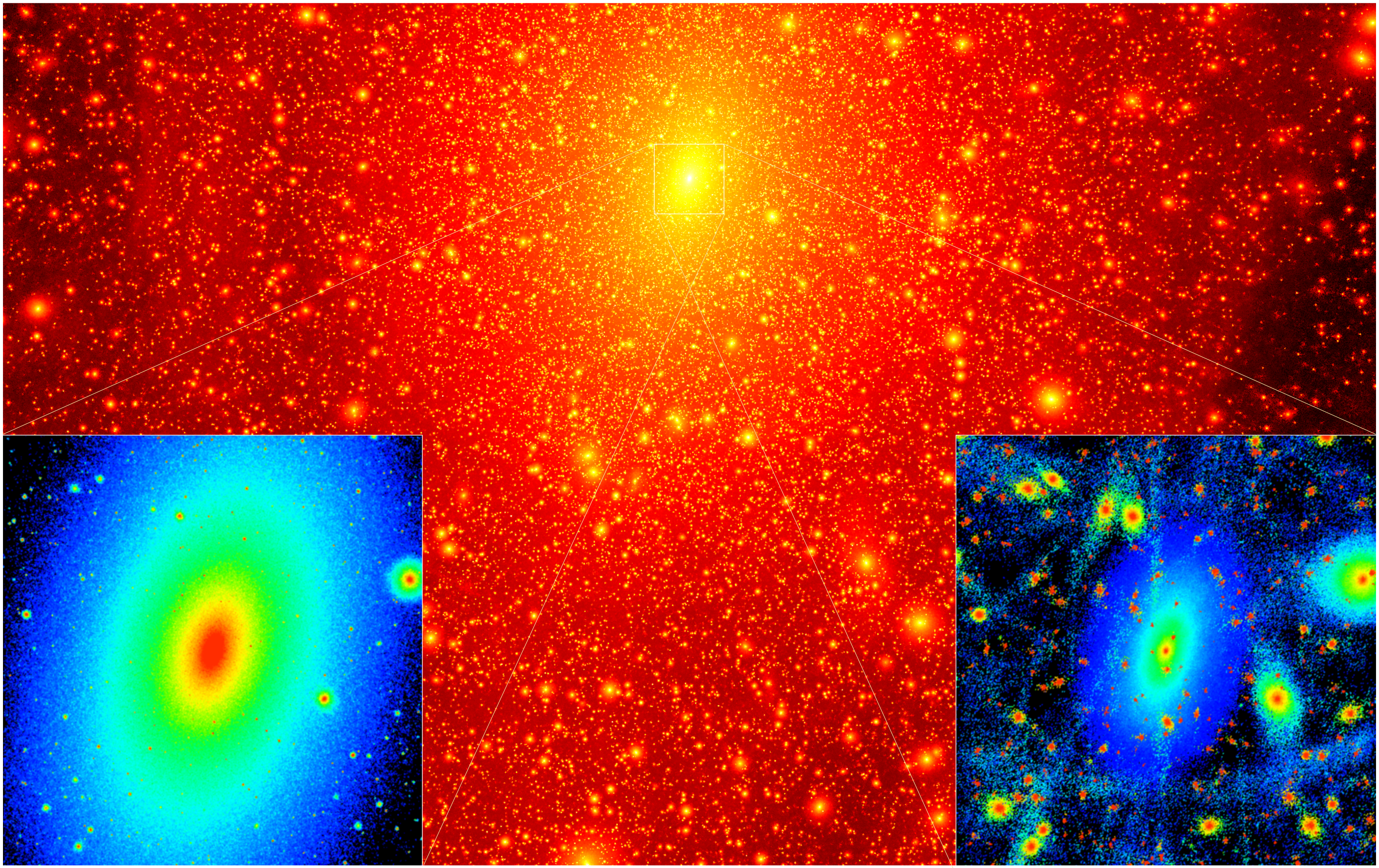
Dark Matter



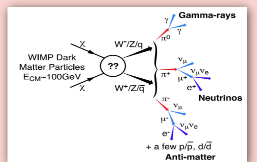
Credit: The Via Lactea Project

Fermi LAT Dark Matter Searches

Cosmological observations indicate that a large amount of invisible non-baryonic matter (dark matter, DM) may comprise most of the matter in the Universe. However, its fundamental properties remain a mystery. No indication for a new fundamental particle, which could constitute the DM, has been found so far in dedicated laboratory experiments or colliders.

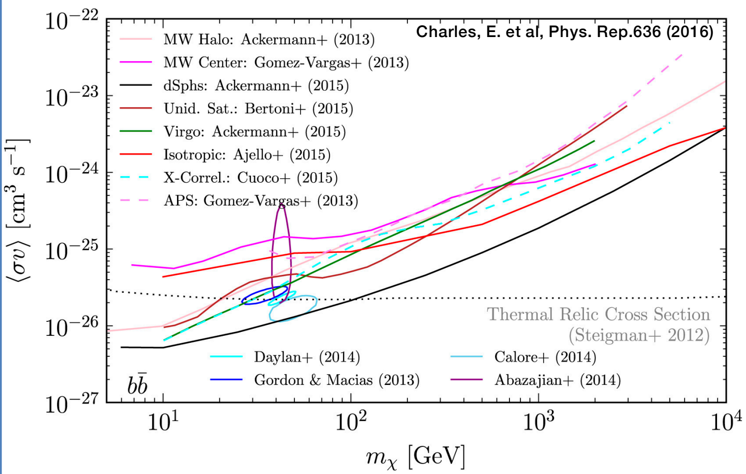
Why Fermi *LAT?*

The *Fermi* Large Area Telescope (LAT) observes the whole gamma-ray sky from 0.3-300 GeV. Though designed to detect gamma rays, the LAT can also detect cosmic-ray electrons and positrons (CREs). Some DM particle candidates such as **weakly interacting massive particles** are thought to have self-annihilation cross sections and/or decay rates that would allow them to produce gamma rays and CREs in the sensitivity range of *Fermi* LAT.



The *Fermi* LAT is also sensitive to the detection of other DM candidates such as **axion-like particles (ALPs)**. These particles could oscillate into photons, which leads to unique features in the spectra of gamma-ray sources.

With its excellent sky coverage and sensitivity, the *Fermi* LAT provides a unique platform for indirect DM searches by surveying a wide variety of astrophysical sources and probing astrophysical processes thatcould reveal clues to the nature of DM.



Dwarf Galaxy Searches

Dwarf spheroidal galaxies (dSphs) are considered to be excellent targets for indirect DM searches as they are believed to be **dominated by DM** and not contain a significant population of known gamma-ray sources. A study combining observations of 25 dSphs has provided some of the most constraining upper limits on the thermally averaged **self-annihilation cross section of WIMP DM.**

Shown above with the solid black line are limits on the DM self-annihilation cross section as a function of WIMP mass for a given DM annihilation channel (to b-quarks). The horizontal dashed line represents the expected cross section from cosmological considerations (for the so called 'thermal relics'). Other lines represent results from several DM searches with the LAT data in complementary targets, as described in the right column.

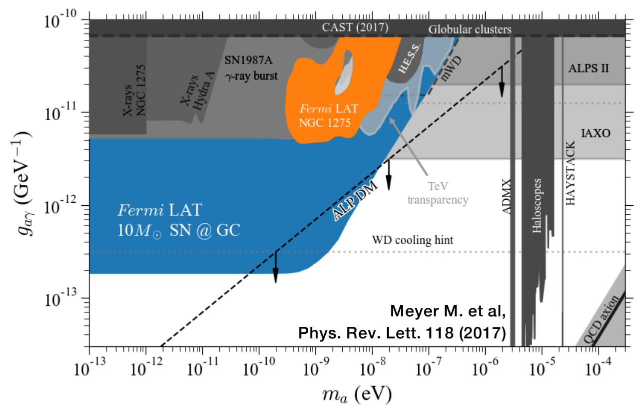
For more information, visit http://fermi.gsfc.nasa.gov/

NASA's Fermi mission is an astrophysics and particle physics partnership managed by NASA's Goddard Space Flight Center in Greenbelt, Md., and developed in collaboration with the U.S. Department of Energy, with important contributions from academic institutions and partners in France, Germany, Italy, Japan, Sweden and the United States.

Fermi Gamma-ray Space Telescope

Other Dark Matter Investigations with Fermi LAT

- The Galactic Center (GC) is predicted to be the **closest, brightest source of gamma rays from DM annihilation.** Analysis of that region (about 10 degrees wide) has revealed excess emission over templates of the diffuse gas emission. However, the GC harbors many astrophysical gamma-ray sources, and it is thus difficult to attribute this excess solely to DM annihilation. The discussion of the origin of this excess is still ongoing. In the figure on the left, the circles represent DM models that could explain the GC excess.
- Nearby clusters of galaxies could also be bright sources of gamma-ray emission from DM annihilation. Searches for gamma rays from nearby clusters revealed no significant emission, and the current DM limits are presented with the green line in figure on the left.
- DM annihilation in the halos of all galaxies could contribute to the isotropic diffuse extragalactic gamma-ray background (EGB), and the current limits are presented with the red line in the figure on the left. In addition, DM subhalos could result in an anisotropy in the EGB. However, the measured anisotropy of the EGB is consistent with expectations of astrophysical sources. Resulting DM limits are shown with magenta and cyan dashed lines in figure on the left.
- Also, a search for a DM signal from Milky Way subhalos is ongoing among unassociated sources in the *Fermi* LAT catalogs (dark red line on the left figure).
- *Fermi* LAT observations of the radio galaxy NGC 1275, which is the central source of the Perseus galaxy cluster, did not reveal any signs of oscillations of photons into axion-like particles in the magnetic field of the cluster.



Limits on low mass ALPs. Grey regions show excluded regions, theoretical predictions for the QCD axion, and sensitivities for the future ALPS-II and IAXO experiments. The *Fermi*-LAT limits from the observation of NGC1275 are shown in orange. The blue region shows the parameter space that could be probed by *Fermi*-LAT observations of a supernova that occurred in the Milky Way. ALPs would be produced in such an explosion and could subsequently convert into gamma rays in the Galactic magnetic field.