Neutrino Solar Flare detection for a saving alert system of satellites and astronauts

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Abstract: Largest Solar Neutrino Flare may be soon detectable by Deep Core neutrino detector immediately and comunicate to satellites or astronauts. Its detection is the fastest manifestation of a later (tens minutes,hours) dangerous cosmic shower. The precursor trigger maybe saving satellites and even long flight astronauts lives. We shall suggest how. Moreover their detection may probe the inner solar flare acceleration place as well as the neutrino flavor mixing in a new different parameter windows. We show the updated expected rate and signature of neutrinos and antineutrinos in largest solar flare for present tens Megaton Deep Core telescope at tens Gev range. Speculation for additional Icecube gigaton array signals are also considered.

Keywords:

1 Deep Core and Solar neutrino Flare

During largest solar flare, of a few minutes duration, the particle flux escaping the corona eruption and hitting later on the Earth, is 3-4 order of magnitude above the common atmospheric CR background . If the flare particle interactions on the Sun corona is taking place as efficiently as in terrestrial atmosphere, than their secondaries by charged pions and muons decays, are leading to a neutrinos fluency on Earth comparable to one day terrestrial atmospheric neutrino activity (upper Bound). One therefore may expect a prompt increase of neutrino signals of the order of one day integral events made by atmospheric neutrinos [1]. In present neutrino detectors the signal is just on the edge, but as long as the authors know, it has been never revealed [2],[5]. Sun density at the flare corona might be diluted and pion production maybe consequently suppressed (by a factor (0.1-0.05)) respect to terrestrial atmosphere, leading to a signal at few percent the expected one under the above considerations. This may be the reason for the SK null detection. Indeed the low Gamma signals recently reported [3] confirm this suppressed signal, but just at the detection edge (See Fig.1,2). Unfortunately the neutrino signal at hundred MeV energies is rare while the one at ten MeV or below is polluted by Solar Hep neutrinos. The expected signal is dominated by $10-30$ MeV neutrinos, that might be greatly improved by anti-neutrino component via Gadolinium presence in next SK detectors [2]. Our earliest (2006) upper limit estimate for October - November 2003 solar flares [1] and the recent January $20th$ 2005 [2] exceptional flare were leading to signal near unity for Super-Kamiokande and to a few events above unity for few Megaton detectors (See Fig.1,2). Indeed large size neutrino detectors ($5-10$ Megaton) at ten GeV (Deep Core) are just recording data; ten GeV is a little high energy but hard solar flare have been observed up to tens GeV gamma. Moreover even GeV (PINGU) detectors, may soon be born. Our recent estimate based on a lower (gamma) bound of neutrino signal, while below the upper ones, still confirms the order of magnitude and the near edge discovery (See Fig.1,2). The recent peculiar solar flares as the October-November 2003 and January 2005 [3] were source of high energetic charged particles: large fraction of these *primary* particles, became a source of both neutrons [2] and *secondary* kaons, $K^{\pm}$, pions, $\pi^{\pm}$ by their particle-particle spallation on the Sun surface [1]. Consequently, $\mu^{\pm}$, final secondaries muonic and electronic neutrinos and anti-neutrinos, ν_{μ}, $\bar{\nu}_{\mu}$, ν_e, $\bar{\nu}_e$, γ rays, are released by the chain reactions $\pi^{\pm} \rightarrow \mu^{\pm}+\nu_{\mu}(\bar{\nu}_{\mu})$, $\pi^0 \rightarrow 2\gamma$, $\mu^{\pm} \rightarrow e^{\pm}+\nu_e(\bar{\nu}_e)+\nu_{\mu}(\bar{\nu}_{\mu})$ occurring on the sun atmosphere. There are two different sites for these decays (see [1]): A brief and sharp solar flare, originated within the $solar$ corona itself and a diluted and delayed $terrestrial$ neutrino flux, produced by late flare particles hitting the Earth's atmosphere. This latter delayed signal is of poor physical interest, like an inverse missing signal during the E. Forbush phase. The main and first *solar* flare neutrinos reach the Earth with a well defined directionality and within a narrow time range. The corresponding average energies $< E_{\nu_e} >$, $< E_{\nu_{\mu}} >$ (since low solar corona densities) suffer negligible energy loss: $< E_{\nu_e} > \simeq 50MeV$, $< E_{\nu_{\mu}} > \simeq 100 \div$ 200 MeV. The opposite occur to downward flare. In the simplest approach, the main source of pion production is

$p + p \to \Delta^{++}n \to p\pi^{+}n$; $p + p \to \Delta^{+}p \begin{smallmatrix}\nearrow p+p+\pi^0 \\ \searrow p+n+\pi^+\end{smallmatrix}$ at the center of mass of the resonance Δ (whose mass value is $m_{\Delta} = 1232$ MeV). As a first approximation and as a useful simplification after the needed boost of the secondaries energies one may assume that the total pion π^{+} energy is equally distributed, in average, in all its final remnants: ($\bar{\nu}_{\mu}$, e^{+}, ν_e, ν_{μ}):$E_{\nu_{\mu}} \geq E_{\bar{\nu}_{\mu}} \simeq E_{\nu_e} \simeq \frac{1}{4}E_{\pi^{+}}$. Similar nuclear reactions (at lower probability) may also occur by proton-alfa scattering leading to: $p + n \to \Delta^{+}n \to n\pi^{+}n$; $p + n \to \Delta^{o}p \begin{smallmatrix}\nearrow p+p+\pi^- \\ \searrow p+n+\pi^o\end{smallmatrix}$. Here we neglect the π^{-} additional role due to the flavor mixing and the dominance of previous reactions π^{+}. To a first approximation the flavor oscillation will lead to a decrease in the muon component and it will make the electron neutrino component a bit harder. Indeed the oscillation length (at the energy considered) is small with respect to the Earth-Sun distance: $L_{\nu_{\mu}-\nu_{\tau}} = 2.48 \cdot 10^{9}\, cm \left(\frac{E_{\nu}}{10^{9}\, eV}\right)\left(\frac{\Delta m_{ij}^{2}}{(10^{-2}\, eV)^{2}}\right)^{-1} \ll D_{\oplus\odot} = 1.5 \cdot 10^{13} cm.$ While at the birth place the neutrino fluxes by positive charged pions π^{+} are Φ_{ν_e}:$\Phi_{\nu_{\mu}}$:$\Phi_{\nu_{\tau}} = 1 : 1 : 0$, after the mixing assuming a democratic number redistribution we expect Φ_{ν_e}:$\Phi_{\nu_{\mu}}$:$\Phi_{\nu_{\tau}} = (\frac{2}{3}) : (\frac{2}{3}) : (\frac{2}{3})$. Naturally in a more detailed balance the role of the most subtle and hidden parameter (the very recent, possibly detected, neutrino mixing Θ_{13} [6]) may be deforming the present averaged flavor balance. On the other side for the anti-neutrino fluxes we expect at the birth place: $\Phi_{\bar{\nu}_e}$:$\Phi_{\bar{\nu}_{\mu}}$:$\Phi_{\bar{\nu}_{\tau}} = 0 : 1 : 0$ while at their arrival (within a similar democratic redistribution): $\Phi_{\bar{\nu}_e}$:$\Phi_{\bar{\nu}_{\mu}}$:$\Phi_{\bar{\nu}_{\tau}} = (\frac{1}{3}) : (\frac{1}{3}) : (\frac{1}{3})$. This neutrino flux, derived by gamma one, hold 100 s duration and it is larger by two order of magnitude over the atmospheric one.

2 Solar Flare in Deep Core

Therefore in present paper we conclude that, even if SK just marginally missed the Solar neutrino flares (See Fig.1,2), Hyper Kamiokande, HK, or Megaton, Titand [4] or at best Deep Core [5], and future PINGU detectors should discover solar neutrino signals quite above threshold edge (See Fig.3), [5]. Finally full km^3 ICECUBE, being detecting at highest 50 GeV may or may-not reveal tens GeV neutrinos (as observed gamma found in Milagro ones) just at edge (See Fig.).Solar Neutrino ν_e, ν_{μ} Flare After their mixing in two different upper bounds considered in early papers [1],[2],[5],derived by Solar flare energy equipartition in two solar corona density target. Antineutrino exhibit comparable fluxes over a noise-free solar antineutrino background [2]. Here the signal is derived, by pions connection and gamma detection of Solar flare on 20 January 2005,[3] in SK. While upper bounds appears well within SK detection, the observed lower gamma bound quite below, is just (marginally) out of the SK detection thresholds. This is consistent and it explains the solar flare neutrino absence (SK private communication). The solar flare duration and power (here and in next figures), from where we derived the expected neutrino signals are assumed about 100 s long as powerful as the observed 20 Jan. 2005 event. The vertical arrows among the arcs describes our estimated solar flare neutrino flux windows. The vertical dotted lines are related to SK and Deep Core or PINGU cut-threshold via neutrino-nucleon CC, whose cross-section are quite variables with energy. The solar neutrino noise rules lowest energies, but not above tens MeV energy band. Icecube as a gigaton at hundred GeV maybe not ideal. In figures above, the dashed line , along ν_{μ} , shows the muon neutrino thresholds,(near GeV), just out SK detection but within Deep Core and PINGU ranges. The different dotted lines split on from electrons, taus and the most inclined ones for muons because cross section energy dependance. In conclusion a Deep Core alarm system for satellites and astronauts maybe the fastest and most useful ones. Astronauts on the longest flight and largest spacestation may find a partial screening by hiding each other in largest volume water reserve containing (one or few tons of water) in full immersion, just a few hour after the solar neutrino flare.

References

[1] D.Fargion,JHEP06,(2004),045;
D.Fargion,F.Moscato,
Chin.J.Astron.Astrophys.3(2003)S75-S76.

[2] D.Fargion,Phys.Scripta,T127,(2006),22-24

[3] Grechnev V.V. et al.,arXiv:0806.4424, Solar Physics,Vol.1,October,(2008),252

[4] Matthew D. Kistler et al. 0810.1959v1

[5] D.Fargion,Nuclear Physics B (Proc. Suppl.) 188 (2009) 142145

[6] K2K Collaboration, K. Abe et al.(15 June 2011) $www.t2k.org/docs/pub/003/t2k-nue1st.pdf$

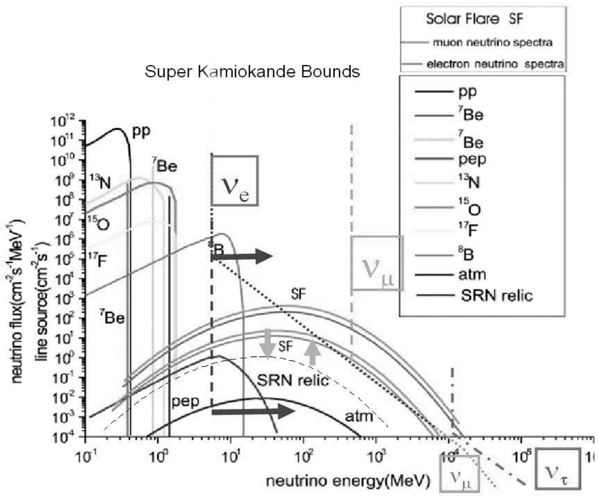

Figure 1: Solar Neutrino ν_e, ν_μ flare versus noises. Note the expected windows by up-down arrows.

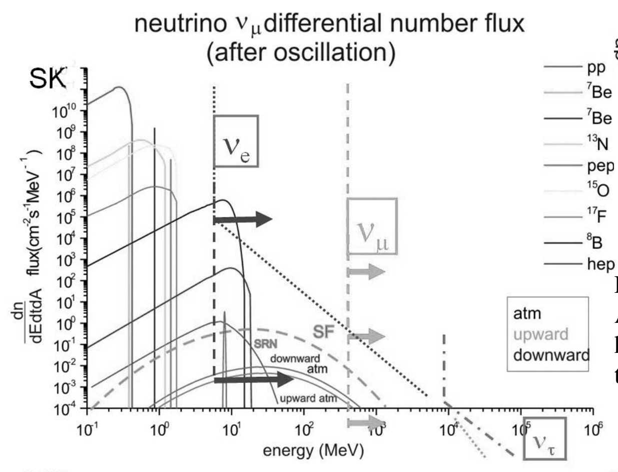

Figure 2: As above in SK, by γ flux calibration impling a Solar ν_e, ν_μ neutrino flare as small as 5% of the corresponding cosmic solar flare, because a much diluted solar atmosphere.

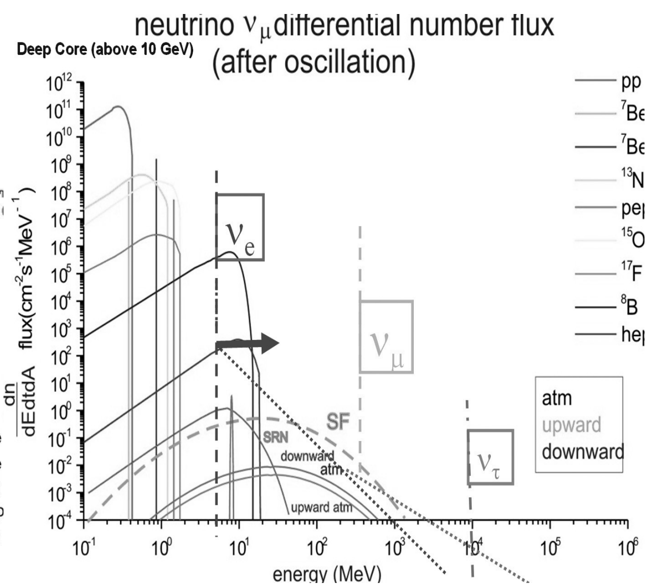

Figure 3: As above, for Deep Core detecotor above 10 GeV. As shown the ν_μ signal is nearly revealed at the GeV edge; however future PINGU enhanced detector might reach the threshold of GeV neutrino discover from solar flare