# Supernova neutrino search and underground physics at LVD

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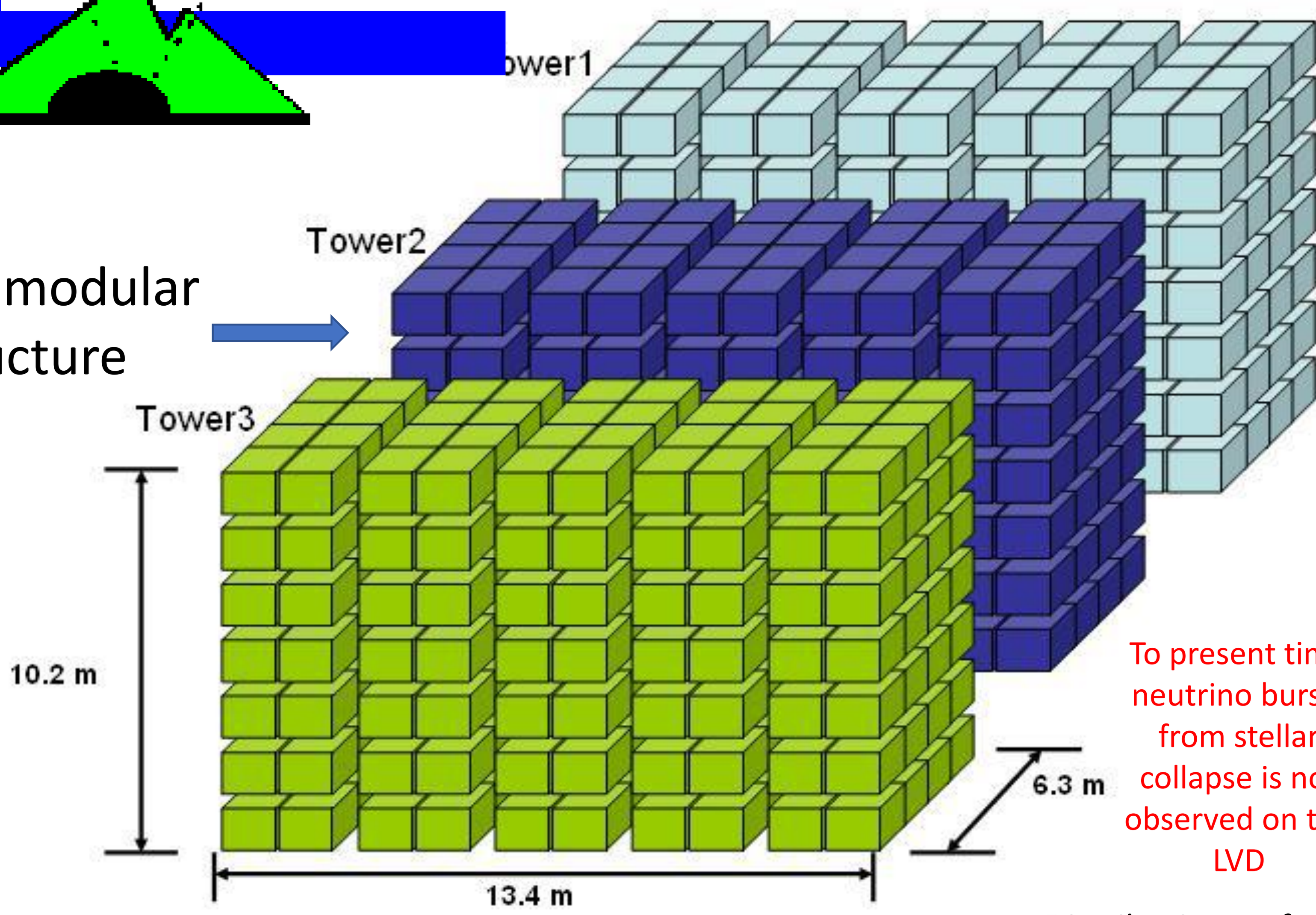
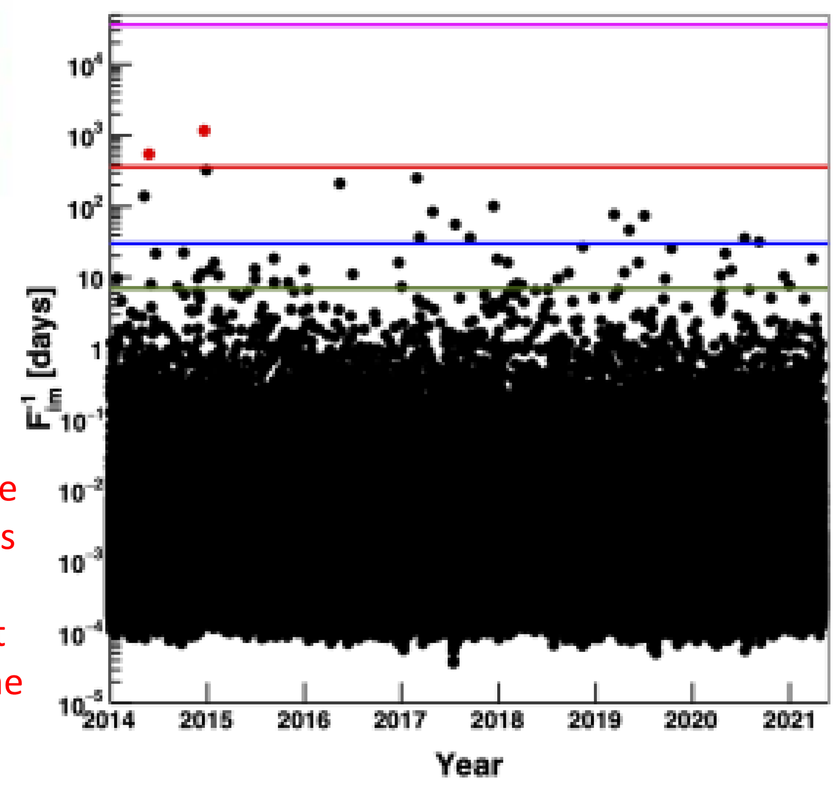
LVD modular structure




| | |
|---|---|
| Length× Width× Height | 22.7×13.2×10 m |
| Iron mass | 1020 t |
| Scintillator mass | 1008 t |
| Amount of counters | 840 |
| Amount of PMTs | 2520 |
| Average depth (min) | 3620 m w.e. 3000 m w.e. |
| Average muon energy | 280 GeV |
| $E_\mu$ at see lev. (min.) | 1.3 TeV |
| Muon rate (per 1 tower) | ~ 120 $h^{-1}$ |
| $\varepsilon_{th}$ threshold –inner -external | 4 MeV, 7 MeV |

$$F_{im_i} = f_{bk}^2 \Delta t_{max} \sum_{k \geq m_i - 2} P(k, f_{bk_i} \Delta t_i)$$

$P(k, f_{bki}, \Delta t_i)$ is the Poisson probability to have k events in the time window $\Delta t_i$ if $f_{bk}$ is the background frequency




Distributions of detected clusters versus time for the present dataset. Red dots represent clusters with imitation frequency less than $F_{im}$ = 1 year$^{-1}$. Green, blue, red and purple lines corresponds to $F^{th}$ = 1 week$^{-1}$, $F^{th}$ = 1 month$^{-1}$, $F^{th}$ = 1 year$^{-1}$, $F^{th}$ = 1/100 year$^{-1}$, respectively. Cluster multiplicity greater than or equal than 2 and cluster duration less than or equal 100 seconds

| | $\nu$ interaction channel | $E_\nu$ threshold | % |
|---|---|---|---|
| 1 | $\bar{\nu}_e + p \to e^+ + n$ | (1.8 MeV) | (88%) |
| 2 | $\nu_e + {}^{12}C \to {}^{12}N + e^-$ | (17.3 MeV) | (1.5%) |
| 3 | $\bar{\nu}_e + {}^{12}C \to {}^{12}B + e^+$ | (14.4 MeV) | (1.0%) |
| 4 | $\nu_i + {}^{12}C \to \nu_i + {}^{12}C^* + \gamma$ | (15.1 MeV) | (2.0%) |
| 5 | $\nu_i + e^- \to \nu_i + e^-$ | (-) | (3.0%) |
| 6 | $\nu_e + {}^{56}Fe \to {}^{56}Co^* + e^-$ | (10. MeV) | (3.0%) |
| 7 | $\bar{\nu}_e + {}^{56}Fe \to {}^{56}Mn + e^+$ | (12.5 MeV) | (0.5%) |
| 8 | $\nu_i + {}^{56}Fe \to \nu_i + {}^{56}Fe^* + \gamma$ | (15. MeV) | (2.0%) |

Reactions of neutrino (antineutrino) interaction with LVD

The Large Volume Detector (LVD) is located underground at a depth of 1400 m under rock (minimal depth 3000 m w.e.), in the INFN Gran Sasso National Laboratory (Italy). The experiment consists of an array of 840 scintillator counters, 1.5 m3 each, viewed from the top by three photo multipliers PMTs) and arranged in a modular geometry[9]. This modularity allows LVD to achieve a very high duty cycle, that is essential in the search of unpredictable sporadic events. Failures involving one or more counters do not affect, in general, other counters. The detector maintenance can be done during data acquisition by stopping only the part that needs to be maintained, even a single counter. This peculiarity allows a dynamic active mass Mact and a high duty cycle. The experiment has been in operation since 1992, June 9th after a short commissioning phase, its mass increasing from 300 t to its final one, 1000 t, at time of building phase completion in January 2001.

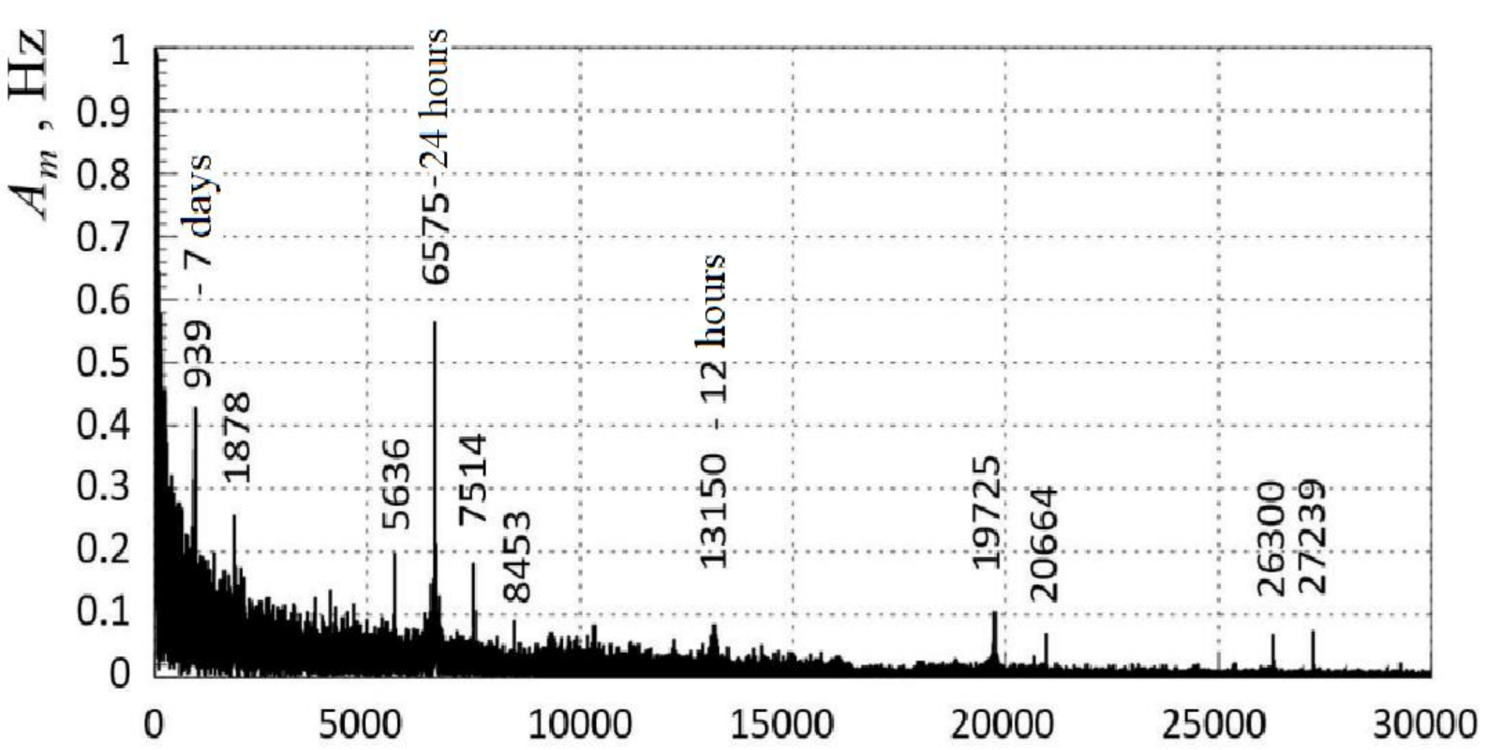
The main goal of the experiment is detection of neutrinos from the gravitation collapse of stellar cores due to IBD reaction ($\tilde{\nu}_e + p \to e^+ + n$ ).
LVD has been observing our Galaxy searching for neutrino bursts since 9 June 1992. The detector is one of the founding members of the SuperNovae Early Warning System project.

Also LVD be able to register natural radioactivity products, and in particular, from radon decay.

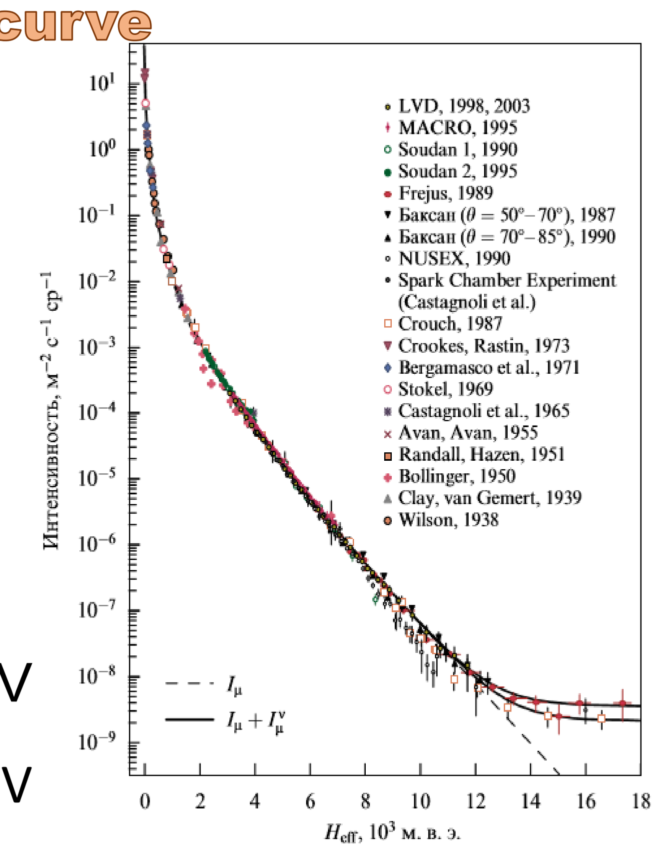
Monitoring of radon concentrations is possible owing to the detection of gammas from decays of daughter nuclei of the radon isotope $^{222}$Rn.

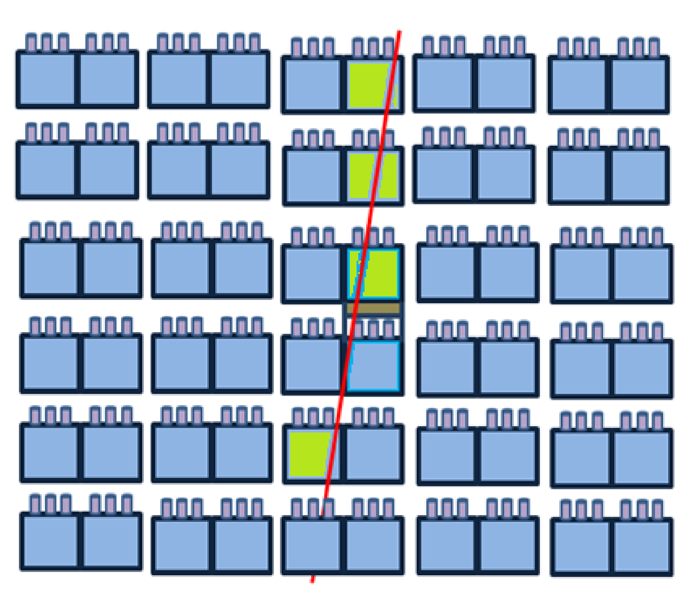
$${}^{222}_{86}Rn \xrightarrow{\alpha} {}^{218}_{84}Po \xrightarrow{\alpha} {}^{214}_{82}Pb \xrightarrow{\beta} {}^{214}_{83}Bi \xrightarrow{\beta} {}^{214}_{84}Po \xrightarrow{\alpha} {}^{210}_{82}Pb$$

Thanks to a lot of time of radon counting rate (during to 18 years of observation) measuring we have got its Fourier spectrum



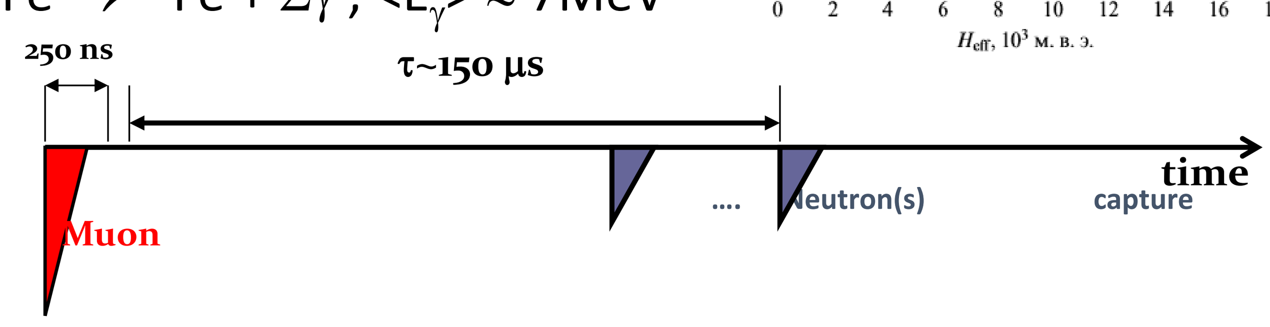

depth-intensity curve



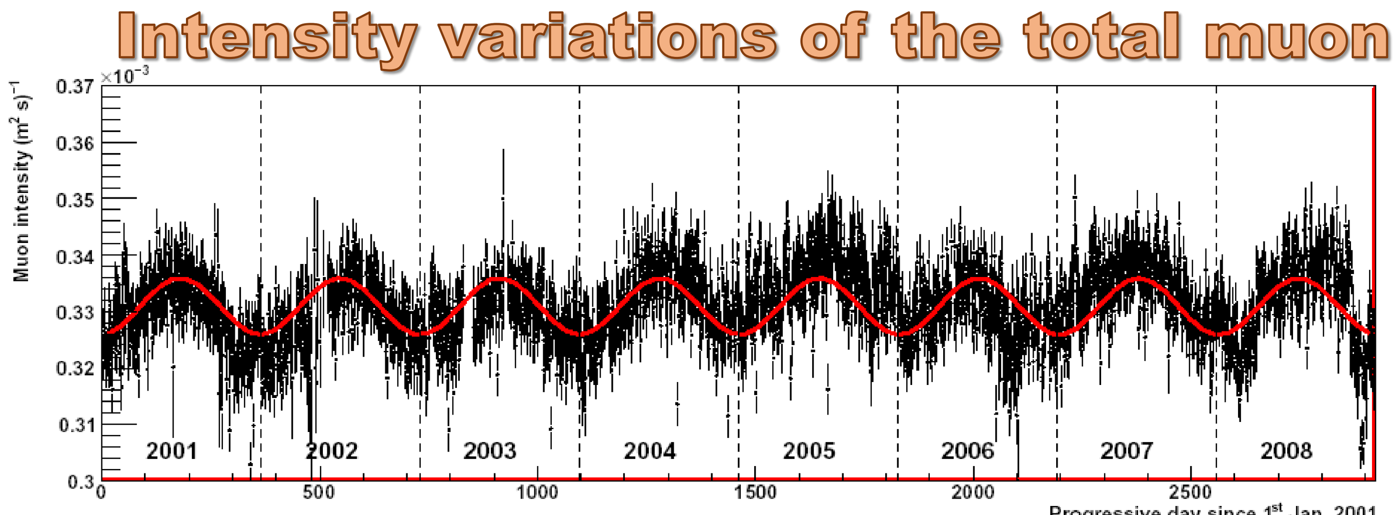


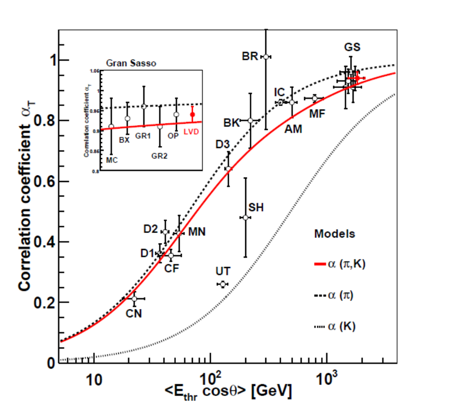
$n + p \to d + \gamma$, $E_\gamma$ = 2.2MeV

$^{56}Fe \to {}^{57}Fe + \Sigma\gamma$ , $\langle E_\gamma \rangle \approx$ 7MeV




## Intensity variations of the total muon flux

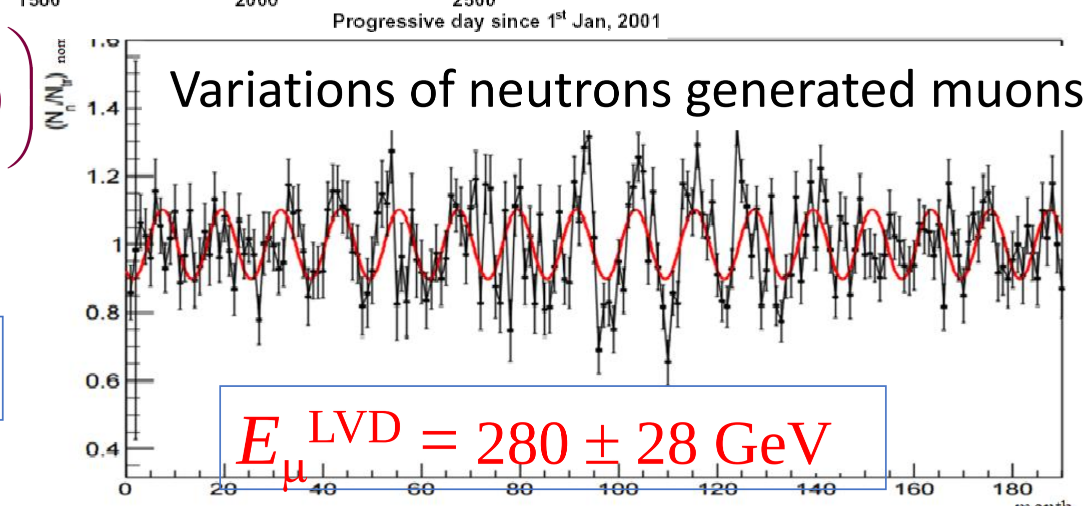


$$I_\mu = I_0^\mu + \delta I^\mu \cos\left(\frac{2\pi}{T}(t - t_0)\right)$$

$$Y_n(E_\mu) \propto E_\mu^{0.78}$$

Variations of neutrons generated muons

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