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A PROPOSAL TO STUDY K^-p INTERACTIONS BETWEEN 450 AND 900 MeV/c

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Introduction

In order to extend our high statistics studies of the formation of $S = -1$ baryon resonances, we propose an exposure of 5×10^5 pictures in the CERN 2 m HBC to K^- at approximately 8 momenta between 450 and 900 MeV/c. This proposal follows the letter of intent CERN/TCC/74-16.

Physics Interest

Most of our knowledge of the Y* states comes from partial wave analyses of low energy K^-p reactions. The existence and resonance parameters of several of the states in the mass region below 1750 MeV are not well established(1). The world data available for these reactions are shown in fig. 1A. The data used in the region 450-900 MeV/c come essentially from a single experiment(2), which yielded about 200 events/mb/25 MeV/c. Fig. 1B shows the low energy K^-p bubble chamber experiments that are currently being analysed. There are data at the level of 1000 to 3000 events/mb/25 MeV/c over the range from 300 MeV/c to 1.8 GeV/c, with the exception of the region 450 to 900 MeV/c. The proposed experiment, together with the CHM film, would bring the data in this region up to the level of 1800 events/mb/25 MeV/c giving complete high statistics coverage of the low energy K^-p reactions. This will improve the knowledge of partial waves in the region of the new data and also facilitate the continuation of low partial waves, helping to resolve existing ambiguities in the energy region from 900 MeV/c upwards, which has been the subject of more intensive work.

Further investigation of the K^-p partial waves and their resonant parameterization has been stimulated by the continuing success of the SU3 classification of baryon states, and extension of this classification to higher symmetry schemes(3). Specifically the $SU(6)_W \times O(3)$ symmetry (and related dynamic quark models) classifies many of the known baryon states satisfactorily. Reliable determination of the resonance masses and widths, and more especially the signs and magnitudes of the couplings to various channels, provides crucial tests for symmetry schemes. The Y*'s are particularly suitable for this kind of study because even the sets of simple two body final states ($\Lambda\pi$, $\Sigma\pi$, $\bar{K}N$) yield this information, giving indication to which SU3 multiplets they should be assigned and the degree of mixing between pure SU3 multiplets. The bubble chamber technique is of proven value for this simultaneous type of study.

Secondly the SU3 inelastic reactions such as $K^-p \rightarrow \Sigma(1385)\pi$ (of the form $[8] + [8] \rightarrow [10] + [8]$) yield additional information of the couplings to different SU3 multiplets, which can also be used to test higher symmetry schemes. These three body final states have as yet only received cursory treatment in K^-p interactions. In the proposed experiment the $\Lambda\pi\pi$ final state would be the main candidate for such studies. Note that this final state yields polarisation information from the Λ^0 decay, unlike the corresponding states studied in $\pi N \rightarrow \pi\pi N$(4).

The situation concerning Y* states seen in formation reactions as deduced from the current RL-IC two body partial wave analyses is shown in Table 1(5). These analyses combined data from previously published experiments in the range 400-1800 MeV/c, with our own high statistics data in the range 960-1400 MeV/c.

In order to emphasise the uncertainties present in our knowledge of the Y* states in the energy region covered by the proposed experiment, we list here some specific points that a new analysis with the increased data would hope to sort out, noting also the relevance of such measurements to the symmetry schemes:

$\underline{\Lambda(1670)\ S01}$. The measured decay rates of this established resonance vary by as much as 50% and there is very significant disagreement between different analyses.

$\underline{\Lambda(1690)\ D03}$. Inconsistencies exist for all its decay modes and its total width. Both this and the S01(1670) are important in measuring the extent of singlet-octet mixing.

$\left.\begin{array}{l}\underline{\Lambda(1605)\ P01}\\ \underline{\Sigma(1670)\ P11}\end{array}\right\}$ If these two states are established they can be accommodated as octet partners of the N*(1470) Roper resonance in $(56, 0^+)_2$ supermultiplet predicted by SU(6) quark models.

Σ(1750) S11. This state has been observed at masses between 1620 and 1780 MeV and there could thus be more than one s-wave resonance here.

Σ(1580) D13. This narrow (10 MeV width) state has been seen only in the $\Lambda\pi^0$ final state and in the I-spin 1 total cross-sections$^{(6)}$. It was not seen in $\Sigma\pi$ and $\bar{K}N$ final states. Higher statistics are required to establish the existence of this state. Earlier production experiments have suggested a state at 1480 MeV$^{(7)}$.

Σ(1660) D13. That there is one state is well established, but evidence from two production experiments suggests two resonances of similar mass and width$^{(8)}$. The (70, 1-) super multiplet requires three D13 states, in the energy range ~1500 to ~1950 MeV, hence more information on these D13 states provides interesting tests$^{(9)}$.

Further we stress the importance of the analysis of the $\Lambda\pi\pi$ channel in tests of the symmetry models. With higher statistics we could attempt an isobar analysis, using the Σ(1385) decay information, in a manner analogous to that used in $\pi N \rightarrow \pi\pi N^{(4)}$, but with additional information from the Λ decay, as mentioned previously. The solutions would connect with our current $\Lambda\pi\pi$ analyses. Energy continuation from low energies is probably necessary to avoid the difficulties that were present in the first stages of the $\pi\pi N$ analyses due to an energy gap in the data.

Film Requirement

We propose that this experiment together with the available CHM film should provide data at approximately the level of 1800 ev/mb/25 MeV/c evenly distributed between 450 and 900 MeV/c. This would be achieved by exposure of 500K pictures in the 2 m bubble chamber, assuming a flux of 10 K^- per picture. We are currently negotiating for the 80 cm film from the Heidelberg-Munich collaboration. If this film is not satisfactory an additional 200K 2 metre chamber pictures would be required.

Table 2 shows the number of events that would be obtained in the various channels for a typical momentum setting with 70K pictures. Note the number of events in the $\Lambda\pi^+\pi^-$ channel should be sufficient for a full scale three-body analysis comparable to the SLAC-Berkeley work on $\pi\pi N^{(4)}$, where they used about 5000 to 10000 events in each 40 MeV cm energy bin.

K^- Beam

The current K8 beam line is not suitable for K^- of momentum below about 900 MeV/c. After the 2 m HBC has been moved to its new position, during the winter of 1974-75, the disposition of the extracted proton beam and the chamber will be such that a much shorter K^- beam can be built which would be capable of yielding a usable flux at momenta well below 900 MeV/c.

The use of the Booster would also assist in attaining adequate fluxes at the lowest momenta in the range proposed (450-900 MeV/c).

If it is technically feasible, we would prefer that the beam transport be such that a momentum degrader is not required. In this way, we hope that the pictures will have few background tracks and can thus be scanned easily, a prime consideration for a large exposure. Also, this will restrict the effective momentum bite of the beam.

To achieve long potential path lengths of beam particles and secondaries in the chamber, it will be necessary that the chamber be run at reduced field (at the lowest momentum, about 0.6T). It is probable that the superconducting pipe, as used for our previous experiment, would be required to transmit the beam through the fringe field of the chamber magnet.

Measuring Capacity

The proposed exposure should yield some 700K events corresponding to 22 events/μb. At present we do not intend to measure all two prong events, but only those that occur on a frame with another event present. This means that the total number of events to be measured should be around 500K.

Both laboratories have fully operational HPD's and it is anticipated that at least half of the available pre-digitizing capacity will be devoted to the proposed experiment. On the conservative assumption that only one half of the joint capacity is used the measurement of these events should take 1½ years.

Computing Requirements

The processing of the 250K events to be measured at RL would require approximately 230 hrs of 360/195 computer time. For the 250K events measured at IC the corresponding figure is 75 hrs, since the HPD and pre-Geometry processing would all be done at IC. The time required for the analysis of these data is difficult to predict but judging from our recent experience of K^-p partial wave analysis, the analysis of the two body reactions (in the context of adding the new data to existing world data) is estimated to require some 200 hrs. The corresponding estimate for the three body final states analysis is about 100 hrs. We therefore estimate that 325 hours of 195 computing is required for data reduction and an additional 300 hours is required for analysis. This time is shared between ICL and RL and would be used mainly in 1975, 1976 and 1977.

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Partial Wave

nel:		S01	S11	P01	P11	P03	P13	D03	D13	D05	D15	F05	F15	F07	F17	G07
	Mass :	1665	1770	1813	1657	1905		1693	1665	(1822)	1774	1820	1917	2120	2035	2096
	Γ :	35	85	110	200	62	No consistent states	34	26	(111)	143	80	100	90	168	274
	t :	.20	.16	.30	.06	.19		.21	.09	.06	.41	.60	.03	.07	.22	.29
	Status:	Established	Probable	Prob	Poss	Prob		Est	Est	Est	Est	Est	Est	Prob	Est	Est
	Mass :	1860	1960		2008			1874	1922							
	Γ :	310	189		500			330	192							
	t :	.50	.48		.07			.18	.10							
	Status:	Possible	Prob		(?)			Poss	Poss							
	Mass :	1679	1987	1605	1697	1915	1843	1682	(1662)	1822	(1774)	(1820)	1925		2040	2136
	Γ :	31	104	260	240	50	250	58	(40)	111	(140)	(80)	110		175	156
	t :	-.22	-.16	-.20	-.13	-.12	.05	-.25	.21	-.16	.08	-.32	-.15		-.10	.14
	Status:	Est	Poss	Prob	Poss	Poss	Poss	Est	Est	Est	Est	Est	Est		Est	Est
	Mass :								2070			2122	2180			
	Γ :								500			164	150			
	t :								-.10			.18	.09			
	Status:								(?)			Prob	Poss			
	Mass :		1700		1630				1658		1772		1920		2040	
	Γ :		60		270				30		135		100		173	
	t :		-.14		±.10				.08		-.29		-.08		.19	
	Status:		Prob		Poss				Est		Est		Est		Est	
	Mass :		2020						1912				2240			
	Γ :		180						170				300			
	t :		.10						±.08				-.10			
	Status:		Poss						Poss				(?)			

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* Mass = Energy at Resonance (MeV), Γ = Full Width (MeV), t = Amplitude at Resonance.

Parameters in brackets have been constrained.

Table 2

Expected numbers of events for a typical momentum setting.

K^- momentum = 677 MeV/c.

70K pictures.

Channel	Events	
K^-p	25,300	(Measured as described in text)
$\Sigma^-\pi^+$	9,900	
$\Sigma^+\pi^-$	1,000	
$\Lambda\pi^0$	5,900	Λ decay to $p\pi^-$
$\Lambda\pi^+\pi^-$	4,600	" " " $p\pi^-$
$\overline{K}^0n$	3,900	$\overline{K}^0$ decay to $\pi^+\pi^-$
$\Sigma^0\pi^0$	4,000	Λ decay to $p\pi^-$
$\Sigma^+\pi^-\pi^0$	1,200	
$\Sigma^-\pi^+\pi^0$	900	
$\Sigma^0\pi^+\pi^-$	700	Λ decay to $p\pi^-$
Λ + neutrals	1,600	" " " $p\pi^-$
$\Lambda\pi^+\pi^-$	1,100	" " " $n\pi^0$
$\Sigma^0\pi^+\pi^-$	100	" " " $n\pi^0$
Total	61,600 events	

Cross-sections from Armenteros et al, Nucl. Phys. B21 (1970) 15.

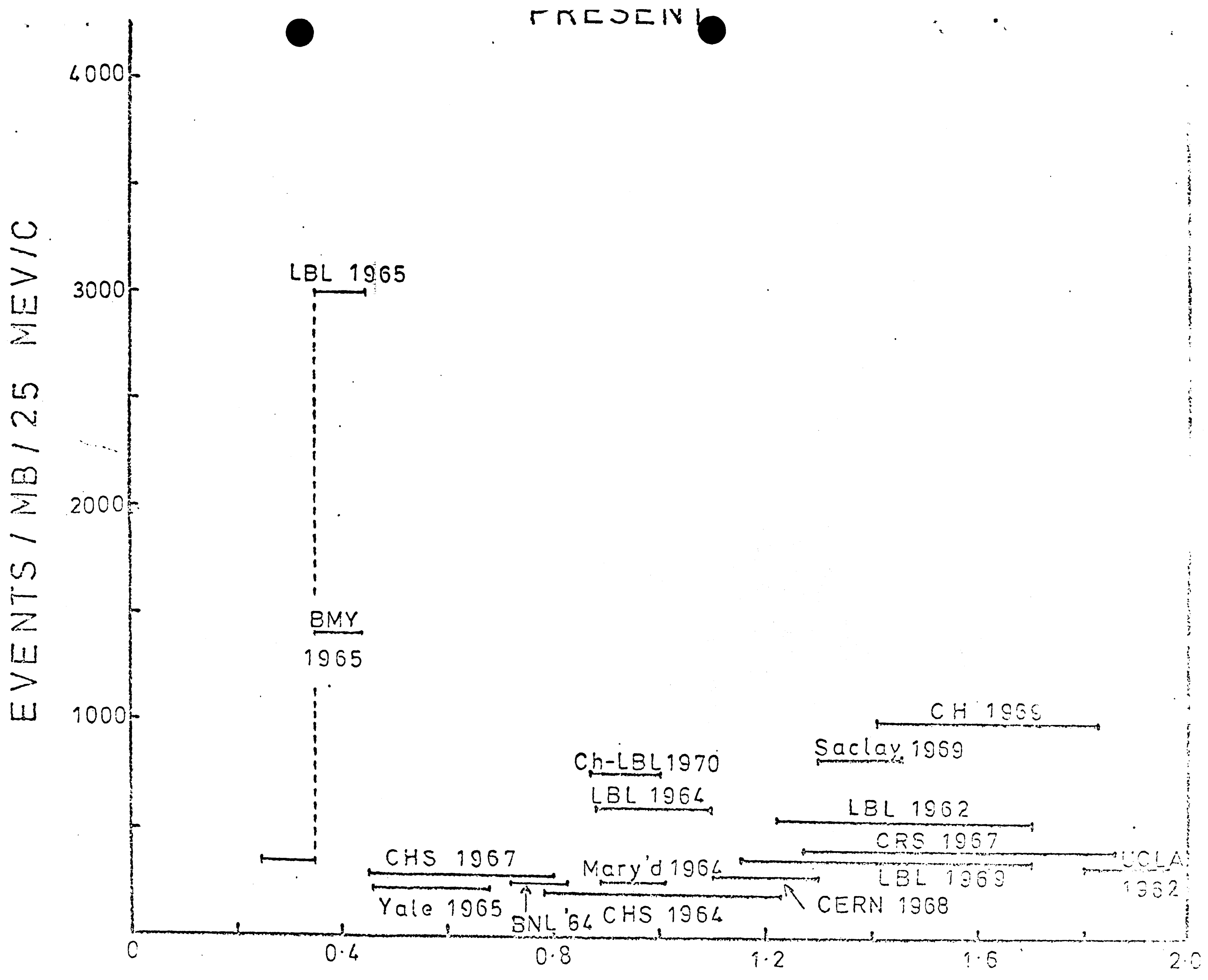
PRESENT
EVENTS / MB / 25 MEV/C
4000
3000
2000
1000
0
0·4
0·8
1·2
1·6
2·0
K⁻ MOMENTUM GeV/c
LBL 1965
BMY 1965
Ch-LBL 1970
LBL 1964
CH 1969
Saclay 1969
LBL 1962
CRS 1967
LBL 1969
UCLA 1962
CHS 1967
Mary'd 1964
CERN 1968
Yale 1965
BNL '64
CHS 1964

FIG. 1A

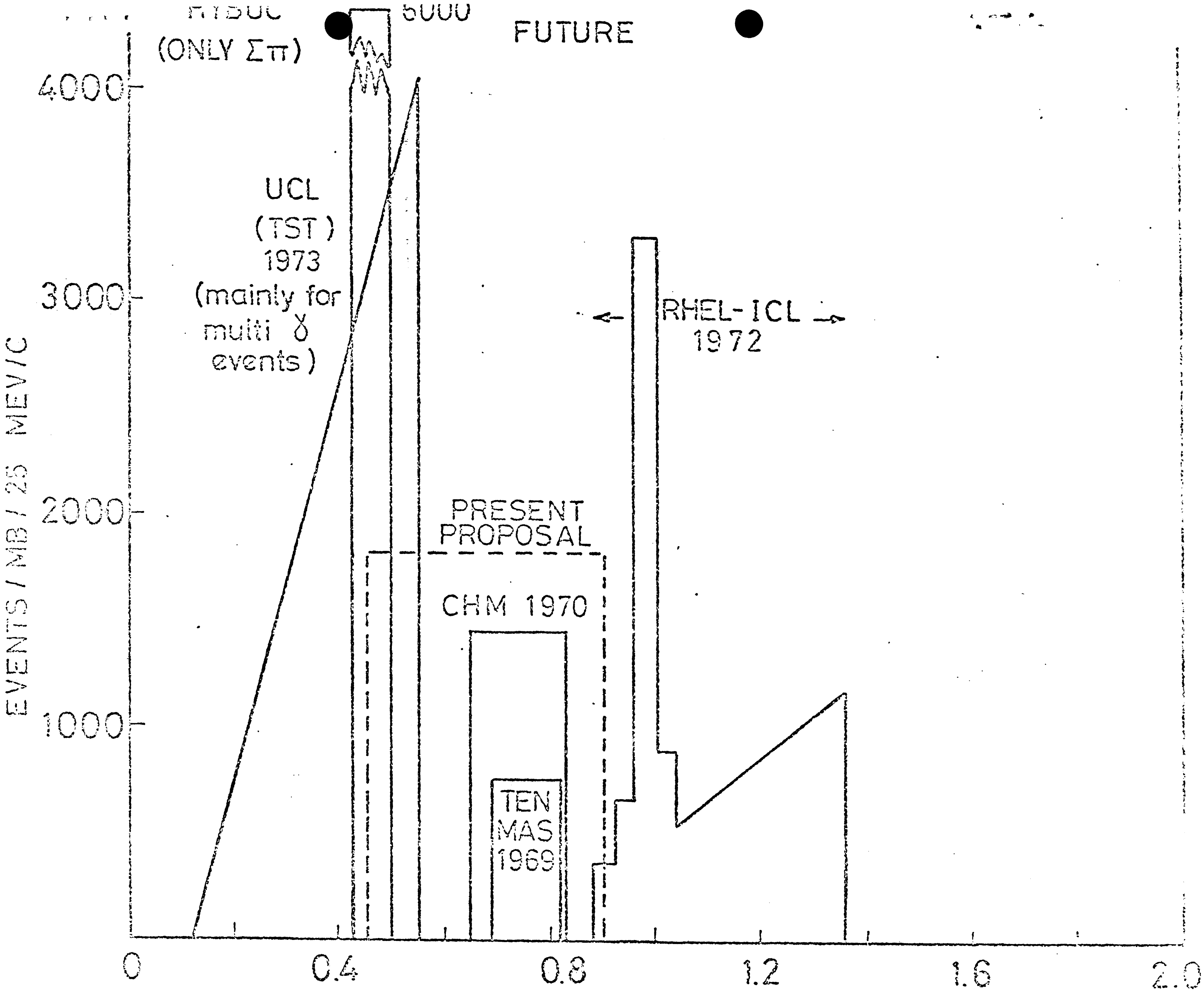

FIG 1B K^- MOMENTUM GeV/c