Multi-class classification of gamma-ray sources and the nature of excess of GeV gamma rays near the Galactic center

ERLANGEN CENTRE FOR ASTROPARTICLE PHYSICS

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Dark matter in the Galactic center

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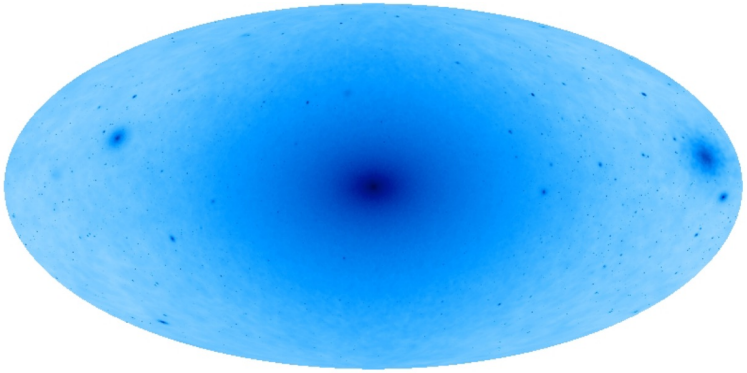
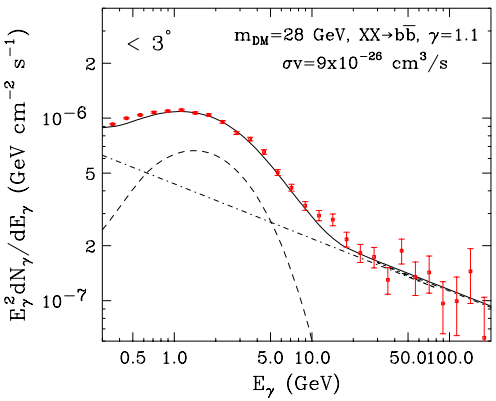
- Galactic center (GC) is the strongest possible source of dark matter (DM) annihilation signal



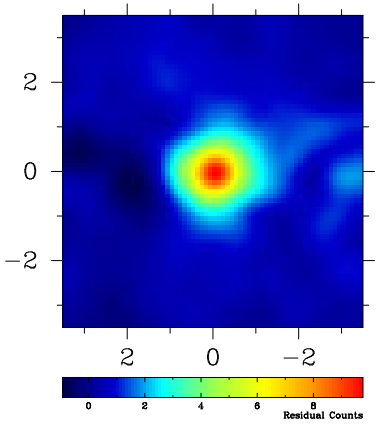
Via Lactea II simulation of a Milky-way-like galaxy. Kuhlen et al. (2009)

- Excess consistent with DM annihilation was detected in Fermi-LAT gamma-ray data two months after the data became public

Goodenough & Hooper (2009), Vitale & Morselli (2009), Hooper & Linden (2011), Abazajian & Kaplinghat (2012), Hooper & Slatyer (2013), Gordon & Macias (2013), Calore et al. (2015), Daylan et al. (2016), Ajello et al. (2016), Ackermann et al. (2017) etc



Goodenough & Hooper (2009)



Abazajian & Kaplinghat (2012)

Astrophysical explanation

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- A population of millisecond pulsars (MSPs) near the GC can explain the Galactic center excess (GCE)

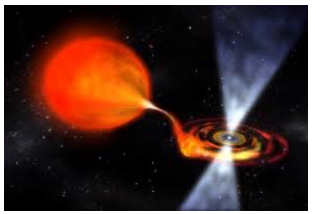
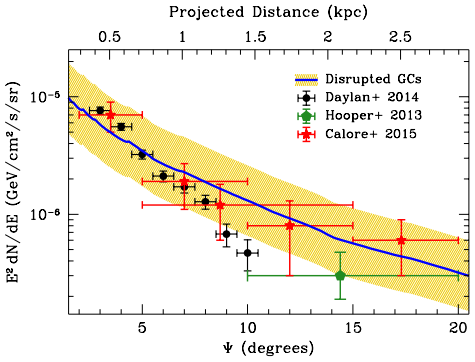
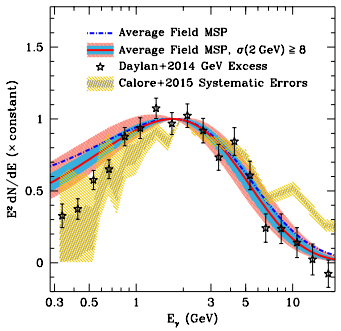


Image credit: NASA



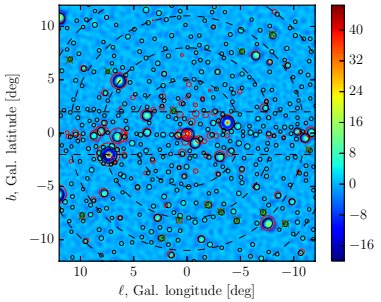


Brandt & Kocsis (2015)

- Statistical studies

  Lee et al. (2015, 2016), Bartels et al. (2016), Leane & Slatyer (2019, 2020), Zhong et al. (2020), List et al. (2020), Calore et al. (2021), Mishra-Sharma & Cranmer (2022), Caron et al. (2023), Manconi et al. (2024) etc.

  - Based on statistical properties of the Gamma-ray data

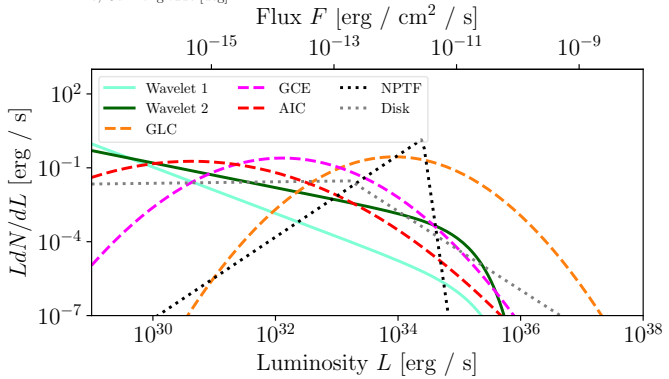


Bartels et al. (2016)

- Population studies

  Brandt & Kocsis (2015), Hooper & Linden (2016), Bartels et al. (2018), Ploeg et al. (2020), Dinsmore & Slatyer (2022) etc.

  - Associated (bright) MSPs are used to constrain the models



Dinsmore & Slatyer (2022)

How can machine learning help?

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Number of sources

Detection threshold

All

All detected

All associated

MSPs

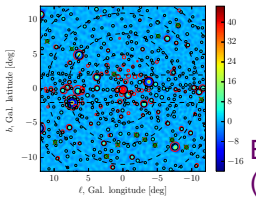
Associated MSPs

Flux

Subthreshold

Low

High

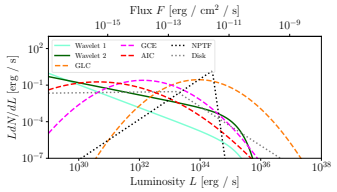


Bartels et al. (2016)

Statistical studies

Use ML to determine MSPs among unassociated sources and constrain MSP models

Population studies



Dinsmore & Slatyer (2022)

Details and results: poster session B, location 116 & arXiv:2401.04565