Diffuse high-energy neutrino searches in AMANDA-II and IceCube

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What is Diffuse Neutrino Search?

- If individual neutrino sources are too faint...
  - Still possible to investigate overall feature of isotropically distributed sources
- If extraterrestrial neutrinos follow more harder energy spectrum than background...

Investigate energy-related observable to search for astrophysical neutrinos!
AMANDA-II

- Depth
- Top view
- 19 Strings
- 677 OM's
- Completed 2000

IceCube

- South Pole surface (Alt. 2835m)
- IceTop surface array
- 80 Strings
- 4800 DOMs
- 2006: 9 strings are deployed
**Event Selection Strategy**

- **Target neutrinos**: 
  \[ \pi^+ \rightarrow \mu^+ + \nu_\mu \]
  \[ \rightarrow e^+ + \nu_e + \bar{\nu}_\mu \]
  (similar for \( \pi^- \), \( K^\pm \))

- **Detect muons** generated from neutrinos via Charged Current interaction

- **Choose up going** events to reject atmospheric muons

- **Choose good quality tracks** (depends on detector)
Practically we observe much more amount of atmospheric muon events which are misreconstructed as upgoing track. → Apply quality cuts
AMANDA-II 2000-2003 integrated analysis

Event selection

- Require enough number of hit close to the expected hit time for the reconstructed track
- Hits should distribute smoothly along with the reconstructed track
- Require enough long track
- Remove horizontal events

![Graph](image)

- Data 2000 - 2003
- Uncertainty in atm. \( \nu \)
- Barr et al. atm. \( \nu \)
- Honda et al. atm. \( \nu \)
- CORSIKA atm. \( \mu \)

\[ E^{2 \phi}_{\text{sig}} = 10^{-6} \text{ GeV cm}^{-2} \text{ s}^{-1} \text{ sr}^{-1} \]
AMANDA-II 2000-2003 integrated analysis
Nch distribution after final selection

- Data 2000 - 2003
- Uncertainty in atmospheric $\nu$
- Barr et al. atms. $\nu$ + prompt $\nu$
- Honda et al. atms. $\nu$ + prompt $\nu$

$E^2 \phi_{\text{signal}} = 1.0 \times 10^{-6} \text{ GeV cm}^{-2} \text{s}^{-1} \text{sr}^{-1}$
$E^2 \phi_{\text{signal}} = 7.4 \times 10^{-8} \text{ GeV cm}^{-2} \text{s}^{-1} \text{sr}^{-1}$

Final event sample

Atms. $\nu$ rescaled
AMANDA-II 2000-2003 integrated analysis
Upper Limit

AMANDA-II 4yr NuMu analysis

* assumes a 1:1:1 flavor ratio at Earth
IceCube 9 string ~ Event selection

Basically same as AMANDA-II analysis, but...

- do not require track length
- Keep events that arrive from horizontal direction then apply energy-related cut to reject horizontal atms. muon

NuMu Effective Area

-0.8 > cos(true zenith) >= -1.0
-0.6 > cos(true zenith) >= -0.8
-0.4 > cos(true zenith) >= -0.6
-0.2 > cos(true zenith) >= -0.4
0.0 > cos(true zenith) >= -0.2
0.2 > cos(true zenith) >= 0.0
IceCube 9 string ~ 137 days Nch distribution (MC)
After final selection

Number of events (for 137 days)

-2
-1
1

MCνAtmospheric
MCνSignal

(test flux 1.0e-6 E^-2)
IceCube 9 string ~ 137 days
Scale factor of test flux vs Nch cut threshold

Best mrf(paraboloid) = 0.144495
Best cut at Nch=60 (bin 61)
Best Integrated Bgd = 0.40043
Int. Bgd (<bestcut) = 631.497
Best Integrated Sig = 21.86

Best mrf(bottom) = 0.115573
Best cut at Nch=55 (bin 56)
Best Integrated Bgd = 0.694991
Int. Bgd (<bestcut) = 629.709
Best Integrated Sig = 26.1636
IceCube 9 string ~ 137 days Sensitivity

IC9 137 days sensitivity is factor 2 above AMANDA-II 4yr!
Summary

- AMANDA-II 4 year upper limit on the diffuse flux of muon neutrino with a $A_{\text{const}} E^{-2}$ spectrum for the energy range 16 TeV to 2.5 PeV is

$$E^2 < 7.4 \times 10^{-8} \text{ GeV cm}^{-2} \text{ s}^{-1} \text{ sr}^{-1}$$

- The sensitivity of IceCube 9 string 137 days for the energy range from 40 TeV to 20 PeV is

$$E^2 < 1.4 \times 10^{-7} \text{ GeV cm}^{-2} \text{ s}^{-1} \text{ sr}^{-1}$$

which is factor 2 above from AMANDA-II 4yr

- Physics run of IceCube 22 string started

Analyses for 22 string is now ongoing