

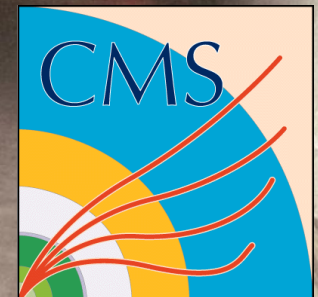
Fundamental research innovates Technology

"Discovering the origin of mass"

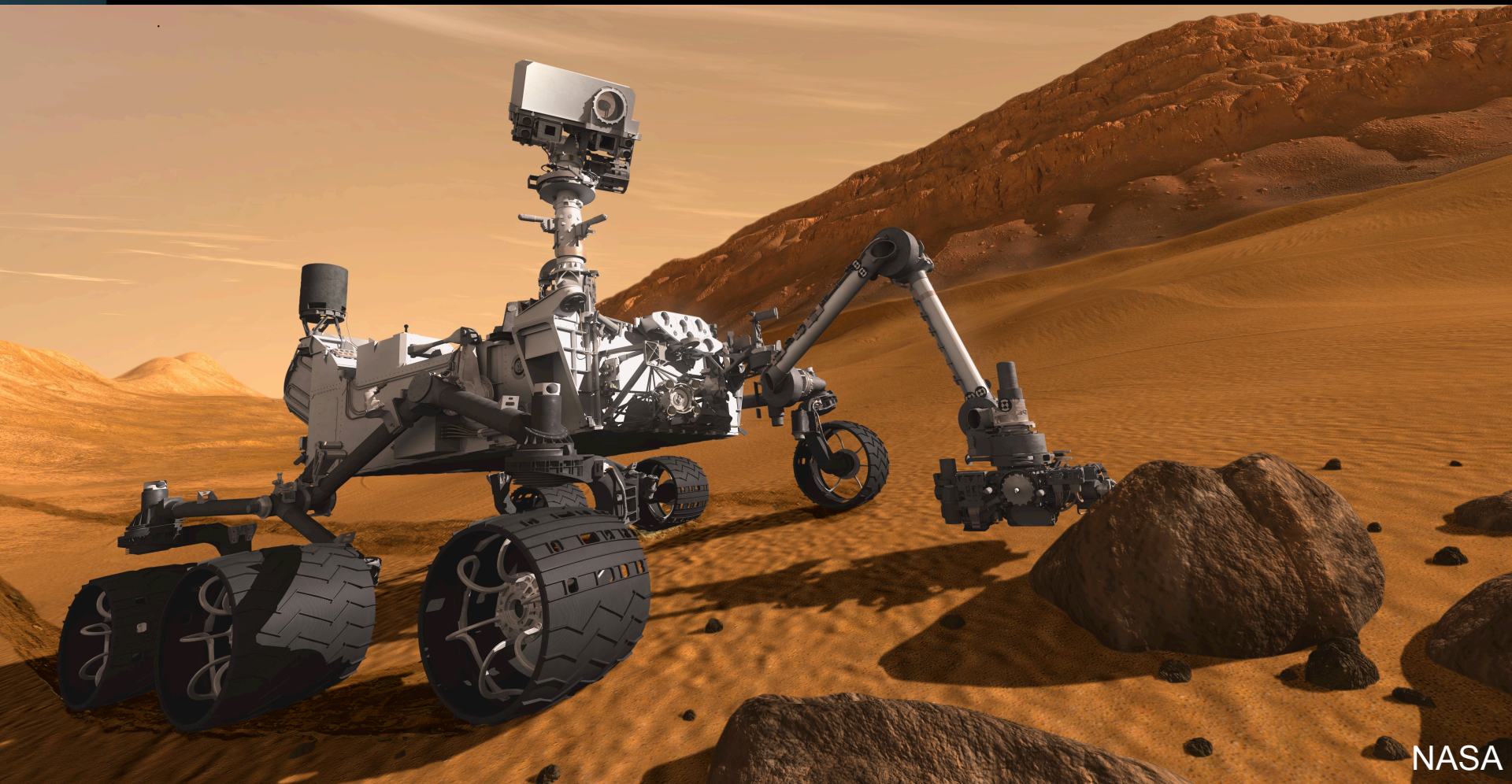
Jorgen D'Hondt



Vrije Universiteit Brussel



Curiosity driven science

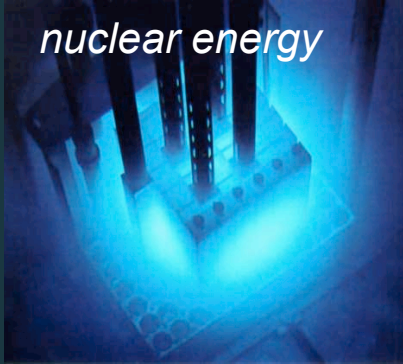


NASA

Early 20th century:

Quantum physics innovates technology

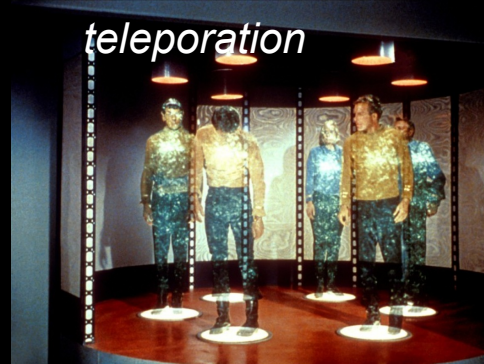
nuclear energy



NMR



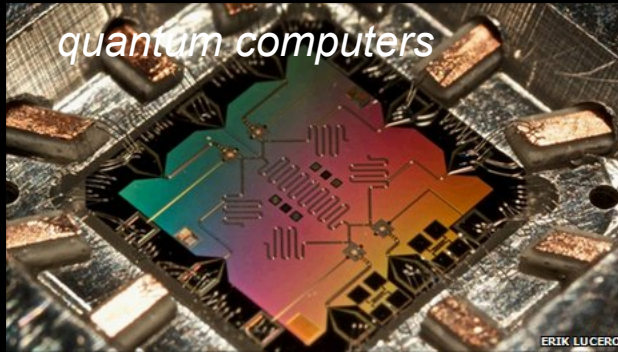
teleportation



instantaneous communication



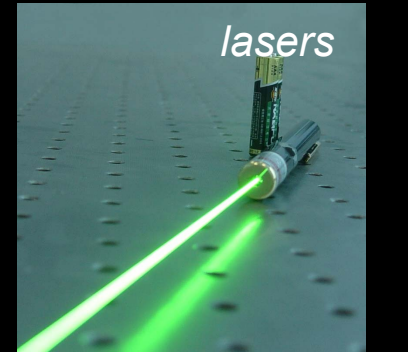
quantum computers



ultra-precise thermometers



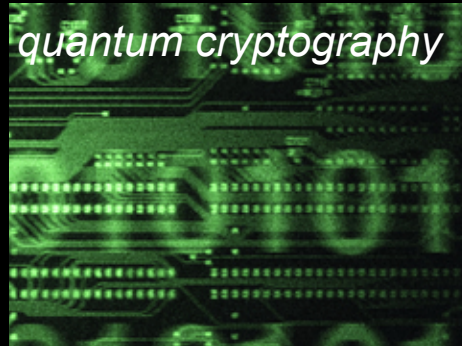
lasers



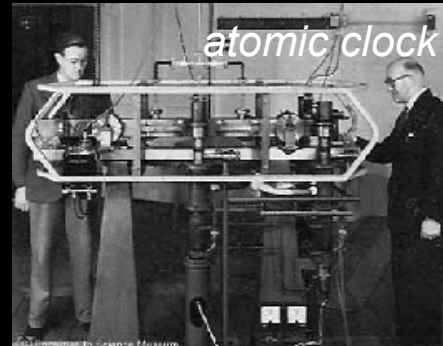
random generator



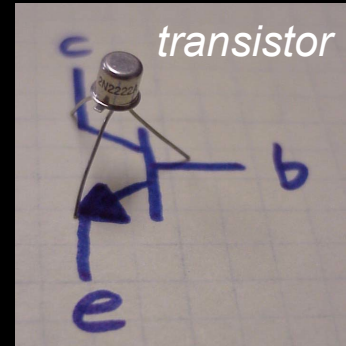
quantum cryptography



atomic clock



transistor



Early 20th century:

Quantum physics innovates technology

"Scientific curiosity which ends up in your pocket"

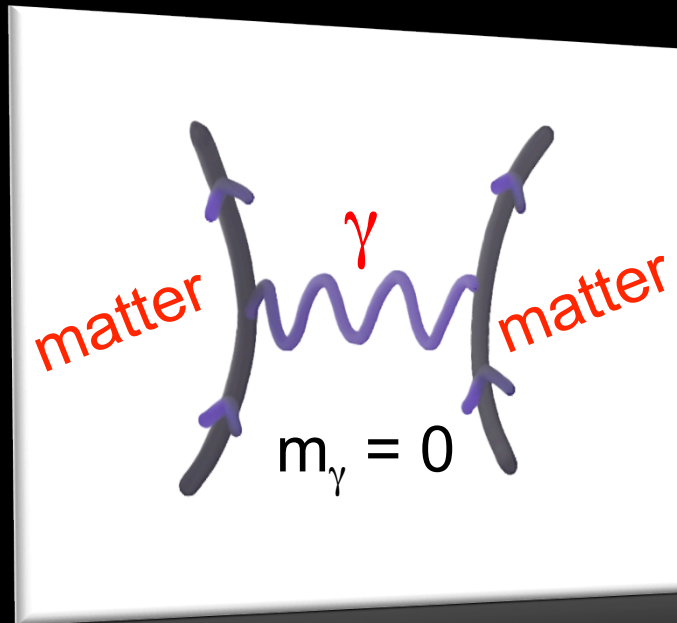
Rolf Heuer (Director General of CERN)

Today 30-40% of the Western economy at least touches concepts related to quantum physics, of which the fundamentals have been discovered less than 100 years ago.

Late 19th century:

Curiosity in Fundamental Interactions

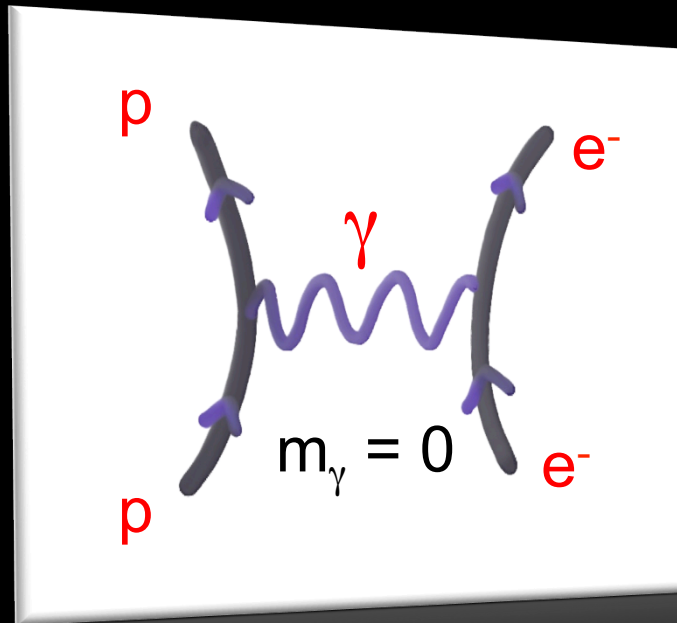
Electro-magnetic interactions
(light, electricity, ...)



Late 19th century:

Curiosity in Fundamental Interactions

Electro-magnetic interactions
(light, electricity, ...)

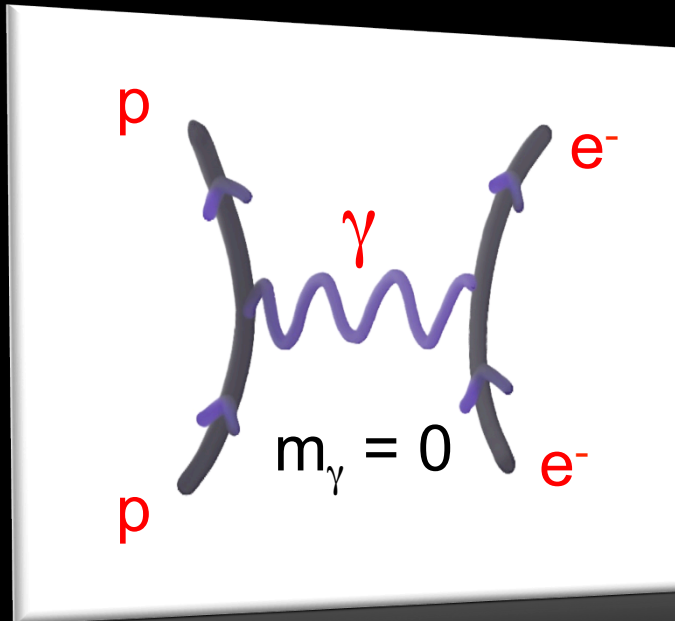


Force that keeps the electron
and proton bound in an atom.

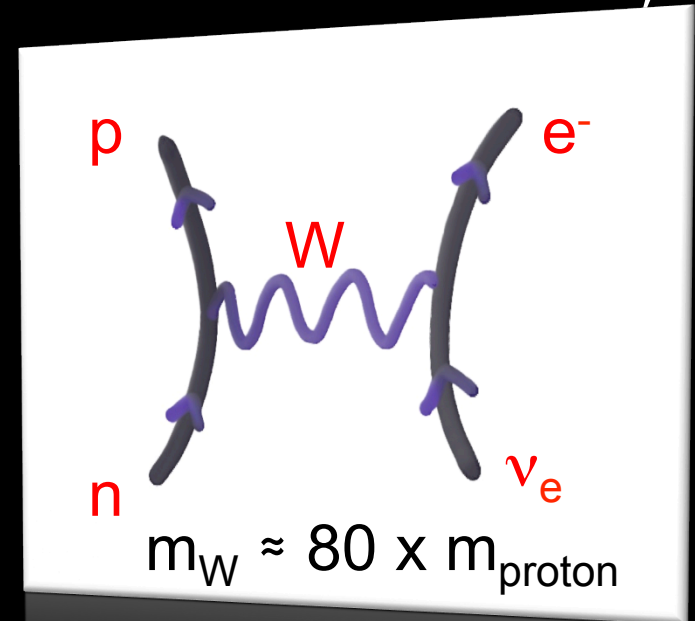
Late 19th century:

Curiosity in Fundamental Interactions

Electro-magnetic interactions
(light, electricity, ...)



Weak interactions
(radio-active decay,
nuclear fusion, ...)



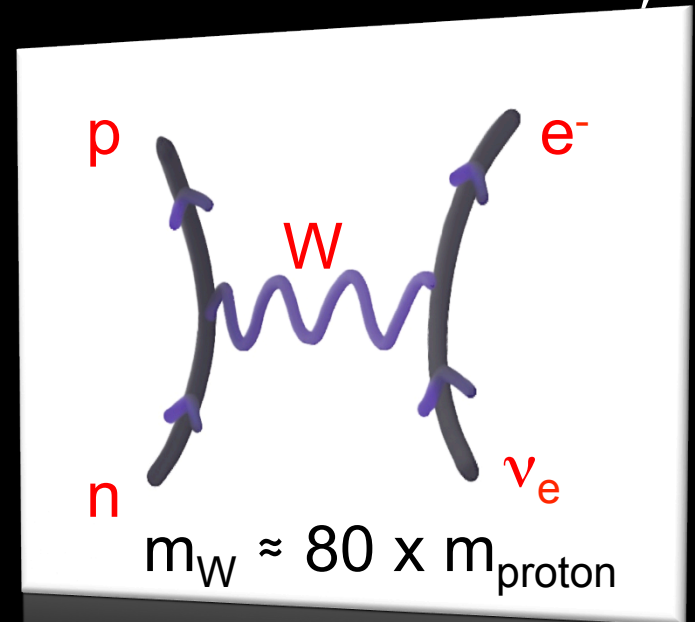
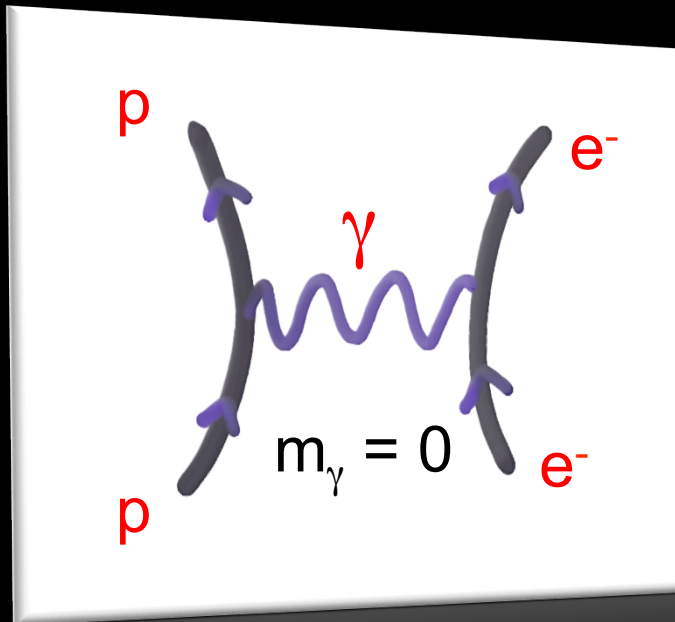
Very symmetric diagrams but also very much different behavior.

Late 19th century:

Curiosity in Fundamental Interactions

Electro-magnetic interactions
(light, electricity, ...)

Weak interactions
(radio-active decay,
nuclear fusion, ...)



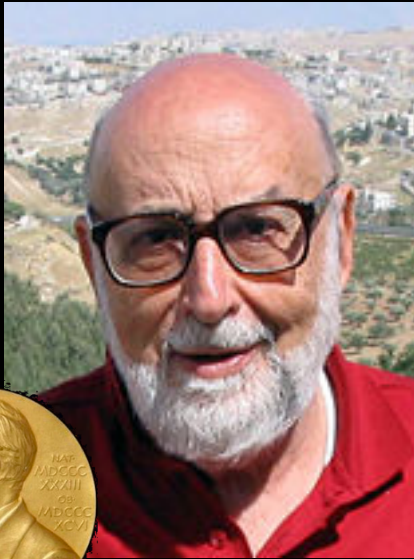
Same Electro-Weak interaction



Spontaneous symmetry breaking

Different behavior at low energies

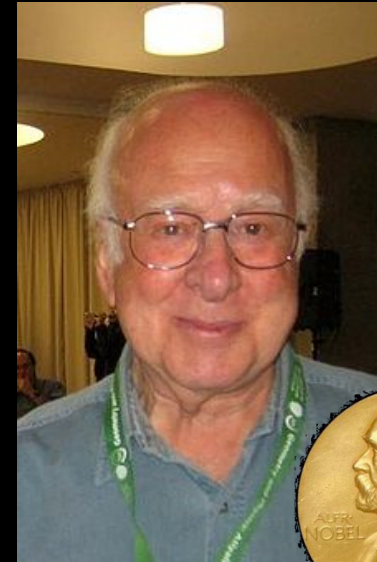
The Brout-Englert-Higgs mechanism (° 1964)



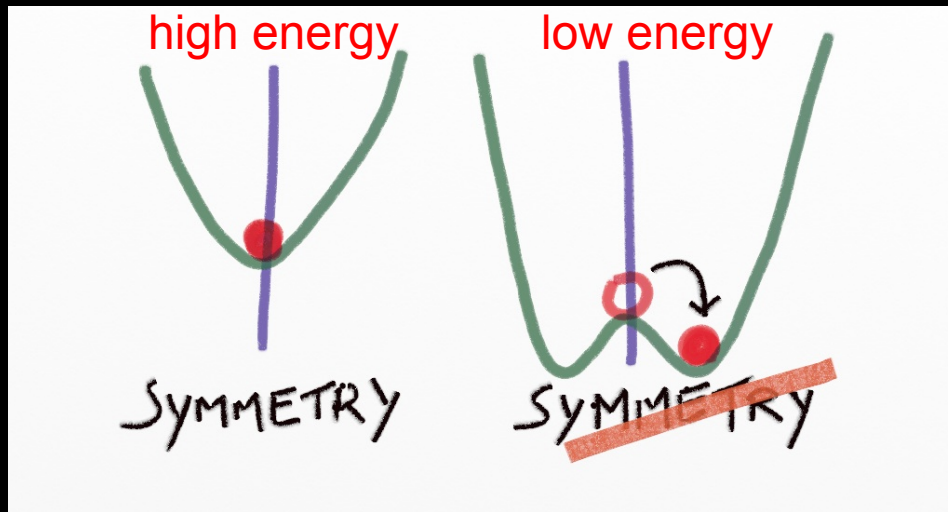
F. Englert



R. Brout (*deceased*)



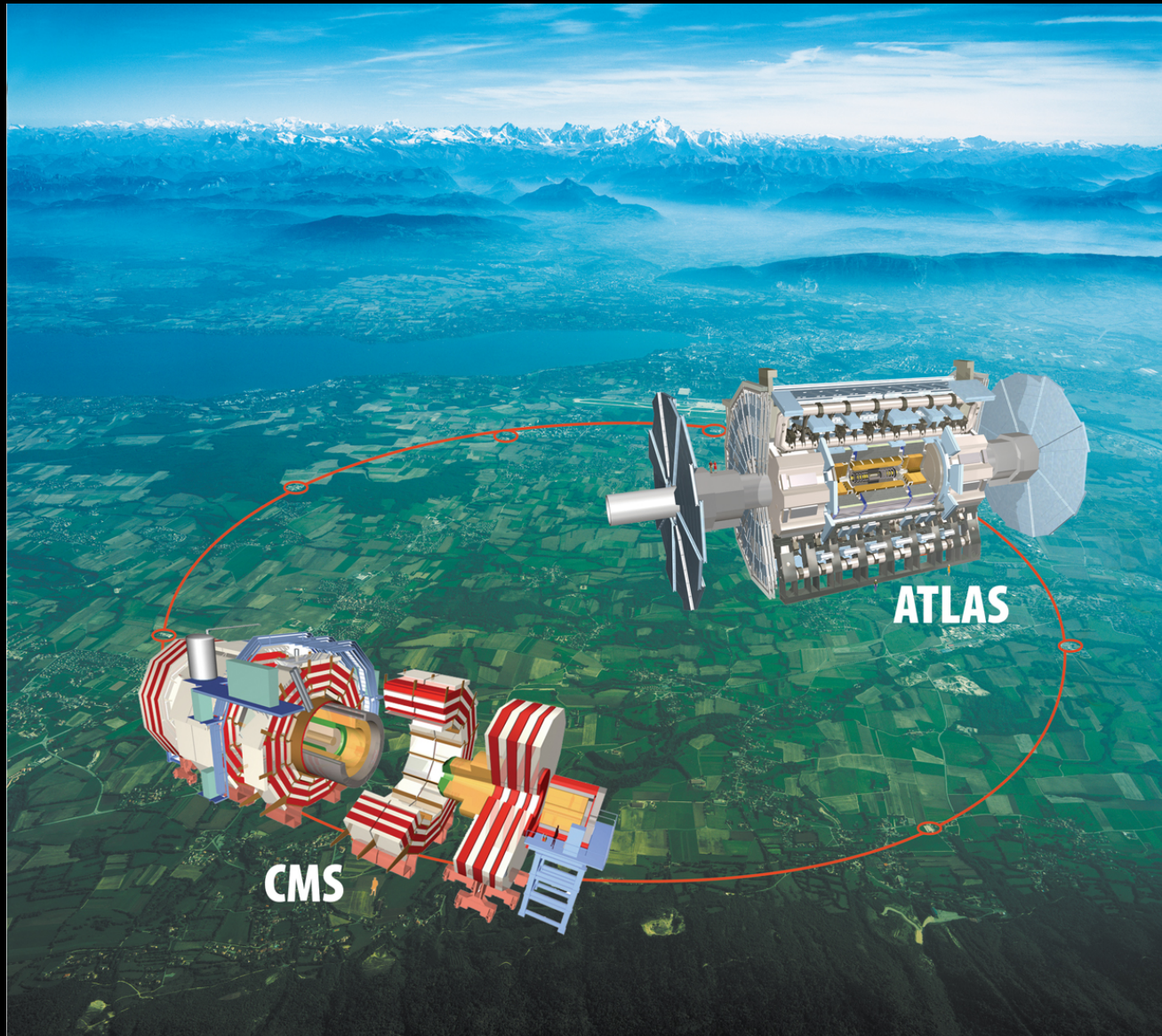
P. Higgs



The Higgs field breaks the symmetry spontaneously and generates masses for the W (and Z) particles, and predicts a new scalar particle, **the Higgs boson**.

Early 21th century:

CMS detects high-energy collisions



“Breakthrough of the Year 2012”, *Science Magazine*



July 4th, 2012

CERN: where researchers are trained



Today about 850 doctoral students and about 700 undergraduate students are trained in the CMS

CERN: where researchers are trained

Instrumentation

System Engineering
R&D and Prototyping
Assembly and Operation

Electronics

Data Acquisition
Detector Front-End
R&D and Board Design

Software

Numerical Techniques
Algorithm Development
Distributed Computing

Data Analysis

Statistical Interpretation
Development of Methods
Data Mining

Management

Supervision & Training
Strategic Planning
Crisis Management

Communication

Teaching
Oral & Written
Defending Case

Particle Physics

In-depth knowledge
Quantum Physics
Theoretical Calculations

Collaboration

International
Peer review system
Constructive Competition

General

Problem Solving
Flexibility
Strong Motivation

**a snap-shot of the diversity of
skills of an experimental Particle Physicist**

CERN: where fundamental research innovates technology

- Accelerators: 30.000 around the world produce, sterilize or examine for 400 B euro/year of goods (isotopes, ion implants in transistors, cure carbon composites, treat nuclear waste and wastewater, models of protein for pharmaceutical industry, ...)
- Nuclear medicine: a growing 10 B euro/year market (PET scanners, proton therapy for cancer, ...)
- World Wide Web: stimulates 1500 B euro/year of commercial traffic
- Energy: more efficient solar panels, ...
- Power transmission: progress in superconducting wires, ...
- And what if soon we bring accelerators and nuclear reactors together... the 4th generation of nuclear reactors

All for only 1 B euro/year investment in particle physics.

Fundamental Research innovates Technology



... prepare your future !