Indirect Detection of Dark Matter

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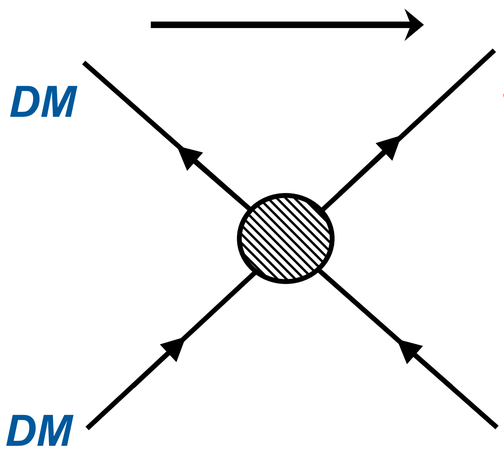
Indirect Detection



Neutrinos, photons, …

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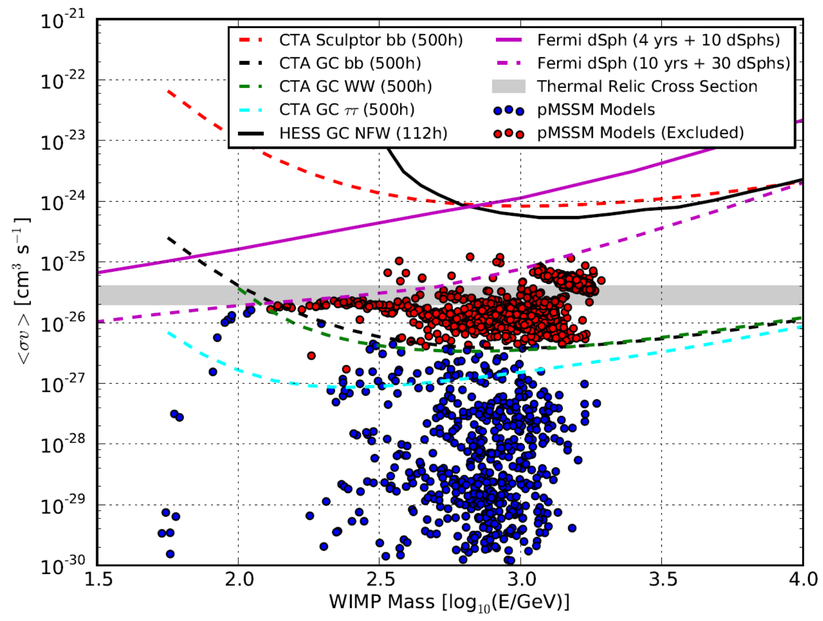
- Flux $\propto$ (dark matter density)^2 for annihilating dark matter
- If no signal found, put limits on $\langle\sigma_{ann}v\rangle$ and dark matter mass

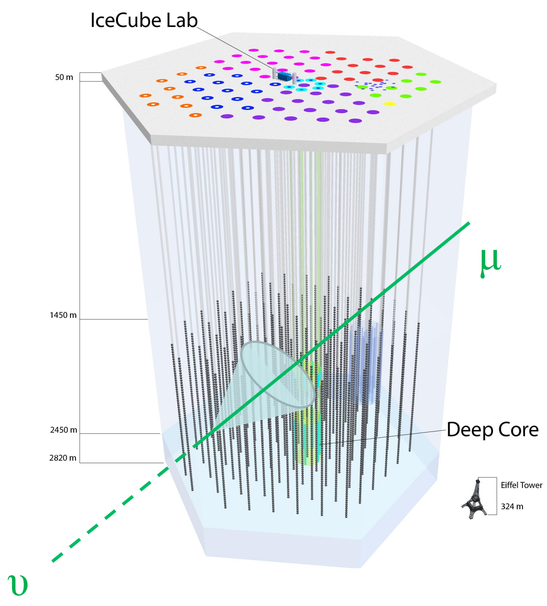
Projected Limit from Gamma-ray Telescopes



Comparison of current (solid) and projected (dashed) limits from gamma-ray searches in the Galactic Center (GC) and in dwarf galaxies (dSph) [1]

- Expected limits for 10 years of Fermi and 500 hours of CTA below the thermal relic $\langle\sigma_{ann}v\rangle$ for most WIMP masses

The IceCube Neutrino Observatory



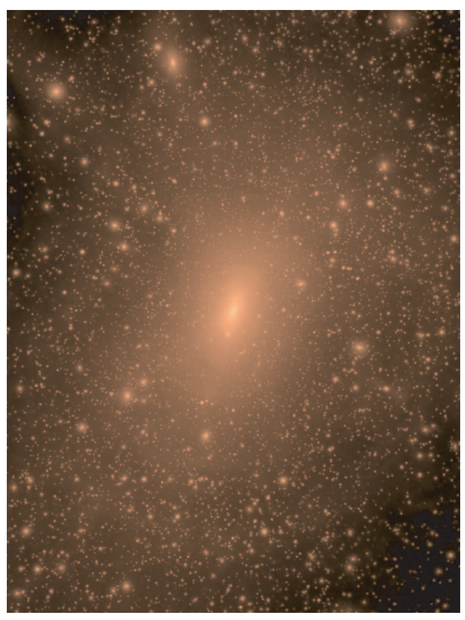
- Detect Cherenkov photons from particles created in neutrino interactions
- Neutrino energy threshold:

  ~100 GeV for IceCube

  ~10 GeV for DeepCore
- Located at the South Pole

Galaxies and Galaxy Clusters

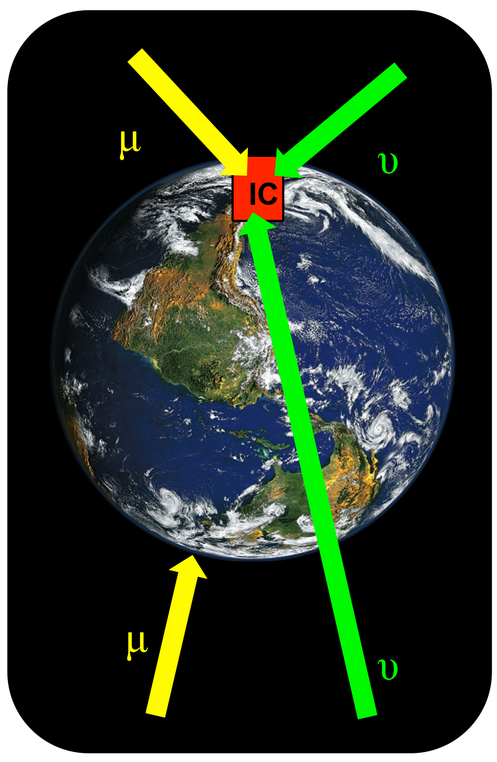
- Expect measurable flux from regions with enhanced dark matter density
- For this analysis, use haloes around galaxies and clusters in Northern Hemisphere, e.g.:
  - Virgo cluster
  - Andromeda galaxy
- Possibly boosted signal due to substructures



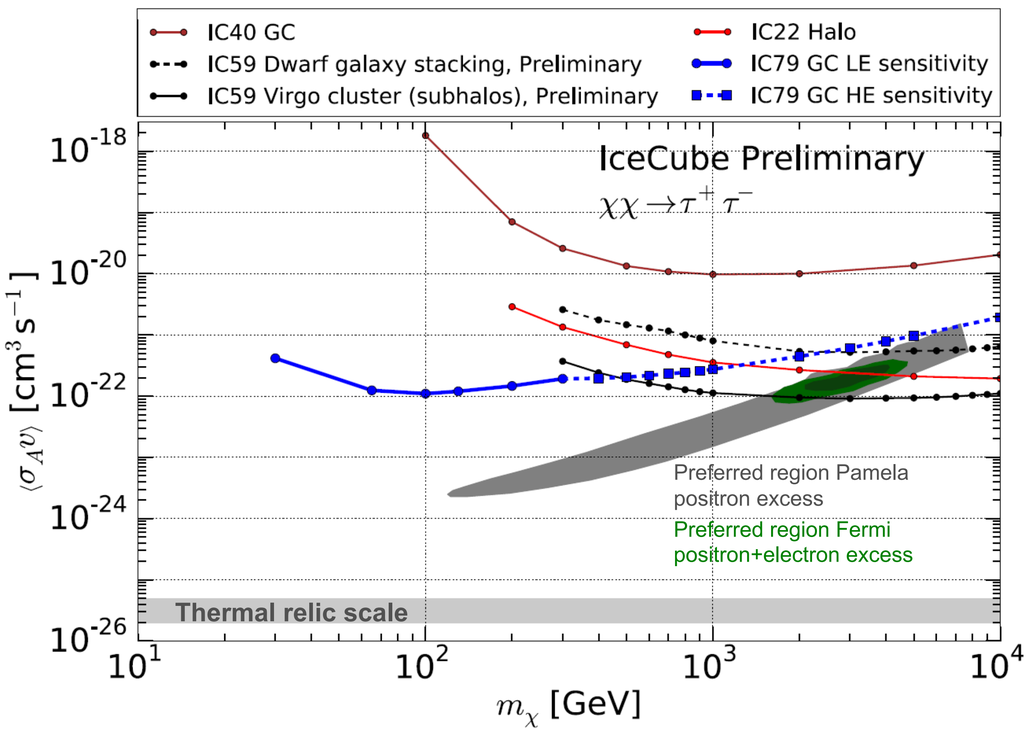
Projected DM density squared map of a simulated galaxy halo (Via Lactea) [2]

Event Selection

- Signal neutrinos have GeV-TeV energies and are upgoing
- Background:
  - Atmospheric muons (downgoing, enter detector from outside)
  - Atmospheric neutrinos (irreducible)
- Use cuts to remove upgoing events, badly reconstructed tracks and uncontained events:
  - remove 99.8 % of atmosph. muons
  - keep 30-50 % of signal
- Next and final step will be a multivariate method (e.g. BDT)
- After event selection, search for excess from direction of the galaxies and clusters



Limits and Sensitivities from IceCube



Comparison of current limits and sensitivities fom IceCube, for searches in the Galactic Center (both high-energy and low-energy), Galactic Halo, dwarf galaxies and the Virgo cluster (including substructure boost) [3]

[1] M. Wood et al., arXiv:1305.0302 (2013)
[2] J. Diemand, M. Kuhlen and P. Madau, Astrophys. J. **657**, 262 (2007)
[3] M. Wolf et al. for the IceCube Collaboration, Proceedings of the 33rd ICRC (2013)