GADZOOKS! project at Super-Kamiokande

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for Super-K collaboration

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GADZOOKS! project

Gadolinium Antineutrino Detector Zealously Outperforming Old Kamiokande, Super!

Identify $\bar{v}_e p$ events by neutron tagging with Gadolinium in SK. Gadolinium has large neutron capture cross section and emit 8MeV gamma cascade. Beacom & Vagins PRL.93, (2004) 171101





Supernova Relic Neutrino (SRN)



Theoretical flux prediction : 0.3~1.5 /cm2/s (17.3MeV threshold)

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Search for SRN at Super-K

Search window for SRN at SK : From ~10MeV to ~30MeV



Now SRN search is limited by BG. We need BG reduction by the neutron tagging which can be achieved by GADZOOKS! 5

EVALUATING Gadolinium's Action on Detector Systems 200 m³ tank with 240 PMTs



Transparency measurement (UDEAL)







15m³ tank to dissolve Gd

Gd water circulation system (purify water with Gd)

EGADS detector: Baby-Kamiokande



One of main goals for EGADS is to study the Gd water quality with actual detector materials. Thus, the detector fully mimic Super-K detector. : SUS frame, PMT and PMT case, black sheets, etc.

Gd dissolving test has been performed since Oct.2014. (see next page)



Transparency of Gd water with PMTs



The light left at 15 m in the 200m³ tank was ~75% for 0.2% $Gd_2(SO_4)_3$, which corresponds to ~92% of SK-IV pure water average.

Where we are now?

- Now, we are summarizing the R&D results and making a proposal.
- A committee which was formed to review and evaluate the proposal has started the review.
- After the review of the committee, we will start collaboration wide discussion in this June.
- If the proposal is approved, more detailed plan will be made also with T2K members.

Summary

- GADZOOKS! is a project to upgrade Super-K, so that SRN \bar{v}_e can be tagged by the delayed coincidence signal from a neutron capture of Gd.
- EGADS detector was build for R&D of Gd water purification system and check Gd effect to Super-K.
- EGADS has been keeping a good water quality with the target Gd concentration after PMT installation.
- Collaboration wide discussion to decide the Gd installation to Super-K will start in June (two weeks).

Improvement for Proton decay

Neutron multiplicity for



If one proton decay event is observed at Super-K after 10 years Current background level: 0.58 events/10 years Background with neutron anti-tag: 0.098 events/10 years

Background probability will be decreased from 44% to 9%.

Supernova burst case



Pointing accuracy (1000 simulations for 10kpc supernova)



Improve pointing accuracy e.g. $4 \sim 5^{\circ} \rightarrow 3^{\circ}(90\%$ C.L.) for 10kpc.

Transparency of Gd-loaded water (before mounting PMTs)



The light left at 15 m in the 200m³ tank (stainless steel) was ~69% for 0.2% $Gd_2(SO_4)_3$, which corresponds to ~84% of pure water.

Thermal Neutrinos during Si burning phase

A.Odrzywolek, M.Misiaszek, M.Kutschera, AIP Conf. Proc. 944, 109(2007)



In this paper, distance is assumed to be 0.13kpc. So, the numbers must be reduced to 50%. Neutrinos during the Si-burning phase can be used for precursor of core collapse.

SRN upper limit from SK PRD 85, 052007 (2012) SK combined 90% C.L. (SK4 is not included yet)

