SEARCH FOR EXOTICS AND CHARM
AT THE CERN OMEGA SPECTROMETER

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1. Introduction

This paper reports some recent interesting results obtained with the CERN Ω-spectrometer, concerning both traditional and "new" meson spectroscopy. The experimental programme carried out at CERN with the Ω-spectrometer is schematically shown in Table 1. Operations at Ω started in June 1973 and ended on July 2, 1975, somewhat later than scheduled. In fact, shortly before the West Hall was due to shut down (for the construction of the SPS tunnel), an exciting possibility to look for charmed particles was offered to CERN physicists.

During these three years of operation the Ω-spectrometer was given ∿ 250 days running time, and about 20 different experiments were performed using the several trigger facilities available. About 5×10^7 events have been recorded, needing something like 5000 hours of CPU on a CDC-7600 for the first reduction, i.e. to obtain geometric quantities like momenta and angles of the tracks, and some kinematic fits. It is not unlikely that the analysis of this data will take another 5000 hours, and this makes it pretty obvious why one cannot expect quick results out of this enormous amount of magnetic tapes, unless huge collaborations are set-up (18 labs and 52 names for the Charm Search experiment).

So far, no experimental result has been published. In my opinion, this is due to an underestimation of the difficulty encountered in the data reduction. Nevertheless, preliminary results have been presented at London (1974) and Palermo (1975) Conferences. These papers are reviewed hereafter, together with other recent results not mentioned in previous reviews [1].

2. The CERN Omega

The Ω-spectrometer consists essentially of a large aperture magnet with superconducting coils, yielding a field of 1.8 T over a volume of $11\ m^3$ (Fig. 1). A large hole in the top pole allows TV cameras of the plumbicon type [2] to view optical spark chambers occupying a volume of $3.2 \times 1.5 \times 1.2\ m^3$ in the central region of the magnet. A good parametrization of such non-uniform field is possible and, especially for tracks faster than 2.5 GeV/c, the tracing need not to be done in step with the Runge-Kutta method: a fast program using a polynomial approximation for ∫B.dl works well [3]. Anyway, the non-uniformity of the field remains a limitation for on-line momentum analysis of the particles, therefore rendering fancy triggers difficult to realise. Some of the technical characteristics of OMEGA are given in Table 2.

The dead time of the plumbicon readout which was originally 18 msec has been reduced to 12 msec, therefore allowing a data taking rate of 15/burst [*]. The resolution of the readout system is 1 cm and the accuracy achieved after off-line correction of the staggering effect is ±0.5 mm. Nevertheless, a poor surrounding of the target makes the vertex to be determined only to ±0.5 cm. The extrapolation error on angle measurements is responsible for a K^* width being 14 MeV in the less favourable case (Fig. 2a). The momentum resolution is 0.7%, yielding, for instance, the expected 150 MeV wide neutron peak for the $\pi^+\pi^-$ missing mass in the reaction $\pi^-p \to \pi^+\pi^-n$ (Fig.2b).

An unseparated beam (∿ 1% K and ∿ 0.3% $\bar{p}$) of momentum up to 19 GeV/c impinges on a 30 (or 60) cm long H2 or D2 target. Beam particles are identified in three Čerenkov counters, their trajectory is measured (± 0.2 mrad) in four small MWPC, and their momentum can be determined to ± 0.3%. An intensity of 7×10^5 particles/burst is available, but only less than 2×10^5 has been generally used, because the number of old beam tracks recorded in the spark chambers makes the pattern-recognition efficiency drop to unacceptable values, especially for multi-pronged events.

The program used for pattern recognition and geometry reconstruction (NOMEO) has been developed at CERN for about three years and during the past year physicists were given the "last" version every month or so. Today a typical efficiency of 80% for 4-prong events and 50% for 6-prong events is considered satisfactory.

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*) Typical CERN PS operation has bursts of 400 msec every 2 sec.

A number of different trigger facilities makes it relatively easy to set-up a new experiment at Ω, although the complexity of the system does not allow an infinite flexibility. There is a series of four large MWPC which can be used to require a given multiplicity or to select certain momenta by a predefined correlation matrix; there is a Čerenkov counter (isobutane atmospheric pressure) which covers the forward cone and helps to separate pions from kaons and protons in the momentum band of 2.7-9.8 GeV/c; there is a smaller Čerenkov counter (freon at 5 atmosphere) which allows the separation of kaons from protons in the momentum band of 5-10 GeV/c; there is an array of long scintillation counters which has been used to identify protons, either on-line or off-line, by precise measurement of their time-of-flight; there is a neutron counter which also uses time-of-flight techniques to select a given band of missing masses to the neutron. The fact that these devices are constantly available made it possible, last springtime, to set-up the "Search for charmed particles" experiment in less than six weeks.

3. Traditional Meson Spectroscopy

Some of the results presented at Palermo are summarised in the following. The trigger names given in Table 1 are used.

3.1 SN (π^-12)

A study of the reaction $\pi^-p \to \omega^\circ n$ at 12 GeV/c using the Slow Neutron Trigger was presented at Palermo [4]. Fig. 3 shows a beautiful ω° peak which the authors use to measure the differential cross section in the range $0.02 < |t| < 0.65$ $(GeV/c)^2$. They also produce the ω decay density matrix elements and make comparison with a Regge model. The question whether ρ' exchange has to be added to ρ and B is not answered yet.

3.2 FA (π^-8)

Some preliminary results on backward K^*_{890} production in the reaction $\pi^-p \to \Lambda^\circ K^*$ at 8 GeV/c were presented at Palermo [5]. The data was taken using a fast Λ° trigger, i.e. selecting the proton coming from the Λ° decay. Fast pions were rejected by the Cerenkov counter placed downstream after the OMEGA magnet. Fig. 4a shows the Λ^0 mass distribution and Fig. 4b the Λ^0 missing mass distribution for events having one or two associated charged tracks. The total backward cross section for K^*_{890}, after several corrections, turns out to be (0.5 ± 0.1) μb. No results are quoted for the K^*_{1420}.

This experiment is able to analyze the Λ^0 polarization and indeed it is claimed that the Λ^0 is always highly polarized, except when $u' = -0.1$ $(GeV/c)^2$ where it is compatible with zero. Correspondingly, there is one point in the differential cross-section plot which is 4 standard deviation lower than its neighbours. No explanation whatsoever is presented.

3.3 FP (π^-12)

Preliminary results on the backward reaction $\pi^- p \to p\pi^+\pi^-\pi^-$ at 12 GeV/c were presented at Palermo by the Fast Proton Trigger group [6]. Figs. 5a and 5b show the $\pi^+\pi^-$ and $p\pi^-$ mass spectra, respectively. All well known resonances are observed, and the production mechanism will be carefully studied in a forthcoming paper.

The same experiment can study the 3π system in detail. At present, only the backward A_2^- cross section has been estimated to be (0.34 ± 0.18)μb, where the uncertainty also takes into account an error in the acceptance calculation.

3.4 F$\bar{\Lambda}$ (K^+ 12) by-products

The Fast $\bar{\Lambda}$ Trigger selected fast (p > 2.9 GeV/c) forward $\bar{p}$ without any restriction on the $\bar{\Lambda}$ decay region, to avoid biases. Moreover, the K^- were also accepted because no use was made of the high pressure Čerenkov, which has a smaller acceptance. The experiment, set-up to study $\bar{\Lambda}$ production, therefore contains some by-products.

i) Reaction $K^+ p \to \bar{p}pK^+p$ [7] is dominated by a $p\bar{p}$ threshold enhancement which is about 200 MeV/c^2 wide. It seems that in most cases the $p\bar{p}$ system is associated with a backward K^+. Quantitative analysis is in progress. The $K^+\bar{p}$ mass distribution shows a peak at 1520 MeV/c^2 which the authors identify with a $\bar{Y}^*$ (Fig. 6a). The production angular distribution is strongly in favour of a baryon exchange mechanism.

ii) Reaction $K^+p \to K^-K^+K^+p$ [8] allows the K^+K^- mass spectrum to be studied in detail up to 1.8 GeV/c^2. Apart from a strong ϕ signal there is no evidence for any other K^+K^- resonant state in this mass region (Fig. 6b solid line). One cannot attribute the lack of f' to acceptance problems, because another Ω experiment, with a very similar trigger in a similar reaction ($K^-p \to K^-K^+K^-p$) at almost the same energy (10 GeV/c instead of 12 GeV/c), does see a huge f' signal (Fig. 6b dashed line) [9].

3.5 F$\bar{\Lambda}$ (K^+12)

A study of $\bar{\Lambda}$ production in K^+p interactions at 12 GeV/c was presented at Palermo [10]. Fig. 7a shows the $\bar{\Lambda}$ mass spectrum which allows the selection of the $K^+p \to \bar{\Lambda}$+ anything channel to be made. In particular the authors focus their attention on the reactions where a $\bar{\Lambda}$ is produced with a proton and a nucleon sometimes accompanied by a π^0 or π^+. Adding up the different channels they can produce a total mass spectrum with a peak at 3.1 GeV/c^2 (Fig 7b). The signal remains also after subtraction of Δ^{++}, Δ^+ and Y^{*+} events. No interpretation is given for this effect.

4. Search for Exotic Mesons

In April 1975 an experiment was performed to search for exotic mesons [11] produced in the reaction $\pi^- n \to pX^{--}$ at 12 GeV/c, using the forward Fast Proton Trigger and the Slow Proton counter (Fig. 8). The X^{--} final state is in fact $\bar{p}p\pi^-\pi^-$ and it is hoped to identify the $\bar{p}$ by comparing the on-line measured time-of-flight with the one which can be calculated by the off-line measured momentum of that track. This experiment, called FPSP (π^-12) in Table 1, should be able to reach a sensitivity of ~ (0.3-0.1) events/μb in the X^{--} mass interval (2.5-2.9) GeV/c^2.

Two other Ω experiments have carried out some search for exotics:

4.1 $F\bar{\Lambda}$ (K^+12) exotic

In the paper already mentioned about $\bar{\Lambda}$ production [10] another puzzling effect is shown. In the reaction $K^+p \to \bar{\Lambda}p\pi^+n$ the mass spectrum of the exotic combination $\bar{\Lambda}p\pi^+$ shows a peak at 2.5 GeV/c^2 (Fig. 9), which the authors do not explain. It could be an interference effect between Δ^{++} and $\overline{Y}^{*+}$, since the scatter plot ($p\pi^+$) vs ($\bar{\Lambda}\pi^+$) effective masses shows the accumulation of events in the overlap region.

4.2 $F\Lambda$ (π^+12)

Using thr forward Fast Λ Trigger (section 3.2) an experiment has been performed at 12 GeV/c to study the reaction $\pi^+p \to \Lambda X^{*++}$. The results, presented at Palermo [12] and reported in Fig. 10, are based on the Λ° missing-mass smooth spectra. The shaded area corresponds to events with $u' > -0.5$ (GeV/c)^2, a cut which should enhance baryon exchange mechanism. The estimated upper limits for the production cross section of the reaction $\pi^+p \to \Lambda^\circ X^{++}$ are:

$$\sigma\,(\text{EXOTICS}) < 150 \text{ nb in the range } (2.5\text{–}3.0)\ \text{GeV}/c^2$$
$$\sigma\,(\text{EXOTICS}) < 60 \text{ nb in the range } (3.0\text{–}3.5)\ \text{GeV}/c^2$$

5. Search for Charm Associated Production

5.1 FK^- (π^-16)

A short experiment was performed in November-December 1974 by the so-called Rare Decays Collaboration triggering on a forward K^- with some cut on its transverse momentum. A Pb wall extended the Ω iron yokes so as to provide a rough identification of muons in a MWPC placed behind it. The idea is to look at K^-n or $K^-\pi$ mass combinations associated to a μ. A sensitivity of 1000 ev/μb has been reached for the production of charmed meson pairs having a total mass of 4.5 GeV/c^2. Analysis is in progress.

5.2 FK^- (π^-19)

A search for the production of charmed particles in π^-p interactions at 19 GeV/c has been carried out and a preliminary analysis of the 4-prong and 6-prong events has been presented at Palermo by the OMEGA groups [13].

The trigger required a forward K^- or $\bar{p}$ with transverse momentum greater than ~ 0.5 GeV/c, to enhance the signal produced by the decay products of massive charmed particles. A total energy of 6 GeV in the π^-p center of mass system was available for the production of a charmed pair of either two mesons or a meson and a baryon. Some 3.2 million triggers were recorded and about 1.3 satisfy the requirements of an interaction vertex in the target volume and a forward fast K^- with $P_y > 0.5$ GeV/c. These events have been analysed in terms of the following final states:

$\pi^-p \to D^-D^\circ p$	$\to (K^+\pi^-\pi^-) + (K^-\pi^+) + p$	$\sigma <$ 55 nb
$\pi^-p \to \bar{D}^\circ D^\circ\pi^-p$	$\to (K^+\pi^-) + (K^-\pi^+) + \pi^- + p$	$\sigma <$ 45 nb
$\pi^-p \to D^-C^+$	$\to (K^+\pi^-\pi^-) + (K^-p\pi^+)$	$\sigma <$ 105 nb
$\pi^-p \to \bar{D}^\circ C^\circ$	$\to (K^+\pi^-) + (K^-p)$	$\sigma <$ 65 nb
$\pi^-p \to \bar{D}^\circ C^\circ$	$\to (K^+\pi^+\pi^-\pi^-) + (K^-p)$	$\sigma <$ 125 nb

Fig. 11 shows one of the scatter plots which have been studied for the first of the above reactions. An accumulation of events somewhere along the diagonal would be considered as evidence for the associated production of two charmed mesons. The upper limits for the production cross section of all the considered reactions are calculated in such a way that a 2 standard deviation statistical fluctuation below this limit would produce as many events in an 80 X 80 (MeV/c^2)^2 bin as the maximum one actually observed.

Rumours have spread around Palermo about 9 events found in one bin of the (K^-p) vs ($K^+\pi^+\pi^-\pi^-$) scatter plot. Now, it is hard to deny that these events are there, but it is hazardous to interpret them exclusively as due to charmed meson-baryon production. They could be due to a pure statistical fluctuation ($\lesssim 1\%$ probability) or to traditional resonant states with or without some interference effects. Anyway, if the events were due to an associated $C\bar{D}^0$ production, the observed cross section times the branching ratios of $C^0 \to K^- p$ and $\bar{D}^0 \to K^+\pi^-\pi^+\pi^-$ final state would be $\sim$ 50nb. The angular distribution of those events is not different from that one which is typical of diffractive dissociation, i.e. the $K^- p$ system is slow and the $K^+\pi^-\pi^+\pi^-$ system goes essentially forward. This is hard to explain in terms of single quark diagrams, likewise for the $\pi^- p \to K^+\Sigma^-$ reaction the forward K^+ are forbidden and actually not observed experimentally. A last piece of information concerning the masses: the 9 events all fall in the mass interval of (2.74-2.78) GeV/c^2 for the ($K^- p$) and (1.78-1.82) GeV/c^2 for the ($K^+\pi^-\pi^+\pi^-$). The calculated FWHM resolutions are 20 MeV/c^2 and 30 MeV/c^2, respectively.

As it is often the case, the relevance of this result is tied to the "*prediction*" made by theoreticians. Let us keep in mind nevertheless that there is at least 1% probability that the observed effect be due to a statistical fluctuation.

6. A Concluding Remark

The Ω spectrometer, after a difficult start in 1972 when one coil broke down, has worked satisfactory during 3 years. Less than 20% of the beam time allocated to Ω was lost for major break-downs of the apparatus. The efficiency of the experimental groups using Ω has been slightly worse: it can be estimated to be 50% by dividing the total number of useful triggers which have been actually recorded and the calculated ones. May be I am pessimistic, but my feeling is that using Ω to repeat bubble chamber experiments has not been a good investment. Let us hope that the SPS operation will be more fruitful.

I am grateful to many colleagues for illuminating discussions and in particular to P. Sonderegger for his encouraging suggestions.

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TABLE I - OMEGA EXPERIMENTS WITH PS (1973 - 1975)

CERN CODE	COLLABORATION	REACTION	TRIGGER AND BEAM	RUN	PRELIMINARY RESULTS	INTERNATIONAL CONFERENCE
S112	Birmingham, Rutherford, Tel Aviv, Westfield College	$\pi^-p \to \pi^+\pi^-n$ $\pi^-p \to \omega^0 n$ $\pi^-p \to X^0 n$	SM(π^-12) SM(π^-15)	Aug-Dec.73 Oct.74	Mass spectrum $d\sigma/dt$, density matrix -	1974 1975 -
S 113	Bari, Bonn, Daresbury, Liverpool, Milan	$\pi^-p \to K^-K^+n$, $\bar{p}pn$, $K^-K^+\pi^-p$	EP(π^-12)	Aug-Oct.73	Mass spectrum	1974
S 114	CERN, ETH, Freiburg, Saclay	$\pi^-p \to \Lambda^0 K^{*}(890)$ $\pi^+p \to \Lambda^0 K^{++}$	FA(π^- 8) FA(π^+12)	Jun 73 Oct.73-Oct.74	$d\sigma/dt$, Backward σ, Λ polariz Upper limits for σ(EXOTICS)	1975 1975
S 115	DESY, Glasgow	$K^+p \to \bar{\Lambda}p\pi^+n$ $\to K^-K^+K^+p$ $\to \bar{p}p\,K^+p$ $\pi^+p \to (K^-,\bar{p}) + X^+$	$F\bar{\Lambda}(K^+12)$ $F\bar{\Lambda}(\pi^+12)$	Aug. 73-Mar. 74 Mar. 74	$\bar{\Lambda}N$ enhancement, 3.1 bump $N_0 f'$ $\bar{p}p$ enhancement, $Y^*(1520)$ -	1975 1975 1975 -
S117	CERN, College de France, Ecole Polytechnique, Orsay	$\pi^-p \to p\,X^-$ $\pi^+p \to p\,X^-$ $\pi^-p \to p\,X^-$	FP(π^- 9) FP(π^+ 9) FP(π^-12)	Apr.-June Oct.-Nov. 1974	- - ρ^+, f^+ spectra, $\sigma(A_2^{\,-})$backward	- - 1975
S 139	Bari, Bonn, CERN, Glasgow, Daresbury, Liverpool, Milano, Purdue, Vienna	$\pi^+p \to K^+X^-$ $\pi^-p \to K^-X^+$ $\pi^-p \to (K^-,\bar{p}) + X^+$	FK$^+$(π^-10) FK$^-$(π^-10) FK$^-$(π^-16)	Nov. 74 Dec. 74	- - -	- - -
S 133	CERN - Saclay	$\pi^{\pm}p \to \pi^{\pm}\pi^+n$	$\pi\pi(\pi^{\pm}3,2)$	Apr.-Dec.74	Scattering length	1974
S 116 S 148 S 145	CERN, ETH Aachen, CERN, ETH, Haifa CERN, CdF, Ecole Pol., Orsay	$K^-p \to K^0\pi^+\pi^-n$ $\pi^-p \to K^{\pm}\pi^{\pm}n$ $\pi^-n \to p\bar{p}p\pi^-\pi^-$	VZ(K^-10) VZ(π^-16) PPSP(π^-12)	Aug.74 Jun.75 Apr.75	- - -	- - -
S 146	OMEGA GROUPS	$\pi^-p \to K^-$+anything $\pi^-p \to K^+$ + anyth.	FK$^-$(π^-19) FK$^+$(π^-19)	Mar.75 Apr.75	Upper limits on $C\bar{D}$ and $D\bar{D}$ production cross section	1975 -

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TABLE II - CERN OMEGA SPECTROMETER

MAGNET	Superconducting coils - Gap volume 6x6x1.5 m^3
FIELD	1.8 T - Good parametrization to a few tens of a Gauss
SPARK CHAMBERS	Optical - Plumbicon cameras for digitization - 1 μs memory time - Not deadened in beam region - Poor target surrounding
READ-OUT	Plumbicon with 12-18 msec dead time Resolution 1 cm - Zero crossing for different brightness
ACCURACY	± 0.5 mm (Staggering corrected off-line) K^0-width = 14 MeV due to bad extrapolation in target region $\Delta p/p \sim 0.7\%$
TARGET	30 or 60 cm (H2/D2)
BEAM	up to 19 GeV/c unseparated (1% K, 3% $\bar{p}$, $\check{C}$ identification) Momentum measured to 0.3% (angle 0.2 mrad) Intensity 7×10^5/burst, but in fact $<2 \times 10^5$ usable
DATA TAKING RATE	Typically 500 msec over 2.5 sec (or 400 msec over 2 sec) 15 trigger/burst saturates (~ 100μb cross section and $10^5\pi$)
TRIGGER FACILITIES	Target Side Scintillation counter (avoid plate interaction) MWPC after target (multiplicity) Atmospheric pressure Čerenkov (π from K,p 2.7 - 9.8 GeV/c) High pressure Čerenkov (π, K from p 5-10 GeV/c) Slow proton counter (<1 GeV/c) Slow neutron counter
TYPICAL BREAKDOWNS	Compressor, Data Acquisition Computer, MWPC, Spark Boxes.

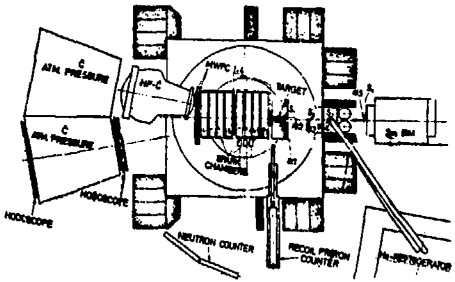

Fig. 1 - Layout of the CERN OMEGA spectrometer. See Table 2 for technical details.

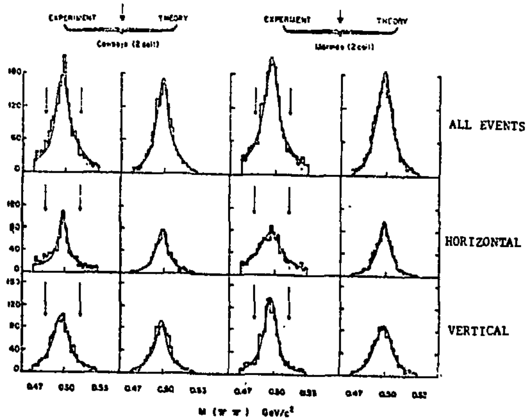

Fig. 2 a - Plots of K^0 mass for different classes of events together with the corresponding calculated distributions. Full lines are Breit-Wigner functions fitted within the mass limits shown by arrows. (From the internal report NP/OM/601).

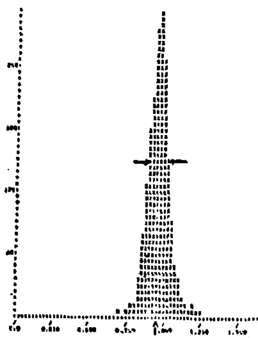

Fig. 2 b - Missing mass to $\pi^+\pi^-$ in the reaction $\pi^- p \to \pi^+\pi^- n$ at 12 GeV/c. (From the internal report NP/OM/530).

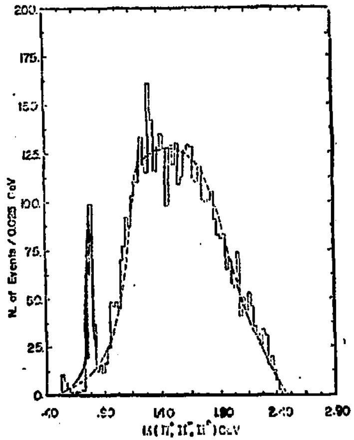

Fig. 3 a - Invariant mass distribution (uncorrected for acceptance) of the ($\pi^+\pi^-\pi^0$)-system for the reaction $\pi^- p \to \omega^0 n$. (Ref. 4).

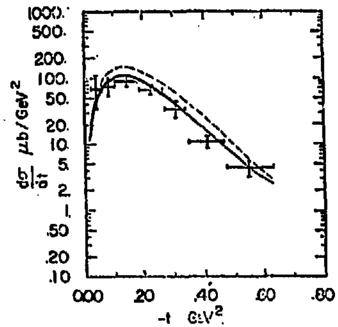

Fig. 3 b - The $\pi^- p \to \omega n$ differential cross section normalized to 23.4 μb.

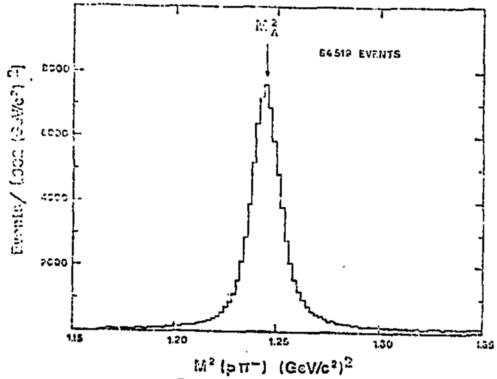

Fig. 4 a - Distribution of the ($p\pi^-$) effective mass squared in the reaction for all V° topologies found by the analysing program ROMEO.

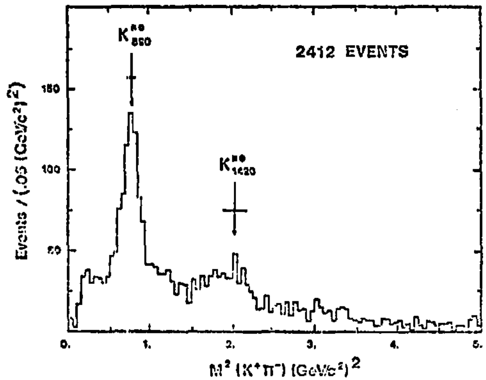

Fig. 4 b - Missing mass squared to the Λ for events with both K^+ and π^- measured or with either the K^+ or the π^- missing. (Ref. 5).

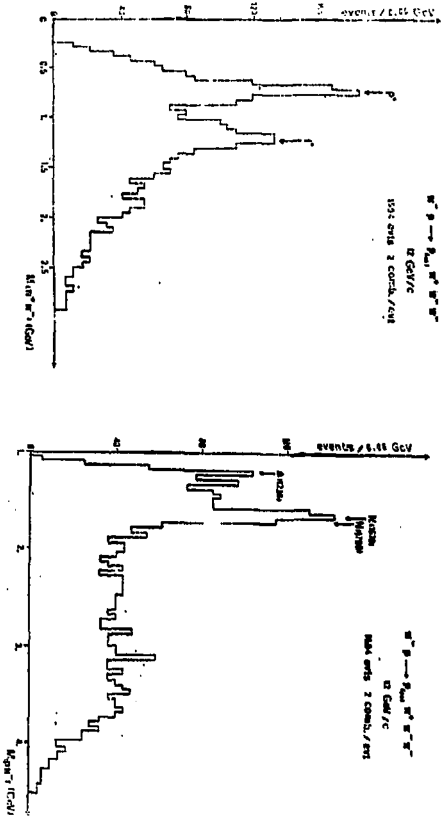

Fig. 5 - Plot of a) $\pi^+\pi^-$ and b) $p\pi^-$ invariant mass for all events $\pi^- p \to p\pi^+\pi^-\pi^+\pi^-$, (Ref. 6).

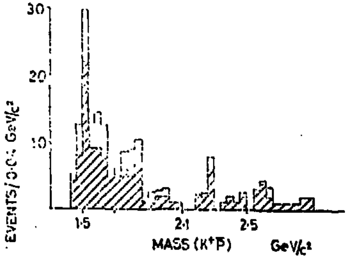

Fig. 6 a - Effective mass distribution for $K^+\bar{p}$ 4C-fit events in the reaction $K^+p \to K^+\bar{p}pp$. (Ref. 7).

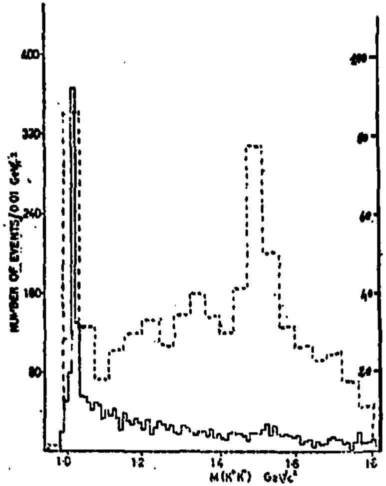

Fig. 6 b - Effective mass distribution (without acceptance correction) for K^+K^- combinations in the reaction $K^+p \to K^-K^+K^+p$, (Ref. 8). The dashed line shows the same plot for the similar reaction $K^-p \to K^-K^+K^-p$ at almost the same incident momentum (10 GeV/c instead of 12 GeV/c), (Ref. 9).

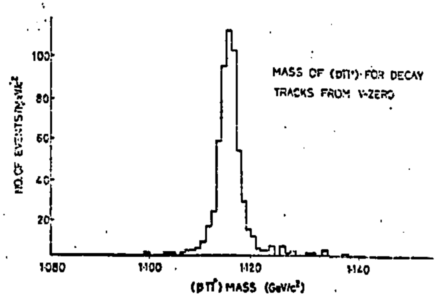

Fig. 7 a - Distribution of the $\bar{p}\pi^+$ invariant mass in the reaction $K^+p \rightarrow \bar{p}\pi^+$ + anything for all V° topologies satisfying the trigger.

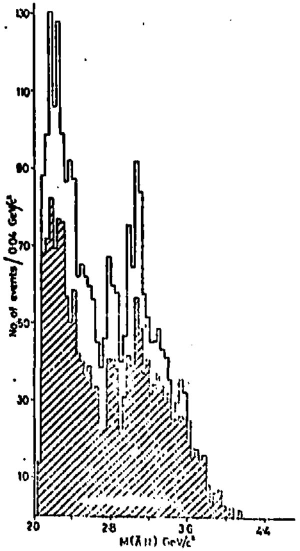

Fig. 7 b - Combined $\bar{\Lambda}N$ mass spectrum for the final states $\bar{\Lambda}pp$, $\bar{\Lambda}pp\pi^{\circ}$, $\bar{\Lambda}pn\pi^+$. The dashed area corresponds to unweighted events. (Ref. 10).

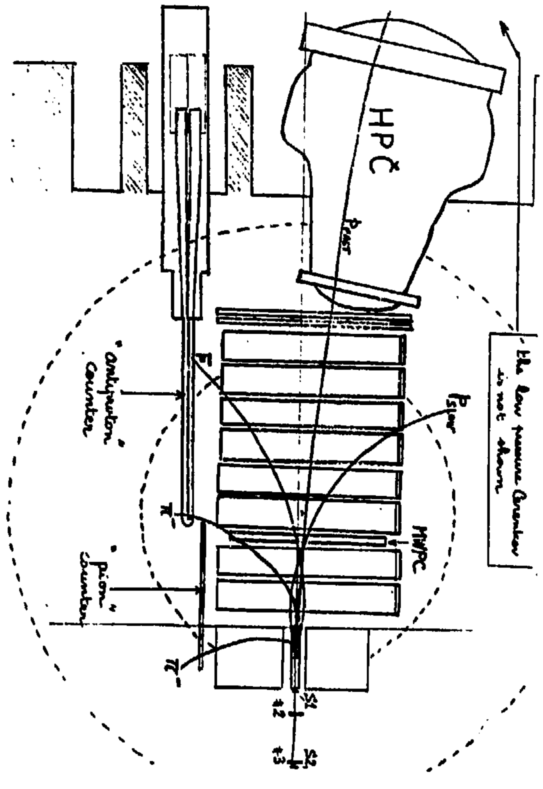

Fig. 8 - Layout of the experiment to search for exotic mesons. (Ref. 11).

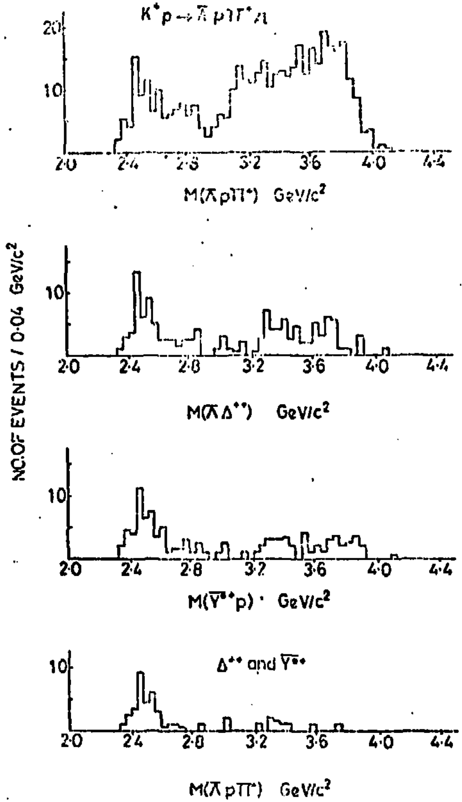

Fig. 9 - Effective mass distributions $\bar{\Lambda}p\pi^+$, $\bar{\Lambda}\Delta^{++}$, $\overline{Y^{*+}}p$ in the reaction $K^+p \to \bar{\Lambda}p\pi^+n$. (Ref. 10). The peak at 2.5 GeV/c^2 for the "exotic" combination is not fully understood yet.

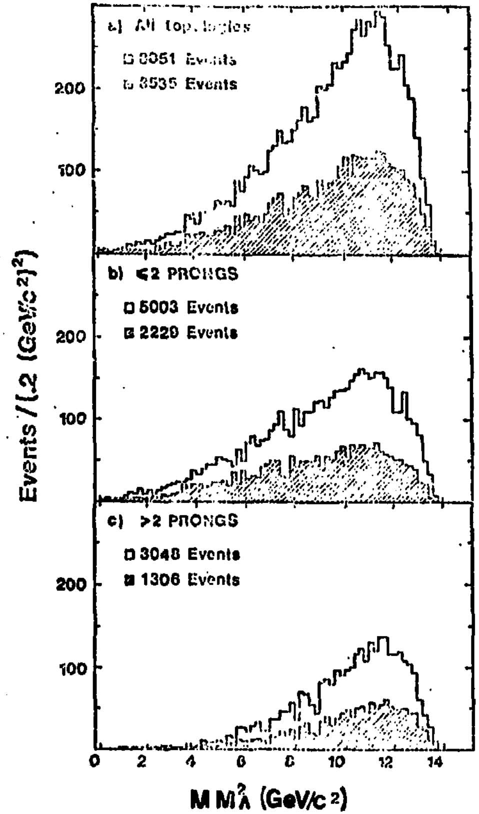

Fig. 10 - Missing mass squared to the Λ in the reaction $\pi^+p \to \Lambda^\circ X^{++}$. Shaded events correspond to $u' > -0.5$ $(GeV/c^2)^2$. (Ref. 12).

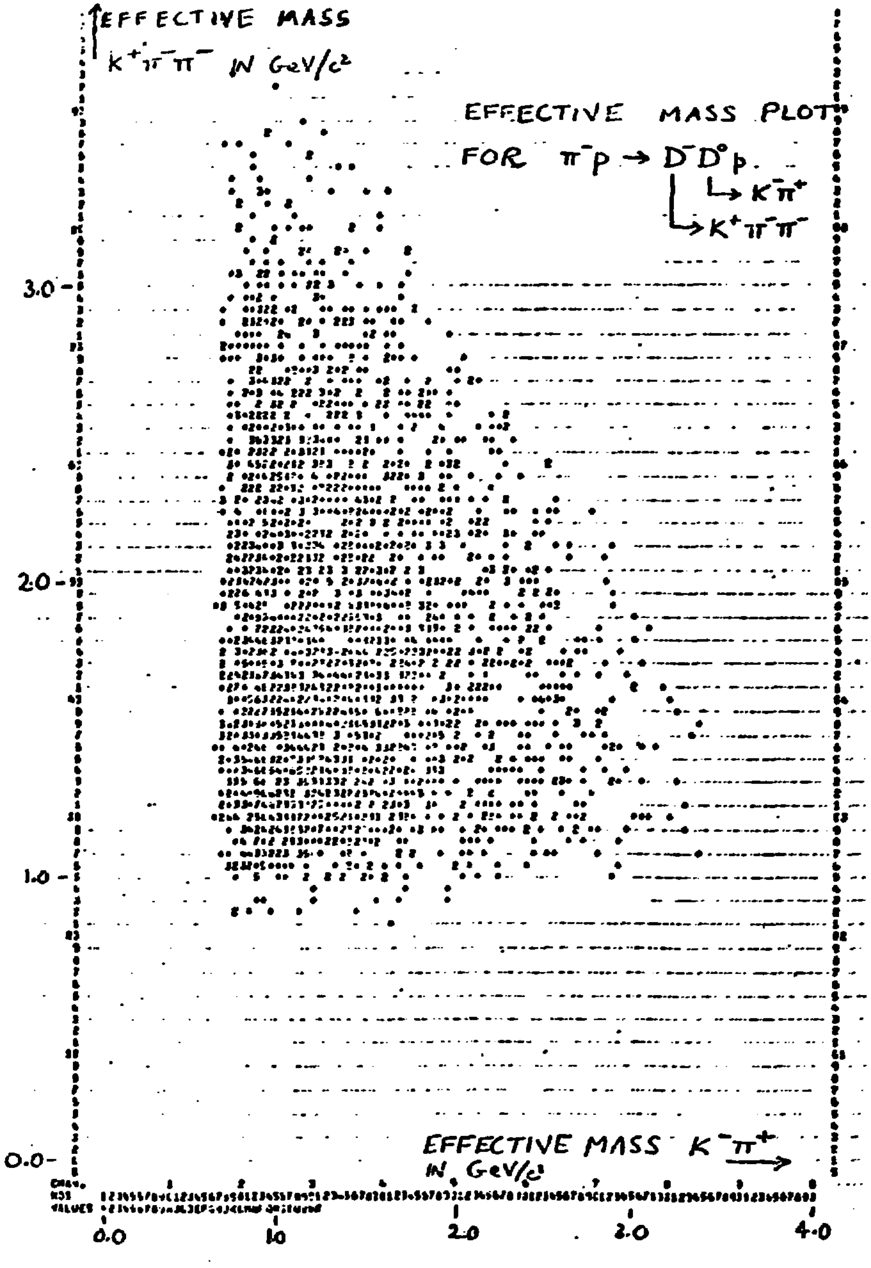

Fig. 11 - Scatter plot of the effective mass $K^+\pi^-\pi^-$ versus $K^-\pi^+$ for the reaction $\pi^- p \to (K^+\pi^-\pi^-) + (K^-\pi^+) + p$ at 19 GeV/c. (Ref. 13). The associated production of two charmed mesons should appear as an accumulation of points along the diagonal.