CHARMED MESON PAIR COHERENT PHOTOPRODUCTION OFF ACTIVE SILICON TARGET

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ABSTRACT

The preliminary results of CERN NA1 photoproduction experiment are presented 46 charmed pair have been found so far in a sample of 670000 events analysed out of 1.8 million collected. A first indication of charged D lifetime is also given.

RESUME

Les résultats préliminaires de l'expérience de photoproduction cohérente NA1 au CERN sont présentés. 46 paires de mésons charmés ont été trouvés parmi 670000 évènements analysés sur un total de $1.8 \cdot 10^6$ enregistrés. On donne aussi une première indication de la durée de vie moyenne du méson D chargé.

I report here the preliminary results coming from 670000 out of 1.8 million events collected in the NA1 experiment performed by FRAMM Collaboration [1] at SPS using the 150 GeV H4/E4 beam in electron mode.

During the experiment a bremsstrahlung photon beam radiated by electrons in a 0.1 radiation length lead converter, was interacting in a Silicon target (0.15 radiation length).

The aim of the experiment is to study the diffractive excitation of the photon into heavy states $J^P = 1^-$ and, in particular, to measure with electronic technique the decay path of charmed mesons produced in pairs with such a mechanism. The physical processes are illustrated in fig. 1.

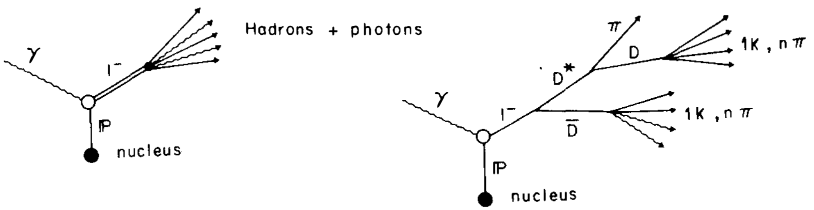

Fig 1. Coherent photoproduction of $D\bar{D}$ pairs.

1. THE APPARATUS

The experimental apparatus, as shown in fig. 2, is composed of a tagging system, a vertex detector including target and a forward spectrometer[2]. The tagging system is a hodoscope for momentum measurement of the electron bent by a magnet positioned after the converter where the photon is radiated. Since the bremsstrahlung of high energy electrons is always dominated by multiphoton emission, in order to reconstruct the energy of the photon interacting in the target, the information given by the tagging hodoscope is used together with the measurement of the energy of extra photons produced in the converter. The energy of photons non interacting in the target is measured in the last electromagnetic calorimeter. The energy of interacting photons is eventually determined in intervals of $DE_\gamma/E_\gamma = 5\%$.

The target, 1.6 cm long, is a telescope of 40 silicon detectors 300μm thick and 100 μm apart, its granularity along the beam being 400 μm. The telescope has been expressely designed to detect the decay of charmed mesons[3], it takes into account the fact that in coherent photoproduction on

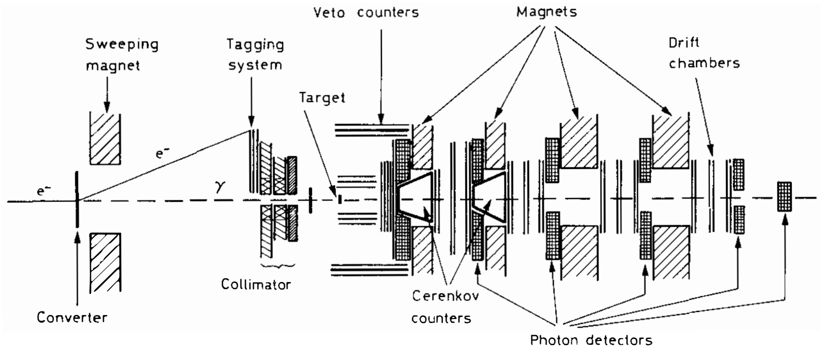

Fig. 2 Experimental apparatus.

silicon nucleus the photon energy (typically above 60 GeV) flows almost entirely into the charmed meson pair. The short decay path of D mesons can therefore be stretched by a large Lorentz γ-factor up to the order of a millimeter or more (several silicon layers). Since the signal amplitude in a single detector is proportional to the multiplicity of transversing minimum ionizing particles, we look for steps in pulse height produced by the increase of the multiplicity of charged particles after the charm decay. In fig. 3 a pulse height pattern of an expected DD event in the target is shown.

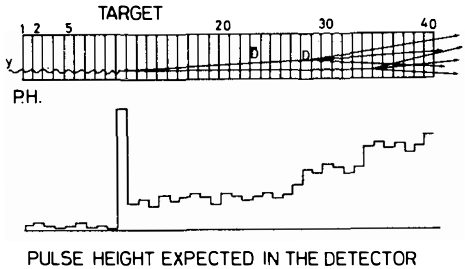

Fig. 3. Pulse height pattern in the target.

A set of magnets interspaced with MWPC and drift chambers[4)] measures the momentum of all particles with momentum larger than 0.5 GeV/c and produced within a cone of 90 mrad half-aperture. This system provides a rather uniform resolution between 1 and 150 GeV/c, generally better than 1%. A set of counters positioned around the target vetoes all events in which particles are produced at large angles. However, to accept events where the π from the D^* decay goes outside the magnetic spectrometer acceptance, a single particle is allowed to be detected in a cone up to 30°.

Two multicell Cerenkov counters are installed inside the first two magnets to select kaons from pions in the momentum interval 4-20 GeV/c. Five shower detectors subdivided with a very fine granularity measure all photons and electrons produced within ± 30. They provide standard energy and a very good space (± 1.5mm) resolutions. Their information is also used at the trigger level.

2. TRIGGER

The experiment was run with the following trigger conditions:

a) At least 2 hadrons or 1 hadron and 1 photon in the forward spectrometer.
b) Nothing outside experimental acceptance.
c) No geometrical cut in the horizontal plane.
d) The trigger efficiency was then > 70% for 4 hadrons, nearly 100% for photons.

1.8 Million events have been collected using the 150 GeV electron beam of $3 \cdot 10^6$ electrons pulse. About 1/3 of the full statistics has been processed so far, in this sample 50 charm pairs coherently photoproduced are expected to be visible in FRAMM apparatus (Montecarlo calculations).

3. ANALYSIS CRITERIA

a) Removal of e^+e^- pairs, using the momentum measured in the magnetic spectrometer and the energy measured in electromagnetic detectors.
b) π^0 reconstruction.
c) Take events with total energy measured in the forward spectrometer $E_{TOT} > 80$ GeV and ask for them a match within an uncertainty of ± 30% between photon energy given by the tagging and E_{TOT}.
d) Check on total P_T according to the silicon form factor to insure the coherence of the event.
e) Use Cerenkov information for positive identification of pions in the interval $4 \leqslant P \leqslant 20$ GeV/c to have kaons candidates.
f) Ask for multiplicity at the end of target less or equal to the charged multiplicity in forward spectrometer. In addition only events with a spectrometer charged multiplicity $\geqslant 6$ have been accepted.
g) Require at least 1 visible step in the target corresponding to a multiplicity variation $\Delta n \geqslant 2$ (from 2 to 4 or more, from 4 to 6 or more, etc.).

e) Allow K^0 short when $\pi^+\pi^-$ invariant mass is ≈ 500 MeV.
Combination are then built to form the individual D's of the pair using 2 further criteria:

i) To build combinations only 1 K or K^0, chosen among candidates, for each of the two mass states (D and $\bar{D}$) is assigned in building combinations.

ii) Exoticity condition according to Cabibbo's selection rule is imposed in combinations giving charged D's.

All the events where no combination gives a total invariant mass above DD threshold have been rejected (to be safe the software thereshold has been set at 3.5 GeV). In our selection we have events with even number of charged prongs 6 or 8 and events with an odd number of charged prongs 7 or 9 reconstructed in momentum, these latter have been kept, because of the possibility of 1 pion from $D^* \to \pi D$ decay gone out of magnetic acceptance. For each event several combinations have been built giving the masses M_1 and M_2 of the two states charm and anticharm to be identified.

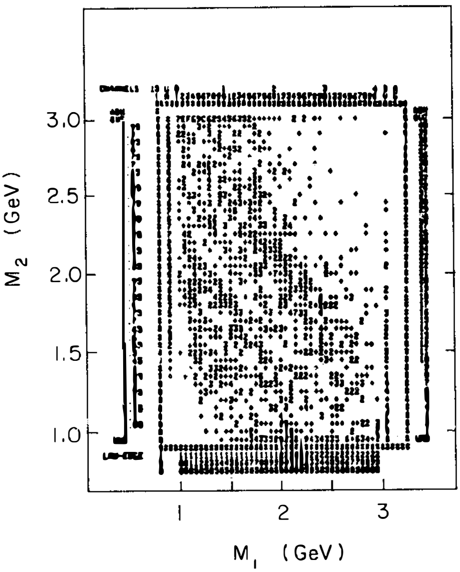

Fig. 4. M_1 vs. M_2 scatter plot

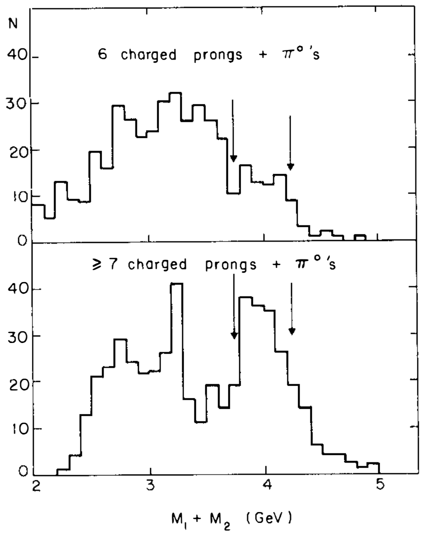

Fig. 5. Sum of the two mesons masses

Fig. 4 shows a scatter plot M_1 versus M_2 where combinations have been entered, a transverse band more populated than outside is well visible in it. Separate projections for 6 and > 7 prong events along the principal diagonal corrisponding to plot combinations versus $(M_1 + M_2)$ are presented in fig. 5, in the higher multiplicity sample of events a clear bump is shown in the 4 GeV region $[(2\ M_D), (M_D^* + M_D), 2\ M_D^*]$ allowing to select a window, marked by the arrows where charmed mesons have to be searched . In fig. 6 is reported the mass of one state M_2 when the other state mass M_1 is contained in the interval 1.9 to 2.1 GeV, a signal corresponding to charmed meson mass is clearly visible, the arrows mark the nominal values of D and D^* masses.

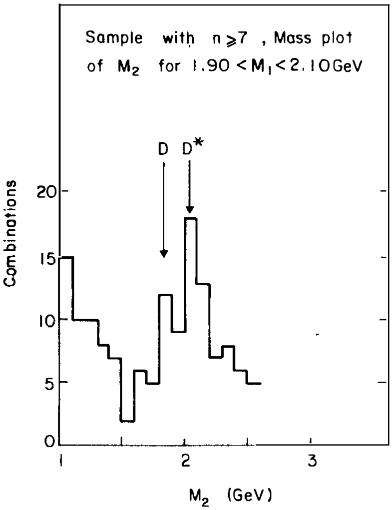

Fig. 6. Mass plot for D and D^*.

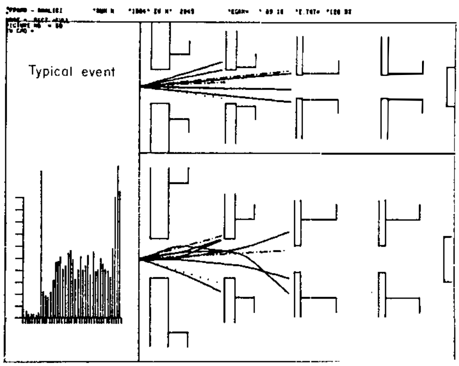

Fig. 7. Typical event.

Therefore for the events giving at least one combination inside a region where both states have their masses, M_1 and M_2, simultaneously in the range between 1.85 and 2.15 GeV, a more accurate scanning of pulse height patterns of the target was done looking for steps and levels.

46 events (∿1/3 of selected) inside the mass window present steps, levels and multiplicity compatible with charmed meson pair decays, most of them present also a high energy release in the silicon layer where the production accured, compatible with the recoil of silicon nucleus.

The computer display of one of these events reconstructed in the spectrometer is shown in fig. 7. In the left hand side of the figure the pulse height pattern of the target is shown, where the first spike is due to the recoil of silicon nucleus, the following 4 layers show a pulse height compatible with the energy released by 2 minimum ionizing particles, and then a long level corresponding to 4 particles, the last jump heing not incompatible with 8 particles. The event is interpreted as D^+D^-, one of D's decaying into 3 charged prongs, the other into 5 charged prongs, seven charged particles and three π^0 have been fully reconstructed in the forward spectrometer. 10 events out of 46 have been positively identified as D^+D^- pairs with both decays measured inside the telescope target. In the remaining 36 events, 40 decays have been measured, one of two mesons often decays either immediately in the production layer or outside the telescope. For all these events the identification between $D^o\bar{D}^o$, D^+D^-, $D^oD^{\pm}\pi^{\pm}$ still remains ambiguous, therefore at this stage we have given up in recognizing the fine structure of the event namely:

i) discriminate D^+D^- versus $D^o\bar{D}^o$ channels
ii) attribute energy to the individual D meson

4. CONCLUSIONS

All the decays observed have been entered in the same plot and individual decay paths have been corrected for the finite lenght of the target. The stretching γ Lorentz factor has been therefore appoximately attributed to D mesons in the following way:

$$\gamma_D = \gamma_{\bar{D}} = E_{TOT}/2M_D$$

where E_{TOT} is the total energy of $D\bar{D}$ pair.

Since the hadron collision length of the target is 5%, a nuclear interaction of pions (for instance a coherent production of A_1) can produce steps corresponding to variations in charged multiplicity and a normal hadronic event with a high number of pions could simulate a decay event. The plot of fig. 8 shows the decay path distribution of the 46 events identified as a pair of charmed mesons. In the low part of the figure is shown the background extracted from a sample of hadronic events with 4 charged prongs and no photons in the spectrometer. The target pattern of the events entered in the plot presents a step from 2 to 4 minimum ionizing particles, due to interaction of one pion. Real decay and background events are treated in the same way and both are corrected for the finite length of the target. The distribution of background events is flat whereas the $D\bar{D}$ events show a clear exponential decrease.

Making use of the average γ factor, the plot of the number of charmed mesons with a life longer than t versus t is built and displayed in fig.9 in logarithmic scale. Points are in agreement with a straight line. I have to remark again that this plot contains $D^{\pm}$ and D^{o}s well.

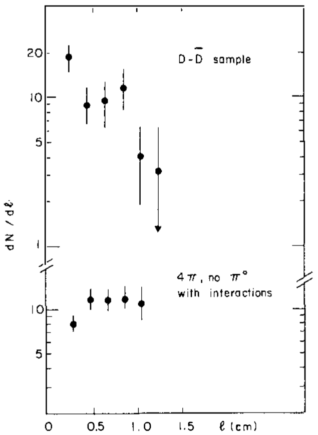

Fig. 8. Living path plot.

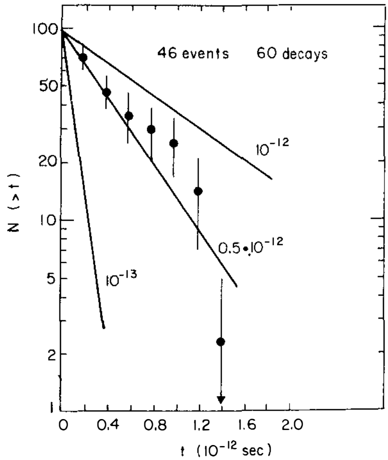

Fig. 9. Lifetime plot.

A statistical treatment of 18 measured decays in the sample of 10 events positively identified as $D^{+}D^{-}$ pairs, gives a mean lifetime between $5 \cdot 10^{-13}$ and 10^{-12} sec.

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