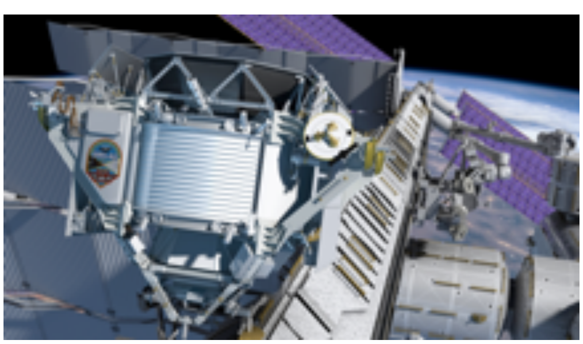
Doubly Indirect Detection Searches

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

What Can We Look For? - Last week, we discussed searches for gamma-rays from dark matter annihilations. However, we can also search for other particles produced in dark matter annihilation events — such as electrons and protons. There are two primary methods of searching for these particles:

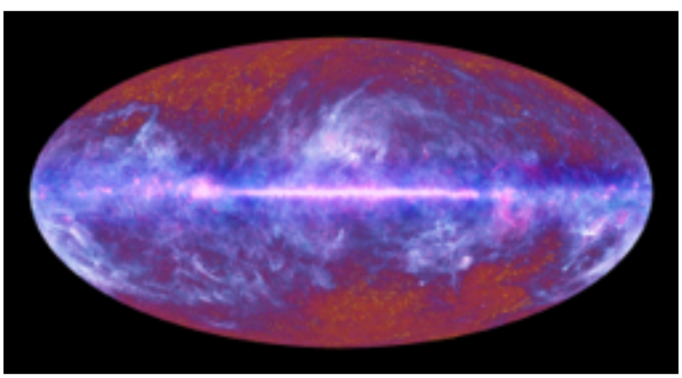
(1) **Cosmic-Ray Antimatter Searches -** Remember, dark matter annihilates equally to particles (such as protons) and their antiparticles (such as anti-protons). Most conventional astrophysics processes produce very few antiparticles — so we can search for antimatter excesses that might be produced by dark matter annihilation.



The AMS-02 experiment, attached to the International Space Station, examines the fluxes of high energy cosmic-rays observed near the Earth. By examining the energy spectrum and particle content of these cosmic-rays, AMS-02 hopes to understand the production of cosmic-rays in our galaxy.

(2) **Radio and X-Ray Searches -** Dark matter annihilation can produce copious electron/positron pairs. These electrons and positrons quickly lose their energy by producing synchrotron radiation in nearby magnetic fields, producing bright radio signals which can be observed by telescopes. This method is similar to searching for gamma-ray signals (as we discussed last lecture), except that the electrons might move considerably distances before producing synchrotron radiation, so we do not have as much knowledge about the expected distribution of the dark matter synchrotron signal.

The Very Large Array (a creative name indeed), located in New Mexico studies the radio sky with superb angular resolution. The VLA can accurately study regions very close to the galactic center, where the dark matter annihilation rate is expected to be bright, and the magnetic fields are expected to be strong.



In addition to studying the cosmic microwave background, the Planck satellite also sees radio emission from throughout our galaxy. The bright blue emission is produced by our galaxy, including a bright bulge of emission above and below the galactic plane, known as the “haze”.

Have We Found Anything? - Maybe? There is strong evidence for an overabundance of high energy positrons in our galaxy, compared to some theoretical models. However, reasonable astrophysical models have also been produced, which can explain the excess antimatter. We will discuss this in detail today!