

# The Cherenkov Telescope Array (CTA): Prospects for Fundamental Physics with Very-High-Energy Gamma Rays

Qi Feng<sup>1</sup> for the CTA Consortium<sup>2</sup>

<sup>1</sup> Center for Astrophysics | Harvard & Smithsonian, Cambridge, MA 02138, USA

<sup>2</sup> See [www.cta-observatory.org](http://www.cta-observatory.org)

With support from:



## ABSTRACT

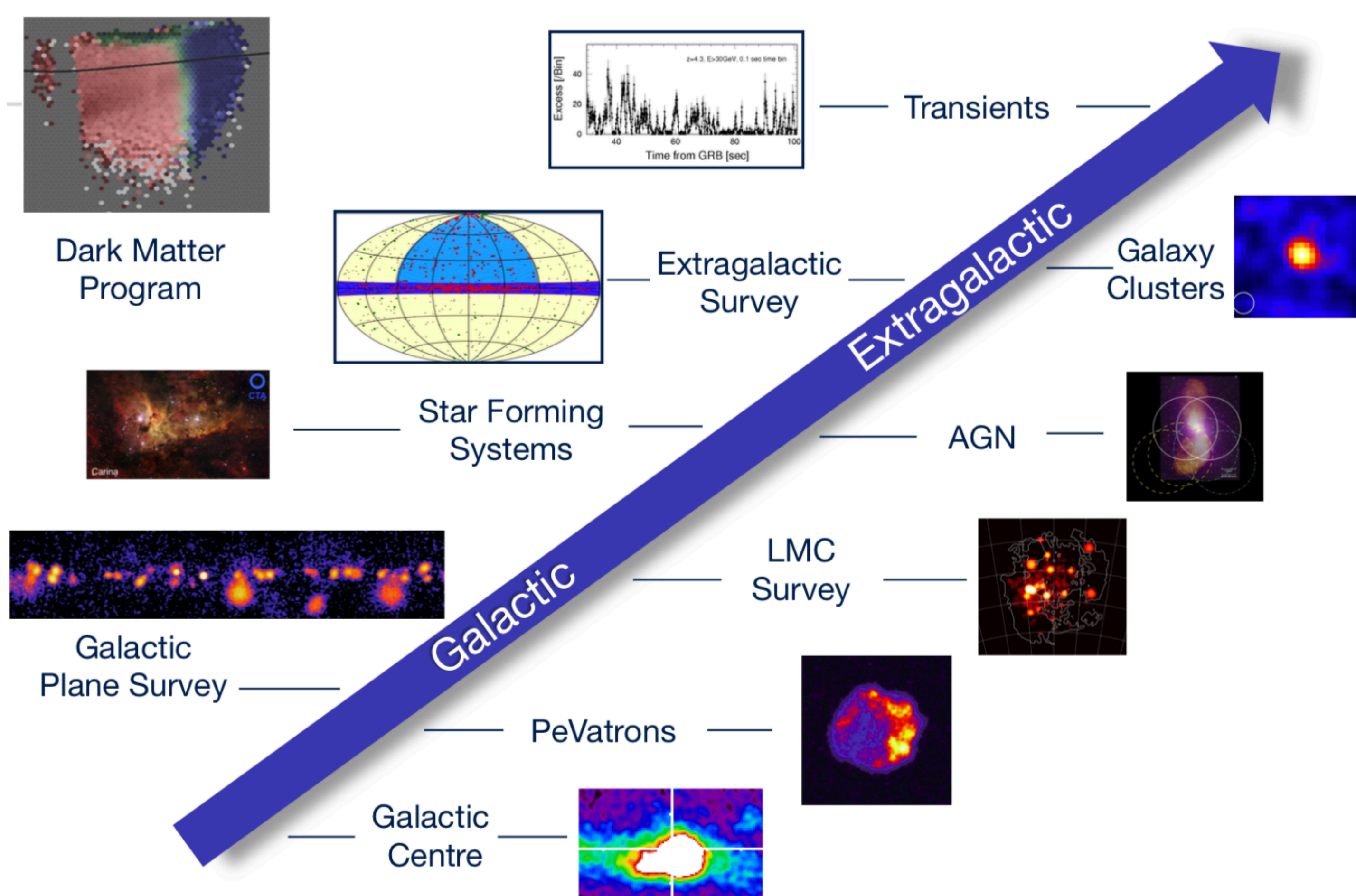
The Cherenkov Telescope Array (CTA) is designed to improve the sensitivity to 20 GeV – 300 TeV gamma rays by a factor of 5 – 20 compared to current instruments. It will provide the unprecedented capability to probe extreme astrophysical environments, explore fundamental physics, and search for dark matter (DM) signatures. In particular, the CTA DM sensitivity will reach the thermal relic cross-section for DM masses above ~200 GeV, and extend to DM masses above ~1 TeV, which are inaccessible to other existing or upcoming experiments. Observations of extragalactic gamma rays enable tests of Lorentz invariance and measurements of the extragalactic background light, cosmological parameters, intergalactic magnetic fields, axion-like particles, and primordial black holes. CTA is an international project that profits from strong U.S. participation in technology development in the form of a novel dual-mirror Schwarzschild-Couder Telescope and in science planning. The U.S. support for CTA construction, if provided, will enhance the science reach of the observatory and ensure U.S. access to this transformational facility and the discoveries it will enable.

## The CTA Observatory

CTA will have two sites (Spain & Chile) and three sizes of telescopes (LST 23 m, MST 10–12 m, and SST ~4 m) to detect gamma rays from 20 GeV to 300 TeV (see poster from Lab Saha in this session). Data will be public after a 1-yr proprietary period.

## Key Science Projects

The CTA Key Science Projects [1] are summarized in Fig. 1.



**Fig. 1: The CTA Key Science Projects [1]:**

- **Dark Matter Program:** annihilation or decay (see Fig. 2)
- **Transient follow-up/multi-messenger astrophysics program**
- **Surveys of the Galactic Center/Plane +  $\frac{1}{4}$  of the remaining sky**
- **PeVatron candidates, star forming/active galaxies and clusters**

## Constraints from gamma rays and their propagation

CTA will be able to improve [2], by a factor of few over the current imaging atmospheric Cherenkov telescopes, the constraints on:

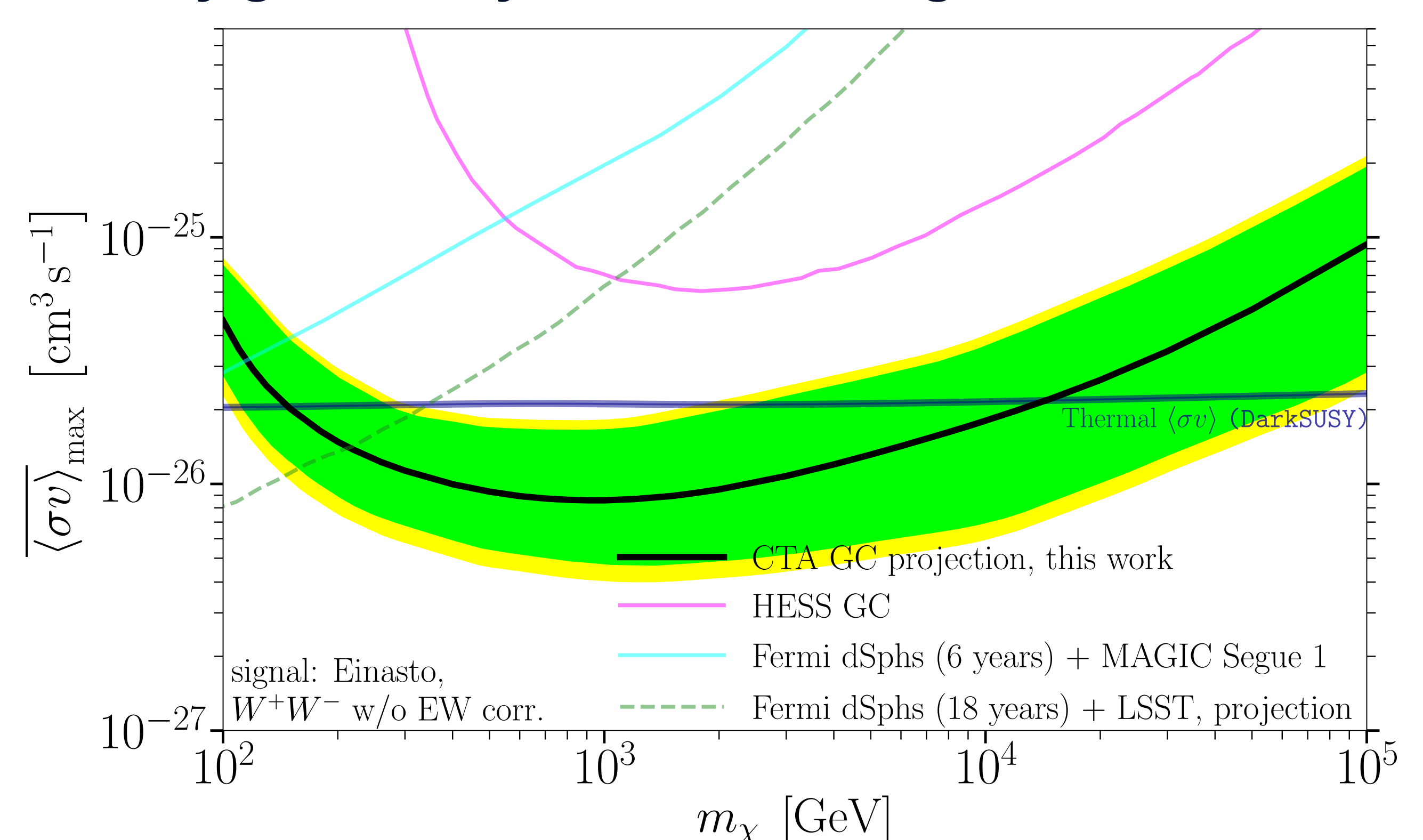
- **Extragalactic background light** (intensity vs wavelength & redshift) [2]
- **Intergalactic magnetic fields** (strength) [2]
- **Axion-like particles** (mass & coupling strength, see Fig. 3) [2]
- **Lorentz invariance violation** (minimum energy for LIV) [2]
- **Primordial black holes** (evaporation rate-density) [3]

## REFERENCES

- [1] The CTA Consortium, Acharya B. S., et al., 2019, arXiv:1709.07997.
- [2] The CTA Consortium, Abdalla H., et al., 2021, JCAP, 2021, 02, 048.
- [3] Doro M., Sánchez-Conde M. A., Hütten M., 2021, arXiv:2111.01198.
- [4] The CTA Consortium, Acharyya A., et al., 2021, JCAP, 2021, 01, 057.

## Indirect Searches for WIMP Dark Matter

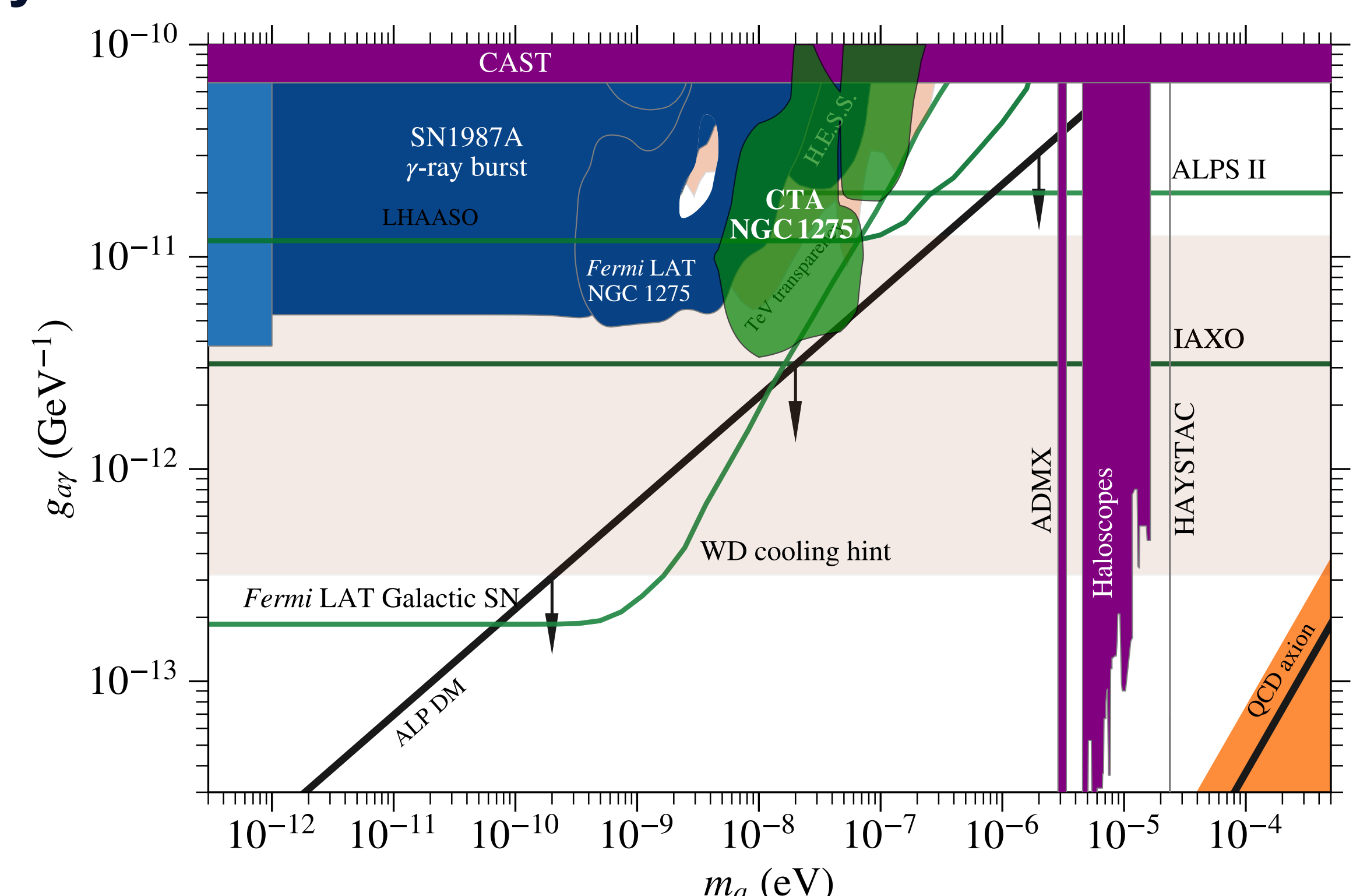
WIMPs are expected to self-annihilate to produce prompt or secondary gamma rays for a wide range of models.



**Fig. 2: Sensitivity of CTA to the DM annihilation signal ( $W^+W^-$ ) from 525-hour simulated observations of the Galactic center (GC) region (95% C.L.), reaching the ‘thermal’ cross-section  $\sim >200$  GeV [4].**

## Constraints on Axion-Like Particles

Gamma rays can interact with astrophysical magnetic fields to convert to axion-like particles (ALPs). If they reconvert to gamma rays before reaching Earth, they can be detected by CTA.



**Fig. 3: Projected CTA constraints on the mass and photon-coupling strength of ALPs (95% C.L.; 10-hour simulated observations of the radio galaxy NGC 1275 during a flaring state) [2].**

## ACKNOWLEDGMENTS

We gratefully acknowledge financial support from the agencies and organizations listed here: [www.cta-observatory.org/consortium\\_acknowledgments](http://www.cta-observatory.org/consortium_acknowledgments)