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Earth WIMPs Analysis

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ICECUBE

Earth WIMPs Analysis: Motivation

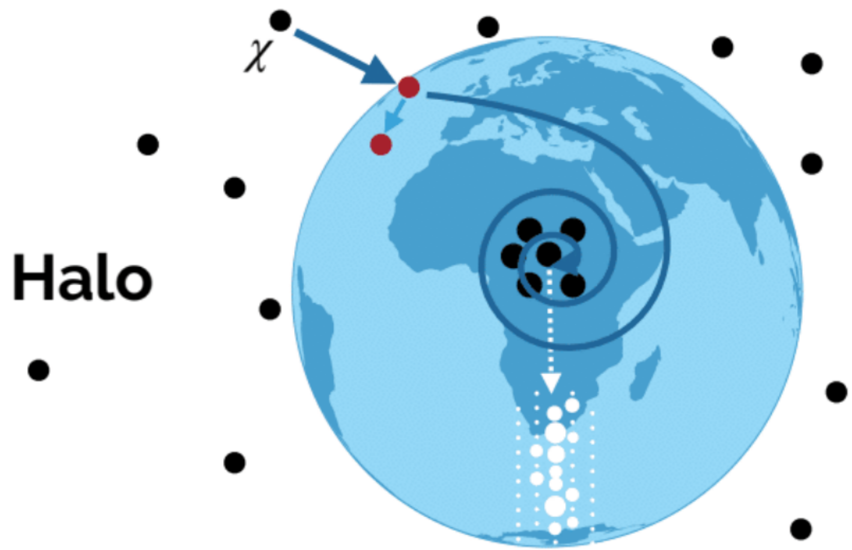
Dark Matter Halo models predict gravitational capture of WIMPs via scattering by massive bodies, included **Earth**.

Accumulated DM particles can then **self-annihilate** into Standard Model (SM) particles.

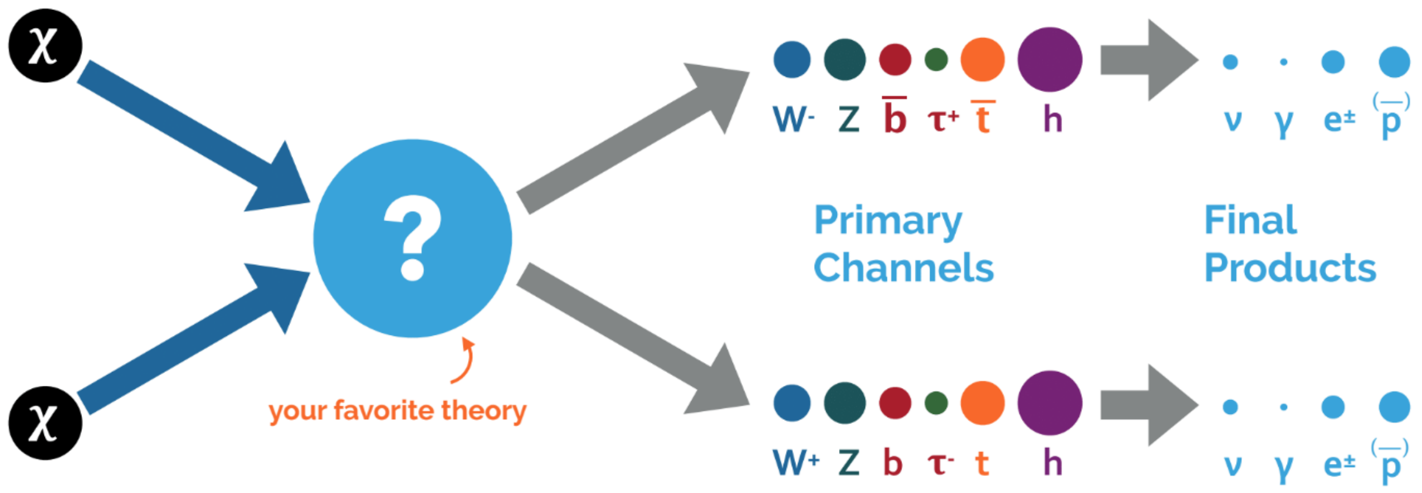
The whole process is described by:

$$\frac{\mathrm{d}N}{\mathrm{d}t} = C_C - C_A N^2$$

where C_c is the **capture rate** and the second term is the **annihilation rate** Γ_A and is proportional to the **annihilation cross-section** $< \sigma_A v >$



Earth WIMPs Analysis: Indirect Detection



We can search for a flux of neutrinos from the center of the Earth

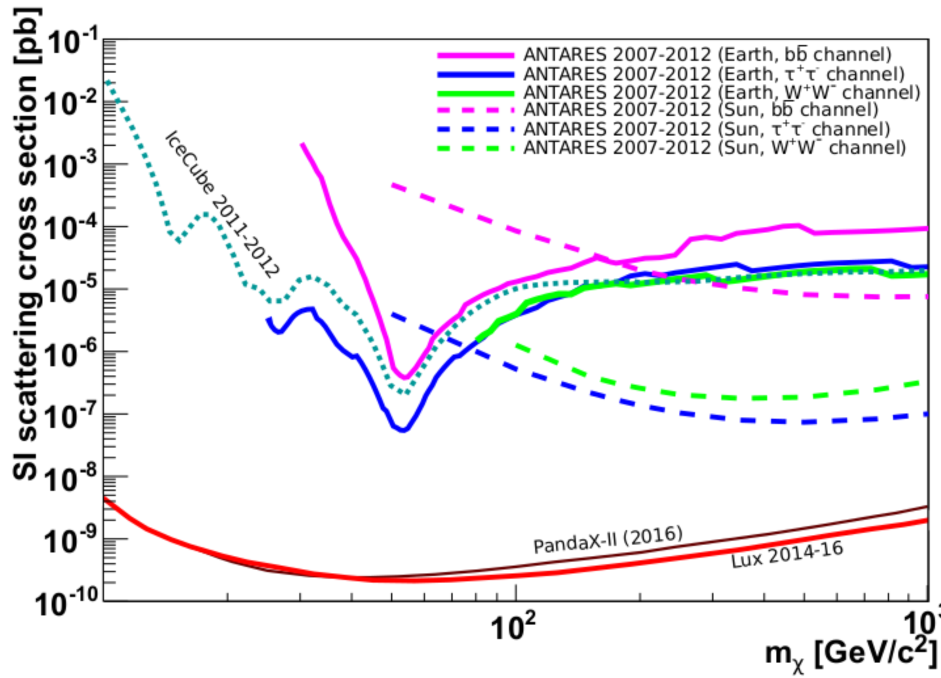
Earth WIMPs Analysis: Expected outcomes

We can measure/set-upper-limits-to:

- Neutrino flux
- Γ_A : WIMPs annihilation rate
- $\sigma^{SI}_{\chi\text{-}N}$: WIMP-nucleon cross section (with an assumption on $< \sigma_A v >$)

Earth WIMPs Analysis: previous works

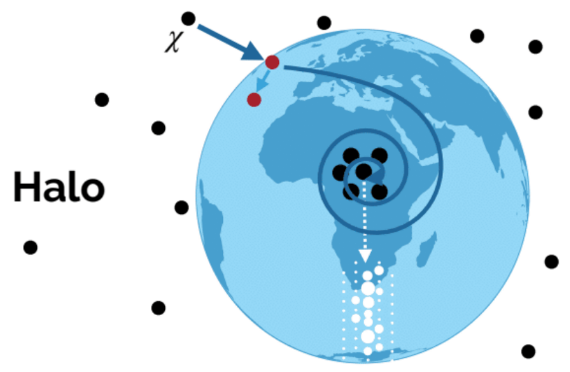
- IceCube: 2013, 1 year of data, muon neutrinos, J. Kunnen and J. Lünemann here @IIHE
- Last: ANTARES in 2017 (plot) *arXiv:1612.06792v2*



Earth WIMPs Analysis: why a new analysis

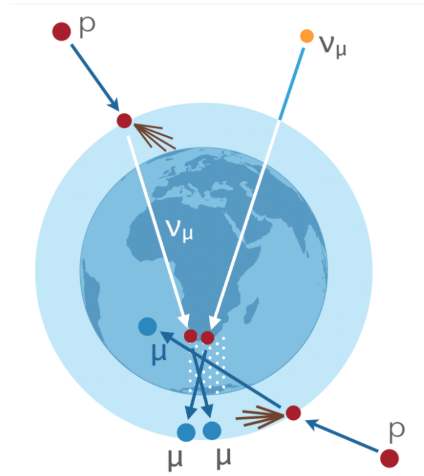
- Almost 7 more years of data
- Better knowledge of IceCube detector properties and systematics
- Refined analysis methods in IceCube
- Extension to all neutrino flavours
- Software development during the years:
  - Better simulations
  - Better implementation of analysis

Earth WIMPs Analysis: signal and background



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

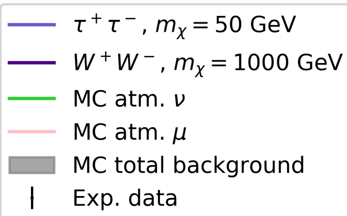
Signal **energy** spectrum depends on WIMP mass: 10 GeV – 10 TeV
=> we have to split into a **low energy** and a **high energy** selection



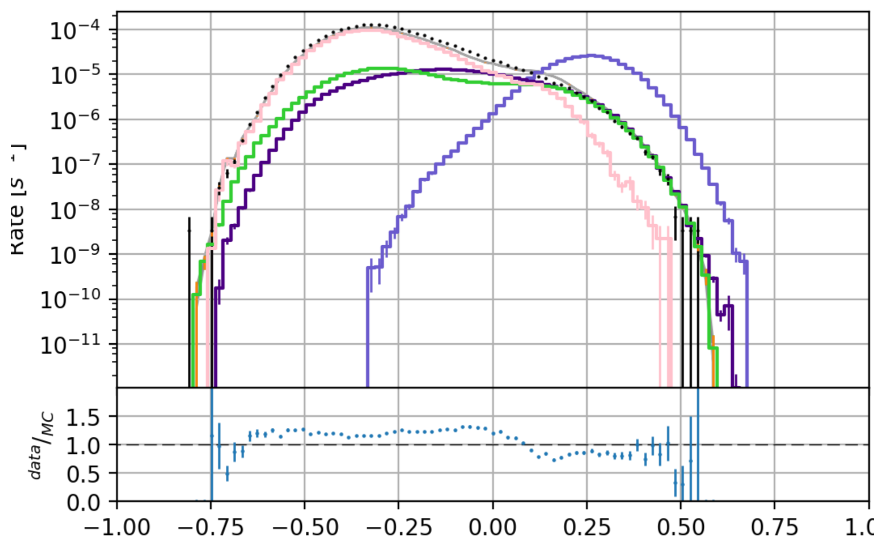
Two backgrounds:
- Down-going atmospheric **muons** wrongly reconstructed as up-going
- Up-going atmospheric **neutrinos**

Event selection

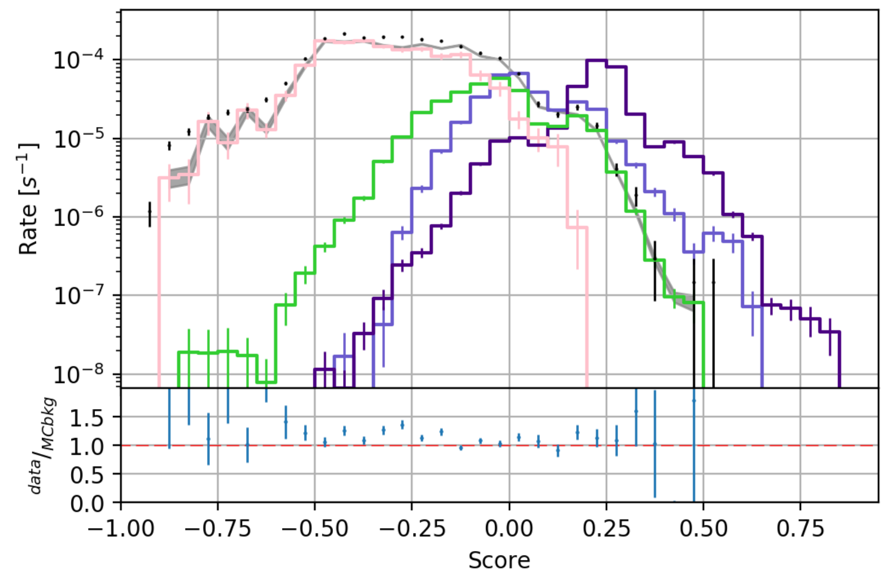
We apply **cuts** on variables to reduce the signal to background ratio.
We use variables linked to the event **shape**, **position** and **direction**.
The last step is a **BDT:** we train **two different** BDTs on two different signal **expectations**.



Low energy signal



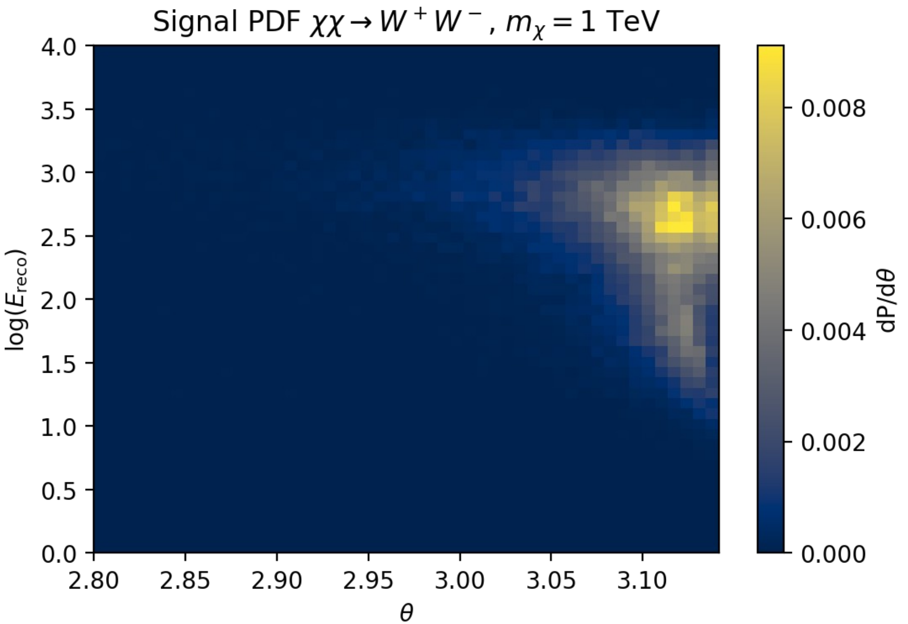
High energy signal

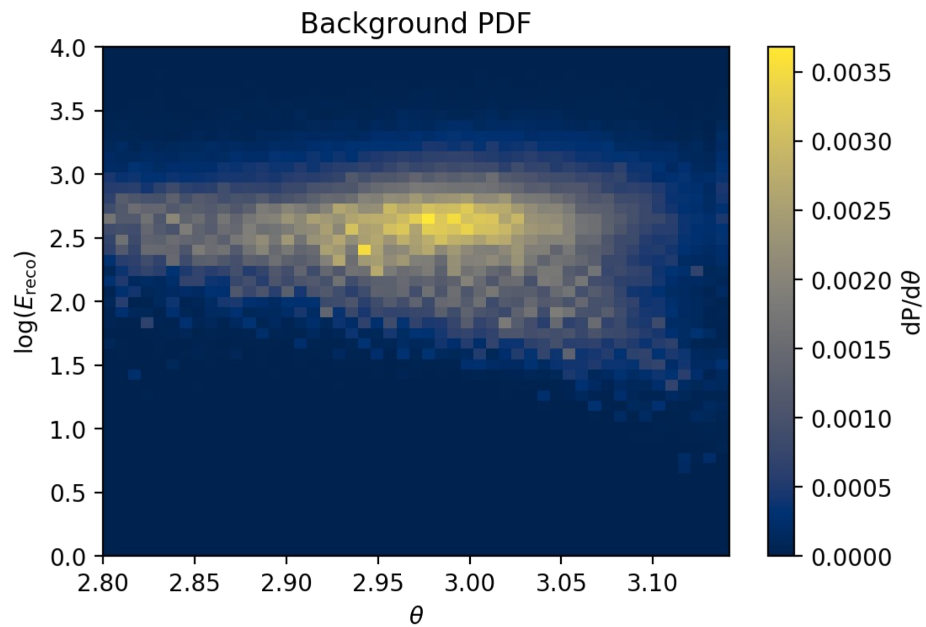


Likelihood method

We use a binned likelihood method where every bin represents a certain position in the (θ, E_{reco}) plane

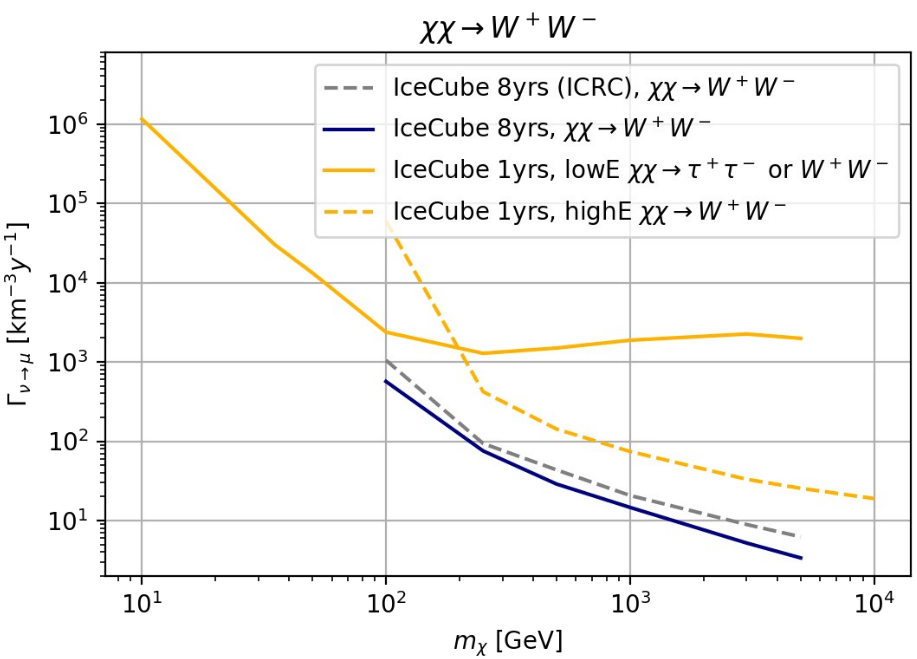
$$\mathscr{L}(\mu) = \prod_{\mathrm{bin}_i=\mathrm{bin}_{min}}^{\mathrm{bin}_{max}} \mathrm{Poisson}(N_{\mathrm{obs}}(\mathrm{bin}_i)|N^{\mathrm{tot}}_{\mathrm{obs}} f(\mathrm{bin}_i|\mu))$$

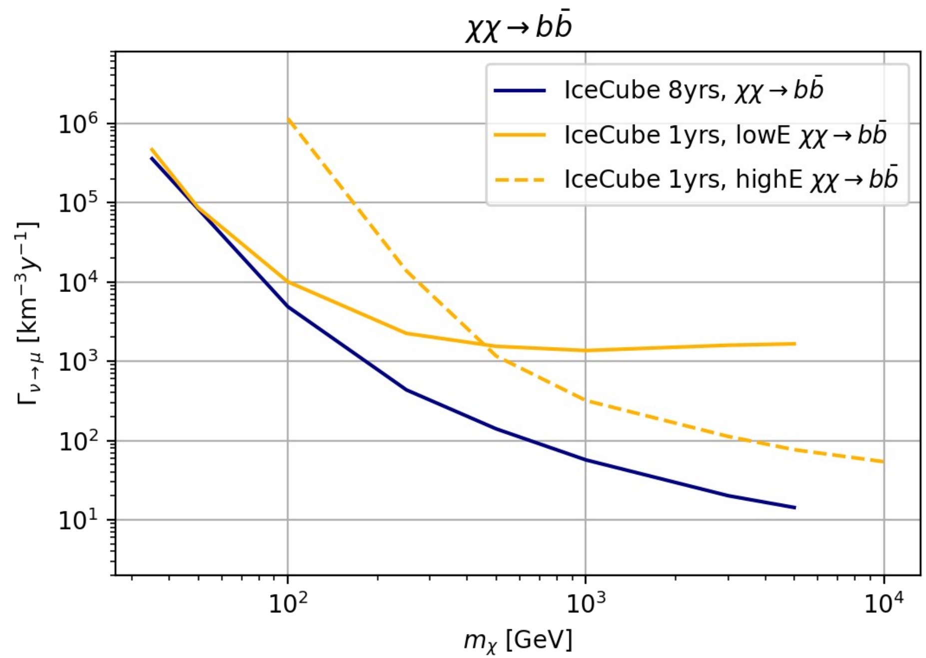




Sensitivities – High energy selection

Sensitivities have been computed for two annihilation channels for the high energy event selection





Next steps

- Finalize the low energy event selection (possible missing background component, more important systematics)
- Compute sensitivities
- Simulate all flavours
- Simulate systematics datasets
- Unblind

Thank you for your attention