Inelastic process observed in isobaric charge-exchange reaction of ^{56}Fe at 500 MeV/u

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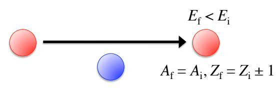
Abstract.

In the longitudinal-momentum (P_L) distribution of products in isobaric charge-exchange reactions (p, n) and (^{3}He, t), inelastic component, which is attributed to Δ excitation, has been investigated. For example, Udagawa et al. showed that the inelastic component can be a good probe to study nuclear medium effect on Δ excitation [1]. Recently, inelastic component was successfully observed in P_L distribution with ^{208}Pb beam at 1A GeV by using the spectrometer FRS at GSI [2]. In the present study, the P_L distribution in isobaric charge-exchange reaction was observed at E = 500 MeV/u, which is relatively lower than the previous experiments.

The measurement was performed at NIRS. ^{56}Co was produced through isobaric charge-exchange reaction by bombarding a 0.5-mm thick C-target and a 1-mm thick CH_2 target with a primary beam of ^{56}Fe at E=500 MeV/u, provided by HIMAC synchrotron accelerator. The target thickness was selected to make the energy loss equivalent for C and CH_2 target. In order to observe the P_L distributions, the magnetic rigidity of the spectrometer was varied with a step of 0.1% of that corresponding to the primary-beam velocity. The produced ^{56}Co was separated and identified with a high-energy transport system, SB2, used as a doubly achromatic spectrometer. P_L distribution with the proton target is provided by subtracting P_L distribution with C target from that with CH_2 target. As shown in Fig. 1, the inelastic peaks are observed for both target nuclei. P_L distribution with the proton target shows similar behavior to that observed in very recent experiment with a ^{136}Xe beam at 500A MeV [3]. The inelastic peak grows and shifts upward for C target compared with proton target.

Significance of isobaric charge-exchange reaction at intermediate/relativistic energies



Downward E shift and amplitude of inelastic component

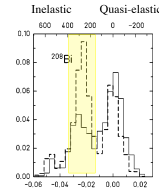


Fig. 1 Longitudinal velocities (lower scale) of ^{208}Bi produced from ^{208}Pb beam with E=1A GeV and the proton (full line), deuteron (dashed line), and "Ti" targets (dotted line). The upper scale represents the energy transfer in the laboratory frame. [1]

Inelastic component

A) Excitation and in-medium behavior of Δ particle [2]

B) Neutron density distribution [3]

(^{3}He, t)

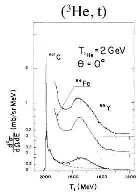


Fig. 2 Energy spectra observed in reactions, C, Fe, Y (^{3}He, t). [4]

^{208}Pb + target -> ^{208}Bi
Inverse kinematics

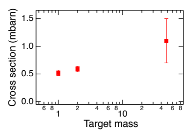


Fig. 3 Total prod. cross section of ^{208}Bi through isobaric charge exchange reaction [1]

Possibility of experimental studies depends on accuracy obtained for the measurement of the Δ-resonance properties. [5]

Object of this study

Feasibility of HIMAC facility for experimental investigation of inelastic component in isobaric charge-exchange reactions.

Secondary beam course SB2 (Doubly achromatic spectrometer) [6]

Simple particle detection system

Rigidity (Bρ), TOF, ssd x 2

no-position sensitive (tracking) detector

Experimental

Experiment was performed by using HIMAC facility at NIRS

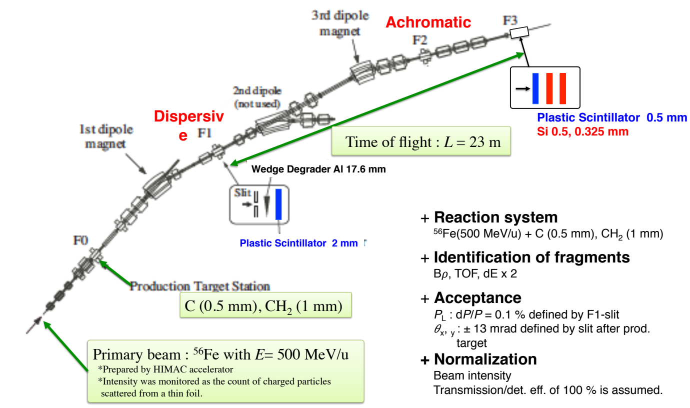


Fig. 4 Secondary beam course SB2 at HIMAC facility

+ Reaction system
^{56}Fe(500 MeV/u) + C (0.5 mm), CH_2 (1 mm)

+ Identification of fragments
Bρ, TOF, dE x 2

+ Acceptance
P_L : dP/P = 0.1 % defined by F1-slit
$\theta_{x,y}$: ± 13 mrad defined by slit after prod. target

+ Normalization
Beam intensity
Transmission/det. eff. of 100 % is assumed.

Identification of reaction products and angular acceptance

A. Identification of ^{56}Co

Successful identification and purification achieved by use of wedge degrader at F1.

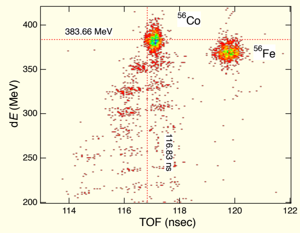


Fig. 5 Particle identification in the dE–TOF plane at Bρ = 7.4615 Tm with the C target.

B. Resolution of TOF and dE

Resolutions of TOF and dE are enough good to provide a reliable value for the amount of ^{56}Co

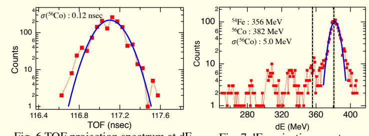


Fig. 6 TOF projection spectrum at dE ~ 384 MeV

Fig. 7 dE projection spectrum at TOF ~ 117 nsec

C. Angular acceptance

Ang. dispersion ; s_θ ~ 2.6 mrad -> s_P ~ 160 MeV/c
Transmission in 0 ± 13 mrad ~ 100%

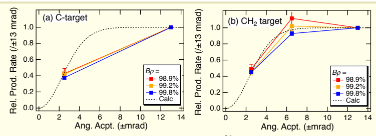


Fig. 8 Normalized production rate of ^{56}Co as a function of angular acceptance

Results

A. Observed P_L distribution of ^{56}Co

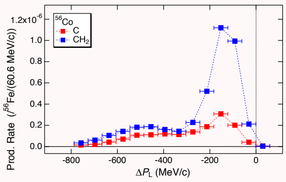


Fig. 9 P_l distribution of ^{56}Co with C and CH_2 target. Observed production rate was normalized by beam intensity

B. P_L distribution of ^{56}Co produced from H and C

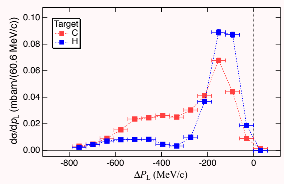


Fig. 10 P_l distribution of ^{56}Co produced from H and C. Thickness of target is evaluated from observed energy loss in target.

Inelastic components are significantly observed.

C. Analysis of P_L distribution

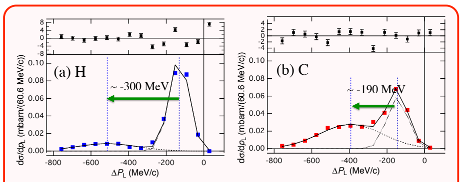


Fig. 11 Analysis of P_l distribution by integrated double Gaussian functions. The contribution of momentum acceptance dP/P = 0.1 % is considered.

The inelastic component grows and shifts upward for C target compared with proton target.

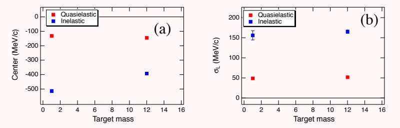


Fig. 12 Center and dispersion of two components observed in P_l distribution.

A dispersion of ^{56}Co momentum, caused by position dependent energy loss, is ~ 22 MeV/c estimated by using LISE++.

The present results are consistent with the previous results [1].

A) The inelastic component grows with target mass.

B) The mean energy transfer corresponding to the Δ-resonance contribution is equal to 293±12 MeV for proton target.

5. Conclusions

The inelastic component of ^{56}Co, which was produced through isobaric charge exchange reaction at 500 MeV/u, was successfully observed at HIMAC facility with simple particle detection system.

A) Target dependence, which is consistent with previous results, were observed.

B) The possibility of HIMAC facility to investigate excitation and in-medium behavior of Δ particle has been shown.

References

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