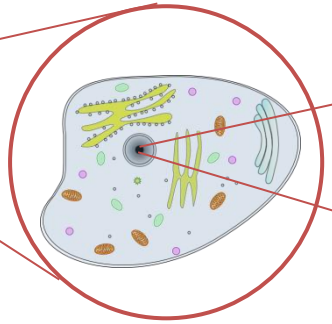
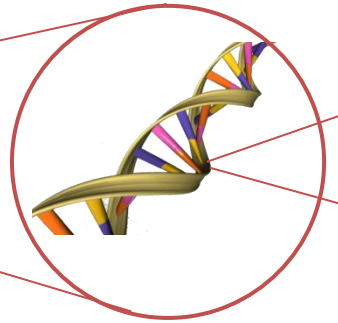
What are we made of ? What is the smallest thing there is ?

Us! (~1m)

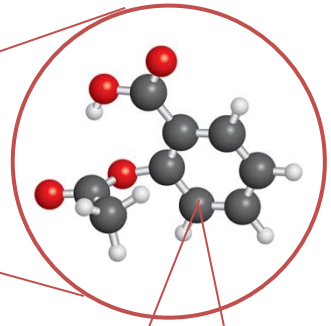
biological cells (~0.000 1m)



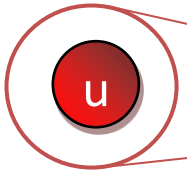
DNA (~0.000 01)

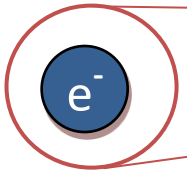


molecules (~0.000 000 1m)

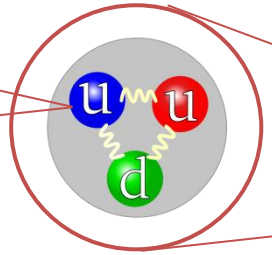


quarks & electrons
(<10^{-19}m or smaller than we can measure)

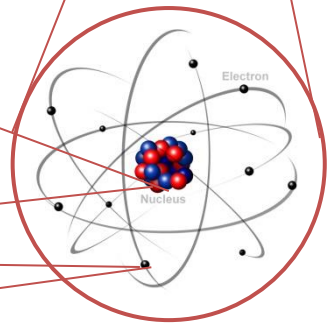




protons & neutrons (~10^{-15}m)



atoms (~0.000 000 000 1m or ~10^{-10}m)



…but quarks and electrons aren't the only 'elementary particles' we have found…

What are the smallest things there are (the ‘elementary particles’) ?

Quarks – for example in protons and neutrons

Up Quark | Down Quark | Charm Quark | Strange Quark | Top Quark | Beauty Quark

Leptons – e.g. the electron and its (almost) imaginary friend, the electron neutrino

Electron | Muon | Tau | Electron Neutrino | Muon Neutrino | Tau Neutrino

Anti-quarks – like the quarks, but with the opposite electrical charges

Anti-Up Quark | Anti-Down Quark | Anti-Charm Quark | Anti-Strange Quark | Anti-Top Quark | Anti-Beauty Quark

Anti-leptons – like the leptons, but with the opposite electrical charges

Anti-Electron (Positron) | Anti-Muon | Anti-Tau | Electron Anti-Neutrino | Muon Anti-Neutrino | Tau Anti-Neutrino

Bosons – to do with forces and mass

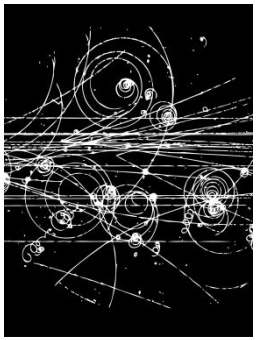
Photon | W+/W- Boson | Z Boson | Gluon | Higgs Boson | …but is this the Higgs boson or a Higgs boson?

The PARTICLE ZOO
Subatomic Particle Plush Toys FROM THE STANDARD MODEL OF PHYSICS & beyond!

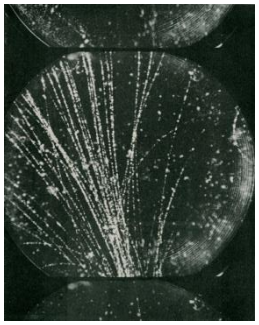
How can we detect elementary particles ?

Historic particle detectors:

Bubble chambers



Cloud chambers



Modern general-purpose particle detectors:

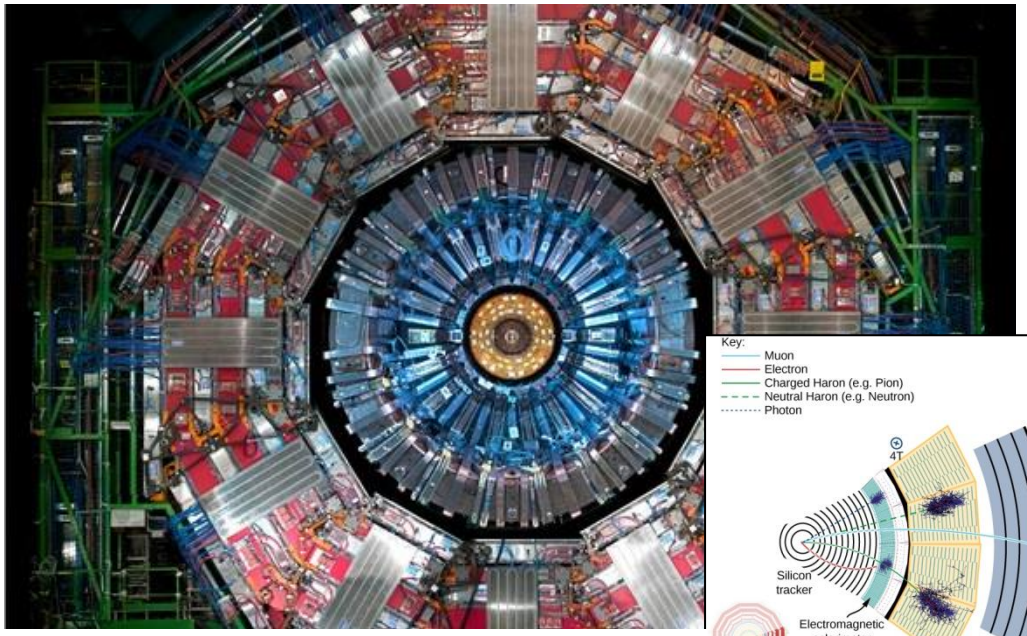
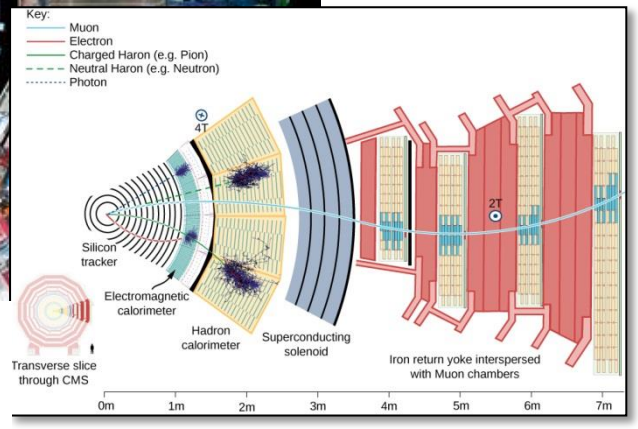


Photo credit: CMS, CERN



Modern detectors have several layers of different types of detector – for example using semiconductors, charge-sensing wires and calorimeters (which absorb energy).

What's the biggest thing there is?

Earth (~1,000,000m or 10^6m across)

Your **Solar System** (~10^{12}m across)

Galaxies like ours (~10^{21}m)

Hubble Deep Field Photo – a tiny part of the **Universe**

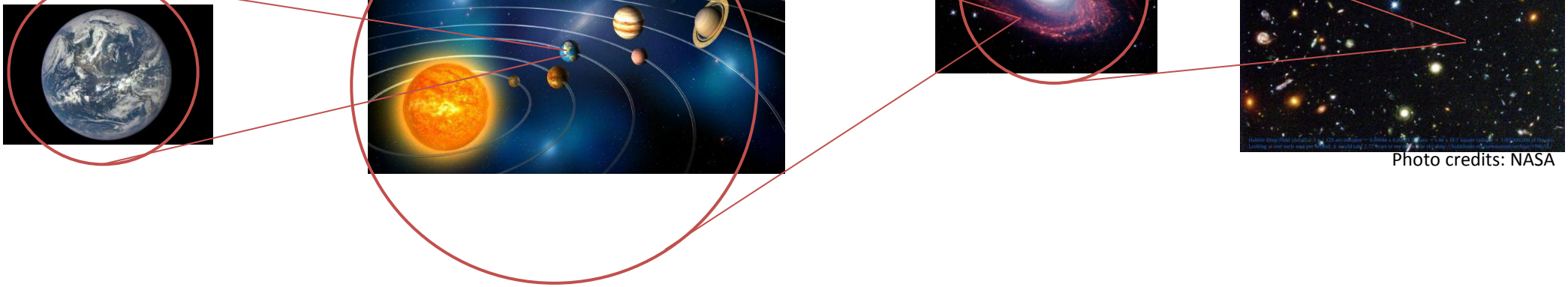


Photo credits: NASA

Where did we come from ? What will happen in the future ?