Search for Supernova Neutrino Bursts at LVD

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on behalf of the LVD Collaboration

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The Detector Performances

- 1000 tons liquid scintillator neutrino observatory in operation at INFN Gran Sasso Laboratories since 1992
- 840 counters are arranged in a compact and modular geometry
- Mean Energy Threshold: $E_{\text{th}} \sim 4$ MeV

Sensitive to Neutrino Burst from a Gravitational Stellar Collapse (GSC) in the Milky Way (D$\leq$25 Kpc) with minimum trigger mass of M$\geq$300 tons

The Trigger Stability

Quality cuts and the energy threshold E$\geq$10 MeV considered for this analysis provide trigger stability over the whole monitored period.

Distribution of delays between filtered triggers over 20 years has been normalized to the average frequency (0.03 Hz) / In agreement with Poisson statistics.

The LVD Experiment

- Data set: all recorded triggers in the 10-100 MeV energy range after a-like event rejection and quality cuts.
- The cluster definition: each possible sequence of $n \geq 2$ events within 100 ms $\Delta t \leq 100$ s time window/ $\Delta t$ is determined by the first and last event of the cluster.

The cluster imitation frequency:

$$F_{\text{im}} = f_{\text{im}} \cdot \Delta t \cdot \sum P(k, f_{\text{im}} \cdot \Delta t)$$

P is the Poisson probability to have a cluster of multiplicity $k$ being (m, $\Delta t$) the mean value and $\Delta t_{\text{max}} = 100$ s.

Statistical selection of clusters: the background is under control and it is possible to select clusters below a given imitation frequency $F_{\text{im}}$ ($<1$/day, $<1$/week, $<1$/month).

The search for supernova $\nu$ bursts

The $\nu$ burst candidate: cluster with $F_{\text{im}} = \sqrt{100}$ year$^{-1}$

If there is a positive detection on statistical basis a second level analysis is applied to the selected cluster: event topology, energy and time distribution of pulses are checked.

Results

<table>
<thead>
<tr>
<th>Total Livetime</th>
<th>N. of Cluster</th>
</tr>
</thead>
<tbody>
<tr>
<td>7335 days</td>
<td>26914419</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>$F_{\text{im}}$</th>
<th>&lt;1 Day$^{-1}$</th>
<th>&lt;1 Week$^{-1}$</th>
<th>&lt;1 Month$^{-1}$</th>
<th>&lt;1 Year$^{-1}$</th>
<th>$&lt;0.01$ Year$^{-1}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clusters</td>
<td>1123</td>
<td>165</td>
<td>45</td>
<td>4</td>
<td>0</td>
</tr>
</tbody>
</table>

4 candidates @ $F_{\text{im}} < 1$ year$^{-1}$ have been individually checked: they are compatible with background fluctuation.

No evidence for a neutrino burst from a gravitational stellar collapse over the whole monitored period.

Conclusions

LVD continuously monitors the whole Galaxy

No evidence of $\nu$-burst detection on 7335 days

Upper limit to GSC event $0.11$ year$^{-1}$ (90% c.l.)

The Detector Performances

The Trigger Stability

The LVD Experiment

Expected $\nu$ signal in LVD

GSC @ 10 Kpc

<table>
<thead>
<tr>
<th>Neutrino interaction</th>
<th>Expected events</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\nu_e + p \rightarrow e^+ n$</td>
<td>250</td>
</tr>
<tr>
<td>$\bar{\nu}_e + \bar{\nu}_e \rightarrow \nu_e + \nu_e$</td>
<td>15</td>
</tr>
<tr>
<td>$\nu_e + \bar{\nu}_e \rightarrow \nu_e + \bar{\nu}_e$</td>
<td>15</td>
</tr>
<tr>
<td>$\nu_e + \nu_e \rightarrow \nu_e + \nu_e$</td>
<td>10</td>
</tr>
<tr>
<td>$\nu_e + 3\bar{\nu}_e \rightarrow \nu_e + \bar{\nu}_e + e^-$</td>
<td>10</td>
</tr>
<tr>
<td>$\nu_e + 3\bar{\nu}_e \rightarrow \nu_e + \bar{\nu}_e + e^-$</td>
<td>25</td>
</tr>
</tbody>
</table>

Total 300


Expected LVD Sensitivity

Conclusions

LVD continuously monitors the whole Galaxy

No evidence of $\nu$-burst detection on 7335 days

Upper limit to GSC event $0.11$ year$^{-1}$ (90% c.l.)