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8 years search for Dark Matter from the center of the Earth

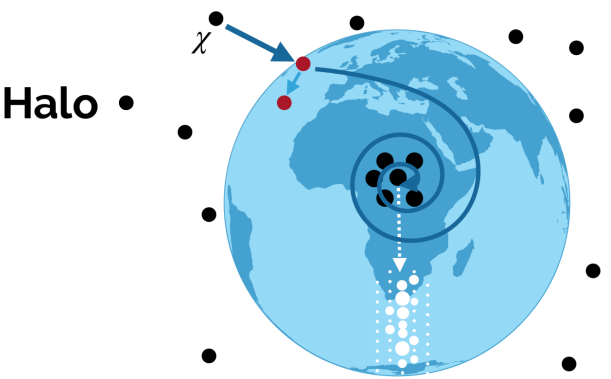
ICRC 2021

Poster

Giovanni Renzi

IceCube

Dark matter from the center of the Earth



$$\frac{dN}{dt} = C_C - C_A N^2$$

Rate at the detector

Capture rate

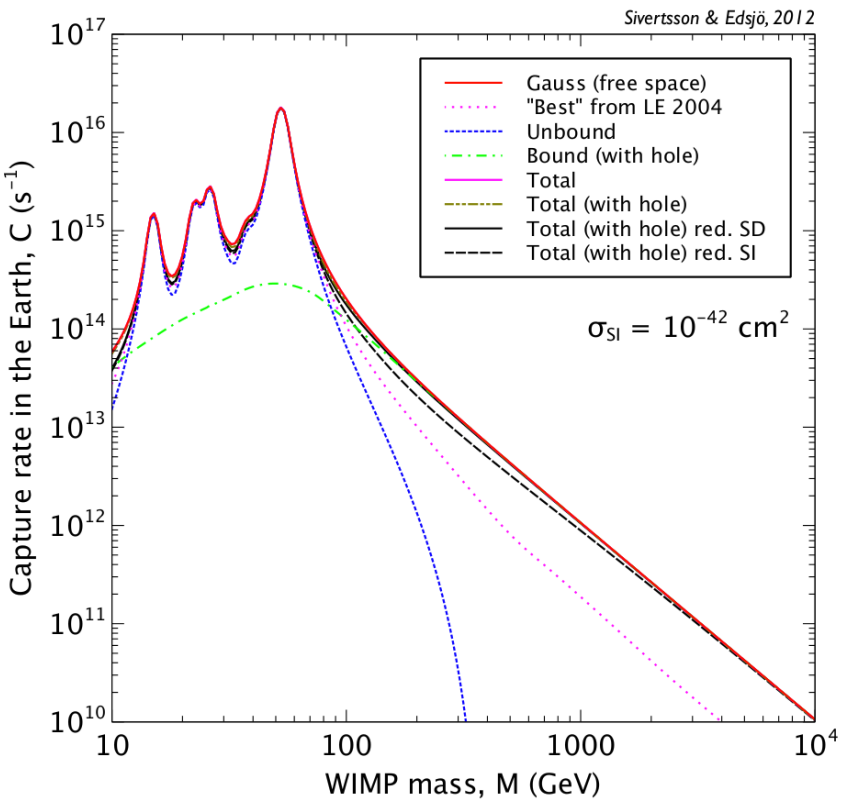
Annihilation rate Γ_A

Solution: $\Gamma_A = \frac{C_C}{2} \tanh^2\left(\frac{t_\oplus}{\tau}\right)$

Equilibrium time not reached!

$\tau = (C_C \cdot C_A)^{-1/2}$

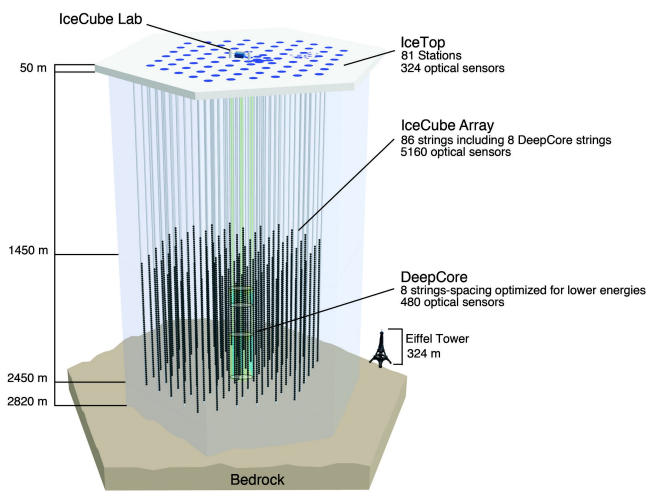
An assumption on $\langle\sigma_A v\rangle$ must be made



The IceCube Neutrino Telescope

IceCube is a cubic kilometer neutrino detector located at the geographical South Pole.

An array of optical modules detects the **Cherenkov** light emitted along the path of relativistic charged particles produced by neutrino interactions in the ice or bedrock.



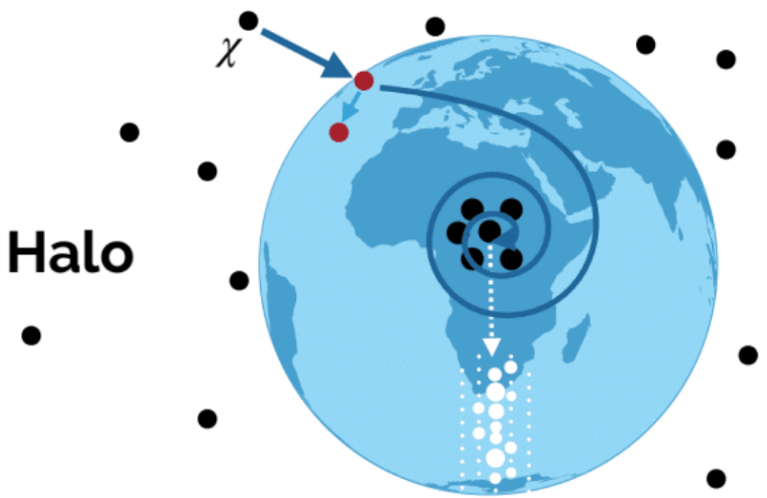
Time Direction

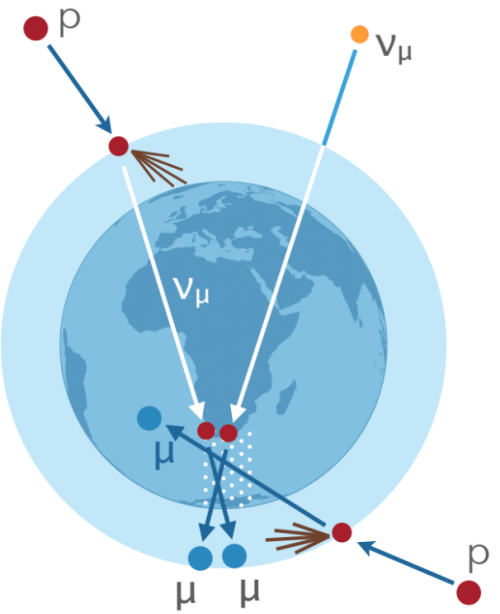
N. of photo-electrons

Reconstruction of particles **direction** and **energy**

Signal and background expectations

Signal direction: zenith ~ 180 deg
No off-source region!
=> we have to rely on MC simulations for background





Two backgrounds:
- Down-going atmospheric **muons** mis-reconstructed as up-going
- Up-going atmospheric **neutrinos**

Signal and background expectations. LE

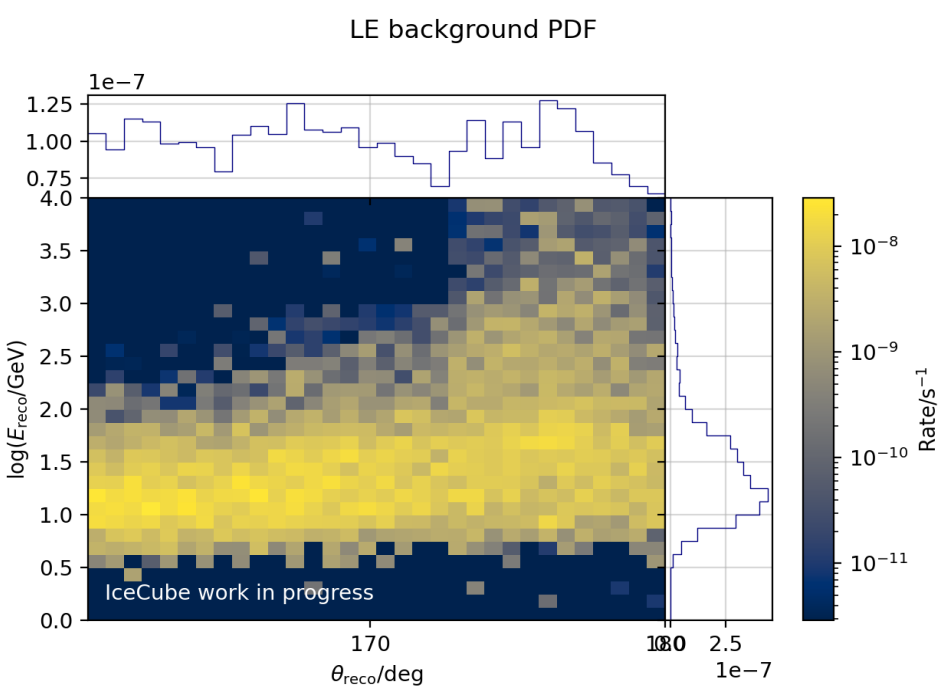
2D zenith-energy PDFs

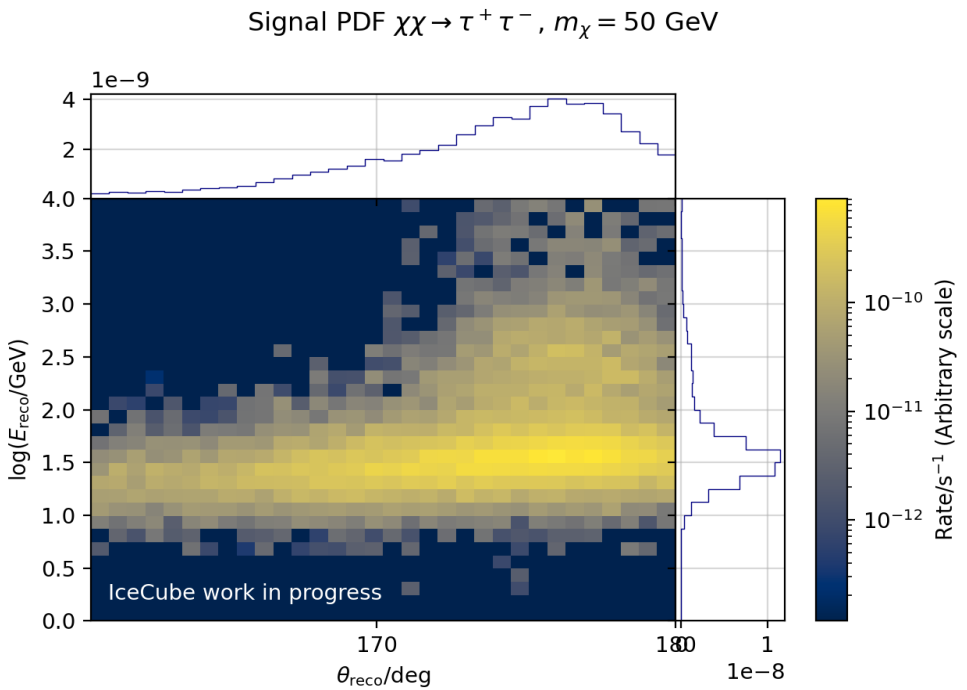
32x32 bins grid for the low energy selection

Zenith: bin width ≃ 0.61°

Energy: 8 bins per decade

Showing: *Atmospheric* background (~100% neutrino purity) and the baseline signal





Signal and background expectations. HE

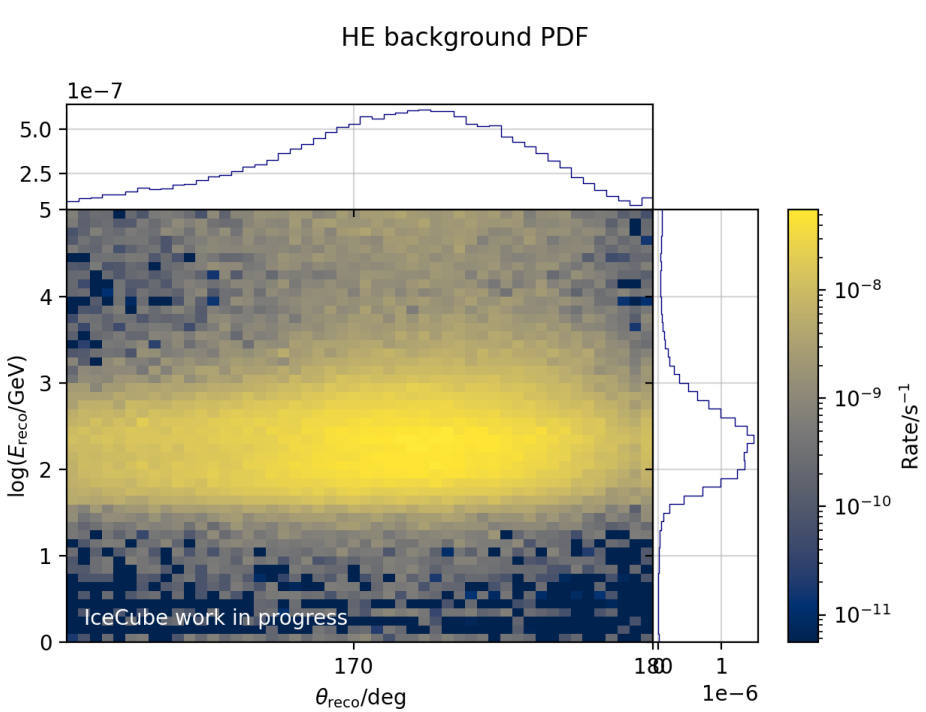
2D zenith-energy PDFs

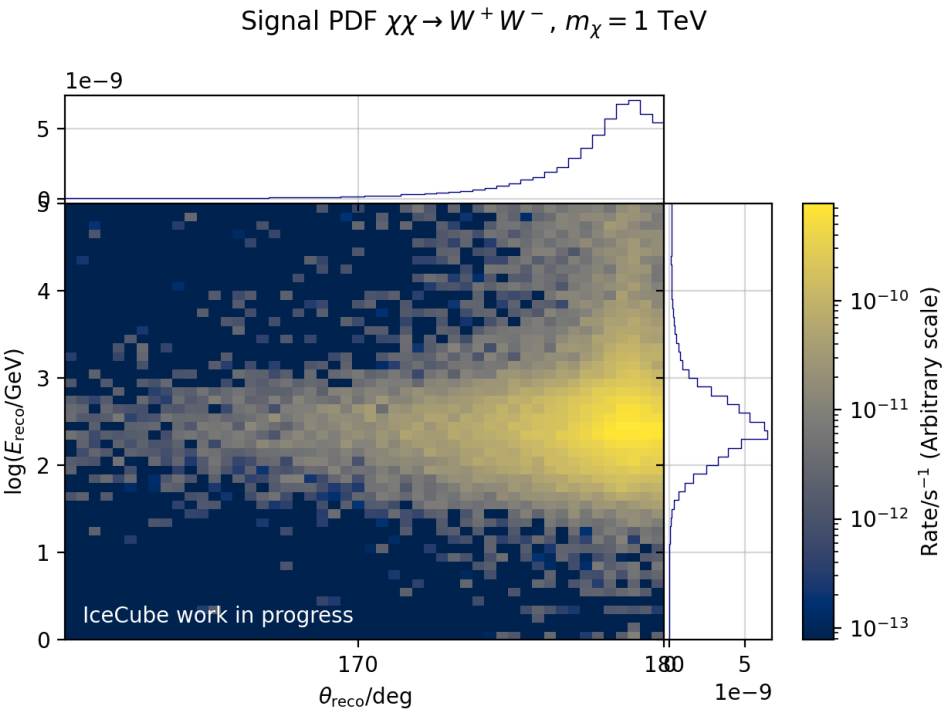
50x50 bins grid for the high energy selection

Zenith: bin width ≃ 0.49°

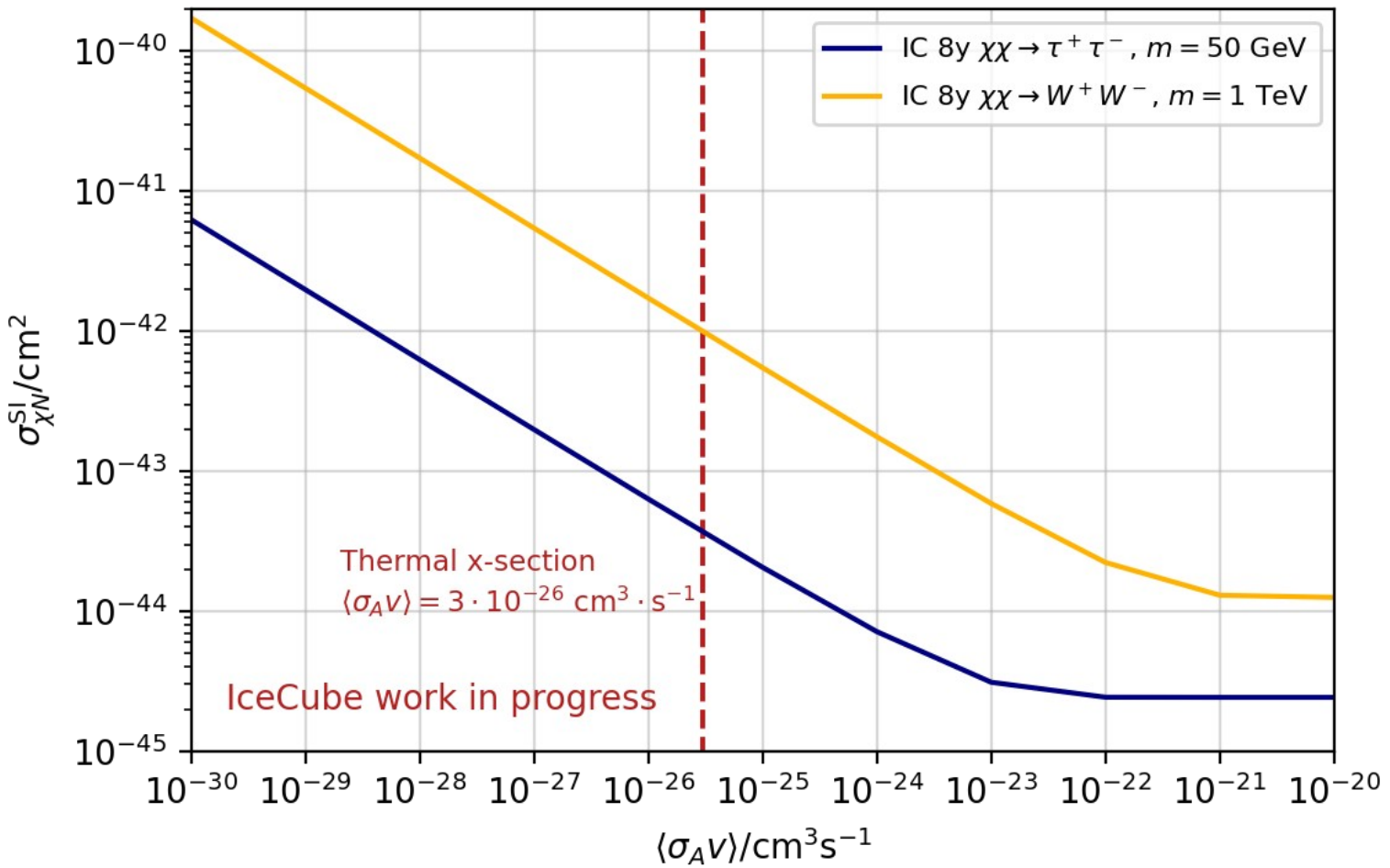
Energy: 10 bins per decade

Showing: *Atmospheric* background (~100% neutrino purity) and the baseline signal

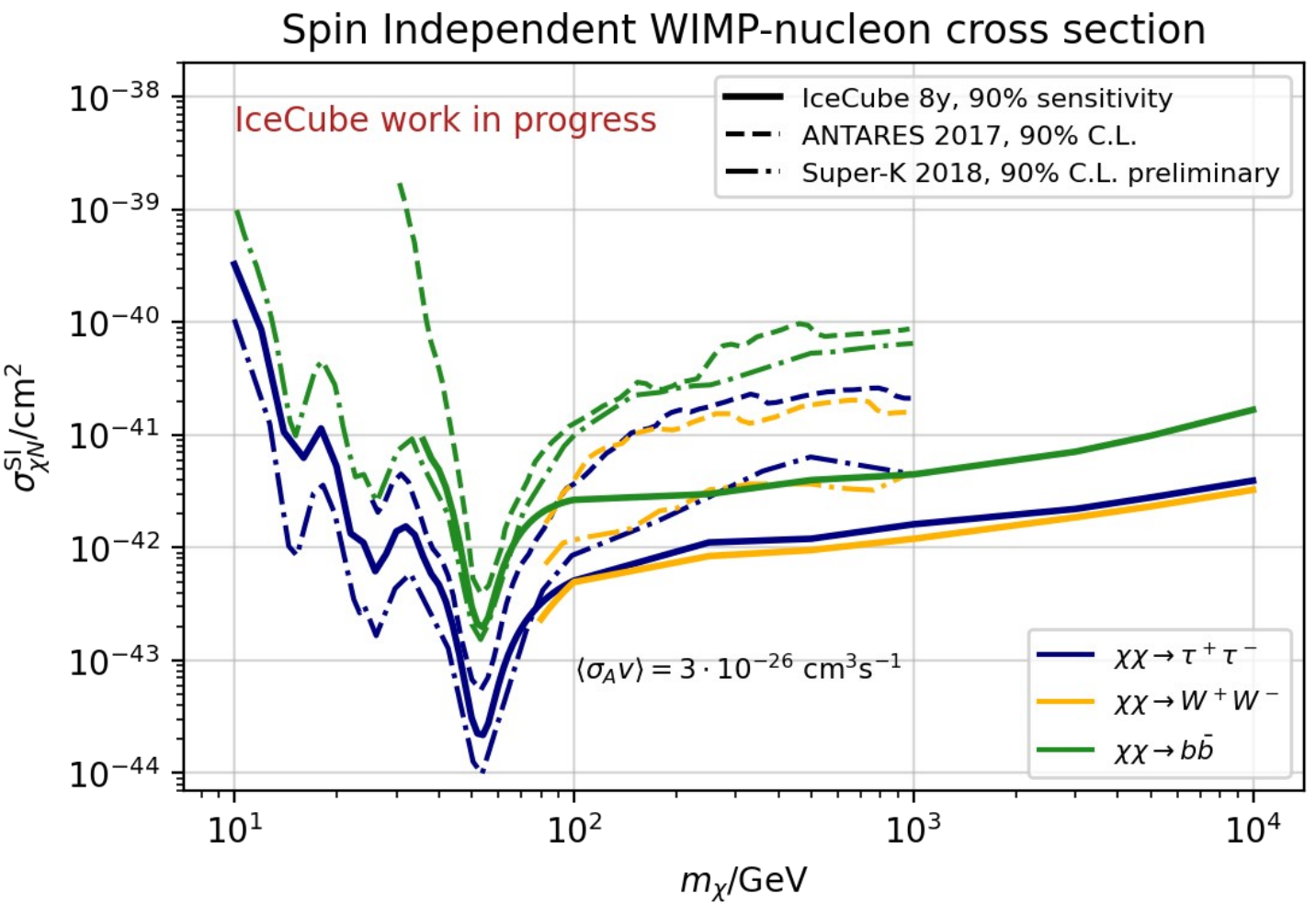




Sensitivities. Cross-section inter-dependency



Sensitivities



Outlook

- Analysis in the final stages
- Evaluating changes in the PDFs construction and likelihood method
- Going to extend to 10 years of data, including the last two seasons
- The analysis is promising competitive limits, world best for E>100 GeV

THANK YOU FOR YOUR ATTENTION

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Backup slides

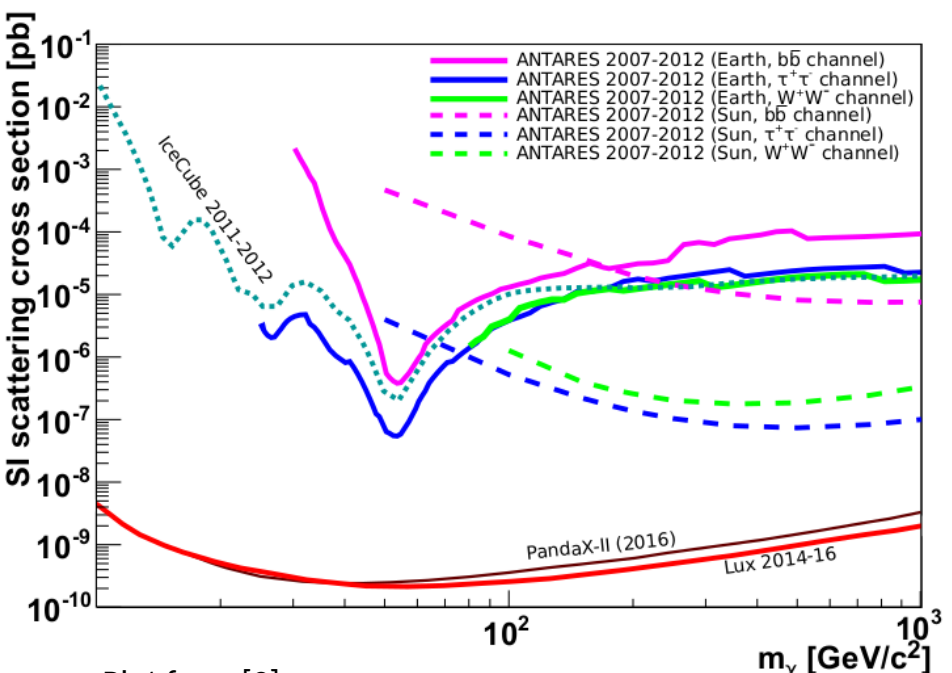
IceCube

Previous analyses

- IceCube: 2013, 1 year of data [1]
- ANTARES in 2017 [2]
- SuperK: new preliminary results [3]

New analysis:

- **8 years** of IceCube data
- Refined event selection
- New **2D PDF** (θ vs. *E*)



Plot from [2]

[1] *arXiv:1609.01492*
[2] *arXiv:1612.06792v2*
[3] *J.Phys. Conf. Ser. 1342 (2020) 1, 012075*

Event selection: L4: BDT

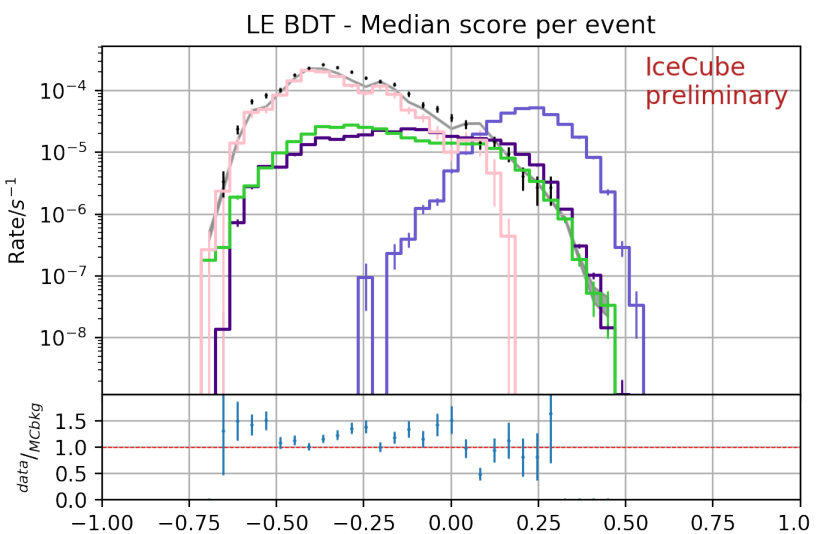
Train on **data** (~20% of BurnSample) for background, on **WimpSim** for signal
Low energy signal ≠ *High* energy signal **=>** **Split** the analysis

Low energy

PullValidation

200 different BDTs are trained on *subsamples*

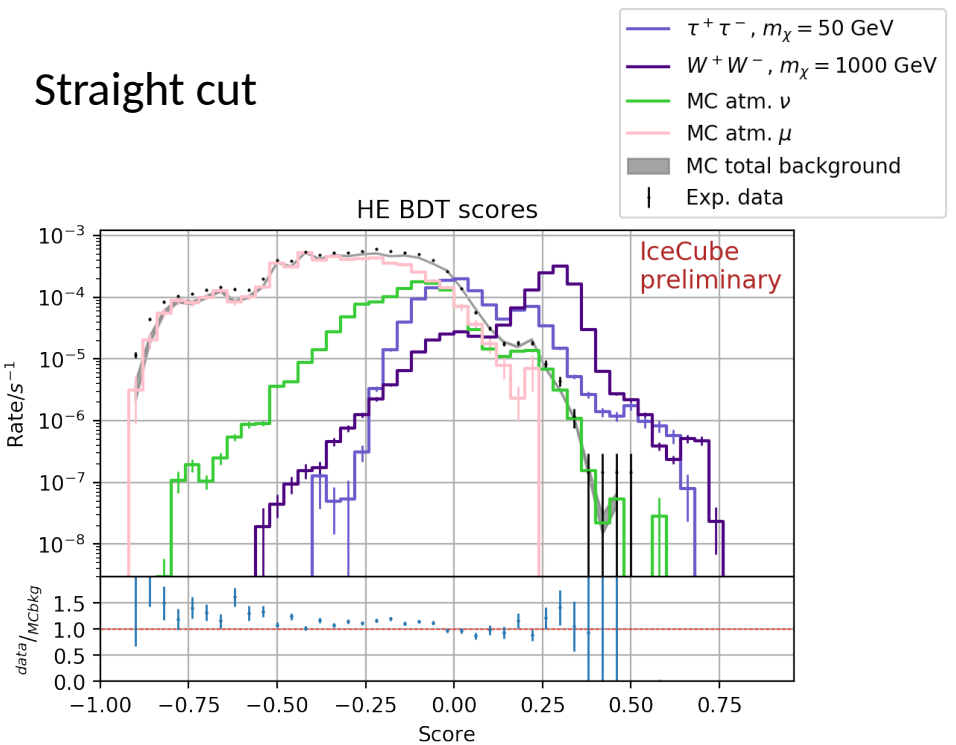
$$weight_{\text{cut}} = \frac{\#BDTs\ passing\ cut}{200}$$



High energy

One BDT

Straight cut



Statistical method

Effective LLH [1]

$$\mathcal{L}_{\mathrm{Eff}}(\xi, \overrightarrow{f_{bkg}}|k) = \frac{\beta^{\alpha}\Gamma(k+\alpha)}{k!(1+\beta)^{k+\alpha}\Gamma(\alpha)}$$

where

$$\alpha = \frac{\mu^2}{\sigma^2}$$

$$\beta = \frac{\mu}{\sigma^2}$$

$$\mu = \mu(\xi, \overrightarrow{\eta})$$

$$\sigma = \sigma(\xi, \overrightarrow{\eta}|w^2)$$

and the test statistic

$$TS = 2\ln\frac{\mathcal{L}(\hat{\xi}, \overrightarrow{\eta})}{\mathcal{L}(\xi = 0, \overrightarrow{\eta})}$$

LLH analyser developed at the ULB is used

[1] *arXiv: 1901.04645*