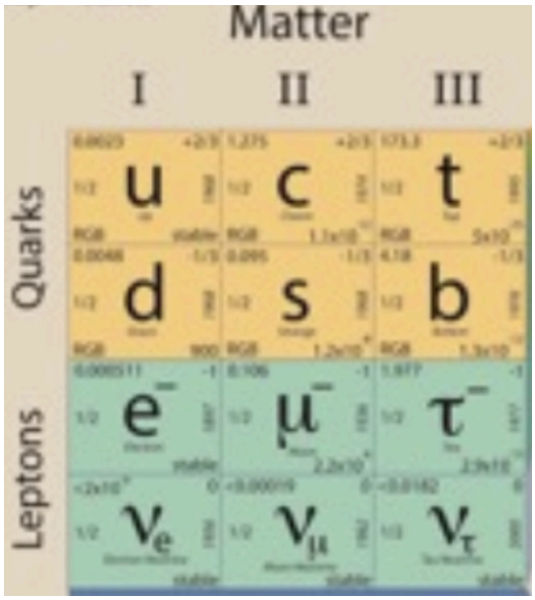
# BNL-SB QuarkNet Workshop 2022 Muon Tutorial

**Group 1**

**Foundation Question: What are muons?**

Muons are like electrons, except they're heavier. Like electrons, muons are leptons, which are fundamental particles. As far as we know, they aren't made of any smaller particles. However, they do decay. In fact, they decay via the W- boson (moderator of the weak nuclear force) to an electron and a couple of neutrinos.




**Question 1: What are some of the characteristics of muons and how do they fit into the standard model?**

Muons are about 207 times heavier than electrons.

Mass of electron: $9.1 \times 10^{-31}$ kg

Mass of muon: $1.9 \times 10^{-28}$ kg

Muons and electrons have the same charge: $-1.6 \times 10^{-19}$ C

Muons have an average lifetime (some are longer, some are shorter) at rest of about 2.2 $\mu$s, but much longer when they travel at relativistic speeds.

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**Foundation Question: What are muons?**
A muon is a lepton with a charge of -1 e. It is unstable and decays into an electron, an muon neutrino and an anti-electron neutrino. It is more massive than an electron and penetrates much further into ordinary matter. Produced in particle accelerators and in cosmic ray interactions.

**Question 2: Describe current research studying or employing muons.**

Muon - Muon collider (proposed) one limitation is the short life

Muon g-2 may indicate a problem with the standard model

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**Group 3**

**Foundation Question: What are muons?**
Muons (u)
Leptons (Generation II)
Unstable and relatively long-lived (2.2 x 10-6 s)
Negatively charged (-1.6 x 10-19 C or -1e)
Spin +½
Larger mass than the electron
Decays into an electron, an electron anti-neutrino, and muon neutrino
There is also an anti-muon

**Question 3: How are muons produced in cosmic rays and how are they detected?**

A high energy proton enters the atmosphere and collides with an atmospheric atom results in a production pions. The pions decay into muons.

The detectors in our school have a scintillating plastic that as the muon travels through the material it produces photons. The light stimulates the photomultiplier tube which produces and amplifies the signal from the photon into a detectable electronic signal.