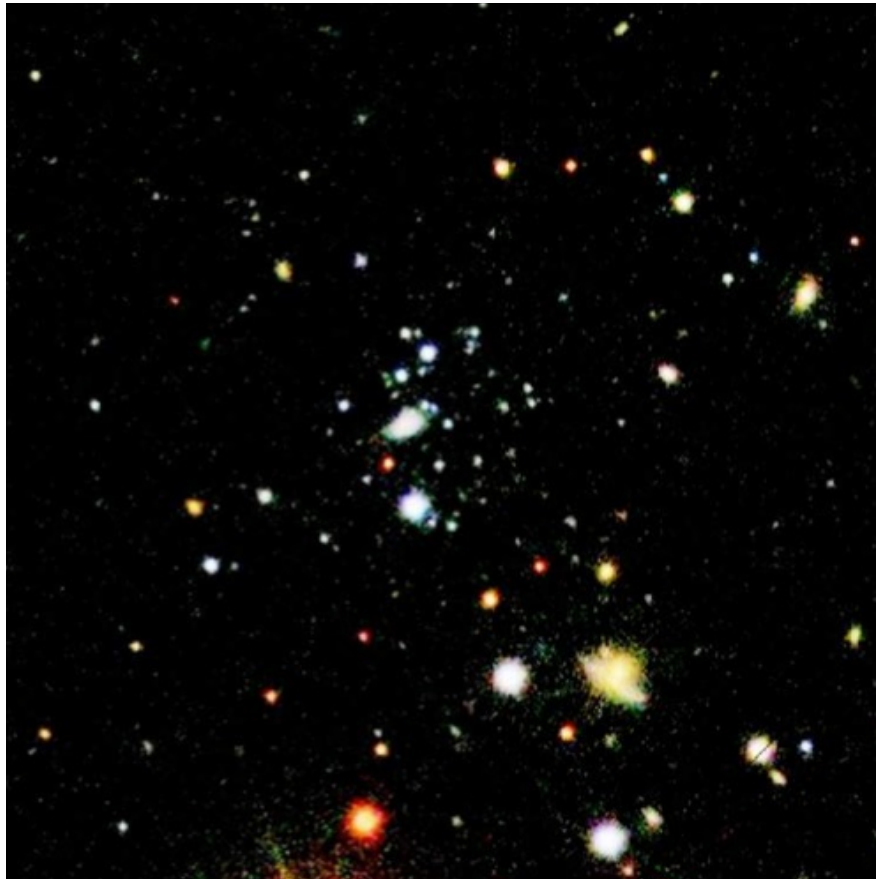
EVALUATING THE POTENTIAL TO CONSTRAIN DARK MATTER ANNIHILATION WITH *Fermi*-LAT OBSERVATIONS OF ULTRA-FAINT COMPACT STELLAR SYSTEMS



Speaker: A. Circiello

Authors: A. Circiello, A. McDaniel, A. Drlica-Wagner, C. Karwin, M. Di Mauro, M. Ajello, M. Sánchez-Conde

11th International Fermi Symposium – 09/11/24

DM SIGNATURES WITH THE *Fermi*-LAT

- The *Fermi*-LAT is able to probe annihilating/decaying DM at the GeV-TeV energies
- MW dSphs are ideal targets due to proximity and low background
- DM content of dSphs can be gauged from scaling relations
- *Fermi*-LAT observations of dSphs have put stringent constraints on annihilating DM

Title picture: Koposov 2 - Koposov et al. (2007)

DM SIGN… …E *Fermi*-LAT

CHECK OUT TALK BY CHRIS

- …ite …ying DM at the GeV-TeV energies
- *Fermi*-LA…

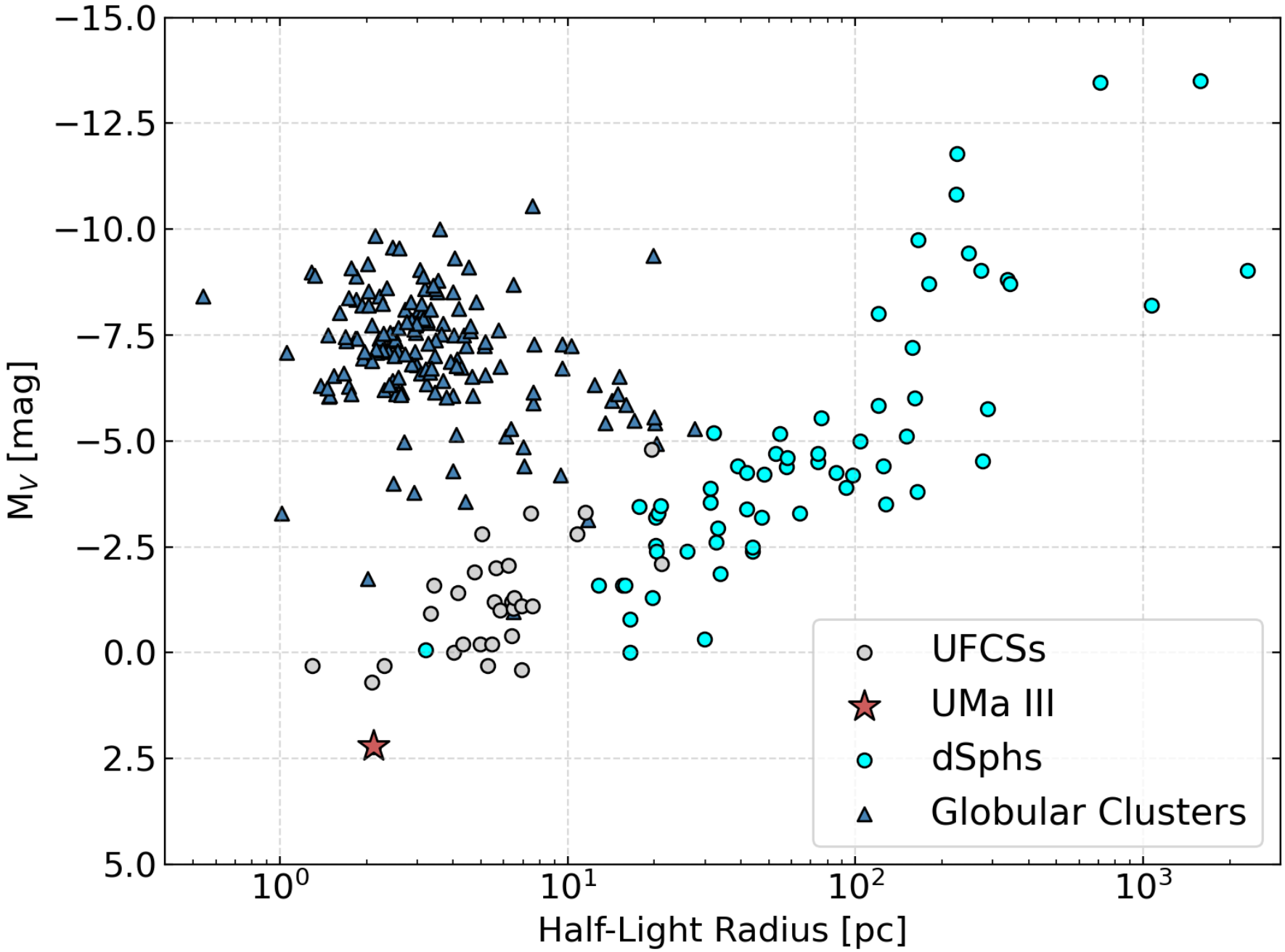
	Lunch			
	Neutrinos and Gamma-rays Session Chair: Naoko Neilson Orem Hall 2/3		Parallel 11B: Dark Matter and Diffuse Session Chair: Benjamin Safdi Orem Hall 1/3	
	Stephen Sclafani	Correlation of High Energy Neutrinos with Fermi-LAT diffuse emission templates	Deheng Song	Robust inference of the Galactic center excess spatial morphology
1:45 pm - 2:00 pm	Mehr Nisa	Search for Astrophysical Neutrinos from 4FGL Galactic Plane Sources with the Pion Bump Signature	Chris Karwin	Legacy Analysis of Dark Matter Annihilation from the Milky Way Dwarf Spheroidal Galaxies with 14 Years of Fermi-LAT Data
2:00 pm - 2:15 pm	Abhishek Desai	Multi-Messenger and Multi-Wavelength Studies with Active Galactic Nuclei	Thomas Venville	A search for dark matter annihilation from the Sagittarius Dwarf and Stream
2:15 pm - 2:30 pm	Sara Buson	Hadronic processes at work in 5BZB J0630- 2406	Peter Marinos	Variability of the Galactic CRs and Diffuse Gamma-Ray Emission Predicted with GALPROP

ULTRA-FAINT COMPACT STELLAR SYSTEMS (UFCSs)

- Optical surveys like DES and Delve have been discovering a large number of ultra-faint compact stellar systems (UFCSs)

- Faint ($M_V > -5$) and Compact ($r_{1/2} < 30$ pc) targets, their nature is yet to be confirmed

- This work explores their potential as targets for DM annihilation studies

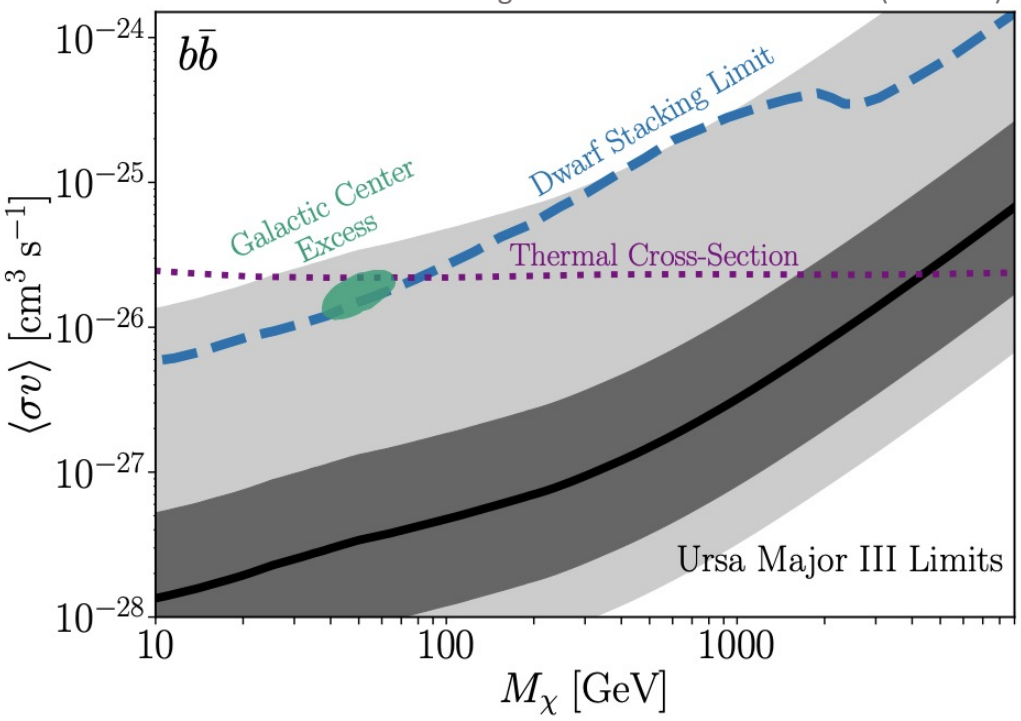

−15.0
−12.5
−10.0
−7.5
−5.0
−2.5
0.0
2.5
5.0
M_V [mag]
10^0
10^1
10^2
10^3
Half-Light Radius [pc]
UFCSs
UMa III
dSphs
Globular Clusters

An example:
Ursa Major III/UNIONS 1

From Errani et al. (2023b):

- $D \sim 10$ kpc
- $M_v \sim 2.2$
- $r_{1/2} \sim 3$ pc
- $V_d \sim 3.7$ km/s

Crnogorčević & Linden (2023)

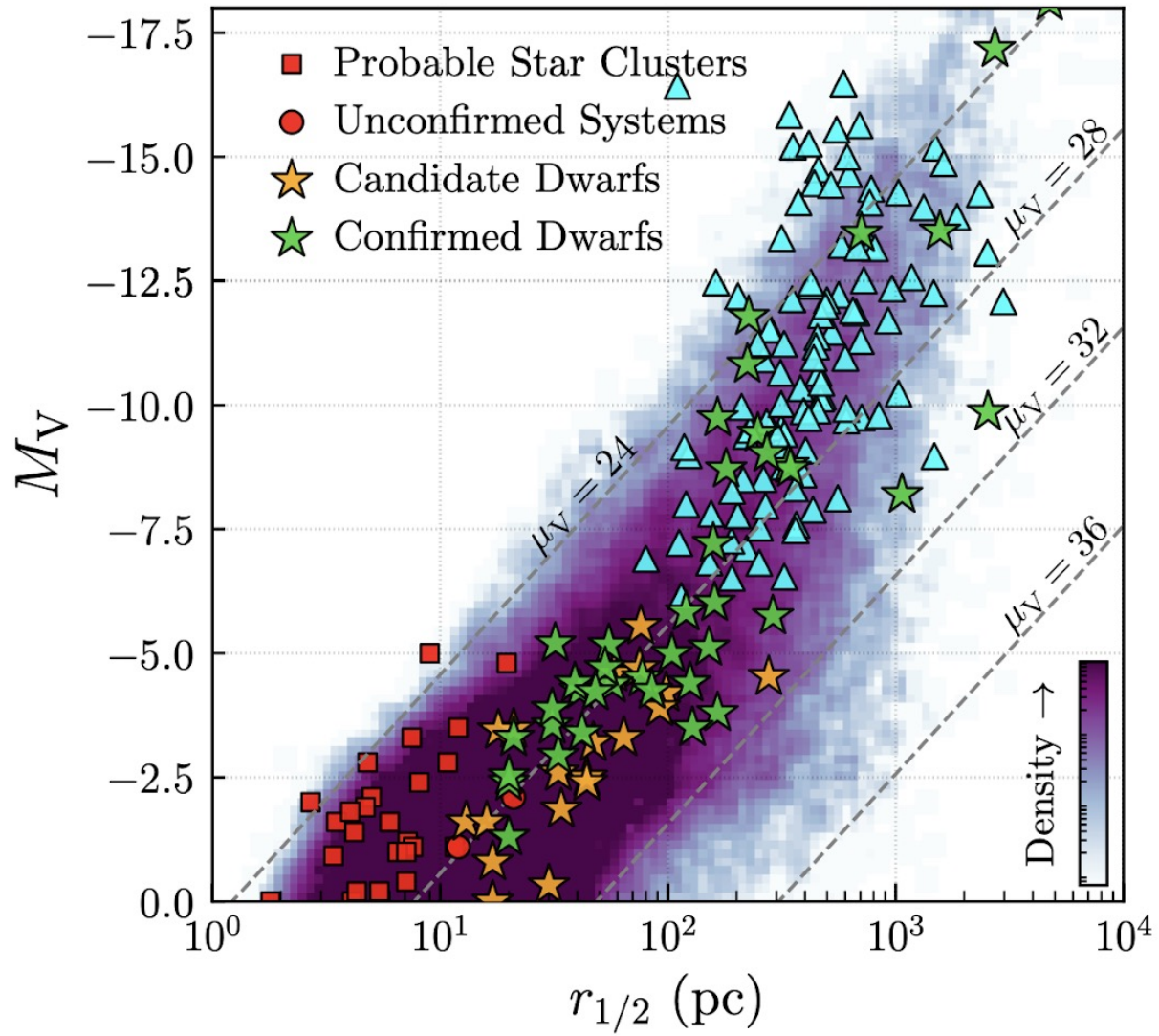


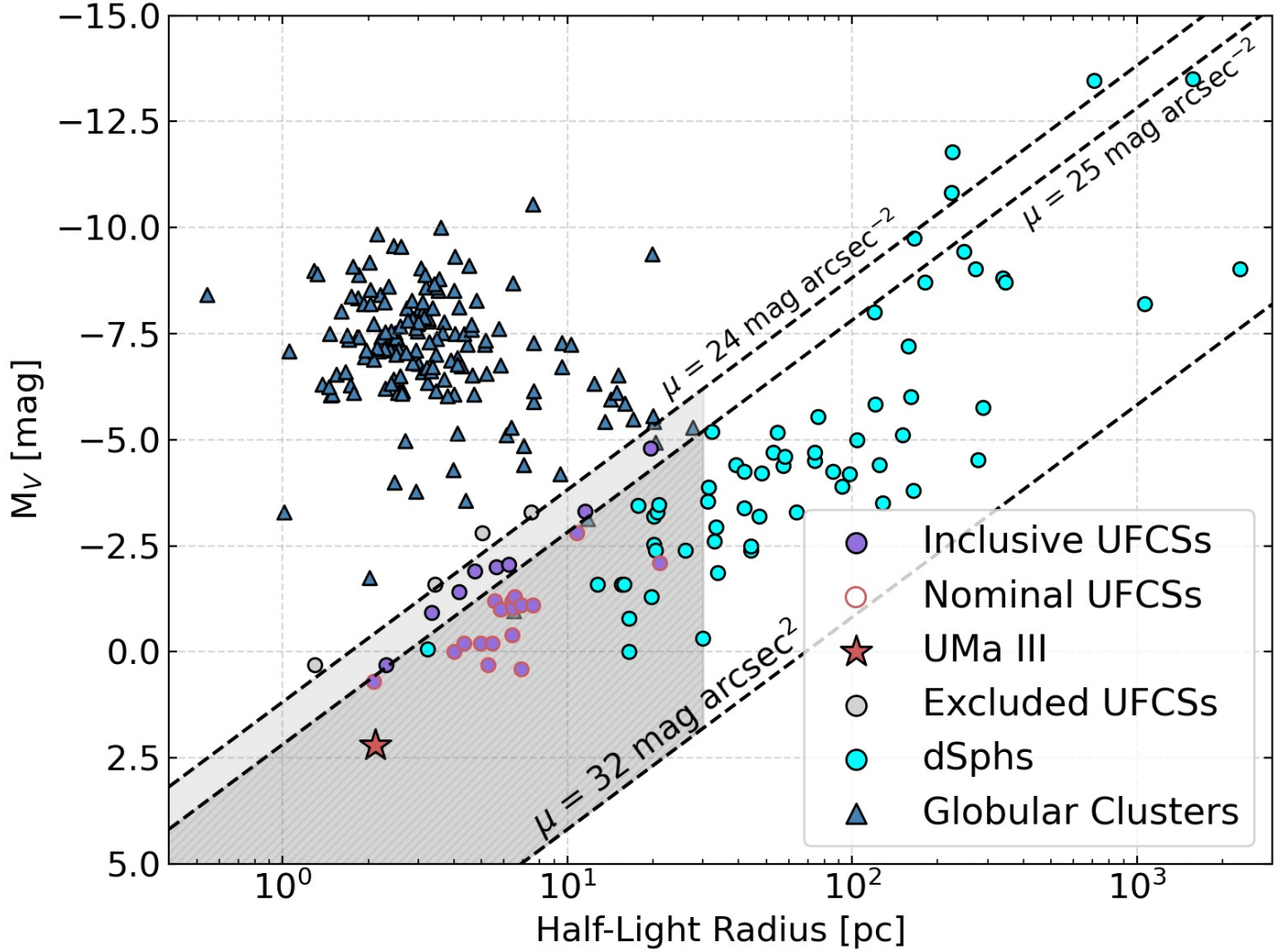
UMa III could be the NEAREST and FAINTEST galaxy observed so far.

Measurements of V_d are uncertain, though simulation hint at the presence of a DM subhalo.

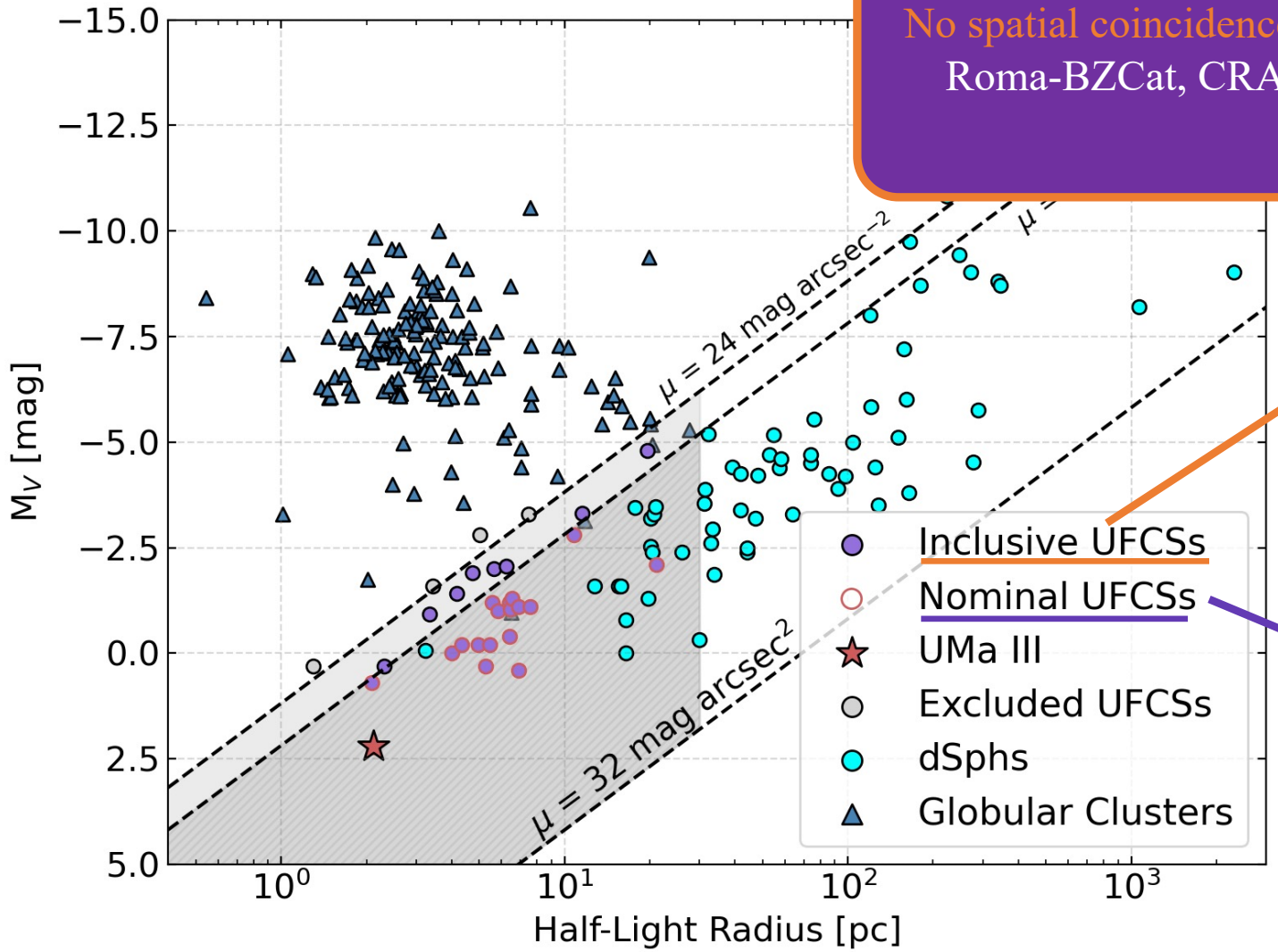
Crnogorčević & Linden (2023), assuming DM domination showed that UMa III can put strong constraints on DM annihilation

Manwadkar & Kravstov (2022)



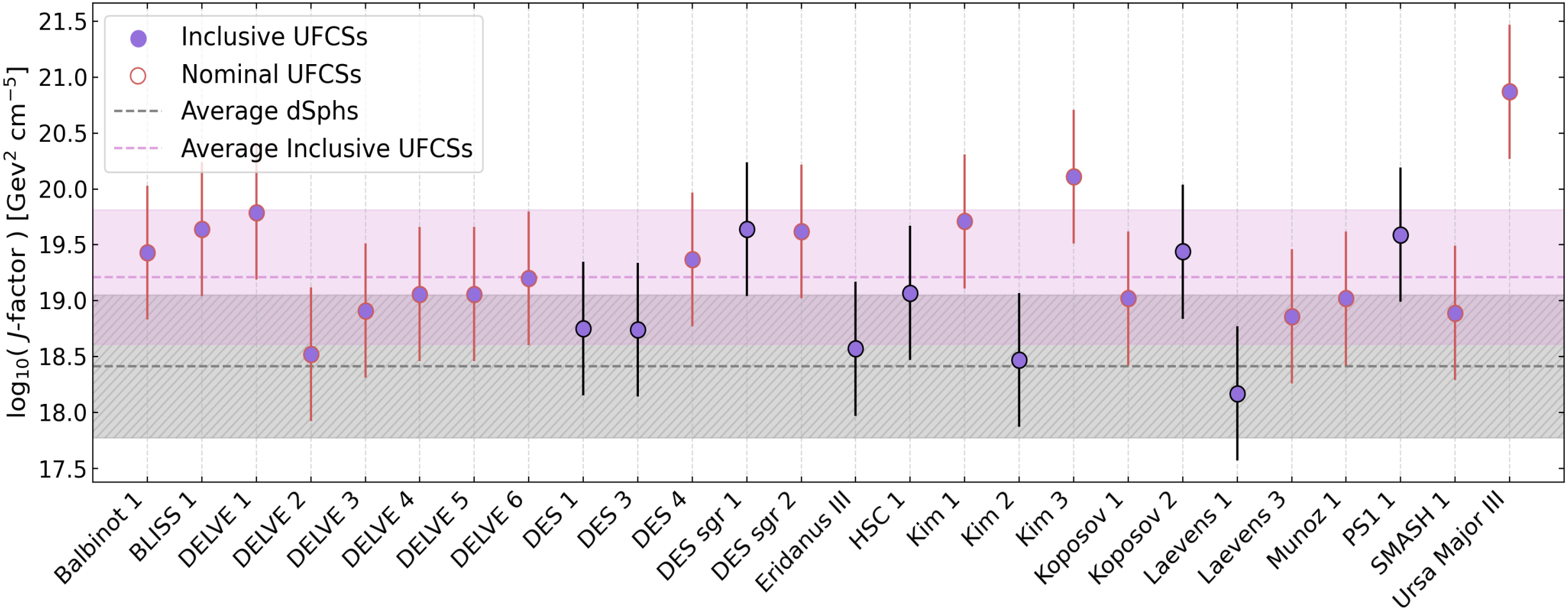

−15.0
−12.5
−10.0
−7.5
−5.0
−2.5
0.0
2.5
5.0
M_V [mag]
10^0
10^1
10^2
10^3
Half-Light Radius [pc]
$\mu = 24$ mag arcsec^{-2}
$\mu = 25$ mag arcsec^{-2}
$\mu = 32$ mag arcsec^2
Inclusive UFCSs
Nominal UFCSs
UMa III
Excluded UFCSs
dSphs
Globular Clusters

No spatial coincidence with 4FGL-DR3, Roma-BZCat, CRATES, WIBRaLS



26 targets

17 targets


Inclusive UFCSs
Nominal UFCSs
Average dSphs
Average Inclusive UFCSs
log10(J-factor) [Gev2 cm−5]
21.5
21.0
20.5
20.0
19.5
19.0
18.5
18.0
17.5
Balbinot 1
BLISS 1
DELVE 1
DELVE 2
DELVE 3
DELVE 4
DELVE 5
DELVE 6
DES 1
DES 3
DES 4
DES sgr 1
DES sgr 2
Eridanus III
HSC 1
Kim 1
Kim 2
Kim 3
Koposov 1
Koposov 2
Laevens 1
Laevens 3
Munoz 1
PS1 1
SMASH 1
Ursa Major III

Fermi-LAT ANALYSIS

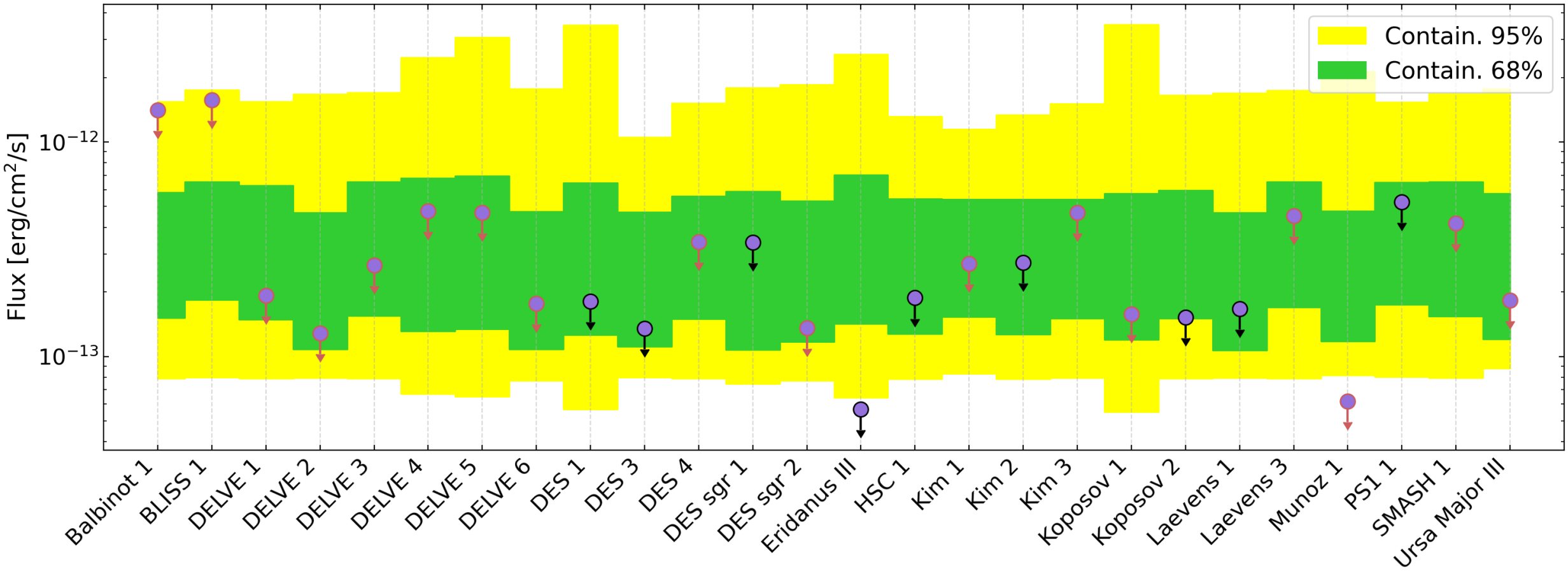
Follows McDaniel et al. (2023)

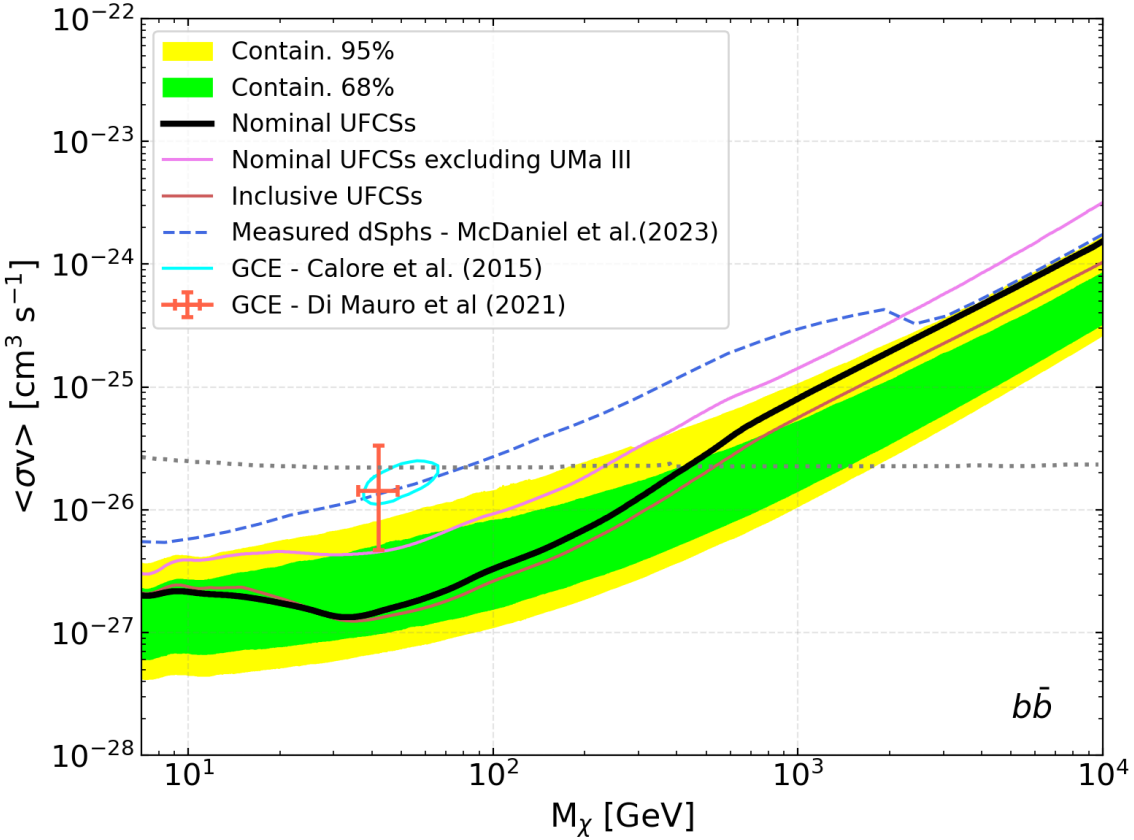
- 14.3 years of data
- Energy range: [500 MeV; 1 TeV]
- 8 energy bins per decade
- 10°x10° ROI
- 0.1° pixel size
- Joint Likelihood Analysis

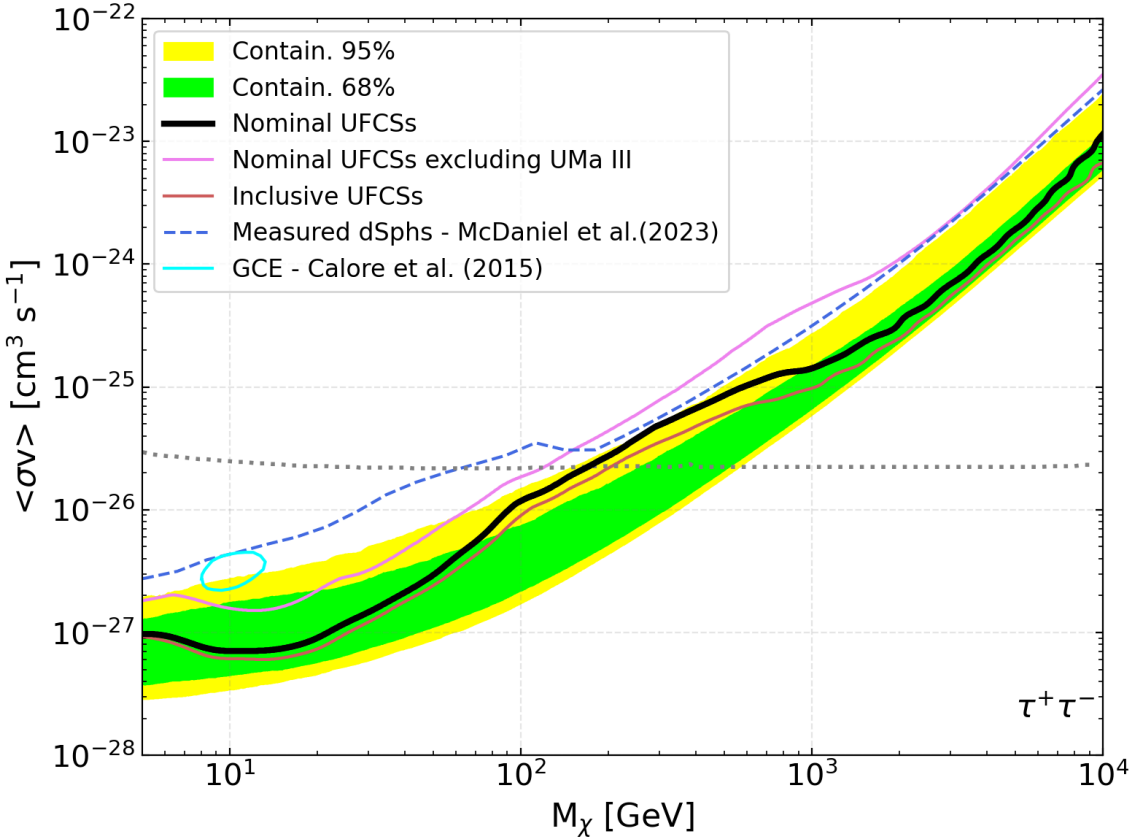
PREPROCESSING → TS PROFILES → STACKING

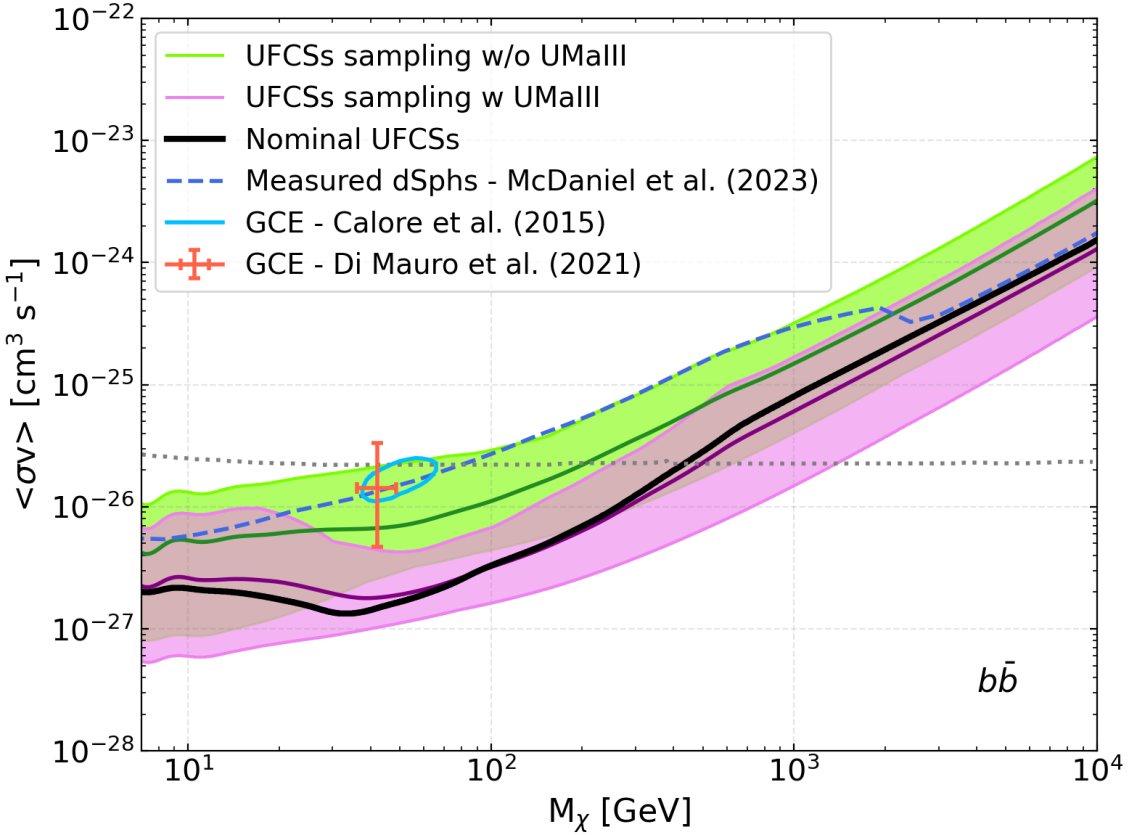
Compare to the background from 'blank-fields':

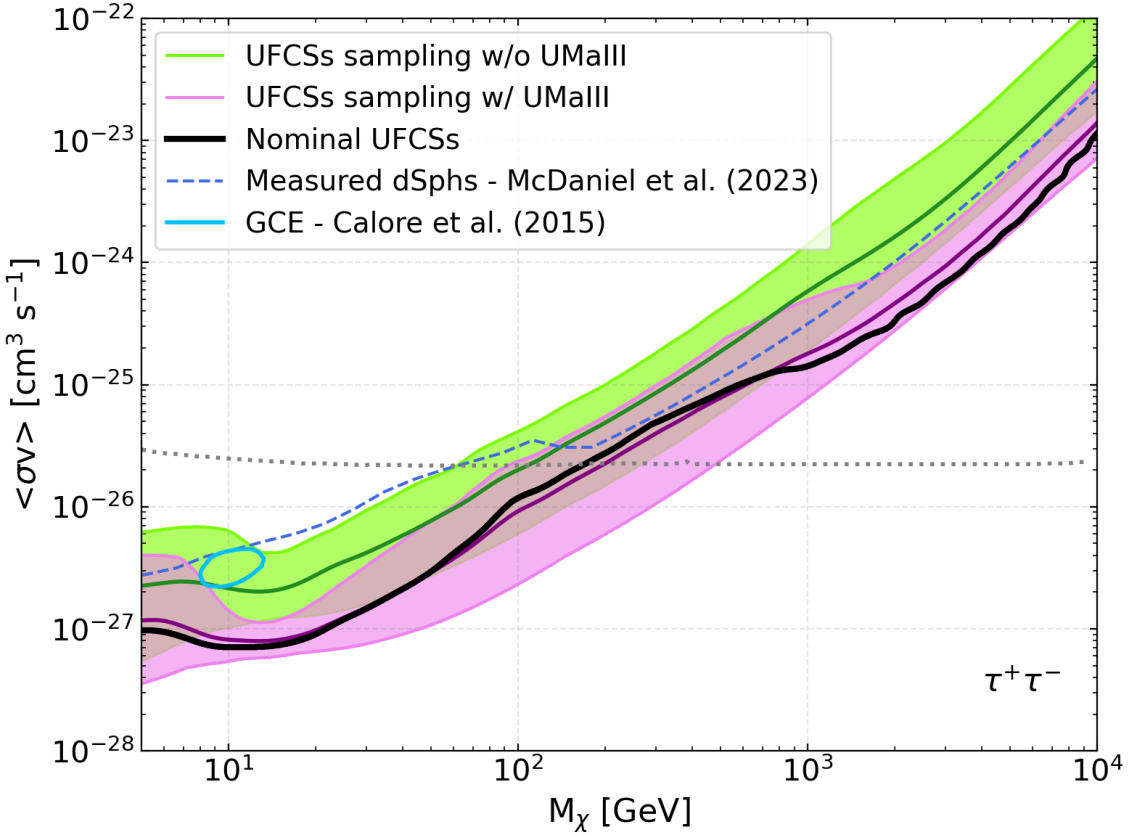
- Randomly selected regions ($b > |15°|$) of the sky with no known or potential ɣ-ray source
- Selection of empty regions from McDaniel et al. (2023) (https://figshare.com/articles/dataset/24058650/1)
- Used to accounts for background effects due to undetected sources and imperfect modeling of the diffuse emission

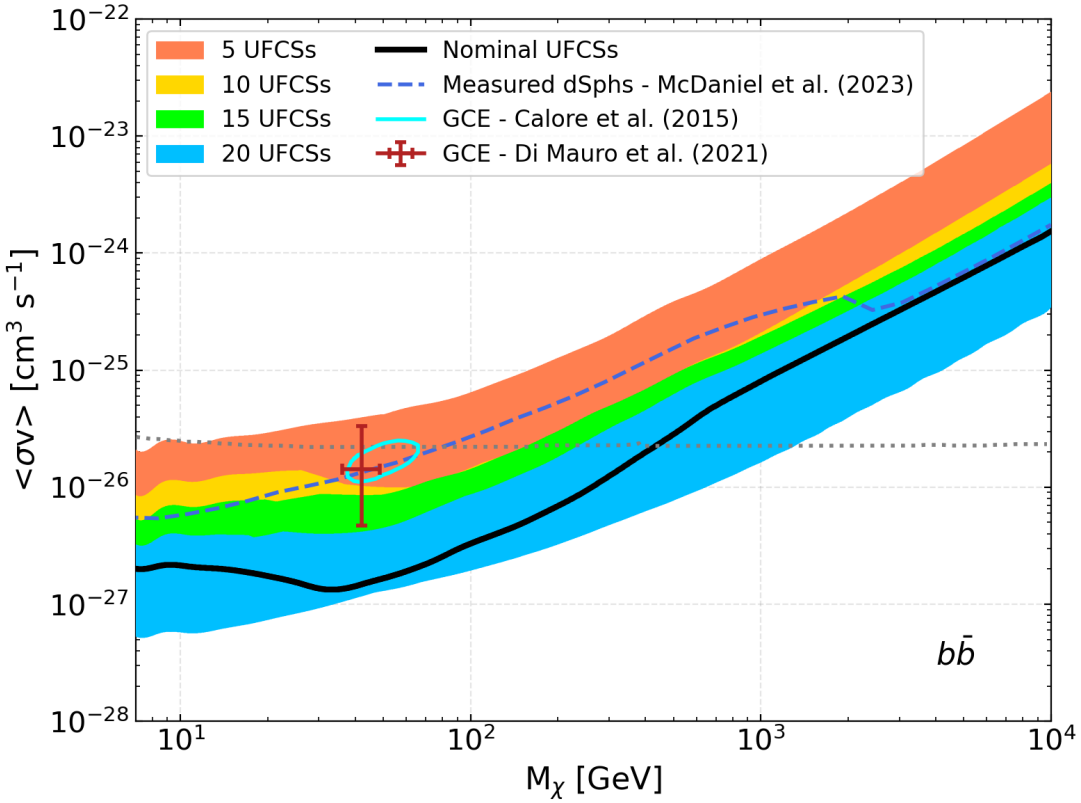

Contain. 95%
Contain. 68%
Flux [erg/cm^2/s]
10^{-12}
10^{-13}
Balbinot 1
BLISS 1
DELVE 1
DELVE 2
DELVE 3
DELVE 4
DELVE 5
DELVE 6
DES 1
DES 3
DES 4
DES sgr 1
DES sgr 2
Eridanus III
HSC 1
Kim 1
Kim 2
Kim 3
Koposov 1
Koposov 2
Laevens 1
Laevens 3
Munoz 1
PS1 1
SMASH 1
Ursa Major III

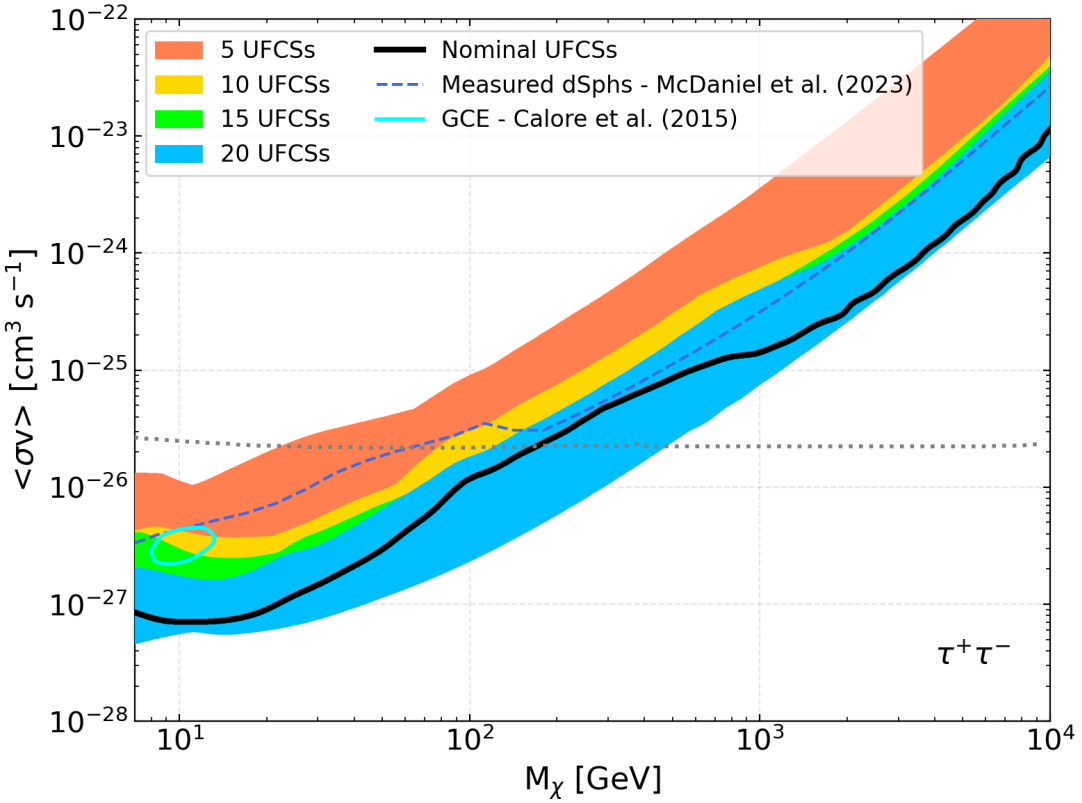

Contain. 95%
Contain. 68%
Nominal UFCSs
Nominal UFCSs excluding UMa III
Inclusive UFCSs
Measured dSphs - McDaniel et al.(2023)
GCE - Calore et al. (2015)
GCE - Di Mauro et al (2021)
$b\bar{b}$
$<\sigma v>$ [cm^3 s^{-1}]
M$_\chi$ [GeV]


Contain. 95%
Contain. 68%
Nominal UFCSs
Nominal UFCSs excluding UMa III
Inclusive UFCSs
Measured dSphs - McDaniel et al.(2023)
GCE - Calore et al. (2015)
$\tau^+\tau^-$
$<\sigma v>$ [cm^3 s^{-1}]
M$_\chi$ [GeV]


UFCSs sampling w/o UMaIII
UFCSs sampling w UMaIII
Nominal UFCSs
Measured dSphs - McDaniel et al. (2023)
GCE - Calore et al. (2015)
GCE - Di Mauro et al. (2021)
$b\bar{b}$
$<\sigma v>$ [cm^3 s^{-1}]
M$_\chi$ [GeV]


UFCSs sampling w/o UMaIII
UFCSs sampling w/ UMaIII
Nominal UFCSs
Measured dSphs - McDaniel et al. (2023)
GCE - Calore et al. (2015)
$\tau^+\tau^-$
$<\sigma v>$ [cm^3 s^{-1}]
M$_\chi$ [GeV]


5 UFCSs
10 UFCSs
15 UFCSs
20 UFCSs
Nominal UFCSs
Measured dSphs - McDaniel et al. (2023)
GCE - Calore et al. (2015)
GCE - Di Mauro et al. (2021)
$b\bar{b}$
$\langle\sigma v\rangle$ [cm^3 s^{-1}]
M$_\chi$ [GeV]


5 UFCSs
10 UFCSs
15 UFCSs
20 UFCSs
Nominal UFCSs
Measured dSphs - McDaniel et al. (2023)
GCE - Calore et al. (2015)
$\tau^+\tau^-$
$\langle\sigma v\rangle$ [cm^3 s^{-1}]
M$_\chi$ [GeV]

- UFCSs have the potential to put the most stringent constraints on DM properties so far.

- Improvement on dSphs even if only a part of the sample is confirmed to be DM dominated

- Our results emphasize the importance of precise observation on the UFCSs to determine their DM content empirically

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