



# **Results of the irradiation tests of Slavich NTE. Proposal on exposures of NTE to beam of $^{11}\text{C}$ nuclei at 400 A MeV**

*Denis Artemenkov,  
VBLHEP, JINR  
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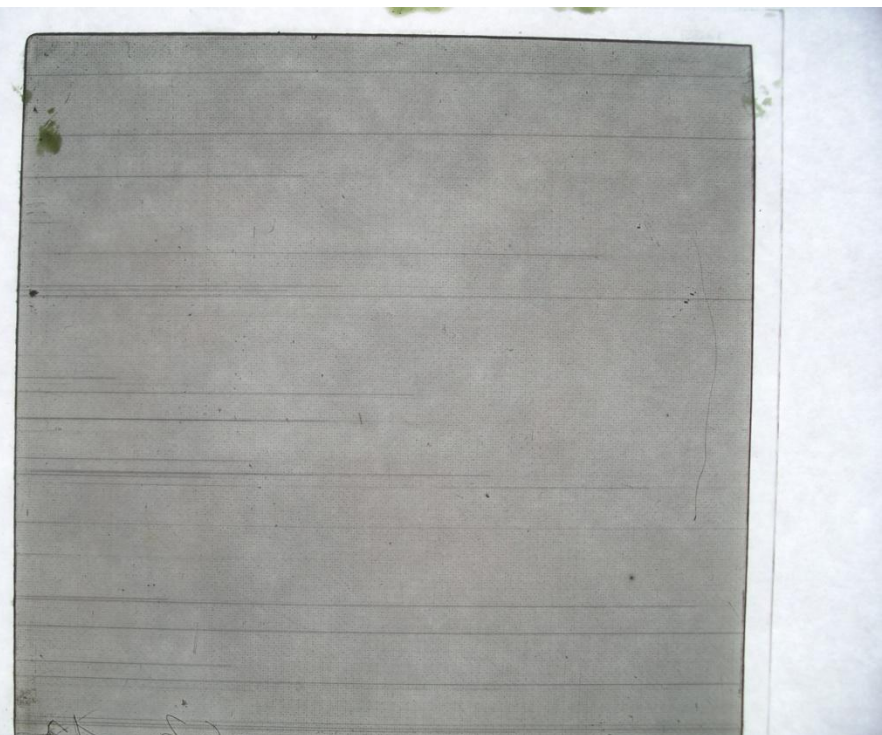
BECQUEREL  
PROJECT

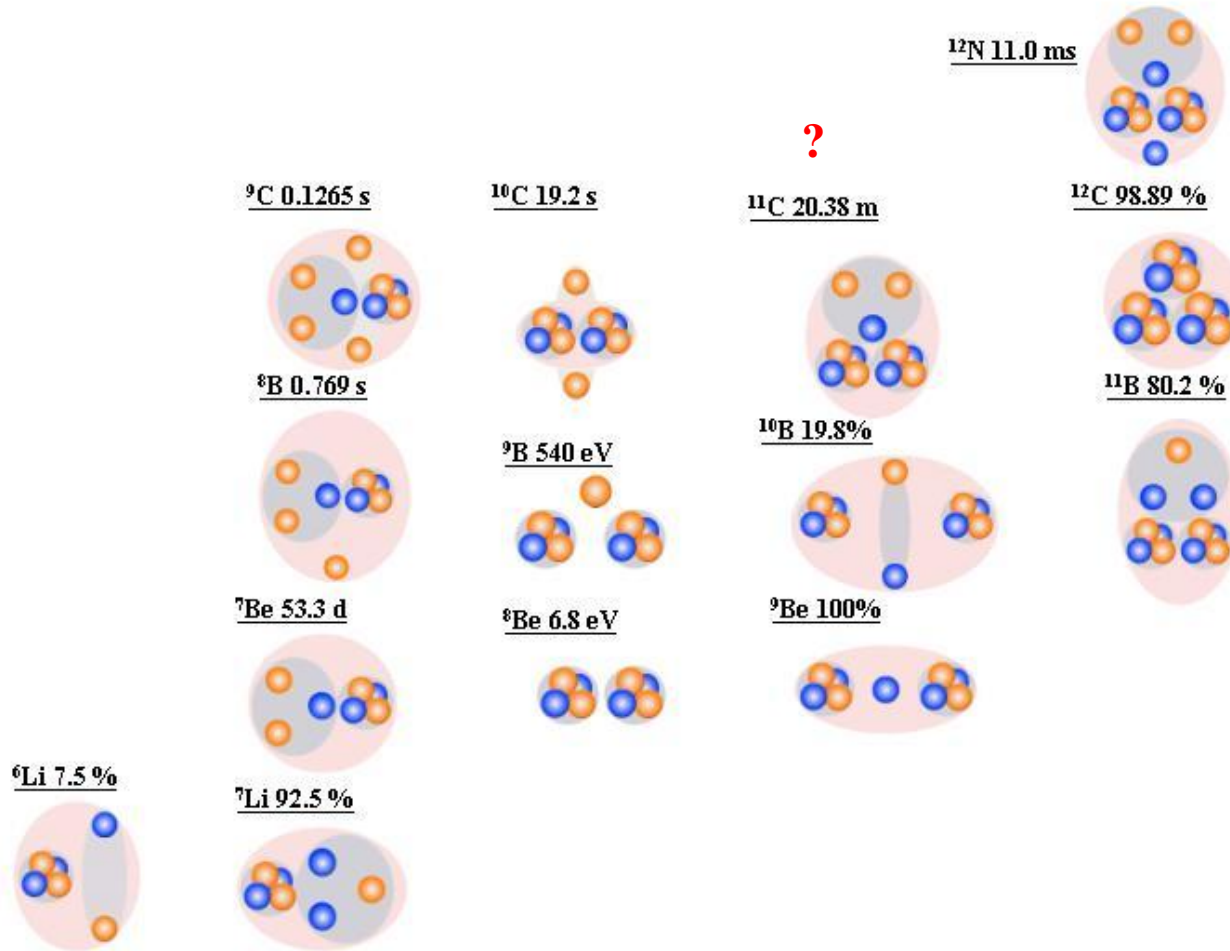
Проект  
БЕККЕРЕЛЬ

Beryllium (Boron)  
Clustering  
Quest in  
Relativistic Multifragmentation

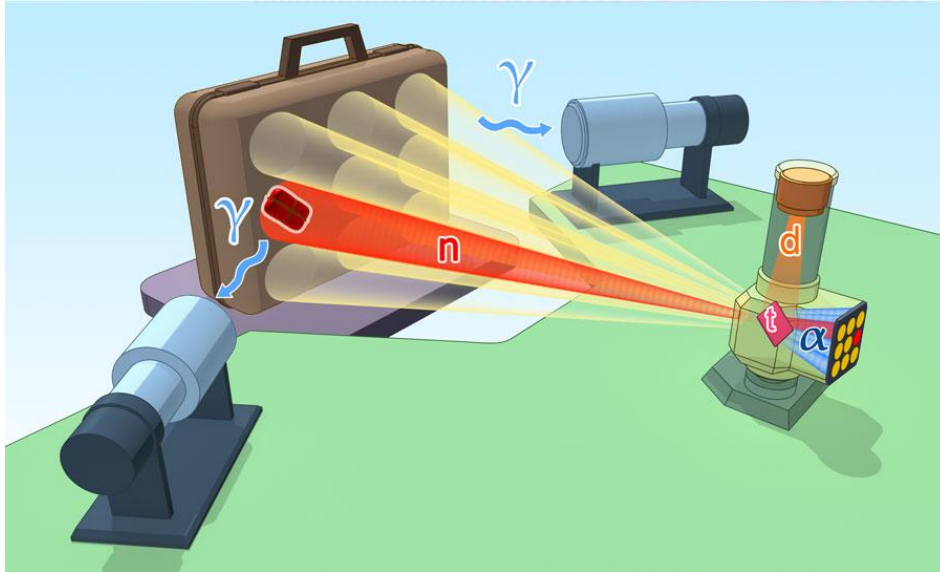
<http://becquerel.jinr.ru>

**BECQUEREL at the JINR Nuclotron is devoted systematic exploration of clustering features of light stable and radioactive nuclei.**

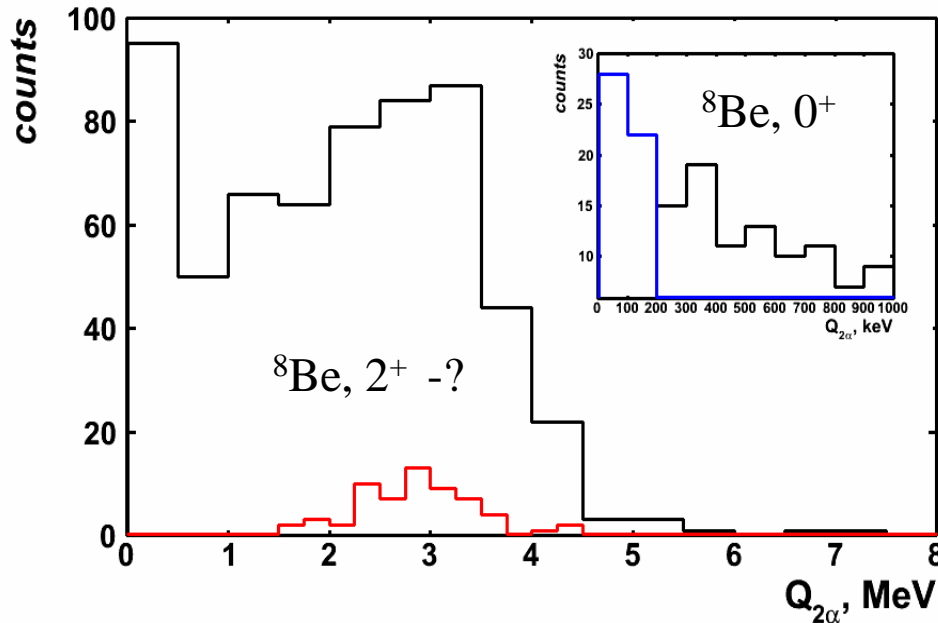
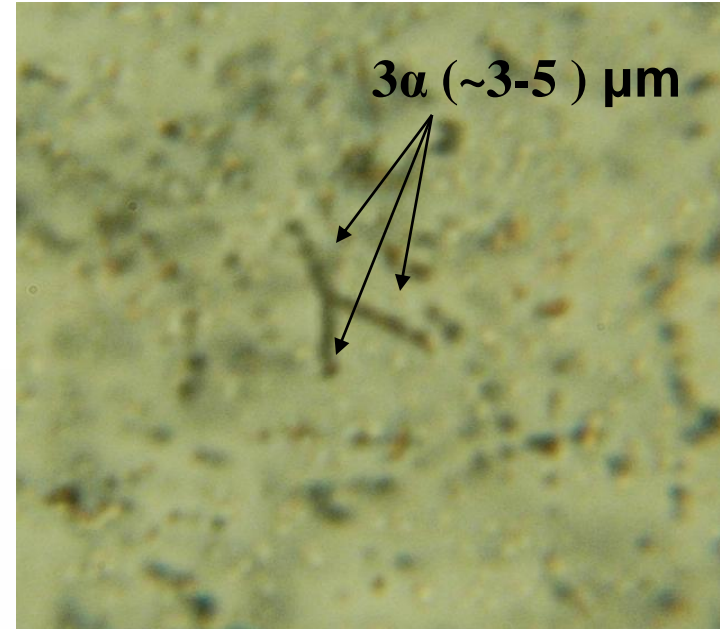




The fragmentation of a large variety of light nuclei was investigated using the emulsions exposed to few A GeV nuclear beams at JINR Nuclotron. A nuclear track emulsion is used to explore the fragmentation of the relativistic nuclei.

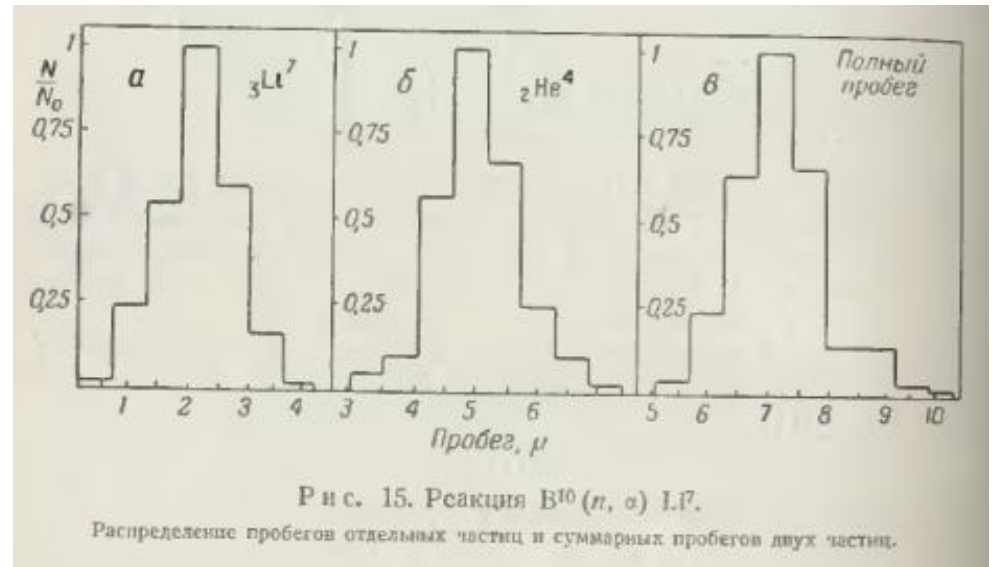


DVIN - explosives detector on the basis of fast tagged neutron method for complex program for population safety in transport



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

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

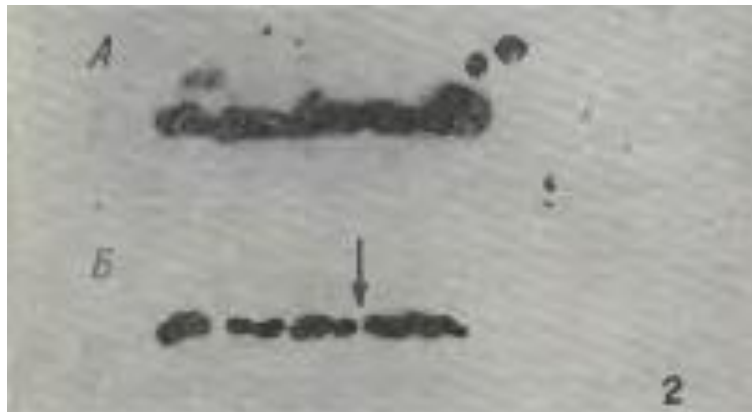
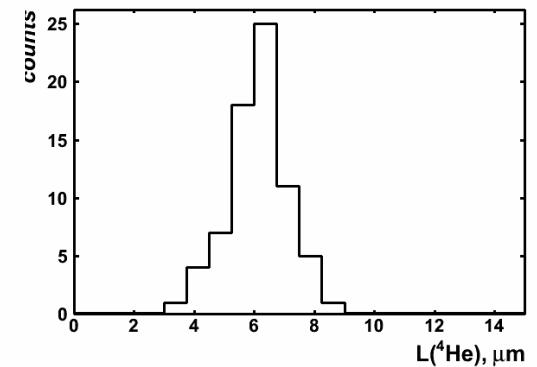
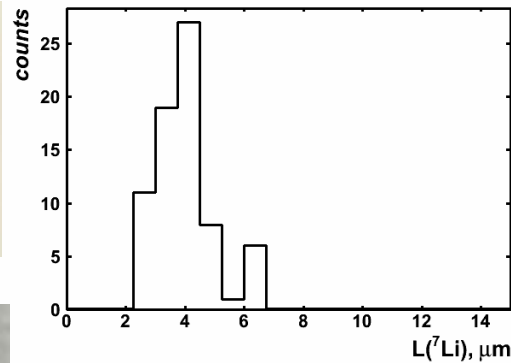


**БОР**

Расщепление бора тепловыми нейтронами

$${}_5B^{10} + {}_0n^1 \rightarrow {}_2He^4 + {}_3Li^7$$

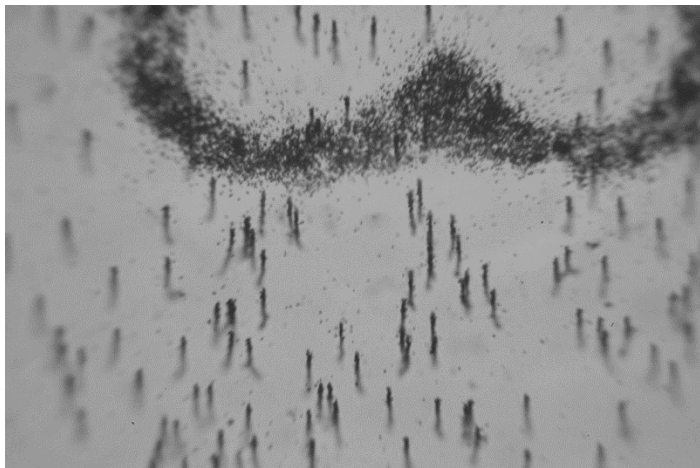
приводит к испусканию  $\alpha$ -частицы и образованию ядра лития в возбужденном состоянии с энергией 478 кэв [53]. В этом случае, так же как и в предыдущей реакции, ядро отдачи лития поглощает значительную часть кинетической энергии, и ионизирующие способности  ${}_2He^4$  и  ${}_3Li^7$  отличаются слишком мало, чтобы их можно было распознать путем нормального проявления.



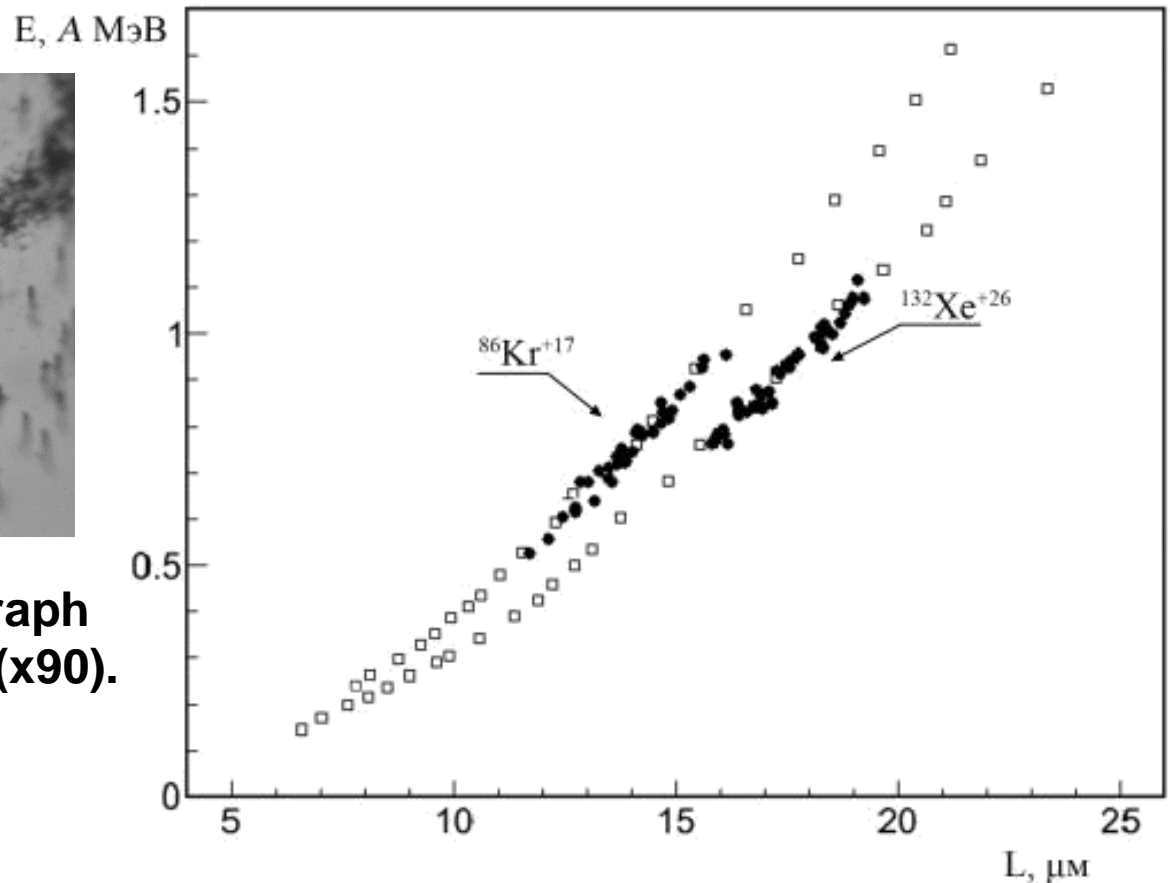
<http://flnp.jinr.ru>

Emulsion layers with size  $9 \times 12 \text{ cm}^2$  and with thickness  $\sim 100$  (Xe) and  $\sim 180$  (Kr)  $\mu\text{m}$  on a glass substrate with thickness  $\sim 2 \text{ mm}$ , placed at an angle  $45^\circ$  to the beam axis. Tilting plate has provided observability tracks of ions in the emulsion.

<http://flerovlab.jinr.ru/flnr/ic-100.html>



Examples of microphotograph of tracks (Xe) in emulsion (x90).

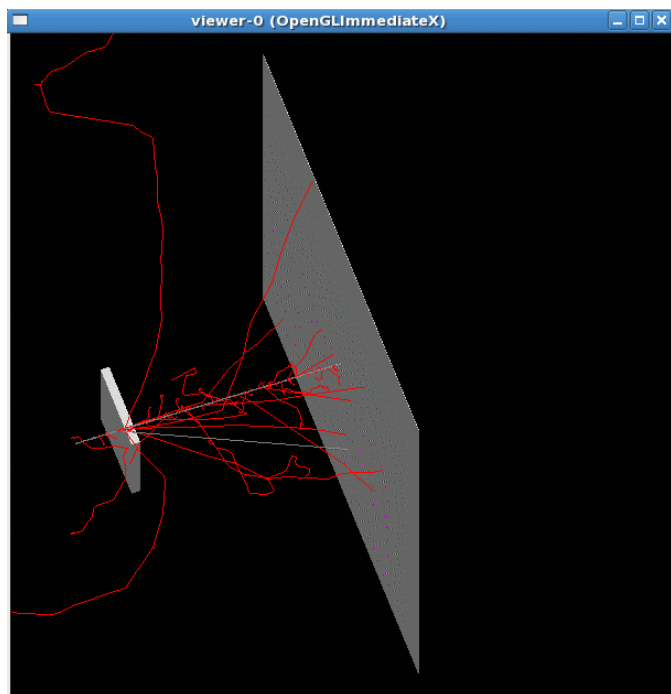


Definition energy of ions  $^{86}\text{Kr}$  and  $^{132}\text{Xe}$  by the measured track length. Dots - experimental data, squares - calculation by the model SRIM.

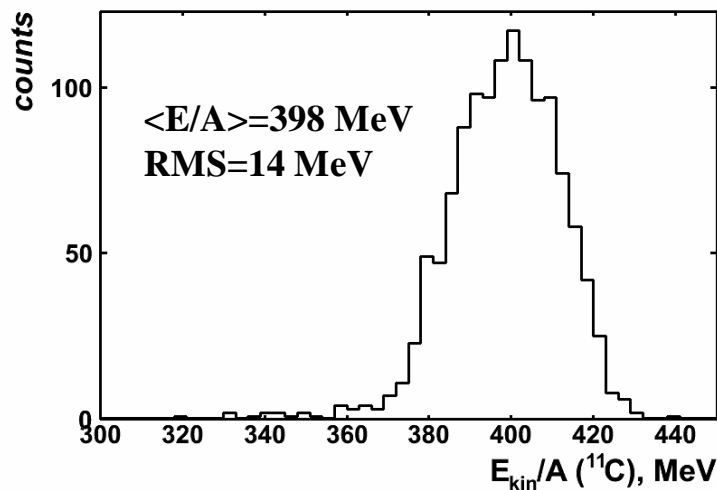
# Proposal on exposures of NTE to beam of $^{11}\text{C}$ nuclei at 400 A MeV

based on:

- [http://becquerel.jinr.ru/text/Papers/C12\\_U70\\_run\\_2012\\_1.pdf](http://becquerel.jinr.ru/text/Papers/C12_U70_run_2012_1.pdf) from Institute for High Energy Physics (IHEP) Protvino,
- P.A. Rukoyatkin et al., “Secondary nuclear fragment beams for investigations of relativistic fragmentation of light radioactive nuclei using nuclear photoemulsion at Nuclotron”, <http://arxiv.org/abs/1210.1540>



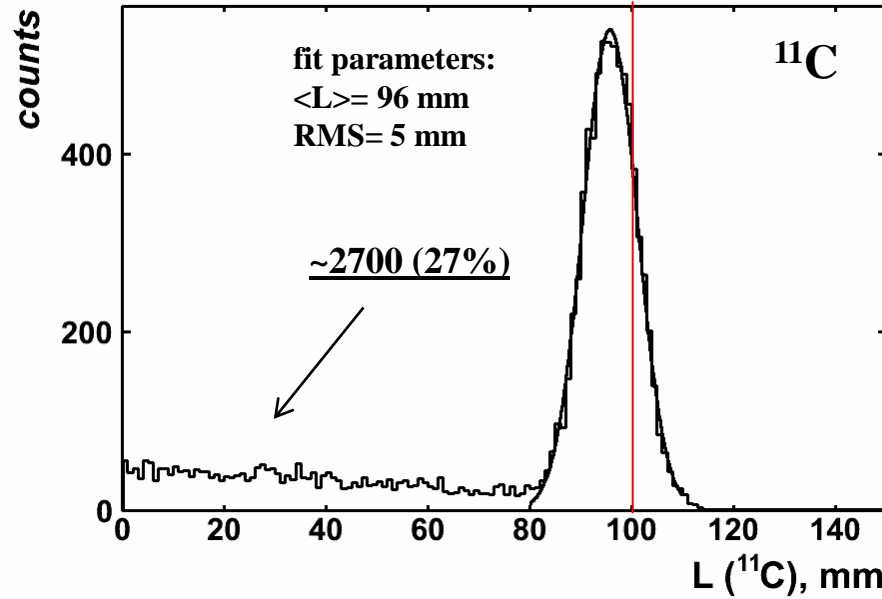
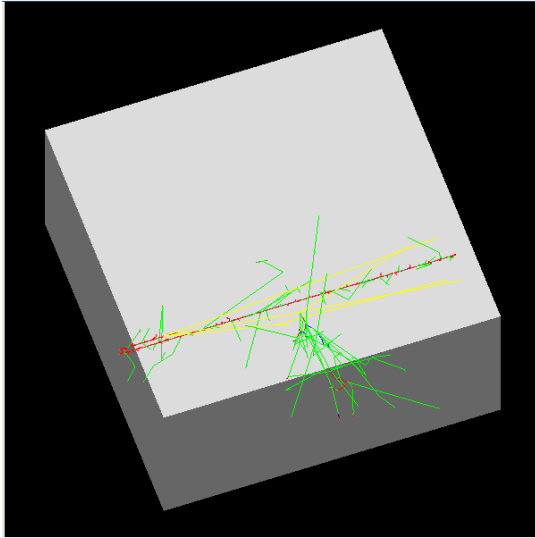
1272 nuclei of  $^{11}\text{C}$  produced from  $10^4$  of  $^{12}\text{C}$



Polyethylene target (thickness - 1 cm) irradiated by  $^{12}\text{C}$  nuclei with 420 A MeV. Used CHIPS physics list, and G4\_POLYETHYLENE target (Geant4). All equipment located in air.

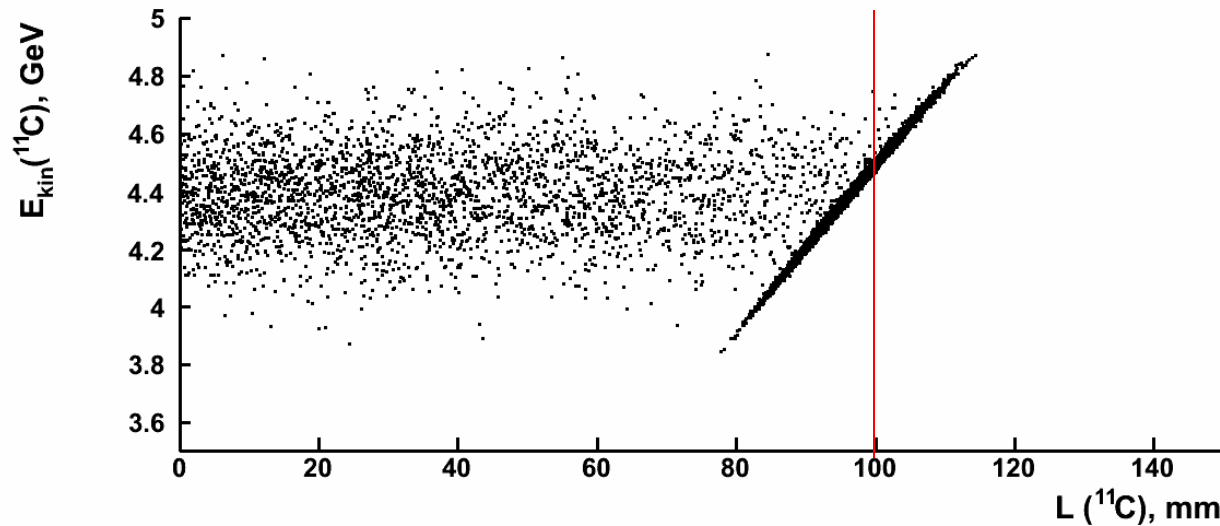
Break of NTE ( $10 \times 10 \times 5 \text{ cm}^3$ ) irradiated by  $10^4$  of  $^{11}\text{C}$  nuclei (400 A MeV, RMS = 14 A MeV)

Track length of  $^{11}\text{C}$  in NTE at 400 A MeV



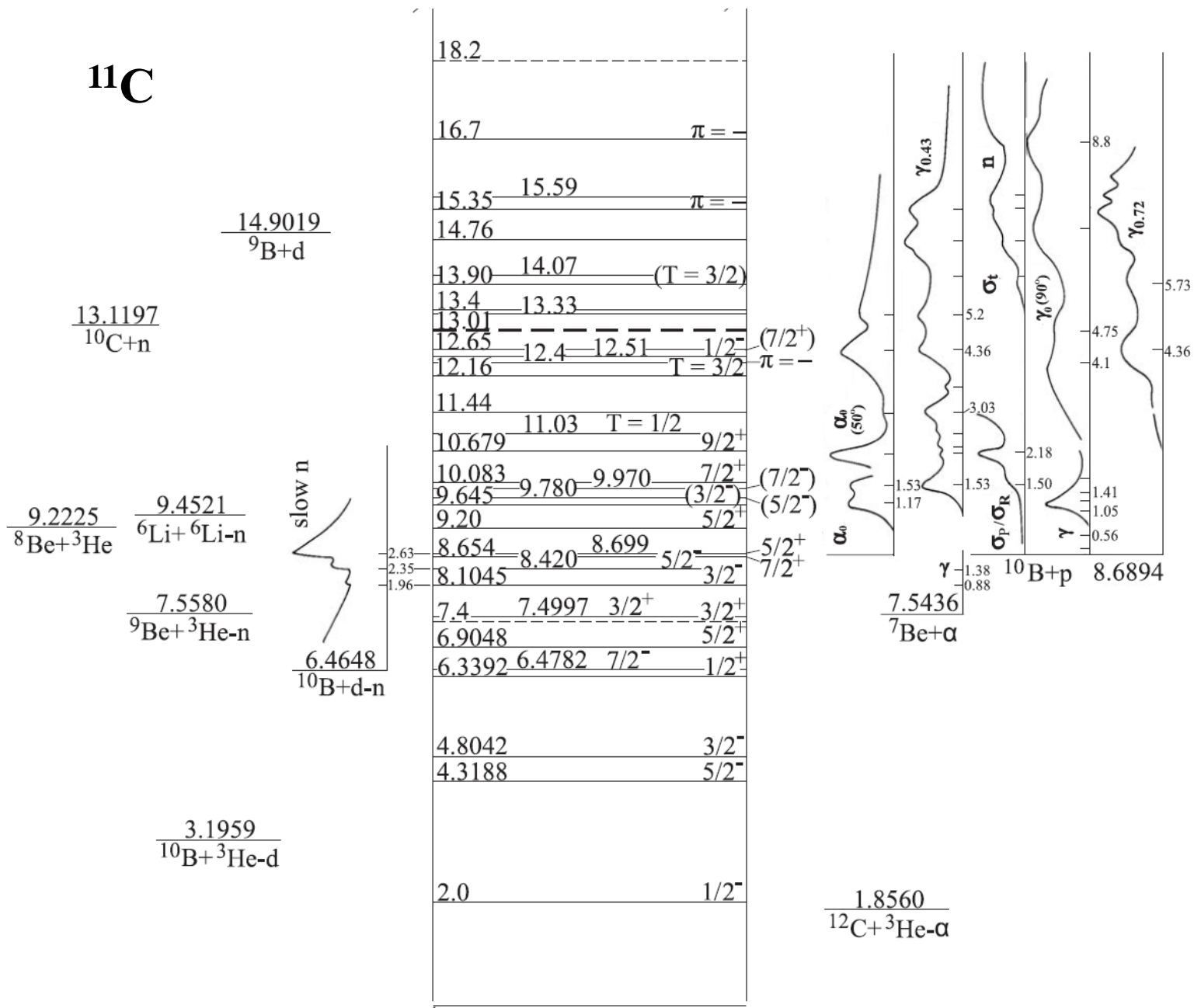
G4\_PHOTO\_EMULSION

SRIM:  $E_{\text{kin}}$  (4.0, 4.4) GeV;  $L$  (90.3, 104.5) mm



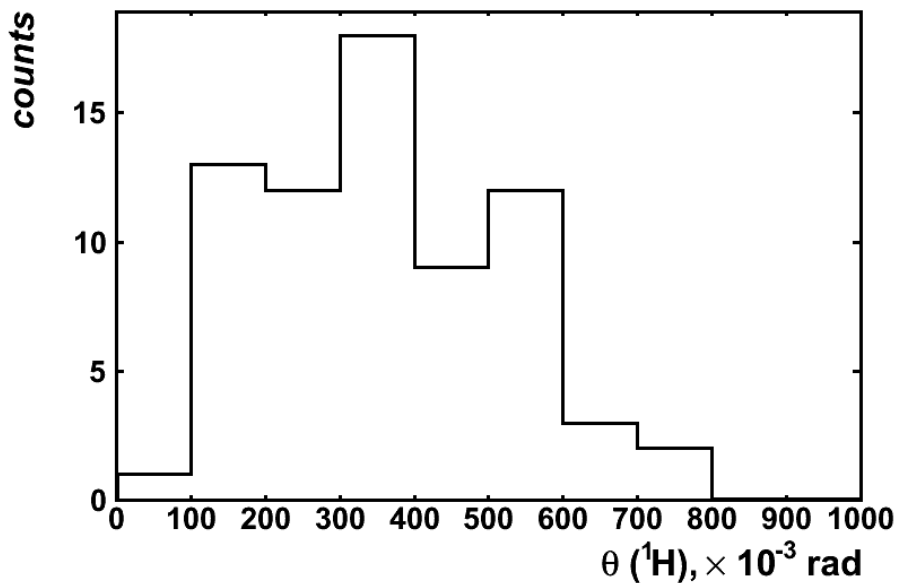
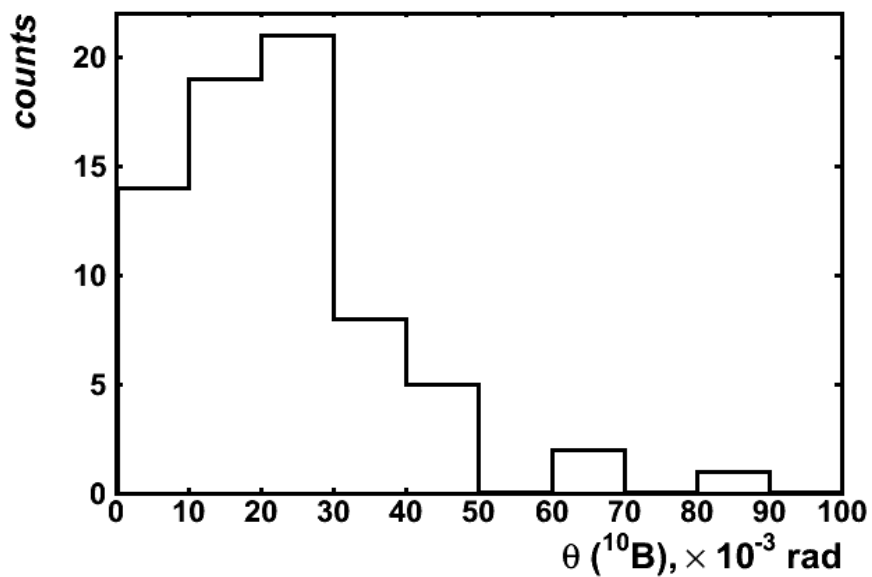
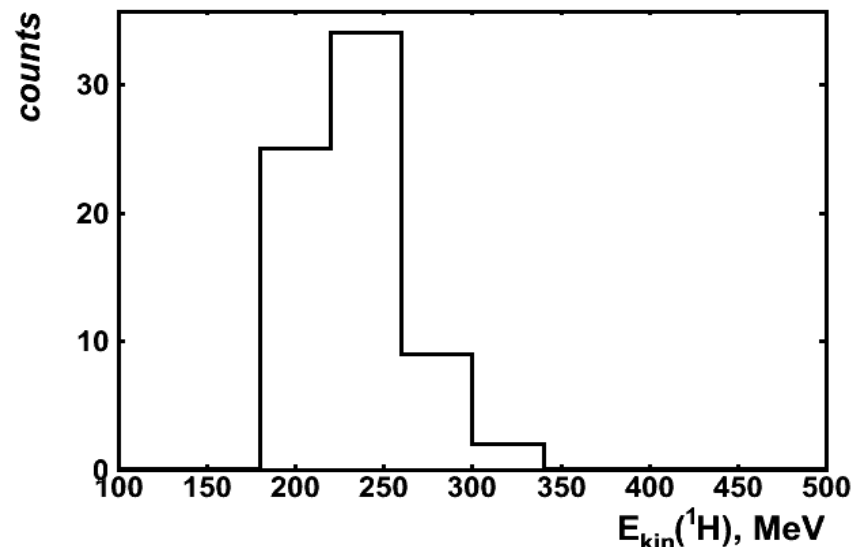
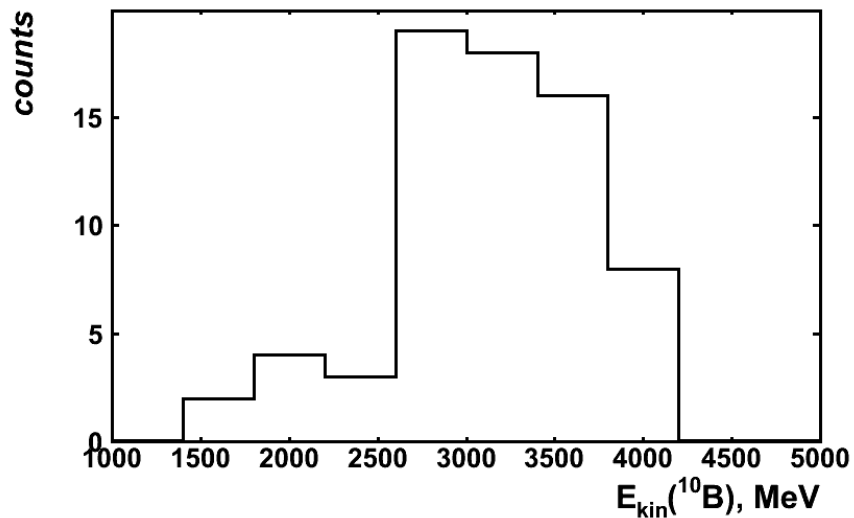
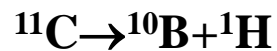


# <sup>11</sup>C



Channel	Number	Energy threshold, MeV
$^{11}\text{C} \rightarrow ^8\text{Be} + ^3\text{He} \rightarrow 2^4\text{He} + ^3\text{He}$	16	9.23
$^{11}\text{C} \rightarrow 2^4\text{He} + ^3\text{He}$	4	9.13
$^{11}\text{C} \rightarrow ^{10}\text{B} + ^1\text{H}$	69	8.69
$^{11}\text{C} \rightarrow ^9\text{B} + ^2\text{H} \rightarrow 2^4\text{He} + ^1\text{H} + ^2\text{H}$	61	14.90
$^{11}\text{C} \rightarrow ^8\text{B} + ^3\text{H}$	14	27.22
$^{11}\text{C} \rightarrow ^9\text{Be} + 2^1\text{H}$	8	15.28
$^{11}\text{C} \rightarrow ^7\text{Be} + ^4\text{He}$	25	7.54
$^{11}\text{C} \rightarrow ^6\text{Li} + ^4\text{He} + ^1\text{H}$	10	13.15
$^{11}\text{C} \rightarrow ^{10}\text{C} + \text{n}$	3	13.12
$^{11}\text{C} \rightarrow 2^4\text{He} + ^2\text{H} + ^1\text{H}$	8	14.62
$^{11}\text{C} \rightarrow ^{11}\text{B}$	17	-1.98

# Typical energy and angular scale for produced fragments from $^{11}\text{C}$ at 400 A MeV



## *Summary*

*The presented report serve as an illustration of possibilities of the NTE for study nuclear structure of carbon isotopes in wide energy range.*

*Proposal on exposures of NTE to beam of  $^{11}\text{C}$  nuclei at 400 A MeV are overviewed.*

*All the results for  $^{11}\text{C}$  are approximate and model dependent (physics list dependent). At the same time, they allow us to get an idea about the features of the study  $^{11}\text{C}$  in with NTE.*

**Thank you for your attention!**