Dark Matter searches with the Super-Kamiokande detector

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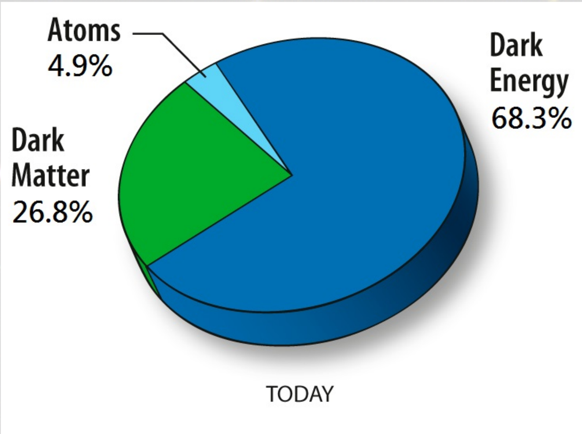
on behalf of the Super-Kamiokande Collaboration

DARK MATTER neither emits nor absorbs electromagnetic radiation and therefore cannot be observed directly with telescopes. However, there is a great diversity of ongoing global efforts to detect or produce DM particles.



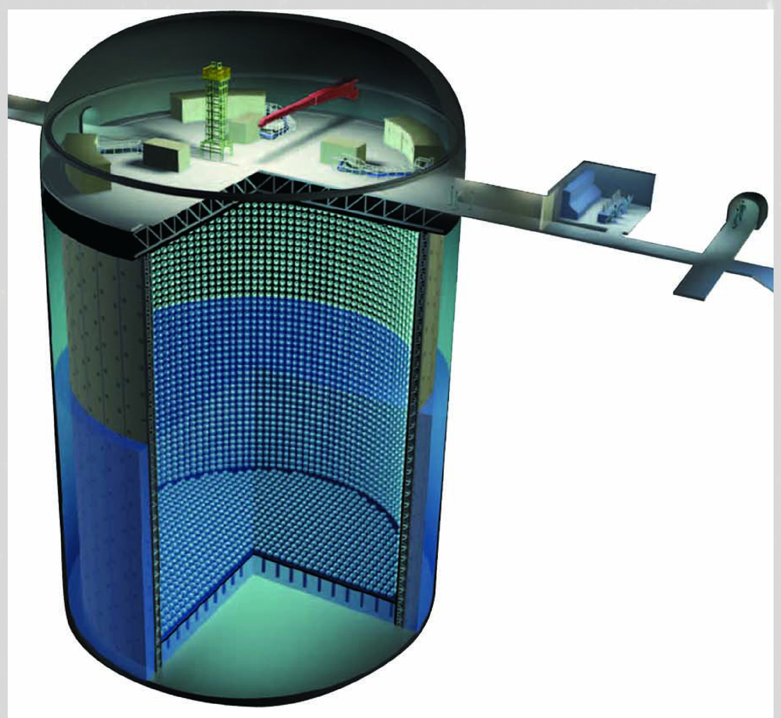
Planck's results [1]. According to study of CMB and standard cosmology model, DM is expected to account for a large part of the Universe.

INDIRECT DETECTION EXPERIMENTS focus on search for the products of DM annihilation, e.g. neutrinos, among the cosmic rays. Produced ν's remain unchanged during their propagation through the cosmic space and provide very good information about:

- source position
- generated energy spectra.

$$\chi\chi \to \begin{matrix} q\bar{q}(c\bar{c}, b\bar{b}, t\bar{t}, ...) \\ l\bar{l} \\ W^{\pm}, Z^{0}, H \end{matrix} \to ..... \to \nu, \gamma, \bar{e}, \bar{p}, \bar{H}_2,$$

SUPER-KAMIOKANDE is water Cherenkov detector, which measures solar, atmospheric, cosmic and accelerator neutrinos.

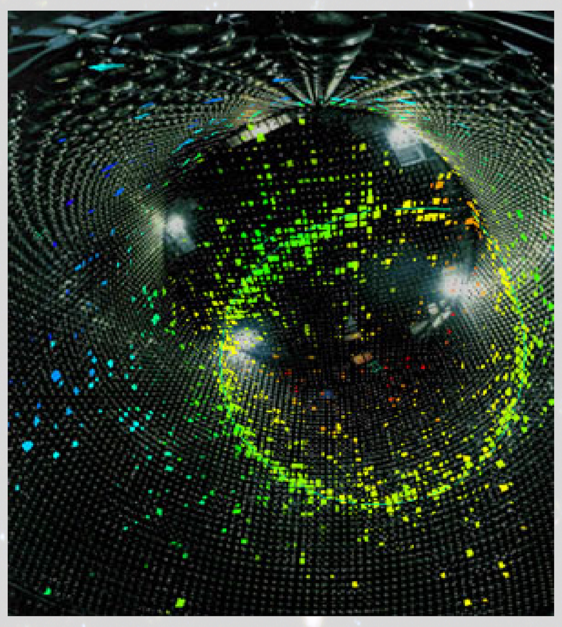


- 50 000 tons of water (22.5 kt FV)
- located in Japan, 1 km underground
- ID ~12 000 PMTs, OD ~2 000 PMTs
- far detector for T2K experiment

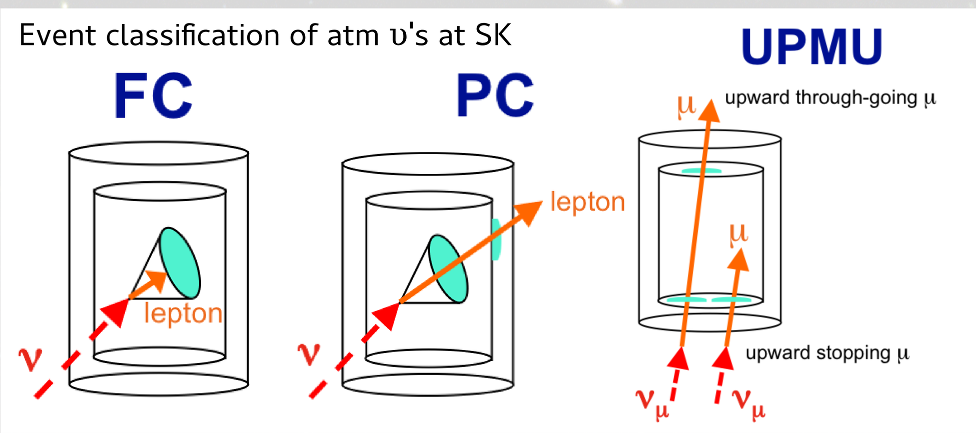
20 years of data taking !!!
1996-2016

Detected light allows for reconstruction of ν's energy, direction and flavor.

$\nu + N \to \mu/\tau/e + N' + ...$



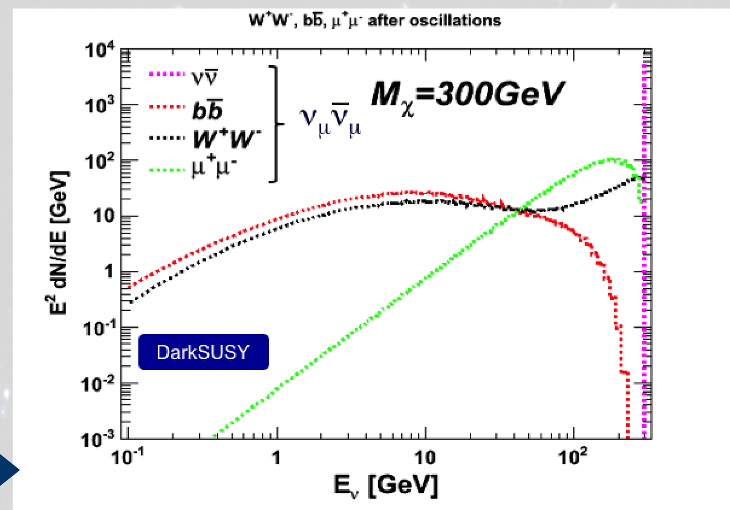
Atmospheric neutrinos constitute the main background in search for DM-induced ν's.



ANALYSIS: Search for an excess of ν's from the Galaxy/Sun/Earth as compared to atmospheric neutrino background.

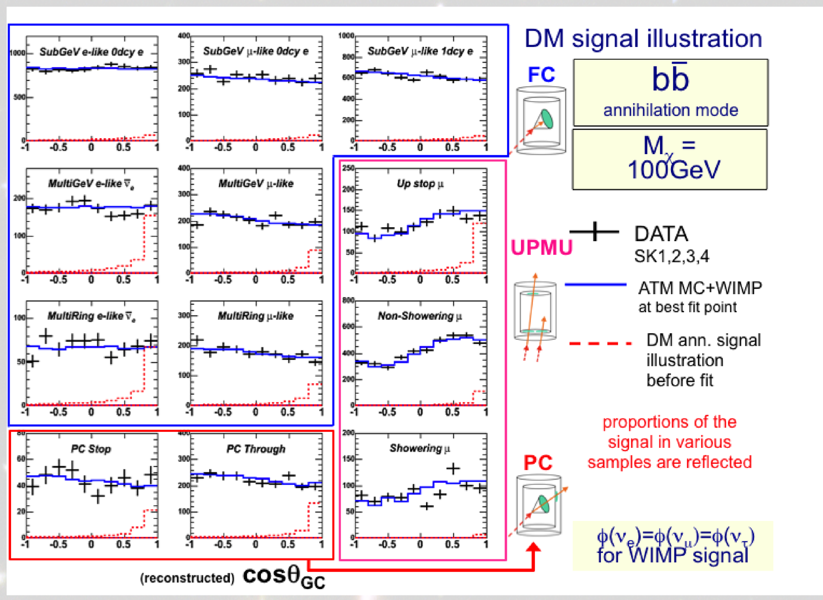
STEP 1. Simulate ν's produced in DM annihilation in Galactic Center, Sun or Earth ➡ DarkSUSY [2] & WimpSim [3].

Example: differential $\nu_\mu\bar{\nu}_\mu$ energy spectra per DM annihilation in the CG for M_χ = 300 GeV.



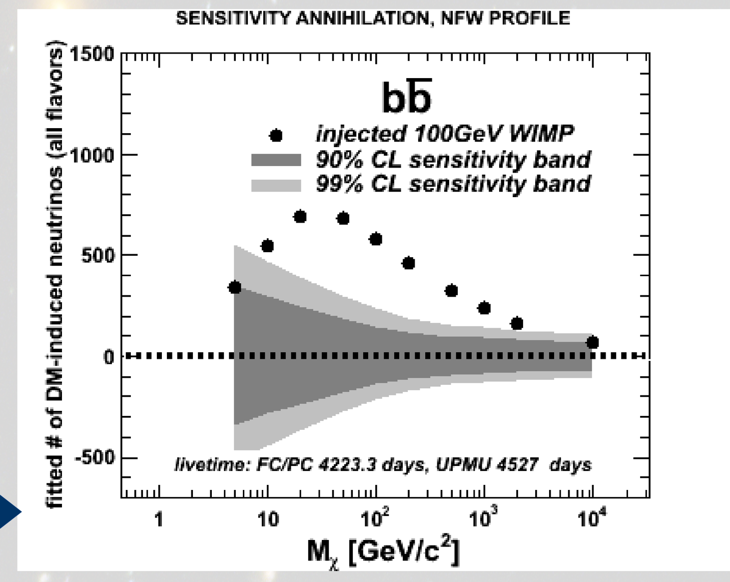
STEP 2. Simulate the detector response in outgoing lepton momentum and $\cos\theta_{GC/SUN/ZENITH}$.

Example: signal illustration for M_χ = 100 GeV WIMPs annihilating into $b\bar{b}$ in the Galactic Center.



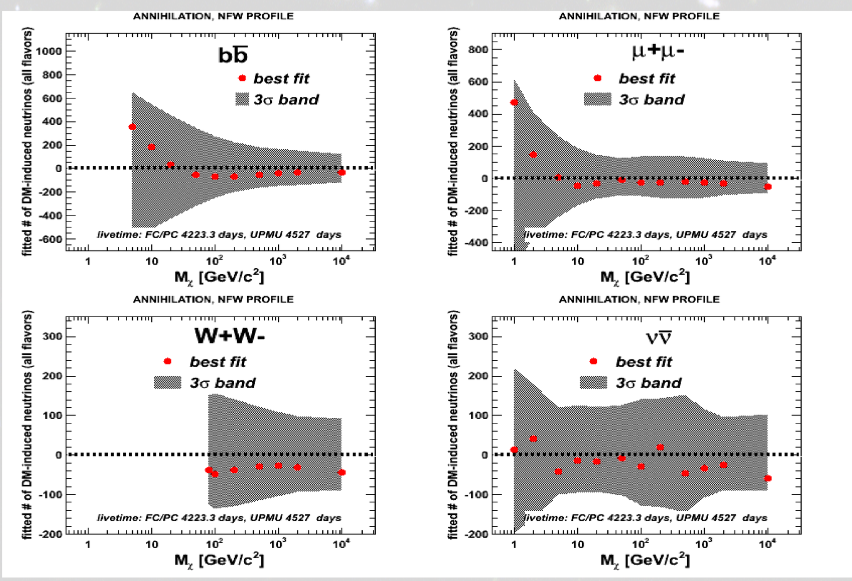
STEP 3. Fit SIGNAL + BKG to DATA with constrains from systematic uncertainties.

Example: Injected M_χ=100 GeV WIMPs as 1.5% of background.

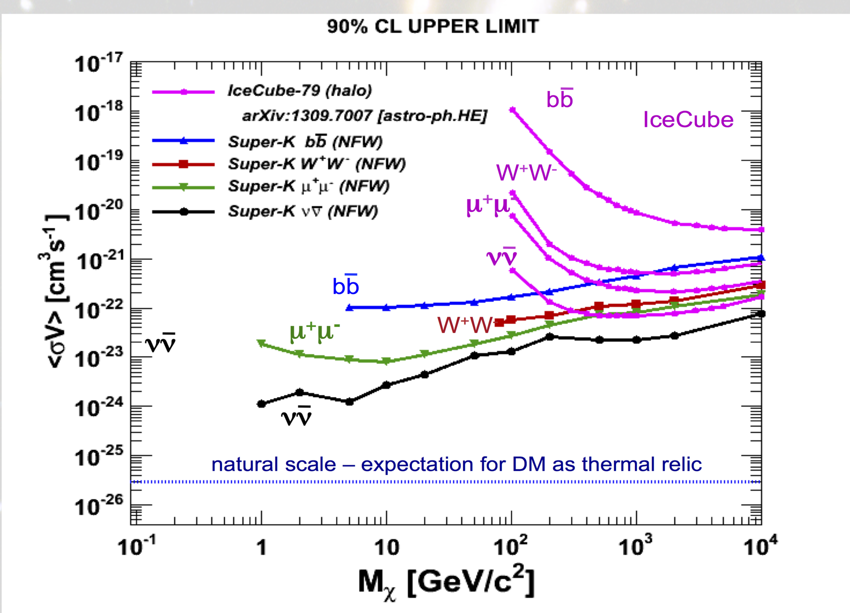


GALACTIC WIMP SEARCH

No significant excess of ν's from the Galactic Center has been observed. Fit results are consistent with zero

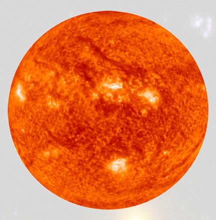


Upper limits on DM-induced neutrino flux from Milky Way halo can be constrained and then translated to upper limit on DM self-annihilation cross section $\langle\sigma_A V\rangle$.



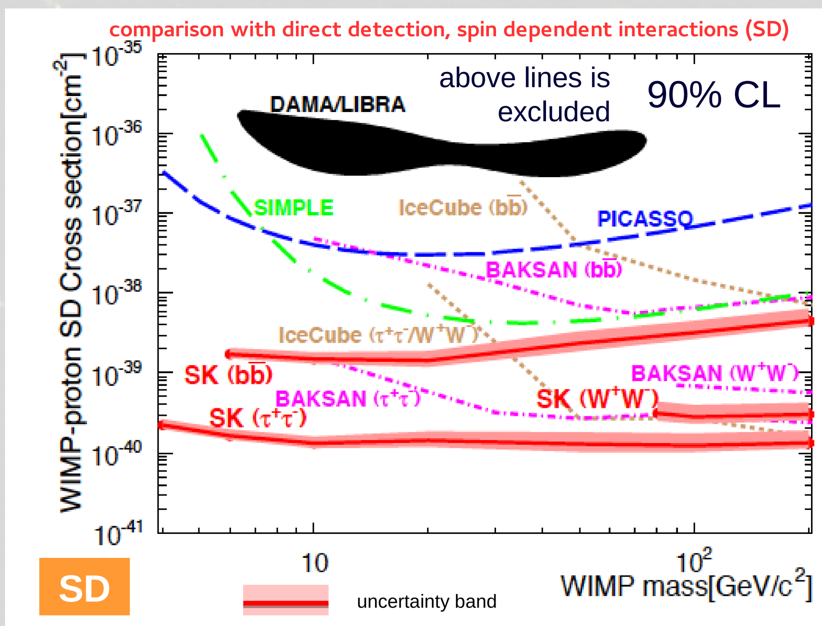
For each annihilation channel 100% BR is assumed.

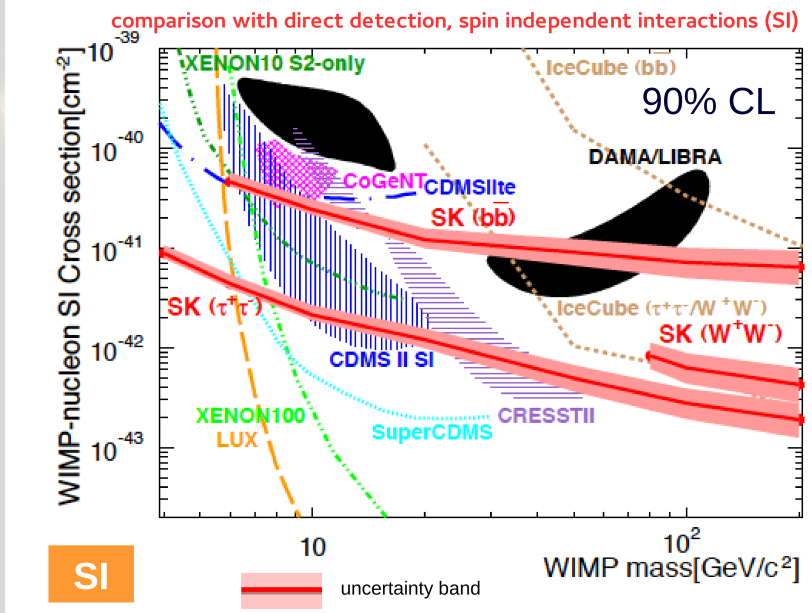
SOLAR WIMP SEARCH



No significant excess of ν's from the Sun has been observed.

DM particles passing through the Sun can be elastically scattered with a nucleus and lose energy. WIMP-nucleon elastic scattering cross-section can be constrained [5] and compared with results from direct DM detection.

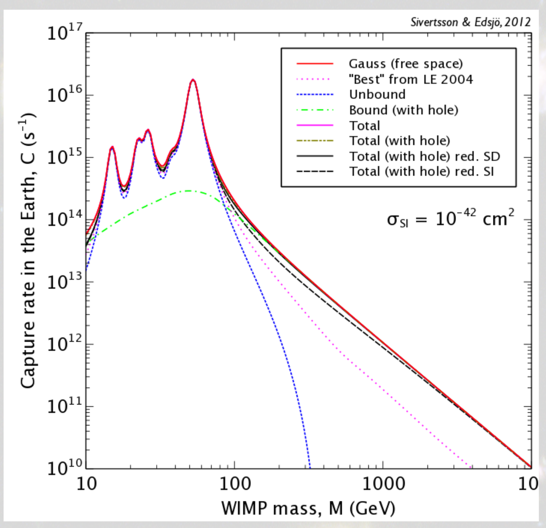




Results recently published, see more details in [6].

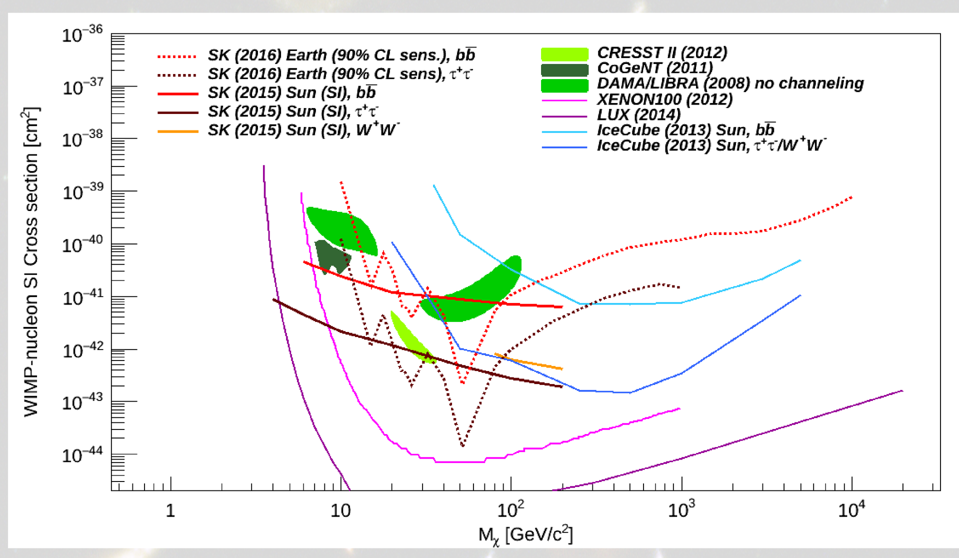
EARTH WIMP SEARCH

For the Earth, the SI interaction dominates in the capturing process. If the mass of DM almost matches one of the heavy elements in the Earth, the capture rate will increase considerably.



Capture rate for DM particles captured to the Earth core. The peaks correspond to resonant capture on the most abundant elements ^{16}O, ^{24}Mg, ^{28}Si and ^{56}Fe and their isotopes.

Preliminary results from sensitivity studies. Dashed lines show 90% CL limits for background only scenario.



REFERENCES:

[1] P. Ade et al., arXiv: 1303.5062 (2013).
[2] P. Gondolo et al., JCAP 07, 008 (2004).
[3] M. Blennow et al., arXiv: 0709.3898 (2008).
[4] M. Aartsen et al., arXiv: 1309.7007 (2013).
[5] G.Wikström, J.Edsjö, JCAP 04, 009 (2009).
[6] K.Choi et al., Phys. Rev. Lett. 114, 141301 (2015).

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