Water flow analysis and Rn background after loading Gd in Super-Kamiokande

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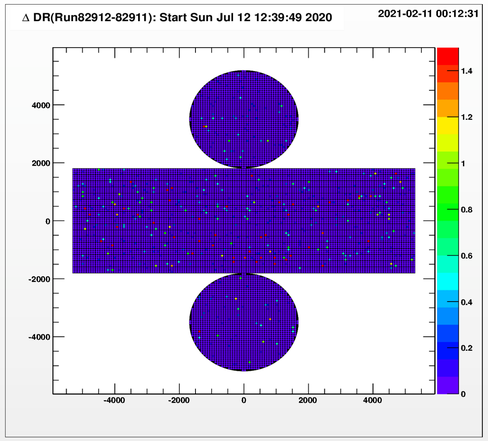
1. Motivation; “2 big issues for Solar *v* study in Super-Kamiokande”

1) Dark noise in SK tank had been increasing since SK-Gd started.



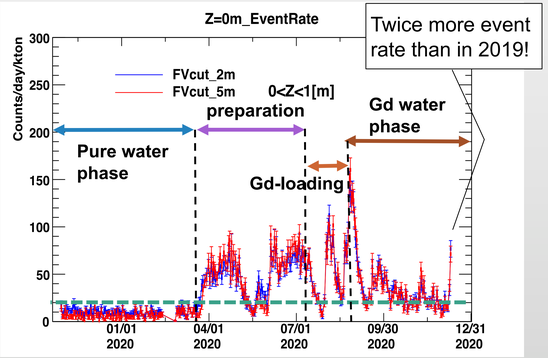
It seems the water itself emits photons and the strong emission is observed where the water flow is stagnated.
Aiming to resolve the stagnation, **the flow control and the supply water temperature were changed on Nov.27 2020.**
In order to evaluate this, ^{222}Rn was injected to SK tank at certain 3 positions as the flow tracer before(1st injection) and after (2nd injection) the flow change.

1st injection(Nov.7)　　**2nd injection(Dec.8)**

~8[Bq/L] Rn injected at 3 vertices

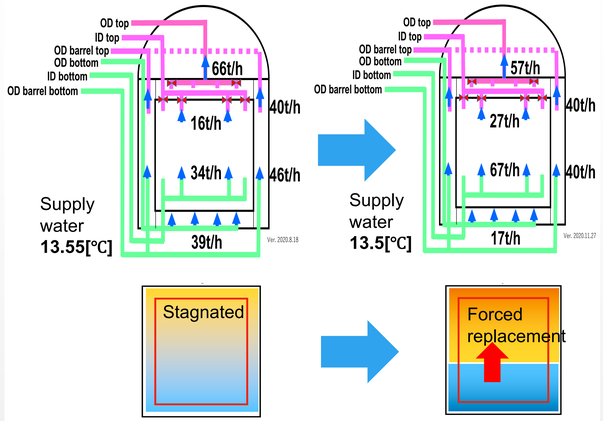
center: 6.2±0.2[Bq/L]
z=10m: 4.7±0.2[Bq/L]
wall: 6.0±0.2[Bq/L]

2) Low energy (<5MeV) event rate is higher than that in pure water phases.



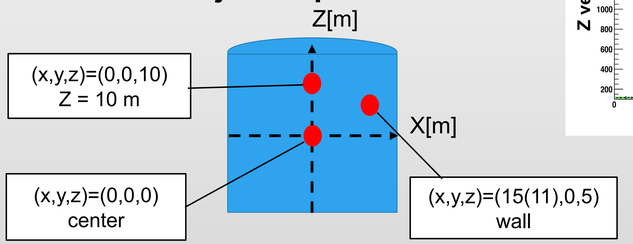
The reason might be that the 13 tons of $Gd_2(SO_4)_3 \cdot 8H_2O$ loaded to SK had ^{226}Ra(<0.05mBq/kg) and ^{228}Ra (0.5mBq/kg) contaminations.
↓ To check if the increase of the rate is consistent with the RI contaminations…
①The ^{222}Rn concentration in the tank was directly measured by Rn detectors[1].
②The expected event rate from ^{222}Rn was derived and compared with real data as the injected Rn concentration in 1) was estimated independently shown above.

2. Water flow analysis

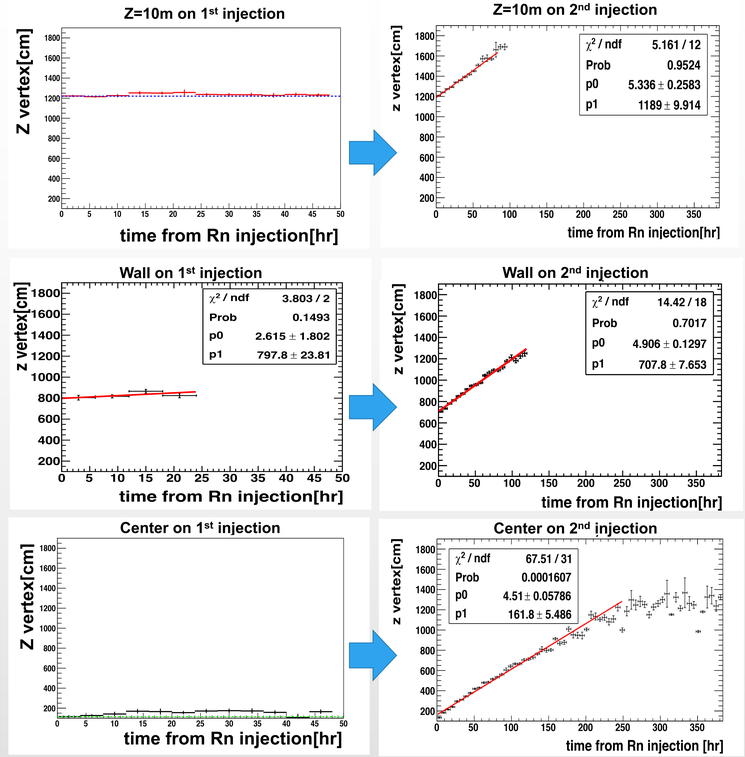


Both before and after changing the water flow, Rn was injected at 3 positions as shown below and Z direction movement of the Rn signal was plotted as shown on the right 6 graphs.

Injected position



Rn signal z vertex distribution
Fitted function **[p0]*x + [p1]**



→ almost no vertical flow everywhere

→ Flow was moving at a speed of ~5cm/h in + z direction everywhere
→It also seems to be stagnated again after 250 hr.

3. Rn concentration & SK event rate

Z [m]	date	Rn concentration (mBq/m^3)	Predicted Event Rate (cts/day/kton)	Real Event Rate (cts/day/kton)
0	2020/11/24	1.24±0.32	17.3±4.52	27.8 (0<Z<1[m])
12	2020/11/25	0.988±0.258	13.8±3.62	18.5 (12<Z<13[m])
-14	2020/10/26	2.76±0.41	38.4±5.87	102.5 (-14<Z<-13[m])

Most fraction of the observed event rate can be explained by ^{222}Rn except for bottom.

→ The remaining Rn in the 1st Rn injection might affect the result.

→ We will measure Rn concentration on February 2021.

4. Summary and future prospect

- By the Rn injections, it was confirmed that **the water flow had been stagnated and 5cm/h-upward-movement was recovered after changing the water flow.**
  → **The dark noise got decreased.** Something has been purged out?
- From the Rn study, it turned out that most of the observed low energy events(Z>0m) at this stage are ^{222}Rn background.
- **Investigate light emission from bacteria? as the noise source.**
- **Continue to make quantitative comparisons of the event rate and the Rn concentration to judge the effect of RI contaminations.**

Reference [1]Y.Nakano et al（2020),Nucl. Inst. Meth A, 977(11.Oct.2020) 164297, arXiv: 1910.04823, p2~7