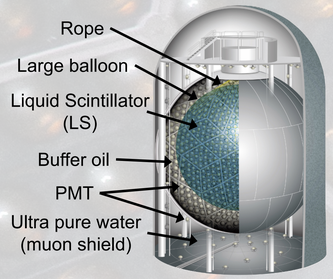
Development of a Large Low-Radioactivity Balloon for KamLAND2

Natsu Obata, on behalf of the KamLAND Collaboration
Research Center for Neutrino Science, Tohoku University, Japan

Upgrade plan

KamLAND2 (Early 2028-)

→ See Kawada's poster #260

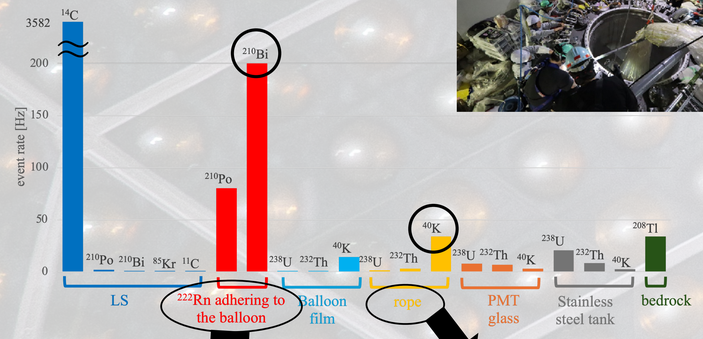


■ Detector upgrade
- High Quantum Efficiency PMT (x1.9)
- Light-collection mirror on PMT (x1.8)
- High transparency liquid scintillator (x1.4)

■ Balloon
- **Low radioactivity Balloon**
- **Low radioactivity Rope**

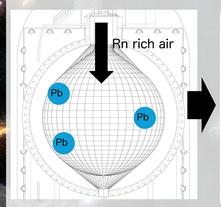
■ Enhanced Energy Resolution
- ~5-fold increase in light collection expected
- σE: 4% → 2% @2.45 MeV
- 2νββ background suppression: ~1/100

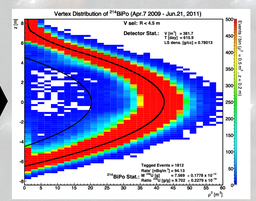
Reduce RI of Balloon

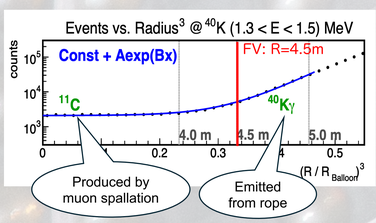


- ^{210}Bi was attached to the balloon surface
- The production environment was not sufficiently clean

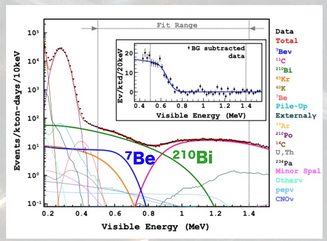
FV limitation of ^{7}Be solar neutrino







BG for ^{7}Be solar neutrino

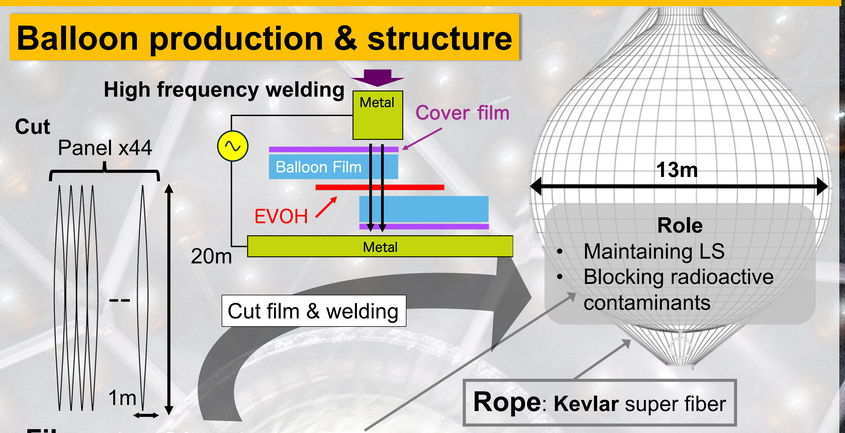


Improvement list

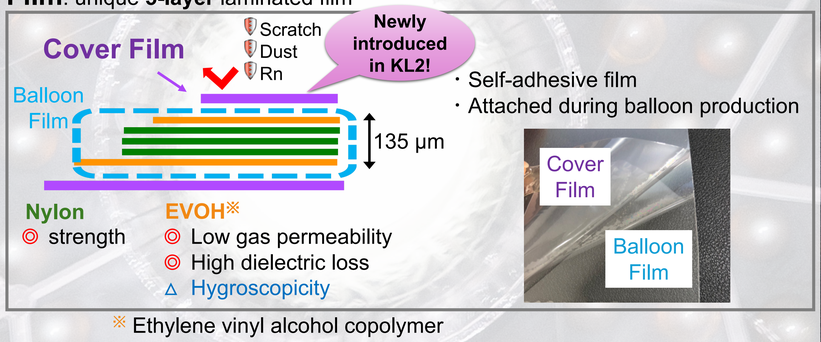
- Use low Rn air
- **Optimize the production environment → Cover film**
- **Reduce radioactive impurities in the rope**

This work

Balloon production & structure



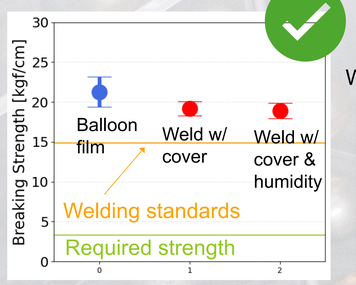
Film: unique **5-layer** laminated film



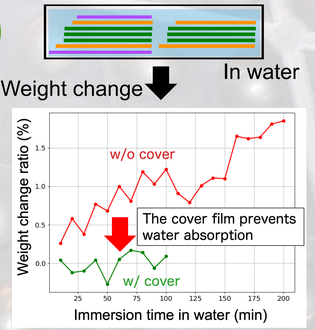
※ Ethylene vinyl alcohol copolymer

Quality validation

Effect on welding



Effect by humidity



- No adverse effect on weld strength
- No degradation under high-humidity conditions
- Suppresses moisture absorption

→ The cover film is suitable for KamLAND2 balloon production.

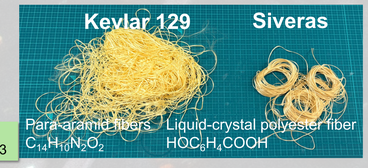
Rope

KamLAND1: **Kevlar 29**, **9000 lbs** strength (**52 g/m**)

KamLAND2: ▶**Material** with lower radioactivity | ▶Minimum required **strength**

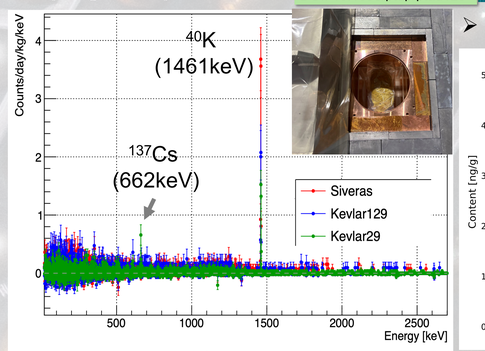
Materials

- Candidates: Kevlar 129, Siveras
- Radioactivity assay results:

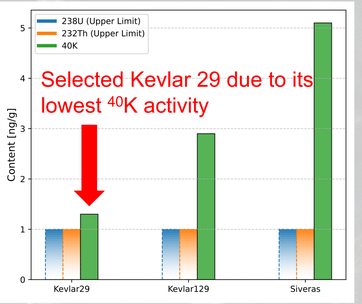


➢ By High-Purity Ge detector

K Ichimura
DOI: 10.1093/ptep/ptad123



➢ By ICP-MS (U, Th, K)



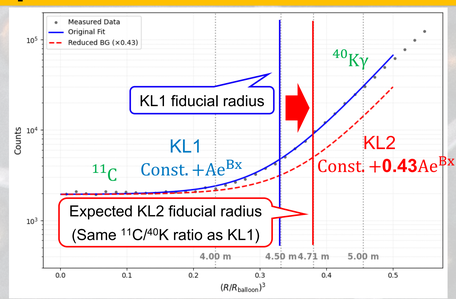
Strength

- Required strength for KL2: **16kN**
- KL1: 9000 lbs (40kN) → **KL2: 4000 lbs (17.8kN)**
  52.0 g/m → 22.2 g/m

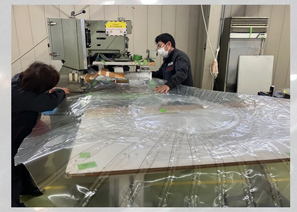
57% reduction in material quantity

KamLAND2 uses a **4000-lbs Kevlar 29** rope

Expected increase in the ^{7}Be-ν fiducial volume



Rope mass ×**0.43**
↓
^{40}K background reduced
↓
Same ^{11}C/^{40}K ratio
↓
Fiducial volume 29%↑

Summary

- ✓ Developed a low-radioactivity balloon with a cover film and optimized rope to suppress backgrounds and increase the fiducial volume for ^{7}Be neutrinos measurement
- ✓ Quality validation completed for production conditions
- ✓ Full-scale manufacturing starts October 2026; KamLAND2 operation begins early 2028