

LINEAR MOMENTUM TRANSFER IN 40-150 MeV PROTON-INDUCED REACTIONS WITH ^{238}U

M. Fatyga, K. Kwiatkowski, L.W. Woo and V.E. Viola
 Indiana University Cyclotron Facility, Bloomington, Indiana 47405

H.J. Karwowski
 University of North Carolina, Chapel Hill, North Carolina

A systematic analysis of linear momentum transfer for the total reaction cross section in proton-induced reactions in the intermediate-energy regime has been performed. Measurements involved use of the fission fragment angular correlation technique. Data are shown for proton energies of 40, 90 and 150 MeV in Fig. 1. Linear momentum transfer distributions derived from these data were corrected for the effects of spallation products.

Over this entire region the proton is found to be the most effective agent of linear momentum transfer on a per nucleon basis when compared with complex projectiles. While our data are in general agreement with previous measurements at 150 MeV, the lower energy results do not support the concept of projectile scaling in the energy region $E/A = 20-70$ MeV, as previously suggested.² Maximum average values of $\langle p_{\parallel} \rangle \approx 300-350$ MeV/c are observed, compared with heavier ions, for which maximum values are $\langle p_{\parallel} \rangle / A \approx 150$ MeV/c. This projectile dependence can be qualitatively explained on the basis of the longitudinal linear momentum transfer properties of elementary N-N, d-N and α -N scattering cross sections.¹

These data can also be used as a consistency check on estimates of the nucleon mean free path λ associated with inelastic projectile-nucleus interactions. Using values of λ from Ref. 5 and determining the number of collisions as in Ref. 1, values of the average linear momentum transfer are calculated which are in general agreement with the data. These are compared in Table I.

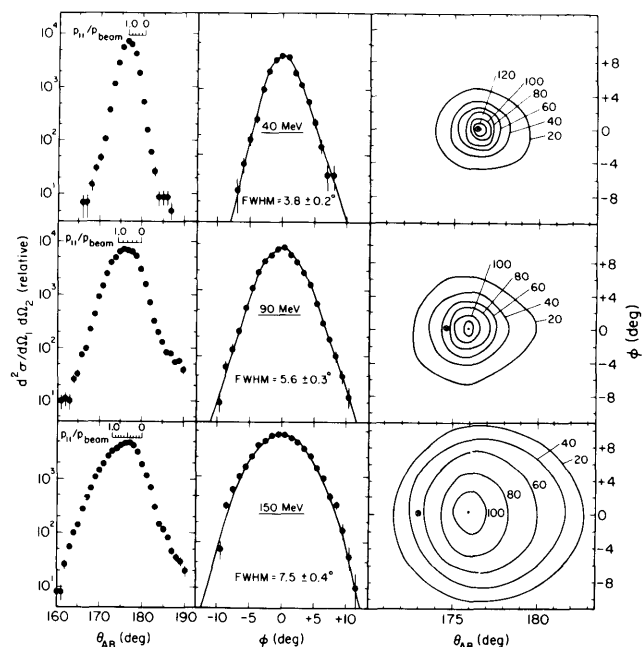


Figure 1. Fission-fragment angular-correlation data for 40, 90 and 150 MeV proton-induced fission of ^{238}U . Right-hand column shows two-dimensional coincidence contours as a function of in-plane angle θ_{AB} and out-of-plane angle ϕ . Dot indicates most probable value of the correlation function and x indicates the calculated value for complete linear momentum transfer. The left-hand column presents the angular correlation results with all-out-of-plane events projected on to the reaction plane. Data are shown both as a function of correlation angle θ_{AB} (lower scale) and the ratio of longitudinal momentum transfer to the beam momentum (upper scale). The center column shows the angular correlation in the ϕ dimension corresponding to the calculated value for complete momentum transfer, θ_{AB}° .

The major features of these data can be understood in terms of intranuclear cascade calculations.³ Precompound decay calculations⁴ are similarly successful at 40 and 90 MeV, but diverge somewhat from the slope of the data at 150 MeV. Comparison of the linear momentum transfer distributions with calculations are presented in Fig. 2. Both the cascade

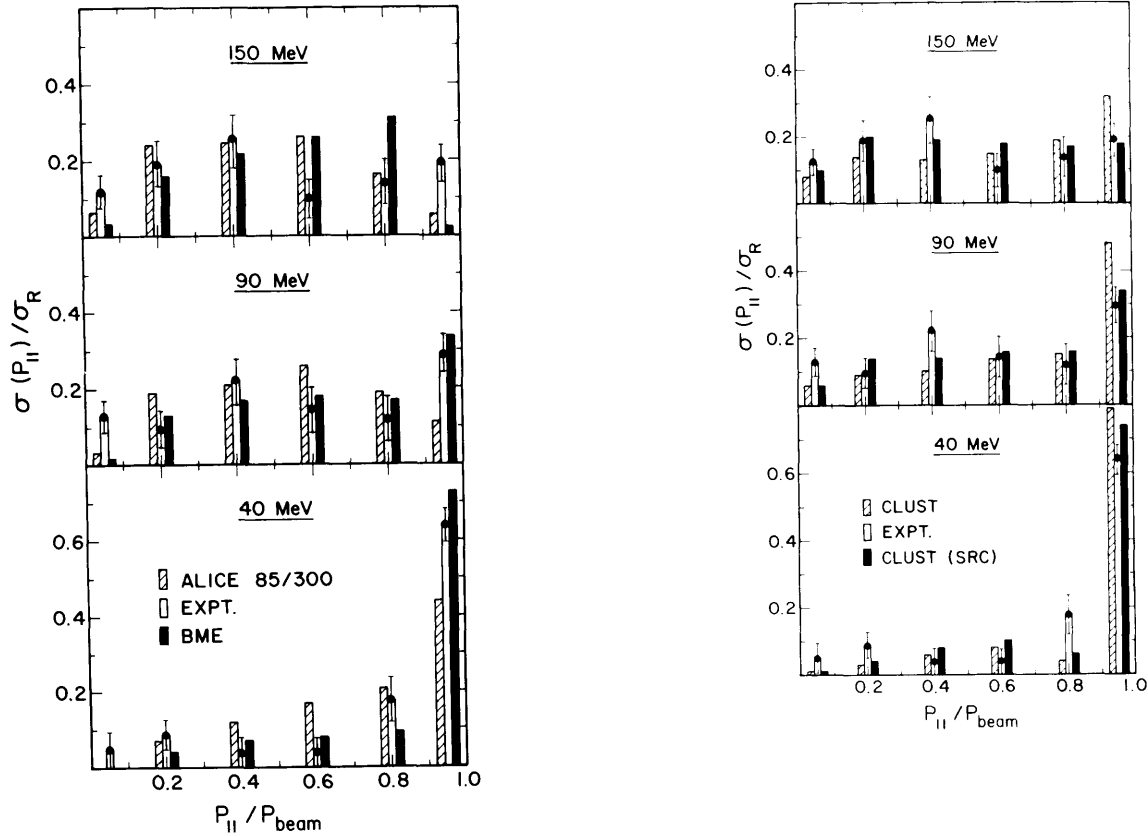


Figure 2. Comparison of experimental linear momentum transfer distribution, $\sigma(p_{\parallel})/\sigma_R$, as a function of momentum transfer, $p_{\parallel}/p_{\text{beam}}$, with intranuclear cascade code and precompound decay predictions. (a) Dashed bar shows the ALICE 85/300 result and solid bar is for BME calculation.⁴ (b) Dashed bar shows cascade code without short-range correlations and solid bar gives results which include this effect.

TABLE I

Estimates of proton-nucleus linear momentum transfer based on the average number of collisions, $\langle \nu \rangle$, as determined from mean-free-path arguments (Ref. 5) and the average linear momentum transfer in fundamental N-N collisions (Ref. 1).

$E_p(\text{MeV})$	$\lambda(\text{fm})$	$\langle \nu \rangle$	$\langle p_{\parallel} \rangle_{\text{calc}} (\text{MeV}/c)$	$\langle p_{\parallel} \rangle_{\text{exp}} (\text{MeV}/c)$
40	2.3	4.4	195	230 ± 20
90	3.2	3.4	254	255 ± 20
150	3.2	3.4	328	265 ± 20

code^{1,3} with short-range correlations and the precompound predictions⁴ account to first order for the distribution of linear momentum transfer events in

proton-induced reactions. The results of this study demonstrate that theoretical approaches of this type should provide an important first step in the satisfactory description of intermediate-energy reactions induced by complex projectiles.

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