Probing the pulsar explanation of the Galactic-Center GeV excess using CW

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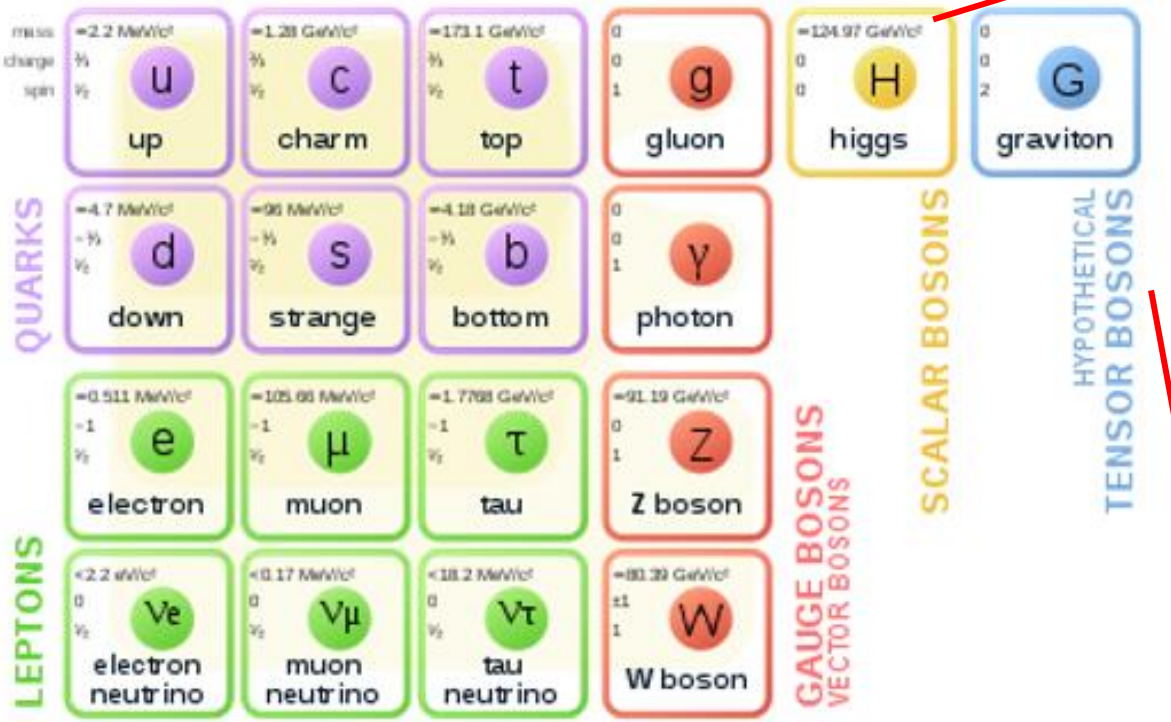
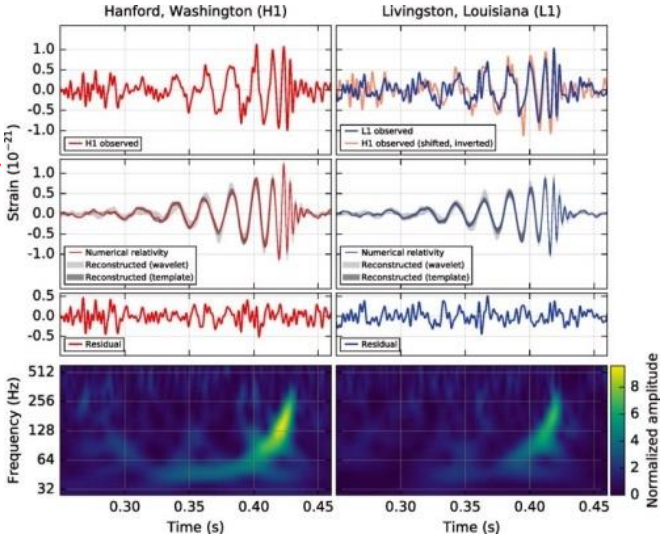
University of Utah

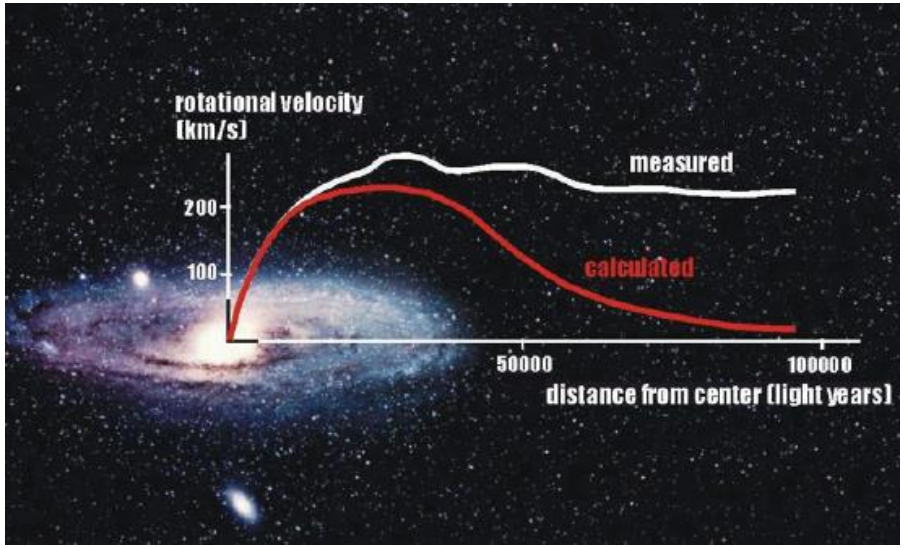
Current Status of Particle Physics:

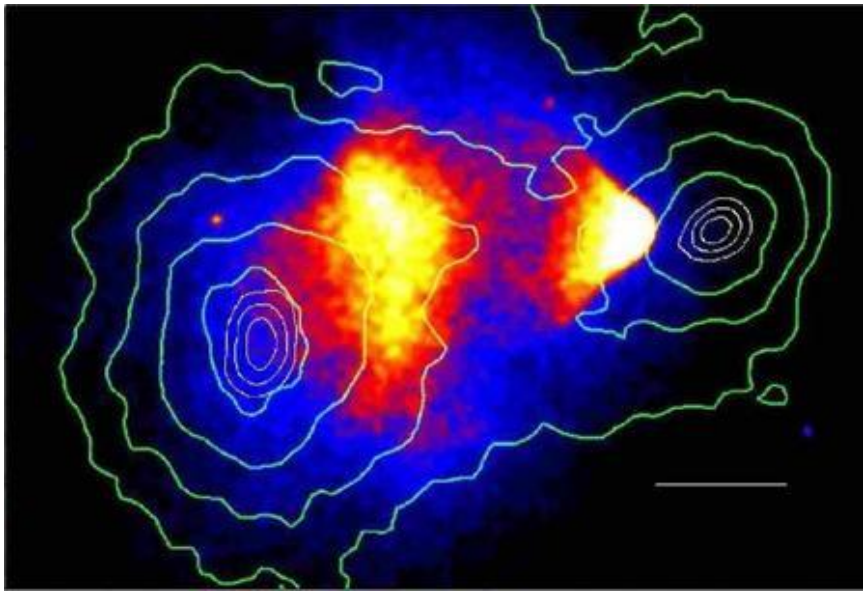


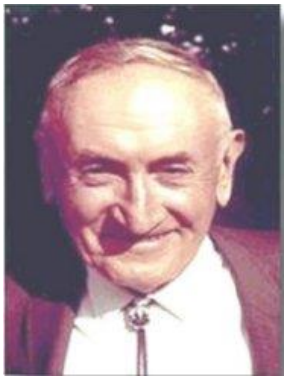


+ anything else?

Dark Matter Overview:

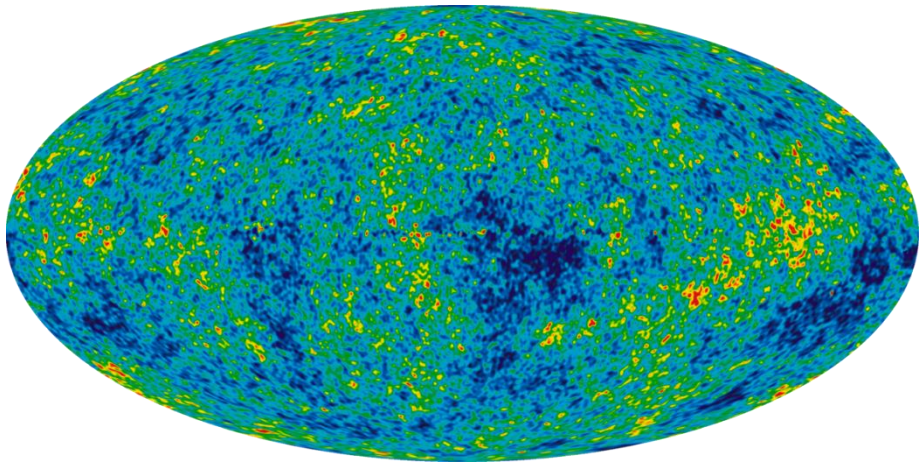




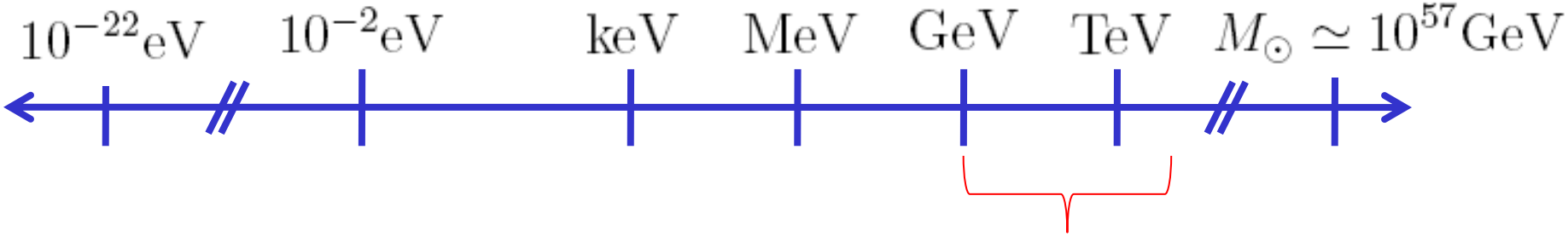


Fritz Zwicky

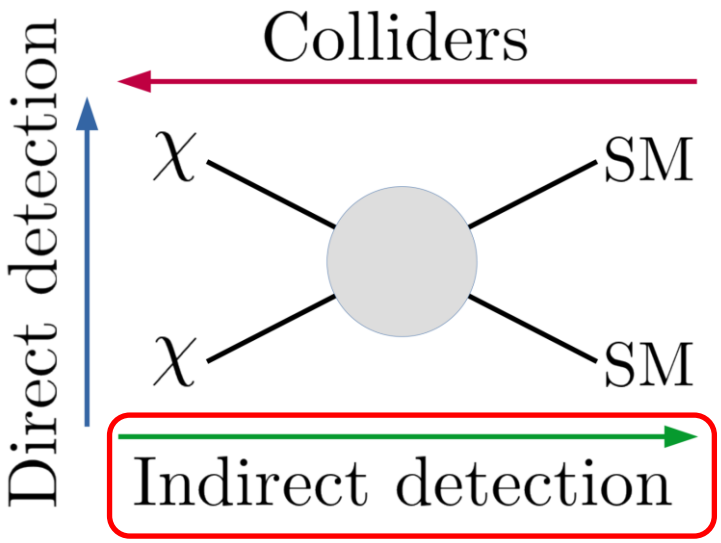
Vera Rubin

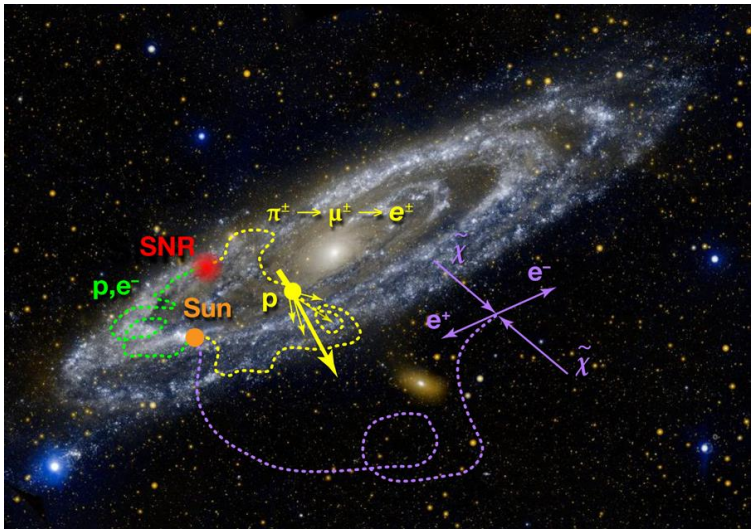


A GeV excess at the Galactic Center:



Well motivated.
Correct relic abundance.
Searched for decades.





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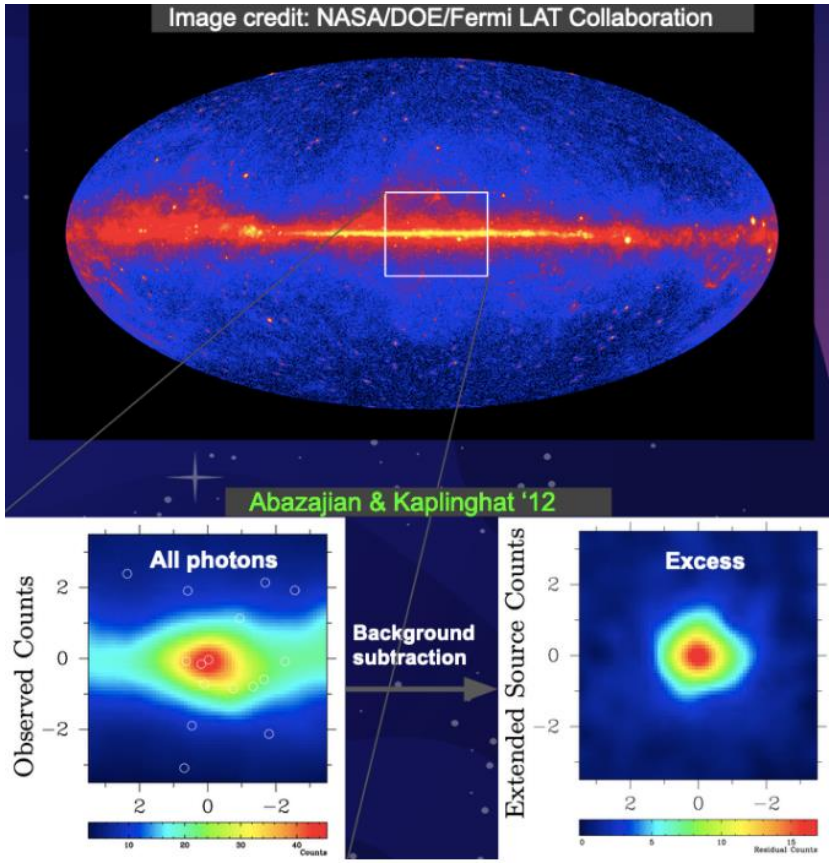
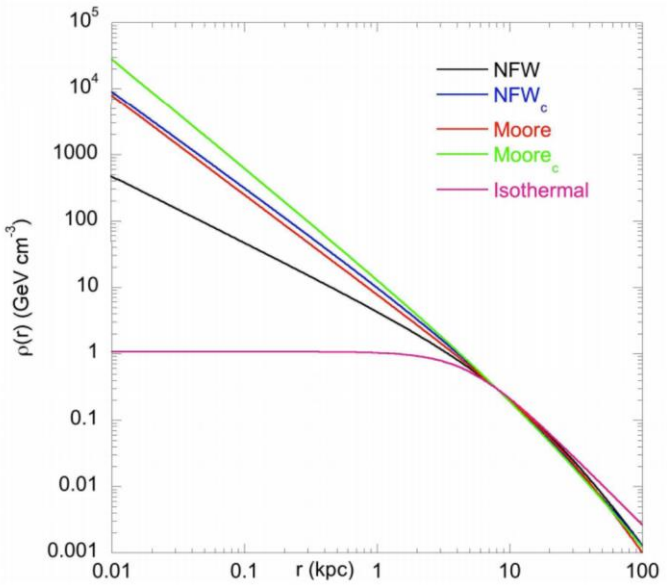
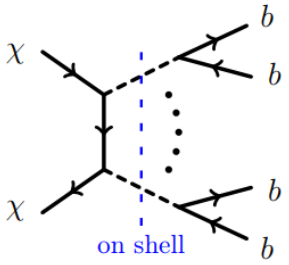
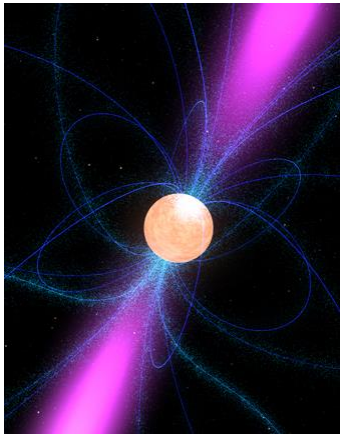


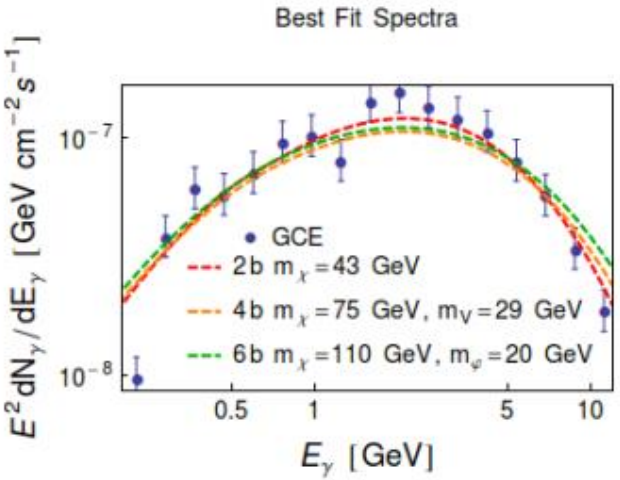


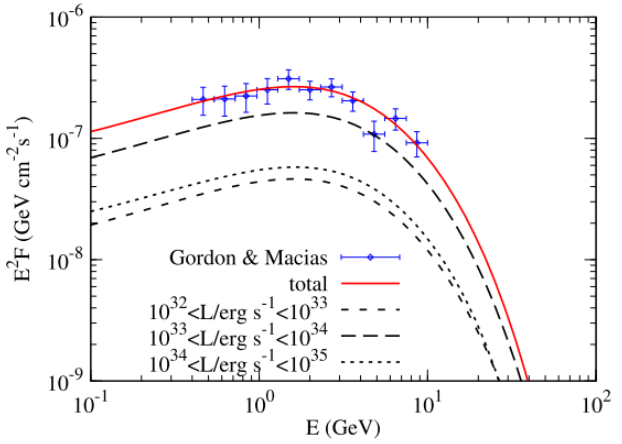
Fermi
Gamma-ray
Space Telescope

Two explanations:







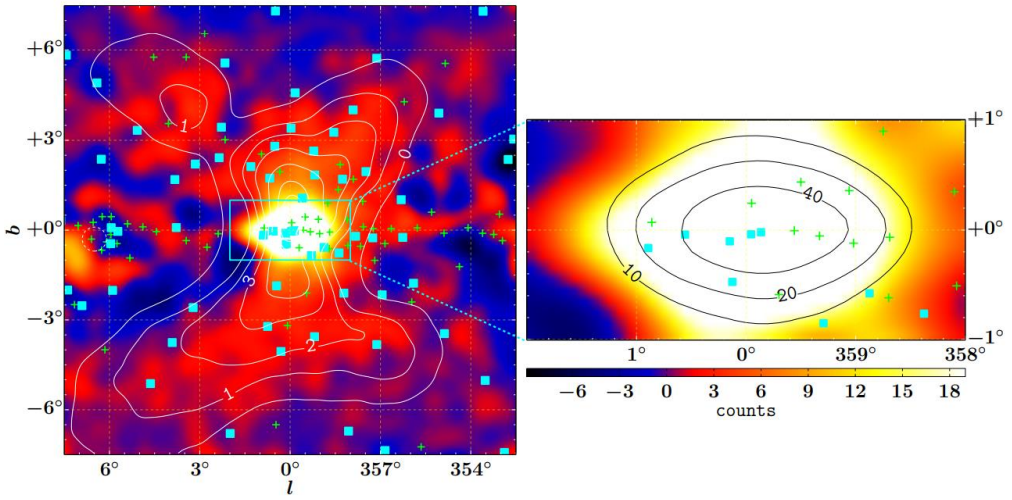


Abdullah, et. al.
Phys. Rev. D 90, 035004 (2014)

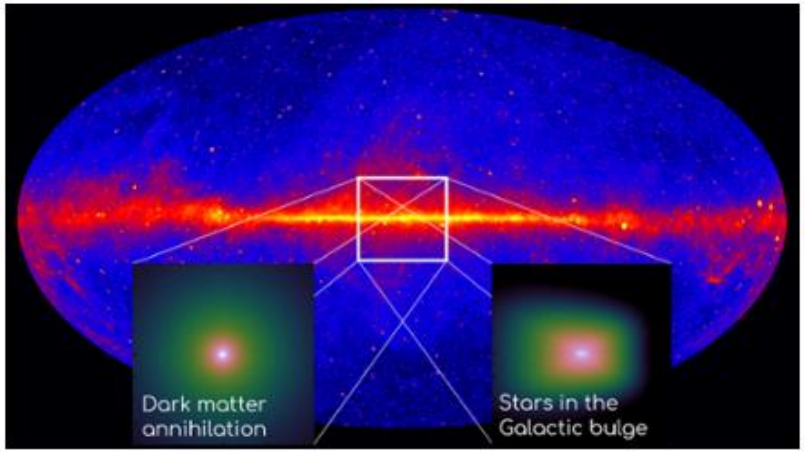
Yuan, et. al.
JHEAp 3 (2014) 1

Efforts to distinguish these two explanations:

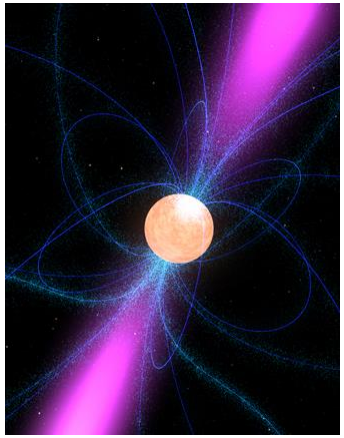
- Smoothness: Point Source v.s. Smeared Distribution

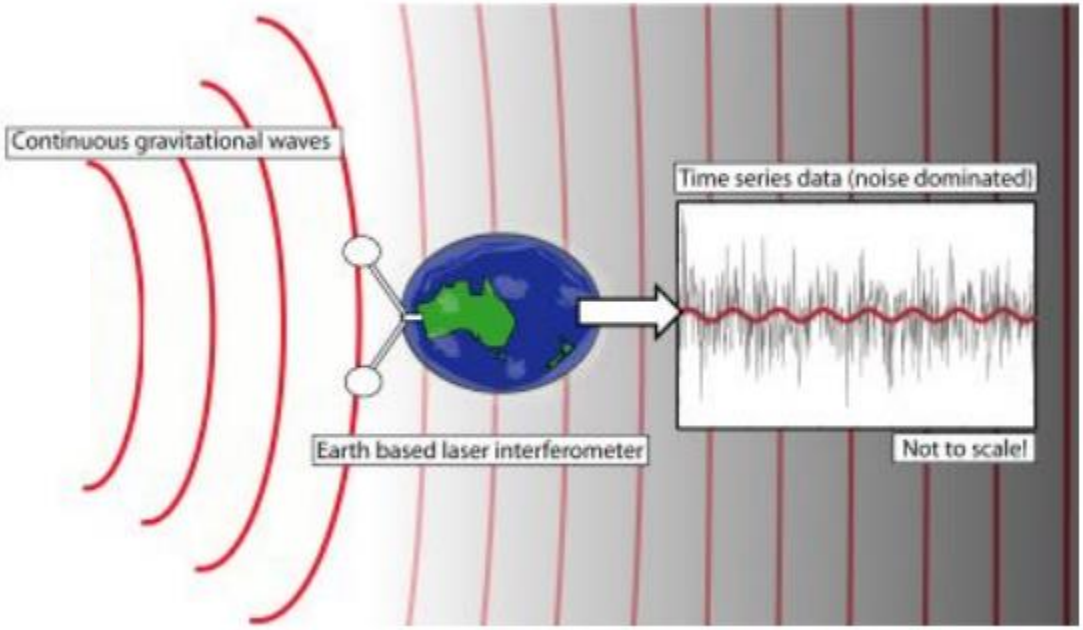


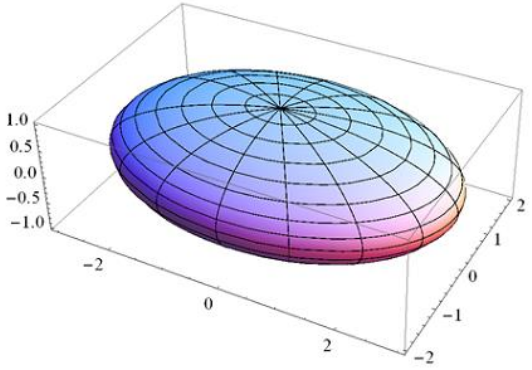
- Morphology: Spherical v.s. Bulge-like



GW channel can be useful:



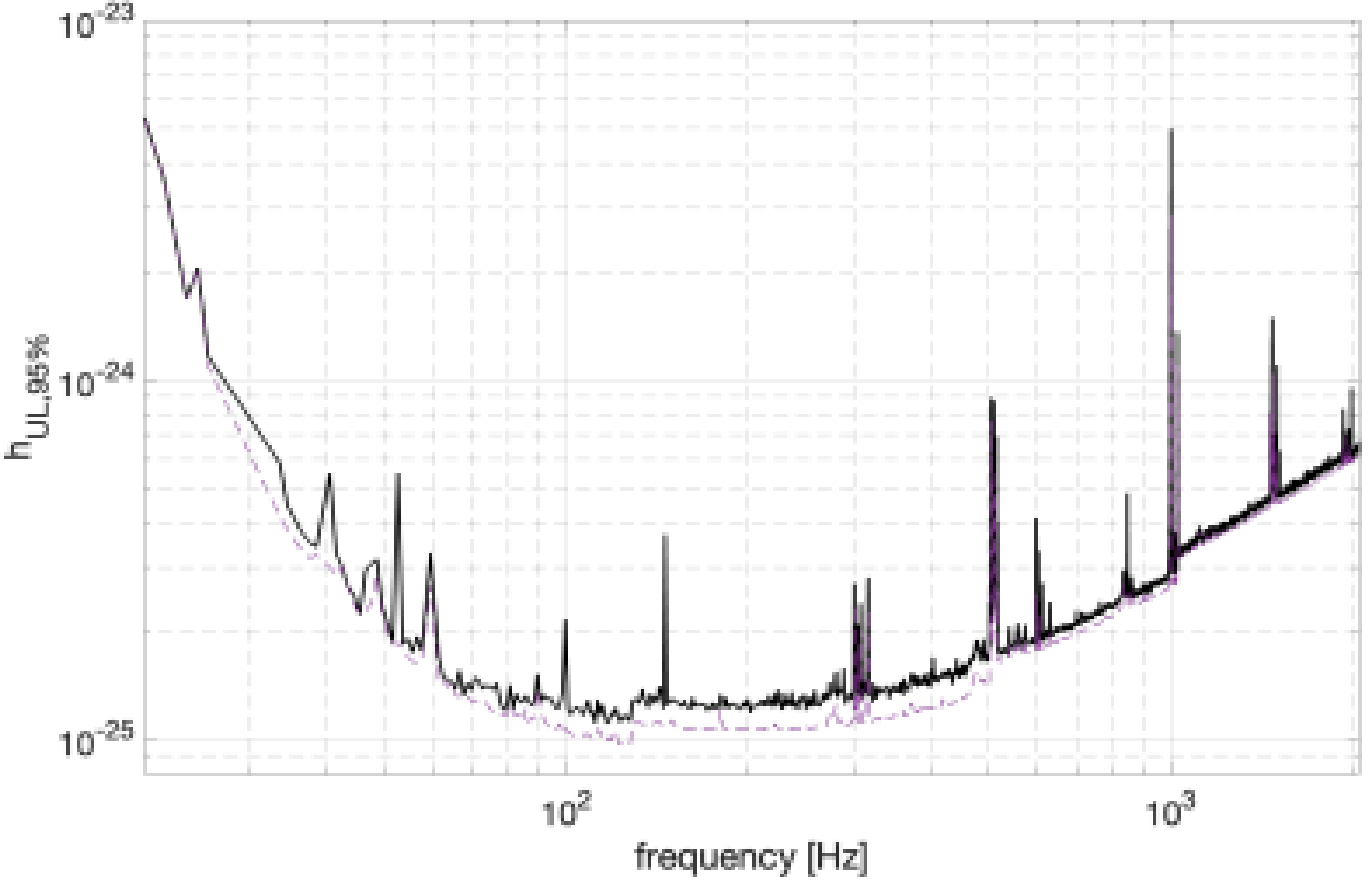




$$h_0 = \frac{16\pi^2 G}{c^4} \frac{I_{zz} \epsilon f_{rot}^2}{d}$$

WIMP DM:

The LVK collaboration
Phys. Rev. D 106, 102008

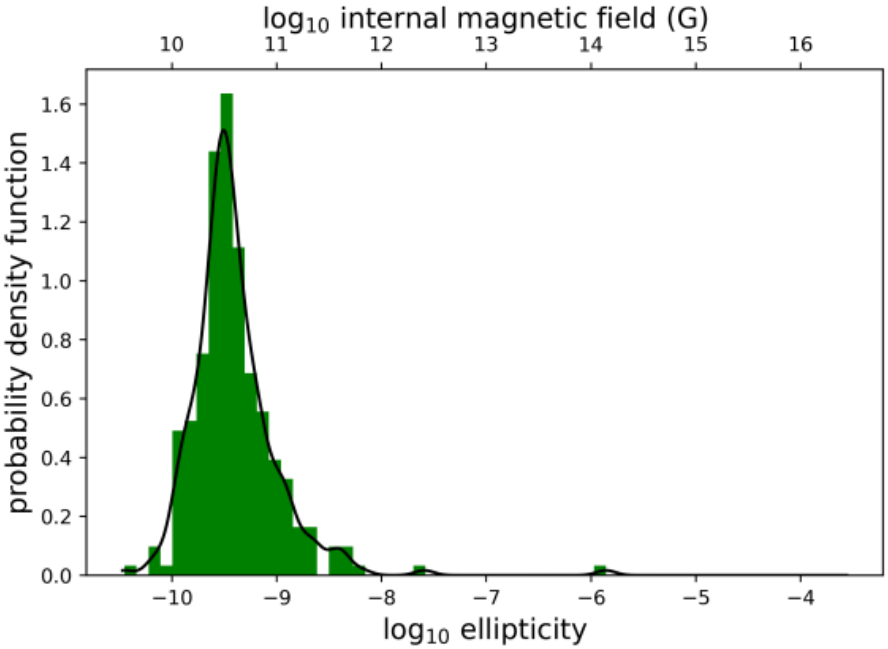


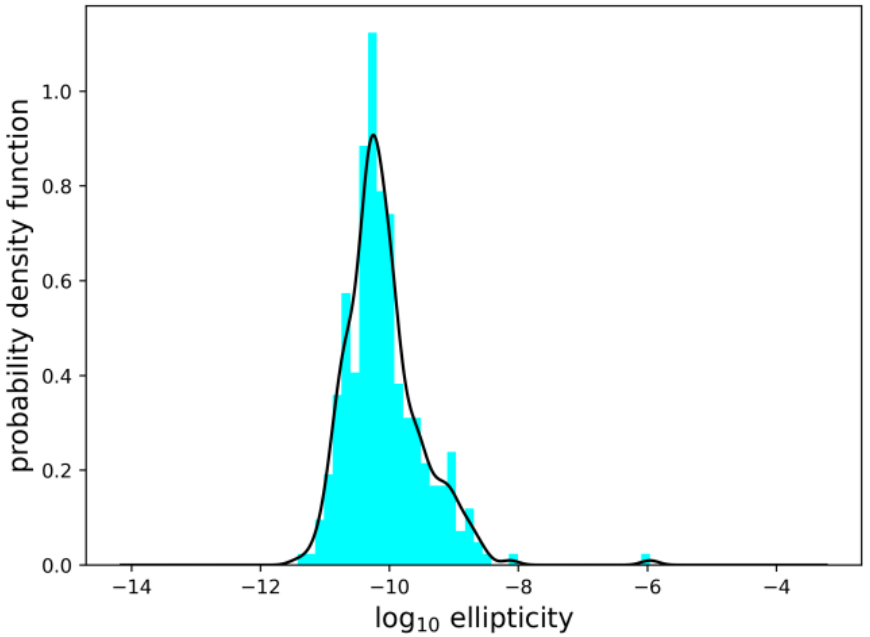
Ellipticity distribution:

$$h_0 = \frac{16\pi^2 G}{c^4}\frac{I_{zz}\epsilon f_{rot}^2}{d}$$

$$\epsilon \equiv |I_{xx} - I_{yy}|/I_{zz}$$

principal moments of inertia





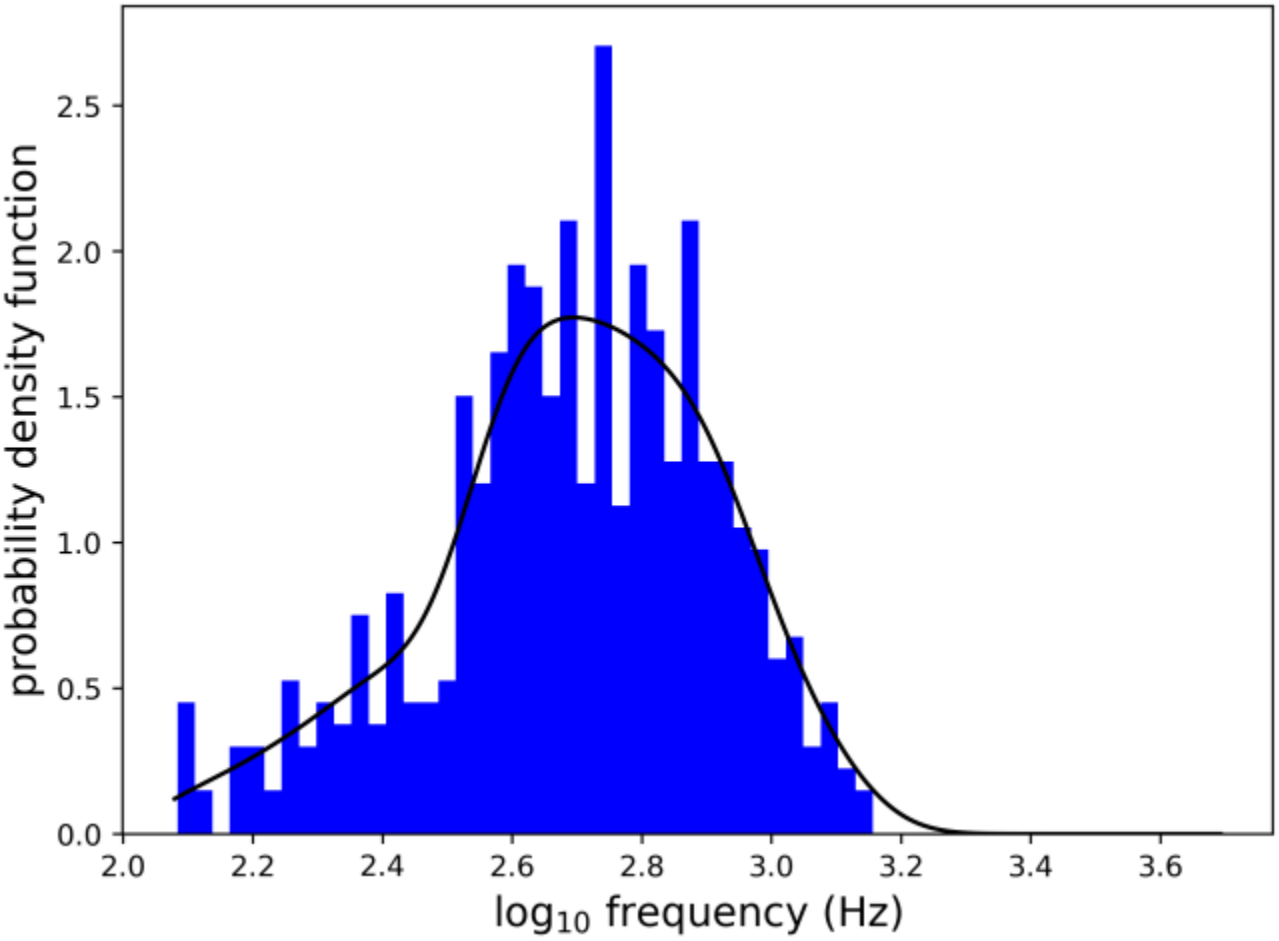
$$\epsilon \approx 10^{-8}\left(\frac{B_{int}}{10^{12}\,\mathrm{Gs}}\right)$$

$$B_{int} = 150 B_{ext}$$

GW radiation accounts for 1% rotational energy loss.

Frequency distribution:

$$h_0 = \frac{16\pi^2 G}{c^4}\frac{I_{zz}\epsilon f_{\rm rot}^2}{d}$$

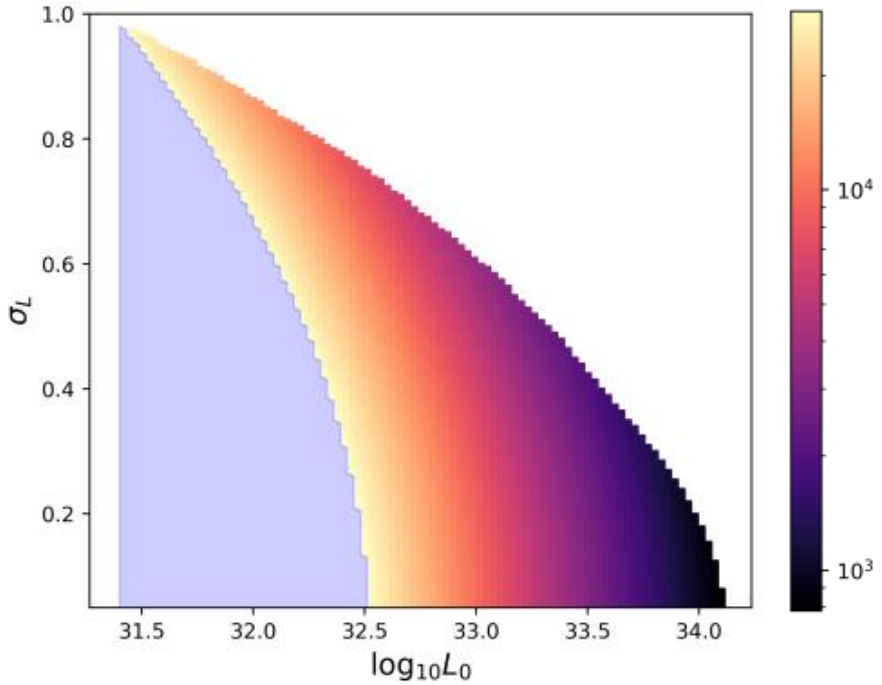


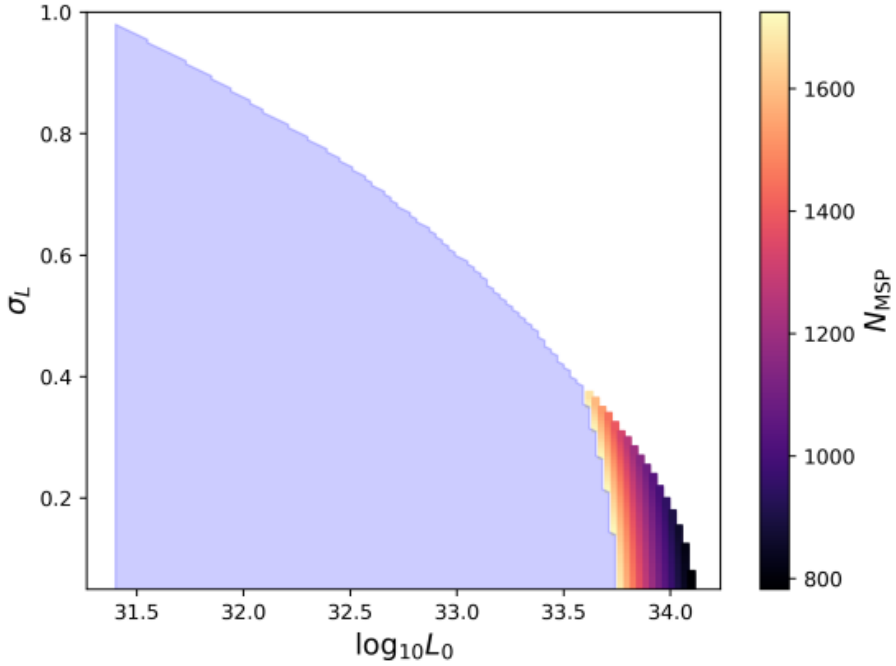
WIMP DM:

Andrew Miller, Y.Z.

Phys.Rev.Lett. 131 (2023) 8, 081401

$$\frac{dP(L)}{dL} = \frac{\log_{10} e}{\sigma_L \sqrt{2\pi} L} \exp\left(-\frac{\log_{10}^2(L/L_0)}{2\sigma_L^2}\right)$$





1% energy loss through GW

$$d = 8 \text{ kpc}$$

$$I_{zz} = 10^{38} \text{kg}\cdot\text{m}^2$$

$$B_{\rm int} = 150 B_{\rm ext};\ d = 8 \text{ kpc}$$

$$I_{zz} = 5 \times 10^{38} \text{kg}\cdot\text{m}^2$$

Future Plan:

Optimize the search strategy:

Current searches:

All-sky: Not focused on the galactic center

Galactic center search: ~ 1 degree by 1 degree

We need to find the middle point for the GeV excess.

~10 degree by 10 degree

Complementarity between CW search vs Stochastic search:

If none of the MSP is bright enough to be identified individually, we can look for the broad band incoherent SGWB.

Build a better model:

Aim for a better understanding on the connection between gamma ray and the NS deformation.

Conclusion

MSPs may explain the GeV excess at GC.

CW is an ideal method to search for these MSPs.

GW and gamma ray will push the boundaries from two ends.

There is large room for future improvements.

Welcome to join the efforts!