

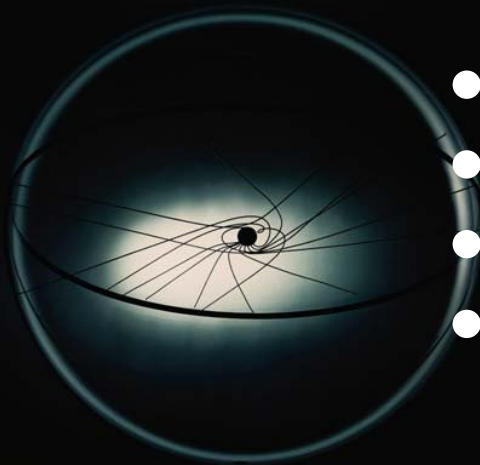
Status and results from IceCube



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Cosmic Rays · 1949

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Outline

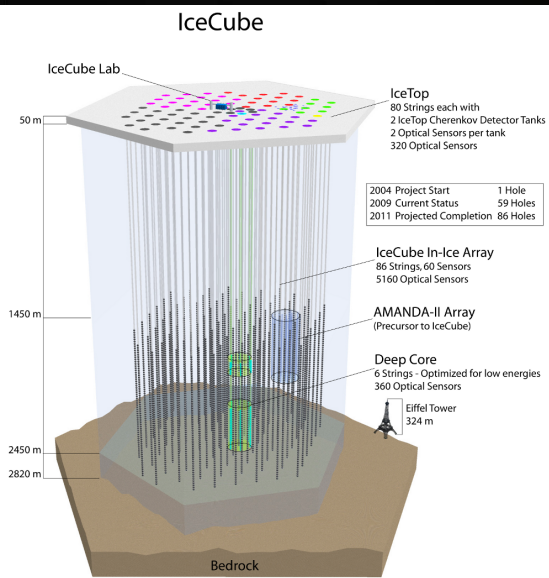


- Status of the Observatory
- Dark Matter Search IC22
- Point Source Search IC40
- Current projects @ EPFL

The IceCube Observatory



IceCube



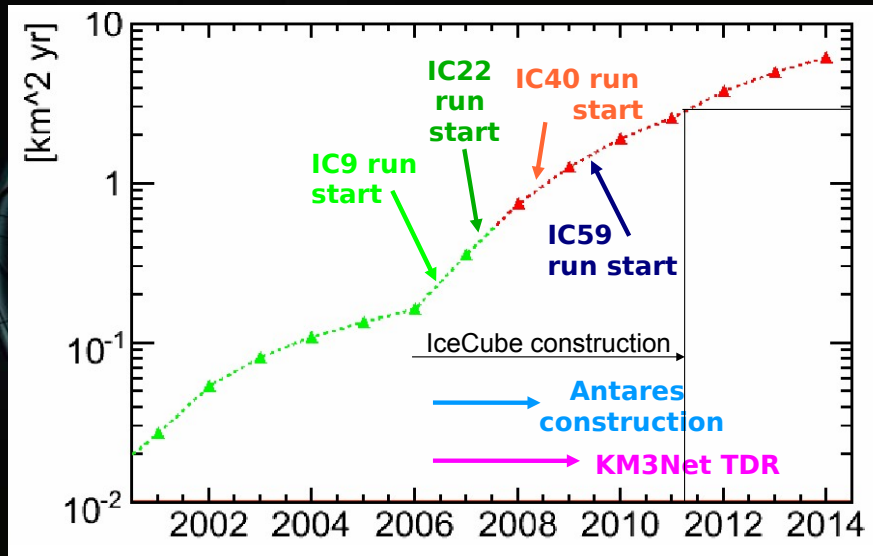
Current status after 08/09 season:

- IceTop: 59 stations
- IceCube: 58 strings with 60 DOM each.
- Amanda: Out of commission since April 2009
- DeepCore: First string deployed.

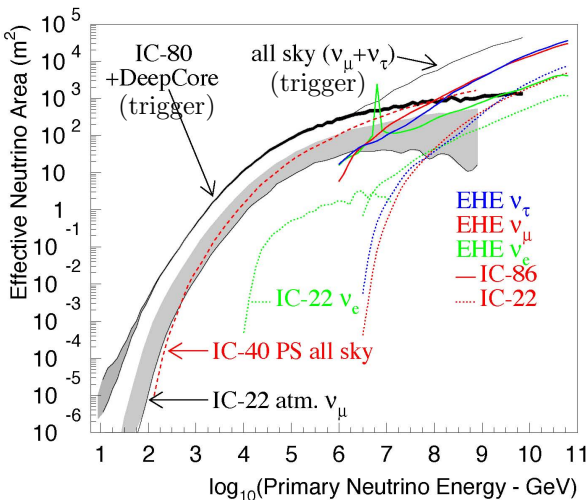
Data taking status:

- IC59 runs started May 20, 2009
- Livetime for runs so far: 97.38%.
- Event rates ≈ 1800 Hz

IceCube Integral Exposure @ 100 TeV



Effective Area

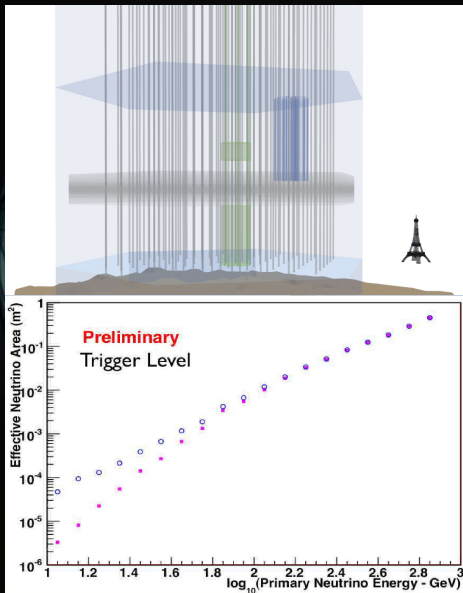


Eff. Area at 1 TeV:
 AMANDA-II: 0.005 m²
 IceCube 86: 0.3 m²

Eff. Area at 100 TeV:
 AMANDA-II: 3 m²
 IceCube 86: 100 m²

Deep Core lowers threshold
 from 100 GeV to 10 GeV.

The DeepCore Low Energy Extension



A core detector consisting of
7 IceCube and 6 additional strings:

- 360 HQE 10" PMT (Hamamatsu R7081-Mod)
- depth: 2100m-2450m
- shallow veto component (1750m – 1850m)
- sensor spacing: 7m (IceCube: 17m)
- Inter-string spacing: 72m

Enhanced detection of low energy neutrinos (below 100 GeV)

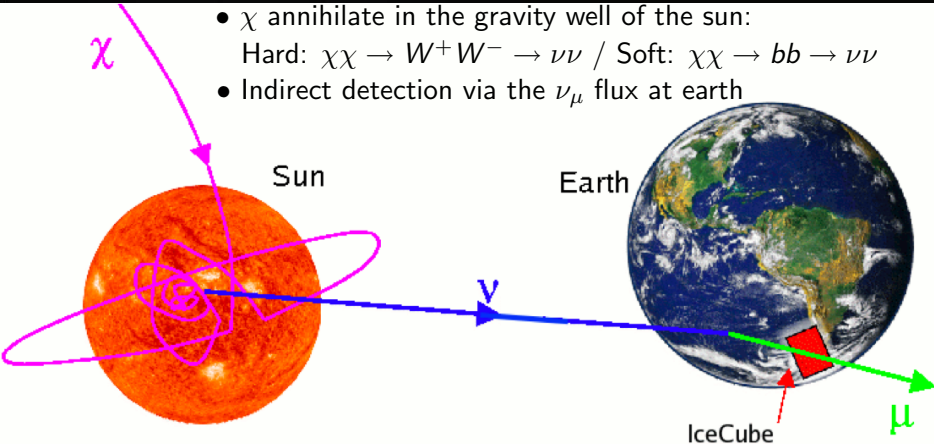
Low energy physics interests:

- PS searches in the southern sky (galactic sources)
- Oscillation studies between 10 – 100 GeV
- Extension of WIMP search to lower masses

WIMP Annihilation in the Sun



- χ annihilate in the gravity well of the sun:
Hard: $\chi\chi \rightarrow W^+W^- \rightarrow \nu\nu$ / Soft: $\chi\chi \rightarrow bb \rightarrow \nu\nu$
- Indirect detection via the ν_μ flux at earth



IC22 data with 104 days of livetime (when the sun was below horizon)

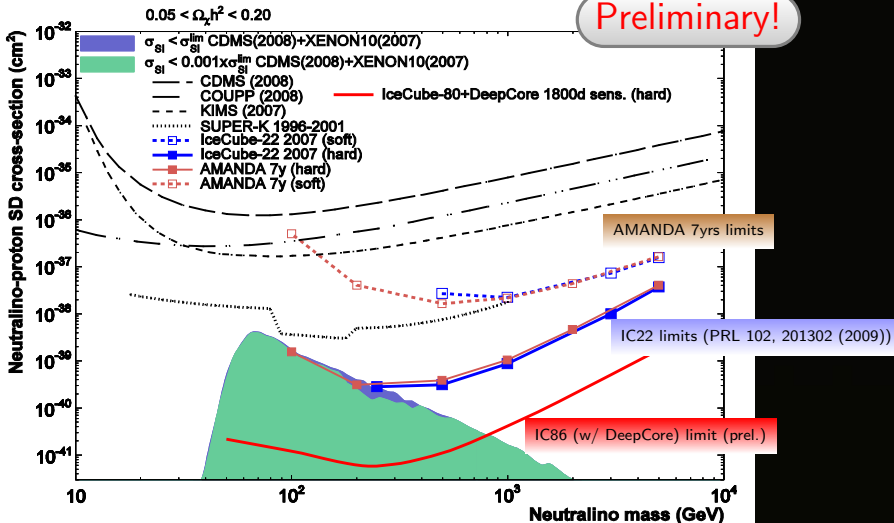
Neutralino: LSP in MSSM, R-parity conserving scenario
is a Majorana particle and self-annihilates

Consider 7 neutralino masses from 50 GeV to 5 TeV

WIMP Annihilation in the Sun



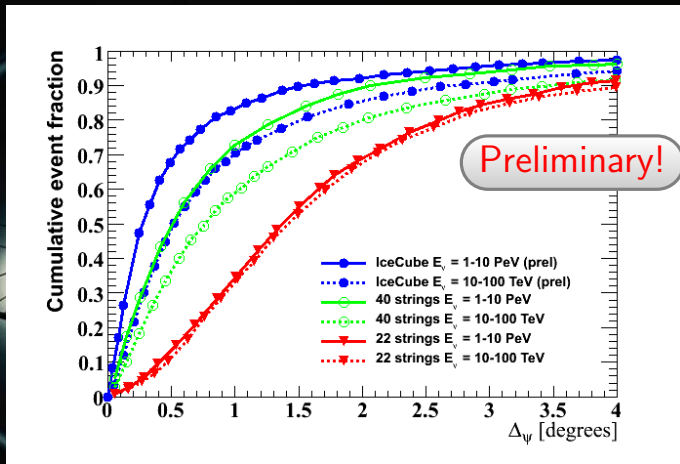
Preliminary!



Under assumption of equilibrium in the sun \rightarrow limit on WIMP–nucleon cross–section.

SD = spin dependent

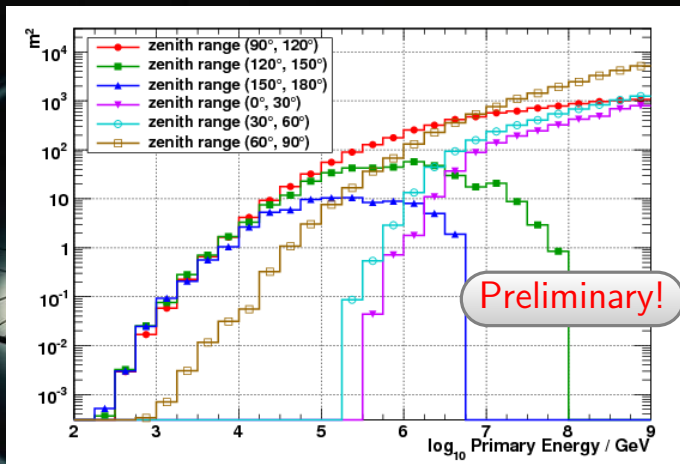
IC40 6 month PS search: PSF



Median of the avg. PSF for an E^{-2} signal spectrum:

- 0.7° in the northern sky, 0.5° in the southern sky

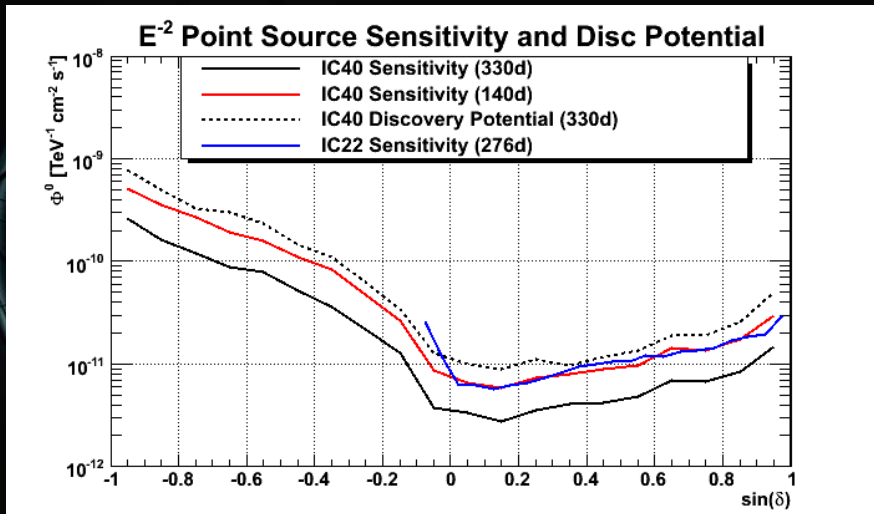
IC40 6 month PS search: Effective Area



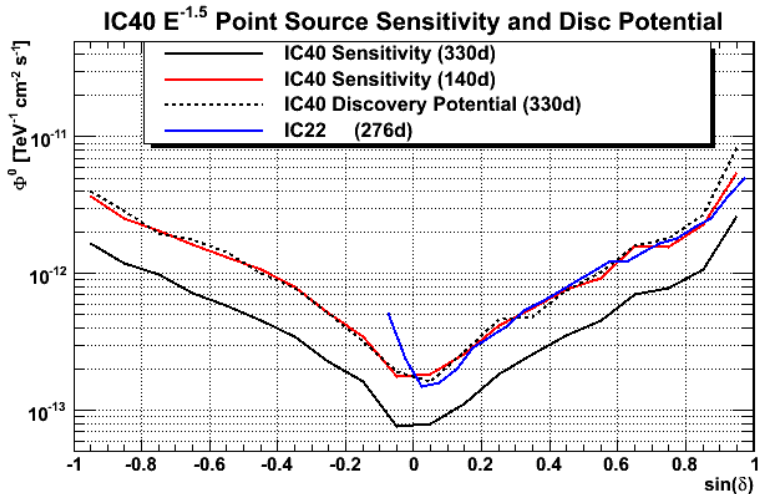
Solid angle averaged effective areas:

- final selection level, plus
- reconstructed position within 2° of the true position

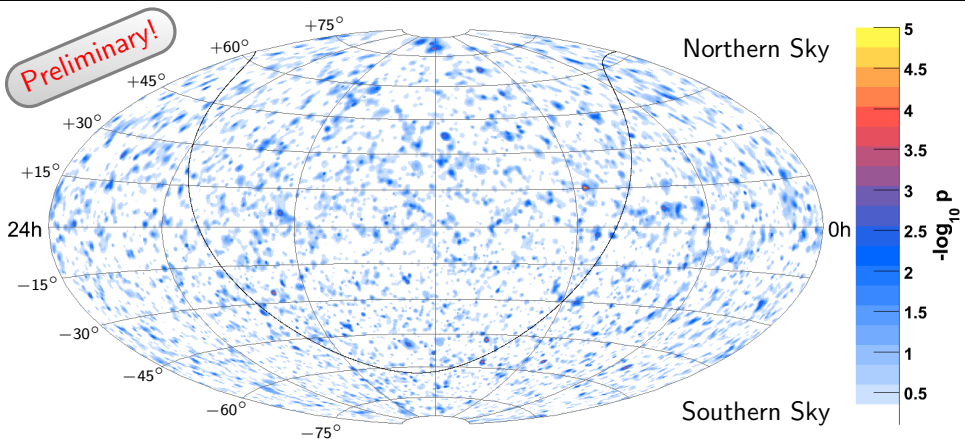
IC40 6 month PS search: Sensitivity for E^{-2} flux



IC40 6 month PS search: Sensitivity for $E^{-1.5}$ flux



IC40 6 month PS search: sky map

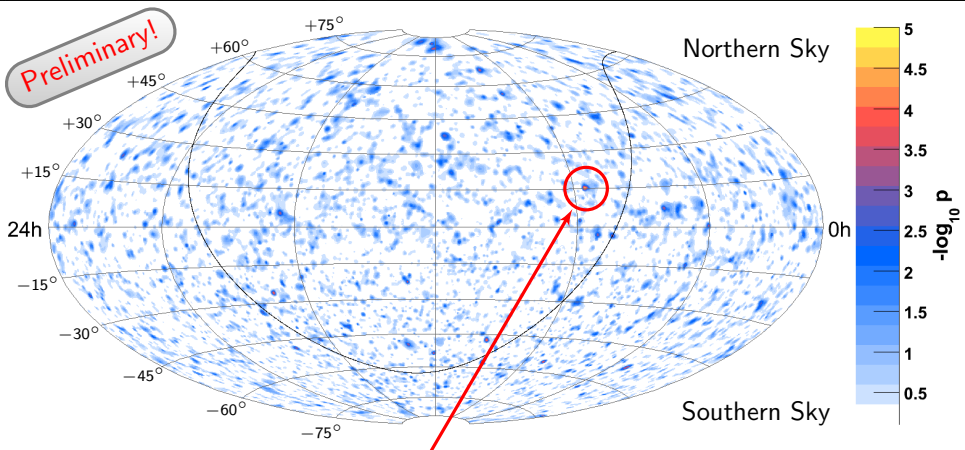


Livetime: 175.5 days, Events: 17777 (all-sky)

Northern hemisphere (up-going): 6796 (background: atm. neutrinos)

Southern hemisphere (down-going): 10981 (background: atm. muons)

IC40 6 month PS search: all sky results



- Hottest spot at $(\alpha, \delta) = (114.95^\circ, 15.36^\circ)$
- Pre-trial $-\log_{10}(p) = 4.43$.
- Post-trial all-sky p -value = 61.1% \rightarrow not significant.

IC40 6 month PS search: source list results



Northern Sky

Source Name	Ra. Dec (deg)	p-value
Cyg_OB2	(308.083, 41.510)	: 0.47834
MGRO_J2019+37	(305.220, 36.830)	: ---
MGRO_J1908+06	(286.976, 6.269)	: ---
Cas_A	(350.850, 58.815)	: ---
IC443	(94.179, 22.529)	: ---
Geminga	(98.476, 17.770)	: ---
Crab_Nebula	(83.633, 22.014)	: ---
1ES_1959+650	(299.999, 65.149)	: ---
1ES_2344+514	(356.770, 51.705)	: ---
3C66A	(35.673, 43.043)	: 0.36423
H_1426+428	(217.136, 42.672)	: ---
BL_Lac	(330.680, 42.278)	: ---
Mrk_501	(253.468, 39.760)	: 0.42203
Mrk_421	(166.114, 38.209)	: 0.32724
W_Cornae	(185.382, 28.233)	: ---
1ES_0229+200	(38.202, 20.287)	: 0.34695
M87	(187.706, 12.391)	: ---
S5_0716+71	(110.473, 71.343)	: ---
M82	(148.967, 69.680)	: ---
3C_123.0	(69.268, 29.671)	: ---
3C_454.3	(343.491, 16.148)	: ---
4C_38.41	(248.815, 38.135)	: 0.47002
PKS_0235+164	(39.660, 16.620)	: ---
PKS_0528+134	(82.735, 13.532)	: ---
PKS_1502+106	(226.104, 10.494)	: 0.27947
3C_273	(187.278, 2.052)	: ---
NGC_1275	(49.951, 41.512)	: ---
Cyg_A	(299.868, 40.734)	: ---
IC-22_maximum	(153.375, 11.375)	: ---

Southern Sky

Source Name	Ra. Dec (deg)	p-value
Sgr_A*	(266.417, -29.008)	: 0.50000
PKS_0537-441	(84.710, -44.086)	: ---
Cen_A	(201.365, -43.019)	: 0.34066
PKS_1454-354	(224.361, -35.653)	: ---
PKS_2155-304	(329.717, -30.225)	: 0.20422
PKS_1622-297	(246.525, -29.857)	: 0.05233
QSO_1730-130	(263.261, -13.08)	: 0.25087
PKS_1406-076	(212.235, -7.874)	: ---
QSO_2022-077	(306.420, -7.640)	: ---
3C279	(194.050, -5.790)	: ---

- List of 39 sources selected a priori.
- P-values ≥ 0.5 (downward fluctuations) are given as "—"
- Highest significance from PKS 1622-297
 $-\log_{10}(p) = 1.28$.
- Post-trial source list p-value = 61.8%
 \rightarrow not significant.

Search for neutrinos from selected x-ray binary systems / blazars

- phenomenology and neutrino flux predictions, time-averaged & time-dependent
- on-going time averaged searches for excess from selected Fermi blazars
- Multiwavelength time-dependent analysis.

Atmospheric neutrinos

- selection of contained tracks with high efficiency.
- improving reconstruction of low energy events
- search for neutrino oscillations, i.e. flux variations w.r.t. angle and/or energy in 50-100 GeV range.
- extend analysis to higher energies (up to 10 TeV)

Diffuse flux of UHE neutrinos

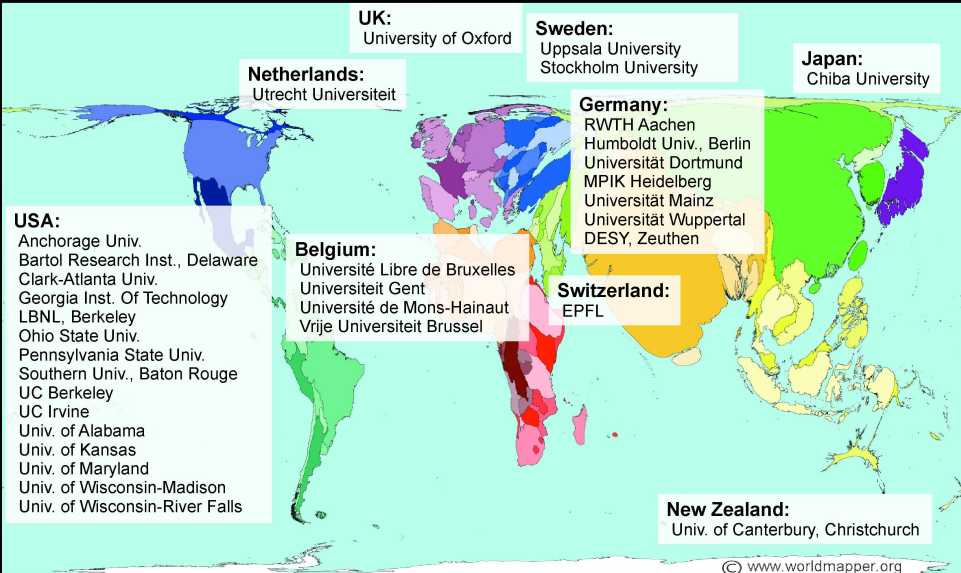
- due to screening, UHE neutrinos can be observed only from the southern sky
- Needs high efficiency discrimination of muon bundles vs. single muons.
- search will look at the horizon first, with the aim to extend it to the whole southern hemisphere.

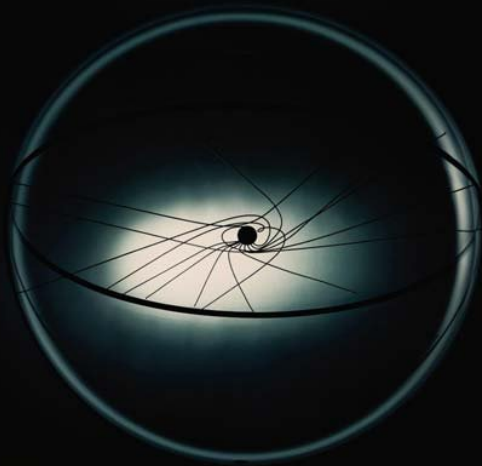
R&D for acoustic detection of neutrino / CTA

The IceCube Collaboration



IceCube

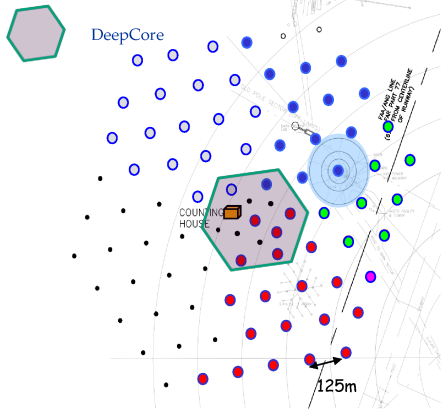




Installation of 1st DeepCore string

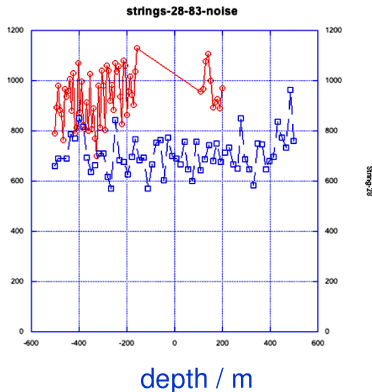


● 2008/2009 : IC-59 (DC1) IT-59



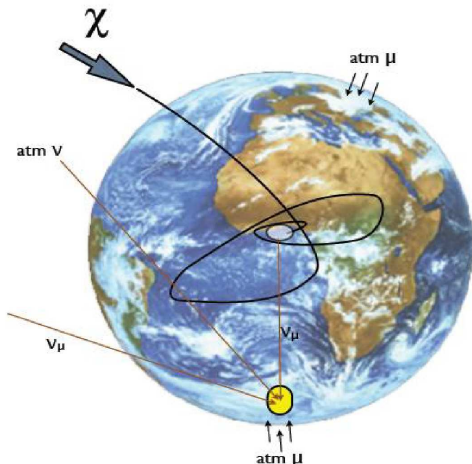
noise rate / Hz

—○— String-83 —□— String-28



- First string of DeepCore (#83) was deployed Jan 2009
- All HQE DOMs work as expected.
- Noise rates are $\approx 30\%$ higher than the regular IC DOMs.

Other Searches for WIMPs



Current AMANDA/IceCube WIMP searches:

Search at other locations:

- Earth
- Galactic Halo

Search of different types of WIMPs

- Kaluza–Klein dark matter