

Extracting the *cumulative* pulsar contribution to the gamma-ray background

Savvas M. Koushiappas

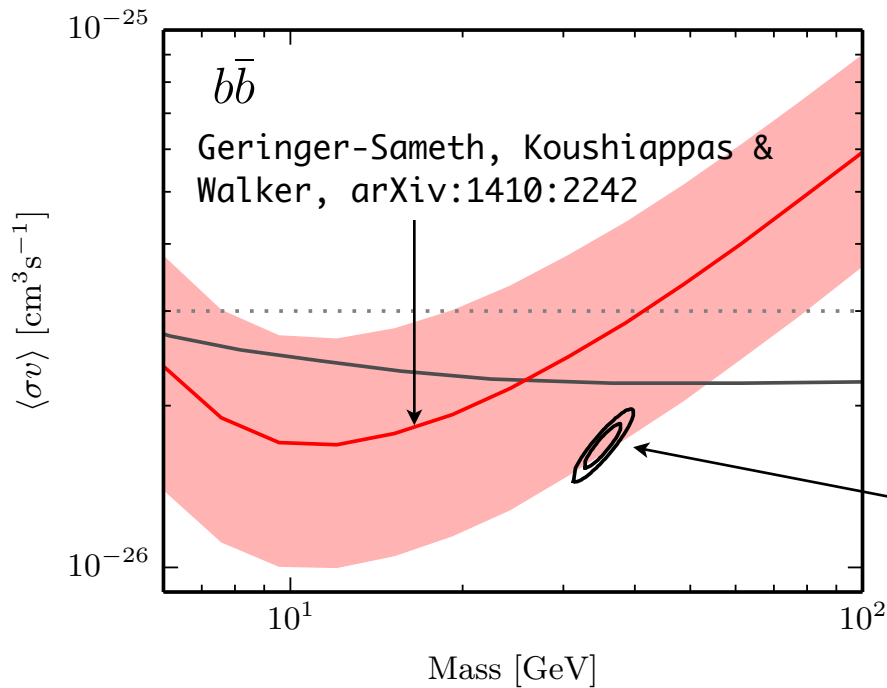


Based on Geringer-Sameth & Koushiappas, MNRAS 421, 1813.
Many thanks to Alex Geringer-Sameth for some of the figures/slides.



Characterizing the origin of the Galactic excess requires

1. Data from independent data/experimental techniques.

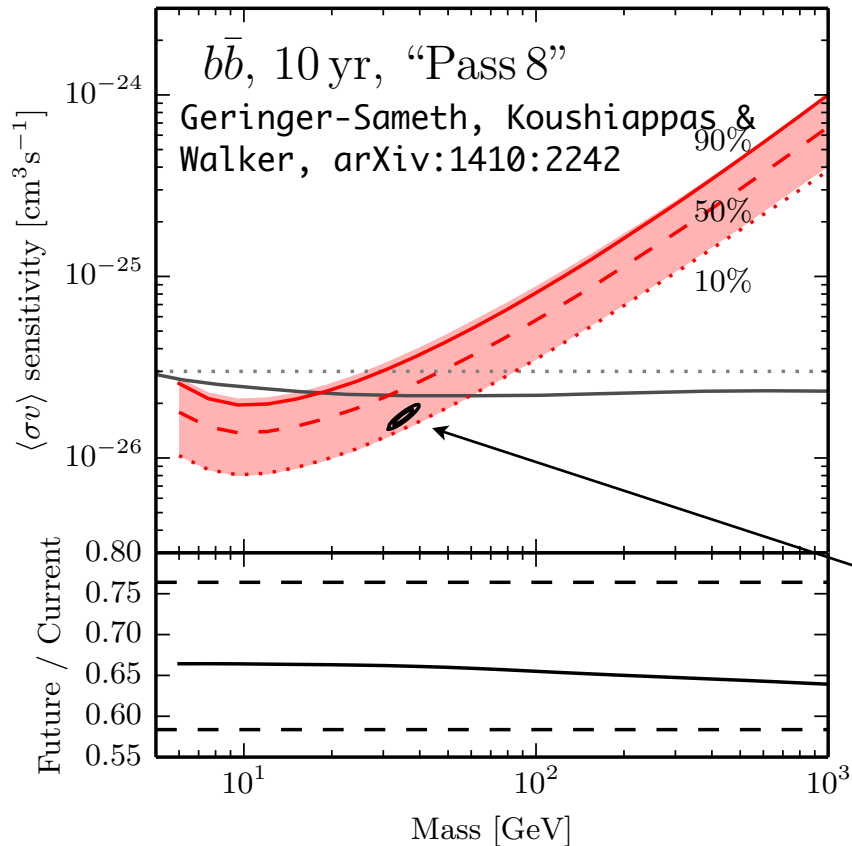


e.g., searching for similar signal properties from other sources such as **dwarf galaxies**.

Daylan et al., arXiv:1402.6703

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1. Data from independent data/experimental techniques.
2. Sophisticated theory and modeling of sources/diffuse emission.

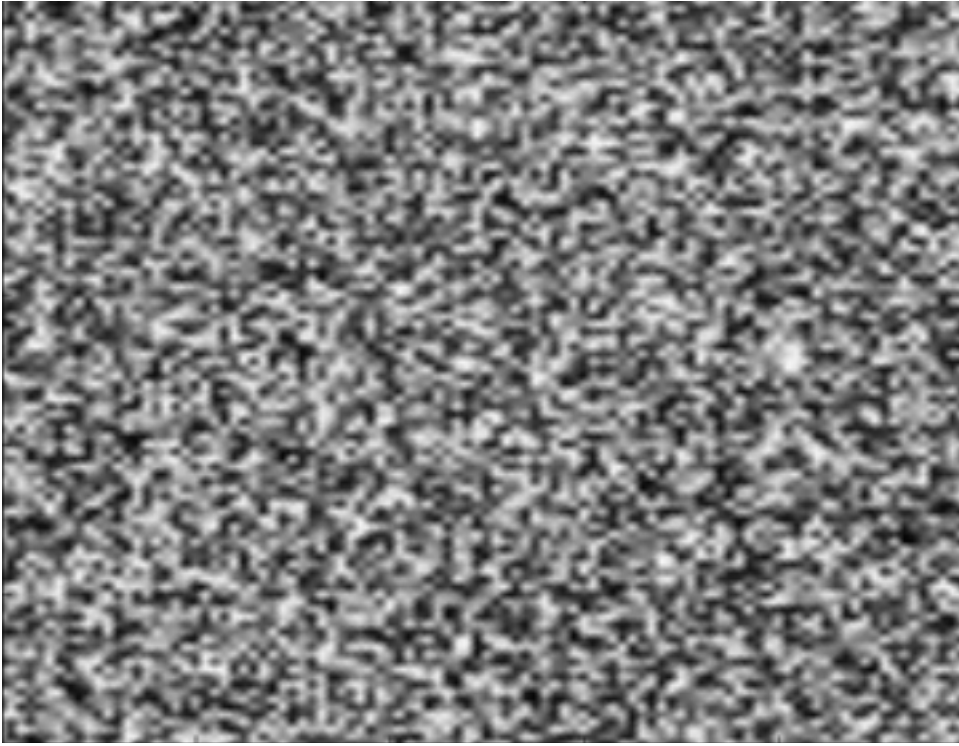
e.g., see talks at this meeting by *Andrey Timokhin, Helene Laffon, Albert Kong, Zhongxiang Wang, Matthew Kerr, Anne Archibald, Simon Johnston, Roberta Zanin, Mutsumi Sugizaki, Andrew McCann, Jumpei Takata, Dan Hooper, Takayuki Saito, Diego Torres, Mallory Roberts, Pablo Saz Parkinson, Anna Franckowiak, Luigi Tibaldo, Jean-Marc Casandjian, Simona Murgia, Tim Linden, Makoto Arimoto, Takafumi Kawano, Markus Ackermann, Gudlaugur Johannesson*, and many many more contributions in the literature.

Characterizing the origin of the Galactic excess requires

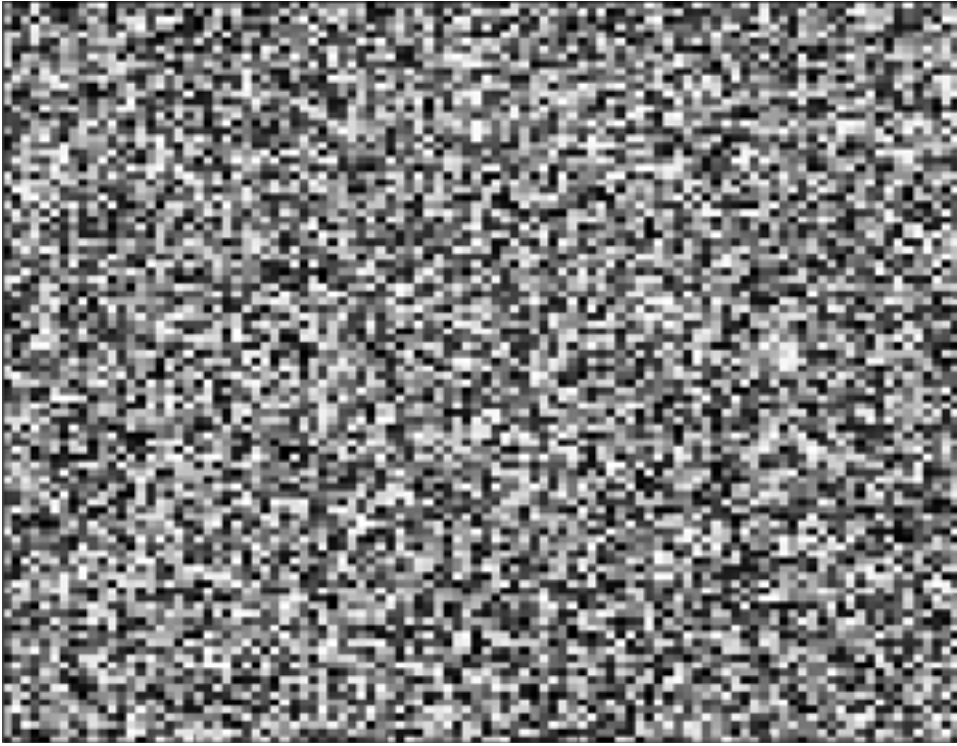
1. Data from independent data/experimental techniques.
2. Sophisticated theory and modeling of source populations.
3. New and existing statistical and analysis tools.

QUESTION: What is the ***cumulative*** contribution of faint unresolved pulsars to the gamma-ray background?

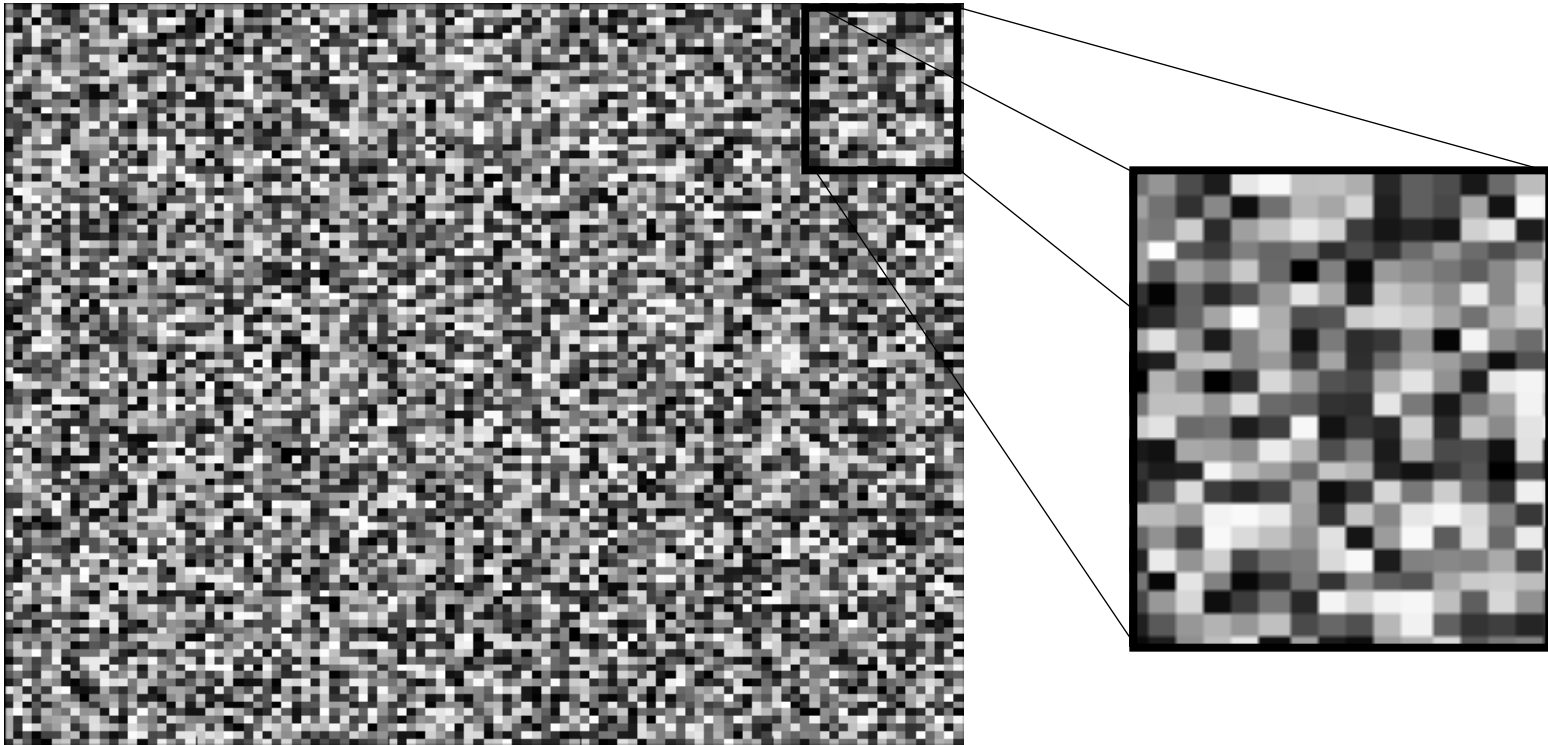
PSF-smoothed map

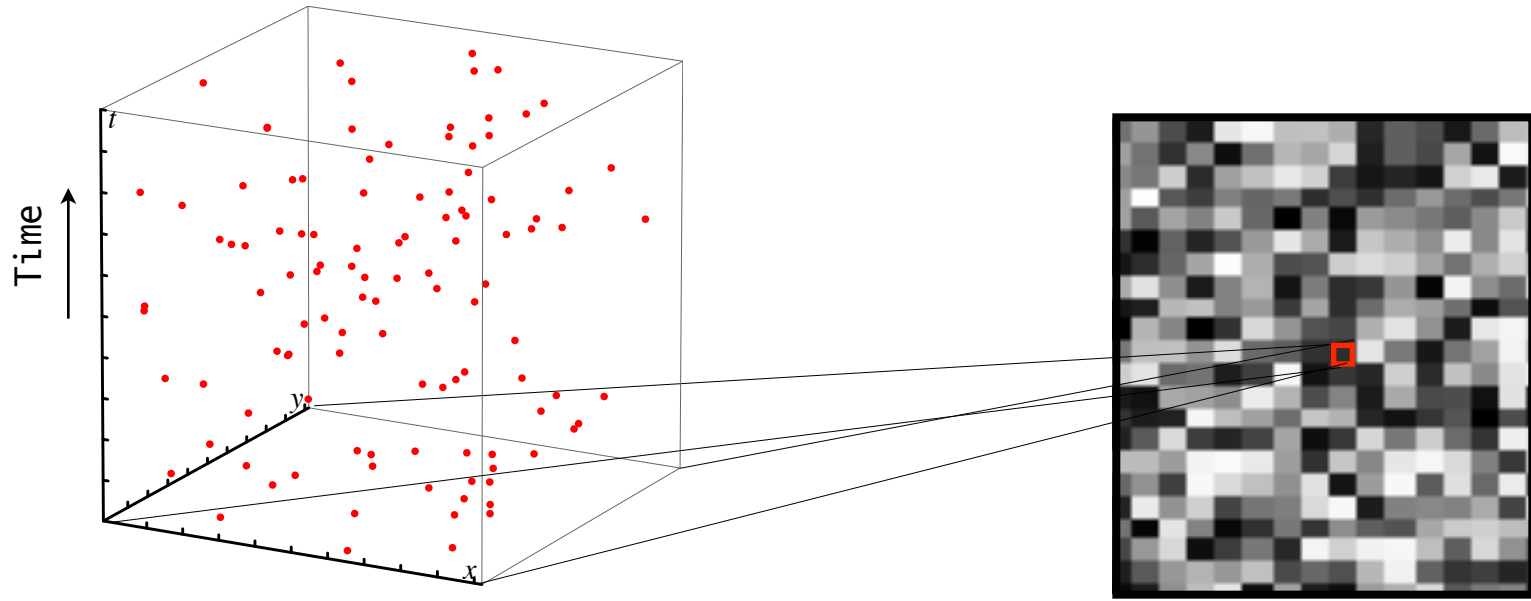


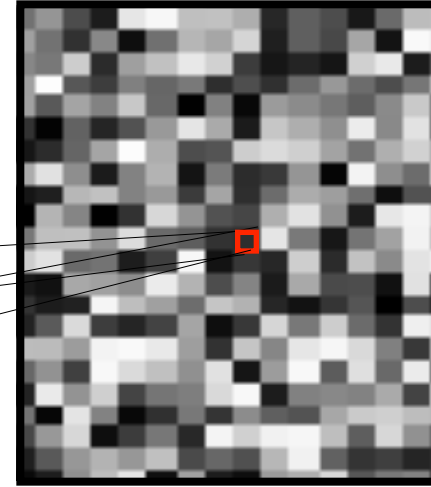
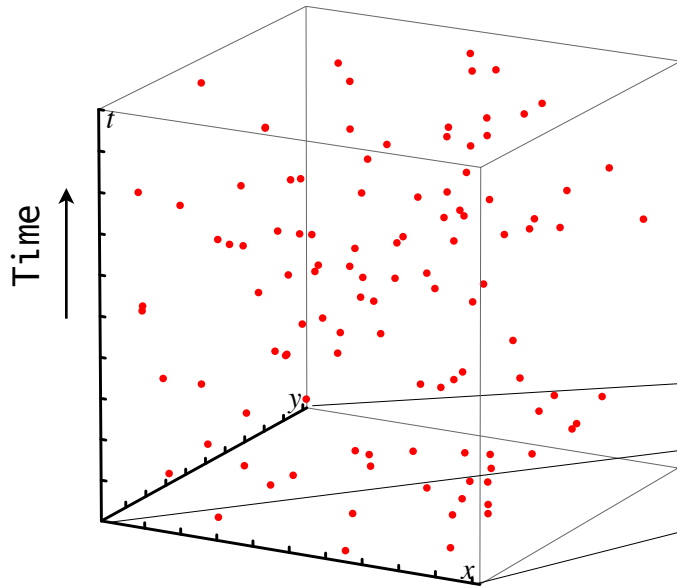
Pixelized 2-D map



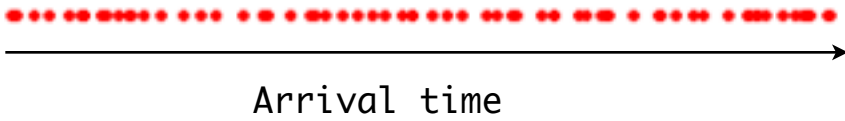
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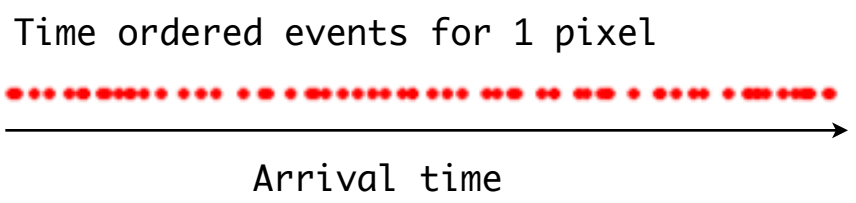
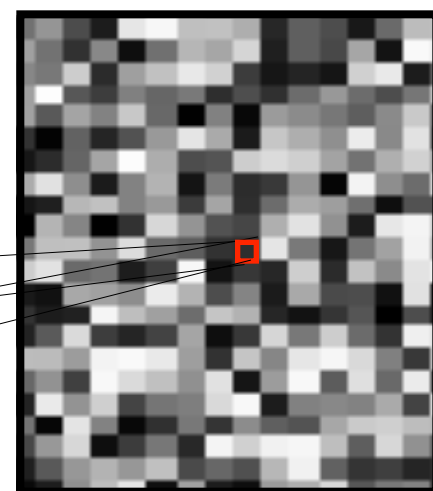
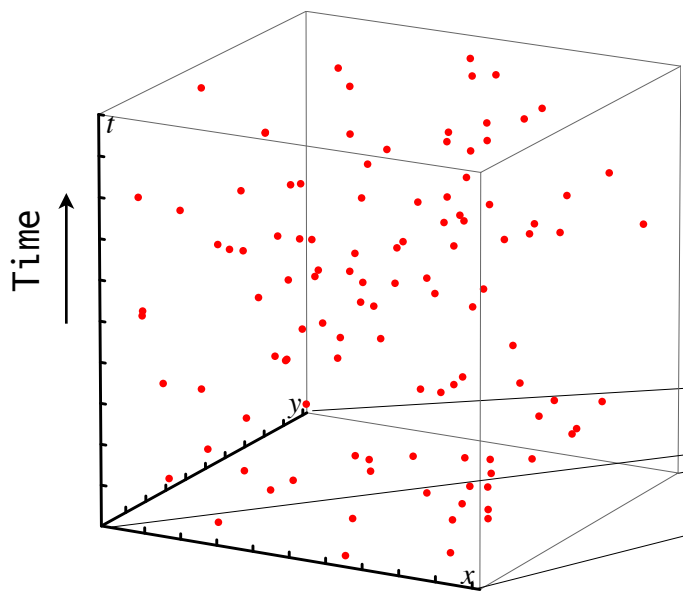






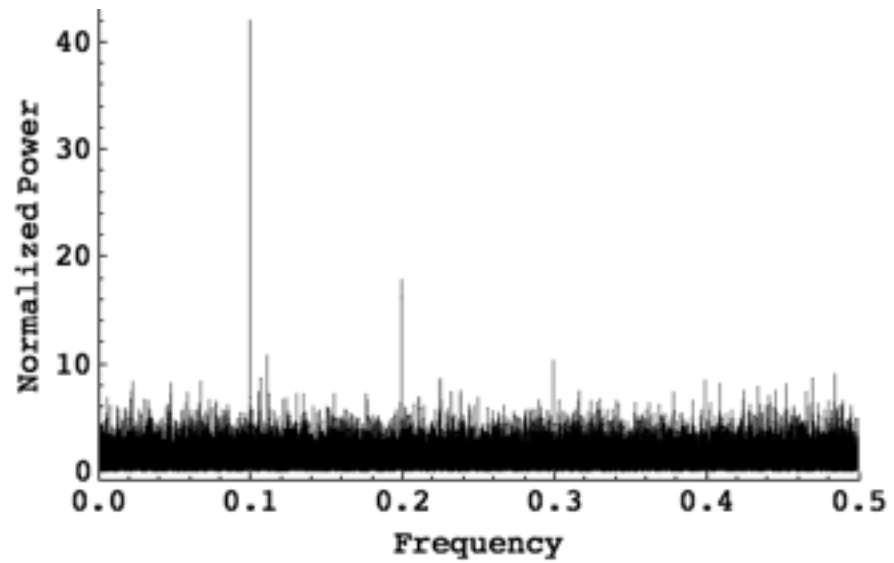
Time ordered events for 1 pixel

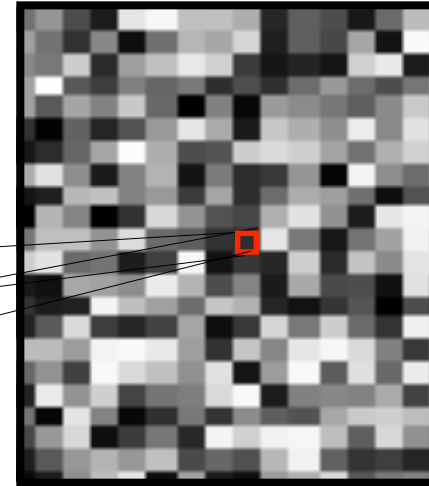
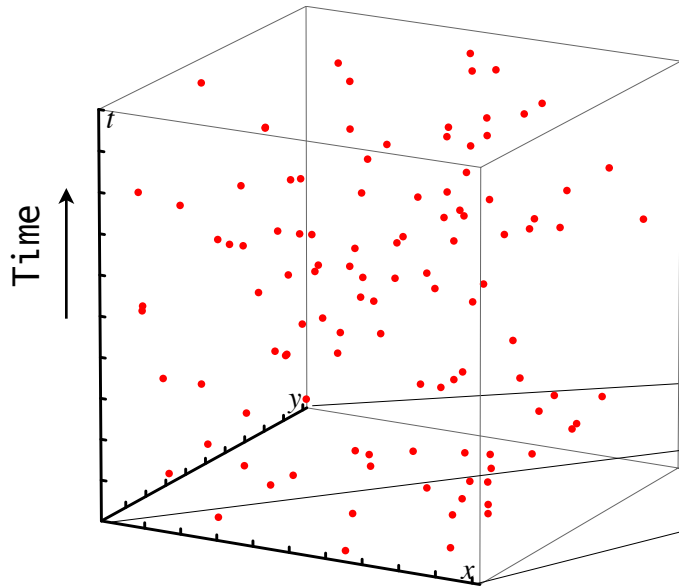




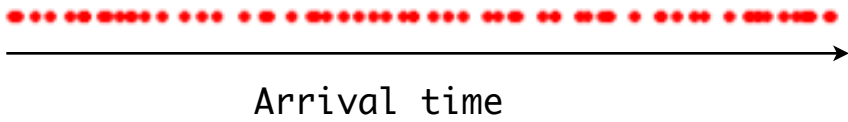
$$P(> 42) \approx 10^{-14}$$

Pulsar discovery - rare



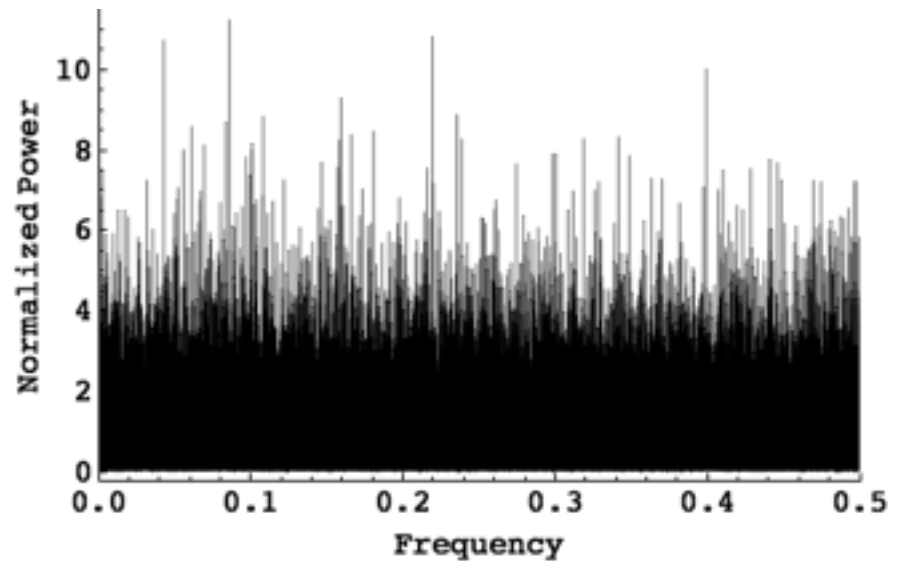


Time ordered events for 1 pixel



$$P(> 13) \approx 0.11$$

Ambiguous result - most often

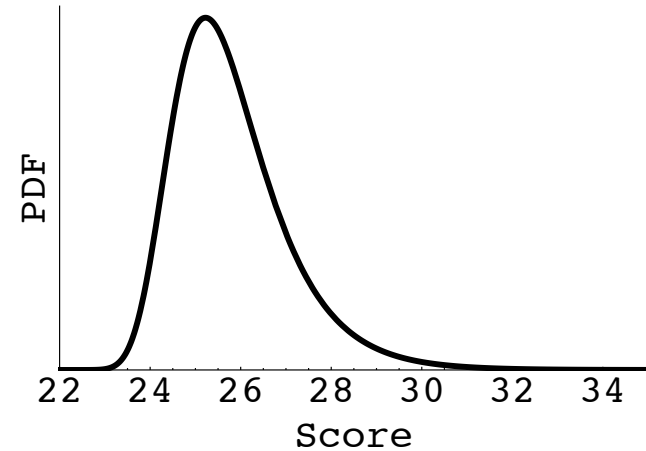


Main idea: A large sample of ambiguous “scores” may be inconsistent with the null hypothesis at high significance.

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For the null hypothesis (white noise), the “score” is ***Gumbel*** distributed:

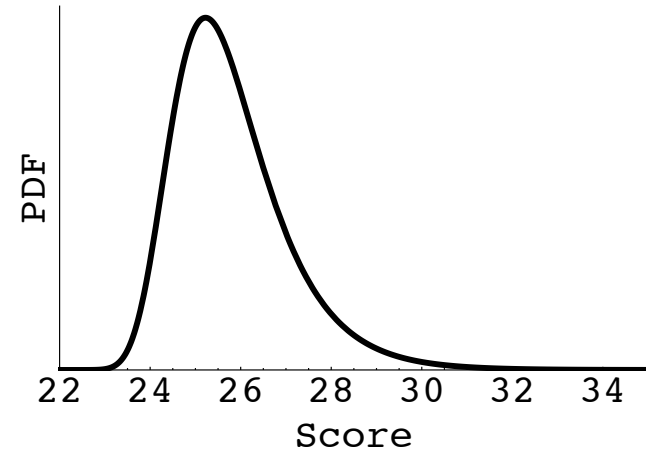
$$F(x; \mu, \beta) = e^{-e^{-(x-\mu)/\beta}}$$



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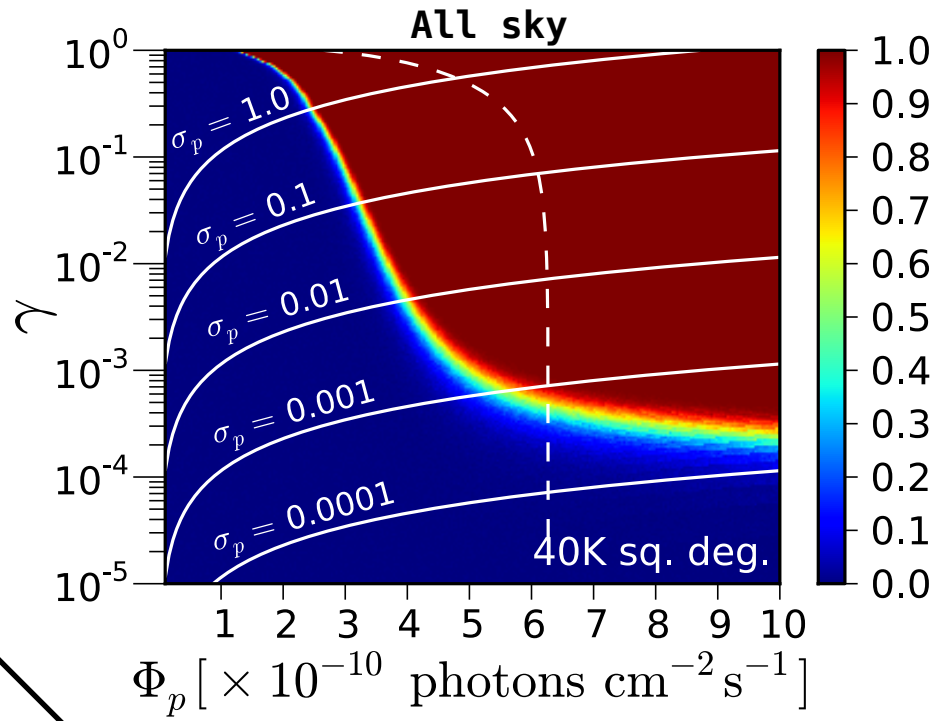
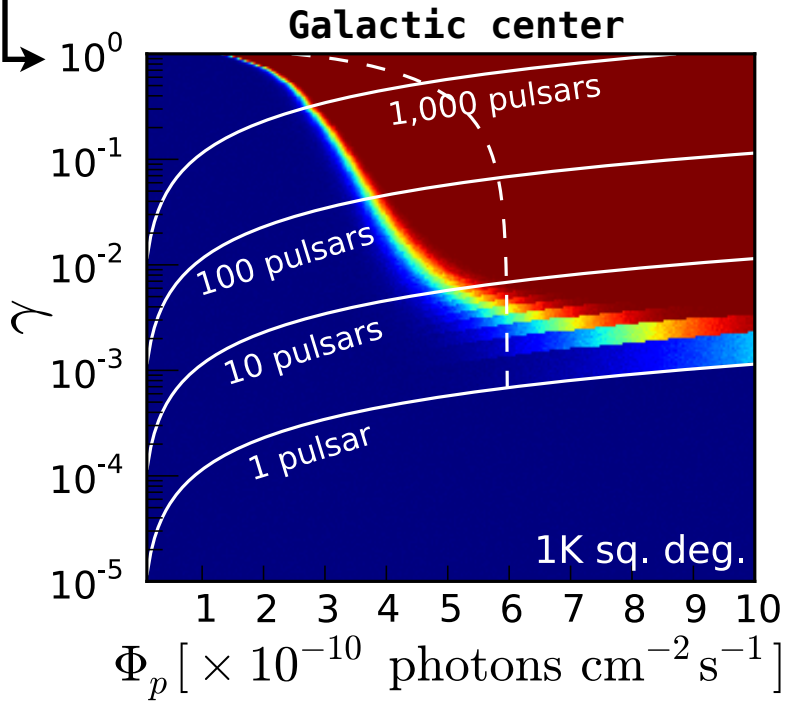
$$F(x; \mu, \beta) = e^{-e^{-(x-\mu)/\beta}}$$



Method:

1. Assign a “score” to each pixel based on its time series (e.g., maximum of normalized power spectrum).
2. Is the ***collection*** of scores inconsistent with the null hypothesis?

Current bound on pulsar contribution



Current limit of pulsar detection

Probability of rejecting the null hypothesis at 99.7% significance

Conclusion

1. No source detection \neq No information

2. The *distribution of the maximum* of the normalized power spectrum of a *large sample* of time series contains information about the underlying *cumulative contribution* of pulsars to the gamma-ray background.