

Neutrino Physics Possibilities at Jinping Underground Lab

Shaomin CHEN (陈少敏)

Tsinghua University, Beijing

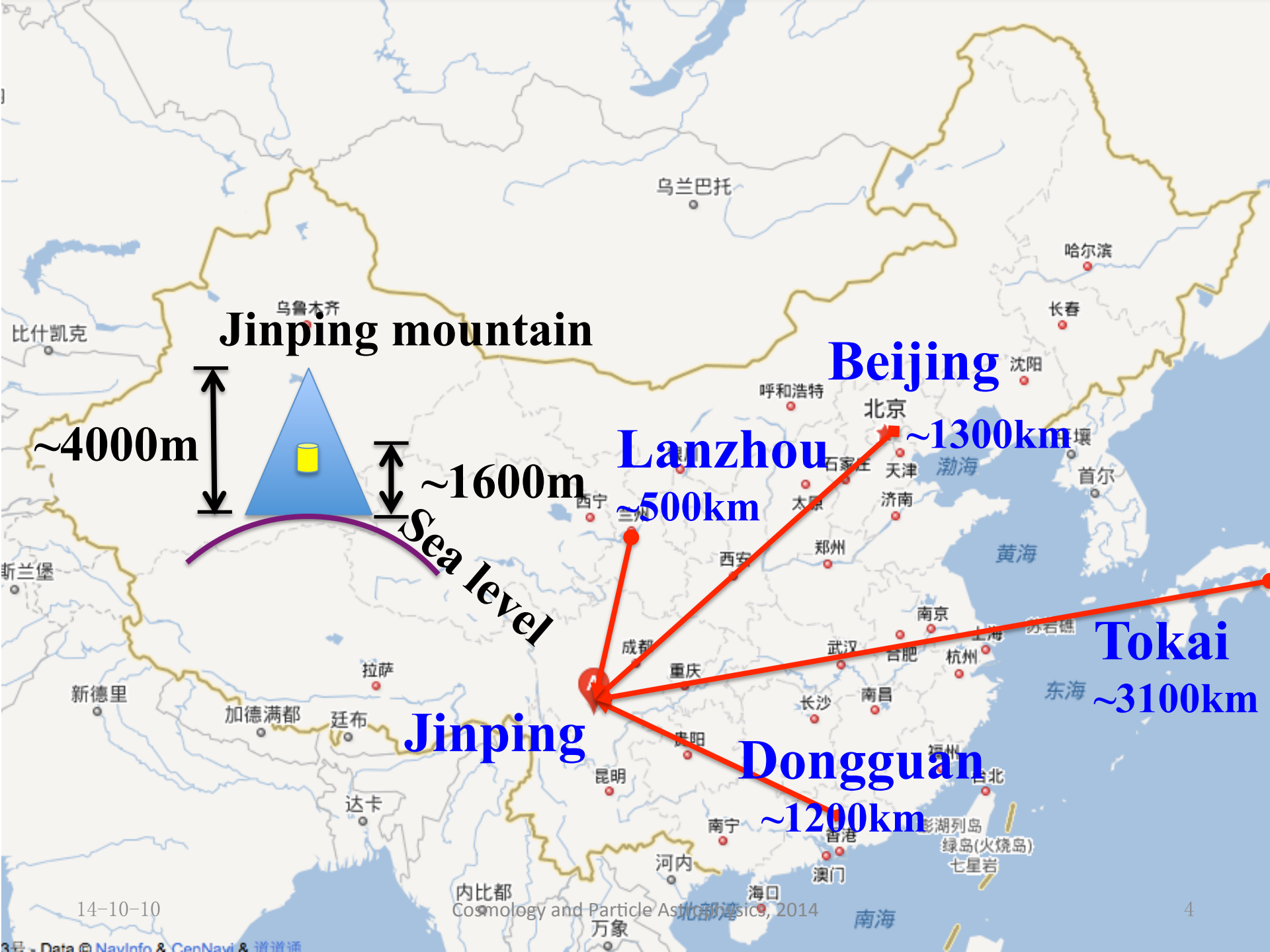
chenshaomin@tsinghua.edu.cn

Outline

- ✧ Jinping underground lab
- ✧ Neutrino physics possibilities at Jinping
 - ✓ Low energy neutrino physics
 - Solar neutrinos
 - Geo-neutrinos
 - Supernova relic neutrinos
 - ✓ High energy neutrino physics
- ✧ Summary

Jinping underground lab





Jinping



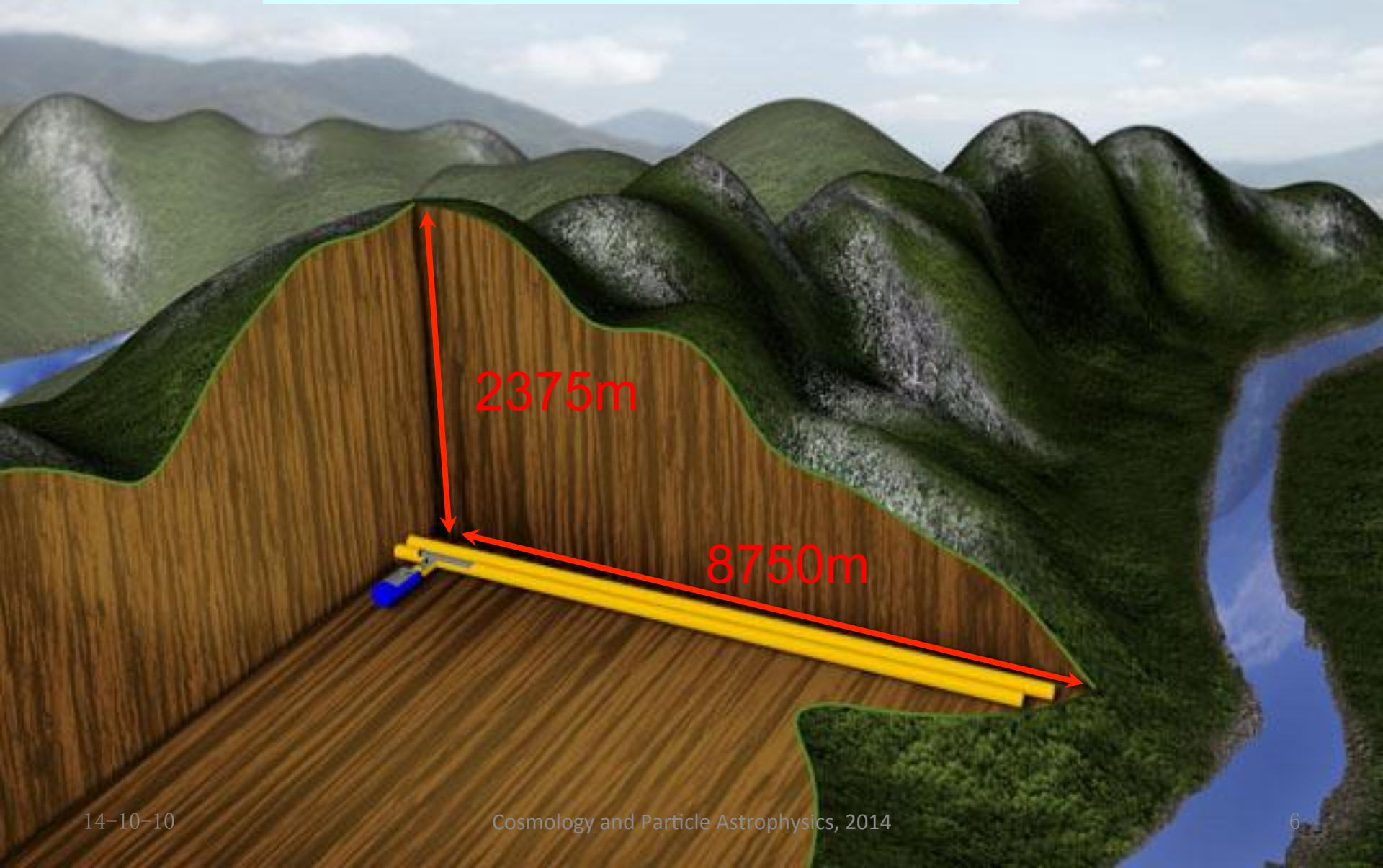
10 km

Xichang Airport

Cosmology and Particle Astrophysics, 2012

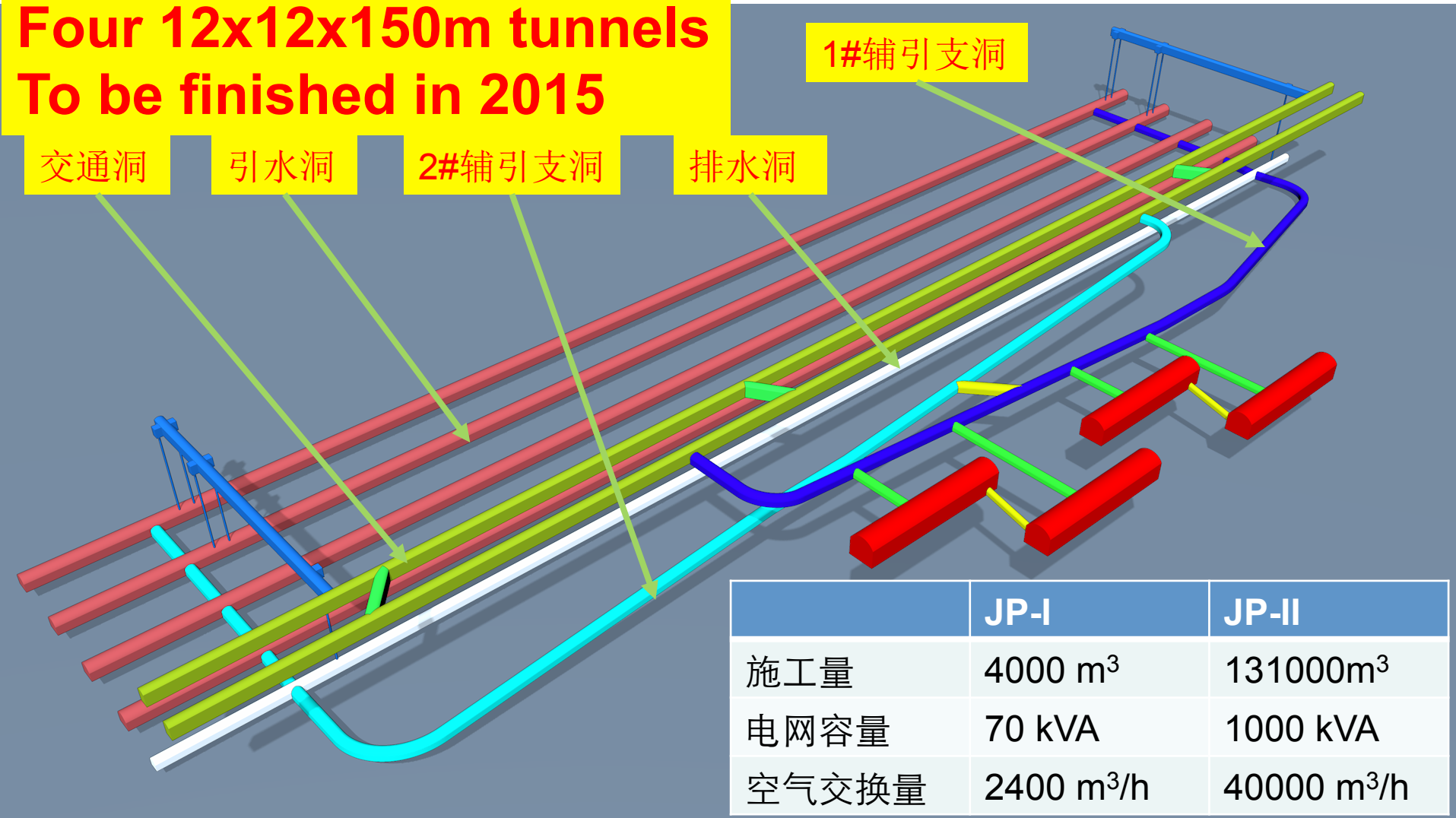
西昌青山机场

Jinping Phase I



Jinping Phase II

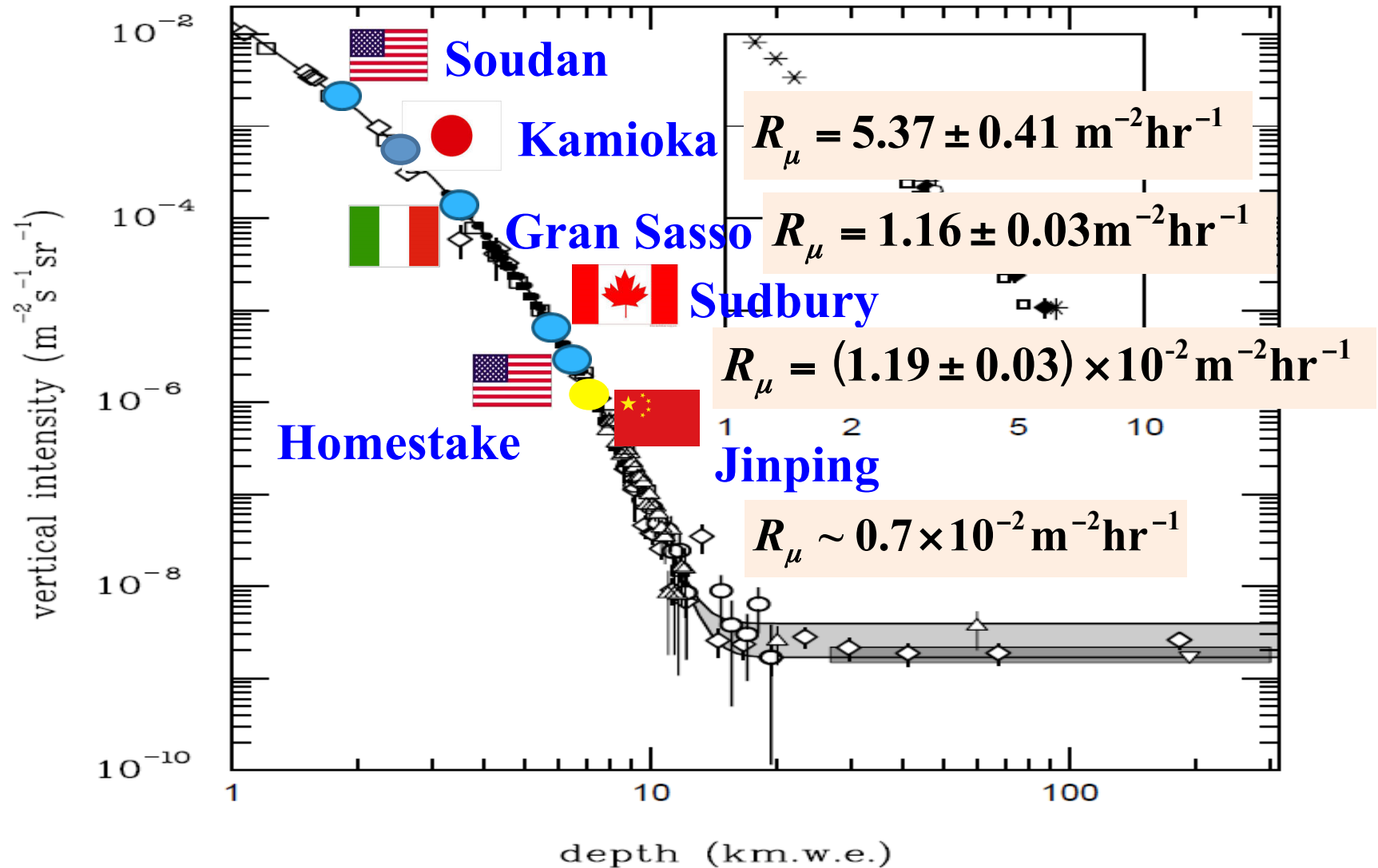
**Four 12x12x150m tunnels
To be finished in 2015**



JP Rock Background

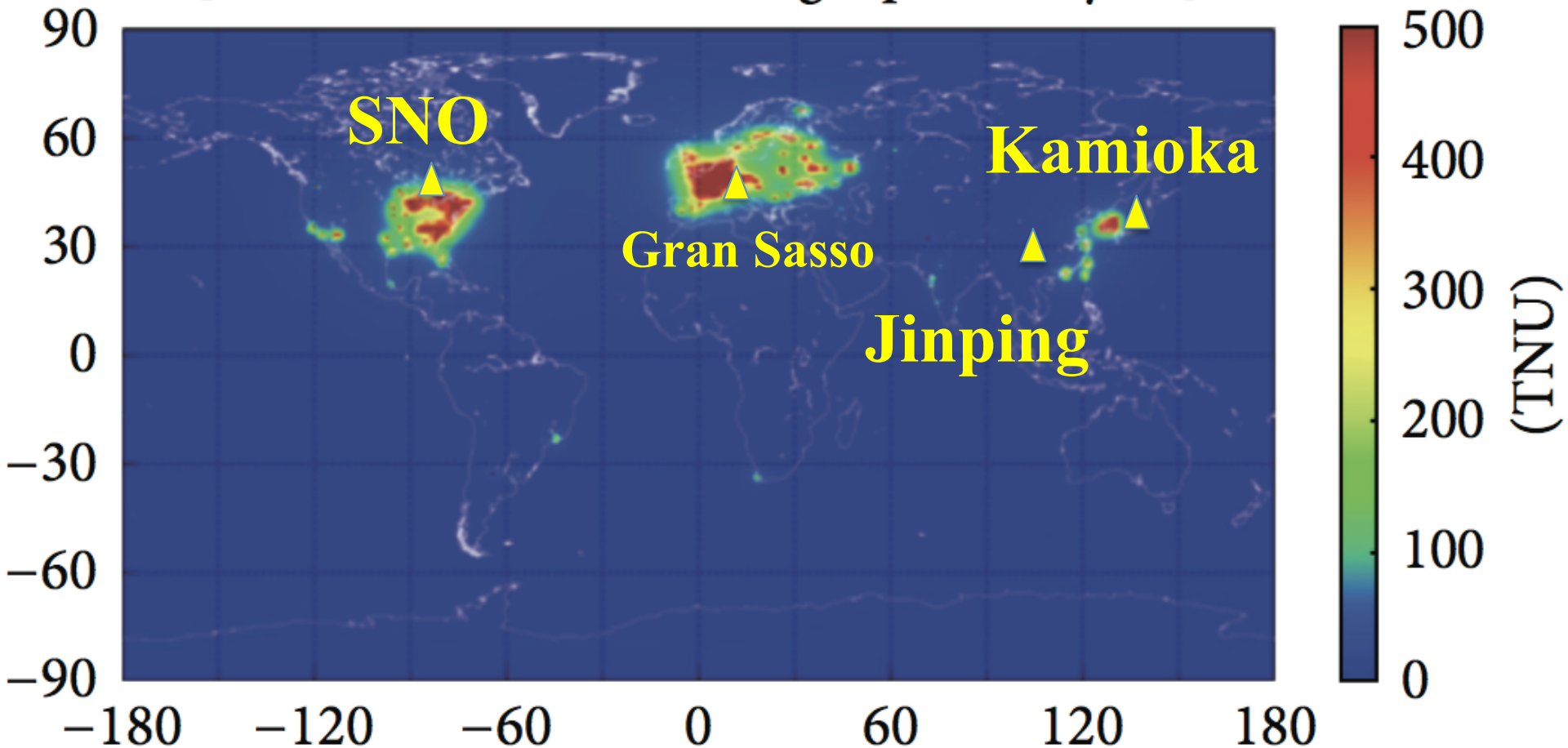
(Unit: Bq/kg)	K-40	Ra-226 (609keV)	Th-232 (911keV)
JP Rock Sample	< 1.1	1.8±0.2	< 0.27
Beijing Normal Ground Level	~600	~25	~50

Muon Flux vs. Overburden



Reactor Neutrino Map(2012)

[1 TNU = 1 event/ 10^{32} target protons/year]



Reactors Around Jinping



Reactor Neutrino Background

Jinping

$$R_{\text{reactor}} = 0.3 \text{ TNU now}$$

$$R_{\text{reactor}} = 1.1 - 2.3 \text{ TNU, 10 years later}$$

Gran Sasso

$$R_{\text{reactor}} = 31.2 \text{ TNU (measurement)}$$

$$R_{\text{reactor}} = 30.4 \text{ TNU (our estimate)}$$

Kamioka

$$R_{\text{reactor}} = 2.0 \text{ TNU now}$$

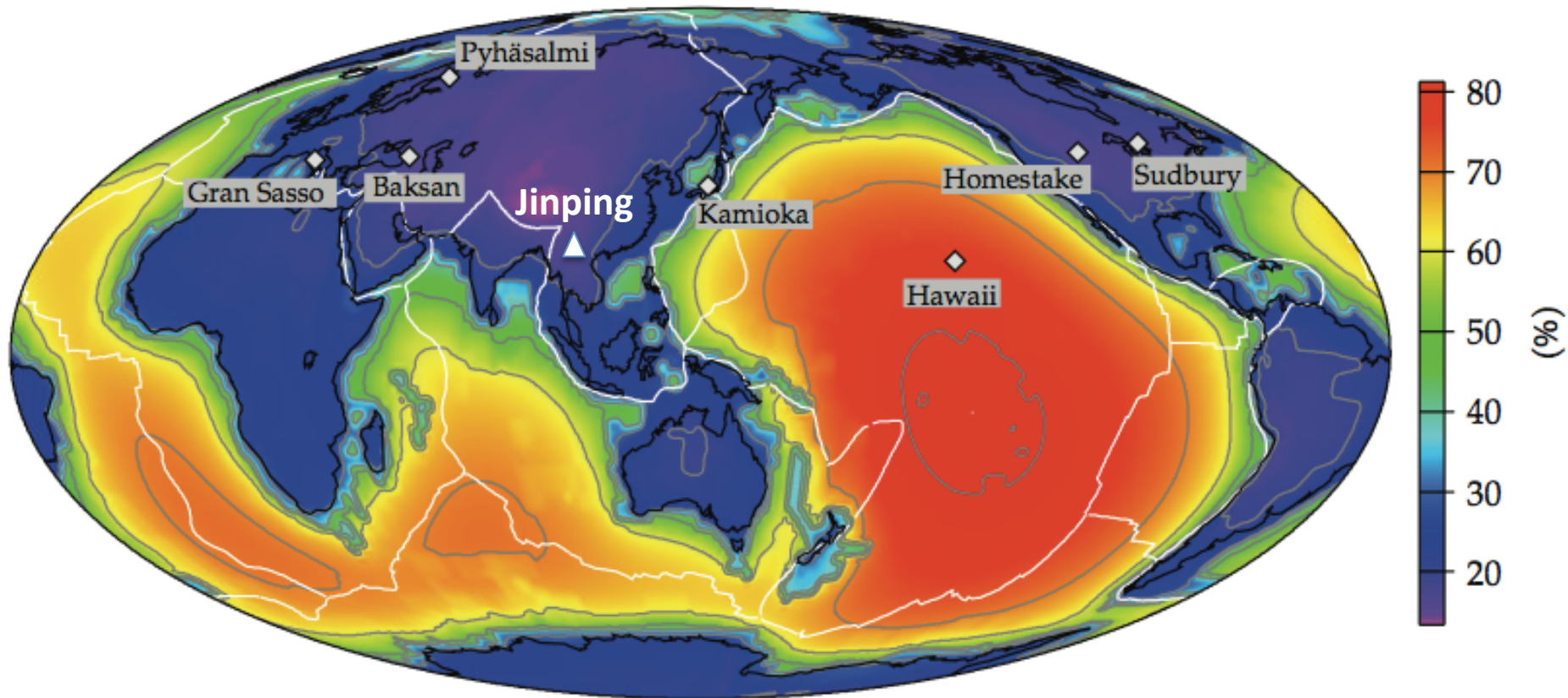
SNO

$$R_{\text{reactor}} > 15.0 \text{ TNU}$$

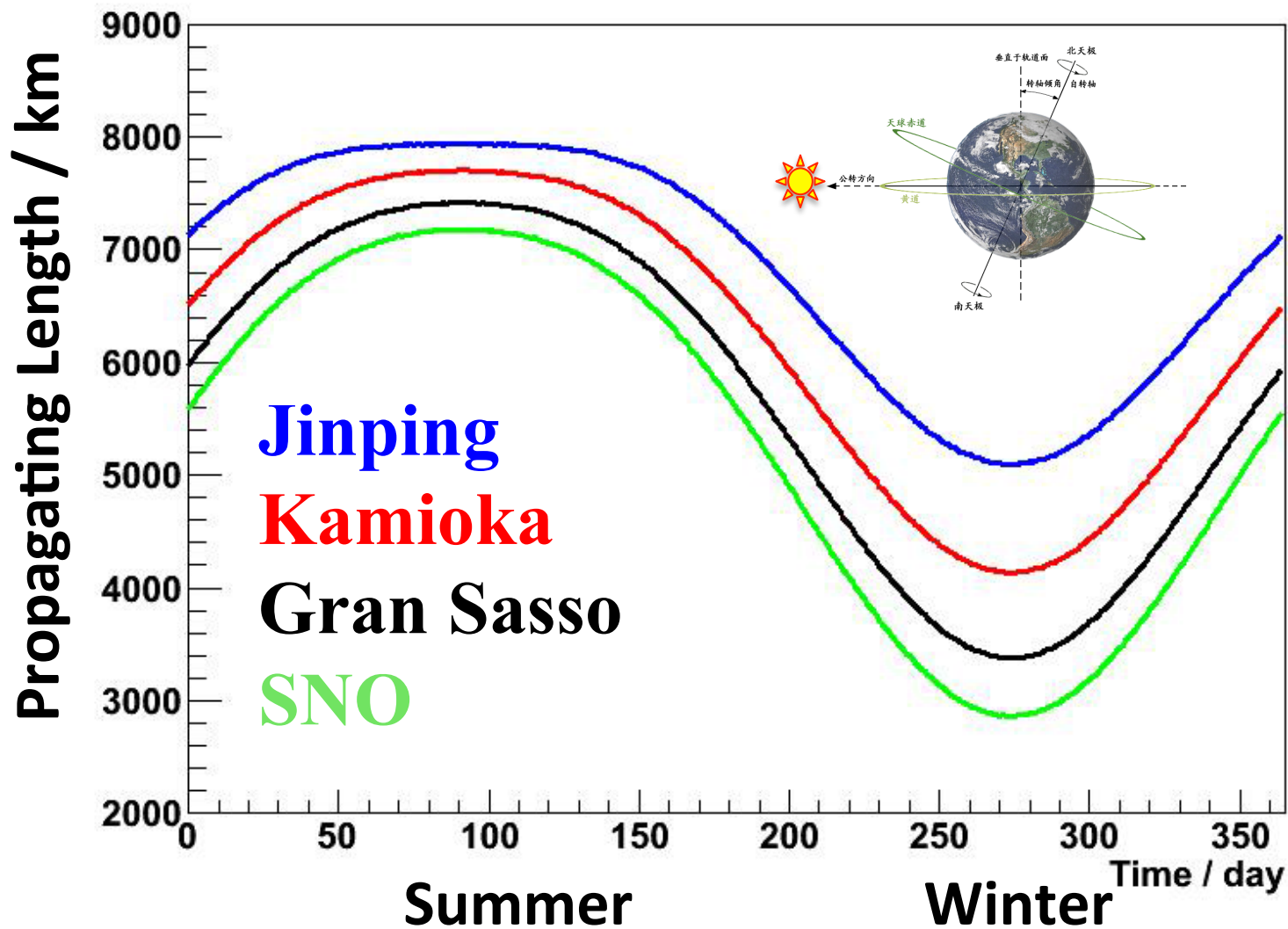
Mantle/total Geo-neutrinos

doi:10.1155/2012/235686

Mantle/total geoneutrino signal

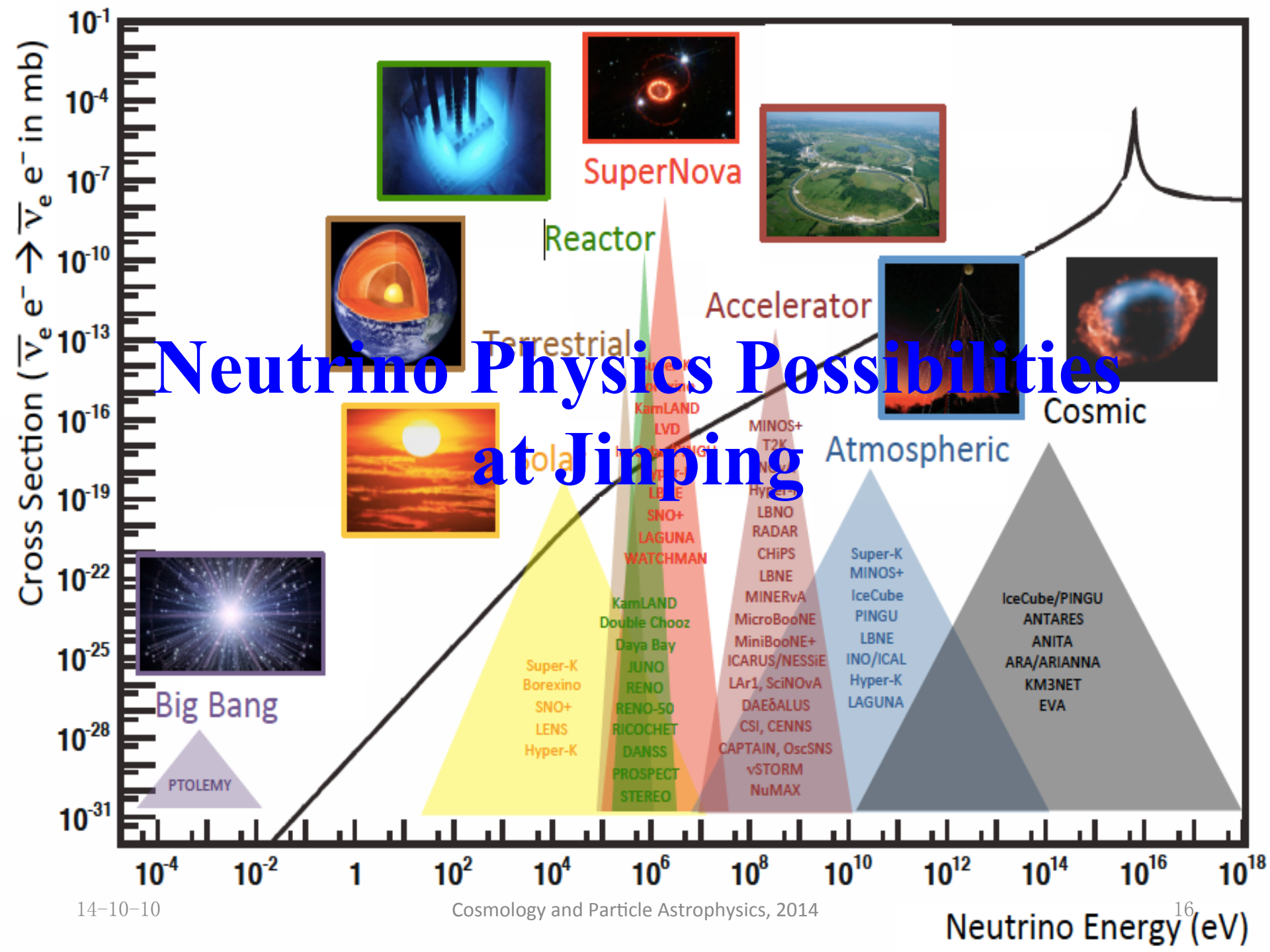


Solar ν 's Path length in Earth



Findings

- ✓ **Thickest overburden leads to the least cosmic background**
- ✓ **Far away from nuclear power plants results in the least reactor neutrino background**
- ✓ **Closest to the equator gives the longest path length and highest electron density through the earth**
- ✓ **Nearby hydraulic power plants and Yalong river provide the enormous convenience**



Neutrinos

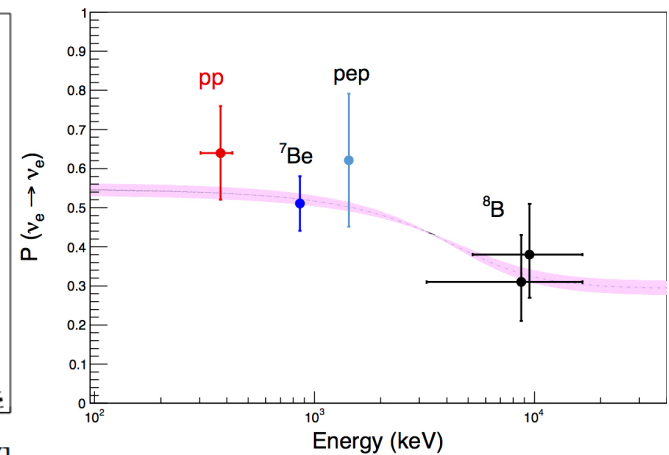
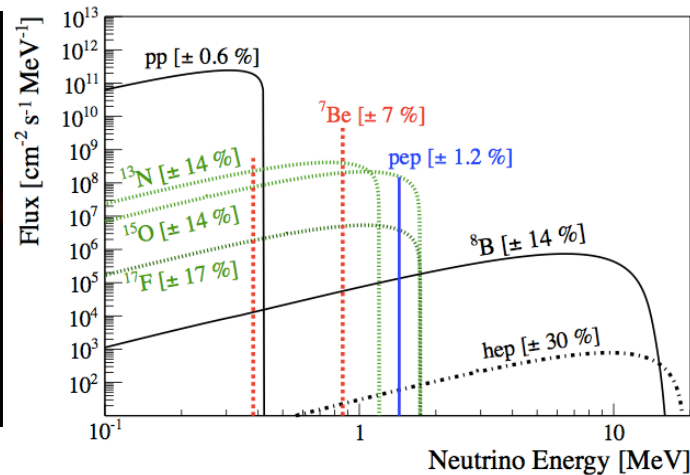
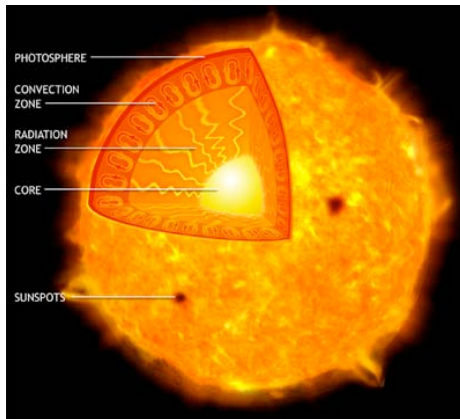
Conveners: A. de Gouvêa⁵⁰, K. Pitts³², K. Scholberg²⁶, G.P. Zeller²⁷

Subgroup Conveners: J. Alonso⁴⁶, A. Bernstein⁴¹, M. Bishai⁸, S. Elliott⁴², K. Heeger⁷⁸, K. Hoffman⁴³, P. Huber⁷⁴, L.J. Kaufman³⁵, B. Kayser²⁷, J. Link⁷⁴, C. Lunardini⁴, B. Monreal¹⁵, J.G. Morfin²⁷, H. Robertson⁷⁵, R. Tayloe³⁵, N. Tolich⁷⁵

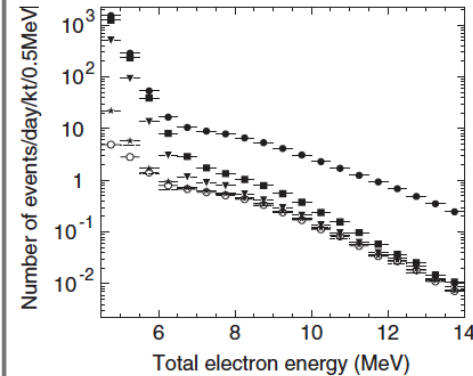
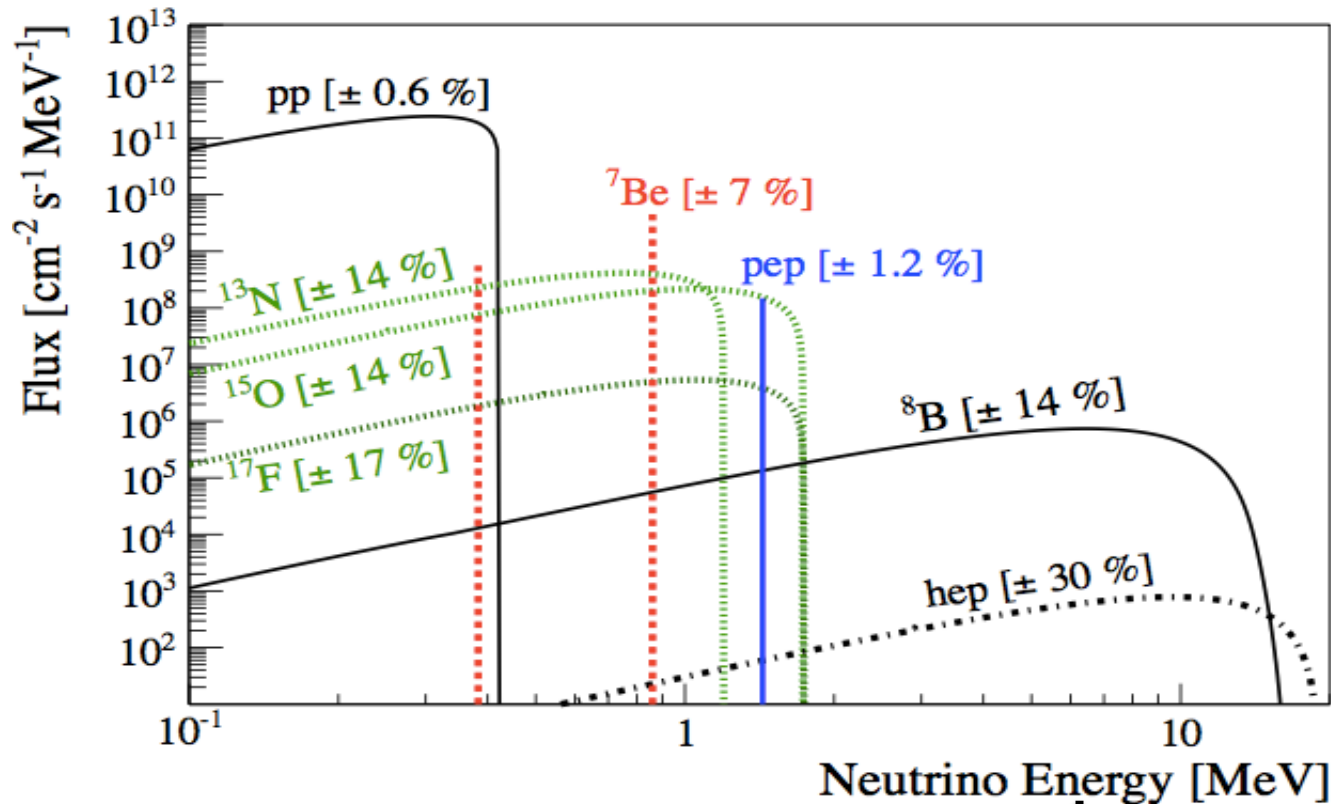
Expt. Type	$\sin^2 \theta_{13}$	$\text{sign}(\Delta m_{31}^2)$	δ	$\sin^2 \theta_{23}$	$ \Delta m_{31}^2 $	$\sin^2 \theta_{12}$	Δm_{21}^2	NSI	ν_s
Reactor	***	**	—	—	*	**	**	—	**
Solar	*	—	—	—	—	***	*	**	**
Supernova	*	***	—	—	—	*	*	**	**
Atmospheric	**	**	**	**	**	—	—	***	**
Pion DAR	***	—	***	*	**	*	*	—	**
Pion DIF	***	***	***	**	**	*	*	**	**
μ DIF	***	***	***	***	***	*	*	**	**
Isotope DAR	—	—						**	**
β Beam	***	—	***	**	**	*	*	—	**

Low-energy neutrino physics

I. Solar neutrino physics



Solar Neutrinos at SK



① External bkg (PMT, rock...)

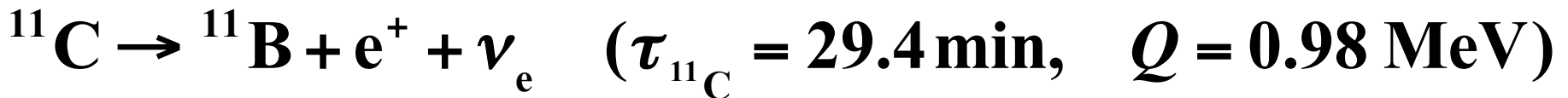
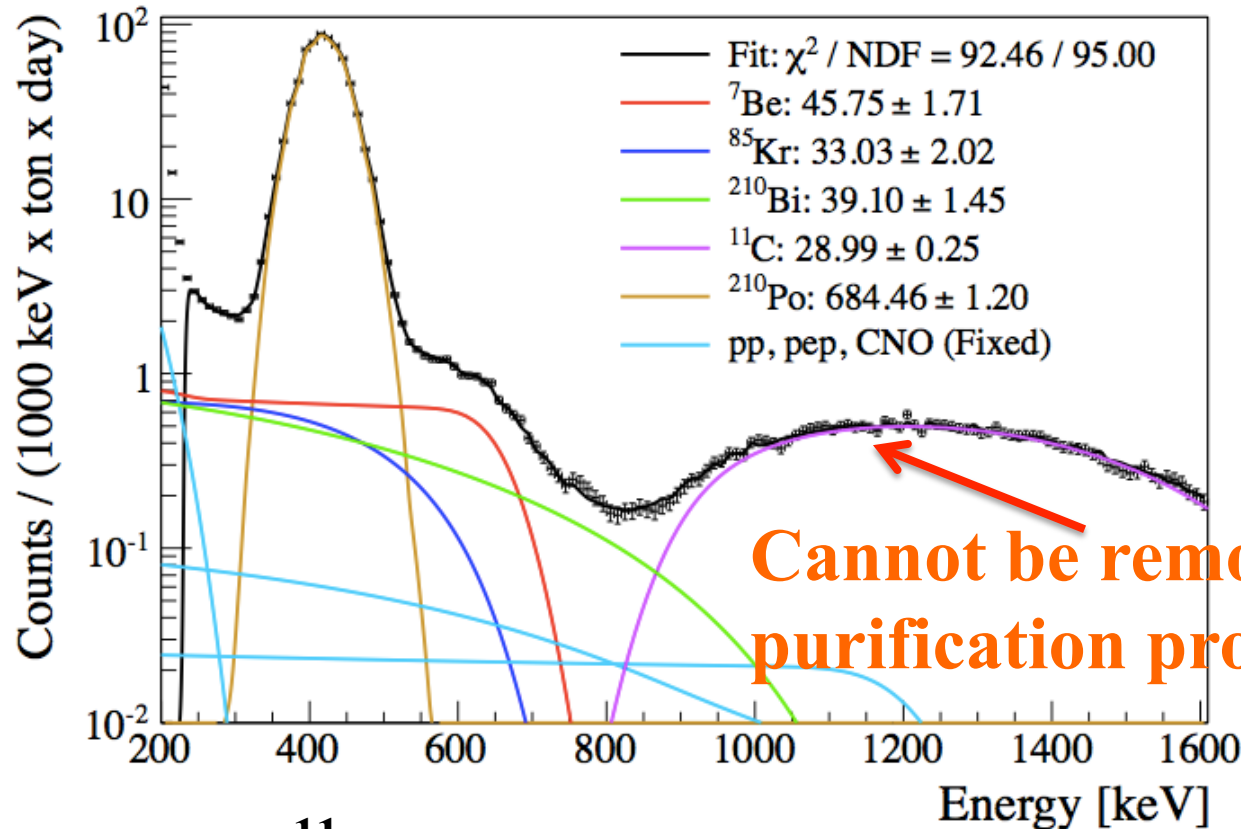
② Radon ^{222}Rn

③ Reactor neutrinos?

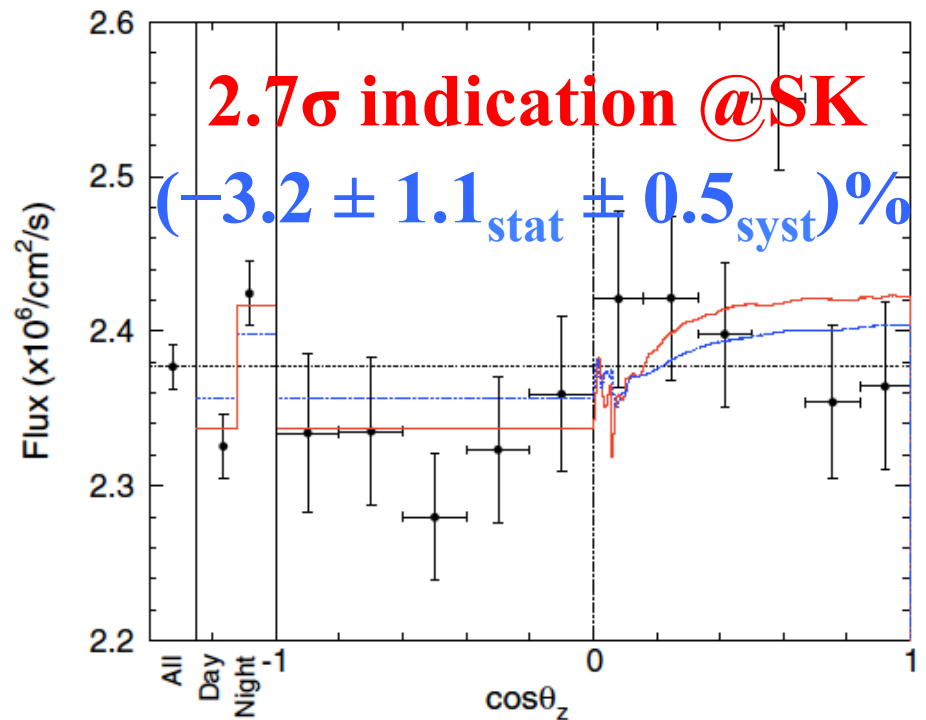
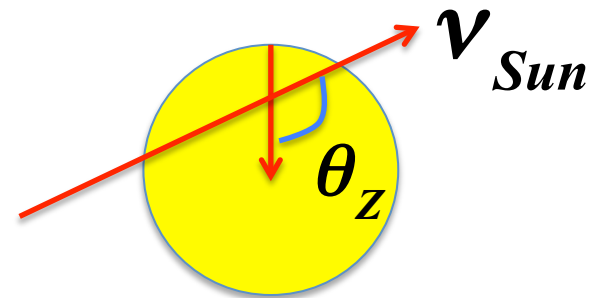
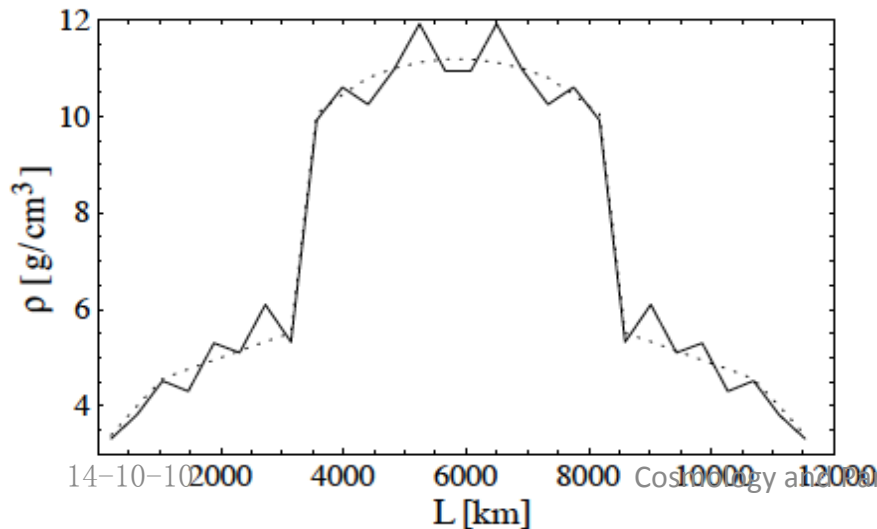
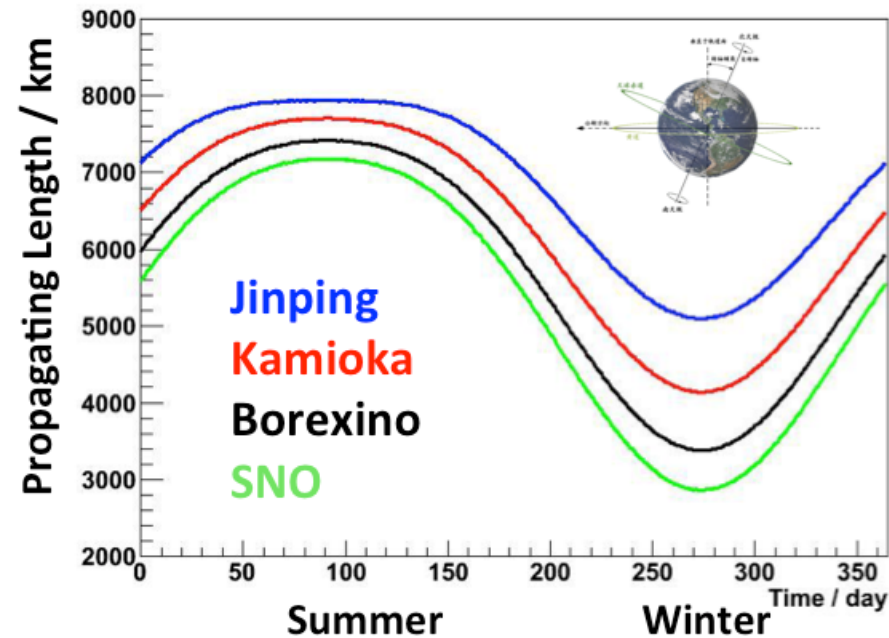
6.5 MeV

Spallation
background

Solar Neutrinos at Borexino



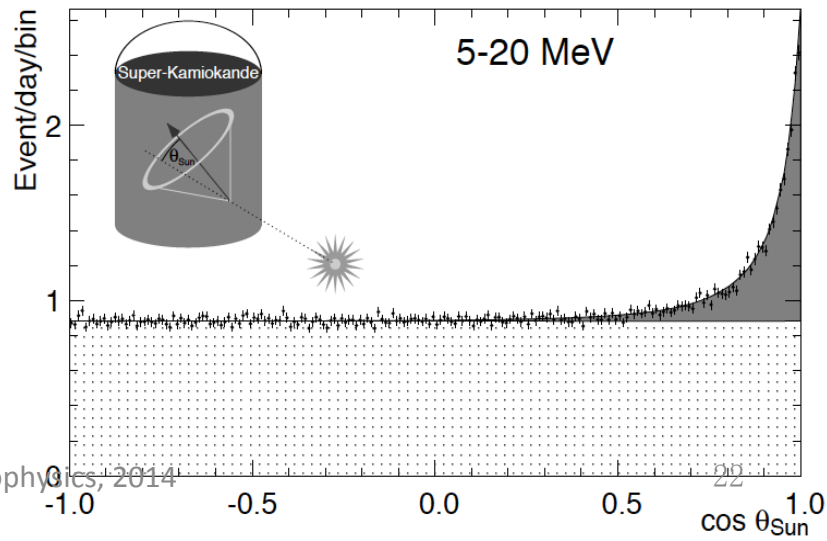
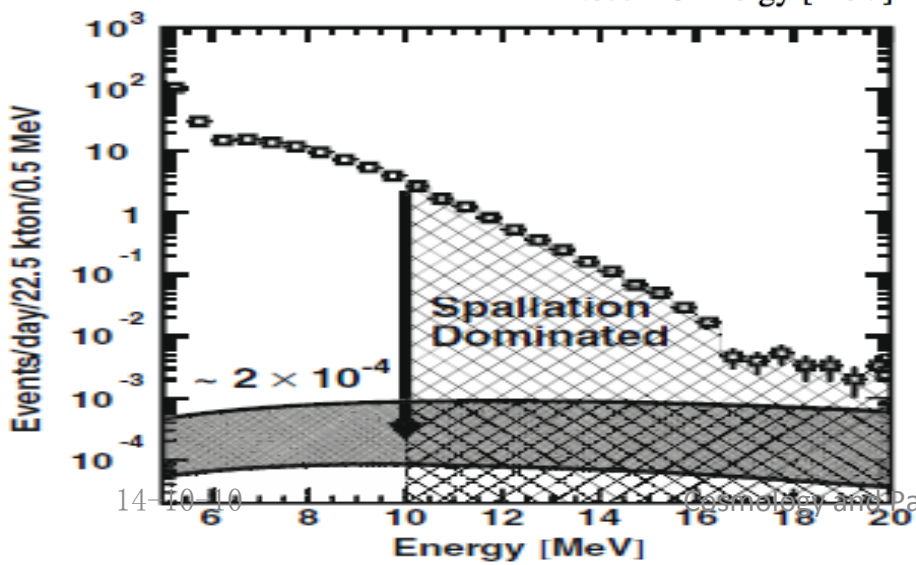
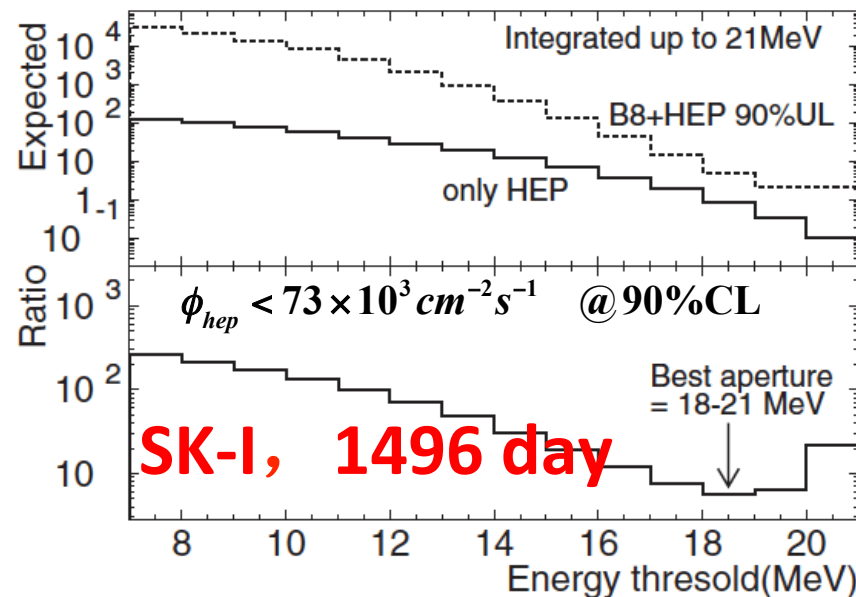
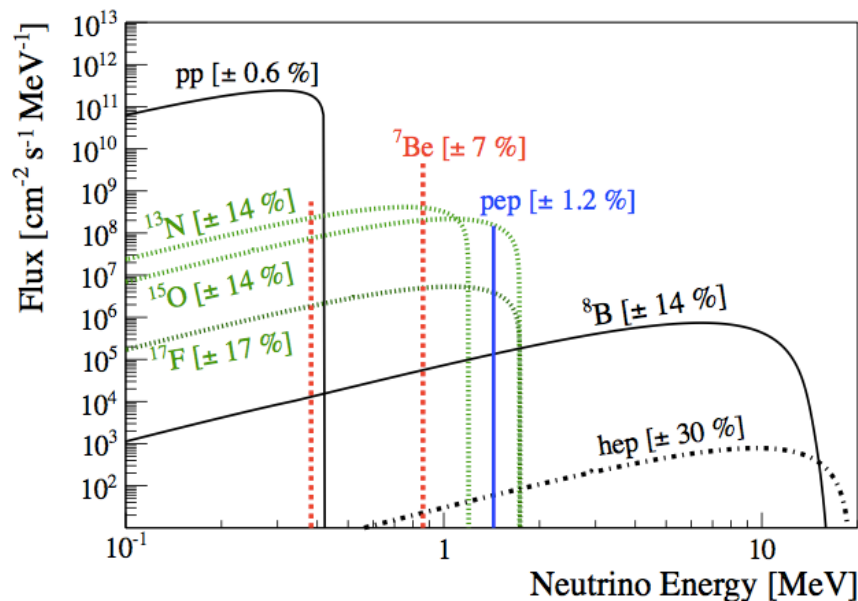
Day-Night Difference



PRL 112, 091805 (2014)

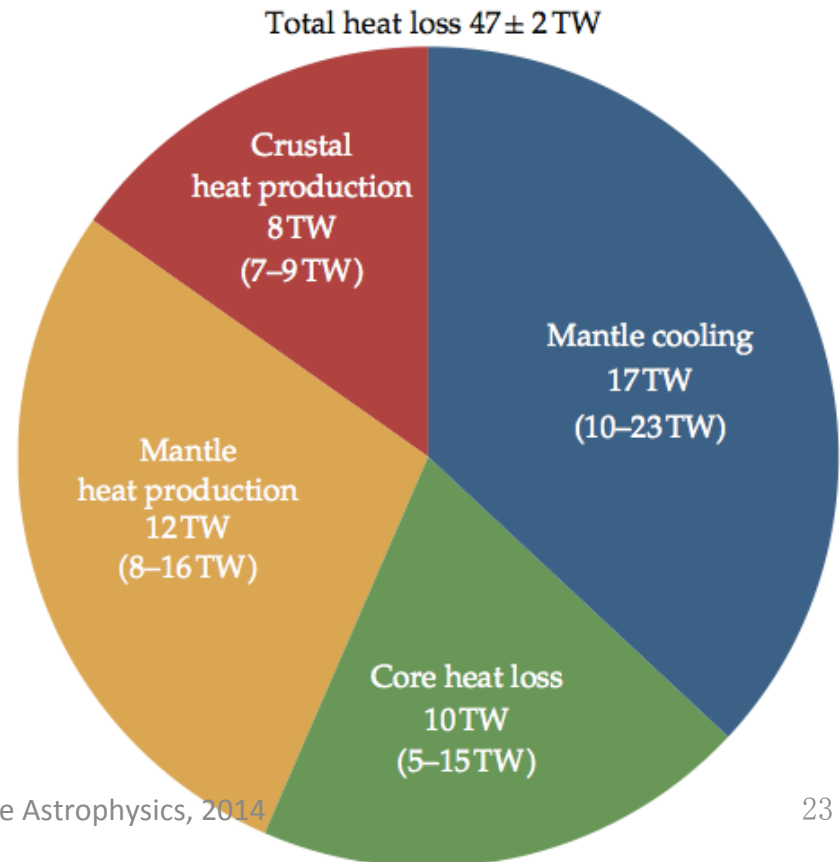
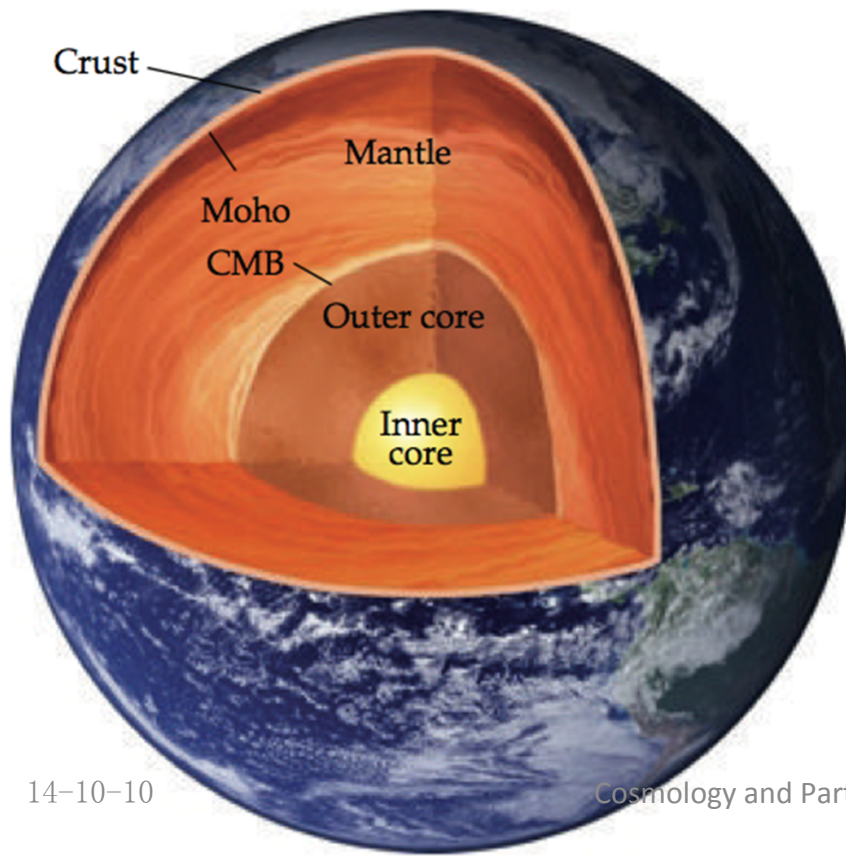
hep Solar Neutrinos

PHYSICAL REVIEW D 73, 112001 (2006)

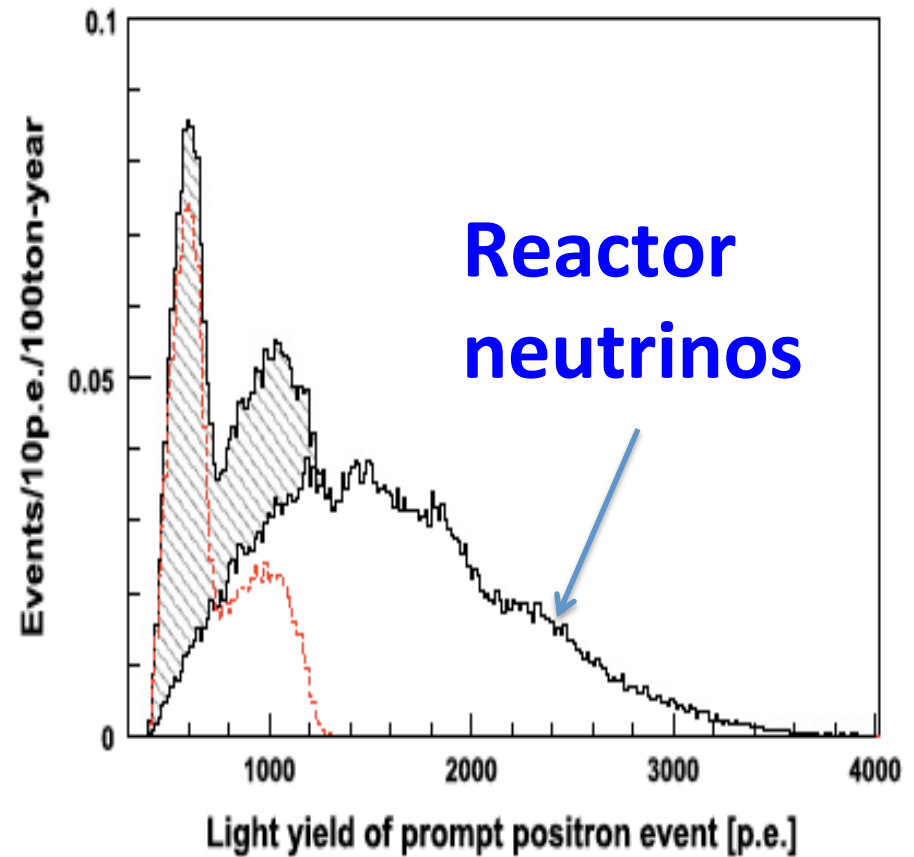
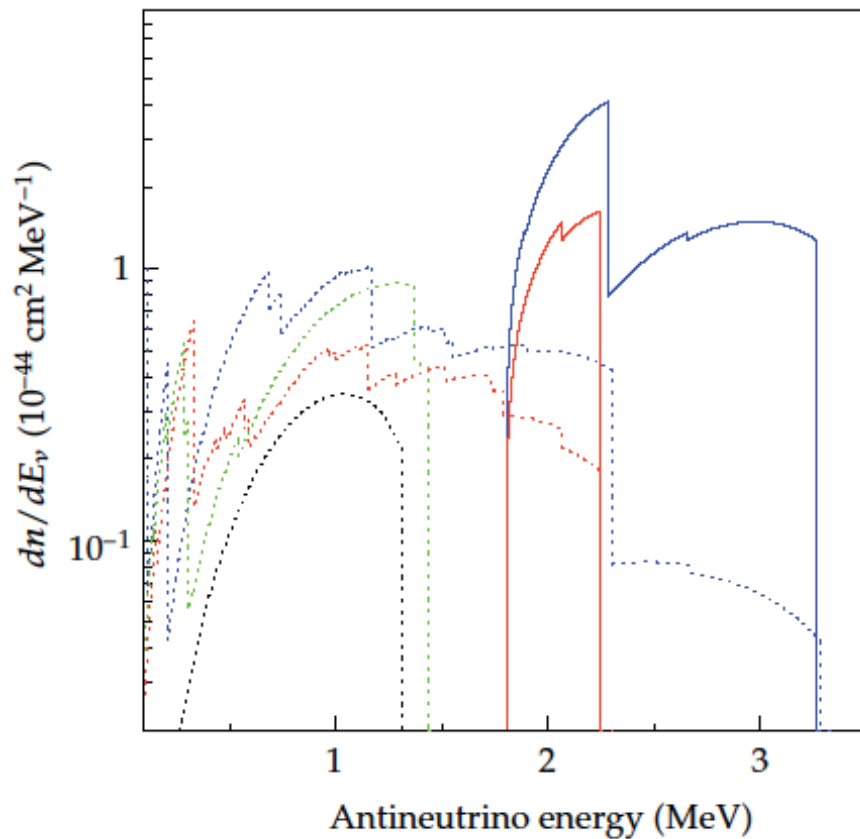


Low-energy neutrino physics

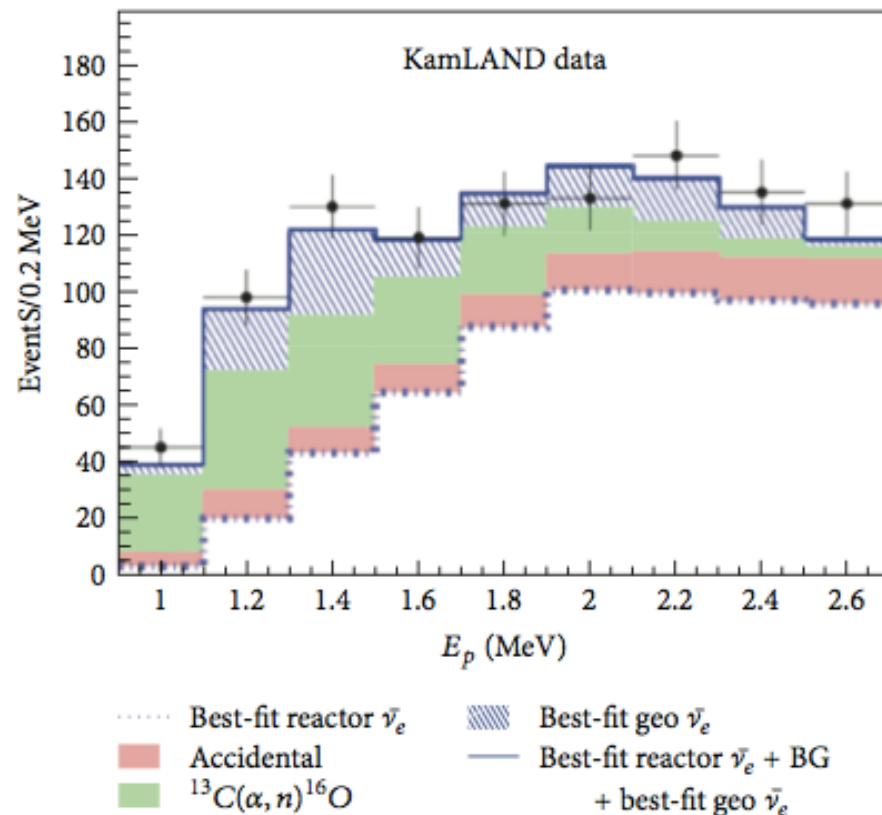
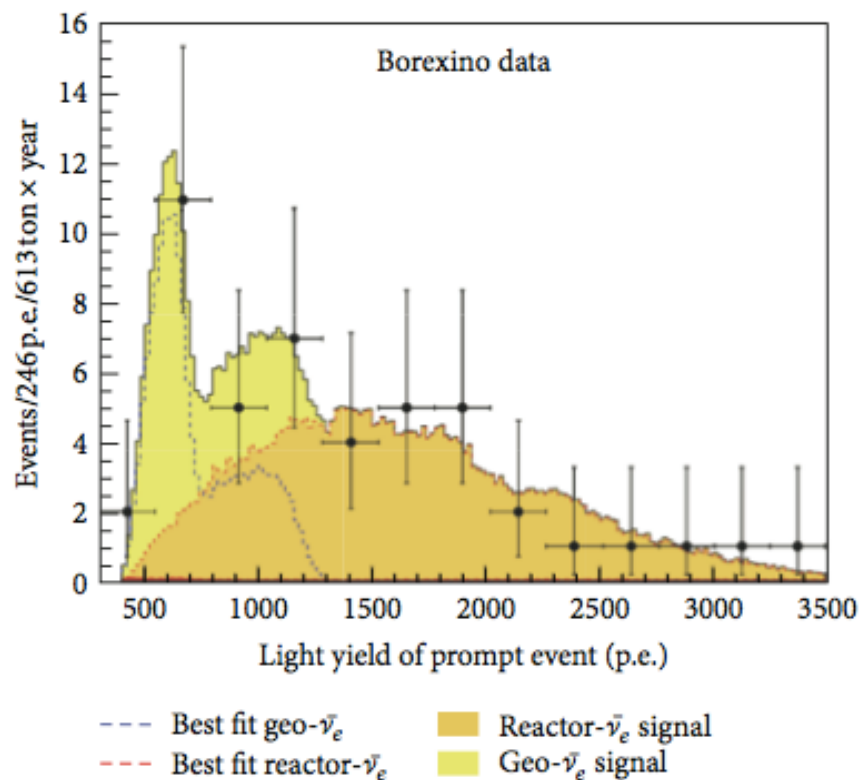
II. Geo-neutrino physics



Geo-neutrino Spectrum

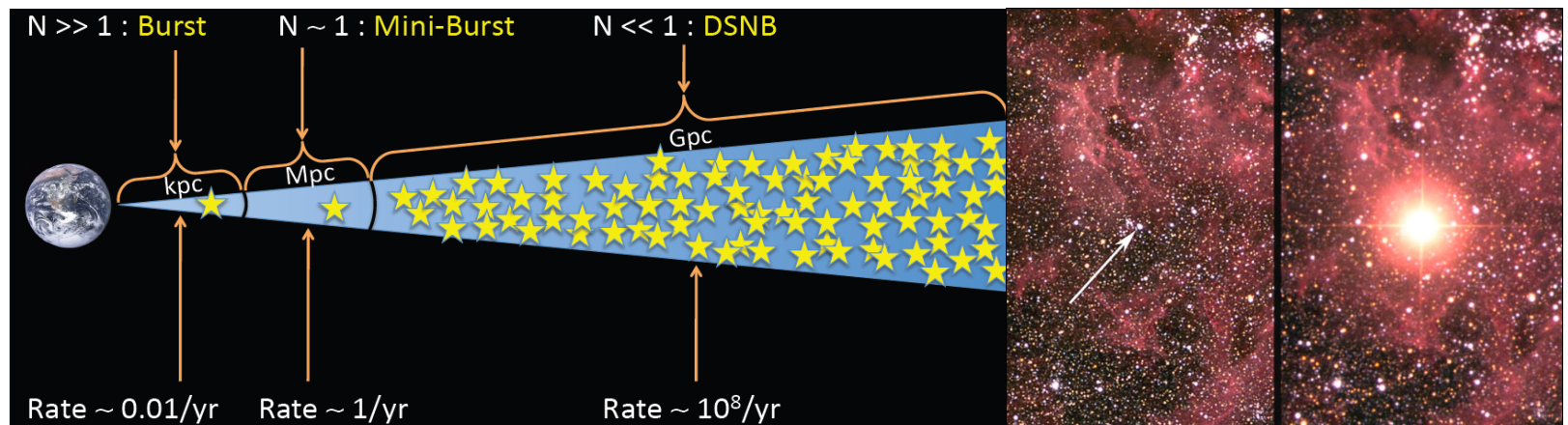


Geo-neutrino Measurements

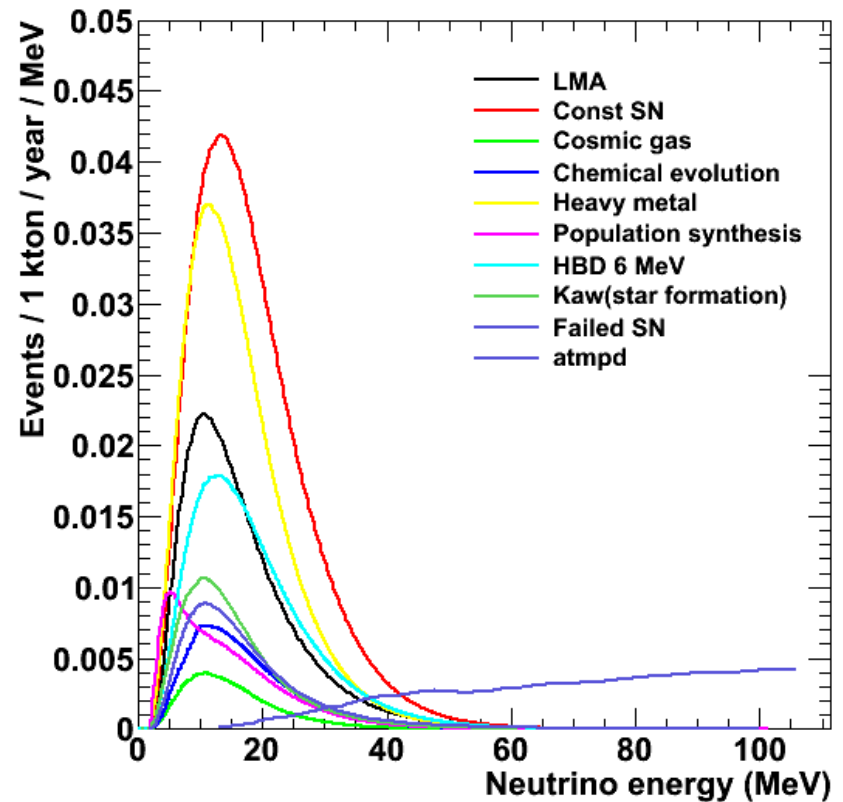
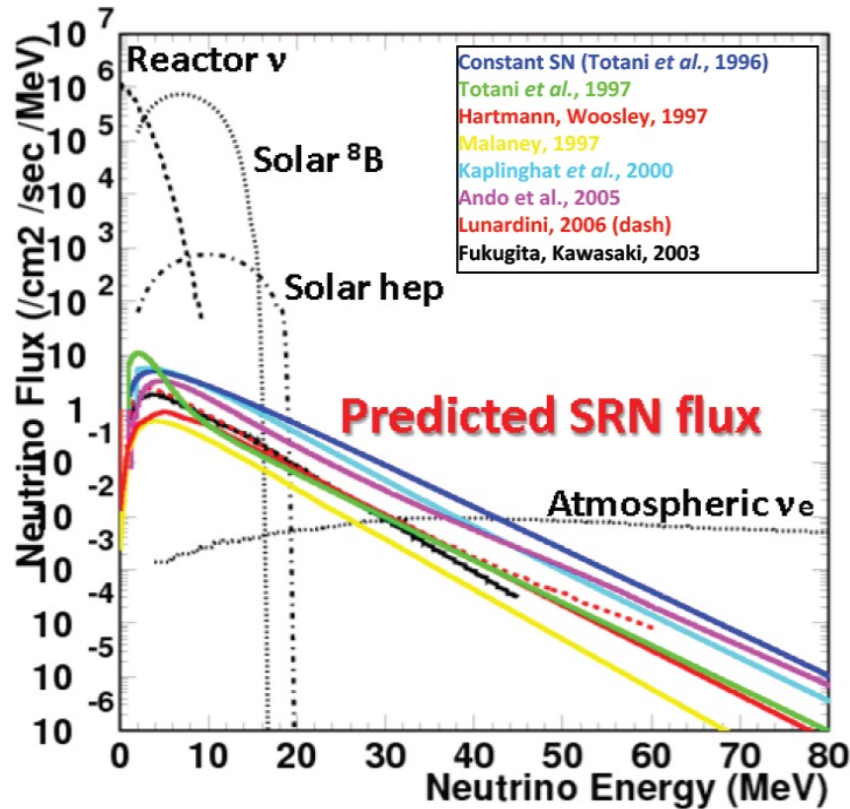


Low-energy neutrino physics

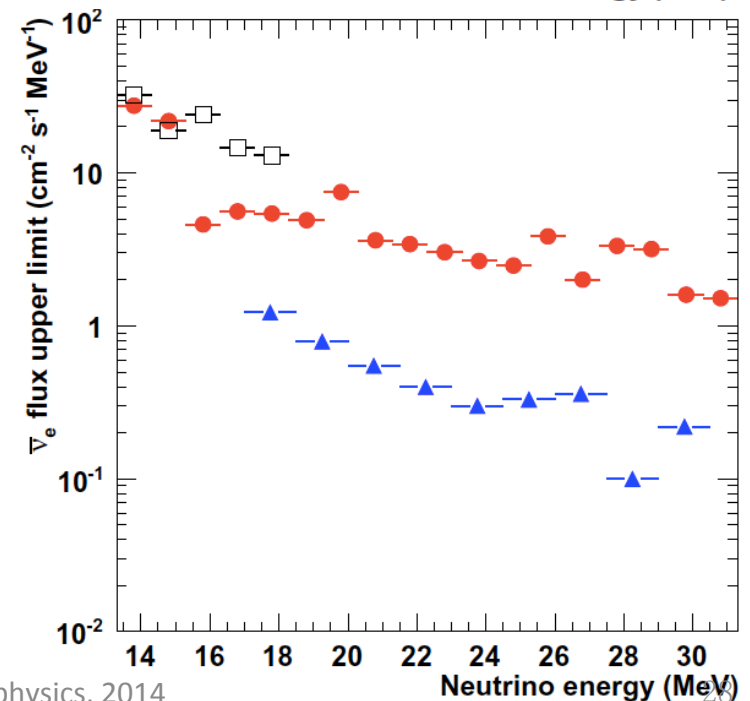
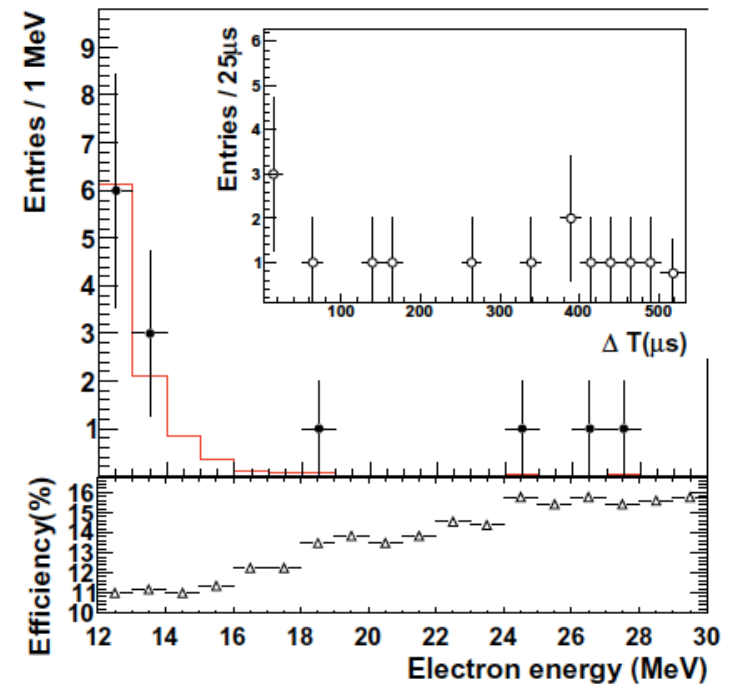
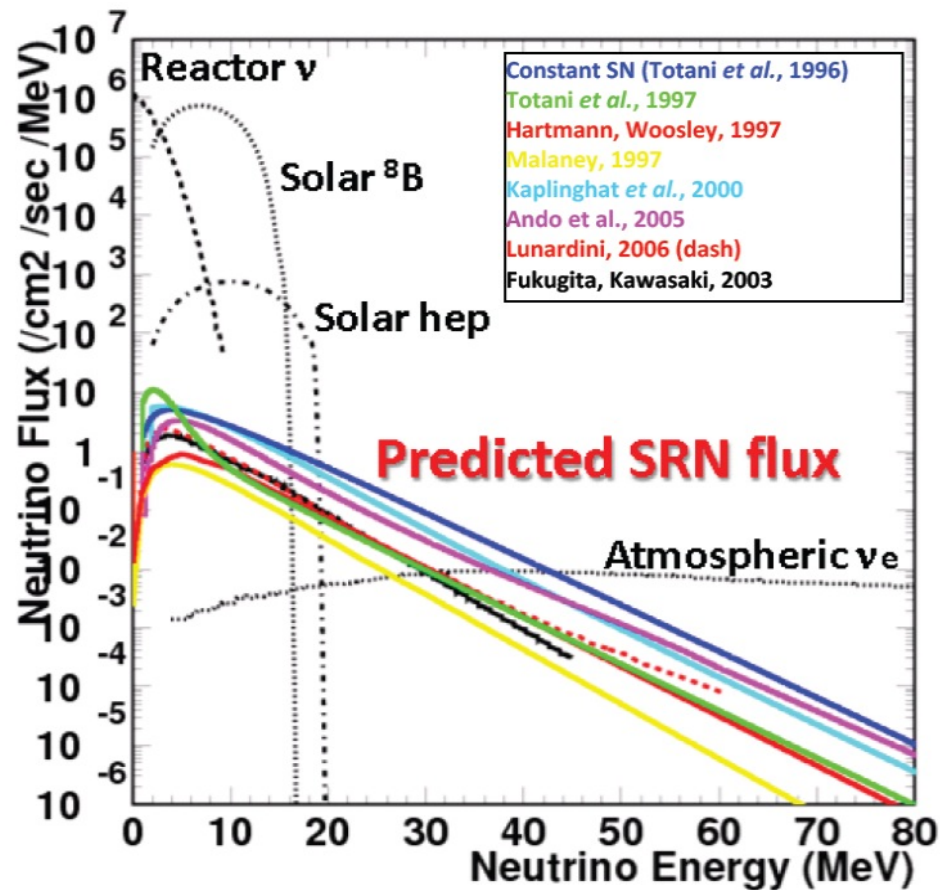
III. Supernova Relic neutrino physics



Supernova Relic Neutrinos

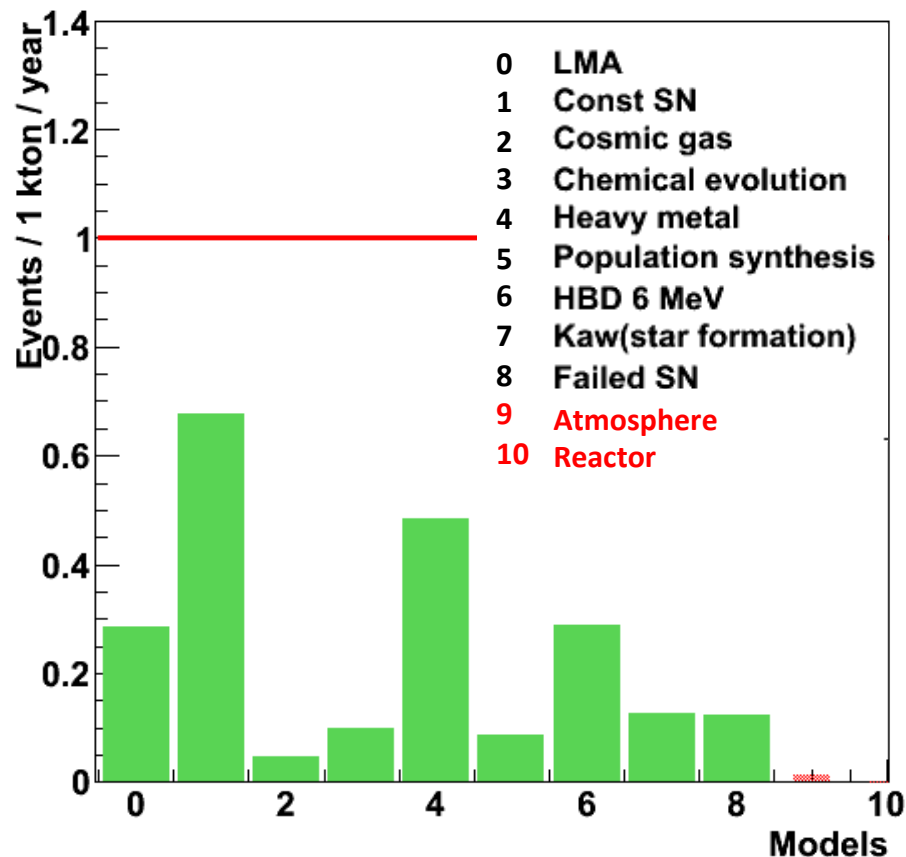
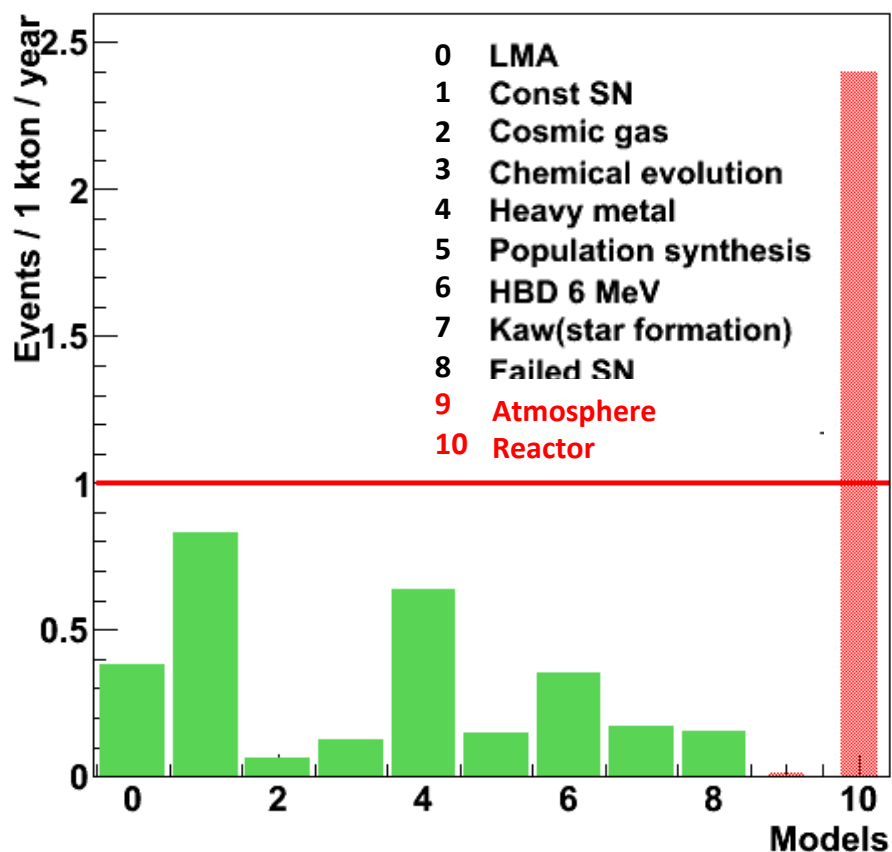


Current Approach



H. Zhang et al./Astroparticle Physics 60 (2015) 41–46

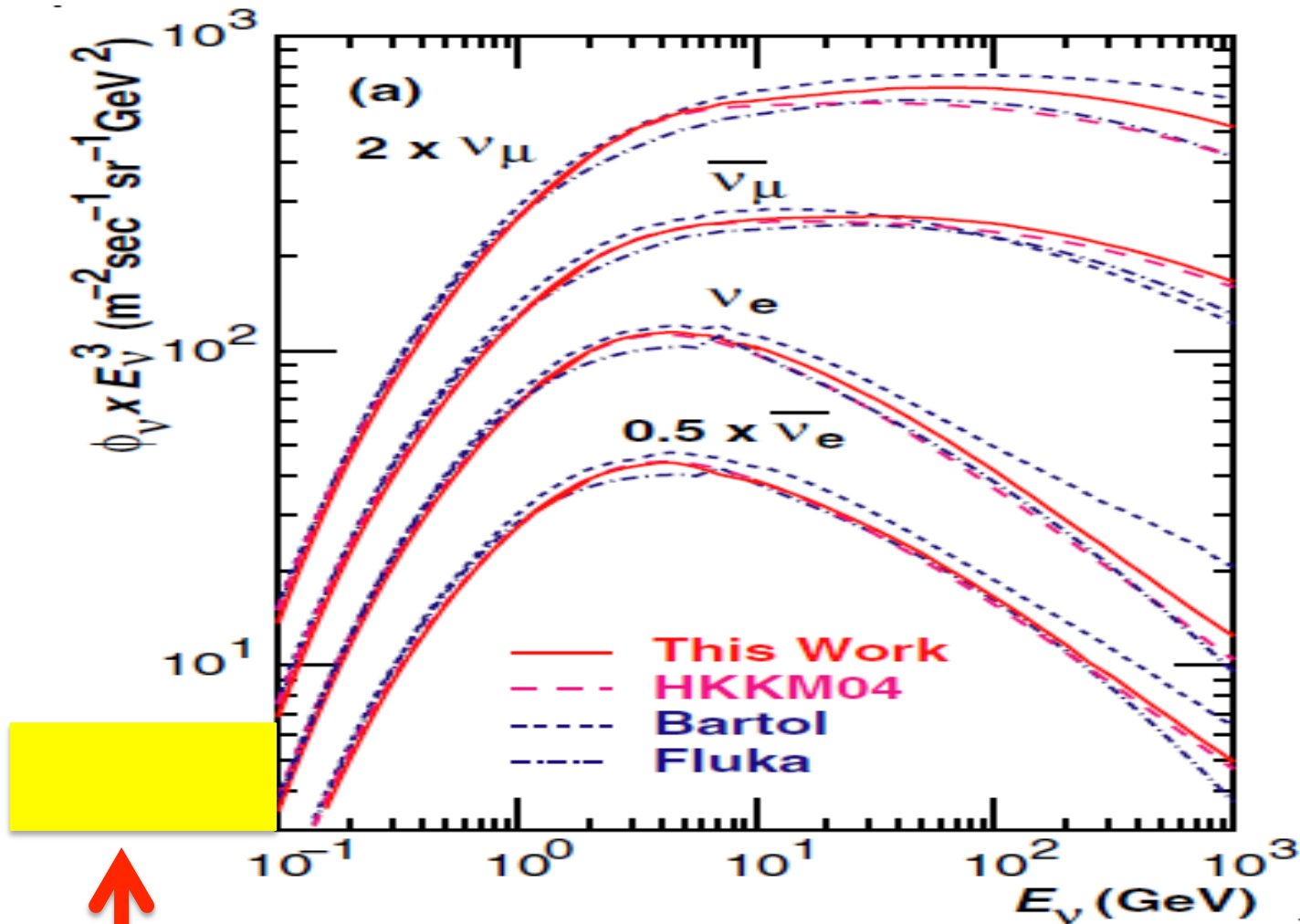
Expected Sensitivity at Jinping



Energy range **0~50MeV**

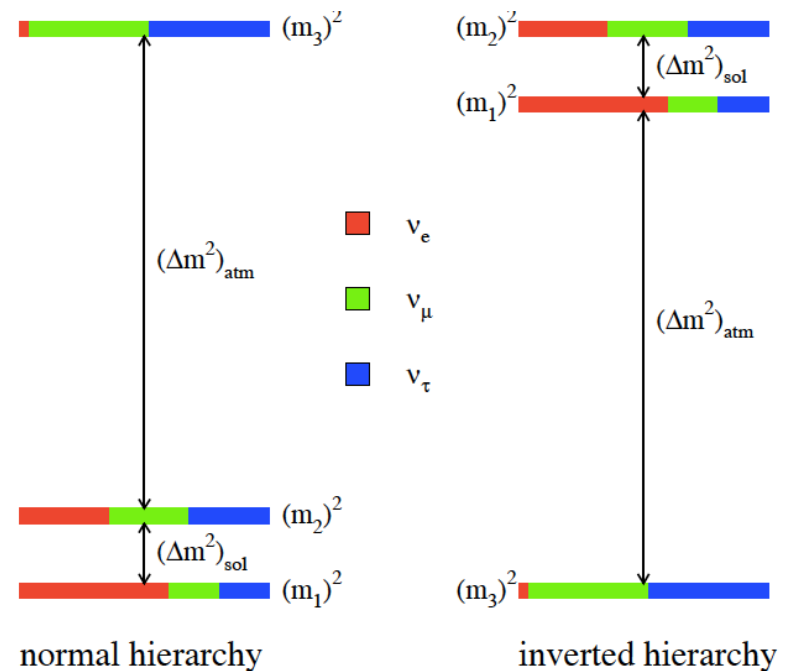
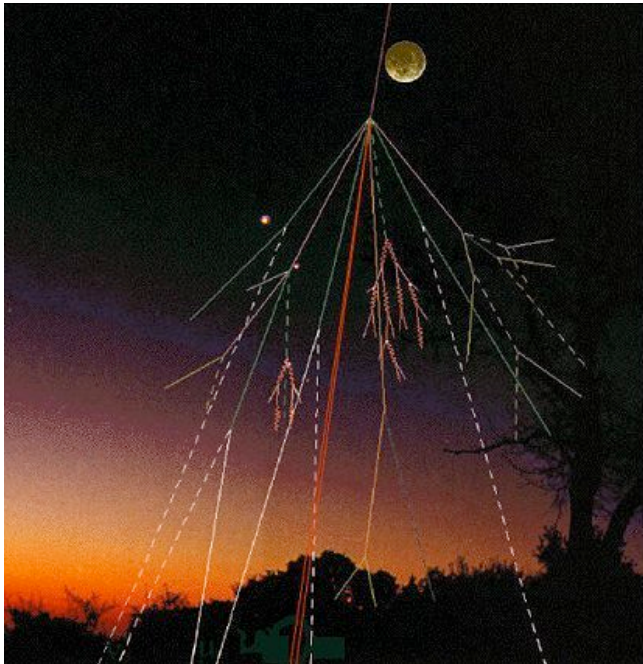
Energy range **10~50MeV**

A By-Product of SRN Searches

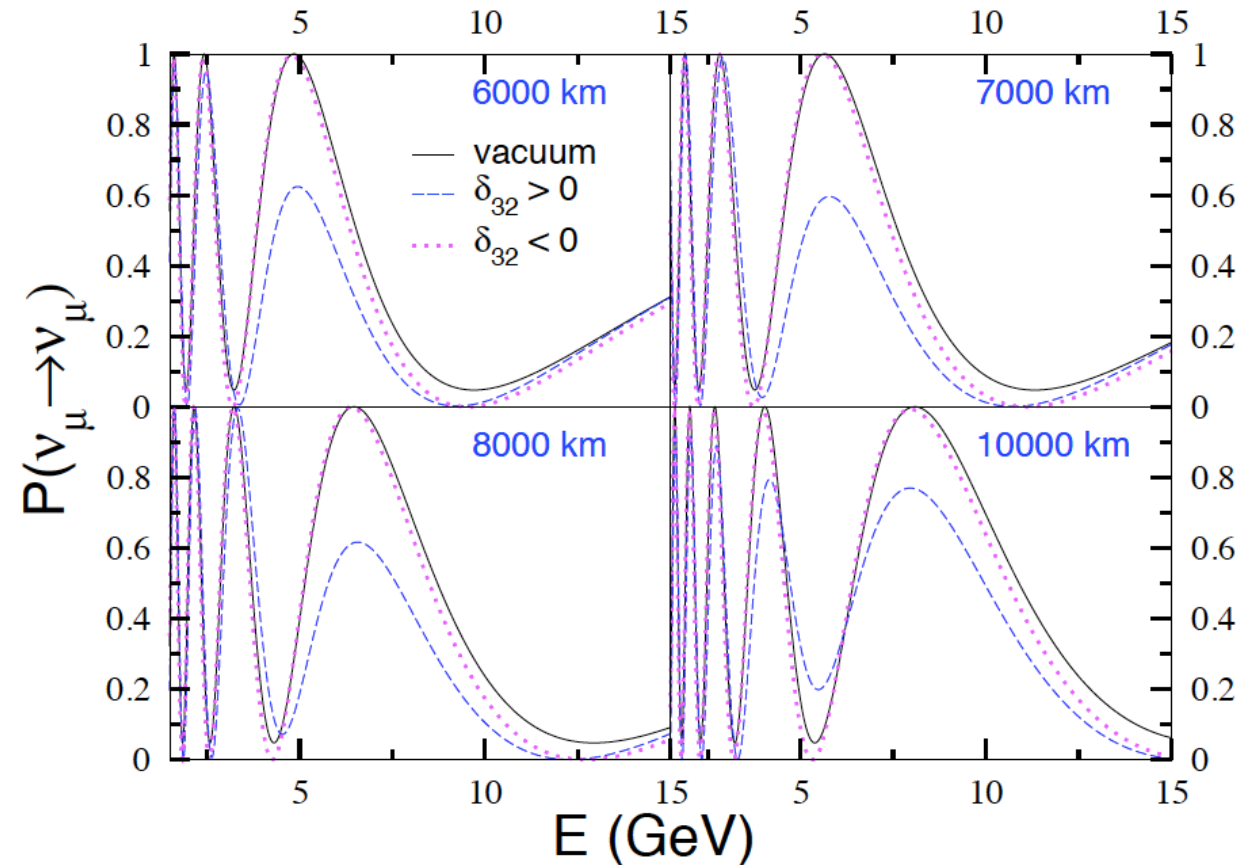


No measurement for $E < 100$ MeV

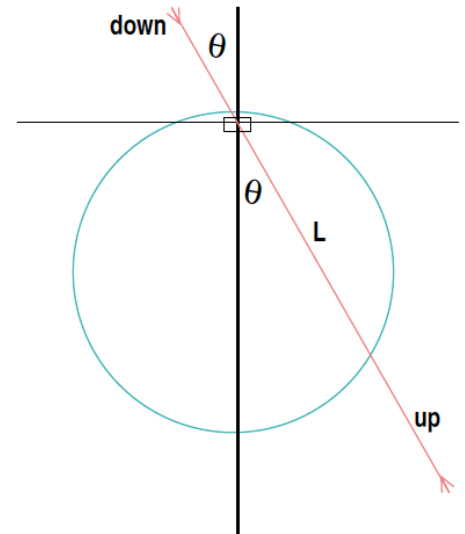
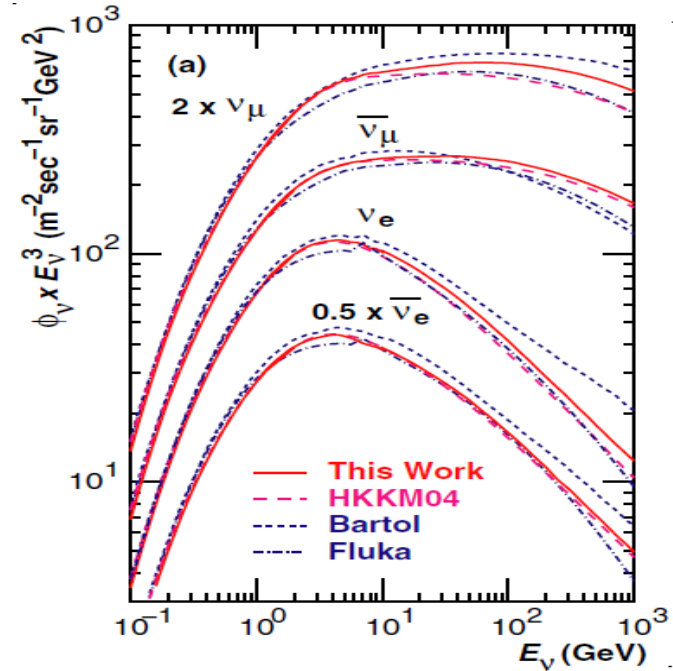
High energy neutrino physics



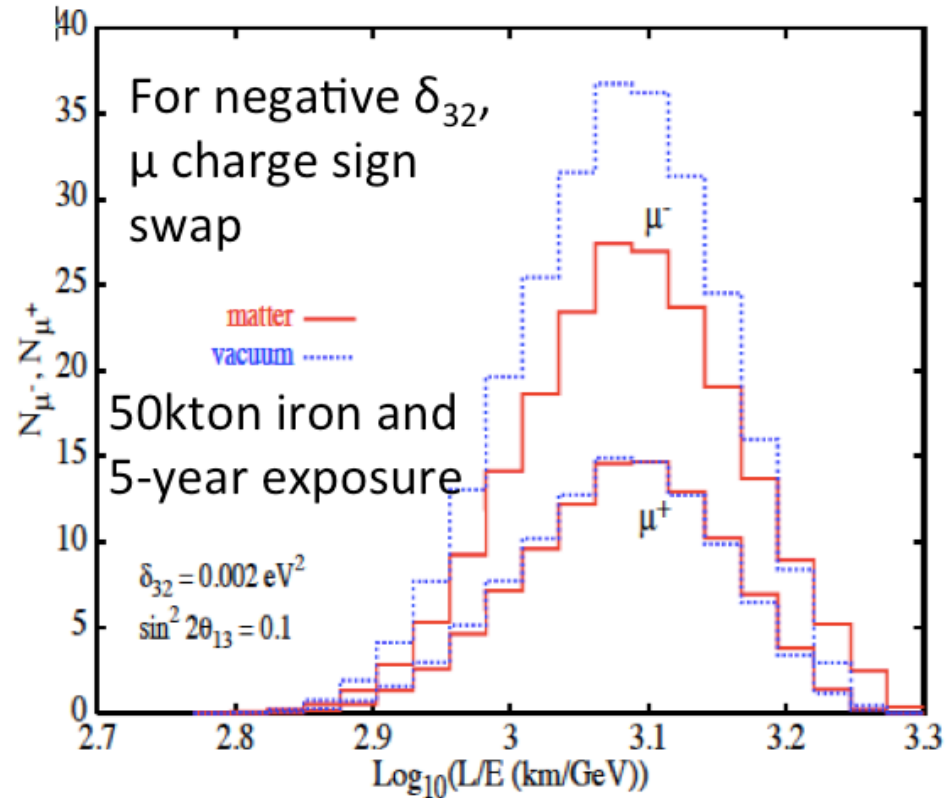
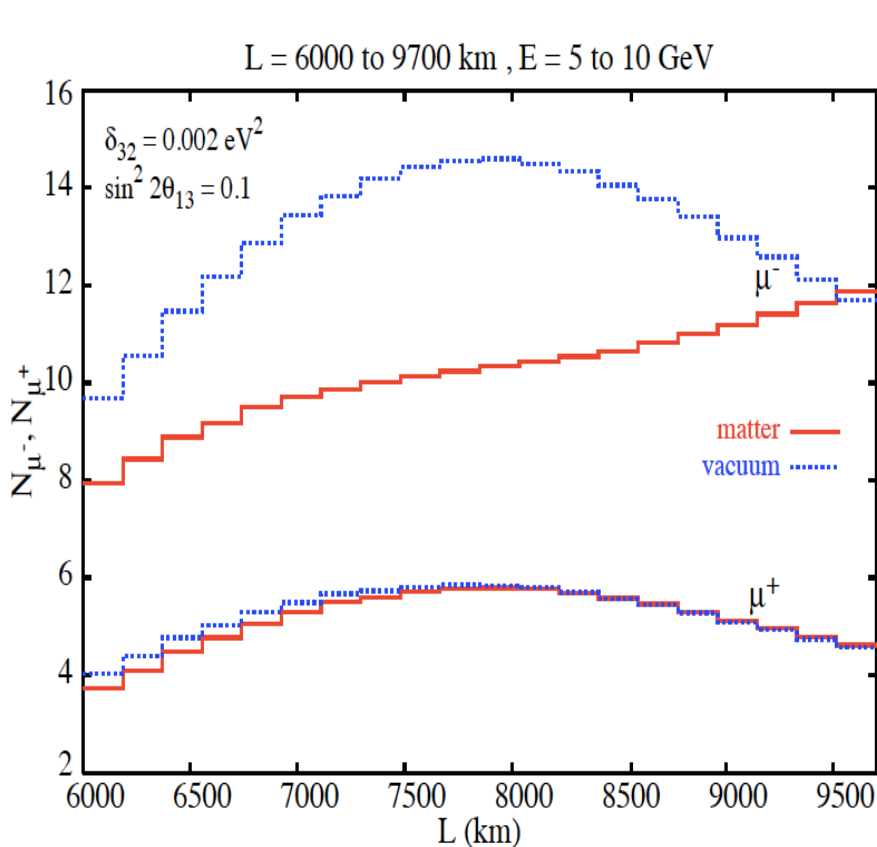
Sensitivity to MH



INO report



MH Study W/ Charge Information



W/ Directional Information

INO report

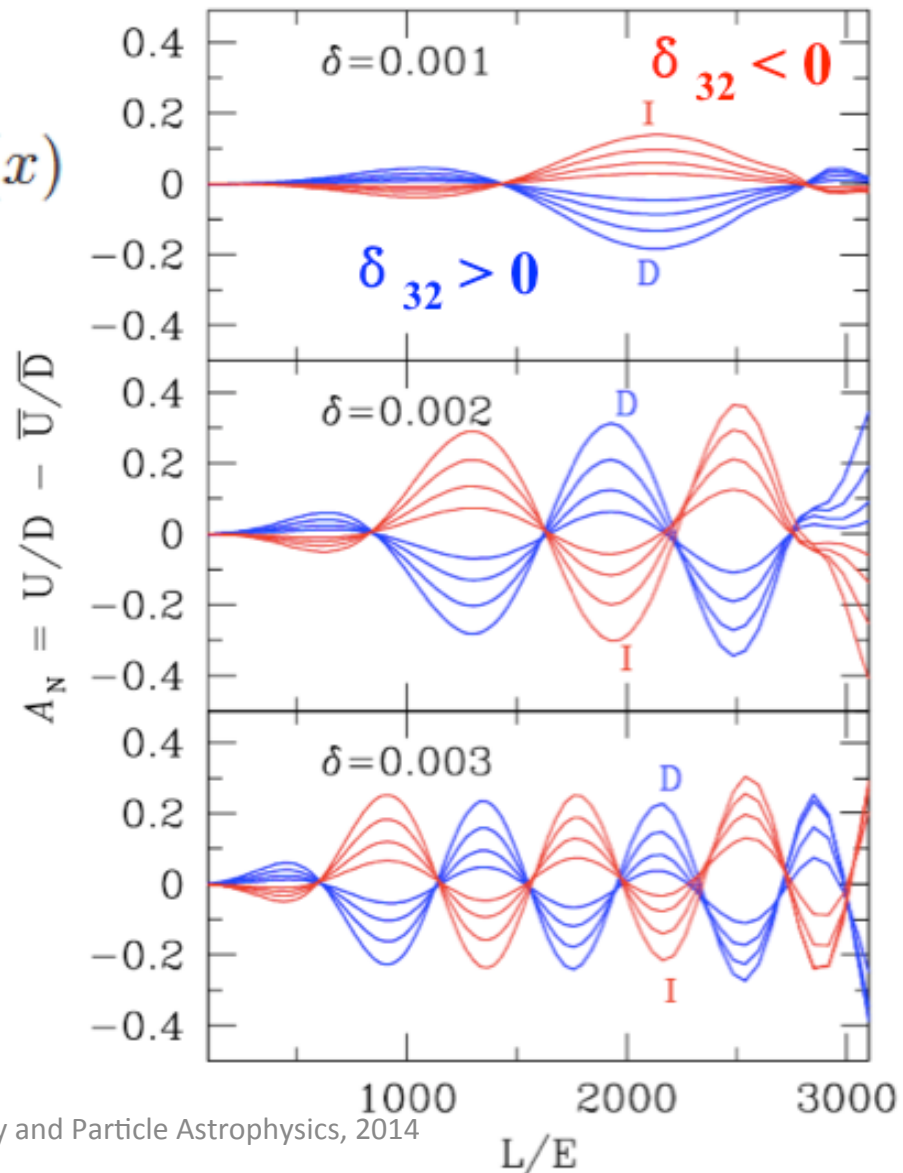
$$\mathcal{A}_N(x) = \frac{U}{D}(x) - \frac{\overline{U}}{\overline{D}}(x)$$

$$E > 4 \text{ GeV}.$$

$$\theta_{13} = 5^\circ, 7^\circ, 9^\circ, 11^\circ$$

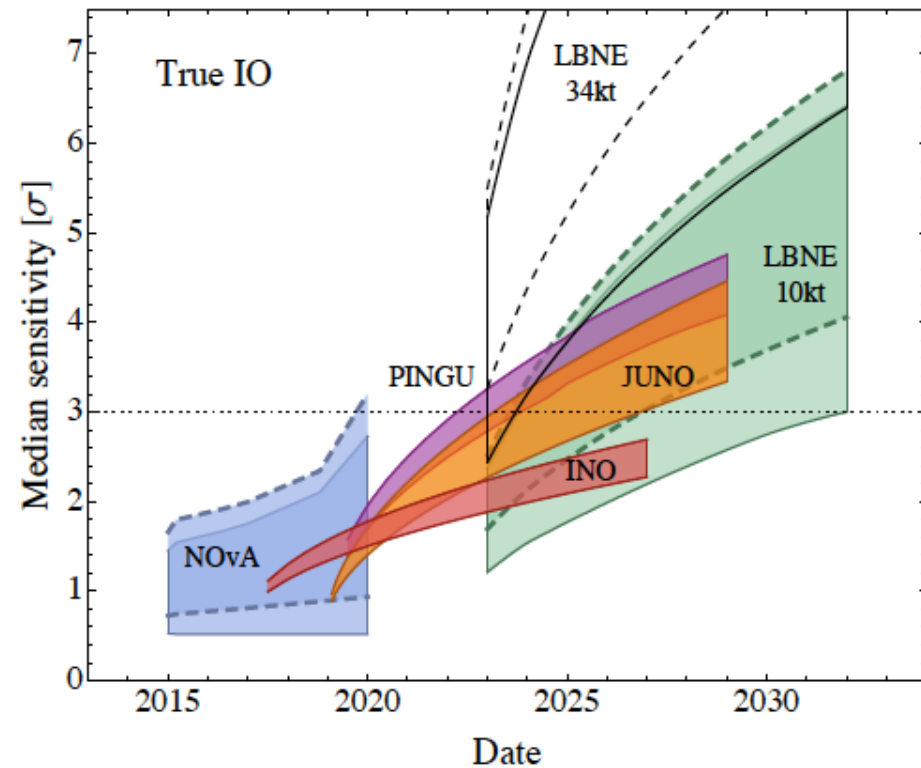
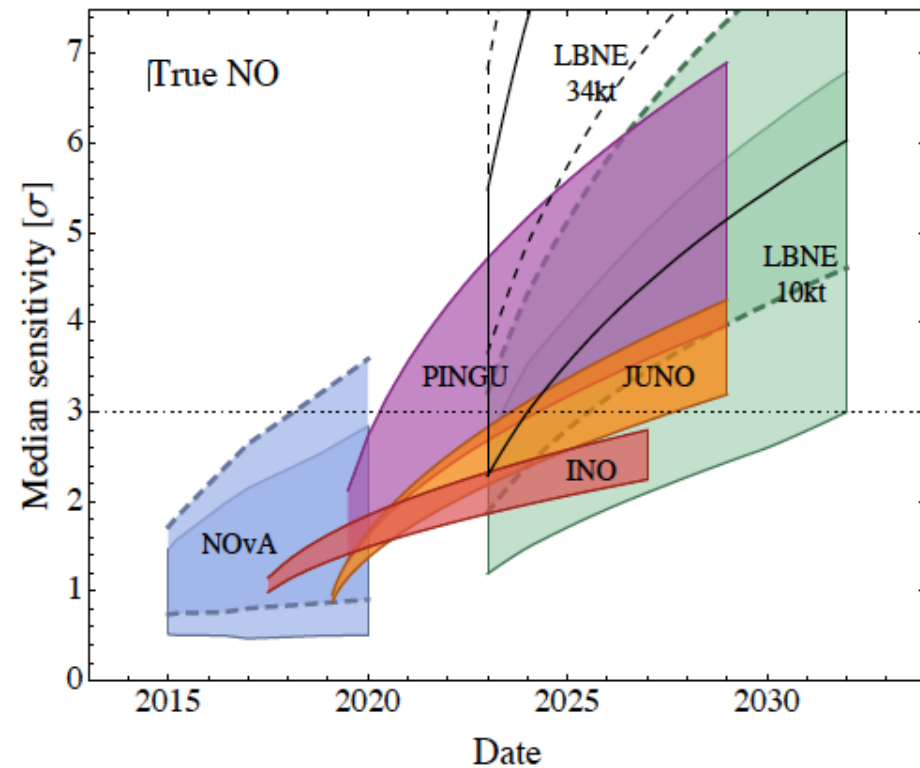
From inside out

With no resolution



Expected Sensitivity

arXiv:1311.1822



- **Jinping may have a similar sensitivity as INO**
- **Limited by low statistics and energy resolution**

Summary

- ✓ Jinping is the best underground lab in view of overburden, cosmic flux, reactor neutrino background, path length in earth, power and water supply...
- ✓ Best place for solar neutrino expt.
- ✓ Best place for supernova relic neutrino expt.
- ✓ Best place for crustal geo-neutrinos expt.
- ✓ A present available place to determine MH with less engineering challenges
- ✓ ...

Thanks for your attention!