



Imaging camera at KamLAND

**Koji Ishidoshiro, Syouhei Ishio,
Hiroko Watanabe, Tadano Mitsui
(Tohoku university)**

KamLAND

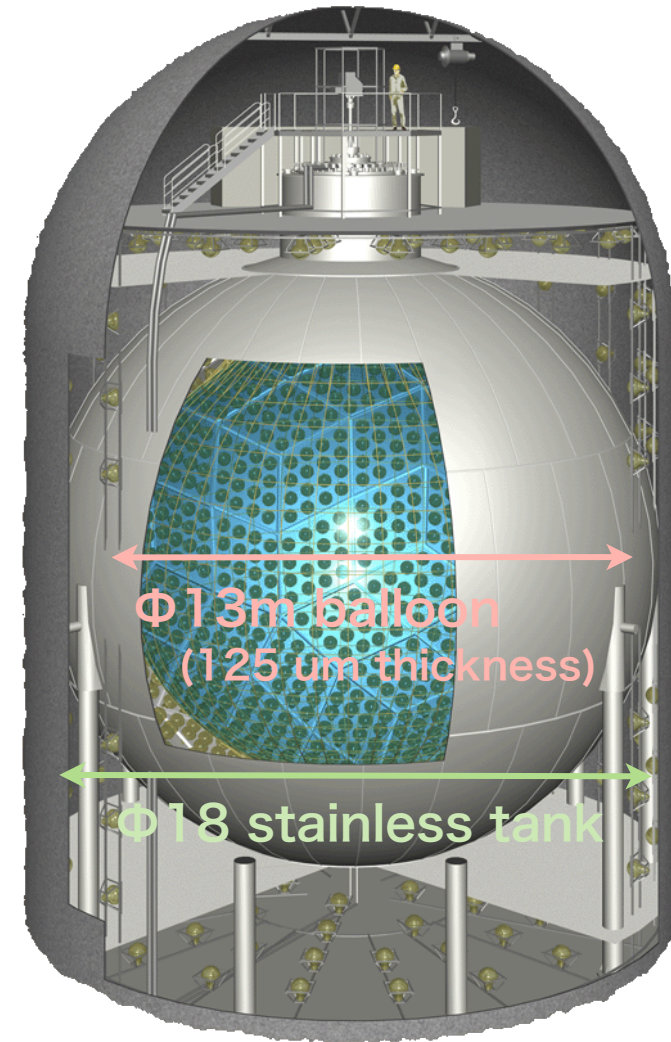
Kamioka Liquied scintillator
Anti-Neutrino Detector (since 2002)

1 kt Liquid Scintillator
Dodecan (80%), Pseudocumene (20%), PPO (1.36g/l)

1,325 17inch + 554 20inch PMTs



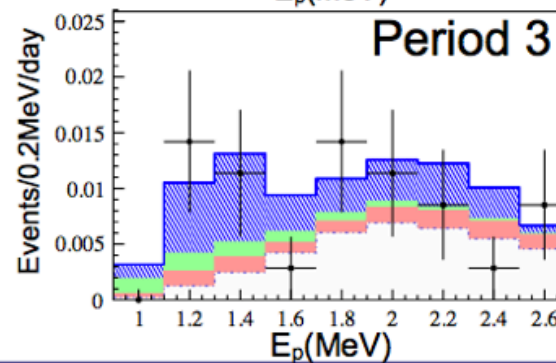
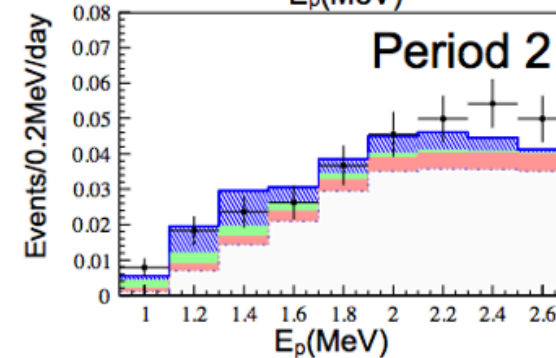
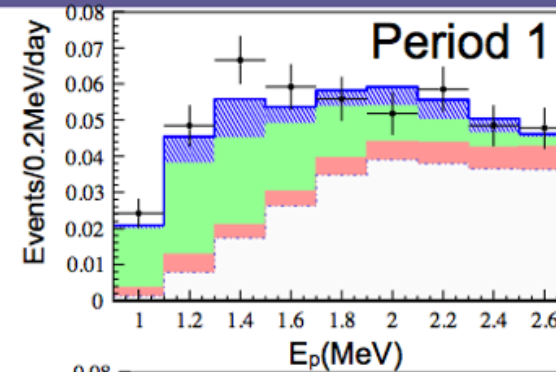
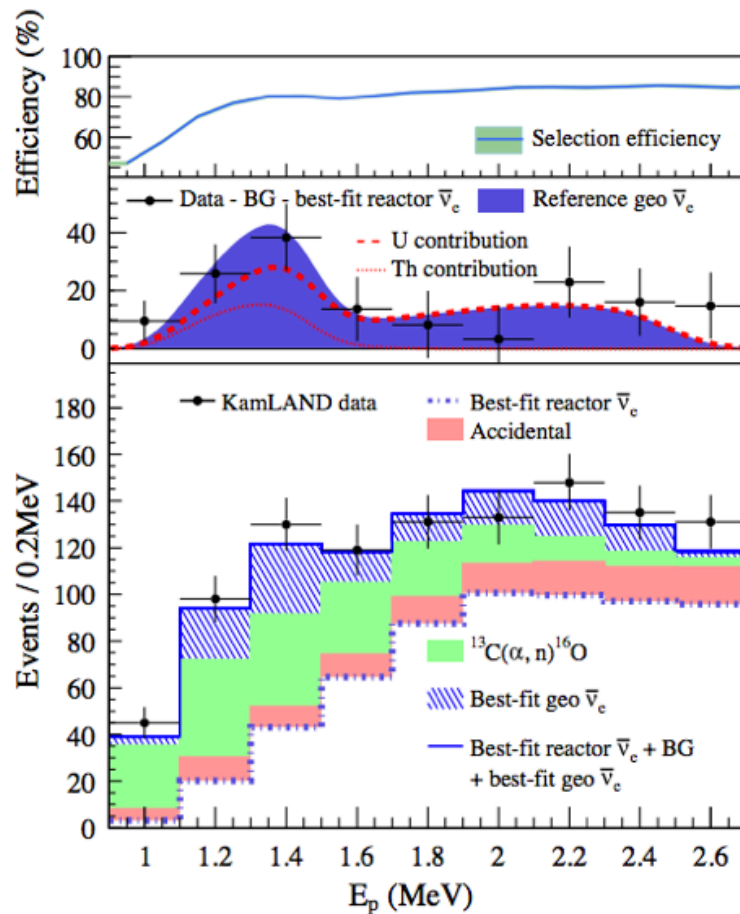
In a mine **1,000 m deep** from the top of Mt. Ikenoyama



Water cherenkov detector
for muon veto

Geo-neutrino with KamLAND

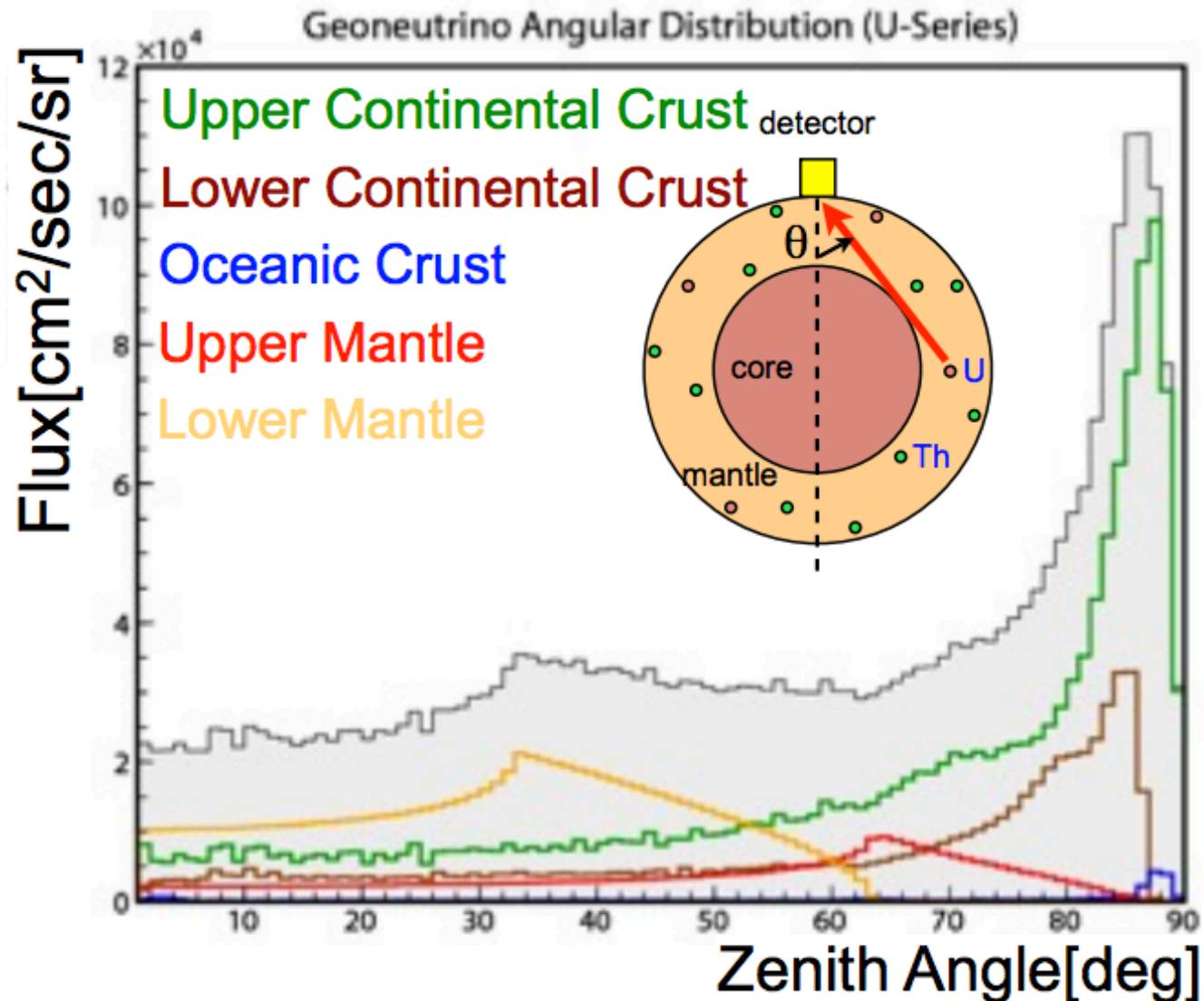
► Analysis : Energy Spectrum (0.9-2.6 MeV)



Dream in geo-neutrinos

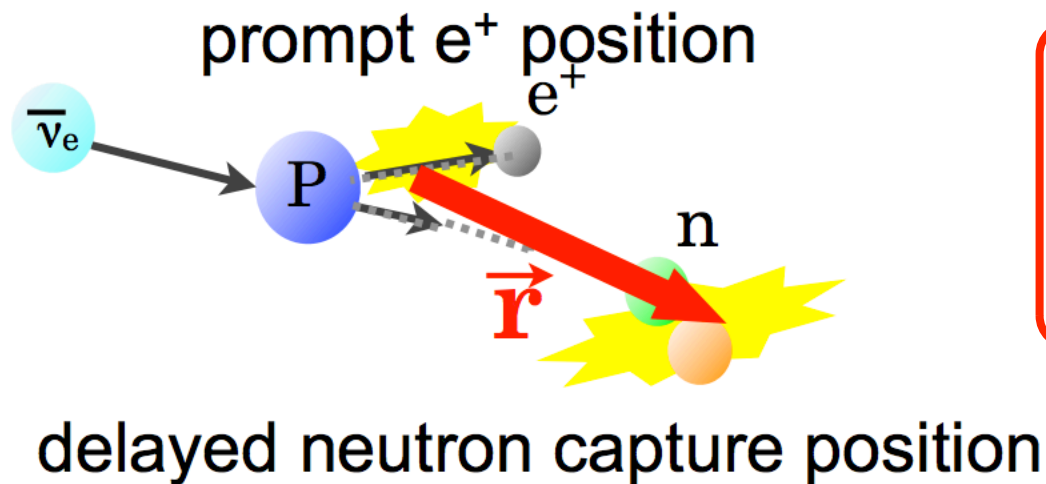
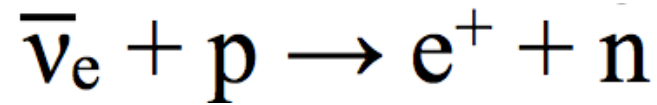
Directionality measurement

Search for radiogenic heat source in the earth's deep interior



How to measure

Inverse-beta reaction



Differential vector \vec{r} :
well correlation
with $\bar{\nu}_e$ direction

Problems

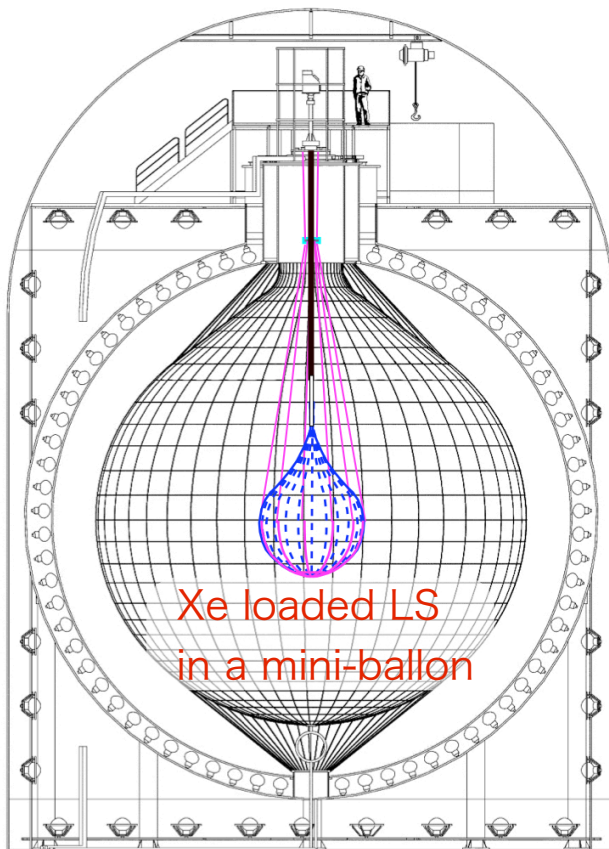
- Minimization of the thermal diffusion
KamLAND developed Li-loaded liquid scintillator.
- **High vertex resolution**

Particle identification

KamLAND: trouble in particle identification

Much important for solar-nu analysis and **double-beta decay search**

KamLAND-Zen: neutrino-less double-beta decay experiment with ^{136}Xe loaded LS (~320kg 90% enriched ^{136}Xe)

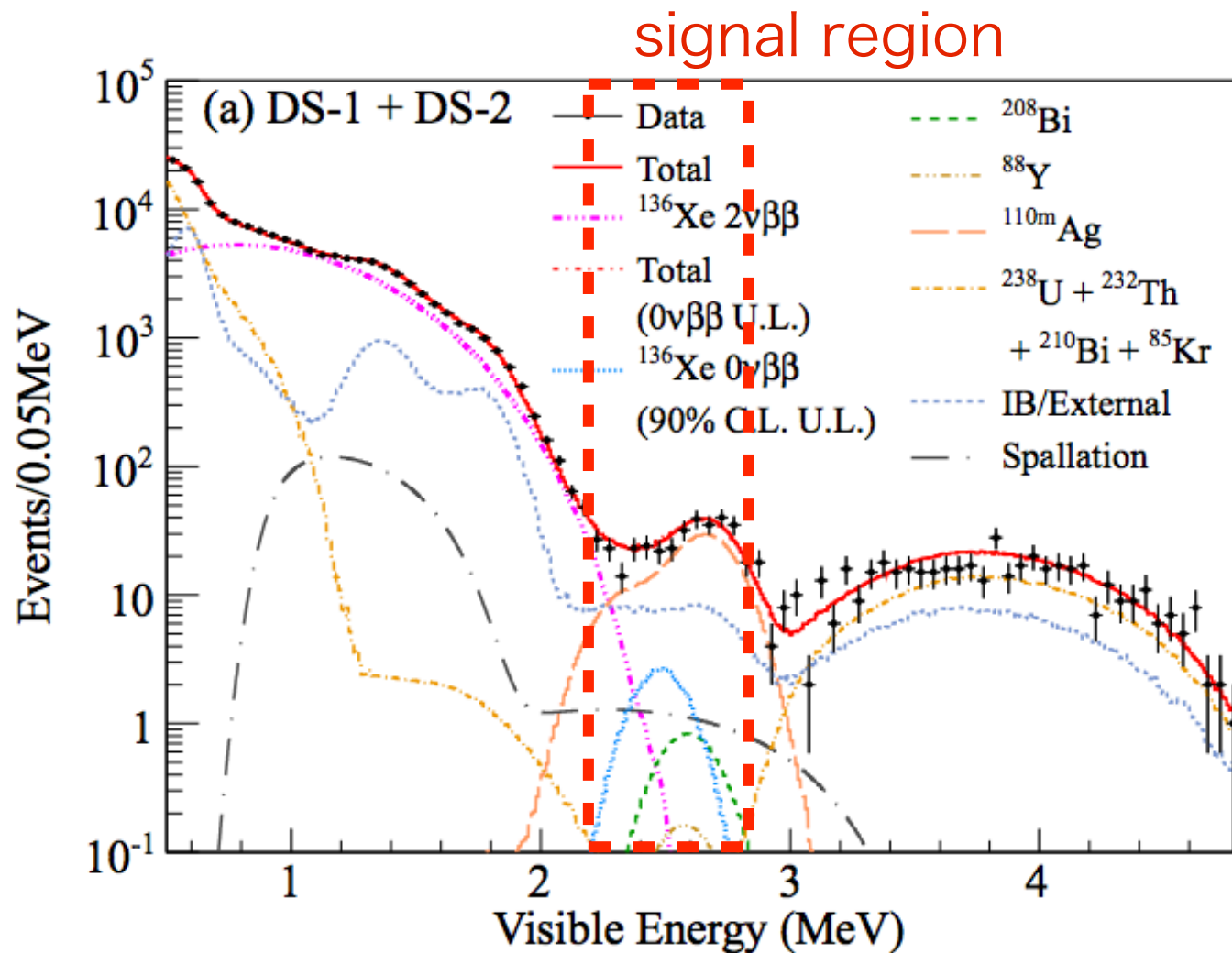


Impact (if observed):

- Majorana particle
- Neutrino effective mass
- Lepton number violation
- > Mystery of matter dominated universe

Geo-neutrino measurement continues with outside of the mini-balloon.

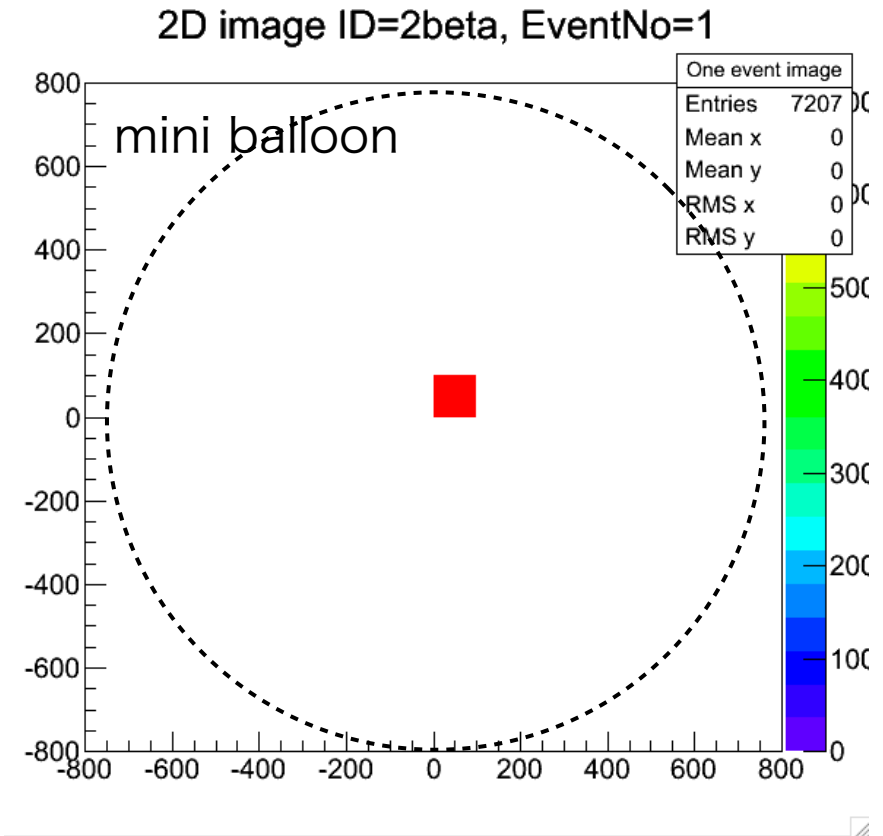
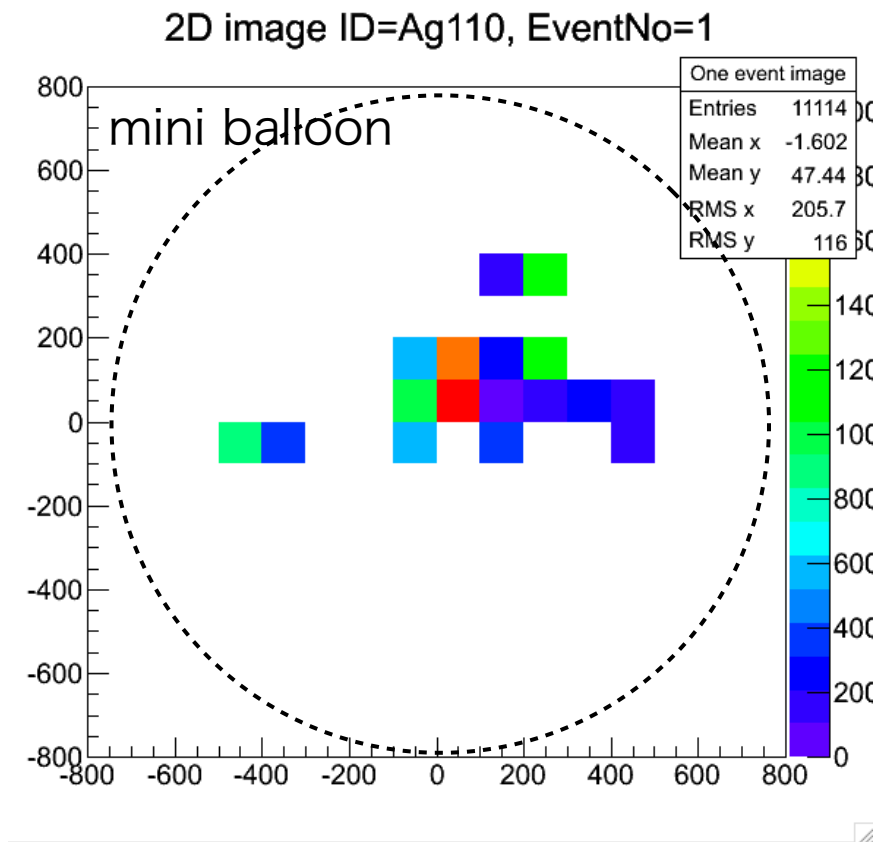
Particle identification



$^{110\text{m}}\text{Ag}$ and many backgrounds: $\gamma + \beta$ events

Width of vertex

2D image



2D imaging method -> particle identification

Short summary

KamLAND detector

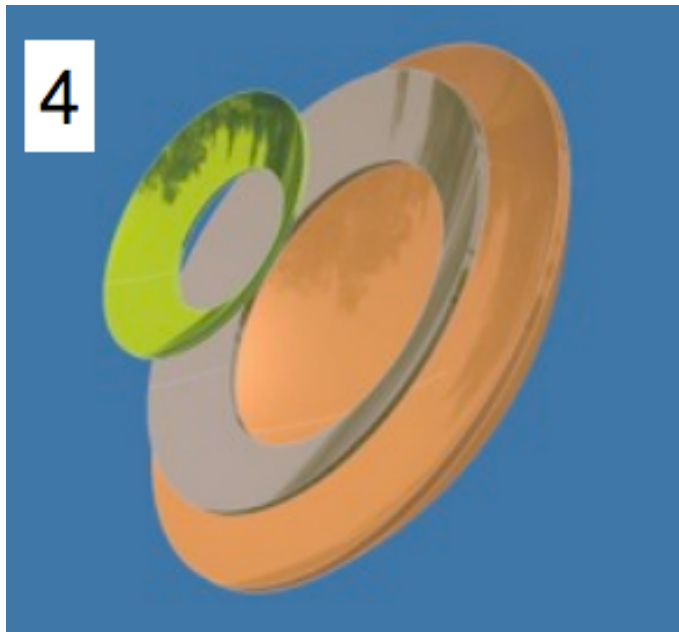
- Directionality measurement
- Particle identification

High resolution imaging camera

We started the development of the imaging camera, focusing on the particle identification.

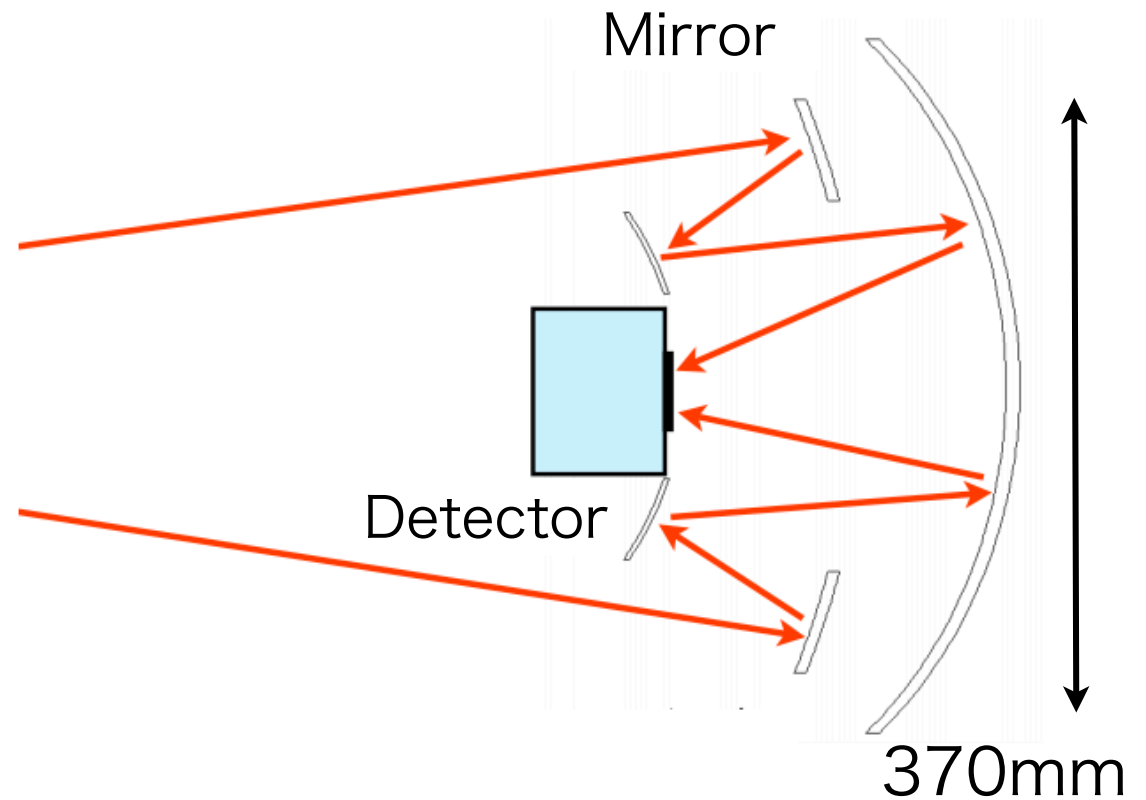
Very preliminary design

Ref: Hanakago, Mater thesis (2013)

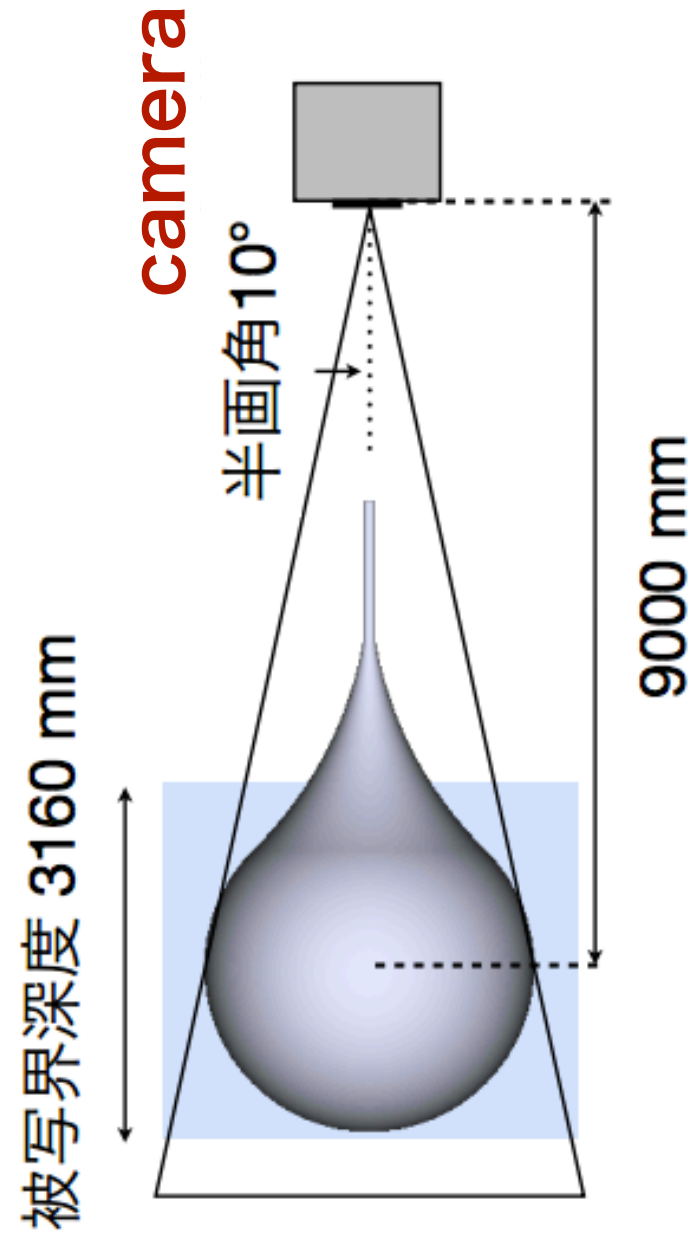
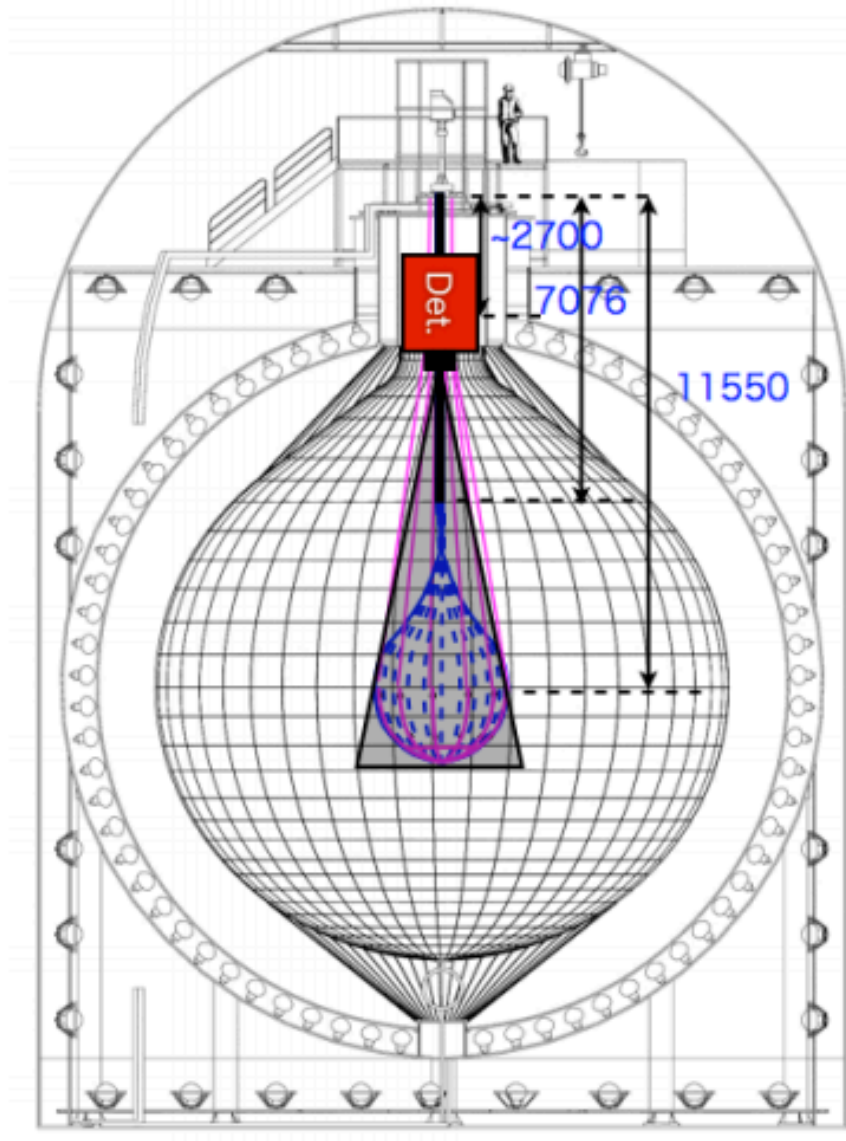


Triple reflector with large angle of view ($\sim 20^\circ$)

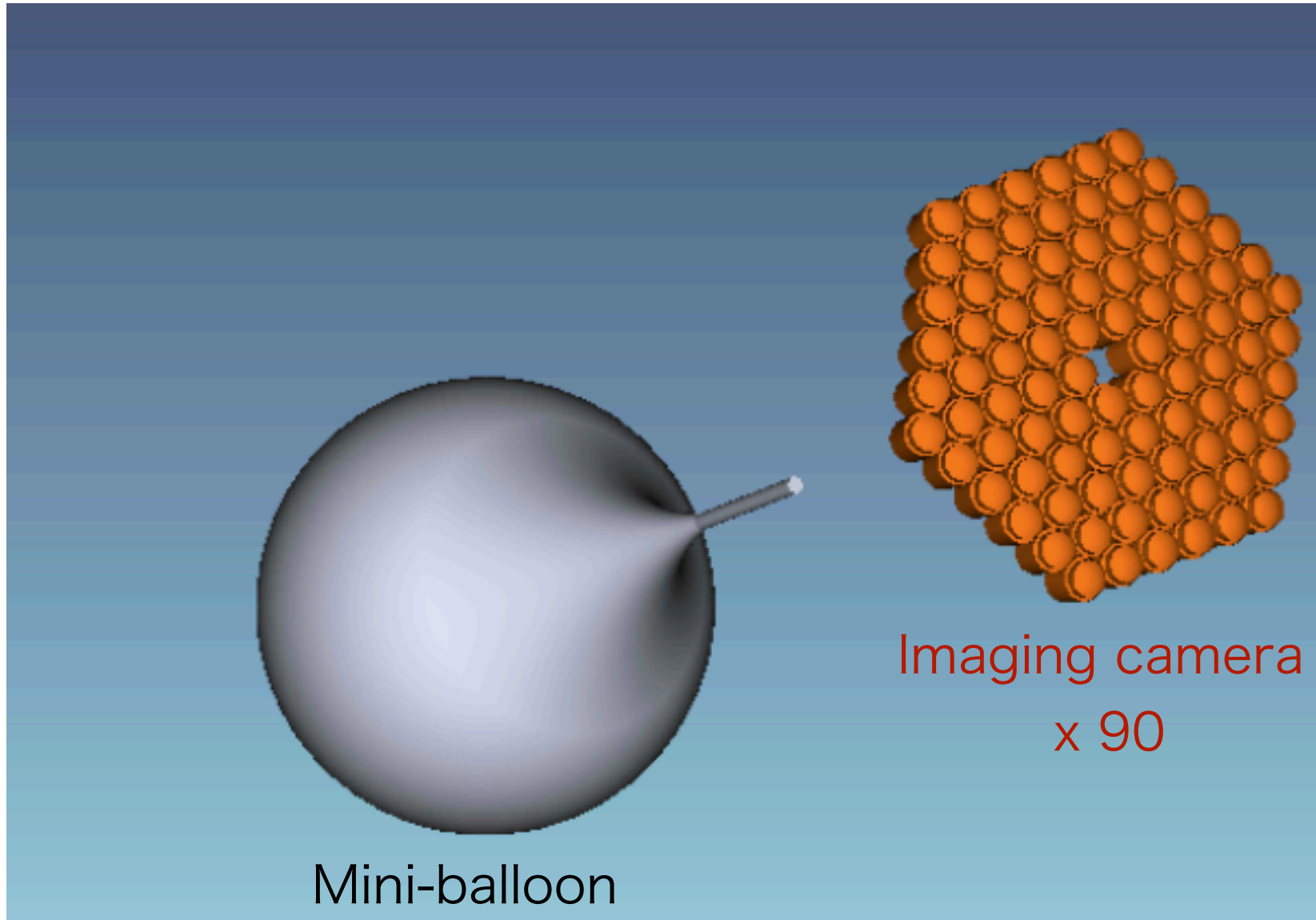
Resolution $< 5\text{cm}$



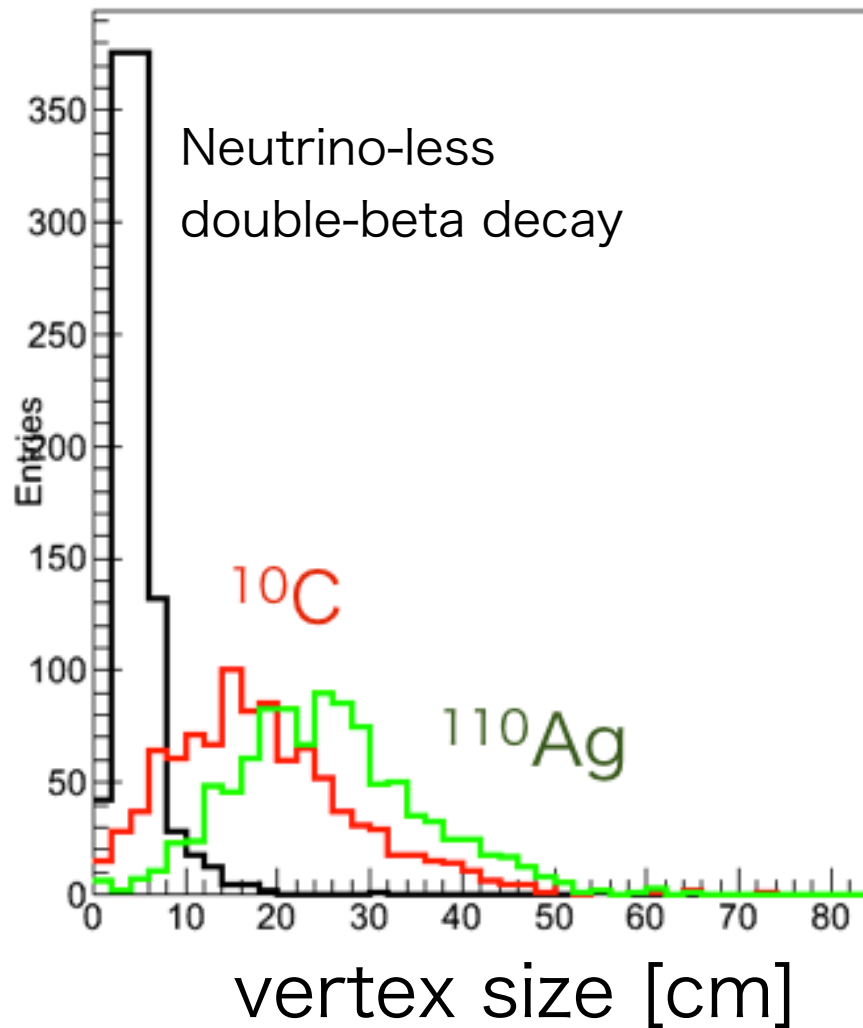
Very preliminary design



Very preliminary design



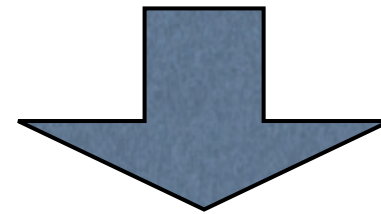
Very preliminary performance



Tagging efficiency: >90%
with 10% accidental tagging

We confirmed

- **our scheme is useful.**



Next works

- More realistic design
- Light detector
- Readout ??

Summary

KamLAND

- 1 kt anti-neutrino detector
- Achievement of geo-neutrino detection
- Neutrino-less double-beta decay experiment

KamLAND improvement

- Directionality measurement
- Particle identification

Imaging camera is a key instrument

Very preliminary design of the camera

=> performance of the particle identification.