Detecting supernova neutrino bursts with SK-Gd prototype: EGADS

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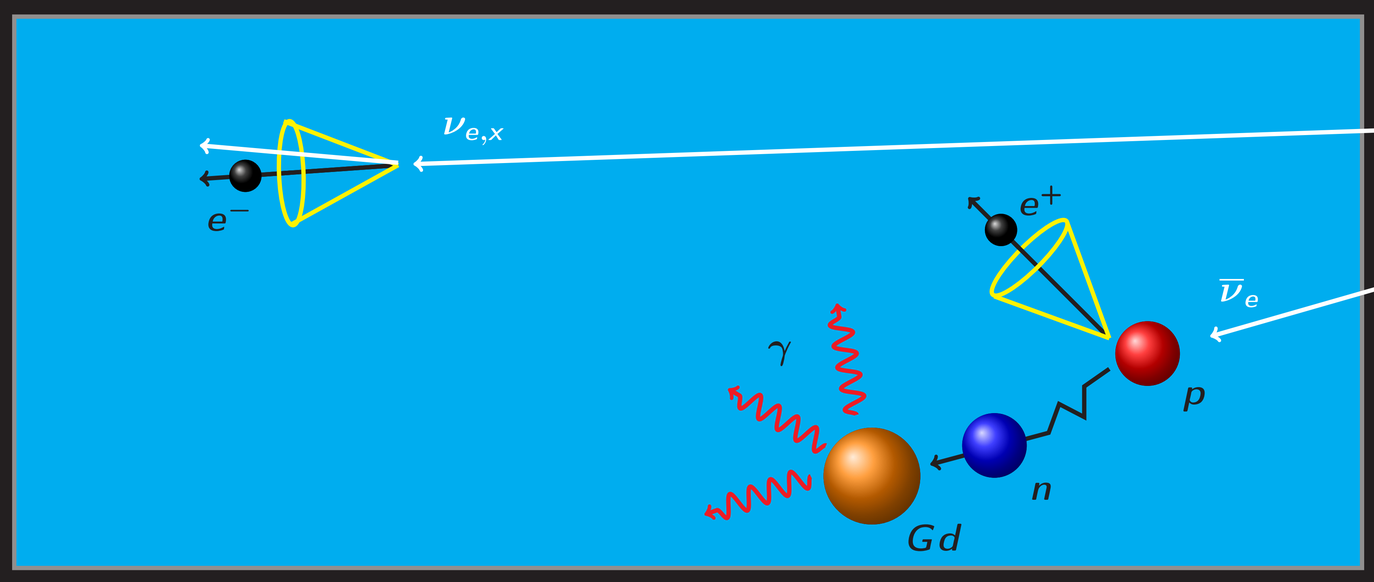
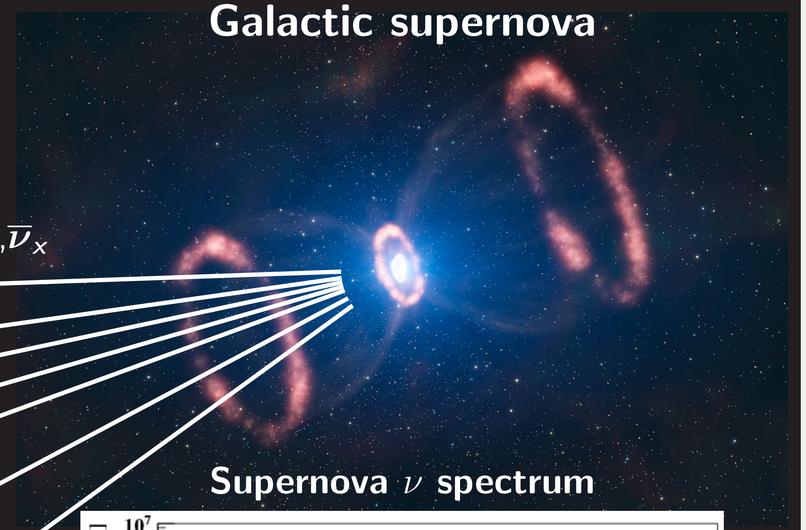
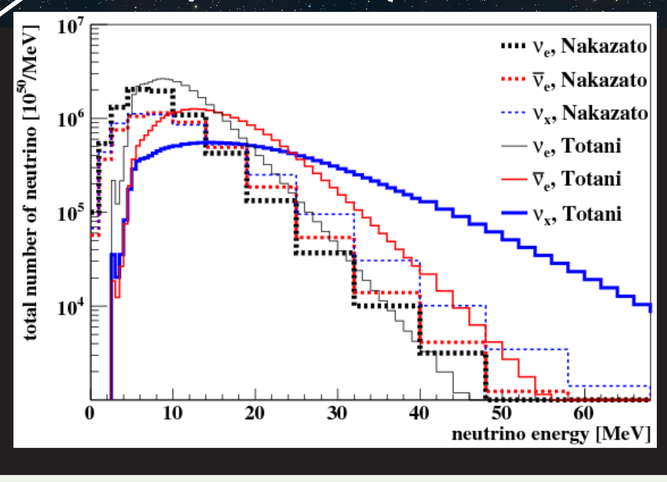
Supernova ν main interactions in a Gd-loaded water Čerenkov detector on Earth



Galactic supernova



Supernova ν spectrum



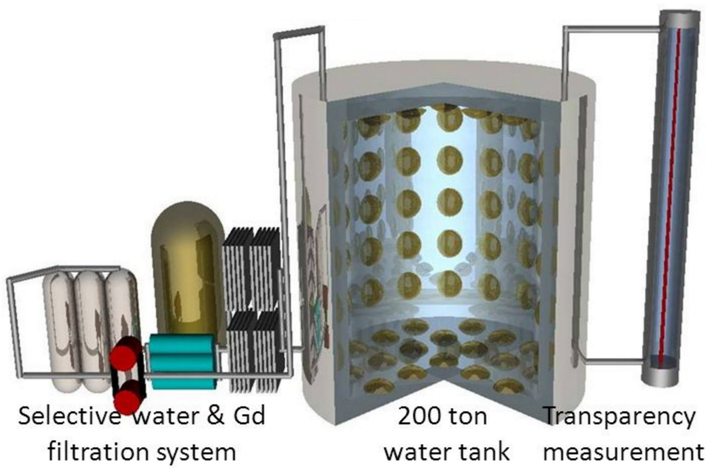
$\nu - e^-$ elastic scattering: indication of the ν's direction

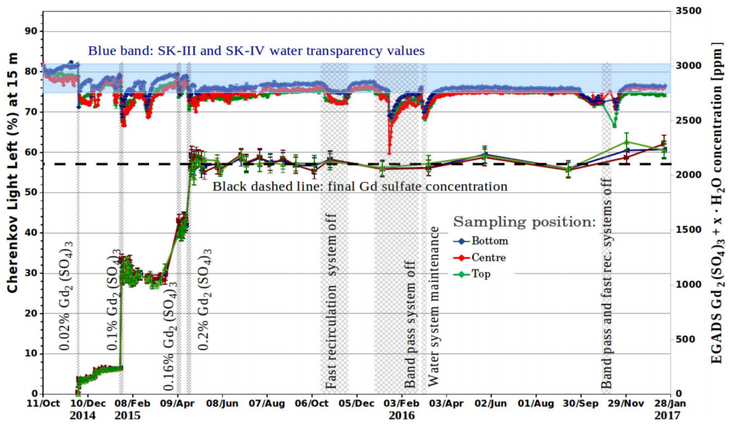
Inverse β decay (IBD): $\sim$ **95%** of SN ν interactions in the detector. **Delayed coincidence signal.**

1987A picture is from ©ESO/Luis Calcada ; SN neutrino spectrum is from XMASS Collaboration (Abe, K. et al.) Astropart.Phys. 89 (2017) 51-56

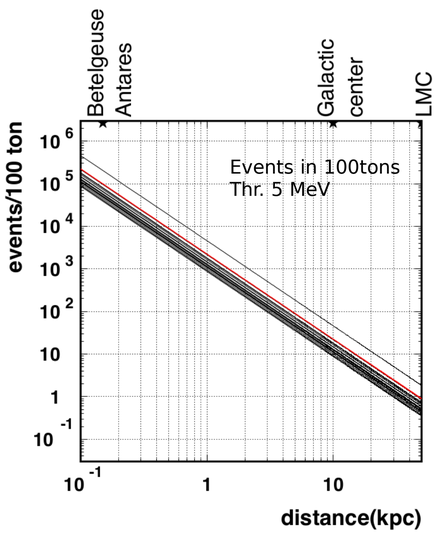
1 EGADS: From a Super-Kamiokande Gd prototype to a Supernovae detector

- **EGADS** (**E**valuating **G**adolinium's **A**ction on **D**etector **S**ystems): successful Super Kamiokande prototype for SK-Gd project, to test the feasibility and the stability of an SK-like Gd-loaded water Čerenkov detector.
- Now converted as a stand alone detector for supernovae (SNe) ν research, named **EGADS** (**E**mploying **G**adolinium to **A**utonomously **D**etect **S**upernovae).
- In Summer 2017, electronics were replaced from old SK electronics to current SK electronics (QTC-based) in order to allow the DAQ to support high event rate.





2 Expected supernova ν in EGADS detector



- Expected number of events:
  - ▷ Betelgeuse ($\sim$ 200pc):

	Nakazato et al.[A]	Livermore
IBD:	$25 \times 10^3 \sim 32 \times 10^3$	$56 \times 10^3 \sim 78 \times 10^3$
elas.:	$1.4 \times 10^3 \sim 1.5 \times 10^3$	$2.5 \times 10^3 \sim 2.9 \times 10^3$

  - ▷ Galactic center ($\sim$ 10kpc):

	Nakazato et al.[A]	Livermore
IBD:	$10 \sim 13$	$22 \sim 31$
elas.:	~ 0.6	~ 1

- **EGADS can see SNe in the full Milky Way**

Nakazato et al, (ApJ Supp. 205, 2 (2013)) ([A]20 $M_\odot$, Z=0.02, $t_{revival}$=200msec)
Livermore simulation (ApJ 496, 216 (1998))

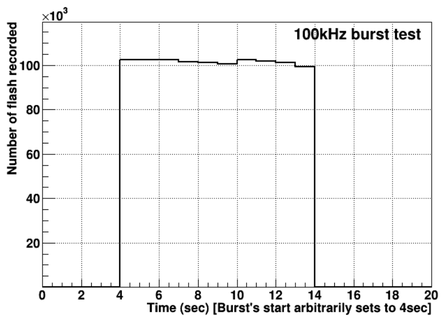
3 EGADS capability for supernova burst

- We designed a setup to produce a 10 sec long burst of light in EGADS detector, using a Laser Diode (LD).

Flash rate

LD[A]	Measured
1 kHz	1.0 ± 0.1 kHz
10 kHz	10.0 ± 0.1 kHz
50 kHz	51.2 ± 0.2 kHz
100 kHz	$\mathbf{102.5 \pm 0.2}$ **kHz**
500 kHz	518.5 ± 0.3 kHz
	(crash after 9 sec)

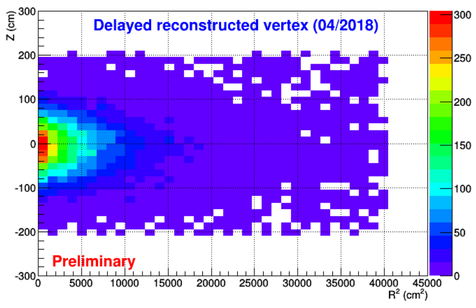
[A]: The uncertainty on the rate delivered by the module is $\sim$ 5%

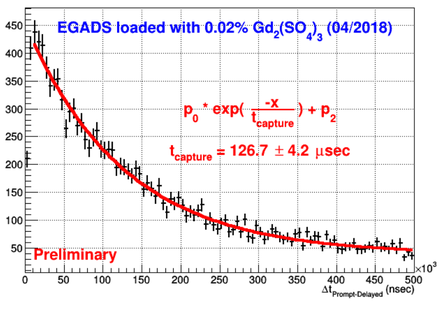


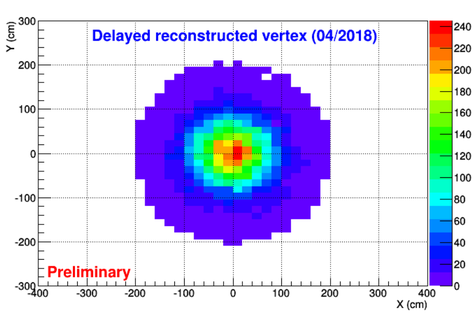
- EGADS is able to register a 10^6 events burst without trouble
- **EGADS can support burst from stars as near as Betelgeuse**

4 Inverse β decay in EGADS with Am/Be source

- Am/Be source: produces a γ and a neutron, allowing the test of Inverse β Decay detection
- Current Gd-loading in EGADS is 0.02% of $Gd_2(SO_4)_3$, re-loading to 0.2% is under-planned.

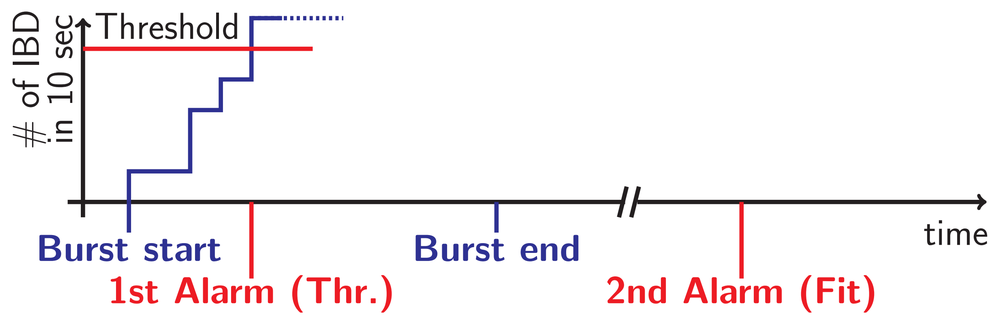






5 Supernova burst Alarm System

- Online event reconstruction system developed for EGADS.
- SN detected in case of a few IBD events within 10 sec:
  - ▷ 1st alarm (# of IBD above threshold) $\rightarrow$ **automatic, immediate, and autonomous mails and phone calls to the whole community**
  - ▷ 2nd alarm (after event reconstruction, few minutes after the 1st) $\rightarrow$ mails to the whole community with physics informations (direction, etc.)



- The system is being tested currently, release expected end of this year

Poster presented at **Neutrino 2018**, Heidelberg, Germany

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