Detection of Electron Anti-neutrino at Jinping

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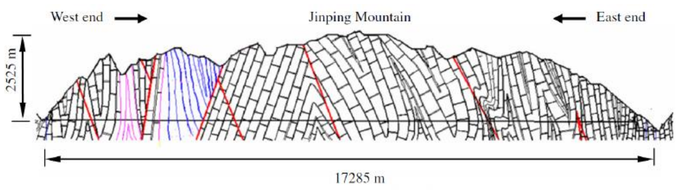
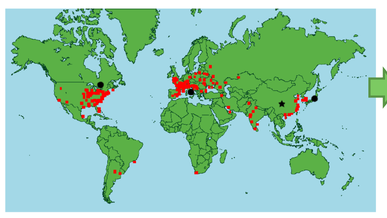
Location of Laboratory

Southwestern region of China (Sichuan Province)
Direct flight from Beijing to Xichang + 2 hour drive.

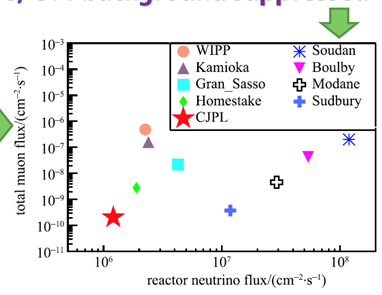
Advantages of Laboratory



2400 m overburden, C10, C11 background suppressed



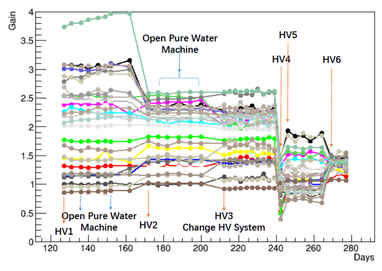
950 km to closest reactor



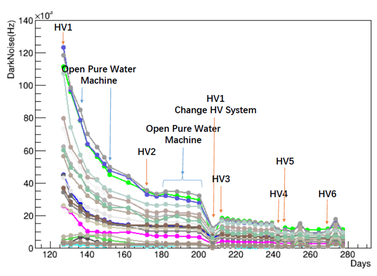
One-ton Prototype

Since May 10, 2017, Started with pure water. Now taking data with a type of liquid scintillator.

Gain Calibration and Dark Noise



PMT gains are set uniformly

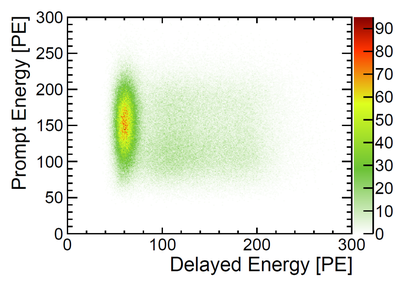


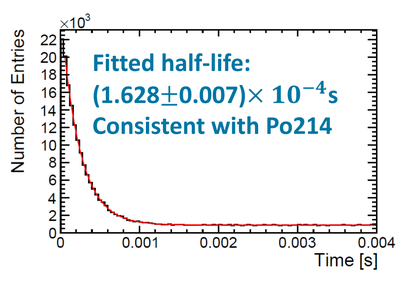
PMT dark noise has settled down to 5k-10k

Background and dark noise cooled down.

Bi214 Prompt-delayed Signal

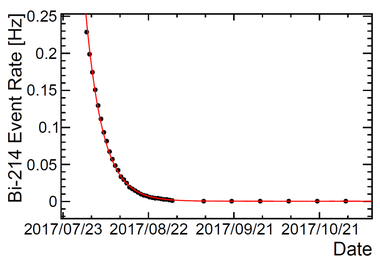
Po214, which is the daughter of Bi214 has a very short life. So the beta from Bi214 and alpha from Po214 can form a cascade signal.

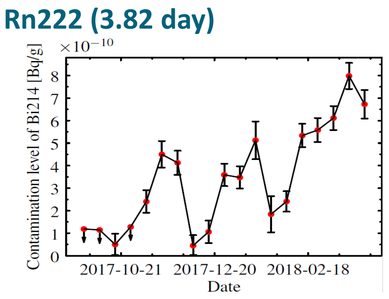




Rn222 Decay and Bi214 Event Rate

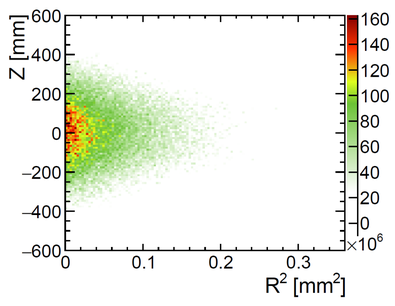
Initial Radon contamination shown in the following left figure:
Initially decay away with half-life (4.219±0.014) day, which is slightly longer than half-life of Rn222 (3.82 day)



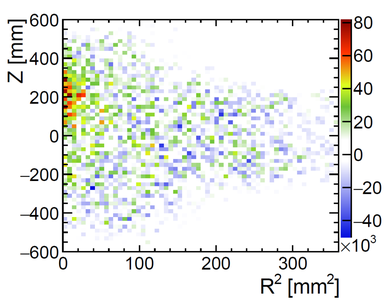


Air (Rn222) leaks in shown in the above right fig :
Later fluctuate at a low level out of statistical uncertainty.

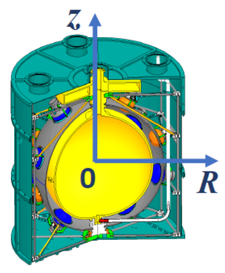
Rn Leakage



First month



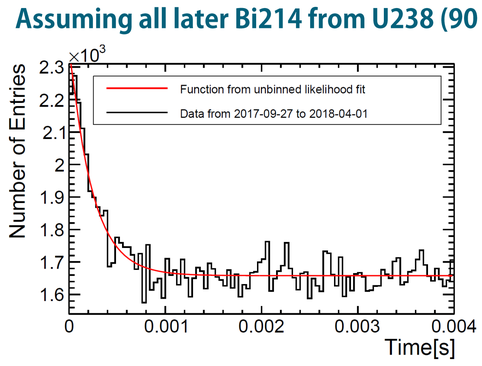
Later



The deviation of Bi214 vertex distribution in Z-axis from origin indicates that air leak from top filling and instrument pipes.

Low Background Detection

Assuming all later Bi214 from U238 (90 days after beginning):

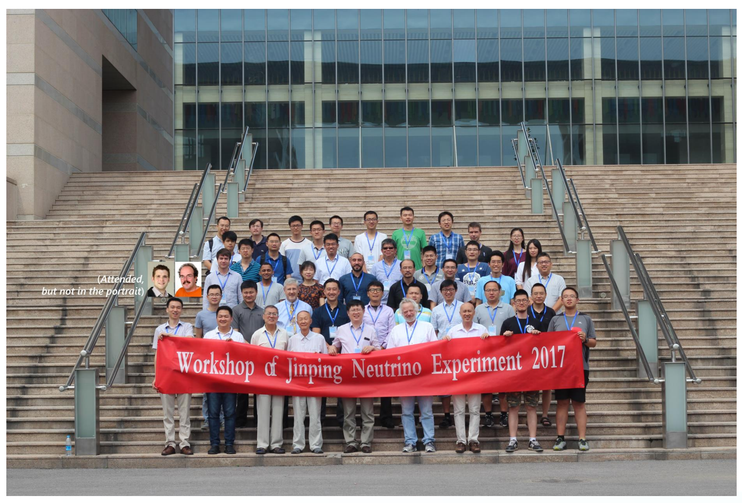


Considering the current background level, the U238 detection limit: reach 10^{-15} g/g.

Planning LS purification and equipment upgrade.

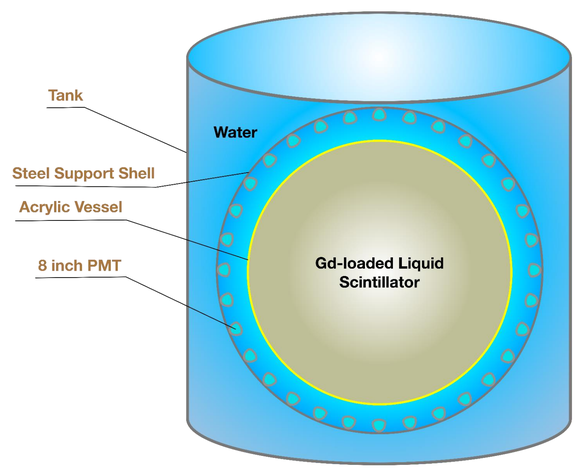
$$R_{U238} = (2.457 \pm 0.088) \times 10^{-9} \mathrm{Bq/g}$$
$$= (1.99 \pm 0.07) \times 10^{-13} \mathrm{g/g}$$

Welcome to Jinping!



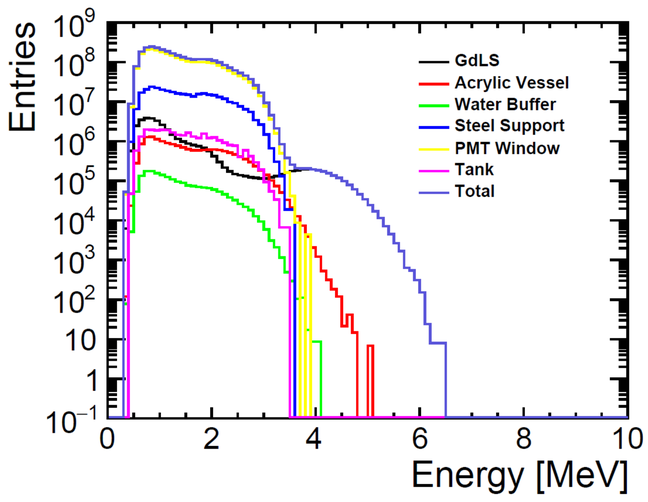
200 ton Detector Simulation Study

Conceptual Detector Design.



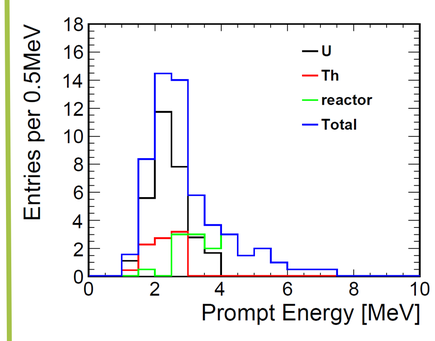
With the primary physics goals for geo-neutrino detection, the 200ton detector design follows the structure adopted by the recent underground neutrino experiments, and it will also consider the unique features of the low environmental backgrounds and the tunnel structure.

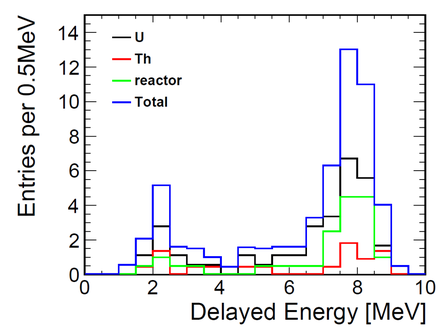
Total Spectrum by Monte Carlo. [Exposure=200ton×5yr]



Expected Spectrum of geo-neutrino and reactor neutrino.

Approximately 30 geo-neutrino events will be observed by n-Gd capture in 5years. [1]





Geo-neutrino and Background

Due to the 8 MeV gammas from n-Gd capture, the accidental coincidences for geo-neutrino detection is negligible. However, the (alpha, n) bkg will be dominant compared with pure LS detector. Assuming gadolinium compound with 0.04 mBq(U)/kg and 0.06 mBq (Th)/kg [2] and ~1m water shield, the number of (alpha, n) and fast neutron events in 5yr are listed in the following table.

If the contamination level of gadolinium compound can be reduced to 10^{-3} mBq (U/Th)/kg, the (alpha, n) events will also be negligible.

Preliminary estimation of backgrounds and geo-neutrino signal

Source	Background [events/(200ton·5yr)]
Accidental coincidences	0.4
(α, n) in GdLS	4.1
Fast neutrons(muons in rock)	~ 2.0
Reactor neutrino	7.9
Geo-neutrino(U238)	22.5
Geo-neutrino(Th232)	6.3

References

1. Phys. Rev. D 95 (2017), 053001
2. Prog. Theor. Exp. Phys. 2017, 113H01