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Short note

Search for d' in pion inclusive spectra from pp-interactions

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Abstract. We report on our measurement of the inclusive spectrum of positive pions from the reaction $pp \to \pi^+ + X$ on a CH_2 internal target of the ITEP proton synchrotron at 1.5 GeV/c with a missing mass resolution of about 1 MeV/c^2. The goal of our experiment was the search for the hypothetical narrow πNN resonance (0.5 MeV/c^2 width and a mass of 2.06 GeV/c^2) with $I(J^P) = even(0^-)$, called d'. We do not see any statistically significant d'-signal. The upper limit for d' production cross-section in pp-interactions is near 2 μb at 84% $C.L.$

PACS. 13.75.Cs Nucleon-nucleon interactions

In recent measurements of an energy dependence of pion double charge exchange (DCX) on different nuclei [1] a resonance-like behaviour of DCX cross section has been found in the energy region below delta-resonance. To explain this phenomena the dibaryon hypothesis was put forward [2]. In the framework of this hypothesis the resonance-like DCX energy dependence is connected with the existence of a dibaryon called d' which is non-coupled to the NN-channel. Such a dibaryon appears in some QCD-inspired models. Suggested quantum numbers are $I(J^P) = even(0^-)$ and the main decay channel is $NN\pi$. Analysis of DCX data gives a d' mass of 2.06 GeV and a narrow width of 0.5 MeV. It was pointed out in [2] that a stringent test of the d' hypothesis is a direct observation of d' production in pp-interactions. The cross section of d' production near threshold has been also calculated in [2].

Recently several experiments reported the results of a d' search. In an experiment at CELSIUS the WASA/PROMICE collaboration [3] performed an exclusive measurement of the reaction $pp \to d'\pi^+ \to pp\pi^-\pi^+$ at $T_p = 750$ MeV using a H_2 cluster jet target. In the $pp\pi^-$ effective mass spectrum they observed a narrow d' peak at 2063 ± 2 MeV with a statistical significance of 4σ. The resulting $M(pp\pi^-)$ spectrum included about 900 events and the experimental resolution was 3 MeV.

In a previous measurement of the same reaction at $T_p = 920$ MeV performed at ITEP [4] with the use of CH_2 and C targets a structure at 2.06 GeV has been also seen in the effective mass spectrum of $pp\pi^-$ system. The width of the structure was associated with the 10 MeV experimental resolution.

In an experiment at TRIUMF [5] using the CHAOS detector to study the DCX reaction $\pi^+ {}^4He \to \pi^- pppp$ a narrow enhancement near 2.06 GeV in an $pp\pi^-$ effective mass spectrum has been observed at a two sigma statistical level. The experimental resolution was 9 MeV.

In our experiment we chose an inclusive approach. We investigated the reaction $pp \to \pi^+ X$. Our goal was to achieve 1 MeV resolution in the missing mass to a pion and obtain a large event sample ($10^6 \ldots 10^7$ events), so we could solve the main problem of inclusive experiments – severe background from the $pp \to \pi^+ np$ reaction and utilise the advantages of this approach which are a simple detector and trigger scheme and the possibility to register d' in all decay modes ($pp\pi^-$, $nn\pi^+$, $pn\pi^0$) thus gaining a factor of 3 in statistics compared to exclusive reactions.

The experiment was performed at the ITEP proton synchrotron. An internal proton beam with momentum $p_b = 1.5$ GeV/c hit the polyethylene internal target. The reaction products emitted at a 3^o angle are focused by quadruples and momentum analysed by a bending magnet. The detector system was placed at a focal plane. It comprised a two coordinate multi-element scintillation hodoscope and two TOF scintillation counters at 2 m base. The pion momentum was derived from the horizontal hit position at the scintillation hodoscope. Data were collected using a CAMAC/PC based DAQ system capable of processing about 2000 events per 300 ms spill. A special monitoring counter system directed to the internal target was used for proton flux normalisation.

In order to search for the d' signal we scanned region of pion momenta $250 - 300$ MeV/c (d' mass $2050 -$

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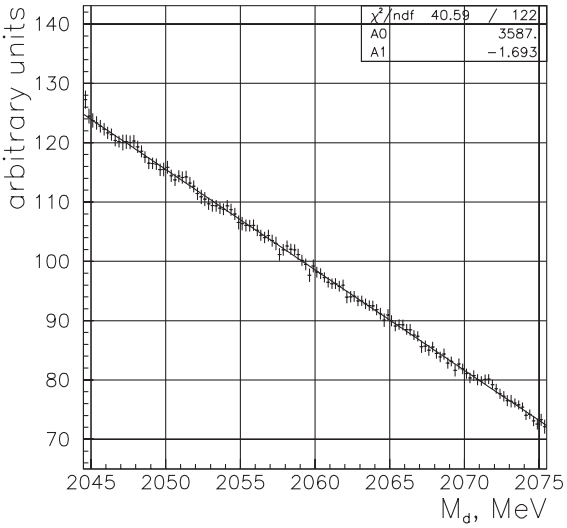

Fig. 1. Missing mass spectrum for the reaction $pp \to \pi^+ X$

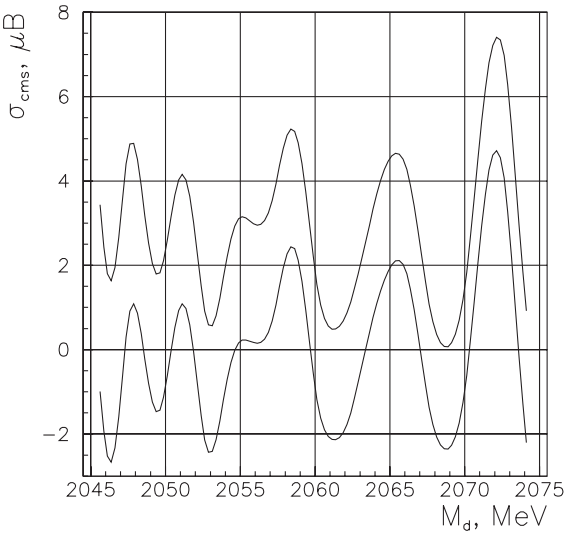

Fig. 2. The most probable value (*dashed line*) and 84% *C.L.* upper limit (*solid line*) for d' production cross section

2070 MeV/c^2). This region was subdivided in 11 intervals which were measured separately and then merged together. The whole region was scanned several times changing the current in the bending magnet and quadruples. The present results are based on the total sample of 2.6×10^6 events.

To perform the calibration and estimate the resolution we measured deuterons and pions from $pp \to d\pi$ and protons from the quasi elastic scattering $pp \to pp$ at two beam momenta ($p_b = 1.103$ GeV/c and $p_b = 1.499$ GeV/c). At each beam momentum we observed four peaks: deuterons at 0^0 in pp c.m.s., quasi elastic protons, deuterons at 180^0 in pp c.m.s. and pions at 0^0 in pp c.m.s. The pion peak from $pp \to d\pi$ at 1.1 GeV/c was in the momentum region of the d' from $pp \to d'\pi$ at 1.5 GeV/c. Positions of these peaks were used to calibrate the absolute momentum measured with the focusing spectrometer and to check the linearity of the hodoscope system. The observed widths of the peaks were used to decouple all contributions to momentum resolution.

The following sources contributed to the momentum resolution :

1. multiple scattering $\sigma_{ms} = 1$ MeV/c;
2. the resolution of magnetic optics $\sigma_T = \alpha p$, which is proportional to the momentum of a measured particle ($\alpha = 0.20\%$);
3. the internal proton beam momentum resolution $\Delta p/p = 0.2\%$ which dominates the resolution in missing mass in d' region.

The experimental resolution in the missing mass was $\sigma = 1.1$ MeV in the d' region.

Using data from the flux monitoring system we obtained the positive pion momentum spectrum. This spectrum recalculated to the missing mass spectrum of X in the reaction $pp \to \pi^+ X$ is shown in Fig. 1. No statistically significant structures can be seen. By fitting the spectrum with a straight line plus a Gaussian for a d' peak with its width set to our experimental resolution we obtained the most probable value for the d' production cross section and one sigma upper limit (at 84% $C.L.$) which are shown in Fig. 2 by a dashed and solid line, respectively.

The 84% $C.L.$ upper limits for the narrow d' production vary from 2 to 7 μb in the whole mass region of the experiment from 2045 to 2075 MeV. For $M_{d'} = 2060 \ldots 2063$ MeV where the d' has been seen in other experiments our upper limit is below 2 μb. This value is a few times lower than the cross section estimated in [2] for explanation of the 50 MeV peak in the DCX energy dependence by d' production. This result does not support a d' hypothesis of the anomalous DCX energy dependence below the Δ resonance. It emphasises that other non-d' approaches should be tried to understand a low energy DCX phenomenon.

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