National Research Nuclear University MEPhI

Formation of ^{3,4}He in the reaction of stopped pion absorption

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Practical significance:

- cumulative processes accompanying nuclear reactions at low and intermediate energies (100 MeV - 1 GeV).

Reaction:

- π^- is captured by the Coulomb field of the nucleus of the target;
- π^- is absorbed by the nucleus:
  - ✓ pion is absorbed by an intranuclear cluster;
  - ✓ a pre-equilibrium stage;
  - ✓ an evaporation stage;

$$\pi^- + A \rightarrow p, n, d, t, {}^{3,4}He + X;$$

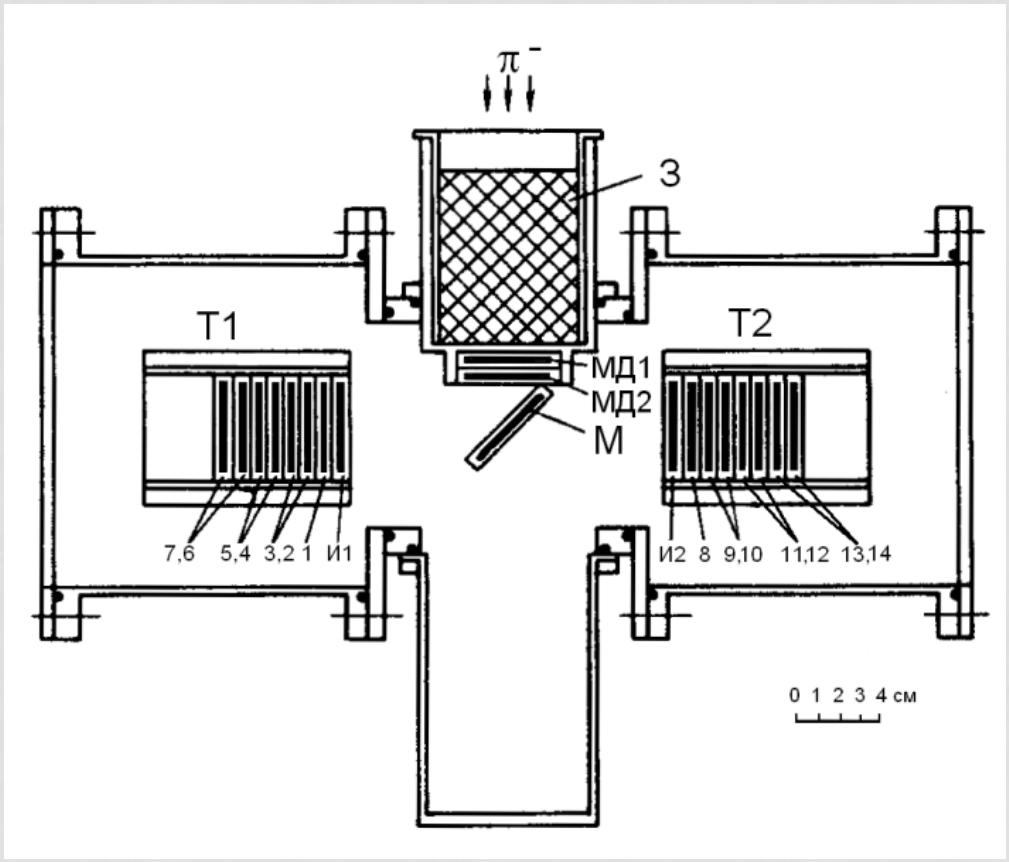
Purpose of the work:

- to describe the spectra of ^{3,4}He formed in the stopped pion absorption reaction:

  $$\pi^- + A \rightarrow {}^{3,4}He + X;$$

- to evaluate contribution of different mechanisms to yields on the different stages of the reaction;
- to describe the yields of ^{3}He formed through the pick-up mechanism.

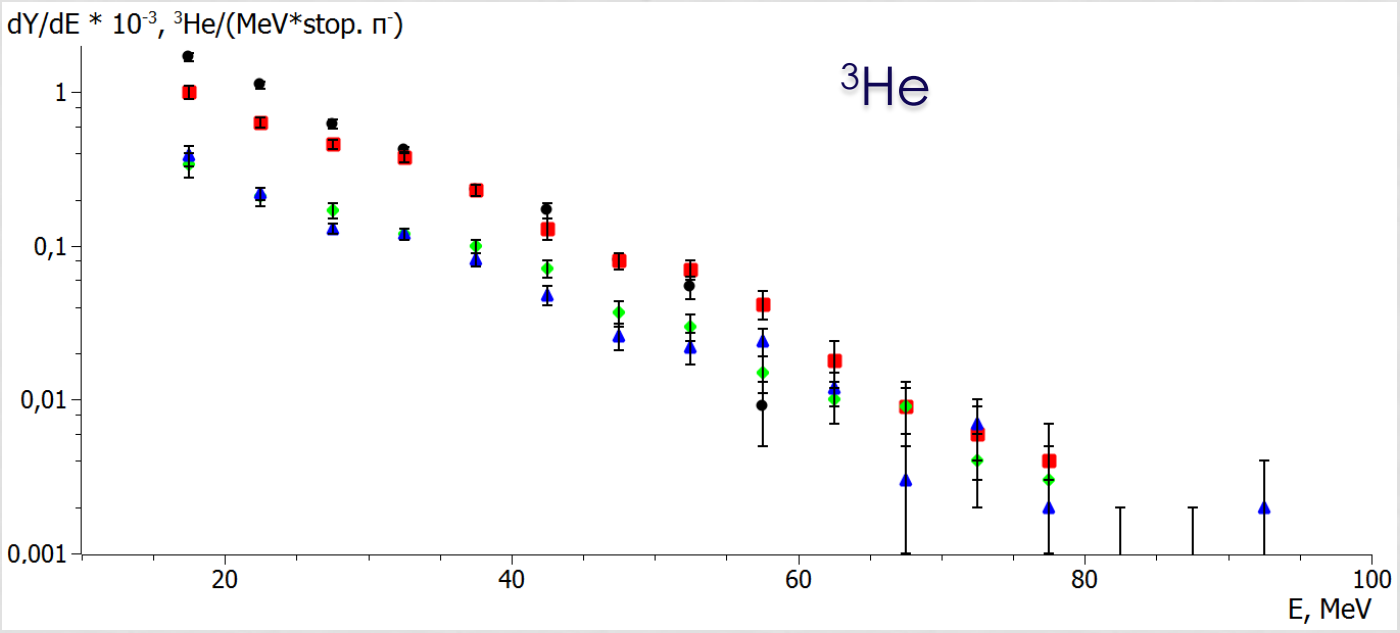
Experiment

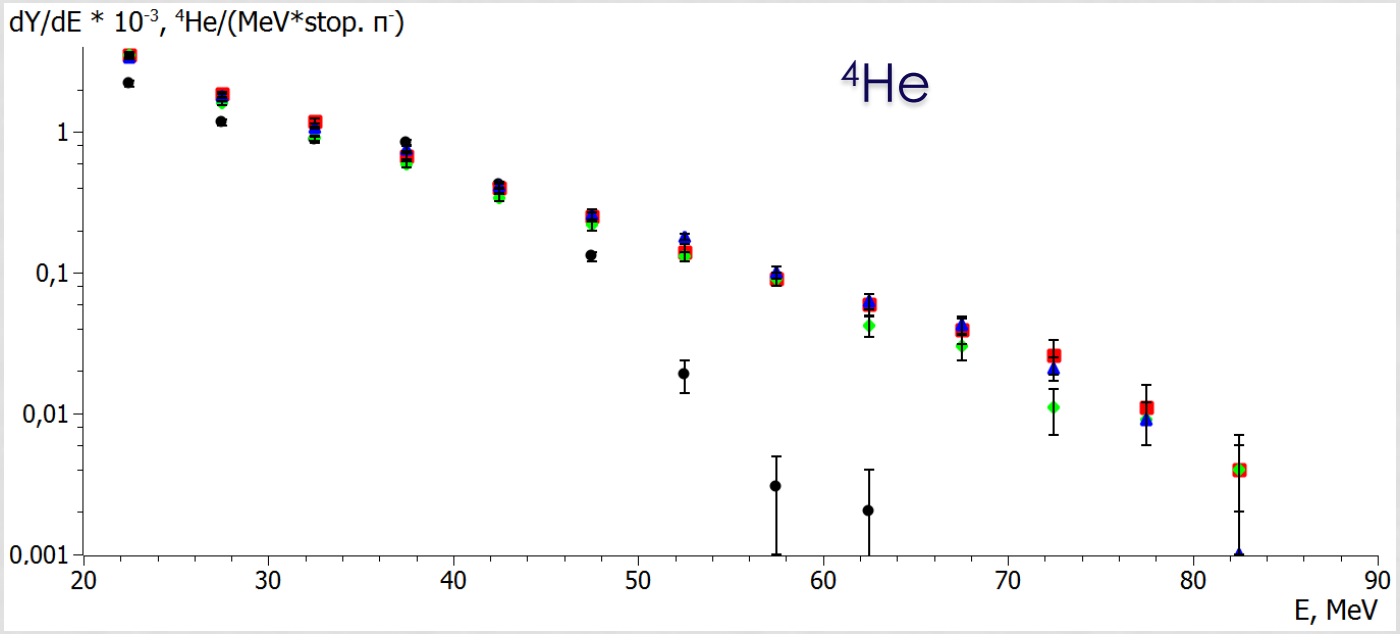


- absolute error – 7%, relative error – 3,5%;
- 17 targets were studied;
- energy resolution – 0,6 MeV;
- measurements were carried out up to the kinematic limits of the reaction.

^{6,7}Li, ^{9}Be, ^{10,11}B, ^{12}C, ^{28}Si, ^{40}Ca, ^{59}Co, ^{93}Nb, ^{114,117,120,124}Sn, ^{169}Tm, ^{181}Ta, ^{209}Bi.

Experimental results





● - ^{6}Li,

■ - ^{40}Ca,

◆ - ^{117}Sn,

▲ - ^{181}Ta.

Simulation of knock-out mechanism

- $\pi^- + (pn) \rightarrow n + n;$

  $n + {}^3He \rightarrow n + {}^3He.$

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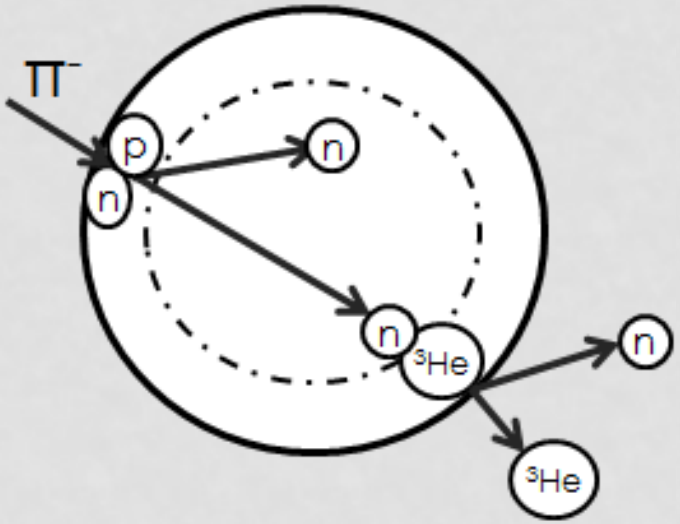
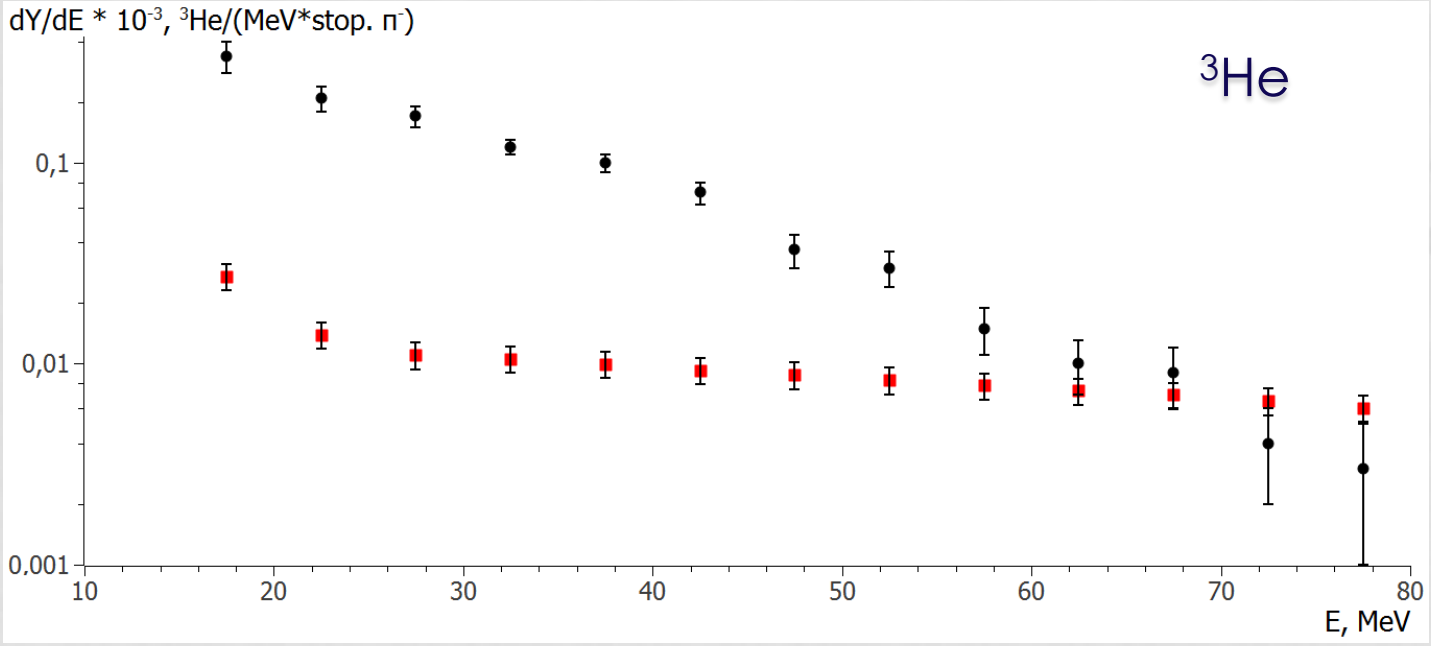
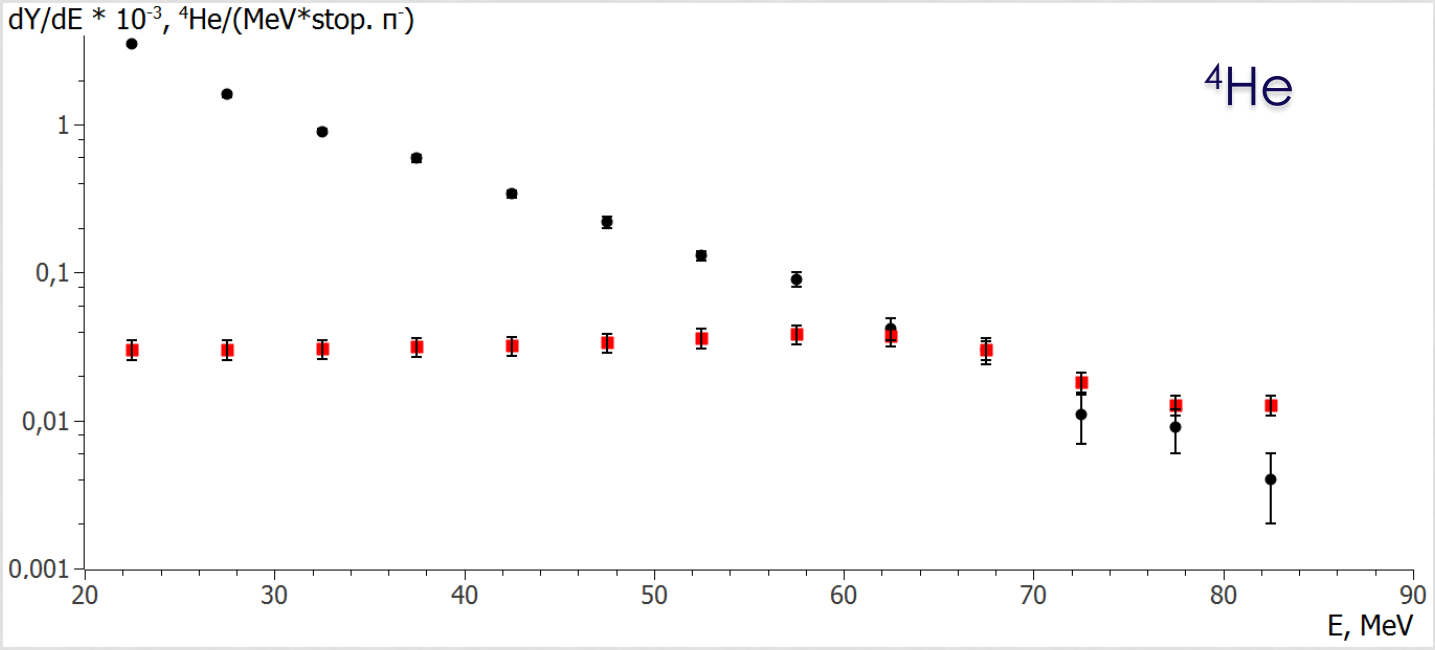
  $n + {}^4He \rightarrow n + {}^4He.$



Simulation of knock-out mechanism

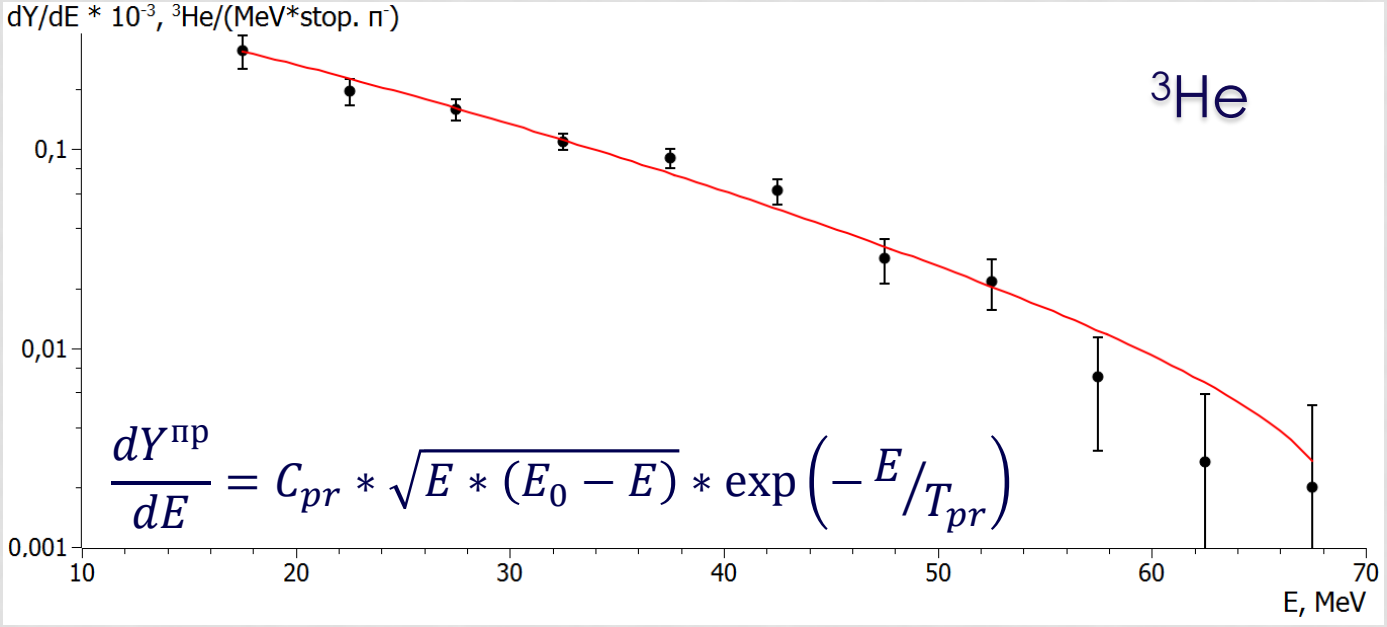




^{117}Sn

- ● - experiment
- ■ - simulation of knock-out

Description of the difference

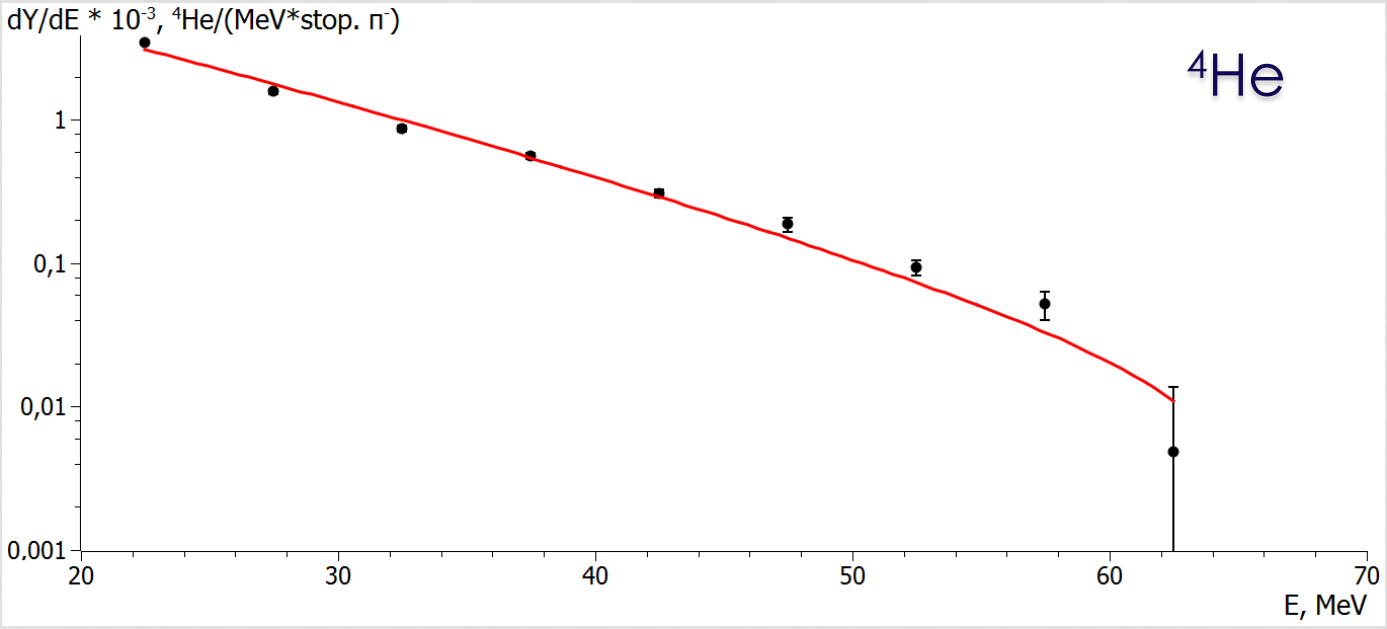


^{117}Sn

● - difference

▪ - description

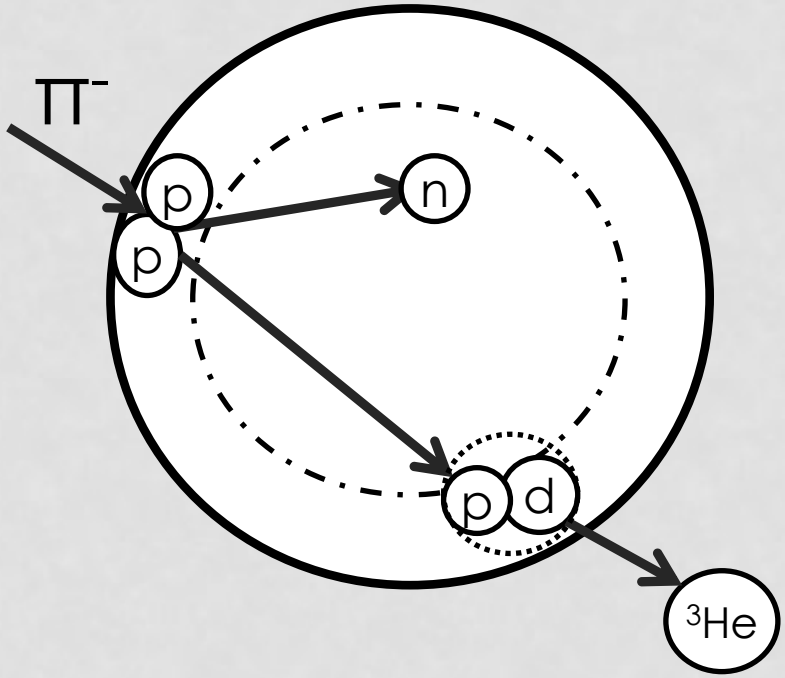
T=14.8 ± 0.1MeV



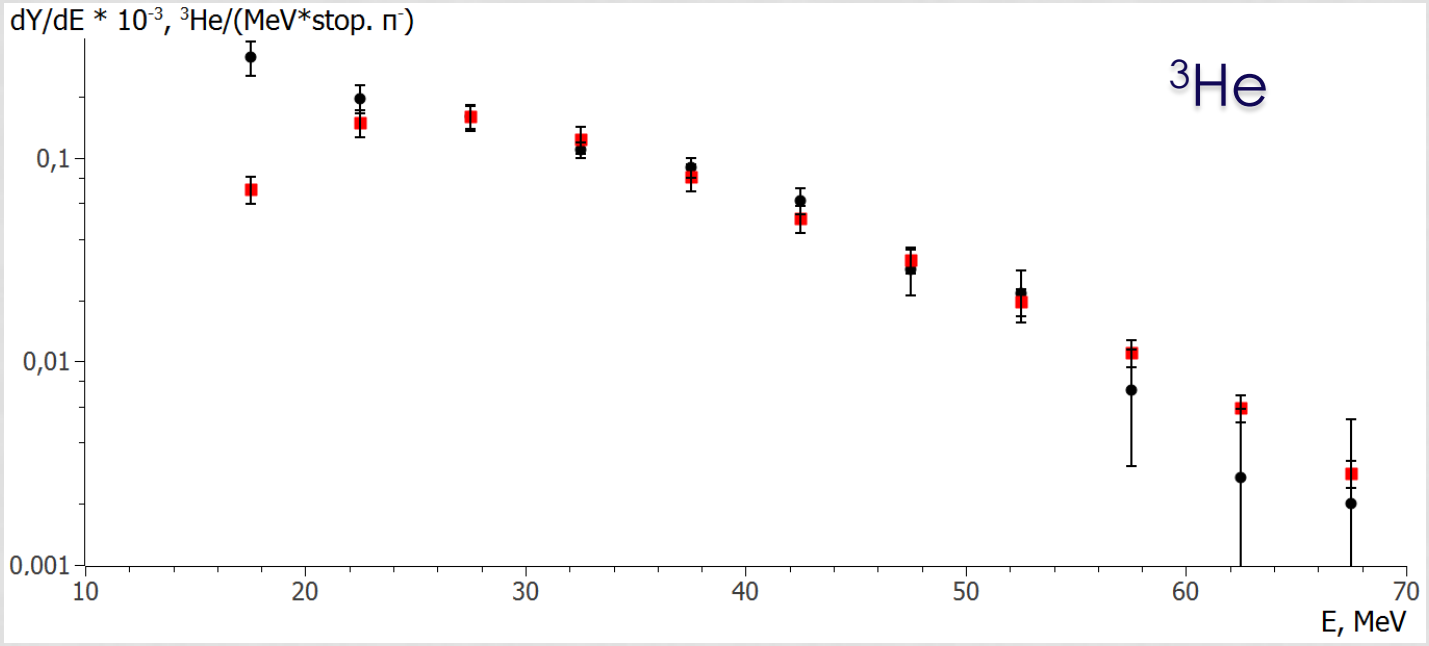
T=8.4 ± 0.3 MeV

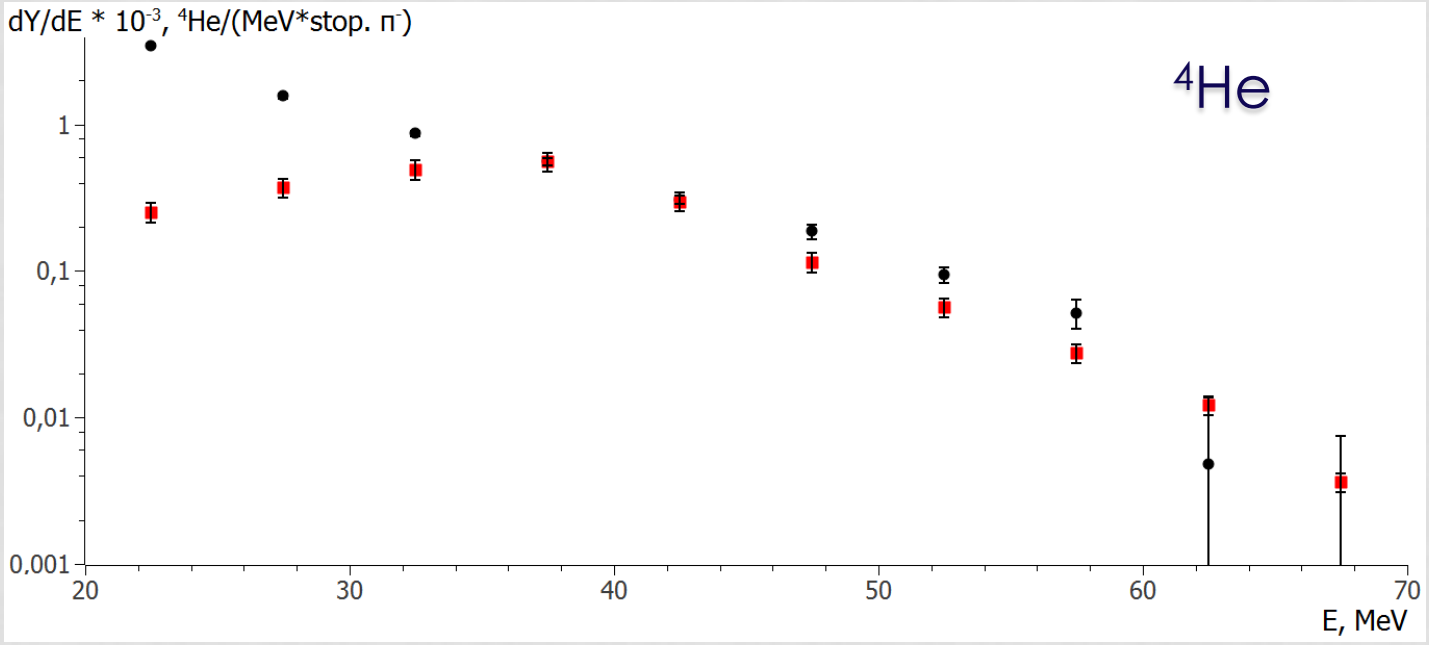
Simulation of pick-up mechanism

- $\pi^-+(pp)\rightarrow p+n$; $p+d\rightarrow {}^3He$
- $d+d\rightarrow {}^4He$
- spectrum of primary p was used



Simulation of pick-up mechanism



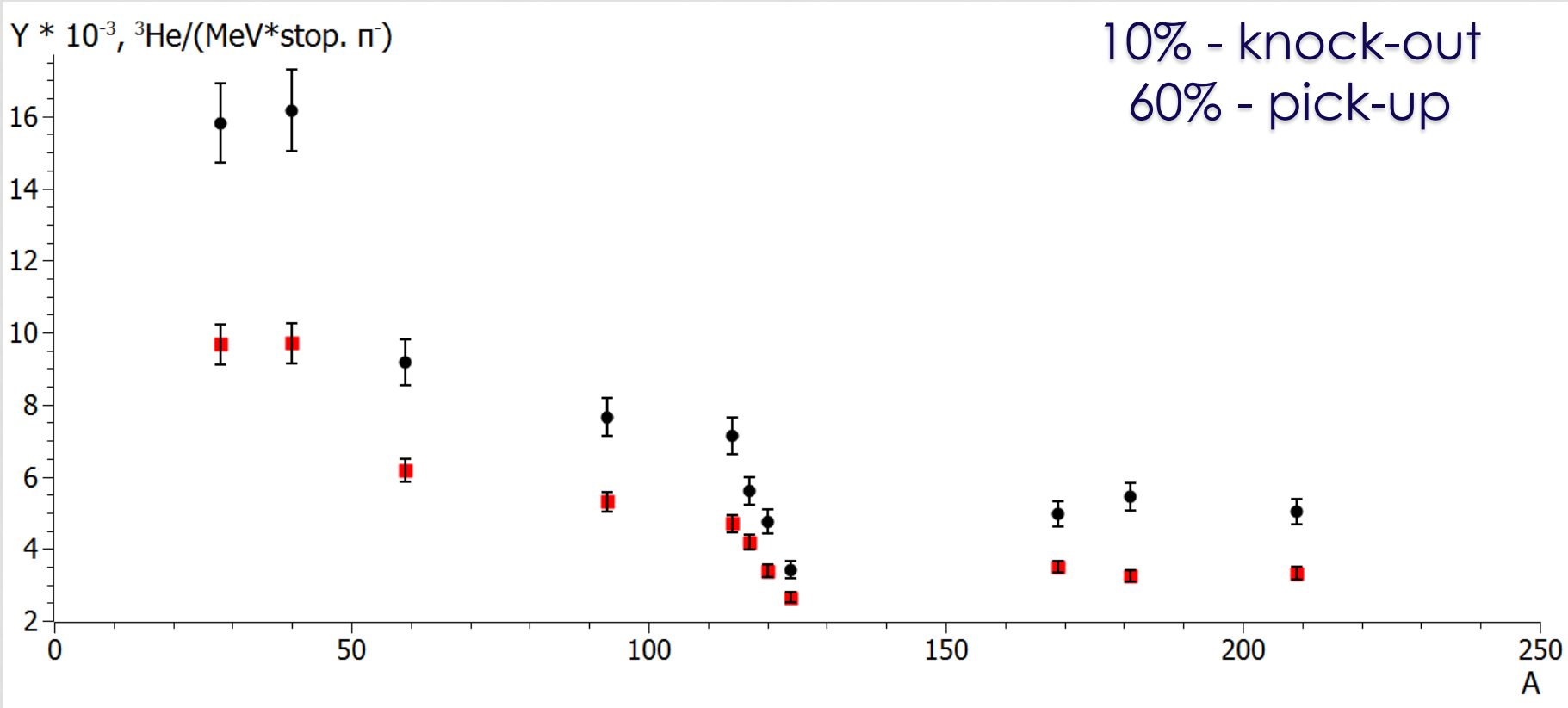


^{117}Sn

● - experiment

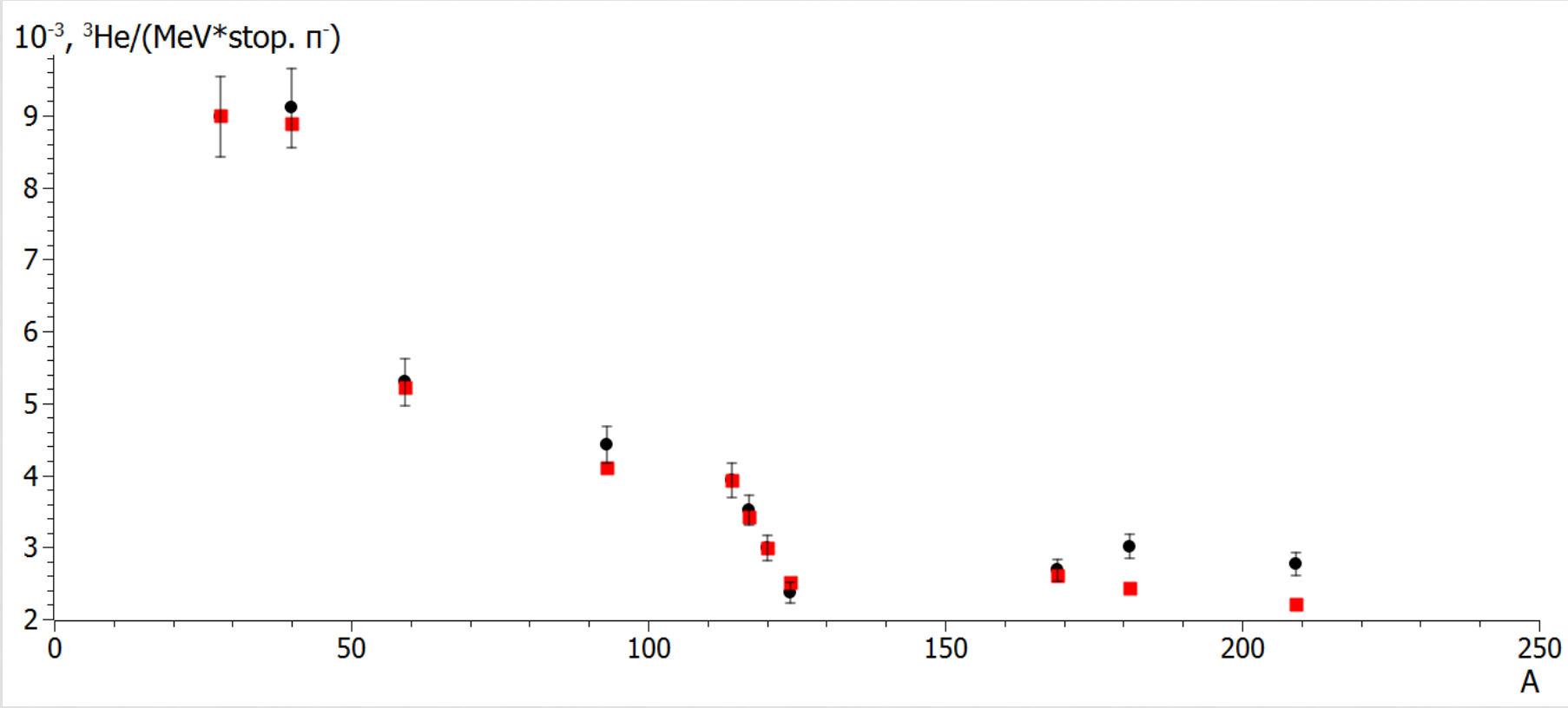
■ - simulation of pick-up

A-dependence of the yields of ^{3}He



● - experimental yields, ■ - yields from knock-out and pick-up

Description of ^{3}He pick-up yields



● - pick-up yields, ■ - description

$$Y = C * P_{pp} \cdot P_{pick-up} \cdot P_{3_{He}}$$

$$P_{pp} = \frac{Z-1}{Z-1+2 \cdot R' N} \qquad P_{pick-up} = \left(\frac{Z}{N}\right)^{2.1} \qquad P_{3_{He}} = \exp(-\beta \cdot A^{1/6})$$

Conclusions:

- the model allows satisfactorily reproduce the spectra of ^{3,4}He at energies >30 MeV;
- the contribution of the knock-out process into the formation of ^{3}He is ~ 10% of the total yield, ^{4}He is ~ 5%;
- the contribution of the pick-up process into the formation of ^{3}He is ~ 60% of the total yield, ^{4}He is ~ 40%;
- the analytical dependence for describing the pick-up yields of ^{3}He has been obtained.

Thank You for attention!