A Search for Dark Matter Annihilation from the Sagittarius Dwarf and Stream

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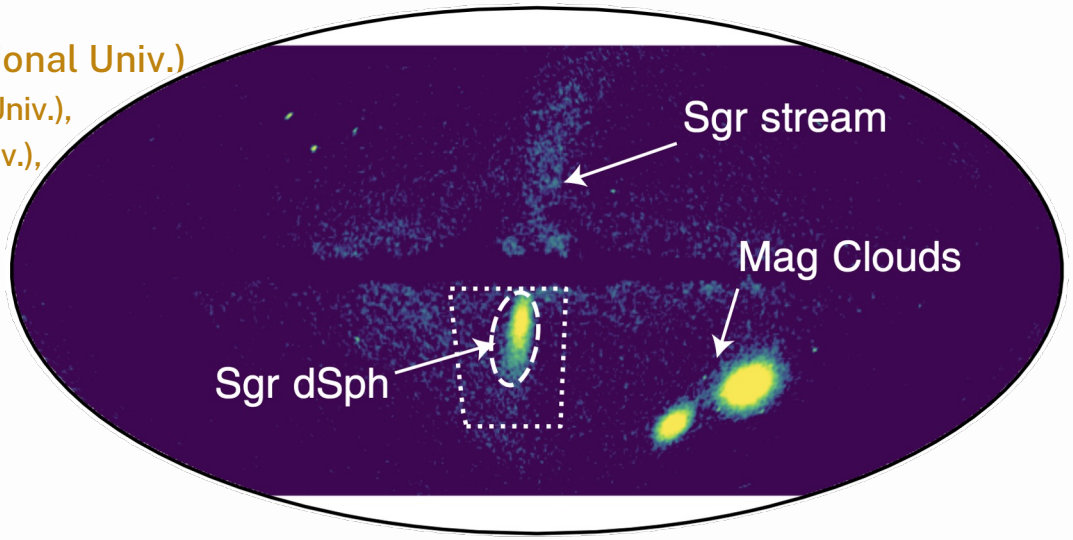
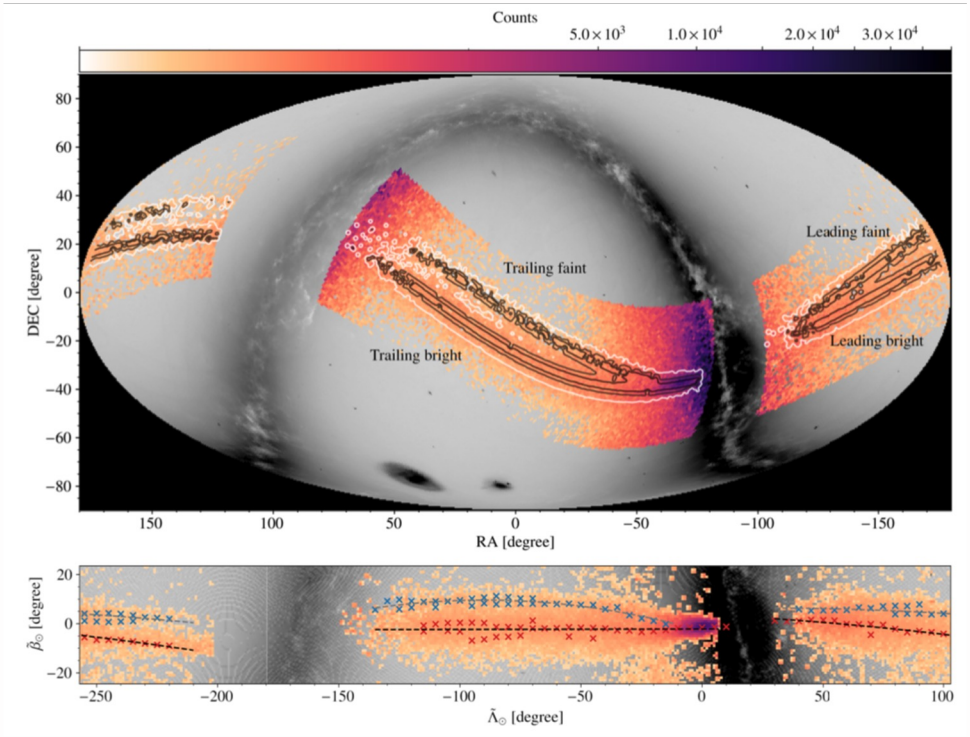


Image credit: Crocker, Macias et al (2022), *Nature Astronomy*

Australian National University

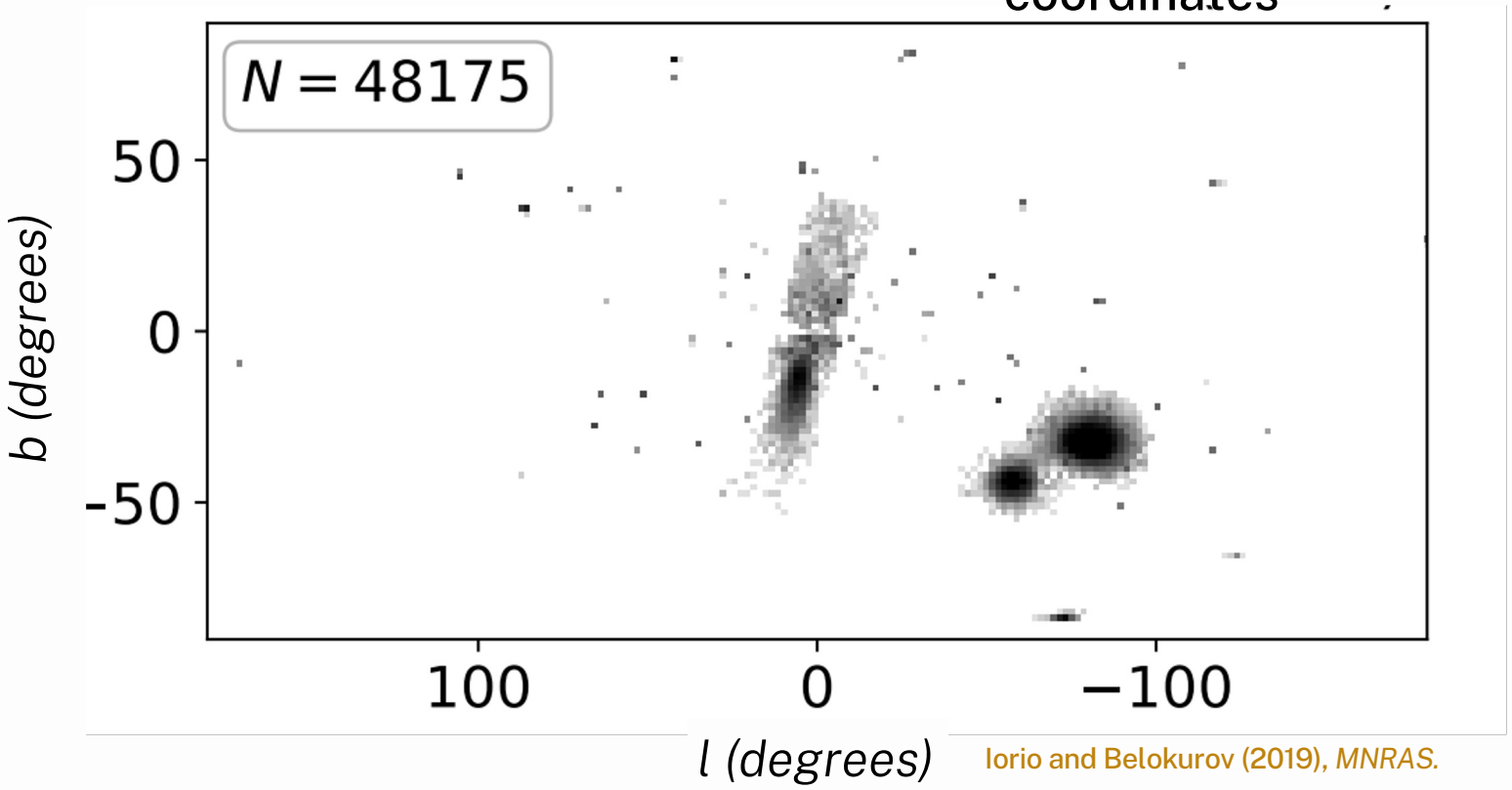
Introducing the Sagittarius Stream.

+ A tidal stream formed from a LMC mass galaxy.
+ Bound remnant is the Sagittarius Dwarf, 26.5 kpc from Earth at .



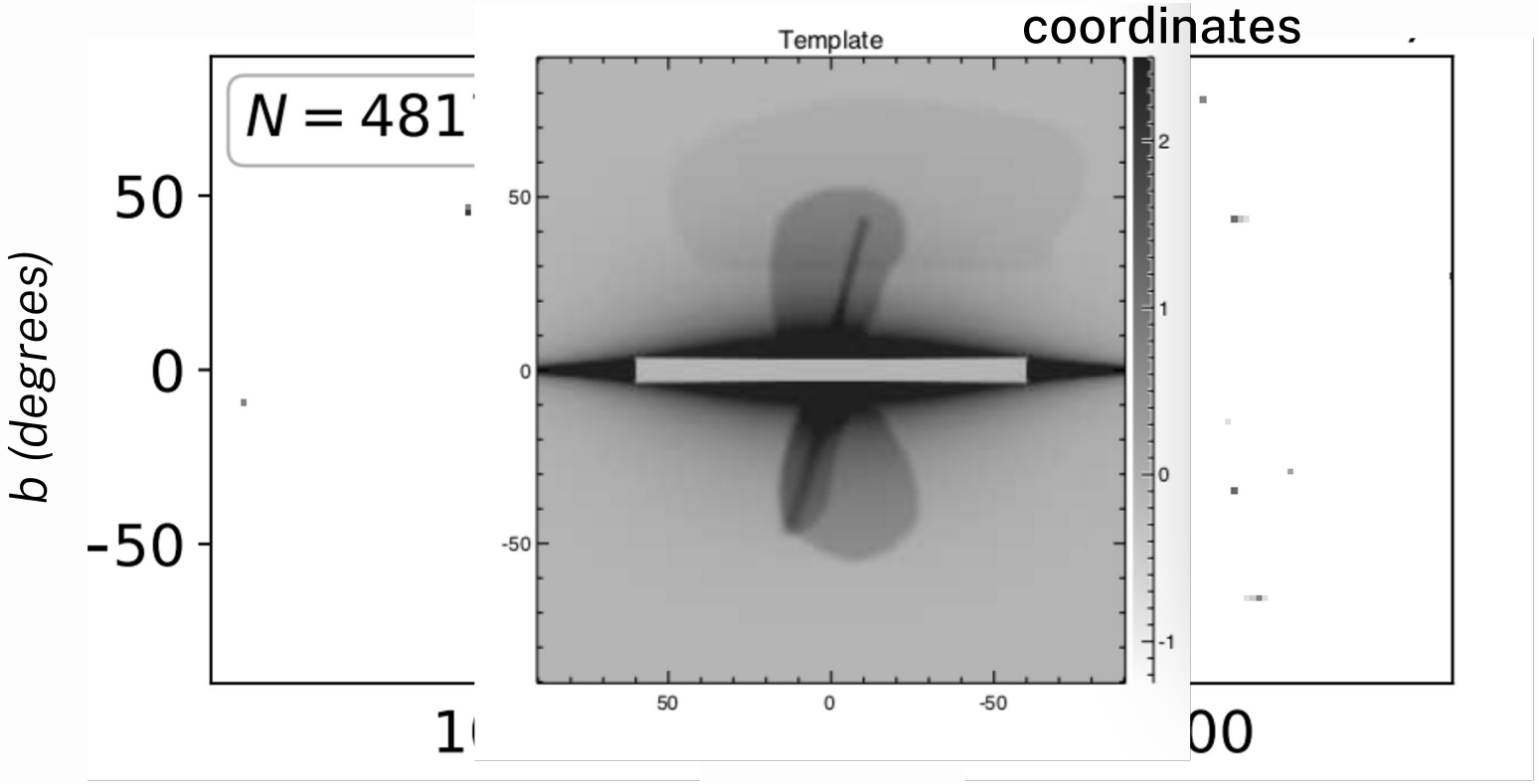
Ramos et al (2022), *MNRAS*

Galactic coordinates



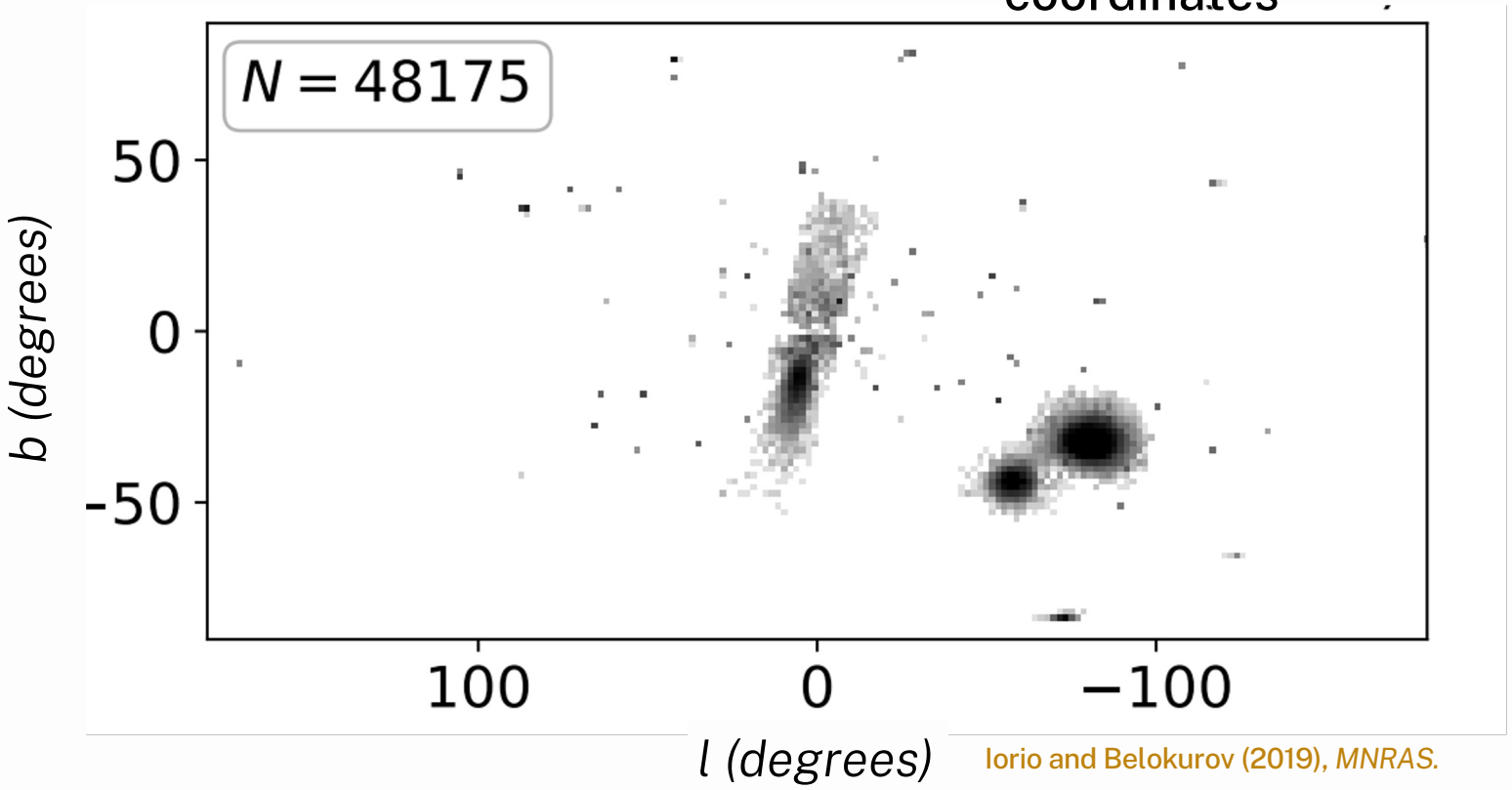
Iorio and Belokurov (2019), *MNRAS.*

Galactic coordinates



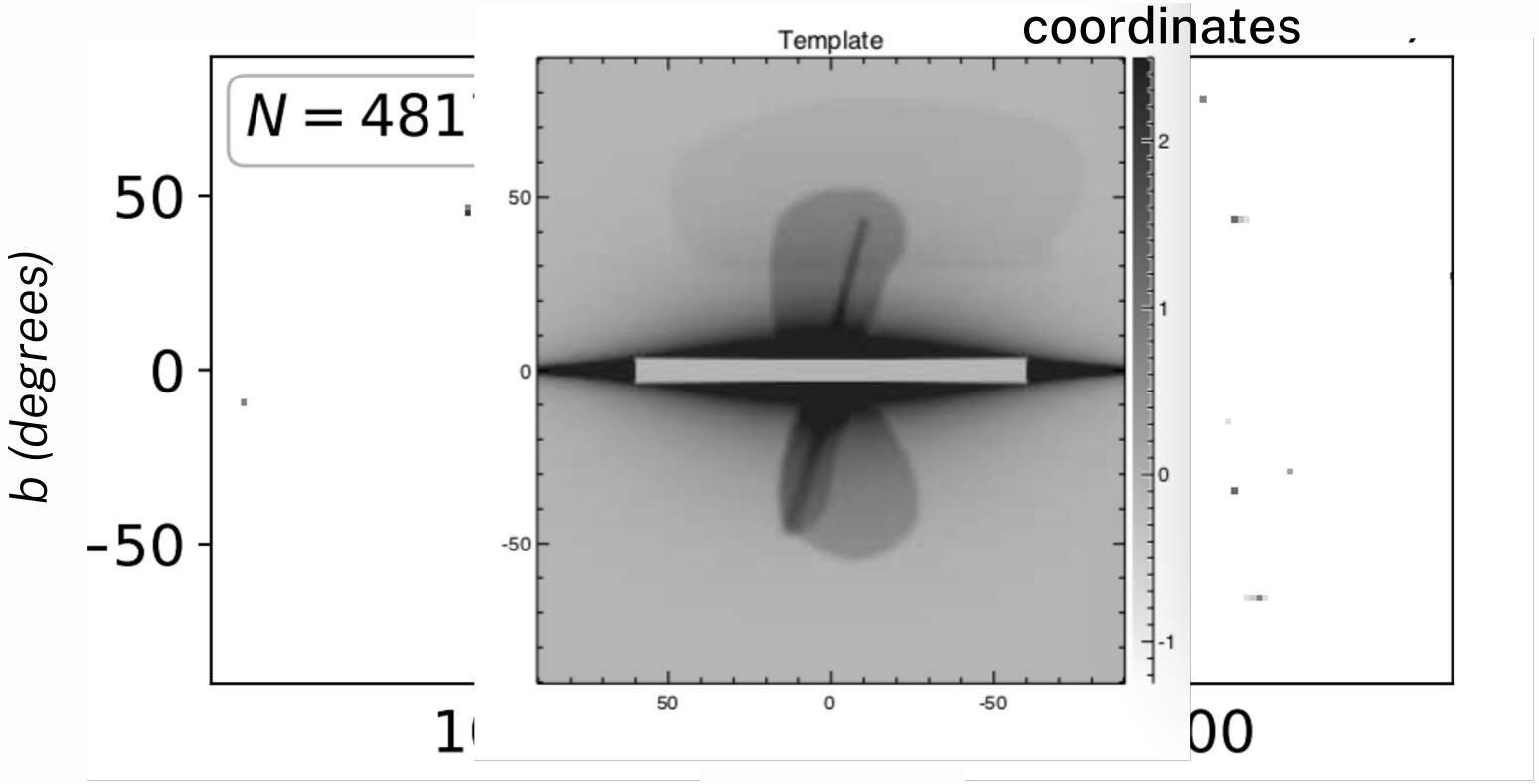
Iorio and Belokurov (2019), *MNRAS;* Su and Finkbeiner (2012), *ApJ.*

Galactic coordinates



Iorio and Belokurov (2019), *MNRAS.*

Galactic coordinates



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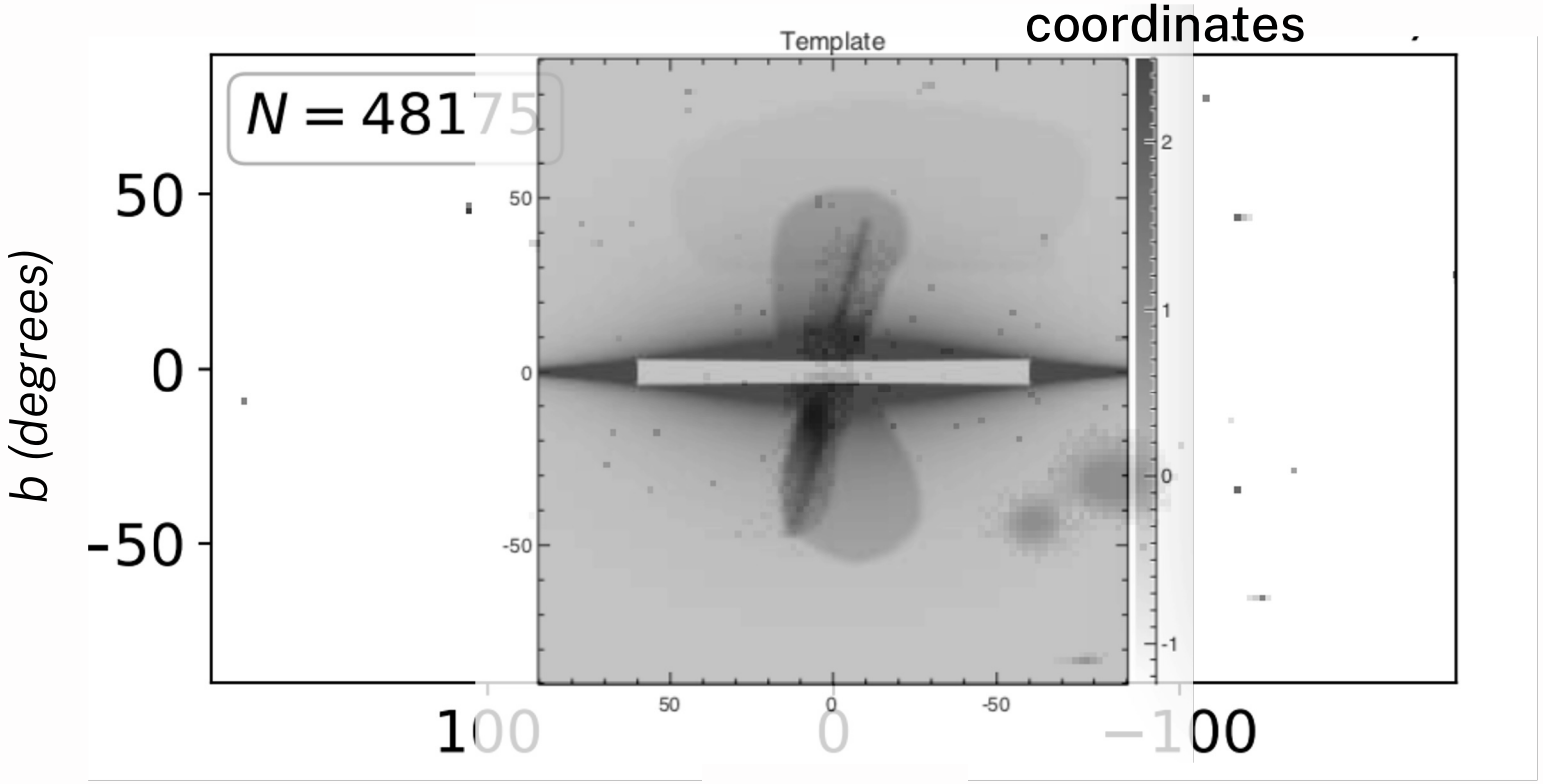

Iorio and Belokurov (2019), *MNRAS;* Su and Finkbeiner (2012), *ApJ.*

nature astronomy

ARTICLES

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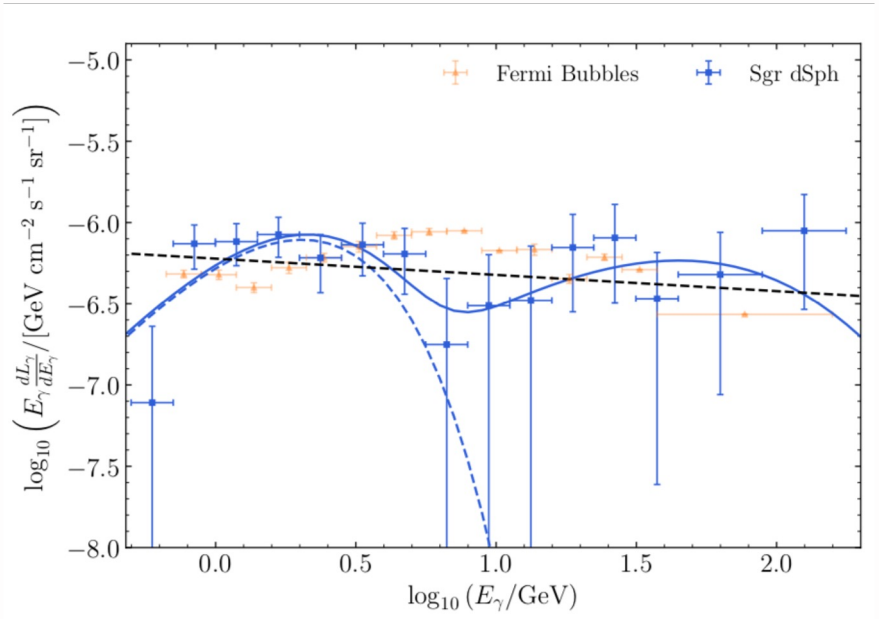
Gamma-ray emission from the Sagittarius dwarf spheroidal galaxy due to millisecond pulsars

Roland M. Crocker[1,2,15] ✉, Oscar Macias[3,4,15] ✉, Dougal Mackey[1], Mark R. Krumholz[1], Shin'ichiro Ando[3,4], Shunsaku Horiuchi[4,5], Matthew G. Baring[6], Chris Gordon[7], Thomas Venville[8], Alan R. Duffy[8], Rui-Zhi Yang[9,10,11], Felix Aharonian[2,12], J. A. Hinton[2], Deheng Song[5], Ashley J. Ruiter[13] and Miroslav D. Filipović[14]

Gamma-rays from the Sagittarius Dwarf!

+ 8.1σ detection in Crocker, Macias et al (2022).
+ SED consistent with MSP emission in the Sagittarius Dwarf's unique environment.



Crocker, Macias et al (2022), *Nature Astronomy*

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Prospective dark matter annihilation signals from the Sagittarius Dwarf Spheroidal

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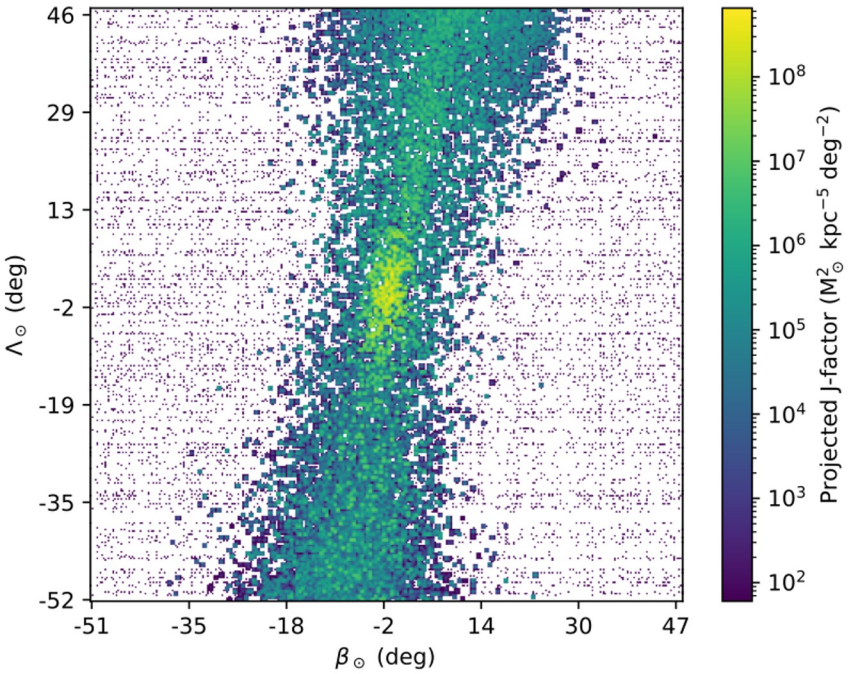
[6]*School of Physics, Sydney Institute for Astronomy, The University of Sydney, NSW 2006, Australia*
[7]*Centre of Excellence for All Sky Astrophysics in Three Dimensions (ASTRO-3D), Australia*

Simulating the Sagittarius Dwarf.

- We use a hydrodynamic simulation (Tepper-García and Bland-Hawthorn 2018) to model the dark matter halo of the Sagittarius Dwarf.
- We compute the J-factor distribution as

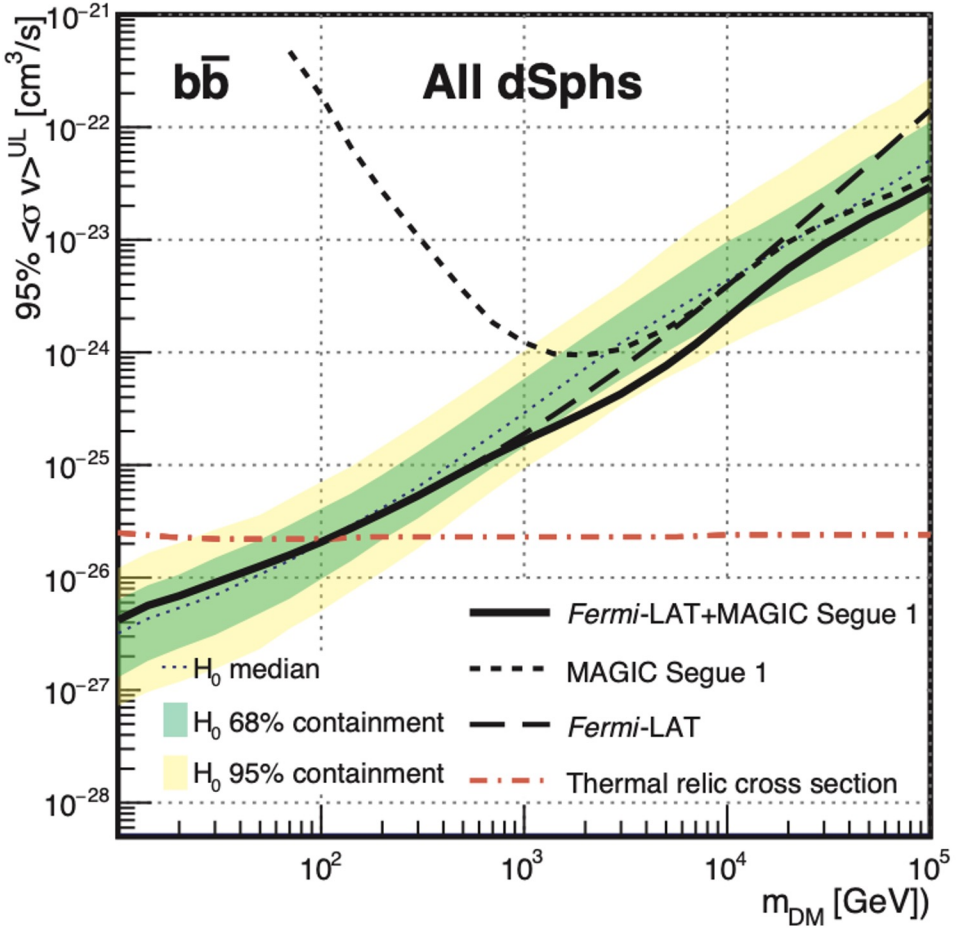
$$J_p = \int_{\mathcal{V}_p} \rho_{DM}(r)^2 / (4\pi r^2)\, dV = \Sigma_i \rho_i m_i / (4\pi r_i^2)$$

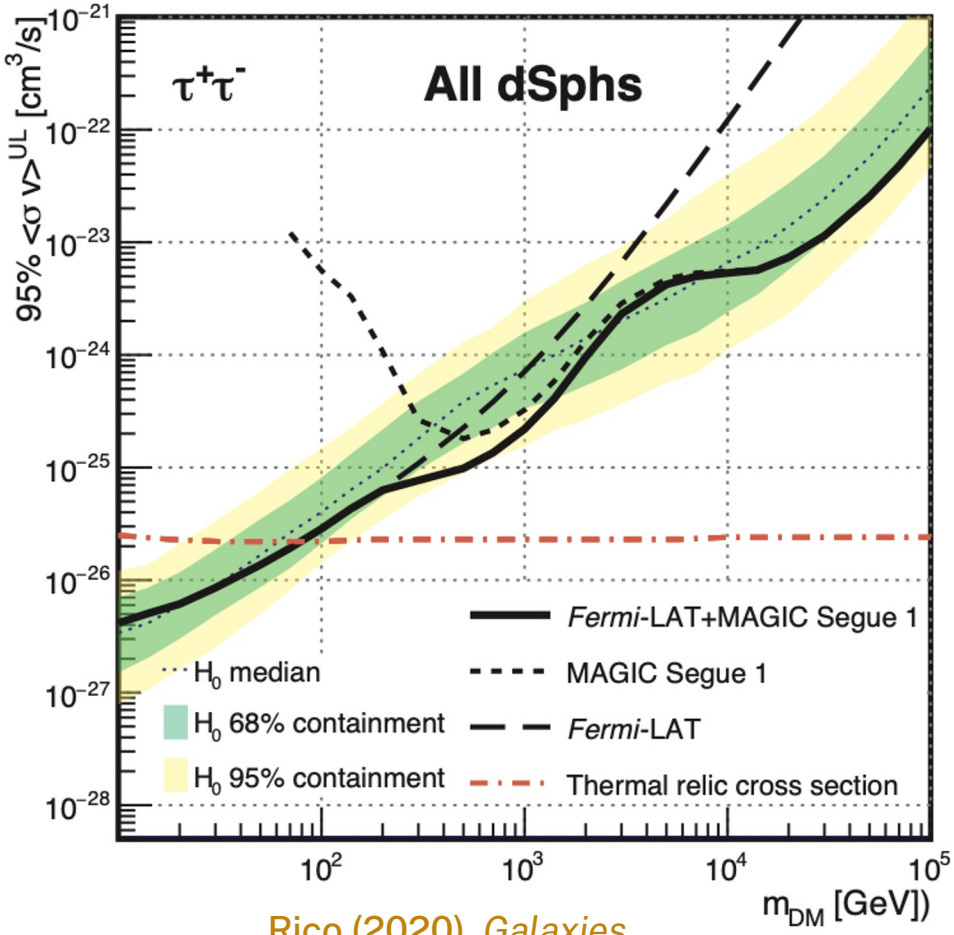


Venville et al. (2024), *MNRAS.*

The J-factor calculated in Venville et al (2024) is.

Explaining the observed emission would require a *lower* *limit* on the cross section of:





Rico (2020), *Galaxies*

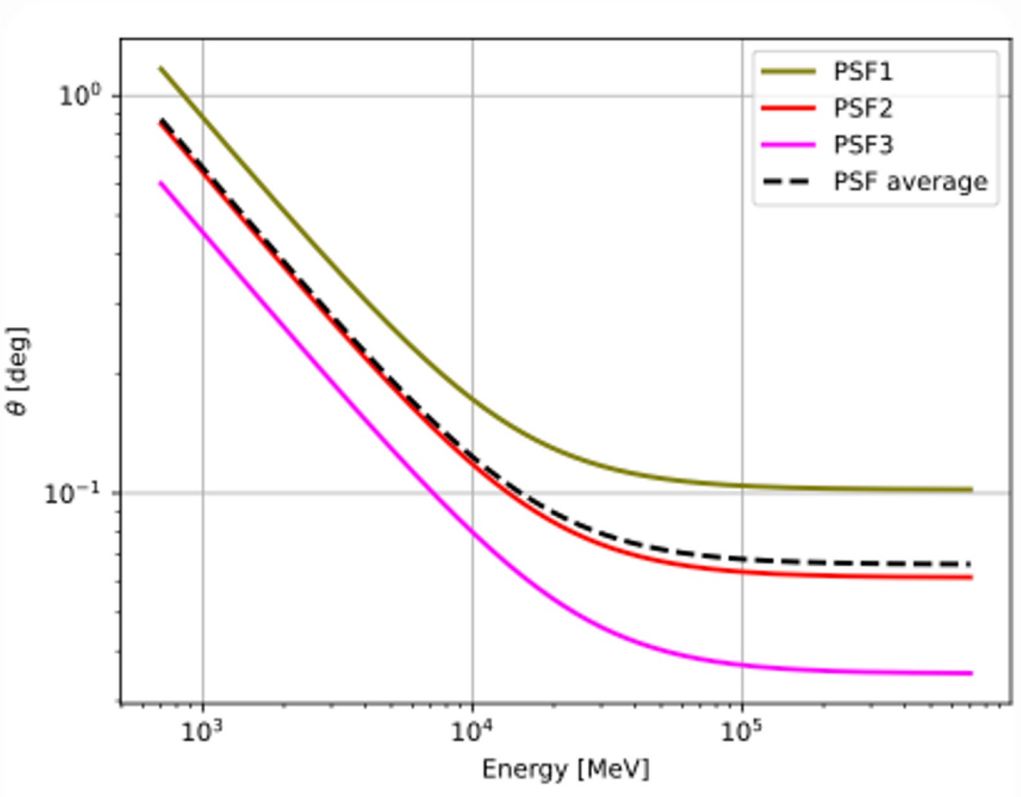
The J-factor calculated in Venville et al (2024) is.

Explaining the observed emission would require a *lower* *limit* on the cross section of:

Analysis of the Sagittarius Stream
- *in preparation.*

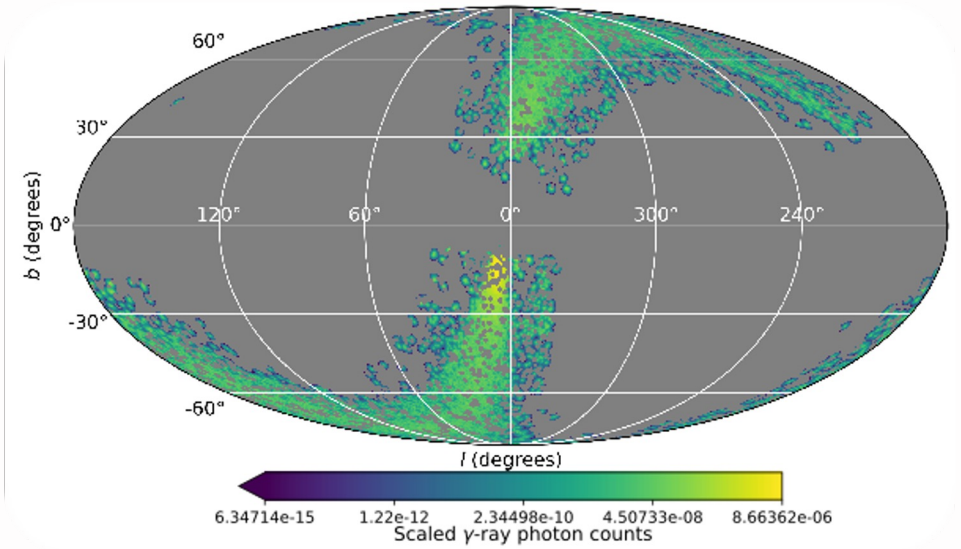
Analysis procedure.

+ Used a maximum-likelihood fitting procedure in 10 energy bins, spanning from 700 MeV to 1,000,000 MeV.
+ Data selection: P8RS3_SOUCEVETO_V3 event class, Zenith angle cut of .
+ nside of 256 assumed.
+ Three masks applied - energy dependent point source mask, extended source mask, and mask of .
+ All fitted models include the background sources detailed in Crocker, Macias et al (2022).



Stellar-associated source template.

+ Constructed using the projected number density of Sagittarius Stream stars following Crocker, Macias et al. (2022).
+ Uses catalog of Ramos et al (2022) extracted from Gaia EDR3.

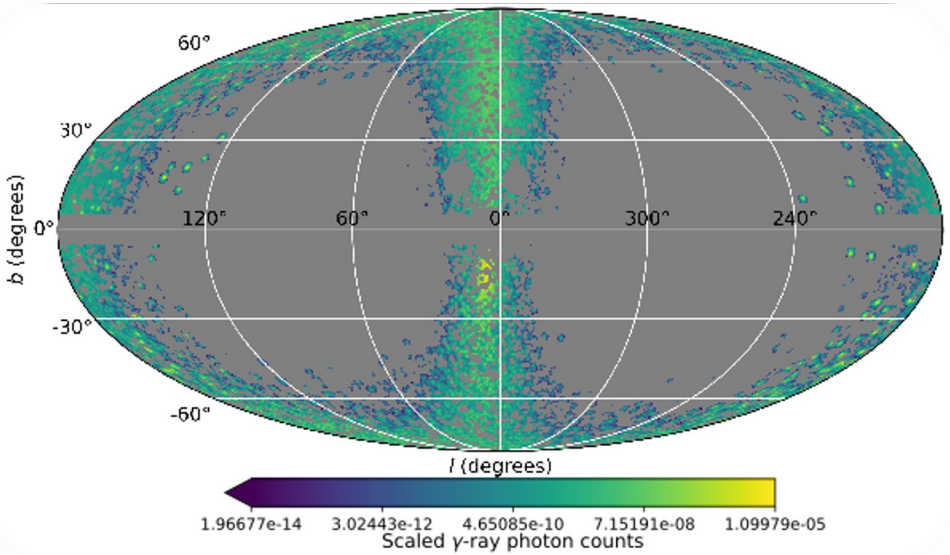


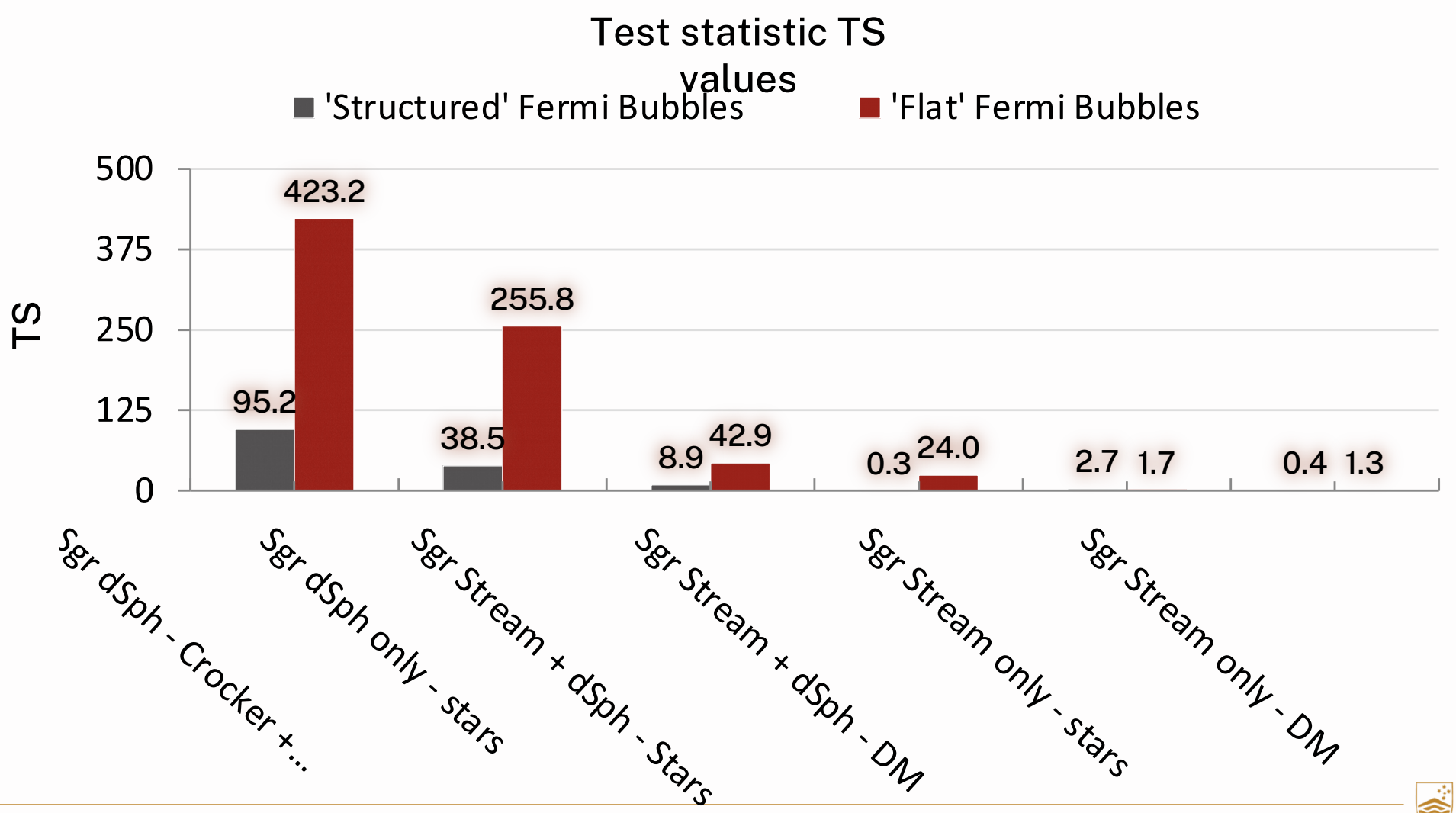
Dark matter annihilation template.

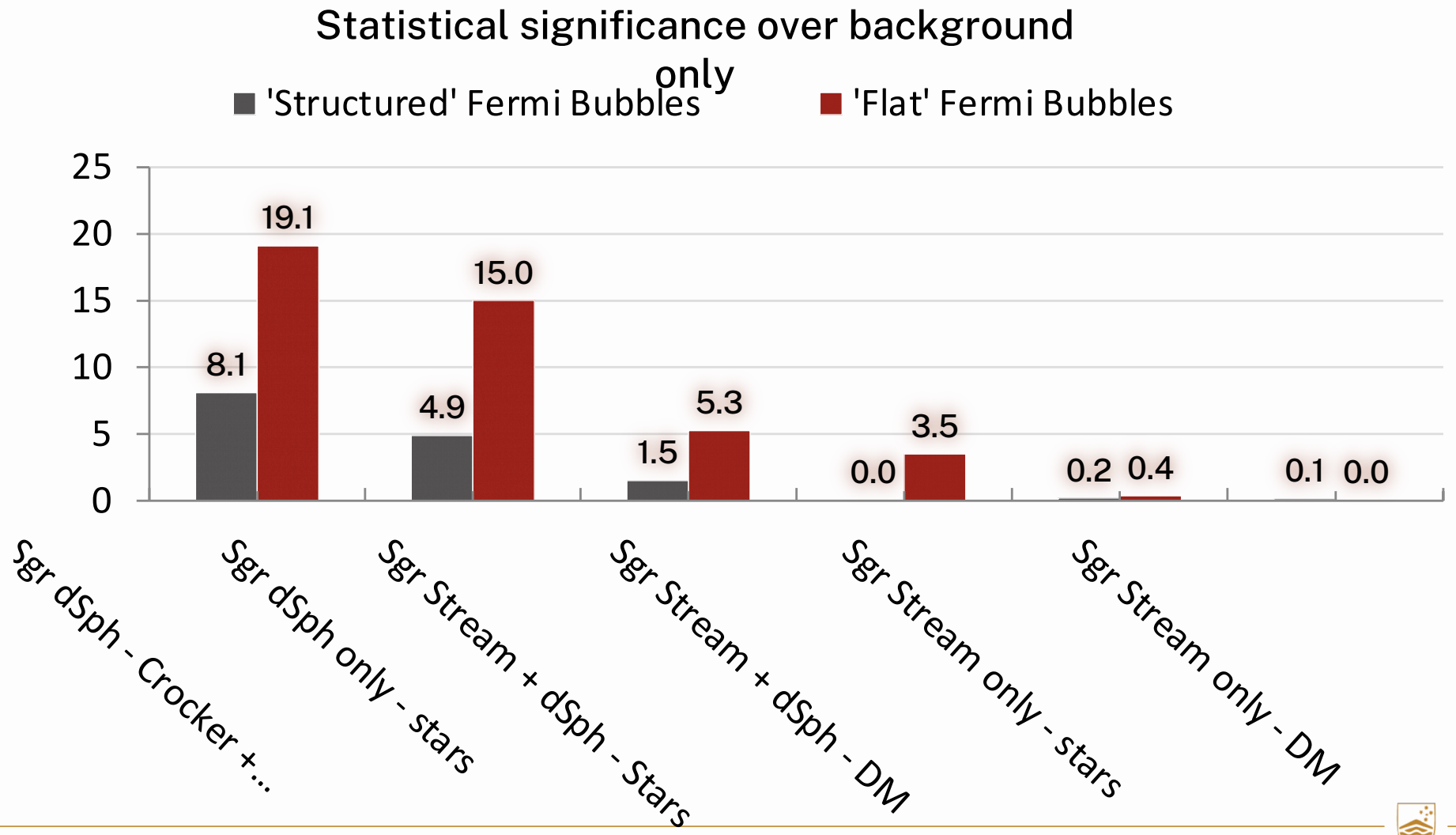
+ Constructed using the method from Venville et al. (2024):

$$J_p = \int_{V_p} \rho_{DM}(r)^2/(4\pi r^2)\,dV \approx \Sigma_i \rho_i m_i/(4\pi r_i^2)$$

+ Misalignment at high Galactic latitudes.




Test statistic TS values
'Structured' Fermi Bubbles
'Flat' Fermi Bubbles
TS
500
375
250
125
0
423.2
255.8
95.2
38.5
8.9
42.9
0.3
24.0
2.7
1.7
0.4
1.3
Sgr dSph - Crocker +...
Sgr dSph only - stars
Sgr Stream + dSph - Stars
Sgr Stream + dSph - DM
Sgr Stream only - stars
Sgr Stream only - DM


Statistical significance over background only
'Structured' Fermi Bubbles
'Flat' Fermi Bubbles
25
20
15
10
5
0
19.1
15.0
8.1
4.9
5.3
1.5
3.5
0.0
0.2
0.4
0.1
0.0
Sgr dSph - Crocker +...
Sgr dSph only - stars
Sgr Stream + dSph - Stars
Sgr Stream + dSph - DM
Sgr Stream only - stars
Sgr Stream only - DM

Key points

01 -ray emission is detected from the Sagittarius Dwarf

02 This is unlikely to be due to DM annihilation.

03 We don't detect -ray emission from the Sagittarius Stream.

Thank-you

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Australian
National
University

Key points

01 -ray emission is detected from the Sagittarius Dwarf

02 This is unlikely to be due to DM annihilation.

03 We don't detect -ray emission from the Sagittarius Stream.