warranted, assumption that all the spin-dependent amplitudes are negligible. Thus, we ascribe the entire H-D discrepancy to an isospin dependence of T. With this assumption, it follows from (3) that

$$R^{\text{coherent}} = 4\left(1-\left|\frac{a_1}{a_1+a_0}\right|^2 - \frac{2\,\mathrm{Re}a_0{}^*a_1}{|a_1+a_0|^2} + G(0)\right),$$

$$R^{\text{incoherent}} = 2\left(1-\frac{2\,\mathrm{Re}a_0{}^*a_1}{|a_1+a_0|^2} + 2G(t)\right). \quad (4)$$

From the measured values of R, we find

$$\frac{\mathrm{Re}a_0{}^*a_1}{|a_1+a_0|^2} = -0.02 \pm 0.02,$$

and

$$\left|\frac{a_1}{a_1+a_0}\right| = 0.14 \pm 0.06. \quad (5)$$

Thus, we require a substantial $I=1$ exchange to account for the discrepancy.

The results of (5) are obtained by averaging all the measurements. We do not mean to imply that these results are independent of energy.

We repeat that, in view of our assumptions, (5) should only be taken as indicative of the nondiffractive amplitudes.[8] It is quite clear that the questions investigated here can only be settled by more data. In particular, information on C of Eq. (2) is required. Such information can be obtained by measuring the density matrix using polarized photons. Thus, a more comprehensive analysis awaits experiments of this kind.

We are indebted to Professor D. R. Yennie for a number of illuminating conversations.

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[1]G. McClellan et al., following Letter [Phys. Rev. Letters 22, 377 (1969)].

[2]The mass distribution we use is given by

$$P_{\mathrm{BW}}(m_{\pi\pi};\Gamma_\rho,m_\rho) = \frac{2}{\pi}\frac{m_{\pi\pi}m_\rho\Gamma(m_{\pi\pi})}{(m_\rho{}^2-m_{\pi\pi}{}^2)^2+m_\rho{}^2\Gamma^2(m_{\pi\pi})},$$

where

$$\Gamma(m_{\pi\pi}) = \frac{m_\rho}{m_{\pi\pi}}\left(\frac{m_{\pi\pi}{}^2/4-m_\pi{}^2}{m_\rho{}^2/4-m_\pi{}^2}\right)^{3/2}\Gamma_\rho;$$

$\Gamma_\rho = 120$ MeV and $m = 770$ MeV. This distribution is normalized to within 1% when cut off at our maximum mass.

[3]H. Blechschmidt et al., Nuovo Cimento 52A, 1348 (1967).

[4]K. J. Foley et al., Phys. Rev. Letters 11, 425 (1963).

[5]For $F(t)$ in Eq. (3) we use the electron-scattering result, which, for small t, can be approximated by $F(t) = (1-56t)$ [t in $(\mathrm{GeV}/c)^2$].

[6]V. Franco and R. Glauber, Phys. Rev. 142, 1195 (1966).

[7]We reported $R = 2.87 \pm 0.09$ at $\theta = 0°$ to the Fourteenth International Conference on High Energy Physics, Vienna, Austria, 28 August-5 September 1968 (unpublished). This was in error. The correct value is $R = 3.04 \pm 0.10$. The error was due to the use of an incorrect deuteron form factor. We are grateful to Professor D. R. Yennie for pointing out this error to us.

[8]The relative phase of a_0 and a_1 is determined by the data in the incoherent region where (2) may be inadequate—another reason for viewing the results of (5) with caution.

PHOTOPRODUCTION OF ρ^0 MESONS FROM COMPLEX NUCLEI*

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We have measured the photoproduction of ρ^0 mesons from several complex nuclei. Good agreement with a diffraction model is obtained, and comparison is made with the vector-dominance model. If we write the ρ-photon coupling constant as $em_\rho{}^2/2\gamma_\rho$ we find $\gamma_\rho{}^2/4_\pi = 1.10 \pm 0.15$.

We report here the results obtained for the production of ρ mesons by 6.2-GeV photons on complex nuclei. The apparatus used is described in the preceding paper,[1] which contains results from protons and deuterons.

Our apparatus determines the directions and momenta of both pions into which the ρ's decay. Assuming the decay angular distribution appro-

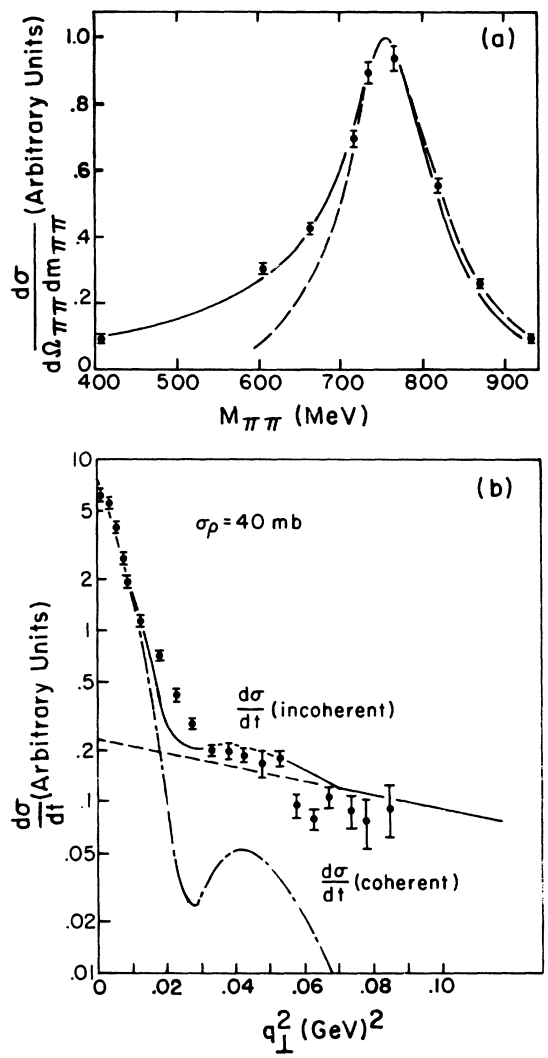

FIG. 1. (a) Measured $m_{\pi\pi}$ distribution of pion pairs from carbon. The fits are described in the text. (b) Measured t dependence from copper at $k_\gamma = 6.0$ GeV; $t = q_\perp^2 + 0.0020$ GeV^2. The smooth curves are the optical-model predictions, using GM radii.

priate to the diffraction picture which follows, we reduce the measured rates to cross sections $d^2\sigma/d\Omega_{\pi\pi}dm_{\pi\pi}$, which are differential in the mass $m_{\pi\pi}$, and the lab solid angle $d\Omega_{\pi\pi}$. We have investigated the dependence of this quantity on $m_{\pi\pi}$, on the angle $\theta_{\pi\pi}$ of the two-pion system, on the incident energy k_γ, and on the nuclear atomic weight, A.

In Fig. 1(a) we plot values of $d\sigma/d\Omega_{\pi\pi}dm_{\pi\pi}$ for carbon. All nuclei yield closely similar shapes, at least for masses above 600 MeV. At $m_{\pi\pi} = 400$ MeV the cross section relative to the peak decreases with increasing A, from a value higher than carbon by almost a factor of 2 at hydrogen to a value almost a factor of 2 less than carbon at lead. These data were taken at $\theta_{\pi\pi} \simeq 0°$ and $k_\gamma = 6.2$ GeV (although, strictly, in these particular data, k_γ varies approximately proportionately to $m_{\pi\pi}$ and is 6.2 GeV when $m_{\pi\pi} = m_\rho = 760$ MeV). The dominant feature of the data is the ρ resonance.

A detailed theory of the observed line shape is not available. Ross and Stodolsky[2] have predicted a shape differing from a Breit-Wigner shape by a factor $(m_\rho/m_{\pi\pi})^4$. Among the previous experimenters,[3] Asbury et al. and Blechschmidt et al. used this modification to analyze their data. All of the previous measurements find a small background on the low-mass side of the ρ peak and little background for $m_{\pi\pi} > 750$ MeV. The broken curve of Fig. 1(a) shows the fit to our data using this modification to the Breit-Wigner shape, defined in the previous paper, with $\Gamma_\rho = 120$ MeV and $m_\rho = 770$ MeV. Our data also show the low-mass background. An alternative picture, as described by Söding[4] and by Eisenhandler et al.,[5] explains the low-mass contribution as being due to a one-pion-exchange amplitude which is coherent with the ρ amplitude. There is no $(m_\rho/m_{\pi\pi})^4$ modification. Such a fit with $\Gamma_\rho = 120$ MeV, $m_\rho = 770$ MeV is shown in Fig. 1(a) by the solid curve. While this fit is less empirical it does not easily account in detail for the A dependence at low masses. In both fits we assume the k_γ dependence to be given by our optical model.

In view of the uncertainties we have chosen to assume no background near the ρ peak. An uncertainty of perhaps 10% is introduced by this assumption. Since, within the range $m_{\pi\pi} = m_\rho \pm \Gamma_\rho$, the shapes are independent of A, we expect negligible A-dependent error. With this assumption we can extract the differential cross section from

$$\frac{d^2\sigma}{d\Omega_{\pi\pi} dm_{\pi\pi}} = \frac{d\sigma}{d\Omega_\rho} P_{\mathrm{BW}}(m_{\pi\pi}; m_\rho, \Gamma_\rho), \quad (1)$$

where P_{BW} is a normalized Breit-Wigner distribution[6] of $m_{\pi\pi}$. Subsequent values of $d\sigma/d\Omega_\rho$ are inferred, using Eq. (1), from values of $d^2\sigma/d\Omega_{\pi\pi}dm_{\pi\pi}$ measured at the peak. We consistently use $\Gamma_\rho = 120$ MeV and $m_\rho = 770$ MeV.

We now turn to an analysis of the t and A dependence of the data. We base our analysis on a generalization of a formula of Drell and Trefil[7] for the diffraction production of ρ mesons from complex nuclei. The production amplitude $A_{\gamma\rho}$ is given in terms of the one-nucleon amplitude A_0 by

$$A_{\gamma\rho} = A_0 \int d^2 b \int_{-\infty}^{\infty} dZ\, \rho(\vec{b}, Z) \exp(iq_{\parallel} Z)\, e^{i\vec{q}\cdot\vec{b}}$$

$$\times \exp[\tfrac{1}{2}\sigma_{\rho N} \int_Z^{\infty} \rho(\vec{b}, Z')dZ']. \qquad (2)$$

This formula yields the total nuclear amplitude as a volume integral over the nucleus with distance along the beam being Z and $\vec{b}$ being a two-dimensional impact-parameter vector normal to the beam. $q_{\perp}$ is the component of the recoil momentum normal to the beam and $q_{\parallel}$ is the component along the beam. $\sigma_{\rho N}$ is the total ρ-nucleon cross section. It is implicit in the analysis that the neutron and proton amplitudes are equal. $\rho(\vec{b}, Z) = \rho(r)$ is the nuclear density for which we use a Woods-Saxon distribution

$$\rho(r) = \rho_0\{1 + \exp[(r-c)/a]\}^{-1}$$

with $a = 0.545 \times 10^{-13}$ cm.

In order to determine the sensitivity of our results to nuclear radii we have carried through the analysis using the two different sets of radii shown in Table I. The set labeled GM is due to Glauber and Matthiae[8] who deduced them from an analysis of proton-nucleus scattering data of Bellettini et al.[9] The set of radii labeled ES are derived from electron scattering.[10] The GM radii are about 7% larger than the ES radii and about equal to those used by Kölbig and Margolis[11] to analyze the ρ-production data of Asbury et al.[3] Since R_{ES} are determined from electromagnetic interactions and R_{GM} from strong interactions they are quite independent of each other. It is gratifying that they differ rather little and in a way that seems "reasonable." This fact lends some support to the method by which R_{GM} were determined. Other relevant data on nuclear radii may be obtained from neutron-nucleus scattering.[12]

Figure 1(b) shows the t dependence obtained from copper. t is given approximately by $t = q_{\parallel}^2 + q_{\perp}^2$, where $q_{\parallel} = m_\rho^2/2k_\gamma = 46$ MeV and $q_{\perp} = k_\gamma \theta_\rho$. The smooth curve is the sum of a coherent contribution calculated from Eq. (2) using GM radii and an incoherent contribution with a slope appropriate to hydrogen and absolute value computed by Kölbig and Margolis.[11] The t dependence is very insensitive to $\sigma_{\rho N}$. (We use $\sigma_{\rho N} = 40$ mb.) The slope of the curve for small t is closely related to the nuclear radius. Our data agree reasonably well with the computed curves for all nuclei.

The A dependence of the 0° cross section is sensitive to $\sigma_{\rho N}$, and, indeed, we wish to extract $\sigma_{\rho N}$ from this dependence. We obtain the 0° cross section by integrating the cross section given by Eq. (2) over our aperture. The finite-aperture effect is quite substantial, particularly for big nuclei. It depends sensitively on the nuclear radius but is insensitive to $\sigma_{\rho N}$. As a check on the dependence of our results on aperture we carried out two different sets of measurements with substantially different apertures.

The results of all the 0° measurements are shown in Table I. All the cross sections were calculated for both sets of radii. Cross sections obtained with the small (large) apertures are tabulated separately. For the small (large) count-

Table I. Measured cross sections and calculated 0° and $t = 0$ cross sections using GM and ES radii. For the small (large) counters $\bar{k}_\gamma = 6.5$ GeV (6.2 GeV) and $\bar{q}_{\perp} = 29$ MeV (47 MeV).

	ELEMENT	Measured Cross Sections Averaged Over Aperture			Calculated Assuming R_{GM}		Calculated Assuming R_{ES}		Half Density Radius (fm)	
		$\frac{d\sigma}{d\Omega_{\pi\pi} m_{\pi\pi}}$	Error %	$\frac{d\sigma}{dt}$	$\frac{d\sigma}{dt}(\theta=0)$	$\frac{d\sigma}{dt}(t=0)$	$\frac{d\sigma}{dt}(\theta=0)$	$\frac{d\sigma}{dt}(t=0)$	R_{GM}	R_{ES}
Small Counters	D	.0251 b/ster-GeV	3.1	.408 mb/GeV^2	.420	.454	.420	.454		
	C	.468	2.9	7.61	7.98	8.71	7.98	8.71	(2.35 rms)	(2.37 rms)
	Mg	1.61	3.5	26.5	29.0	34.0	28.9	33.7	3.14	2.86
	Cu	6.21	3.0	101	118	150	117	147	4.48	4.28
	Ag	13.0	3.0	211	260	352	255	334	5.44	5.15
	Pb	27.4	3.1	446	612	938	589	839	6.99	6.46
Large Counters	D	.0200	3.1	.374	.402	.436	.402	.43		
	Be	.238	2.9	4.48	4.93	5.38	4.93	5.38	(2.50 rms)	(2.52 rms)
	C	.407	2.9	7.59	8.56	9.36	8.56	9.36		
	Mg	1.17	2.9	22.3	27.6	32.5	27.6	32.3		
	Cu	4.64	2.9	86.1	122	157	121	152		
	Ag	8.53	2.9	159	252	345	244	322		
	Au	14.2	2.8	263	510	785	483	690	6.91	6.38
	Pb	15.1	2.9	282	546	849	516	745		

ters the average $q_\perp$ determined by our aperture was 29 MeV (47 MeV) and the average photon energy was 6.5 GeV (6.2 GeV). They are in reasonable agreement. As well as the values of $d^2\sigma/d\Omega_{\pi\pi}dm_{\pi\pi}$ at the ρ peak and the value of $d\sigma/dt$, both averaged over our finite aperture, we show the inferred $\theta_\rho = 0°$ cross sections. Also shown are the inferred $t = 0$ cross sections. [This high-energy limit is obtained by setting $q_\parallel = 0$ in Eq. (2).] We can see that for lead a change from the GM radius to the ES radius yields a 10% change in the $t = 0$ cross section. The dependence on radius becomes negligible for small nuclei. We also investigated the dependence on nuclear-skin thickness [a in Eq. (3)] and found it to be unimportant. Also a real ρN amplitude as large as 30% does not significantly affect the analysis.

Our $t = 0$ cross sections agree within the errors (~10%) with those of Blechschmidt et al. Our copper cross section agrees with Lanzerotti et al. but their carbon cross section is about 50% larger than ours.

In the remainder of this Letter we concentrate on extracting from our data the ρ-nucleon total cross section $\sigma_{\rho N}$ and the ρ-photon coupling constant γ_ρ.[13] Since the former determination does not depend on the assumptions of vector dominance, we do that first. To determine $\sigma_{\rho N}$ from the A dependence we need to know A_0 in Eq. (2). If the ρ-production amplitude is purely diffractive with only $I = 0$ exchange, A_0 can be determined from the hydrogen cross section. But our data[1] from protons and deuterons suggest that the $I = 1$ exchange is not quite negligible, contrary to previous assumptions. For all targets but hydrogen, however, the $I = 1$ amplitudes from the neutrons and protons approximately cancel. Hence, we determine A_0 from the $t = 0$ deuterium cross section using a Glauber correction as described in the preceding paper. This yields

$$\frac{d\sigma^C}{dt}(A=1, t=0) = \frac{\pi}{k_\gamma^{\,2}}|A_0|^2$$

$$= 124\ \mu\text{b/GeV}^2\ \text{nucleon}.$$

In this form we explicitly exhibit the energy dependence expected of diffraction models, and substantiated in the previous paper.

We determine a value of $\sigma_{\rho N}$ from the measurements on each nucleus in the following way. If $d\sigma(A, \theta_\rho = 0°)/dt$ is the 0° cross section for a nucleus, A, we can write that

$$\frac{d\sigma(A, \theta_\rho = 0°)/dt}{d\sigma^C(A=1, t=0)/dt} = N_{\text{eff}}^{\,2}(A, R, \sigma_{\rho N}, k_\gamma) = \left(\frac{A_{\gamma\rho}}{A_0}\right)^2, \tag{4}$$

where N_{eff}, the effective number of nucleons for any nucleus A depends upon the nuclear radius R upon $\sigma_{\rho N}$, and weakly upon k_γ. Thus, for a particular value of R, we can determine the value of $\sigma_{\rho N}$ to use in Eq. (2) in order to obtain the measured ratio. In Fig. 2(a) we plot the values of $\sigma_{\rho N}$ using R_{GM} and the small-counter data.

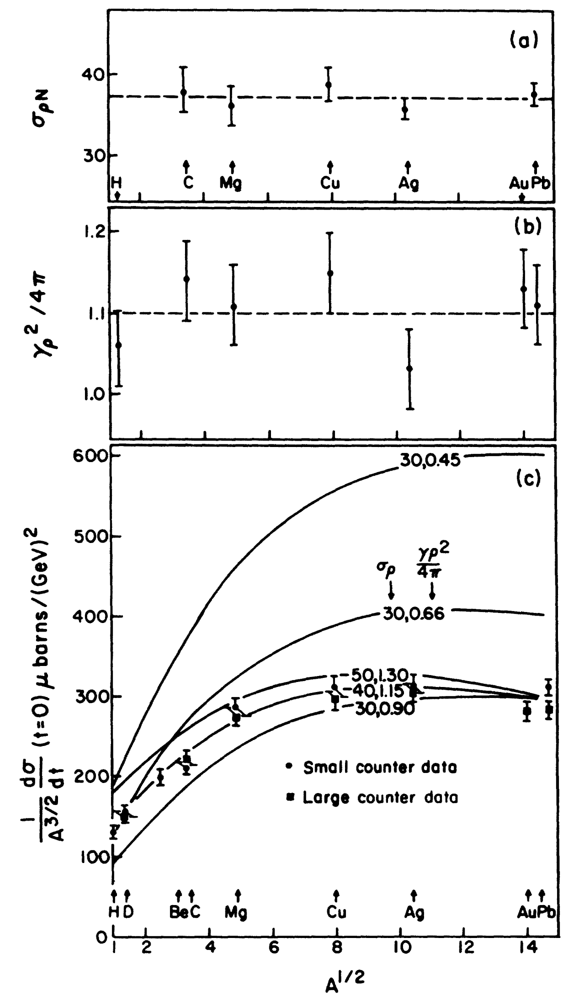

FIG. 2. (a) Values of $\sigma_{\rho N}$ computed from the ratios of cross sections for particular nuclei to that of deuterium. (b) Values of $\gamma_\rho^2/4\pi$ computed from Eq. (5) using $\sigma_{\rho N} = 38$ mb and GM radii. (c) $t = 0$ cross sections, as a function of A. The smooth curves are derived from Eq. (5) for various values of $\gamma_\rho^2/4\pi$ and $\sigma_{\rho N}$.

These measurements were made during a single run, with frequent target changes, and with particular care taken to obtain reliable measurements of the relative cross sections for the various nuclei. The value of $\sigma_{\rho N}$ we determine is[14] $\sigma_{\rho N} = 37.5 \pm 1.4$ mb. The error is statistical. If we use $R_{\rm ES}$ we determine a value of $\sigma_{\rho N} = 35.0 \pm 1.5$ mb.

If we now take the assumption of vector dominance we can extract γ_ρ and also redetermine $\sigma_{\rho N}$ by a slightly different prescription. The basic formula supplied by the vector-dominance model[2] is

$$\frac{d\sigma}{dt}(A, t=0) = \frac{\alpha}{4}\frac{4\pi}{\gamma_\rho^2}\frac{1}{16\pi}\sigma_T^2(\sigma_{\rho N}, A). \qquad (5)$$

This gives the forward photoproduction on any nucleus in terms of the ρ total cross section on the same nucleus. In the absence of a measurement of this total cross section we calculate it using an optical-model integral resembling that in Eq. (2). Again $\sigma_{\rho N}$ is a free parameter and the integral will depend on the choice of nuclear radius. But recall that the GM radii were determined to yield a fit to measured nucleon-nucleus cross sections on the basis of the same optical model. To the extent, then, that ρ-nucleus scattering resembles nucleon-nucleus scattering, Eq. (5) is independent of the optical model and the nuclear size.

In Fig. 2(b) we plot the values of $\gamma_\rho^2/4\pi$ calculated from Eq. (5). We have assumed $\sigma_{\rho N} = 38$ mb and have used the $R_{\rm GM}$ radii to calculate the total ρ-nucleus cross sections. The values used for these cross sections were $\sigma_T({\rm H}) = 38$ mb, $\sigma_T({\rm C}) = 0.328$ b, $\sigma_T({\rm Mg}) = 0.620$ b, $\sigma_T({\rm Cu}) = 1.34$ b, $\sigma_T({\rm Ag}) = 1.95$ b, $\sigma_T({\rm Au}) = 3.09$ b, and $\sigma_T({\rm Pb}) = 3.26$ b. We obtain the result $\gamma_\rho^2/4\pi = 1.10 \pm 0.04$. The error is statistical. If we use the electron-scattering radii $R_{\rm ES}$ rather than $R_{\rm GM}$ we find $\gamma_\rho^2/4\pi = 1.01 \pm 0.04$.

In Fig. 2(c) we plot $A^{-3/2}d\sigma/dt|_{t=0}$ for various nuclei, assuming GM radii. Here, all the measurements, including both the small and large counters, are included. The factor $A^{-3/2}$ permits a manageable scale. The smooth curves are derived from Eq. (5) for various choices of the two free parameters, $\sigma_{\rho N}$ and γ_ρ. It is interesting to note that the predictions become less sensitive to $\sigma_{\rho N}$ for very large nuclei. This is, of course, because such nuclei are almost black as long as $\sigma_{\rho N}$ is sufficiently large. From analysis of the data of Fig. 2(c) we obtain the values (GM radii) $\sigma_{\rho N} = 39.0 \pm 2.0$ mb and $\gamma_\rho^2/4\pi = 1.15 \pm 0.10$. These are in serious contradiction to the values quoted by Asbury et al.[3] of $\sigma_{\rho N} = 31.8 \pm 2.3$ mb and $\gamma_\rho^2/4\pi = 0.45 \pm 0.1$. The nature of the discrepancy is illustrated in Fig. 2(c) by the theoretical curve with essentially their values (30, 0.45). This curve does not fit at hydrogen, where Asbury et al. had no measurement. Our measurement there is in agreement with other experiments.[15] In Fig. 2(c) the curve with parameters (30, 0.66) presumably approximates the results of renormalizing the data of Asbury et al. to give agreement at hydrogen. This still disagrees badly with our data.

The reason we obtain a value of $\sigma_{\rho N}$ nearly equal to the proton-nucleon cross section σ_{pN} can be understood by comparing the left side of Eq. (4), evaluated from our data at $t=0$, with the experimentally determined value of $\sigma_{\rm tot}^2(p,A)/\sigma_{pN}^2$ for protons on the same nucleus. The ratios for ρ photoproduction (proton-nucleus scattering) are, for Be, 43.4 ± 1.8 (47 ± 1.6); for C, 70 ± 2.4 (70 ± 1.1); for Cu, 1185 ± 50 (1140 ± 18); for Pb, 6750 ± 2000 (6760 ± 205). These same ratios measured in π-nucleus[16] scattering are, for Be, 60 ± 3.4; for C, 85 ± 8; and for Cu, 1700 ± 85. We conclude that $\sigma_{\rho N}$ is greater than $\sigma_{\pi N}$ and approximately equal to σ_{pN}.

In summary, we have analyzed our data using the optical-model result of Eq. (2) and nuclear radii, $R_{\rm ES}$, determined from electron scattering. This analysis relies on no information from strong interactions. We have also done the analysis using the nuclear radii $R_{\rm GM}$ determined from proton-nucleus cross sections. This latter analysis is based on the experimentally observed cross sections of Bellettini[9] and Engler[12] and depends only very weakly on the validity of the optical model or on the choice of nuclear radii. The two methods yield nearly the same result.

In consideration of the various uncertainties and the sensitivity to them, our best determinations are $\sigma_{\rho N} = 38 \pm 3$ mb, $\gamma_\rho^2/4\pi = 1.10 \pm 0.15$. We have, as discussed previously, assumed no nonresonant background in arriving at this result. Subtraction of such a background would increase the value of $\gamma_\rho^2/4\pi$ which we obtain.

This determination of γ_ρ raises a serious question about the validity of the vector-dominance model since determinations of $\gamma_\rho^2/4\pi$ in other processes are generally about 0.6.[17] Just how difficult it would be for the theory to accomodate to our determination is not yet clear to us.

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[5]E. Eisenhandler, N. Mistry, P. Mostek, H. Silverman, and R. Talman, Phys. Rev. Letters 20, 758 (1968).

[6]The exact form is given in Ref. 2 of the previous Letter.

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[8]R. J. Glauber and G. Matthiae, Istituto Superiore di Sanità, Laboratori di Fisica, Report No. ISS 67/16, 1967, (unpublished).

[9]G. Bellettini et al., Nucl. Phys. 79, 609 (1966).

[10]R. Hofstadter, Ann. Rev. Nucl. Sci. 7, 231 (1957).

[11]K. S. Kölbig and B. Margolis, Nucl. Phys. B6, 85 (1968).

[12]The GM radii also fit the neutron-nucleus total cross sections of J. Engler et al., Phys. Letters 28B, 64 (1968), whose cross sections agree with those of Bellettini et al. (Ref. 9) to a few percent. They would not yield the neutron-nucleus cross sections as measured by M. Longo et al., in Proceedings of the Topical Conference on High Energy Collisions of Hadrons, CERN, 1968 (CERN Scientific Information Service, Geneva, Switzerland, 1968), Vol. 1, p. 523, or V. S. Pantuev et al., Zh. Eksperim. i Teor. Fiz 42, 909 (1962) [translation: Soviet Phys.—JETP 15, 626 (1962)]. The latter two experiments disagree both with Engler et al. and with each other. They both require a lead radius smaller than the electron-scattering radius, a curious result. If either of these experiments is correct, our subsequent analysis requires considerable modification.

[13]γ_ρ used here is related to the γ-ρ coupling constant by $em_\rho^2/2\gamma_\rho$. The constant $f_\rho = 2\gamma_\rho$ is also used extensively in the literature [see J. J. Sakurai in "Lectures on Theoretical Physics, Summer Institute, University of Colorado, 1968" (to be published)].

[14]One can also determine $\sigma_{\rho N}$ without using hydrogen or deuterium cross sections as was done by Asbury et al., Ref. 3. They normalized at beryllium. This entails some loss of statistical accuracy and also assumes good accuracy of the optical model for small nuclei. This method does, however, have the advantage of being insensitive to any spin dependence of the production amplitude. In our analysis we assumed this amplitude to be spin independent. We have, therefore, also analyzed the data using only the results obtained from magnesium and heavier nuclei. The best fit to the data, using this method, gives $\sigma_{\rho N} = 38.5 \pm 4.5$ mb, in agreement with the value obtained normalizing at deuterium.

[15]See Ref. 3 of the preceding paper.

[16]M. J. Longo and B. J. Moyer, Phys. Rev. 125, 701 (1962).

[17]Sakurai, Ref. 13.