Neutrino Experiments Using Daya Bay Nuclear Power Plants

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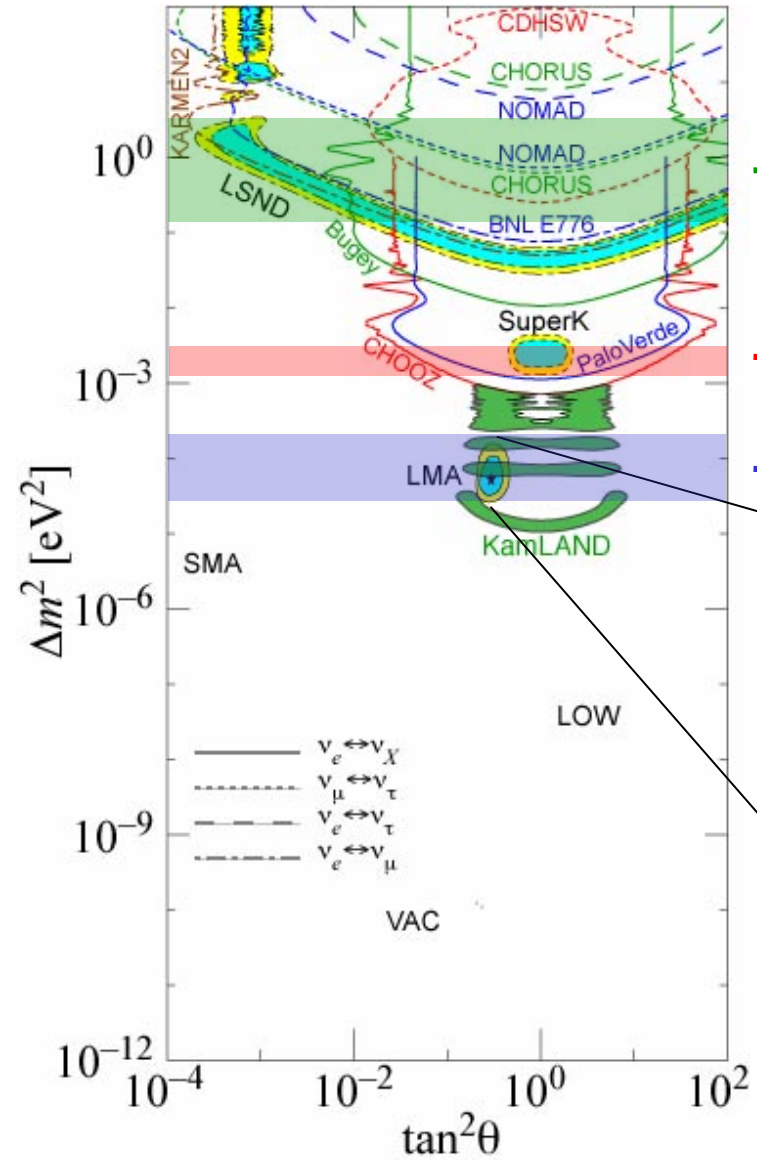
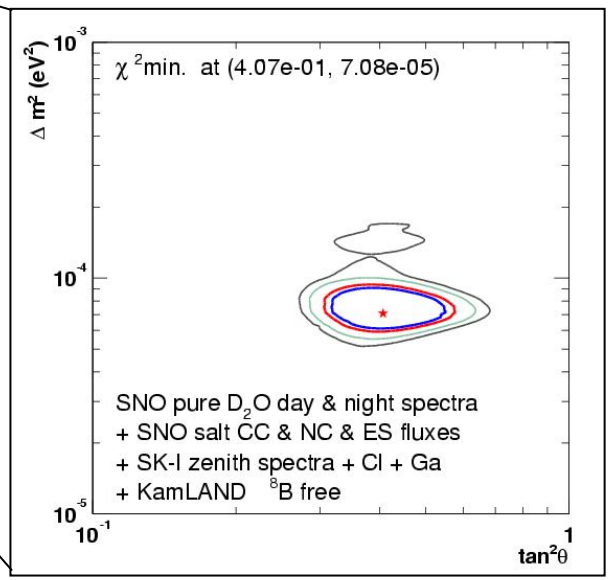
What Can Be Determined With Reactor $\bar{\nu}_e$?



- Does $\nu_e \rightarrow \nu_{sterile}$ exist?
- Value of θ_{13}
- Value of $\Delta m^2_{31} \approx \Delta m^2_{32}$
- Value of Δm^2_{21}
- Oscillation pattern



Mixing Angle θ_{13}

Motivations

- It is one of the key parameters in determining the mixing matrix in the lepton sector.
- In the lepton sector, amount of CP violation is given by

$$J_{lepton} \sim \cos^2(\theta_{13})\sin(2\theta_{12})\sin(2\theta_{23})\sin(2\theta_{13})\sin\delta$$

If $\theta_{13} \neq 0$, neutrino mixing will have profound implications to astrophysics and cosmology, e.g. lepto-genesis could account for matter-anti-matter asymmetry of the Universe.

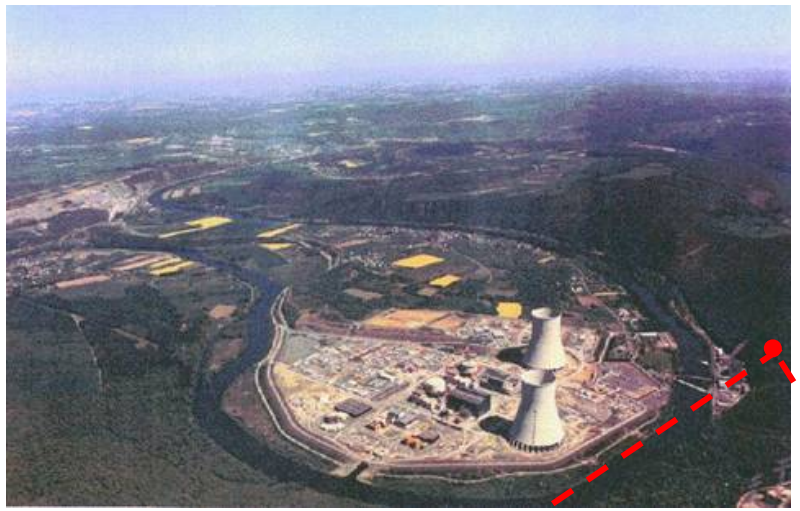
- In KamLAND, what is measured is actually

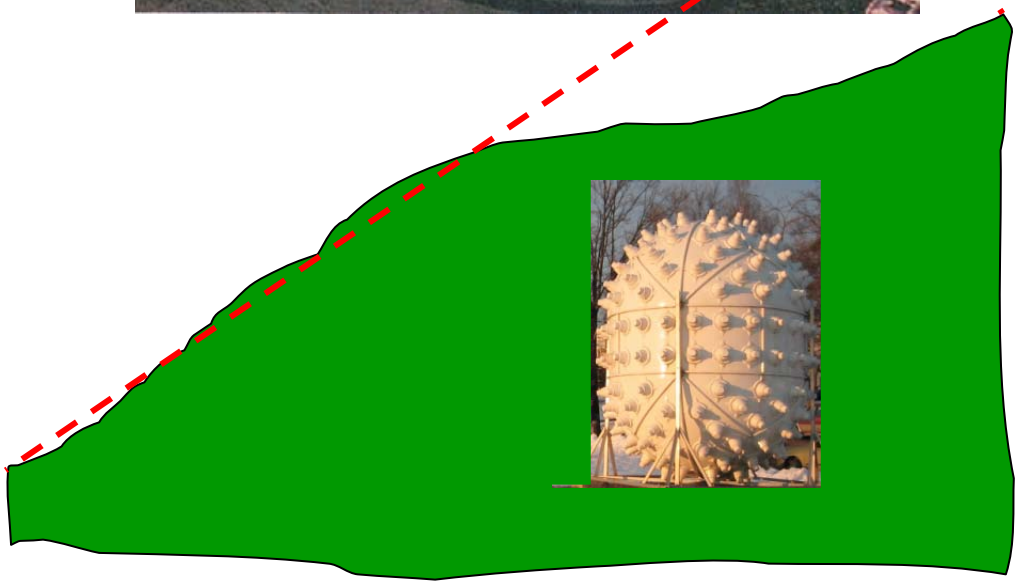
$$P(\bar{\nu}_e \to \bar{\nu}_e) \approx \cos^4\theta_{13}\left[1 - \sin^2 2\theta_{12}\sin^2\left(\frac{\Delta m^2_{21} L}{4E}\right)\right]$$

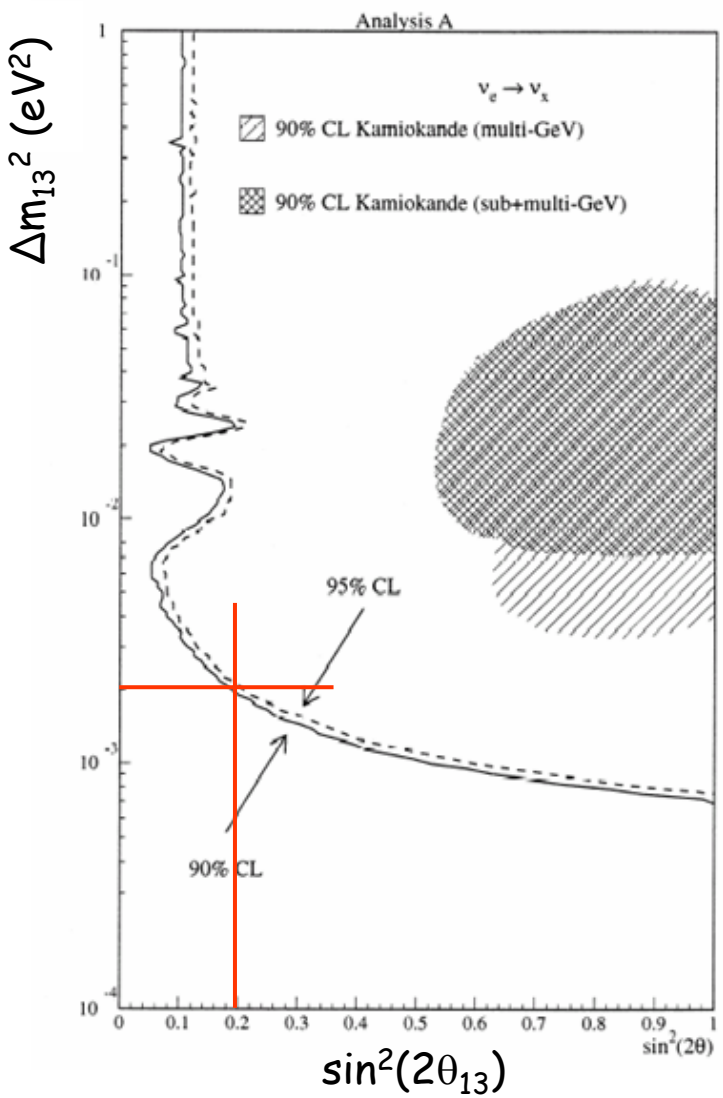
Knowing θ_{13} would help in measuring θ_{12}.

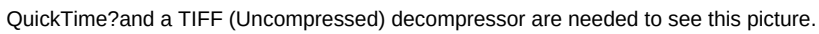
Current Knowledge of θ_{13}

- Reactor anti-neutrinos ($\nu_e \rightarrow \nu_x$) at 1 km: CHOOZ (France)





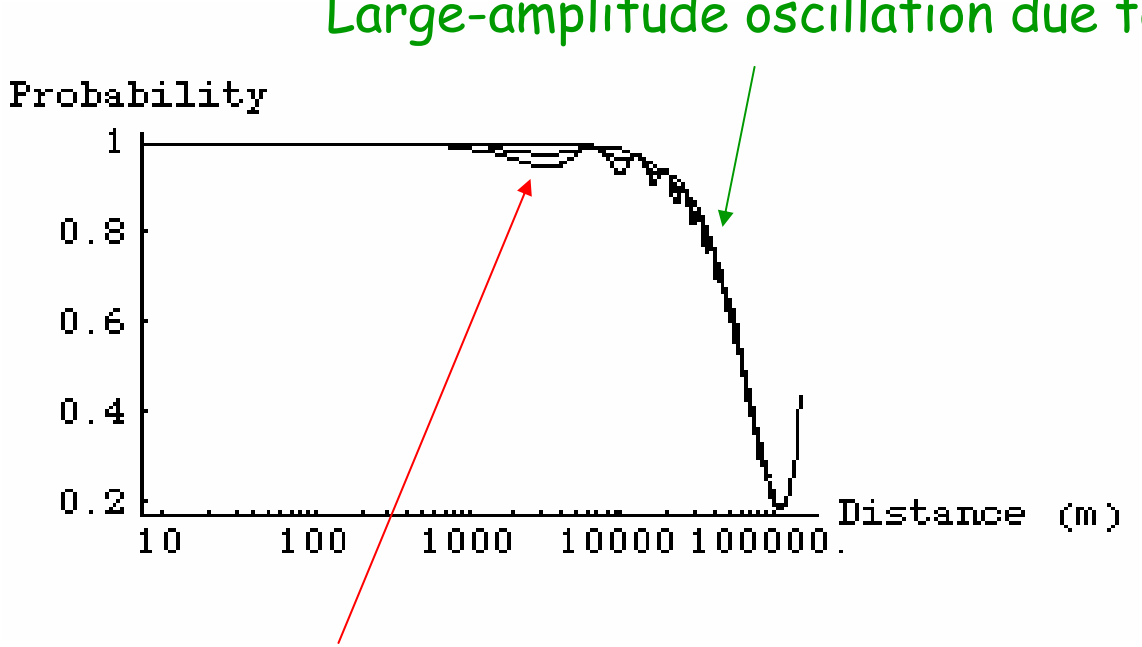



QuickTime?and a TIFF (Uncompressed) decompressor are needed to see this picture.

Subdominant Oscillation Due to θ_{13}

$$P(\bar{\nu}_e \to \bar{\nu}_e) \approx \cos^4\theta_{13}\left[1 - \sin^2 2\theta_{12}\sin^2\left(\frac{\Delta m^2_{21} L}{4E}\right)\right]$$

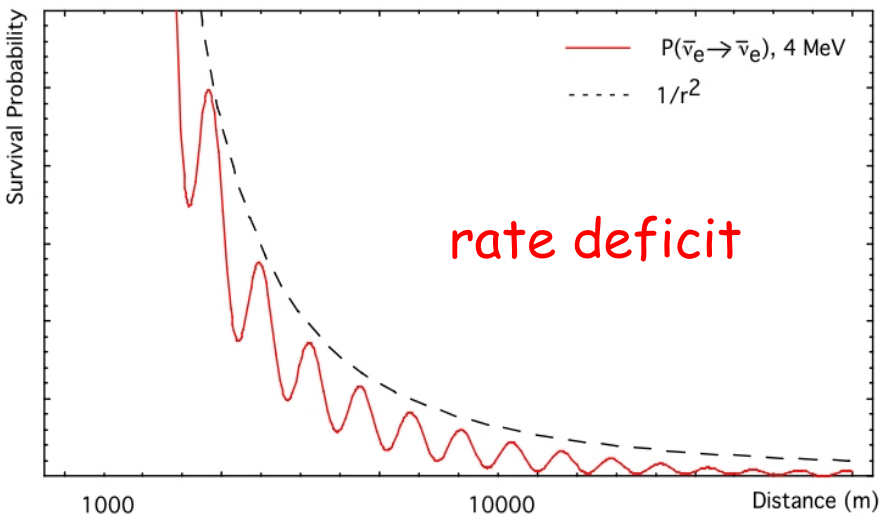
Large-amplitude oscillation due to θ_{12}

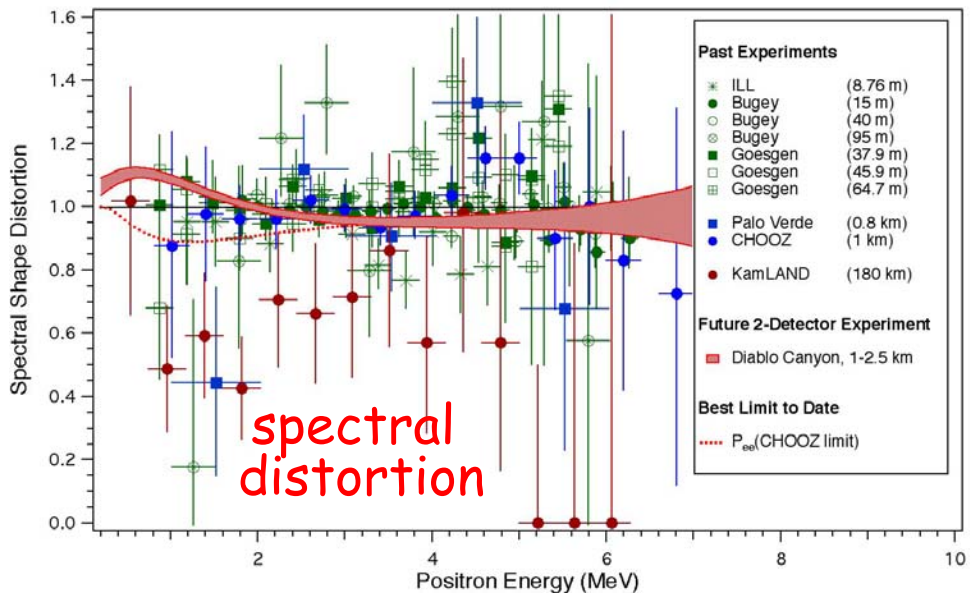


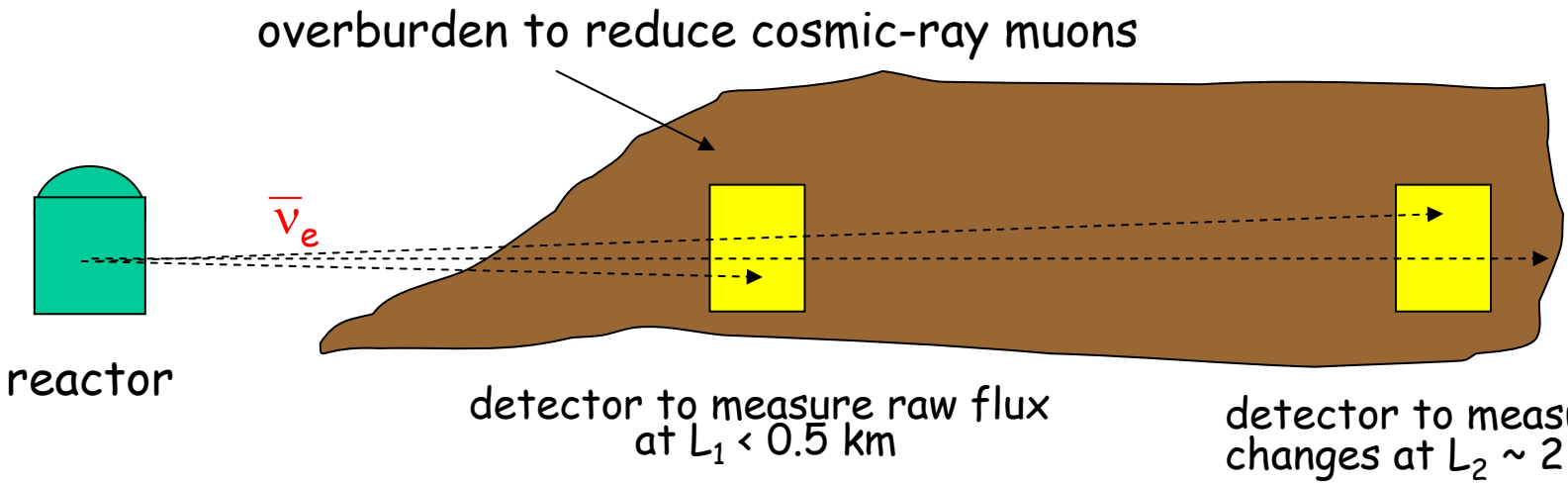
small-amplitude oscillation due to θ_{13}

$$P(\bar{\nu}_e \to \bar{\nu}_e) \approx 1 - \sin^2 2\theta_{13}\sin^2\left(\frac{\Delta m^2_{31} L}{4E}\right) - \cos^4\theta_{13}\sin^2 2\theta_{12}\sin^2\left(\frac{\Delta m^2_{21} L}{4E}\right)$$

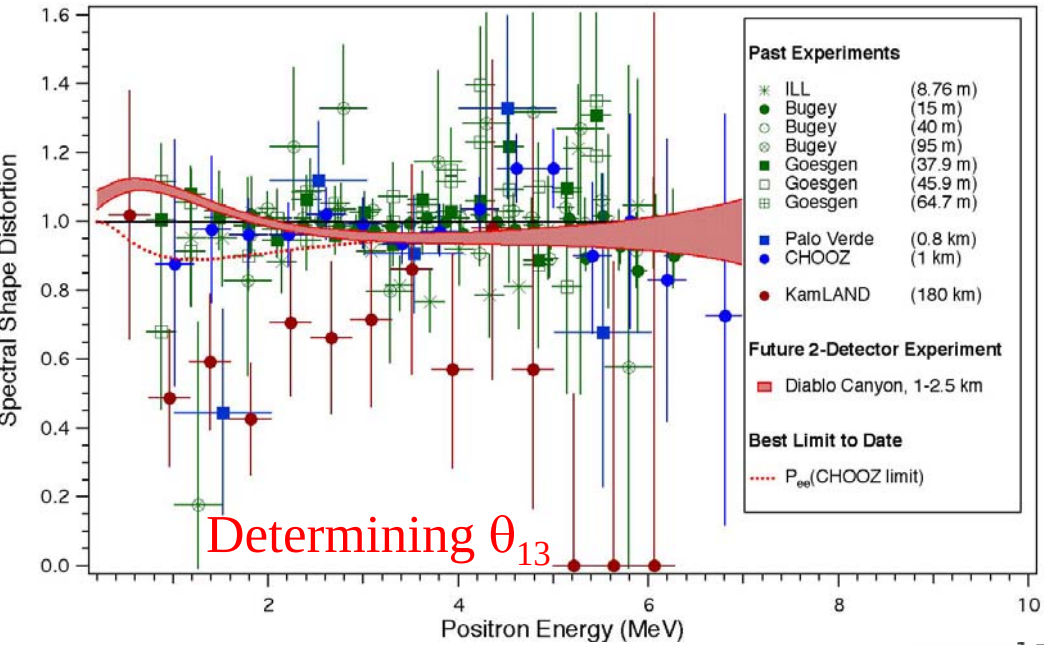
How To Measure θ_{13} With a Reactor?





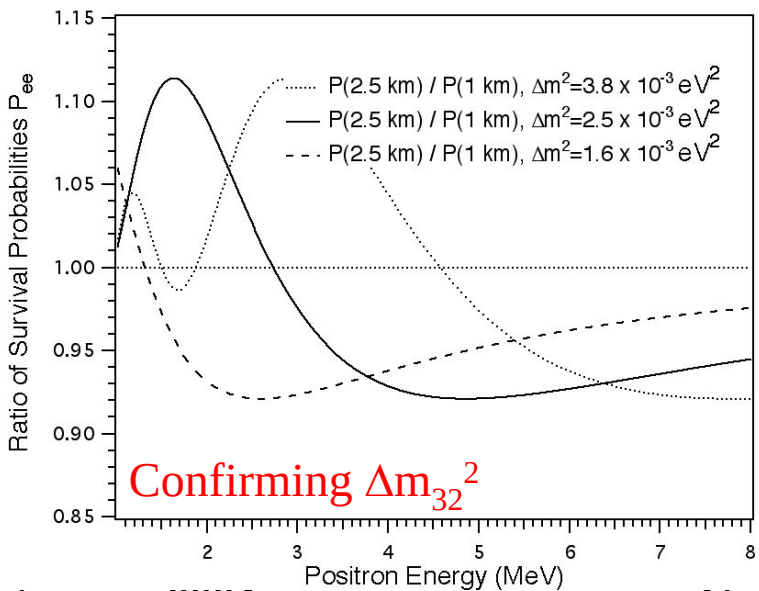


Physics Goals

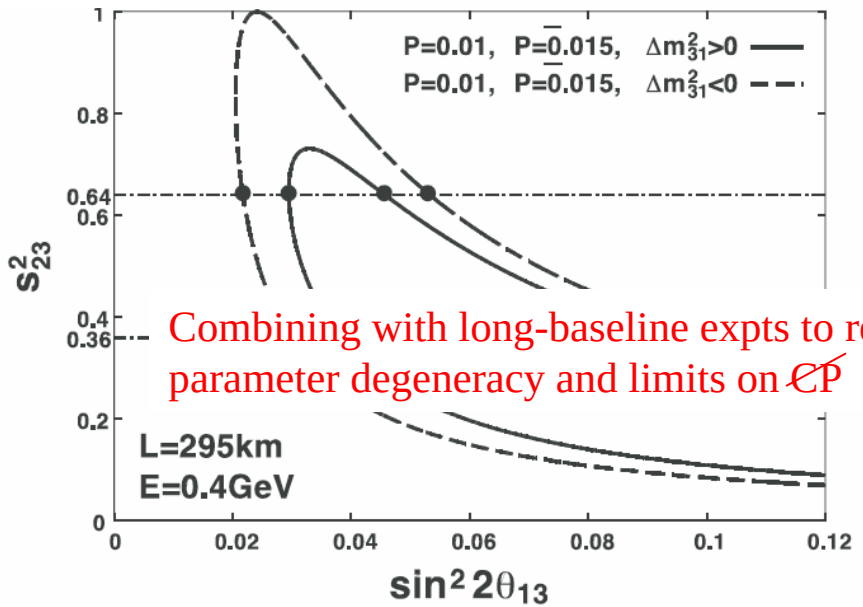


Determining θ_{13}

Search for the effect of sterile ν.



Confirming Δm_{32}^2



Combining with long-baseline expts to resolve parameter degeneracy and limits on ~~CP~~

Nuclear Reactors In The World

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Nuclear Reactors In China

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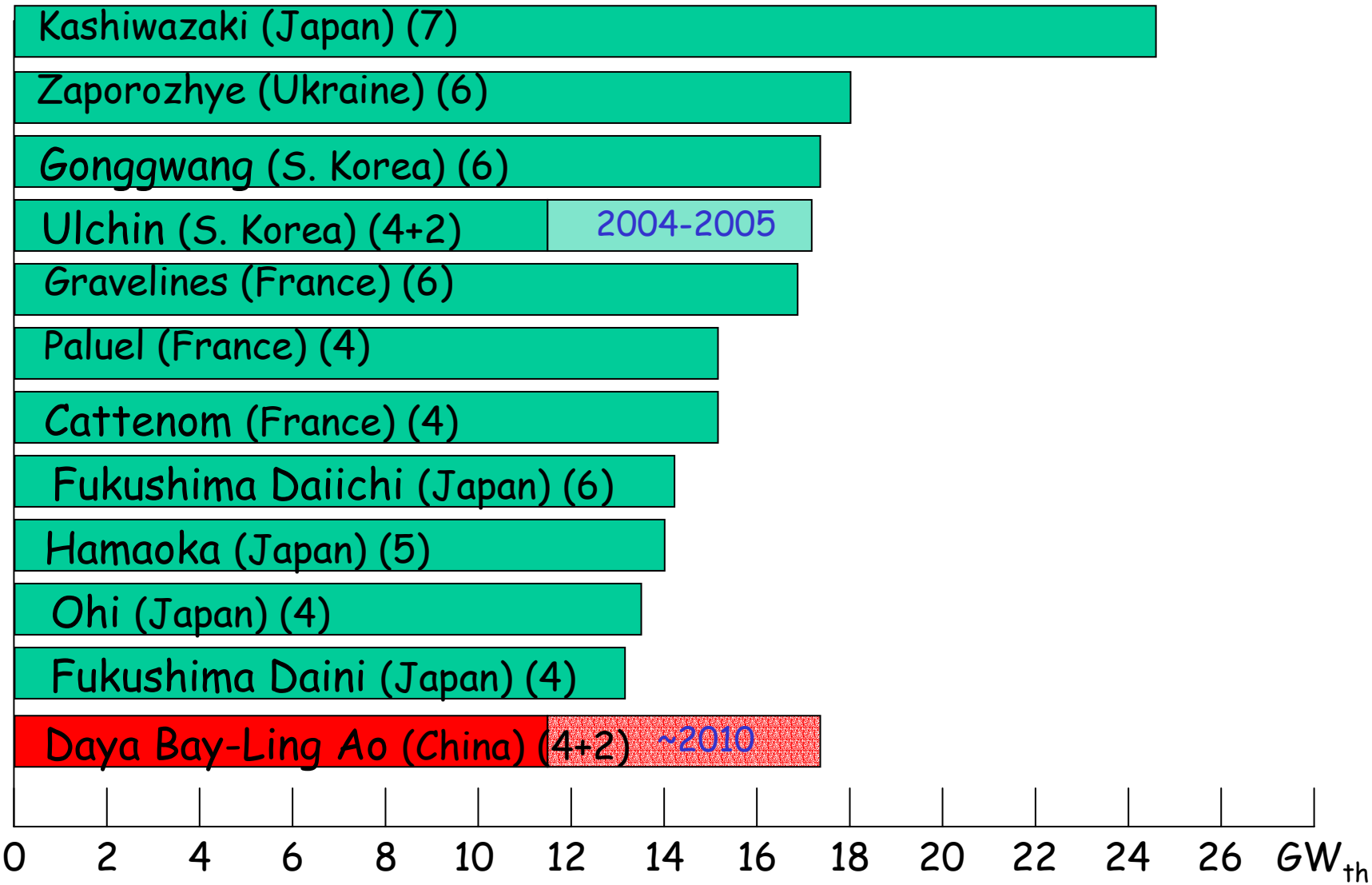
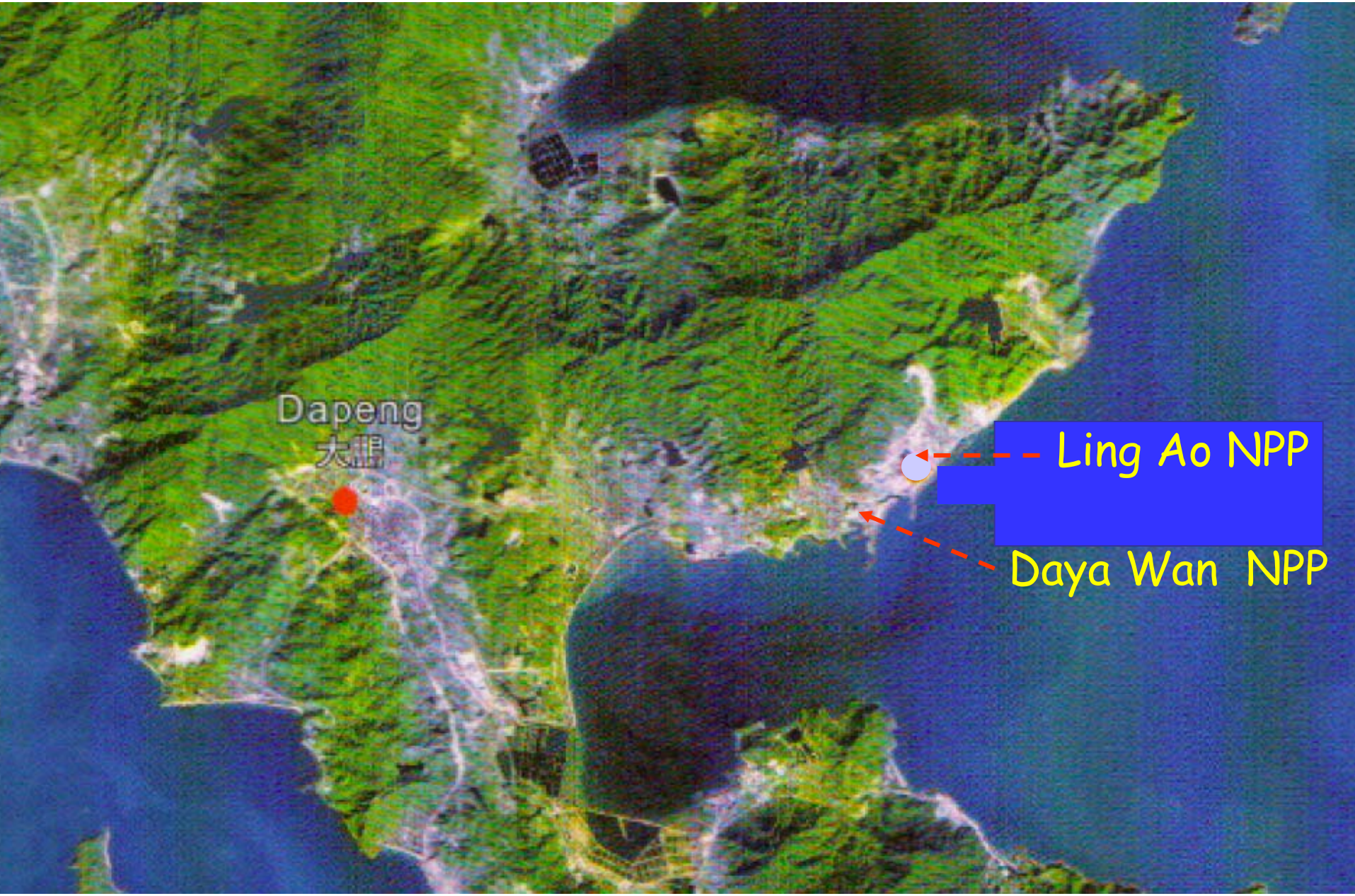
Ranking of Reactors




Dapeng
大鵬
Ling Ao NPP
Daya Wan NPP

Daya Bay And Ling Ao Nuclear Power Plants

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Daya Bay Nuclear Power Plant

$P_{total} = 5.8\ GW_{th}$

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Ling Ao Nuclear Power Plant

$P_{total} = 5.8\ GW_{th}$

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TIFF (Uncompressed) decompressor
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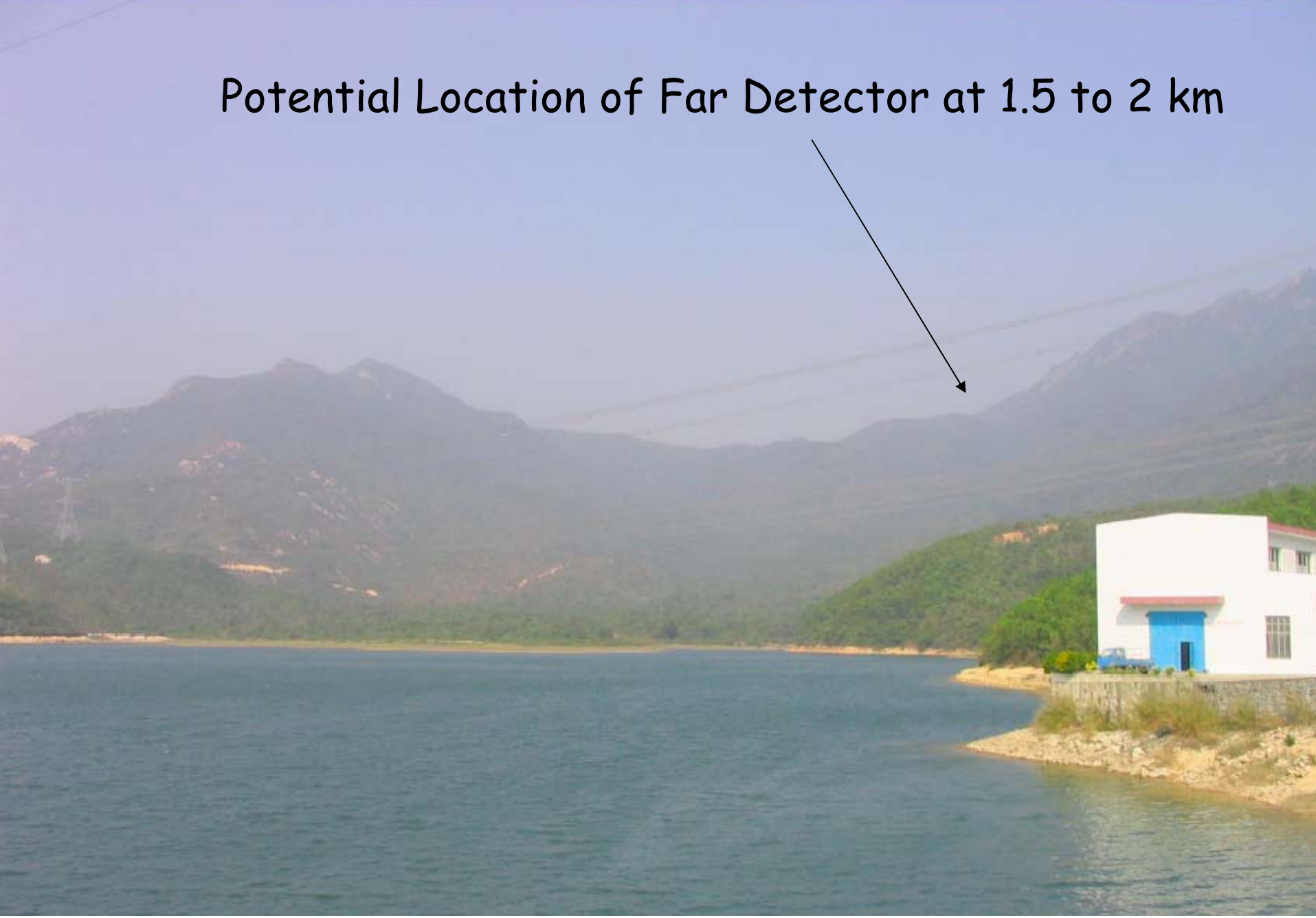
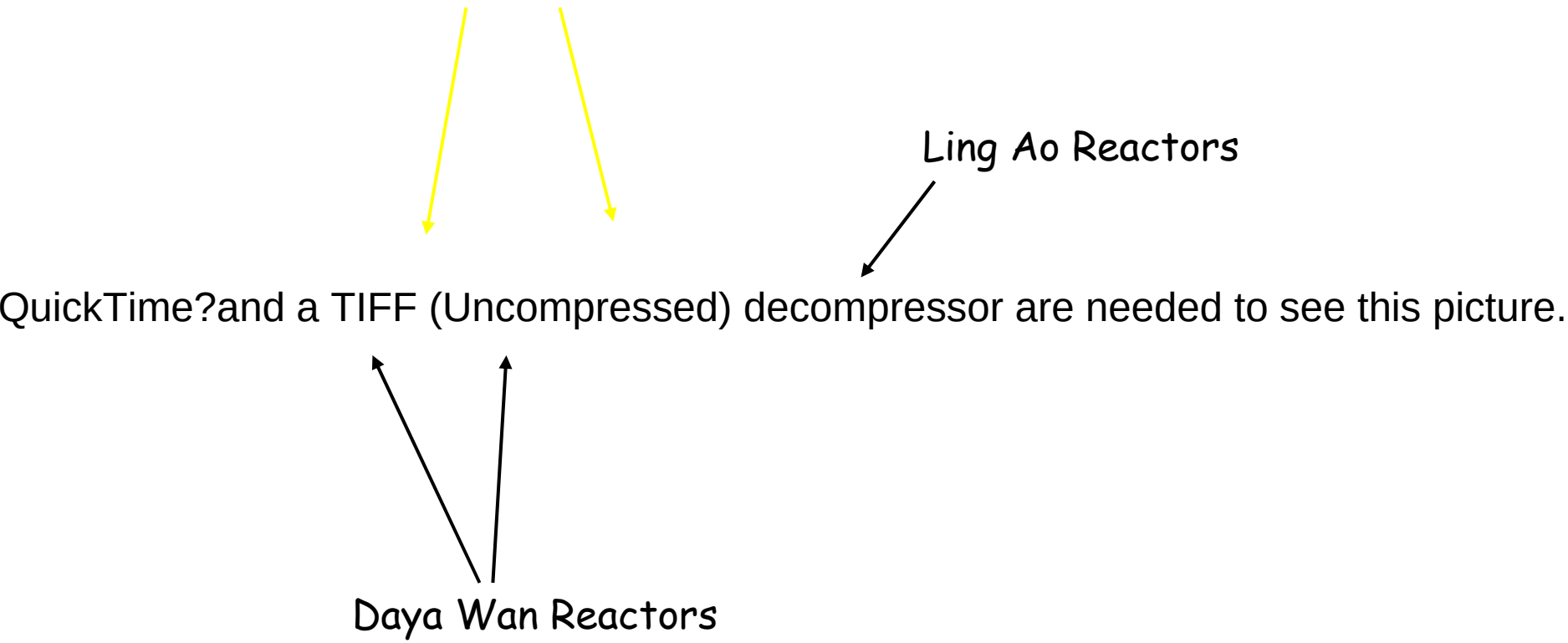
Far Detector
Reservoir
Daya Wan
Nuclear Power St
大亞灣核電
1 km
2 km

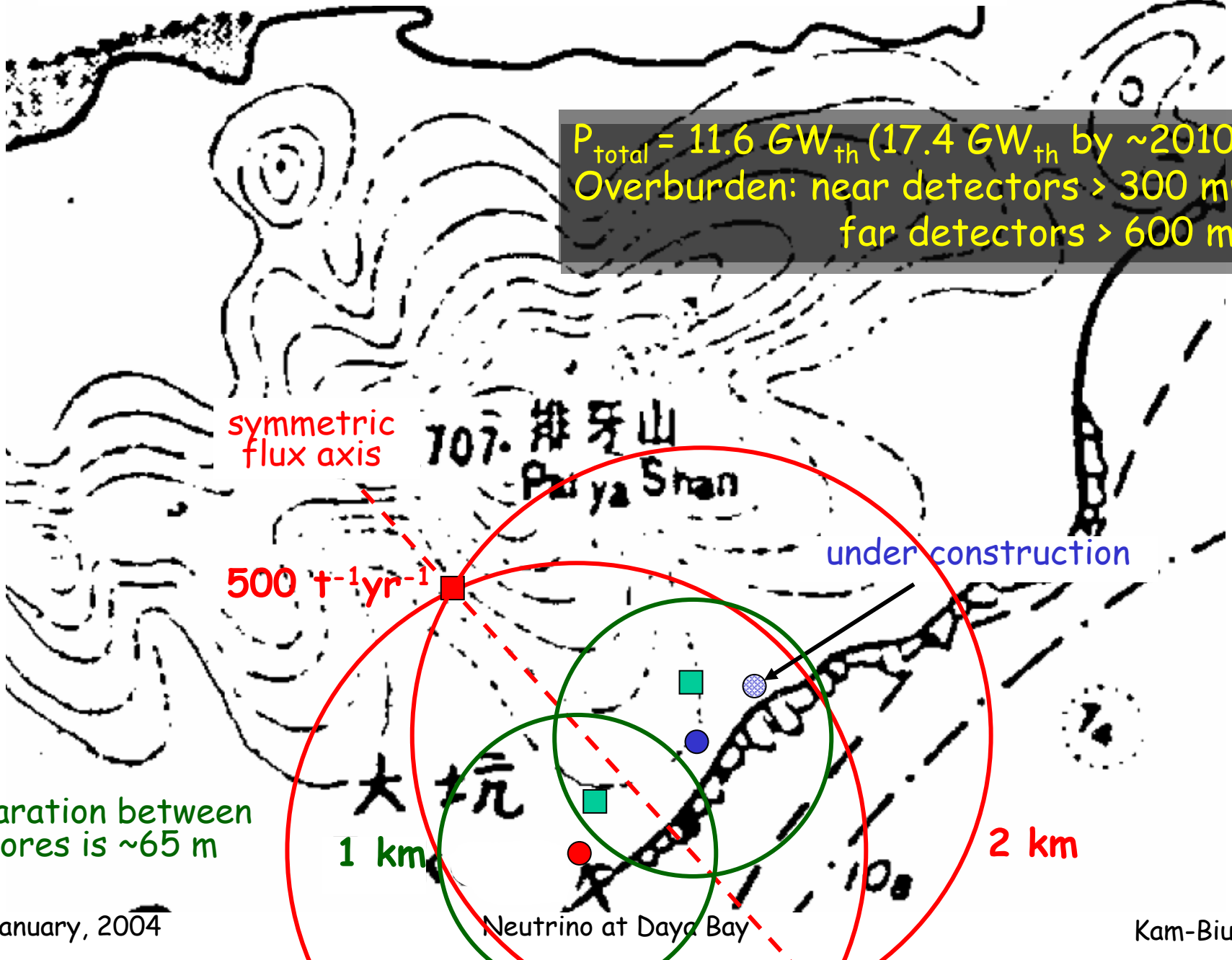

Reservoir


Potential Location of Far Detector at 1.5 to 2 km

Potential locations of Near Detectors



Possible Locations of Detectors at Daya Bay

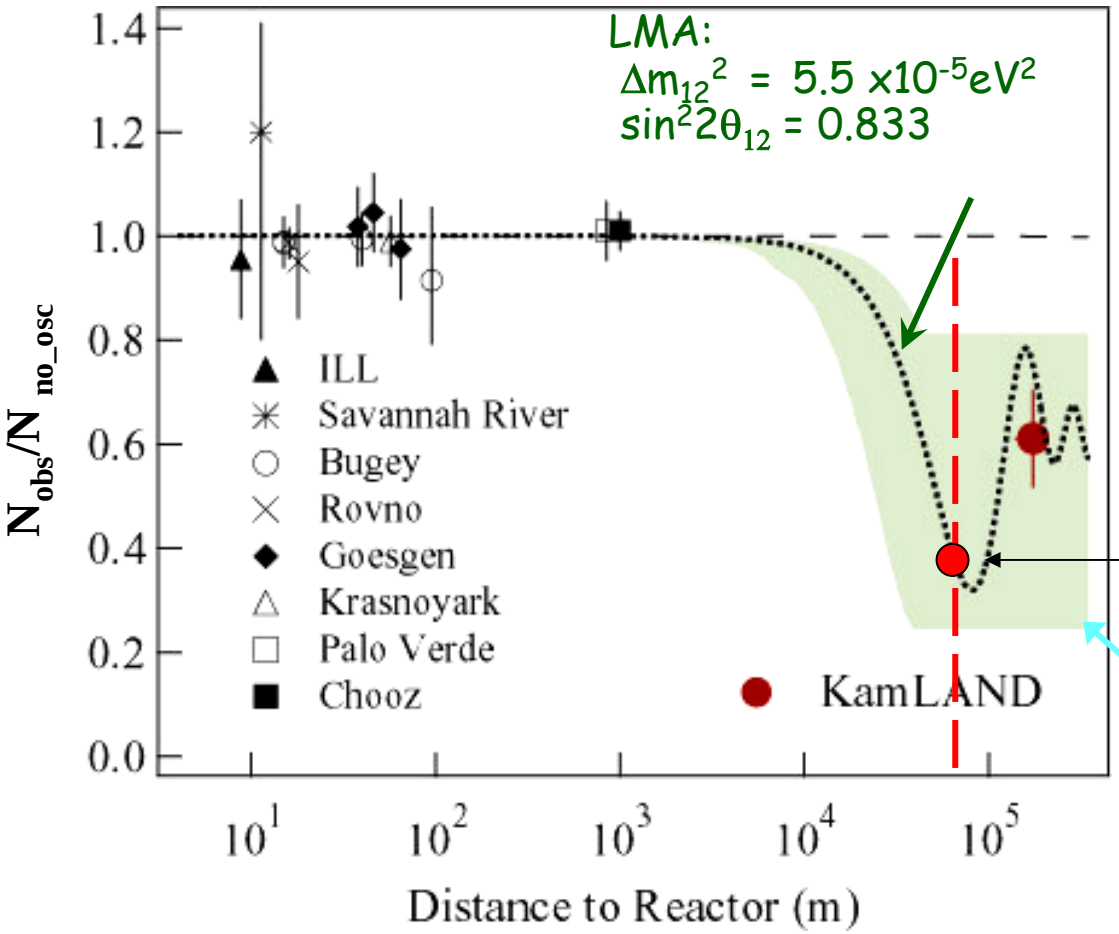


Hill side opposite to the Daya Wan reactors

Hill side opposite to the Ling Ao Reactors

Oscillation Due to Δm^2_{12} ?

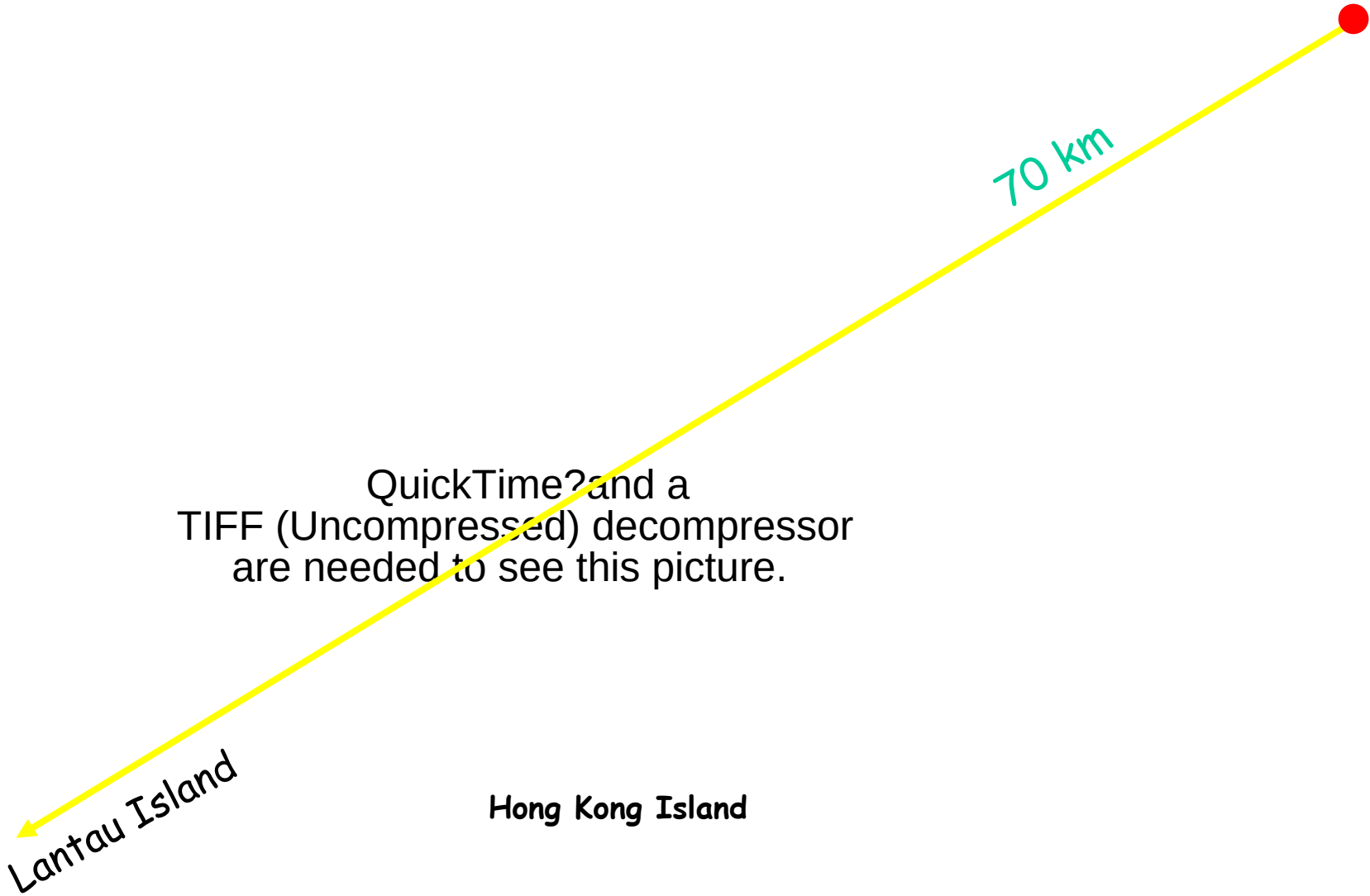
Neutrino Oscillation Due to Δm^2_{12}



G.Fogli et al., PR D66, 010001-406, (2002)

Daya Bay-Ling Ao

LMA flux prediction at 95% C.L.


70 km
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Lantau Island
Hong Kong Island

- With similar overburden as KamLAND
- Need a KamLAND-size detector and run for a few years
- As a supernova observatory
- Evolve into a underground laboratory

QuickTime?and a
TIFF (Uncompressed) decompressor
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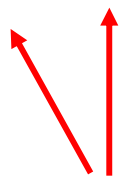

Potential locations of underground facility

Can we piggy tail to it?

Conclusions

- Daya Wan+Ling Ao (+Ling Tung by ~2010) is emerging as a powerful nuclear-power complex in the world, offering an excellent opportunity to study neutrino physics.
- The complex meets many of the requirements for carrying out the next generation of experiment on θ_{13}:
  - high anti-neutrino flux
  - good overburden in the vacinity of the cores
  - convenient access to the site
  - good infra-structure
- By installing a large LS detector in Lantau Island and using the Daya Wan Stations, we can contribute to the study of the neutrino-oscillation pattern due to θ_{12} and determination of Δm^2_{12} and beyond.