Cross-section:

Cross-section calculated by *crosssection.f*, based on [1]. Command line:

```
gfortran -o c.exe crosssection.f -lmathlib
```

When executed, create file *crosskaml.dat* with:

$$\frac{d^2\sigma(E_\nu, T_{e^+})}{dE_\nu dT_{e^+}}$$

Effective cross-section:

Based on L/E binning (fig.5 in [2]), we calculate an effective cross-section based on that particular energy binning with program *espectrokamland.le.f*:

```
gfortran -o e.exe espectrokamland.le.f -lmathlib -lkernlib
```

where the following is calculated:

$$\frac{d\sigma(E_\nu)}{dE_\nu} = \int_{\tilde{T}_{e^+}^{min}}^{\tilde{T}_{e^+}^{max}} d\tilde{T}_{e^+} \int dT_{e^+} R(T_{e^+}, \tilde{T}_{e^+}) \frac{d^2\sigma(T_\nu, T_{e^+})}{dT_\nu dT_{e^+}}$$

where

$$R(T_{e^+}, \tilde{T}_{e^+}) = \frac{1}{\sqrt{2\pi\sigma_T^2}} \exp\left[-\left(\frac{\tilde{T}_{e^+} - T_{e^+}}{2\sigma_T}\right)^2\right]$$

with

$$\sigma_T = 0.065\sqrt{T_{e^+}}$$

Statistical Analysis:

The χ^2 analysis is performed with routine *chi2.f* and subroutines *subchi2.f* and *subspec.f*:

```
gfortran -o c.exe chi2.f subchi2.f subspec.f -lmathlib
```

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Table 1: Neutrino flux parameters

ϕ_i	0.570	0.295	0.078	0.057
a_0	0.870	0.896	0.976	0.793
a_1	-0.160	-0.239	-0.162	-0.080
a_2	-.0910	-0.0981	-0.079	-0.1085

which calculates the rates and χ^2 of KamLAND. We used the following expression for the χ^2, based on Poisson statystics:

$$\chi^2 = 2\sum_i \left[fR_i^{th} - R_i^{exp} + R_i^{exp} log\left(\frac{R_i^{exp}}{fR_i^{th}}\right)\right] + \left(\frac{1-f}{0.041}\right)^2$$

where the χ^2 is minimized in the total flux normalization factor f.

Flux and Data:

The Flux is calculated through the following parameterization:

$$\phi = \sum_{j=1,4} \phi_j \exp\left(a_{0,j} + a_{1,j}E_\nu + a_{2,j}E_\nu^2\right)$$

where the factors a and ϕ_i are provided by KamLAND, table 1.

We assume the same flux composition for all reactors. We use 22 reactors with the distances and contributions to total flux in KamLAND given by table 2

References

[1] P. Vogel and J. F. Beacom, "Angular distribution of neutron inverse beta decay, anti-neutrino(e) + p → e+ + n," Phys. Rev. D **60**, 053003 (1999) doi:10.1103/PhysRevD.60.053003 [hep-ph/9903554].

[2] A. Gando *et al.* [KamLAND Collaboration], "Constraints on θ_{13} from A Three-Flavor Oscillation Analysis of Reactor Antineutrinos at KamLAND," Phys. Rev. D **83**, 052002 (2011) doi:10.1103/PhysRevD.83.052002 [arXiv:1009.4771 [hep-ex]].

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Table 2: Reactors

name	contribution (%)	distance (km)
	30.9	160
	13.8	179
	9.0	191
	7.9	88
	7.6	138
	7.5	214
	7.4	146
	3.8	349
	3.5	351
	1.3	141
	1.2	295
	0.9	138
	0.8	401
	0.7	431
	0.6	561
	0.4	754
	0.2	830
	0.2	783
	0.8	712
	0.6	735
	0.5	709
	0.5	986