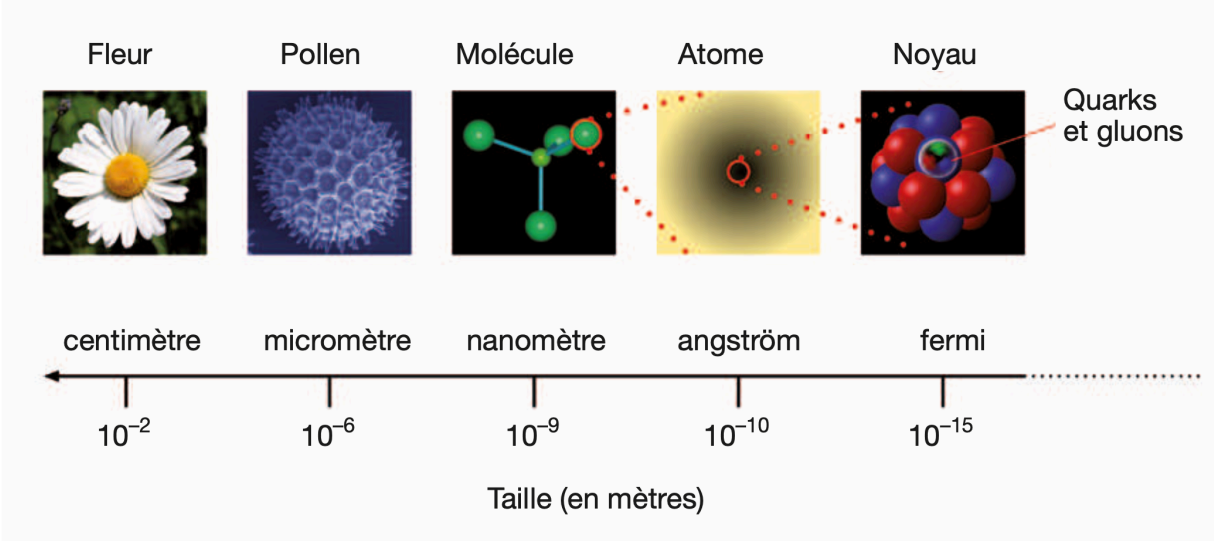
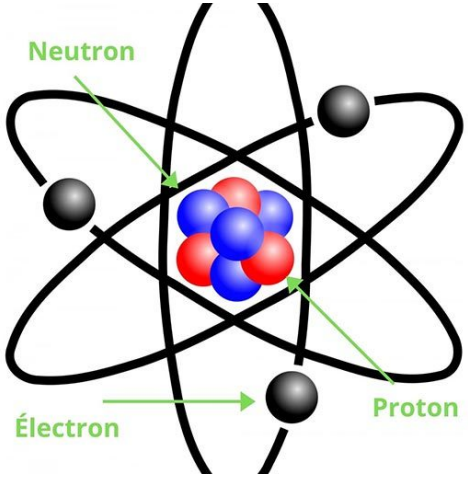
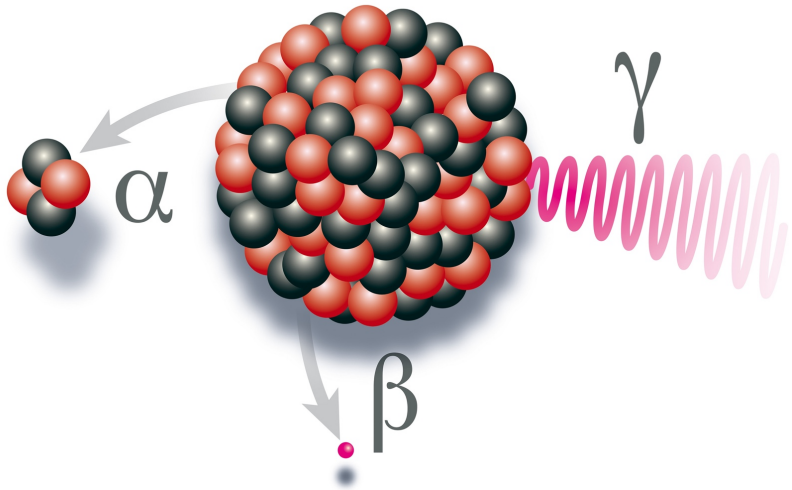
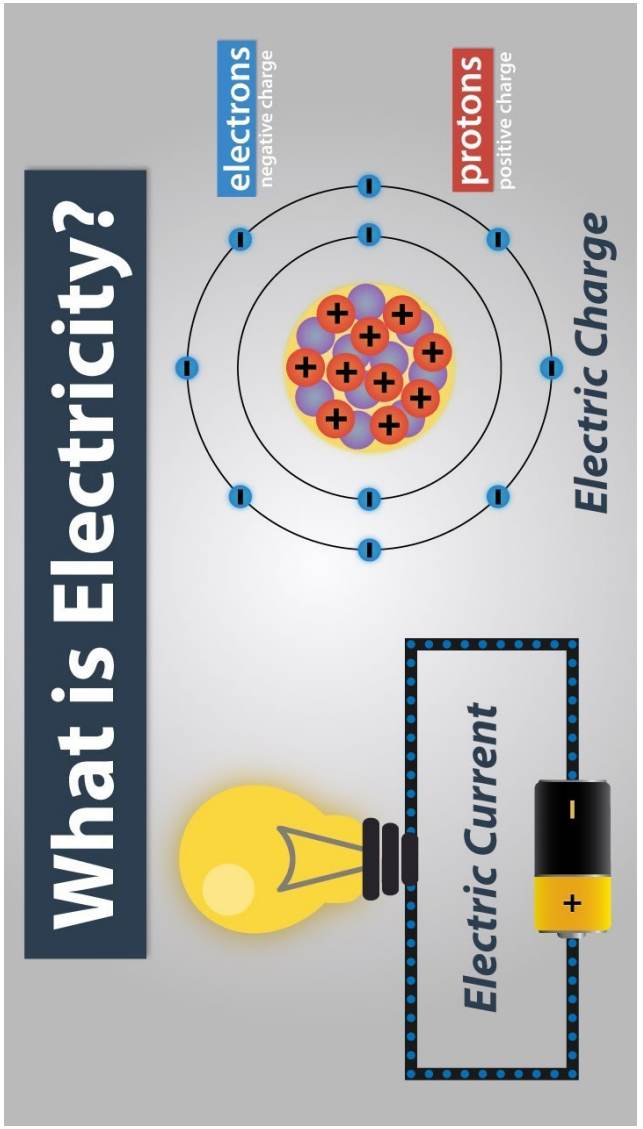
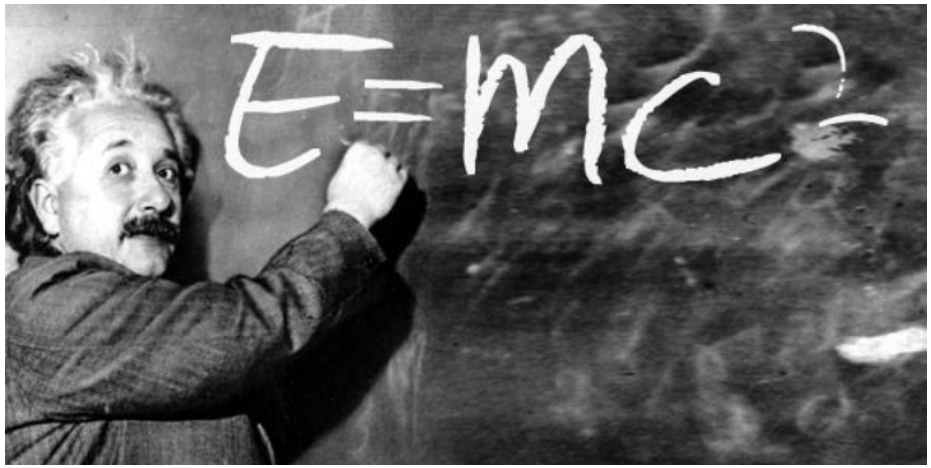
Connaissez-vous des particules élémentaires ?

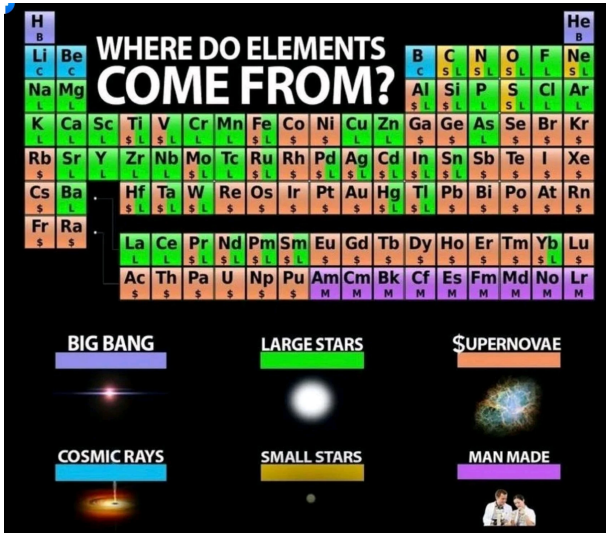


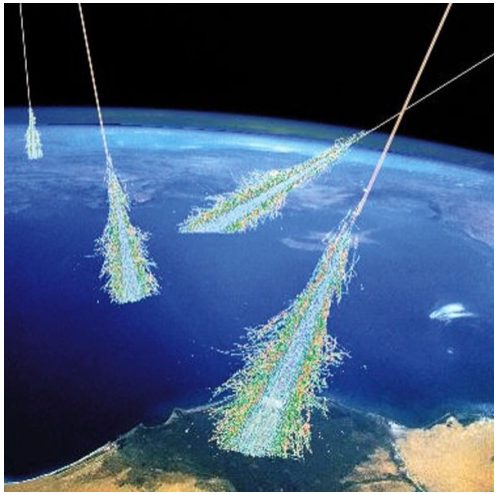



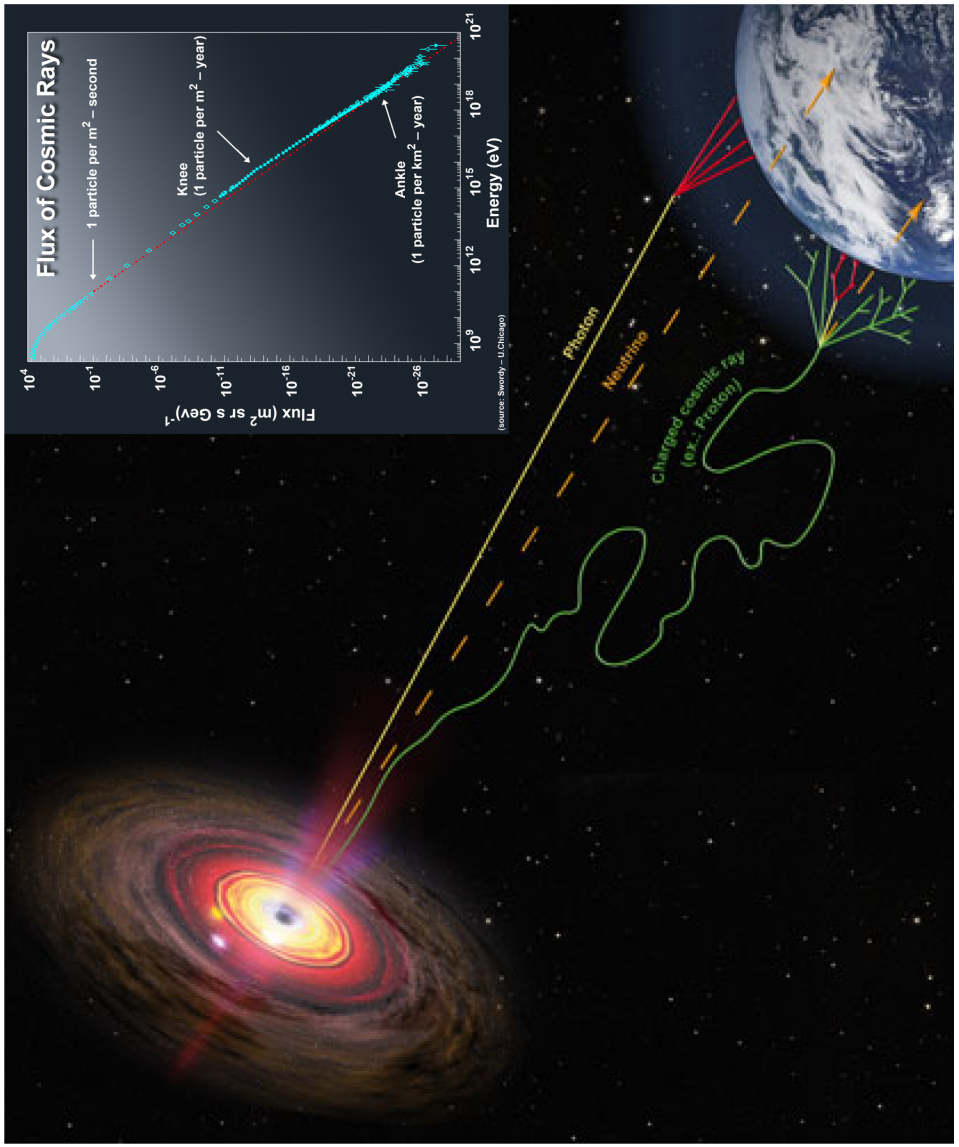



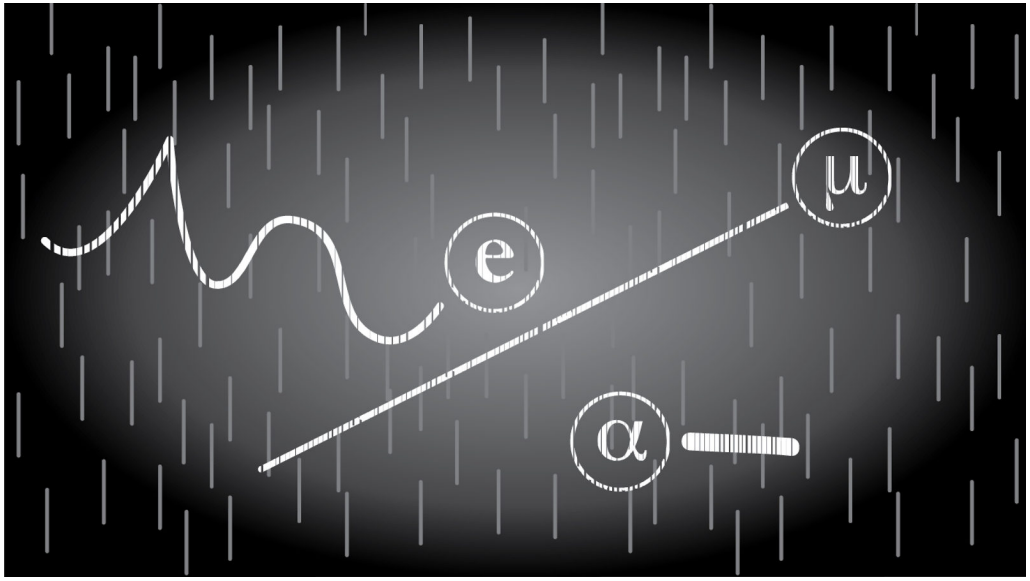



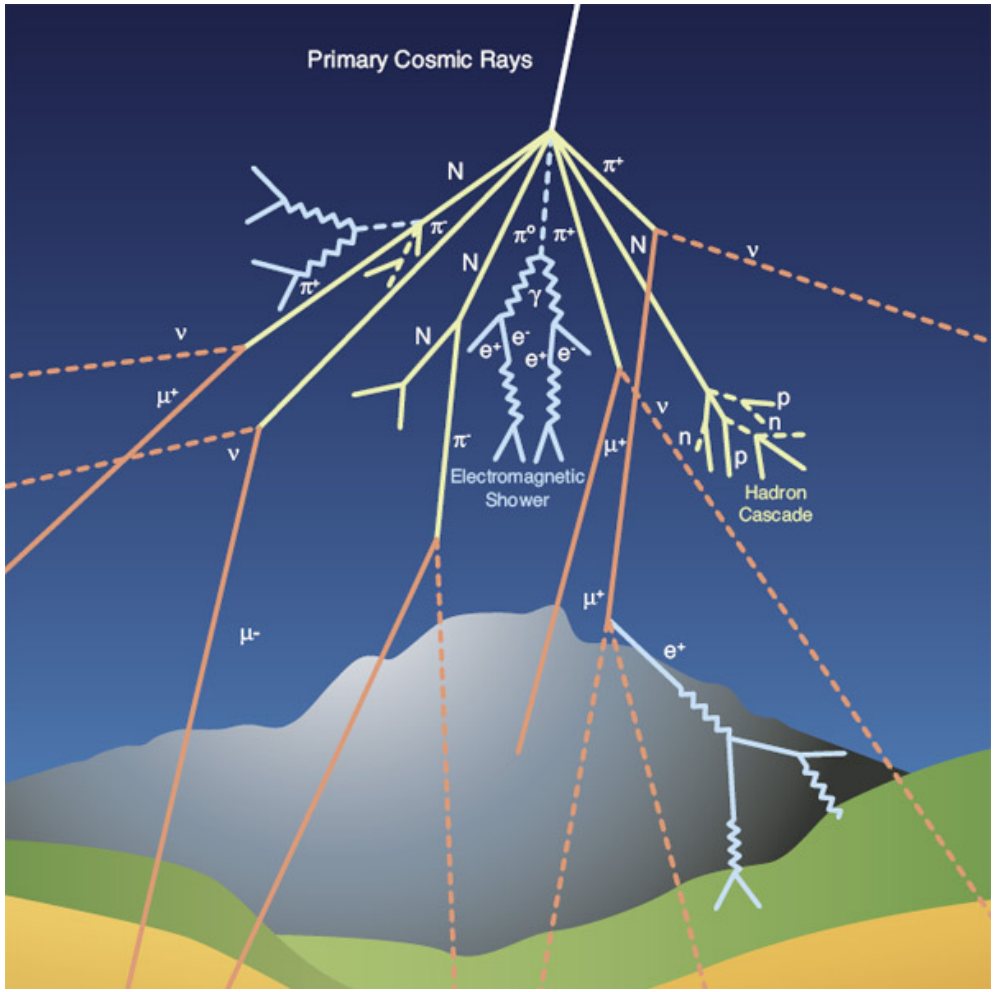

E=mc²

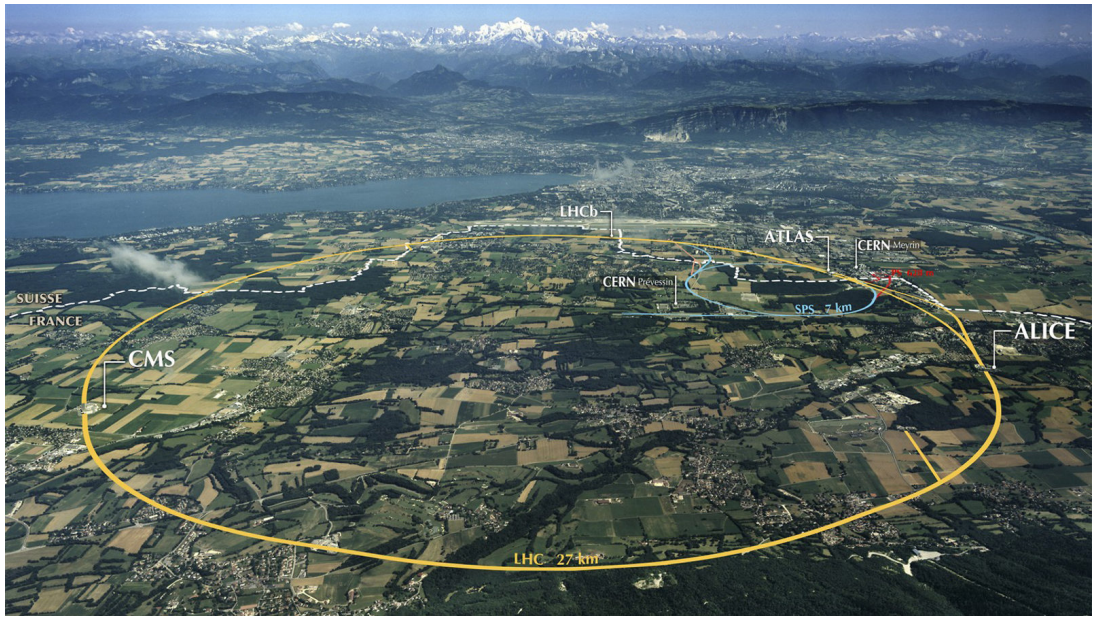

WHERE DO ELEMENTS COME FROM?
BIG BANG
LARGE STARS
SUPERNOVAE
COSMIC RAYS
SMALL STARS
MAN MADE

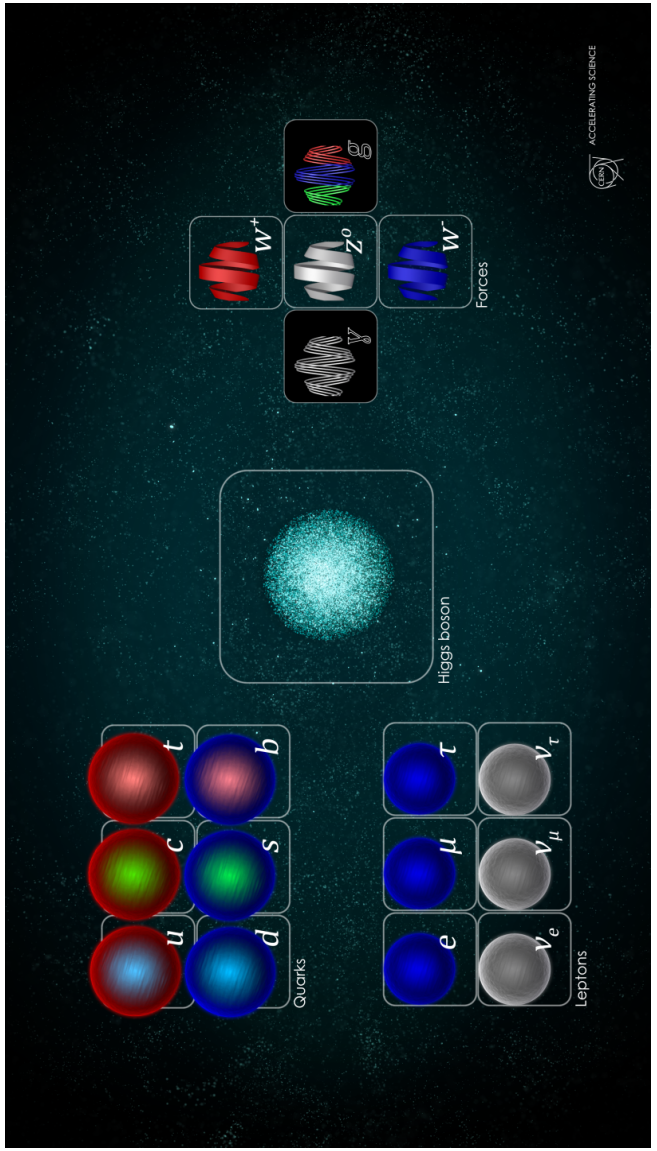


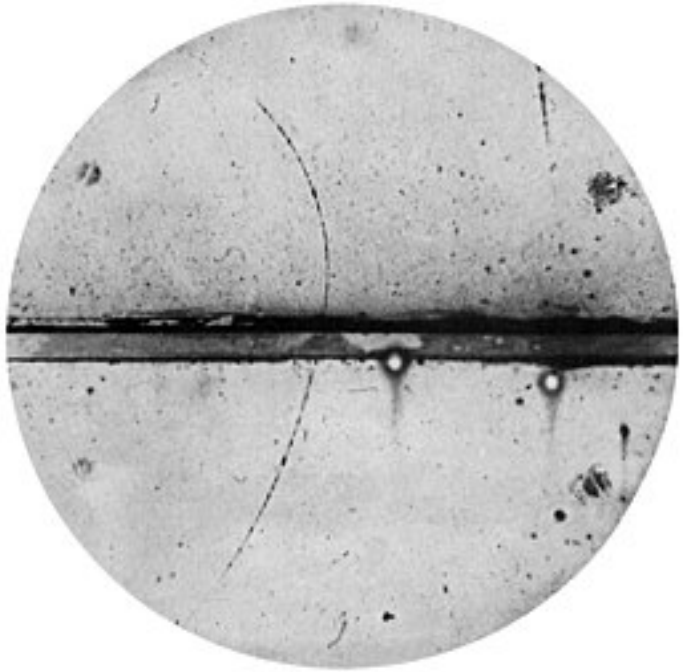

Flux of Cosmic Rays
1 particle per m² – second
Knee
(1 particle per m² – year)
Ankle
(1 particle per km² – year)
Energy (eV)
Flux (m² sr s Gev)⁻¹
(source: Swordy – U.Chicago)
Photon
Neutrino
Charged cosmic ray
(ex.: Proton)

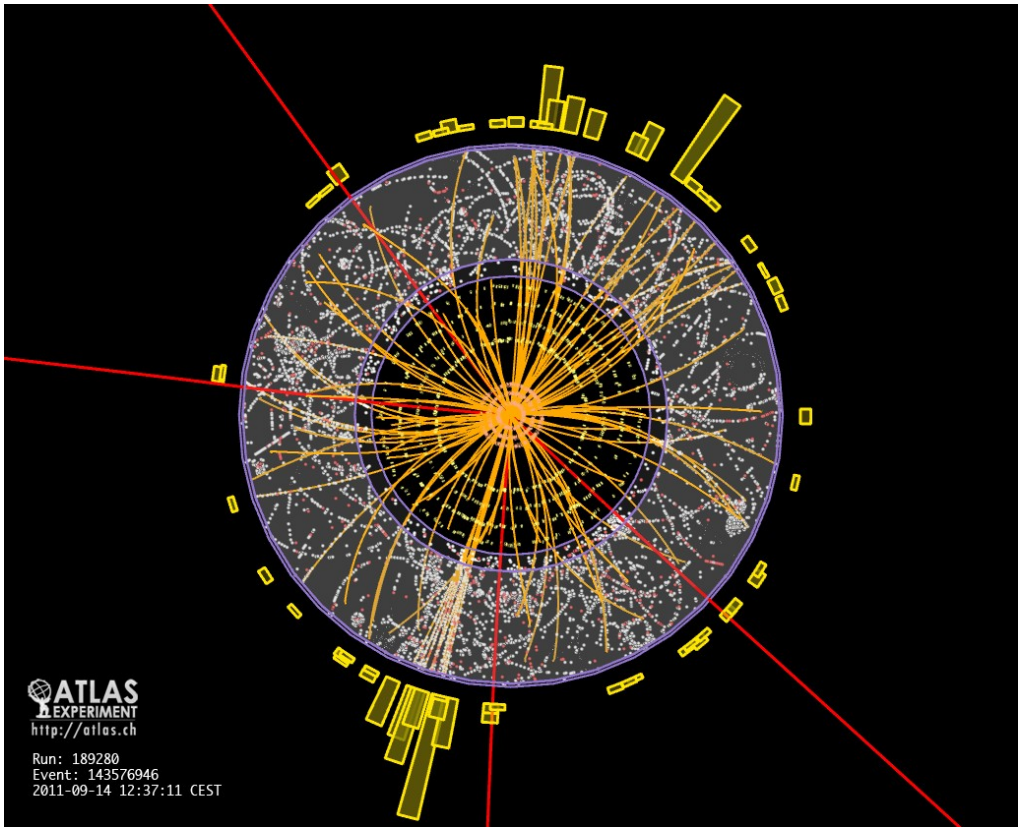

e
μ
α

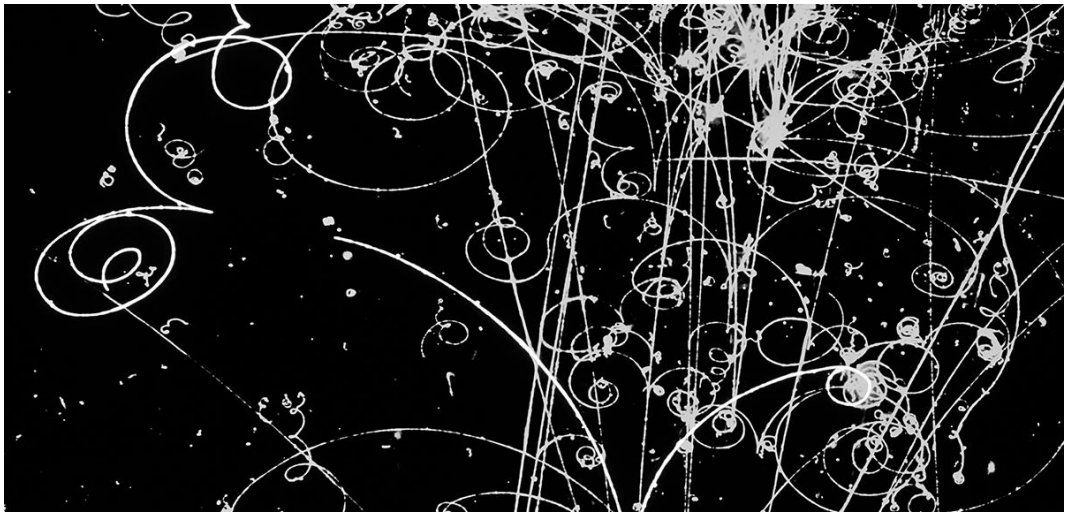

Primary Cosmic Rays
N
π+
π-
π+
π0
π+
N
N
N
γ
e+
e-
e+
e-
ν
ν
μ+
ν
μ+
π-
Electromagnetic
Shower
ν
n
p
n
p
Hadron
Cascade
μ+
μ-
e+


LHCb
ATLAS
CERN Meyrin
CERN Prévessin
SPS ~7 km
SUISSE
FRANCE
CMS
ALICE
LHC ~27 km


ACCELERATING SCIENCE
Quarks
Leptons
Higgs boson
Forces

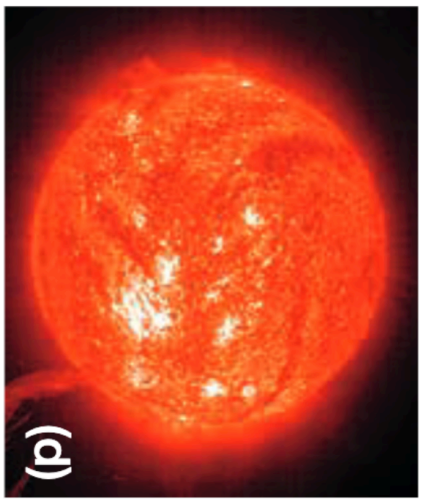




Détecter le passage d’une particule

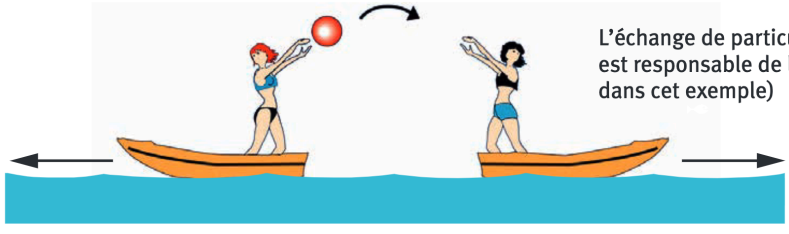






## Les forces fondamentales

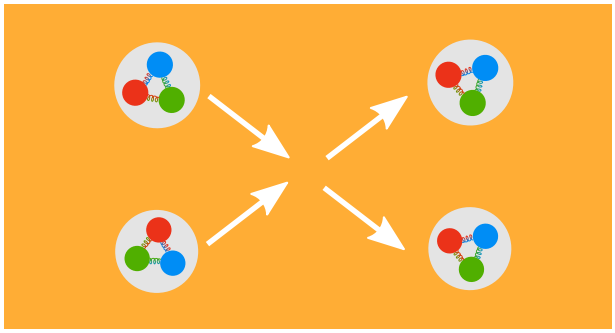
| *Type* | *Intensité relative* | *Particules médiatrices* | *Domine dans* |
|---|---|---|---|
| Force forte | ~ 1 | Gluons | noyau atomique |
| Force électromagnétique | ~ $10^{-3}$ | Photon | électrons entourant le noyau |
| Force faible | ~ $10^{-5}$ | Boson $Z^0$, $W^+$, $W^-$ | désintégration radioactive bêta |
| Gravitation | ~ $10^{-38}$ | Graviton ?<br>(pas encore observé) | astres |



L'échange de particules médiatrices est responsable de la force (répulsive dans cet exemple)

# proton - proton collisions

*collisions proton - proton*

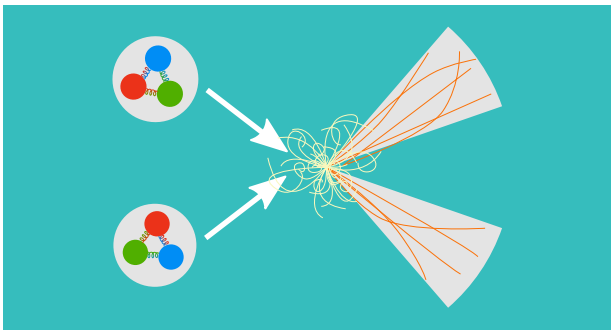


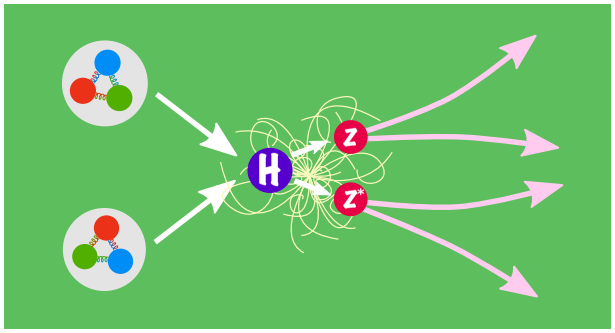
at **low** energies, protons will bounce off each other

*à **basses** énergies, les protons rebondissent l'un sur l'autre*

as the collision energy increases, the constituent quarks and gluons will start to interact **inelastically**

*lorsque l'énergie augmente, les quarks et gluons qui composent le proton interagissent de façon **inélastique***



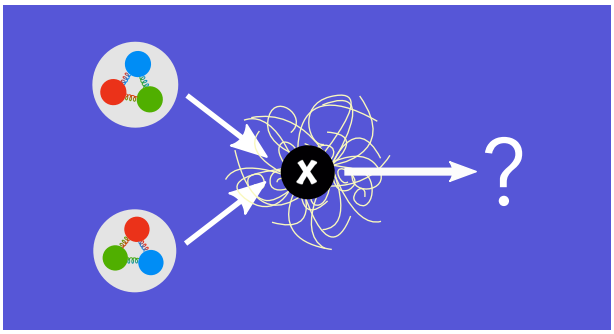



inelastic collisions will also sometimes create a **Higgs Boson**

*les collisions inélastiques créent parfois un **Boson de Higgs***

at the high energies in LHC collisions, it's possible that **heavy new particles** are created

*à haute énergie, il est possible de créer de **nouvelles particules***




**increasing energy** • *énergie qui augmente*

ATLAS EXPERIMENT

# PROTONS AT THE LHC
# *LES PROTONS DANS LE LHC*

## 1.

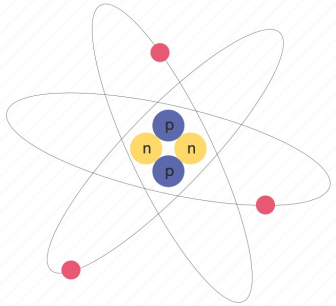
The LHC collides protons.

*Le LHC fait entrer des protons en collision.*

## 2.

Protons exist inside the atom along with neutrons. Electrons whizz around the outside.

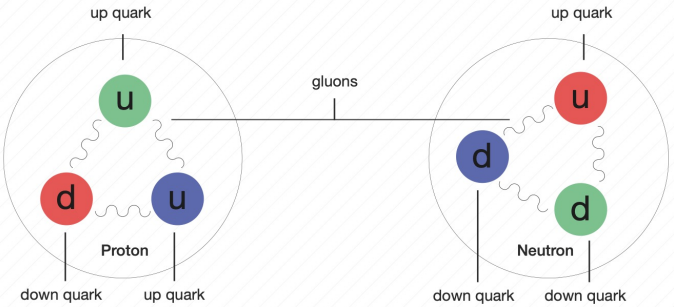
*Les protons forment l'intérieur des atomes, avec les neutrons. Autour d'eux tournoient des électrons.*




## 3.

Protons and neutrons are made of quarks and gluons. Quarks come in three colours (red, green, blue) and two types (up and down). Gluons bind the quarks together.

*Les protons et les neutrons sont composés de quarks et de gluons. Les quarks qui les composent sont de trois couleurs (rouge, vert et bleu) et de deux types (up et down). Les gluons lient les quarks entre eux.*




### 3a.

The proton has two up quarks and one down quark.

*Les protons contiennent deux quarks up et un quark down.*

### 3b.

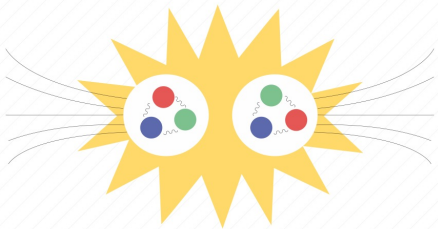
Neutrons have two down quarks and one up quark.

*Les neutrons contiennent deux quarks down et un quark up.*

## 4.

When protons hit each other at very high speeds, their mass gets turned into energy, and then back into mass in the form of new particles.

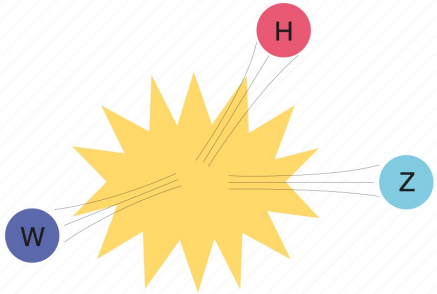
*Lorsque des protons entrent en collision à de très hautes vitesses, leur masse se transforme en énergie, puis se retransforme en masse sous la forme de nouvelles particules.*

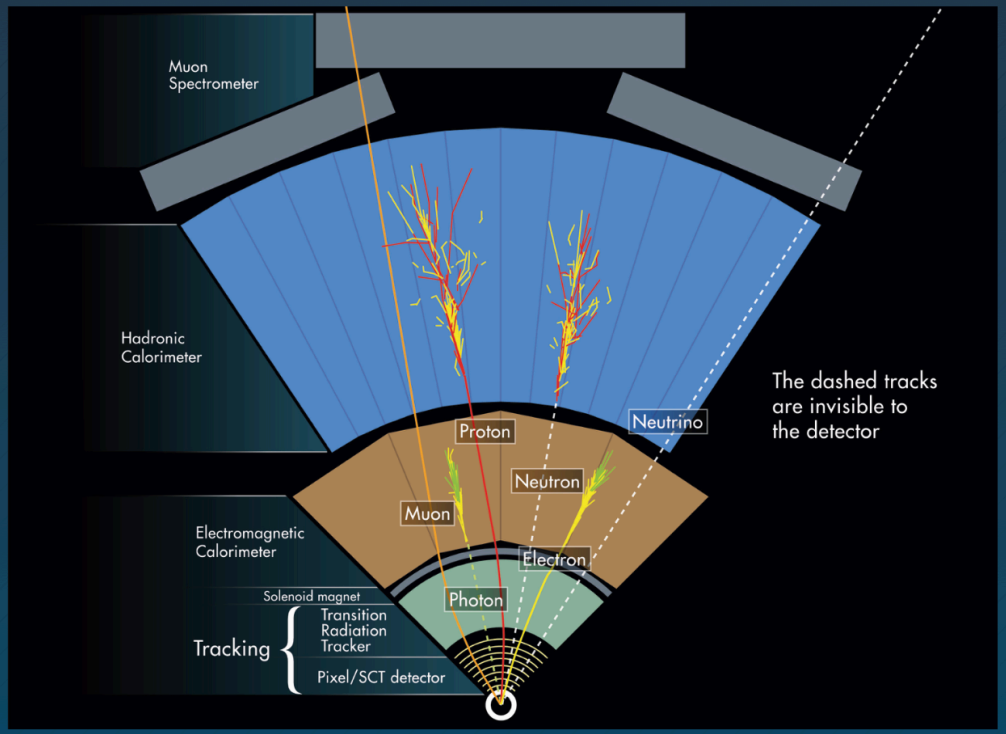


## 5.

Similar processes happened in the moments after the Big Bang.

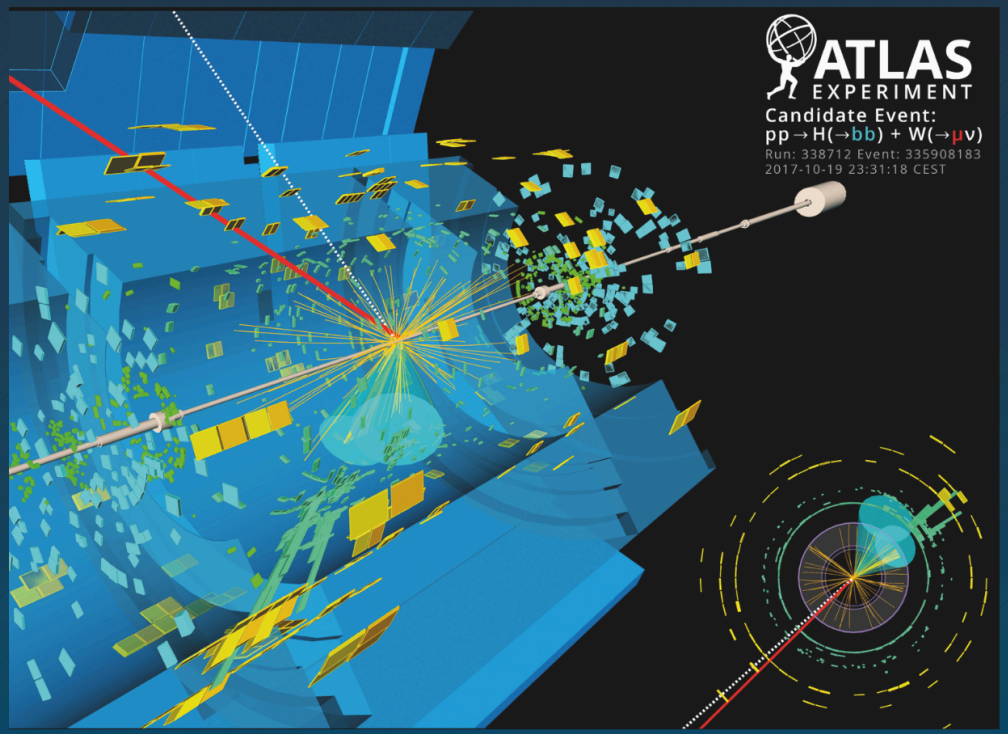
*Des phénomènes semblables se sont produits juste après le Big Bang.*






The ATLAS detector has many layers, with different types of detectors. Different particles leave behind different types of signatures in ATLAS as they travel through these layers.

*ATLAS est composé de plusieurs couches, formées de différents détecteurs. En traversant ces différentes couches, chaque particule laisse derrière elle des traces particulières.*




Electrons (blue) leave tracks in the inner detector, before reaching the calorimeter.
Muons (red) have tracks extending from the inner detector to the muon spectrometer. Muons may leave small energy deposits in the calorimeter.

*Les électrons (en bleu) sont visibles dans le détecteur interne, puis ils se désintègrent dans le calorimètre.*
*Les traces laissées par les muons (en rouge) s'étendent du détecteur interne jusqu'au spectromètre à muons. Les muons peuvent déposer une faible quantité d'énergie dans le calorimètre.*