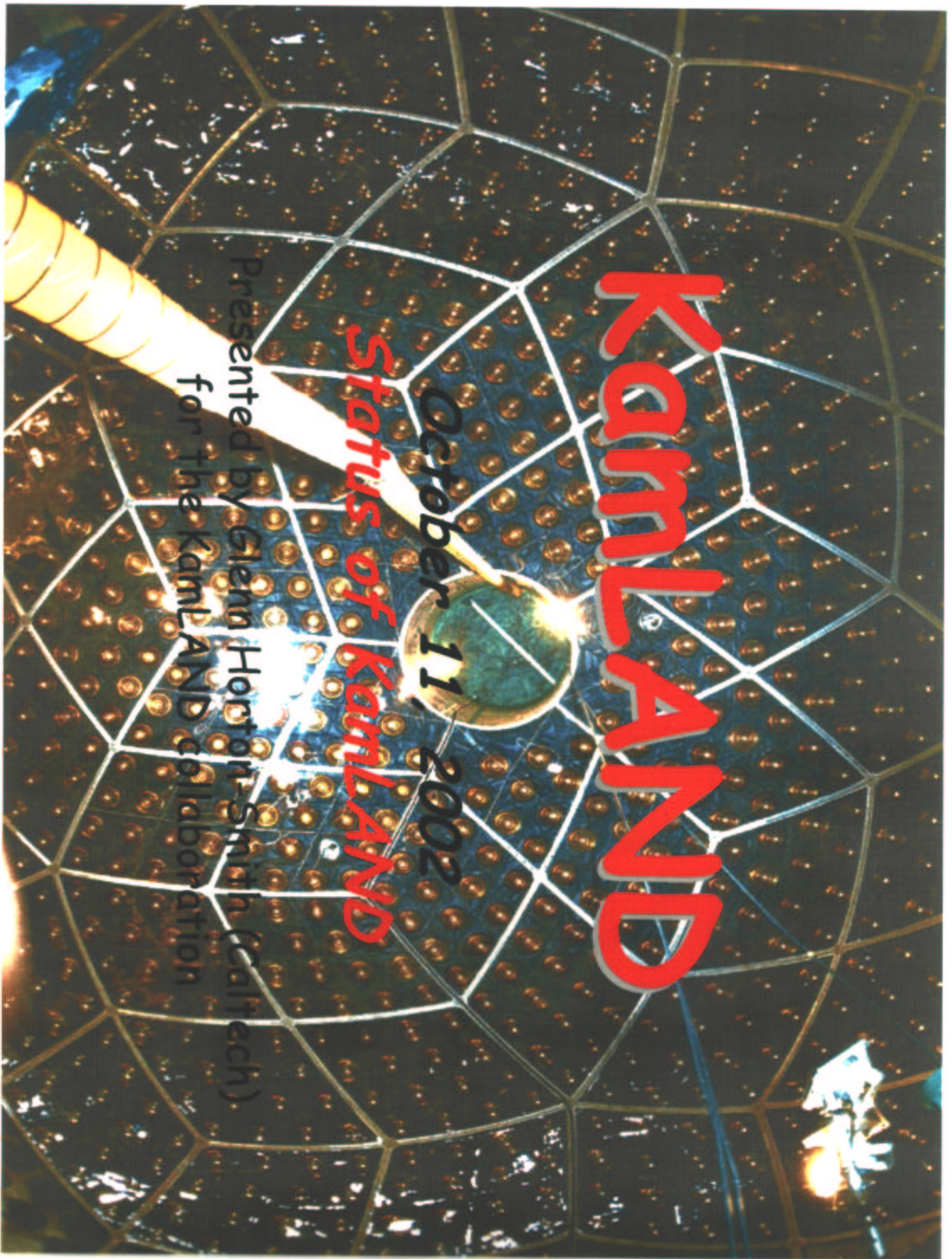


# KAMLAND

October 11, 2002

Status of KAMLAND

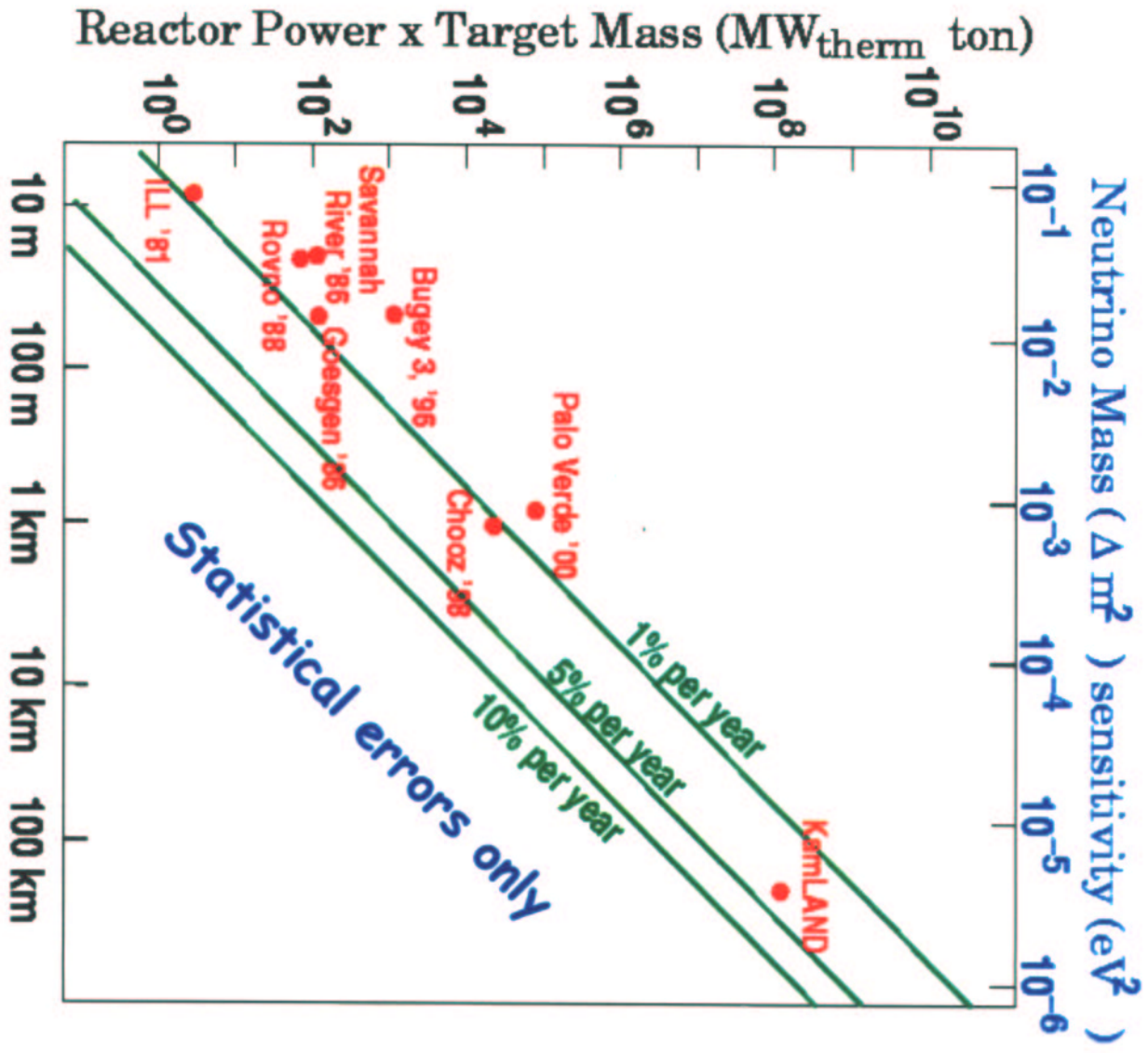
Presented by Glenn Horton-Smith (Caltech)  
for the KAMLAND collaboration



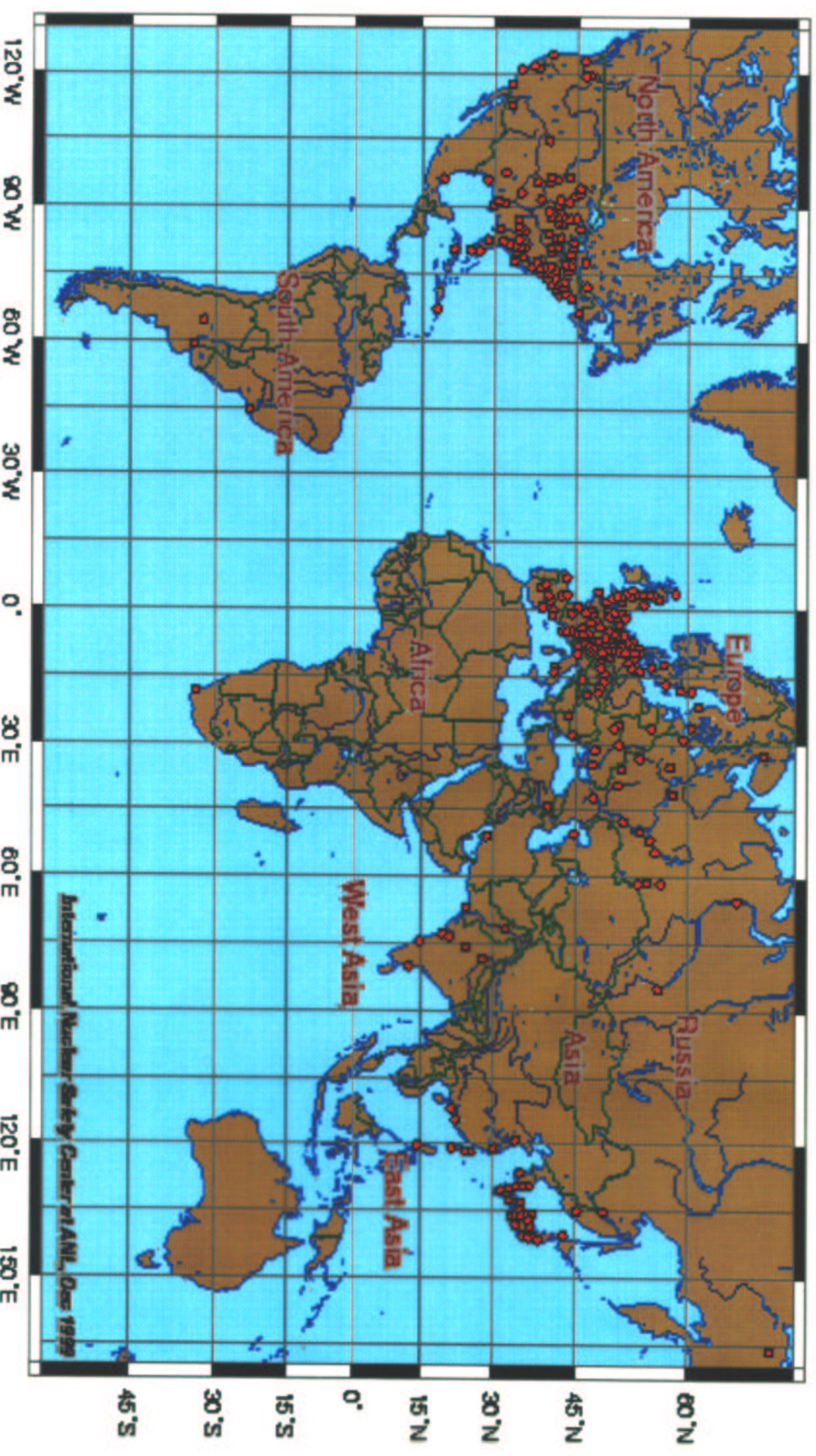
Designed to test solar neutrino oscillation parameters **on Earth (!)**

KamLAND has a much longer baseline than previous (reactor) experiments

*...still quite a difficult experiment*

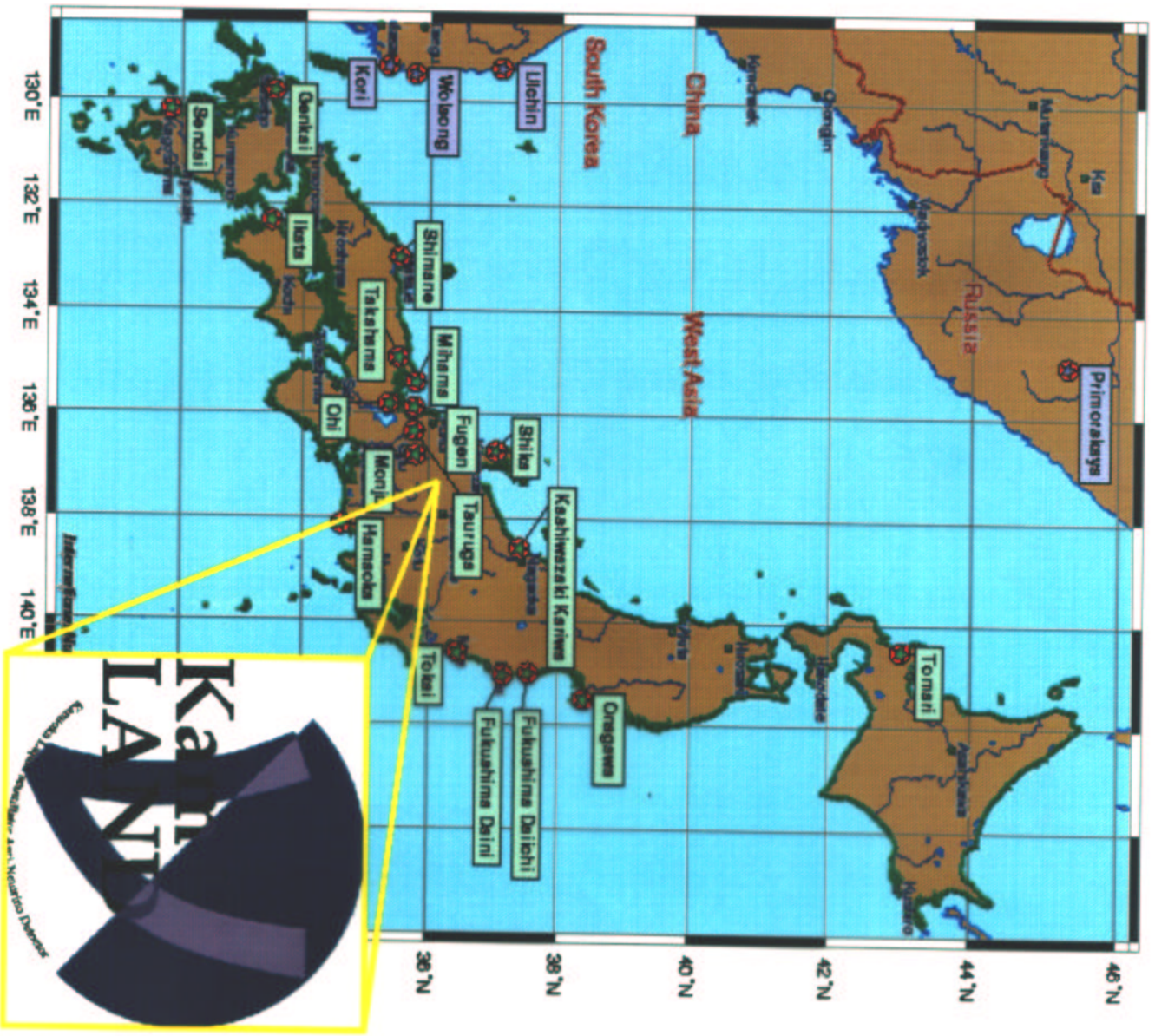


**Only a few places in the World could host  
an experiment like KamLAND...**



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Kam LAND Status



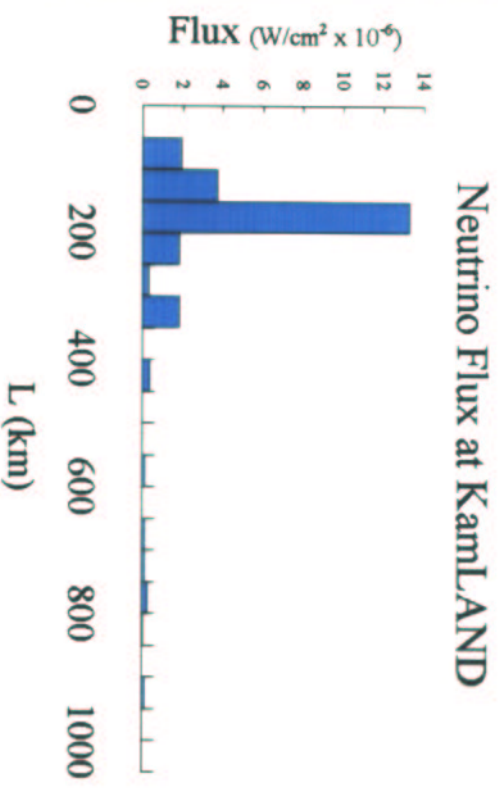
Oct11, 2002

Kam LAND Status

langis betsqaxə latot  
:stotdər morf  
yab\vs Sə

OS ə oitar M2  
Уор , NT , U +1-01 @  
ni noitanimdnos  
rotallitniz sht

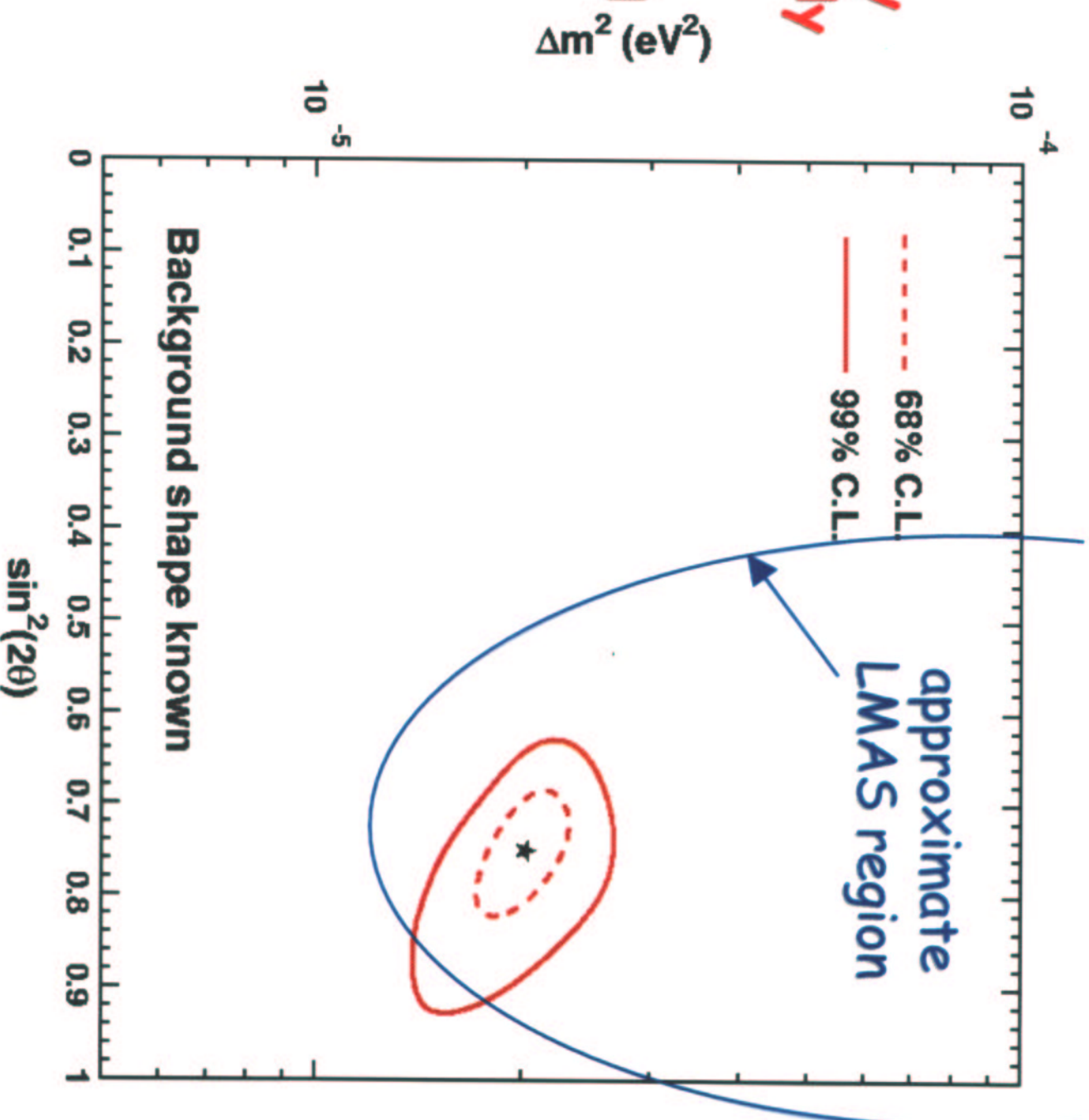
**Baseline is limited:**  
**85.3% of signal has**  
**140 km < L < 344 km**



**The total electric power produced “as a by-product” of the vs is:**

- ~60 GW or...**
- ~4% of the world's manmade power or...**
- ~20% of the world's nuclear power**

The ability to measure the solar LMA-MSW solution accurately "in the lab" puts KamLAND in a very special category of experiments



Oct11, 2002

KamLAND Status

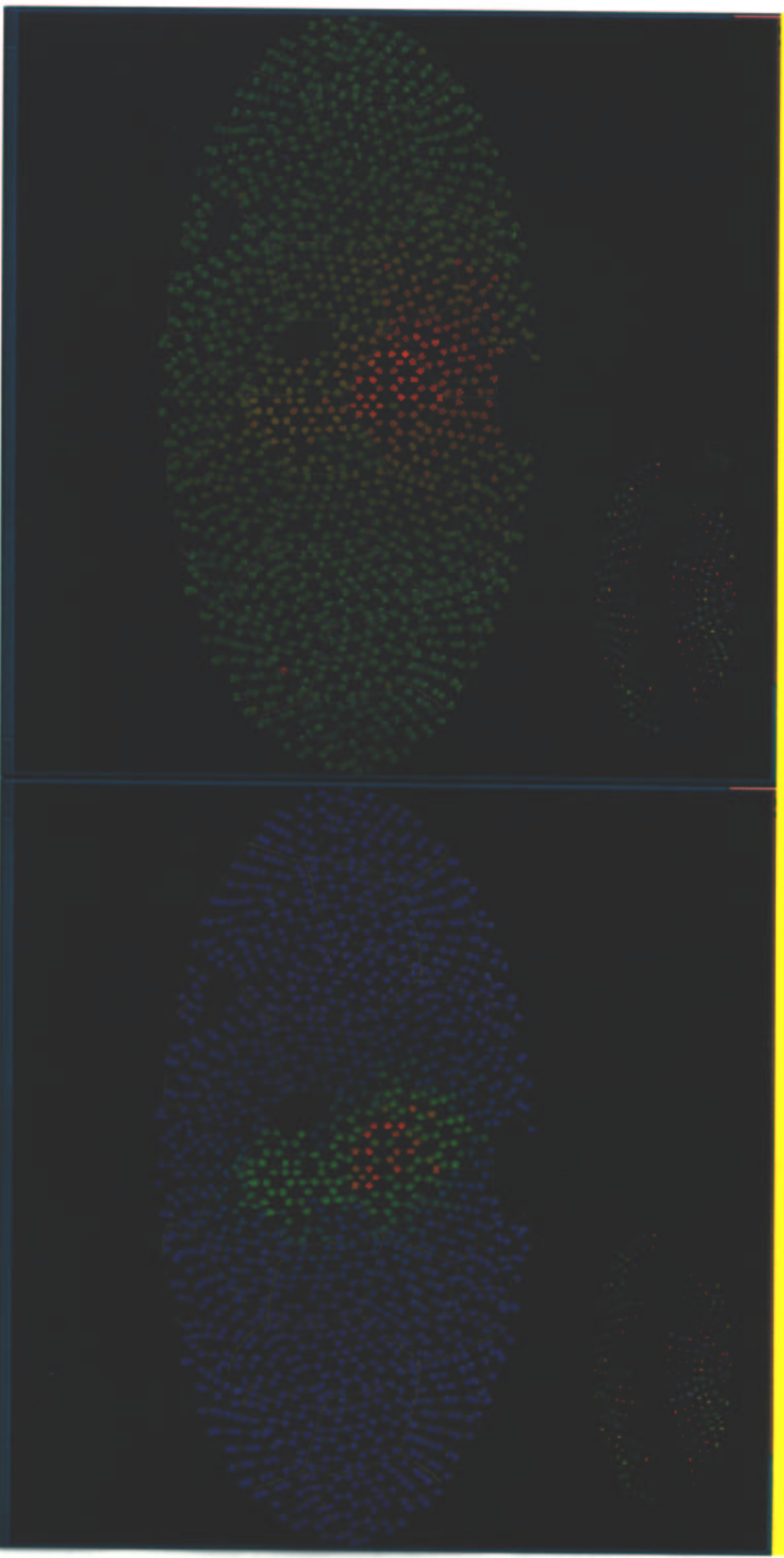
## Other initial physics topics include:

- **Geological neutrinos**
- **Supernovae detection**
- **Solar anti-neutrinos**
- **Exotic nucleon decay modes**

## **KamLAND: neutrino physics on a shinkansen**

- **Summer 2000** **PMT installation**
- **Winter 2000-01** **Veto counter installation**
- **Feb 2001** **Balloon insertion**
- **Mar-Apr 2001** **Balloon inflation and test**
- **Apr-May 2001** **Plumbing for fill**
- **Jun-Sept 2001** **Fill MO and LS**
- **Aug-Sept 2001** **Eng. runs with Macro Elec.**
- **Sept 2001** **FEE/DAQ/Trigger int. (LBL)**
- **end Sept 2001** **First data taking with FEE**
- **Jan 22, 2002** **Begin Data Taking**

# First muon events, Jan 2002



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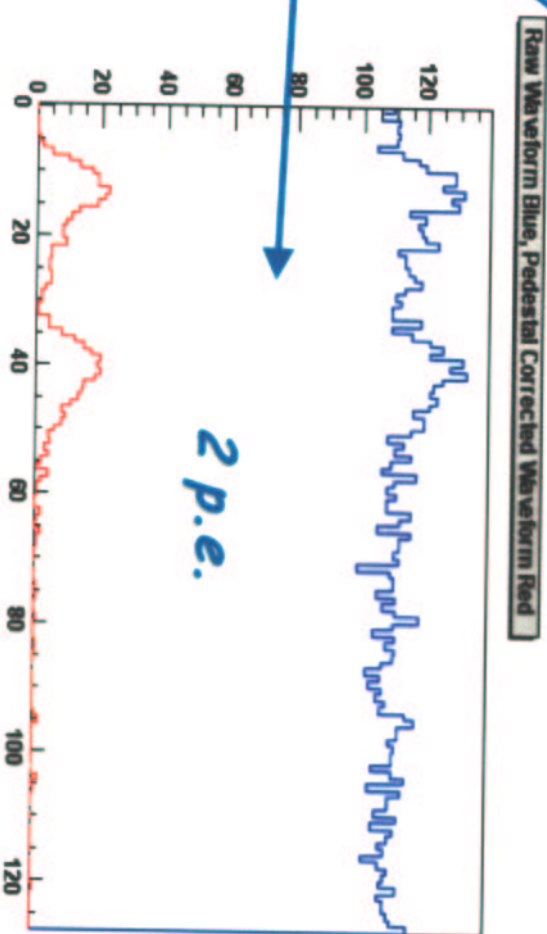
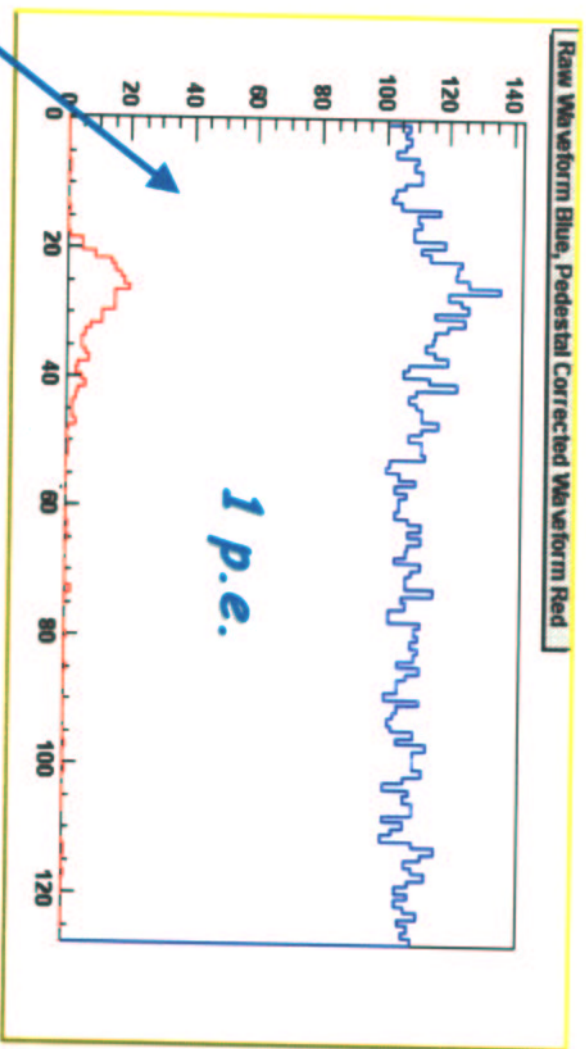
KamLAND Status

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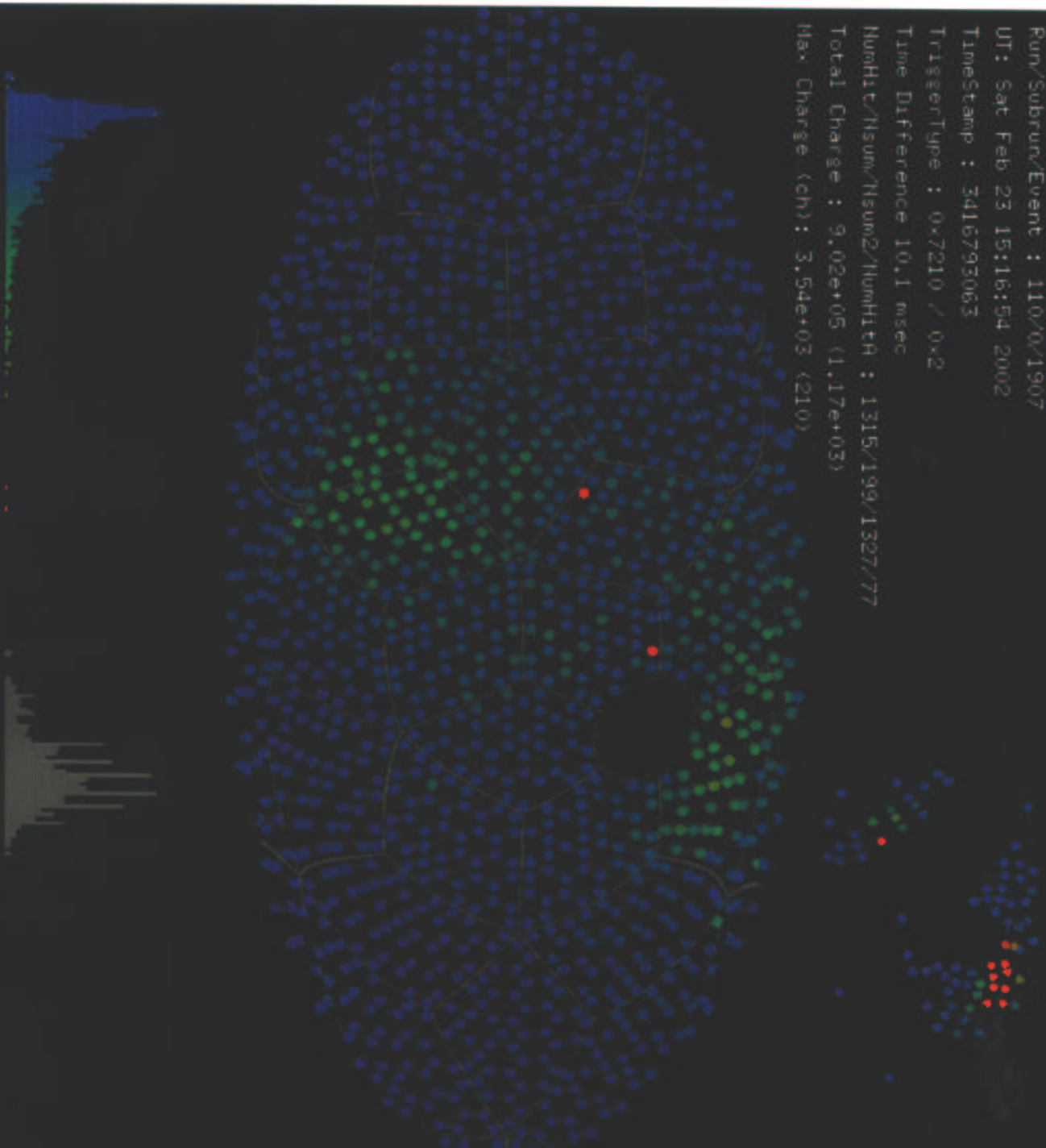
# Have full waveform digitizers on every central and veto channel

Very important for exploring new physics and reject complex background signatures

*Signals from blue LED flashers in the detector*



KamLAND Event Display  
Run/Subrun/Event : 110/0/1907  
UT : Sat Feb 23 15:16:54 2002  
TimeStamp : 3416793063  
TriggerType : 0x7210 / 0x2  
Time Difference 10.1 msec  
NumHit/Num/Num2/NumHitR : 1315/199/1327/77  
Total Charge : 9.02e+05 (1.17e+03)  
Max Charge (ch) : 3.54e+03 (210)



**through-going  
muon**

**color is  
pulseheight**

**all tubes  
illuminated**

KamLAND Event Display

Run/Subrun/Event : 110/0/19244

UT: Sat Feb 23 15:25:11 2002

TimeStamp : 13052924536

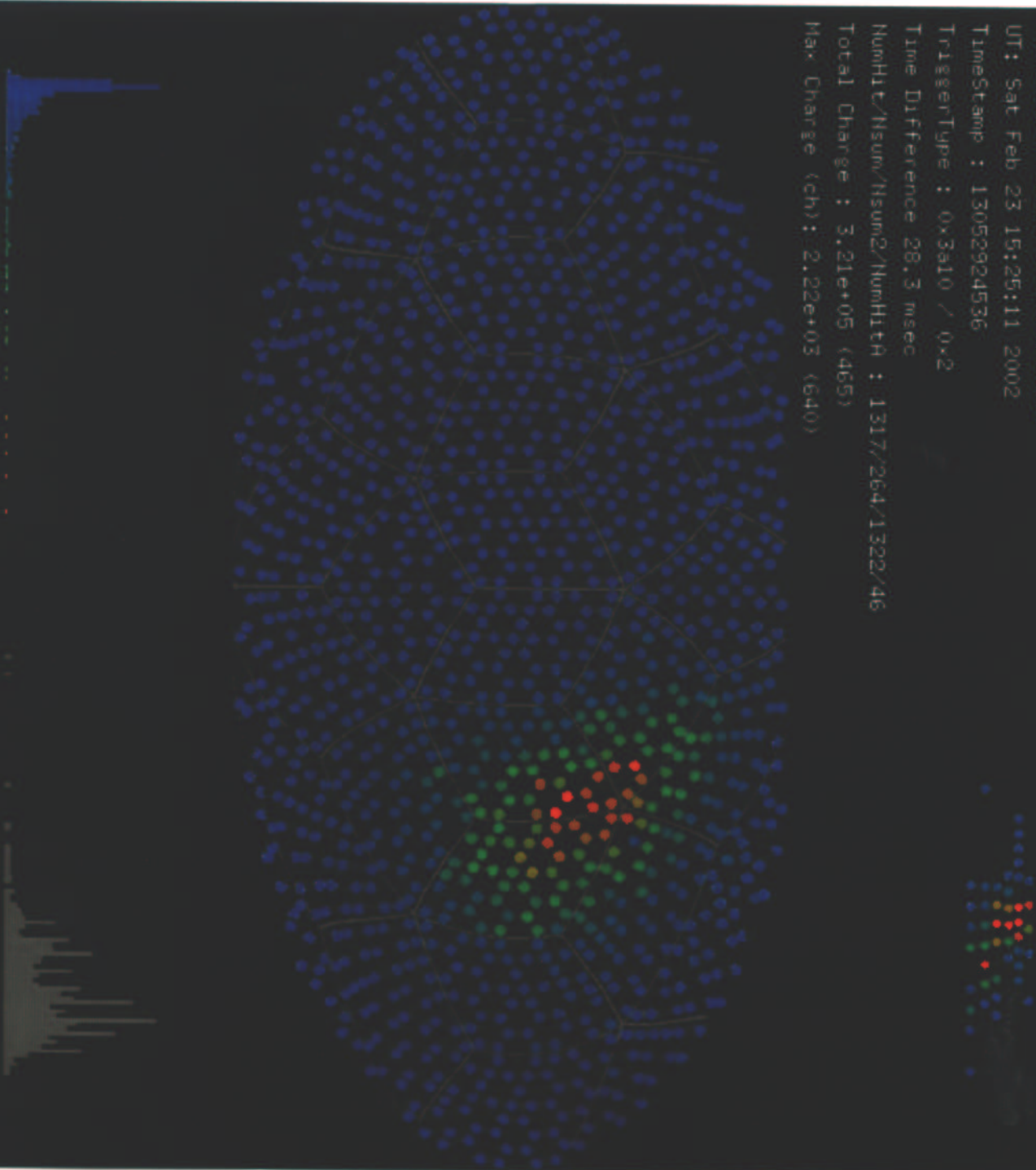
TriggerType : 0x3a10 / 0x2

Time Difference 28.3 msec

NumHit/Hsum/Hsum2/NumHitR : 1317/264/1322/46

Total Charge : 3.21e+05 (465)

Max Charge (ch): 2.22e+03 (640)



Stopped muon

KamLAND Event Display

Run/Subrun/Event : 110/0/91185

UT : Sat Feb 23 15:57:50 2002

TimeStamp : 530000002993

TriggerType : 0xb00 / 0x2

Time Difference 925 nsec

NumHit/Num/Num2/NumHitH : 585/466/1071/0

Total Charge : 4.12e+03 (0)

Max Charge (ch) : 38.7 (210)



....decaying into  
a Michel electron

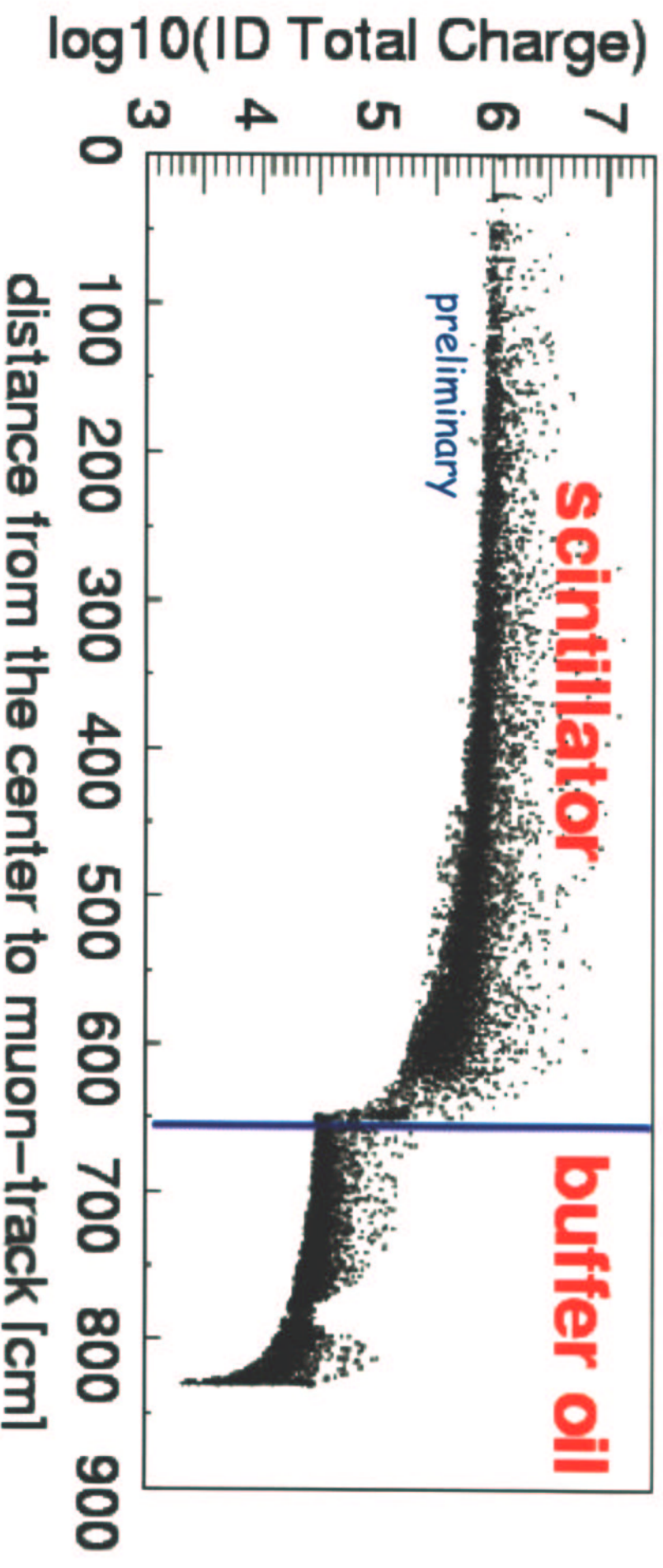
KamLAND Event Display  
Run/Subrun/Event : 110/0/3772  
UT: Sat Feb 23 15:17:50 2002  
TimeStamp : 4363651980  
TriggerType : 0x3210 / 0x2  
Time Difference 4.13 msec  
NumHit/Num/Num2/NumHitR : 468/177/427/45  
Total Charge : 3.05e+03 (471)  
Max Charge (ch): 882 (46)



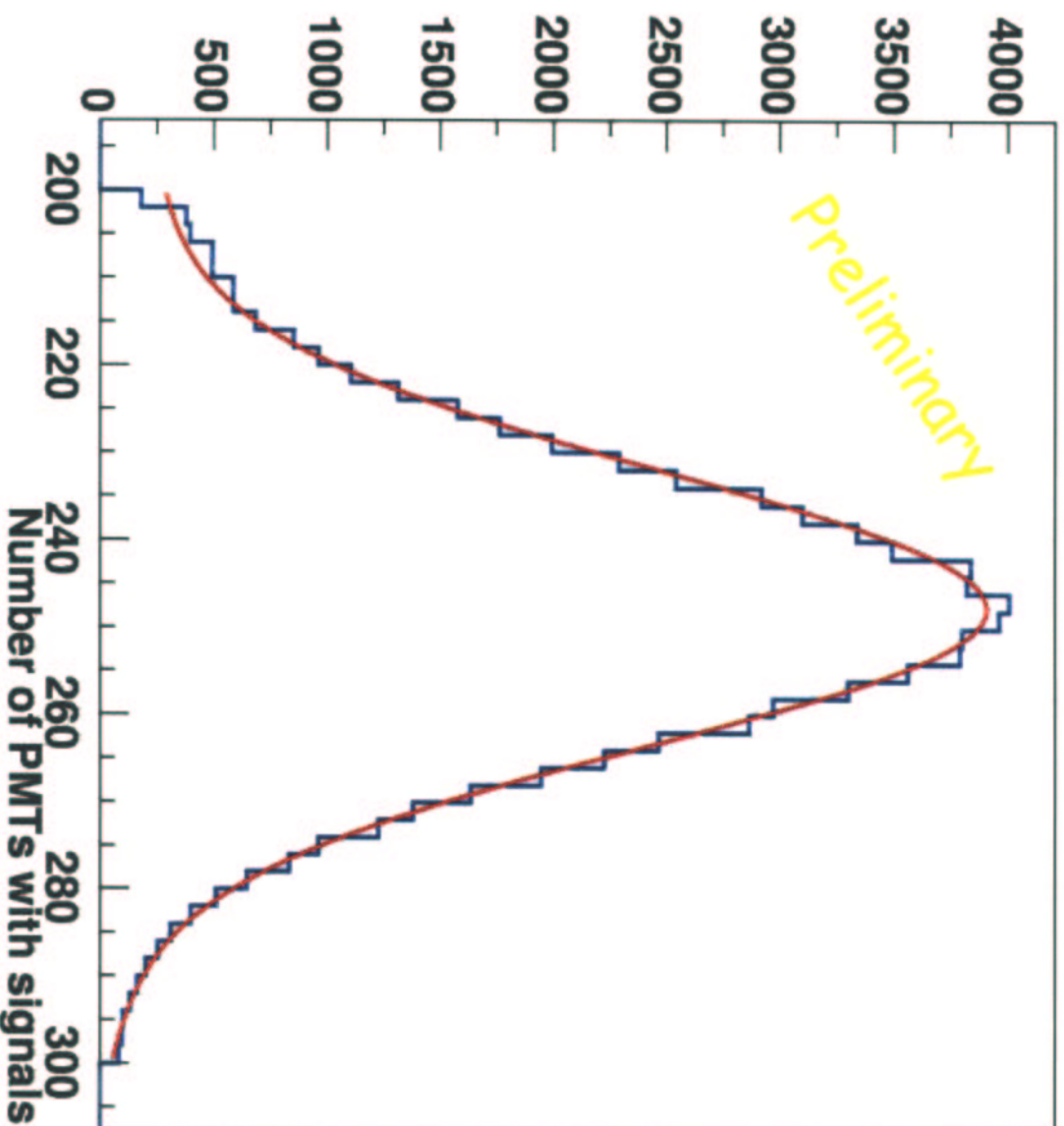
**Corner-clipper  
muon:**

***Cherenkov  
ring in the  
buffer but  
no scintillation  
activity***

Muon track reconstruction reveals the balloon boundary and the different light yield in scintillator and buffer oil (Cherenkov)



**Zn65 At Center Of Detector**



$^{65}\text{Zn}$  :

**1.115 MeV in  
the detector**

**$\sigma/E = 6.5\%$**



***Light Yield  
241 p.e./MeV***

Preliminary

$^{60}\text{Co}$  :  
1.173+1.333 MeV in  
the detector

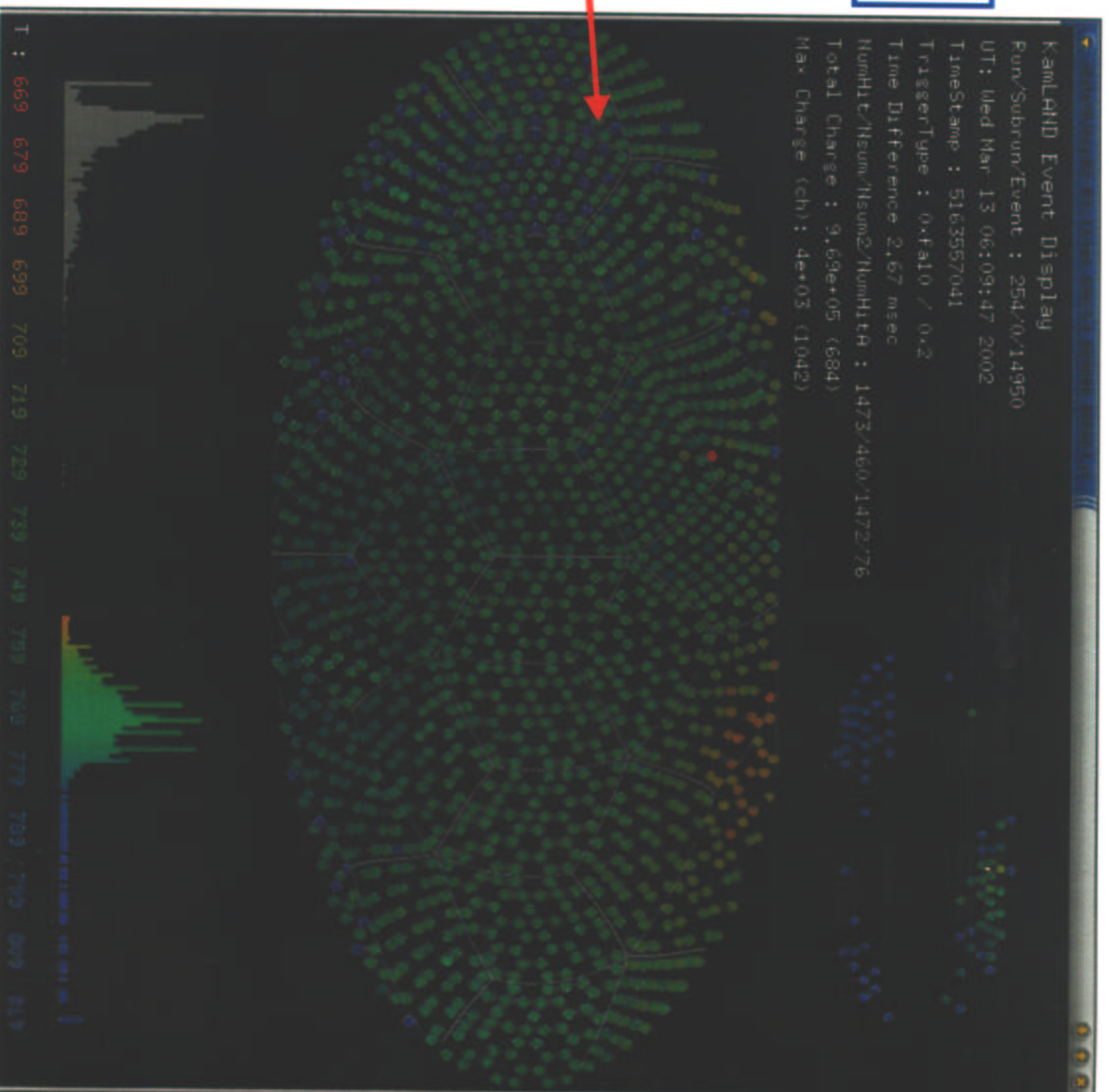
$$\sigma/E = 4.2\%$$



*Light Yield*  
*239 p.e./MeV*

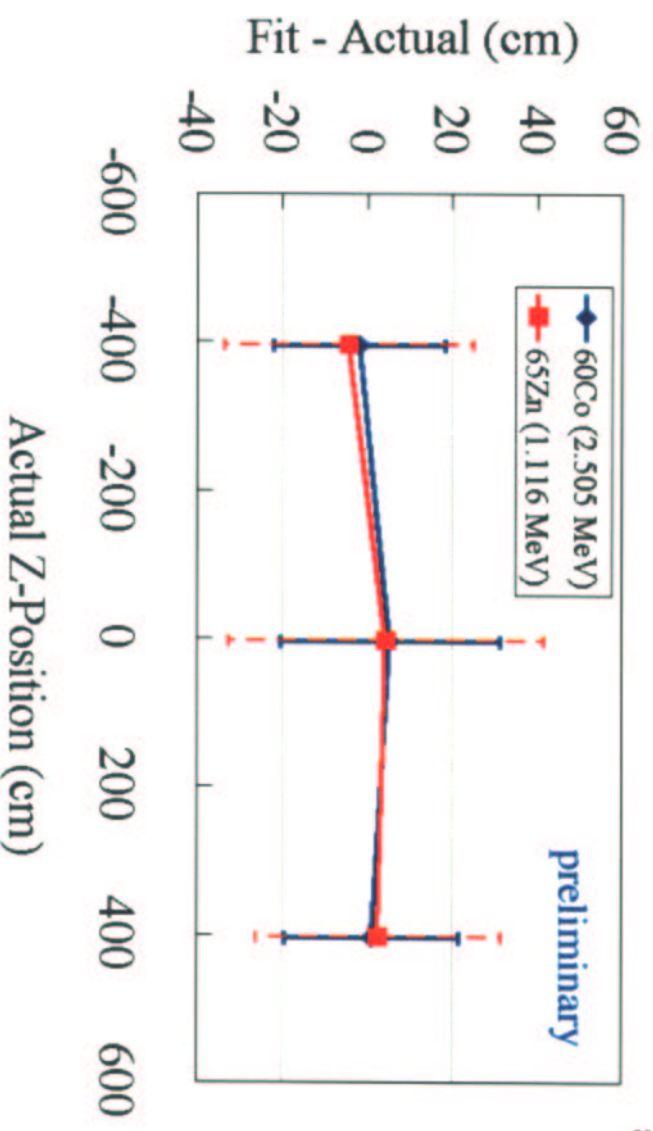
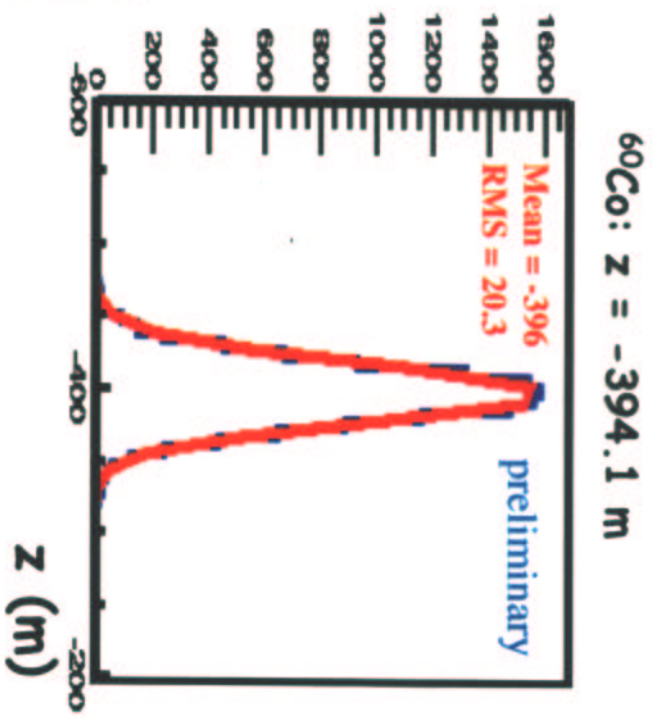
# 20" PMT test, Mar '02

*Energy  
resolution  
(and data  
load !!)  
will improve  
by  $\sim\sqrt{2}$*

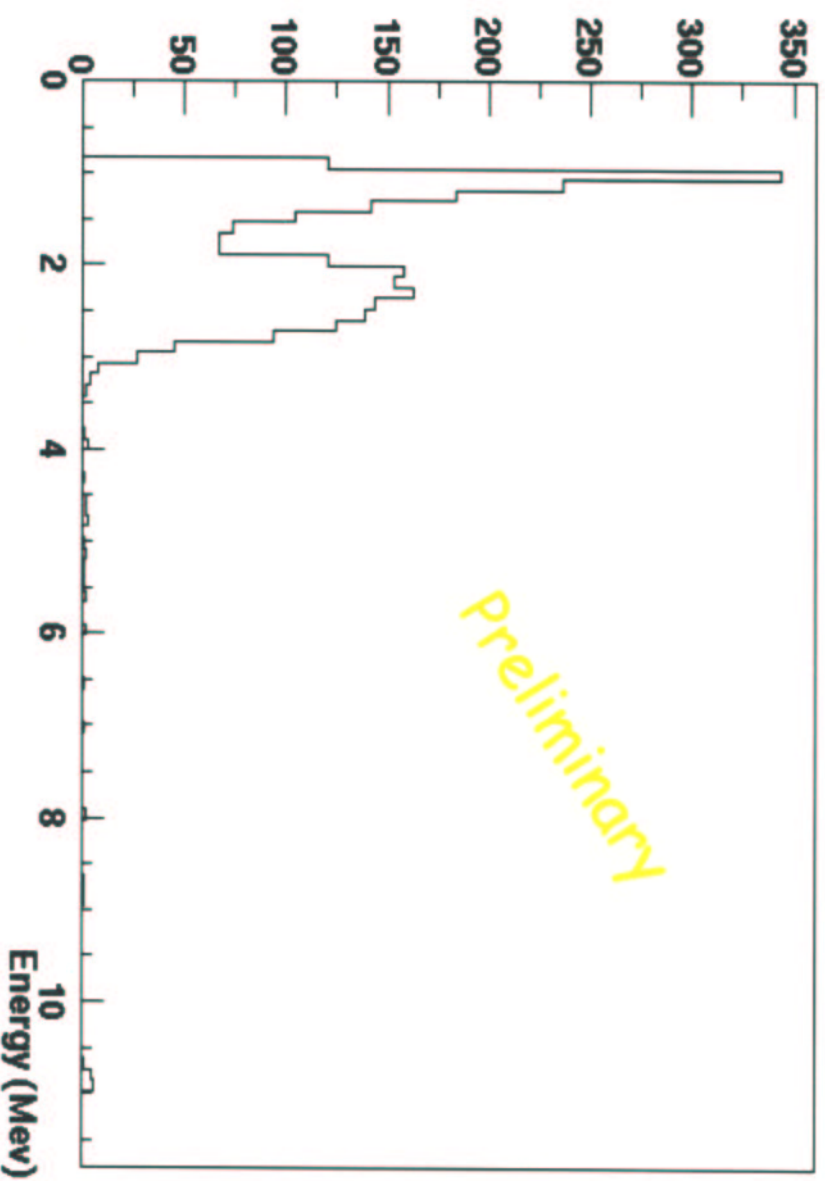


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# Position Calibration



**Now find cosmic ray muons traversing the detector and look for energy deposits following them**

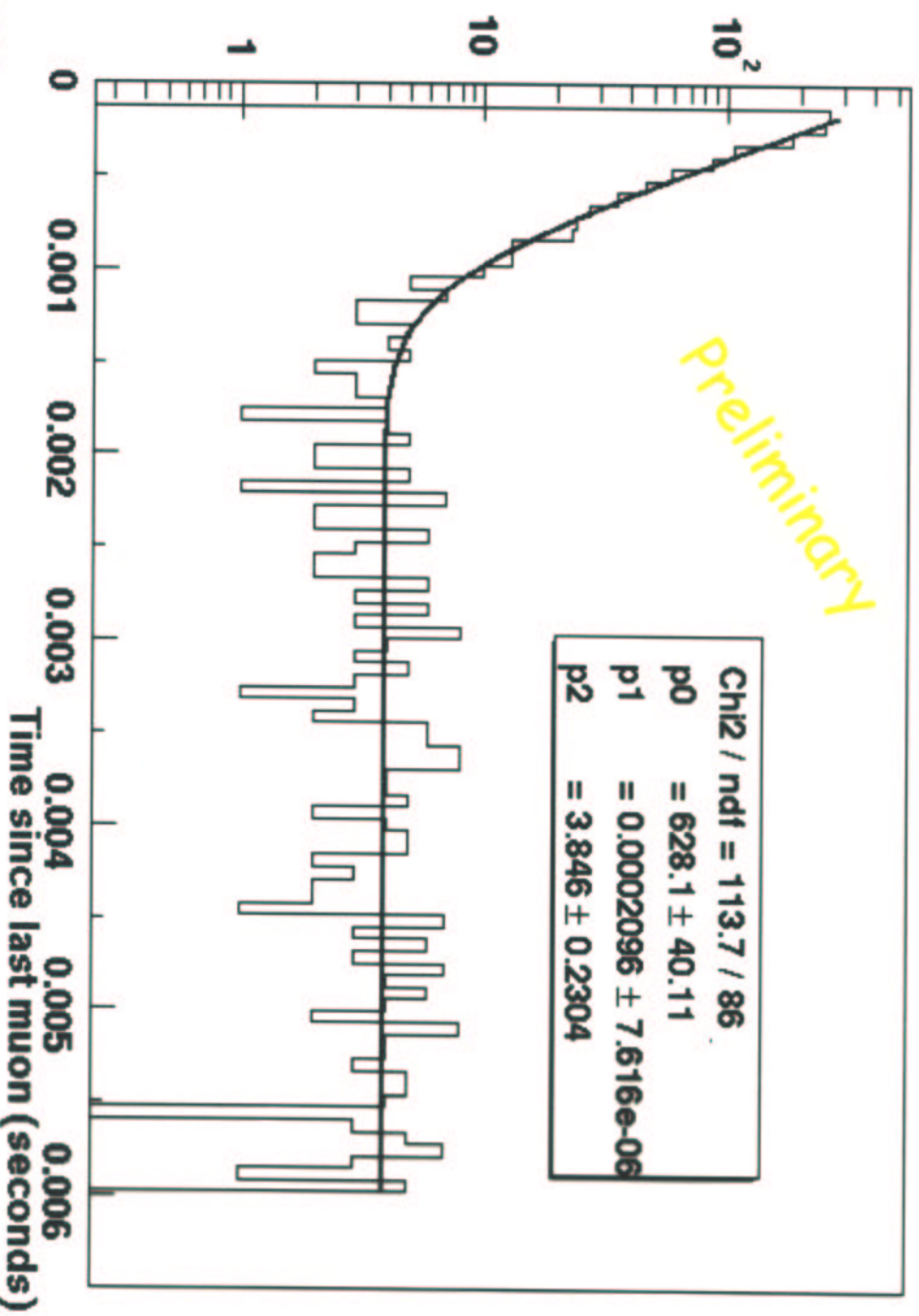


**Using E cal.  
from previous  
slide the peak  
is here at  
 $\approx 2.3$  MeV**

**n-capture in  
hydrogen gives  
2.2 MeV**

**Prompt - delayed correlation time distributed  
as an exponential with  $210 \pm 8 \mu\text{s}$   
Expectation for neutron capture is  $\sim 223 \mu\text{s}$**

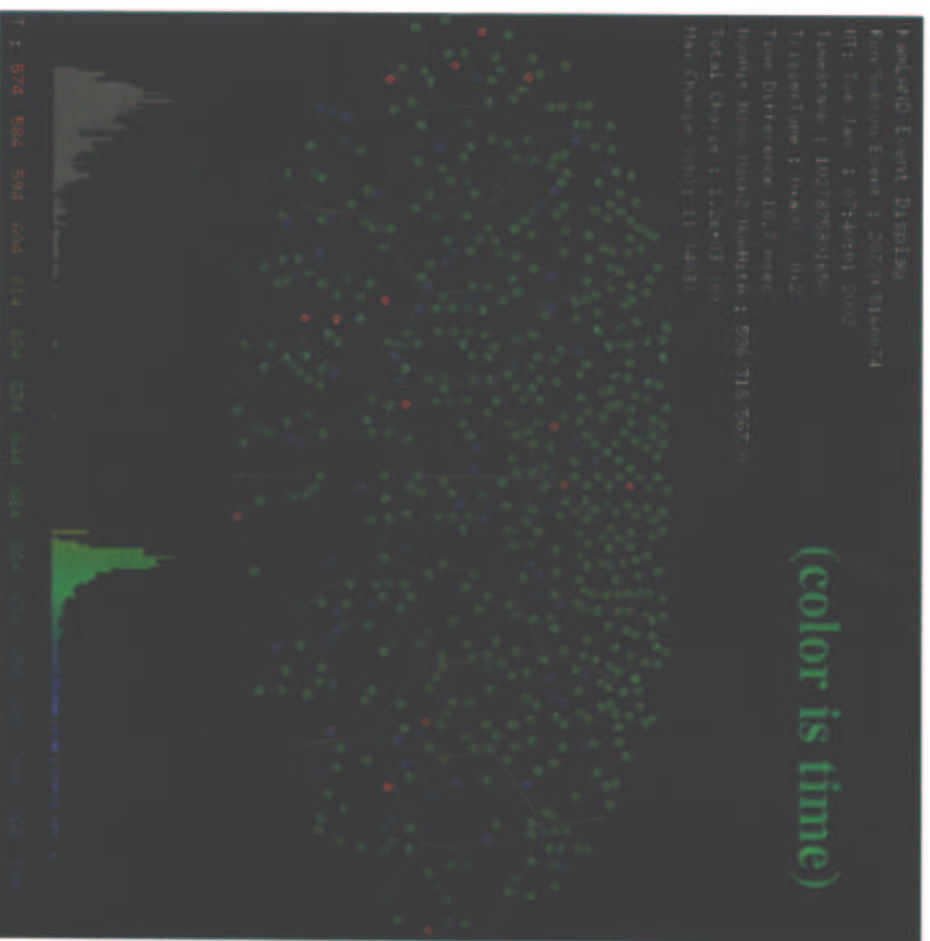
**Neutrons Following Muons ( $300 < n_{\text{sum}} < 60p$ )**



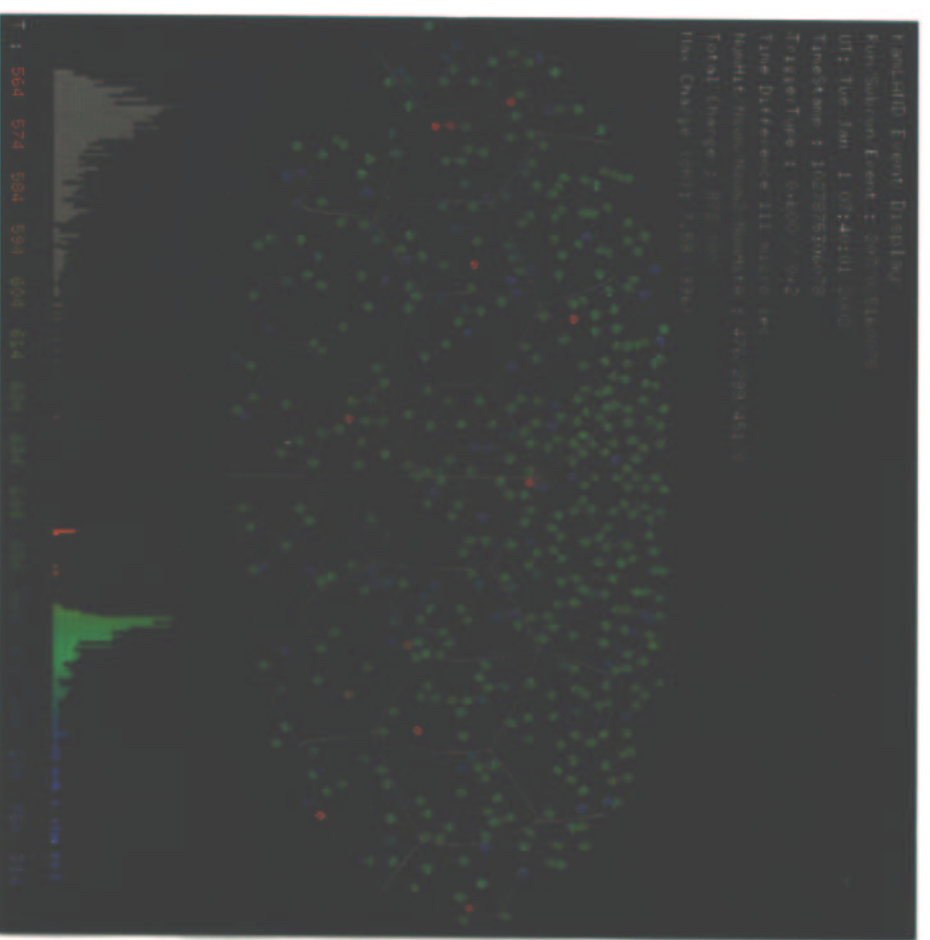
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KamLAND Status

# Anti-Neutrino Candidate



**Prompt Signal**  
**E = 3.20 MeV**

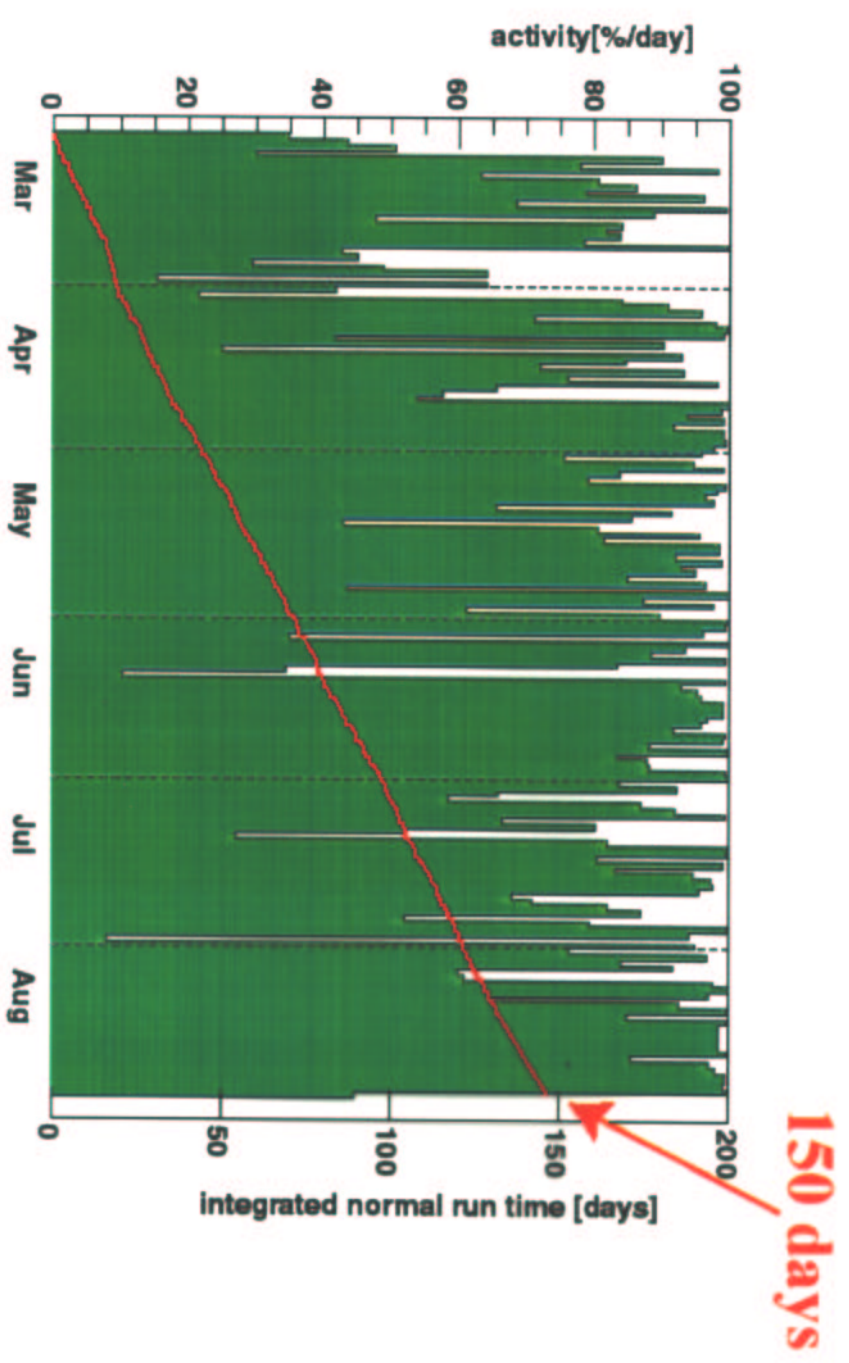


**Delayed Signal**  
**E = 2.22 MeV**  
 **$\Delta t = 111 \mu s$**   
 **$\Delta R = 34 \text{ cm}$**

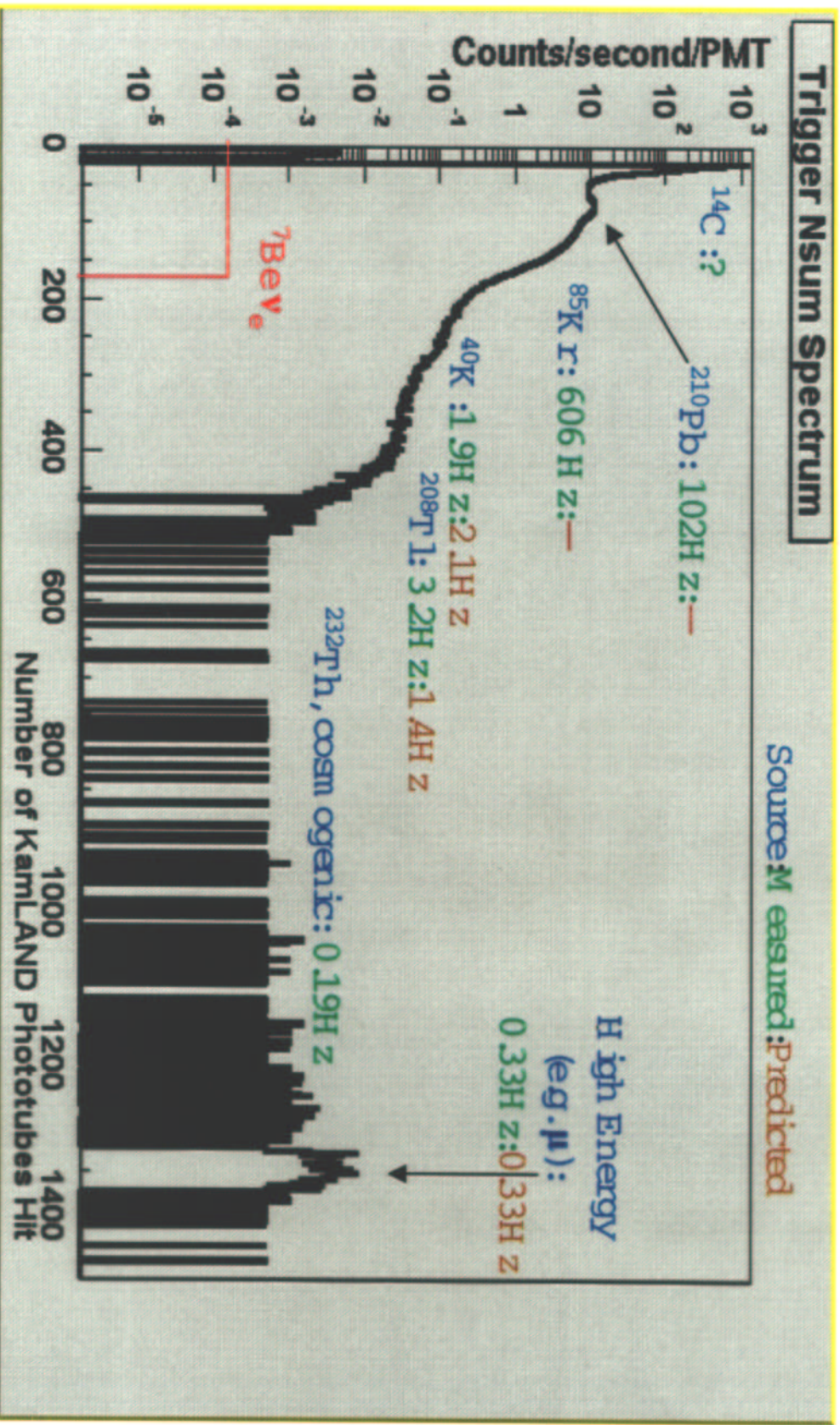
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Kam LAND Status

**KamLAND anti-neutrino live-time  
since the beginning of physics runs**



# Singles Background



## Scintillator contamination by mass

Measured from data:

- Th: using the  $^{212}\text{Bi}$ - $^{212}\text{Po}$  300 ns correlation
  - $< 1.8 \cdot 10^{-16}$  g/g
- U: studying the high energy background
  - $< 6.4 \cdot 10^{-16}$  g/g
- $^{40}\text{K}$ : fitting background spectra
  - $< 2.3 \cdot 10^{-16}$  g/g

**Consistent with Neutron Activation Analysis:**

- Th  $< 2.8 \cdot 10^{-15}$  g/g
- U  $< 8 \cdot 10^{-15}$  g/g
- $^{40}\text{K}$   $< 1.3 \cdot 10^{-15}$  g/g (record NAA sensitivity)

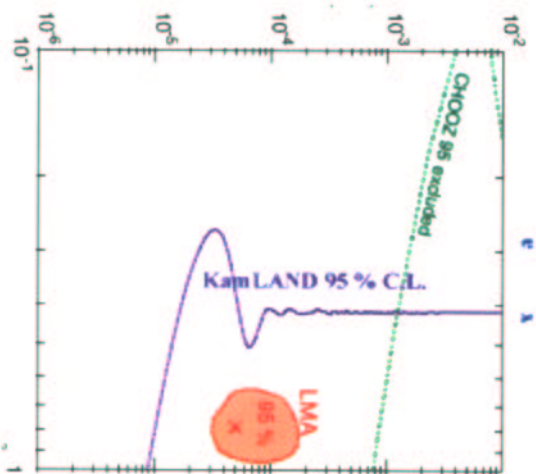
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# Signal - Background

---

Flux\*CrossSection\*LiveTime\*Volume\*ProtonDensity\*CutAcceptance

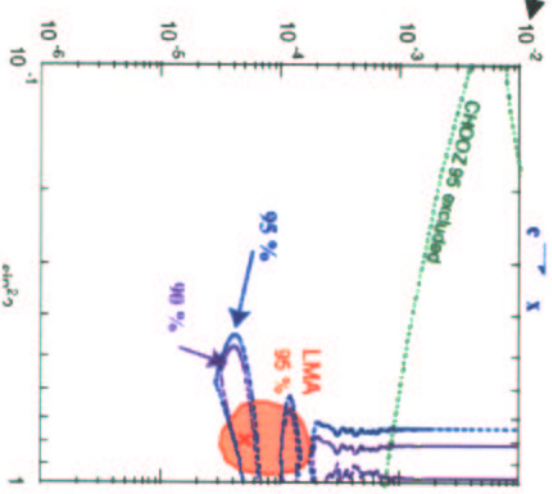
We are in the final stages of evaluating our numbers for all of these quantities and their systematic errors.



No oscillation?

LMA<sub>2</sub>

We'll publish the real exclusion plot with our numbers...



**Data is coming in smoothly...**

**stay tuned for many years  
of exciting results...**