Searches for WIMP Dark Matter from the Sun with AMANDA

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for the IceCube Collaboration

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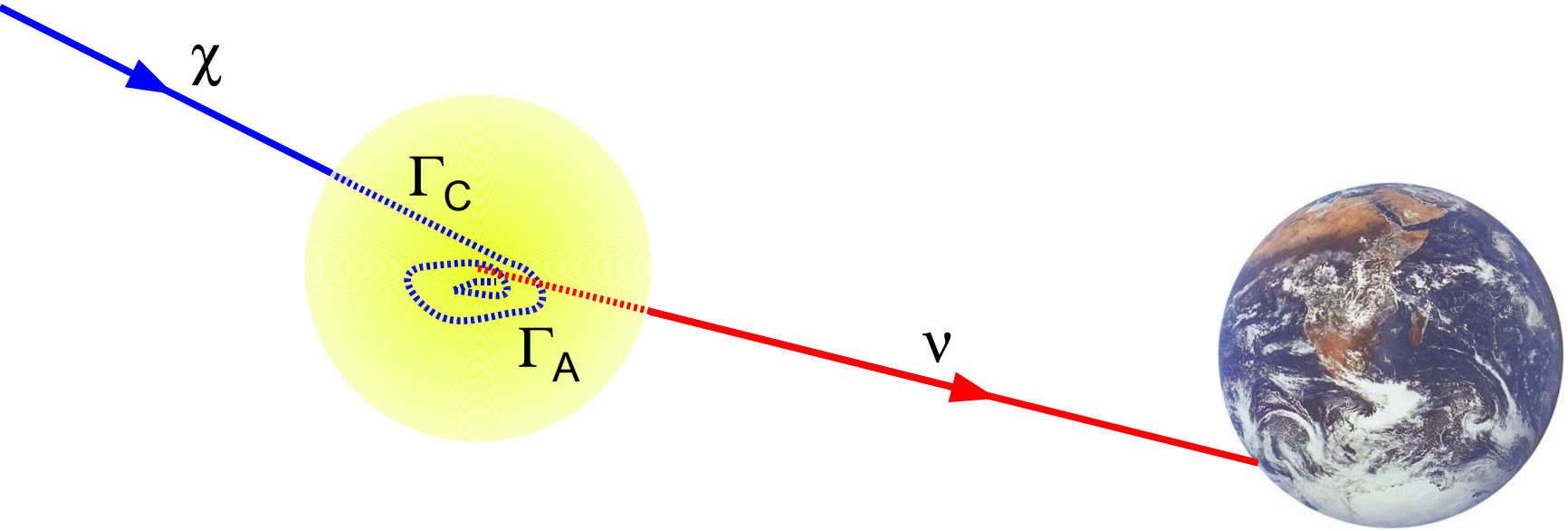
Solar WIMP Capture and Annihilation



Solar capture rate determined by galactic WIMP flux and WIMP-nucleon cross section

WIMPs accumulate at center of the Sun and annihilate

- Annihilation rate should approach equilibrium with capture rate

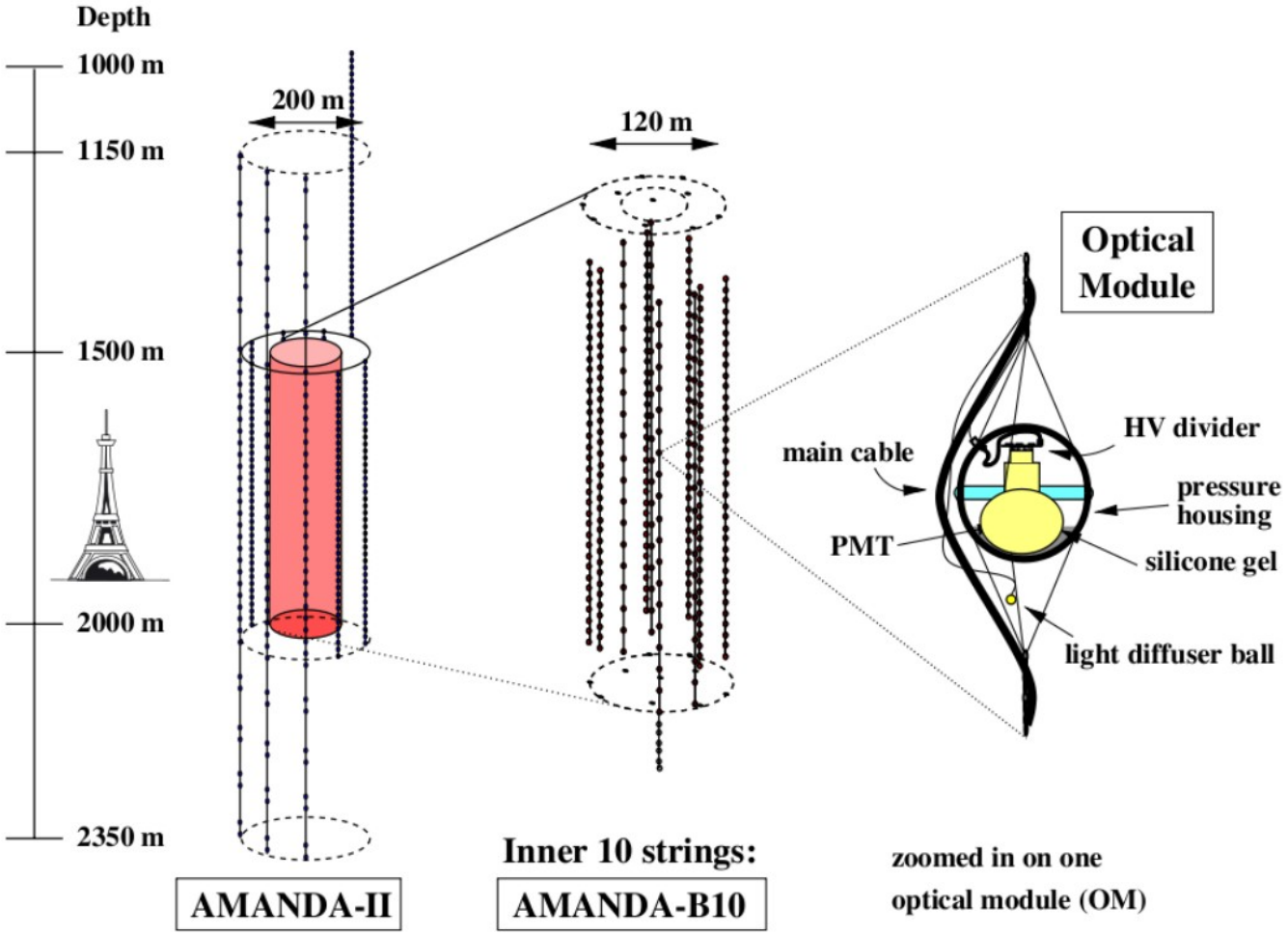
Annihilation produces a neutrino flux at Earth

- Neutrino spectra dependent on annihilation mode

$$\Gamma_A \sim \tfrac{1}{2}\Gamma_C$$

$$\chi\chi \rightarrow \begin{matrix} WW \\ b\bar{b} \\ \text{etc.} \end{matrix} \rightarrow \nu, e^-, \ldots.$$

AMANDA



Search for neutrino-induced muons from the Sun with AMANDA

AMANDA standard DAQ operational 2000-2006

Two Analyses

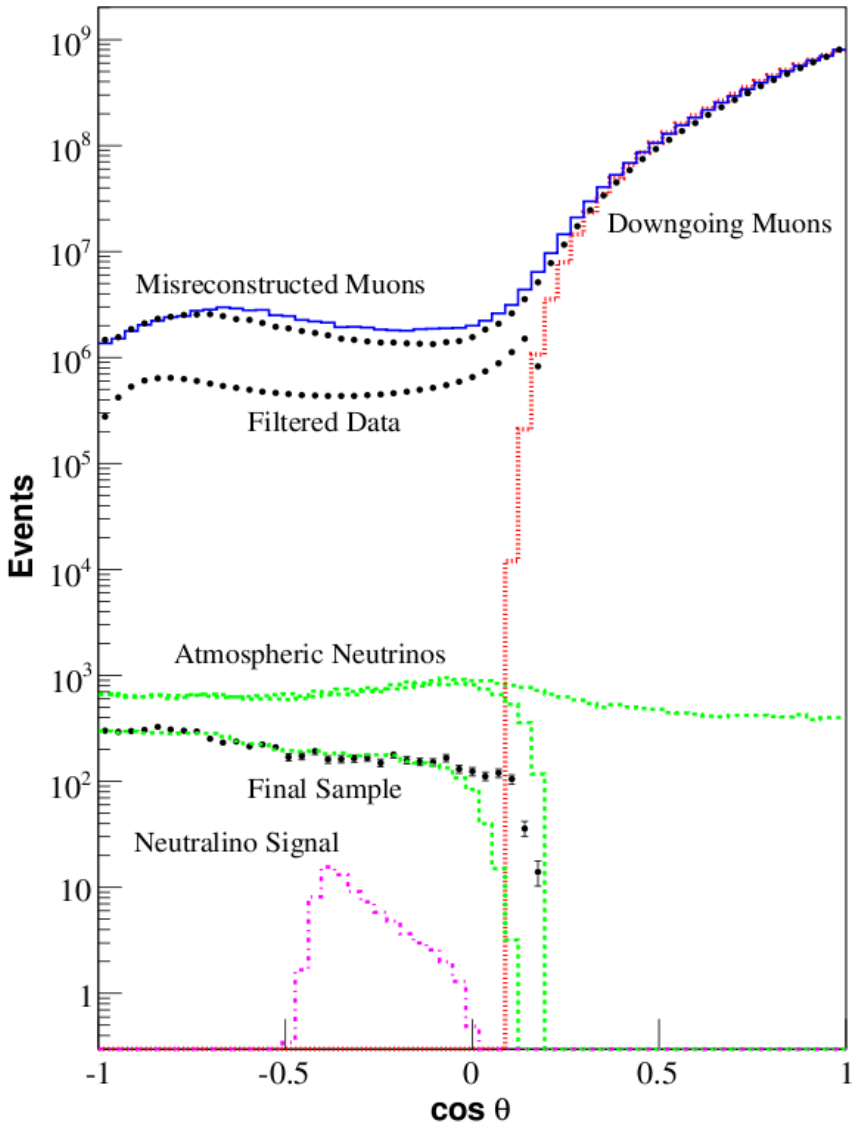
1. 2001-2003:

   Optimized for low energy neutrinos → small m_χ

2. 2000-2006:

   Use neutrino point source sample already available

Event Selection



Select events below horizon to avoid cosmic ray muons

Topological quality cuts reduce misreconstructed cosmic ray muons

Cannot avoid the background from atmospheric neutrinos

2000-2006:

- 4665 final events while Sun is below the horizon

2001-2003:

- Three event selections dependent on neutralino mass (398 – 670 events)

WIMP signal from the Sun peaks near 23 degrees

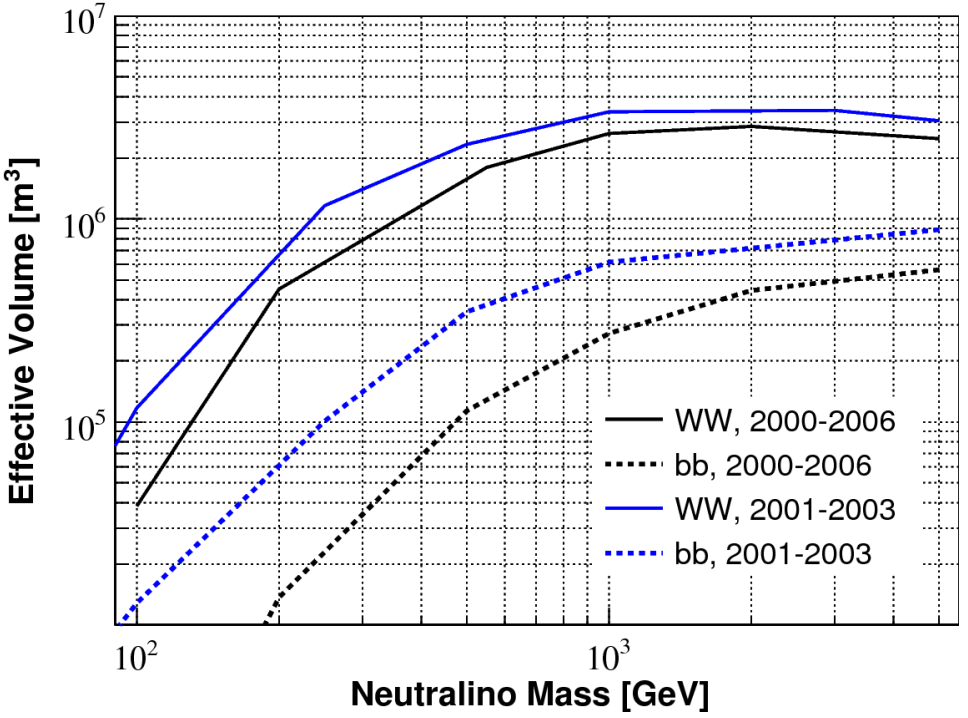
Analysis

Neutrino spectra are dependent on WIMP mass and annihilation channel

Detector characterized by effective volume (V_{eff})

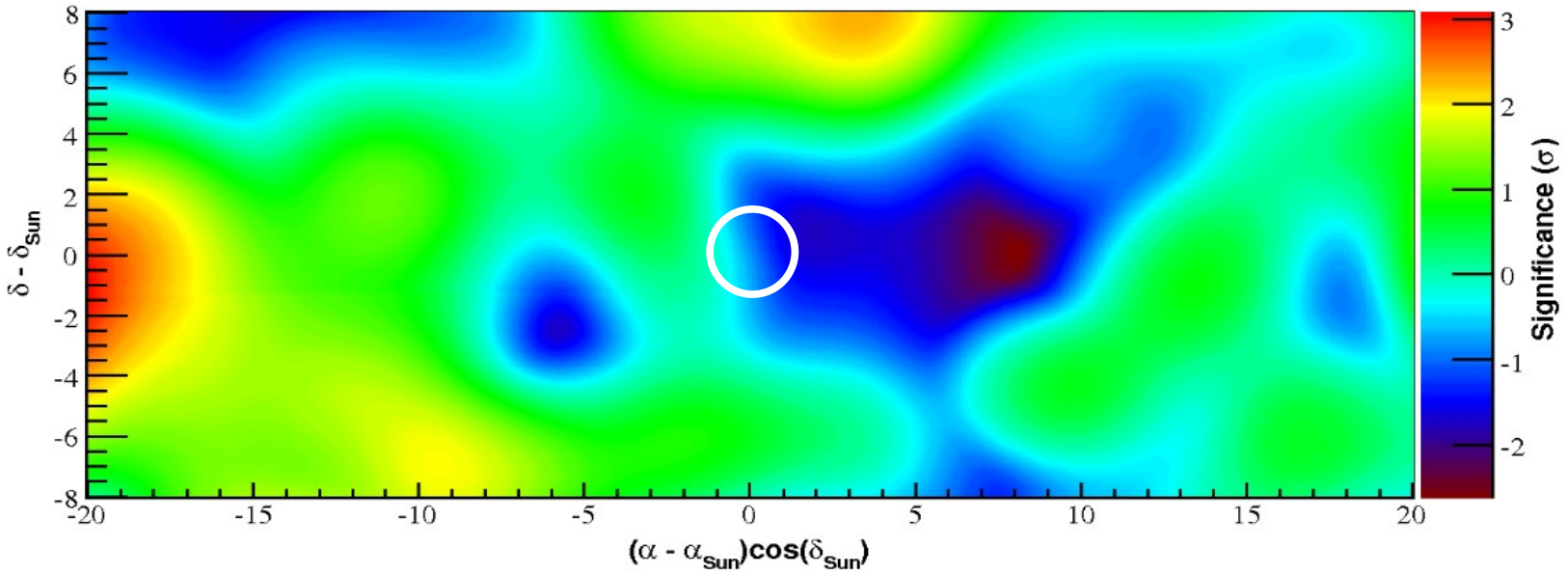
$$\frac{dN}{dt} = \Gamma_{\nu \to \mu} \times V_{eff}$$

AMANDA is most sensitive to higher energy spectra produced by large WIMP masses and hard annihilation channels (e.g. *WW*).

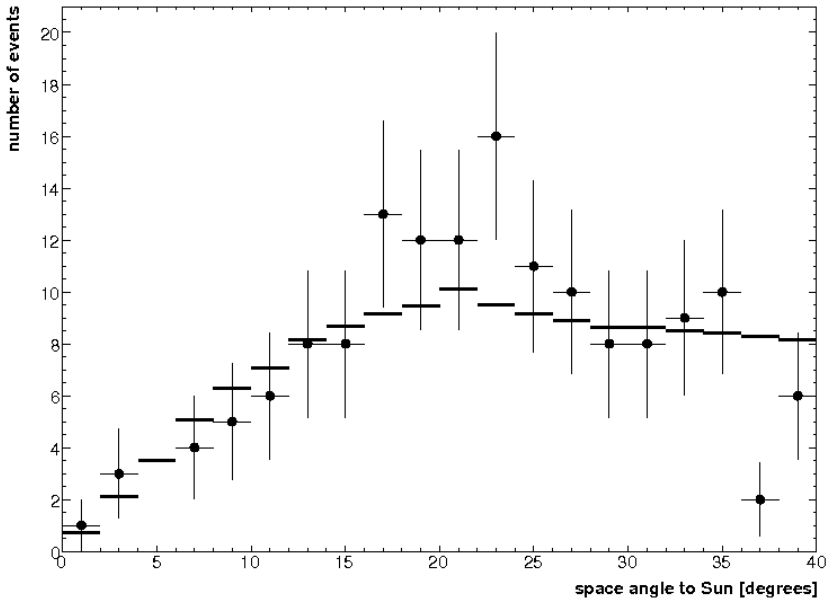


Use an unbinned maximum-likelihood method to search for an excess from the coordinates of the Sun

2000-2006



2001-2003

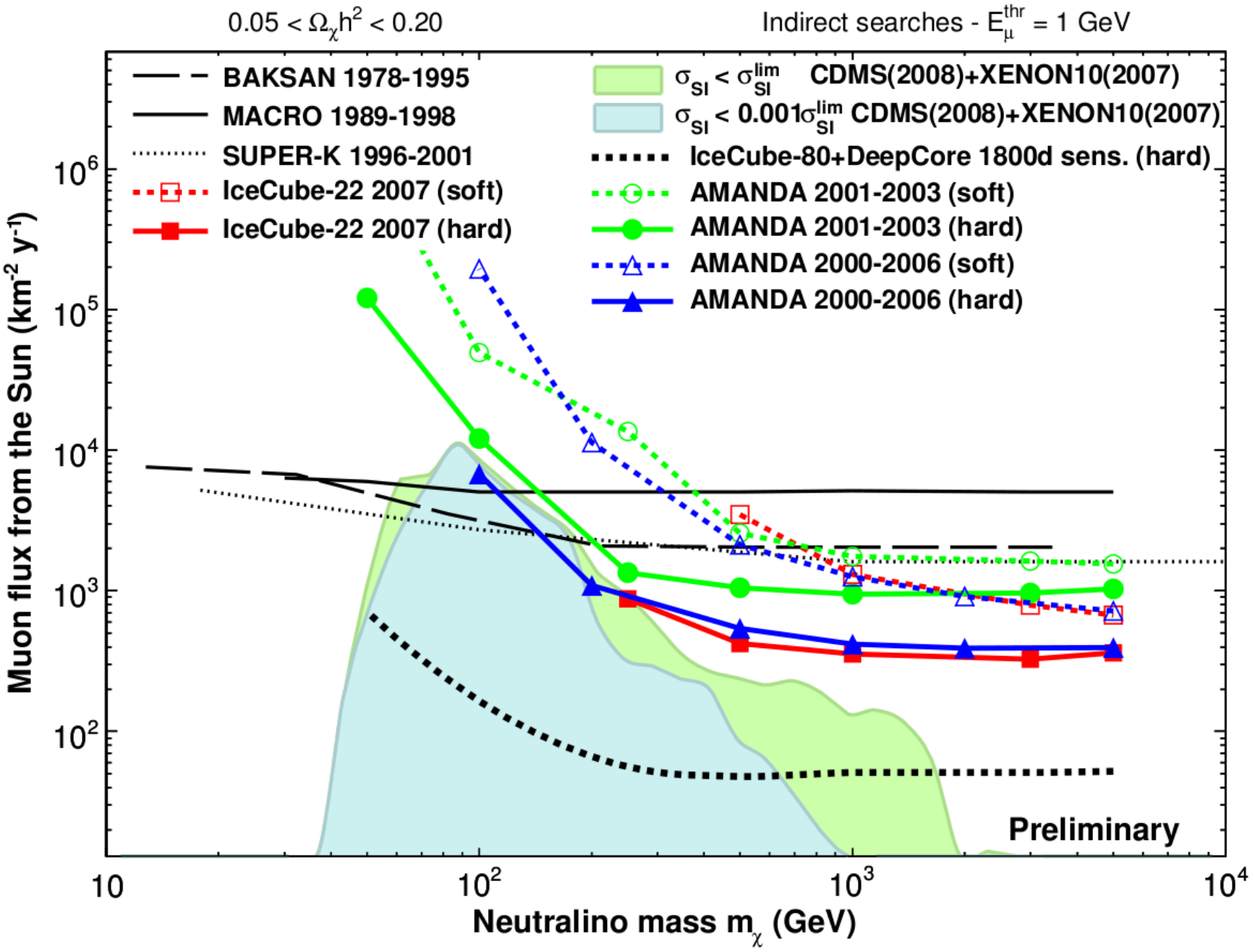


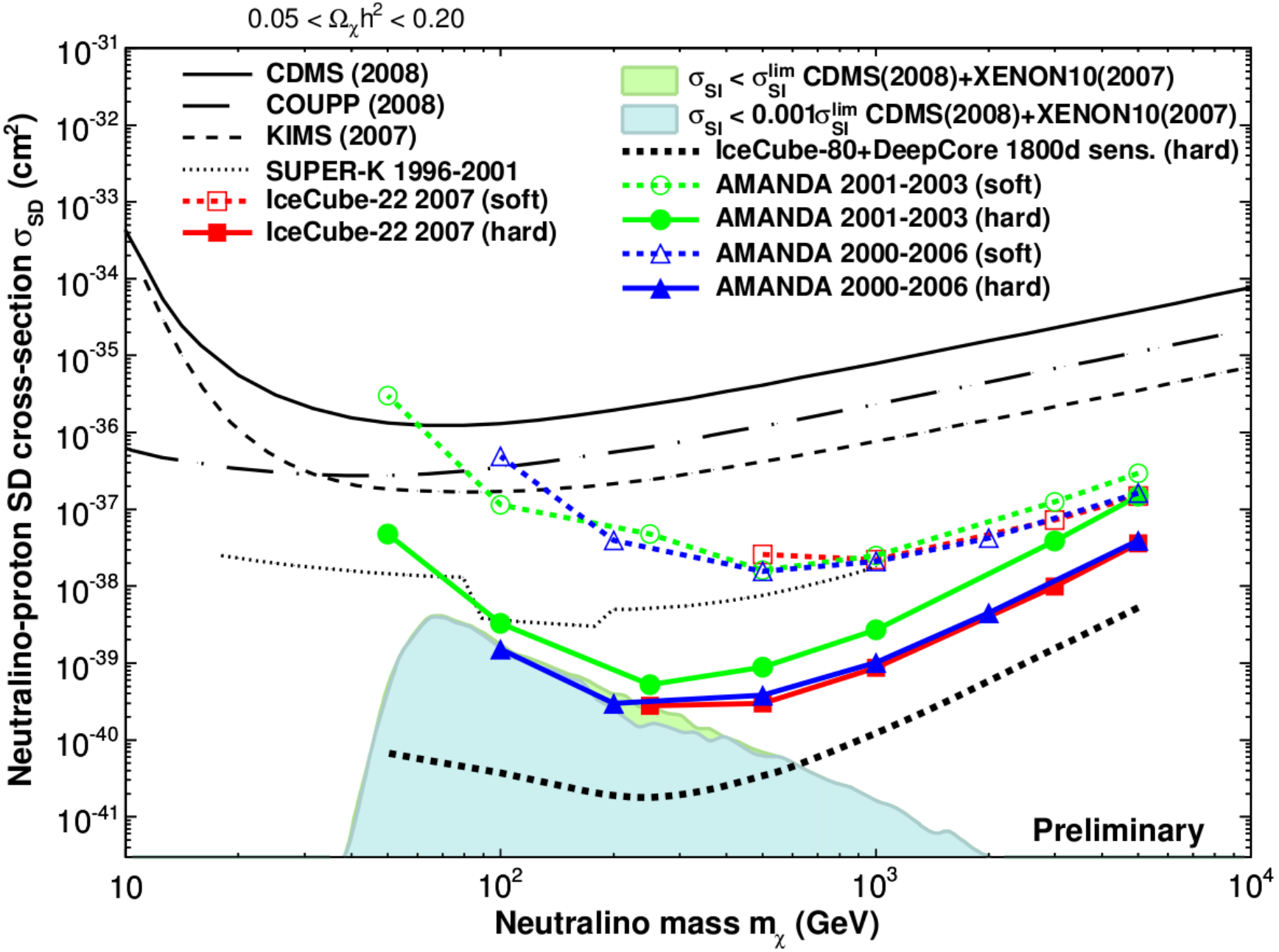
2000-2006:

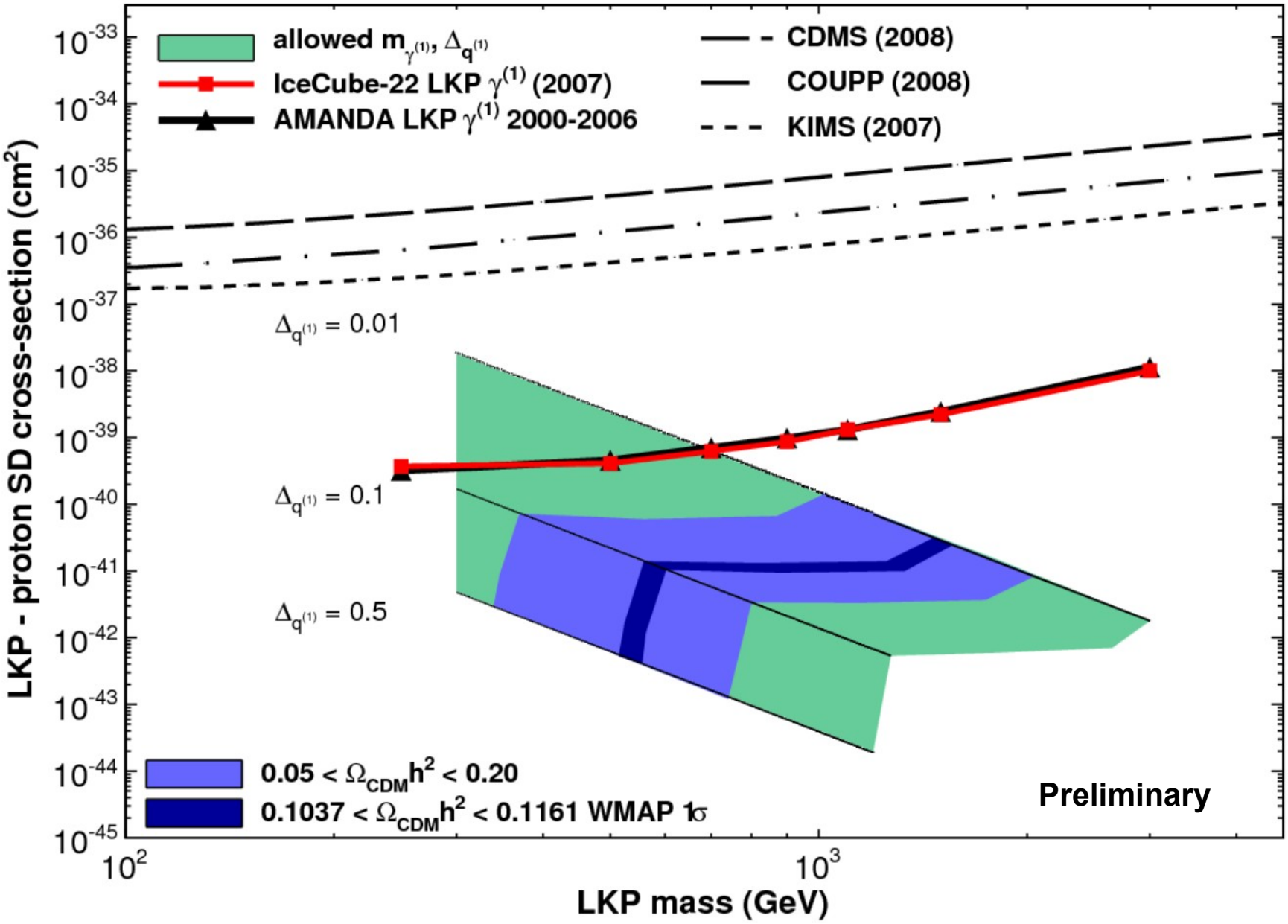
0.8σ deficit from direction of the Sun

2001-2003:

No excess observed in any of three event selections


$0.05 < \Omega_\chi h^2 < 0.20$
Indirect searches - E_μ^{thr} = 1 GeV
BAKSAN 1978-1995
MACRO 1989-1998
SUPER-K 1996-2001
IceCube-22 2007 (soft)
IceCube-22 2007 (hard)
$\sigma_{SI} < \sigma_{SI}^{lim}$ CDMS(2008)+XENON10(2007)
$\sigma_{SI} < 0.001\sigma_{SI}^{lim}$ CDMS(2008)+XENON10(2007)
IceCube-80+DeepCore 1800d sens. (hard)
AMANDA 2001-2003 (soft)
AMANDA 2001-2003 (hard)
AMANDA 2000-2006 (soft)
AMANDA 2000-2006 (hard)
Preliminary
Muon flux from the Sun (km^{-2} y^{-1})
Neutralino mass m_χ (GeV)
10^2
10^3
10^4
10^5
10^6
10
10^2
10^3
10^4


$0.05 < \Omega_\chi h^2 < 0.20$
CDMS (2008)
COUPP (2008)
KIMS (2007)
SUPER-K 1996-2001
IceCube-22 2007 (soft)
IceCube-22 2007 (hard)
$\sigma_{SI} < \sigma_{SI}^{lim}$ CDMS(2008)+XENON10(2007)
$\sigma_{SI} < 0.001\sigma_{SI}^{lim}$ CDMS(2008)+XENON10(2007)
IceCube-80+DeepCore 1800d sens. (hard)
AMANDA 2001-2003 (soft)
AMANDA 2001-2003 (hard)
AMANDA 2000-2006 (soft)
AMANDA 2000-2006 (hard)
Preliminary
Neutralino-proton SD cross-section σ_{SD} (cm^2)
Neutralino mass m_χ (GeV)
10^{-31}
10^{-32}
10^{-33}
10^{-34}
10^{-35}
10^{-36}
10^{-37}
10^{-38}
10^{-39}
10^{-40}
10^{-41}
10
10^2
10^3
10^4



See poster by M. Danninger and K. Han

Summary

Annihilation of WIMPs in the Sun should produce a neutrino flux observable in neutrino telescopes

No evidence of such a neutrino flux has been observed in either of two AMANDA analyses

WIMP-proton spin-dependent cross section limits complement those from direct detection experiments

IceCube with the DeepCore extension will significantly improve these limits in the coming years

This Proceeding: **arXiv:0906.1615**