THE UNIVERSITY OF CHICAGO

Collider and Direct Detection Searches

What is WIMP Dark Matter - WIMPs (or weakly interacting massive particles), are a dark matter particle candidate that is well motivated in supersymmetric models. Miraculously, if the new particle interacts via the weak force, then the particle will naturally have the dark matter density observed today.

How Do We Search for WIMP Dark Matter? - By searching for these weak interactions! A convenient property of WIMP dark matter is that it tells us the strength of the interaction we are trying to find. If dark matter particles can interact with normal matter via the weak force, then we can predict what types of instruments should be able to detect them.

So this should be easy, right? - Easy is not the right word… Unfortunately the weak force is, as you may have guessed, weak. These interactions occur very rarely, and so we need extremely large, and extremely sensitive, instruments in order to find the rare dark matter interactions occurring today.

What type of machines? - Today, we will talk about two types of WIMP detectors. The first are particle accelerators, such as the LHC, and the second are direct detection experiments based deep underground.

The Large Hadron Collider, located near Geneva, Switzerland, accelerates particles up to 0.999999991x the speed of light. When these particles collide, they can all sorts of massive particles, including pairs of dark matter particles. By detecting hints of these dark matter particles, the LHC could determine the mass of the dark matter particle and study it's interactions in great detail.

How Does the LHC Observe Dark Matter? - This is a particularly tricky problem. While the LHC might produce many dark matter particles during high energy collisions, these particles don't interact with light, and so they can't be observed again inside the particle detector. Dark matter particles produced in the LHC just pass through everything and are never observed again. Instead of searching for the dark matter particle itself, physicists look for *signs* that another missing particle was produced, such as a missing amount of energy in a particle collision.

What is Direct Dark Matter Detection - Instead of producing new dark matter particles in a particle accelerator, we can instead try to observe the dark matter particles that already exist in nature. The bright side of this method is that there are many of these dark matter particles all around us (approximately 1 in every 5 cm x 5 cm x 5 cm box in this room)!

How Do we Detect a Particle That Doesn't Interact with Light? - By looking for the very rare weak-force interactions between a moving dark matter particle and a baryonic particle in our detector. These interactions are very rare, and we need very large, and very sensitive detectors to observe when WIMPs "bump" a normal particle.

The LUX (Liquid Underground Xenon experiment), based in the Homestake mine in Lead South Dakota, looks for rare dark matter interactions with a sensitive, ultra cold detector. To avoid contamination from cosmic-rays and radioactivity, these massive machines must be placed deep underground in old mines.