

^8He SPECTROSCOPY IN STOPPED PION ABSORPTION BY ^{11}B

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^8He

Among nucleon-stable nuclei the ${}^8\text{He}$ isotope has a record ratio of the neutrons number to protons: $N/Z = 3$.

- Binding energy of neutrons:

$$S_n = 2.58 \text{ MeV}$$

$$S_{2n} = 2.14 \text{ MeV}.$$

- Rms radius:

$$R_m({}^8\text{He}) = 2.52 \pm 0.03 \text{ fm}$$

$$R_m({}^6\text{He}) = 2.50 \pm 0.05 \text{ fm}$$

I.Tanihata et al., *Progr. Part. Nucl. Phys.* 68, (2013), 215

- Structure of valence neutrons:

$$(1p_{3/2})^4 + (1p_{3/2})^2 (1p_{1/2})^2$$

$$(1p_{3/2})^2 (2s_{1/2})^2 + (1p_{3/2})^2 (1d_{5/2})^2 ???$$

Excited states of ${}^8\text{He}$

$E_x, \text{ MeV}$	$\Gamma, \text{ MeV}$	work
$2.7 \div 3.6$	0.6 ± 0.2	[1]
3.62 ± 0.14	0.3 ± 0.2	[2]
$3.6 \div 3.9$	~ 0.5	[3]
3.9 ± 0.2	0.3 ± 0.1	[4]
4.36 ± 0.2	1.3 ± 0.5	[1]
4.6 ± 0.3	0.3 ± 0.1	[4]
5.4 ± 0.5	0.3 ± 0.5	[2]
$5.3 \div 5.5$		[3]
6.03 ± 0.10	0.15 ± 0.15	[1]
7.16 ± 0.04	0.1 ± 0.1	[1]

1. D. R. Tilley et al., Nucl. Phys. A, 745, 155 (2005).
2. V. Lapoux et al., J. Phys. Conf. Ser., 49, 161 (2006).
3. M. S. Golovkov et al., Phys. Lett. B., 672, 22 (2009).
4. B.A. Chernyshev et al., KnE Ener. Phys. 2018, 78.

Reactions of ${}^8\text{He}$ formation in stopped pion absorption reaction

- ${}^9\text{Be}(\pi^-, \text{p}) {}^8\text{He}$

B.A. Chernyshev et al., The 3rd International Conference on Particle Physics and Astrophysics, KnE Energy & Physics, p. 78–82.

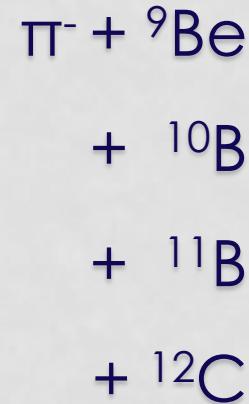
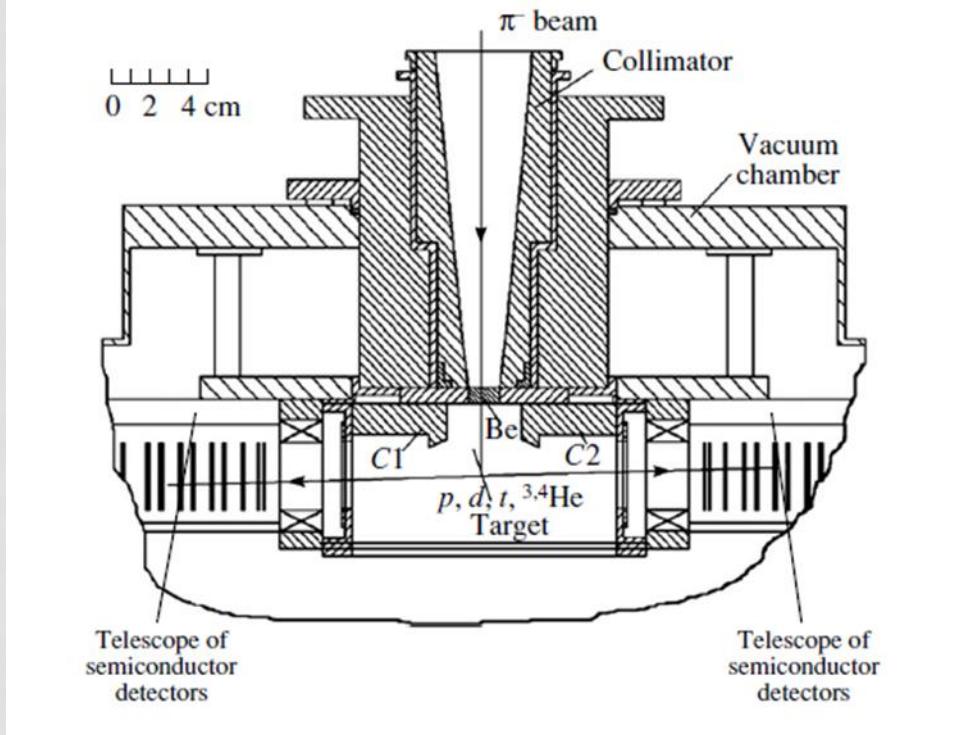
- ${}^{10}\text{B}(\pi^-, \text{pp}) {}^8\text{He}$, ${}^{10}\text{B}(\pi^-, \text{pp}) {}^8\text{He}$

- ${}^{11}\text{B}(\pi^-, \text{pd}) {}^8\text{He}$

- ${}^{12}\text{C}(\pi^-, \text{p}{}^3\text{He}) {}^8\text{He}$

- ${}^{14}\text{C}(\pi^-, \text{t}{}^3\text{He}) {}^8\text{He}$, ${}^{14}\text{C}(\pi^-, \text{d}{}^4\text{He}) {}^8\text{He}$

LAMPF experiment



Two arm semiconductor spectrometer

$$\delta E(p, d, t) \leq 0.45 \text{ MeV}$$

$$\delta E({}^3, {}^4\text{He}) \leq 2 \text{ MeV}$$

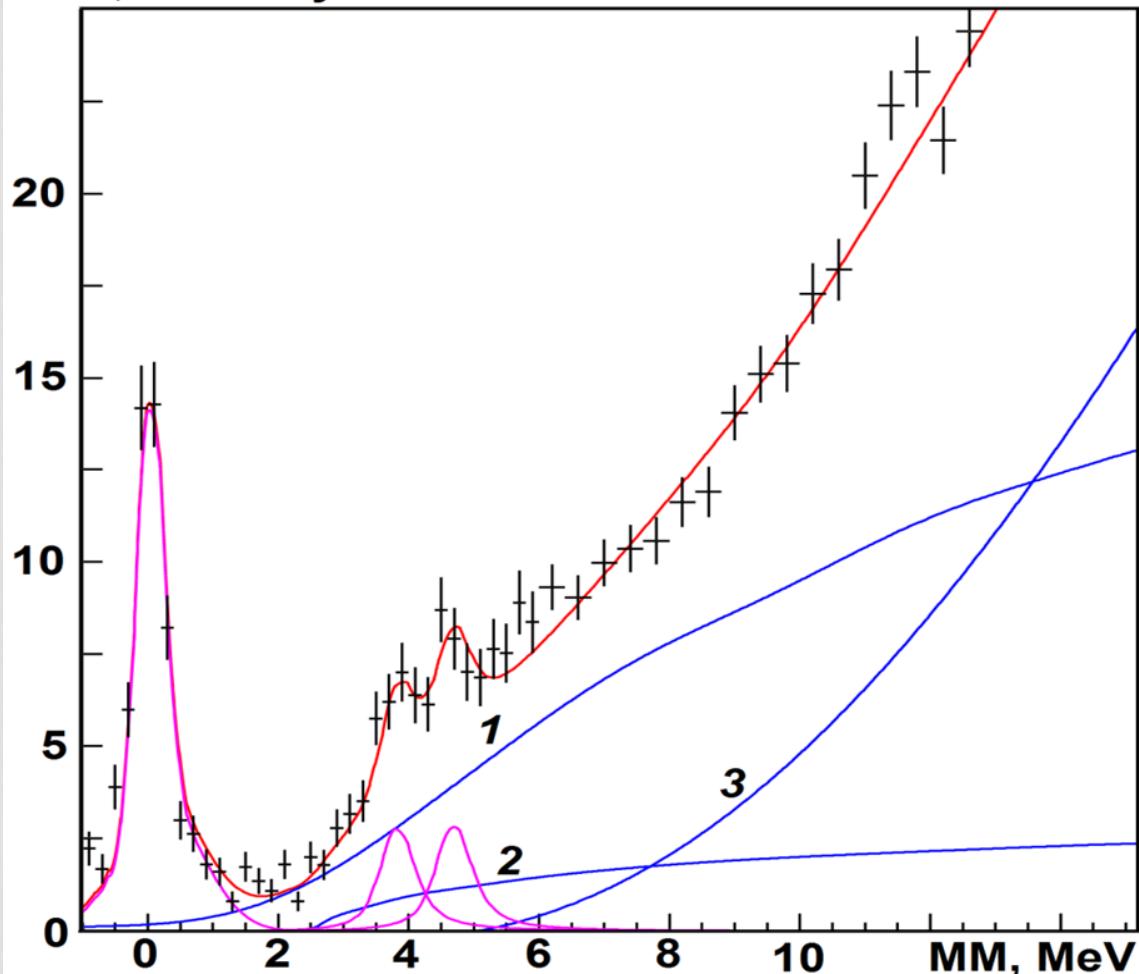
$$\delta MM(H, H) \leq 1 \text{ MeV}$$

$$\delta MM(H, \text{He}) \leq 3 \text{ MeV}$$

Absolute energy calibration $MM \leq 100 \text{ keV}$

Formation of ${}^8\text{He}$ in the ${}^9\text{Be}(\pi^-, \text{p})X$ reaction

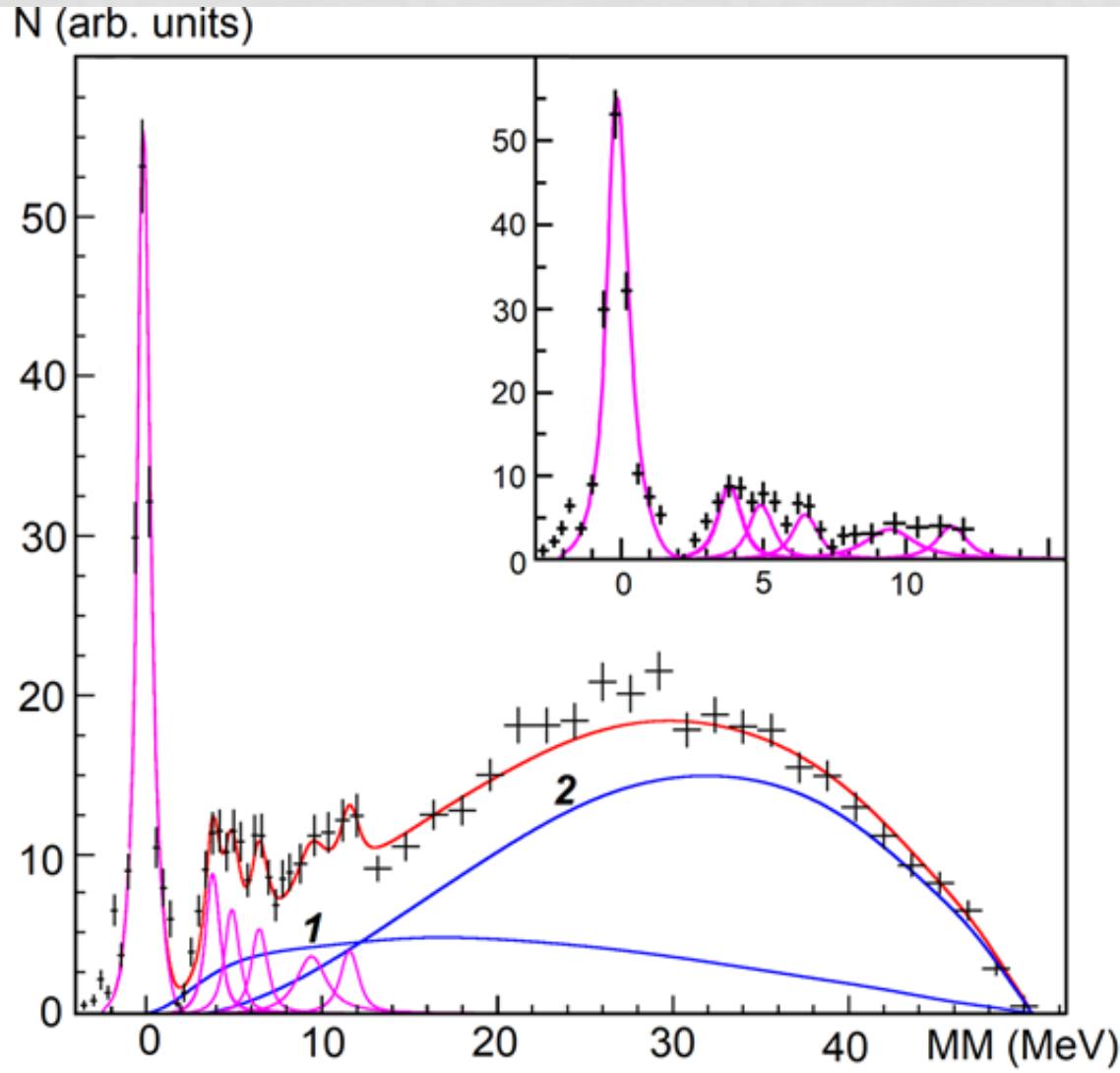
N, arbitrary units



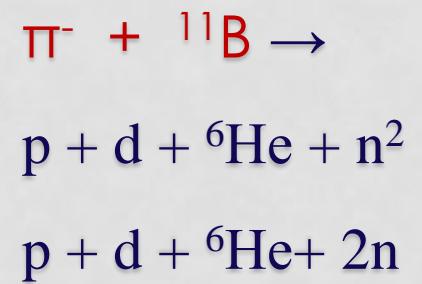
$E_x, \text{МэВ}$	$\Gamma, \text{МэВ}$
3.9 ± 0.2	0.3 ± 0.1
4.6 ± 0.3	0.3 ± 0.1

- $$\pi^- + {}^9\text{Be} \rightarrow$$
- p+ ${}^6\text{He} + 2\text{n}$ (1)
- p+ ${}^7\text{He} + \text{n}$ (2)
- p+ ${}^6\text{He}^*(1.8) + 2\text{n}$ (3)

Formation of ${}^8\text{He}$ in the ${}^{11}\text{B}(\pi^-, \text{pd})\text{X}$ reaction



E_x , MeV	Γ , MeV
3.9	0.3
4.6	0.3
≈ 6.4	~ 0.5
≈ 9.3	~ 1.5
≈ 11.5	~ 1



Excited states of ${}^8\text{He}$ in stopped pion absorption reactions

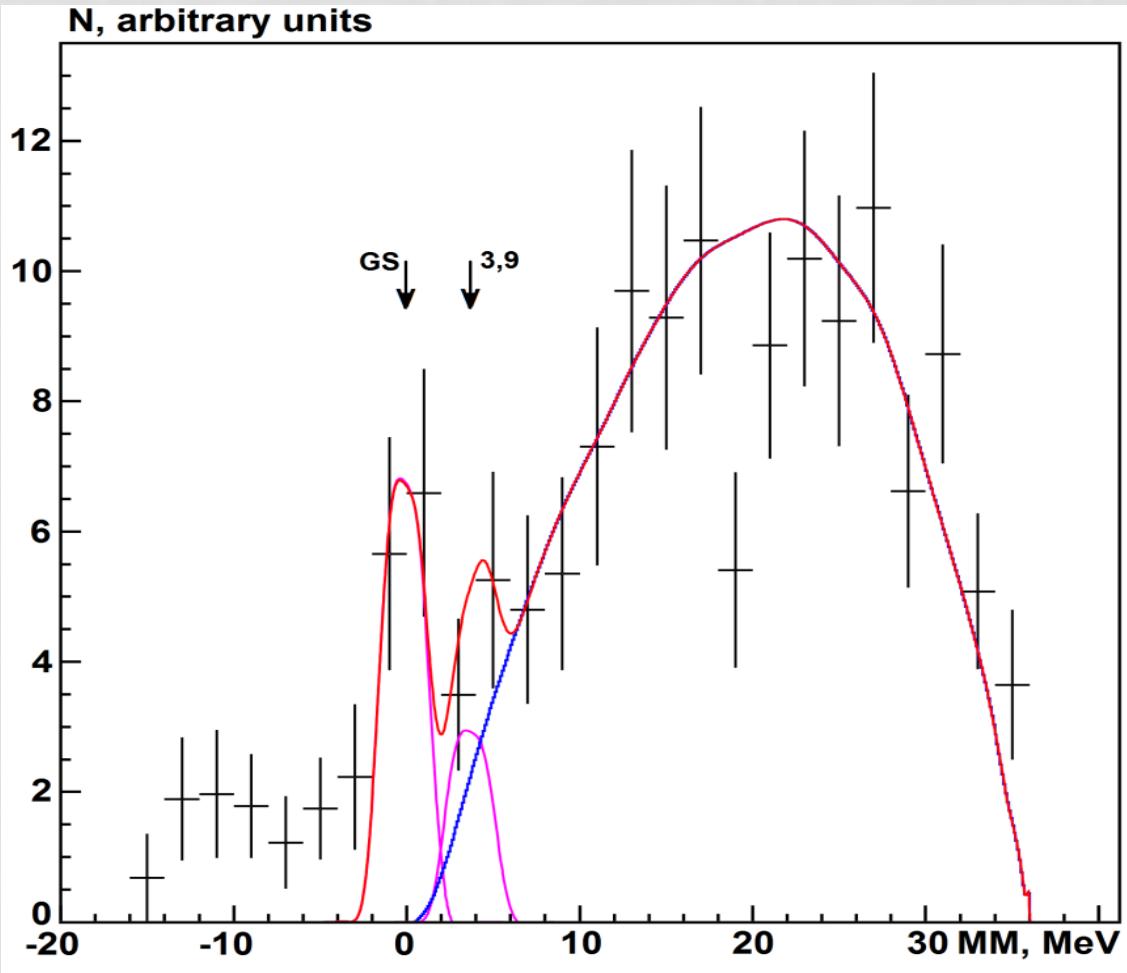
E_x , MeV	Γ , MeV	reaction
3.9 ± 0.2	0.3 ± 0.1	${}^9\text{Be}(\pi^-, p)\text{X}$ ${}^{12}\text{C}(\pi^-, p{}^3\text{He})\text{X}$ ${}^{14}\text{C}(\pi^-, d{}^4\text{He})\text{X}$ ${}^{14}\text{C}(\pi^-, t{}^3\text{He})\text{X}$ ${}^{11}\text{B}(\pi^-, pd)\text{X}$
4.6 ± 0.3	0.3 ± 0.1	${}^9\text{Be}(\pi^-, p)\text{X}$ ${}^{11}\text{B}(\pi^-, pd)\text{X}$
≈ 6.4	≤ 1	${}^{11}\text{B}(\pi^-, pd)\text{X}$ ${}^{14}\text{C}(\pi^-, d{}^4\text{He})\text{X}$ ${}^{14}\text{C}(\pi^-, t{}^3\text{He})\text{X}$
≈ 9.3	2	${}^{11}\text{B}(\pi^-, pd)\text{X}$
≈ 11.5	1	${}^{11}\text{B}(\pi^-, pd)\text{X}$

Conclusion:

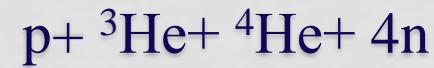
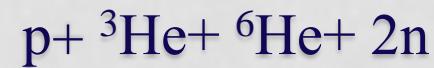
- exited states of ${}^8\text{He}$ have been observed in the stopped pion absorption reaction by ${}^{11}\text{B}$;
- the first three excited states agree with previous results;
- the states $E_x = 9.3$ and 11.5 have been observed in the first time.

THANK YOU FOR ATTENTION!

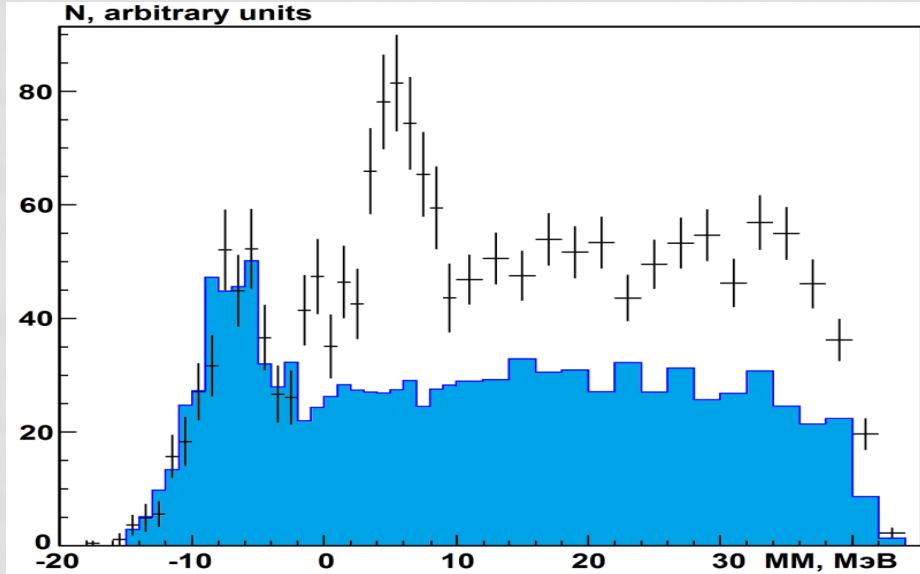
Formation of ^8He in the $^{12}\text{C}(\pi^-, \text{p}^3\text{He})X$ reaction



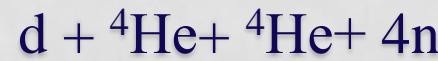
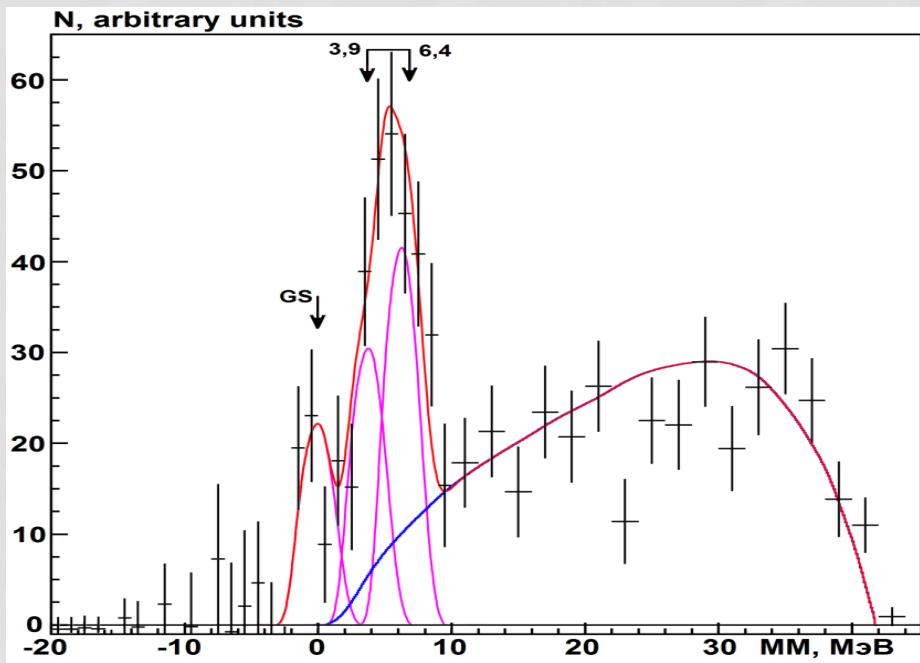
E_x, MeV	Γ, MeV
≈ 3.9	≤ 1



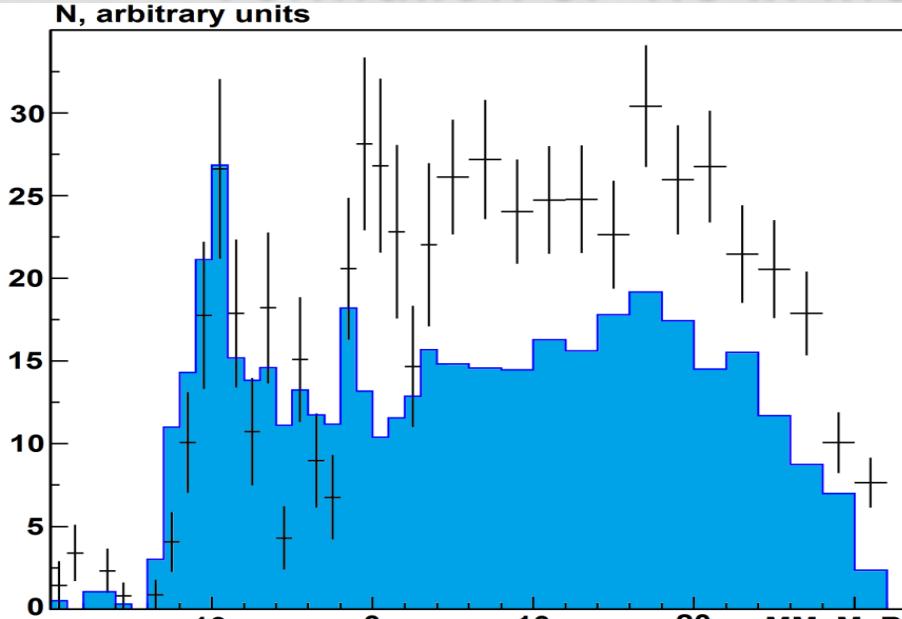
Formation of ${}^8\text{He}$ in the ${}^{14}\text{C}(\pi^-, \text{d}{}^4\text{He})\text{X}$ reaction



E_x, MeV	Γ, MeV
≈ 3.9	≤ 1
≈ 6.4	≤ 1



Formation of ${}^8\text{He}$ in the ${}^{14}\text{C}(\pi^-, t {}^3\text{He})X$ reaction



E_x, MeV	Γ, MeV
≈ 3.9	≤ 1
≈ 6.4	≤ 1

