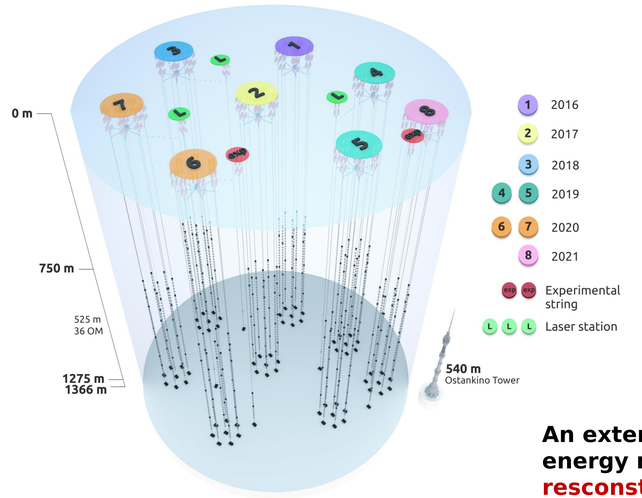
Performance of the muon track reconstruction with the Baikal-GVD neutrino telescope

Grigory Safronov (INR RAS) for Baikal-GVD collaboration



INTRODUCTION

Baikal-GVD neutrino telescope incorporates 8 clusters since April 2021

64 strings, 2304 optical modules (OM)
Effective volume for high-energy cascade detection~0.4km^3

Muon track detection channel provides the best neutrino direction mesurement (sub-degree median resolution)

Low-energy muon reconstruction was developed. A sample of 44 neutrino candidates is selected in data from April-June 2019 (see talk by Dmitry Zaborov)

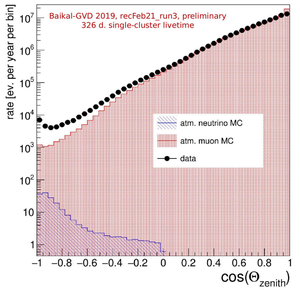
An extension of muon reconstruction towards high-energy muons is discussed in this report, single-cluster resconstruction results are presented

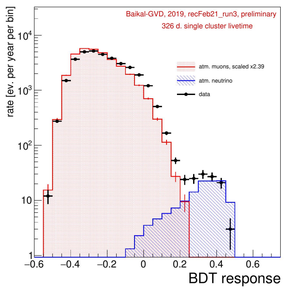
NEUTRINO SELECTION

Low-energy neutrino selection method complimentary to cut-based analysis (talk by Dmitry Zaborov) is developed

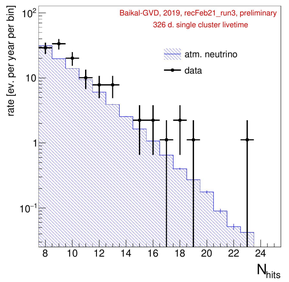
Boosted decision tree (BDT) classifier as implemented in root TMVA framework was used

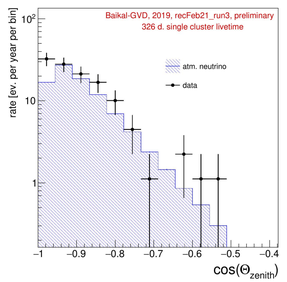
Analysis is performed for events with $\theta_{zenith} > 120°$





Distributions of events with $R_{BDT} > 0.25$:





Set of 15 track quality variables is used at the BDT input, such as: χ^2/ndf, track isolation, p_{hit}, etc.

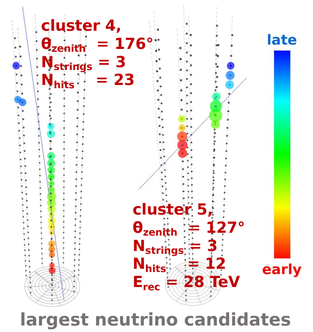
BDT is applied to Monte Carlo (MC) samples of atmospheric neutrinos, 643 days single-cluster livetime of atmospheric muon MC and to 326 days single-cluster livetime data April-June 2019

Atmospheric muon MC is scaled by 2.39 to match the data normalisation in signal region

Cut on BDT response, $R_{BDT} > 0.25$, is applied for neutrino selection, 100% of MC background events are rejected

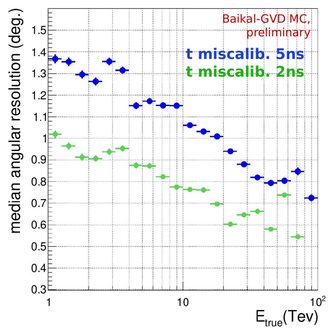
106 neutrino candidates are selected in data, 81.2 expected from atm. neutrino MC

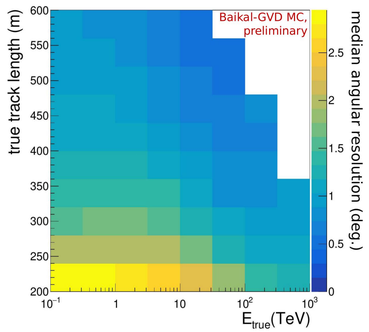
Improvement of neutrino detection efficiency by the factor ~2 is demonstrated with respect to low-energy reconstruction algorithm



largest neutrino candidates

ANGULAR RESOLUTION



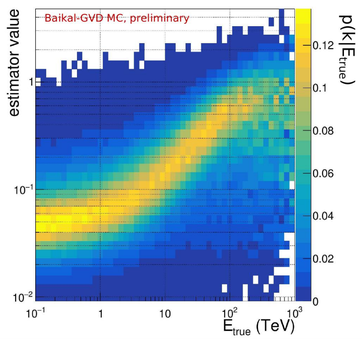


Reconstruction incorporates efficient hit finding algorithm (see poster by Bair Shaybonov and Alexander Avrorin) and χ2(t)-based track fitter

Conservative channel-by-channel miscalibration of 5ns is applied to hit time measurement in MC. 50% degradation of resolution with respect to optimistic scenario

Median angular resolution of 0.5-0.7° for E~100 TeV tracks with L > 300 m

MUON ENERGY MEASUREMENT



Muon energy is estimated using track dE/dX measurement:

$$k = \frac{1}{\epsilon L}\sum_{N_{hits}} q_i, \qquad \epsilon = \sum_{N_{ch}} \frac{e^{-d/\lambda_{att}}\alpha(\Theta)}{d}$$

Where ***k*** is the energy estimator and ϵ is a measure of detector sensitivity to the track

Correlation of ***k*** and muon energy is observed in 1 TeV - ~150 TeV range

Reconstructed muon energy is defined from fit of median of E_{true} in bins of ***k***

Energy measurement uncertainty is defined as ±34.1% E_{true} containment intervals around median value

Factor ~3 uncertainty for ~100 TeV muon energy measurement is achieved