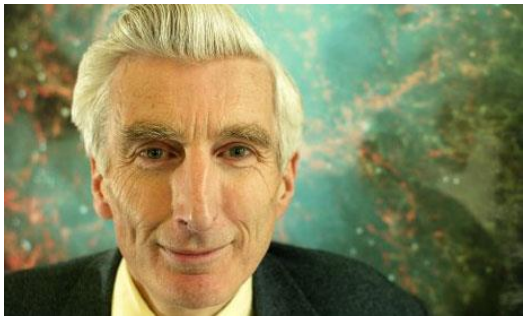
Mecánica Estadística

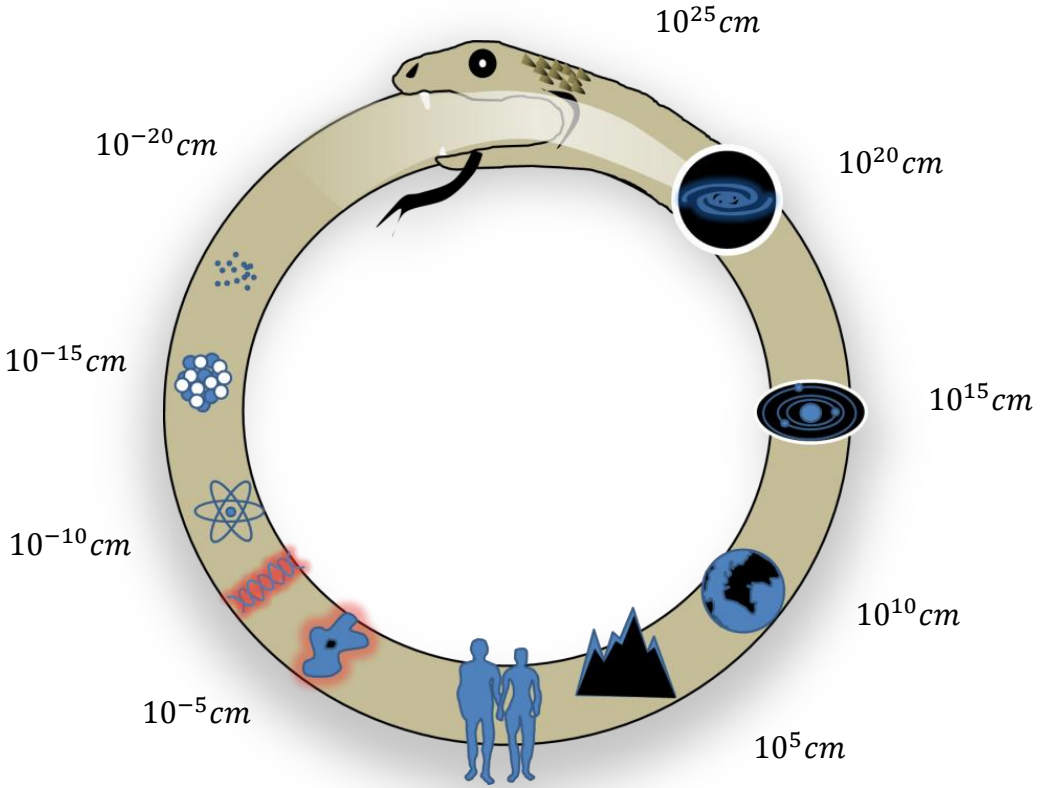
2015

Charla 1: Sabor
Partículas elementales

Cosmología y partículas elementales

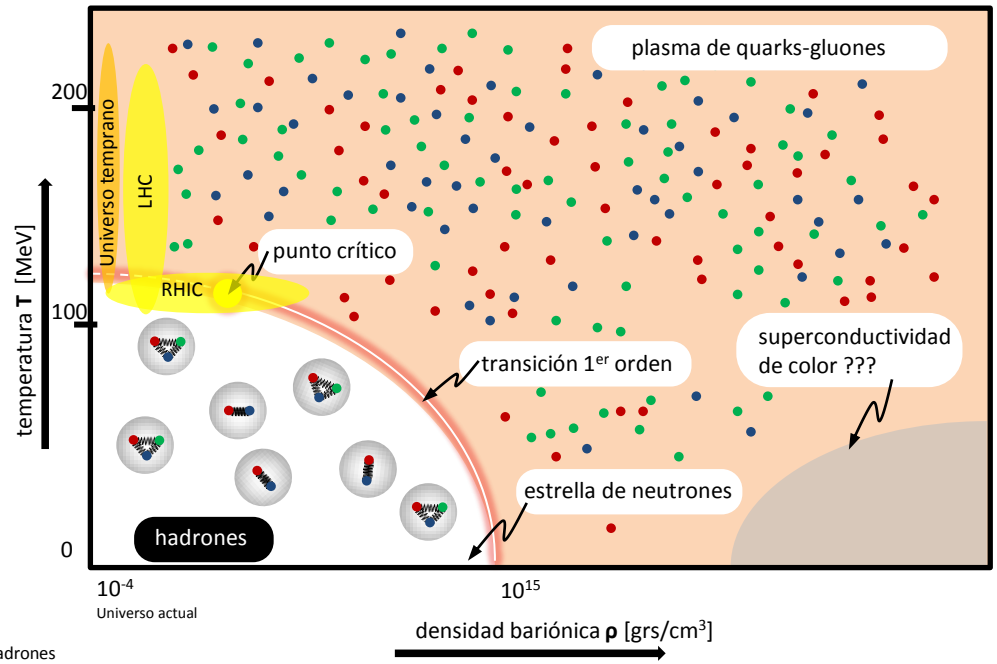


Martin Ress



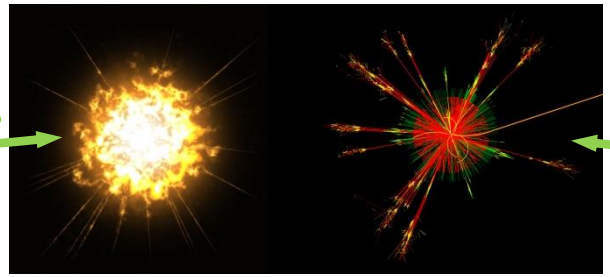
Martin Rees. Seis números nada más. (2001)

Big Bang-Micro Bang



LHC= gran colisionador de hadrones
RHIC=colisionador relativista de iones pesados

Big Bang



Micro Bang

$\tau \cong 10\mu s$
$N_b/N \cong 10^{-10}$

$\tau \cong 4x10^{-23}s$
$N_b/N \cong 0{,}1$

J. Letessier, J. Rafelski. Hadrons Quarks-Gluons Plasma. (2002)

R. L. Jaffe, W. Busza, F. Wilczek, and J. Sandweiss. Review of speculative "disaster scenarios" at RHIC. Rev. Mod. Phys. **72**, 1125. (2000)

Partículas elementales

fermiones

quarks

2,4 MeV/c^2 2/3 1/2 **u** up	1,27 GeV/c^2 2/3 1/2 **c** charm	171,2 GeV/c^2 2/3 1/2 **t** top
2,4 MeV/c^2 -1/3 1/2 **d** down	104 MeV/c^2 -1/3 1/2 **s** strange	4,2 GeV/c^2 -1/3 1/2 **b** botton

leptones

0,511 MeV/c^2 -1 1/2 **e** electrón	105,7 MeV/c^2 -1 1/2 **μ** muón	1,777 GeV/c^2 -1 1/2 **τ** tau
<2,2 eV/c^2 0 1/2 ν_e electrón neutrino	<0,17 MeV/c^2 0 1/2 ν_μ muón neutrino	<15,5 MeV/c^2 0 1/2 ν_τ tau neutrino

bosones

0 0 1 **γ** fotón	0 0 1 **g** gluón
91,2 GeV/c^2 0 1 Z^o bosón Z	80,4 GeV/c^2 ±1 1 $W^\pm$ bosón W

D. Griffiths. Introduction to Elementary Particles (2008)

Partículas elementales

Interacción	Intensidad relativa	Alcance	Partícula mediadora			
			Nombre	Masa	Carga	Spin
Fuerte	1	Corto $(\sim 1fm)$	Gluón	0	0	1
Electromagnética	$1/137$	Largo $(\frac{1}{r^2})$	fotón	0	0	1
Débil	10^{-9}	Corto $(0{,}0001fm)$	$W^{\pm}Z^{0}$	80.4-91,2 GeV/c²	±e,0	1
Gravitacional	10^{-38}	Largo $(\frac{1}{r^2})$	Gravitón	0	0	2

D. Griffiths. Introduction to Elementary Particles (2008)

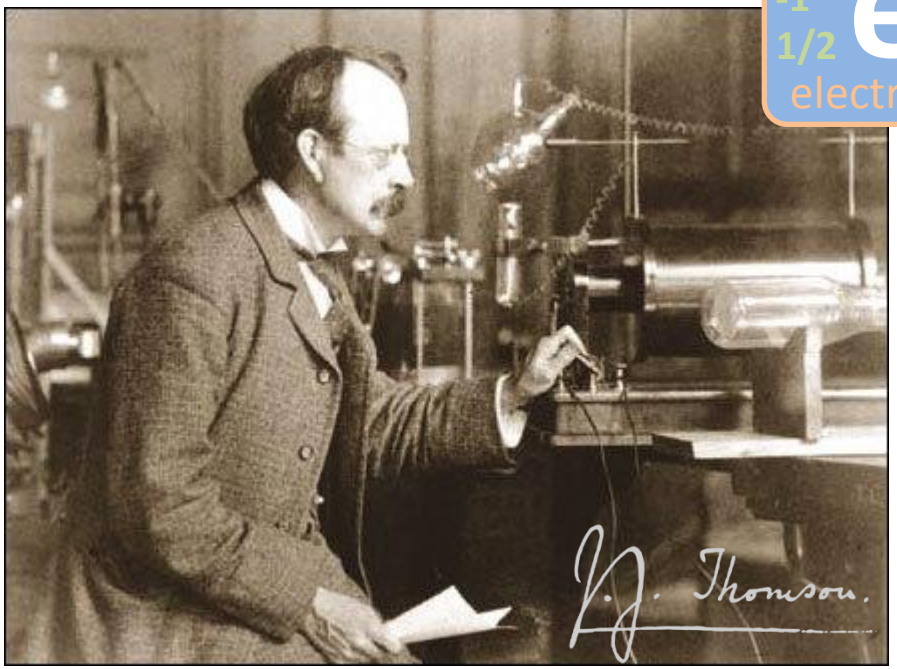
Partículas elementales

"todo está
hecho de átomos"

R. Feynman

Partículas elementales

0,511 MeV/c^2
-1
1/2
e
electrón



Modelo atómico "budín de pan"
(1904)

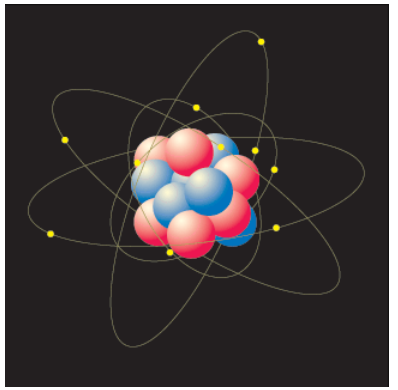
- J. J.Thomson (1897)
- premio Nobel (1906)

$\sim 10^2 eV$

J. J. Thomson Cathode Rays. *Philosophical Magazine* **44**-293.(1897)

Partículas elementales

Partículas elementales



Modelo atómico "planetario" (1911)

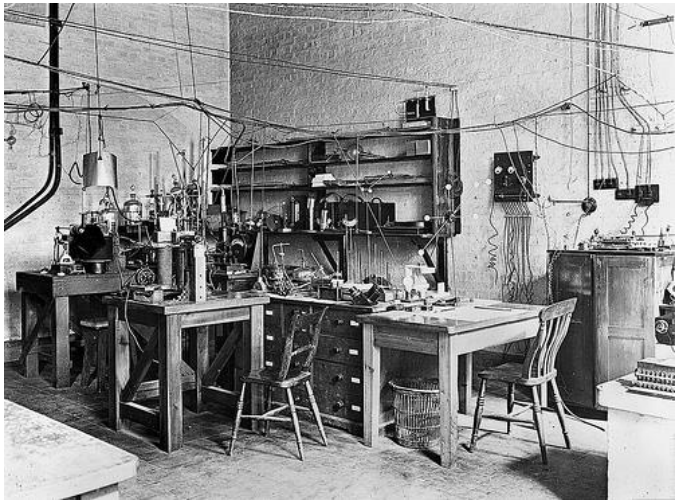
➡ E. Rutherford (1911)

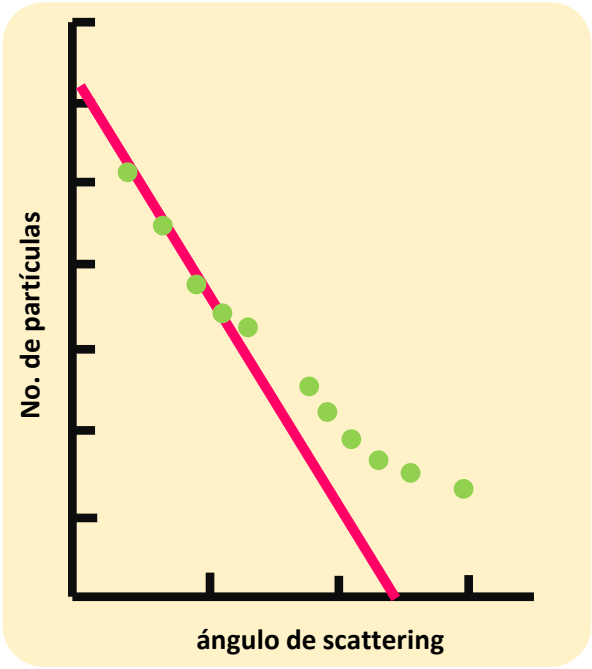
$$\sim 10^6 eV$$

E. Rutherford, The Scattering of α and β Particles by Matter and the Structure of the Atom. *Philosophical Magazine* Series 6, vol. 21 (1911).

Partículas elementales

➡ E. Rutherford (1911)





protón
Q=+1
$m=938,3 MeV/c^2$

electrón
Q=-1
$m=0,511 MeV/c^2$

Partículas elementales

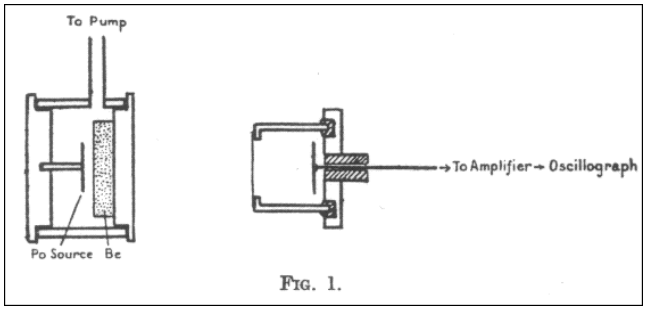


FIG. 1.

protón
Q=+1
$m=938,3 MeV/c^2$

electrón
Q=-1
$m=0,511 MeV/c^2$

neutrón
Q=0
$m=939,6 MeV/c^2$

- James Chadwick(1931)
- premio Nobel (1935) 

Cavendish 1931

Ern levantó la vista del artículo. James estaba exultante.

—¡Son neutrones, Ern! ¡Son neutrones! La radiación gamma no puede producir esos efectos.

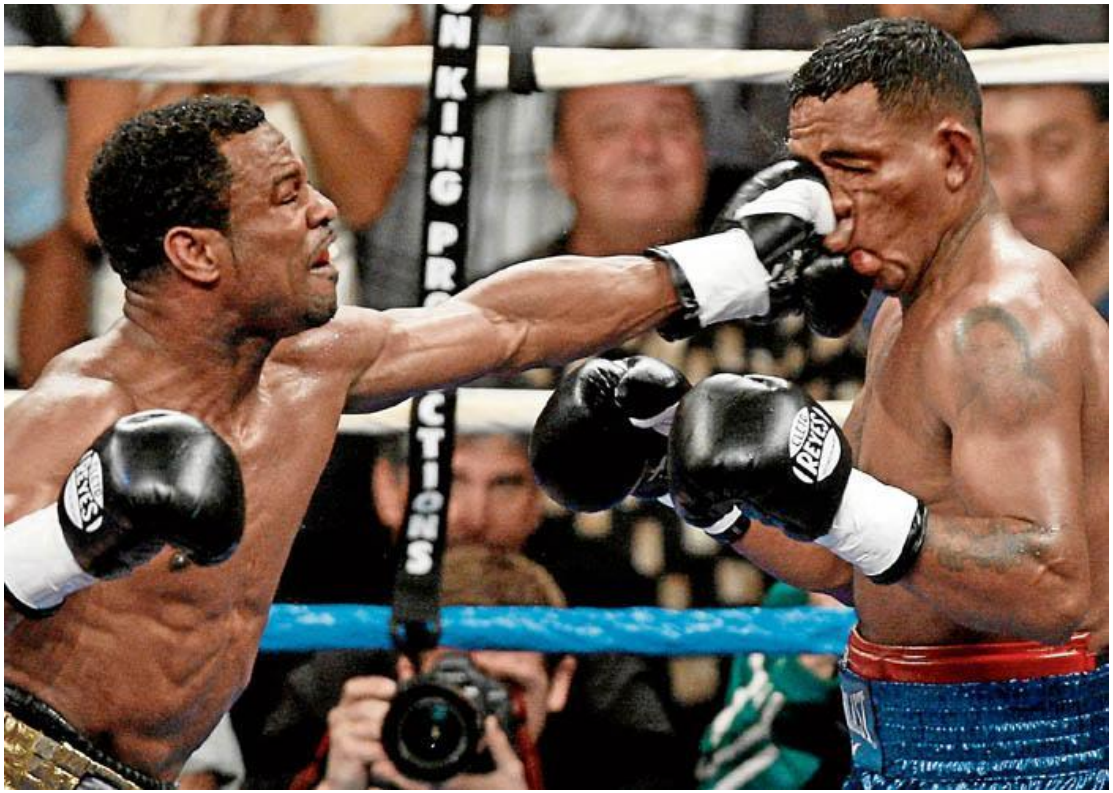
—Tenemos que repetir el experimento, James, lo antes posible.

—Vamos a encontrarlo, Ern, vamos a encontrarlo.

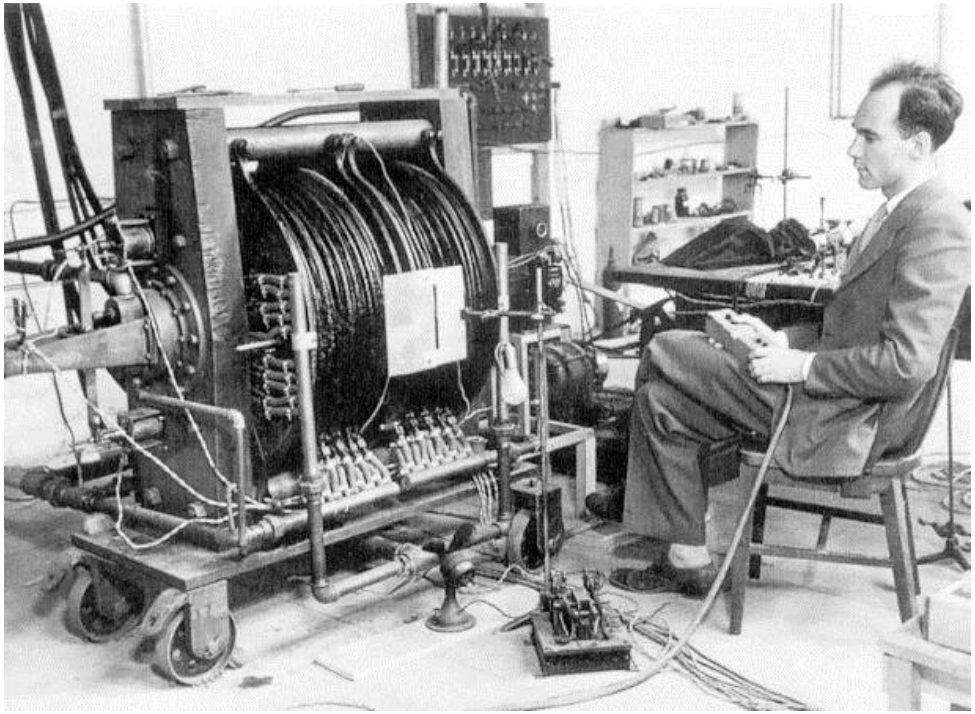
«Por favor, dadme cloroformo y dejadme dormir un día entero» .

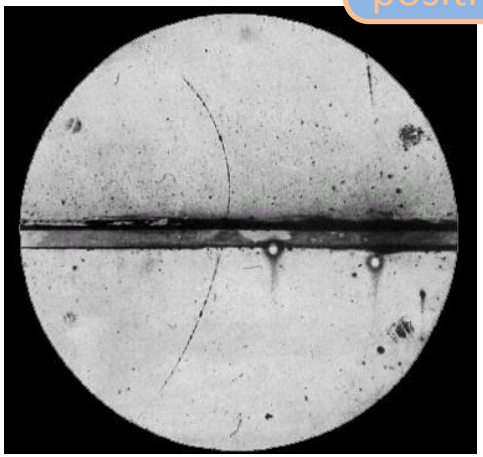
Chadwick, J. (1932). "Possible Existence of a Neutron". Nature 129 (3252): 312

Partículas elementales



Partículas elementales





0,511 MeV/c^2

1

1/2

$\bar{e}$

positrón

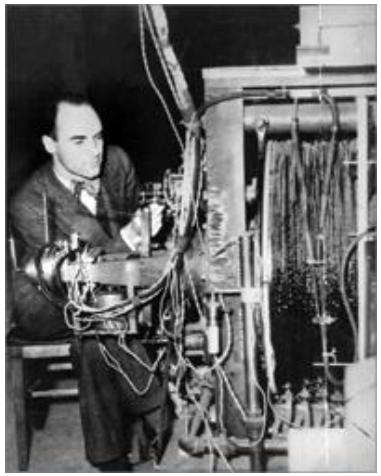
- C. D. Anderson (1932)
- premio Nobel (1936) 

$\sim 10^{15} eV$

C.D. Anderson. The Positive Electron. *Physical Review* **43** - 491 (1933)

C.D. Anderson. The Apparent Existence of Easily Deflectable Positives. *Science* **76** -239 (1932)

Partículas elementales



105,7 MeV/c^2
-1
1/2
μ
muón

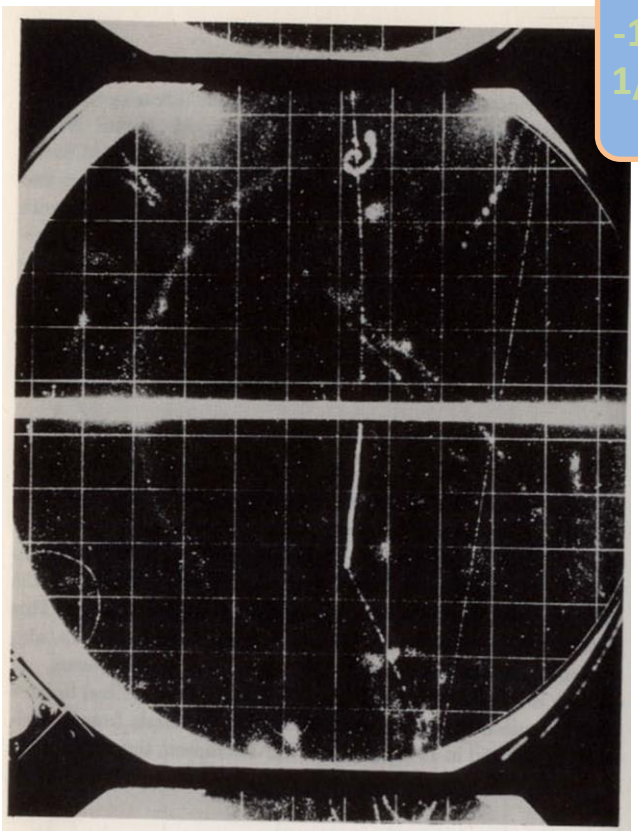


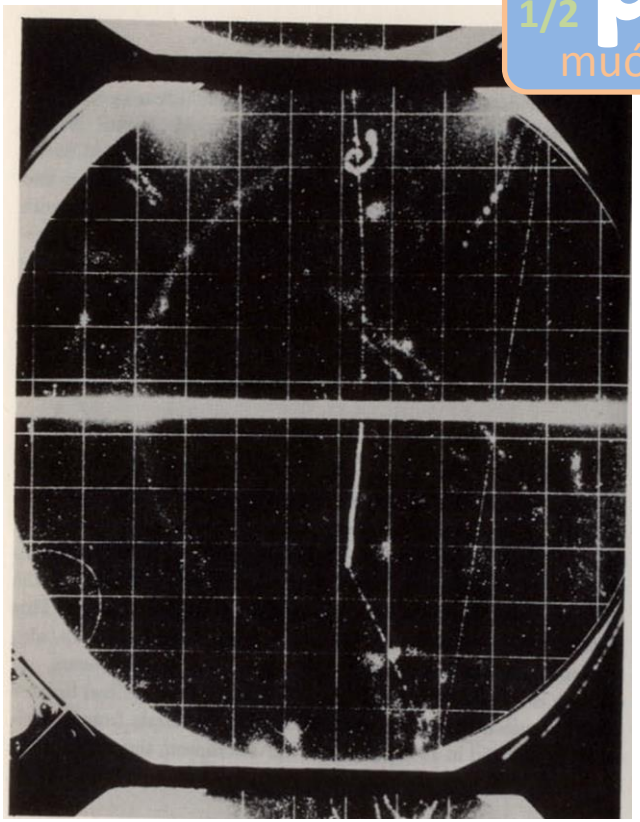
Fig. 8-9 Decay of a μ meson. The meson enters the cloud chamber from above. It traverses an aluminum plate 0.63 cm thick, where it loses most of its energy. The meson, which leaves the plate as a slow and therefore heavily ionizing particle, comes to rest in the gas. The track of an electron originates from the end of the μ-meson track. The electron, traveling at nearly the speed of light, produces a track approximating that of a minimum-ionizing particle. The tracks of the meson and the electron are slightly bent by a magnetic field, and the direction of the deflection shows that both particles are positively charged. (From R. W. Thompson, *The Physical Review*, vol. 74, p. 490, 1948.)

➡ C.D. Anderson (1937)

S.H. Neddermeyer, C.D. Anderson. Note on the Nature of Cosmic-Ray Particles. Physical Review 51 (10): 884–886. (1937).

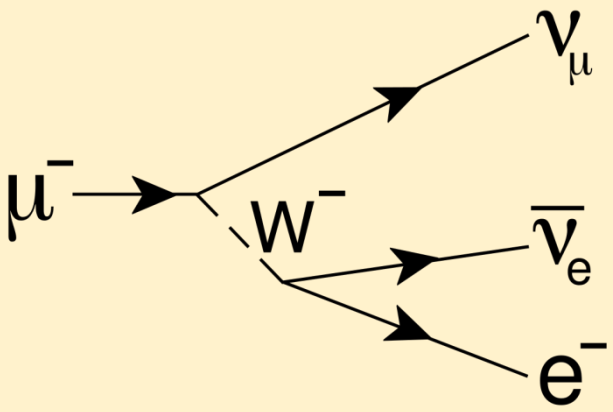
Partículas elementales

105,7 MeV/c^2
-1
1/2
μ
muón



Tiempo de vida 2,2 microsegundos

$$\mu^- \rightarrow e^- + \bar{\nu}_e + \nu_\mu$$
$$\mu^+ \rightarrow e^+ + \nu_e + \bar{\nu}_\mu$$



S.H. Neddermeyer, C.D. Anderson. Note on the Nature of Cosmic-Ray Particles. Physical Review 51 (10): 884–886. (1937).

Emulsiones fotográficas

No. 4047 May 24, 1947 NATURE 695

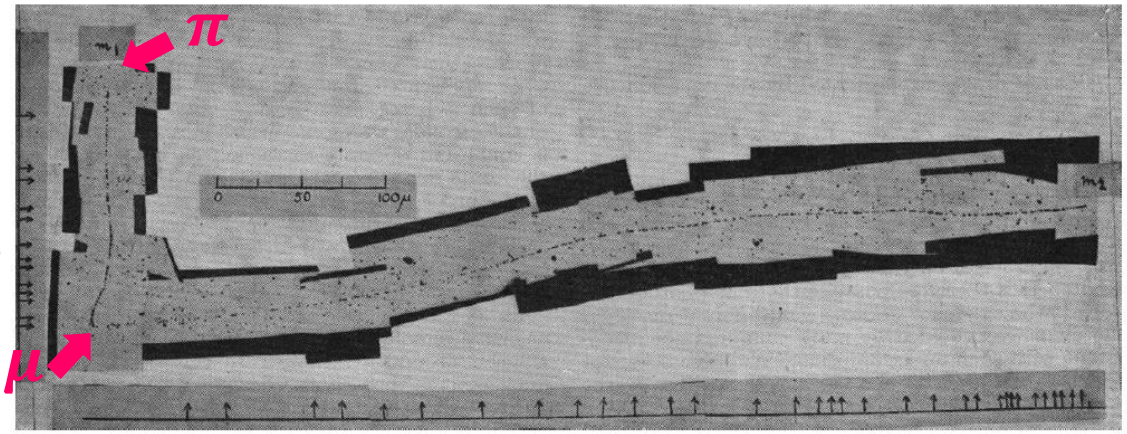
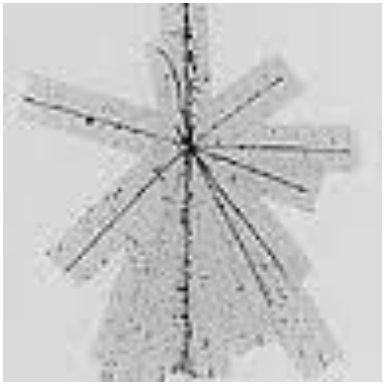


Fig. 1. Observation by Mrs. I. Roberts. Photomicrograph with Cooke × 45 'fluorite' objective. Ilford 'Nuclear Research', boron-loaded C2 emulsion. m_1 is the primary and m_2 the secondary meson. The arrows, in this and the following photographs, indicate points where changes in direction greater than 2° occur, as observed under the microscope. All the photographs are completely unretouched

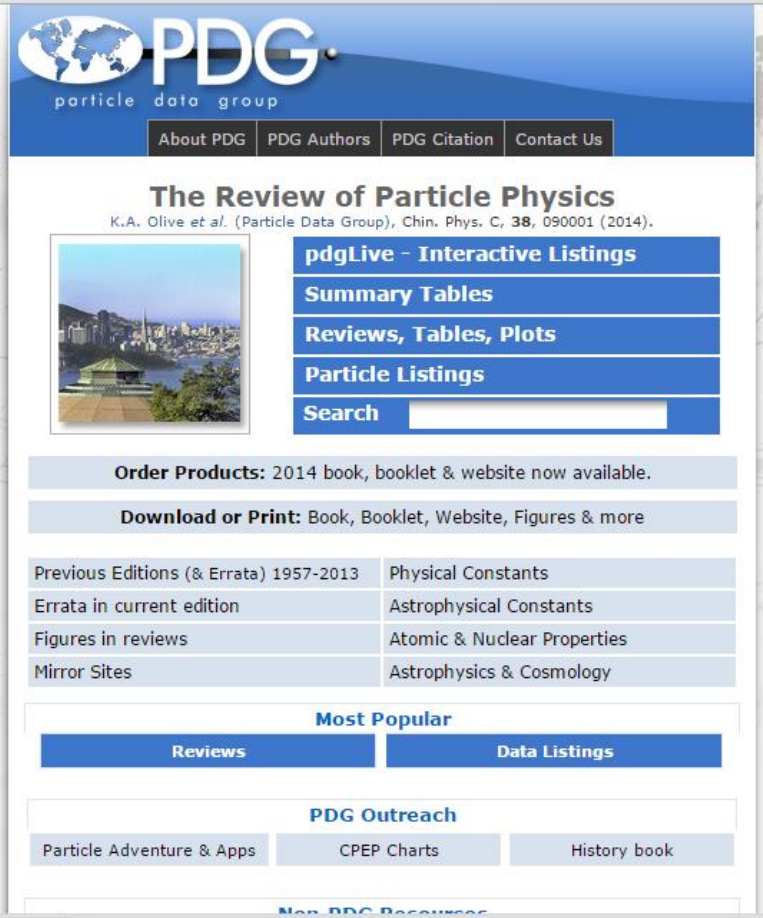
C. F. Powell



C. M. G. Lattes, H. Muirhead, G. Occnialini and C. F. Powell. Processes involving charged mesons. *Nature* **159**, 694 (1947).

Zoo de partículas

π^- Σ^- n Λ^0 K^- Σ^0

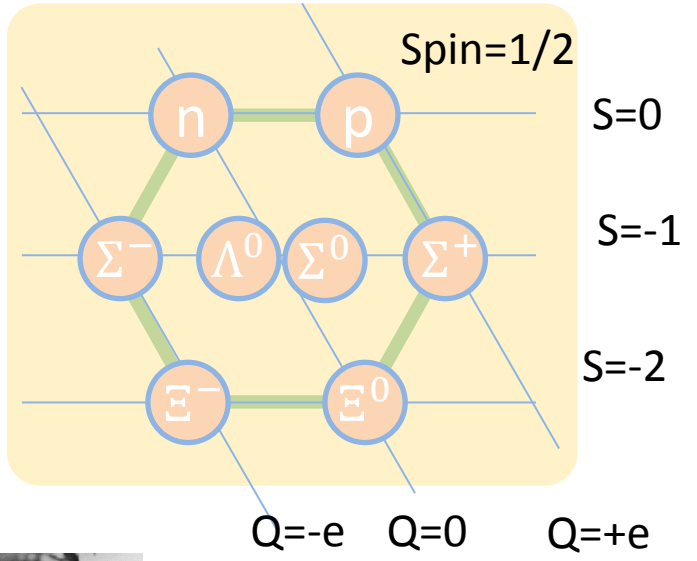


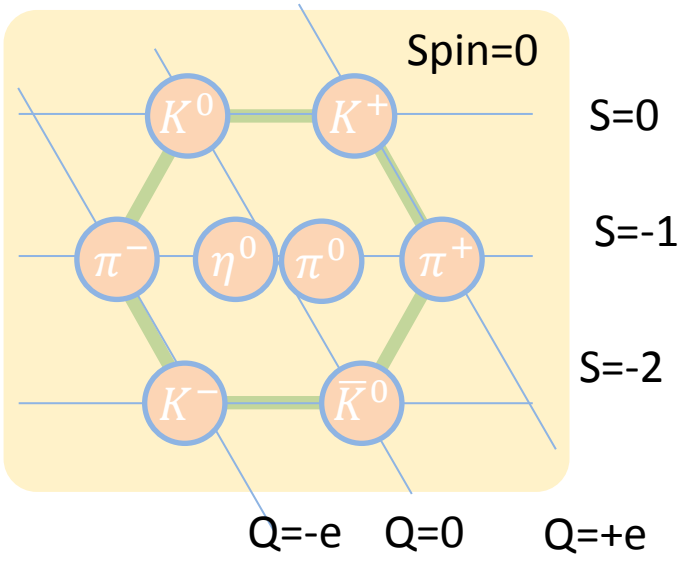
Σ^+ K^+ Ξ^- Ξ^0 p η^0

Particle Data Book. http://pdg.lbl.gov/

Extrañeza-el camino óctuple

Murray Gell-Mann
Yuval Neeman
(1961)





Murray Gell-Mann

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

$$0 \quad 0 \quad -1 \quad +1$$

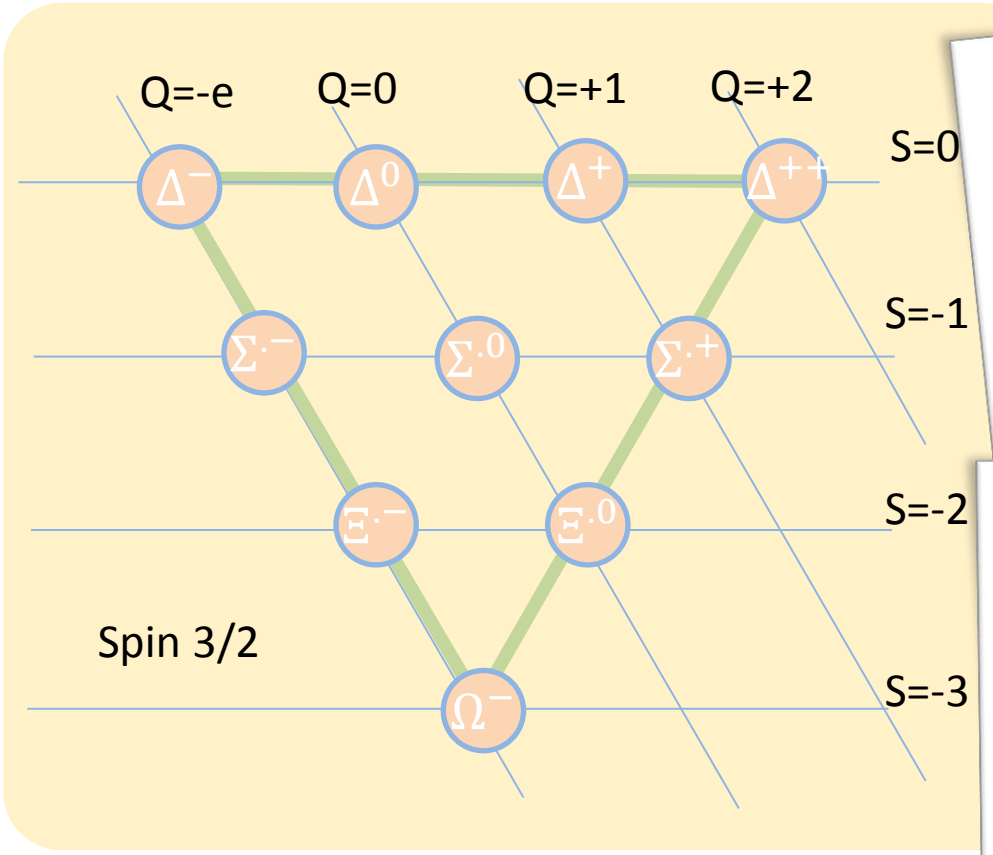
S= extrañeza
Q= carga

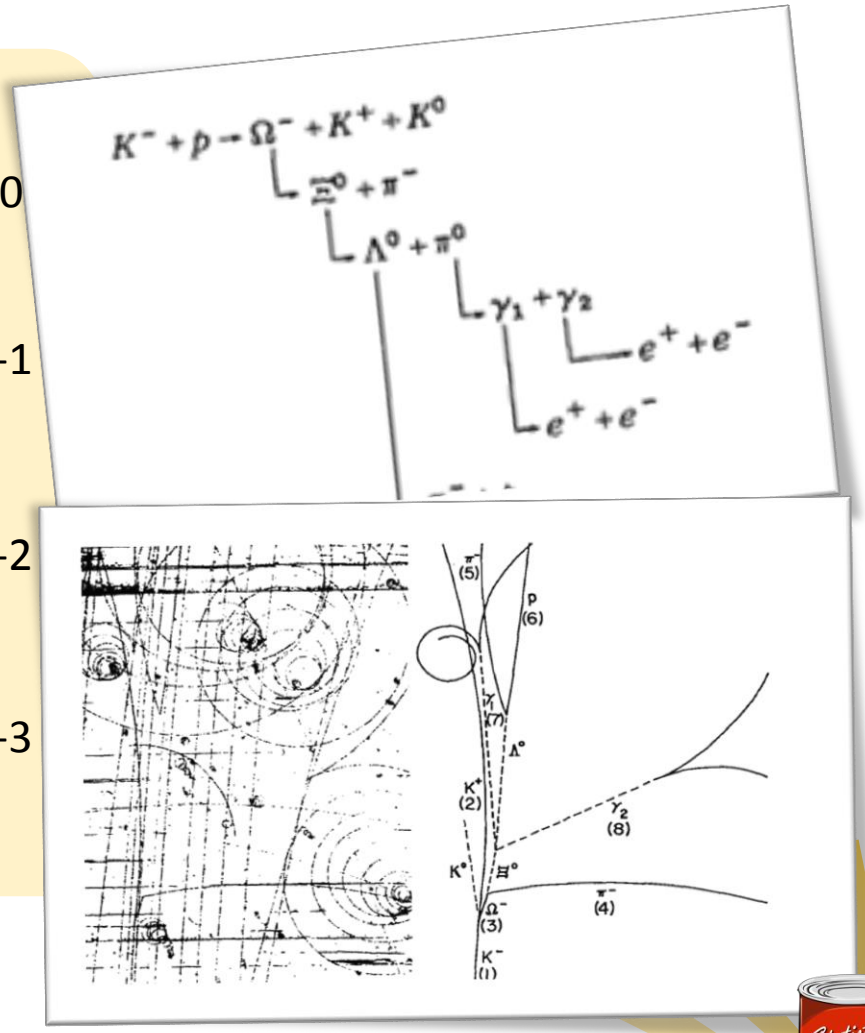
$$p + \pi^- \rightarrow \pi^- + K^- \quad \times$$

$$0 \quad 0 \quad 0 \quad -1$$

M. Gell-Mann The Eightfold Way: A theory of strong interaction symetry. Caltech synchrotron laboratory report No CTSL-20 (1961)
Y Ne eman. Nucl. Phys 26-222 (1961)

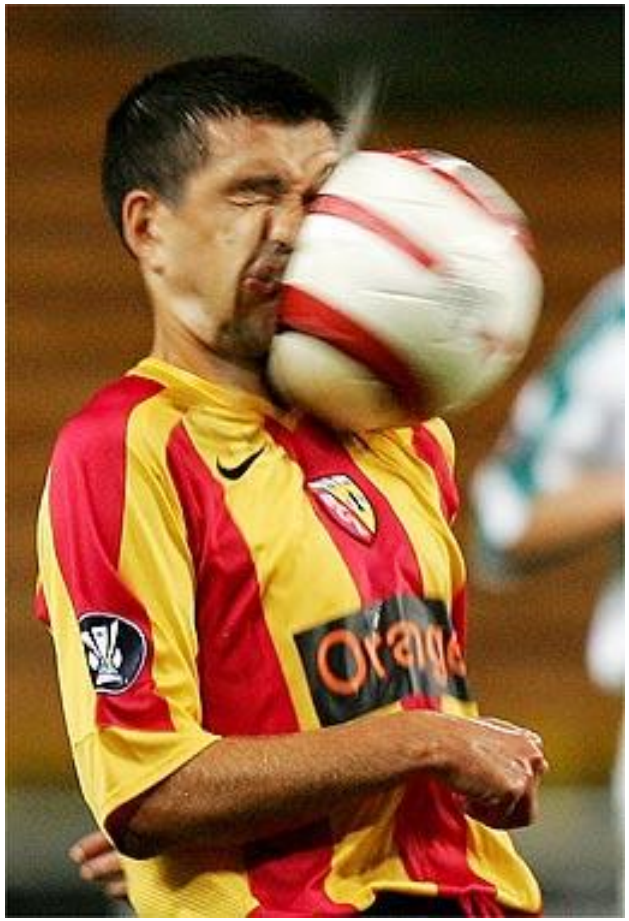
Partícula con extrañeza 3





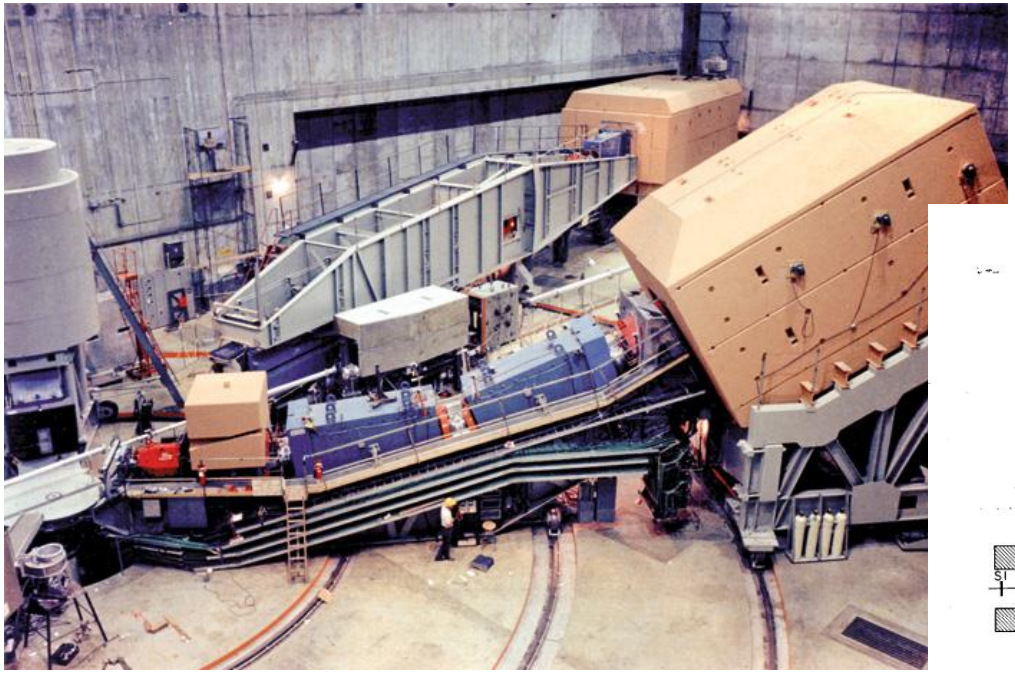
V. E. Barnes et al. Observation of a Hyperon with Strangeness Number Three. Physical Review Letters 12-204. (1964).

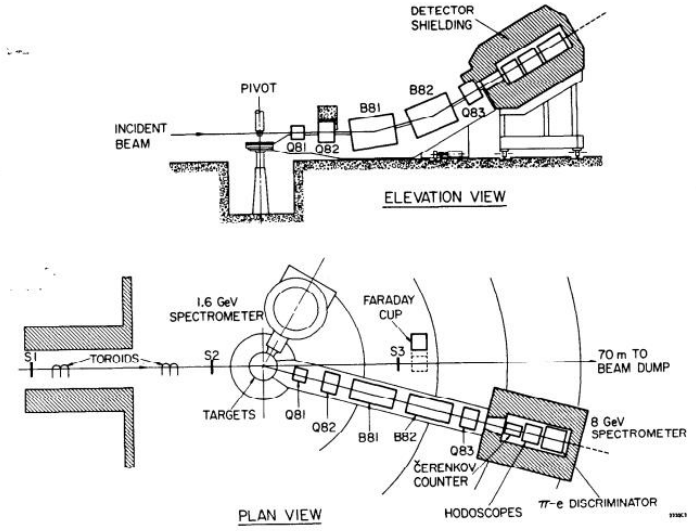
Partículas elementales



Estructura interna de los protones

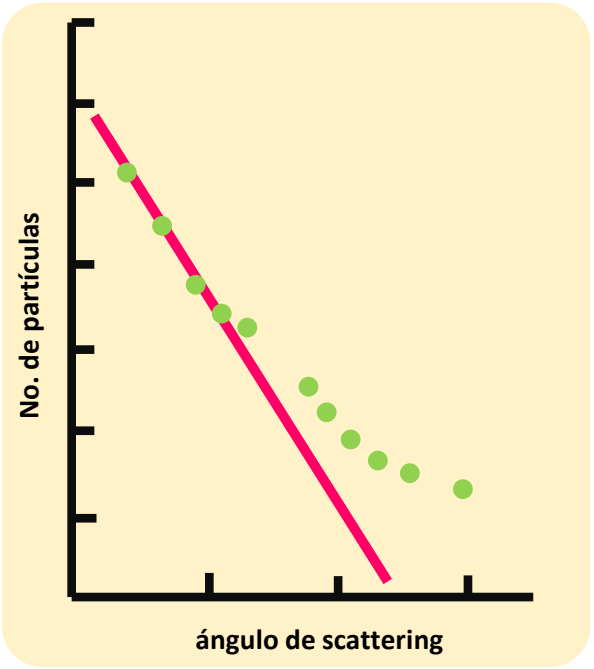
- C. Hofstadter (1956) radio del protón 10^{-15} m
- SLAC Centro del Acelerador Lineal de Stanford (1967-1973)

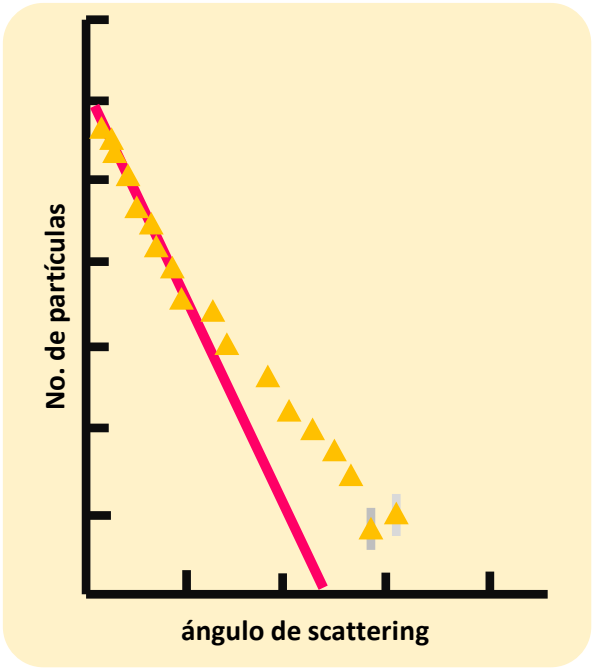




E. E. Chambers and R. Hofstadter. Structure of the Proton. Phys. Rev. 103,-1454 (1956)
M. Riordan. The Discovery of Quarks. Science 29 -1287 (1992)

Estructura interna de los protones





➡ E. Rutherford (1911)

$$50\ GeV$$
$$\lambda_e \approx 0{,}025 fm$$

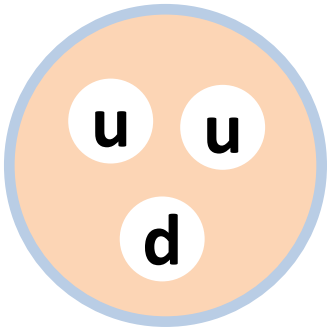
➡ Richard E. Taylor (SLAC)
Jerome I. Friedman (MIT)
Henry W. Kendall (MIT)
(1967)

➡ SLAC-MIT-CIT colaboration. Proposals for initial electron scattering experiments using the SLAC spectrometer facilities. Stanford linear accelerator center proposal No. 4 (1966).
E. D. Bloom, D. H. Coward, H. DeStaebler, J. Drees, G. Miller, L. W. Mo, R. E. Taylor, M. Breidenbach, J. I. Friedman, G. C. Hartmann, and H. W. Kendall. High-Energy Inelastic e−p Scattering at 6° and 10°. Phys. Rev. Lett. **23**, 930 (1969).

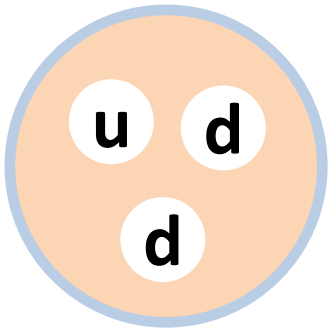
Tres quarks para el Muster Mark

Símbolo	Q/e	Spin	No. Bariónico B	Extrañeza S
u (arriba)	2/3	1/2	1/3	0
d (abajo)	-1/3	1/2	1/3	0
s (extraño)	-1/3	1/2	1/3	-1

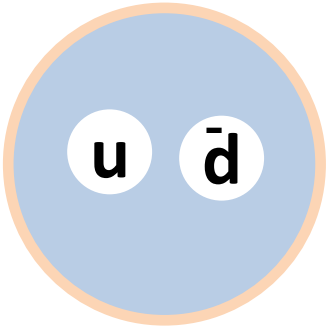
bariones (pesados) ← **hadrones** (fuertes) → **mesones** (medianos)



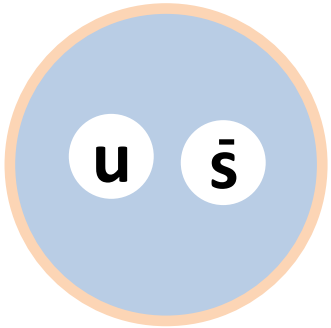
p proton
Q=2/3+2/3-1/3=+1
B=1/3+1/3+1/3=1
S=0+0+0=0



n neutron
Q=2/3-1/3-1/3=0
B=1/3+1/3+1/3=1
S=0+0+0=0



π^{+} pion +
Q=2/3+1/3=+1
B=1/3-1/3=0
S=0+0=0



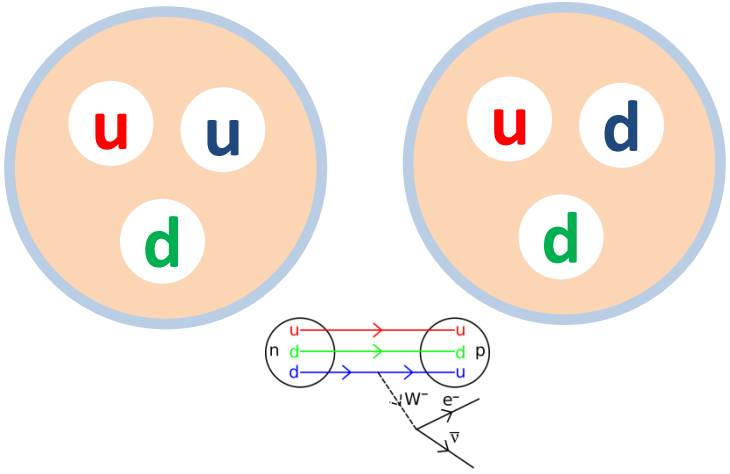
K^{+} kaon +
Q=2/3+1/3=+1
B=1/3-1/3=0
S=0+1=1

M. Gell-Mann. A Schematic Model of Baryons and Mesons. Physics Letters 8-214. (1964).
Zweig, G . An SU3 model for strong interaction symmetry and its breaking. CERN Report No.8182/TH.401 (1964).

Colores y sabores

Símbolo	Q/e	Spin	No. Bariónico B	Extrañeza S	Encanto S	Fondez B´	Tapez T
u (arriba)	2/3	1/2	1/3	0	0	0	0
d (abajo)	-1/3	1/2	1/3	0	0	0	0
s (extraño)	-1/3	1/2	1/3	-1	0	0	0
c (encanto)	2/3	1/2	1/3	0	+1	0	0
b (fondo)	-1/3	1/2	1/3	0	0	+1	0
t (cima)	2/3	1/2	1/3	0	0	0	+1

sabor



F. Abe et al. Evidence for top quark production in p¯p collisions at √s =1.8 TeVPhys. Rev. D 50, 2966 . (1994).