Neutrinos from captured dark matter annihilation in a galactic population of neutron stars

(arXiv : 2108.12420)

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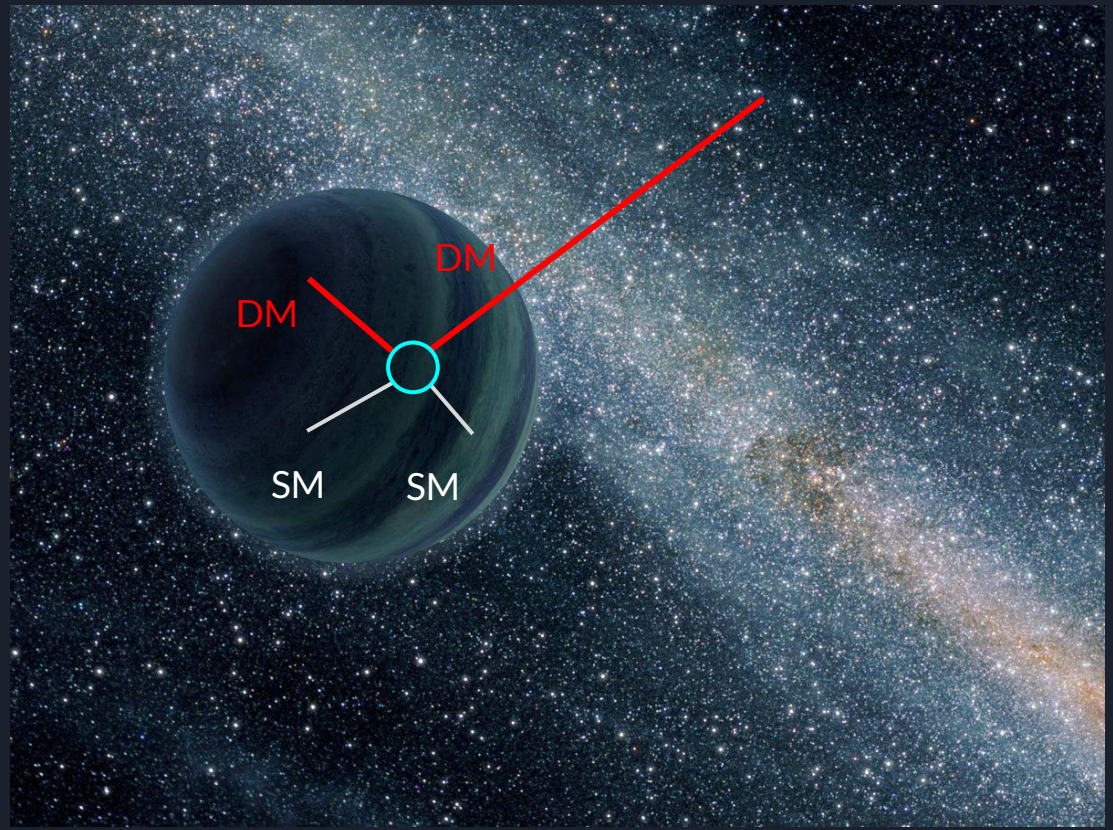
Outline -

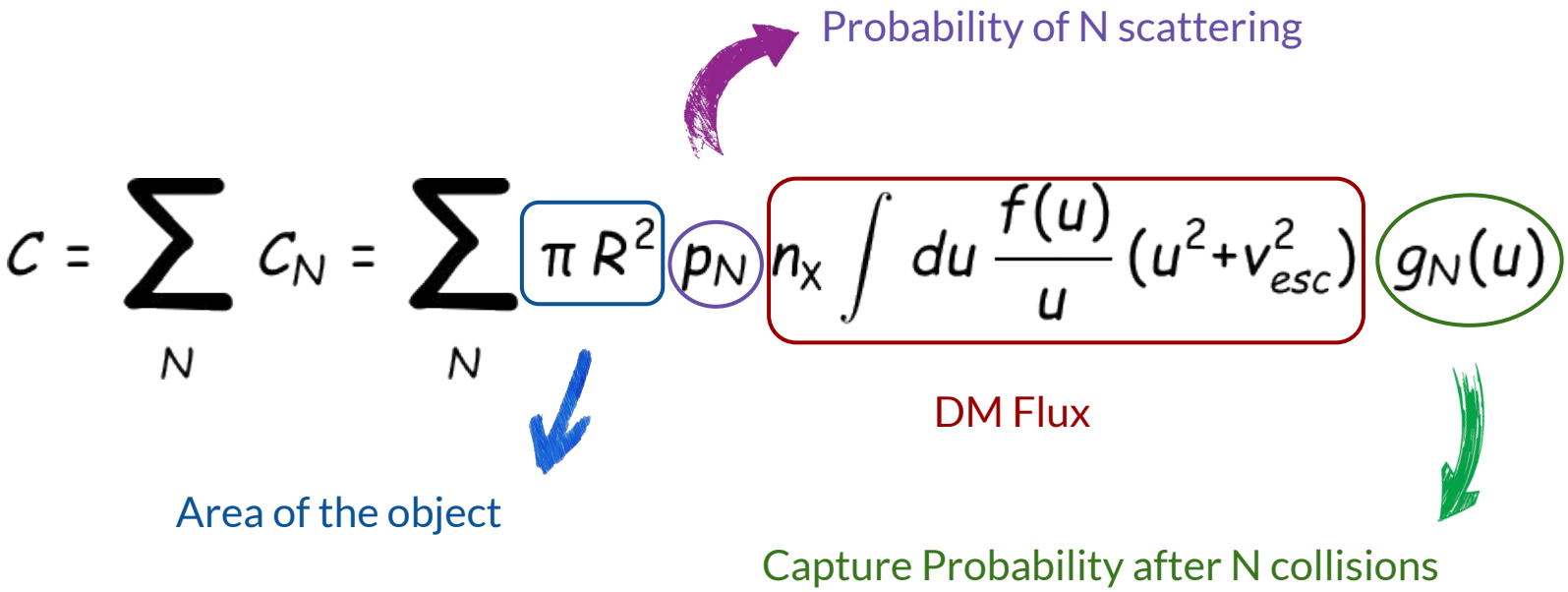
1. Capture Mechanism
2. DM capture in NS population
3. Neutrino flux from captured DM
4. Detection Prospects
5. Results
6. Conclusions

Capture Mechanism



Source - NASA, JPL-Caltech

Capture Rate -

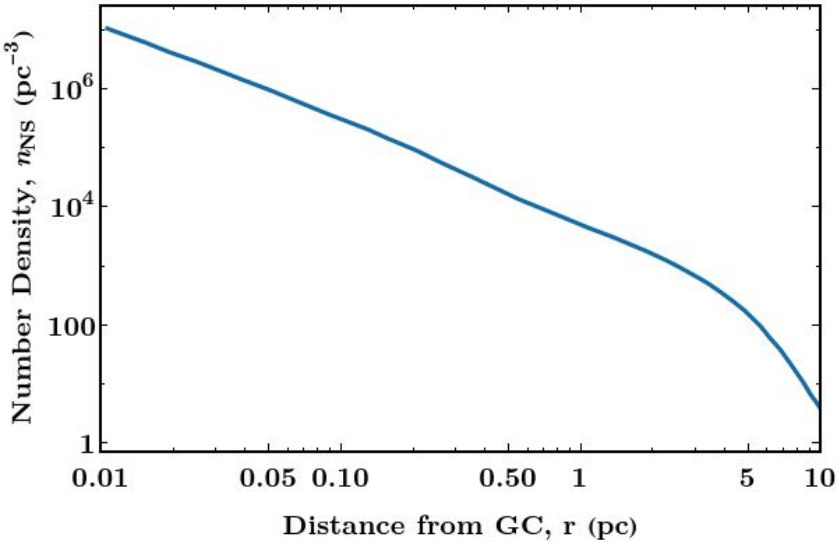


Capture Rate due to a distribution of stars -

NS density

$$C_{tot} = 4\pi \int_{r_1}^{r_2} r^2 \, n_{NS}(r) \, C(r) \, dr$$

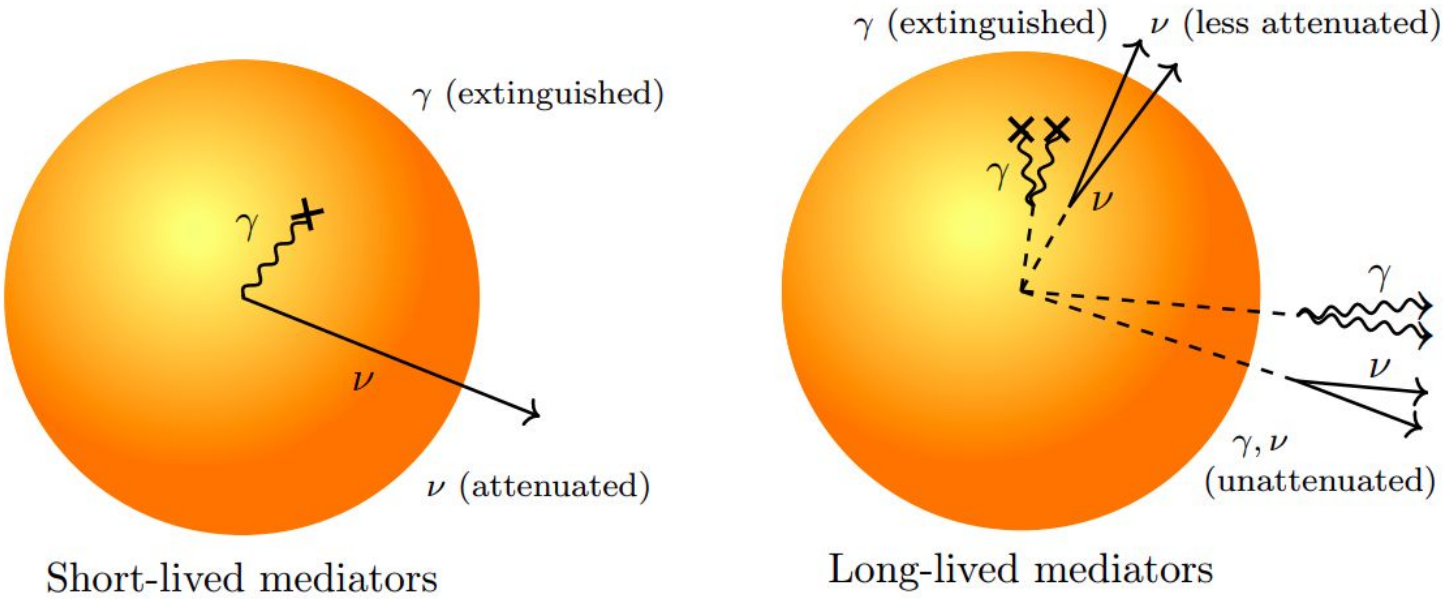
Capture rate of DM in a star



Adopted from - N.C. Stone, A. Generozov et al. (2018)

Annihilation Signatures -

Neutrino/photon signal



Heating

Source - R.K.Leane, J.F.Beacom, Kenny.C.Y.Ng (2017)

Annihilation Spectra -

Capture Rate

Evaporation Rate

DM number density - $\frac{dN}{dt} = C_{tot} - C_{ann}N^2 - C_{evap}N$

Annihilation Rate

For Equilibrium - $\Gamma_{ann} = \frac{1}{2}C_{ann}N^2 = \frac{1}{2}C_{tot}$

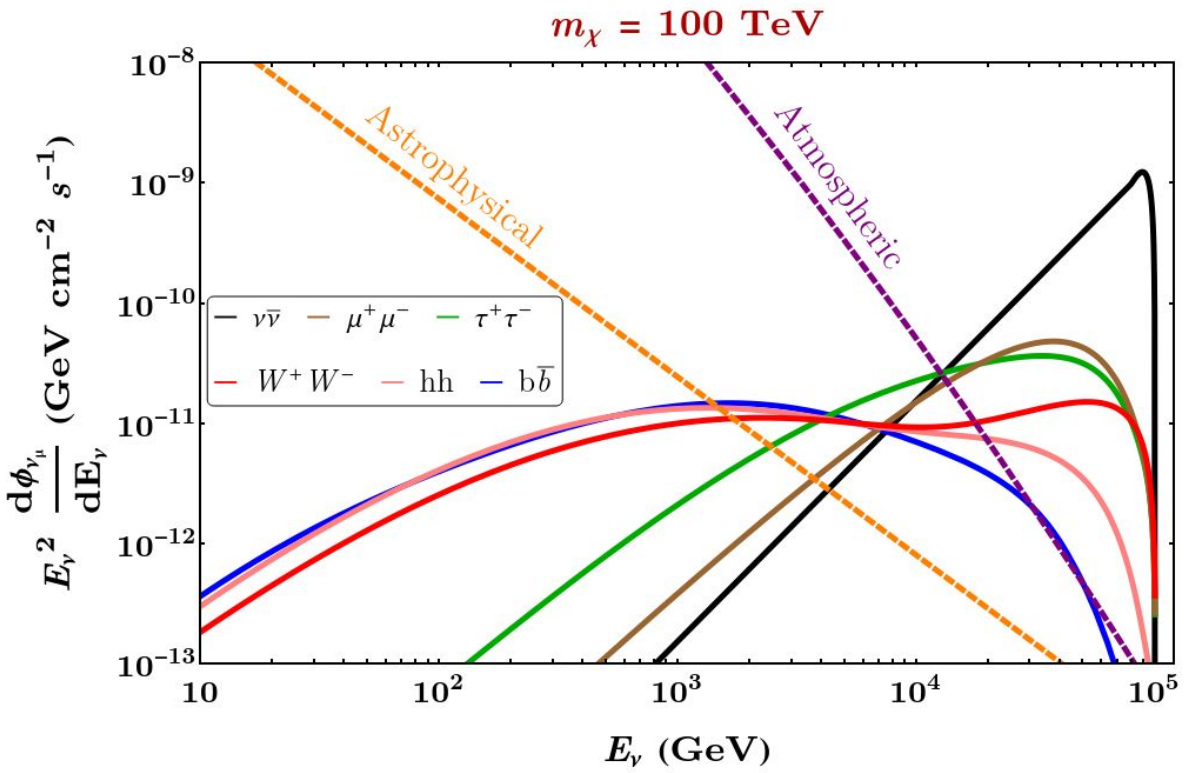
$$E_\nu^2 \frac{d\varphi_{\nu_\mu}}{dE_\nu} = \frac{\Gamma_{ann}}{4\pi D^2} E_\nu^2 \frac{dN}{dE_\nu} Br(Y \rightarrow SM\bar{SM}) \left(e^{-\frac{R}{\eta c\tau}} - e^{-\frac{D}{\eta c\tau}}\right)$$

Neutrino spectra

Branching Ratio

Survival Probability

Neutrino Flux -

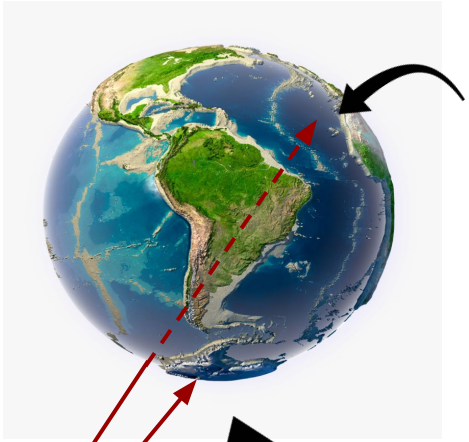


100 % branching ratio

Mediator mass - 2 TeV

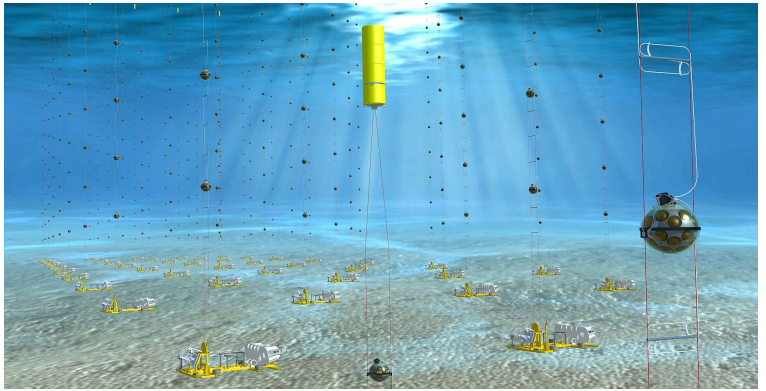
Detection Prospects -

Source - https://www.pngitem.com/middle/hJhhbmx_earth-planet/

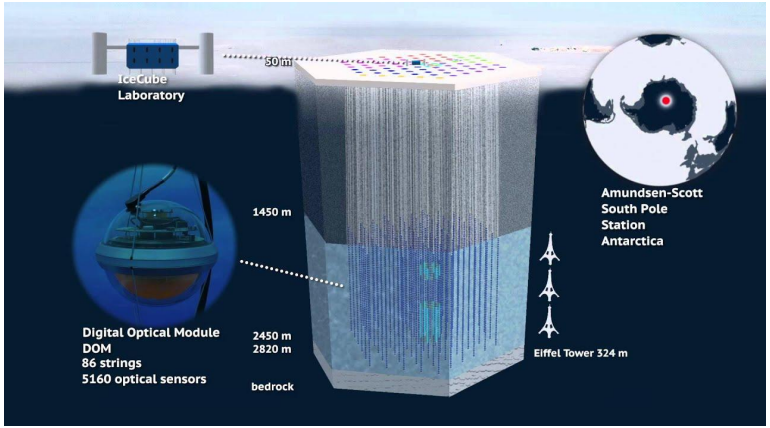


Neutrinos

Galactic Center



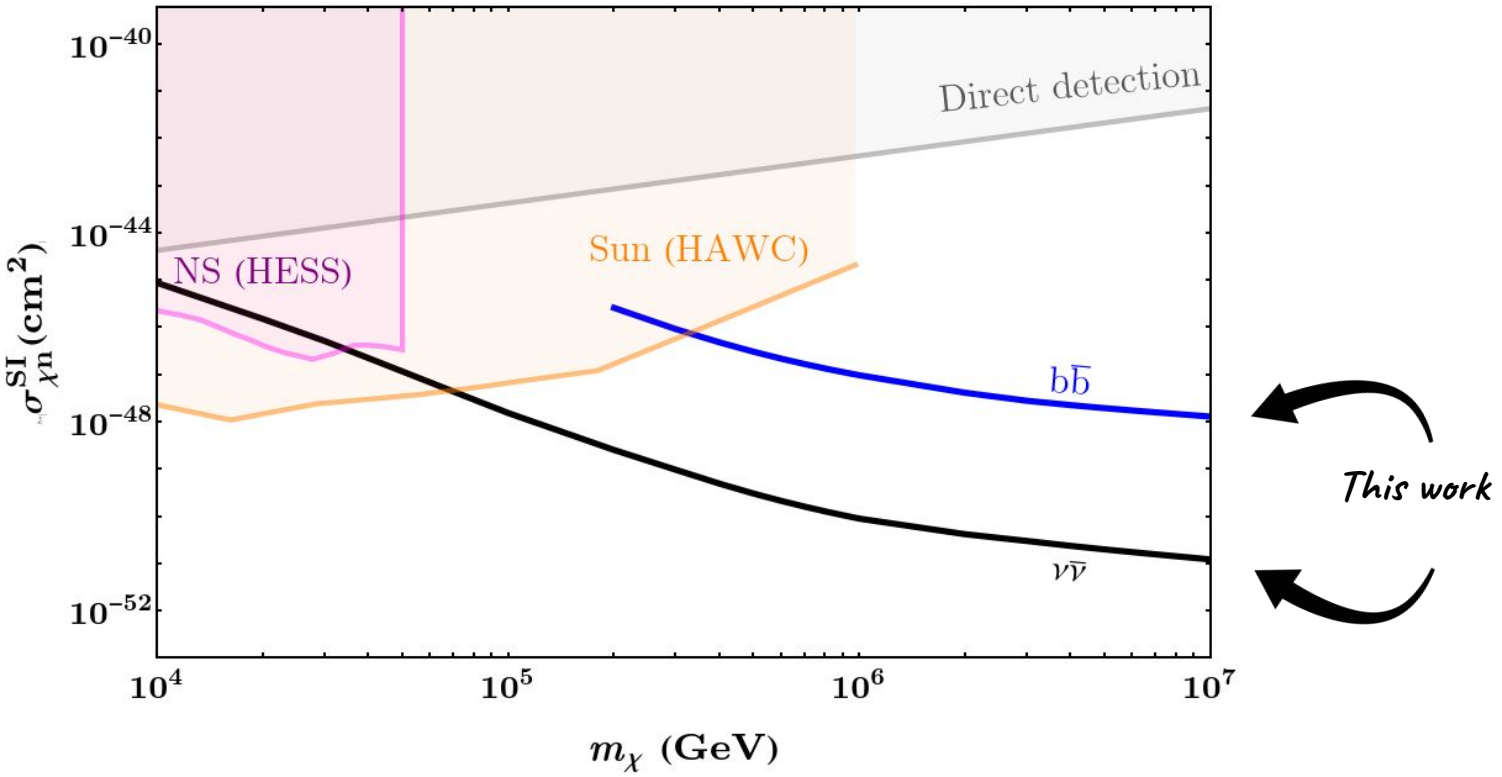
Source - Wikipedia/KM3Net



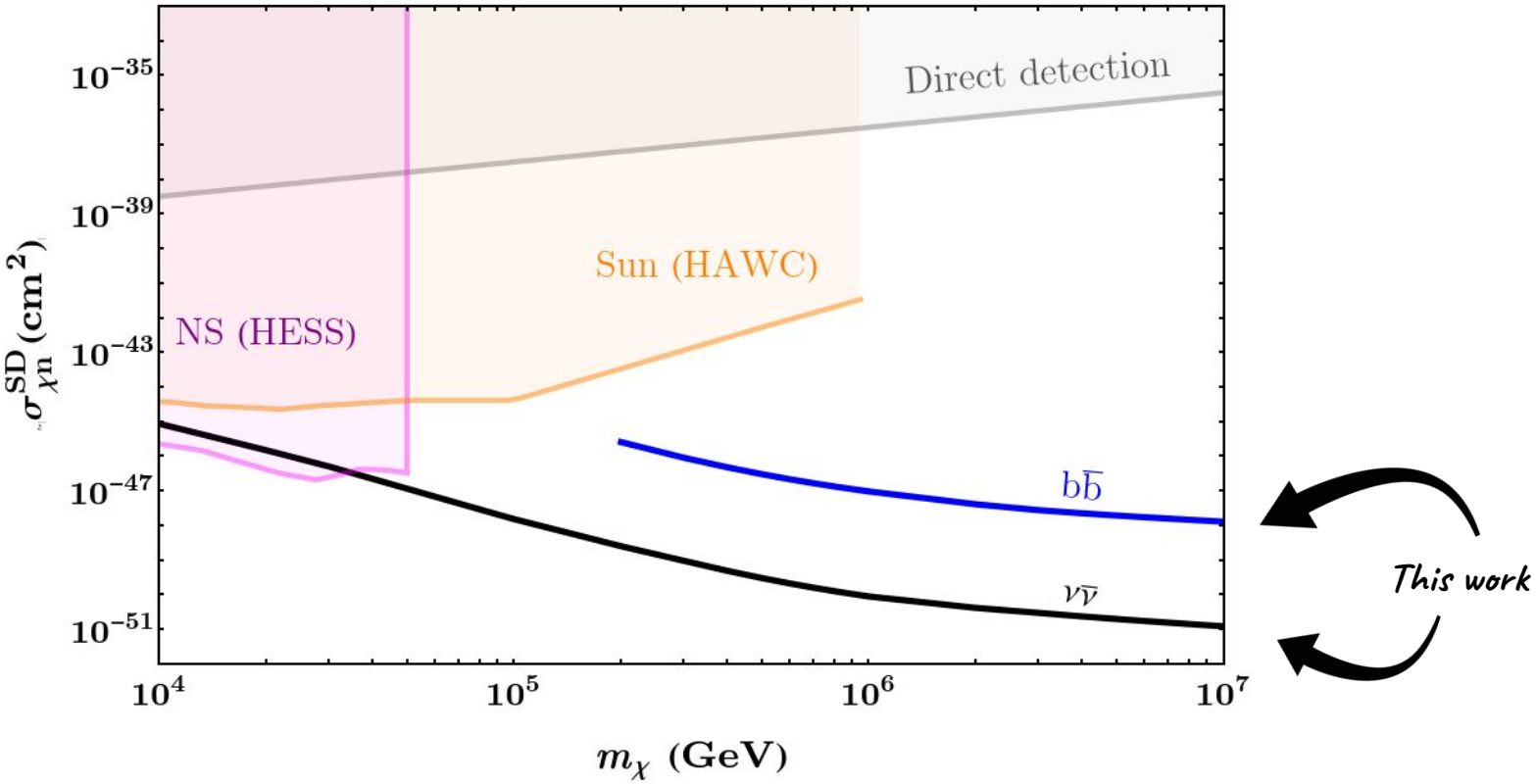
Source - Youtube/IceCube Observatory

Results -

Spin independent limits



Spin dependent limits



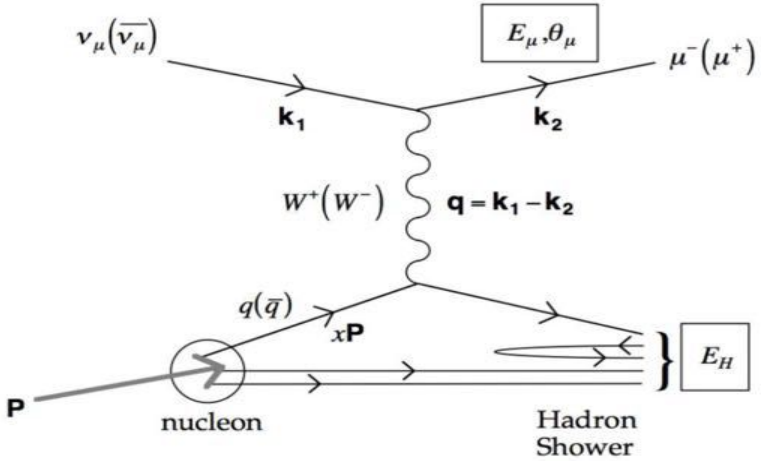
Conclusions -

1. Interesting to probe non-gravitational interactions between DM and SM by detecting annihilation spectra in Earth based experiments
2. We have analysed neutrino signals from DM captured in the galactic center distribution of neutron stars
3. Conservative limits obtained by requiring signal events with the leading background events
4. For SD and SI interactions, galactic center neutron star population can give more stringent limits in the TeV-PeV DM mass range

THANK YOU

Backup Slides

Detector Sensitivity -

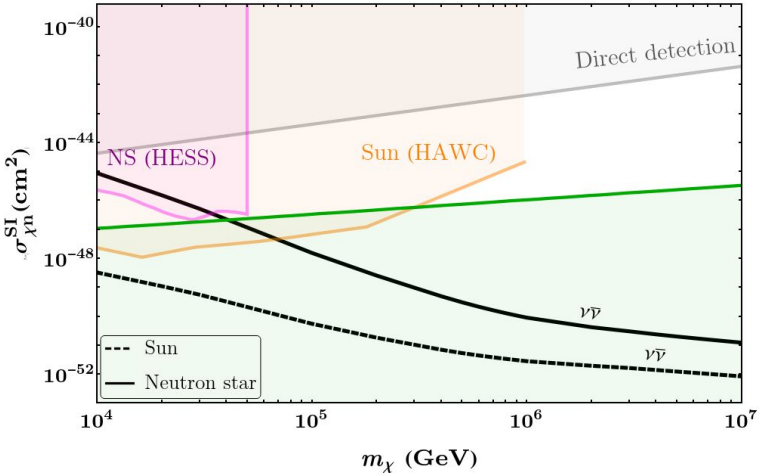


Source - Dissertation of Pablo Fernandez (2017)

Constraints -

$$N_{signal} = \int_{\frac{m_X}{5}}^{m_X} \frac{dN}{dE_\mu} dE_\mu = N_{bkg}$$

Include Solar Limits



Spin-independent limits

Spin-dependent limits