

SEARCH FOR A POSSIBLE  $I = 0$ ,  $Y = 0$  BARYON  
IN  $K^- D$  INTERACTIONS AT LOW ENERGY\*

Tai Ho Tan

Stanford Linear Accelerator Center  
Stanford University, Stanford, California 94305

ABSTRACT

An attempt has been made to detect possible existence of a new neutral hyperon by studying both the missing mass system and the  $\Delta\gamma$  system. Our result does not warrant the necessity of introducing any new hyperon near the mass of  $\Lambda$ , although it is not sensitive enough to dismiss the possibility entirely.

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According to  $SU_3$  scheme, existence of a singlet member belonging to the baryon nonet that contains the nucleons is possible, although its mass cannot be predicted. Even without the theoretical motivation it would still be interesting to search for any possible new  $I = 0$  hyperon near the  $\Lambda$ - $\Sigma$  mass region, hereafter referred to as  $X^0$ . An investigation in this region has not previously been reported. We have carried out a search for the possible existence of  $X^0$  that might be produced in  $K^-D$  interactions at low energy. In particular, we looked for it in the region just slightly above the mass of  $\Lambda$ . Our investigation includes the study of the missing mass system as well as the search for the possible decay products  $\Lambda + \gamma$  and/or  $\Lambda + 2\gamma$ .

Approximately 80,000 pictures were taken to study  $K^-D$  interactions by exposing the 30-inch BNL deuterium-filled bubble chamber to a low energy separated  $K^-$  beam at the AGS. About half of the  $K^-$  interacts at rest while the remainder interacts in flight with momenta ranging up to 250 MeV/c. We scanned for the following event types: (a) 2 prong that consists of a proton and a  $\pi^-$ , (b) 2 prong plus a  $\Lambda$ , and (c) both configurations associated with a Dalitz pair or with obvious  $e^+e^-$  conversion pairs. The scan for (a) and (b) covers about two-thirds of the available pictures, while the scan for (c) includes the entire exposure. To minimize the measurement errors, a fiducial region is imposed to ensure that at least 10 cm of measurable charged track length is available for all non-stopping tracks in the selected events. Events which do not contain any secondary scatterings were measured, reconstructed, and appropriately fitted to the hypotheses:

$$K^- + D \rightarrow p + \pi^- + \text{missing mass} \quad (1)$$

$$p + \pi^- + \Lambda \quad (2)$$

$$p + \pi^- + \Sigma^0 \quad (3)$$

$$p + \pi^- + \Lambda + \gamma \quad (4)$$

All events with a stopping proton having a measured track length of less than 2 mm are discarded.

Figure 1 shows the missing mass distribution from reaction (1). It includes 13,827 events, and the average mass error is estimated to be about 16 MeV. Figure 2 exhibits the  $\Lambda\gamma$  combined mass distribution from a sample of 656 stopping  $K^-$  events fitting reaction (4). These events also fit (2) and (3). From both figures it is obvious that the  $\Lambda$  and  $\Sigma^0$  peaks are very well separated. In fact, there are no ambiguous fits between hypotheses (2) and (3). Events outside the peaks were investigated. If  $X^0$  exists, its mass is not expected to be smaller than the  $\Lambda$  mass, otherwise  $\Lambda$  would have preferred to decay into  $X^0 + \gamma$  rather than decaying into the dominantly observed pion-nucleon mode. Therefore, all the events in the tail of the lower mass half of  $\Lambda$  peak may be attributed entirely to statistical errors. The events in the region between 1135 to 1170 MeV and between 1210 to 1250 MeV can also be ascribed to similar experimental uncertainties. The upper limit for the production of  $X^0$  outside  $\Lambda$  and  $\Sigma^0$  peaks is estimated to be no more than three percent of the  $\Sigma^0$  production rate. Above 1250 MeV, production of  $\pi^0$  is possible, however, no significant number of events are present in this region and the distribution is excluded. If  $X^0$  exists, its signature may be revealed only by detecting the possible decay modes such as  $\Lambda + \gamma$  and  $\Lambda + 2\gamma$ . In the event when  $X^0$  is close to the  $\Sigma^0$  peak, the separation of  $X^0$  from  $\Sigma^0$  will be almost impossible unless  $X^0 \rightarrow \Lambda + 2\gamma$ . Detection of just one  $\gamma$  will not allow unambiguous distinction from the  $\Sigma^0$ . On the other hand, chances of observing both  $\gamma$ 's is negligible in this study. However, if  $X^0$  is hidden under the  $\Lambda$  peak, then its existence can be uncovered unambiguously as long as the production rate is large enough to allow conversion of some gammas into  $e^+e^-$  pairs or detection of unambiguous Compton scatterings. We discuss the detailed examination below.

### Compton Electrons

Compton scattering cross section rises rapidly as the energy of gamma decreases. Therefore, in principle it should offer the best means to detect soft photon emission from  $K^-D$  interaction. In practice, however, it is difficult to associate the Compton electron with the interaction vertex simply by scanning. From the sample of 656 events fitting reaction (4), efforts were made to measure all possible Compton electrons that appear along the direction of the emitted gammas. At least 77 events with low energy photon fitted the reaction (4) with 7 constraints. In most cases, however, only a small fraction of the photon energy is imparted to the scattered-off electron. Therefore, spurious fits cannot be ruled out. To examine the problem we investigated the events with higher energy  $\gamma$  from  $\Sigma^0$  where less than three Compton scatterings is expected to occur. We found 32 good fits. This implies a Compton scattering cross section of  $\gamma$  at an energy of about 60 MeV to be 10 times larger than expected. Since we cannot eliminate the stray electrons from the sample, we are unable to draw any conclusions from these Compton events.

### Events with $e^+e^-$ Pair

Twenty-one events with a low energy  $e^+e^-$  pair were found to fit hypothesis (4) with 10 constraints. Another 18 events with unmeasured  $\Lambda$  were found to fit (4) with 4 constraints. The  $\chi^2$  of these events are less than four times the constraint number. The average gamma energy and  $\Lambda\gamma$  mass of these events are respectively 7.5 and 1122 MeV. Two sources of background must be considered: (a) radiation at the production vertex and (b) stray photons originated from outside the chamber volume. Contribution from (a) is estimated to be less than one event. By scanning for all  $e^+e^-$  pairs inside the chamber, we have estimated that there are about 3300 conversion pairs with energy lying between 5 to 10 MeV

for the entire exposure. From the 41 observed candidates we found that the average distance the photon traveled before conversion is about 20 cm, and the average angular uncertainty reconstructed for the gammas line-of-flight is about 1.5 degree. If we take the uncertainty of the vertex association to be about  $l\Delta\theta = .5$  cm, then the contribution ascribing to (b) is estimated to be about  $35 \pm 6$  events. This result may be interpreted as being consistent with no evidence of any  $X^0$  production. On the other hand, it is also consistent to assume that there may be  $6 \pm 6$  possible genuine candidates present. Hence, a total of about  $1000 \pm 1000 X^0$  may be produced in the reaction of the kind (1) for the entire sample because the conversion efficiency for photon at 7.5 MeV inside the fiducial region is estimated to be about 1/180. This corresponds to a production rate of about  $0.25 \pm 0.25$  times the  $\Sigma^0$  production rate via reaction (3).

#### Dalitz Pairs

Observation of associated Dalitz pair will undoubtedly provide the most convincing evidence for the existence of  $X^0$ . Using the formula in Kroll and Wada paper,<sup>1</sup> the probability of gamma conversion into Dalitz pair at 7 MeV is estimated to be about 0.002. We have not observed any candidates with Dalitz pairs at this energy nor at any other energy which is not consistent with  $\Sigma^0 \rightarrow \Lambda + e^+ + e^-$ . However, it is worth pointing out that the production of  $1 \pm 1$  Dalitz pairs could still be possible, which would imply the possibility that  $1000 X^0$  may be produced.

The result of our experiment certainly does not warrant the necessity of introducing any new hyperon near the mass of  $\Lambda$ , although it is not sensitive enough to dismiss the possibility entirely.

#### Acknowledgements

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## References

1. N. M. Kroll and W. Wada, Phys. Rev. 98, 1355 (1955). The ratio is estimated by assuming  $R_T(x) = R_T(0) = 1$  and  $R_L \leq 1$ .

## Figure Captions

1. Missing mass distributions.
2.  $\Lambda\gamma$  combined mass distributions from a sample of 651  $K^-\bar{D}$  interactions at rest.

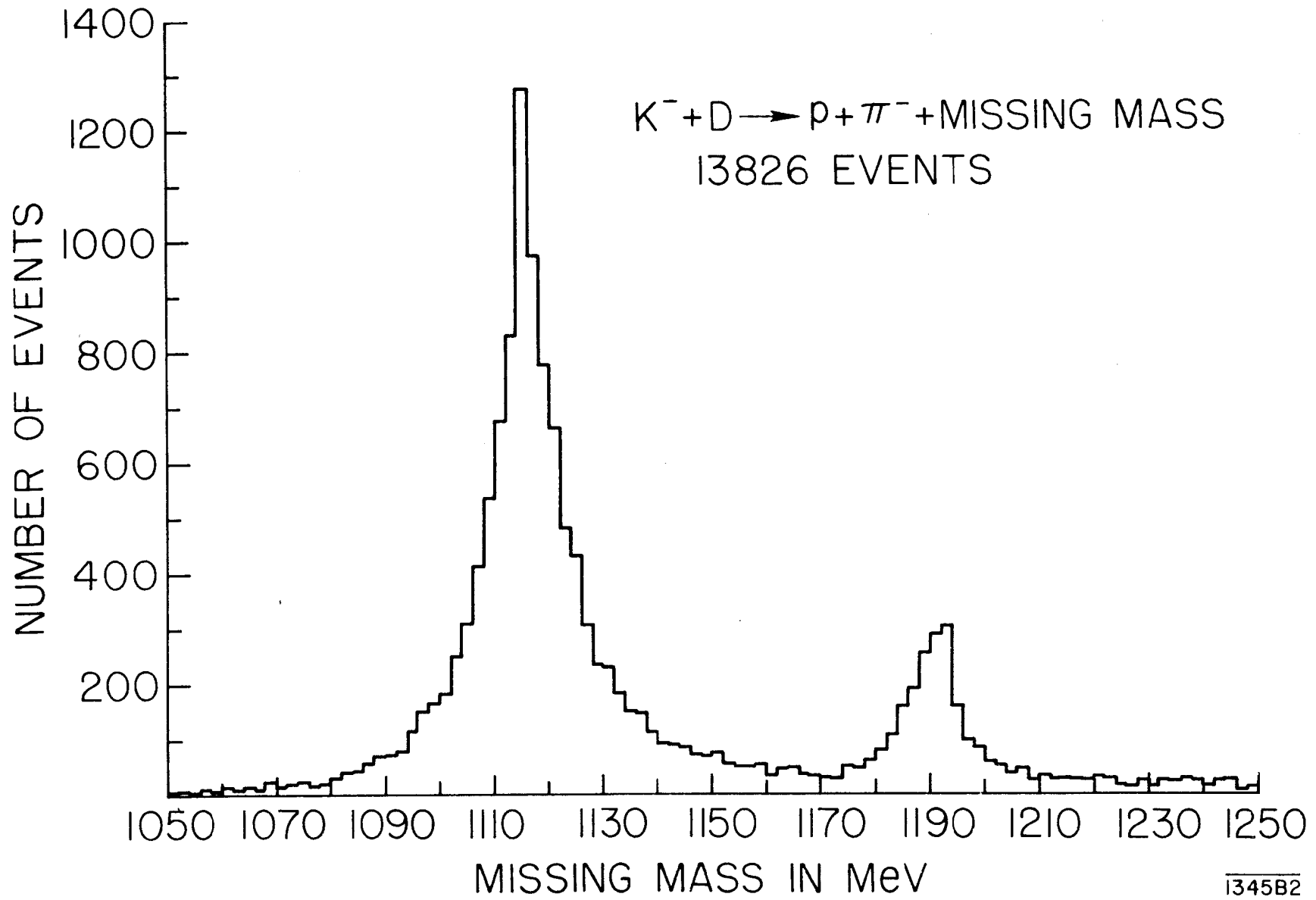


Fig. 1

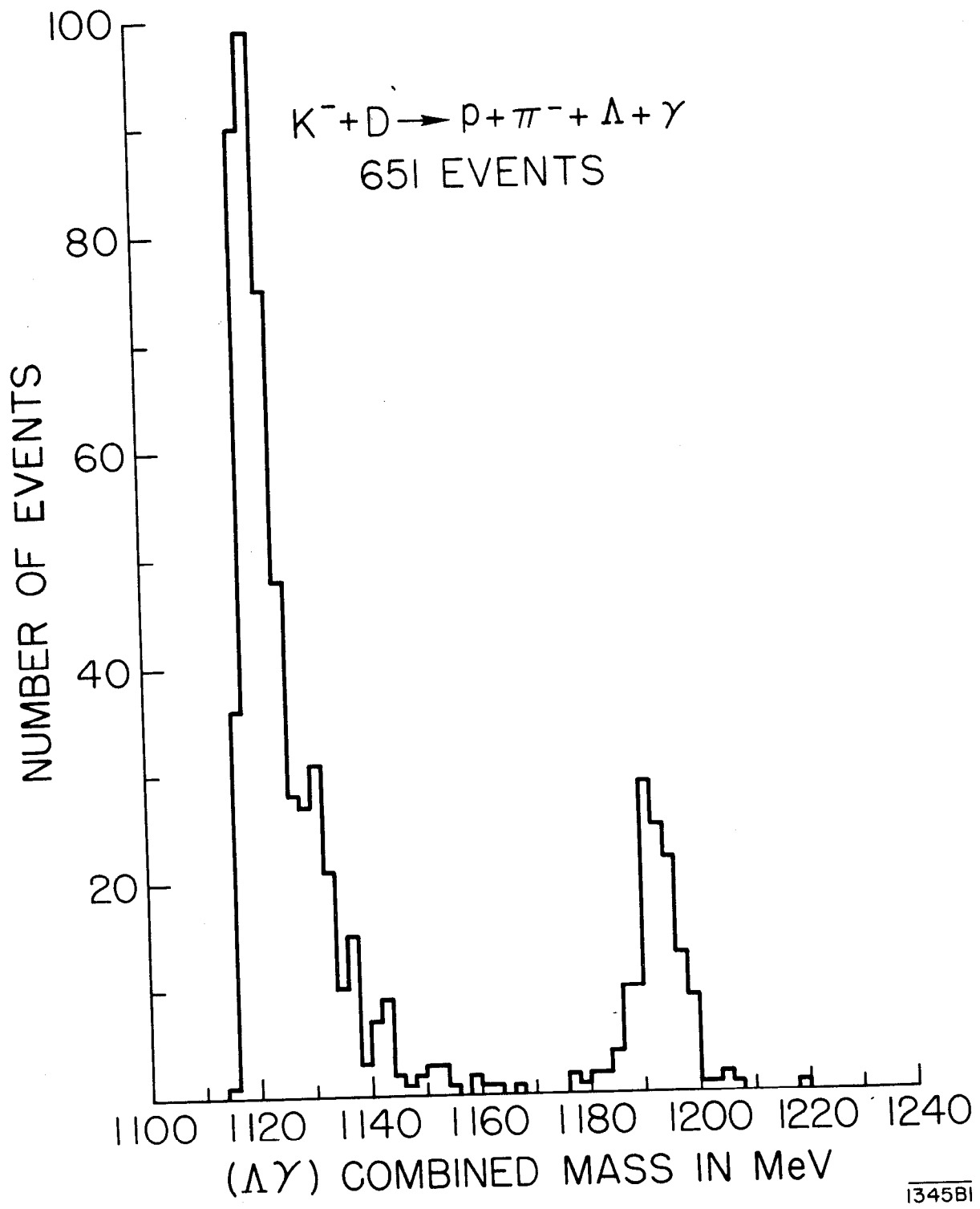


Fig. 2