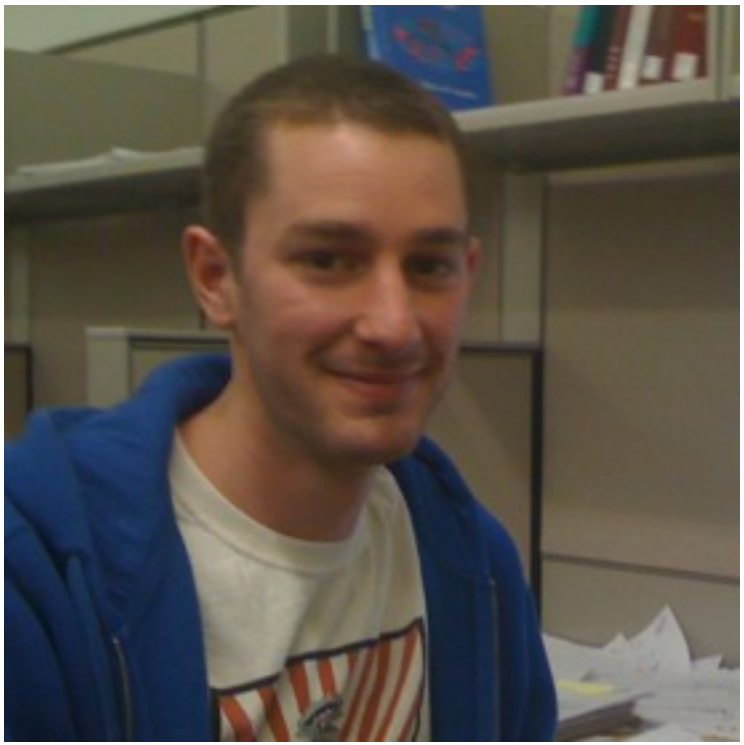
Dark matter constraints from dwarf spheroidals

Savvas M. Koushiappas

BROWN

Based on

Alex Geringer-Sameth & Koushiappas, PRL 107,241303 (2011) 1108.2914



Based on

Alex Geringer-Sameth & Koushiappas, PRL 107,241303 (2011) 1108.2914

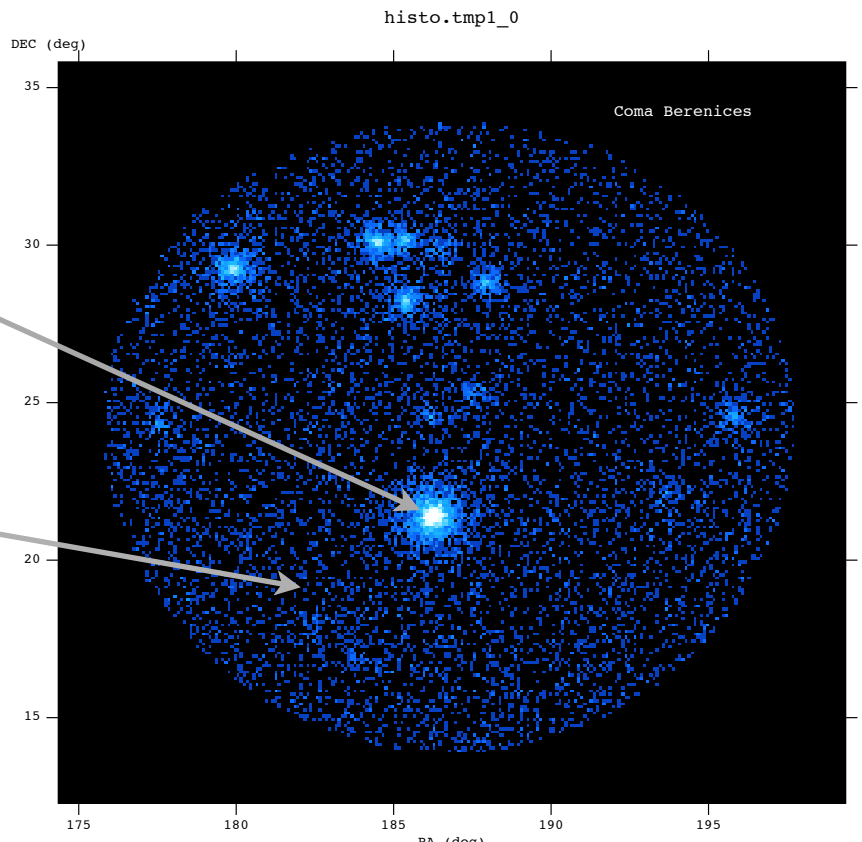
Constraints from Dwarf Galaxies: Usual approach to the problem

1. Construct a theoretical model which in principle characterizes the background
2. Compute the signal/noise ratio (and place bound)

Background at this source

Computed by how much one understands this

Very difficult!



Alex Geringer-Sameth & Koushiappas, PRL 107,241303 (2011) 1108.2914

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.

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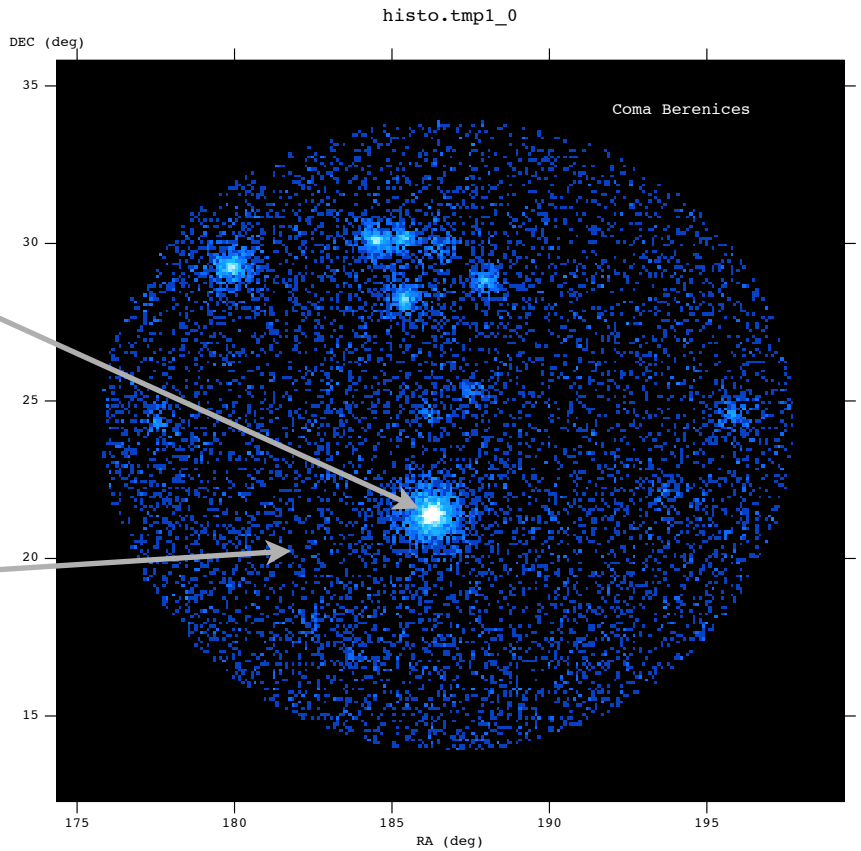

Background at this source

Same as here

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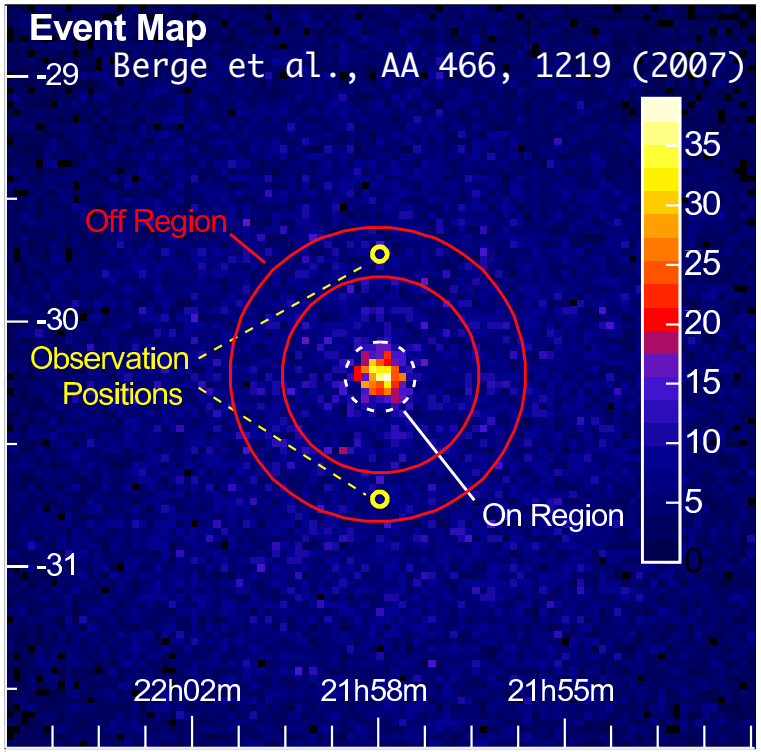
Not new:

- Particle physics

- Cerenkov telescopes



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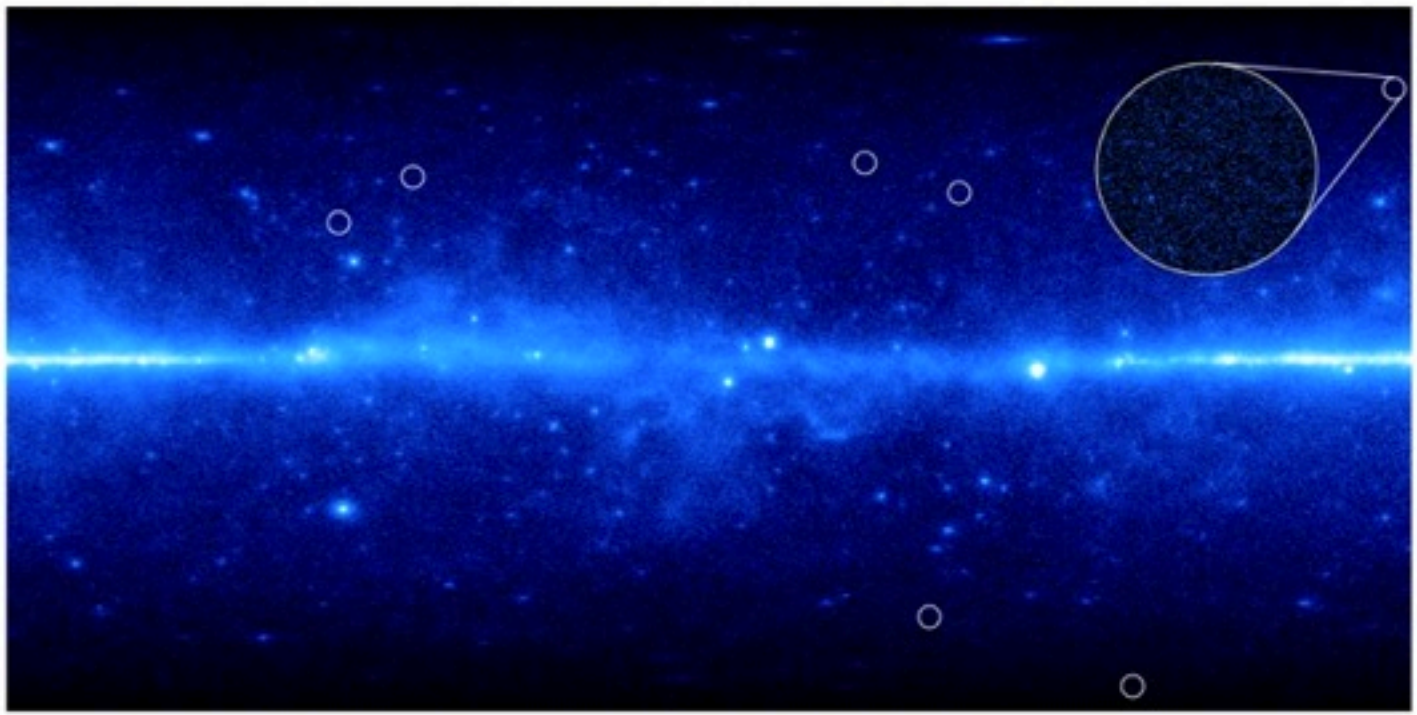
Data

- 3 years of FERMI public data
- PASS 7 photon events
- Energy range: [1-100] GeV (dictated by size of PSF--more on this later)
- 7 Dwarf galaxies (Bootes I, Draco, Fornax, Sculptor, Sextans, Ursa Minor & Segue 1)



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Gamma-ray flux

Total Number of photons along the direction of a dwarf

$$\Phi_{\rm PP} = \frac{\langle \sigma v \rangle}{8\pi M_\chi^2} N_\gamma$$

Quantity of interest

$$\mu(\Phi_{\rm PP}) \equiv {\rm Exp} \times \Phi_{\rm PP} \times J + {\rm Background}$$

Derive empirically

Dark matter distribution
SYSTEMATIC Uncertainty
(See Louie Strigari's talk)

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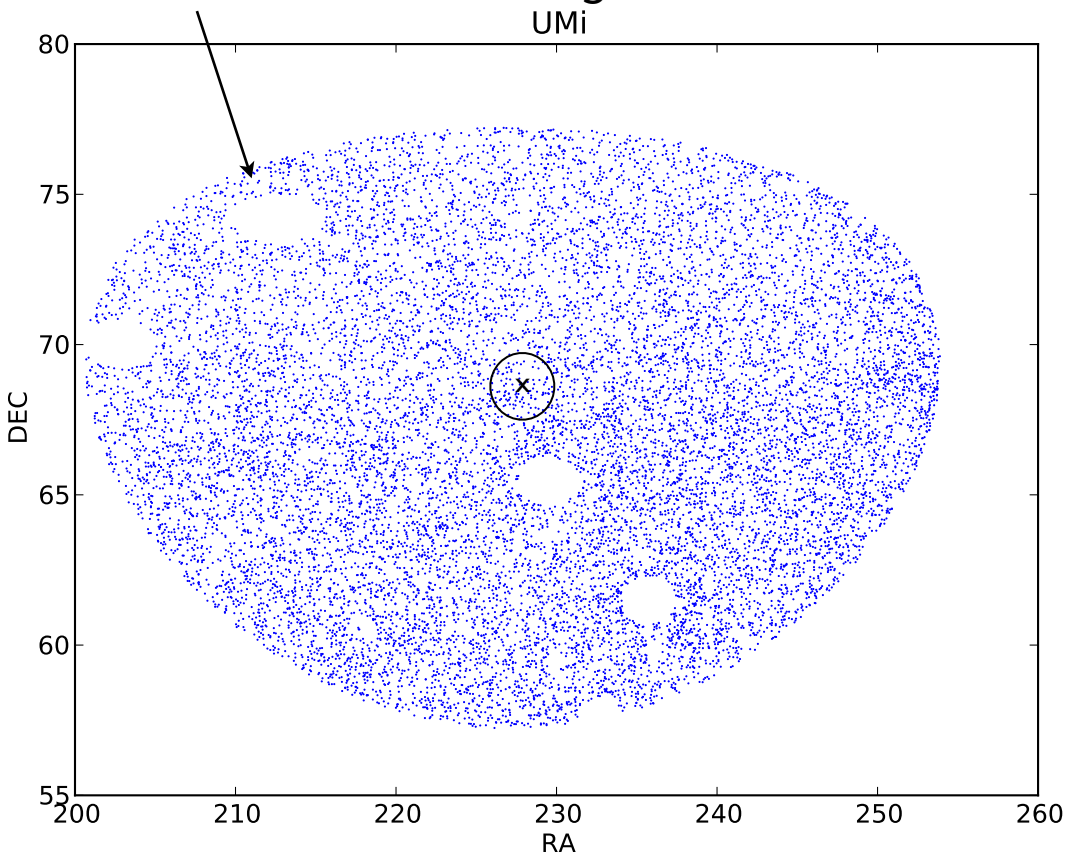
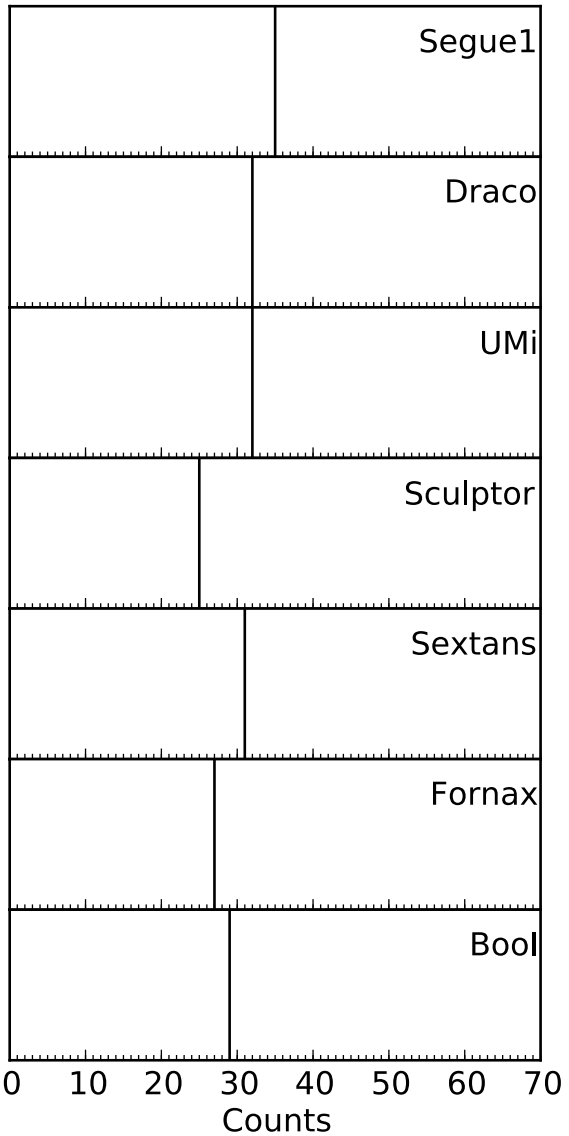
Background determination

Mask sources present in the 2nd Fermi Catalogue





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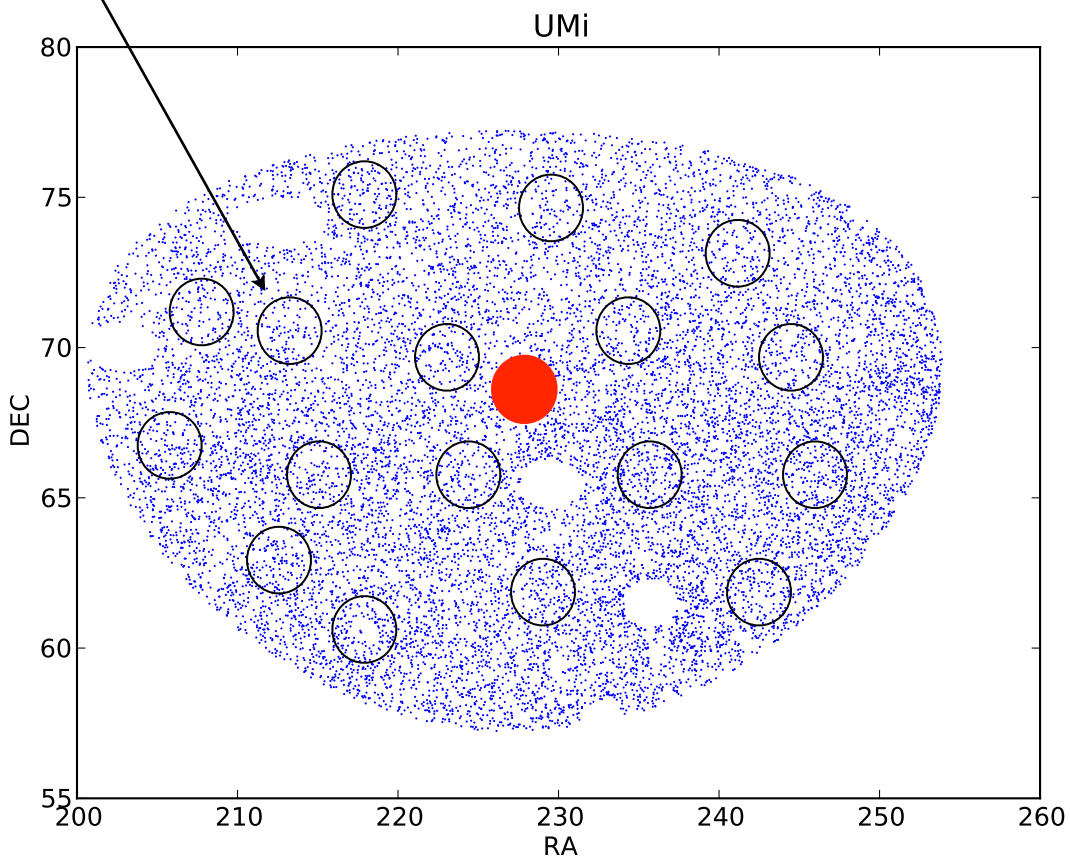
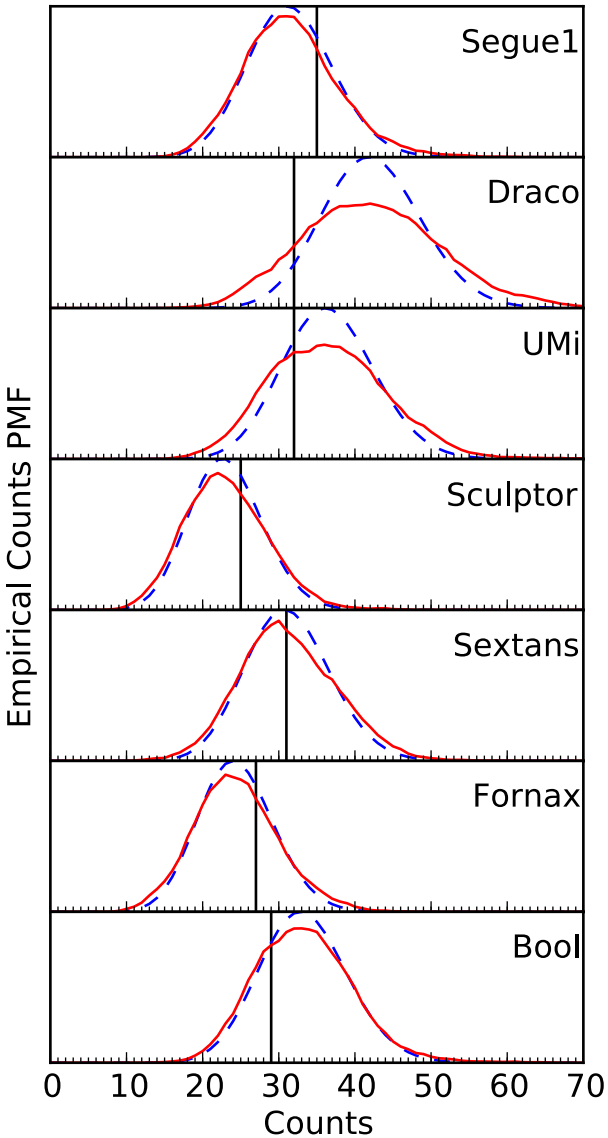
Background determination

400 independent ROI





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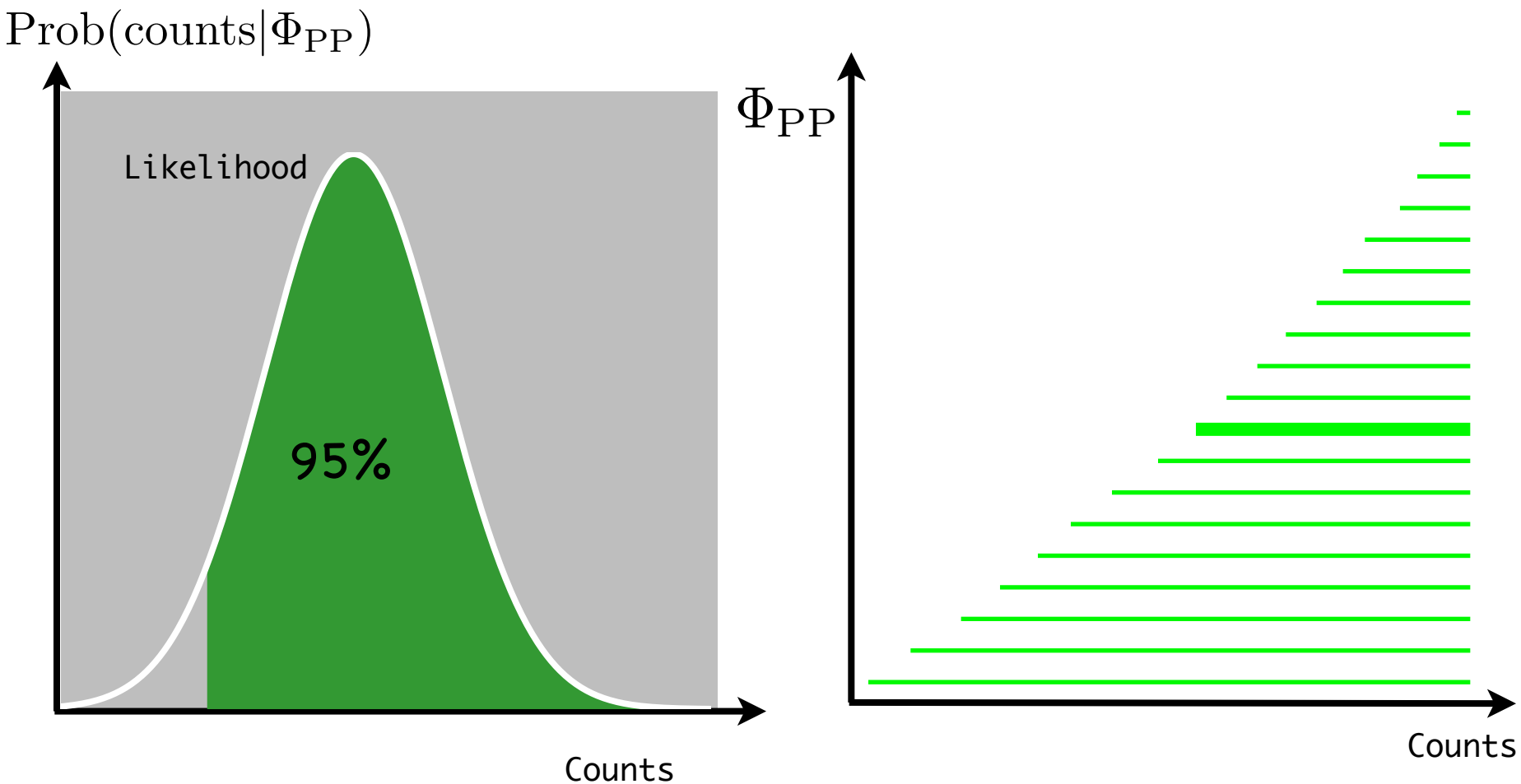
Multi-dimensional Neyman Construction



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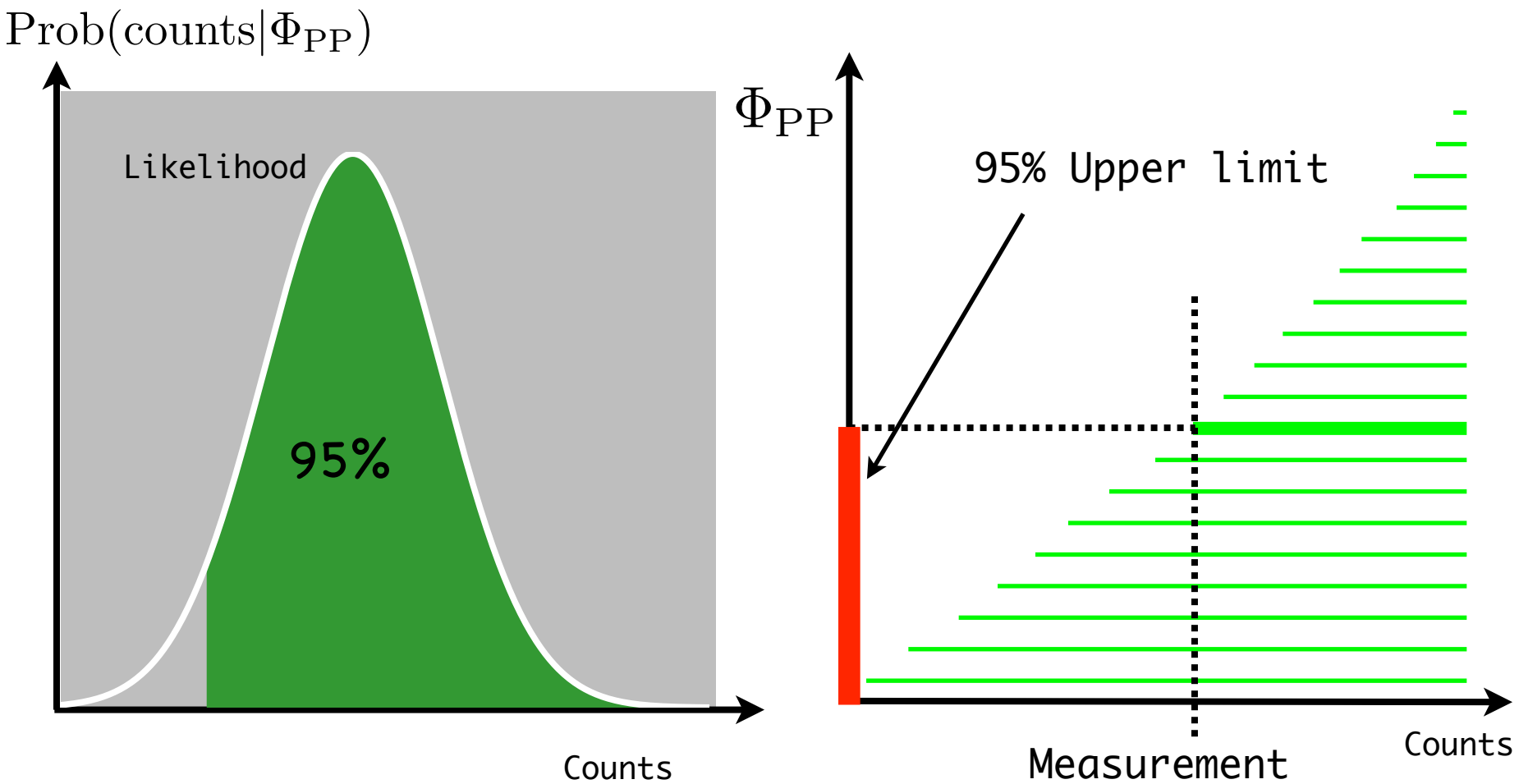

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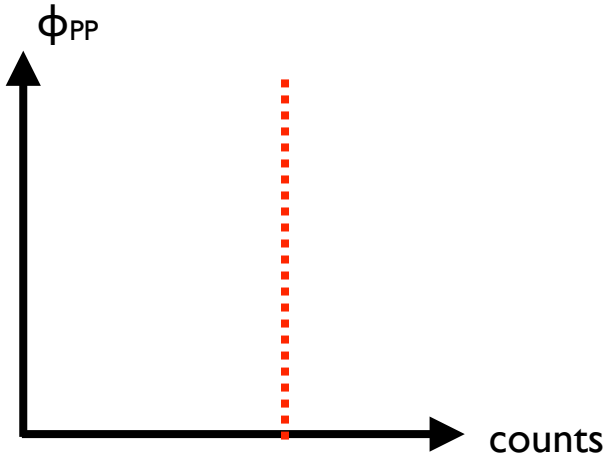
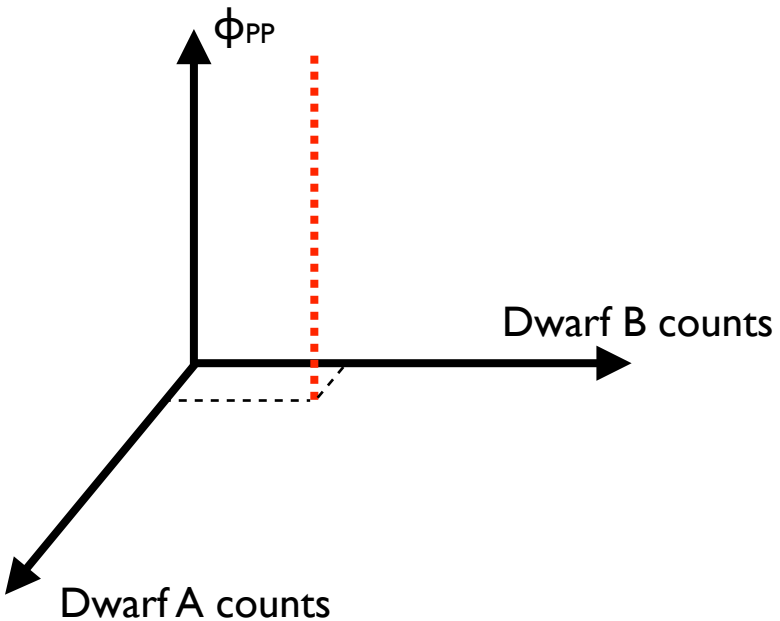
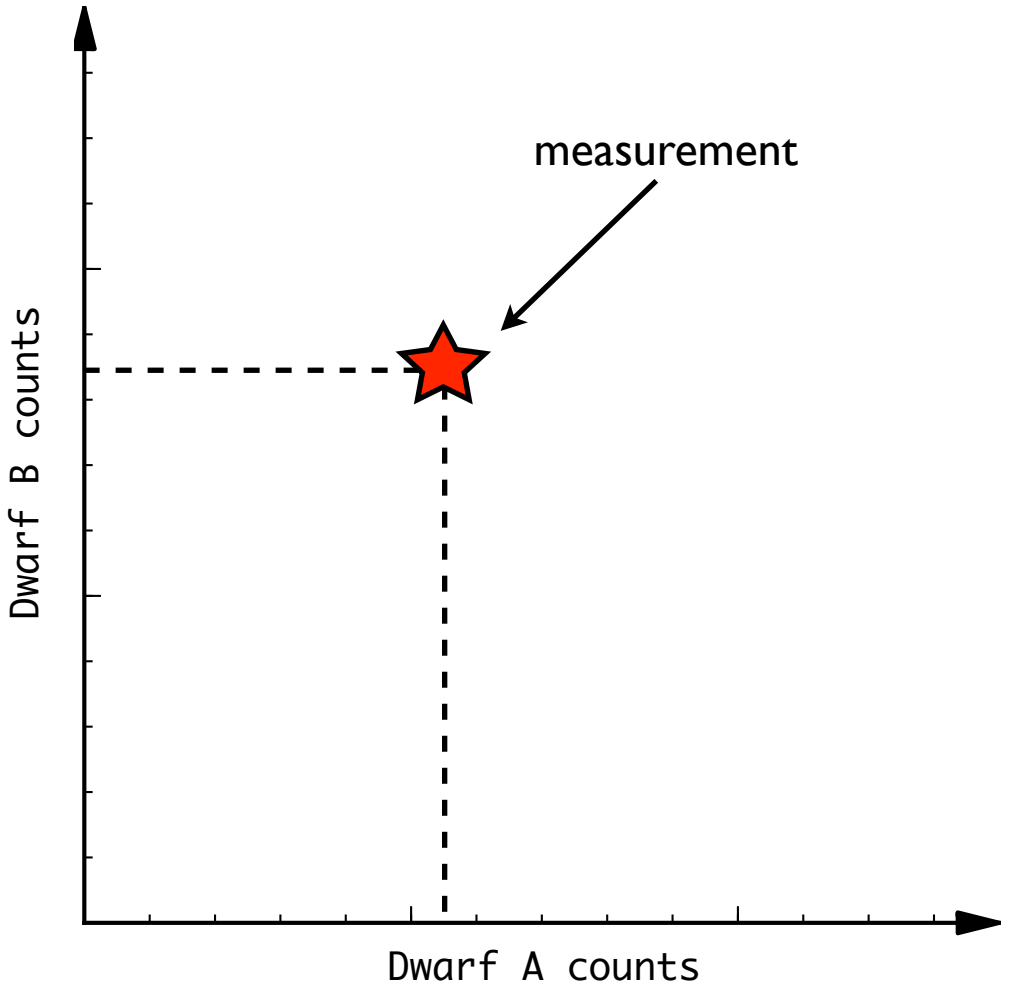
Combining observations of dwarfs







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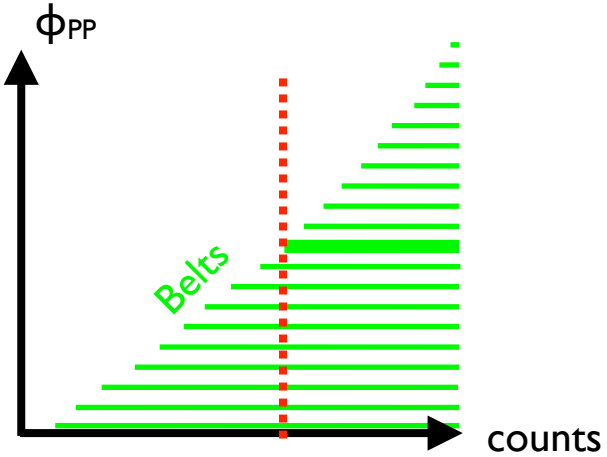

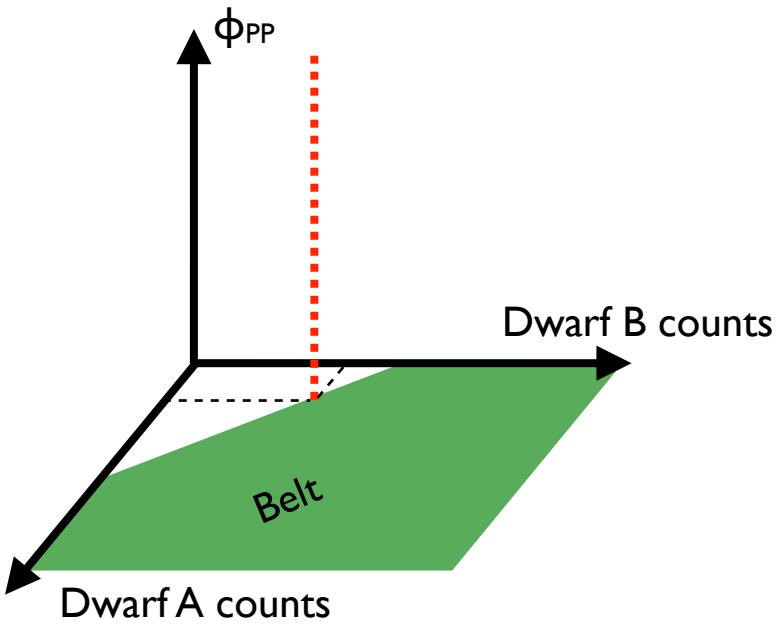

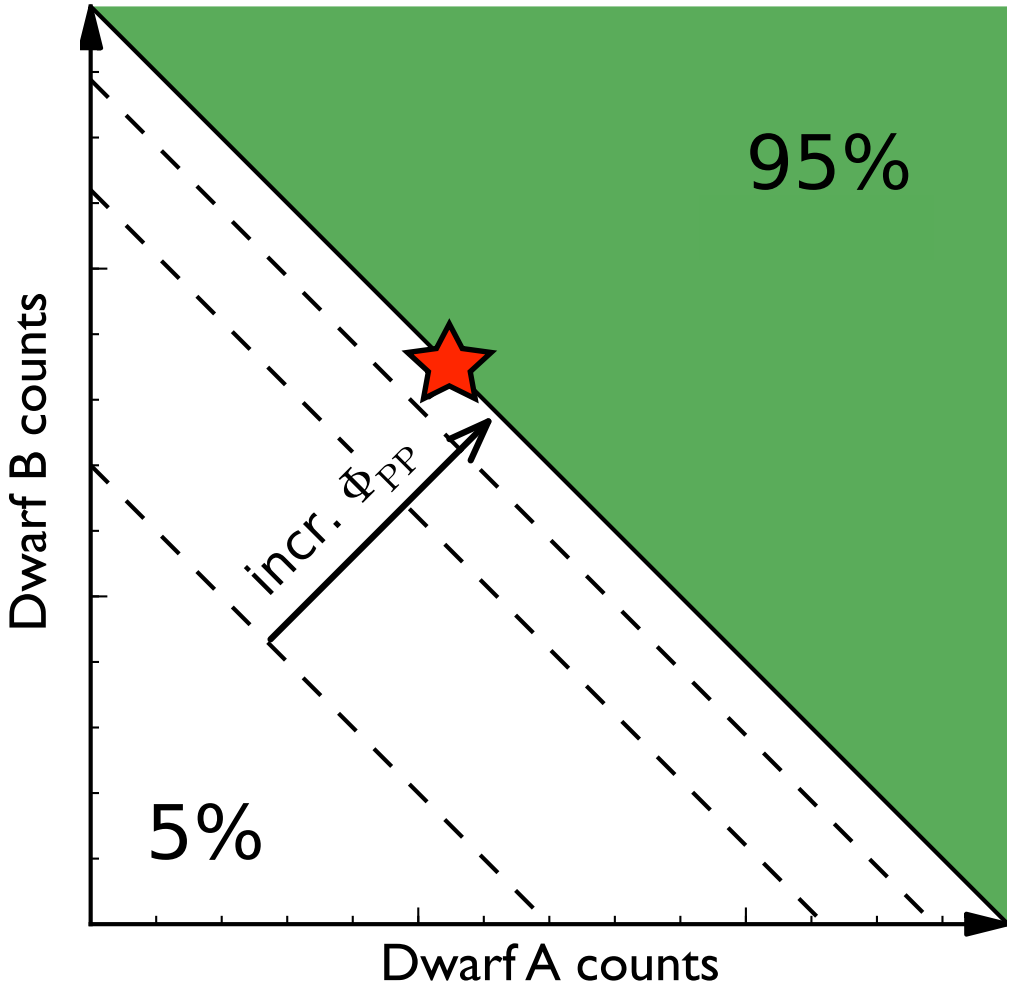

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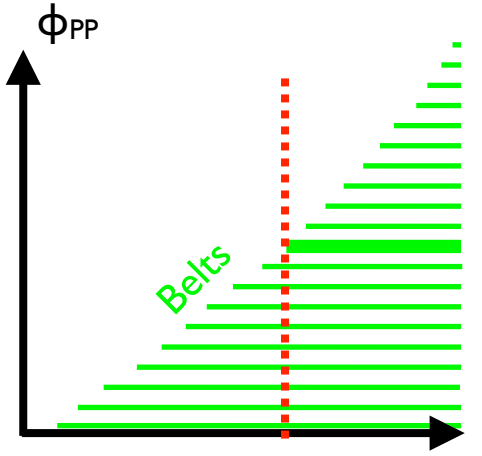

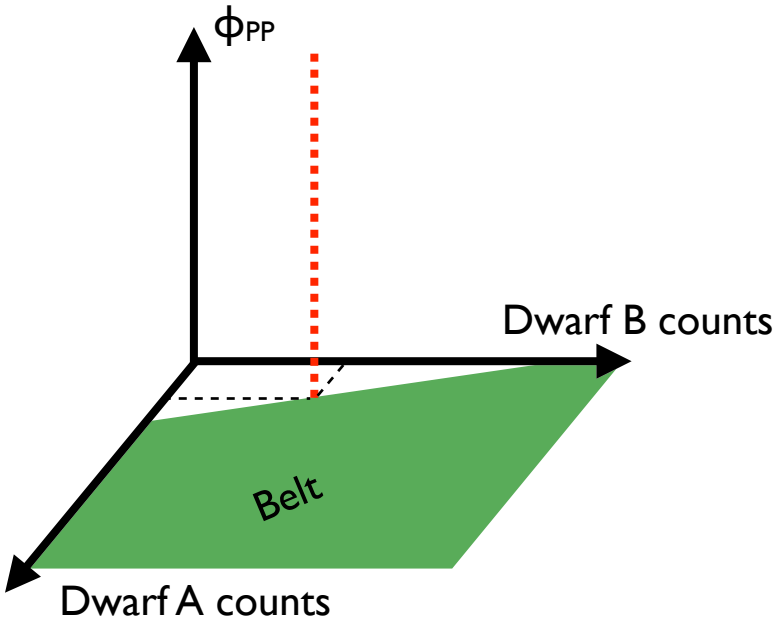

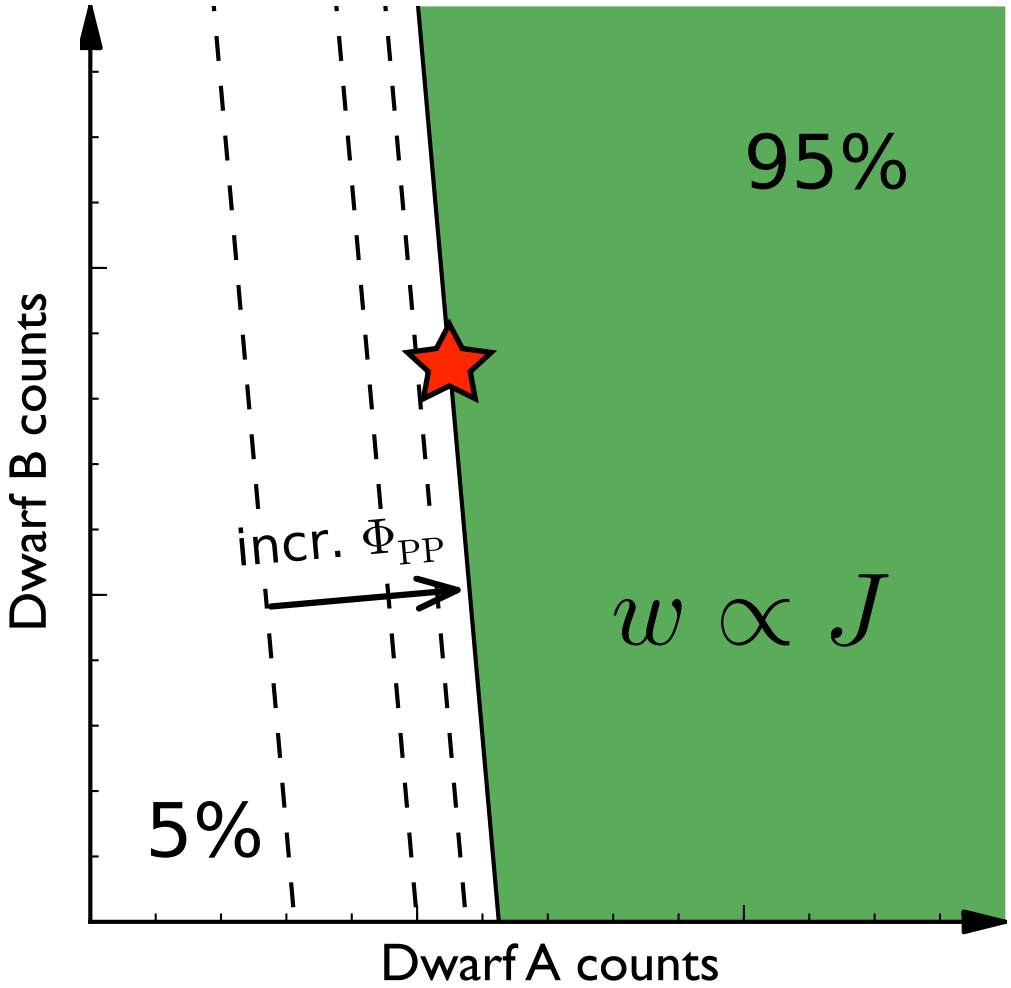

See Sutton, Classical and Quantum Gravity, 26, 245007 (2009)

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Result

True 95% upper bound

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

$$\langle \sigma v \rangle = \frac{8\pi}{N_\gamma} \, \Phi_{\rm PP} \, M_\chi^2$$

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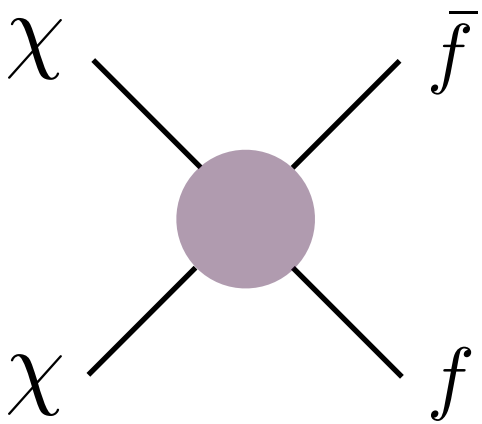
Choose annihilation channel



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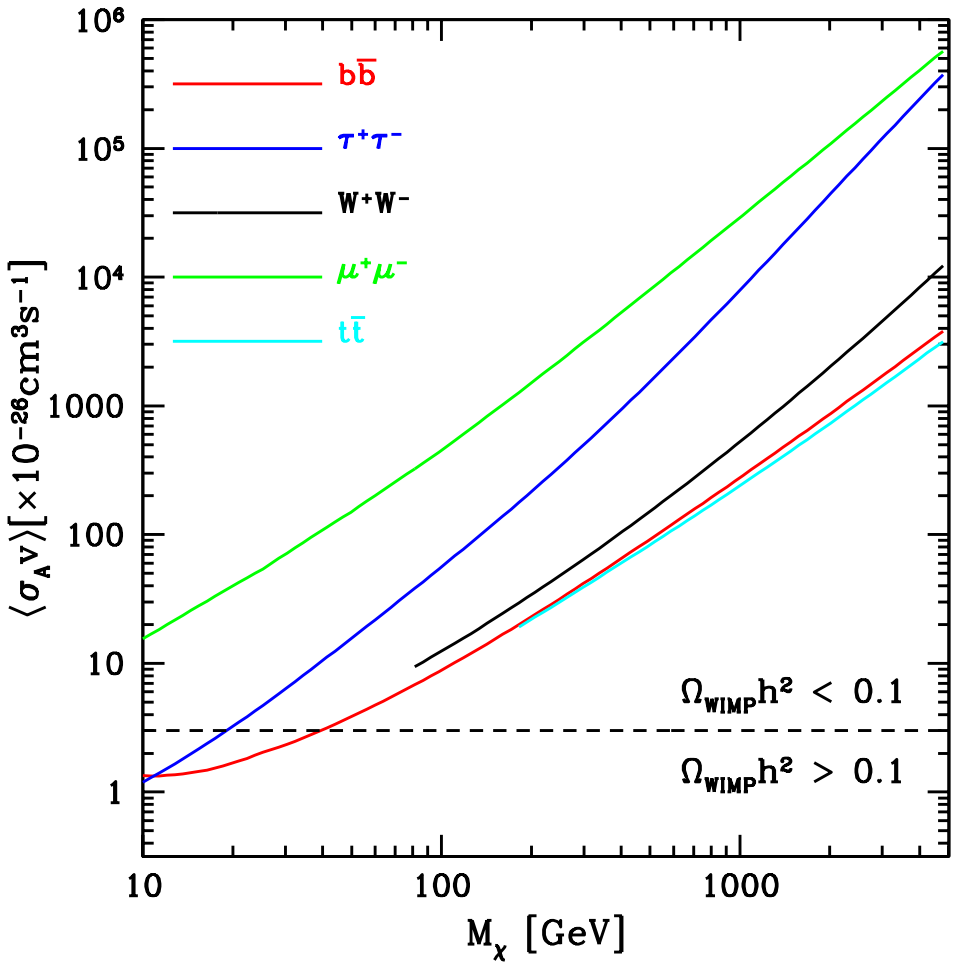

For $\langle\sigma v\rangle = 3\times10^{-26}\mathrm{cm}^3/\mathrm{s}$

See also Steigman et al. arXiv:1204.3622

$b\bar{b}$

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

$\tau^+\tau^-$

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

See also Ackermann et al. PRL 107,241303 (2011), and Manoj Kaplinghat's talk after this one.

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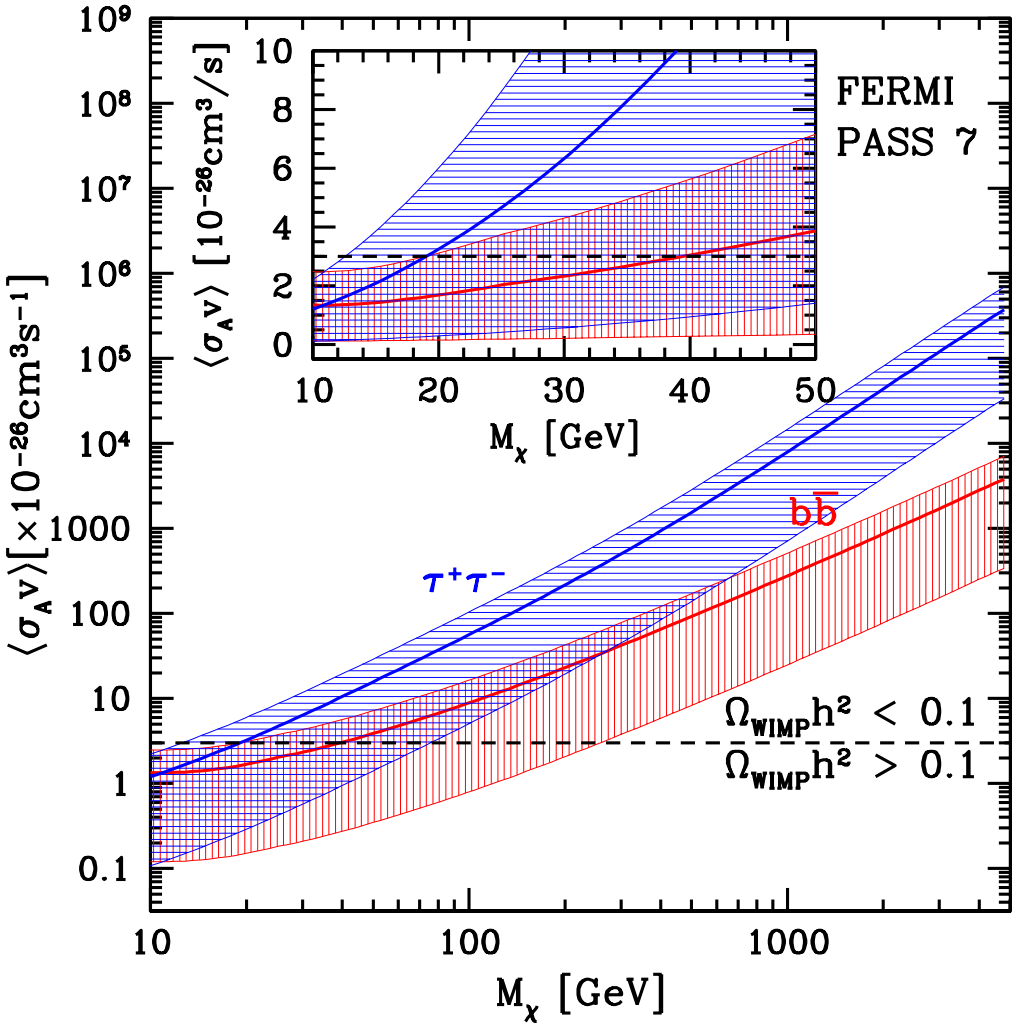

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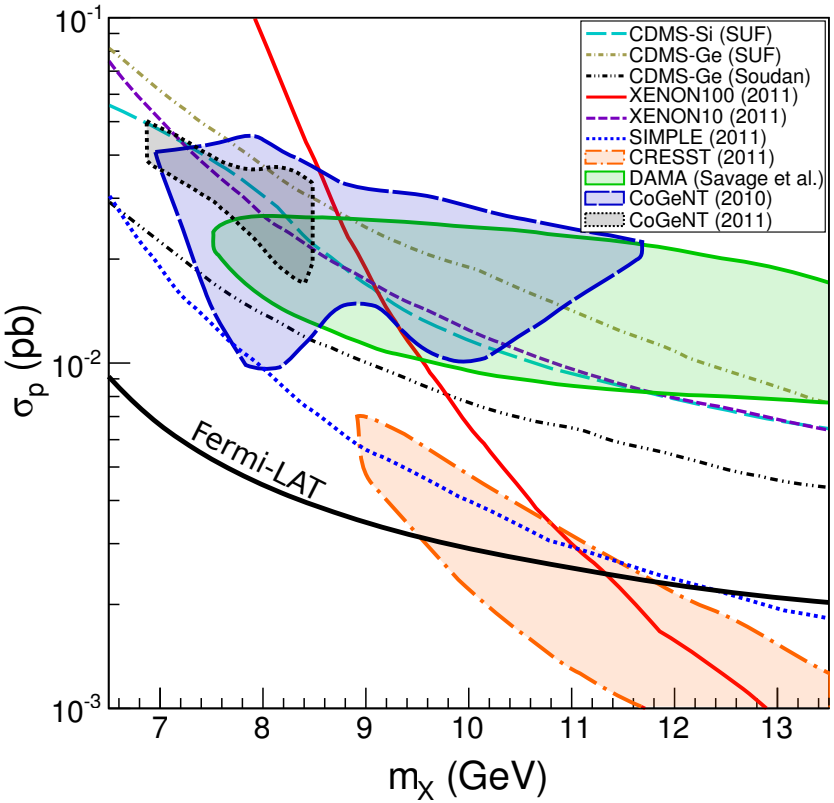
Major Caveat

J enters as a systematic

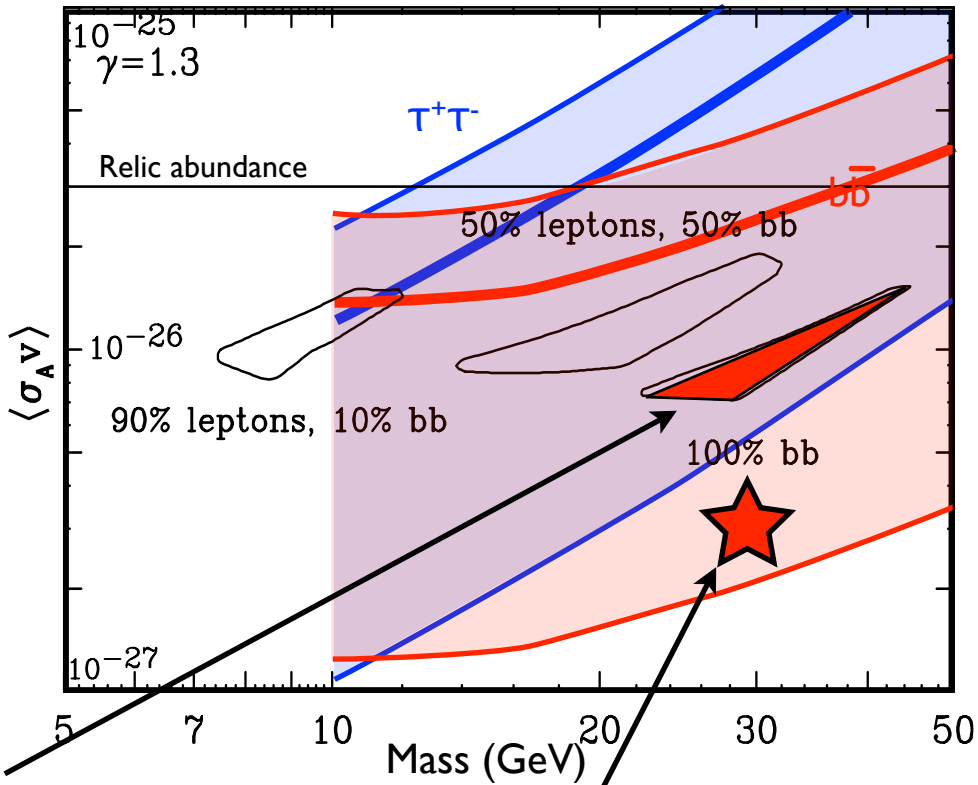
Charbonnier et al. arXiv:1104.0412
Ackermann et al. arXiv:1108.3546

Where do these limits fit in the big picture?

Direct detection



Indirect detection



Galactic center
Hooper & Linden arXiv:1110.0006

Isospin Violeting DM
Kumar, Sanford & Strigari, arXiv:1112.4849

Galaxy Clusters
Han et al. arXiv:1201.1003

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Photon energy distribution and spatial information

Spectrum

$$\frac{dN_\gamma}{dE}$$

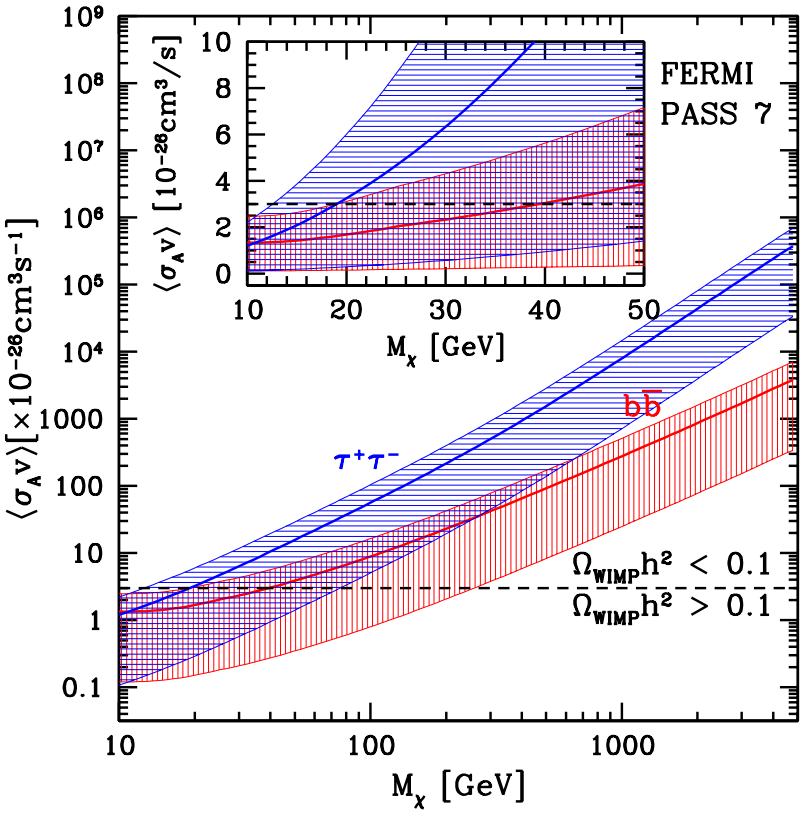
PSF

$$P(\theta)d\theta$$

Alex Geringer-Sameth & Koushiappas, In Preparation (2012)

Conclusion

Current indirect detection constraint from dwarf galaxies:



Stay tuned for results at the high-energy regime from the joint analysis of dwarfs using VERITAS.

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