A search for Dark Matter in the centre of the Earth with the IceCube neutrino detector.

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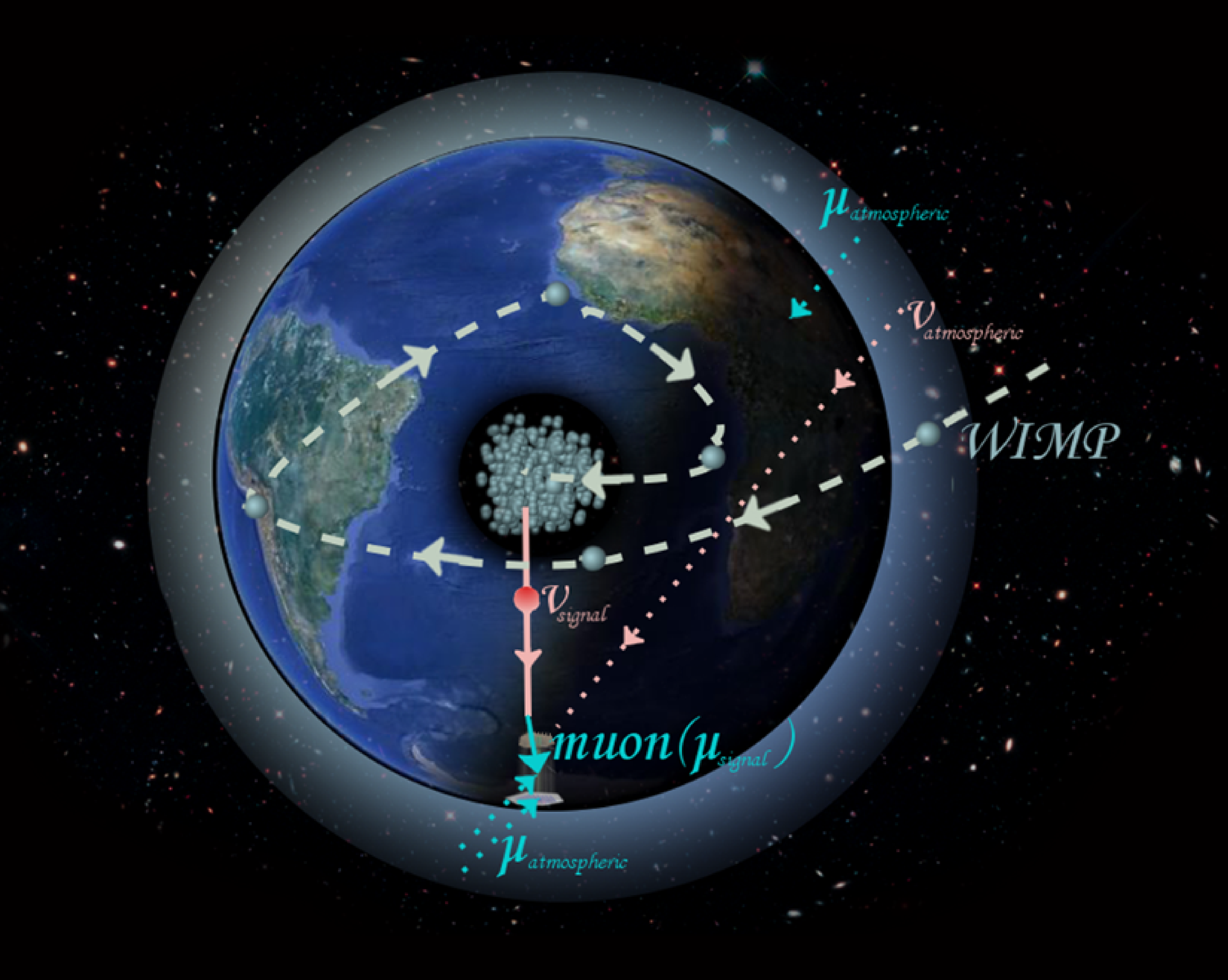
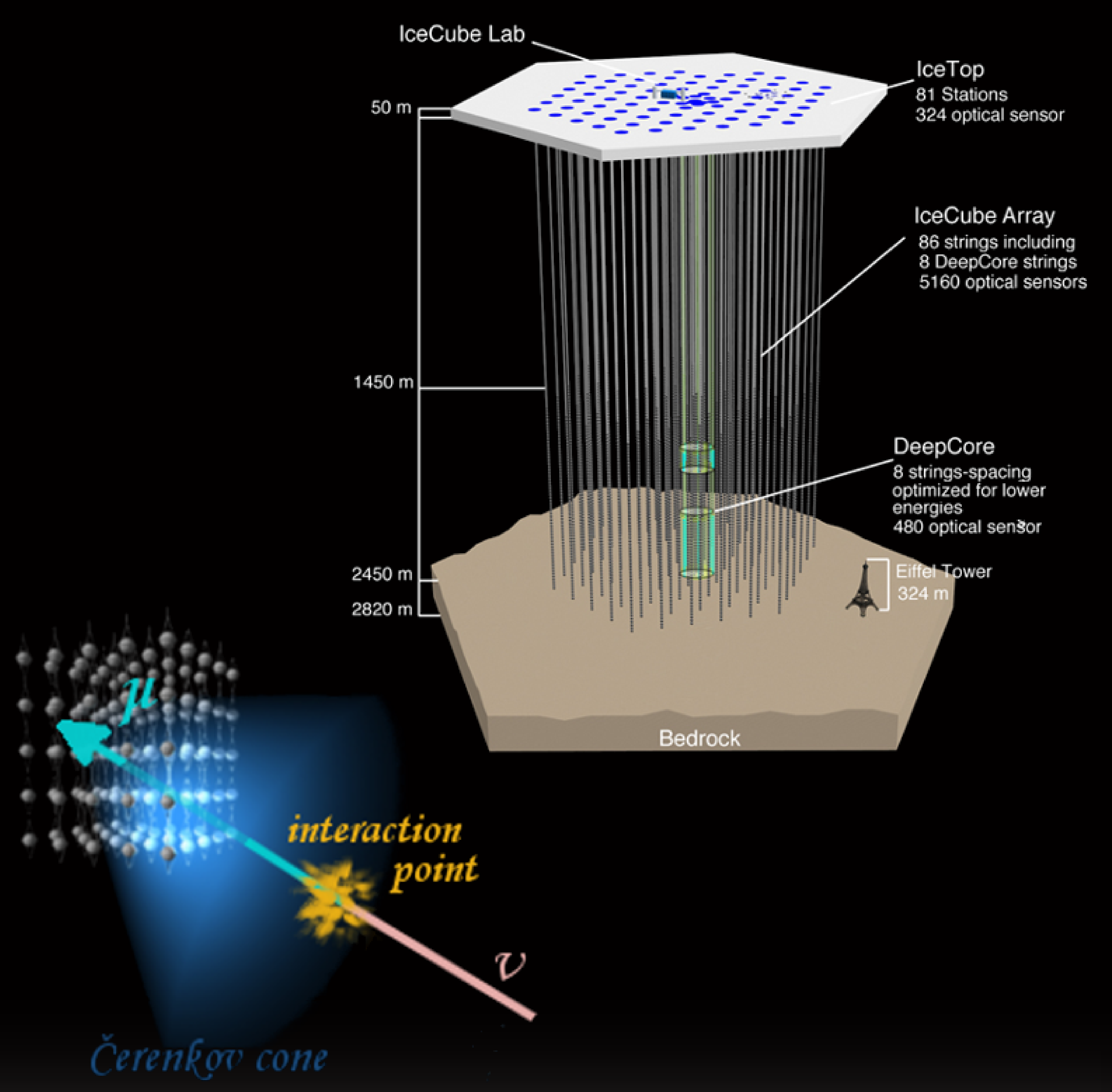


Dark Matter in the centre of the Earth

Many models predict that dark matter consists of Weakly Interacting Massive Particles (WIMPs). Heavy celestial bodies, such as the Earth, would capture these WIMPs and over time the WIMPs will self-annihilate. These annihilations may produce standard model particles, including neutrinos.
Large scale neutrino telescopes, such as the cubic kilometre IceCube Neutrino Observatory located at the South Pole, can be used to search for such neutrino fluxes.

The IceCube neutrino Detector

The IceCube detector uses the Antarctic ice as the detection medium where muon-neutrino interactions produce muons that induce Čerenkov light. The light propagates through the transparent medium and can be collected by photo multiplier tubes housed inside Digital Optical Modules (DOMs).



The Analysis

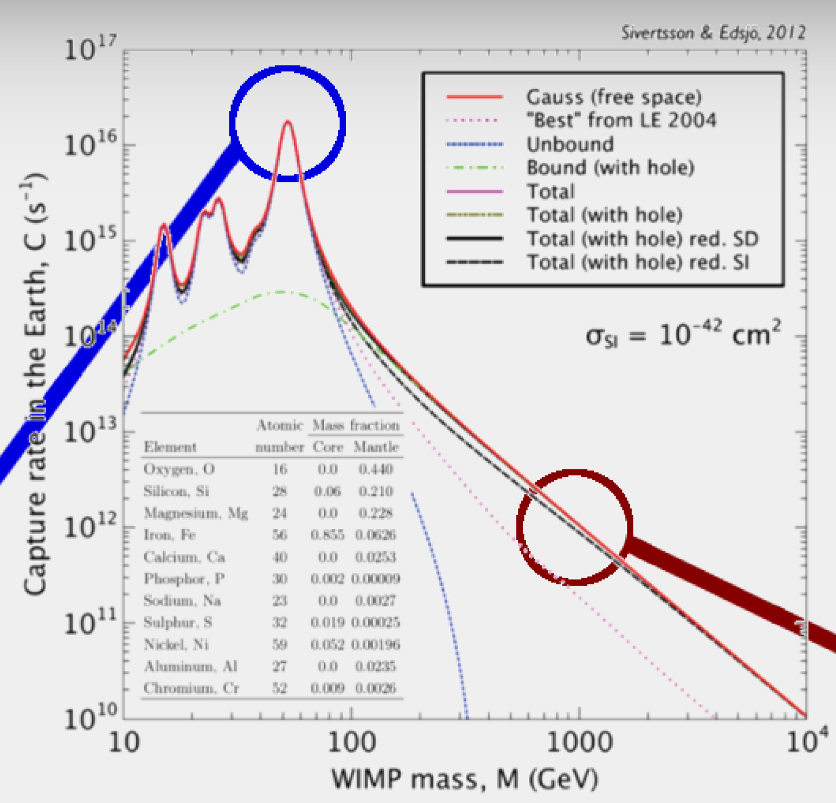
The Analysis in 4 steps.

1. First some cuts are done on the whole sample (before splitting the data) to reduce the data rate.

2. Next a division at 100 GeV is used to split the datasets into low and high energy samples.

3. Both analyses then further remove the background in an optimal way, untill the data is dominated by atmospheric neutrinos.

4. In the final step, the reconstructed zenith distribution of the experimental data is statistically analyzed to look for an excess in the direction of the centre of the Earth..

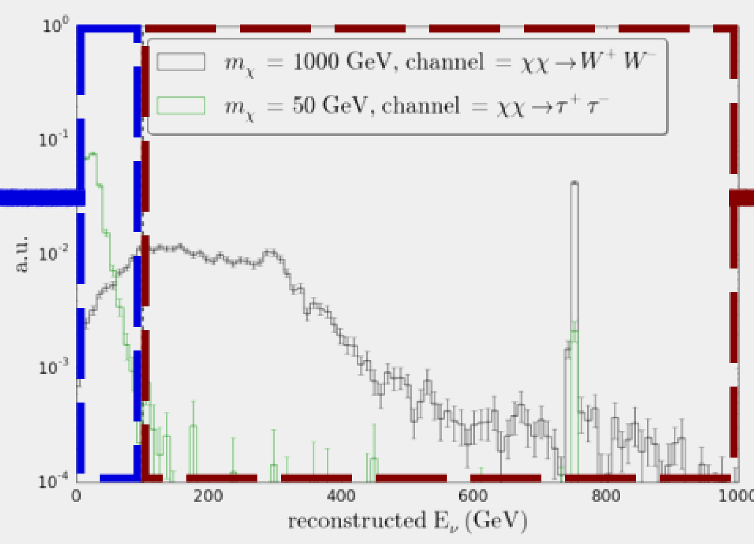


To be sensitive to a wide range of WIMP masses, the analysis is split in two parts, one that is optimised for low masses and the other for higher masses.

The low mass analysis is optimised on WIMPs with a mass m_χ = 50GeV, that annihilate into $\tau\bar{\tau}$. As the capture rate is highest for WIMPs for this mass, the annihilation and thus neutrino rate are also highest.

The high mass optimisation is done on WIMPs with a mass m_χ = 1TeV, that annihilate into W^+W^-.

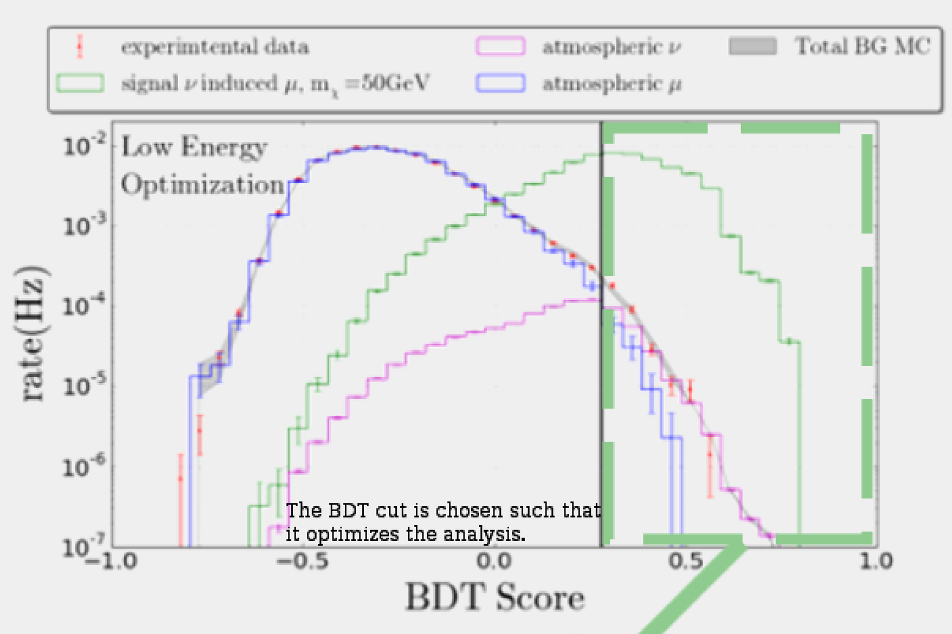
Splitting the datasets w.r.t. reconstructed energy



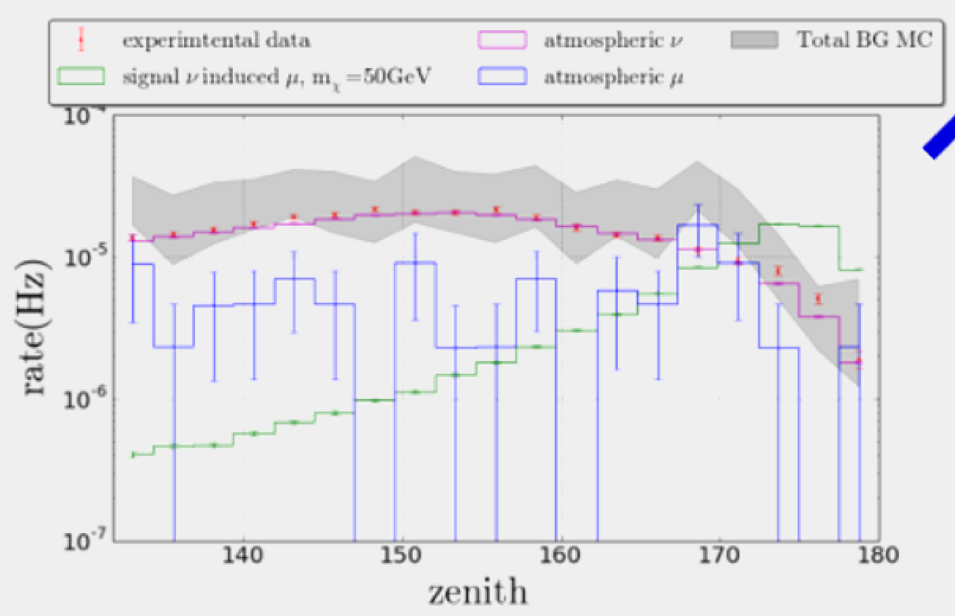
A. The Low Energy Analysis

Reducing the data to neutrino level : BDT

Both analyses make use of Boosted Decision Trees (BDT), which is a machine learning technique that is designed to optimally separate signal from background by assigning a score between -1 (background-like) and +1 (signal-like) to each event.



An excess in the zenith angle distribution?

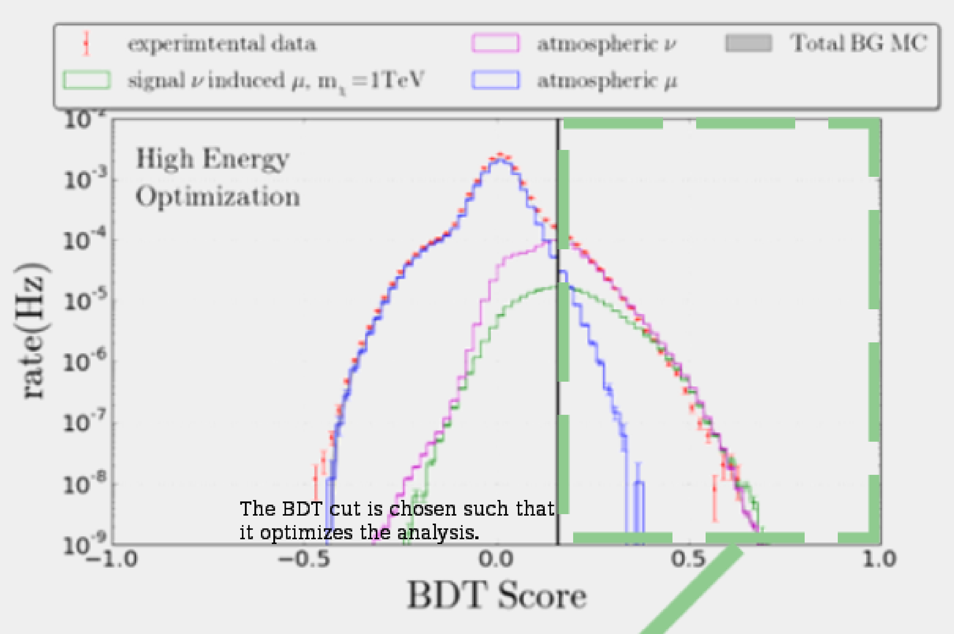


The sensitivities and upper limits on the WIMP annihilation rate Γ_A in the Earth are calculated using the zenith distributions of the final samples as probability density functions in the likelihood calculation, using the Feldman-Cousins unified approach.

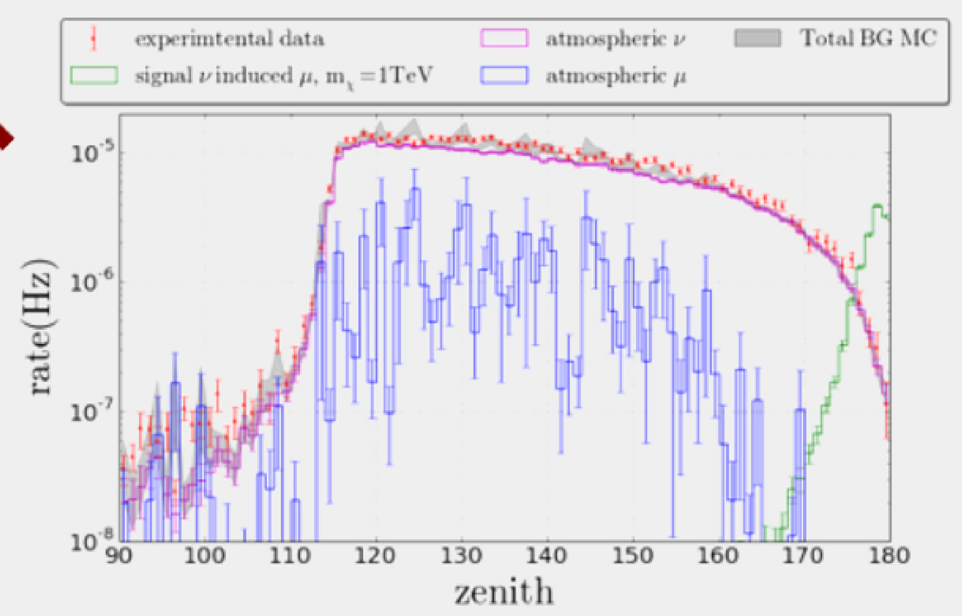
B. The High Energy Analysis

Reducing the data to neutrino level : Pull-validation

The high energy analysis uses the *Pull-Validation* method, which is a method in which several BDTs are trained on small subsets that are randomly resampled from the complete dataset.
See contribution *PoS(ICRC2015)1211* for more details.

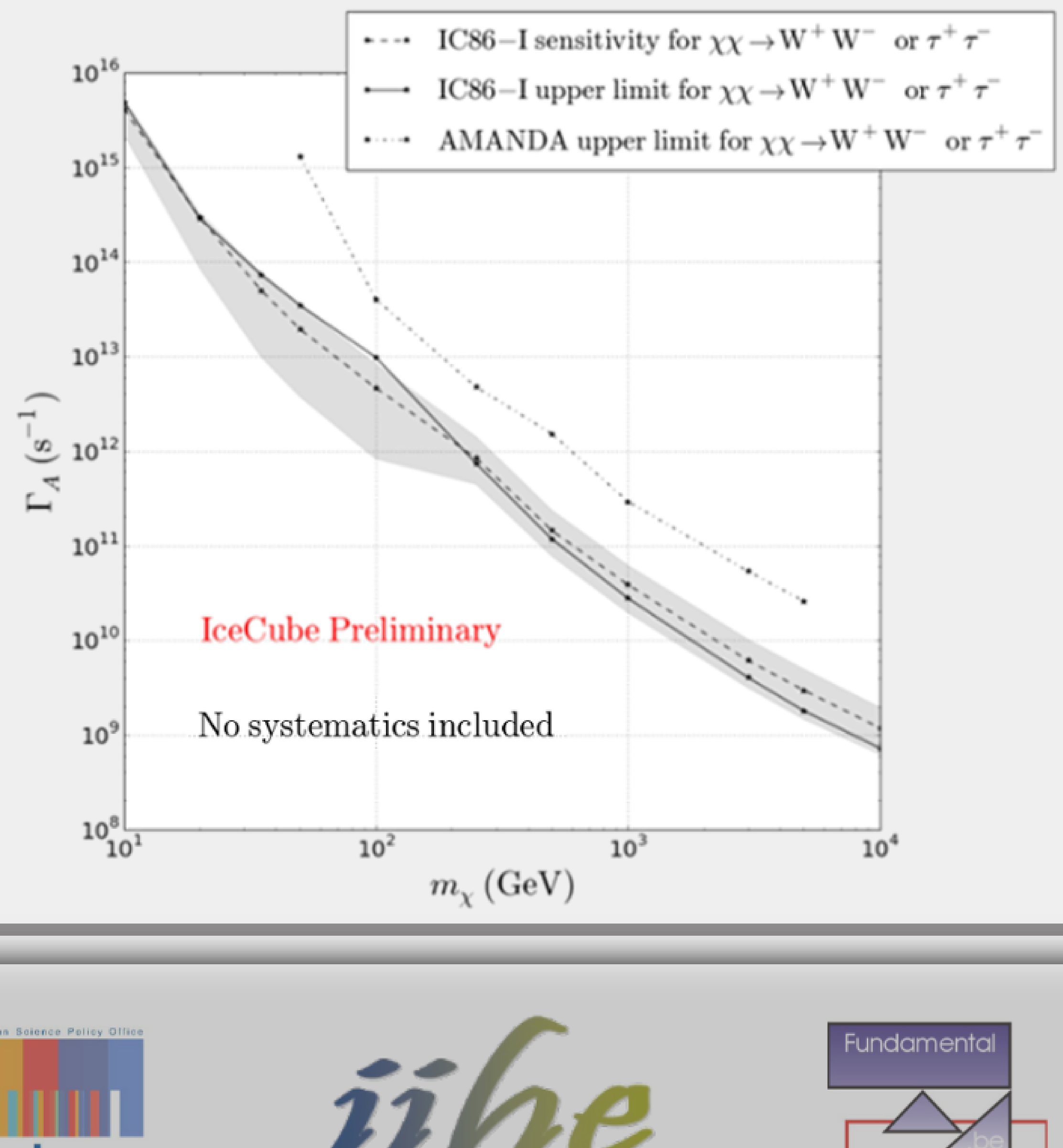


An excess in the zenith angle distribution?



Results

As the reconstructed zenith angle distribution of the experimental data is consistent with the background expectation, it can be concluded that no signal for Earth WIMPs has been found in the first year of IC86 data. Therefore an upper limit on the WIMP annihilation rate Γ_A in the Earth can be set.



The upper limits for 1 year of IC86 data (2011-2012) are shown and are compared with the AMANDA limits which is the last Earth WIMP neutrino search. An improvement of a factor 10 has been found, meaning that a whole new part of the theoretical phase space has been ruled out with this analysis.