show a large proton polarization in the transition region (i.e., between the first and second peak), such a polarization would be a very striking confirmation of Peierls's model. Of course the possibility exists that neither Peierls's model nor Wilson's model is correct. We expect that most other models[8] are likely to give a proton polarization substantially smaller than 80%. The energy and angular dependence of the proton polarization will throw further light on the nature of the second peak.

The investigation discussed here was sparked by stimulating conversations the author had with Dr. Oreste Piccioni. Thanks are also due to Dr. M. J. Moravcsik and Dr. T. J. Ypsilantis for helpful discussions.

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†On leave of absence from the University of Chicago, Chicago, Illinois.

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[4]In Wilson's model, however, the neglect of the $E2 \to p\frac{3}{2}$ transition in the second resonance region may not be justified on a priori theoretical grounds.

[5]For the construction of the production matrix see, e.g., M. J. Moravcsik, Brookhaven National Laboratory Report BNL-459, 1957 (unpublished), p. 15-16.

[6]In principle we can resolve the ambiguity by using a polarized γ-ray beam. The A term gives $1+3\sin^2\theta\sin^2\phi$, whereas the B term gives $1+3\sin^2\theta\cos^2\phi$, where ϕ is the angle between $\hat{\epsilon}$ and $\hat{q}$. However, the possibility of obtaining a polarized γ-ray beam at 700 Mev seems to be rather remote at present.

[7]See, e.g., E. M. Haffner, Phys. Rev. 111, 297 (1958).

[8]See remarks by R. L. Walker and M. Gell-Mann, Proceedings of the Eighth Annual Conference on High-Energy Nuclear Physics, CERN, Geneva, 1958 (to be published).

F^{18} LEVELS NEAR 1 MEV

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As a result of increased interest in the application of current shell and collective model calculations[1,2] to the mass-18 system, measurements have been carried out recently in a number of laboratories on the low levels of F^{18}. It is the purpose of this letter to present evidence for a new level in F^{18} which resolves the apparent discrepancies between the measurements in different laboratories on the F^{18} spectrum in the region of one Mev excitation.

Early measurements on the $Ne^{20}(d,\alpha)F^{18}$ reaction[3] indicated a $T=0$ level at 1.05 Mev. Measurements in several laboratories on the $N^{14}(\alpha,\gamma)F^{18}$,[4] $O^{18}(p,n)F^{18}$[5] and $O^{16}(He^3,p\gamma)F^{18}$[6] reactions indicated two levels, at energies near 0.94 and 1.07 Mev; the upper one of these was assumed to be the analog of the $T=1$, 0+ ground state of O^{18} while the lower one was assumed to be identical with that observed in the $Ne^{20}(d,\alpha)F^{18}$ measurements. Measurements carried out in this laboratory[7] on $O^{16}(He^3,p\gamma)F^{18}$ showed two levels; the energies were assumed to be 0.94 and 1.08 Mev as measured under the inherently better experimental conditions in our $N^{14}(\alpha,\gamma)F^{18}$ studies.[8]

More recently high resolution magnetic spectrograph measurements have been made at the Rice Institute[9] and the Atomic Weapons Research Establishment, Aldermaston,[10] using the reaction $O^{16}(He^3,p)F^{18}$. Proton groups corresponding to levels at 0.940, 1.045, and 1.125 Mev and at 0.935, 1.040, and 1.120 Mev, respectively, are reported. In addition gamma-ray transitions of energy 0.94 and 1.04 Mev have been observed in the reaction[11] $O^{18}(p,n\gamma)F^{18}$. None of these energies are in agreement with the value 1.075 $\pm$0.010 observed in the $N^{14}(\alpha,\gamma)F^{18}$ studies.[4,8]

In order to check on the energies of the gamma-ray transitions involved in the $N^{14}(\alpha,\gamma)F^{18}$ and $O^{16}(He^3,p\gamma)F^{18}$ reactions, the gamma-ray spectra shown in Fig. 1 were measured. Clearly the higher energy transitions from the two reactions do not have the same energy. Since more detailed measurements have demonstrated for each reaction that the de-excitations involved are ground-state transitions, it is necessary to postulate a fourth level, not observed in the spectrograph measurement, at 1.08 Mev.

No evidence for a transition of 1.12 Mev has been found.

The measured de-excitation branching and angular distributions of the radiation from the $N^{14}(\alpha,\gamma)F^{18}$ reaction strongly support a $T=1$, 0+ assignment[8] to the state near 1.08 Mev; there is no obvious reason why this level should not be observed in the reaction $O^{16}(He^3,p)F^{18}$. However, since this reaction is known to show

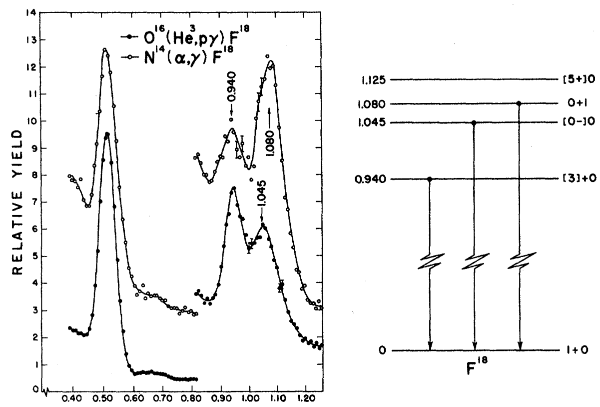

FIG. 1. Gamma-ray pulse-height spectra from $O^{16}(He^3, p\gamma)F^{18}$ ($E_{He^3} \sim 2.43$ Mev) and $N^{14}(\alpha, \gamma)F^{18}$ ($E_{He^4} \sim 1.53$ Mev), together with a level diagram showing the transitions involved. The assignments in brackets are not certain.

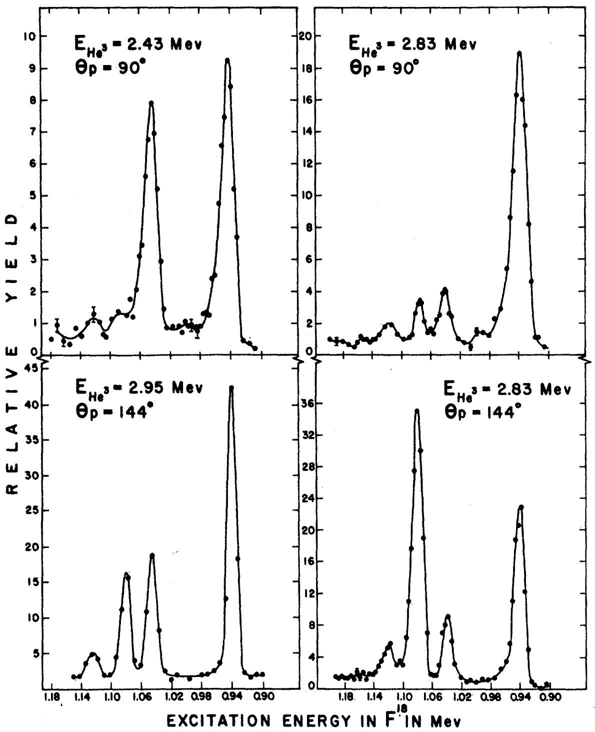

FIG. 2. Proton energy spectra from $O^{16}(He^3, p)F^{18}$ obtained in a Kellogg type 180° magnetic spectrometer. The abscissa gives the corresponding excitation in F^{18}. The angle of observation with respect to the He^3 beam and the incident He^3 energy are inset for each spectrum.

strong resonance effects[12] it appeared possible that the spectrograph measurements were made at either angles or incident energies where the corresponding differential cross section was small. For this reason measurements were carried out at several angles and bombarding energies with a Kellogg type 180° magnetic spectrometer in a search for the proton group from the $O^{16}(He^3, p)F^{18}$ reaction leading to the 1.08-Mev level in F^{18}. Some of the results are shown in Fig. 2. All the groups were identified as protons by their pulse heights in a calibrated CsI detector; the variation of their measured momenta with angle and beam energy establish that they all are from the $O^{16}(He^3, p)F^{18}$ reaction. These measurements corroborate the existence of levels at 0.94, 1.04, and 1.12 Mev and establish the existence of a new level in F^{18} at 1.080 ± 0.005 Mev. This energy value is obtained by assuming a magnet calibration based on the average energy values reported for the other three states in the previous spectrographic studies.

With the single exception of the $F^{19}(d, t)F^{18}$ measurements of El Bedewi and Hussein,[13] which suggest negative parity for the 0.94-Mev level, all of the available data are consistent with the assignments shown on the level diagram in Fig. 1. Both the $F^{19}(p, d)F^{18}$ measurements of Bennett[14] and linear polarization measurements carried out in this laboratory on the 0.94-Mev radiation[15] require positive parity for the 0.94-Mev state. Gamma-ray angular distribution and (p, γ) angular correlation measurements involving the 1.04- and 1.08-Mev gamma rays show spherical symmetry while those involving the 0.94-Mev level do not. *A* 0-, $T = 0$ assignment to the 1.040-Mev level, which corresponds to the removal of a $p_{\frac{1}{2}}$ neutron from the O^{16} core, is consistent with a small reduced width for the $F^{19}(p, d)F^{18}$ reaction to this level and Bennett's observation of only $l = 0$ and $l = 2$ components in the pickup pattern to the unresolved states near one Mev.

A report of detailed studies of the de-excitation branching ratios and other properties of states of F^{18} at higher excitations observed in the reactions $O^{16}(He^3, p\gamma)F^{18}$ and $N^{14}(\alpha, \gamma)F^{18}$ will be published shortly.

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POLARIZATION EFFECTS IN CASCADE SHOWERS*

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The possibility of the "transmission" of polarization effects through matter by means of electromagnetic cascade showers has been suggested by Goldhaber and emphasized by Dyson and McVoy.[1] If the showers are generated by polarized high-energy electrons, this effect can be used to measure the polarization of the incident electron beam by observing the resulting bremsstrahlung photons.[2] We have therefore made preliminary calculations for the effect by means of a Monte Carlo technique.[3]

At the present time, the cross sections used for the polarized bremsstrahlung and pair-production processes are essentially those of Dyson and McVoy[1] for the case of complete screening. The (2/9) term neglected by Dyson and McVoy has been combined with the $d\sigma_{FFF}$ cross section because it was noticed that in pair production the inclusion of any fractional part of this term with either of the other two cross sections allowed them to become negative. Calculations using more accurate cross sections are planned.[4]

For given initial conditions, i.e., particle, energy, and spin,[5] three numbers were determined by making correspondences between the cross sections and random numbers. The procedure was as follows: the distance to an interaction was found by a correspondence between the total cross section for an event[6] and a random number; the energy loss was calculated if the particle was an electron, and the polarization combination was obtained by a correspondence between the polarization cross sections (integrated over the energy range) and random numbers; by use of the appropriate polarization cross section, the energies of the resulting particles were obtained by another random-number correspondence. Each particle generated was followed through the material in a similar fashion until the shower "died." Electrons and photons with energies less than one Mev were considered "dead." The random numbers ranged over the integers from 0 to 10^7. A constant energy loss was assumed, and for our calculations, which are for lead, the value 19.6 Mev/cm was used. The final results obtained were the numbers, polarizations, and energies of electrons, positrons, and photons after traversing a particular distance in the material. In these calculations, multiple scattering has been neglected.

The polarization transmitted in a shower is defined as

$$P(x) = 100\,[\gamma_+(x) - \gamma_-(x)]/[\gamma_+(x) + \gamma_-(x)],$$

where $\gamma_+(x)$ is the number of "spin-forward" photons at a given distance, x, for a particular shower, and $\gamma_-(x)$ refers to the "spin-backward" photons. Table I gives $\bar{P}(x)$, the average polarization, for an incident 30-Mev electron, polarized forward, on the basis of 500 showers. The symbol ($E_\gamma > 5$) signifies that only those photons present at x with an energy greater than 5 Mev were counted; similarly for ($E_\gamma > 10$). Physical significance is to be attached only to the top entry in the left column and to the top two en-

Table I. Average polarization for an incident 30-Mev electron polarized forward.

	$E_\gamma > 5$		$E_\gamma > 10$	
x(cm)	$\bar{P}(x)$	$2\sigma_{\bar{P}}$	$\bar{P}(x)$	$2\sigma_{\bar{P}}$
0.5	55	10	72	12
1.0	61	8	90	10
1.5	55	14	80	22
2.0	43	20	39	54
2.5	40	26	64	