THE UNIVERSITY OF CHICAGO

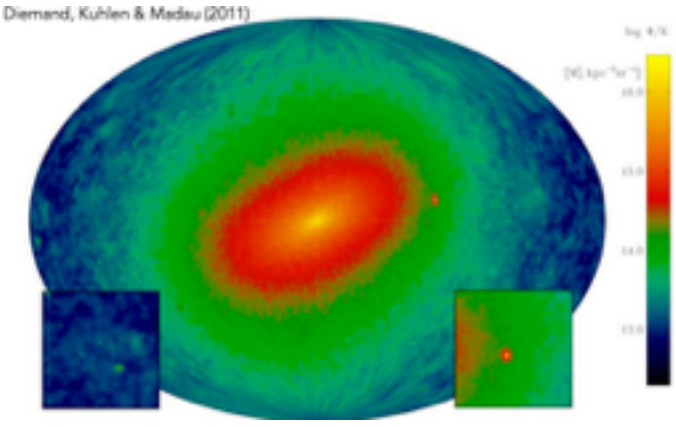
Indirect Detection with Gamma-Rays

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! If dark matter particles can interact with normal matter via the weak force, then we can predict what instruments can see them.

What is the indirect detection of dark matter - In indirect detection, unlike collider detection and direct detection, we are searching for the annihilations of WIMPs in space. We call this indirect detection, because we are not seeing the WIMPs themselves, but instead are searching for known particles (like photons and electrons) that are created by WIMP annihilations.

Why Do We Search for Indirect Signs of Dark Matter? - We get to use the whole universe as our experiment! There is not much dark matter near the sun (about 1 particle in a 5x5x5cm box). However in some regions of space (like the centers of galaxies and galaxy clusters) the dark matter density is much higher - so we should be able to see many interactions?



This map of the sky shows the expected distribution of signals from WIMP dark matter in the sky. The brightest part is the center of the Milky Way galaxy, which both contains a high density of dark matter, and is also relatively close to Earth.

Why is this hard? - Unlike direct detection or measurements with particle accelerators, we don't actually see the dark matter particle in indirect detection. It's impossible to know whether a specific photon was produced by a dark matter annihilation, or by any of the standard astrophysical processes that also produce photons. We have to use models of the expected signal from astrophysics, in order to determine whether there is any excess due to dark matter.

What type of instruments do we use? - All types of telescopes! We use gamma-ray instruments to search for the high energy light produced during dark matter annihilation events. We use X-Ray and radio telescopes to search for additional light produced when electrons produced in dark matter annihilation events interact with the surrounding magnetic fields. We use particle detectors above the Earth's surface to search for the electrons, protons, and antimatter particles which can be produced by dark matter annihilation.

The Fermi-LAT telescope, pictured here, is among the most sensitive detectors for dark matter annihilation events. Launched in 2008, the Fermi-LAT looks for gamma-rays (light with energies 30 million to one trillion times as energetic as the visible light in this room). It has a large field of view, which allows it to see the entire sky every few hours. The Fermi-LAT produces high resolution maps of these events, and can use the morphology, spectrum, and timing of these events to look for hints of dark matter annihilation.