The BIG questions...

What are we made of?
What are we made of?

atom $\sim 10^{-8} \text{ cm}$
The BIG questions...

What is matter made of?

- Electron: ~10^{-16} cm
- Nucleus: ~10^{-12} cm
What is matter made of?
What is matter made of?

quark
$<10^{-16}$ cm
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?

1,000,000 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 $= 0.000000000001$ 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 $\rightarrow$ Liquid water $\rightarrow$ 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?
The charged particles are seen, but the event is “lopsided” with “missing energy”.

Atlas Detector @ LHC
Goals of LHC: Wrapup

Higgs boson: origin of mass

Dark Matter: holds galaxies and Universe together

New Physics: search for the unknown!