KAMLAND Collaboration
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Online monitoring system for KAMLAND
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Water Cherenkov Outer Detector

3m thick acrylic barrier for FN emulsion.

- Present analysis: ~22% only 17-inch PMTs
- Photocathode coverage: ~34%
- 1.325 17-inch + 554 20-inch PMTs

Partition oil (AIP = 0.4% lighter than LS)

18m diameter stainless steel tank filled with

1800 m$^3$ Buffer Oil

Supported by a network of Kevlar ropes

Composite film (1354 m)

Transparent EVOH/Nylo/Seal/EVCH

Housed in spherical balloon (diam. 13 m)

1.52 g/L PPO (p = 0.78 g/cm$^3$)

80% docetane, 20% pseudocumene

1000 ton liquid scintillator

KAMLAND Detector

Mt. Ikenoyama
TCP/IP by the connection with PC.

It is possible to observe it from anywhere by way of

truncated.

The system which used the LON protocol was cons

$$< < < < < < < < < < < < < < < < < <$$

The stability of the system is needed.

incident happens

Emergency data log for cause investigation when a

The work of the shift handily and surely.

oon weight, liquid scintillator temperature.

We need to monitor the detector status such as ball

Kameleon detector is complicated system.
Neuron Chip

- The Features are:
  - Incorporation of the communication program in the Neuron Chip as firmware
  - Neuron C language, a special version of the C programming language, is used to develop application program.
  - The Neuron Chip has eleven I/O ports which are equipped with the firmware programmable function I/O facility. These I/O ports are used to take monitor data.
- LON node via TCP/IP by using PClinux interface node.
- LON Monitoring System are controlled even from SE
  m.

<table>
<thead>
<tr>
<th>Total distance of LON network in this figure is 400</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maximum communication distance is 1.4 km covering</td>
</tr>
<tr>
<td>the whole KamLAND area.</td>
</tr>
</tbody>
</table>

- Each neuron Chip Node are bonded via LON protocol
- LON Network
KamLAND Area and Monitoring Network
KamLAND Area and Monitoring Network
ADC receives data from each amplifier according to the received commands. Then, the Chip sends these data to the ADC. ADC sends commands to each ADC to gather monitored data. Application program on EPROM that are attached to Node, etc. are taken by these nodes.

Sensor data, load cell, temperature, pressure, oil flow rate, and water purification system. ADC Nodes are set in dome, clean room, purification system. 12 bit dynamic range. Maximum 4096 ch/system (Now 120 ch).
All the ADC Node data are sent to PC I/F Node in order to store monitor data in PC.

Data flow rate is 78 kbps on LON network and 116 kbps on serial network. The features of PC I/F Node are command transaction, data format transformation, and application program execution by serial port in Neuron Chip UART (Universal Asynchronous Receiver/Transmitter). This makes it possible to communicate fast with PC.
Max 64 ADC ch/node

Neuron chip

Controller

Each node has micro

PC I/R Node

LON-RS232C

LON Monitor
Command can be send even from anywhere via TCP/IP.

- Monitor data.
- Order to store monitor data, user process 2 starts to store
- When user process 1 send command to user process 2 in
  - to send command to each Neuron Chip.
- User process 1, User process 2 was send from user process 1. User process 1 is also use
  - Real time task is waked up by handler, and this command action.
  - Real time task is waked up by handler, and this command trans
  - Real time task on the real time Linux is used to gather mon
  - Monitor data are stored in PC put in the control room.
Dome Area

- Temperature (Balloon) x3
- Oxygen Monitor (LS) I
- Anti Water Pressure x2
- Nitrogen Valve Status
- Detector LS Level
- Detector LS Level
- Detectors Pressure (LS-BO)
- Detector Pressure (BO-Dome)
- Detector Pressure (LS-Dome)
- Inner Box
- Over Box
- Over Press

Loaded Cell in +4
Purification Area

- 10m³ LS Buffer tank oil level
- LS Filter In differential Pressure
- LS Nitrogen supply tank pressure
- Oxygen Monitor x2
- Flammable gas monitor
- NO filter out differential Pressure
- NO filter In differential Pressure
- Detonation LS level
- BO level
- LS 20m³ tank level
- BO 20m³ tank level
Mineral Oil Temperature

Upper

4 1°C up

2002

2003

1°C up

Equator

July

1 0.5°C up
GUI Interface (Java)
eral 100 jBq/m³ level.

Establishment of measuring method of radon at sev

• Removal of Pb in liquid scintillator

• Radon-free air is sent to the pit.

• Radon of experiment area

• Making of automatic detection system of density of R

• Future.

A large amount of background of Pb exists in the de

Solar Neutrino
Radioactive background in LS
**Solar Neutrino at KamLAND**

*First observation of real time $^7$Be neutrinos*

<table>
<thead>
<tr>
<th>Background</th>
<th>Current</th>
<th>Goal</th>
<th>Method</th>
</tr>
</thead>
<tbody>
<tr>
<td>$^{238}$U</td>
<td>$3.5 \times 10^{-18}$ g/g</td>
<td>OK</td>
<td></td>
</tr>
<tr>
<td>$^{232}$Th</td>
<td>$5.2 \times 10^{-17}$ g/g</td>
<td>OK</td>
<td></td>
</tr>
<tr>
<td>$^{222}$Rn</td>
<td>$3.3 \times 10^{-8}$ Bq/m$^3$</td>
<td>OK</td>
<td></td>
</tr>
<tr>
<td>$^{40}$K</td>
<td>$&lt;2.7 \times 10^{-16}$ g/g</td>
<td>$&lt;10^{-18}$ g/g</td>
<td>Water Extraction</td>
</tr>
<tr>
<td>$^{210}$Pb</td>
<td>$\sim 10^{-20}$ g/g</td>
<td>$5 \times 10^{-25}$ g/g</td>
<td>Water Extraction</td>
</tr>
<tr>
<td>$^{85}$Kr</td>
<td>$0.7$ Bq/m$^3$</td>
<td>$10^{-6}$ Bq/m$^3$</td>
<td>N$_2$ purge</td>
</tr>
<tr>
<td>$^{222}$Rn leak</td>
<td></td>
<td></td>
<td>N$_2$ purge/ air tight valves</td>
</tr>
</tbody>
</table>
KamLAND
Solar

KamLAND (expected 3y, R<4m)

After statistical subtraction ($^{238}$U, $^{232}$Th) and assume all BG = $^{210}$Bi/$^{210}$Pb

LMA (global analysis: $\phi/\phi_{SSM}$=0.64)

$\pm$ 4.4% (99% CL)

$^{14}$C (assume $^{14}$C/$^{12}$C=0.18)

$^{210}$Bi (BG), $^{85}$Kr (BG), $^{13}$Nv $^{15}$Ov

$^{39}$Ar, $^{85}$Kr (assume 1$\mu$Bq/m$^2$)

$^{352}$Th (5x10$^{-17}$/y/1)

Energy [keV]

Energy [keV]

Counts/25keV

Counts/25keV
These Pb is due to the invasion of Rn.

Therefore, the system which measured the Rn density in the pit was constructed.

Requirements:

Because there is a seasonal variation of the Rn density in the pit, it is necessary to measure Rn level online.

Because R&D continues, the extendibility should be easy, and independent of a present system.
1-Wire is a registered trademark of Dallas Semiconductor

- 1-Wire devices
- The twisted pair wiring and associated connector
- A bus master with controlling software
- A 1-Wire net consists of 3 main elements:
  - A resistor pull-up to a nominal 5V supply at the master N(D) master/slave multidrop architecture that uses a
  - The network is defined with an open drain (wired-

1-Wire (Dallas Sem.) Network
I-Wire monitoring node

- I-Counter
- Temperature, Humidity
- 4-Inst. Amp-ADC
Developing SK type radon monitor

Therefore, the electrostatic collection method is used.

Wet purifying liquid scintillator is returned to the detector.

It is necessary to measure the Rn density before the

\[ 100 \text{ Bq/m}^3 \]

Rn high sensitivity Rn Monitor
Schematic view of Rn monitor

Electrically polished (ECB) stainless steel vessel

PIN photodiode

Pre Amp.

HV (-6 kV)
Electro-polished after welding.

The inside of the vessel is

>>> Background level,

In order to achieve a low

We made 100L test vessel.

Electropolished Stainless Steel Vessel

H = 496 mm

r = 250 mm
Mirror-smooth surface finish

Flat surface

Abrasive, mechanical polishing with and electrolytic metal dissolution combines the power of finishing technology that ECB is dual-action surface

Electro-Chemical Buffing
This R decides the voltage of PIN photodiode (about 150V)

R for HV divider

HV divider circuit

To preamplifier.

HV POWER SUPPLY (600V)
Preamplifier circuit

Charge amp: $\tau = 1.3 \text{mS}$

Diff. circuit: $\tau = 50 \mu \text{S}$

Drive amp.: Output impedance = 50 $\Omega$
HV divider and PreAmp. circuit

Double decker Circuit.

PreAmp.

HV divider

We are working on R&D (PD 2, Graduate student 2)
(1) Raw data ~160GB/day
   - That include trigger information and Wave form
   - 10bitsX128sample/channel
(2) Data Tape are sent to Sendai once a week.
(3) After wave form analysis, the size down to ~1/15, ~12GB/day.
   - Reduced trigger information,
   - Time-charge for each PMT (64bits/channel)
(3) In addition, After reconstruction process, the size down to ~1/120, ~100MB/day.
   - vertex, energy, muonID etc.
Experimental Data flow -feature-

- Data(3) for the analysis is automatically made by shell.
- All the data(2) are stored on HSM (~10TByte), then we can access all data easily.
- LTO Tape(100GByte) is sent by car because Kamioka-Sendai is 10Mbps. But Kamioka-Sendai network will be improved and we will be able to send data via a network.
Summary

- The KamLAND LON monitoring system was constructed.
- Establishment of shift task.
  - KamLAND experiment (nuclear reactor anti-neutrino) started.
- The monitoring system of the density of the radon in the pit was constructed.
- The high sensitivity radon measuring detector is developed.
  - Aiming at the Solar Neutrino detection experiment
- Experimental data process is done almost automatically.