Title
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Previous partial wave analyses[1,2,3,4] of the channel $K^-p \rightarrow \Lambda\pi^0$ have investigated the $\Sigma(1915)$ resonance in conjunction with the $\Sigma(1775)$ or the $\Sigma(2030)$. These results, summarized by Galtieri[5] have been consistent with a resonance in the F5 $(5/2^+)$ wave with a mass of about 1905 Mev and a width of 50 to 80 Mev. Unfortunately, there has been little data in the vicinity of the resonance itself. Moreover, recently Feynman et al.[6] on the basis of a three-quark model have questioned the assignment of the $\Sigma(1915)$ to the $5/2^+$ octet, suggesting that the spin-parity assignment be reassessed.

Our experiment consists of 860 000 pictures of K^-p interactions in the 25-inch hydrogen bubble chamber at the Bevatron at 15 center-of-mass energies ranging from 1865 to 2106 Mev. In this report we have used the first seven energies from 1865 to 2001 Mev: (1) to check the mass, width, coupling, and relative phase of the resonance, assuming that it is $5/2^+$; and (2) to look for alternative spin-parity assignments.

The film was measured on the COBWEB system and the measurements were processed with the FOG-CLOUDY-FAIR analysis system. Events were identified as $K^-p \rightarrow \Lambda\pi^0$ if they were consistent with Λ production (Λ-θ) ambiguities were resolved by the ionization of the positive track) and if the square of the missing mass (mm) in the reaction $K^-p \rightarrow \Lambda + mm$ was within the interval 0.0177 ± .05 Bev^2. The contamination of $K^-p \to \Sigma^0\pi^0$ is estimated to be less than 5%. Each event was assigned a weight to correct for Λ's which decayed outside of the chamber and for real events for which the square of the missing mass would have differed from the mean by more than 0.05 Bev^2.

A complete τ scan was made to determine the K^- path length. Table I lists our cross sections and they are plotted in Fig. 1 together with a compilation of existing data. Figures 2 and 3 show the Legendre expansion coefficients for the angular distributions ($\cos\theta = \hat{p}_\pi \cdot \hat{p}_K$) and the polarizations

$$I(\theta) = \lambda\!\!\!^{-2} \sum_{n=0}^{7} A_n P_n(\theta)$$

$$IP(\theta) = \lambda\!\!\!^{-2} \sum_{n=1}^{7} B_n P_n^1(\theta)$$

where

$$P = \vec{P}_\Lambda \cdot \hat{n} = (3/\alpha_\Lambda)(\hat{p} \cdot \hat{n})$$

and $\hat{p}$ is a unit vector parallel to the proton in the Λ decay ($\hat{n} = \hat{k} \times \hat{\pi}/|\hat{k} \times \hat{\pi}|$). Coefficients greater than 7th order were consistent with zero.

We have used an energy dependent partial wave analysis fitting the T matrix elements in the angular momentum basis directly to the distributions $I(\theta)$ and $IP(\theta)$ with the technique described by Smart.[1] The expansions of the A_n and B_n are

$$A_n = \sum_n c_n^{ij} \,\mathrm{Re}\, T_i^* T_j$$

and

$$B_n = \sum_n d_n^{ij} \,\mathrm{Im}\, T_i^* T_j$$

where the T_i and T_j are the T matrix elements for each spin-parity state and the c and d coefficients are in the notation of Tripp.[7] Our program allows each T matrix element to be expressed as an energy-dependent background plus a Breit-Wigner resonance

$$T = (a + bq)e^{i(c + dq)} + \frac{t\, e^{i\phi}}{x + i\Gamma/2}$$

where $x = E-E_R$, q is the c.m. momentum in the "in" channel, a, b, c, and d are real variables describing the background and t, E_R, Γ and ϕ are the coupling, mass, width and phase of resonance, respectively.

Rather than try to vary all possible parameters we have chosen to look at a limited energy region and to assume that the D5 and F7 amplitudes are dominated by the $\Sigma(1775)$ and the $\Sigma(2030)$, respectively, with fixed parameters. In addition, we have not tried to simultaneously vary the background and the resonance parameters within a single partial wave. Even under these restricted conditions the solution of the minimization process depends upon the starting point. The procedures and the results are characterized by the following solutions:

1) Resonances in the D5 and F5 only. Presuming that over a limited energy interval even a wave with a resonance can be approximated by the four-parameter background, we first tried to fit with variable backgrounds in all waves up to F5 (and fixed resonances in the D5 and F7). Using Smart's solution 5 as a starting point, we found the solution shown in Fig. 3a. This segment of the Argand plot is in good agreement with previous analyses which include the resonance parameterization and, if the known small value of the F5 amplitude at low energies is included, it is very suggestive of a resonance in the F5 wave.

2) Resonance in D5, F7 and F5 waves. To determine the parameters of the presumed resonance in the F5 wave, we have used a resonance parameterization both with and without background. Figures 4 and 5 show the Argand plots using a fixed background with the parameters found by Smart (fit 2a) and with no background in the F5 wave (fit 2b).

These fits are summarized in Table II. The identical χ^2 for solutions 2a and 2b indicates we are very insensitive to the background under the F5 resonance. We also attempted to include a resonance in the P1 wave following Smart, Litchfield, and Galtieri. However, the width of the proposed resonance is larger than our energy interval and no satisfactory solutions were obtained.

The general consistency of solutions 1 and 2 indicate that a $5/2^+$ resonance at about 1915 Mev is very compatible with the data. We have looked for an alternative spin-parity assignment in the lower partial waves by forcing a small F5 amplitude. However, no satisfactory solutions have been found to date. We have not tried substituting a resonance in the higher partial waves as yet.

Our best estimate of the resonance parameters, assuming the $5/2^+$ spin-parity assignment, are those associated with fit 2b [$m = 1911 {}^{+15}_{-5}$ Mev, $\Gamma = 74 \pm 10$ Mev, $t = .085 \pm .01$ and $\phi = 179^{\circ} {}^{+20}_{-10}$]. The errors associated with these values have been increased to account for the uncertainty in the background. These values are consistent with all other determinations but the mass is somewhat higher. The coupling is negative in the notation of Galtieri and in phase with the coupling of the $\Sigma(1775)$ resonance. These values may be improved if we can make a better determination of the background under the F5 by fitting over a larger energy interval.

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TABLE I

Cross Sections $K^-p \to \Lambda\pi^0$

P_{lab} (bev/c)	$E_{c.m.}$ (bev)	Weighted Events	σ (mb)	$\Delta\sigma$ (mb)
1.153	1.865	496	1.81	.47
1.190[1]	1.882	323	1.33	.35*
1.208[1]	1.890	611	1.50	.39*
1.262[2]	1.915	331	1.29	.34*
1.278[2]	1.922	488	1.32	.34*
1.310	1.937	724	1.34	.34
1.345	1.953	387	1.20	.32
1.384	1.970	350	1.20	.32
1.453	2.001	619	1.20	.31

*Final scanning efficiencies not yet completed.

[1,2]Energies combined for analysis.

TABLE II. Summary of the Partial Wave Analysis.

Column 2 contains the total number of variables. In each case there were fixed resonances in the D5 and F7 waves and the four background parameters in the S1, P1, P3, D3, and D5 waves were variables. The fixed resonant parameters (m, Γ, t, ϕ) were D5 (1775, 146, .266, 180°) and F7 (2032, 160, .212, 0°).

				F5 Resonance*			
Solution	N	χ^2/d.f.	F5 Background	m (Mev)	Γ (Mev)	±	ϕ
1	23	202/141	Variable	--	--	--	--
2a	23	194/141	Fixed	1928 ± 6	82 ± 7	.092 ± .01	210° ± 8°
2b	23	194/141	None	1911 ± 4	72 ± 5	.085 ± .01	179° ± 7°

*The errors are determined from the curvature of the χ^2 surface in each fit and do not reflect either the correlations between variables or the variation between solutions.

FIGURE CAPTIONS

Fig. 1. Cross-section for $K^-p \to \Lambda\pi^o$. A compilation of data including the fifteen momenta for this experiment.

Fig. 2a. Legendre expansion coefficients A_0-A_7 for the angular distribution

$$\frac{d\sigma}{d\Omega} = \lambda^2 \sum_n A_n P_n (\cos\theta), \quad \cos\theta = \frac{\hat{\pi}^o \cdot \hat{K}^-}{|\hat{\pi}^o||K^-|}$$

in the K^-p center of mass.

Coefficients above A_7 were consistent with zero in the energy range of this experiment.

Fig. 2b. Legendre expansion coefficients B_1-B_7 for the polarization distribution $IP = \lambda^2 \sum_n B_n P_n^1 (\cos\theta)$.

Fig. 3. Argand diagram of complex partial wave amplitudes for solution 1. The F17 is parameterized as a resonance only ($\Sigma(2030)$), the D15 ($\Sigma(1775)$) is parameterized as a resonance plus energy dependent background. All other waves below F15 are parameterized as energy dependent backgrounds. The behavior of the F15 leads to a resonant parameterization shown in Figs. 4a and 4b.

Fig. 4a. Argand diagram with the F15 parameterized as a resonance plus an energy dependent background for solution 2A. The F17 is parameterized as a resonance only; the D15 is parameterized as a resonance plus energy dependent background and all other waves are energy dependent backgrounds.

Fig. 4b. Argand diagram with the F15 parameterized as a resonance only for solution 2B. The F17 is parameterized as a resonance only; the D15 as a resonance plus energy dependent background, and all other waves as energy dependent backgrounds.

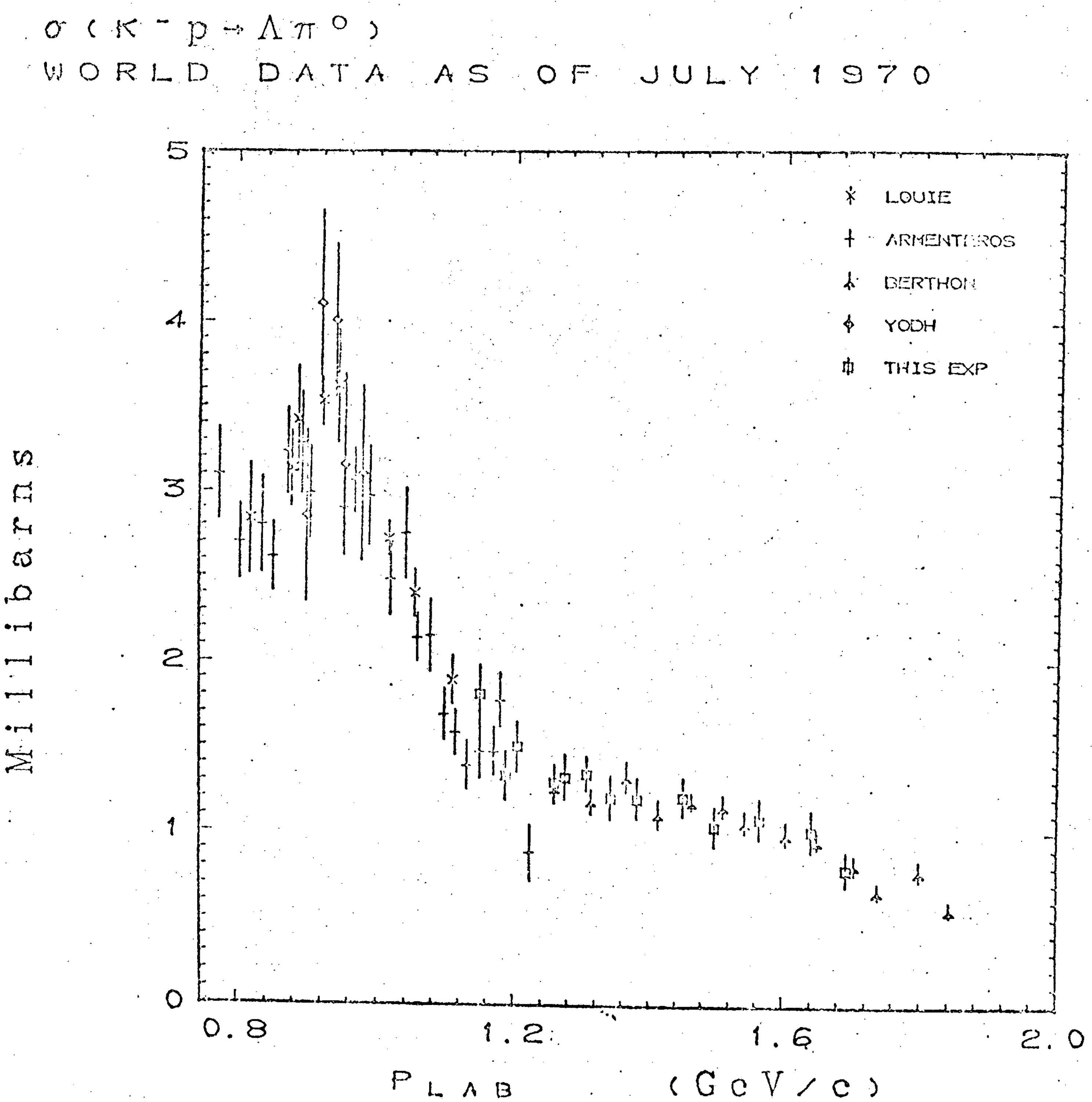

σ(K⁻p→Λπ⁰)
WORLD DATA AS OF JULY 1970
LOUIE
ARMENTEROS
BERTHON
YODH
THIS EXP
Millibarns
0
1
2
3
4
5
0.8
1.2
1.6
2.0
PLAB (GeV/c)

FIG. 1

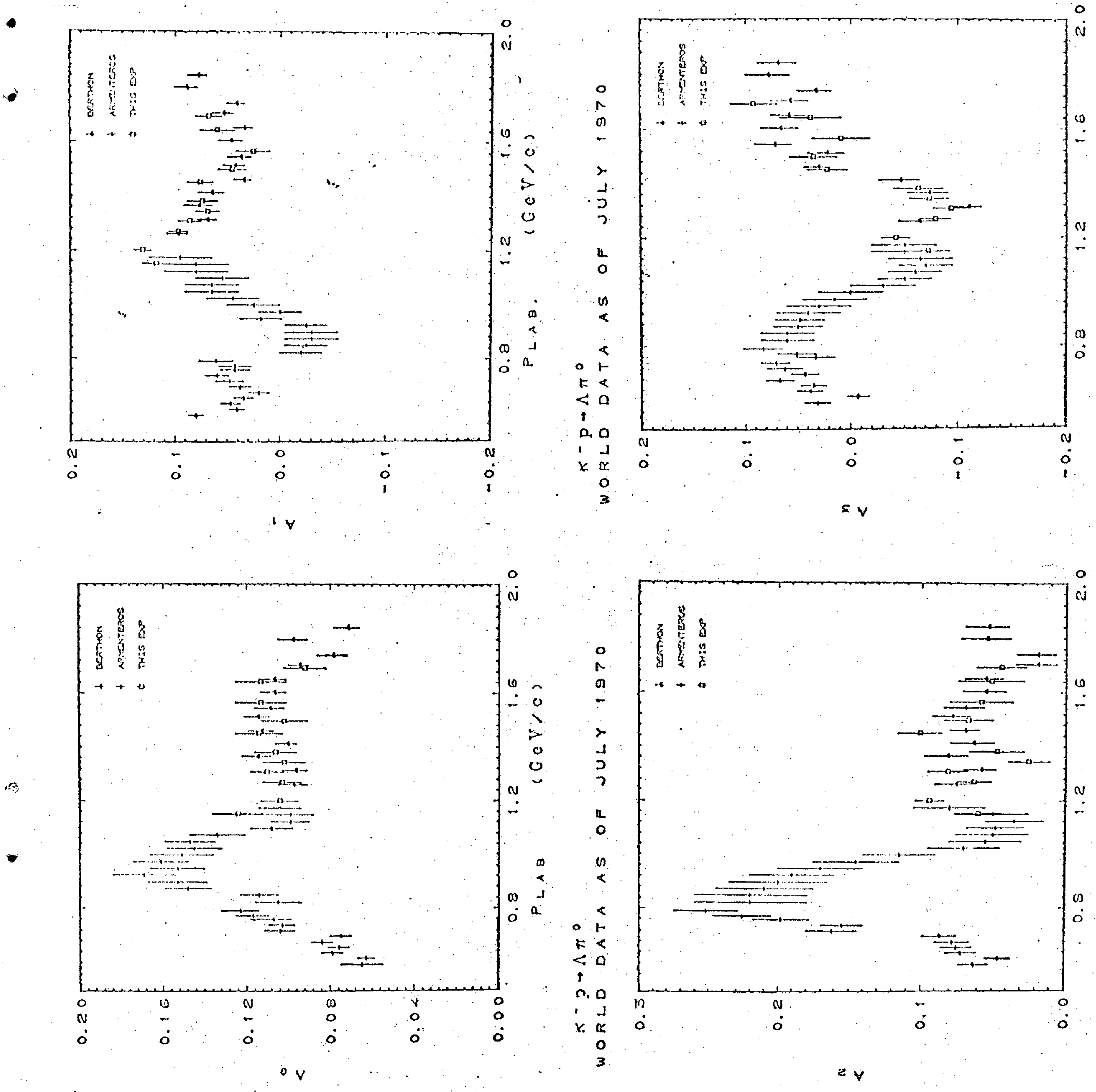
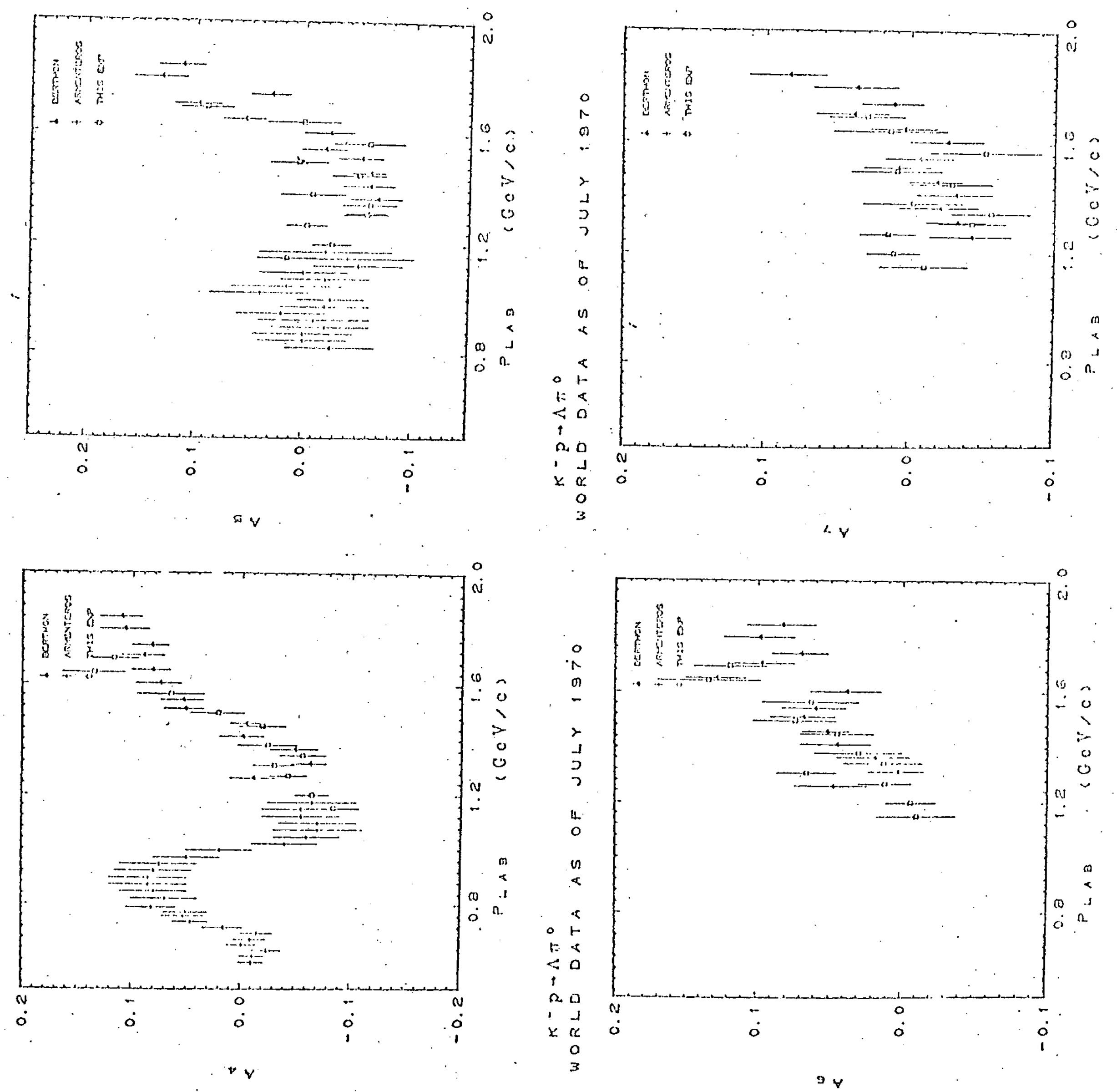

K⁻p→Λπ⁰
WORLD DATA AS OF JULY 1970
P LAB (GeV/c)
BERTHON
ARMENTEROS
THIS EXP
A_0
A_1
A_2
A_3

Fig. 2A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WORLD DATA AS OF JULY 1970
K⁻p→Λπ⁰
WORLD DATA AS OF JULY 1970
P LAB (GeV/c)
P LAB (GeV/c)
P LAB (GeV/c)
P LAB (GeV/c)
A5
A7
A4
A6

Fig. 2A

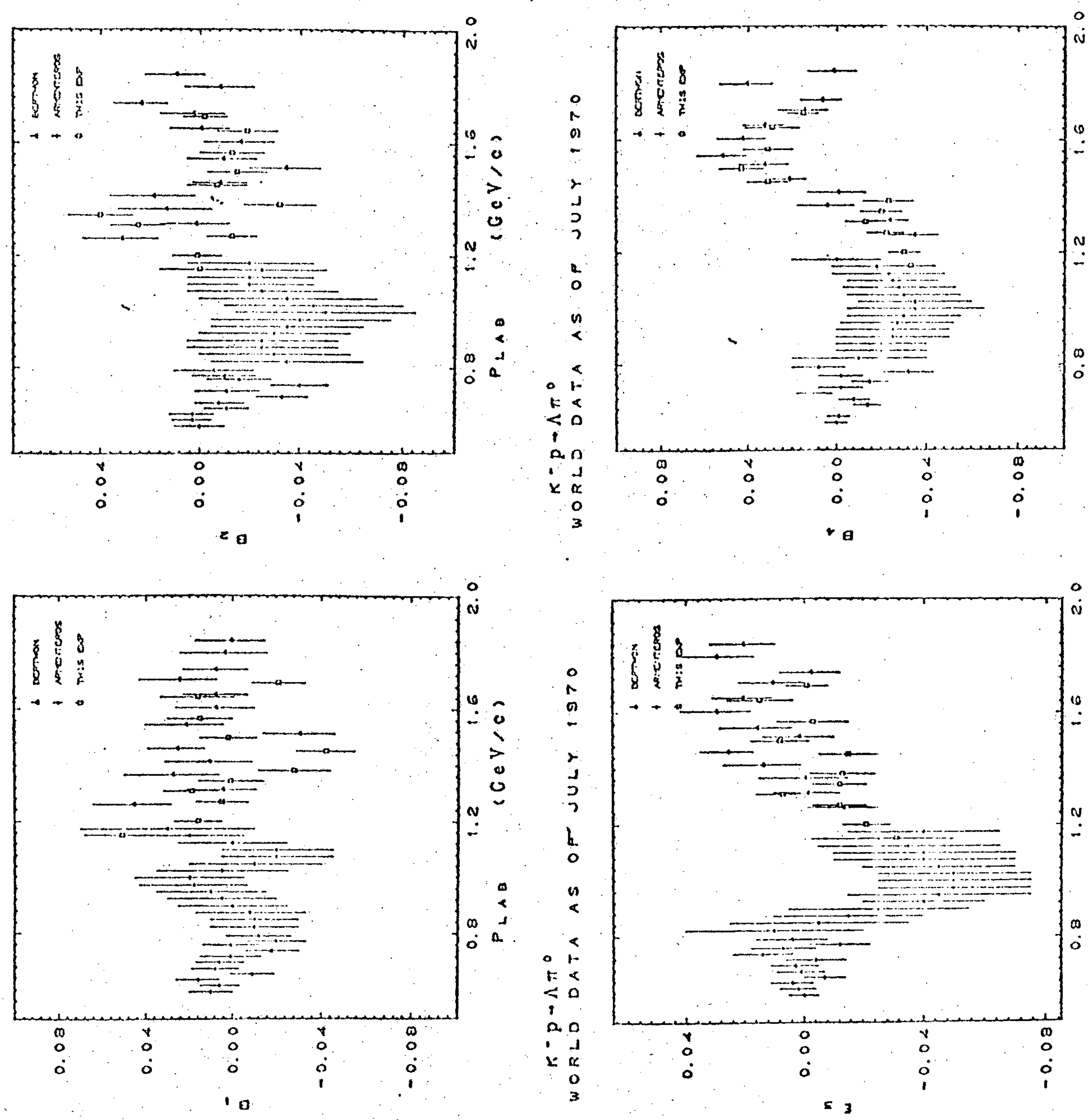
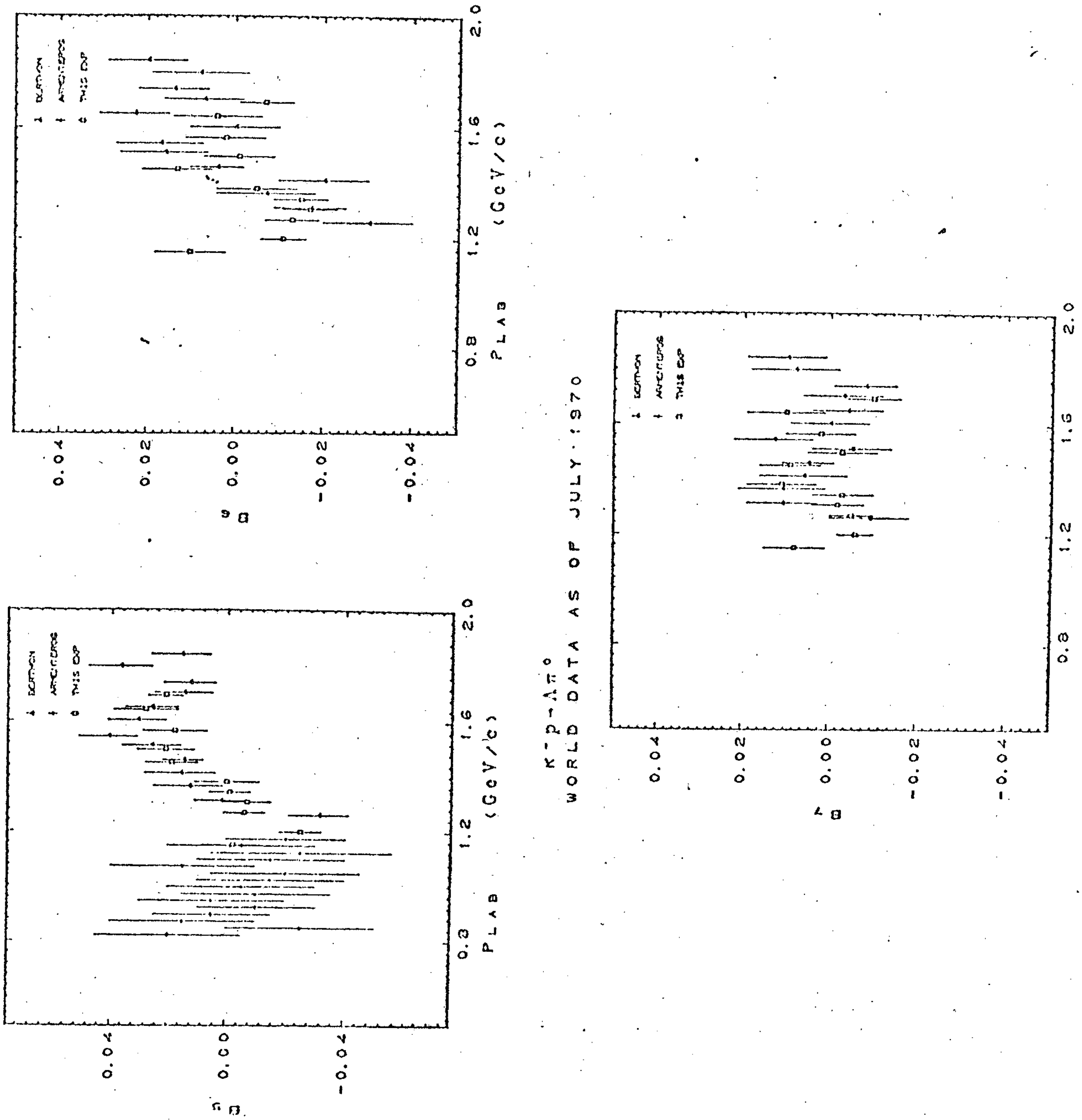

$K^-p \to \Lambda\pi^0$
WORLD DATA AS OF JULY 1970
P LAB (GeV/c)
B_1
B_2
B_3
B_4

Fig. 2B


K⁻p → Λπ⁰
WORLD DATA AS OF JULY 1970
PLAB (GeV/c)
THIS EXP
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-0.02
-0.04
0.8
1.2
1.6
2.0

Fig. 2B

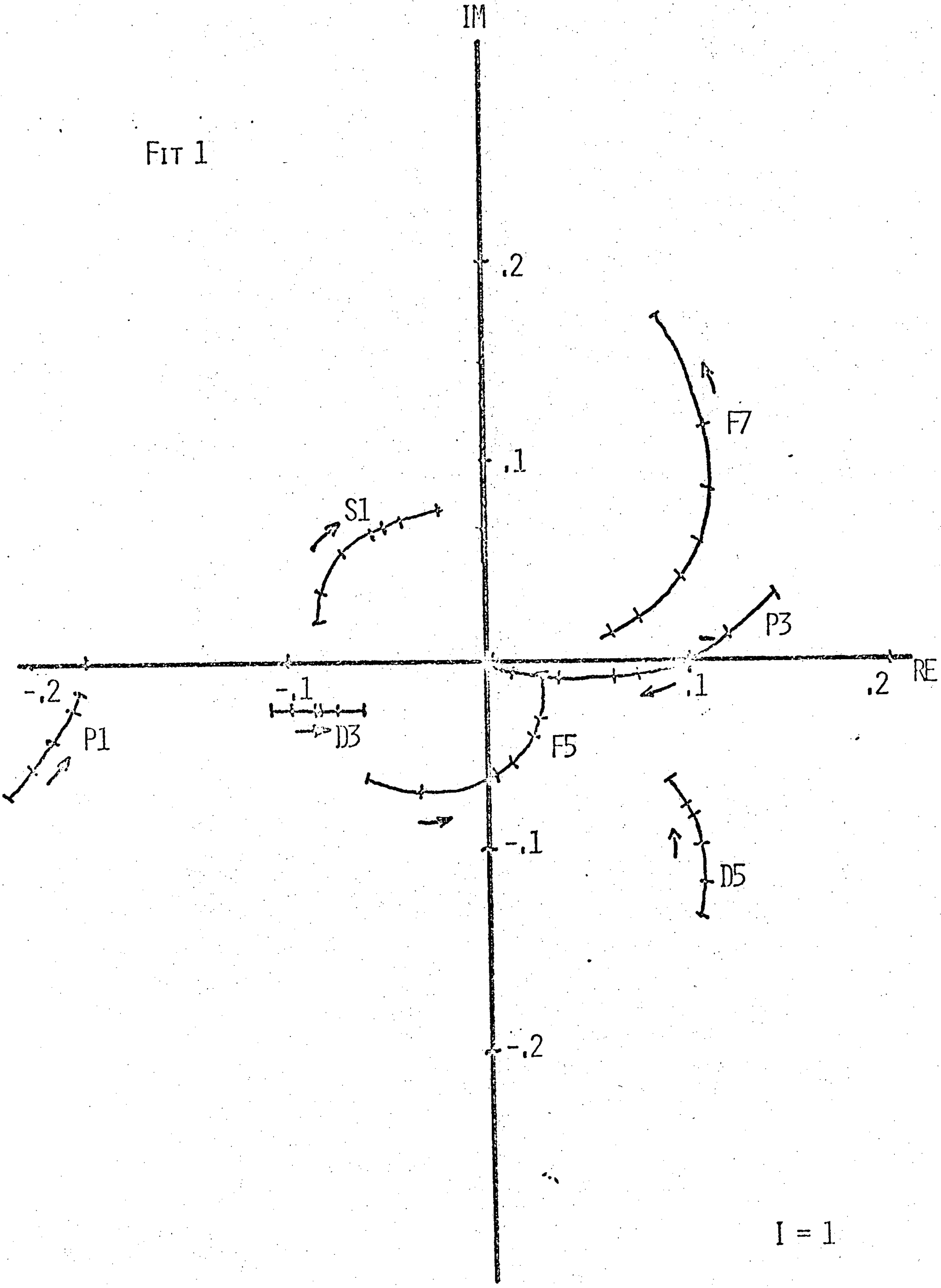
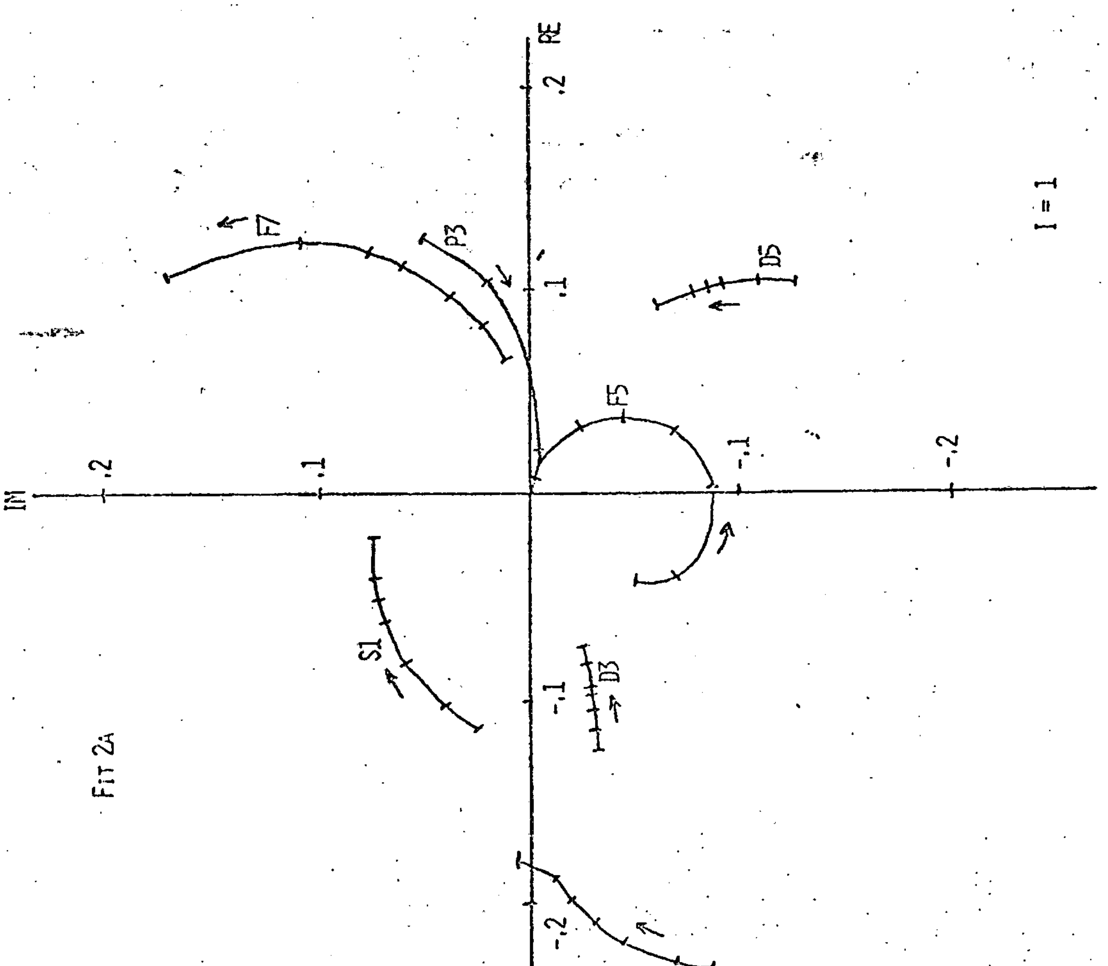


Fig. 3


Fit 2A
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IM
RE
.2
.1
-.1
-.2
S1
D3
F5
F7
P3
D5

Fig. 4A

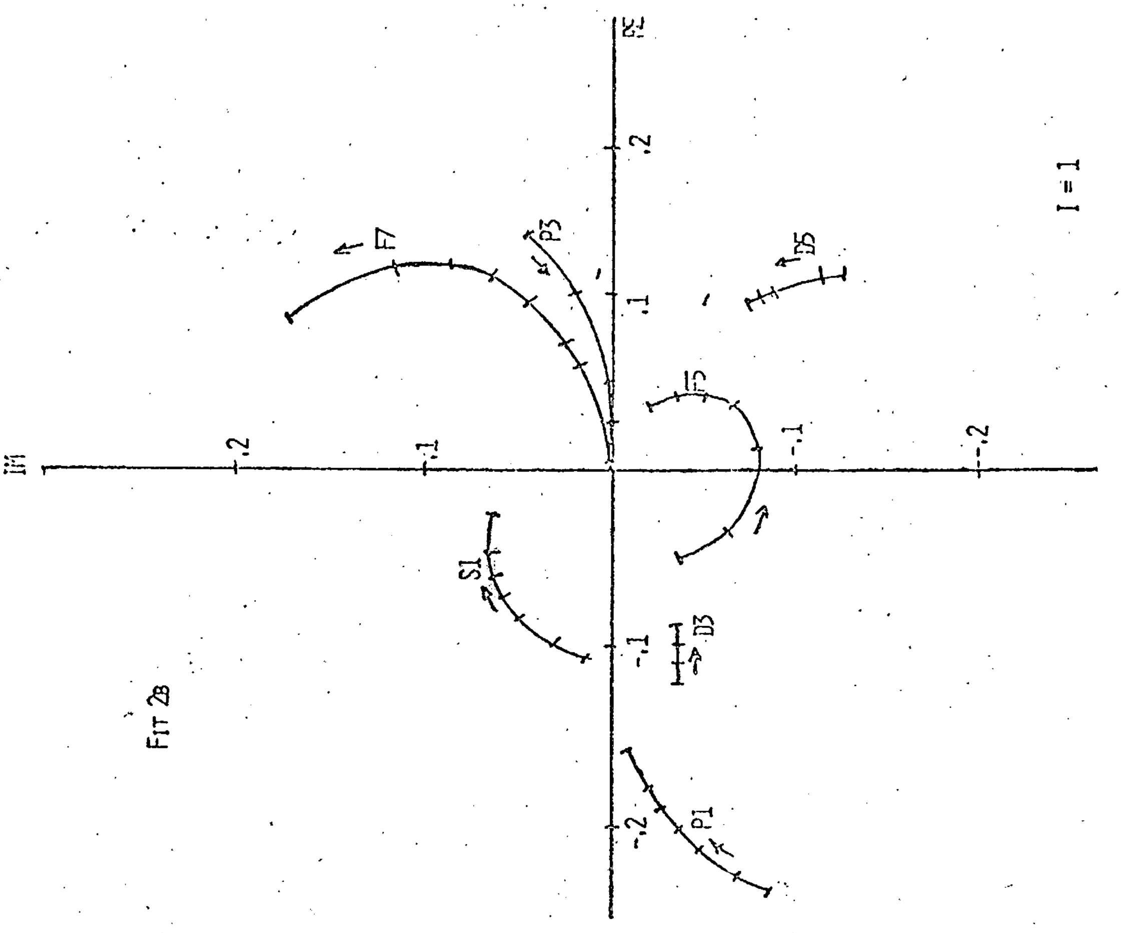
Fit 2B
I = 1
IM
RE
.2
.1
-.1
-.2
S1
D3
P1
F5
F7
P3
D5

Fig. 4B

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