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STUDY OF Λ-NUCLEON INTERACTIONS IN DEUTERIUM*

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I. INTRODUCTION

An experiment has been performed to study principally the inelastic Λ-nucleon reactions up to a momentum of about 1500 MeV/c, using the LRL 25-inch bubble chamber filled with deuterium. The technique used is the same as used for study of Λ interactions in hydrogen,[1] viz., use of an internally-mounted platinum plate as a target for a K^- beam. The results presented here, based on an analysis of 90,000 pictures, are preliminary, and confined to the study of reactions:

$$\Lambda d \rightarrow \Sigma^- pp \qquad (1)$$

and

$$\Lambda d \rightarrow \Lambda pp\pi^- \quad . \qquad (2)$$

The use of deuterium as the medium for inelastic Λ interactions is motivated by several factors. The rates of reactions (1) and (2) are expected to be enhanced by virtue of charge independence by a factor of 2 over the corresponding analyzable Λp reactions, $\Lambda p \rightarrow \Sigma^0 p$ and $\Lambda p \rightarrow \Lambda p\pi^0$. Furthermore, reaction (1) is enhanced by an additional factor of 1.5 since all Σ^- particles decay visibly. Finally a better kinematic fit to the interaction should result from the higher constraint class of (1) and (2); namely 3 constraint, rather than 1C and 0C respectively for the hydrogen reactions.

II. SCANNING AND MEASURING CRITERIA; TOPOLOGIES

The film was scanned for events with topologies having a V^o or a Σ^- decay associated with a production vertex in the liquid. The production vertex in deuterium may have 1, 2, or 3 prongs. The one-prong events which have not yet been analyzed contain mainly events of the following type:

$$\Lambda d \rightarrow \Lambda pn \tag{3}$$

and

$$\Lambda d \rightarrow \Lambda d \quad . \tag{4}$$

In order to obtain as clean a sample of events as possible the following requirements were imposed:

(a) All events were restricted to an appropriate fiducial volume.

(b) The Σ^- track was required to be at least 2 mm in length.

(c) Events were required to satisfy 3C kinematic fits at the interaction vertex. The incident Λ^o line of flight was determined as described for our hydrogen experiment; and, in the case of two-prong events (spectator missing) a spectator with momentum components $p_x = p_y = 0 \pm 30$ and $p_z = 0 \pm 40$ MeV/c was assumed.

(d) Because of confusion between 2-prong $\Sigma^- pp$ events and Λ^o decays in which the π^- goes a short distance and scatters without leaving a visible recoil particle, special care was exercised to check that the bubble density of the presumed Σ^- agreed with the prediction of the fit. Furthermore for these two-prong events, the transverse momentum from the Σ decay was required to be greater than 100 MeV/c. Only 14% of real events and a much larger fraction of the background are eliminated by this cut.

(e) For the $\Lambda\pi^- pp$ events, in addition to the kinematic fit at the interaction point, the Λ decay was required to satisfy a 3C fit to that interaction point.

Appropriate weighting factors were applied to correct for losses introduced by the cuts described above. The 2-prong and 3-prong events, after these corrections were applied, came out about equal in number as expected from the known spectator momentum distributions. At present all our film has been scanned and about 20% has been rescanned. Scanning efficiency corrections based on this rescan have been applied.

III. RESULTS

After making the preceding requirements, 24 inelastic events remain in the sample, 17 for reaction (1) and 7 for reaction (2). The Λ pathlength distribution shown in Fig. 1 is derived from free Λ decays, just as in the hydrogen experiment. The total Λ pathlength for this experiment was found to be 2100 meters. Two- and three-prong Λ interaction events have been combined for the momentum and angular distributions shown in Figs. 2-5. In the case of reaction (2), the distributions are in agreement with those from the hydrogen experiment, within the very limited statistics and the average cross section for the $\Lambda p\pi^-$ reaction in the momentum range between 1200 and 1800 MeV/c is:

$$\sigma(\Lambda pp\pi^-) = 4.1 \pm 1.5 \text{ mb} .$$

Presumably this is a good measure of the cross section for the reaction $\Lambda n \to \Lambda p\pi^-$. It agrees satisfactorily with the value predicted for this reaction, 6.0±2.1 mb, based upon the events $\Lambda p \to \Lambda p\pi^0$ observed in hydrogen in the same momentum interval and application of charge independence.[2] In the case of reaction (1), there is a significant deviation in the angular distribution from that observed in hydrogen, the present data being much more strongly forward peaked. In addition, a much smaller cross section is observed. In the momentum range 600-1400 MeV/c $\sigma(\Lambda d \to \Sigma^- pp) = 5 \pm 2$ mb, while charge independence predicts a cross section of 10±2 mb, based upon the events $\Lambda p \to \Sigma^0 p$ in the same momentum range.

The deficit of Σ^- events cannot easily be attributed to scanning bias or stopping Σ^- which interact rather than decay. However rough estimates suggest that the small $\Lambda d \to \Sigma^- pp$ cross section may be due to reabsorption of the Σ within the same deuteron via the reaction $\Sigma^- p \to \Lambda^o n$. Thus the overall effect is to decrease the rate of $\Lambda d \to \Sigma^- pp$ and increase $\Lambda d \to \Lambda np$.[3] Since the reaction $\Sigma^- p \to \Lambda n$ has a cross section rapidly increasing with decreasing Σ momentum, the reabsorption effect should be most marked for slow Σ^- in good agreement with the observed angular distribution shown in Fig. 4.

We wish to thank Glen Eckman and the 25-inch bubble chamber crew, as well as the Bevatron operations staff for assistance in performing this experiment.

REFERENCES

*Work supported by the U. S. Atomic Energy Commission.

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FIGURE CAPTIONS

For each of the two reactions studied, events of the two-prong and three-prong topologies have been combined in the plots shown in Figs. 2-5. Angular distributions are for the Λ-hyperon angle in the Λ-neutron c.m. system, assuming a stationary neutron.

Fig. 1. Pathlength distribution for a sample of free Λ decays.

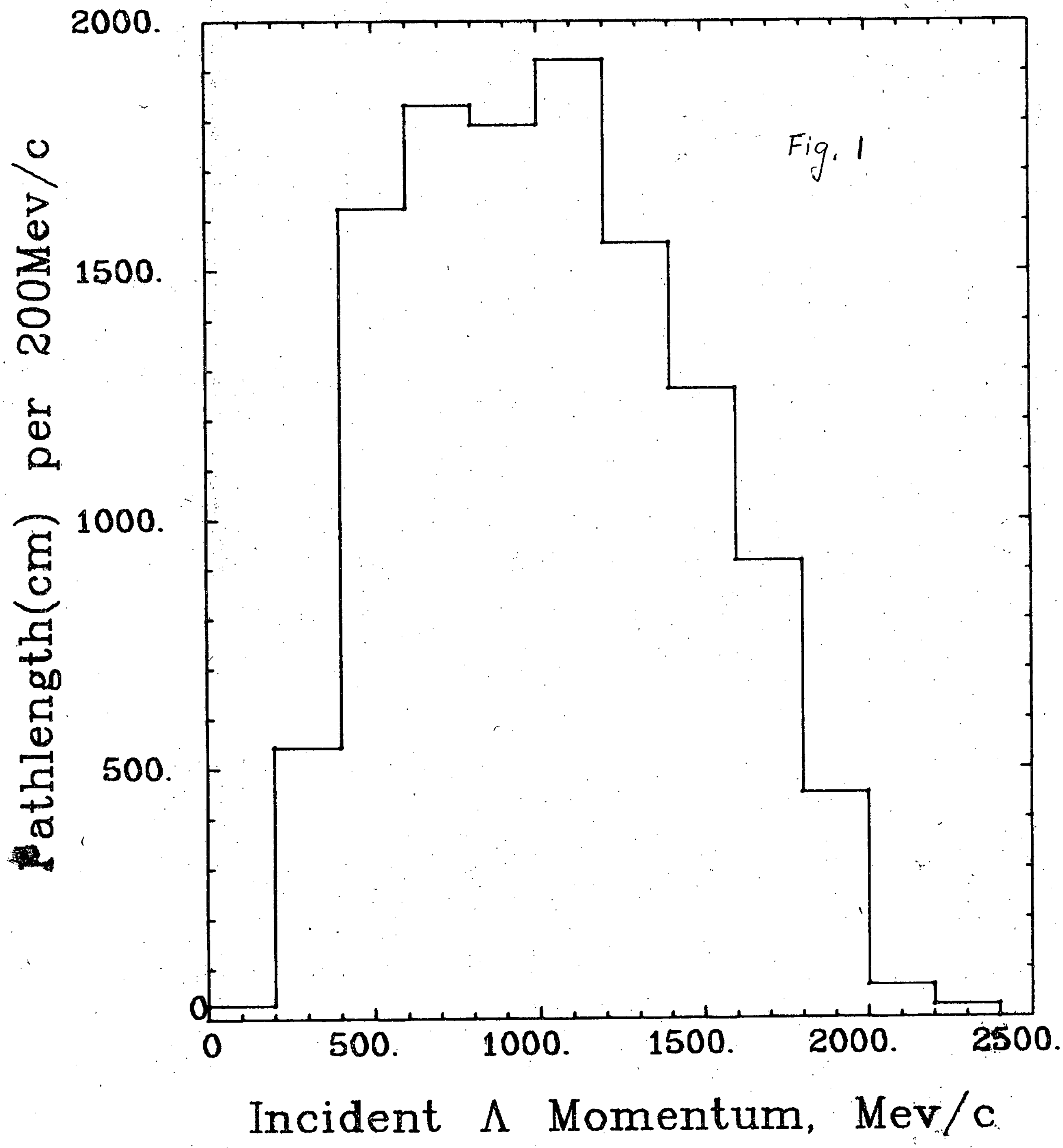
Fig. 2. Momentum distribution for events of the type $\Lambda d \rightarrow \Sigma^- pp$.

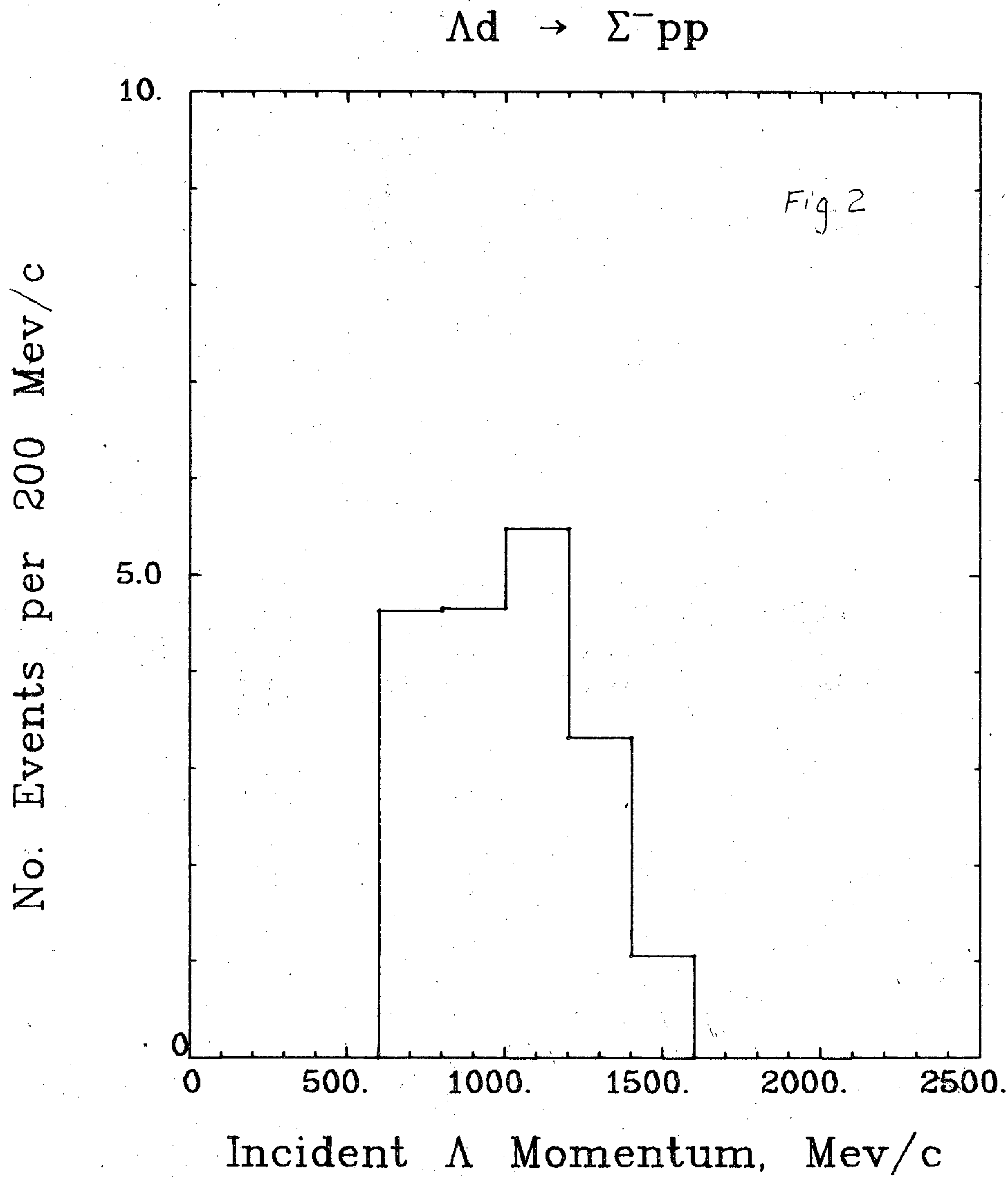
Fig. 3. Momentum distribution for events of the type $\Lambda d \rightarrow \Lambda pp\pi^-$.

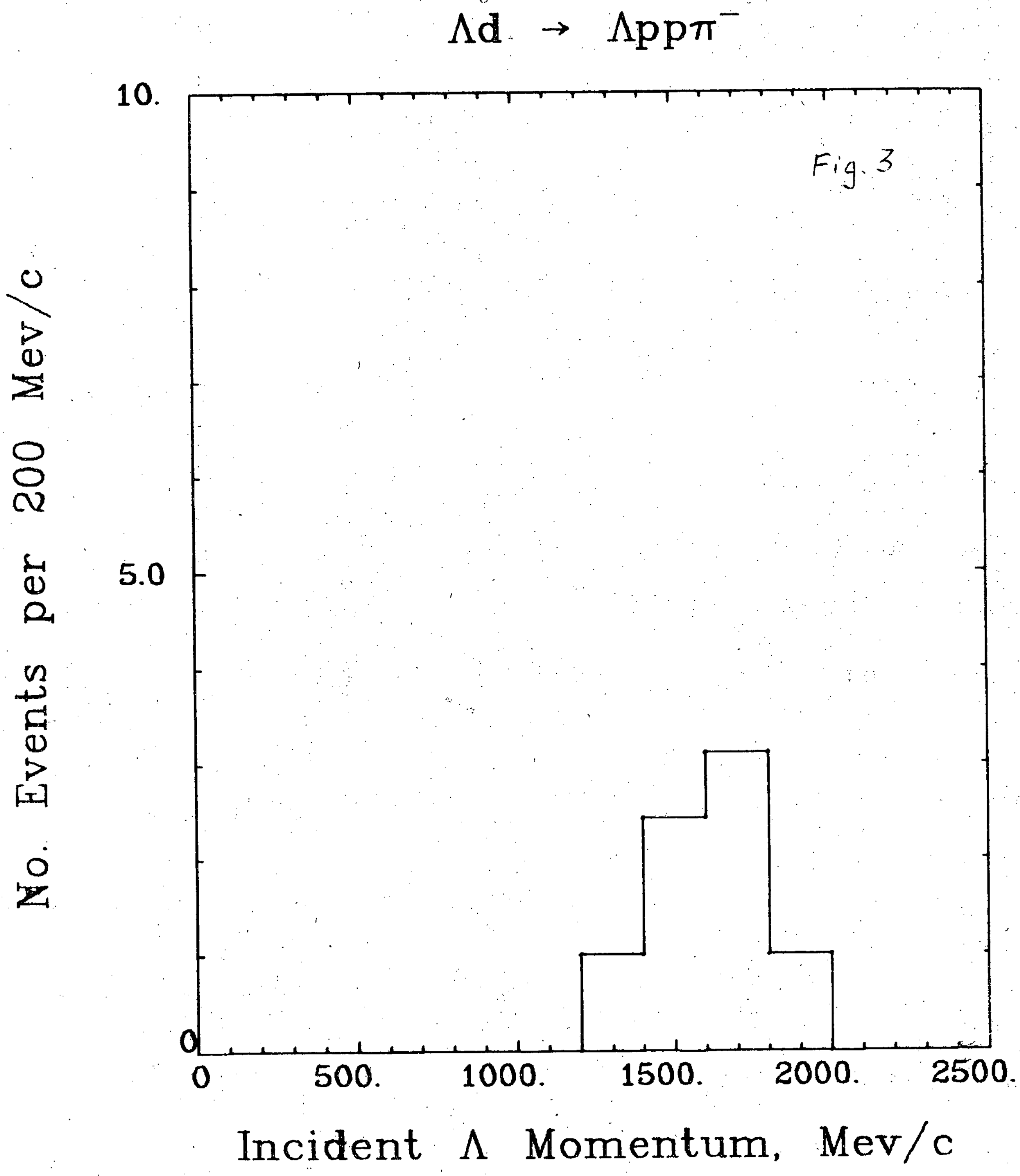
Fig. 4. Angular distribution for the reaction $\Lambda d \rightarrow \Sigma^- pp$.

Fig. 5. Angular distribution for the reaction $\Lambda d \rightarrow \Lambda pp\pi^-$.

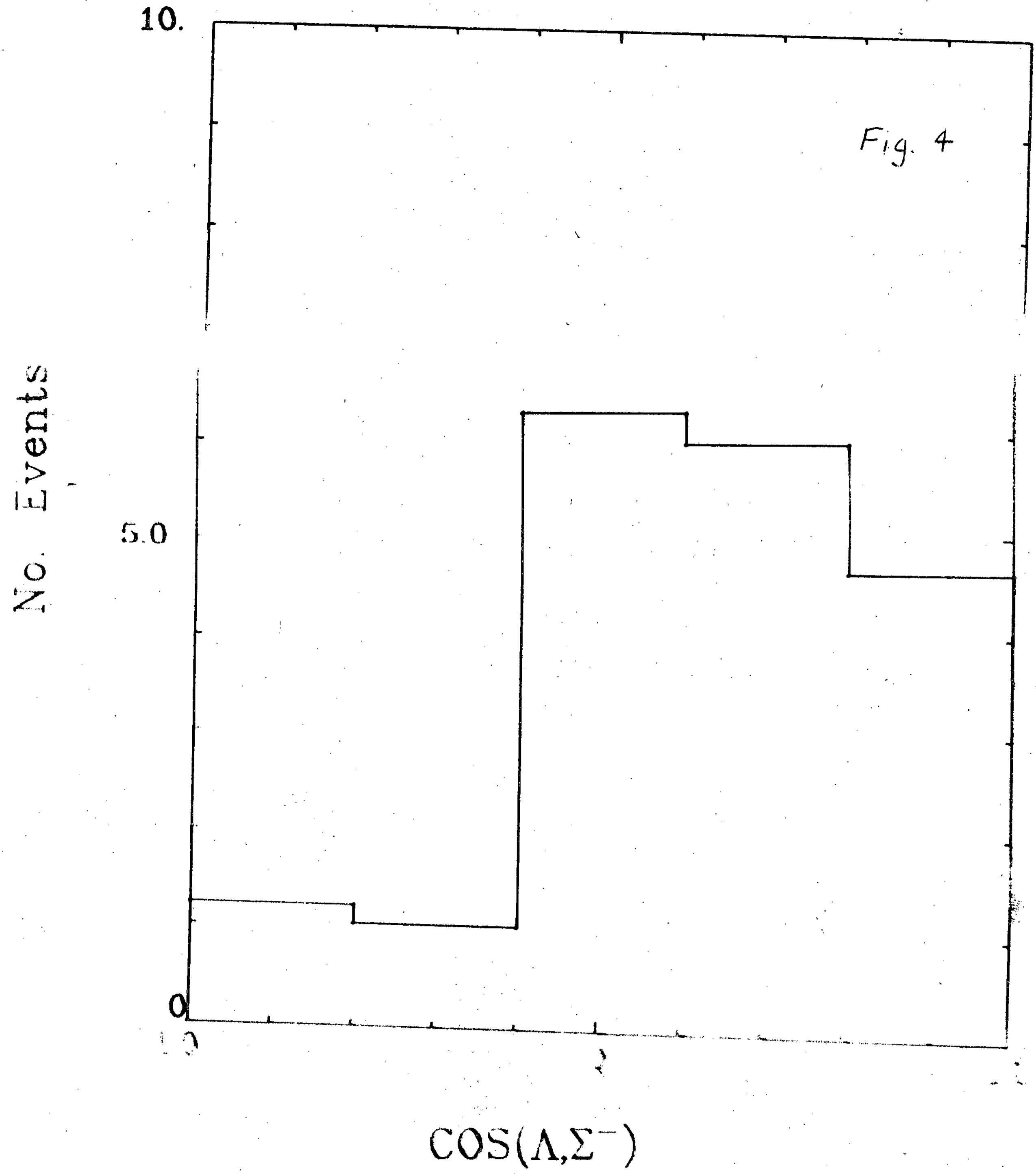
Λ PATHLENGTH DISTRIBUTION

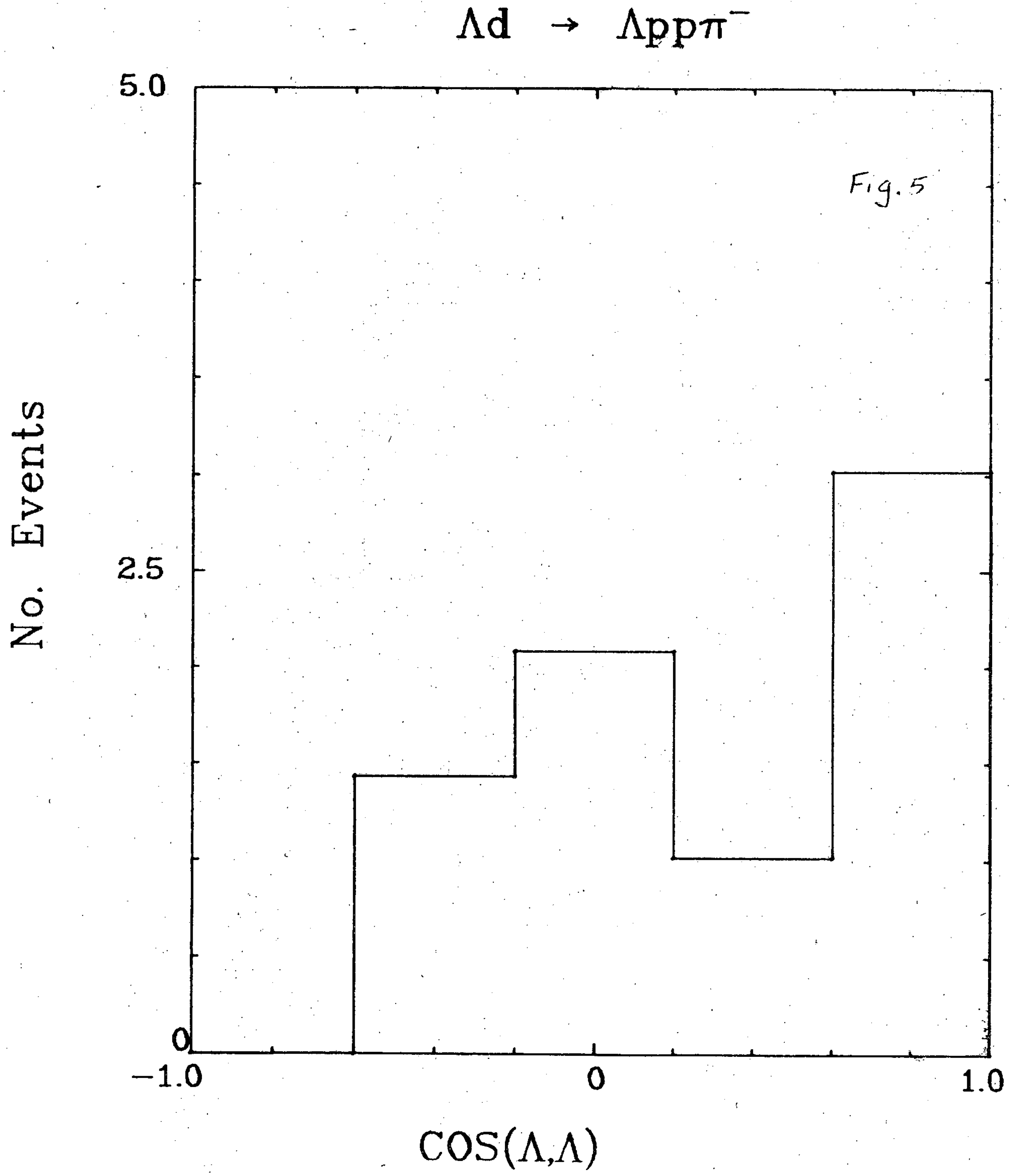



Λd → Σ⁻pp
10.
5.0
0
0
500.
1000.
1500.
2000.
2500.
No. Events per 200 Mev/c
Incident Λ Momentum, Mev/c
Fig. 2


Λd → Λppπ⁻
10.
5.0
0
No. Events per 200 Mev/c
Fig. 3
0
500.
1000.
1500.
2000.
2500.
Incident Λ Momentum, Mev/c

$\Lambda d \rightarrow \Sigma^- pp$




Λd → Λppπ⁻
5.0
2.5
0
No. Events
−1.0
0
1.0
COS(Λ,Λ)
Fig. 5

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