

Table 4.18 from (1992TI02): Measurements and summaries (S) of photonuclear cross sections on ${}^4\text{He}$

Reaction	E_γ (MeV)	Description	Refs.	
${}^4\text{He}(\gamma, \pi^0){}^4\text{He}$	1500 – 4500	Developed apparatus. Measured $\sigma(E, \sigma)$.	1978AL08	
	1 – 10 (above threshold)	Measured relative yields for ${}^1\text{H}$, ${}^2\text{H}$, ${}^3\text{He}$, ${}^4\text{He}$ targets. DWBA analysis.	1980AR06	
	139 – 153	Analyzed $\sigma(E, \theta)$ data, deduced yields.	1981AR10	
	1500 – 4500	Measured $\sigma(\theta)$ versus momentum, deduced Ω meson trajectory.	1982AL09	
	450	Measured $\sigma(\theta)$ for ${}^4\text{He}$ recoils versus recoil energy. Bremsstrahlung beam.	1982AN16	
	290	Measured $\sigma(\theta)$ near $\Delta(1232)$ resonance.	1984TI04	
	190 – 430	Measured $\sigma(\theta)$ near $\Delta(1232)$ resonance.	1985AN14	
	138 – 155	Measured pion yields, deduced $\sigma(E)$, s-wave threshold amplitudes.	1988AR08	
	179	Measured σ_{total} .	1989JA07	
	${}^4\text{He}(\gamma, n){}^3\text{He}$	< 30	Measured $\sigma(E, E_n)$ at 90° .	1972BE06
		30.0 – 51.8	Determined $\sigma(E)$ for (γ, n) and (γ, p) in same apparatus (mag. spectrometer).	1972DO03
		24 – 120	Determined $\sigma(E)$ for (γ, n) and (γ, p) under same physical conditions.	1973AR07
		$E_x = 22 – 37$	Measured $\sigma(E)$ at 98° . Compared results for liquid and gas targets.	1973IR02
		1 – 10 (above threshold)	Measured $\sigma(E, \theta)$. Confirmed 2^+ state at ≈ 35 MeV.	1973MA57
20 – 120		Measured σ_{total} . Determined energy moments.	1974AR18	
35		Measured $\sigma(\gamma, n)$ versus beam intensity.	1974IR02	
270 – 400		Measured $\sigma(E)$ at 90° , 120° in region of $\Delta(1236)$ resonance.	1975AR01	
27 – 30		Measured σ_{total} and $\sigma(E, \theta)$. Determined E1, E2 amplitudes, phases.	1975AR13	
22 – 32		Measured $\sigma(E, \theta)$. Determined E1, E2 contributions, obtained σ_{total} .	1975IR01	
$E_{\text{th}} – 150$		Determined E1, E2 cross sections.	1976AR17	
< $E_x = 80$		Measured σ_{total} and $\sigma(E, \theta)$ for (γ, n) and (γ, p) . Used cloud chamber.	1977BA35	
31 – 51		Measured $\sigma(\gamma, p)/\sigma(\gamma, n)$ ratio at 90° by detecting ${}^3\text{H}$ and ${}^3\text{He}$ recoils.	1979PH04	
21 – 47		Measured $\sigma(E)$ with gas target. Used monoenergetic photons. Compared with other measurements.	1980BE45	
${}^4\text{He}(\gamma, n){}^3\text{He}$	22.5 – 137	Measured cross section versus E_γ . Analyzed by assuming $2^+ T = 0$ levels in ${}^4\text{He}$ at 29.6, 35.6 MeV.	1981AR23	
	40	Measured asymmetry of (γ, n) and (γ, p) cross sections for linearly polarized γ -rays.	1985VI07	

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Reaction	E_γ (MeV)	Description	Refs.
${}^4\text{He}(\gamma, \text{p}){}^3\text{H}$	100 – 360	Measured $\sigma(E, \theta)$ for (γ, n) and (γ, p) for $60^\circ, 90^\circ, 120^\circ$. Compared to calculations with MEC contributions.	1986SC01
	40	Measured asymmetry of (γ, n) and (γ, p) cross sections for linearly polarized γ -rays.	1989VI05
	30.0 – 51.8	Determined $\sigma(E)$ for (γ, n) and (γ, p) in same apparatus (mag. spectrometer).	1972DO03
	24 – 120	Determined $\sigma(E)$ for (γ, n) and (γ, p) under same physical conditions.	1973AR07
	180 – 320	Measured $\sigma(E, \theta)$ at $\theta_{\text{c.m.}} = 60^\circ - 120^\circ$ in spark chamber.	1973KI06
	20 – 120	Measured σ_{total} .	1974AR18
	190 – 420	Measured $\sigma(E)$ at $60^\circ, 90^\circ$ in region of $\Delta(1236)$ resonance.	1975AR01
${}^4\text{He}(\gamma, \text{p}){}^3\text{H}$	$E_{\text{th}} - 150$	Determined E1, E2 cross sections.	1976AR17
	$< E_x = 80$	Measured σ_{total} and $\sigma(E, \theta)$ for (γ, n) and (γ, p) . Used cloud chamber.	1977BA35
	200 – 450	Measured $\sigma(E, \theta)$ at $30^\circ - 150^\circ$ in $\Delta(1236)$ resonance region.	1979AR07
	31 – 51	Measured $\sigma(\gamma, \text{p})/\sigma(\gamma, \text{n})$ ratio at 90° by detecting ${}^3\text{H}$ and ${}^3\text{He}$ recoils.	1979PH04
	50 – 140	Analyzed $\sigma(E, \theta)$ data to estimate proton momentum distribution in ${}^4\text{He}$.	1982AR17
	187 – 427	Measured momentum spectrum of protons at 30° . Tagged photons. Deduced pion photo-production σ .	1984HO24
	40	Measured asymmetry of (γ, n) and (γ, p) cross sections for linearly polarized γ -rays.	1985VI07
${}^4\text{He}(\gamma, \text{p}){}^3\text{H}$	100 – 360	Measured $\sigma(E, \theta)$ for (γ, n) and (γ, p) for $60^\circ, 90^\circ, 120^\circ$. Compared to calculations with MEC contributions.	1986SC01
	187 – 427	Measured $\sigma(E_p)$ at $\theta_p = 30^\circ, 60^\circ, 90^\circ$, and 105° in Δ -region.	1987HO17
	28.6 – 58.1	Measured absolute $\sigma(E)$ with monochromatic photon beam. Deduced $\sigma(\gamma, \text{p})/\sigma(\gamma, \text{n})$ ratio.	1988BE38
	350	Measured polarization of inclusive protons. Compared with quasideuteron mechanisms of photon absorption.	1988ZY01
	120 – 250	Measured asymmetry versus θ_p . Linearly-polarized photons.	1988GA29
	60, 140, 350	Measured asymmetry at $\theta_p = 90^\circ$. Linearly-polarized monochromatic photons.	1988GA25
	40	Measured asymmetry of (γ, n) and (γ, p) cross sections for linearly polarized γ -rays.	1989VI05

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Reaction	E_γ (MeV)	Description	Refs.
${}^4\text{He}(\gamma, n\pi^0){}^3\text{He}$	63 – 71	Absolute measurement of $\sigma(\theta)$, quasi-monochromatic photons.	1991JO04
	450	Measured σ versus θ , E of recoil ${}^3\text{He}$. Impulse approximation calculation.	1982AN16
	450	Measured σ versus θ_π , $\theta_{3\text{He}}$, $E_{3\text{He}}$ -deduced pion production mechanism.	1984AN02
${}^4\text{He}(\gamma, p\pi^-){}^3\text{He}$	< 150	Measured cross section near $\Delta(1236)$.	1972AR23
	350	Measured asymmetry at 90° for linearly polarized photons.	1988GA25
	120 – 250	Measured asymmetry versus θ for linearly polarized photons.	1988GA29
${}^4\text{He}(\gamma, d){}^2\text{H}$	< 150	Measured $\sigma(\theta, E)$. Bremsstrahlung beam. Diffusion chamber.	1972AR21
	20 – 120	Measured $\sigma(E)$. Determined energy moments, E1, E2 contributions, ${}^4\text{He}$ radius.	1974AR18
	190 – 380	Measured $\sigma(E)$, dd coin.	1976AR05
	25 – 40	Measured $\sigma(E)$. Multipole expansion. Deduced level in ${}^4\text{He}$.	1978AR23
${}^4\text{He}(\gamma, np){}^2\text{H}$	< 80	Measured $\sigma(E, \theta)$ for (γ, n) , (γ, p) , (γ, d) , (γ, np) , $(\gamma, 2n2p)$ with diffusion cloud chamber.	1977BA35
	28 – 150	Determined distributions in the Treiman-Yang angle.	1979AR15
	30 – 40	Measured $\sigma(E, \theta)$ for (γ, n) , (γ, p) , (γ, d) , (γ, np) , $(\gamma, 2n2p)$. Deduced reaction mechanism.	1979BA47
	150	Measured quasideuteron momentum distribution. Deduced quasideuteron channel radius.	1982AR17
${}^4\text{He}(\gamma, np){}^2\text{H}$	40 – 150	Analyzed data to determine $\sigma(E)$ off the mass shell.	1985AR22
	< 450	Analyzed particle spectra to deduce possible free superdense deuteron.	1985CH35
	200 – 400	Reviewed measurements of $\sigma(\theta, E_p)$.	1985HO27(S)
	75 – 150	Measured $\sigma(\theta, E_d)$. Deduced breakup normalization constant.	1986AR16
${}^4\text{He}(\gamma, 2p2n)$	not given	Measured $\sigma(E_d, E_p, E_n)$. Studied quasideuteron correlations.	1986CH15
	130 – 450	Measured $\sigma(E_d, E_p, E_n)$, spectrometer development.	1990NI11
	< 80	Measured $\sigma(E, \theta)$ for (γ, n) , (γ, p) , (γ, d) , (γ, np) , $(\gamma, 2n2p)$ with diffusion cloud chamber.	1977BA35
	30 – 40	Measured $\sigma(E, \theta)$ for (γ, n) , (γ, p) , (γ, d) , (γ, np) , $(\gamma, 2n2p)$. Deduced reaction mechanism.	1979BA47