

大科学装置与大模型交叉科学

研讨会会议背景介绍

大科学装置： 江门中微子观测站



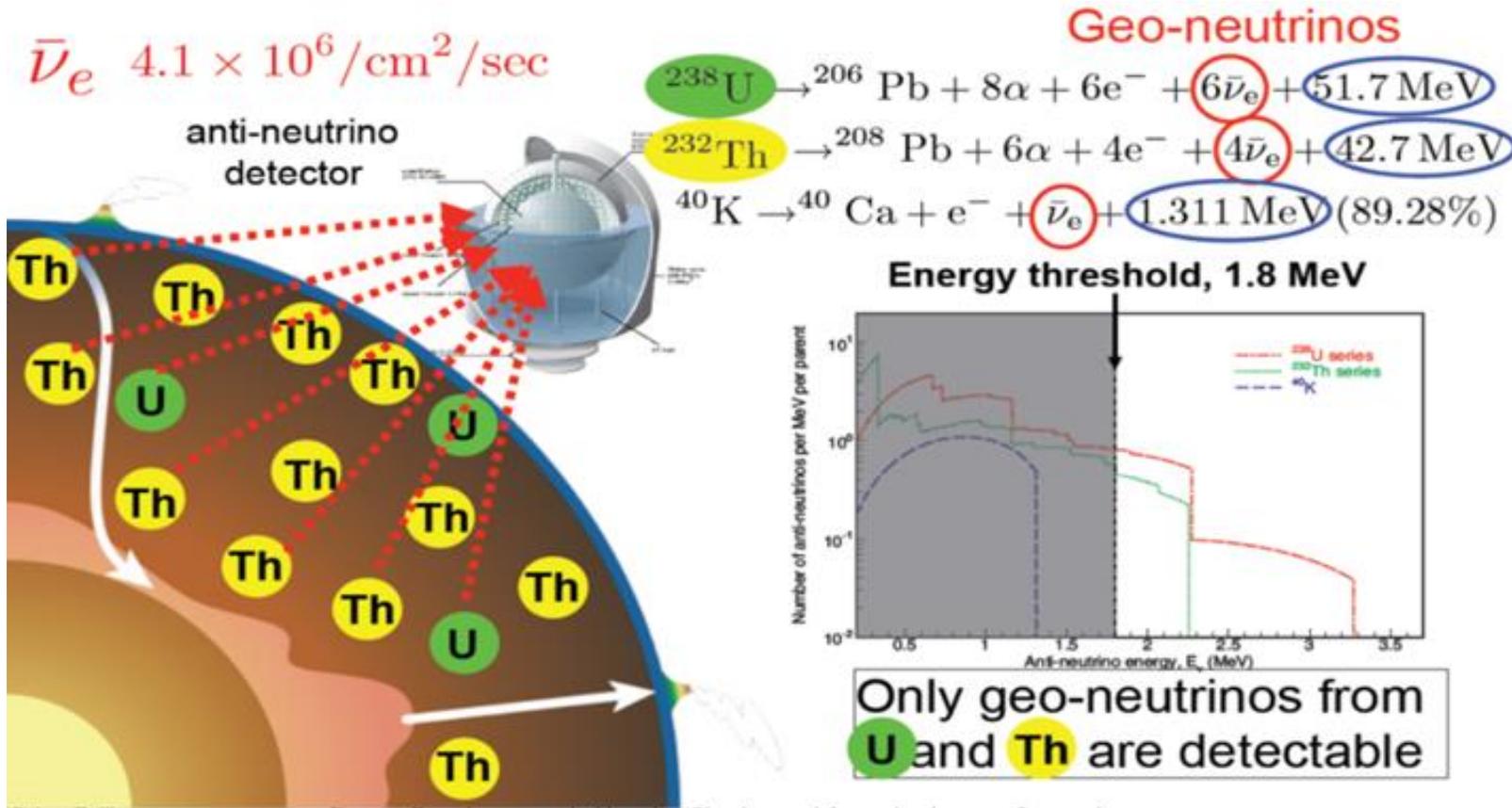
地球中微子工作小组



中国航天



什么是地球中微子



Bulk Silicate Earth (BSE) models

Low Q
~10TW

Middle Q
~20TW

High Q
~30TW

Geo-neutrinos: 地球内部放射性元素产生，与地球内部结构、性质、演化等息息相关，是一扇打开地球内部的窗口！

地球中微子的地球科学意义

- 检验不同的地球化学模型（放射性元素分布）——地球的组成问题
 - 地球热量研究（放射性生热、全球地热总热量等）
 - 地幔演化（Th/U比，地幔放射性生热）
 - 地心是否含有裂变元素（地心热量及作用）
- 地球的演化问题

研究基础：3D地球结构模型（地壳结构模型）

？ 如何描述结构：几何形状，物理属性（密度、速度、温度、……）

高能物理关注问题：地球中微子通量

$$\Phi_i = \underbrace{A_i \cdot n_i}_{\textcircled{1}} \cdot \underbrace{P_{\nu_e \rightarrow \nu_e}}_{\textcircled{2}}(E_\nu, |\vec{L}|) \cdot \int_V \frac{\underbrace{a_i(\vec{L})}_{\textcircled{3}} \cdot \underbrace{\rho_i(\vec{L})}_{\textcircled{4}}}{\underbrace{4\pi}_{\textcircled{5}} \underbrace{|\vec{L}|^2}_{\textcircled{5}}} \cdot \underbrace{dV}_{\textcircled{5}}$$

① *Activity and number of produced geoneutrinos*

② *Survival probability function*

③ *Abundance of radioactive sources*

④ *Density distribution function*

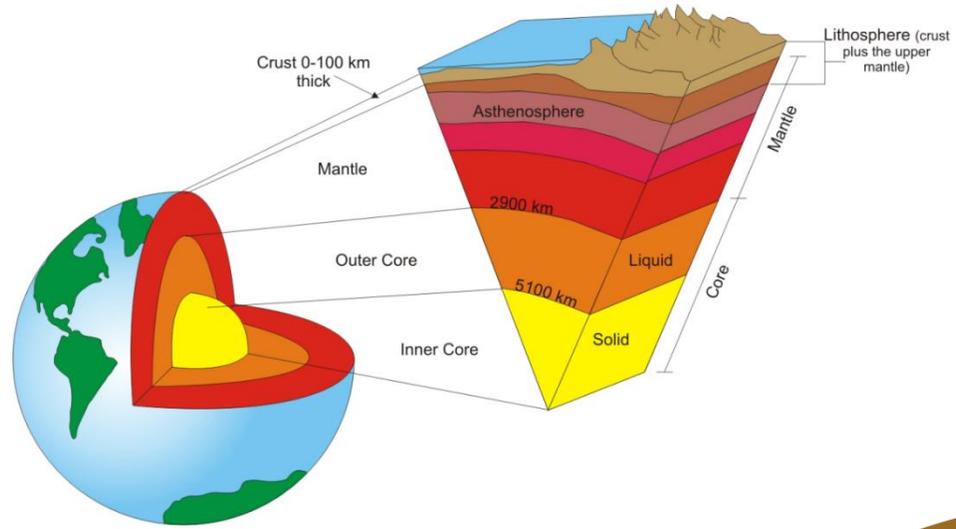
⑤ *Geometry parameters for whole source (the Earth)*

P **Physics**

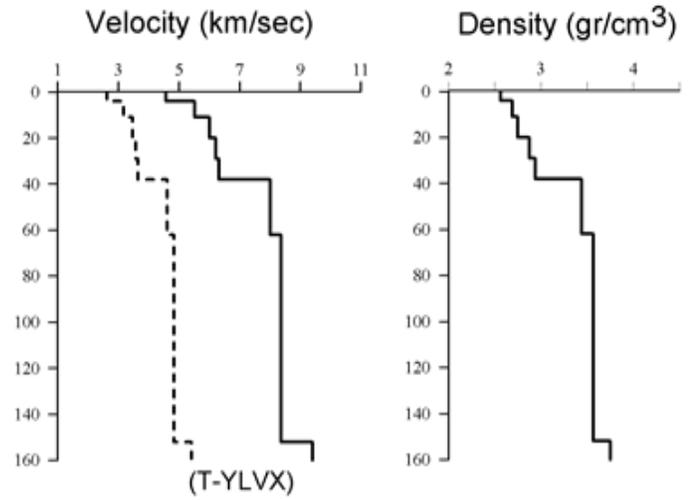
G **Geomodel**

地球物理模型

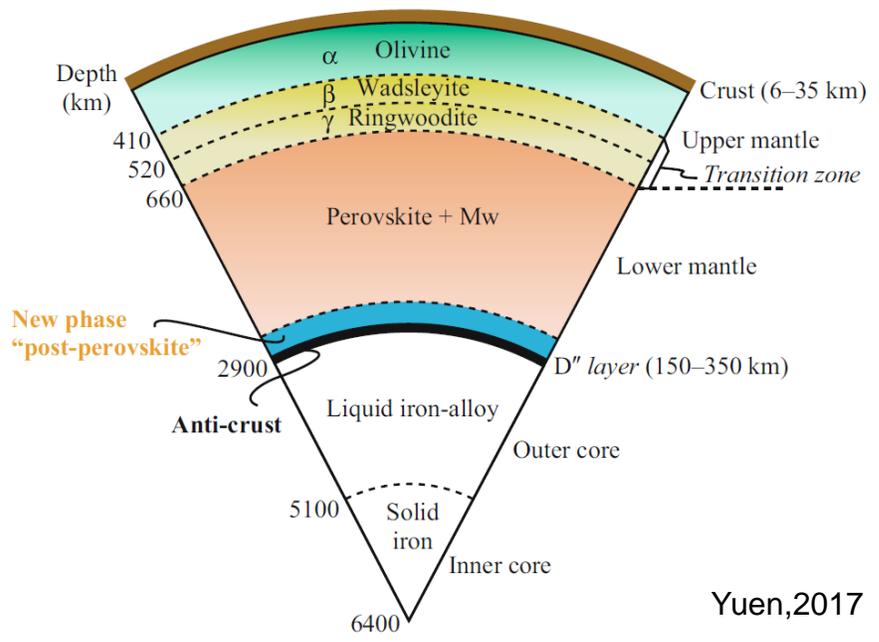
- Layered structure (Geometry)
- Physical properties (Density/Velocity/Heat/.....)
- Composition (Rock type, abundance)



地球内部物质成分



Sayil, 2014



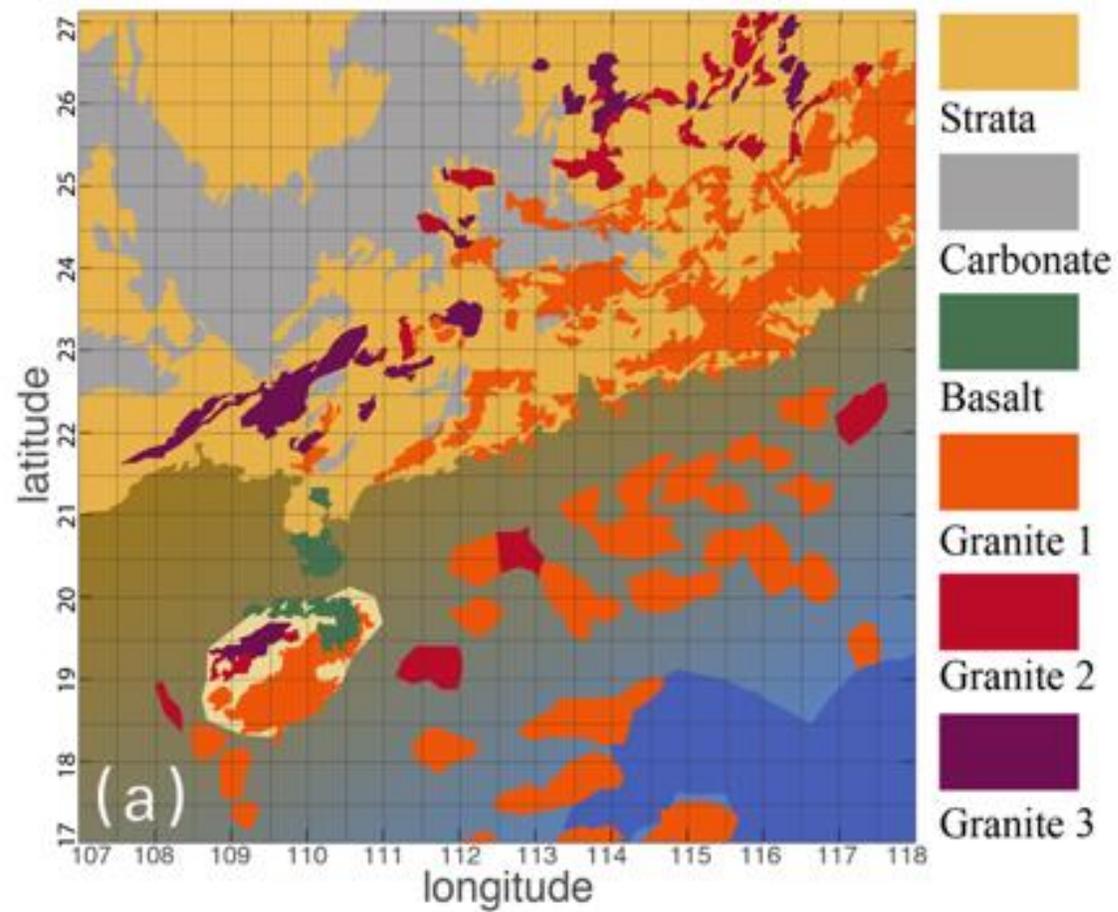
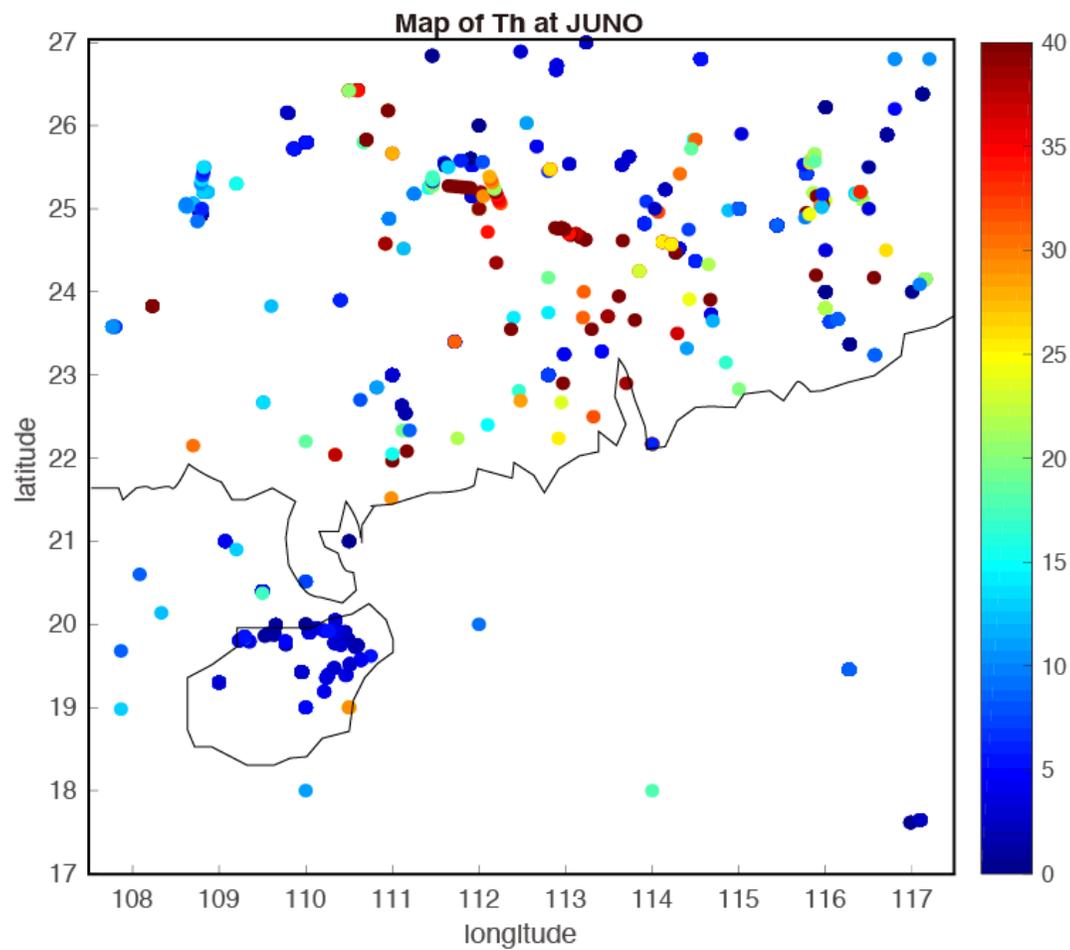
Yuen, 2017

Geochemistry Abundance Geophysics Density

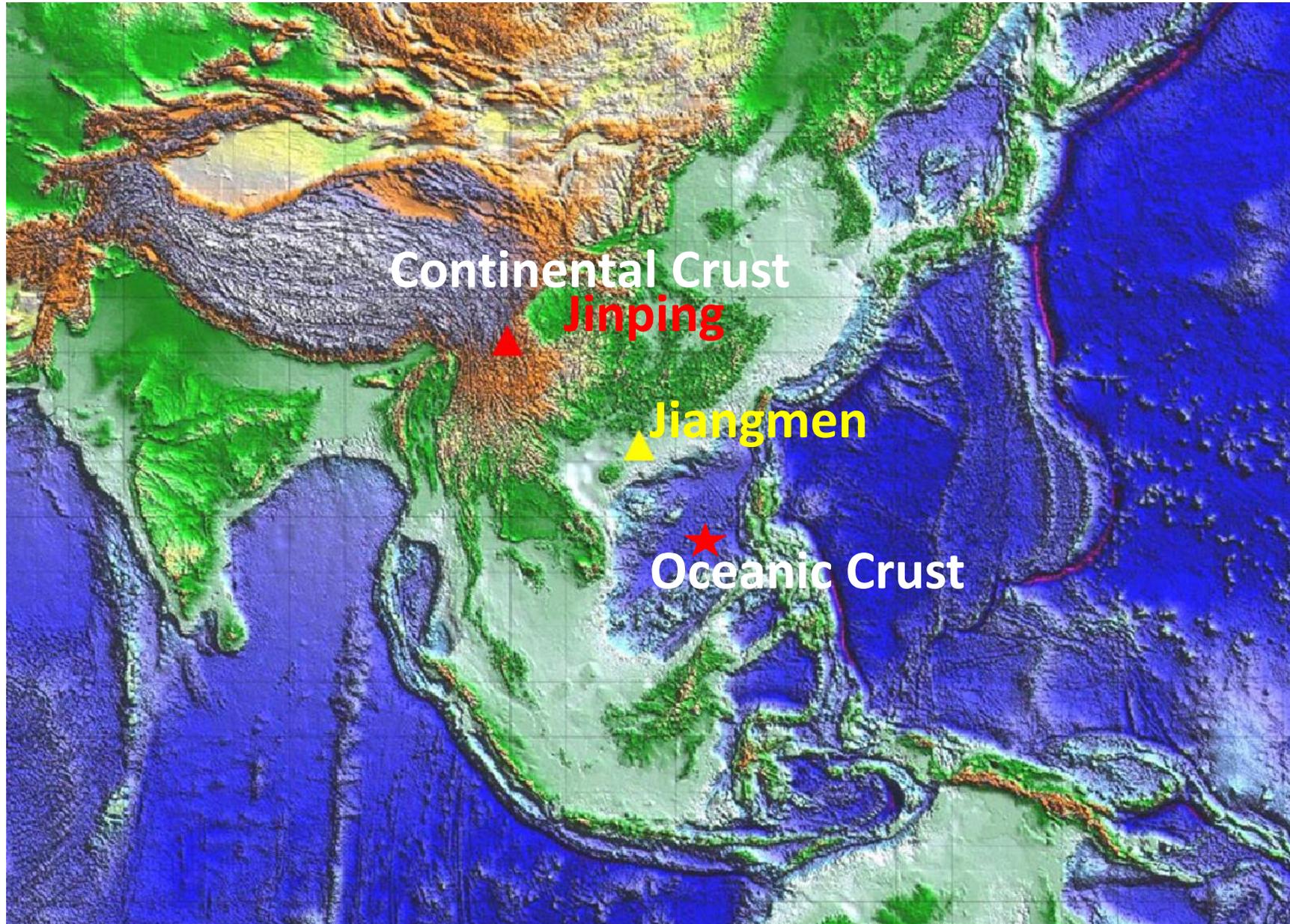
$$\int_V \frac{a_i(\vec{L}) \cdot \rho_i(\vec{L})}{4\pi |\vec{L}|^2} \cdot dV$$

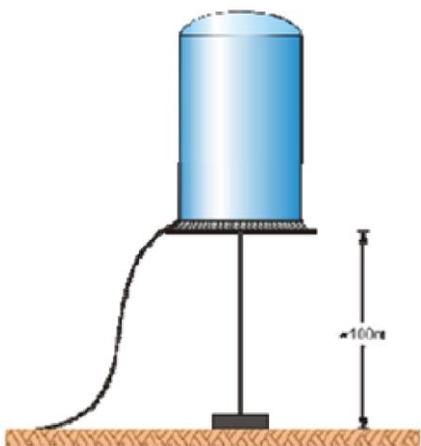
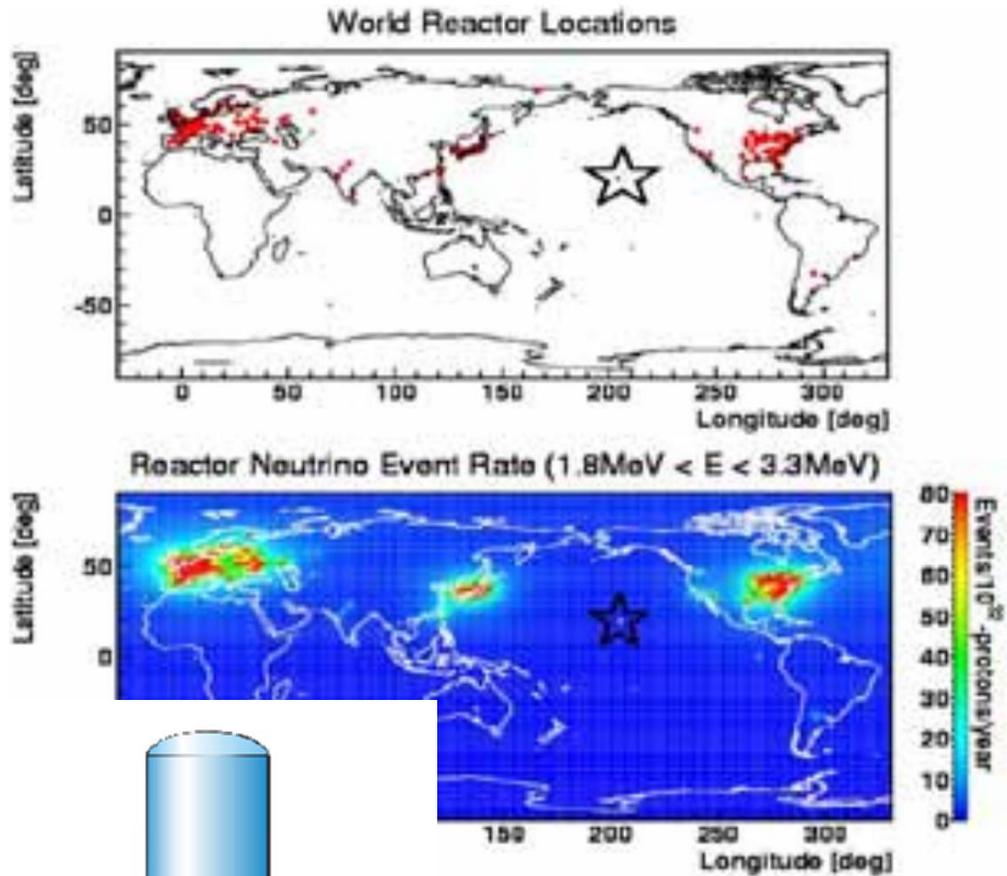
Geometry Geophysics

地球化学模型

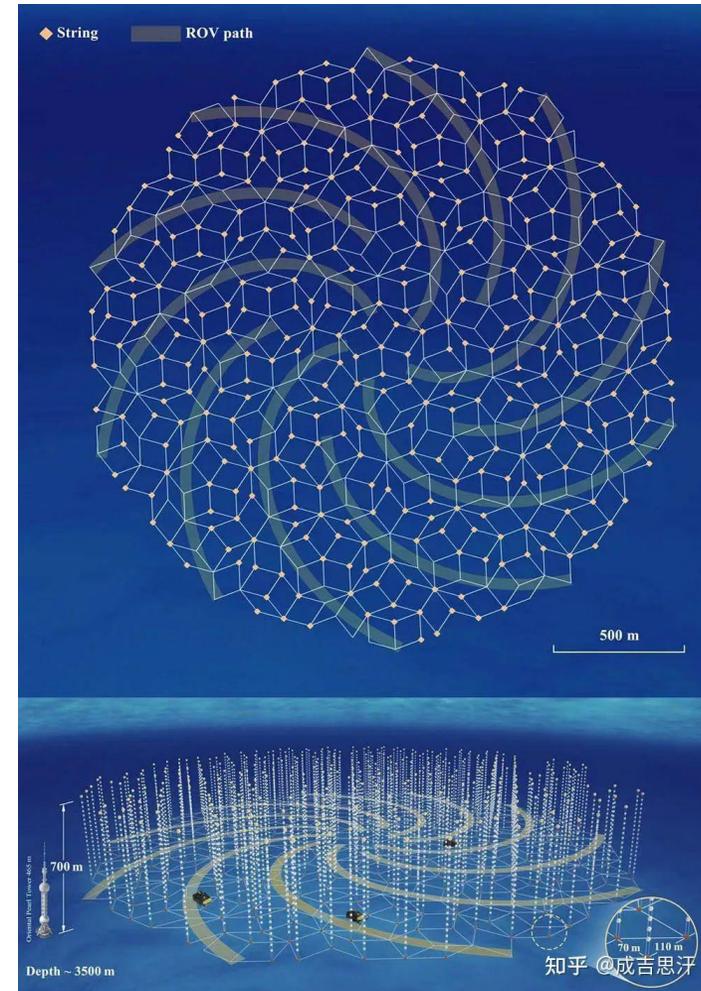


中国实验现状



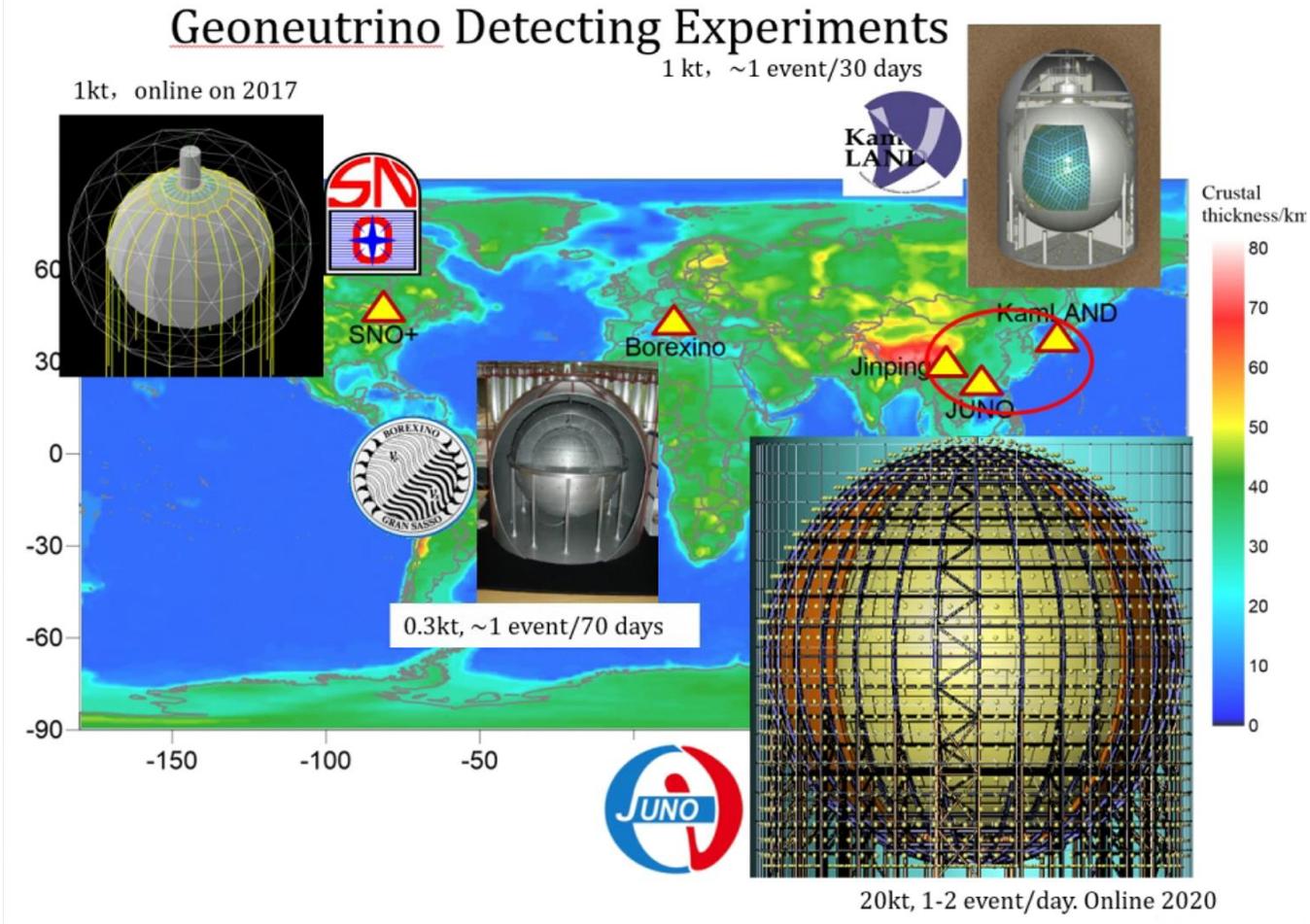


HANOHANO Detector (Plan)



上海交通大学南海中微子望远镜“海铃计划”
天体中微子来探索极端宇宙。

地球中微子研究：国际现状



Past meetings

- [Neutrino Sciences 2005](#) – Neutrino Geophysics, Honolulu, Hawaii, 14–16 December 2005
- [Neutrino Sciences 2007](#) – Deep Ocean Anti-Neutrino Observatory Workshop, Honolulu, Hawaii, 23–25 March 2007
- [Neutrino Geoscience 2008](#) – SNOLAB, Sudbury, Ontario, Canada, 17–19 September 2008
- [Neutrino Geoscience 2010](#) – Gran Sasso National Laboratory, Italy, 6–8 October 2010
- [Neutrino Geoscience 2013](#) – Takayama, Japan, 21–23 March 2013
- [Neutrino Geoscience 2015](#) – IPG Paris, France, 15–17 June 2015
- [Neutrino Research and Thermal Evolution of the Earth](#) – Tohoku University, Sendai, Japan, 25–27 October 2016

Mark Chen	Introduction to geoneutrinos
Hiroko Watanabe	Geoneutrino measurement with KamLAND
Sindhujha Kumaran	Borexino: Latest improvements of the geoneutrino results
coffee break	
Bill McDonough	<u>The mantle's radioactive power</u> - Understanding the geoneutrino signal
Paul Tackley	<u>Mantle convection, plate tectonics and the thermo-chemical evolution of the Earth</u>
Lukas Maderer	<u>Earth tomography with KM3NeT/ORCA</u>
lunch	
Chao Zhang	Reactor antineutrino flux and spectrum
Nozomu Takeuchi	<u>Crust modeling with quantitative and objective uncertainty estimation</u>
break	
Kenta Ueki	<u>Geochemical modeling for no-bias balance calculation</u>
Sanshiro Enomoto	<u>Geoneutrino flux integration without underestimation of errors</u>
Jaroslav Zálešák	Neutrino research in the Czech Republic

地球演化

量化建模

观测

Ingrida Semeneč	<u>Geo-neutrinos in SNO+</u>
Bedřich Roskovec	<u>Geoneutrino measurement at JUNO</u>
Benda Xu	Progress of Jinping neutrino experiment program
coffee break	
Christoph Burkhardt	Old truths and new views on the formation and evolution of the Earth
Yury Malyskin	Geo-neutrino program at Baksan Neutrino Observatory
Wolfgang Szwilius	<u>Global crustal thickness and velocity structure from geostatistical analysis of seismic data</u>
lunch	
Javier Fullea	<u>WINTERC-grav</u> : a new upper mantle thermochemical model constrained coupled geophysical-petrological inversion of seismic waveforms, heat flow, surface elevation and gravity satellite data
Zhiwei Li	<u>JULOC</u> : A local 3-D high-resolution crustal model in South China for forecasting geoneutrino measurements at JUNO
Mirko Reguzzoni	<u>GIGJ</u> : a crustal gravity model of the Guangdong Province for predicting the geoneutrino signal at the JUNO experiment
coffee break	
Bill McDonough	Reference models for lithospheric geoneutrino signal
Laura Sammon	Geoneutrino contributions from the deep lithosphere
Valery Sinev	Terrestrial 40K geoneutrinos and solar CNO neutrinos

方法

模型

JUNO取数在即，中国地球中微子研究的机遇和挑战

- **建模到综合性科学研究→地球演化or?** **科学前沿**
- **交叉研究→更多地学界的关注和投入（人）** **研究力量（投入）**
- **方法学创新及对物理/地学的推动** **研究手段**

江门：有国际影响力的地球中微子研究



谢谢!

贡献更多地学力量!