A Little Ghost Growing Big

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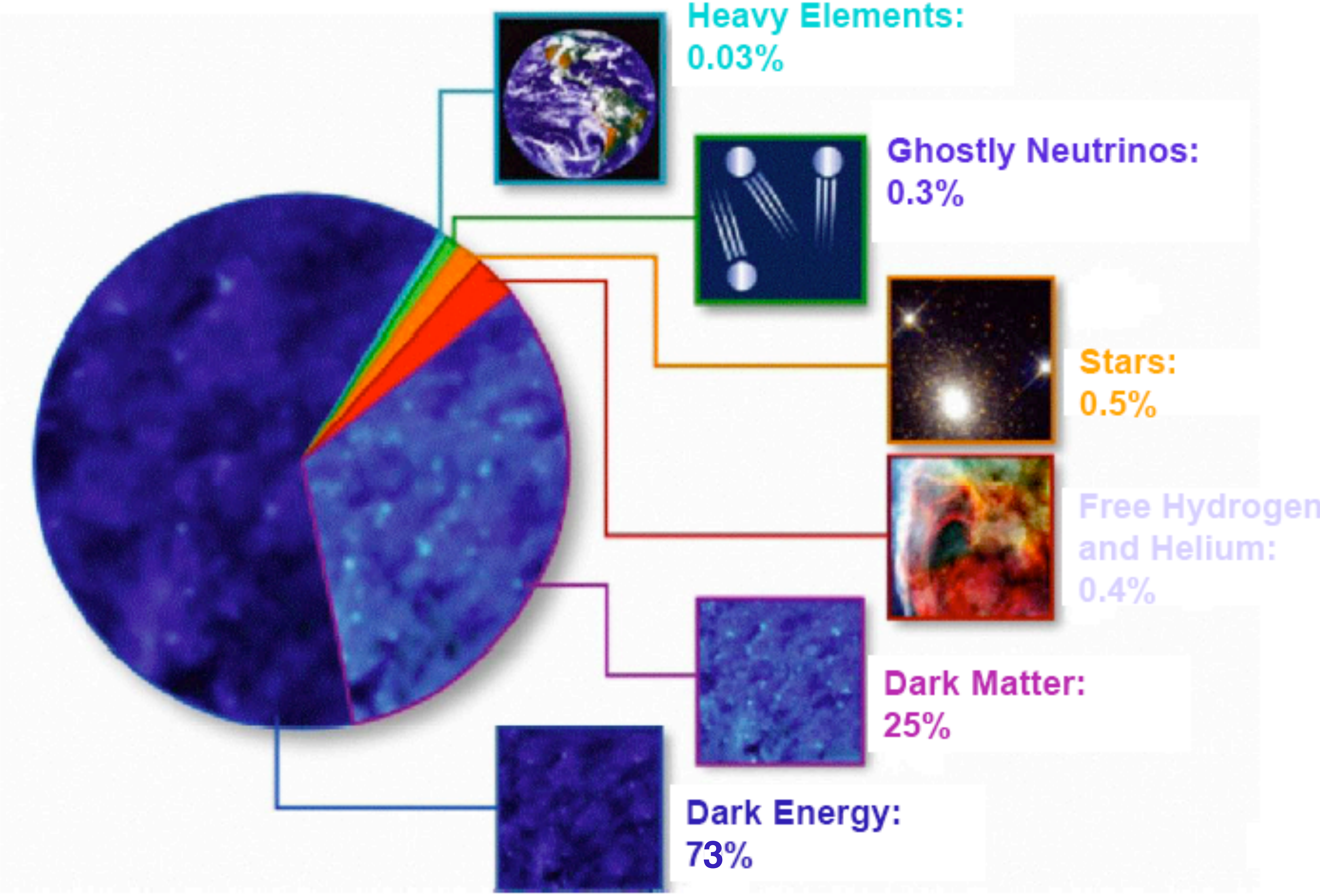
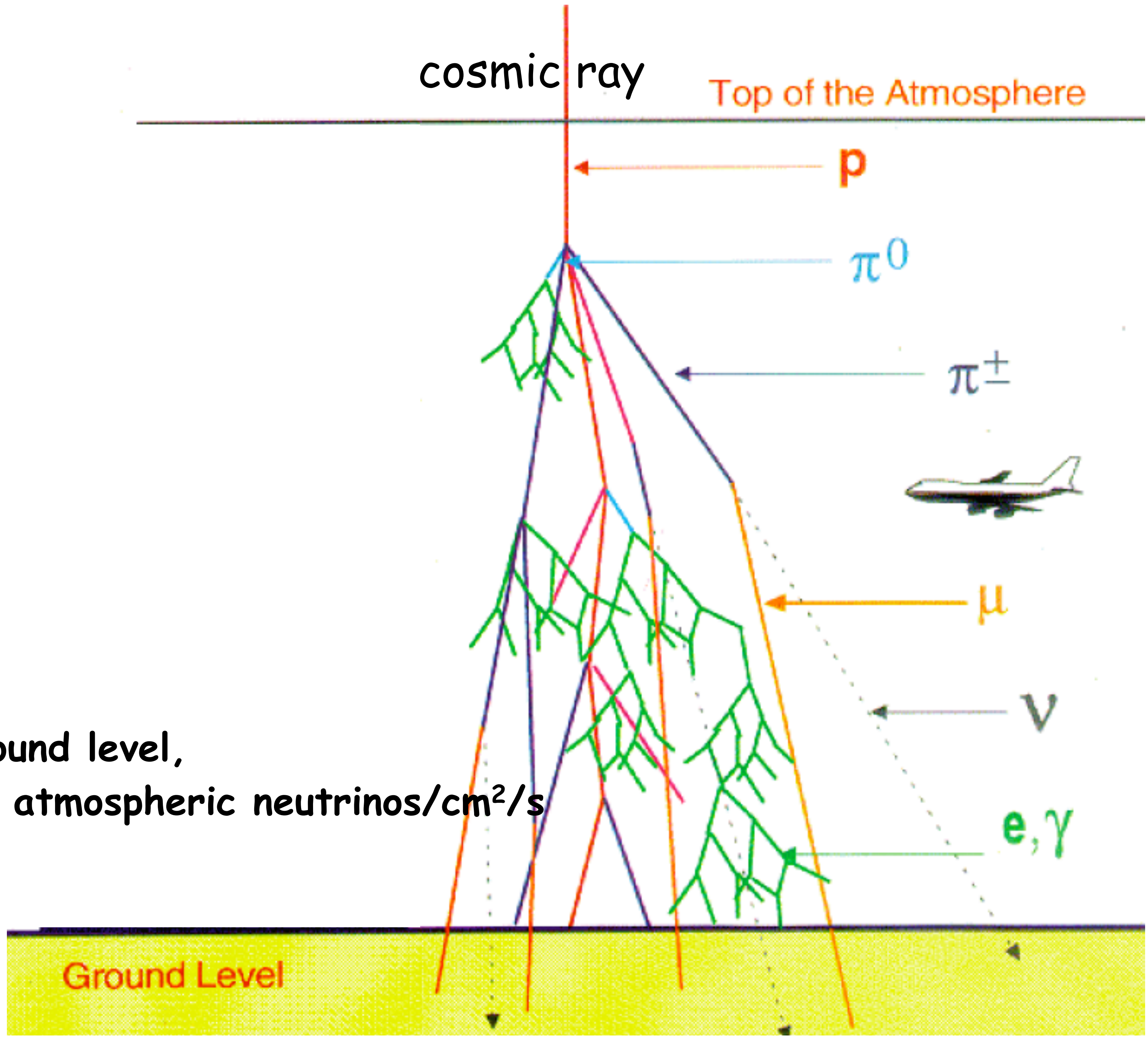
Neutrino

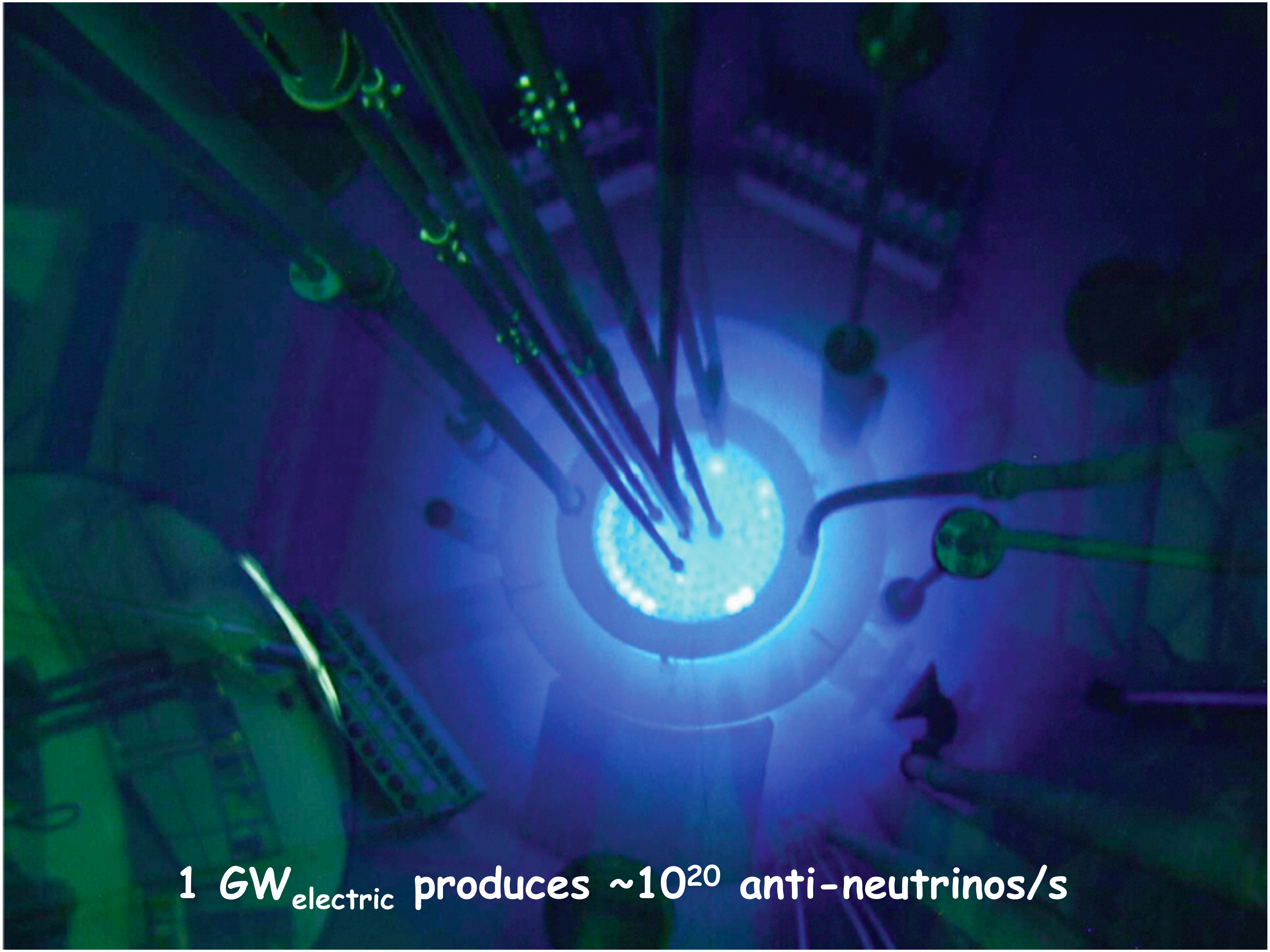
Neutrinos Are Key Cosmic Ingredient

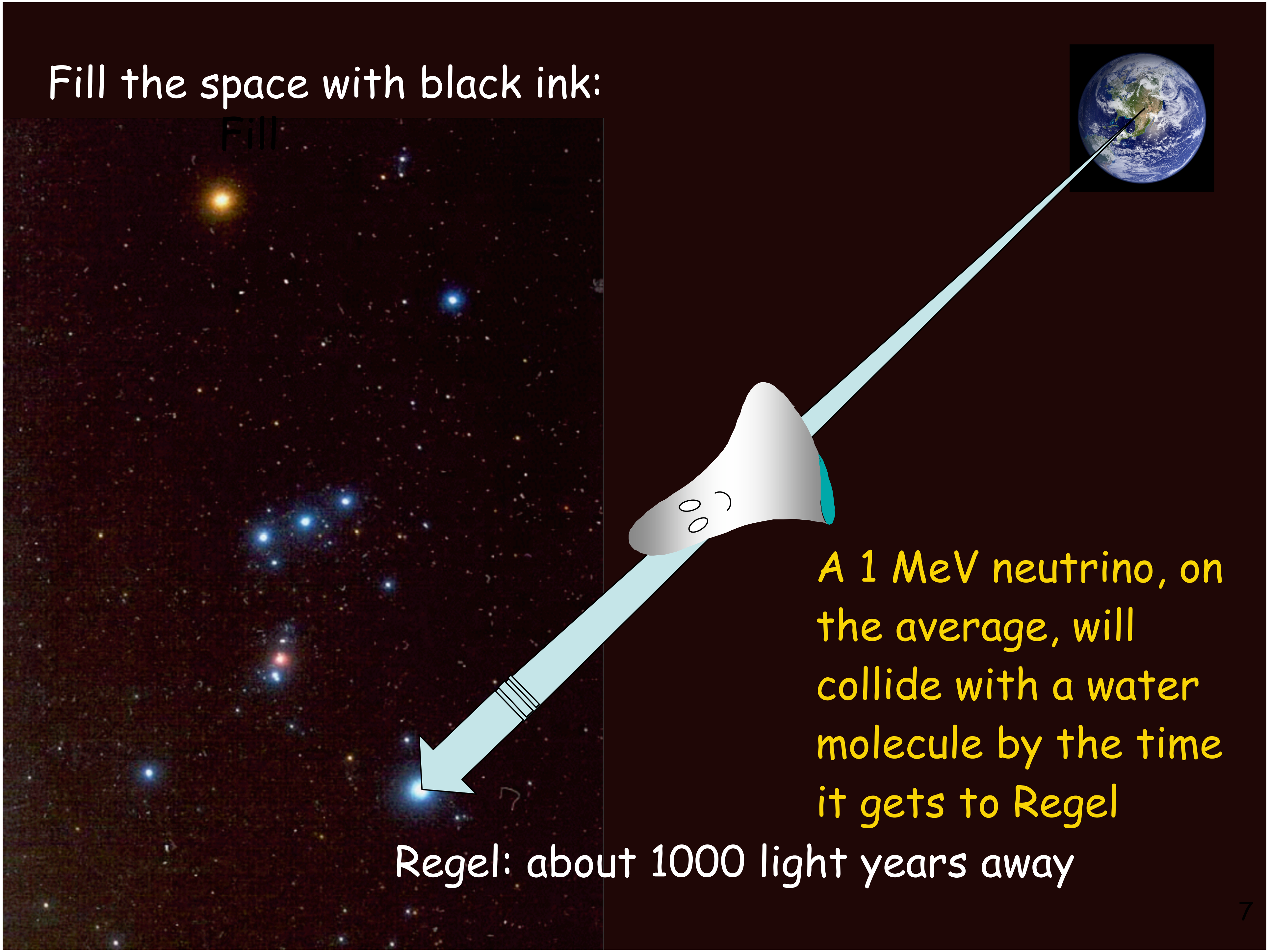



~5 x 10^{6} solar neutrinos/cm^{2}/s
raining down on Earth



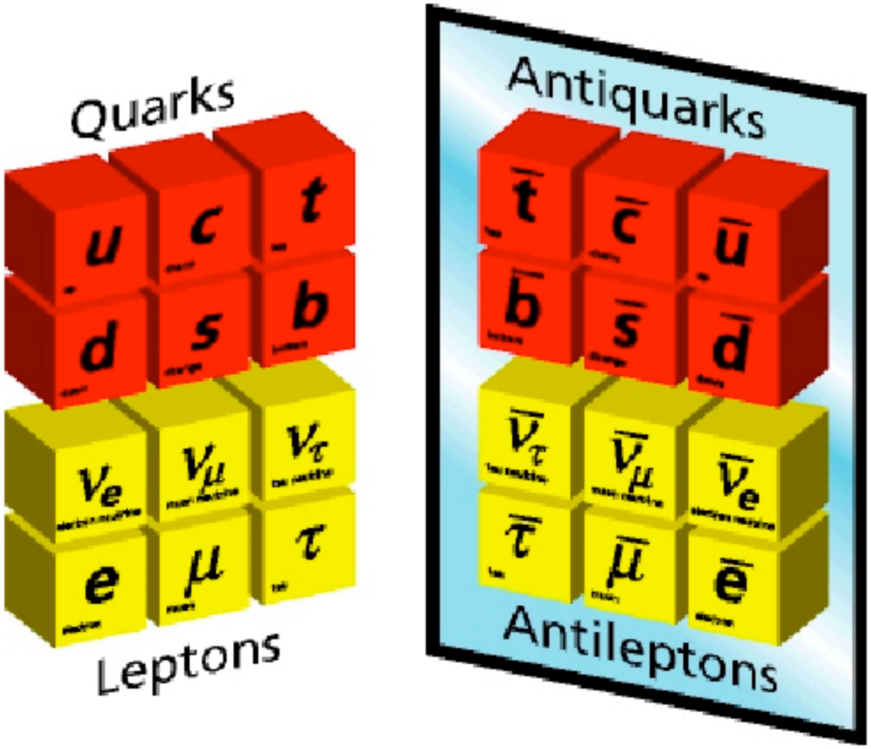
At ground level,
~0.03 atmospheric neutrinos/cm^2/s


1 GW$_{electric}$ produces ~10^{20} anti-neutrinos/s


Fill the space with black ink:
Fill
A 1 MeV neutrino, on the average, will collide with a water molecule by the time it gets to Regel
Regel: about 1000 light years away
7

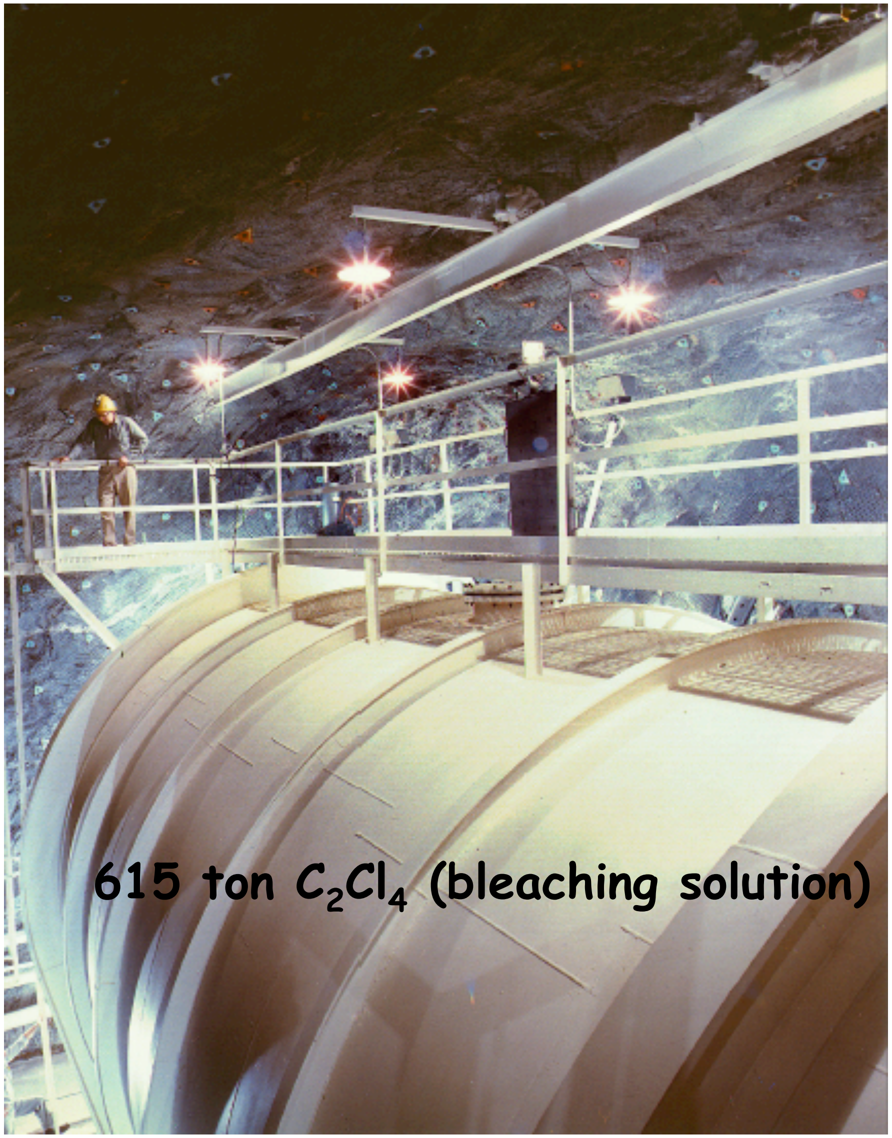
Standard Model

- Three types of massless neutrinos in the Standard Model of particle physics



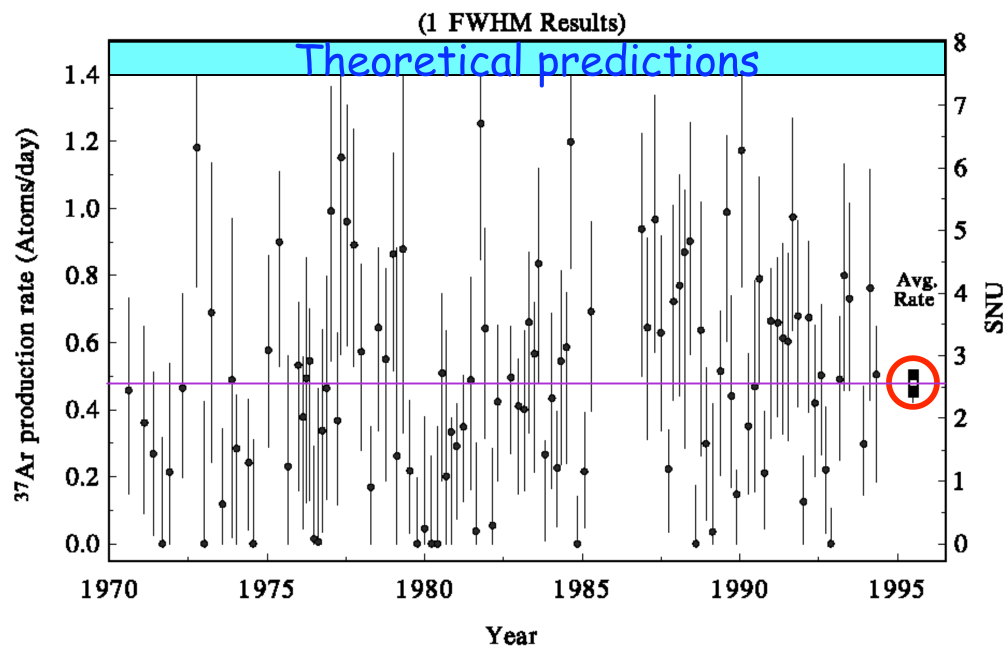
- Massive neutrinos will indicate the Standard Model is incomplete and have profound implications

Something Funny Is Going On In The Sun



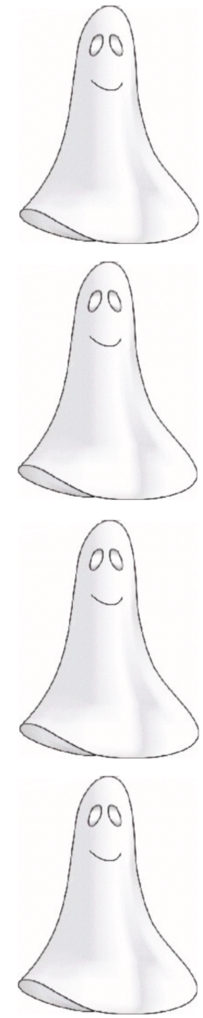
Davis experiment in Homestake mine
2002 Nobel prize

Solar $\nu_e + {}^{37}Cl \rightarrow e^- + {}^{37}Ar$

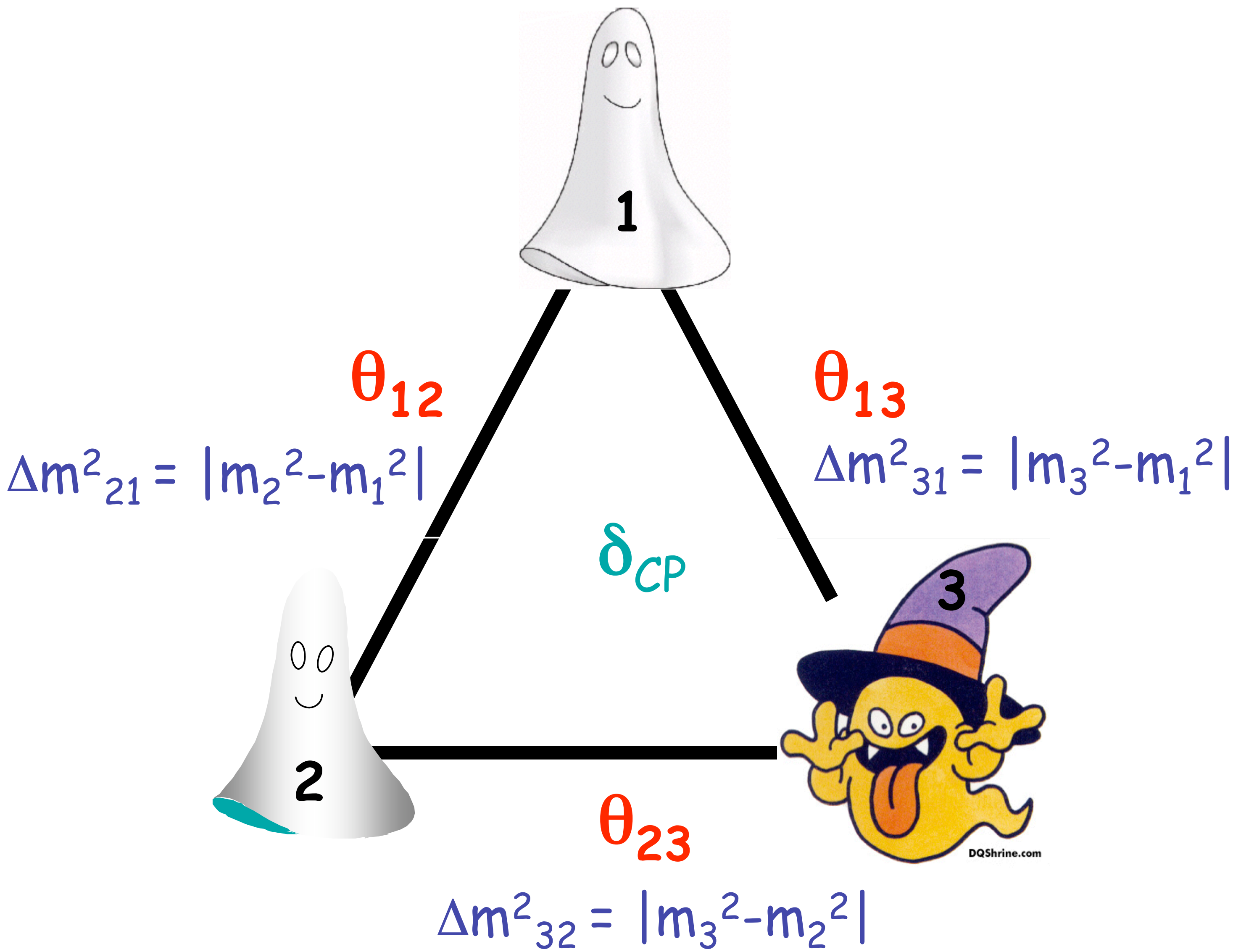


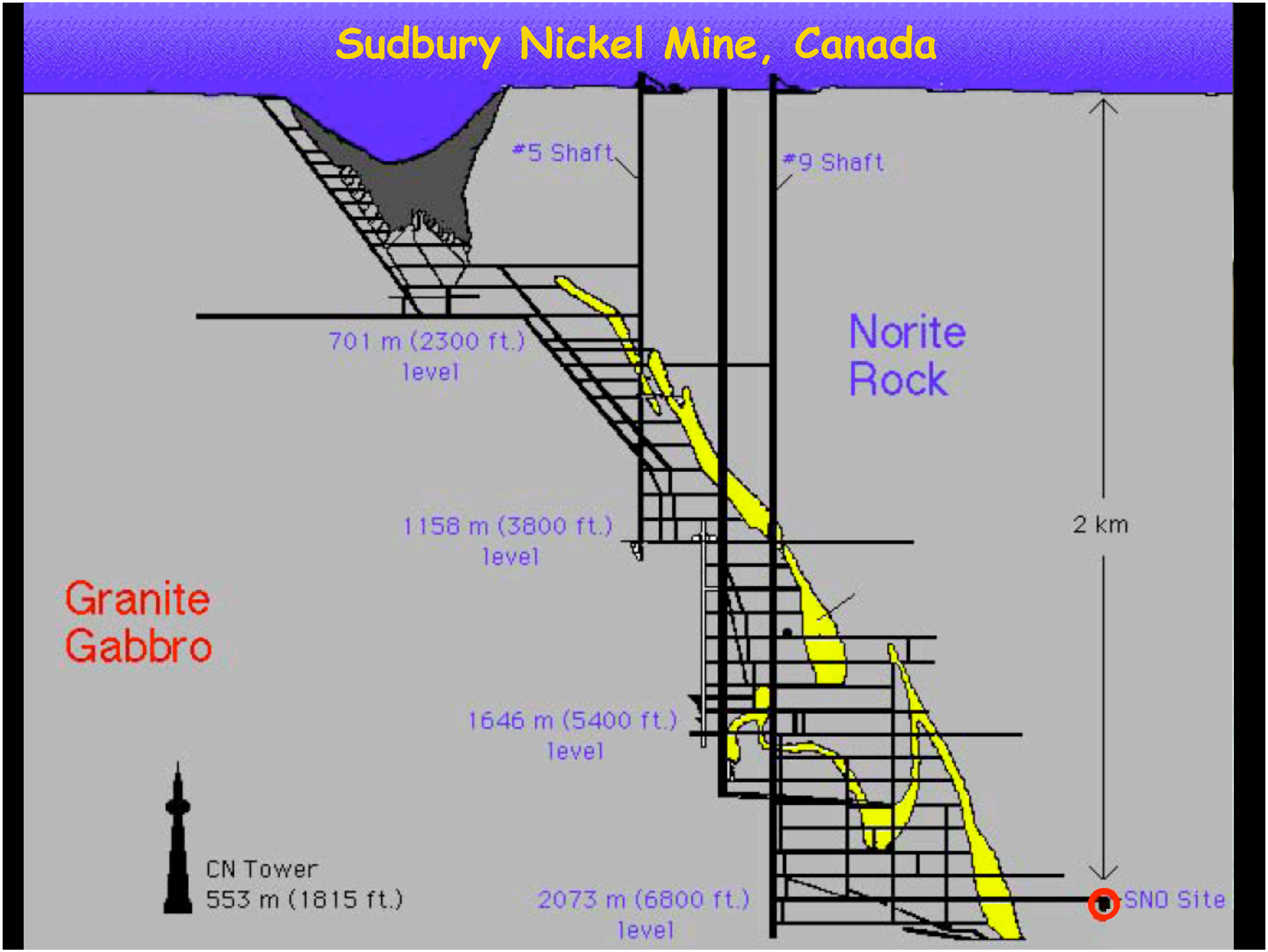
1 SNU = 1 interaction/10^{36} target atoms/sec

Neutrino Oscillation

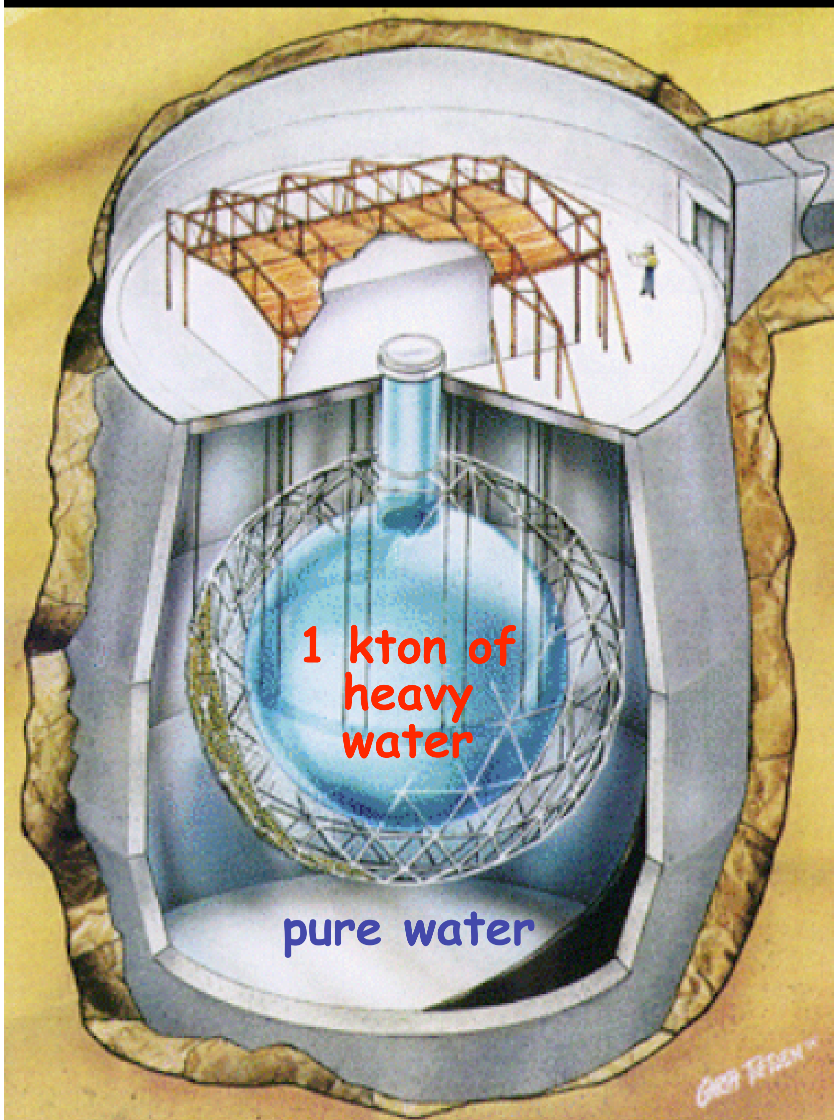


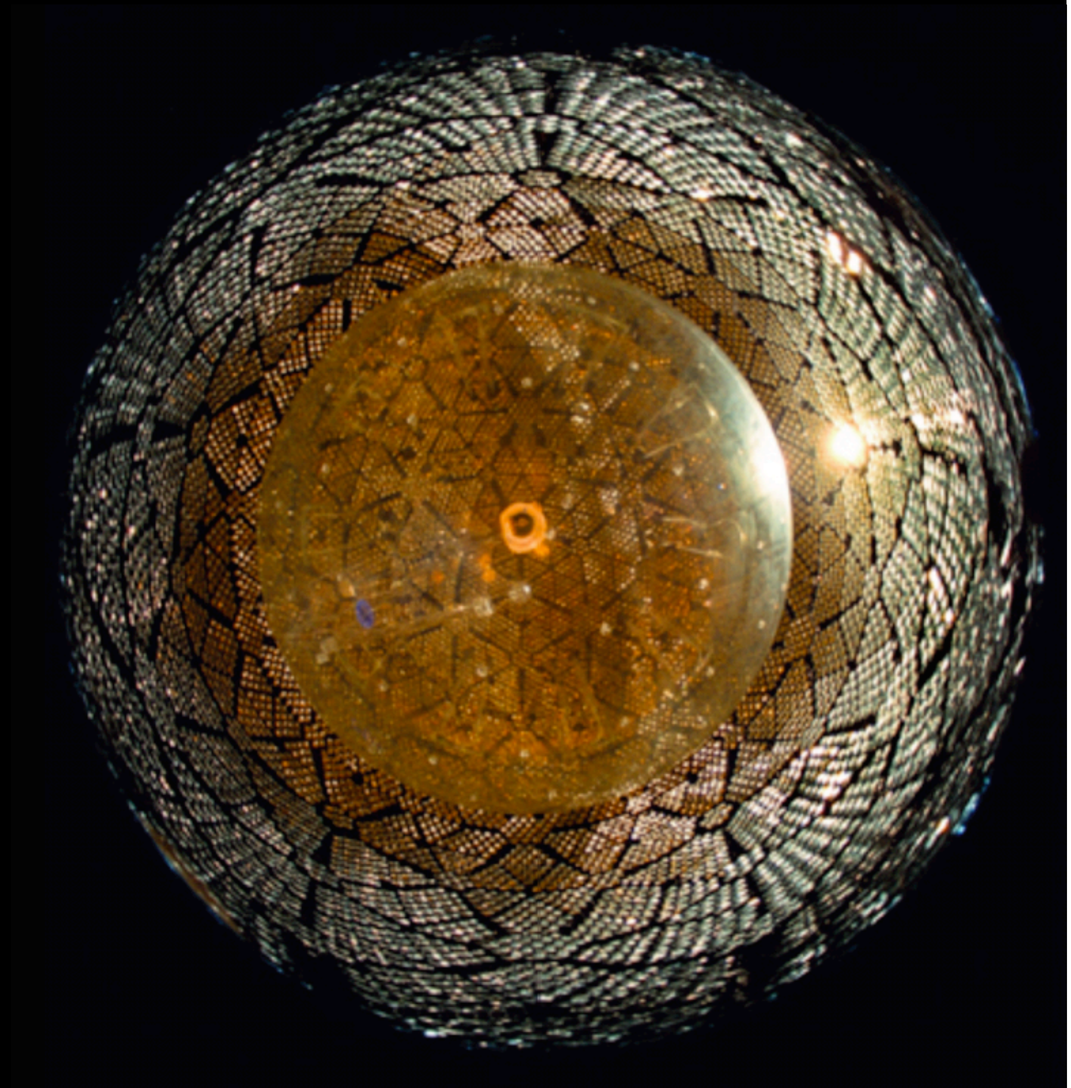
Neutrino Oscillation

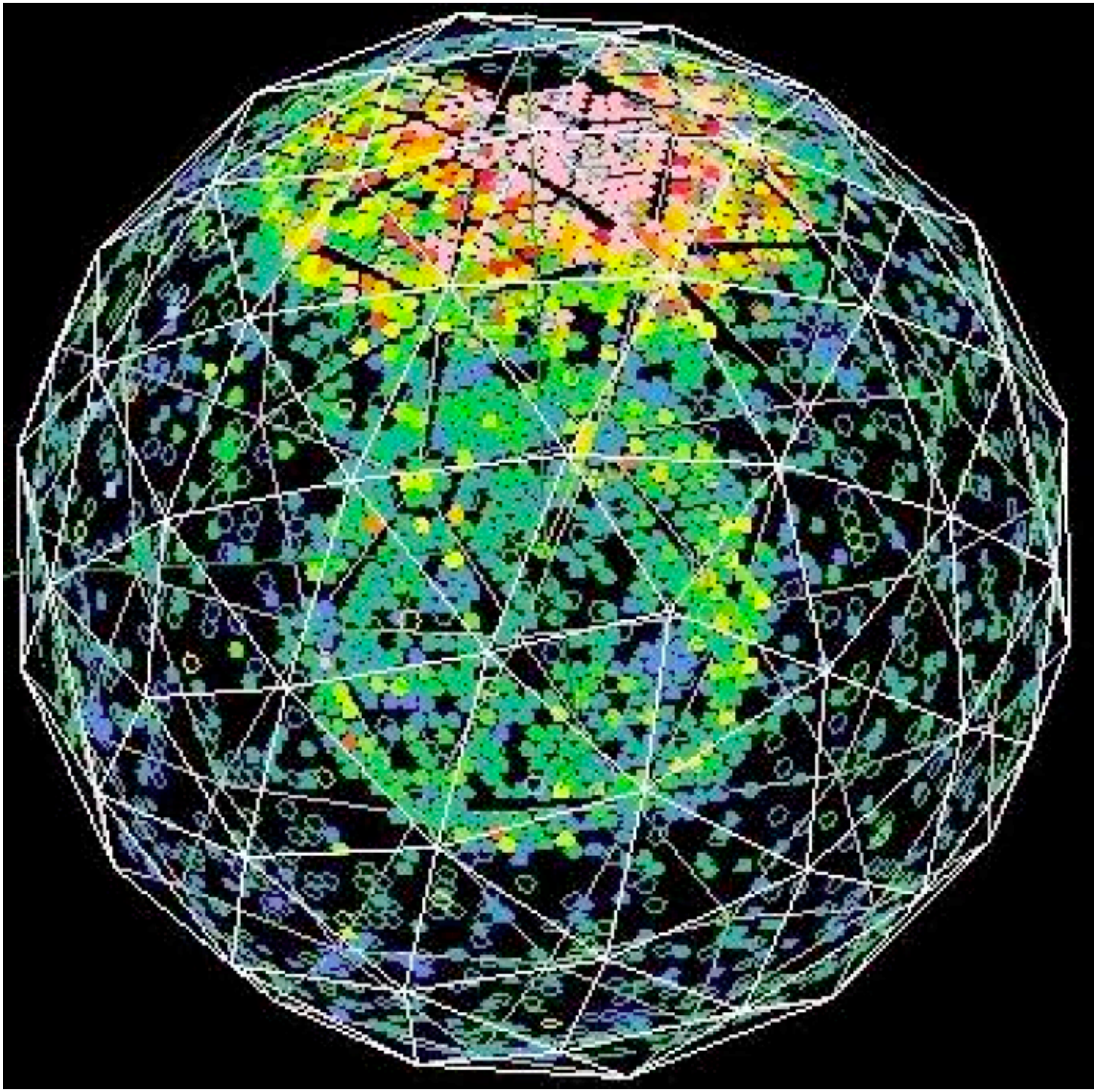


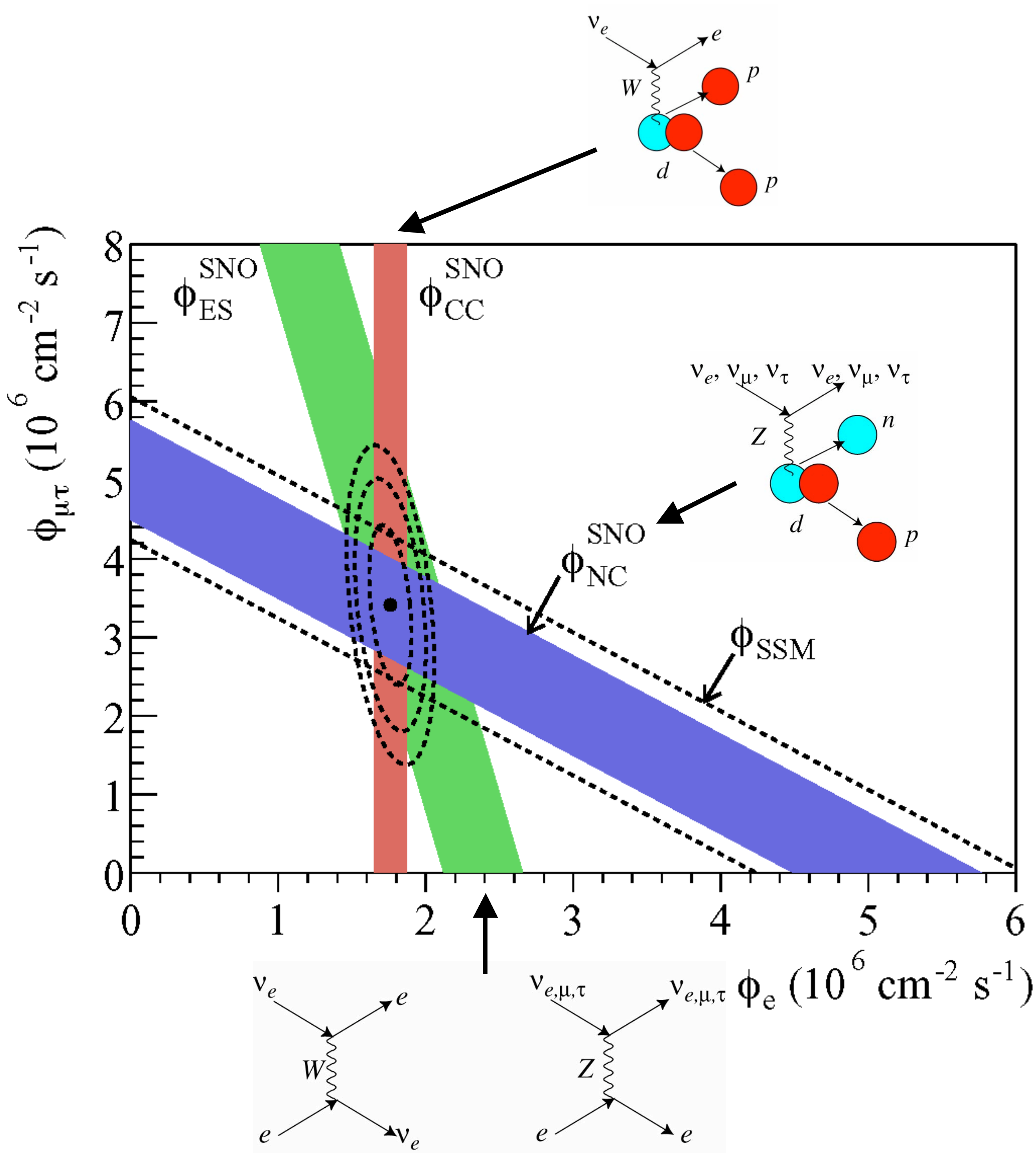

Sudbury Nickel Mine, Canada
#5 Shaft
#9 Shaft
Norite Rock
701 m (2300 ft.) level
1158 m (3800 ft.) level
1646 m (5400 ft.) level
2073 m (6800 ft.) level
2 km
SNO Site
Granite Gabbro
CN Tower
553 m (1815 ft.)

Sudbury Neutrino Observatory



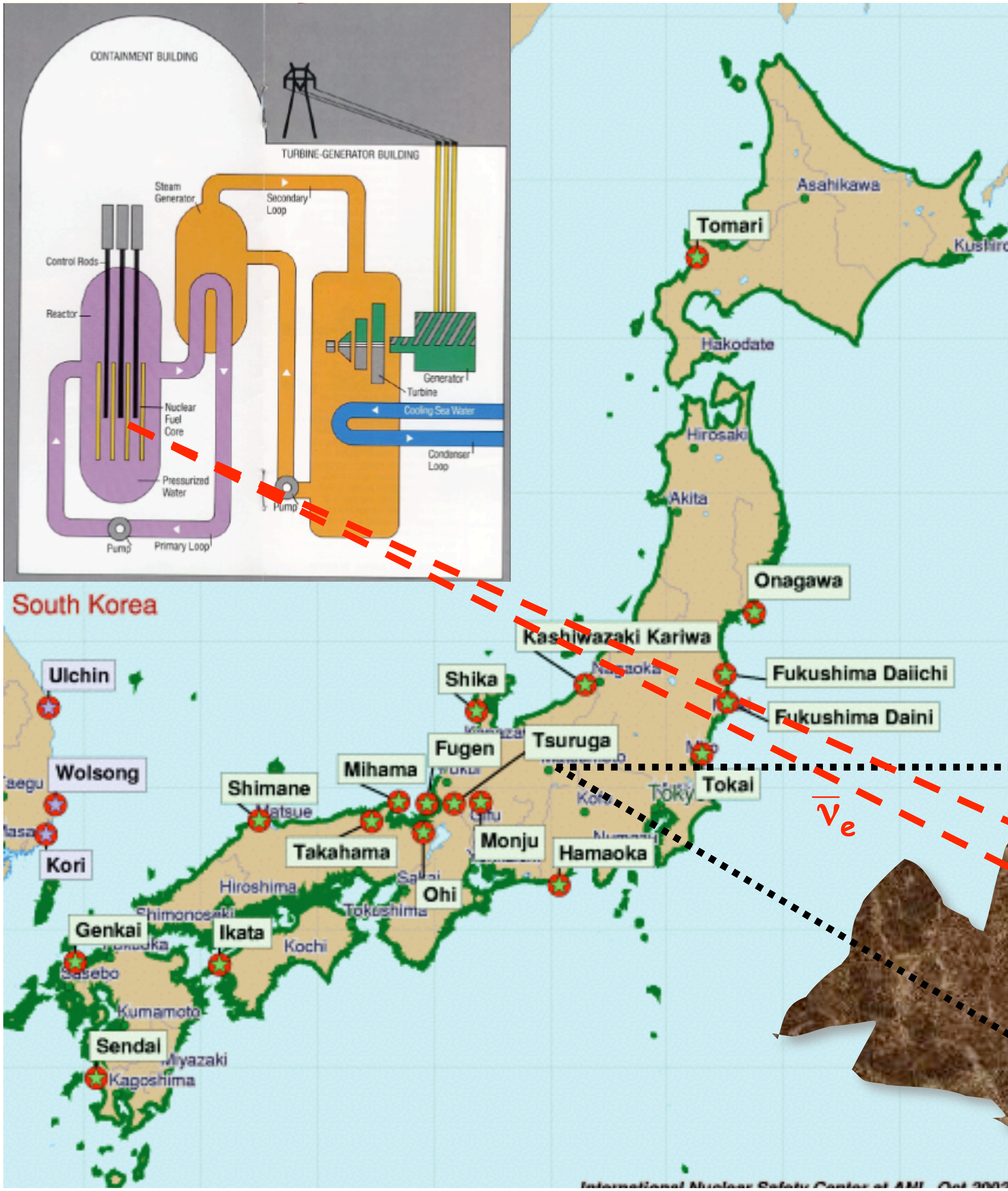


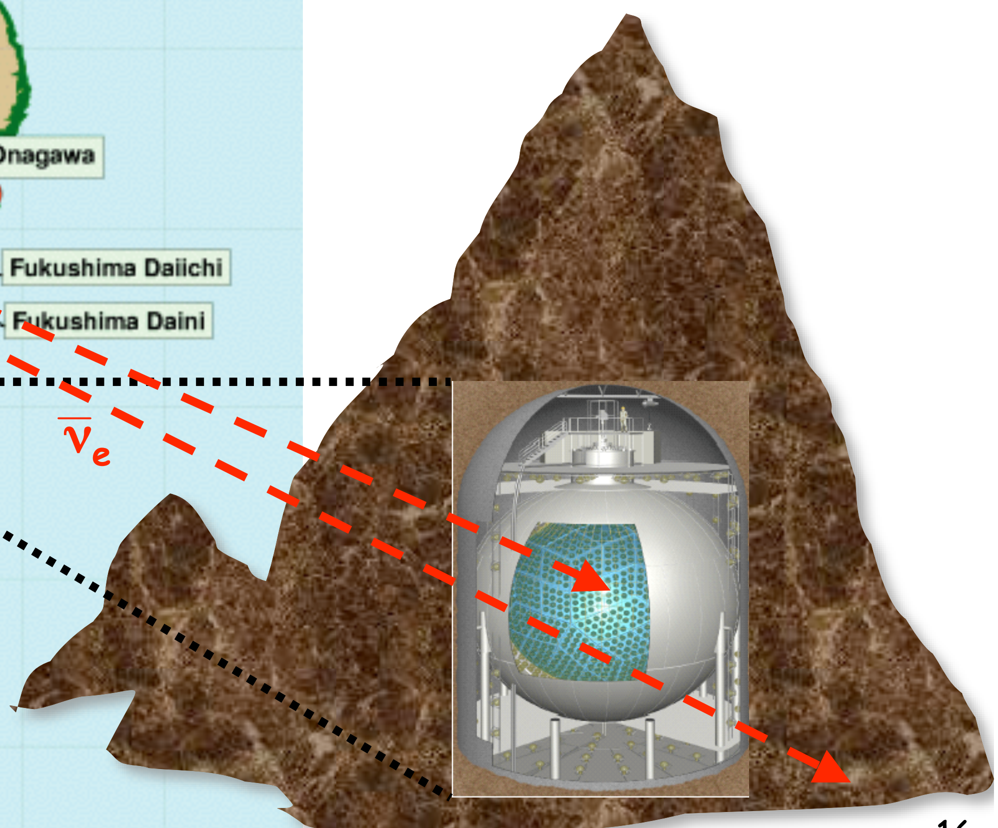




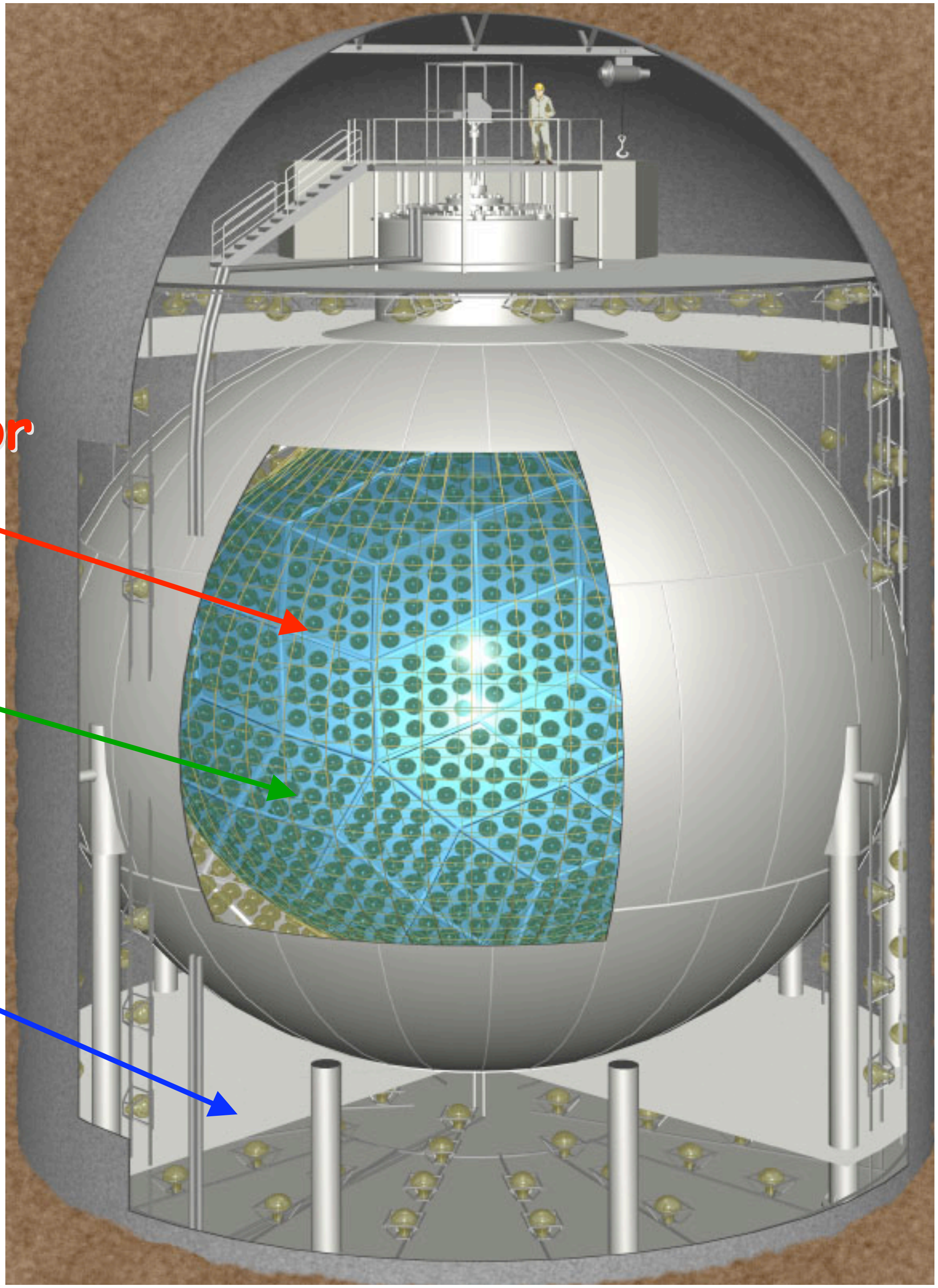
ν_e
e
W
p
d
p
ϕ_{ES}^{SNO}
ϕ_{CC}^{SNO}
ν_e, ν_μ, ν_τ
ν_e, ν_μ, ν_τ
Z
n
d
p
ϕ_{NC}^{SNO}
ϕ_{SSM}
$\phi_{\mu\tau}$ (10^6 cm^{-2} s^{-1})
ϕ_e (10^6 cm^{-2} s^{-1})
0
1
2
3
4
5
6
7
8
ν_e
e
W
e
ν_e
$\nu_{e,\mu,\tau}$
$\nu_{e,\mu,\tau}$
Z
e
e

KamLAND in Japan

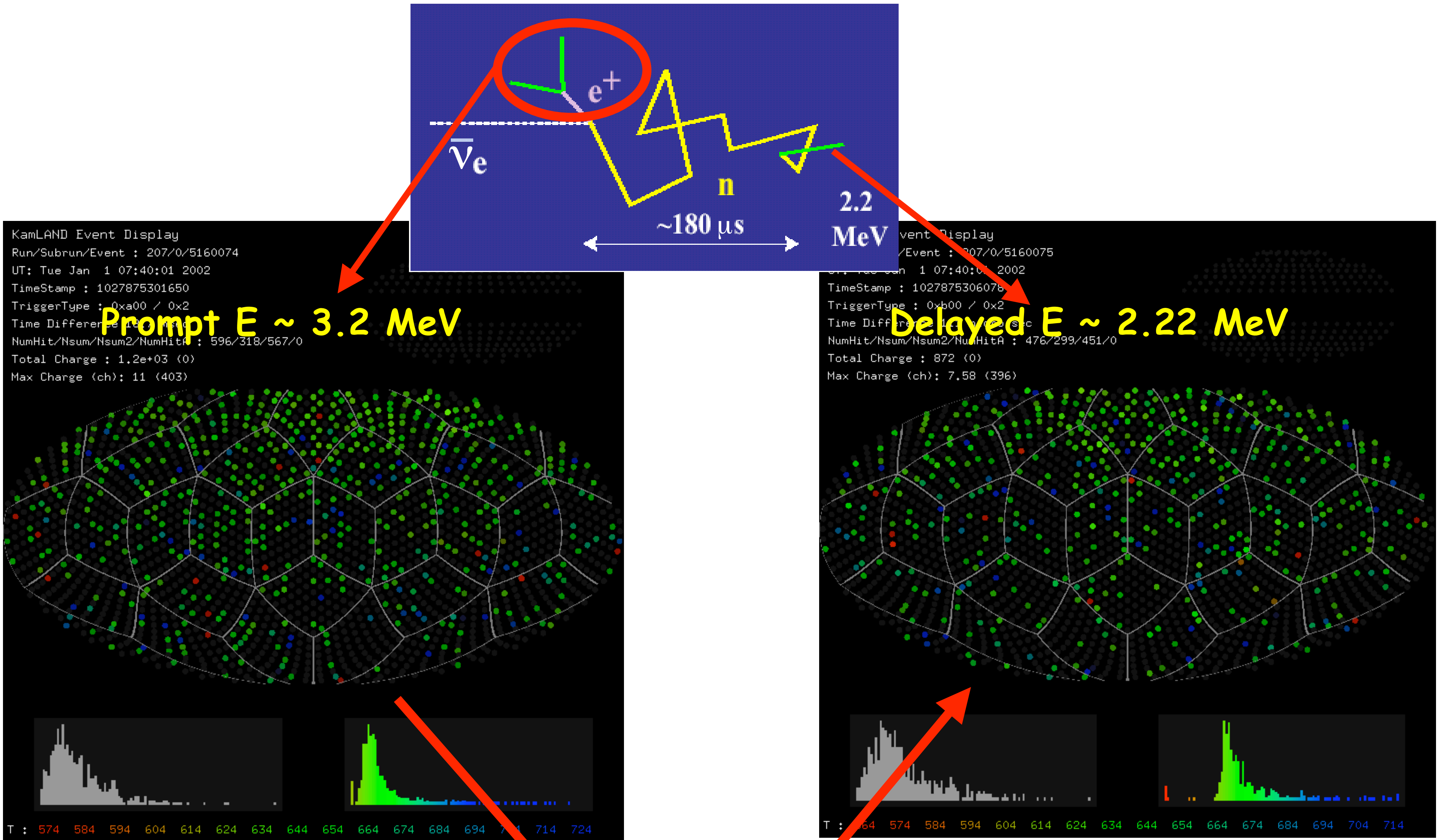




- 1 kton of liquid scintillator
- Photo-multiplier tubes
- 6 kton of pure water



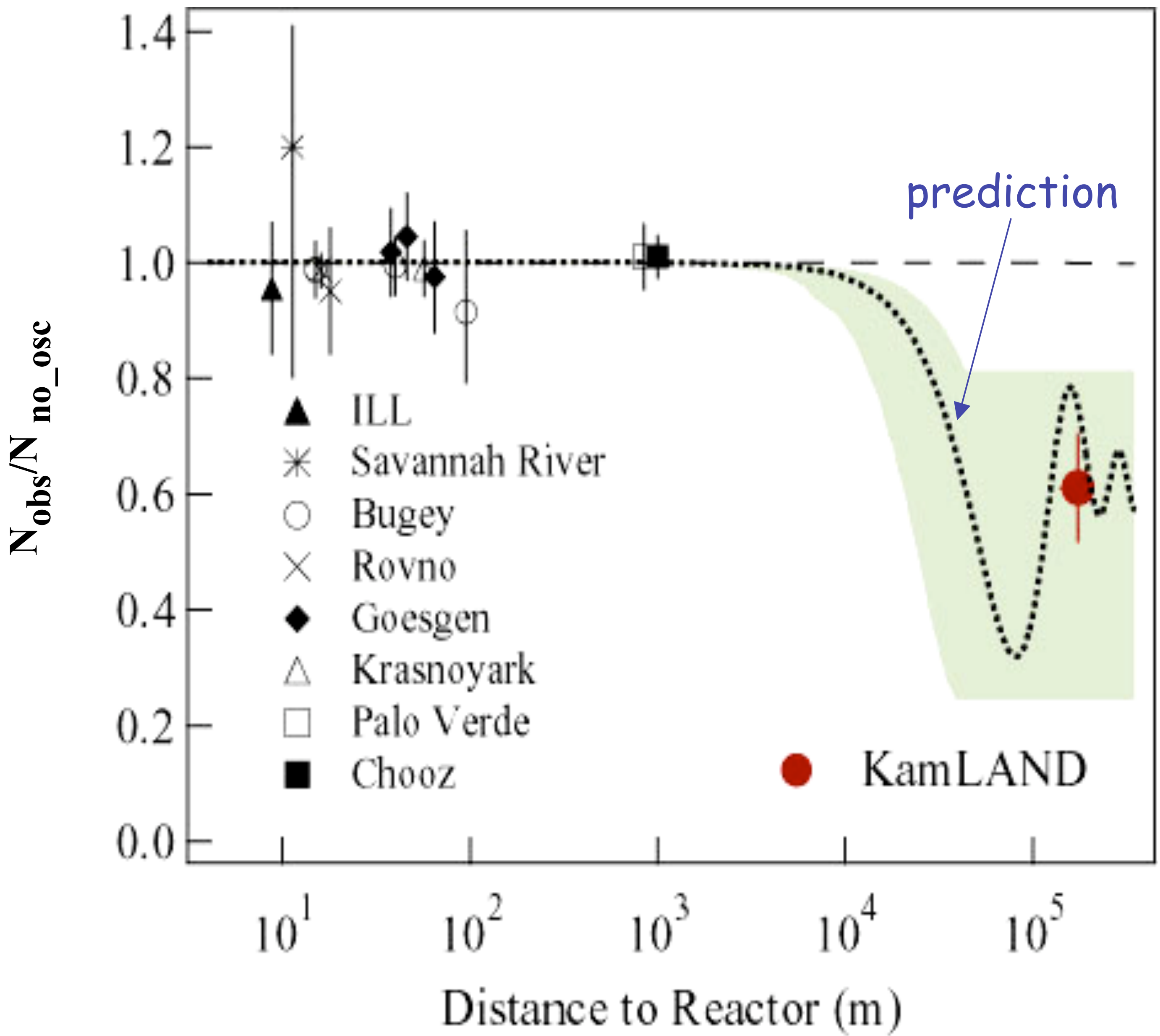
An Anti-neutrino Candidate



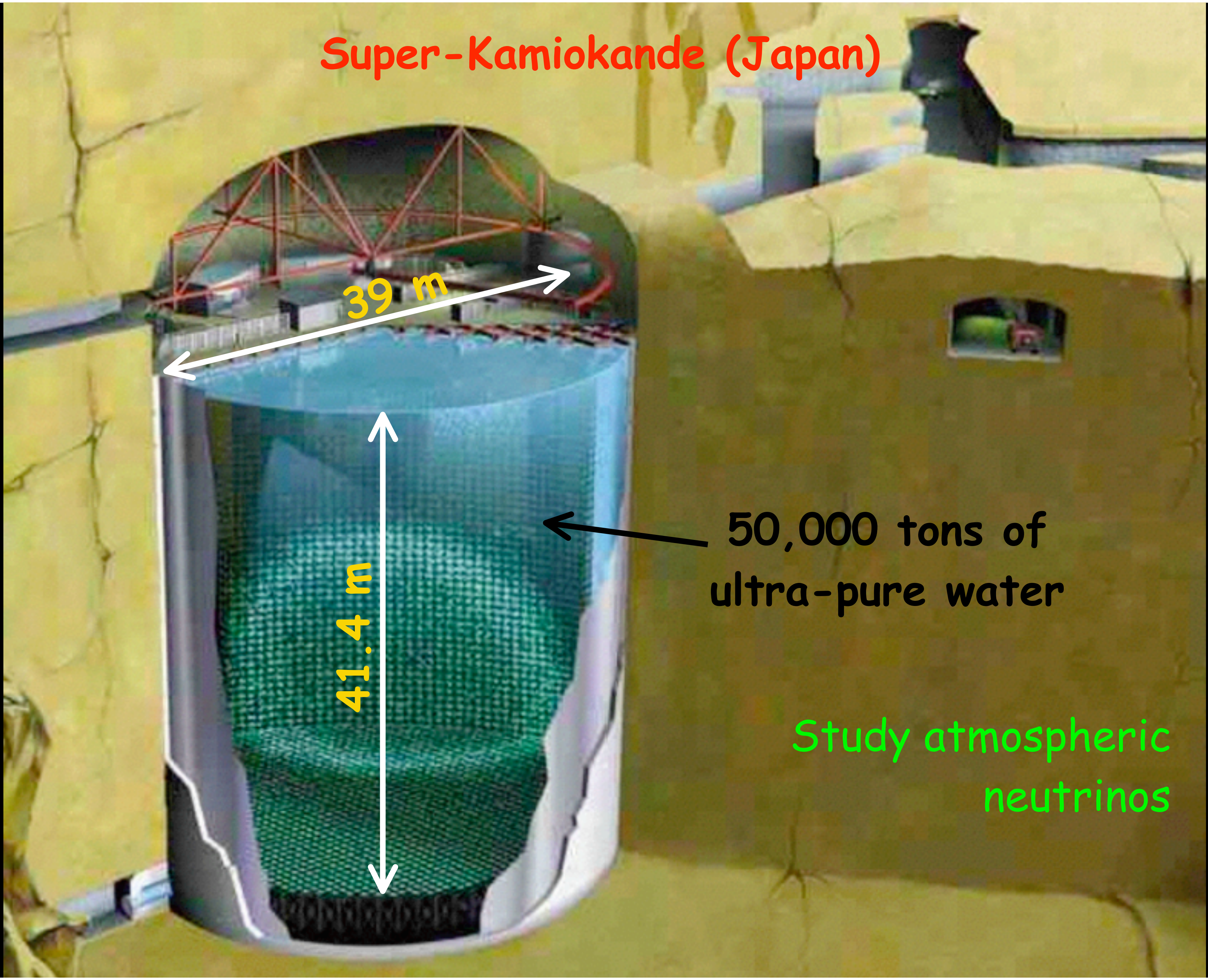
Δt~110 μs

ΔR~0.35 m

Some Reactor $\bar{\nu}$'s are missing!

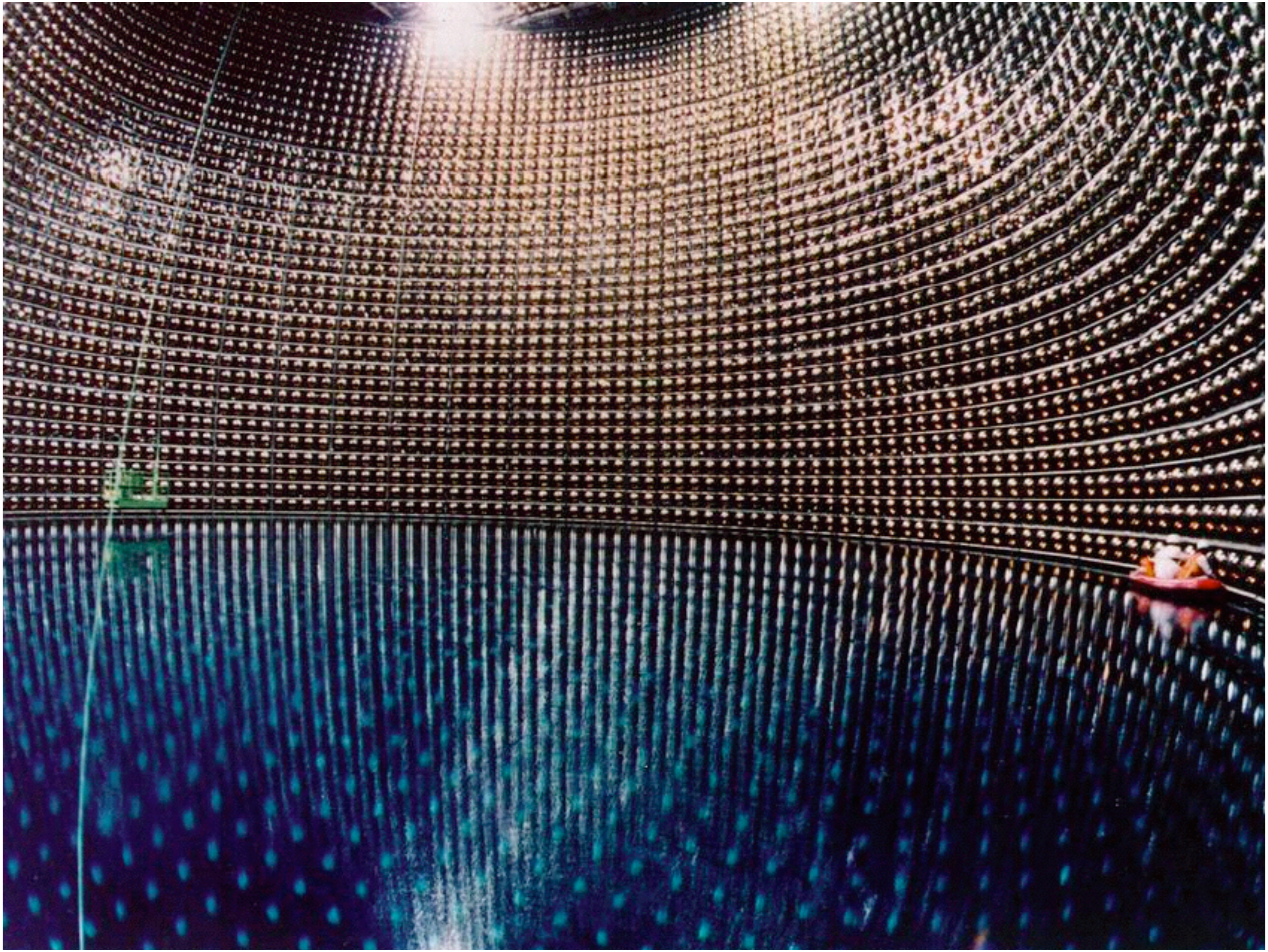


Super-Kamiokande (Japan)

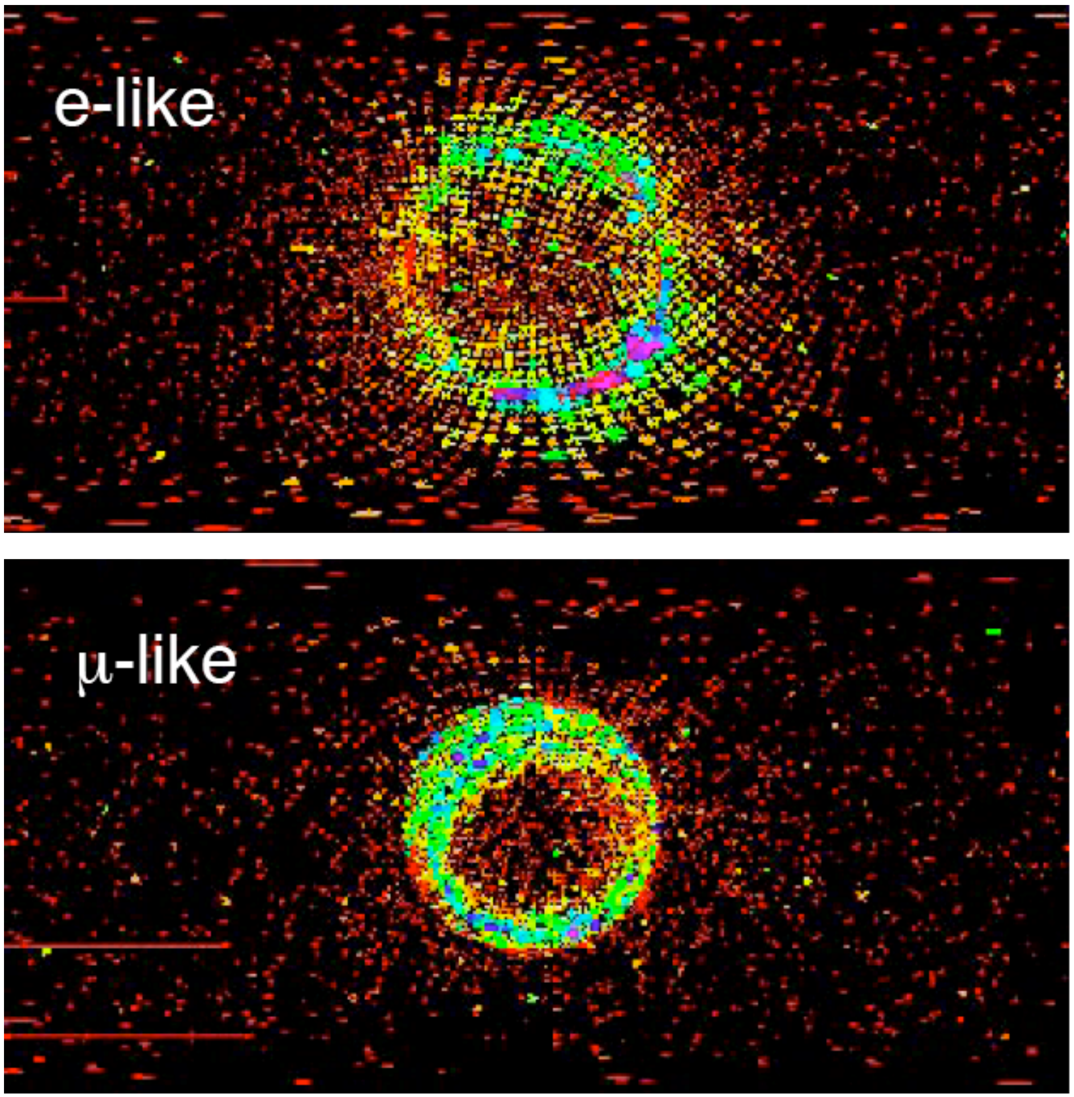


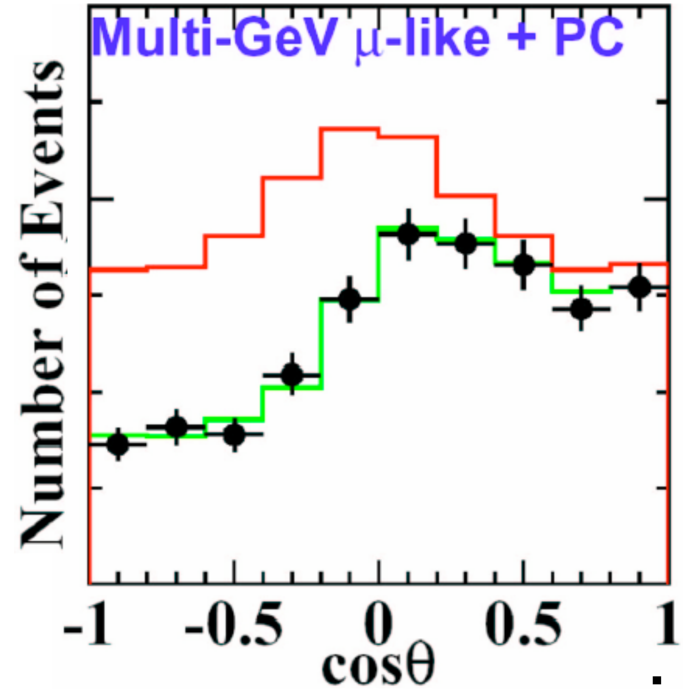
50,000 tons of ultra-pure water

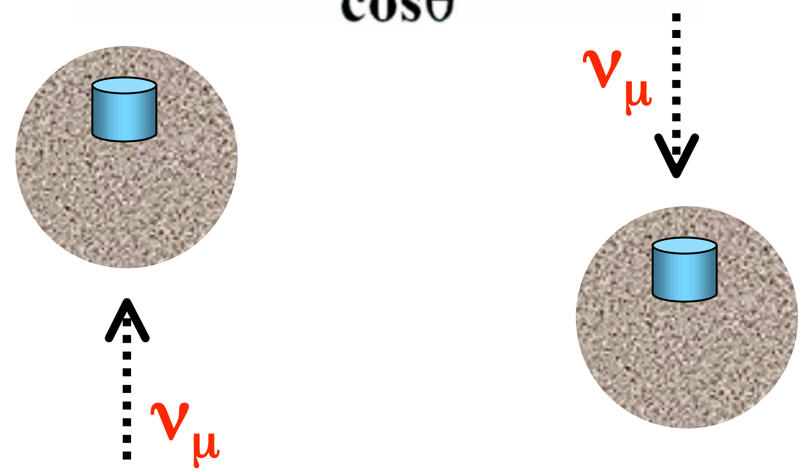
Study atmospheric neutrinos



Half of atmospheric ν_μ Is Missing!

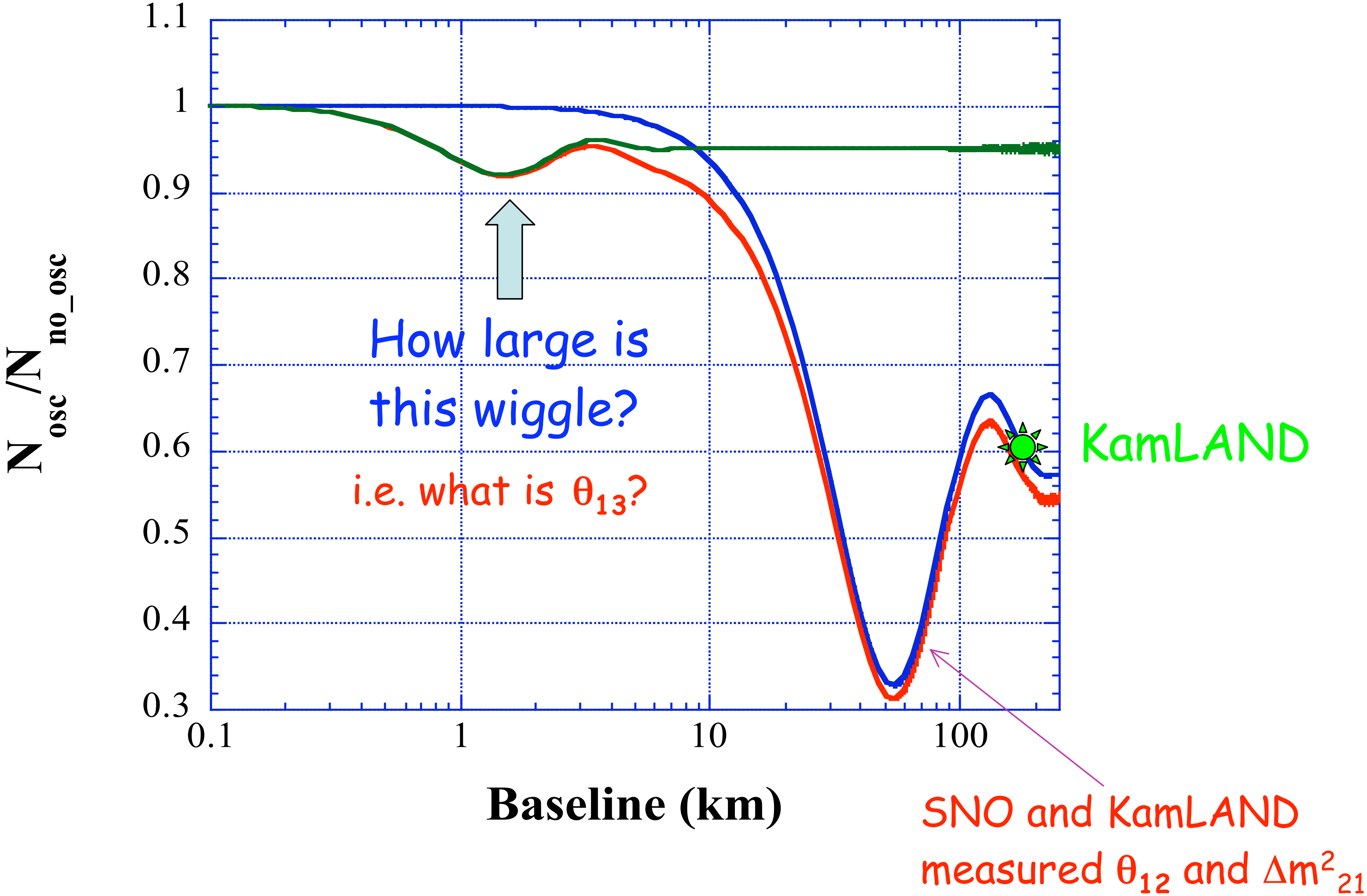






Measured θ_{23} and Δm^2_{32}

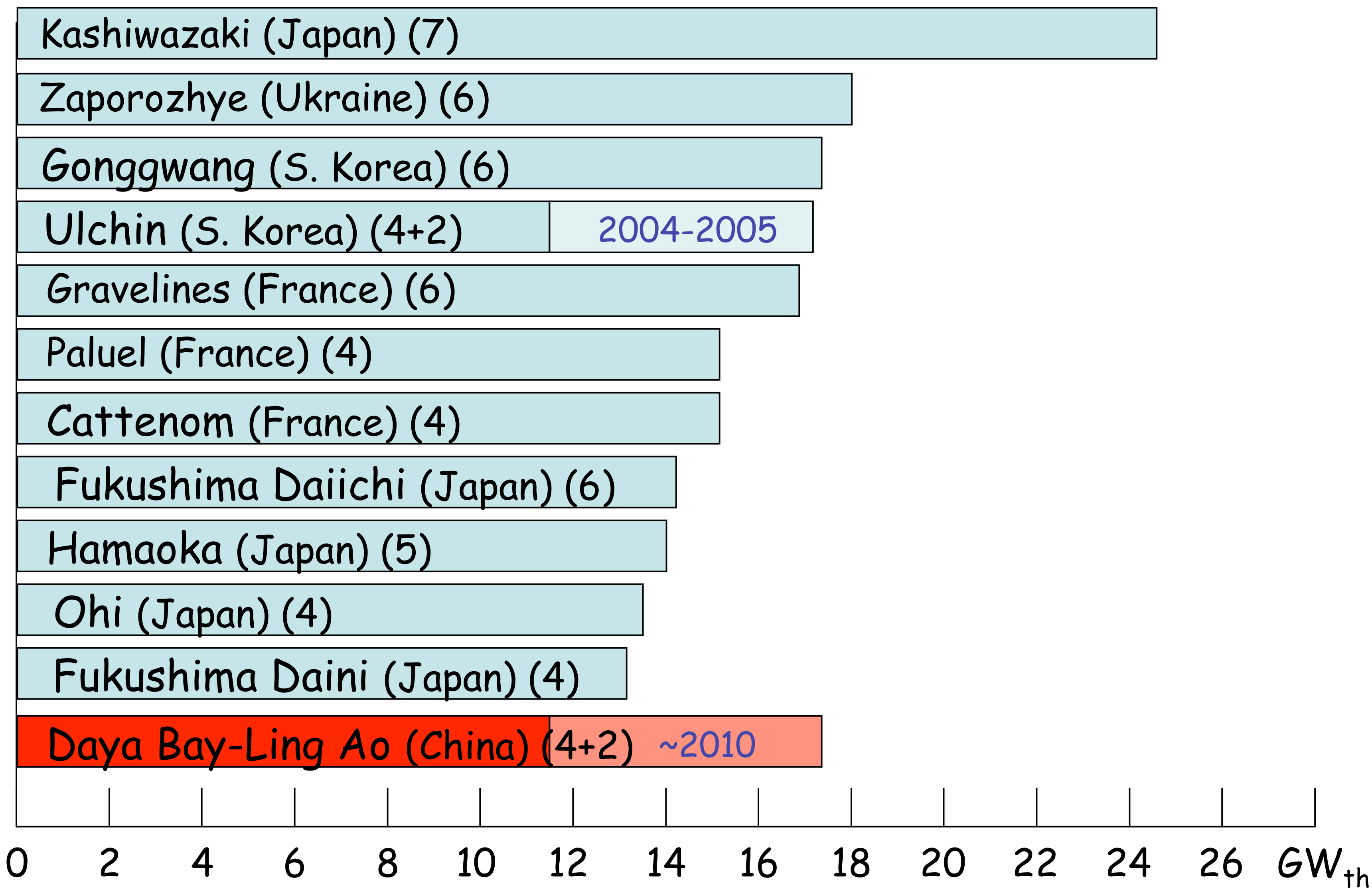
Another Kind of Neutrino Oscillation

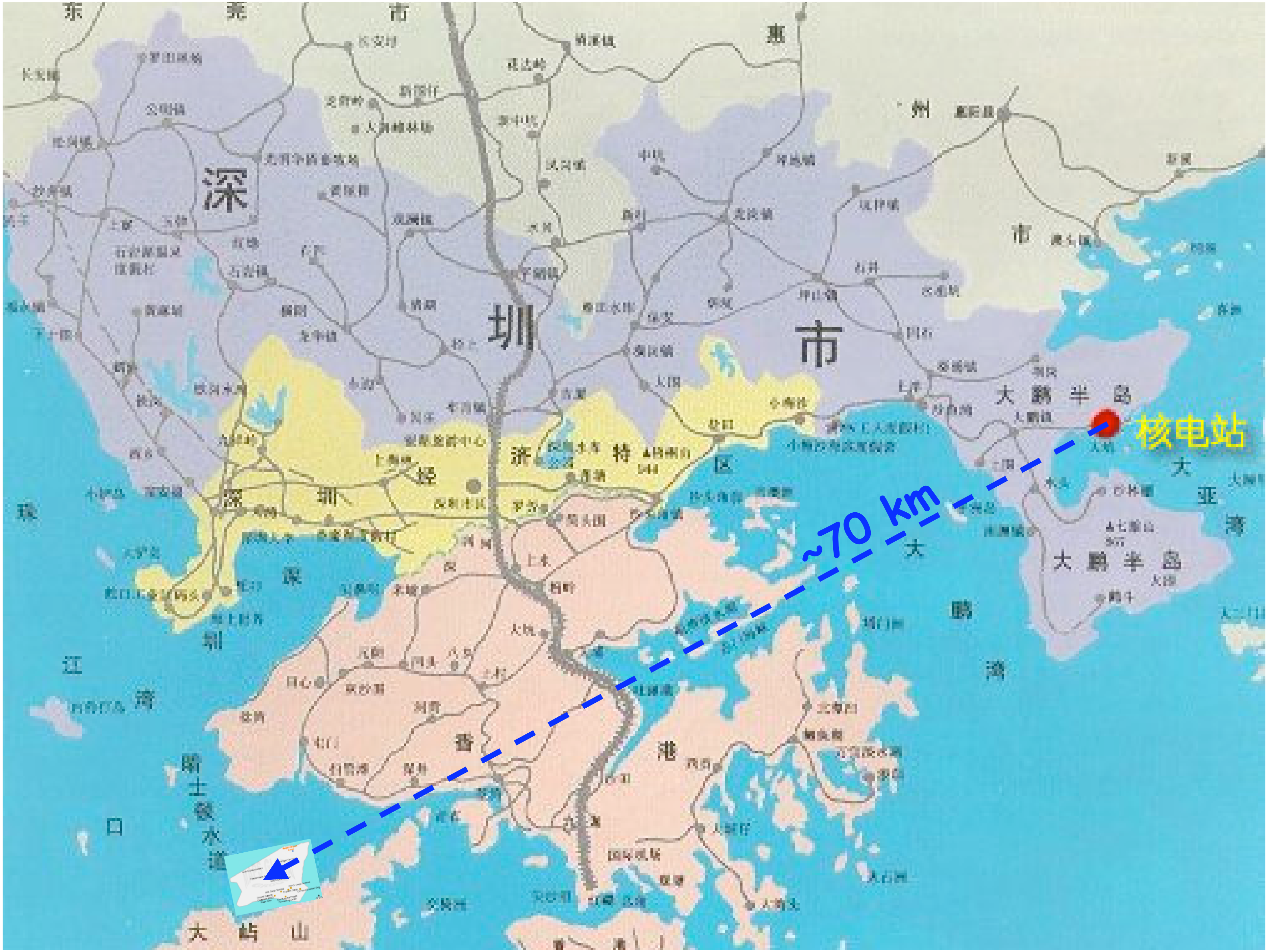


Daya Bay (China)

2+2(+2) reactors: 11.6 (17.4) GW_{th}

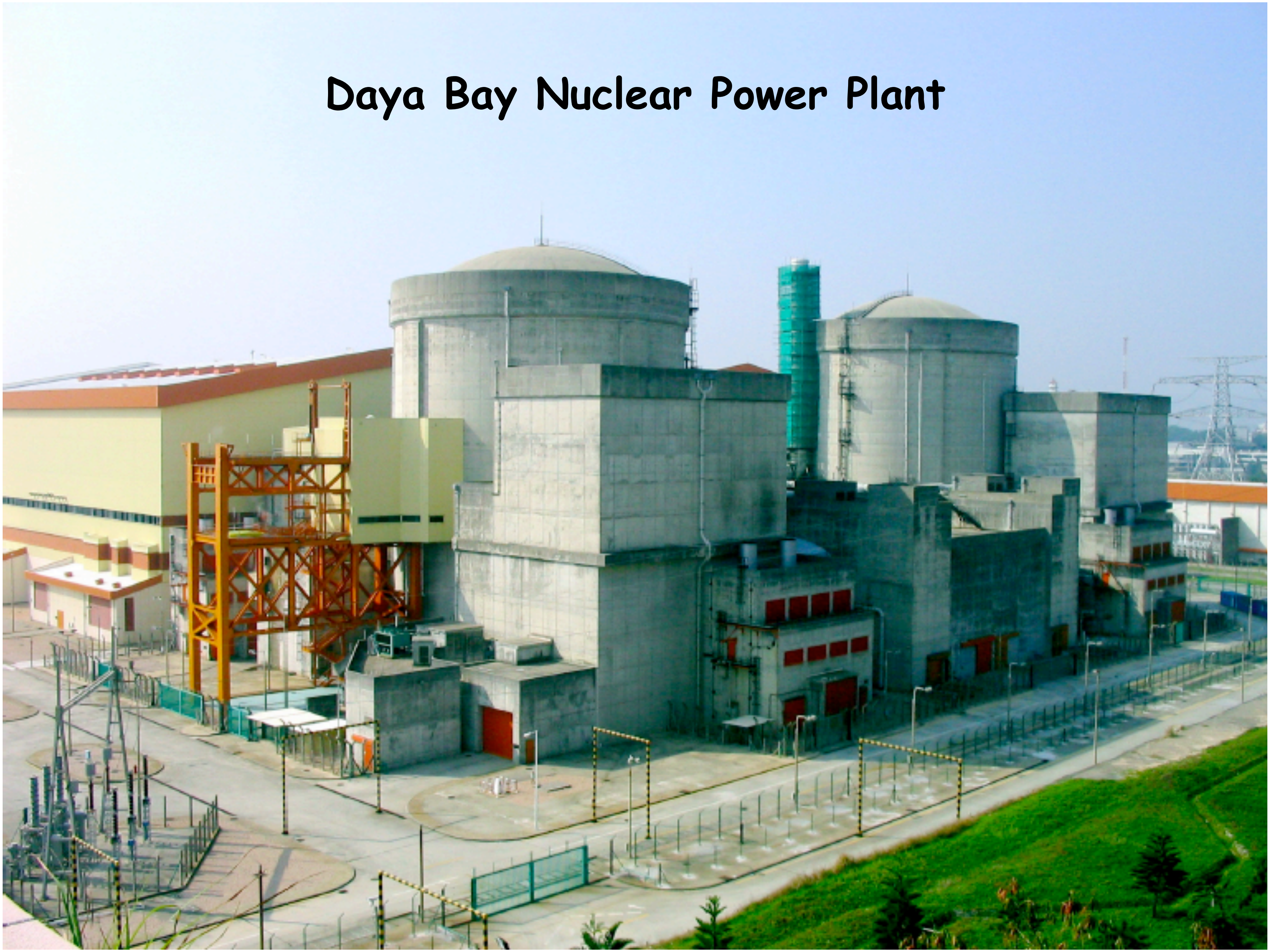
Ranking of Reactors




核电站
~70 km
深圳市
深圳经济特区
大鹏半岛
大亚湾
大鹏湾
香港
深圳湾
珠江口
东莞市
惠州市
大屿山


Far site
Mid site
Ling Ao Near
Ling Dong NPP
(under const.)
Ling Ao
NPP
Daya Bay Near
Daya Bay
NPP

Daya Bay Nuclear Power Plant




Ling Ao Nuclear Power Plant


Location of Far Detector

What Need To Be Done?

- Where should we position the detectors?
- How deep should we place the detectors underground to reduce the cosmic-ray background?
- How bad is the cosmic-ray background?
- How can we identify and remove the unwanted events?
- Can we do study the background before we start the Daya Bay experiment?
- What should be the size of the detector?
- What is the optimal design of the detector?
- What kind of materials should be used to build the detector?
- What are the properties of the liquid scintillator?

- Need to carry out a lot of calculations (Monte Carlo simulation)
- Need to carry out small-scale experiments in the laboratory and in the Aberdeen underground laboratory.

Summary

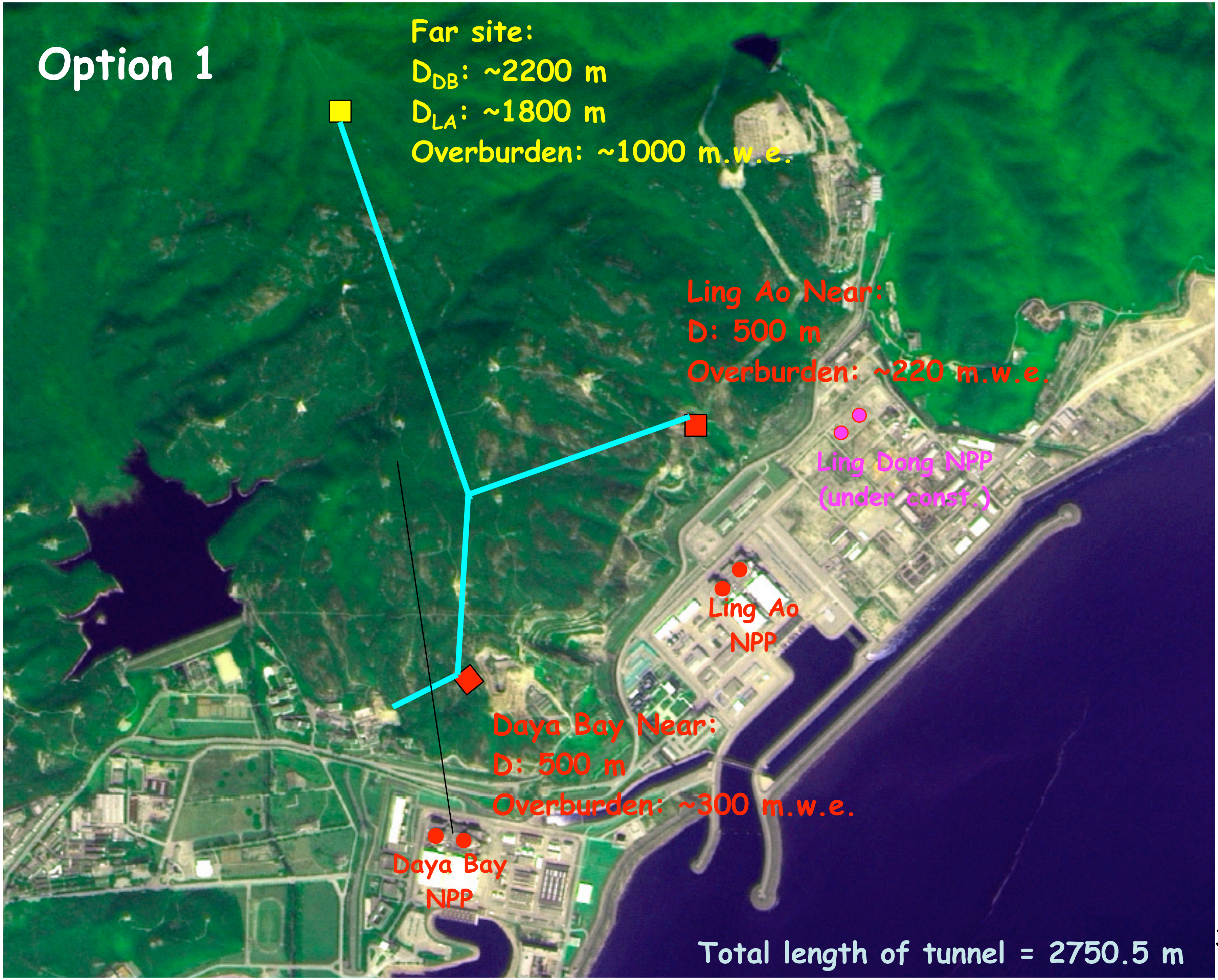
Neutrinos

- are tiny particles, a lot lighter than electrons.
- are plentiful
- are ghostly
- can change type when running in space
- are magicians, full of surprises:

What is next?

- the Daya Bay experiment will tell

Thank You


Option 1
Far site:
D_DB: ~2200 m
D_LA: ~1800 m
Overburden: ~1000 m.w.e.
Ling Ao Near:
D: 500 m
Overburden: ~220 m.w.e.
Ling Dong NPP
(under const.)
Ling Ao
NPP
Daya Bay Near:
D: 500 m
Overburden: ~300 m.w.e.
Daya Bay
NPP
Total length of tunnel = 2750.5 m