

Unraveling the Mysteries of the Universe with the Large Hadron Collider

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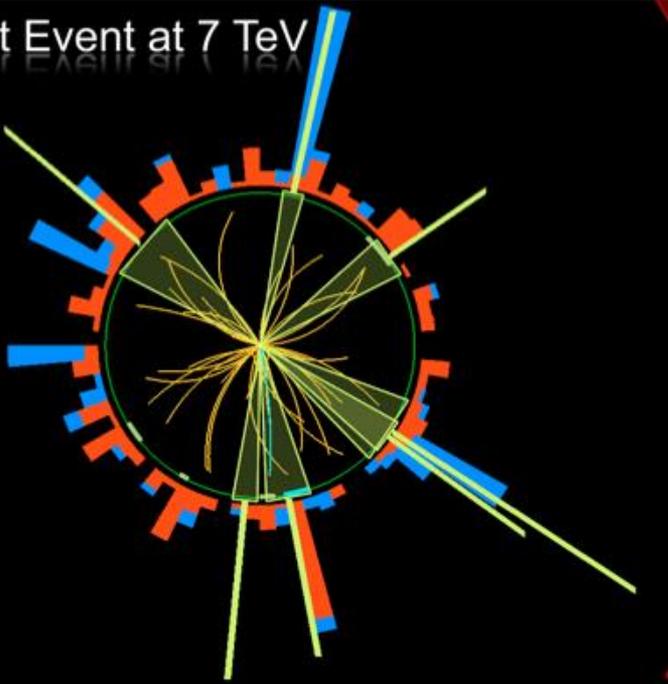
23 July 2025

**NEUTRINO
PHYSICS**

July 21 - 25, 2025,
ICISE Quy Nhon, Vietnam

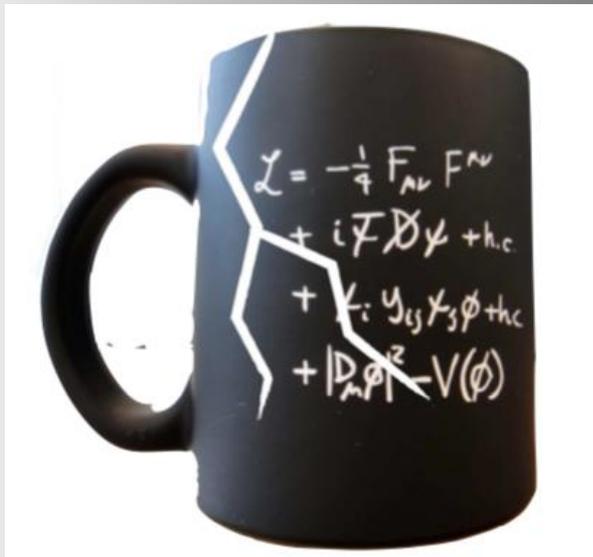


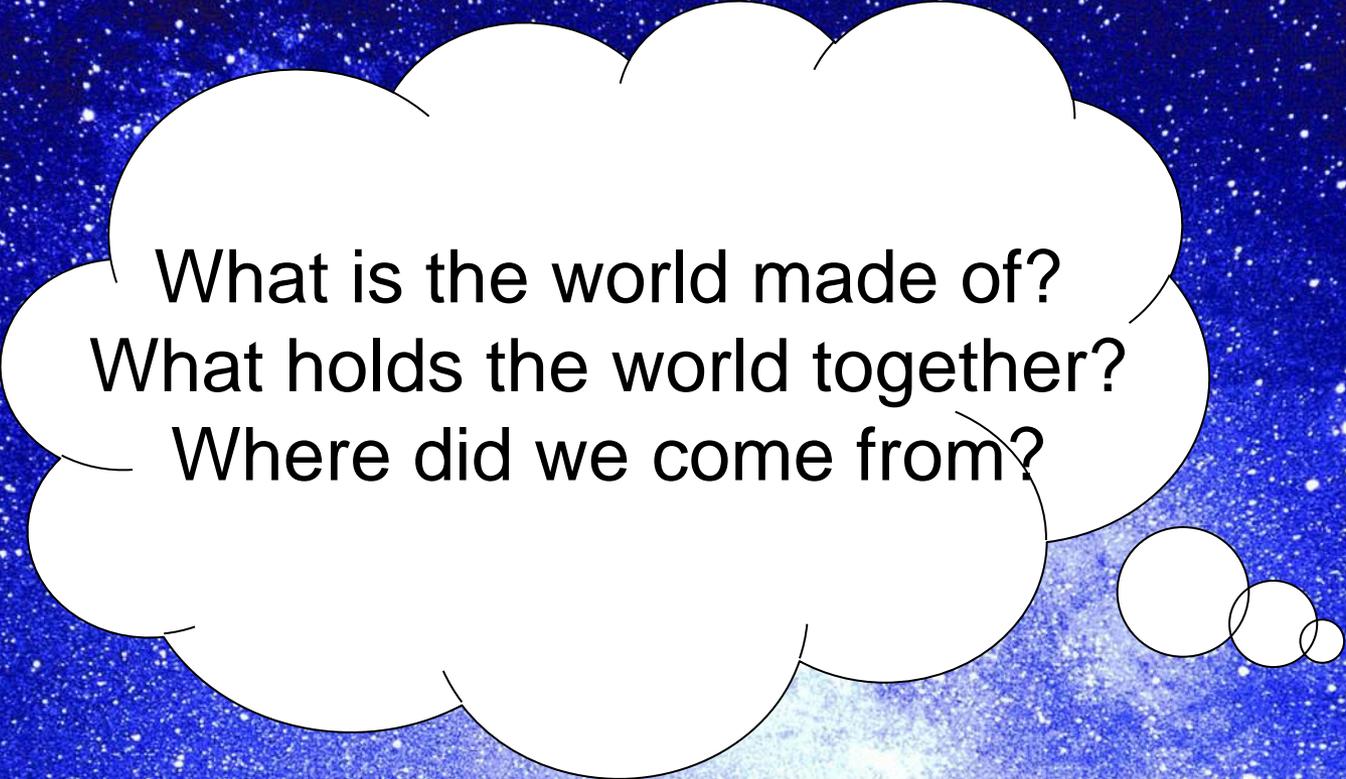
Multi Jet Event at 7 TeV



Outline

- Introduction - Physics at accelerators:
- **The LHC and experiments**
- Example of the Higgs Boson
- Searches for New Physics
 - Dark Matter?
 - Supersymmetry?
 - Matter Substructure?
 - Exotica?
- Next ideas for Colliders
- Neutrinos at the LHC!
- Outlook



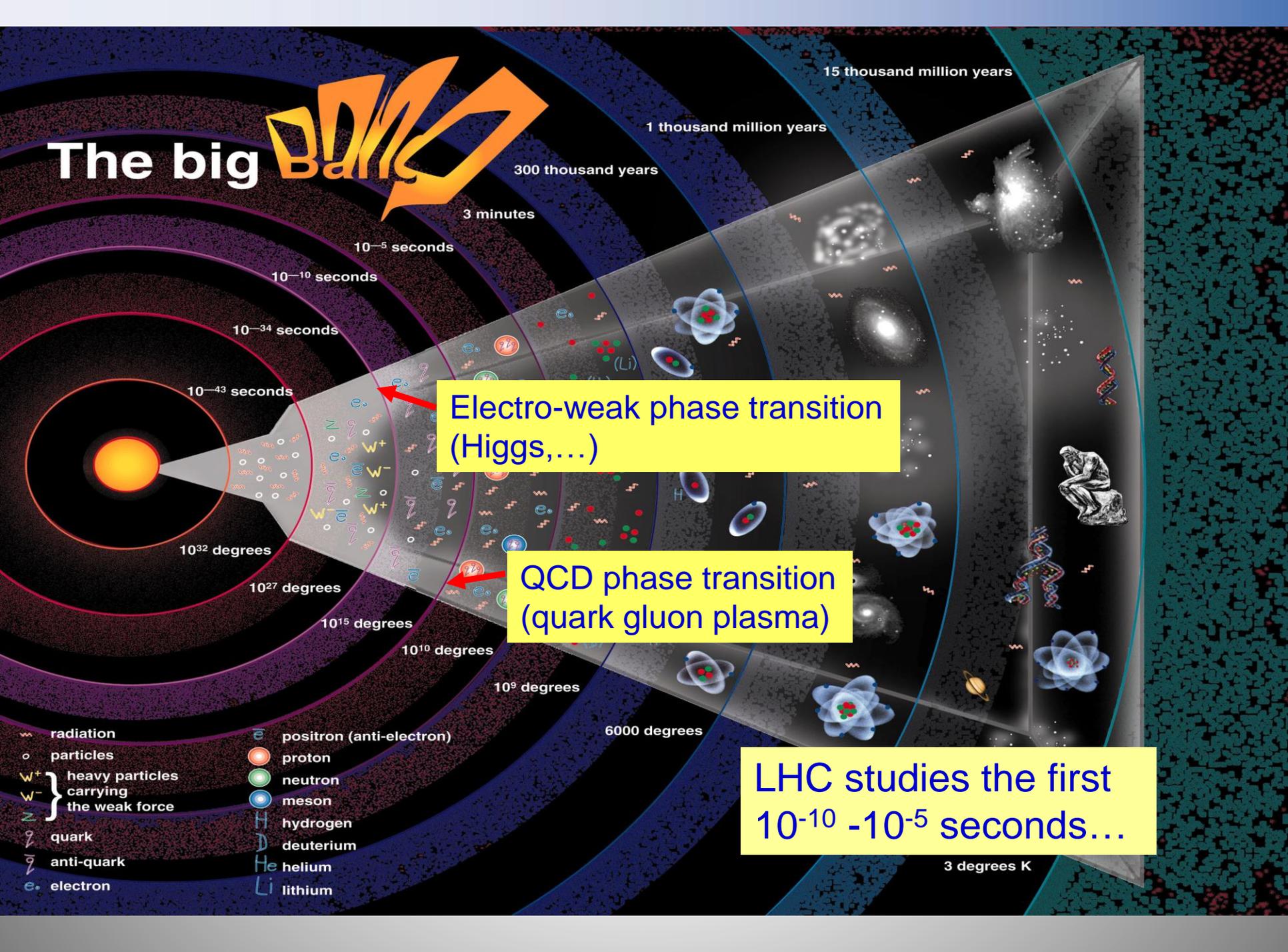


What is the world made of?
What holds the world together?
Where did we come from?



CERN is the largest research laboratory that provides the tools for conducting these studies: Particle Accelerators

The big Bang



- radiation
- particles
- W^+ } heavy particles carrying the weak force
- W^- }
- q quark
- \bar{q} anti-quark
- e^- electron
- e^+ positron (anti-electron)
- proton
- neutron
- meson
- H hydrogen
- D deuterium
- He helium
- Li lithium

LHC studies the first 10⁻¹⁰ - 10⁻⁵ seconds...

3 degrees K

CERN: founded in 1954: 12 European States

“Science for Peace”

Today: 25 Member States

Employees: ~2700 staff, 800 fellows

Associates: ~12600 users, 1800 others

Budget (2021) ~ 1200 MCHF

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

Associate Members in the Pre-Stage to Membership: Cyprus

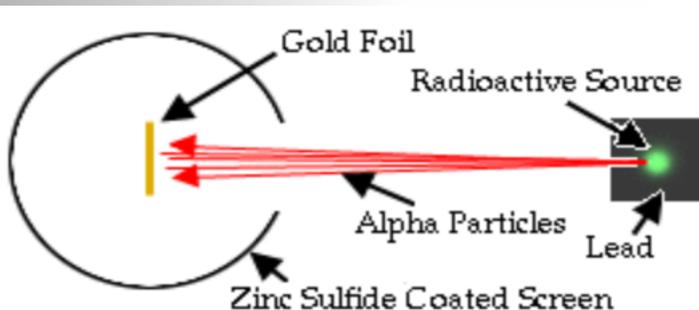
Associate Member States: Brazil, Croatia India, Latvia, Lithuania, Pakistan, Turkey, Ukraine

Observers to Council: Japan, Russia, United States of America; European Union, JINR and UNESCO

High Energy Physics Experiments

First High Energy Physics Experiments:

Beam on fixed target!

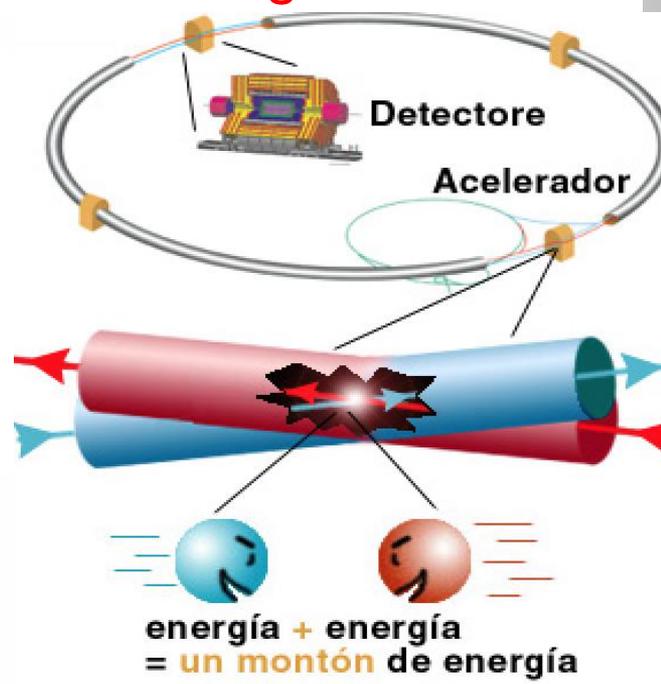


Rutherford experiment (1909)

Centre of mass energy squared $s=2E_1m_2$

High Energy Physics Experiments since mid 70's:

Colliding beams!



Centre of mass energy squared $s=4E_1E_2$

Detectors techniques have followed these developments

Accelerators are Powerful Microscopes

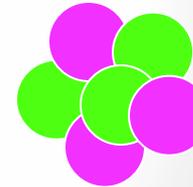
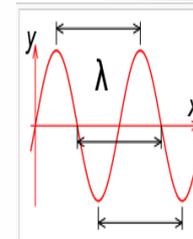
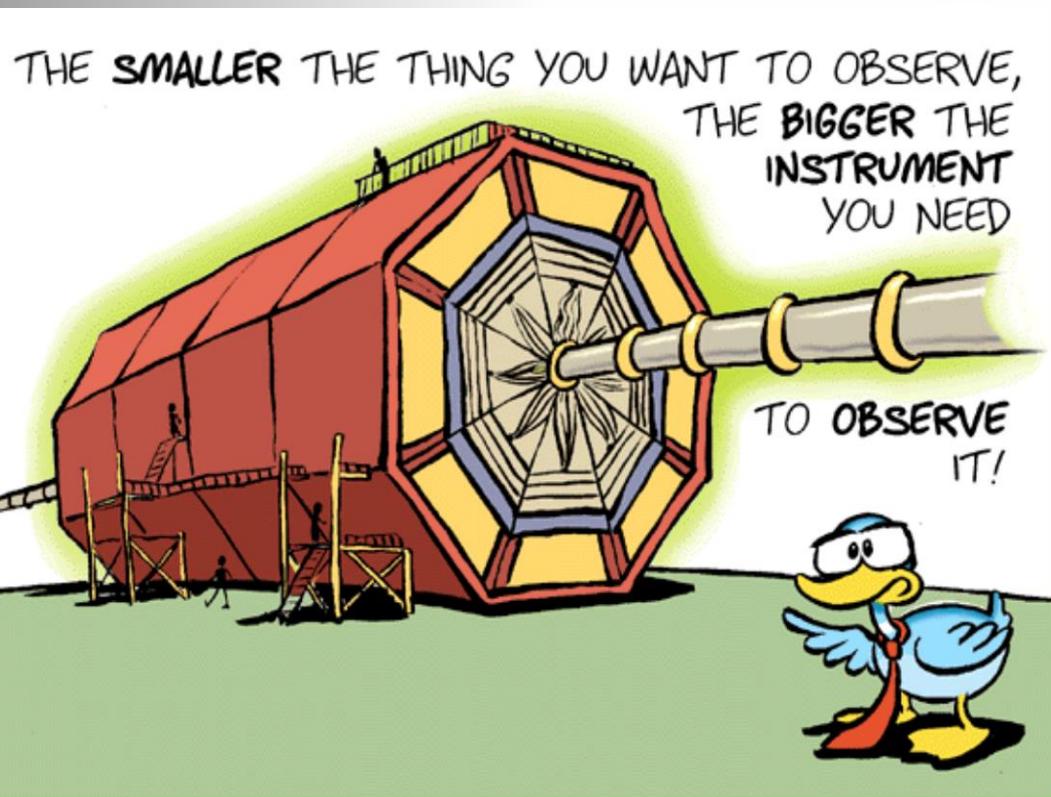
They make high energy particle beams that allow us to see small things.

$$\lambda = \frac{h}{p}$$

wavelength

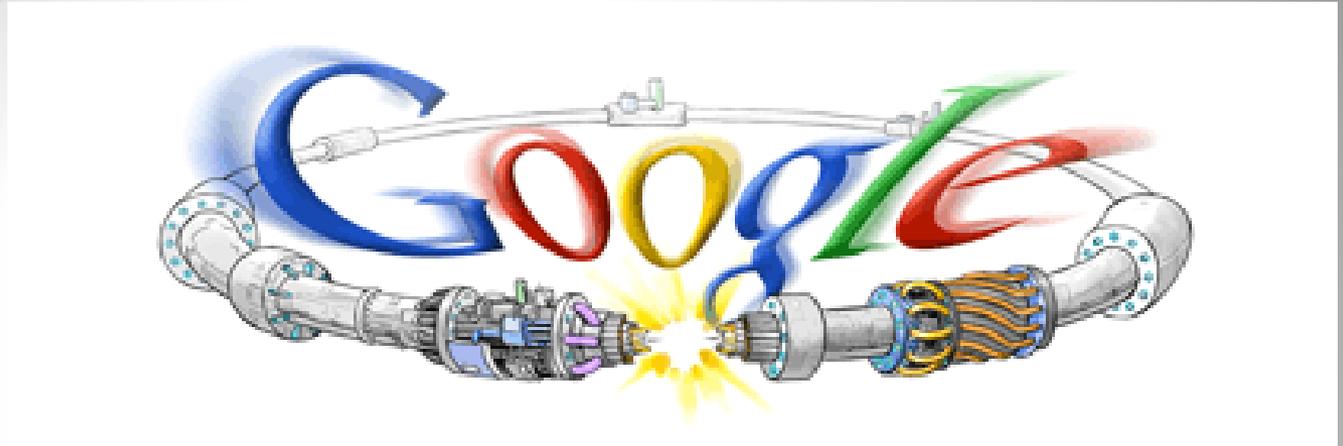
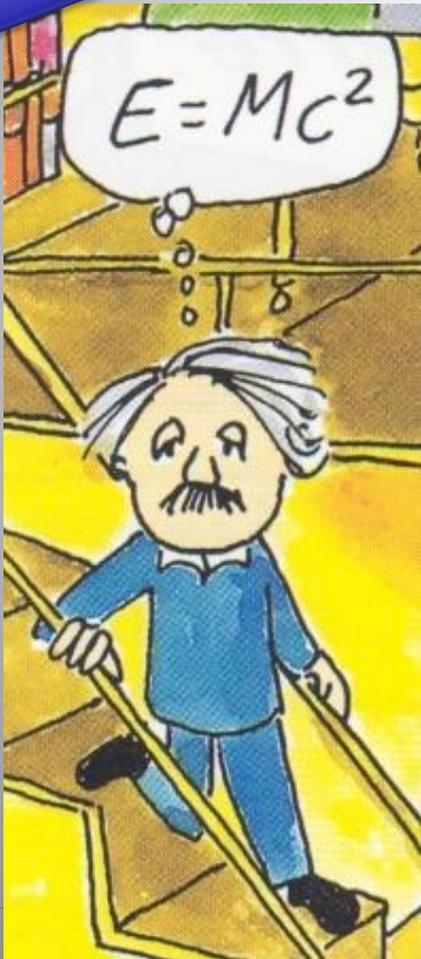
Planck constant

momentum
~ energy



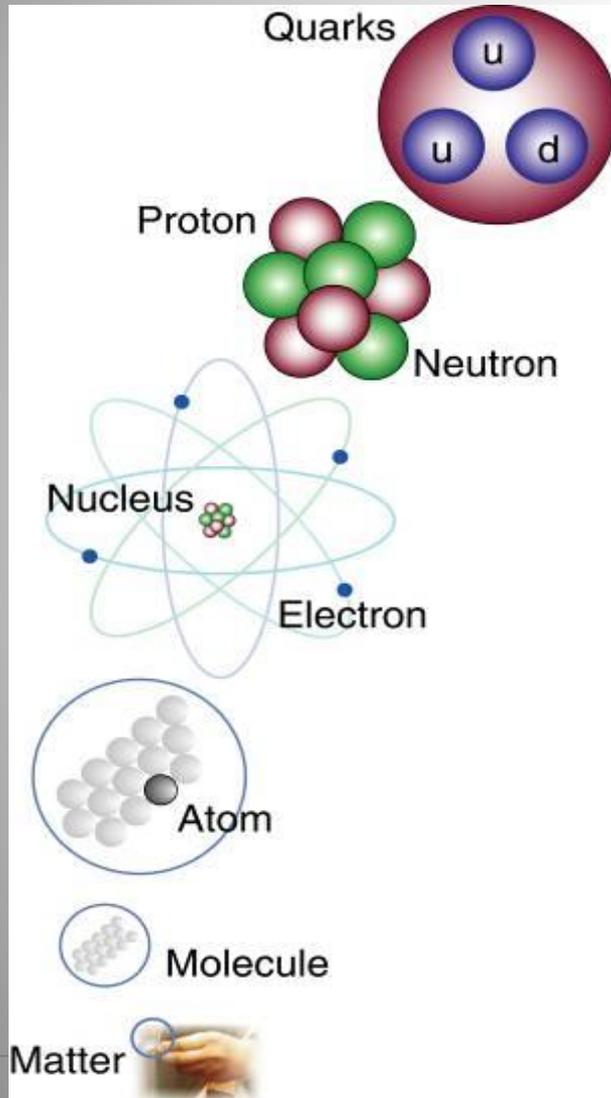
seen by **high energy**
beam of particles
(better resolution)

We can create particles
from energy



- Two beams of protons collide and generate, in a very tiny space, temperatures over a billion times higher than those prevailing at the center of the Sun.
- Produce particles that may have existed at the beginning of the Universe, right after the Big Bang

Particle Physics: The Standard Model



matter particles

	1st gen.	2nd gen.	3rd gen.
Q U A R K	<i>u</i> <i>up</i>	<i>c</i> <i>charm</i>	<i>t</i> <i>top</i>
	<i>d</i> <i>down</i>	<i>s</i> <i>strange</i>	<i>b</i> <i>bottom</i>
L E P T O N	<i>ν_e</i> <i>e neutrino</i>	<i>ν_μ</i> <i>μ neutrino</i>	<i>ν_τ</i> <i>τ neutrino</i>
	<i>e</i> <i>electron</i>	<i>μ</i> <i>muon</i>	<i>τ</i> <i>tau</i>

gauge particles

Strong Force	<i>g</i> <i>Gluon</i> x8
Electro-Magnetic Force	<i>γ</i> <i>photon</i>
Weak Force	<i>W⁺</i> <i>W⁻</i> <i>Z</i> <i>W bosons</i> <i>Z boson</i>

scalar particle(s)



Elements of the Standard Model

Until 2011 no single fundamental scalar had been observed yet! Do they exist in Nature?

The Standard Model is however not expected to be the final solution → Search for BSM signals!

The Hunt for the Higgs

Where do the masses of elementary particles come from?

The key question (pre-2012):
Does the Higgs particle exist?

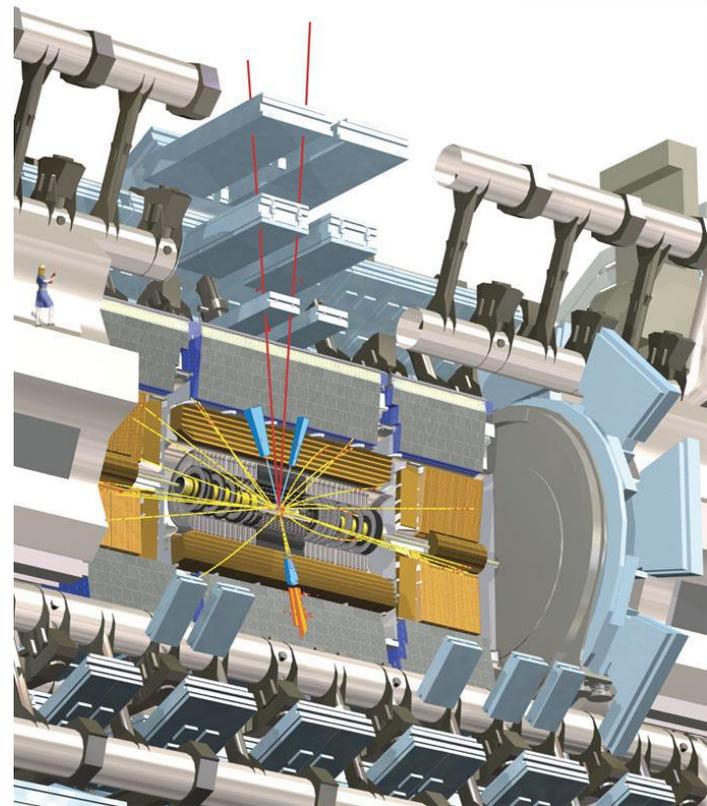
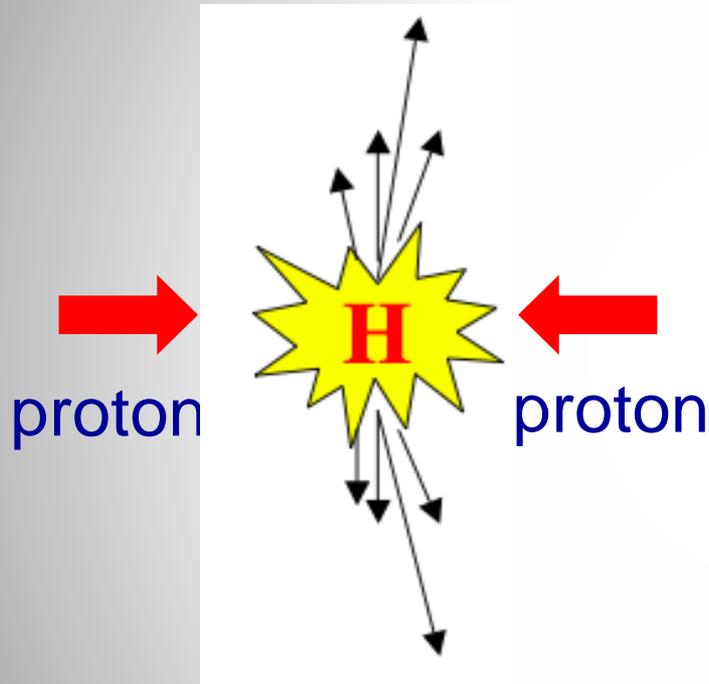
Massless particles move at the speed of light \rightarrow no atom formation!!

We do not know the mass of the Higgs Boson!!
Proton mass: 1 GeV



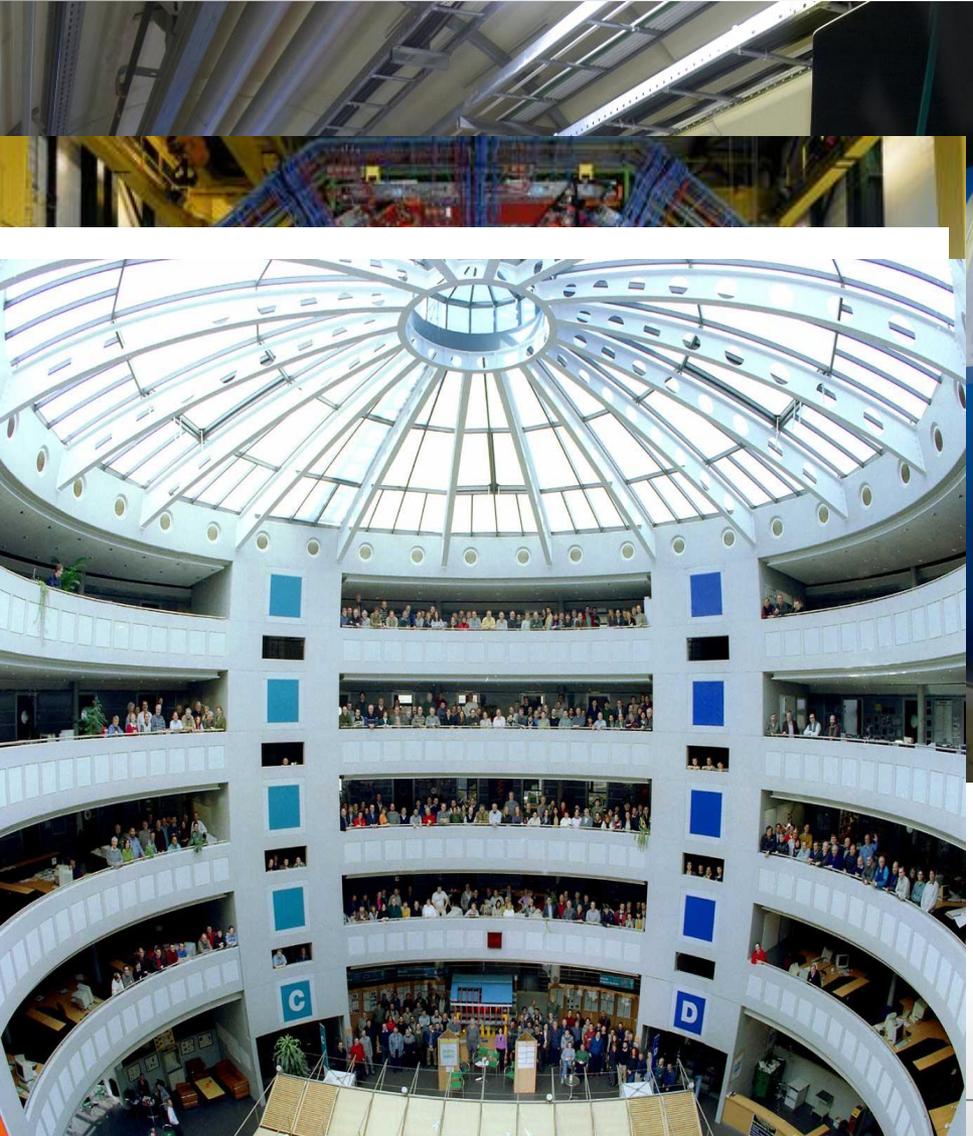
The Higgs Particle

Technique: Produce and detect **Higgs** Particles at Particle Colliders



The Higgs particle is the last missing particle in the Standard Model

This Search Requires.....



1. Accelerators : powerful machines that accelerate particles to extremely high energies and bring them into collision with other particles

2. Detectors : gigantic instruments that record the resulting particles as they “stream” out from the point of collision.

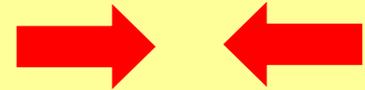
3. Computing : to collect, store, distribute and analyse the vast amount of data produced by these detectors

4. Collaborative Science on Worldwide scale : thousands of scientists, engineers, technicians and support staff to design, build and operate these complex “machines”.

The Large Hadron Collider = a proton proton collider

Also a heavy ion collider

7 TeV + 7 TeV
6.5 TeV + 6.5 TeV

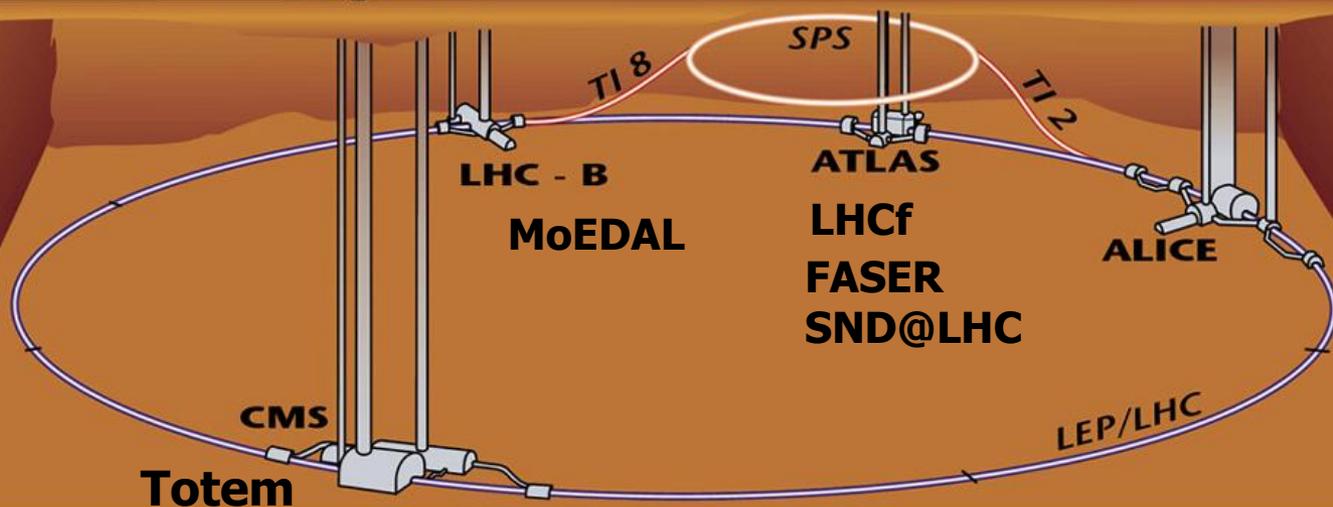
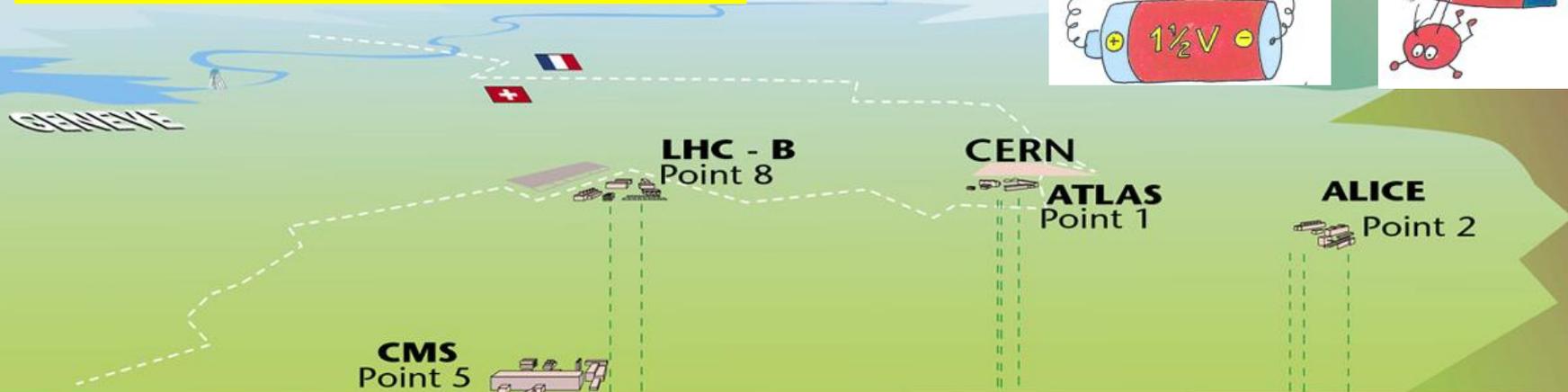
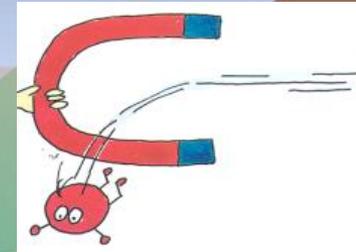
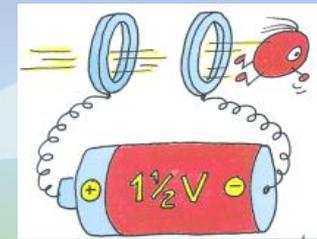


1 TeV = 1 Tera electron volt
= 10^{12} electron volt

The LHC is a Discovery Machine

The Large Hadron Collider and Experiments

27 km long, 100 m underground

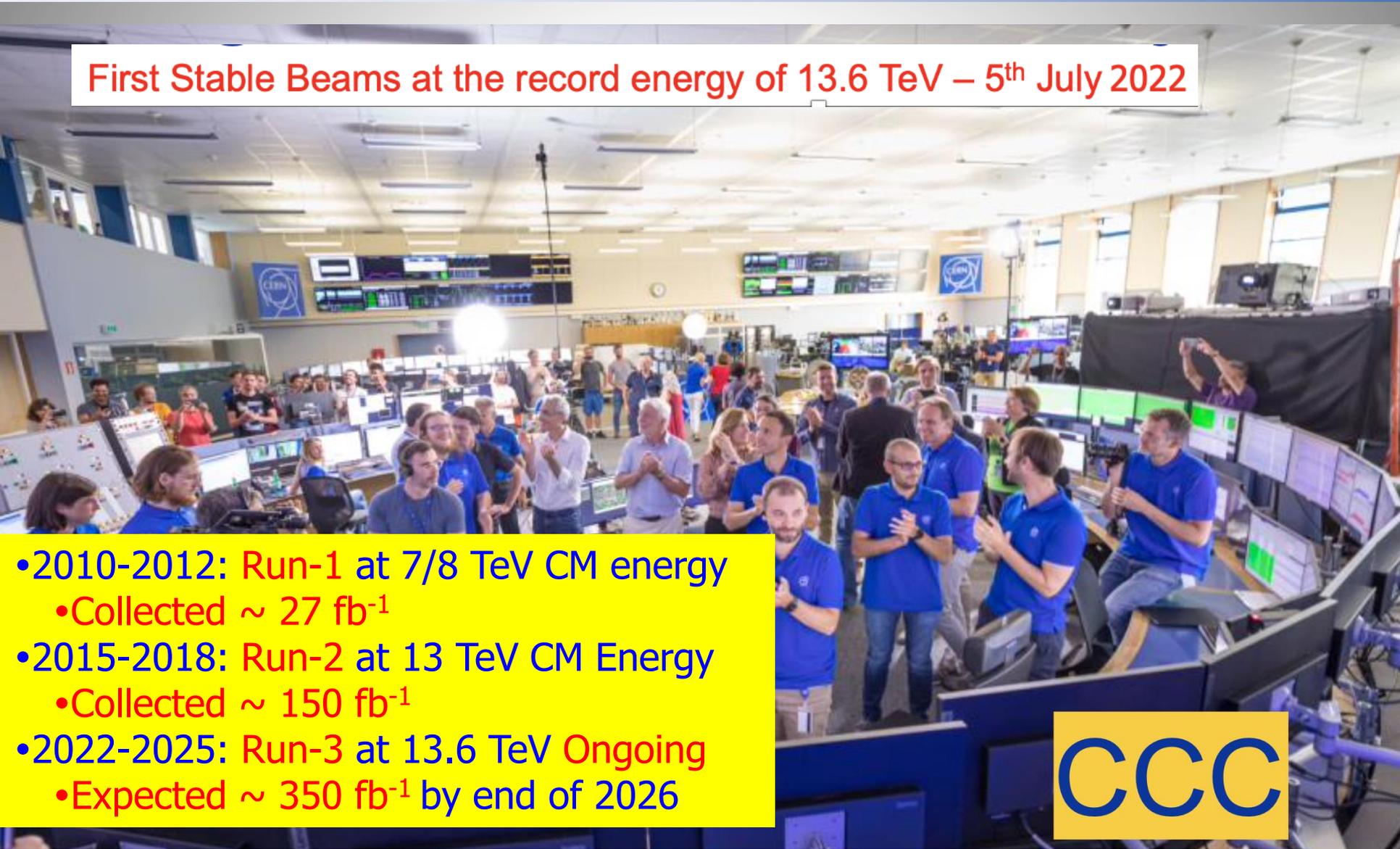


There are now 9 experiments at the LHC

LHC Operations 2010-Today

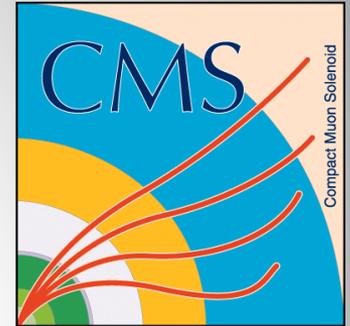
First Stable Beams at the record energy of 13.6 TeV – 5th July 2022

- 2010-2012: Run-1 at 7/8 TeV CM energy
 - Collected $\sim 27 \text{ fb}^{-1}$
- 2015-2018: Run-2 at 13 TeV CM Energy
 - Collected $\sim 150 \text{ fb}^{-1}$
- 2022-2025: Run-3 at 13.6 TeV Ongoing
 - Expected $\sim 350 \text{ fb}^{-1}$ by end of 2026

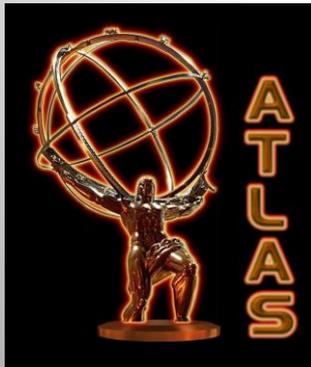


CCC

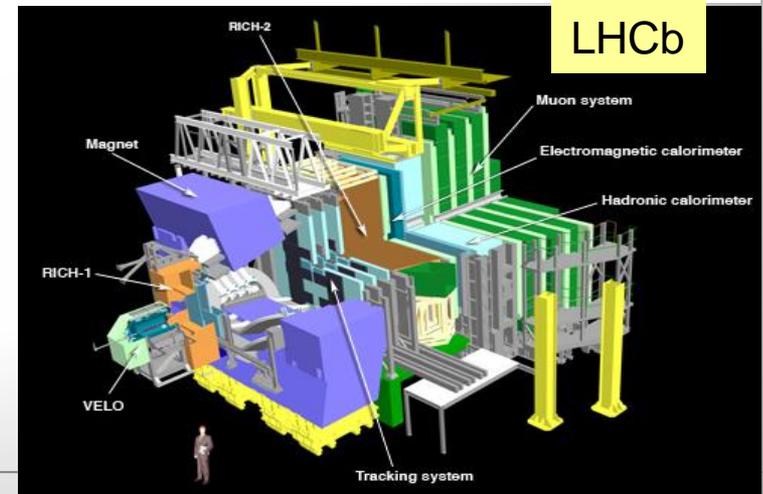
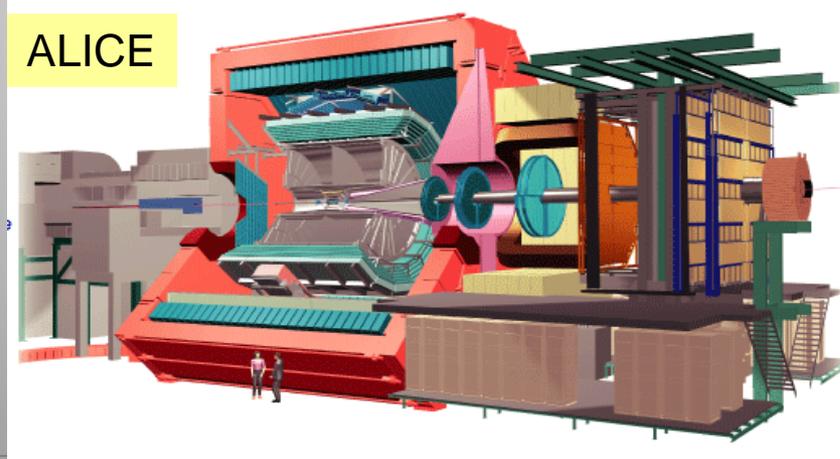
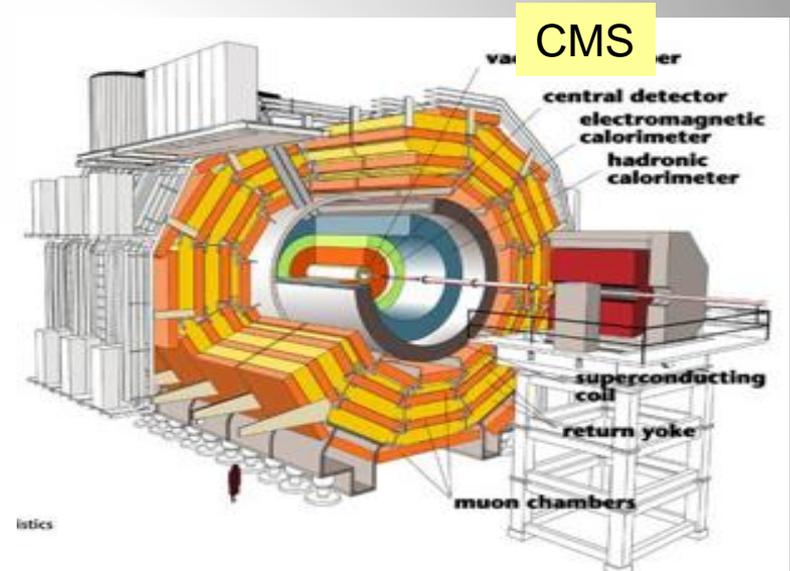
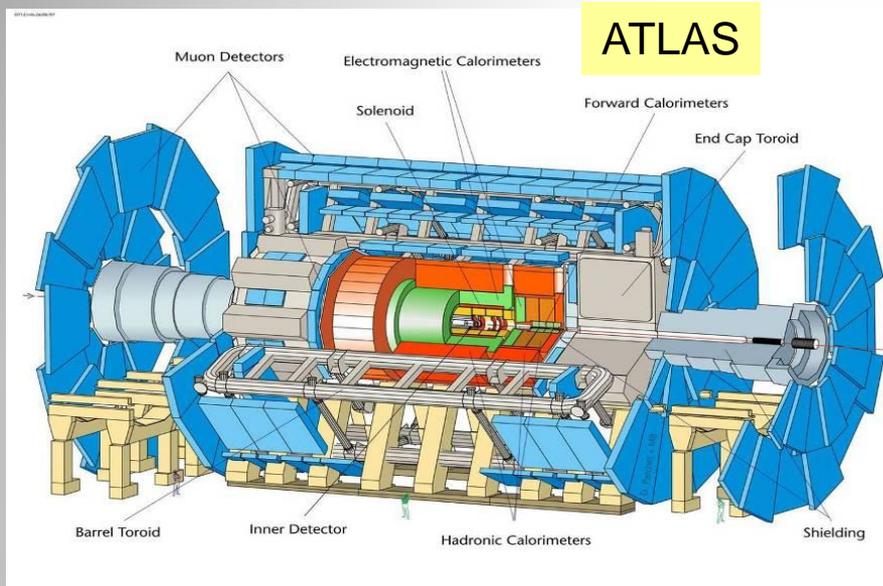
Integrated Luminosity = a measure of the # of collisions e.g. per year (unit: fb^{-1})



Experiments at the LHC

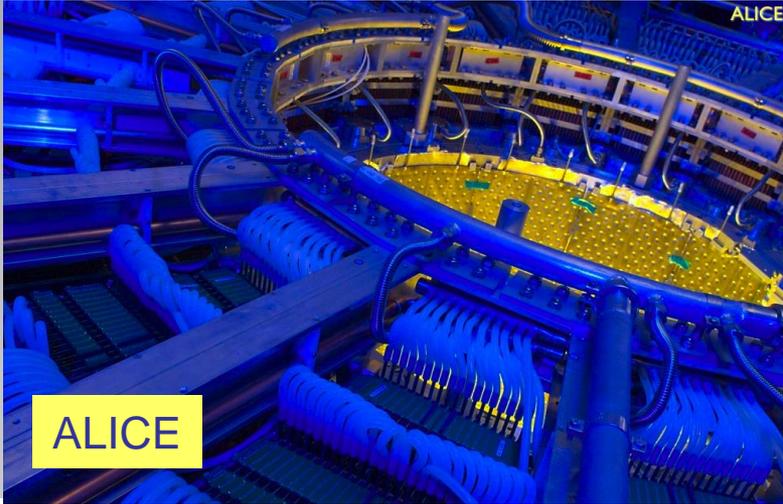


Central Detectors at the LHC

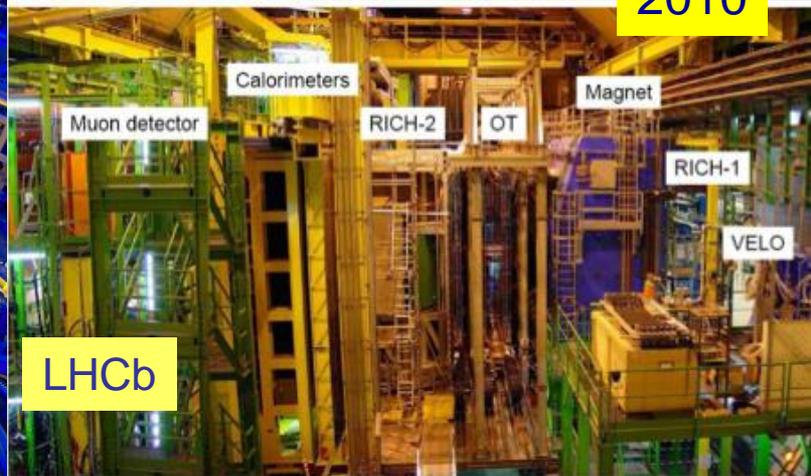


Central Detectors Completed in 2010

2010



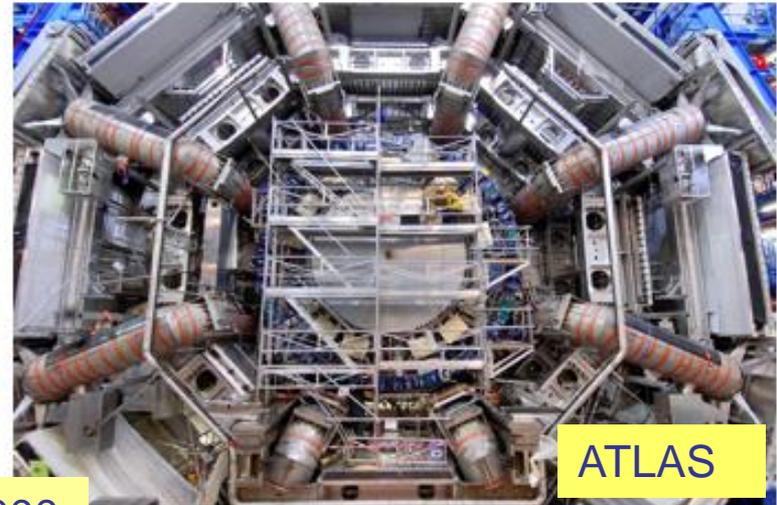
ALICE



LHCb



CMS



ATLAS

ATLAS & CMS construction started around 2000

Schematic of a LHC Detector

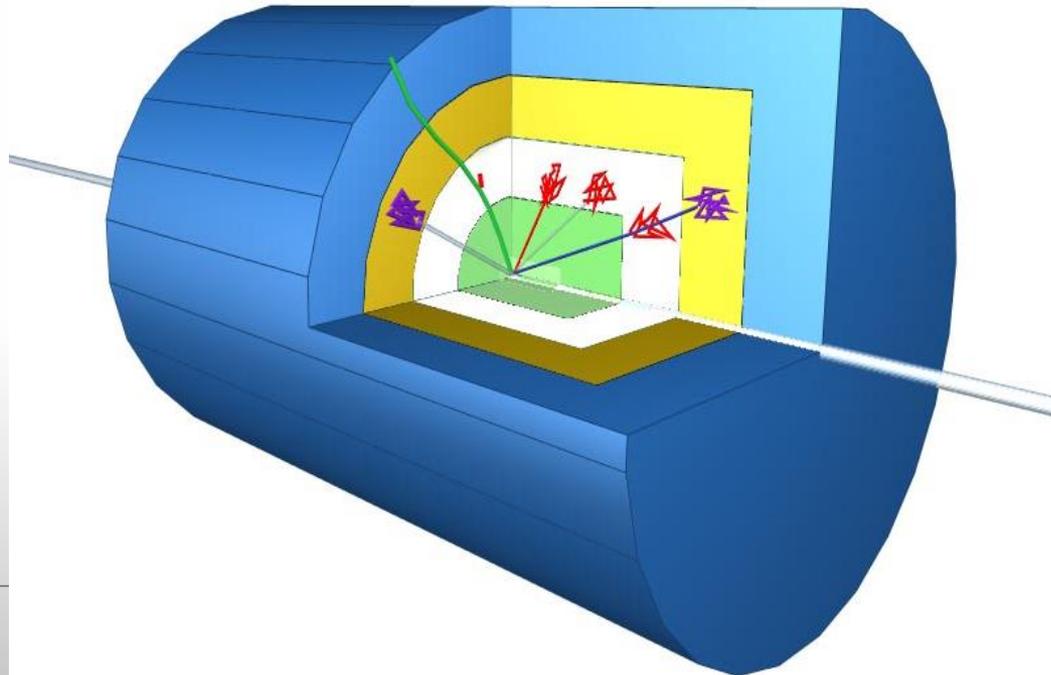
Physics requirements drive the design!

Analogy with a cylindrical onion:

Technologically advanced detectors comprising many layers, each designed to perform a specific task.

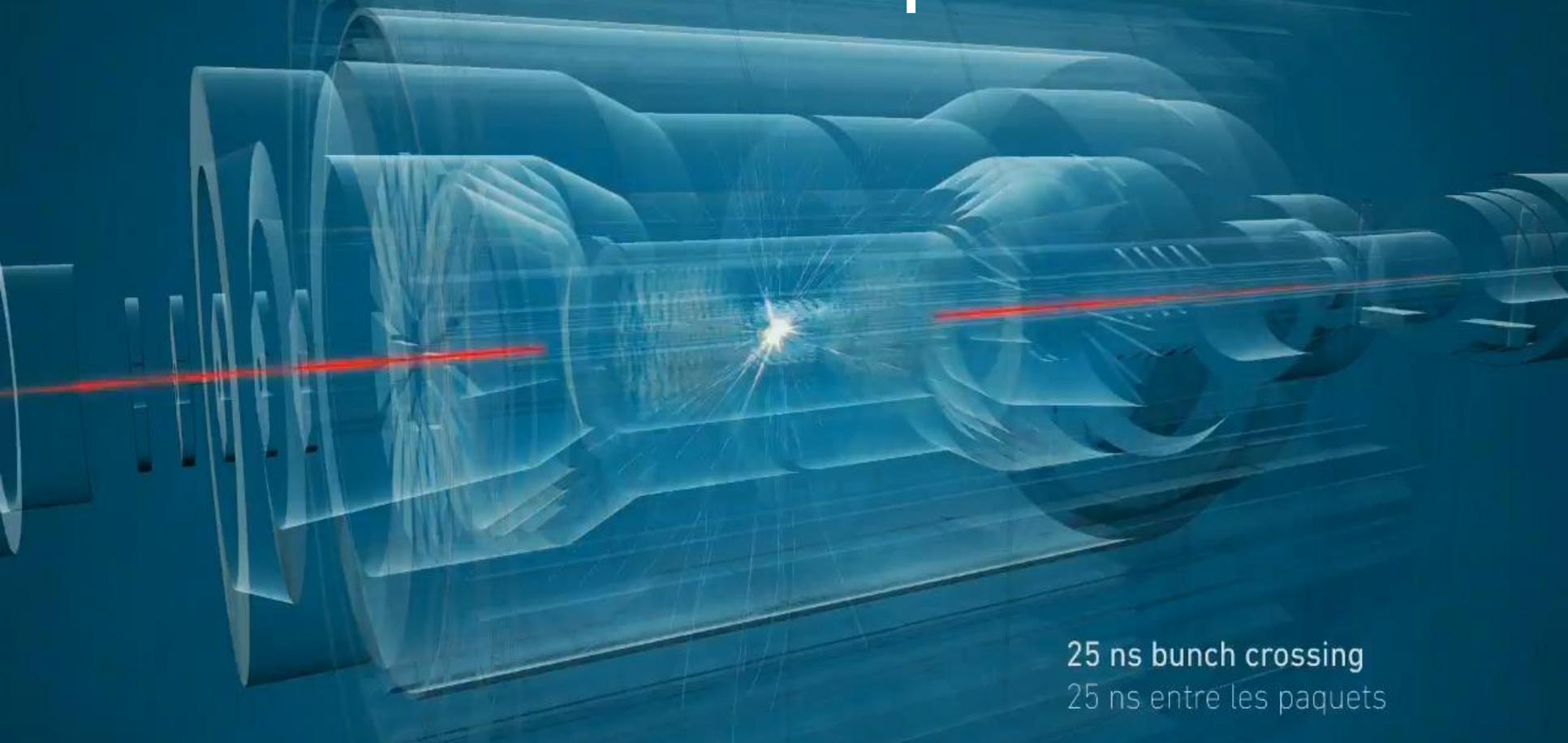
Together these layers allow us to identify and precisely measure the energies and directions of all the particles produced in collisions.

Such an experiment has ~ 100 Million read-out channels!!



The LHC

Millions of collisions per second

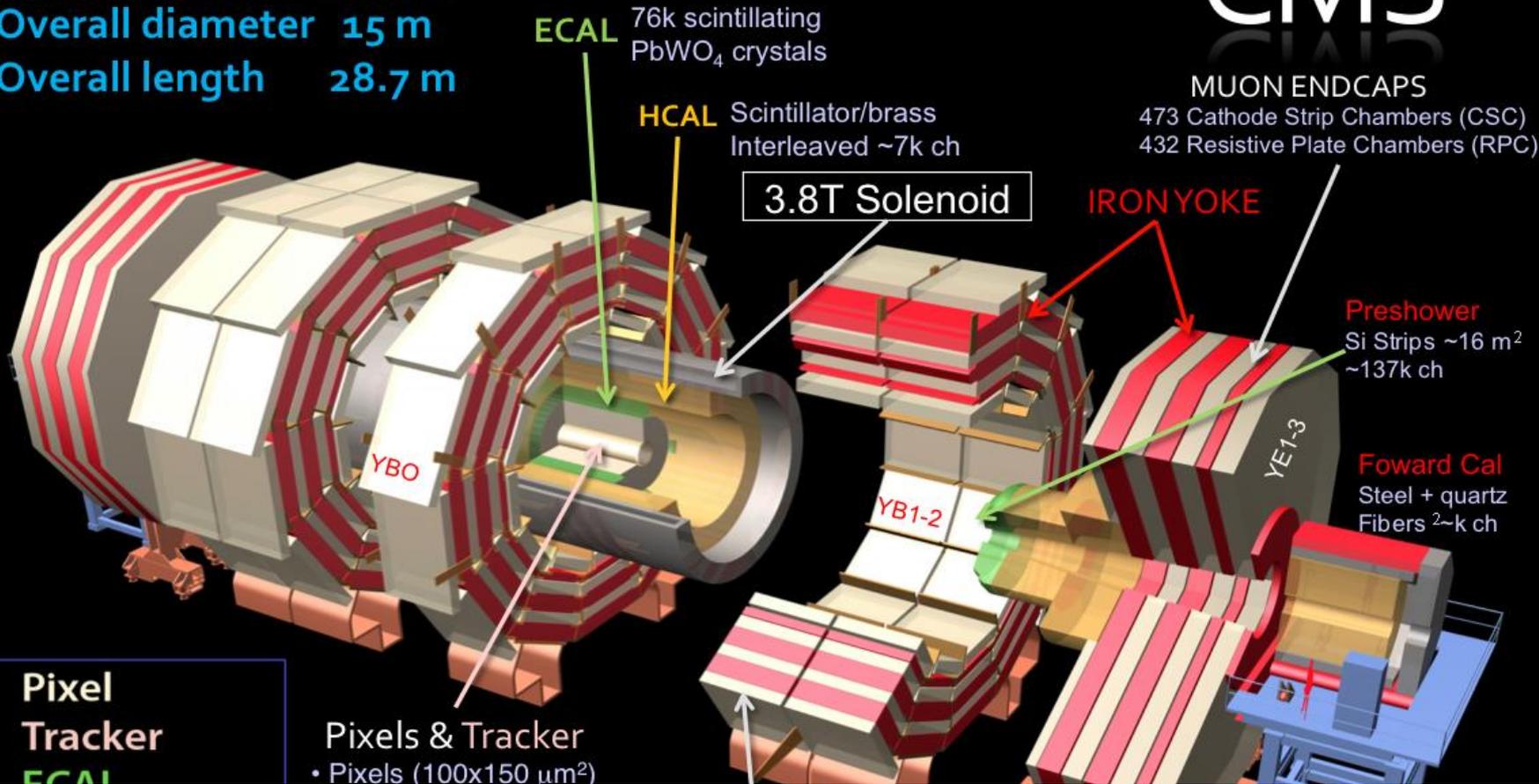


25 ns bunch crossing
25 ns entre les paquets

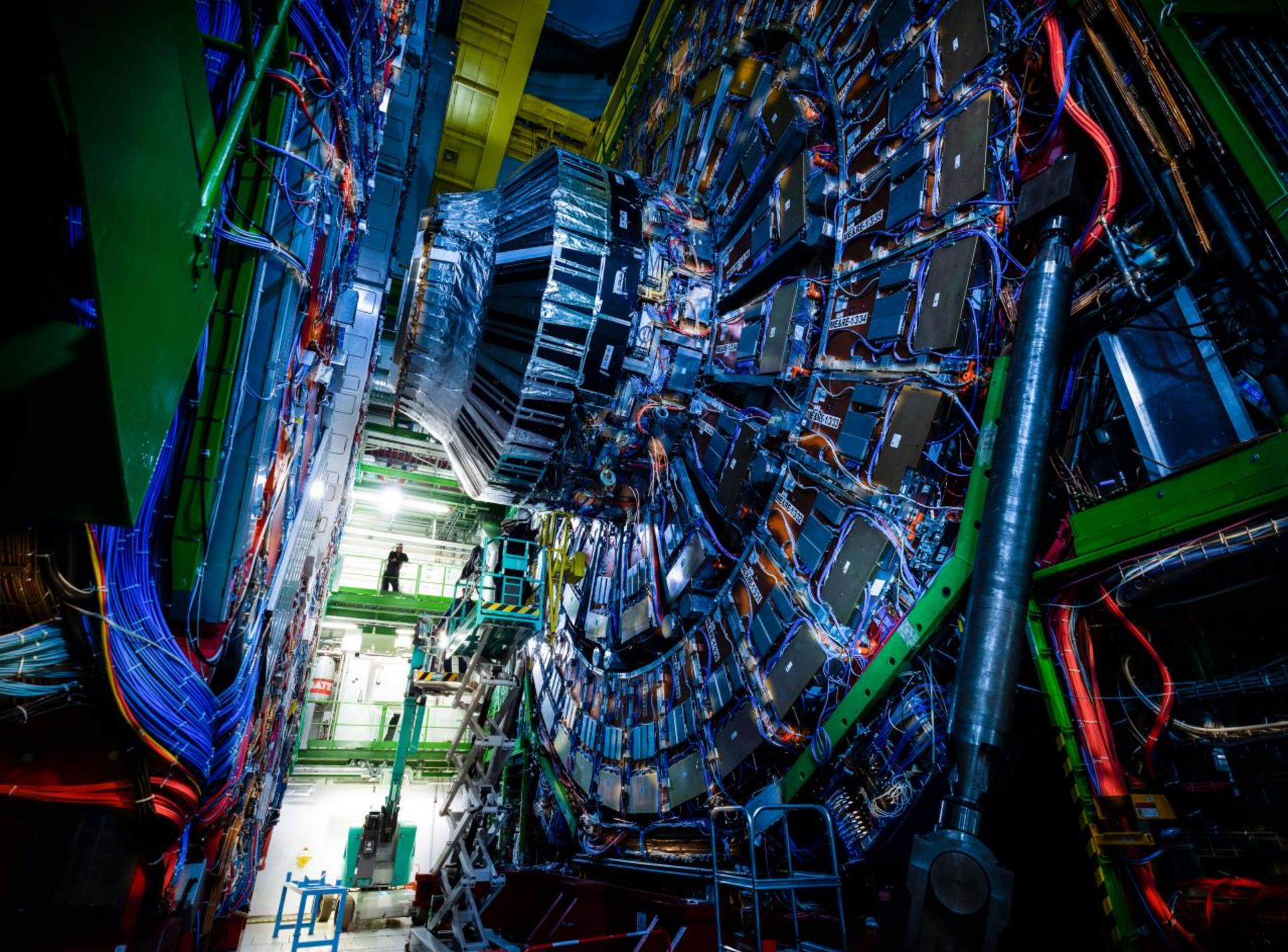
The Compact Muon Solenoid Experiment

Total weight 14000 t
Overall diameter 15 m
Overall length 28.7 m

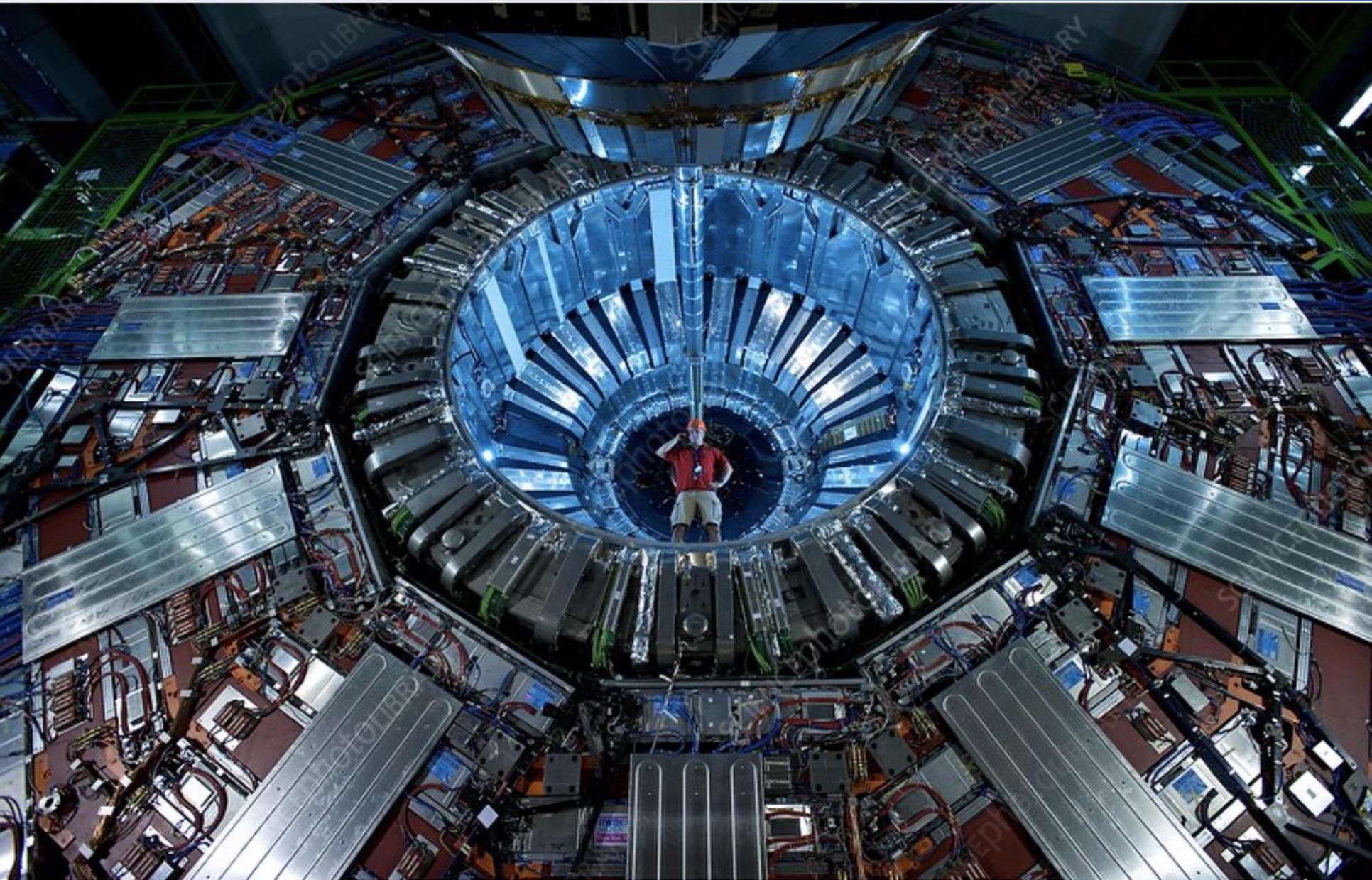
CMS

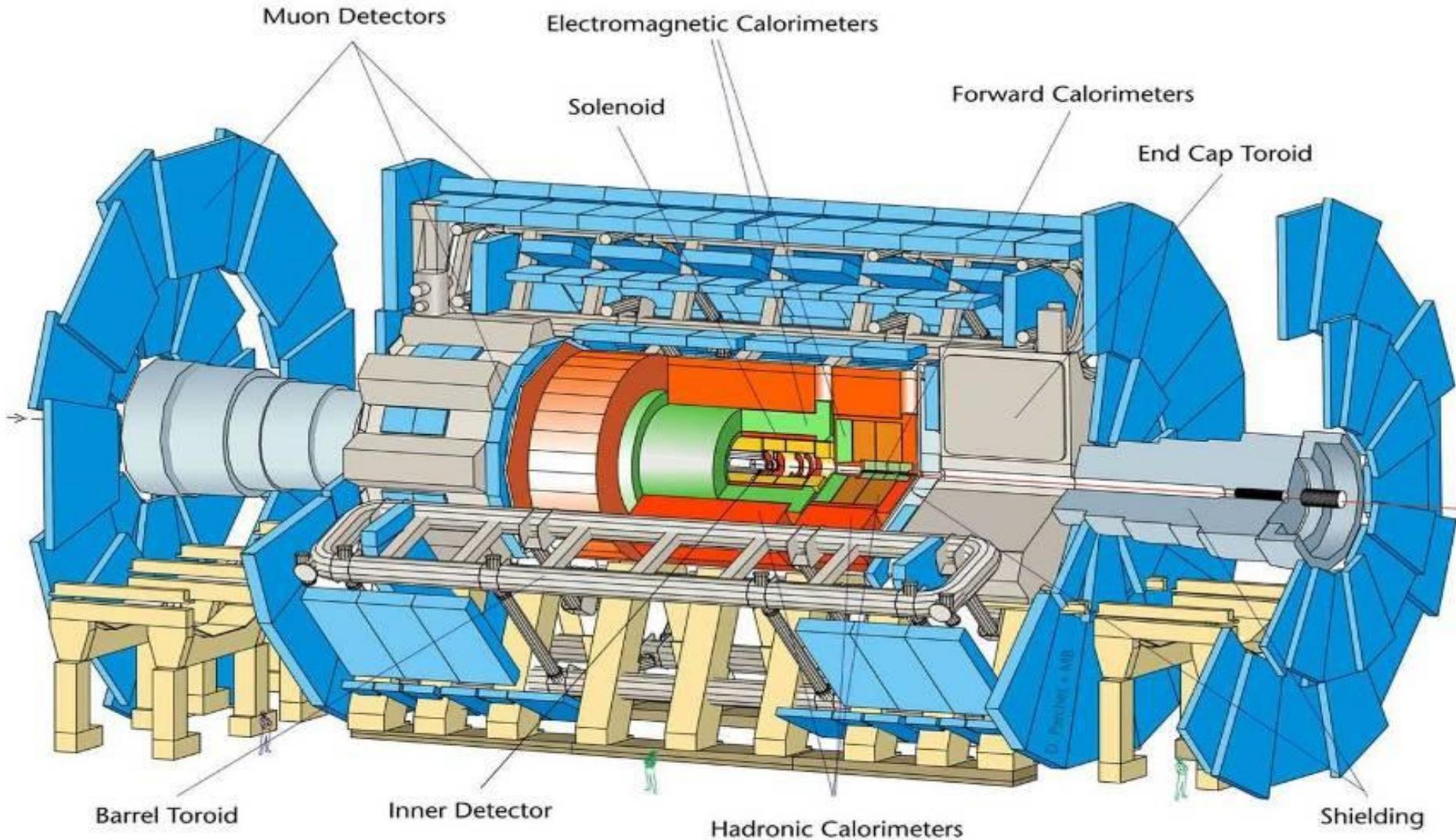


In total about ~100 000 000 electronic channels
Each channel checked 40 000 000 times per second (collision rate is 40 MHz)
An on-line trigger selects events and reduces the rate from 40MHz to ~300 Hz
Amount of data of one collisions ~1 000 000 Bytes (>10 PetaByte/Year)



Artistic CMS

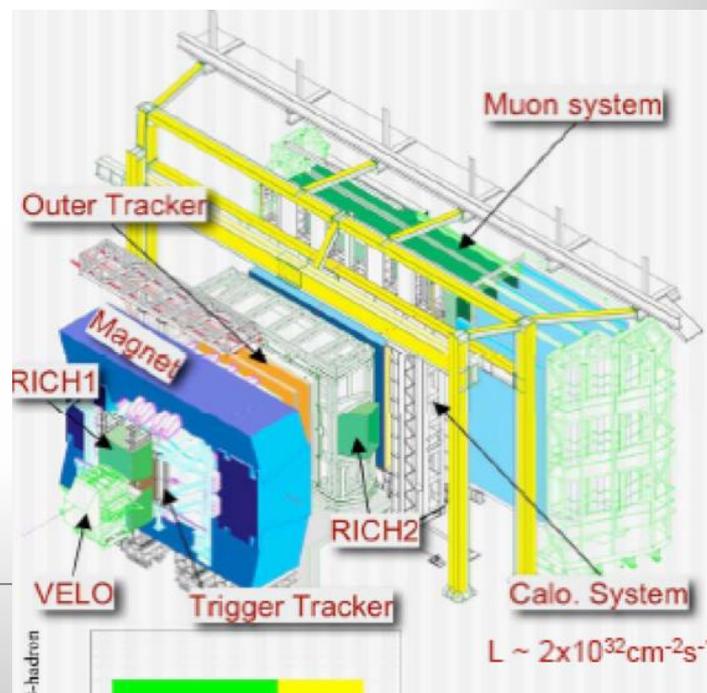
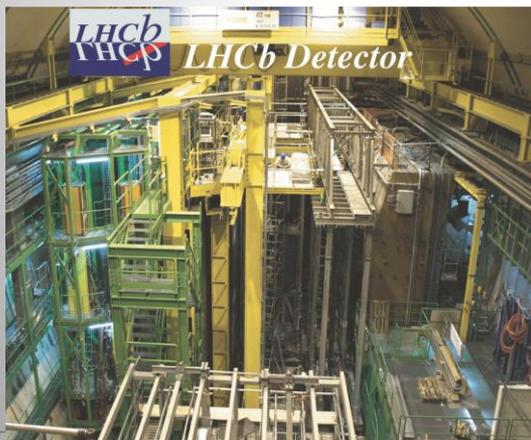
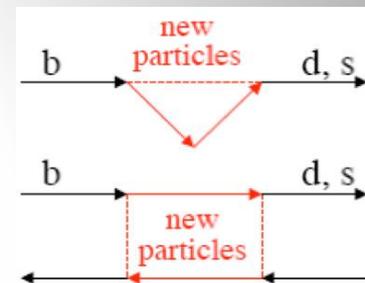
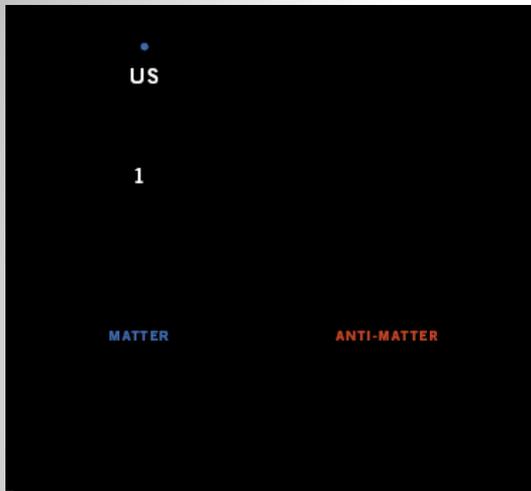




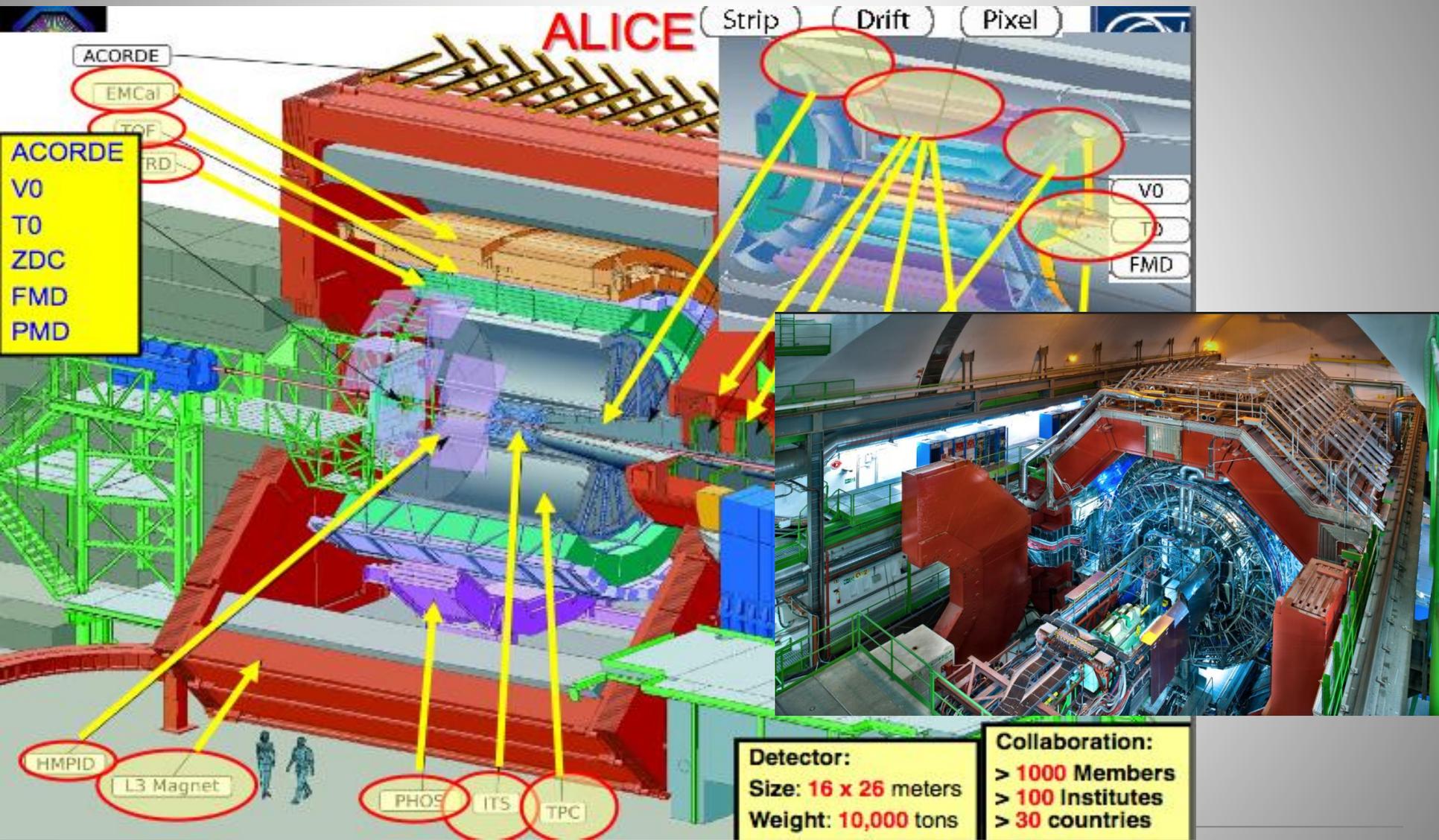
Length = 55 m Width = 32 m Height = 35 m but spatial precision ~ 100 μm

Other Experiments: Matter-Antimatter

The properties and subtle differences of matter and anti-matter using mesons containing the beauty quark, will be studied further in the **LHCb experiment**



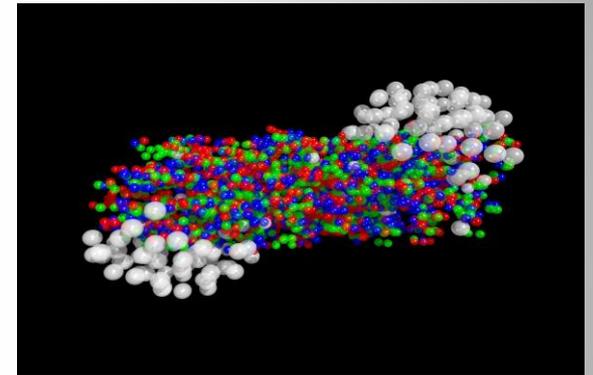
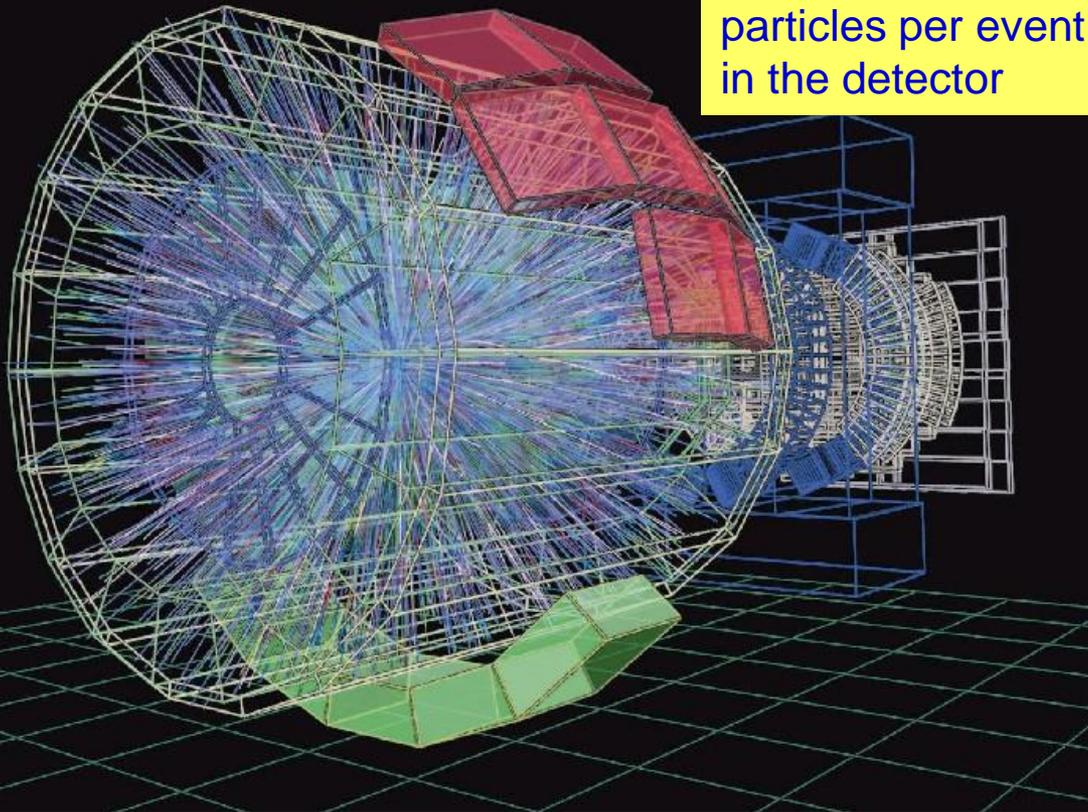
ALICE: Heavy Ion Physics at the LHC



Primordial Plasma

Lead-lead collisions at the LHC to study the primordial plasma, a state of matter in the early moments of the Universe

More than 10,000 particles per event in the detector



Study the phase transition of a state of **quark gluon plasma** created at the time of the early Universe to the **baryonic matter** we observe today

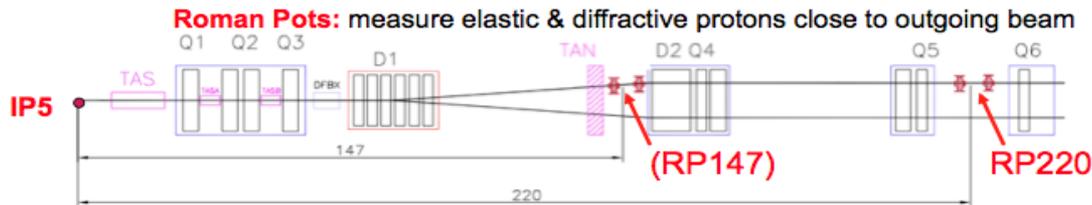
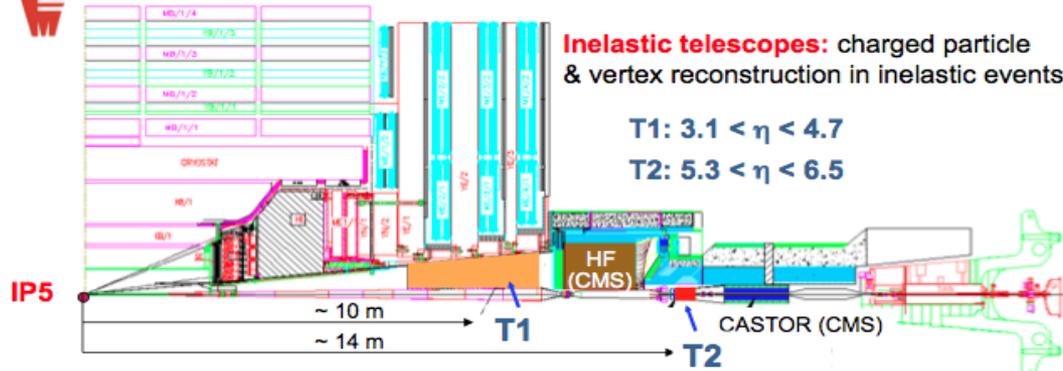
A lead lead collision simulated in the ALICE detector

TOTEM Detector

TOTEM uses the same Interaction Point as CMS (IP5)
 TOTEM has forward detectors and Near Beam Detectors
 (Roman Pots 150m-220m away from the IP)

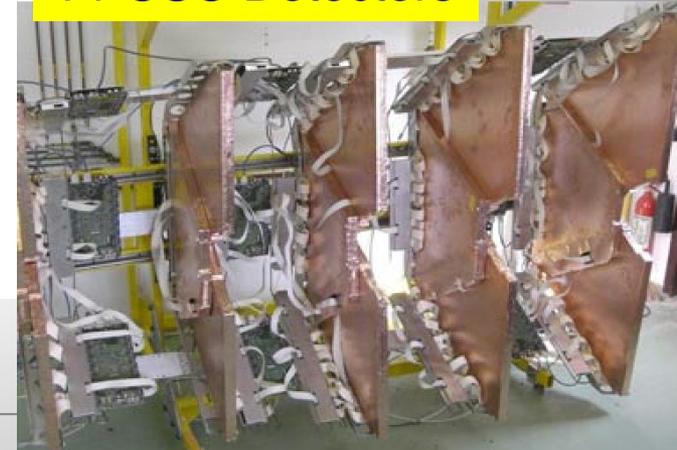


Totem experimental setup



Roman Pot

T1 CSC Detectors



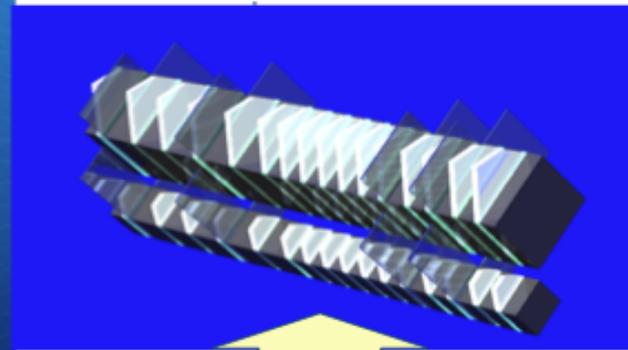
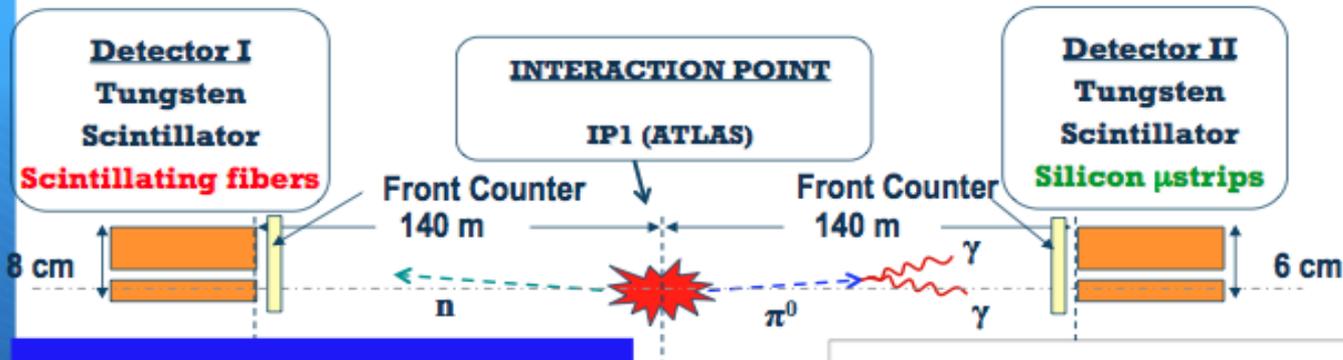
Physics Goals: Total cross section;
 Elastic cross section; Diffractive studies

LHCf Experiment

LHCf uses the same Interaction Point as ATLAS (IP1)

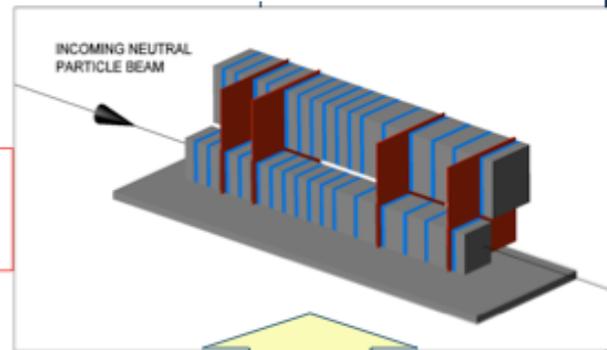
LHCf has forward detectors at zero degrees seen from the IP (140 away from the IP)

LHCf: location and detector layout

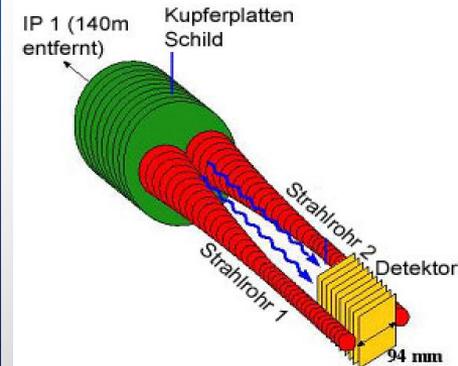


Arm#1 Detector
20mmx20mm+40mmx40mm
4 X-Y SciFi tracking layers

$44X_{or}$
 $1.6\lambda_{int}$



Arm#2 Detector
25mmx25mm+32mmx32mm
4 X-Y Silicon strip tracking layers



15 years of LHC Operation

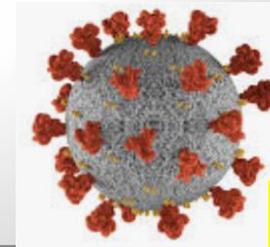
- LHC switched on at 7 TeV end of March 2010
 - >The highest energy in the lab!
- LHC @ 13 TeV from 2015 onwards
- Most important highlight so far:
 - The discovery of a Higgs boson
- Many results on Standard Model process measurements, top-physics, b-physics, heavy ion physics, searches, Higgs physics
- Waiting for the next discovery...
 - > Searching beyond the Standard Model
- 10 years later: CERN in “safe mode” due to COVID19... ☹ ☹ ☹
- July 2022: Start of run-3 at 13.6TeV



March 30 2010
...waiting..
...since 4:00 am

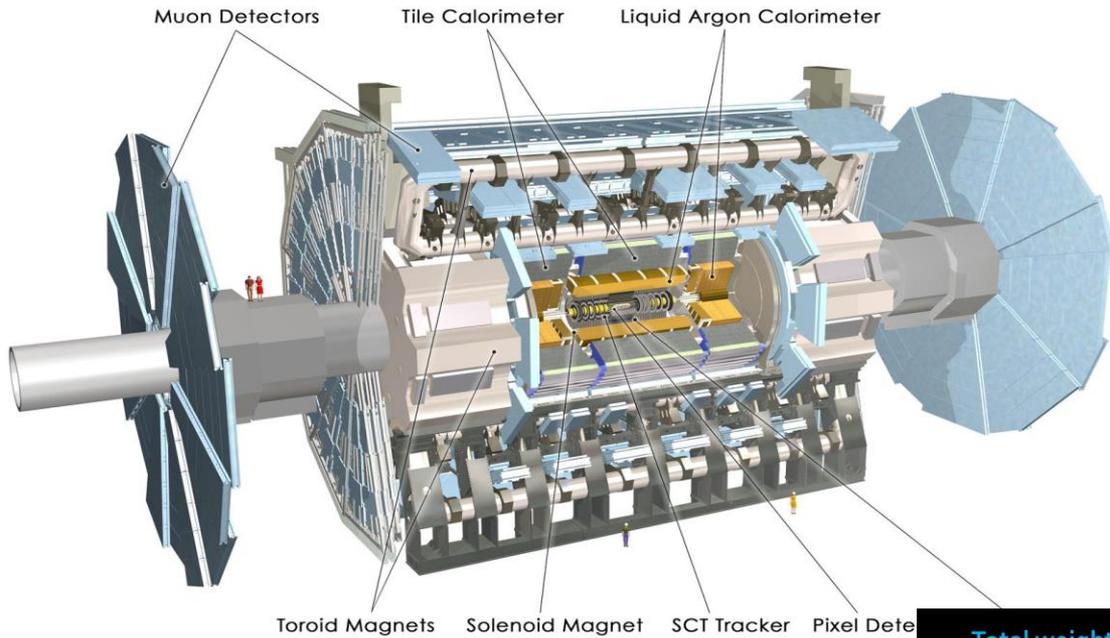


12:58 7 TeV collisions!!!



2020..2021

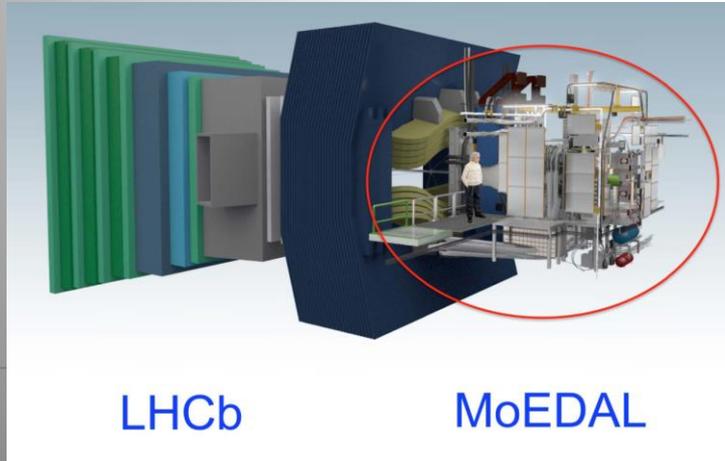
New Physics Hunters @ the LHC



The ATLAS experiment

The CMS experiment

...And also LHCb and MoEDAL



CMS

Total weight 14000 t
Overall diameter 15 m
Overall length 28.7 m

ECAL 76k scintillating PbWO₄ crystals
HCAL Scintillator/brass Interleaved ~7k ch
3.8T Solenoid
IRON YOKE
MUON ENDCAPS 473 Cathode Strip Chambers (CSC) 432 Resistive Plate Chambers (RPC)
Preshower Si Strips ~16 m² ~137k ch
Forward Cal Steel + quartz Fibers ~k ch
MUON BARREL 250 Drift Tubes (DT) and 480 Resistive Plate Chambers (RPC)

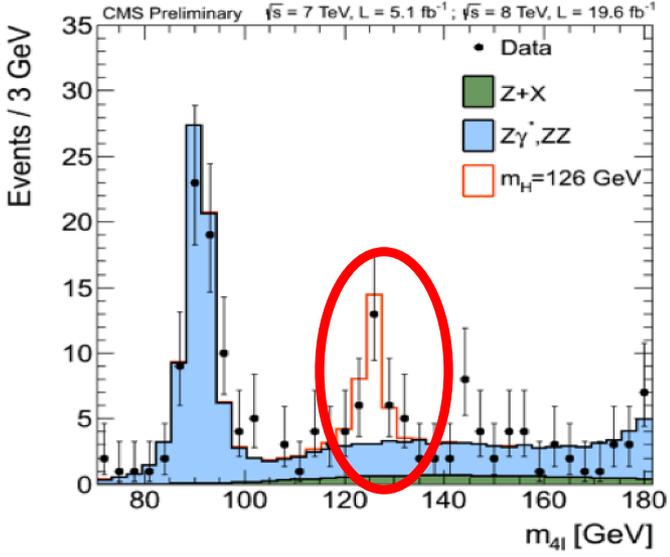
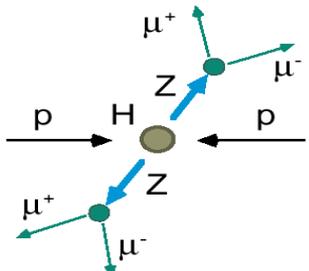
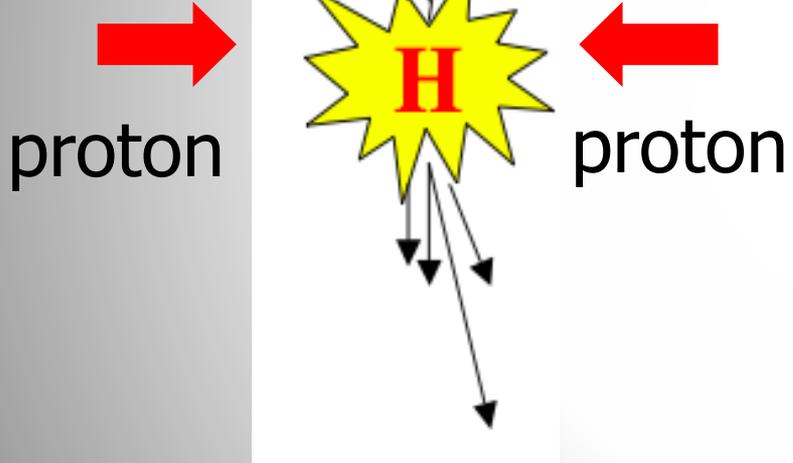
Pixel Tracker
ECAL
HCAL
Muons
Solenoid coil

YB0
YB1-2
YET-3

Pixels & Tracker
 • Pixels (100x150 μm²) ~ 1 m² ~66M ch
 • Si Strips (80-180 μm) ~200 m² ~9.6M ch

2012: A Milestone in Particle Physics

Observation of a **Higgs** Particle at the LHC, after about 40 years of experimental searches to find it : **it's mass is ~ 125 GeV**

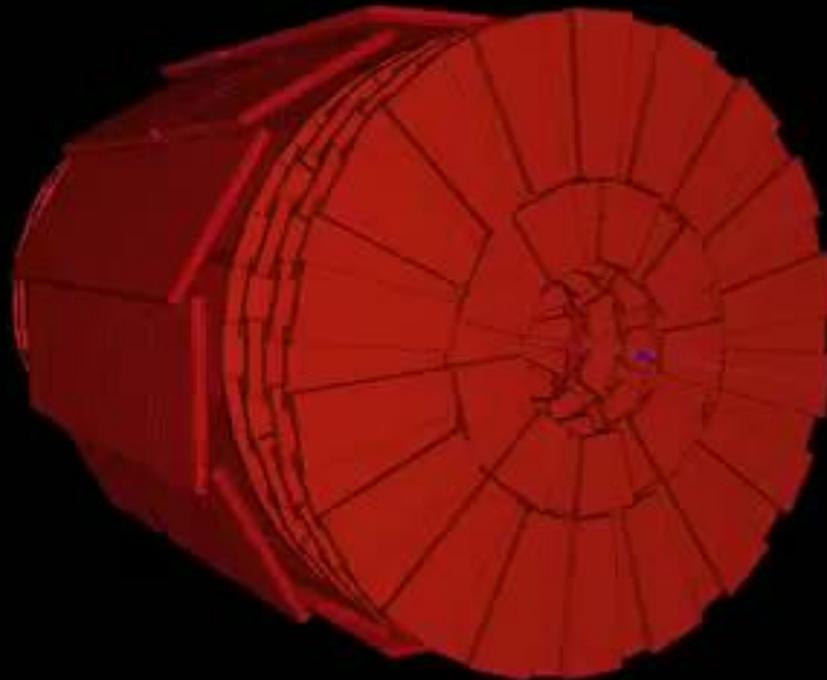


2013

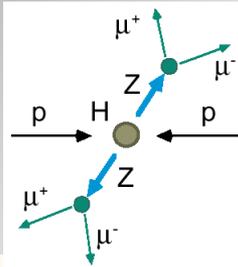
The Higgs particle was the last missing particle in the Standard Model and possibly our portal to physics Beyond the Standard Model

A Higgs Particle Candidate...

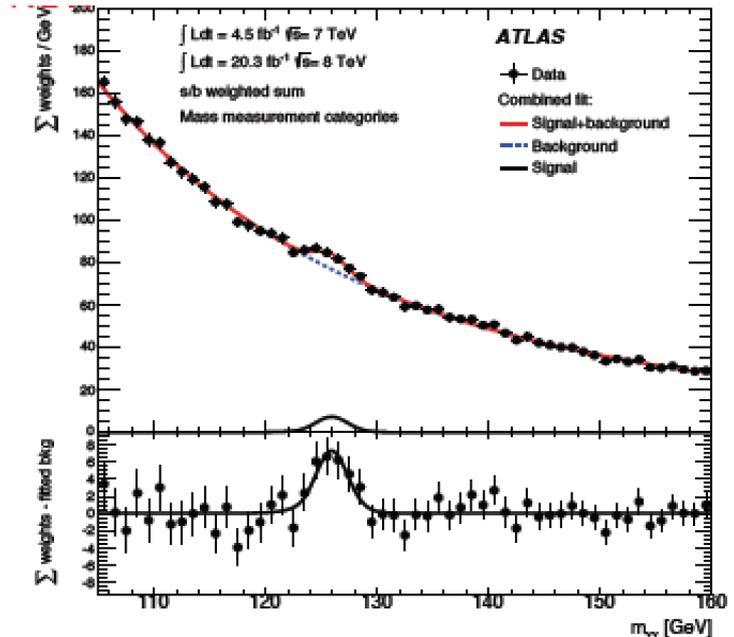
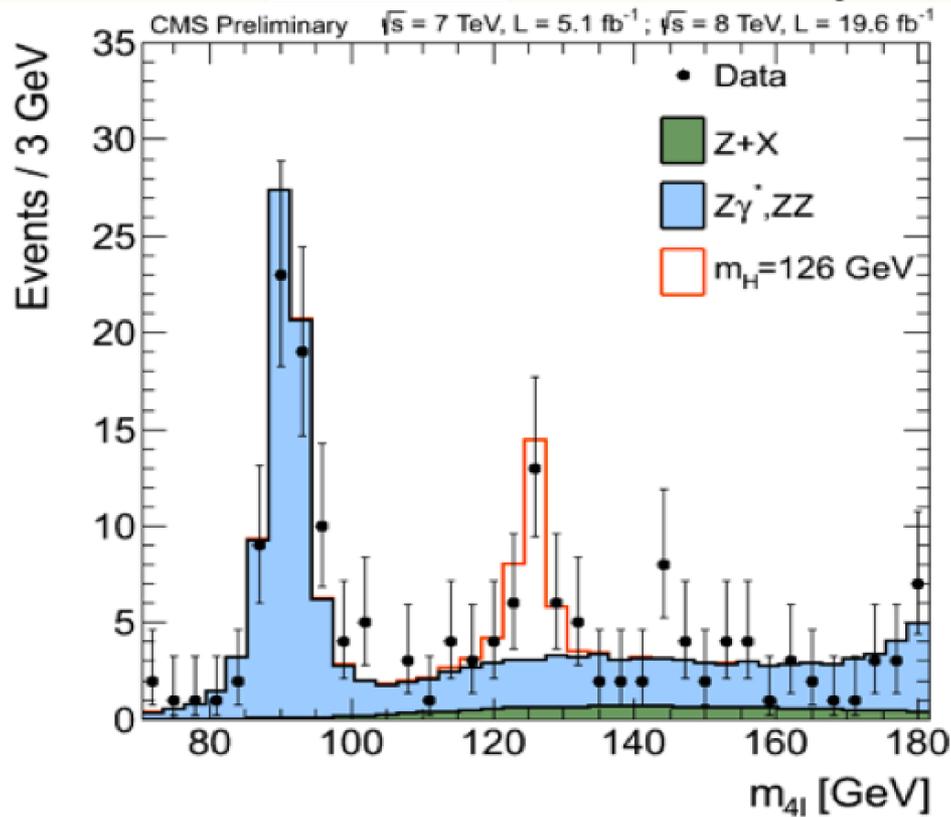
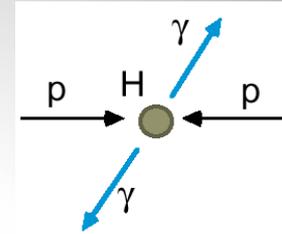
CMS Experiment at the LHC, CERN
Sat 2011-Jun-25 08:34:20 CET
Run 167675 Event 876656967
C.O.M. Energy 7.00TeV
HbZZ-4e candidate



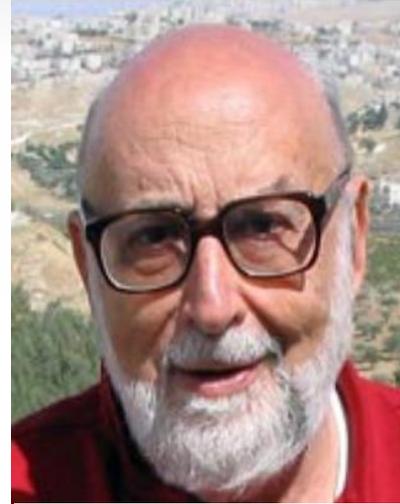
Higgs \rightarrow ZZ and $\gamma\gamma$



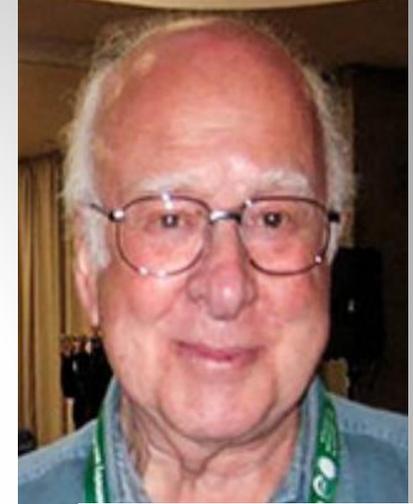
Discovery Channels!



Tuesday 8 October 2013



Francois Englert



Peter Higgs

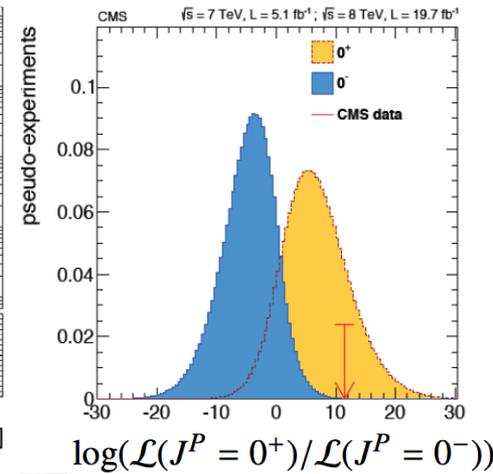
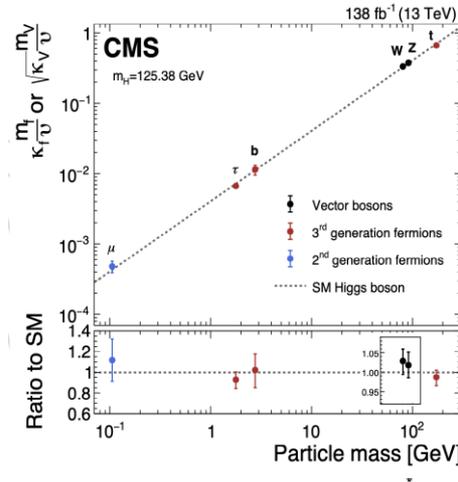
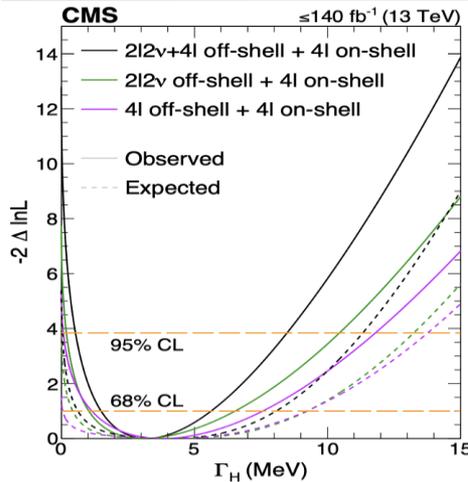
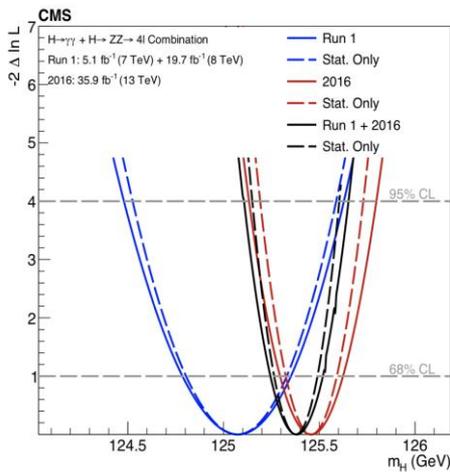


Congratulations!!!!



Brief Higgs Summary

We know already a lot on this Brand New Higgs Particle!!



Higgs Mass

$125.38 \pm 0.14 \text{ GeV}$

Higgs Width:

$$\Gamma_H = 3.2^{+2.4}_{-1.7} \text{ MeV}$$

Couplings are within $\sim 10\text{-}15\%$ of the SM values

Spin = $0^{+(+)}$ preferred over $0^-, 1, 2$

SM-like behaviour for most properties, but continue to look for anomalies, i.e. unexpected decay modes or couplings, multi-Higgs production...

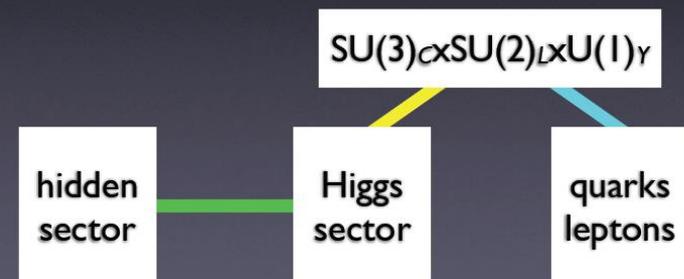
The Future: Studying the Higgs...



- More LHC Data 2015-2026
- LHC upgrade ! 2030-2040
- Experiment upgrades!!
- Other/new machines after 2040??

Higgs as a portal

- having discovered the Higgs?
- Higgs boson may connect the Standard Model to other “sectors”

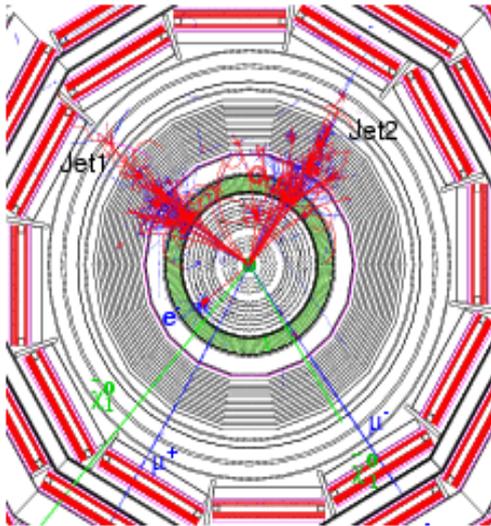


Many questions are still unanswered:

- What explain a Higgs mass ~ 125 GeV?
- What explains the particle mass pattern?
- Connection with Dark Matter?
- Where is the antimatter in the Universe?
- ⑤

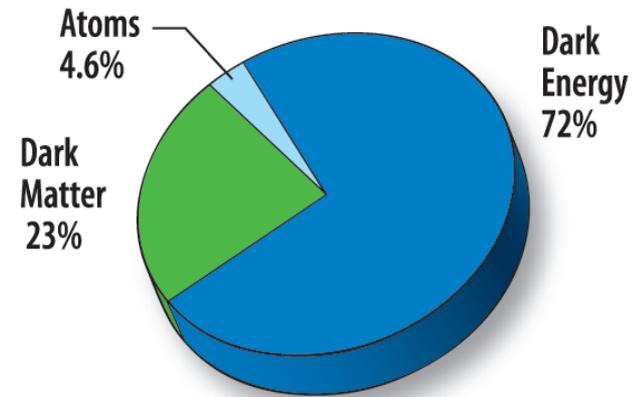
The Standard Model cannot be the complete story! -> Searches

Next LHC Physics Targets



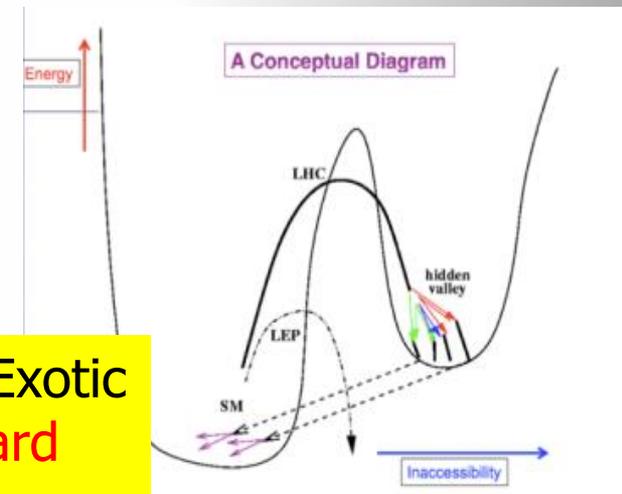
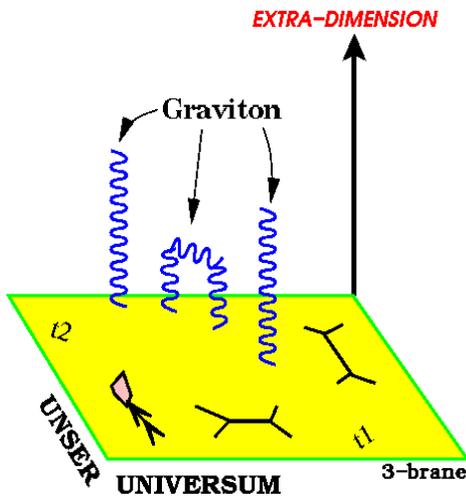
Searching for
Supersymmetric
Particles

Searching for
Dark Matter



Searching for
Extra Dimensions

Searching for Exotic
Beyond Standard
Model Phenomena



And many more topics...

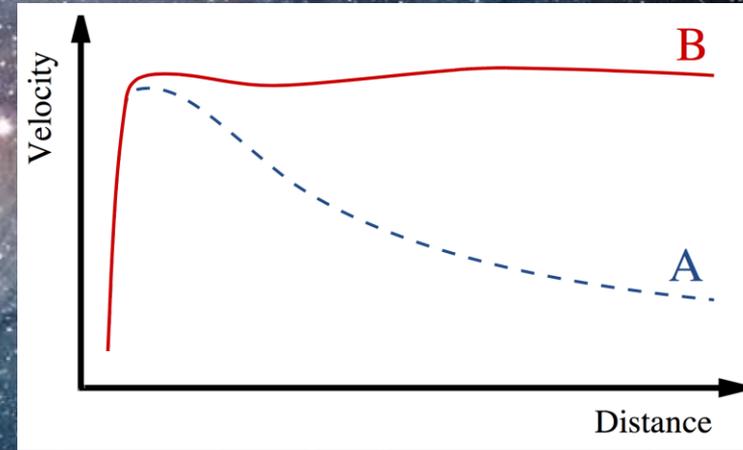
Next Questions...

Dark Matter at the LHC?

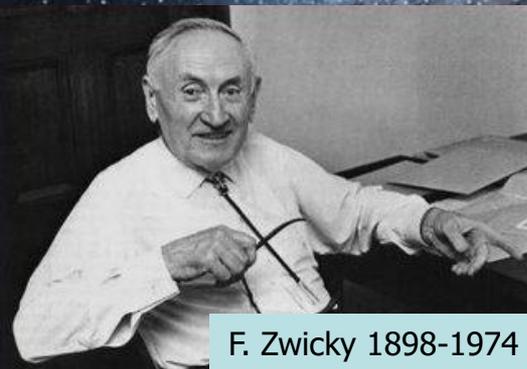
Are we Supersymmetric?

Dark Matter in the Universe

Astronomers found that most of the matter in the Universe must be invisible Dark Matter



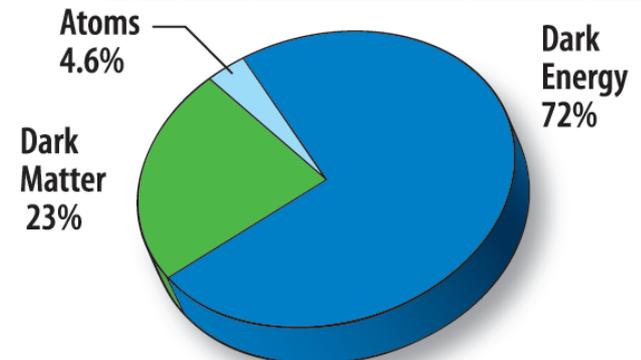
'Supersymmetric' particles ?



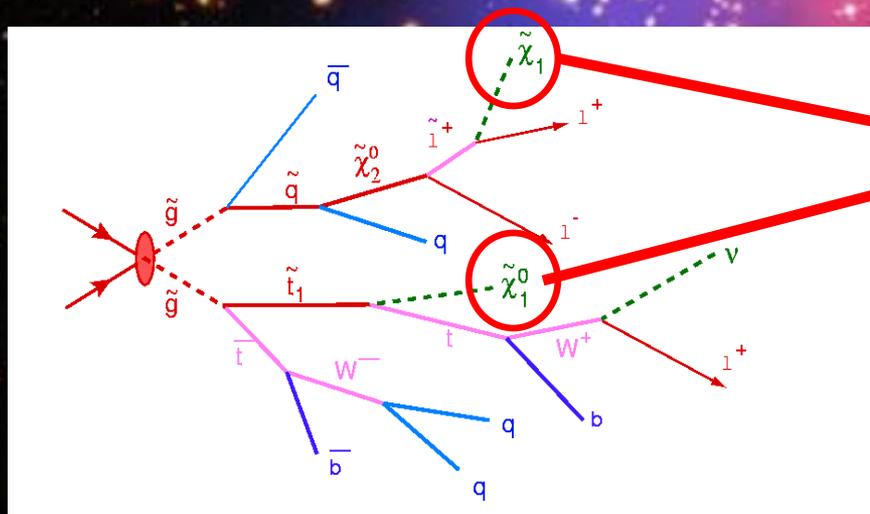
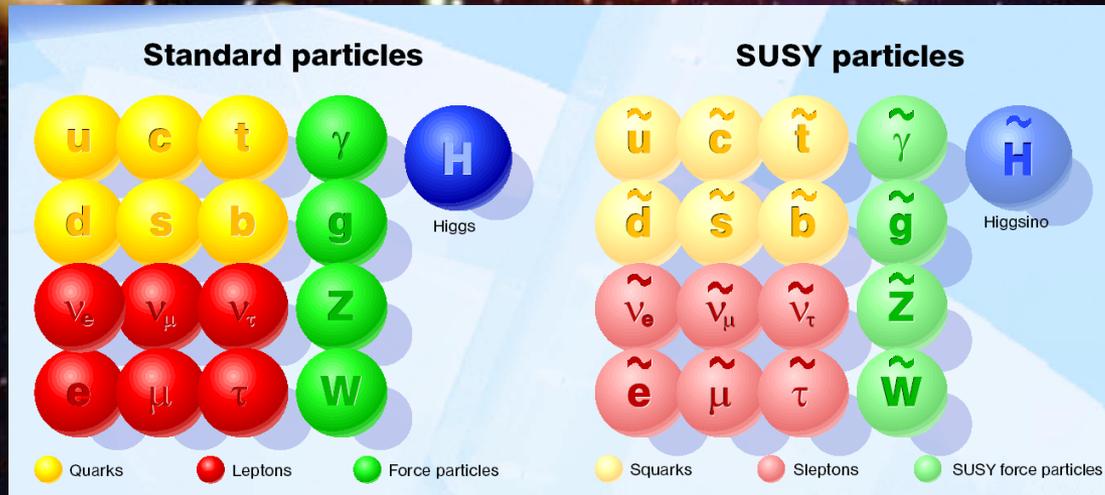
F. Zwicky 1898-1974



Vera Rubin ~ 1970



Supersymmetry: a new symmetry in Nature?



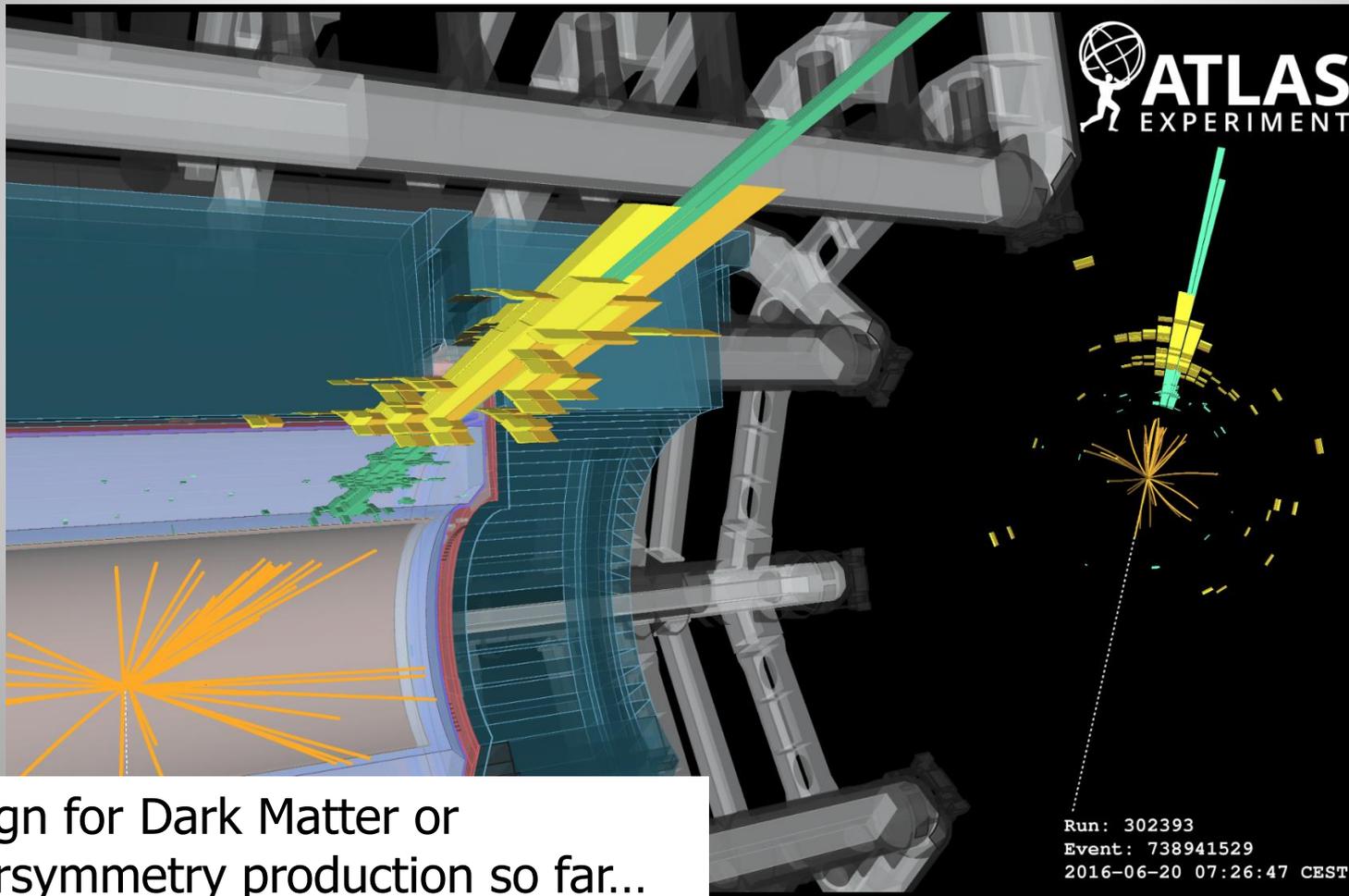
Candidate particles for Dark Matter
 \Rightarrow Produce Dark Matter in the lab

SUSY particle production at the LHC

A High p_T Mono-jet event

This is a potential signal for Dark Matter at the LHC!

Measured event rate so far consistent with Standard Model Processes

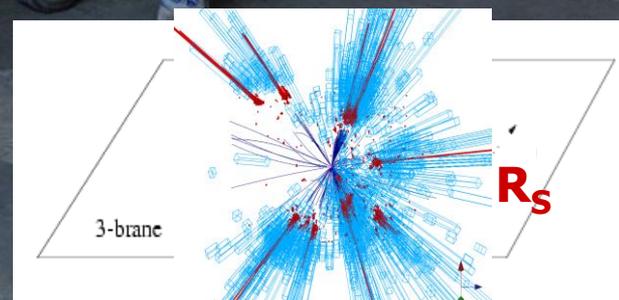


No sign for Dark Matter or Supersymmetry production so far...

Black Holes Hunters at the LHC...



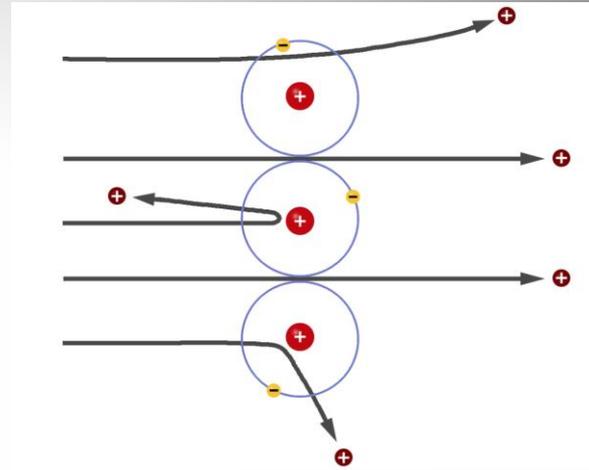
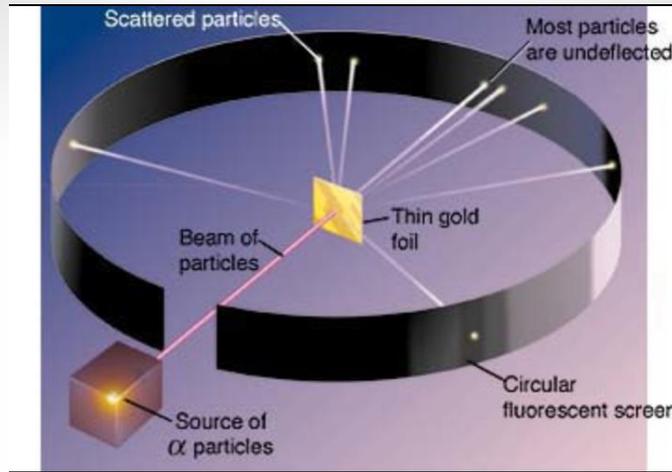
Not observed
so far



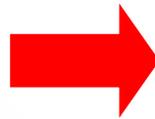
Are Quarks Elementary Particles?



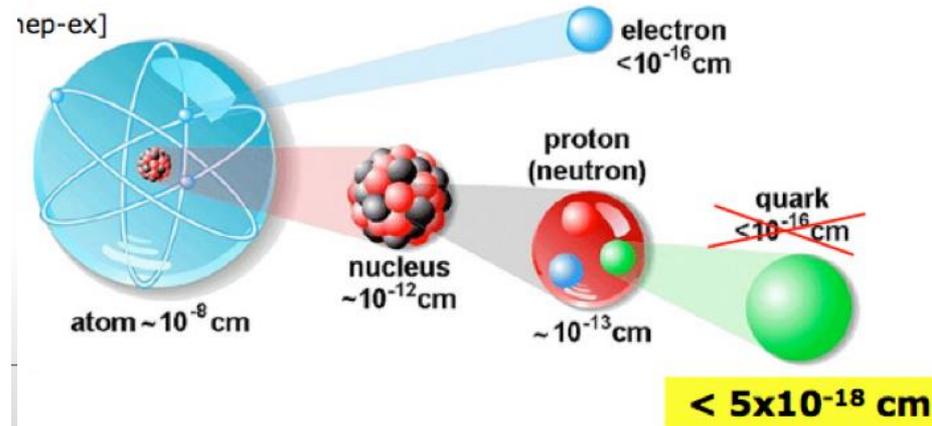
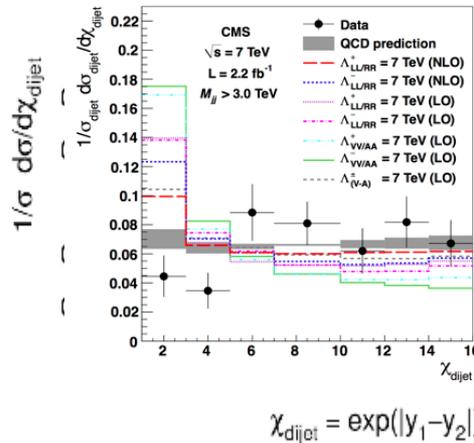
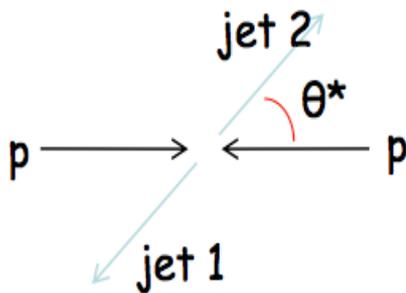
Rutherford experiment:
Evidence for the structure
of atoms !! (1911)



LHC experiment:
Evidence for the structure
of quarks? (2021)



No evidence so far! quarks are
still elementary particles (2021)



The Physics Program at LHC

Data taking started in 2010

Now we have more than 1300 reviewed scientific papers per experiment!

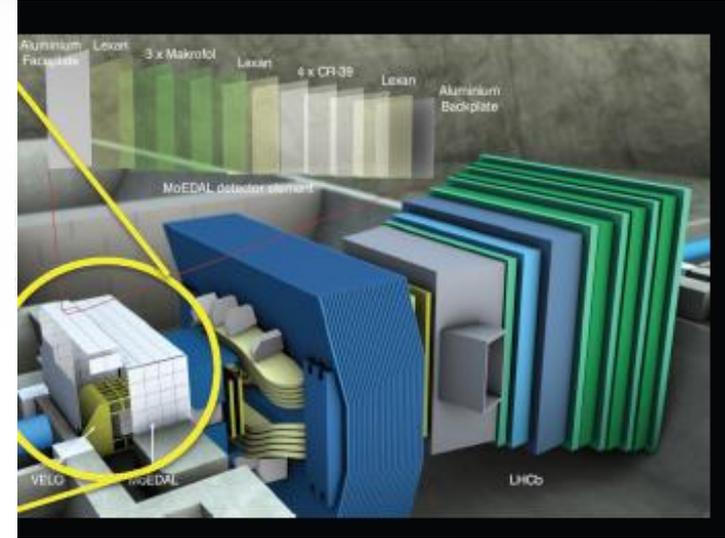
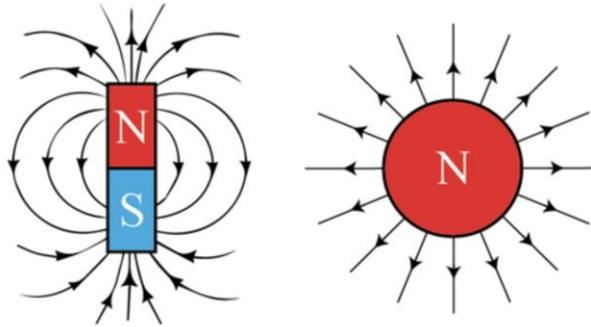
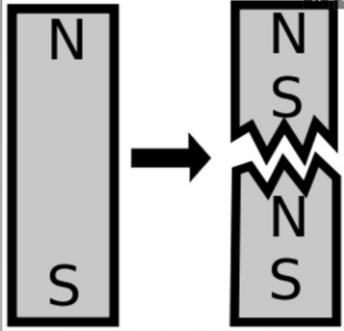
Mostly measurements of the strong and electroweak force at 7/8/13/13.6 TeV and Searches

- | | |
|--|-------------------|
| -Are quarks the elementary particles? | So far yes |
| -Do we see supersymmetric particles? | Not yet |
| -Do we see extra space dimensions? | Not Yet |
| -Do we see micro-black holes? | No |

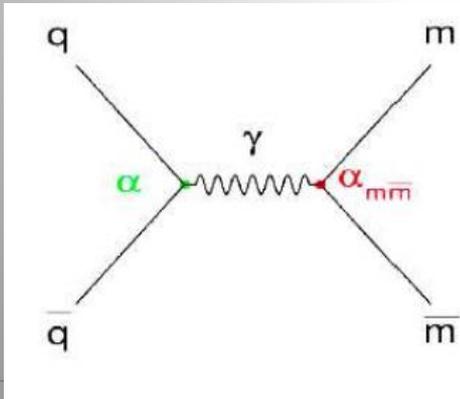
->The Discovery of a Higgs-like particle!!

MoEDAL: Monopole and Exotics Detector at the LHC

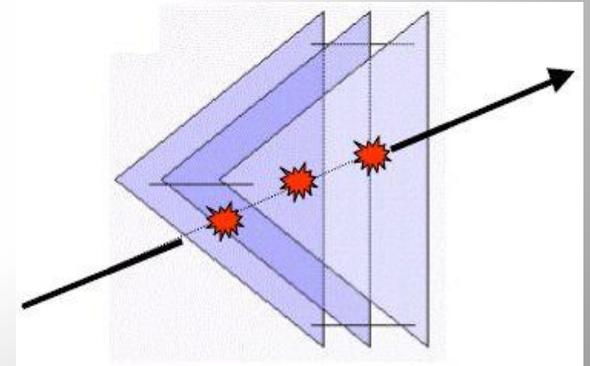
A dedicated experiment for searches for exotica



Monopoles are new particles which carry “magnetic charge”. Could eg explain why particles have “integer electric charge”



Direct Monopole anti-Monopole production



Remove the sheets after some running time and inspect for ‘holes’

Particles with Milli-Charges?

CMS search for fractional charged particle arXiv:1210.2311
 $Q=1/3e > 140 \text{ GeV}$; $Q=2/3e > 310 \text{ GeV}$ (95% CL. dE/dx)

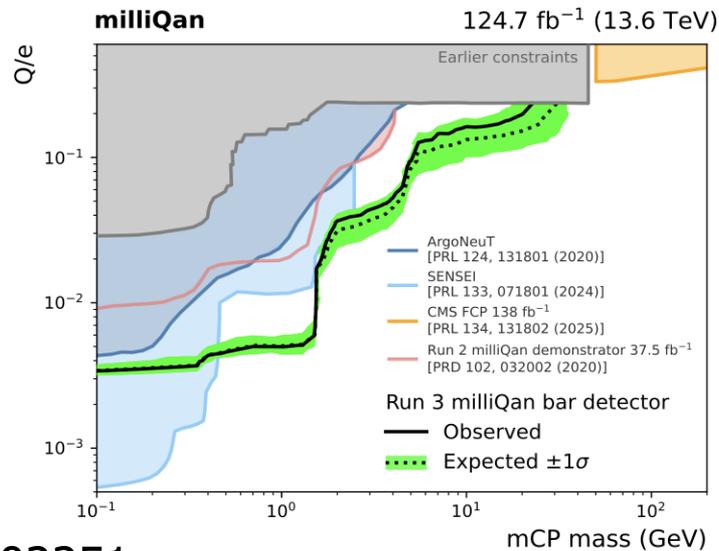
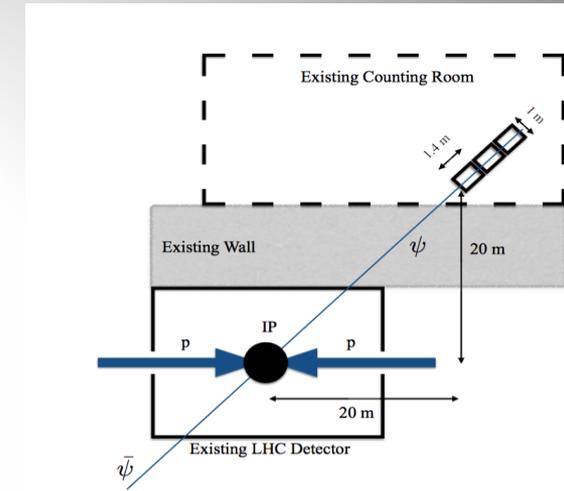
A "new" idea -> Hunting for particles with charges $\sim 0.1-0.001e$ arXiv:1410.6816

Looking for milli-charged particles with a new experiment at the LHC

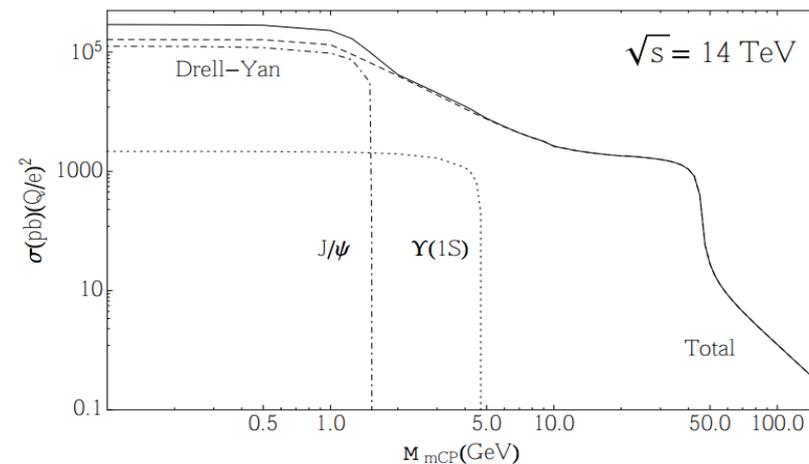
Andrew Haas, Christopher S. Hill, Eder Izaguirre, Itay Yavin

(Submitted on 24 Oct 2014)

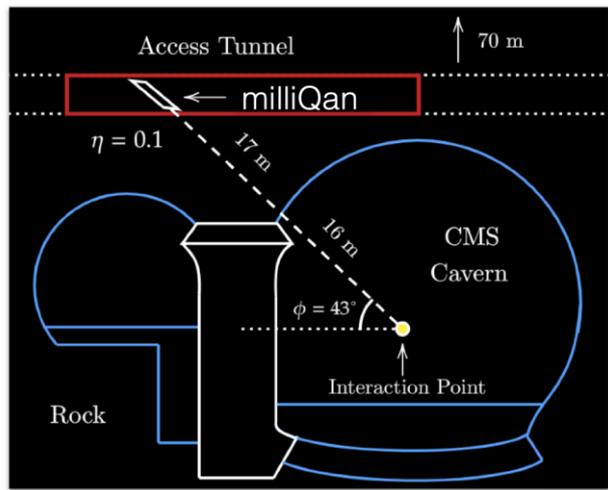
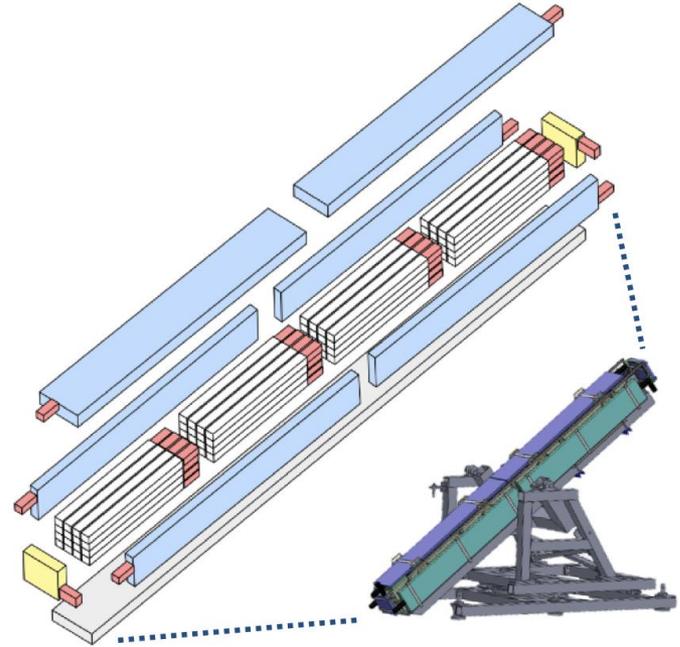
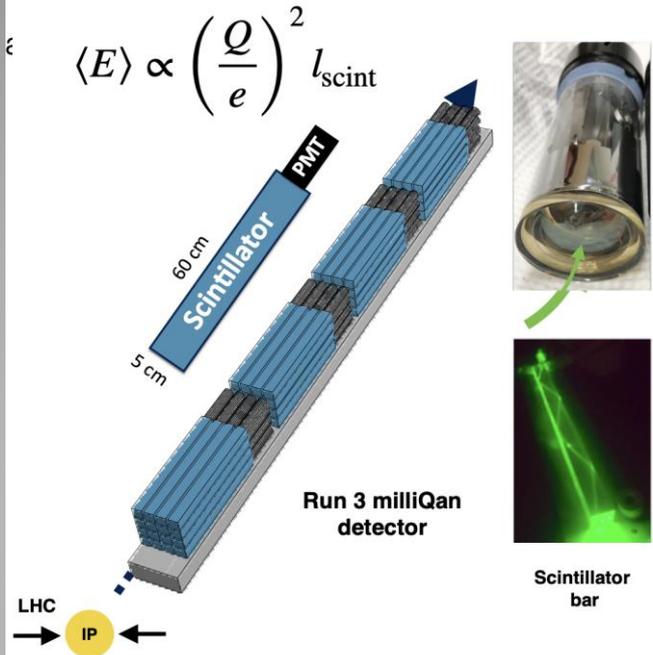
We propose a new experiment at the Large Hadron Collider (LHC) that offers a powerful and model-independent probe for milli-charged particles. This experiment could be sensitive to charges in the range $10^{-3}e - 10^{-1}e$ for masses in the range $0.1 - 100 \text{ GeV}$, which is the least constrained part of the parameter space for milli-charged particles. This is a new window of opportunity for exploring physics beyond the Standard Model at the LHC.



... A new experiment at the LHC



The MilliQan Experiment

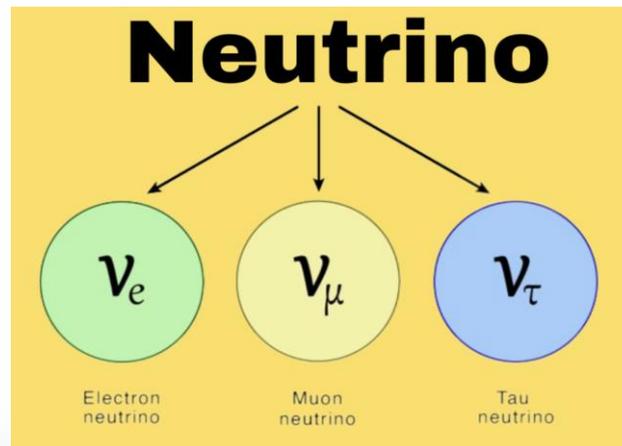


Simple/relatively cheap experiment:
 Detector principle is scintillator bars + photomultiplier readout



Neutrinos!

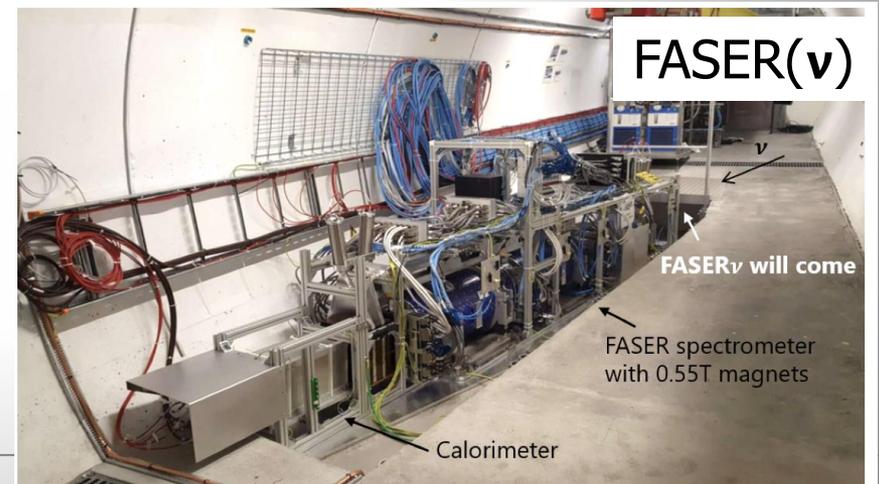
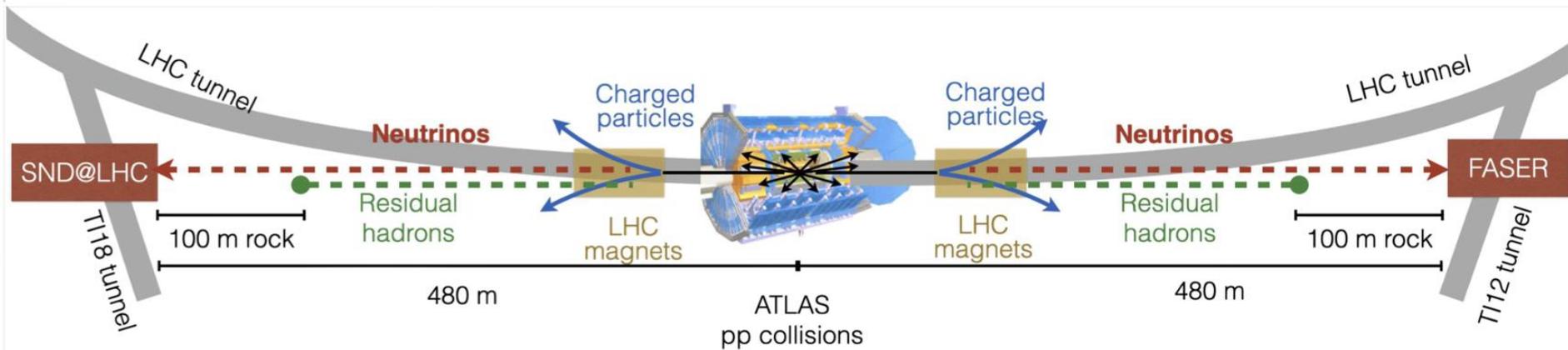
The most mysterious particles that we know!!



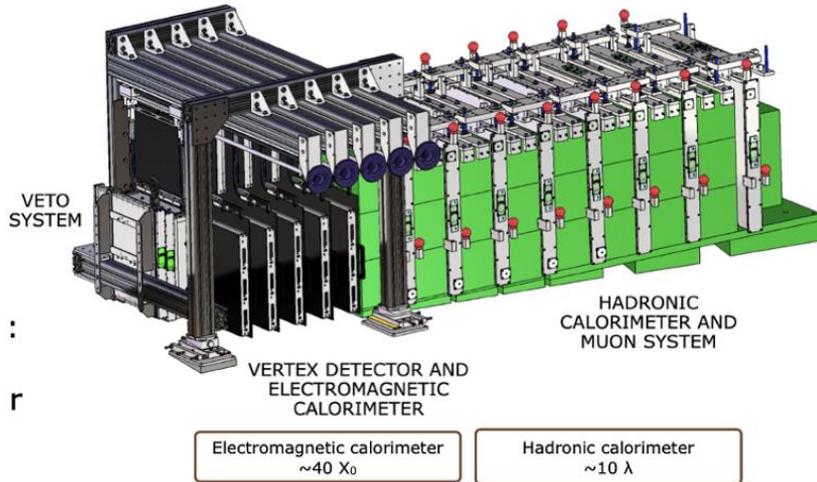
In 1998 it was experimentally established neutrinos have a tiny but non-zero mass. This requires new physics beyond the Standard Model

New: Neutrino Experiments at the LHC

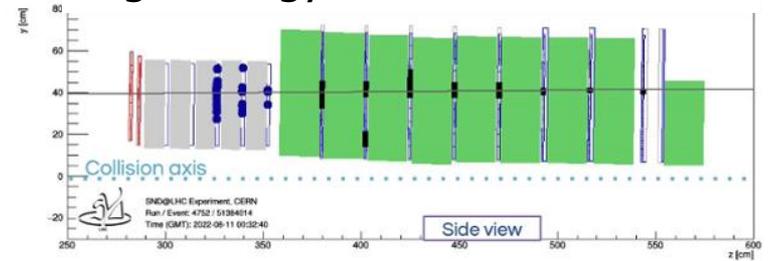
- Two new experiments took data in 2022 480m away from the ATLAS-IP
- Goal: Detection of forward produced neutrinos and search for long lived Beyond the Standard Model particles (dark photons, light DM...)



New: Neutrino Experiments at the LHC



High energy neutrino interaction

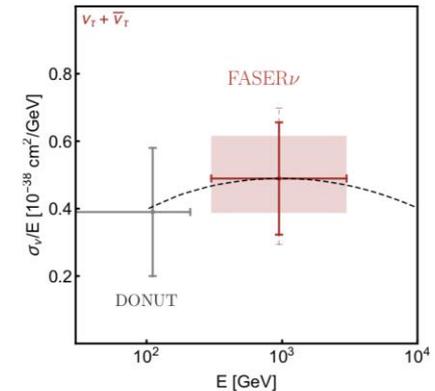
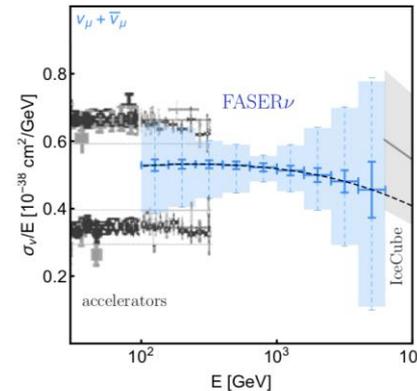
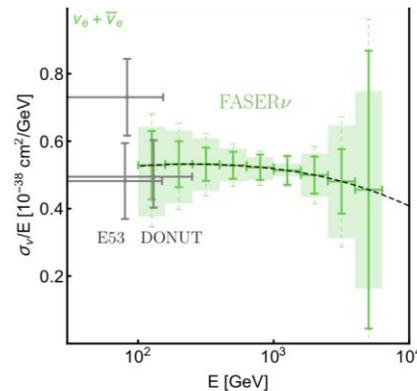
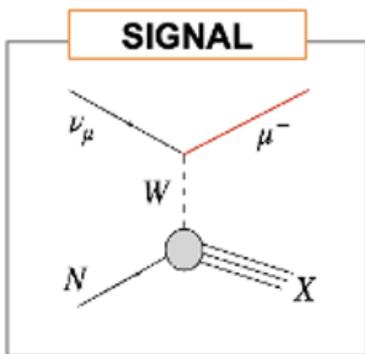


Physics program

- TeV neutrino cross sections
- Neutrino Flavor Universality
- Heavy Flavor production in pp
- CC/NC process ratios

- Observed ν_μ candidates: 8 (expected 5)
- Preliminary estimate of background yield: 0.2

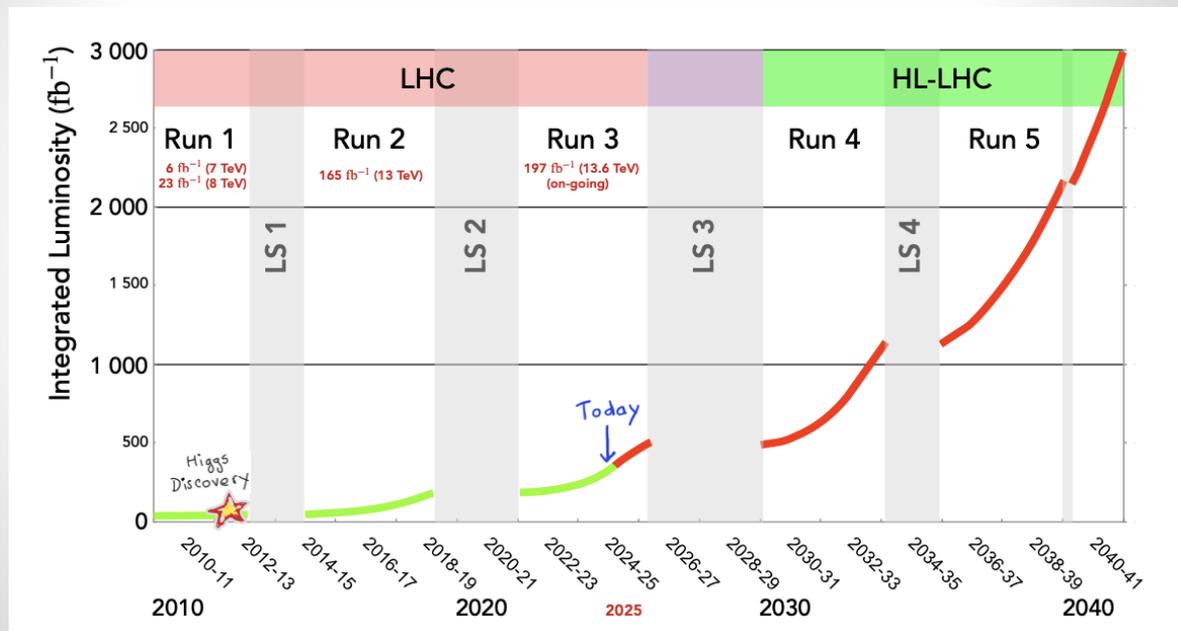
Prospects (by 2026)



Next Steps at the LHC

The Large Hadron Collider is presently scheduled to operate till 2041. In 2030 starts the High Luminosity (HL-LHC) operation.

It should collect 10 times more integrated luminosity (number of collisions) than what has been collected so far



Detectors like CMS and ATLAS will be upgraded in 2027-2029 to deal with the 5x higher peak luminosity at the HL-LHC

Major topics: searches for anomalies, new Higgs studies, precision measurements e.g. on top quarks

We Expect Answers from the LHC, but...

Will LHC answer all questions?: **Likely not**

Some/all New Particles out of mass range?

Need for higher energies at colliders?

Higher precision measurements needed

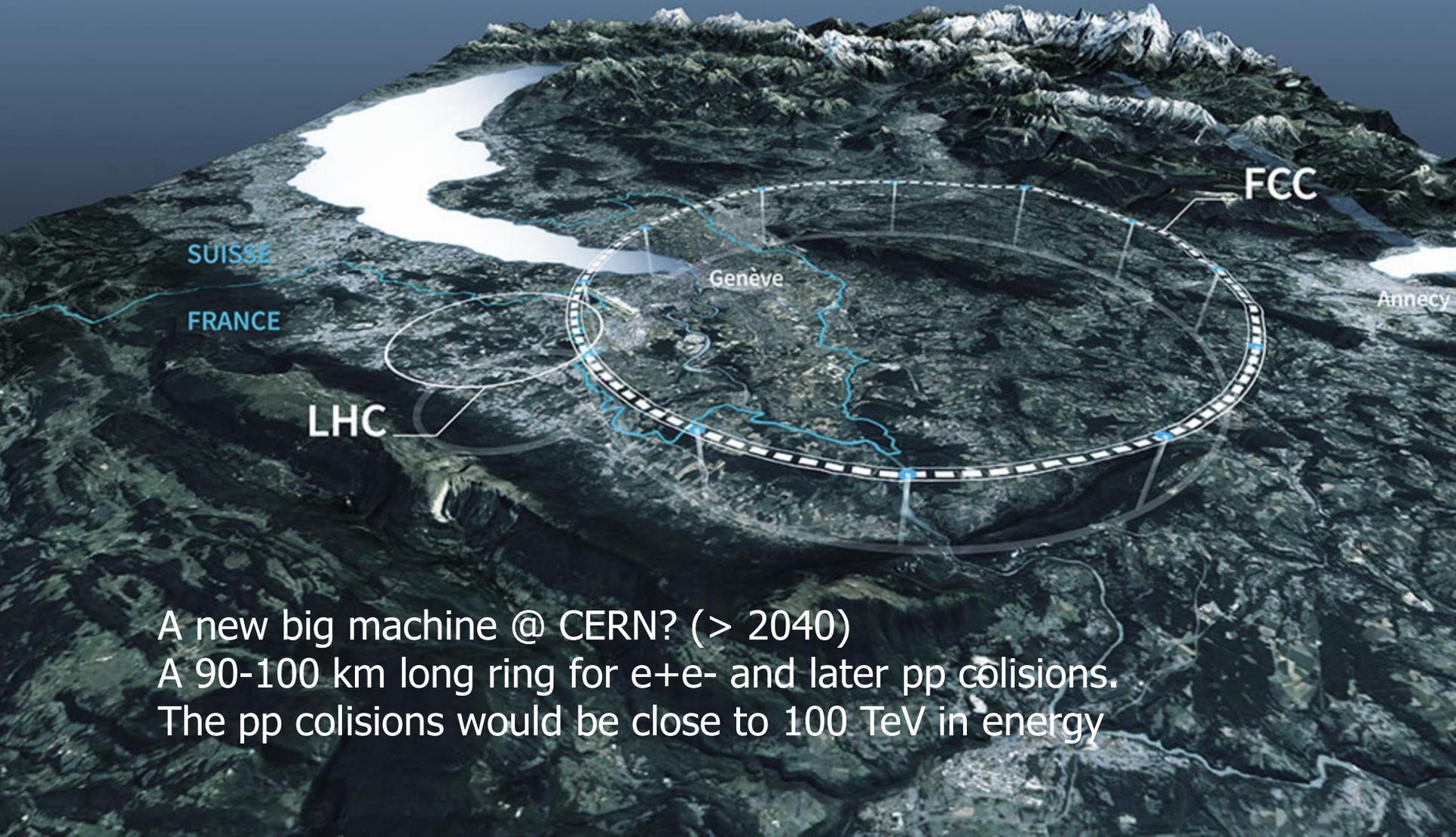
Need for higher luminosity or $e+e^-$?

Measuring details of the Higgs?

Need for a Higgs factory?

2019: European Particle Physics Strategy -> study the Higgs with best possible precision!! **Several future projects are being studied**

A Future Collider @ CERN?



A new big machine @ CERN? (> 2040)
A 90-100 km long ring for e^+e^- and later pp collisions.
The pp collisions would be close to 100 TeV in energy

Future Circular Collider Study

Goal: CDR for European Strategy Update 2018/19

International collaboration to Study Colliders fitting in a new ~100 km infrastructure, fitting in the *Genevois*

- *Ultimate goal:* ≥ 16 T magnets
 ≥ 100 TeV *pp*-collider (*FCC-hh*)

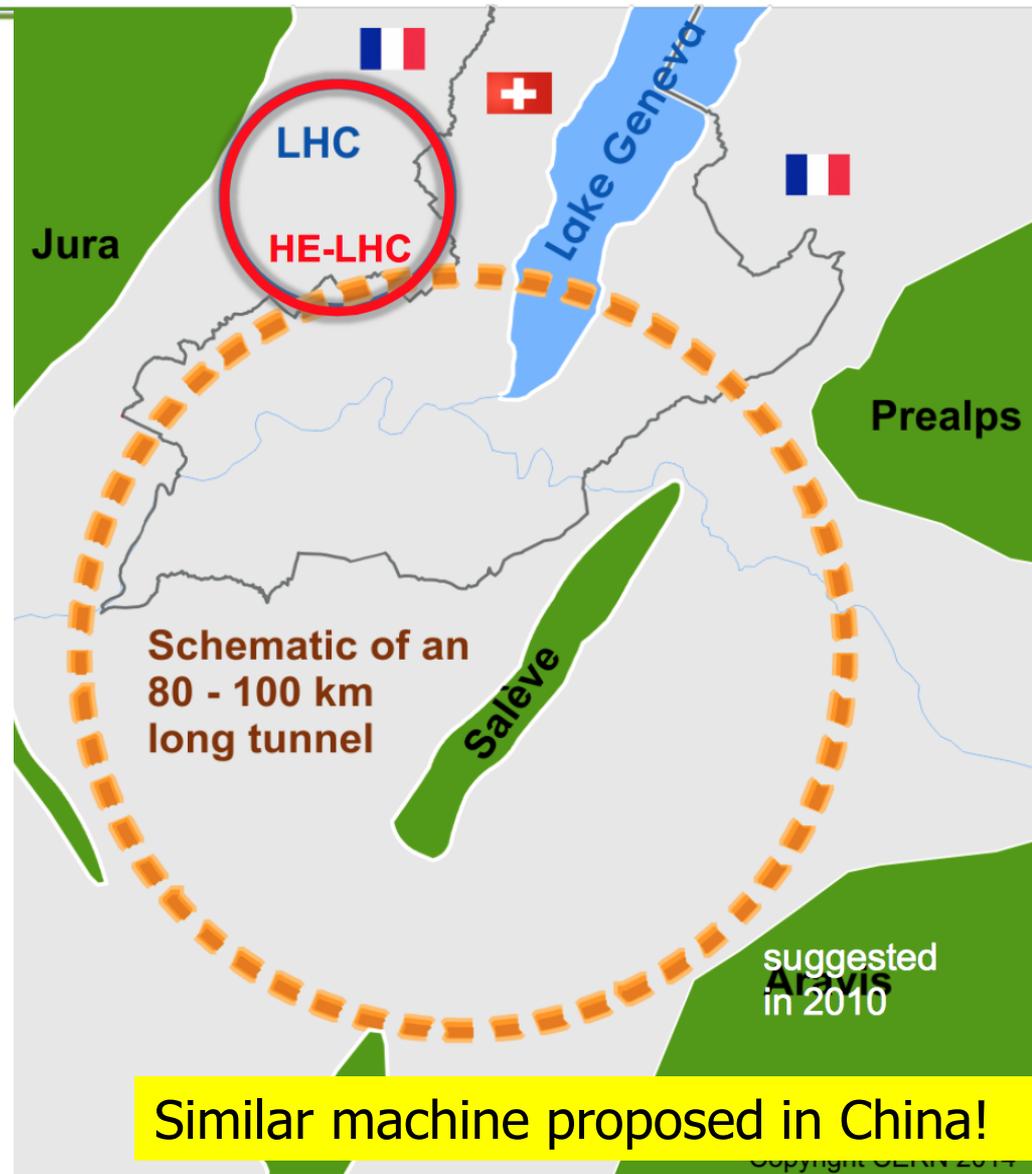
→ defining infrastructure requirements

Two possible first steps:

- e^+e^- collider (*FCC-ee*)
High Lumi, $E_{\text{CM}} = 90\text{-}400$ GeV
- *HE-LHC* 16T \Rightarrow 27 TeV
in LEP/LHC tunnel

Possible addition:

- p - e (*FCC-he*) option



Summer 2012 the CMS and ATLAS experiment found a new particle, with a mass of 125-126 GeV, which looked like the long sought fundamental scalar boson, postulated in 1964.

This is a brand new fundamental particle, never seen before!

This Higgs boson is 'very light' which suggest new physics Beyond the Standard Model will be needed. Supersymmetry? Other? Can we produce Dark Matter at the LHC? We are looking for it!!

Other important study areas, e.g. high energy neutrinos...

The Higgs discovery has launched a new program for new studies: Higgs factories, higher energy pp colliders, high intensity beams...

Detectors play a crucial role in our capabilities to explore and search for new phenomena beyond the Standard Model

We look forward to the future high intensity run of the LHC

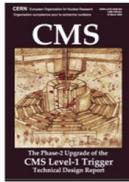
....maybe one day soon



Backup

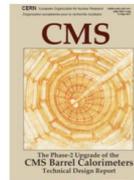


CMS Upgrade Projects



L1-Trigger

- <https://cds.cern.ch/record/2714892>
- Tracks in L1-Trigger at 40 MHz
- Particle Flow selection
- 750 kHz L1 output
- 40 MHz data scouting



Barrel Calorimeters

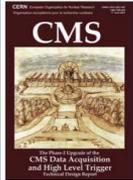
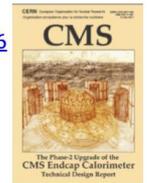
- <https://cds.cern.ch/record/2283187>
- ECAL crystal granularity readout at 40 MHz with precise timing for e/γ at 30 GeV
- ECAL and HCAL new Back-End boards

Absorber (-1 endcap)



Calorimeter Endcap (HGCAL)

- <https://cds.cern.ch/record/2293646>
- 3D showers and precise timing
- Si, Scint+SiPM in Pb/W-SS

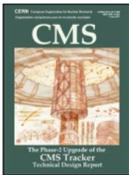


DAQ & High-Level Trigger

- <https://cds.cern.ch/record/2759072>
- Full optical readout
- Heterogenous architecture
- 60 TB/s event network
- 7.5 kHz HLT output

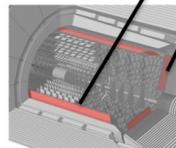


First double disk



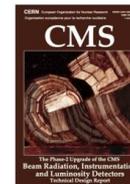
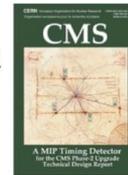
Tracker

- <https://cds.cern.ch/record/2272264>
- Si-Strip and Pixels increased granularity
- Design for tracking in L1T
- Extended coverage to $\eta \approx 3.8$



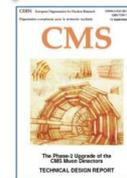
MIP Timing Detector

- <https://cds.cern.ch/record/2667167>
- Precision timing with:
 - Barrel layer: Crystals + SiPMs
 - Endcap layer: Low Gain Avalanche Diodes



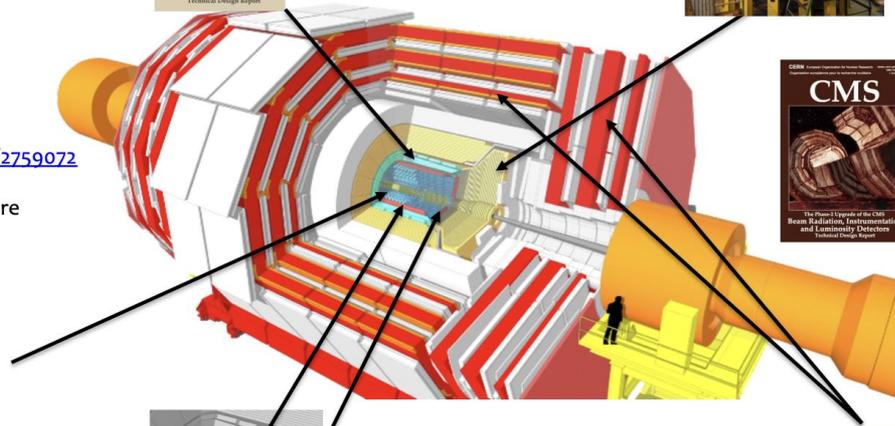
Beam Radiation Instr. and Luminosity

- <http://cds.cern.ch/record/2759074>
- Beam abort & timing
- Beam-induced background
- Bunch-by-bunch lumi: 1% offline, 2% online
- Neutron and mixed-field radiation monitors



Muon systems

- <https://cds.cern.ch/record/2283189>
- DT & CSC new FE/BE readout
- RPC back-end electronics
- New GEM/RPC $1.6 < \eta < 2.4$
- Extended coverage to $\eta \approx 3$



The Phase II upgrade program



[ATL-UPGRADE-PUB-2025-001/](#)

1% luminosity accuracy
New and upgraded forward
and luminosity detectors

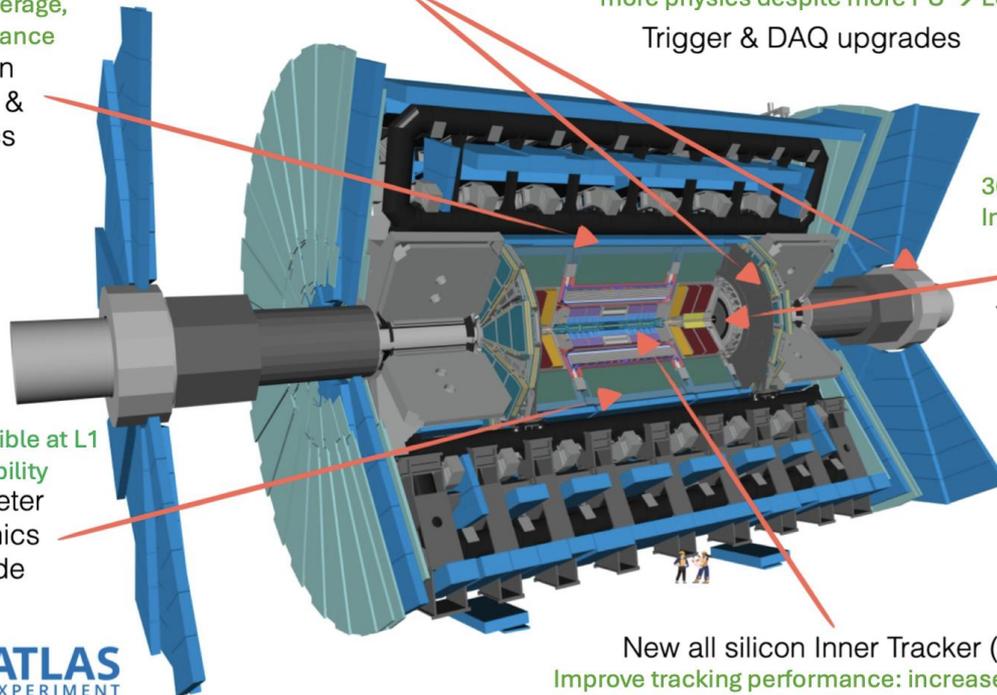
Improve trigger performance/rate:
more physics despite more PU → L0 trigger at 1 MHz, EF 10kHz
Trigger & DAQ upgrades

Improve muon trigger coverage,
electronics and performance
New muon
chambers &
electronics

30ps time resolution per track
Improve PU rejection in forward region
New High
Granularity
Timing Detector
(HGTD)

Full granularity data accessible at L1
trigger, increased rate capability
Calorimeter
electronics
upgrade

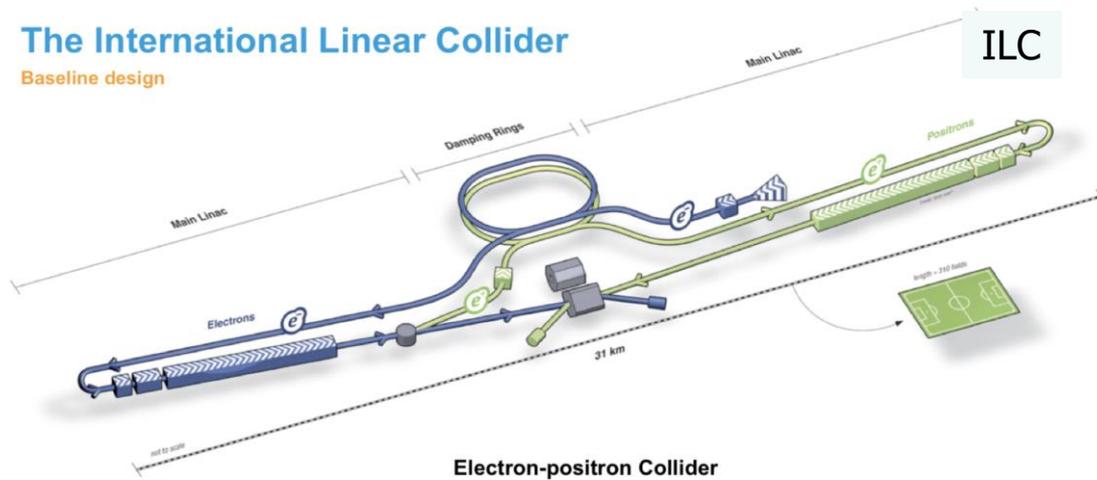
New all silicon Inner Tracker (ITk)
Improve tracking performance: increased coverage,
reduced occupancy, better track p_T resolution



Possible Future e+e- Projects

The International Linear Collider

Baseline design



Electron-positron Collider

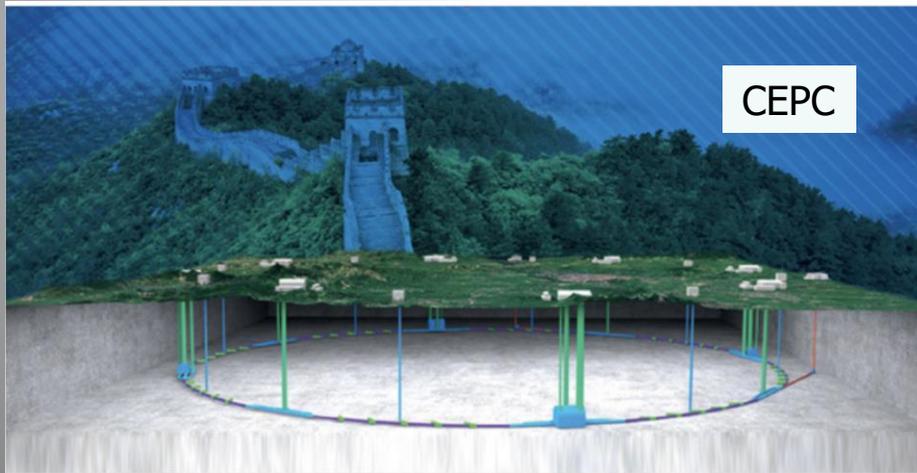
ILC

ILC Japan?

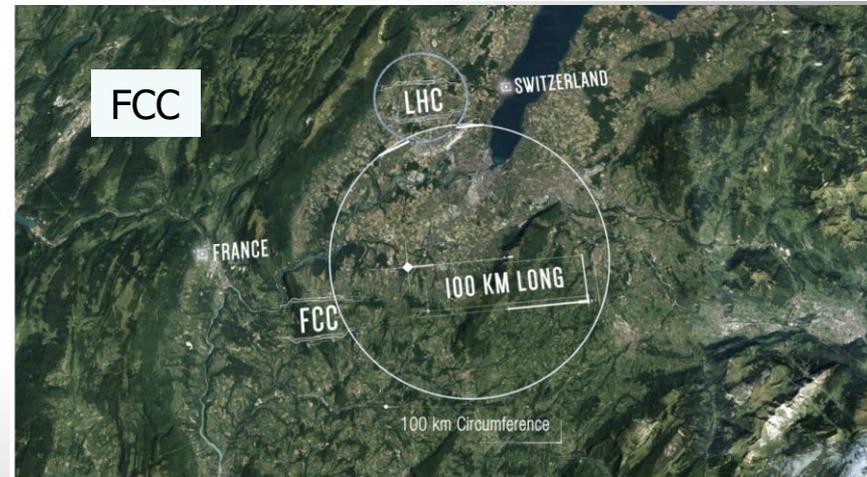
- Superconducting cavities
- 250 GeV CM Energy maximum
- Extendable to 500 GeV
- ~ 30 km long

CEPC (China)? FCC (CERN)

- 365 GeV CM Energy maximum
- ~ 90-100 km long circle



CEPC



FCC

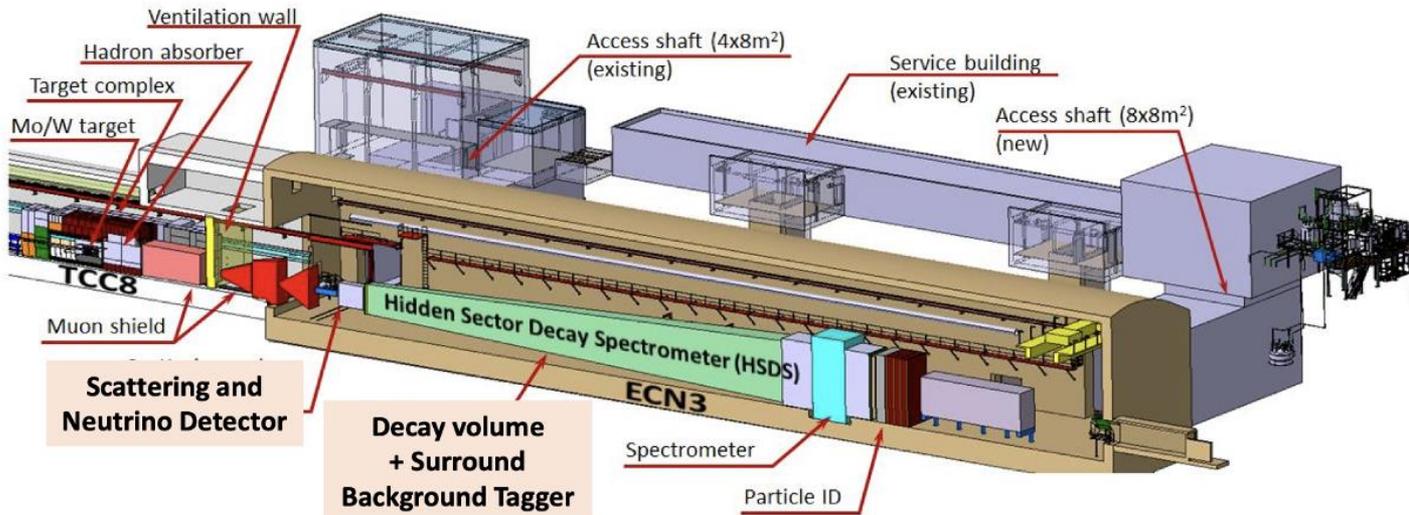
100 km Circumference

2nd stage: 70-120 TeV pp collisions ? Will depend on dipole strenght...

Intensity Frontier: The SHiP Experiment

SHiP: Search for Hidden Particles

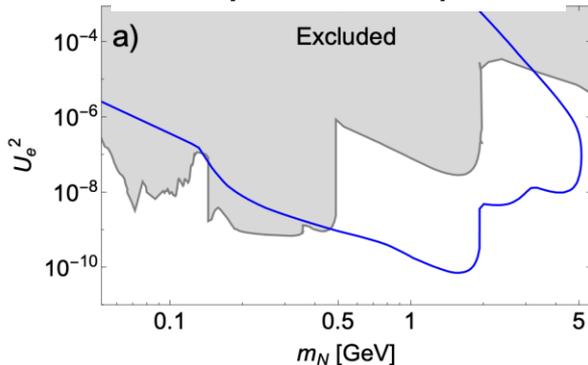
Beamdump experiment @ CERN 400 GeV SPS



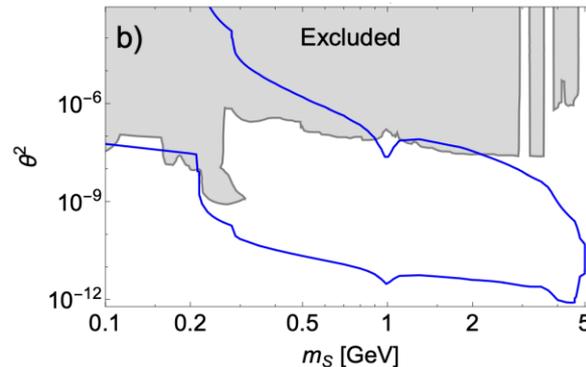
Proposed: 2014
 Selected : 2024
 Data: ~2030

- Searches for
- Light dark matter,
 - Heavy neutral leptons
 - Dark scalars,
 - Axion-like particles
 - Milicharged particles
 - ...

Heavy neutral leptons



Dark Scalars



Based on 6×10^{20} Protons on target
 Limits correspond to 90% CL