Status of the purification at KamLAND

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CENBG CNRS/IN2P3 and Université Bordeaux I

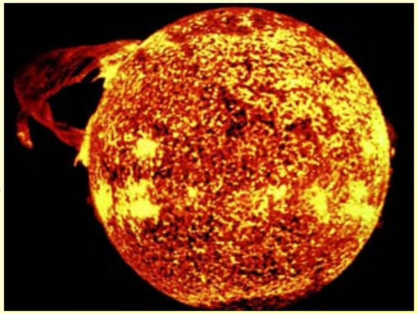
LRT workshop, Aussois (France) October,1-4 2006

KamLAND Collaboration

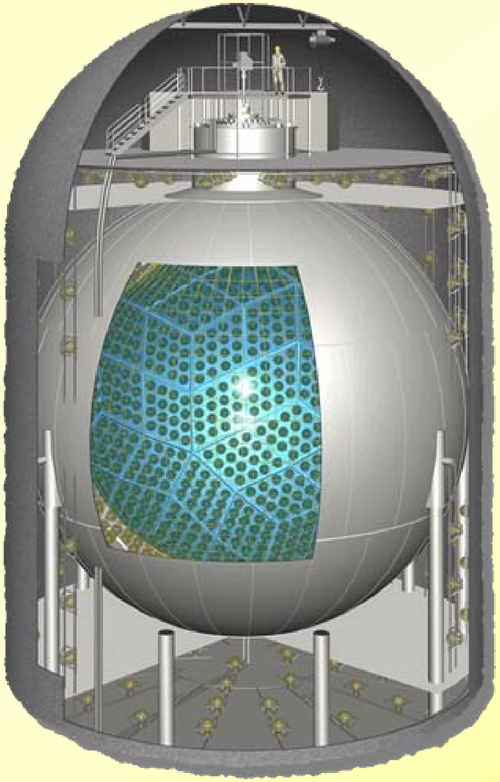
Tohoku University, Japan,
California Institute of Technology, USA
University Bordeaux 1, France,
Drexel University, USA,
IHEP, China,
Kansas State University, USA,
Triangle Universities Nuclear Lab., USA,
University of Alabama, USA,
University of Hawaii, USA,
University of New Mexico, USA,
University of Tennessee, USA,
Lawrence Berkeley National Lab., USA,
Louisiana State University, USA,
Stanford University, USA

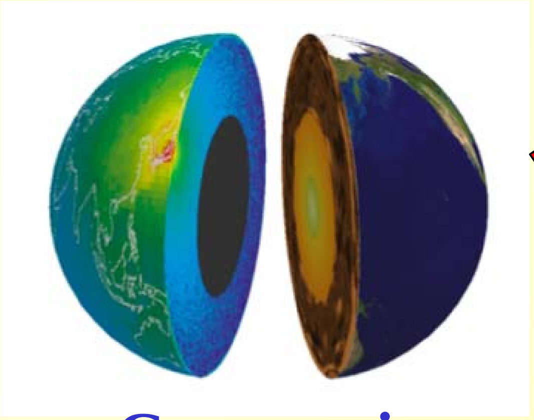
KamLAND Physics

Reactors



Solar neutrinos

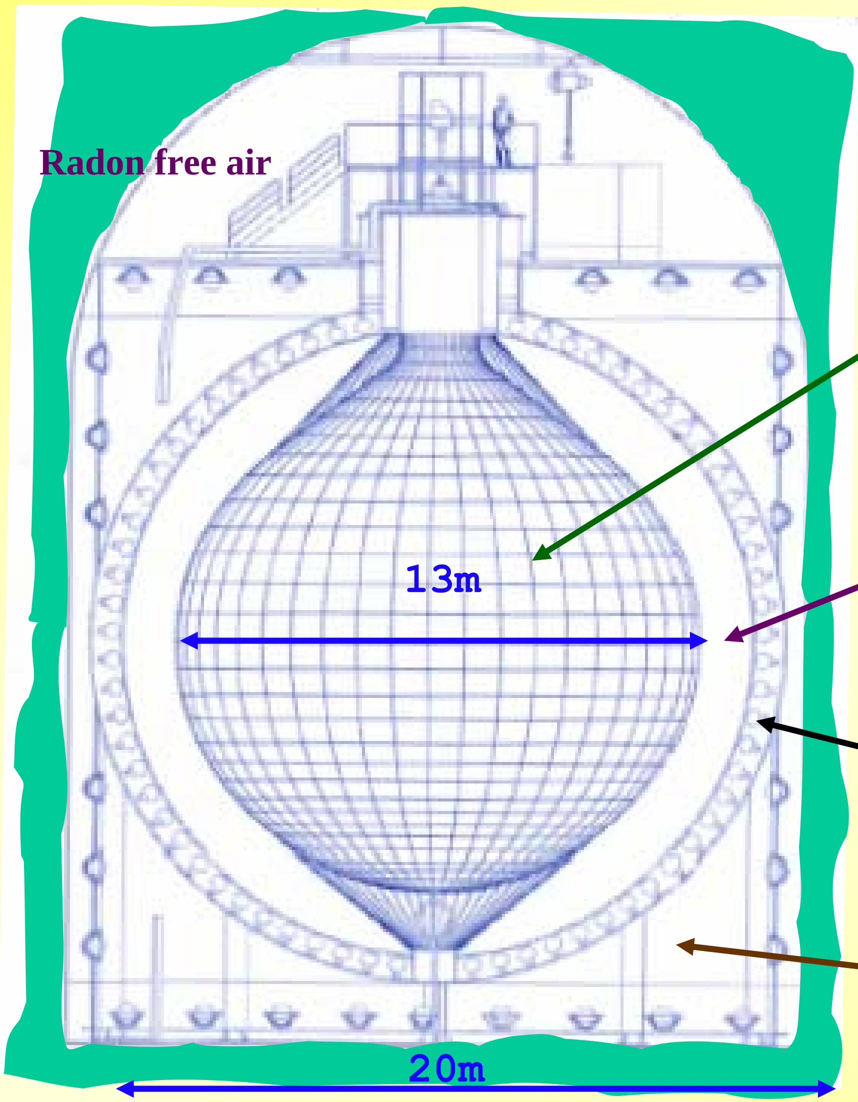




Geoneutrinos

Supernovae neutrinos

KamLAND Detector



Kamioka mine overburden: 2700 w.m.e.
Muon rate: 0.34 Hz

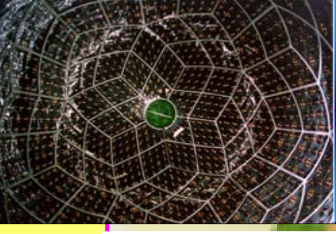
1000 tons of liquid scintillator
80% dodecane+ 20% pseudocumene + PPO

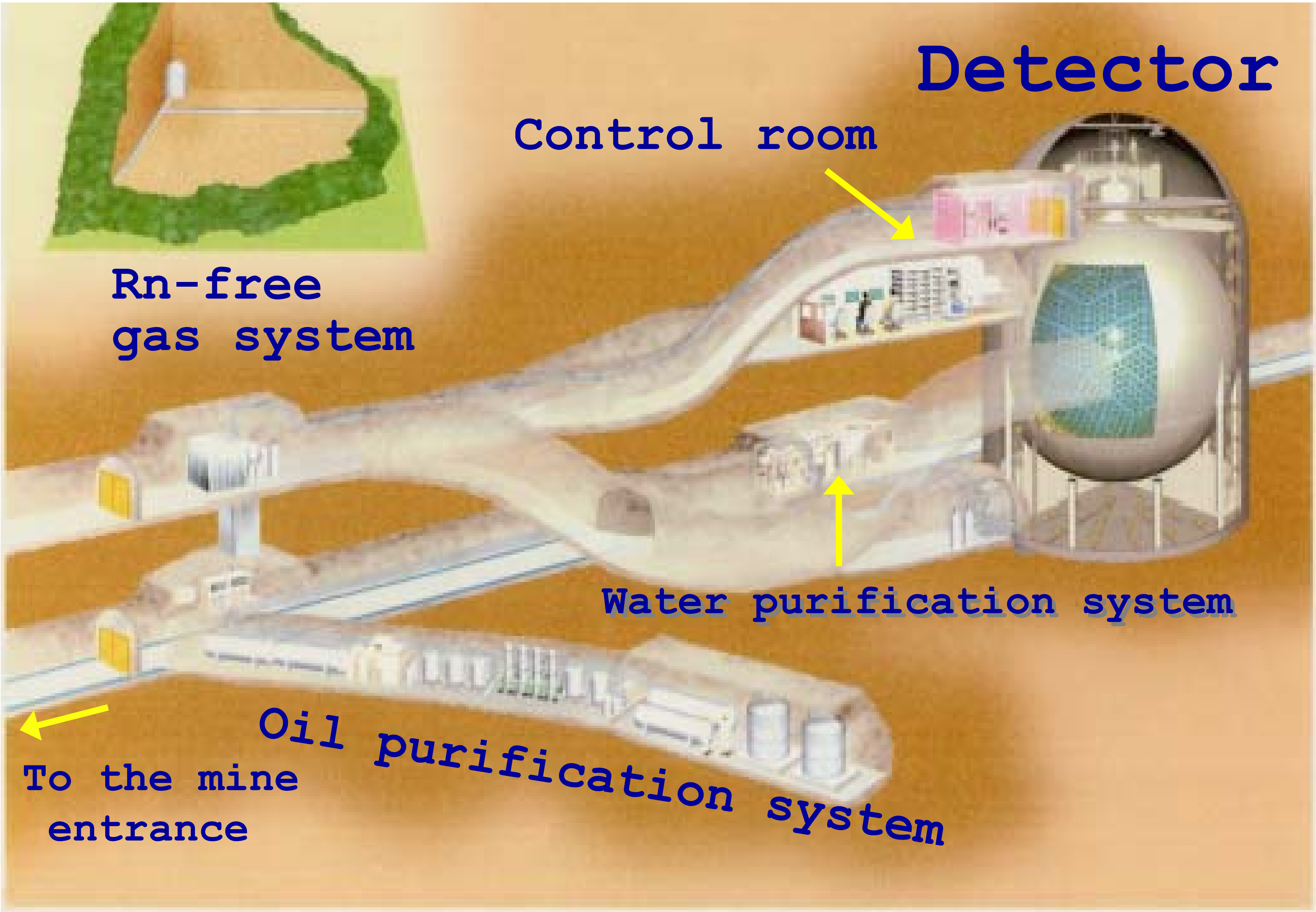
Mineral oil
Buffer against external radiation

1979 PMTs (1325 17" + 554 20"
Photocathode coverage 34%

Outer water Cherenkov detector
for μ veto

KamLAND installation



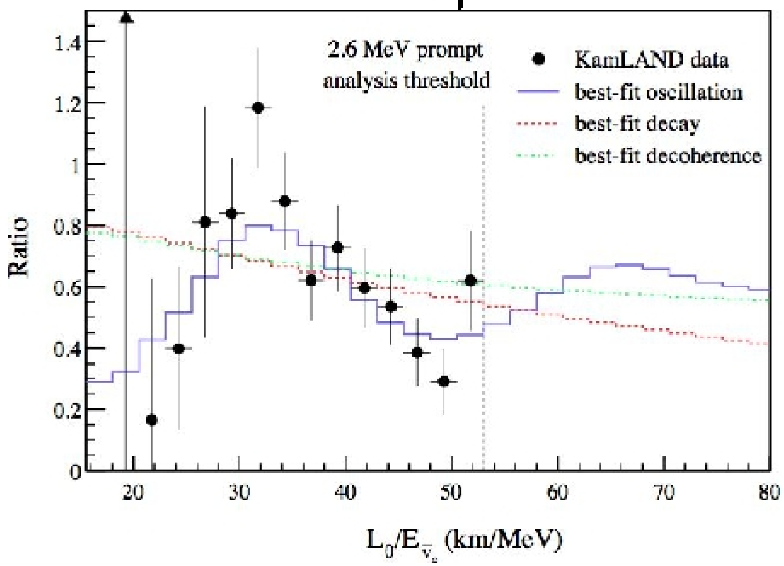


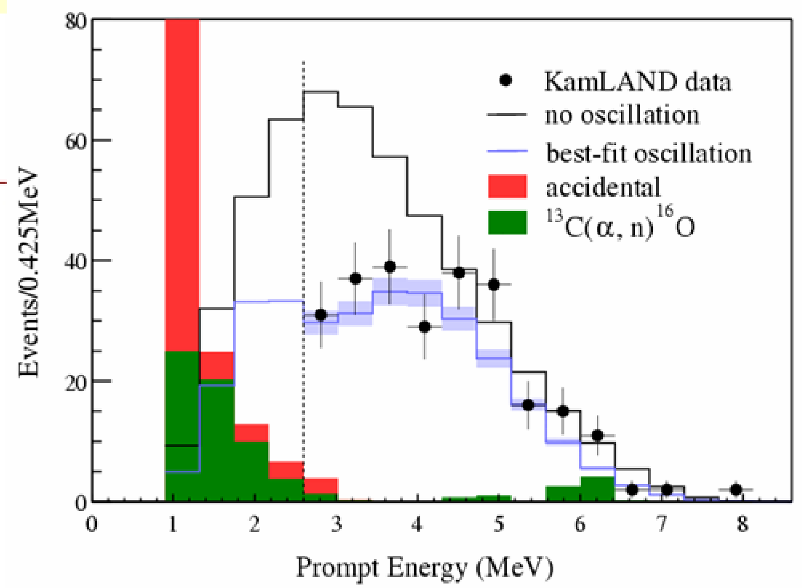
Reactor Anti-Neutrino Results

Phys.Rev.Lett. 94, 081801 (2005)

2nd result : disappearance confirmed at 99.998% CL

L/E plot

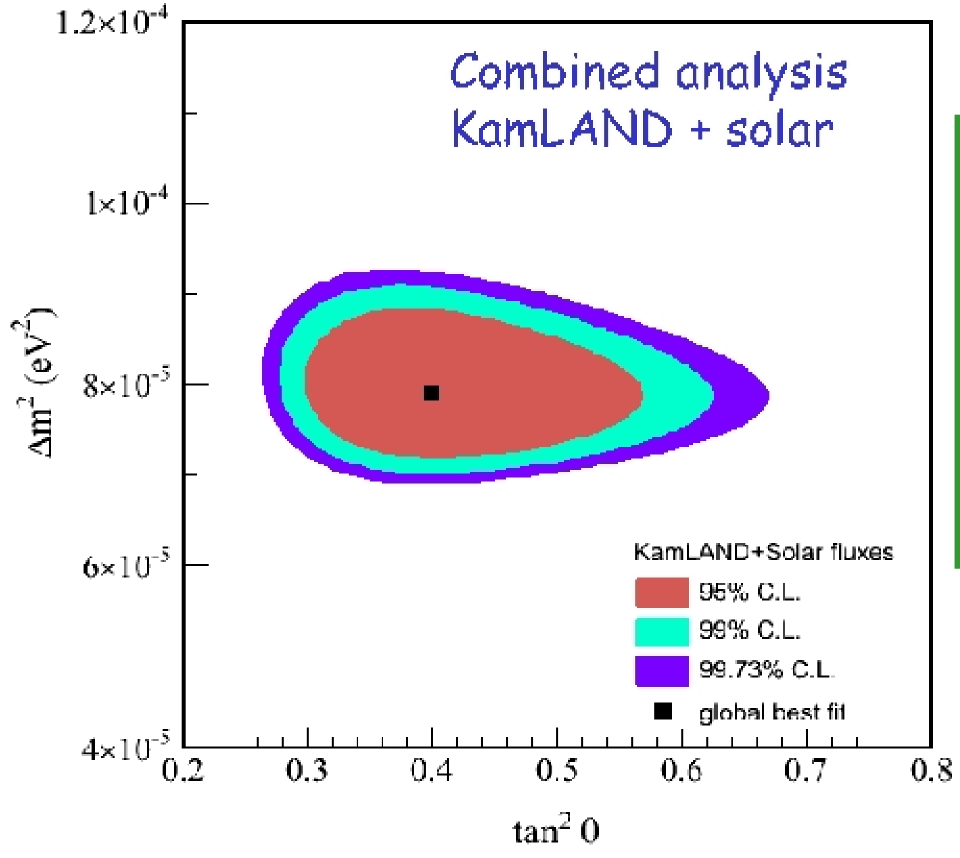




Scaled reduced spectrum rejected @ 99.6 % CL

Eliminate other disappearance hypothesis at 98% CL

Reactor Anti-Neutrino Results

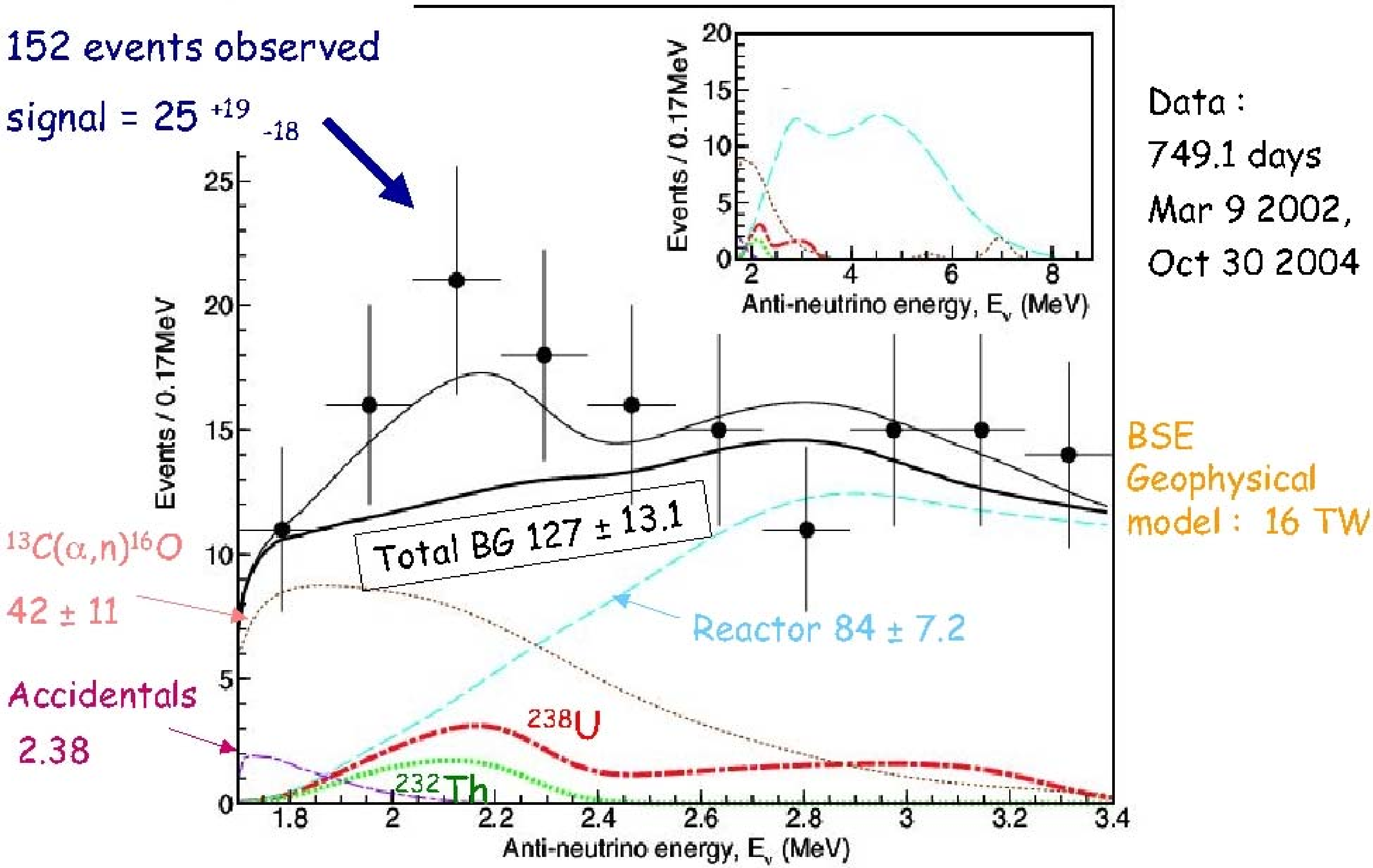


Best fit :

$\Delta m^2 = 7.9^{+0.6}_{-0.5} \times 10^{-5}\ eV^2$

$\tan^2\theta = 0.40^{+0.10}_{-0.07}$

Geoneutrinos Results

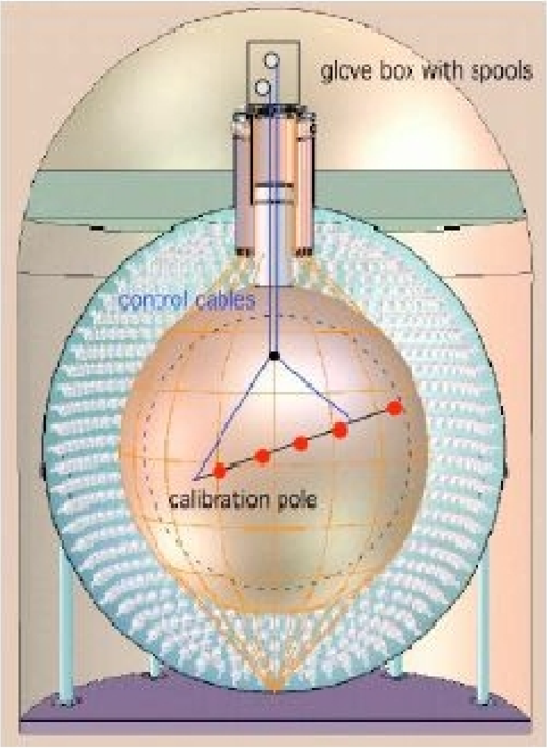


Data :
749.1 days
Mar 9 2002,
Oct 30 2004

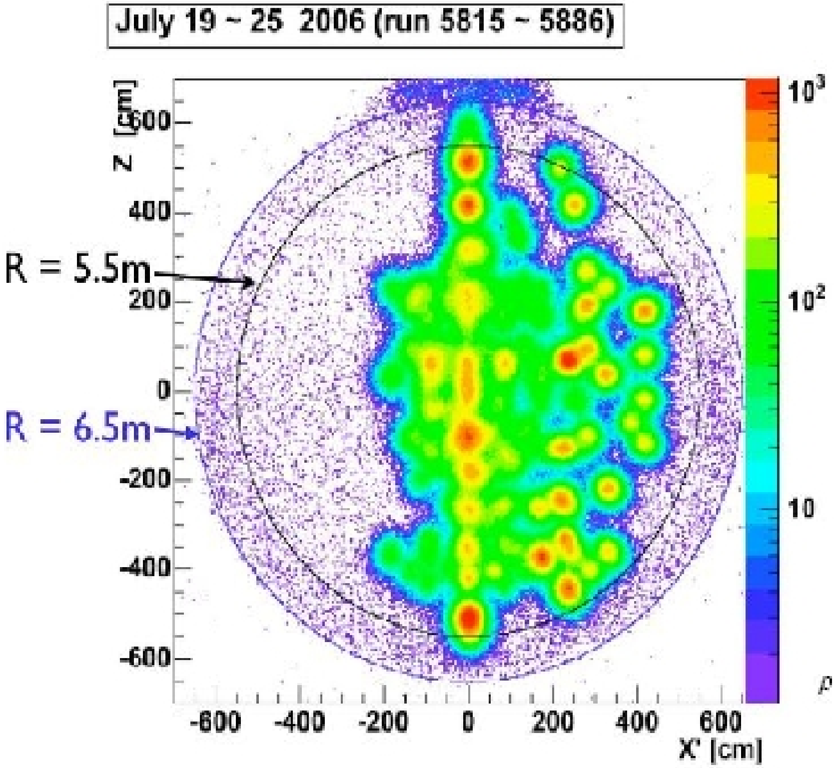
Nature 436, 499 (2005)

Calibration improvements

4pi calibration system

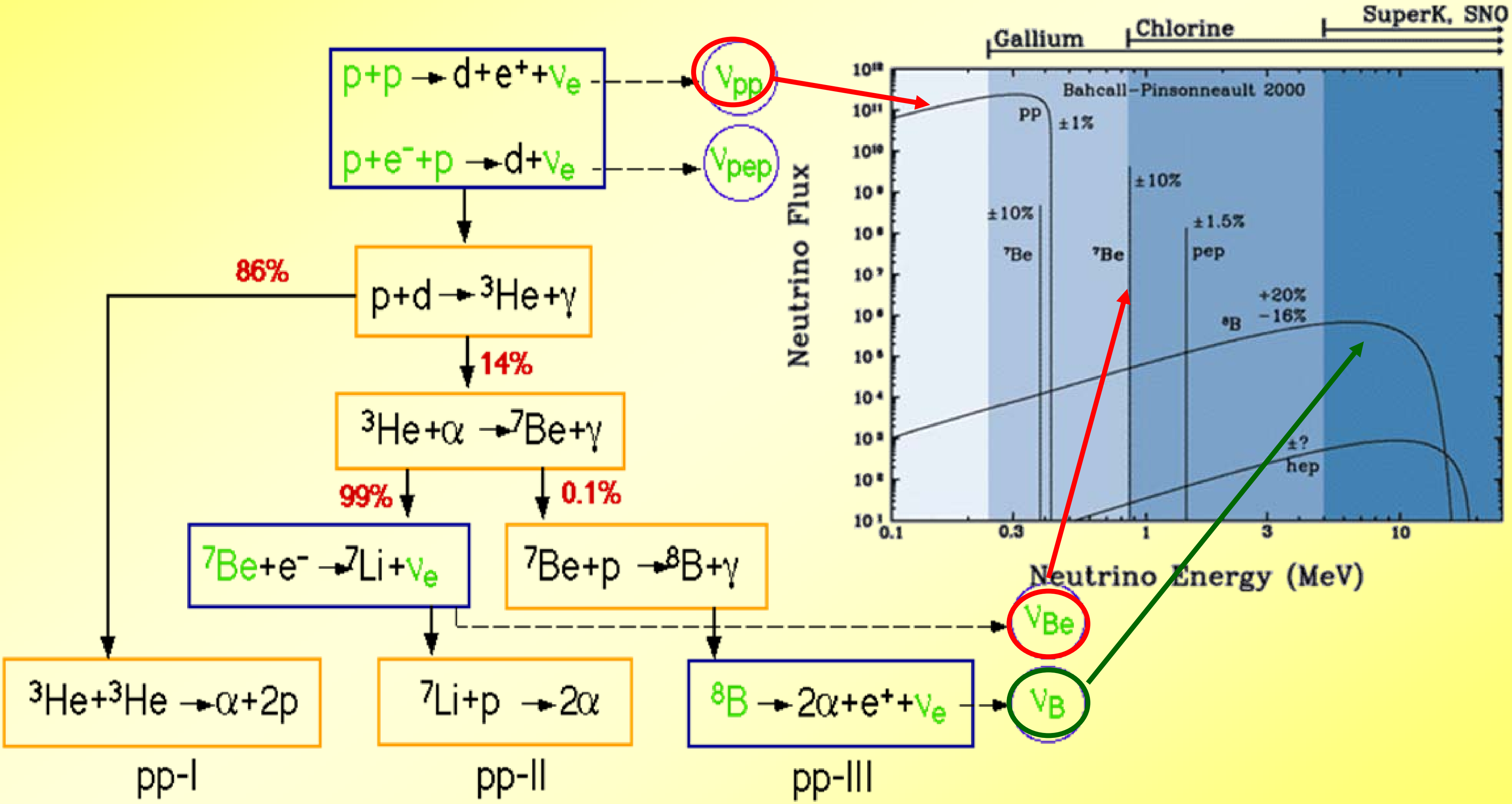


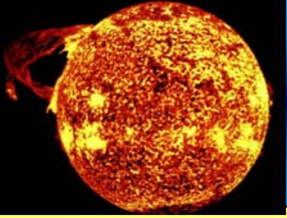
^{60}Co calibration data



Systematics on anti-neutrino reactor 6.5 % → 4%

Solar Neutrinos





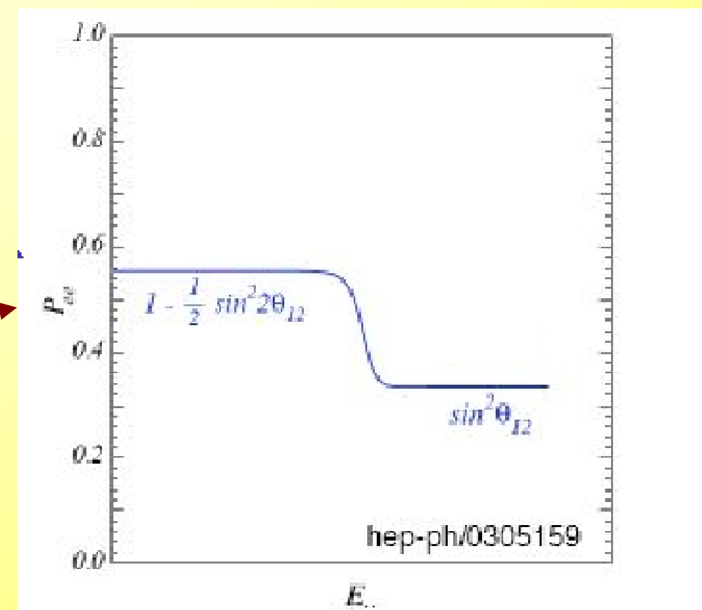
^{7}Be neutrinos

Experimental uncertainty: 40 %

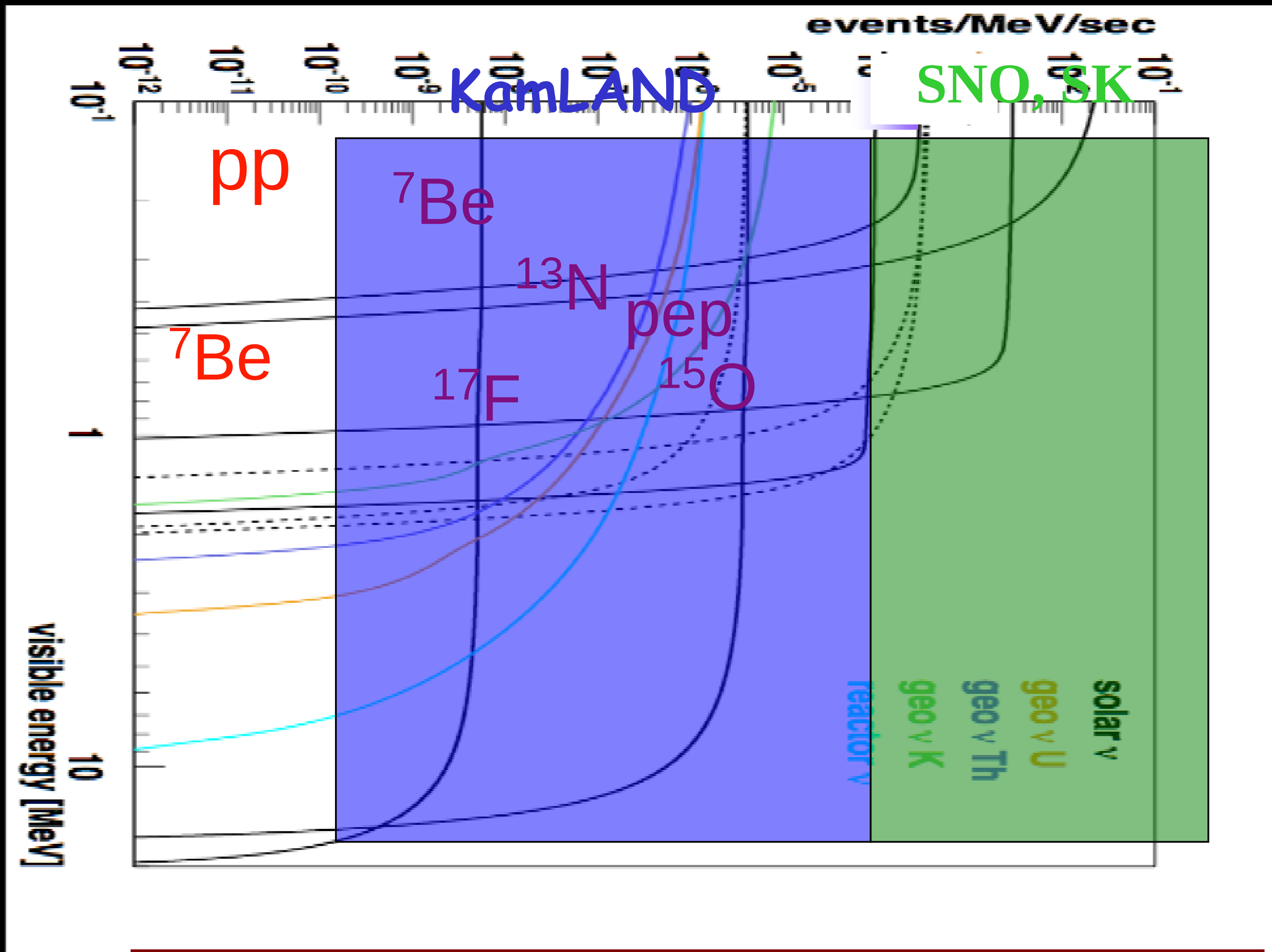
Real-time measurement

$$\frac{2\Phi(^{7}\mathrm{Be})}{(\Phi(pp)-\Phi(^{7}\mathrm{Be}))} = \frac{\langle {}^{3}\mathrm{He}+{}^{4}\mathrm{He} \rangle}{\langle {}^{3}\mathrm{He}+{}^{3}\mathrm{He} \rangle}$$

^{7}Be neutrinos below MSW threshold
Check of MSW effect



Solar Neutrinos



Expected solar yield: 340 ν /Kt/day (280 keV – 800 keV

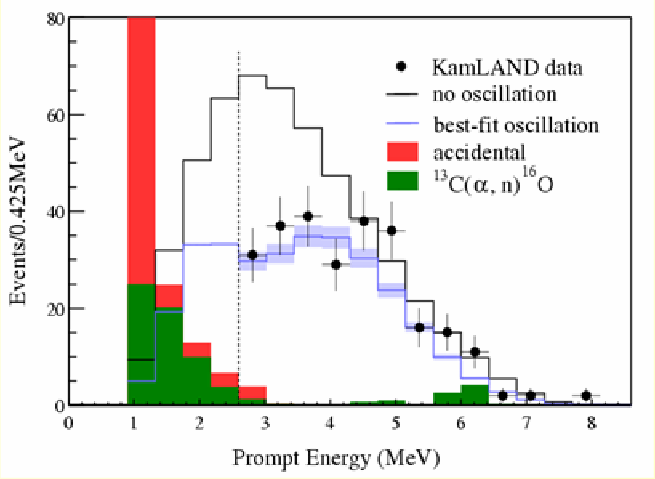
Solar Neutrino detection

Anti-neutrino detection

$\bar{\nu} + p \longrightarrow e^+ + n$ **prompt**

delayed $n + p \longrightarrow \gamma$ (2.2 MeV)

Powerful signature

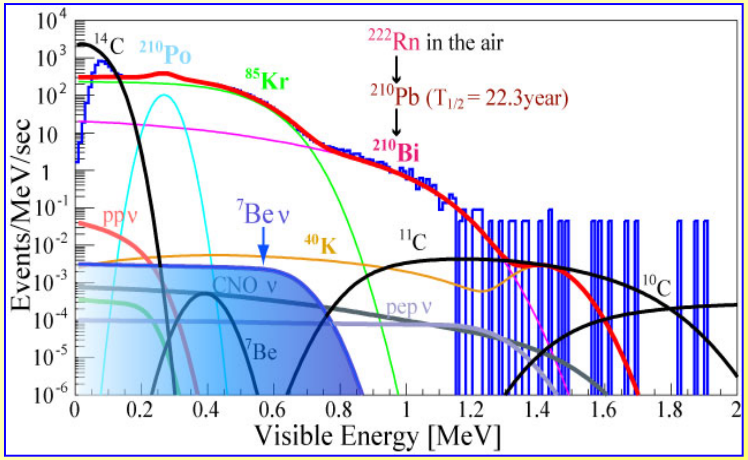


Small background

Neutrino detection

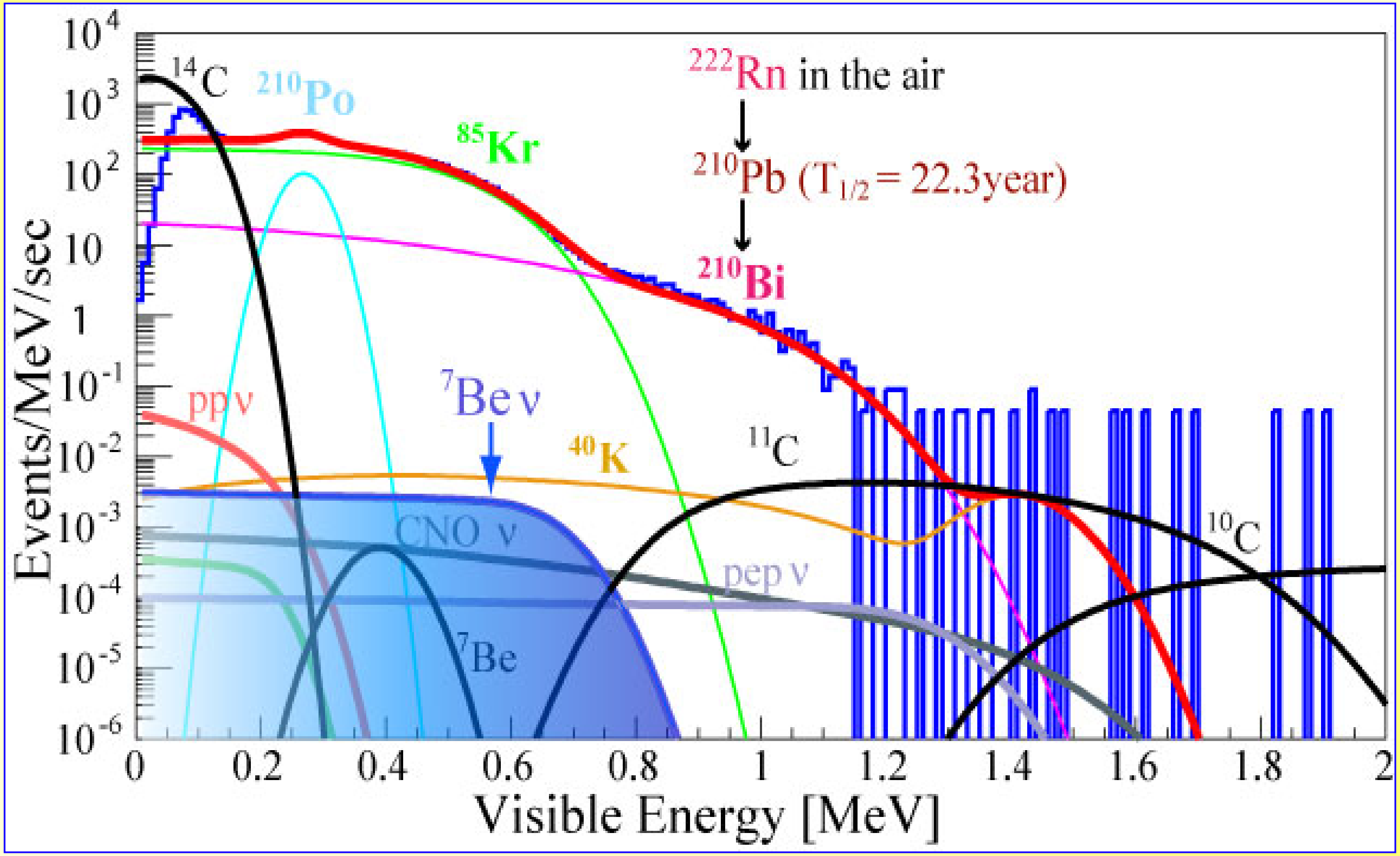
$\nu_x + e^- \longrightarrow \nu_x + e^-$

Unspecific Signature

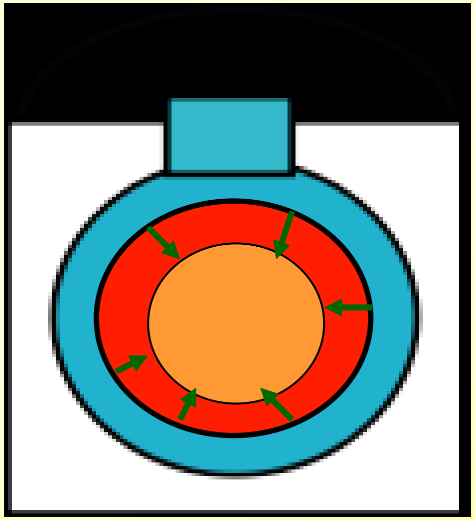


High level of background

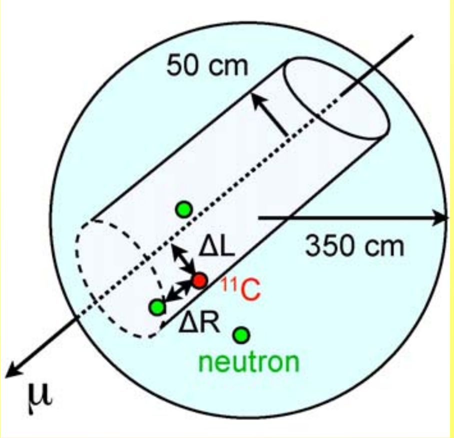
Internal Backgrounds



External Backgrounds



External background : ^{40}K and ^{208}Tl
Supressed by fiducial cut R < 4 m
Expected rates 200 x lower than $\nu_{(7Be)}$ signal



Cosmogenic induced by muons :
^{11}C, ^{12}B, ^{7}Li, ^{7}Be,…
Tagged by veto and in some case by delayed neutron

Purification goals

Measured Activities in KamLAND

	$T_{1/2}$	Current KamLAND Concentrations	Purification Goal	
^{14}C	5730 y	0.5 Bq/m^3	0.5 Bq/m^3	**OK**
^{210}Pb	22 y	60 mBq/m^3	0.6 µBq/m^3	
^{40}K	10^9 y	$1.9 \cdot 10^{-16}$ g/g	10^{-18} g/g	
^{85}Kr	11 y	700 mBq/m^3	1 µBq/m^3	
^{238}U	10^9 y	$3.5 \cdot 10^{-18}$ g/g	10^{-18} g/g	**OK**
^{232}Th	10^{10} y	$5.2 \cdot 10^{-17}$ g/g	10^{-16} g/g	**OK**

LS Purification

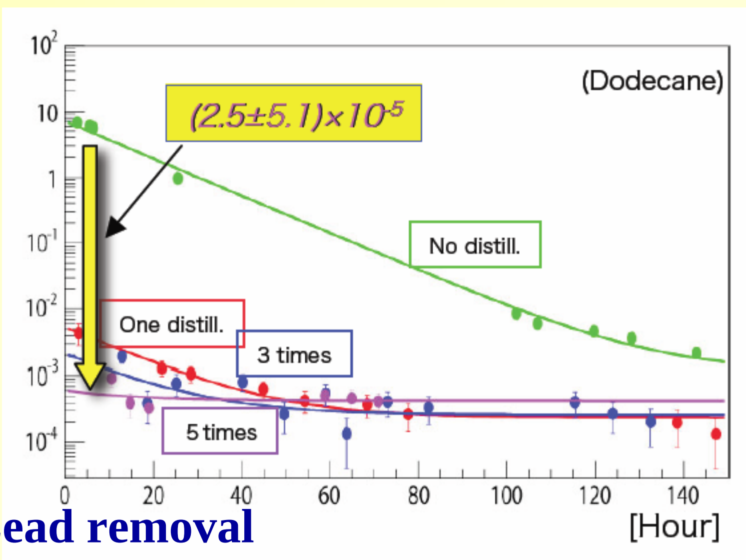
Removal of ^{85}Kr, ^{40}K, ^{210}Pb, ^{210}Bi, ^{210}Po, ^{222}Rn

The KamLAND Collaboration is currently studying the effects of :

- Distillation
- Nitrogen Purging
- Adsorption
- Heating

LS Distillation

Test plant (Tohoku University)



Lead removal

^{nat}Kr Reduction: 10^5
Measured by GC

^{222}Rn Reduction: 10^6
Measured by β-α coincidence of ^{214}Bi – ^{214}Po decay (233 μs)

^{212}Pb Reduction: 10^4
Measured by β-α coincidence of ^{212}Bi – ^{212}Po decay (0.43 μs)

Operates at a 1-2 L/hr

Adsorption

Adsorption is the adherence to a surface.

Adsorption removes charged atoms,
i.e. Pb^{+2} by retention on the surfaces of
the adsorption particles (silica, Alusil, Cu/Mn).

^{212}Pb Reduction: 30

Measured by Germanium detector or
β-α coincidence of ^{212}Bi – ^{212}Po decay
(0.43 μs)

Heating

Heating is used to break organo-metallic bonds which then ionize the Pb, Po, Bi, etc atom and can be removed by adsorption or distillation.

Operating Temperature: 100 – 200 ^{o}C

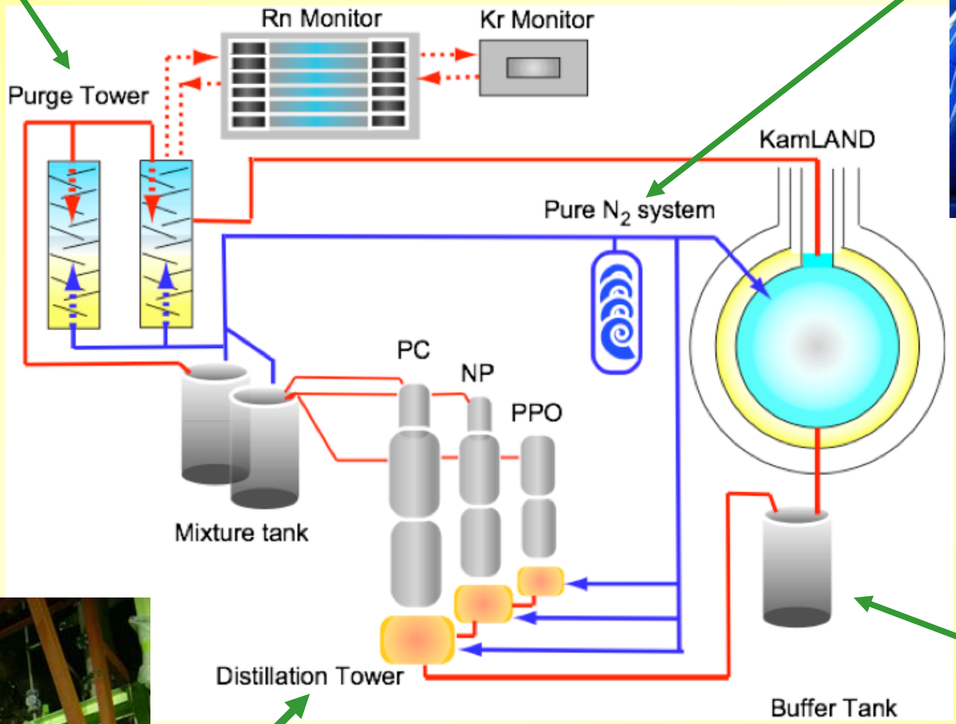
Used in combination with distillation or adsorption column. Same removal efficiency seen in both systems

^{212}Pb Reduction boost factor: 10

Online monitoring

- Purpose is to insure that we are obtaining high levels of purification and not re-contaminating after purification procedure.
- ^{85}Kr measurement system which will increase our sensitivity to low concentrations by using a cold trap and then passing through an RGA.
- ^{222}Rn measurement (mini-KamLAND)
- Other activities (U, Th, ^{210}Pb) are too low to measure without a detector like KamLAND or long counting times.

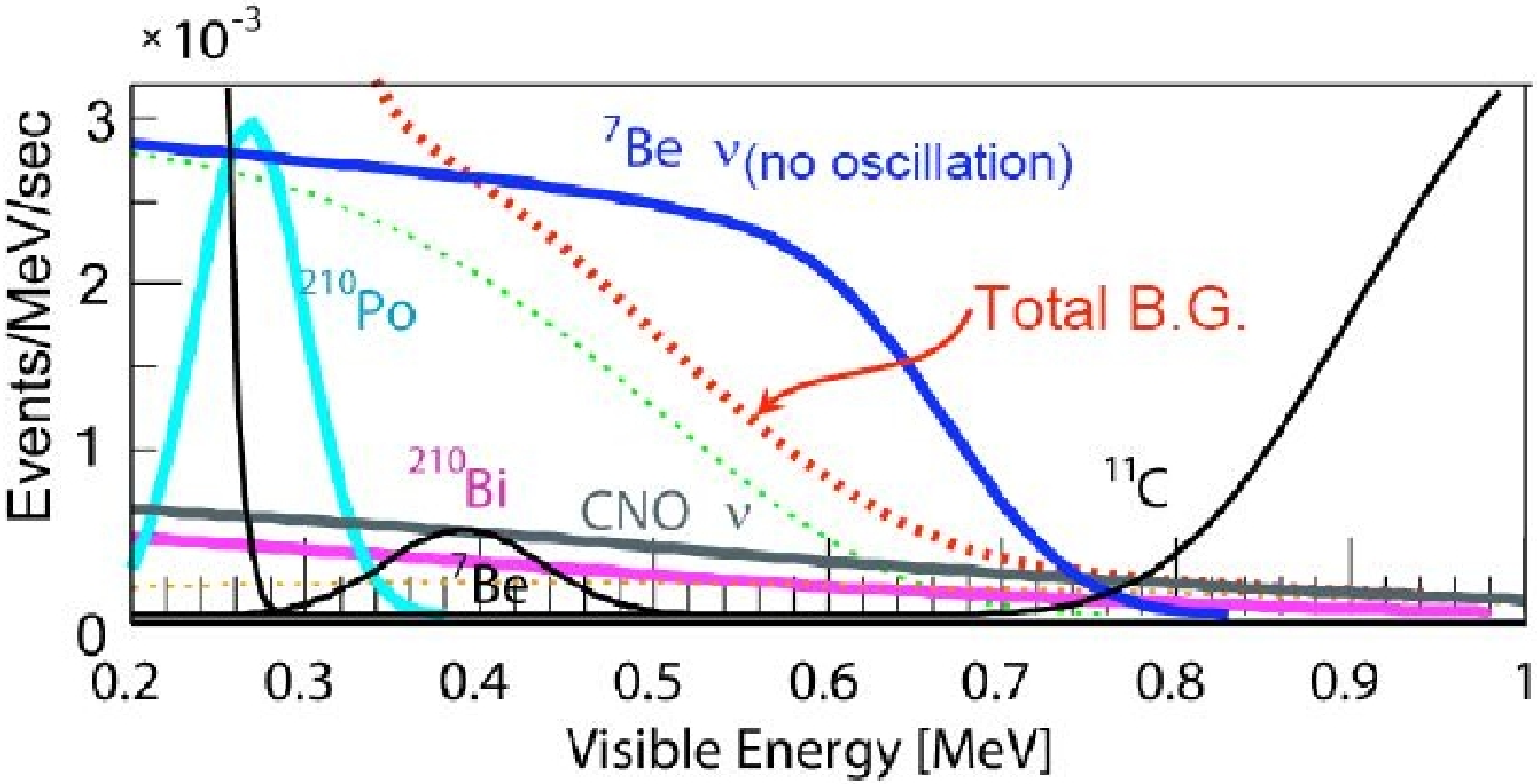
Purification line



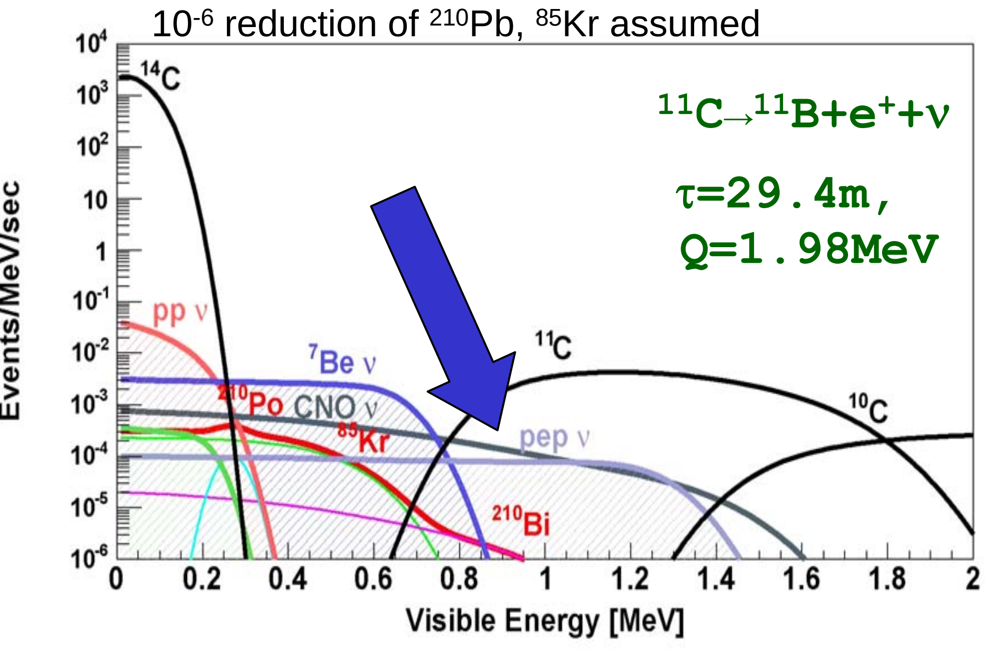
Purification line ready

Expected signal for ^{7}Be ν

After 3. 10^{-5} reduction for ^{210}Pb



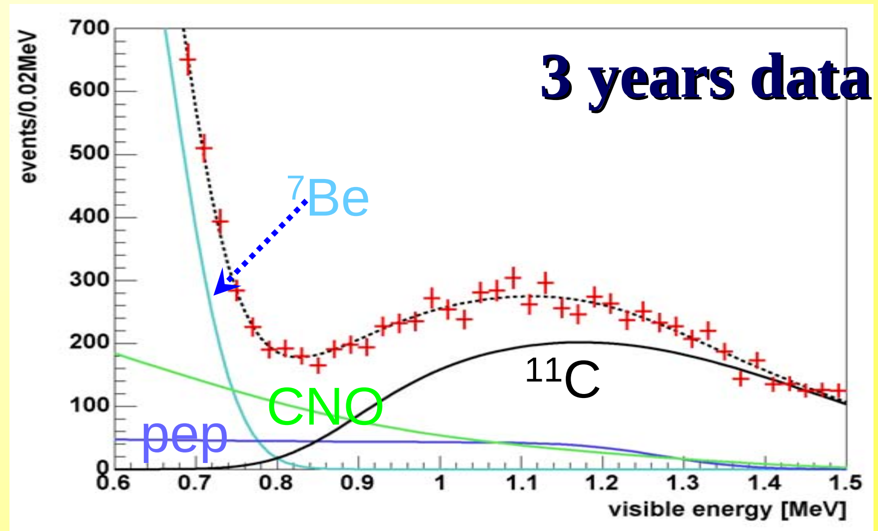
Toward pep/CNO detection

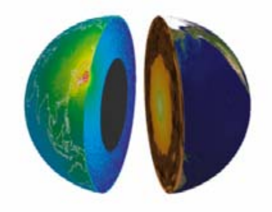


^{11}C reduction by 3-fold coincidence:

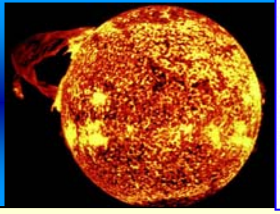
1) Muon
2) Neutron (2.2MeV γ after ~200μs)
3) ^{11}C decay (τ=29.4m)

New electronics to detect neutrons
After large muon signal
Improvement of muon fitter and
Muon tracking



Summary




Anti-neutrino reactor:
- Spectral distorsion
- Data taking ongoing
- Update of data with full volume calibration soon

Geoneutrinos:
- First detection of geoneutrinos
- Effort to reduce systematic error on background

Solar neutrinos:
- LS purification line is ready
- Goal is to measure 7Be neutrino flux whithin 10%
- Backgrounds improvements for reactor anti-neutrino and geoneutrinos
- Studies for pep neutrinos detection