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Statistical significance of the $\pi^- p$ data in the η' (958) mass region

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ABSTRACT
We have examined the statistical significance of some results on the η' (958) meson produced in the $\pi^- p$ interaction near its production threshold which are useful to reduce backgrounds avoiding the pile-up-effects. The curve with minimum value of χ^2 (12.81) Corresponding to high Confidence level (CL) fits very well to the data. The absence of a peak in the η' (958) mass region is attributed mainly to its low production cross - section near threshold in this interaction.

Keywords – Meson , backgrounds , Pion beam momentum, yield curve , fast peak.

Introduction: The η' (958) is a well known narrow meson at its mass (957.78 ±0.14) Mev. It has been produced in many interactions, Viz $\pi^- Þ$, $\pi^+ d$, $Þ^- Þ$.$k^- Þ$ and $e^+ e^-$ etc.

We report here results on the analysis of the $\pi^- Þ \rightarrow \eta' n$ nteraction near its production threshold. The momentum of the pion beam incident on a liquid hydrogen target (LH_2) is measured by a system of magnets.

Neutrons are detected by a ring of six thick scintillation counters arranged on a trolley. It was placed 6.15 m downstream of the target (LH_2).The target is surrounded by a system of especially designed scintillation counters called decay system. Each scintillation counter has been equipped with the light guide (LG) of different shape and size and a PMT whose size depends upon the size of counters. With the knowledge of the pion beam momentum, $P\pi$ and the neutron time of flight, the missing mass of the η' meson is estimated by applying the laws of conservation of energy and momentum. The experimental details and method of analysis have been given elsewhere.

A meson would appear as an enhancement in the yield curve over a specified time-of flight region, called gate. It corresponds to a centre of mass (CM) gate of 6 to 12 ns after a reference peak called fast-peak. The yield curve is obtained by plotting the number of events normalised to 10^8 Pions against the pion beam momentum, P_π. The novelty of the experiment lies in the fact that only two parameters i.e. P_π and t_n are measured for estimating the missing mass of the meson. Consequently the resolving power of the apparatus depends upon the errors in the measurements of P_π ,t_n and angle of emission of nucleons(θ_n).

Discussion Fig. I shows the yield curve over the CM gate $0.5 \leq |t| \leq 1.0(\text{GeV/c})^2$ for neutron events. No decay selection on the decay modes of the η' (958) meson has been made .Where $|t|$ is the four momentum transfer squared. No significant enhancement for the η' (958) meson has been observed in the yield curve.

In order to check statistical significance of the data, hand drawn curves have been fitted and the values of χ^2 for each curve are calculated.

The χ^2 is defined as

$\chi^2 = \sum_{i=1}^{n} \frac{(V_{0i} - V_{ti})^2}{\sigma_i^2}$. Here V_{oi} is observed point with an error of one standard deviation σ_i and V_{ti} are the corresponding theoretical (values) points on the fitted line, n is the number of degree of freedom.

Values of χ^2 for lines 1, 2, and 3 have been calculated to be 12.81, 19.91,and 15.64. The first line has minimum value of χ^2 (12.81). It corresponds to high confidence level (CL). Hence it fits very well to the data.

Conclusion : An absence of the η' enhancement in the yield curve is attributed to its low production cross-section in the $\pi^- p$ interaction near threshold.

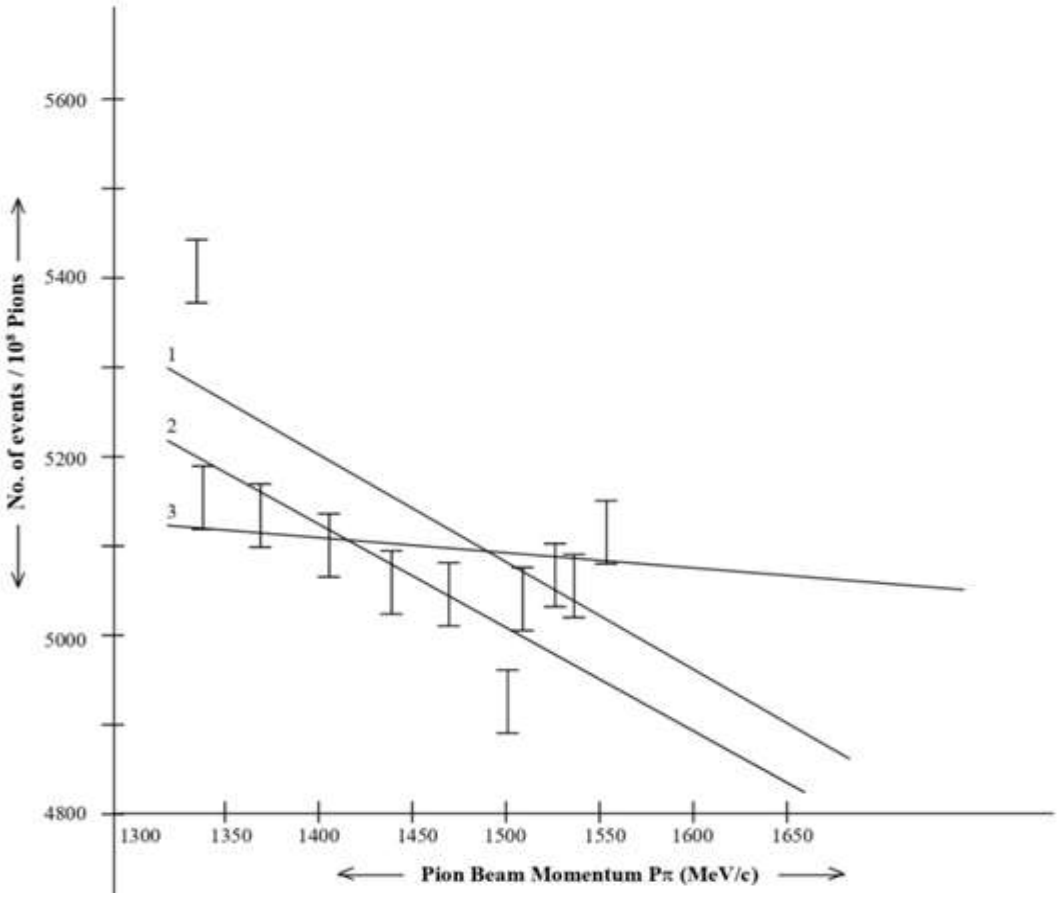

Fig 1 shows the yield curves over a CM gate for neutron event. No decay selection has been made.

Table- 1 enlists the values of χ^2 fitted to all the points in η' (958) mass region over a CM gate

Pion beam Momentum P_π (MeV/c)	No of Events/10^8 Pions.						
	Experimental Value	Line – 1		Line - 2		Line -3	
		Theoretical value	χ^2	Theoretical value	χ^2	Theoretical value	χ^2
1332.5	5425±27.1	5285	26.69	5195	75.09	5110	135.07
1362.5	5110±25.6	5245	27.77	5150	2.44	5100	0.15
1377.5	5115±25.6	5240	23.82	5125	0.14	5090	0.95
1442.5	5045±25.2	5130	11.37	5030	0.35	5070	0.98
1477.5	5000±25	5085	11.56	4980	0.64	5055	4.84
1497.5	5025±25.1	5055	01.19	4950	8.93	5050	0.99
1500	4925±24.6	5050	25.81	4945	0.63	5050	25.81
1512.5	5025±25.1	5035	0.16	4925	15.87	5045	1.43
1525	5040±25.2	5020	0.63	4910	26.61	5040	0.00
1540	5020±25.1	5000	0.63	4885	28.93	5035	0.36
1555	5060±25.3	4975	11.29	4865	59.41	5030	1.41
Total χ^2 =			12.81		19.91		15.64

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