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**Λ AND, $\bar{\Lambda}$ PRODUCTION IN SULPHUR-TUNGSTEN INTERACTIONS
AT 200 GeV/c PER NUCLEON
WA85 Collaboration**

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ABSTRACT

Results from the WA85 Experiment at the CERN Ω Spectrometer are presented. A 200 A GeV/c beam of ^{32}S ions was used with a tungsten target. The apparatus is used to detect V^0 's and charged tracks in the range $p_T > 0.9$ GeV/c and $2.3 < Y_{\text{lab}} < 3.0$. Production of Λ , $\bar{\Lambda}$ and negative hadrons all show a linear increase with rapidity density in the range from 70 to 140 as expected from models based on a superposition of independent NN collisions.

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The WA85 Experiment [1] was performed using the CERN Omega spectrometer with a 200 A GeV/c beam of ^{32}S ions incident on a tungsten target in order to probe the dynamics of hadronic matter under extreme conditions where it has been suggested that a Quark–Gluon Plasma (QGP) may be formed. For this purpose we have studied strangeness production at $p_T > 0.9$ GeV/c and in the central rapidity region.

Strange particle [2–5] and in particular strange baryon and antibaryon [3,5] production is expected to be a useful probe for the dynamics of hadronic matter in heavy ion collisions. In addition, it has been proposed [6] that strange particles with medium p_T (≥ 1 GeV/c) should originate from the early stages of the QGP, allowing a more direct observation of the QGP than via the large number of particles produced at low p_T during hadronization.

Experimental results on strangeness production in heavy ion collisions have been presented by E802 who see an enhancement in K^+ production [7]. Recent NA35 results [8] from S + S interactions at 200 A GeV/c also indicate strangeness enhancement; Λ and K^0 production is reported which is larger than what expected from a superposition of nucleon–nucleon interactions. They observe a faster than linear increase with the event multiplicity, i.e. with the centrality of the impact; such an effect was not observed in O + Au at 200 A GeV/c [9].

In this paper, we present a study of the multiplicity dependence of both Λ and $\bar{\Lambda}$ at $p_T > 0.9$ GeV/c and central rapidity, thus allowing a direct comparison of baryons and antibaryons. We also present the multiplicity dependence for negative hadrons (mainly pions) in the same kinematic region.

The WA85 set-up is designed to enable the central rapidity, medium p_T region to be studied at high rates. Several tracks are recorded out of several hundred produced in a central collision making reconstruction of both strange and multi-strange baryons possible in this kinematic region. 10^7 triggers were recorded in ten days of data taking.

The layout of the apparatus is shown in fig. 1. A quartz Cerenkov counter was placed in the beam upstream of the target to identify sulphur ions. The beam was incident on a thin tungsten target (0.005 interaction lengths) placed in the Omega magnetic field. Tracks were measured using seven multiwire proportional chambers (MWPCs) placed in the magnetic field. The MWPC planes were operated with a "butterfly" geometry [10] using only the upper hemisphere. This technique has already been used at the Omega Spectrometer for the WA77 Experiment [11]. The sensitive region of the chambers was chosen so that charged particles from the target can reach it through the magnetic field only if

$$p_T > 0.6 \text{ GeV/c}$$

$$2.2 < Y_{\text{lab}} < 3.2.$$

The p_T threshold for particles coming from V^0 decays is somewhat lower as they travel a shorter distance in the magnetic field. The two hodoscopes HZ0 and HZ1 also have a butterfly shape and detect particles in the same p_T – rapidity range as the chambers; each hodoscope was divided into four quadrants with 6 active elements each.

Two arrays of 50 μm pitch silicon microstrips, each with 512 channels, were placed above and below the beam 15 cm downstream from the target in order to sample the overall multiplicity for central rapidities, i.e. in the pseudorapidity range

$$2.1 < \eta < 3.4.$$

Microstrip multiplicity, henceforth called multiplicity, is defined as the total number of strips hit in the upper and lower microstrip arrays.

A hadron calorimeter was placed 25 m downstream of the target to veto non central events.

The trigger required:

- (a) an incident sulphur ion identified in the beam Cerenkov,
- (b) a minimum multiplicity (≥ 6) in each of the microstrip arrays,
- (c) at least one hit in at least two quadrants of the hodoscope HZ1, and
- (d) low energy deposited in the forward hadron calorimeter.

It was designed to select events where a sulphur ion (condition (a)) had interacted in the target region (condition (b) and condition (c)). Condition (d) is used to select central events.

Fig. 2(a) shows a fully reconstructed event with a V^0 candidate. As can be seen, the number of background hits is not excessive.

These results are based on a sample of 8.5×10^6 processed triggers. We consider any pair of oppositely charged tracks as a V^0 candidate if:

- (a) the distance of closest approach between the two oppositely charged tracks is < 1.0 cm,
- (b) the angle between the sum of the three-momenta for the V^0 decay tracks and the line of flight from the centre of the target is $< 0.75^\circ$, i.e. the candidate comes from the target,
- (c) each track traces through the seven MWPCs,
- (d) the decay distance is > 140 cm, and
- (e) the V^0 momentum is > 6.5 GeV/c.

The quality of the V^0 candidates can be assessed by studying their distribution on the Podolanski–Armenteros [12] plot. The three-momenta of the V^0 decay particles are resolved into components q_L^+ , q_L^- parallel to the direction of motion of the V^0 for positive and negative tracks respectively, and q_T transverse to the direction of motion. The variable α is defined by: $\alpha = (q_L^+ - q_L^-)/(q_L^+ + q_L^-)$.

The distribution for the data is shown in fig. 2(b) where clear accumulations are seen along bands corresponding to the Λ , $\bar{\Lambda}$ and K^0 ellipses. A depletion of Λ and $\bar{\Lambda}$ candidates can be seen at high values of $|\alpha|$ due to the geometrical acceptance of the apparatus. We consider Λ and $\bar{\Lambda}$ candidates over the full kinematically allowed region ($|\alpha| > 0.45$). To eliminate the small number of candidates corresponding to gamma conversions we require $q_T > 0.01$ GeV/c. The background due to tracks from the primary vertex is removed by demanding non-zero impact parameters for the tracks from V^0 candidates at the target plane in the bend direction of the magnetic field. We require the impact parameter $\Delta y > 1.8$ cm for the π^- (π^+) and $\Delta y > 0.8$ cm for the $p(\bar{p})$ from $\Lambda(\bar{\Lambda})$. A Monte Carlo study has shown that this cut has no effect on good V^0 candidates, the decay tracks from which cannot point back to the target. For this paper we consider the region $2.3 < Y_{\text{lab}} < 3.0$ and $p_T > 0.9$ GeV/c. The resulting mass plots are shown in figs 3(a,b). We select candidates in a 50 MeV mass interval centred on the Λ mass, giving 8671 Λ and 2103 $\bar{\Lambda}$ candidates. The rapidity and p_T distributions for these candidates are shown in figs 3(c–f).

We have estimated from the Podolanski–Armenteros plot distribution that the K^0 contamination in these Λ and $\bar{\Lambda}$ samples is 6% and 24% respectively; this has been found not to vary with multiplicity.

A preliminary study has been made of Λ , $\bar{\Lambda}$ and negative hadron production as a function of the charged multiplicity measured by the silicon microstrips. These multiplicities range from 12 to 80. The multiplicity region below 35 is contaminated by interactions taking place in the ceramic supports of the silicon microstrips rather than the tungsten target. For this paper we consider the region above 35 in multiplicity where this effect can be neglected.

We have studied the multiplicity dependence of negative hadrons detected in the butterfly MWPCs. We consider the same rapidity and p_T region as that defined for the Λ and $\bar{\Lambda}$ samples. Fig. 4(a) shows the average number of negative hadrons per event, $\langle n^- \rangle$, as a function of multiplicity corrected for geometrical acceptance (triangles) and for both geometrical acceptance and track reconstruction efficiency (circles).

A simulation study using the FRITIOF 3.1 Monte Carlo program [13] adapted for our set-up shows that the mean rapidity density for tracks in the region $2.3 < Y_{\text{lab}} < 3.0$ is proportional to the multiplicity and it is shown in the lower scales of fig. 4.

Figs 4(b) and (c) show the average number of Λ and $\bar{\Lambda}$ per event, $\langle n_{\Lambda} \rangle$ and $\langle n_{\bar{\Lambda}} \rangle$ respectively, as a function of multiplicity. The data are corrected for geometrical acceptance, including correction for decays outside the fiducial region and unseen decay modes (triangles) and both for geometric acceptance and reconstruction efficiency^(*) (circles). The acceptances are calculated under the assumption that Λ and $\bar{\Lambda}$ are unpolarized.

Fig. 4(d) shows the ratio of Λ , $\bar{\Lambda}$, and negative hadron yields to multiplicity as a function of multiplicity. The ratio for negative hadrons is essentially constant over the multiplicity range considered. For the Λ sample, the ratio is also consistent with being constant over the same range, and we note that no increase is predicted by models based on a superposition of independent NN collisions. For example a FRITIOF 3.1 [13] simulation predicts, under our experimental conditions, a constant ratio over our range of multiplicities both for Λ and for negative hadron production. The $\bar{\Lambda}$ sample has lower statistics and the ratio is also compatible with being constant as a function of multiplicity. A comparison of the Λ and $\bar{\Lambda}$ yields with proton–tungsten reference data is underway.

In conclusion, we present a preliminary study of $p_T > 0.9$ GeV/c central Λ and $\bar{\Lambda}$ production in 200 A GeV/c sulphur–tungsten interactions. The multiplicity dependence for Λ , $\bar{\Lambda}$ and negative hadrons has been studied in the same $Y_{\text{lab}} - p_T$ region. The average number of negative hadrons shows a linear rise over the multiplicity range investigated i.e. over the rapidity density range $70 < dN/dy < 140$. The Λ and $\bar{\Lambda}$ ratios are also compatible with this behaviour, with no evidence for a faster than linear increase over the rapidity density range considered. We note that the FRITIOF model, which is based on a superposition of independent NN collisions, predicts a similar behaviour in all three cases.

(*) The reconstruction efficiencies are good over the multiplicity range considered, decreasing from 90% to 60% for single tracks and from 85% to 40% for Λ s and $\bar{\Lambda}$ as the multiplicity increases from 24 to 70. These efficiencies have been determined by implanting simulated Λ , $\bar{\Lambda}$ and π^- in real events of varying multiplicity. We estimate that the systematic error they introduce is less than 10%.

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FIGURE CAPTIONS

Fig. 1 Layout of the WA85 Experiment.

Fig. 2 (a) Example of a fully reconstructed event with a V^0 candidate.

(b) Podolanski-Armenteros plot for V^0 candidates.

Fig. 3 Effective mass distributions for V^0 candidates as (a) $p\pi^-$ and (b) $\bar{p}\pi^+$; (c) rapidity and (d) p_T distributions for uncorrected Λ data; (e) rapidity and (f) p_T distributions for uncorrected $\bar{\Lambda}$ data.

Fig. 4 (a) $\langle n^- \rangle$, (b) $\langle n_\Lambda \rangle$ and (c) $\langle n_{\bar{\Lambda}} \rangle$ as a function of measured multiplicity: circles show data corrected for geometrical acceptance and reconstruction efficiency and triangles show data with acceptance correction only. The errors are statistical only. (d) $\langle n^- \rangle / \text{multiplicity}$, $\langle n_\Lambda \rangle / \text{multiplicity}$ and $\langle n_{\bar{\Lambda}} \rangle / \text{multiplicity}$ as a function of multiplicity. Points for negative particles have been divided by 2, points for $\bar{\Lambda}$ have been multiplied by 2. The data are corrected for geometric acceptance and reconstruction efficiency. The lower scale shows the average rapidity densities (evaluated in the interval $2.3 < Y_{\text{lab}} < 3.0$) which correspond to the measured multiplicity.

Fig. 1

Fig. 2

Fig. 3

Fig. 4