PAINUC: investigation of pion interactions with the ^4He nucleus at beam energies below the Δ-resonance

(topic: Physics of light mesons)

Financial support of PAINUC has been suspended in 2015.

In 2016-2017 PAINUC continued analysing existing data on $\pi^{\pm 4}He$-interactions obtained with a self-shunted streamer chamber for extracting information on various channels of three-prong events (Fig.1). Work also continued for improving parameters of the pion beams of energies around 100 MeV from the phasotron of the JINR Laboratory of nuclear problems. Our most recent results were presented at the National Congress of the Italian Physical Society held in September, 2014.

Our analysis of a relatively small statistics (250) of "good" events, i.e. of events with long, well measurable, tracks of reaction products, reveals a significant difference in the branching ratios of reaction channels observed in $\pi^{-4}He$ and $\pi^{+4}He$ interaction events (see Table 1). This is most likely due to the significant difference between the interaction cross sections of positive and negative pions with protons. For this reason reactions with negative pions producing positively charged secondaries are not likely to proceed via production of the Δ-resonance, contrary to reactions with positive pions. Final-state reaction products were identified by track brightnesses ($\mathrm{Br}\cdot p^2 \propto m$) and, also, from the reaction kinematics. The ratio between the masses of the two charged secondaries mainly turns out to be close to unity, from which the two charged particles must be identical, i.e. deuterons. The feasibility of the production of two deuterons is also upheld by energy arguments: $\mathrm{m}_{\Delta}+\mathrm{m}_{^3H} > \mathrm{m}_{\pi}+2\cdot\mathrm{m}_{D}$. We have also estimated the mass of the Δ^0-resonance from π^-p^{3}H- and π^-ppnn-events to be $\mathrm{m}_{\Delta^0} = 1132 \pm 32$ MeV in agreement with the value previously obtained from two-prong events ($\mathrm{m}_{\Delta^0} = 1160\pm5$ MeV, see Eur. Phys. J. A 34, 255-269 (2007)).

With time we hope to continue the analysis of all four components of the $\Delta_{33}-$resonance based on observation and measurements of $\pi^{\pm 4}He$-interaction events performed using the same experimental device, namely a self-shunted streamer chamber filled with helium at atmospheric pressure in a magnetic field. The point is that the Δ^- component has still not been clearly identified (see "Particle Data"), although measurements of the $\pi^- n$ invariant mass were already performed in the JINR Laboratory of nuclear problems back in 1970 by Blokhinteva et al. (see Journal of Nuclear Physics 11(1970)387, 12(1970)101 (in Russian)).

Since our experimental device STREAMER is in working condition, and till now only about 20% of $\pi^{\pm 4}$He interaction events, obtained at an incident pion energy of 106 MeV, have been measured, our further plans would include the following:

- Sustaining our experimental device STREAMER in working condition.
- Further measurement of events of $\pi^{\pm 4}$He reactions; data analysis.
- Increasing the intensity of the phasotron pion beam incident upon the streamer chamber from $10^3 \div 10^4 \pi/s$ by about an order of magnitude required for collection of a statistic ($\geq 10^4$) of $\pi^{\pm 4}He$-interaction events within a reasonable time.
- In the future, performing runs with pion beams of the JINR phasotron at different pion beam energies (financial support required).

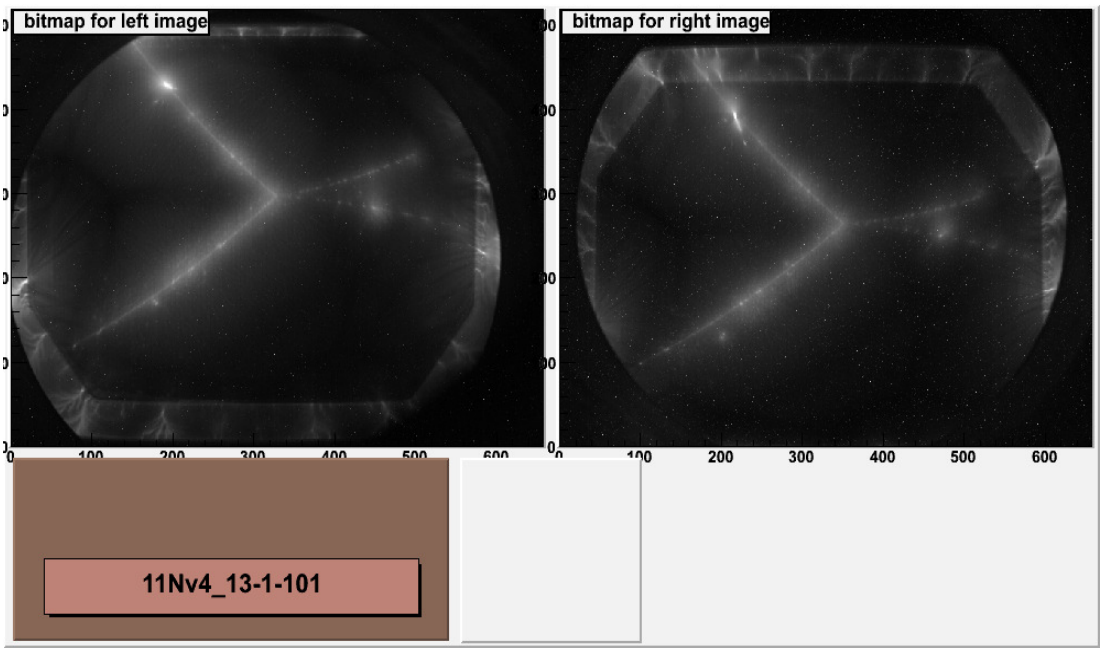

Figure 1: Videoimage of three-prong π^4He interaction event. The tracks of the incident (lower track incoming from the right) and of the scattered (backward) pions are clearly distinguishable from the tracks of the strongly ionizing reaction products.

Table 1: Branching ratios of different $\pi^{\pm}$^{4}He reaction channels observed in diffusion chamber (π^+, 1980) and self-shunted streamer chamber (π^-, 2017)

reaction products	Diff.ch.: 15 atm ^{4}He π^+, 120 MeV	Stream.ch.: 1 atm ^{4}He π^-, 106 MeV
$\pi^{\pm}$pt	0.66	0.34
$\pi^{\pm}$dd	–	0.43
$\pi^{\pm}$ppnn	0.34	0.09
$\pi^{\pm}$pdn	–	0.13

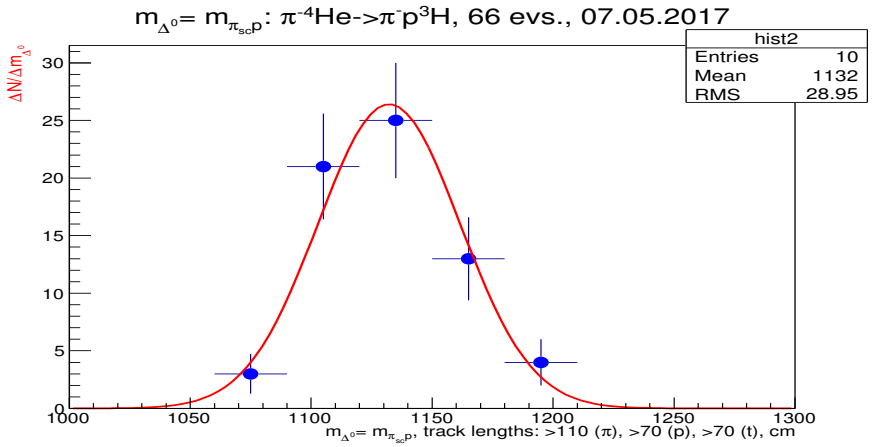

Figure 2: Invariant $\pi^- p$ mass, i.e. mass of Δ^0-resonance: $m_{\Delta^0} = 1132 \pm 29$ MeV.