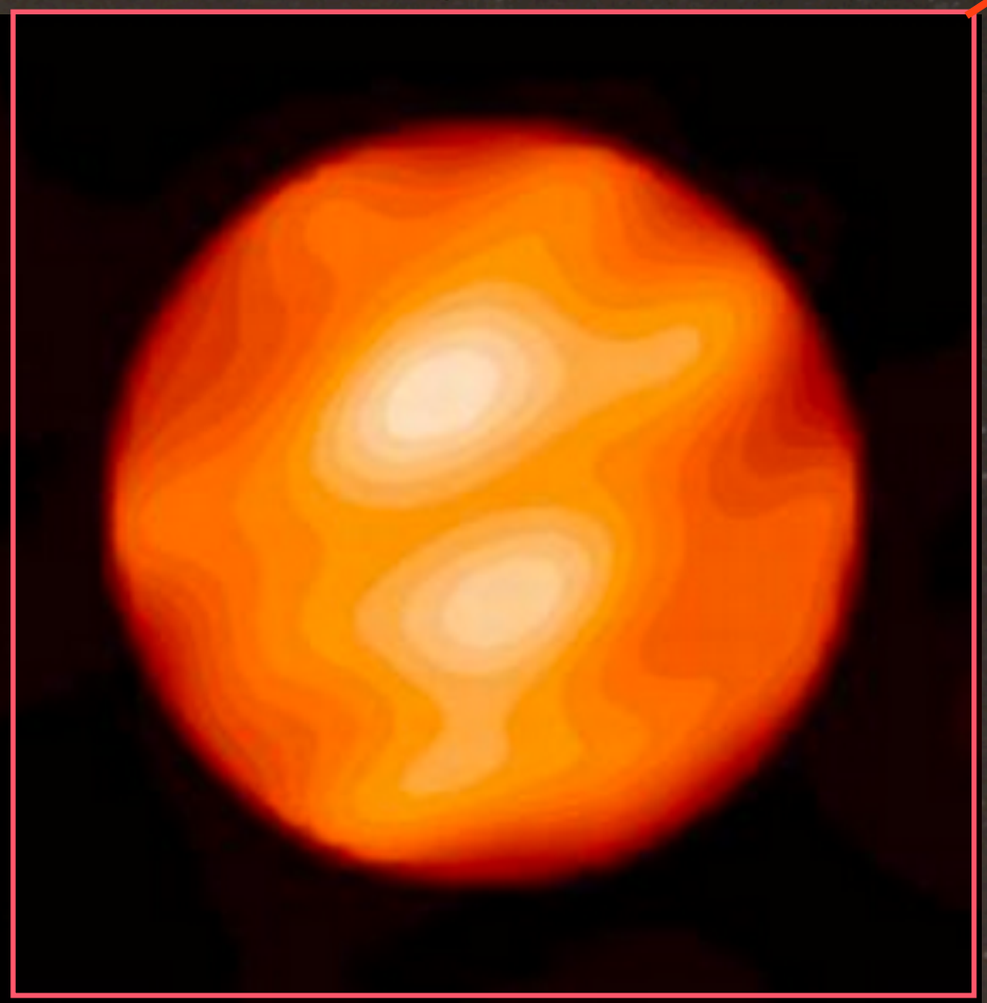
Nearby SNe with KamLAND

Koji Ishidoshiro (Tohoku Univ.)

Revealing the history of the universe with underground particle and nuclear research 2019

Betelgeuse
(~200pc)



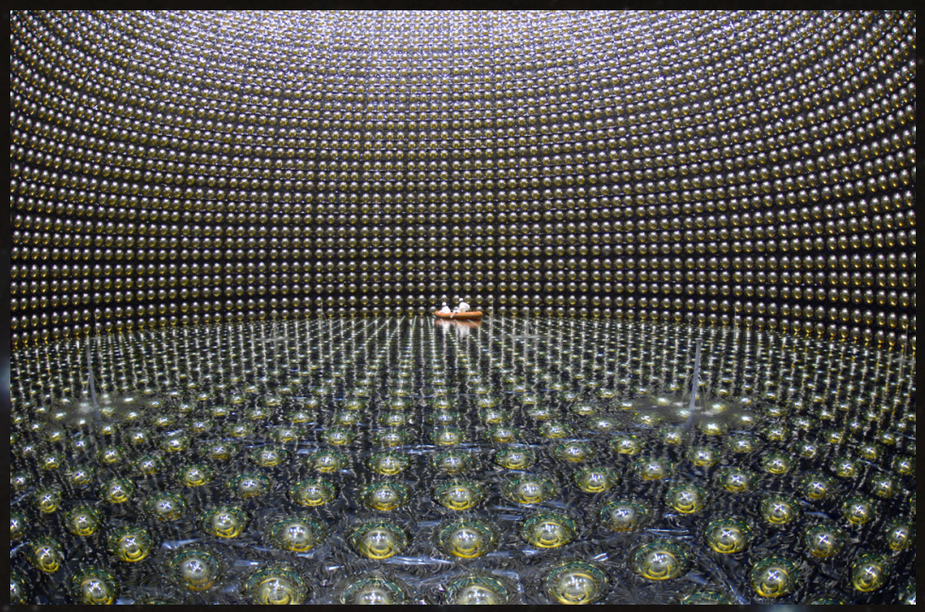
Antares
(~170pc)

Nearby red-supergiant

Next SN candidates

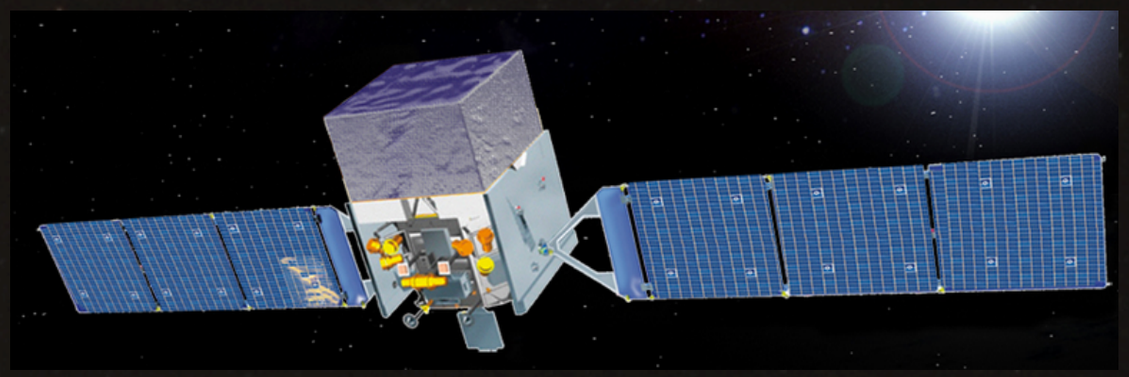
Which firstly detect nearby SN ?

Subaru



Super-Kamiokande

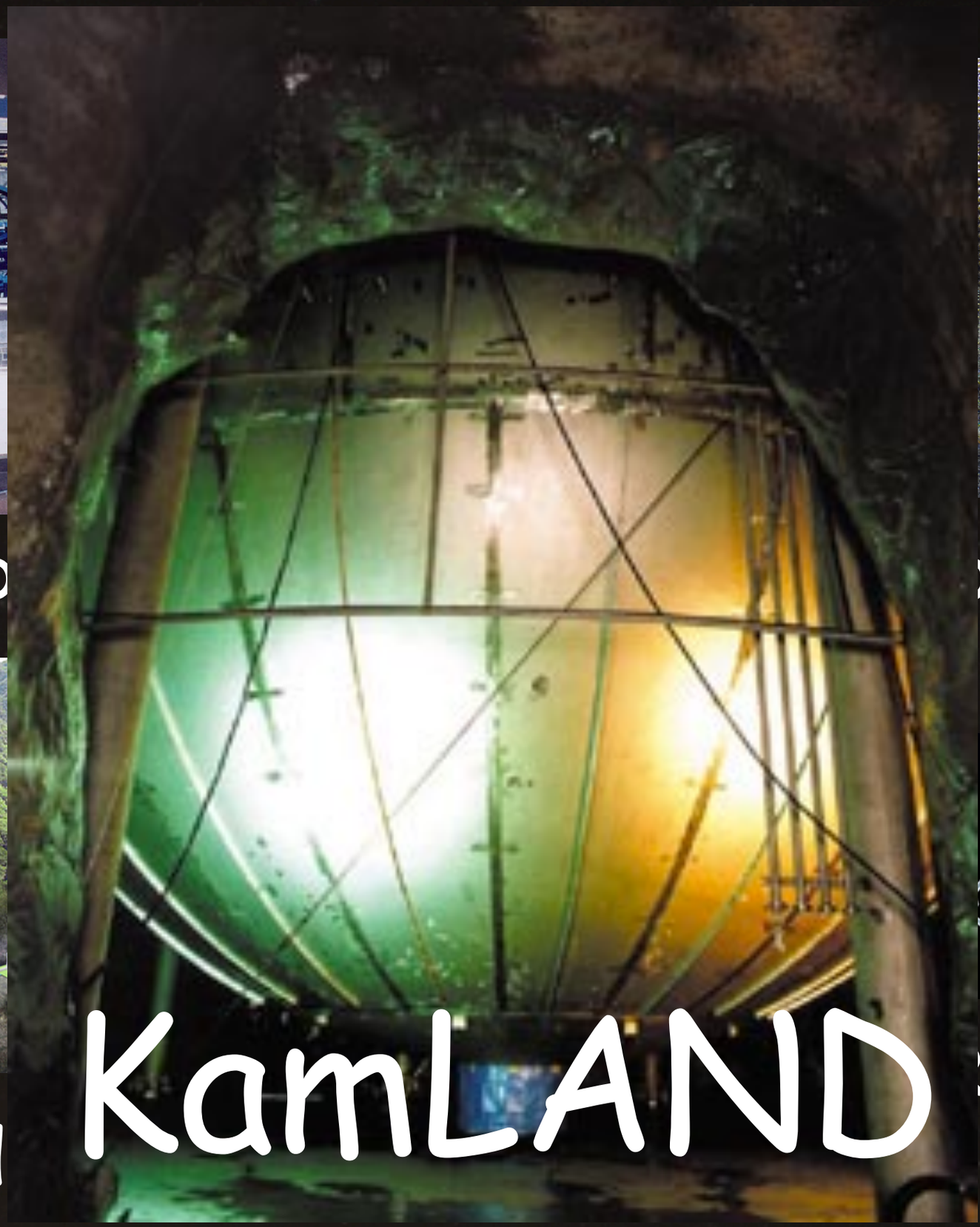
GW detector

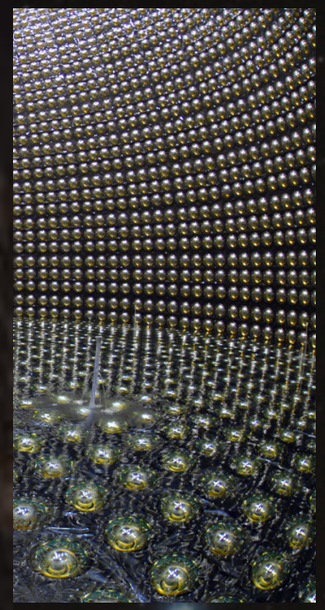


FERMI

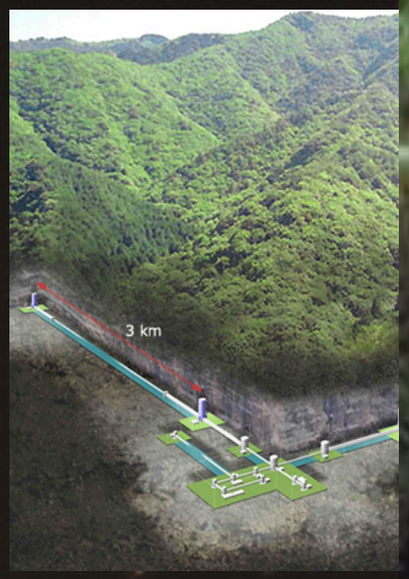
Which firstly detect nearby SN ?

Sub

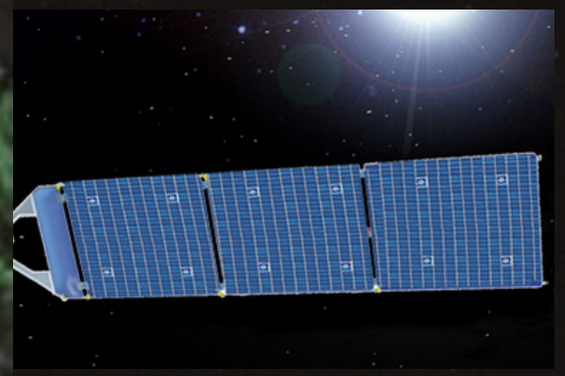




okande

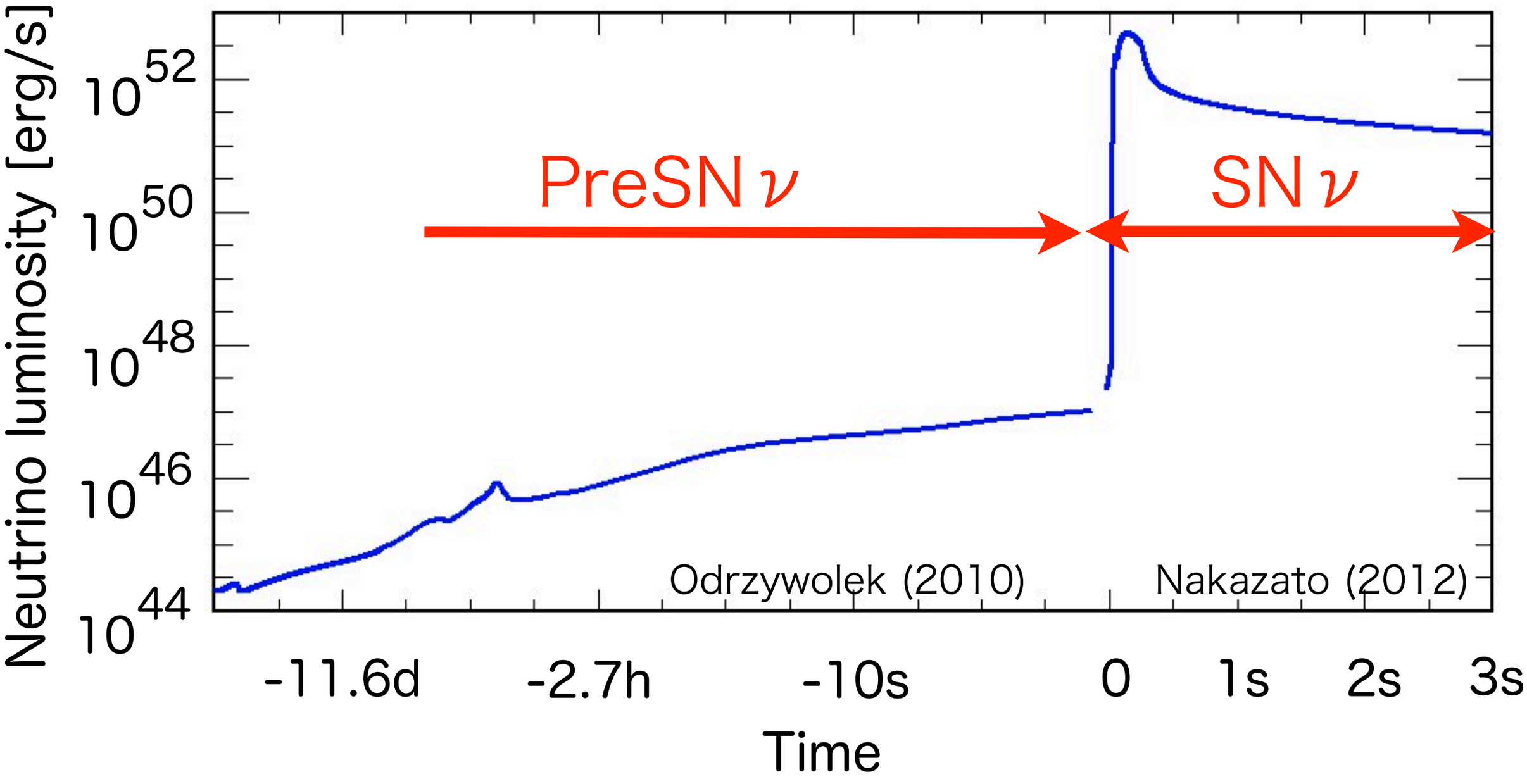


GW d



MI

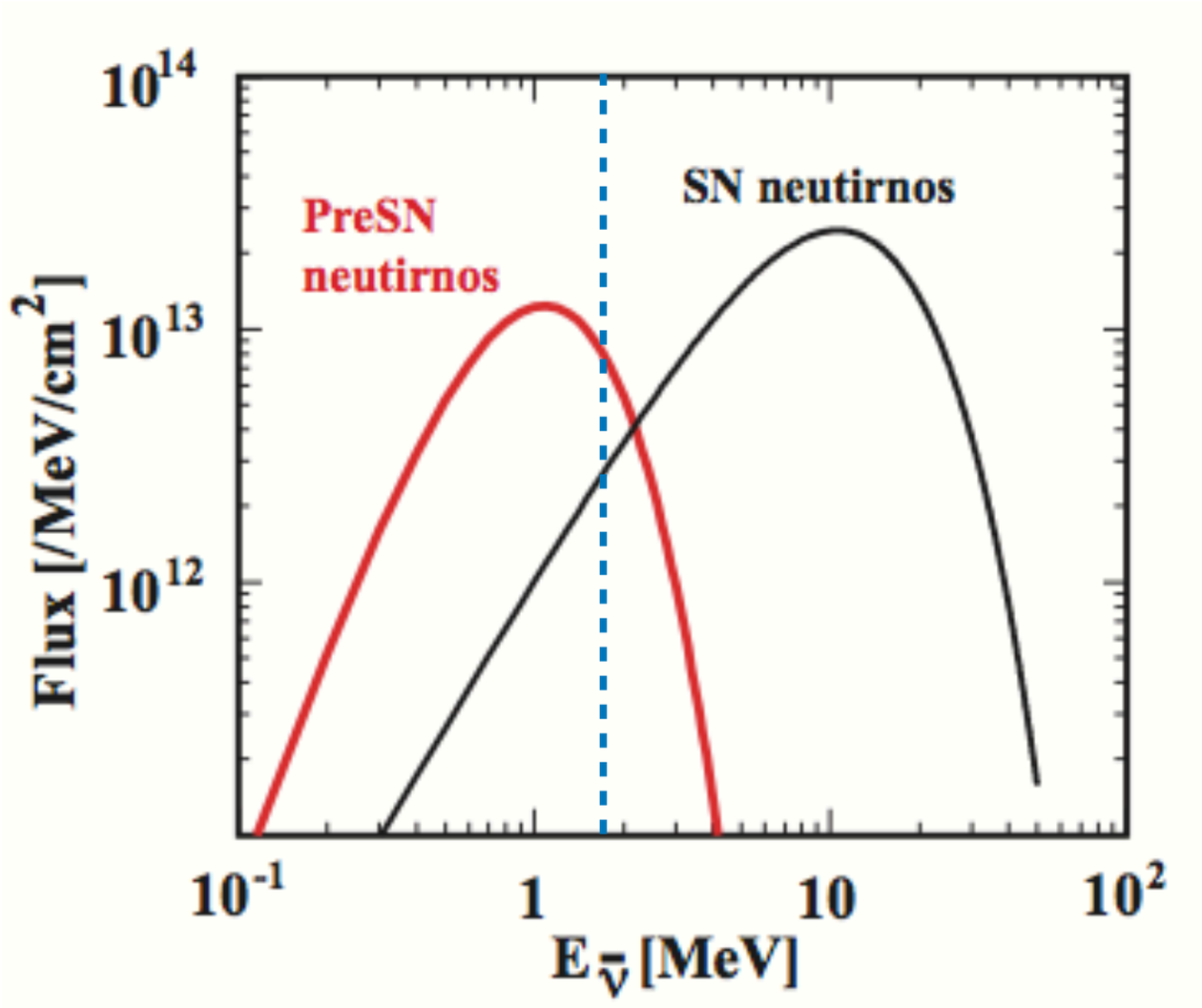
PreSN neutrinos



PreSN neutrinos

Assumption of SNe at d = 200 pc

Flux at the earth



Expected number of events: ~10 (last 48hr)

Normal event rate: ~0.1 events/day

Theoretical models will be discussed by Yoshida and Odrzywolek.

KamLAND

Kamioka **L**iquid scintillator **A**nti-**N**eutrino **D**etector (since 2002)

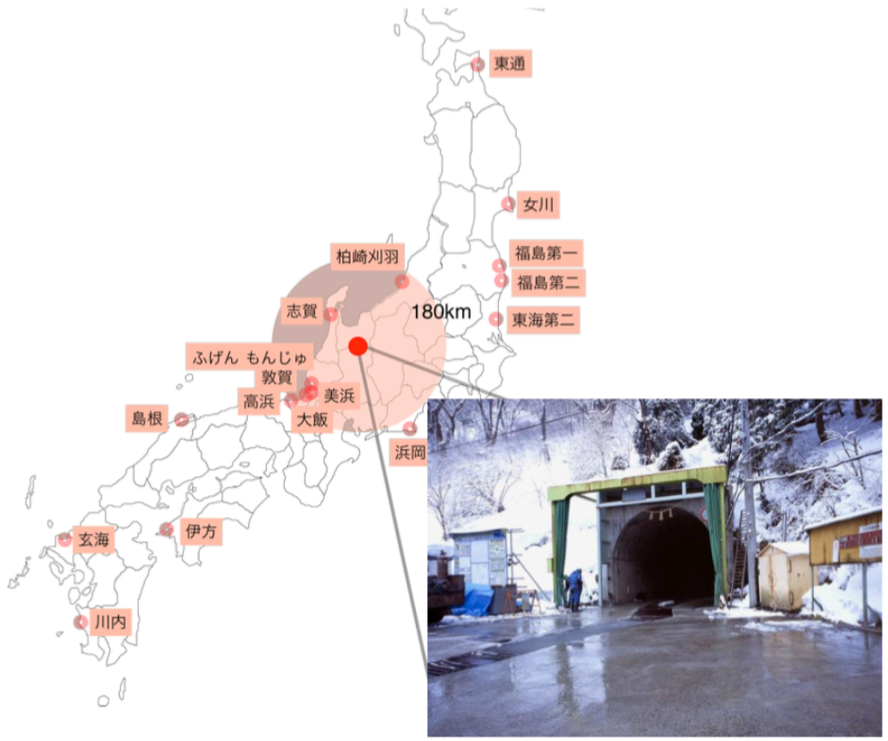
- 1,000m depth (Kamioka mine)

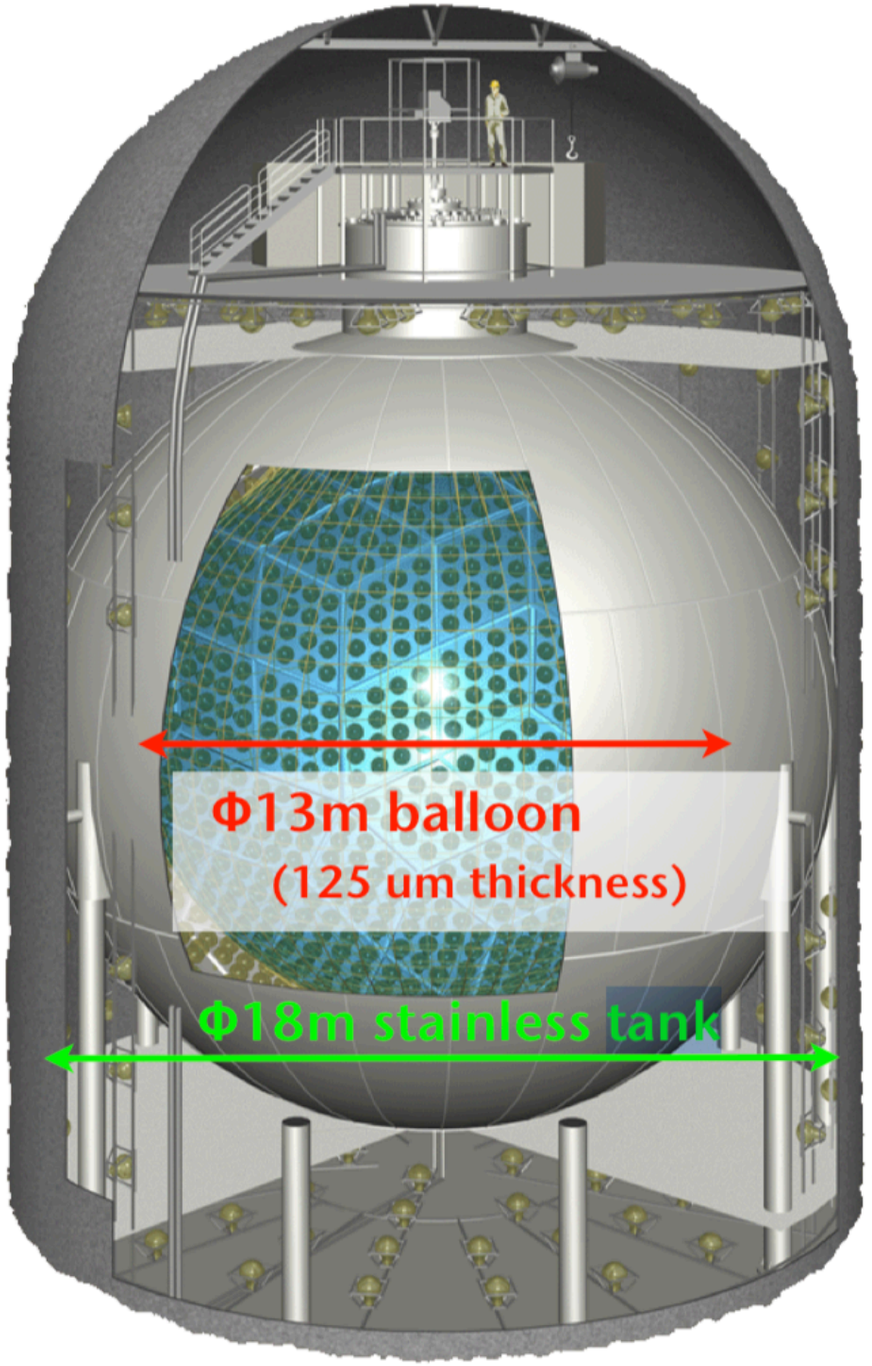
Inner detector

- 1kt liquid scintillator
- 1,325 17inch + 554 20inch PMTs

Outer detector

- 3.2kt cherenkov detector (OD)
- 140 20inchPMTs

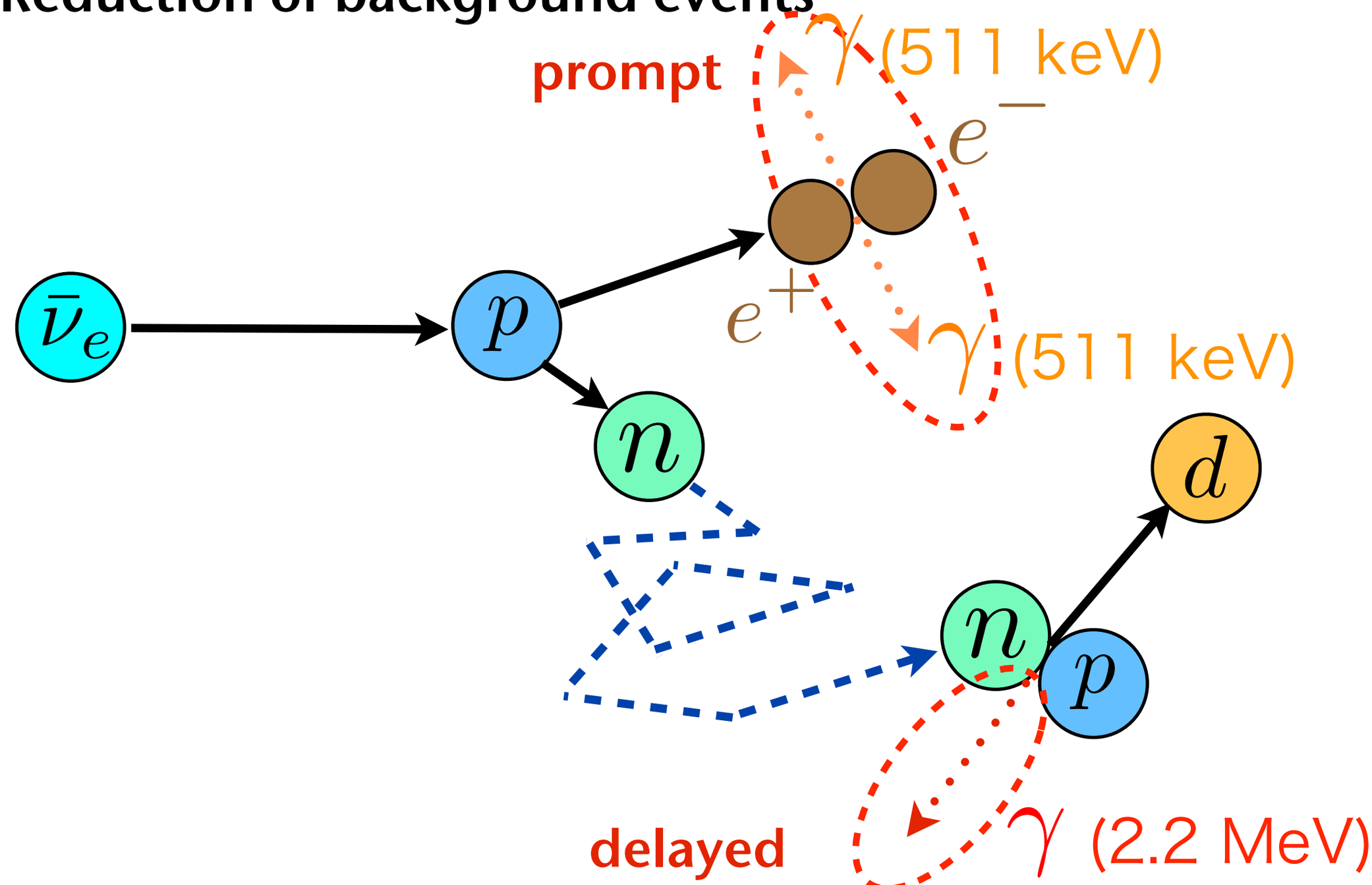




Inverse-beta decay

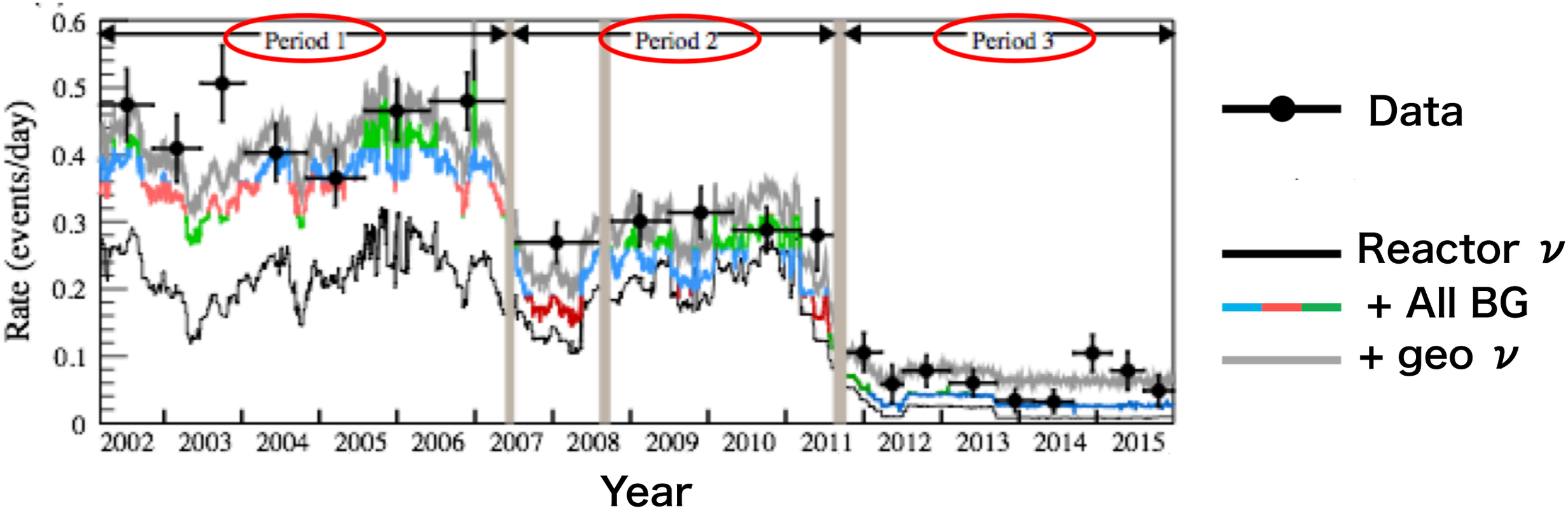
Anti-neutrino detection: delayed coincidence measurement

- **time-spatial correlated events**
- **Reduction of background events**



Event rate

0.9 < Ep < 2.6 MeV

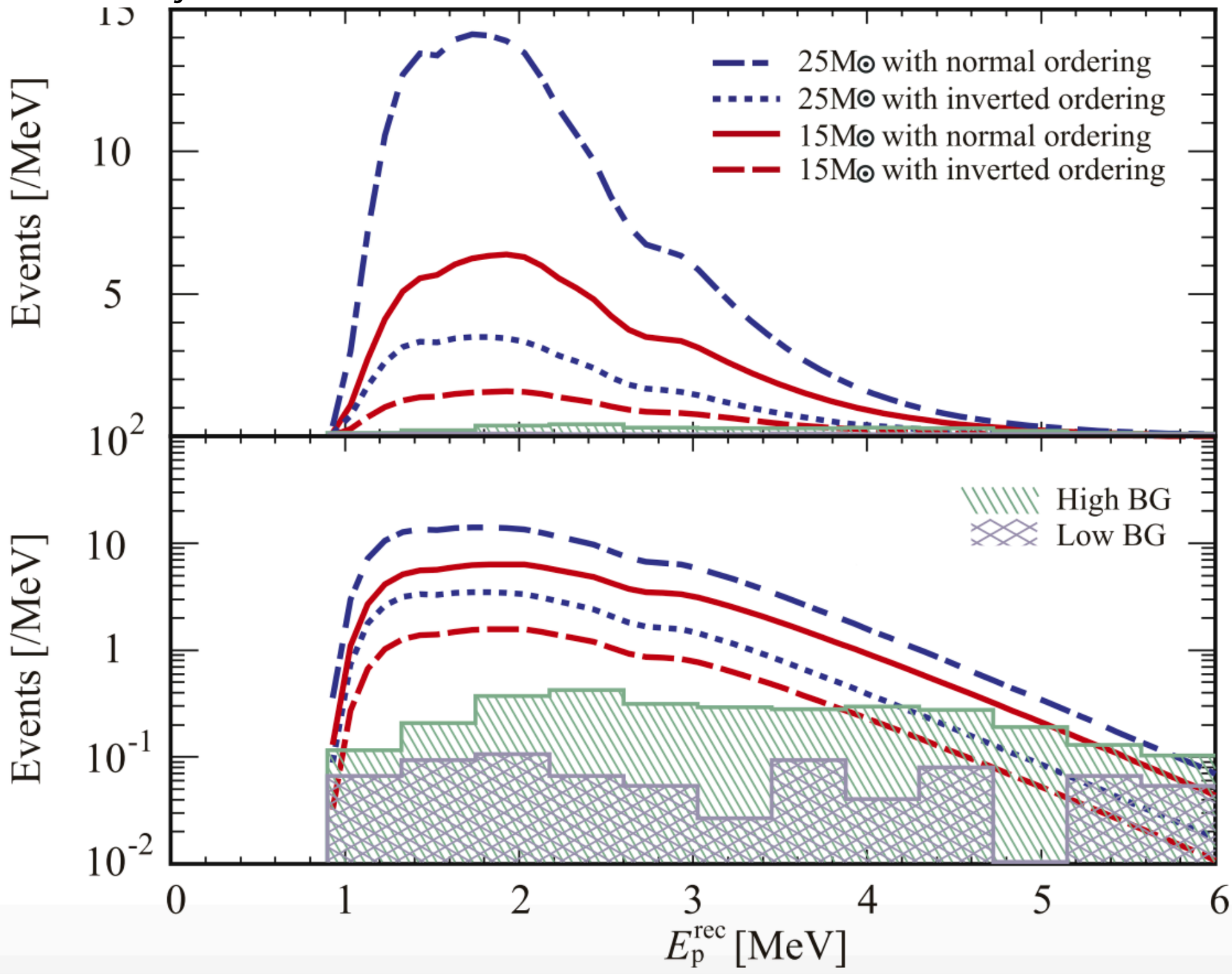


- Background rate < 0.1 events/day
- Wider range for PreSNv monitor

  Even so, background rate < 0.1 events/day

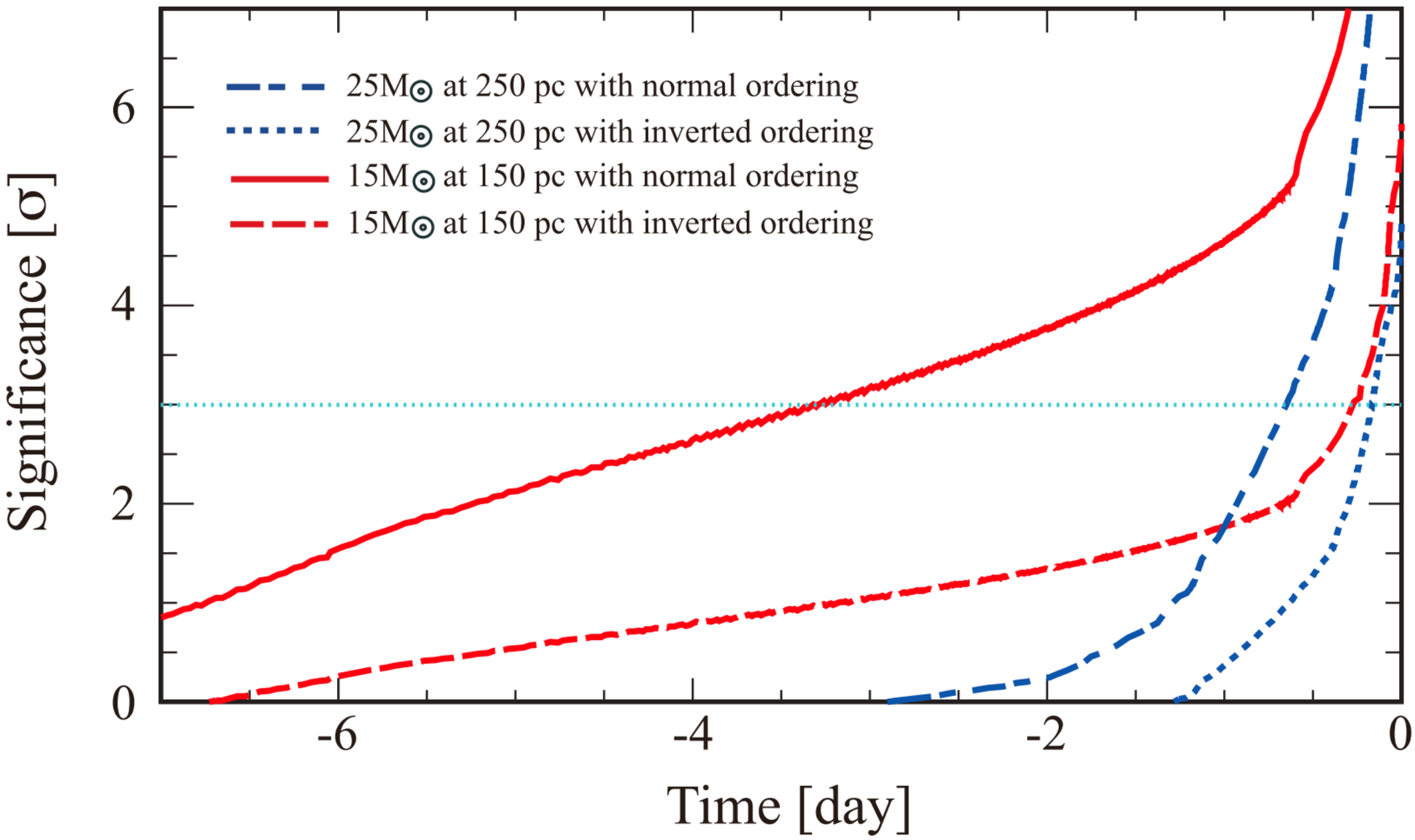
Event spectrum

With Odrzywolek model



When we detect ?

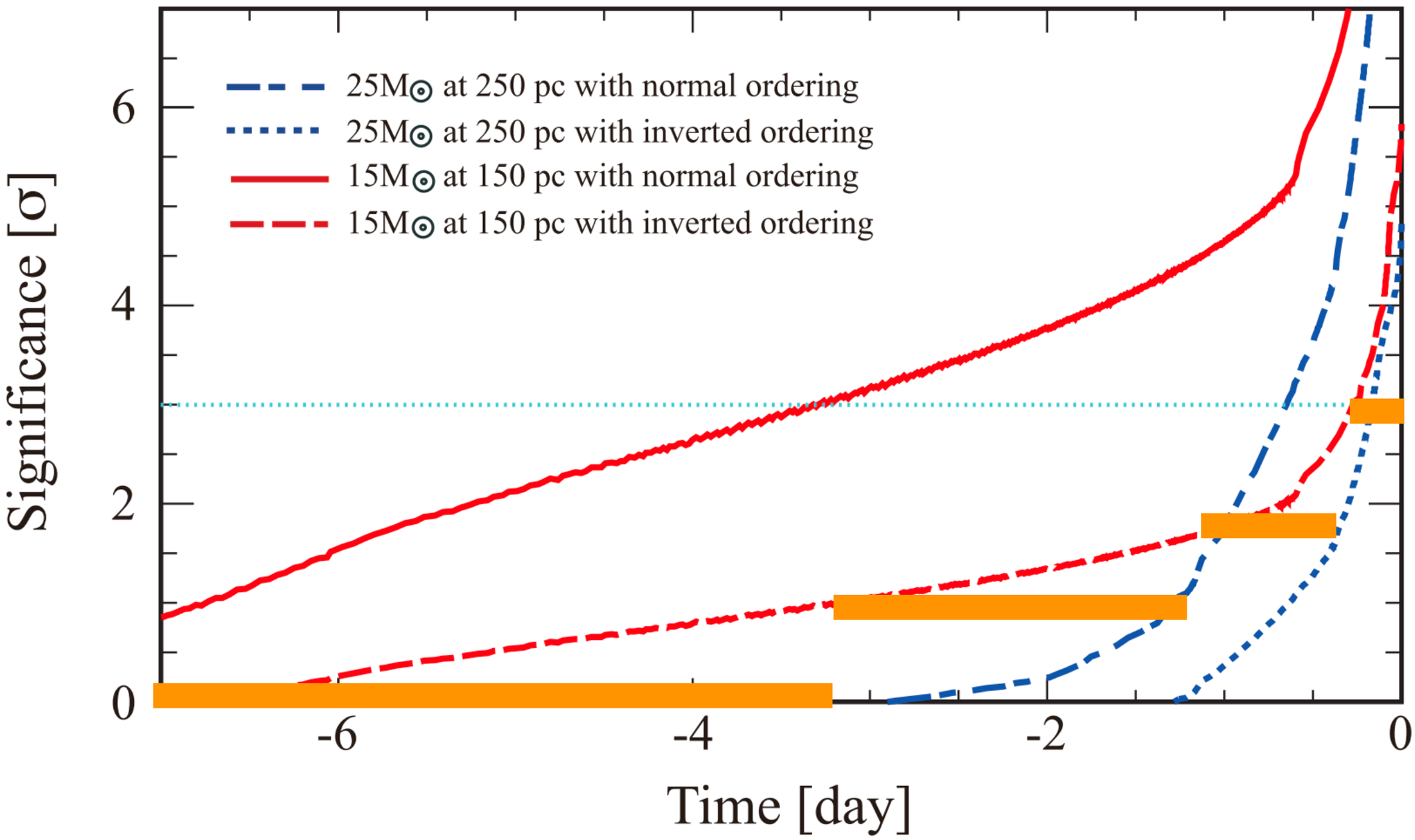
With Odrzywolek model



Detection before collapse is possible.

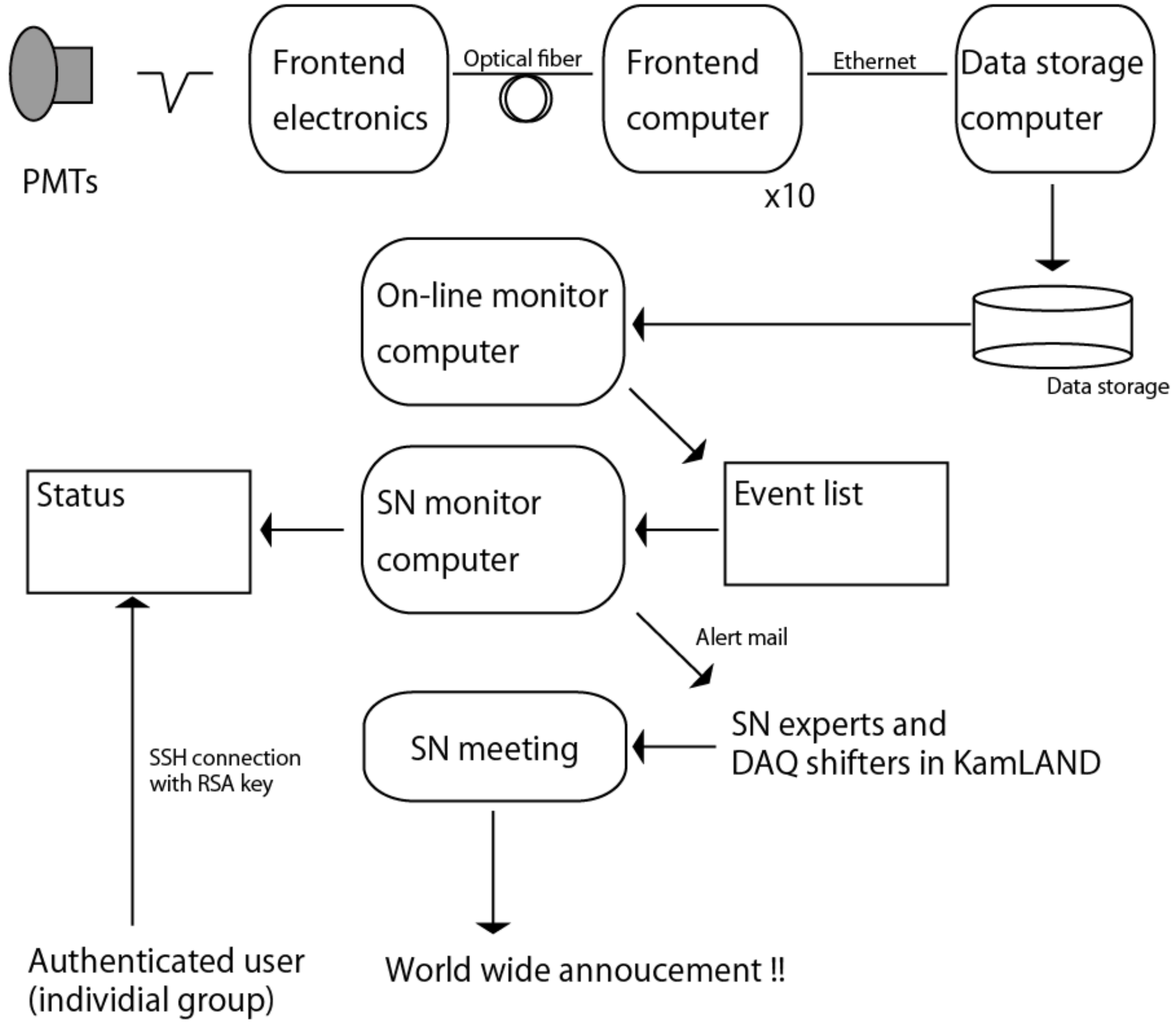
When we detect ?

With Odrzywolek model



Detection before collapse is possible.

PreSNv alarm system



Status

PreSNv alarm system: running from 2015
Example of users: LIGO, VIRGO, XMASS, SNO+, Borexino, astronomer

We are considering the connection to GCN with the private mode.

GWNU

Combined studies for SNe: ongoing

MoU for Data share:

Memorandum of Understanding among the Borexino Collaboration, the IceCube Collaboration, the LVD Collaboration, the KamLAND Collaboration and the LIGO Scientific and VIRGO Collaborations

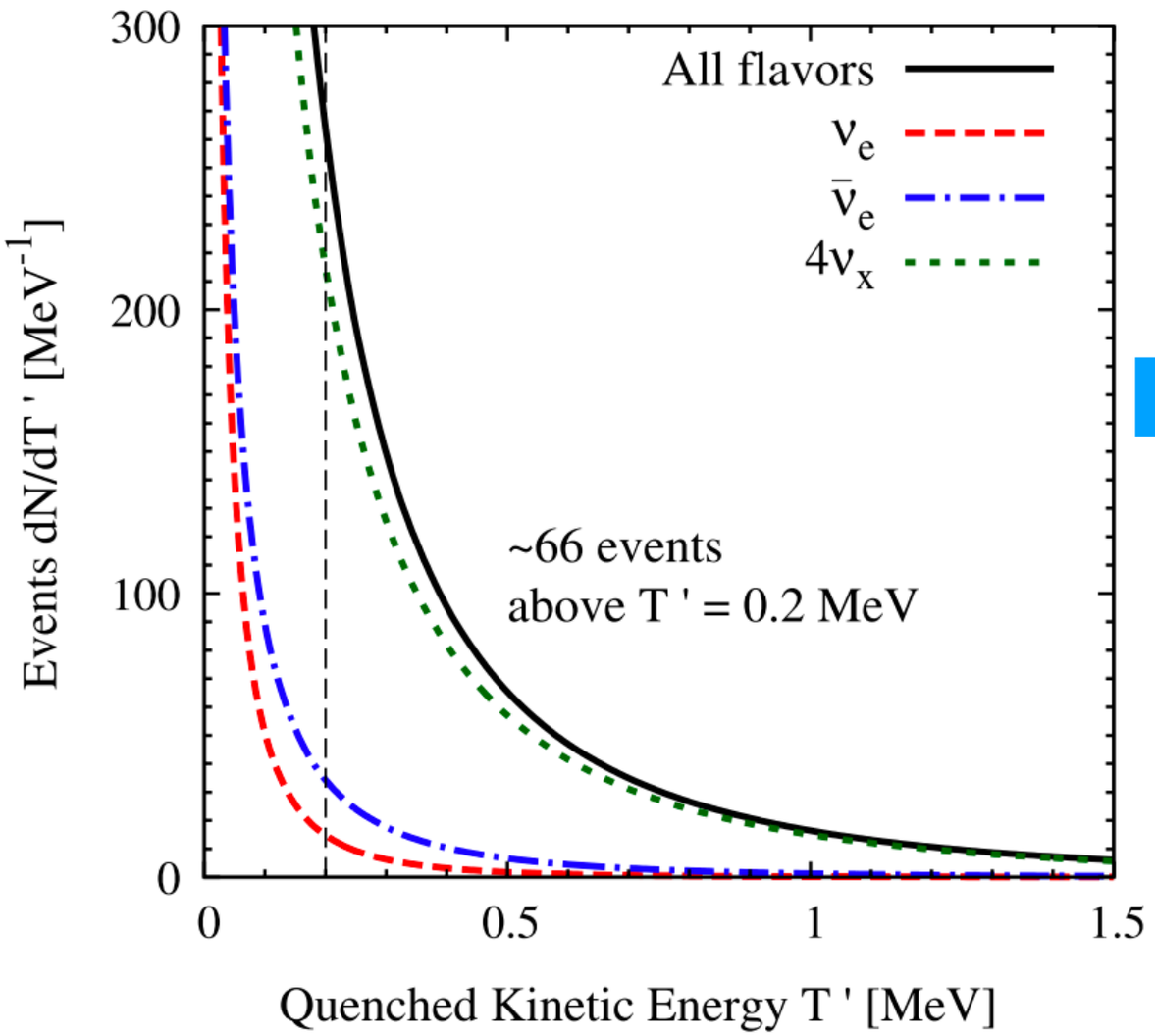
Other SN channel

Proton recoil is an unique channel to study ν_x in LS detectors

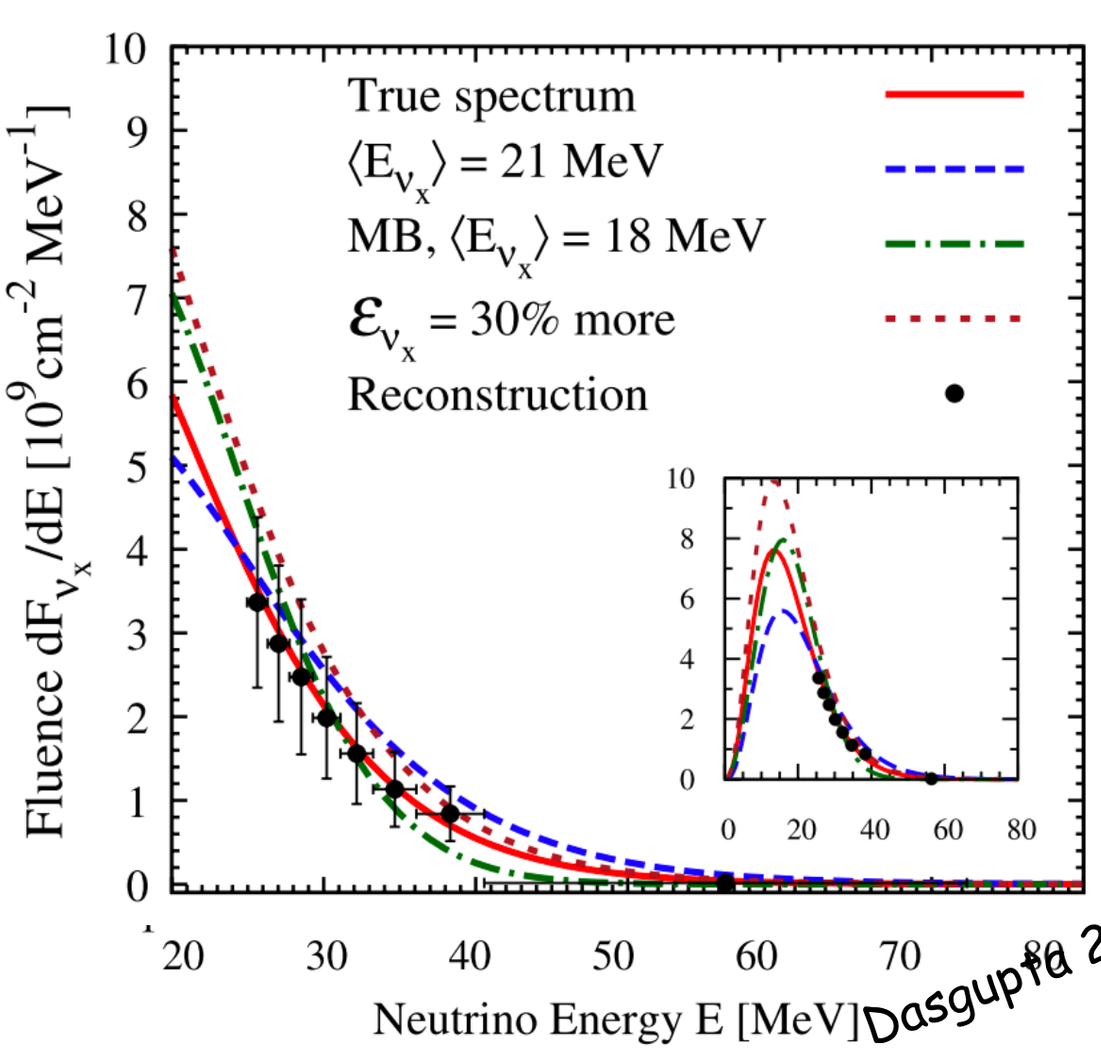
$$\nu + p \rightarrow \nu + p$$

Beacom 2002

Event spectrum



Reconstructed ν_x flux



Dasgupta 2012

Other SN channel

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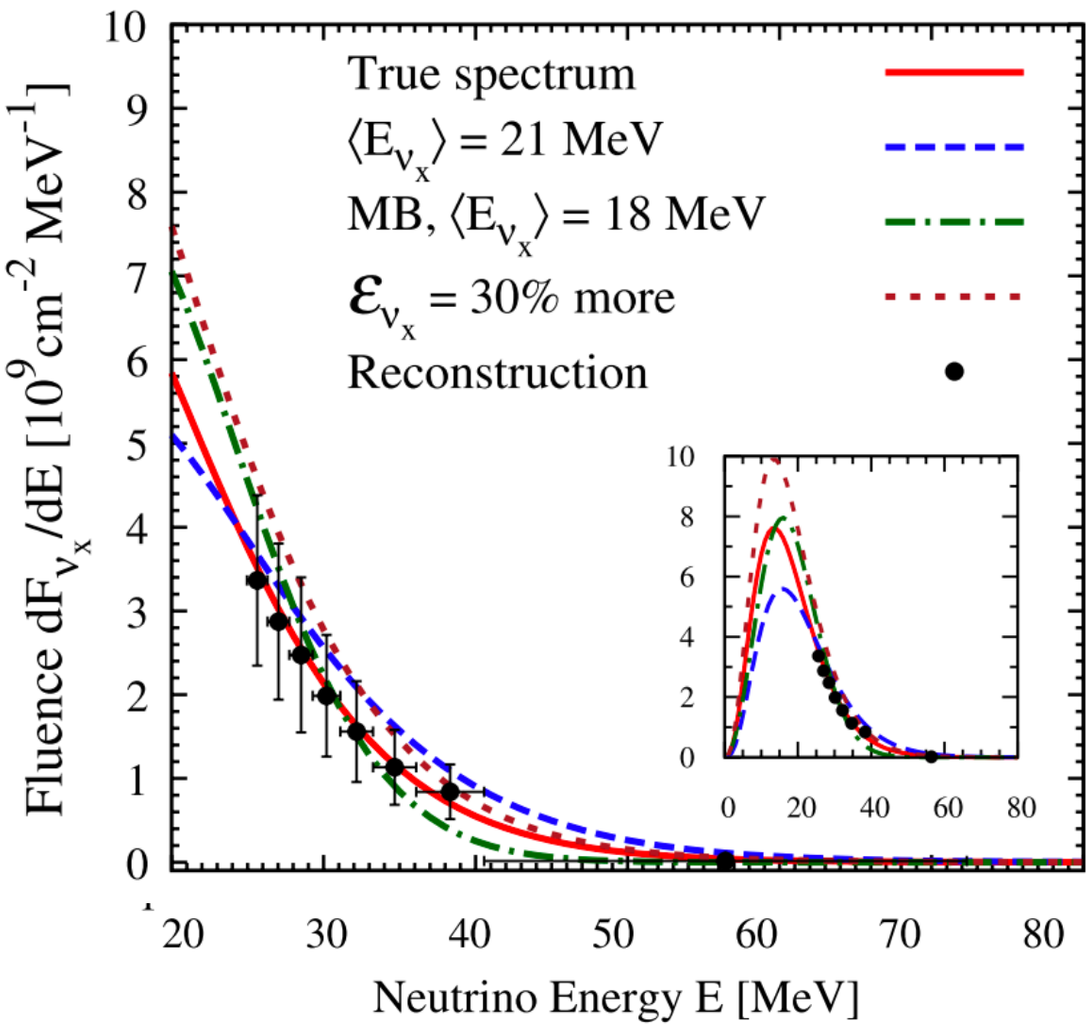
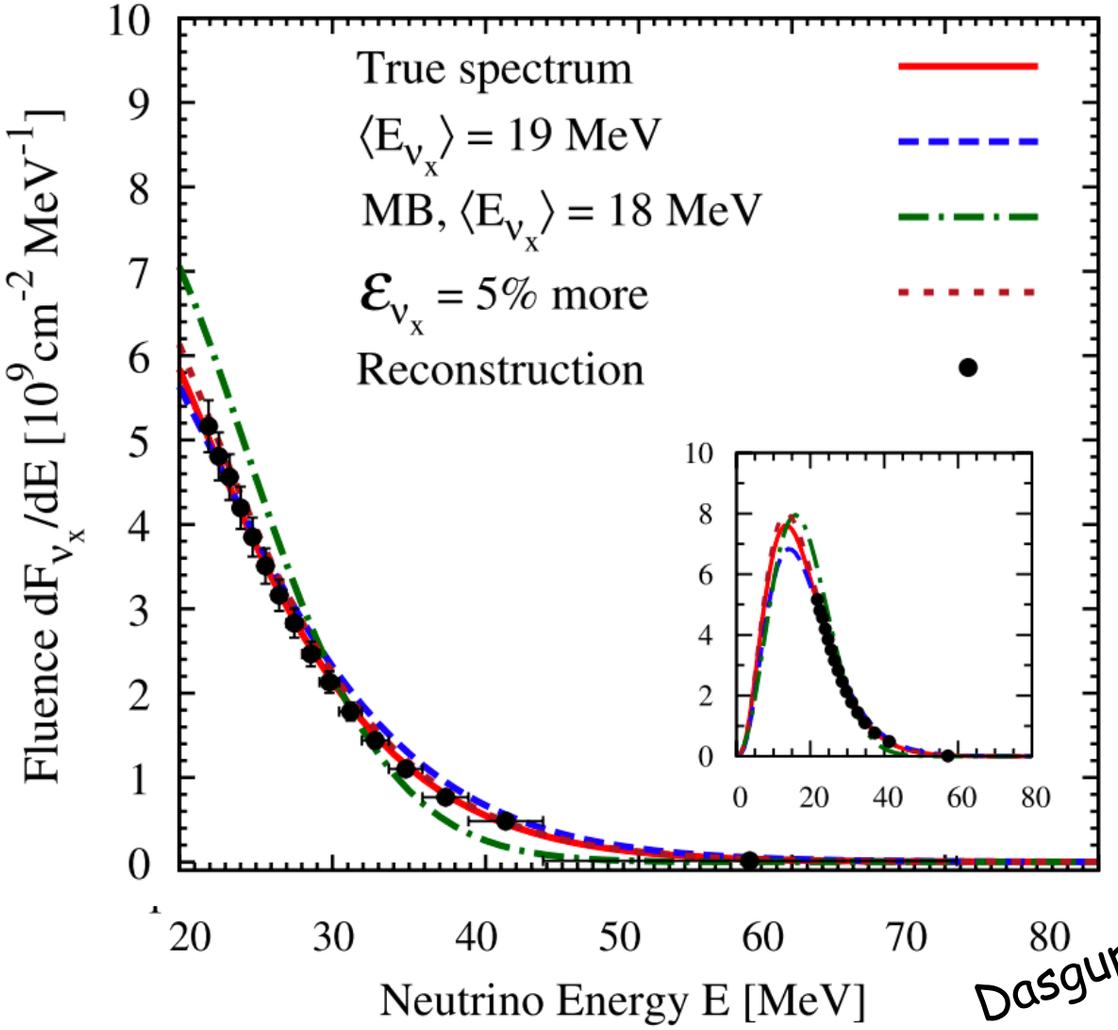
Beacom 2002

Galactic SNe



Nearby SNe



Dasgupta 2012

By the way

DAQ crush!!

KamLAND DAQ: designed for rare-event search

Impossible to record all events in nearby SNe

Overall updates of DAQ: hard works

Updates to avoid crush with on-board SN detection and decimation of the record data.

Updates to record all trigger data

Developments of new front-end electronics with large on-board memory and high speed readout

+ improvements of ^{10}C tagging for 0ν2β search (Takeuchi's poster)

We will install new front-end electronics in the next 5yr.

Other astrophysics with KL

Search for $\bar{\nu}_e$ related to first three GWs ApJL 829 L34 2016

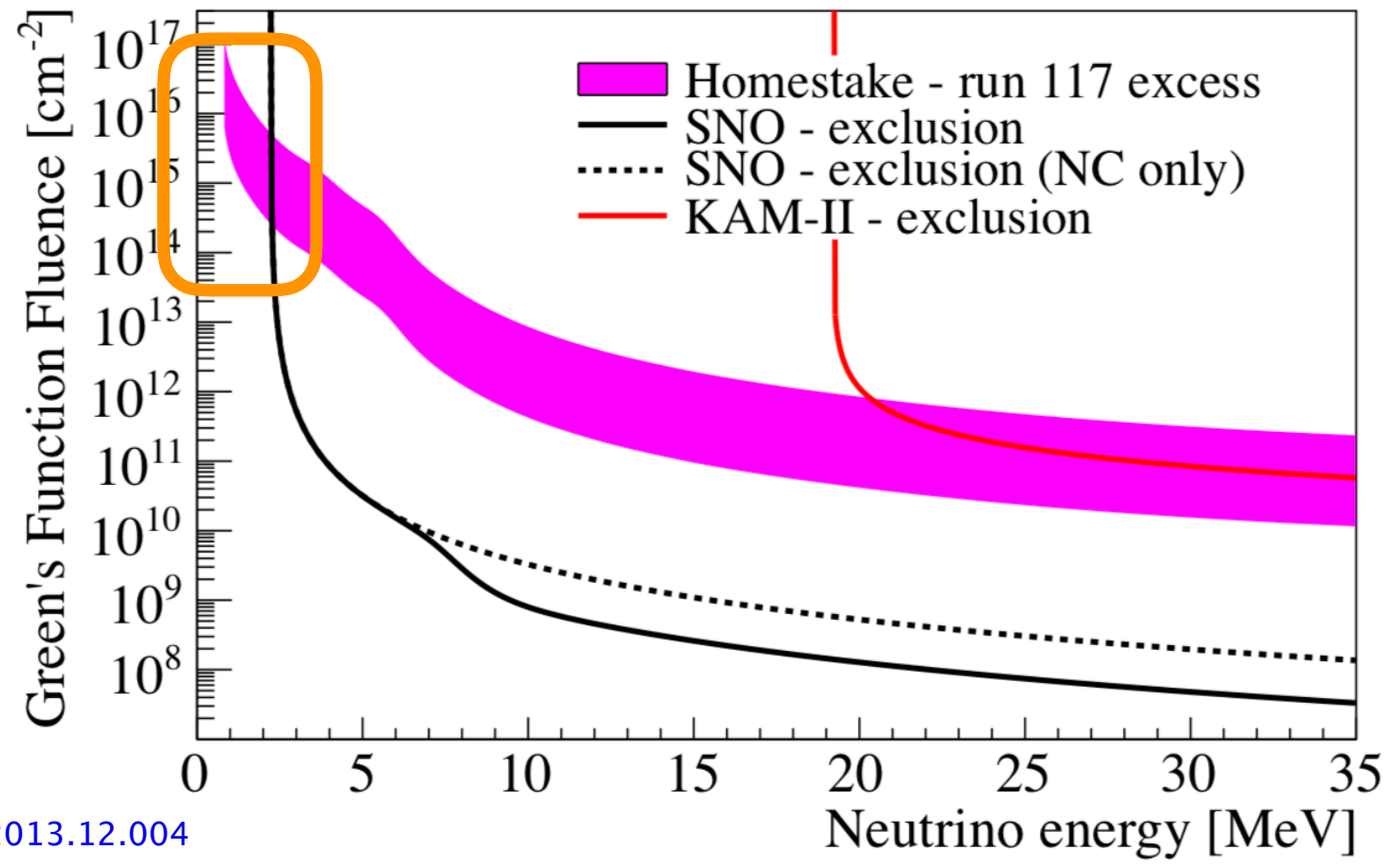
Search for $\bar{\nu}_e$ related to GRBs. ApJ 806 87 2015

Search for ν related to GW (NS-NS merger)

Search for SN relic $\bar{\nu}_e$

Search for charged excitations of dark matter

Search for ν related to solar flares Kawada's poster



j.astropartphys.2013.12.004

Summary

KamLAND:unique detector for nearby SNe at this time

PreSNv monitor: running from 2015

- Strong collaboration with the GW committee
- Future possibility: connection to GCN with private mode

Proton recoil: reconstruction of **SN ν_x flux**

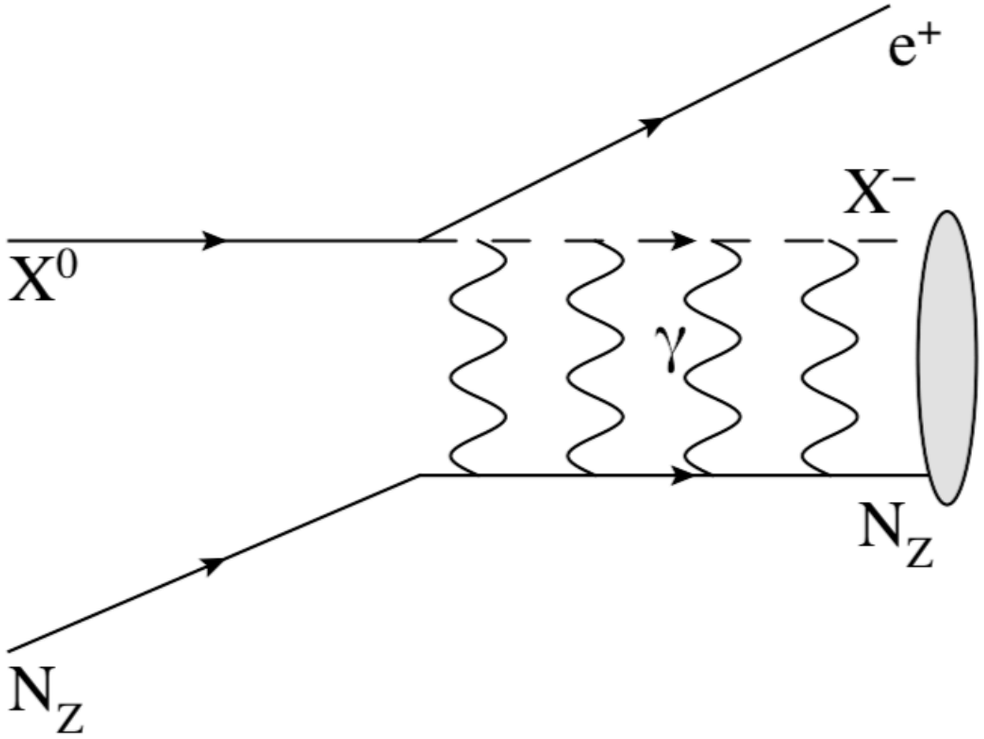
R&D of electronics and DAQ: ongoing

Studies of other astrophysics: ongoing

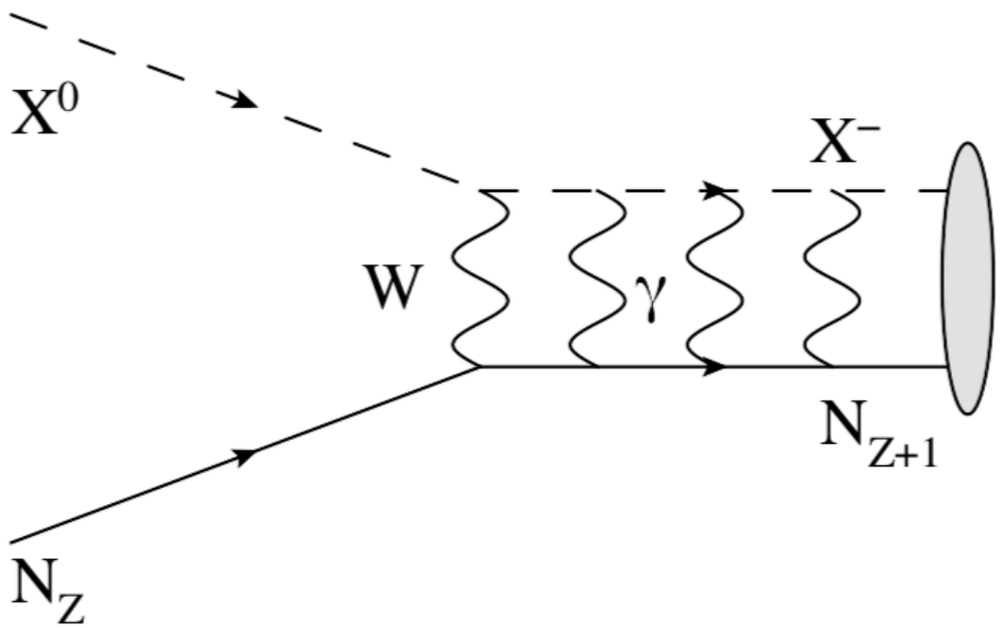
Denote by (NX^-) the bound state of DM with a target nucleus N. Depending on the relation between spins of X^0 and X^- two generic scenarios can be envisaged,

$$\text{Case A:} \quad N_Z + X^0 \to (N_Z X^-) + e^+, \tag{1}$$

$$\text{Case B:} \quad N_Z + X^0 \to (N_{Z+1} X^-) \ , \tag{2}$$

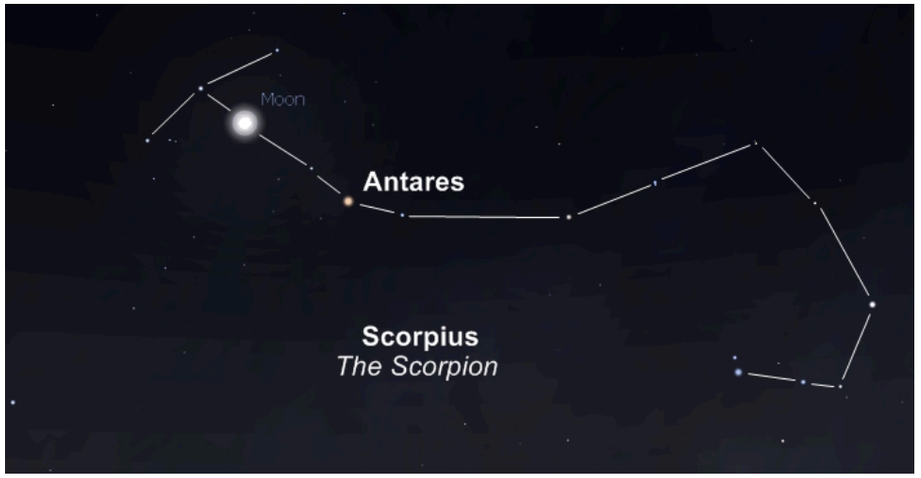


(a)



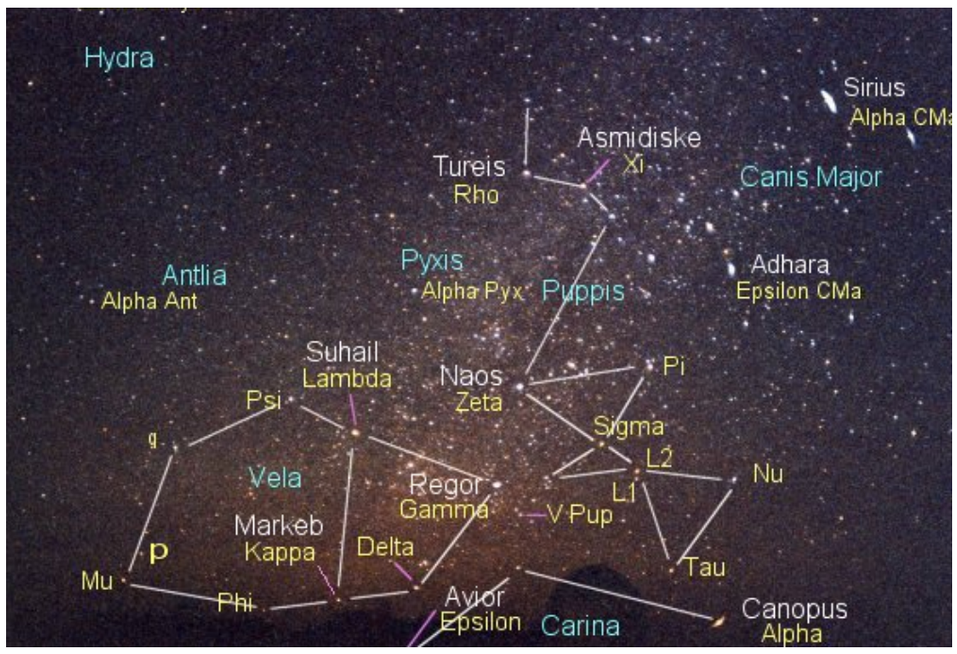
(b)

Background		Period 1 (1486 days)	Period 2 (1154 days)	Period 3 (351 days)	All Periods (2991 days)
1	Accidental	76.1 ± 0.1	44.7 ± 0.1	4.7 ± 0.1	125.5 ± 0.1
2	$^{9}\mathrm{Li}/^{8}\mathrm{He}$	17.9 ± 1.4	11.2 ± 1.1	2.5 ± 0.5	31.6 ± 1.9
3	$^{13}\mathrm{C}(\alpha, n)^{16}\mathrm{O}_{\mathrm{g.s.}}$, elastic scattering	160.4 ± 16.4	16.5 ± 3.8	2.3 ± 1.0	179.0 ± 21.1
	$^{13}\mathrm{C}(\alpha, n)^{16}\mathrm{O}_{\mathrm{g.s.}}$, $^{12}\mathrm{C}(n, n')^{12}\mathrm{C}^{*}$ (4.4 MeV γ)	6.9 ± 0.7	0.7 ± 0.2	0.10 ± 0.04	7.7 ± 0.9
4	$^{13}\mathrm{C}(\alpha, n)^{16}\mathrm{O}^{*}$, 1st e.s. (6.05 MeV $e^{+}e^{-}$)	14.6 ± 2.9	1.7 ± 0.5	0.21 ± 0.09	16.5 ± 3.5
	$^{13}\mathrm{C}(\alpha, n)^{16}\mathrm{O}^{*}$, 2nd e.s. (6.13 MeV γ)	3.4 ± 0.7	0.4 ± 0.1	0.05 ± 0.02	3.9 ± 0.8
5	Fast neutron and atmospheric neutrino	<7.7	<5.9	<1.7	<15.3
Total		279.2 ± 22.1	75.2 ± 7.6	9.9 ± 2.1	364.1 ± 30.5



さそり座アンタレス(170pc)

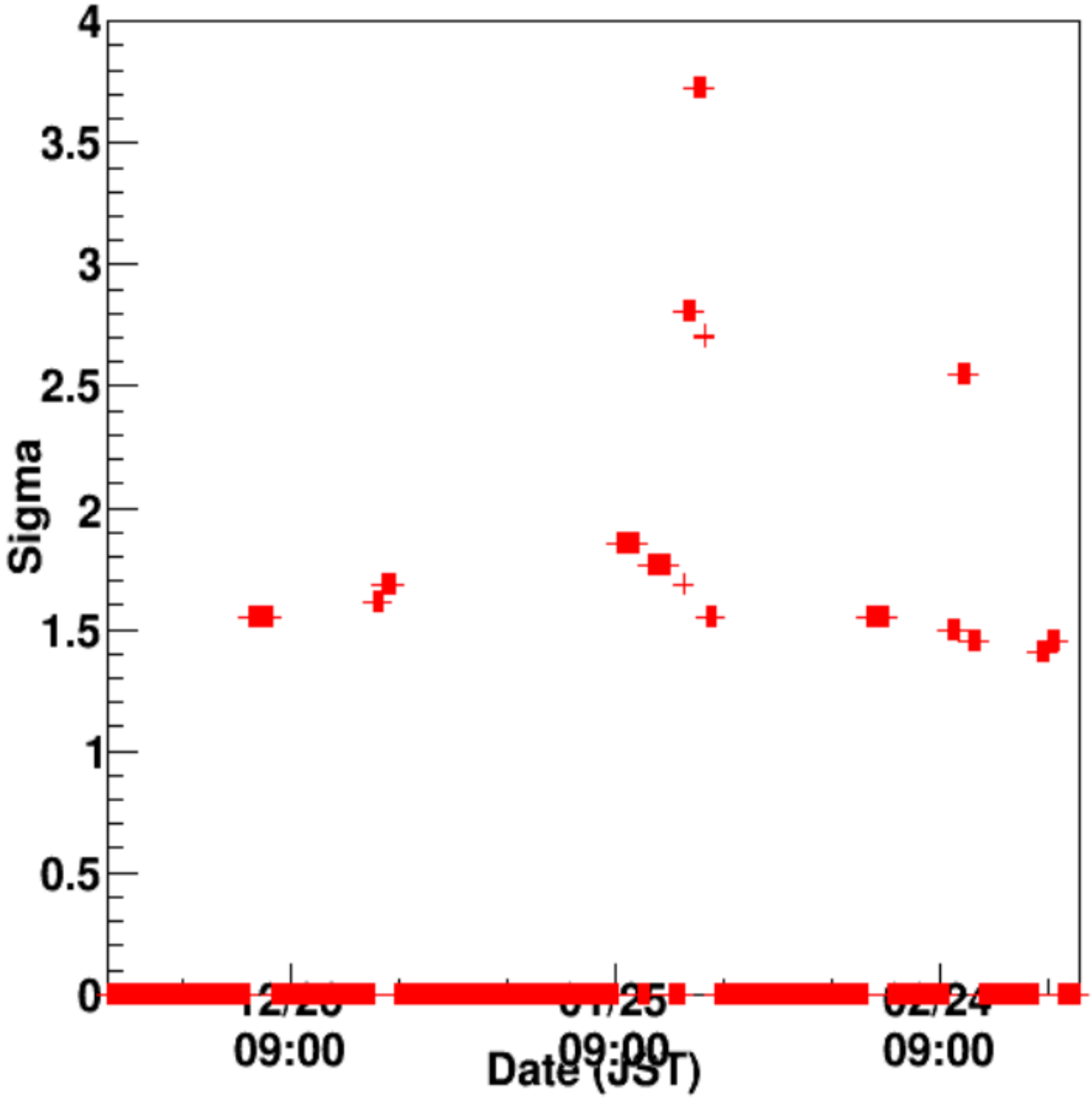
ペガスス座イプシロン星
(210pc)



とも座π(250pc)

(340pc)

おおいぬ座シグマ星 (340pc)


4
3.5
3
2.5
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