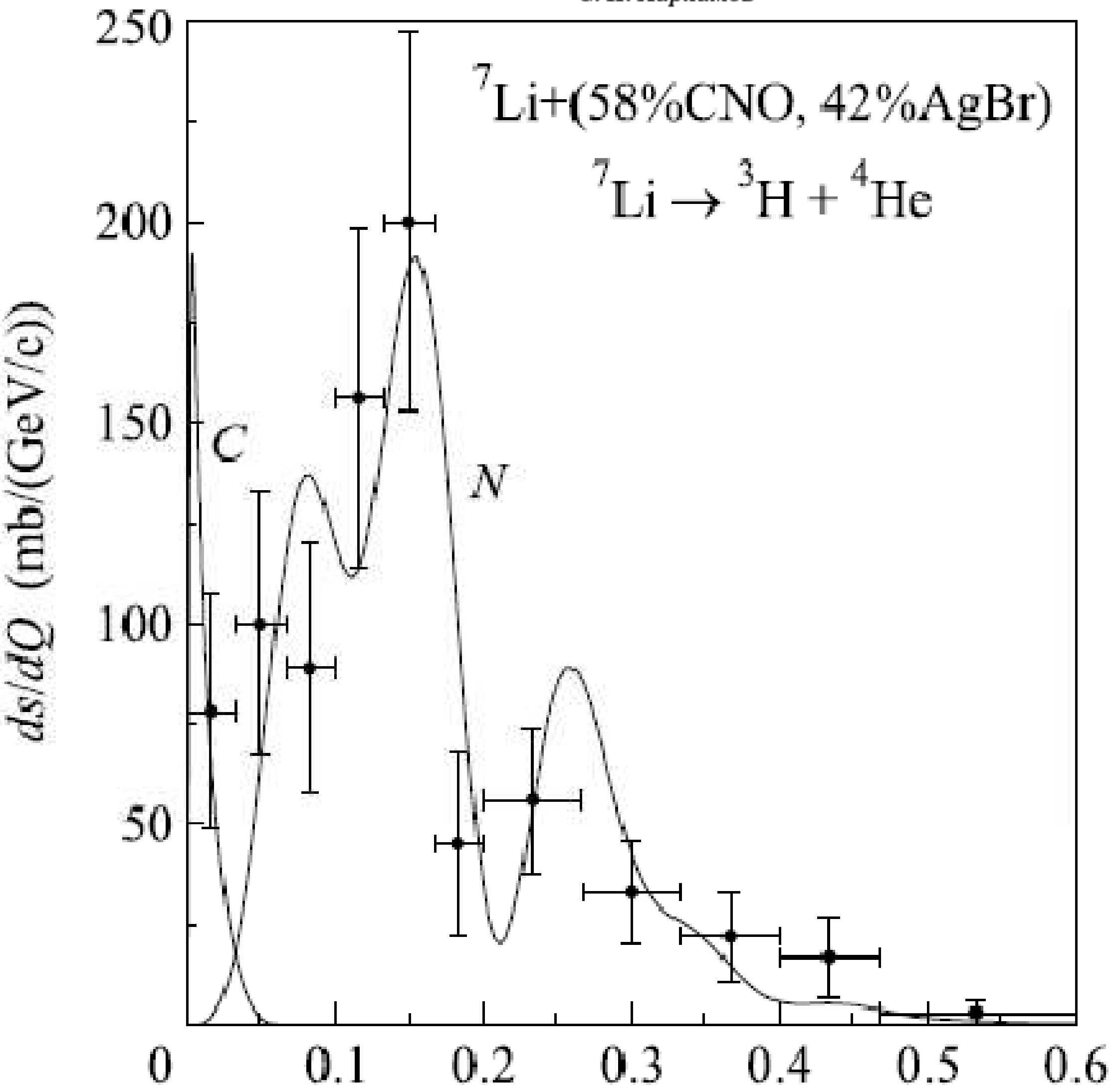


12N 11 ms
9C 0.13 s
10C 19 s
11C 20 m
12C 99%
8B 0.8 s
10B 19.8%
11B 80.2%
7Be 53 d
9Be 100%
6Li 7.5%
7Li 92.5%

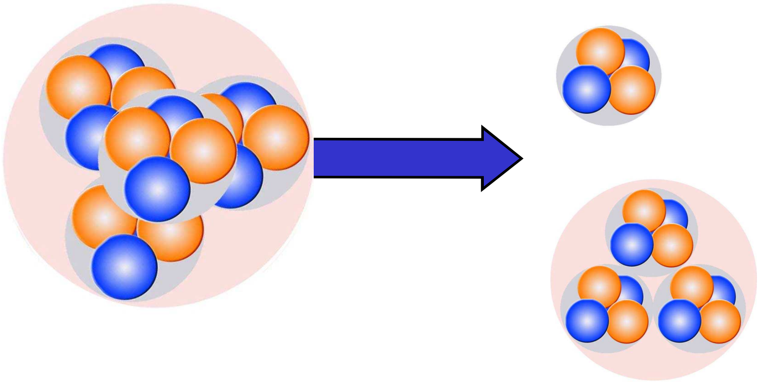
Письма в ЖЭТФ, том 88, вып. 2, с. 83 – 87

Роль ядерного и электромагнитного взаимодействий в когерентной диссоциации релятивистского ядра ^{7}Li по каналу ^{3}H + ^{4}He

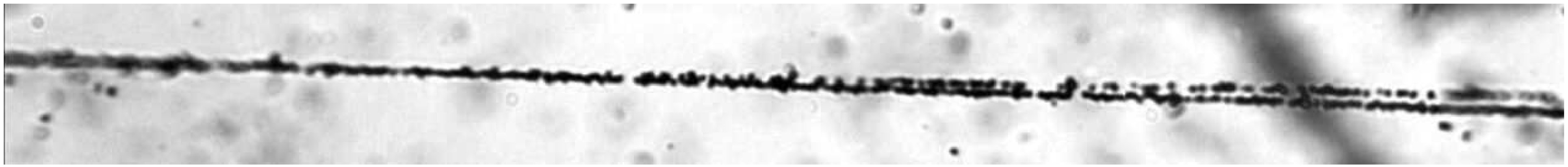
Н. Г. Пересадько, В. Н. Фетисов[1], Ю. А. Александров, С. Г. Герасимов, В. А. Дронов, В. Г. Ларионова, Е. И. Тамм, С. П. Харламов

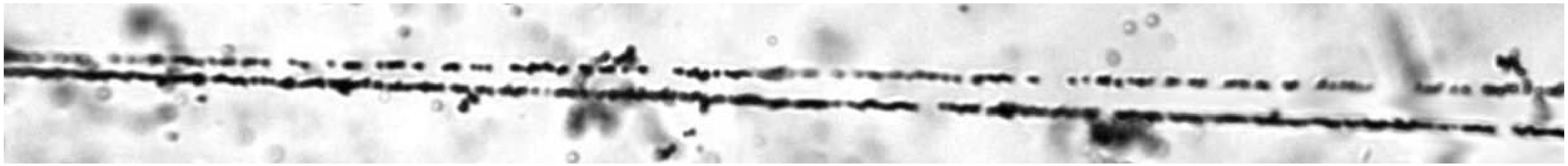


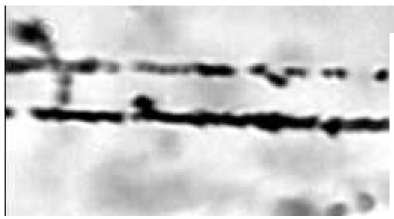
P_T (^{7}Li), GeV/*c*



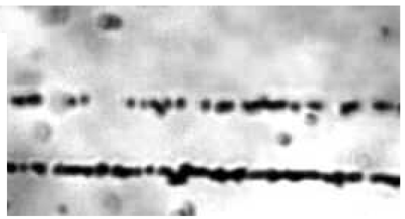
4.5 A GeV/c ^{16}O





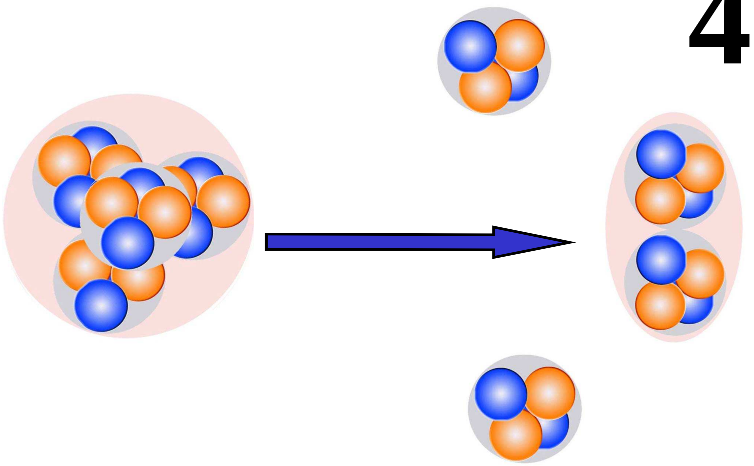


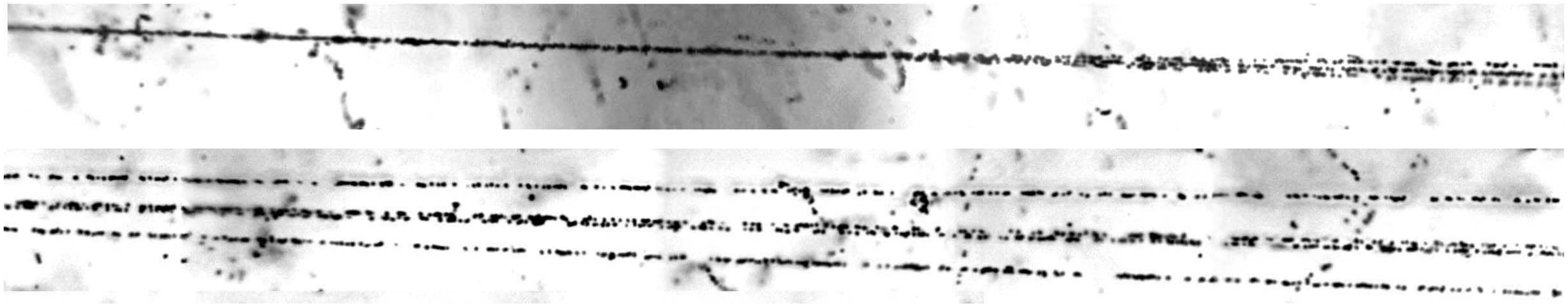
$Z_{fr} > 3$	N	C	C	B	B	Be	Be	-	-
$N_{Z=1}$	1	-	2	3	1	-	2	-	2
$N_{Z=2}$	-	1	-	-	1	2	1	4	3
N_{ev}	18	21	7	2	10	1	1	9	3



4.5A GeV/c 641 events

$^{16}O \rightarrow 4\alpha$





PHYSICAL REVIEW C VOLUME 41, NUMBER 6 JUNE 1990

Electromagnetic dissociation of relativistic heavy ions

W. J. Llope and P. Braun-Munzinger
Department of Physics, State University of New York at Stony Brook, Stony Brook, New York 11794
(Received 12 January 1990)

A framework is developed for the quantitative analysis of the electromagnetic dissociation of relativistic nuclei. This includes treatment of multiple excitations of the giant dipole resonance, coupled with calculations of the fragmentation probabilities in the framework of the statistical model.

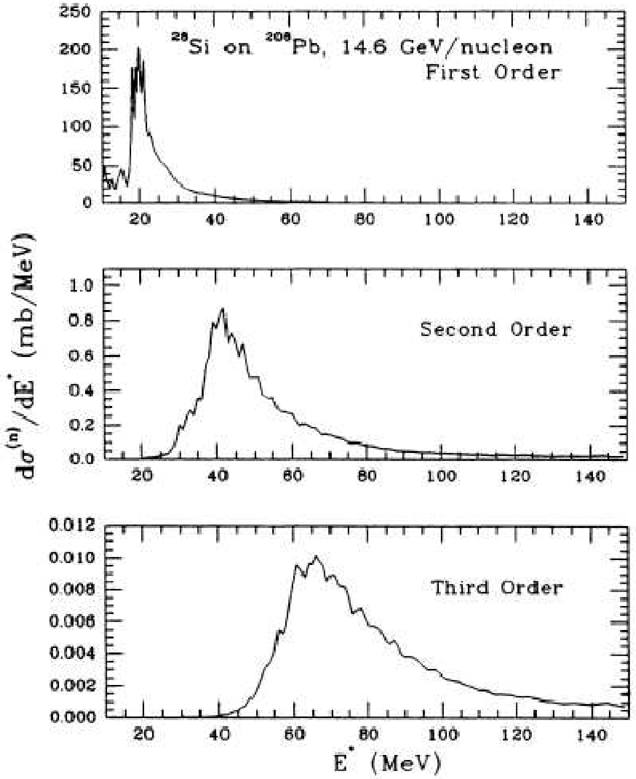
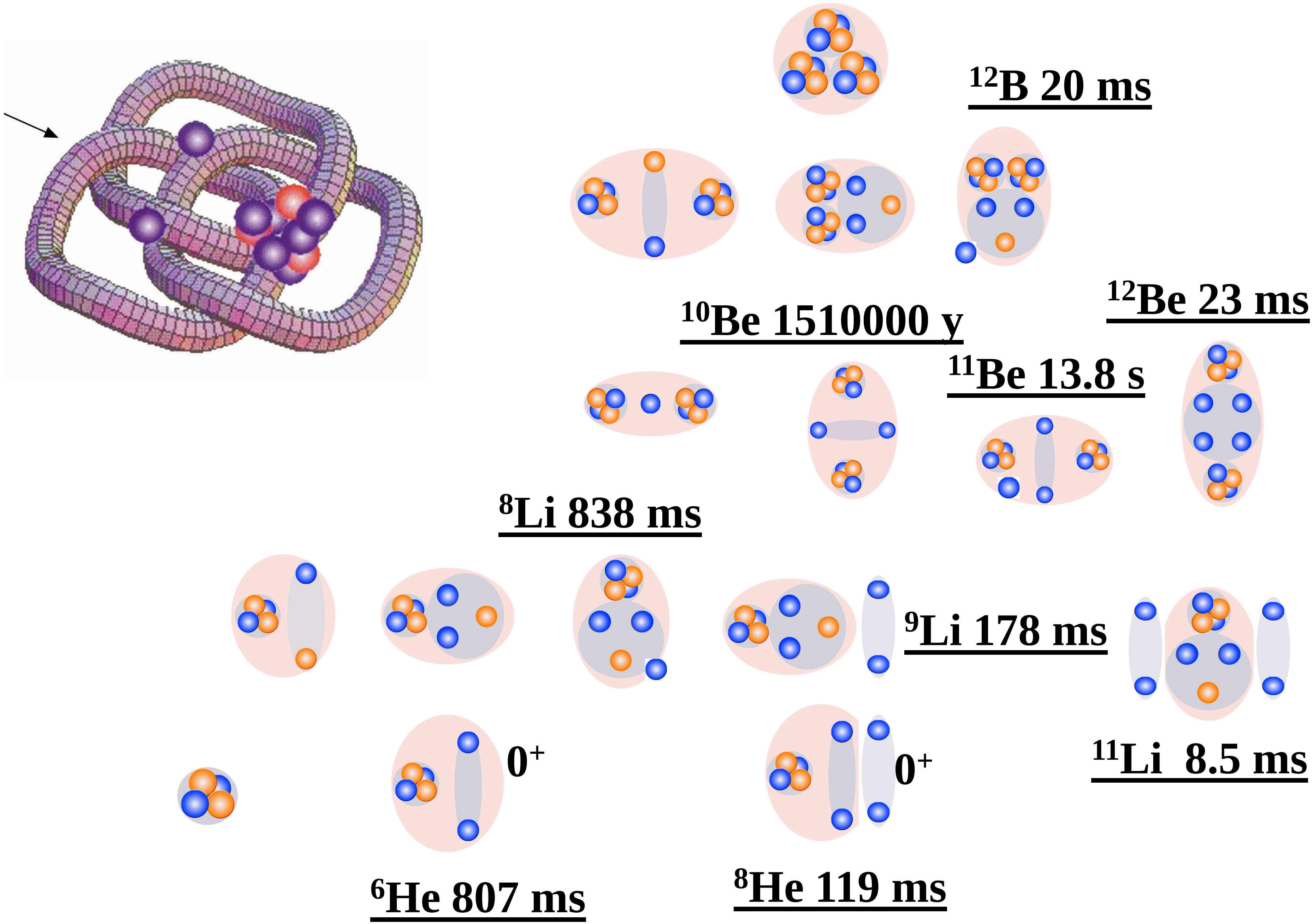


FIG. 3. The total differential Coulomb excitation cross sections for ^{28}Si on ^{208}Pb at $E_{lab}/A = 14.6$ GeV for the first-, second-, and third-order processes.


12B 20 ms
10Be 1510000 y
12Be 23 ms
11Be 13.8 s
8Li 838 ms
9Li 178 ms
0+
0+
11Li 8.5 ms
6He 807 ms
8He 119 ms

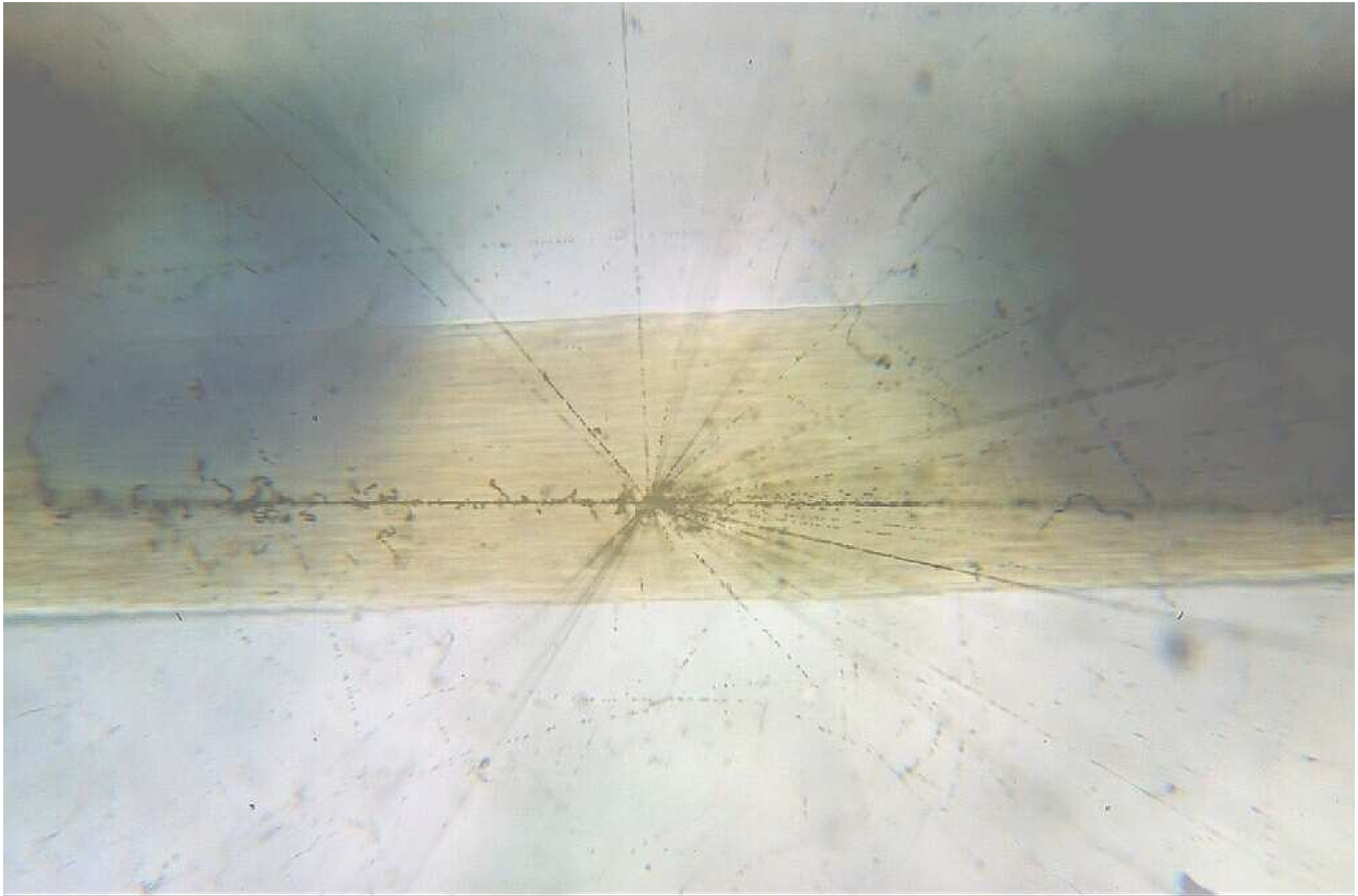
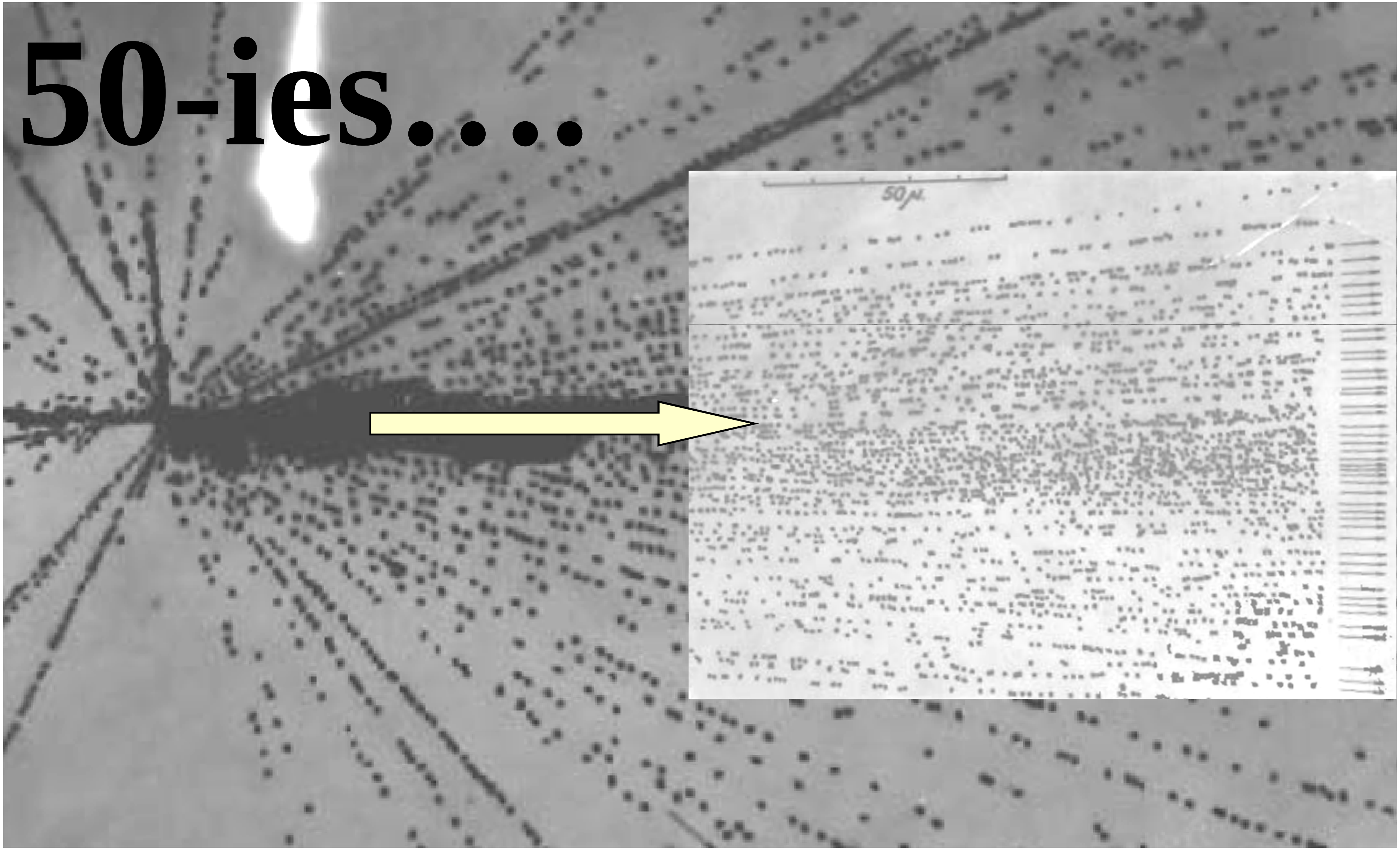


Photo of human hair superposed on nuclear star induced by relativistic sulphur nuclei in nuclear track emulsion

Lebedev PI (FIAN)

50-ies….



Dynamica ... rusts

Nuclear Theory ... N 47405

University ... 408

Dep

The nuclear p ... complex shapes — is exp ... novae at subnuclear dens ... ges from the competition ... ion, the nuclear pasta di ... ns could have a strong in ... h stellar environments. T ... ynamics simulation invol ... classical plasma oscillatio ... energies. Yet this low-ene ... entative heavy nucleus. ... likely to be a density wa

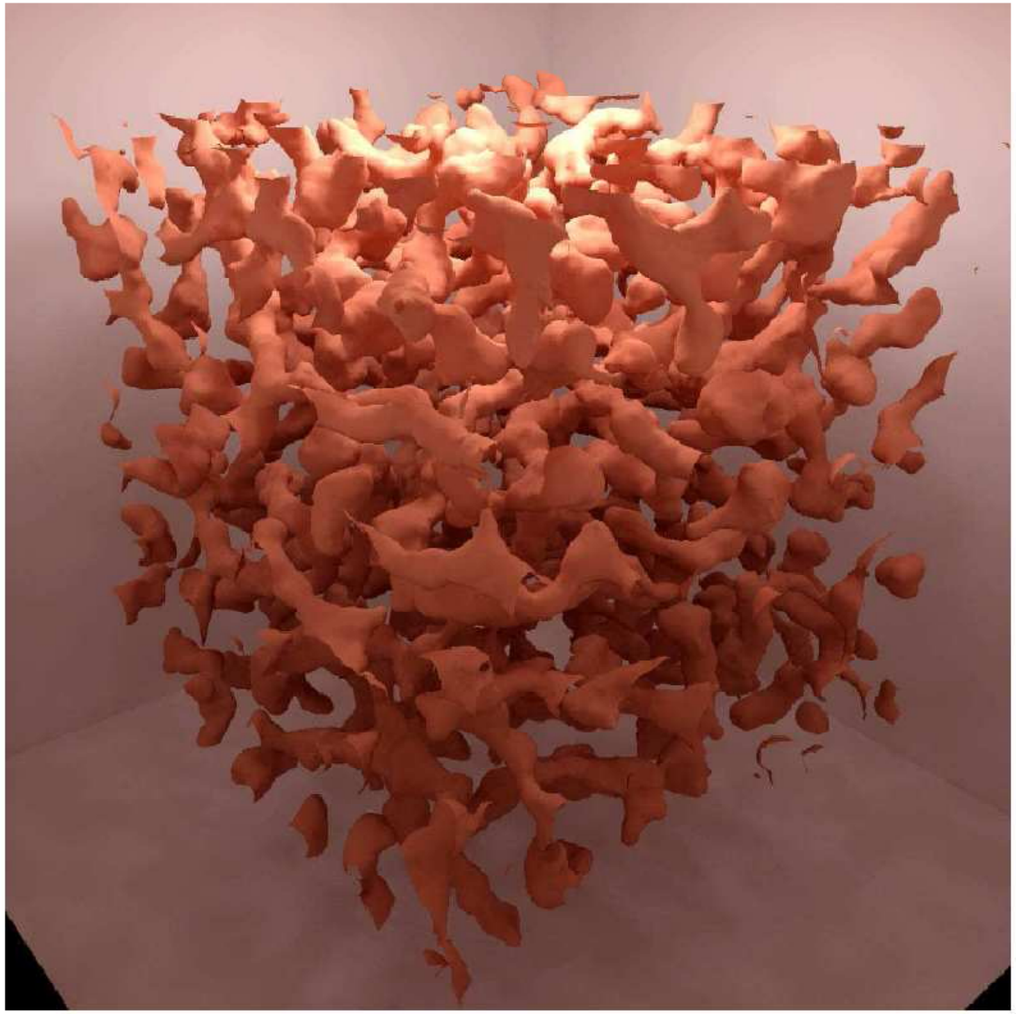
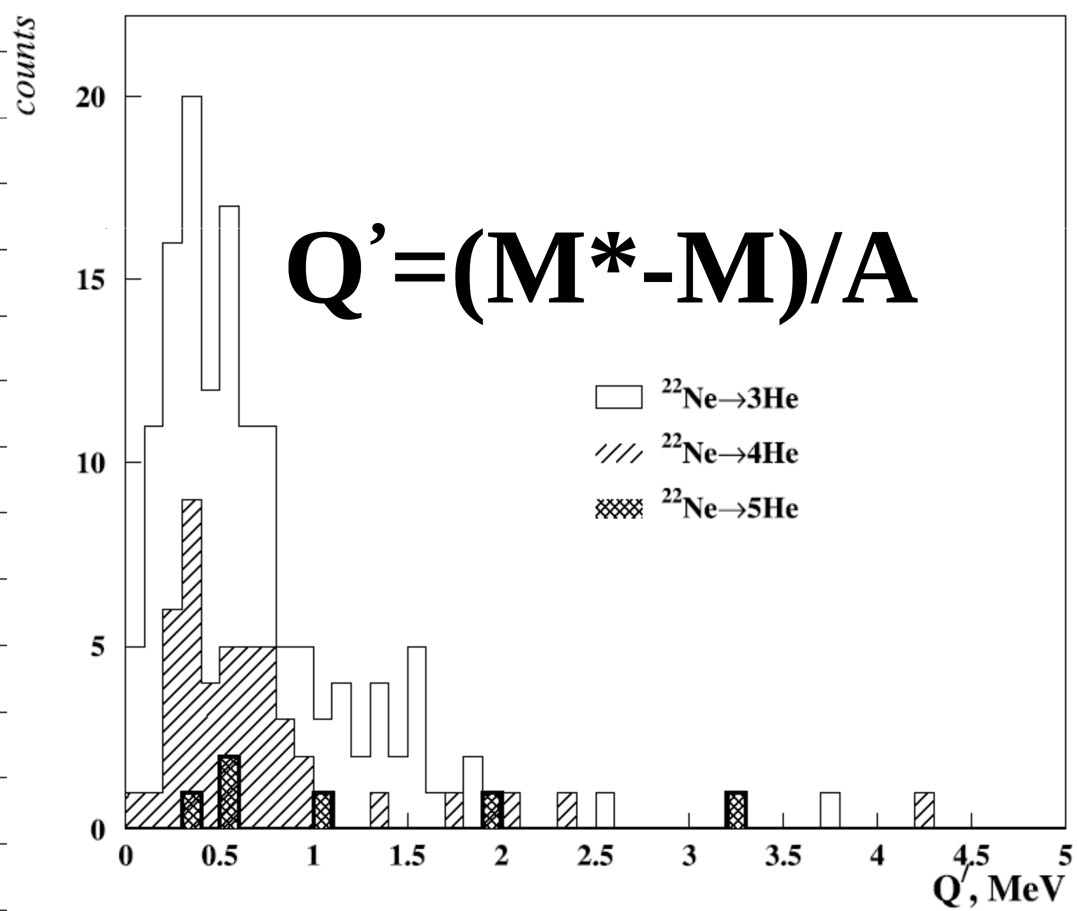


FIG. 1: (Color online) The 0.03 fm^{-3} proton density isosurface for one configuration of 100,000 nucleons at a baryon density of 0.05 fm^{-3}. The simulation volume is a cube of 126 fm on a side.

n_b	0	0	1	2	3	>3
n_g	0	1	0	0	0	0
F + H	26 (19.5)	9 (15.0)	13 (44.8)	2	-	1
O + He	54 (40.6)	19 (31.7)	2 (6.9)	-	1	
O + 2H	12 (9.0)	7 (11.7)	-	-	-	
N + He + H	12 (9.0)	7 (11.7)	4 (13.8)	1	-	
N + 3H	3 (2.3)	3 (5.0)	-	-	-	-
C + 2He	5 (3.8)	3 (5.0)	3 (10.3)			
C + 2He + 2H	5 (3.8)	3 (5.0)	3 (10.3)			
C + 4H	2 (1.0)	-	-			
B + Li + H	1 (0.8)	-	-			
B + 2He + H	2 (1.5)	1 (1.7)	-			
B + He + 3H	2 (1.5)	1 (1.7)	-			
B + 5H	1 (0.8)	-	1 (3.4)			
2Be + 2H	-	1 (1.7)	-			
Be + Li + 3H	1 (0.8)	-	-			
Be + 3He	2 (1.5)	-	-			
Be + He + 4H	1 (0.8)	-	-			
Li + 3He + H	-	1 (1.7)	-			
5He	3 (2.3)	-	1 (3.4)			
4He + 2H	1 (0.8)	5 (8.3)	2 (6.9)			

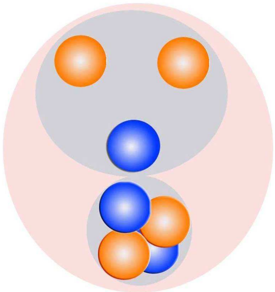
^{22}Ne 3.22A GeV
4100 Inelastic Interactions



$$Q' = (M^* - M)/A$$

High statistics analysis of ^{7}Be dissociation

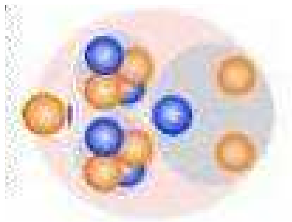
The BECQUEREL Collaboration performed irradiation of nuclear track emulsion in a mixed beam of ^{12}N, ^{10}C and ^{7}Be nuclei. Thus, there are new opportunities with regard to the issue of "dihelion" based on the analysis of the found about 400 "non-white" stars ^{7}Be → 2^{3}He with knocking out of a neutron and the formation of fragments of target nuclei or mesons, as in the case of ^{8}B → 2He + H. Thus, the indication to the existence of "dihelion" will be reviewed using a significantly larger statistics.

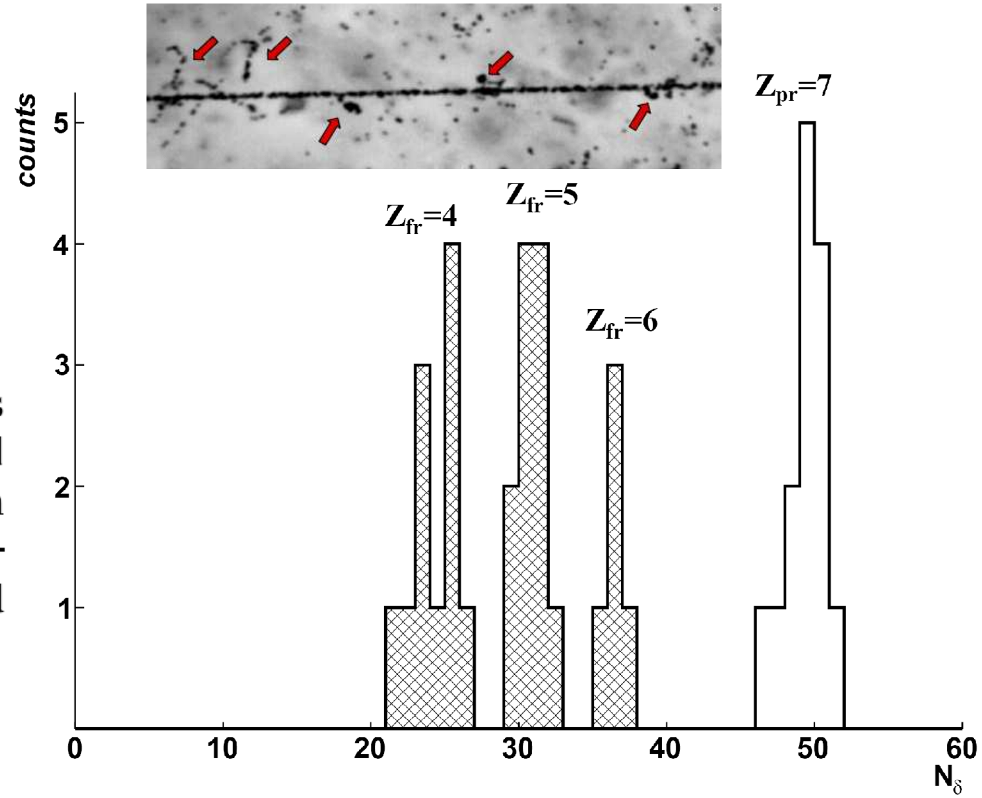


Distribution of the number of "white" stars, N_{ws}, and the number of events involving the production of target fragments, N_{tf}, with respect to $\sum Z_{fr} = 4$ channels

$\sum Z_{fr} = 4$	2He	He+2H	4H
N_{ws}	95	116	14
N_{tf}	371	554	16

Coherent dissociation of ^{12}N nuclei



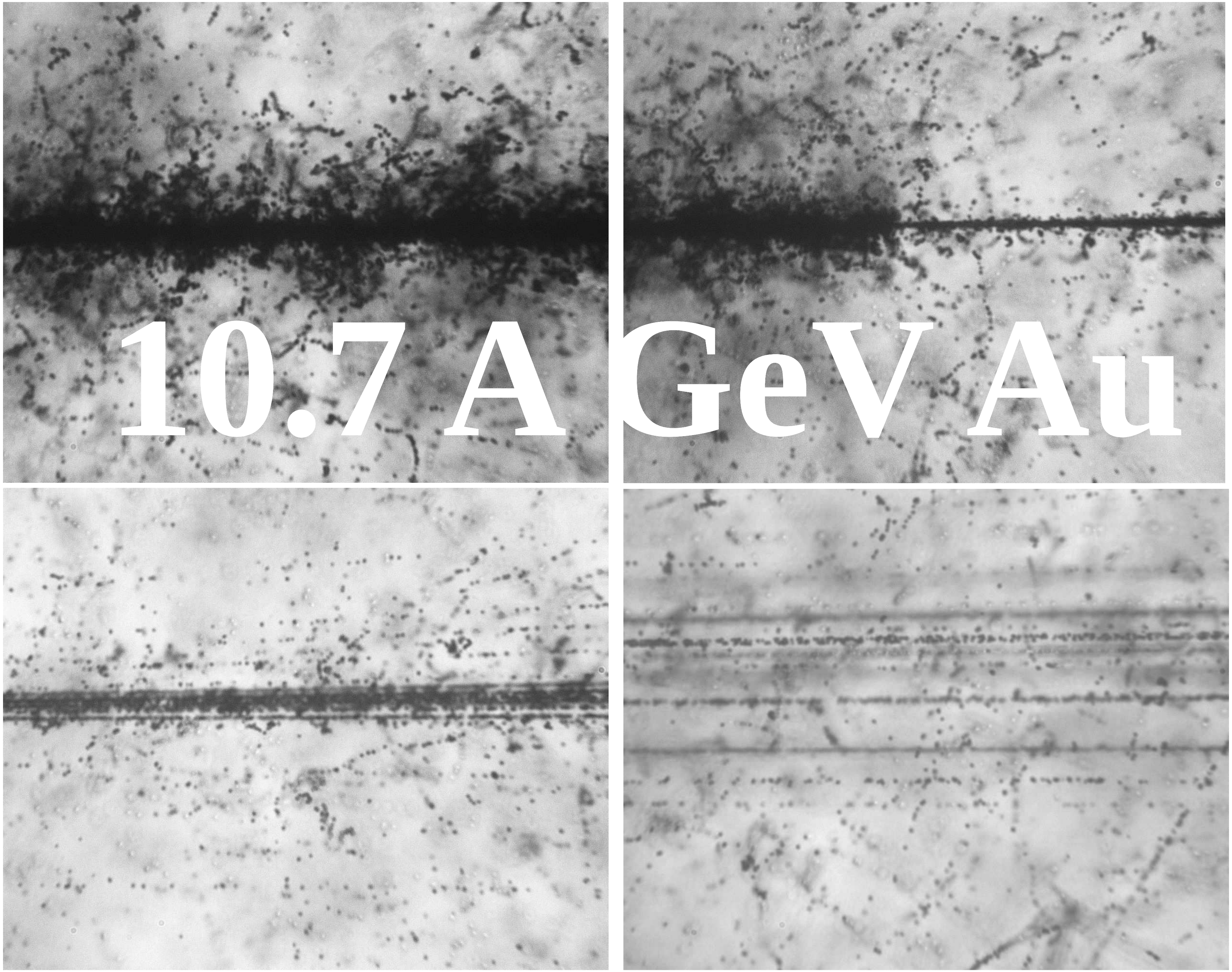


The particular feature of the ^{12}N nucleus consists in the low proton separation threshold (600 keV). Furthermore, the dissociation can occur through the channels α + ^{8}B (8 MeV), p + ^{7}Be + α, as well as into more complicated ensembles with the ^{7}Be core break.

In this irradiation 41 "white" stars N_{ws} with Z_{pr} = 7 and $\sum Z_{fr}$ = 7 are found, corresponding to the dissociation of ^{12}N nuclei. About half of the events contain a fragment $Z_{fr} > 2$, clearly differing from the cases of nuclei ^{14}N and ^{10}C.

Distribution of the number of “white” stars, N_{ws}, with respect to the channels $\sum Z_{fr}$ = 7 and Z_{pr} = 7

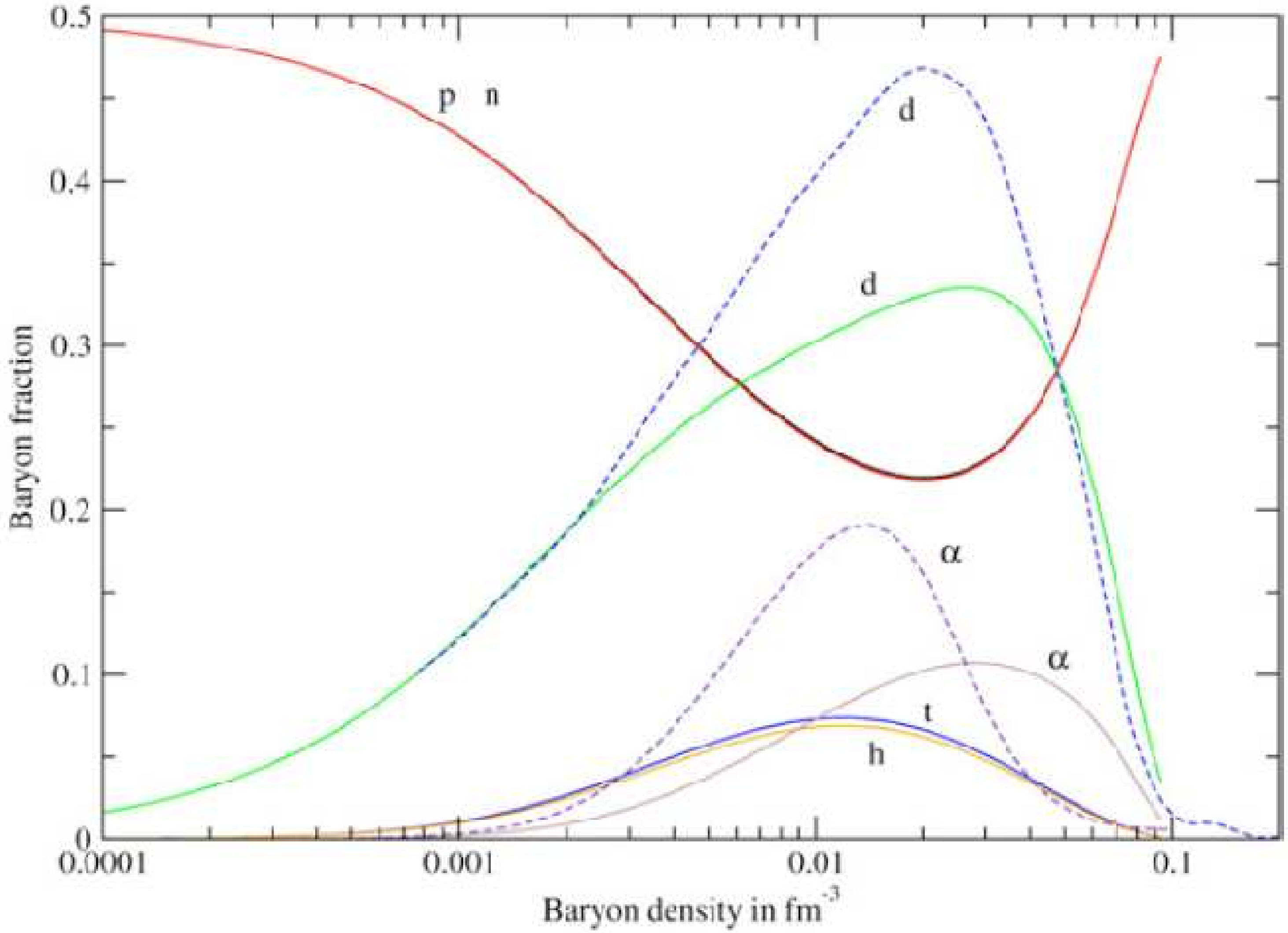
C + H	^{8}B + He	^{7}Be+He+H	^{8}B+2H	^{7}Be+3H	3He + H	2He + 3H	He +5H
5	6	6	5	5	2	10	2

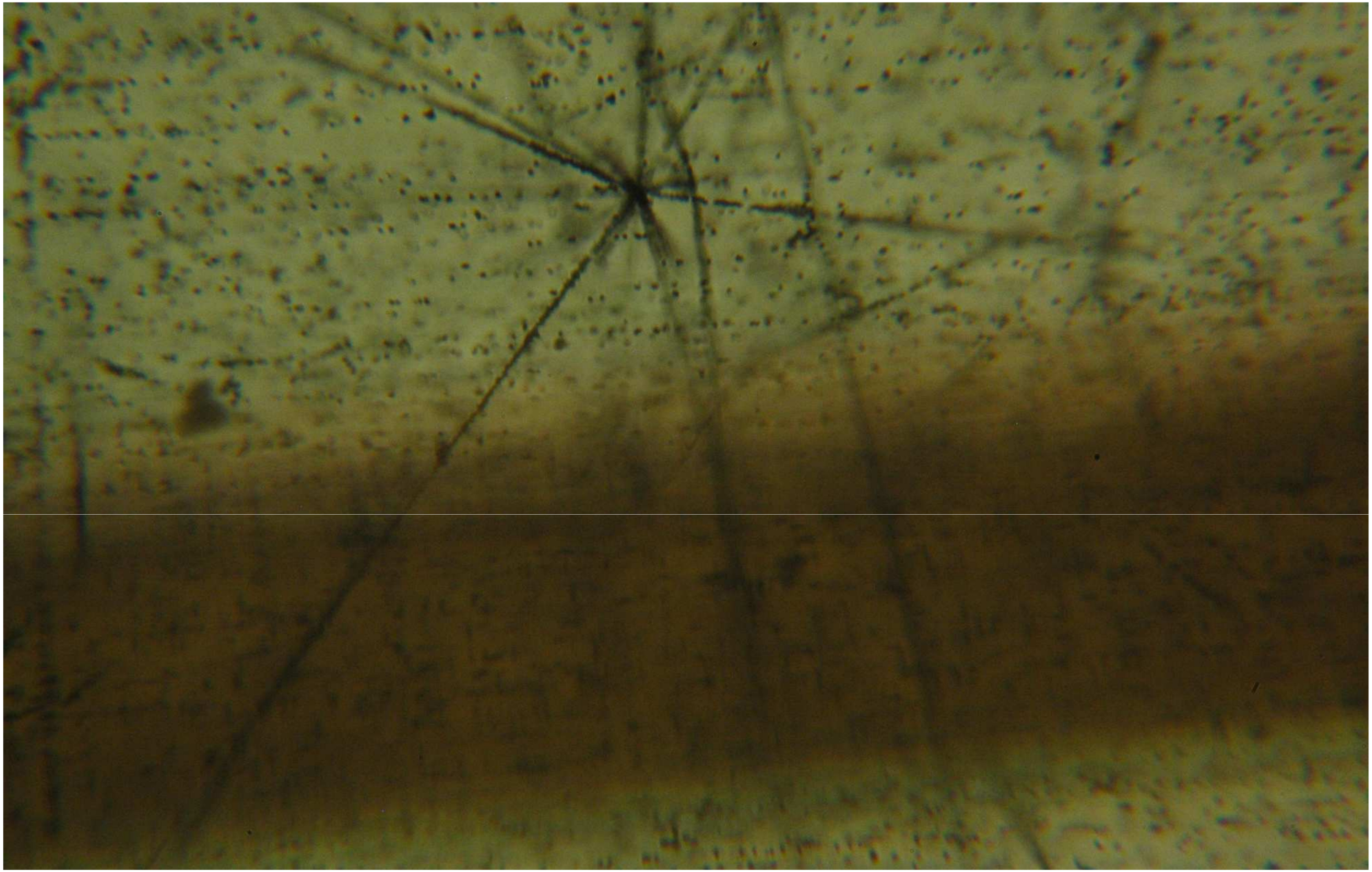

10.7 A GeV Au

Composition of symmetric nuclear matter

T=10 MeV

G.Ropke, A.Grigo, K. Sumiyoshi, Hong Shen, Phys.Part.Nucl.Lett. **2**, 275 (2005)





Close up of a nuclear star in nuclear track emulsion, exposed to the secondary particle beam (IHEP, Protvino). The beam is mainly represented by 5 GeV pions. The photo is taken with a 90-fold increase in the microscope lens. Tracks of minimum ionizing particles, giving grains of about 0.5 microns, can be seen clearly. For comparison, a hair is introduced in the vision field (about 30-40 microns).