The observation of deeply bound pionic states of xenon produced in the $Xe_{nat.}(d,^{3}He)Xe_{\pi-bound}$ reaction

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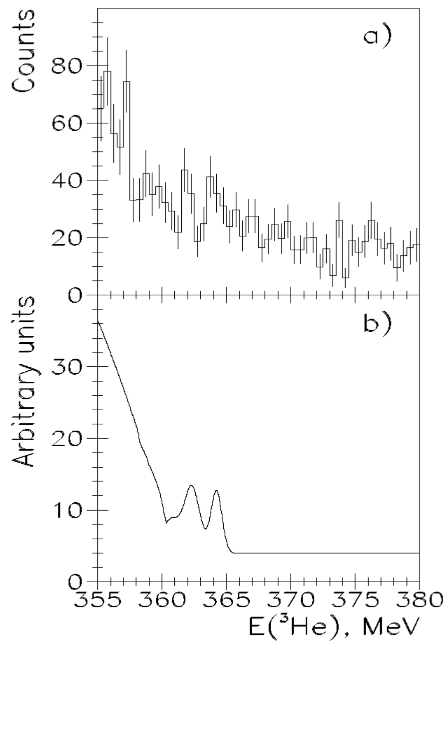
The observation of a clear peak structure corresponding to the 2p state of pionic atoms of ^{207}Pb and ^{205}Pb produced in $(d,^{3}He)$ reactions at an energy of E_d =600MeV [1,2] confirmed the theoretical prediction of the existence of deeply bound pionic states in heavy nuclei [3]. At the same time these experiments confirmed that the 2p state is populated preferentially in the case of a lead target in contrast to the 1s state, which is suppressed by the lack of s-state neutrons in the outer shell. The closed shell nucleus ^{136}Xe is suggested by Umemoto et al. [4], to be a particularly good candidate as a target for observation of the deeply bound 1s state in the $(d,^{3}He)$ reaction.

Here we report on a pilot study of the production of pionic atoms of xenon in $(d,^{3}He)$ reactions at E_d=500 MeV, using natural xenon as a target. The experiment was done at the CELSIUS storage ring [5] using a zero-degree spectrometer [6] with internal high-purity germanium detectors. The expected energy resolution of the spectrometer was ≤1.2 MeV in the measured energy range of ^{3}He ions.

The measured ^{3}He spectrum from the $Xe_{nat.}(d,^{3}He)X$ reaction is shown in fig.1a. Two peaks are observed at approximately 362 and 364 MeV. The peak positions are in a good agreement with those expected following the population of the 1s state in odd A and even A isotopes of xenon, respectively (fig1.b). Thus we conclude that the production of deeply bound pionic states in the mixture of xenon isotopes has been observed in the $Xe_{nat.}(d,^{3}He)X$ reaction. An experiment on the $^{136}Xe(d,^{3}He)^{135}Xe_{\pi\text{-bound}}$ reaction is being prepared with an isotopically enriched target. Based on the present results such an experiment offers very good perspectives for a precise determination of the binding energy and the width of the 1s state.



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