COMMENTS to the Internal Report[1] *201107001*: V. Baum, L. Keopke and G. Kroll, *A study of SN alarms in IC40, IC59 and IC79 - the role of atmospheric muons*

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Key statements of report[1] are: Increasing number of DOMs with every new IceCube configuration along with the atmospheric muon flux are responsible for increase of the width (RMS) of significance distribution.

Below, we show **inconsistency of the key statements**.

Logical approach: If amount of DOMs is infinite, the first statement above requires infinitely large width of significance distribution, so obviously something is wrong.

1. The obtained width (standard deviation, RMS) 1.3-1.5 of significance distribution is not due to non-Poisson behaviour of the DOM noise rate. The significance distribution according to definition[2] ($\xi=\Delta\mu/\sigma_\Delta$) and statistical theory has to be *t*-distribution[3] (or quasi normal) with zero average and unit standard deviation regardless of noise rate distributions for DOM number N_{DOM} >>1. Moreover, the significance distribution, according to definition, slightly depends on a number of active DOMs[3] (or IceCube configuration). It is well seen in our simulation results presented below (Fig.1).

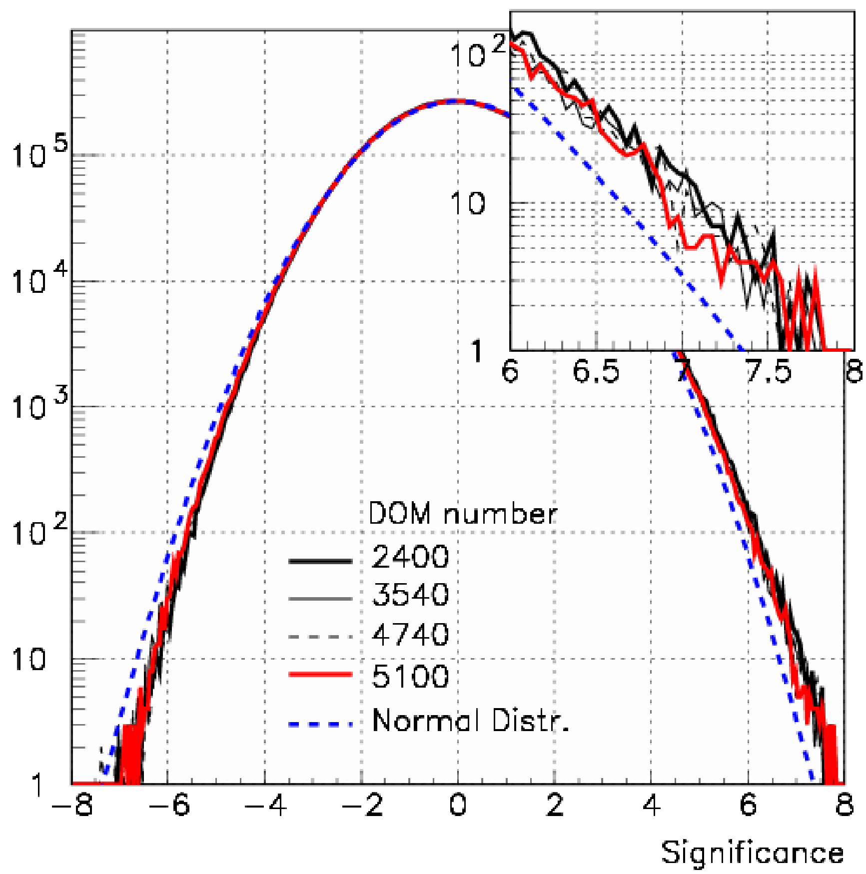

Figure 1. Simulation of Non-Poisson noise rate for 4 configurations of IceCube with different number of DOMs. The RMS of DOM noise rate[2] was equal to σ_i/ε_i =30 Hz for $i=1,...,N_{DOM}$. It is seen, that width of significance distribution does not increase with increasing number of DOMs. Instead, distributions get closer and closer to the normal distribution with zero average and 1.46 RMS (blue dashed line). In the range of statistical errors the standard deviations for all presented distributions are the same.

Significance distributions for different DOM numbers in Fig.1 were obtained using simulations of DOM noise rate according to IC40 data taken from[2] and presented in Fig.2 (line).

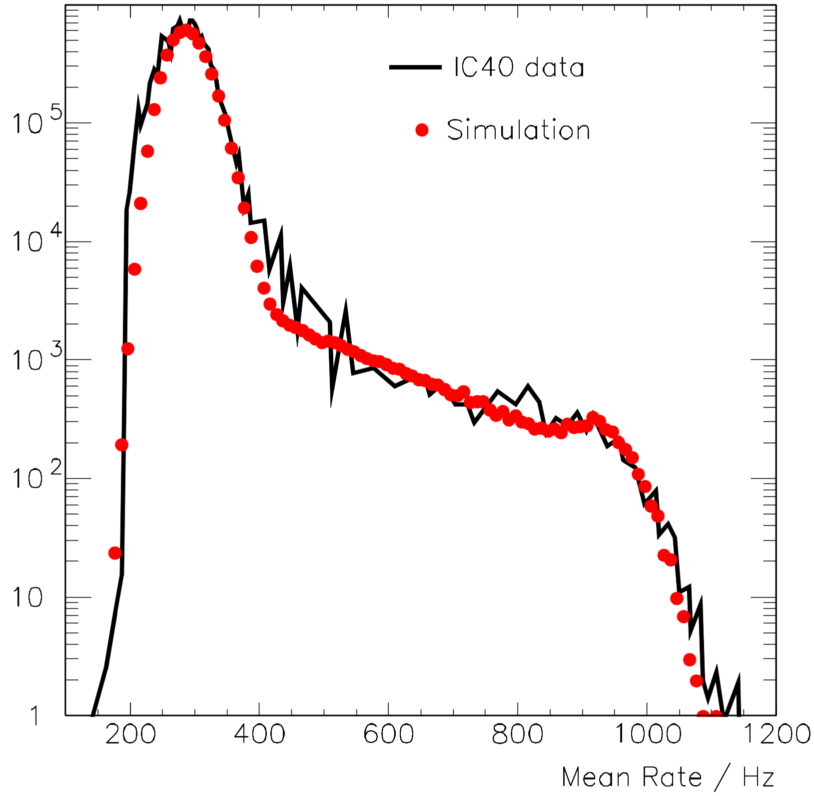

Figure 2. Experimental IC40[2] (line) and simulated DOM noise rate (red symbols) distribution. Average and RMS values for simulated noise rate are 290 Hz and 44.54 Hz respectively.

It is well seen that obtained RMS of noise rate strongly differs from the accepted RMS of IceCube which is 20-30 Hz. **This is the main reason for broadening** (~1.5 times) of significance distribution but not the non-Poisson form of noise rate as it is mentioned in[1]. If RMS of DOM noise rate is equal to the actual value (~44.5 Hz), taking into account the right shoulder (tail) of distribution, the width of significance distribution will be equal to 1. This statement was checked out by our simulation model (Fig.4 below).

From our results presented in Fig.1 it stems that width of **significance distribution does not depend on number of DOMs**. This result **strongly contradicts** data from report[1]. We infer that broadening has another cause. For instance, high energy solar neutrino flux increases due to increasing Solar activity[6]. The right shoulder of noise rate distribution can be accounted for by these solar neutrinos (average neutrino energy ~1 GeV). Increasing rate of Solar neutrino should increase the height of right shoulder in Fig.2 and in turn, increase the RMS of noise rate that will result in increase in the width of significance distribution. This statement can be easily checked by the Mainz group by investigating the time dependence of the noise rate distributions.

2. Interpretation of increasing trigger rate (~200-500%) by the seasonal variation of atmospheric muon flux (~10%) is really surprising.

We know from[2] that the DOM noise rate is actually sensitive to the variation of muon flux and the measured magnitude of this variation is less than 1%, whereas muon flux variation at South pole is about 10%. We know the sensitivity of string noise rate to the variation of muon flux from[2]. The string seasonal noise rate variation is also about 1%.

As was mentioned above (Section **1**), the width of significance distributions is equal to 1, only if standard deviation of DOM noise rate distribution (σ_i [2]) is computed correctly taking into account the right shoulder of distribution. However, the width of significance distribution in the report[1] (Fig.1, right upper panel in the page 3 of report[1]) reaches the plateau value about **1.05** after correction for muon hits. It means that muon extraction procedure used in the report[1] should have significantly decreased the fraction of the right shoulder of DOM noise distribution (Fig.2) making the resultant distribution practically Gaussian. The results of testing of this conjecture is presented in Fig.3.

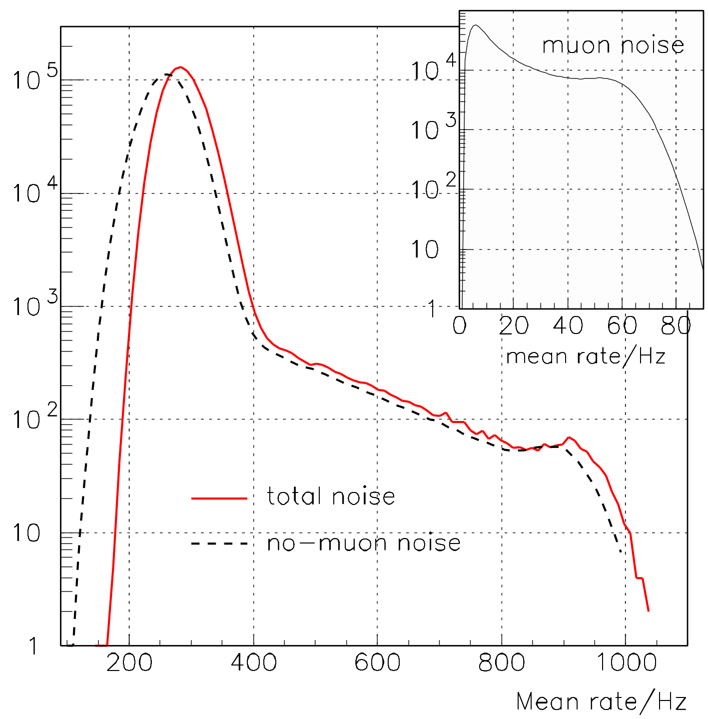

Figure.3 Simulated DOM total noise rate distribution (red solid line) and DOM noise rate distribution without muon contribution (dashed line). Inset graph is a DOM noise rate distribution due to only atmospheric muons.

We simulated the contribution of muons to the DOM noise rate distribution using CORSIKA EAS simulation code, approximations of balloon and satellite data for primary energy spectra[5] with energies E_0>1 TeV, IceCube geometry and GEANT simulations for muon detection in IceCube[4]. The depth dependence of muon hits was also taken into account. The total DOM noise rate was simulated according to IceCube data presented in Fig.2.

The results are shown in Fig.3, where no-muon noise data (dashed line) were obtained extracting the muon hits from the total noise rate. As it is well seen from the Fig.3 above, DOM noise rate distribution moved slightly left according to muon contribution (~20 Hz) without any significant change of fraction of non-Poison right shoulder. This result **strongly contradicts** data from report[1] and points out on the stability of width of significance distribution regardless of muon contribution.

In Fig.4 the simulated significance distributions for 85 string configuration of IceCube are presented. The solid black line corresponds to significance distribution from total DOM noise rate shown in Fig.2 with average $<r_i>$=290.8 Hz and standard deviation σ_i=44.5 Hz. The black dashed line represents the significance distribution for no-muon condition, where all muon hits were excluded. Corresponding average DOM noise rate and standard deviation were equal to $<r_{i,\mu=0}>$=271.1 Hz and $\sigma_{i,\mu=0}$ =47.4 Hz. For both distributions (black lines) in Fig.4 the average and standard deviation are equal to 0 and σ_S=1.0 respectively as it should be according to statistical theory[3]. The red lines in fig.4 represent the ICECUBE SN trigger imitation, where RMS of DOM noise rate is artificially picked up in the region of ~30 Hz. Interesting to note, that width of distribution is larger for no-muon condition. As was mentioned above these results **strongly contradicts** data from report[1] showing opposite behaviour for significance distribution with extracted muon hits.

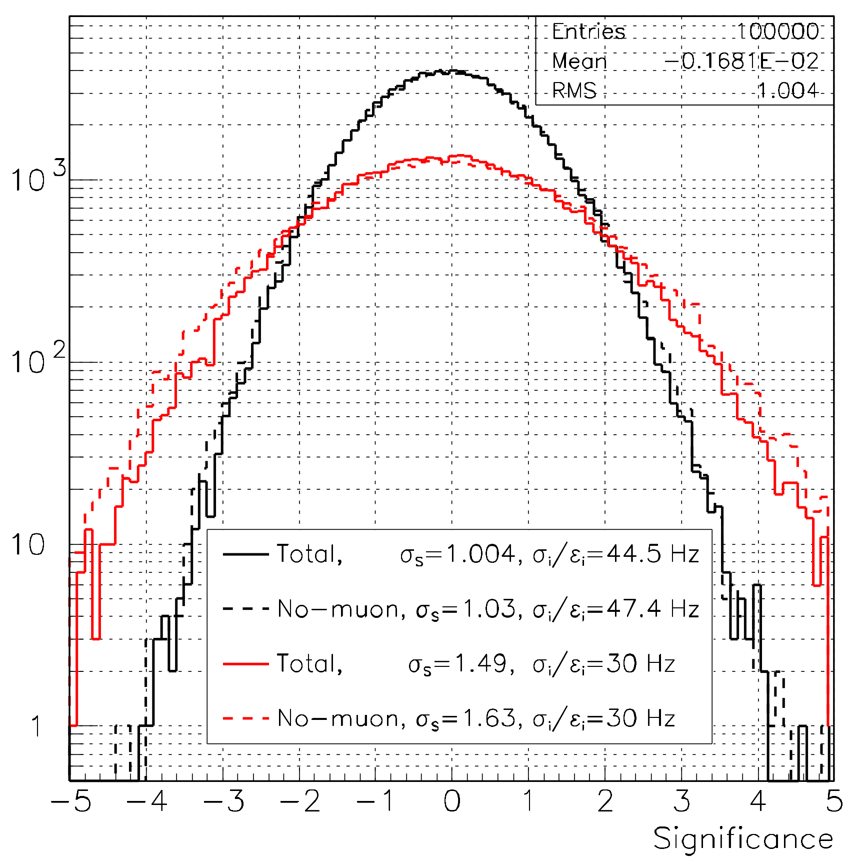

Figure.4 Significance distributions for total (solid lines) and no-muon (dashed lines) noises. The σ_s is the standard deviation for corresponding significance distributions and σ_i/ε_i is the RMS of DOM noise rate distributions [2]. The value of ~30 Hz (red lines) for RMS is used in ICECUBE and ignores the right shoulder of DOM noise rate distribution.

CONCLUSION

The results presented in the report[1] did not account for detected gain of SN trigger rate presented in Fig.5 (lower panel) below.

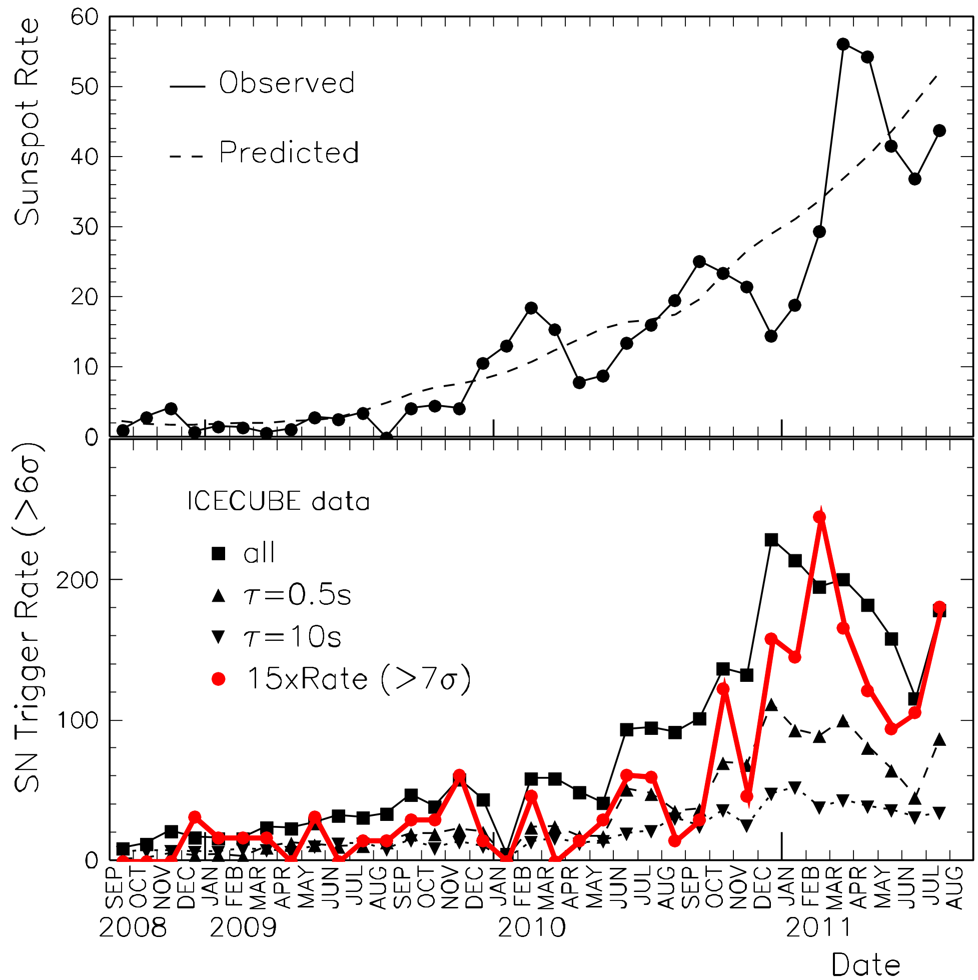

Figure 5. Last update (August 1 2011) of Solar sunspot number versus time (upper panel) and SN trigger rate at different signal time gates and significance thresholds.

The best interpretation of the obtained IceCube SN trigger rate gain remains a hypothesis of existence of the high energy neutrino flux from the Sun[6] correlating with current Solar activity, even though the model of Solar high energy (~1 GeV) neutrino production is still unknown.

REFERENCES

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