STRANGE PARTICLE PRODUCTION AT THE SPS-COLLIDER

UA5 Collaboration

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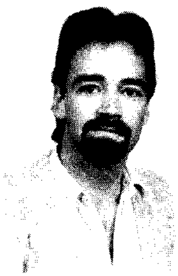


ABSTRACT

Results from the UA5 streamer chamber experiment on strange particle production are presented, obtained during the second run of the CERN $\bar{p}p$-collider at $\sqrt{s}$ = 540 GeV in September 1982. The data are still preliminary but already confirm the increase of the average transverse momenta of K^0_s and Λ / $\bar{\Lambda}$ observed previously. The K/π ratio is found to be 12.3 $\pm$ 1%. The multiplicity dependence of strange particle production is studied and no significant effect is seen. For the first time Ξ-production is observed at the SPS-Collider.

1. APPARATUS

A schematic layout of the UA5 detector [1], as used in the second collider run in September 1982, is shown in fig. 1. It consisted of two large streamer chambers (6 m x 1.25 m x 0.5 m)

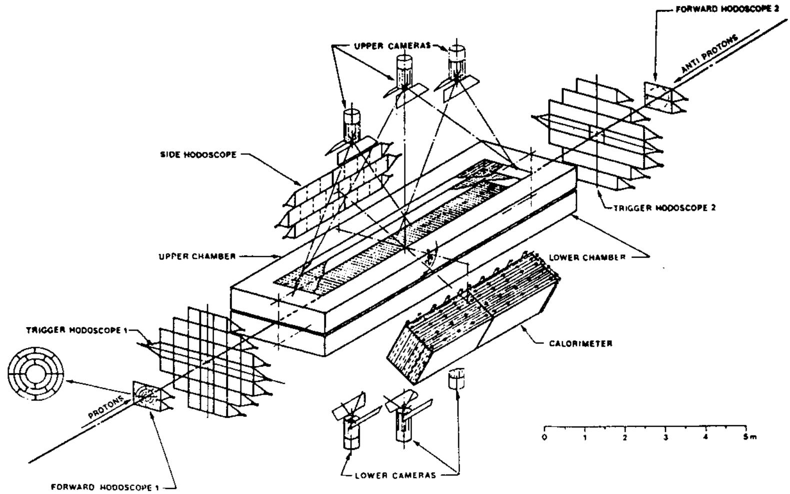


Fig. 1 Schematic layout of the UA5 detector (September 1982 run)

placed 4.5 cm above and below the SPS beam axis. This small distance between the sensitive volumes and the interaction point left a significant probability to observe neutral strange particle decays in the chambers. Each chamber was viewed by 3 cameras, equipped with image intensifier tubes, each of which recorded a stereo pair of views. Compared to the first collider run in October/November 1981 the 0.4 mm thick corrugated steel beam pipe was replaced by a 2 mm beryllium vacuum chamber thus reducing the number of electromagnetic background tracks by a factor of ~ 5.

The trigger was provided by 4 modular planes of scintillation counter hodoscopes forming the 2 arms of the trigger system which covered the pseudorapidity ranges $2 < |\eta| < 5.6$ ($\eta = -\ln \tan \theta/2$, θ = polar production angle in the C.M.). Our basic 'minimum bias' trigger which demanded at least 1 hit in each arm in coincidence with a bunch-bunch-crossing accepted $\sim$ 95% of the non single diffractive (NSD) inelastic cross section. Due to the absence of a magnetic field charged particles produced straight tracks in the chambers so that for individual charged particles the measurement of momentum was impossible. This was different in the case of 2-body decays of neutral strange particles where the measured decay angles in the laboratory frame could be used to determine the 4-momentum. Fig. 2 shows an event containing 3 two-prong neutral decays (V's) and a one-prong charged decay.

2. DATA ANALYSIS

The search for V-decays visible in the chambers was done in two independent ways: first by scanning the events on film visually and secondly by using the digitized and reconstructed track measurements. All decay candidates found by each of these methods were checked visually. Since the scan- and the measurement-search for V's were performed independently, the efficiency for a decay to appear in the final sample could be calculated. This 'finding' efficiency was obtained as 96 ± .5%.

The sample of V's found was a mixture of K^o_s, $\Lambda/\bar{\Lambda}$, K^o_L and photon conversions in the chamber gas. To remove the photon conversions the opening angle of the V's was required to be greater than 3°. To separate K^o_L decays the fact was used that K^o_s and $\Lambda/\bar{\Lambda}$ decay into 2 particles whereas K^o_L perform 3-body decays producing V's not being coplanar with the primary interaction vertex. Each of the coplanar V's was then interpreted as $K^o_s \rightarrow \pi^+\pi^-$ and the decay angle θ^*_K in the rest frame calculated from the measured laboratory angles. Since $\Lambda/\bar{\Lambda}$ decays reconstructed as K^o_s yield large values of $|\cos\theta^*_K|$ a cut at $|\cos\theta^*_K| = 0.5$ left a clean K^o_s sample with less than 2% contamination of $\Lambda/\bar{\Lambda}$. On the other hand, K^o_s populate the $\cos\theta^*_K$ distribution uniformly so that the number of $\Lambda/\bar{\Lambda}$ as well as other properties could be deduced by subtraction.

3. RESULTS ON NEUTRAL STRANGE PARTICLE PRODUCTION

3.1 Introduction

The results of the 1982 run presented here are based on ∿6500 measured minimum bias events. They are compared to the already published results of the 1981 run [2] based on ∿ 2100 events. All 1982 results refer to the pseudorapidity range $|\eta| \leq 3.5$ where the probability to observe V-decays in the chambers is sufficiently large.

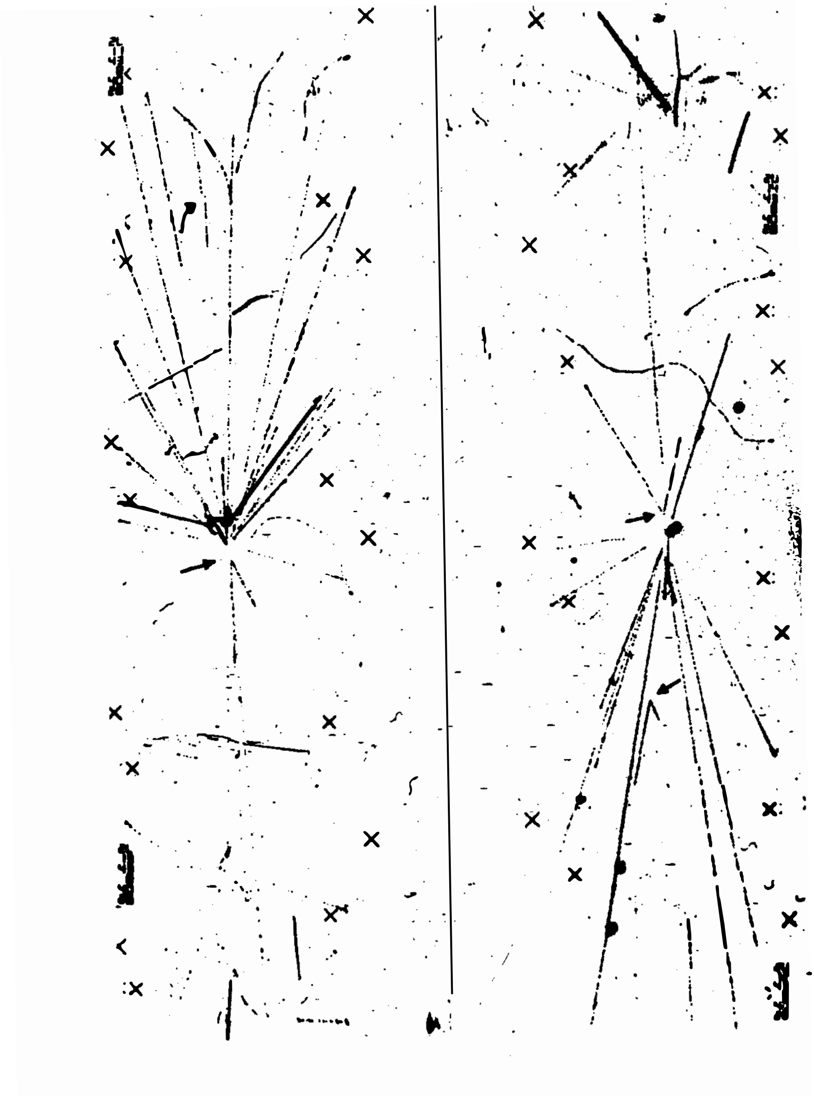
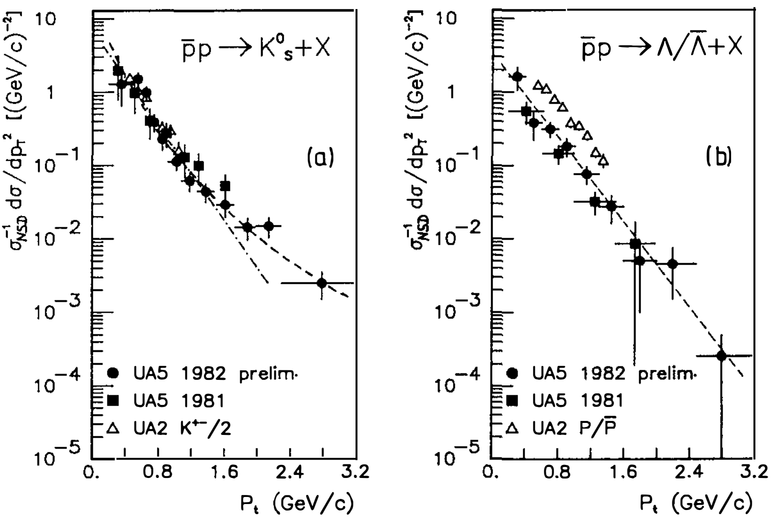


Fig. 2 An event as seen by the lower chamber (left) and upper chamber (right) [one stereo view only]. The arrows point to strange particle decay candidates: a V and a one-prong charged decay in the lower, two V's in the upper chamber.

A Monte Carlo program was used to correct the data for the geometrical detector efficiency and the various cuts applied to the V-sample. Further corrections were made for trigger losses, scanning and measuring losses and for unseen neutral decay modes. The observed number of decays used for the analysis are given in table 1.

3.2 Inclusive distributions

Fig.3a shows the inclusive p_T distribution for the K_s^o sample compared to our published 1981 result and the distribution obtained by the UA2 collaboration for charged kaons[3]. The dashed dotted straight line shows the result of fitting the p_T spectrum with an exponential in p_T, e^{-bp_T}, a form which describes the distribution fairly well for $P_T \leq 1.4$ GeV/c. A fit of the empirical form $A\cdot(P_T^o)^n/(P_T+P_T^o)^n$ as already used by the UA1 collaboration to fit their P_T spectrum of charged hadrons[4] describes the data well over the entire range of P_T observed as indicated by the dashed curve in fig. 3a. To estimate the average P_T we proceed as



<u>Fig. 3</u> Inclusive transverse momentum distribution for K_s^o (a) and $\Lambda/\bar{\Lambda}$ (b). The curves represent fits described in the text.

follows: for the oberved range of P_T down to .2 GeV/c we use the result of the power law fit. To take however into account that this power law parametrization overestimates the P_T spectrum at small P_T, we assume for the range $0 \leq P_T \leq .2$GeV/c a simple exponential in P_T. The resulting average transverse momentum for K_s^o $\langle P_T \rangle = .56 \pm .06$ GeV/c is compared in fig. 4a with our 1981 result and with lower energy data[5]. We observe a ∿ 30% increase of $\langle P_T \rangle$ for kaons to the collider energy.

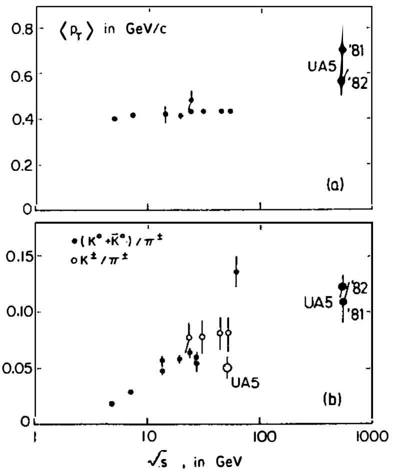


Fig. 4 Dependence on centre-of-mass-energy (a) of inclusive kaon average transverse momentum (b) K/π ratio

The inclusive P_T distribution for $\Lambda/\bar{\Lambda}$ is shown in fig. 3b and compared to our 1981 data and the distribution measured by the UA2 collaboration for $p/\bar{p}$[3] having about the same P_T dependence. The $\Lambda/\bar{\Lambda}$ distribution is consistent with an exponential form e^{-bP_T} over the observed P_T range as indicated by a straight line in fig. 3b. Assuming an exponential form to hold at all P_T one gets for the average transverse momentum of $\Lambda/\bar{\Lambda}$: $\langle P_T \rangle = .64 \pm .07$ GeV/c. This value is in good agreement with our previous result of $.67 \pm .2$ GeV/c.

The inclusive pseudorapidity distributions for the K_s^o sample, shown in fig. 5a for the two runs, are consistent with each other. Fig. 5b shows the corresponding distribution in rapidity $y = .5 \ln[(E + P_L)/(E - P_L)]$, E and P_L being the energy and the longitudinal momentum of the particle.

3.3 Strange particle yields and K/π ratio

The corrected average numbers of K_s^o and $\Lambda/\bar{\Lambda}$ produced per inelastic event in $|\eta| \leq 3.5$ are given in table 1. For comparison of the K_s^o results with lower energy data we calculated the ratio of neutral kaons $(K^o + \bar{K}^o)$ to charged pions. The average number of charged pions was obtained by integrating our published

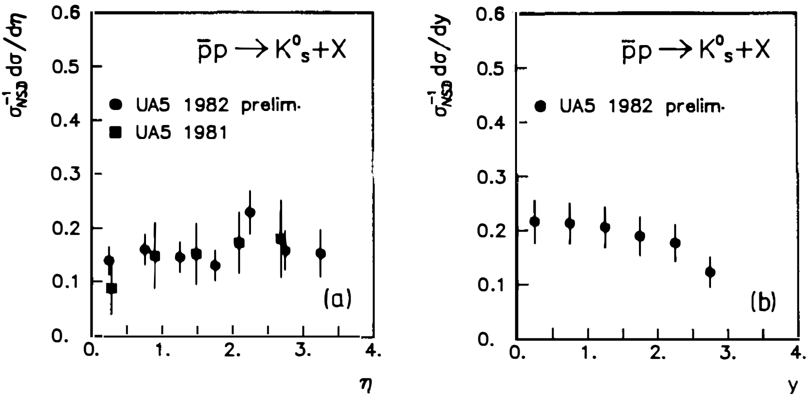


Fig. 5 Inclusive distribution for K_s^0 in pseudorapidity η (a) and rapidity y (b).

charged particle pseudorapidity distribution[6] over $|\eta| \leq 3.5$ and subtracting the average numbers of charged kaons (assuming $\langle K^{\pm}\rangle = 2\langle K_s^0\rangle$) and $p/\bar{p}$ (assuming $\langle p/\bar{p}\rangle = 3\langle \Lambda/\bar{\Lambda}\rangle$). The resulting $(K^0+\bar{K}^0)/\pi^{\pm}$ ratio of 12.3 ± 1% in the range $|\eta| \leq 3.5$ is shown in fig. 4b together with our previous result, 11 ± 2%, and compared with lower energy data.[5,7] With the exception of one of the ISR results we observe a continuous increase of the K/π ratio with energy.

TABLE 1

Neutral strange particle yields

	decay type	UA5 (1982) ∿6500 events		UA5 (1981) ∿2100 events
		$\|\eta\| \leq 3.5$	$\|\eta\| \leq 3$	$\|\eta\| \leq 3$
uncorrected no. of decays used	K_s^0	344	318	92
	$\Lambda/\bar{\Lambda}$	247	237	46
mean no. per event (corrected)	K_s^0	1.12±.09	.98±.08	1.0 ±.2
	$\Lambda/\bar{\Lambda}$	.49±.05	.44±.05	.35±.1

3.4 Multiplicity dependence

The increased V-statistics now available (a factor of ∿4 compared to the 1981 run) enables us to study the production of strange particles in more detail. To investigate the multiplicity dependence of strange particle P_T spectra we divided the K_s^0 sample into 2 subsamples belonging to different intervalls of the observed charged event multiplicity. The P_T distributions for the 2 K_s^0 samples are shown in fig. 6. Within errors the distributions are the same indicating that the P_T spectrum of K_s^0 does not depend on the event multiplicity.

The multiplicity correlation between neutral strange particles and charged particles is illustrated in fig. 7 showing the average number of V's observed per event in the range $|\eta| \leq 3.5$(*) as a function of the number of charged particles observed in the same pseudorapidity range. For both the K_s^0 and the coplanar V-sample (K_s^0 and $\Lambda/\bar{\Lambda}$) the data are consistent with a linear increase.

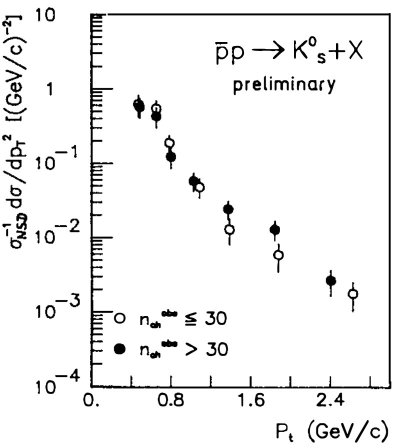


Fig. 6 K_s^0 P_T distribution for 2 ranges of observed charged multiplicity.

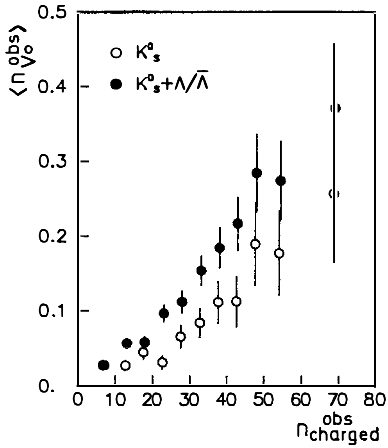


Fig. 7 Multiplicity correlation between neutral strange particles and charged particles (raw data)

4. FIRST OBSERVATION OF Ξ-PRODUCTION AT THE SPS-COLLIDER

In scanning our films for V-candidates we observed some V's associated to a one-prong decay of a charged particle (fig. 8) which is the typical decay topology of the decays of Ξ^--particles $\Xi^- \to \Lambda\pi^-$, $\Lambda \to p\pi^-$ or their corresponding antiparticles. So far 10 good cascade candidates have been found in our event sample. A Monte

(*) raw data not yet corrected for the losses described in section 3.1.

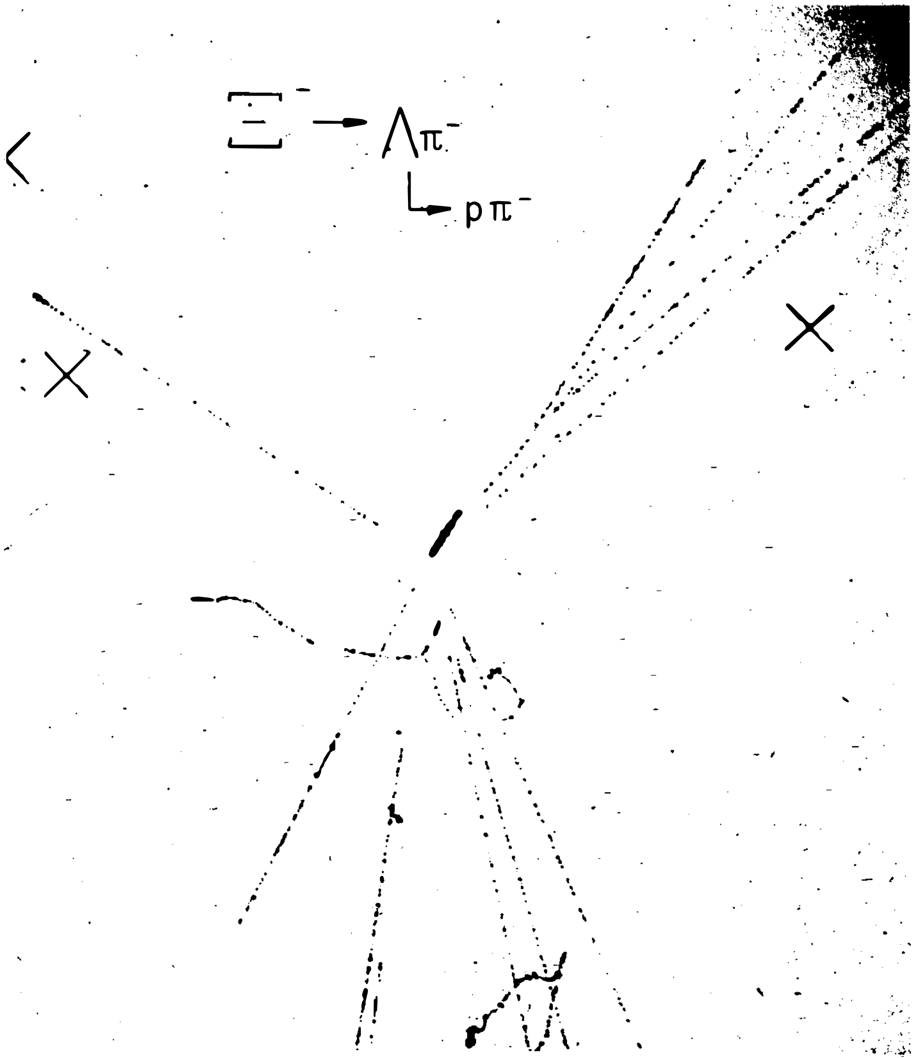


Fig. 8   Decay of a cascade particle.

Carlo study of possible sources of background e.g. Ω^- decays, random associations of V's and one-prong charged decays, hadronic interactions in the chamber gas etc. showed that ≤ 1 event in our present cascade sample could be background.

5. SUMMARY

New data on strange particle production in $p\bar{p}$ interactions at $\sqrt{s}$ = 540 GeV have been presented. The results of the second collider run in 1982 are in good agreement with the already published 1981 data.

i) The average multiplicity per inelastic event in the range $|\eta| \leq 3.5$ is 1.12$\pm$.09 for K_s^o and .49$\pm$.05 for $\Lambda/\bar{\Lambda}$.

ii) The average transverse momenta are found to be .56$\pm$.06 GeV/c for K_s^o and .64$\pm$.07 GeV/c for $\Lambda/\bar{\Lambda}$.

iii) The ratio of neutral kaons ($K^o+\bar{K}^o$) to charged pions is found to be 12.3 $\pm$ 1%.

iv) So far there is no indication for a multiplicity dependence of the K_s^o P_T spectrum.

v) The average number of observed neutral strange particles increases with the observed charged multiplicity.

vi) For the first time Ξ-production was observed at the SPS-collider.

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