Fermi Gamma-ray Space Telescope

Dwarf Galaxy Searches with the Fermi Large Area Telescope

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on behalf of the Fermi-LAT Collaboration

CERN/LAT Session

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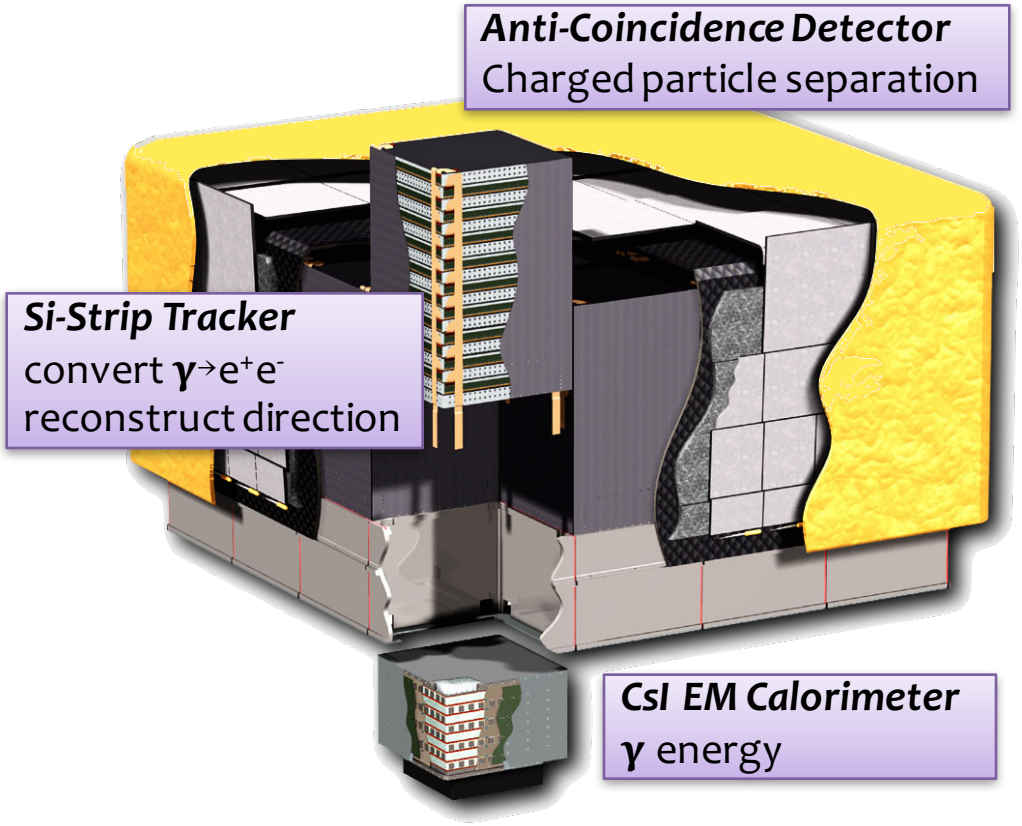
SLAC NATIONAL ACCELERATOR LABORATORY

KIPAC

Fermi Large Area Telescope



- Gamma-ray space telescope launched in June 2008
- Covers 20 MeV to > 300 GeV energy band
- 2.4 sr Field-of-View (20% of the sky)
- Surveys the entire sky every ~3 hr

Fermi-LAT DM Search Targets

Satellites

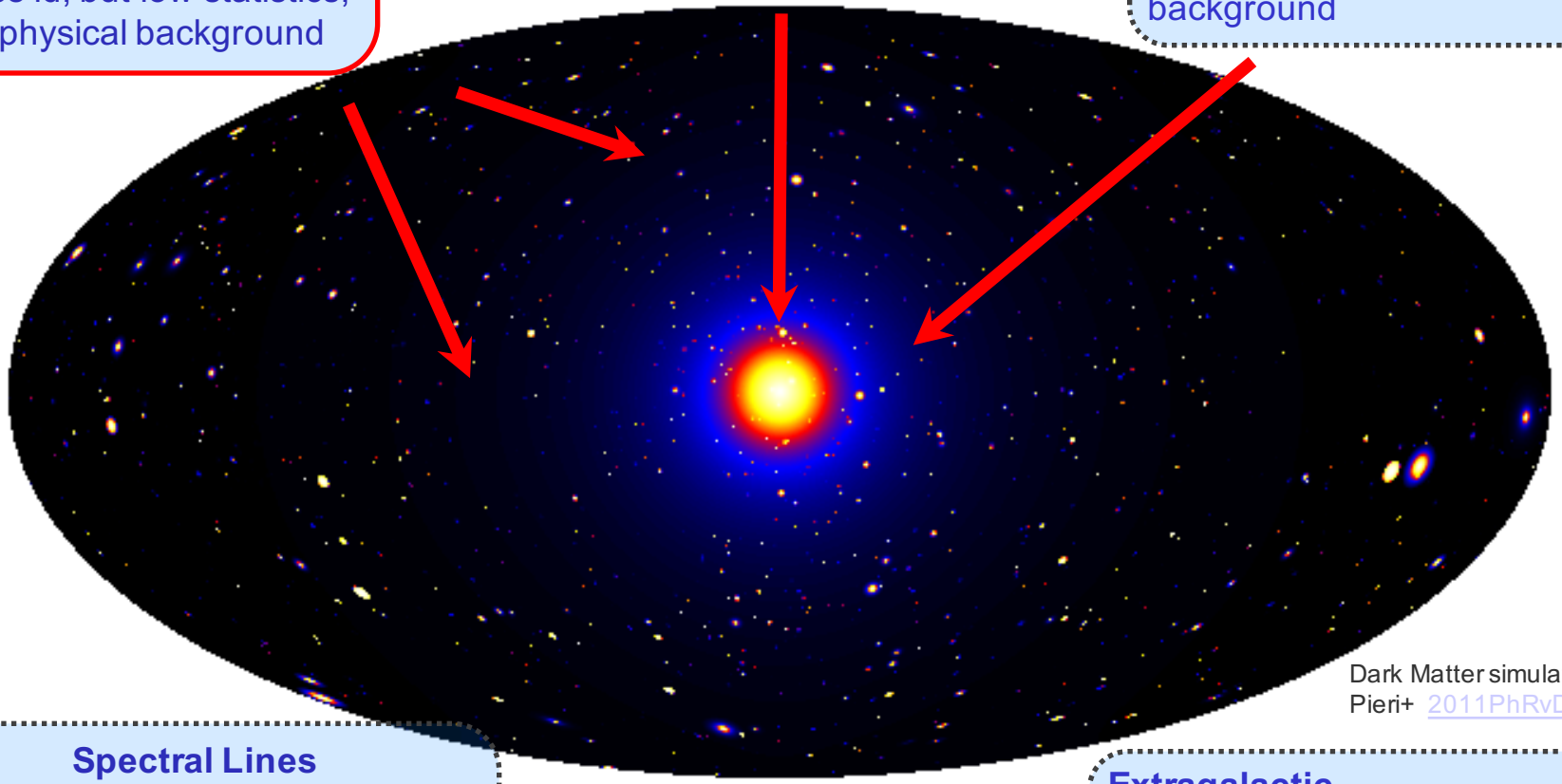
Low background and good source id, but low statistics, astrophysical background

Galactic Center

Good Statistics but source confusion/diffuse background

Milky Way Halo

Large statistics but diffuse background



Dark Matter simulation: Pieri+ 2011PhRvD..83b3518P

Spectral Lines

No astrophysical uncertainties, good source id, but low sensitivity because of expected small BR

Galaxy Clusters

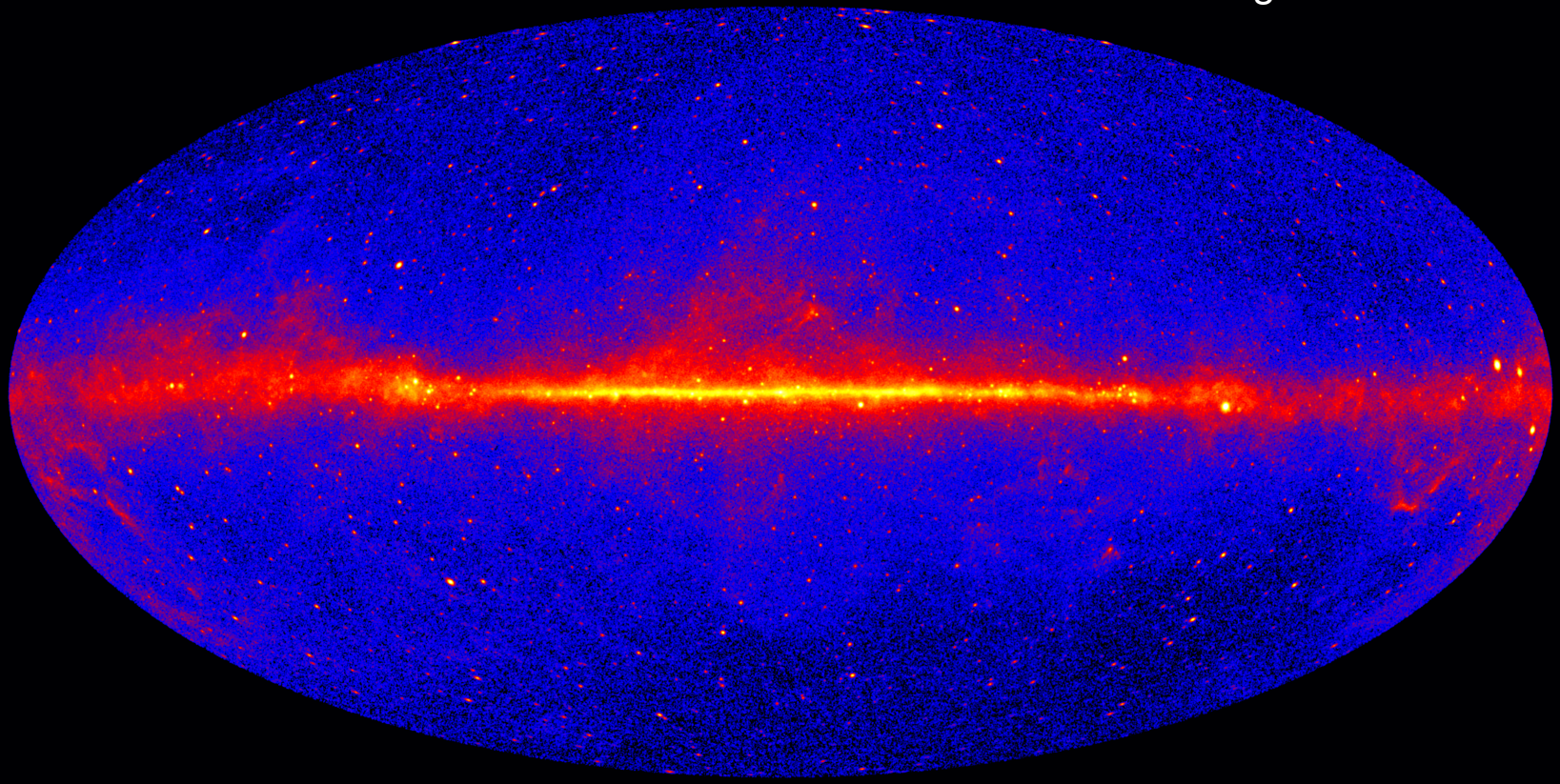
Low background, but low statistics

Extragalactic

Large statistics, but astrophysics, galactic diffuse background

Gamma-ray Sky

Fermi-LAT: 7 Year Sky,
Front-converting events > 1 GeV



Gamma-ray Sky

Fermi-LAT: 7 Year Sky,
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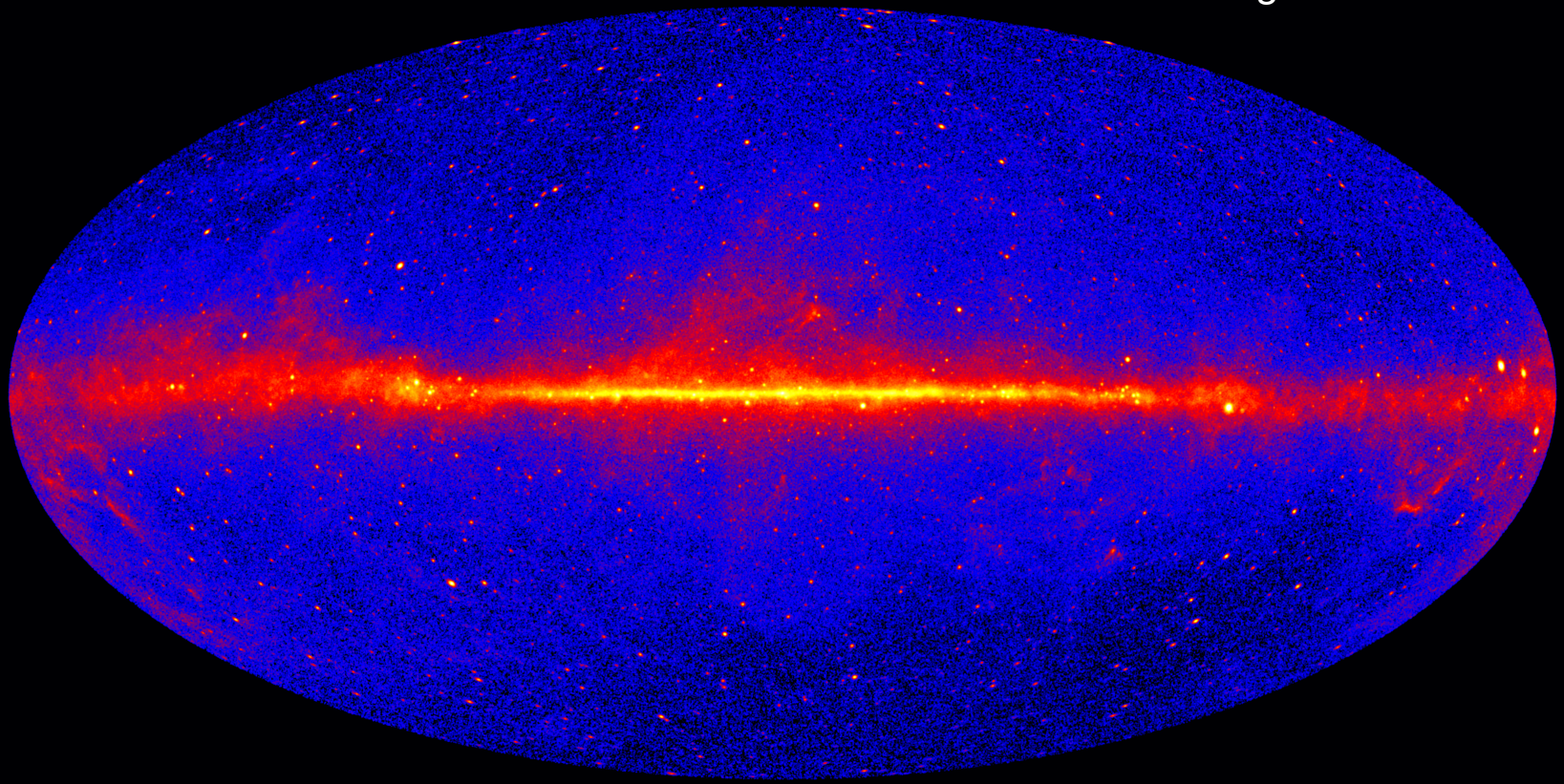
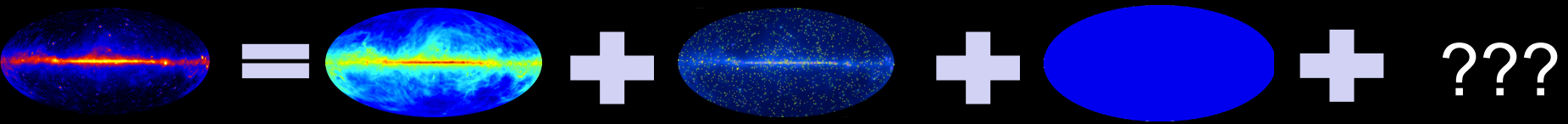
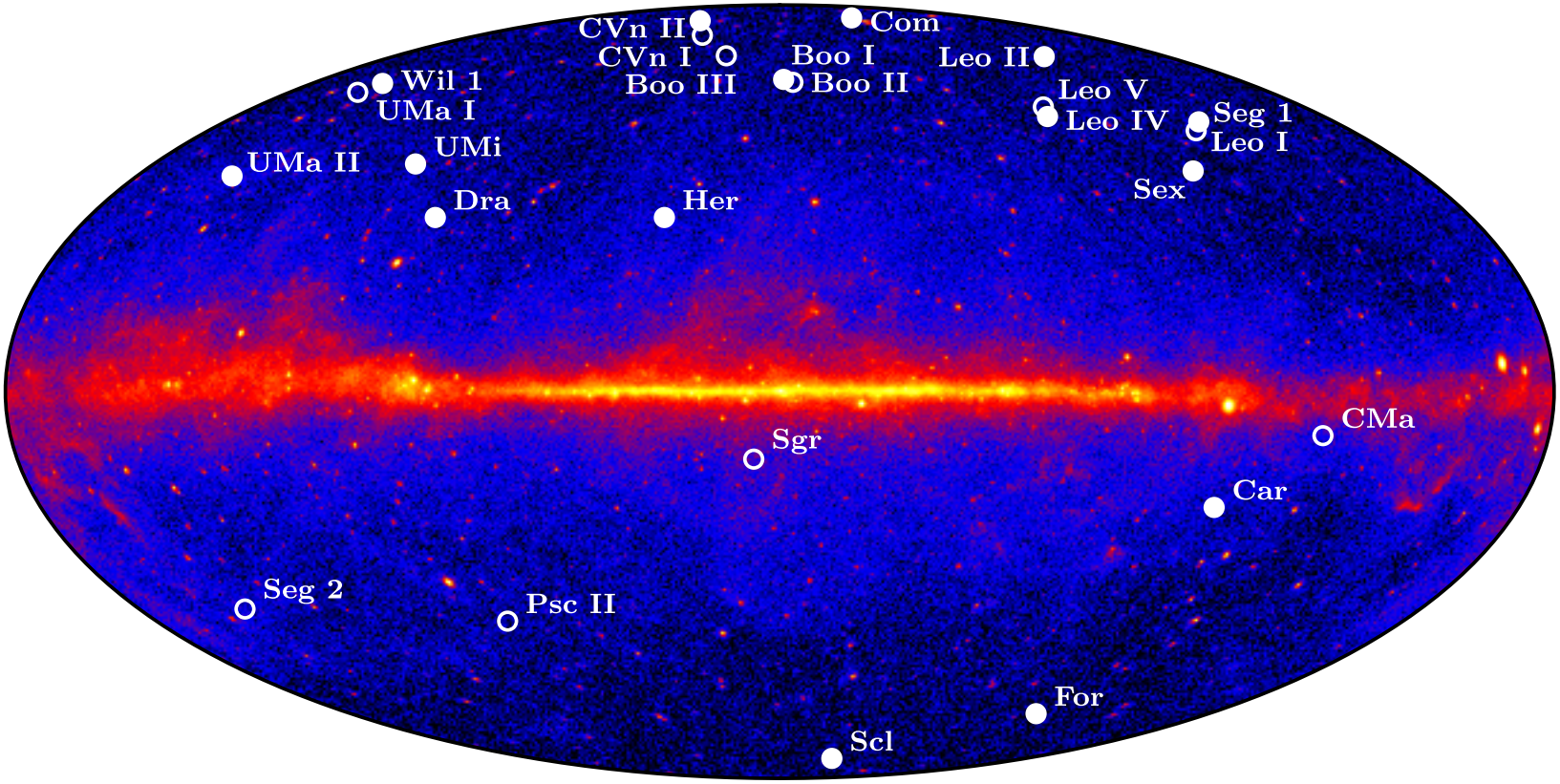




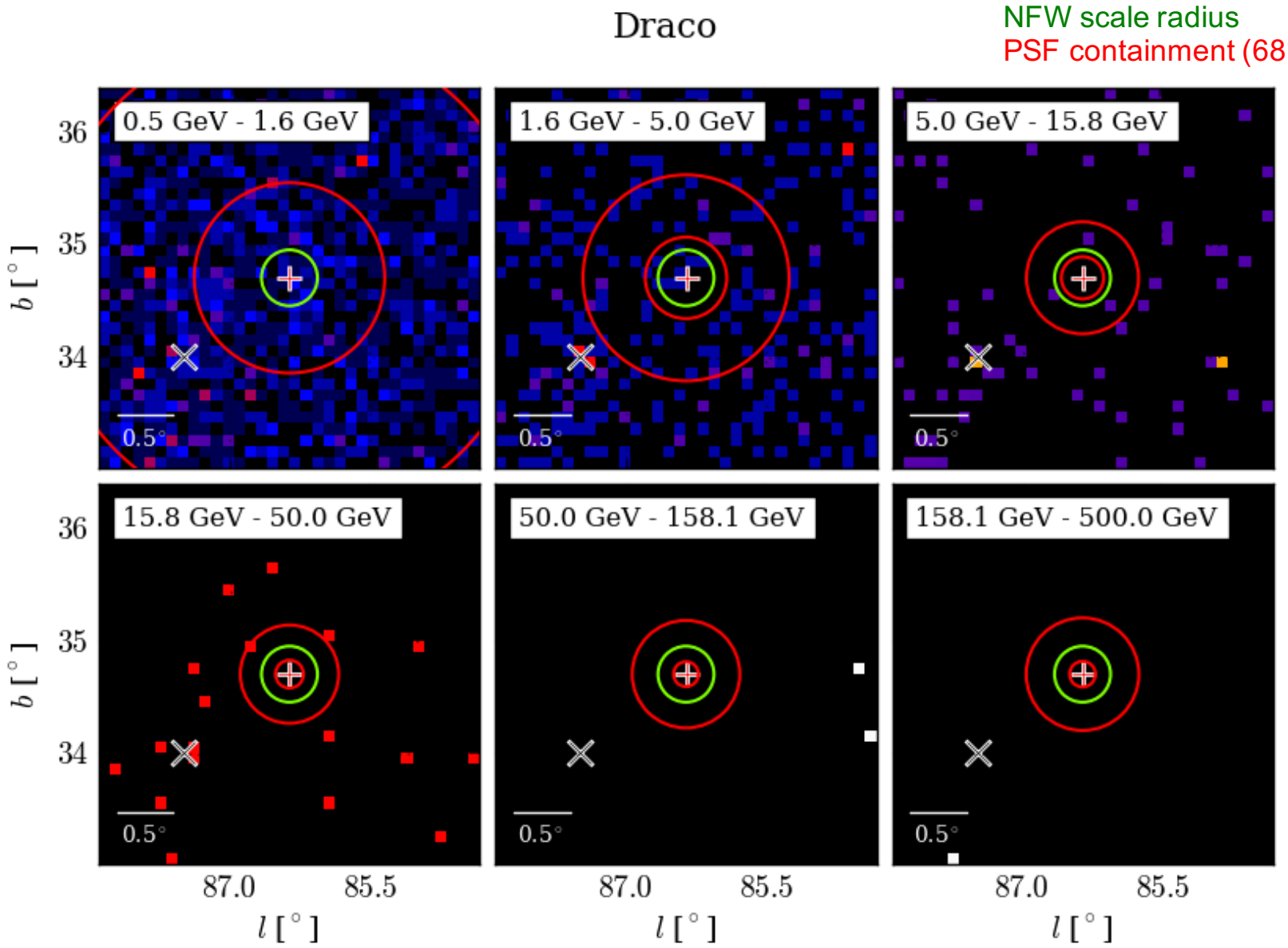
GeV Sky | Galactic | Point Sources | Isotropic

Dwarf Spheroidal Galaxies (dSphs)



Dwarf spheroidal galaxies (dSphs) are highly **DM-dominated** systems orbiting the MW at typical distances of 25-100 kpc

Example Count Maps for a dSph Galaxy



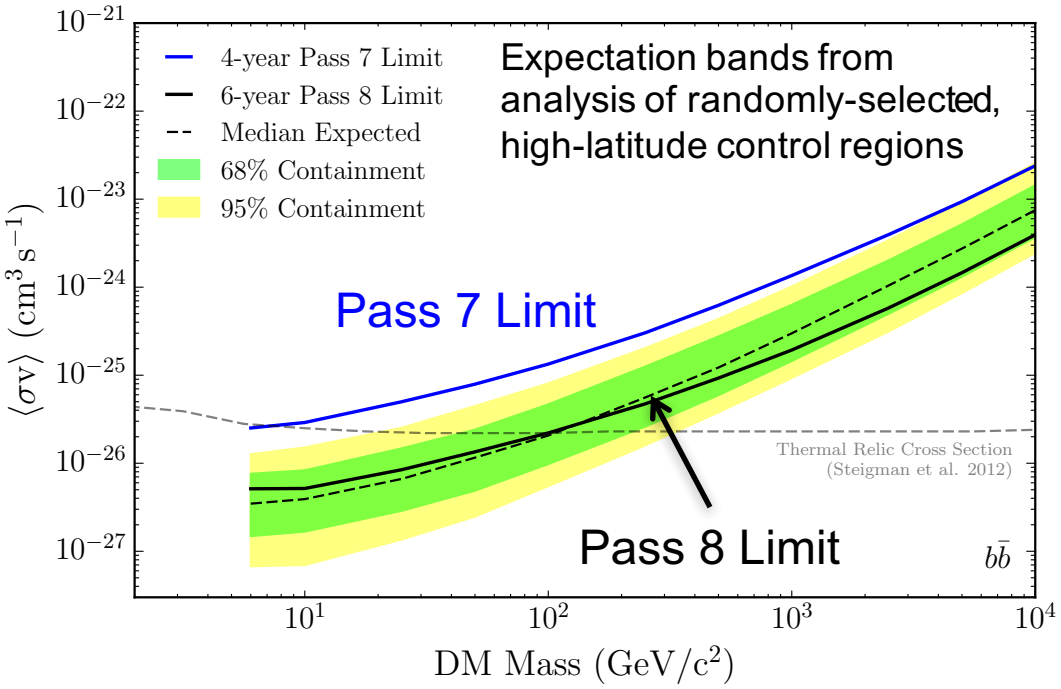
Albert+ 2017ApJ...834..110A

Dwarf Search with Six Years of LAT Data

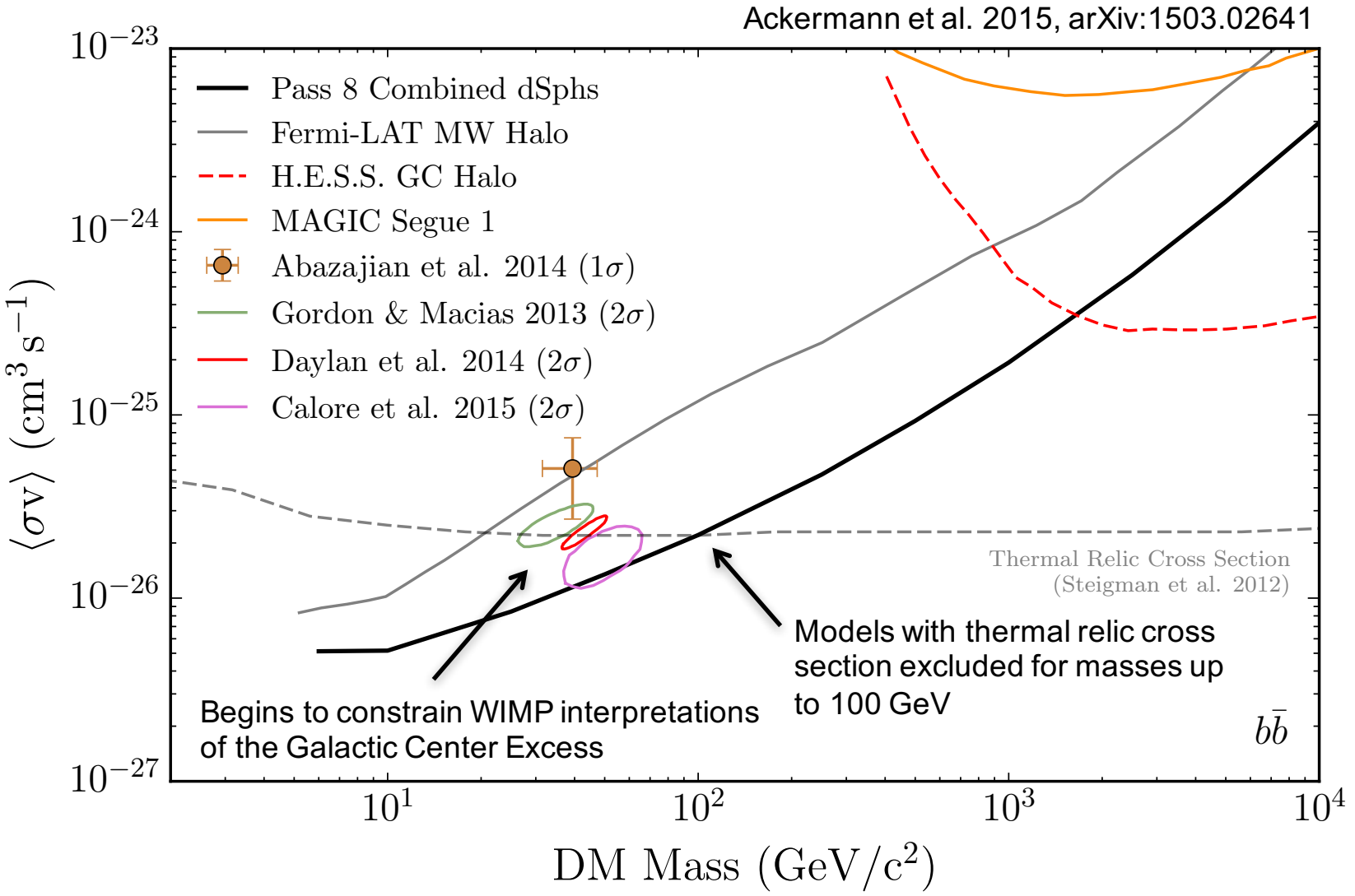
Ackermann+ PRL 115 231301 (2015)

- A sample of 15 known dSphs were analyzed for evidence of DM annihilation signals using **6 years** of **Pass 8** LAT data
- No detection in the combined sample or from any individual dSph
- Observed limits are in good agreement with expectation bands from randomized control regions

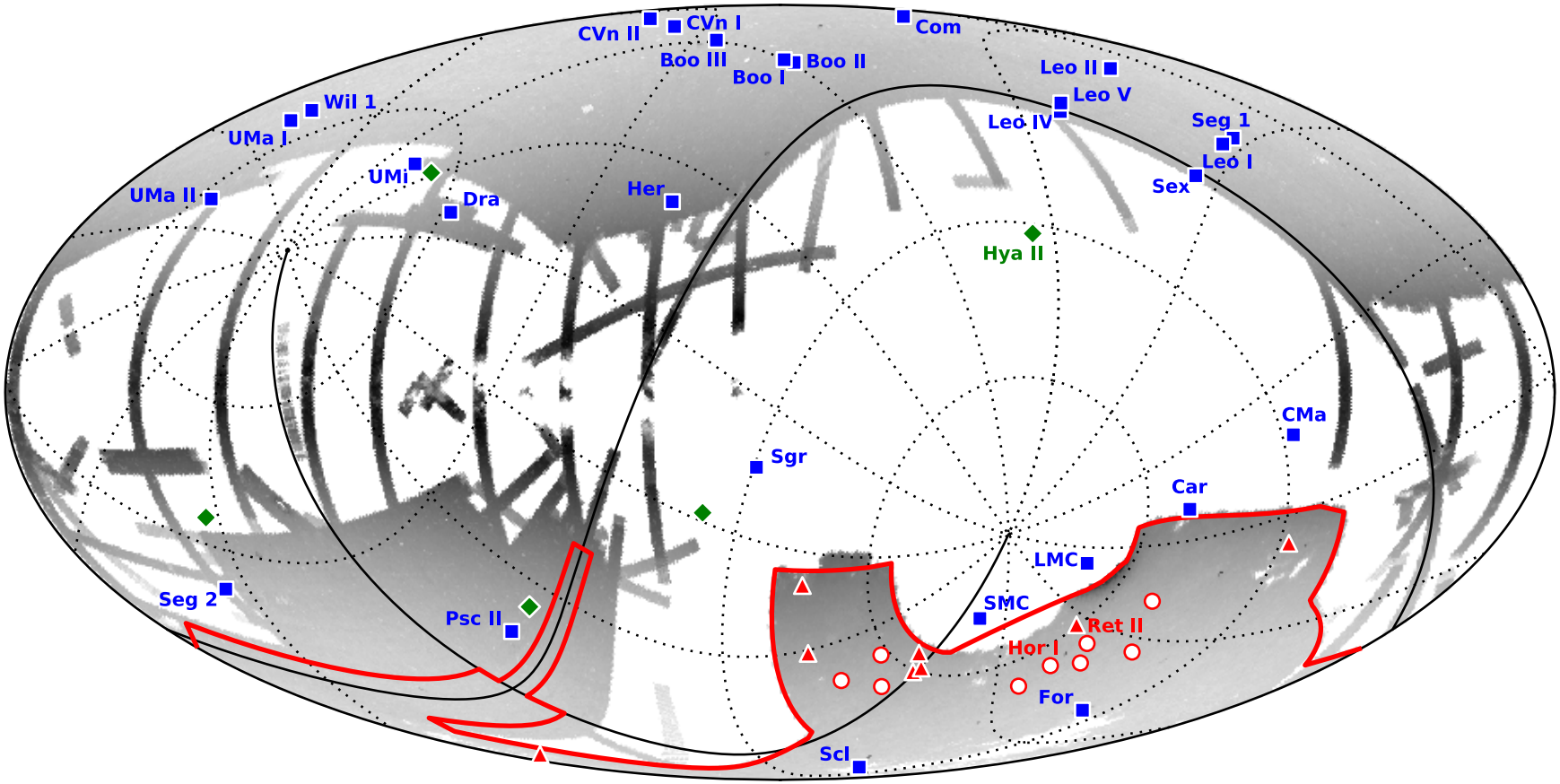
Ackermann et al. 2015, arXiv:1503.02641



Comparison with other Searches



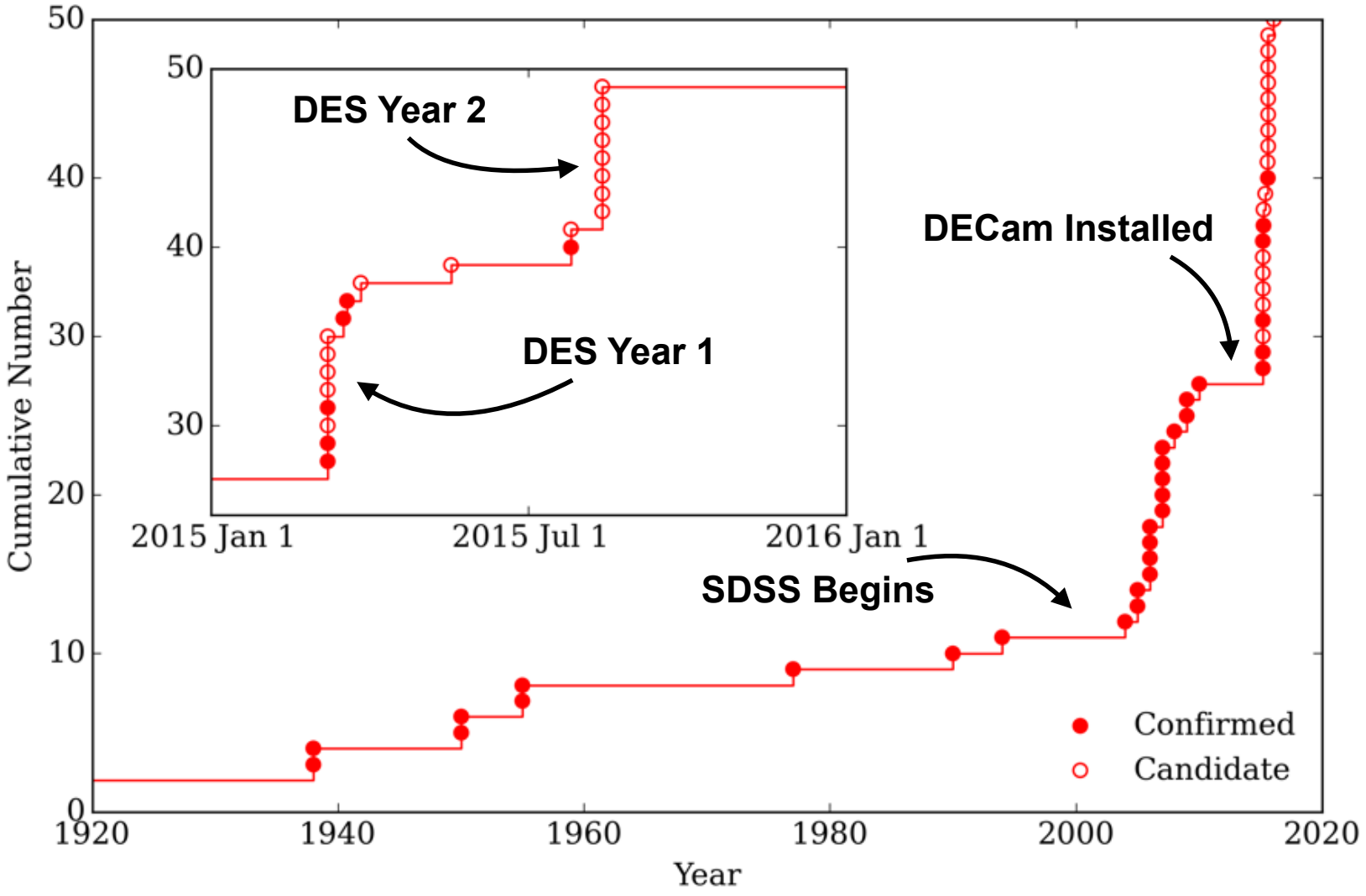
Finding New Satellites



Blue - Previously discovered satellites
Green - Discovered in 2015 with PanSTARRS/SDSS

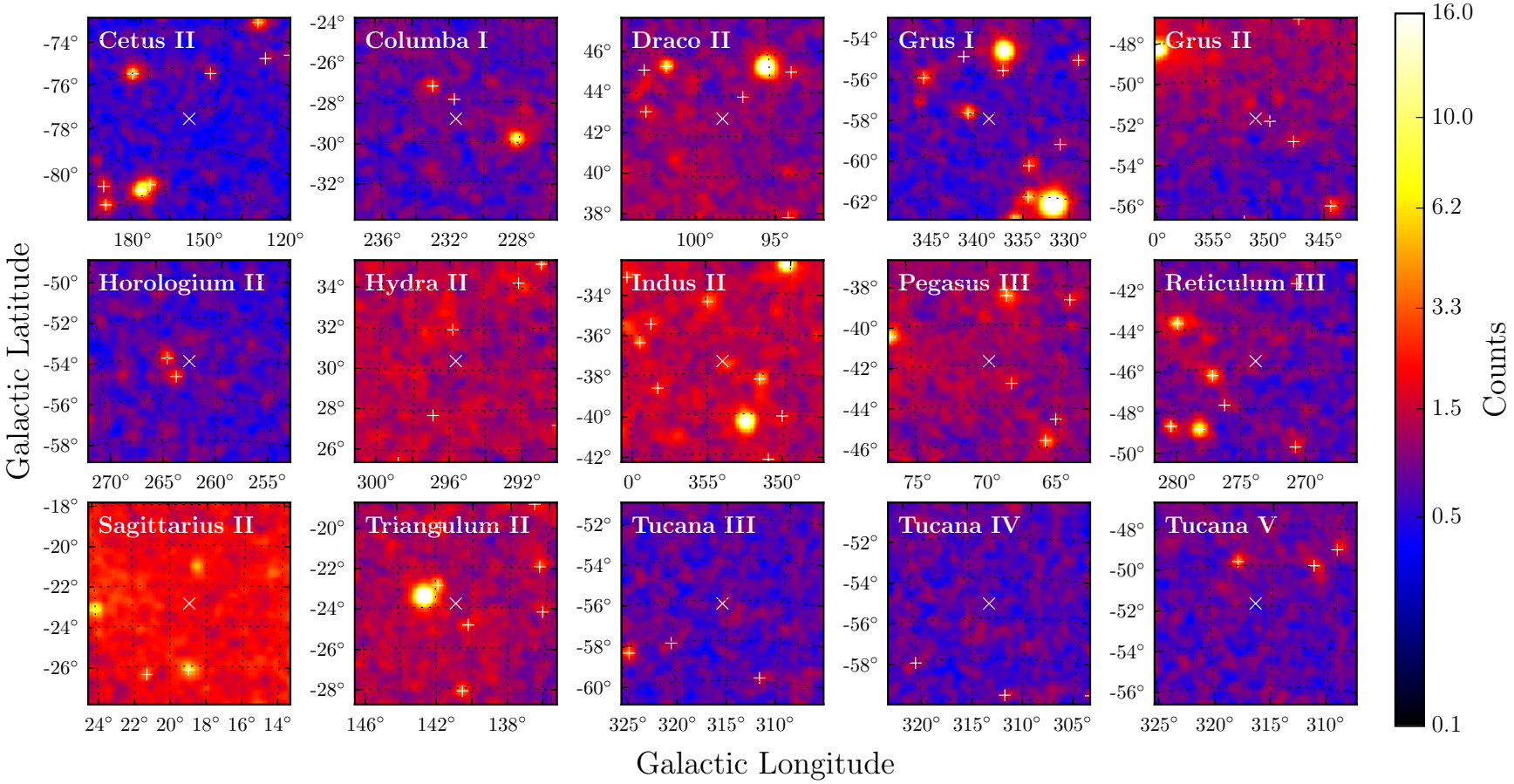
Red outline - DES footprint
Red circles - DES Y1 satellites
Red triangles - DES Y2 satellites

Finding New Satellites



Gamma-ray Follow-up of New Candidates

Albert+ 2017 ApJ 834, 110



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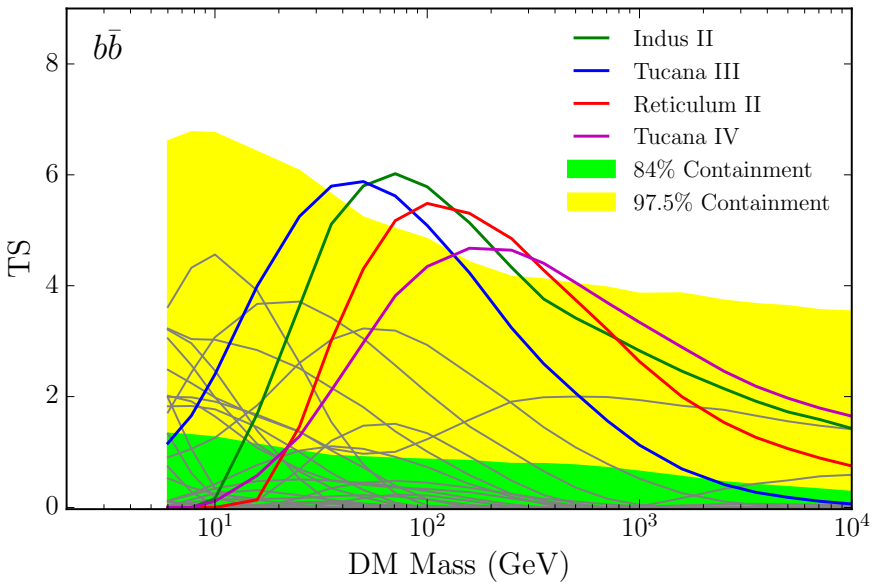


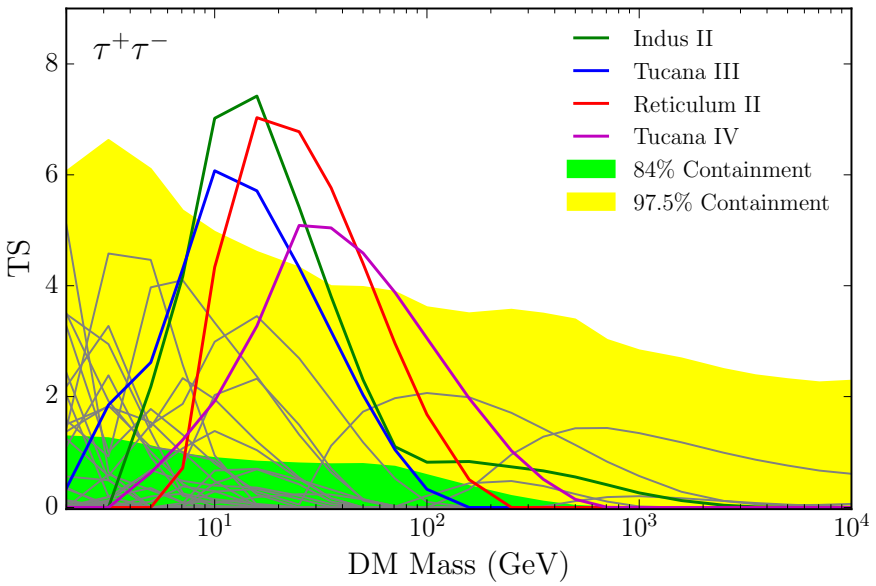
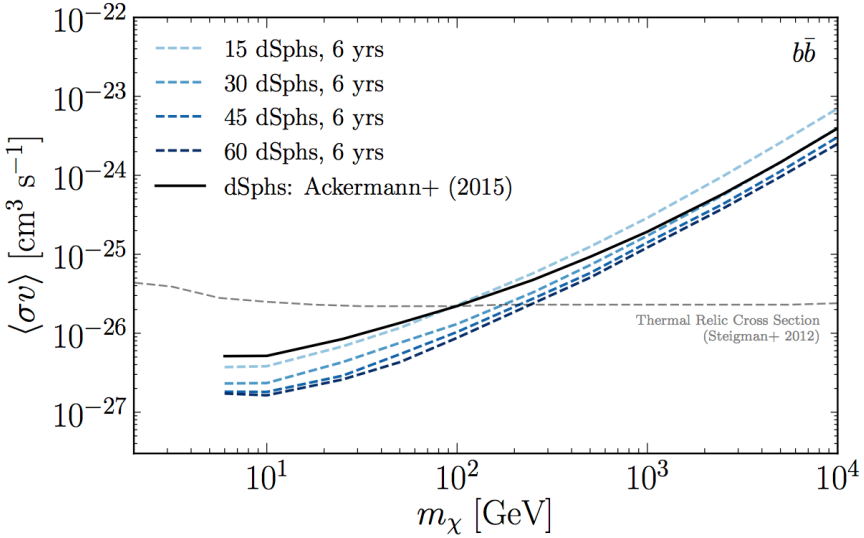


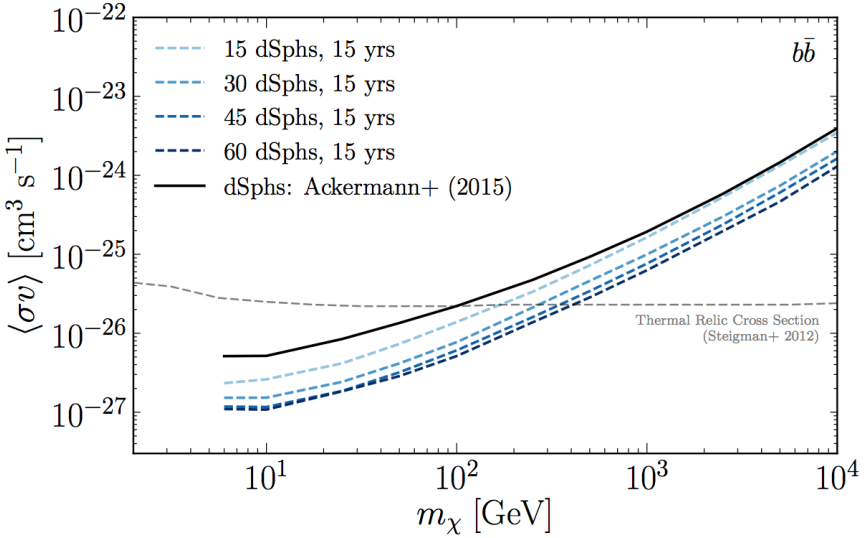
Table 2
Targets with the Largest Excesses above Background

(1) Name	(2) Channel	(3) Mass (GeV)	(4) TS	(5) $p_{\rm local}$	(6) $p_{\rm target}$	(7) $p_{\rm sample}$
Indus II	$\tau^+\tau^-$	15.8	7.4	0.01 (2.3σ)	0.04 (1.7σ)	0.84 (-1.0σ)
Reticulum II	$\tau^+\tau^-$	15.8	7.0	0.01 (2.3σ)	0.05 (1.7σ)	0.88 (-1.2σ)
Tucana III	$\tau^+\tau^-$	10.0	6.1	0.02 (2.1σ)	0.06 (1.5σ)	0.94 (-1.6σ)
Tucana IV	$\tau^+\tau^-$	25.0	5.1	0.02 (2.1σ)	0.09 (1.3σ)	0.98 (-2.1σ)

Projected LAT Sensitivity

Charles+ 2016, Phys Rep 636, 1, (arxiv:1605.02016)





- Projections for more dSphs and deeper exposure show an increase in LAT sensitivity of 2-3 with respect to current searches
- For high-mass DM models (M > 300 GeV) the LAT continues to gain sensitivity linearly in time

Projected LAT Sensitivity

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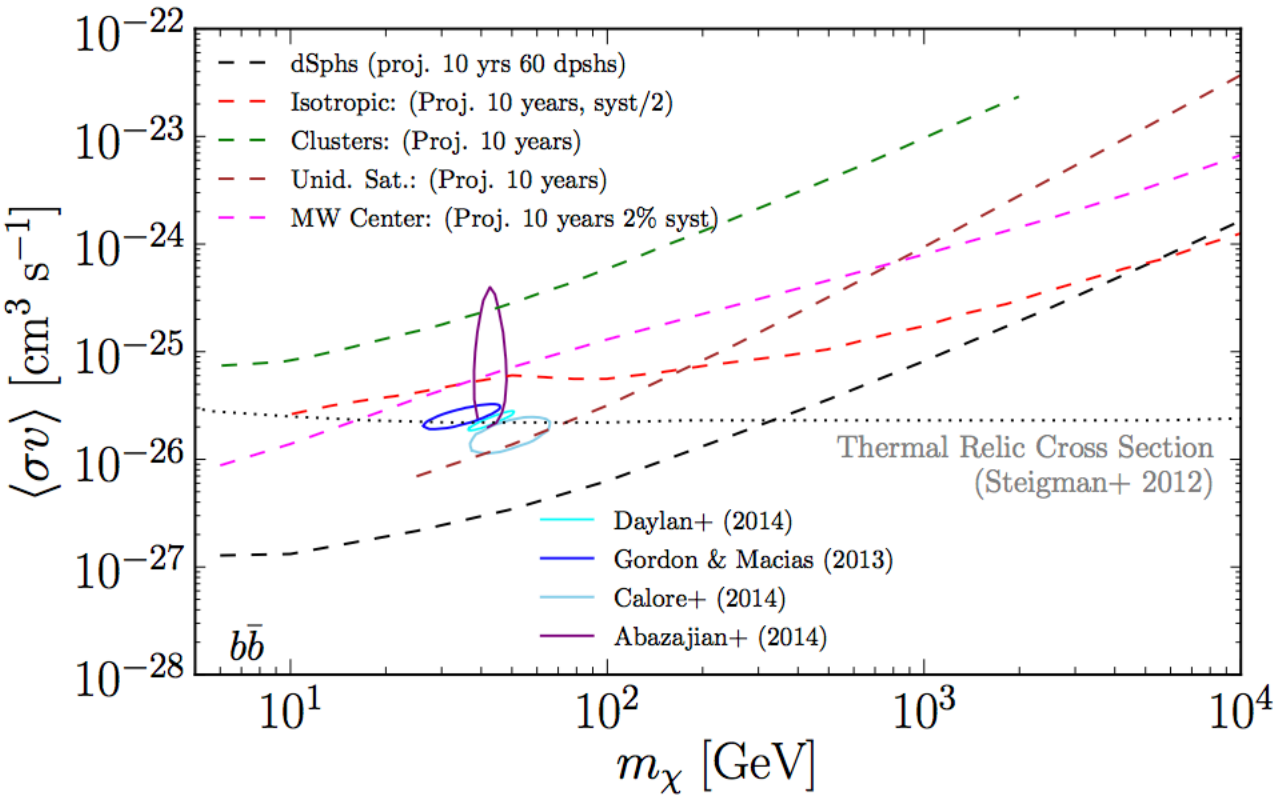
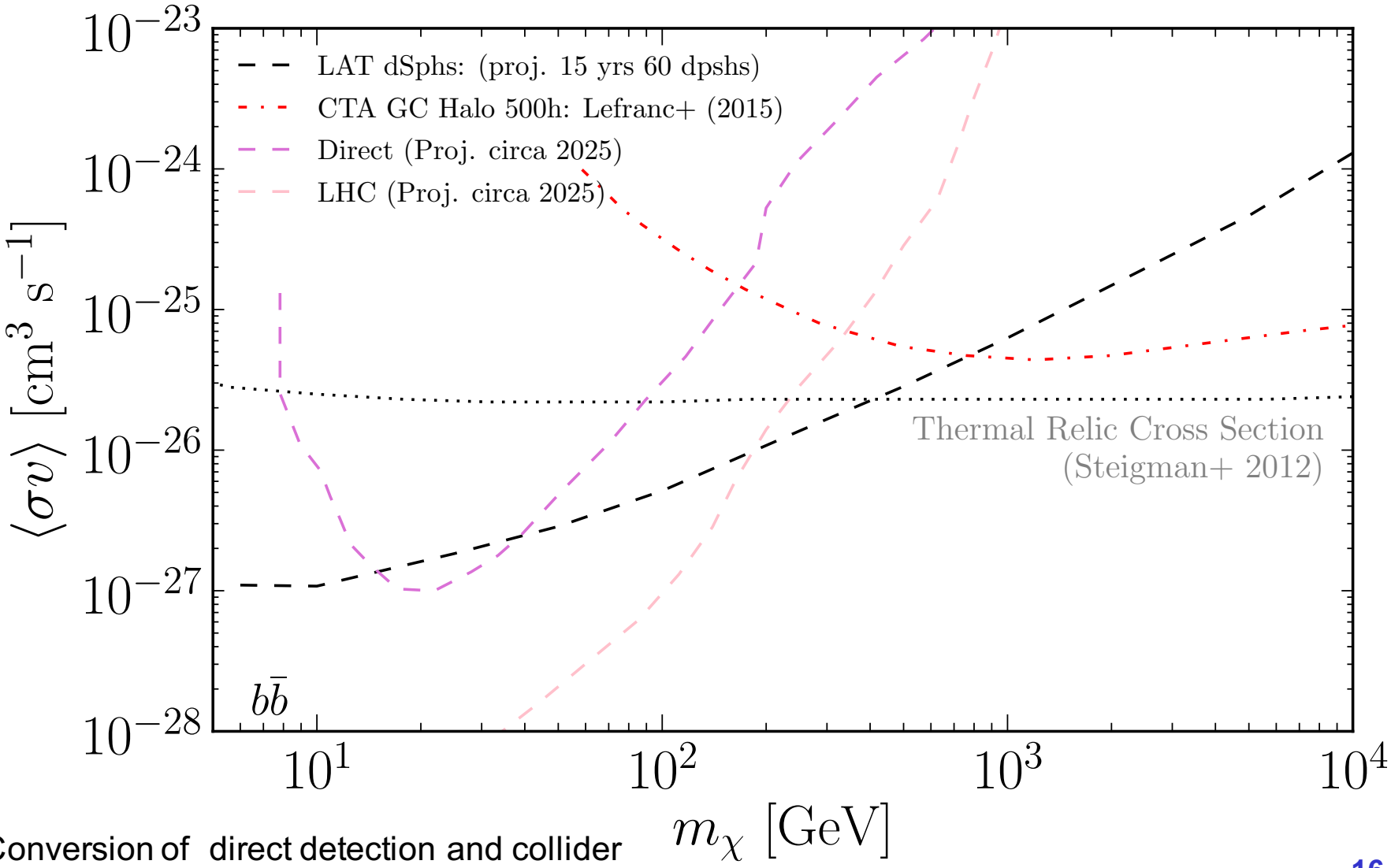


- Dwarfs are expected to yield the strongest and most robust DM constraints among future LAT DM searches
- Powerful cross-check against signals detected in other targets (e.g. the GCE)

Dark Matter Sensitivity, circa 2025

Charles+ 2016, Phys Rep 636, 1, (arxiv:1605.0201)

Comparison of LAT Projected Limits with Direct-Detection and Collider Limits for b-quark Channel



Conversion of direct detection and collider limits following EFT methodology of Bauer+ 2015PDU.....7...16B

Conclusions

- LAT dSph searches currently offer some of the strongest and most robust indirect DM constraints
  - Canonical thermal relic is excluded for M < 100 GeV
  - Current limits are in tension w/ DM interpretations of other gamma-ray and cosmic-ray anomalies (Galactic Center Excess, rising positron fraction)

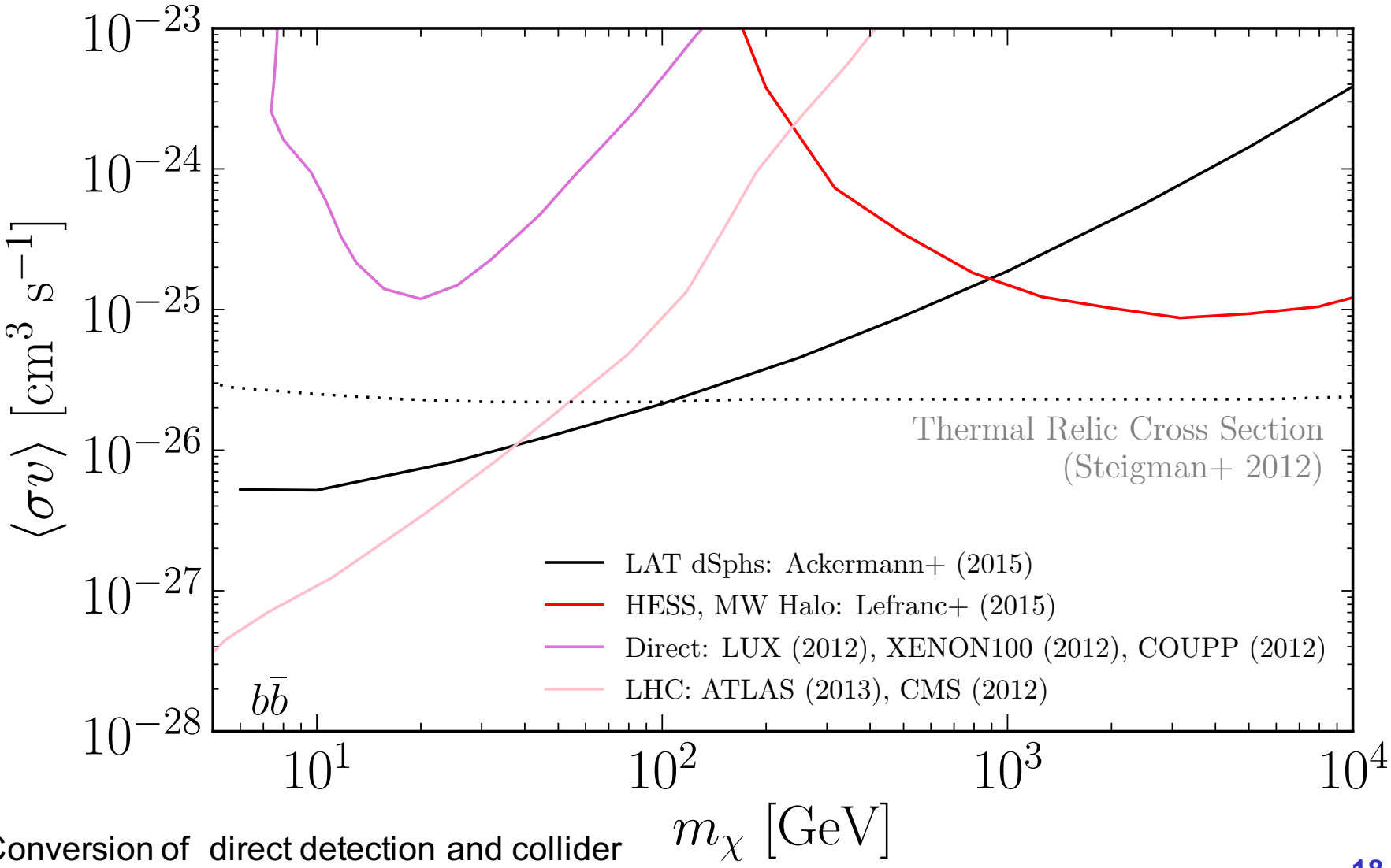
- Prospects for discovering additional dSphs are excellent
  - DES has doubled the number of dSph candidates in the last 2 years
  - LSST will survey of a larger region of the sky to much greater depth and is expected to detect as many as 100 new systems

- Indirect Detection will continue to play a complementary role in the hunt for DM with direct and collider searches

Importance of Indirect-Detection Searches

Charles+ 2016, arxiv:1605.02016

Comparison of LAT Current Limits with Direct-Detection and Collider Limits for b-quark Channel



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