BSM in the neutrino sector

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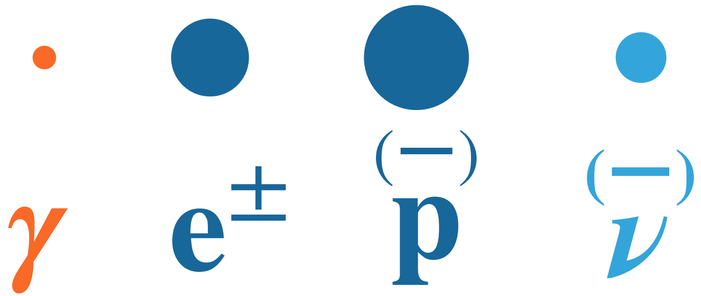
Indirect Detection of Dark Matter



Gamma-rays

- Mature detection technique
- Large signal expectations
- Lots of astrophysical sources!
  - **Long standing "excess" in GeV**

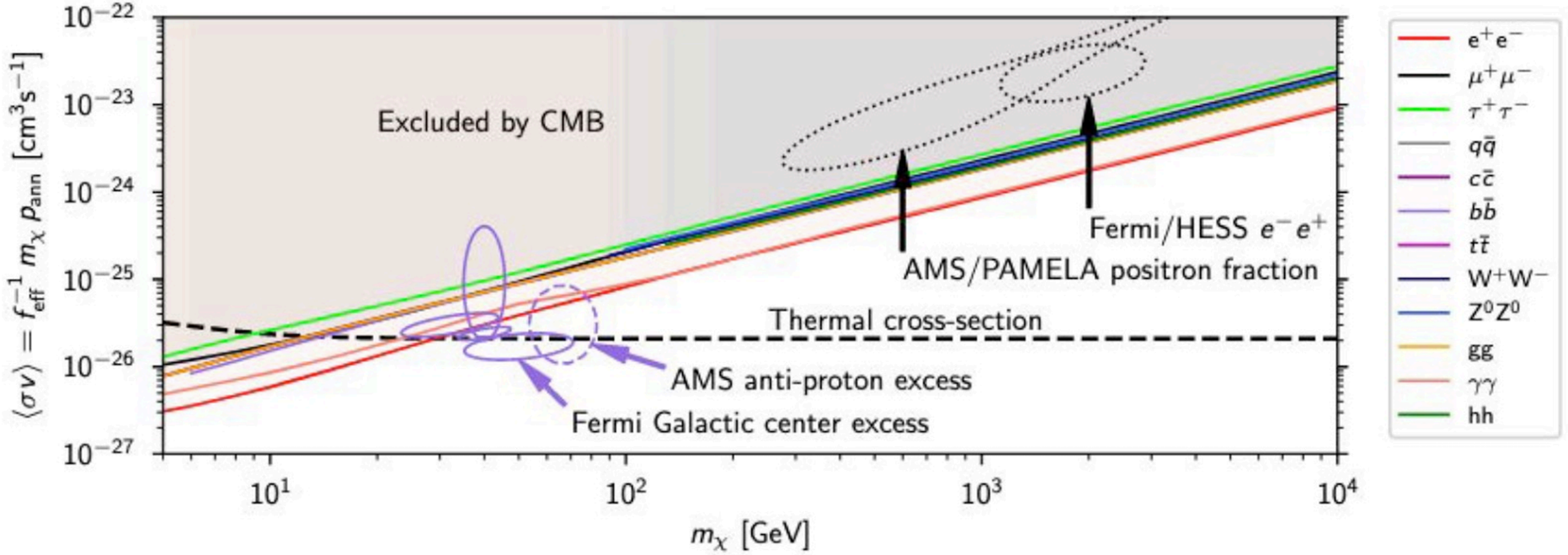
Cosmic Rays

- Largest expected signal
- Large uncertainties due to propagation (diffusion)
- Astrophysical background
  - **Long standing "excess" in $e^{\pm}$**
  - **Excess in $\bar{p}$**

Neutrinos

- Small signal expectations
- Some places only accessible via neutrinos
- Negligible astrophysical background (so far)
- Challenging detection!
  - **No "excess"**

Indirect Detection of Dark Matter



Questions:

- Can neutrinos shed light on the situation?
- Can we combine with gamma-ray experiments? Is it the neutrino channel $\chi\chi \rightarrow \nu\nu$ the only way?
- How to deal with different systematics uncertainties?
- How to put astro-particle results in context with other “indirect” detections such as radio emission?

Using Neutrinos as a Laboratory

- We have at our disposal an atmospheric neutrino and an astrophysical neutrino flux.

- Some studies done using **nature neutrino beams**:
  - Dark Matter-Neutrino Scattering [*arXiv:2205.12950*]
  - Unitarity tests from atmospheric neutrinos (ν_τ appearance) [PDR 2019]
  - Quantum gravity [arXiv:2111.04654]
  - …

Questions:

- Which additional tests we could do with astrophysical/atmospheric neutrinos?
- What is the most important observable to measure to find new physics?
- How the observation of **new sources,** like NGC1068, can help to test **new physics**?

Anomaly Detections

- ANITA detected something they were not looking:
  - Two very energetic (~ 0.5 EeV) up-going air showers consistent with τ decay from a CC of a neutrino.
  - But EeV cannot cross the Earth (even with -regeneration). Also if astrophysical, they should more TeV neutrinos in from the same direction (IceCube observed none).
  - So? Dark Matter

- With tons of accumulated neutrino data should we be looking for anomalies?
  - Examples: Slow moving particles, fractional charge particles, trident (DiMuons) events,…
  - We can adapt our triggers and filters, but what if we don’t know what we are looking for?
  - Can we use ML (auto encoders) to search for anomalous events?

It is never dark matter…

It is never dark matter… until it is!