Search for secluded dark matter with IceCube

Christoph Tönnis

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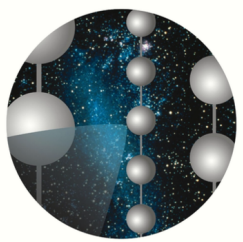

What is secluded dark matter?

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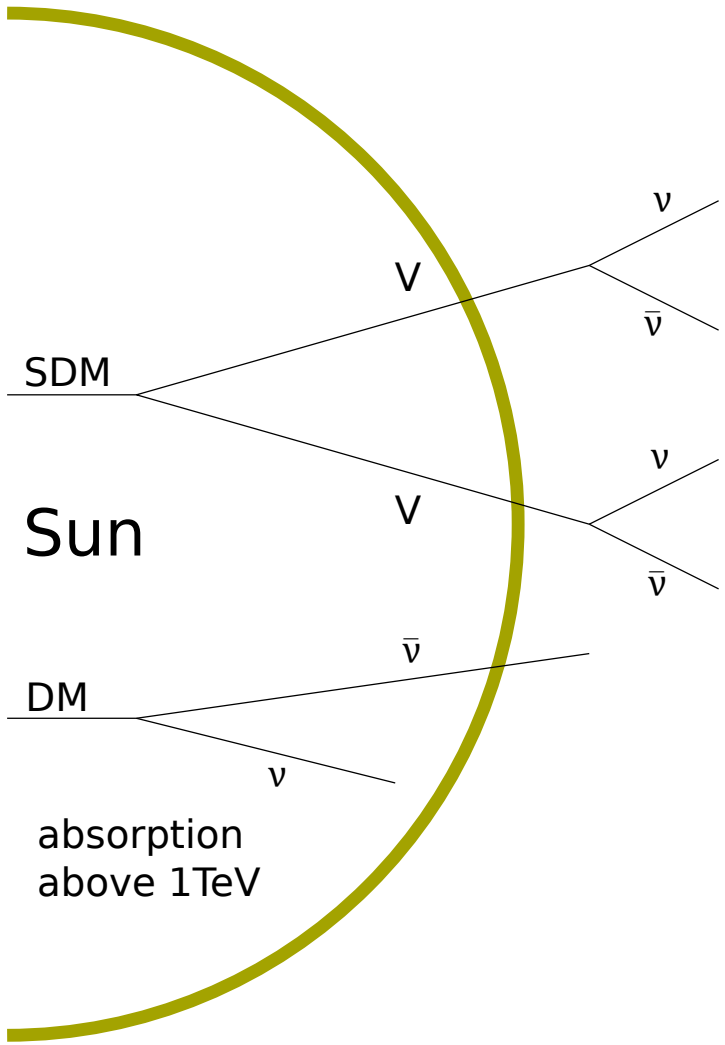
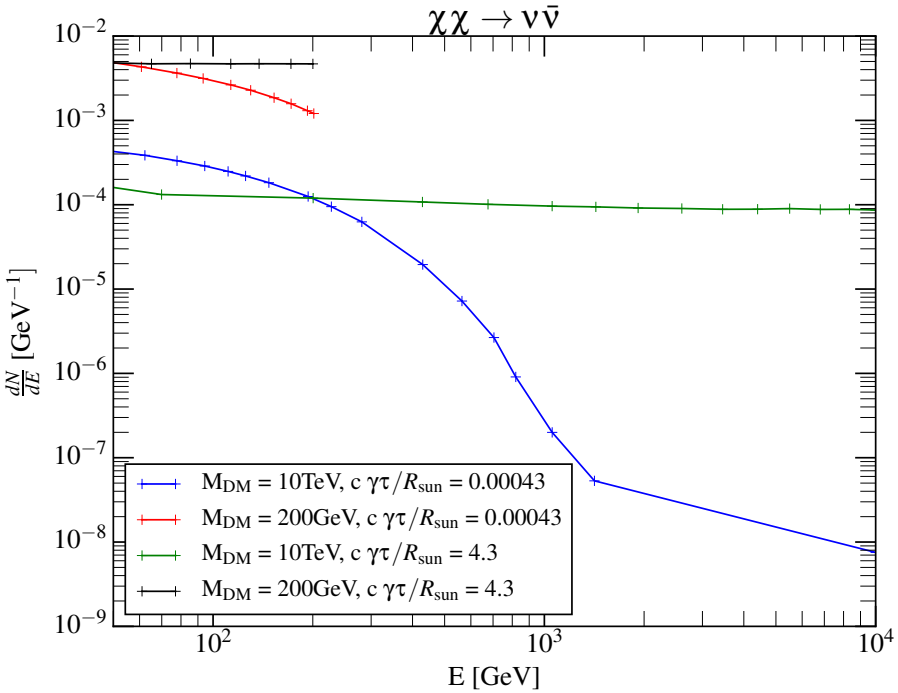
- Secluded dark matter is a particle model for dark matter where the DM particles annihilate into pairs of metastable mediator particles. [Phys. Lett. B662 (2008) 53–61,Phys. Lett. B671 (2009) 391–397]
- These mediators are assumed to have lifetimes between microseconds and 10 s
- They themselves decay into pair of SM particles such as photons, charged leptons or neutrinos.
- For sufficiently long lived mediators absorption in the Sun can be avoided



Secluded dark matter signal

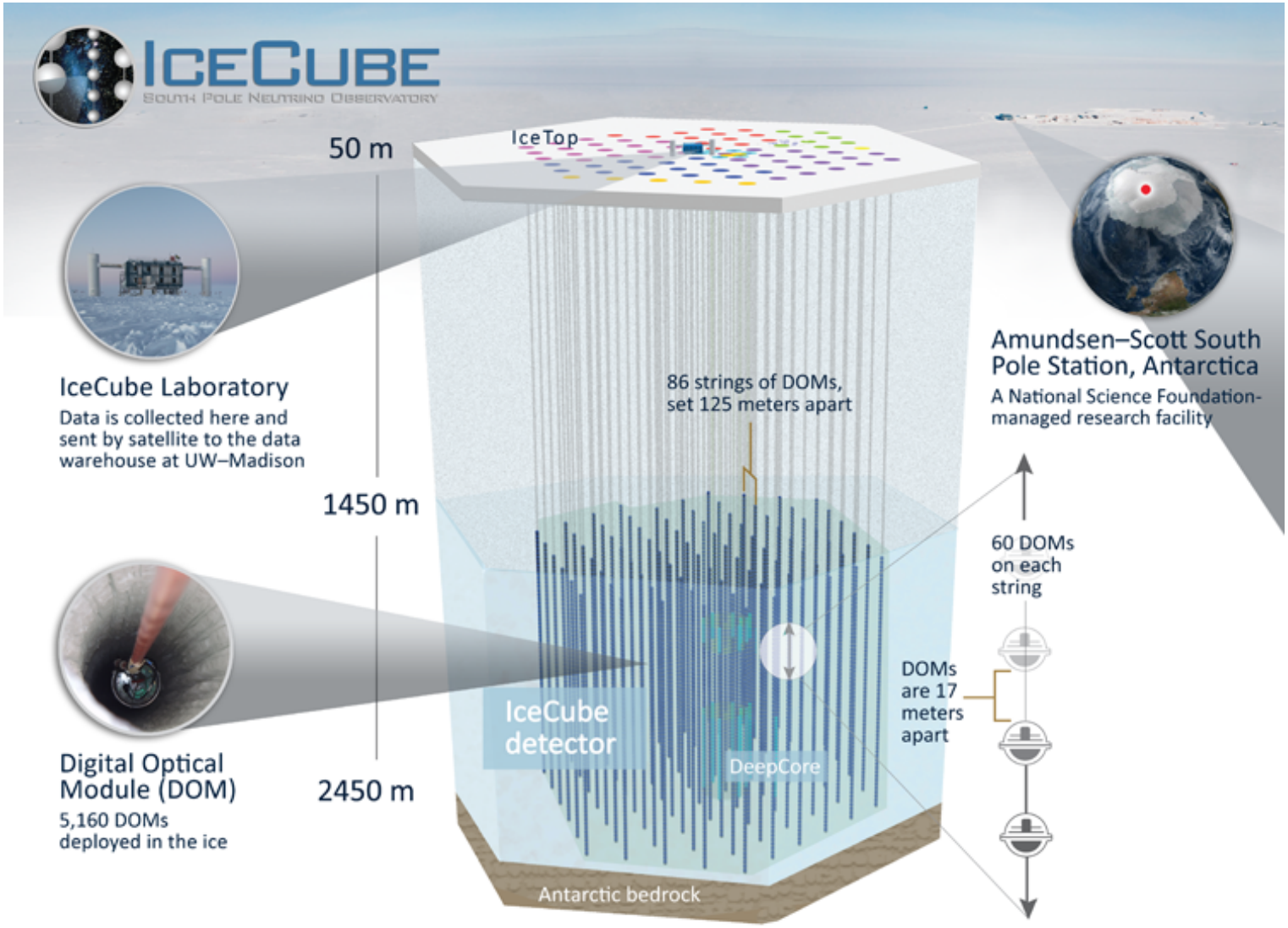
- Due to the DM particles producing pairs of mediators the DM particle mass is effectively half as large
- The intensity per annihilation is however increased
- Mediators are assumed to have few to no interactions with baryonic matter
- If they are sufficiently long lived the absorption of neutrinos in the solar plasma can be avoided



- This leads to a significantly enhanced signal at high neutrino energies
- The spectra for this analysis were taken from N. Bell et.al. JCAP 1104:003,2011

Analysis method

The IceCube Detector



Analysis method

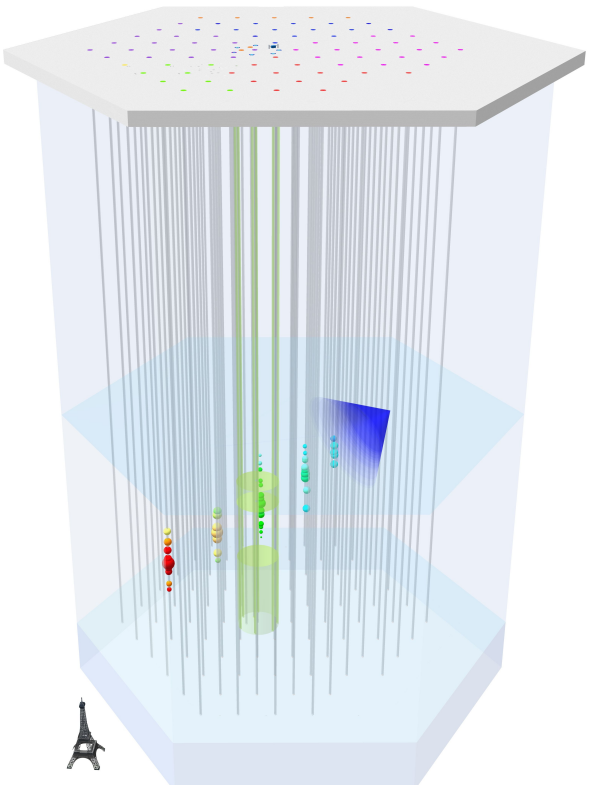
- In this analysis an 'unbinned' likelihood method is applied
- In this method a likelihood function is used to identify and quantify signal events in a datasample:

$$\mathcal{L}(n_s) = (n_s S(\psi, E) + (n_s + N_{tot})\, B(\psi, E))\, e^{-(n_s + N_{tot})}$$

- n_s is the supposed number of signal events, N_{tot} is the total number of events in the sample and S and B are functions describing the likelihood of an event with an angular separation to the Sun ψ and energy E to be Signal/Background
- The likelihood is the optimised with respect to n_s and a test statistic is calculated. From the test statistic values of the data and Pseudo Experiments sensitivities and limits are calculated

IceCube data

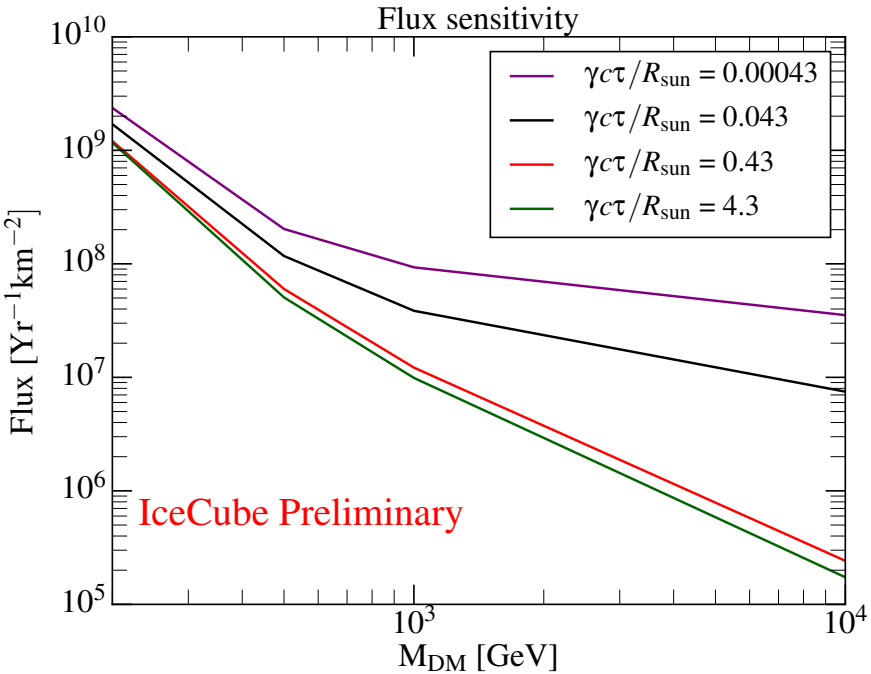
- For this analysis a diffuse muon neutrino set with 7 years of data was used.
- This sample was recorded between 2009 and 2016 and contains data from IC59, IC79 and IC86
- Only upgoing events were considered leaving an effective livetime of 1386.9 days
- The analysis is currently in development and only sensitivities were generated



Results

Setting sensitivities

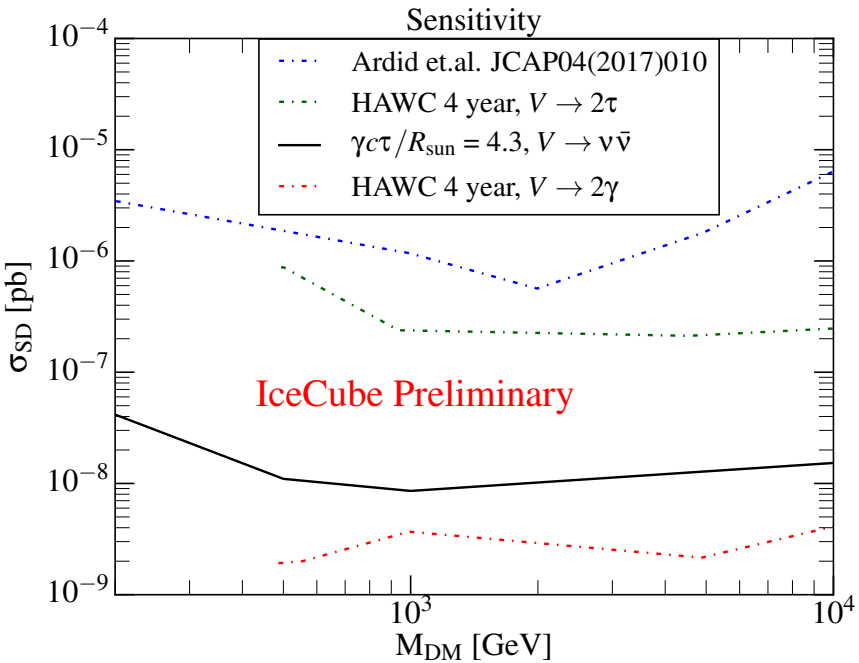
- Sensitivities are set with the Feldman-Cousins method.
- Sensitivities are first set on neutrino fluxes using the detector acceptance of IceCube for the given signal
- These are then converted to spin dependent and spin independent scattering cross sections assuming an equilibrium between annihilation and capture of dark matter particles ($\Gamma = 2C_{DM}$) and the following equation:

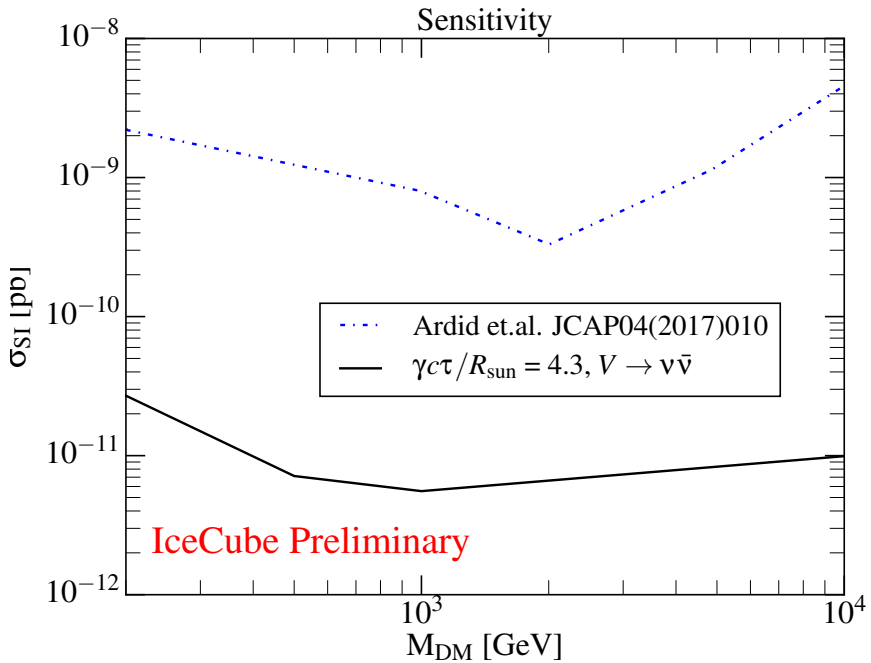


$$C_{DM} = \left(\frac{TeV}{m_\chi}\right)^2 \frac{10^{20}s}{10^{-40}cm}(2.77\sigma_{SD} + 4270\sigma_{SI})$$

- This equation is an approximation taken from M. Ardid et.al. JCAP04(2017)010

Cross section sensitivity





The sensitivities to spin dependent (right) and spin independent (left) scattering cross sections. The sensitivities showa significant improvement over the previous analysis. The HAWC limits were taken from A.Albert et.al. MIT-CTP/5038 and show limits for mediator decays into photons. The comparison to HAWC is not entirely apt since different decay channels were used.

Summary and outlook

- The sensitivities are promising a strong improvement over previous results for IceCube
- With the current spectra a limited range of masses and mediator lifetimes can be investigated
- In the future more simulations will be done to probe higher dark matter masses
- Application of analysis on recorded IC data planned towards the end of the year