

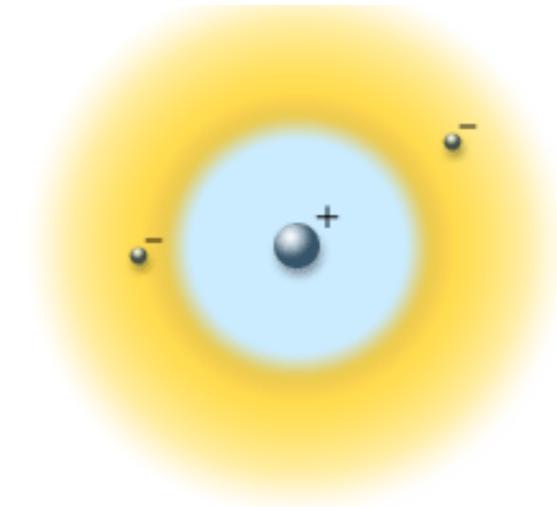
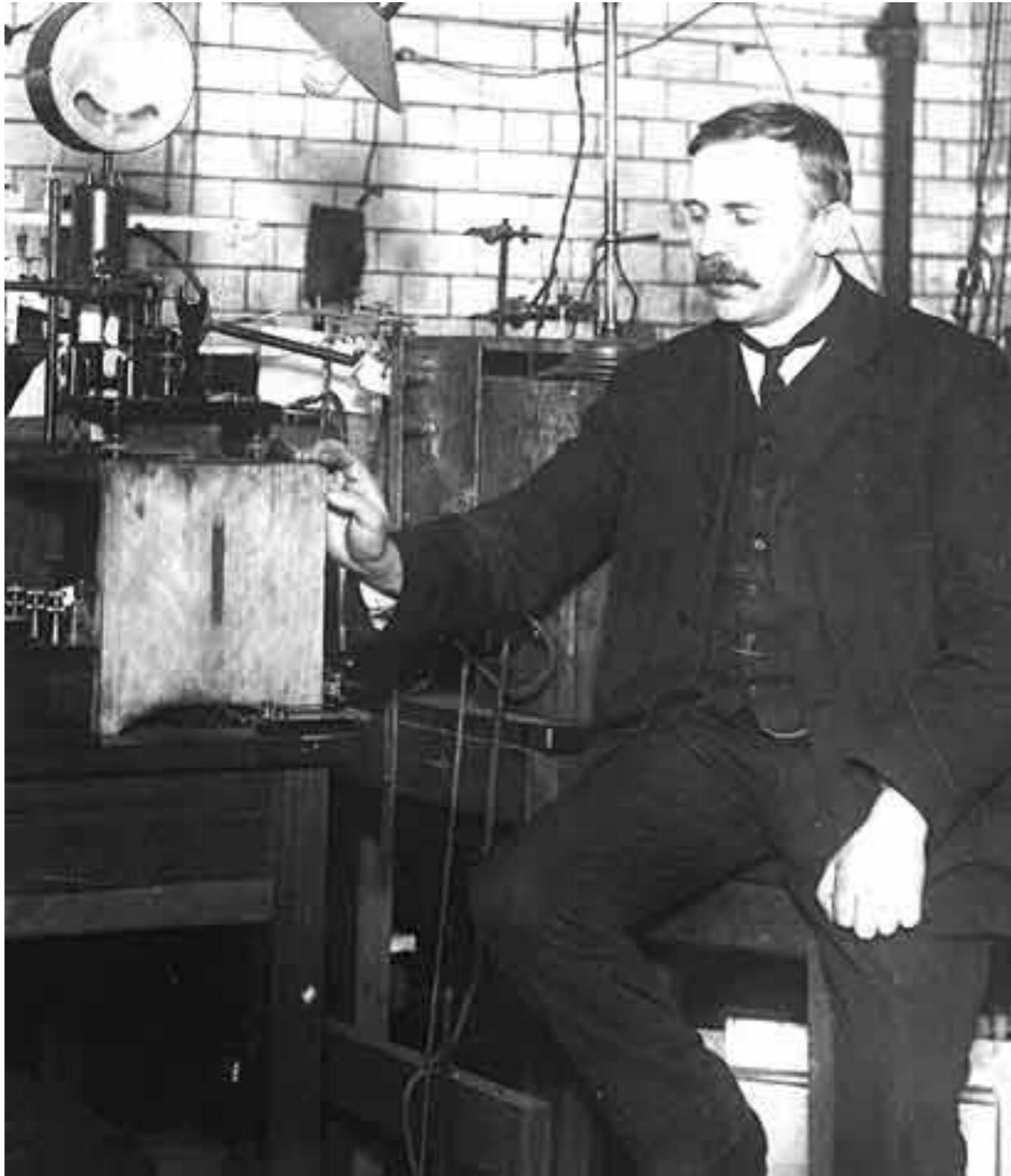
CMS Masterclass
11.Enero.2018

Mecánica Cuántica

Relatividad Especial

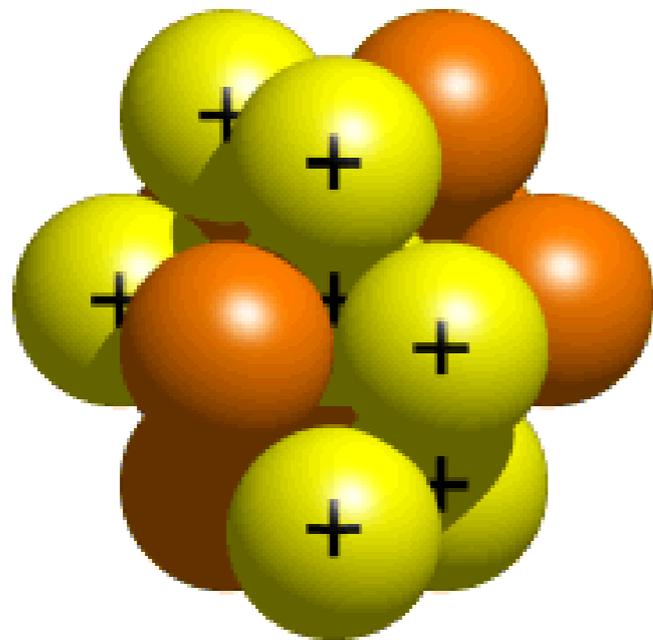
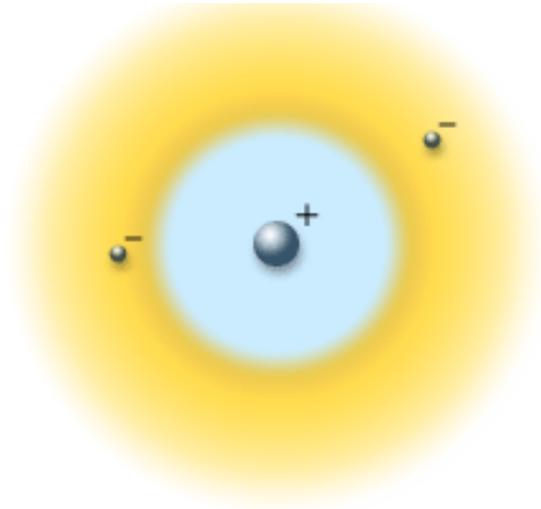


¿De qué está formado el Universo?

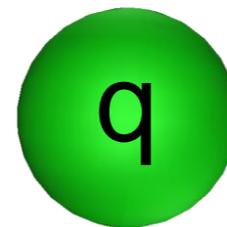
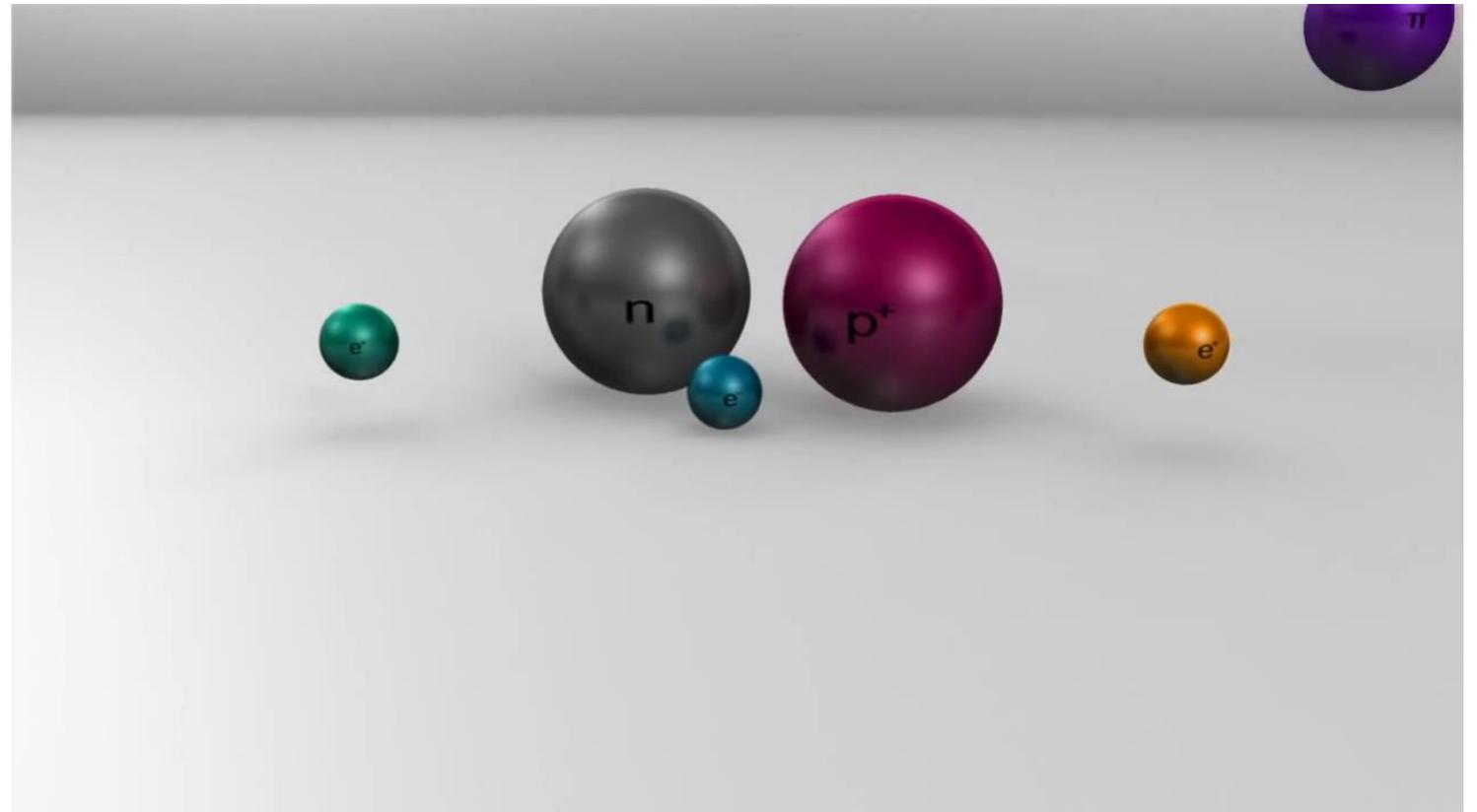


Ernest Rutherford

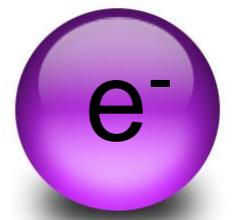
¿De qué está formado el Universo?



James Chadwick
(Cambridge - 1932)



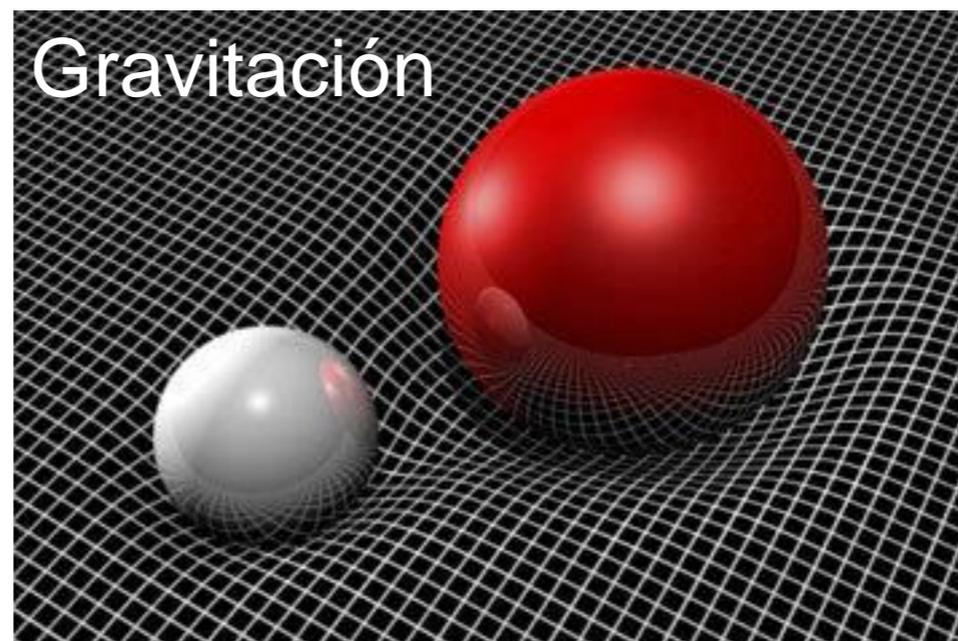
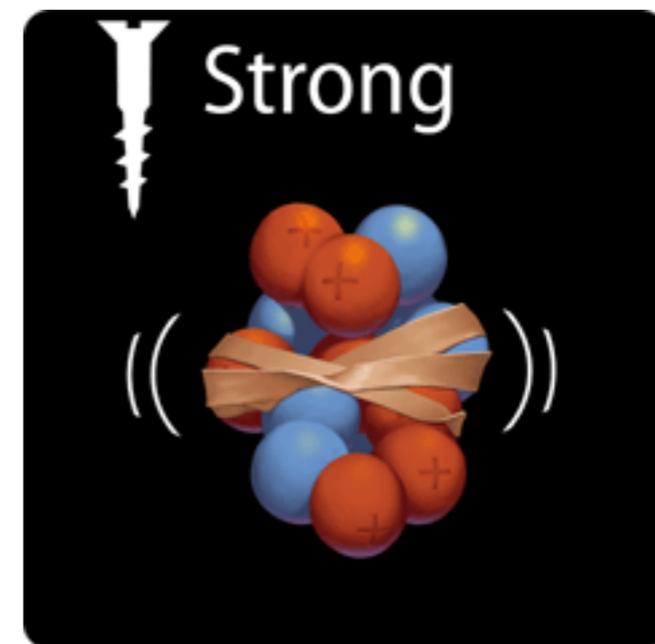
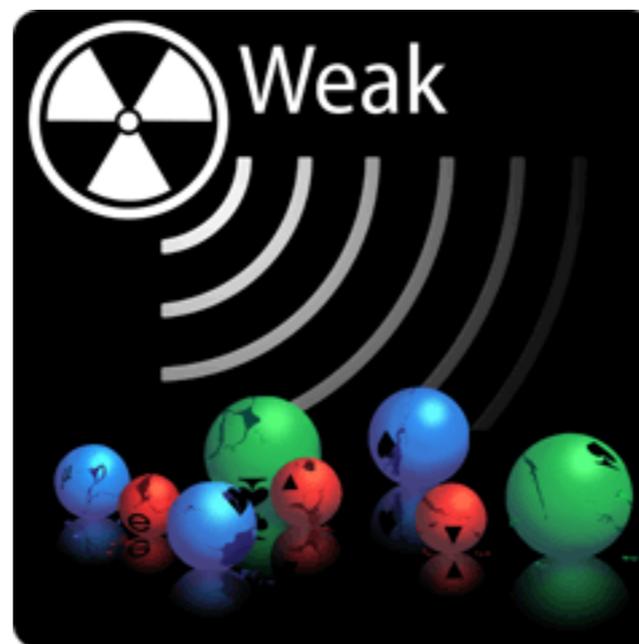
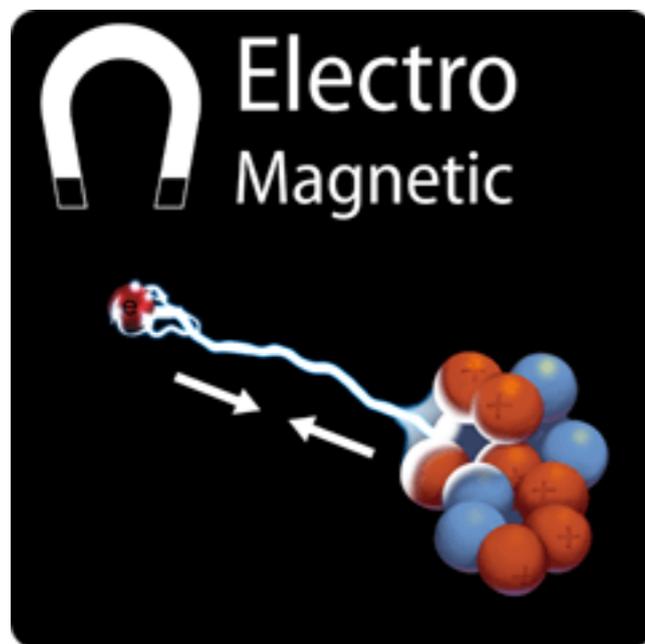
Stanford Linear Accelerator
(1968)



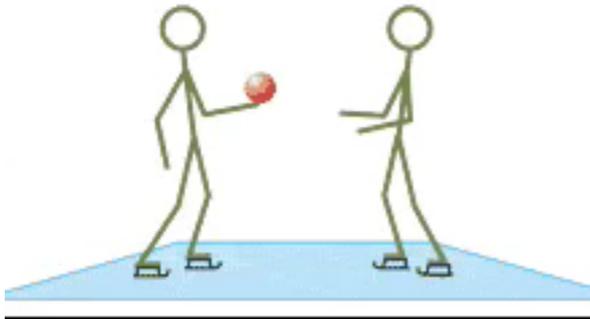
J. J. Thomson
(Cambridge - 1897)

¿Cuáles son sus interacciones?

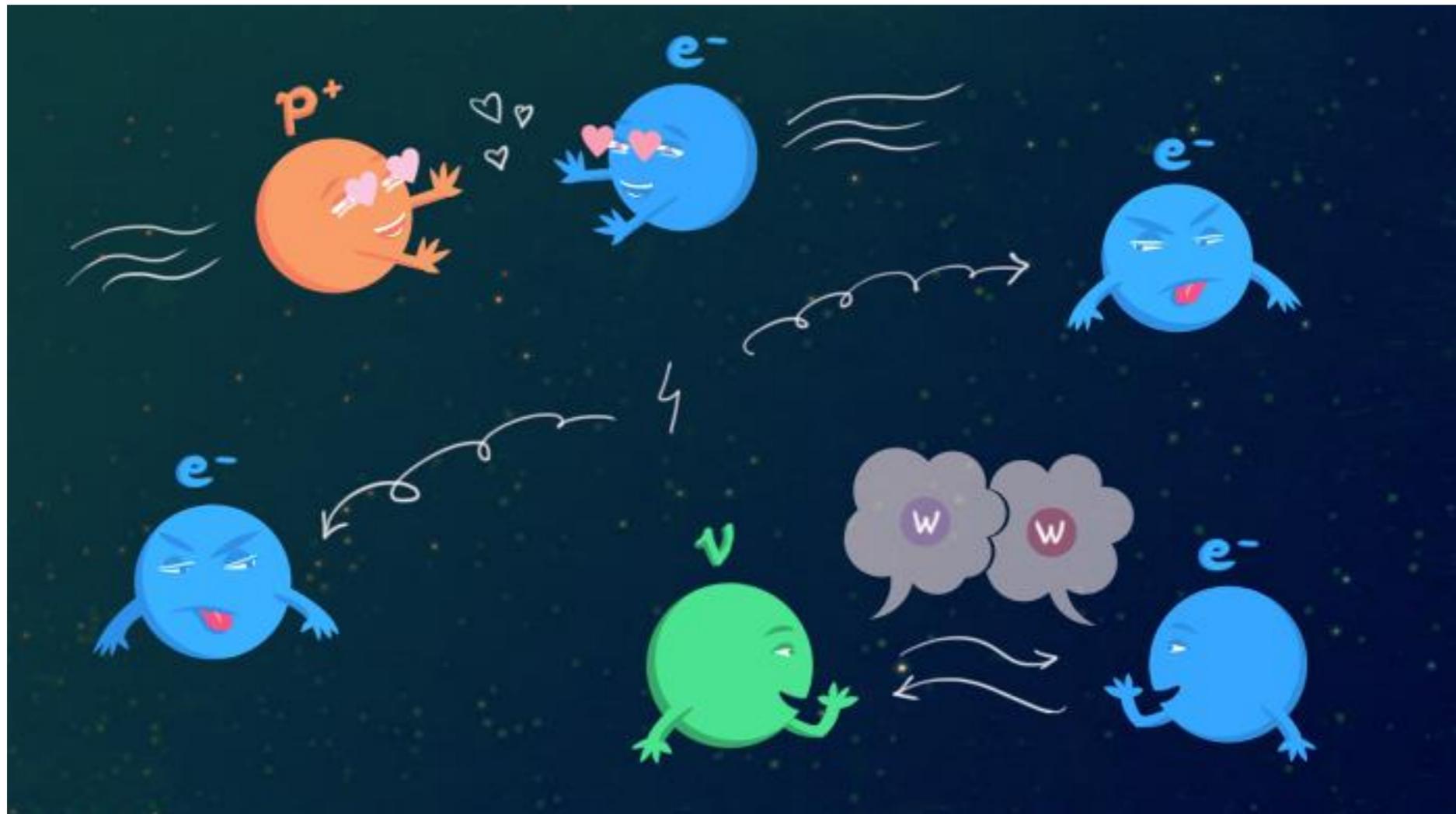
Las interacciones fundamentales de la Naturaleza son:



Interacciones



En física de partículas, las interacciones se entienden como el intercambio de partículas portadoras, llamadas también bosones.



Interacción Electromagnética

Interacción entre partículas cargadas.

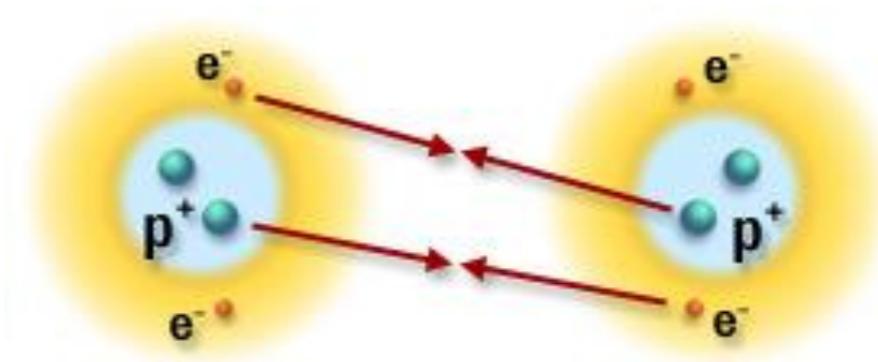
Cargas iguales se repelen; cargas opuestas se atraen.



Bosones portadores: fotones

Carga: carga eléctrica

Bosones sin masa \Rightarrow Interacción de largo alcance



RESIDUAL E-M FORCE IN ACTION: THE ATOMS ARE ELECTRICALLY NEUTRAL, BUT THE ELECTRONS IN ONE ARE ATTRACTED TO THE PROTONS IN ANOTHER, AND VICE VERSA!

Interacción Débil

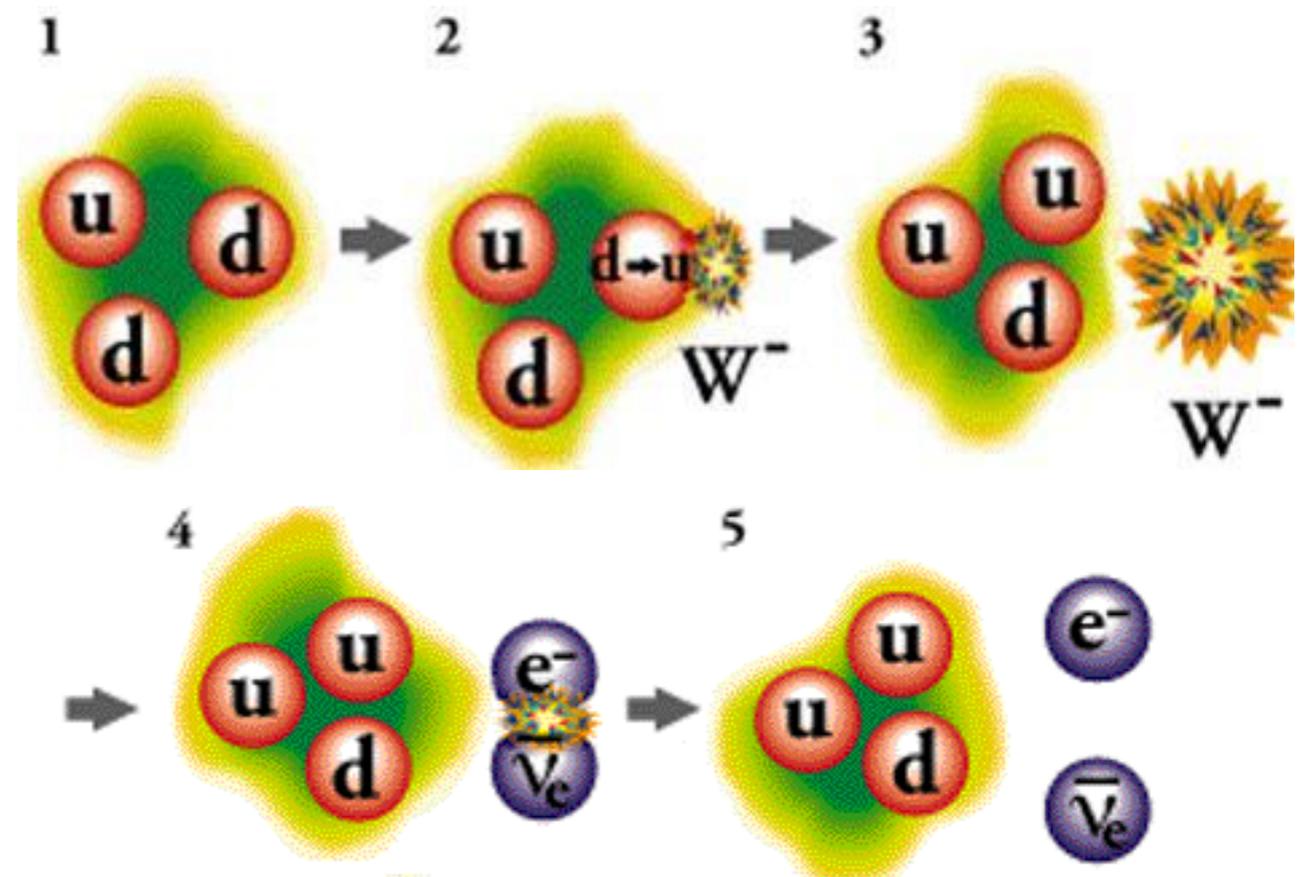
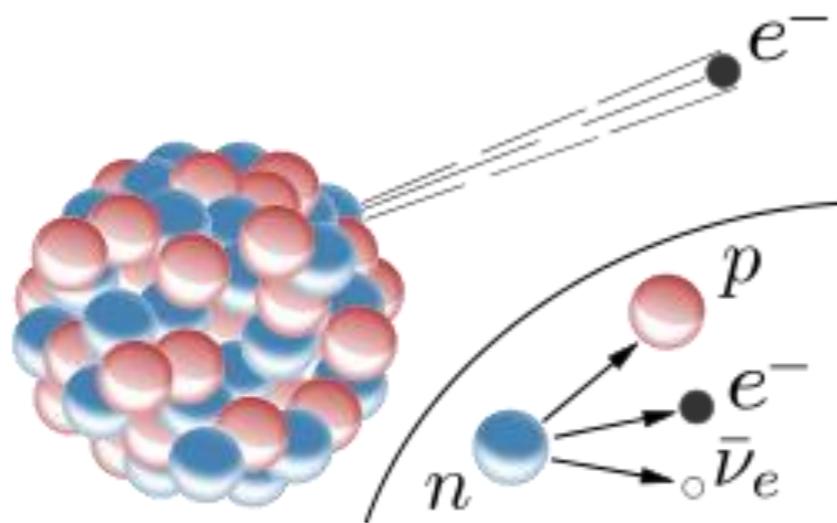
Decaimiento de partículas.

Bosones portadores: W^+ , W^- y Z^0

Carga: sabor



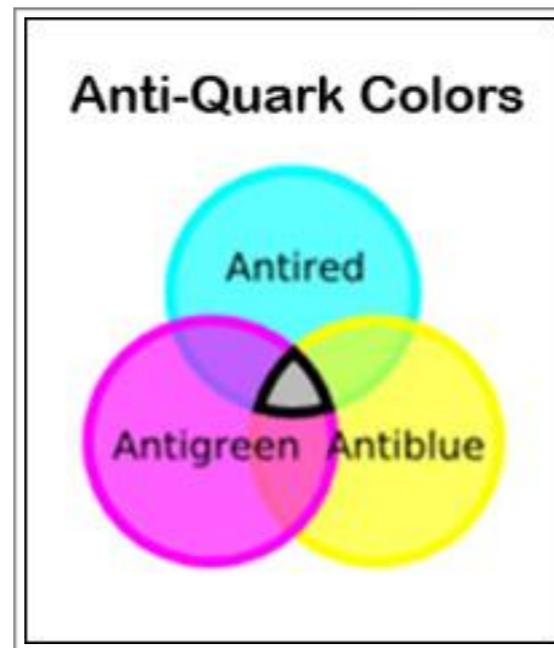
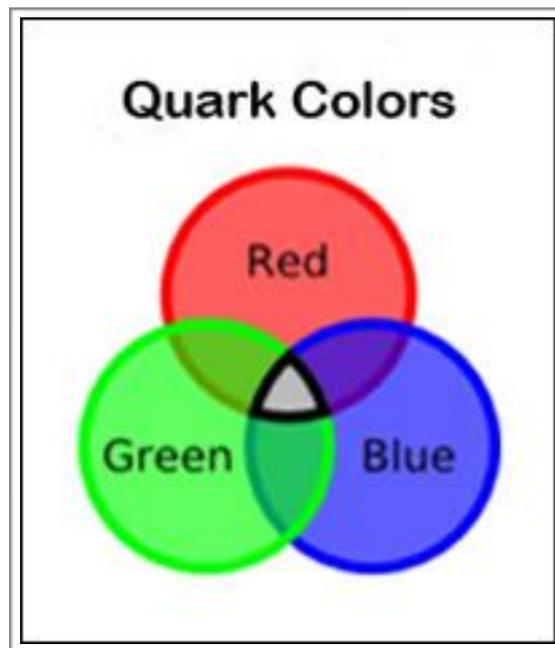
Bosones son masivos \Rightarrow Interacción de corto alcance



Interacción Fuerte

Interacción entre quarks.

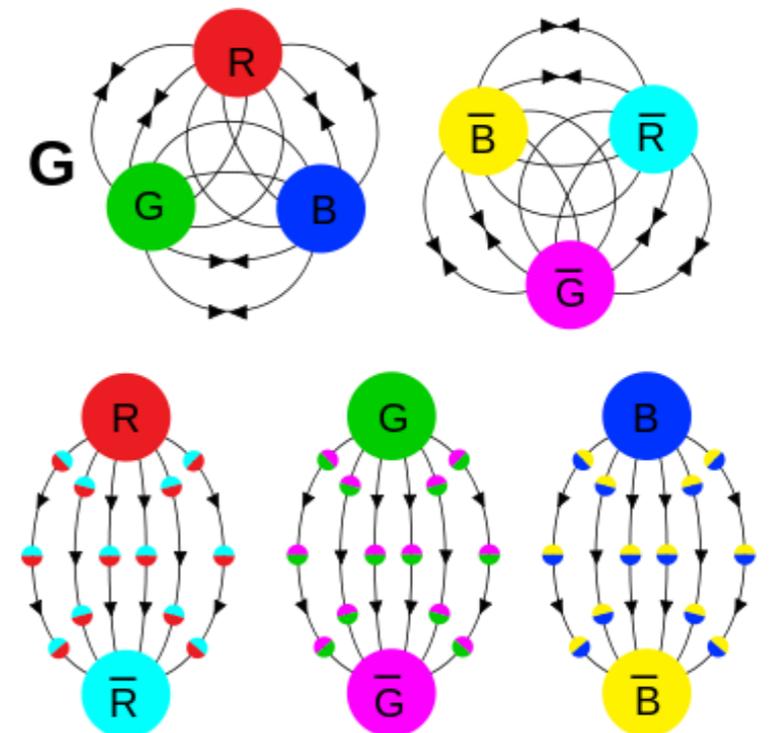
Mantiene unidos a los quarks dentro de los nucleones y a los nucleones unidos en los núcleos.



Bosones portadores: gluones
Carga: color

Los quarks se combinan de tal forma que el 'color' final de la partícula sea neutro (blanco - sin color):

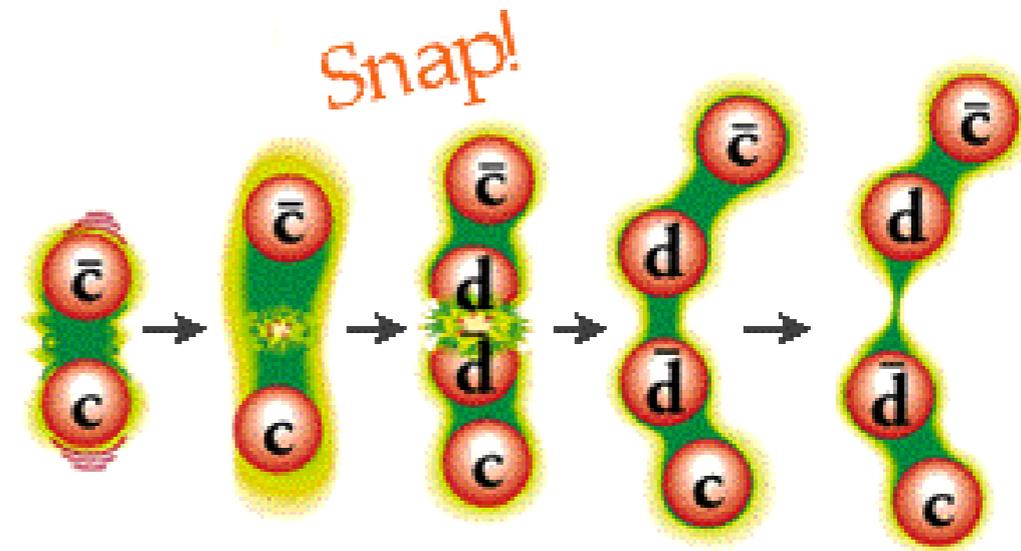
Bariones (qqq) y Mesones ($q\bar{q}$)



Interacción Fuerte

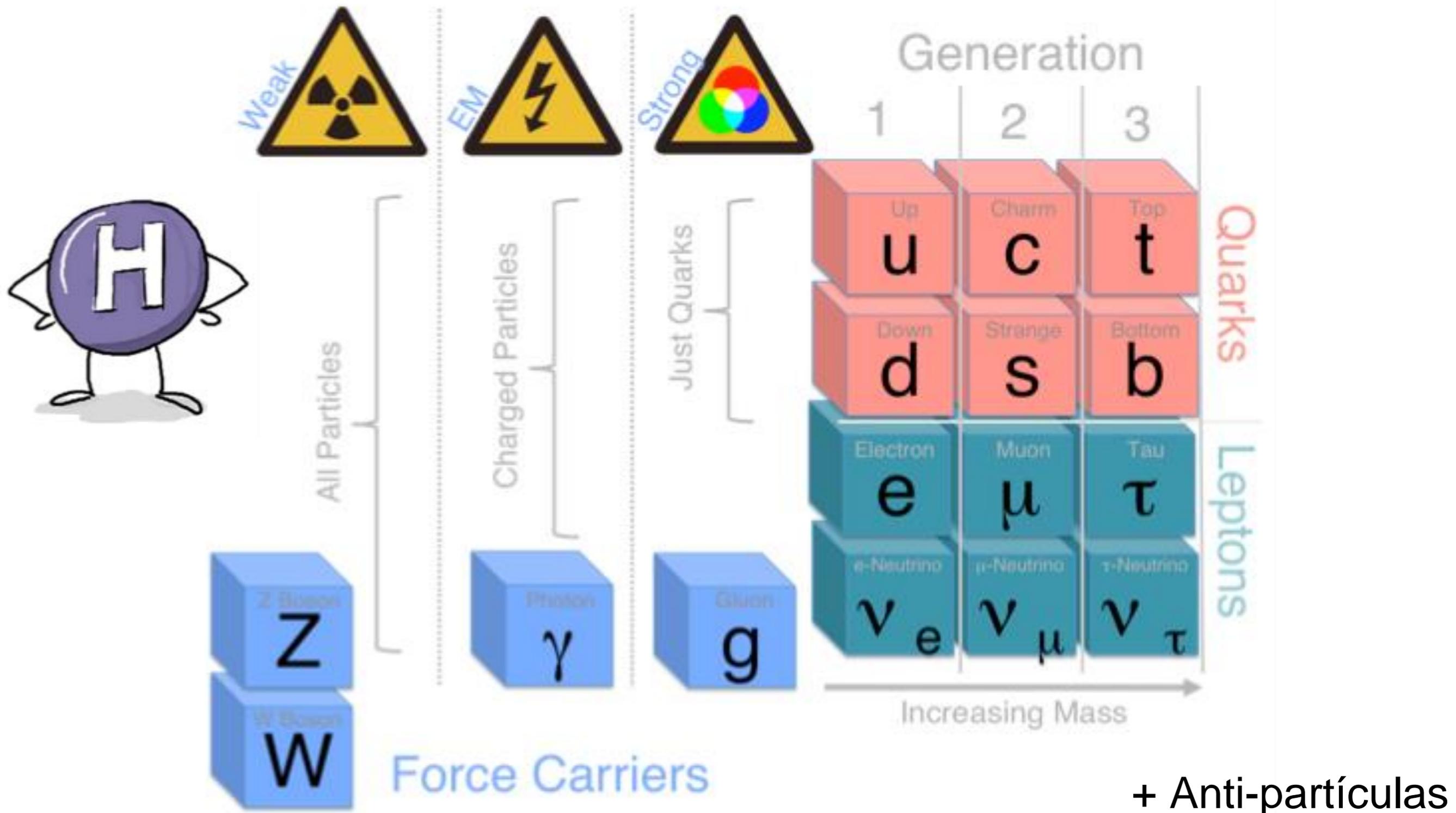
La interacción fuerte es diferente a las demás:

Mientras más alejemos dos quarks, mayor será la intensidad de interacción entre ellos.



¡Responsable de la estructura de la materia!

El Modelo Estándar



La primera generación

Quarks

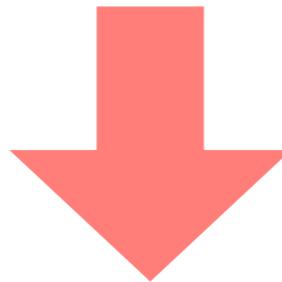
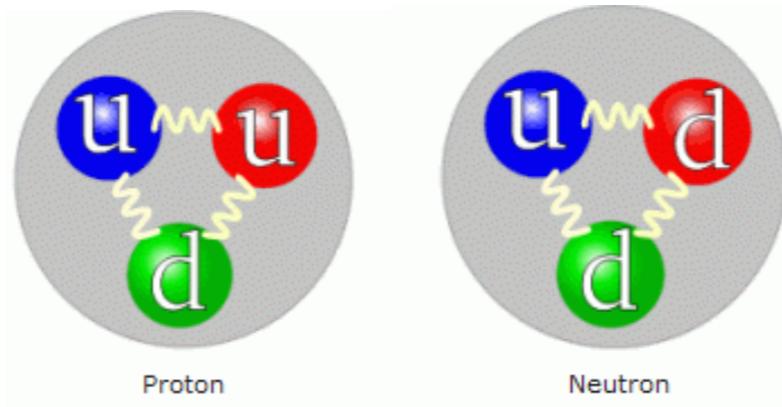
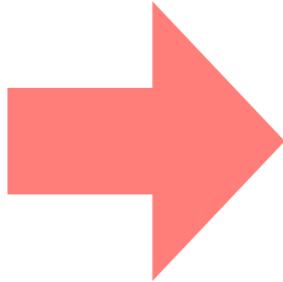
u

d

Leptons

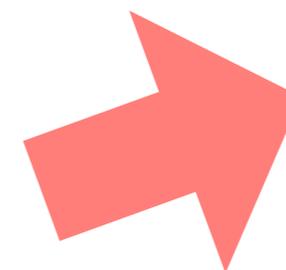
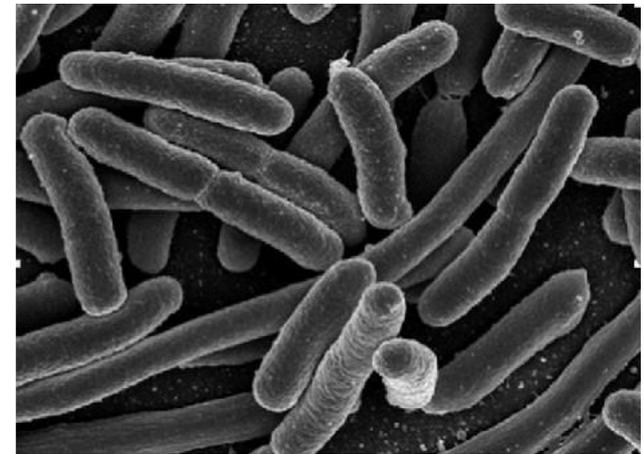
e

ν_e

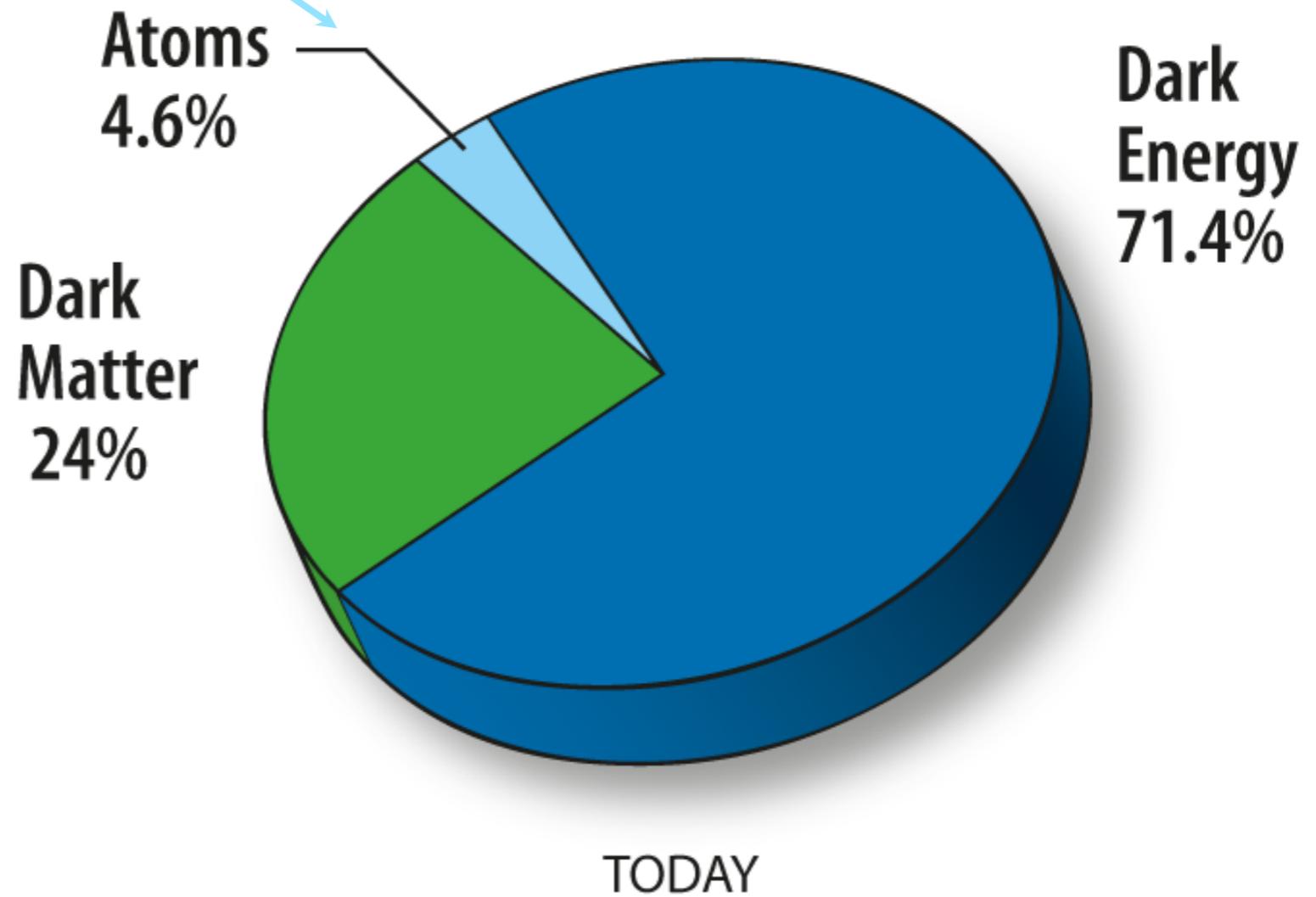


Periodic Table of the Elements

1 1IA 11A	2 IIA 2A											13 IIIA 3A	14 IVA 4A	15 VA 5A	16 VIA 6A	17 VIIA 7A	18 VIIIA 8A
1 H Hydrogen 1.0079	2 He Helium 4.00260																
3 Li Lithium 6.941	4 Be Beryllium 9.01218											5 B Boron 10.811	6 C Carbon 12.011	7 N Nitrogen 14.00674	8 O Oxygen 15.9994	9 F Fluorine 18.998403	10 Ne Neon 20.1797
11 Na Sodium 22.989768	12 Mg Magnesium 24.305	3 III B 3B	4 IV B 4B	5 V B 5B	6 VI B 6B	7 VII B 7B	8 VIII 8	9 VIII 8	10 VIII 8	11 IB 1B	12 IIB 2B	13 Al Aluminum 26.981539	14 Si Silicon 28.0855	15 P Phosphorus 30.973762	16 S Sulfur 32.065	17 Cl Chlorine 35.4527	18 Ar Argon 39.948
19 K Potassium 39.0983	20 Ca Calcium 40.078	21 Sc Scandium 44.95591	22 Ti Titanium 47.88	23 V Vanadium 50.9415	24 Cr Chromium 51.9961	25 Mn Manganese 54.938	26 Fe Iron 55.847	27 Co Cobalt 58.9332	28 Ni Nickel 58.6934	29 Cu Copper 63.546	30 Zn Zinc 65.39	31 Ga Gallium 69.723	32 Ge Germanium 72.64	33 As Arsenic 74.92159	34 Se Selenium 78.96	35 Br Bromine 79.904	36 Kr Krypton 83.80
37 Rb Rubidium 85.4678	38 Sr Strontium 87.62	39 Y Yttrium 88.90585	40 Zr Zirconium 91.224	41 Nb Niobium 92.90638	42 Mo Molybdenum 95.94	43 Tc Technetium 98.9062	44 Ru Ruthenium 101.07	45 Rh Rhodium 102.9055	46 Pd Palladium 106.42	47 Ag Silver 107.8682	48 Cd Cadmium 112.411	49 In Indium 114.818	50 Sn Tin 118.71	51 Sb Antimony 121.760	52 Te Tellurium 127.6	53 I Iodine 126.90447	54 Xe Xenon 131.29
55 Cs Cesium 132.90545	56 Ba Barium 137.327	57-71 Lanthanide Series	72 Hf Hafnium 178.49	73 Ta Tantalum 180.9479	74 W Tungsten 183.85	75 Re Rhenium 186.207	76 Os Osmium 190.23	77 Ir Iridium 192.22	78 Pt Platinum 195.08	79 Au Gold 196.9665	80 Hg Mercury 200.59	81 Tl Thallium 204.3833	82 Pb Lead 207.2	83 Bi Bismuth 208.98037	84 Po Polonium [209]	85 At Astatine [209]	86 Rn Radon 222.0176
87 Fr Francium 223.0197	88 Ra Radium 226.0254	89-103 Actinide Series	104 Rf Rutherfordium [261]	105 Db Dubnium [262]	106 Sg Seaborgium [266]	107 Bh Bohrium [264]	108 Hs Hassium [265]	109 Mt Meitnerium [268]	110 Ds Darmstadtium [269]	111 Rg Roentgenium [272]	112 Cn Copernicium [277]	113 Uut Ununtrium unknown	114 Uuq Ununquadium unknown	115 Uup Ununpentium unknown	116 Uuh Ununhexium unknown	117 Uus Ununseptium unknown	118 Uuo Ununoctium unknown
		57 La Lanthanum 138.9055	58 Ce Cerium 140.115	59 Pr Praseodymium 140.90765	60 Nd Neodymium 144.24	61 Pm Promethium 144.9127	62 Sm Samarium 150.36	63 Eu Europium 151.9654	64 Gd Gadolinium 157.25	65 Tb Terbium 158.92534	66 Dy Dysprosium 162.50	67 Ho Holmium 164.93032	68 Er Erbium 167.26	69 Tm Thulium 168.93421	70 Yb Ytterbium 173.04	71 Lu Lutetium 174.967	
		89 Ac Actinium 227.0277	90 Th Thorium 232.0377	91 Pa Protactinium 231.0362	92 U Uranium 238.0289	93 Np Neptunium 237.0482	94 Pu Plutonium 244.0642	95 Am Americium 243.0614	96 Cm Curium 247.0754	97 Bk Berkelium 247.0754	98 Cf Californium 251.0794	99 Es Einsteinium [254]	100 Fm Fermium [257]	101 Md Mendelevium [258]	102 No Nobelium [259]	103 Lr Lawrencium [260]	
		Alkali Metal	Alkaline Earth	Transition Metal	Basic Metal	Semimetals	Nonmetals	Halogens	Noble Gas	Lanthanides	Actinides						



El Modelo Estándar



¿Cómo experimentamos con partículas?

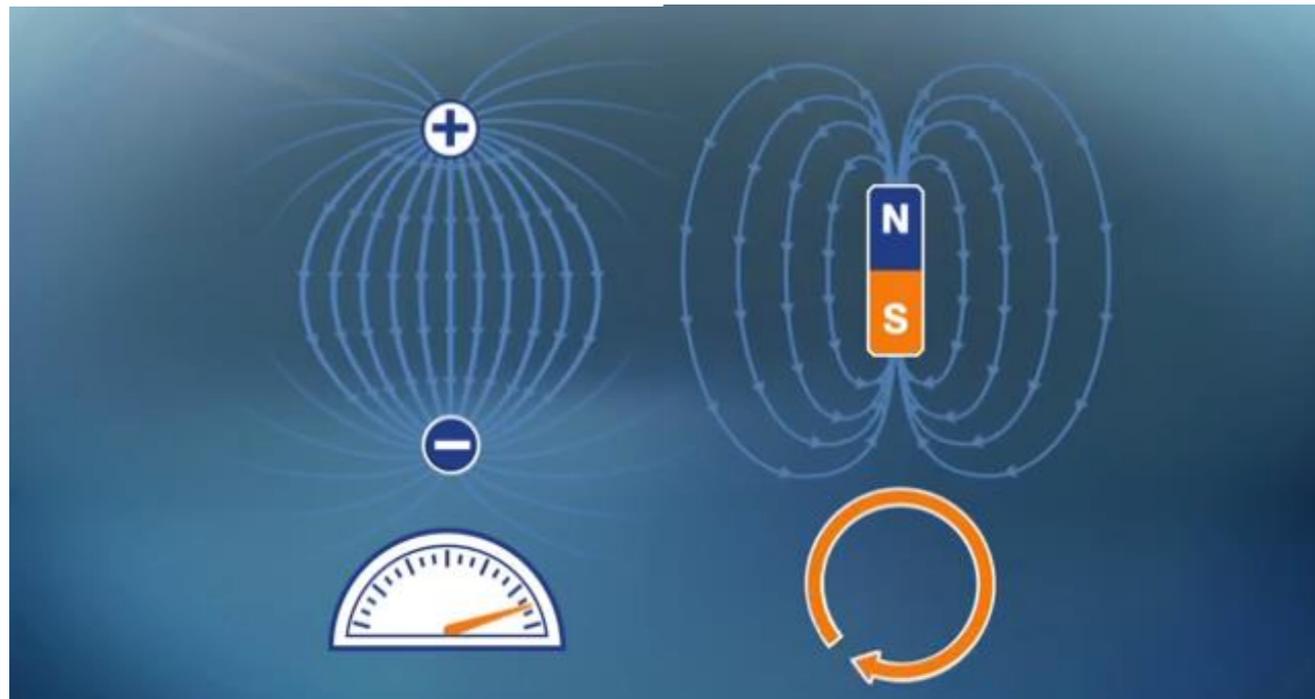
Aceleradores



Fermilab

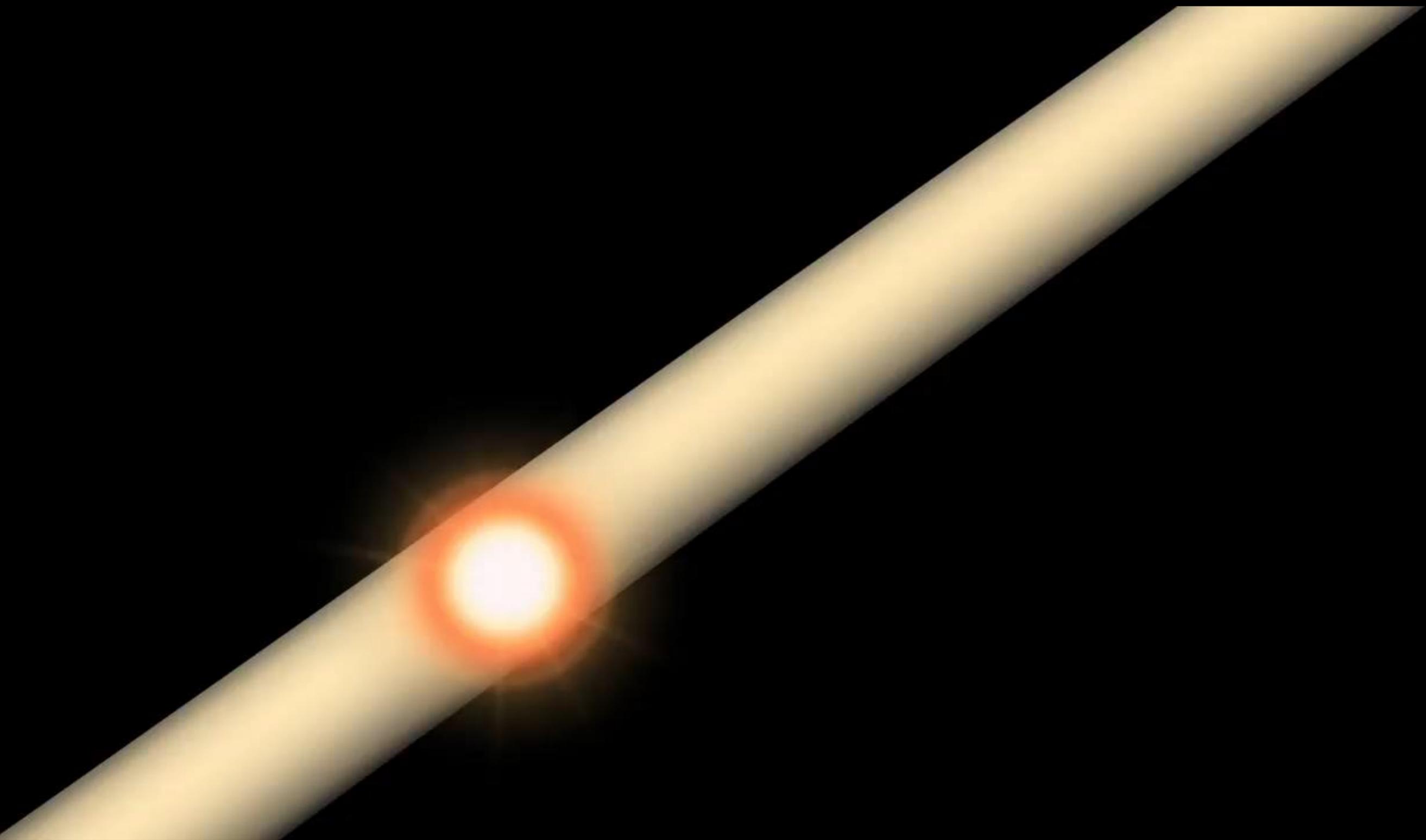
¿Cómo sabemos todo esto?

Aceleradores



Campos eléctricos - aceleración (aumentar la energía)

Campos magnéticos - trayectoria circular + colisiones



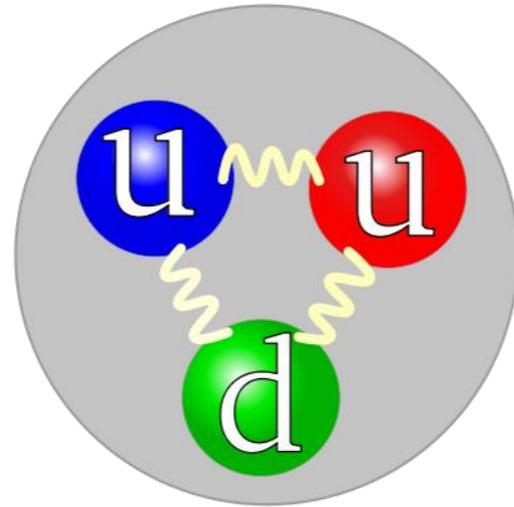
EI LHC

Large

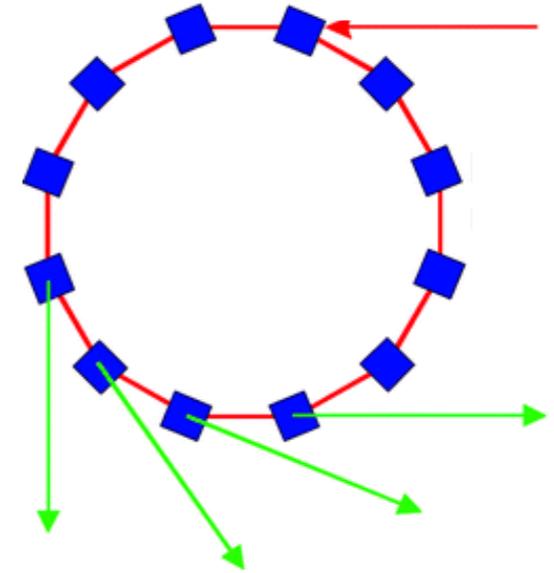


EI LHC

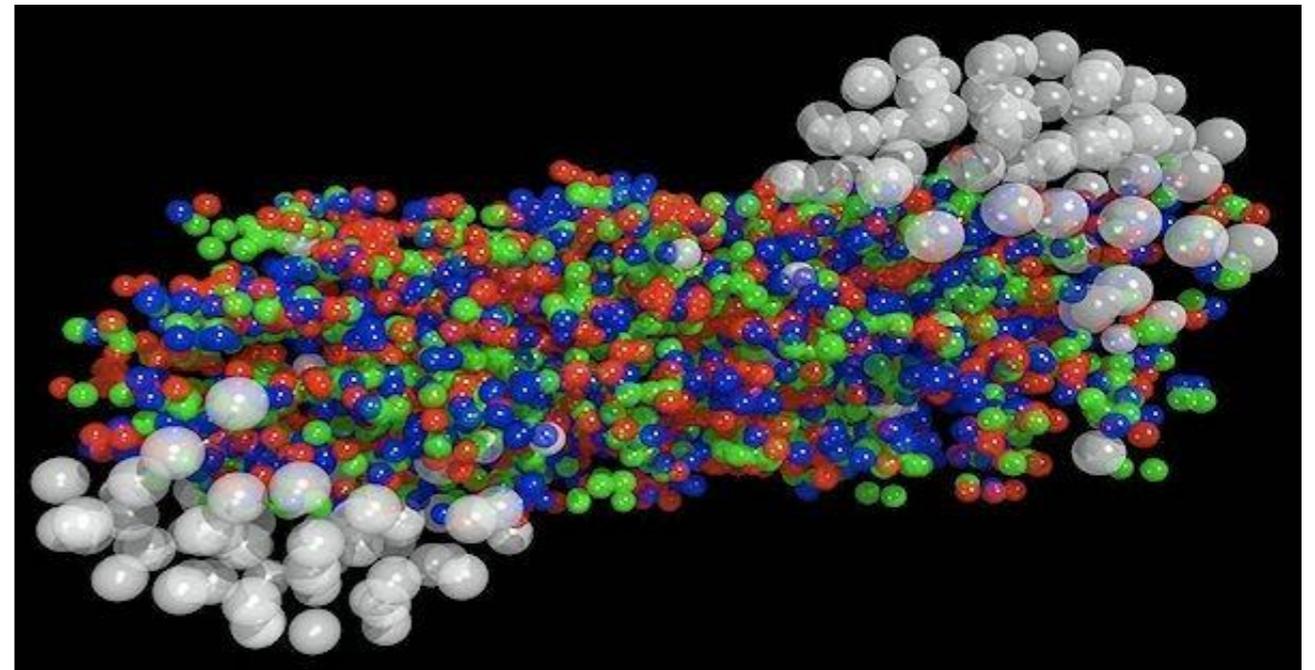
Hadron



Protones

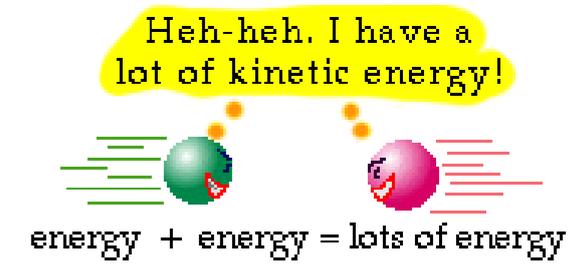
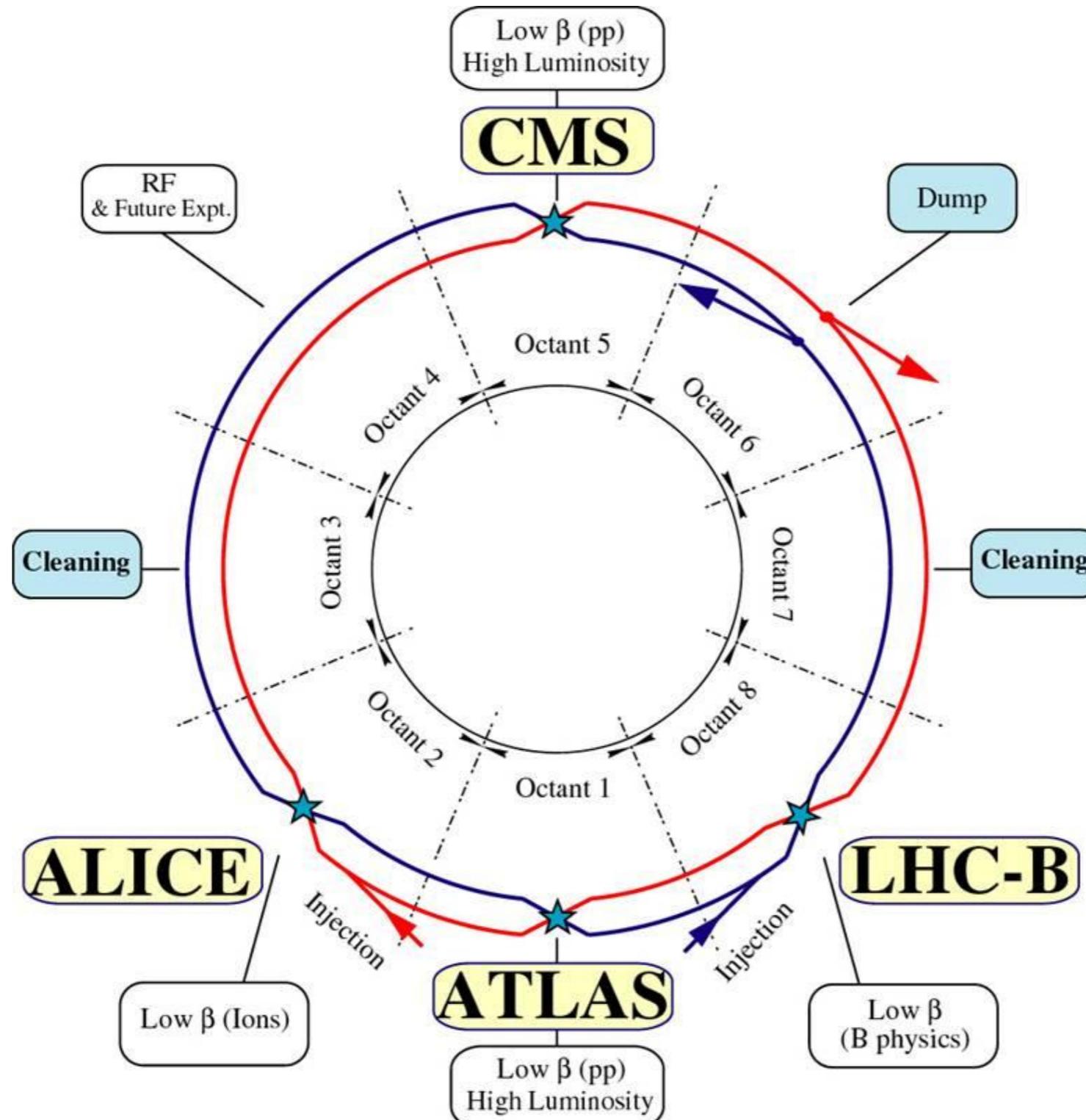


Iones Pesados
Pb, Au

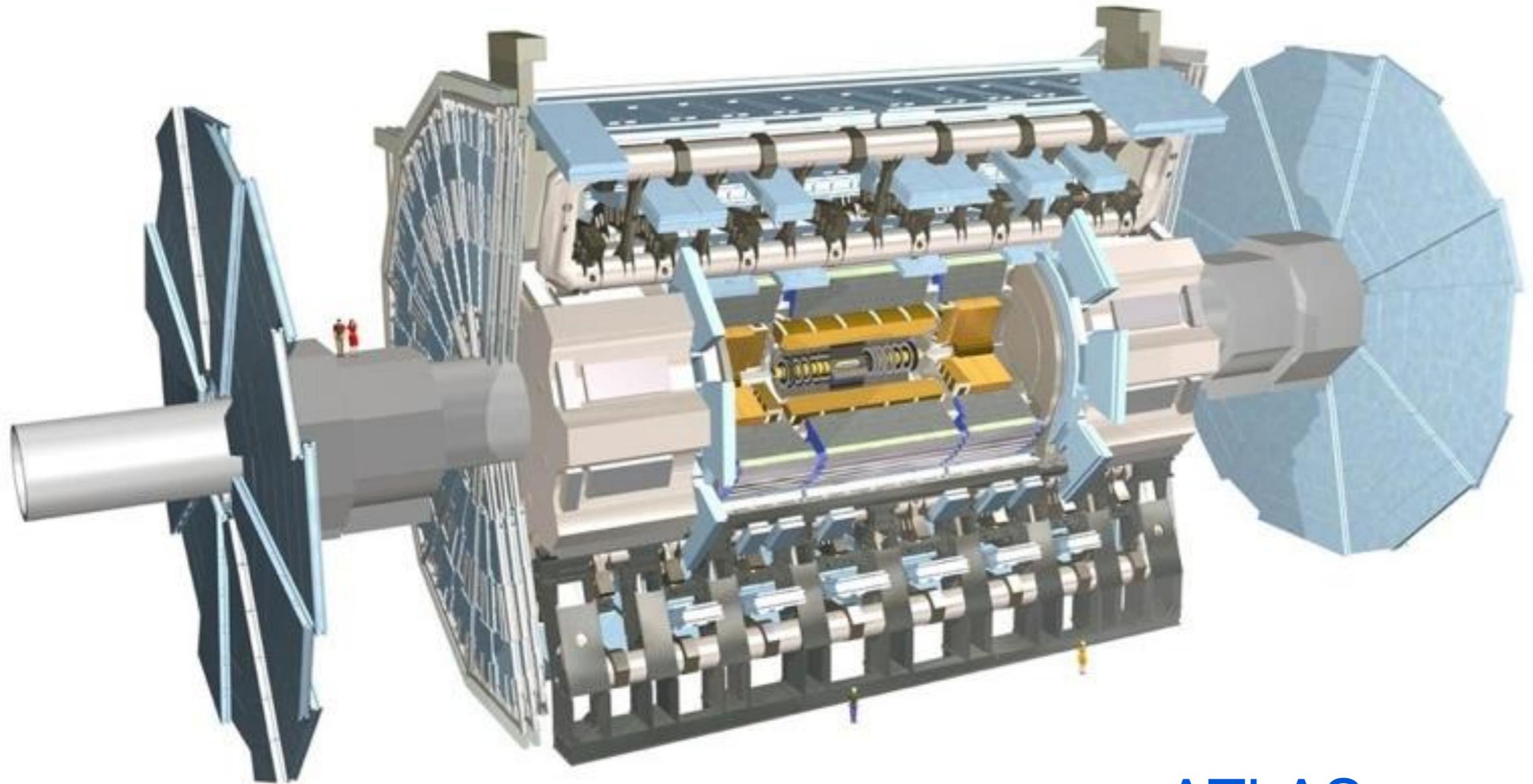


EI LHC

Collider



Experimentos del LHC



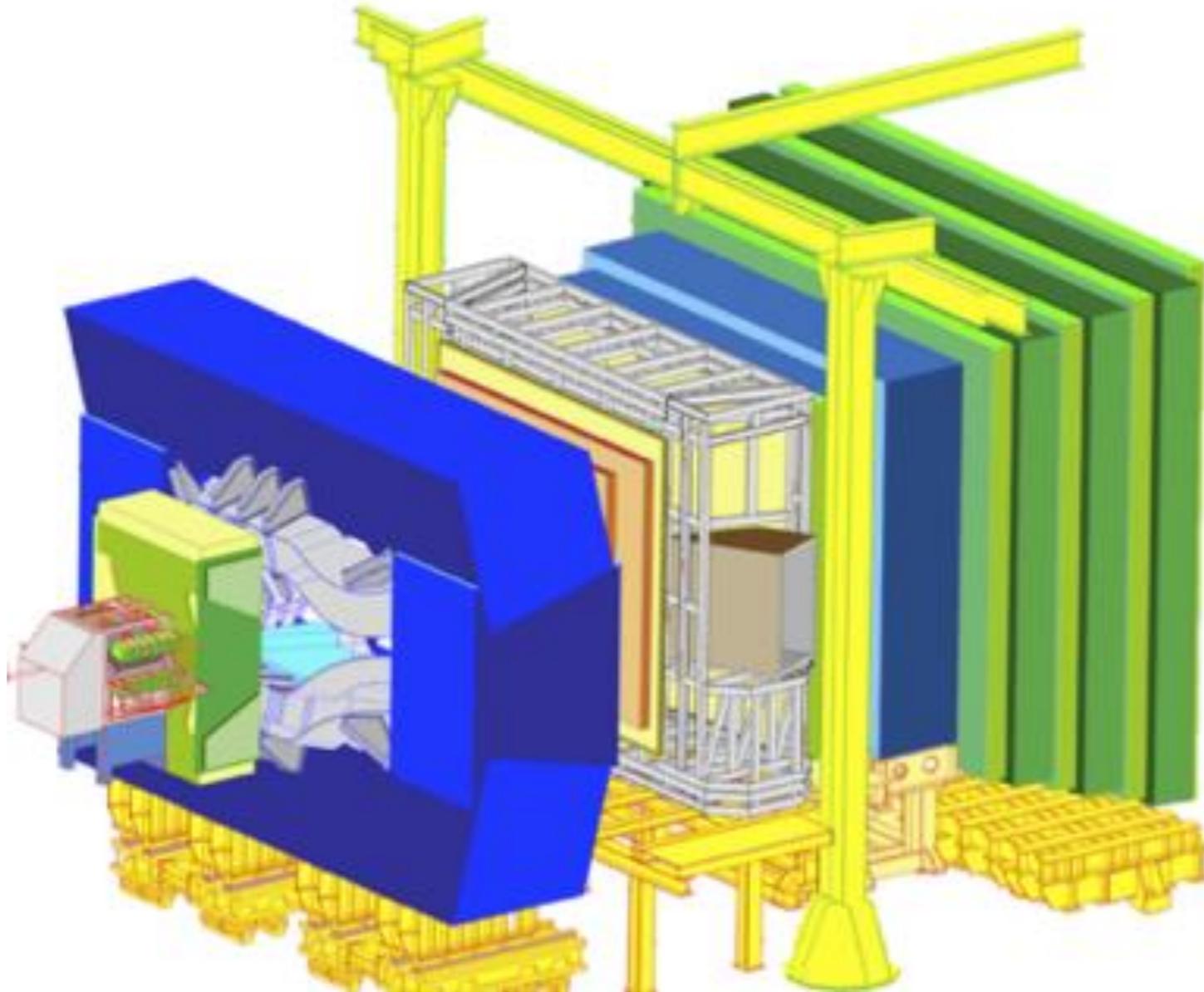
ATLAS

Multi-propósito

46 m x 25 m x 25 m

7,000 tons

Experimentos del LHC



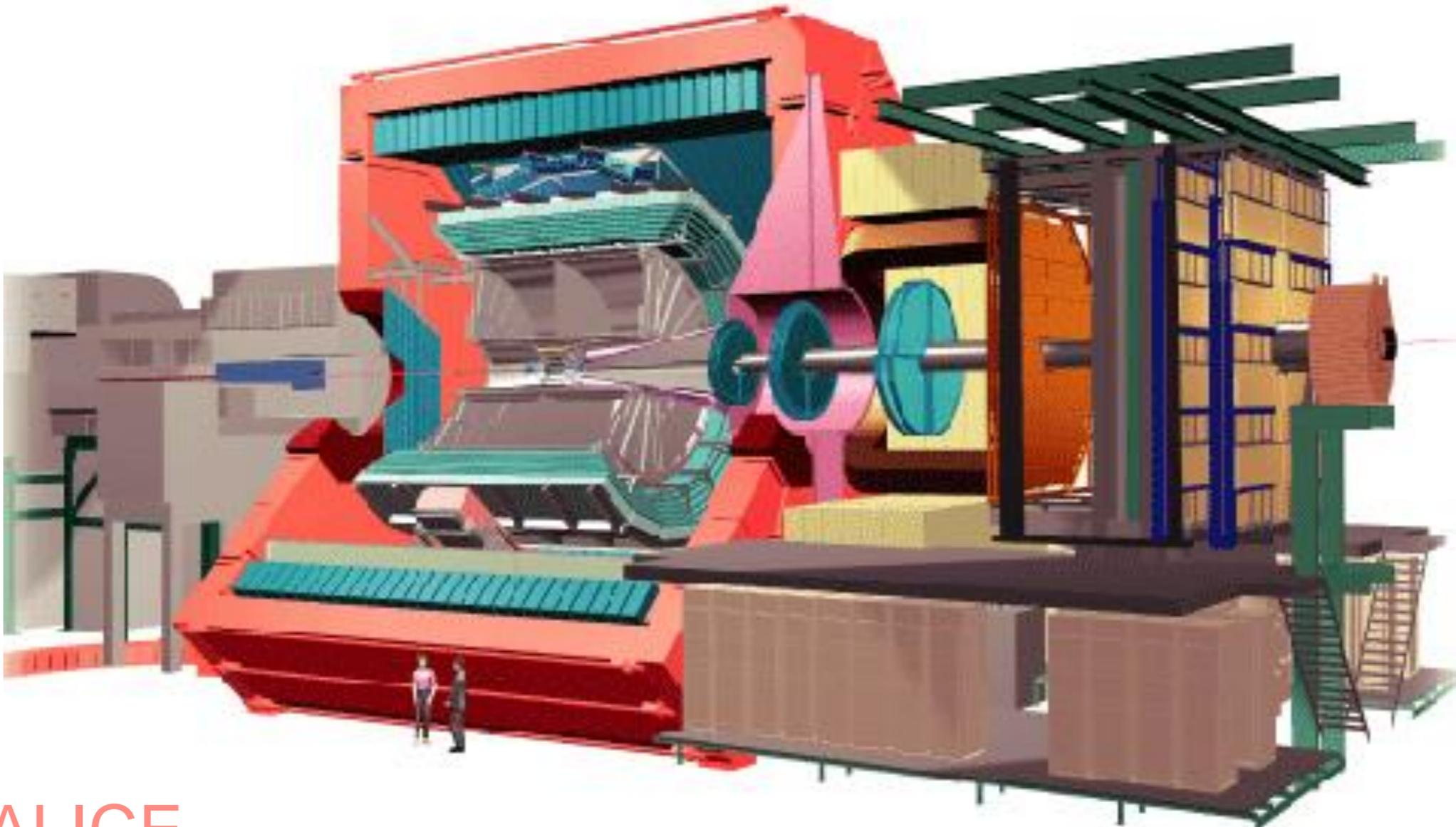
LHCb

Física del quark b

21 m x 10 m x 13 m

5,600 tons

Experimentos del LHC



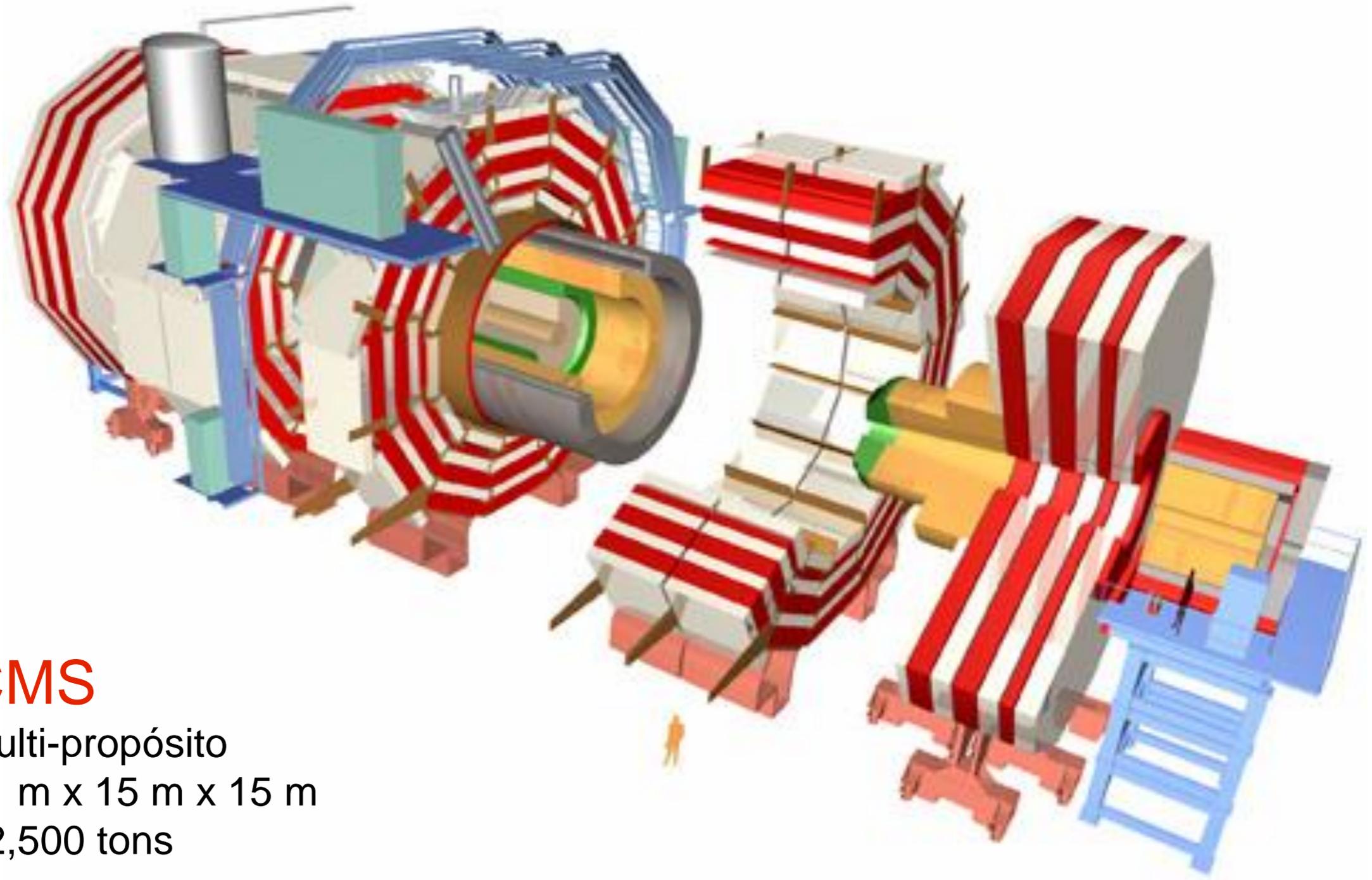
ALICE

Iones pesados

26 m x 16 m x 16 m

10,000 tons

Experimentos del LHC



CMS

Multi-propósito

21 m x 15 m x 15 m

12,500 tons

Identificación de partículas

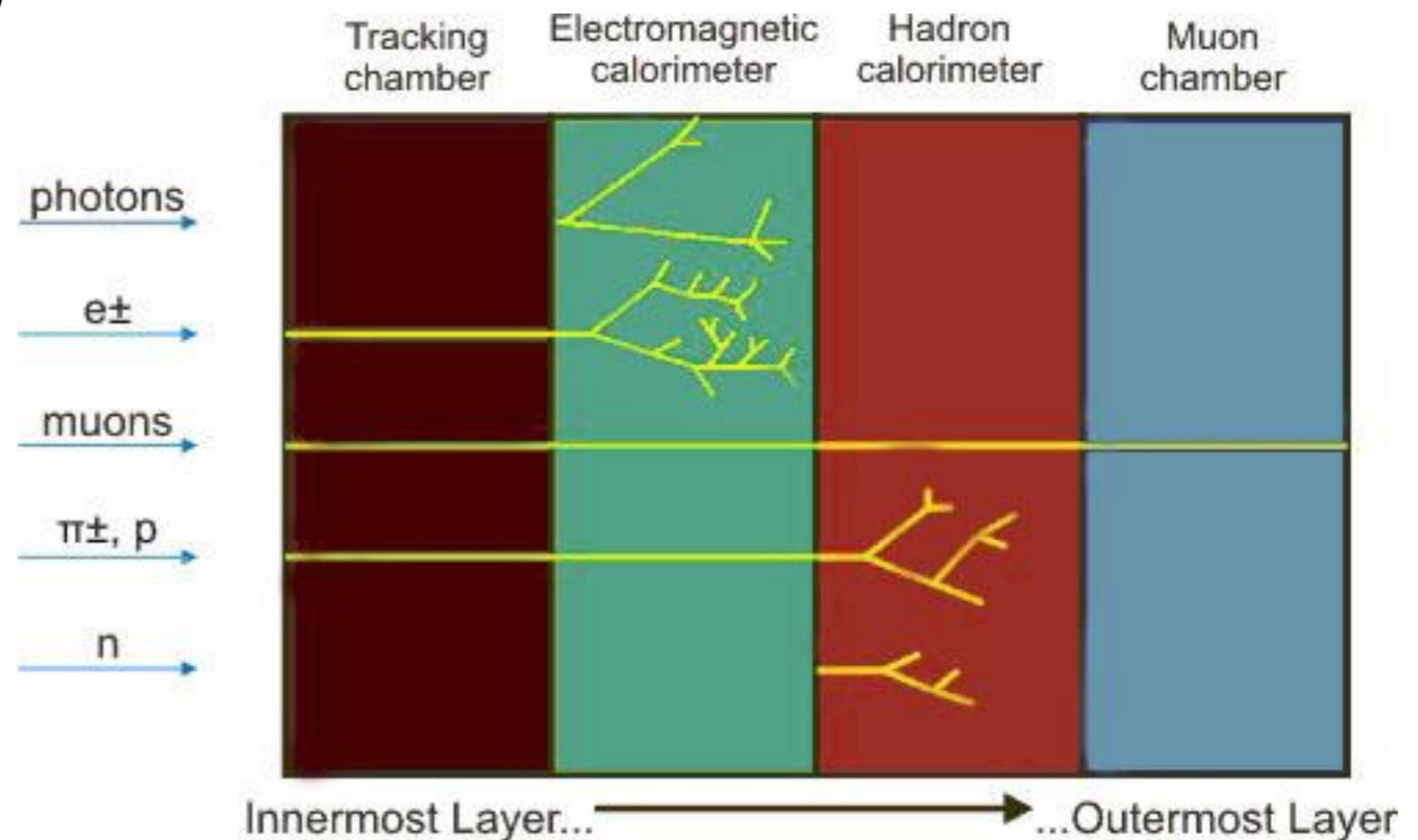
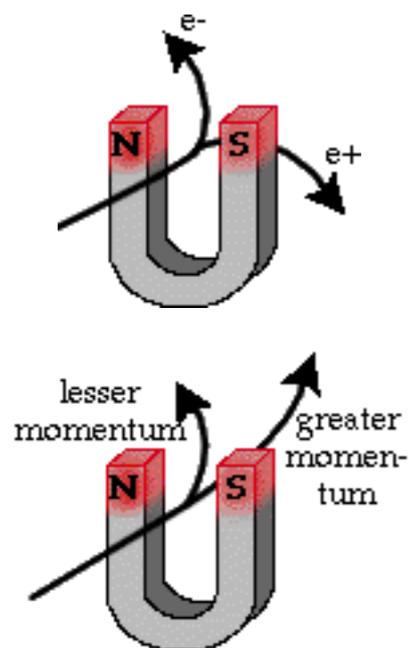
Cada 'capa' está diseñada para medir una propiedad específica:

carga eléctrica

energía

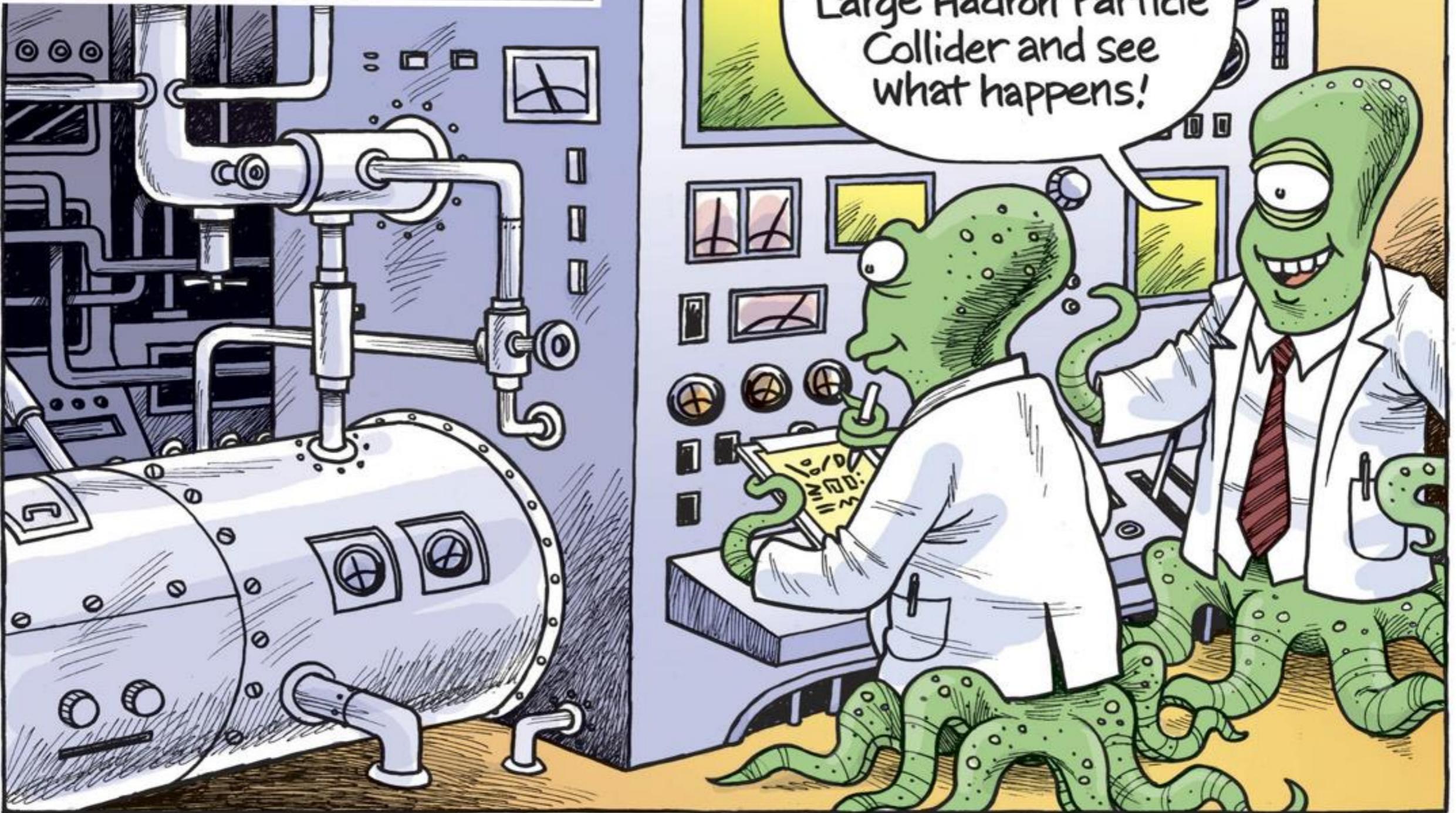
momento (velocidad)

Campos magnéticos:



13,8 BILLION YEARS AGO,
A FEW SECONDS BEFORE THE
CREATION OF OUR UNIVERSE...

MREU
2008



¿Preguntas?