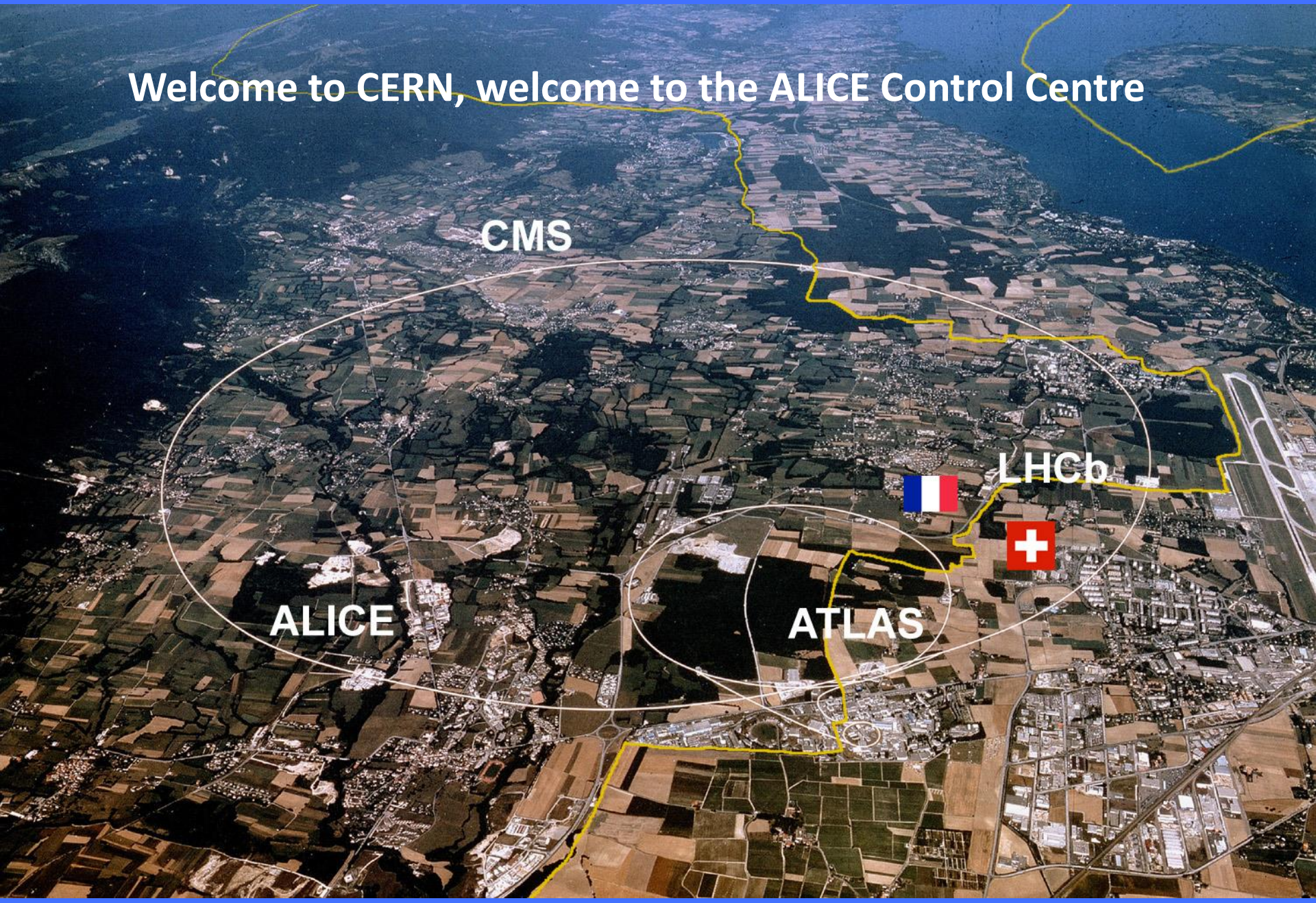
Welcome to CERN, welcome to the ALICE Control Centre

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CERN: European Organization for Nuclear Research (European Particle Physics Laboratory)

It was founded in 1954 by 12 European countries

Today it has 23 member states

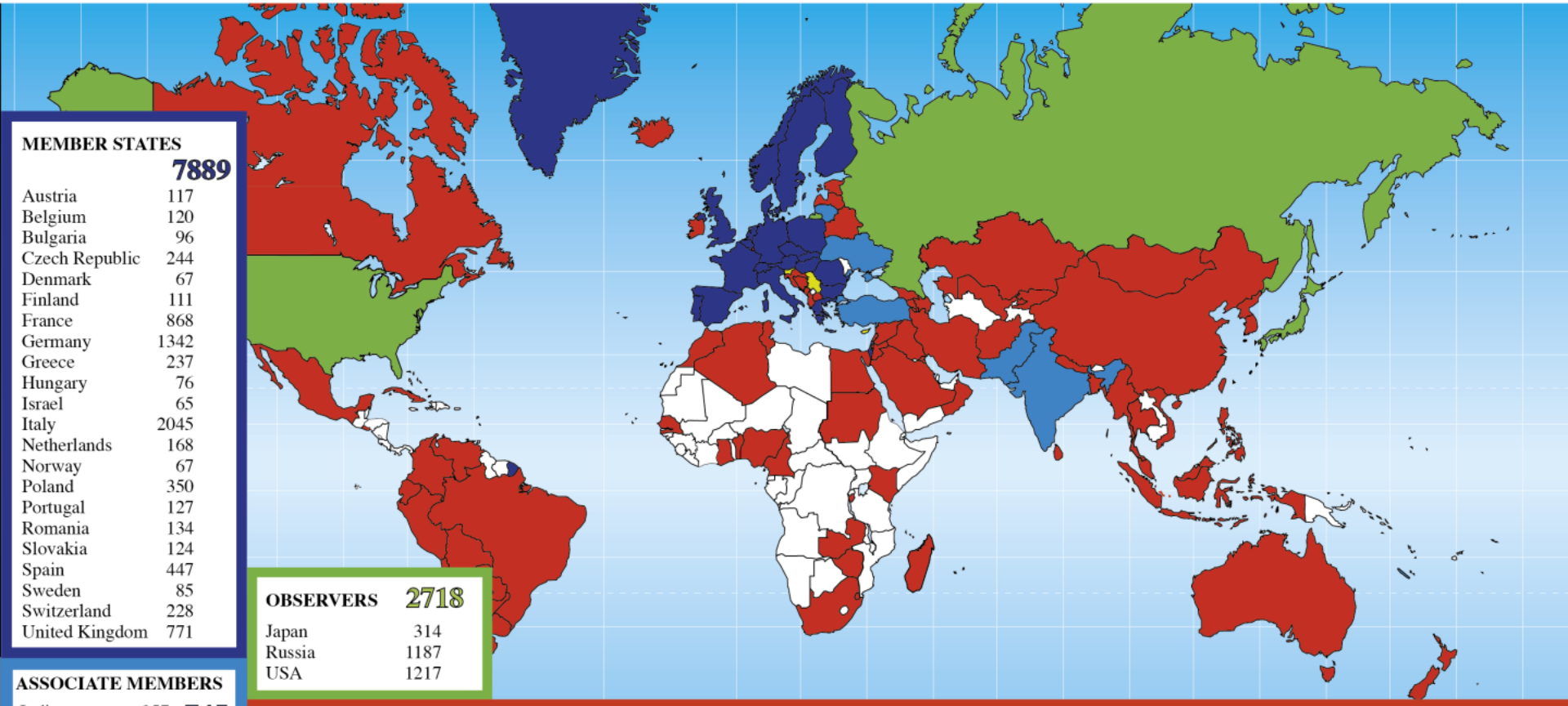
Member States: Austria, Belgium, Bulgaria, Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Israel, Italy, Netherlands, Norway, Poland, Portugal, Romania, Serbia, Sweden, Switzerland, and United Kingdom

Associate Member States: India, Lithuania, Pakistan, Turkey, Ukraine

Associate Member States in the pre-stage to Membership: Cyprus, Slovenia

Observers to Council: Japan, Russia, US, European Union, JINR, and UNESCO

Distribution of All CERN Users by Nationality on 24 January 2018



MEMBER STATES 7889

Austria	117
Belgium	120
Bulgaria	96
Czech Republic	244
Denmark	67
Finland	111
France	868
Germany	1342
Greece	237
Hungary	76
Israel	65
Italy	2045
Netherlands	168
Norway	67
Poland	350
Portugal	127
Romania	134
Slovakia	124
Spain	447
Sweden	85
Switzerland	228
United Kingdom	771

OBSERVERS 2718

Japan	314
Russia	1187
USA	1217

ASSOCIATE MEMBERS 745

India	357
Lithuania	35
Pakistan	65
Turkey	173
Ukraine	115

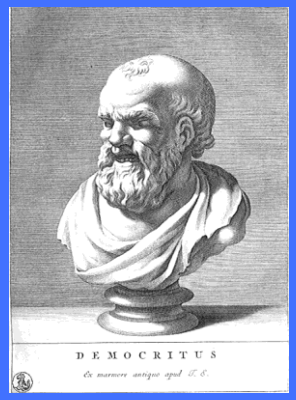
ASSOCIATE MEMBERS IN THE PRE-STAGE TO MEMBERSHIP 118

Cyprus	26
Serbia	57
Slovenia	35

OTHERS 1872

Afghanistan	1	Bolivia	4	Egypt	31	Kazakhstan	5	Mongolia	2	Philippines	3	Thailand	22
Albania	3	Bosnia & Herzegovina	2	El Salvador	1	Kenya	3	Montenegro	11	Saint Kitts and Nevis	1	T.F.Y.R.O.M.	2
Algeria	14	Brazil	135	Estonia	15	Korea Rep.	185	Morocco	20	Saudi Arabia	2	Tunisia	5
Argentina	27	Burundi	1	Georgia	46	Kyrgyzstan	1	Myanmar	1	Senegal	1	Uruguay	1
Armenia	19	Cameroon	1	Ghana	1	Latvia	2	Nepal	10	Singapore	4	Uzbekistan	4
Australia	31	Canada	161	Hong Kong	1	Lebanon	23	New Zealand	5	South Africa	56	Venezuela	10
Azerbaijan	10	Chile	20	Iceland	3	Luxembourg	2	Nigeria	3	Sri Lanka	6	Viet Nam	13
Bangladesh	11	China	510	Indonesia	11	Madagascar	4	North Korea	1	Sudan	1	Zambia	1
Belarus	48	Colombia	45	Iran	51	Malaysia	15	Oman	3	Swaziland	1	Zimbabwe	2
Benin	1	Croatia	41	Iraq	1	Malta	9	Palestine (O.T.).	7	Syria	1		
		Cuba	12	Ireland	16	Mauritius	1	Paraguay	2	Taiwan	51		
		Ecuador	6	Jordan	1	Mexico	82	Peru	7				

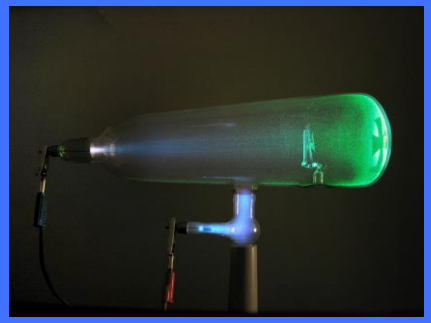
Democritus believed that all matter is made of indivisible elements, the atoms



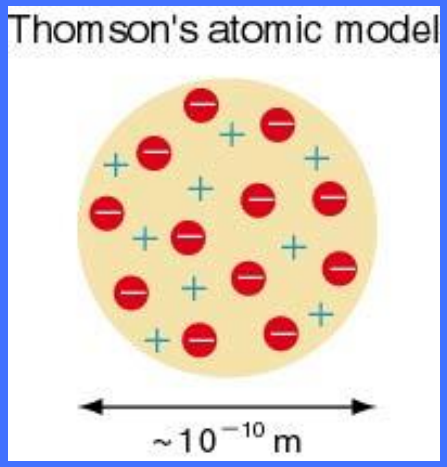
Mendeleev's periodic table of elements (1869) – 80 different indivisible atoms

I	II	III	IV	V	VI	VII	VIII		
H 1.01									
Li 6.94	Be 9.01	B 10.8	C 12.0	N 14.0	O 16.0	F 19.0			
Na 23.0	Mg 24.3	Al 27.0	Si 28.1	P 31.0	S 32.1	Cl 35.5			
K 39.1	Ca 40.1		Ti 47.9	V 50.9	Cr 52.0	Mn 54.9	Fe 55.9	Co 58.9	Ni 58.7
Cu 63.5	Zn 65.4			As 74.9	Se 79.0	Br 79.9			
Rb 85.5	Sr 87.6	Y 88.9	Zr 91.2	Nb 92.9	Mo 95.9		Ru 101	Rh 103	Pd 106
Ag 108	Cd 112	In 115	Sn 119	Sb 122	Te 128	I 127			
Ce 133	Ba 137	La 139		Ta 181	W 184		Os 194	Ir 192	Pt 195
Au 197	Hg 201	Ti 204	Pb 207	Bi 209					
			Th 232		U 238				

JJ Thomson

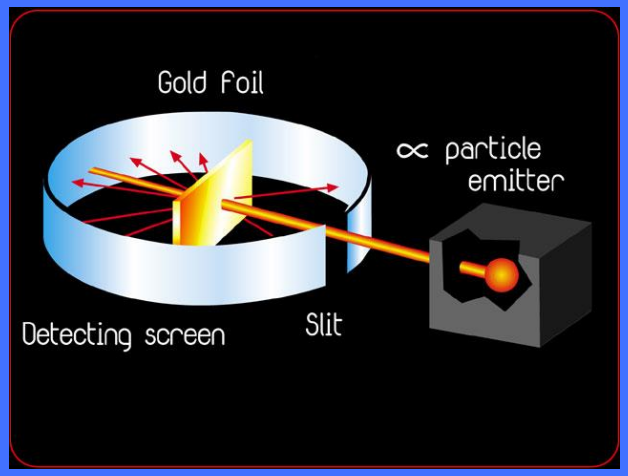


Discovery of the electron with cathode ray tube
first elementary particle
1896

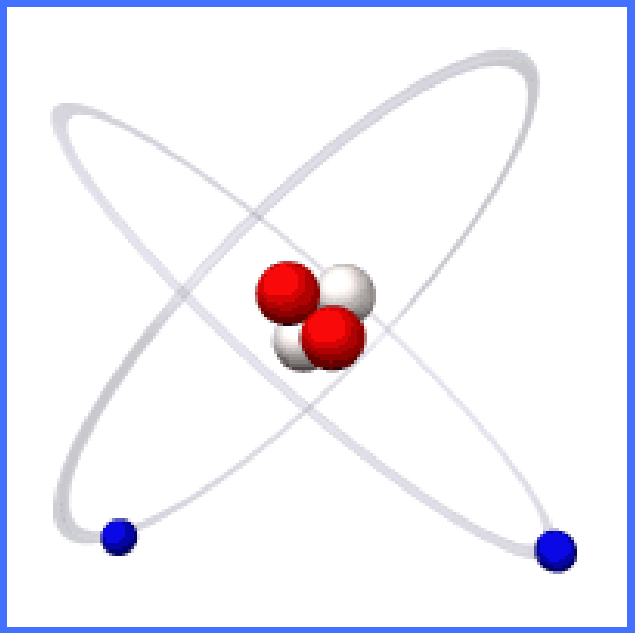


Thomson's plum pudding model (1904)

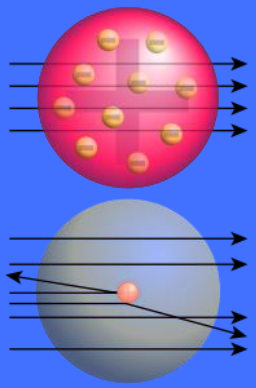
2011 : 100-year anniversary from the introduction of Rutherford's atomic model



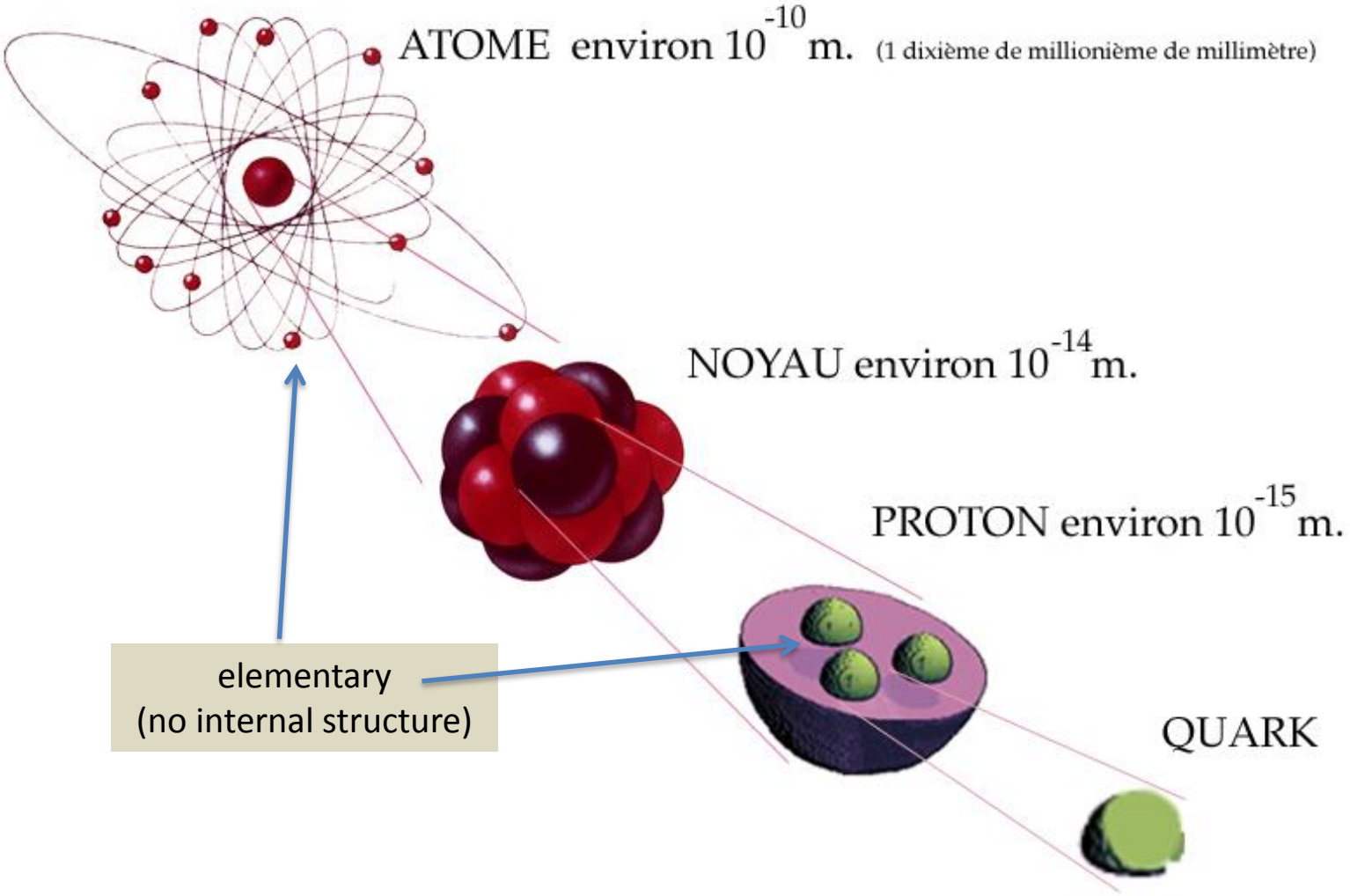
alpha scattering experiment
Geiger – Marsden



Ernest Rutherford

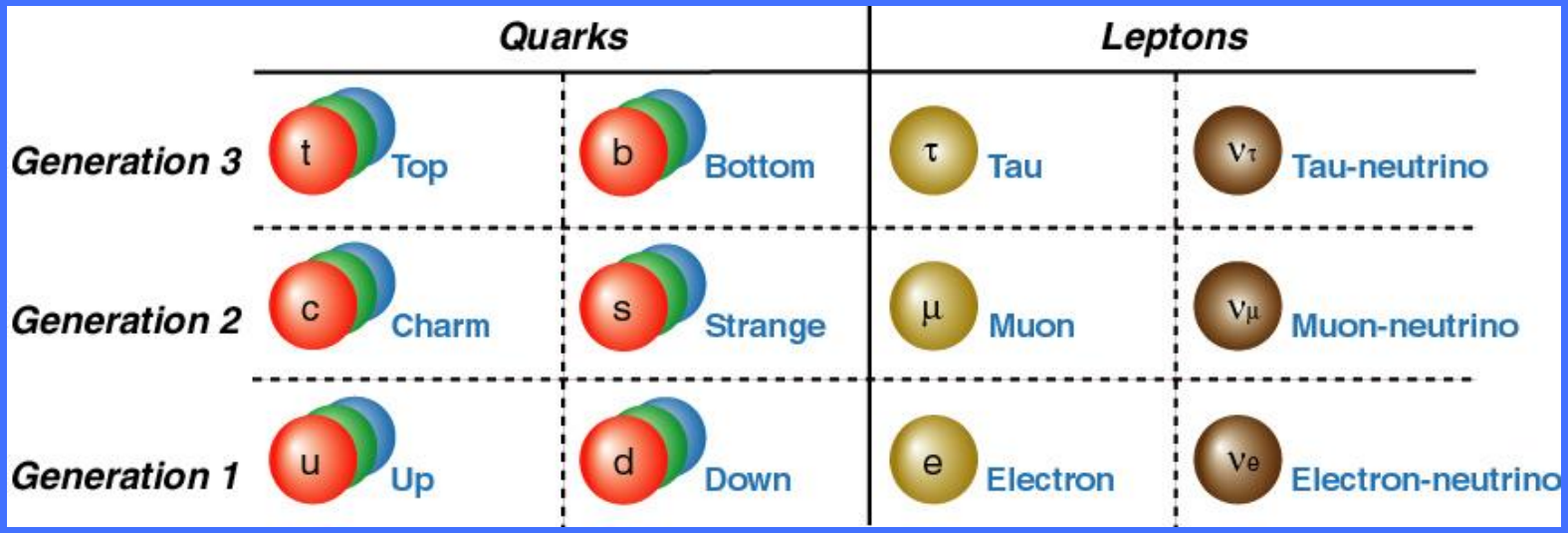


Nucleus: most of the mass, positive charge; atom is mainly empty
Later on it was found that the nucleus consists of protons and neutrons



Il y a environ onze milliards de milliards d'atomes de fer dans un milligramme de fer !

Periodic system of elementary particles



ONLY elementary particles of the 1st generation exist in nature

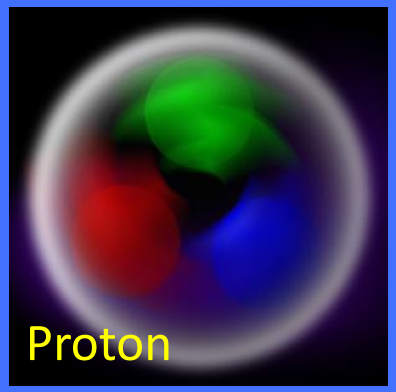
Particles of the 2nd and 3rd generation decay to those of the 1st (lighter)
Observed in accelerator experiments and cosmic rays

All particles have their antiparticles (same mass, opposite electric charge)

Quark Confinement

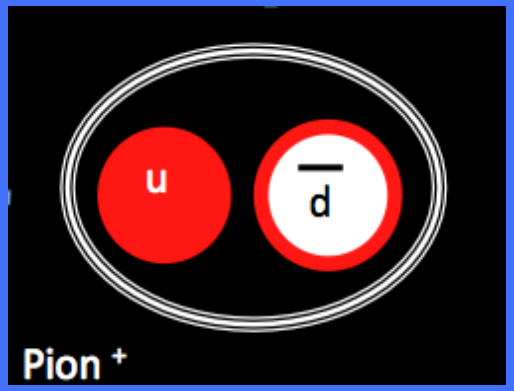
Quarks can not exist free in nature

They can only exist bound inside hadrons



baryons consisting of 3 quarks

mesons consisting of a quark and an anti-quark



Baryons qqq and Antibaryons $\bar{q}\bar{q}\bar{q}$

Baryons are fermionic hadrons.

These are a few of the many types of baryons.

Symbol	Name	Quark content	Electric charge	Mass GeV/c^2	Spin
p	proton	**uud**	1	0.938	1/2
$\bar{\mathbf{p}}$	antiproton	$\bar{\mathbf{u}}\bar{\mathbf{u}}\bar{\mathbf{d}}$	–1	0.938	1/2
n	neutron	**udd**	0	0.940	1/2
Λ	lambda	**uds**	0	1.116	1/2
Ω^-	omega	**sss**	–1	1.672	3/2

Mesons $q\bar{q}$

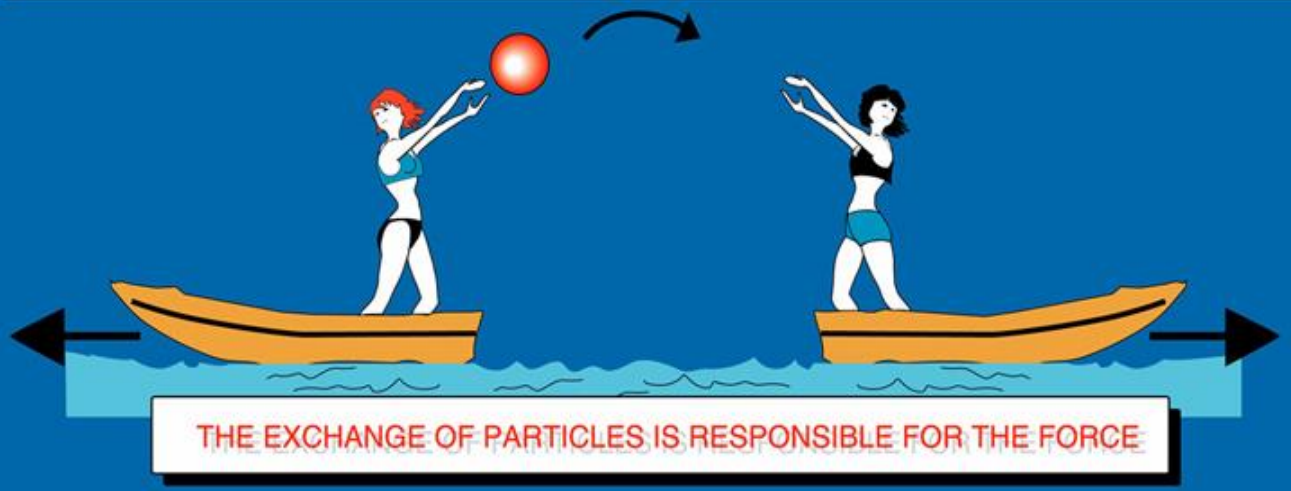
Mesons are bosonic hadrons

These are a few of the many types of mesons.

Symbol	Name	Quark content	Electric charge	Mass GeV/c^2	Spin
π^+	pion	$\mathbf{u\bar{d}}$	+1	0.140	0
$\mathbf{K^-}$	kaon	$\mathbf{s\bar{u}}$	–1	0.494	0
ρ^+	rho	$\mathbf{u\bar{d}}$	+1	0.776	1
B^0	B-zero	$\mathbf{d\bar{b}}$	0	5.279	0
η_c	eta-c	$\mathbf{c\bar{c}}$	0	2.980	0

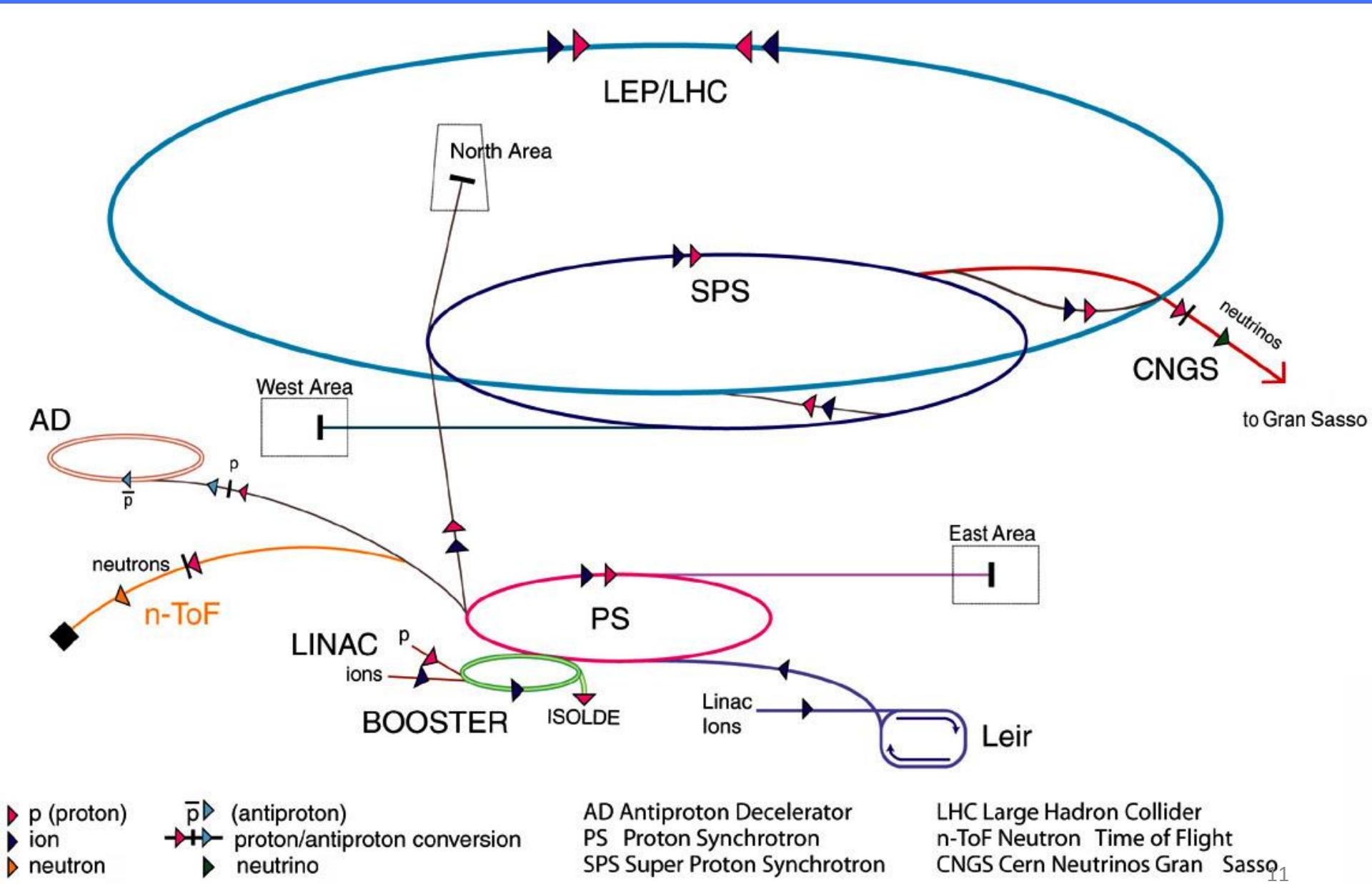
The forces in Nature

TYPE	INTENSITY OF FORCES (DECREASING ORDER)	BINDING PARTICLE (FIELD QUANTUM)	OCCURS IN :
STRONG NUCLEAR FORCE	~ 1	GLUONS (NO MASS)	ATOMIC NUCLEUS
ELECTRO -MAGNETIC FORCE	~ 10^{-3}	PHOTONS (NO MASS)	ATOMIC SHELL ELECTROTECHNIQUE
WEAK NUCLEAR FORCE	~ 10^{-5}	BOSONS Z^0 , W+ , W- (HEAVY)	RADIOACTIVE BETA DESINTEGRATION
GRAVITATION	~ 10^{-38}	GRAVITONS (?)	HEAVENLY BODIES



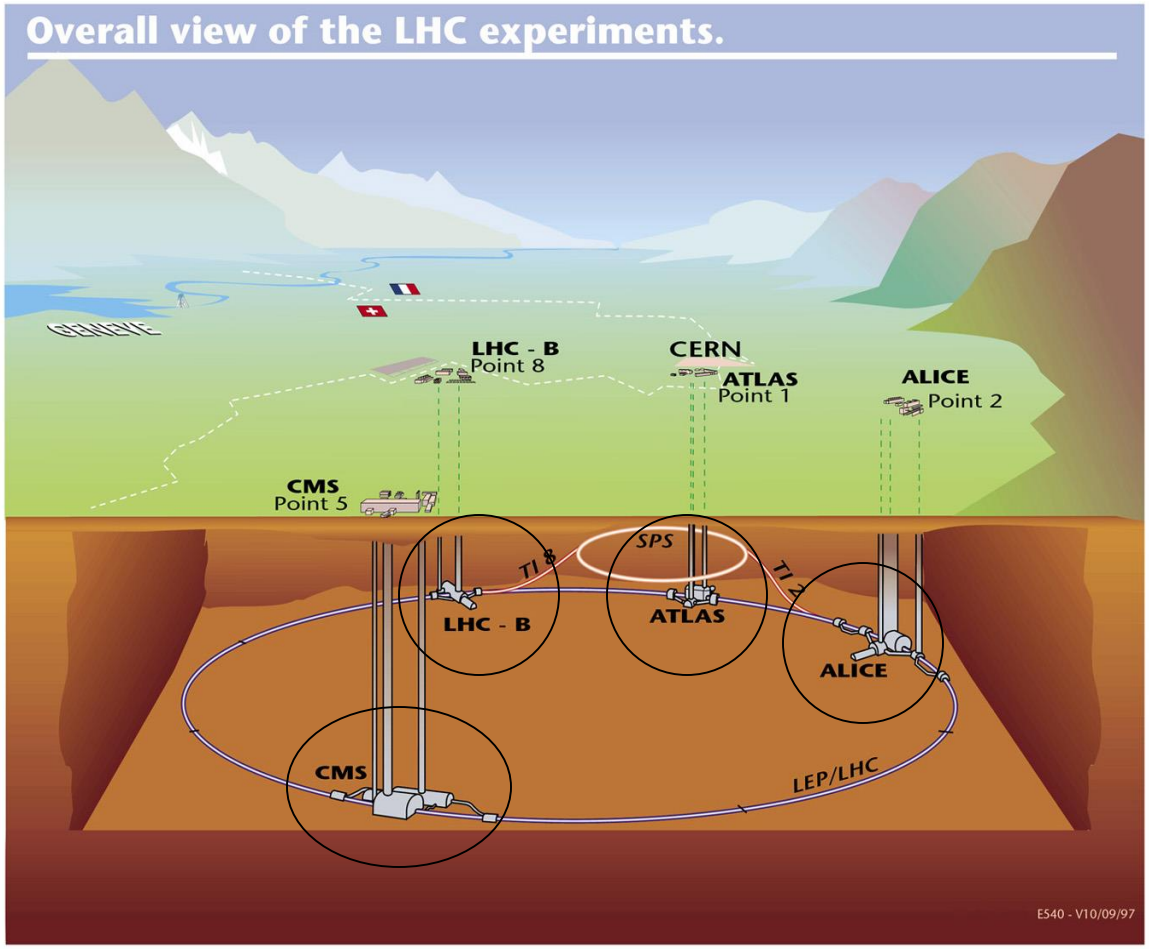
THE EXCHANGE OF PARTICLES IS RESPONSIBLE FOR THE FORCE

CERN's mission : to provide accelerators for the experiments



LHC : The Large Hadron Collider

It collides beams of protons at an energy of 13 TeV (the highest energy in the world)



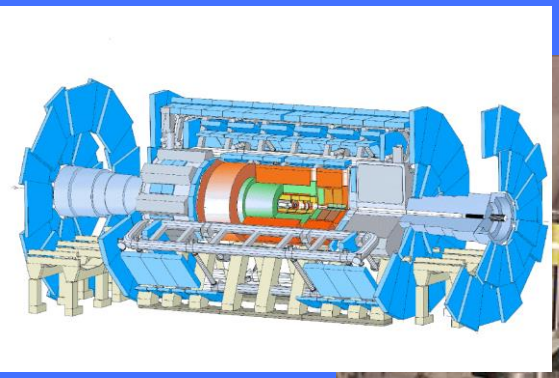
- Using the latest superconducting technologies, it operates at - 271^{0}C (1.9 degrees above absolute zero, colder than outer space)

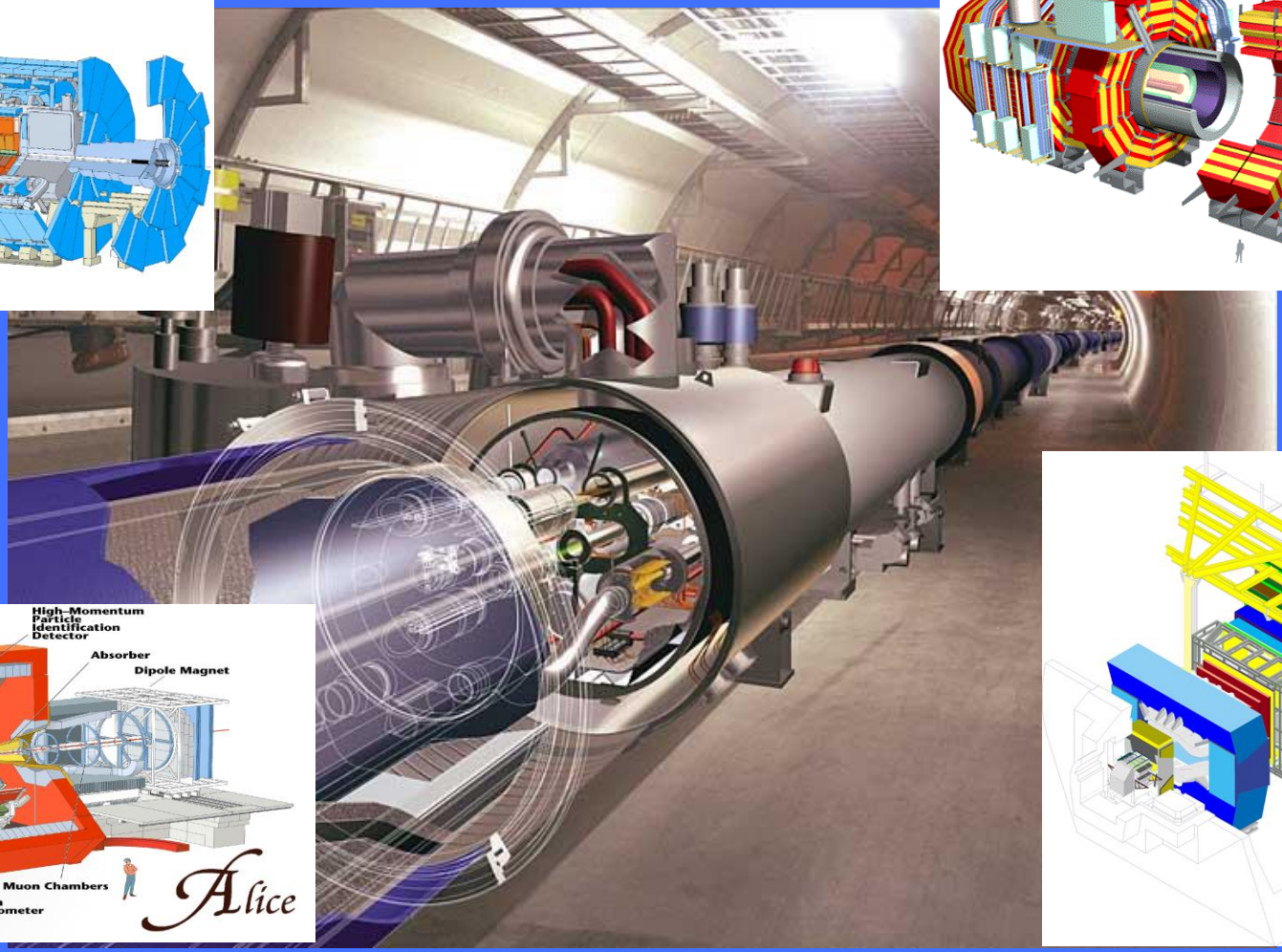
- With its 27 km circumference, the LHC is the largest superconducting installation in the world.

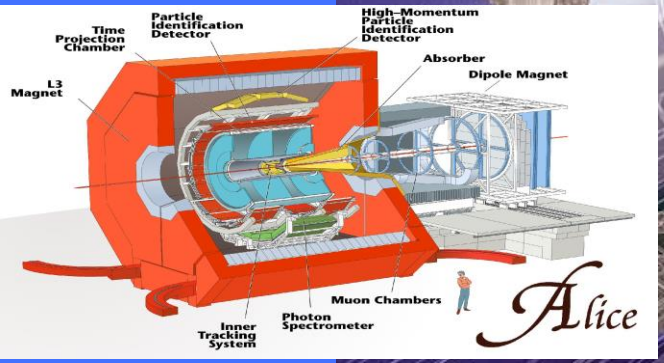
- It is installed 100 m below ground

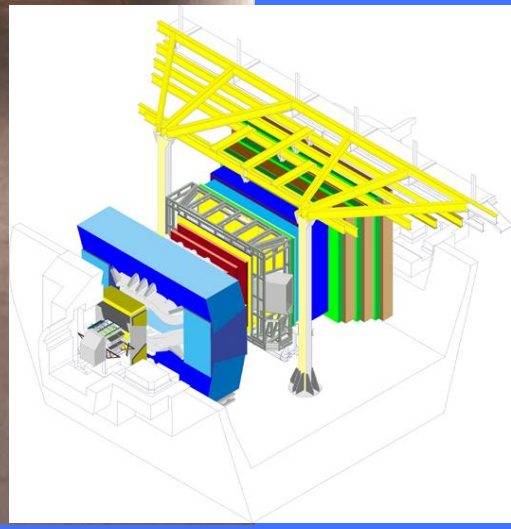
- Protons go around the LHC 11500 times / second

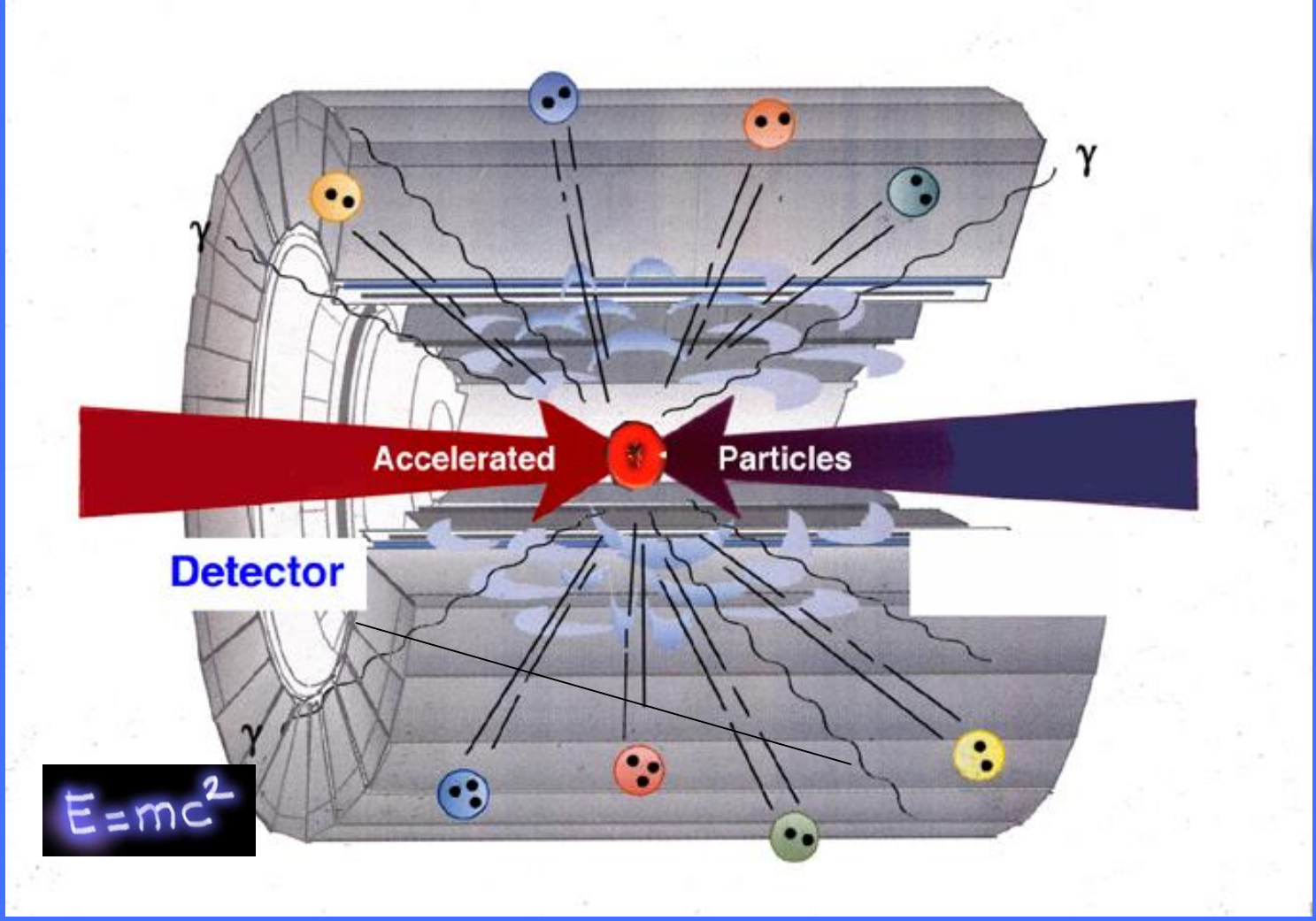
4 big experiments are installed at LHC



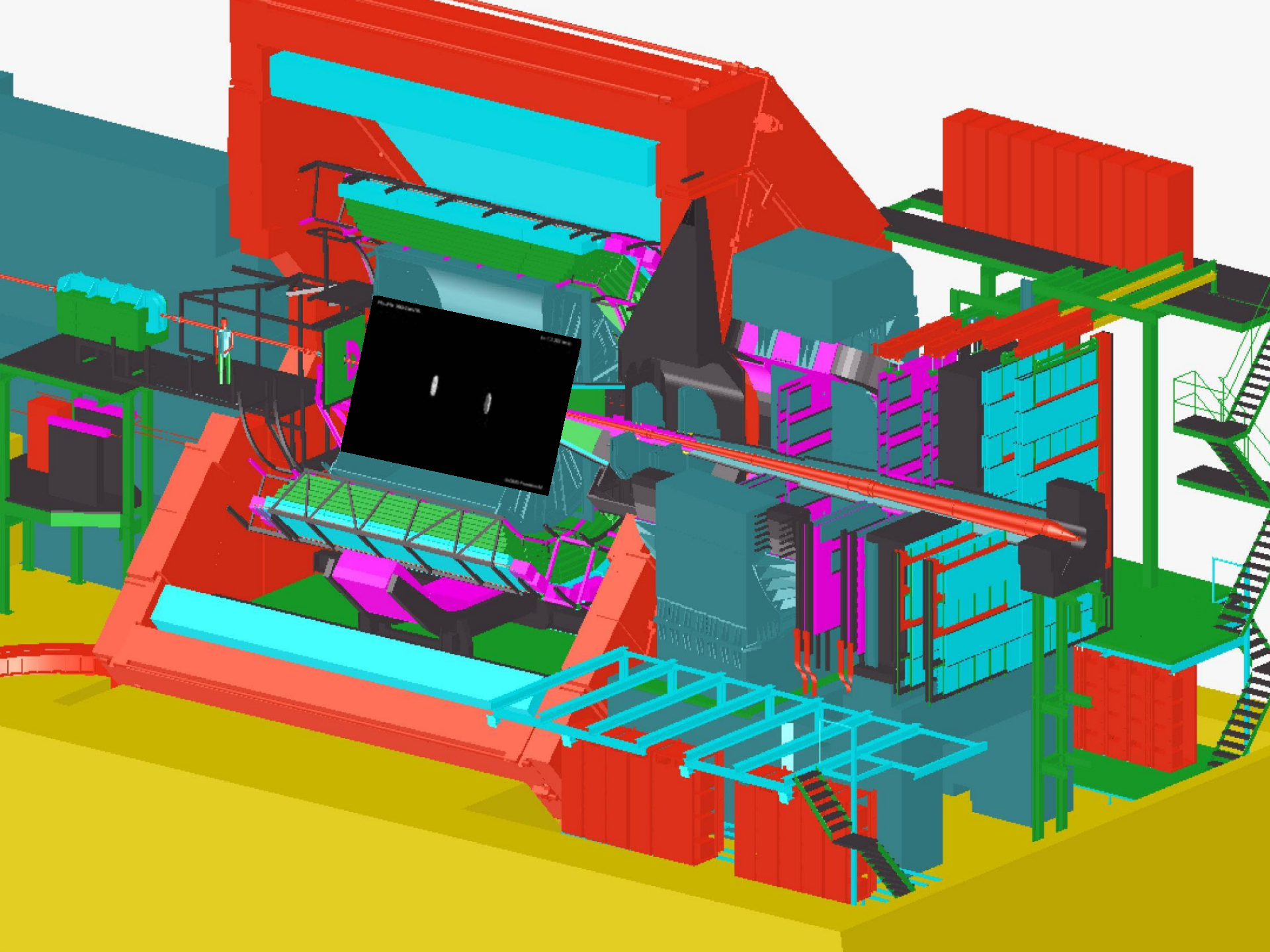


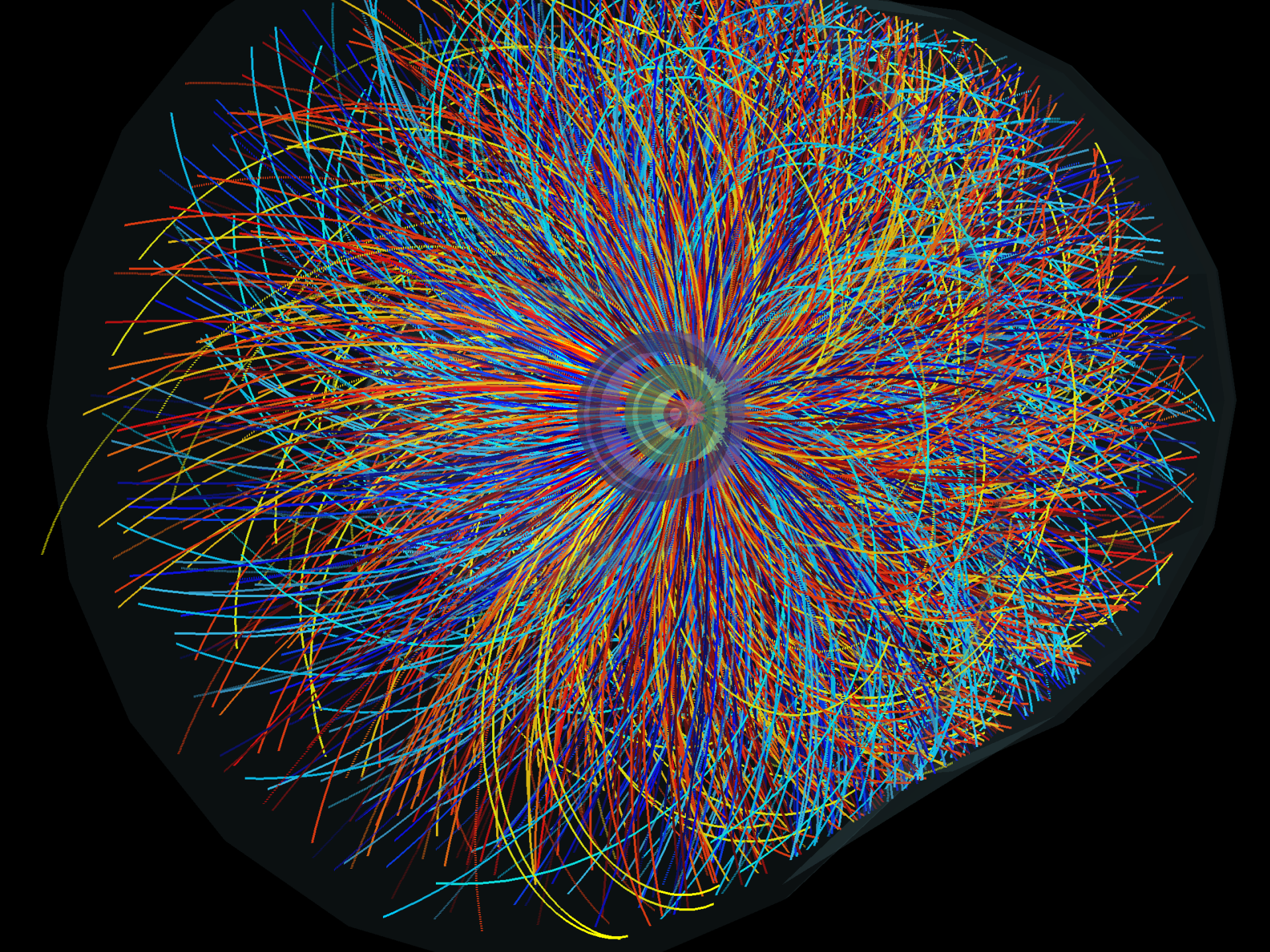


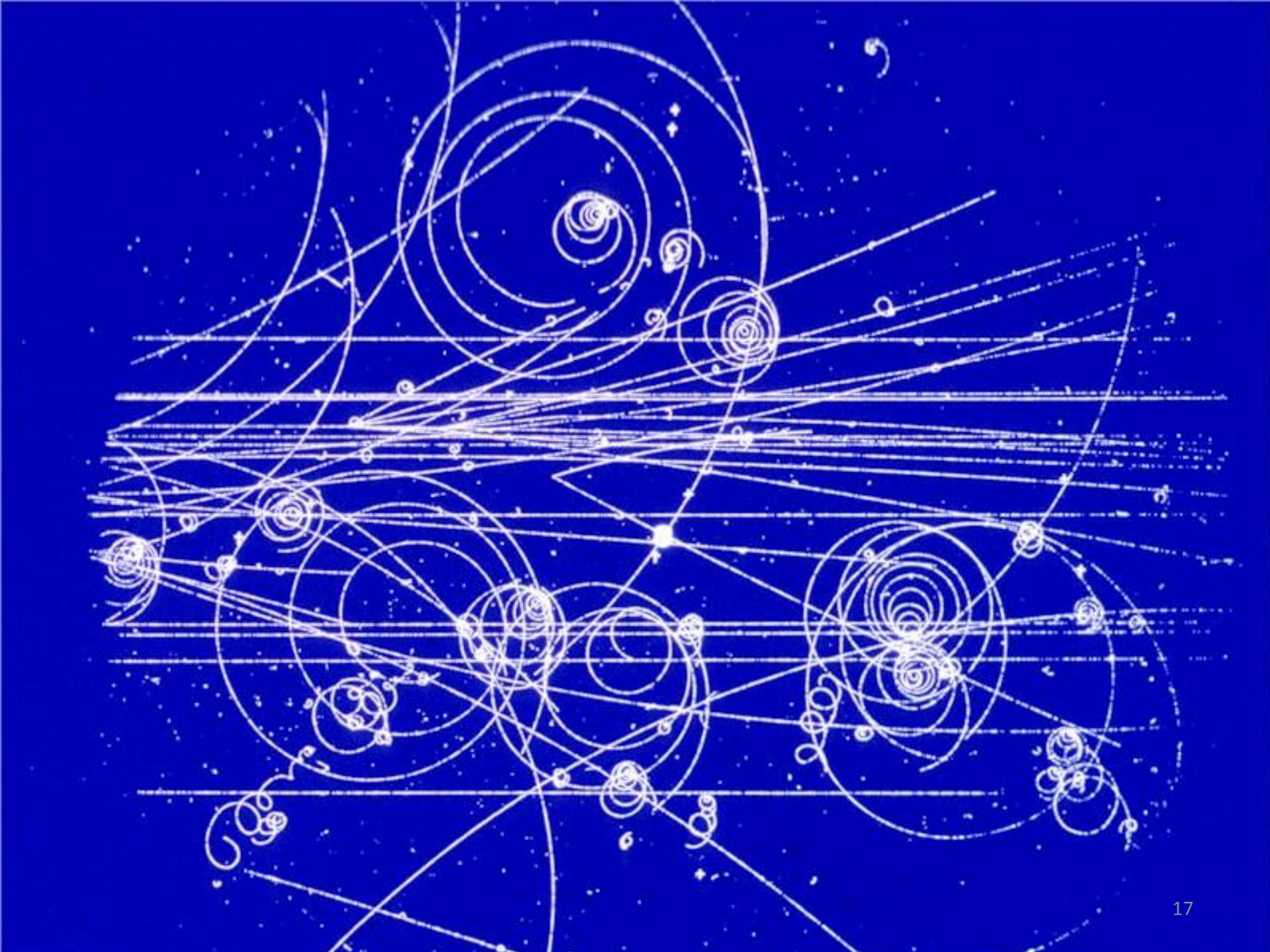




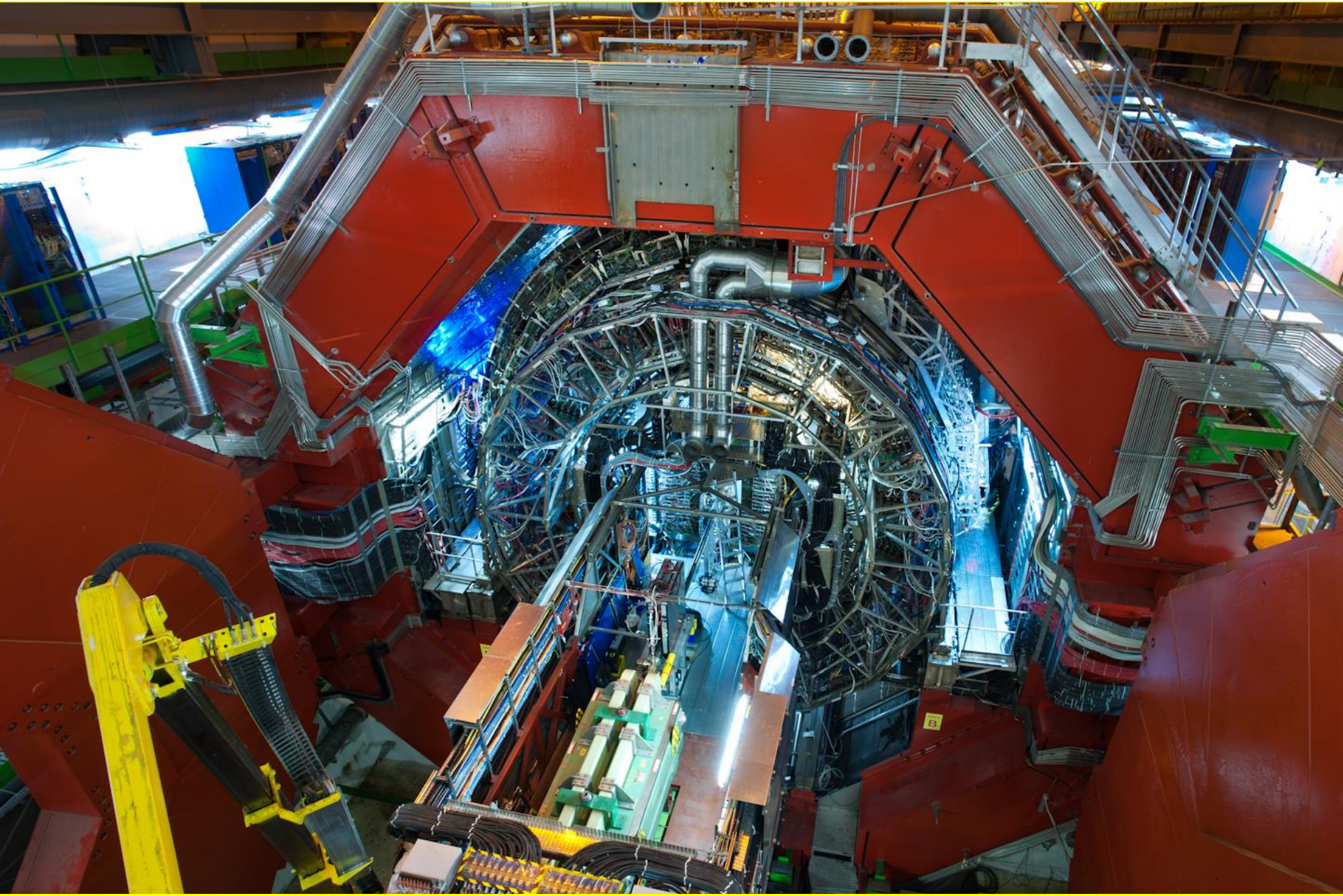
we “see”the particles produced from the collision with our detectors



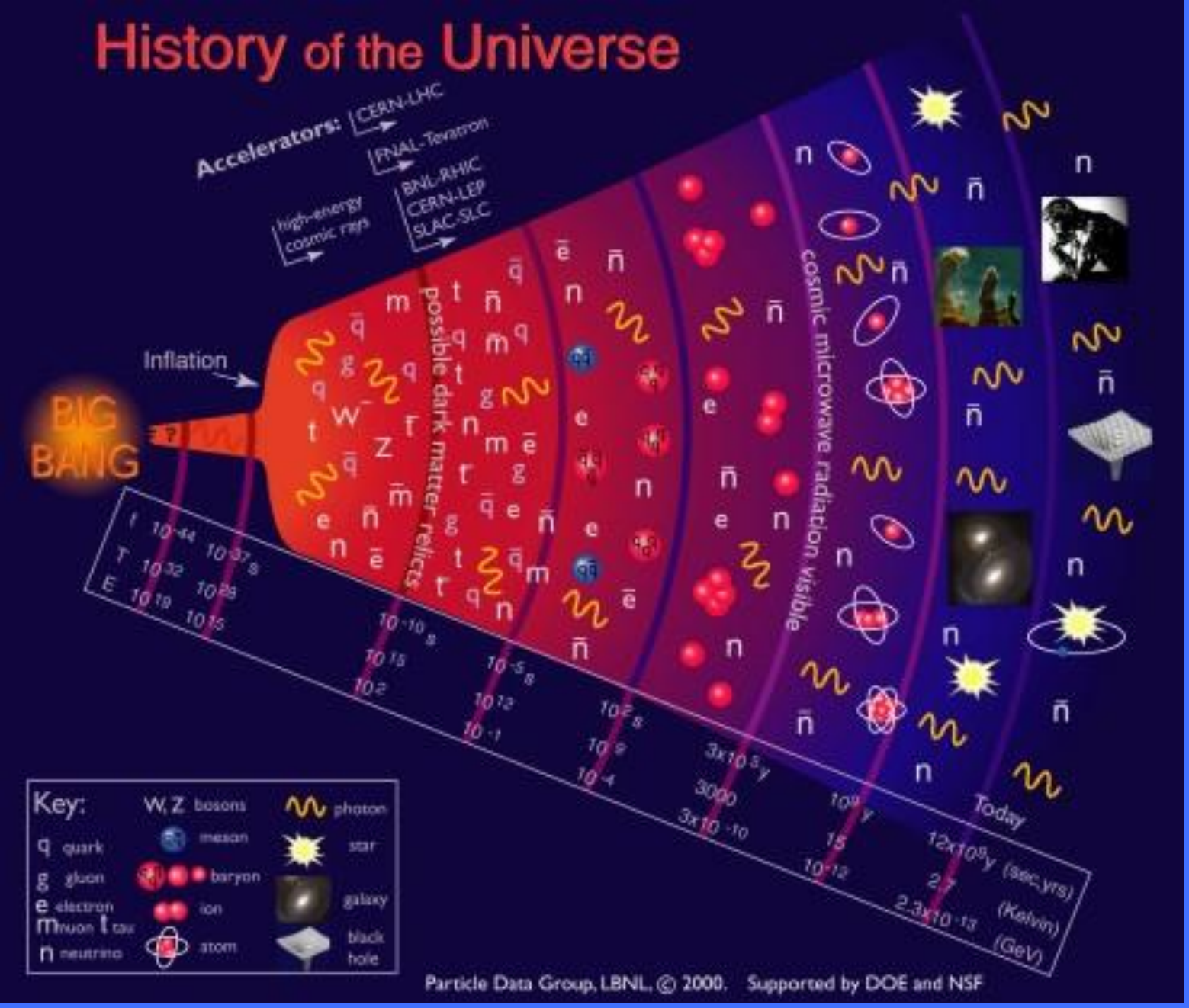




ALICE : A Large Ion Collider Experiment



16 m x 16 m x 26 m 10 000 tons installed 56 m underground (@ point 2 of LHC)



13.7 billion years ago the universe was born from a Big Bang

Millionths of a second after the big bang, all matter is made of free quarks and gluons,

THE QUARK GLUON PLASMA

As the universe cools and expands, the quarks and gluons are "imprisoned" for ever inside hadrons: from these, only protons and neutrons remain today

Little Bang

By colliding lead nuclei at very high energies we recreate the conditions of density and temperature which existed fractions of a second after the Big Bang

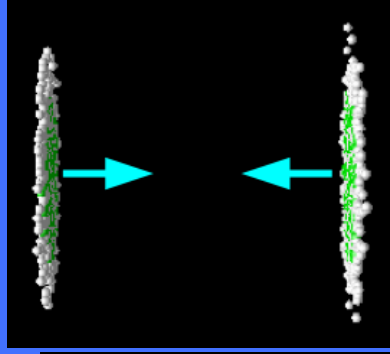
The protons and neutrons which constitute the lead nuclei melt liberating the quarks and gluons which are bound inside them

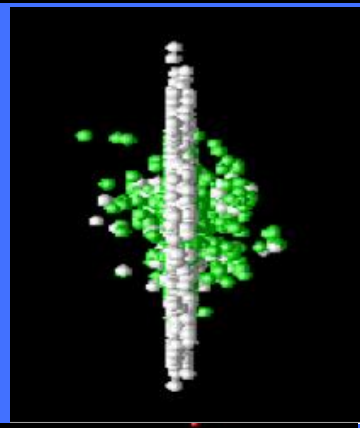
A new state of matter is created : the QUARK GLUON PLASMA

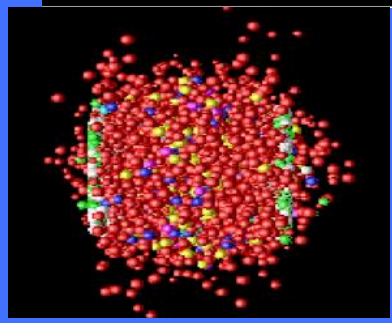
By studying its properties

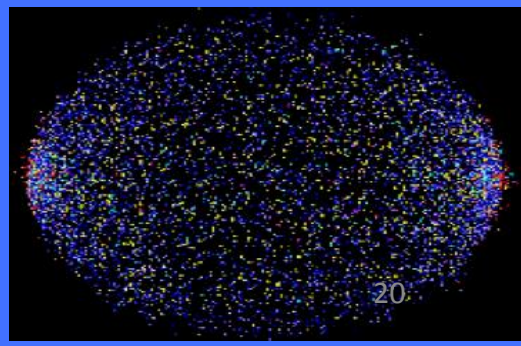
- We will understand better the processes which took place during the first fractions of a second in the life of the universe

- We will understand better the strong interaction and how the protons and neutrons acquire their mass





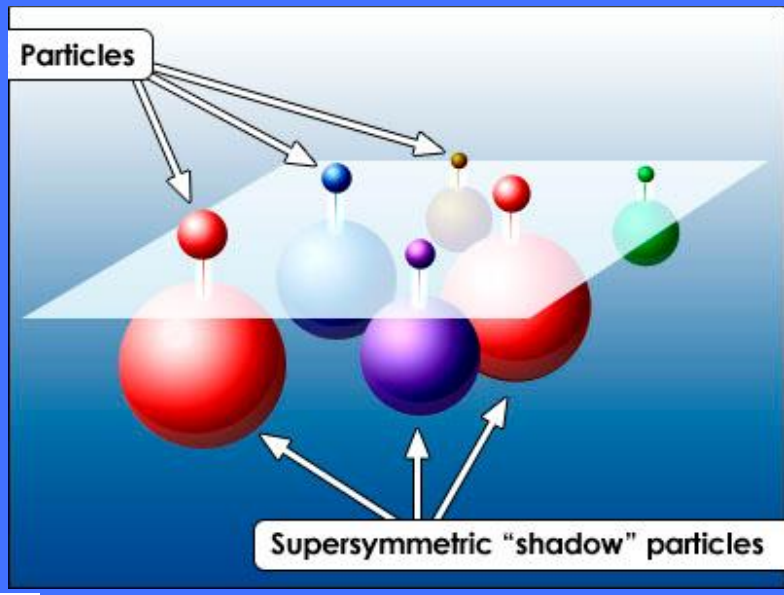


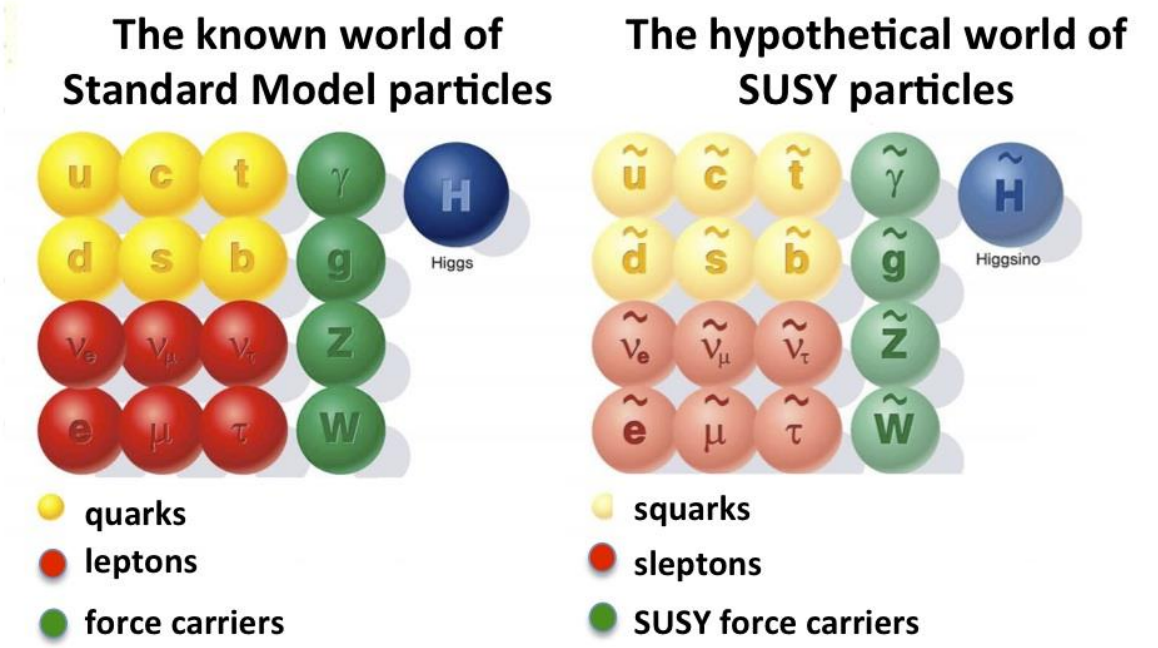


SUperSYmmetry (SUSY)

Symmetry between matter (elementary particles -> fermions) and forces (force carriers -> bosons)

To unify the forces
To solve problems in the Standard Model (deviations in the Higgs mass)

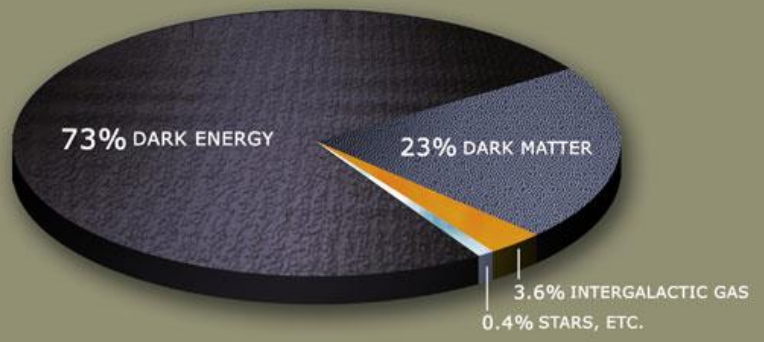




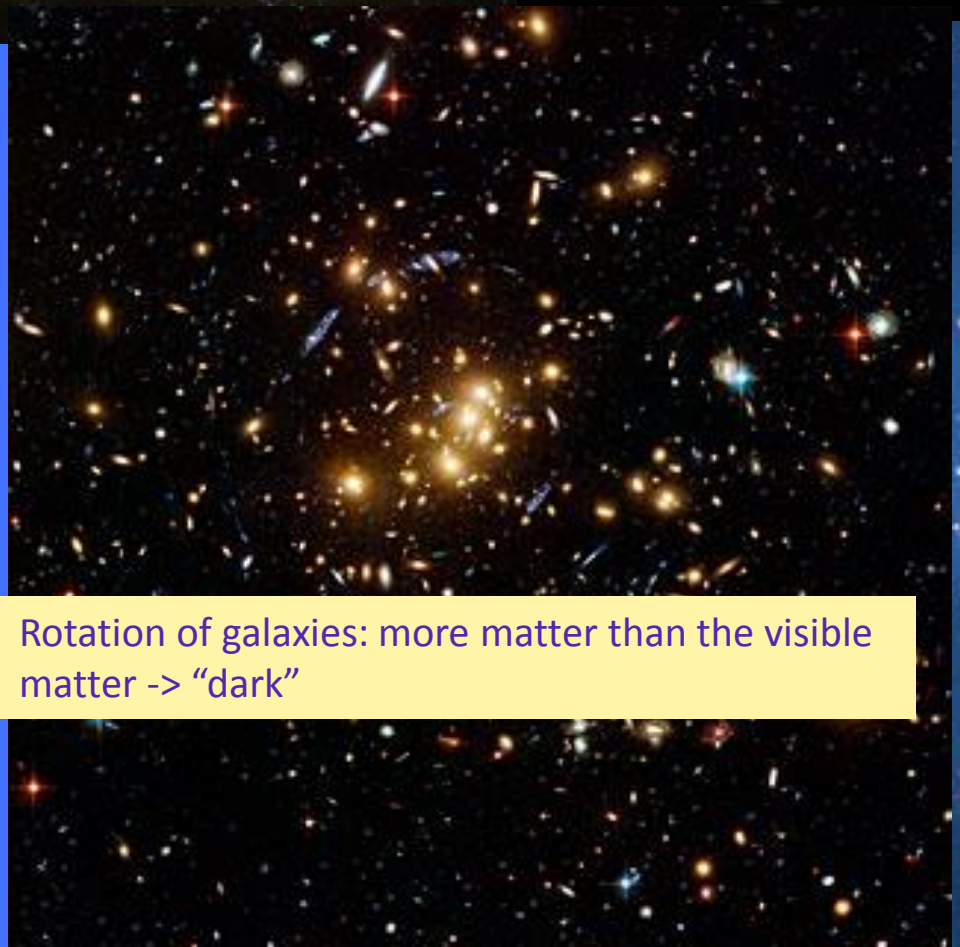
Every particle with spin s has its supersymmetric partner with spin s-1/2

Quark (s=1/2) -> squark (s=0)
Gluon (s=1) -> gluino (s=1/2)

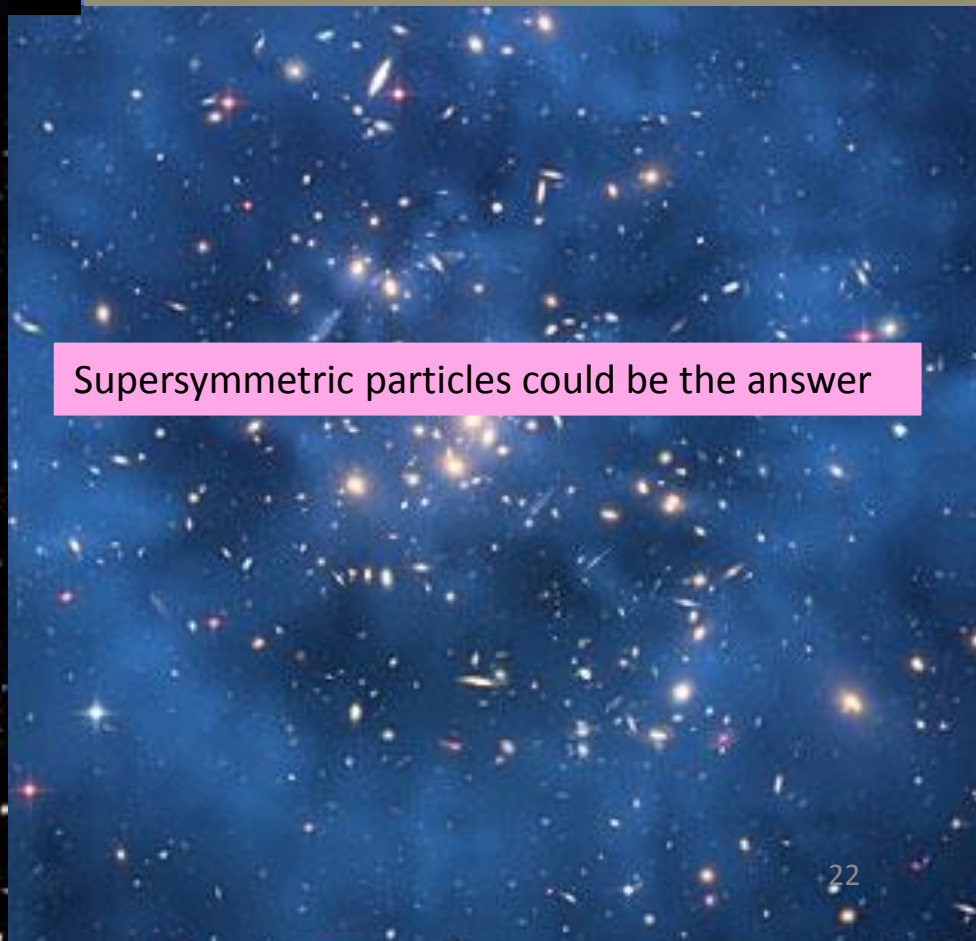
Dark matter



4 % ONLY is matter that we see



Rotation of galaxies: more matter than the visible matter -> “dark”



Supersymmetric particles could be the answer