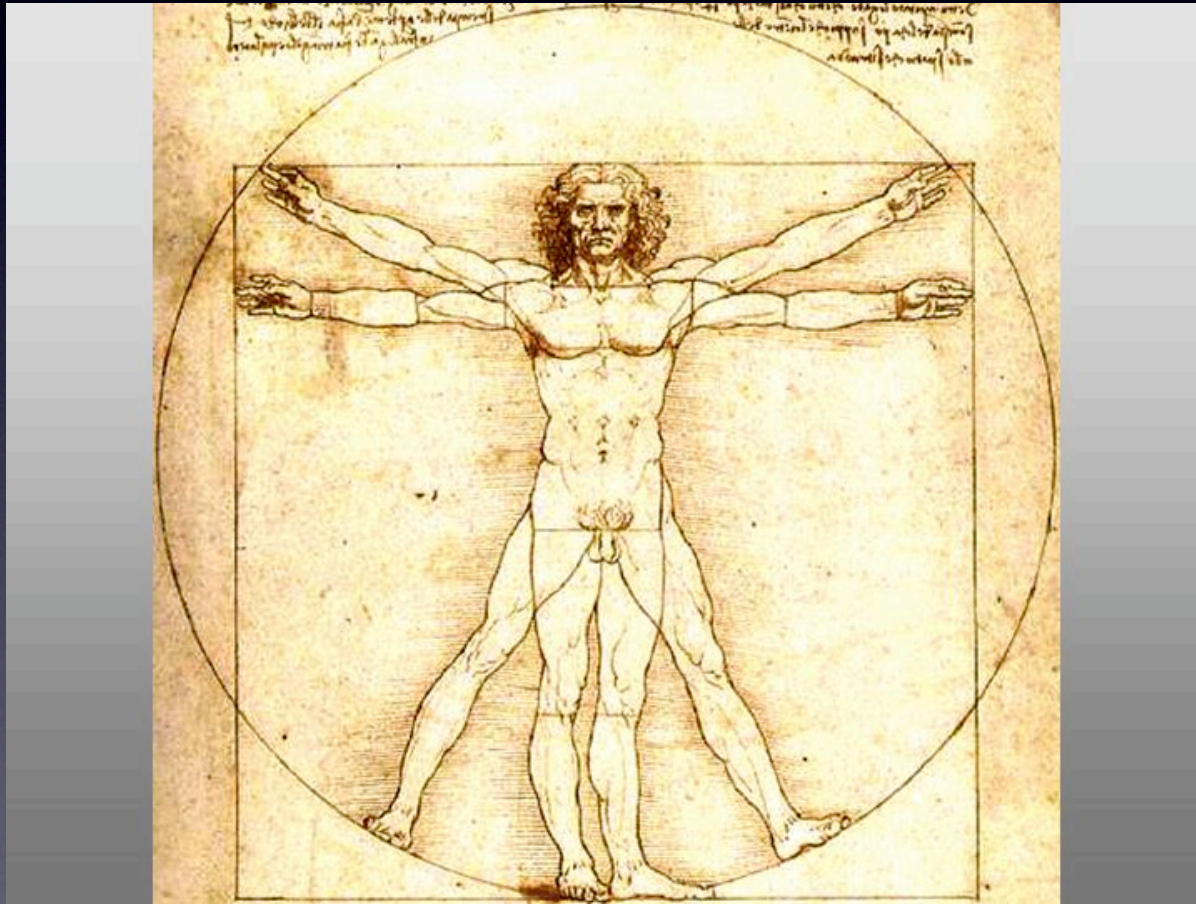


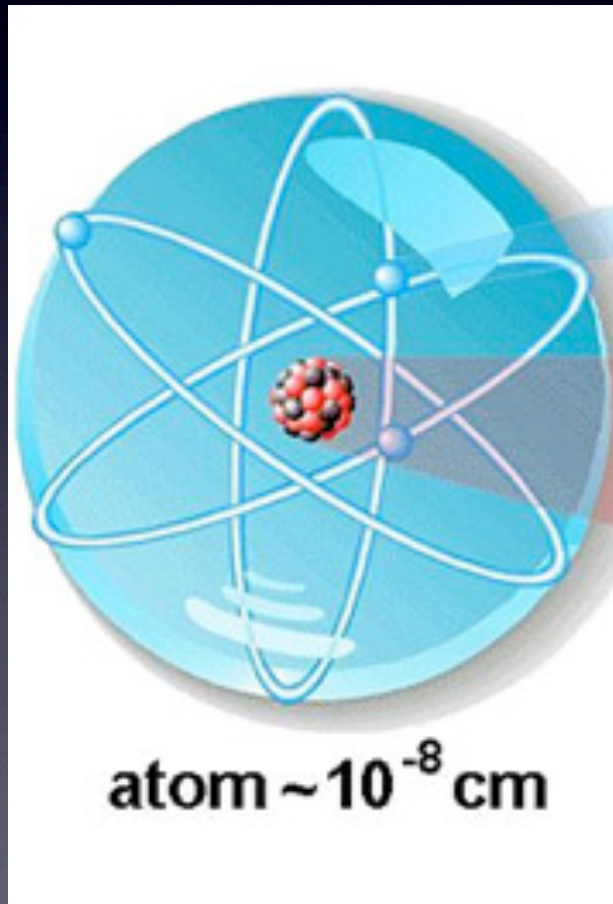
The BIG questions...

What are we made of?



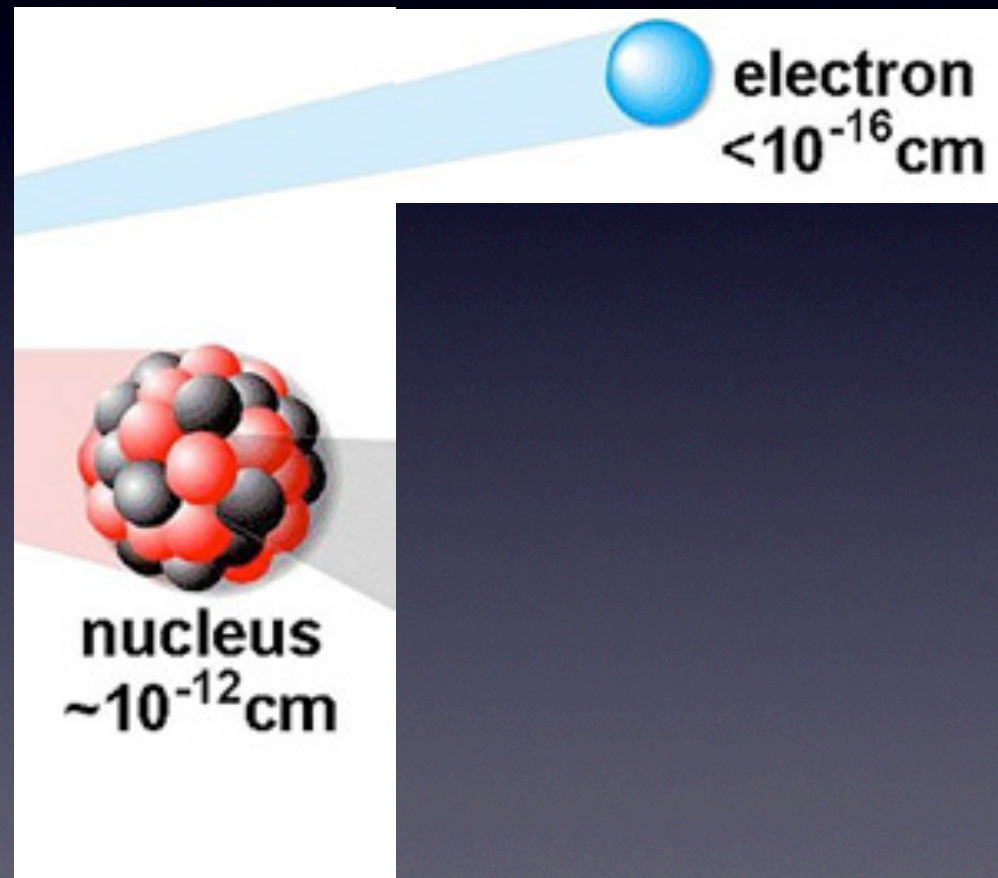
The BIG questions...

What are we made of?



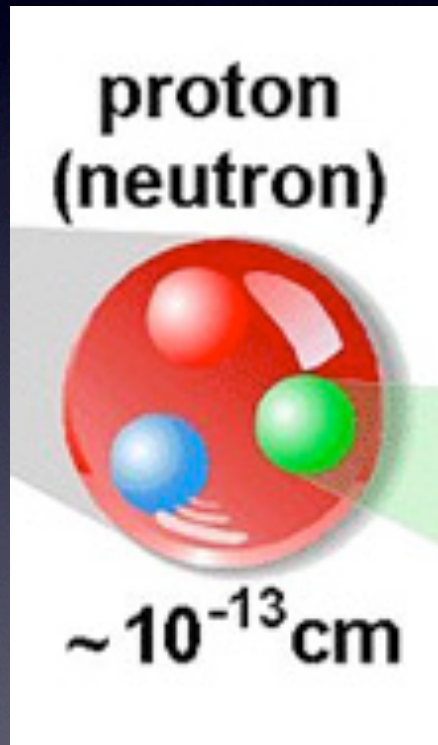
The BIG questions...

What is matter made of?



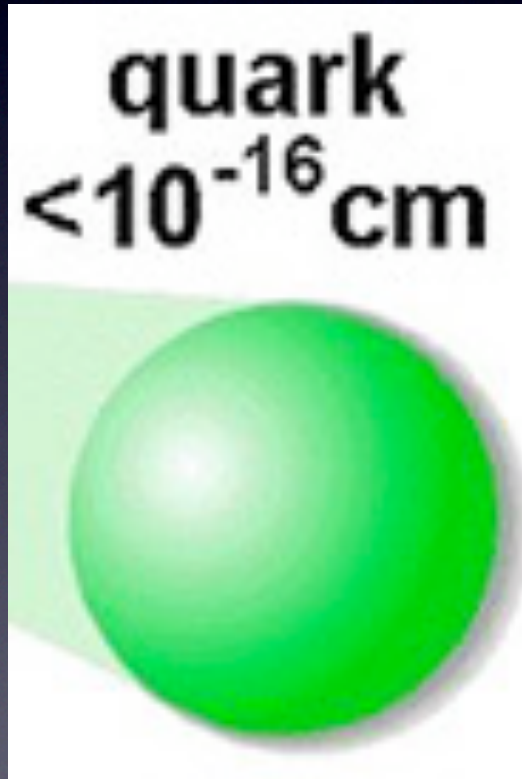
The BIG questions...

What is matter made of?



The BIG questions...

What is matter made of?



The BIG questions...

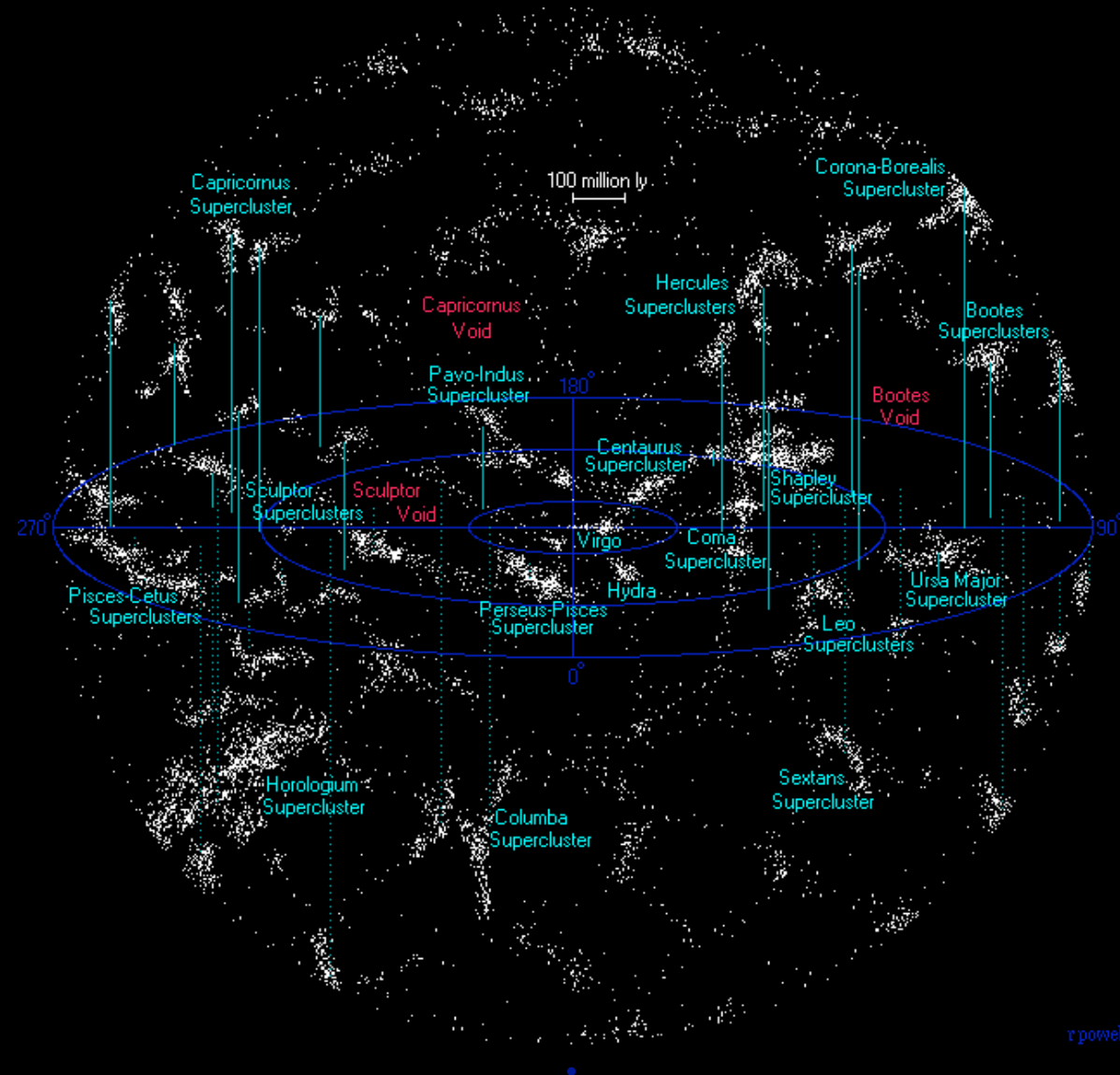
What is matter made of?



The BIG questions...

What is the Universe made of?

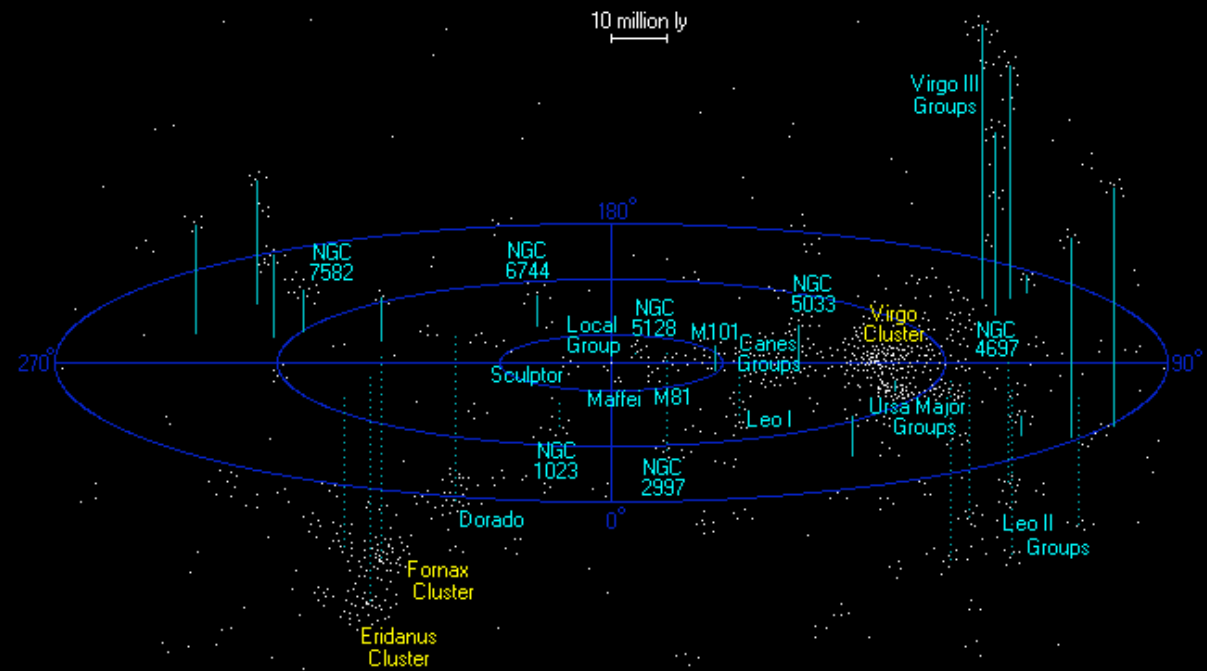
1 billion
light years



The BIG questions...

What is the Universe made of?

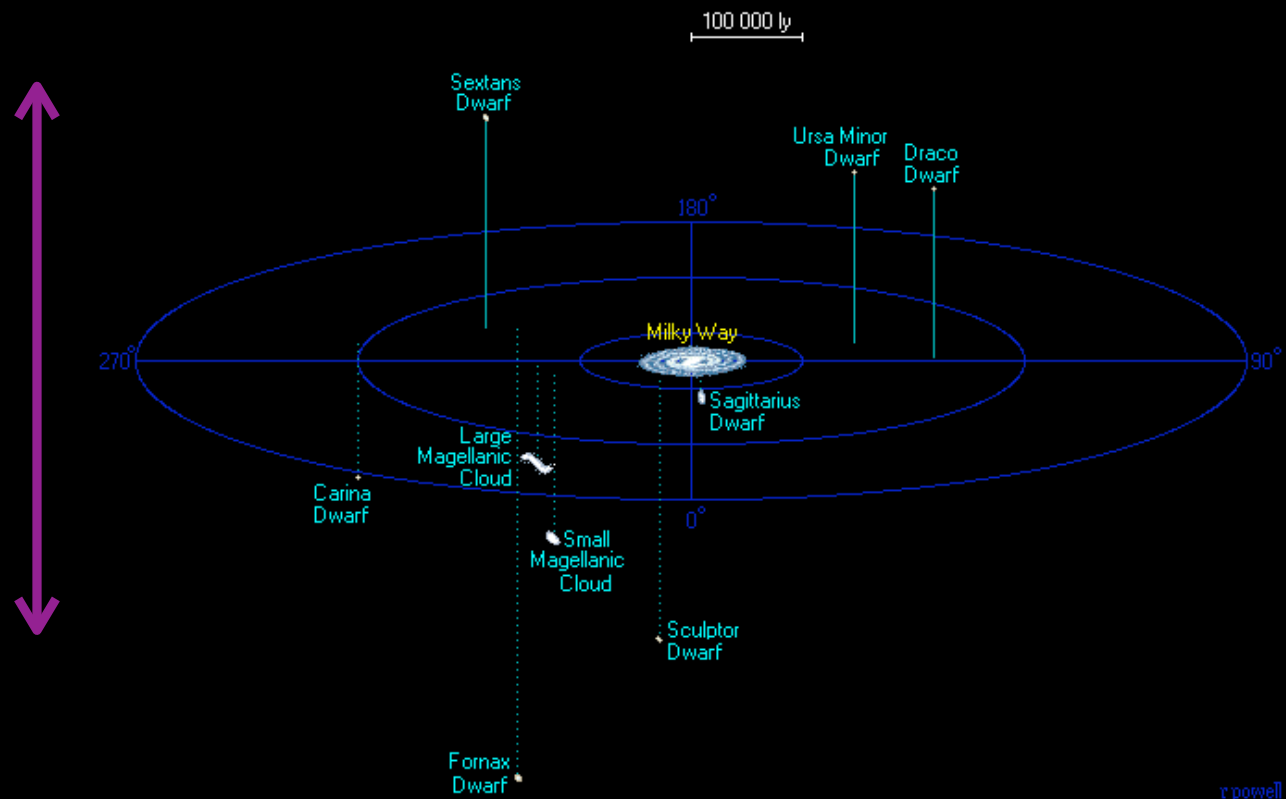
100 million
light years



The BIG questions...

What is the Universe made of?

1 million
light years



The BIG questions...

What is the Universe made of?

100000
light years



The BIG questions...

How does it all fit together?



The BIG questions... for LHC:

What are we made of?

How do particles get mass?

What is the Universe made of?

What is dark matter?

How does it all fit together?

Do the forces unify?

Part I

How do particles get mass?

Over the last century, particle physicists have found elementary particles with a huge range of mass:



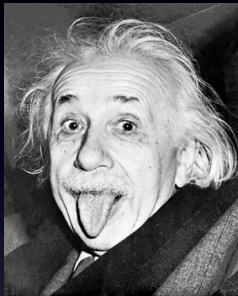
Animal Kingdom

100 humans

1 human

10^{-6} humans = 0.000001 humans

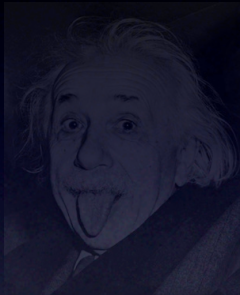
10^{-10} humans = 0.0000000001 humans



Particle Kingdom



top quark 180 protons



proton 1 proton



electron 10^{-3} protons



neutrino 10^{-10} protons



Just like all animals started from a tiny cell
and grew....

The Universe began very hot and very small

All particles were without mass

After it cooled, the Universe underwent a
“phase transition” after which almost all
particles became massive

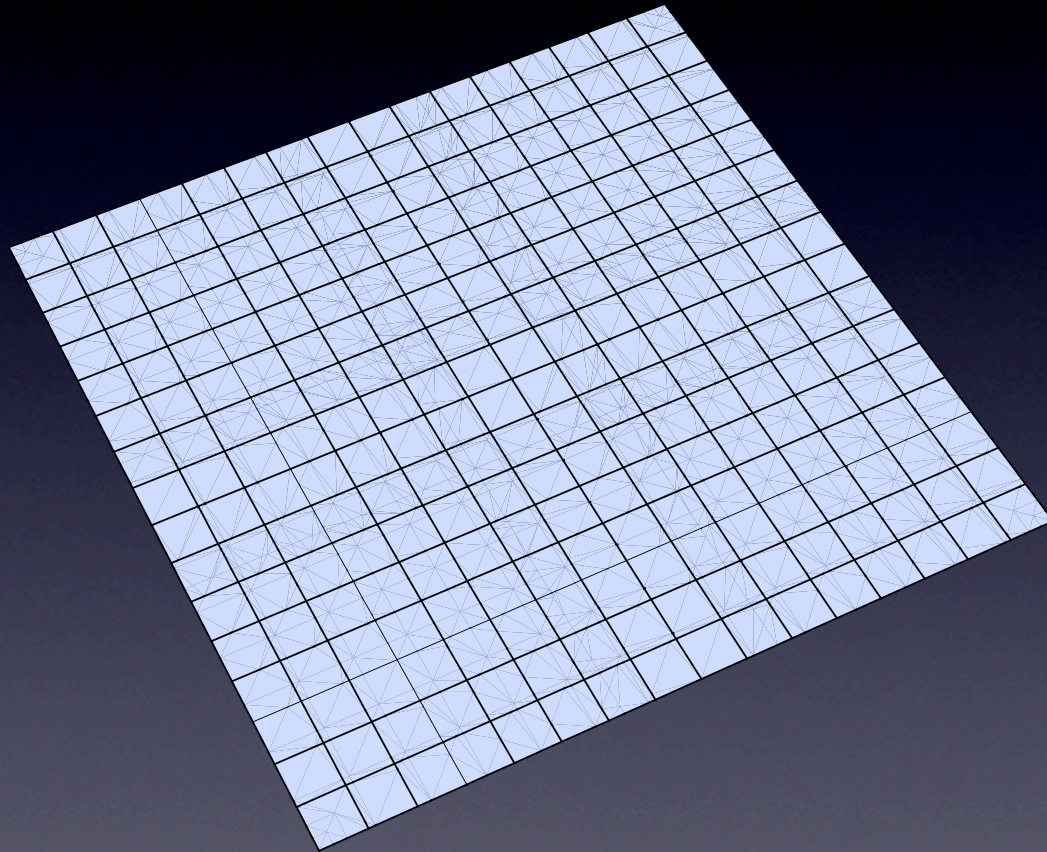
Hot gas →



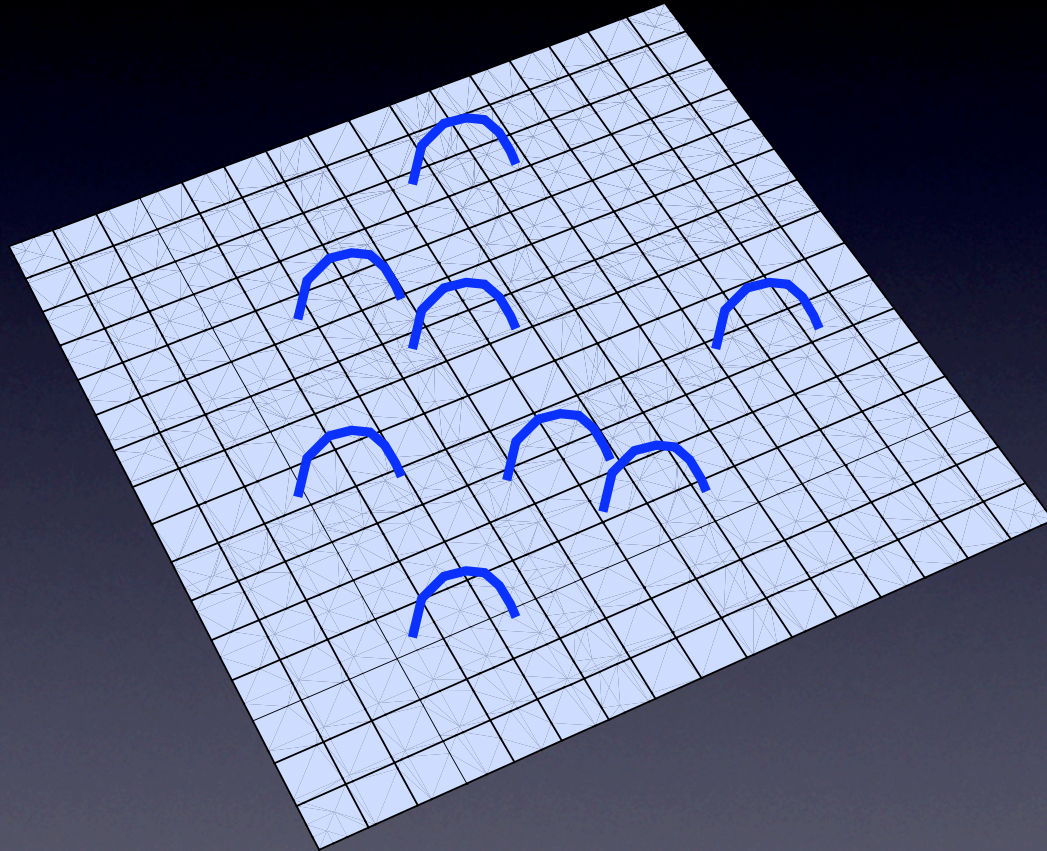
Hot gas → Liquid water → Cold ice



In the early Universe, *empty space itself* underwent a kind of phase transition.

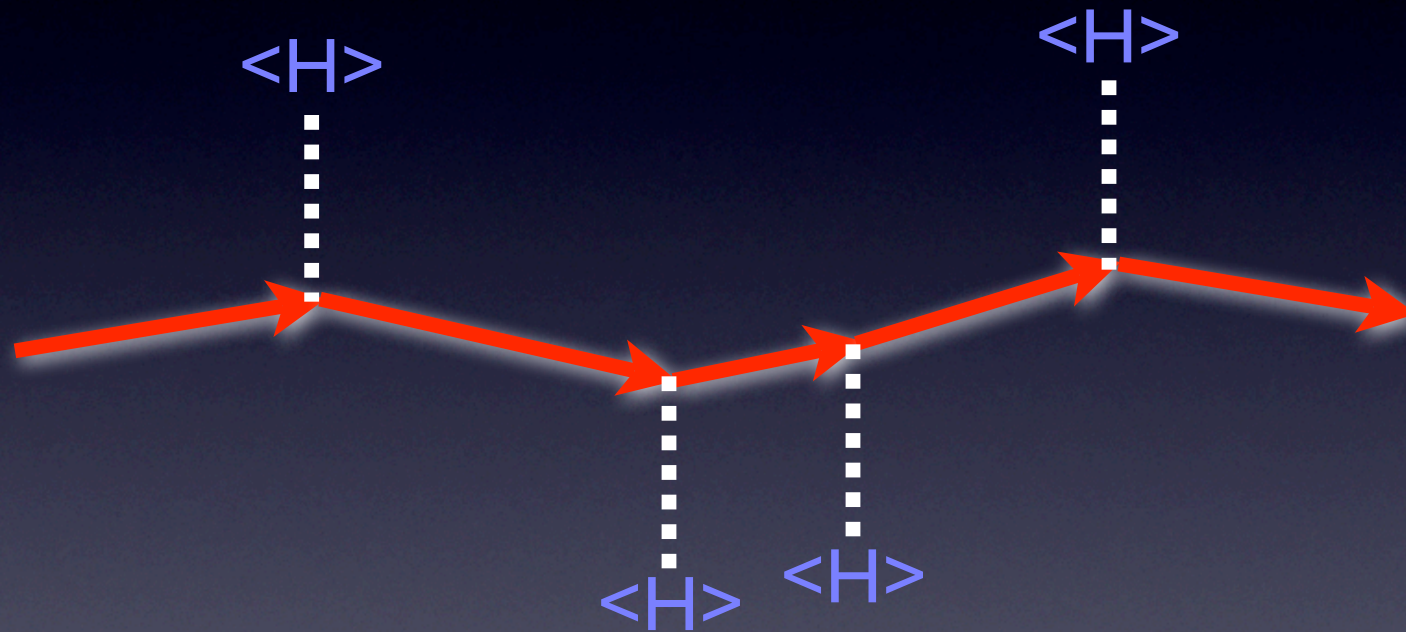


This is because empty space
is not empty at all!



It is filled with a sea of “virtual particles”

Massive particles “feel” the phase transition of empty space by bumping into virtual particles



called “Higgs bosons”

Prof. Peter Higgs...



The central goal of the LHC
is to find the Higgs boson.

Its discovery will revolutionize our
understanding of one of the most
basic quantities of physics: MASS!

Part II

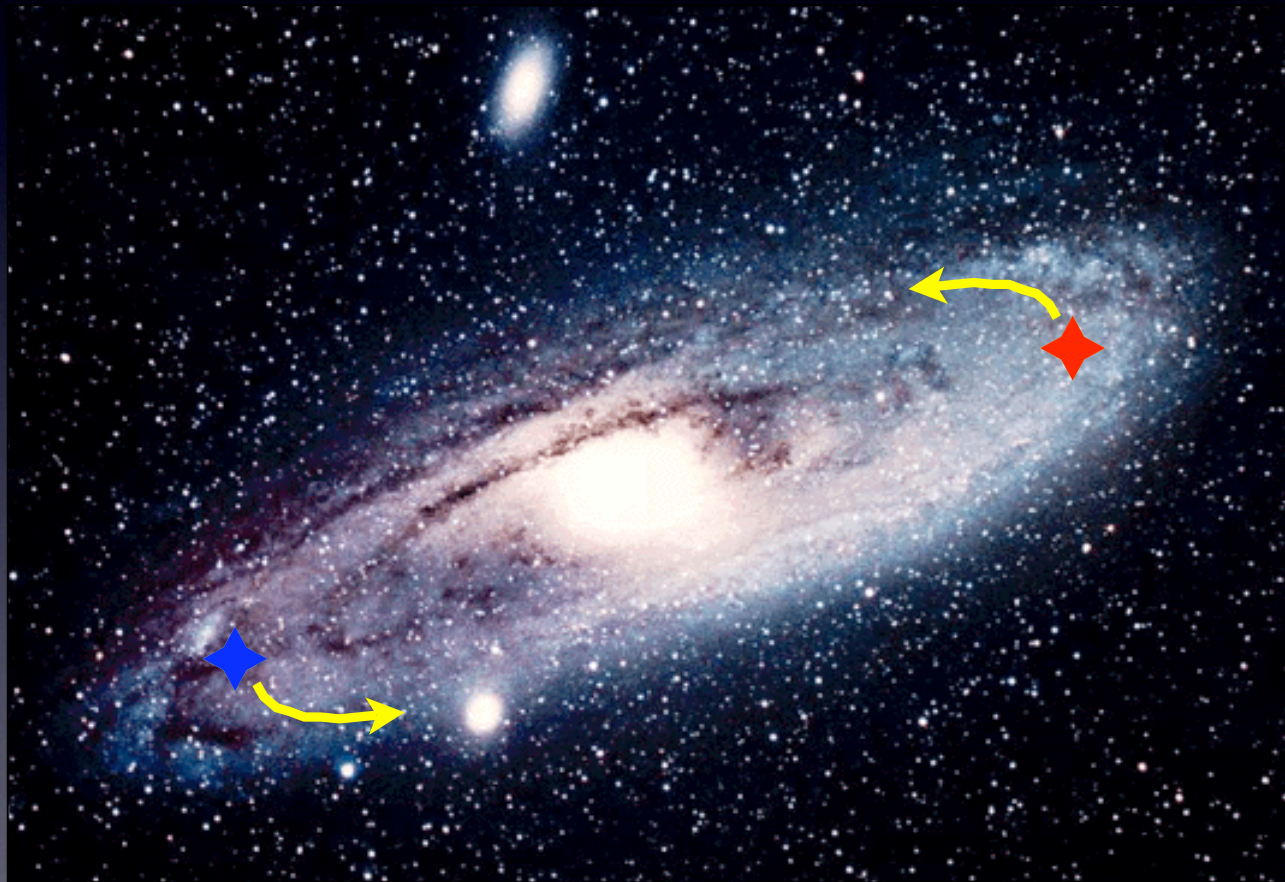
What holds galaxies together?

What is dark matter?

Vera Rubin pioneered
observations
of galactic motion

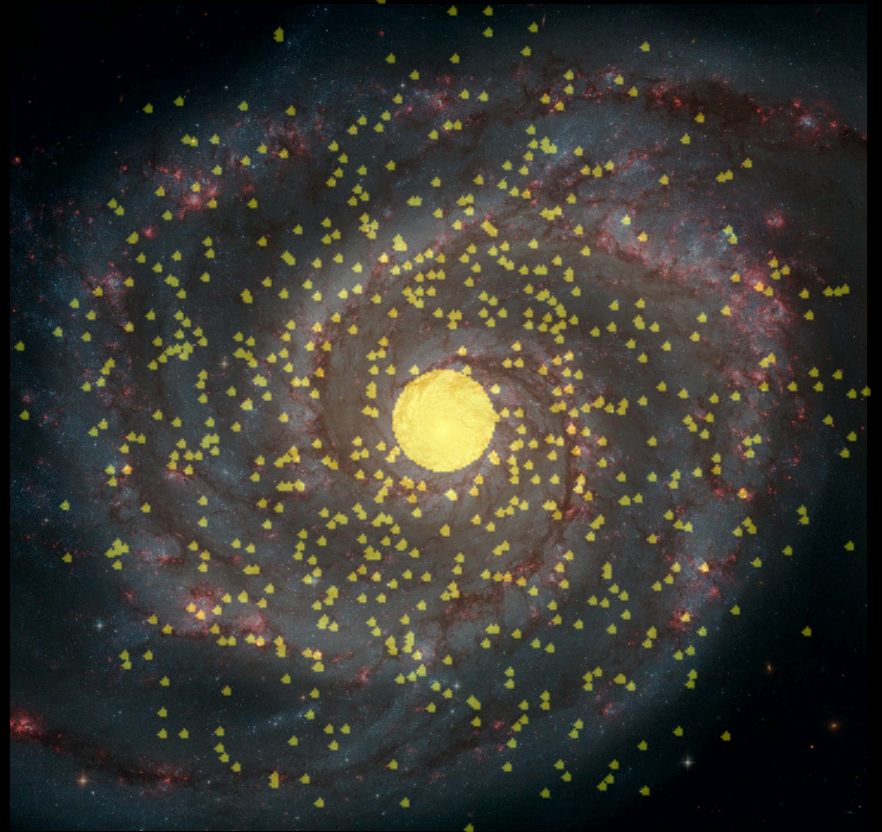
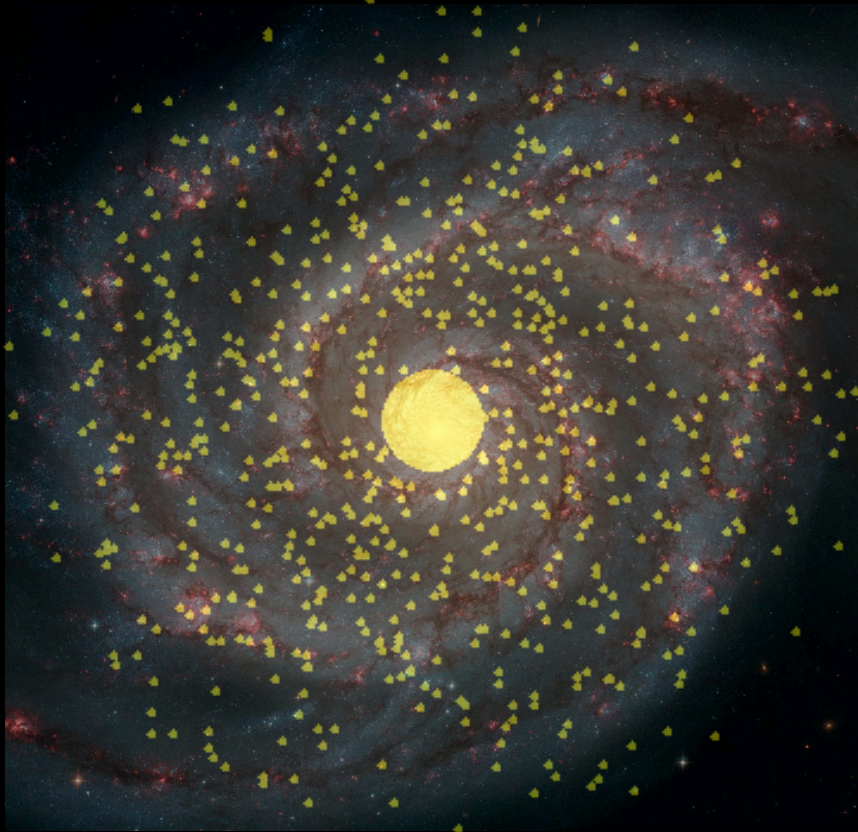


Velocities of spiral arms determined through light “blue-shifting” or “red-shifting”



Expected...

Actually observed...

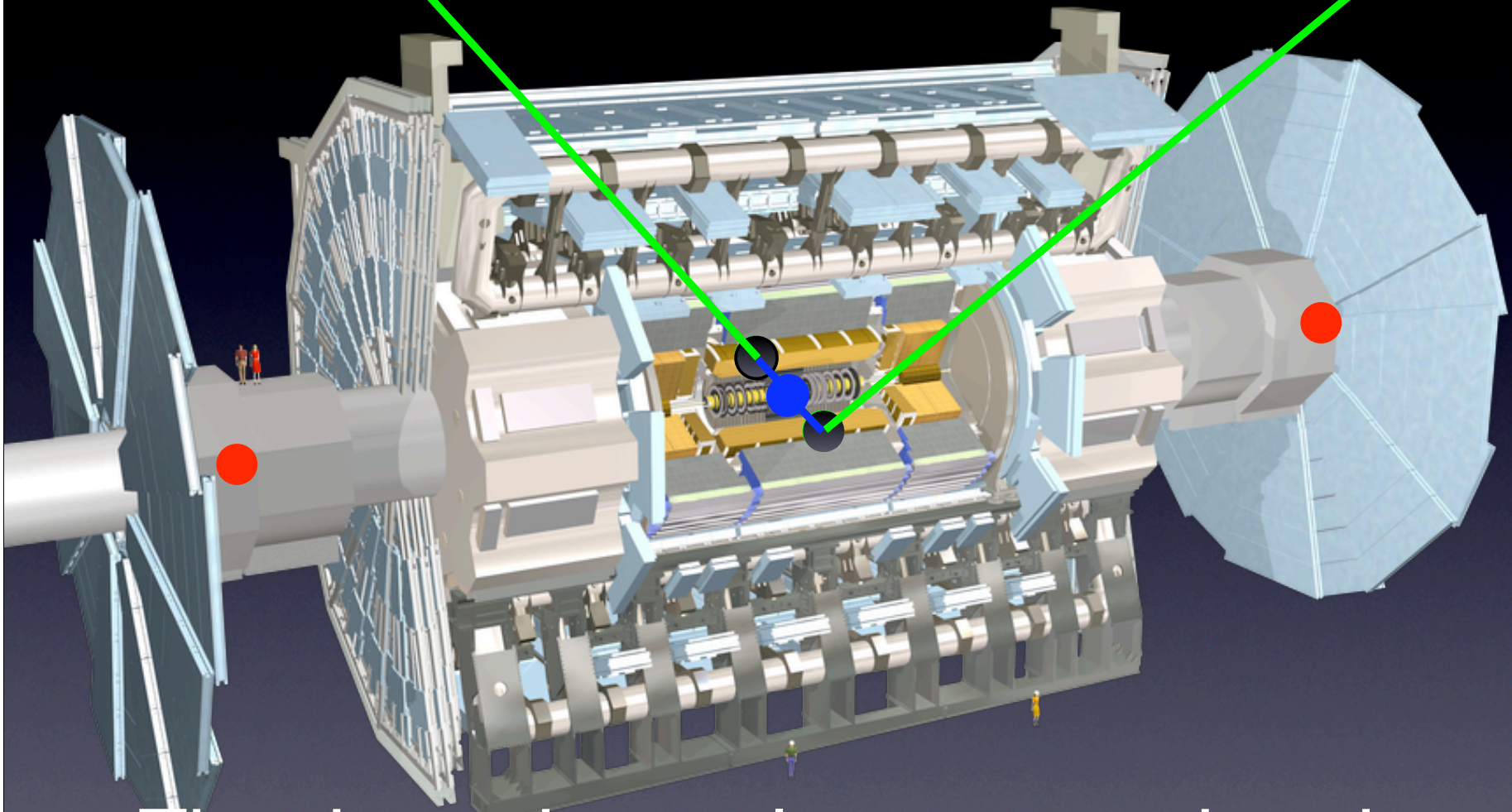


Missing Mass: **Dark Matter**

We think **dark matter** is made of heavy,
weakly-interacting particles

But if **dark matter** is so dark, how could
the LHC see it?

Atlas Detector @ LHC



The charged particles are seen, but the event is “lopsided” with “missing energy”.

Goals of LHC: Wrapup

Higgs boson: origin of mass

Dark Matter: holds galaxies and
Universe together

New Physics: search for the unknown!