

# Gamma-ray emission of dwarf galaxies & globular clusters: *The Sagittarius / M54 system*

**Fermi Symposium 2022**

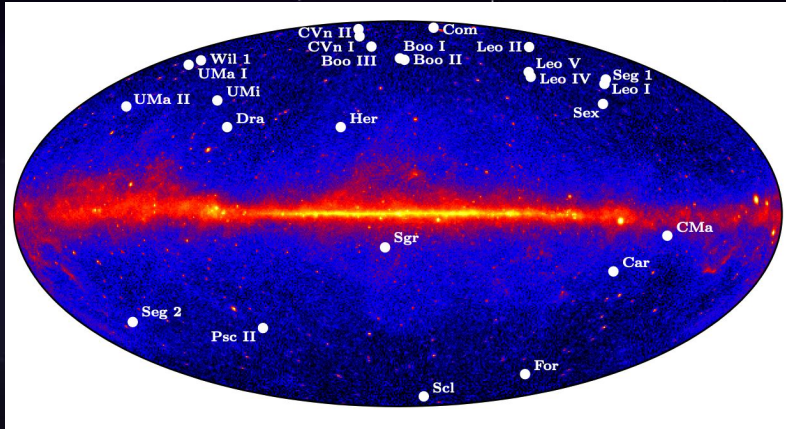
**Addy J. Evans**

*Texas A&M University*

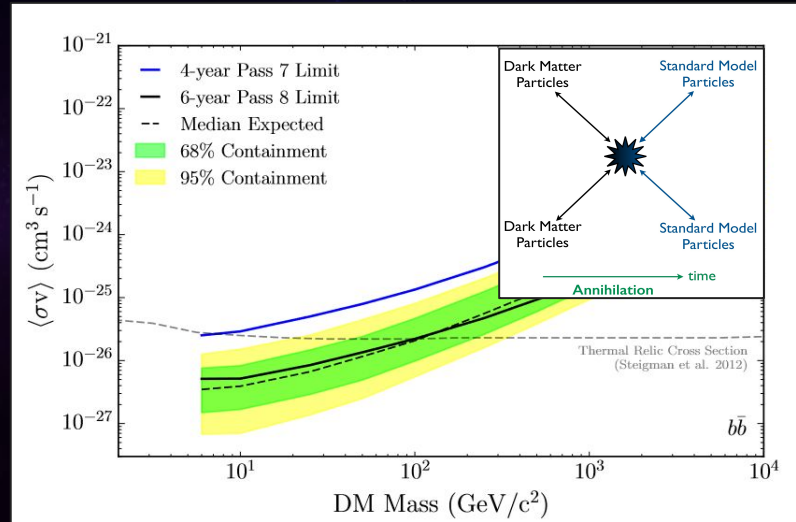
with Louis Strigari, Pat Harding, Andrea Albert, Tim Linden, Dan  
Hooper, and Oskar Svenborn

# Gamma-ray emission of dwarf galaxies

→ There have been many studies of dwarf galaxies with the Fermi-LAT



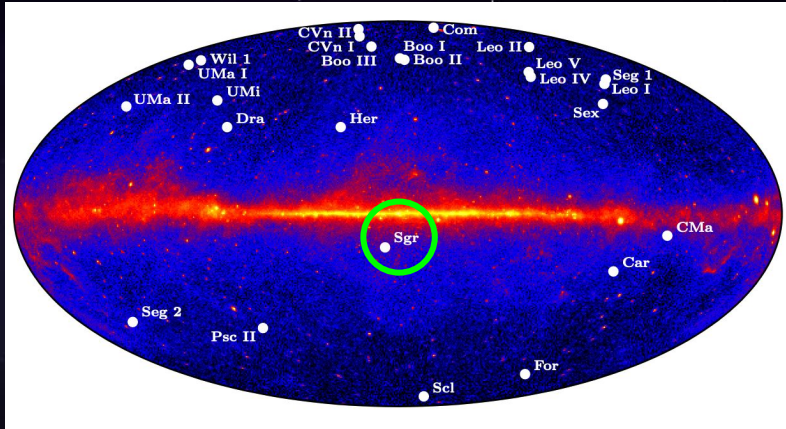
Drlica-Wagner, 2013



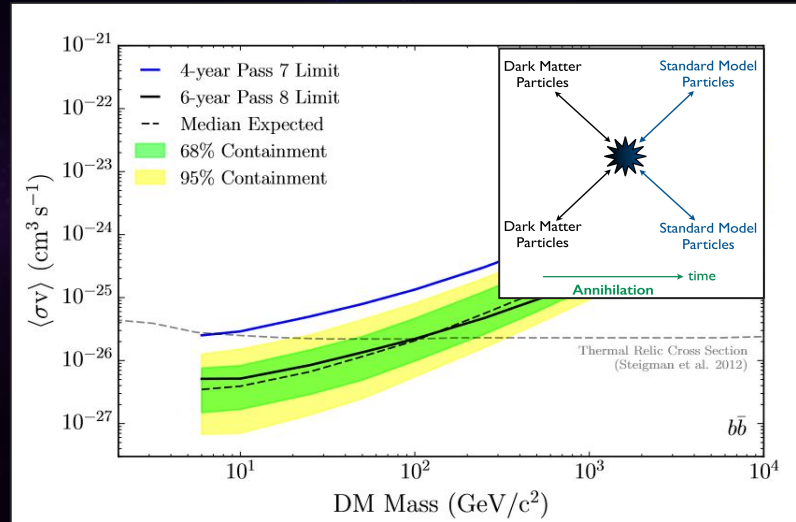
Fermi-LAT Collaboration, 2014

# Gamma-ray emission of dwarf galaxies

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Fermi-LAT Collaboration, 2014

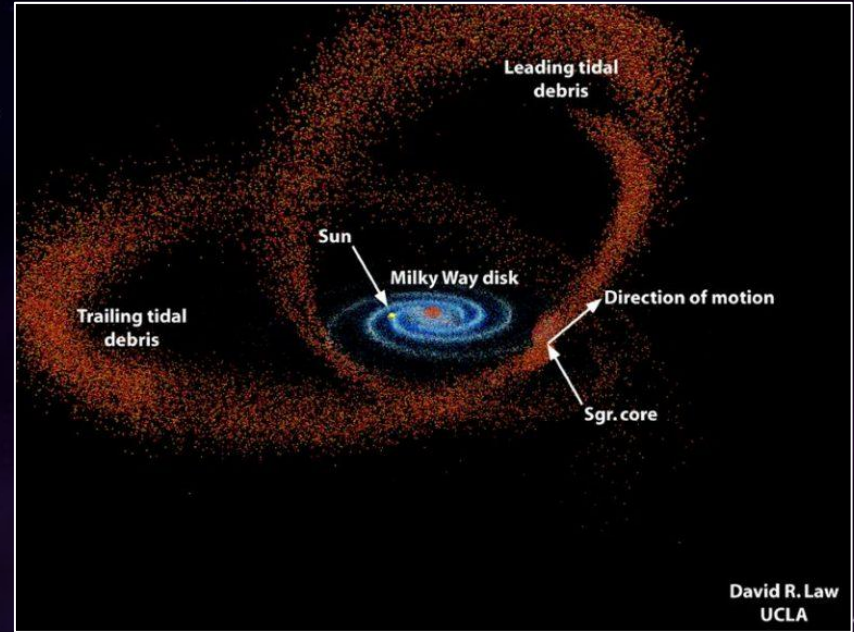
# The Sagittarius dwarf spheroidal galaxy

→ Near the Galactic center & overlapping with structure in the Fermi bubbles

→ Undergoing tidal disruption

→  $\sim 26$  kpc away

→ Population of globular clusters, including recently identified ones (Minniti et al, 2022)





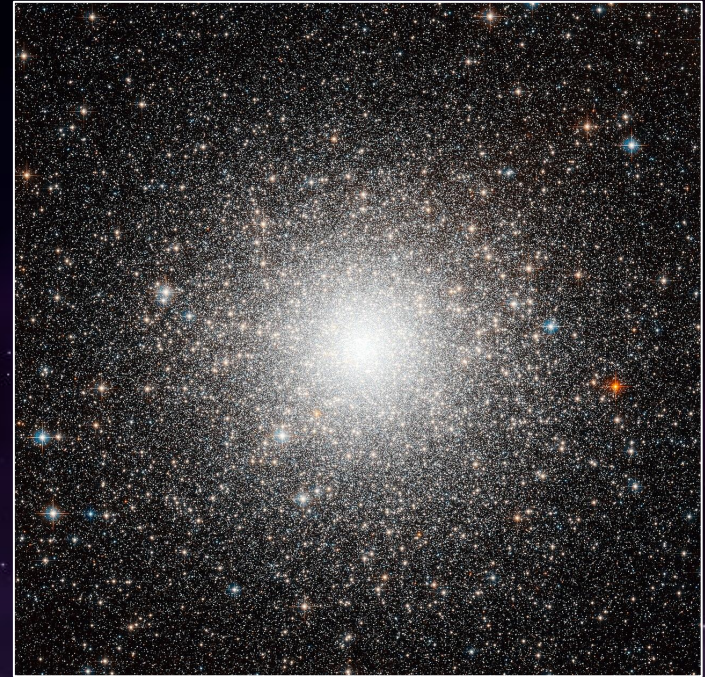
# Fermi detections of the Sgr/M54 system

→ Recently detected by the Fermi Collaboration (4FGL-DR3)

→ TS of  $\sim 26$

→ At the core of the Sagittarius dwarf spheroidal galaxy (Sgr)

→ Coincident with the globular cluster M54



M54 (credit: Hubble/NASA)

# Possible sources of gamma-ray emission in Sgr

→ Point-like

- a. Gamma-rays from millisecond pulsar population in M54 and other globular clusters



M54 (Hubble/NASA)

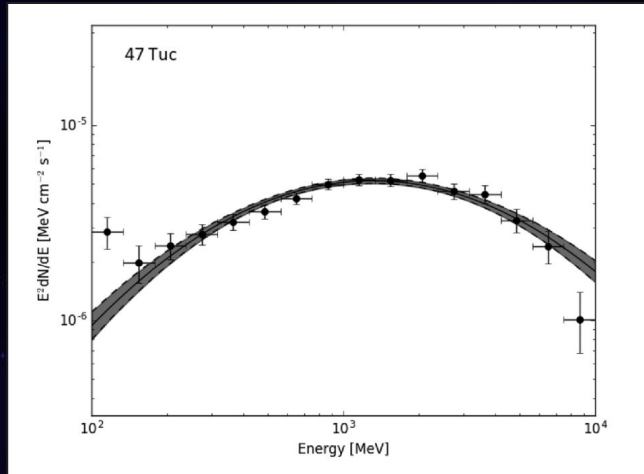
→ Extended

- a. Dark matter annihilation in the dense DM core of Sgr
- b. Emission from an isotropically distributed population of millisecond pulsars

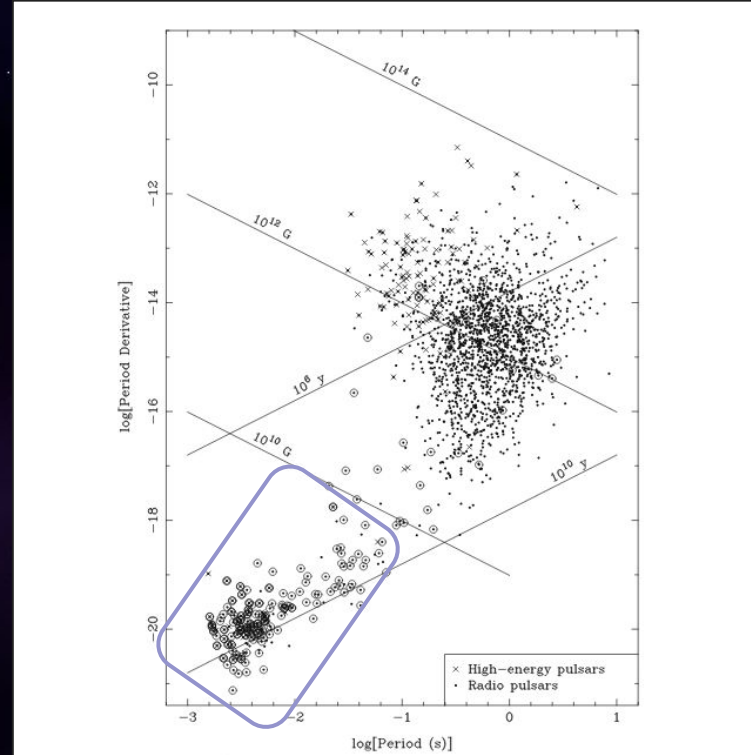


Dark matter substructure (Springel et al., 2008)

# The gamma-ray emission of globular clusters



S.J. Lloyd et al., 2018

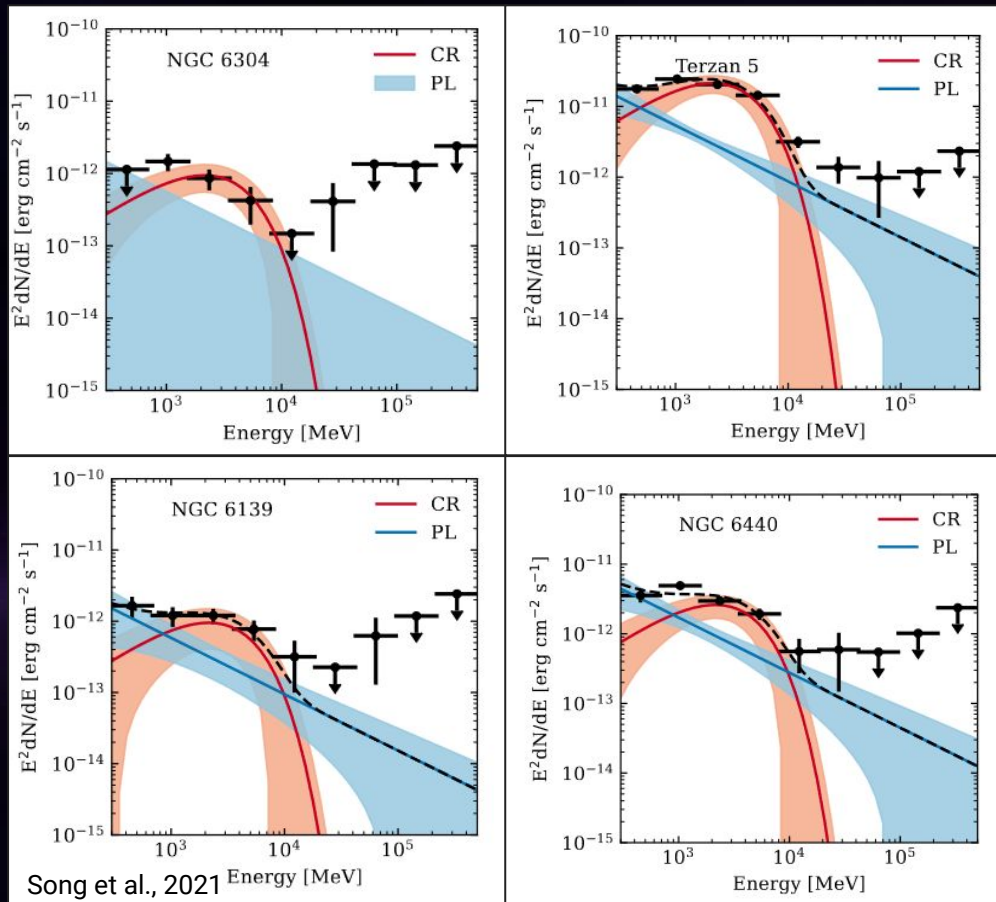


R.N. Manchester, 2017

# The source of $\gamma$ -ray emission in globular clusters

Two possible sources of emission:

1. Curvature or prompt radiation from millisecond pulsar magnetospheres (Harding et al., 2005)
2. Inverse Compton emission from leptons injected by millisecond pulsars into the surrounding environment (Bednarek & Sitarek, 2007)

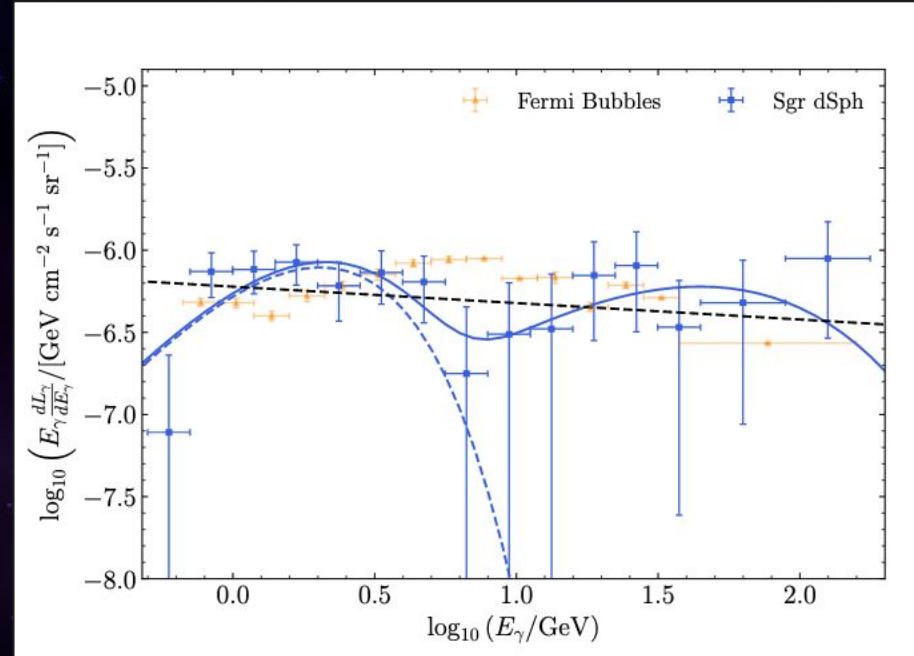




# The Sgr/M54 system in gamma-rays

→ Crocker et al. report a highly significant, extended source associated with Sgr

→ Attributed to the dwarf's millisecond pulsar population, with a high-energy component that is comparable to the low-energy component



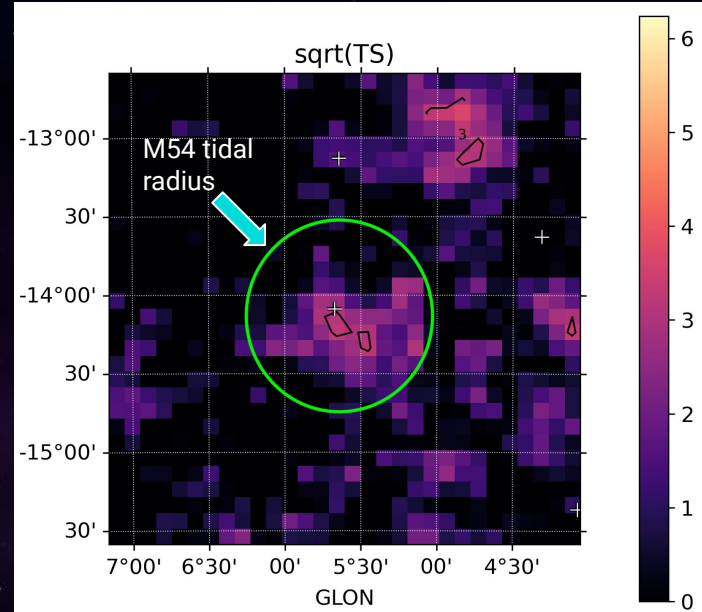
Crocker et al.,  
2022

# The Sgr/M54 system in gamma-rays

→ We find point-like emission from the core of the Sgr galaxy, in agreement with the 4FGL-DR3 catalog

→ Source is spatially coincident with the M54 globular cluster and the core of Sgr

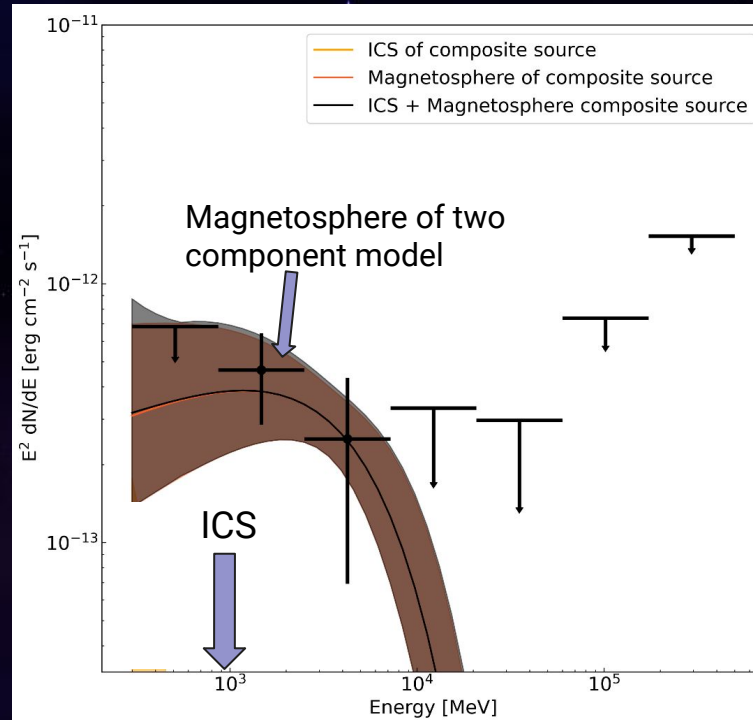
→ TS of  $\sim 23$



AJE et al., in prep

# The Sgr/M54 system in gamma-rays

→ When using a two-component model, we find no evidence for a high-energy component with an ICS flux upper limit two orders of magnitude lower than the detected flux

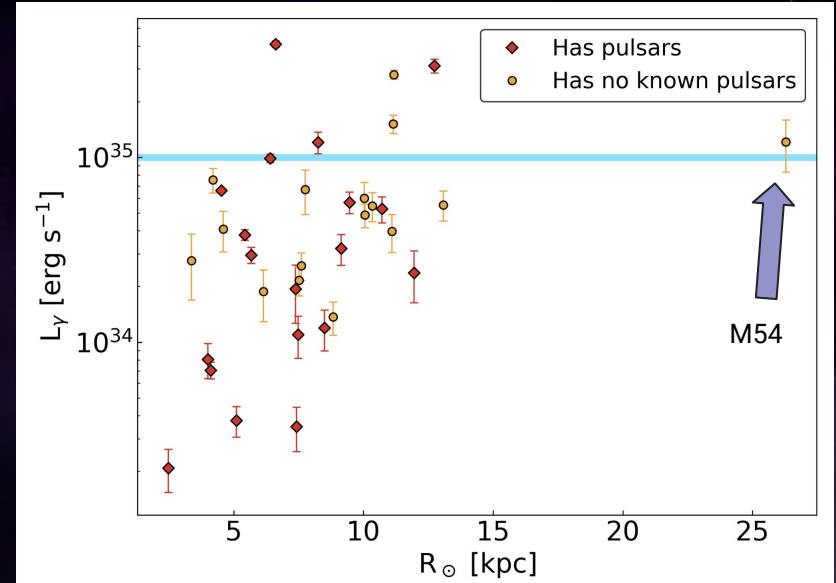
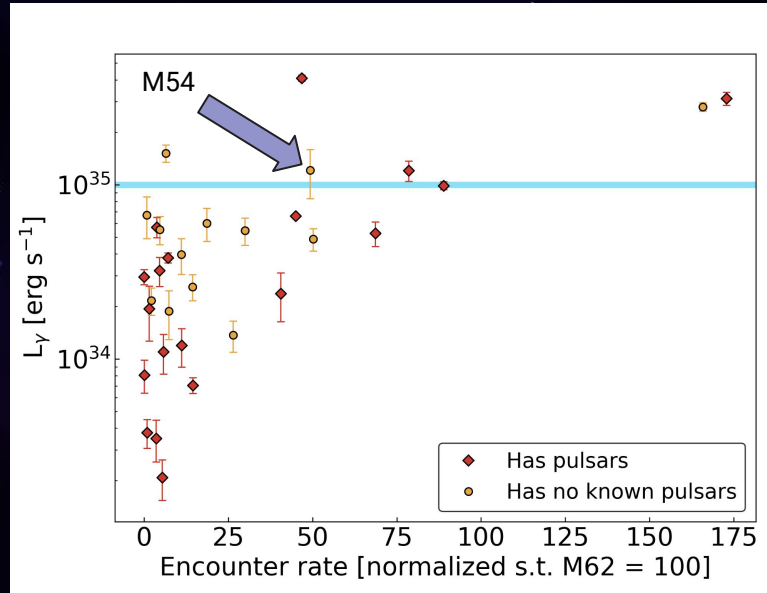


AJE et al., in prep

# If the source is associated with M54...

→ M54 is the furthest globular cluster detected by Fermi-LAT thus far

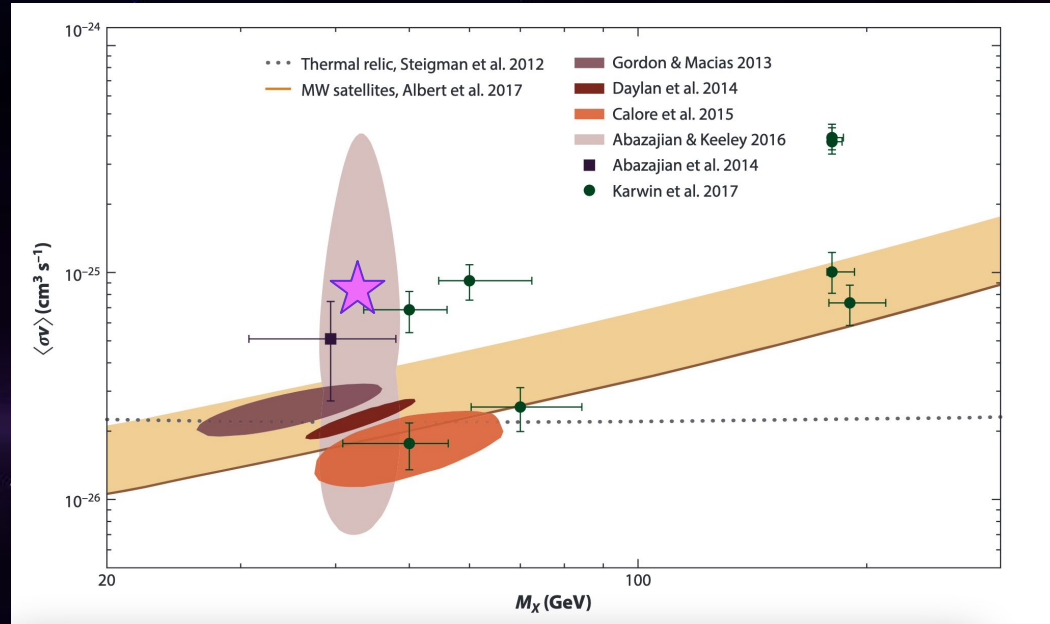
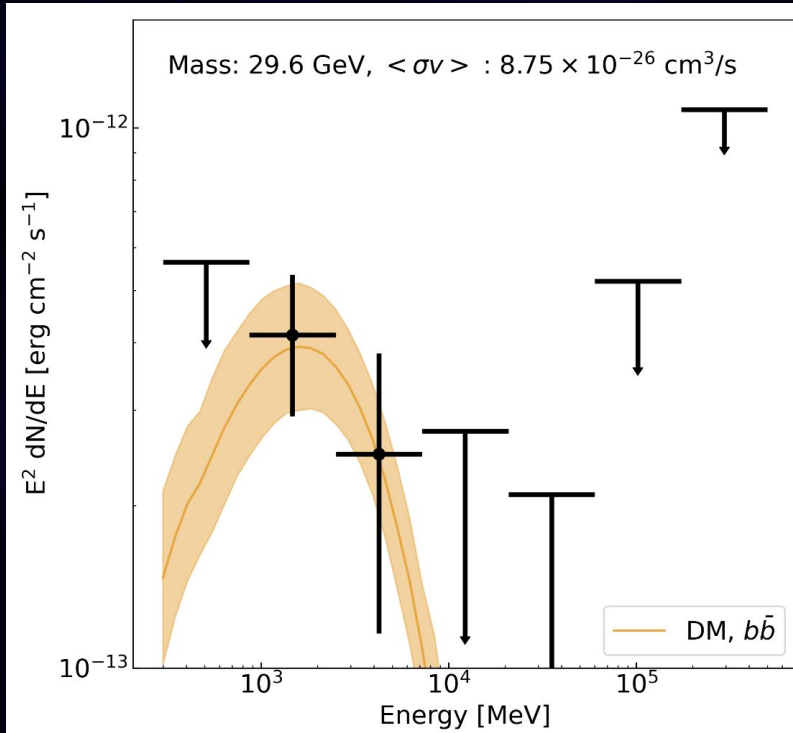
→ Other parameters agree with known gamma-ray bright globular cluster population





# Dark matter interpretation of the emission

→ Assuming a dark matter scenario, we derive a particle mass of  $\sim 30$  GeV and annihilation cross-section of  $\sim 9 \times 10^{-26} \text{ cm}^3/\text{s}$

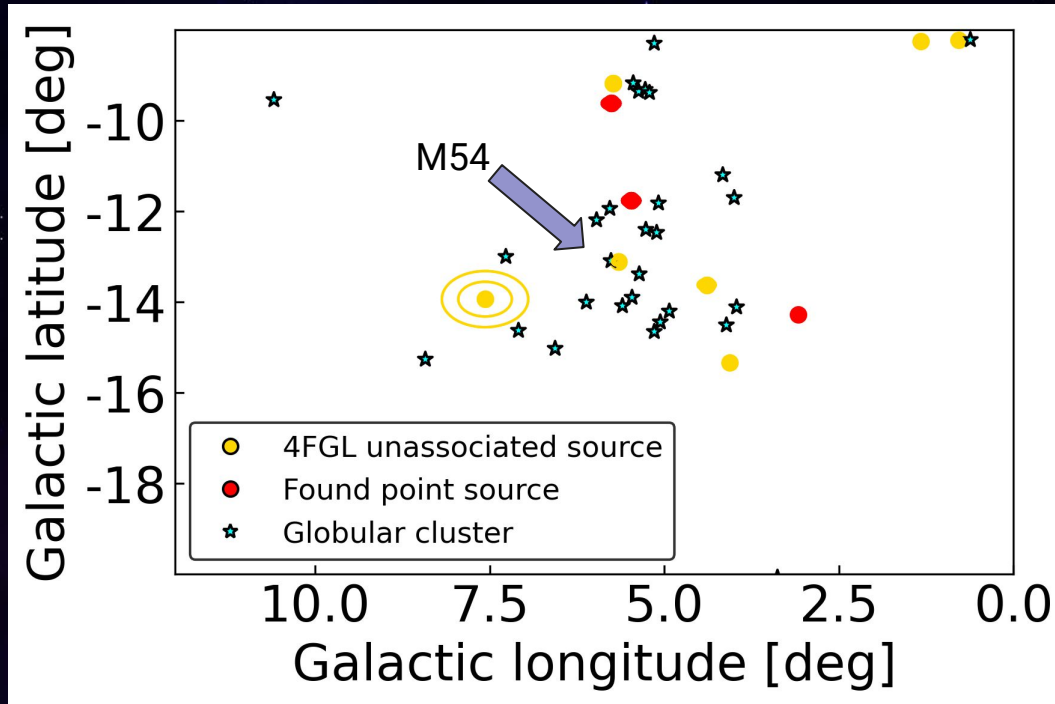


Murgia 2020

AJE et al., in  
prep

# The Sgr/M54 system in gamma-rays

→ We search for other sources possibly associated with the Sgr/M54 system and find no substantial evidence for further sources



AJE et al., in prep

# Summary

*Stay in touch :)*  
addyevans@tamu.edu

- We search the Sgr/M54 system in Fermi data and find point-like emission associated with the core of the Sgr galaxy
- This emission is possibly due to a millisecond pulsar population within the globular cluster M54
- However, a dark matter interpretation is also possible
- We find no evidence for high-energy emission from the catalog source, nor do we find any other sources possibly associated with Sgr
- While basic extension models show preference for point-like emission, a more detailed analysis testing extension models is in prep





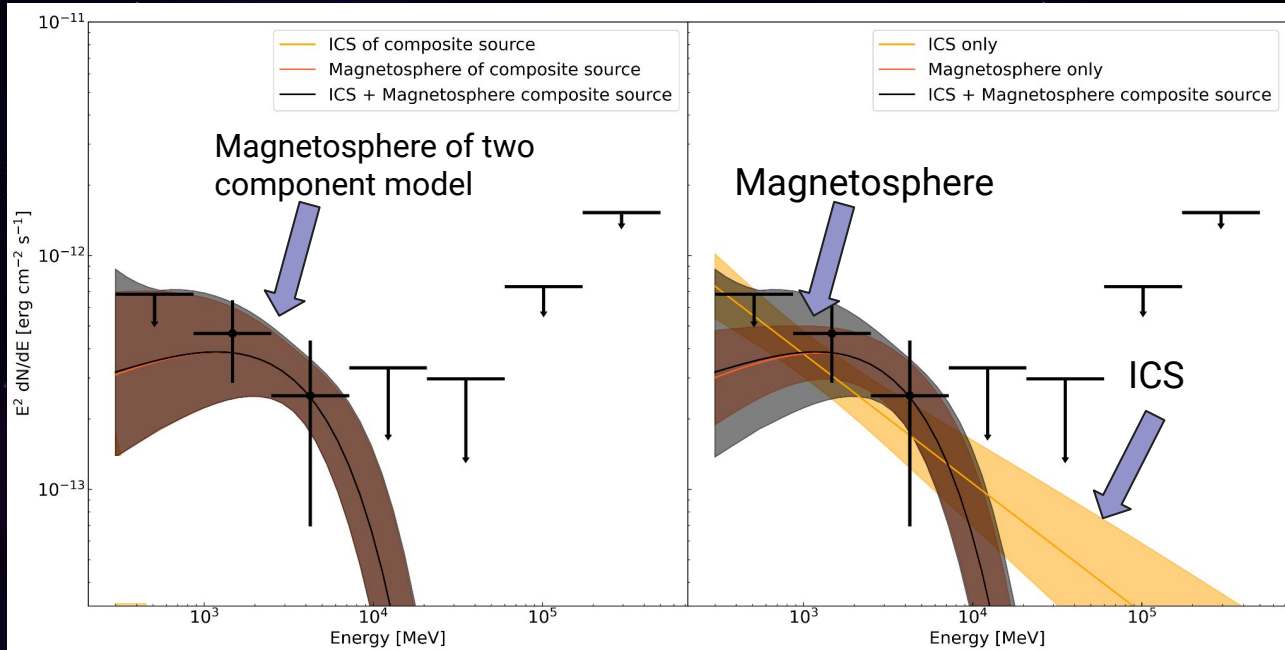
The background is a deep purple space scene. A large, dark planet with a thin, glowing purple ring is positioned in the upper right. The sky is filled with numerous small, bright white stars and faint, wispy purple nebulae. The word "Extras" is centered in a white, elegant serif font.

*Extras*



# The Sgr/M54 system in gamma-rays

→ When using a two-component model, we find no evidence for a high-energy component with an ICS flux upper limit two orders of magnitude lower than the detected flux



# Two-component modeling of Terzan 5

