利用方向-能量重建探测 K-40 地球中微子

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地球中微子通量计算

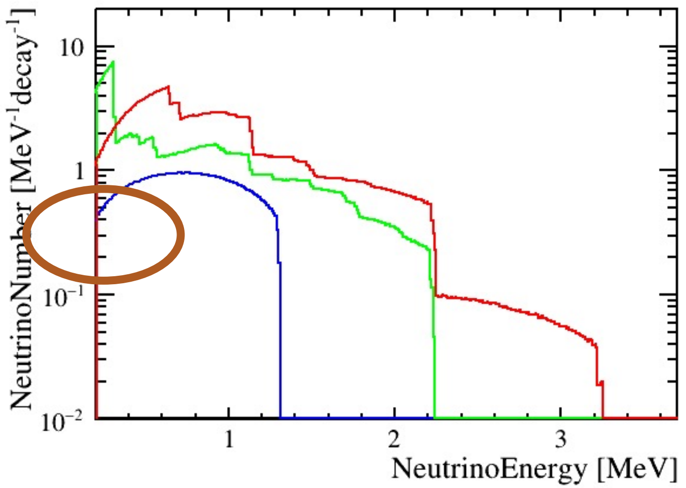
2025.05.21

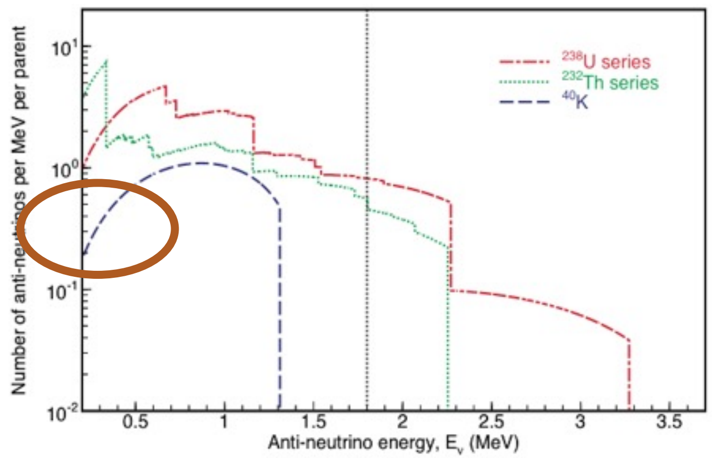
地球中微子通量计算

- K40 Th232 U238衰变中微子能谱
- 地球模型
- 地球中微子通量计算

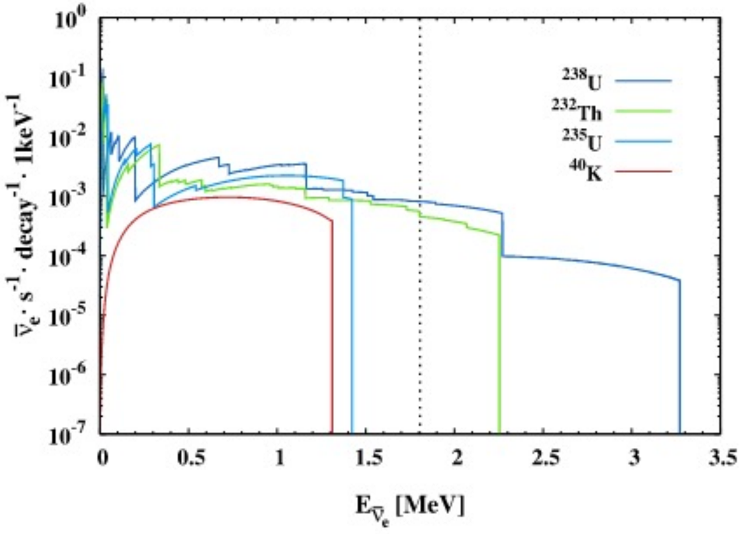
K40 Th232 U238衰变中微子能谱

红色： U238
绿色： Th232
蓝色： K40





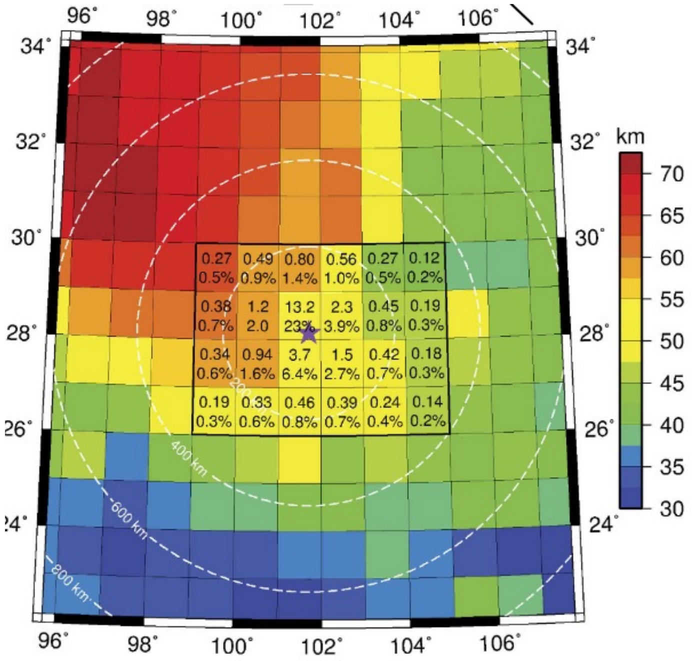
KamLAND

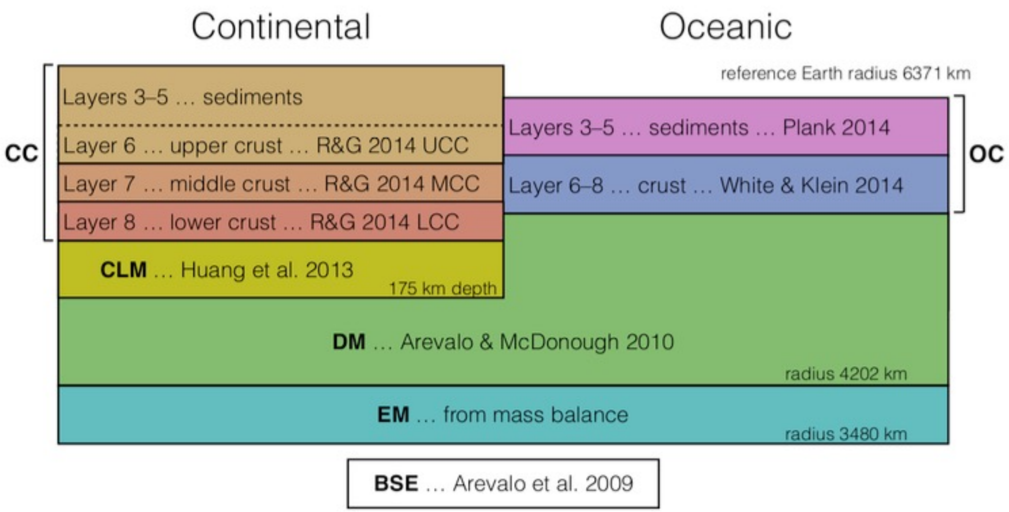


Borexino

地球模型

- 地壳 Crust1.0
  - 1deg x 1 deg
  - 8 layers
- 地幔
  - CLM DM EM
- 元素含量
- 依据文献





	K	Th	U	Ref.
Upper CC + sediments	$(2.32 \pm 8\%) \times 10^{-2}$	$(10.5 \pm 10\%) \times 10^{-6}$	$(2.7 \pm 21\%) \times 10^{-6}$	64
Middle CC	$(1.91 \pm 14\%) \times 10^{-2}$	$(6.5 \pm 8\%) \times 10^{-6}$	$(1.3 \pm 31\%) \times 10^{-6}$	64
Lower CC	$(0.51 \pm 30\%) \times 10^{-2}$	$(1.2 \pm 30\%) \times 10^{-6}$	$(0.2 \pm 30\%) \times 10^{-6}$	64
OC sediments	$(1.83 \pm 7\%) \times 10^{-2}$	$(8.10 \pm 7\%) \times 10^{-6}$	$(1.73 \pm 5\%) \times 10^{-6}$	69
OC crust	$(716 \pm 30\%) \times 10^{-6}$	$(0.21 \pm 30\%) \times 10^{-6}$	$(0.07 \pm 30\%) \times 10^{-6}$	70
CLM	$315^{+432}_{-183} \times 10^{-6}$	$150^{+277}_{-97} \times 10^{-9}$	$33^{+49}_{-20} \times 10^{-9}$	15
Depleted Mantle	$(152 \pm 20\%) \times 10^{-6}$	$(21.9 \pm 20\%) \times 10^{-9}$	$(8.0 \pm 20\%) \times 10^{-9}$	71
Enriched Mantle*	$402^{+350}_{-238} \times 10^{-6}$	$147^{+74}_{-57} \times 10^{-9}$	$30^{+24}_{-18} \times 10^{-9}$	
Bulk Silicate Earth	$(280 \pm 21\%) \times 10^{-6}$	$(80 \pm 15\%) \times 10^{-9}$	$(20 \pm 20\%) \times 10^{-9}$	72

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Geoneutrinos at Jinping: Flux prediction and oscillation analysis

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地球中微子通量计算

- 由模型给出不同格点的密度、元素含量

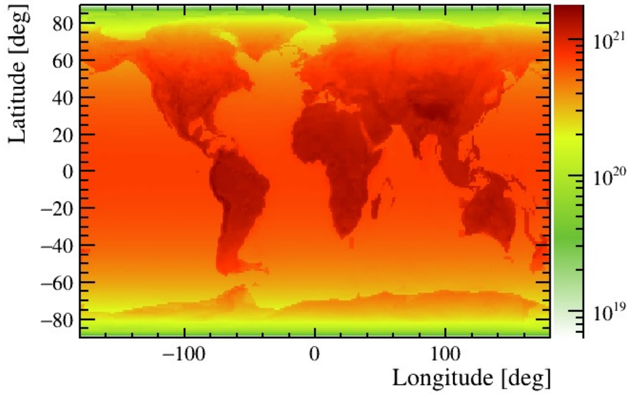
- 计算该格点放出中微子数

$$d\phi(\vec{r})_e = \frac{X\lambda N_A}{\mu} n_\nu P_{ee}^{\oplus} \frac{A(\vec{r})\rho(\vec{r})}{4\pi|\vec{r}-\vec{d}|^2} dv,$$

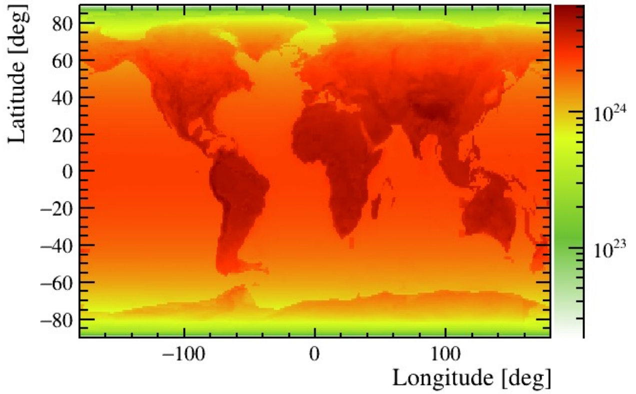
- 按照距离计算锦屏处的通量
- 振荡概率

- 锦屏位置
  - (28.15323° N，101.7114° E，海拔1500 m)

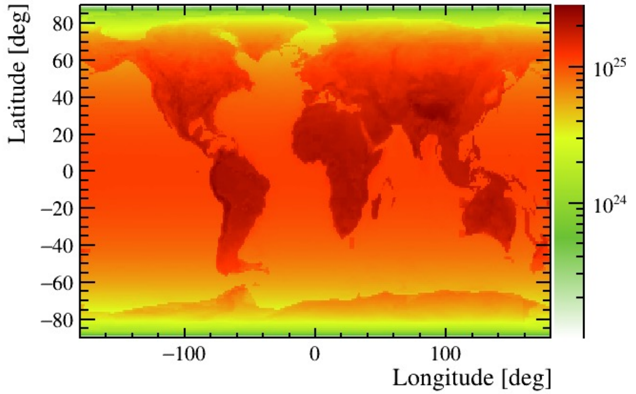
地球中微子通量计算



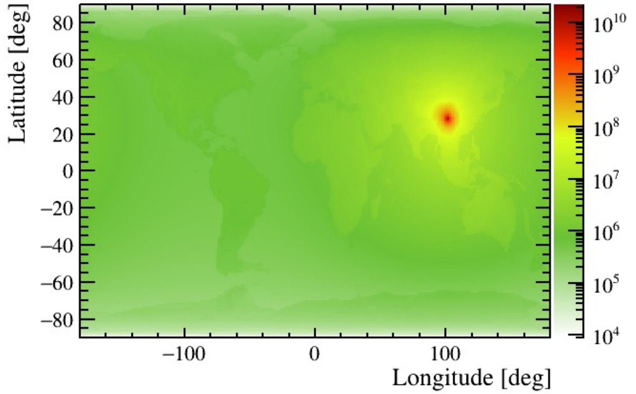
K40 NeutrinoRate



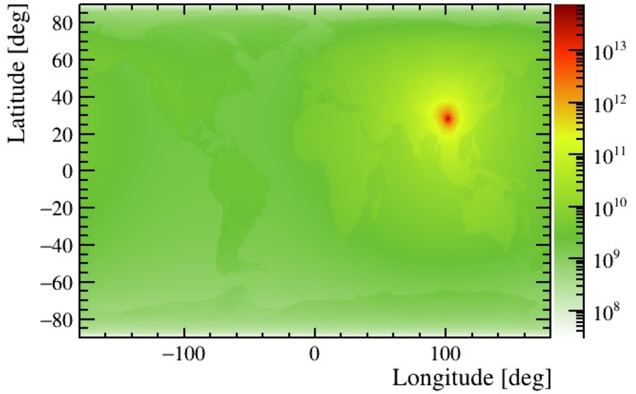
Th232 NeutrinoRate



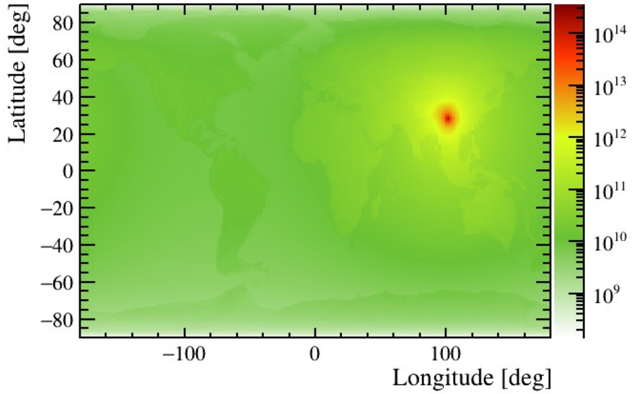
U238 NeutrinoRate



K40 NeutrinoFlux

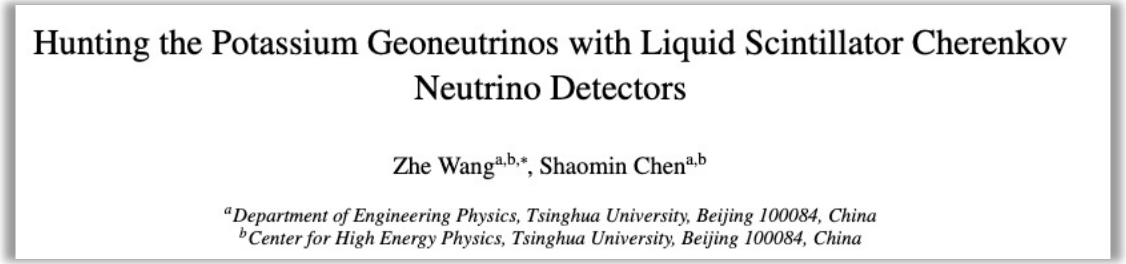


Th232 NeutrinoFlux



U238 NeutrinoFlux

地球中微子通量计算



Hunting the Potassium Geoneutrinos with Liquid Scintillator Cherenkov Neutrino Detectors

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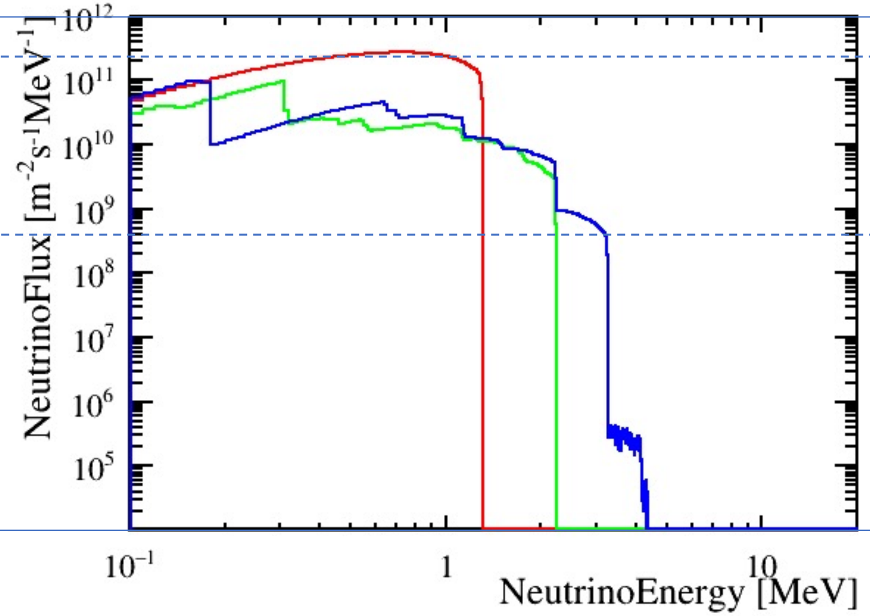


地球中微子通量（无振荡）

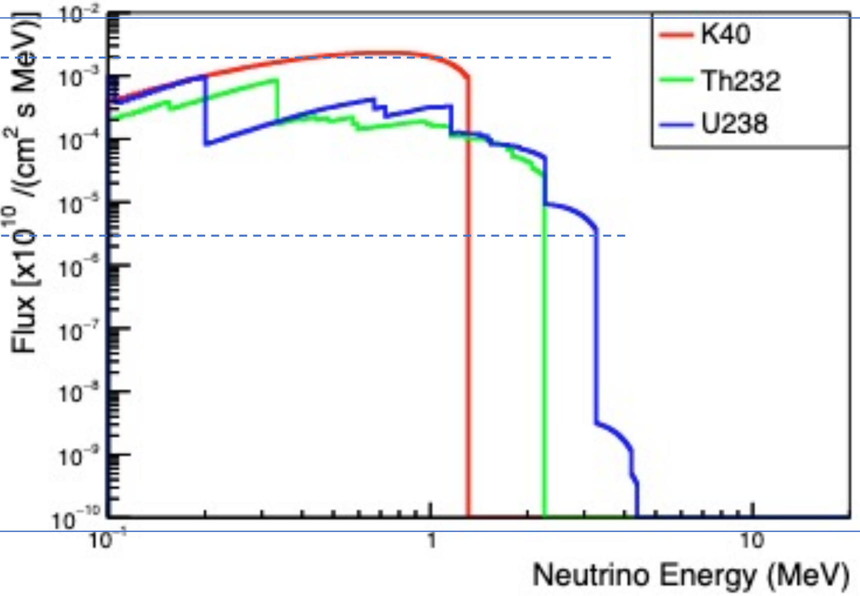
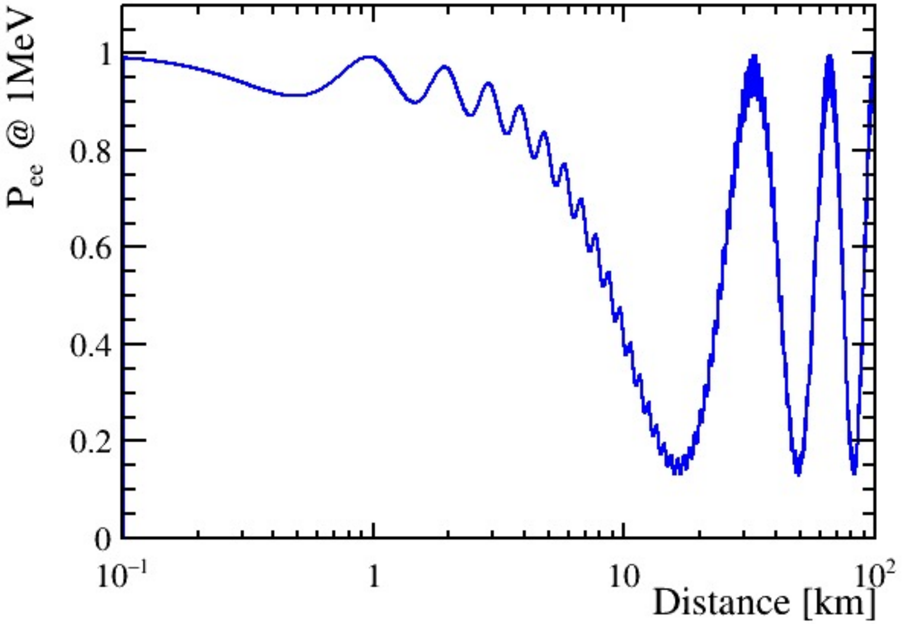
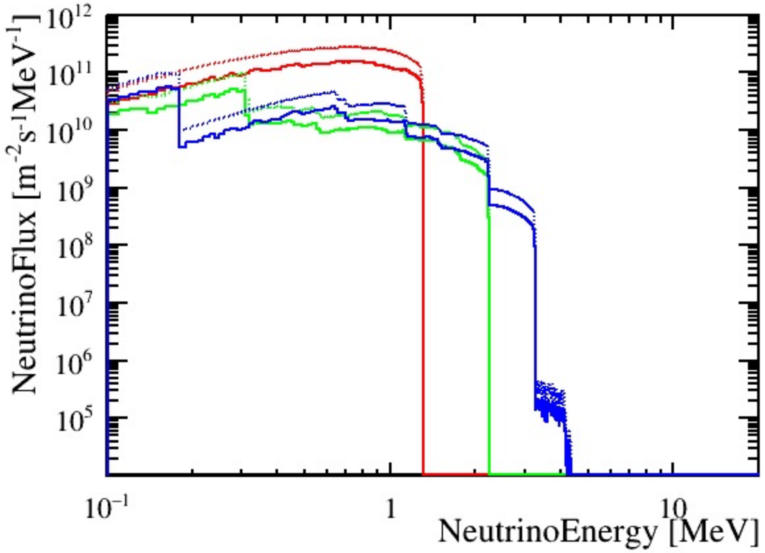


Figure B.15: Predicted non-oscillating geo electron-antineutrino energy spectra on the Earth's surface.

中微子通量计算



电子型(反)中微子存活概率



振荡前后中微子能谱

中微子通量计算

TABLE V. Summary of predicted geoneutrino event rates in TNU at Jinping.

Geo $\bar{\nu}_e$ (TNU)	Crust	Mantle	BSE
Th	10.6 ± 0.8	2.1 ± 0.5	12.7 ± 1.0
U	38.4 ± 6.6	8.3 ± 2.3	46.7 ± 6.7
Th + U	49.0 ± 7.3	10.4 ± 2.7	59.4 ± 7.6

	Curst	Mantle	Total
Th232	7.06	2.44	9.51
U238	26.21	9.98	36.19
Total	33.27	12.42	45.70

- 实验室位置
- 近点计算精度
- ……

下一步

- 对照数据结果
  - IBD TNU：

- 振荡周期~10km@1MeV，格点长度~20km，近点需精细计算

22240	3.76	3.76	3.76	3.75	3.75	3.75	-27.36	-42.29	-58.47
22241	3.84	3.84	3.84	3.84	3.84	3.84	-22.37	-45.60	-55.72
22242	3.42	3.42	3.42	3.41	3.41	3.41	-20.36	-41.44	-50.63
22243	2.61	2.61	2.61	2.31	2.31	2.31	-19.09	-38.05	-46.32

- 用电子散射截面计算散射电子能谱