Particle identification of projectilelike residues

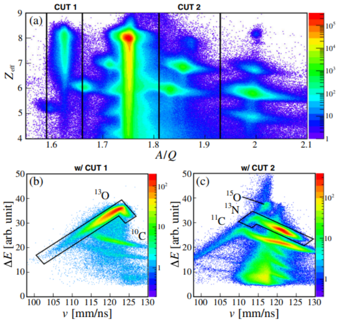


FIG. 1. Particle identification of projectilelike residues. Particle's velocity (v) is deduced from TOF. Combining $B\rho$ and velocity allows to determine particle's mass-to-charge ratio A/Q. $Z_{\rm eff}$ is the deduced effective atomic number with ΔE and velocity using the Bethe-Bloch formula. The energy deposit of a charged particle in a material is related to its velocity, charge, and mass, as shown in the ΔE-v spectra with (w/) the A/Q selections from 1.59 to 1.66 (b) and from 1.81 to 1.93 (c). Black contours in (b) and (c) select ^{13}O and ^{13}N, respectively.

^{13}O: A/Q = 1.625, ^{14}O :$A/Q = 1.75$.

TOF$\rightarrow v$; $B\rho \rightarrow \frac{A}{Q}$; $\Delta E, v \rightarrow Z_{eff}$

Z_{eff} : the deduced effective atomic number.

(a):Tails of ^{14}O and ^{13}O extending to smaller Z_{eff} region, since:

- ^{14}O: unreacted projectiles interacting in the hodoscope
- ^{13}O: low-energy ^{13}O stopped in the hodoscope.

(b): most ^{13}O stopped in the hodoscope, ΔE proportional to velocity.

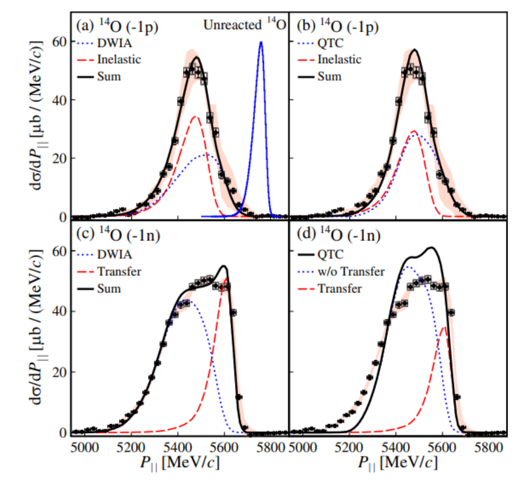
(c): most 13N punched through the hodoscope, ΔE antiproportional to velocity.

Experimental and theoretical cross sections for one-nucleon removal from ^{14}O

TABLE I. Experimental (σ_{exp}) and theoretical (σ_{th}) cross sections for one-nucleon removal from ^{14}O at 94 MeV/nucleon. SF represents the spectroscopic factor from shell-model calculations (see SM [58]). The reduction factors $R_s = \sigma_{\mathrm{exp}}/\sigma_{\mathrm{th}}$ are also given.

Residue	J^π	σ_{exp} (mb)	SF	Theory	σ_{sp} (mb)	σ_{th} (mb)	R_s
$^{13}\mathrm{N}_{\mathrm{g.s.}}$	$1/2^-$	10.7(16)	1.58	DWIA	5.2	8.8	1.22(18)
				Inelastic	...	9	
				Sum		17.8	0.60(9)
				QTC	7.0	11.9	0.90(13)
				Inelastic	...	9	
				Sum		20.9	0.51(8)
$^{13}\mathrm{O}_{\mathrm{g.s.}}$	$3/2^-$	16.7(24)	3.42	DWIA	6.3	23.2	0.72(10)
				Transfer	3	11	
				Sum		34.2	0.49(7)
				QTC	10.2	37.6	0.44(6)
				w/o transfer			
				QTC	13.5	49.7	0.34(5)

Parallel momentum distributions of ^{13}N and ^{13}O



$$^{14}O(p,2p)^{13}N \quad \text{and} \quad ^{14}O(p,pn)^{13}O$$

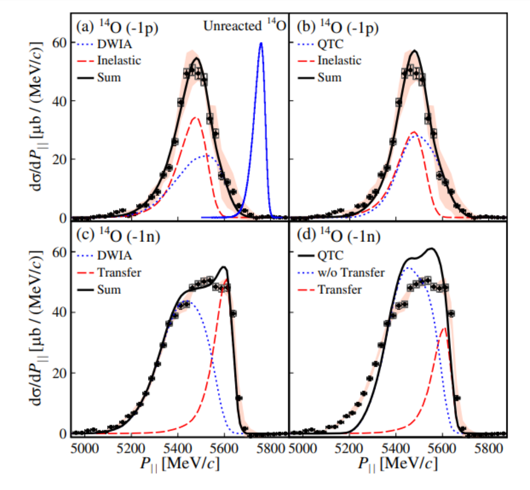
· Comparison of DWIA and QTC calculation.

· Key difference is how they handle three body final state:

· DWIA: product of the p-residue and N-residue states.

· QTC: expands in terms of $p-N$ states, include deuteron ground state for $1n$ removal.

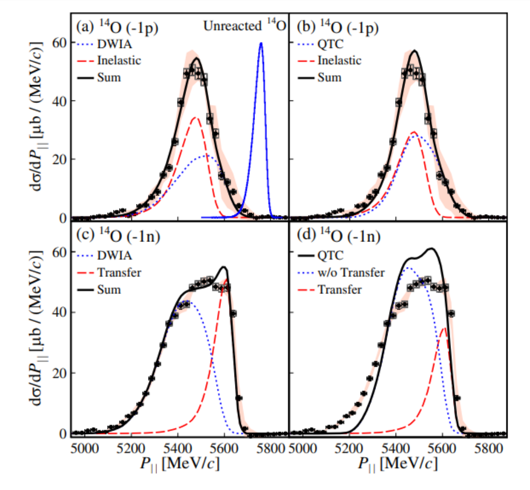
Parallel momentum distributions of ^{13}N and ^{13}O



Blue solid line: distribution of the unreacted ^{14}O. Shift by −200 MeV/c , broadened of the momentum.

Symmetrical properties:
(a)(b)
(loosely bound) 1p removal: close to symmetric.
(c)(d)
(deeply bound) 1n removal:
low-momentum tail and
high-momentum sharp edge.

Parallel momentum distributions of ^{13}N and ^{13}O



(a)(b) 1p removal:

· Considered the (p, p') inelastic excitation of ^{14}O to its low-lying excited states, emit one proton to get ^{13}N.

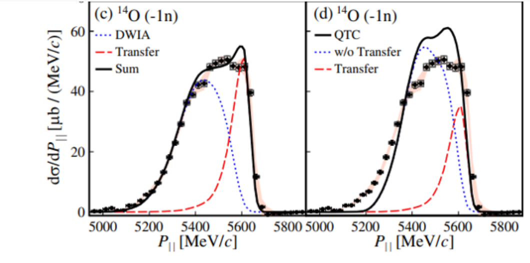
· Large contribution of inelastic scattering: 51% with DWIA, 43% with QTC.

· If ignore inelastic scattering: R_s is around unity, equivalent to eikonal model.

· Use multiparticle-multihole configurations to describe low-lying excited states.

· Beyond the (p, pN) and the eikonal models, which assume the projectile is a single-particle state plus an inert core.

Parallel momentum distributions of ^{13}N and ^{13}O



(c)(d) $1n$ removal:

· Perform QTC with outgoing channel coupled only to deuteron ground state: equivalent to DWBA.

· QTC σ_{sp} without the (p, d) transfer is still larger than the DWIA result.

Symmetrical properties:

· Low-momentum tail is caused by the attractive potential between the outgoing nucleons and ^{13}O.

· Due to the two-body kinematics of the transfer reaction, transfer reaction creates a sharp high-momentum edge, which is inaccessible to knockout.

· QTC reproduces better the sharp high-momentum side ,since it treats (p, d) transfer consistently with(p, pn).

R_s as a function of ΔS

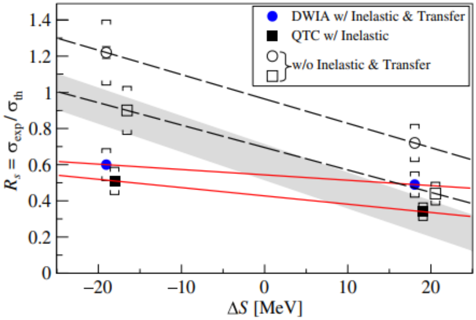


FIG. 3. R_s as a function of ΔS from the present work (blue dots and black squares) compared to the trend extracted from Be or C induced nucleon-removal cross sections analyzed with the eikonal model [19–21] (gray shaded region). The square brackets indicate the total systematic uncertainties. Red solid and black dashed lines are shown to guide the eyes.

- Eikonal model: gray shaded area. Slope is −1.6 × 10^{-2} MeV^{-1} for light-ion induced nucleon removal.
- Analyses of low-energy one-nucleon transfer and high energy quasifree scattering data: slope is $(10^{-3} - 10^{-5})$ MeV^{-1}
- Present work: DWIA and QTC with inelastic and transfer: R_s have a weak ΔS dependence; the slope is −3.0(5)(5) × 10^{-3} MeV^{-1} and −4.6(4)(7) × 10^{-3} MeV^{-1} respectively.
- Neglect inelastic and transfer: slopes are 3–5 times larger.