NEUTRINO BURSTS FROM GRAVITATIONAL STELLAR COLLAPSES WITH LVD

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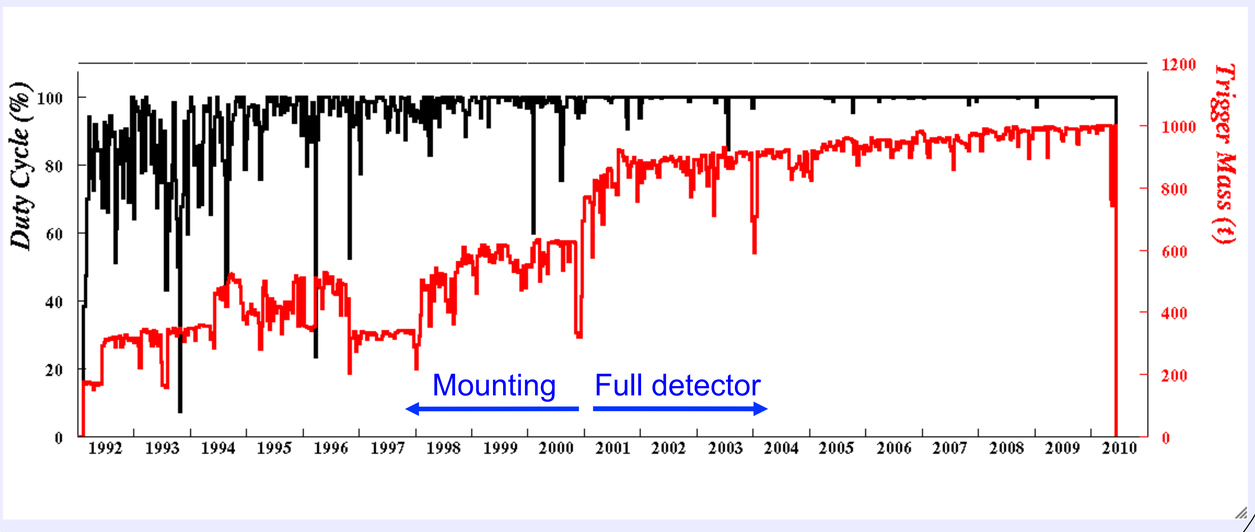
The LVD detector

840 counters are arranged in a compact and modular geometry

1000 tons liquid scintillator neutrino observatory @ Laboratori Nazionali del Gran Sasso

A single counter is 1.5x 1.0x1.0 m^3, 1.2 tons of liquid scintillator.
Three PMTS on the top: the trigger is given by the coincidence of the three PMTs above the threshold.
The detector energy threshold is: $E_{thr} \sim 4$ *MeV*



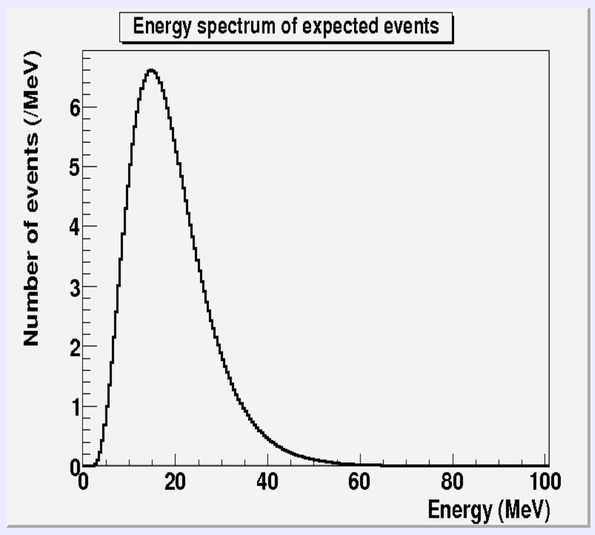
Aglietta et al., Il Nuovo Cimento A 105 (1992)

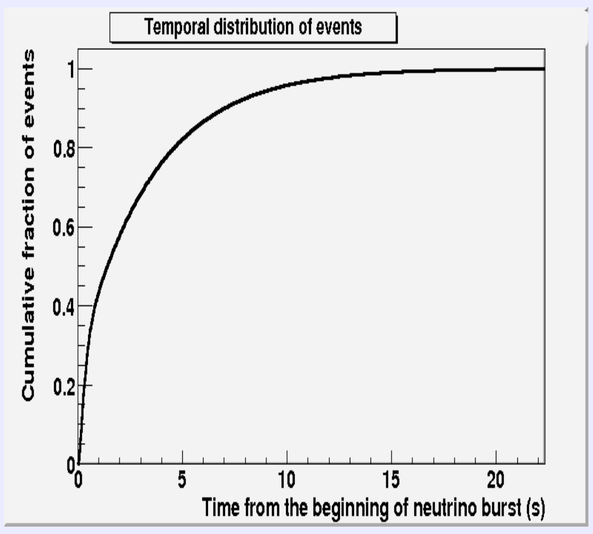
The expected signal

We fix a distance of the stellar collapse of D = 10kpc

Effect of neutrino oscillations are taken into account.

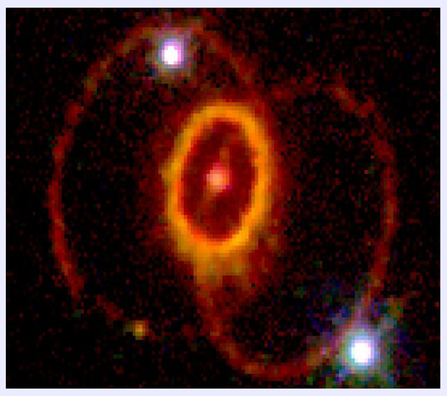
Neutrino interaction	Expected events
$\overline{\nu_e} + p \rightarrow e^+ + n$	250
$\nu_e + {}^{12}C \rightarrow {}^{12}N + e^-$	15
$\overline{\nu_e} + {}^{12}C \rightarrow {}^{12}B + e^+$	
$\nu_i + {}^{12}C \rightarrow \nu_i + {}^{12}C + \gamma$	
$\nu_i + e^- \rightarrow \nu_i + e^-$	10
$\nu_e + {}^{56}Fe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





Supernova neutrino emission model according to
Pagliaroli et al., Astroparticle Physics 31, (2009) 163-176

Neutrino from gravitational collapse



Gravitational stellar collapse is a complex problem.
It can be studied with the detection of neutrinos emitted in the process.

It can be associated to the explosion of the external envelope: type II supernova.

It is a rare event in our Galaxy: it is expected every 20-30 years.

Time scale of the collapse: 1-100 *s*

Total emitted energy: $E = 3 \cdot 10^{53}$ *erg*

99% of emitted energy in neutrinos

Energy equipartition among neutrino flavours

In total 10^{58} neutrinos are emitted.

Mean energy of emitted neutrinos

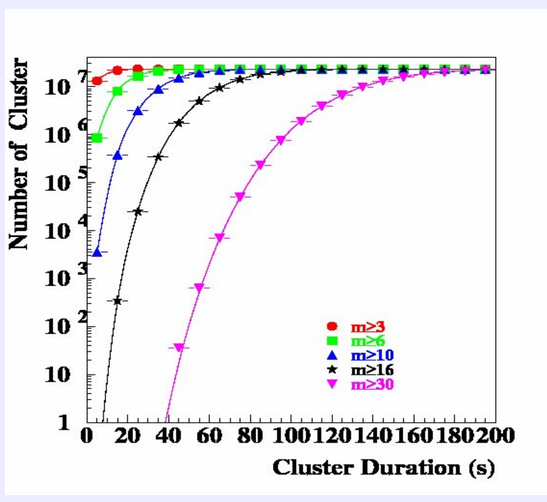
$\langle E\nu_e \rangle \sim 12$ *MeV*
$\langle E\bar{\nu}_e \rangle \sim 15$ *MeV*
$\langle E\nu_{\mu,\tau} \rangle \sim 20$ *MeV*

Bethe e Wilson, Astrophys.J. 295 (1985)14-23

Search for neutrino bursts

Data set: triggers in the 7-100 *MeV* energy range.
A cluster is a set of *m* events within a Δt time window.

Background behaviour is well described by Poisson statistic.



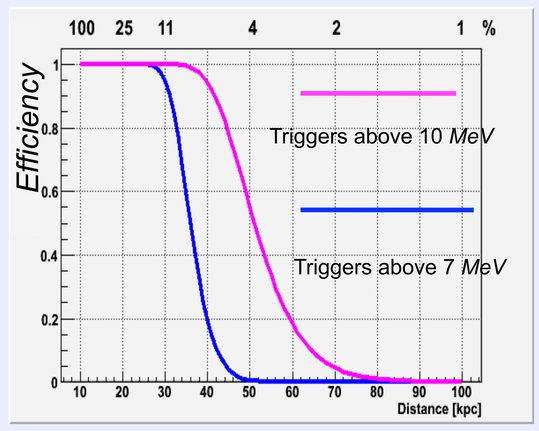
Selection of neutrino bursts candidates on a statistical basis: clusters that can be produced by background fluctuations less than *1/(100 years)*.

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

Full efficiency for supernova neutrino burst detection up to 30 *kpc*

NO CANDIDATES SELECTED IN THE WHOLE PERIOD 1992-2010

% of SN1987A ν flux



Distance (kpc)

Agafonova et al., Astroparticle Physics 28 (2008) 516-522

Conclusions

LVD has been continuously monitoring the whole Galaxy for 18 years with a very high duty cycle.

No gravitational stellar collapses has been detected so far (6043 days of observation); the limit to the supernova rate in the Galaxy is

0.14 / year (90% c.l.)