

Graham

his first research years

and some stories

45 yrs ago to the day Graham started his Ph.D. studies in Durham

(Particle theory in Durham started in 1963-64)

1966 when Graham arrived: well before QCD
SU(3) of u,d,s fractional charges? statistics?
→ ad hoc colour

Before DIS (before the puzzle that q's were felt, but not seen) before Feynman's partons
well before gluons to sniff

Theory of Strong interactions ? $g(\pi NN)^2 \sim 14$

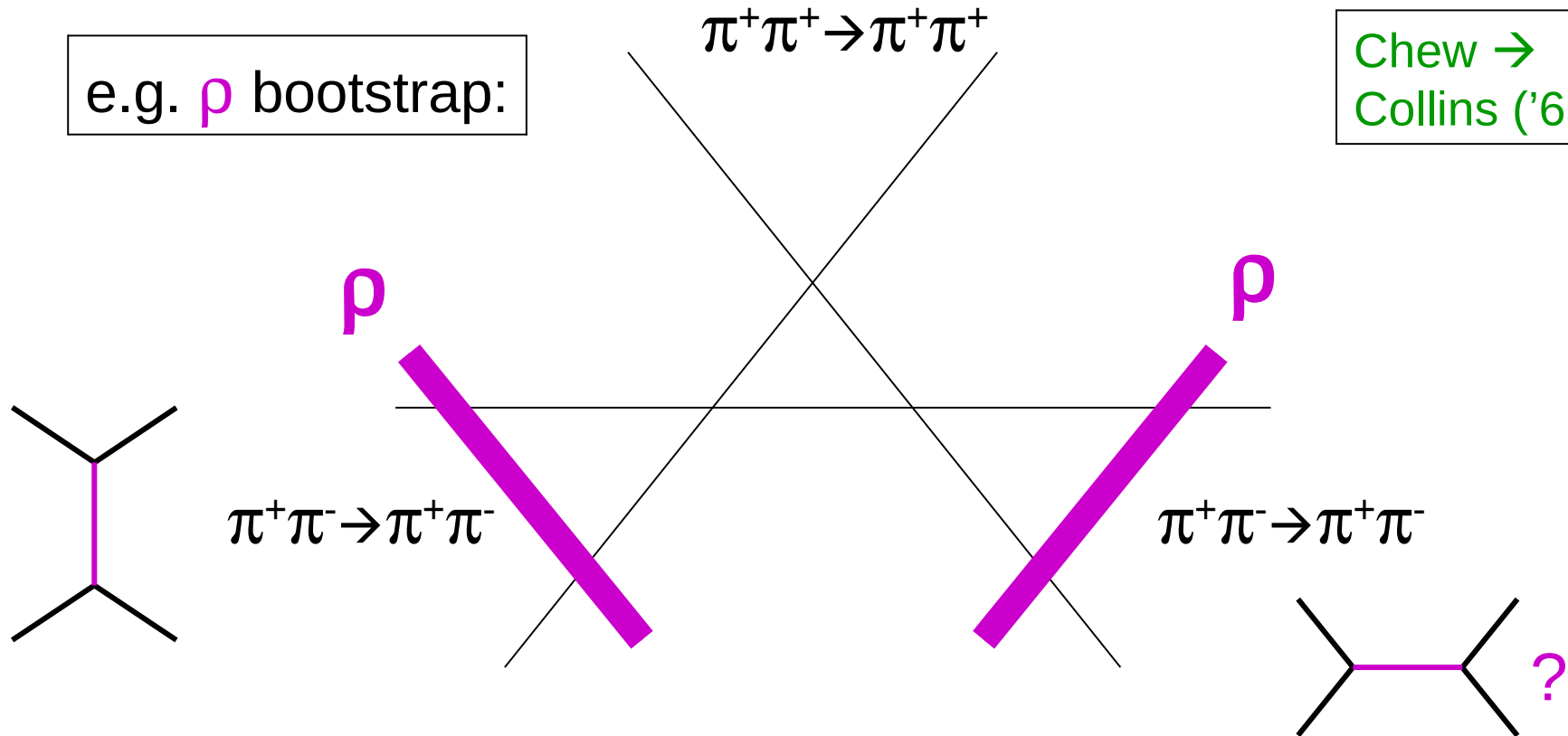
(QFT -- a quirk which only applied to QED ?
-- with hindsight: Yang-Mills, Higgs...)

Bootstrap Mechanism -- Nuclear democracy

hadron spectrum was **unique** solution of analyticity, crossing and unitarity

e.g. ρ bootstrap:

Chew \rightarrow
Collins ('65)

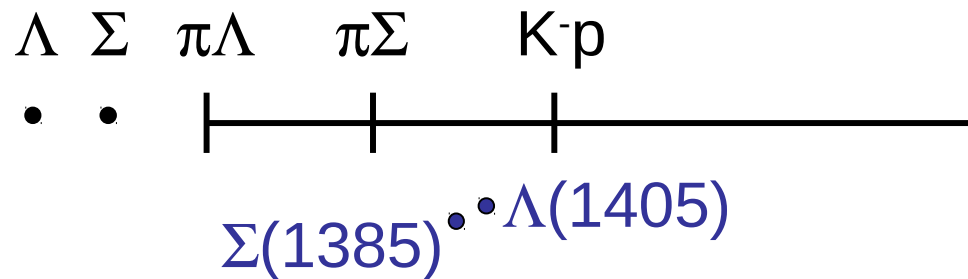


\rightarrow Veneziano model (1968)

but mechanism not unique

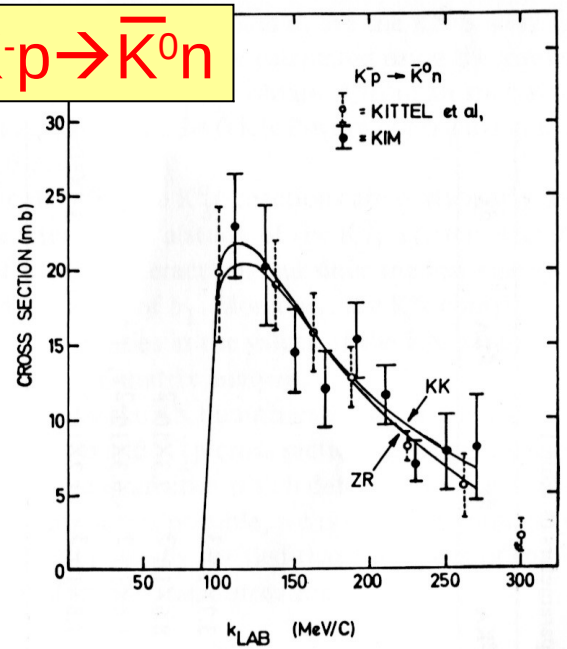
K-matrix analysis of low energy

$K\bar{p} \rightarrow K\bar{p}, \bar{K}^0 n, \pi\Lambda, \pi\Sigma$ scattering data

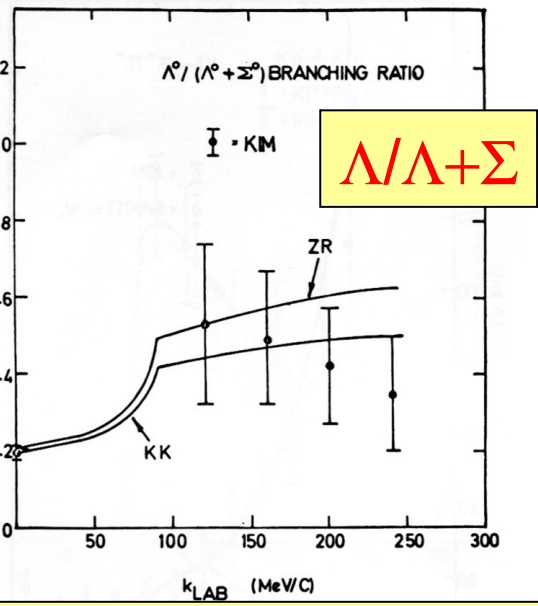
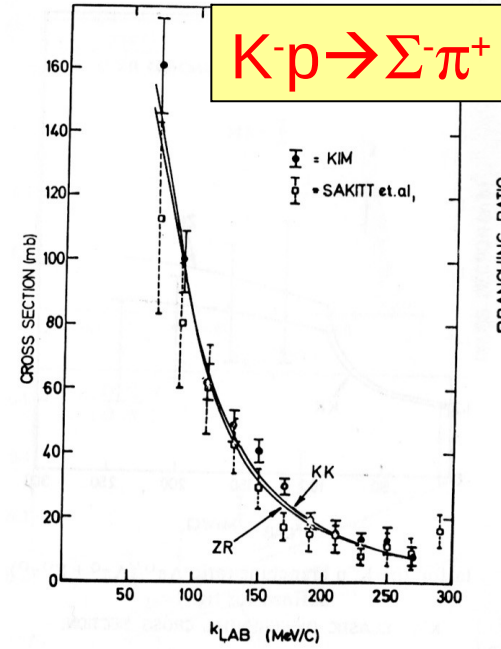


as well as determining ΛKN and ΣKN coupling constants via dispersion relations

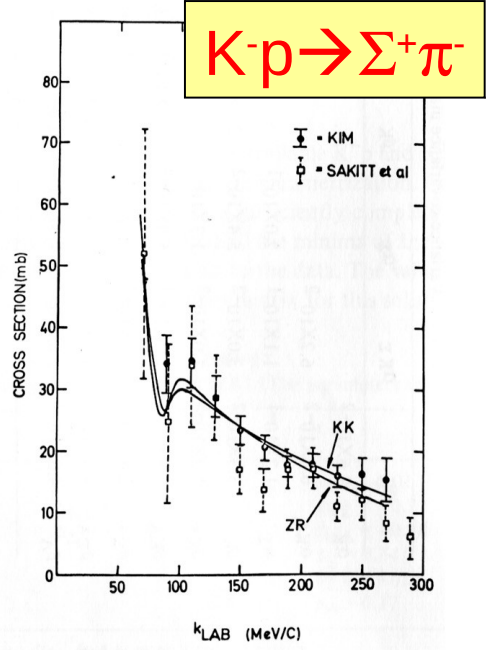
$K^-p \rightarrow \bar{K}^0 n$



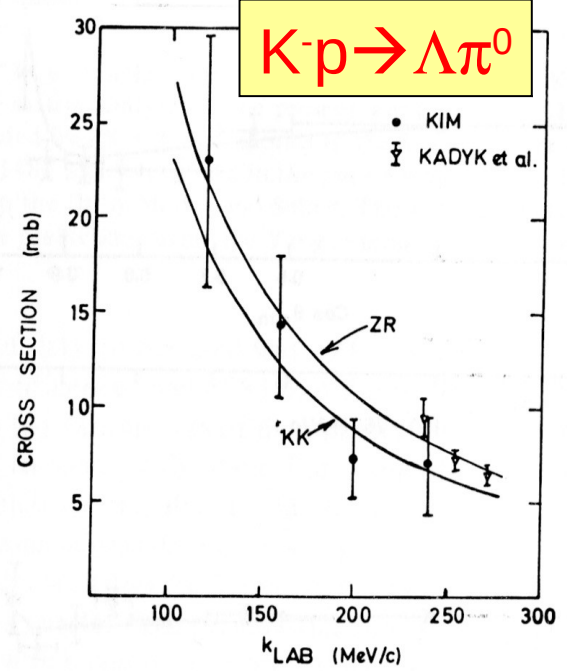
$K^-p \rightarrow \Sigma^- \pi^+$



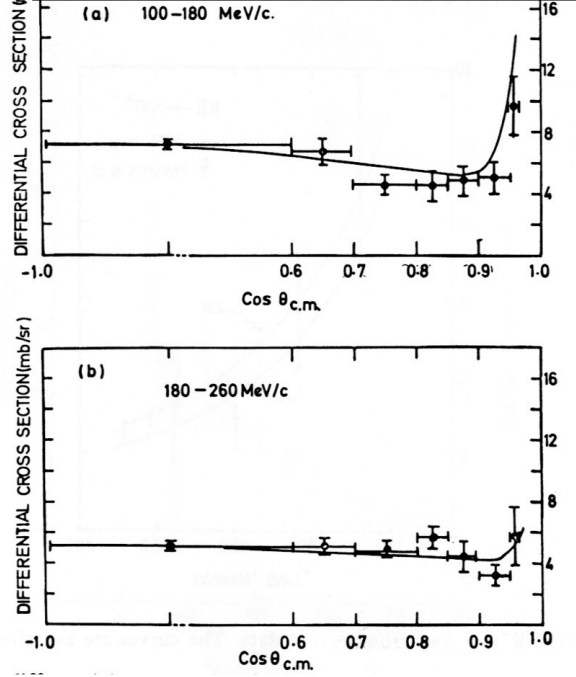
$K^-p \rightarrow \Sigma^+ \pi^-$



$K^-p \rightarrow \Lambda \pi^0$

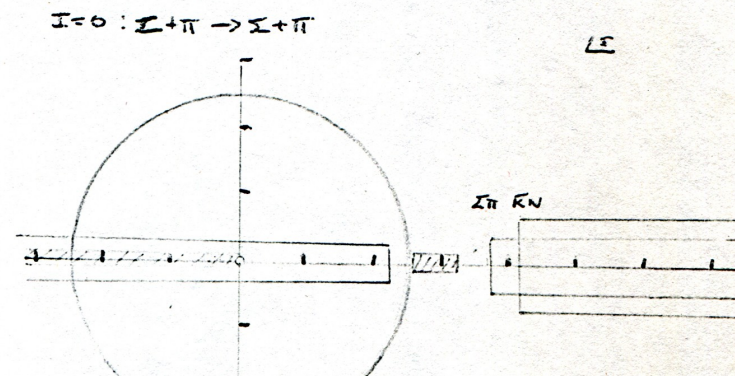
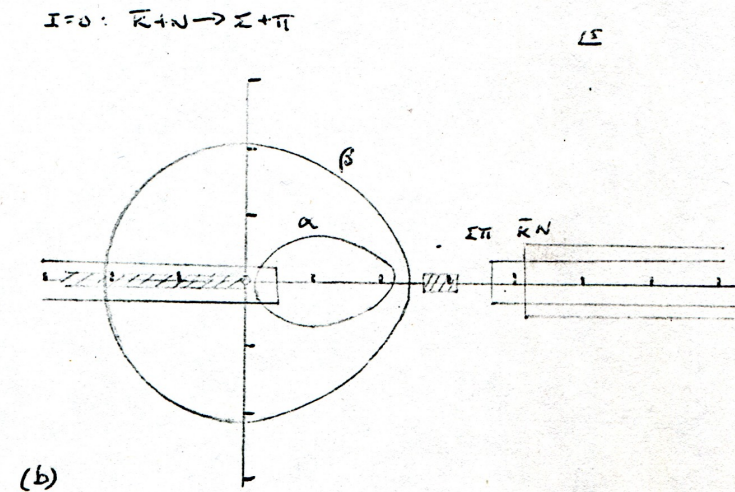
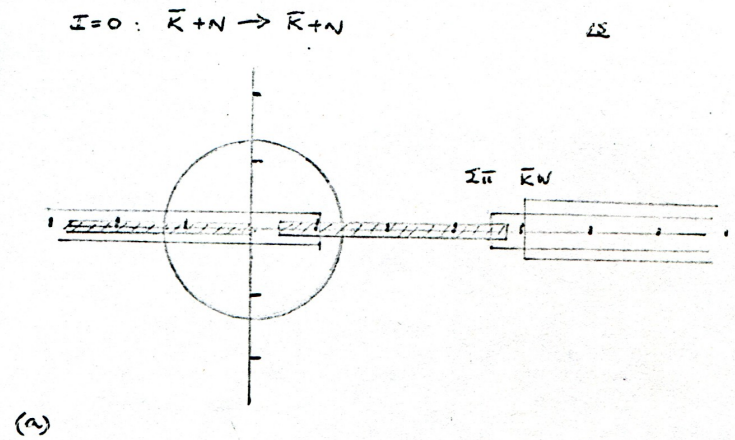


$d\sigma(K^-p \rightarrow K^-p)/d\cos\theta$

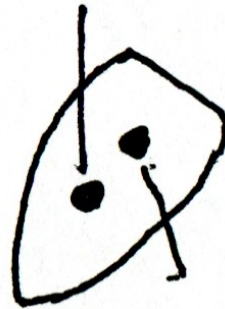
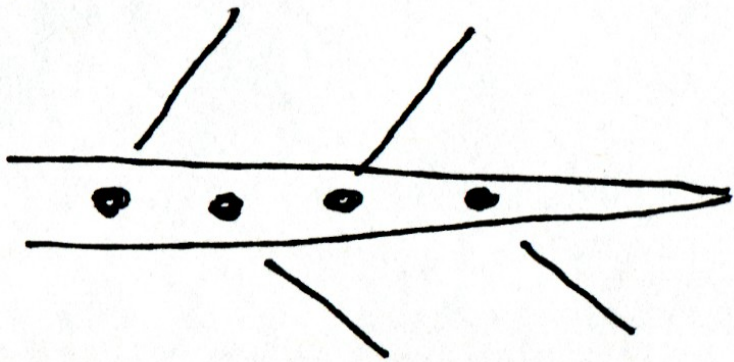


Singularity structure
of partial waves
for $l=0$,
 $\bar{K}N, \pi\Sigma \rightarrow \bar{K}N, \pi\Sigma$
processes

Graham's first paper
(Jan.1968) was on
predicting $\Lambda KN, \Sigma KN$
coupling constants



1. Search for the truth was paramount
2. His command of the tutorial class was total
3. Role reversal occurred not long after



Preparation of papers --- incredible procedure

Written out by hand.

Secretary then typed text on waxy 'skins'.

Author scratched in equations using a stylo.

Mistakes obliterated by quick drying pink paste
and then retyped or scratched over.

Figures drawn by hand and given to drawing office.

Skins put, in turn, on gestetner drum in the reproduction dept.,
and copies made.

Typically ~30 copies made.

Posted to CERN, SLAC,

CERN, SLAC compiled lists of titles, which were posted out.

Interesting titles were then requested from Authors by
posting preprint request cards.

Seminars and colloquia

either chalk and talk

Peter Higgs

or using 35mm slides (subject to the whims of
the projector and the projectionist)

Abdus Salam

Graham's thesis

Computers v.primitive -- calculations were far from easy --- especially to achieve a stable error matrix --- but he did it

As was usual, the thesis was typed with 'carbon' copies and then the equations written into **each** copy

with such a limited edition (June 1969)

→ collector's piece

Graham, it may be best to close your eyes...

Label	K_{RR}^0	K_{RE}^0	K_{RE}^0	K_{RE}^1	K_{RE}^1	K_{RE}^1	K_{RE}^1	K_{RE}^1	K_{RE}^1	a_{1+}	b_{1+}	ϵ_{1+}	ϕ_{1+}	a_{1-}	b_{1-}	ϵ_{1-}	ϕ_{1-}
K_{RR}^0	5.9×10^{-2}																
K_{RE}^0	4.9×10^{-2}	4.1×10^{-2}															
K_{RE}^0	9.5×10^{-2}	8.0×10^{-2}	1.6×10^{-1}														
K_{RE}^1	1.4×10^{-2}	1.1×10^{-2}	2.2×10^{-2}	8.1×10^{-3}													
K_{RE}^1	-3.4×10^{-3}	-2.9×10^{-3}	-5.5×10^{-3}	-1.8×10^{-3}	8.0×10^{-4}												
K_{RE}^1	-1.8×10^{-2}	-1.6×10^{-2}	-3.2×10^{-2}	2.1×10^{-3}	-3.8×10^{-4}	1.8×10^{-2}											
K_{RE}^1	4.9×10^{-2}	4.1×10^{-2}	8.0×10^{-2}	1.3×10^{-2}	-3.4×10^{-3}	-1.4×10^{-2}	4.2×10^{-2}										
K_{RE}^1	7.7×10^{-3}	6.5×10^{-3}	1.3×10^{-2}	-1.2×10^{-4}	3.3×10^{-4}	-5.8×10^{-3}	5.7×10^{-3}	2.5×10^{-3}									
K_{RE}^1	-4.7×10^{-2}	-4.0×10^{-2}	-8.0×10^{-2}	3.5×10^{-3}	-5.6×10^{-4}	4.2×10^{-2}	-3.5×10^{-2}	-1.4×10^{-2}	9.8×10^{-2}								
a_{1+}	-2.5×10^{-3}	-2.0×10^{-2}	-3.9×10^{-3}	-9.4×10^{-4}	-1.7×10^{-4}	3.2×10^{-4}	-1.8×10^{-3}	-7.4×10^{-4}	7.1×10^{-4}	1.4×10^{-3}							
b_{1+}	4.5×10^{-5}	3.5×10^{-5}	6.7×10^{-5}	9.9×10^{-6}	3.2×10^{-6}	-1.6×10^{-5}	3.0×10^{-5}	1.6×10^{-5}	-4.2×10^{-5}	1.4×10^{-5}	1.5×10^{-4}						
ϵ_{1+}	-1.4×10^{-6}	-1.1×10^{-6}	-2.0×10^{-6}	-5.6×10^{-7}	-3.2×10^{-7}	3.1×10^{-7}	-6.9×10^{-7}	-8.5×10^{-7}	6.0×10^{-7}	-1.8×10^{-7}	4.0×10^{-8}	1.1×10^{-4}					
ϕ_{1+}	-2.0×10^{-2}	-1.6×10^{-2}	-3.3×10^{-2}	-2.1×10^{-3}	8.9×10^{-5}	1.3×10^{-2}	-1.6×10^{-2}	-3.6×10^{-3}	2.8×10^{-2}	-1.7×10^{-3}	2.1×10^{-4}	-2.3×10^{-6}	1.4×10^{-1}				
a_{1-}	-2.3×10^{-3}	-1.7×10^{-3}	-3.5×10^{-3}	-7.2×10^{-4}	-2.2×10^{-5}	5.0×10^{-4}	-1.7×10^{-3}	-4.1×10^{-4}	1.3×10^{-2}	-3.5×10^{-4}	-3.1×10^{-5}	7.7×10^{-7}	2.7×10^{-3}	1.4×10^{-3}			
b_{1-}	-2.0×10^{-4}	-7.7×10^{-5}	-1.5×10^{-4}	-3.8×10^{-5}	-1.4×10^{-6}	1.1×10^{-5}	-7.6×10^{-5}	-1.8×10^{-5}	3.3×10^{-5}	-2.2×10^{-5}	-2.1×10^{-6}	-1.0×10^{-7}	-4.2×10^{-5}	7.6×10^{-5}	4.4×10^{-6}		
ϵ_{1-}	-2.3×10^{-6}	-2.0×10^{-6}	-3.7×10^{-6}	-2.1×10^{-6}	-6.5×10^{-7}	-1.1×10^{-6}	-1.2×10^{-6}	-1.9×10^{-6}	-3.6×10^{-6}	2.5×10^{-7}	-4.3×10^{-8}	-1.3×10^{-9}	-2.0×10^{-6}	-7.3×10^{-7}	1.1×10^{-7}	1.2×10^{-4}	
ϕ_{1-}	-2.2×10^{-2}	-1.8×10^{-2}	-3.6×10^{-2}	-1.5×10^{-3}	-1.4×10^{-2}	1.6×10^{-2}	-1.5×10^{-2}	-7.3×10^{-3}	3.5×10^{-2}	1.9×10^{-3}	8.3×10^{-5}	-3.1×10^{-6}	1.2×10^{-1}	3.1×10^{-3}	1.2×10^{-5}	-9.2×10^{-7}	1.6×10^{-1}

TABLE (6.2)

As is usual, there was a bit of a rush to complete the thesis, and get it bound -- but all was done, and he walked over to the faculty office to submit two copies

-- but !###!!

The Oral

Dick Dalitz (the External Examiner), Graham and I were sitting having tea before the oral exam, when Dick announced he automatically failed any thesis over 200 pages

How long was Graham's thesis ?

- E1 W.E. Humphrey and R.R. Ross: Phys. Rev. 127,
1305 (1962).
- E2 M. Sakitt et al.: Phys. Rev. 139, B719
- E3 J.K. Kim: Columbia University Report, Nevis-149
(1969).
- E4 W. Kittel, G. Otter and I. Wacek: Phys. Letts.
21, 349 (1966).
- E5 M.B. Watson, M. Ferro-Luzzi and R.D. Tripp:
Phys. Rev. 131, 2248 (1963).
- E6 J.A. Kadyk et al.: Phys. Rev. Letts. 17, 599 (1966).
- E7 G. Sayer et al.: Phys. Rev. 169, 1045 (1968).
- E8 R.L. Cool et al.: Phys. Rev. Letts. 16, 1228
(1966), 17, 102 (1966).
J.D. Davies et al.: Phys. Rev. Letts. 18, 62
(1967).
R.J. Abrams et al.: Phys. Rev. Letts. 19, 259
(1967), 19, 678 (1967).
D.V. Bugg et al.: Phys. Rev. 168, 1466 (1968).

Conclusions

- It is a privilege and pleasure to know and to collaborate with **Graham**
- He combines a deep knowledge, with an impish sense of humour and distinctive chuckle
- In seminars etc. he delights in the awkward, penetrating question.....but he is the **most generous Devil's Advocate** that I know
- Ruth, please ensure he does not retire from Physics
.....**we need him**