

Big Bangs, Black Holes and Extra Dimensions



University
of Glasgow

Brian Colquhoun

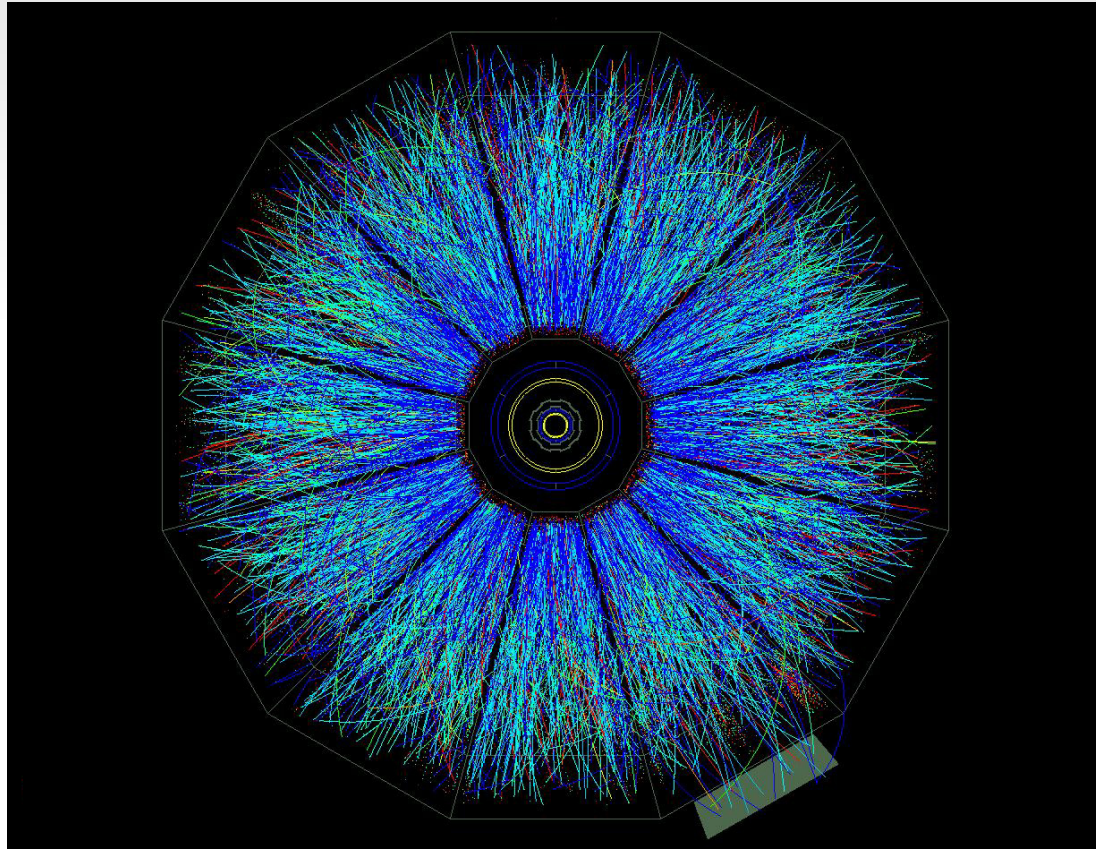
Physicists



“A physicist is a man who does research on natural things like black holes etc, and research on the future when it will be the end of the world” - Dilan

What is particle physics?

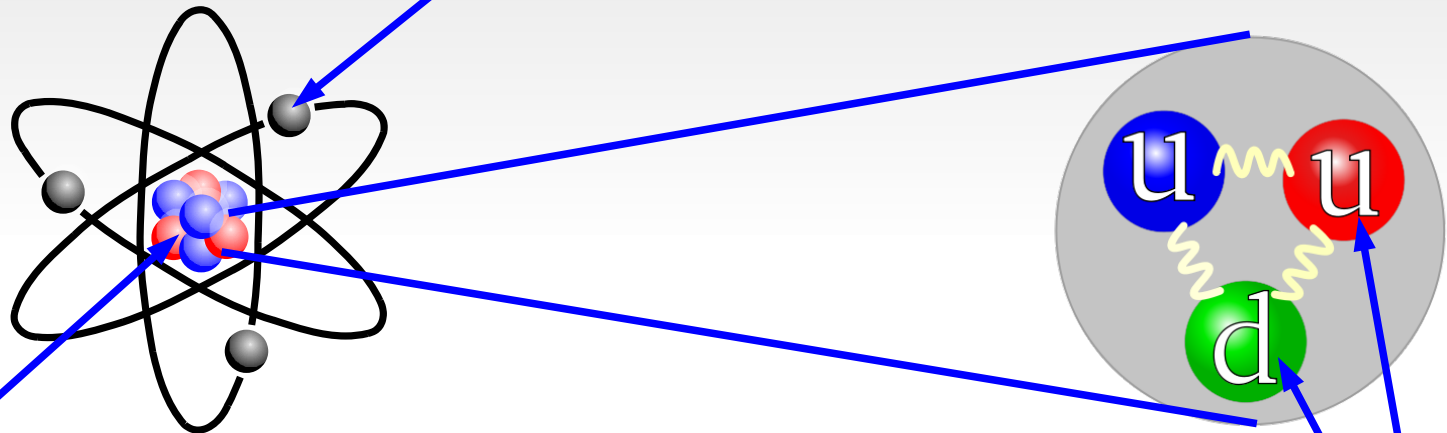
Particle physicists want to understand what particles there are in the universe.



But importantly we want to understand the forces that act between the particles, too!

What stuff is made of...

electrons

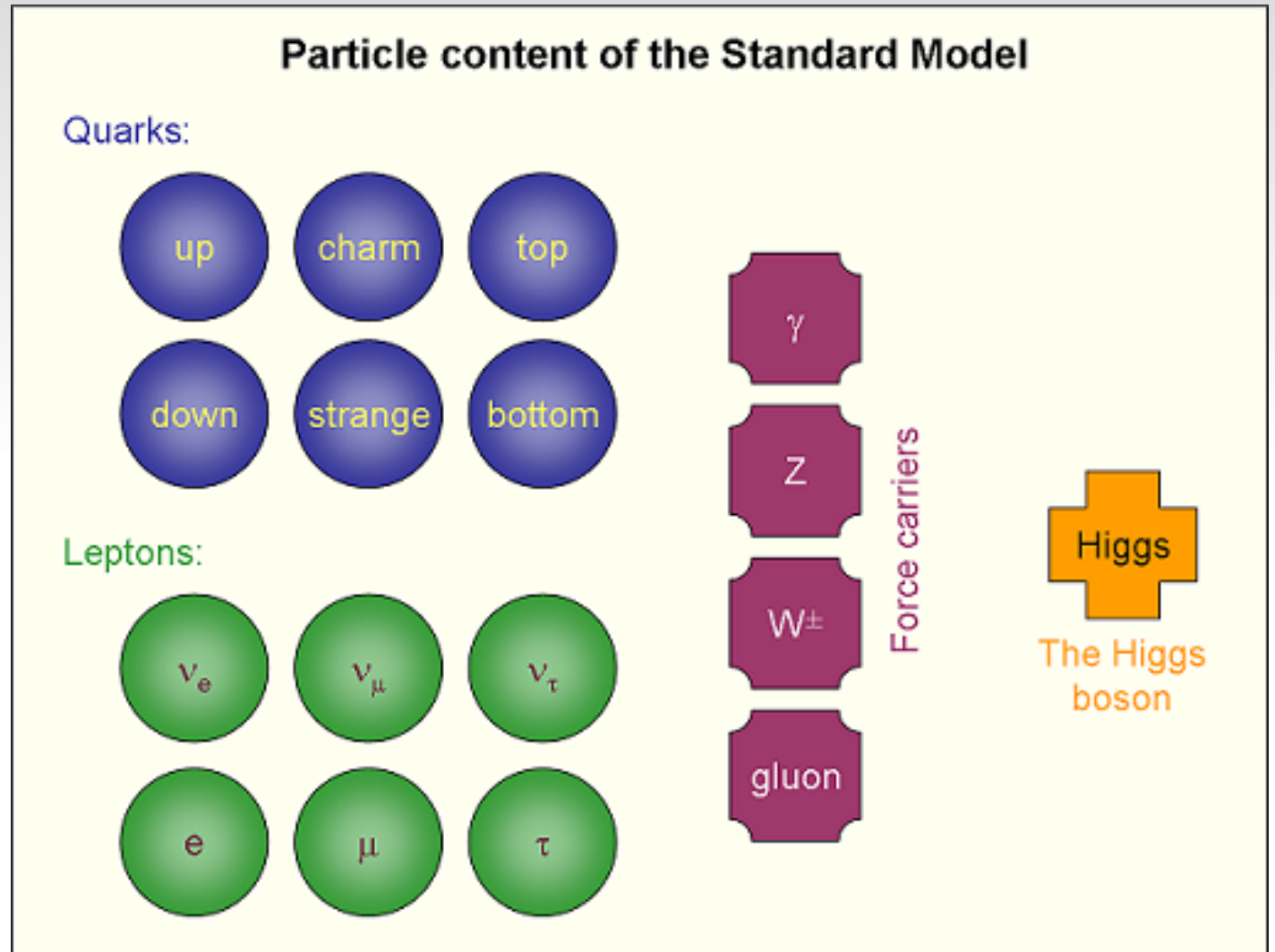


Nucleus: contains protons and neutrons, which are made of quarks.

The Standard Model

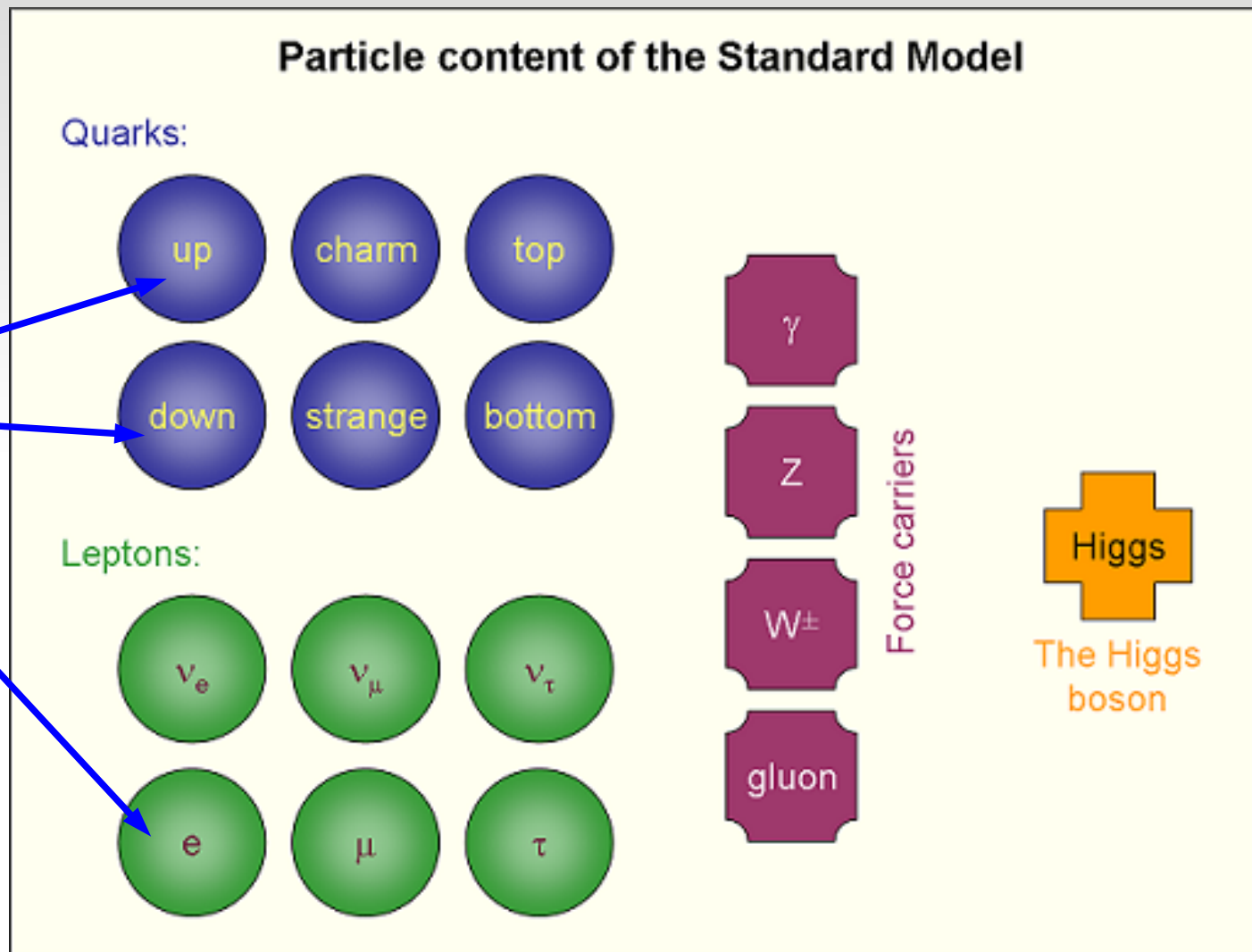
This is the standard model.

Everything we know about particle physics is here; every particle we have discovered has either been one of these or made of of these.

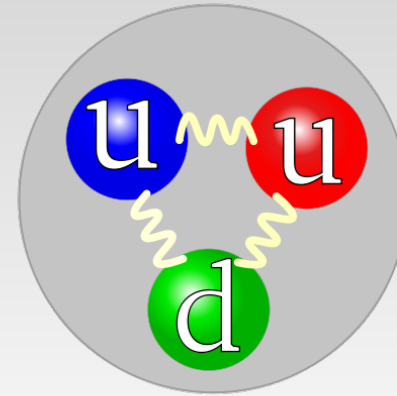
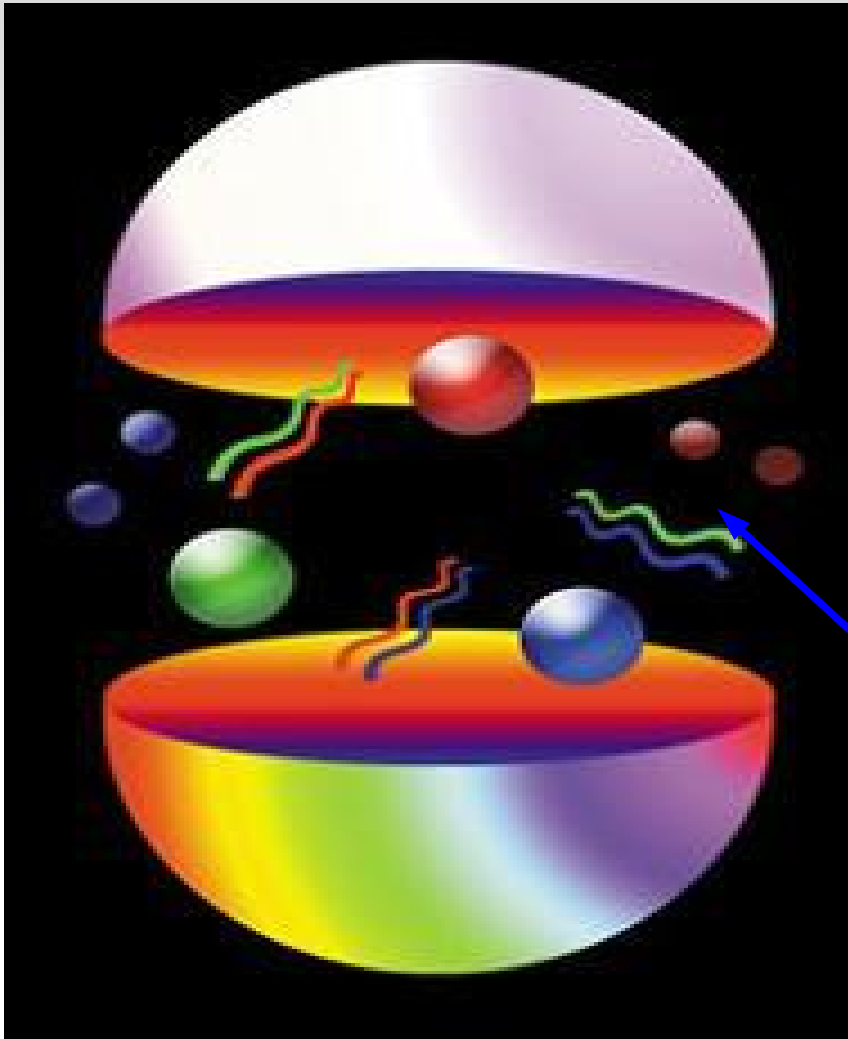


The Standard Model

You are made of these three. In fact, everything you can see is made of these three...



What protons are made of...



Three quarks: up, up and down.

Also, there's a lot of other things happening. That's lucky for us – because of this other stuff we don't fly apart.

Any particles made up of quarks is called a hadron. That's why the machine at CERN is called...

The Large Hadron Collider

Underground tunnel almost 27km in circumference

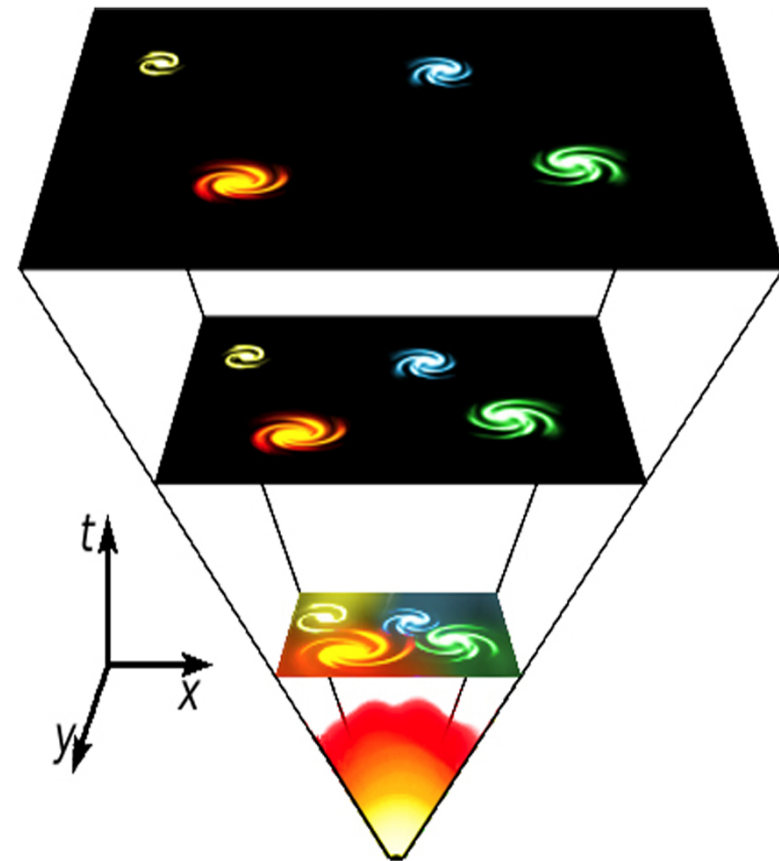
Biggest particle collider ever built and it has the highest energy.



Two beams of protons are steered round the accelerator at almost the speed of light and collide together at four different experiments: ATLAS, CMS, LHCb and ALICE.

Unravelling the mysteries

The conditions a fraction of a second after the big bang are created and we look through the debris.



Math, Science, History

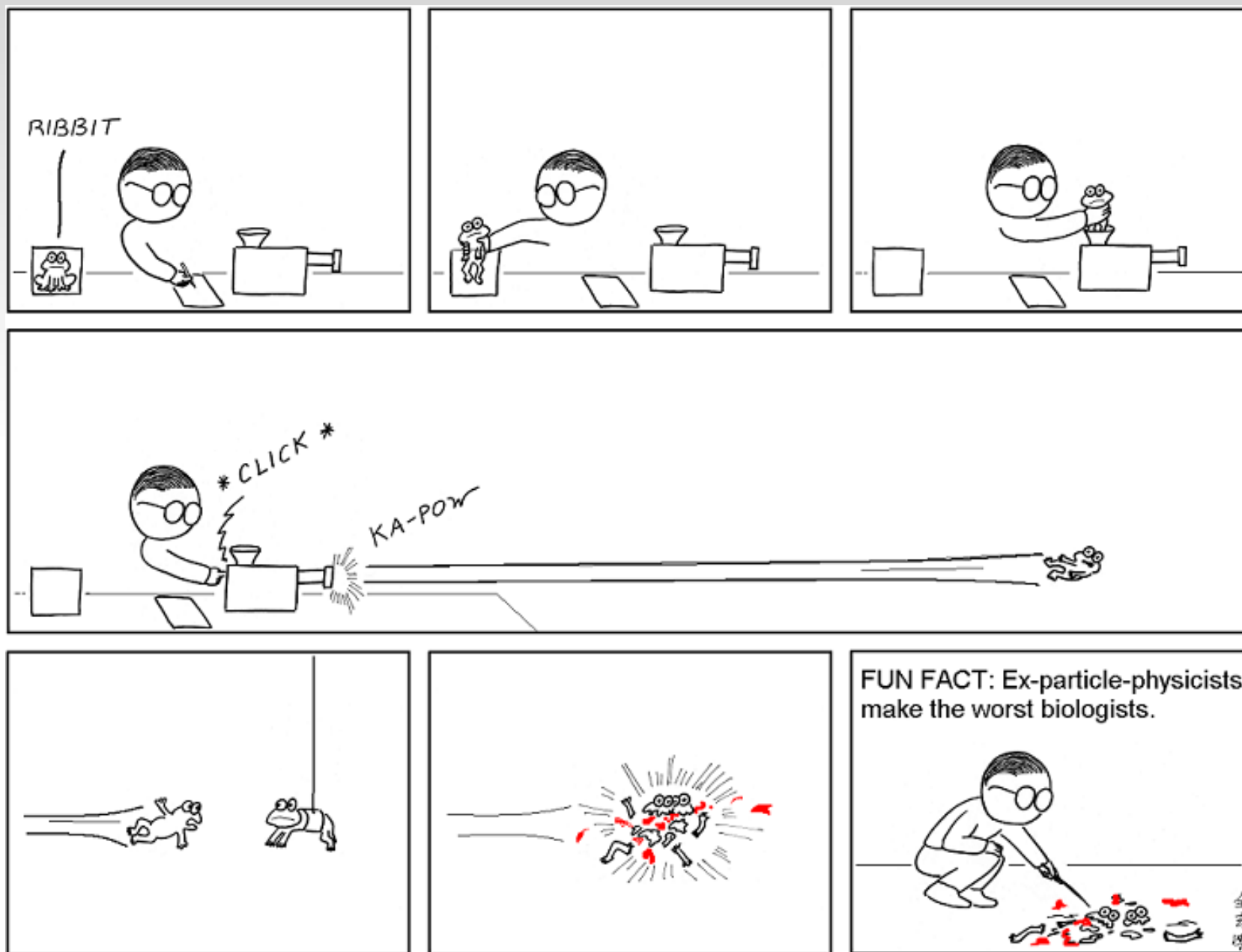
UNRAVELLING THE MYSTERIES

That all started with the

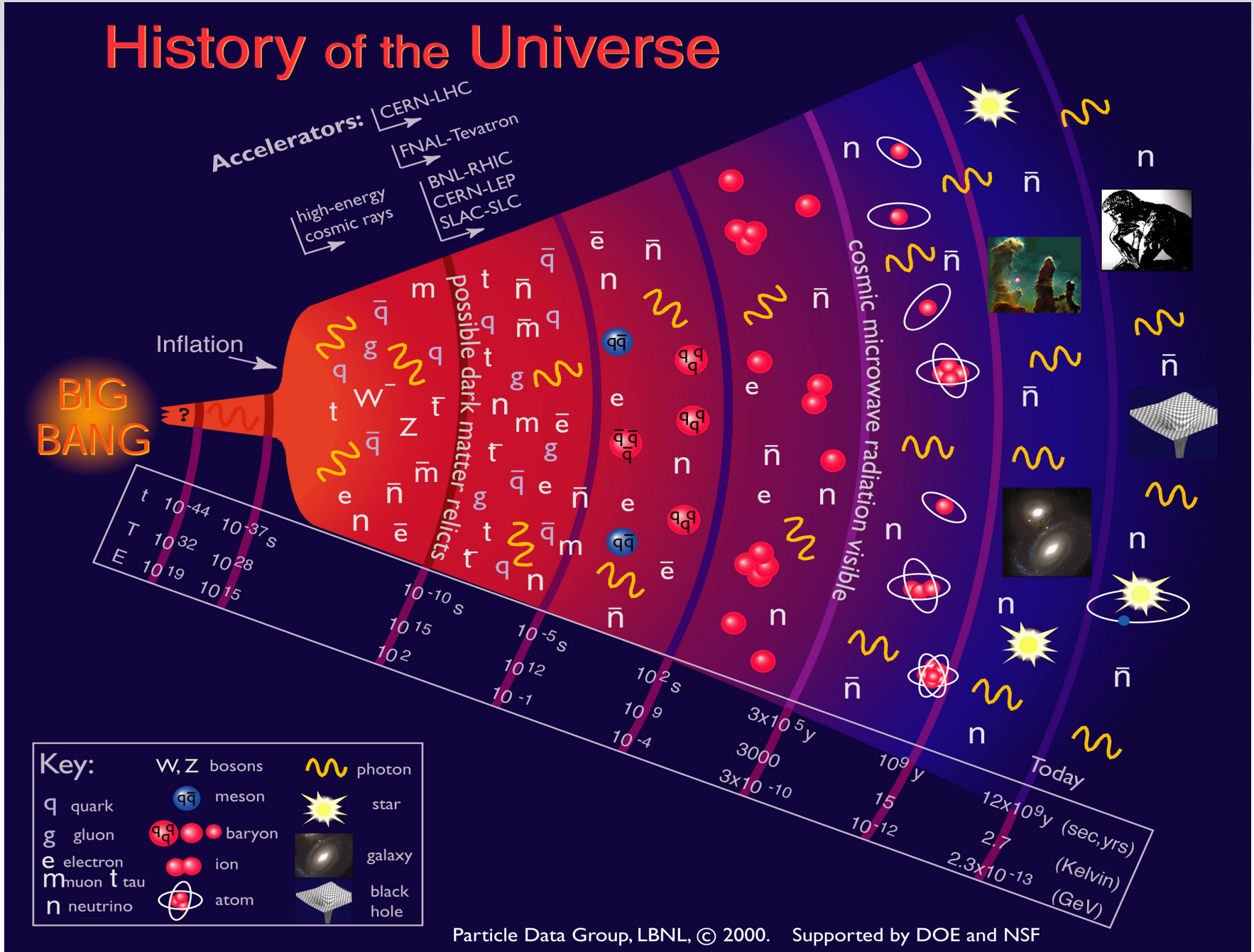
BiG BANG



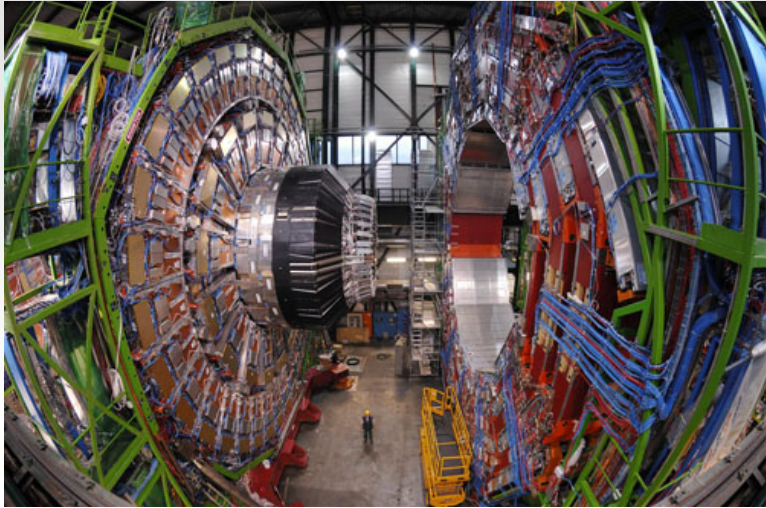
Colliders aren't always the best way



Big Bangs



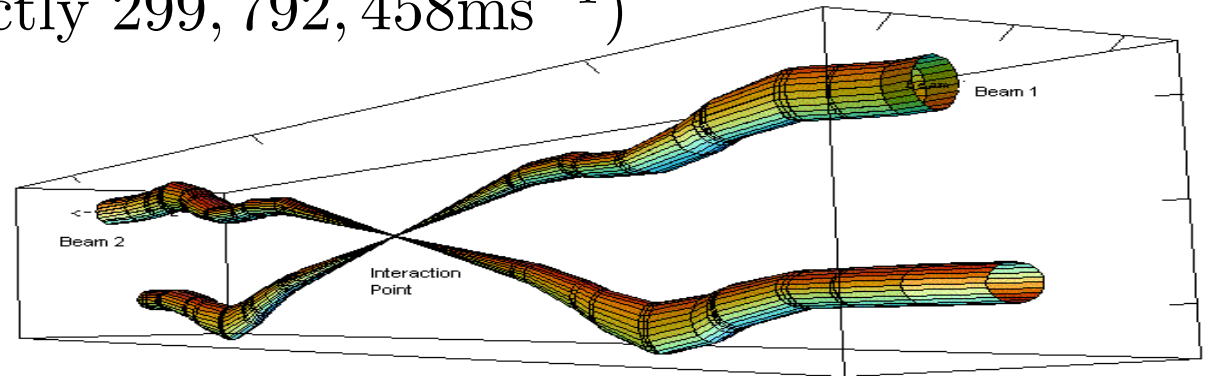
Facts and figures



26,659m in circumference.

9300 magnets inside to steer the beam.

Protons travel at 99.9999991% the speed of light.
(The speed of light is exactly $299,792,458\text{ms}^{-1}$)

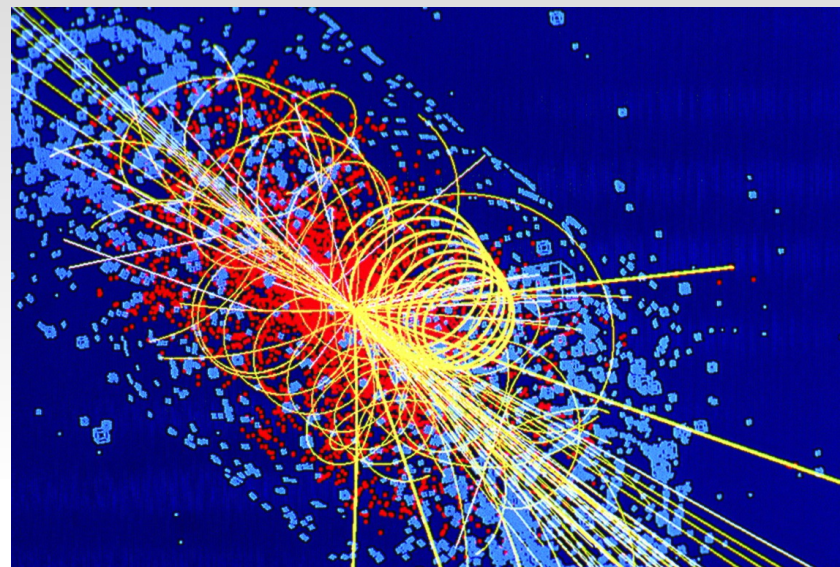
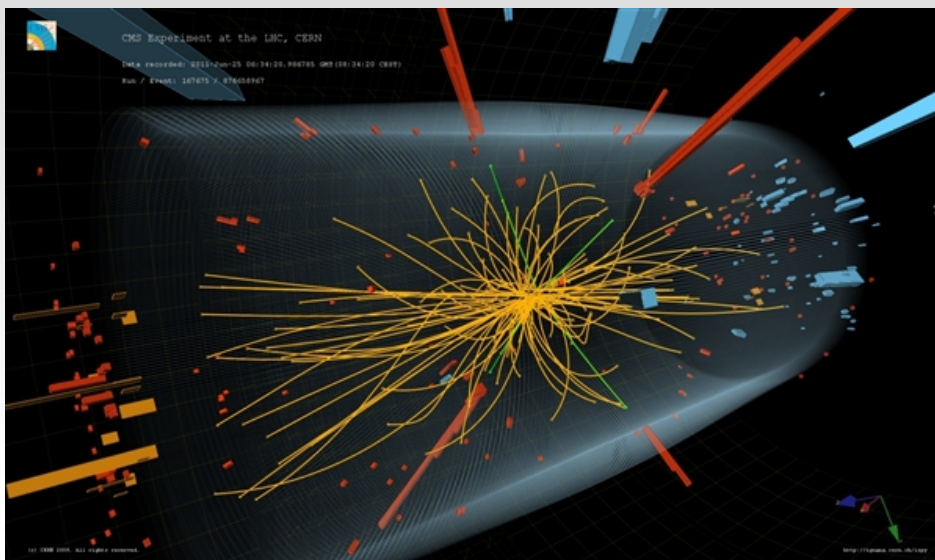


Relative beam sizes around IP1 (Atlas) in collision

The protons get round the accelerator ring 11,245 times every second.

Facts and figures

Pressure is ten times lower than pressure on the moon

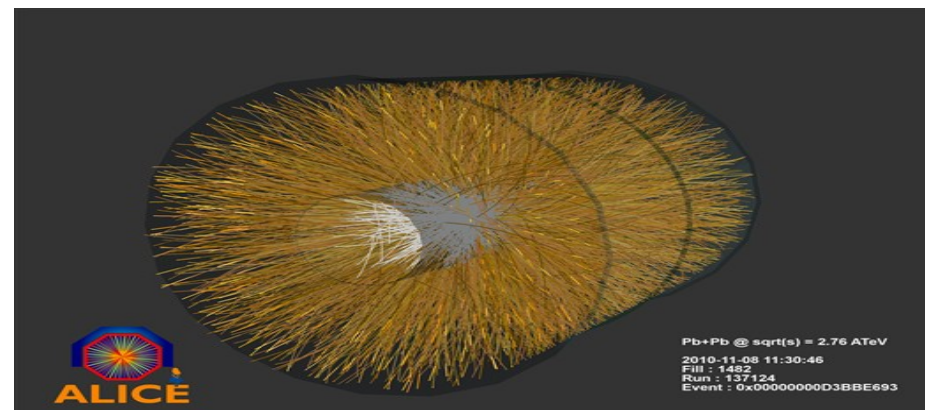


1.9 K (that's -271.3°C !); outer space is hotter at about 2.7K

Collisions are 100,000 times hotter than the sun.

600 million collisions a second.

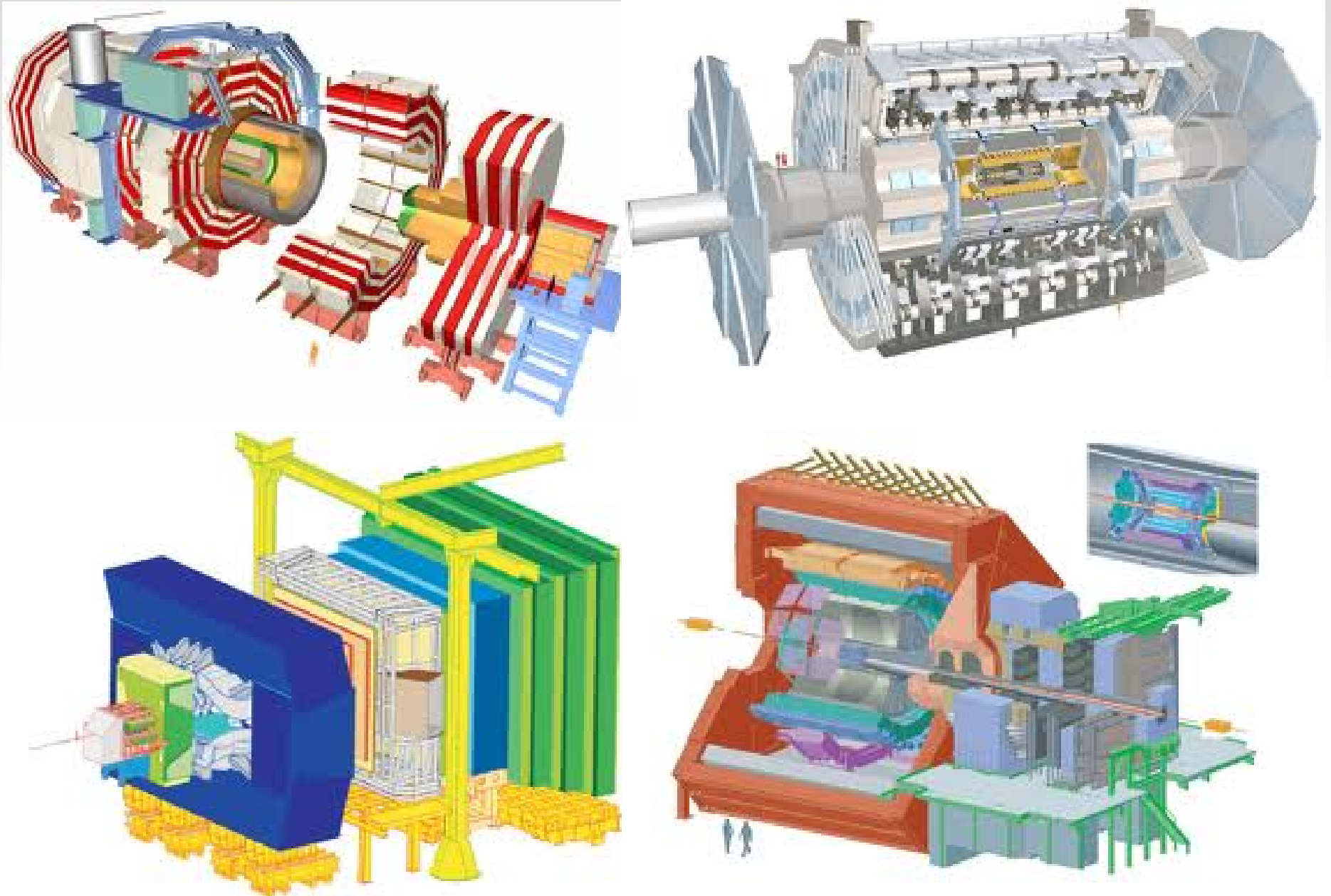
100,000 dual layer DVDs worth of data every year.



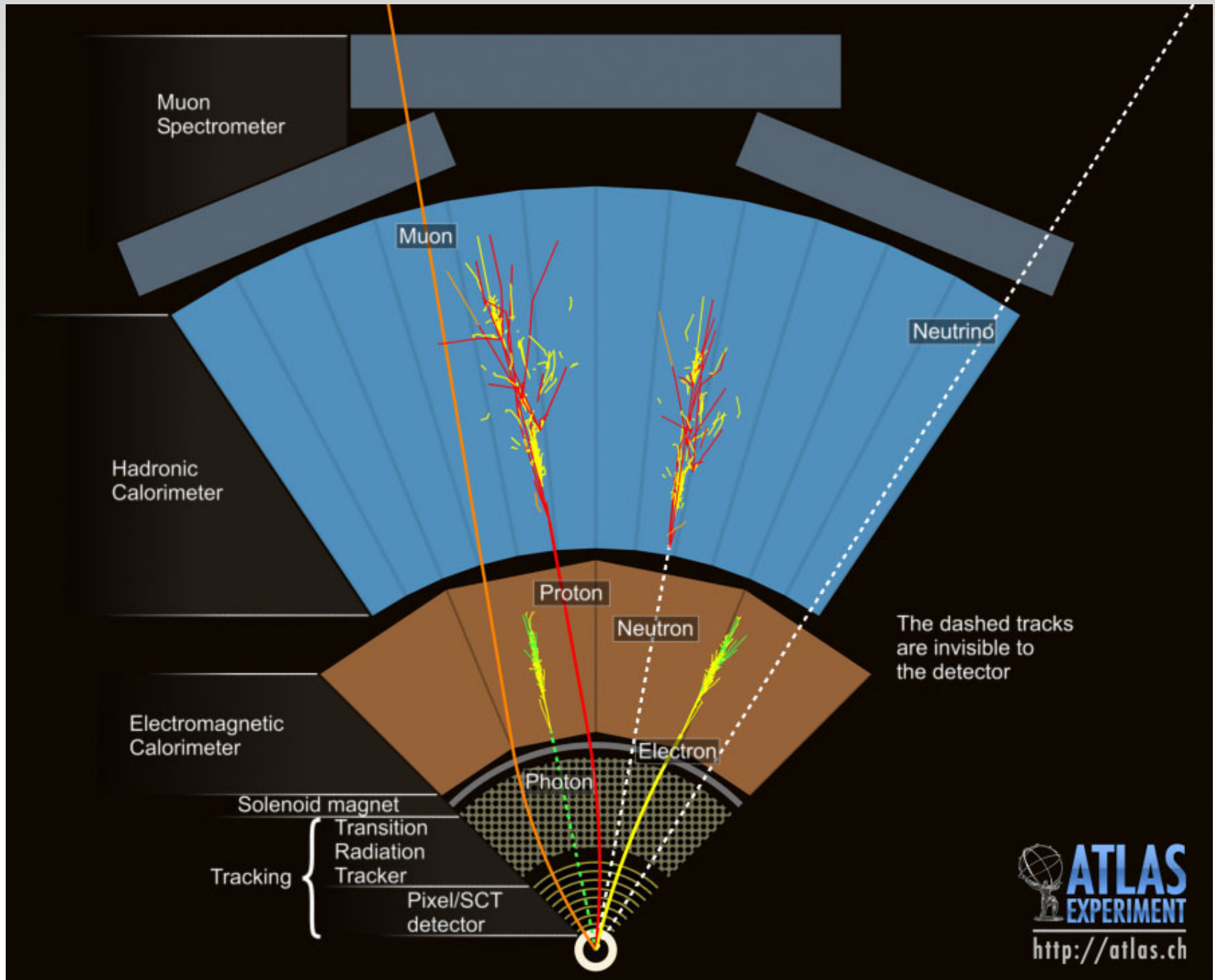
The Grid



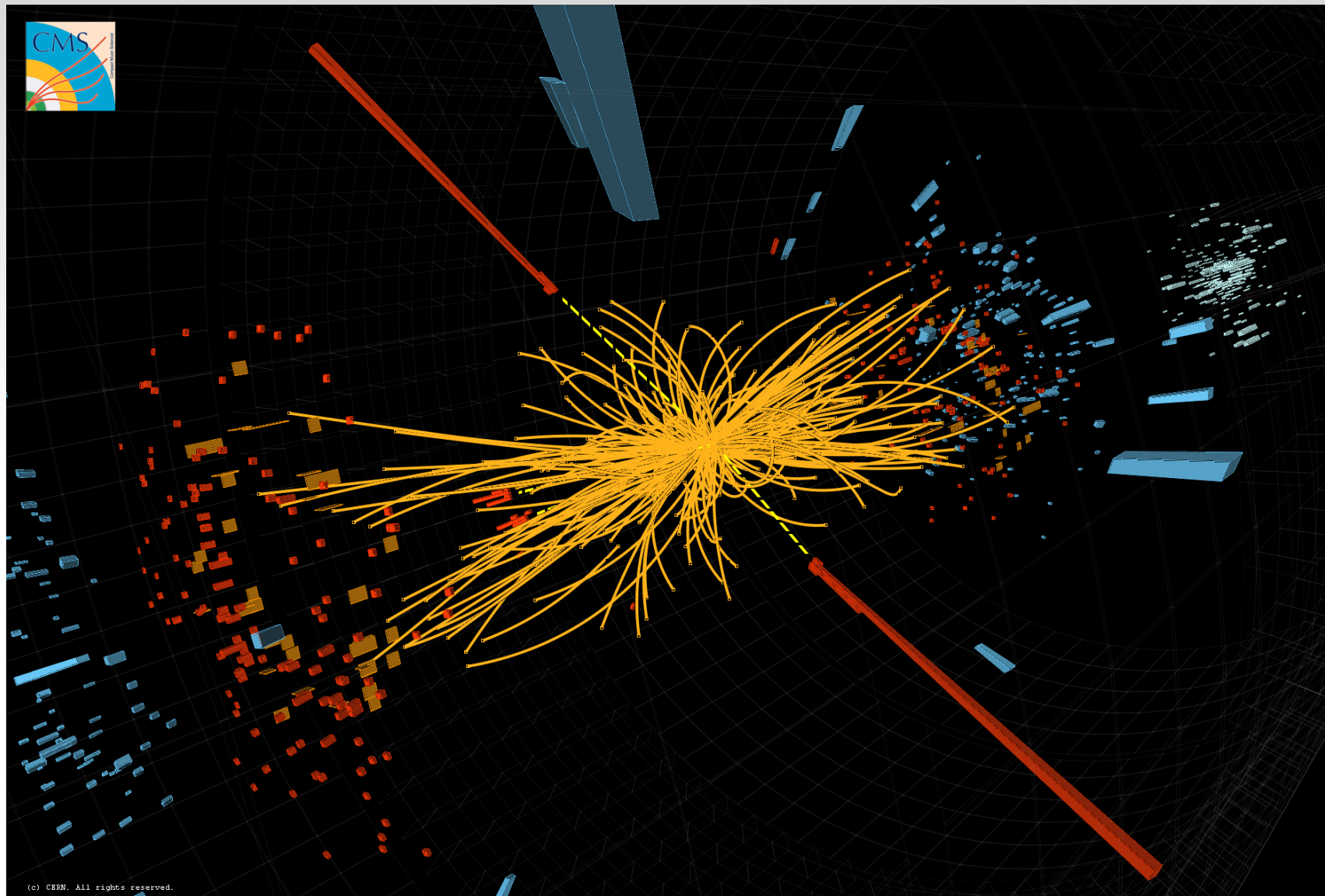
The experiments



Detectors



Reconstructing

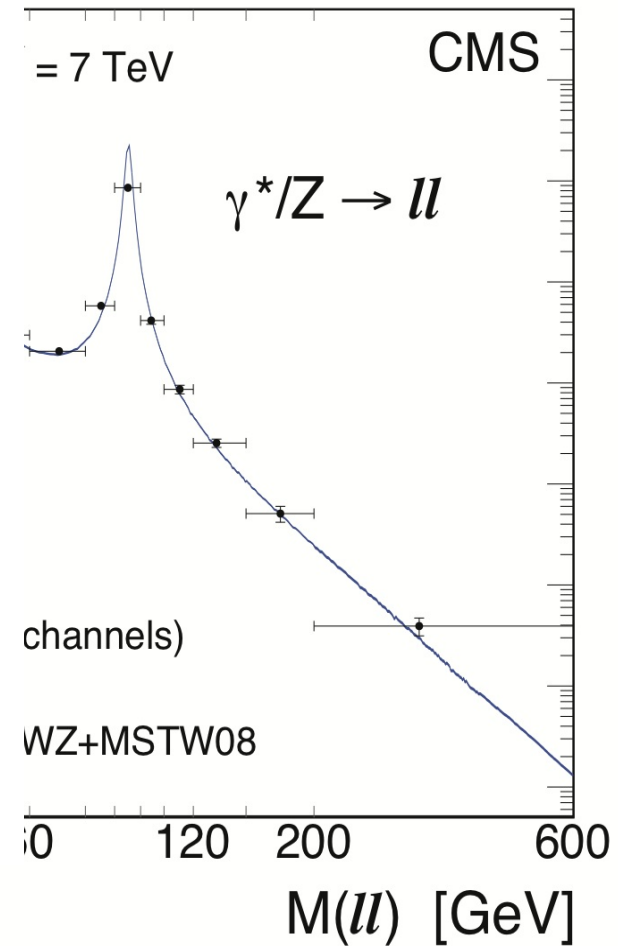
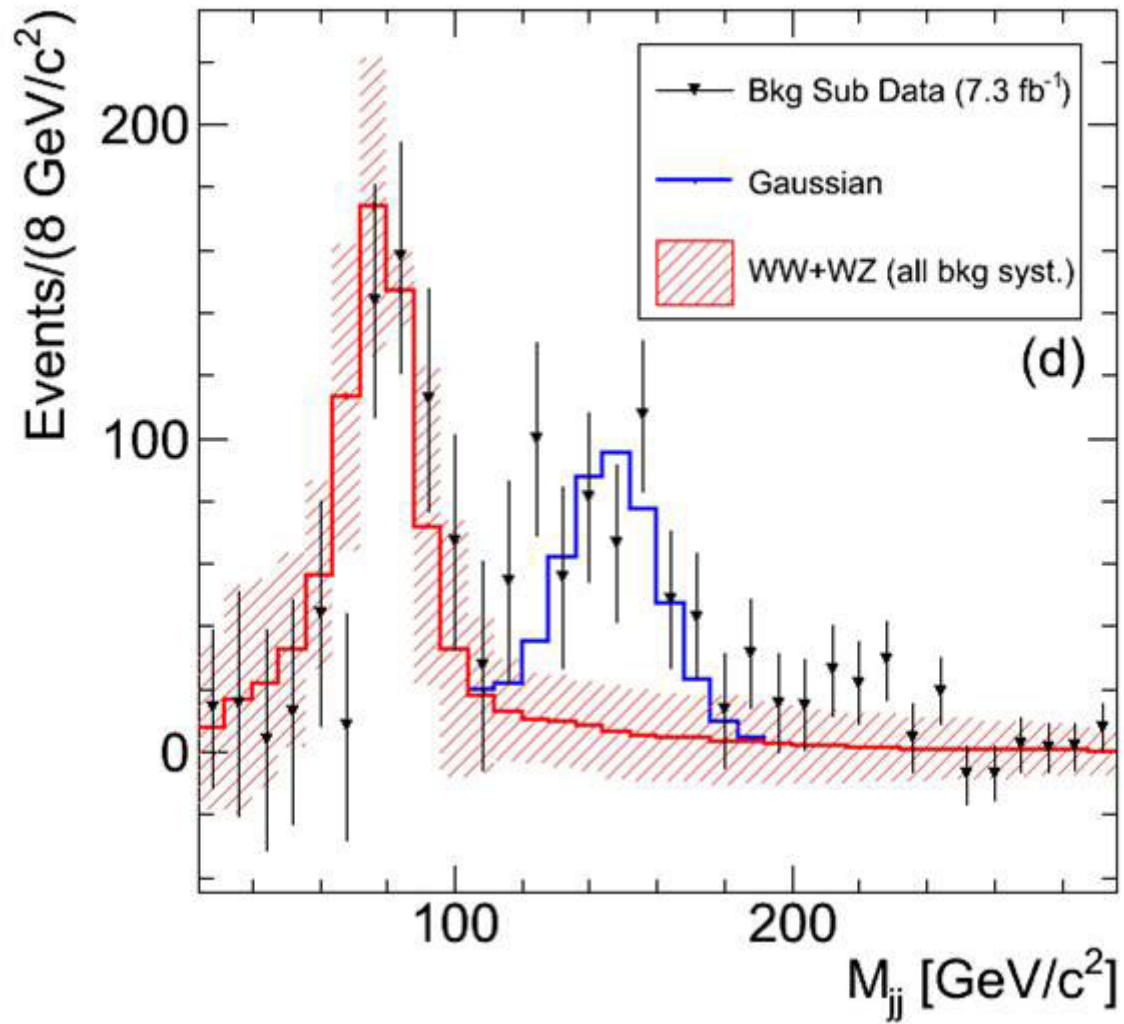


Do we really know what we're looking for?



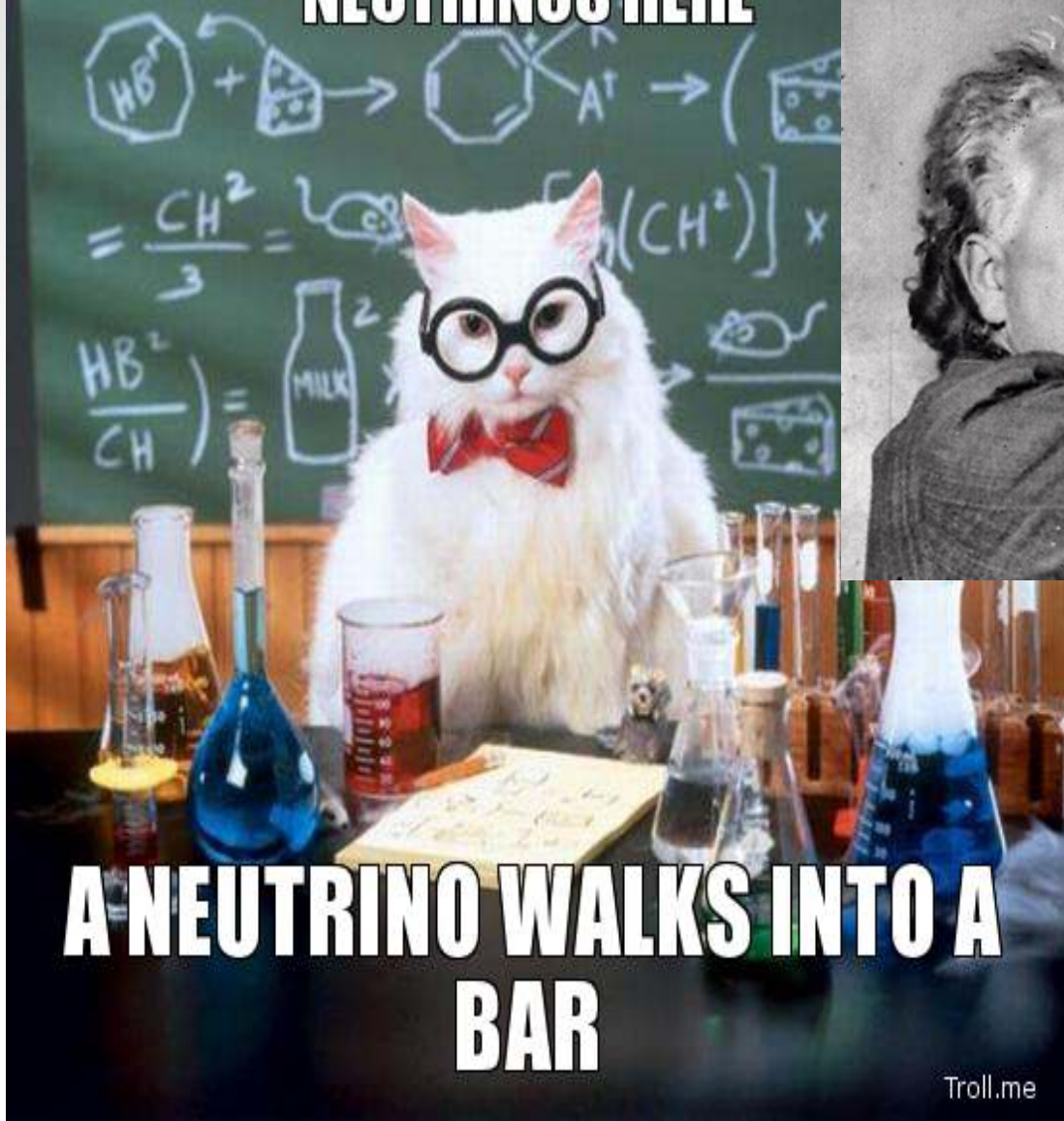
This is why experimental scientists hate theoretical scientists.

Looking for bumps

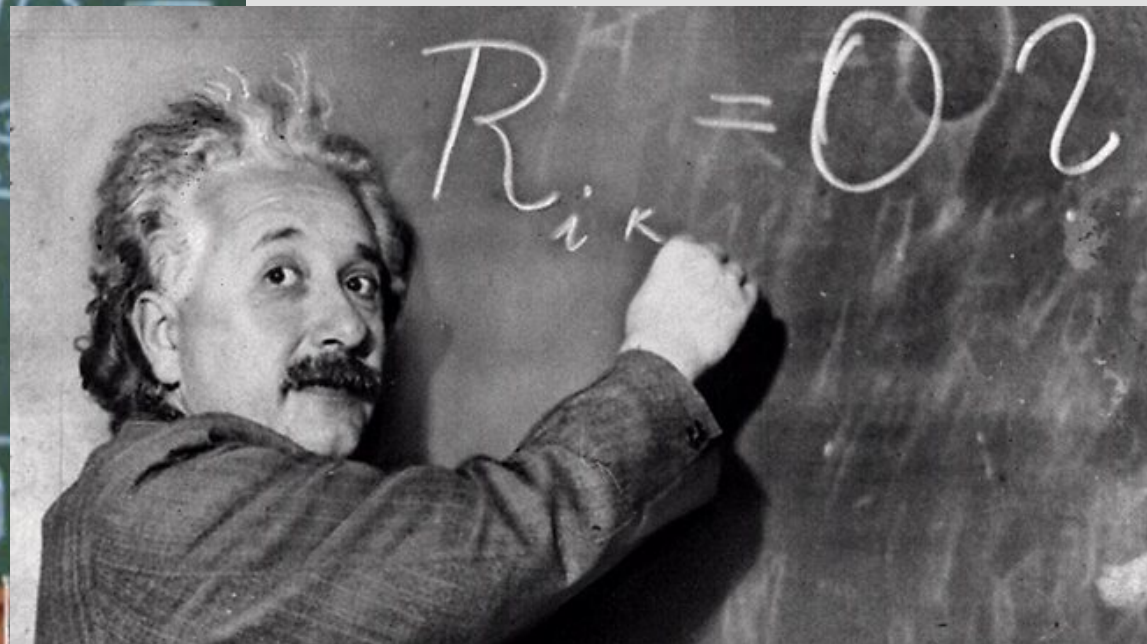


Faster than light neutrinos

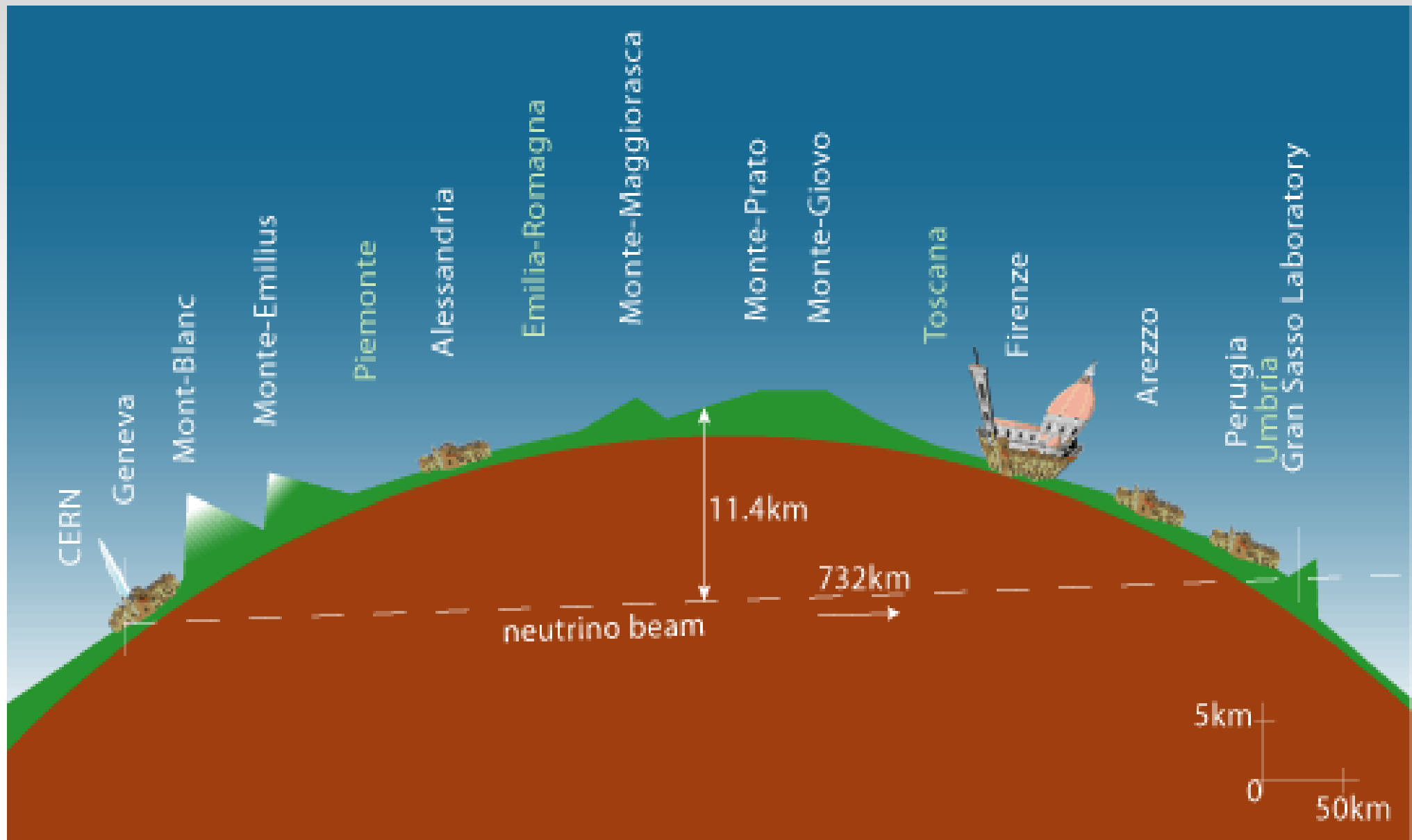
THE BARTENDER SAYS WE DONT SERVE NEUTRINOS HERE



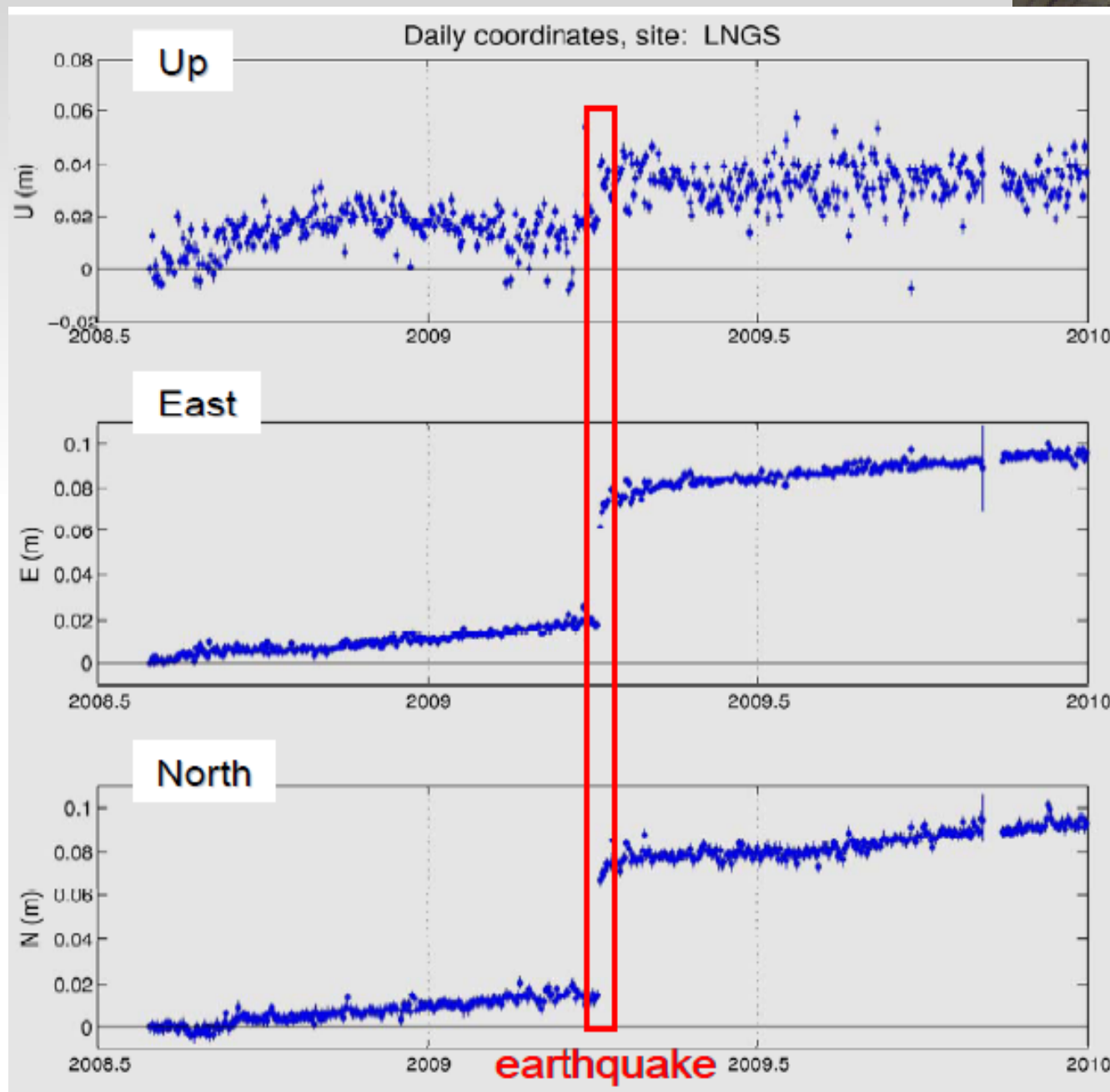
A NEUTRINO WALKS INTO A BAR



Faster than light neutrinos



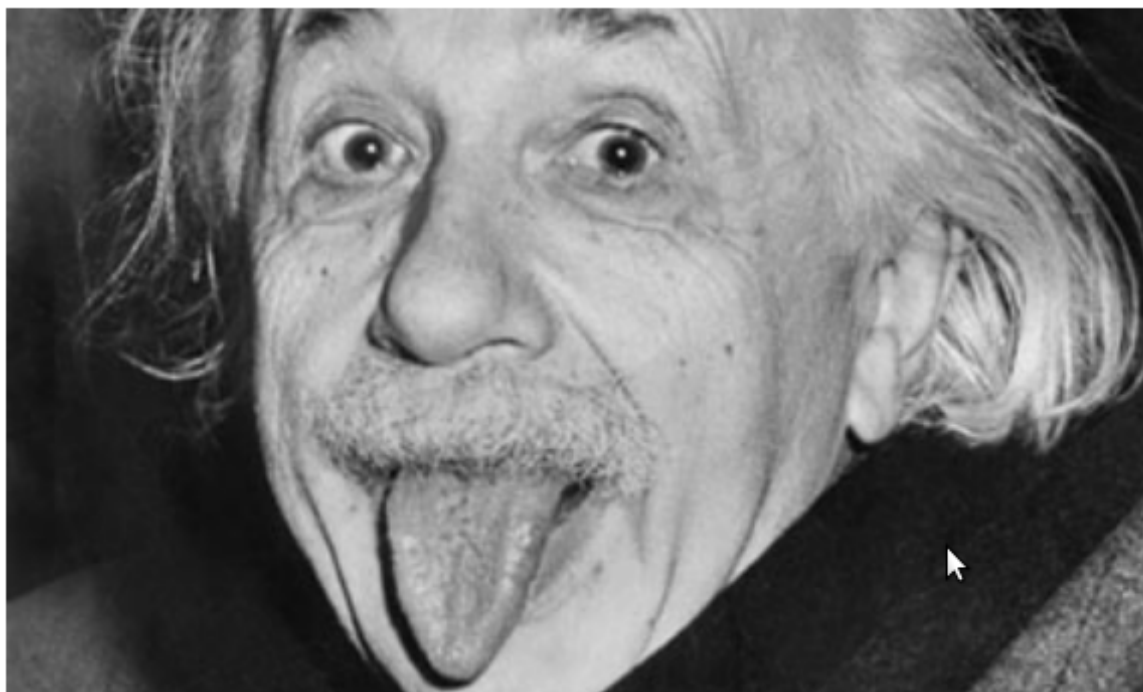
Faster than light neutrinos



Breaking News!

Einstein Right Yet Again

Posted: 02/23/2012 5:50 pm



Faster-than-light neutrinos: was a faulty connection to blame?

BREAKING NEWS: Error Undoes Faster-Than-Light Neutrino Results

by Edwin Cartlidge on 22 February 2012, 1:45 PM | [0 Comments](#)

Faster-than-light neutrinos could be down to bad wiring

By Jason Palmer

Science and technology reporter, BBC News

Most were skeptical already...

**Can apparent superluminal neutrino speeds be explained
as a quantum weak measurement?**

M V Berry¹, N Brunner¹, S Popescu¹ & P Shukla²

¹H H Wills Physics Laboratory, Tyndall Avenue, Bristol BS8 1TL, UK

²Department of Physics, Indian Institute of Technology, Kharagpur, India

Abstract

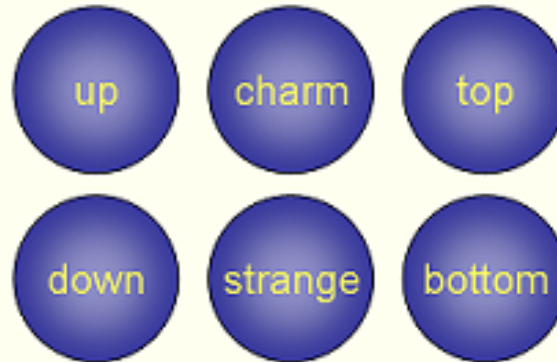
Probably not.

The Higgs Boson

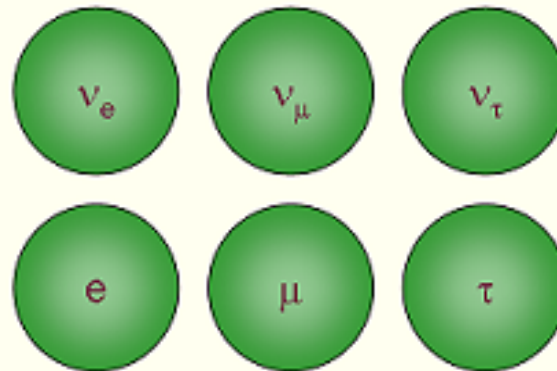


Particle content of the Standard Model

Quarks:



Leptons:



Force carriers



The Higgs Boson

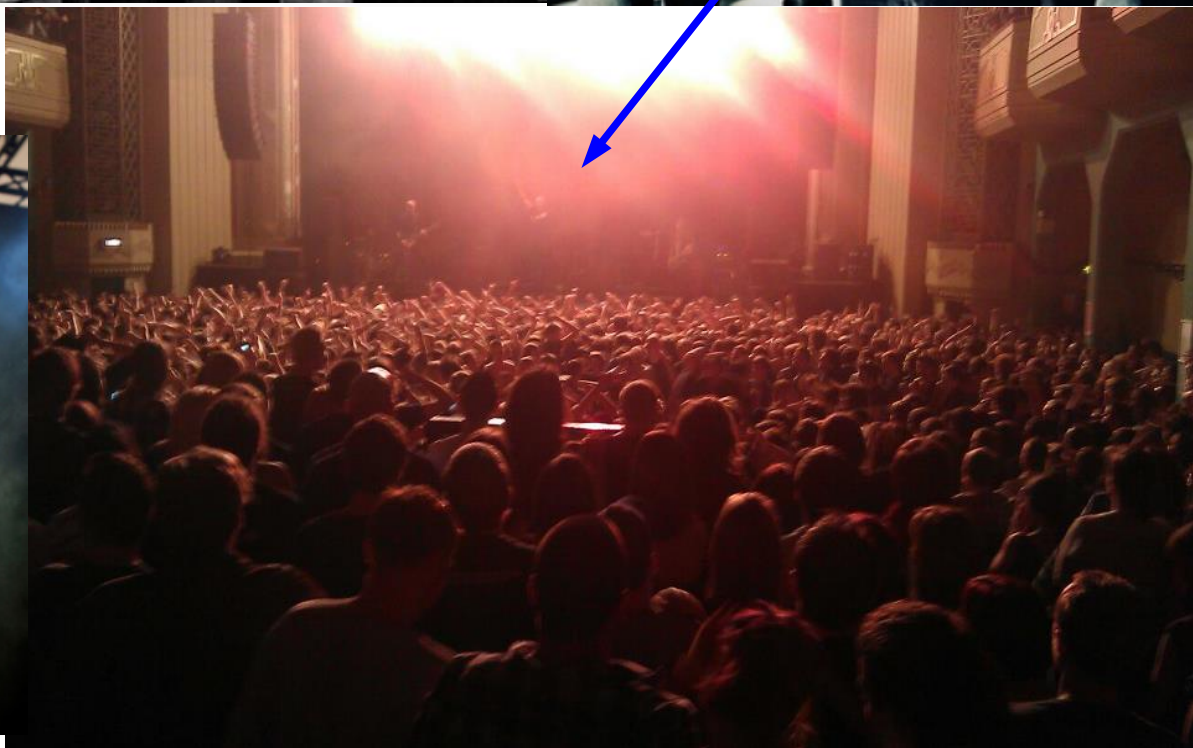
The Higgs Boson is designed to fix a problem: although we predict the other particles in the standard model, they should be massless. The Higgs fixes this by giving the particles mass.



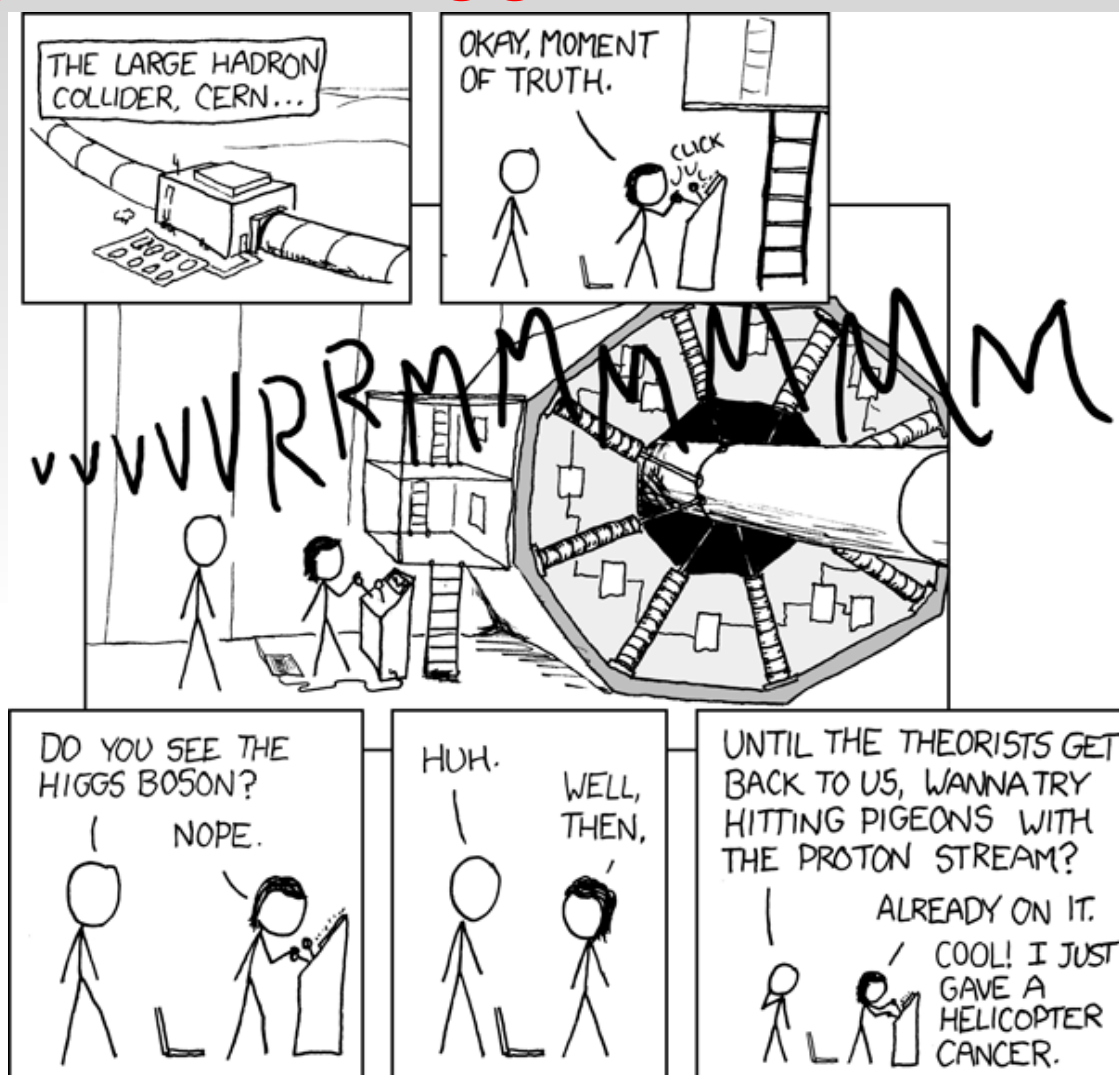
The Higgs Boson



The Higgs Boson



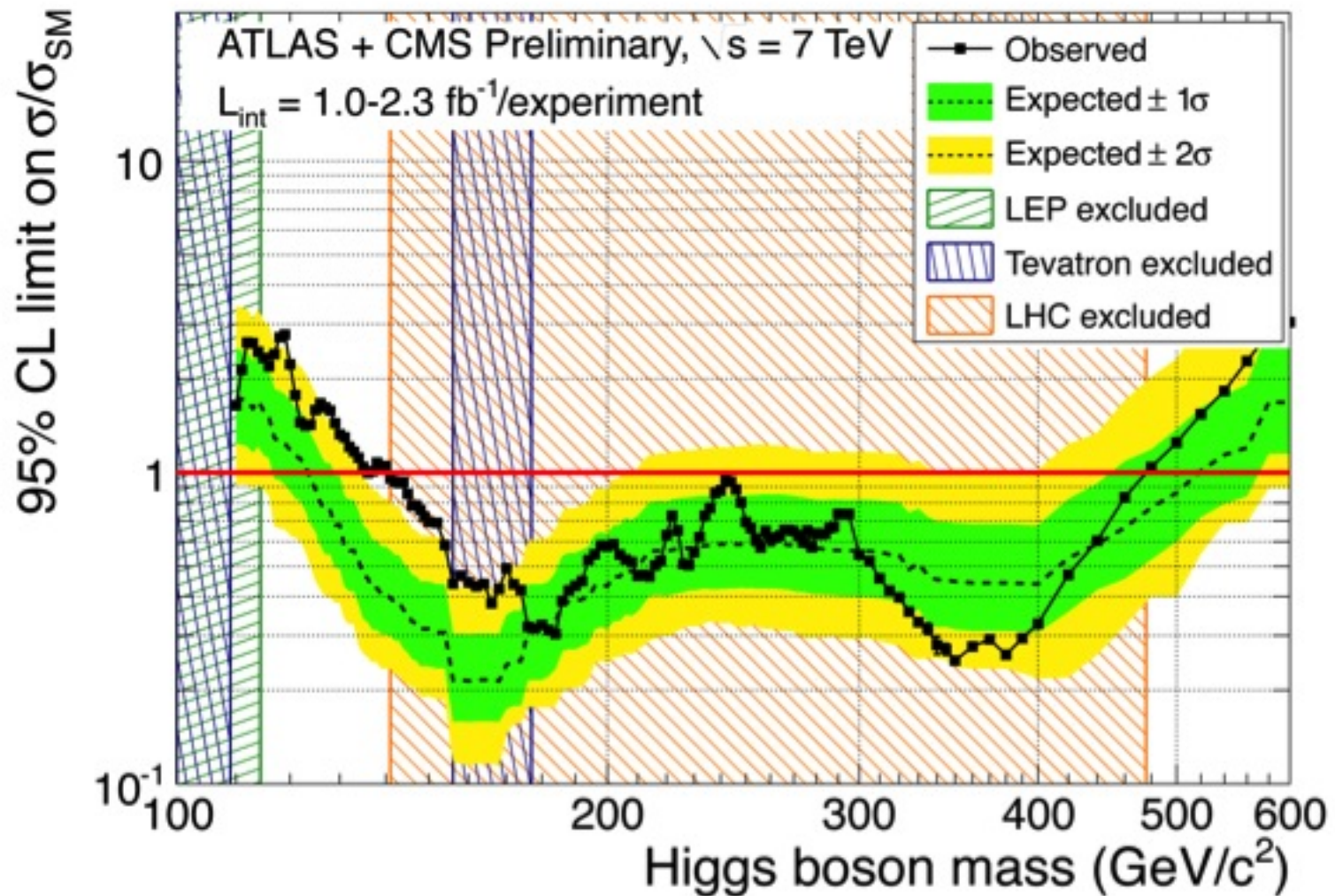
Looking for the Higgs



We can't see the Higgs itself – it decays to other things too quickly. What we look for are the particles to which it decays. One thing we can look for is $H \rightarrow \gamma + \gamma$

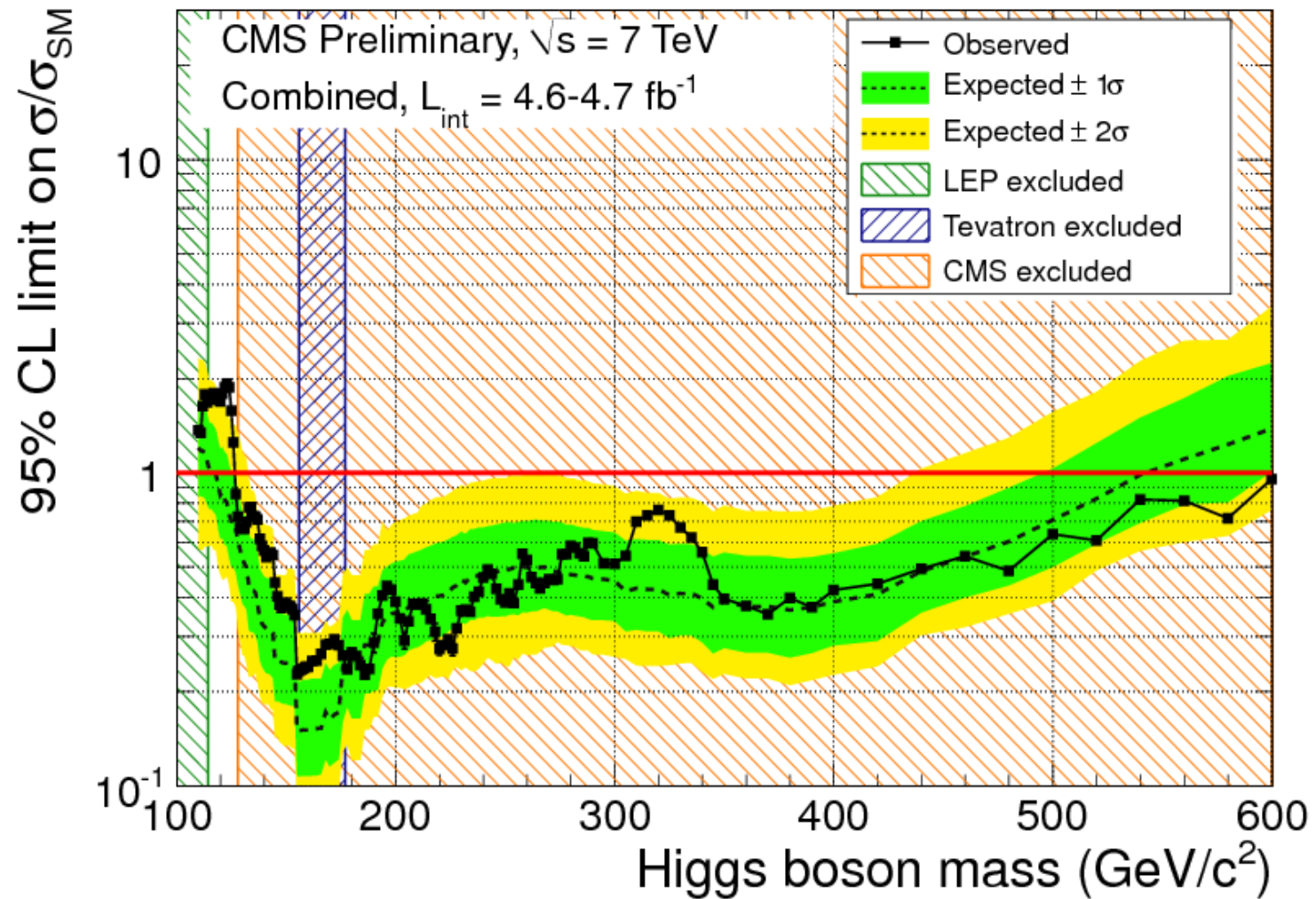
Looking for the Higgs

We might be close...



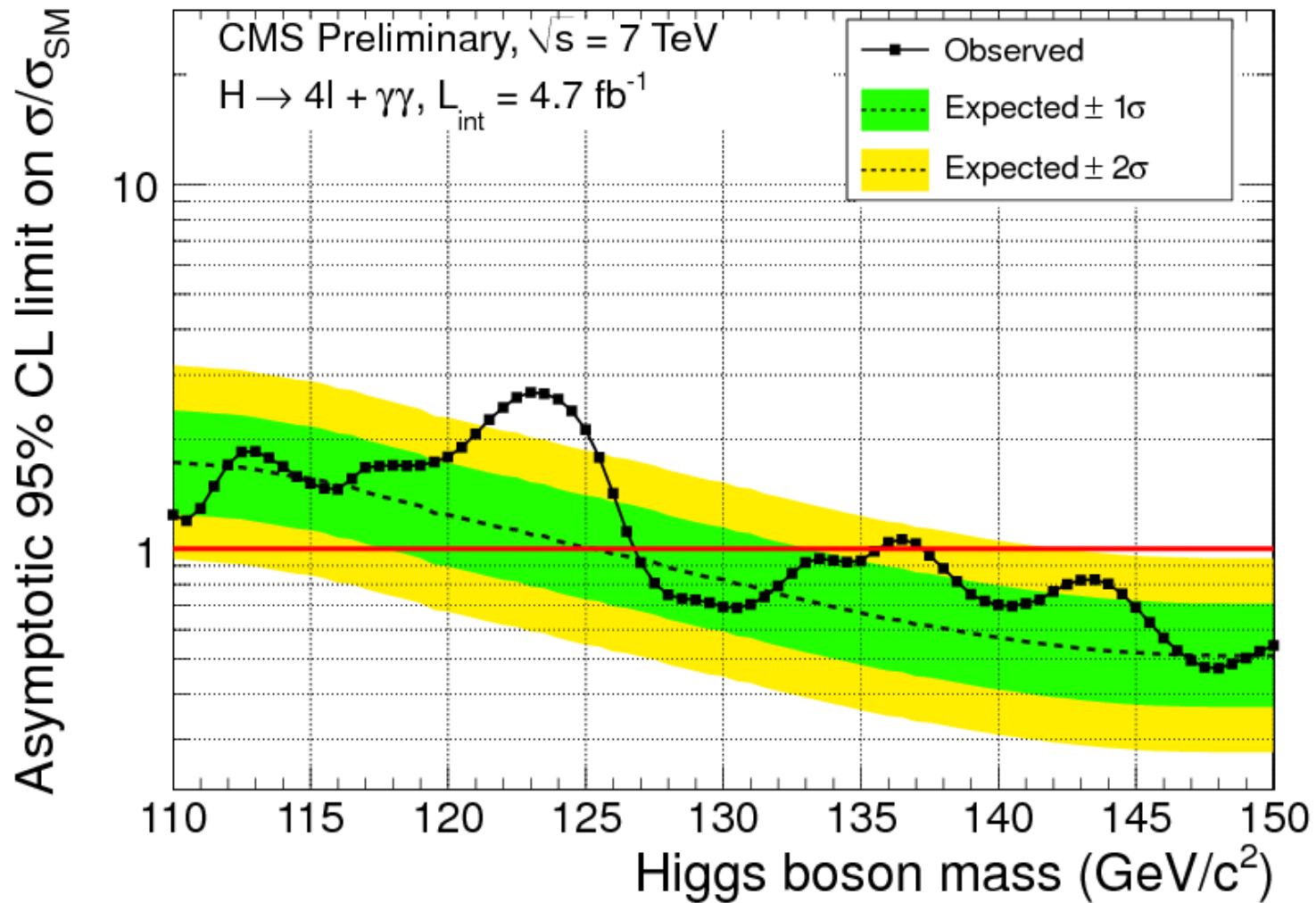
Looking for the Higgs

We might be close...

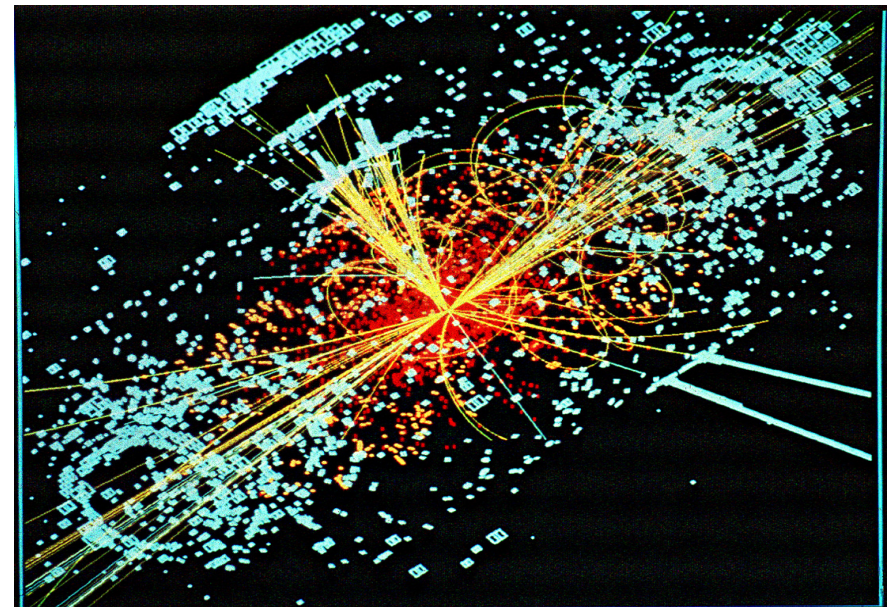
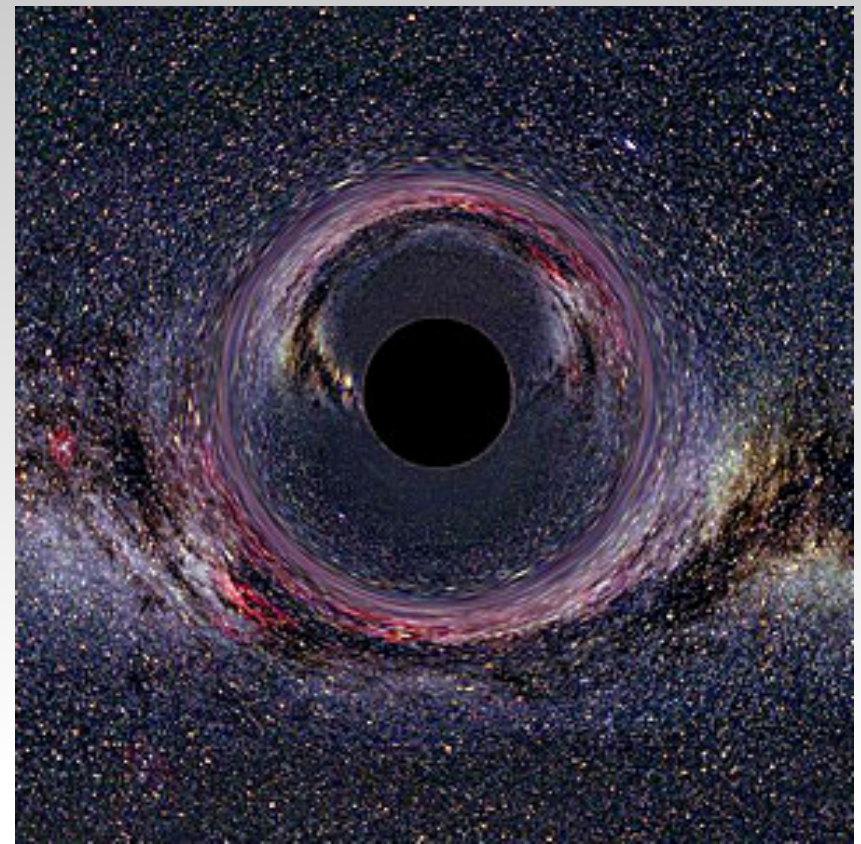
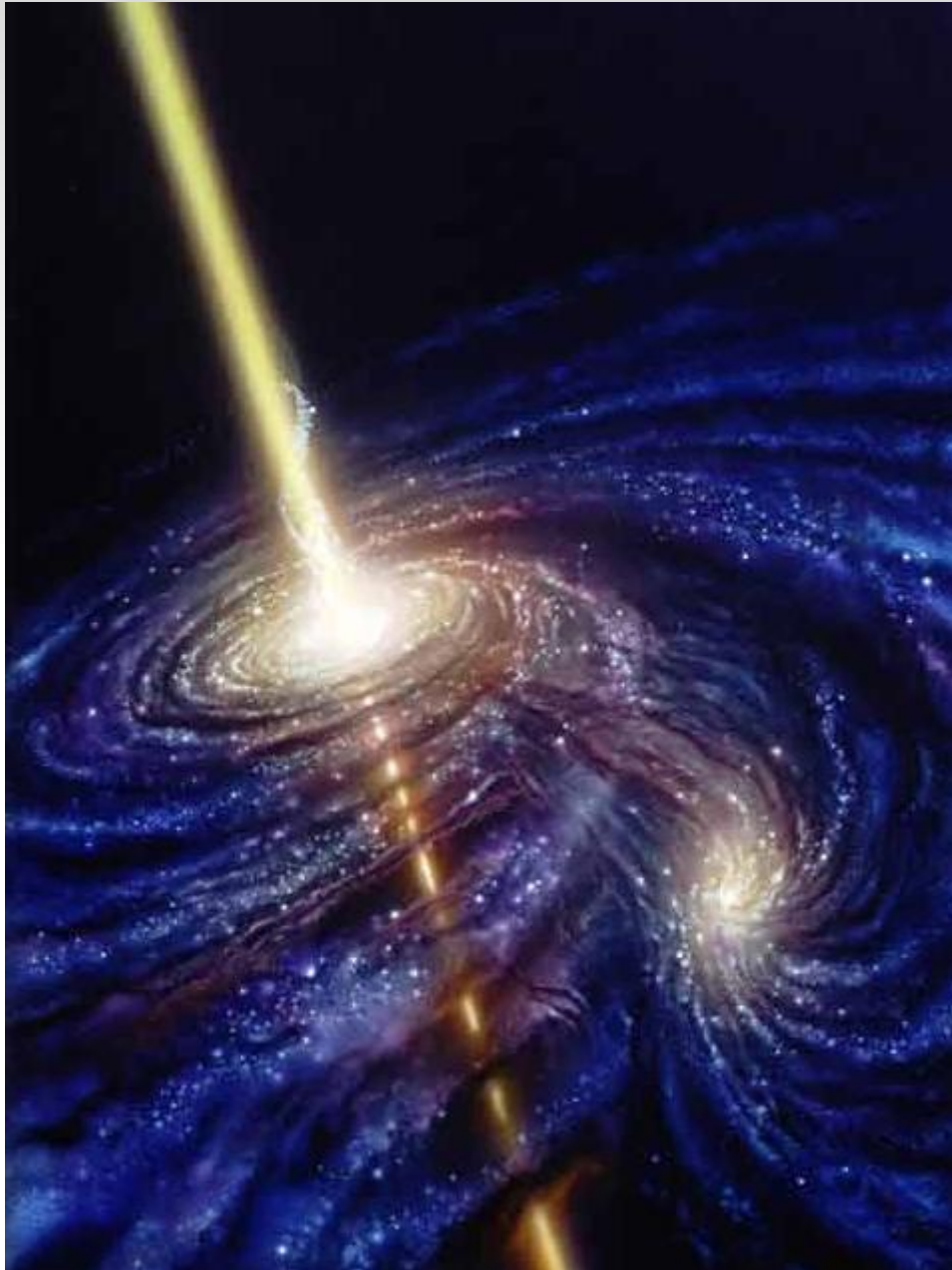


Looking for the Higgs

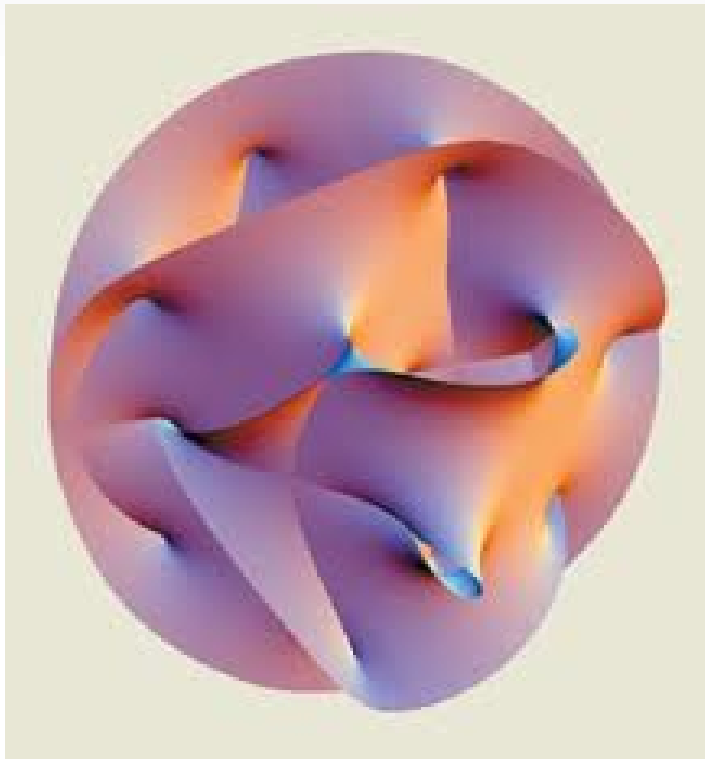
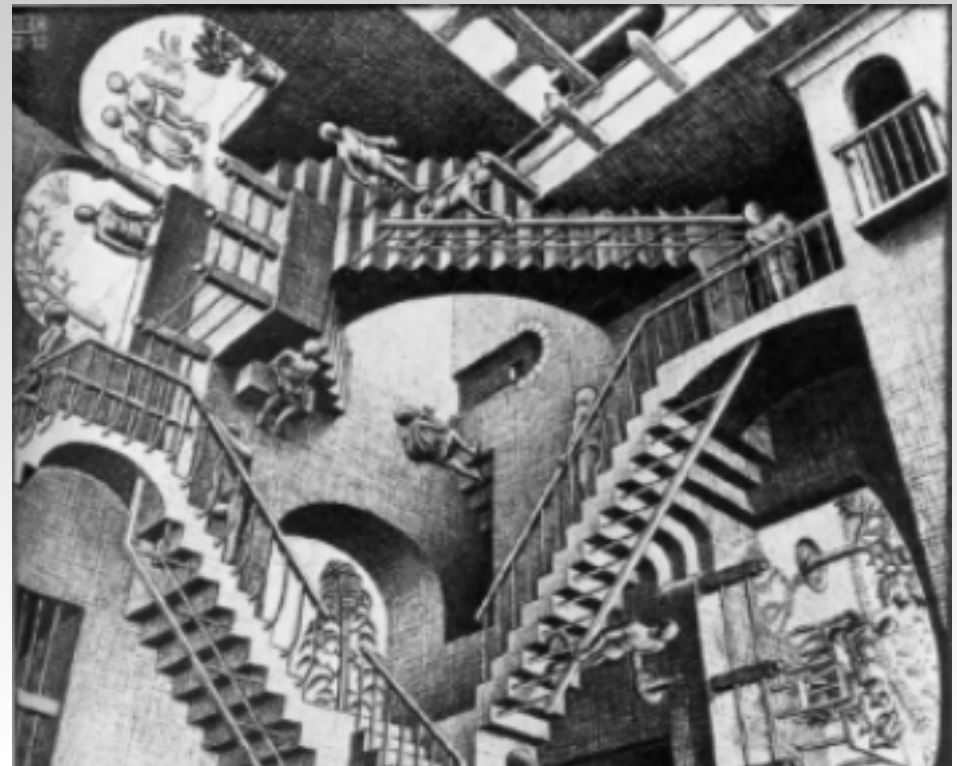
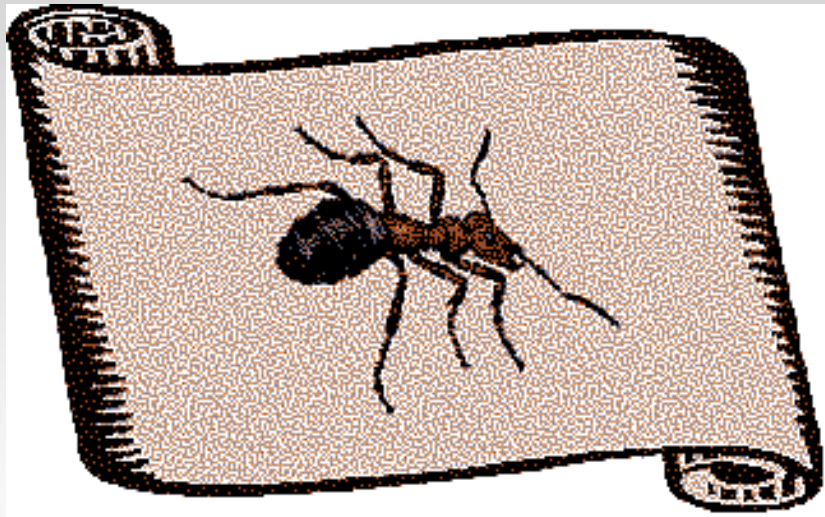
We might be close...



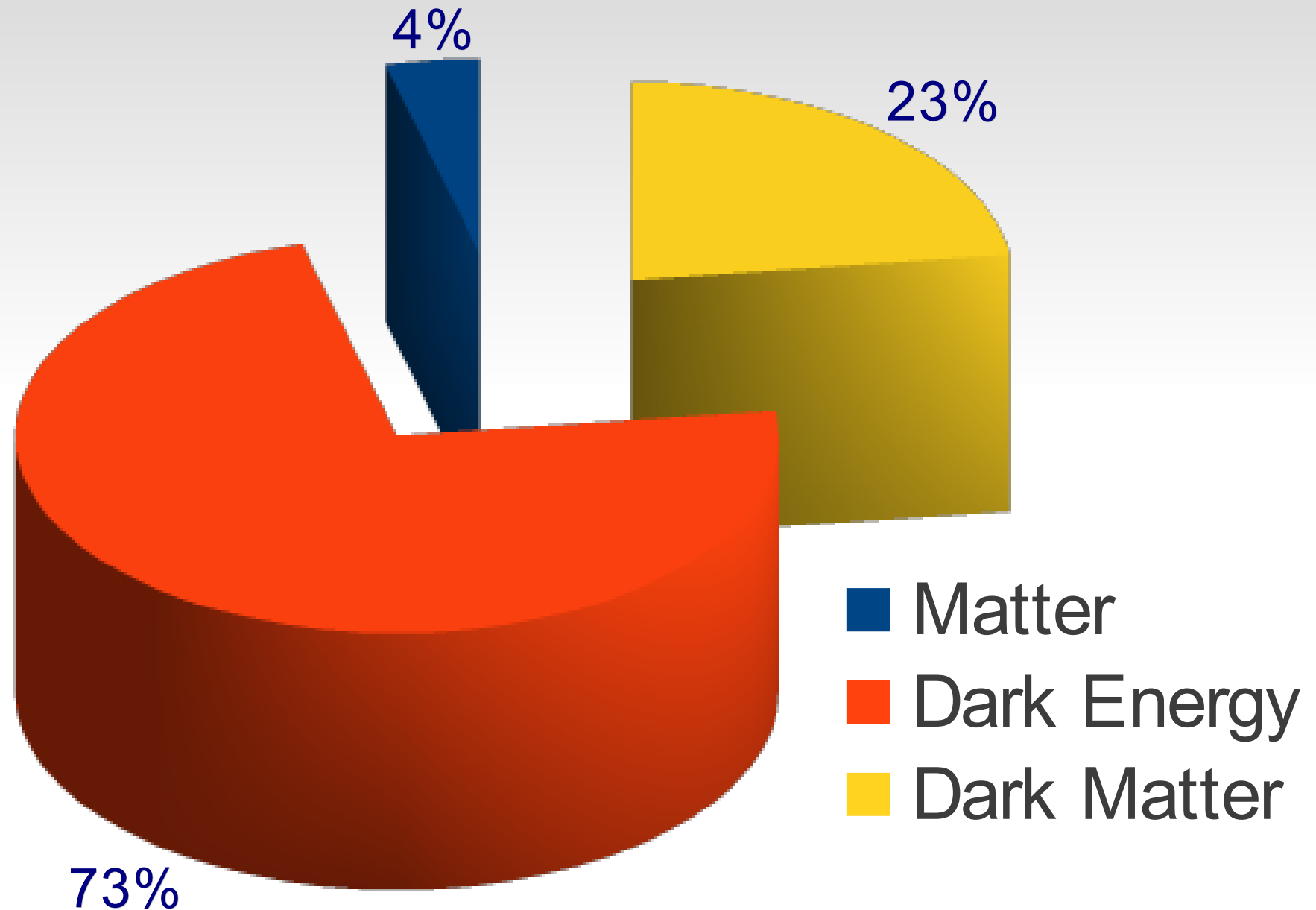
Black Holes



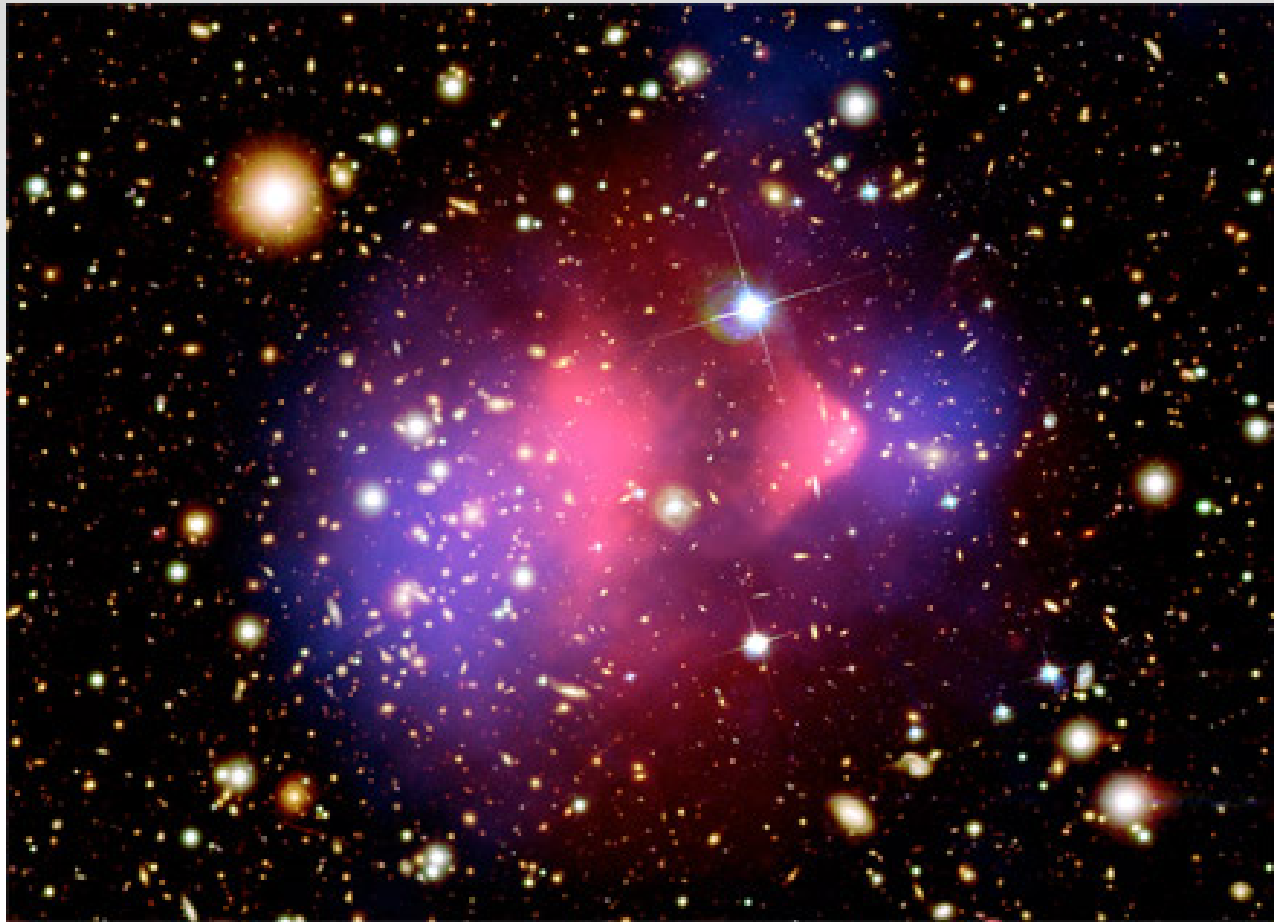
Extra Dimensions



Turns out we know less than we thought...

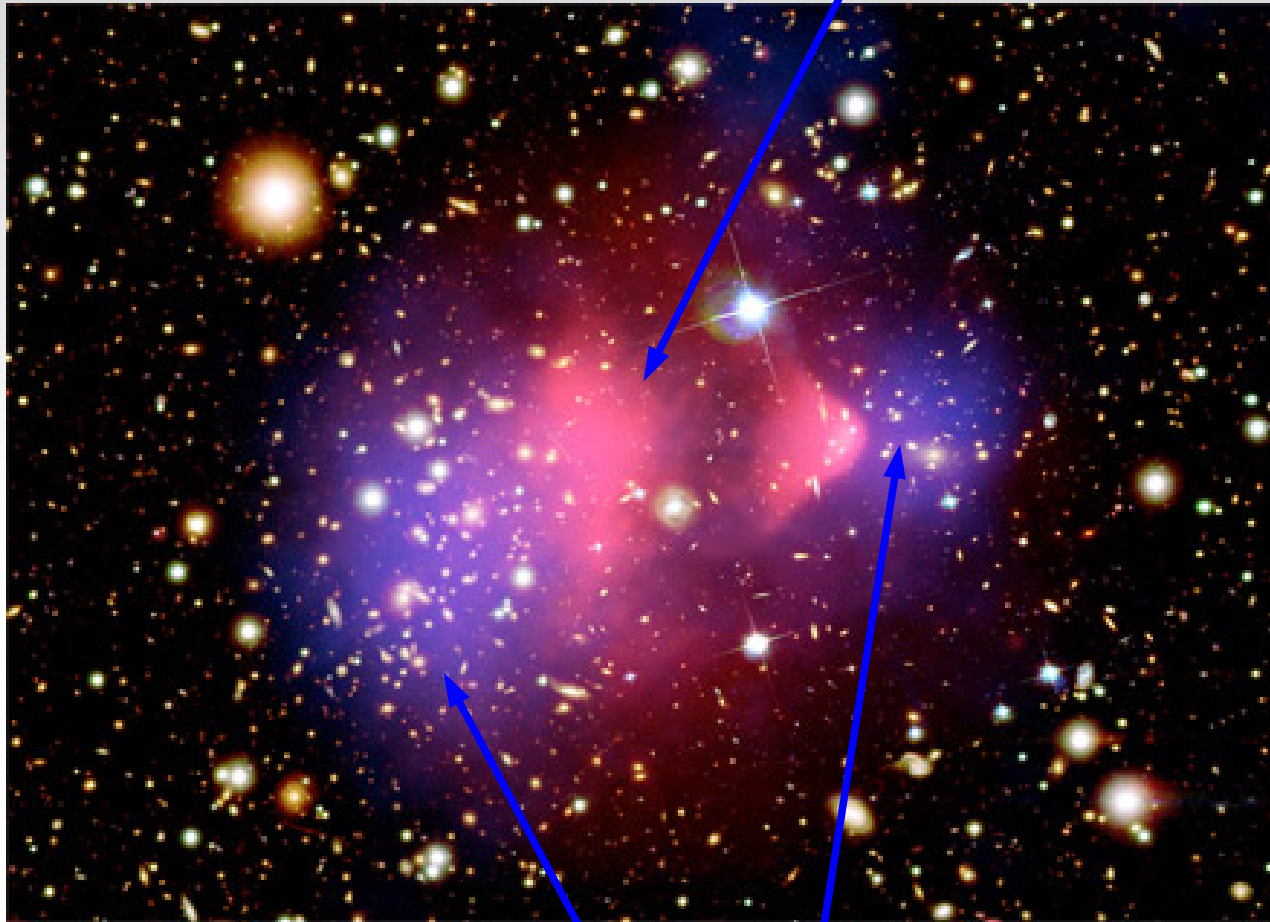


Dark Matter



Dark Matter

Hot gas



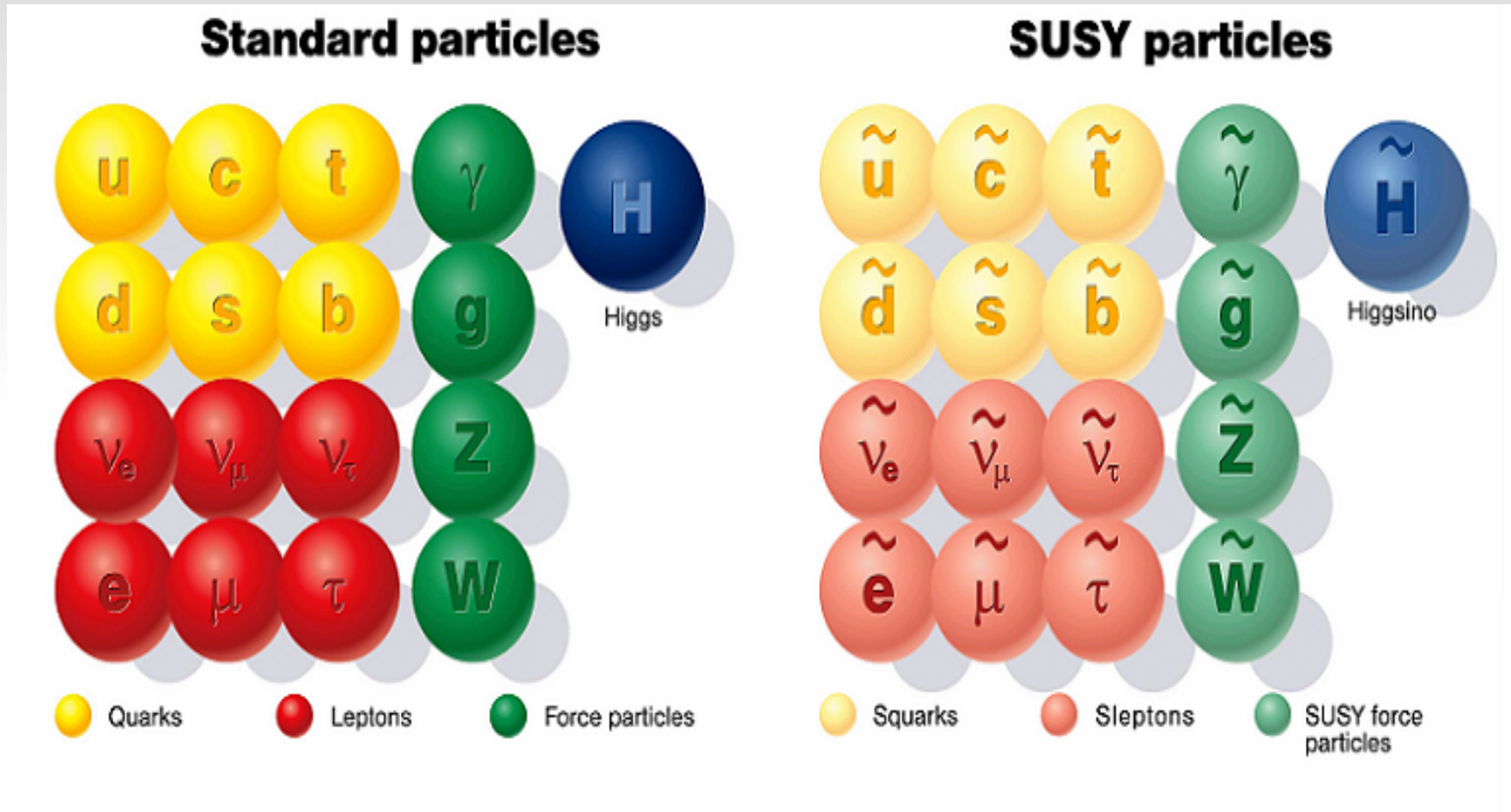
Dark matter

Dark Matter

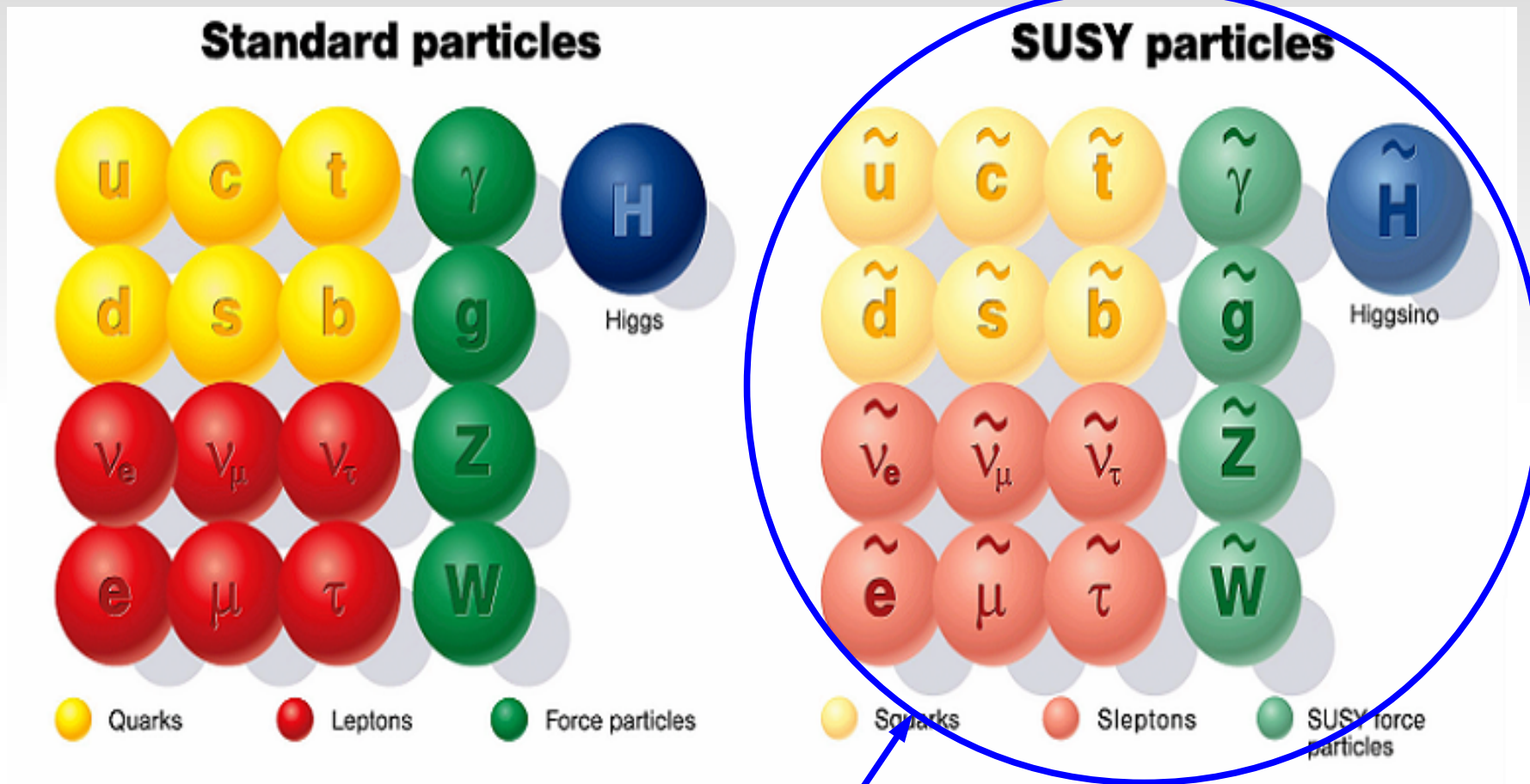
There are experiments looking for dark matter including the LHC. But it could be hard to find because it hardly interacts with matter at all.

Weakly interacting massive particles: WIMPs – we can try to look for these, but it could be hard work.

Supersymmetry

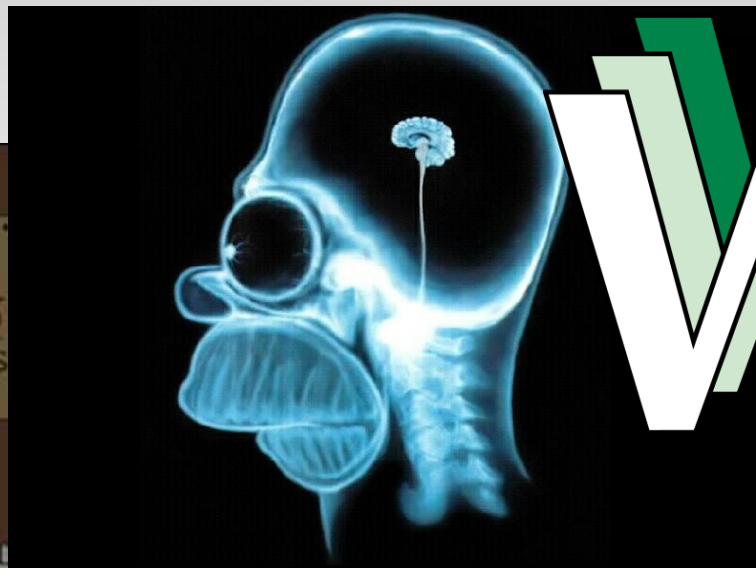
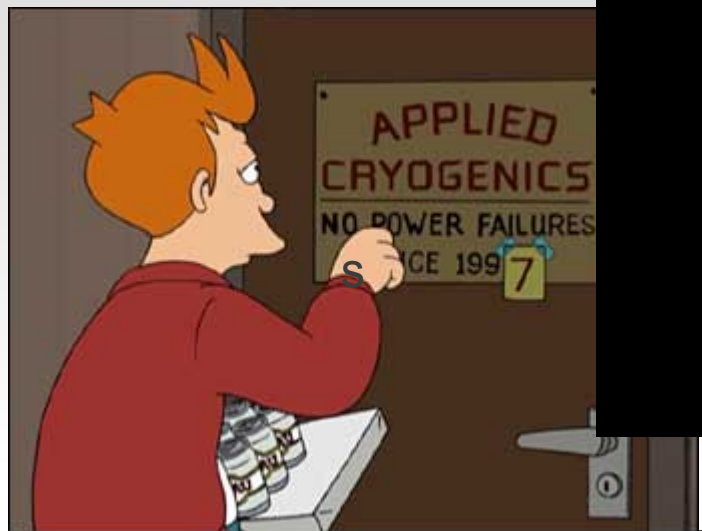


Supersymmetry



Dark matter in here somewhere?

Physics is everywhere...



But the most important thing is this:



Some websites and information

<http://www.physics.gla.ac.uk>

<http://www.physics.gla.ac.uk/ppt>

<http://cern.ch>

I also have an email address if you ever have questions:
b.colquhoun@physics.gla.ac.uk