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MESON PRODUCTION IN THE 1 GeV/c^2 MASS REGION IN THE $p\,d \rightarrow {}^3He\,X$ REACTION

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† Talk held at HADRON95, 10-14th of July 1995, Manchester, UK

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Meson production near threshold has been studied at the SPES4 spectrometer at SATURNE using the $p\,d \rightarrow\ ^3He\,X$ missing mass reaction. Differential cross sections in the CM system for ω, η' and ϕ are less than 1 nb/sr. The observed ϕ cross section is surprisingly large at threshold and clearly violates the naive OZI rule. No clear signals were obtained at the $K\bar{K}$ thresholds. The measurements can be extended to study broader mesons like f_0 and a_0.

The threshold excitation function of the $p\,d \rightarrow\ ^3He\,X$ missing mass reaction was studied in the range of T_p = 1.28 to 2.0 GeV [1] and double differential laboratory cross sections are shown on fig. 1. Clear peaks near the $\eta\prime$ and ϕ thresholds can be seen, but indications of signals at the $K\bar{K}$ thresholds marked by arrows in fig. 1 were not confirmed in a later run.

Figs. 2(a) and (b) show the data from two runs for $\eta\prime$ and ϕ. The curve illustrates the result of a Monte Carlo simulation that considers all important parameters, like beam emittance and energy spread, energy loss and straggling in the target, as well as angular and momentum acceptance. It is assumed that near threshold the meson is produced in S-wave, which means that the particle distribution is isotropic and the CM cross section rises linearly with p^*. Partial gain of the Breit-Wigner shaped resonance is important near threshold and was considered. In effect the simulation computes the Jacobian of the two-body reaction very close to threshold. The averaged squared amplitude can be defined as $|f|^2 = p_p^*/p_{meson}^* \times d\sigma/d\Omega^*$ and values are given in table 1.

As the $\eta\prime$ has a very narrow width of only about 0.2 MeV/c^2, the curve generated with the Monte Carlo has an almost a gaussian shape (fig. 2(a)), while for the ϕ the Breit-Wigner is dominant (fig. 2(b)). This depends on the intrinsic mass resolution of the apparatus, which is less than 100 keV/c^2.

We find meson masses $m_{\eta\prime} = (959.1 \pm 0.2)$ MeV/c^2 and $m_\phi = (1020.6 \pm 0.6)$ MeV/c^2, to which systematic error of 1.5 MeV/c^2 must be added, due to possible deviations of the SATURNE beam energy by 2-3 MeV from nominal values [1]. Using the precisely known ϕ mass [2] ((1019.413 ± 0.008) MeV/c^2) to calibrate our mass scale, we find an $\eta\prime$ mass of $m_{\eta\prime} = (957.9 \pm 0.2 \pm 0.6)$ MeV/c^2 in perfect agreement with the PDG value of (957.77 ± 0.14) MeV/c^2.

For the resonance widths, we find $\Gamma_{\eta\prime} = (0.40 \pm 0.22)$ MeV/c^2, which is compatible with the PDG average [2]. The result is worth noticing as there exists only one other direct measurement [3] giving $\Gamma_{\eta\prime} = (0.28 \pm 0.1)$ MeV/c^2. Our value of $\Gamma_\phi = (6.4 \pm 0.6)$ MeV/c^2 appears too large, due to beam intensity calibration uncertainties which occurred around the ϕ mass in our first run.

Our preliminary results have been recently discussed by Fäldt and Wilkin [4] within a two-step model, which includes the $\pi^- p \to nX$ reaction, which shows similar threshold behaviour. While the η, ω and $\eta\prime$ are well described, the ϕ cross section is about 2-3 higher than expected. By comparing ϕ and ω amplitudes, we find a significant violation of the OZI rule. The observed ratios are $|f_\phi|^2/|f_\omega|^2 = (3.4 \pm 0.3^{+1.0}_{-0.4})\%$, both cross sections being measured at their respective thresholds after correcting for the observed threshold suppression [1] in the ω case. Comparing the data at the same incident beam energy would yield something even higher, $|f_\phi|^2/|f_\omega|^2 = (12.0 \pm 1.0^{+3.3}_{-1.0})\%$, but dynamic aspects might be important and more systematic data on ϕ production away from threshold are necessary. The values should be compared with recent results from $N\bar{N}$ annihilations LEAR, where OZI violations of 10-30 % were observed in certain reaction channels [5]. OZI violation is now in lively discussion as being a hint on a possible $s\bar{s}$ content in the nucleon [5], or being due to a final-state interaction [6], or as being enhanced through vector meson dominance [7].

Due to rapidly varying kinematics a few hundred MeV above threshold, the spectrometer missing mass acceptance increases to more than 100 MeV/c^2. In 2-3 days running time more than 10,000 f_0 and a_0 events could be expected in an exclusive experiment [8], with a mass resolution of about 1 MeV/c^2.

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Table 1: Observed CM cross sections and averaged squared amplitudes $|f|^2$ for the $p\,d \to {}^3He\,X$ reaction. Note that the cross sections are given for $p^*_{meson} = 20$ MeV/c.

	$d\sigma/d\Omega^*$ pb/sr	$\|f\|^2$ nb/sr	stat. error %	syst. error %
ω	1110	70	4	≈ 10
$\eta\prime$	13	0.9	13	14
ϕ	33	2.4	7	$^{+27}_{-7}$

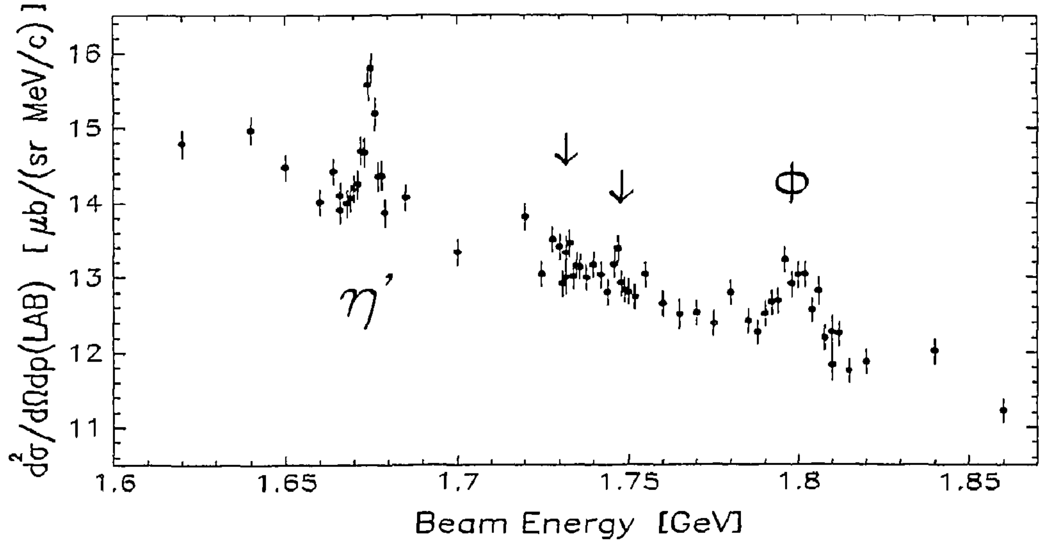

Figure 1: Laboratory cross sections of the threshold excitation function of the $p\,d \to {}^3He\,X$ reaction. The flat target-empty contribution has been subtracted. The arrows mark the thresholds for K^+K^- and $K^0\bar{K}^0$ production.

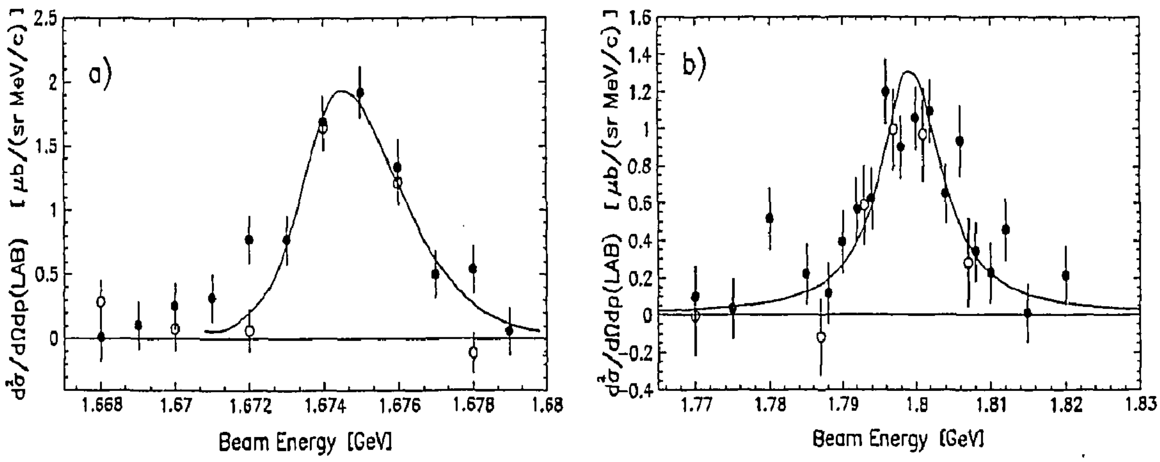

Figure 2: $\eta\prime$ (a) and ϕ (b) production. The continuum contribution has been subtracted by a linear fit. Open and closed symbols are from two different runs. The solid lines are results of a Monte Carlo simulation.