Velocity distributions of Bi produced in charge-pickup reactions of ^{208}Pb

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In nuclear charge-pickup reactions at projectile energies well above the Fermi energy there are two processes mostly responsible for the increase of the nuclear charge of the projectile [1]: A quasi-elastic collision between a target proton and a projectile and the excitation of a target or a projectile nucleon into the Δ(1232)-resonance state and its subsequent decay. These two mechanisms populate different regions of velocity distributions of charge-pickup products [1]: While the quasi-elastic (QE) component is situated at the velocities close to that of the beam, the deexcitation of Δ(1232)–resonance state populates a broader peak at lower velocities. At relativistic energies charge-exchange reactions involve the formation of Δ–particles and pions, they can be used as a tool for studying the in-medium behaviour of these particles [2]. These reactions can also give some insight into the neutron density distribution in the nucleus [3].

The charge-pickup reactions of 1 *A* GeV ^{208}Pb with ^{1}H, ^{2}H and Ti were studied [4] at the FRS. As a magnetic spectrometer, the FRS allows one to measure the kinematical properties of the reaction residues with high resolution. Details on the experiment can be found in Ref. [4].

The experimental velocity distributions in the projectile frame are shown in Fig. 1. In the same figure, on the upper axis is shown the energy transfer in the laboratory frame, which was calculated applying two-body kinematics. For ^{208}Bi, events with negative energy transfer reflect the finite resolution of the experiment. In the cases $A <$ 208 the two-body kinematics applied for calculating the energy transfer is not strictly valid, which additionally contributes to the events with apparent negative energy transfer. In case of ^{208}Bi one can see a clear presence of both components. Going from the ^{1}H to the ^{2}H target, the QE contribution leading to the production of ^{208}Bi decreases by a factor 1.4. The QE component of a charge-pickup reaction can occur only on the target proton, and, consequently, it is expected to be about two times weaker in the ^{2}H case. Distortion effects of the ^{2}H target could influence this ratio. On the other hand, the contribution of the Δ–resonance excitation to the formation of ^{208}Bi is larger for the ^{2}H target than for the ^{1}H target. In case of the ^{1}H target a process leading to the production of ^{208}Bi is p(^{208}Pb, ^{208}Bi)Δ^0, while in case of the ^{2}H target, depending on the orientation of a deuteron with respect to the projectile, one can excite the Δ–resonance either on the target proton or on the target neutron via n(^{208}Pb, ^{208}Bi) Δ^- reaction. Considering that the isospin Clebsch-Gordan coefficient for neutrons is three times larger than for protons [5], one would expect the Δ-resonance component to be about two times stronger in case of the ^{2}H target as compared to the ^{1}H target. A distortion of the ^{2}H could also influence this ratio. From the fits to the measured velocity distributions of ^{208}Bi, we obtain that the Δ–resonance contribution for the ^{2}H target is by a factor of 1.7 larger as compared to the ^{1}H target. From the same fit, we have obtained that the mean energy transfer corresponding to the Δ–resonance contribution is equal to (293 ±12) MeV and (274±12) MeV for ^{1}H and ^{2}H target, respectively, which is in agreement with other data [2].

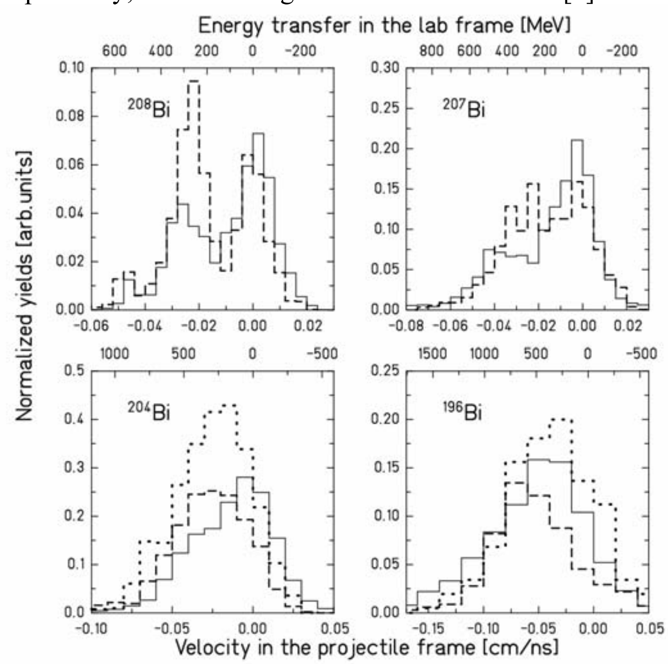

Fig 1. Longitudinal velocities (lower scale) of several bismuth isotopes produced in the interaction of 1 *A* GeV ^{208}Pb with the ^{1}H- (full line), ^{2}H- (dashed line) and Ti-target (dotted line). The velocity distributions are normalised to the corresponding production cross sections. The upper scale represents the energy transfer in the laboratory frame.

An interesting finding is that for the isotopes $^{204\text{-}207}$Bi produced on the ^{1}H target, the QE component is stronger as compared to the ^{2}H or the Ti target. For the lightest bismuth isotopes (A < 204) the overall shape and mean value of the velocity distributions are very similar for all three targets.

The velocity distributions of the bismuth residues were also calculated with INCL4+ABLA code and were found to be in qualitative agreement with the measured distributions [4]. It was shown that the experimental data can help to improve the treatment of the Pauli blocking in the intra-nuclear cascade model.

References

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