

Multi-Messenger Tomography of Earth

MMTE – 2022

Workshop Goals



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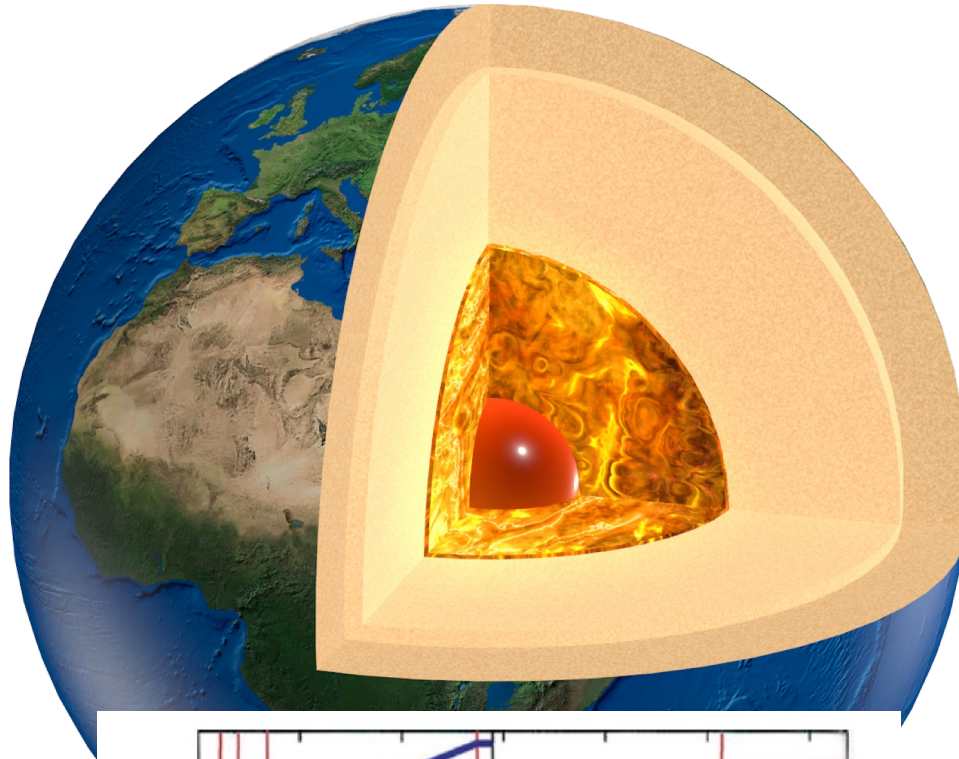


We welcome you all to this Mini-Workshop on
“Multi-Messenger Tomography of Earth – MMTE 2022”

A Fusion of Scientists from
Neutrino and Geoscience Communities
to discuss the knowns and unknowns of our planet Earth

We wish you a very enjoyable and fruitful stay
at Snowbird, Slat Lake City, Utah!

The Interior of Earth



- What lies in the interior of Earth has been a long-standing puzzle and active research is being carried out in this direction
- The regions deep below the Earth's surface are inaccessible due to large temperatures, pressures, and extreme environments.
- The information about the interior of Earth is obtained indirectly using

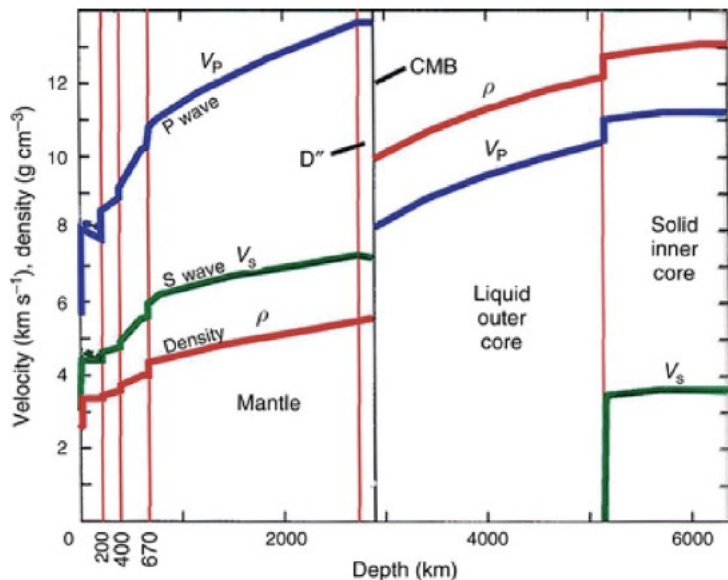
→ Gravitational measurements

→ Seismic studies

- Neutrinos can penetrate deep inside the Earth and may shed light on internal structure and composition

→ ν oscillation tomography
w/ low-energy neutrinos

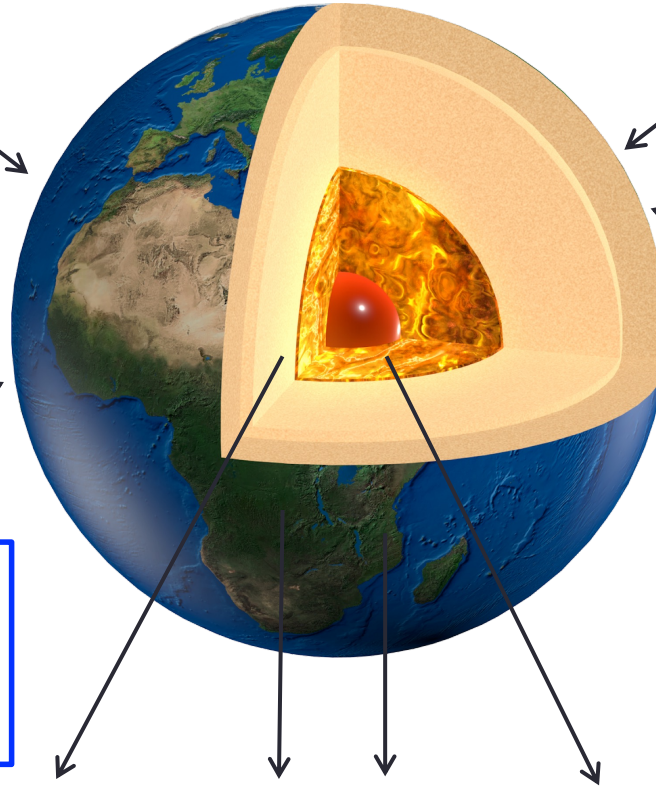
→ ν absorption tomography
w/ high-energy neutrinos



Multi-Messenger Tomography of Earth

Gravitational measurements exploits the **gravitational interactions** of matter inside Earth and provide information on Earth's total mass and moment of inertia

Geophysicists use seismic waves from earthquakes exploiting the **electromagnetic interactions** of matter inside Earth.



Neutrinos get attenuated at energies greater than a few TeV using **weak interactions**

Neutrino Absorption Tomography

Sub-GeV and multi-GeV electron neutrinos undergo charged current coherent forward scattering with ambient electrons inside deep Earth via **weak interactions** and this results in the modification of oscillation patterns significantly

Neutrino Oscillation Tomography

Combine neutrino data with seismic and gravitational measurements

Start a new era of
Multi-Messenger Tomography of Earth

This workshop is an important step along this direction!

Goal of MMTE – 2022

- The idea is to bring together leading experts from the neutrino and geoscience communities to discuss in depth the present status of the field and its future developments.
- The main aim of this workshop is to explore the role of oscillation and absorption neutrinos towards the tomography of Earth - complementary to the seismic studies and gravitational measurements - paving the way for multi-messenger tomography of Earth.
- The huge amount of high-precision atmospheric neutrino data that we expect to collect in the next 10 to 15 years using IceCube/IceCube-Gen2, DeepCore and its upgrade, ORCA and ARCA, Hyper-K, DUNE, and INO-ICAL with its unique muon charge identification (CID) capability, are going to play an important role towards neutrino tomography of Earth.
- These enormous amount of high-quality atmospheric neutrino data can measure the Earth's density profile.
- It may shed light on the composition [Z (atomic no.)/ A (mass no.) ratio] and hydrogen content inside the Earth's core.

Organizing Committee



Bill McDonough
Univ. of Maryland & Tohoku Univ.



Francis Halzen
Univ. of Wisconsin-Madison



Patrick Huber
Virginia Tech



Carsten Rott
Univ. of Utah & Sungkyunkwan Univ.



Hiroyuki Tanaka
ERI, Univ. of Tokyo



Hiroko Watanabe
Tohoku Univ.

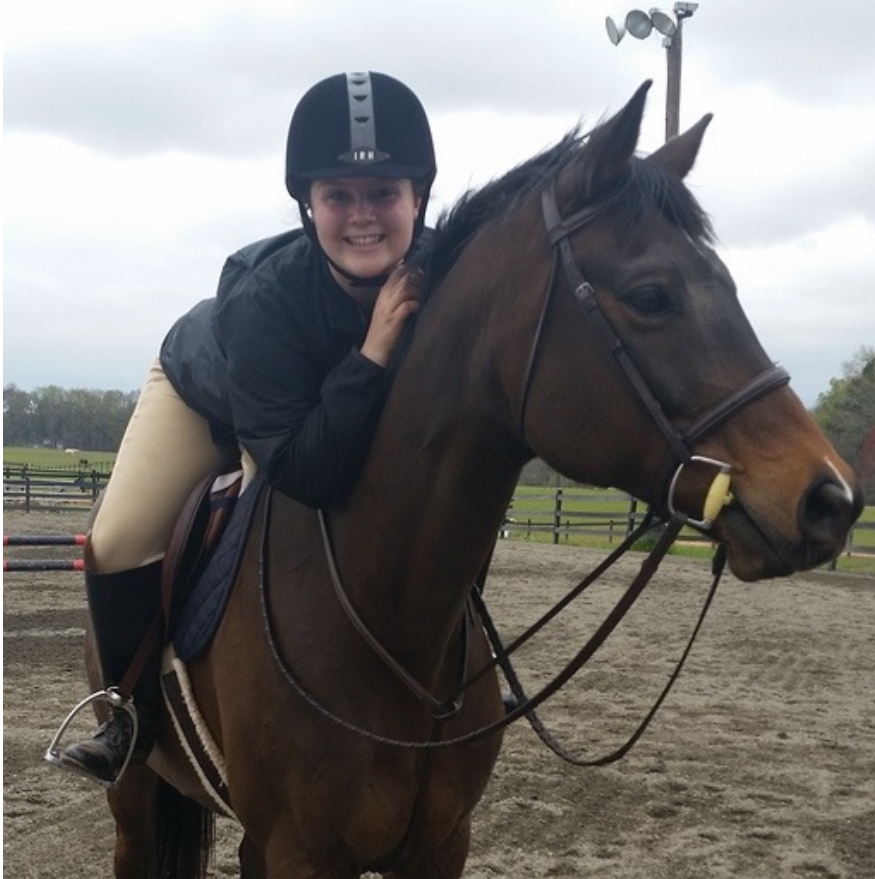


Amol Dighe
TIFR



Sanjib Kumar Agarwalla
IOP, Bhubaneswar & UW Madison

Special Mention



**Special thanks to Rebecca Corley for her
tireless effort to organize this workshop**

Scientific Program of MMTE 2022

local Utah time	Saturday July 30		Sunday July 31
0900-0915	Welcome (Carsten Rott)	0900-0945	Landscape of Neutrino Physics (Francis Halzen)
0915-0930	Workshop goals (Sanjib Kumar Agarwalla)	0945-1030	Earth's matter effect in neutrino oscillation (Sanjib Kumar Agarwalla)
0930-1015	Atmospheric Neutrinos for Non-Specialists (Edward Kearns)	1030-1100	Coffee break
1015-1100	The Internal Structure of the Earth (Bill McDonough)	1100-1125	Current understanding of the Earth's core (Francis Nimmo)
1100-1130	Coffee break	1125-1150	Neutrino tomography of the Earth: the potential of ORCA detector (Serguey Petcov)
1130-1215	Imaging the Earth's Interior using Seismic Waves (Vedran Lekic)	1150-1215	Current understanding of inner core structure and open questions (Keith D. Koper)
1215-1300	Present status and future prospects of geoneutrinos towards Earth tomography (Andrea Serafini)	1215-1240	Measuring the Earth's outer core composition using neutrino oscillations (Joao Coelho)
1300-1430	Lunch break	1240-1400	Lunch break
1430-1515	The first neutrino absorption Earth tomography (Andrea Donini)	1400-1425	An overview of the core-mantle boundary region from seismological studies (Mike Thorne)
1515-1540	Measuring density of Earth's core using high-energy neutrinos observed by IceCube (Kotoyo Hoshina)	1425-1450	Unstable structure and dynamics in Earth's deepest mantle (Mingming Li)
1540-1610	Coffee break	1450-1515	Neutrino oscillation tomography of the Earth and core composition with large water cherenkov detector (Akimichi Taketa)
1610-1655	Chemical composition and Hydrogen content inside Earth (Kei Hirose)	1515-1545	Coffee break
1655-1720	A coupled core-mantle evolution (Takashi Nakagawa)	1545-1610	Validating the Earth's Core using Atmospheric Neutrinos with ICAL at INO (Anil Kumar)
1720-1735	Oscillation tomography of Earth with Solar neutrinos and future experiments (Pouya Bakhti)	1610-1635	Superionic H-bearing iron alloys in the Earth's inner core (Wenzhong Wang)
1735-1800	Discussion (Patrick Huber and Vedran Lekic)	1635-1700	Observing the Earth's Core with Neutrino Oscillations (Rebekah Pestes)
		1700-1725	Neutrino Earth tomography in DUNE (Ivan Martinez-Soler)
		1725-1800	Discussion (Carsten Rott and Keith D. Koper)
Chairperson	Pre-Lunch Session: Patrick Huber		Pre-Lunch Session: Carsten Rott
	Post-Lunch Session: Vedran Lekic		Post-Lunch Session: Keith D. Koper

Total 22 Talks: 9 (in-person) and 13 (virtual)
2 Discussion Sessions

There will be conference proceedings

Details are given on the webpage

We are discussing the possibility of writing a whitepaper based on the outcome of this workshop. We will discuss more on this in detail during the workshop

We need your comments/feedbacks/opinions

Your participation and contribution are needed to make this happen!

Enjoy the workshop!