Field Observations at the Daya Bay Reactor-Neutrino Experiment Site

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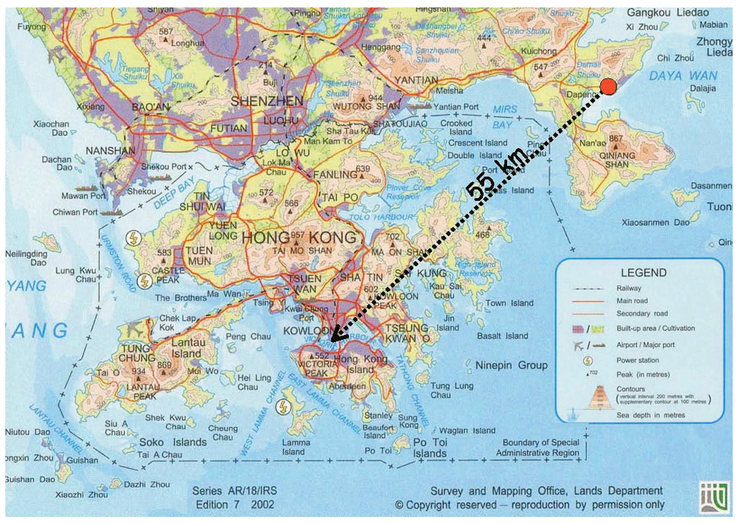
for The Daya Bay Collaboration

Current Status:

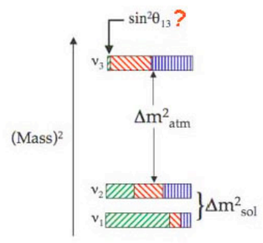
- Proposed to determine the least-known neutrino mixing angle θ_{13} using electron antineutrinos produced at the Daya Bay nuclear power complex in China.
- An international collaboration with institutions from China, the United States, the Czech Republic, Hong Kong, Russia, and Taiwan.
- Design: 8 identical 20-t detectors deployed at 3 different locations optimized for monitoring the antineutrino rates from the six reactors.

- The overburden of the underground experimental halls, ranges from 98 to 350 meters (~250 to 900 mwe), cosmogenic background < number of observed antineutrino events.
- Civil construction of tunnels and experimental facilities started in 2007.
- Field observations: site survey, exploratory drilling, ground breaking, portals.
- Cores: fractured, relatively intact conditions of the granite below the weathered zones. Portals: fair to good conditions, ready for continuing excavations.



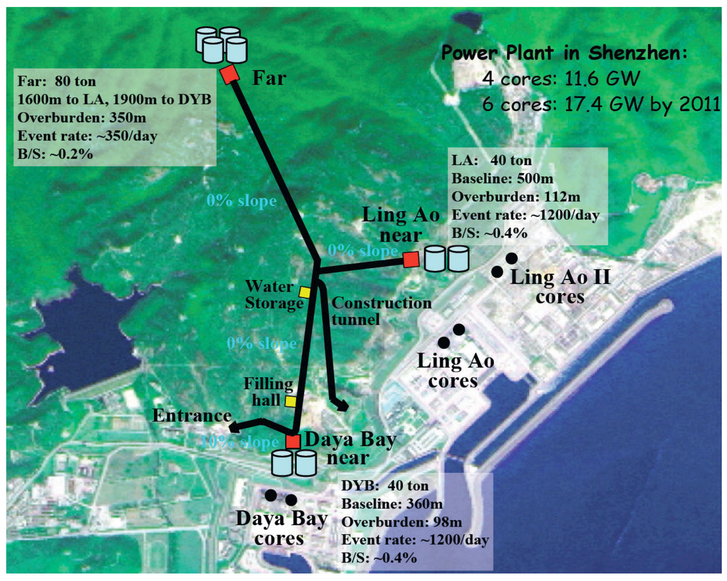
Importance of θ_{13}

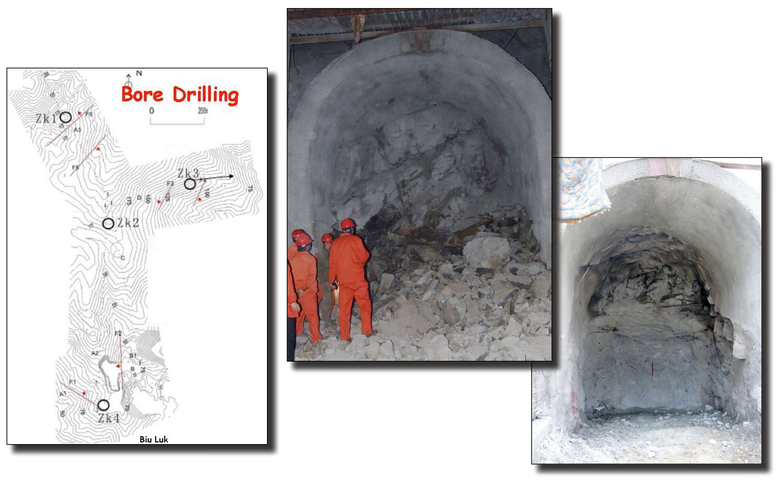
- It is one of the key parameters in determining the leptonic mixing matrix.
- What is ν_e fraction of ν_3?



- U_{e3} is the gateway to CP violation in neutrino sector:

$$P(\nu_\mu \to \nu_e) - P(\bar{\nu}_\mu \to \bar{\nu}_e) \propto \sin 2\theta_{12} \sin 2\theta_{23} \cos^2\theta_{13} \sin\theta_{13} \sin\delta$$

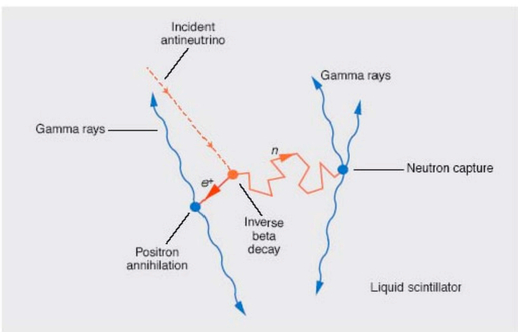




Detecting Low-energy Antineutrinos

Utilize the inverse beta decay reaction:

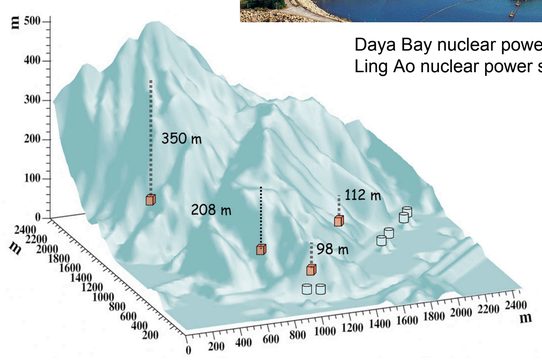
$$\bar{\nu}_e + p \to e^+ + n$$



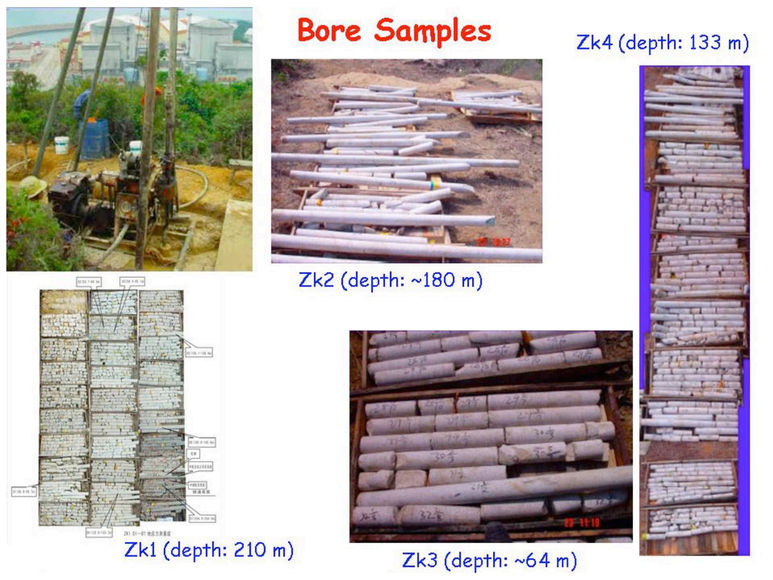
The energy of the antineutrino is related to the kinetic energy of the positron:

$$E_{\bar{\nu}} = T_{e+} + 1.8\ \text{MeV}$$

Daya Bay nuclear power station in foreground, Ling Ao nuclear power station in background

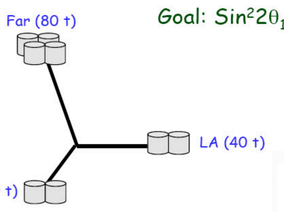


Bore Samples

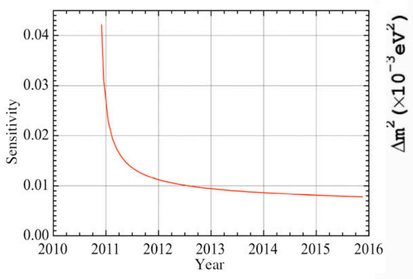


Sensitivity of Daya Bay

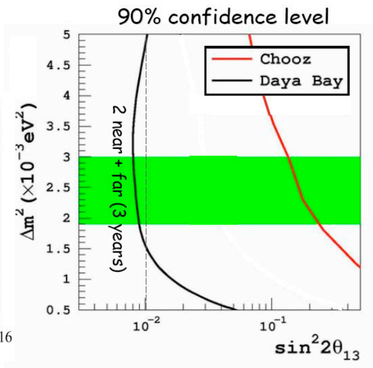
Goal: $\sin^2 2\theta_{13} < 0.01$



- Use rate and spectral shape
- input relative detector syst. error of 0.38%/detector



90% confidence level



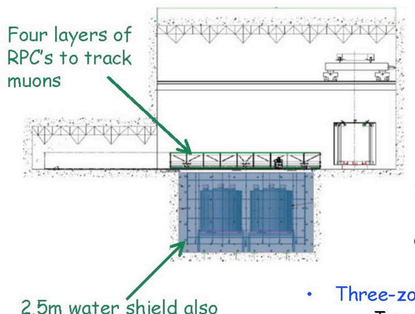
Findings of Geotechnical Survey

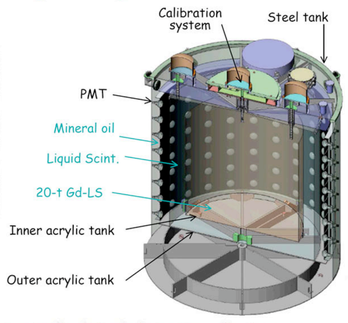
- No active or large faults
- Rock structure: massive and blocky granite
- Rock: most is slightly weathered or fresh
- Groundwater: low flow at the depth of the tunnel
- Quality of rock mass: stable and hard

U.S. experts in geology and tunnel construction assist geotechnical survey:

Excellent conditions for tunnel construction

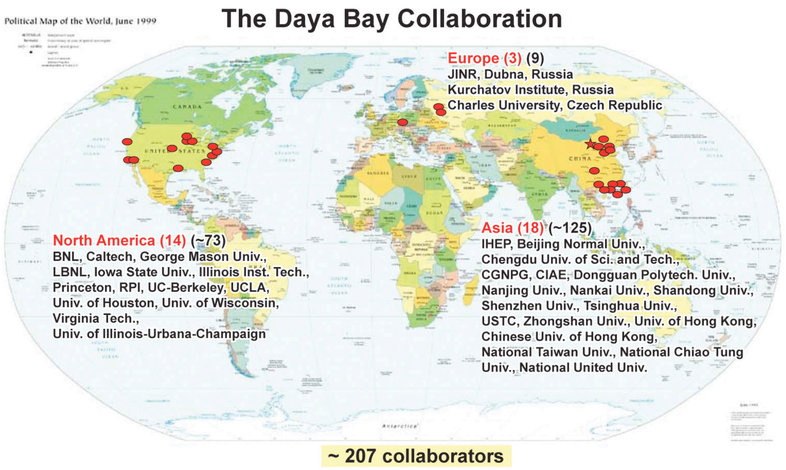
Detector Of Daya Bay





- Three-zone cylindrical detector design
  - Target: 20 t (0.1% Gd-doped LAB LS), 3.1 m
  - Gamma catcher: 20 t (LAB LS), 0.42 m
  - Buffer : 40 T (mineral oil) , 0.48 m
- Low-background 8" PMT: 192
- Reflectors at top and bottom of outer acrylic
- Photocathode coverage:
  5.6 % → 12% (with reflectors)

The Daya Bay Collaboration



~ 207 collaborators

Outlooks:

- The detector construction begins in 2008. The experiment will begin collecting data in 2010.
- By comparing the detected signals at the three locations, with three years of data, a sensitivity in $\sin^2(2\theta_{13})$ of better than 0.01 is expected.
- Tunnels: below localized weathered zones, with a few mapped faults below surface depressions and a stream bed with potential groundwater inflows.
- Considered in the tunnel design and excavation contingency.