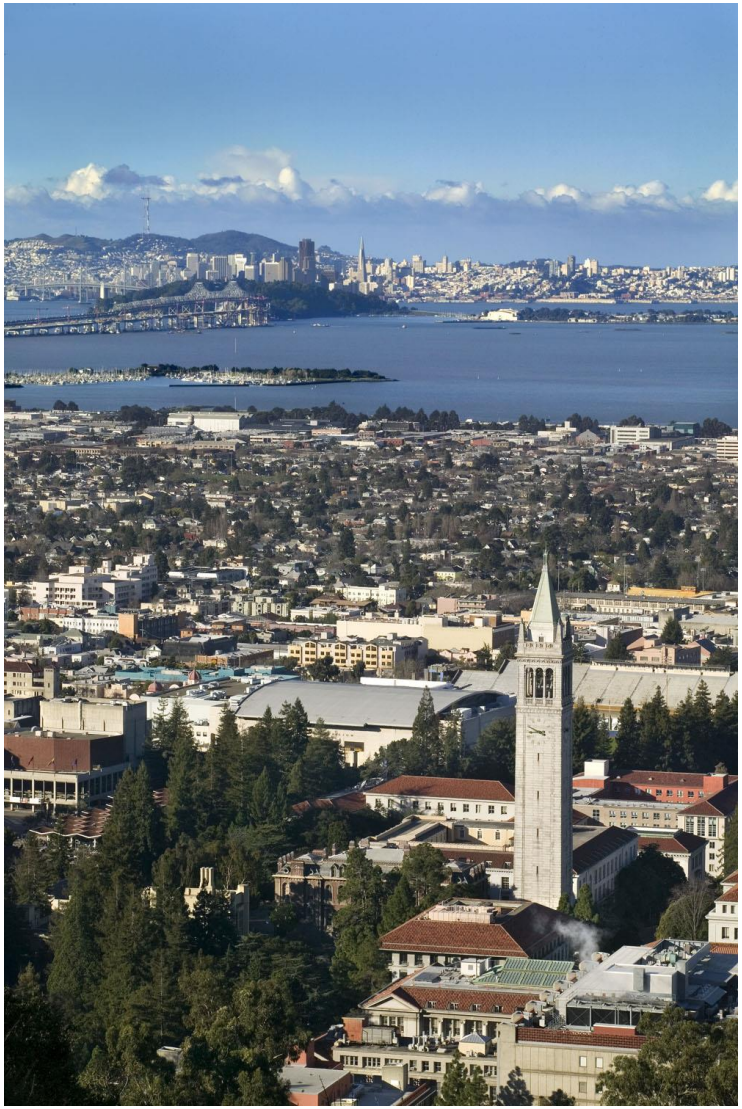
Happy Birthday George

Berkeley and the 60’s

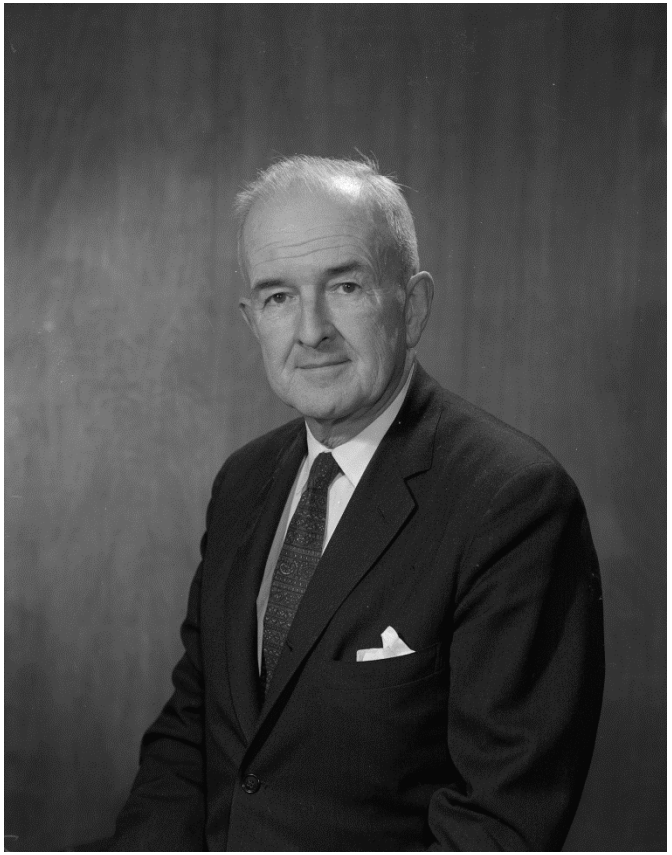
LBL circa 1965

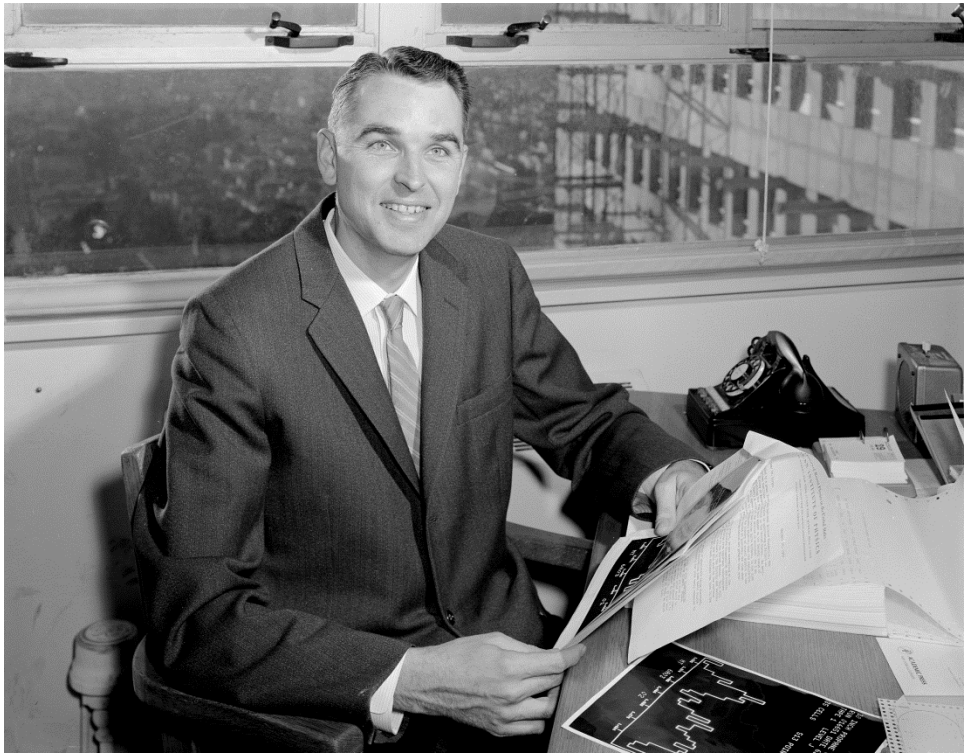
Right: Univ. of California Campanile in the foreground and San Francisco in the distance.

Below: The Bevatron and the Physics and Chemistry Buildings (50 and 70)



Wilson Powell and Bob Birge



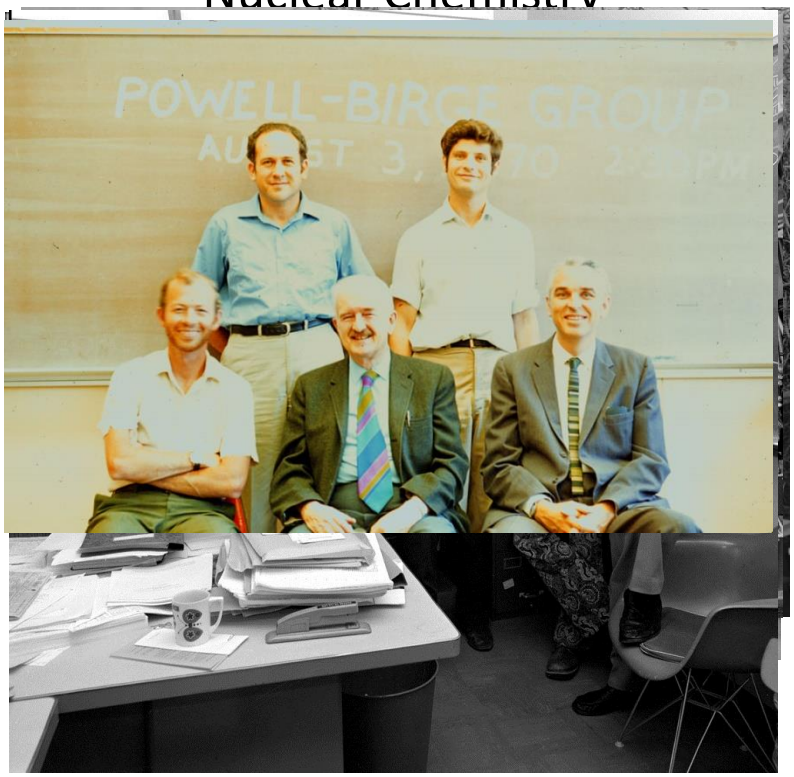


LBL Nobel Laureates - 1970

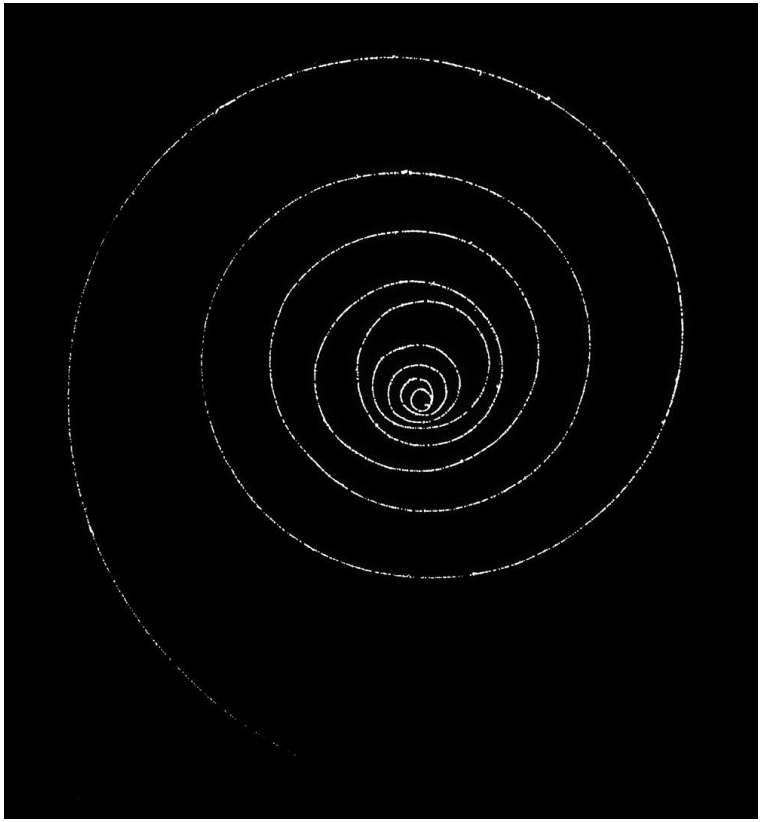
LRL

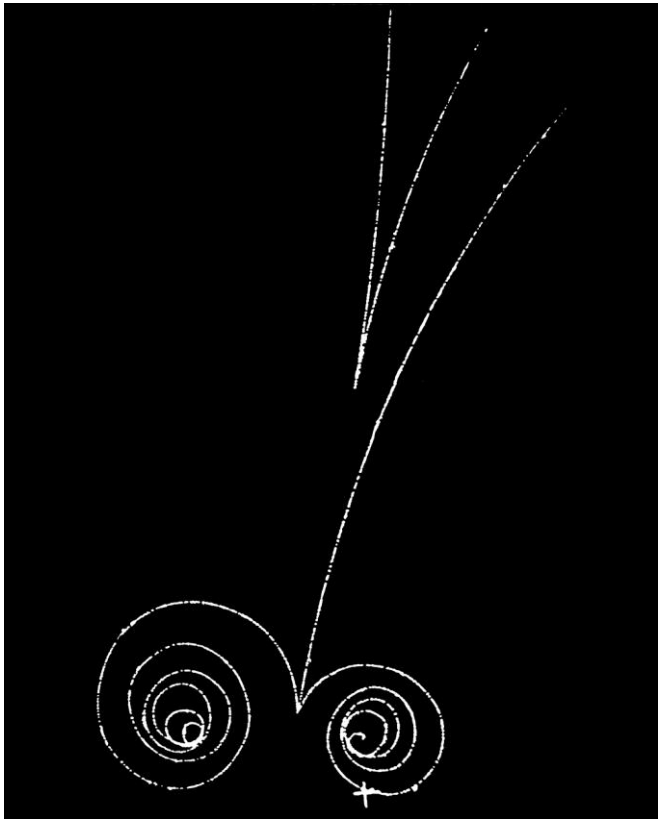
Ed McMillan

- Physics
  - Lofgren group
  - Alvarez group
  - Powell – Birge group
  - Glaser (Trilling – Goldhaber) group
  - Segre – Chamberlain group
  - Moyer – Helmholtz group
- Nuclear Chemistry



Electrons and Positrons





LRL Bubble Chambers

Alvarez 15” Hydrogen Chamber

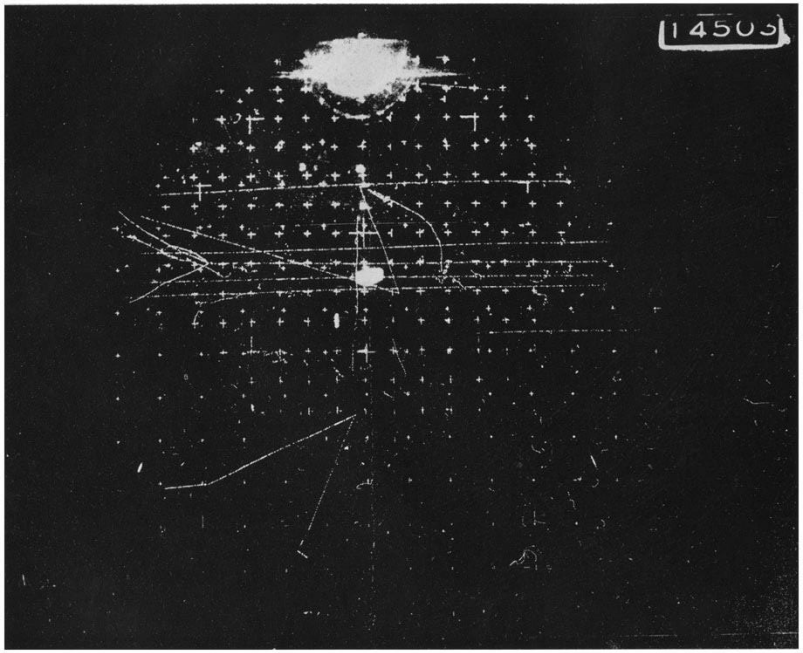
Glaser Xenon Chamber

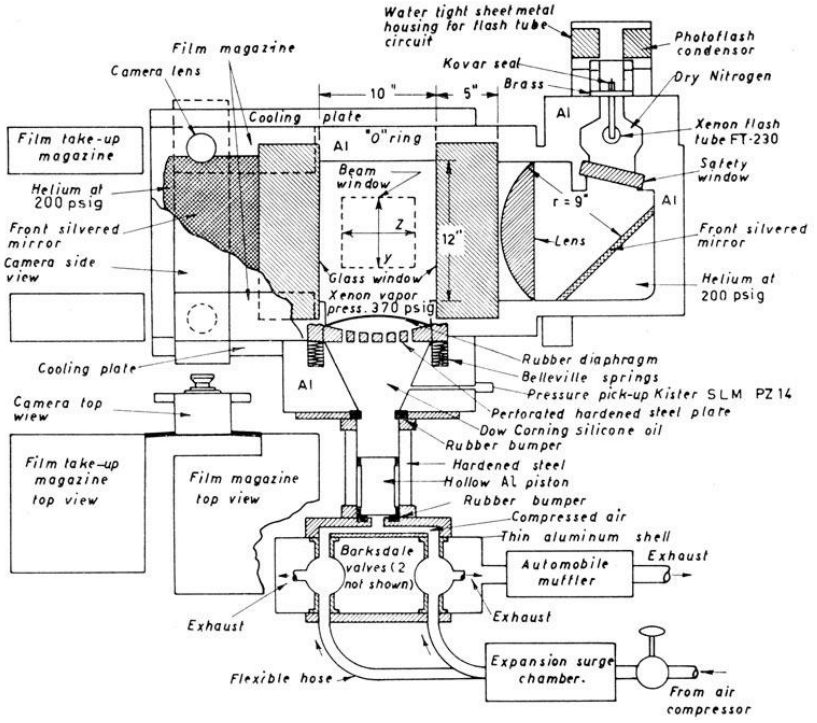
Powell 30” Heavy Liquid Chamber

LRL 25” Hydrogen Chamber

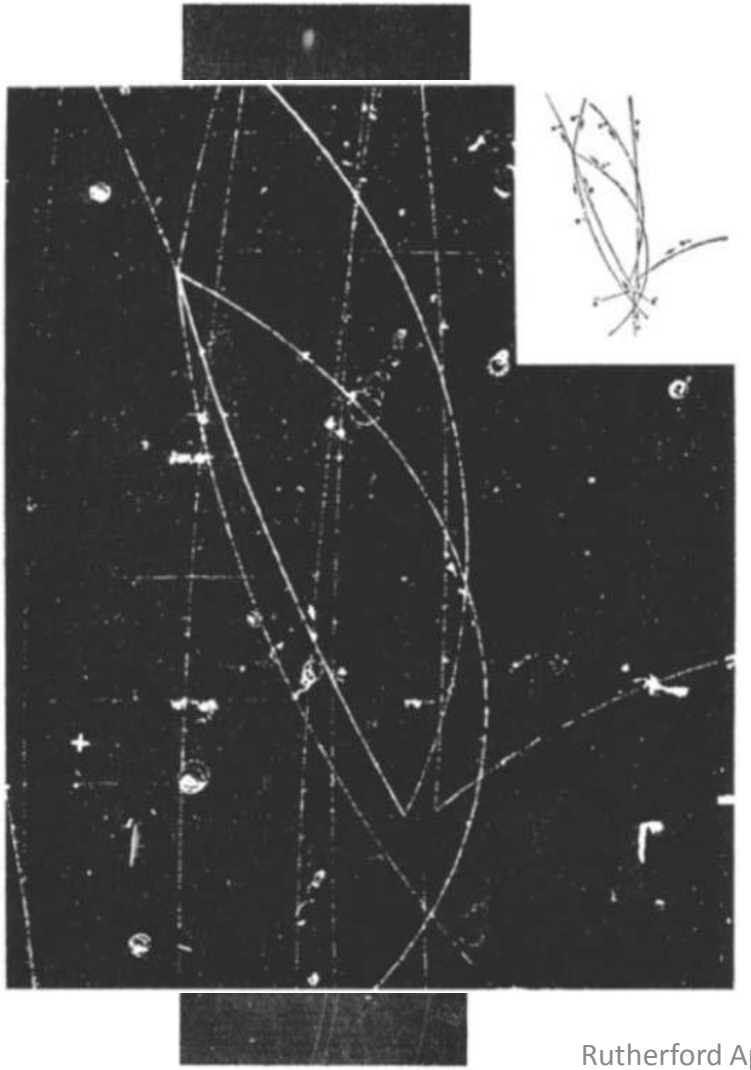
12 “ Xenon Bubble Chamber

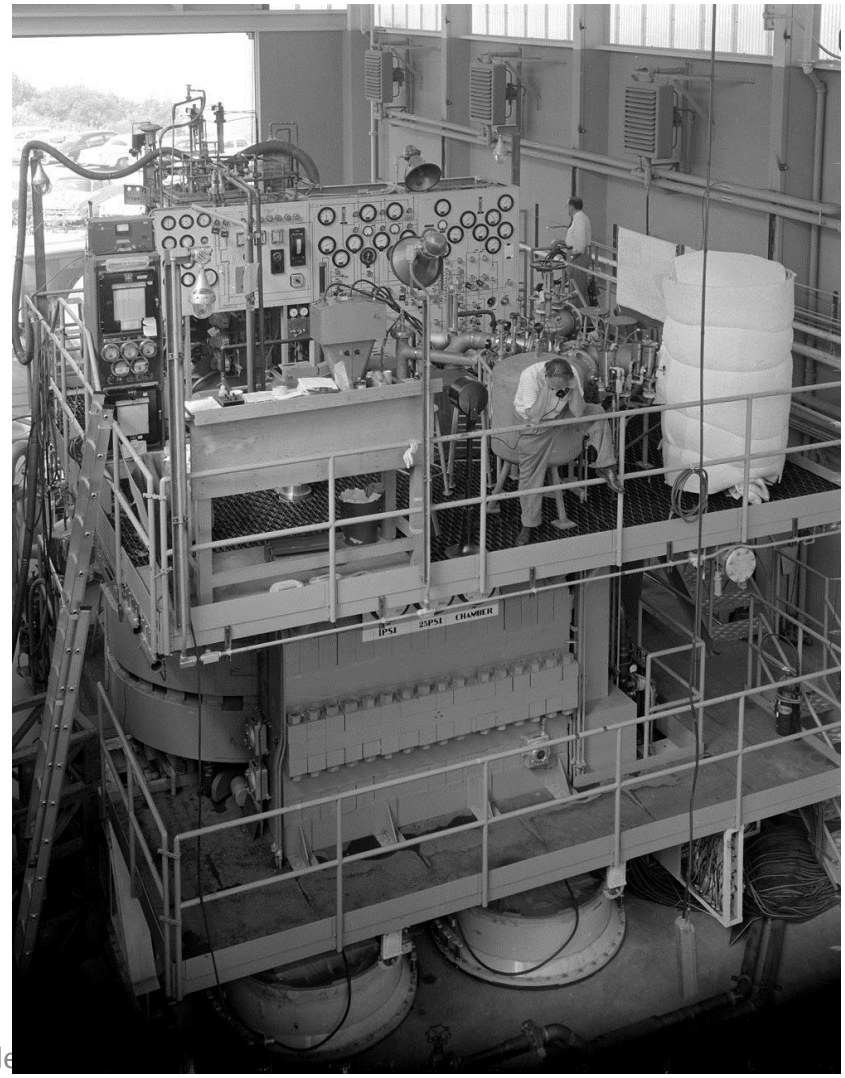
Fig. 2. – Example of $\pi^- + Xe \rightarrow \Lambda_- + K_{1\pm}$.



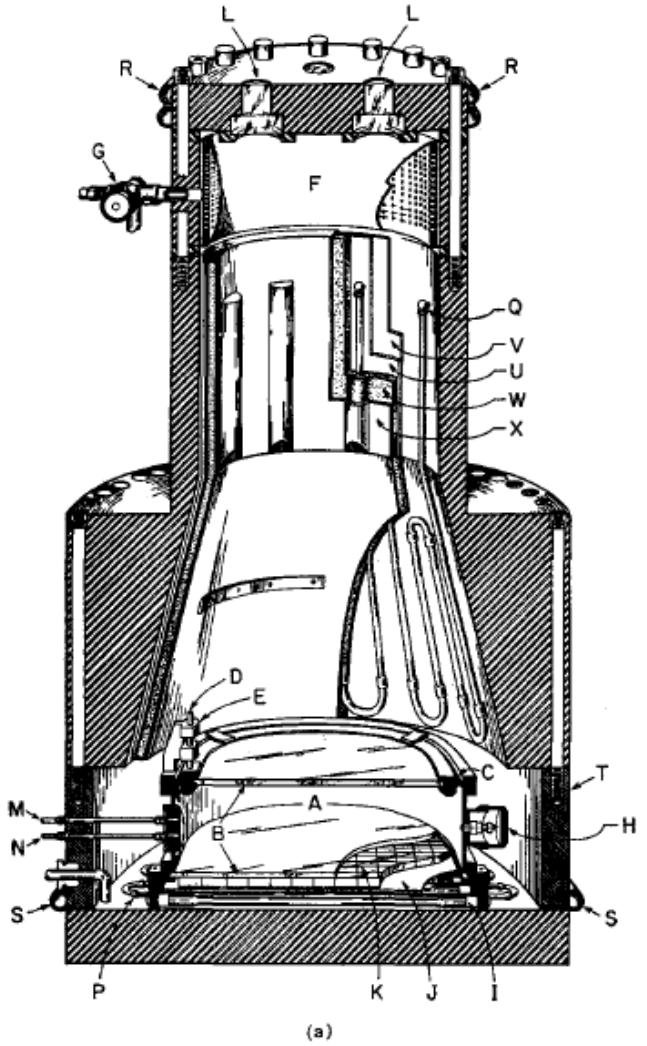


72” Hydrogen Chamber

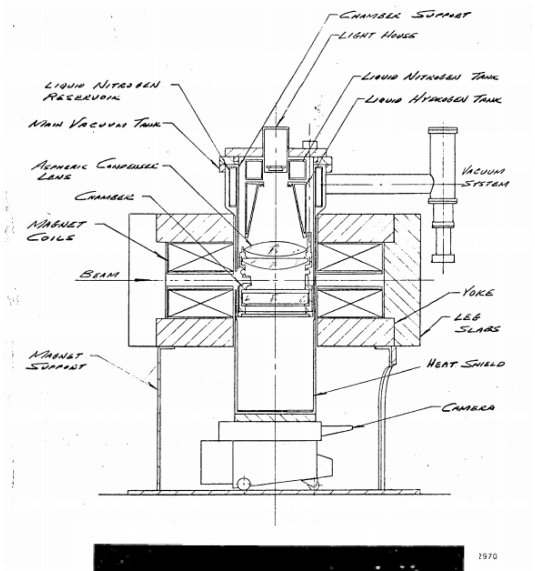


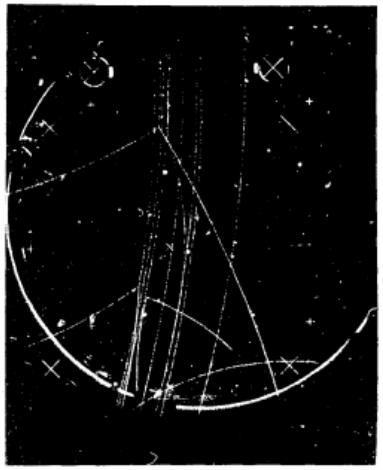


30” Heavy Liquid Chamber

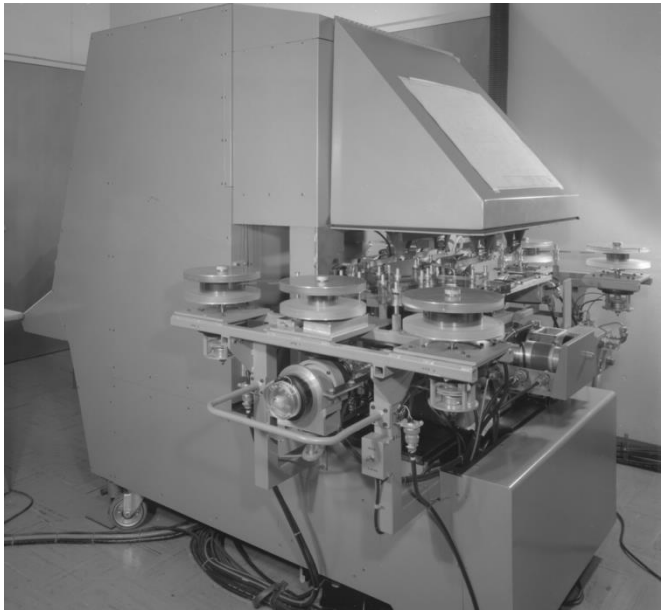


25” Hydrogen Bubble Chamber





Franckenstein



Sakata Model

Mesons (B=0):

	p	n	Λ
$\bar{p}$	?	π^-	K^-
$\bar{n}$	π^+	?	$\bar{K}^0$
$\bar{\Lambda}$	K^+	K^0	?

Note that there are three diagonal states, $\bar{p}p$, $\bar{n}n$, $\bar{\Lambda}\Lambda$.
Therefore, there should be 3 independent states, three neutral mesons:
$\pi^0 = (\bar{p}p - \bar{n}n) / \sqrt{2}$ with isospin I=1
$X^0 = (\bar{p}p + \bar{n}n) / \sqrt{2}$ with isospin I=0
$Y^0 = \bar{\Lambda}\Lambda$ with isospin I=0
Or the last two can be mixed again…
(Actually, later discovered η and η' resonances could be interpreted as such mixtures.)

Baryons (B=1):

S=-1 $\Sigma^+ = (\Lambda\, p\, \bar{n})$
$\Sigma^0 = (\Lambda\, n\, \bar{n})$ mixed with $(\Lambda\, p\, \bar{p})$ → what is the orthogonal mixture?
$\Sigma^- = (\Lambda\, n\, \bar{p})$

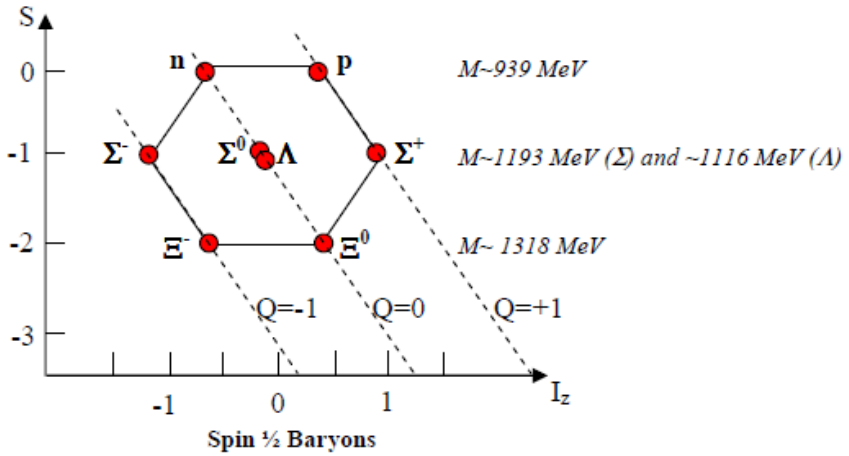
S=-2 $\Xi^- = (\Lambda\, \Lambda\, \bar{p})$
$\Xi^- = (\Lambda\, \Lambda\, \bar{n})$

S=-3 NOT possible

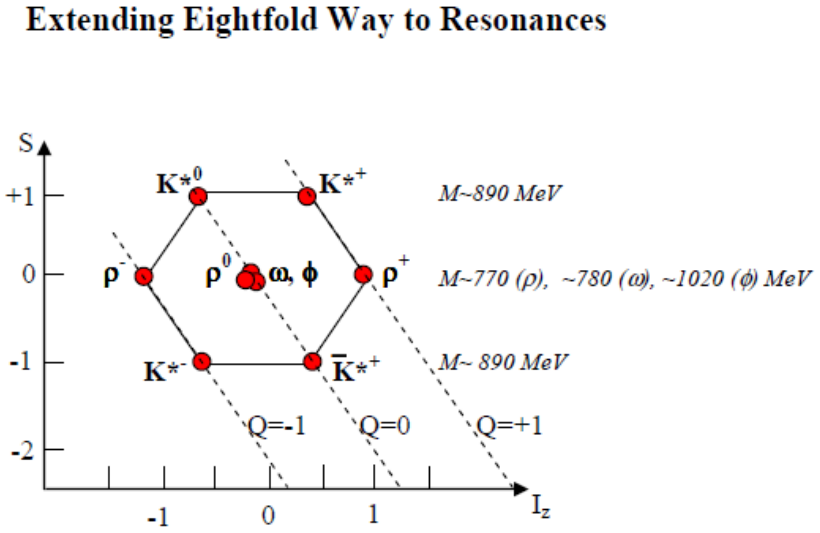
Resonances (B=1):

$\Delta^{++} = (p\, p\, \bar{n})$
$\Delta^+ = (p\, n\, \bar{n})$ mixed with $(p\, p\, \bar{p})$ → what is the orthogonal mixture?
$\Delta^0 = (n\, n\, \bar{n})$ mixed with $(n\, p\, \bar{p})$ → what is the orthogonal mixture?
$\Delta^- = (n\, n\, \bar{p})$

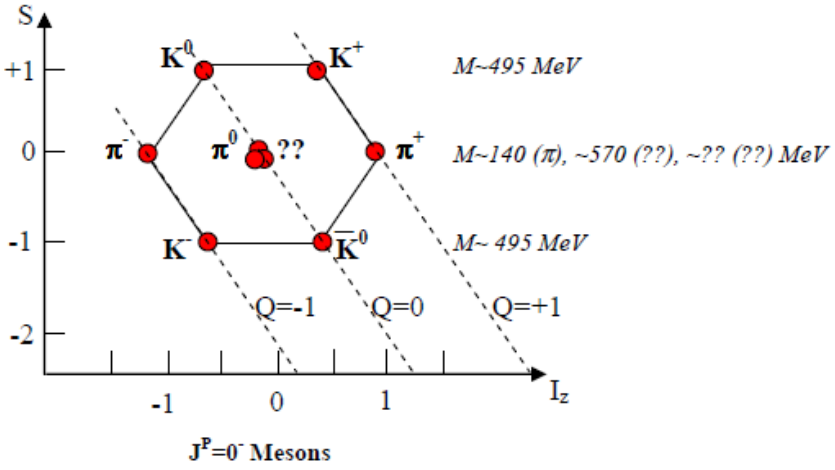
Eightfold Way and SU(3)



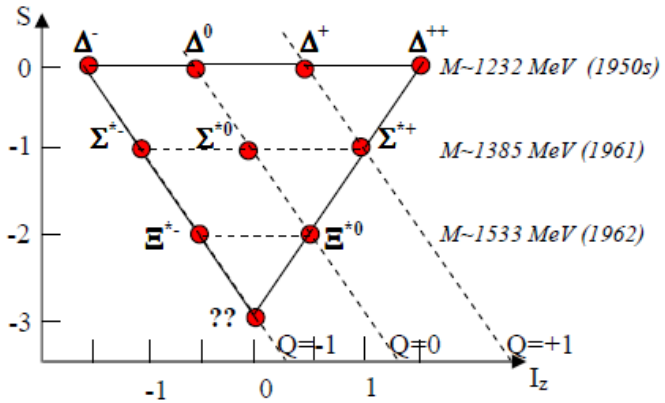
Spin ½ Baryons



$J^P=1^-$ Meson Resonances
(all discovered by 1961)



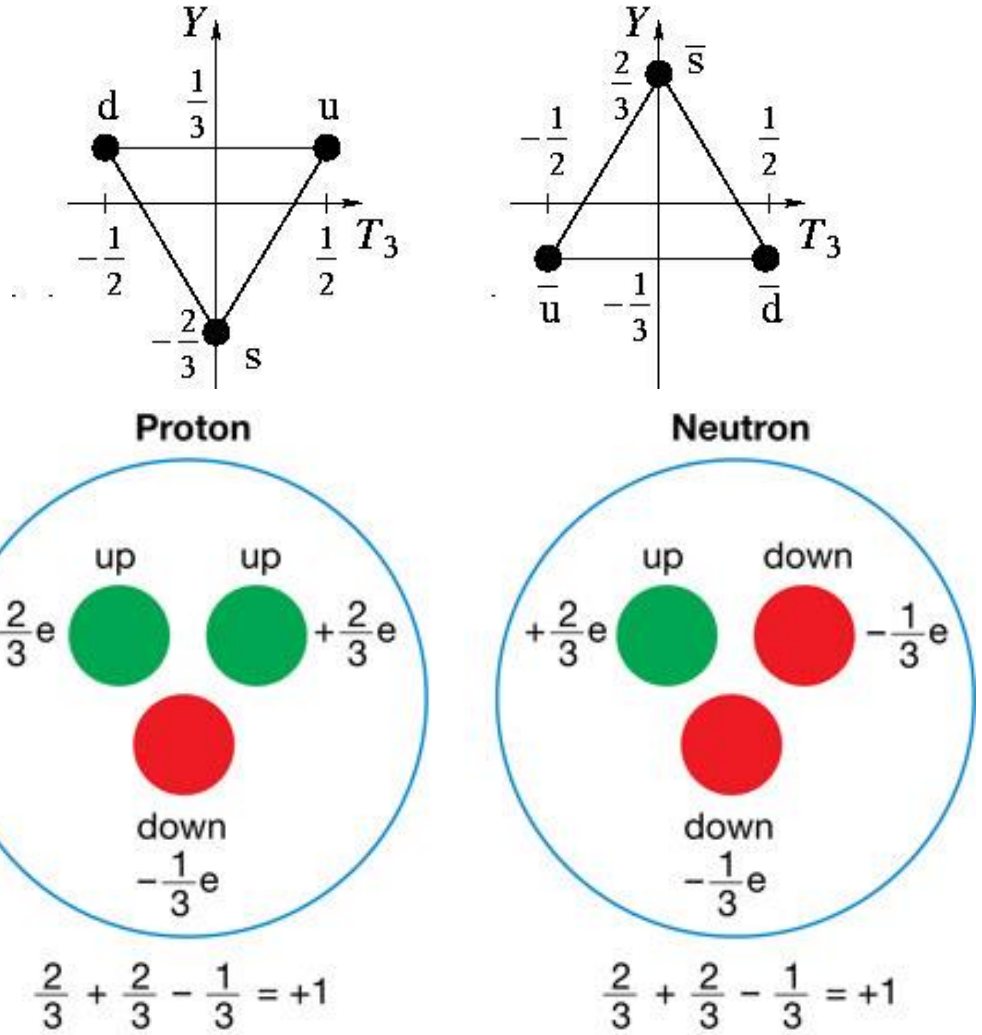
$J^P=0^-$ Mesons



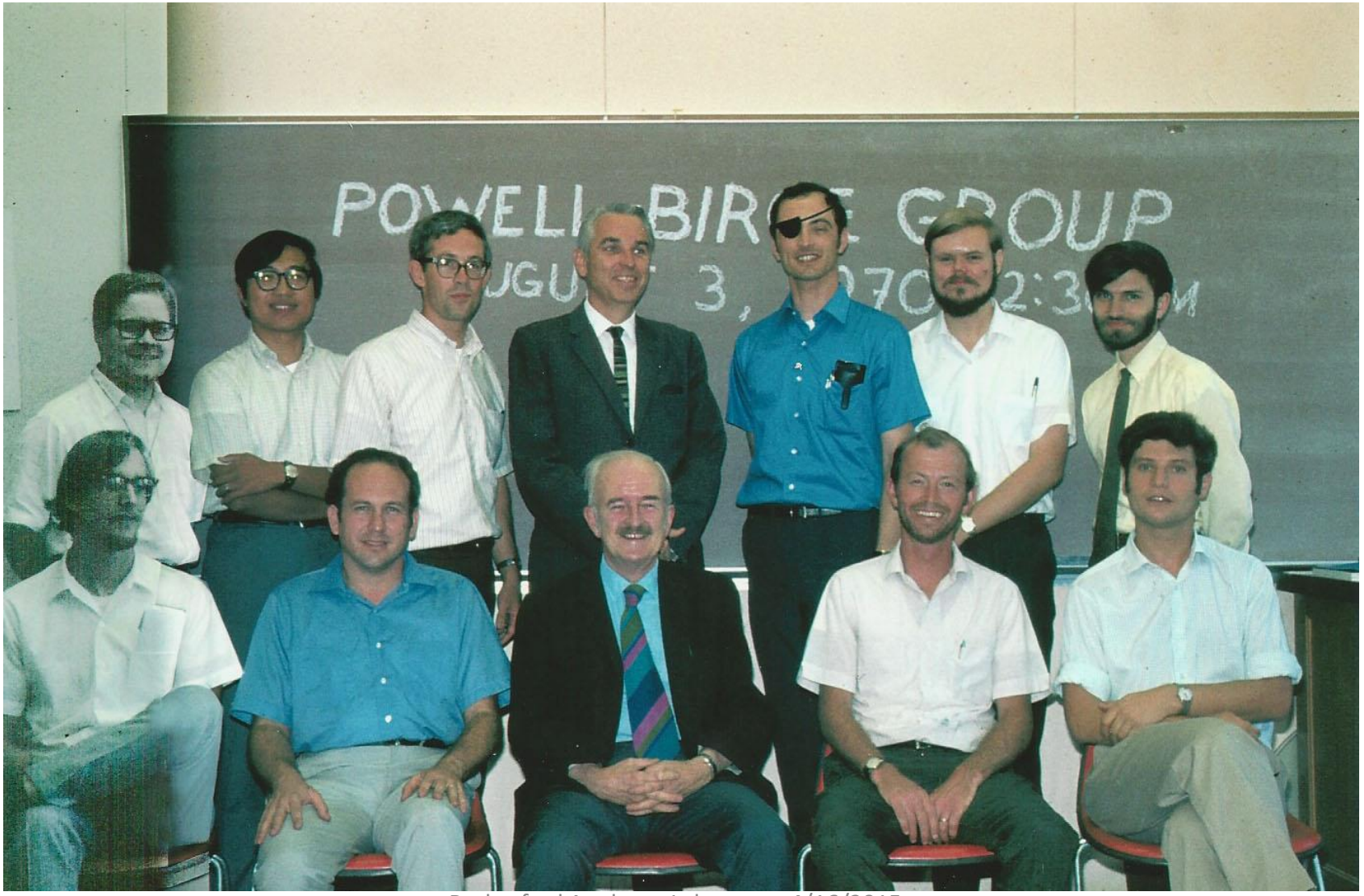
Spin 3/2 Baryon Resonances


$\omega \rightarrow \pi^+ \pi^- + \pi^0$
$\bar{p}$
π^+
π^0
π^-
π
π^+

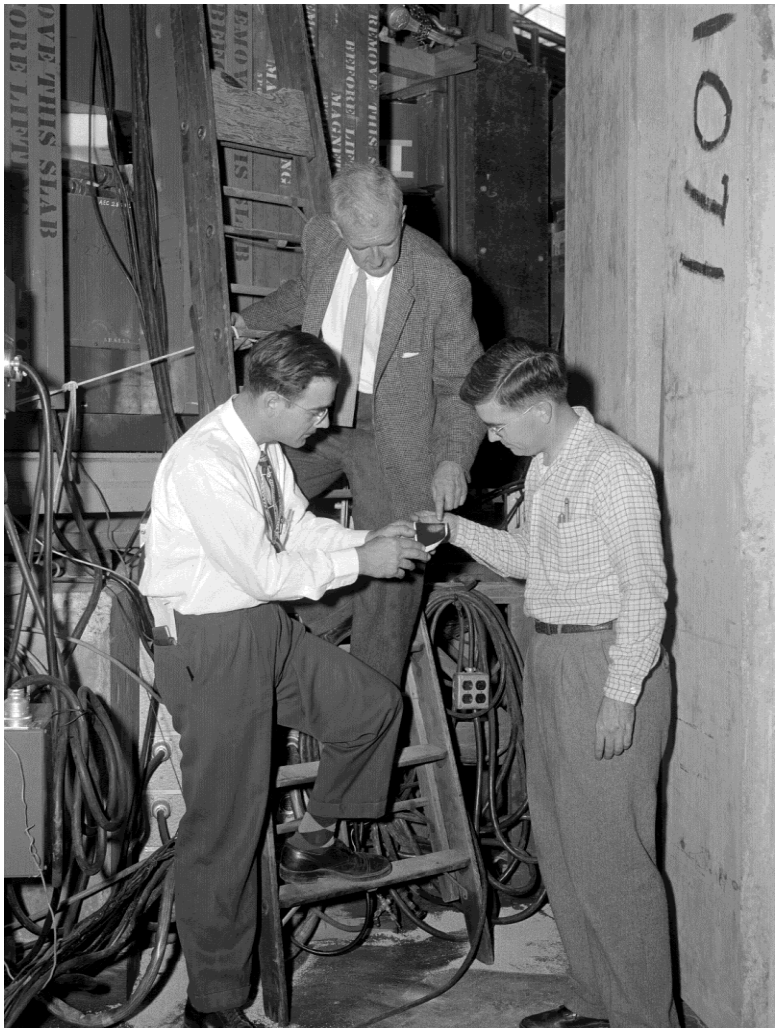
Quarks, ΔS/ΔQ, ΔI=1/2



Powell Birge Group

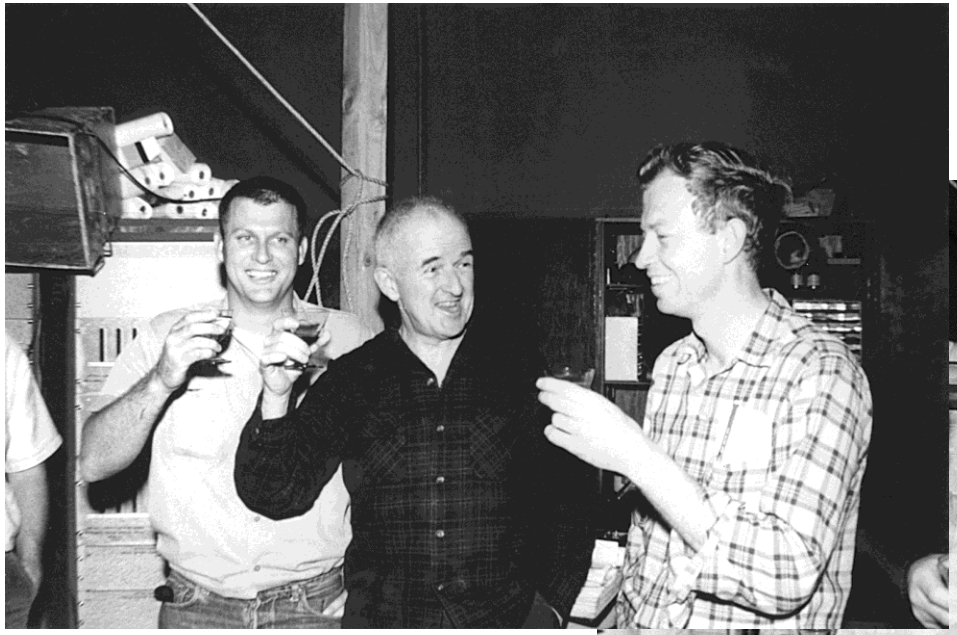


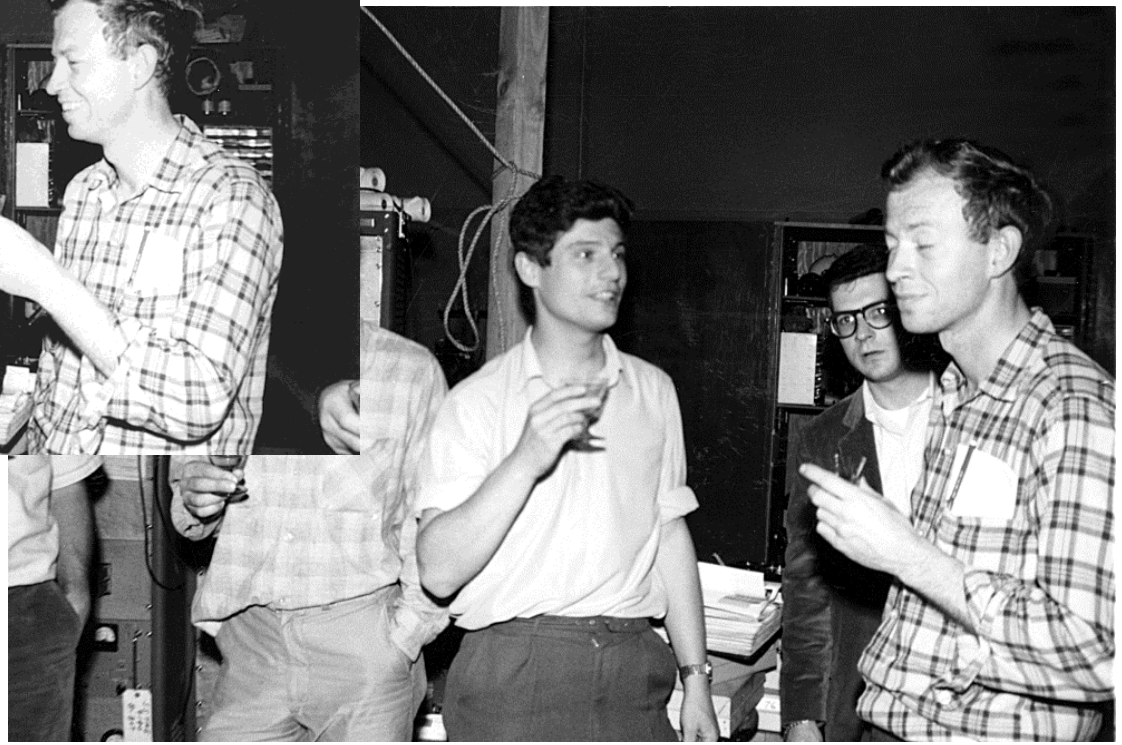
Wilson, Larry and Bill Fowler



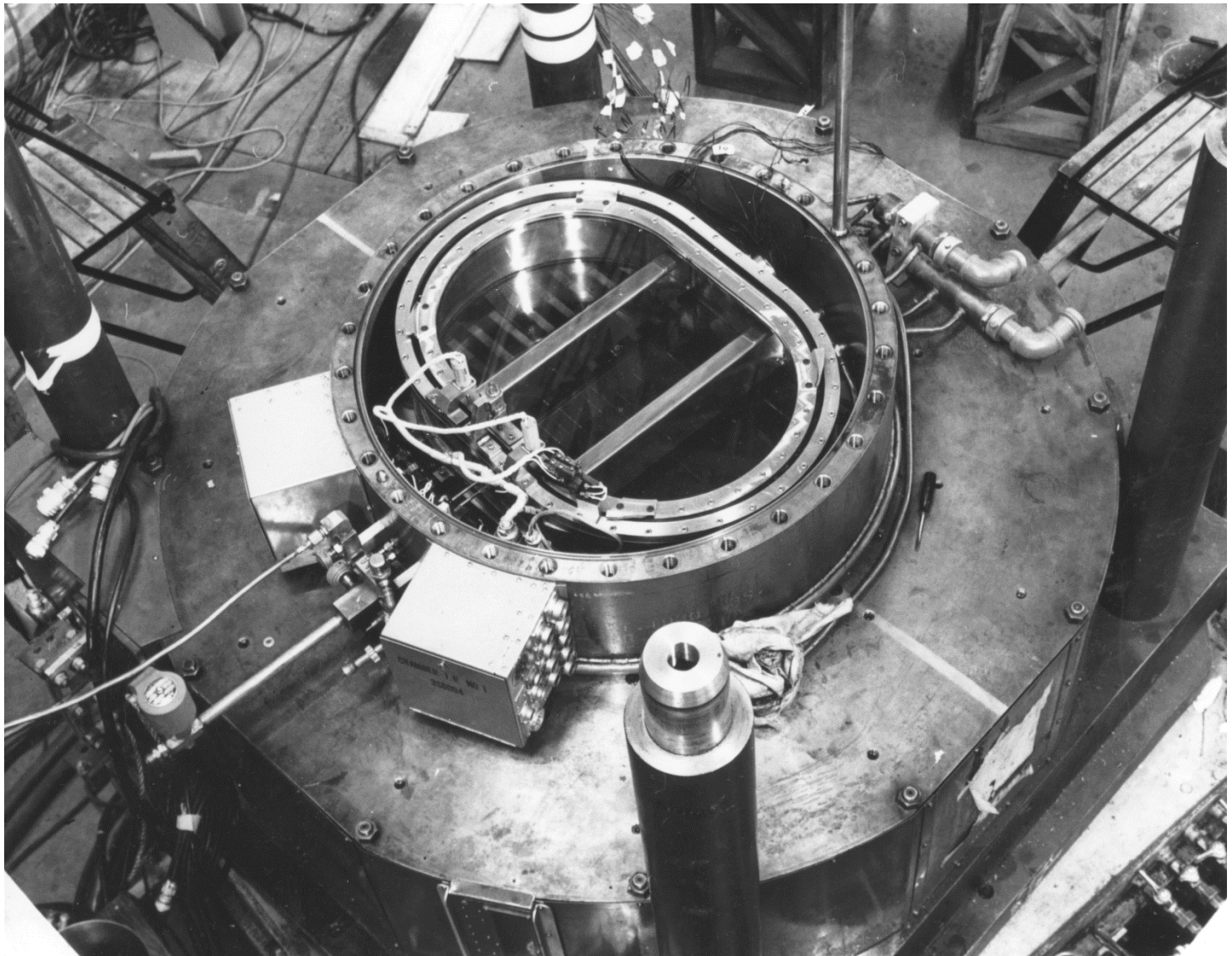
Rutherford Appleton Laboratory 4/16/2015

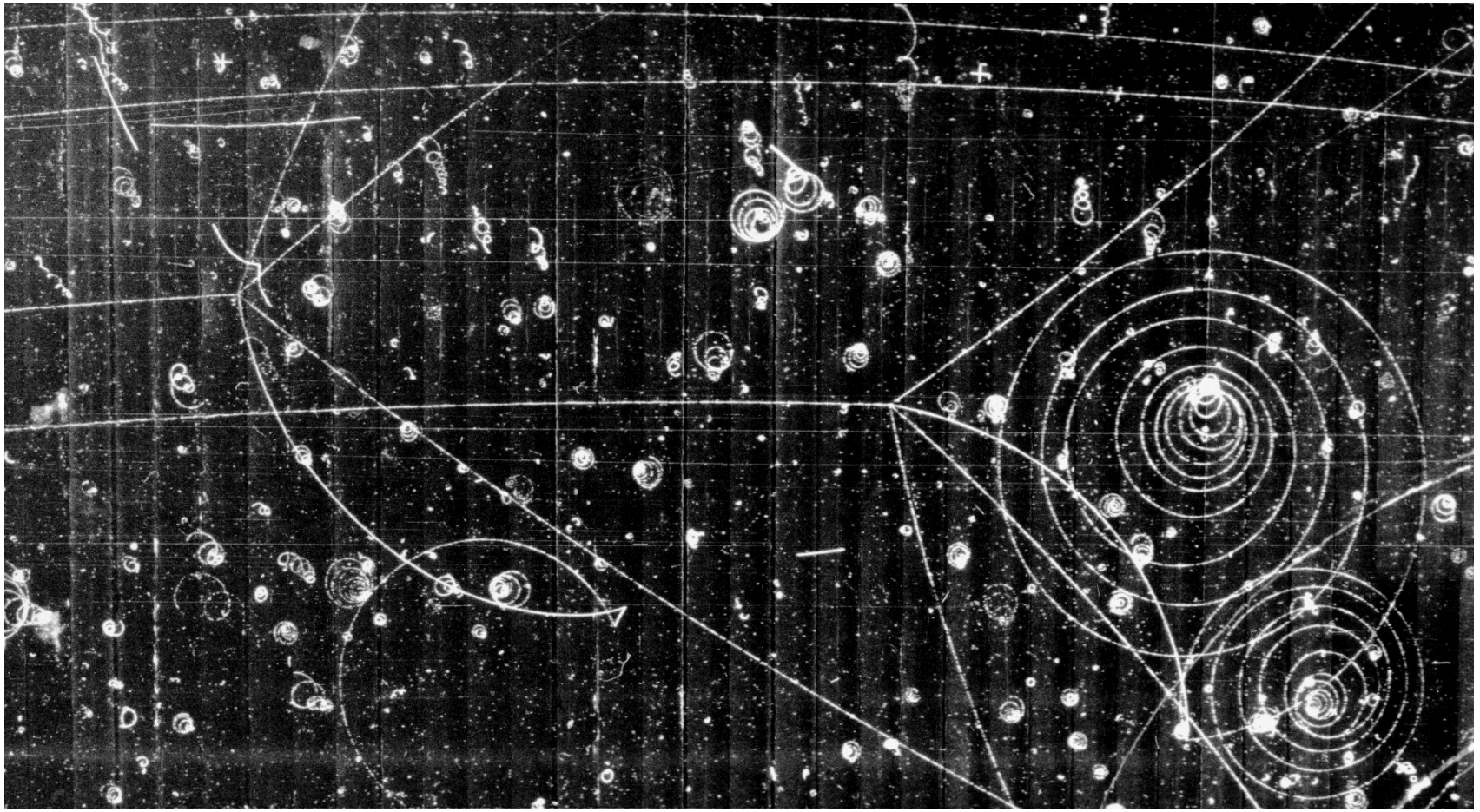
We celebrate the beginning and end of every run





Steel plates for K^0 regeneration





Gary installing scotchlite

George's Pubs

Hadron Resonances

Evidence for Duality Constraints in Δ -> π + Δ(1236) Decays
U. Mehtani, S. Y. Fung, A. Kernan, T. L. Schalk, Y. Williamson, R. W. Birge, G. E. Kalmus, and W. Michael
Phys. Rev. Lett. 29, 1634 (1972) – Published 11 December 1972

Dip Structures in $\pi^+ + p \rightarrow \rho^+ + p$ at 1.55-1.84 GeVc
Y. Williamson, S. Y. Fung, A. Kernan, U. Mehtani, T. L. Schalk, B. C. Shen, W. Michael, R. W. Birge, and G. E. Kalmus
Phys. Rev. Lett. 29, 1353 (1972) – Published 6 November 1972

Strange-Particle Production from π+p Interactions in the c.m. **Energy Range 1820 to 2090 MeV**
P. Hanson, G. E. Kalmus, and J. Louie
Phys. Rev. D 4, 1296 (1971) – Published 1 September 1971

π+p Elastic Scattering Data between 1820- and 2090-MeV c.m. Energy
G. E. Kalmus, W. Michael, R. W. Birge, S. Y. Fung, and A. Kernan
Phys. Rev. D 4, 676 (1971) – Published 1 August 1971

Study of the Reaction $\pi+ p \rightarrow \Sigma^+ K^+$ between 1850 Mev and 2090 MeV c.m. Energy
G. E. Kalmus, G. Borreani, and J. Louie
Phys. Rev. D 2, 1824 (1970) – Published 1 November 1970

Study of the Enhancement in the Λp Invariant Mass Near the ΣΛ Threshold in $K^- d \rightarrow \Lambda p \pi^-$ Interactions Around 1.0 GeV/c
Gideon Alexander, Bronwyn H. Hall, Nathan Jew, George Kalmus, and Anne Kernan
Phys. Rev. Lett. 22, 483 (1969) – Published 10 March 1969

Study of Y_1^* Resonant Amplitudes Between 1660 and 1900 MeV
Wesley M. Smart, Anne Kernan, George E. Kalmus, and Robert P. Ely, Jr.
Phys. Rev. Lett. 17, 556 (1966) – Published 5 September 1966

$\pi^+ p$ Elastic Scattering Data between 1820- and 2090-MeV c.m. Energy*

G. E. Kalmus, W. Michael, and R. W. Birge

Lawrence Radiation Laboratory, University of California, Berkeley, California 94720

and

S. Y. Fung and A. Kernan

University of California, Riverside, California 92502

(Received 18 September 1970)

Total and differential elastic cross-section data are presented at eight incident π^+ momenta: 1.28, 1.34, 1.40, 1.43, 1.55, 1.68, 1.77, and 1.84 GeV/c. These data were obtained from a hydrogen-bubble-chamber exposure at the Bevatron, and contain more than 65 000 events. This represents more than $1\frac{1}{2}$ times the world's data hitherto available in this energy region.

Evidence for Duality Constraints in $\Delta \to \pi + \Delta(1236)$ Decays*

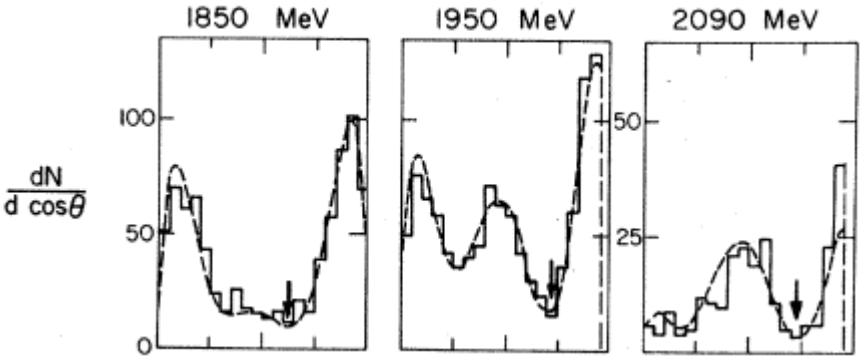
U. Mehtani,† S. Y. Fung, A. Kernan, T. L. Schalk, and Y. Williamson
University of California, Riverside, California 92502

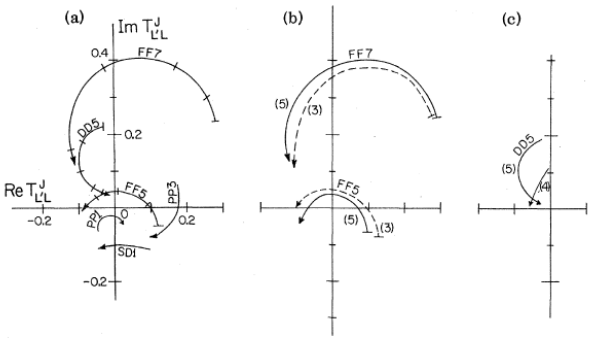
and

R. W. Birge, G. E. Kalmus,‡ and W. Michael
Lawrence Radiation Laboratory, University of California, Berkeley, California 94720

(Received 22 August 1972)

Partial-wave analysis of $\pi^+ + p \to \pi^0 + \Delta^{++}$ at 1820–2090 MeV c.m. energy shows that this reaction is dominated by the $F_{37}(1950)$ resonance decaying to $\Delta(1236)$ with s-channel helicity $\frac{3}{2}$. The analysis also gives evidence for $F_{35}(1890) \to \pi + \Delta$ via F wave. The coupling of F_{37} to helicity-$\frac{3}{2}$ states, and the unexpected dominance of F- over P-wave decay for $F_{35}(1890)$, can both be interpreted as arising from the constraints of s-t channel duality.

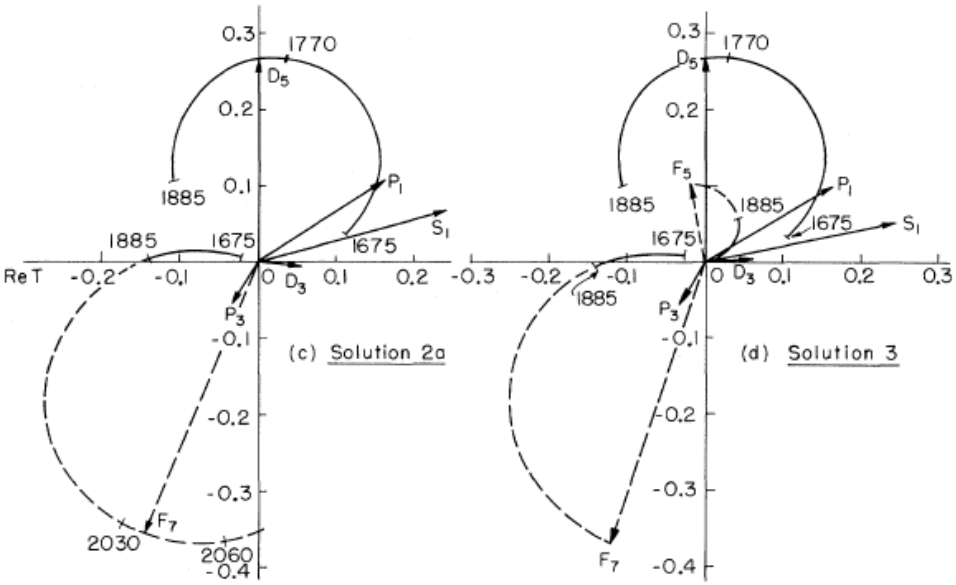




STUDY OF Y_1^* RESONANT AMPLITUDES BETWEEN 1660 AND 1900 MeV*

Wesley M. Smart, Anne Kernan, George E. Kalmus, and Robert P. Ely, Jr.
Lawrence Radiation Laboratory, University of California, Berkeley, California
(Received 18 July 1966)

A partial-wave analysis of the reaction $K^- + n \rightarrow \Lambda + \pi^-$ has confirmed the spin-parity assignments for $Y_1^*(1765)$ and $Y_1^*(2030)$ and measured the mass, width, and $\Lambda\pi$ branching ratio of $Y_1^*(1765)$ as 1776 ± 6 MeV, 129 ± 16 MeV and 0.14 ± 0.02, respectively. A tentative spin-parity assignment for $Y_1^*(1660)$ and $Y_1^*(1915)$ is also made. The resonant amplitudes $Y_1^*(1765)$ and $Y_1^*(1915)$ are in phase at the resonant energy and are 180° out of phase with $Y_1^*(1660)$ and $Y_1^*(2030)$.



George's Pubs

Strange Particle Decays

Beta-Decay Branching Ratio of the Lambda Hyperon
Robert P. Ely, George Gidal, George E. Kalmus, Larry O. Oswald, Wilson M. Powell, William J. Singleton, Frederick W. Bullock, Cyril Henderson, David J. Miller, and F. Russell Stannard
Phys. Rev. 131, 868 (1963) – Published 15 July 1963

Form of the Interaction in Lambda-Hyperon Beta Decay
Robert P. Ely, George Gidal, George E. Kalmus, Wilson M. Powell, William J. Singleton, Cyril Henderson, David J. Miller, and F. Russell Stannard
Phys. Rev. 137, B1302 (1965) – Published 8 March 1965

Energy Spectrum of the π^+ in K => $\pi^+ \pi^0 \pi^0$ Decay
George E. Kalmus, Anne Kernan, Robert T. Pu, Wilson M. Powell, and Richard Dowd
Phys. Rev. Lett. 13, 99 (1964) – Published 20 July 1964

Experimental Tests of Time-Reversal Invariance in K_{M3}^+ Decay
Ugo Camerini, Ronald L. Hantman, Robert H. March, David Murphree, George Gidal, George E. Kalmus, Wilson M. Powell, Robert T. Pu, Carl L. Sandler, Sergio Natali, and Matteo Villani
Phys. Rev. Lett. 14, 989 (1965) – Published 14 June 1965

Experimental Study of K_{E4}^+ Decays
R. W. Birge, R. P. Ely, G. Gidal, G. E. Kalmus, A. Kernan, W. M. Powell, U. Camerini, W. F. Fry, J. Gaidos, R. H. March, and S. Natali
Phys. Rev. Lett. 11, 35 (1963) – Published 1 July 1963

Experimental Study of K_{E4}^+ Decay
Robert W. Birge, Robert P. Ely, Jr., George Gidal, George E. Kalmus, Anne Kernan, Wilson M. Powell, Ugo Camerini, David Cline, William F. Fry, James G. Gaidos, David Murphree, and C. Thornton Murphy
Phys. Rev. 139, B1600 (1965) – Published 20 September 1965

Measurement of K_{M3}^+ Decay Parameters
Andrew C. Callahan, Ugo Camerini, Ronald D. Hantman, Robert H. March, David L. Murphree, George Gidal, George E. Kalmus, Wilson M. Powell, Carl L. Sandler, Robert T. Pu, Sergio Natali, and Matteo Villani
Phys. Rev. 150, 1153 (1966) – Published 28 October 1966

Experimental Study of $\mathbf{K^+ \rightarrow \pi^0 + e^+ + \nu}$ Decay
George E. Kalmus and Anne Kernan
Phys. Rev. 159, 1187 (1967) – Published 25 July 1967

Study of Ke4 Decays
Robert P. Ely, Jr., George Gidal, Vasken Hagopian, George E. Kalmus, Kelvin Billing, Frederick W. Bullock, Michael J. Esten, M. Govan, Cyril Henderson, William L. Knight, F. Russell Stannard, Ortwin Treutler, Ugo Camerini, David Cline, William F. Fry, Hermann Haggerty, Robert H. March, and William J. Singleton
Phys. Rev. 180, 1319 (1969) – Published 25 April 1969

Beta-Decay Branching Ratio of the Lambda Hyperon*

ROBERT P. ELY, GEORGE GIDAL, GEORGE E. KALMUS, LARRY O. OSWALD, WILSON M. POWELL, AND WILLIAM J. SINGLETON
Lawrence Radiation Laboratory, University of California, Berkeley, California

AND

FREDERICK W. BULLOCK, CYRIL HENDERSON, DAVID J. MILLER, AND F. RUSSELL STANNARD
University College London, London, England

(Received 7 March 1963)

Lambda hyperons were produced by K^- mesons at rest in the Berkeley 30-in. heavy-liquid bubble chamber filled with a mixture of 76% CF_3Br−24% C_3H_8 by weight. A search for the β-decay mode $\Lambda \rightarrow p+e^-+\bar{\nu}$ was made. A total of 192 000 Λ decays of the type $\Lambda \rightarrow p+\pi^-$ was observed. Three methods of separating the β-decay mode from the mesonic decay and from other forms of background are discussed. The most successful method of calculating the branching ratio $r=(\Lambda \rightarrow p+e^-+\bar{\nu})/[(\Lambda \rightarrow p+\pi^-)+(\Lambda \rightarrow n+\pi^0)]$ made use of the Λ_β decays identified by the electron's stopping or starting to curl up in the chamber; also, r was calculated from Λ_β decays in which the negative secondaries left the chamber. The nonmesonic nature of these secondaries was established either by δ rays or by decay kinematics. The values of r obtained by the different methods all agree within the errors. The best value obtained is $r=(0.82\pm0.13)\times10^{-3}$.

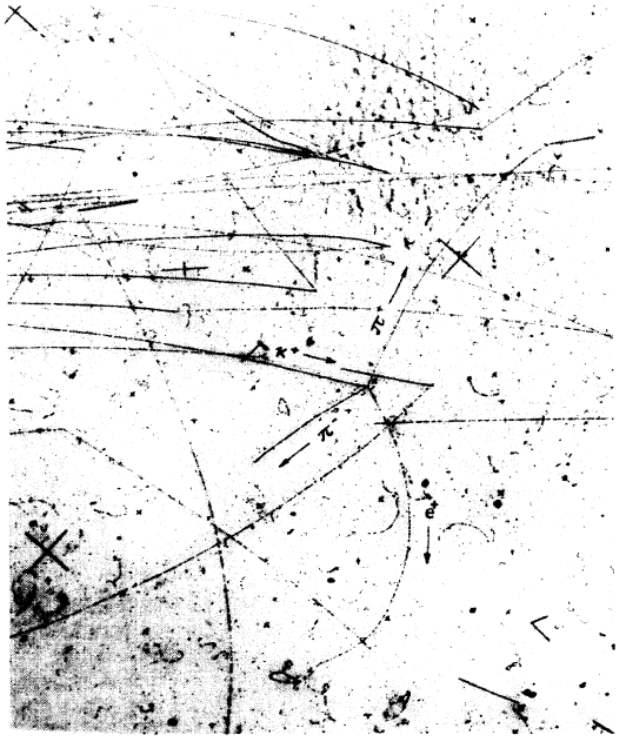
$$r=(0.82\pm0.13)\times10^{-3}.$$

PDG 2002 r = 0.832 +/- .014 X 10^{-3}

Study of Ke4 Decays

Robert P. Ely, Jr., George Gidal, Vasken Hagopian, George E. Kalmus, Kelvin Billing, Frederick W. Bullock, Michael J. Esten, M. Govan, Cyril Henderson, William L. Knight, F. Russell Stannard, Ortwin Treutler, Ugo Camerini, David Cline, William F. Fry, Hermann Haggerty, Robert H. March, and William J. Singleton

Phys. Rev. 180, 1319 (1969) – Published 25 April 1969



550,000 pictures – 24 stopping K^+ per picture
1 meter CERN heavy liquid chamber
Filled with C_2F_5Cl

$K^+ \to \pi^+ + \pi^- + e^+ + \nu$ 269 events

$K^+ \to \pi^+ + \pi^+ + e^- + \bar{\nu}$ 0 events

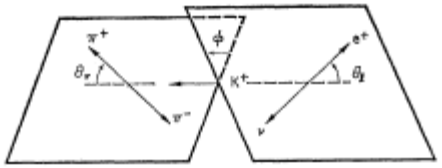


FIG. 1. Diagram illustrating the various angles referred to in the text.

Congratulations George

Many Happy Returns

Glasgow - 1994