The Baikal Neutrino Telescope – Selected Physics Results

R. Wischnewski (DESY) for the

Baikal Collaboration

Institute for Nuclear Research ,Moscow,Russia
Irkutsk State University, Irkutsk, Russia
Joint Institute for Nuclear Research,Dubna, Russia
Skobeltsyn Institute of Nuclear Physics MSU,Russia
DESY,Zeuthen,Germany
N. Novgorod State Technical University, N. Novgorod,Russia
St.Peterburg State Marine University,St.Peterburg,Russia
Kurchatov Institute, Moscow ,Russia

The NT200+ Telescope

The deep underwater neutrino telescope **NT200+** started operation in April, 2005. It is the successor of the smaller **NT200**, operating since 1998 in Lake Baikal at a depth of 1100m [1].
Excellent scattering properties of the water allowed to extend the sensitive volume far beyond the NT200 geometry. NT200 data taken from 1998-2003 yielded relevant physics results.
NT200+ is taylored for diffuse cascade searches. Three outer strings are at radial distance of 100m from **NT200**, Fig.1. The enclosed volume of **5Mton** will increase the sensitivity to high energy diffuse neutrinos by ~4 times.

Abstract

We present results on searches for exotic particles (relativistic magnetic monopoles and WIMPs) and for UHE astrophysical neutrinos, obtained with the Baikal neutrino telescope NT200.

We give the status of R&D works for the Baikal-km3-detector.

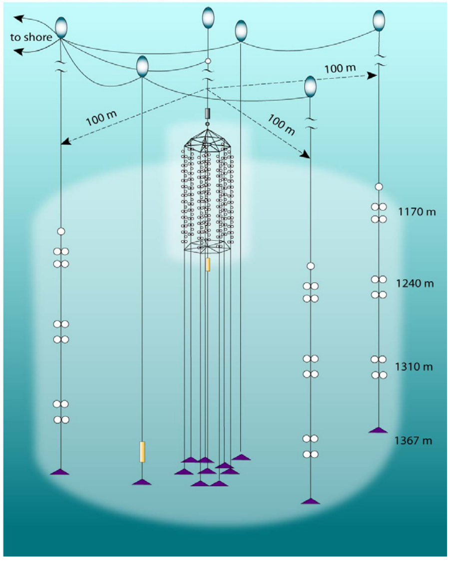


*Fig.1: Baikal Telescope **NT200+** : central NT200 and 3 strings at 100m radius. Instrumented volume: 5 Mton, detection volume at E_{shower}=10PeV: 20 Mton.*

Relativistic Magnetic Monopoles

For a Dirac charge g = 68.5 e, Cerenkov radiation emitted by monopoles is 8300 times that of a muon.
A monopole search is done for bright events (>30 pairs of PMTs hit) with upward moving light patterns ("time-vertical-coordinate correlation"); with an acceptance of 3-6x10^8 cm^2 sr [3]. From non-observation of candidate events, 90%CL upper limits are derived, see Fig.2.

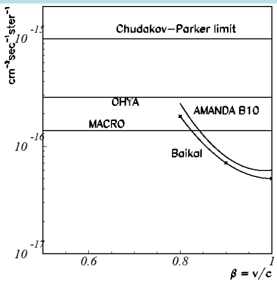


Fig.2: 90%CL Limits on flux of fast magnetic monopoles from BaikalNT200, compared to published results.

A km3 Detector in Lake Baikal

Layout: ~1300-1700PMTs at ~90-100 strings
string: 12-16 PMTs, 300m length

Cascades: V_{eff} ~ 0.5-0.7 km^3 δ(lgE)~0.1 $\delta\theta_{med}$~4°
Muons E_{thr} ~ 10-30 TeV

Milestones:
- TDR in 2008; R&D started in 2006.
- In-situ tests of new components uses running NT200+ telescope.
- Construction start ≥ 2010.

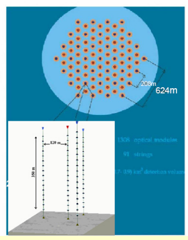


Fig.5: Sketch of the km3-Baikal detector.
The basic detector cell (4-strings, insert) and new technical solutions are studied with the existing NT200+ detector.

UHE Neutrinos

Main focus of neutrino telescopes is the detection of astrophysical neutrinos. In NT200, a search for bright cascades from ν-interactions in a volume much beyond the instrumented volume yields a sensitivity that is comparable to Mton detectors. The experimental signatures are (1) high number of hit PMTs and (2) suitable "upward" time pattern, thus efficiently cutting the high muon-brems background.

From the non-observation of events beyond background expectations, upper limits on an E^{-2} diffuse flux of ultrahigh energy neutrinos are derived, see fig.3. Restrictions on some models for UHE neutrino production are derived (table 1). For details, see [4].

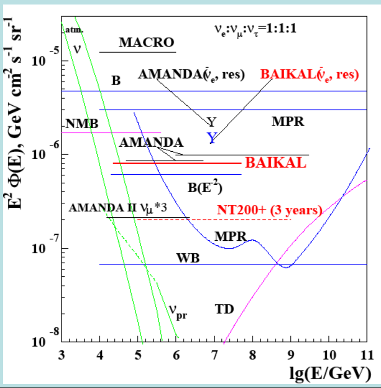


Fig.3: All flavor neutrino flux limits for a E^{-2} spectrum from BAIKAL (and other exp.); and predictions for ν-flux from various source models and atm.BG. See [4].

Model	BAIKAL $n_{90\%}/N_m$	AMANDA $n_{90\%}/N_m$
$10^{-6} \times E^{-2}$	0.81	0.22
SS Quasar	0.25	0.21
SS05 Quasar	2.5	1.6
SP u	0.062	0.054
SP l	0.37	0.28
P $p\gamma$	1.14	1.99
M $pp + p\gamma$	2.86	1.19
MPR	4.0	2.0
SeSi	2.12	-

Table 1: Model rejection factors for models of astrophysical neutrino sources.

R&D for km3 - New Technology String

R&D Milestone for 2008:
Deployment of a km3-prototype string (new electronics, 200MHz FADC).
Common operation with NT200+ : full physics test.

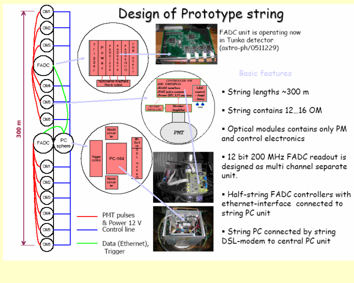


Fig.6: Sketch of the km3-prototype string, to be installed in 2008 with NT200+. Key elements of the new system have been tested in 2006/2007.

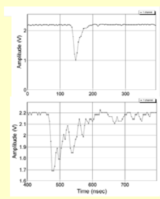


Fig.7: Examples of signals from 13" PMTs; from muons (upper) and bright backward laser pulses (lower), recorded by 200MHz FADC in-situ with NT200+.

WIMPs from Center of Earth

WIMPs annihilating in the center of the Earth will result in an enhanced flux of vertical upward neutrino events. A dedicated search technique, developed for vertical upgoing track patterns, yields a sensitive area of ~1800m^2 (E_μ>10GeV).
Events found for 1038 days of lifetime are compatible with the atmospheric neutrino flux. Resulting flux limits are shown in fig.4.

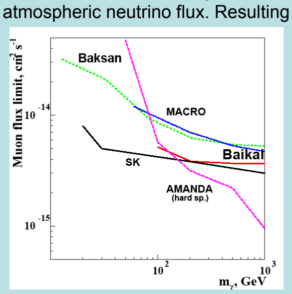
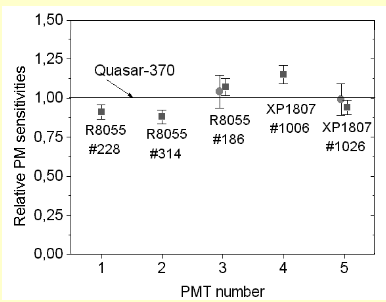


Fig.4: Limits on flux of upward muons from WIMP annihilation in the center of Earth: Baikal NT200, and other experiments (normalized to Eth=1GeV).

R&D for Km3 - PMT Selection

NT200+ uses the 14.6" QUASAR PMT. For km3, various options for large area PMTs are under test: in-situ with the telescope and in laboratory. Emphasis is on large photocathode area, high quantum efficiency and optimal geometry (hemispherical) of PMT and optical module. Classical PMTs (e.g. R8055/Hamamatu and XP1807/Photonis), and also "smart" Quasar-like PMTs are considered.



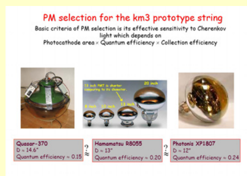


Fig.8: Relative PMT sensitivities for R8055 (13") and XP1807 (12"), normalized to a Baikal Quasar PMT (laboratory and in-situ; prelim.).

References:
[1] V.Aynutdinov et al., NIM A567 (20006) 433; [2] V.Baklanov et al, Astropart.Phys. 12 (1999) 75; [3] K.Antipin et al., Proc.Worksh.Exotic.Phys.,astroph/0701333 [4] V.Aynutdinov et al., Astropart.Phys. 25 (2006) 140