

# SEARCH FOR HEAVY DARK MATTER WITH FERMI LAT

Deheng Song

Yukawa Institute for Theoretical Physics, Kyoto University

Based on arXiv:2401.15606 & arXiv:2308.00589

Job wanted! Check my CV!

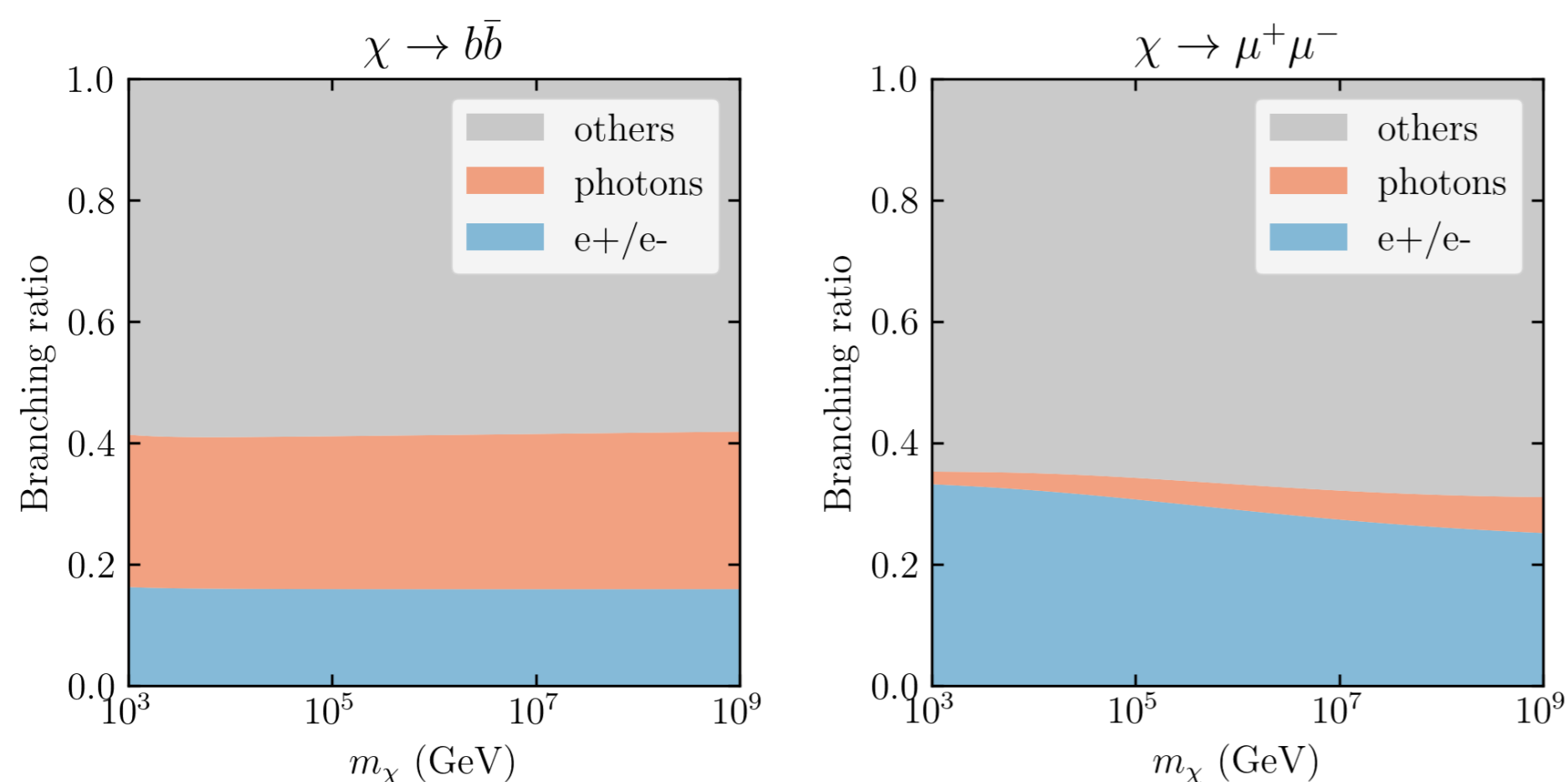


## Motivation

- The *Fermi* Large Area Telescope (LAT), with its exceptional sensitivity, has played a crucial role in the indirect search for Weakly Interacting Massive Particles (WIMPs) as dark matter candidates using gamma rays. However, the domain of dark matter with masses exceeding TeV energies remains less explored.
- In the case of such heavy dark matter, secondary gamma rays can be produced when high-energy electrons and positrons, resulting from the annihilation or decay of heavy dark matter, lose energy through inverse Compton and synchrotron emissions in the interstellar environment.
- By searching for these secondary emissions, we can extend the scope of LAT's dark matter search to include more massive dark matter candidates.

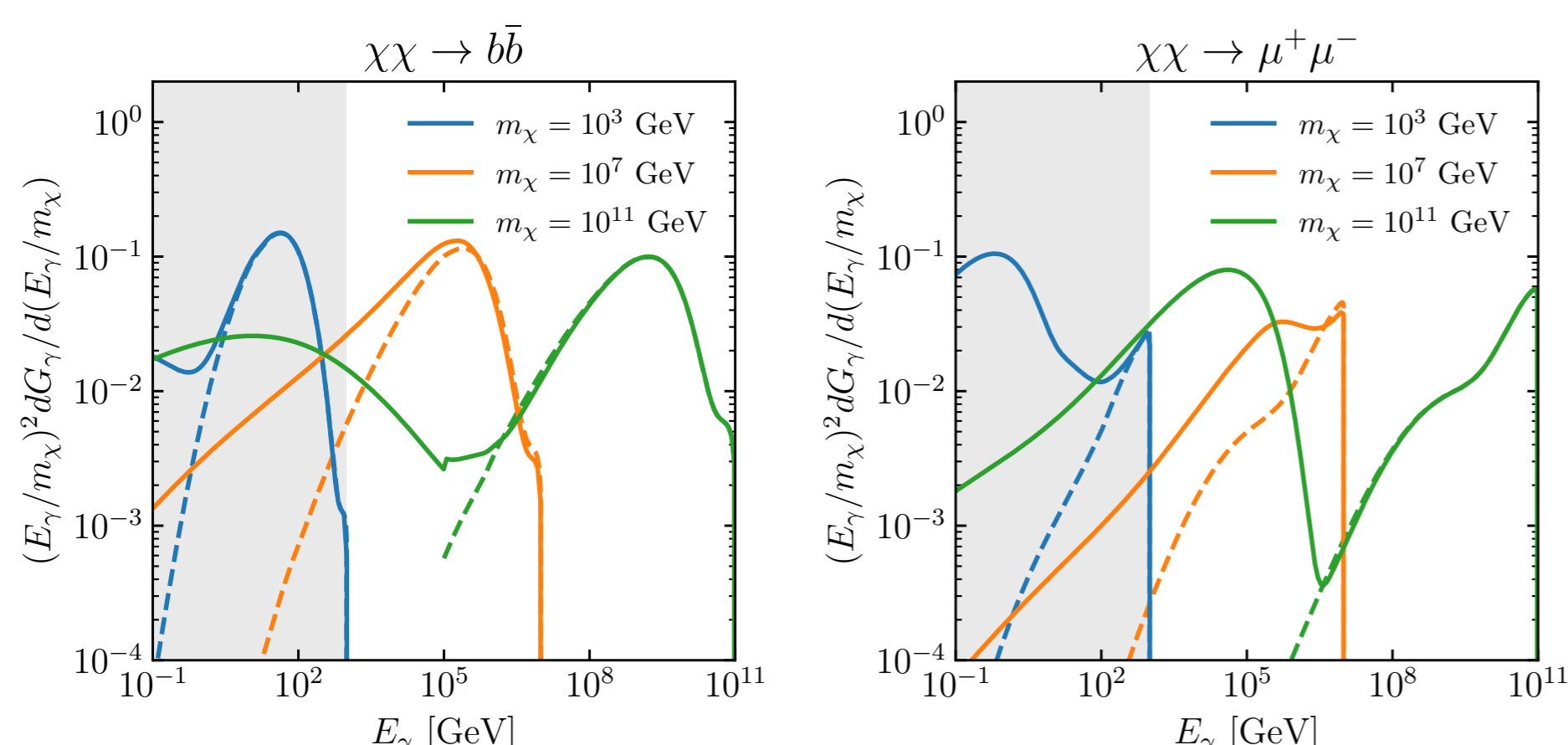
## High-energy $e^\pm$ from heavy dark matter

- Heavy dark matter particles not only annihilate or decay to gamma rays. A substantial fraction of the dark matter annihilation products are high-energy electrons and positrons.
- For the  $b\bar{b}$  channel, the branching ratio of photons and electrons/positrons is comparable. However, for a more leptonic channel like the  $\mu^+\mu^-$  channel, there are even more electrons/positrons than gamma rays.
- These high-energy electrons and positrons are often overlooked in conventional gamma-ray searches.



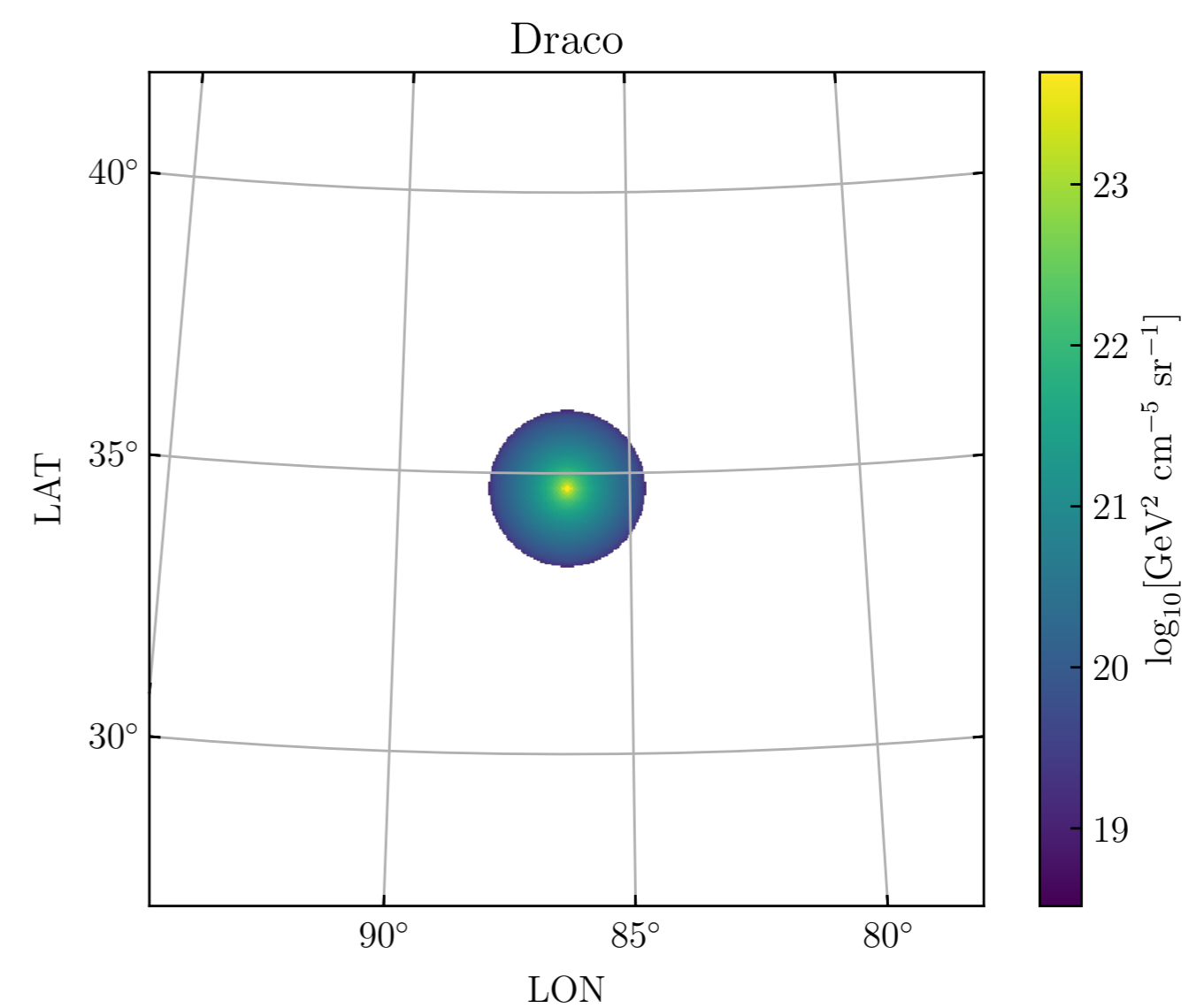
## Secondary emissions from heavy dark matter $e^\pm$

- High-energy electrons and positrons inevitably lose energies in the interstellar medium through the inverse Compton scattering and synchrotron radiation. Secondary gamma rays are generated in these processes.
- We solve the Boltzmann equations for the cascades of  $e^\pm$  and gamma rays from dark matter in galaxy clusters and dwarf galaxies. Pair production process is also included for very high-energy photons. The diffusion of  $e^\pm$  is ignored because they are very energetic and are fast cooling in the radiation and magnetic fields.



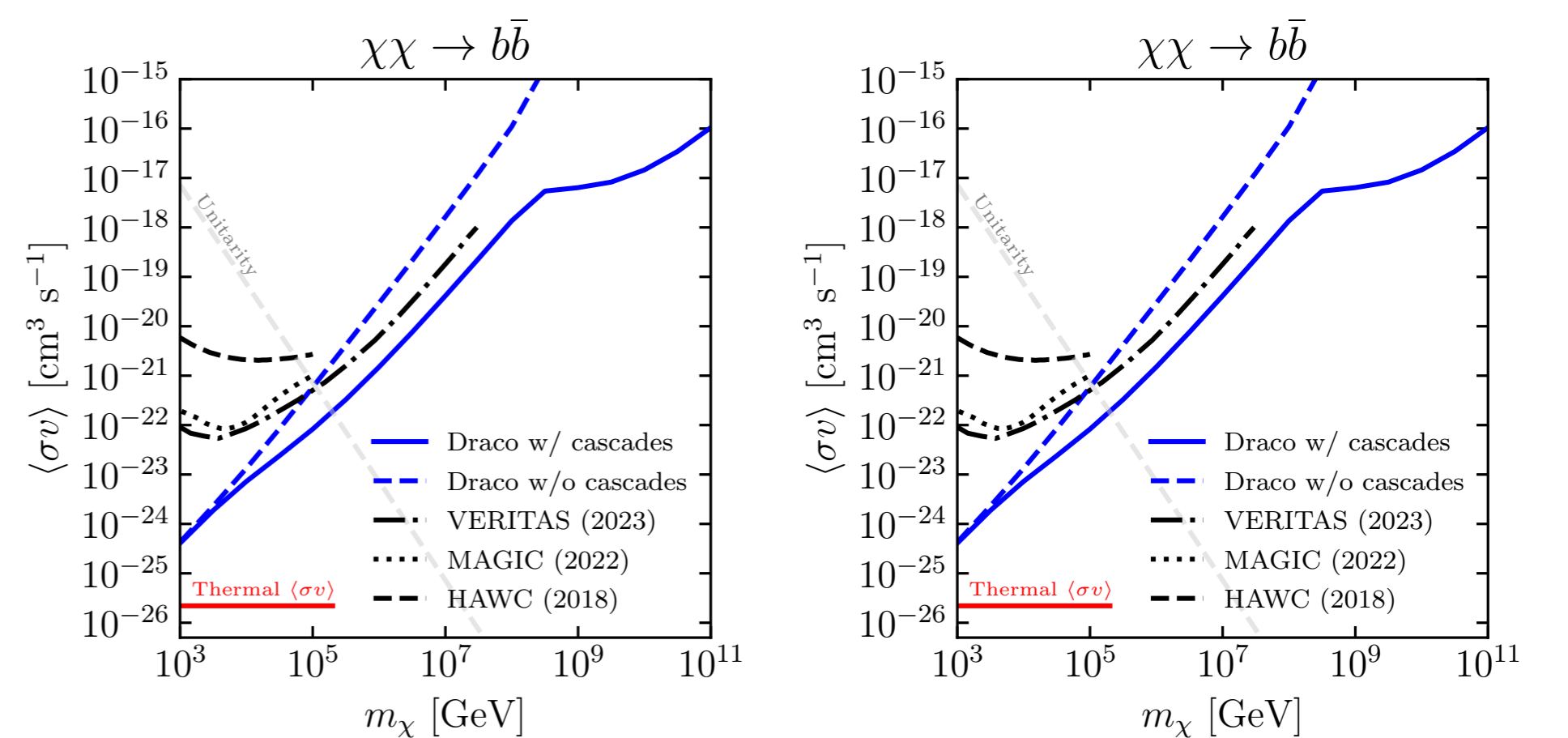
## Galaxy clusters and dwarf galaxies

- We search for secondary gamma rays from heavy dark matter using 14-year *Fermi* LAT observations of 7 nearby galaxy clusters and 8 classical dwarf galaxies
  - Virgo, Centaurus, Norma, Persus, Coma, Hydra, Fornax
  - Carina, Draco, Fornax, Leo I, Leo II, Sculptor, Sextans, Ursa Minor
- Dark matter halos follow the NFW profile. For dwarf galaxies, we also consider tidal stripping from the Milky Way.



## Constraints

- Draco sets the most stringent constraints on heavy dark matter annihilation among dwarf galaxies.
- We also compare our results with those from high-energy gamma-ray instruments such as VERITAS, MAGIC, and HAWC.
- We obtain more stringent constraints for heavy dark matter masses with *Fermi* LAT when we include secondary emissions.



## Summary

- We have set competitive constraints on heavy dark matter annihilation using *Fermi* data by including secondary gamma rays caused by dark matter  $e^\pm$ .
- Please check our papers for all targets and channels, stacking analysis, and systematic uncertainties.
- Including secondary emissions should be a norm for future gamma-ray search of heavy dark matter!