15 November, 2011 Osaka
International Workshop on
Double Beta Decay and Neutrinos

Present Status of KamLAND-Zen

Yoshihito Gando
for the KamLAND-Zen Collaboration
Research Center for Neutrino Science,
Tohoku University

Current

KamLAND-Zen collaboration

Reserch Center for Neutrino Science, Tohoku University
A.Gando, Y.Gando, H.Hanakago, H.Ikeda, K.Inoue, R.Kato, M.Koga, S.Matsuda, T.Mitsui, T.Nakada, K.Nakamura, A.Obata, A.Oki, Y.Ono, I.Shimizu, J.Shirai, Y.Takemoto, K.Tamae, K.Ueshima, H.Watanabe, B.D.Xu, S.Yamada, H.Yoshida
IPMU : A. Kozlov
KEK : A.Suzuki
Osaka University : S.Yoshida
University of Tennessee : Y.Efremenko
Colorado State University : B.E.Berger
TUNL : W.Tornow, D.Markoff, H.Karwowski
University of Washington : S.Enomoto

Contents

- KamLAND with 0νββ decay search
- Production of mini-balloon
- Installation of mini-balloon and Xe loaded LS filling
- Future upgrade
- Summary

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- KamLAND with 0νββ decay search
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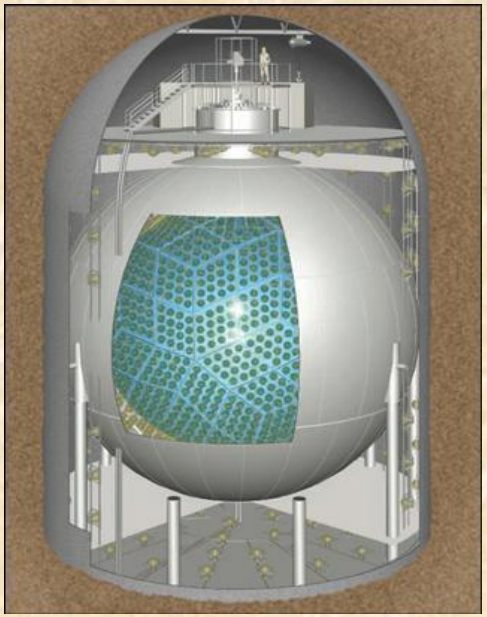
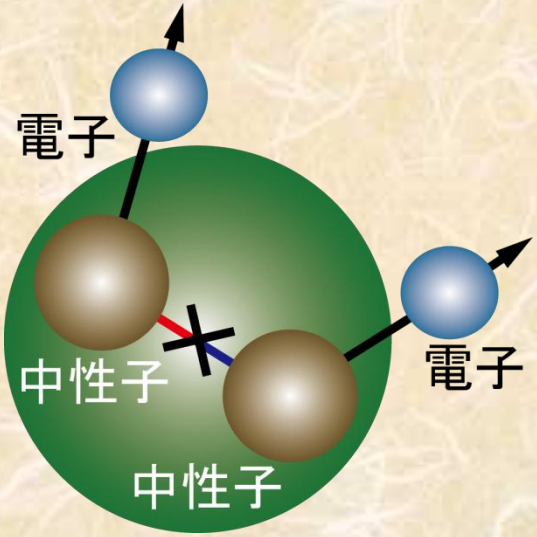
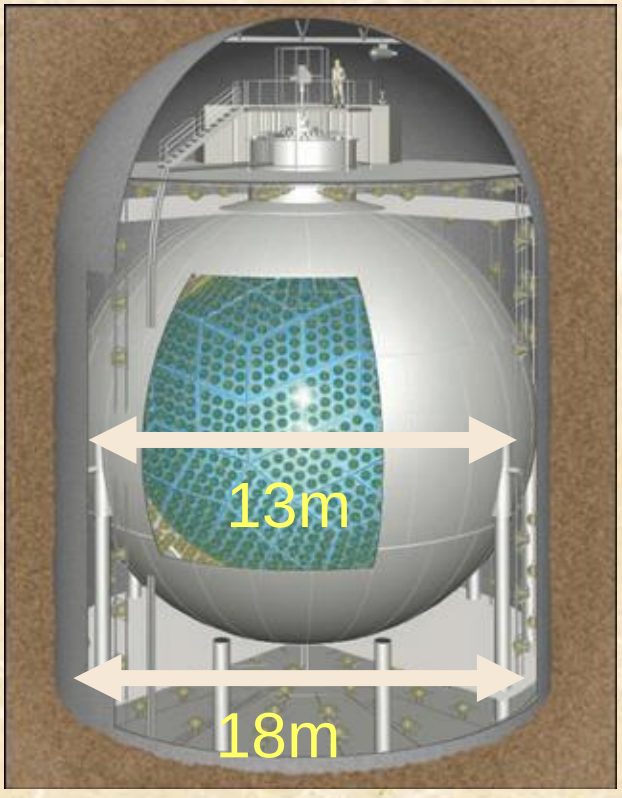
with no analysis results
Sorry for Giorgio!

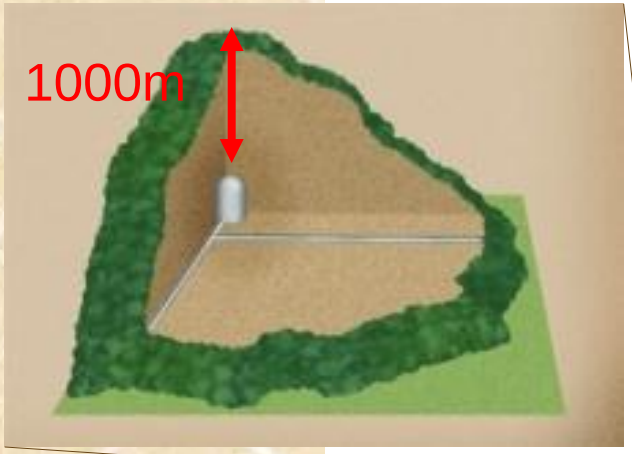
KamLAND with 0νββ decay search





KamLAND : calorimeter type detector





Shield of cosmic ray background ~10^{-5} than ground

1,000 tons pure liquid scintillator (LS)

Buffer oil : for environmental radiation

PMT : 17inch :1325 + 20inch : 554

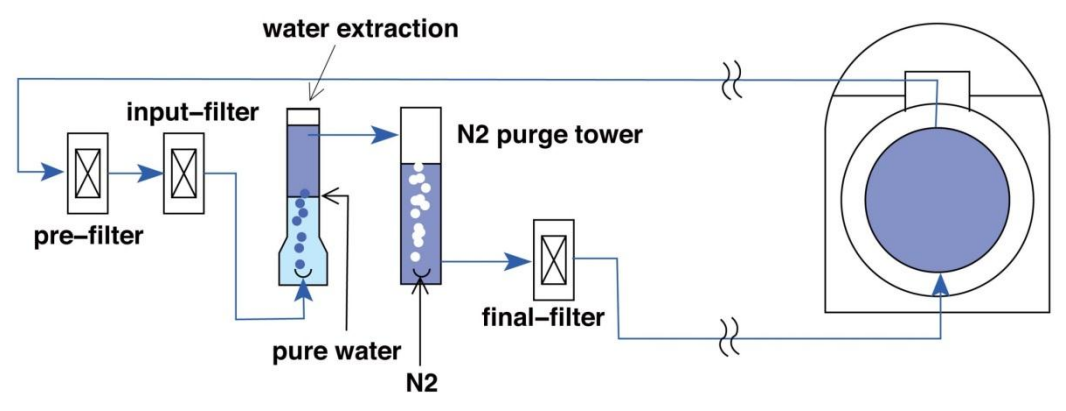
Water cherencov anti counter

225 20inch PMT with water

Resolution : ~12cm / $\sqrt{E(MeV)}$

~6.4% / $\sqrt{E(MeV)}$

KamLAND LS



Solubility of ions
: water >> LS
wash scintillator with water
→ ^{238}U : 3.5×10^{-18}g/g
^{232}Th : 5.2×10^{-17}g/g

2nd purification April. 2007 ~ Feb. 2009
- Distillation for Bi (Pb), Tl, K, U, Th
- N_2 purge for Rn, Kr, Ar

^{238}U : $0.2\sim2.2 \times 10^{-18}$g/g
^{232}Th : $1.9\sim4.8 \times 10^{-17}$g/g

- Very low radioactive impurities
- Large volume

Suitable detector for 0νββ search

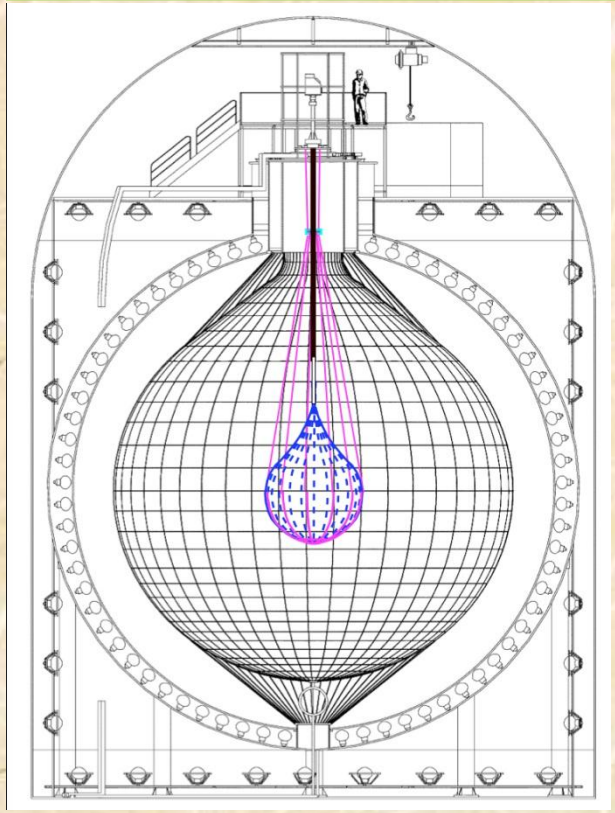
^{136}Xe with KamLAND

- Merit of using Xe
  - isotopic enrichment, purification established
  - soluble to LS more than 3 wt%, easily extracted
  - slow 2vββ requires modest energy resolution
- Merit of using mini-balloon
  - suppress volume depending B.G spallation products, solar ^{8}B neutrinos

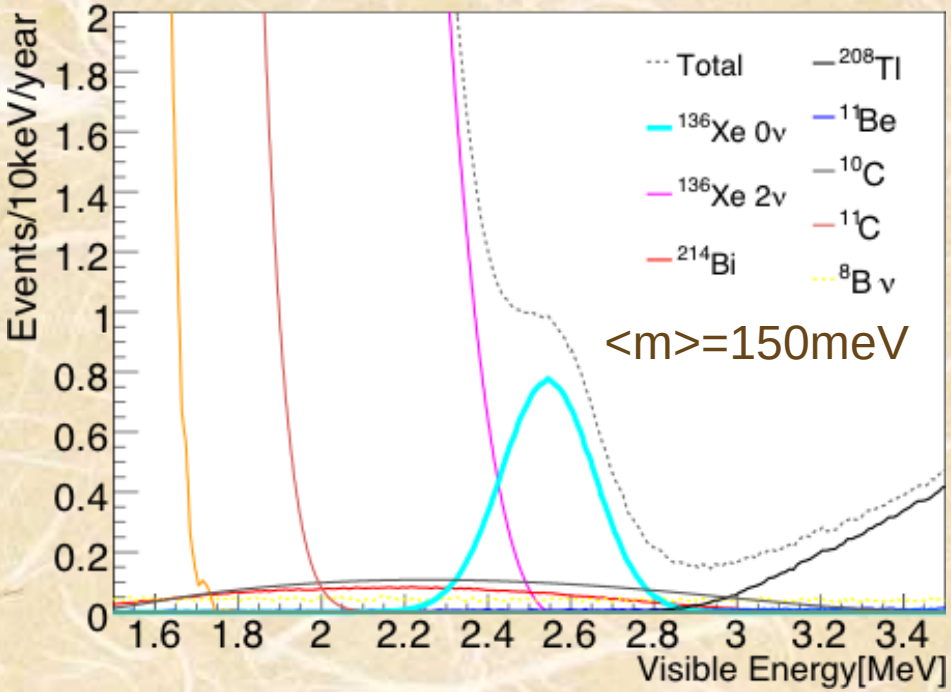
miniballoon

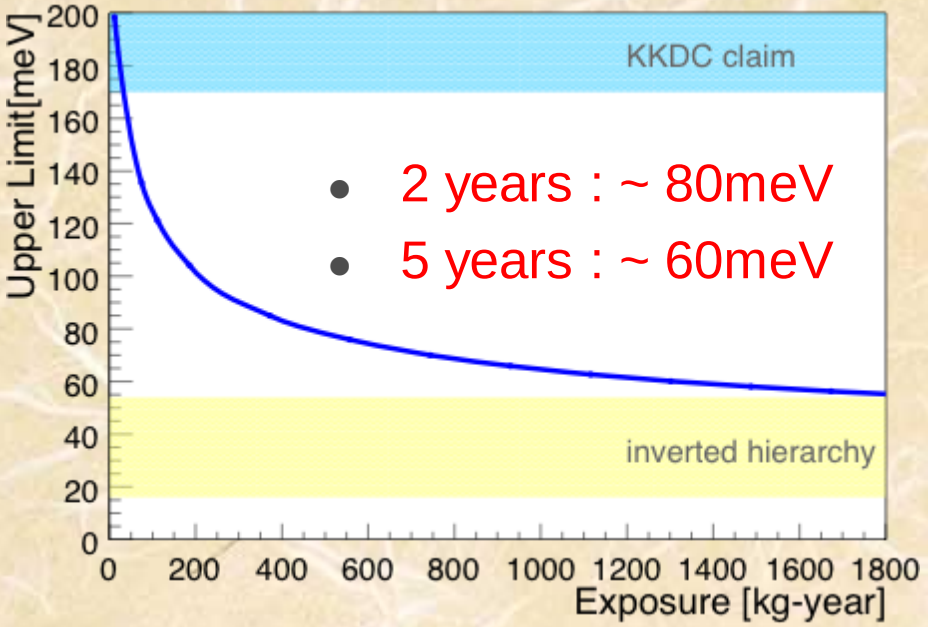
Decane	82%
PC	18%
PPO	2.7g/l
Xenon	2.5wt%

(91% Enriched ^{136}Xe)



^{136}Xe with KamLAND



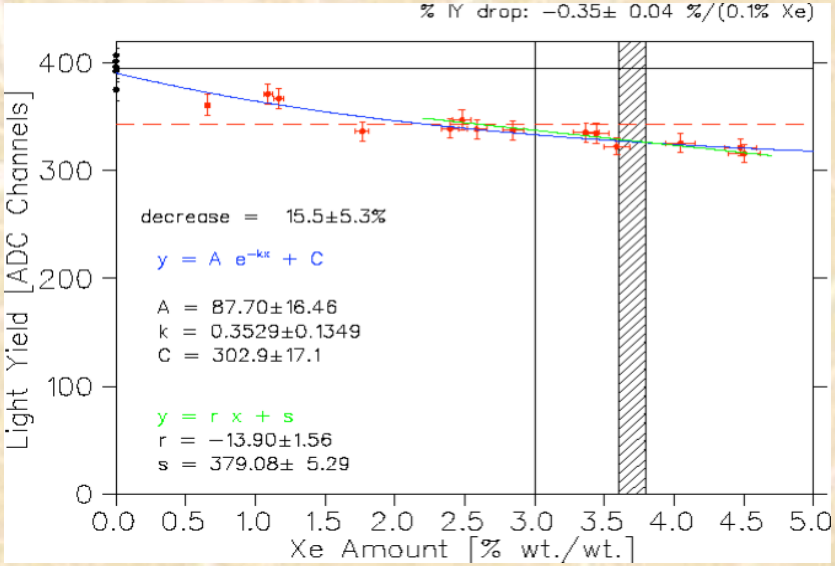


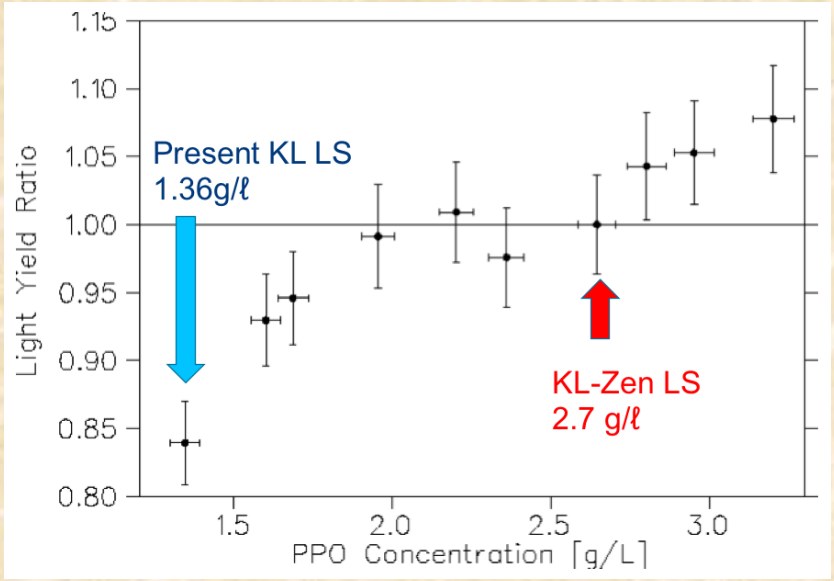
- same light yield between Xe-LS and KamLAND-LS

If lighter Xe-LS → ^{208}Tl will be in the signal region

darker Xe-LS → 2νββ will be in the signal region because of bad resolution

Xe loaded LS properties





- Xe gas is soluble to LS more than 3 wt%
- Light yield is reduced depending on Xe amount in LS

  PPO 1.36g/L → PPO 2.7g/L
- Density increasing by xenon dissolution to LS

  (to avoid tension to mini-balloon)

  KamLAND-LS PC(20%), Dodecane(80%), PPO

  Xe-LS PC(18%), Decane(82%), PPO, Xenon

Film conditions

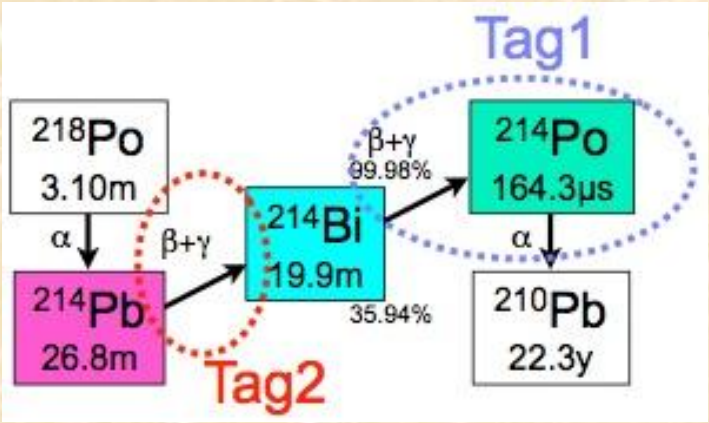
Nylon film : strong, good LS compatibility

Thick : strong, low Xe transparency, high B.G,

Thin : weak, high Xe transparency, low B.G, α tagging

} 25 μm

- Welding connection between films could be done
- Contamination level
  - ^{238}U : 2×10^{-12}g/g
  - ^{232}Th : 3×10^{-12}g/g
  - ^{40}K : 2×10^{-12}g/g
- Fracture intensity : 4.9kg/cm
- light transparency : 99.4%±0.3% @400nm
- Xe transparency : < 1.3kg (r = 1.58m balloon, 5year case)



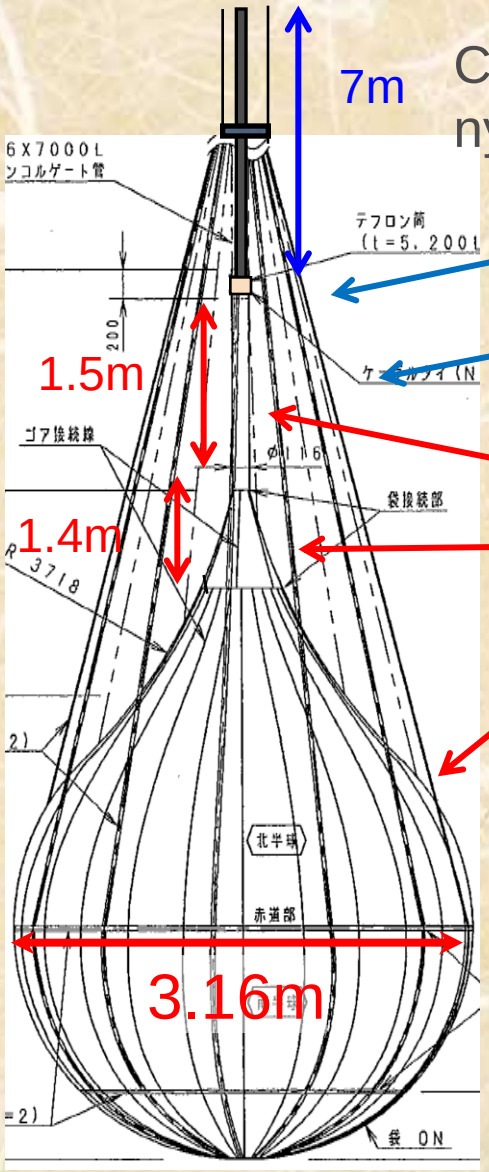
Tag1, film 25μm case

ε(^{214}Po, α pass) : ~80%

ε(^{214}Bi, $E_{\beta\gamma}$>0.3MeV) : ~65%

total tagging ε : ~52%

mini-balloon design



No low B.G. strings

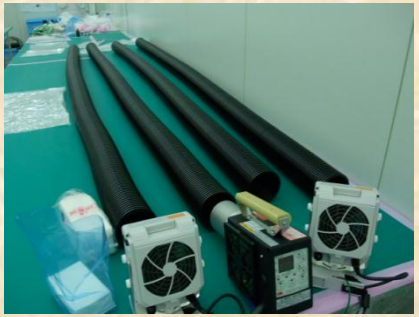
Far from mini-balloon

: Vectran string

Near mini-balloon

: Film belt made by clean nylon

Corrugated nylon tube



guide ring
for string


Production of mini-balloon

mini-balloon production

May ~ Aug., 2011
in class 1 super clean room

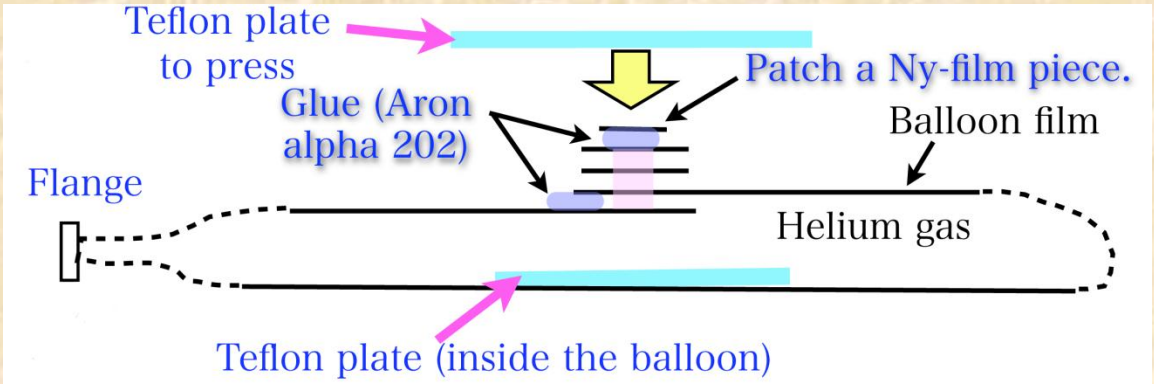
24 gores for
sphere part

Leak check & repair work

^{238}U :
$<5 \times 10^{-12}$g/g
^{232}Th :
$<5 \times 10^{-12}$g/g
^{40}K :
2.4×10^{-12}g/g

He leak check
→ Repair by glue
→ He leak check

- Good LS compatibility
- Xe tightness of the repair samples were comfirmed




Installation of mini-balloon
and
Xe loaded LS filling

Preparation at Kamioka site

Clean room class <10~100

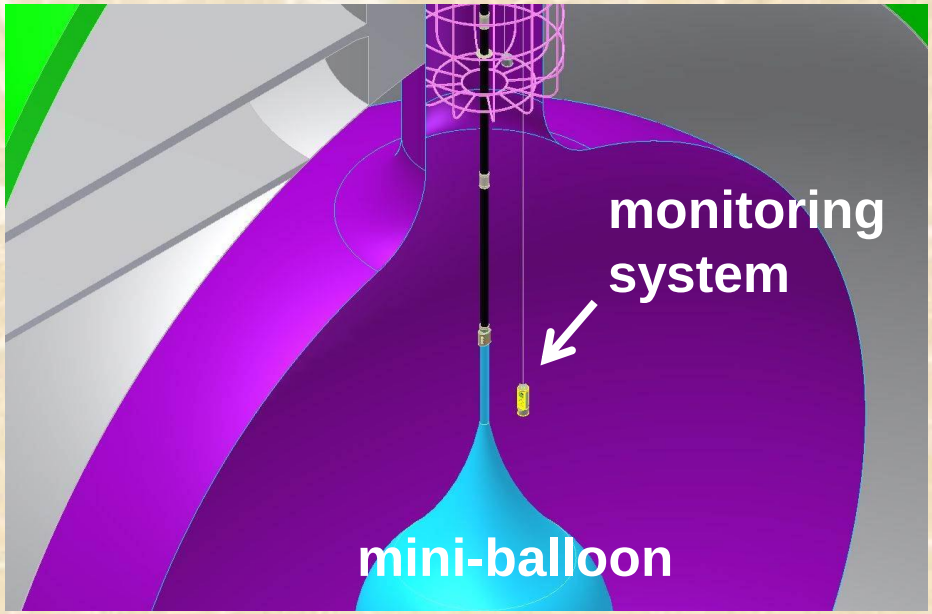
mini-balloon

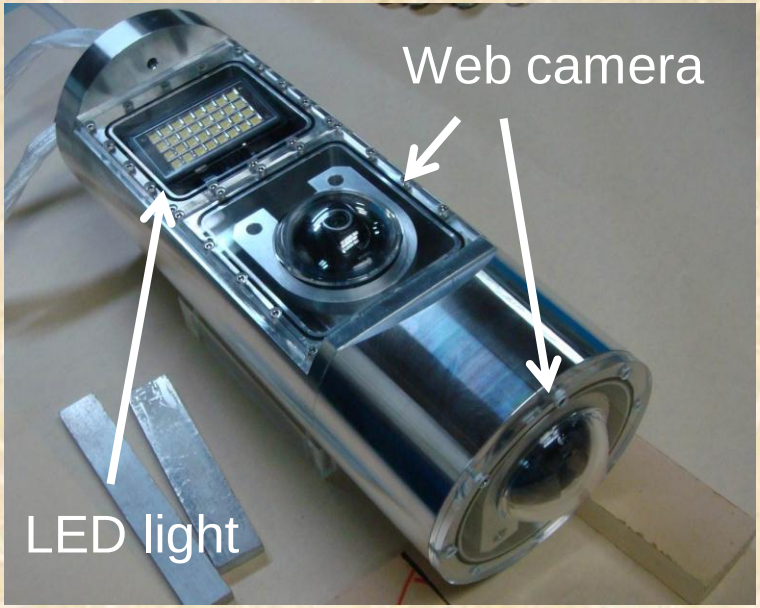
Corrugated tube connection

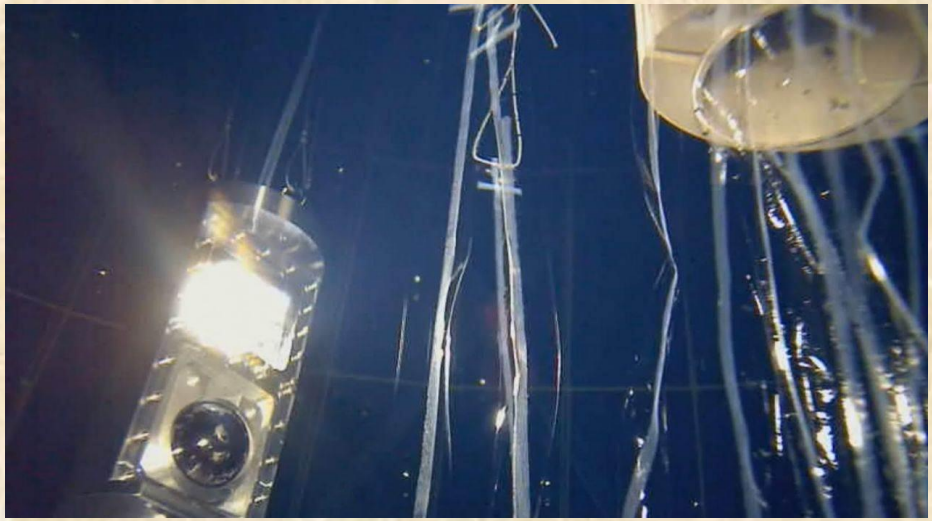
Monitoring system deployment

Strings and balloon cover setting

Monitoring system



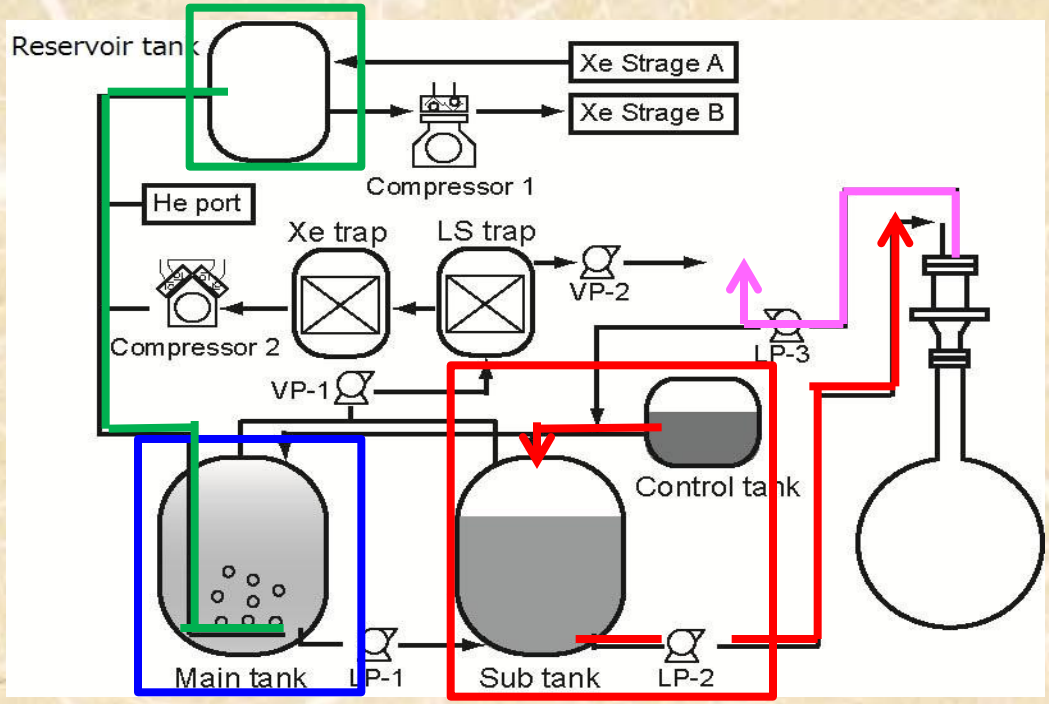




- ✕ go in the KamLAND
- ✕ watch from outside
  - → need monitoring system

2 monitoring systems were installed

Xe loading system



Xe reservoir tank

Main tank : Xe loading with bubbling (or Xe recovered by vacuum, He/N2)

Sub tank : final density adjustment to send Xe-LS to mini-balloon

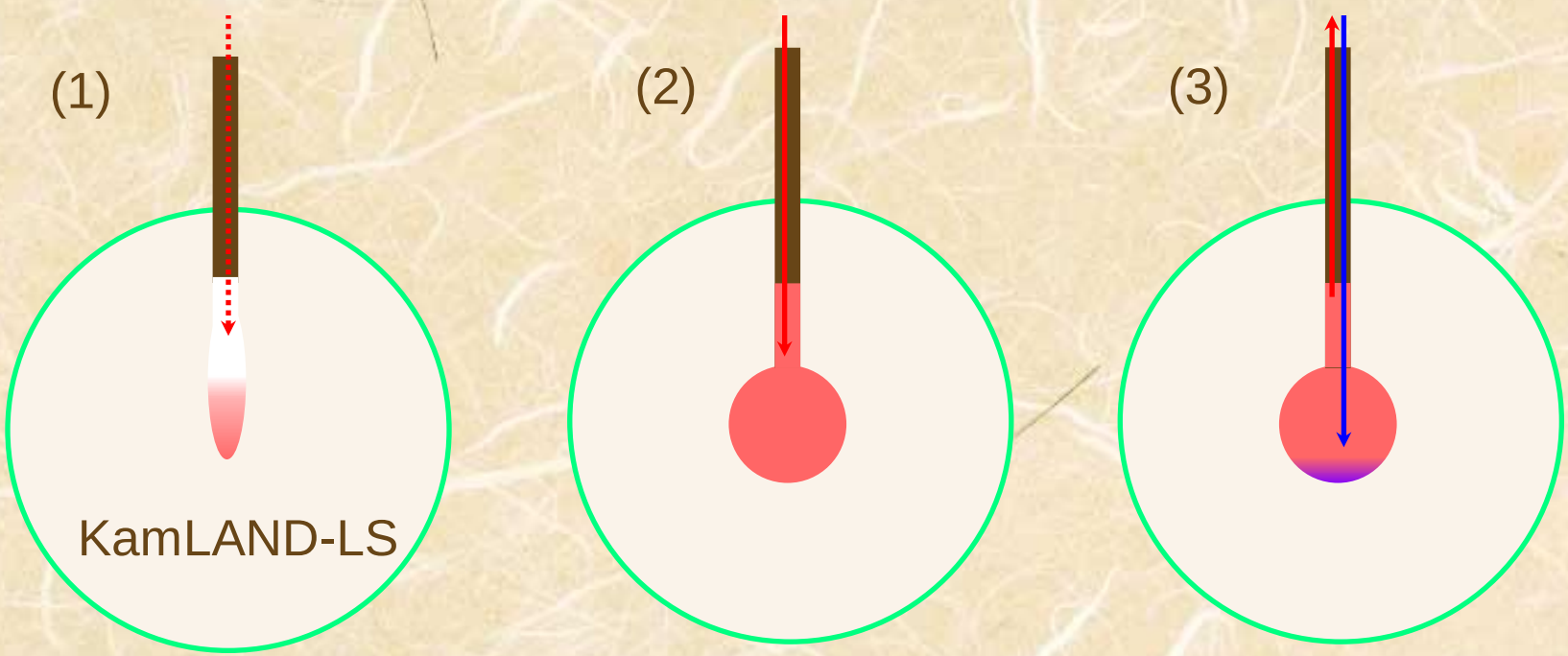
Density control : 0.005~0.01%

Recovery efficiency : 99.99%~99.999% (depending on carrier gas volume)

Installation methods

- Have to keep KamLAND LS for the safety of KamLAND balloon
- Access flange is ~50cm

→ Deploy the folded-up mini-balloon in cover



- Sink mini-balloon with filling heavier dummy-LS (not Xe loaded LS)
- Remove the balloon cover

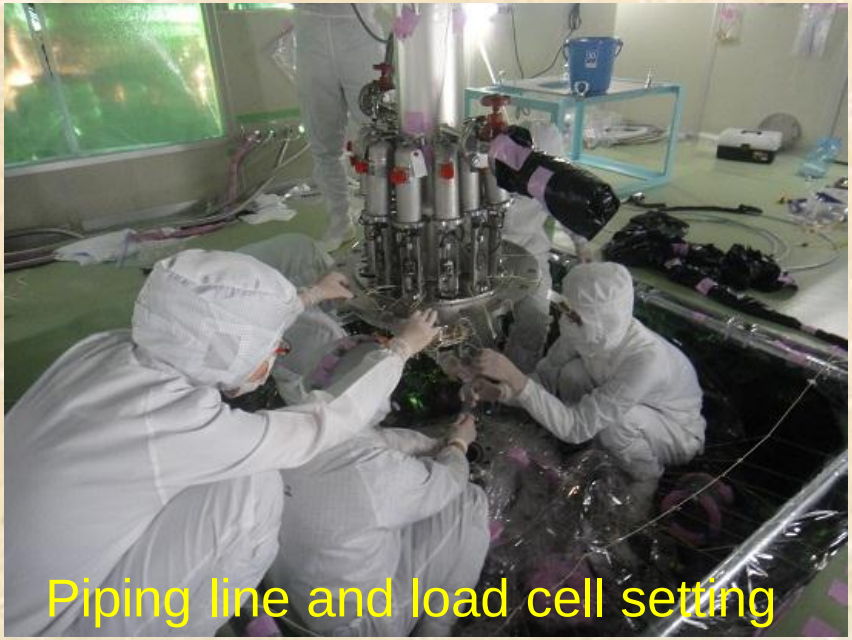
- Inflate mini-balloon with dummy-LS
- DAQ for leak check

- Replace dummy-LS with Xenon loaded LS

mini-balloon installation Aug., 2011

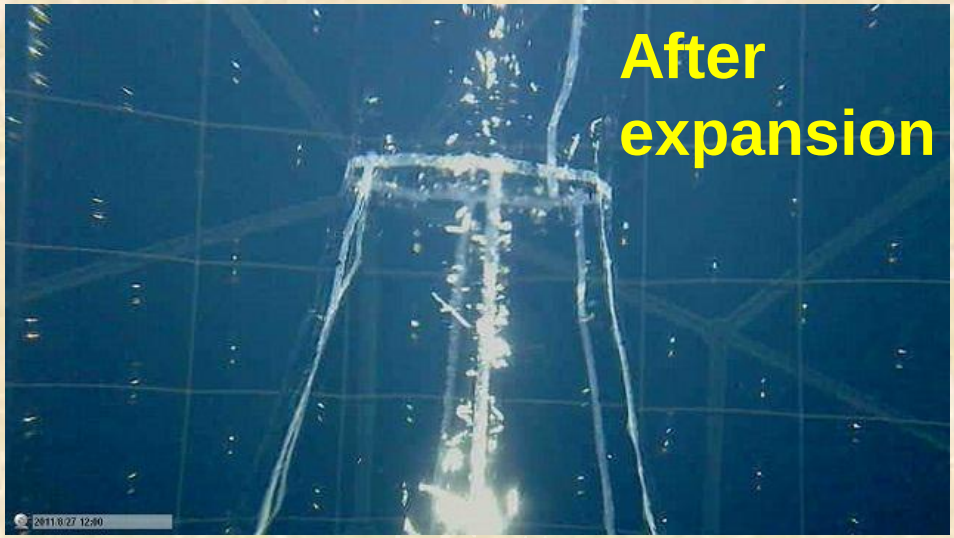

mini-balloon and corrugated tube deployment


Balloon went through the black sheet


Piping line and load cell setting

Dummy-LS filling and expansion

Connection part between corrugated tube and film



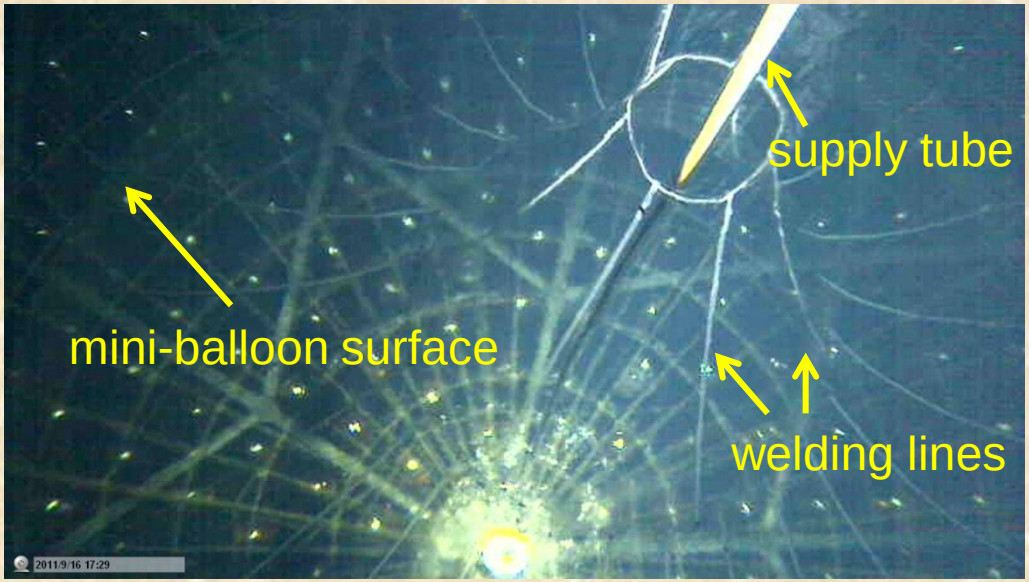
Connection part between straight part and cone part

Density of dummy-LS was +0.015% than KamLAND-LS to avoid mini-balloon floating

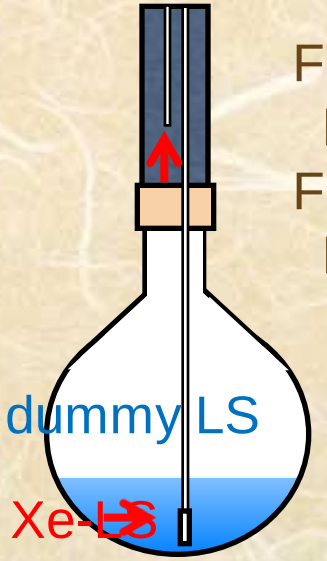
Filling stop was determined by
- check of tension at cone part (by camera)
- check of filling volume calculation by Xe loading system

DAQ for leak check of mini-balloon was done

Xe-LS filling Aug.~Sep., 2011



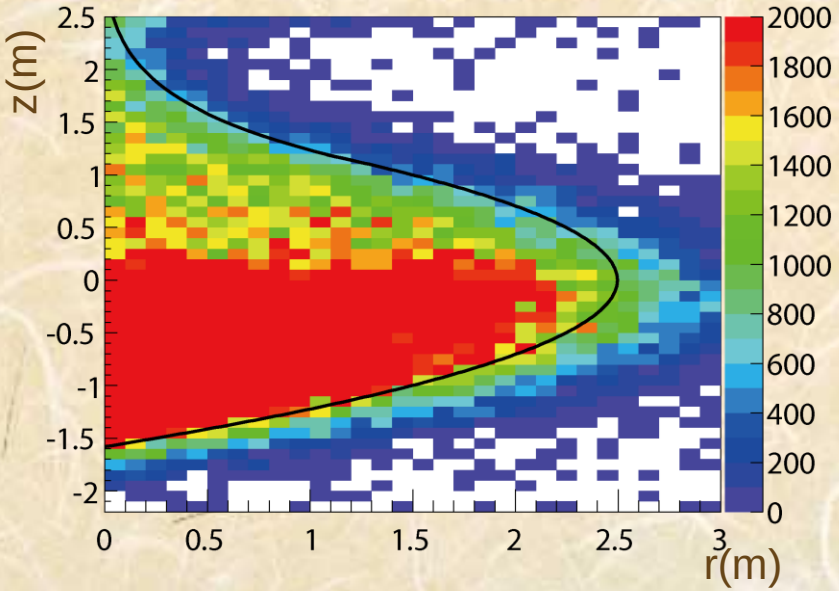
- Dummy-LS was replaced with Xe-loaded LS (0.02% density difference made layer of LS)
- LS replacement was monitored by DAQ using ^{222}Rn events as a tracer



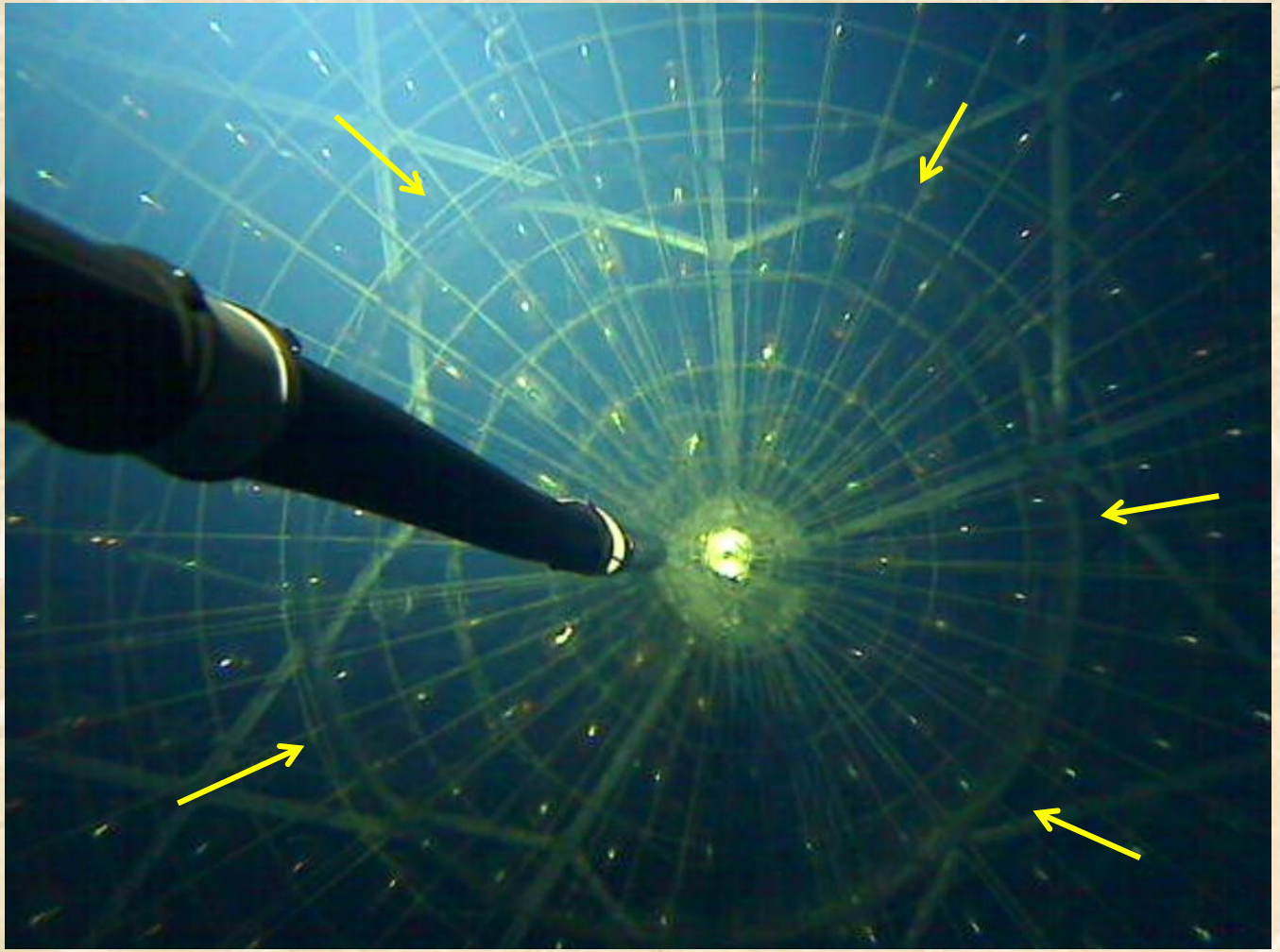
From top :
Draining dummy-LS
From bottom :
Filling Xe-LS

+0.015% density
+0.035% density

Vertex of ^{222}Rn events



After Xe-LS filling

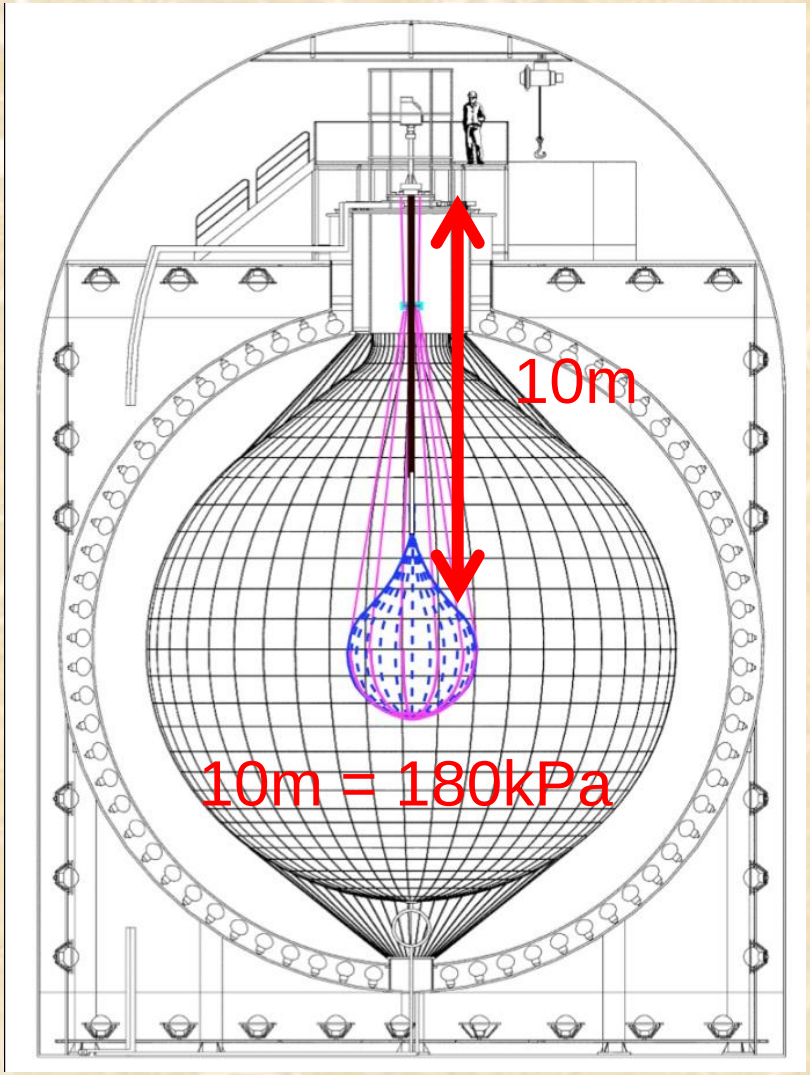


- 330 kg Xenon was installed in mini-balloon
- DAQ for KamLAND-Zen started 24 Sep, 2011

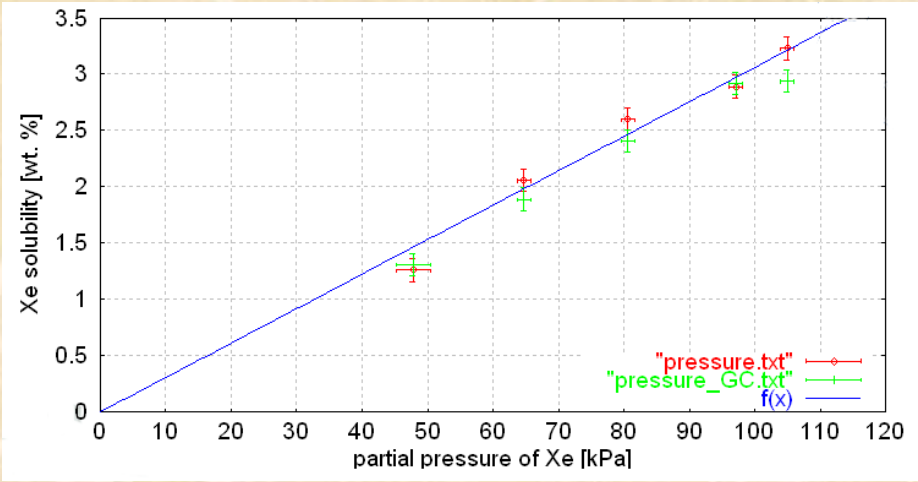
Future upgrade

- KamLAND-Zen pressurized xenon
- KamLAND2-Zen

KamLAND-Zen pressurized xenon



Xe solubility v.s. pressure



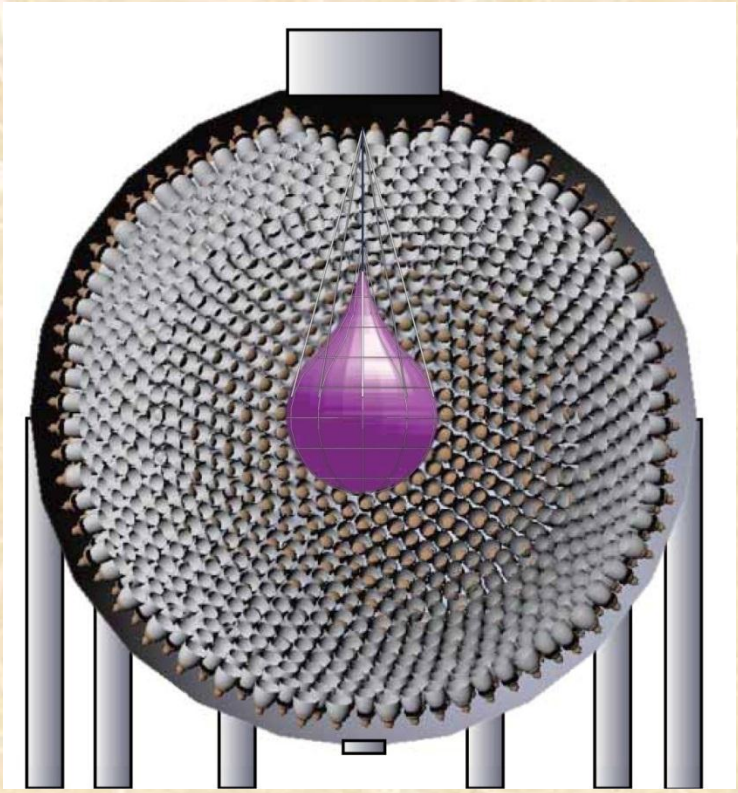
180kPa with 800kg ^{136}Xe could be kept in current or almost same size of mini-balloon

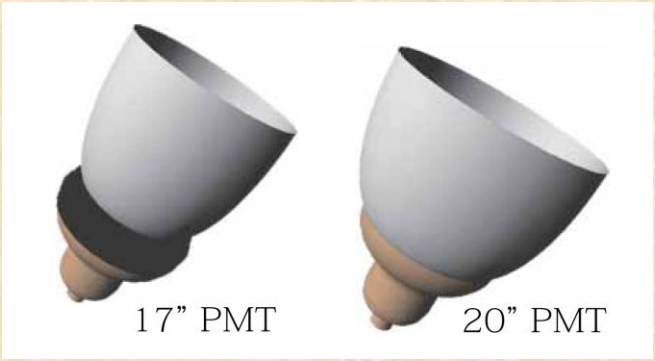
→ 30~40 meV/5years

Option
- More cleaner film
- Scintillation film for B.G. rejection in film (U,Th,K)

KamLAND2-Zen

Future upgrades
2014~





1000kg ^{136}Xe Pressurized ~ 6wt%

Winston cone
- photo-coverage ×2
- photon collection ×1.8

LS renewal
- KamLAND LS 8,000 ×1.4
  (standard LS 12,000)

Total light yield ×2.5
- Low 2νββ G.B.

→ ~20meV/5years

Chimney enlargement
- Capability to accommodate CaF2, CdWO4, NaI, Pbq 144Ce, and others

Details for KamLAND-Zen

Poster session

Hardware related issues

- Liquid scintillator by R.Kato
- Rehearsal of mini-balloon installation by A.Gando
- Mini-balloon construction by T.Nakada
- Mini-balloon deployment by H.Yoshida

Trigger and analysis

- Muon veto by A.Oki
- C11 tagging by Y.Ono
- B.G. study with simulation by S.Matsuda

Future

- R&D of neutrino directional detection in LS by H.Hanakago
- KamLAND2-Zen by A.Obata

Summary

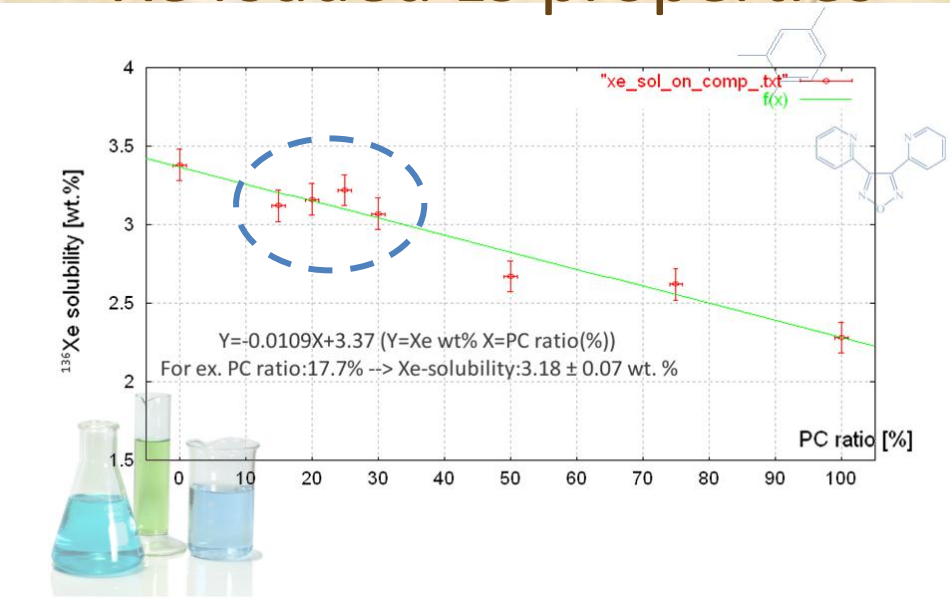
- mini-balloon installation to KamLAND and Xe loaded liquid scintillator filling to mini-balloon were finished.
- KamLAND-Zen started in Sep. 2011
- Future upgrade KamLAND-Zen pressurized xenon, KamLAND2-Zen will start few years later

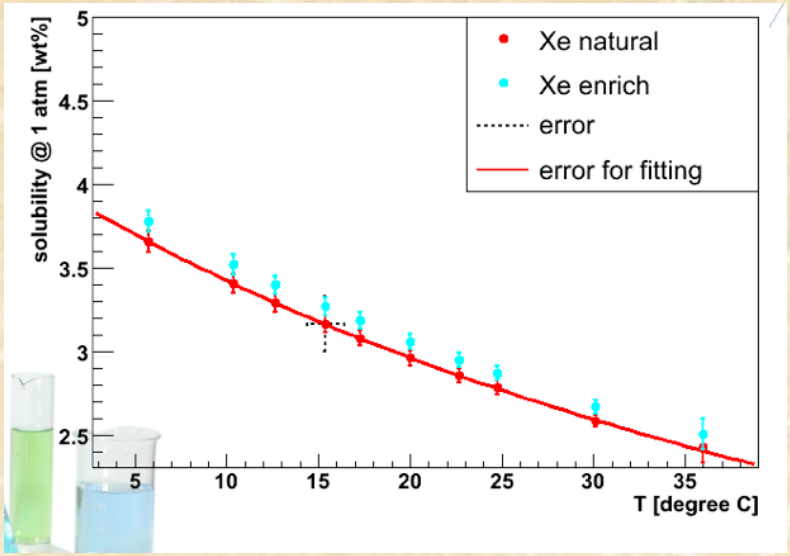
supplements

KamLAND-Zen

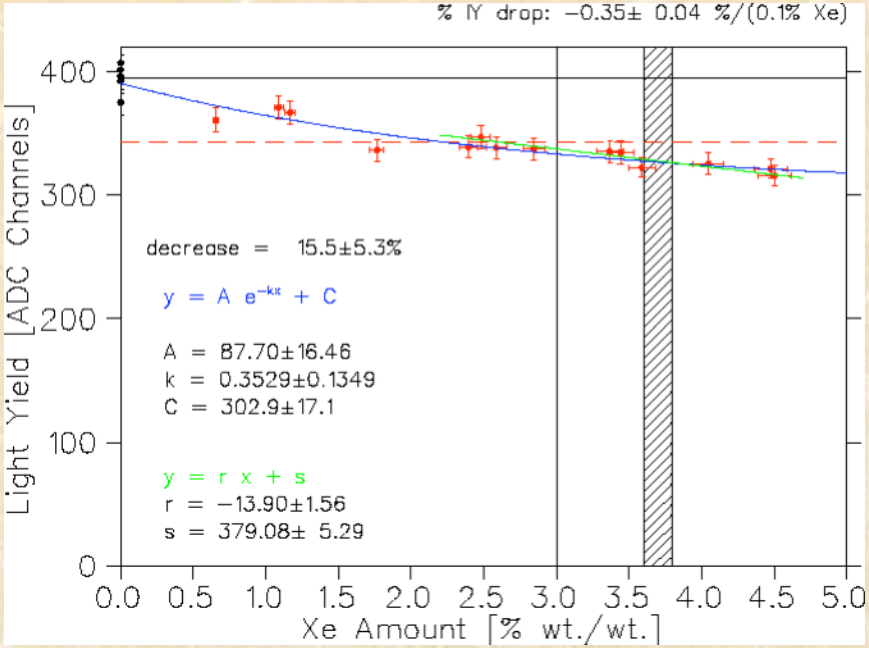
(KamLAND with Zero Neutrino double beta decay search)

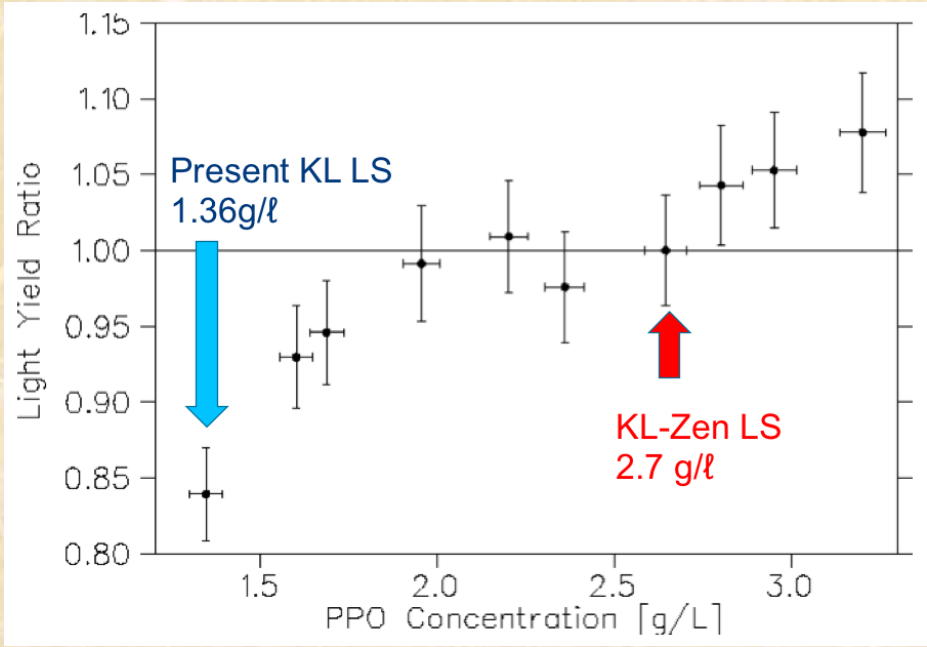
Xe loaded LS properties





PC in LS <30% & temperature <20℃ -> **Xe solubility >3.0 wt.%**





Cleaning work

Cleaning for materials and devices

- Ultrasonic cleaning with ethanol, and ultra-pure-water
- Brushing by toothbrush with detergent
- Ethanol, Ultra-pure-water wiping.
- PC, Ultra-pure-water circulation, N2 purge

Shipping


Balloon is covered by
protection film


Air-tight bag
filled with N_2 gas


KEYENCE