Neutrino Signature

GW-Genesis, CO2 group





Yusuke Koshio (Okayama U.)

Area workshop of innovative area "GW-Genesis" Toyama, 10th October, 2018



Innovative area "GW-Genesis"



M.Vagins

Presentations related to neutrino signature

Supernova neutrino experiment - (15:50-17:40)

- Conveners: Koshio, Yusuke

time	[id] title	presenter
15:50	[7] Supernova detection in Super-K Gd	VAGINS, Mark
16:30	[8] Hyper-Kamiokande project overview	SHIOZAWA, Masato
17:00	[9] Supernova detection in Hyper-Kamiokande and future prospect	SHIMIZU, Itaru

Supernova neutrino theory - (09:00-11:10)

- Conveners: Vagins, Mark

time	[id] title	presenter
09:00	[10] Neutrino Transport and Collective Neutrino Oscillations	CHERRY, JJ
09:50	[11] Diffuse supernova neutrino background physics and predictions	HORIUCHI, Shunsaku
10:30	[12] Light curves and other signals from extreme classes of supernovae	BLINNIKOV, Sergei

Several poster presentations

Supernova neutrinos



Time profile of neutrino emission



Kamioka underground detectors



Kamiokande Successor

I.Shimizu

7

Improved measurement of supernova neutrinos in Kamioka detectors





Kamiokande Super-Kamiokande Hyper-Kamiokande 1983 - 1995 - 2027 -1987A KamLAND 2002 -10th October, 2018

SN search at Super-Kamiokande

Super-K to SK-Gd







) spa ; Kar glob ; larg ; larg m_{21}^2 ND r ; l to l m_{21}^2 is 0.0 ; at tl ng wir $2 \theta_{13}^2$ sip² θ

Super-Kamiokande

50kton Water Cherenkov detector



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Super-Kamiokande

Super-Kamlokande

Run 1742 Event 102496 96-05-31:07:13:23 Inner: 103 hits, 123 pE Outer: -1 hits, 0 pE (in-time) Trigger ID: 0x03 E= 9.086 GEN=0.77 COSSUN= 0.949 Solar Neutrino

Time(ns)

- 1075-1095
 >1095

$$E_e = 8.6 \text{ MeV (kin.)}$$

 $\cos \theta_{sun} = 0.95$





How to reconstruct?

Detector performance

Resolution@10MeV Information

vertex	55cm	hit timing
direction	23deg.	hit pattern
energy	14%	# of hits.

~ 6 hits/MeV

well calibrated by LINAC / DT within 0.5% precision

1500

Expected number of events at SK



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Diffuse Supernova Neutrino Background (DSNB)

Neutrinos emitted from past supernovae

S.Ando



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DSNB search in Super-K

Current Super-K w/o neutron tagging S.Horiuchi



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DSNB in upgraded Super-K



- •Delayed coincidence
 - Suppress B.G. drastically for $\overline{v_e}$ signal
 - ΔT~20µsec
 - Vertices within ~50cm

GADZOOKS!

Dissolve Gadolinium into Super-K J.Beacom and M.Vagins, Phys.Rev.Lett.93 (2004) 171101



Proposed in 2004, but not so easy.

EGADS as R&D

(Evaluating Gadolinium's Action on Detector Systems)

Super-Kamiokande

50m

R&D for Gd test experiment

20' PMT

Water system

Purpose

- ✓ Water transparency✓ How to purify
- ✓ How to introduce and remove
- ✓ Effect on detector
- ✓ Effect from
- environment neutrons

Y.Takahira

New hall (10m(w)x15m(l)x9m(h))

200 ton tank

✓ Substitute detector of SN during SK refurbishment

Detailed presentation by M.Vagins

Nater transparency measureme

Approved the project by the Super-K collaboration in 2015 as "Super-K Gd"

Physics expectation in SK-Gd

DSNB flux: Horiuchi, Beacom and Dwek, PRD, 79, 083013 (2009)

It depends on typical/actual SN emission spectrum



DSNB events number with 10 years observation

Total (positron) energy MeV

HBD models	10-16MeV (evts/10yrs)	16-28MeV (evts/10yrs)	Total (10-28MeV)	significance (2 energy bin)
T _{eff} 8MeV	11.3	19.9	31.2	5.3 σ
T _{eff} 6MeV	11.3	13.5	24.8	4.3 σ
T _{eff} 4MeV	7.7	4.8	12.5	2.5 σ
T _{eff} SN1987a	5.1	6.8	11.9	2.1 σ
BG	10	24	34	

Physics expectation in SK-Gd

For Supernova burst neutrinos



Multi-messenger signals

complementary observation with 3 signals! 500 neutrino ~ |0s 400 ravitational wave Gw . β events/day 005 005 electromagnetic 2. 100 Y.Suwa's art **Y**.Nakano -12 No significant signal associated with GW150914, GW151226, GW170104, GW170817 GW150914 **GW151226** 90% C.L. limit on fluence considering UPMU 32.2 34.8 29.6

Fluence Limit [cm

SN warning by pre-neutrino signal



PRE-SUPERNOVA MONITORING					
	Detector mass	Maximum observation range	% of the Galactic <i>pre-supernovae</i> in the range		
GADZOOKS!	32 kt	0.5 kpc	0.1%		
Hyper-Kamiokande	0.5 Mt	2 kpc	2%		
Single deep ocean balloon	10 Mt	10 kpc	50%		
GIGATON ARRAY	1 Gt	100 kpc	100%		

Important for obtaining light curve

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Schedule of the Super-K Gd

Start refurbishment of Super-K on 31st May, 2018



SN search at Hyper-Kamiokande

Promising future experiment



Notre-Dame de Paris



~ 180.000 m³

M.Shiozawa, I.Shimizu

Hyper-Kamiokande



Expected number of events at HK



Fruitful physics targets



Search for nearby galaxy in HK

Cumulative calculated supernova rate



DSNB at Hyper-K

expected number of events



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DSNB at Hyper-K

expected spectrum



Toward the observation start

- Selected 'Roadmap 2017' in MEXT (Japanese funding agency) as one of the 17 highestpriority large-scale projects in japan.
- The president of UTokyo is making all efforts to get funded.
- Seed funding has been allocated within MEXT budget request for JFY2019.
- UTokyo pledges to ensure construction commences as scheduled in April 2020.
- We are aiming to start observation in 2027.

Thank you for your attendance!

