$$M_\chi^{\to b\bar{b}} > 40^{+200}_{-21}\,\mathrm{GeV} \qquad M_\chi^{\to \tau\bar{\tau}} > 19^{+61}_{-6}\,\mathrm{GeV}$$

Savvas M. Koushiappas

BROWN

Exclusion of canonical WIMPs by the joint analysis of Milky Way dwarfs with data from the Fermi Gamma-ray Space Telescope

Alex Geringer-Sameth* and Savvas M. Koushiappas†
Department of Physics, Brown University, 182 Hope St., Providence, RI 02912

Based on

Alex Geringer-Sameth & Koushiappas, 1108.2914 (PRL in press)

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Alex Geringer-Sameth & Koushiappas, 1108.2914 (PRL in press)

Geringer-Sameth & Koushiappas, arXiv:1108.2914 (PRL in press)

Gamma-ray flux

Detector characteristics

Number of photons

$$\mu(\Phi_{\rm PP}) \equiv (A_{\rm eff}\, T_{\rm obs}) \times \Phi_{\rm PP} \times J$$

$$\Phi_{\rm PP} = \frac{\langle \sigma v \rangle}{8\pi M_\chi^2} \int_{E_0}^{M_\chi} \sum_f B_f \frac{dN_f}{dE}\, dE,$$

Quantity of interest

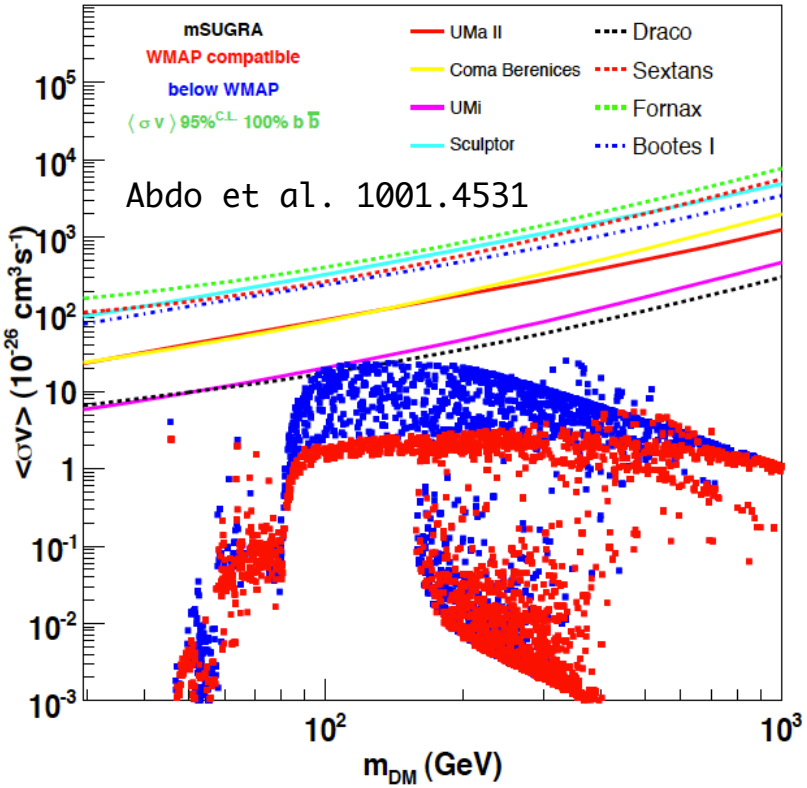
$$J \equiv \int_{\Delta\Omega(\psi)} \int_\ell [\rho(\ell,\psi)]^2\, d\ell\; d\Omega(\psi)$$

Louie's talk

Geringer-Sameth & Koushiappas, arXiv:1108.2914 (PRL in press)

Constraints from Dwarf Galaxies: Usual approach to the problem

1. Use photon events from Fermi-LAT
2. Construct a complicated theoretical model which in principle characterizes the background
3. Compute the signal/noise ratio (and place bound)



Very difficult modeling of the background (unless you are in Fermi!)

Geringer-Sameth & Koushiappas, arXiv:1108.2914 (PRL in press)

Constraints from Dwarf Galaxies: Usual approach to the problem

1. Use photon events from Fermi-LAT
2. Construct a complicate theoretical model which in principle characterizes the background
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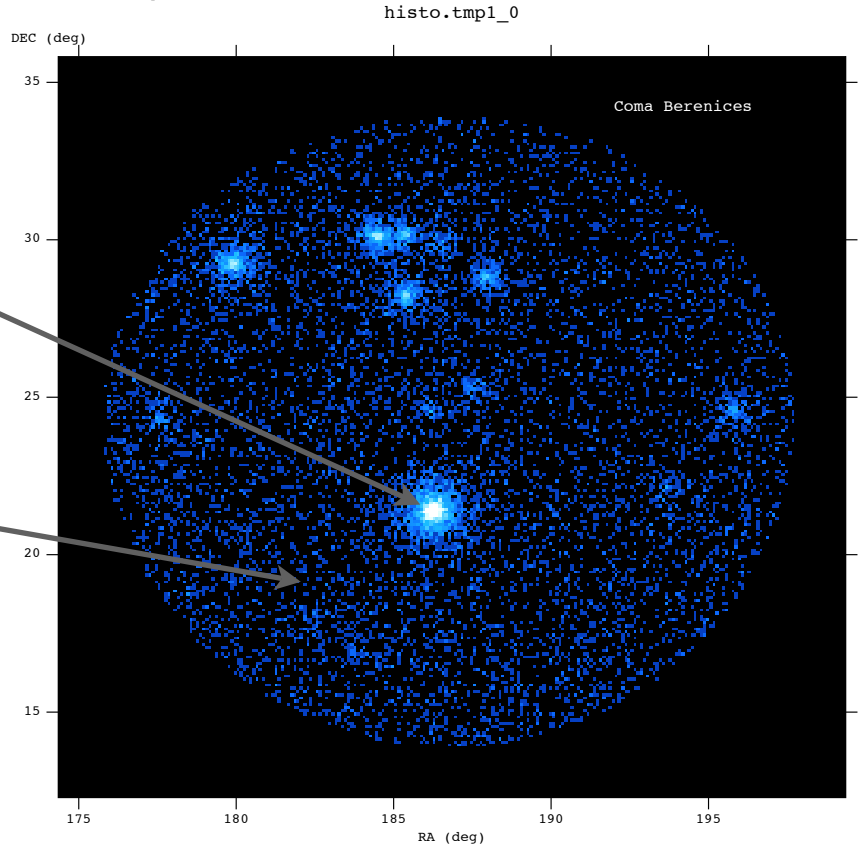
Background at this source

Computed by how much one understands this



Very difficult unless you are in Fermi!

Geringer-Sameth & Koushiappas, arXiv:1108.2914 (PRL in press)

This work

Main assumption:

Whatever the processes are which give rise to the photon events nearby each dwarf, these same processes are also at work in the direction of the dwarf.

Geringer-Sameth & Koushiappas, arXiv:1108.2914 (PRL in press)

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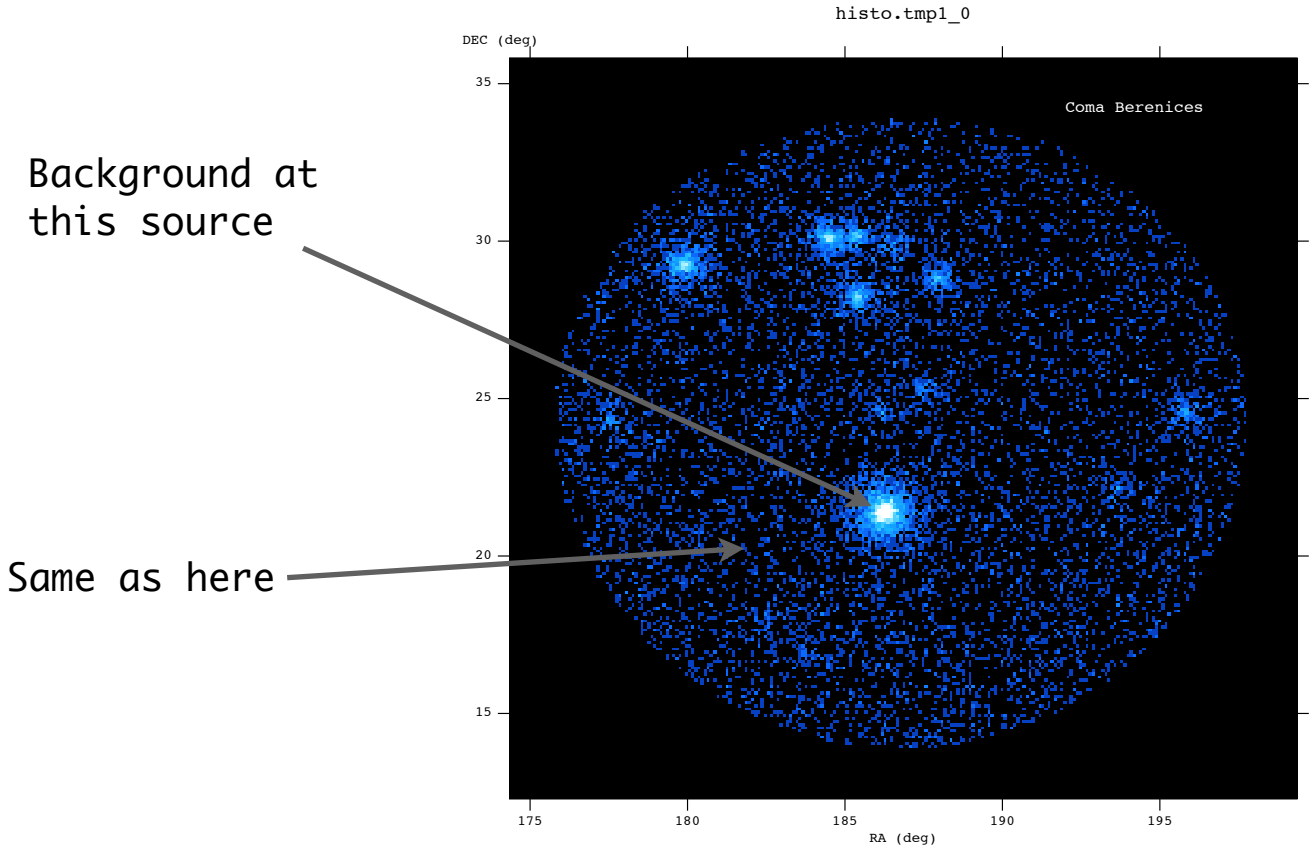

Geringer-Sameth & Koushiappas, arXiv:1108.2914 (PRL in press)

This work

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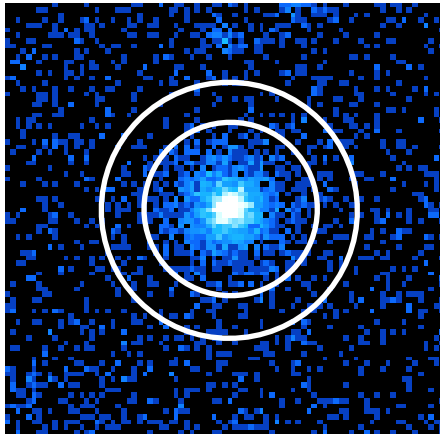
Not new:

- Particle physics

- Cerenkov telescopes (look at rings around source)



Geringer-Sameth & Koushiappas, arXiv:1108.2914 (PRL in press)

Data

- Fermi 3 years

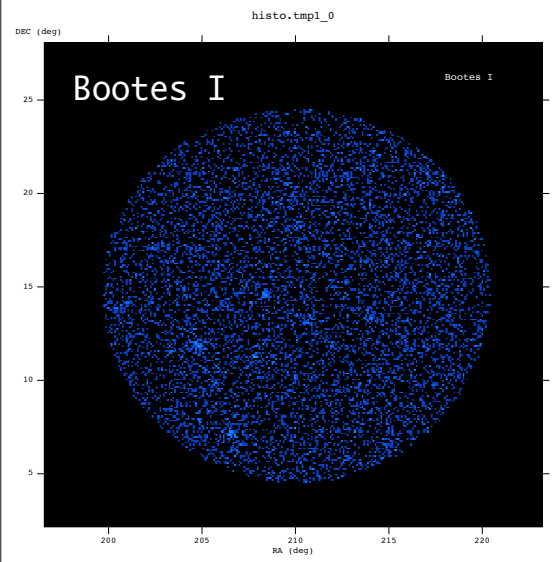
- PASS 7 photon events

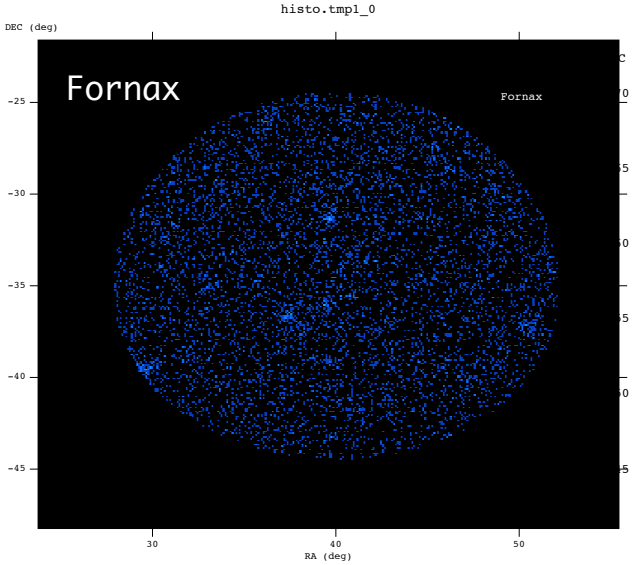
- Energy range: [1-100] GeV (dictated by size of PSF)

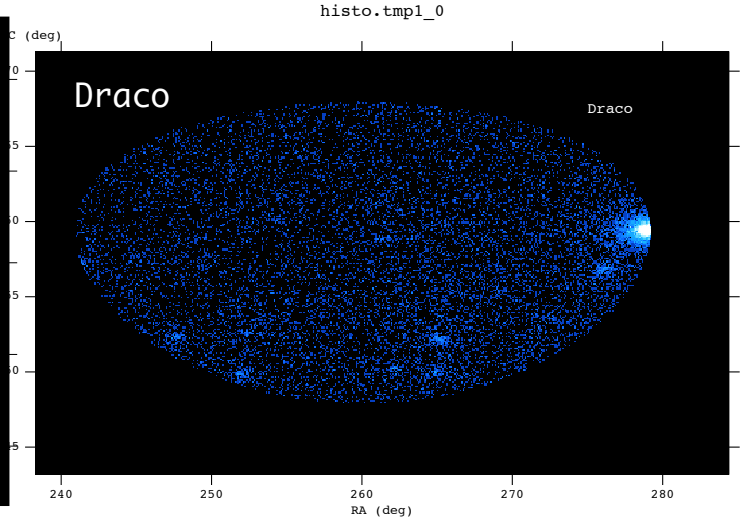
- 7 Dwarf galaxies (Bootes I, Draco, Fornax, Sculptor, Sextans, Ursa Minor & Segue 1)

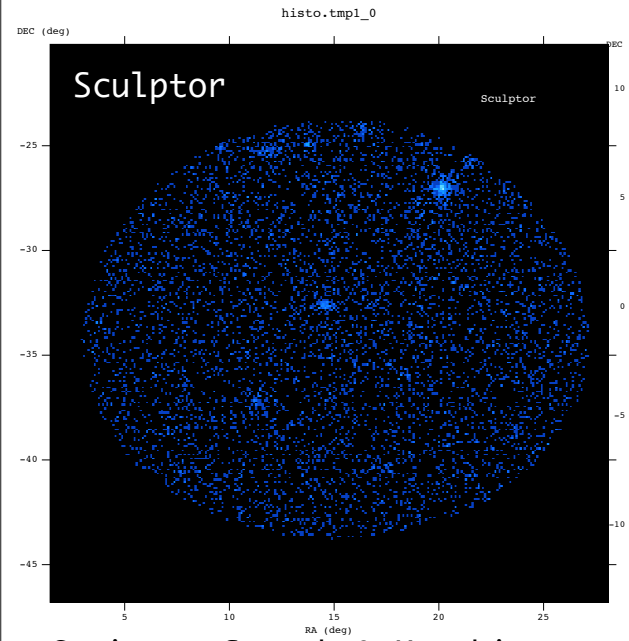
Geringer-Sameth & Koushiappas, arXiv:1108.2914 (PRL in press)

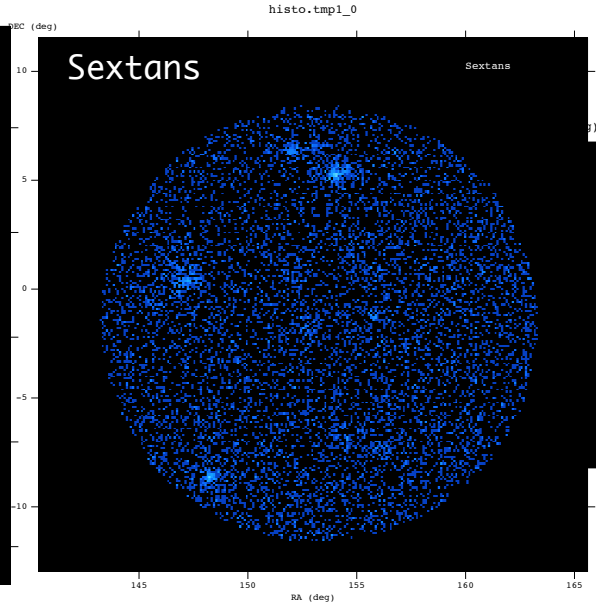
Data

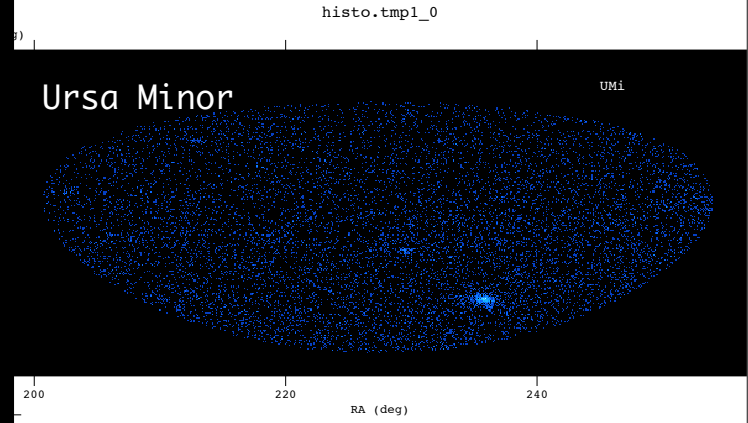










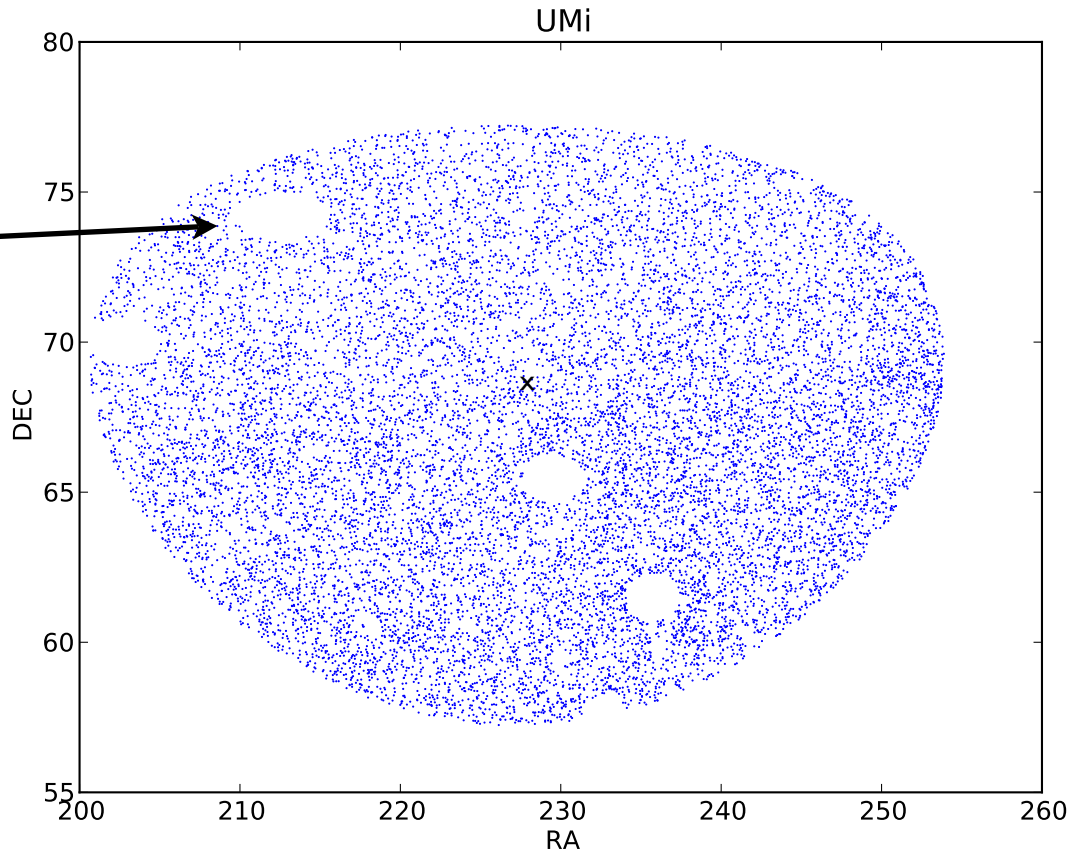


Geringer-Sameth & Koushiappas, arXiv:1108.2914 (PRL in press)

Background determination

Mask sources present in the 2nd Fermi Catalogue

Mask=0.8 degrees, result not sensitive to size



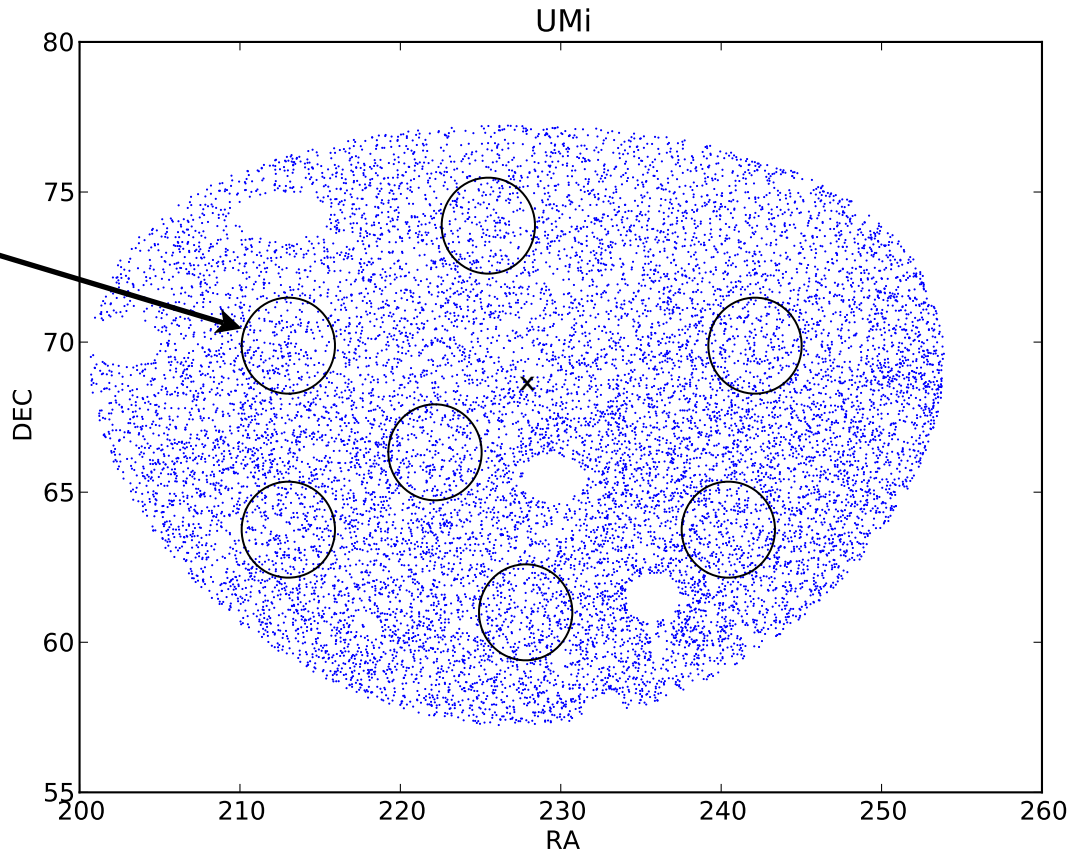
Geringer-Sameth & Koushiappas, arXiv:1108.2914 (PRL in press)

Background determination

R=0.5degrees

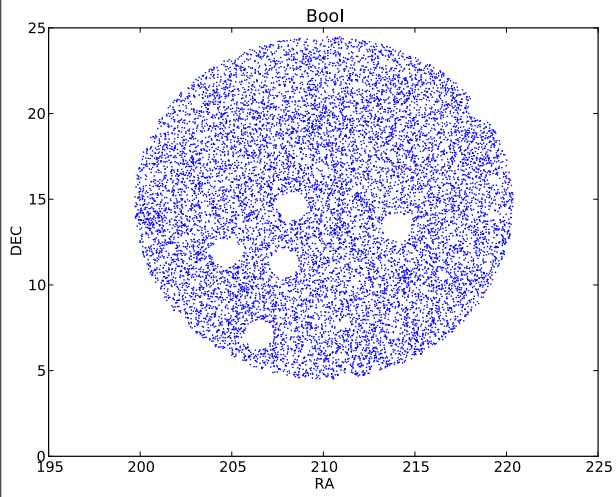
400 independent ROI, but sample 10^5 regions for completeness

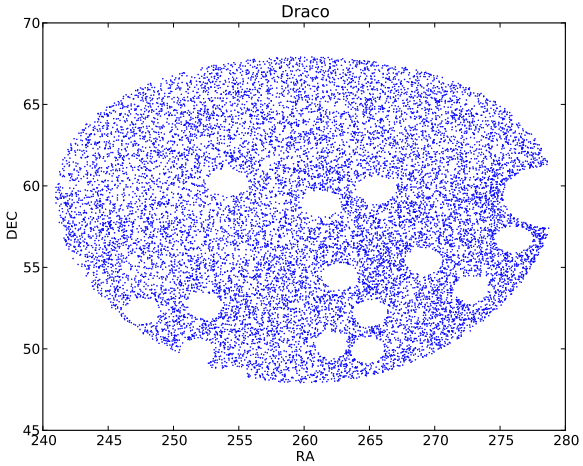
Central ROI NOT included in the background determination

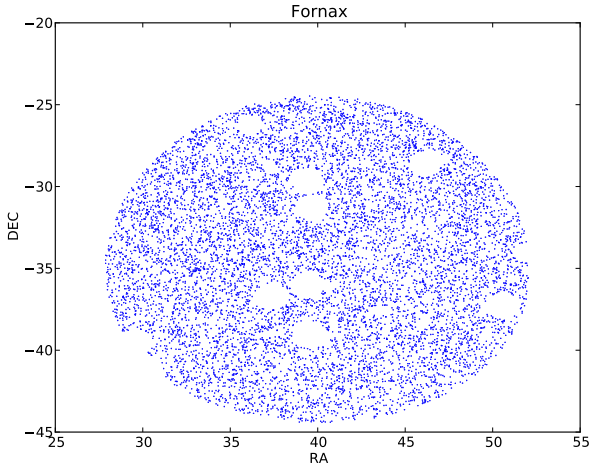


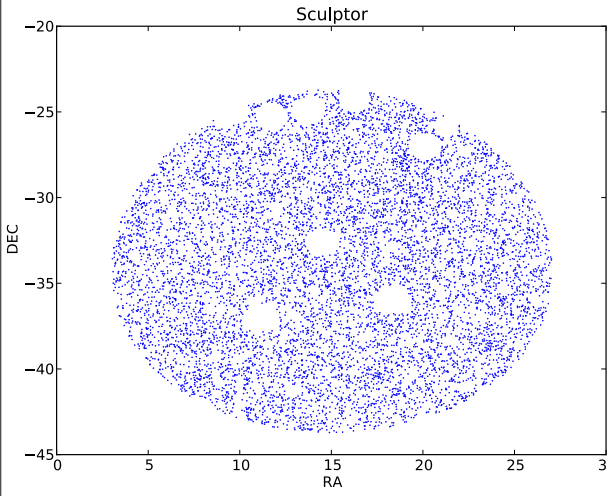
Geringer-Sameth & Koushiappas, arXiv:1108.2914 (PRL in press)

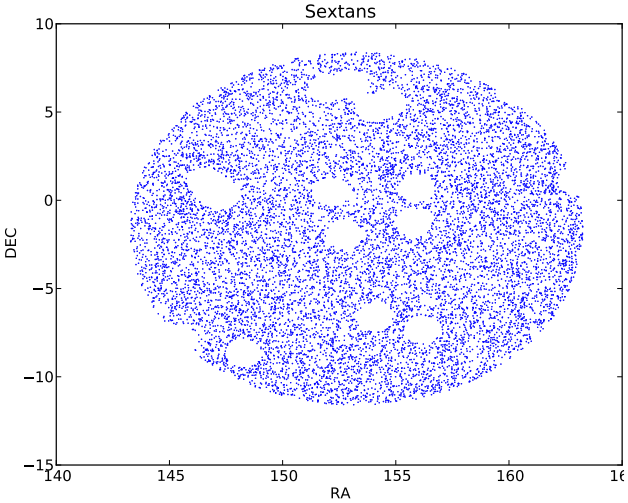
Background determination

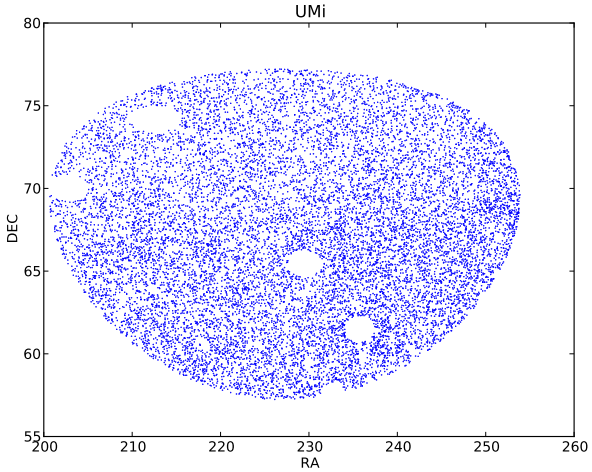




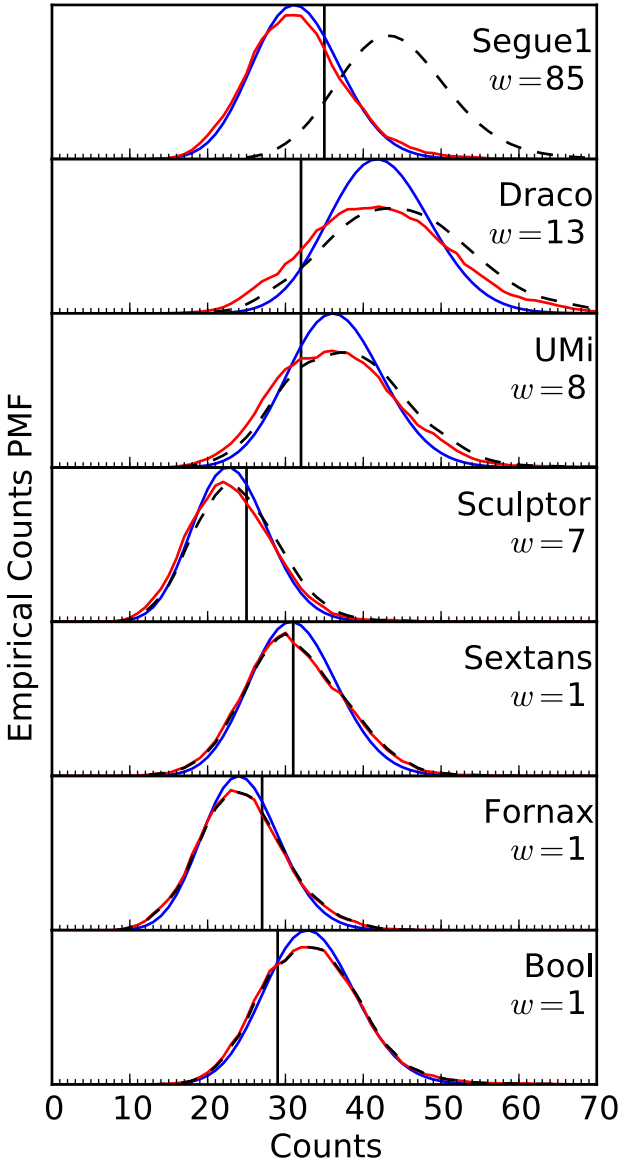








Background determination



Blue: Poisson distribution

Red: Empirically derived PMF

Vertical line: Number of counts in central ROI

Geringer-Sameth & Koushiappas, arXiv:1108.2914 (PRL in press)

Neyman Construction

$$\int_{D(\mu)} P(x|\mu) = \alpha$$

Confidence belt

Probability of observing x if mu is the true value

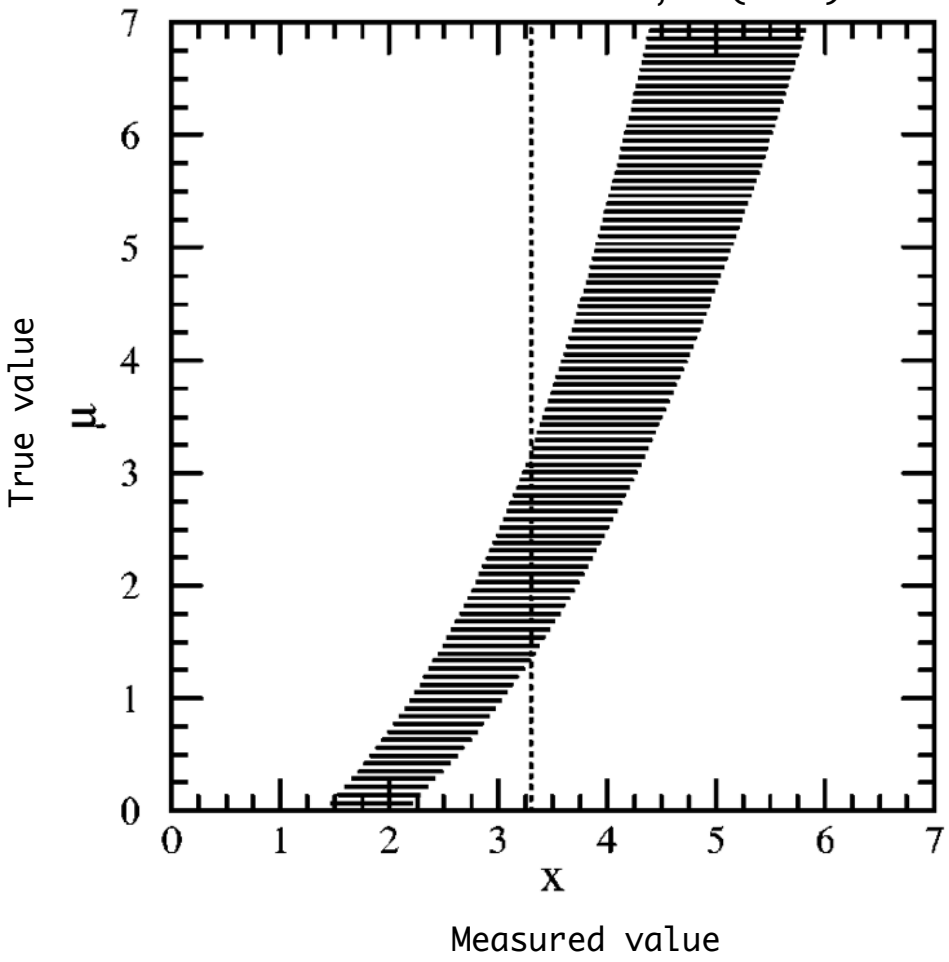
Shape of confidence belt must NOT depend on data (flip flopping)

Here, x lives in a 7-dimensional space

Geringer-Sameth & Koushiappas, arXiv:1108.2914 (PRL in press)

Neyman Construction

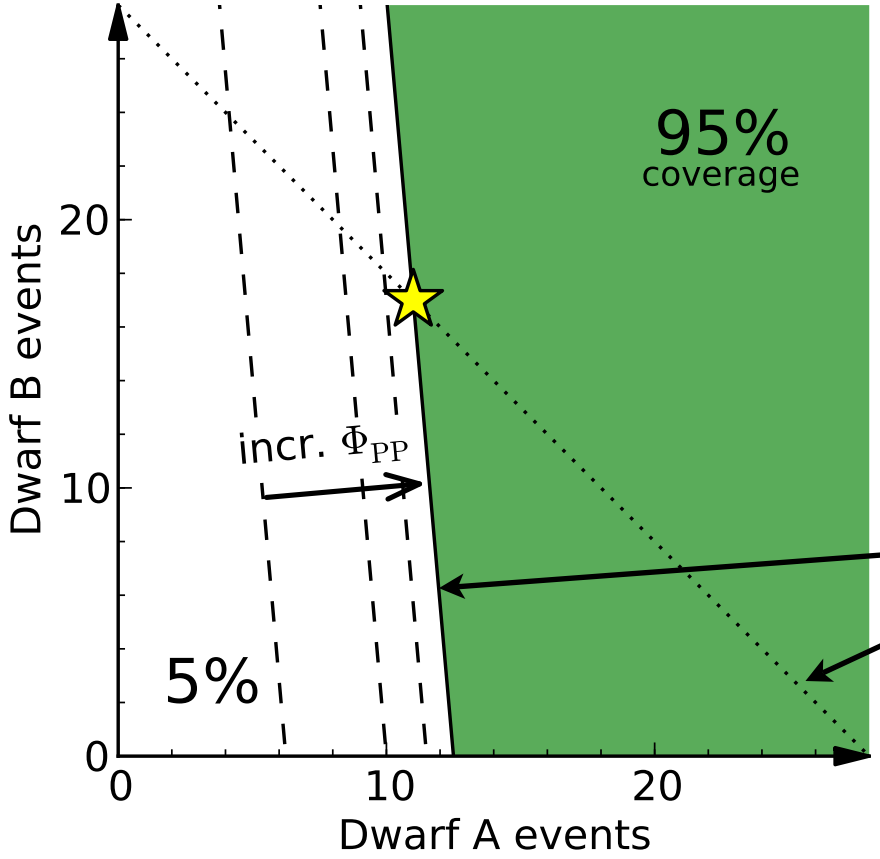
Feldman & Cousins PRD 57, 7 (1998)



$$P(x \in [x_1, x_2]|\mu) = \alpha$$

Geringer-Sameth & Koushiappas, arXiv:1108.2914 (PRL in press)

Neyman Construction



Weight is proportional to expected dark matter flux/PMF

Confidence belt construction (see Sutton, Classical and Quantum Gravity, 26, 245007 (2009)

Geringer-Sameth & Koushiappas, arXiv:1108.2914 (PRL in press)

Result

True 95% upper bound

$$\Phi_{\rm PP} = 5.0^{+4.3}_{-4.5} \times 10^{-30} {\rm cm}^3 {\rm s}^{-1} {\rm GeV}^{-2}$$

Geringer-Sameth & Koushiappas, arXiv:1108.2914 (PRL in press)

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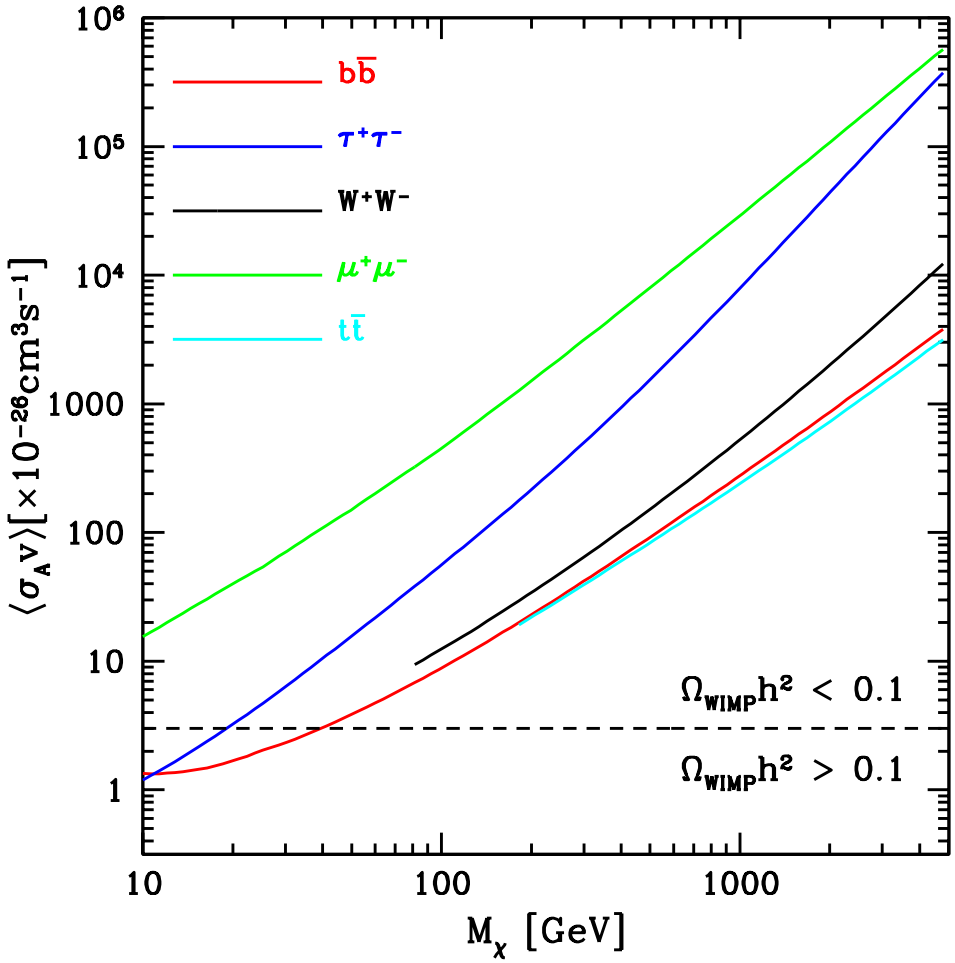
DarkSUSY

Geringer-Sameth & Koushiappas, arXiv:1108.2914 (PRL in press)

Result



$b\bar{b}$

$$M_\chi^{\to b\bar{b}} > 40^{+200}_{-21}\mathrm{GeV}$$

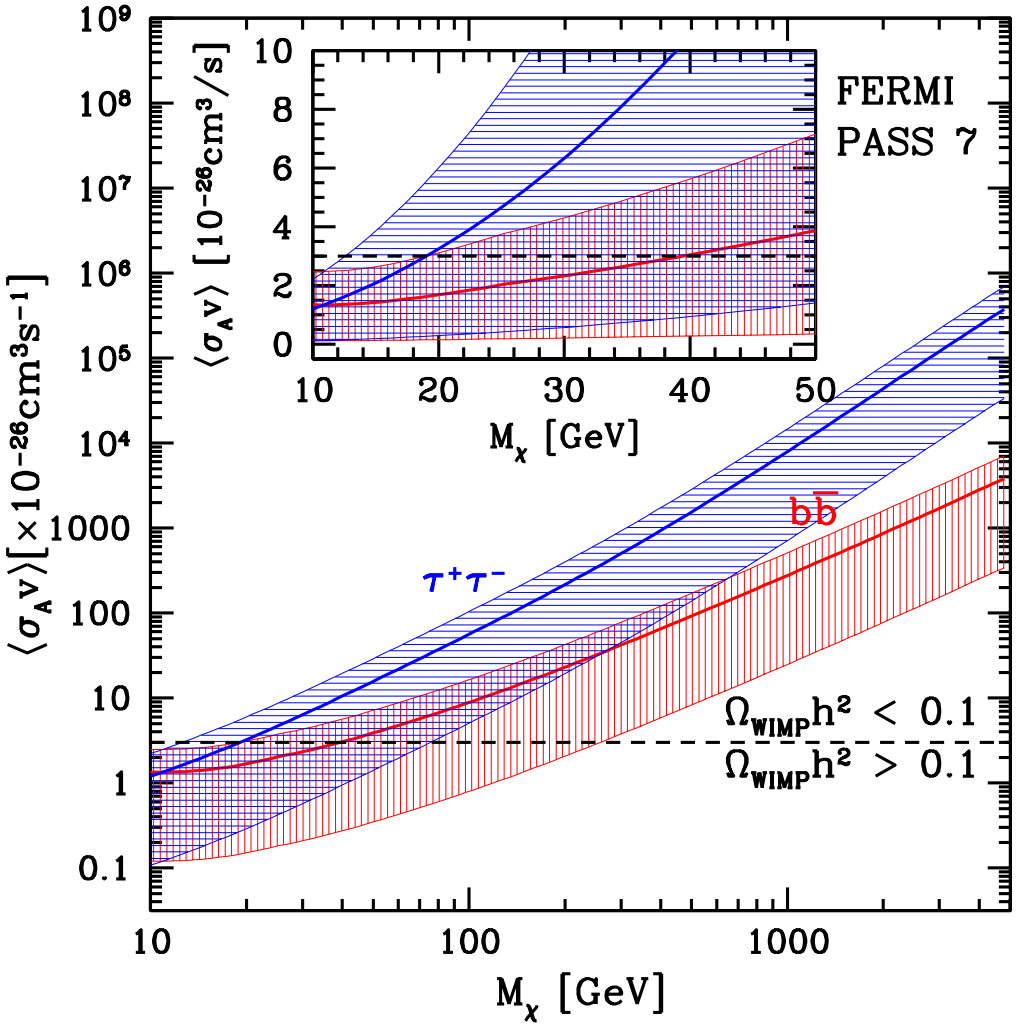
$\tau^+\tau^-$

$$M_\chi^{\to \tau\bar{\tau}} > 19^{+61}_{-6}\mathrm{GeV}$$

See also Ackermann et al. arXiv:1108.3546

Geringer-Sameth & Koushiappas, arXiv:1008.2914

Result



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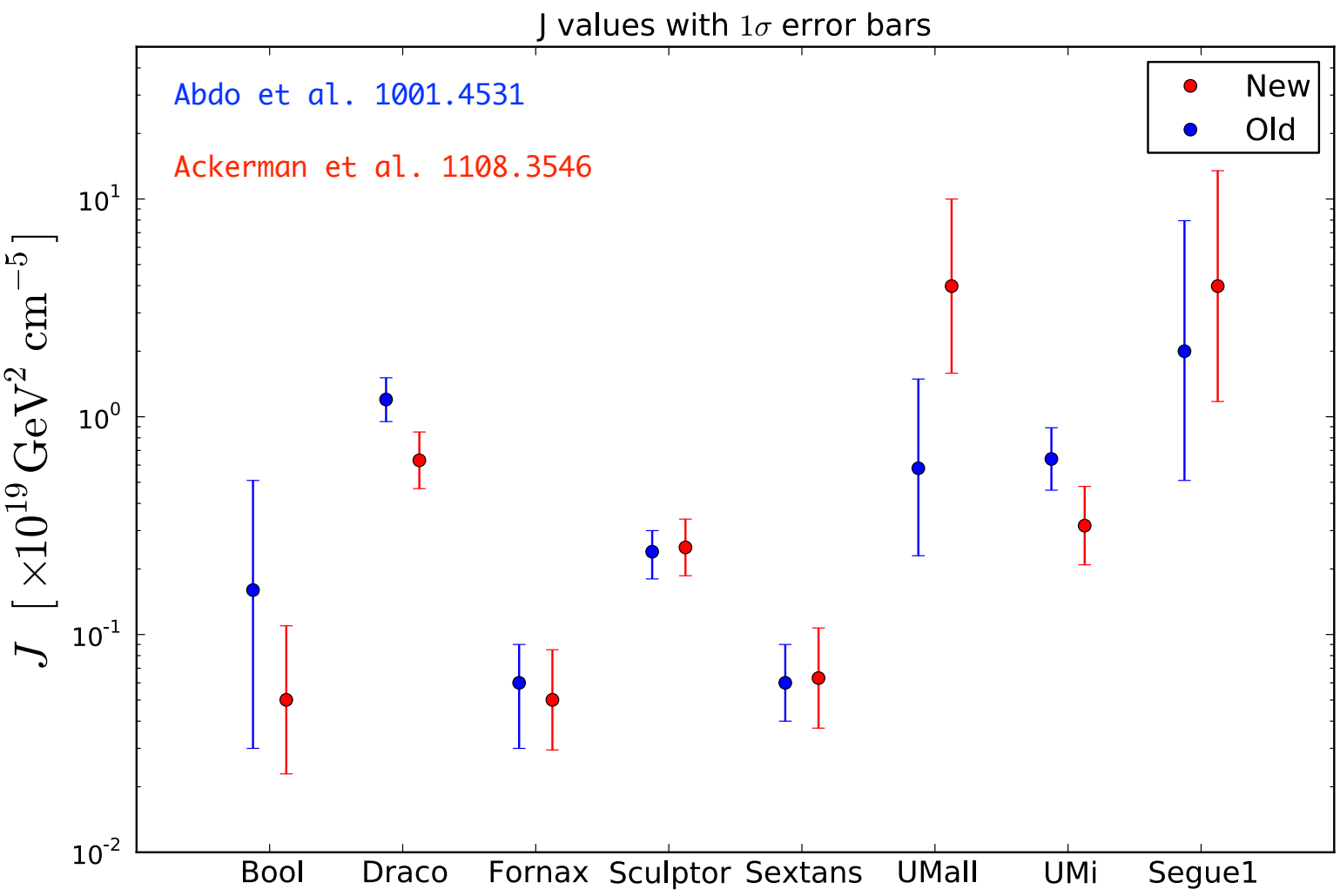
Caveats

J is a systematic

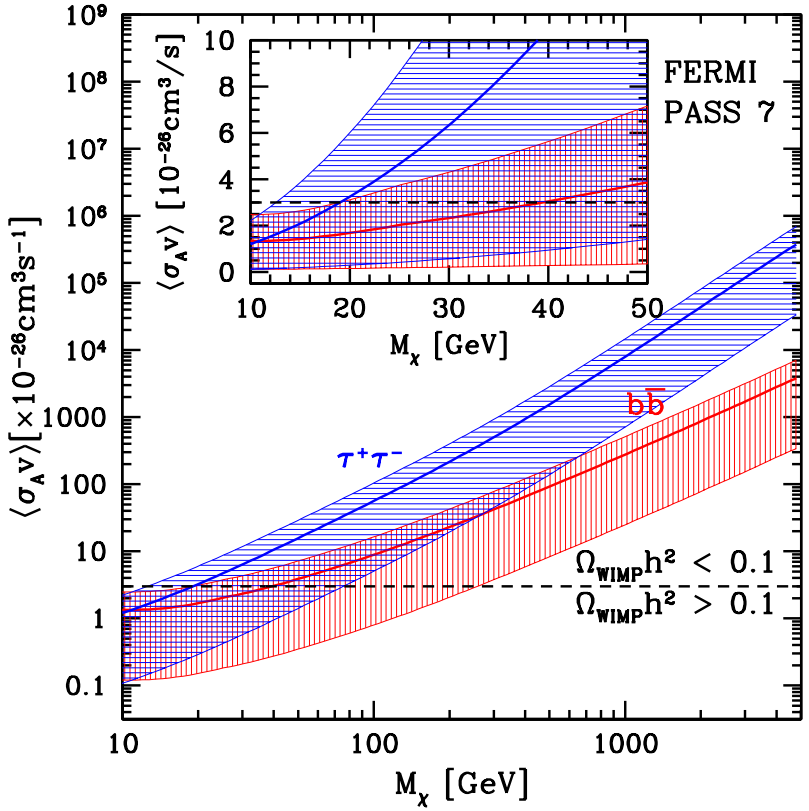
Ackermann et al. arXiv:1108.3546

Charbonnier et al. arXiv:1104.0412

Geringer-Sameth & Koushiappas, arXiv:1108.2914 (PRL in press)


J values with 1σ error bars
Abdo et al. 1001.4531
Ackerman et al. 1108.3546
New
Old
$J\ [\times 10^{19}\,\mathrm{GeV}^2\,\mathrm{cm}^{-5}]$
10^{1}
10^{0}
10^{-1}
10^{-2}
Bool
Draco
Fornax
Sculptor
Sextans
UMaII
UMi
Segue1

Conclusion



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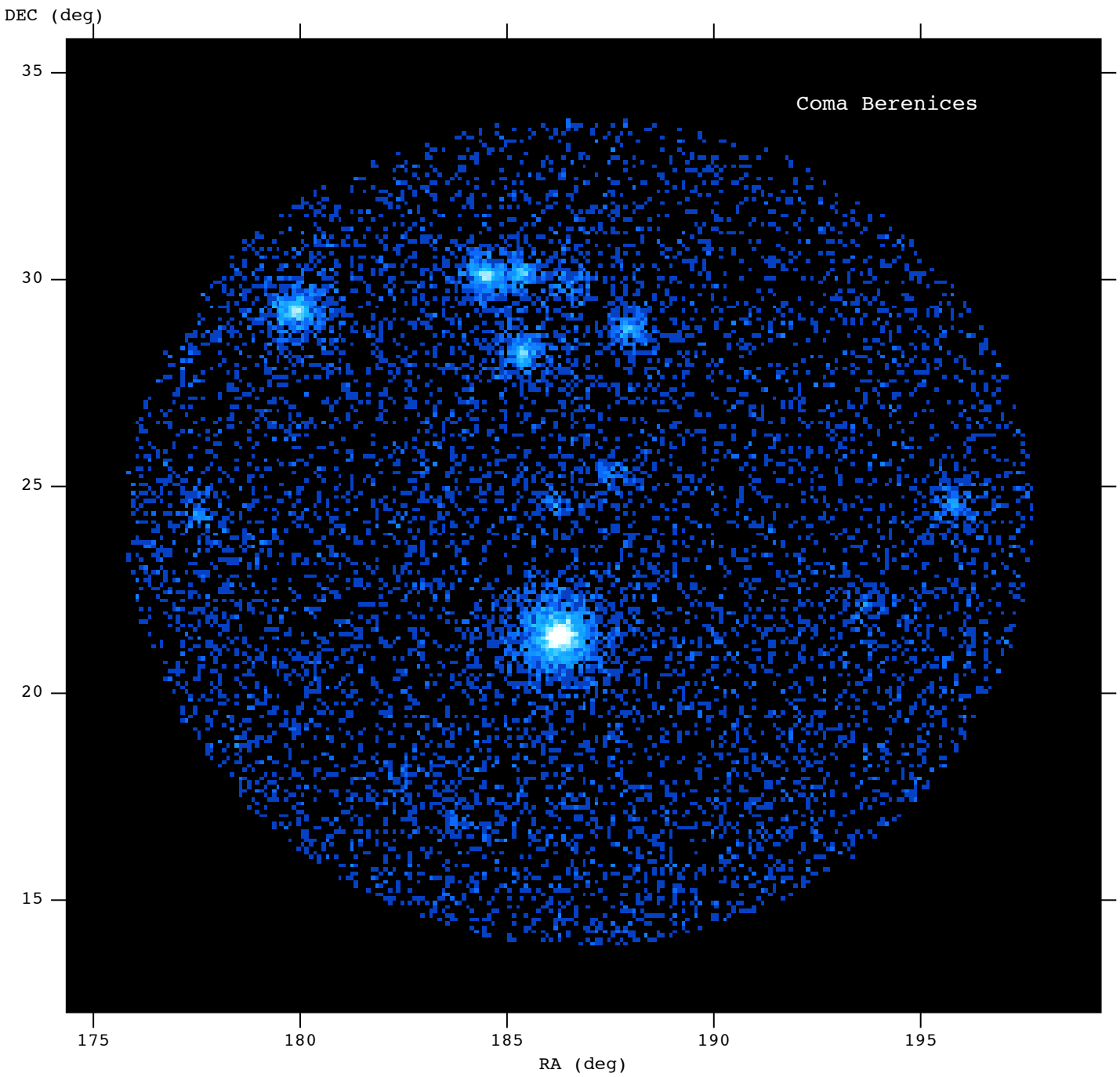
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15
Coma Berenices
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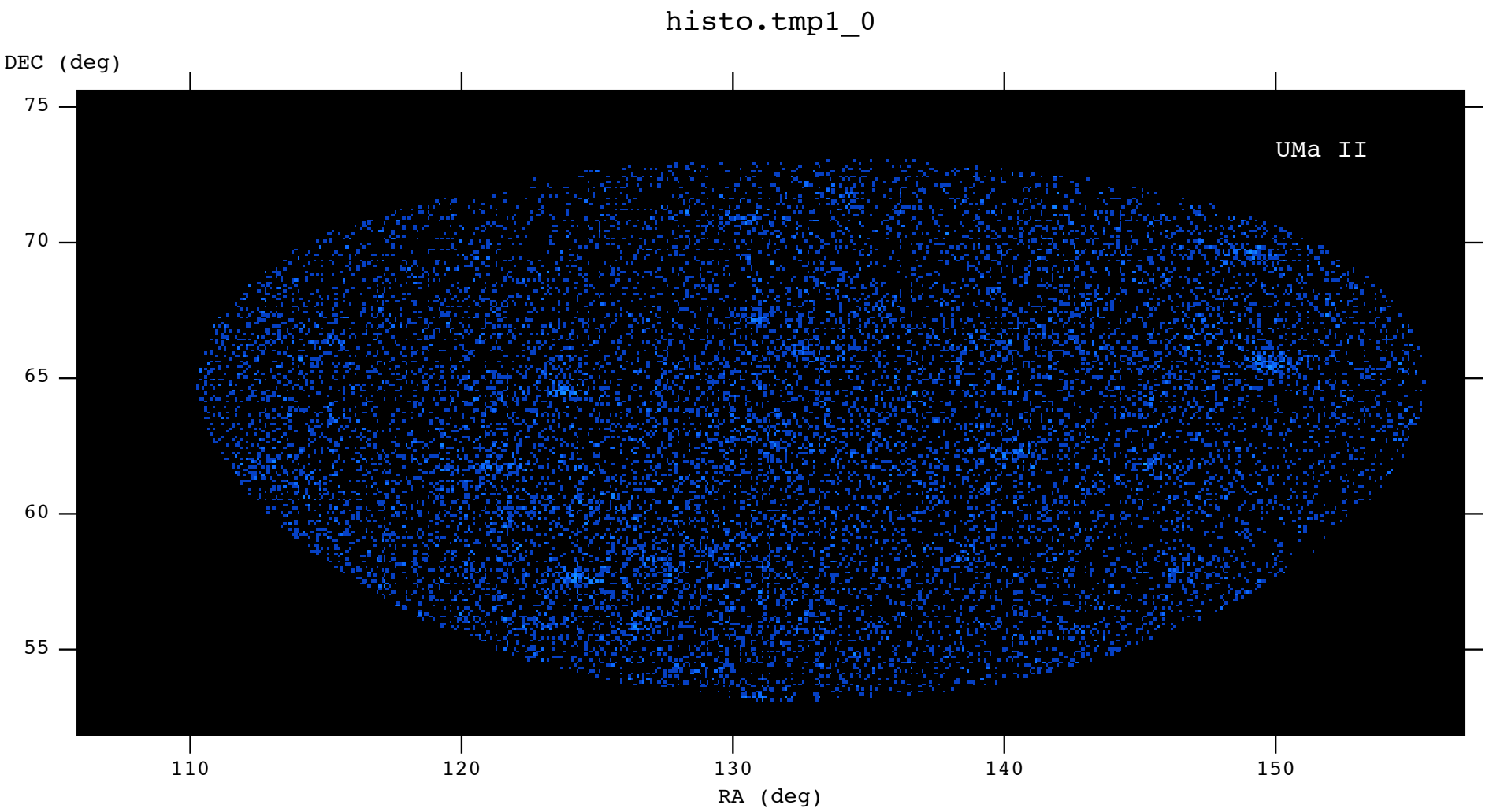
180
185
190
195
RA (deg)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UMa II
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RA (deg)