Dwarf galaxy dark matter annihilation gamma-ray signals and backgrounds

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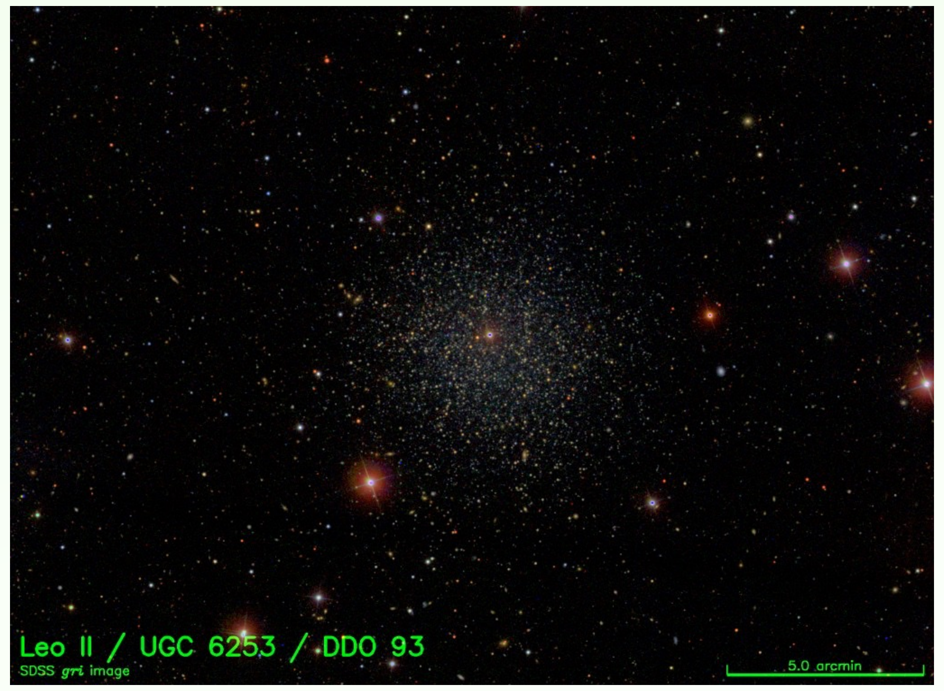
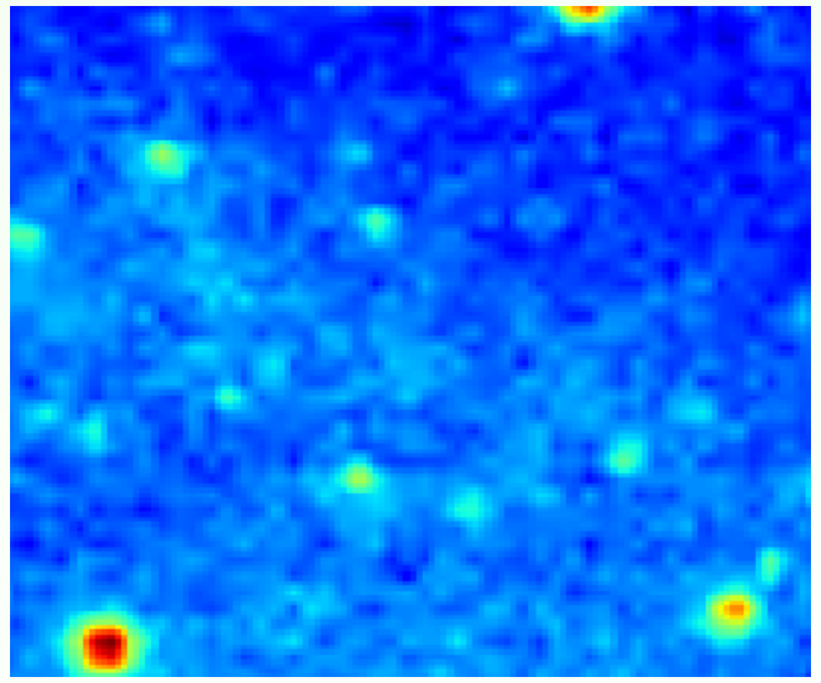
Dwarf galaxies as dark matter laboratories

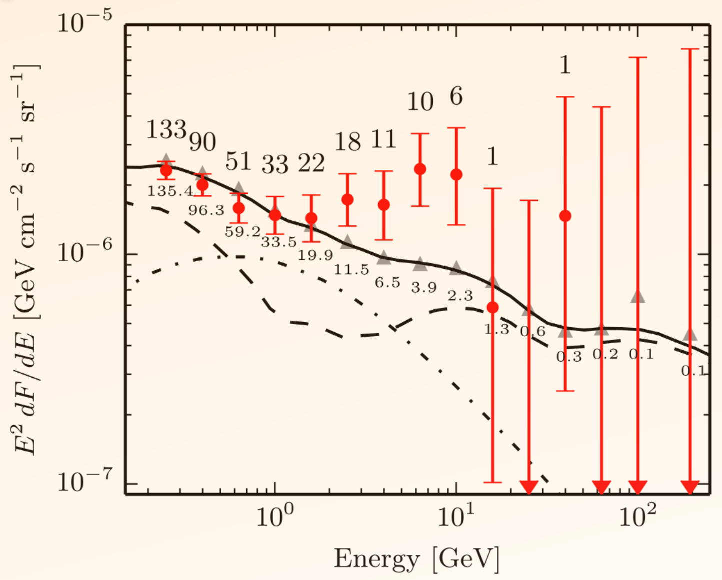
The search for cosmological dark matter annihilation is a major effort in contemporary astrophysics. Educing the dark matter particle physics from observations requires a detailed understanding of the dark matter distribution in the system under study. A productive avenue of approach has been to search for gamma-rays generated by dark matter annihilation in Milky Way dwarf spheroidal galaxies. Such systems are nearby, dark matter-dominated, and contain no conventional sources of astrophysical backgrounds (e.g., cosmic ray generation and propagation through interstellar gas). Mora than 50 dwarf galaxies are currently known, with more to be discovered with upcoming surveys.

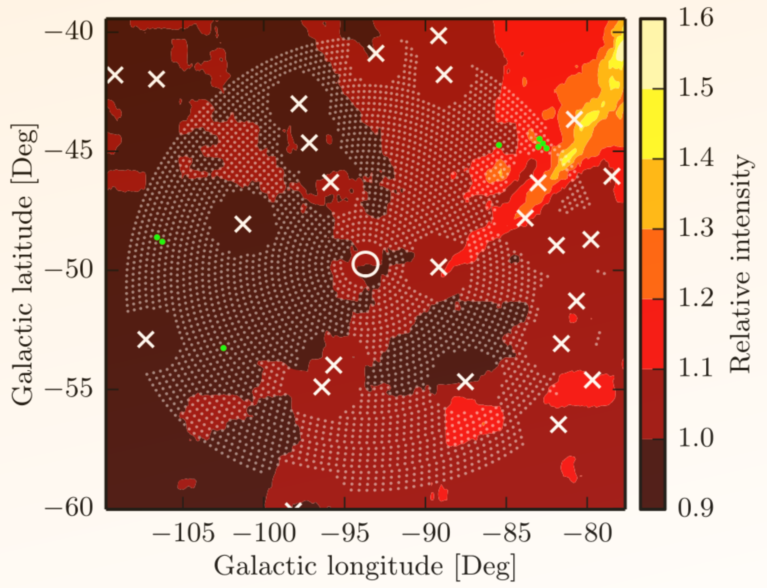




Left: Image of Leo II, an ultra faint dwarf galaxy. Right: Photons with energies greater than 1 GeV along the line of sight to the Ursa Major II dwarf galaxy.

Case study: Reticulum II

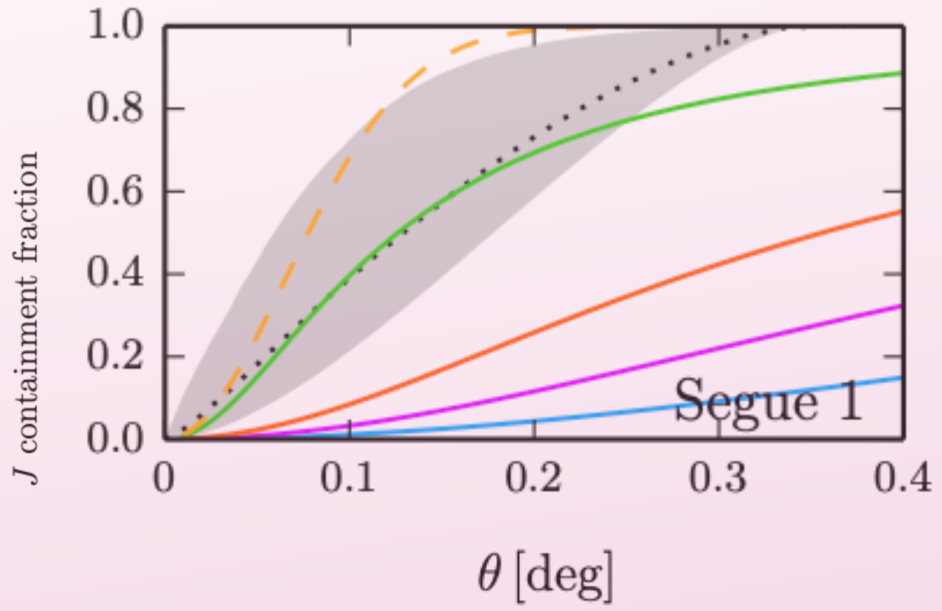


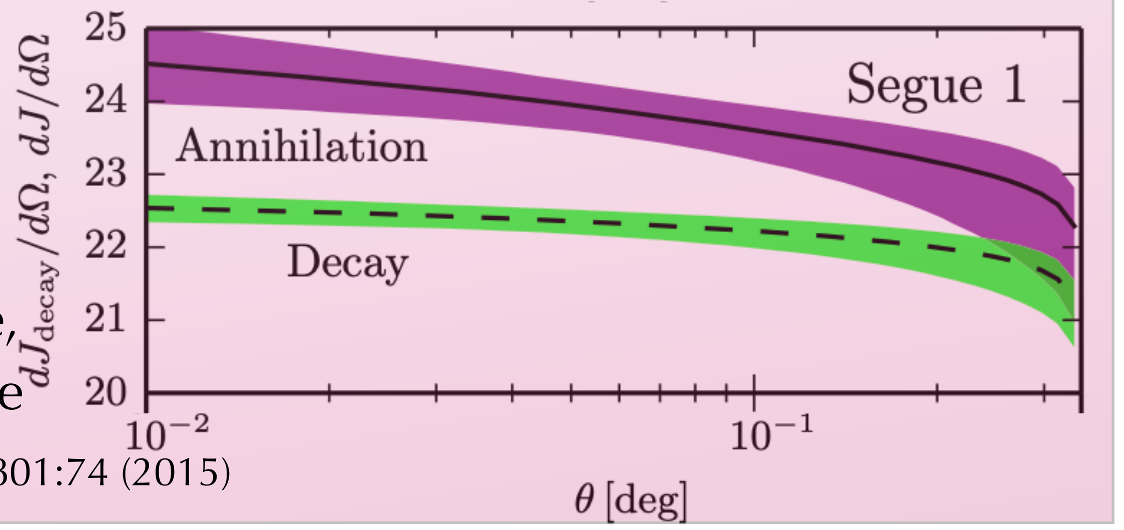


Left: Gamma ray spectrum of photons within 0.5 degrees along the line of sight to the Reticulum II dwarf galaxy. Right: Background amplitude in a broad area around Reticulum II. The spectrum shows a mild excess around few GeV.

The need for high sensitivity and angular resolution detector

Dark matter annihilation depends on the volume integral of the square of the dark matter density. As such, the central regions are brighter than the outer parts. A detector with high sensitivity and angular resolution can increase the signal to noise ratio because it can map out the emission profile, whereas silicon detectors (e.g., Fermi-LAT) are only able to integrate the emission over a larger area. Top: Containment fraction for annihilation as a function of angular distance from the center of Segue 1. The dotted line shows the median value of the containment fraction while the shaded band corresponds to the 16th and 84th percentiles at each angle. The solid colored curves show the PSF of a silicon detector, while the dashed colored line shows the PSF of an Atmospheric Cerenkov telescope. Bottom: Expected emission profile for annihilation (purple) and decay (green) for Segue 1. At each angle, the solid and dashed lines show the median profiles and the shade band corresponds to the +- 1σ distribution. Geringer-Sameth et al., ApJ 801:74 (2015)

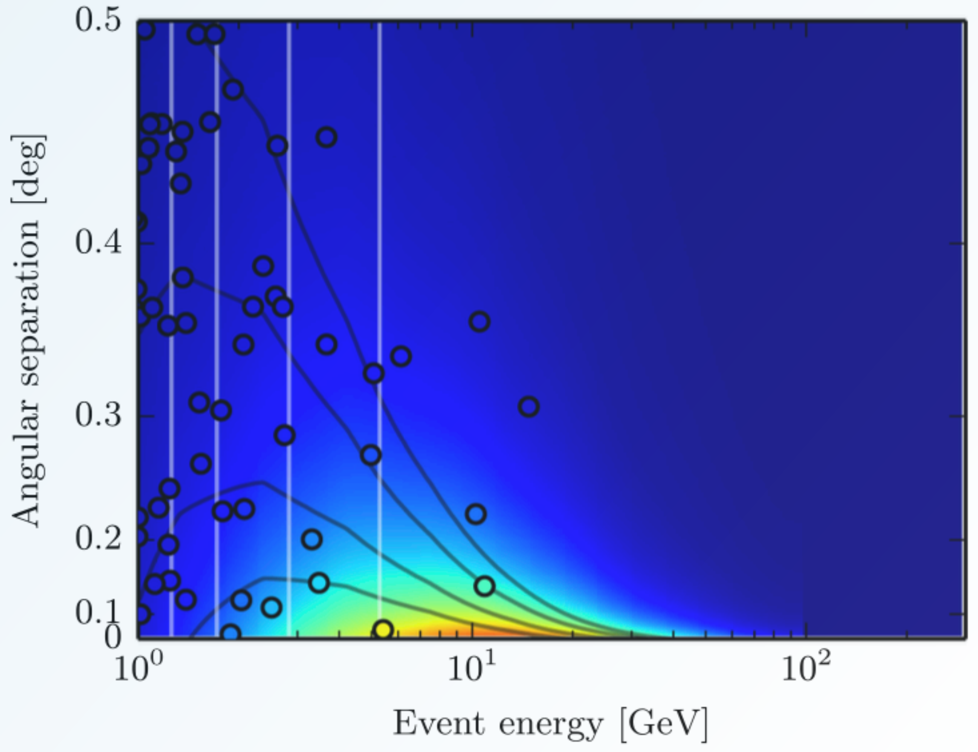




Case study: Segue 1

Right: Dark matter searches must include maximal information. As such we employ the photon weighting scheme of Geringer-Sameth et al., (2015) where we include detector characteristics as well as spatial mapping and energy spectrum of the emission. To the right is an Illustration of the weighting scheme for a 100 GeV particle annihilating to heavy quarks in Segue 1. Color represents the weight given to an event with a particular energy and angular separation from the dwarf (going from zero in blue to a maximum value in red).

Geringer-Sameth et al., PRD 91, 083535 (2015), PRL 115, 081101 (2015)



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