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ELECTRONICS EXPERIMENTS COMMITTEE

Proposal

Charm search on Omega

Omega Groups *

Abstract

It is proposed to search for the associated production of charmed meson pairs using the Omega spectrometer and a 19 GeV/c π^- beam. This will require the secondary beam to be modified and the PS to operate at 26 GeV/c, possibly with the booster. We hope to achieve a sensitivity of $\sim$ 10,000 events/μb.

* See section 6 for a detailed list of participants.

1. Physics

The object of the epxeriment is to search for the associated production of $D\bar{D}$ in $\pi^- p$ collisions at about 19 GeV/c where D and $\bar{D}$ are a charm-anticharm meson pair.

The reactions of interest are the 4 constraint channels

$$\pi^- p \rightarrow pD^o\bar{D}^- \rightarrow pK^-\pi^+K^+\pi^-\pi^- \qquad (1)$$

$$\pi^- p \rightarrow pD^o\bar{D}^- \rightarrow pK^-\pi^+K^o\pi^- \qquad (2)$$

$$\pi^- p \rightarrow pD^o\bar{D}^- \rightarrow pK^-\pi^+K^oK^- \qquad (3)$$

$$\pi^- p \rightarrow N^{*o}D^o\bar{D}^o \rightarrow p\pi^-K^-\pi^+K^+\pi^- \qquad (4)$$

and the 1-constraint channels

$$\pi^- p \rightarrow nD^o\bar{D}^o \rightarrow nK^-\pi^+K^+\pi^- \qquad (5)$$

$$\pi^- p \rightarrow nD^+D^- \rightarrow nK^-\pi^+\pi^+K^+\pi^-\pi^- \qquad (6)$$

The associated charmed meson-baryon reaction

$$\pi^- p \rightarrow C_0^+D^- \qquad (7)$$

followed by C^+ decay into $pK^-\pi^+$ either directly by a weak decay or through the intermediate strong decay $C^+ \rightarrow pD^o$ could also be observed if the mass of the C_o^+ is light enough. The total centre of mass energy at 19 GeV/c is 6.05 GeV.

In addition the 4 pronged events would include the reactions

$$\pi^- p \rightarrow \eta_c n \rightarrow K^{\pm}K^o\pi\ n \qquad (8)$$

$$\pi^- p \rightarrow \eta_c n \rightarrow K^+K^-\pi^+\pi^- n \qquad (9)$$

$$\pi^- p \rightarrow \eta_c n \rightarrow \Lambda\bar{\Lambda}n \qquad (10)$$

which are all one-constraint channels and the 4-constraint reaction

$$\pi^- p \rightarrow \eta_c\Delta^o \rightarrow p\bar{p}\pi^- p \qquad (11)$$

We are considering including 2-pronged channels if the trigger can be made sufficiently tight. This would allow the study of the simple reactions

$$\pi^- p \rightarrow \bar{p}pn \qquad (12)$$

$$\pi^- p \rightarrow K^+ K^- n \qquad (13)$$

2. <u>Study of 16 GeV/c data in Omega</u>

A sample of six-prongs corresponding to 10% of the data (10^5 triggers) obtained by the "rare decays" collaboration in December 1974 has been studied in order to assess the problems of isolating 4C fits and to have an idea of the possible background in the charm search. The trigger for these events was a fast K^- or p^- with momentum $3.0 < p_{K^-} < 10.0$ GeV/c passing through the low-pressure Cerenkov counter.

The most probable 4C reactions are

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

$$\rightarrow \bar{p} p \pi^- \pi^- \pi^+ p$$

In order to select 4C candidates cuts on missing $p_t < 0.08$ GeV/c and missing $p_L < 0.3$ GeV/c have been imposed. The resulting missing p_t and missing p_L distributions for these 135 events are shown in figure 1 and show that the selection is clean.

In figure 2 we show the p_y (horizontal transverse momentum component) distribution for the triggering K^- particle from which one can judge the effect of a p_y selection on the triggering rate.

The events have not yet been passed through the kinematics program and there are ambiguities in the particle assignments. However the mass plots obtained by making various assingments are similar and we show here the case where the trigger particle is taken to be a K^- and the slowest positive particle a proton. We then take the two remaining negative particles both to be π^- and the remaining positives either K^+

or π^+. There are then two choices for the $K^-\pi^+$ combination and correspondingly two for the $K^+\pi^-\pi^-$ combination and these are plotted against each other on figure 3 for both assignments. The region within which a simultaneous 2.0 GeV/c mass enhancement in both channels would be observed is indicated. The background conditions on this evidence appear quite favourable. Studies of published data confirm this impression.

The events plotted here correspond to a cross section of about 10 μb. The product of the branching ratios for the two charmed particles to decay into these channels is believed to be < 10%. Thus we might expect $\lesssim$ 1 charm event in the box shown if the cross section is 1 μb.

As expected it is not possible to make a clean extraction of 1C events and the background under the neutron peak for reaction (5) is estimated to be about equal to the signal. Nevertheless in a search of this kind it is not essential to have clean neutron events since simultaneous narrow enhancements in the $K^+\pi^-$ and $K^-\pi^+$ mass spectra would still establish a charm signal.

We are continuing these studies with the aim of obtaining further estimates of backgrounds and of preparing the programs for the proposed experiment.

3. Layout

The trigger is based on a K^- or $\bar{p}$ identified in the low-pressure Cerenkov. The layout is shown in figure 4. Transverse momentum can be selected either with the hodoscope correlation H1•H2 or by a hardware matrix correlation between proportional chambers MWPC III and IV. The MWPC matrix allows separation of top and bottom elements of the Cerenkov, but can not easily handle multiple tracks. These matrices can be used either on the positive or negative side.

The slow proton time-of-flight counter could be used as a flag for off-line identification of positive tracks below about 1.5 GeV/c. About 25% of the 6-prong events of reaction (1) would have one positive track identified by this counter.

The large multiplicity chamber will be placed after the second forward optical spark chamber. We could require at least four tracks in this chamber. This would reduce the trigger rate by about a factor 2.

4. Trigger rates and acceptance

A trigger on a forward K^- with large p_y would give maximum sensitivity for reactions (1) - (3). If the $D\bar{D}$ system in reaction (1) is produced peripherally, 30% of the K^- enter the low-pressure Cerenkov. Half of these (15% of the total) have $p_y > 0.6$ GeV/c. One-third of these (5% of the total) have 6 tracks in the multiplicity chamber and should give clean four-constraint production fits.

The trigger rate expected can be derived from the rate obtained by the rare-decays experiment at 16 GeV/c with a K^- trigger. They found a reduction by a factor 17 when the cut-off $p_y > 0.6$ GeV/c was imposed.

Rare decays experiment	=	80 triggers /10^5
60 cm target	=	(× 2)
Multiplicity ⩾ 4	=	(× ½)
19 GeV/c	=	(× 3/2)
$p_y > 600$ MeV/c	=	(× 1/17)
Final trigger	=	7 triggers/10^5

The Omega data-taking system saturates at about 30 triggers/burst, (dead-time = 50%).

With this trigger rate, we could increase the beam intensity to 4×10^5. This would require the booster if we stay at 19 GeV/c. About two-thirds of the events would have one or more parasite beam track. We would reach about

10000 events/μb/day × acceptance.

For reaction (1), we would obtain about

1500 events/μb/day

including 500 4C fits/μb/day.

Alternatively, we could work at lower beam intensity, but open the trigger to increase the acceptance. We could either 1) allow smaller p_y (down to about 0.4 GeV/c) to increase the accepance, especially for three-body D decays, or 2) eliminate the multiplicity requirement so that two-body decays of high-mass bosons would be retained. These possibilities are still being studied. The final decision on the trigger conditions will be made after the relevant trigger rates have been measured. This will be done during the Gargamelle test period.

5. Beam considerations

The present limit of the Omega P9 beam is about 17 GeV/c due to the bending power in the first three bending magnets. By reducing the gap in M231 from 14 cm to 11 cm and changing the bending angles in the first three magnets, which means moving 1 bending magnet and 2 quadrupoles, the beam momentum can be raised to 19 GeV/c. This work requires the removal of concrete and steel shielding and is estimated to need 3 men for 2 weeks.

With a target of 200 mm BeO and a production angle of 8 mrad a flux of $\geq$ 150,000 π^- at 19 GeV/c is expected for 10^{12} protons of 26 GeV/c (no booster). Operation of the PS at 24 GeV/c would require the booster ($\geq 2 \times 10^{12}$) to provide the same flux.

Furthermore we would stress that if the triggering rate can be kept to a sufficiently low level we should wish to increase the beam intensity to saturate the triggering rate.

We conclude that booster operation with the PS at 26 GeV/c during the first period should be tested and made available if needed.

6. Organization and manpower

Since the experiment requires a large analysis effort and should be analysed quickly we believe there should be a team of people willing to devote their full-time effort to the analysis at CERN for a period of several months. The following people are ready to do this.

Full time physicists

B. Bouquet	(Orsay)
B. French	(TC)
M. Houlden	(Liverpool)
R. Hubbard	(Saclay)
G. Irwin	(Ecole Polytechnique)
C. Palazzi-Cerrina	(TC)
P. Petroff	(Orsay)
R. Strub	(TC)
A. Thompson	(TC)
P. Woodworth	(Birmingham)
M. Gandois	(Saclay)

In addition two members of the DD Omega off-line analysis group have agreed to participate.

Off-line programmers

J.C. Lassalle	(DD)
J.D. Wilson	(DD)

For the data taking phase the following members of the NP Omega group and the DD Omega on-line group will participate.

NP Omega group

F. Bourgeois	(NP)
J. Eades	(TC)
O. Gildemeister	(NP)

On-line programmers

C. Bizeau	(DD)
H. Davies	(DD)

Lastly the following physicists who have expertise in various areas of Omega activity will contribute in a part-time capacity either to the preparation and running of the experiment or to the analysis or both.

Part-time physicists

B. Aebischer	(ETH)
T. Armstrong	(Glasgow)
H. Bienlein	(DESY)
M. Cribier	(Saclay)
G. de Rosny	(Ecole Polytechnique)
J. Dowell	(Birmingham)
A. Ferrer	(Orsay)
I. Kenyon	(Birmingham)
F. Navach	(Bari)
M. Rumpf	(Ecole Polytechnique)
A. Rougé	(Ecole Polytechnique)
R. Salmeron	(Ecole Polytechnique)
P. Sonderegger	(CERN)
D. Treille	(CERN)
J.P. Wuthrick	(Ecole Polytechnique)

We are satisfied that the effort is sufficient to carry out the experiment.

7. Computing and analysis

The amount of CDC 7600 time required to analyse the data through ROMEO and kinematics is estimated to be in the region of 300 hours. We have approached various laboratories who are supporting the experiment and have definite offers as follows:-

Daresbury	(50 hrs.)
Ecole Polytechnique	(50 hrs.)
Orsay	(25 hrs.)

We hope to obtain some time at

DESY
Saclay
Rutherford
Freiburg

However we feel that the success of the experiment depends largely on having a substantial fraction of the computing done at CERN (say 150 hrs.). It is recognized that to obtain a quick indication of a signal we shall need to pass a much larger fraction of the data through ROMEO at an early stage than the usual 10% that has been computed quickly in existing Omega experiments. The timescale for this phase is expected to be 3-4 months.

We are nevertheless aware of the desirability of following the initial fast analysis of the data with a more orthodox approach taking into account all of the accessible channels and possible by-products of the charm search. The TC group of B. French and his colleagues are willing to accept the responsibility for this sustained analysis and we expect other groups to share this responsibility after the 1975 program for Omega experiments is decided.

7. Running time

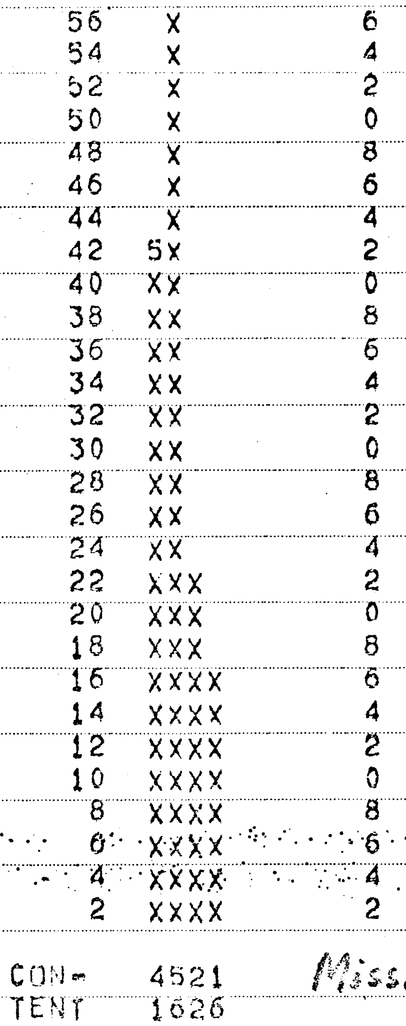
We request the 4½ days of Gargamelle parasitic time starting on 26th February in order to tune the beam and test various triggering schemes, followed by the whole of the first PS period at 26 GeV/c to take the data. If we can analyse the data fast enough and if we find an indication of a charm signal we should like to be considered for further running in the June period before the 1975 West Hall closure.

8. Contact man

Please address all enquiries or communications to J.R. Hubbard (NP).

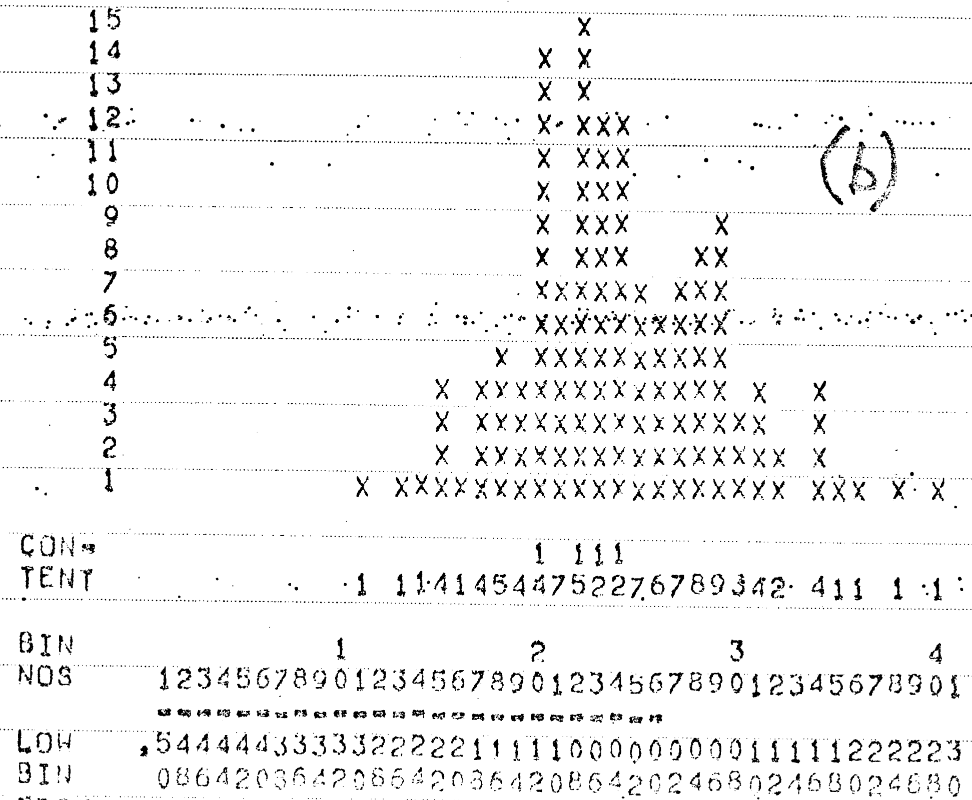
Figure 1

(a)

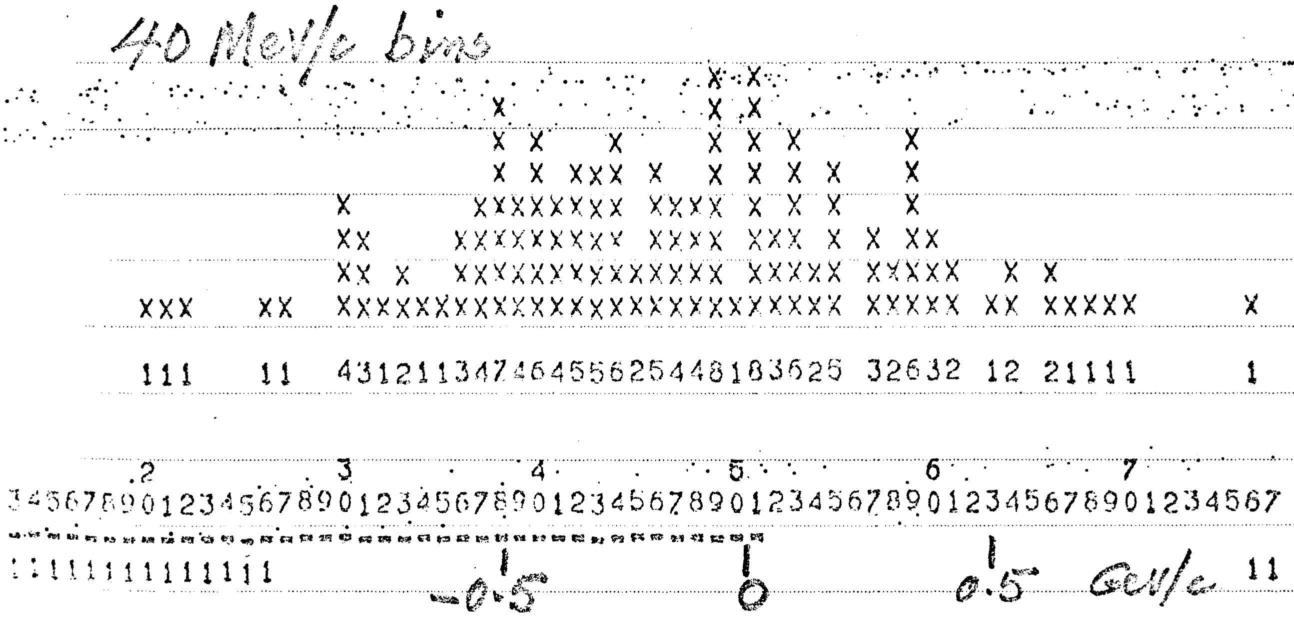


Missing P_t (20 MeV/c bins)

(b)



Missing P_L (20 MeV/c bins)



P_y distribution for K (trigger particle)

Figure 2.

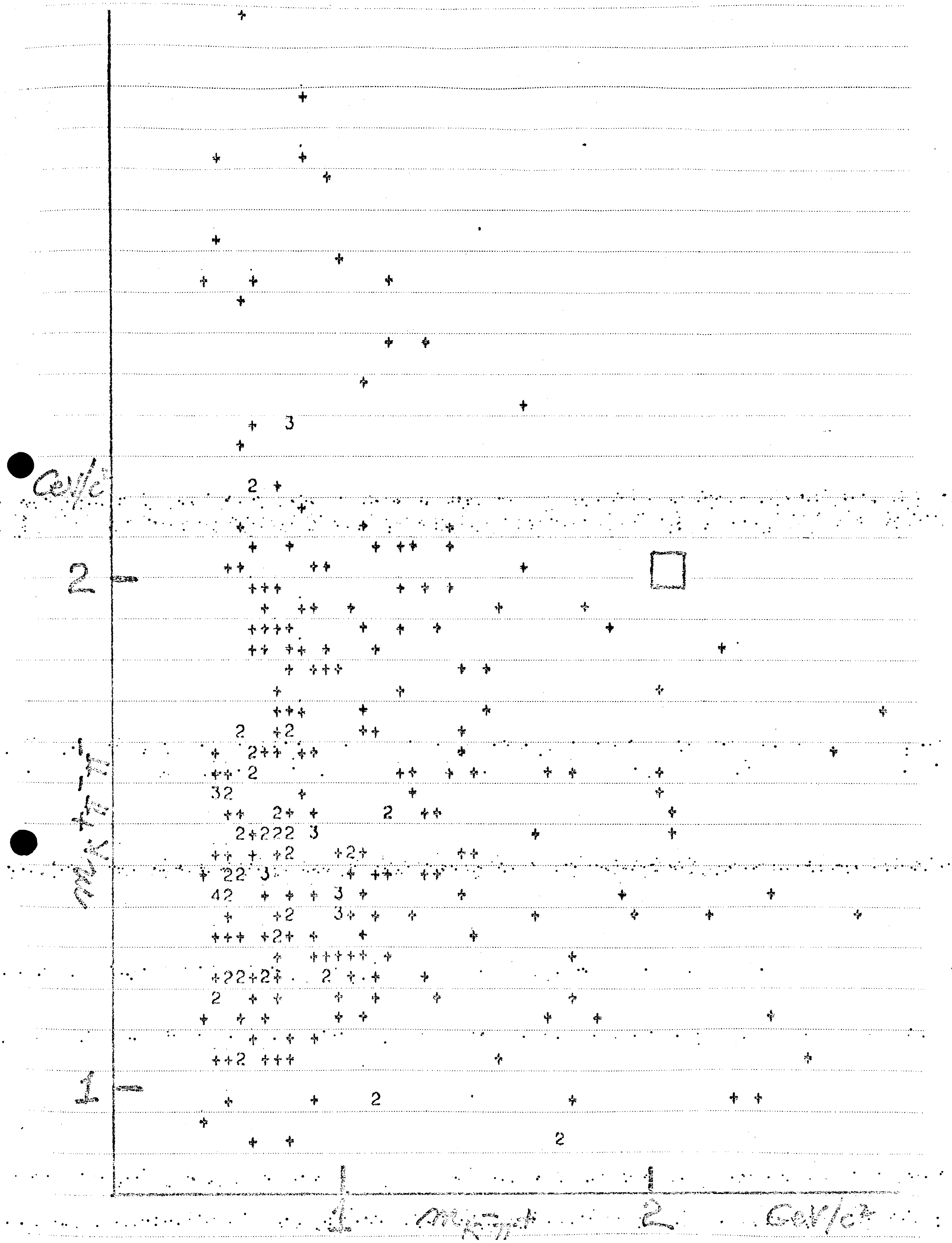
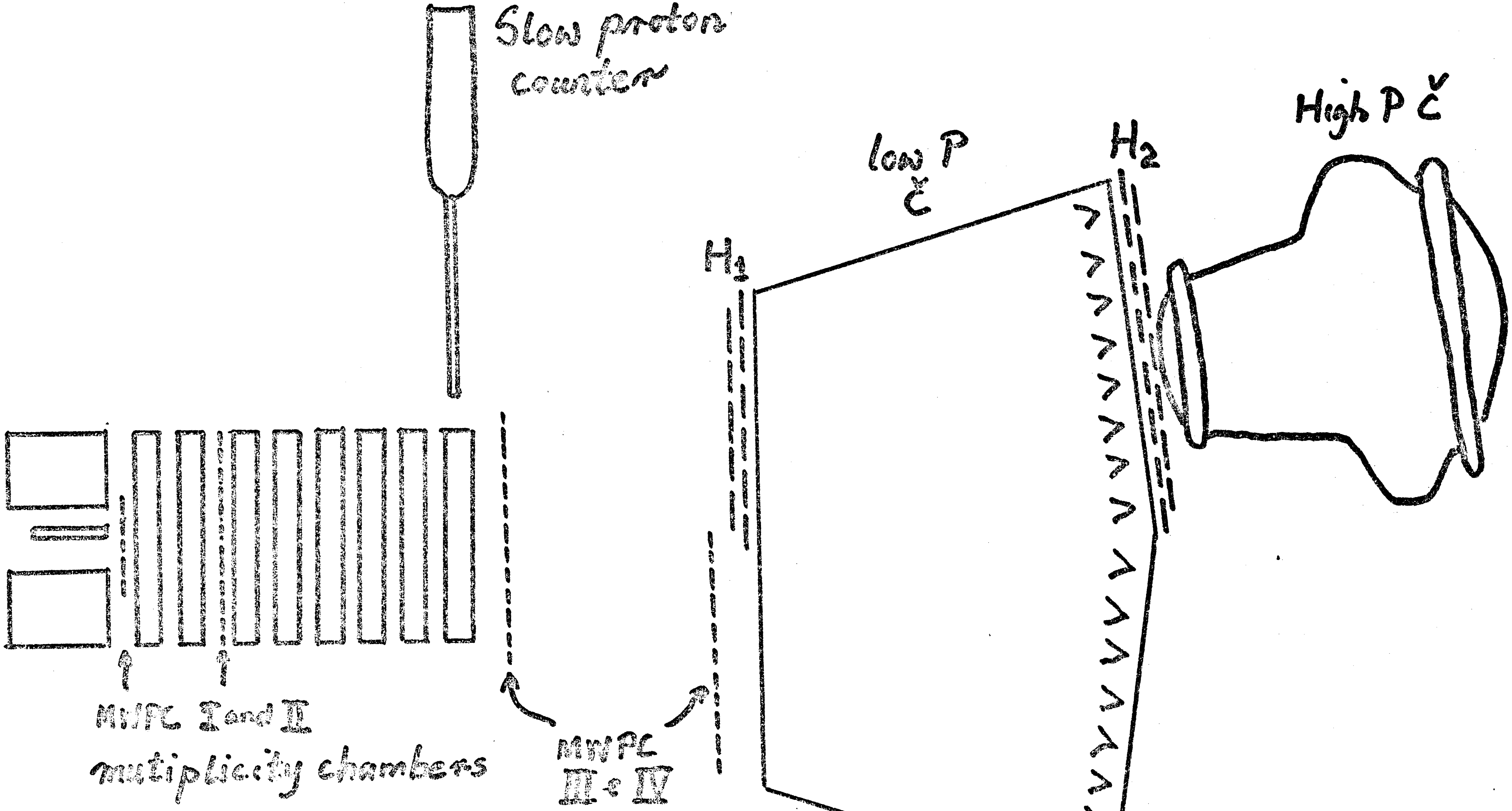


Figure 3



Omega Layout

Figure 4.