GLAST LAT Searches for Particle Dark Matter: An Experimental Point of View

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Representing the GLAST LAT Collaboration

Overview of talk

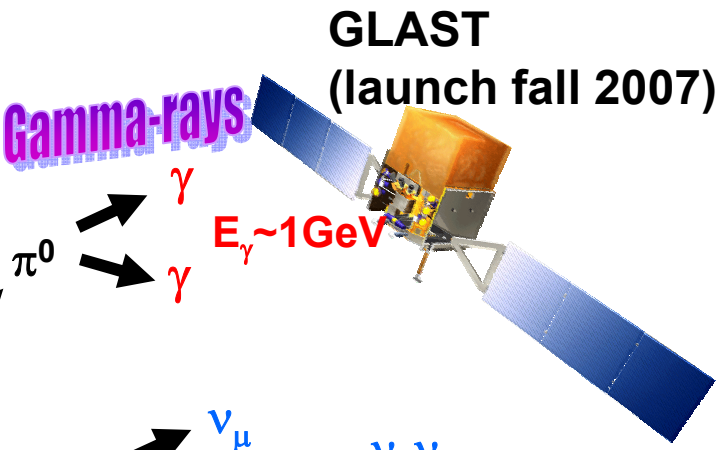
1. **Theoretical uncertainties**
2. **Complementary search techniques**
3. **Dark matter source identification**

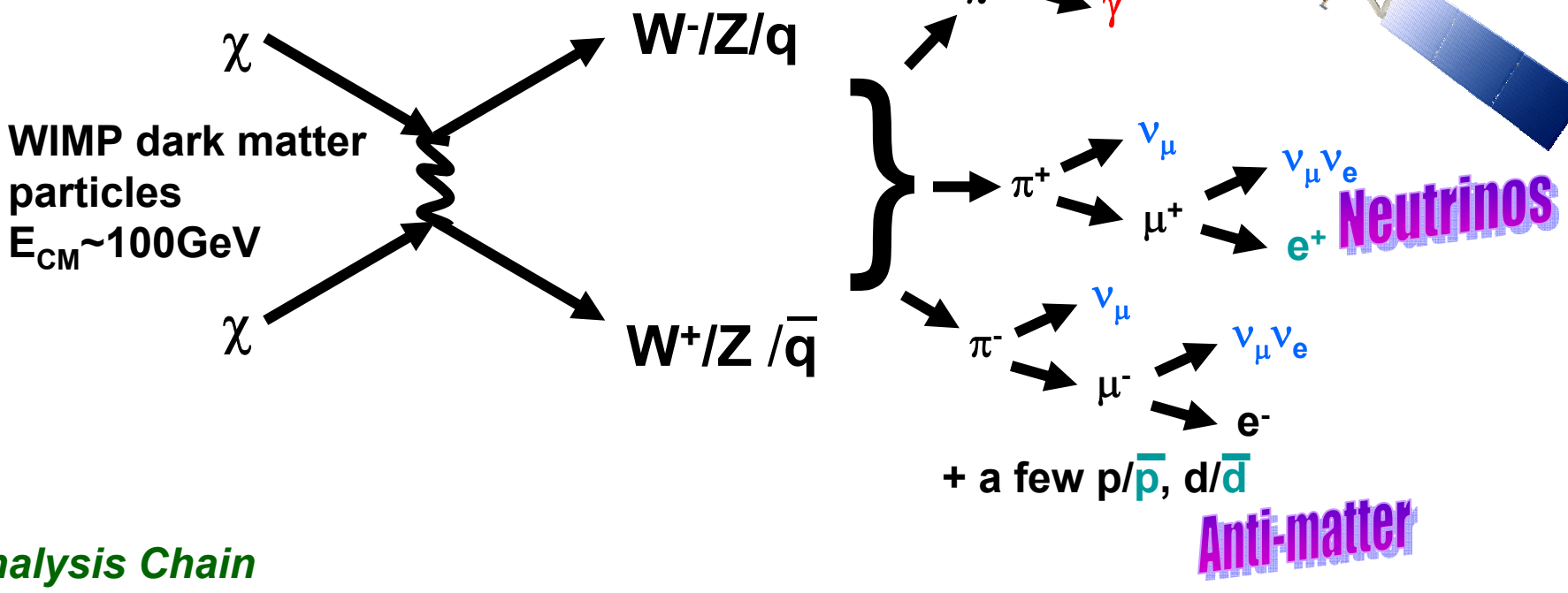
GLAST LAT – a complementary particle dark matter detector

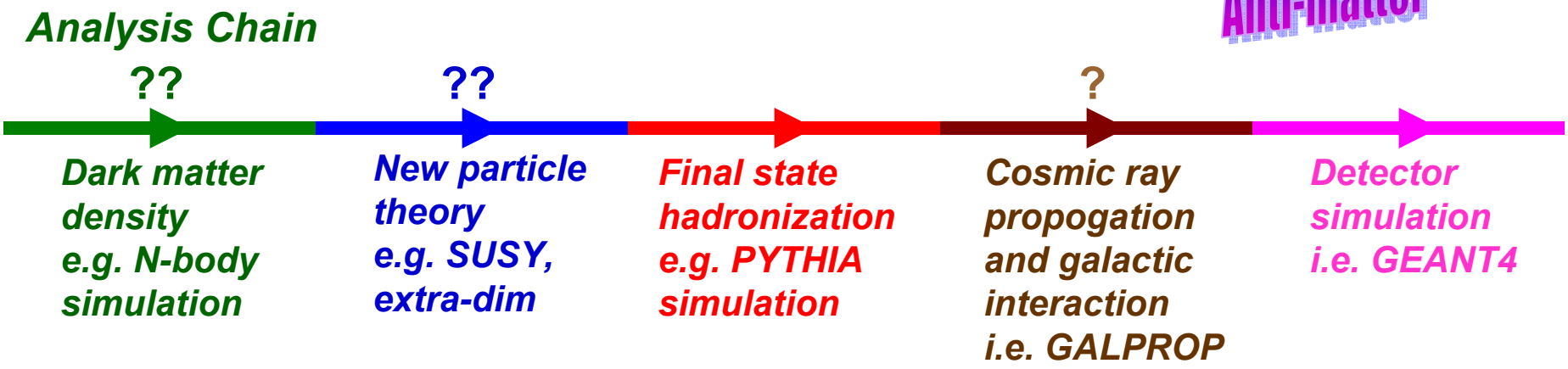
Particle Type	*Production Mechanism*	*Mass Scale*
Axions	Big Bang Non-thermal	~10^{-5} eV
Neutrinos	Big Bang Thermal (small fraction of dark matter)	~10^{-1} eV
Others	…	…
WIMPs	Big Bang Thermal or non-thermal	~10^{2} GeV

WIMP Experiment Type	*Dark matter source location*	*Dark matter interaction*
Direct Detection (e.g. CDMS, ZEPLIN…)	Earth's Surface	WIMP-nucleus scattering
Particle Beam Collider (e.g. LHC…)	Irrelevant	WIMP pair production
Indirect Detection (e.g. GLAST LAT…)	Earth, Sun, Galaxy, extragalactic	WIMP pair annihilation

How γ-rays are produced from dark matter







Spectral shape & flux magnitude

γ-ray flux factors

$\int(\sum_i dN/dE\ B_i)dE$

x

$4\pi \int \rho^2(r) r^2 dr / M^2_{WIMP}$

x

$\langle\sigma v\rangle / 2$

x

$1/4\pi d^2$

Energy spectrum
(depends upon particle mass, branching fractions)

x

number density^2
(depends upon dark matter clustering)

x

annihilation cross-section
(depends upon underlying particle physics, inflation…)

x

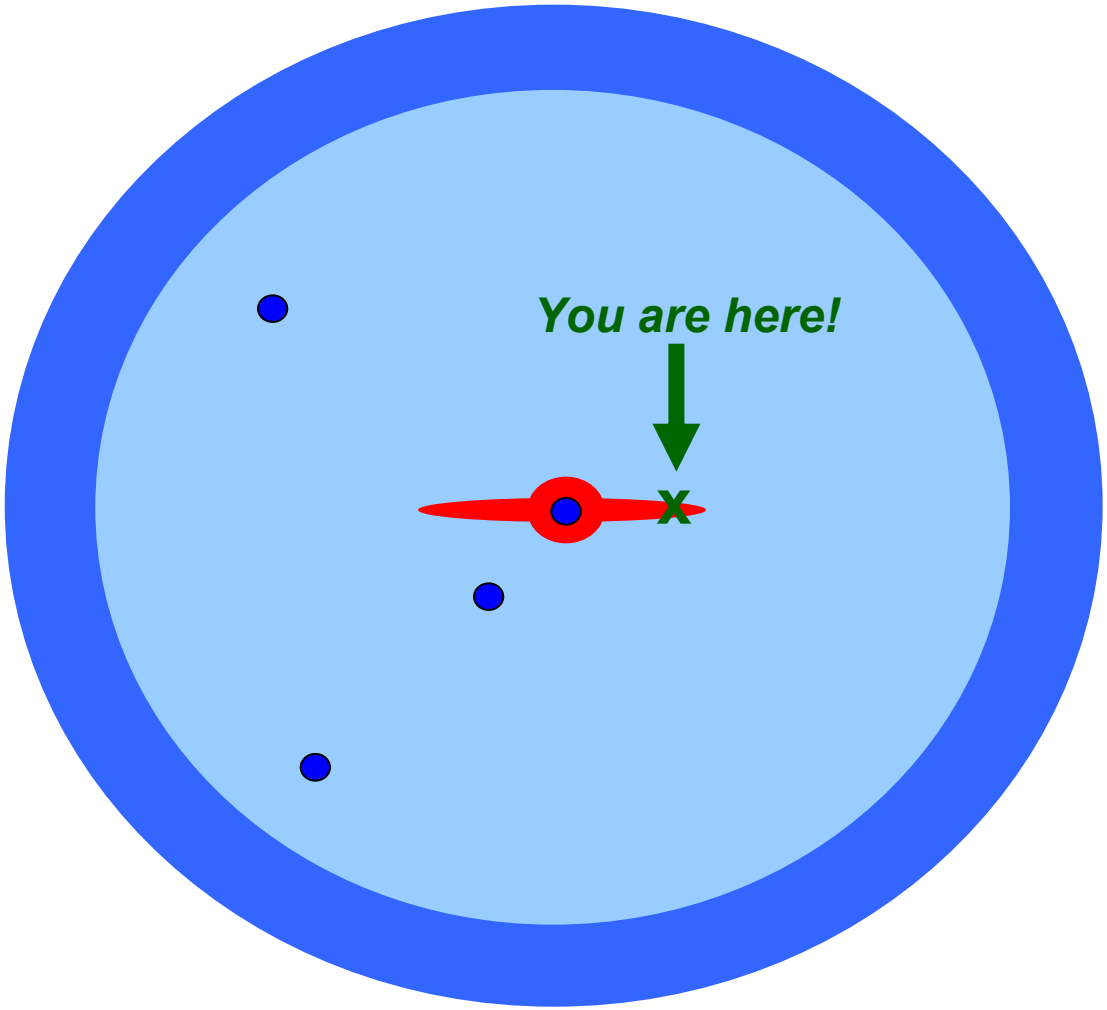
distance^{-2}
(depends upon dark matter clustering)

Spectral shape: Universal

Flux magnitude: *Factors difficult to disentangle for single point source*

Where could the WIMP γ-ray sources be?

- Galactic center
- Satellites/mini-spikes / dwarfs
- Galactic halo
- Extra-galactic



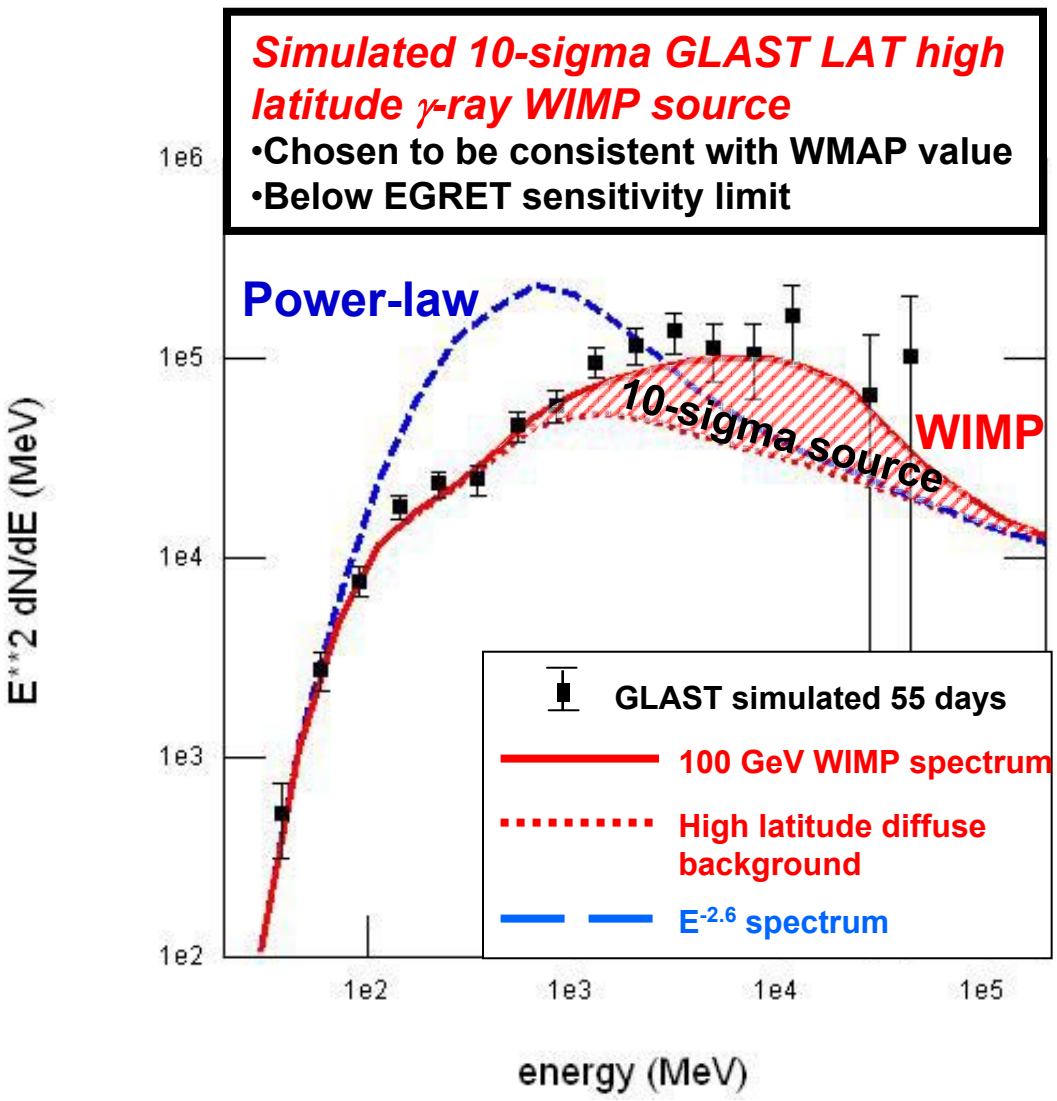
Complementary GLAST WIMP searches

GLAST search technique	advantages	challenges
Galactic center	Good statistics	Source confusion/ Galactic diffuse modeling
Satellites / mini-spikes / dwarfs	Low background	Low statistics, follow-up observations (see below)
Milky Way halo	High statistics	Galactic diffuse modeling
Extragalactic	High statistics	Galactic diffuse modeling, astrophysical uncertainties
Spectral lines	No astrophysical uncertainties	Low statistics

GLAST Symposium WIMP contributions (5 talks, 10 posters)

- ✓ **Galactic Center:** A. Lionetto (P18.9), A.Morselli (P2.8), I.Moskalenko (P18.3)
- ✓ **Satellites / mini-spikes / dwarf galaxies:** S.Koushiappas (8.3), M.Kuhlen (8.1), A.Morselli (P18.2), M.Sanchez-Conde (P18.4), S.Schneebeli/L.Sabrina (P18.6), J.Taylor (P2.7), P.Wang (P19.38)
- ✓ **Milky Way halo:** A.Sander (P19.32)
- ✓ **Extragalactic:** J.Conrad (P18.1)
- ✓ **Lines:** Y.Edmonds (P18.8), J.Conrad (P19.40)

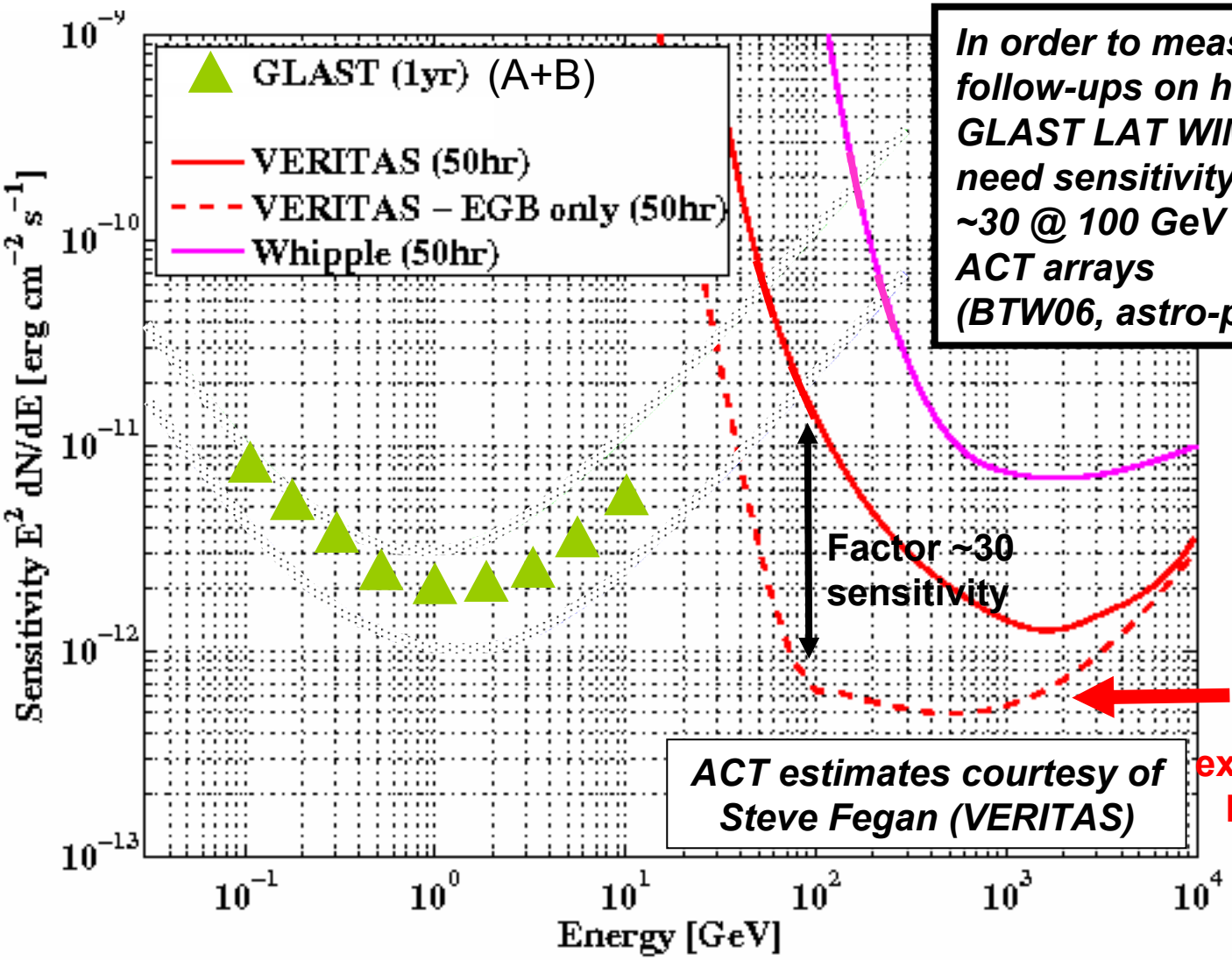
What are the characteristics of WIMP γ-ray sources?



- Extended / diffuse
- High galactic latitude
- Non-variable
- Typically no counterparts
- Hard non-powerlaw spectrum w/ the following observable parameters:
  1. WIMP mass
  2. $\tau^+\tau^-$ / hadron branching fraction ratio
  3. $\gamma\gamma$ line branching fraction
  4. γZ^0 line branching fraction

Pulsars are the main source class with a spectrum which can match the WIMP annihilation spectrum (BTW06, astro-ph/0610731); check for counterparts, spectral lines

Precision follow-up observations for high latitude WIMP candidates

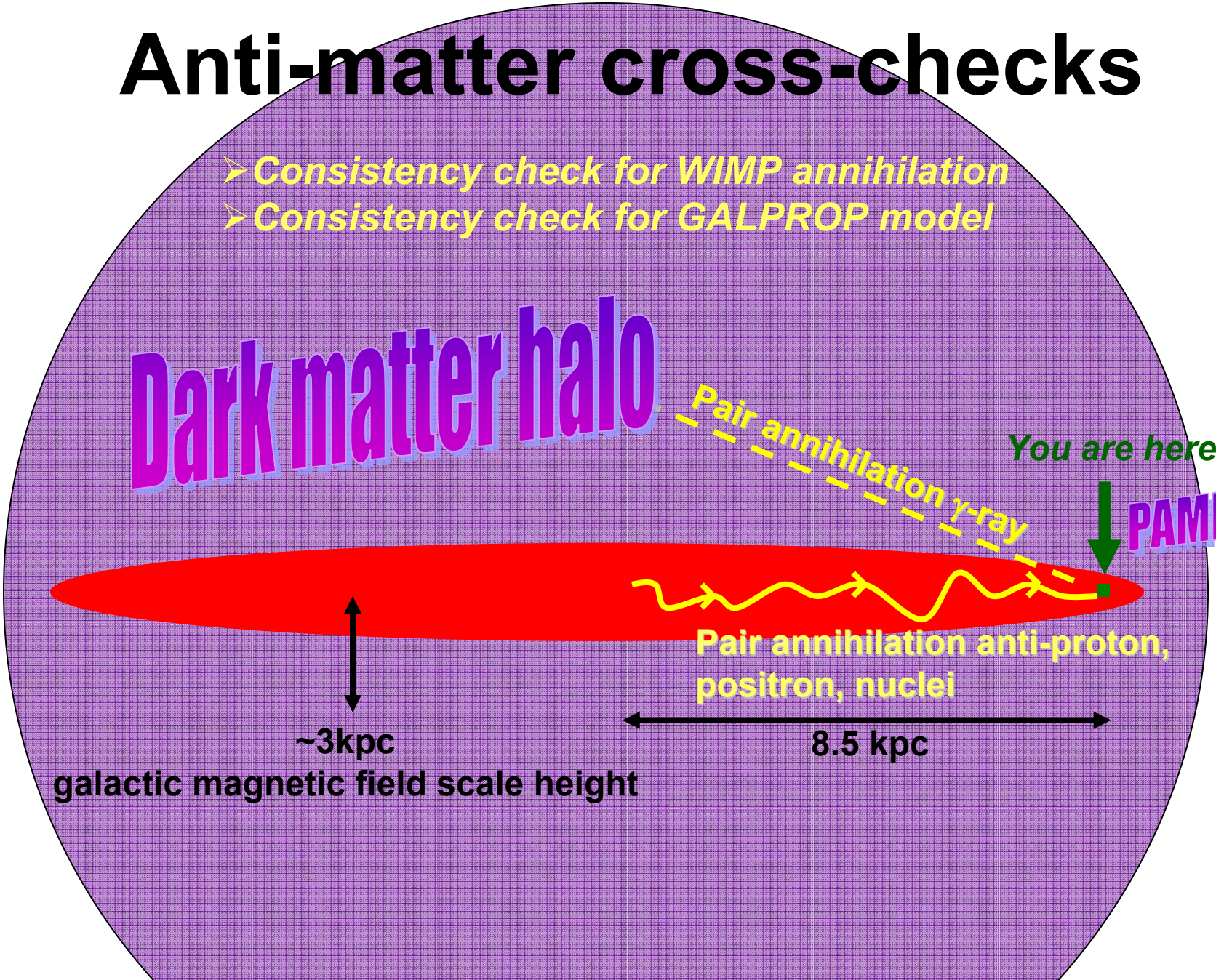


In order to measure lines in follow-ups on high latitude GLAST LAT WIMP candidates, need sensitivity improvement of ~30 @ 100 GeV over existing ACT arrays (BTW06, astro-ph/0610731)

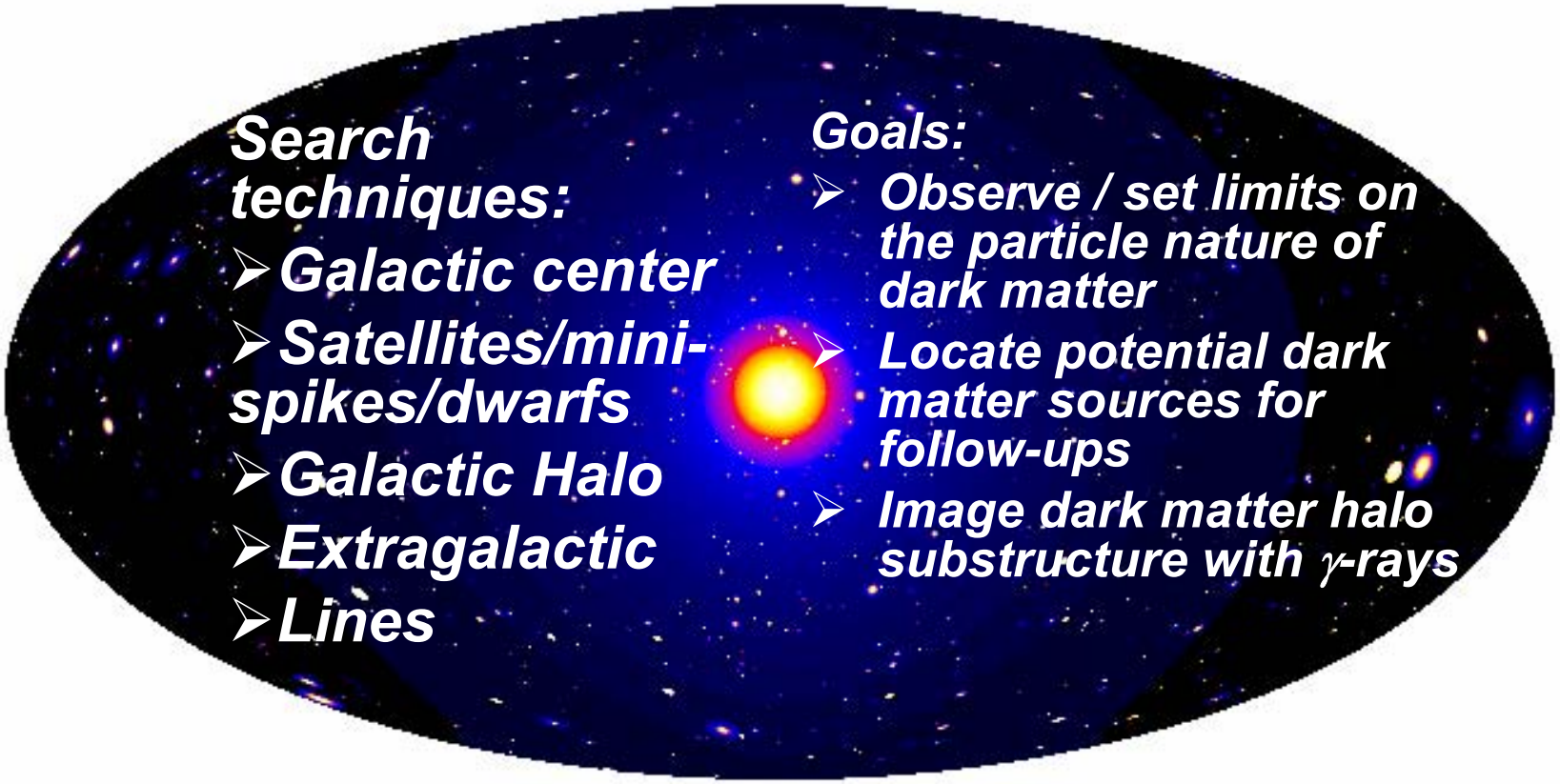
"VERITAS-like" instrument w/ extragalactic diffuse background only

Anti-matter cross-checks

- *Consistency check for WIMP annihilation*
- *Consistency check for GALPROP model*



Summary: detection of γ-rays from dark matter with the GLAST LAT



Search techniques:

- ***Galactic center***
- ***Satellites/mini-spikes/dwarfs***
- ***Galactic Halo***
- ***Extragalactic***
- ***Lines***

Goals:

- ***Observe / set limits on the particle nature of dark matter***
- ***Locate potential dark matter sources for follow-ups***
- ***Image dark matter halo substructure with γ-rays***