Search for Supernova Neutrino Bursts at LVD

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on behalf of the LVD Collaboration

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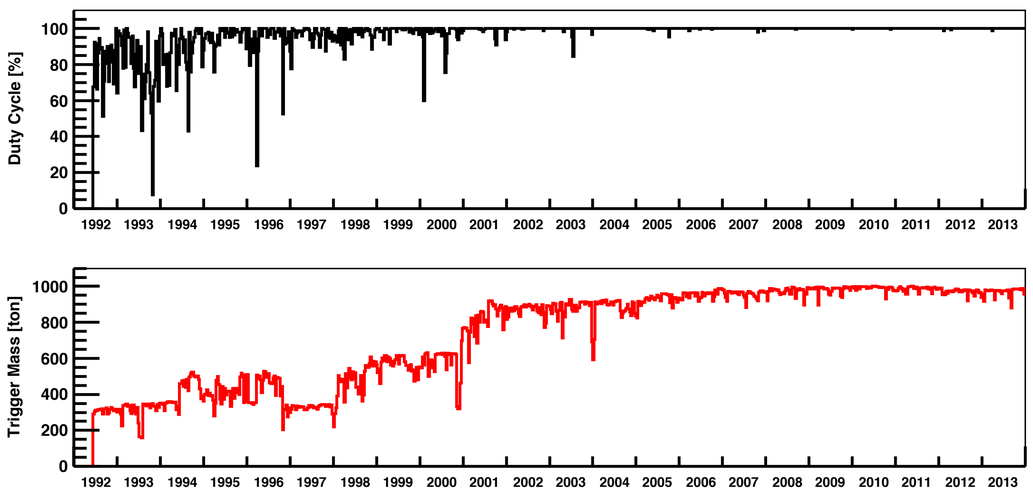
The Detector Performances

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

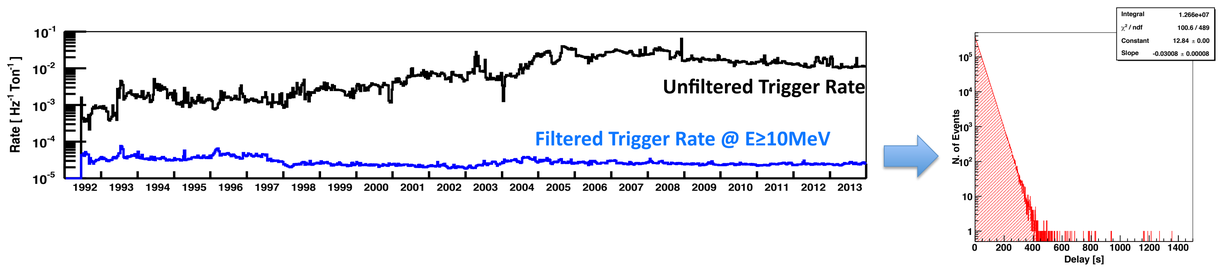
Mean Energy Threshold : E_{th}~4 MeV

Sensitive to Neutrino Burst from a Gravitational Stellar Collapse (GSC) in the Milky Way (D<=25 Kpc) with minimum trigger mass of M>=300 tons

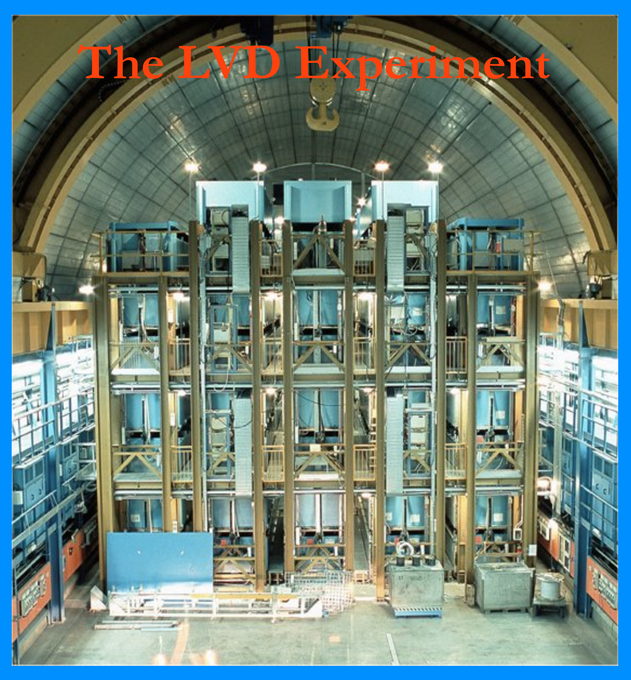


The Trigger Stability

Quality cuts and the energy threshold E≥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.



Expected ν signal in LVD GSC @ 10 Kpc

Neutrino interaction	Expected events
$\bar{\nu}_e + p \rightarrow e^+ + n$	250
$\nu_e + {}^{12}C \rightarrow {}^{12}N + e^-$	15
$\bar{\nu}_e + {}^{12}C \rightarrow {}^{12}B + e^+$	
$\nu_i + {}^{12}C \rightarrow \nu_i + {}^{12}C + \gamma$	
$\nu_i + e^- \rightarrow \nu_i + e^-$	10
$\nu_e + {}^{56}Fe \rightarrow {}^{56}Co + e^-$	25
$\bar{\nu}_e + {}^{56}Fe \rightarrow {}^{56}Mn + e^+$	
$\nu_i + {}^{56}Fe \rightarrow \nu_i + {}^{56}Fe + \gamma$	
Total	300

Neutrino emission model as in G.Pagliaroli et al. Astroparticle Physics 31 (2009) 163-176

The search for supernova ν bursts

The data set: all recorded triggers in the 10-100 MeV energy range after μ-like event rejection and quality cuts.

The cluster definition: each possible sequence of m≥2 events within 100 ms ≤Δt≤ 100 s time window/ Δt is determined by the first and last event of the cluster.

The cluster imitation frequency:

$$F_{im} = f_{bk}^2 \cdot \Delta t_{\max} \cdot \sum_{k \geq m-2}^{\infty} P(k, f_{bk} \cdot \Delta t)$$

P is the Poisson probability to have a cluster of multiplicity k being (f_{bk} Δt) the mean value and Δt_{max}=100 s.

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

The ν burst candidate: cluster with $F_{im} \leq 1/100 \cdot year^{-1}$

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.

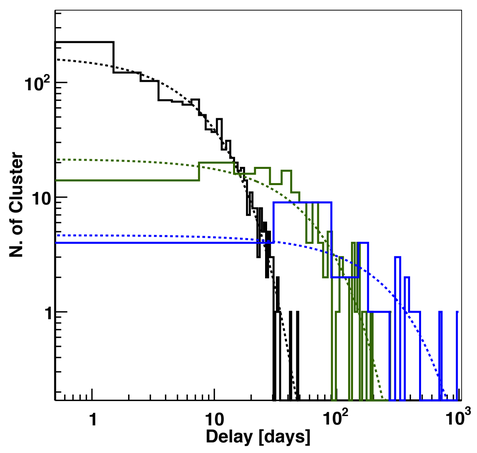
Results

Total Livetime	N. of Cluster
7335 days	26914419

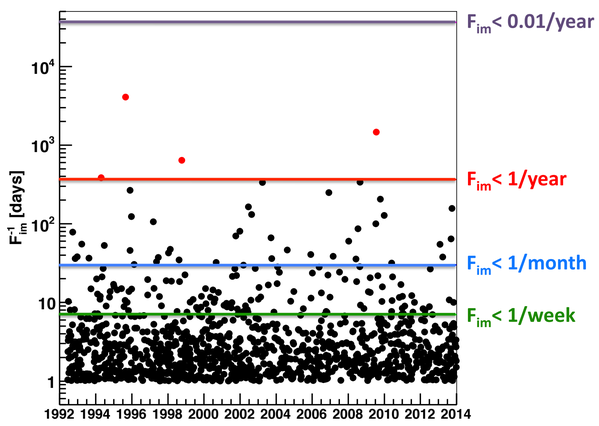
F_{im}^{th}	< 1 Day^{-1}	< 1 week^{-1}	< 1 month^{-1}	< 1 year^{-1}	< 0.01 year^{-1}
Clusters	1123	165	45	4	0

4 candidates @ F_{im}^{th}< 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.

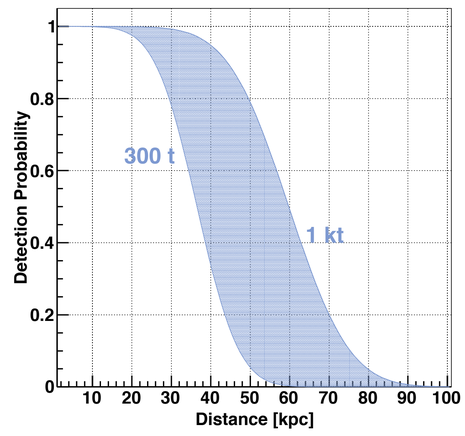


Temporal delay between clusters selected at different F_{im}; the solid line is for the experimental result, the dotted line is the prediction for a Poisson behaviour of the background.



Detected clusters at F_{im}<1/day. Red dots are 4 clusters whose significance is less than 1/year. No clusters fall above the F_{im}<1/100 years limits.

Expected LVD Sensitivity



Trigger Mass between 300 and 1000 tons

Conclusions

LVD continuously monitors the whole Galaxy

No evidence of ν-burst detection on 7335 days

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