SK-Gd project: Status

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on behalf of the Super-K collaboration

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Super-Kamiokande Gd project

- Super-Kamiokande: Successful neutrino experiment located in Kamioka-cho (Hida-shi, Gifu-ken)
- SK-Gd project: load Gd in SK in order to detect neutrons from $\bar{\nu}$ interactions.
  - Gd: largest neutron capture cross-section among stable elements, and clear signal.
- Main goal: detection of Supernovae Relic Neutrinos (SRNs): Diffuse background of neutrino coming from the past supernova bursts in the universe.
- Other physics goal: $\nu$ / $\bar{\nu}$ discrimination, Si-burning pre-supernovae neutrino, etc.
What is needed for the SK-Gd project?

- Test the impact of Gd on water transparency and on SK detector materials → EGADS prototype
- Fix the leak of the detector in order to avoid Gd leakage to the environment.
- Reduce the radioactivity background coming from the Gd powder, which would affect the SRNs and Solar $\nu$ analysis.
- Prepare dedicated water system for Gd water purification.

Important news

In last July, the decision to open the Super-K tank was officially taken.

We will open the tank on June 1st 2018!

The goal is to fix the leaks and to replace the dead PMTs. This will be an important step toward the fulfillment of the SK-Gd project.
EGADS prototype

- EGADS prototype: 200m$^3$ Water Čerenkov detector build using the same materials than SK. Load with 0.2% of Gd sulfate
- Successful demonstration of the stability of Gd-loaded water Čerenkov detector
- Now aiming at detecting SNe as a standalone detector, in order to backup SK during the tank opening
EGADS water transparency

Blue band: SK-III and SK-IV water transparency values

Black dashed line: final Gd sulfate concentration

Sampling position:
- Bottom
- Centre
- Top

Cherenkov Light Left (%) at 15 m

EGADS Gd$_2$(SO$_4$)$_3$ + x · H$_2$O concentration [ppm]
In order to be able to register SNe, new electronics were installed: "QBEE" electronics (SK-IV like electronics), see talk by Lluis [12aU32-8]

Due to the new electronics installation, new calibration has been performed, see talk by Takahira-san [12aU32-9]
Leak fixing

- In order to avoid Gd leakage to the environment, we need to fix the leaks of the tank.

- Since last JPS meeting, there were some improvements on the current leak measurement: \( \sim 1 \) ton/day, data indicates that the main leak is located at the bottom of the tank.

- Development with Hodogaya company of a sealant material with good mechanical properties and low Rn emission.

- Several tests are on-going to check the behavior of the sealant material in very high humidity environment (as inside SK). Results are promising.
In order to reduce the background in the SRNs and Solar \( \nu \) analysis, the radioactivity background from Gd powder needs to be minimalized.

New radiopurity measurement method developed in order to obtain more precise values, see S. Ito-san talk [15pT11-3]

<table>
<thead>
<tr>
<th>Chain</th>
<th>Isotope</th>
<th>Goal (mBq/kg)</th>
<th>Company A Ge</th>
<th>Company B Ge</th>
<th>Company C Ge</th>
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<td>ICPMS</td>
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<td>238U</td>
<td>238U</td>
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<td>(\sim 0.7)</td>
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<td></td>
<td>226Ra</td>
<td>(&lt; 0.5)</td>
<td>0.7 ± 0.4</td>
<td>(\sim 0.2)</td>
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<tr>
<td>232Th</td>
<td>232Th</td>
<td>(&lt; 0.05)</td>
<td>(&lt; 1.3)</td>
<td>(\sim 0.2)</td>
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<tr>
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<td>227Ac/Th</td>
<td>(&lt; 3)</td>
<td>(&lt; 3.1)</td>
<td>(&lt; 2.3)</td>
<td>(&lt; 1.9)</td>
</tr>
</tbody>
</table>

Thanks to the work with the different companies, we are close to our goal.

EGADS prototype will be drained next month and filled with Company C best sample.
A dedicated water purification system has been developed and installed in the Kamioka mine for the SK-Gd project.

In 2018, after the tank opening, we plan to use it in order to improve the water quality early right after the filling. This will be the first real test of the system.
The next main steps for the SK-Gd project are the following:

- $T_0$: Super-K tank opening, leak fix, and PMTs replacement
- $T_1$: Load first batch of Gd sulfate (up to 0.02%)
- $T_2$: Load full batch of Gd sulfate (0.2%)

$T_0$ has been decided to be **June 1st 2018**

If everything go well, we can expect $T_1$ (loading Gd in the Super-K) in 2019
SK collaboration is preparing to analysis Gd neutron capture data:

- Improvements are being done on the simulation of the Gd neutron capture ($\gamma$-rays distribution, and detector simulation), see talk by Hagiwara-san [12aU32-10]

- Improvements on the neutron tagging algorithm, see talk by Ka-Ming Tsui [12aU32-11]

- Studies on the sensibility of T2K after SK Gd loading, see talk by Nakajima-san [12aU32-12]

- Studies on some new physics which could be studied with Gd neutron capture, like the detection of pre-supernova stars antineutrino, see talk by Charles [12aU32-13]
Summary

► Loading Gd in Super-Kamiokande will improve the sensibility of the neutron captures detection, and may allow to detect the first Supernovae Relic Neutrinos within 10 years.

► Several progresses have been done in the last months:
  ▶ Upgrade of the EGADS prototype’s electronics
  ▶ Improvements on the leak fixing
  ▶ Improvements on the Gd powder radiopurity
  ▶ Analysis preparation
  ▶ Etc.

► The next main step is now in June 2018 with the tank opening

► Several SK-Gd related talks will be presented in this JPS Conference, which will give you more details about the different topics of the project
Looking for Supernovae Relic Neutrinos (SRN)

- Since 30 years (1987), we know that Supernovae (SNe) produce neutrinos.
- The study of Supernova neutrinos can provide more insight of how the SNe happen and then a better understanding of our universe.
- However, current detectors, like Super-K, can detect neutrino burst only from near-by SNe. Expected rate: $\sim 1/30$ yrs.
- But SNe happen in the visible universe every seconds. They should also produce a diffuse background of neutrinos: the **Supernovae Relic Neutrinos**.
- Super-K is aiming to the detection of these SRNs.