

锦屏中微子实验百吨计划

续本达
锦屏中微子实验研究组

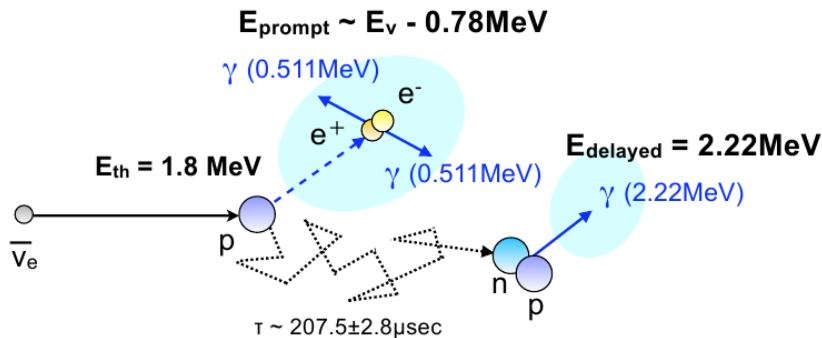
清华大学

2019-12-20 清华大学

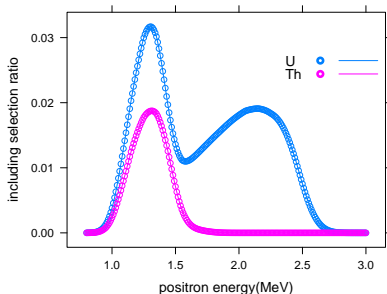
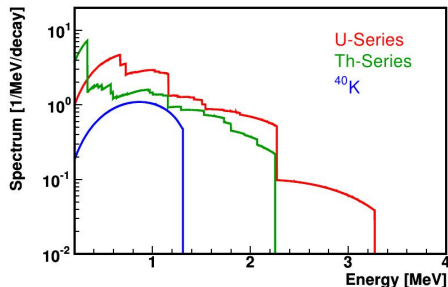
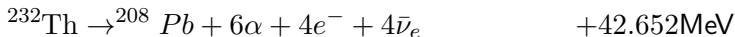
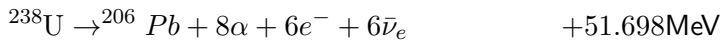
Antineutrino Detection: Inverse Beta Decay

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

- Kinetic energy mostly to e^+ , E^+ in good correlation with E_{ν} .
- Energy threshold 1.8MeV, cannot detect $\bar{\nu}_e$ from ^{40}K , U/Th only.
- Delayed coincidence

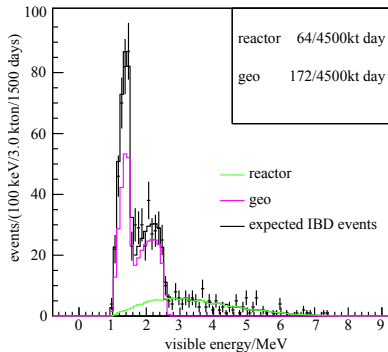
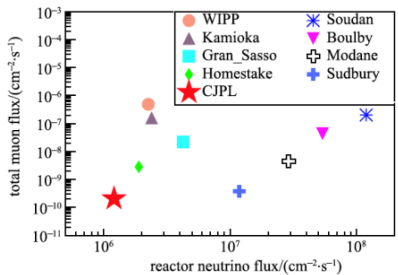


New Messenger from U/Th: Weak Interaction Probe



Probe Into the Earth from Jinping

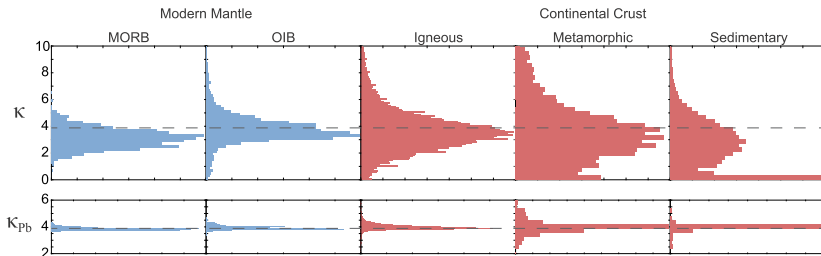
- Low reactor neutrino background.
- Large geoneutrino flux from the tibet plateau.



- Test the geochemical model of U Th concentration in the crust.
- Measure the abundance ratio of U/Th.
- Test georeactor hypothesis.

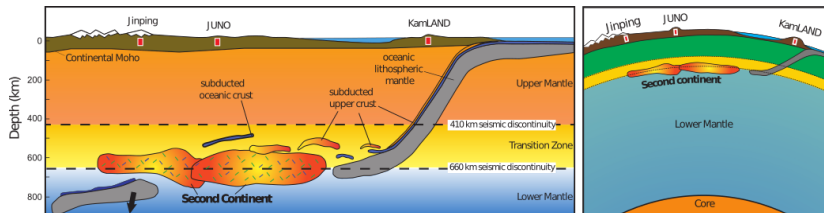
Measurement of Th/U Ratio

- An undifferentiated Earth Th/U ratio has been established.



- Continental crust is hard to estimate in bulk, because of sampling biases, etc.
- At Jinping, the bulk Th/U ratio of the locals and Tibet Plateau can be tested.
 - ▶ At 4500 kton-day exposure, Th/U to be determined to 27%.

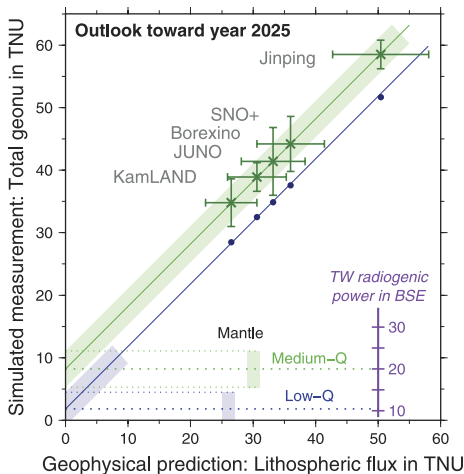
Subducting Continent



- It is speculated that subducting plates could form gravitationally stable "second continent" at the mantle transition zone.
- A second continent below China is predicted, which will give excesses of geoneutrinos at JUNO and Jinping, but not much to KamLAND.
- Test the hypothesis with 3 experiments.

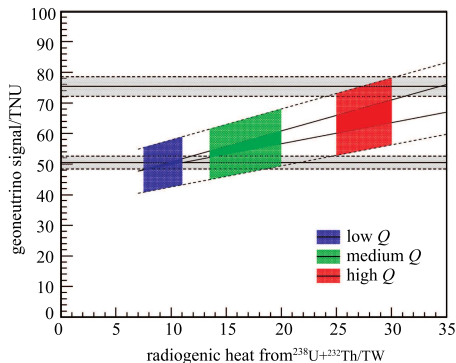
Roskovec et al. 2018 arXiv:1810.10914

Determination of Mantle Heat Production



Šrámek et al. 2016 Sci.Report

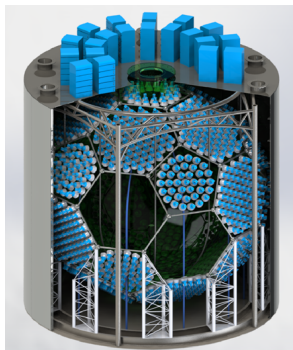
Wan et al. 2017 Phys.Rev.D



- Jinping will contribute an "outlier" to the global fit of mantle heat production.

~100 t prototype

- One of the experimental halls of CJPL 2nd Phase will hold a neutrino experiment, suitable for the next ~100 t detector.

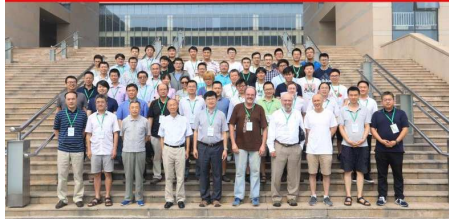


- Sensitivity to geoneutrinos from the Himalaya.
- Measure and control backgrounds.
- Test-bed for novel detection techniques.
 - ▶ Towards detection of ^{40}K neutrino.

- Major parts are being purchased and delivered.
- Potential significant in-kind contribution to boost photo-coverage.

2019 Workshop of Jinping Neutrino Program

27-28 July, 2019, Beijing



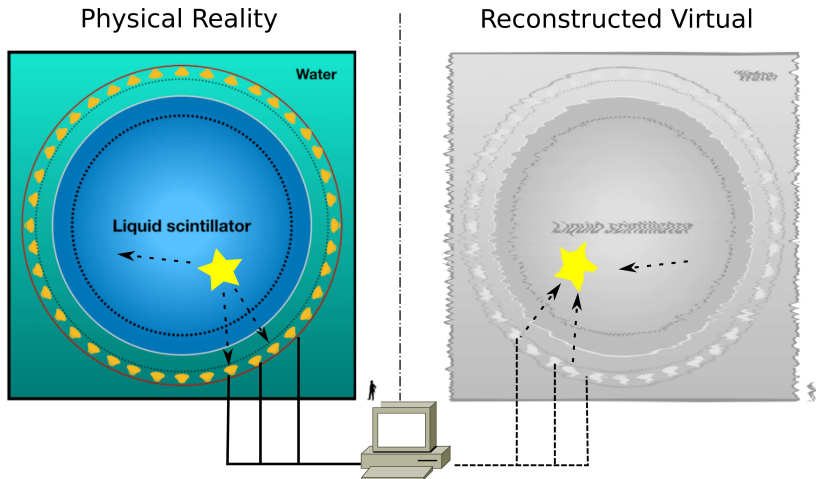
- Ever growing interest from the community.
- Active working group.
- Starting CDR draft: Welcome to join!



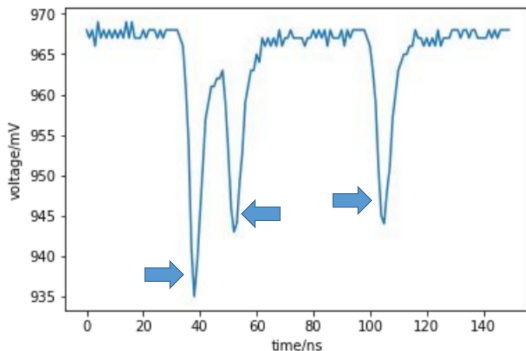
2015 Workshop of Jinping Neutrino Program



Large Liquid Scintillator Detection Principle



Modern Waveform Analysis



- PMT waveforms made available by fast ADC readouts.
- Challenge at <https://ghost-hunter.net9.org/>.
- 60+ participants compete on an auto-grading platform.
- Deep learning methods begin to dominate the leader board.

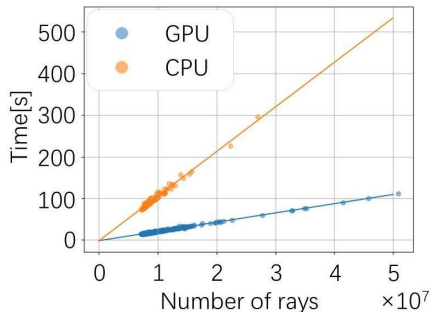
PMT and Light Concentrator

- First round of PMTs are purchased.
- PMTs with optimized TTS, ~ 1 ns is desired.
→ Joint research and development effort with PMT manufacturers.
- PMT light concentrator development, with 3D optimization. Test is ongoing.



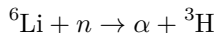
GPU Ray Tracing Simulation

- Light propagation is modeled by GPU ray tracing.
- Acceleration of detector model simulation is proportional to number of photons.



① Directionality: to measure mantle and core directly

- ▶ ${}^6\text{Li}$ -doped liquid scintillator



- ▶ Abundance: 7.59%
- ▶ Can be combined with solar ν effort with ${}^7\text{Li}$.

② Next generation geo- $\bar{\nu}_e$ detectors

- ▶ Lower energy threshold to probe ${}^{40}\text{K}$, ${}^{87}\text{Rb}$
- ▶ Liquid ${}^3\text{He}$ ($Q=0.0186 + 0.511 \times 2$).
- ▶ Resonant electron capture (${}^{209}\text{Bi}$).
- ▶ Better isotopes to dope?

Conclusion

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 - ▶ Th/U determination by geoneutrinos.
 - ▶ Search for second continent.
 - ▶ Measure mantle heat production.
- ② 1 t prototype detector is running in CJPL.

Conclusion

- ① Neutrino experiment at Jinping is important for neutrino geoscience.
 - ▶ Th/U determination by geoneutrinos.
 - ▶ Search for second continent.
 - ▶ Measure mantle heat production.
- ② 1 t prototype detector is running in CJPL.
- ③ ~100 t detector is planned to be constructed in the CJPL II.
 - ▶ Targeting geoneutrinos from Himalaya, 1 per year.
 - ▶ Could be more with doped material.

Call for Action

You are warmly welcomed to join our pre-collaboration, to build neutrino detectors at CJPL.

[100%] Highlights from TAUP2019

- ☒ Newest research from geoscience.
- ☒ Update of background measurement.
- ☒ 100t plan.
- ☒ Light concentrator.
- ☒ Metal doping studies.