Rapporteur Paper on Muons and Neutrinos Posters

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Abstract. In this paper a short summary of the posters presented in the section of muons and neutrinos of ECRS2012 is presented.

1. Introduction
I have divided the poster presented at this Symposium into four groups, namely: 1) papers on large running experiments, 2) papers on recent or proposed installations, 3) papers on theory and phenomenology, 4) papers on temperature and/or pressure effects. In the following, I will give a short overview on these papers.

2. Large running detectors
These posters discuss the performances and some results of NEVOD-DECOR (running on ground), ANTARES (running underwater), LVD and ASD (running underground).

NEVOD-DECOR (posters 532, 523) is a 2 kton water Cherenkov detector with a streamer tubes tracking system. The collaboration discuss the results of an analysis of the energy spectrum of cascade showers initiated by horizontal muons. Data have been collected from Dec. 2011 to May 2012 (2100 hours lifetime), and 5.3 \times 10^5 single track events and 6309 cascades (E > 7 GeV) were reconstructed.

The technique of single muon track reconstruction is based on computing the maximum likelihood probability of the distribution of hit and no hit PMT (546 PMTs in total). results on zenith and azimuth angular distributions are reported and discussed.

ANTARES (posters 392, 436, 543) is located 40 km off the coast of Toulon (France). Now 12 PMT lines are active (885 PMTs), and 5 PMT lines are taking data from 2007. This poster presents the results of a search for neutrino sources during 813 days of data taking, from 2007 to 2010, 183 days with 5 lines of PMTs, the other days with 12 lines. The muon tracks are reconstructed by using the
maximum likelihood method. The angular resolution is $0.46^\circ \pm 0.1^\circ$. No significant excess of events has been found, and upper limits are reported for sources in the southern emisphere.

WIMPs annihilation in the Sun’s core can produce muon neutrinos in an energy range reachable to a neutrino telescope as Antares. These neutrinos have been searched in Antares, during an effective time of 292, 9 days, and upper limits are reported.

Magnetic monopoles (slowly moving, highly ionizing massive particles) have been searched during 136 days of data taking in 2008 in the velocity range $0.550 < \beta < 0.995$. Nuclearites have been searched during 310 days of data taking in 2007-08. In both cases, no candidates have been found.

**LVD** (poster 593) A detector (1 kton of liquid scintillator and 1 kton of iron) to search for neutrinos from gravitational stellar collapses since 1992. Neutrons from CR m’s are the main source of background in underground experiments. Average muon energy $E_m = 280$ GeV. Results from a simulation of neutron generation, transport and detection are reported. Detection efficiency of $\gamma$’s from n-H and n-Fe captures is computed for $E_n = 10$ and 80 MeV. In 2005 it was proposed to add a NaCl target. During the last two years one module of the experiment (8 counters) is running with a salt shield. Monte-Carlo simulation and comparison with experimental data show that salt increases the neutron detection efficiency and reduces the time constant of n capture by 10 to 20 % depending on the neutron energy.

This Figure shows the active mass (in red) and the duty cycle (in black) as a function of time.

**ADS** (posters 594,607) The current status of the Artemovsk Scintillation Detector, an experiment to search for neutrinos from collapsing stars with the detector “Collapse” is presented. The total observation time from October 1977 to July 2012 is 35 years. ASD has been continuously monitoring the Galaxy since 1977 to search for neutrino bursts from gravitational stellar collapses. On the basis of the data of neutrino telescopes “Collapse”, ASD, during more than 35 years the strongest experimental limit on the rate of neutrino bursts from gravitational collapse of stars in the Galaxy was obtained. It is less than 1 event per 15.2 year at 90% confidence level.

**Horizon-T** (poster 450) is a new installation located in Thien Shan mountains at 3340 m above sea level. It consists of three Vavilov-Cherenkov detectors and 5 muon observing points made by 17 scintillation counters. Simultaneous observations of Cherenkov light and charged particles in horizontal showers give important information on the primary cosmic particles and their interactions at energies above $10^{16}$ eV. A prototype of Horizon-T has been running from 2006 to 2009. Up to May 2012 the scintillation system has recorded more than 3000 event. The full system scintillators plus optics have taken data fo 120 hours.
The first results of this work show that high information on the lateral-time characteristics of the showers is available. EAS events at zenith angles 65-75 degrees have muons preceeding by more than 20 s the Cherenkov light, and they are probably heavy primary nuclei.

MUSTAnG (poster 171) telescope was constructed between 2004 and 2006 at Greifswald University in Germany. It consists of 32 muon detectors arranged in two layers separated vertically of 95 cm, with an intermediate 5 cm thick layer of lead. Each detector consists of a scintillator plate 50 cm x 50 cm x 5 cm.

Mean angles and threshold energies of muons for different upper/lower layer detector combinations were computed using GEANT 4. It was found that Mustang detects muon flux above the energy threshold of 0.262 to 0.6 GeV, depending on the zenith angle. The corresponding energy range for primary cosmic rays is from 55.6 to 110.6 GeV.

Poster 660. Cosmic ray muons stopped in 5 cm thick plastic scintillators at surface and at depth of 25 mwe are studied. Apart from the stopped muon rate the authors have measured the spectrum of muon decay electrons and the degree of polarization of stopped muons. Preliminary results yield values lower than the currently accepted value, while the significant asymmetry between the number of decay electrons registered in the upper and lower hemispheres suggest significant polarization of CR muons. The results are: 

\[ N_{\text{Ground}}(m_{\text{stop}}) = 6 \times 10^{-2} \text{ m}^{-2} \text{ s}^{-1} \]
\[ N_{\text{Underground}}(m_{\text{stop}}) = 1.52 \times 10^{-3} \text{ m}^{-2} \text{ s}^{-1} \]

Gamma 400 (poster 399) Comparison of the results of neutron detection efficiency for two models. One with a layer of polyethylene as moderator, a boron target for (n,\(\alpha\)) reaction and a silicon detector of \(\alpha\) particles. The other made of polyethylene layers alternated with plastic scintillator with boron. The results show a higher efficiency in the second case.

Poster 522. A new concept of an EAS detector for UHE neutrinos is presented. A station has been installed at Jungfraujoch to test upward/downward particle separation, and experimental tests were performed in Karlsruhe and Fermilab to study electron-muon separation, time of flight resolution and acceptance.

Poster 366. Studies on radio detection of high energy cosmic rays and neutrinos have been getting momentum since the last several years, due to increasing interest in the investigation of radio emission associated with giant air showers. Most of these works are being confined to frequency > 10 MHz; the region of frequencies < 10 MHz are getting much less attention.
In this paper radio emission for frequencies $< 10 \text{ MHz}$ is presented for showers initiated by high energy neutrinos in salt on the basis of transition radiation mechanism. Conclusions: simultaneous investigation of radio emission from neutrino induced showers in salt in low and high frequencies bands will give concrete information on neutrinos coming from cosmic ray sources.

**Poster 551.** A multidirectional high energy muon telescope, with a sensitive area of $28 \text{ m}^2$ is operational at the Southern Space Observatory in Sao Martinho da Serra, RS, Brazil. This detector is part of a Global Muon Detector Network with the aim to study and forecast Space Weather. Two similar detectors are installed in Nagoya ($36 \text{ m}^2$) and Hobart ($16 \text{ m}^2$). The purpose of this paper is to present a suggestion for a new counting, correlation and recording system for a multi directional muon detector based on an embedded system. A preliminary counting and recording system has been implemented that will allow a long term data recording.

**Poster 547.** This work is a summary of a new direction in astroparticle physics by introducing a second charge in the unified theory of electroweak interactions. Neutrinos and neutrons are the new charge carriers. After spontaneous breaking of gauge symmetry there is a splitting of the two charges, and the n charge becomes much smaller than the e one ($10^{-8}$ – $10^{-9}$). With this constraint, the neutrino magnetic moment will be ($10^{-2}$ – $10^{-3}$) Bohr magneton, i.e. order of magnitudes above the neutrino anomalous magnetic moment. This fact would be of crucial importance for the solar activity, in particular the existence of a new active solar convective zone. In this framework, the author calculated the spectral energy distribution from the Sun, and the effect on the scintillation detectors used for dark matter searches. The signal induced by the conversion into X rays in the energy range ($2 - 6$) KeV would provide an amplitude variation in the counting rate, close to the variation observed by DAMA, but with opposite phase. Also the effect on a gravitational stellar collapses has been evaluated. Because of neutrino emission, an instability develops that would result in a pulsation of the collapsing core.

**Poster 023.** It was shown experimentally [1] that the solar neutrino flux has a complex structure. There were also found "neutrino bursts" - time-limited neutrino fluxes of high-intensity. Impulsive energy release near the center of the sun causes the appearance of a turbulent vortex ring (TVR) [2]. It consists of rotating particles having a charge, so converts a significant part of the kinetic energy of particles in the magnetic field energy. A torus with non-uniform magnetic field is forming. Inside coils of the torus the magnetic field is maximum, and zero outside. Sun neutrinogramm for 500 days measured by Super-Kamiokande detector [3] shows very large deviations from the center of the Sun. This is probably blurred interference pattern, which indirectly confirms our research.

**Poster 329.** The temperature effect of cosmic ray muons was widely under consideration in 50-ties of the previous century. A big number of old and new works (experimental and theoretical) were published. Today many numbers of modern installations continue to study the effect. In this paper temperature coefficients of integral cosmic ray muon fluxes are calculated for muon energies from $10^2$ GeV up to $3 \times 10^6$ GeV in according to data received by today on accelerators for pions, kaons and charmed particles production in nucleon-air nucleus interactions and in frames of charmed particles production in QCD models. It is to note that uncertainties in charm production cross-sections at high energies are very big. The results of calculations of temperature coefficients for integral fluxes of cosmic ray muons, produced in the atmosphere in decays of pions, kaons and charmed particles, coming to the sea level in the vertical and horizontal directions with energies $10^2$, $10^4$ and $3 \times 10^6$ GeV, are shown in figure 1 and figure 2. The calculations are given for maximum and minimum values of cross-sections for charmed particle production in nucleon-air nucleus interactions.
Poster 505. Correction of muon flux at Earth surface for temperature effect with the help of two simple method is considered. In the first method, it is assumed that major part of muons are generated at some effective generation level, whose altitude depends on temperature profile of the atmosphere. In the second method, dependence of muon flux on mass averaged atmosphere temperature is considered. Methods were tested with the data of muon hodoscope URAGAN in Moscow. The difference between data corrected with the help of differential in altitude temperature coefficients and simplified methods does not exceed $1 - 1.5\%$, so the latter ones may be used for fast preliminary correction.

Poster 552. The negative atmospheric temperature effect observed on the muon intensity measured by surface-level detectors is related to the atmospheric expansion during summer periods. According the first explanation given, the path of muons from the higher atmospheric level (where they are generated) to the ground becomes longer, and more muons decay, leading to a muon intensity decrease. A significant negative correlation, therefore, is expected between the altitude of the equi-pressure surface and the muon intensity. We compared measurements of the altitude of 100 hPa equi-pressure surface and data from the multidirectional muon detector installed at the Brazilian Southern Space Observatory in Sao Martinho da Serra, RS. Significant correlation coefficient were found (up to $0.95$) when using data observed in 2008. For comparison, data from the multidirectional muon detector of Nagoya, located in the opposite hemisphere, is studied and an anti-phase in the cosmic ray variation related with the temperature effect is expected between data from detectors of Nagoya and Sao Martinho da Serra. The temperature influence is higher for the directional channels of Nagoya than for ones of Sao Martinho da Serra.
Poster 471. Results of simulation of spectra of CR on the Earth surface are presented. A standard atmospheric model and non standard ones (T and P profile changed at sea level) were used. T and P coefficients were estimated. Spectra were obtained in the energy range 0.1 to 100 GeV, for zenith angles 0 to 60 degrees and for altitude from sea level to 1500 m above sea level.