Prospects for Dark Matter Searches with DeepCore

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for the IceCube collaboration
Overview

- DeepCore – quick summary of key facts
- What is the experimental improvement
- DeepCore Dark Matter prospects:
  - \( \text{(Earth)} \) → work in progress
  - \( \text{(Halo/GC)} \) → talk by C. Rott
  - \( \text{(Sun)} \) → this talk

- Looking forward (infill strings 79+80)
Deep Core

- 6 additional strings – 60 High Quantum Efficiency PMTs (deployed in deep ice)

- 7m DOM spacing (17m standard), 72m inter-string spacing.

  → focus energies (few GeV~1TeV)

- $4\pi$ detector using IceCube as an active veto. Southern sky sources (GC) and year round observation for the Sun.
Deep Core events
Deep Core events
Deep Core events
Improving “observables”

Key-detector quantities for successful track reconstructions improve → DeepCore improves low-energy events 10 GeV ~ 1TeV

- $N_{\text{chan}}$ → Number of hit OMs
- $N_{\text{string}}$ → Number of hit strings
- $N_{\text{dir}}$ → Number of direct hits (un-scattered photons)

IceCube-80 + DeepCore-6 sensitivity:

- final geometry & high QE PMTs included
  (string 79 & 80 @ original location)
- high statistics samples of corsika $\mu$-background and atm $\nu$ background
  (incl. coincident 2$\mu$ and 3$\mu$ background)
- Current reconstruction-methods (IceCube-59) used
- Full analysis chain simulated (incl. multivariate cuts) → IceCube-79
Kaluza-Klein DM (LKP)


IceCube-22 & study:
Only used data, when Sun is below the horizon

main syst. uncertainty:
Photon propagation in the ice & absolute DOM efficiency (~20%)

relate muon flux and WIMP-nucleon cross-section:

$$\Gamma_A = \frac{1}{2} \, C_C.$$
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Neutralino DM (LSP)


0.05 < \(\Omega_\chi h^2\) < 0.20

Indirect searches - \(E_{\mu}^{\text{thr}} = 1\) GeV

\[\sigma_{SI} < \sigma_{SI}^{\text{lim}}\]

\[\sigma_{SI} < 0.001\times\sigma_{SI}^{\text{lim}}\]

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Neutralino DM (LSP)

Neutralino-proton SD cross-section (cm²)

- $0.05 < \Omega h^2 < 0.20$
- ${\sigma_{\chi p}}^{\text{SL}} < {\sigma_{\chi p}}^{\text{lim}} \text{ CDMS}(2008)+XENON10(2007)$
- $0.001 \times {\sigma_{\chi p}}^{\text{SL}} < {\sigma_{\chi p}}^{\text{lim}} \text{ CDMS}(2008)+XENON10(2007)$

- IceCube-22 & study:
  - Only used data, when Sun is below the horizon
  - main syst. uncertainty:
    - Photon propagation in the ice & absolute DOM efficiency (~20%)

- relate muon flux and WIMP-nucleon cross-section:

\[
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Neutralino DM (LSP)


\[ 0.05 < \Omega_c h^2 < 0.20 \]

\[ \sigma_{\chi}\sigma_{\text{SI}} \text{ CDMS}(2008) + \text{XENON10}(2007) \]

\[ \sigma_{\chi}\sigma_{\text{SI}} < 0.001 \sigma_{\text{SI}} \text{ CDMS}(2008) + \text{XENON10}(2007) \]

- CDMS (2008)
- COUPP (2008)
- KIMS (2007)
- SUPER-K 1996-2001
- IceCube-22 2007 (soft)
- IceCube-22 2007 (hard)
- IceCube-80+DeepCore 1800d sens. (hard)
- IceCube-80+DeepCore 1800d sens. (soft)
- IceCube-80 1800d sens. (hard)
- IceCube-80 1800d sens. (soft)

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Matthias Danninger    July 1, 2010     “Low-Energy” Neutrino Workshop
Neutralino DM (LSP)


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WIMP-Model-independent Result


The result is an average over the austral winter.

IC22: Systematic effects are included at the 1σ level, and statistical uncertainty of the same level are shown with error bars.
Looking forward

DeepCore makes low-energy region 10 ~ 100 GeV accessible for IceCube

IceCube-80 + DeepCore-6 sensitivity analysis is starting point for 2010 IceCube-79 string analysis

Further improvements:
- Including isolated hits and new reconstruction techniques
- All year search for low WIMP masses (IceCube active veto for DeepCore)
- String 79 & 80 will create even denser DeepCore array

Thank You