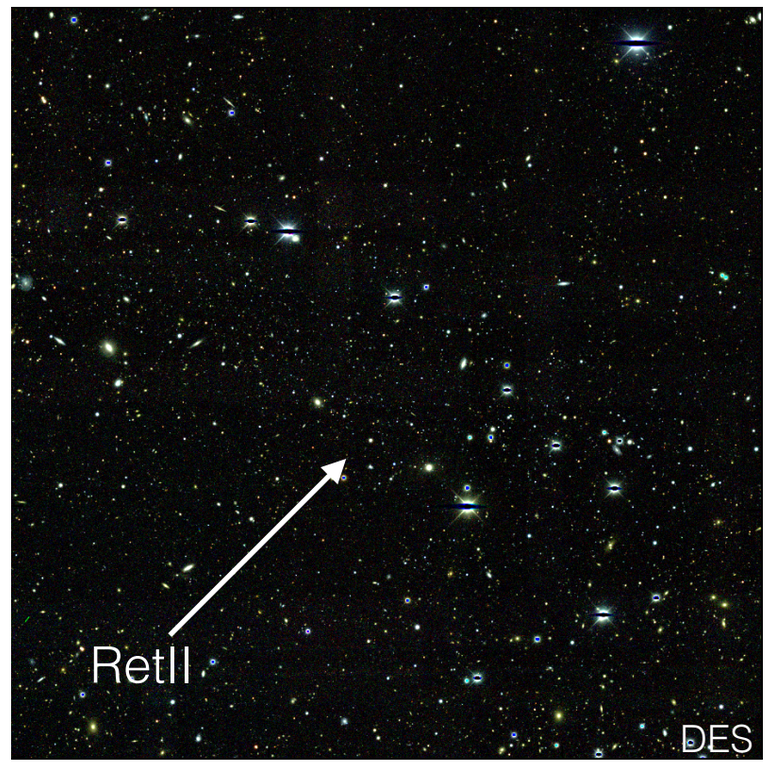
A search for dark matter annihilation in the newly discovered dwarf galaxy Reticulum II



Alex Geringer-Sameth

Carnegie Mellon University

In collaboration with
Matt Walker (CMU)
Savvas Koushiappas (Brown)
Sergey Koposov, Vasily Belokurov, Gabriel Torrealba, Wyn Evans (Cambridge)
Vincent Bonnivard, Celine Combet, David Maurin (LPSC Grenoble)

arXiv:1503.02320 (PRL), arXiv:1410.2242 (PRD), arXiv:1504.03309 (ApJL)

Dark matter

Annihilation $\langle \sigma v \rangle$

Weak scale

Always* get gamma-rays

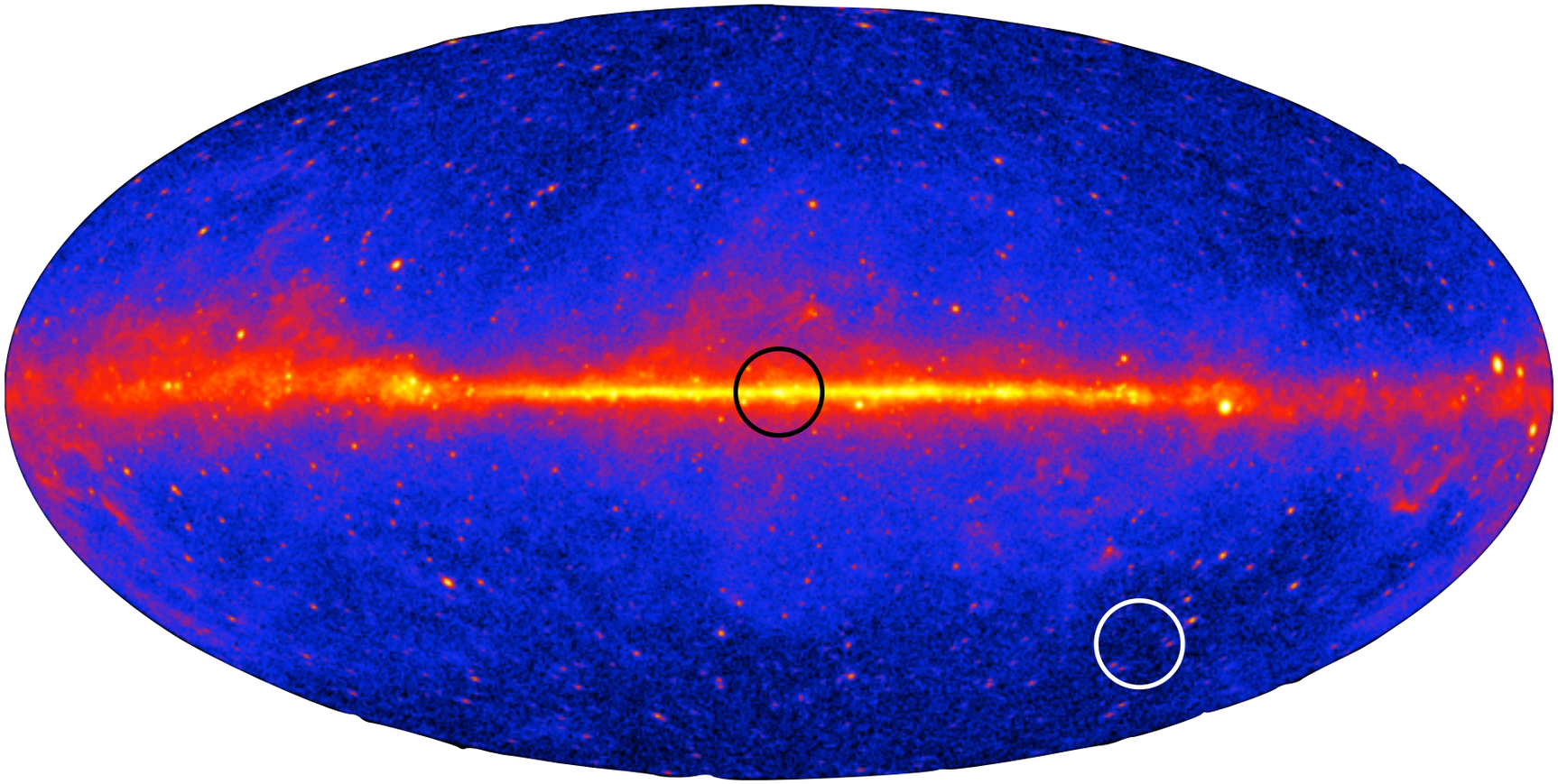
Milky Way dwarf galaxies

Gamma-rays — Fermi satellite

Nearby

Lots of dark matter

Not much else —> no astrophysical background

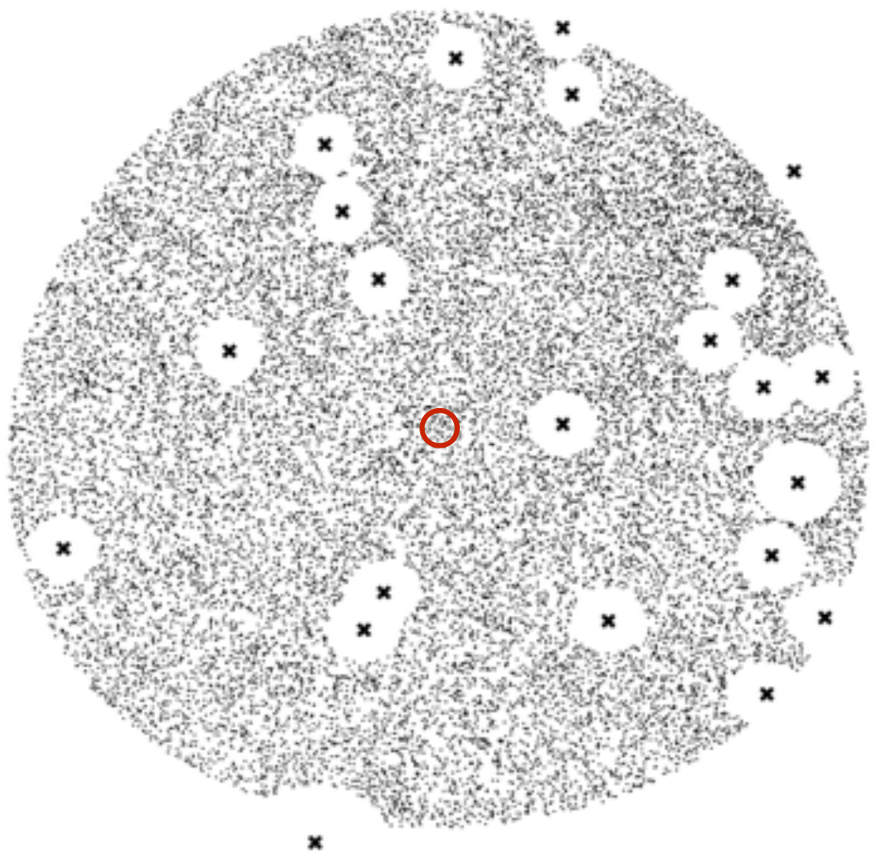


Reticulum II

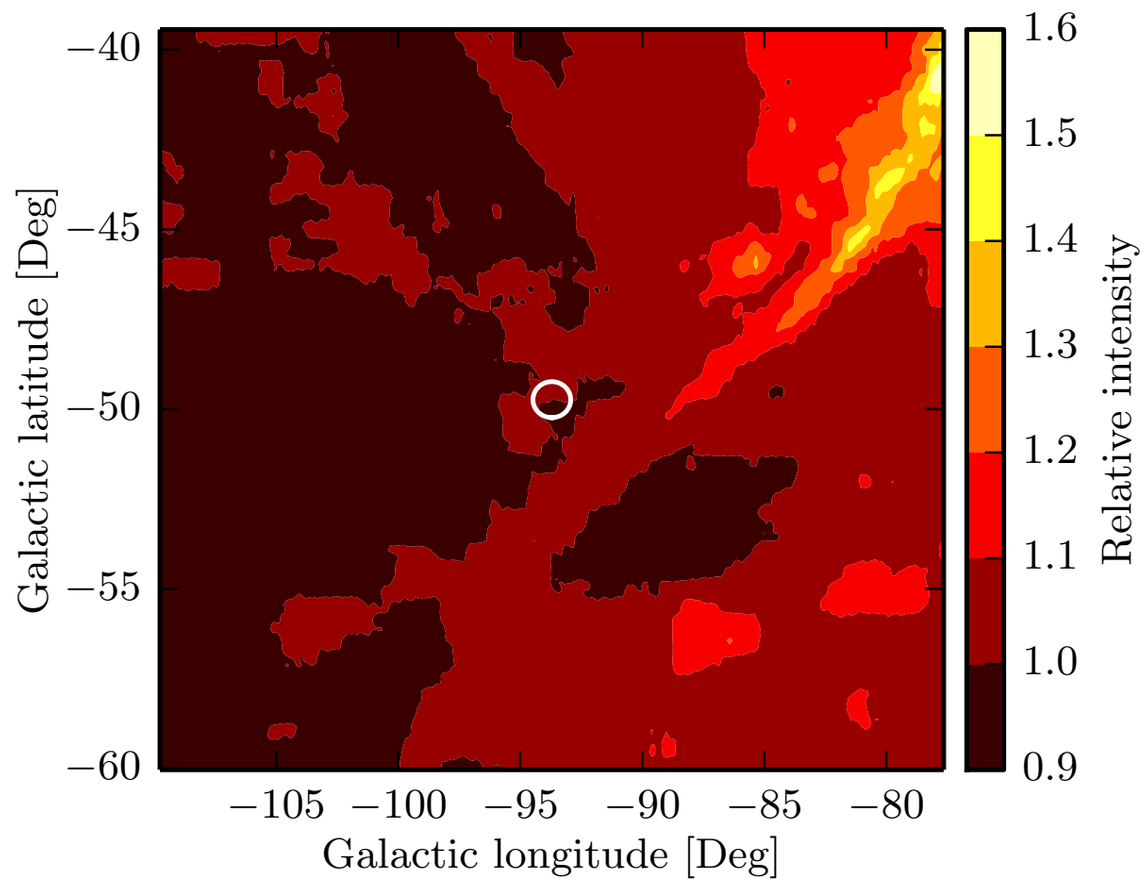
nearest of the new DES dwarfs (30 kpc)

(Koposov+ 2015, Bechtol+ 2015)

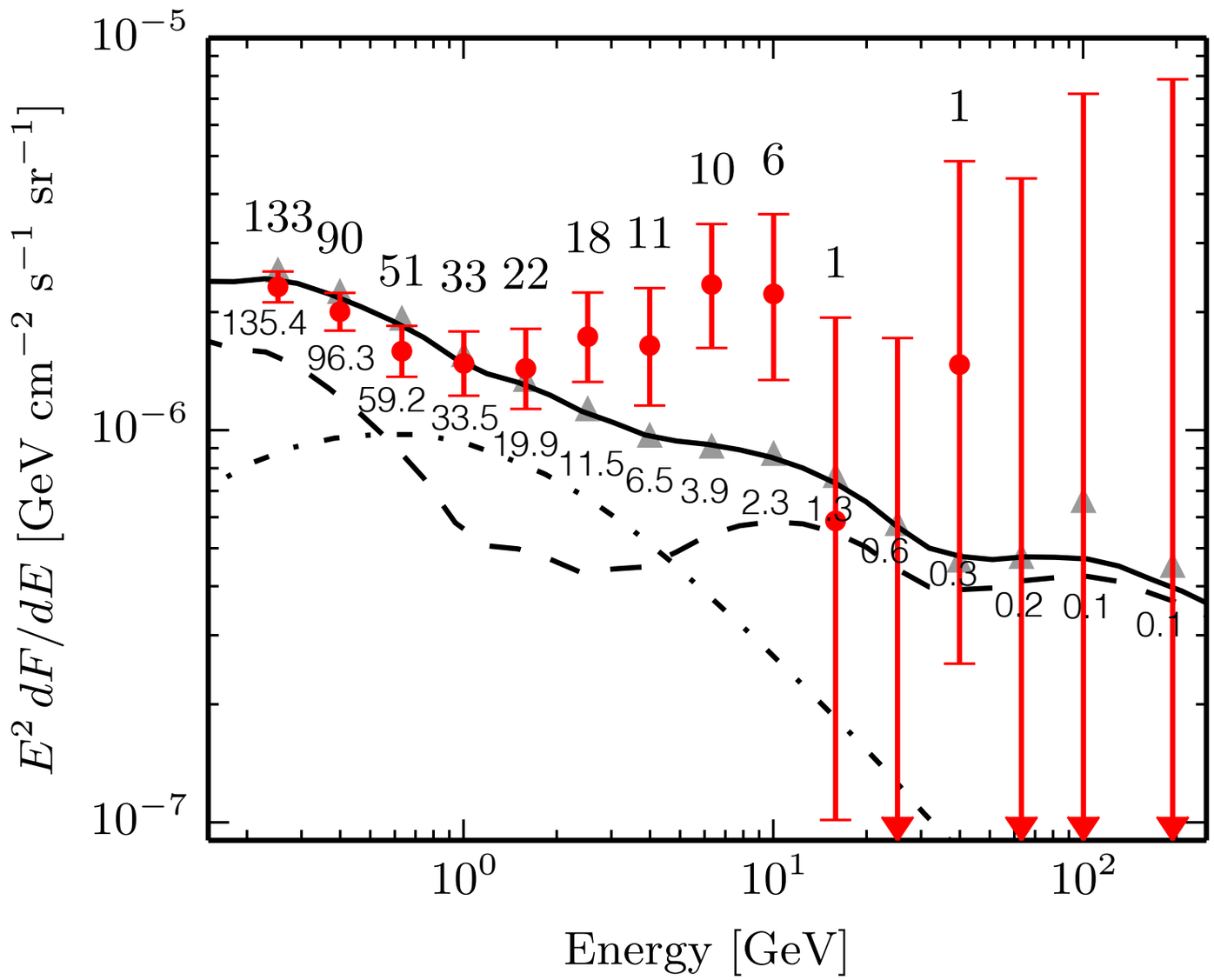
Detected events



Background model



A suggestive feature?



Events within 0.5° of RetII

Geringer-Sameth+ arXiv:1503.02320 (PRL)

Statistical procedure

Quantify the significance of the signal (e.g. *p* value)

Each photon gets a weight

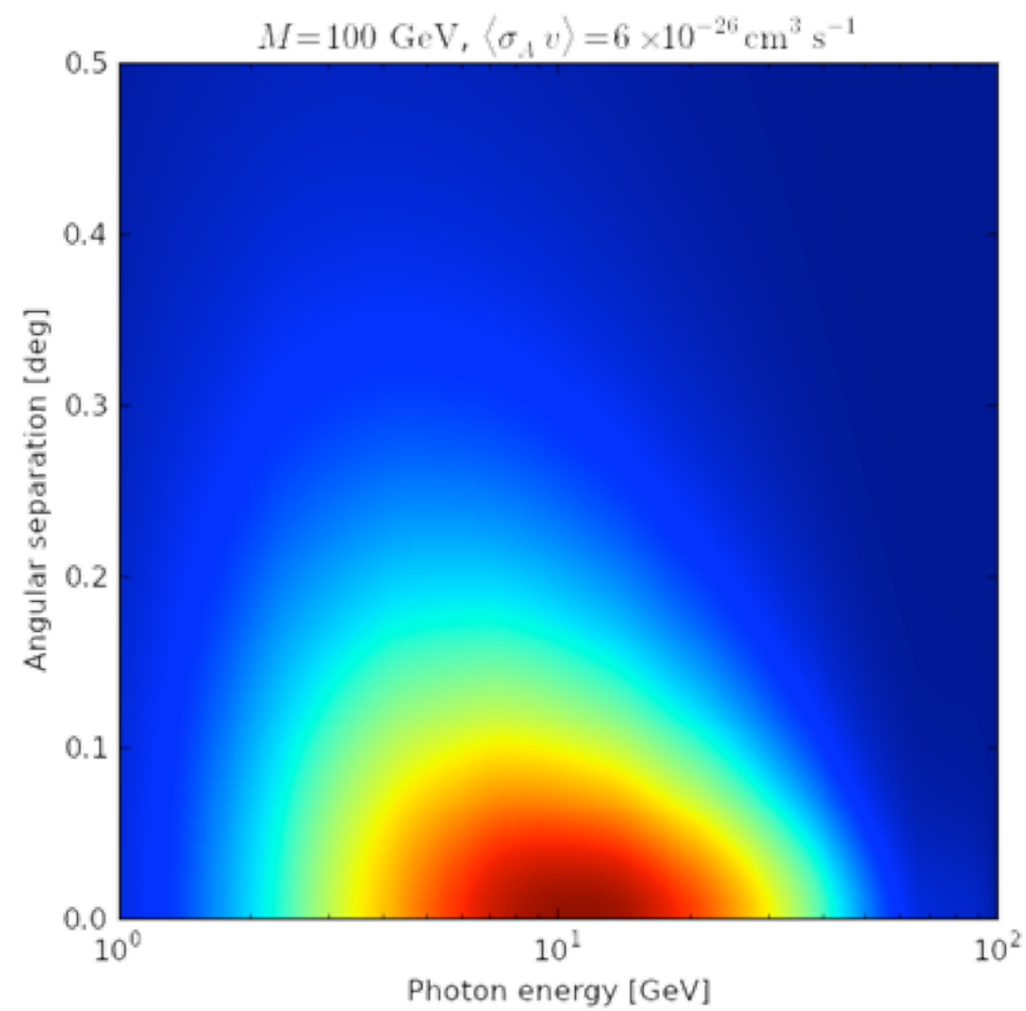
$$T = \sum_{i \in \text{photons}} w(Q_i)$$

sum over all observed events

$$w_Q = \log\left(1 + \frac{s_Q}{b_Q}\right)$$

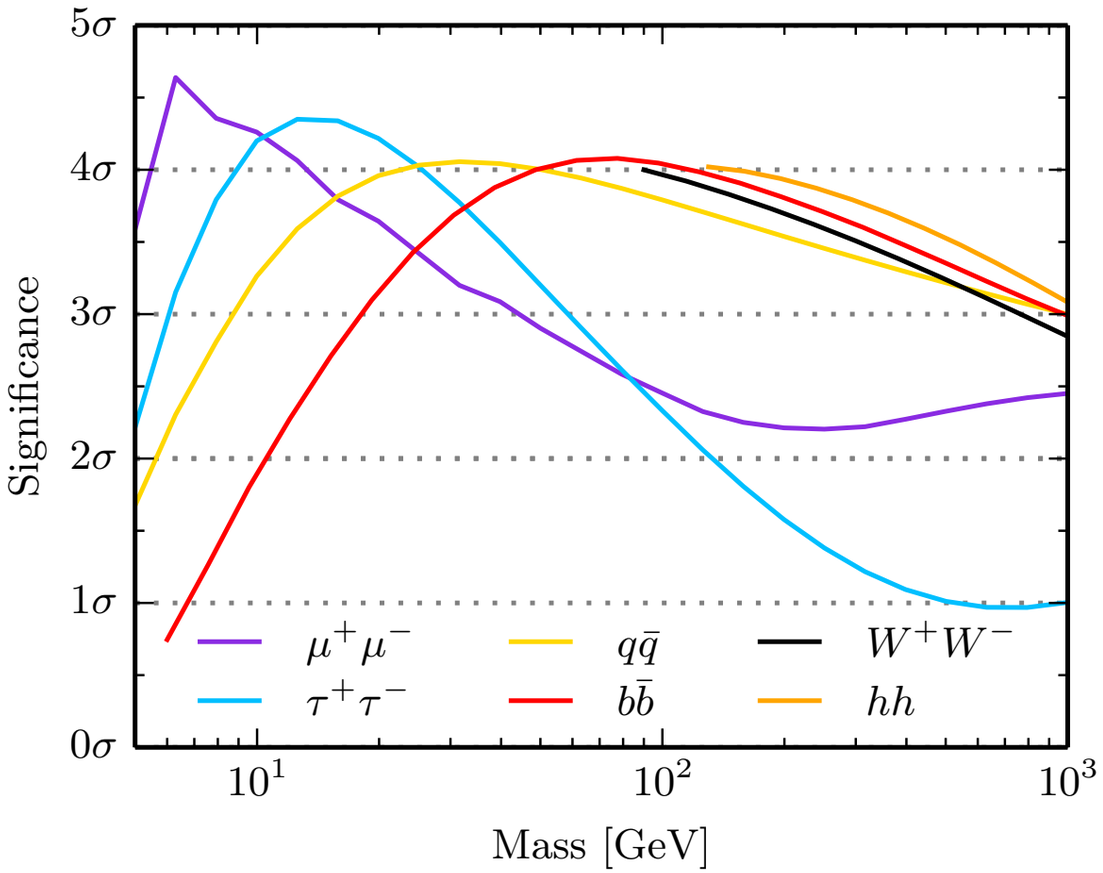
signal

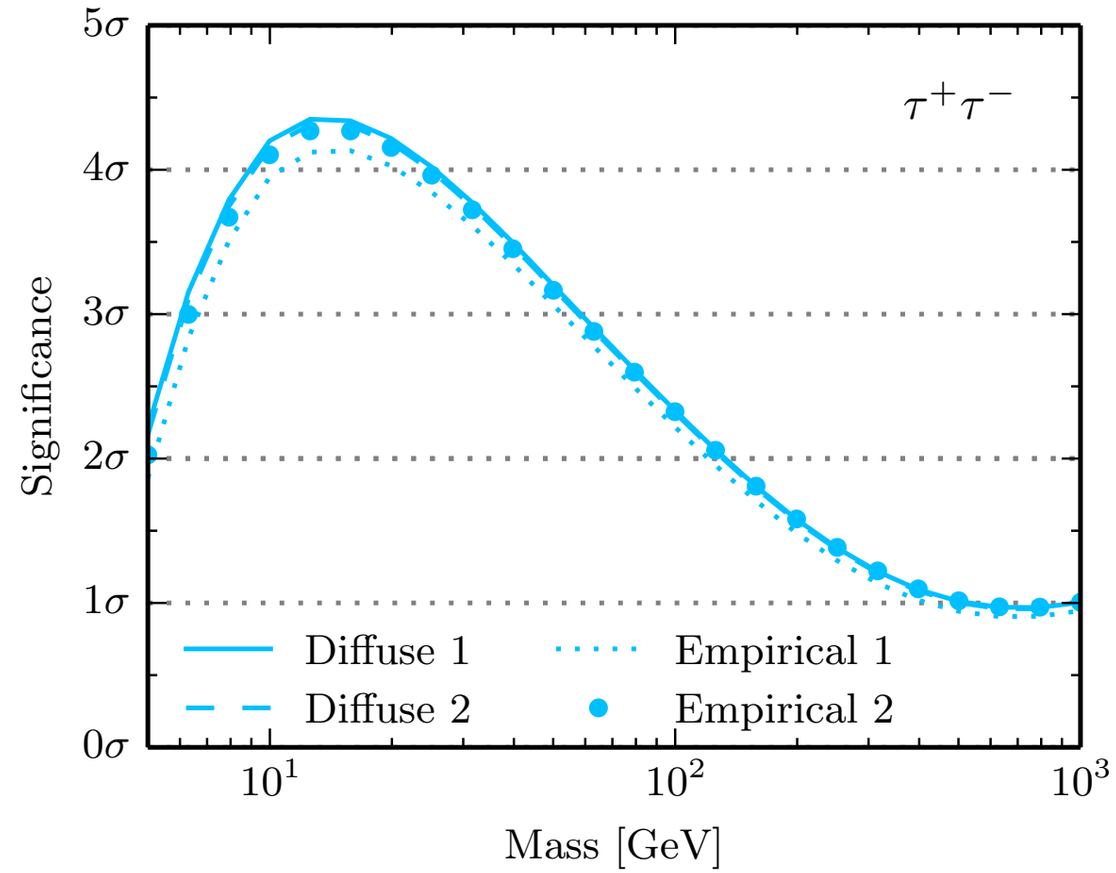
background



Geringer-Sameth, Koushiappas, Walker arXiv:1410.2242 (PRD)

Results





Local *p*-value < 3 ×10^{-5} (4σ) in every channel

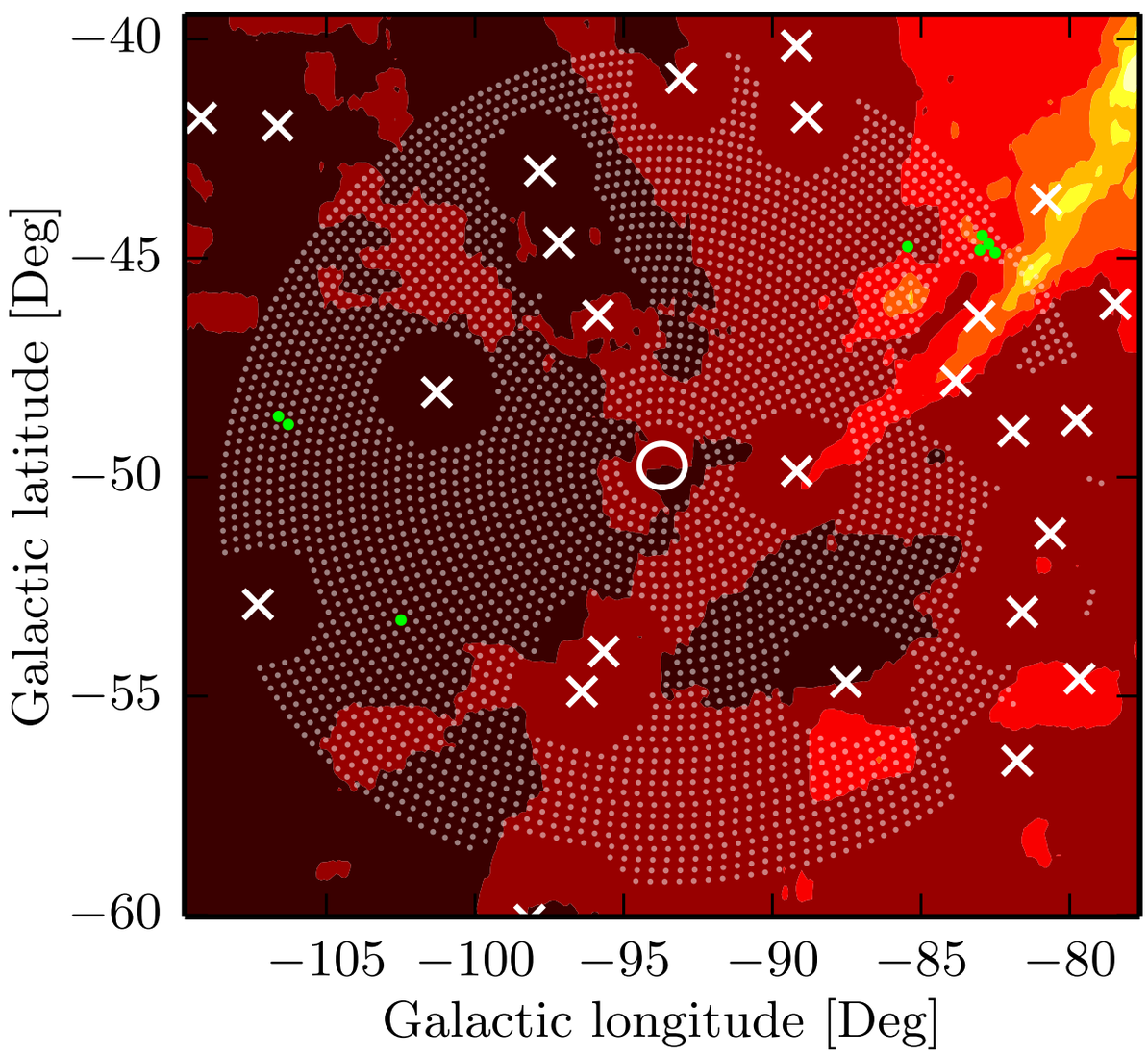
Robust to different background spectra

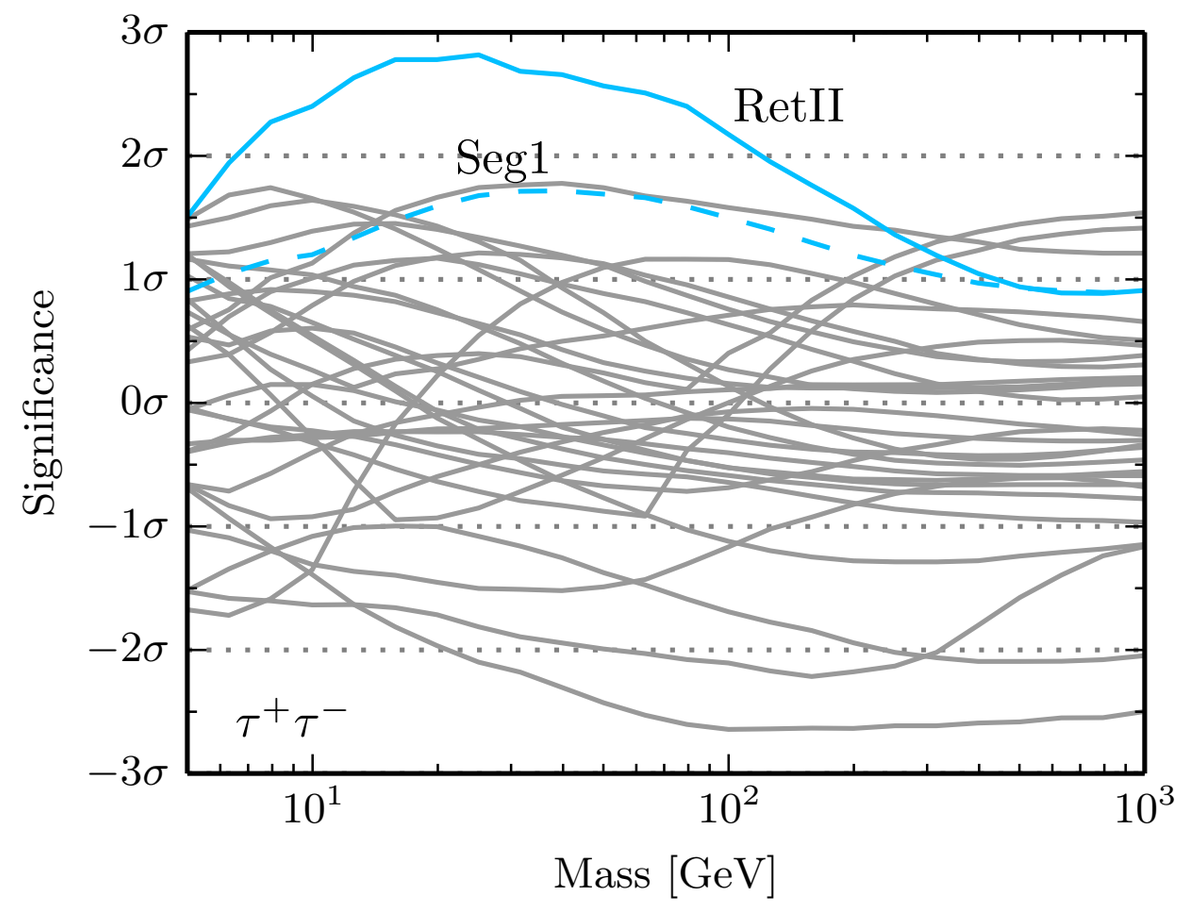
with trials, $p_{global} < 9.8 \times 10^{-5}$

Geringer-Sameth+ arXiv:1503.02320 (PRL)

Results

Empirical background sampling





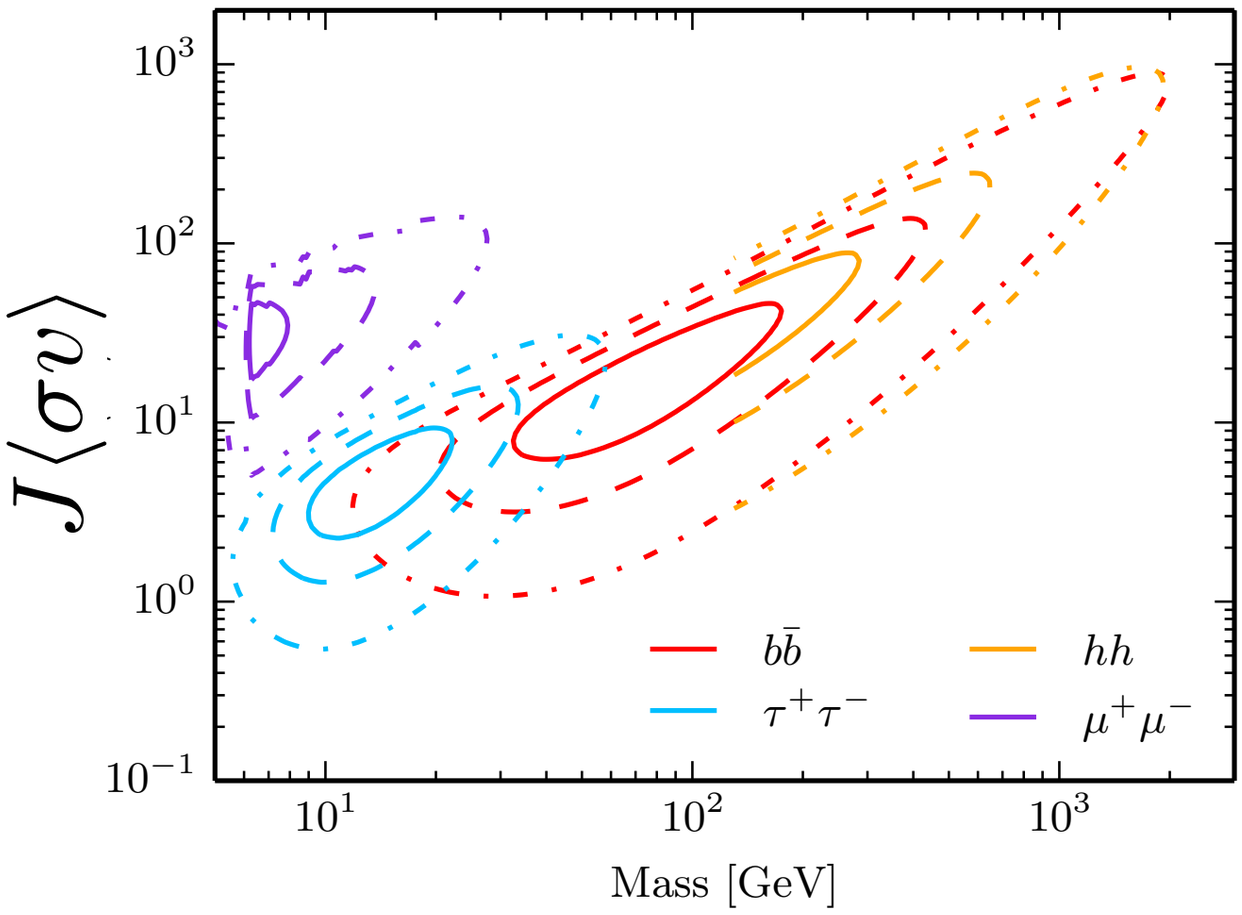
Local *p* value of 8/3306 = 0.0024 (2.8σ)

Global *p* value of 32/3306 = 0.0097 (2.3σ)

Geringer-Sameth+ arXiv:1503.02320 (PRL)

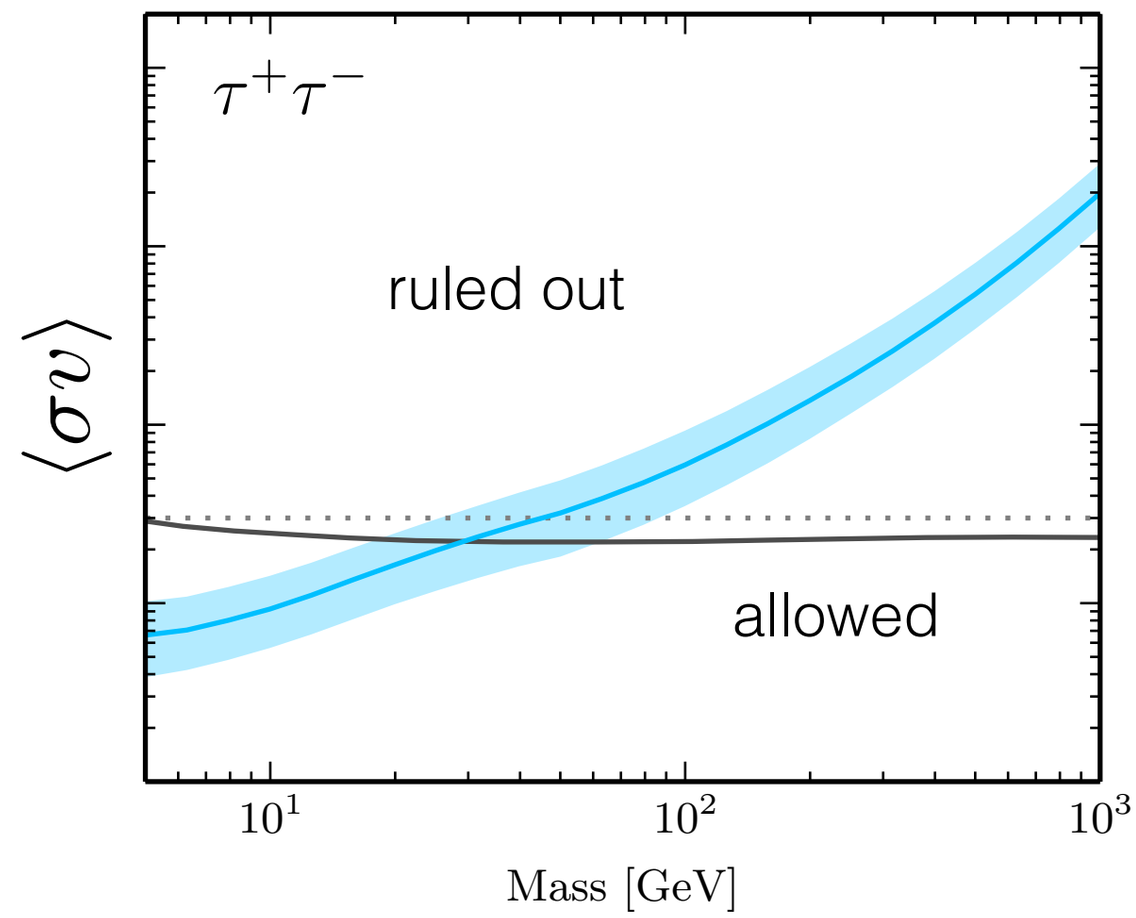
If signal is due to dark matter annihilation what can we say about the dark matter particle?

Reticulum 2



Geringer-Sameth+ arXiv:1503.02320 (PRL)

Other dwarfs



AGS, Koushiappas, Walker (PRD 91, 083535)

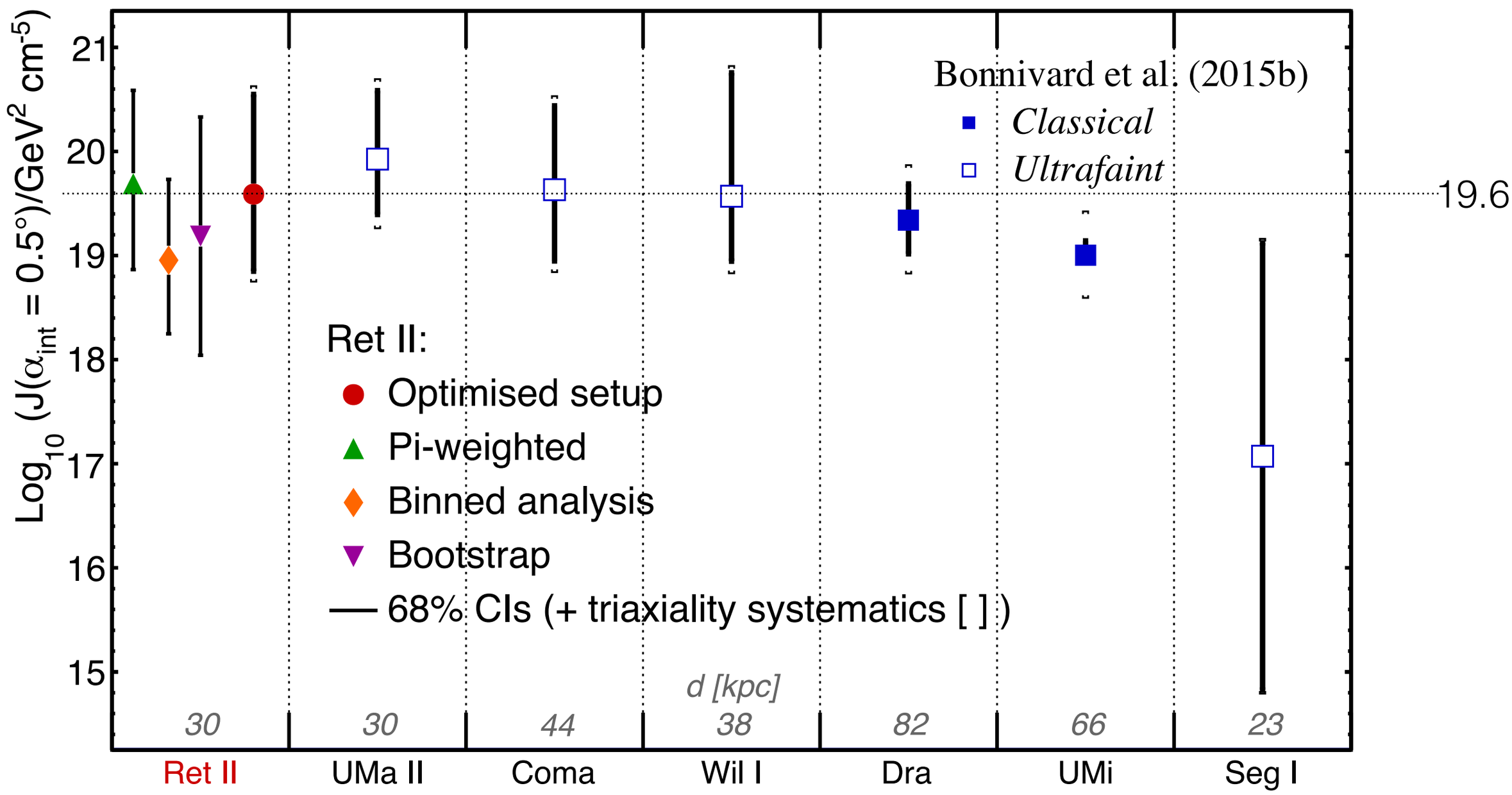
<σv> upper limits from other dwarfs gives a *prediction* for Ret2's *J* value

$$\log_{10} J \gtrsim 19.6 \pm 0.3$$

Measured J values

Use line of sight velocities + Jeans equation to infer dark matter density profile

Bonnivard et. al. arXiv:1504.03309 (ApJL)

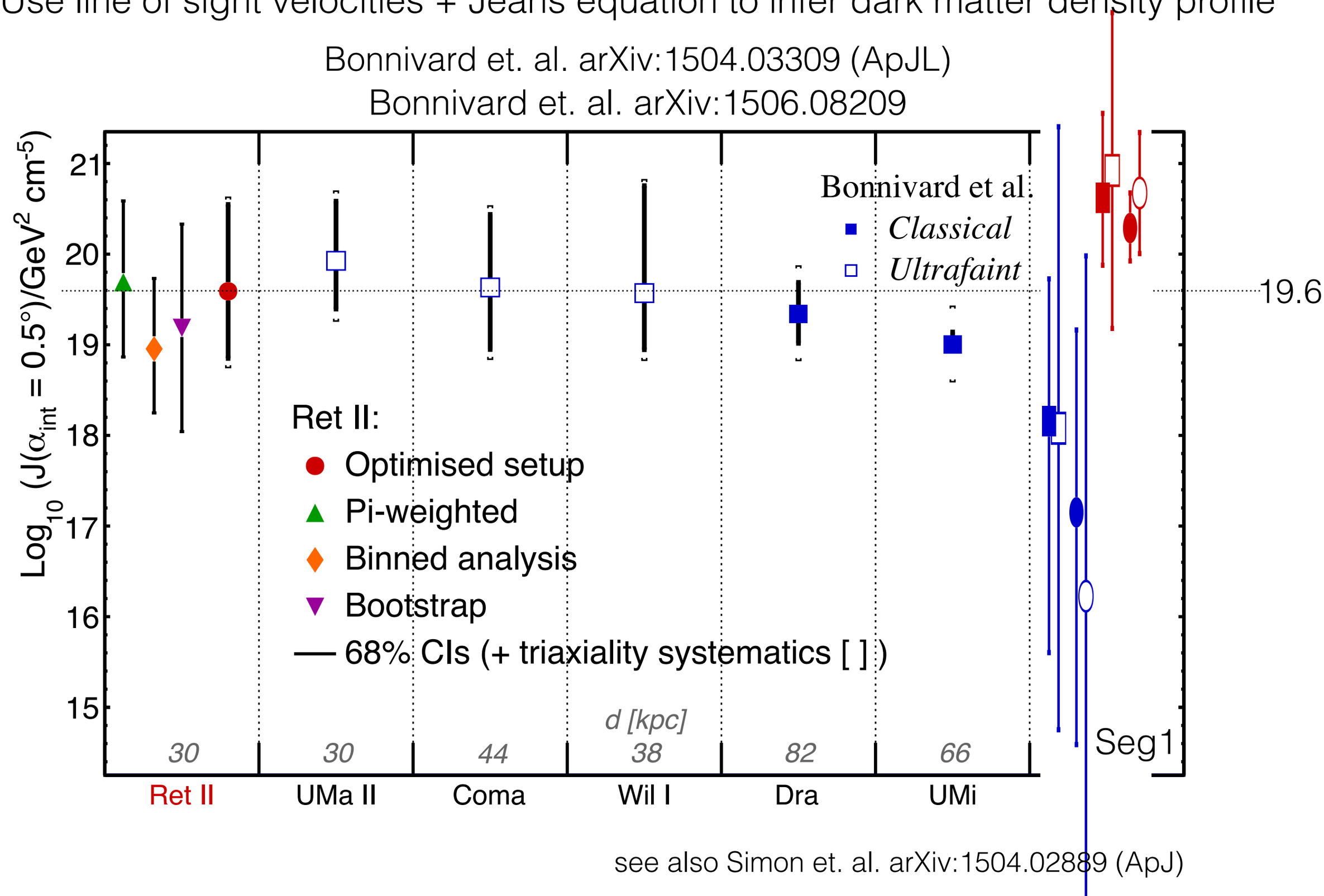


see also Simon et. al. arXiv:1504.02889 (ApJ)

Measured J values

Use line of sight velocities + Jeans equation to infer dark matter density profile

Bonnivard et. al. arXiv:1504.03309 (ApJL)
Bonnivard et. al. arXiv:1506.08209



see also Simon et. al. arXiv:1504.02889 (ApJ)

Hurdles for any dark matter interpretation

1. Gamma-ray data is inconsistent with background

2. Consistent with dark matter annihilation

    Energy spectrum of signal

    Dark matter halo of RetII

3. Inconsistent with any other possible source

    Distant source coincidentally in same direction — related to (1)

    Instrument/data, Pass 8

    Drlica-Wagner+ (Fermi,DES) 1503.02632 (ApJL)
    Hooper & Linden 1503.06209