Group Meeting 04.14

Reaction channel contributions to the triton + ^{208}Pb optical potential

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Coupling Potential

For one-dimensional systems

$$H = -\frac{\hbar^2}{2m}\frac{d^2}{dx^2} + V(x) + H_0(\xi) + V_{\text{coup}}(x, \xi),$$

where $H_0(\xi)\phi_n(\xi) = \epsilon_n \phi_n(\xi)$ $\qquad \Psi(x, \xi) = \sum_n u_n(x)\phi_n(\xi)$

$$0 = \langle \phi_n | H - E | \Psi \rangle = \left[-\frac{\hbar^2}{2m}\frac{d^2}{dx^2} + V(x) + \epsilon_n - E \right] u_n(x) + \sum_{n'} F_{nn'}(x) u_{n'}(x)$$

where $F_{nn'}(x) = \left\langle \phi_n \middle| V_{\text{coup}}(x, \xi) \middle| \phi_{n'} \right\rangle = \int d\xi \phi_n^*(\xi) V_{\text{coup}}(x, \xi) \phi_{n'}(\xi)$

Coupling Potential

Define projection operators P for target nucleus ground state and Q for target nucleus excited state.

$$P^2 = P,\ Q^2 = Q,\ PQ = QP = 0,\ P + Q = 1$$

where Q can be divided into two parts, $Q = p + q$.

p projects onto specific states, like resonance and excited states.

q projects onto the rest, considered to slowly vary with N, Z and E.

How to get DPP

$P \rightarrow$ Bare potential V_{bare}

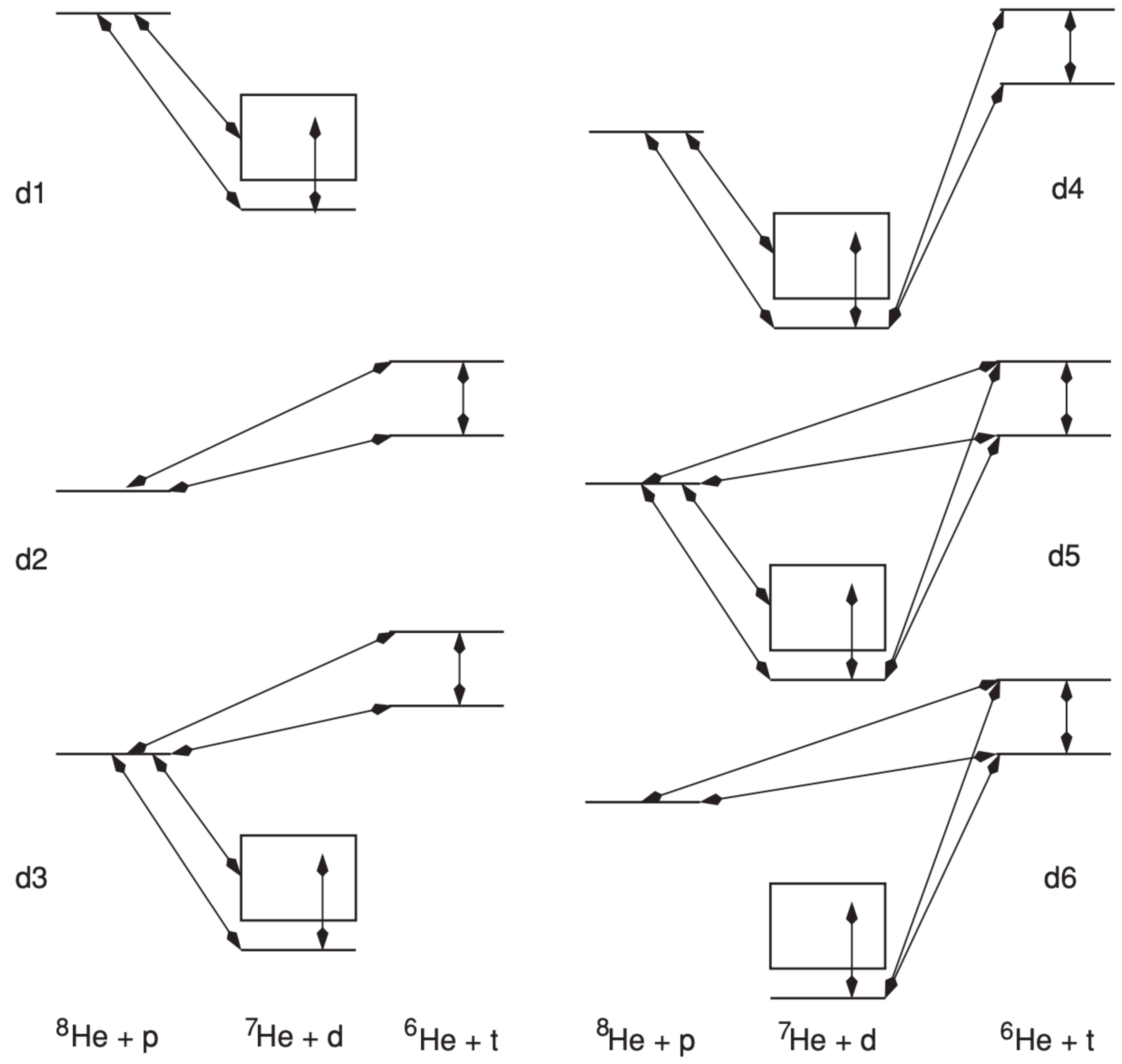
$\pi = P + p \rightarrow V_{\text{cc}}$

$$V_{\text{DPP}} = V_{\text{cc}} - V_{\text{bare}}$$

With different p (consider different coupling), they can get different V_{DPP}.

How to get DPP

Fig. 1 : Schematic representations of the six sets of coupled reaction channels in in proton scattering from ^{8}He [1].



[1]. R. S. Mackintosh and N. Keeley, Phys. Rev. C **81**, 034612 (2010).

How to get DPP

The response of the elastic scattering S-matrix to small changes is assumed to be linear .

$$\Delta S_l = -\frac{\mathrm{i}m}{\hbar^2 k}\int_0^\infty \left(u_l(r)\right)^2 \Delta V(r)\mathrm{d}r$$

Where $u_l(r)$ is normalized with $u_l(r) \to I_l(r) - S_l O_l(r)$.

$$V(r) \to \hat{V}(r) = V(r) + \sum c_i v_i(r)$$

How to get DPP

Take a known 'starting reference potential', $V(r)$ giving S_l. With added term:

$$V(r) \to \hat{V}(r) = V(r) + \sum c_i v_i(r)$$

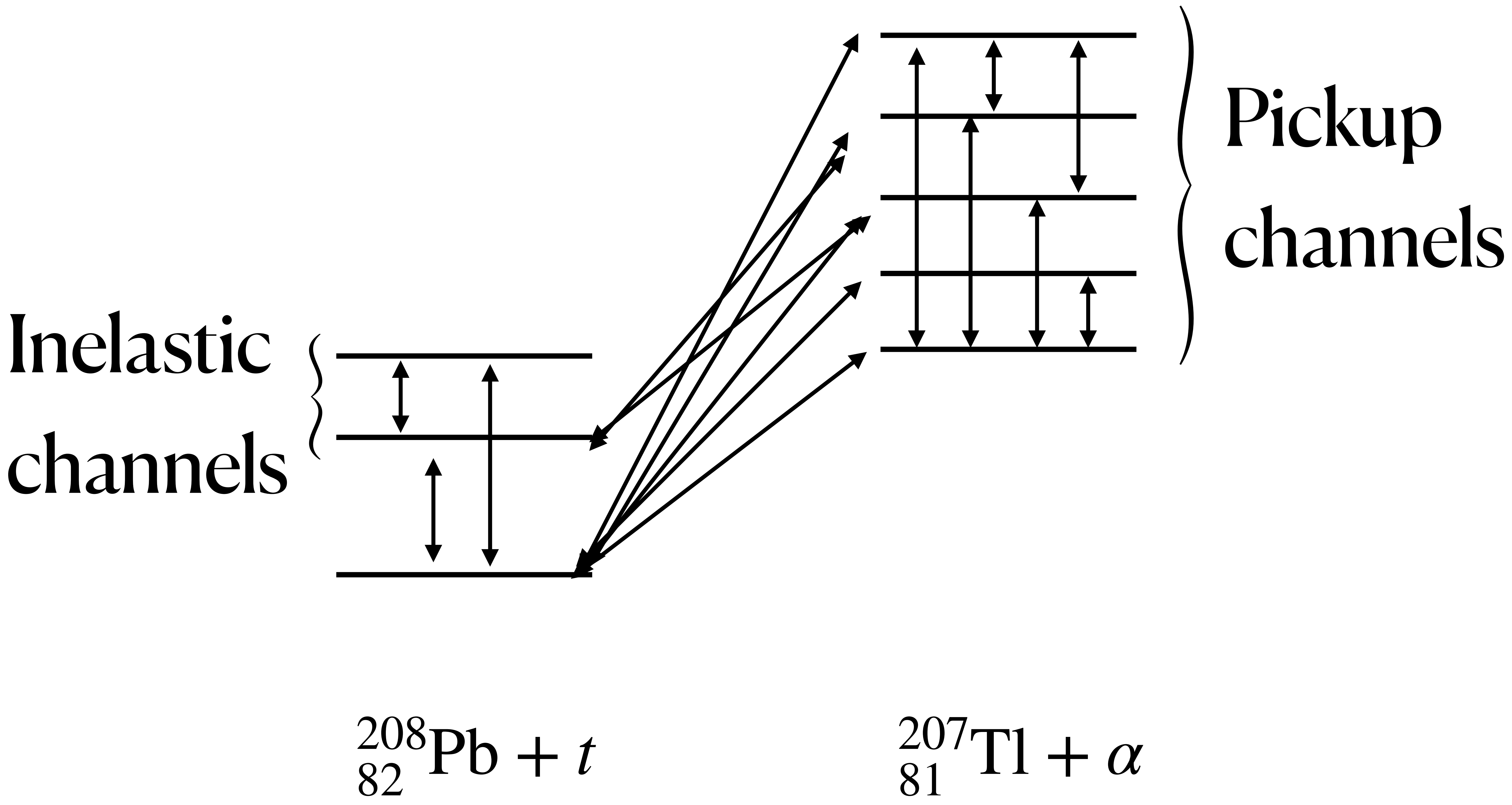
Functions $v_i(r)$ belong to a suitable 'inversion basis'.

$$\Delta V = \sum c_i v_i(r) \quad \Rightarrow \quad \Delta S_l$$

$$\Delta S_l = S_l^{\text{target}} - S_l$$

Different p

Consider 2 $^{208}_{82}\mathrm{Pb}$ excitation states (inelastic) and 5 $^{207}_{81}\mathrm{Tl}$ states (pickup).



(There are still many coupling channels which were not listed in the figure.)

Results

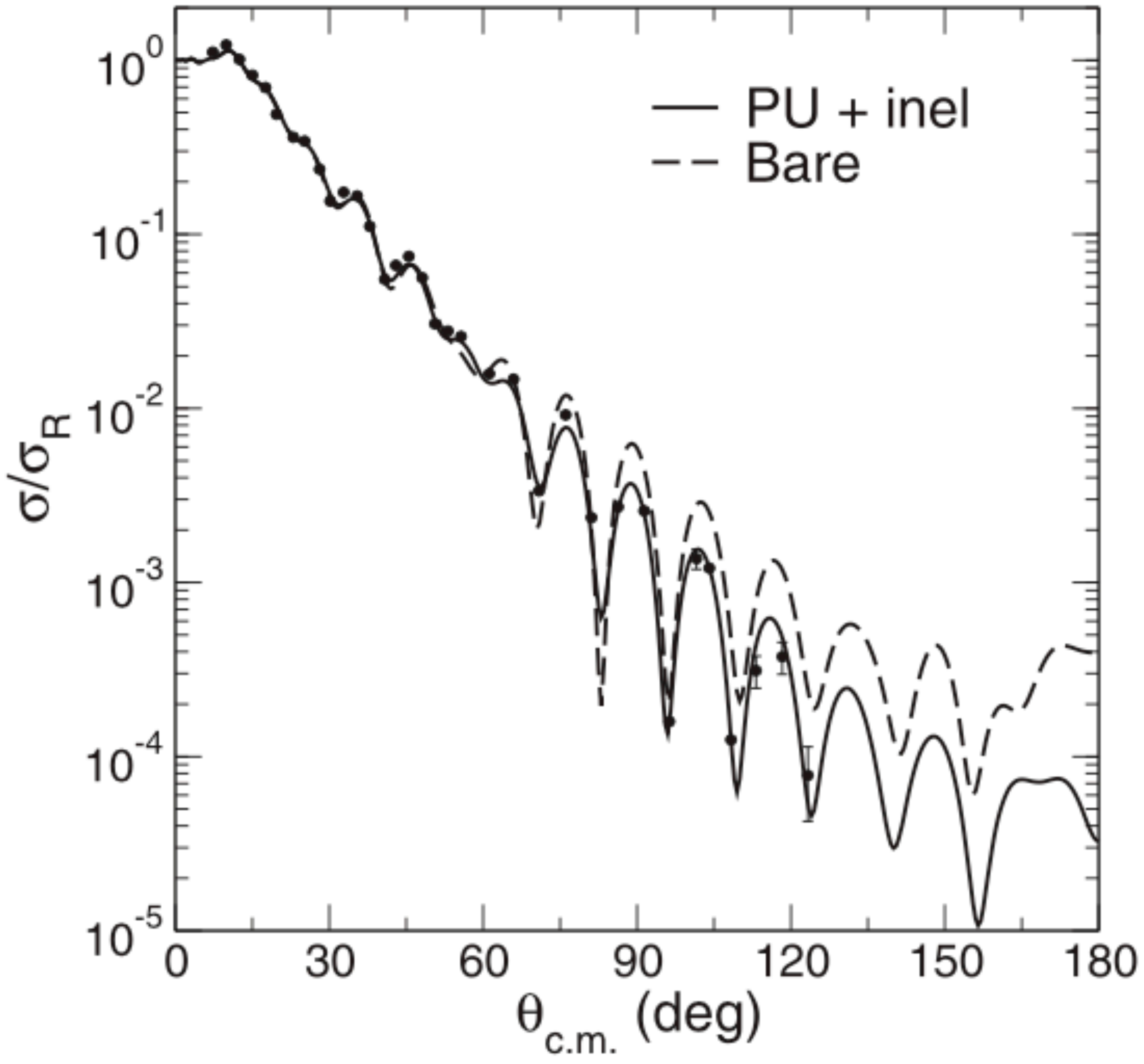


FIG. 1. For 33 MeV ^3H on ^{208}Pb, the solid line is the differential cross section for the full coupled channel calculation with coupling to pickup (PU) and inelastic (inel) channels with fitted optical model parameters. The dashed line represents the result of a calculation using the bare potential alone, i.e., with all couplings switched off.

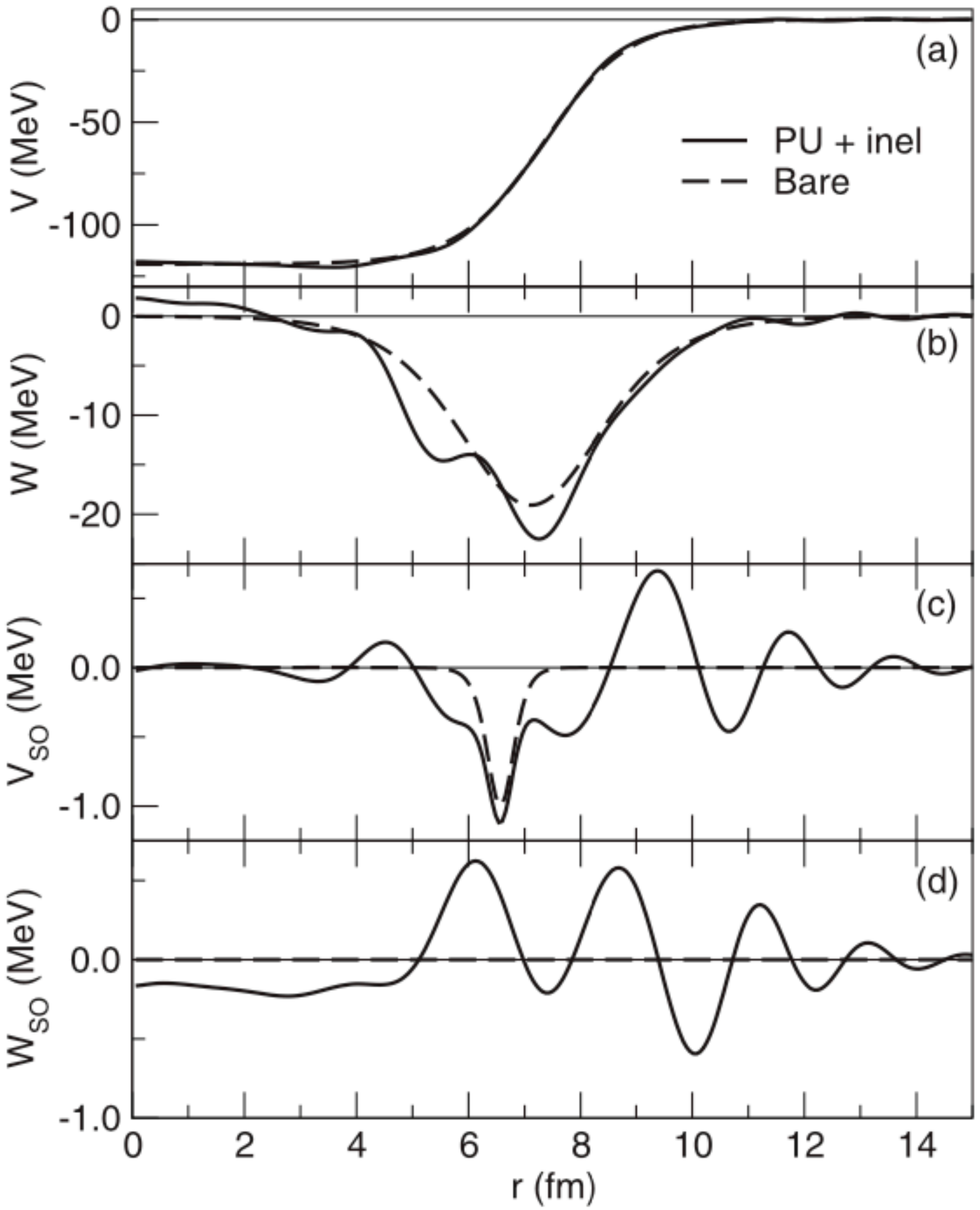


FIG. 2. For 33 MeV ^3H on ^{208}Pb, the bare potential (dashed lines) and the inverted potential including pickup and inelastic coupling contributions (solid lines). From the top downwards, the real central, imaginary central, real spin-orbit, and imaginary spin-orbit components.

Results

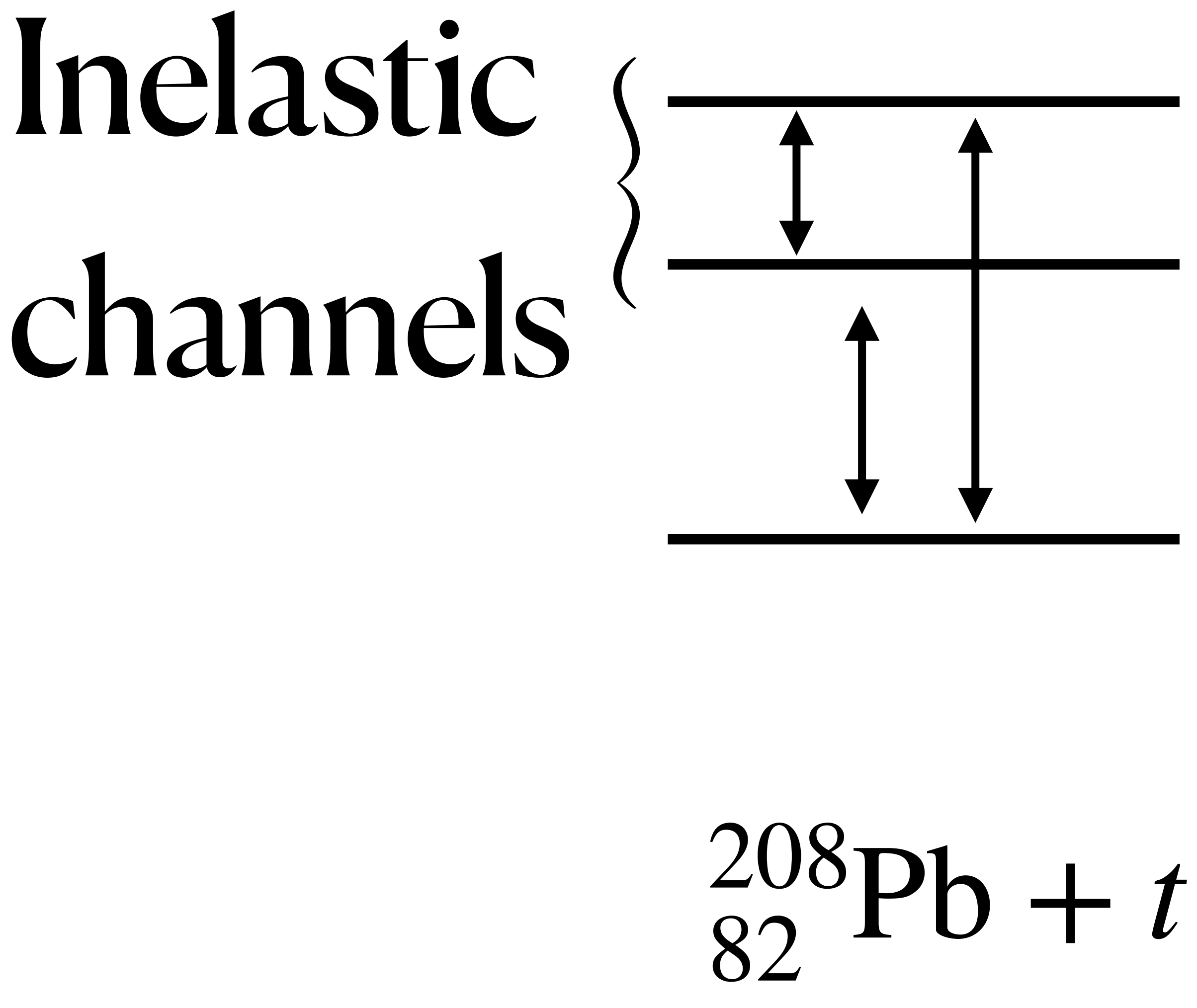
L	Reaction	ΔJ_R	ΔJ_{IM}	ΔJ_{RSO}	ΔJ_{IMSO}	ΔR_{rms}	Δ(CS)	State CS	R	R_{CS}
1	PU	0.81	2.806	0.105	−0.138	−0.0111	1.9	1.90	0.68	1.0
2	Inel	−1.35	5.75	0.126	0.294	−0.0269	−2.0	4.72	−0.35	−0.42
3	Inel and PU	0.33	9.436	0.187	−0.454	−0.023	−1.3	6.51	−0.14	−0.20
4	Sum of Inel, PU	−0.54	8.556	0.231	0.157	−0.038	−0.1	6.62	−0.02	−0.015
1a	PU ^{3}He	−2.33	6.286	0.520	−0.089	−0.603	−16.4	2.91	−2.6	−5.63
2a	Inel ^{3}He	−0.52	1.995	0.310	−1.088	−0.434	−1.4	4.90	−0.70	−0.29
3a	Inel and PU, ^{3}He	−1.68	8.889	0.690	−0.869	−0.063	−18.0	7.88	−2.02	−2.28
4a	Sum of Inel, PU, ^{3}He	−2.85	8.281	0.812	−1.177	−1.037	−17.8	7.81	−2.15	−2.28

ΔJ means integral of sum of DPPs.

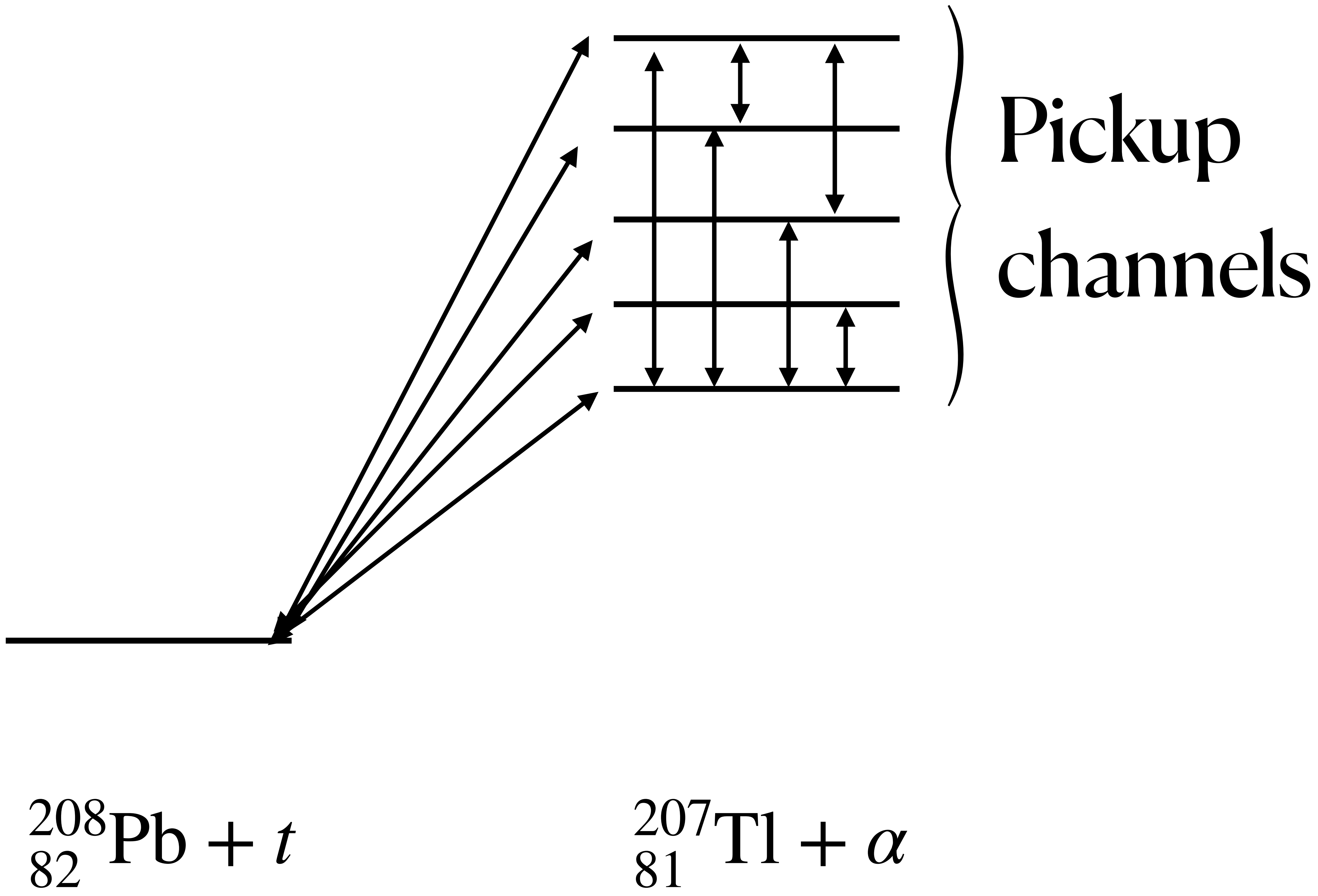
$\Delta(CS)$ means integral of cross section.

$$R = \frac{\Delta(CS)}{\Delta J}$$

Results

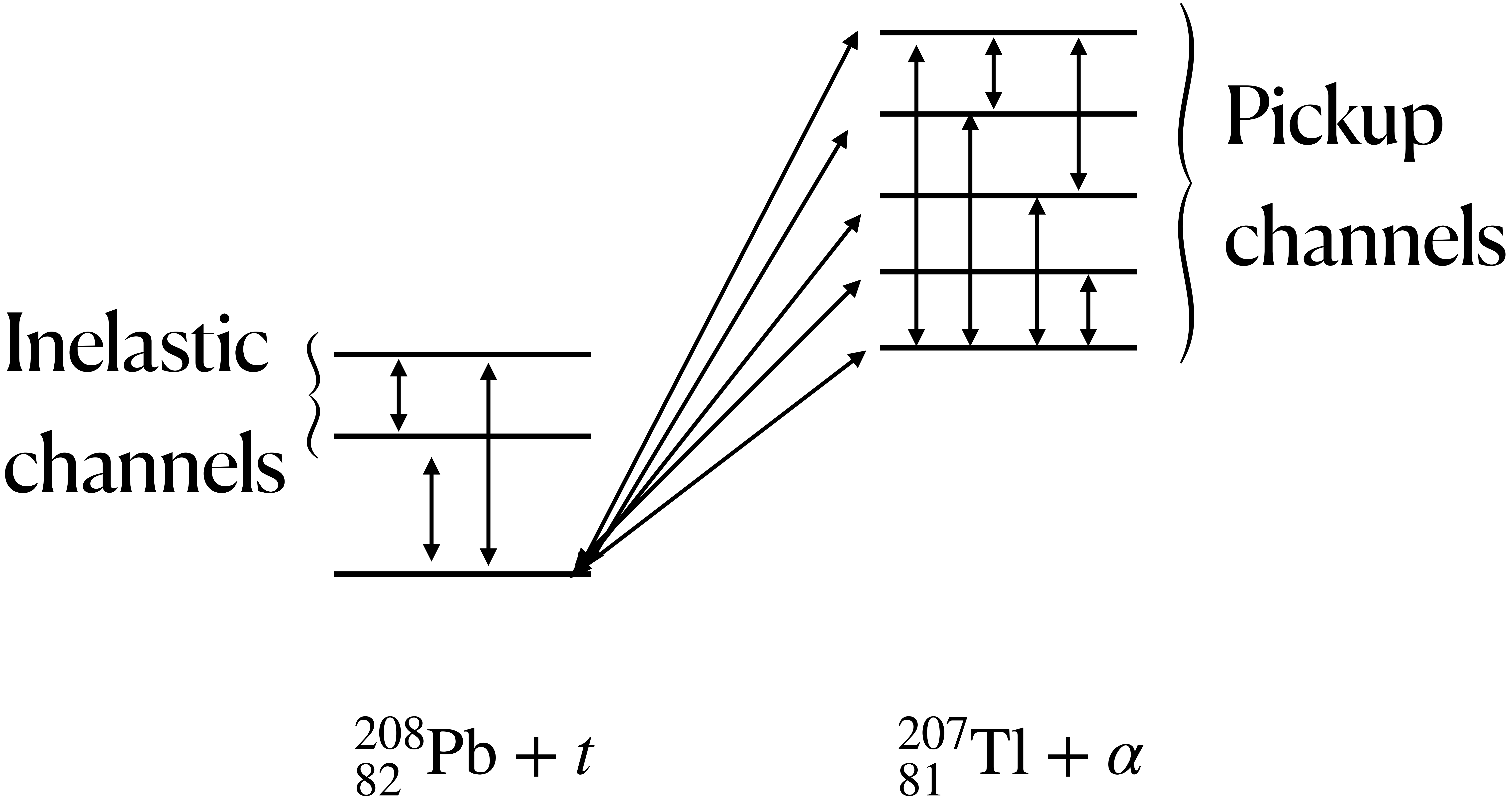


Only Inelastic



Only Pickup
(There are still many coupling channels which were not listed in the figure.)

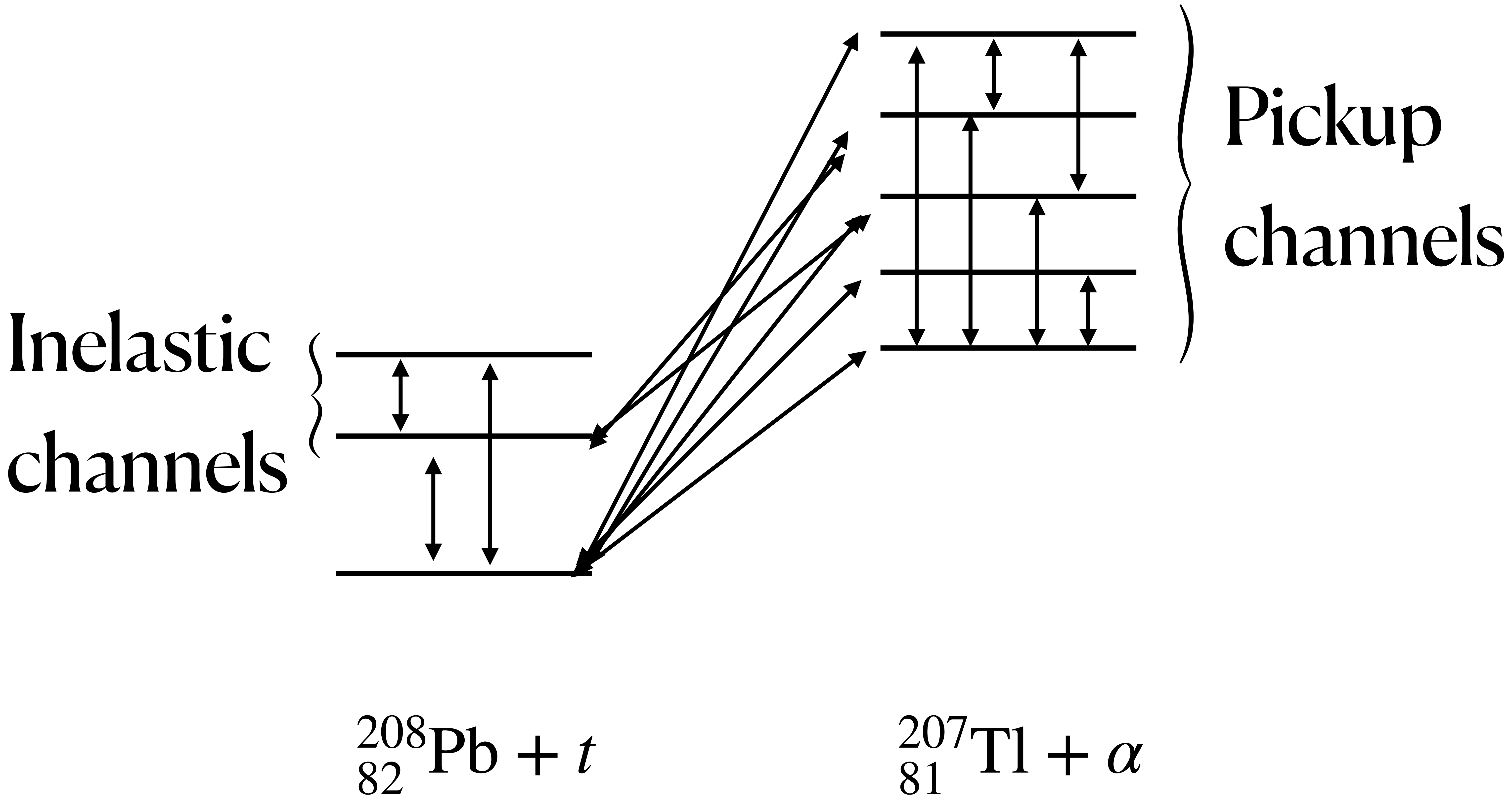
Results



Sum of Inelastic and Pickup

(There are still many coupling channels which were not listed in the figure.)

Results



Inelastic + Pickup

(There are still many coupling channels which were not listed in the figure.)