Title
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ABSTRACT

Answers are given to some recent criticism of the Σ parity determination made in this laboratory.

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In a recent unpublished note, R. K. Adair[1] has purported to show that our conclusion of odd KPΣ parity[2] obtained from a study of the 1520-Mev resonance[3] is quite weak. He accepts the identification of the incoming state as predominantly S wave plus a $D_{3/2}$ resonance, but proposes that the final $\Sigma\pi$ states, instead of being S and $D_{3/2}$ are $P_{1/2}$ and $P_{3/2}$, thereby altering the parity conclusion.

Recall that in our analysis the magnitudes of the nonresonant S wave in $\Sigma\pi$ were determined from the behavior of various total cross sections for $\Sigma^{\pm 0}\pi^{\mp 0}$ production. The resonant-state amplitude and phase were fixed by the Breit-Wigner formula and from a study of the $\overline{K^0}n$ and $\Lambda 2\pi$ total cross sections. With no free parameters, we could then predict quite well the angular distributions for K^-p and $\overline{K^0}n$. Now for the $\Sigma\pi$ angular distributions and polarization ($\sin\theta\cos\theta$ term) we had one free parameter at our disposal, the relative phase angle between S and D. We adjusted this phase angle to give the best fit to the three angular distributions $\Sigma^+\pi^-$, $\Sigma^-\pi^+$, and $\Sigma^0\pi^0$ and corresponding polarizations. The predictions for these terms were in excellent agreement with experiment for KPΣ parity odd and in gross disagreement for KPΣ parity even, which would change the sign of the polarization.

Adair has, however, readjusted the magnitude of the resonant term (now relabeled $P_{3/2}$) retaining the nonresonant $P_{1/2}$ (our $S_{1/2}$) amplitudes but altering their phase with respect to the resonant $P_{3/2}$ in order to get what he considers to be a reasonable fit to the data. To accomplish this, he has also introduced four new parameters: nonresonant $P_{3/2}$ amplitudes and phases in both I = 0 and I = 1 states. He has thus increased the number of free parameters to five, i. e. the four new ones plus the relative $P_{1/2}$ resonant $P_{3/2}$ phase.

We have recalculated his fits and find some significant discrepancies with his curves. Figures 1 and 2 show the data. The solid lines are our curves as they appear in reference 3 for odd KPΣ parity. The dashed lines are our calculations for Adair's choice of amplitudes. Figure 3 is a reprint of his Fig. 1 showing his amplitudes. Although he has five free parameters to our one, there is no doubt as to which curves reproduce the data better. For those who are amused by χ^2 tests, the following table gives the χ^2, the expected value of χ^2, and standard deviations for the various proposed possibilities:

	Our amplitudes		Adair's amplitudes
	KPΣ odd	KPΣ even	KPΣ even
χ^2	55	95	166
expected value of χ^2	36	36	32
standard deviations	2	7	17

Given the liberty of introducing a small and reasonable amount of nonresonant $P_{3/2}$ amplitude into the Σπ system, one could reduce our χ^2 of 55 to a more acceptable value. However, in reference 3 we felt the admission of this additional freedom inappropriate.

Finally, Adair seems to have disregarded the vital point that to alter the Σπ resonant amplitude from our 0.36 to his value of 0.20 does drastic things to the K^-P and K^0 n resonant amplitudes. These amplitudes are closely related through the Breit-Wigner formula. Figure 4 shows the K^-P and K^0 n angular-distribution coefficients. The solid curves are our predictions; the dashed curves are predictions from his parameters.

As Adair, we have attempted to find other solutions compatible with the data but, like he, have failed. Perhaps an even-KPΣ-parity solution can be found, but by a process of frustration we have convinced ourselves that this is extremely unlikely.

Although not in the spirit of our previous papers,[2, 3] we further present a semi-quantitative argument to display the overall consistency of our parity assignment. Consider the two reactions:

$$K^-P \rightarrow \Lambda 2\pi$$
$$\rightarrow \Sigma\pi$$

They are in the following ratios to each other at the indicated K^- momenta:

P_{K^-} (Mev/c)	$\frac{\Lambda 2\pi}{\Sigma\pi}$ ($\times 10^3$)
0	2 ± 1
300	7 ± 4
395[a]	200

a. Resonant state only

We wish to explain the rapid change in this branching ratio between 300 and 395 Mev/c. Below resonance, both reactions are dominated by the nonresonant incident $S_{1/2}$ amplitudes. Taking the KPΛ parity as odd and putting the dipion in an S state,[4] one has for the nonresonant and resonant states:

$$(K^-P)_{S_{1/2}} \rightarrow (\Lambda(2\pi)_S)_{P_{1/2}} \qquad \text{(nonresonant)}$$

$$(K^-P)_{D_{3/2}} \rightarrow (\Lambda(2\pi)_S)_{P_{3/2}}. \qquad \text{(resonant)}$$

For even KPΣ parity the states are

$$(K^-P)_{S_{1/2}} \rightarrow (\Sigma\pi)_{P_{1/2}} \qquad \text{(nonresonant)}$$

and

$$(K^-P)_{D_{3/2}} \rightarrow (\Sigma\pi)_{P_{3/2}}. \qquad \text{(resonant)}$$

The centrifugal barriers are comparable for the nonresonant and resonant states, and there is no simple mechanism to account for this change in branching ratio. However, for odd KPΣ parity, the Σπ states are $S_{1/2}$ and $D_{3/2}$, respectively. Here, there is a difference of 2 between the orbital-angular-momentum of the nonresonant and the resonant states, the D-wave barrier permitting the Λ2π in $P_{3/2}$ to compete effectively against Σπ in the resonant state.

In conclusion, may we remind Professor Adair that "While a beast which looks like a cow might be a malformed horse, there is much to be said for assuming that it is a cow"?[5]

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REFERENCES

1. R. K. Adair, Sigma Parity, Brookhaven National Laboratory, unpublished work, Feb. 20, 1962.
2. M. Ferro-Luzzi, R. D. Tripp, and M. B. Watson, Phys. Rev. Letters <u>8</u>, 28 (1962).
3. R. D. Tripp, M. B. Watson, and M. Ferro-Luzzi, Phys. Rev. Letters <u>8</u>, 175 (1962).
4. At low energy this is the only likely situation, since the Q value is only 37 Mev. At resonance the enhancement is in I = 0; hence the dipion must be in S or D, and D presents a centrifugal barrier too high for pions at this energy.
5. R. K. Adair, "The Botany of Strange Particles" in <u>Aix-en-Provence International Conference on Elementary Particles, 1961</u> (C. E. N., Saclay, 1961).

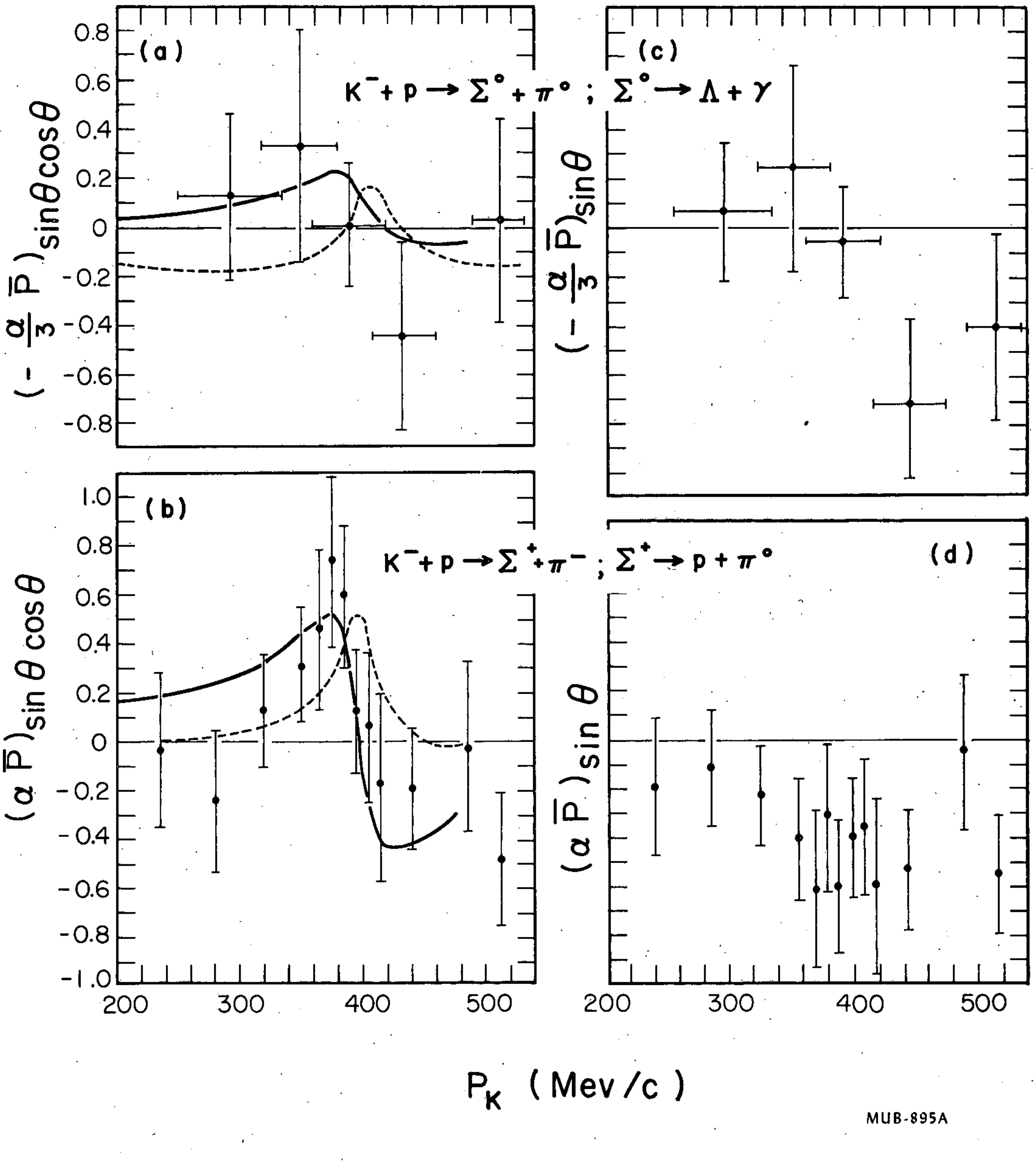
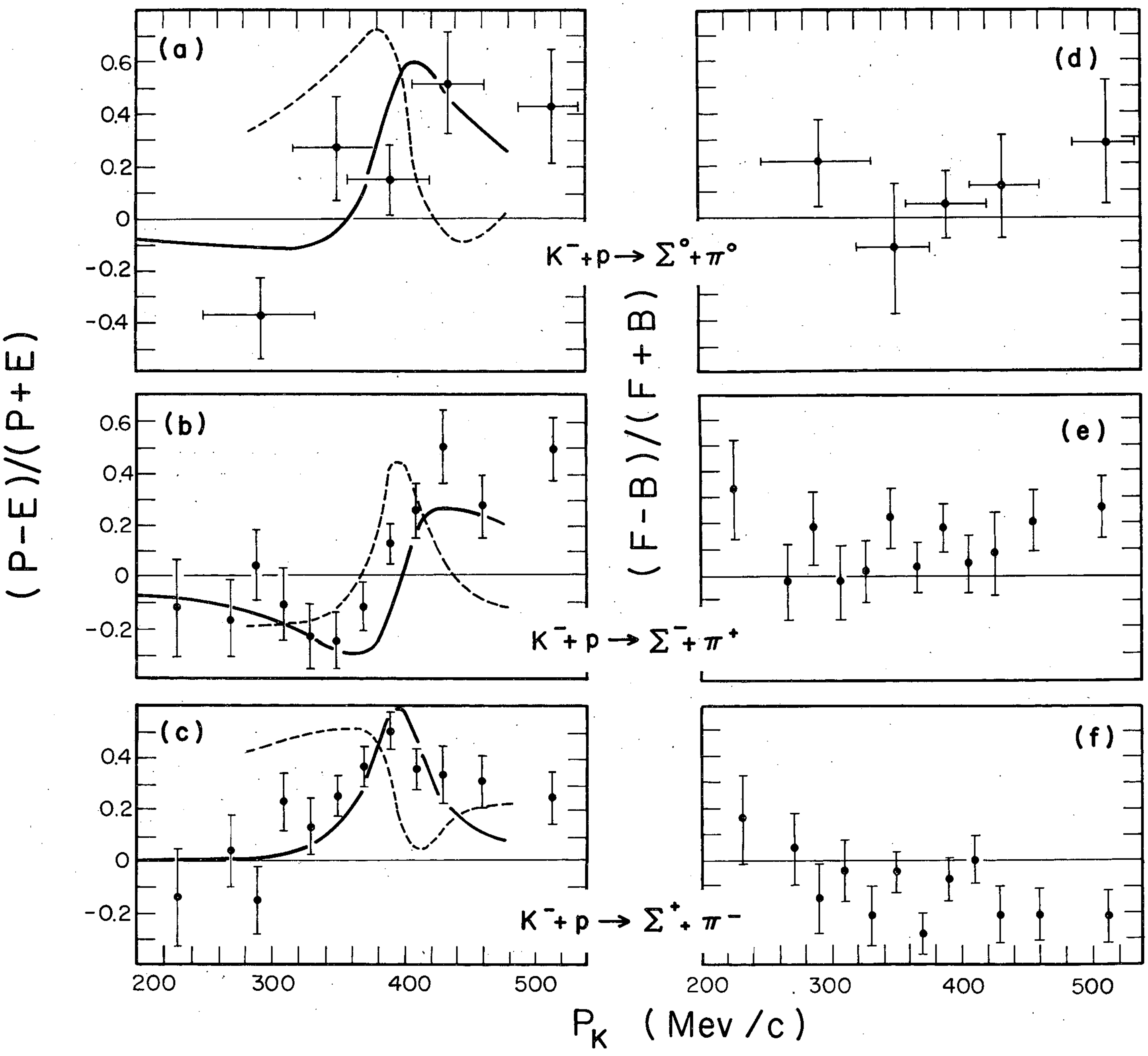
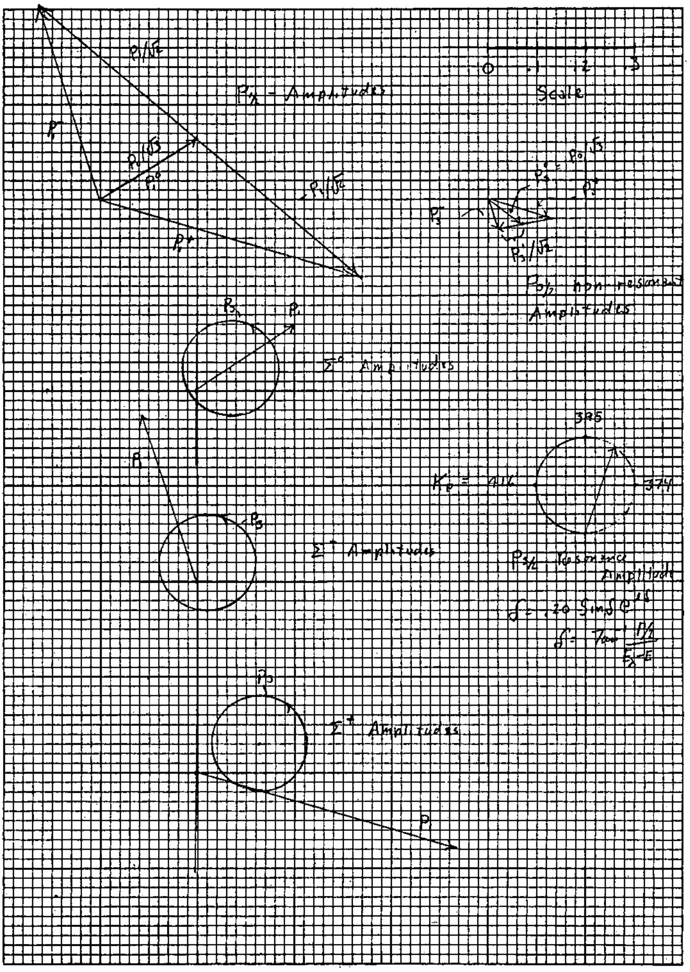

(a)
(b)
(c)
(d)
K⁻ + p → Σ° + π° ; Σ° → Λ + γ
K⁻ + p → Σ⁺ + π⁻ ; Σ⁺ → p + π°
(- α/3 P̄)sinθcosθ
(α P̄)sinθ cosθ
(- α/3 P̄)sinθ
(α P̄)sin θ
0.8
0.6
0.4
0.2
0
-0.2
-0.4
-0.6
-0.8
1.0
-1.0
200
300
400
500
P_K (Mev/c)
MUB-895A

Fig. 1



MUB-894B

Fig. 2



MU-26483

Fig. 3

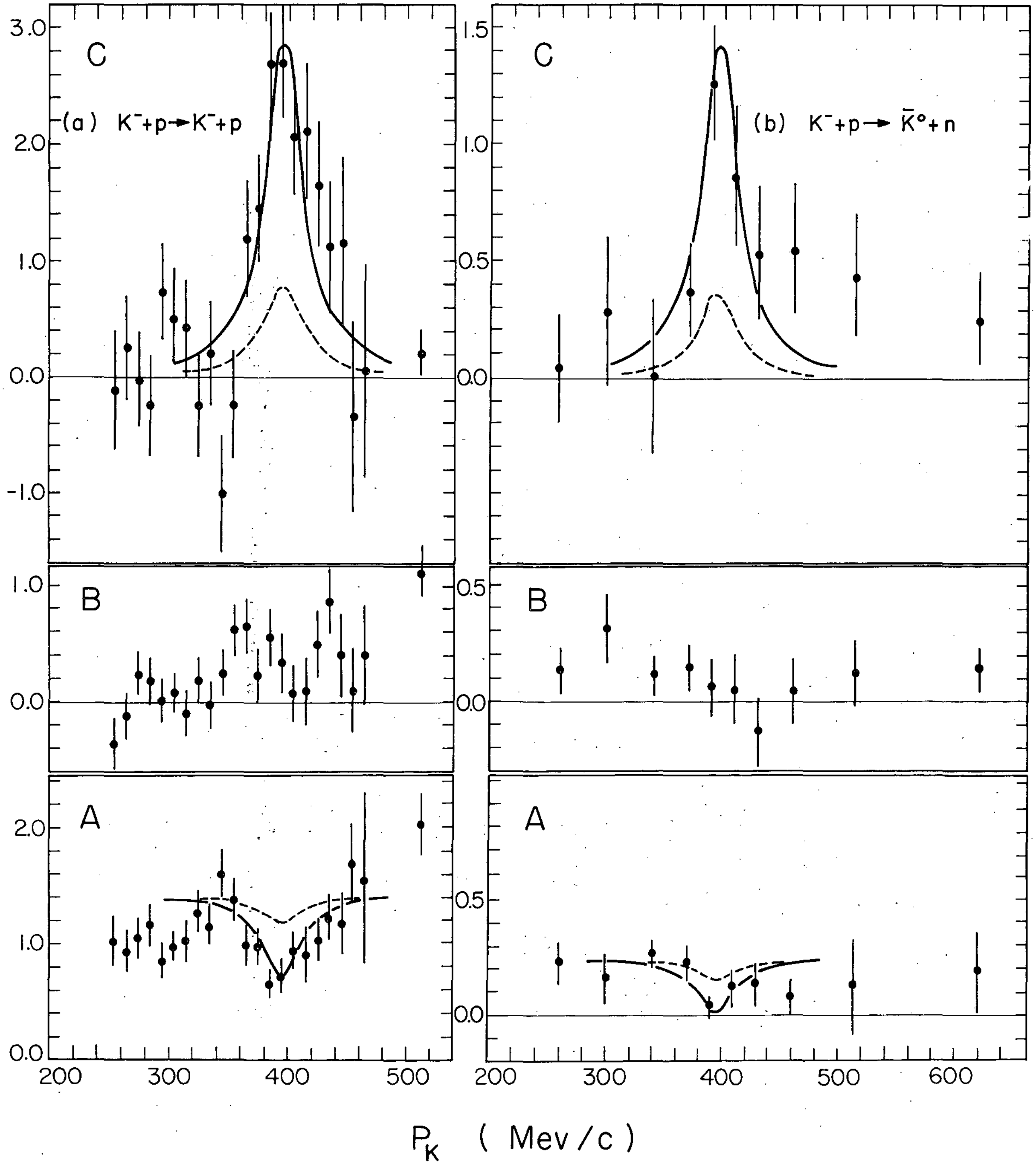

C
(a) K⁻+p → K⁻+p
C
(b) K⁻+p → K̄°+n
B
B
A
A
3.0
2.0
1.0
0.0
-1.0
1.5
1.0
0.5
0.0
1.0
0.0
0.5
0.0
2.0
1.0
0.0
0.5
0.0
200
300
400
500
600
P_K (Mev/c)
MUB-871A

Fig. 4