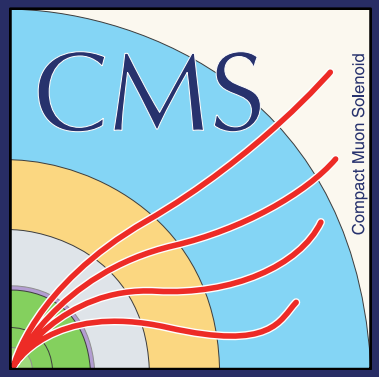


CMS Detector and its Physics

Disclaimer: “I’m just a Computer Scientist”

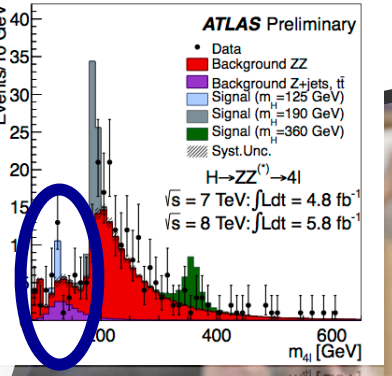
Slides Adapted from the CMS e-Masterclass, André David

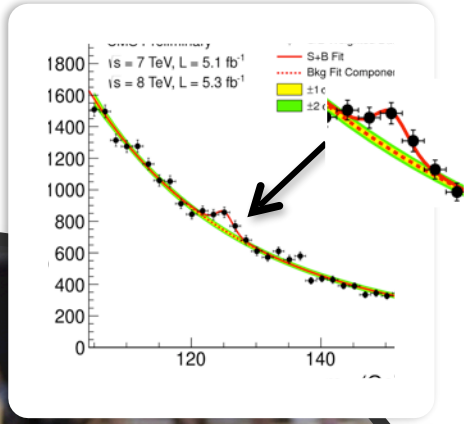
About 10,000 of its inhabitants came together to build…

The Large Hadron Collider
at CERN, Geneva, Switzerland

And in July 2012…

Two of these 10,000 people presented results…





Fabiola Gianotti
ATLAS Spokesperson 2010-2012

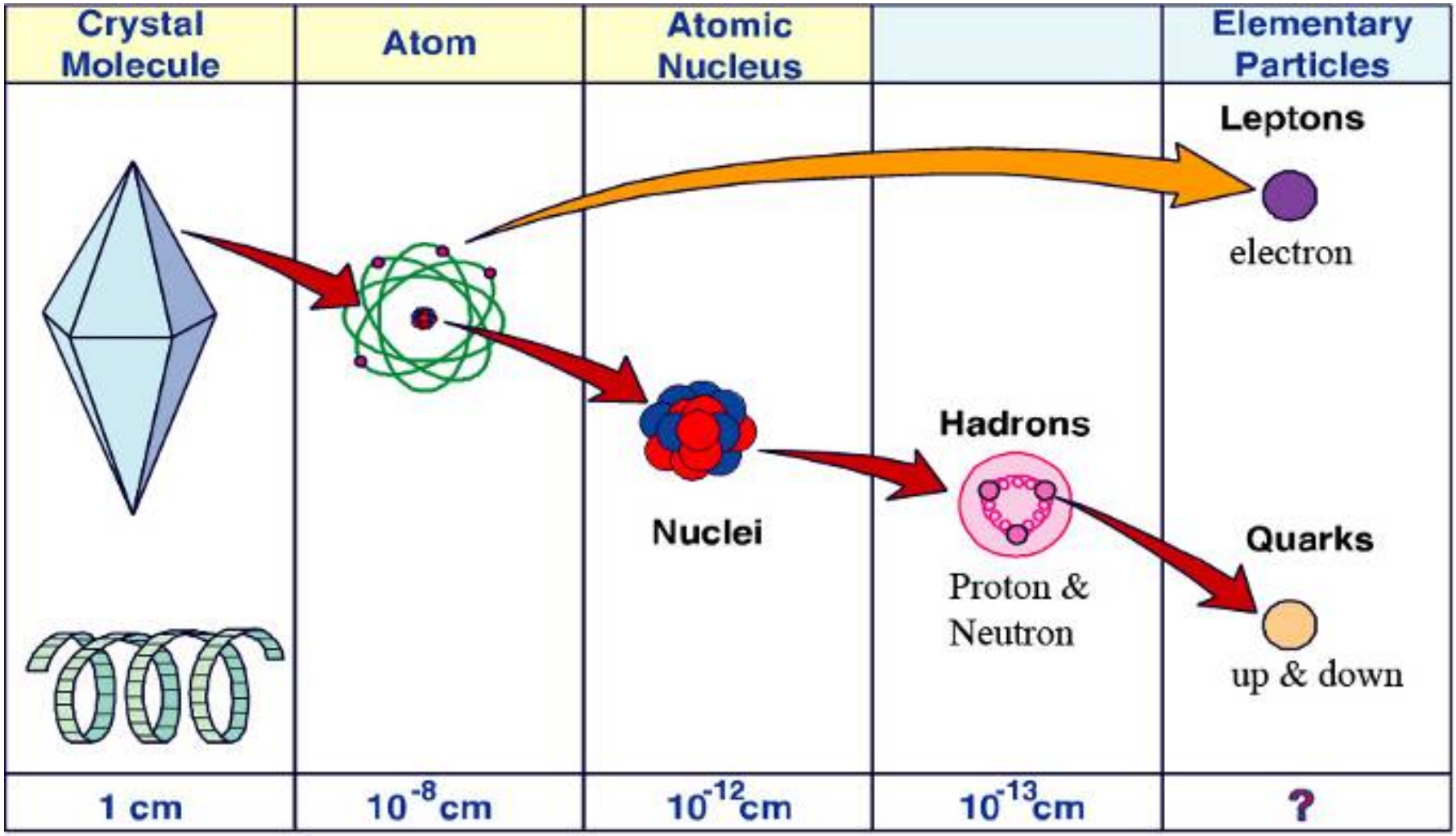
Joe Incandela
CMS Spokesperson 2012-2013

…that made a lot of physicists VERY happy…

… including these two guys!

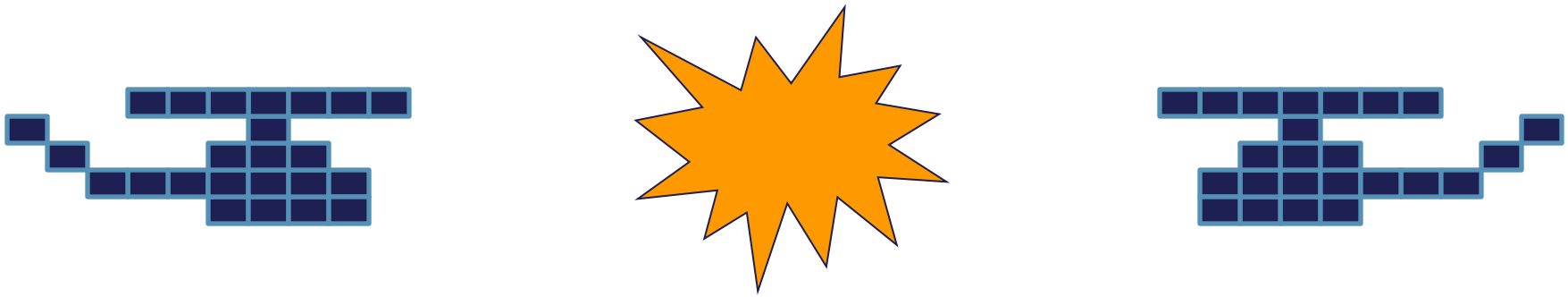
SO WHAT IS ALL THE FUSS ABOUT?

Our current understanding of the constituents of matter

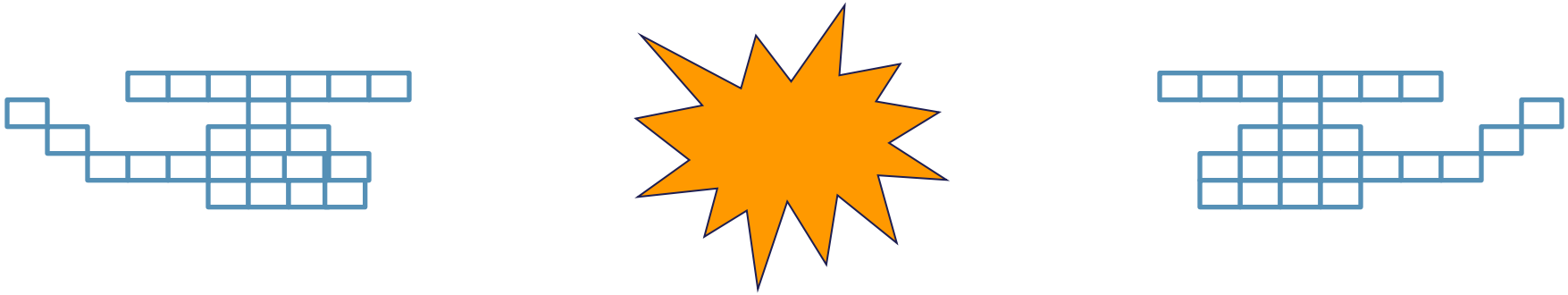


How do we know this?

Smash things together and see what happens!



Accelerator Energy



Accelerator Energy

Universal building blocks

Quarks

Up (u)

Down (d)

Lepton

electron

Chemistry!

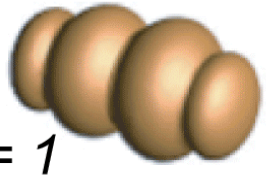
Groups of 3 quarks form Nucleons

- uud = proton
- udd = neutron

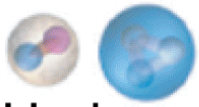
Universal forces

Strong

Gluons



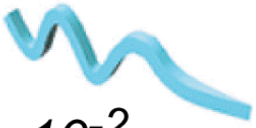
Strength = 1



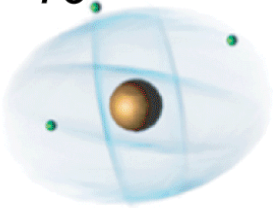
Hadrons Nuclei

Electromagnetic

Photon



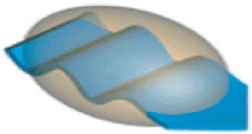
Strength = 10^{-2}



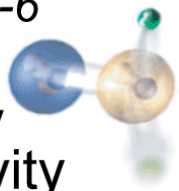
Atoms
Light
Chemistry
Electronics

Weak

W & Z



Strength = 10^{-6}



Neutron decay
Beta radioactivity
Neutrino interactions
Burning of the sun

Gravitational

Graviton

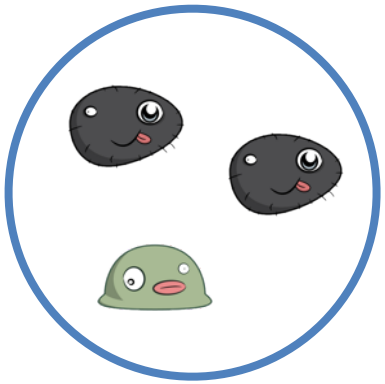
Strength = 10^{-40}

Solar system
Galaxies
Black holes

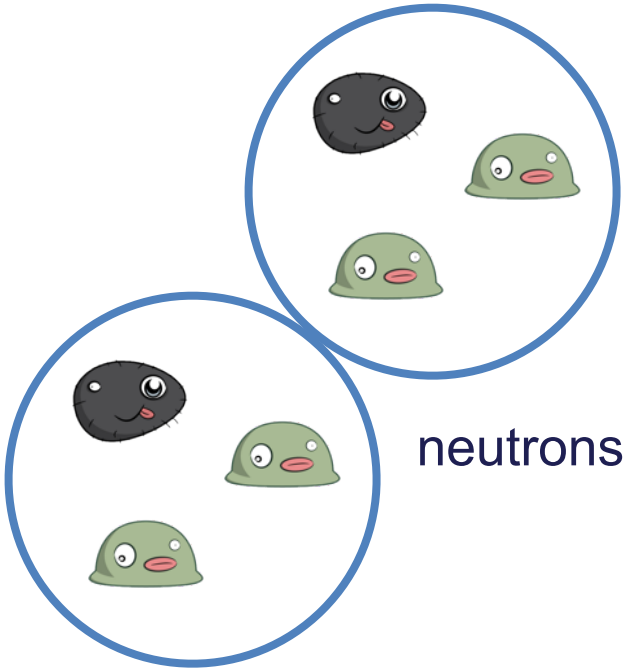
Building atoms

electrons

Helium Atom



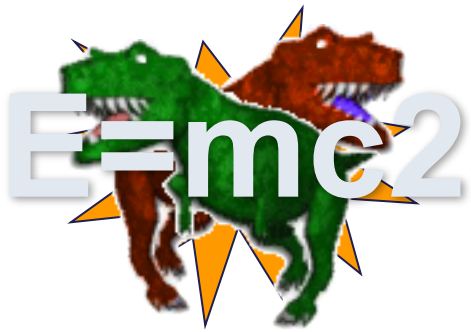
protons



neutrons

Multiply by billions and billions…

BUT THAT IS NOT THE END OF THE STORY…



The collision energy was used ***to create*** something new, that *did* exist but does not any more!

Accelerator Energy

13,700,000,000 years ago there
were other things in the Universe – that we can “create” in the laboratory

So we have built a Time Machine!

Fundamental Particles at the time of the Big Bang

Quarks


up


charm


top


down


strange


bottom

Leptons


electron


muon


tau


electron neutrino


muon neutrino


tau neutrino

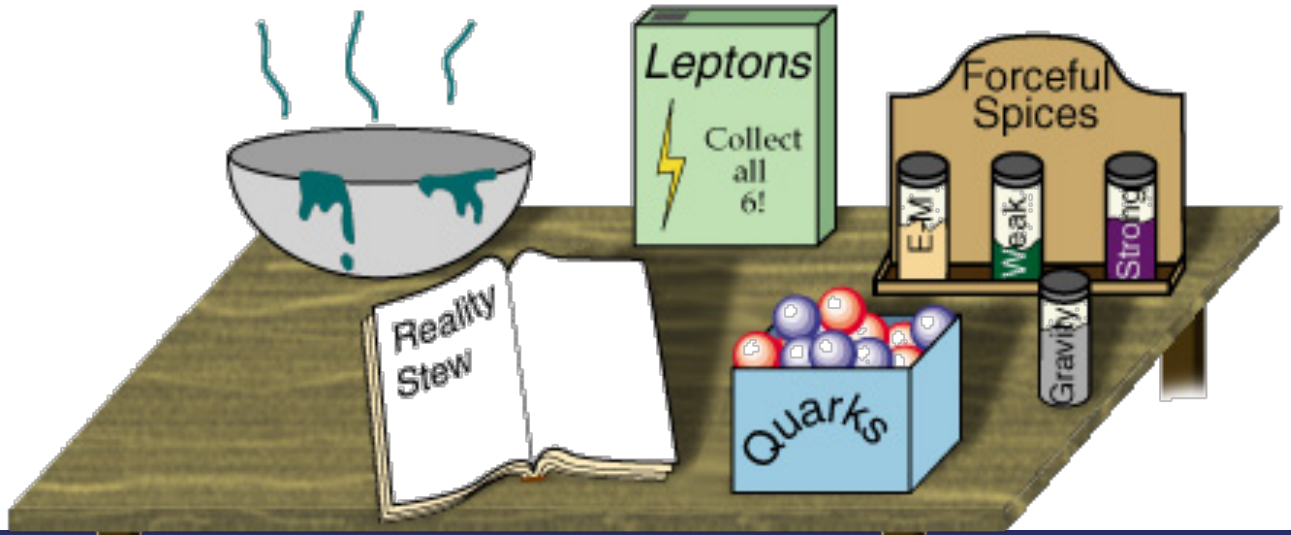
Le Zoo des particules

It looks like we know everything!

In fact we know very little!

Answers to simple questions

- Since the early 70s, particle physicists have synthesized all their knowledge in a single model: the «Standard Model»
- We know and we understand a lot but we do not know everything …
- Mysteries remain unexplained
- There are things to discover ...



The *massive* mystery

Why do some fundamental particles have mass while others don't?

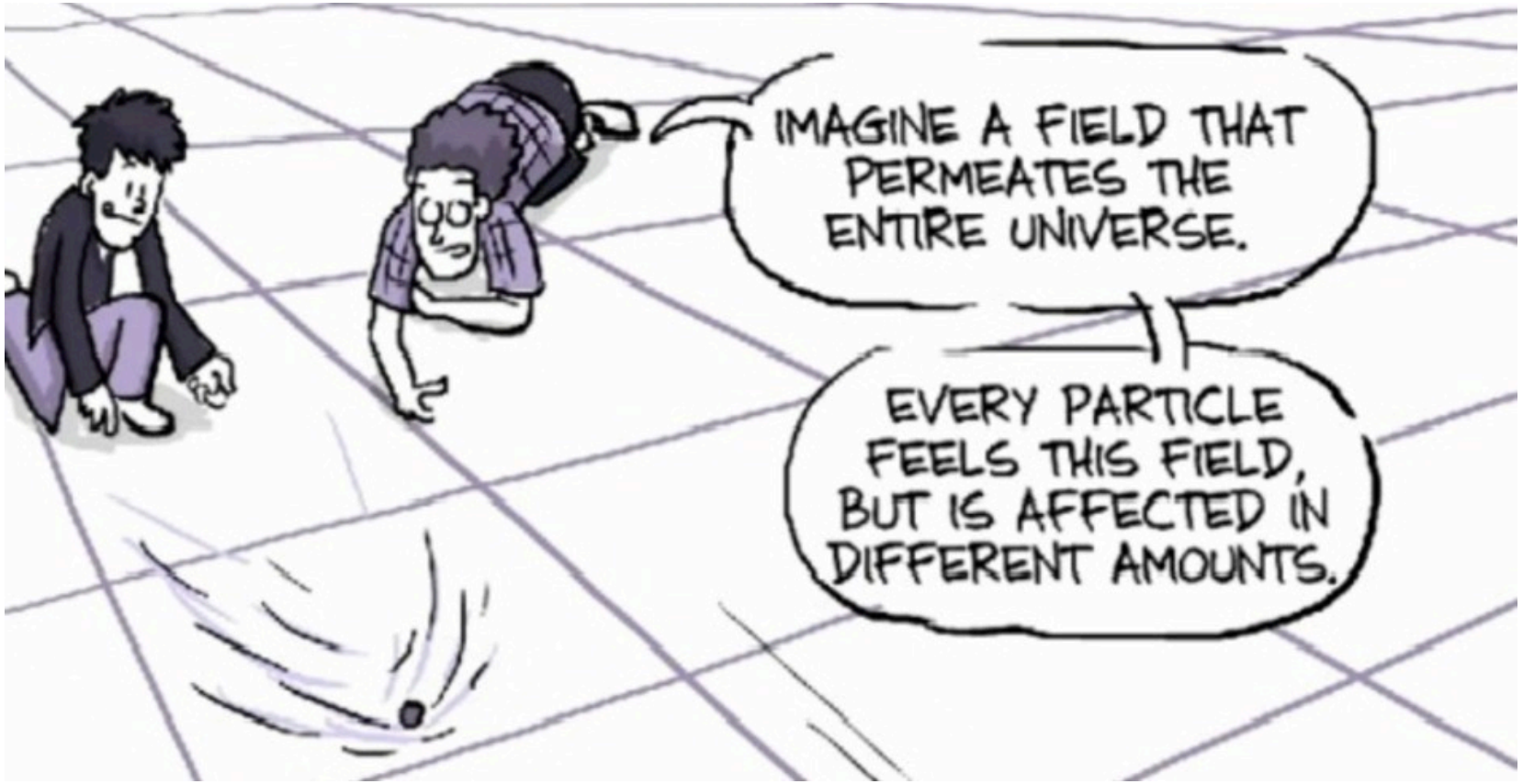
Do you remember these guys?

Nearly 50 years ago six physicists proposed an explanation of how particles get mass…

Kibble Guralnik Hagen Englert Brout

Higgs

THEORY: The Brout-Englert-Higgs Field



The more a particle interacts with this *invisible* field, the more mass it gets.

But if this field is invisible, how can we PROVE it exists?

The theory predicts that the field has an associated particle:

The Higgs Boson!

We can try to create the Higgs boson in our experiment!

It is predicted to be VERY rare

Assume ~7’000 grains of rice in a serving of Kheer…

…then the chances of creating and finding a Higgs boson is…

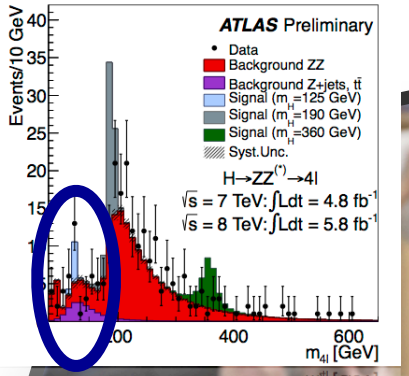
Like finding 1 grain if everyone in Geneva eats Kheer once a day for a whole month!!

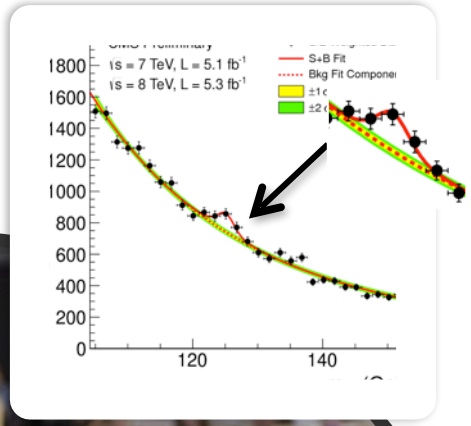
~1 in 1,000,000,000,000
(yes, that’s a million million)

And just to make things even more complicated…

The Higgs boson would “decay” instantly to lighter particles. We only detect these resulting particles – so we have to be like detectives – look at the evidence to see what happened!

But despite all these difficulties





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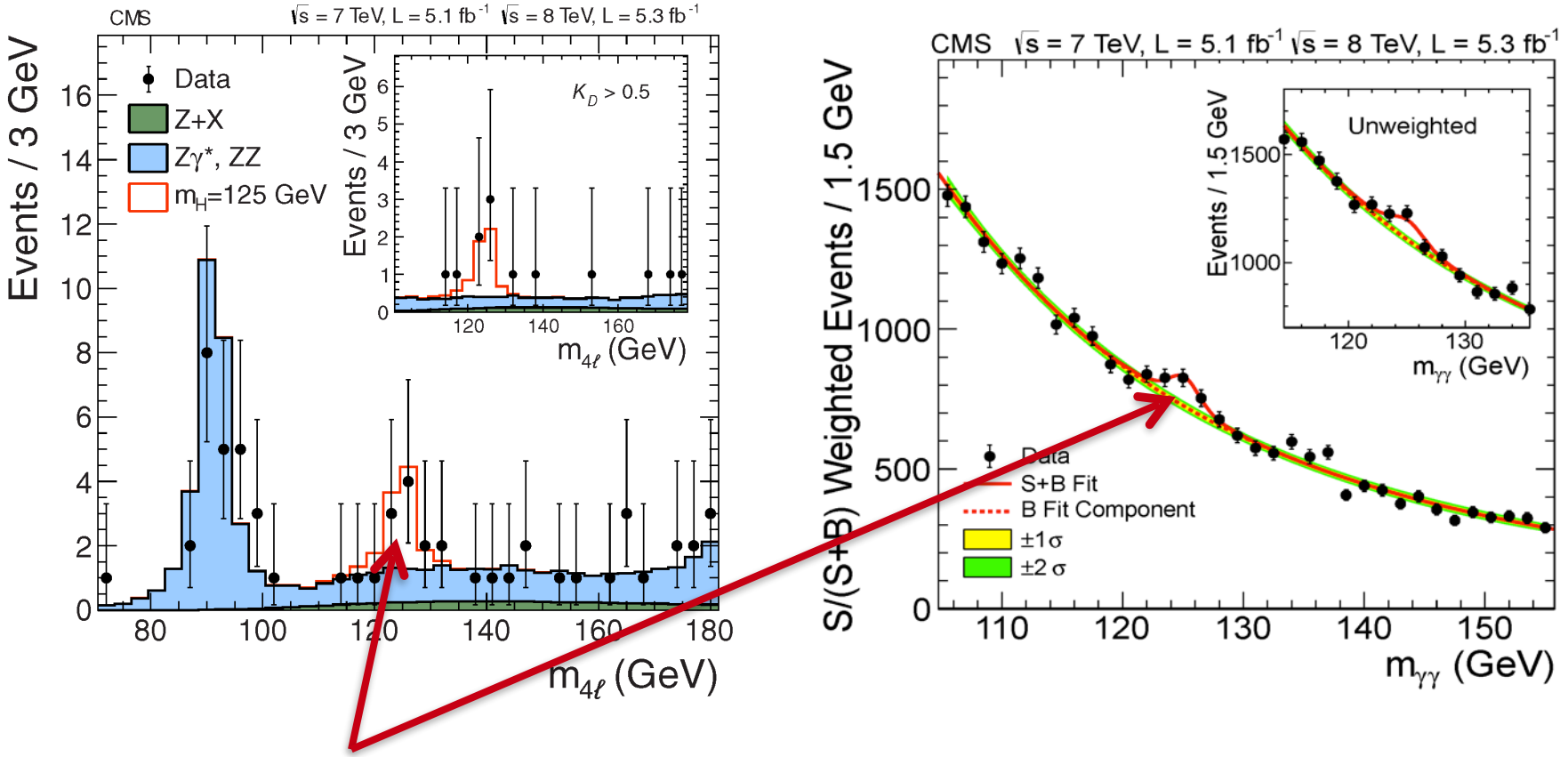
We found it!

We Found Some Higgs Bosons!!



These bumps in the data signify a new particle, found in two different ways, at the same mass – about 125 GeV/c2

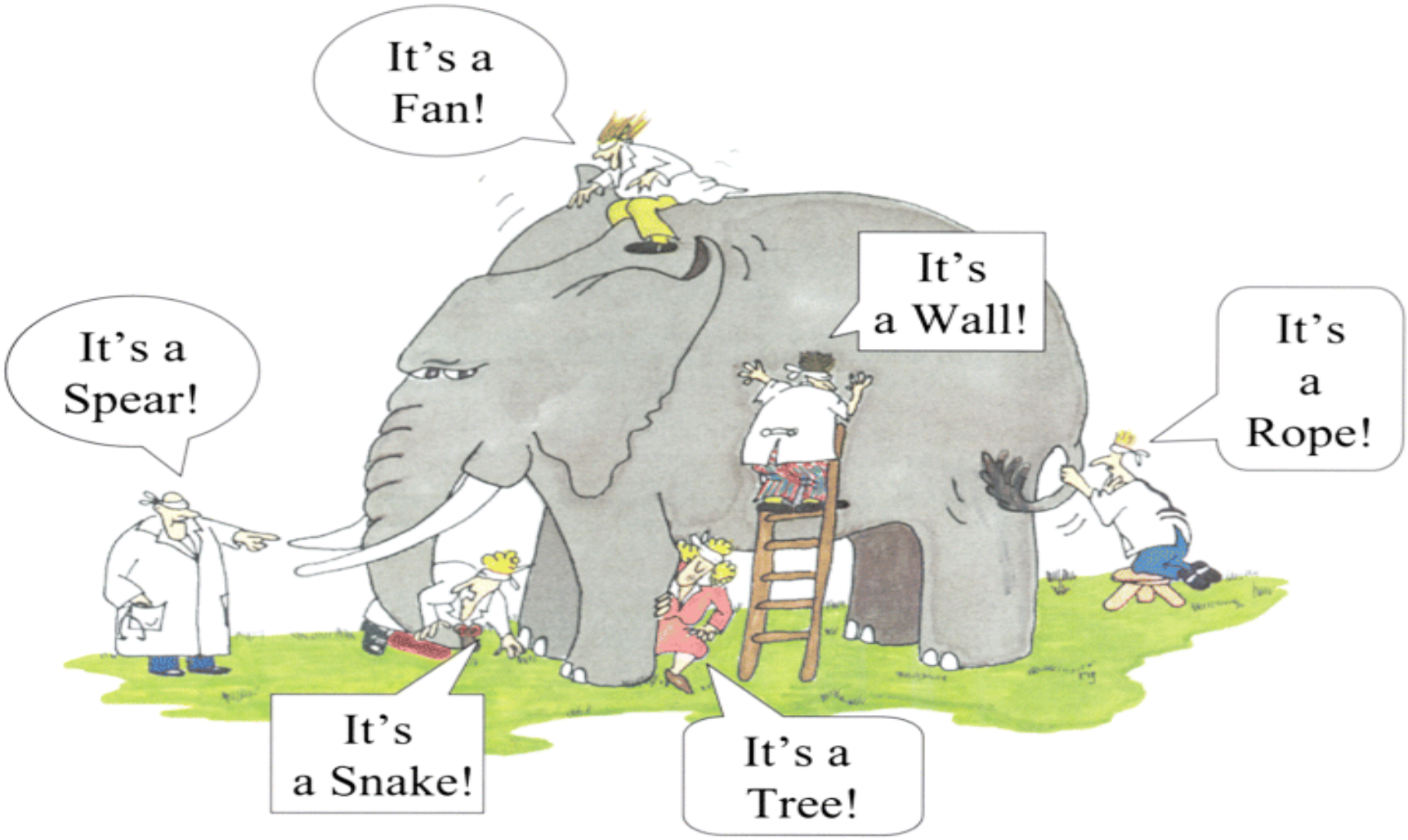
But we have only just started to understand the Higgs boson…


It's
a
Rope!


It’s a
Spear!


It's
a Wall!

But we have only just started to understand the Higgs boson…and we need to look from every angle



SO HOW DO WE “CREATE” PARTICLES IN REALITY?

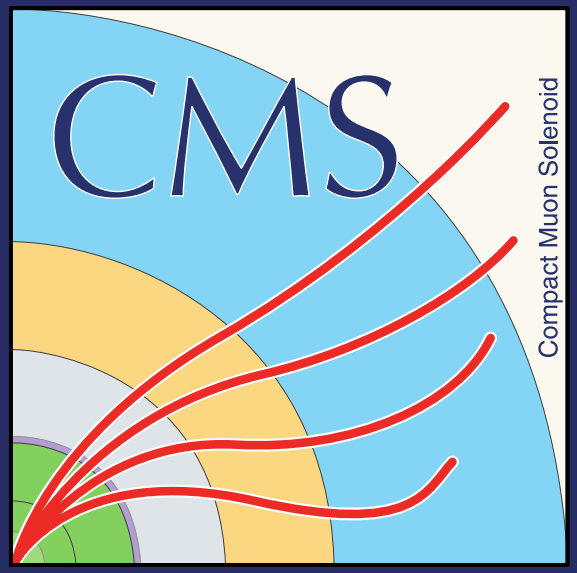
One of the fastest racetracks on earth:

The Large Hadron Collider

Several thousand billion protons travelling at 99.9999991% of the speed of light travel round the **27km ring, 100m underground, over 11000 times a second!**

And then what?

- After the collisions, we have detectors that “reveal” the presence of different particles.


CMS
Compact Muon Solenoid