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Status and new results from the BAIKAL detector

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Abstract. We review the present status of the Baikal Neutrino Experiment. On April 9th, 2005, the 10 Mton scale detector NT200+ was put into operation in Lake Baikal. We describe the configuration and physics potential of this detector. Selected results obtained during 1998-2002 with the neutrino telescope NT200 are presented.

1. Detector NT200+

The Baikal Neutrino Telescope NT200 takes data since April 1998. Description of site properties, detector configuration and performance have been described elsewhere [1, 2].

On April 9th, 2005, the 10-Mton scale detector NT200+ was put into operation in Lake Baikal [3]. A schematic view of NT200+ is shown in Figure 1. The detector comprises NT200, as well as three additional 140 m long external strings. Each external string is placed 100 m from the center of NT200 and holds 12 pairwise arranged Optical Modules (OMs). On each external string, an independent *string trigger* is formed in case the number of fired channels is ≥2 within 1000 ns. *String triggers* are sent to the underwater DAQ center, where the time difference between *string trigger* and the NT200 *trigger* is measured. For time offset synchronization of the external strings with respect to NT200, a laser is used (see Figure 1). The jitter of the time difference between OMs of NT200 and OMs of external strings was found to be less than 3 ns.

With the additional strings, the sensitivity of the Baikal telescope to very high energy neutrinos increases by a factor 4.

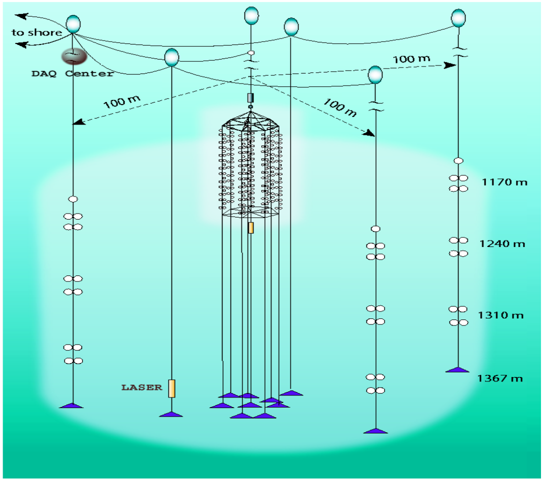

Figure 1. A schematic view of NT200+.

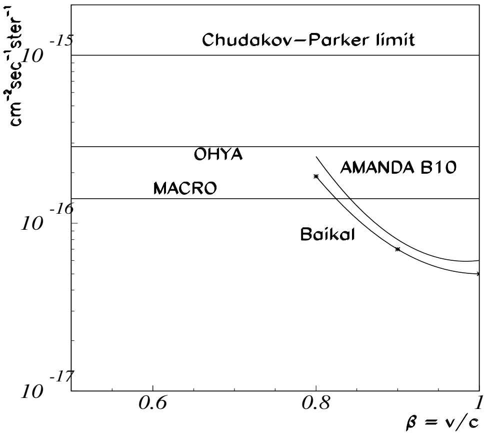

Figure 2. Upper limits on the flux of fast monopoles obtained in this analysis (Baikal) and in other experiments.

2. Selected results obtained with NT200

2.1. Atmospheric neutrinos

The signature of charged current muon neutrino events is a muon crossing the detector from below. Muon track reconstruction algorithms and background rejection have been described elsewhere [4]. Compared to [4] the analysis of the 4-year sample (1038 days live time) was optimized for higher signal passing rate, and accepting a slightly higher contamination of 15-20% fake events [5]. A total of 372 upgoing neutrino candidates were selected. From Monte-Carlo simulation a total of 385 atmospheric neutrino and background events are expected.

2.2. A search for fast magnetic monopoles

Events due to relativistic monopoles ($\beta > 0.75$) are distinguished by their high light output, allowing identification of events beyond the geometrical boundaries of the detector. The search strategy has been described in [6]. An improved analysis [7] including data from 1996 to 2002 yields a limit about a factor of five below the limit published earlier. In Figure 2 this limit is compared to those from other experiments.

2.3. A search for extraterrestrial high energy neutrinos

The BAIKAL survey for high energy neutrinos searches for bright cascades produced at the neutrino interaction vertex in a large volume around the neutrino telescope [2]. From the analysis of data recorded in 1998 - 2002 (1038 live days) no statistically significant excess over the background expectation from atmospheric muons has been observed. Given an E^{-2} behaviour of the neutrino spectrum and a flavor ratio $\nu_e : \nu_\mu : \nu_\tau = 1 : 1 : 1$, the 90% C.L. upper limit obtained with the Baikal neutrino telescope NT-200 (1038 days) is:

$$\Phi_{(\nu_e+\nu_\mu+\nu_\tau)} E^2 < 8.1 \times 10^{-7} \mathrm{cm}^{-2}\mathrm{s}^{-1}\mathrm{sr}^{-1}\mathrm{GeV}. \quad (1)$$

The model independent limit on $\tilde{\nu_e}$ at the W - resonance energy is:

$$\Phi_{\tilde{\nu_e}} \leq 3.3 \times 10^{-20} \mathrm{cm}^{-2}\mathrm{s}^{-1}\mathrm{sr}^{-1}\mathrm{GeV}^{-1}. \quad (2)$$

Figure 3 shows experimental limits on the all-flavor diffuse flux. Also shown are theoretical bounds and model dependent predictions on diffuse neutrino fluxes.

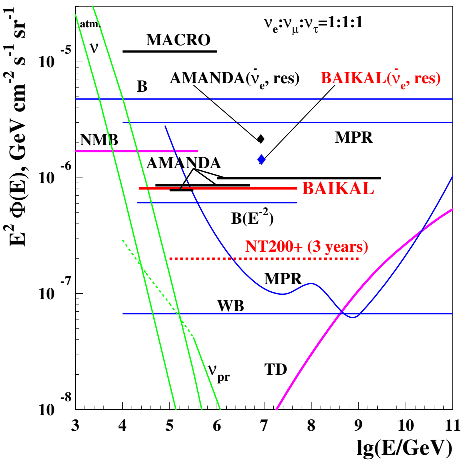

Figure 3. Upper limits on the all-flavor E^{-2} diffuse flux as well as the model independent limits on the resonant $\bar{\nu}_e$ flux (diamond) obtained by Baikal (this work), AMANDA [8, 9] and MACRO [10]. Also shown are theoretical bounds obtained by Berezinsky (model independent (B) [11] and for an E^{-2} shape of the neutrino spectrum (B(E^{-2})) [12], by Waxman and Bahcall (WB) [13], by Mannheim et al.(MPR) [14], predictions for neutrino fluxes from topological defects (TD) [15] and from AGNs according to Nellen et al. (NMB) [16], as well as the atmospheric conventional neutrino fluxes [17] and atmospheric prompt neutrino fluxes (ν_{pr}) obtained by Volkova et al. [18].

3. Conclusion

The Baikal neutrino telescope NT200 is taking data since April 1998. The upper limit obtained for a diffuse ($\nu_e + \nu_\mu + \nu_\tau$) flux with E^{-2} shape is $E^2\Phi = 8.1 \times 10^{-7}$cm^{-2}s^{-1}sr^{-1}GeV. The limits on fast magnetic monopoles and on a $\bar{\nu}_e$ flux at the resonant energy 6.3×10^{6}GeV are presently the most stringent. To extend the search for diffuse extraterrestrial neutrinos with higher sensitivity, NT200 was significantly upgraded to NT200+, a detector with about 5 Mton enclosed volume, which takes data since April 2005. The three-year sensitivity of NT200+ to the all-flavor neutrino flux is approximately 2×10^{-7}cm^{-2}s^{-1}sr^{-1}GeV for $E > 10^2$ TeV (shown in Figure 3). In parallel with exploiting NT200+ we started research & development activities towards a Gigaton Volume Detector in Lake Baikal.

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