The Structure of Our World

I look at our world as having 3 distinct distance scales

1. Very largest scales
   - Size of the known universe ($\sim 10^{25}$ m)
   - Galactic clusters ($\sim 10^{22}$ m)
   - Galaxies ($\sim 10^{21}$ m)
   - Solar System ($\sim 10^{13}$ m)
2. "Mushy" intermediate scales
   - The Earth ($\sim 10^{7}$ m)
   - You and me (~ 1 m)
   - Virus ($\sim 10^{-7}$ m)
3. Very smallest scales
   - Molecules ($\sim 10^{-9}$ m)
   - Atom ($\sim 10^{-10}$ m)
   - Nucleus of an atom ($\sim 10^{-14}$ m)

Big differences in the natural structures

- But very largest and smallest scales very similar
  - "simple" structures
  - have very related problems

The Cosmic Contradiction

The Big Bang happened –

- just energy (matter and anti-matter) to begin with
- "hot soup" rapidly expanded and cooled
- protons and neutrons formed in 1 s
- atoms started forming after about 300,000 years
  - radiation and matter stopped interacting
  - radiation continued cooling undisturbed
  - matter then started forming structure

Radiation is still kicking around today

- Cosmic microwave background discovered in 1965
- Has a temperature of about 3° K (-270° C)
- Turns out to be VERY smooth

Implies Universe was also smooth at 300,000 years

- Can't explain the large structures we see
- Need at least small "ripples" that then grow

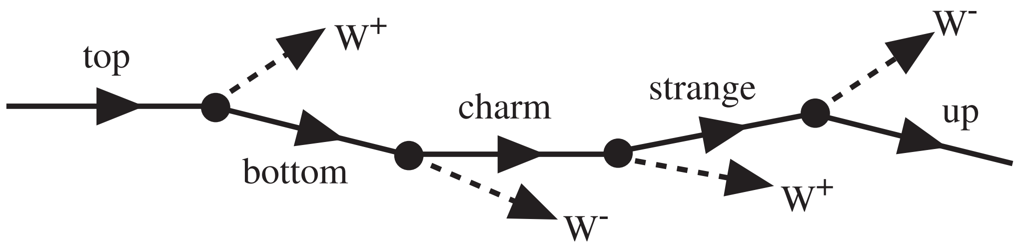
Why are Heavy Quarks Hard to Find?

Hard to produce

- Must sift through lots of matter-antimatter collisions
- Happens about 1 in every billion collisions?

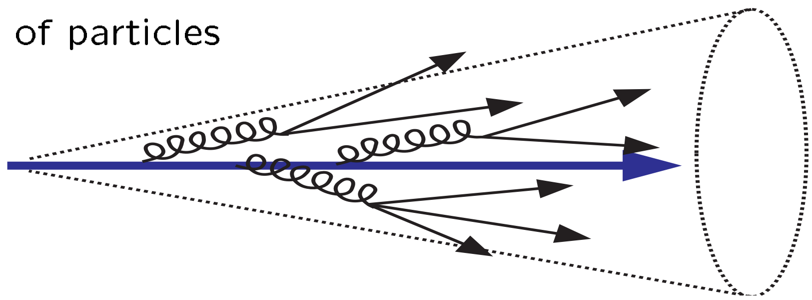
They Decay!

- A top quark decays via the weak force into a bottom quark
- The bottom quark then decays into lighter quarks



Ya can't see free quarks

- Quarks are "not allowed" to appear unescorted in public
- Have to "dress" themselves up around other quarks
- Result in "jets" of particles



Summary

Haven't reached the end of the story

- Many open questions, for example
  - What and where is mass?
  - How did our universe become what it is today?
  - What really are quarks?

But we are making progress

- We have a "picture" that works pretty well already
- Focusing on those pieces that don't quit fit

Soon we will have a much better understanding of

- the very big,
- the very small,
- ...and all that we find in between!