National Research Nuclear University
MEPhI

# Charged particle evaporation in the stopped pion absorption reactions

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# Goals

I. Investigation of the spectra of p, d, t formed in the reaction of stopped pion absorption

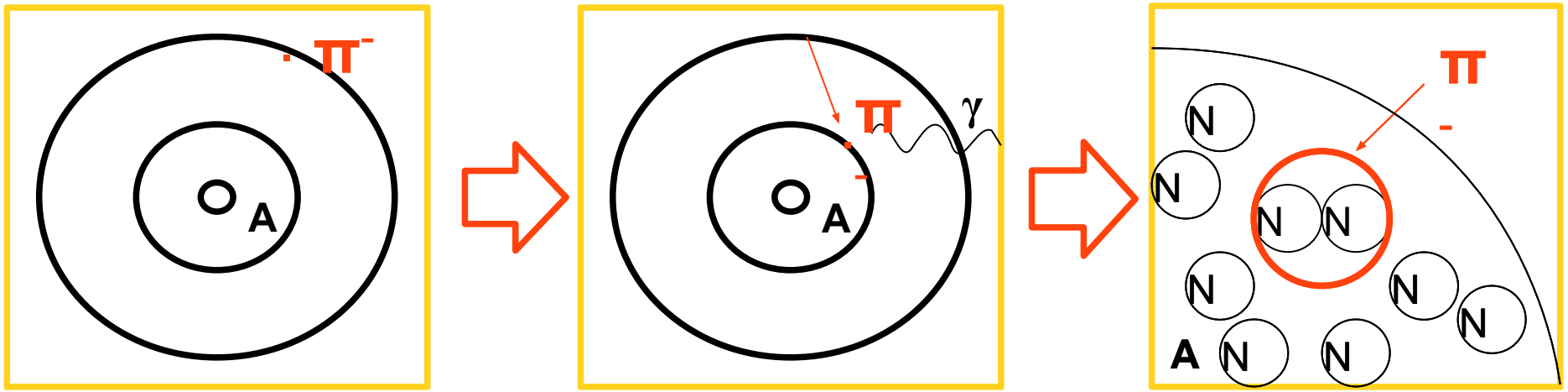
II. Calculation of the contributions of evaporative particles into the total charged particle yields for different nuclei

III. Investigation of the A-dependence of the equilibrium temperature parameter

III. Investigation of the A-dependences of the evaporative particle yields

# Introduction

Investigation on stopped pion absorption




$$\pi^- + (pn) \rightarrow 2n$$

**>90%**

$$\pi^- + A \rightarrow p, d, t$$

**???**

# Experiment

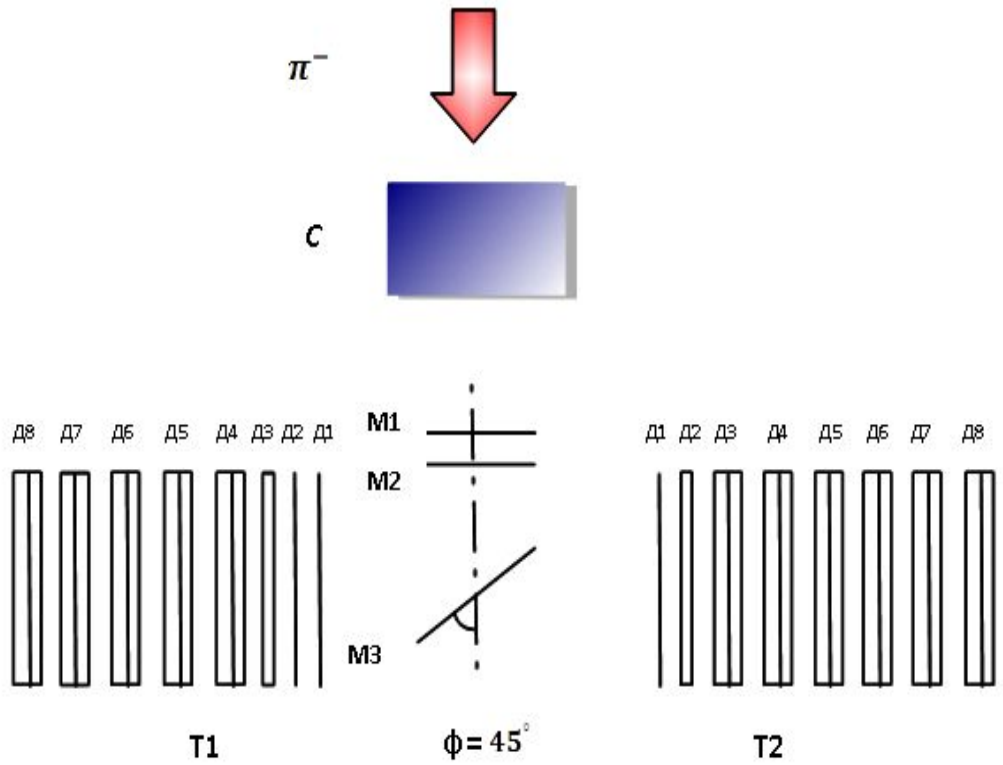
**Target nuclei:**
$^{6,7}$Li, $^{9}$Be, $^{10,11}$B, $^{12}$C,
$^{28}$Si, $^{40}$Ca, $^{59}$Co, $^{93}$Nb,
$^{114,117,120,124}$Sn,
$^{169}$Tm, $^{181}$Ta, $^{209}$Bi

**Energy resolution:**
0.6 МэВ

**Absolute normalization precision:**
7%

**Lower energy boundaries:**
p - 5 МэВ,
d, t – 10 МэВ

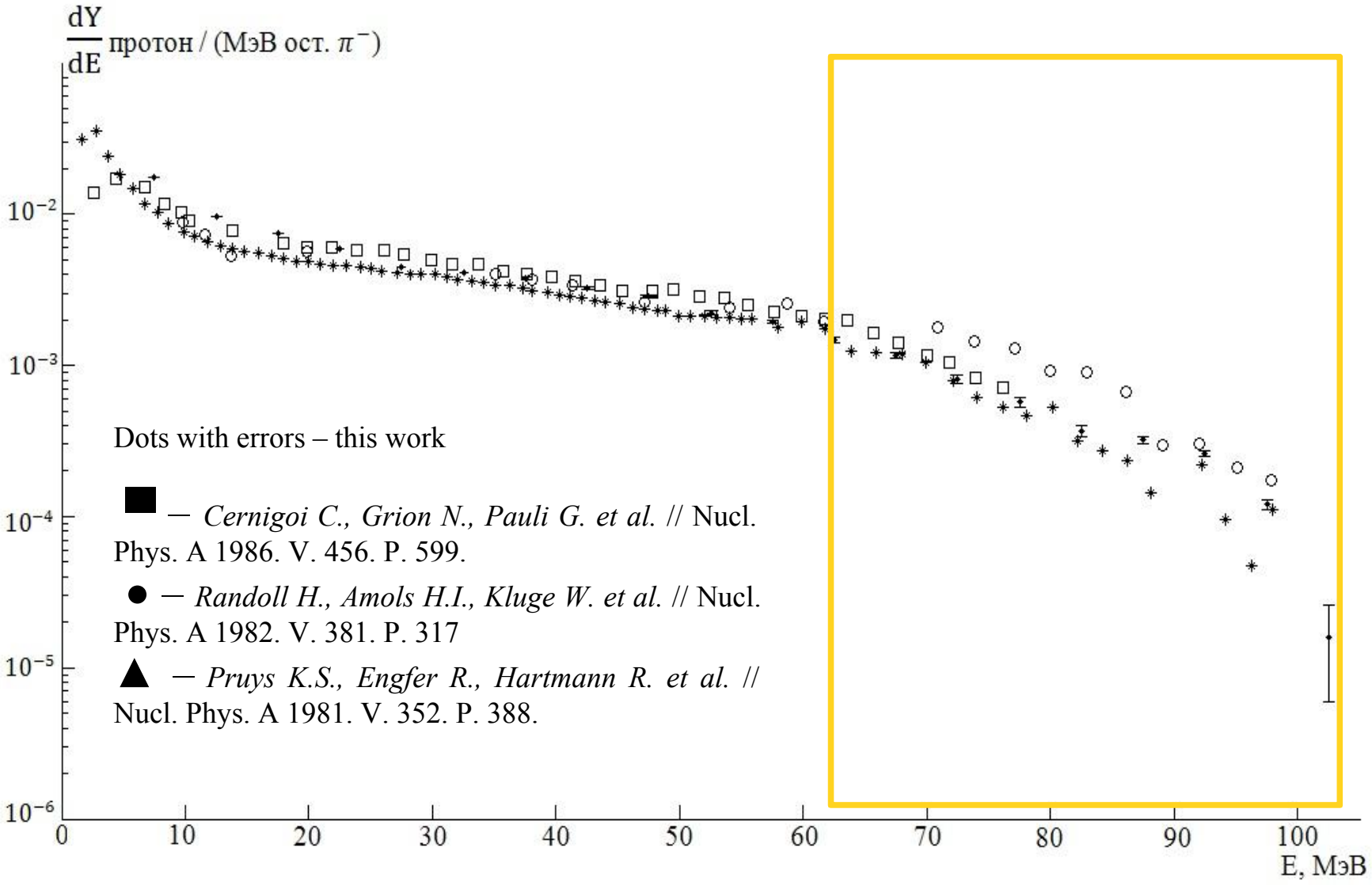
**PNPI RAS, synchrocyclotron**




**Measurements conducted up to kinematic boundaries of the reaction**

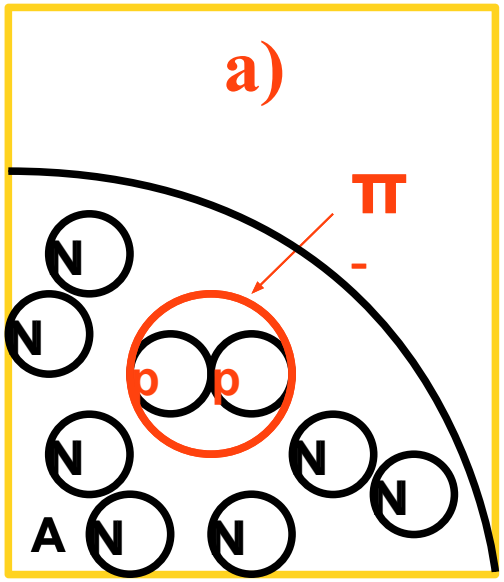
# Experimental results

## Proton spectra, $^{12}C$

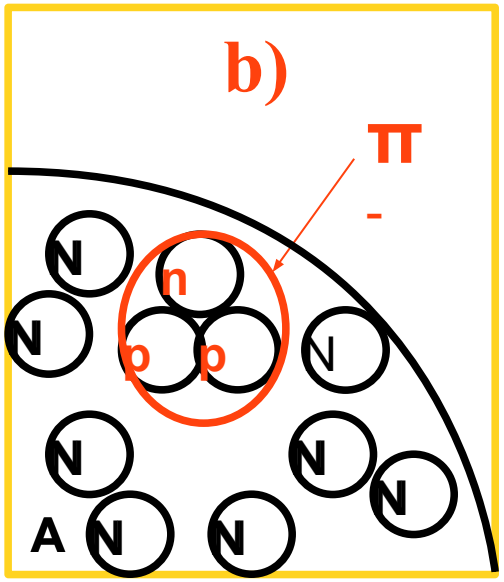


# Model. Cluster absorption

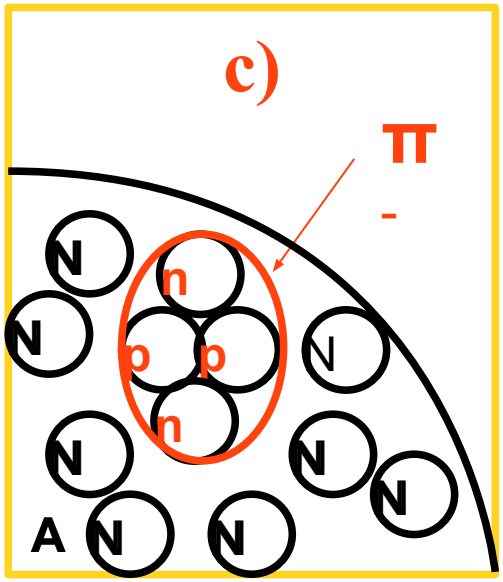
I. We investigate yields of p, d, t formed in pion absorption on pp, $^{3,4}$He clusters.




$\pi^- + (pp) \rightarrow n + p$




$\pi^- + {}^3He \rightarrow n + d$




$\pi^- + {}^4He \rightarrow n + t$

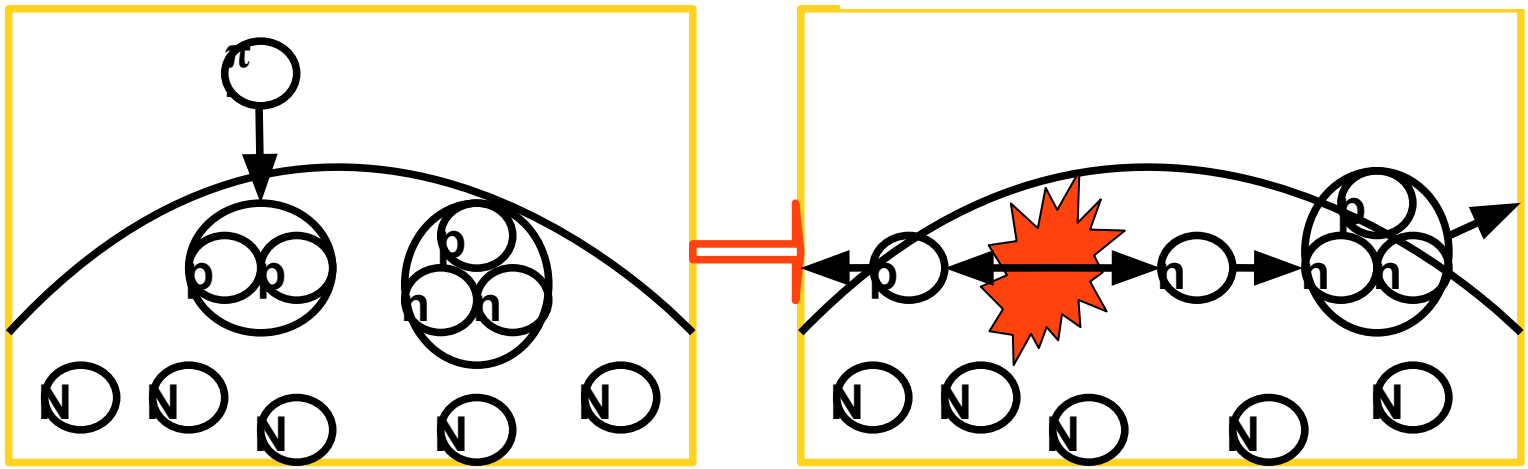
Primary particle spectrum:

$$\frac{dY}{dE} = C_1 * Sinh\left(\frac{2m}{\gamma^2}\sqrt{E(E_{max} - E)}\right)$$

# Model. Secondary particles

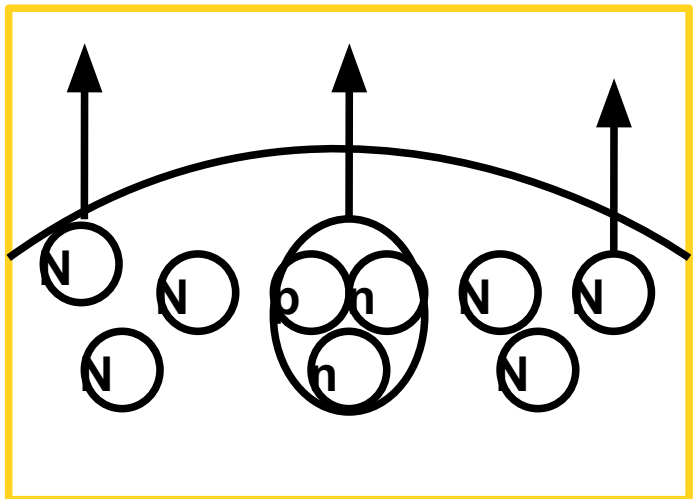
Preequilibrium particles:

$$\frac{dY}{dE} = C_1 * \sqrt{E(E_0 - E)} \cdot \exp(-E / T_1)$$



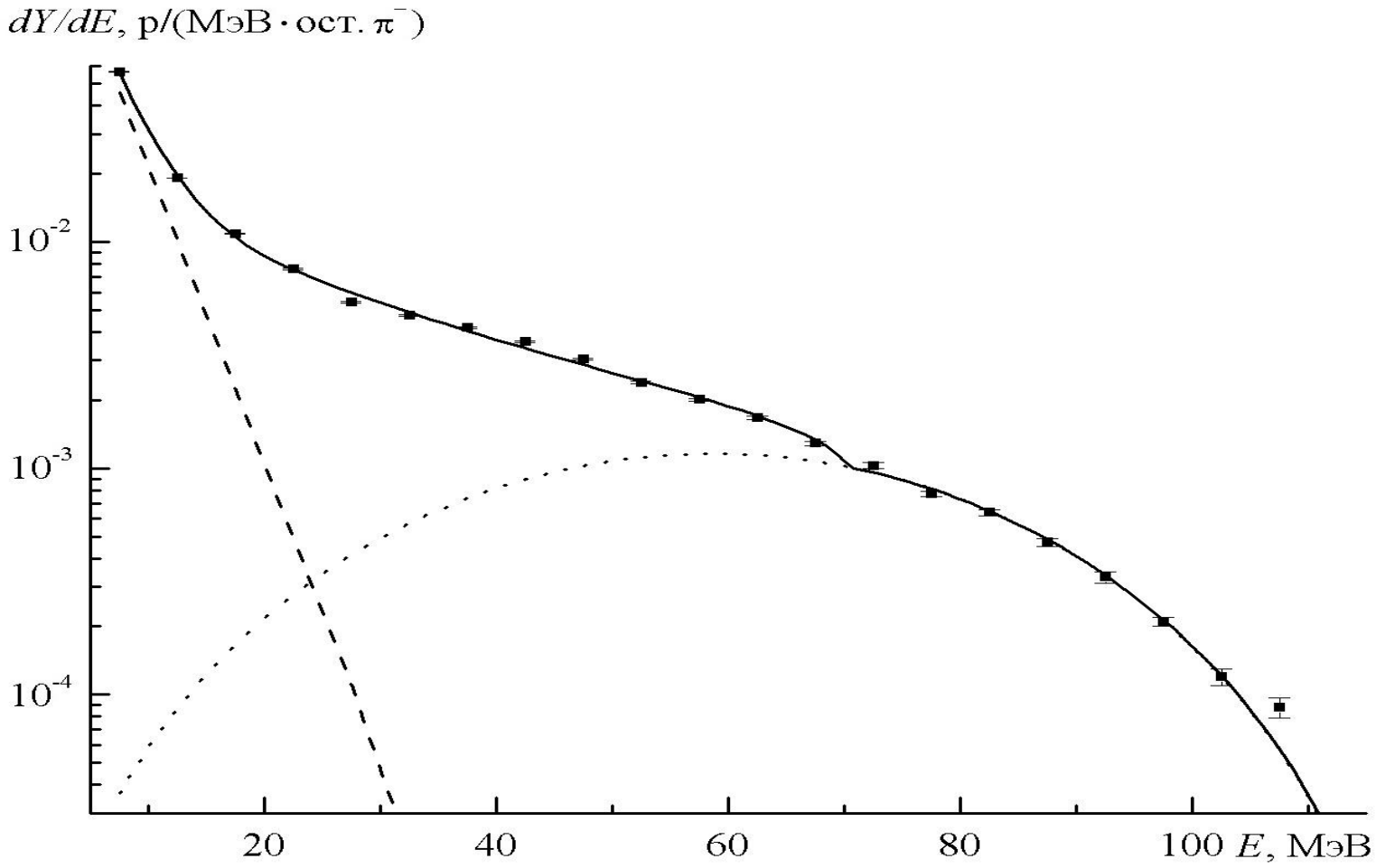
Evaporative particles:

$$\frac{dY}{dE} = C_2 * \exp(-E / T_2)$$



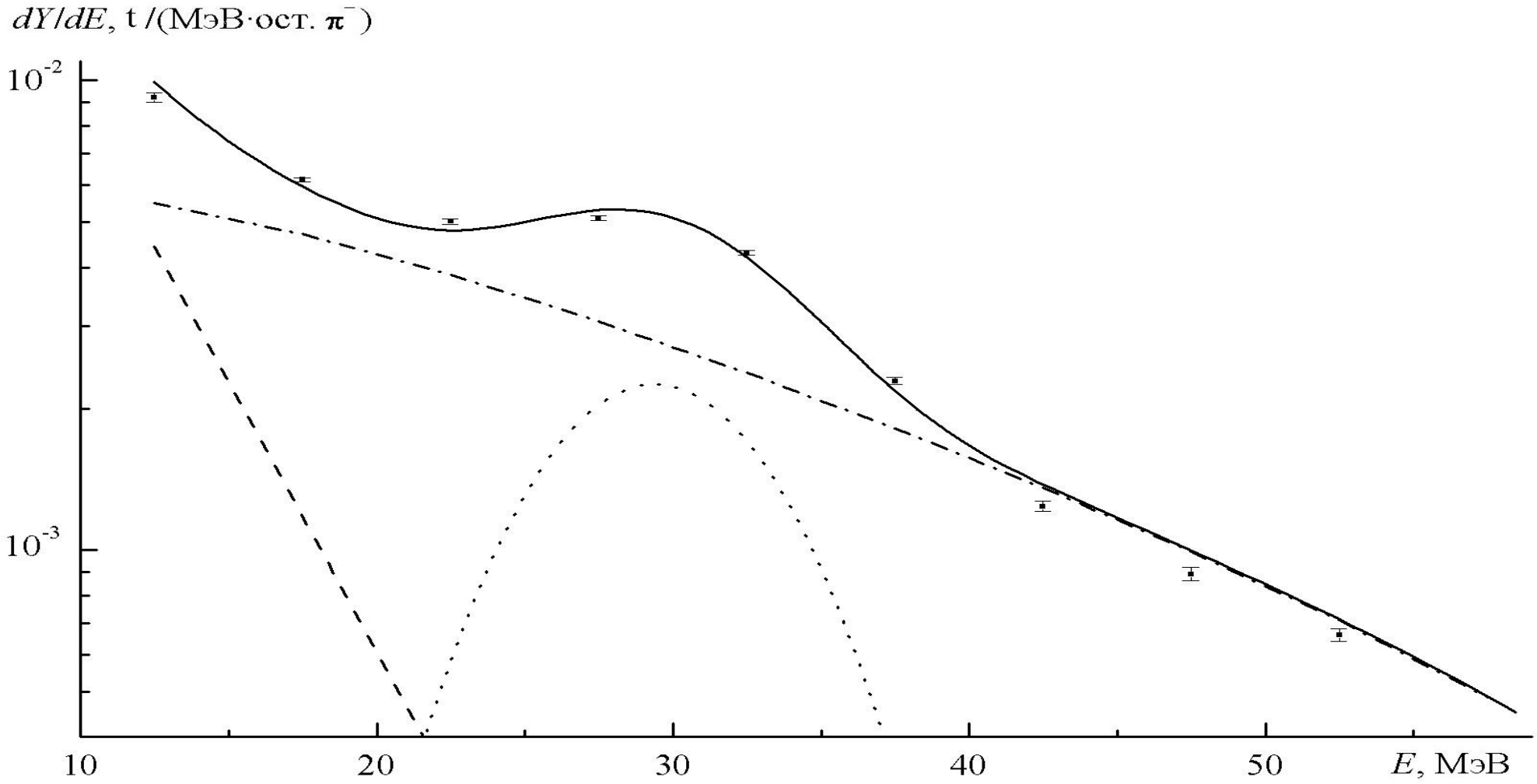
# Spectra

Proton spectrum descriprion, $^{28}$Si (typical spectrum)

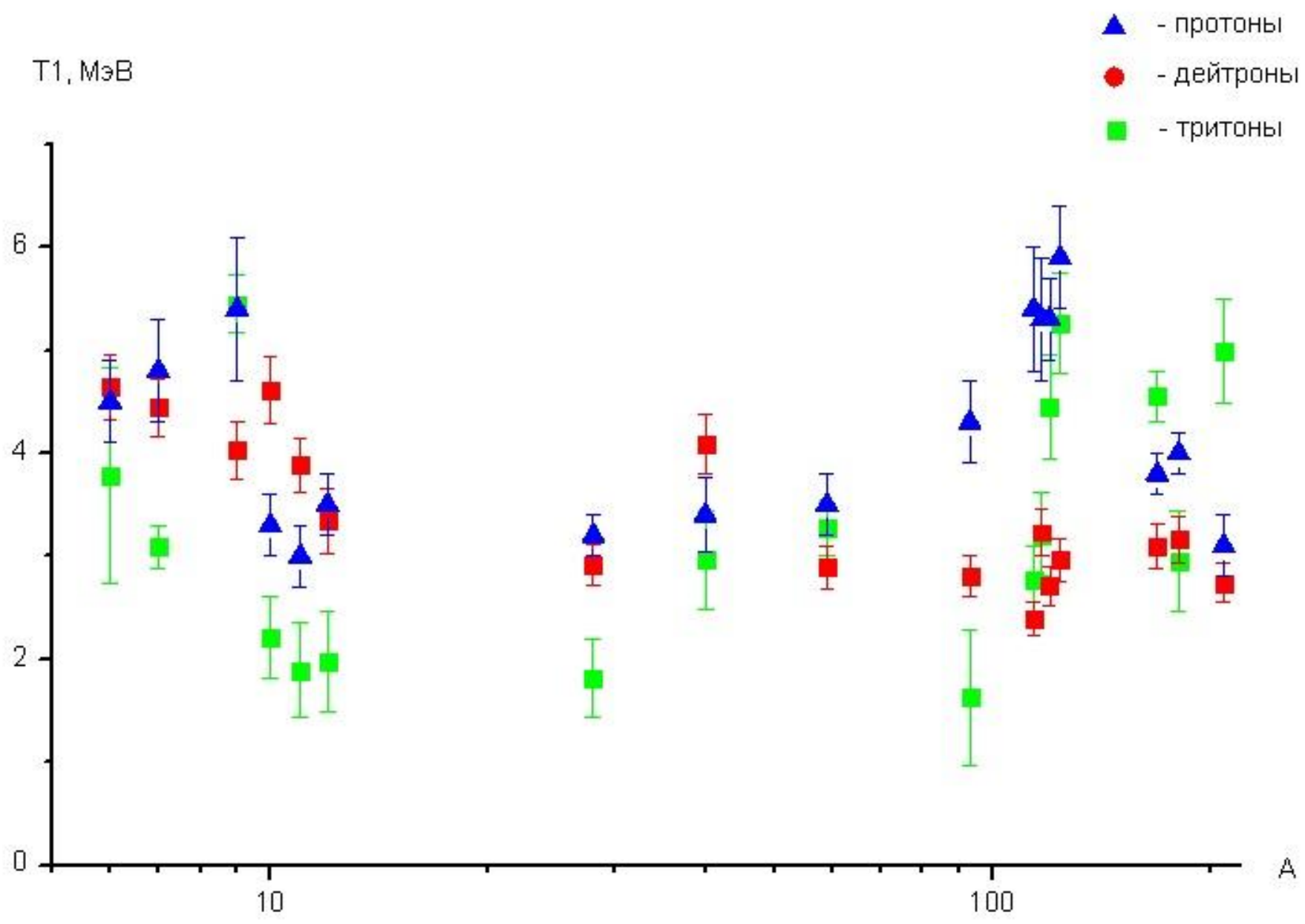


# Spectra

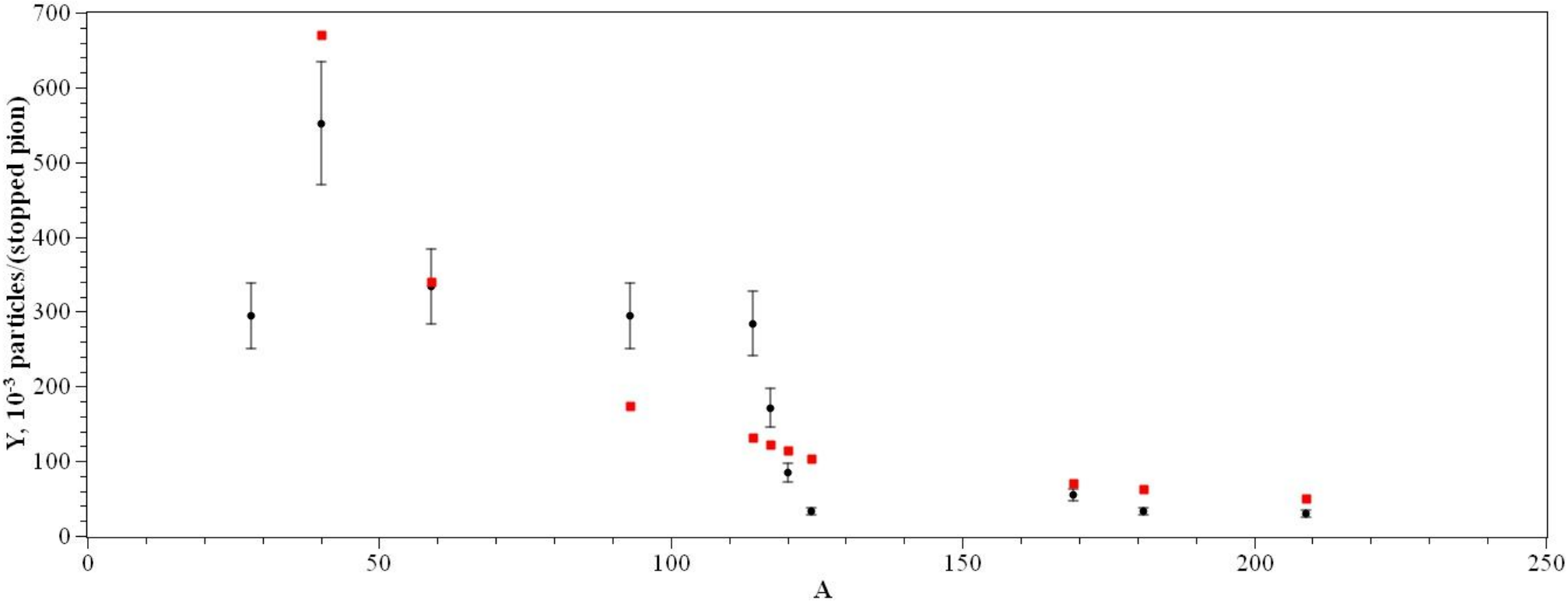
Triton spectrum description, $^{6}$Li (typical spectrum for light nuclei)



# Equilibrium temperatures



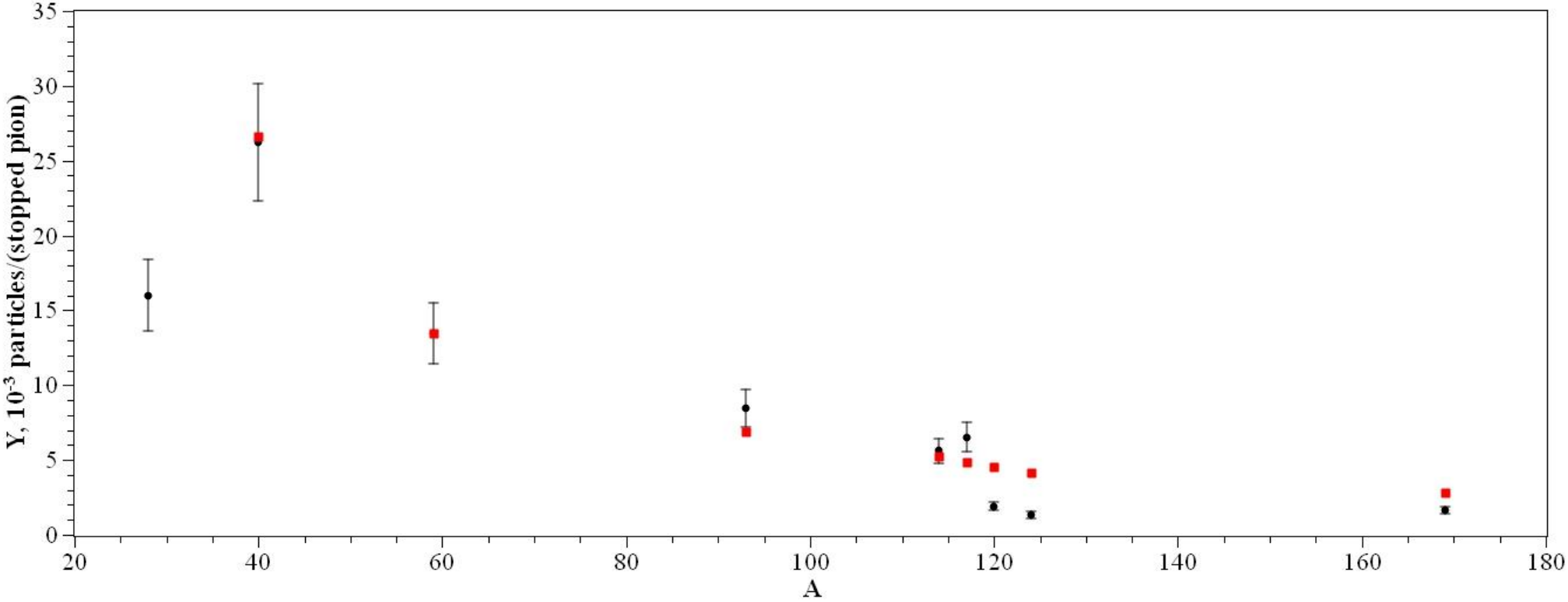
# Proton yields




**Contribution into total yields: ~ 50% for medium, up to 15% for heavy**

**Fit: $Y \sim (A^{2/3} * Z) / (N^{p})$**

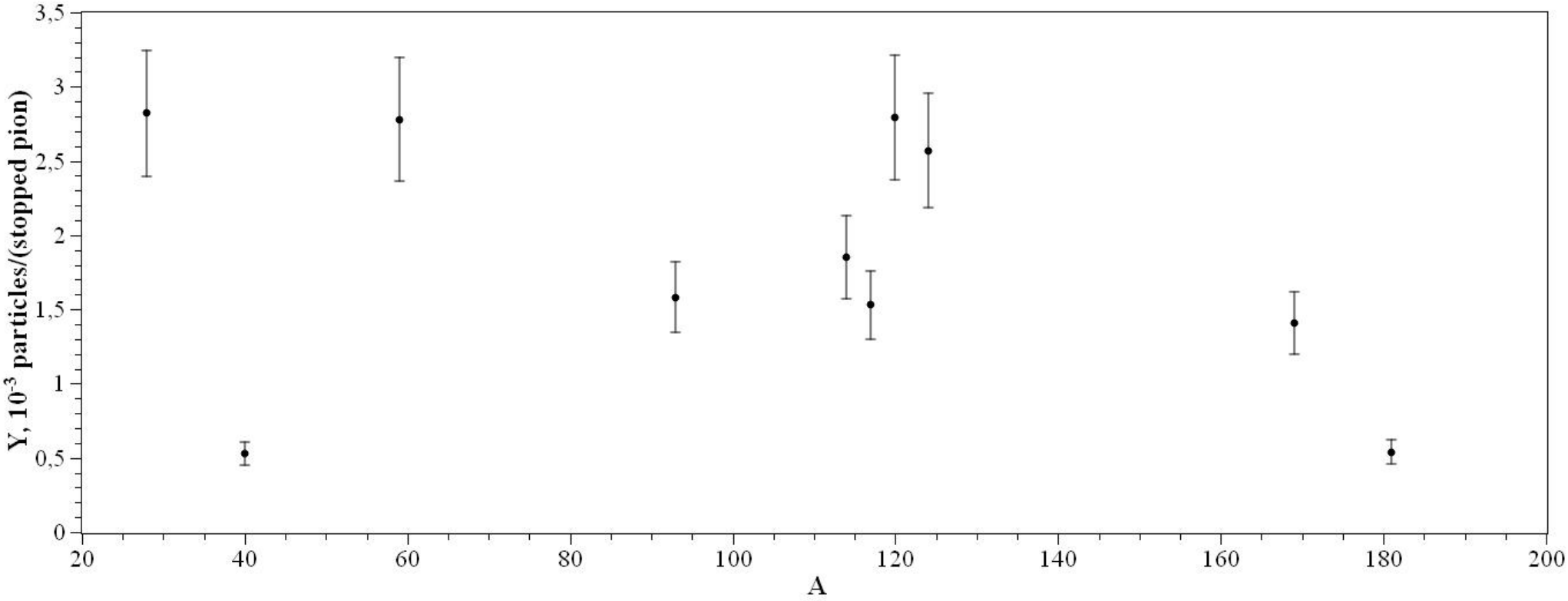
# Deuteron yields




**Contribution into total yields: ~ 15% for medium, up to 5% for heavy**

**Fit: $Y \sim (A^{2/3} * ZN) / (N^{p})$**

# Triton yields




**Contribution into total yields: ~ 15% for medium, up to 5% for heavy**

# Conclusions

I. Model has been developed allowing us to fit energy spectra for p, d, t formed after pion absorption on 17 different targets

II. The model allowed to evaluate contributions of different processes into full particles yields. For the evaporation stage:
p: ~ 50% for medium nuclei, up to 15% for heavy nuclei
d, t: ~ 15% for medium nuclei, up to 5% for heavy nuclei

III. Data on evaporative d yields extrapolated into the medium-heavy nuclei region

**THANK YOU FOR YOUR ATTENTION!**

# ПРИМЕРЫ СПЕКТРОВ

Пример типичного спектра дейтронов (поглощение на ядре $^{59}$Co)