Efforts Towards a Horizontal Tunnel Access Experiment

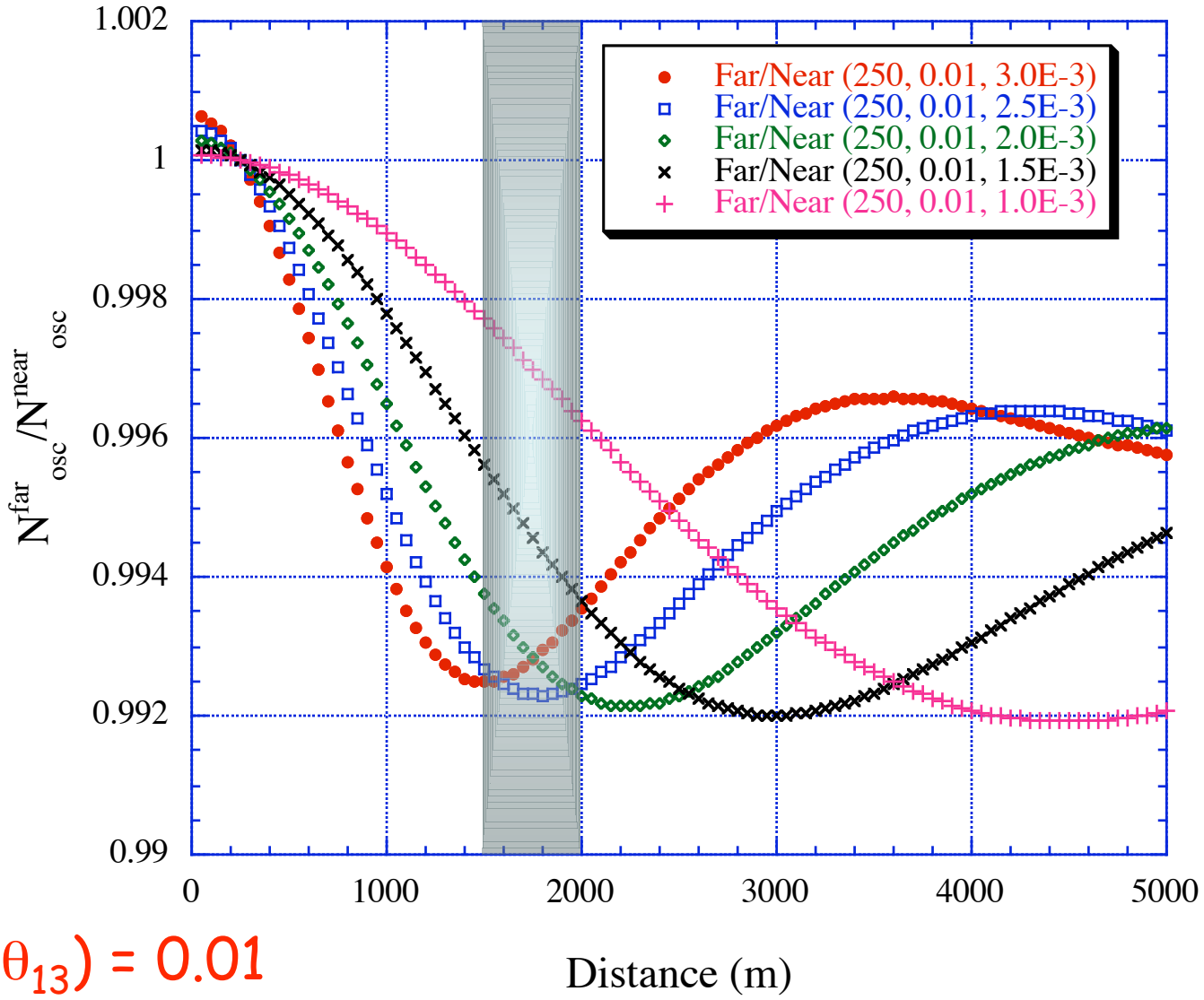
Kam-Biu Luk

University of California, Berkeley

And

Lawrence Berkeley National Laboratory

Optimizing Location of Far Detector



$\sin^2(2\theta_{13}) = 0.01$

Some Statistics

- Location of near detector: 250 m - 400 m
- Location of far detector: 1.5 km - 2.0 km
- Efficiency of identifying event: 80%

- Yield of events:

  near detector: (13 - 5)/ton/GW_{th}/day

  far detector: (0.4 - 0.2)/ton/GW_{th}/day

  For 50-ton detectors:

  near detector: (650-250)/GW_{th}/day

  far detector: (20-10)/GW_{th}/day

Potential Backgrounds

- Ambient radioactivity
- Accidentals
- Cosmic-ray muons induce
  - Gamma-rays and neutrons in the surrounding rock and buffer region of the detector
  - radioactive nuclei that emit delayed neutrons in the detector:

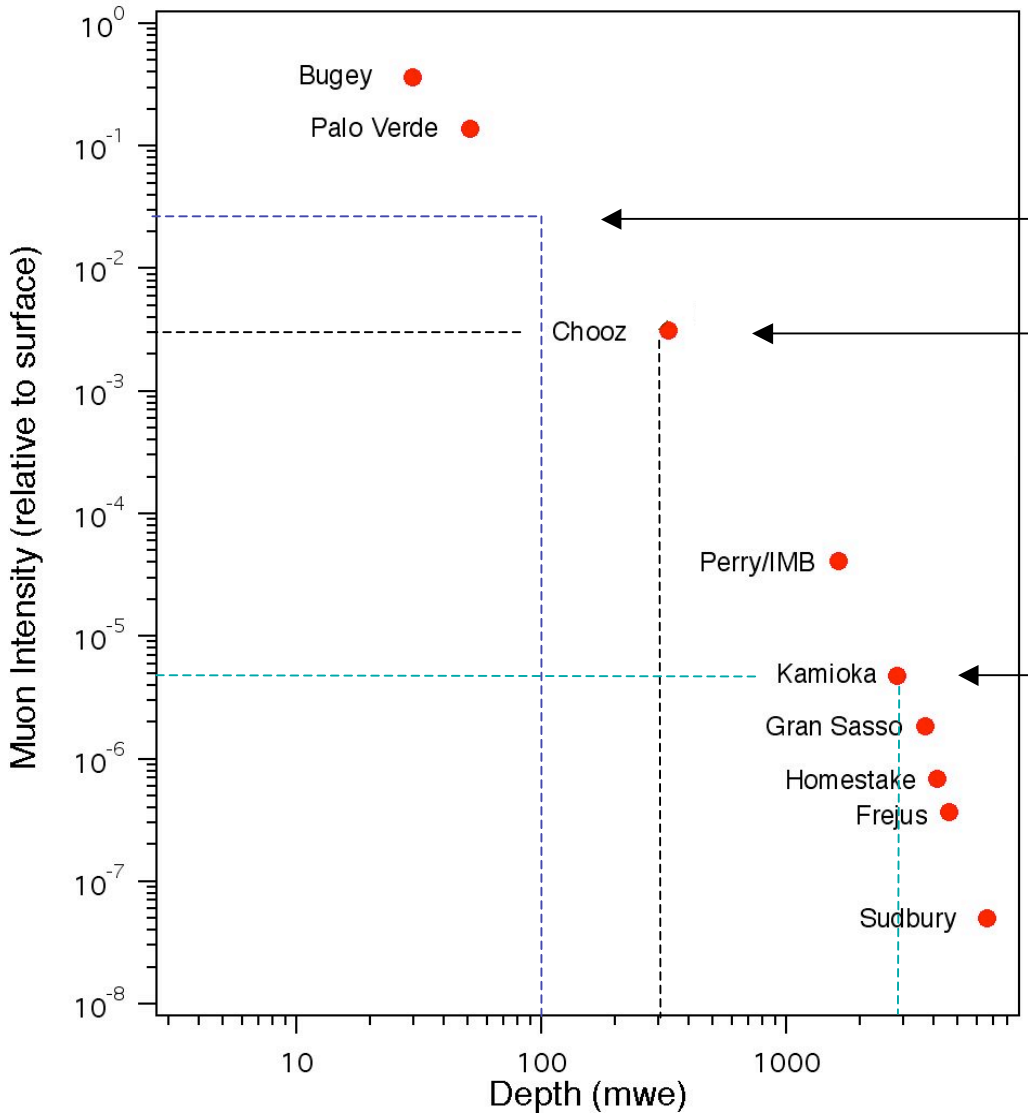
    e.g. ^{8}He ($T_{1/2}$ = 119 ms)

    ^{9}Li ($T_{1/2}$ = 178 ms)

In KamLAND: produces ~1.3 rad.nucl./ton/day

rejection factor ~2 x 10^{5}

Yield of Muon-induced Radioactive Nuclei



~110 rad.nucl./ton/day

~20 rad.nucl./ton/day

~1.3 rad.nucl./ton/day

Neutron Backgrounds

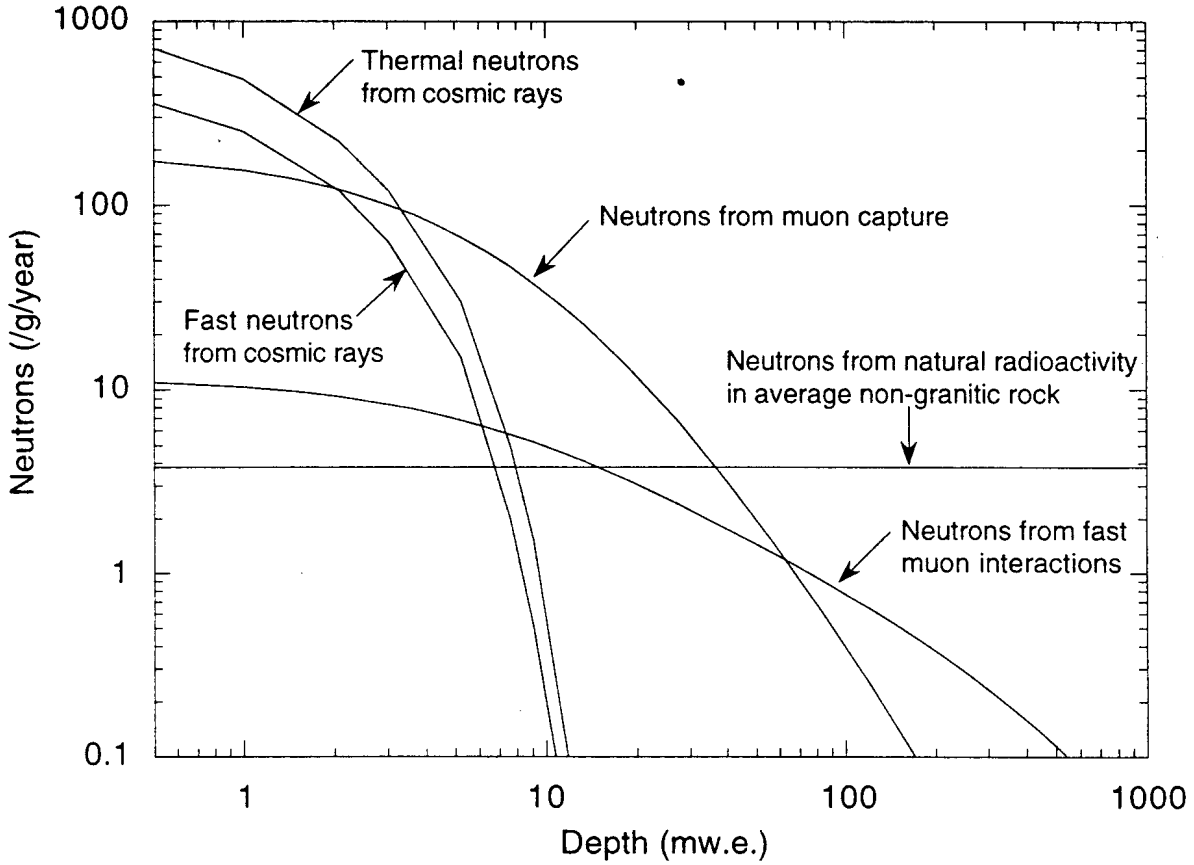


Figure 4.1: Neutron production in rock. Hadronic component of cosmic rays taken from [76]. Neutrons from natural radioactivity taken from [73]. Neutrons from μ^- capture estimated using Equation 4.7. Neutrons from fast muon interactions estimated using Equation 4.8.

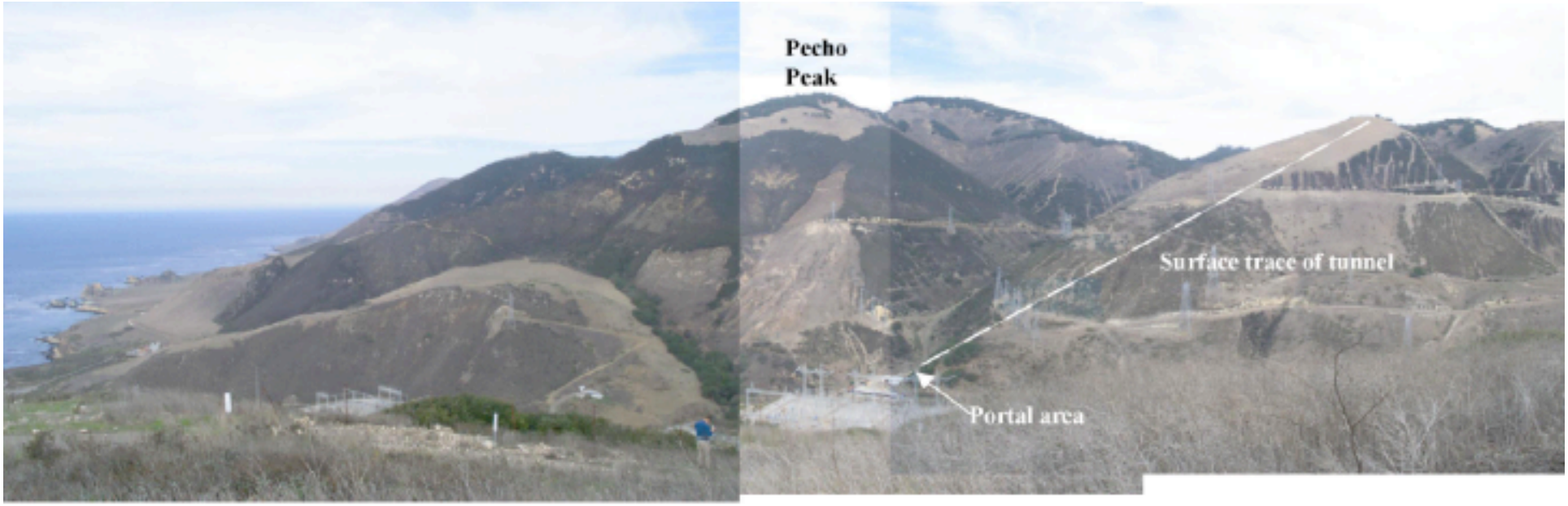
Further Optimization

- To achieve $\sin^2(2\theta_{13}) = 0.01$, require $N_{bgd}/N_{sig} < 10^{-3}$:
  - * A powerful nuclear power plant

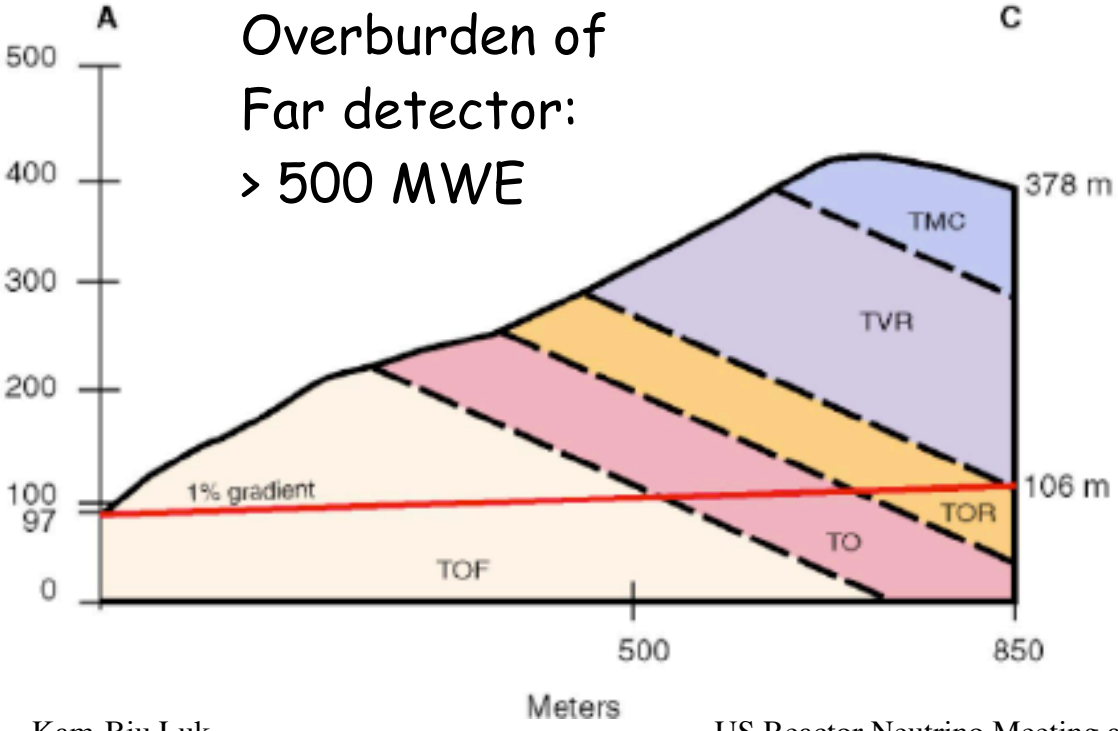
    assume KamLAND's rejection factor 2×10^5,
  - * Overburden for near detector > 100 MWE
  - * Overburden for far detector > 300 MWE
- Adopt horizontal access tunnel:
  - * More flexible in choosing overburden
  - * Relatively easy to change the baseline
  - * Easier to service the detectors
  - * Can get more overburden for similar cost
  - * More overburden reduces deadtime due to less cosmic muons

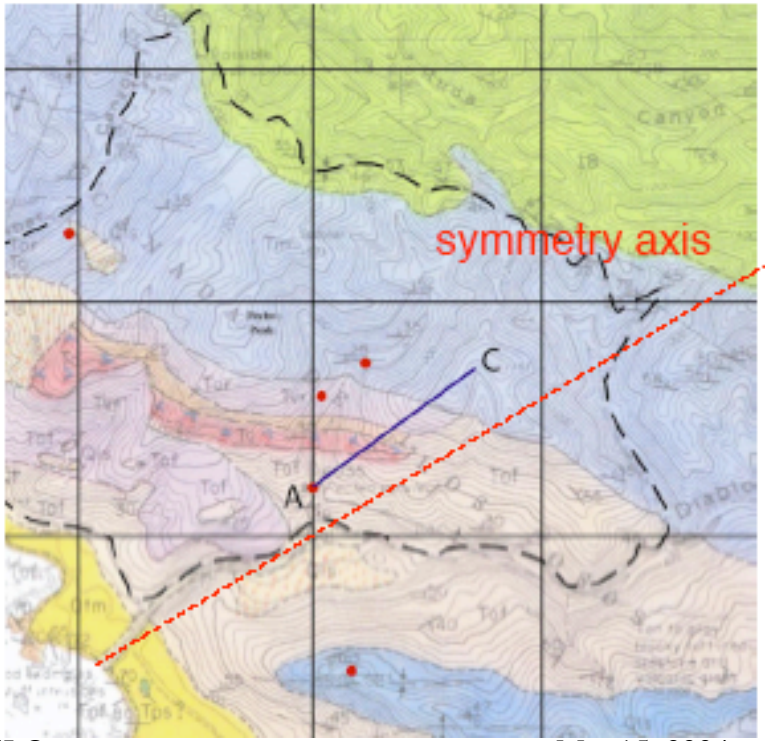
Diablo Canyon, California


1-2 km
area of landfill and site restoration
area III
area II
area I
>1 km
0.4 km

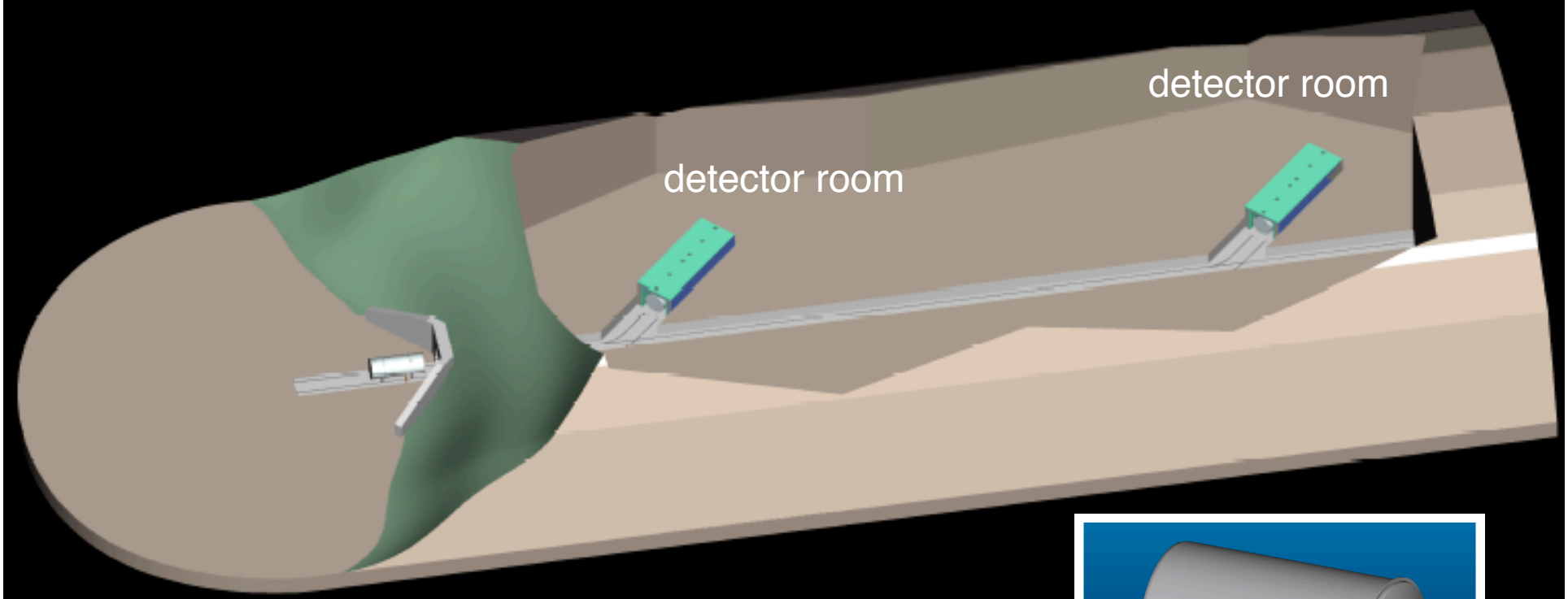


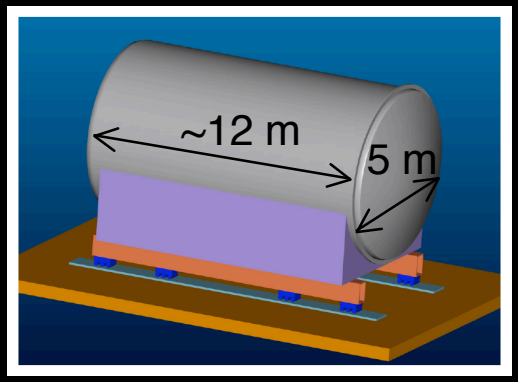
Overburden of
Far detector:
> 500 MWE



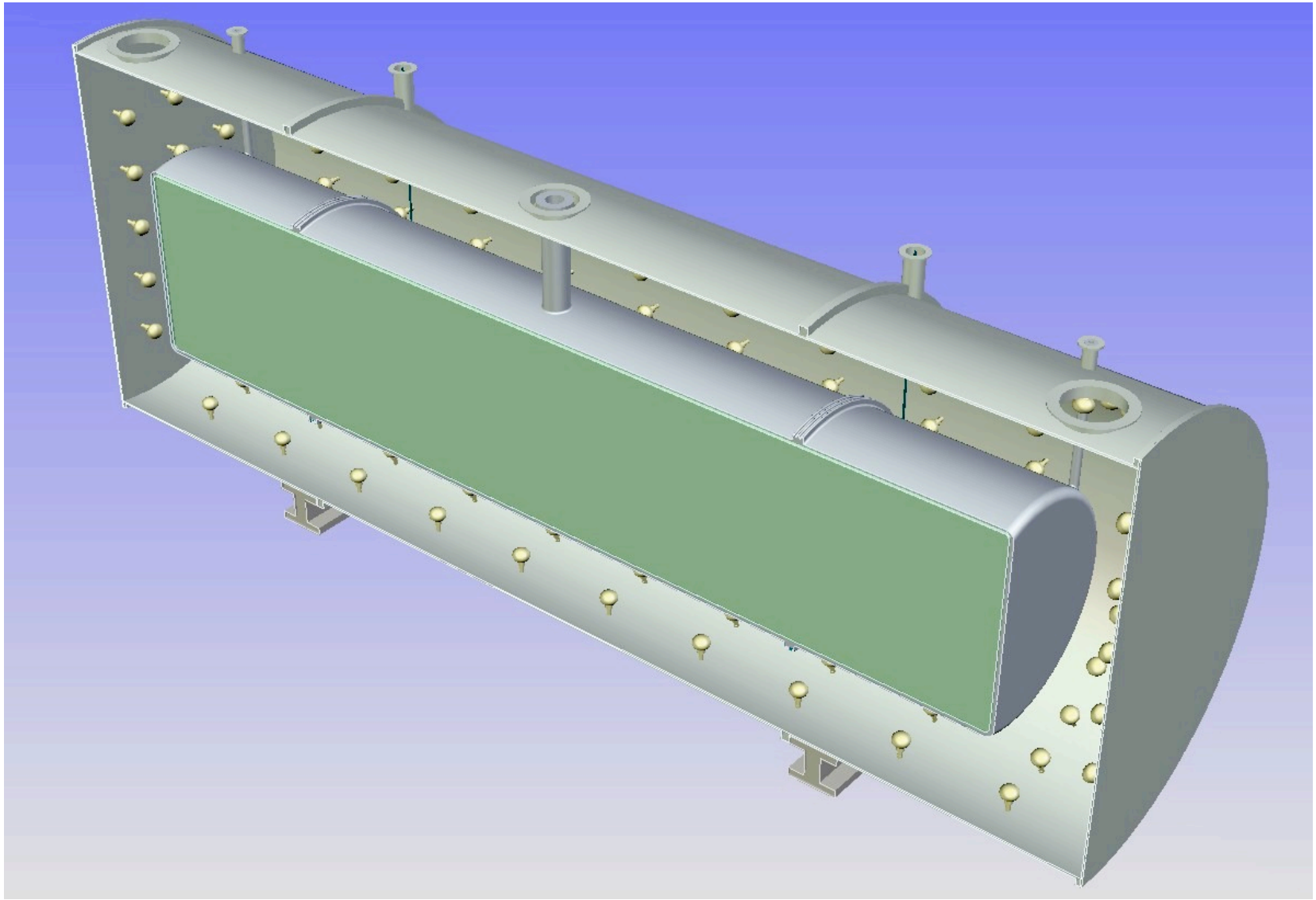


Tunnel with Multiple Detector Rooms and Movable Detectors

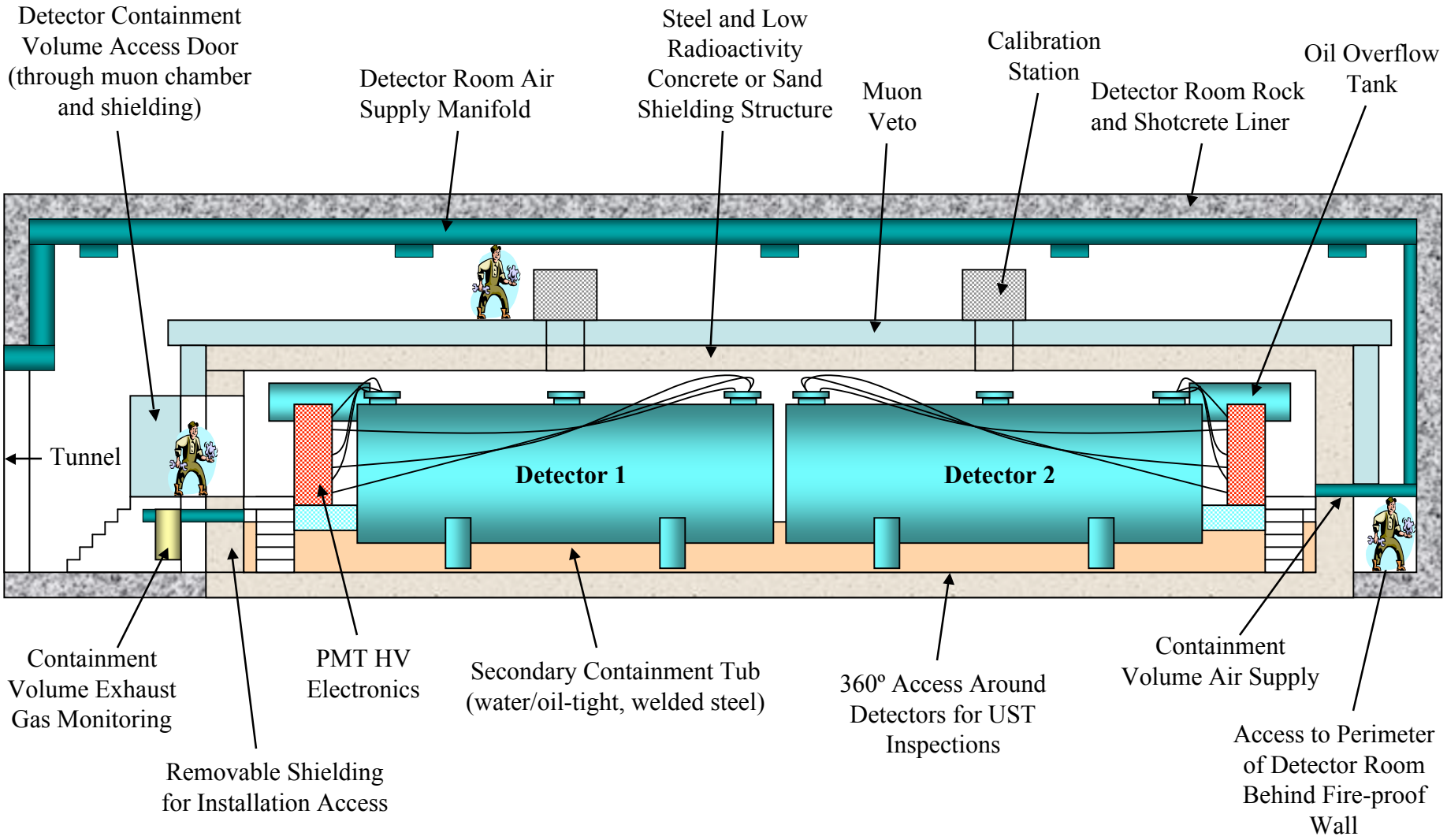


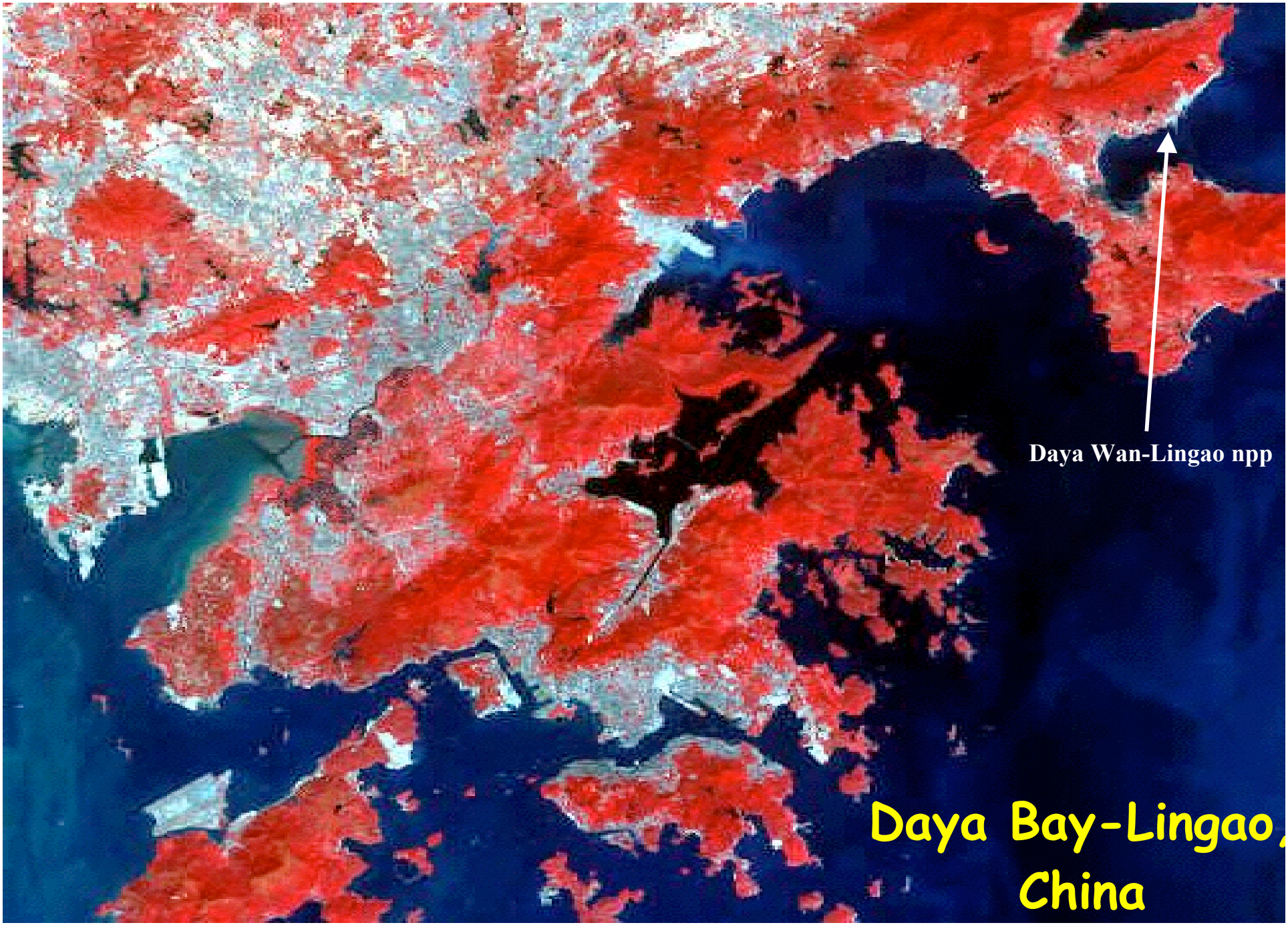


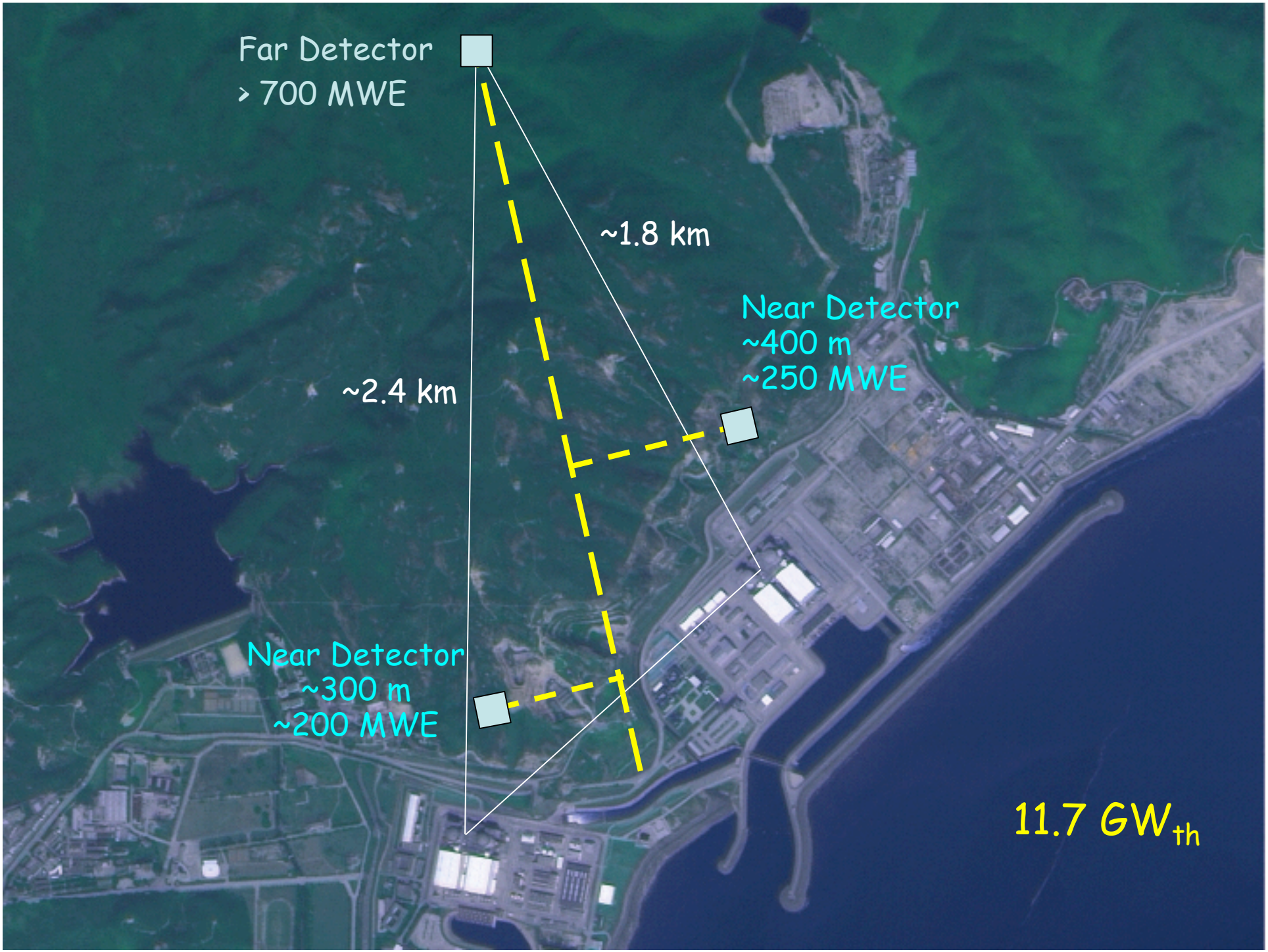
Conceptual Design of Detector



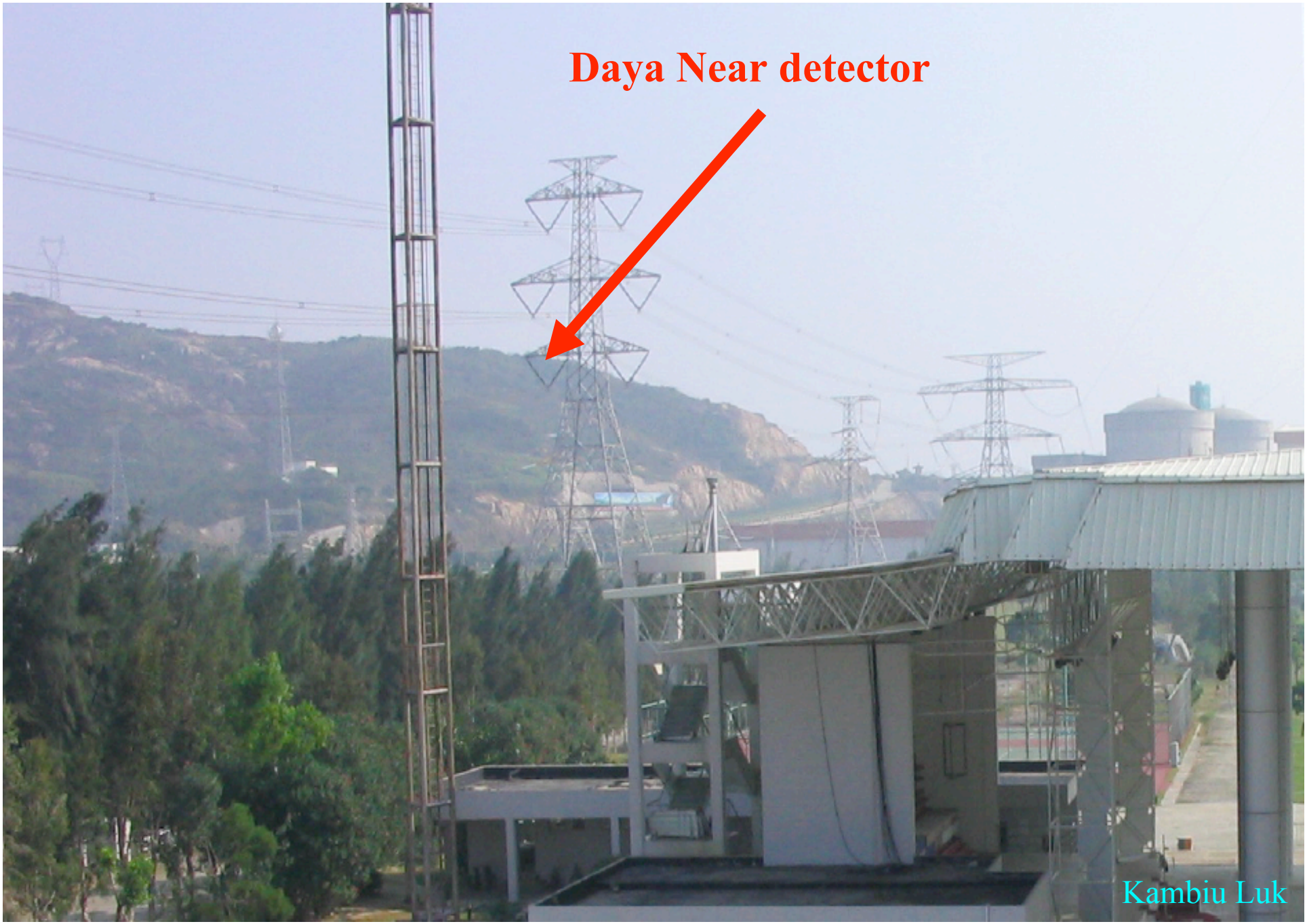
Conceptual Design of Detector Room

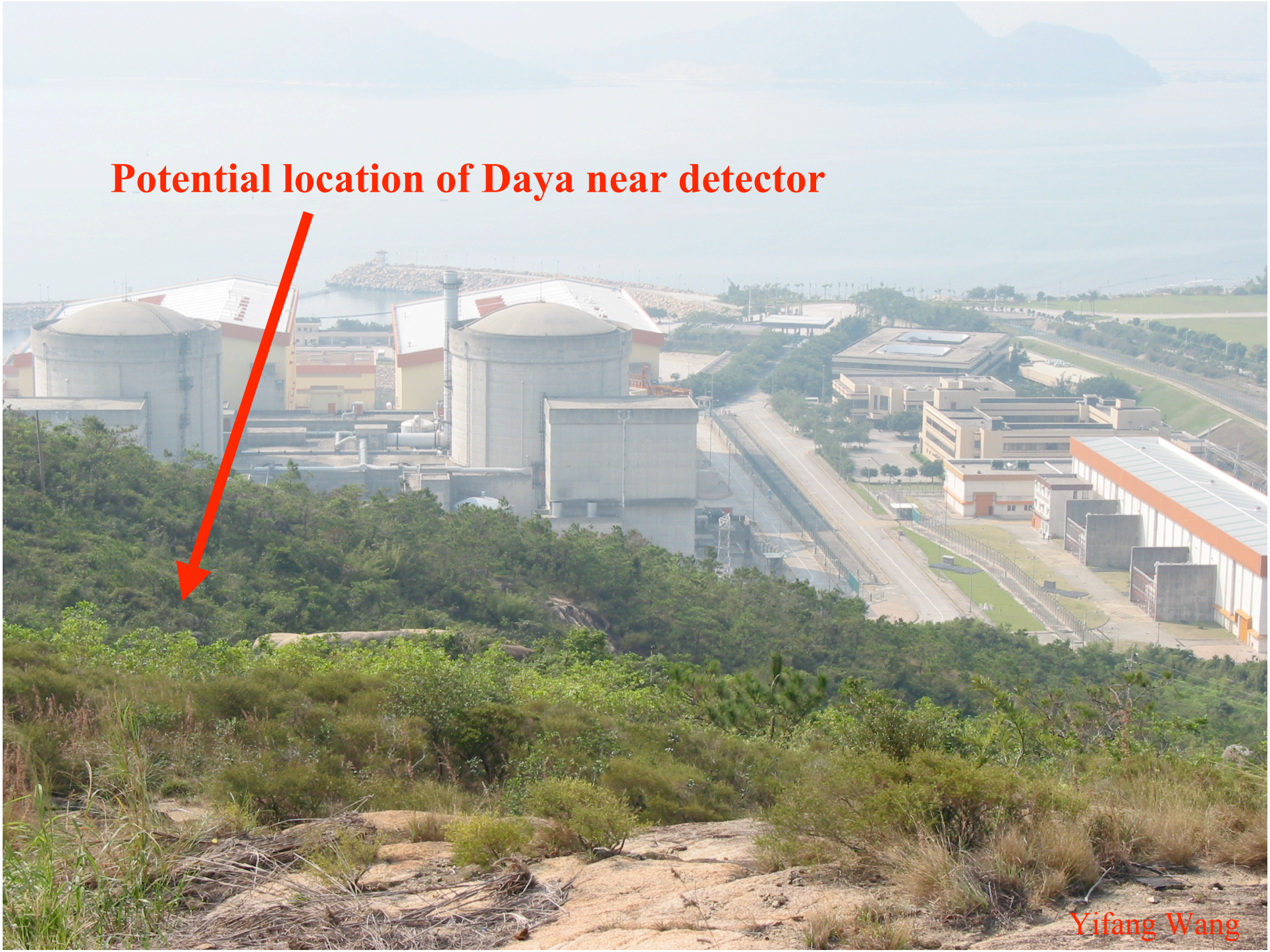



Daya Wan-Lingao npp
Daya Bay-Lingao,
China


Far Detector
> 700 MWE
~1.8 km
Near Detector
~400 m
~250 MWE
~2.4 km
Near Detector
~300 m
~200 MWE
11.7 GW$_{th}$


Proposed Tunnel Location
Bob McKeown


Daya Near detector
Kambiu Luk


Potential location of Daya near detector
Yifang Wang


Potential location of Lingao near detector
Yifang Wang


Potential Location of Far Detector at 1.5 to 2 km
Kambiu Luk


Yes, you can tunnel here!
Bob McKeown

Schematics of a Multi-module Detector