1/3 Էլեմենտար Մասնիկների Ֆիզիկա

2/3 Կոսմոլոգիա

3/3 Նյուտրինոնային Ֆիզիկա

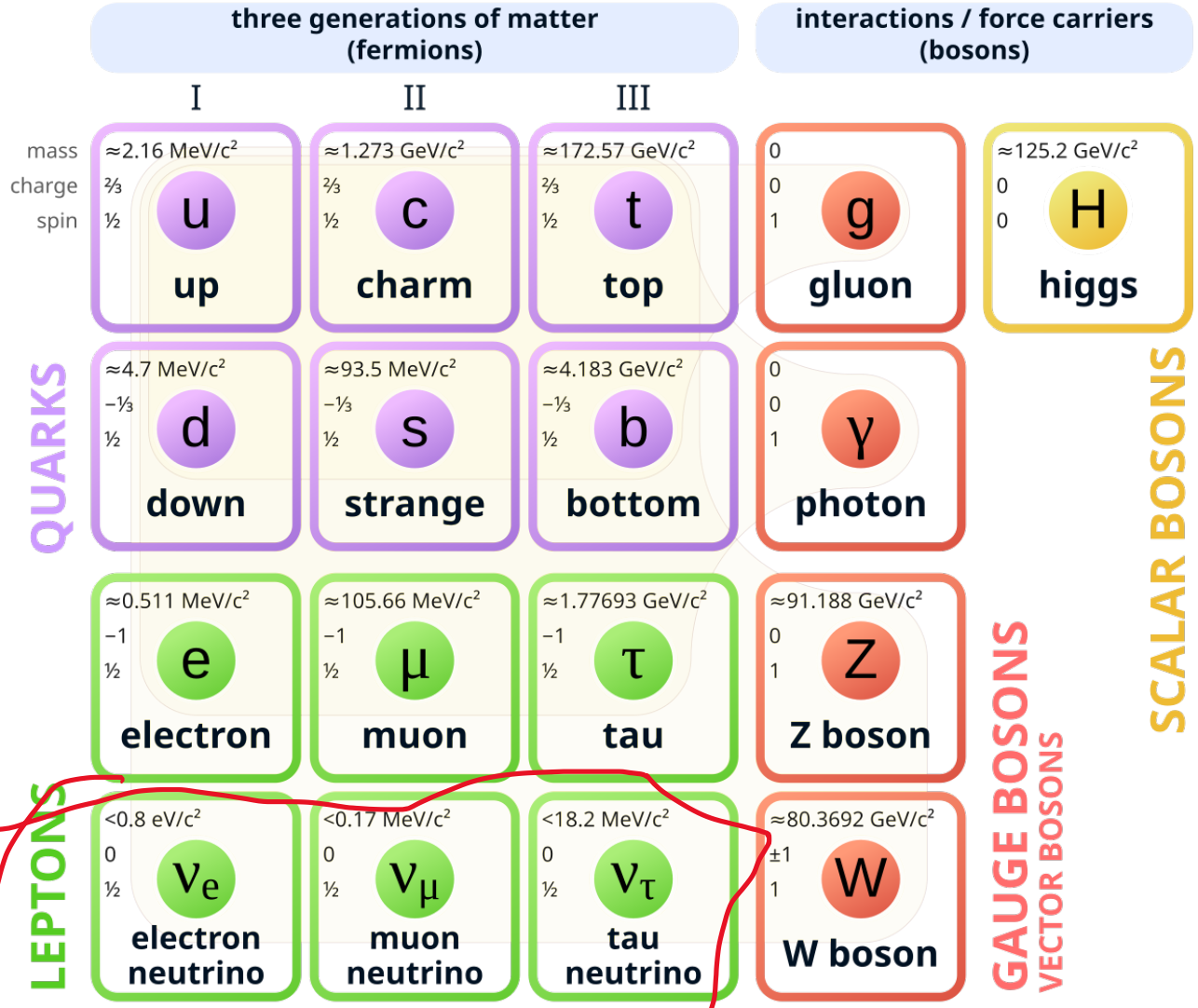
Իոաննիսյան Արա

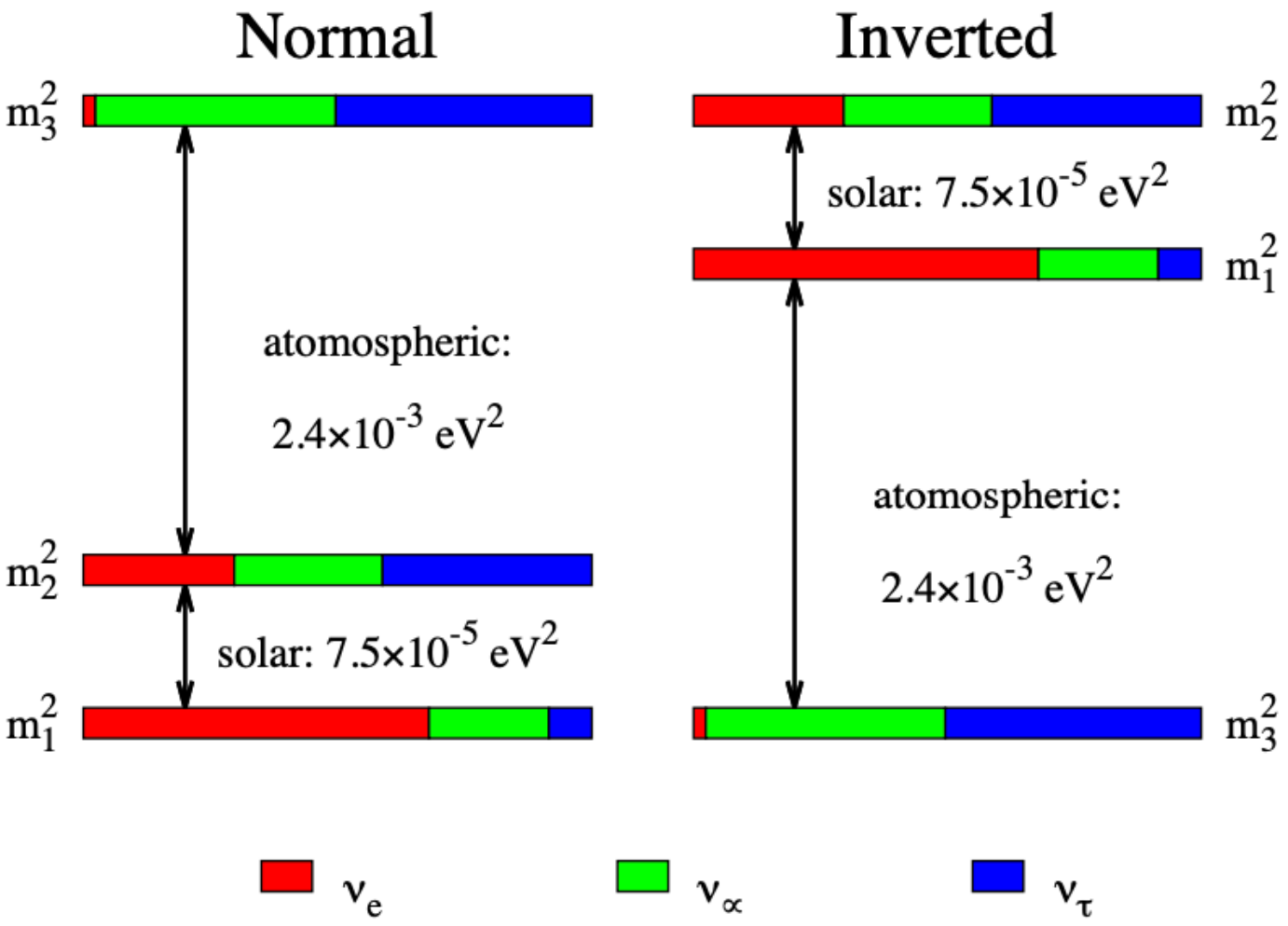
Armenian Teacher Programme CERN24

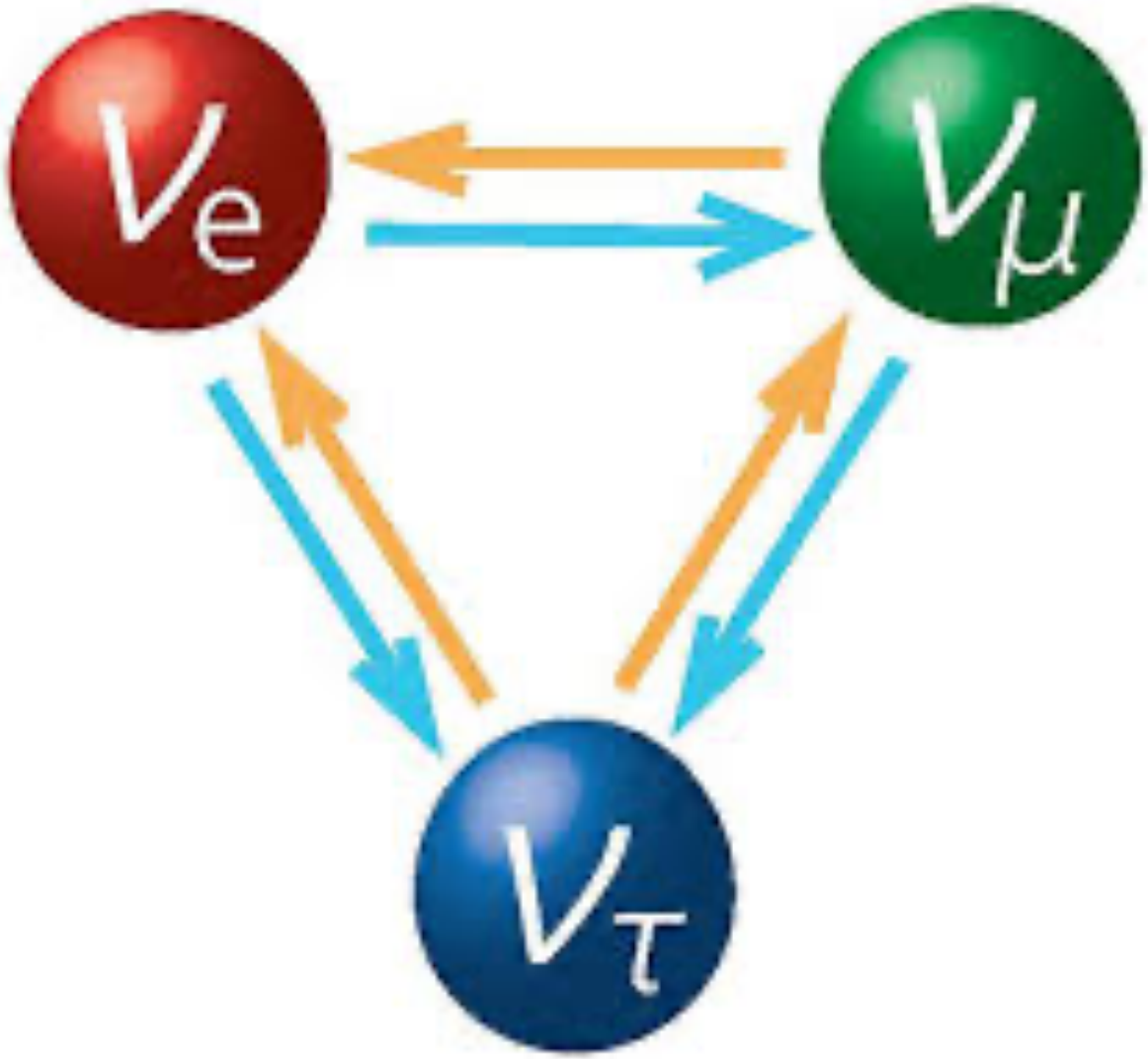
Հայաստանի Ֆիզիկայի Ուսուցիչներ CERN24

3/3 Նեյտրինոնային Ֆիզիկա

Standard Model of Elementary Particles



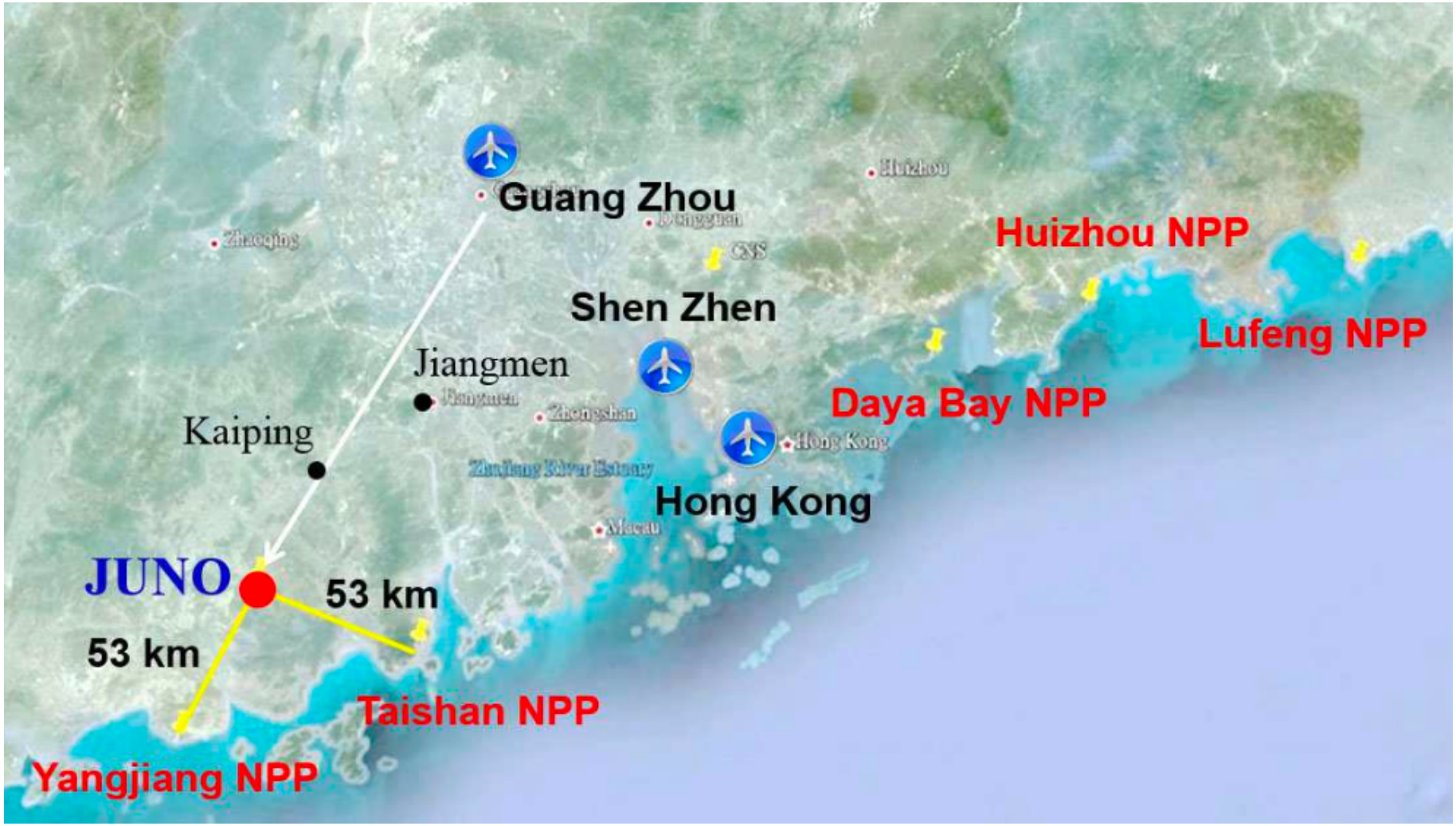

Normal
Inverted
m_3^2
m_2^2
m_1^2
atomospheric:
2.4×10^{-3} eV^2
solar: 7.5×10^{-5} eV^2
m_2^2
m_1^2
solar: 7.5×10^{-5} eV^2
atomospheric:
2.4×10^{-3} eV^2
m_3^2
ν_e
$\nu_\propto$
ν_τ


ν_e
ν_μ
ν_τ

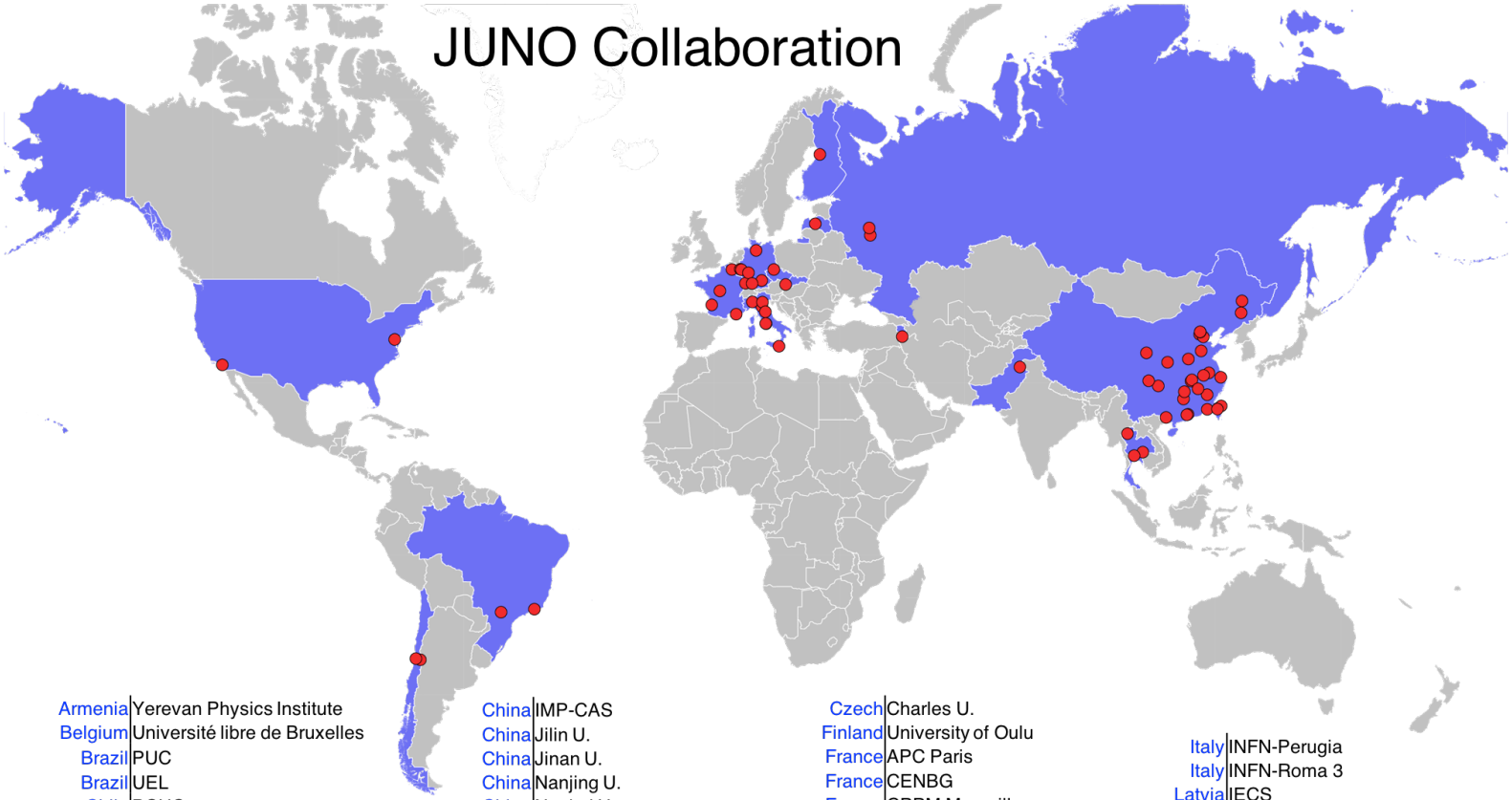
$$
\begin{bmatrix} 1 & 0 & 0 \\ 0 & c_{23} & s_{23} \\ 0 & -s_{23} & c_{23} \end{bmatrix}
\begin{bmatrix} c_{13} & 0 & s_{13}e^{-i\delta_{\mathrm{CP}}} \\ 0 & 1 & 0 \\ -s_{13}e^{i\delta_{\mathrm{CP}}} & 0 & c_{13} \end{bmatrix}
\begin{bmatrix} c_{12} & s_{12} & 0 \\ -s_{12} & c_{12} & 0 \\ 0 & 0 & 1 \end{bmatrix}
$$

$$
= \begin{bmatrix} c_{12}c_{13} & s_{12}c_{13} & s_{13}e^{-i\delta_{\mathrm{CP}}} \\ -s_{12}c_{23} - c_{12}s_{23}s_{13}e^{i\delta_{\mathrm{CP}}} & c_{12}c_{23} - s_{12}s_{23}s_{13}e^{i\delta_{\mathrm{CP}}} & s_{23}c_{13} \\ s_{12}s_{23} - c_{12}c_{23}s_{13}e^{i\delta_{\mathrm{CP}}} & -c_{12}s_{23} - s_{12}c_{23}s_{13}e^{i\delta_{\mathrm{CP}}} & c_{23}c_{13} \end{bmatrix}
$$

$$
\begin{aligned}
\theta_{12} &= 33.41^\circ {}^{+0.75^\circ}_{-0.72^\circ} \\
\theta_{23} &= 49.1^\circ {}^{+1.0^\circ}_{-1.3^\circ} \\
\theta_{13} &= 8.54^\circ {}^{+0.11^\circ}_{-0.12^\circ} \\
\delta_{\mathrm{CP}} &= 197^\circ {}^{+42^\circ}_{-25^\circ}
\end{aligned}
$$


Guang Zhou
Huizhou
Huizhou NPP
Shen Zhen
Lufeng NPP
Jiangmen
Daya Bay NPP
Kaiping
Hong Kong
Hong Kong
JUNO
53 km
53 km
Taishan NPP
Yangjiang NPP

JUNO Collaboration



Armenia	Yerevan Physics Institute
Belgium	Université libre de Bruxelles
Brazil	PUC
Brazil	UEL
Chile	PCUC
Chile	UTFSM
China	BISEE
China	Beijing Normal U.
China	CAGS
China	ChongQing University
China	CIAE
China	CUG
China	DGUT
China	ECUST
China	ECUT
China	Guangxi U.
China	Harbin Institute of Technology
China	IGG
China	IGGCAS
China	IHEP
China	IMP-CAS
China	Jilin U.
China	Jinan U.
China	Nanjing U.
China	Nankai U.
China	NCEPU
China	NUDT
China	Peking U.
China	Shandong U.
China	Shanghai JT U.
China	SYSU
China	Tsinghua U.
China	UCAS
China	USTC
China	U. of South China
China	Wu Yi U.
China	Wuhan U.
China	Xi'an JT U.
China	Xiamen University
China	Zhengzhou U.
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France	CPPM Marseille
France	IPHC Strasbourg
France	Subatech Nantes
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Germany	TUM
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Germany	IKP FZ Jülich
Germany	U. Mainz
Germany	U. Tuebingen
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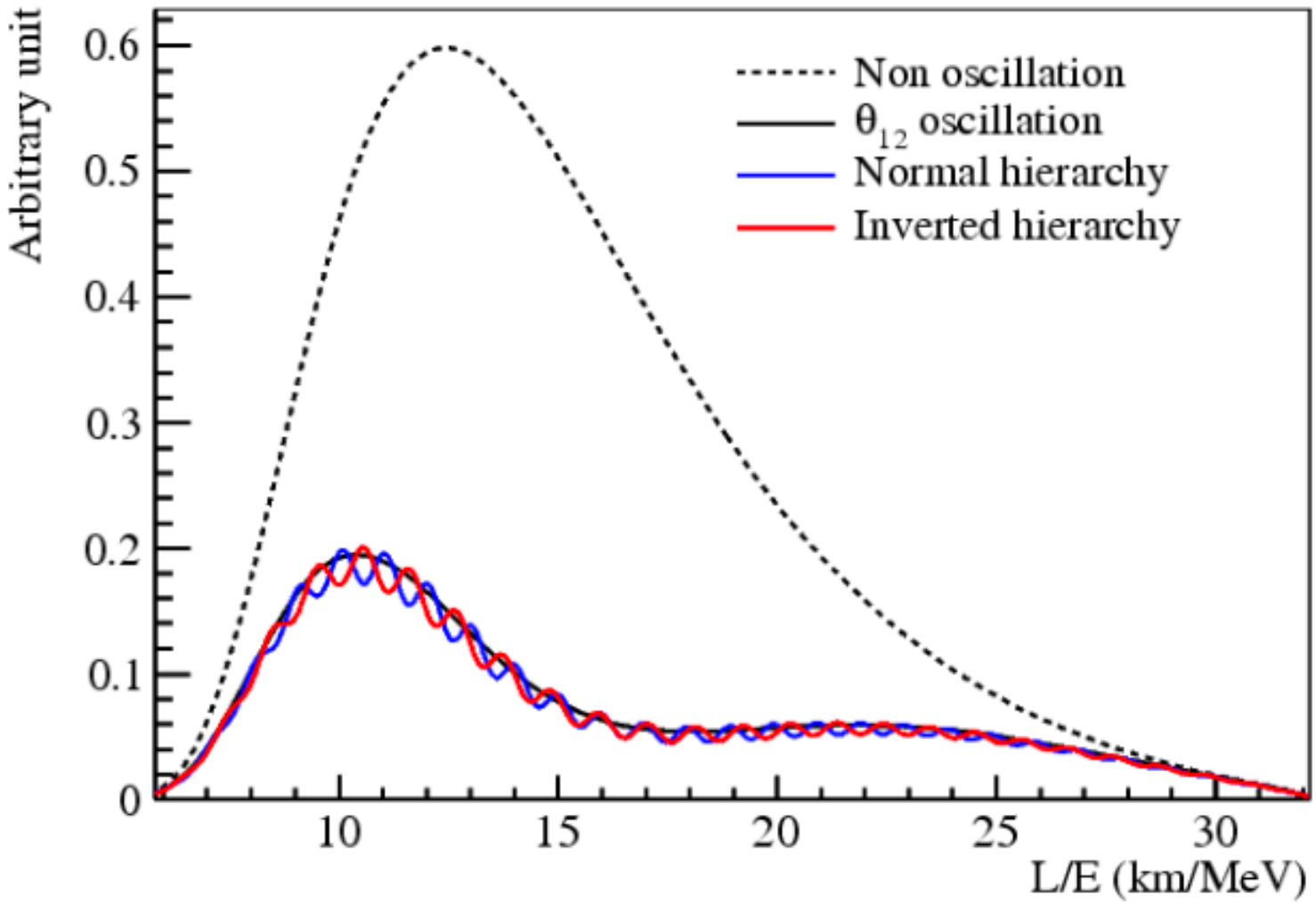
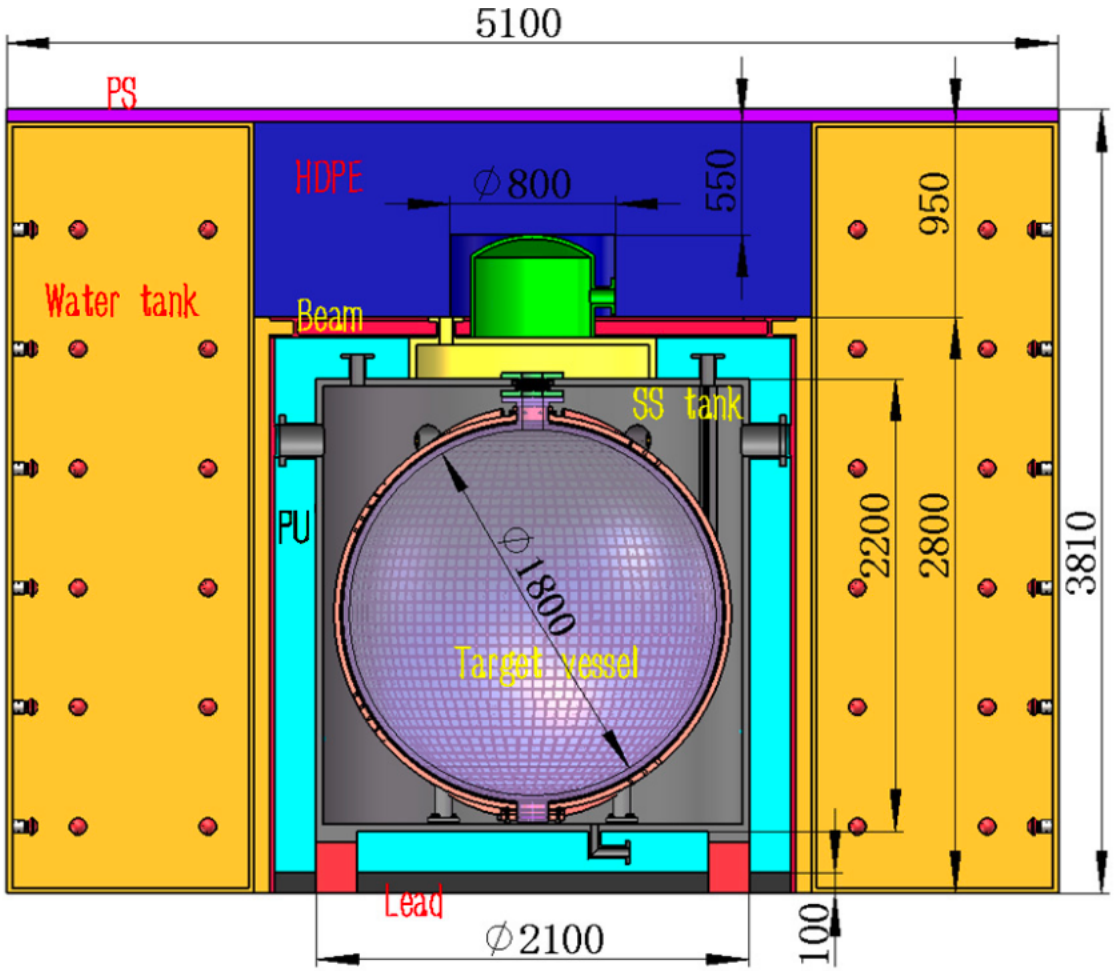
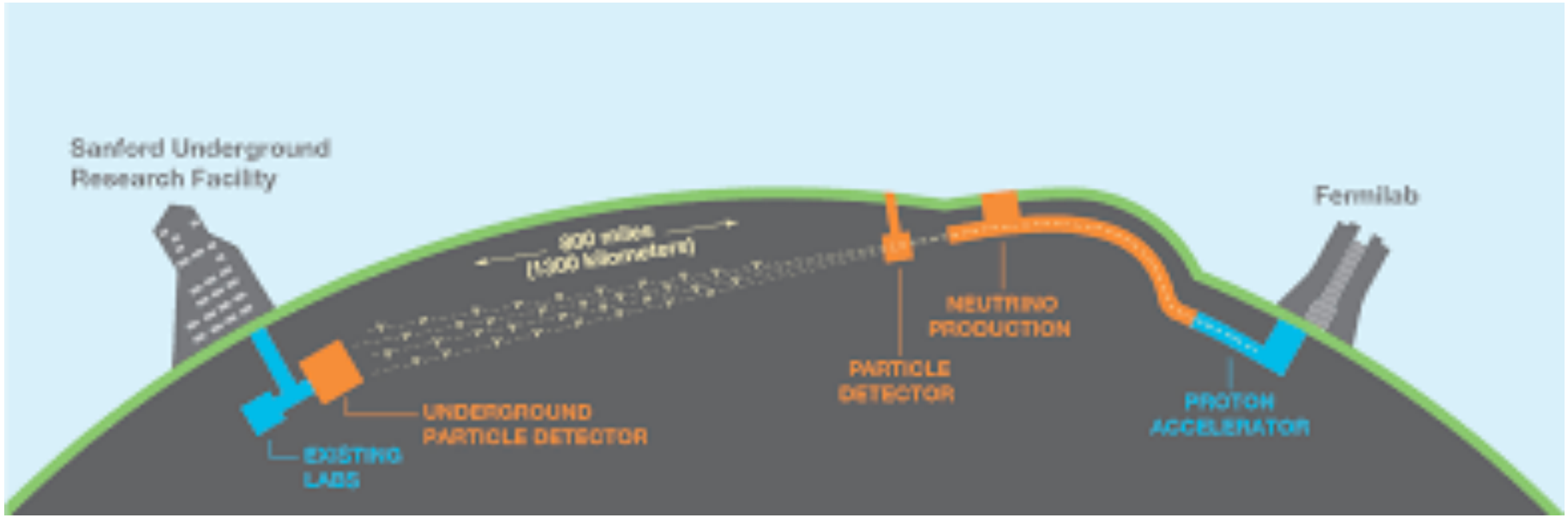
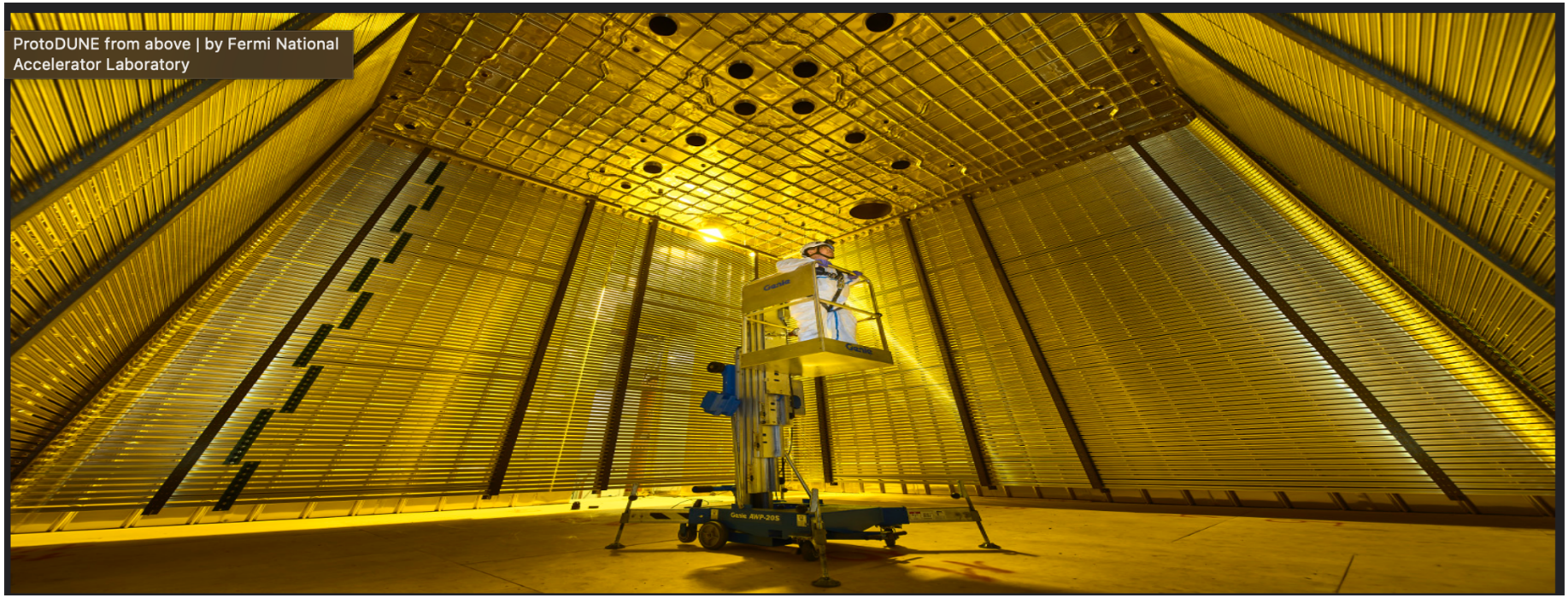
Italy	INFN-Ferrara
Italy	INFN-Milano
Italy	INFN-Milano Bicocca
Italy	INFN-Padova
Italy	INFN-Perugia
Italy	INFN-Roma 3
Latvia	IECS
Pakistan	PINSTECH (PAEC)
Russia	INR Moscow
Russia	JINR
Russia	MSU
Slovakia	FMPICU
Taiwan	National Chiao-Tung U.
Taiwan	National Taiwan U.
Taiwan	National United U.
Thailand	NARIT
Thailand	PPRLCU
Thailand	SUT
USA	UMD1
USA	UMD2
USA	UCI

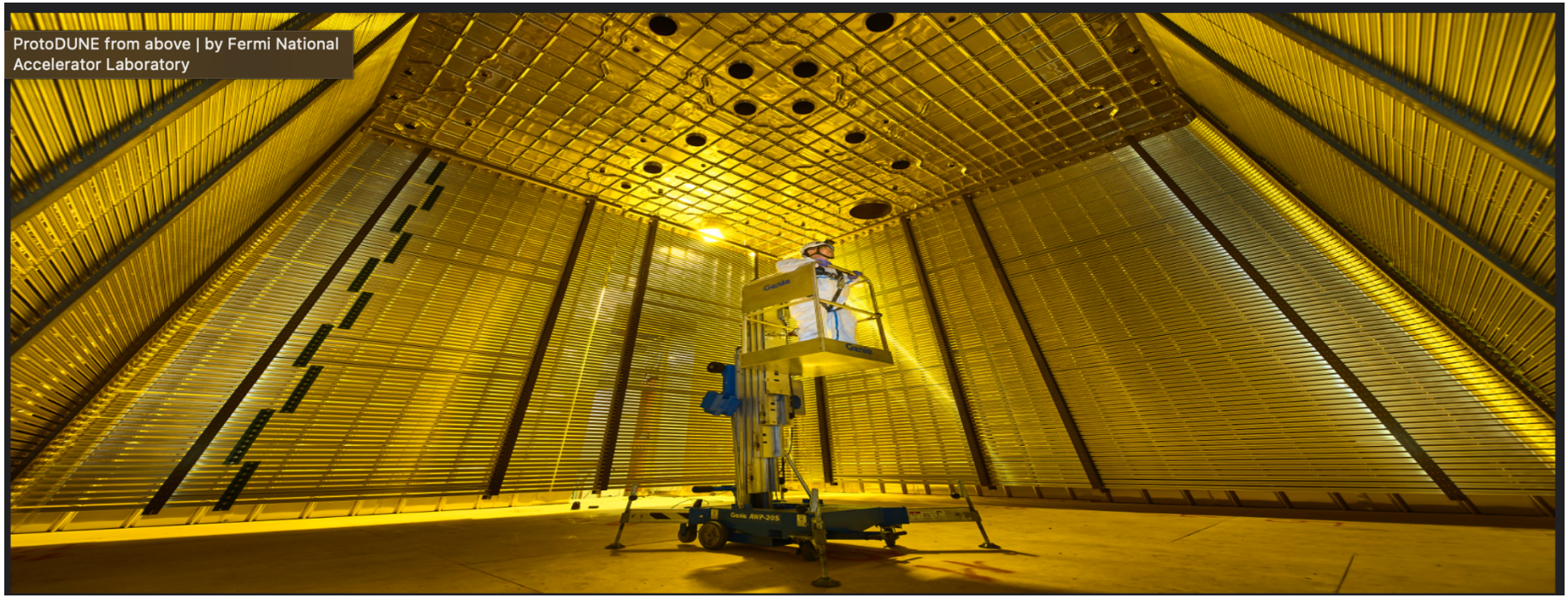

Arbitrary unit
0.6
0.5
0.4
0.3
0.2
0.1
0
10
15
20
25
30
L/E (km/MeV)
Non oscillation
θ12 oscillation
Normal hierarchy
Inverted hierarchy

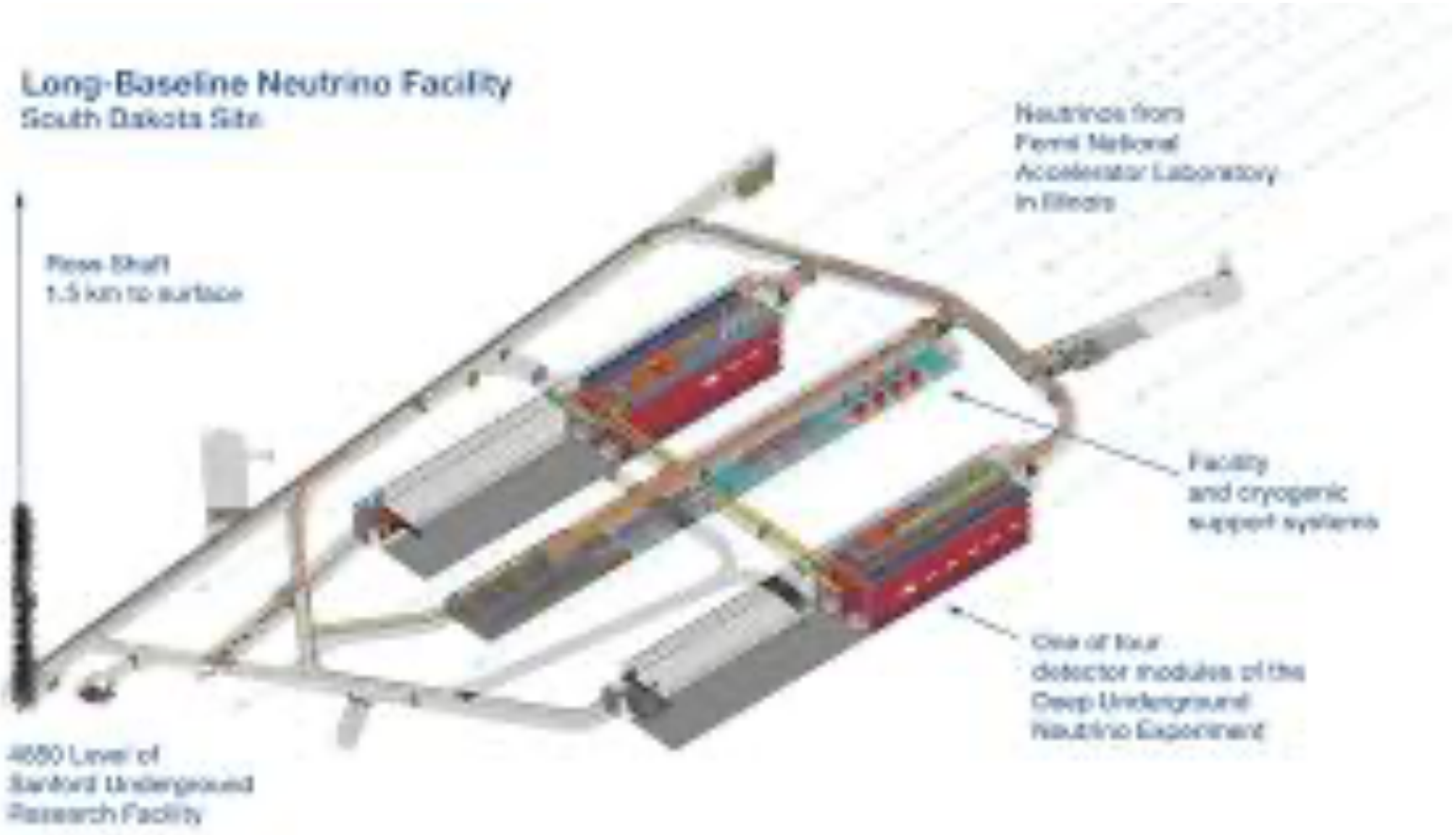

5100
PS
HDPE
∅800
550
950
Water tank
Beam
SS tank
PU
∅1800
Target vessel
2200
2800
3810
Lead
∅2100
100

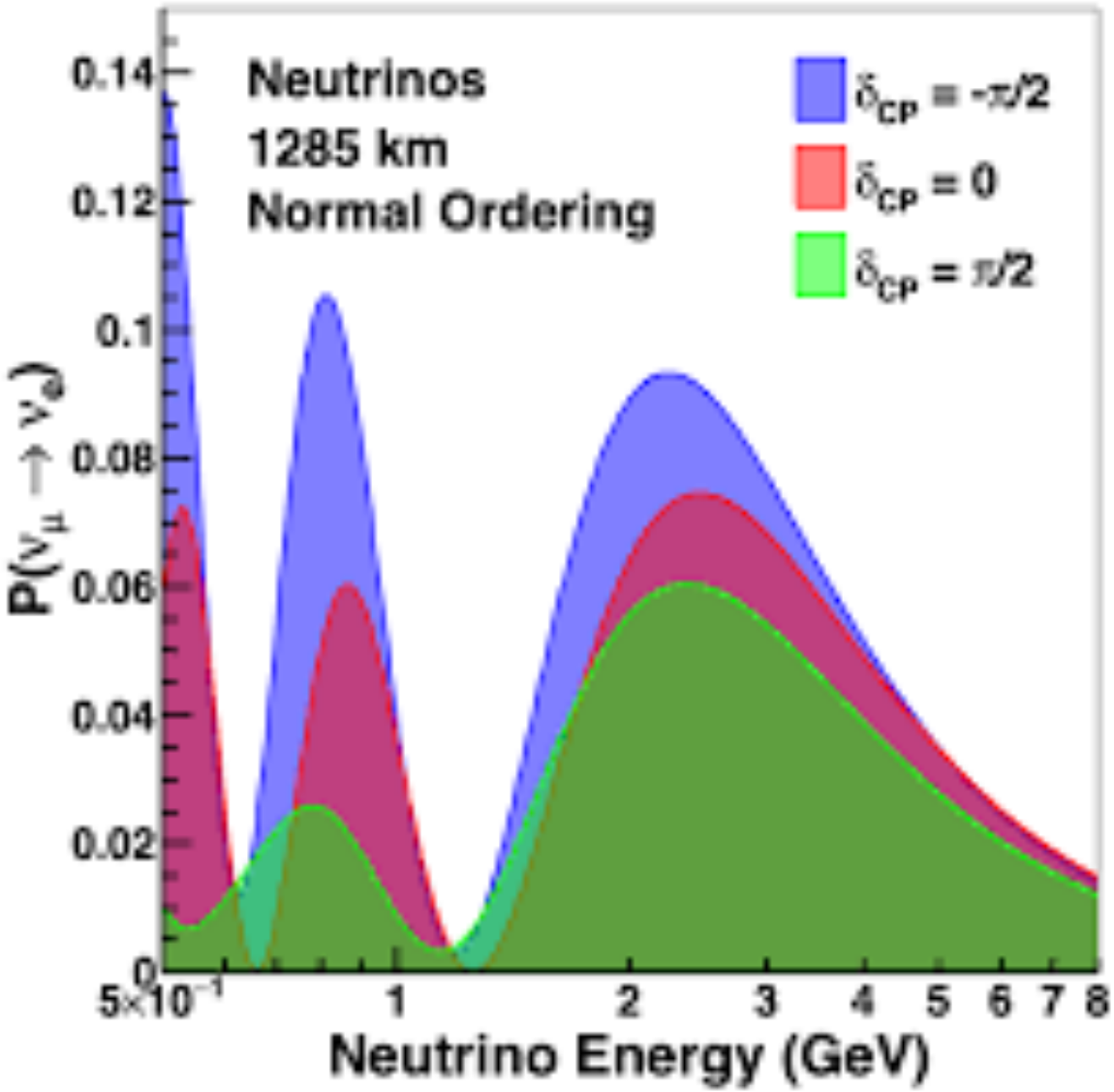

DUNE
DEEP UNDERGROUND
NEUTRINO EXPERIMENT


Sanford Underground
Research Facility
Fermilab
800 miles
(1,300 kilometers)
NEUTRINO
PRODUCTION
PARTICLE
DETECTOR
PROTON
ACCELERATOR
UNDERGROUND
PARTICLE DETECTOR
EXISTING
LABS


ProtoDUNE from above | by Fermi National Accelerator Laboratory

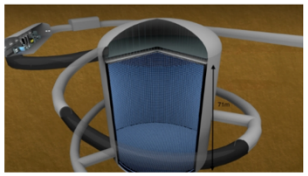

ProtoDUNE from above | by Fermi National Accelerator Laboratory


Long-Baseline Neutrino Facility
South Dakota Site
Neutrinos from
Fermi National
Accelerator Laboratory
in Illinois
Ross Shaft
1.5 km to surface
Facility
and cryogenic
support systems
One of four
detector modules of the
Deep Underground
Neutrino Experiment
4850 Level of
Sanford Underground
Research Facility

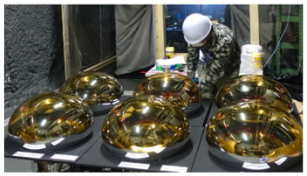

Neutrinos
1285 km
Normal Ordering
$\delta_{CP} = -\pi/2$
$\delta_{CP} = 0$
$\delta_{CP} = \pi/2$
$P(\nu_\mu \rightarrow \nu_e)$
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
5×10^{-1}
1
2
3
4
5
6
7
8
Neutrino Energy (GeV)

Hyper KamiokaNDE

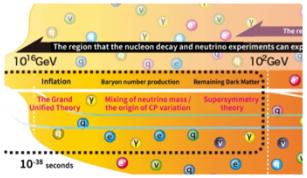
Overview



Detector



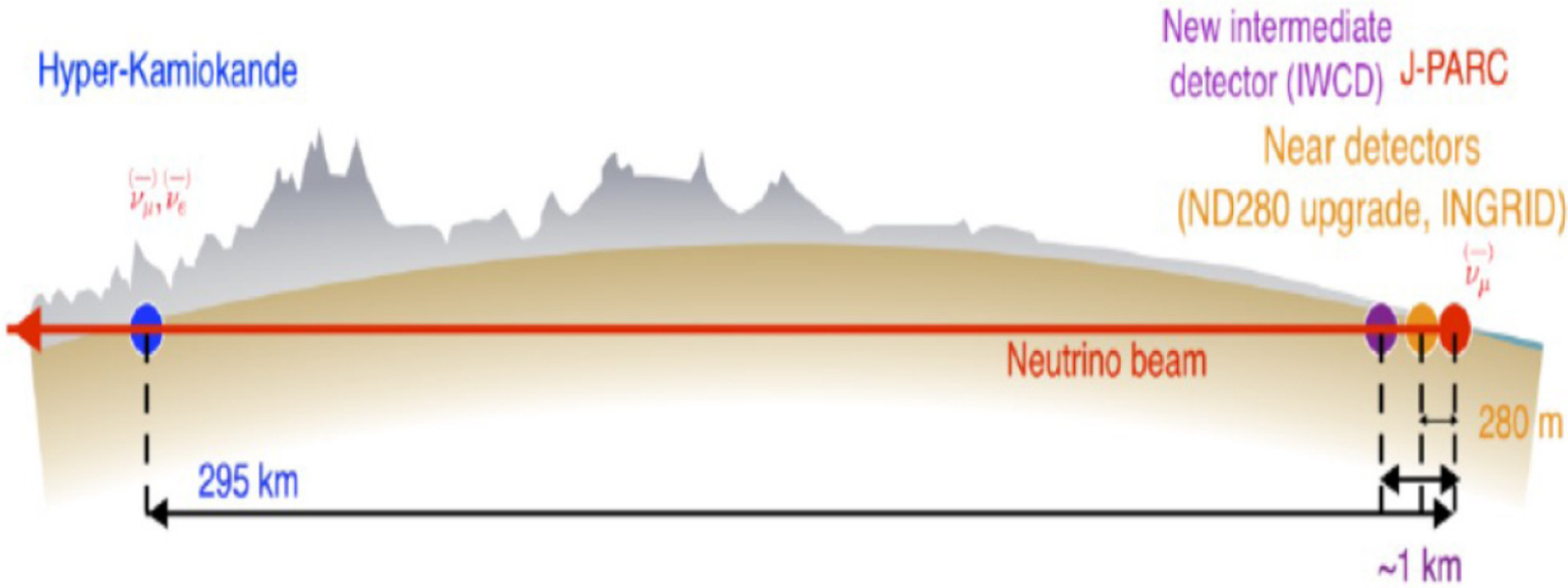
Physics



Collaboration Institutes

The next-generation project to unravel the tiny subatomic particles and the extreme universe.

Toward a next stage of neutrino research and observation of proton decay

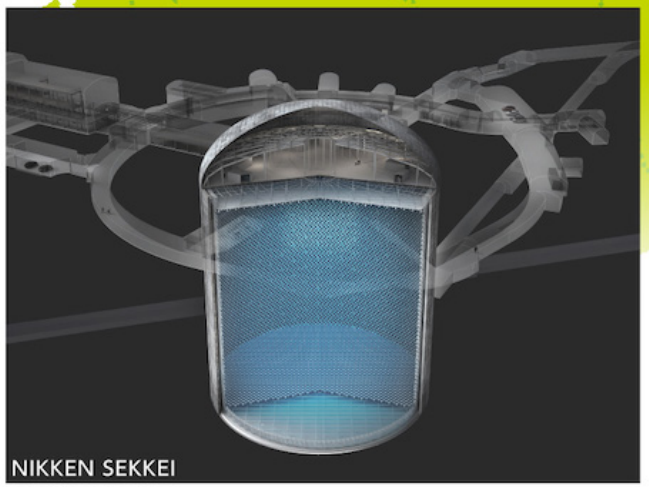

Hyper-Kamiokande
New intermediate detector (IWCD)
J-PARC
Near detectors
(ND280 upgrade, INGRID)
$\overset{(-)}{\nu_\mu}, \overset{(-)}{\nu_e}$
$\overset{(-)}{\nu_\mu}$
Neutrino beam
280 m
295 km
~1 km

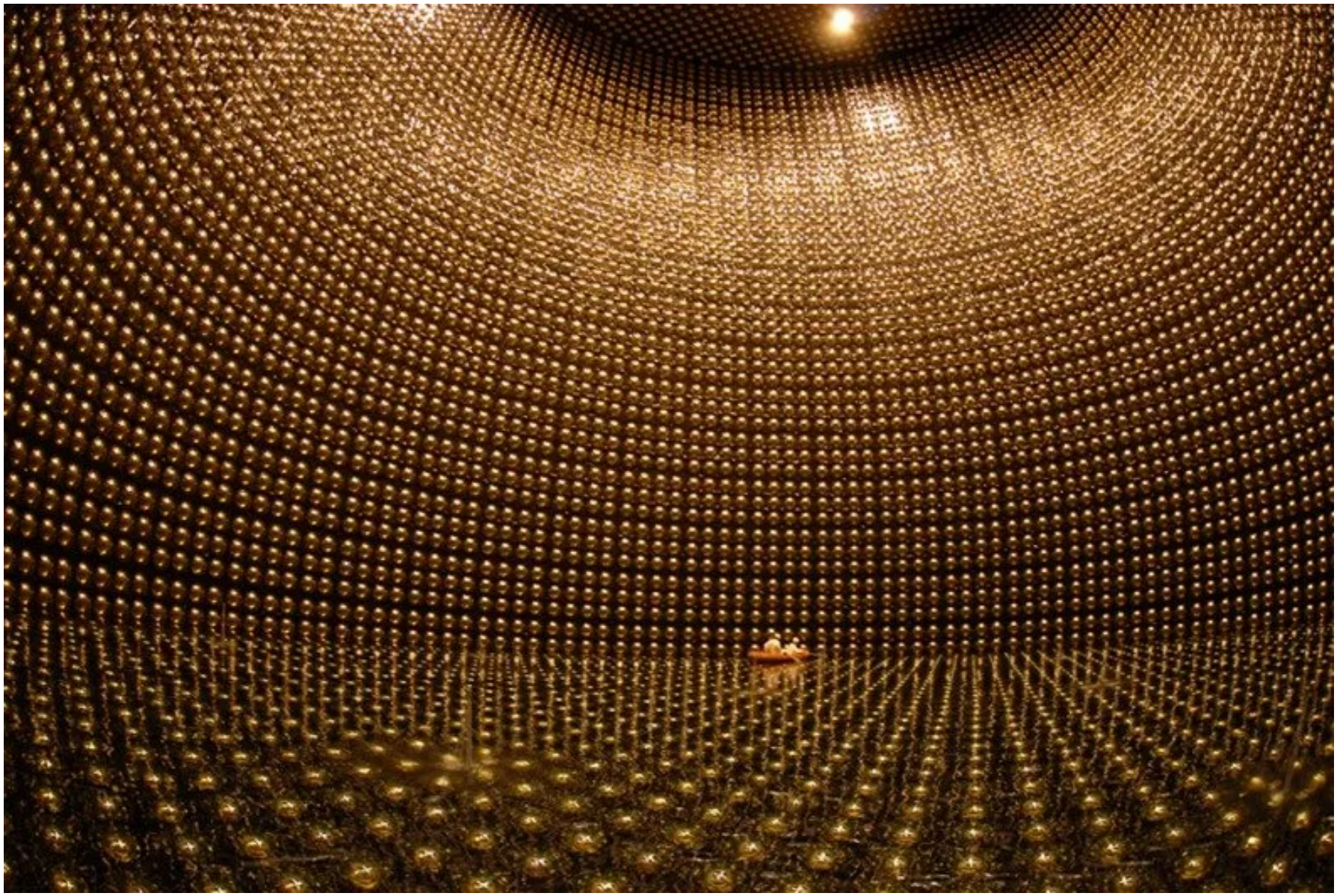
J-PARC accelerator

Tokai

Kamioka

Hyper-Kamiokande



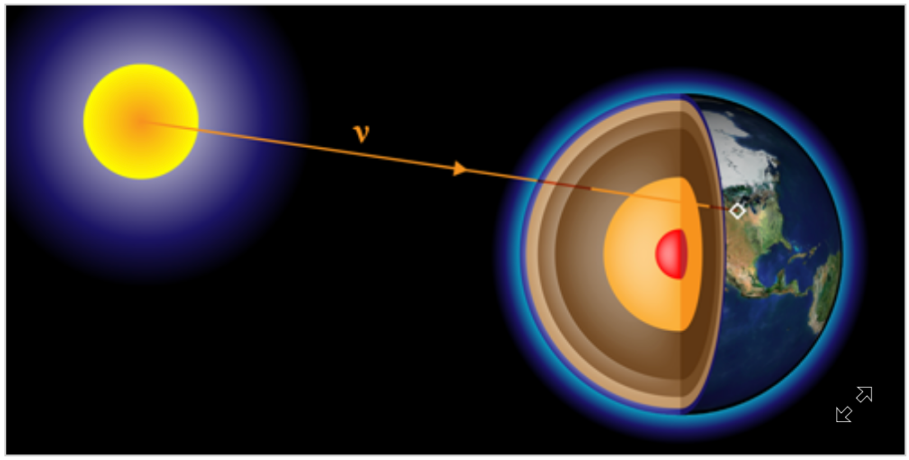


SYNOPSIS

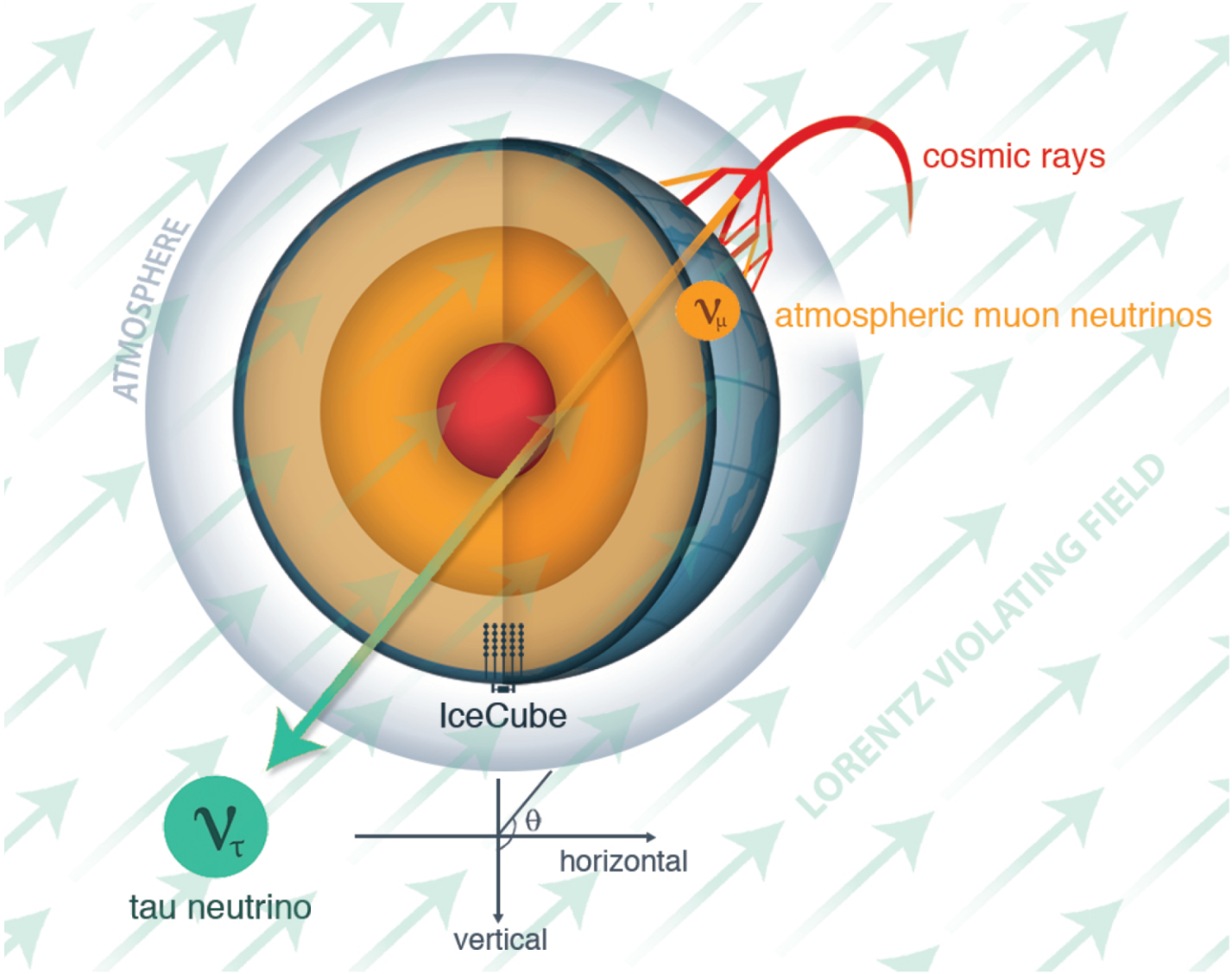
Scanning Earth's Interior with Neutrinos

August 8, 2017 • *Physics* 10, s86

Future neutrino experiments may provide tomographic scans of Earth's interior by viewing solar neutrinos that pass through our planet's layers.



APS/Alan Stonebraker


ATMOSPHERE
cosmic rays
ν_μ
atmospheric muon neutrinos
LORENTZ VIOLATING FIELD
IceCube
ν_τ
tau neutrino
θ
horizontal
vertical

Շնորհակալություն