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34Ar AND T = 1 STATES IN 34Cl FROM TWO-NUCLEON PICK-UP REACTIONS

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Publication Date
1969-05-01

Submitted to Nuclear Physics

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May 1969

AEC Contract No. W-7405-eng-48

DISCLAIMER

NUCLEAR REACTIONS $^{36}Ar(p,t)(p,^{3}He)$, E = 45 MeV; measured $\sigma(E_t, E_{^3He}, \theta)$. $^{36}Ar(d,\alpha)$, E = 45 MeV; measured $\sigma(E_\alpha, \theta)$. ^{34}Ar ^{34}Cl deduced levels, J, π, T, L. Enriched target.

^{34}Ar AND T = 1 STATES IN ^{34}Cl FROM TWO-NUCLEON PICK-UP REACTIONS*

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May 1969

Abstract

The reactions $^{36}Ar(p,t)^{34}Ar$, $^{36}Ar(p,^{3}He)^{34}Cl$, and $^{36}Ar(d,\alpha)^{34}Cl$ have been used to study energy levels in ^{34}Ar and ^{34}Cl. Excitation energies and J^{π}-values have been established for states up to 8 MeV in ^{34}Ar and many of their T = 1 analogues have been identified in ^{34}Cl. These results exemplify the usefulness of the spin and isospin selection rules inherent in two-nucleon transfer reactions. The results are discussed in terms of the mass-34 T = 1 multiplet and the J-dependence of their Coulomb displacement energies.

*This work performed under the auspices of the U. S. Atomic Energy Commission.

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1. Introduction

Two-nucleon transfer reactions are characterized by selection rules which restrict the spin S and isospin T as well as the parity change $\Delta\pi$ which can be transferred during a reaction[1,2]. The most rigourous of these selection rules depends only upon two assumptions: 1) that the reaction is direct, and 2) that the wave function of the transferred pair of nucleons is spatially symmetric. It requires that $S + T = 1$. Further restrictions occur for the (p,t) and (d,α) reactions due to the quantum numbers of the projectiles. For the former reaction the transferred particles are both neutrons and require $T = 1$ (and consequently $S = 0$); for the latter, the zero isospin of the deuteron and alpha particle require $T = 0$ (and $S = 1$).

A somewhat weaker selection rule may be derived by making the additional assumption that the relative motion of the transferred particles is pure s-state. In this event $\Delta\pi = (-)^L$ where L is the total orbital angular momentum transferred by the reaction. For the (p,t) reaction on 0^+ targets this leads to a considerable simplification: since $S = 0$, the total transferred angular momentum J is equal to L and only those final states which have natural parity—i.e., $\pi_f = (-)^{J_f}$—can be produced. Some minor violations of these selection rules have been observed experimentally but only in weak transitions.

It is the purpose of this paper to demonstrate the usefulness of these selection rules by combining the results of the reactions (p,t), (p,^{3}He), and (d,α) in determining the spins and isospins of states in ^{34}Ar and ^{34}Cl.

The excitation energies of low-lying states in ^{34}Ar have recently been reported by several authors[3-5] all of whom utilized the reaction $^{32}S(^3He,n)^{34}Ar$;

there are some discrepancies among their values, and no spins and parities were assigned. We have used the reaction $^{36}Ar(p,t)^{34}Ar$ to observe levels in ^{34}Ar up to 8 MeV; only levels with natural parity can be produced strongly and the characteristic angular distributions have permitted the assignments of spins and parities to many.

The states produced in ^{34}Ar have T = 1, and their analogues should appear at low excitation in ^{34}Cl since the ground state of that $T_z = 0$ nucleus is the T = 1 analogue to the ground state of ^{34}Ar. The excitation energies of levels in ^{34}Cl have previously been determined up to 8 MeV but relatively few spin-parity and isospin assignments have been made unambiguously[6]). We have studied these levels using the reactions $^{36}Ar(p,{}^{3}He)^{34}Cl$ and $^{36}Ar(d,\alpha)^{34}Cl$, and made isospin assignments using the methods to be described.

Since the target nucleus ^{36}Ar has isospin $T_i = 0$, the differential cross sections for the (p,t) and $(p,{}^{3}He)$ reactions leading to analogue final states (in ^{34}Ar and ^{34}Cl) with isospin $T_f = 1$ must both proceed by S = 0, T = 1 transfer and hence should have the same shape; the ratio of their magnitudes can be expressed as follows when charge-dependent effects are neglected[7]):

$$R = \frac{d\sigma/d\Omega\ (p,t)}{d\sigma/d\Omega\ (p,{}^{3}He)} = \frac{2}{2T_f-1} \cdot \frac{k_t}{k_{^3He}} = \frac{2k_t}{k_{^3He}} \qquad (1)$$

where k_t and $k_{^3He}$ are the wave numbers of the outgoing tritons and ^{3}He particles. Thus by comparing the angular distributions of the (p,t) and $(p,{}^{3}He)$ reactions leading to states which, because of their excitation energies, are suspected of being analogues, it should be possible to uniquely determine the $T_f = 1$ final states. This is complicated in practice by the fact that the (p,^{3}He) reaction can produce both $T_f = 0$ and 1 states in ^{34}Cl; consequently, where the density of states is quite high and the possibility of unresolved doublets is significant, some ambiguity can arise. By use of the (d,α) reaction, which can only produce $T_f = 0$ states, this ambiguity can generally be resolved.

2. Experimental Procedure

The experiments were carried out using the external 45-MeV proton and deuteron beams from the Berkeley 88-inch cyclotron. Since a description of the general experimental facilities has been given elsewhere[8]), only a brief summary is given here. The beam was magnetically analysed by being deflected through 40° and passed through a 1 mm slit. It was subsequently brought to a focus in the center of a 50-cm diameter scattering chamber giving a 1 mm by 2 mm spot at the target position. The beam current, which ranged from 50 nA to 1 μA depending on the scattering angle, was monitored using a Faraday cup connected to an integrating electrometer.

The reaction products were detected using two independent counter telescopes on opposite sides of the beam. Each telescope consisted of three detectors: a 155 μ phosphorus-diffused silicon ΔE transmission counter and a 3.0 mm lithium-drifted silicon E counter operated in coincidence, followed by a 0.5 mm lithium-drifted silicon E-reject counter operated in anti-coincidence with the first two, to eliminate long range particles. The signals from each telescope were fed into a Goulding-Landis particle identifier[9]) which produced an output signal characteristic of particle type. This signal was used to generate a routing signal which gated the total energy signal (ΔE+E) into one of the 1024-channel segments of a 4096-channel analyser. For the proton-induced reactions, spectra were recorded for α particles, ^{3}He particles, tritons, and those particles slightly less ionizing than the selected tritons. The first and last groups were taken primarily to check that no ^{3}He or triton counts were lost. For the deuteron induced reactions only α- and ^{3}He-particle spectra were recorded. A schematic layout of the electronic system used is shown in fig. 1.

The argon target used for these experiments was 99.6% enriched in ^{36}Ar. Spectra from the (p,t) and (p,^{3}He) reactions were recorded for angles ranging from $\theta_{lab} = 10.0°$ to $\theta_{lab} = 60.5°$; the α-particle spectra from the (d,α) reaction were taken from $\theta_{lab} = 14.1°$ to $\theta_{lab} = 50.7°$. Triton and ^{3}He spectra recorded for 3450 μC at $\theta_{lab} = 24.1°$ are shown in fig. 2, while a representative α-particle spectrum recorded at $\theta_{lab} = 22.3°$ for 2200 μC is shown in fig. 3.

The excitation energies determined for the states observed in the reaction ^{36}Ar(p,t)^{34}Ar are based on the known Q-value for the ground-state reaction[3-5,10]) as well as on states produced in the reactions ^{16}O(p,t)^{14}O and ^{12}C(p,t)^{10}C. An ^{16}O impurity in the target gas provided continuous calibration, while a carbon dioxide target, run immediately before and after the ^{36}Ar, established the exact energy scale. The excitation energies of states in ^{34}Cl produced by the (p,^{3}He) reaction were determined in a similar manner. Here the known states in ^{34}Cl were used up to 2.162 MeV and the energy scale was extended using ^{14}N and ^{10}B states produced from the carbon dioxide target. The excitations of states in ^{34}Cl produced by the (d,α) reaction were determined using the known low-energy T = 0 states and, in addition, the 4.97 MeV state which had previously been determined from the reaction ^{36}Ar(p,^{3}He)^{34}Cl. The excitation energies determined from this work are shown in square brackets in figs. 2 and 3; the data are summarized in tables 1 and 2.

3. Results

In addition to the present data on ^{34}Ar, table 1 includes the results obtained previously[3-5] from the reaction ^{32}S(^{3}He,n)^{34}Ar. Although the Q-value reported by McMurray et al.[3] for this reaction leading to the ^{34}Ar ground state agrees well with the other work, their determination of the excited states deviates considerably from our work and that of refs. [4] and [5]. Because of the large discrepancies noted, their values have not been included in obtaining the average excitation energies shown in table 1.

Those angular distributions of triton groups which displayed identifiable structure are shown in fig. 4 where they have been grouped according to the L-value characterizing the transitions. [The absolute cross-sections for the larger states should be good to 15%.] The curves correspond to DWBA calculations made using the program DWUCK[11] and the parameters listed in table 3.[12,13] The L = 0 and 2 fits are generally good with the possible exception of the state at 7.53 MeV. Because S = 0 for the (p,t) reaction, the spin-parity of the final state in this case is uniquely determined by the L-value, i.e., $J_f = L$ and $\pi_f = (-)^{J_f}$. These values are listed in table 1. The experimental angular distribution corresponding to the peak at 4.56 MeV, which is shown at the bottom left of fig. 4, is not fitted particularly well by either L=2 or L=3 calculated distributions. However, it is distinctly different from the other experimental L = 2 distributions by being peaked to greater angles; for this reason, and because there is a 3^- state at approximately the same excitation energy in the mirror nucleus ^{34}S, the state produced is identified as probably being 3^-. It is entirely possible, though, that the peak is an unresolved doublet involving both a 2^+ and a 3− state. Again comparison with ^{34}S shows this to be a reasonable possibility, and the detailed agreement with the experimental angular distribution could certainly be improved by assuming such a mixture.

The triton angular distributions leading to the first five states observed in ^{34}Ar are shown again on the left side of fig. 5. On the right side of the same figure are shown the $(p,{}^3He)$ angular distributions to their suspected T = 1 analogues in ^{34}Cl; the latter have been multiplied by $(2k_t/k_{^3He})$ to facilitate the comparison suggested by eq. (1). In this case, the dashed curves are not the results of calculations; their shapes were determined as providing the best fit to the <u>triton</u> data. The same curves, but renormalized, were then drawn through the corresponding $(p,{}^3He)$ angular distributions. Thus, if two states are analogues, the dashed curve should fit the $(p,{}^3He)$ data, and the magnitudes of the distributions as they appear in the figure should be the same.

The comparison afforded by fig. 5 indicates that the shapes of the angular distributions are essentially the same for all the states shown and, with one major exception, the magnitudes appear to agree. A quantitative comparison of the cross-section magnitude ratios is given in table 4. With the exception of the ^{34}Ar 3.30 MeV and ^{34}Cl 3.35 MeV states, the experimental and calculated ratios agree within the expected accuracy[7]) of the approximations used to derive eq. (1). On this basis, it is possible to assign $T_f = 1$ to the ground, 2.16 MeV, 3.94 MeV, and 4.67 MeV states of ^{34}Cl; the assignments are confirmed by the fact that none of these states are produced in the (d,α) reaction (see fig. 3). Of course, having established that they are analogues, their spin-parities follow from the calculations already described for the (p,t) reaction, and the results are listed in table 2.

The states at 3.3 MeV in ^{34}Ar and ^{34}Cl have been noted as exceptions and deserve a separate discussion. Based on the intensity of the (p,t) reaction to the state in ^{34}Ar at 3.30 MeV, a $T_f = 1$ state should be observed in ^{34}Cl at approximately the same energy. However, from fig. 5 and table 4 it can be seen that the peak observed at this energy with the (p,^{3}He) reaction was produced more strongly than eq. (1) would predict. Furthermore, the same peak appears in the ^{36}Ar(d,α)^{34}Cl spectrum for which $T_f = 1$ final states are forbidden. Thus an unresolved doublet of states must be involved: one is the 2+, $T_f = 1$ analogue to the 3.30 MeV level in ^{34}Ar; the other has $T_f = 0$. The composite angular distribution indicates that both transitions involve L = 2 transfer, but in populating the T_f=0 state, the transferred spin is restricted to S = 1 and the spin of the final state must be given by $\underline{J}_f = \underline{L} + \underline{1}$. Consequently it is only restricted[14]) to 1+, 2+, or 3+. Were it 2+ as well, considerable isospin mixing between the two states could be expected.

The angular distributions of ^{3}He particles leading to $T_f = 0$ states in ^{34}Cl are shown in fig. 6. The curves in the figure serve only to guide the eye and have no theoretical significance. No attempt was made to fit these data since many of these transitions will involve two L-values, their relative intensities being determined by the details of the wave functions of the states being produced. Unfortunately, reliable wave functions for these states are unavailable. Thus, in this case, even for transitions apparently characterized by a single L-value, the final spin-parity can at best be restricted to three possible values.

The peaks observed at 4.97 and 6.16 MeV in ^{34}Cl can also be shown to be T_f = 0 and 1 doublets using arguments already developed. Both are at the energy expected for an observable T_f = 1 analogue state; both are produced too strongly in the (p,^{3}He) reaction; and, finally, both are produced in the (d,α) reaction. These peaks are noted as doublets in table 2.

A summary of the data is presented in fig. 7 where the experimentally determined level energy diagrams are shown for ^{34}Cl and ^{34}Ar.

4. Discussion

In addition to the level-energy diagrams for ^{34}Cl and ^{34}Ar, two additional schemes are shown in fig. 7 for comparison. On the left are the levels of ^{34}S, the mirror nucleus to ^{34}Ar, and on the right are the results of shell-model calculations by Glaudemans et al.[15]). These calculations assumed ^{28}Si to be an inert core and considered the active nucleons to be in the $2s_{1/2}$ and $1d_{3/2}$ shells. Unfortunately, such a restricted basis is almost certainly inadequate to describe the wave functions of the states produced in the present experiment since such pick-up experiments should also excite states involving holes in the $1d_{5/2}$ shell. In addition, the fact that a 3^- state was produced in mass 34 below 5 MeV is evidence of $1f_{7/2}$ configurations not only in the low excited states of these nuclei but also in the ground state of ^{36}Ar. The apparent agreement between calculated and experimental level energies is partly a result of the fact that the first two excited states were used in the fitting procedure[15]).

A sufficient number of T = 1 states in ^{34}Cl have been identified as a result of this work that it is possible to examine the variation of Coulomb displacement energies over a greater range of excitation energies and configurations than is normally possible. Several qualitative observations can be made from fig. 7. Having normalized the ground states so that they appear at the same energy, the energy shifts for excited 0+ states are significantly less than those between 2^+ or 3^- states, and the energy shifts between states in the pair ^{34}Cl-^{34}S are in general less than those between the same states in the pair ^{34}Ar-^{34}Cl. These effects are both manifestations of the so-called

Coulomb pairing energy and can be explained as the result of increased Coulomb energy due to the physical proximity of protons that are paired in a seniority-zero configuration. It is noteworthy that the observed effects can be described by taking a very crude approach. For j^n configurations, expressions have been derived[16]) for Coulomb displacement energies between states both with seniority zero and two. Within a given mass number, the J-dependence of the displacement energies depends upon the relative magnitudes of the two-body Coulomb energy matrix elements. Making choices for these matrix elements which are appropriate to this mass region[17]), the Coulomb displacement energy between 2^+ states (averaged over the $1d_{5/2}$, $2s_{1/2}$, and $1d_{3/2}$ shells) is calculated to exceed that between 0^+ states in the pair ^{34}Cl-^{34}S by ~40 keV, and to be less by ~55 keV in the pair ^{34}Ar-^{34}Cl. From fig. 7 corresponding experimental numbers can be obtained by averaging over the two 2^+ and 0^+ states in ^{34}Cl-^{34}S and the three such states in ^{34}Ar-^{34}Cl: the results are 41 keV and 55 keV, respectively. The agreement between these averaged experimental numbers and the calculations is probably only a reflection of the fact that the Coulomb force has a long range and consequently is relatively insensitive to details of the nuclear configurations. However this modest success might invite more detailed calculations.

Acknowledgment

One of us (J.C.H.) gratefully acknowledges a fellowship from the Miller Institute for Basic Research in Science.

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14. Although 1+ is possible in principle, in most cases it would require significant L = 0 transfer in addition to L = 2. Since none is apparent, this J^{π} value is probably precluded.

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TABLE 1

Energy Levels of ^{34}Ar

This work		Previous work		Average
Excitation energy (MeV±keV)	J^{π}	Excitation energy (MeV±keV)	Ref.	Excitation energy (MeV±keV)
g.s.	0^+	g.s.	a,b,c	
2.097±20	2^+	2.190±40[d]	a	2.092±15
		2.058±35	b	
		2.10 ±30	c	
3.303±25	2^+	3.59 ±60[d]	a	3.302±19
		3.30 ±30	c	
3.899±25	0^+	3.90 ±30	c	3.900±19
		4.05 ±30	c	
		4.15 ±30	c	
4.56 ±35	(3^-)			
4.97 ±40	0^+			
5.34 ±40				
6.10 ±40	2^+			
6.86 ±40				
7.34 ±45	2^+			
7.53 ±45	(2^+)			
7.95 ±50				

a) ref. 3 b) ref. 4 c) ref. 5

d) These values were not used in obtaining the average excitation energy.

TABLE 2

Energy Levels of ^{34}Cl

This work		Previous work		Average
Excitation energy (MeV±keV)	J^{π},T	Excitation energy[a] (MeV±keV)	J^{π},T[a]	Excitation energy (MeV±keV)
g.s.	0^+,1	g.s.	0^+,1	
0.146[b]	,0	0.1462±0.3	3^+,0	
0.460[b]	,0	0.460 ±14		
1.231[b]	,0	1.231 ±14		
1.891[b]	,0	1.891 ±14		
2.162[b]	2^+,1	2.162 ±14		
2.596±25	,0	2.587 ±14		2.590±13
3.126±30	,0	3.130 ±20		3.129±17
3.33 ±35[c]	,0	3.340 ±20		3.338±17
3.35 ±50[c]	2^+,1	3.380 ±20		3.376±19
3.94 ±35	0^+,1	high level density		
4.67 ±35	(3^-),1			
4.97 ±35[d]	0 0^+,1			
5.60 ±40	,0			
6.16 ±40[d]	,0 2^+,1			
7.07 ±40	,0			

(continued)

Table 2. Continued

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[a])These data are taken from ref. [6]); only states corresponding to transitions observed in these experiments are listed. Above 3.5 MeV the level density is too high to make a meaningful comparison.

[b])These values were used to determine the energy scale.

[c])The excitation energy 3.33 MeV was obtained from the (d,α) reaction, 3.35 MeV from the (p,^{3}He) reaction. As explained in the text, there is good evidence for the existence of a doublet.

[d])As explained in the text, there must be T = 0 and 1 doublets at these energies.

TABLE 3

Optical Model Parameters[a] Used in DWBA Calculations

Particle	V_0	W_0	W_D	r_0	r_0'	a	a'	reference
proton	45.0	5.7	1.8	1.16	1.37	0.75	0.63	12
triton	143.3	53.3	0.0	1.40	1.40	0.59	0.59	13

[a])The potential used has the form

$$V(r) = V_c(r) - V_0\left(\frac{1}{e^x+1}\right) - i\left(W_0 - 4W_D \frac{d}{dx'}\right)\frac{1}{e^{x'}+1}$$

where $V_c(r)$ is the Coulomb potential for a uniformly charged sphere of radius 1.30 $A^{1/3}$ fm, $x = (r - r_0 A^{1/3})/a$, and $x' = (r - r_0' A^{1/3})/a'$.

TABLE 4

Experimental and Calculated Cross-Section Ratios for Low-Lying States in ^{34}Ar and ^{34}Cl Whose Corresponding Angular Distributions Have the Same Shape

Excitation energy (MeV) in ^{34}Ar	^{34}Cl	J^{π}	Experimental R^{a}	Calculated R^{a}
g.s.	g.s.	0+	1.65±0.20	1.80
2.09	2.16	2+	1.55±0.20	1.78
3.30	3.35	2+	0.50±0.05[b]	1.77
3.90	3.94	0+	1.67±0.20	1.77
4.56	4.67	(3-)	1.35±0.35	1.76

[a])R is defined in the text as $d\sigma/d\Omega\ (p,t) / d\sigma/d\Omega\ (p,{}^{3}He)$.

[b])In the text this anomalous ratio is explained as being due to the presence of an unresolved T = 0 and 1 doublet.

Figure Captions

Fig. 1. A schematic diagram of the electronic apparatus used in conjunction with the three-counter telescope; only system 1 is shown in its entirety, system 2 being alike.

Fig. 2. Energy spectra of the reactions $^{36}Ar(p,t)^{34}Ar$ and $^{36}Ar(p,^{3}He)^{34}Cl$ taken at $\theta_{lab} = 24.1°$. The excitation energies shown in brackets were determined from this work; the calibration is explained in the text.

Fig. 3. Energy spectrum of the reaction $^{36}Ar(d,\alpha)^{34}Cl$ taken at $\Theta_{lab} = 22.3°$. The excitation energies shown in brackets were determined from this work; the calibration was established using other marked states.

Fig. 4. Angular distributions of triton groups from the reaction $^{36}Ar(p,t)^{34}Ar$. The curves are DWBA calculations for the marked L-values using the parameters listed in table 3.

Fig. 5. Angular distributions for the reactions $^{36}Ar(p,t)^{34}Ar$ and $^{36}Ar(p,^{3}He)^{34}Cl$ leading to analogue T = 1 final states. The ^{3}He data points have been multiplied by $(2k_t/k_{^3He})$. The dashed curves have no theoretical significance but are fitted to the (p,t) data; the same curves, but renormalized, are drawn through the corresponding $(p,^{3}He)$ distributions.

Fig. 6. Angular distributions of ^{3}He particles leading to T = 0 final states in ^{34}Cl. The curves have no theoretical significance.

Fig. 7. Energy levels of the known mass-34 states. The ground states of ^{34}S and ^{34}Ar are normalized to the same energy as the ground state of ^{34}Cl. Some known levels in ^{34}S and ^{34}Cl at higher excitations which were not observed in these experiments have been deleted. Those doublets in ^{34}Cl marked with one energy and two (J^{π},T) values were unresolved. At the right of the figure is shown the calculated spectrum[15]) of natural parity T = 1 states in mass 34.

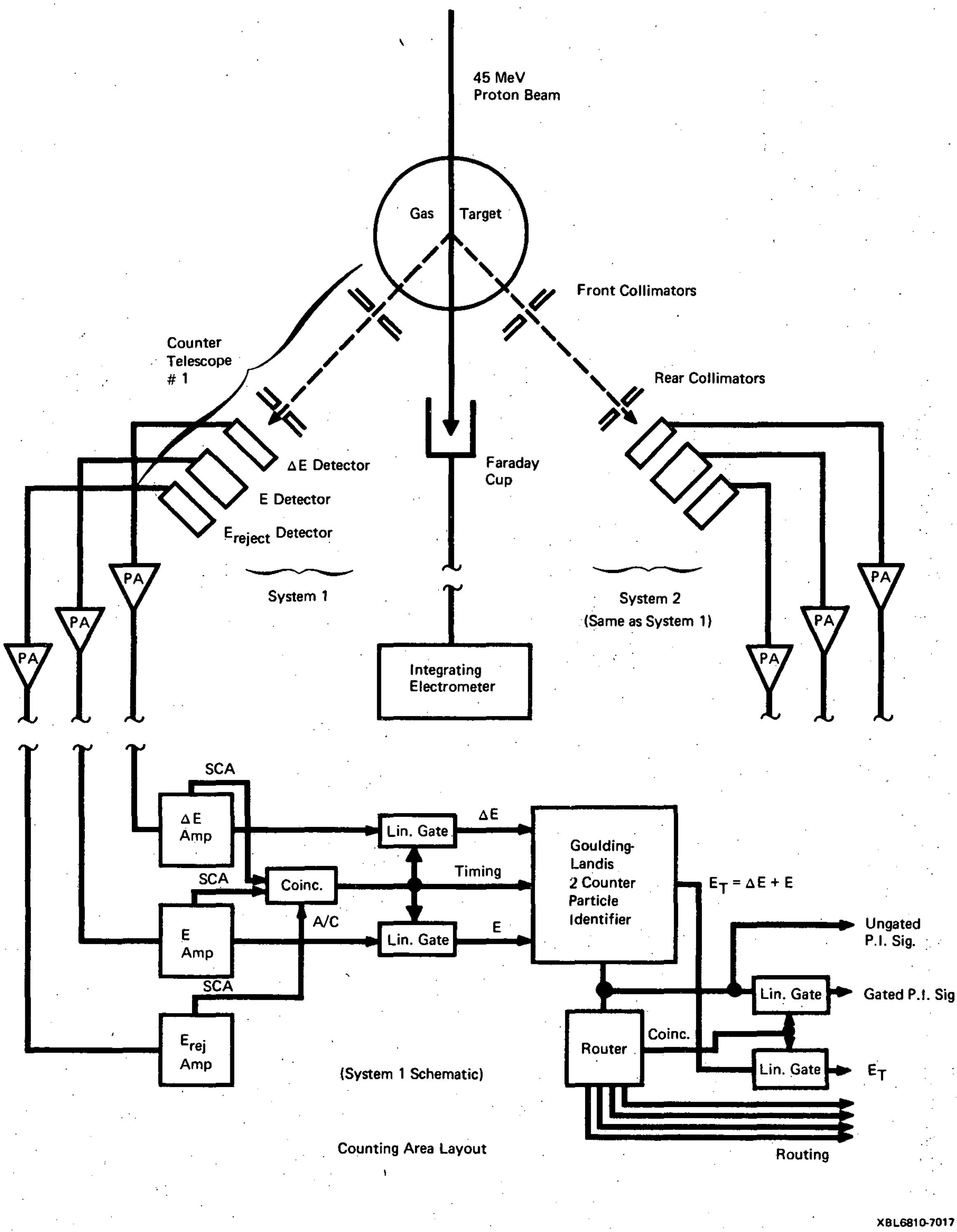
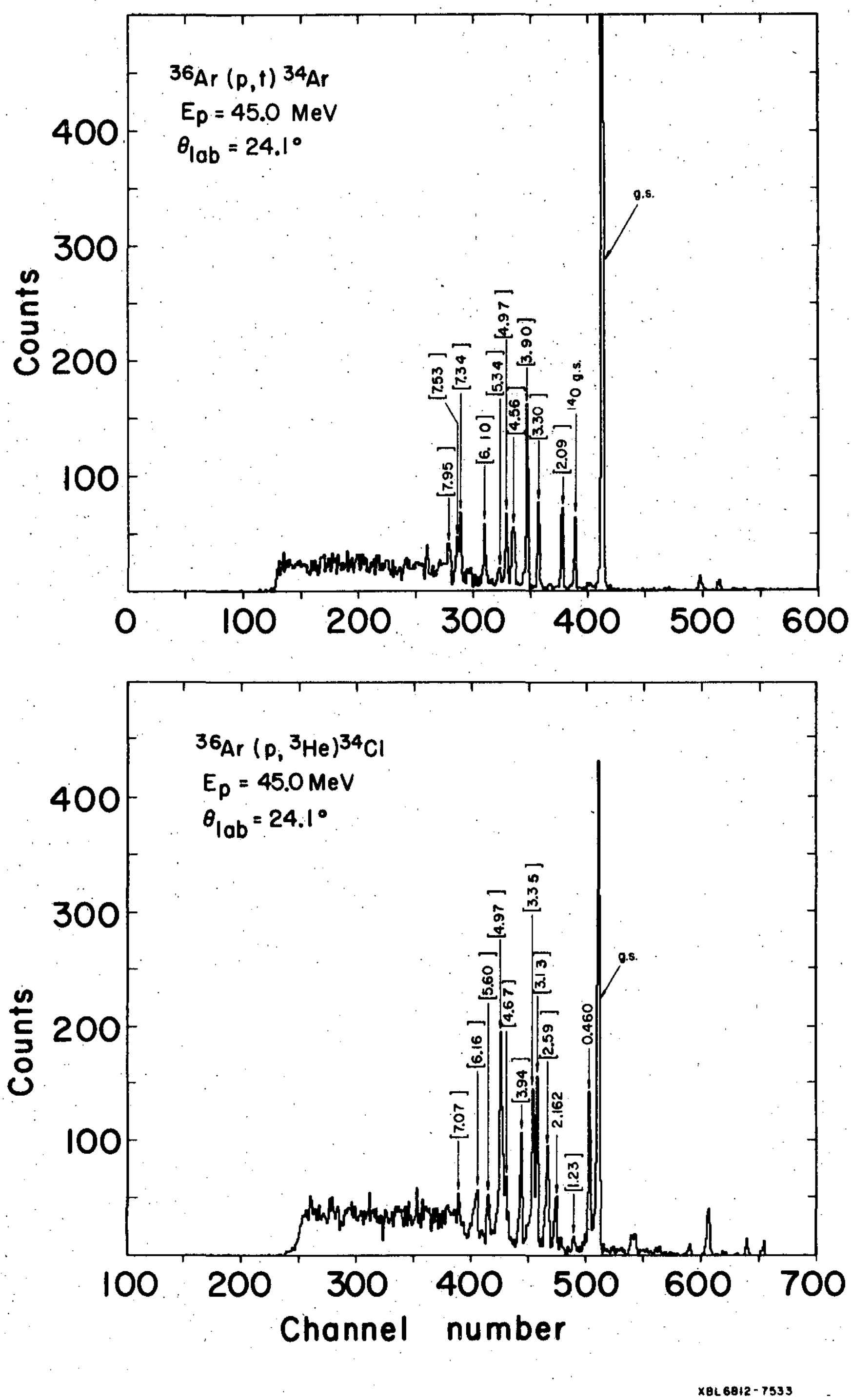
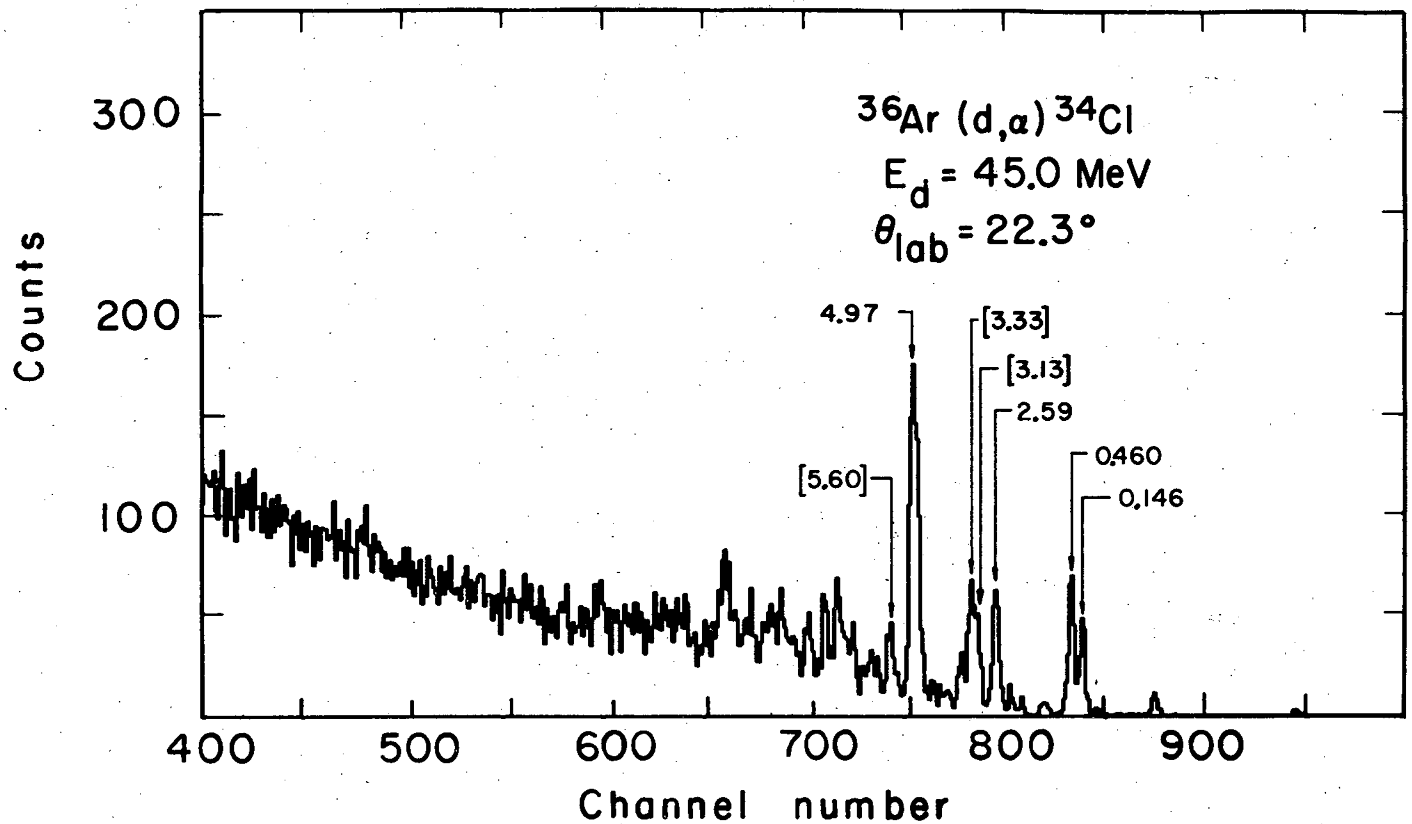

45 MeV
Proton Beam
Gas
Target
Front Collimators
Counter
Telescope
1
Rear Collimators
ΔE Detector
E Detector
E_{reject} Detector
Faraday
Cup
System 1
System 2
(Same as System 1)
PA
Integrating
Electrometer
SCA
ΔE
Amp
Lin. Gate
ΔE
Goulding-
Landis
2 Counter
Particle
Identifier
Coinc.
Timing
$E_T = \Delta E + E$
A/C
E
Amp
E
Ungated
P.I. Sig.
E_{rej}
Amp
Gated P.I. Sig.
Router
Coinc.
E_T
(System 1 Schematic)
Counting Area Layout
Routing
XBL6810-7017

Fig. 1



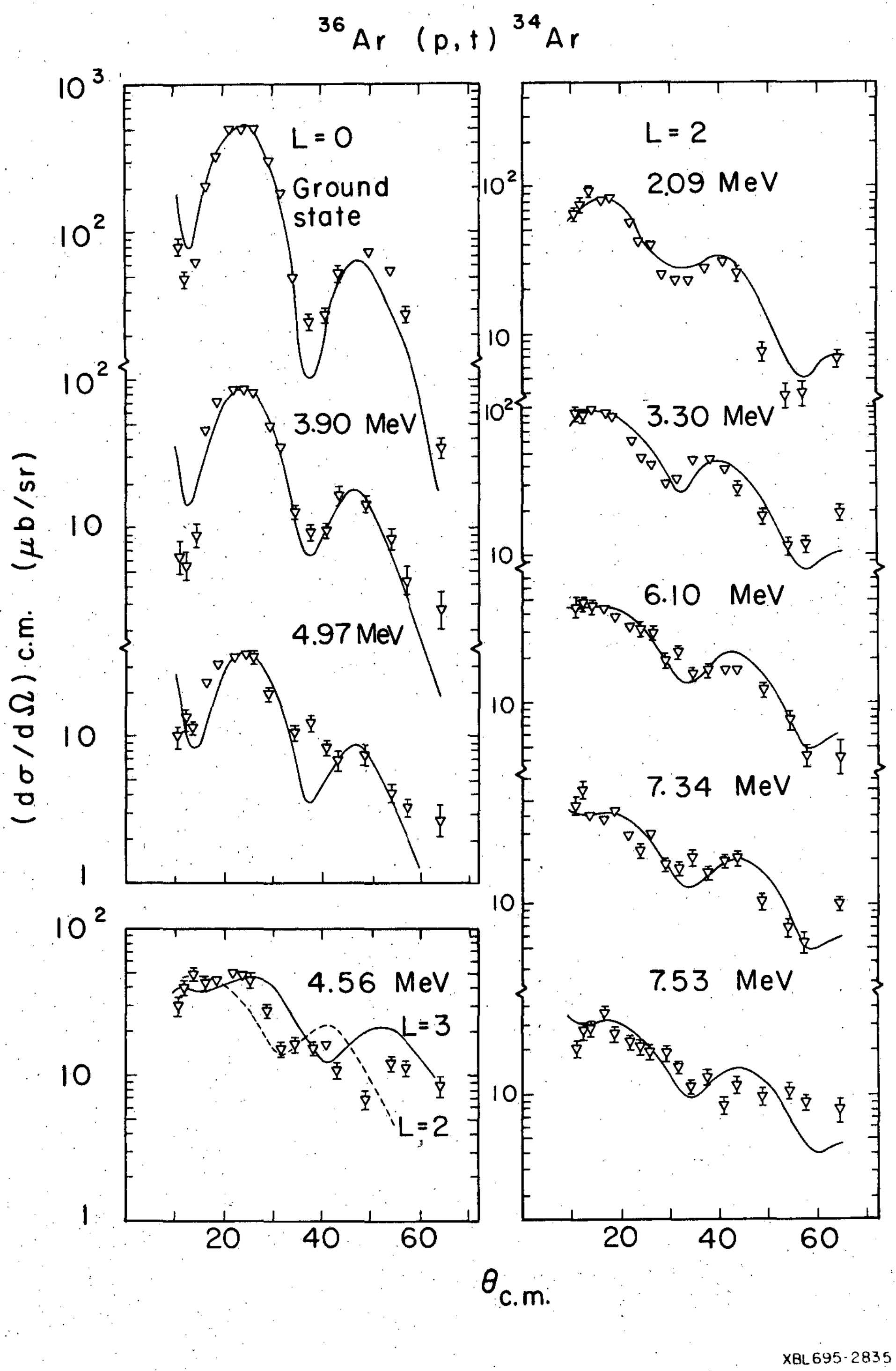
$^{36}Ar(p,t)^{34}Ar$
$E_p = 45.0$ MeV
$\theta_{lab} = 24.1°$
Counts
g.s.
$^{36}Ar(p,{}^3He)^{34}Cl$
$E_p = 45.0$ MeV
$\theta_{lab} = 24.1°$
Channel number
XBL 6812-7533

Fig. 2



XBL 696-607

Fig. 3



$^{36}Ar\ (p,t)\ ^{34}Ar$
L = 0
Ground state
3.90 MeV
4.97 MeV
4.56 MeV
L=3
L=2
L = 2
2.09 MeV
3.30 MeV
6.10 MeV
7.34 MeV
7.53 MeV
$(d\sigma/d\Omega)$ c.m. (μb/sr)
$\theta_{c.m.}$
XBL695-2835

Fig. 4

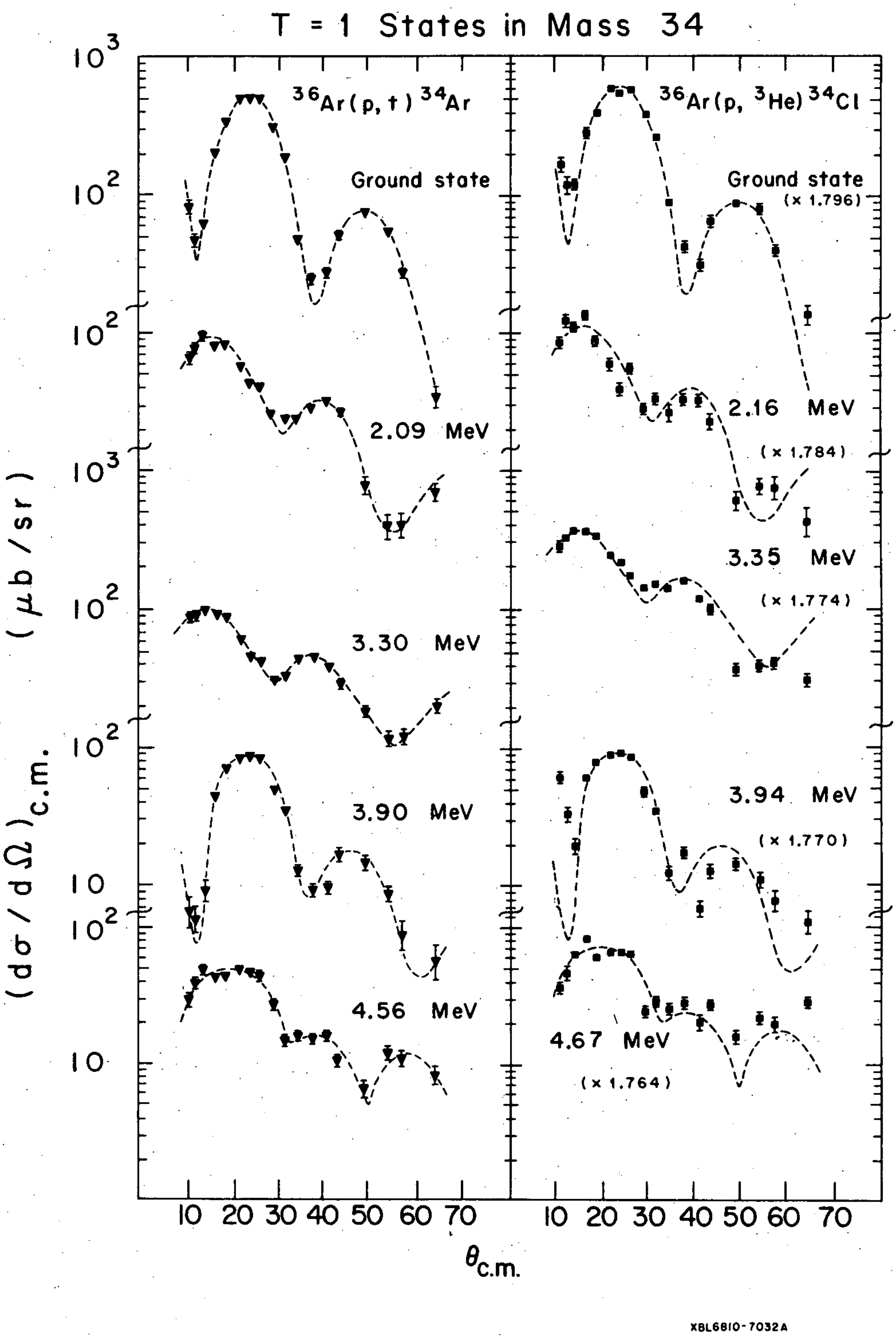

T = 1 States in Mass 34
$^{36}Ar(p,t)^{34}Ar$
$^{36}Ar(p,{}^{3}He)^{34}Cl$
Ground state
Ground state
(× 1.796)
2.09 MeV
2.16 MeV
(× 1.784)
3.30 MeV
3.35 MeV
(× 1.774)
3.90 MeV
3.94 MeV
(× 1.770)
4.56 MeV
4.67 MeV
(× 1.764)
$(d\sigma/d\Omega)_{c.m.}$ ($\mu b/sr$)
$\theta_{c.m.}$
XBL6810-7032A

Fig. 5

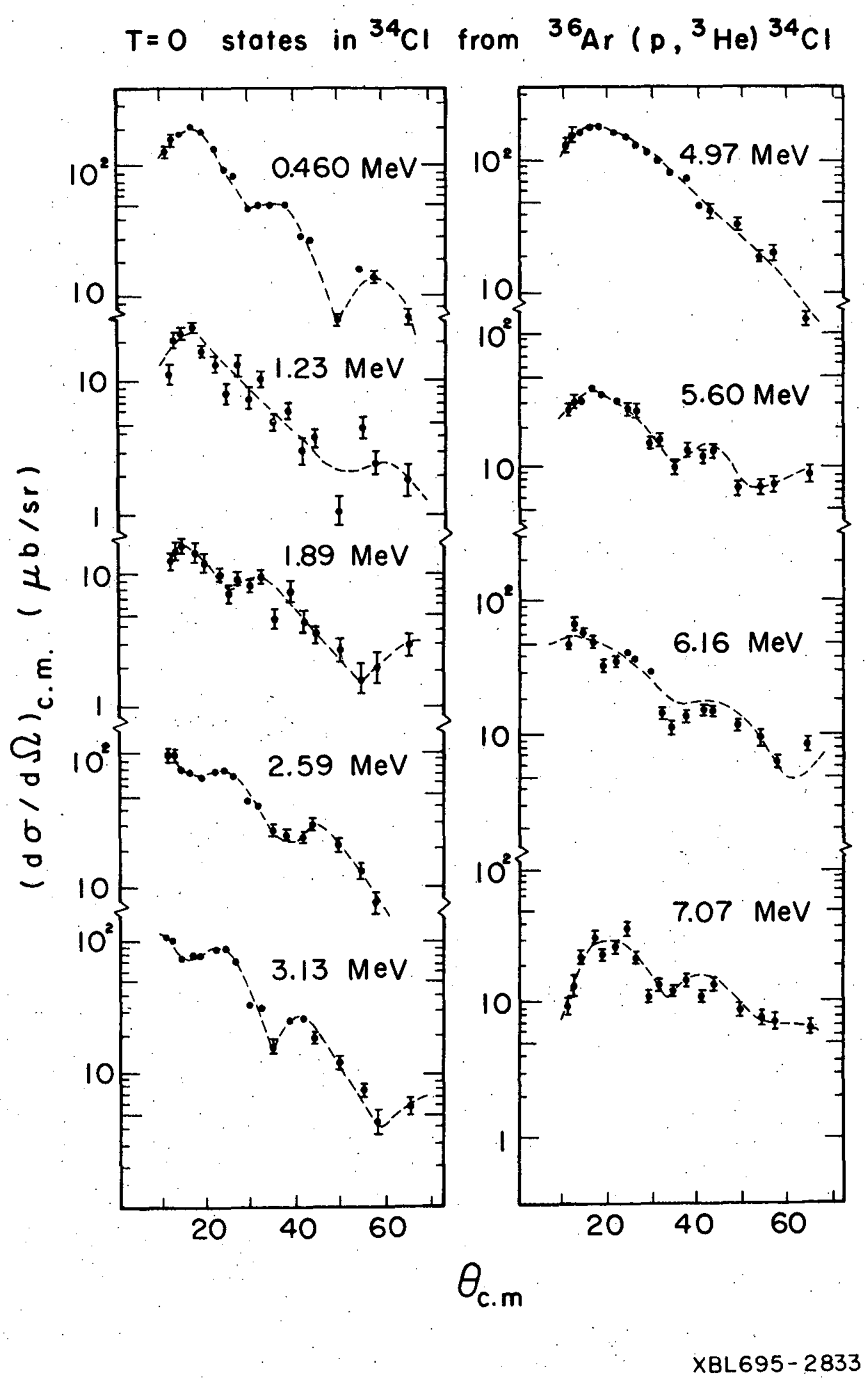

T=0 states in ^{34}Cl from ^{36}Ar (p, ^{3}He) ^{34}Cl
0.460 MeV
1.23 MeV
1.89 MeV
2.59 MeV
3.13 MeV
4.97 MeV
5.60 MeV
6.16 MeV
7.07 MeV
(dσ/dΩ)c.m. (μb/sr)
θc.m
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Fig. 6

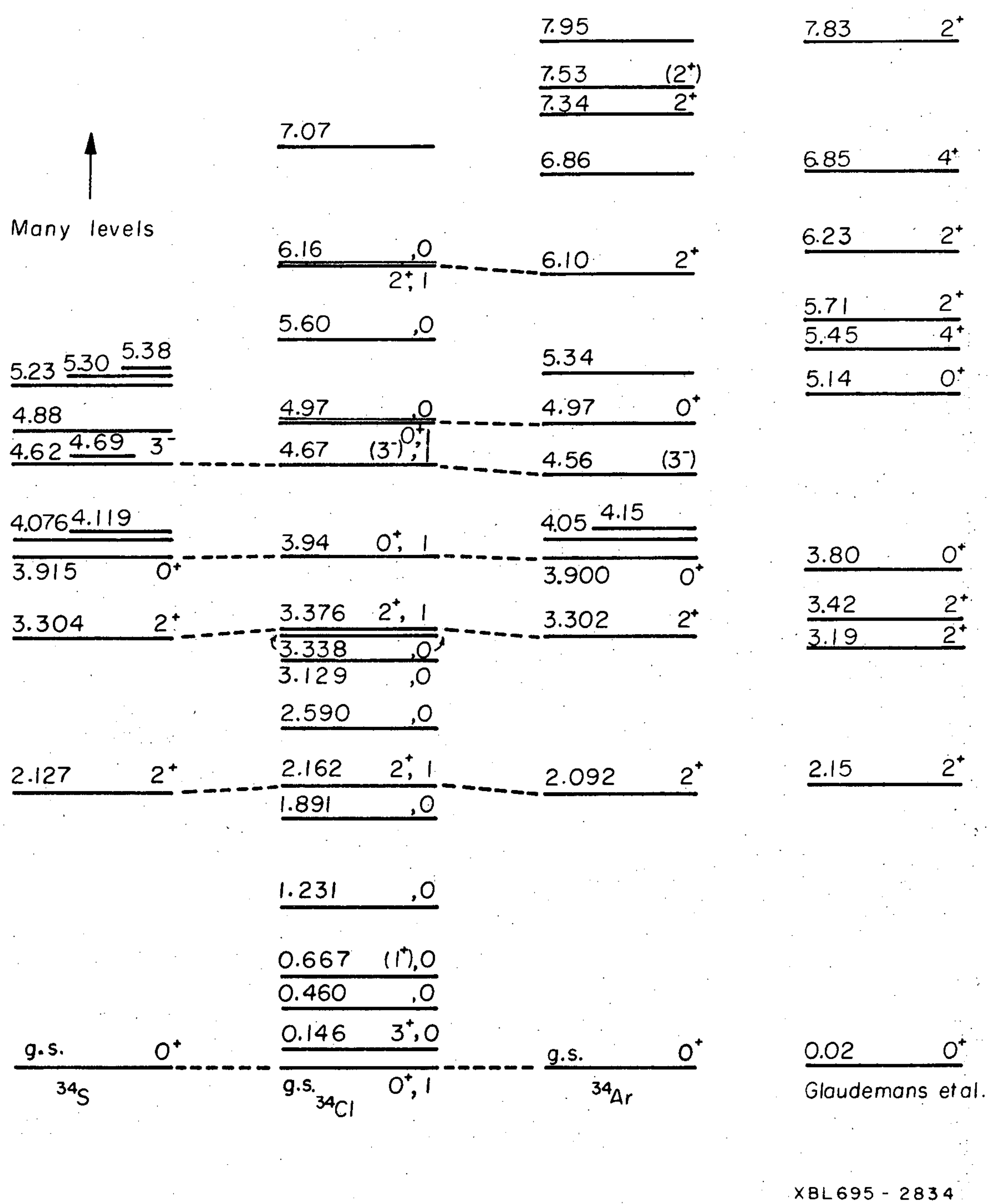
7.95
7.53 (2+)
7.34 2+
7.83 2+
7.07
6.86
6.85 4+
Many levels
6.16 ,0
2+, 1
6.10 2+
6.23 2+
5.60 ,0
5.71 2+
5.45 4+
5.23 5.30 5.38
5.34
5.14 0+
4.88
4.97 ,0
4.97 0+
4.62 4.69 3-
4.67 (3-) 0+; 1
4.56 (3-)
4.076 4.119
4.05 4.15
3.915 0+
3.94 0+, 1
3.900 0+
3.80 0+
3.304 2+
3.376 2+, 1
3.338 ,0
3.129 ,0
3.302 2+
3.42 2+
3.19 2+
2.590 ,0
2.127 2+
2.162 2+, 1
1.891 ,0
2.092 2+
2.15 2+
1.231 ,0
0.667 (1+),0
0.460 ,0
0.146 3+,0
g.s. 0+
34S
g.s. 34Cl 0+, 1
g.s. 0+
34Ar
0.02 0+
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Fig. 7

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