Multiparticle He Fragmentation of ^{22}Ne, ^{24}Mg and ^{28}Si in Emulsion at 4.1- 4.5 A GeV/c.

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BECQUEREL Collaboration

I. Experimental details.

- NIKFI BR-2 stacks of nuclear emulsions, 600μm thick, have been exposed horizontally to the α conjugate nuclei ^{22}Ne, ^{24}Mg and ^{28}Si at the DUBNA synchrophasotron.
- Only the collisions with three and more He fragments in the final state – $N_{He}{}^{3}3$ have been used for the analysis.
- Only the collisions with the sum charge in the narrow forward cone, been approximately equal to that of projectile one – $\Sigma Z_{fr} = Z_0 \pm 1$, have been analyzed.
- Limitation $\Sigma Z_{fr} = Z_0 \pm 1$ means that extra peripheral collisions have been selected for analyses only.
- Peripheral collisions usually have very limited number of target fragments and produced particles.

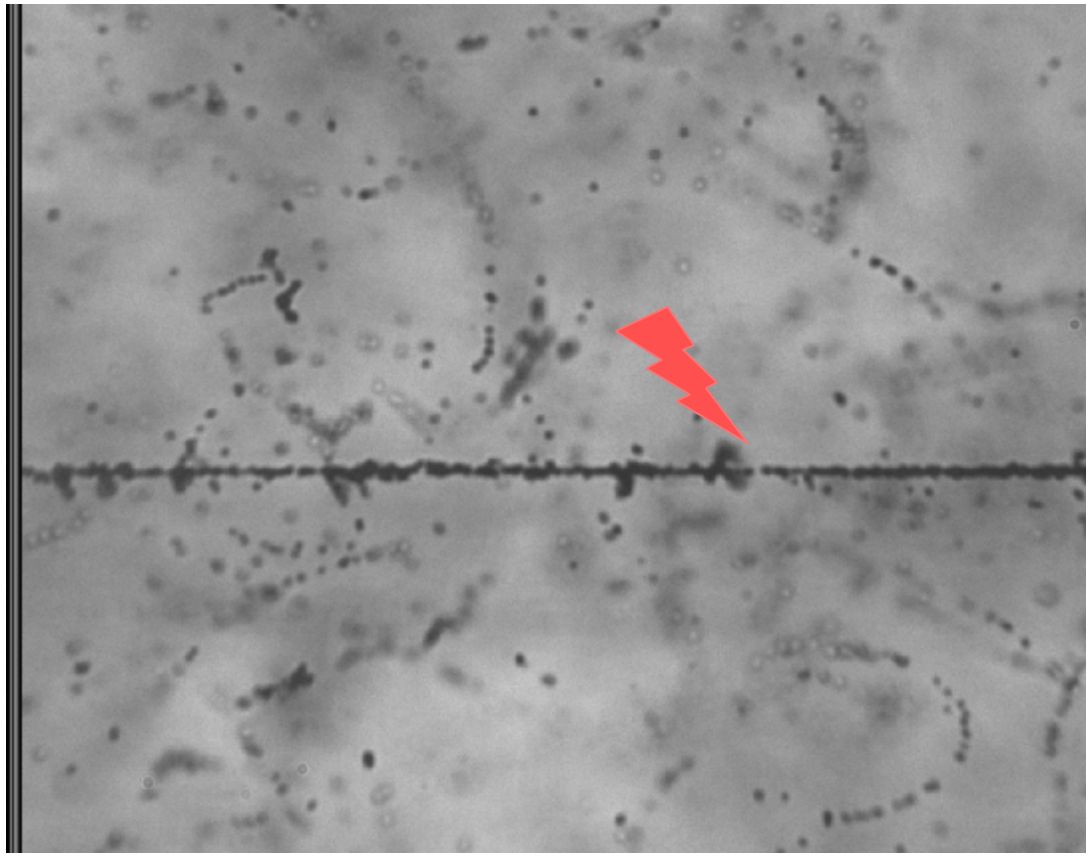
An example of ^{28}Si interaction with 6 He fragments.

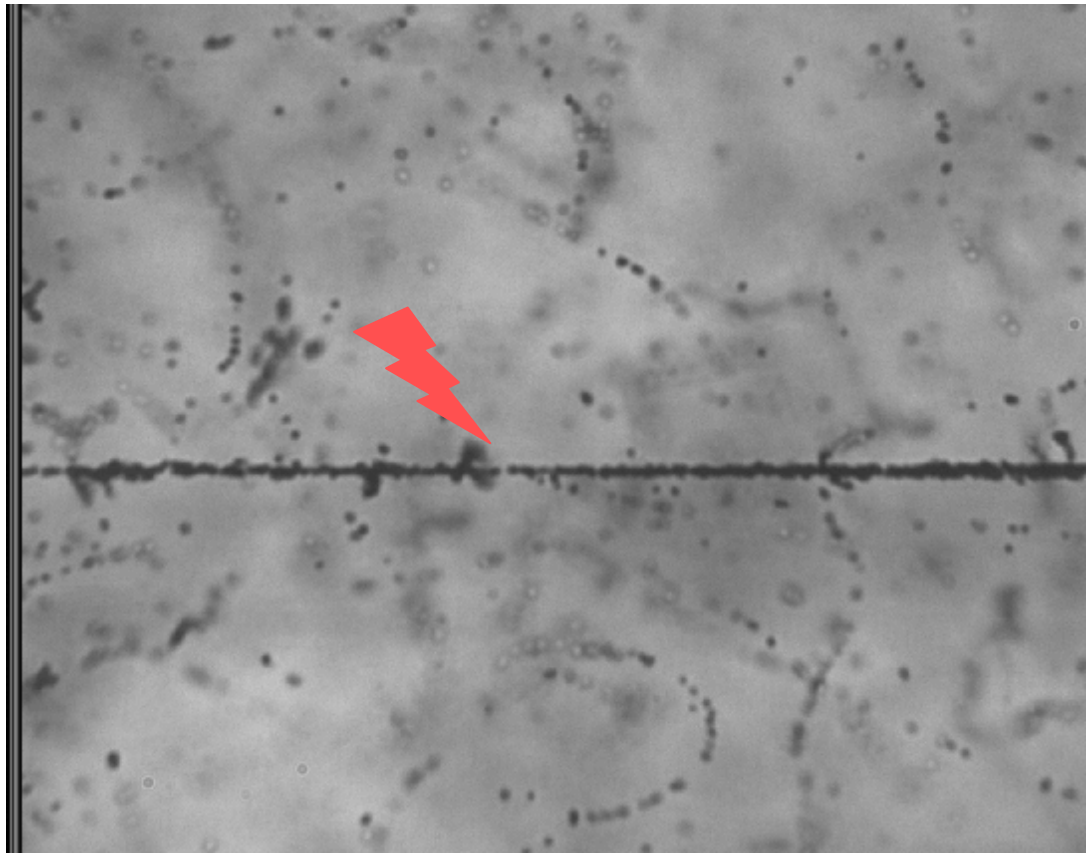
The sum charge in the narrow forward cone (Θ°<2.55°)

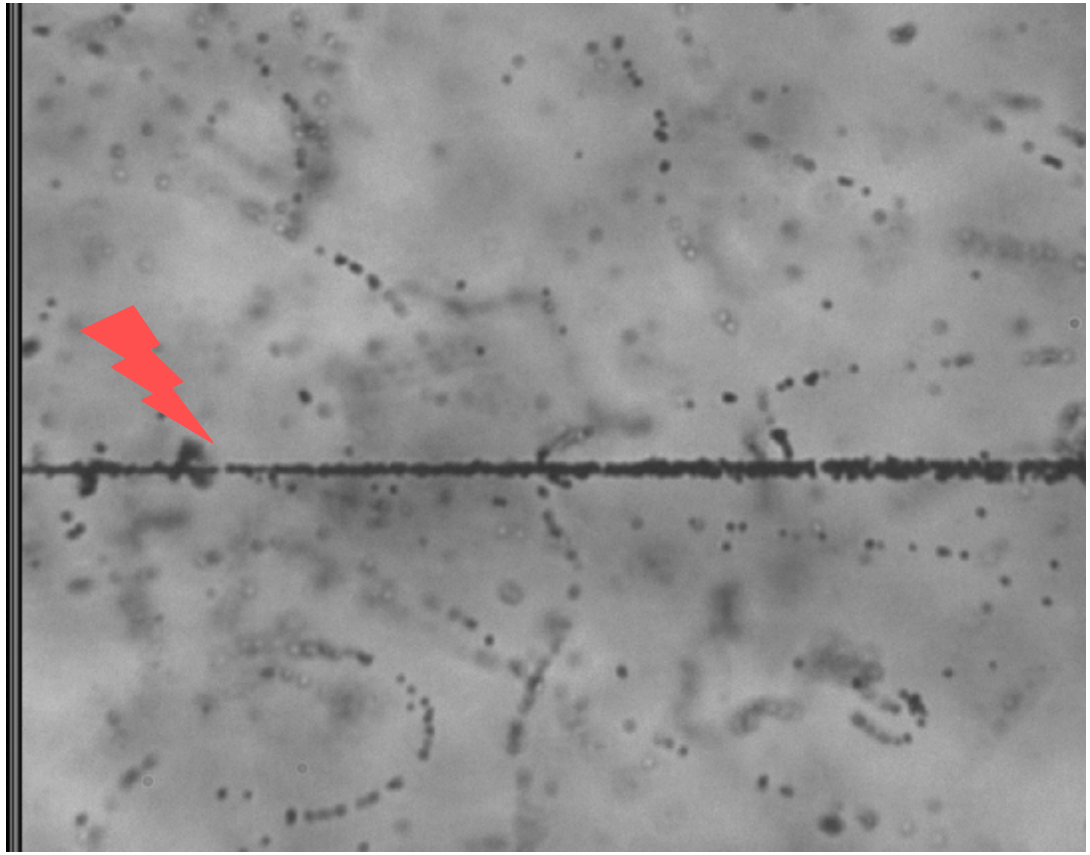
is equal to ΣZfr = 2x6+1 = 13

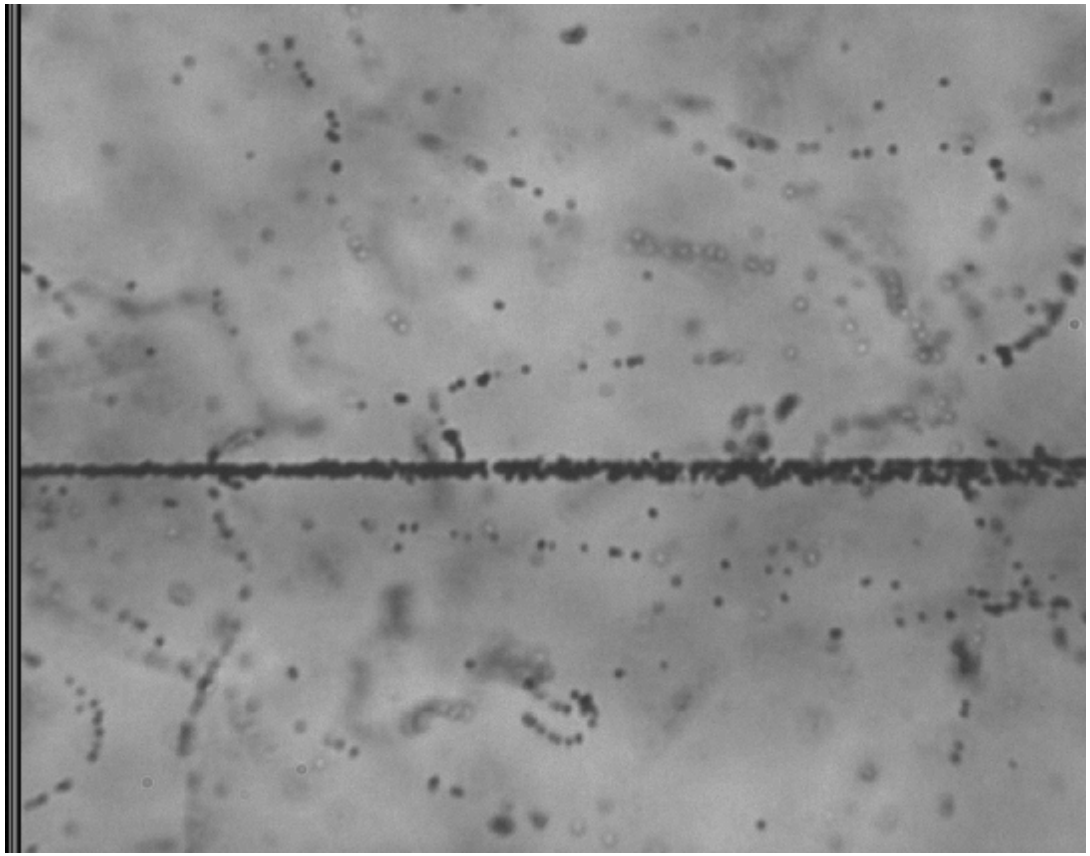
	N	Z	A	Θ°	Ψ°	φ°	α°	P,GeV/c
fr	1.	2.	4.	0.13	224.80	-0.09	-0.09	19.4±5.0
	2.	2.	4.	0.48	16.80	0.46	0.14	22.1±7.0
	3.	2.	3.	0.52	35.66	0.42	0.31	13.1±3.5
	4.	2.	4.	0.60	80.32	0.10	0.60	17.0±2.0
	5.	2.	4.	0.74	129.49	-0.47	0.57	19.1±3.1
	6.	2.	3.	1.77	75.86	0.43	1.72	12.1±2.9
	7.	1.		0.30	119.27	-0.15	0.26	
	8.	1.		6.48	174.58	-6.45	0.61	
	9.	1.		20.85	236.59	-11.85	-17.28	

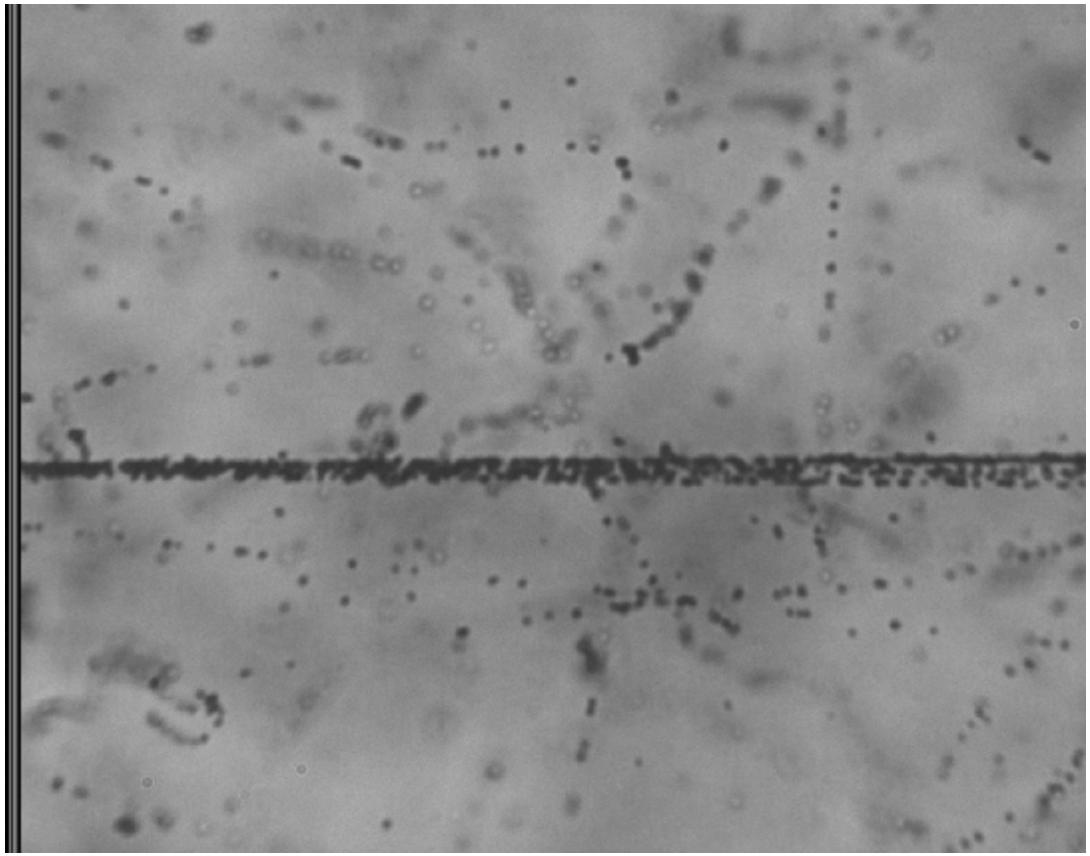
So it looks like in photoemulsion.

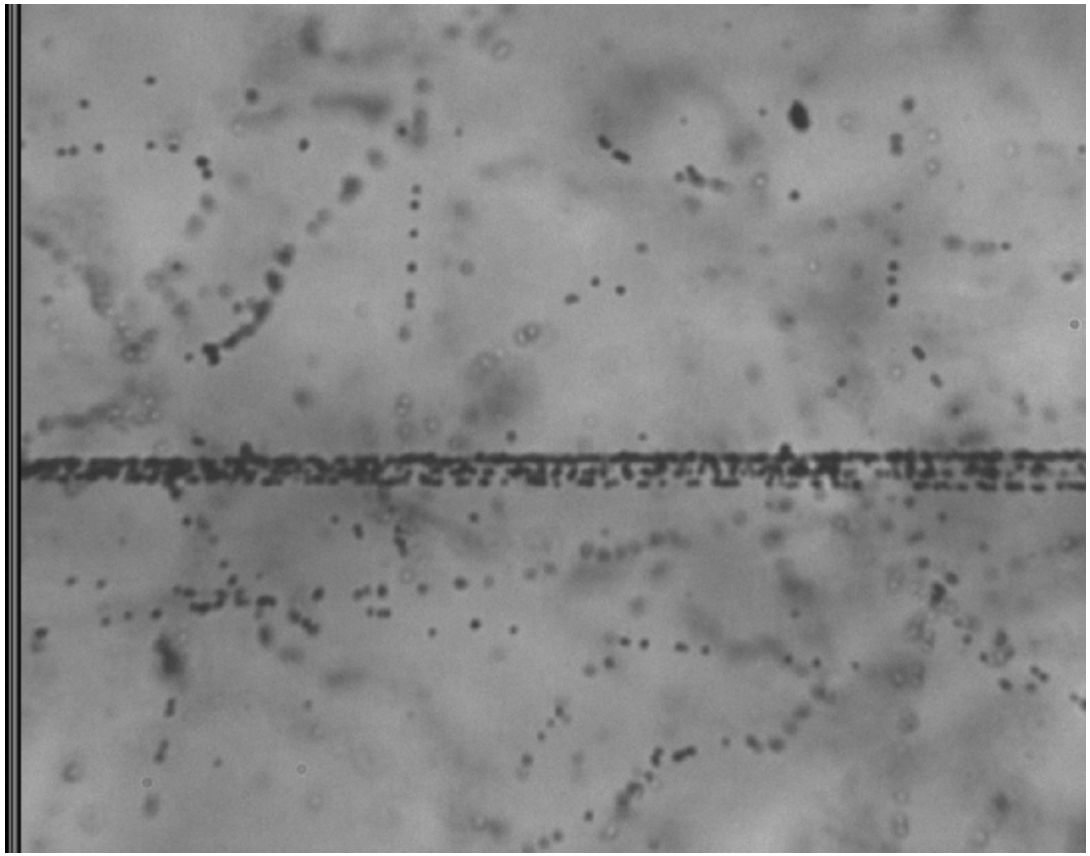


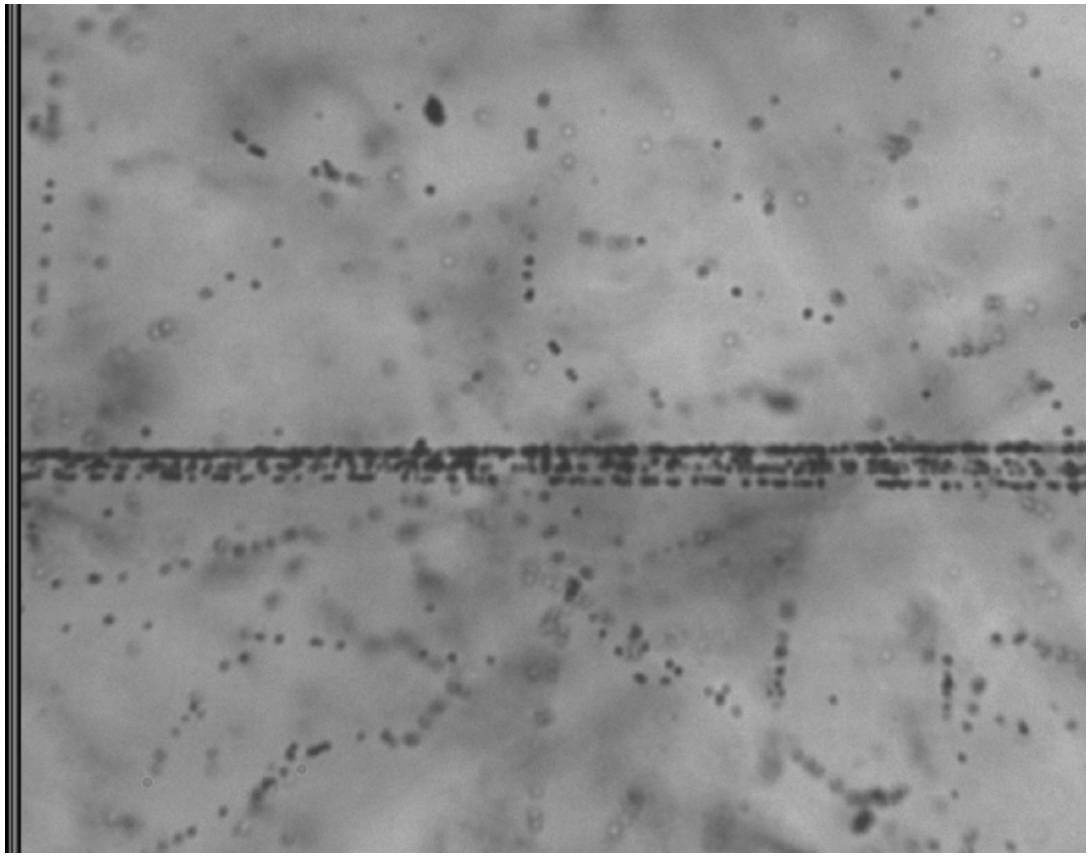


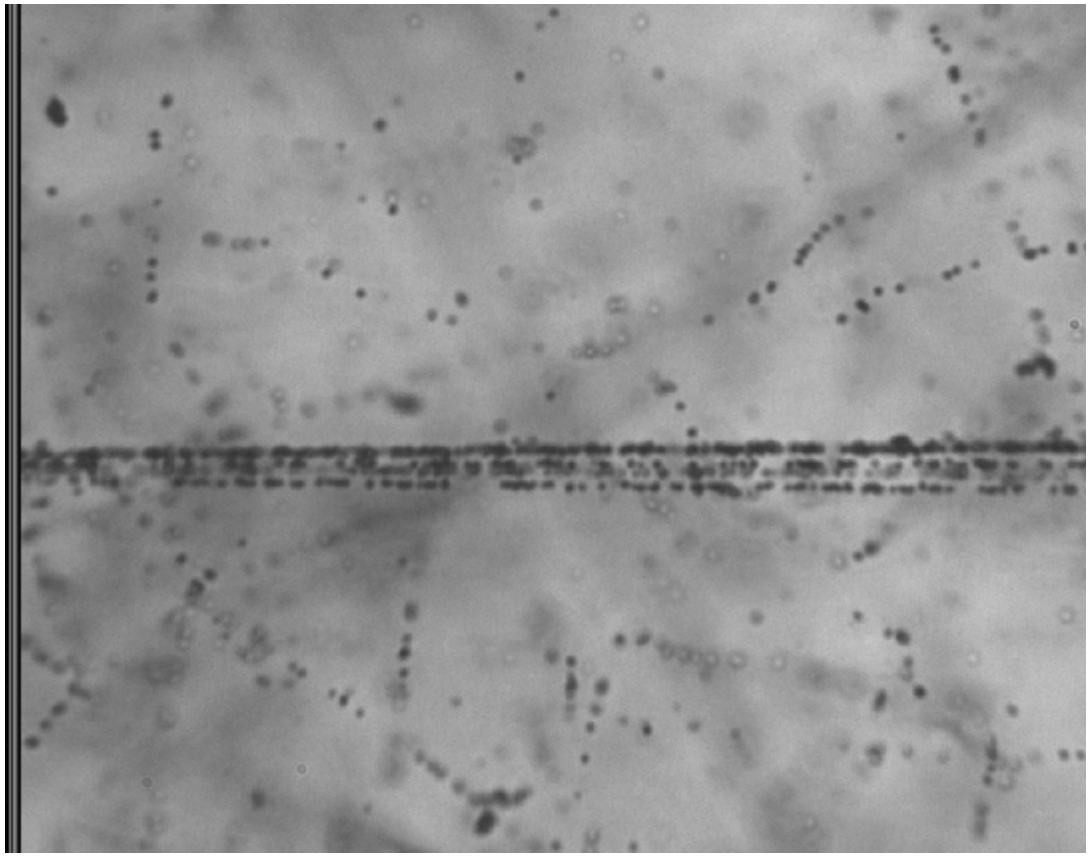




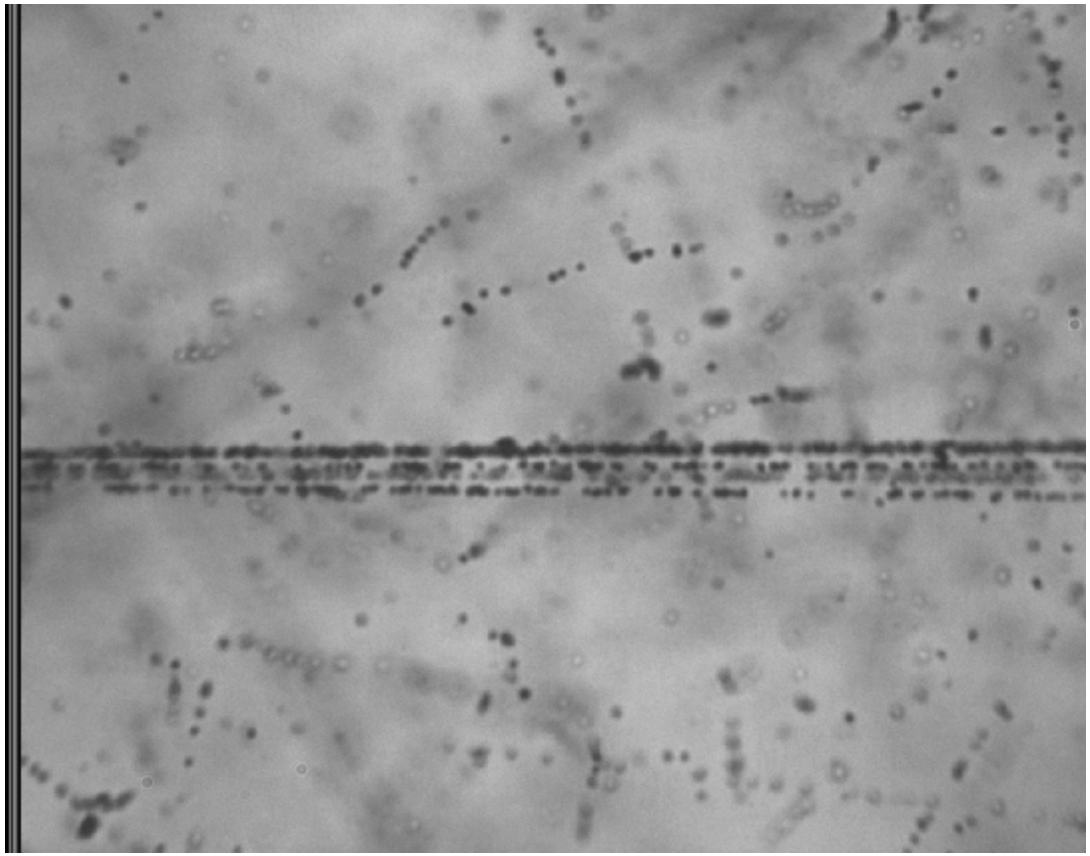








300 mkm from collision center.



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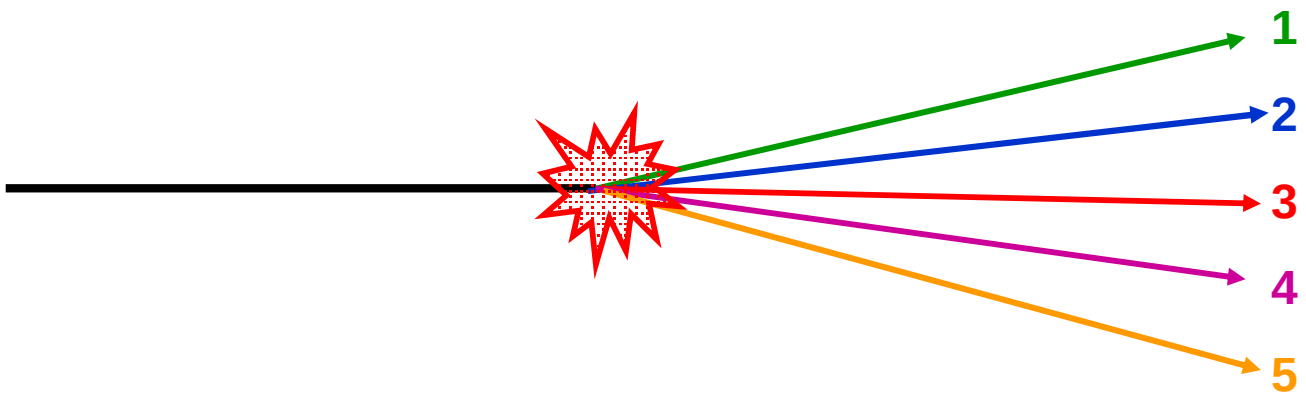
II. The statistics of collisions used for analyses.

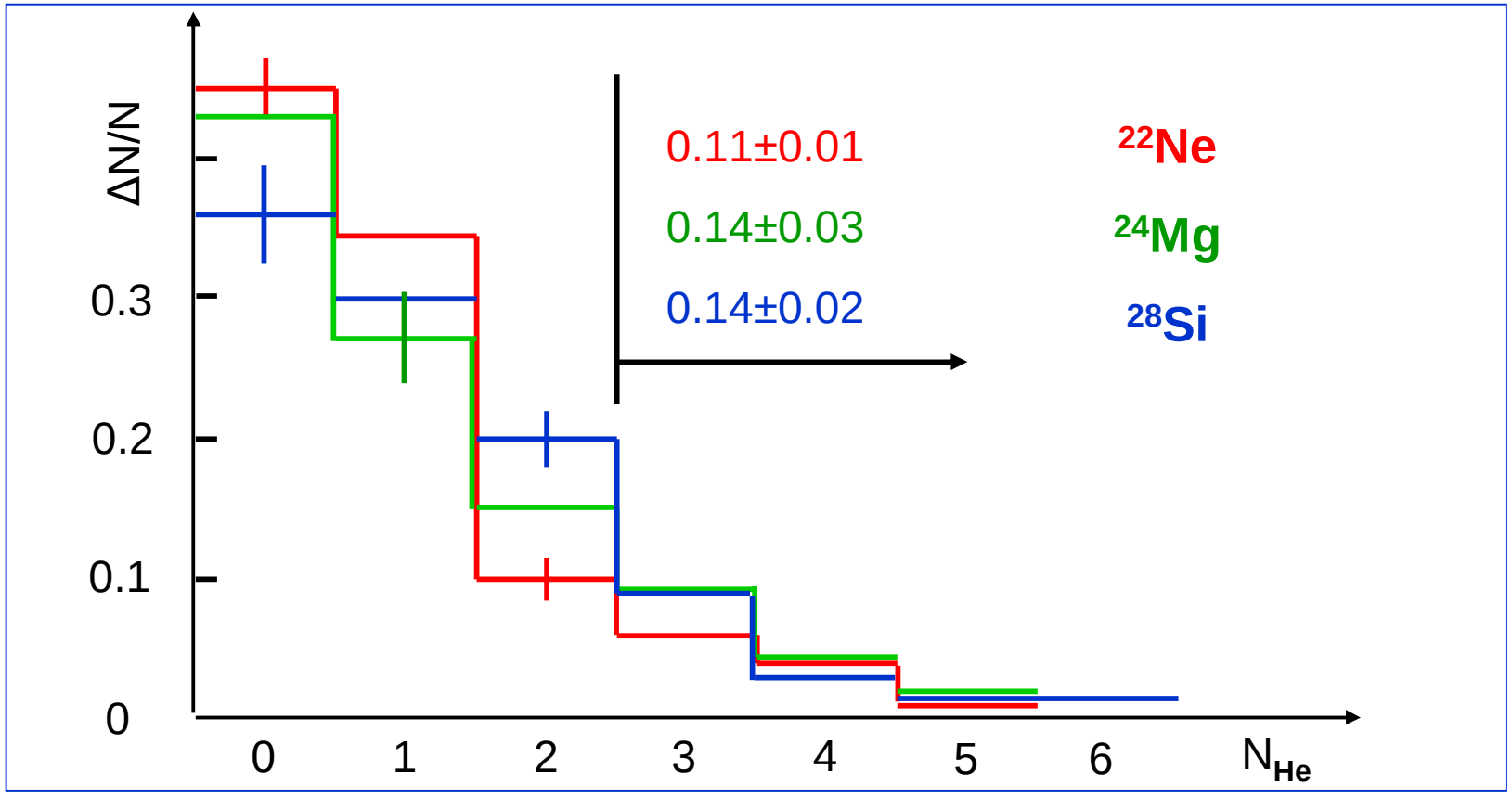
It isn't minimum bias data set.

A_0	P_0, GeV/c	(N_{He}=3)	(N_{He}=4)	(N_{He}=5)	(N_{He}=6)
^{22}Ne	4.1	238	79	10	
^{24}Mg	4.5	28	45	8	1
^{28}Si	4.5	107	40	21	13

III. The multiplicities of He fragments

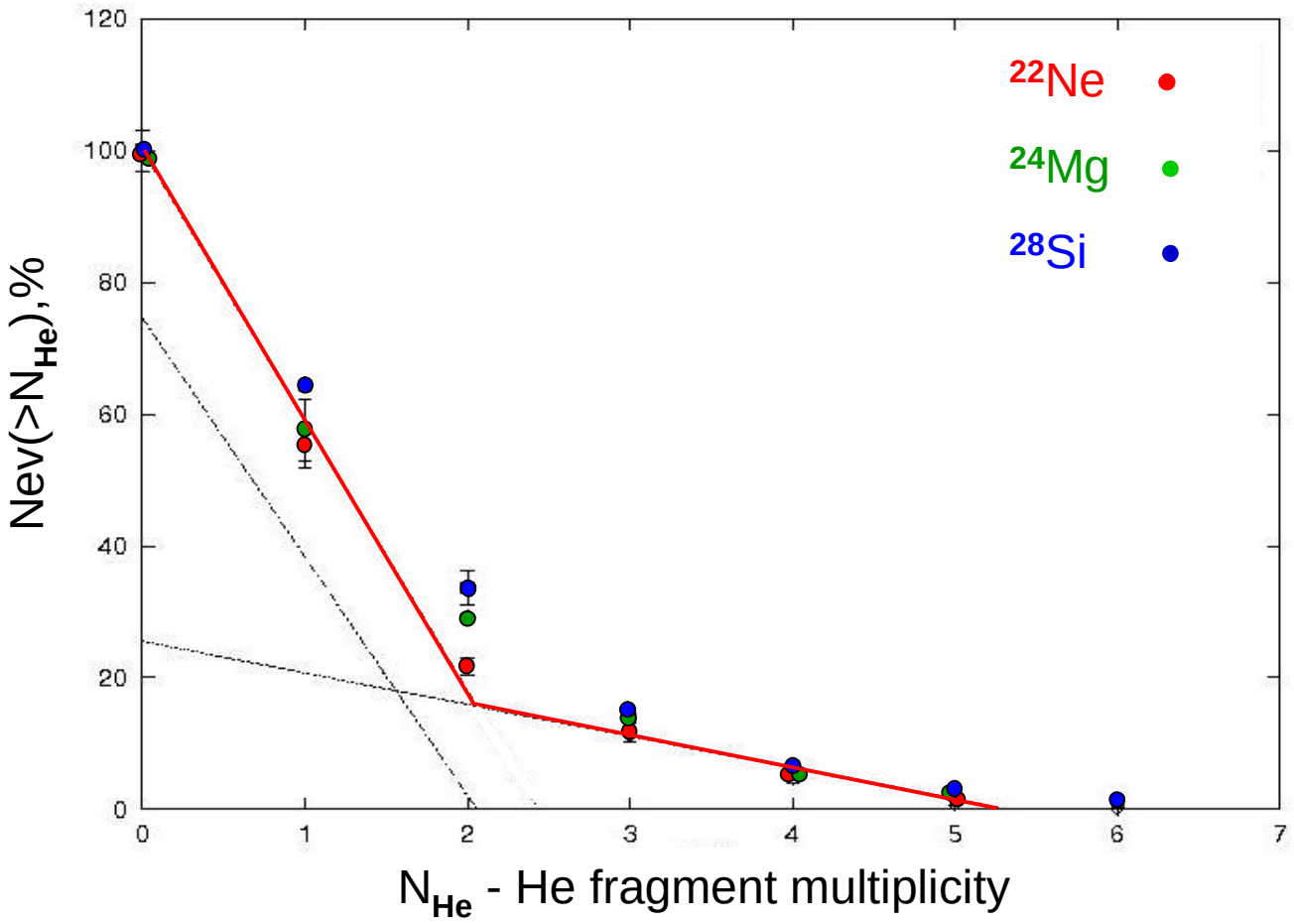


The multiplicity distributions of He fragments

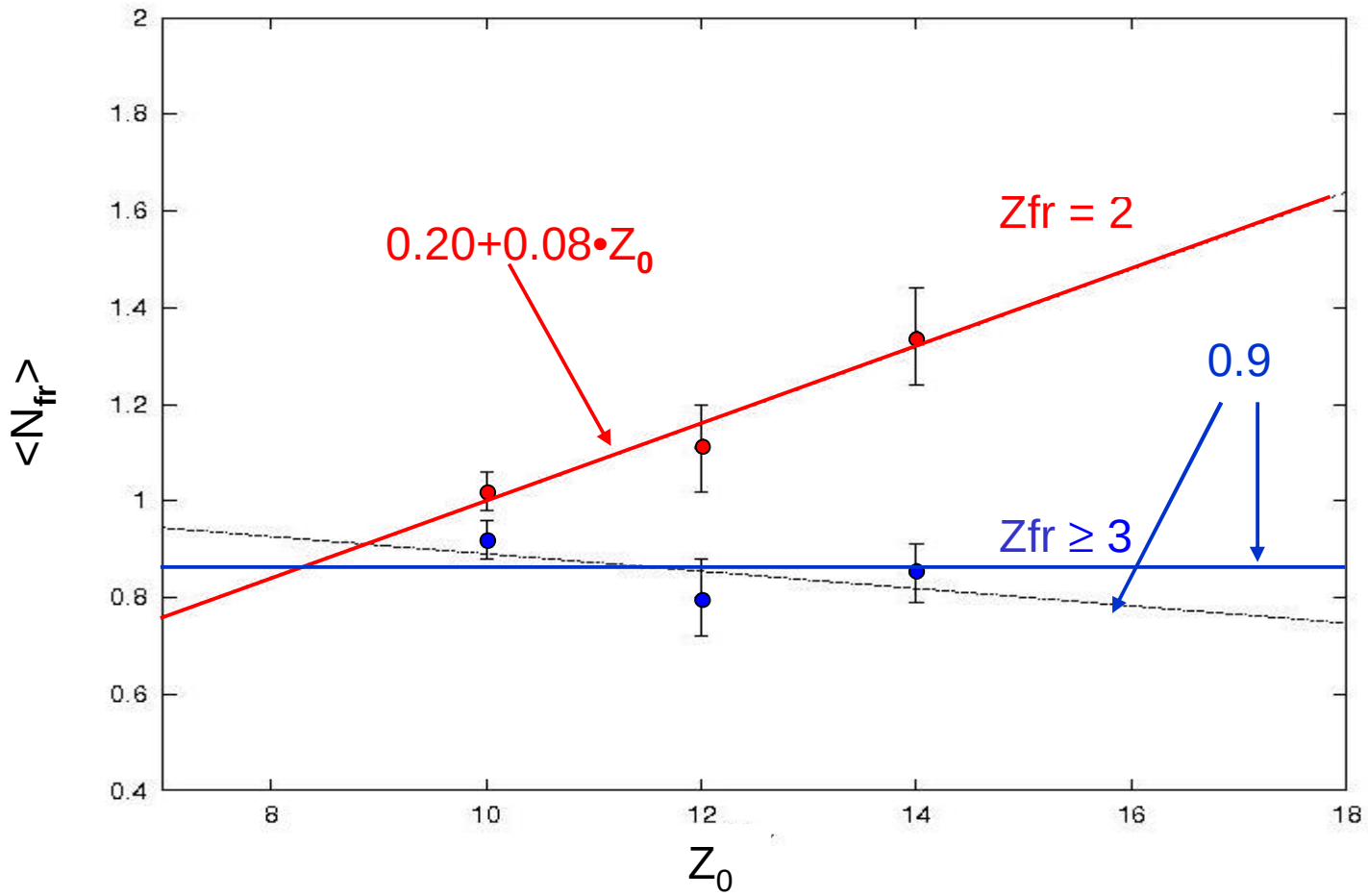


Integral multiplicity distribution of He fragments has a break at $N_{He}=2$.

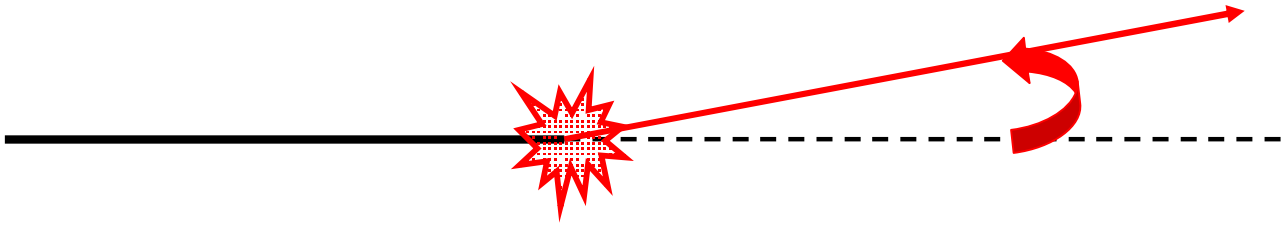
It is minimum biased data set.

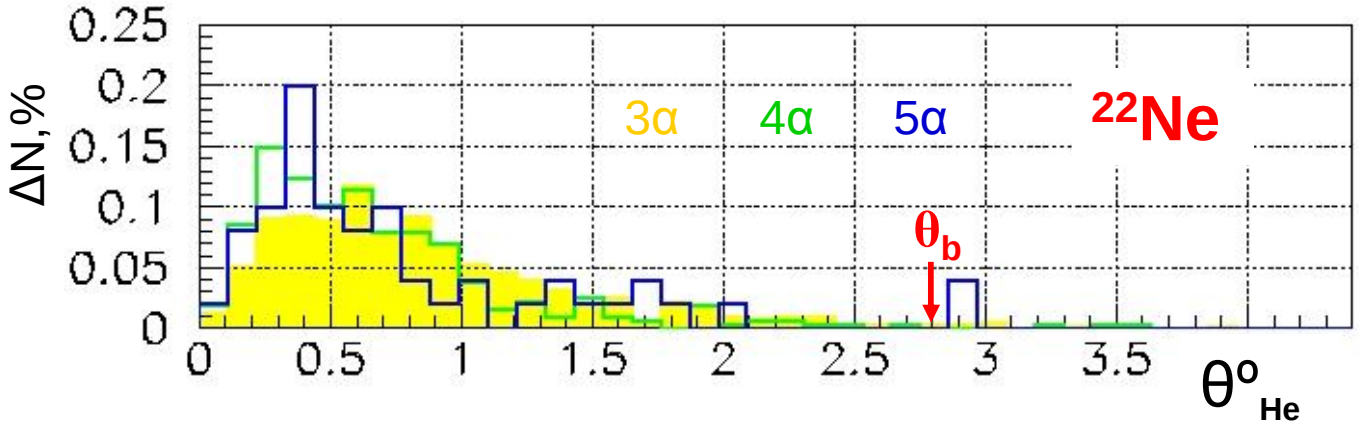


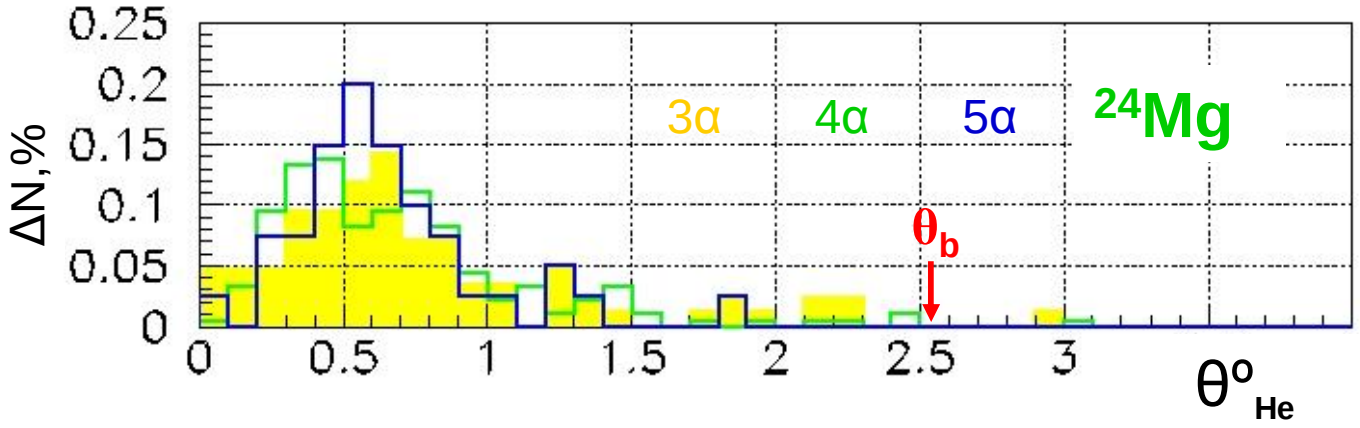
Dependence of average number of projectile fragments with Zfr = 2 and Zfr ³ 3 on the projectile charge Z_0.

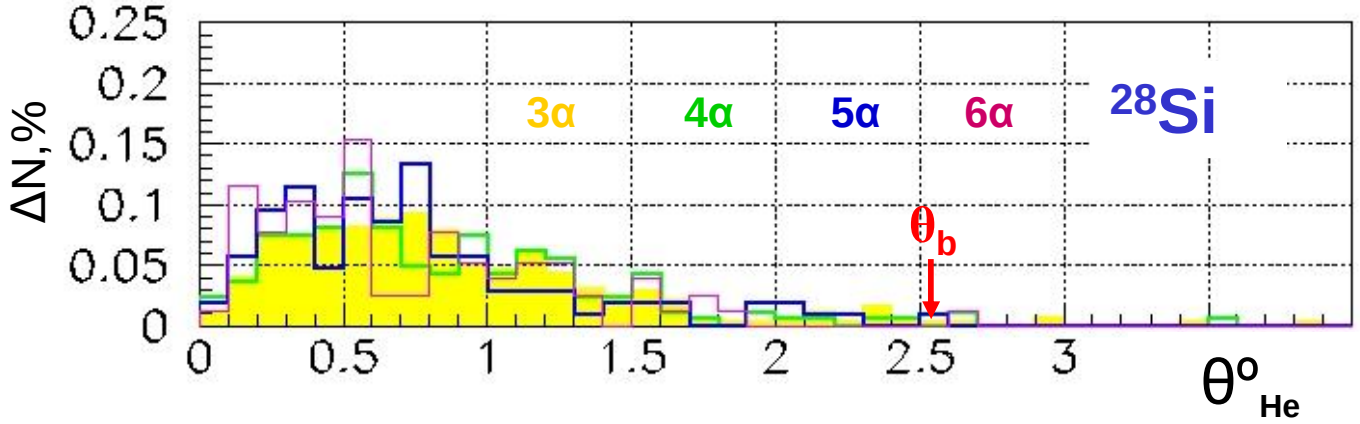


IV. The angles of He fragments







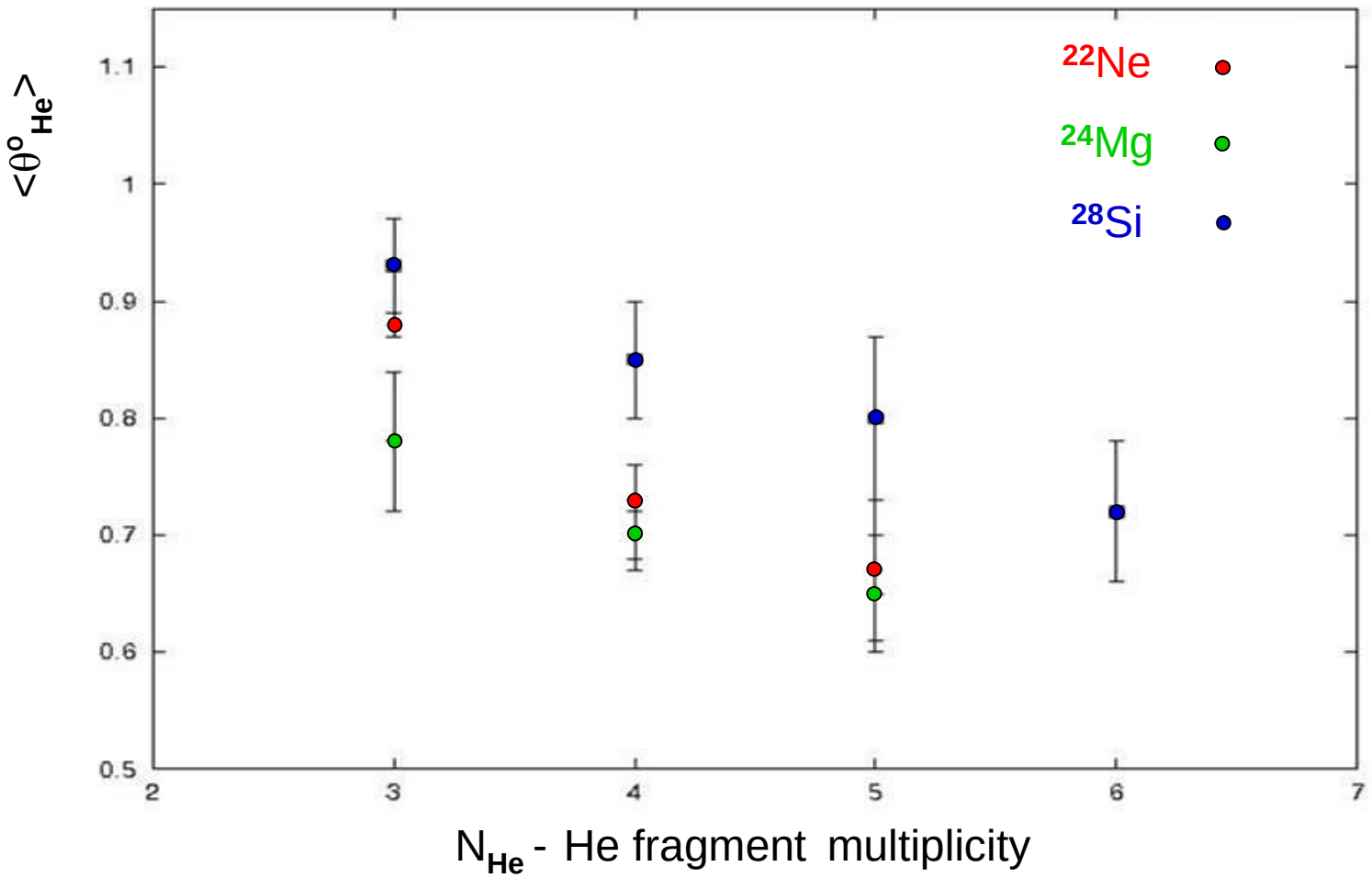


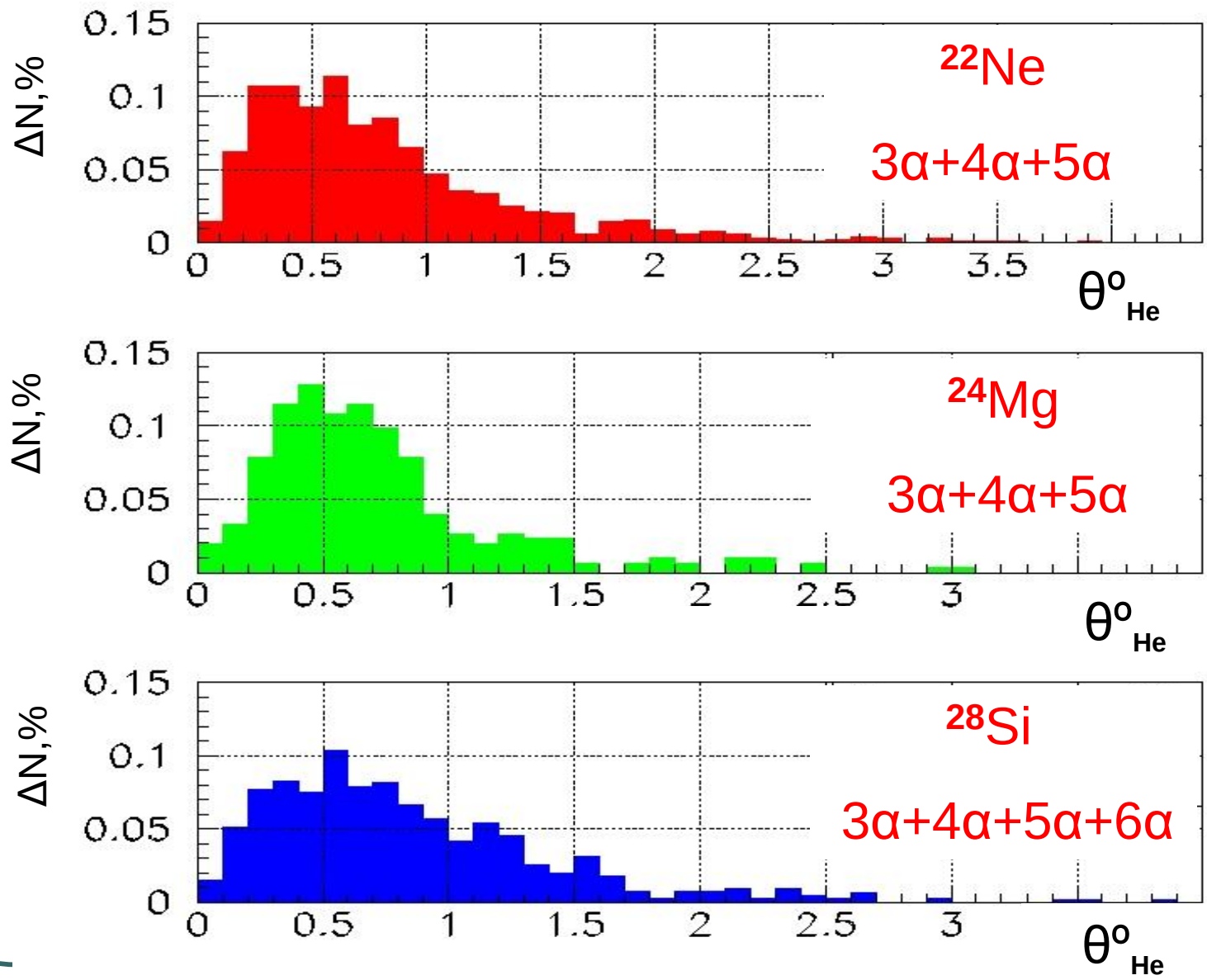
Angular distributions of He fragments

The projectile fragmentation cone is defined by a boundary angle θ_b:

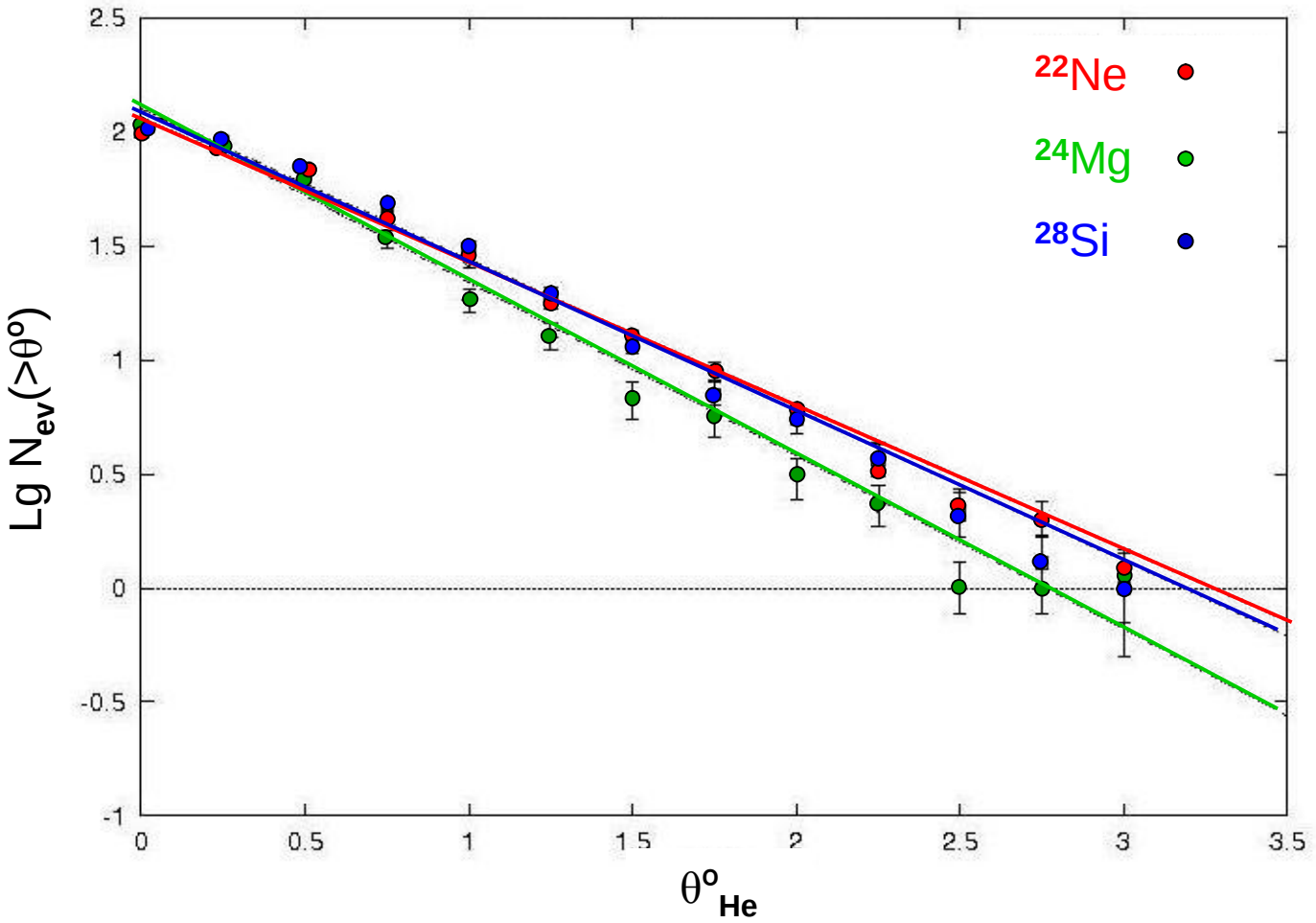
$\mathrm{Sin}\theta_b = 0.2/\mathrm{Po}$.

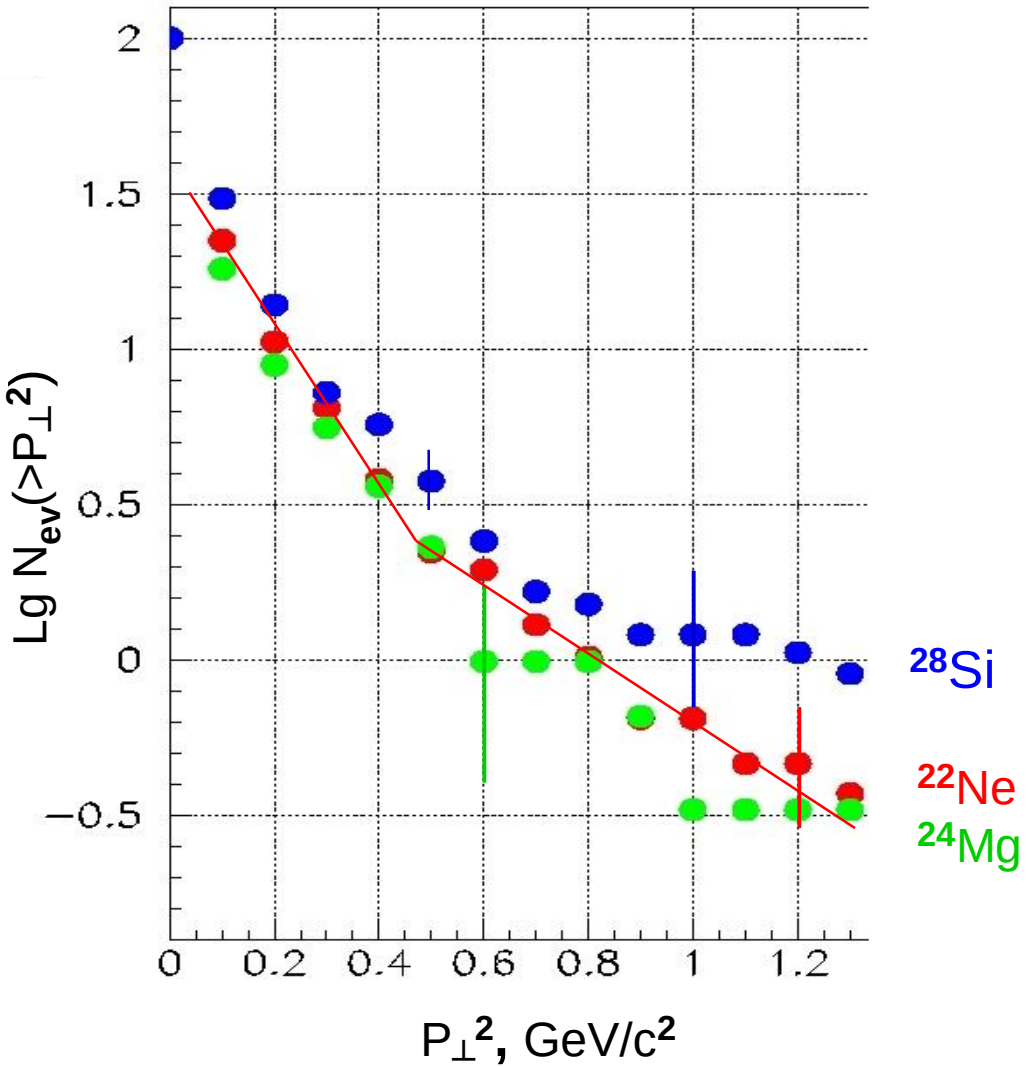
Angles of He fragments decreases with increasing of He fragment multiplicity in collision.




ΔN,%
0.15
0.1
0.05
0
0
0.5
1
1.5
2
2.5
3
3.5
^{22}Ne
3α+4α+5α
θ°$_{He}$
ΔN,%
0.15
0.1
0.05
0
0
0.5
1
1.5
2
2.5
3
^{24}Mg
3α+4α+5α
θ°$_{He}$
ΔN,%
0.15
0.1
0.05
0
0
0.5
1
1.5
2
2.5
3
^{28}Si
3α+4α+5α+6α
θ°$_{He}$

Integral angular spectrum of He fragments may be fitted by a line.



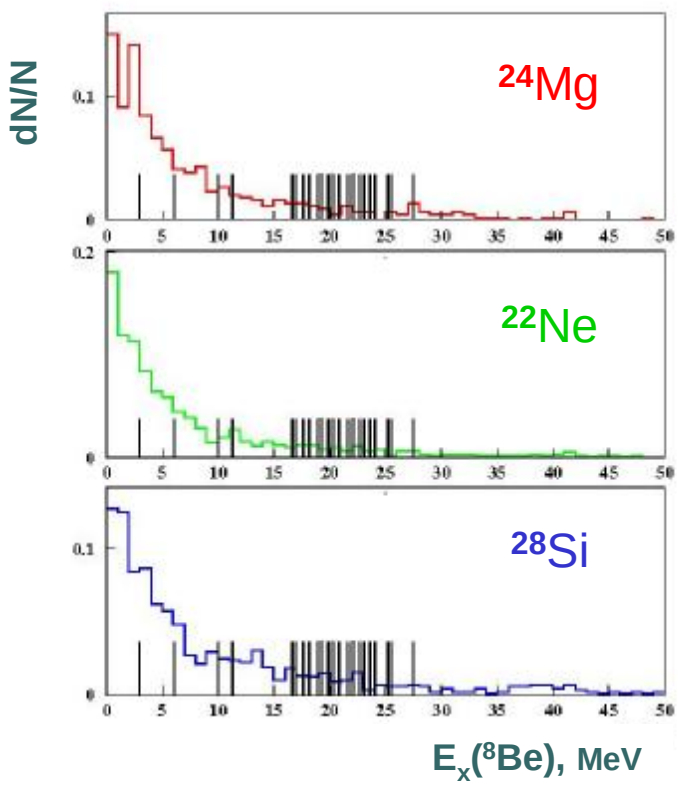


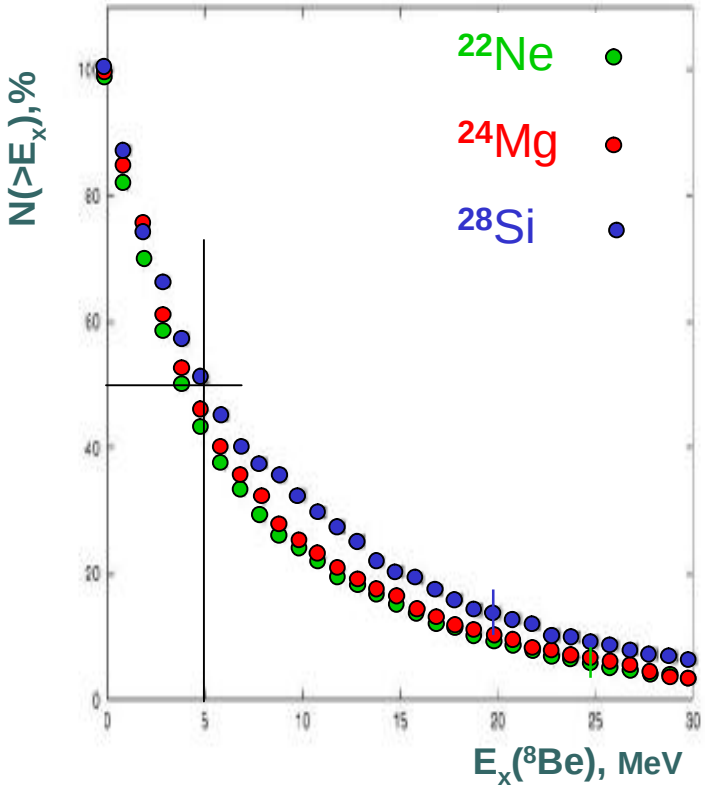
Integral $P_\perp^2$ distributions of He fragments may be fitted by a line with break at $P_\perp^2 \approx (0.5 - 0.6)$ GeV/c^2.

V. Distributions of the excitation energy

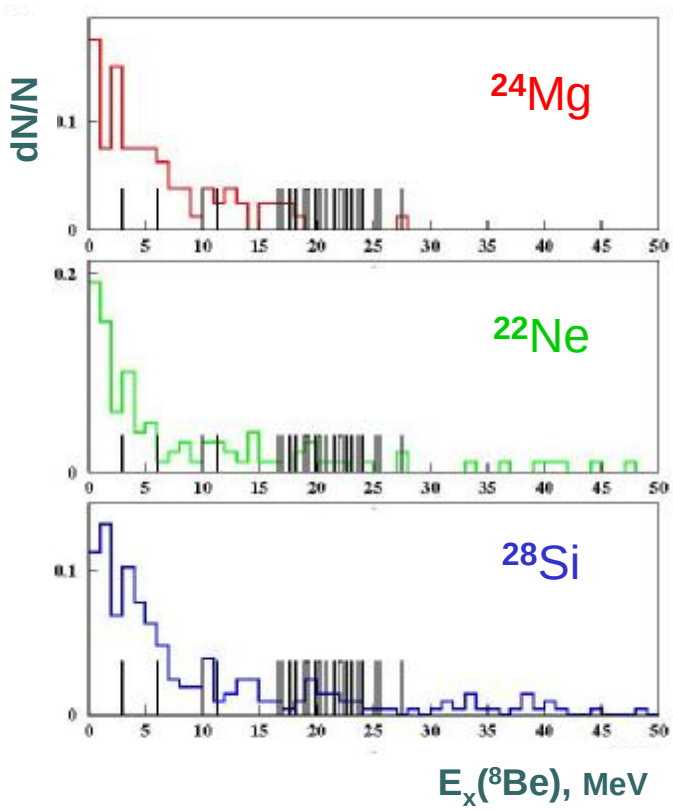
- The reconstructed excitation energy spectrum for decays $^{8}Be \rightarrow 2He$ and $^{12}C \rightarrow 3He$ with respects to the ground state of the nuclei ^{8}Be and ^{12}C have been analyzed.
- The comparison with the exited levels of the nuclei ^{8}Be and ^{12}C have been done.

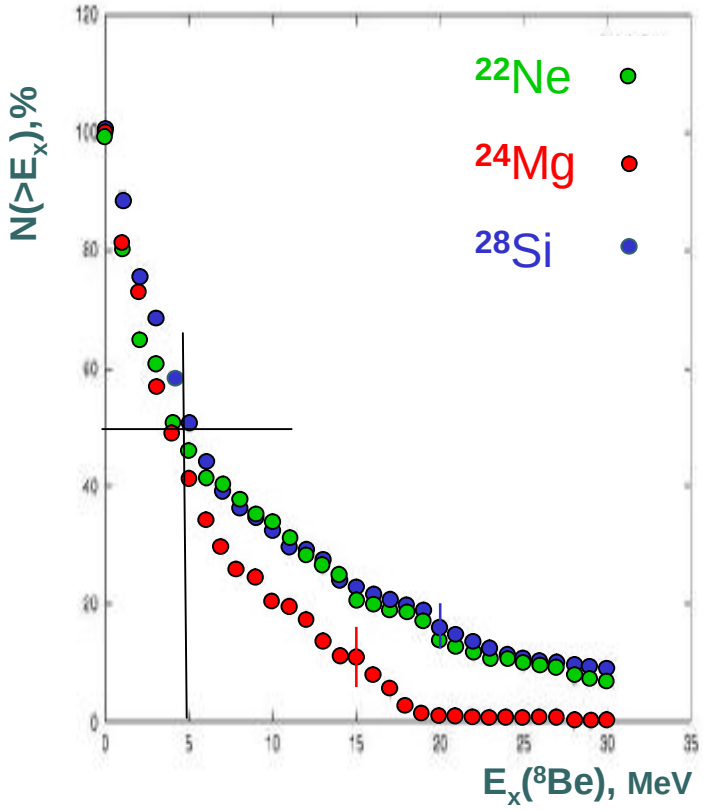
Excitation energy spectrum for decay $^{8}Be \rightarrow 2He$. Sum of cannels with $^{3}3\alpha$ in final state.



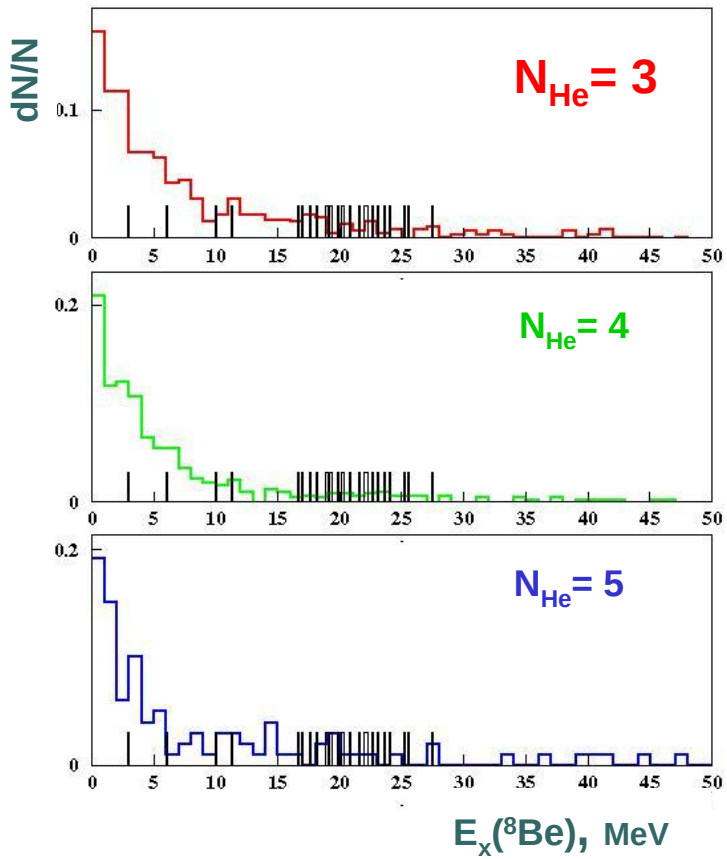


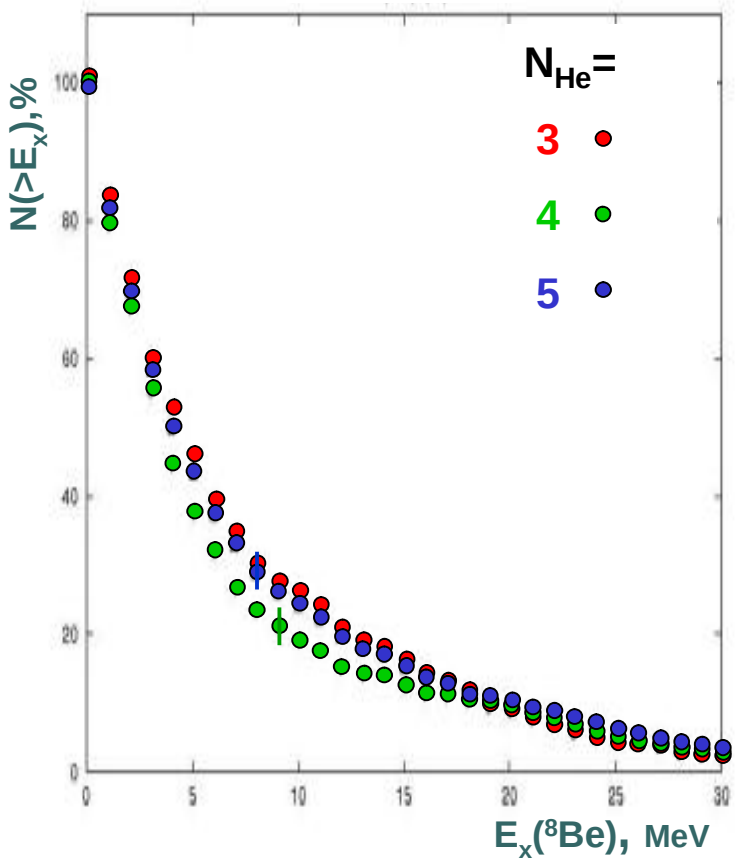
Excitation energy spectrum for decay ^{8}Be→2He. Cannels with 5α in final state.



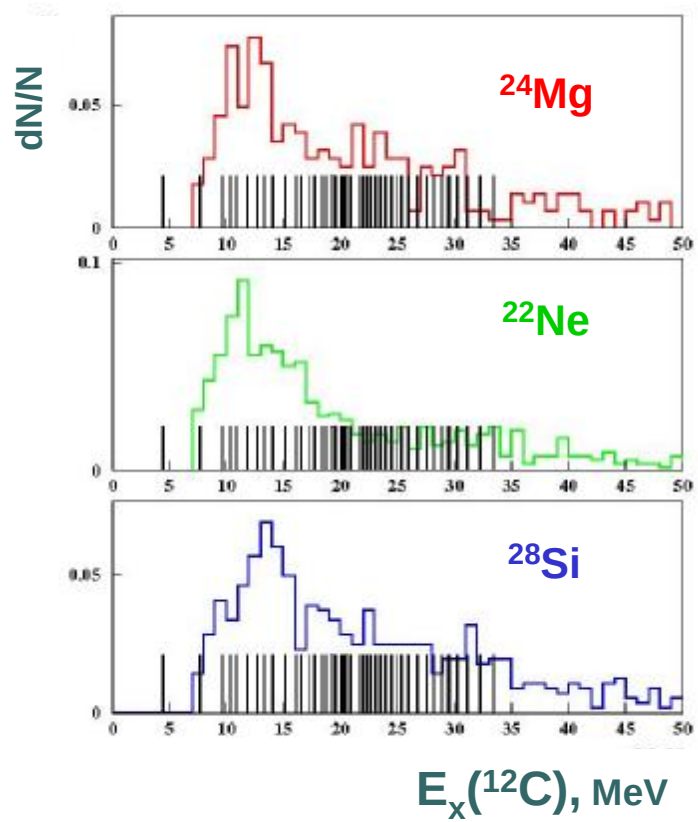


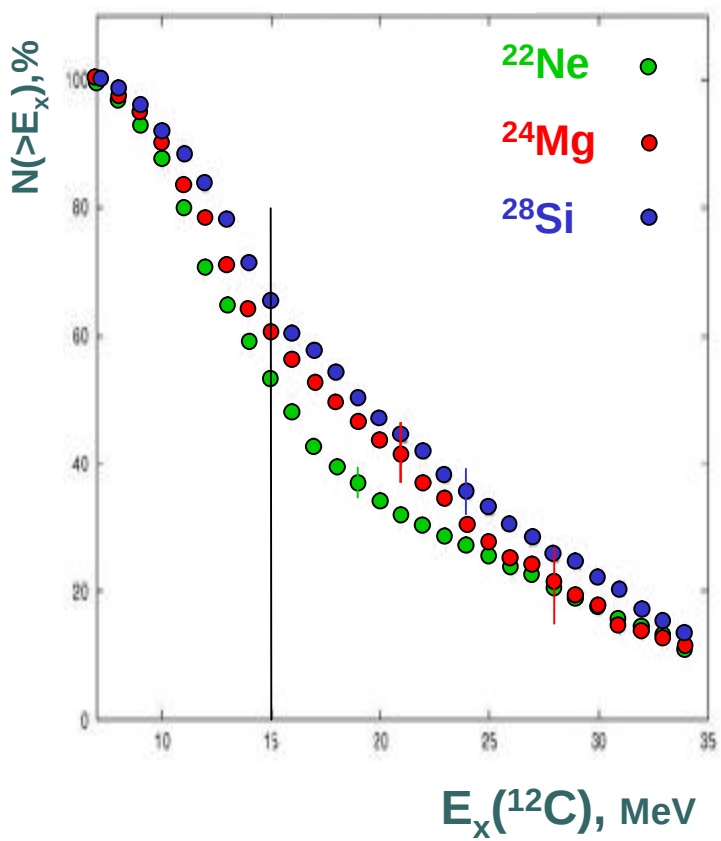
Excitation energy spectrum for decay $^{8}Be \rightarrow 2He$. Interaction of ^{22}Ne at 4.1 A GeV/c.



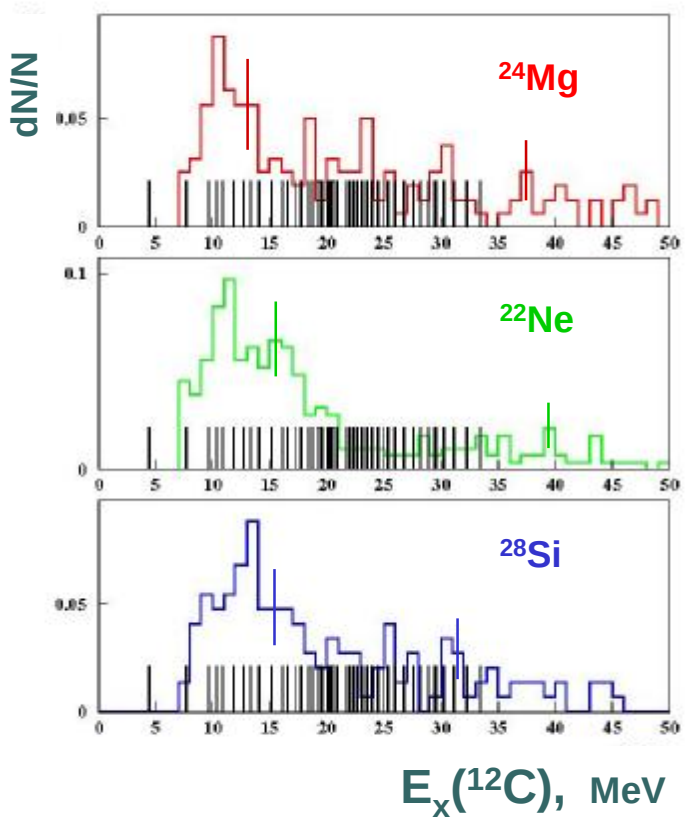


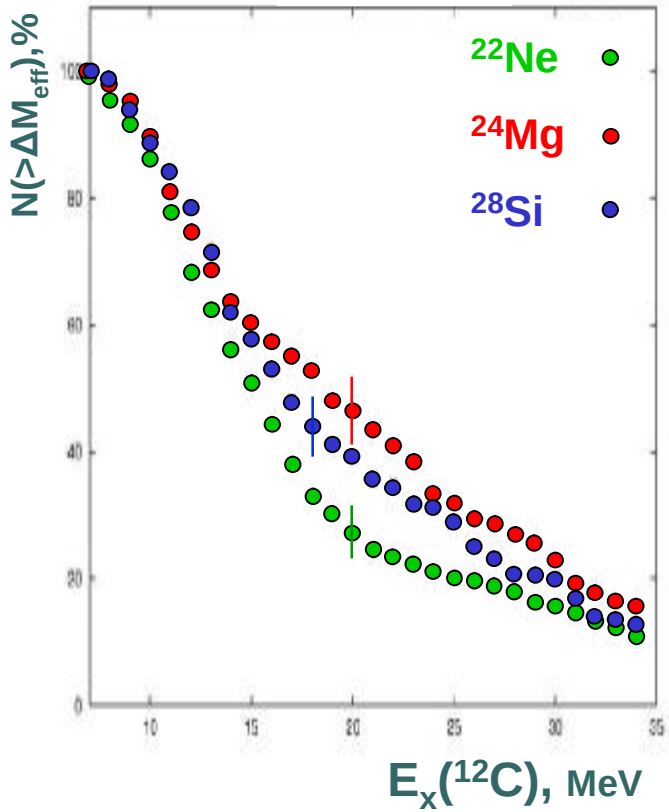
Excitation energy spectrum for decay $^{12}C \rightarrow 3He$.
Sum of cannels with $^{3}3\alpha$ in final state.



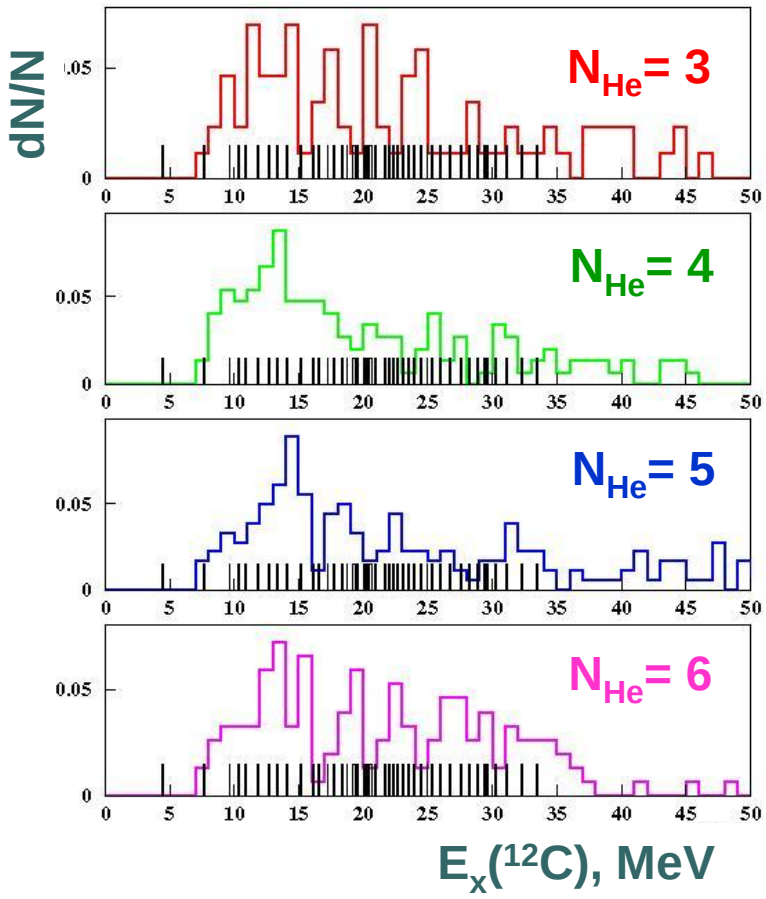


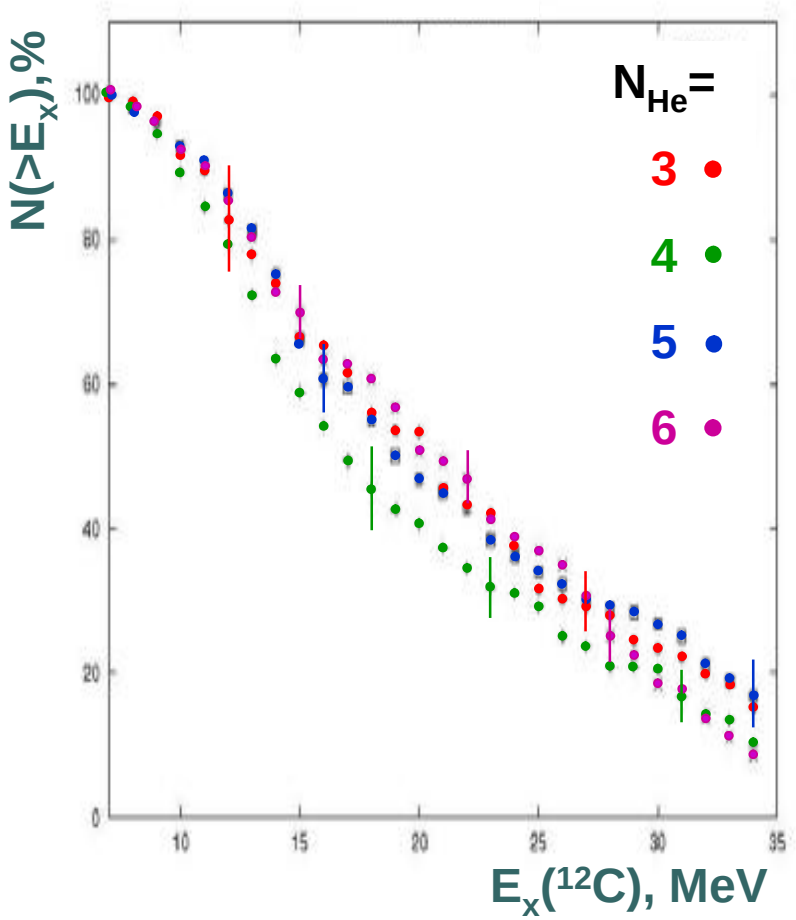
Excitation energy spectrum for decay $^{12}C \rightarrow 3He$. Cannels with 4α in final state.





Excitation energy spectrum for decay $^{12}C \rightarrow 3He$. Interaction of ^{28}Si at 4.5 A GeV/c.





VI. Conclusions.

Projectile He fragments from peripheral ^{22}Ne, ^{24}Mg and ^{28}Si

collisions with $N_{He} \geq 3$ in final state have the next properties:

- **Integral multiplicity distribution of He fragments may be fitted by a line with a break at $N_{He} = 2$.**
- **In the region under investigation average number of He fragments increases with increasing of projectile charge Z_0 as $N_{He}=0.28+0.07 \cdot Z0$, average number of projectile fragments with $Z_{fr} \geq 3$ decreases slowly as $N_{Z \geq 3} = 1.11-0.02 \cdot Z_0$;**
- **Average emission angle of He fragments decrease with increasing of He fragment number in collision.**
- **Integral angular spectrum of He fragments may be fitted by a line.**
- **Integral $P_\perp^2$ spectrum of He fragments may be fitted by a line with a break at $P_\perp^2 \approx 0.2$ $(GeV/c)^2$.**

VI. Conclusions.

Excitation energy.

- For $^{8}Be \rightarrow 2He$ decays in the excitation energy region Ex<15 MeV there are more then 80% of events.
- For $^{12}C \rightarrow 3He$ decays maximum of excitation energy spectra is in the region Ex≈10-15 MeV.
- For $^{12}C \rightarrow 3He$ decays the excitation energy spectrum shifts to the bigger meanings with increasing of projectile mass; for example, in the region Ex $\geq$ 15MeV there are 53, 60 and 66% of events for ^{22}Ne, ^{24}Mg and ^{28}Si collisions, correspondently.