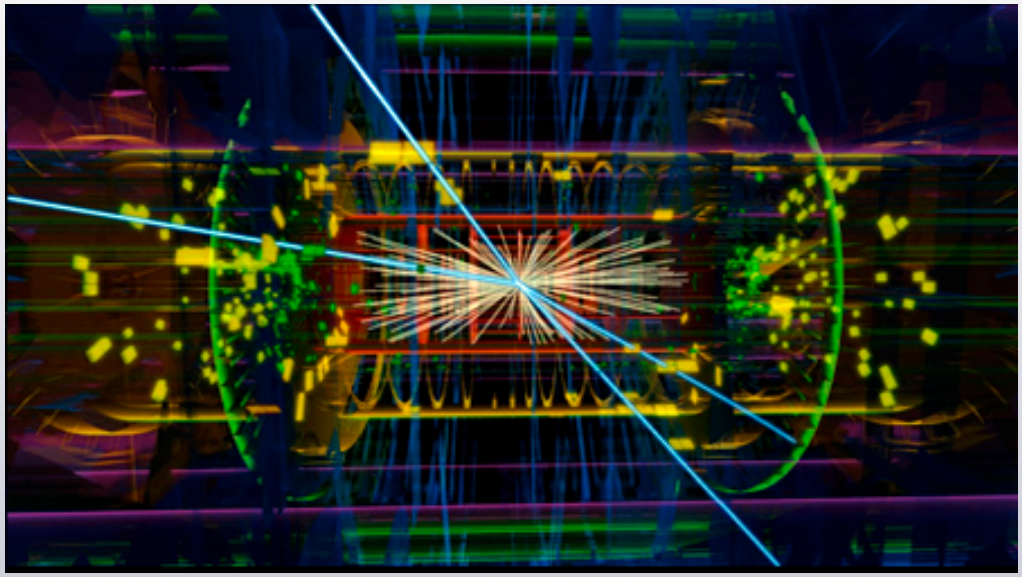

Particle Physics, CERN and the Large Hadron Collider

Juan Rojo
Rudolf Peierls for Theoretical Physics
University of Oxford

St Aloysius Catholic Primary School
Oxford, 23/04/2015

The Stuff of Matter

☑ A **table**, a **cell phone** and a **squirrel** look very different … but ultimately, they are composed by the **same kind of building blocks:** we call them **atoms**

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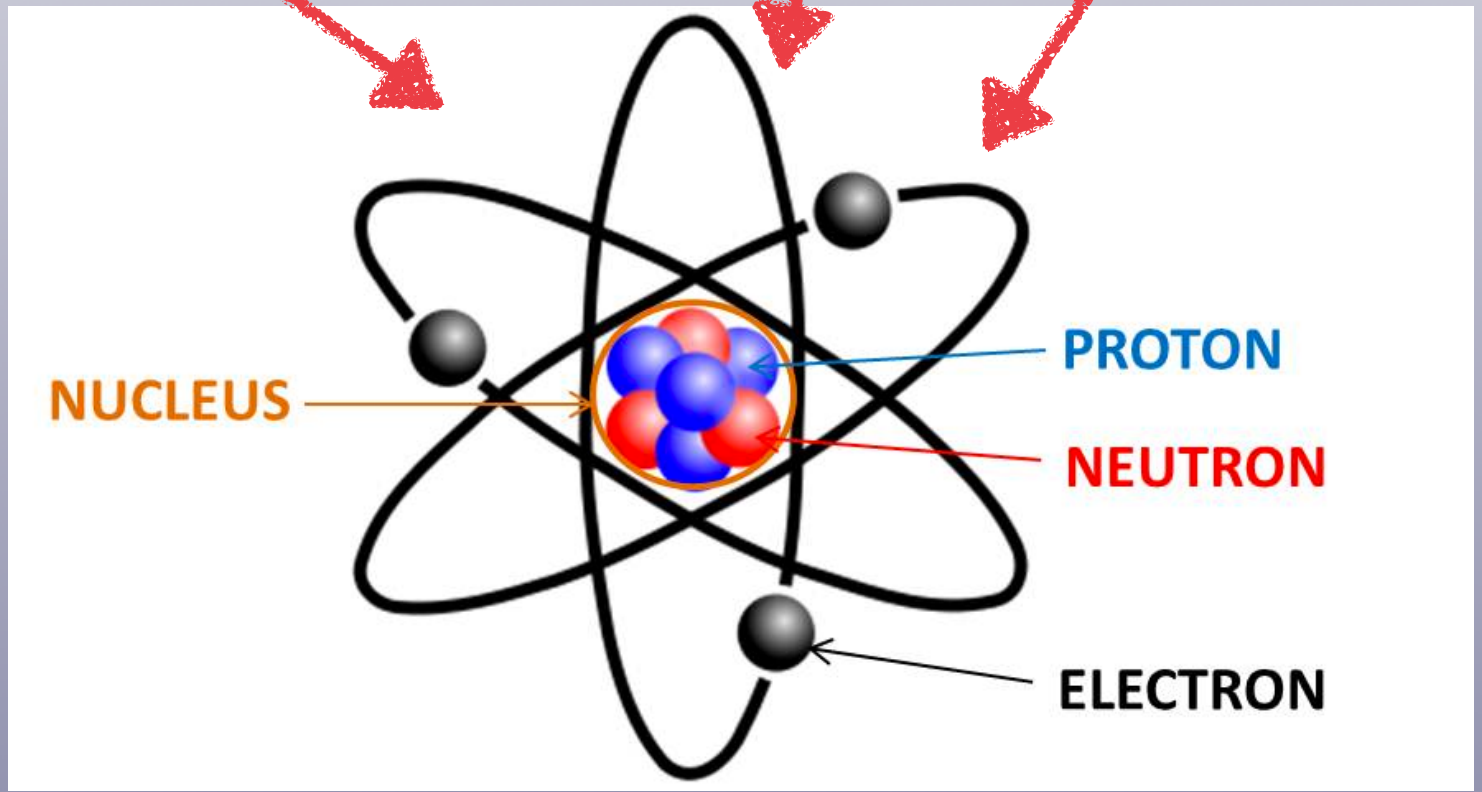

How small are atoms?

A squirrel has a length of **10 centimeters ….**

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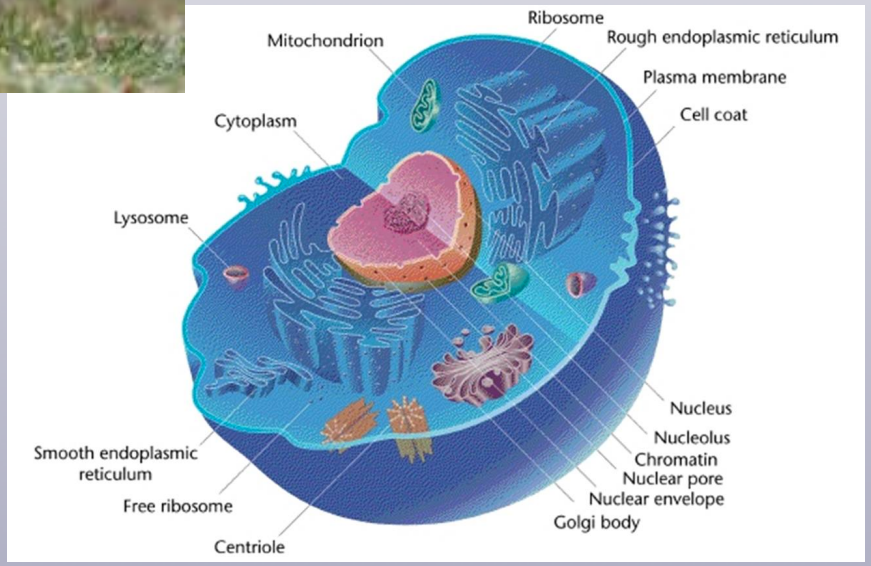
All animals are composed by **cells,** of size 10 **micrometers: 10000 times smaller …..**



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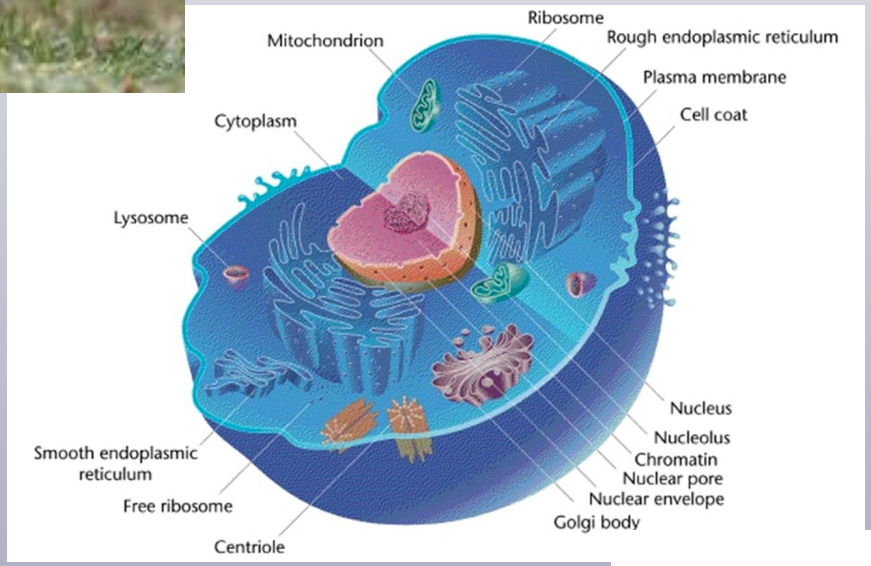
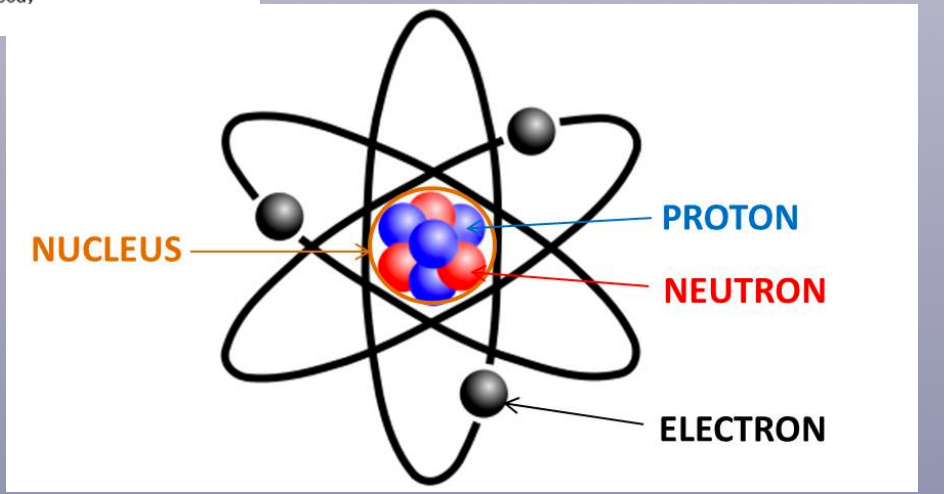
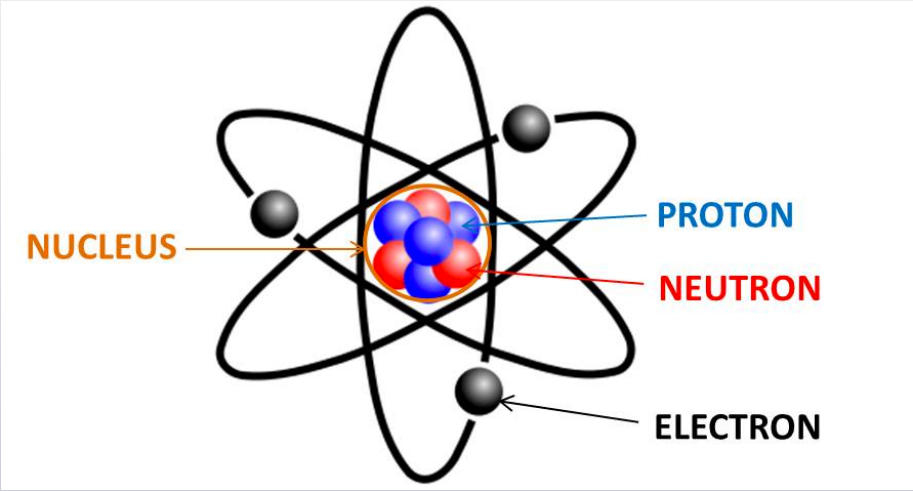


The size of an atom is 0.1 **nanometers, 1000 million times smaller!** Atoms are really very very small!



From atoms to protons to quarks

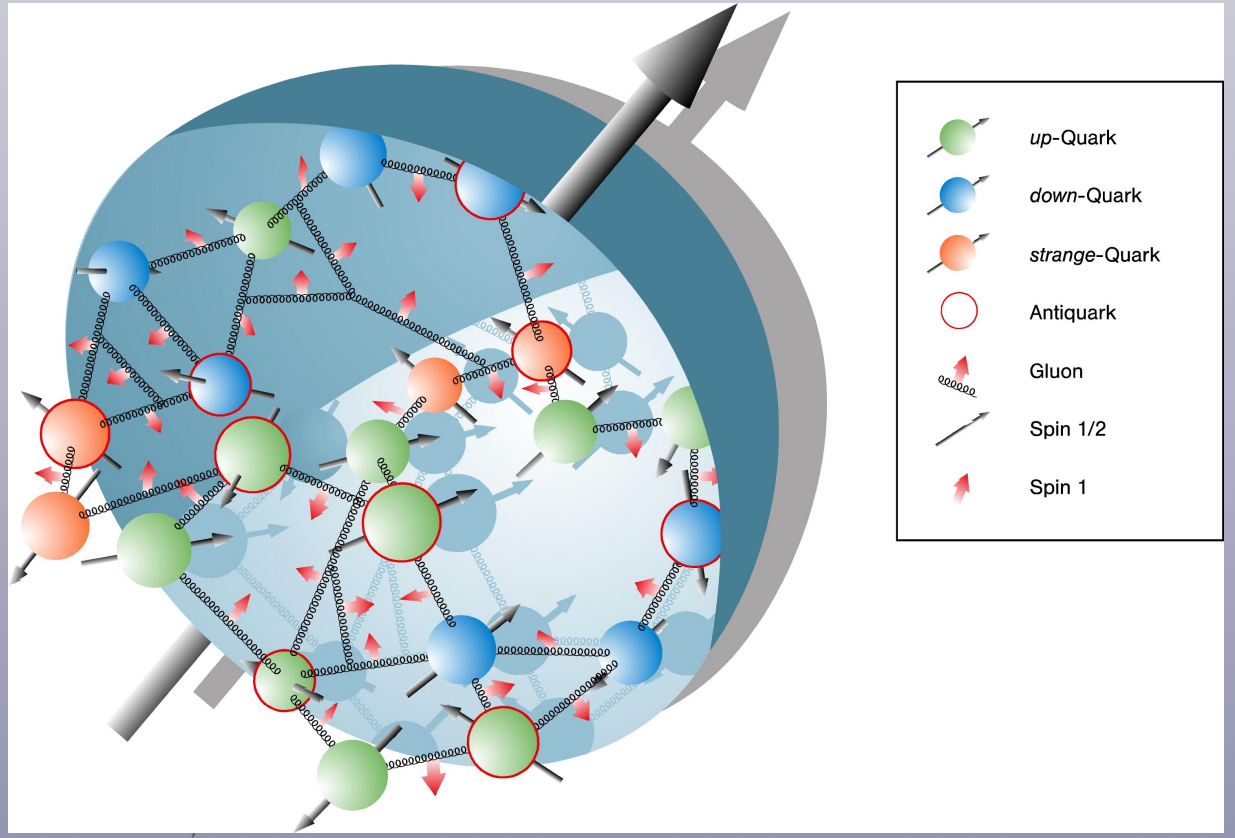


Atoms themselves have even smaller constituents: **protons, neutrons and electrons**

Protons are 10.000 times smaller than atoms!

Even the tiny protons have **smaller constituents:** we call them **quarks and gluons**

Are there **more, even smaller, particles** that we can find? We need **to build gigantic experiments** to answer this!

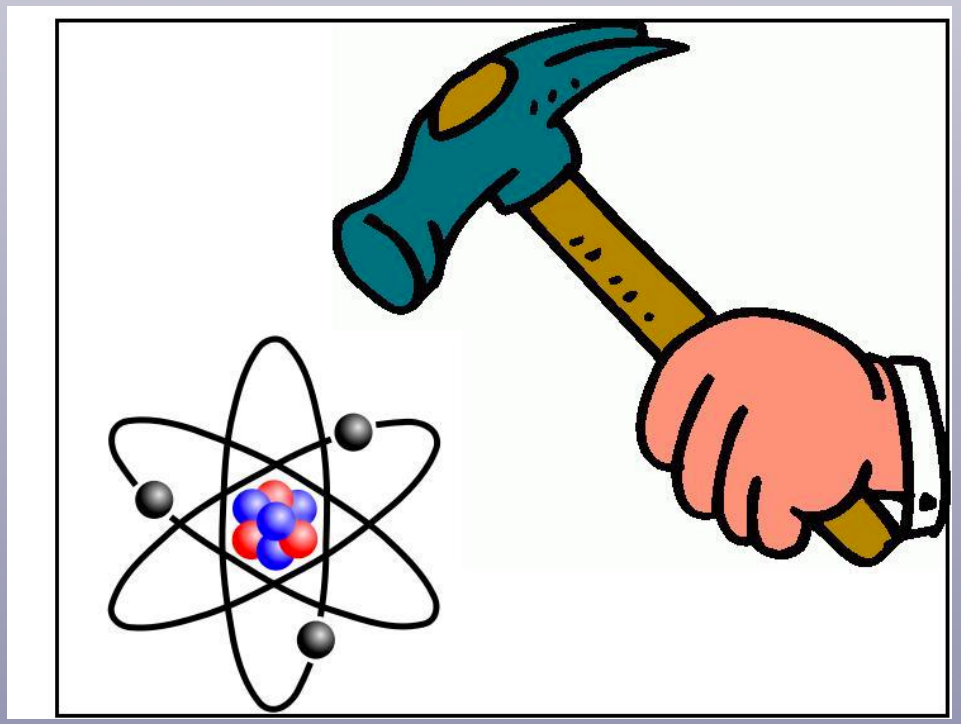


High energy colliders

The idea behind **high-energy colliders** is very simple!

- We want to see **what is inside protons**: we need to **break them**. How we do this?

Bad idea!



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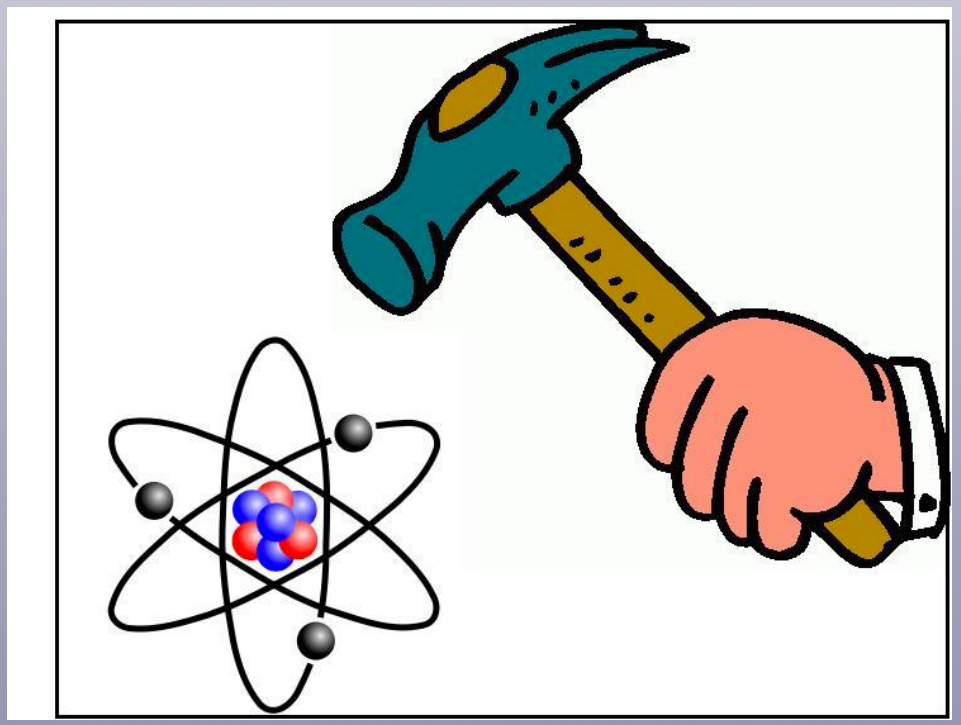
- We want to see **what is inside protons**: we need to **break them**. How we do this?
- We make protons **go very fast**, and then collide them: by looking at the r**esults of the collision,** we can understand the stuff protons are made of, if there are new particles or forces ….
- Since protons are very small, we need **extremely high energies to see inside them**: modern colliders are **gigantic machines**!

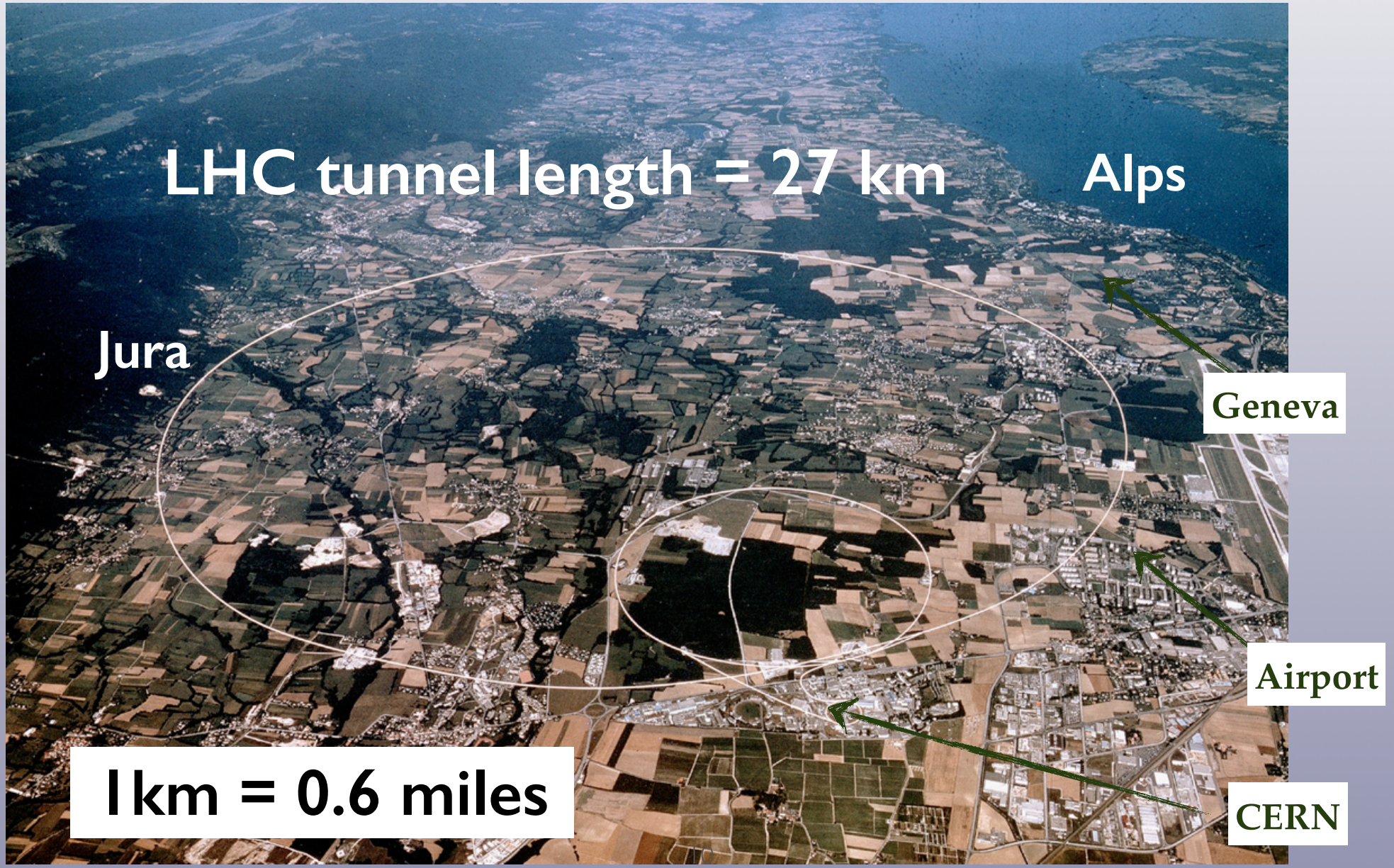
Bad idea!

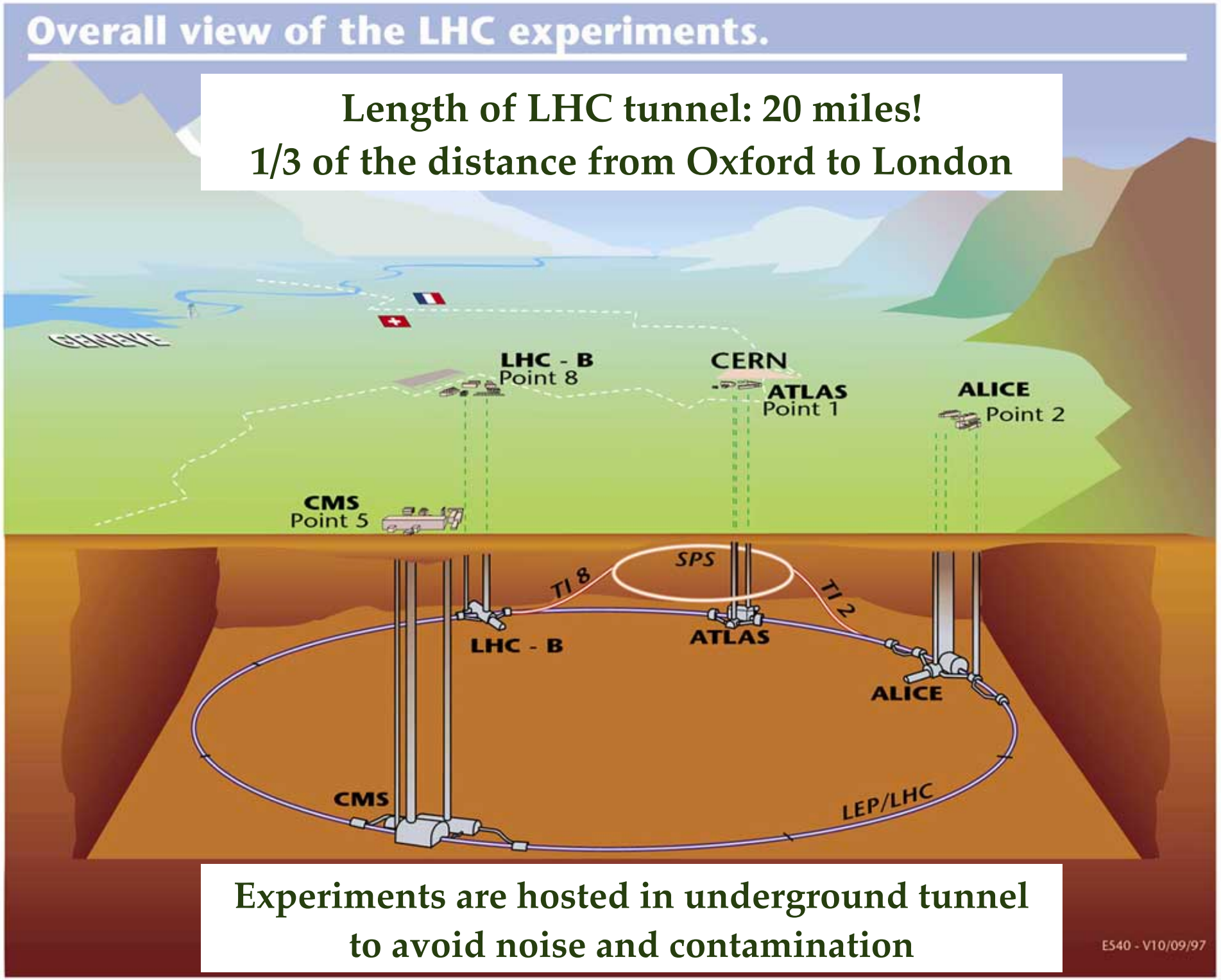


Good idea!

The Large Hadron Collider

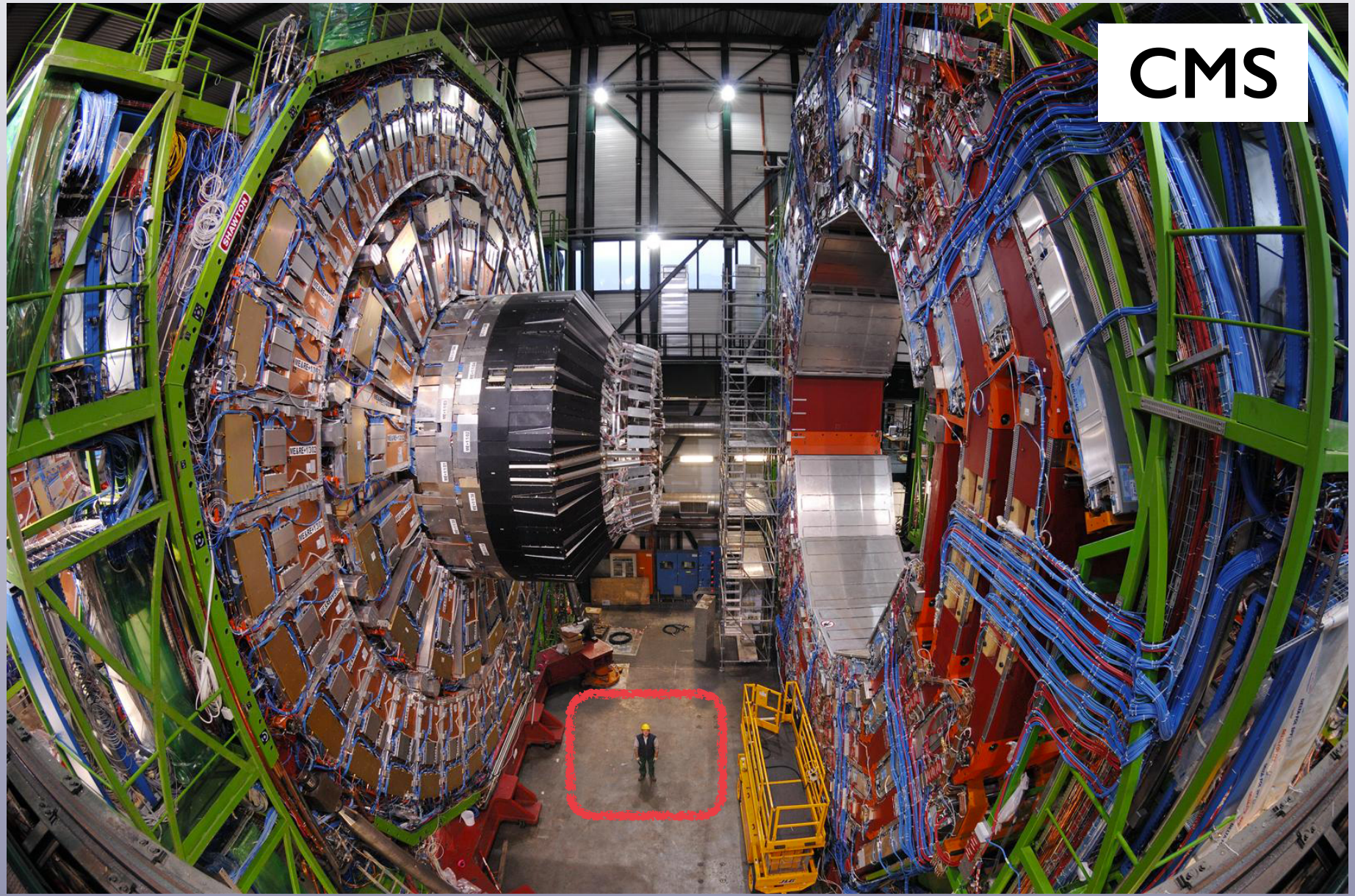
- ☑ The LHC is the **most powerful particle accelerator ever build by mankind**
- ☑ Hosted by CERN in Geneva, the LHC is composed by a **massive 27 km long tunnel** with **four gigantic detectors**

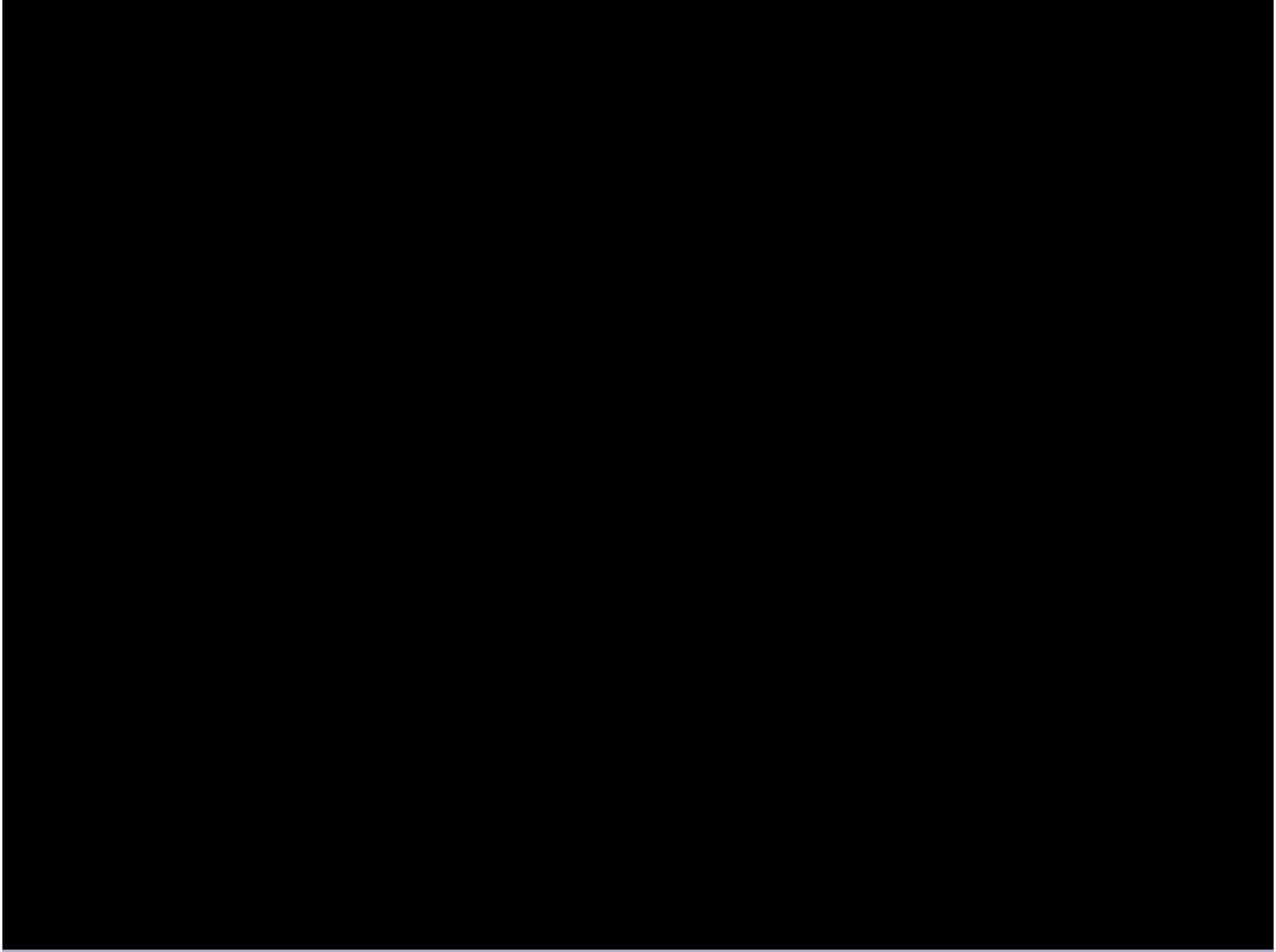



Overall view of the LHC experiments.
Length of LHC tunnel: 20 miles!
1/3 of the distance from Oxford to London
GENEVE
LHC - B
Point 8
CERN
ATLAS
Point 1
ALICE
Point 2
CMS
Point 5
SPS
TI 8
TI 2
LHC - B
ATLAS
ALICE
CMS
LEP/LHC
Experiments are hosted in underground tunnel
to avoid noise and contamination
ES40 - V10/09/97

The LHC Detectors

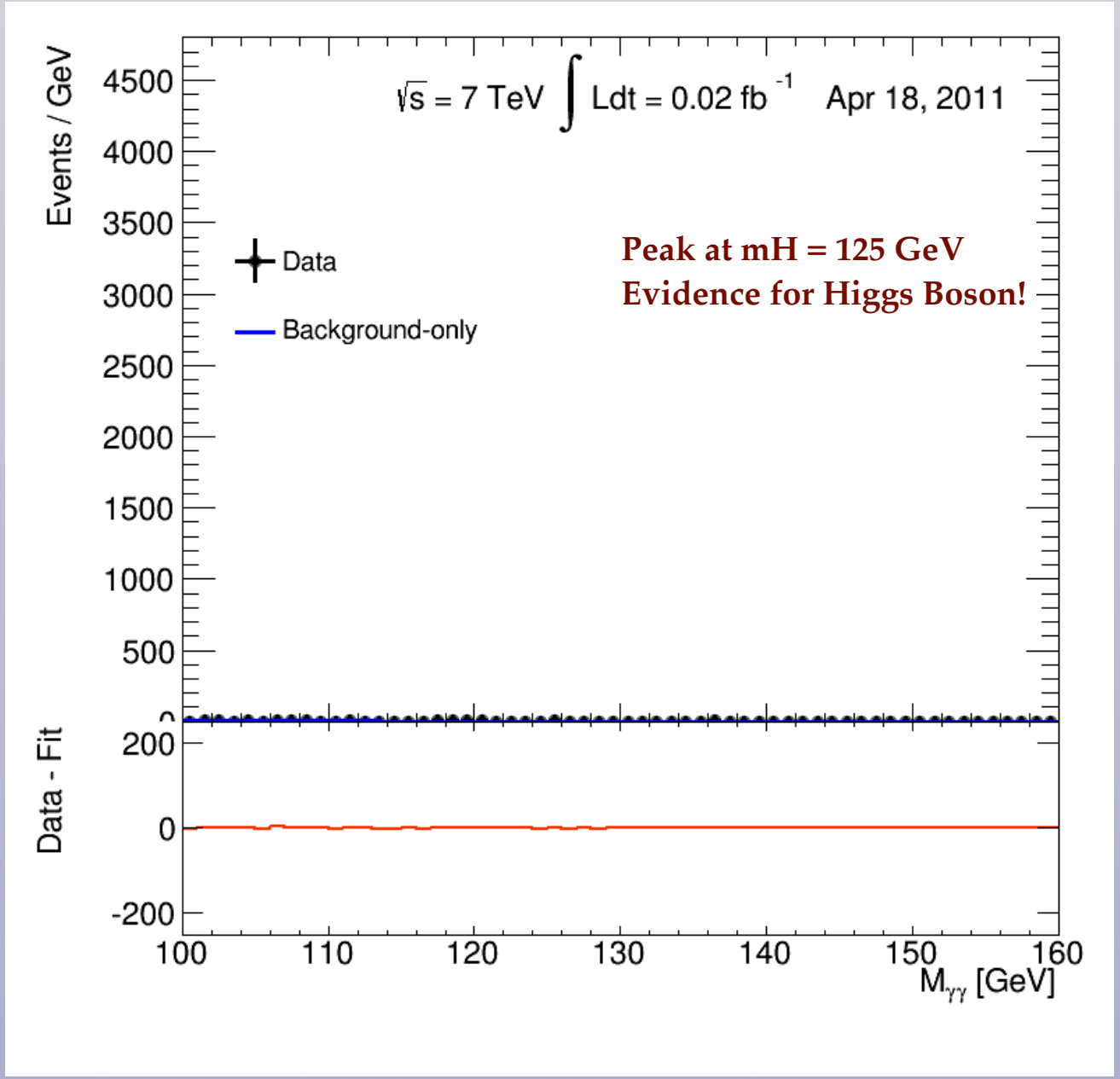
Where proton beams cross and **collisions take place**, huge detectors measure the products of the collision in an attempt to understand **the laws of Nature at the smallest distances**





Discovering New Particles

- At the LHC, we search for new **Fundamental Particles,** like the recently discovered **Higgs Boson,** by **looking for deviations** with respect known processes



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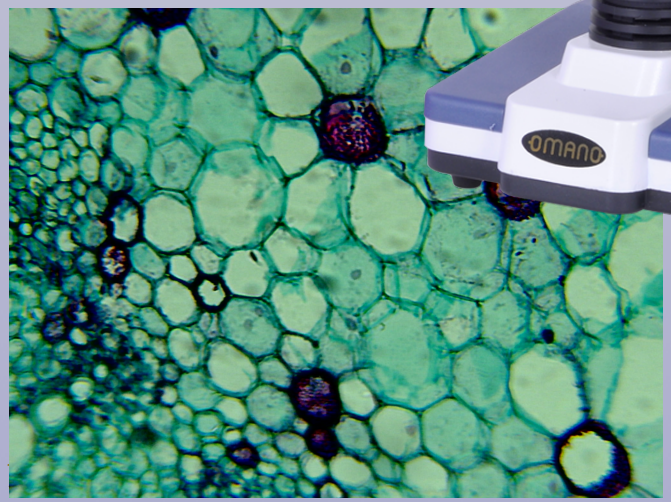
Remarkable facts about the LHC

☑ The LHC is the **most powerful microscope ever constructed**, able to see the smallest things ever seen by mankind!

Just as I can use a **microscope to see cells ….**



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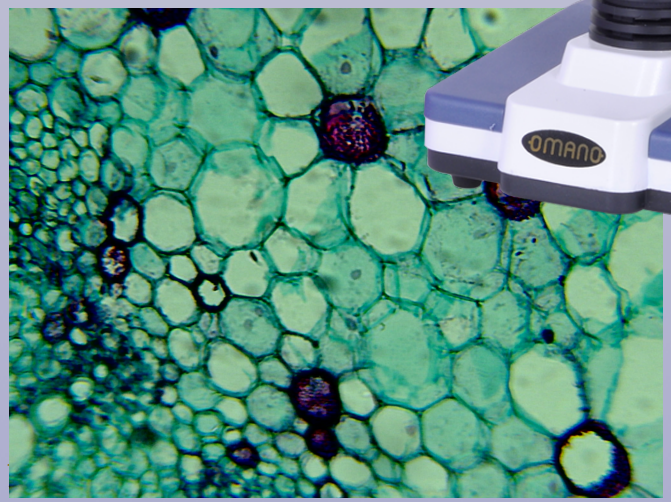
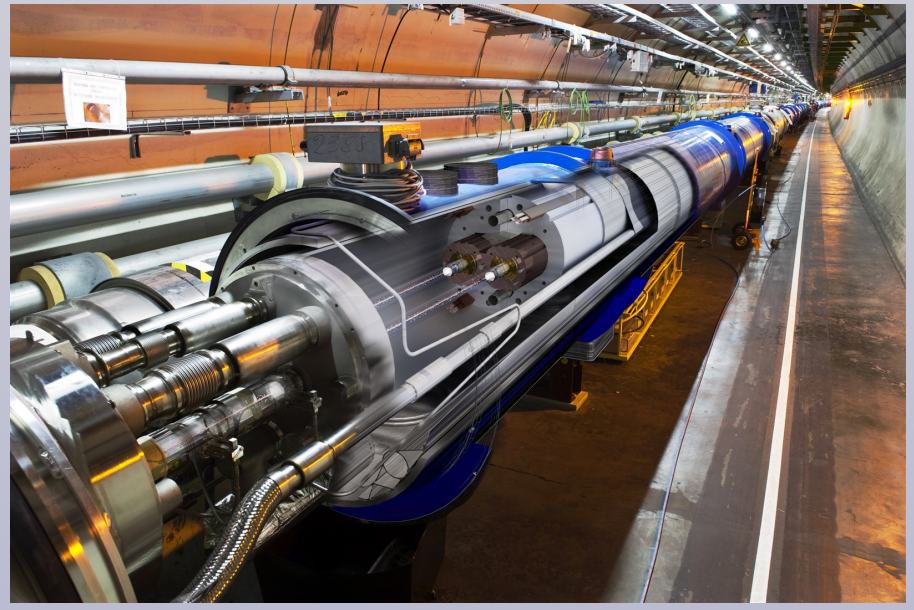
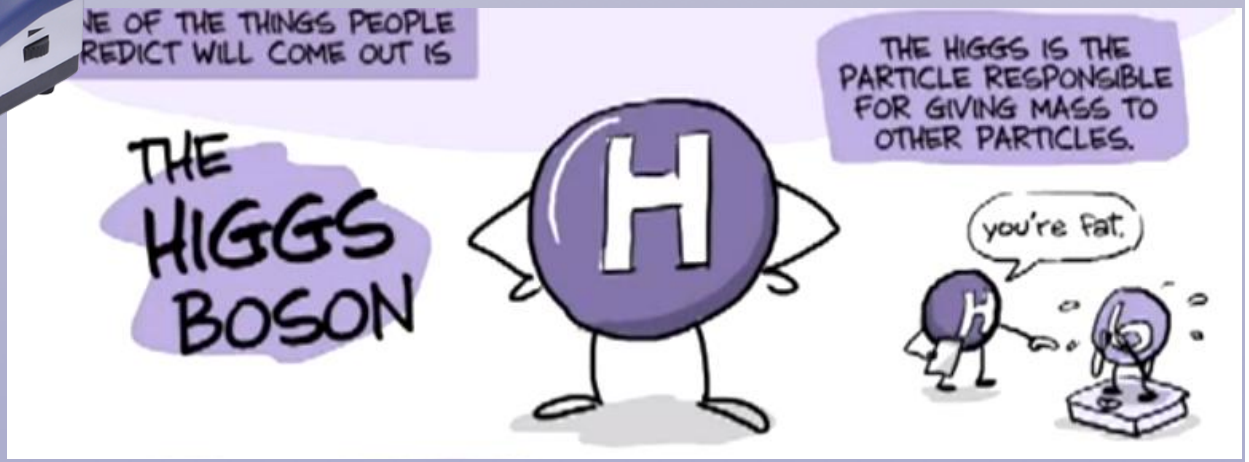


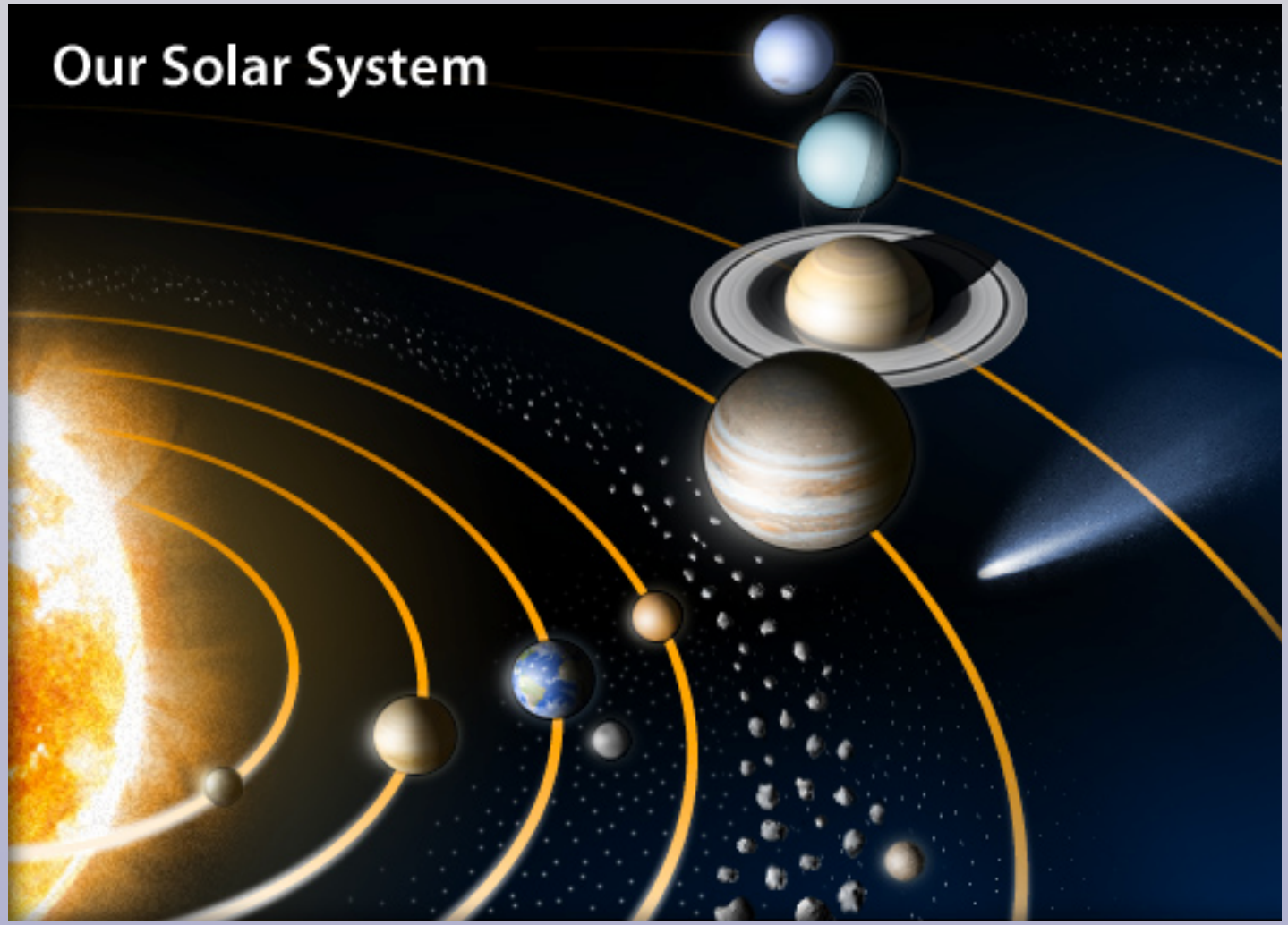
… I can use the LHC **to see new fundamental particles**





Remarkable facts about the LHC

☑ The **emptiest place in the Solar System:** vacuum in the beam pipe similar to **interplanetary space**

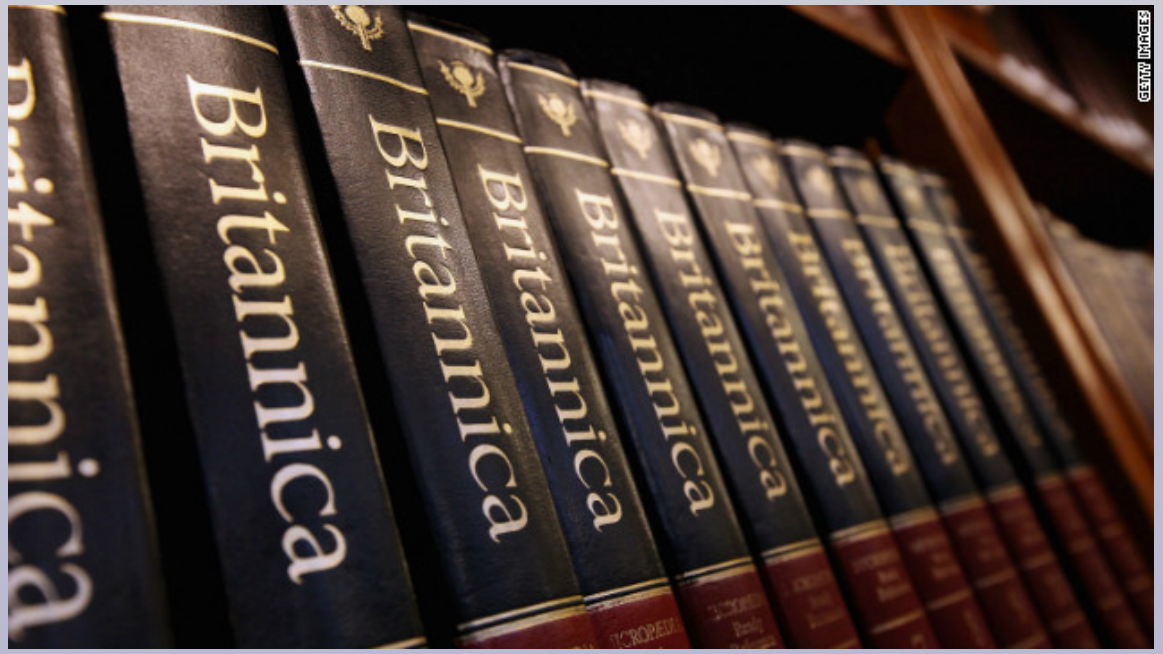


Remarkable facts about the LHC

- One of **coldest places in the Universe:** the LHC magnets are kept at only **1.9 degress** above absolute zero, **colder than interstellar space!**

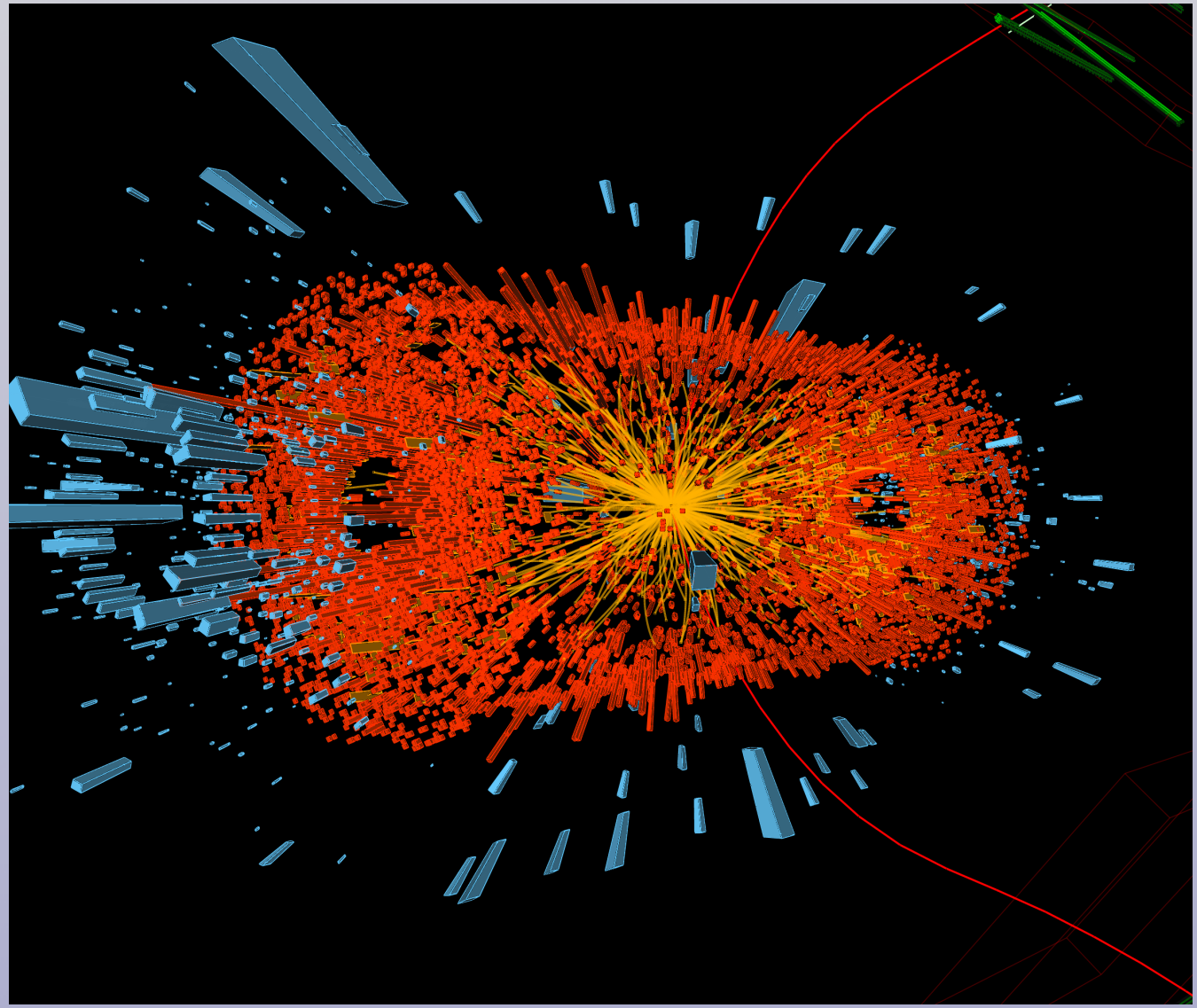
Remarkable facts about the LHC

- The **data volume** recorded is like reading **10,000 times the full Encyclopedia Britannica - each second!**



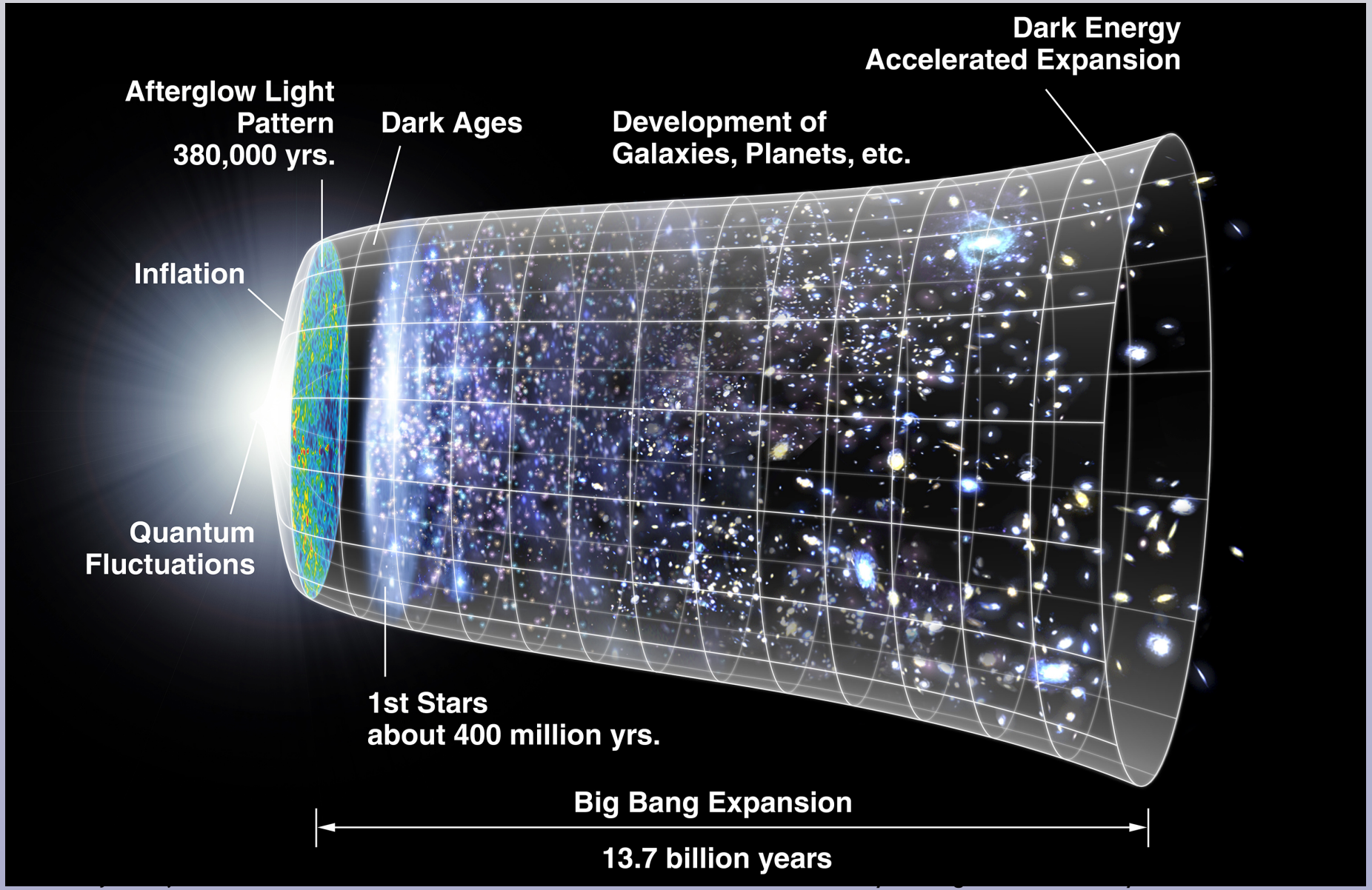
Remarkable facts about the LHC

- One of **hottest places in the Galaxy:** collisions generate a temperature **billions of times larger than the Sun,** reproducing conditions of **early Universe**



Remarkable facts about the LHC

- The LHC is so powerful that can reproduce the conditions of the **Early Universe**, just after the **Big Bang**, about **14 Billion years ago!**

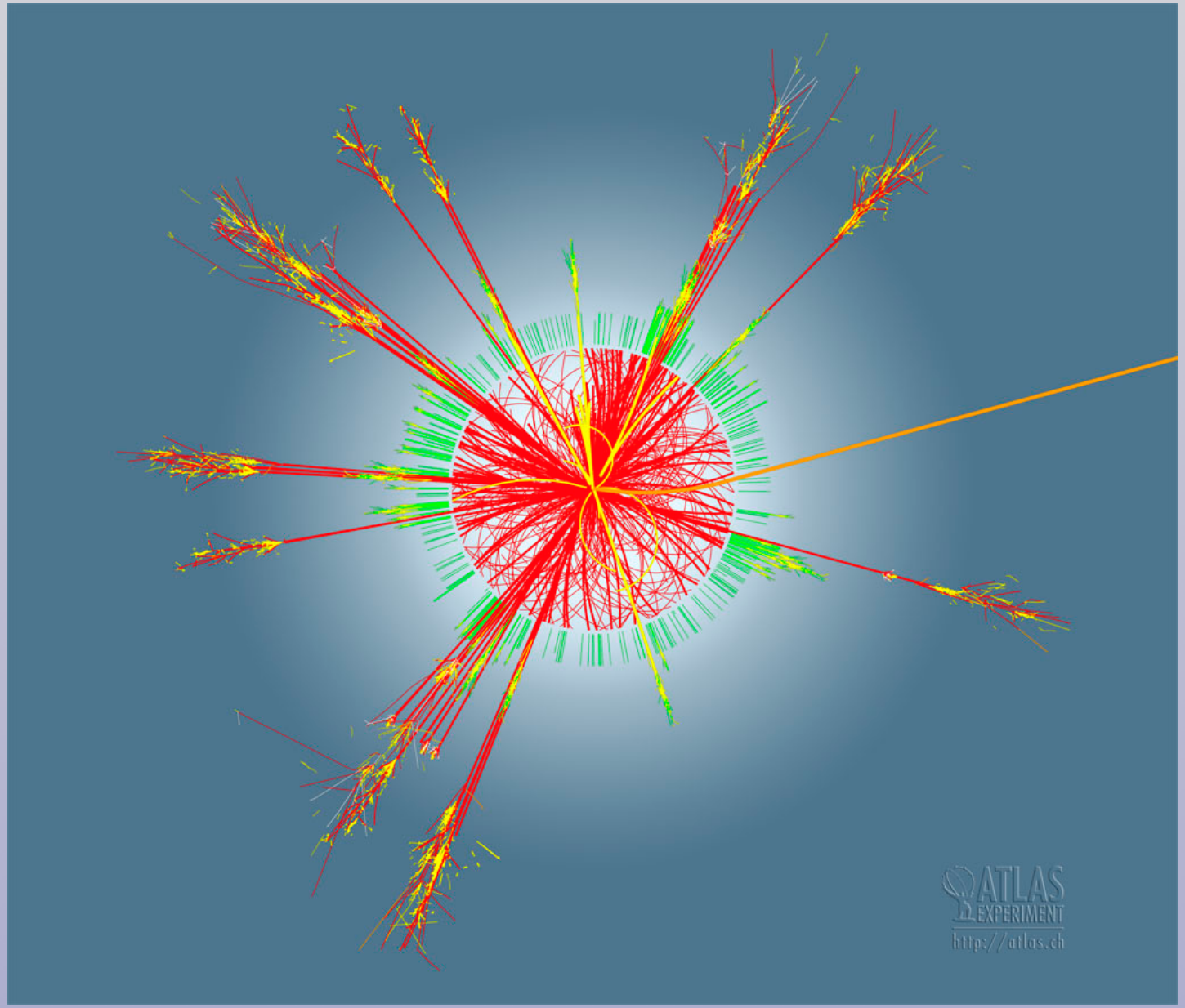


Black Holes at the LHC?

☑ **Black holes** are one of the most fascinating objects in the Universe: **nothing can escape from their attraction**, not even light!

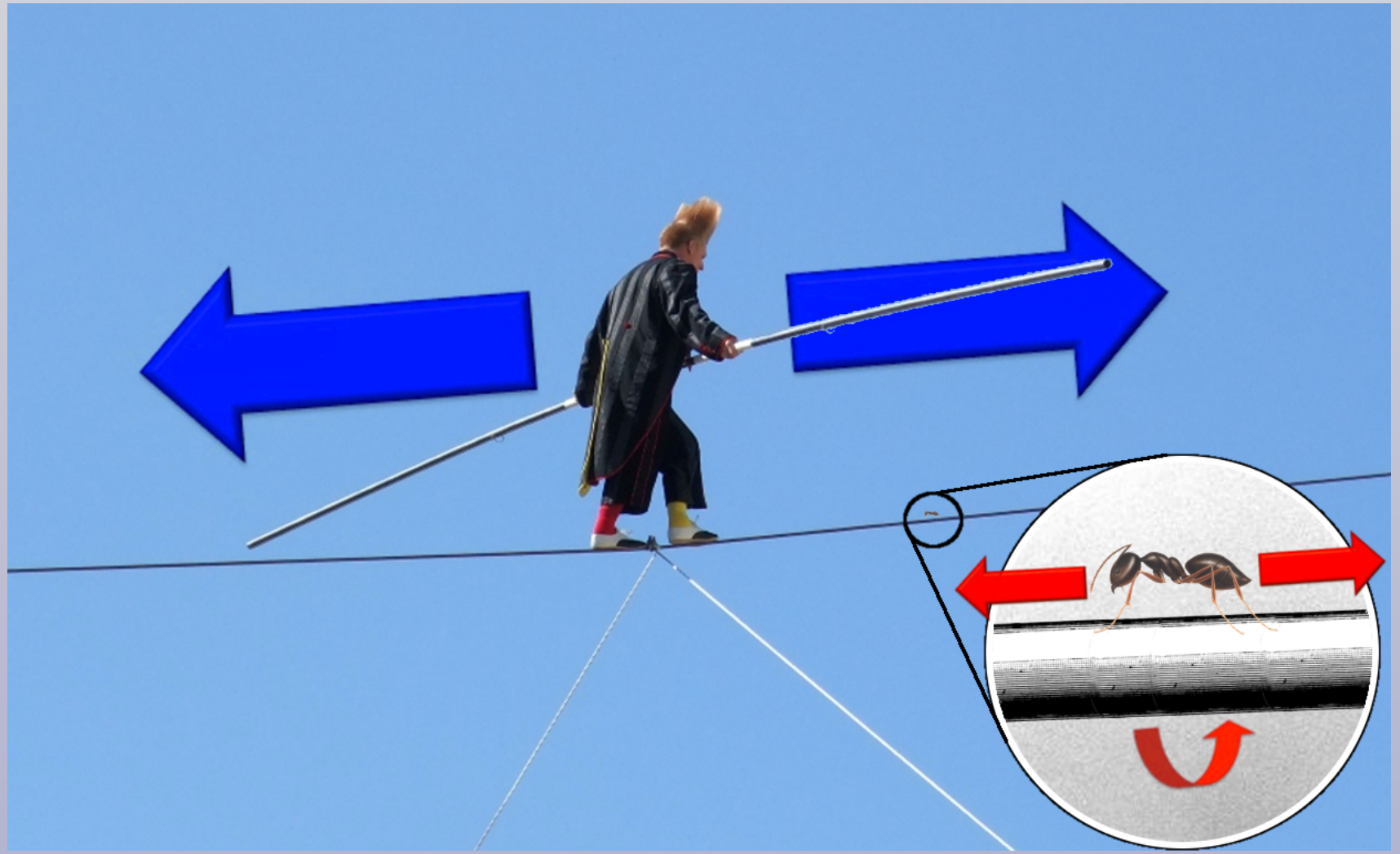
Black Holes at the LHC?

☑ **At the LHC,** we might even create artificially mini **Black Holes**, for example if there are new **space-time dimensions**



Extra Dimensions?

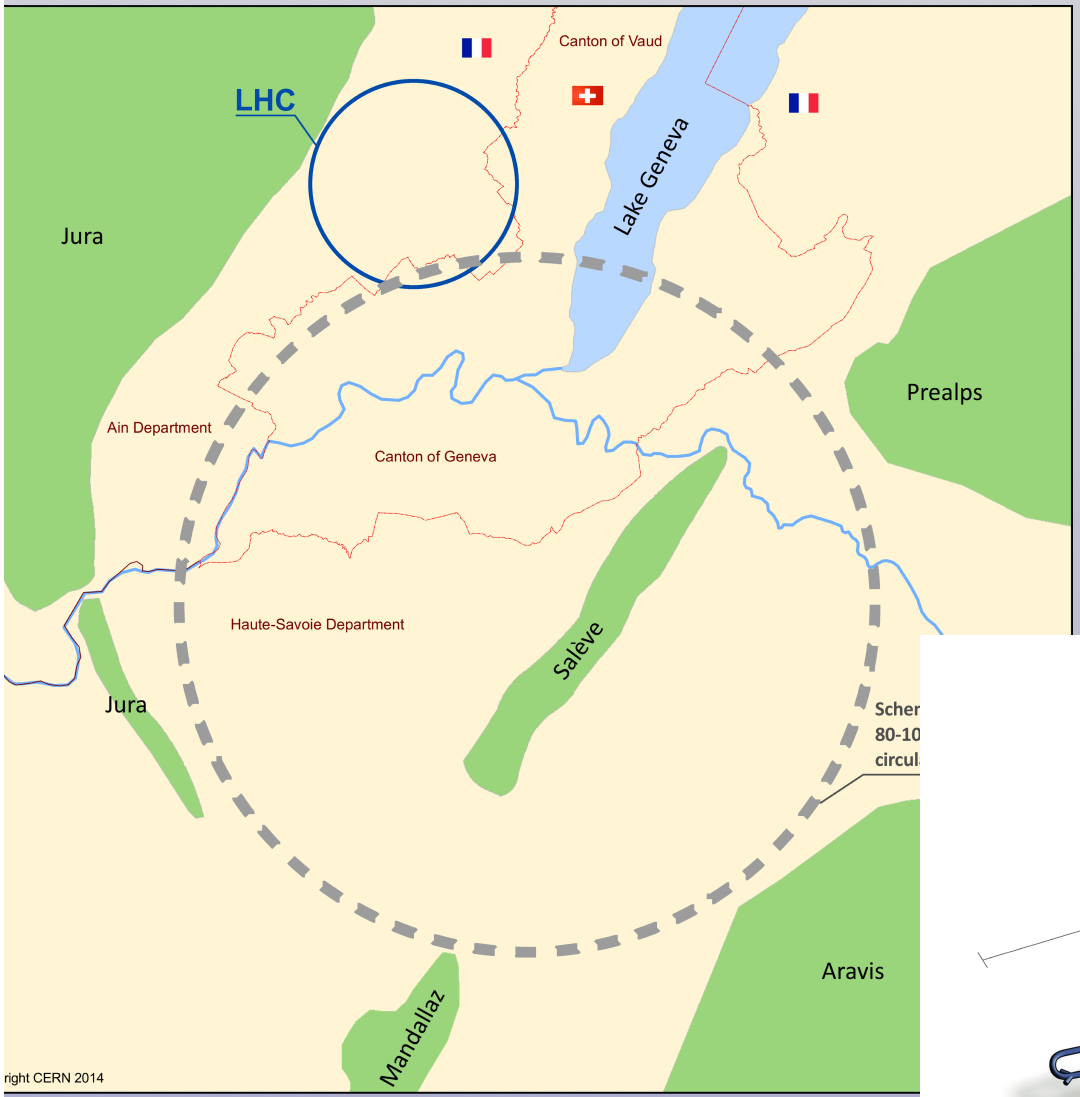
☑ Perhaps space-time has more **dimensions** that we are used to **if they are small enough**



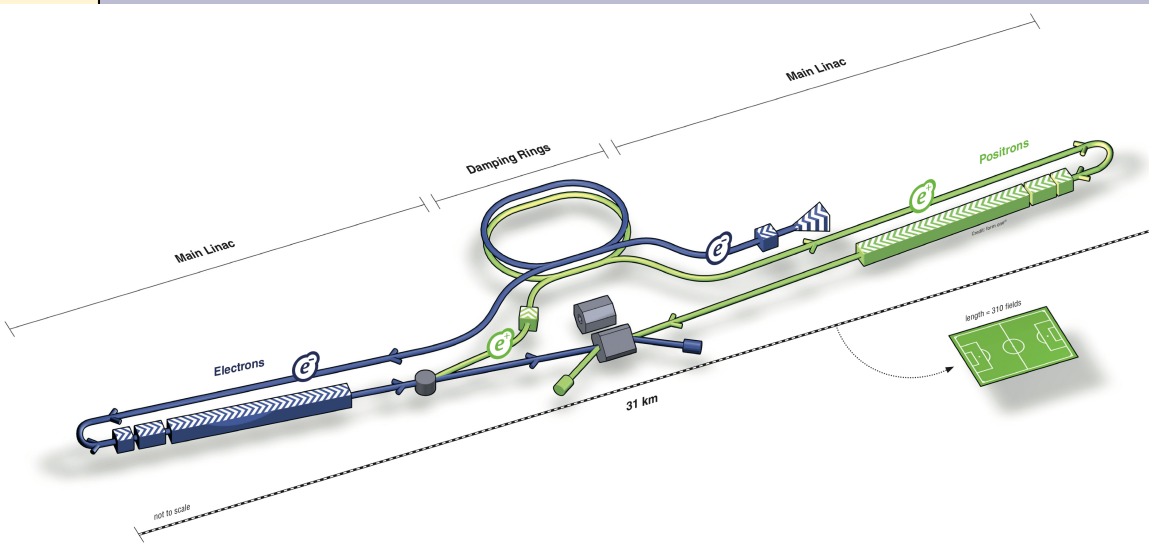
☑ At the LHC, using the very high energy, we might resolve new space-time dimensions!

The future of CERN

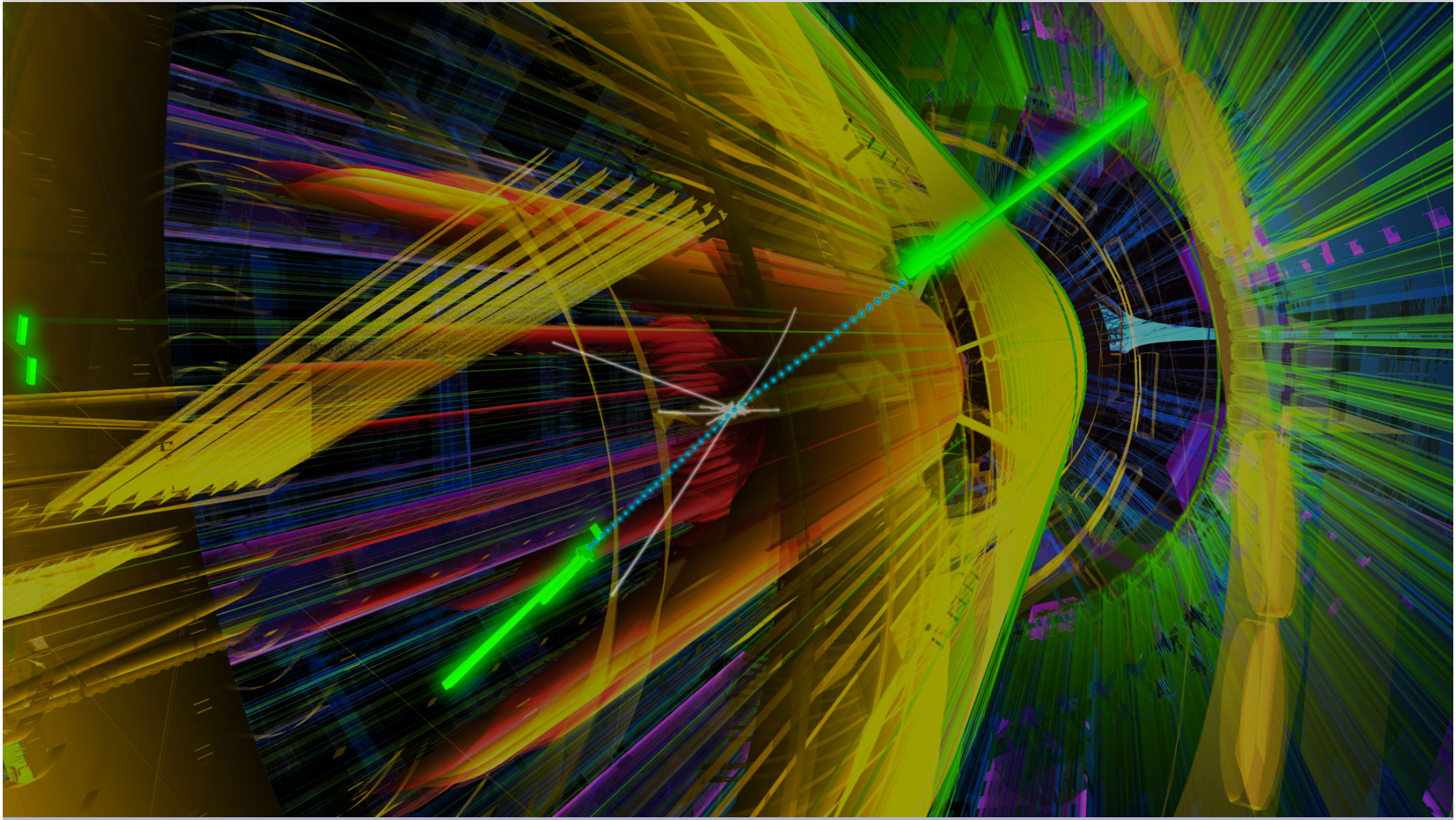
- Building huge accelerators like LHC takes 10-15 years, so CERN is already thinking about what the **next big machine will be**



- Perhaps a **100 km circular proton collider?** or a **linear electron collider?**
- You could be the ones making **the next big discovery there!**



Fascinating times ahead at the high-energy frontier!



Stay tuned for news from the LHC!