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PROPOSAL TO STUDY THE K^* RESONANCES PRODUCED IN K^-p INTERACTIONS AT 40 GeV/c WITH THE CERN-IHEP BOSON-SPECTROMETER

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We propose to use the CERN-IHEP BOSON SPECTROMETER for a study of K^-p interactions at 40 GeV/c.

From preliminary data taken so far (see Fig. 6) we extrapolate that in a proposed 25 days of running the following data will be obtained:

1) A K^* mass-spectrum in $K^-p \to pK^{*-}$ containing 170,000 inelastic events (after all cuts) in the mass interval 0-3.5 GeV.

2) 20,000 events of the type $K^-p \to K^-\pi^-\pi^+p$ fully measured and suited for a partial-wave analysis (Q, $K^*(1400)$, L meson).
Details about this channel are described below.

3) As a byproduct we obtain simultaneously the elastic scattering of K^-p (150,000 events after all cuts) and $\bar{p}p$ (70,000 events) for momentum transfers down to t min= 0.04 $(GeV/c)^2$. Since t min is the same as in the recent ISR experiments on pp elastic scattering the $\bar{p}p$ data would be of special interest for comparison.

Two runs of 50 IHEP shifts (= 12.5 days) would be needed in the period January-March 1972. Full support has been offered by IHEP.

The $K^-\pi^-\pi^+$ channel:

We propose to investigate the $K^-\pi^-\pi^+$ system at 40 GeV/c incident momentum in the reaction

$$K^-p \rightarrow K^-\pi^-\pi^+p$$

with the CIBS (CERN-IHEP Bosonspectrometer) at Serpukhov. For 20,000 fitted events, necessary to perform a partial wave analysis of the $K\pi\pi$ system, we would need 25 days of machine-time, starting January 1972. For this experiment no modification to the experimental setup presently installed in the channel 4B is necessary.

During the last year the CERN-IHEP Bosonspectrometer (CIBS) (fig. 1) has acquired data on the reaction

$$\pi^-p \rightarrow p + \text{missing mass}$$

at 25 and 40 GeV/c incident momentum. The mass spectrum from 0 to 4.5 GeV has been systematically investigated. While no narrow high-mass resonance has been observed within the statistical sensitivity of 1 standard deviation per microbarn (fig.2), we do observe strong structure in the low mass (A_1 - A_3) region. Using the forward magnetic spectrometer 20,000 fitted events corresponding to the reaction

$$\pi^-p \rightarrow \pi^-\pi^-\pi^+p$$

were obtained out of 450.000 raw triggers taken at 40 GeV/c incident momentum. The preliminary analysis of the data has yielded the following results :

The contribution of the different partial waves to the 3 π-spectrum (fig. 3) has been determined using a method developed at the University of Illinois [1] and adopted to this experiment during this summer at CERN *). Compared to the Dalitz-plot analysis, this method has the advantage that the magnitude and phase of interference between states of different spin parity (J^P) can be determined. Thus the resonance interpretation of bumps found in a particular partial wave can be checked directly by determining the variation of its phase relative to a non-resonating amplitude. Fig. 4 shows an Argand diagram for the 2^+ amplitude. The phase of the 2^+ amplitude is measured relative to the 1^+ amplitude and shows the expected behaviour for the 2^+ phase resonating around 1.3 GeV at the A_2-meson mass. Furthermore the amount and phase of interference gives clues for an understanding of the production mechanism of different quasi-particles.

Our present data indicate that production density matrices and decay amplitudes at 40 GeV/c are very similar to the ones derived at lower energy by bubble-chamber experiments [2]. The higher statistics of our experiment however should allow us to answer open questions, e.g. whether the A_3 is a resonance or not.

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*) The cross section for the 3π system is written

$$d\sigma \propto \Sigma \rho_{ab} M_a M_b^*$$

where ρ_{ab} is the density matrix between the states a, b and M_a, M_b are the amplitudes for the decay into 3π's. The amplitudes are calculated under the assumption that the 3π-system decays via a dipion system (e.g. επ, ρπ, fπ). In contrast to the usual Dalitz-plot or angular distribution analysis, the distribution of the events is fitted simultaneously in decay angles and Dalitz-plot variables.

The acceptance of the apparatus (fig. 5) is good (~ 90%) and sufficiently well understood so that reliable corrections can be made.

The results obtained so far in the 3π-channel strongly suggest that we should also study with the CIBS the reaction $K^-p \to K^-\pi^-\pi^+p$ in the Kππ mass region below 2 GeV. Due to the lack of sufficient data in bubble chamber experiments an investigation similar to our 3π-analysis has not been feasible in the Kππ-channel until now. The problems we want to study are the production and resonance interpretation of the Q, K** (1400) and L-mesons. Since the A_1-Q, A_2-K** (1400) and A_3-L are assumed to belong to the same SU3-nonets it is of special interest to compare the 3π-spectrum with the Kππ-spectrum at the same incident energy.

The best bubble-chamber experiment [3] yielded 6,100 fitted events of the reaction $K^-p \to K^-\pi^-\pi^+p$ 650 of which have been assigned to the L-meson. Using the CIBS we should be able to get 1500-3000 "L-mesons" out of a sample of 500,000 raw triggers. This will be sufficient to answer the questions about spin, phase behaviour and possibly different decay modes of the L-meson bump.

From tests during previous runs *) we know that the experiment can run at a rate of at least 3 kaon-triggers per burst, so

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) Fig. 6 shows the K mass-spectrum obtained as a byproduct during the previous runs (25 GeV/c) without special trigger. The strong enhancement seen in the 1400 MeV region would be one of the subjects of the detailed study proposed here.

that 25 days of running time should yield 500,000 raw-triggers and 20,000 events in the final state $K^-\pi^-\pi^+$. This is sufficient to perform the partial wave analysis described above. On the basis of the measurement errors we estimate that the ambiguity between K^- and π^- in the kinematic fit should be about 20%. This estimate is confirmed by an analysis of 2,000 events of the type $\pi^- p \to p\pi^- K^+ K^-$, where there exists the same problem. For the partial wave analysis the effect of these events can be studied by cutting out the ambiguous events and confining the integration over phase space to the unambiguous region when calculating the decay amplitudes.

For this run no change to the experiment is necessary.

REFERENCES

1) and 2) G. Ascoli, D.V. Brockway, H.B. Crawley, L.B. Eisenstein, R.W. Hanft, U.L. Ioffredo and U.E. Kruse, Phys, Rev. Letters 25, 962 (1970).

D.V. Brockway, Ph. D. thesis, University of Illinois, COO-1195-197 (Oct. 1970).

3) Aachen-Berlin-CERN-Vienna Collaboration, CERN D.Ph.II - Phys. 71-30 (17.6.1971).

FIGURE CAPTIONS

Fig. 1 : Layout of the CERN-IHEP Bosonspectrometer presently installed at Serpukhov.

Fig. 2 : X^--massspectrum obtained at 40 GeV/c in the reaction $\pi^- p \to pX^-$. The momentum transfer region is $0.18 < t < 0.35$ $(GeV/c)^2$.

Fig. 3 : Contributions of the different partial waves to the 3π-mass spectrum. Following states are assumed to contribute :

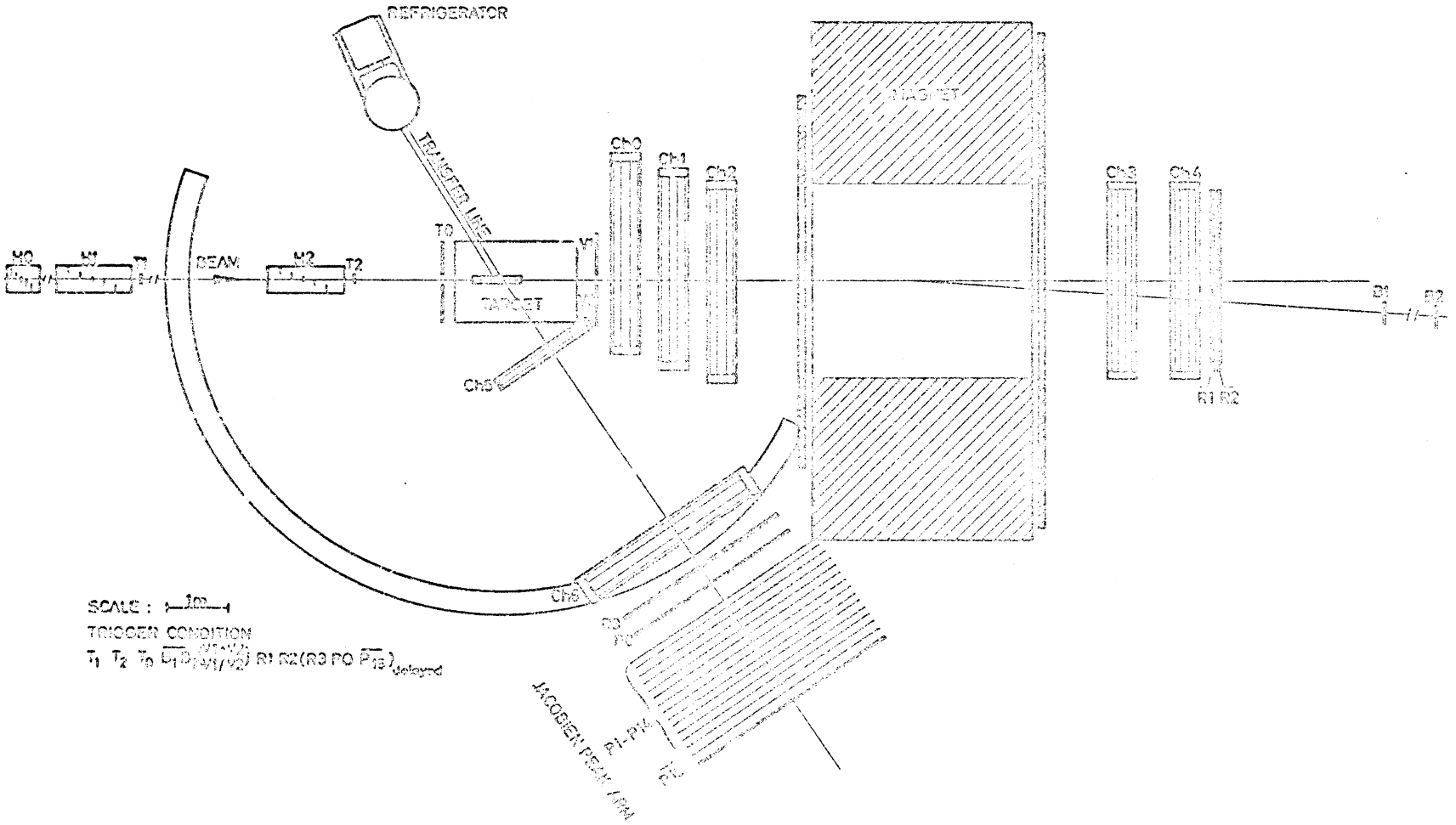
$$\Sigma J^P M_\ell = 0^- 0_{(S+P)} + 1^+ 0_{(S+P)} + 2^+ 1_D + 2^- 0_{(S+P)}.$$

Fig. 4 : Argand diagram for the 2^+ wave in the region of the A_2-resonance. The phase of the 2^+-amplitude is measured relative to the 1^+ amplitude.

Fig. 5 : Efficiency for the magnetic spectrometer to detect all 3π-mesons in the reaction $\pi^- p \to \pi^- \pi^- \pi^+ p$ at 40 GeV/c. In this graph the geometrical acceptance and the sparkchamber and reconstruction efficiency is included.

Fig. 6 : Missing mass spectrum in the reaction $K^- p \to p$ + missing mass obtained at 25 GeV/c in the momentum transfer region $0.10 < t < 0.35$ $(GeV/c)^2$. The arrows indicate the masses of the elastic peak, the K*(890), the K**(1420) and the L(1770)-mesons.

CERN-IHEP BOSON SPECTROMETER



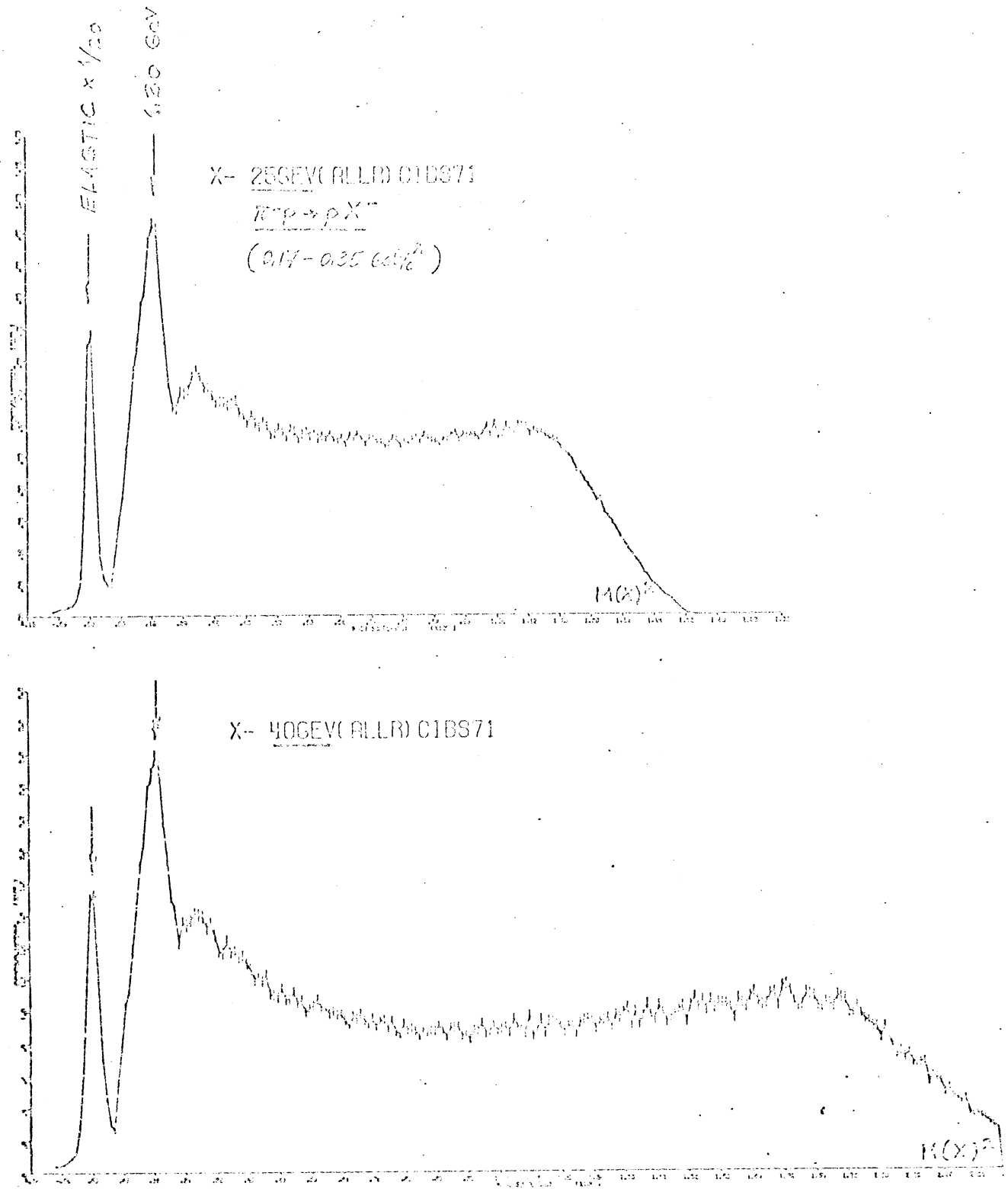

ELASTIC x 1/20
(1.5 GeV
X- 250EV(RLLR) C1BS71
$K^- p \to p X^-$
(0.14 - 0.35 GeV/c)^2
M(X)^2
X- 40GEV(RLLR) C1BS71
M(X)^2

FIG. 2

6.3 [illegible]

0.15 < [illegible] < 0.25 (GeV/c)^2

Partial wave analysis of the 3π syst[illegible]

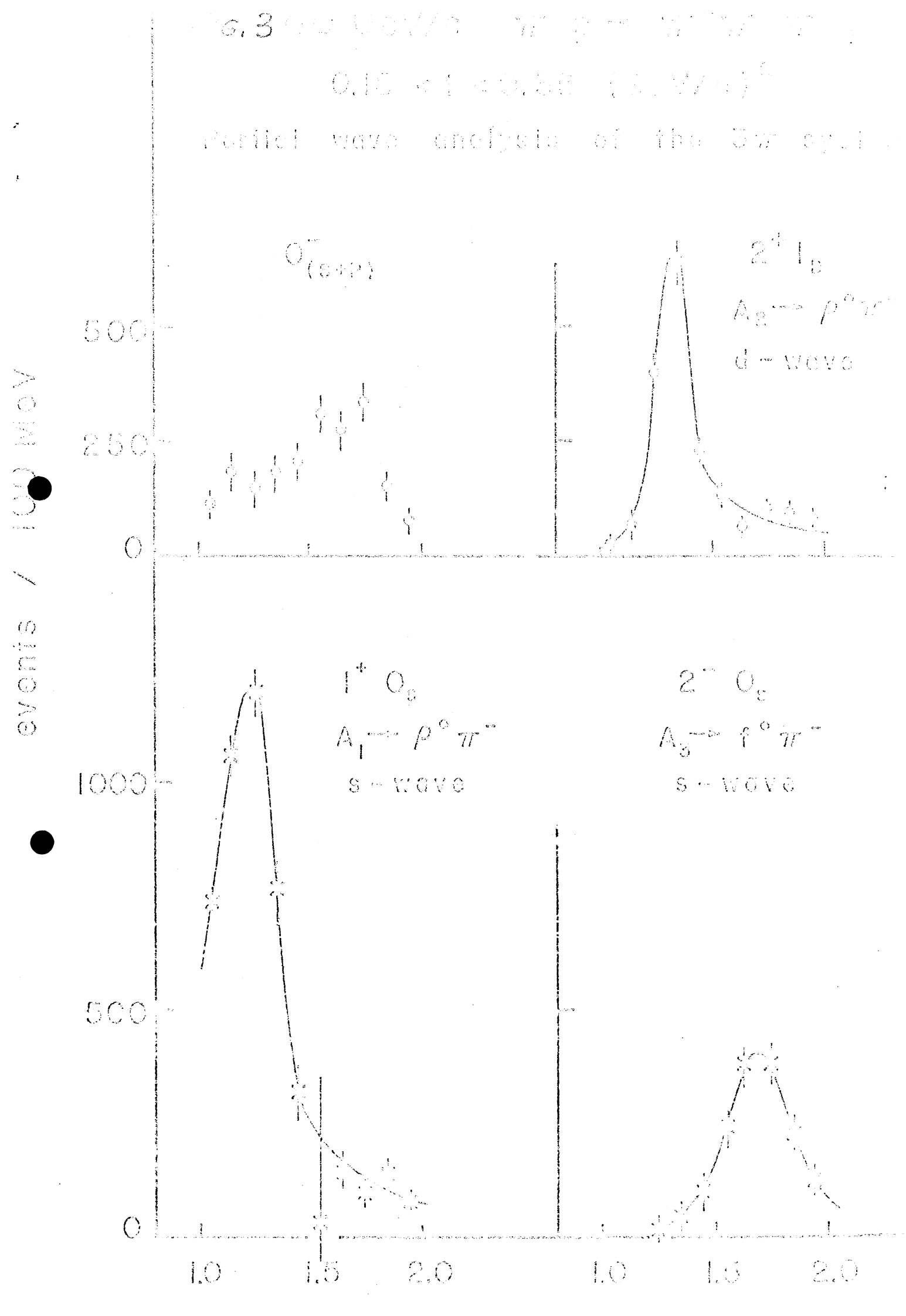
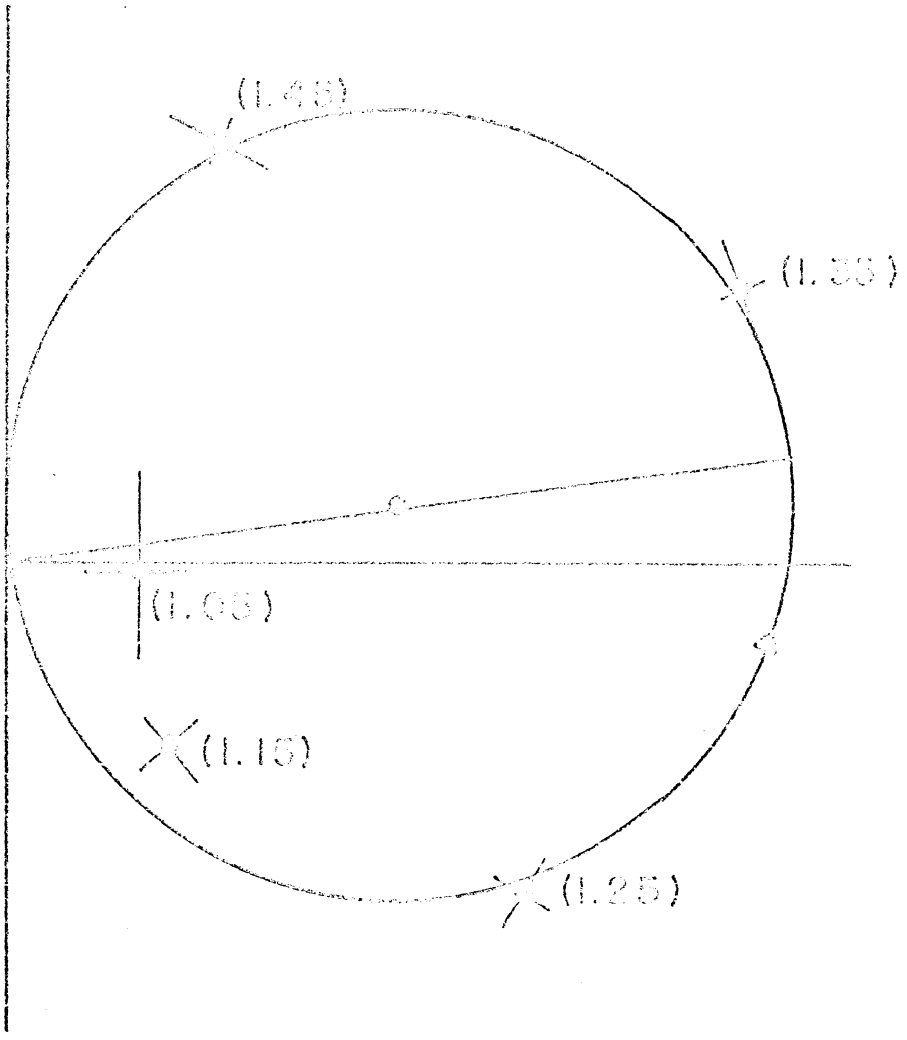


FIG. 4

40 GeV/c $\pi^- p \to \pi^- \pi^- \pi^+ p$

$0.15 < t < 0.35$ $(\mathrm{GeV}/c)^2$



Argand diagram for 2^+ wave

Fig. 5

Efficiency of the magnetic spectrometer to detect 3π in the reaction

$\pi^- p \rightarrow \pi^- \pi^- \pi^+ p$ at 40 GeV/c

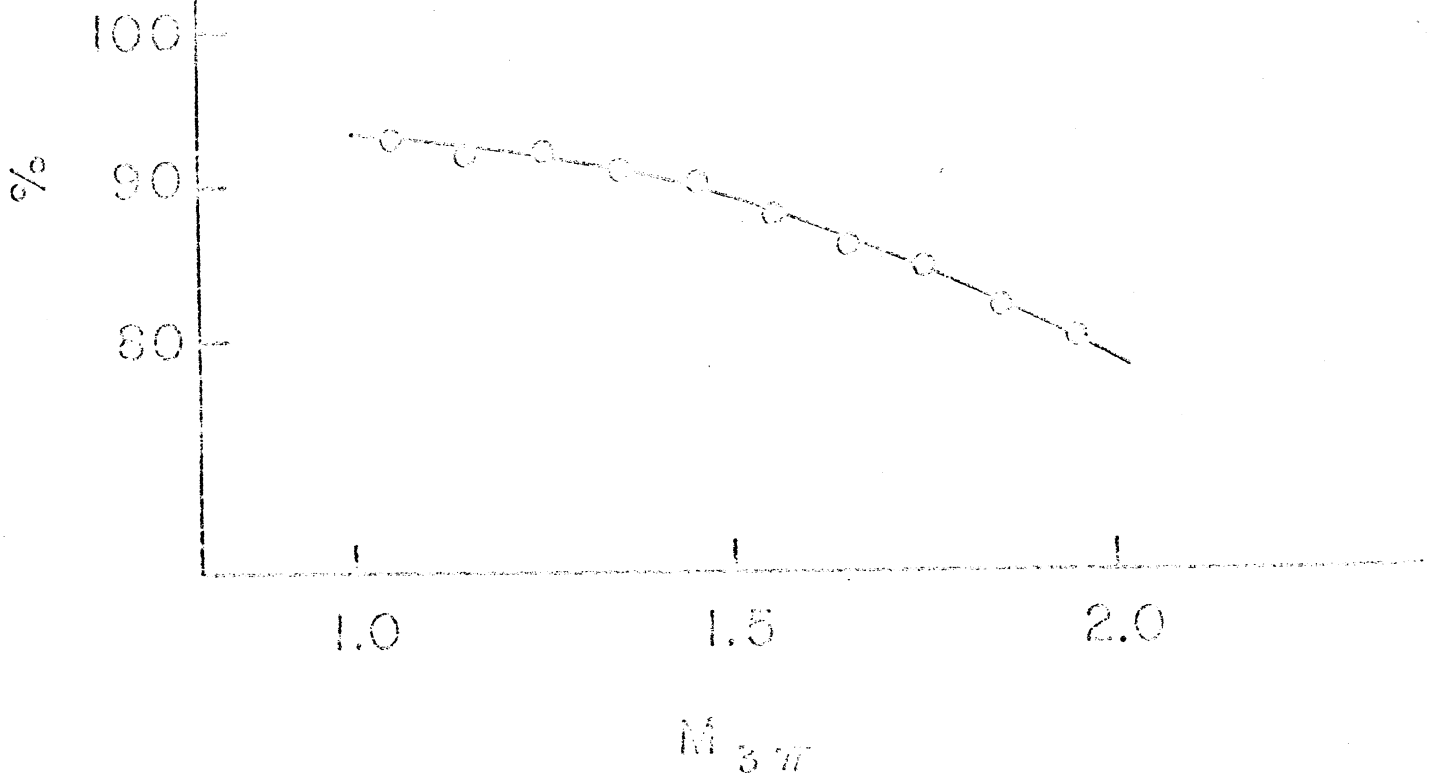


FIG. 6

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