Prospects for Discovery of DM Annihilation to Primary Neutrinos with IceCube

Bradley Knockel
University of New Mexico

Working with...
Rouzbeh Allahverdi (UNM), Alexander Friedland (LANL),
Katherine Richardson (UNM)

IPA2013
Madison, USA, May 13-15

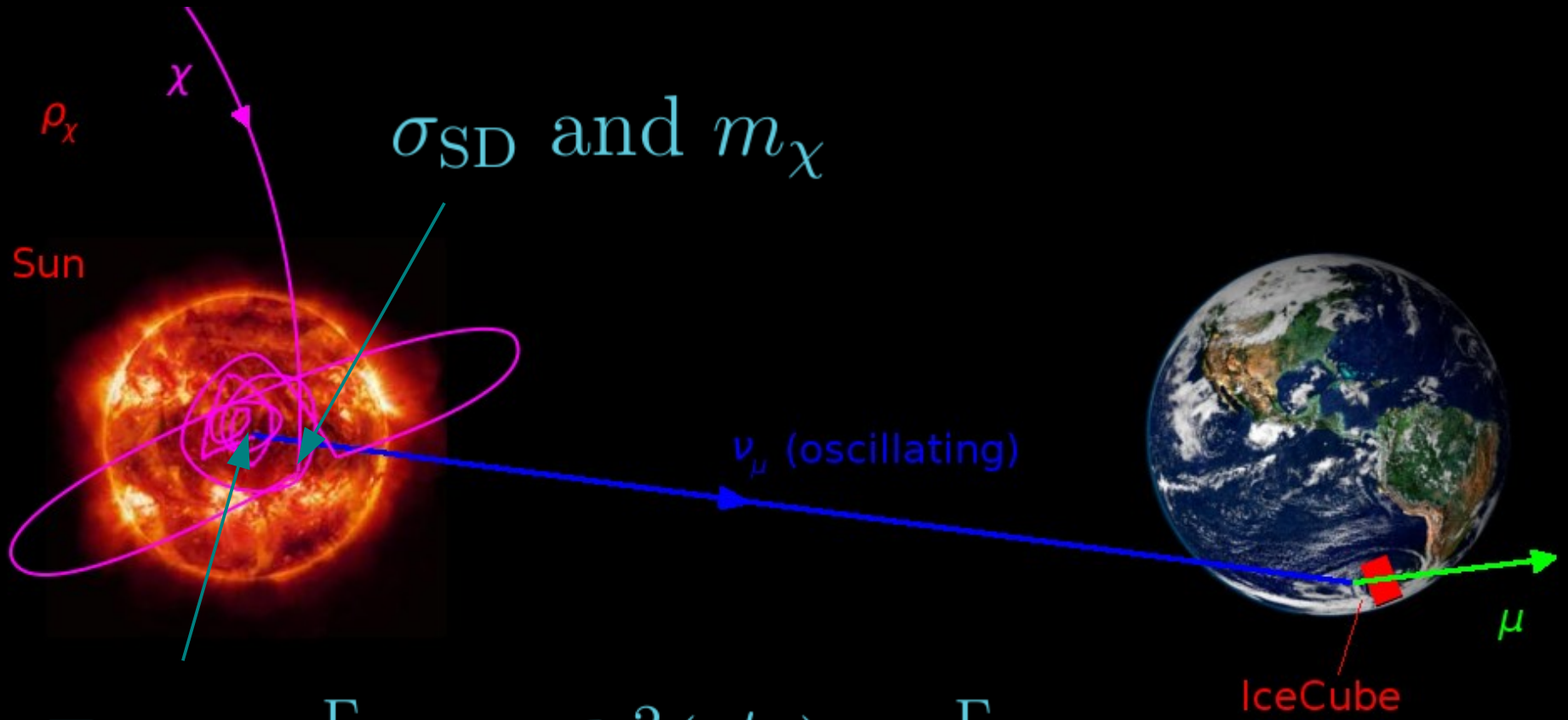
Outline

(1) Introduction

(2) Methods and Results

(3) Conclusions

Indirect Detection via the Sun



$$\Gamma_{\mathrm{ann}} = \frac{\Gamma_{\mathrm{cap}}}{2} \tanh^2\left(\frac{t}{\tau_{\mathrm{eq}}}\right) \approx \frac{\Gamma_{\mathrm{cap}}}{2}$$

and B_i

Why Prompt Neutrinos

- The LHC has constrained the MSSM, so the neutralino may not be the WIMP
- Our analysis is model independent, and we are not biased towards the neutralino
- Many models have enhanced prompt neutrinos
- For example, if the WIMP has lepton number, it can annihilate to $\nu\nu$

Enhanced prompt neutrinos
Lindner, Merle, and Niro, Phys. Rev. D 82, 123529 (2010).

Annihilation Channel Examples

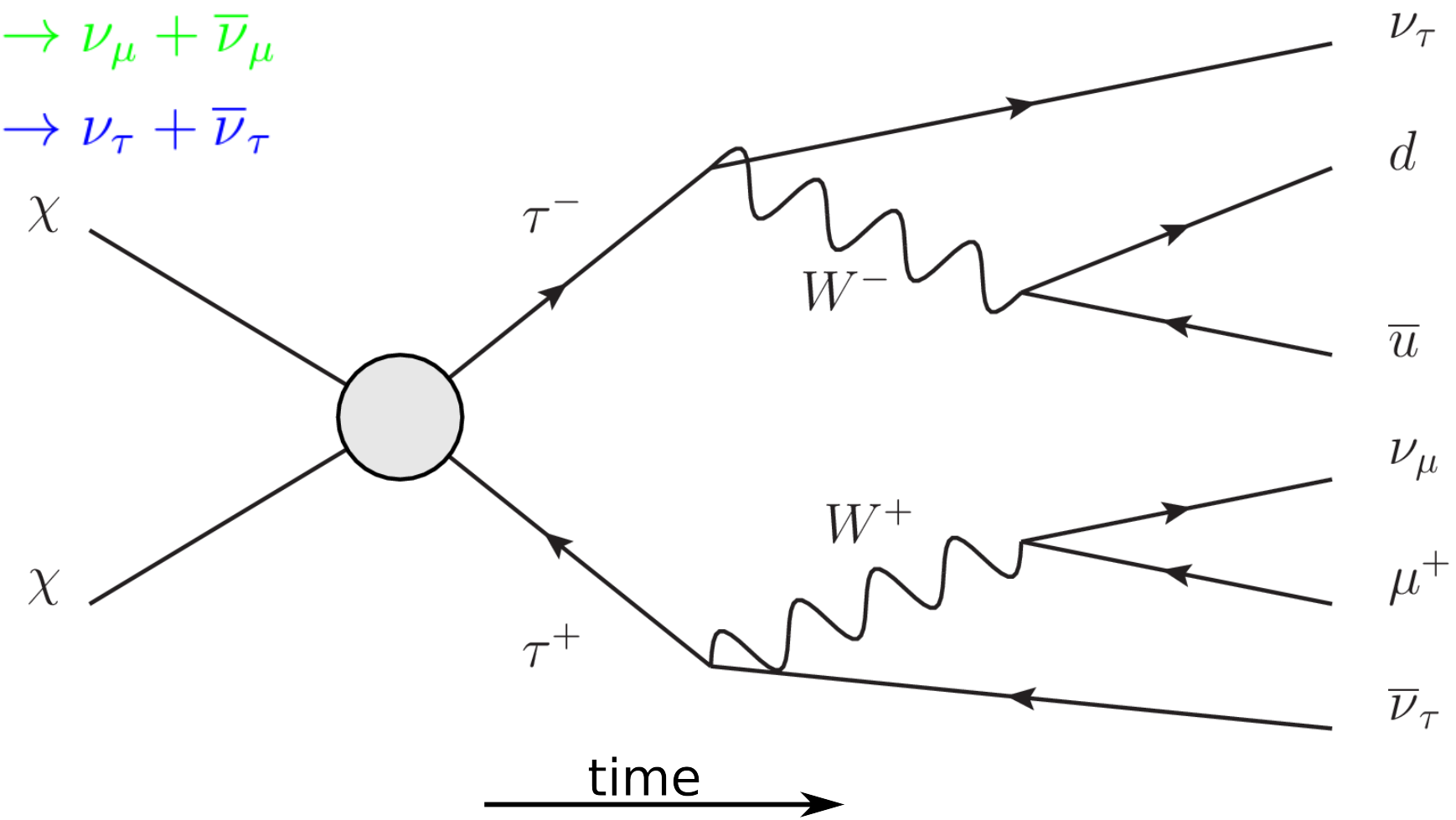
$\chi + \chi \rightarrow \tau^- + \tau^+$

$\chi + \chi \rightarrow W^+ + W^-$

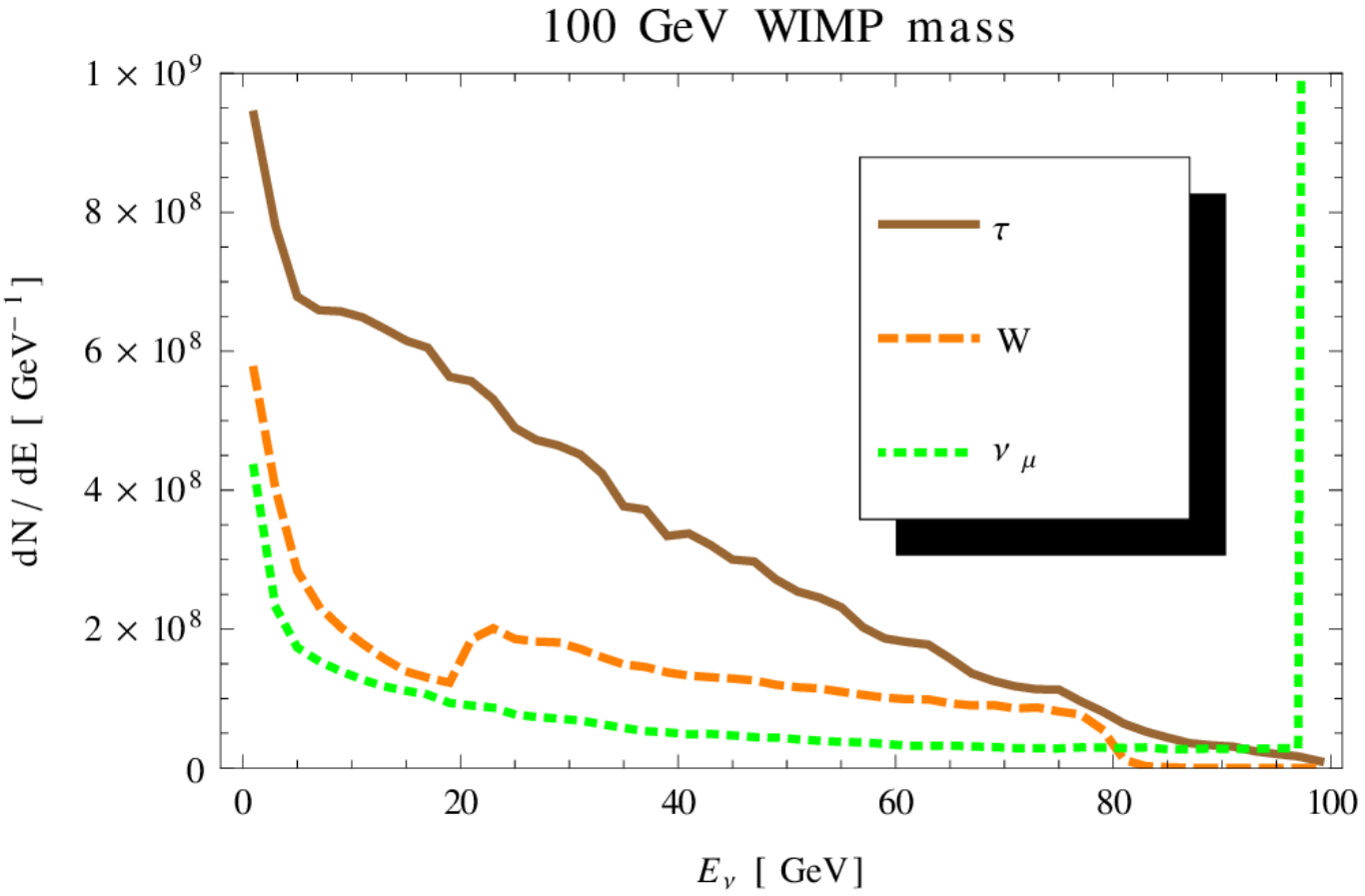
$\chi + \chi \rightarrow \nu_e + \overline{\nu}_e$

$\chi + \chi \rightarrow \nu_\mu + \overline{\nu}_\mu$

$\chi + \chi \rightarrow \nu_\tau + \overline{\nu}_\tau$



Muon Neutrinos Reaching Detector



There are corresponding angular distributions as well.

Outline

(1) Introduction

(2) Methods and Results

(3) Conculsions

Our Analysis

(1) Acquire simulated data for signal and background at IceCube using DarkSUSY. We acquire “contained” and “through-going” muons.

(2) Model IceCube’s detection of the muon tracks using published effective detector volumes and areas and by smearing the angular and energy distributions by 1° and 40 GeV respectively

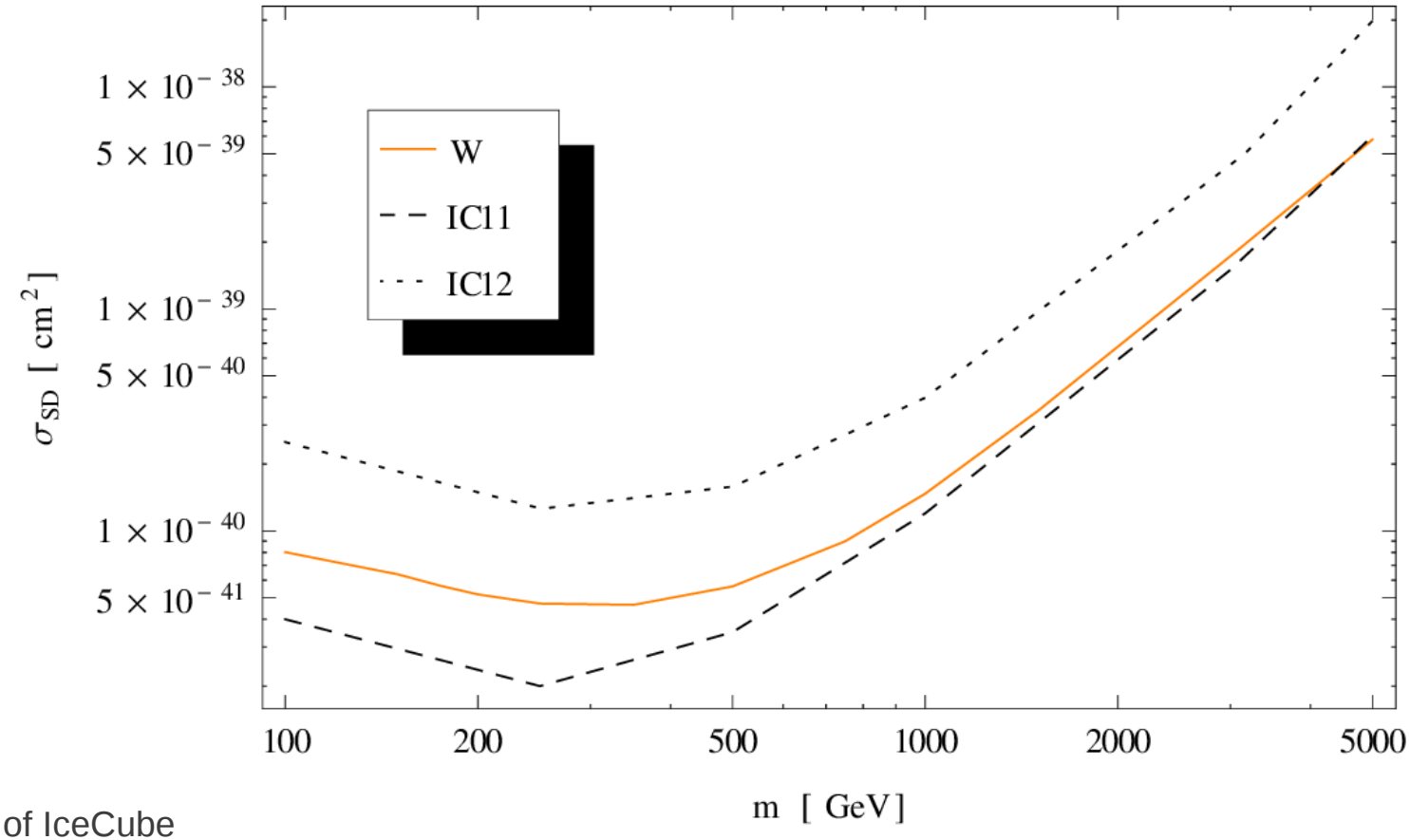
(3) Optimize the analysis for dark matter discovery at 90% confidence

$$\frac{S}{\sqrt{S+1.2B}} = 1.64$$

(4) Distinguish between different annihilation channels assuming a discovery and an independent measurement of mass

$$\sigma = \frac{|S_c - S_t|}{\sqrt{S_c+1.2B_c}} \qquad \sigma_1^2 + \sigma_2^2 = \sigma^2$$

Benchmarking Using the *W* Channel



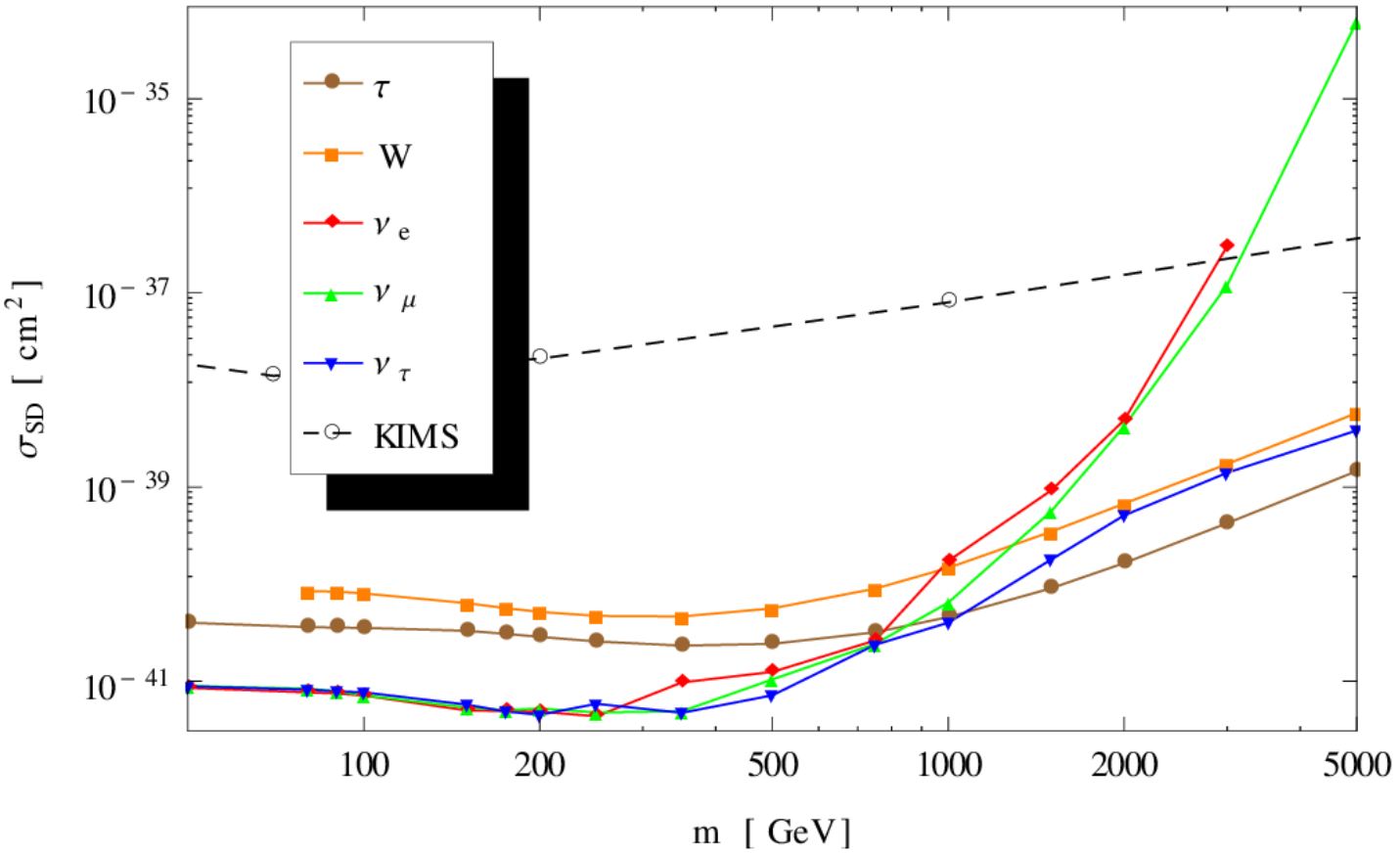
Effective Volume/Area of IceCube
Astropart. Phys. 35, 615 (2012).

IceCube 2011
Phys. Rev. D 85, 042002 (2012).

IceCube 2012
Physical Review Letters 110, 131302 (2013).

IceCube can be modeled simply.

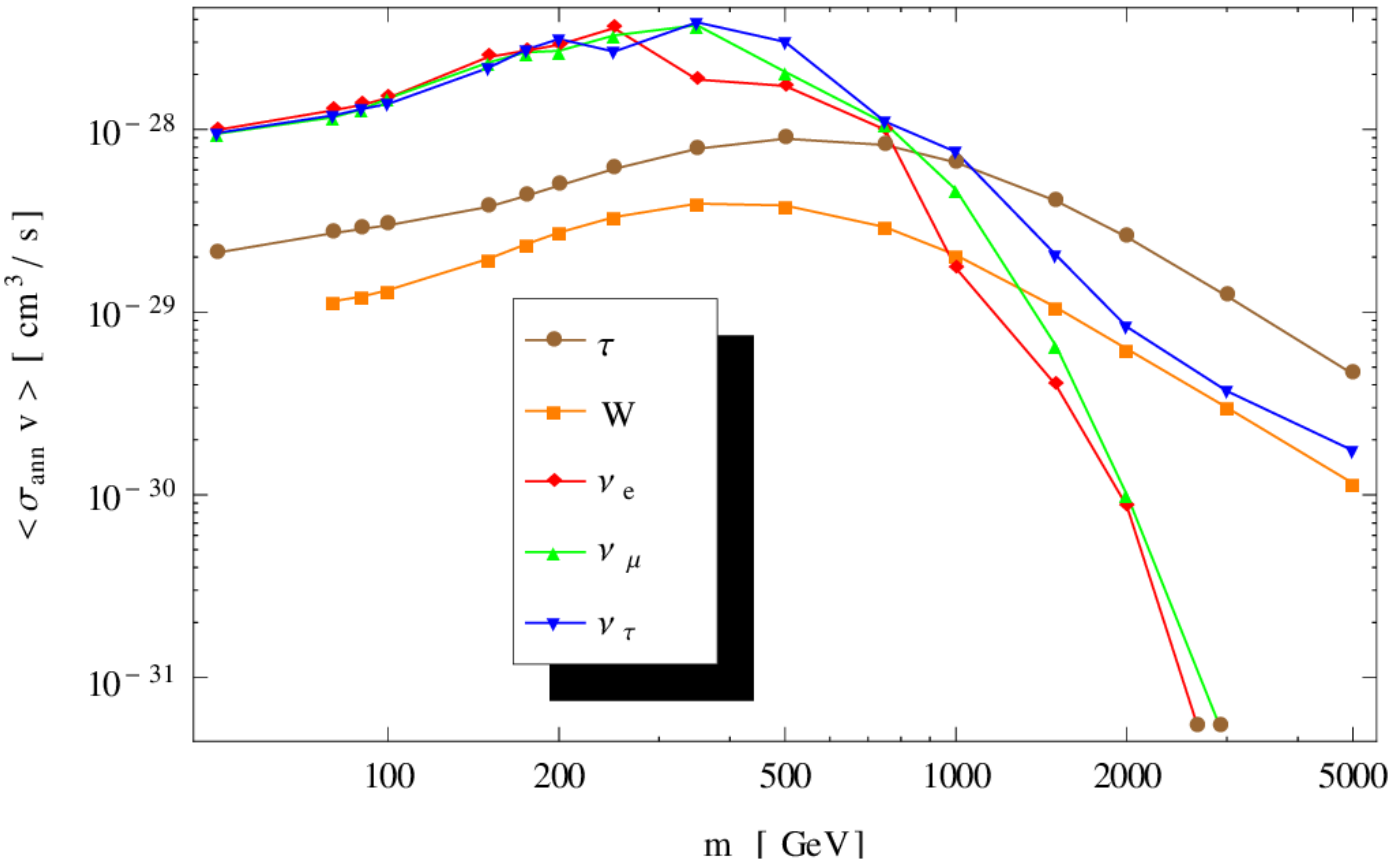
Sensitivity Plot for All Channels



KIMS
Physical Review Letters 108, 181301 (2012).

Factor of ~8 between *ν* and *W*
Allahverdi and Richardson, Phys. Rev. D 85, 113012 (2012).

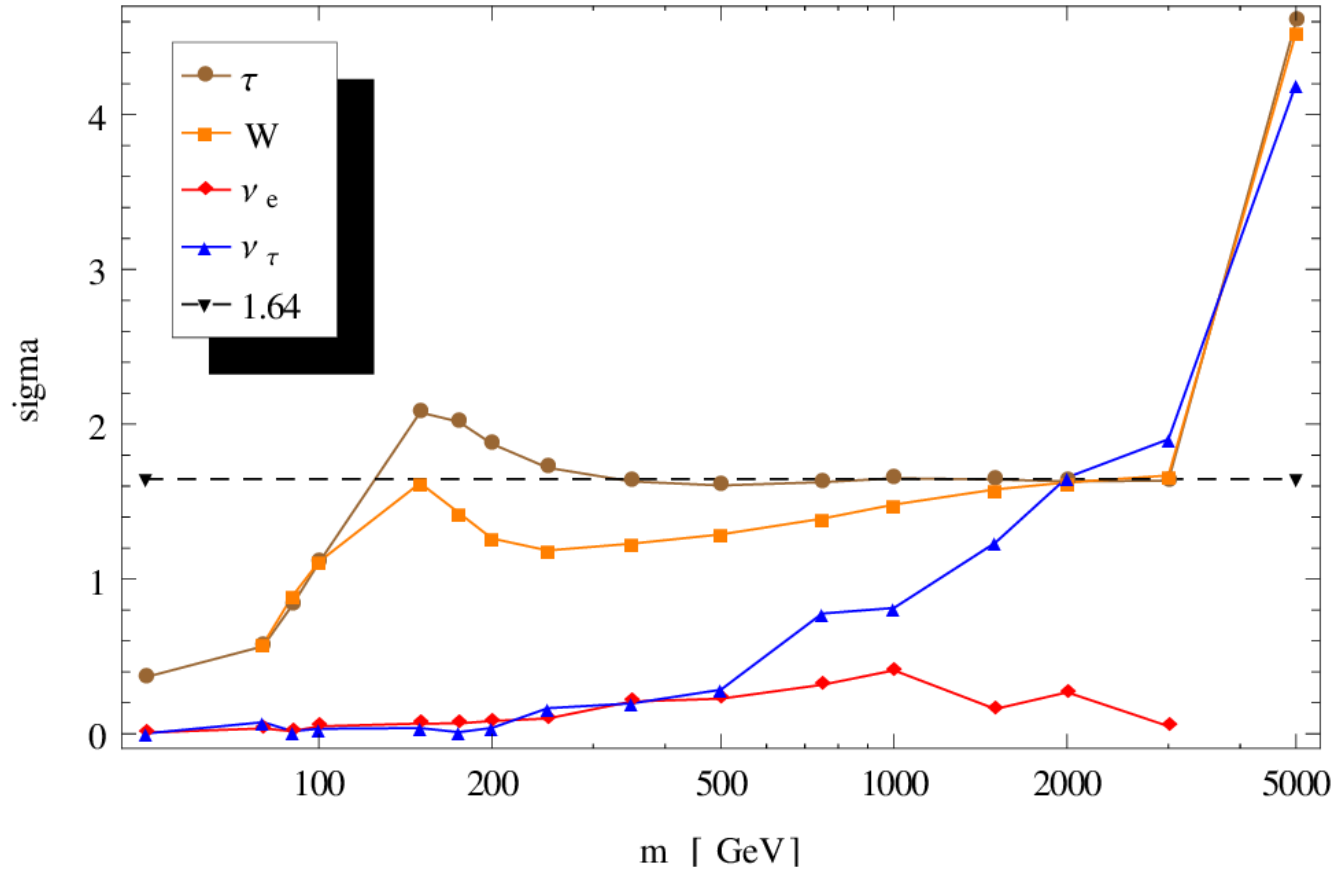
Corresponding $<\sigma_{ann}\ v>$ Required for Equilibrium in Sun



Sun might be the only way the detect prompt neutrinos.

Compare to galactic prompt-neutrino bounds of ~10^{-23}
IceCube (2011), e-Print: arXiv:1111.2738 [astro-ph.HE].

Distinguishing Channels (asking if ν_μ fits the data)



Outline

(1) Introduction

(2) Methods and Results

(3) Conclusions

Conclusions

- We should consider prompt neutrinos
- Although the solar community ignores prompt neutrinos, indirect detection via the Sun may be the only way to detect them
- IceCube is sensitive to prompt neutrinos for DM mass < 1 TeV
- Prompt neutrinos can be distinguished from other annihilation channels

Paper on arXiv soon!