Catching Neutrinos with an IceCube

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04 – 04 – 2011 , Neutrino-Gamma Workshop @ Marseille
IceCube Neutrino Observatory

IceTop
80 stations composed of 2 Cherenkov tanks with 2 DOMs sensors per tank.

IceCube
86 strings of DOMs
Completed December 14th 2010!

AMANDA
Shutdown in March 2009

DeepCore
8 strings of HQ-DOMs
Completed in February 2010.
**IceCube Neutrino Observatory**

**The DeepCore extension**

- **DeepCore**: 8 strings of HQ-DOMs
- **Low-Energy extension**
- Completed in February 2010.
IceCube Neutrino Observatory
Successive configurations

Season 04-05
First IceCube string deployed

Season 05-06 : IC-9

Season 06-07 : IC-22
- Cosmic Ray anisotropy
- Diffuse fluxes
- GRB observations

Season 07-08 : IC-40
- Moon Shadow
- Point Source search
- Diffuse fluxes (Prel.)
- GRB observations

Season 08-09 : IC-59
- GRB observations (Prel.)

Season 09-10 : IC-79

Season 10-11 : IC-86
IceCube is completed!
Signal in IceCube

Cherenkov radiation detected by optical sensors
Information: Time – Intensity – Position
► Energy and/or direction reconstruction

$v_\text{e}$ with $E = 375$ TeV

$v_\mu$ with $E = 6$ TeV

$v_\tau$ with $E = 1$ PeV
Signal in IceCube

Cosmic

Atmospheric

\( \sim E^{-2} \)

\( \sim E^{-3.7} \)

M. Labare, Catching Neutrinos with an IceCube
IC-40 The Moon Shadow
Verification of the IceCube pointing accuracy

observed: $7.173\times10^4$ events
expected: $7.4\times10^4$ events
deficit: -2262 events
error: 285 events
significance: -7.9$\sigma$

G.W. Clark, 1957
IC-22 Cosmic Ray Anisotropy


**June, 2007 - March, 2008**

4.3 $10^9$ atm. $\mu$  \hspace{1cm} $<E> = 14$ TeV

**Very first measurement for Southern Hemisphere**

- Anisotropy up to 100 TeV
- Energy dependence

![Map of cosmic ray anisotropy](image.png)

*Preliminary*
IC-40 All sky Point Source Search

Northern sky: 14,121 ev. (atm-ν)

\[ E^2 \frac{dN}{dE} \sim 2 - 200 \times 10^{-12} \text{ Tev cm}^{-2} \text{ s}^{-1} \]

Southern sky: 22,779 ev. (atm µ)

\[ E^2 \frac{dN}{dE} \sim 3 - 700 \times 10^{-12} \text{ Tev cm}^{-2} \text{ s}^{-1} \]

Post-trial proba: 18%
IC-40 All sky Point Source Search

ArXiv:1012.2137 (To be published in ApJ.)

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M. Labare, Catching Neutrinos with an IceCube
IC-22 (IC-40) Astroph. $\nu$ diffuse flux

IC-22: 333.3 days lifetime
IC-40: 375.5 days livetime
IC-40\textsuperscript{(IC-59)} : Search for GRB $\nu$ signal

From April 5, 2008 till May 20, 2009
129 GRBs (GCN) $\rightarrow$ 117 GRBs

Model-dependant: Unbinned LLH
Direction – arrival time – muon energy
No event observed (2.99 expected)

Model-independant: time window search
[-10s ; +10 s] $\rightarrow$ [-1 day ; +1 day]
No candidate event in $\pm 2248s$ (4.2 expected)
IC-22 : Constraint on HE $\nu$ from SN2008D

A&A, n.15770

January, 9 2008
SWIFT X-Ray flash detection
09h09m30.70s ra ; 33°09’19,1” decl.

Soft jet model
massive star collapse $\rightarrow$ neutron star or B.H.
$\Gamma_b \sim 1 – 10$  \hspace{1cm} $\theta \sim 5° - 50°$  \hspace{1cm} $E_j \sim 3 – 6 \times 10^{51}$ erg

IC-22 : 275,72 days
Time range : [-9.5h ; +1.8h]
Bg rate : 0.03 Hz \hspace{1cm} 0.26 signal ev. expected
Summary

IceCube is completed after 7 years of deployment!
► 86 strings with more than 5000 sensors for the biggest neutrino telescope in full activity.
► **DeepCore** extension: 8 densely instrumented region lowering the energy threshold @ 10 GeV

Data has been taken during construction phase
► 1\textsuperscript{st} observation of CR anisotropy in the Southern Sky (IC-22)
► Limits for Point Source (IC-40)
  ● NS: ~ 2 – 200 \(10^{-12}\) Tev cm\(^{-2}\) s\(^{-1}\)
  ● SS: ~ 3 – 700 \(10^{-12}\) Tev cm\(^{-2}\) s\(^{-1}\)
► Limits for Atm. Neutrino diffuse flux (IC-22/IC-40)
  ● We're under the WB limit !!
► Search for GRB signal (IC-22/IC-40/IC-59)
  ● No event observed
  ● Constraints on soft jet models
  ● Optical Follow-up with SWIFT, Fermi, ROTSE,...
Summary

Additional topics:
- DarkMatter
- Exotic particles
- Electronic cascades
- Tau physics

Additional detectors for new channels:
- SPATSE
- Antarctic Radia Array (ARA) will start soon.

Analyses with partially built detector have been successful

The full km³-sized detector will provide an important increase in sensitivity for future analyses

NEW DISCOVERIES?
Detector characteristics (Back-up)
Searches for Dark Matter (Back-up)

Indirect detection of $\nu$ from DM annihilation


**Galactic Halo observation**

*ArXiv*: 1101.3349v1