Solar WIMP Annihilation Search with IceCube

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On behalf of the IceCube Collaboration

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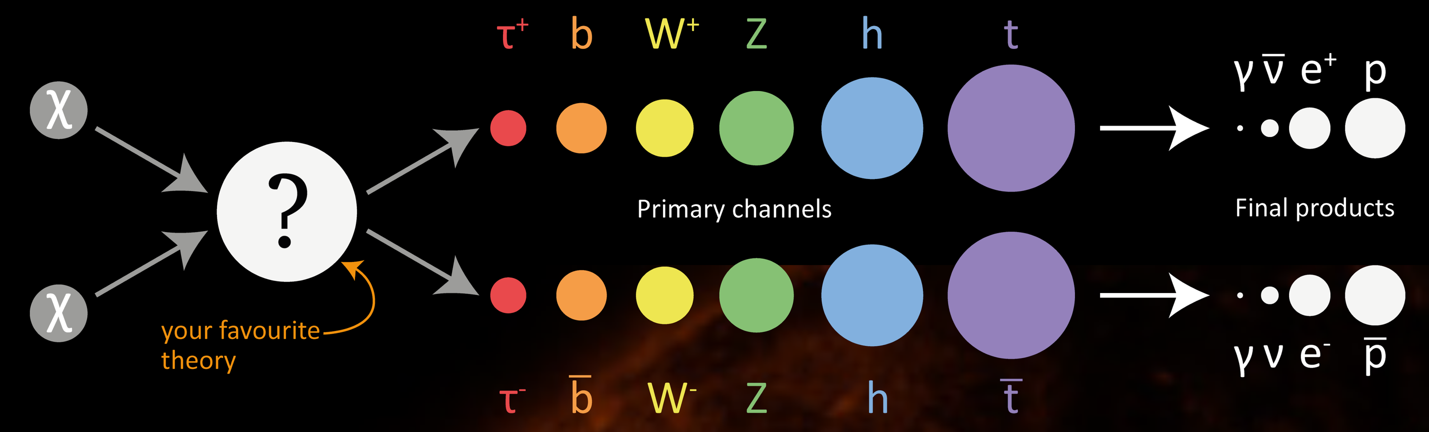
Dark matter refers to matter that neither emits nor absorbs light and does not interact electromagnetically. Thus, it cannot be seen directly by telescopes. Cosmology tells us that it must make up the bulk of the matter in the universe.

Weakly interacting massive particles (WIMPs) are a class of dark matter candidates. If they exist, they can scatter off nucleons in massive celestial bodies, losing energy, and eventually falling to the core of that body. There, they annihilate to Standard Model particles, producing neutrinos directly, or indirectly via subsequent decays.

Indirect Detection Searches look for the products of WIMP annihilations, in this work muon neutrinos.



IceCube is a cubic-kilometer Cherenkov detector installed in the antarctic ice at the geographic South Pole[2] embedded between 1450 m and 2450 m below the surface of the ice. Completed in 2013, it has detected a diffuse astrophysical neutrino flux extending to ~PeVs, as well as an atmospheric neutrino flux from cosmic rays from 100GeV to 400TeV.

Detection of the Cherenkov radiation allows reconstruction of energy, direction, and flavor.

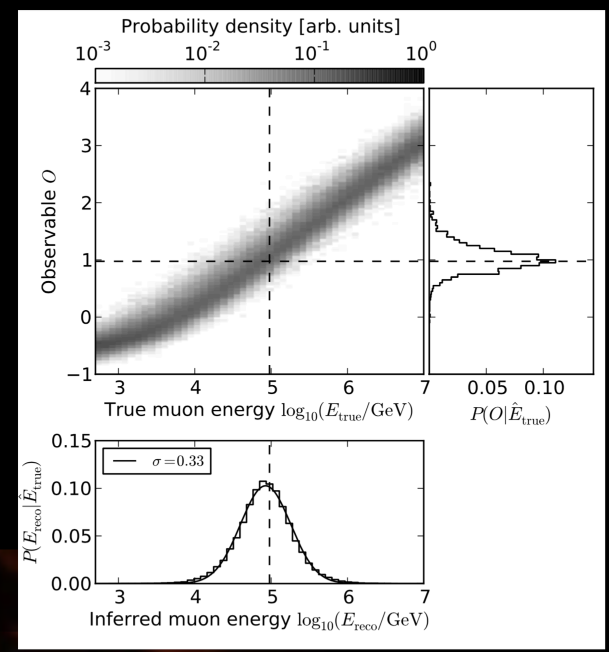
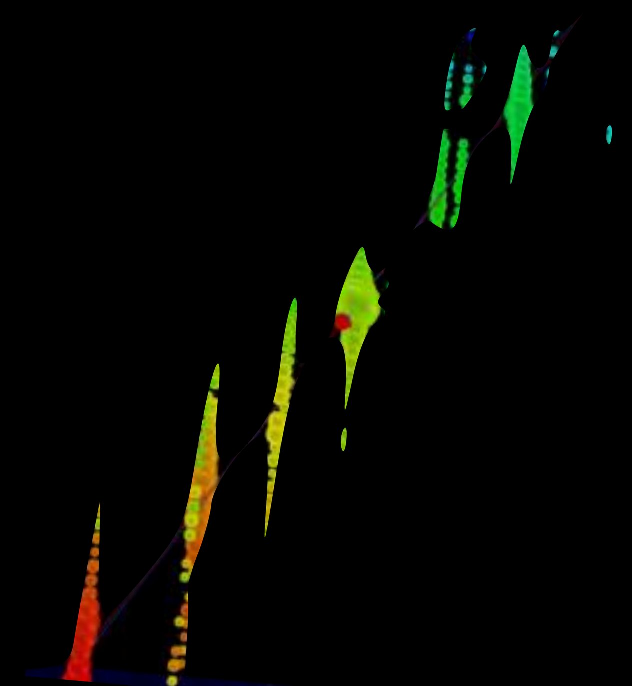


Fig.1: Reconstructed muon energy versus true muon energy in IceCube[3]



Capture equation $\dot{N} = C_C - C_A N^2 - C_E N$

Capture rate	Proportional to $\sigma_{N\chi}/m_\chi$
Annihilation rate	Sets the rate at which neutrinos are produced and thus the number of neutrinos IceCube expects
Evaporation	Is expected to be negligible for all WIMP masses to which this analysis is sensitive[4]
Rate of WIMPs entering sun	Is expected to be zero for stars the age of the sun for the WIMP masses to which this analysis is sensitive[4]

For the range of WIMP masses considered in this analysis, the number of neutrinos IceCube detects should be constrained only by the WIMP-nucleon cross section

The Strategy: Look for an excess of neutrinos over the atmospheric flux from the direction of the sun.

Step one: Signal simulation

In this work, we use the DMFlux module, which include an updated treatment of the electroweak correction from Bauer et al[5].

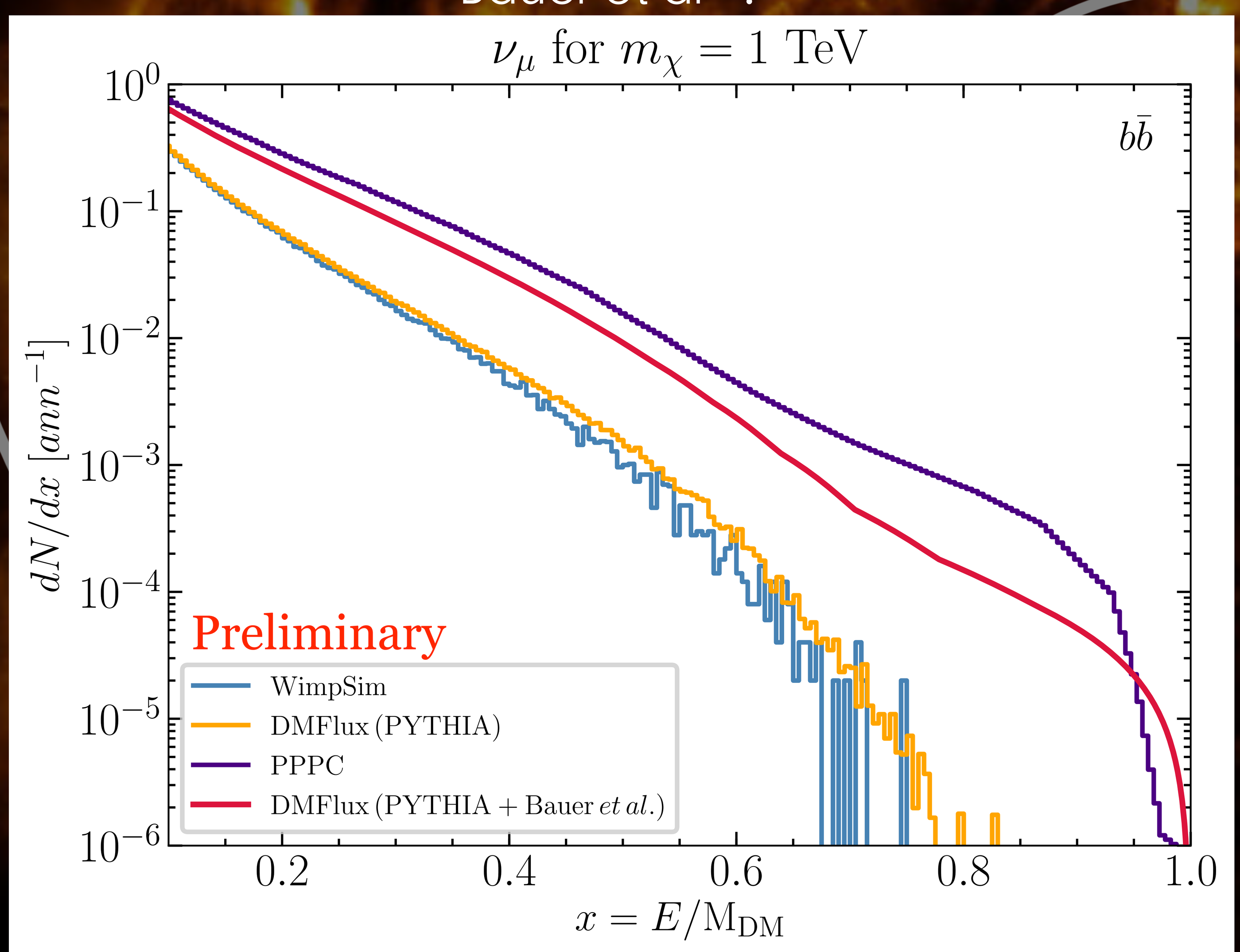


Fig.2: Here we show a comparison of our spectrum and the spectra obtained from WIMPSim[6], Pythia8[7] without EW correction, PPPC[8]. See Qinrui Liu's poster (#434) for a more in depth discussion of our flux calculation[9].

Step two: Detector response

Simulate the detector response in reconstructed muon quantities

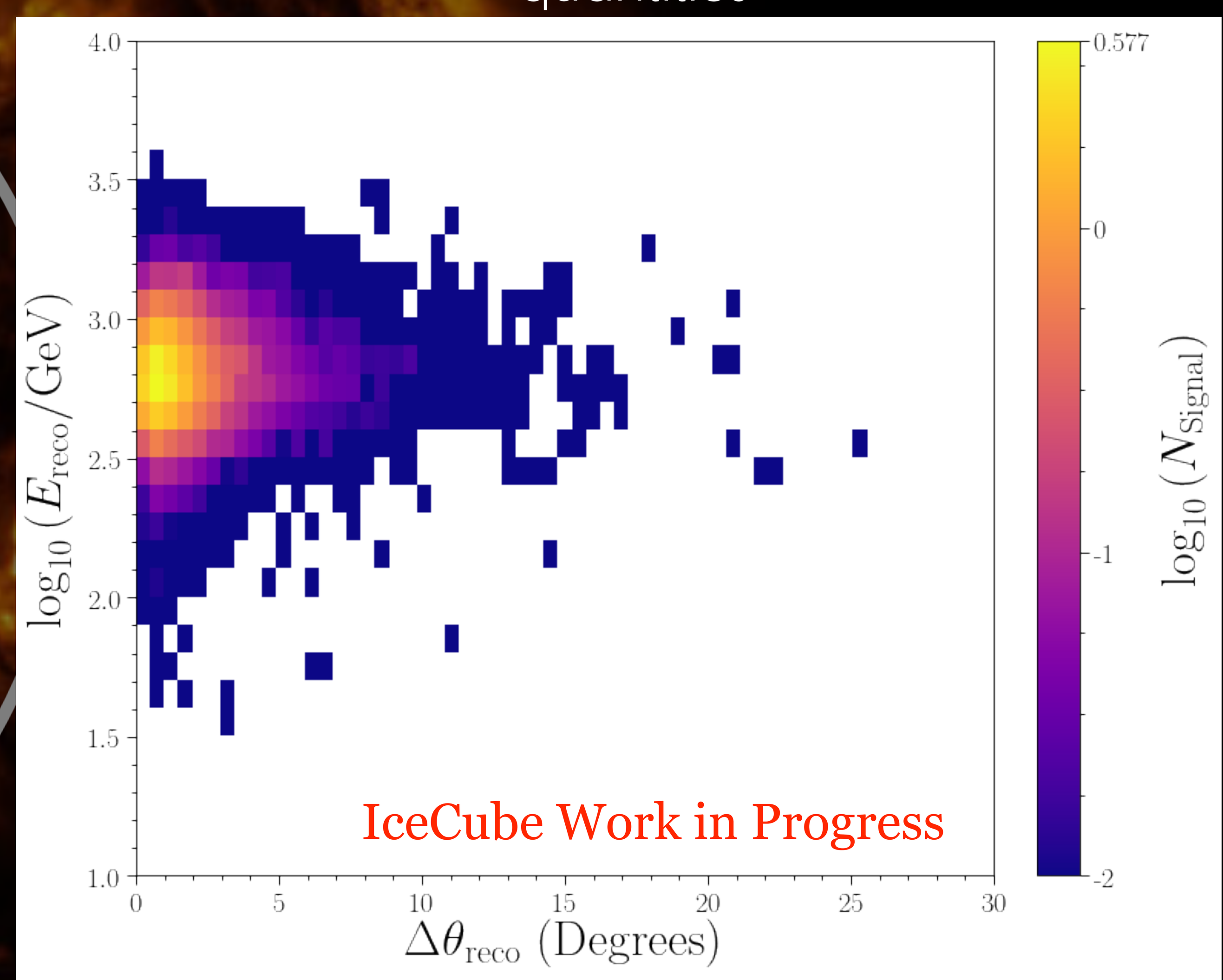


Fig. 3: Event display in reconstructed quantities for $\chi\chi \rightarrow W^+W^-$, with $m_\chi = 1000$ GeV

Step three: Compute expected sensitivity of the analysis

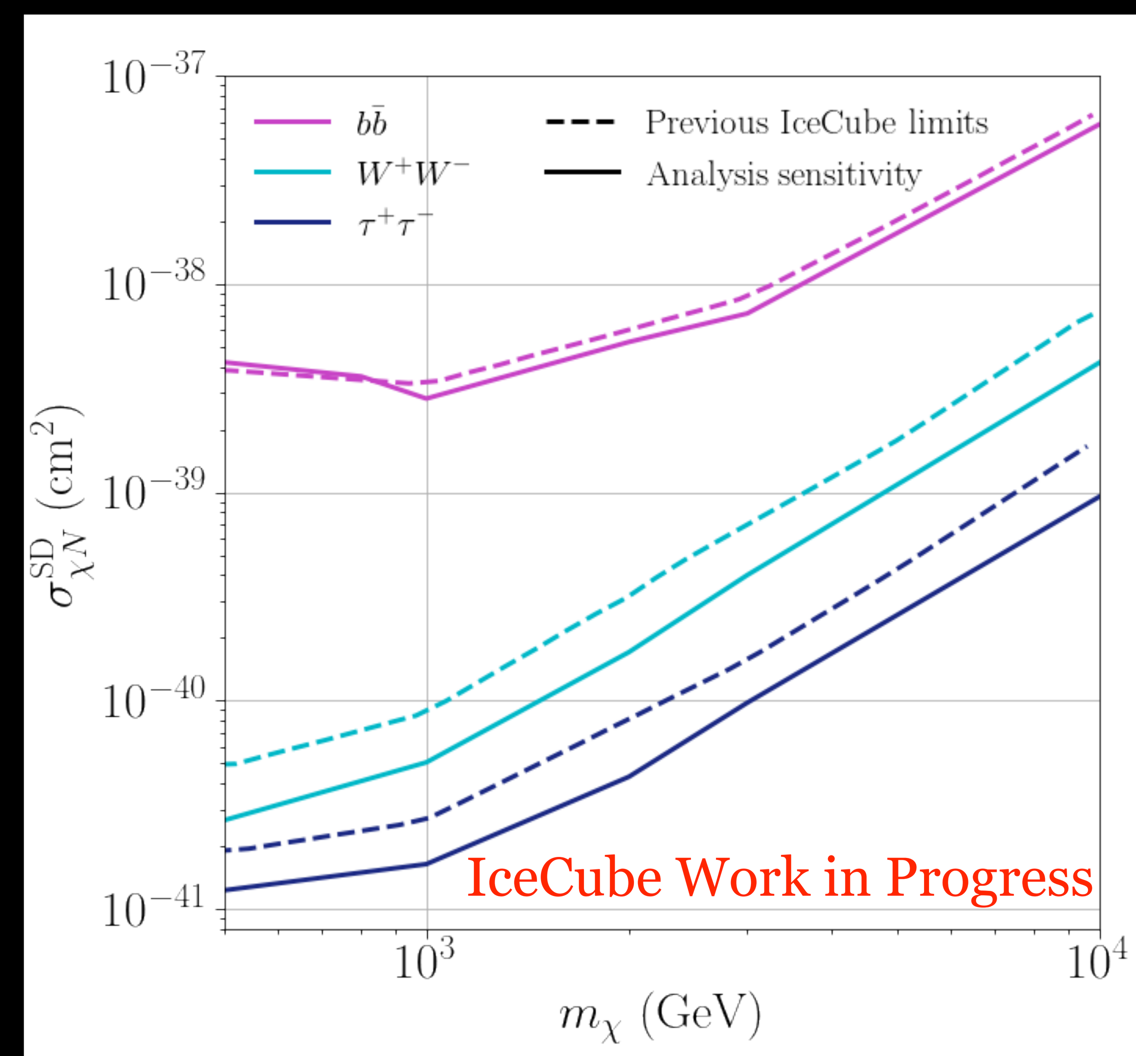


Fig. 4: Sensitivities to WIMP-nucleon cross section for different annihilation channels for previous analysis (3 years) and current analysis using yellow spectrum from Fig. 2

References
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