

# Welcome to the Multi-messenger Tomography Workshop - MMTE2022

## Carsten Rott



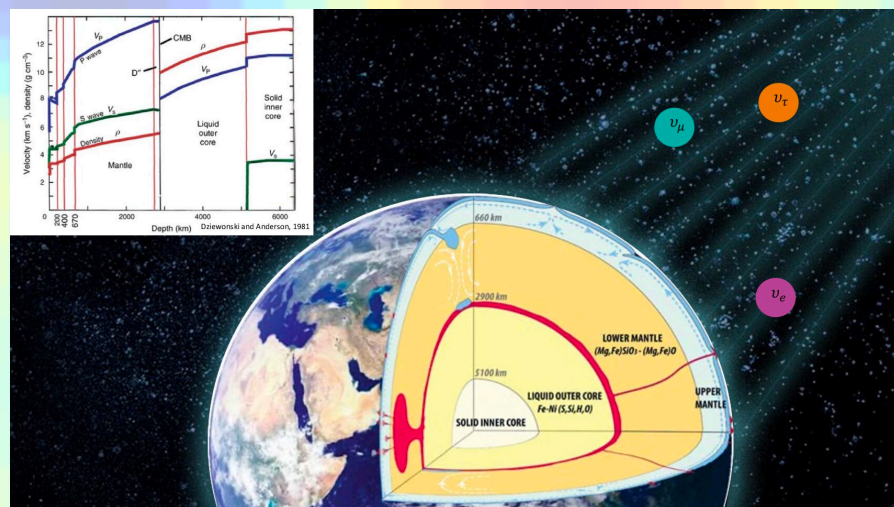
Supporting Institutions  
and Organizations



*instruments*



**CAEN**  
Technologies Inc.  
On the Edge of Discovery



<https://www.physics.utah.edu/mmte-2022/>

Members of the organizing committee for MMTE 2022:

- **Sanjib Kumar Agarwalla** (Institute of Physics, Bhubaneswar and UW Madison)
- **Bill McDonough** (University of Maryland & Tohoku University)
- **Francis Halzen** (UW Madison)
- **Amol Dighe** (TIFR)
- **Patrick Huber** (Virginia Tech)
- **Carsten Rott** (University of Utah & Sungkyunkwan University)
- **Hiroyuki Tanaka** (ERI, University of Tokyo)
- **Hiroko Watanabe** (Tohoku University)

<https://www.physics.utah.edu/mmte-2022/committees/>

# COVID Safety

- COVID-19 safety is our highest priority. Please help us all to stay safe.
- We highly recommended to **wear masks** - you can find a mask in your conference welcome package
- During coffee breaks you can go and **enjoy coffee and snacks outside** on the patio
- Please **keep distance** to other participants whenever possible
- Please **test yourself frequently** - anti-gun tests are available at the registration desk and are part of your conference welcome package

**COVID-19:** Attendees will receive a KN-95 mask as well as antigen rapid self test at conference check-in. Please review guidelines on the conference website. More detailed information about the COVID related topics at Cliff Lodge, especially the nearby places to take COVID tests, can be found at <https://www.snowbird.com/covid-19/>



**ACKNOWLEDGEMENT OF RECORDING AND CODE OF CONDUCT:** All attendees must read and acknowledge the following by completing the [ONLINE FORM](#) prior to attending the conference.

- **PRESENTATION RECORDING RELEASE:** Sessions broadcast on Zoom will be recorded and be made publicly available. You confirm that you understand all Zoom sessions will be shared, and that any questions asked or presentations shared will be recorded.
- **CODE OF CONDUCT:** Please read the NuFact code of conduct, which can be found here: <https://indico.fnal.gov/event/53004/page/2913-code-of-conduct>

# Information for In-person attendees

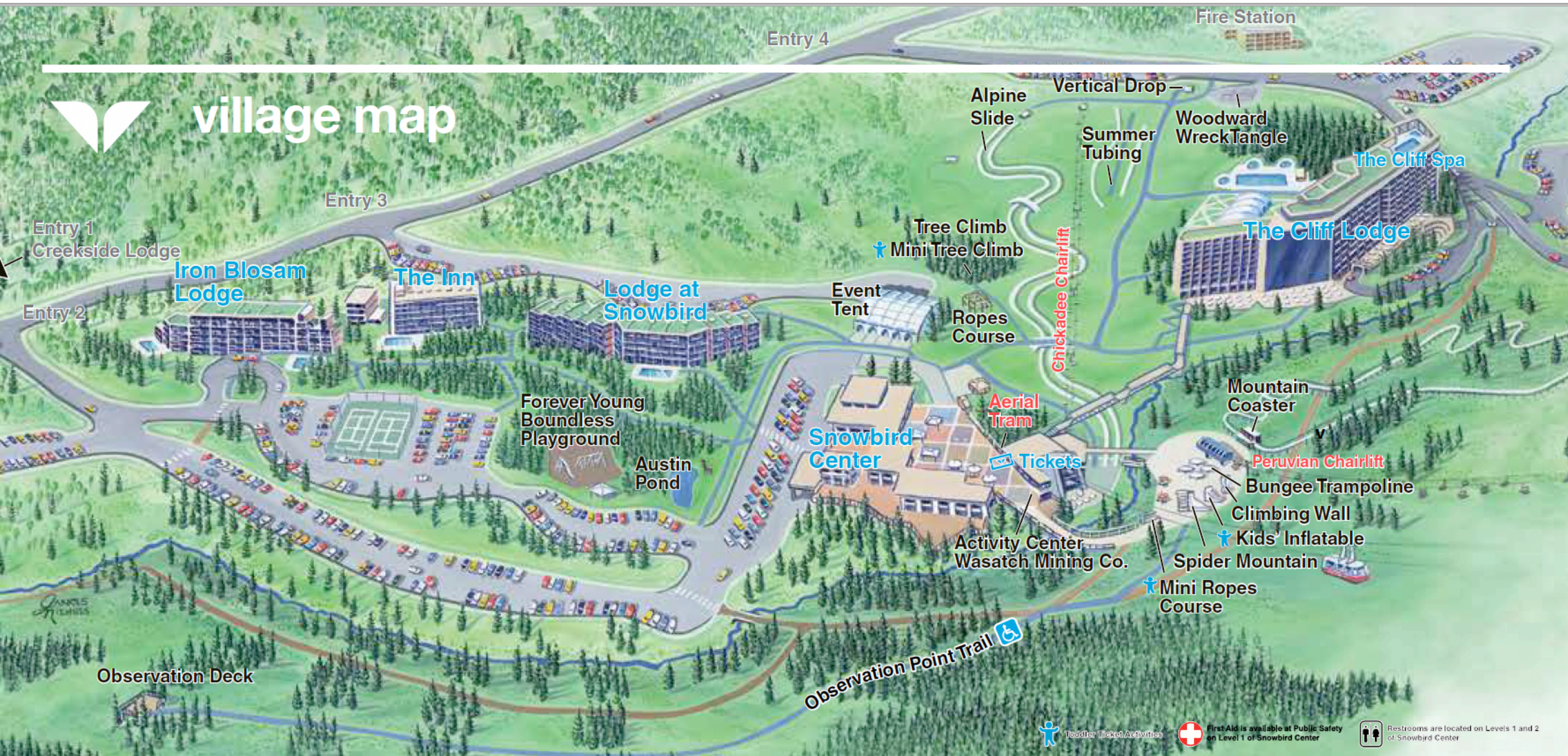
**CONFERENCE VENUE:** MMTE will take place at the [The Cliff Lodge](#) at Snowbird located at 9320 Cliff Lodge Dr, Snowbird, UT 84092. [Click here](#) for maps and directions to Snowbird or view the [conference website for transportation options](#). The MMTE workshop will take place in the Wasatch A/B conference room

**WORKSHOP CHECK-IN:** Check-in will take place at the Cliff Ballroom Lobby in the Cliff Lodge at Snowbird.

- MMTE Workshop check in will take place Saturday July 30 and Sunday July 31 from 8:00 - 9:00 am.

**WORKSHOP AGENDA:** Click [HERE](#) to view the online schedule







# Information for In-person attendees



<https://www.thecliffclub.net/accommodations-amenities/cliff-club-layout/>

# Motivation (Particle Physics $\Rightarrow$ Earth Science)

- What can neutrino detectors do for Solid Earth Science ?

- **Muon Radiography**

- Atm. airshower **muon absorption**

- **Geo-neutrinos**

- Low-energy neutrino detection from **nuclear decays**

- **Neutrino absorption tomography**

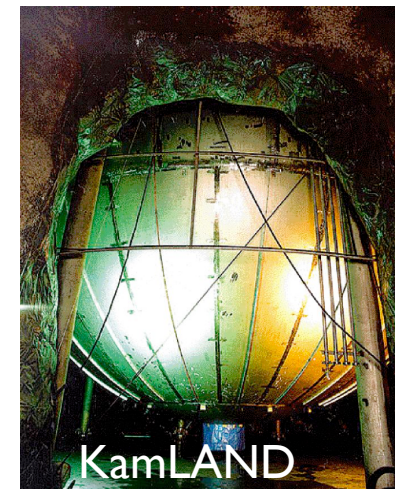
- Atmospheric air shower high-energy **neutrino absorption**

- **Neutrino oscillation tomography**

- Atmospheric air shower **neutrino oscillations**

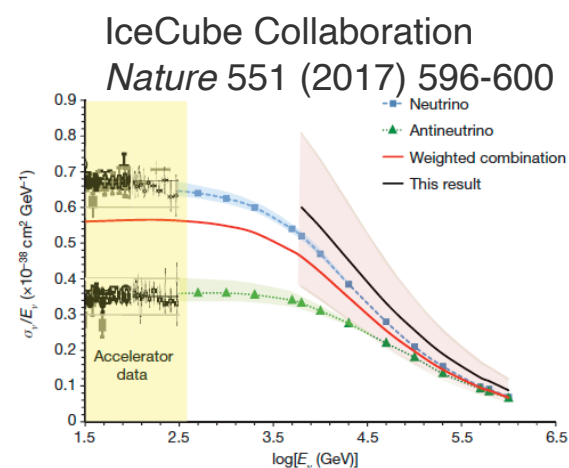
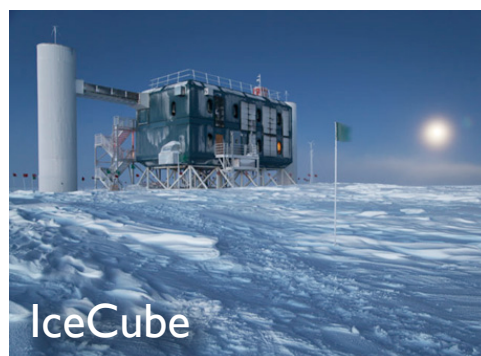
## Geo-neutrinos

U and Th geo- $\nu$

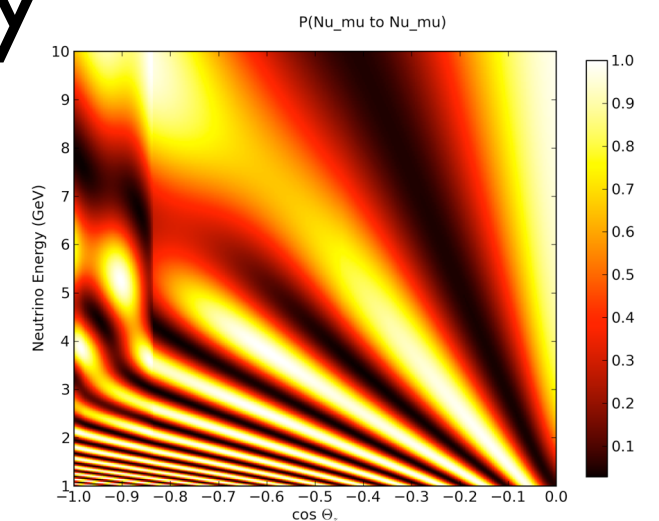
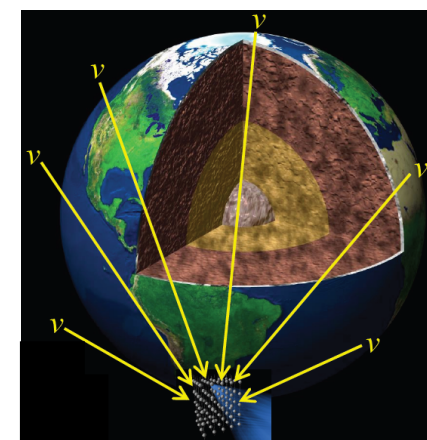


Nature Geoscience;  
Volume: 4, 647–651 (2011)

## Neutrino absorption tomography



## Neutrino oscillation tomography





# Motivation (Particle Physics $\Leftarrow$ Earth Science)

- What can neutrino detectors do for Solid Earth Science ?

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- **Neutrino absorption tomography**

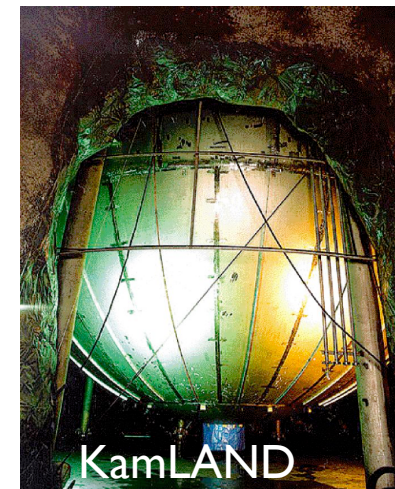
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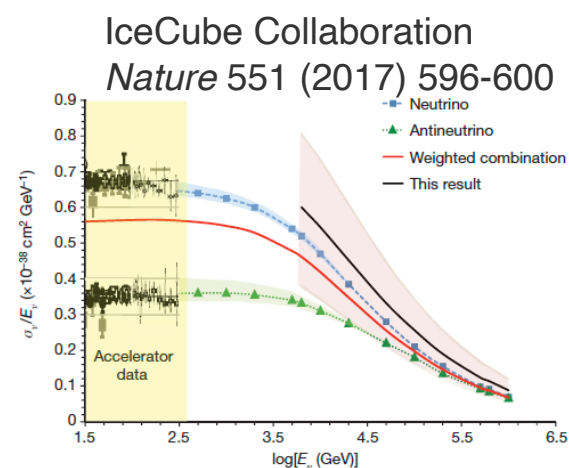
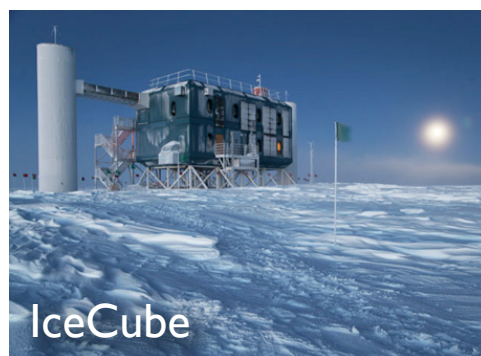
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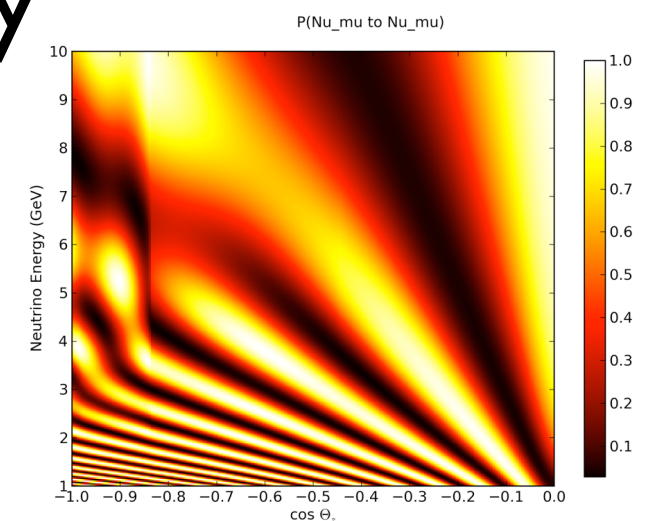
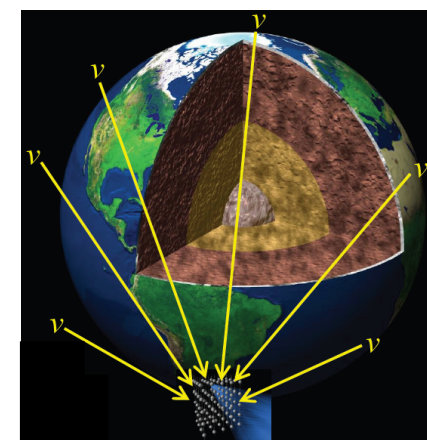


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## Neutrino absorption tomography



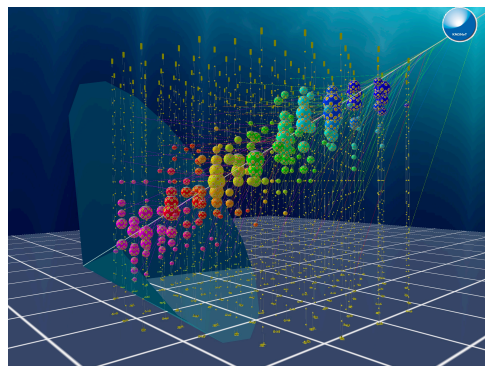
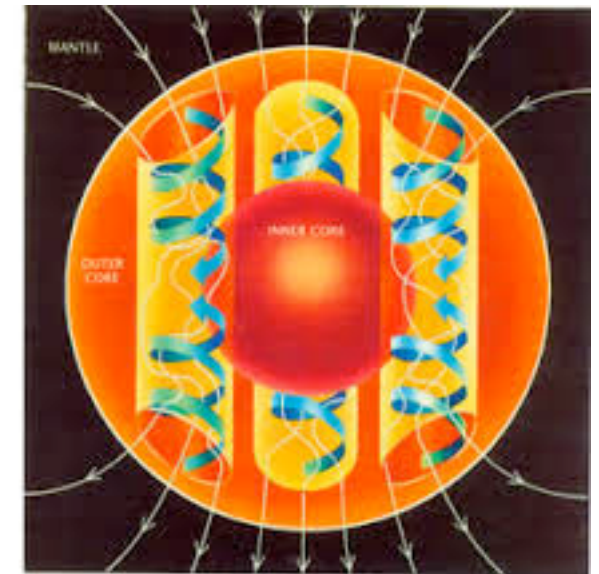
## Neutrino oscillation tomography



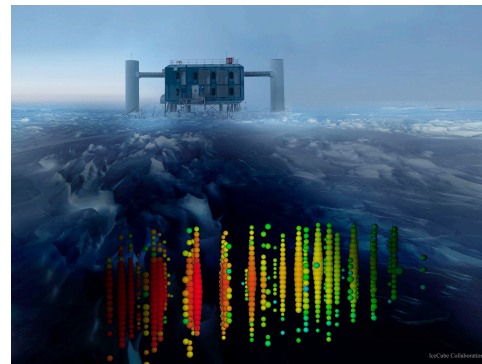


# Motivation - Example - Neutrino Oscillation Tomography

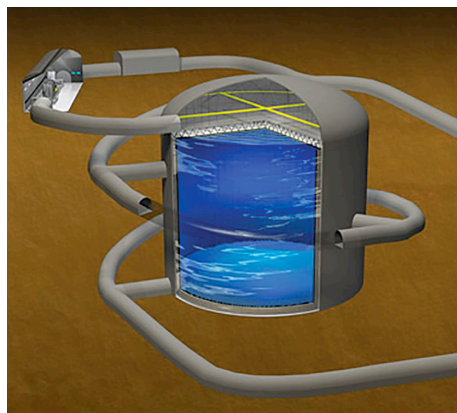
- New Method to understand inner Earth
  - Inner Earth Composition
    - Light elements in the outer core ?
    - Understand the Geodynamo
  - Lower mantle density and anisotropy
- Apply neutrino physics to Earth Science
- Unique opportunity now with new large scale experiments



<https://www.km3net.org/>



<http://icecube.wisc.edu>



<http://www.hyper-k.org/>

**NuFact 2022** | Salt Lake City, Utah, United States  
July 31<sup>st</sup> - Aug. 6<sup>th</sup>, 2022

The 23<sup>rd</sup> International Workshop on Neutrinos from Accelerators

**LOCAL ORGANIZING COMMITTEE**

**SPONSORING AGENCIES**

**SCIENTIFIC PROGRAM COMMITTEE**

**WORKING GROUPS**

**DELEGATES**

**SPONSORS**

**CONTACTS**

**WEBSITE**

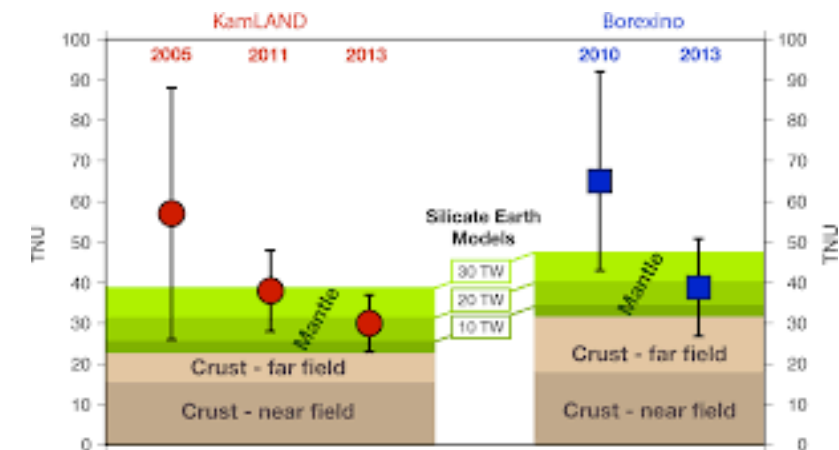
**EMAIL**

**WEBSITE**

**THE UNIVERSITY OF UTAH**

**CAEN Technologies Inc.**

**instruments**



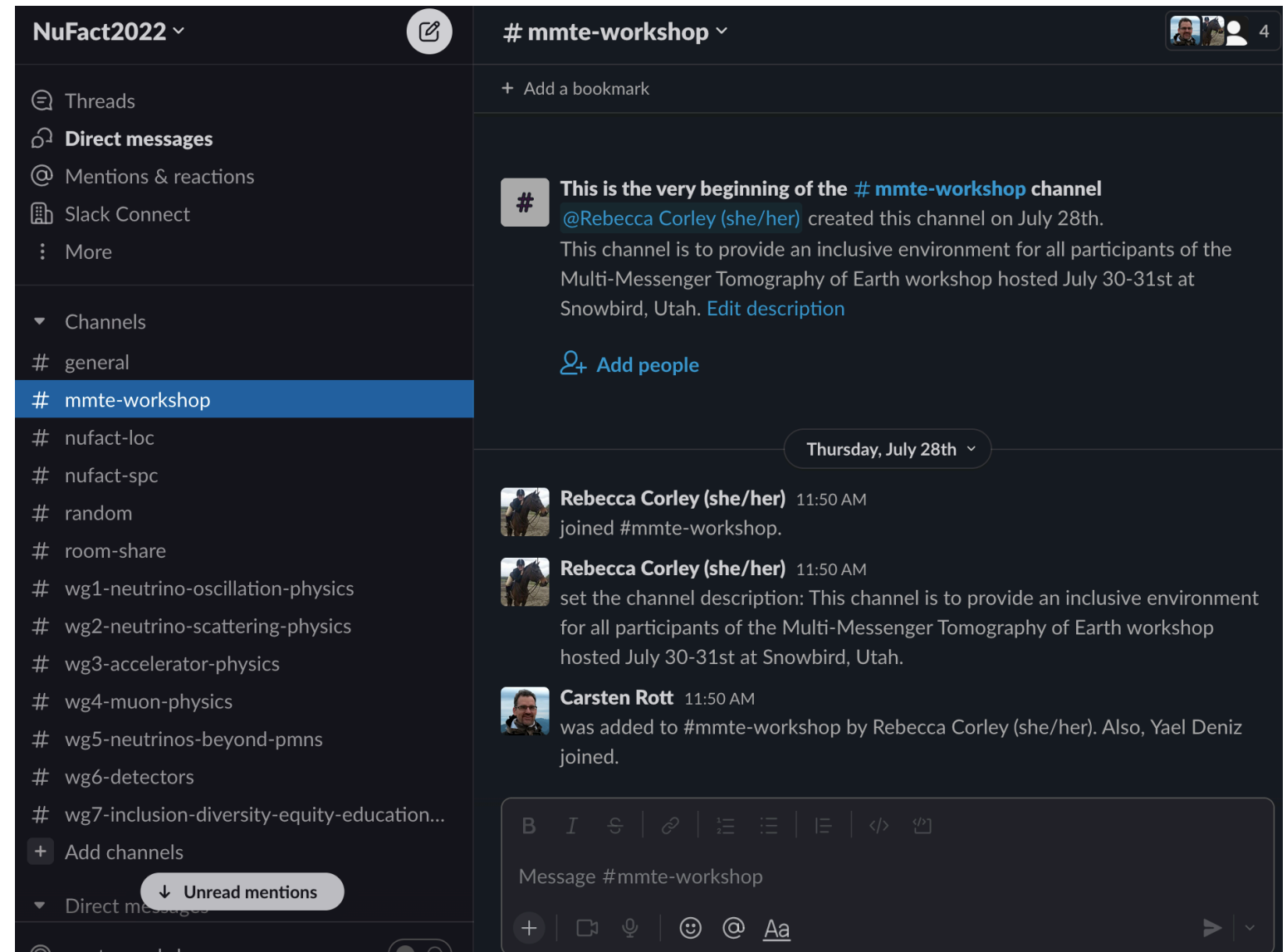
# This workshop

- We like this workshop to be interactive
  - Ask questions
- We highly encourage discussions,
  - Short discussions during talks, but take longer discussion to dedicated discussion time at the
  - Feel free to propose topics for the discussion time
- We invited participants from different fields and with different backgrounds (~one expert from each area)
  - Be curious and open minded



# Slack channel

- Participants received an invitation to our slack channel for this workshop. We invite you to join for an enhanced online experience !
- Please use the MMTE slack channel for questions and discussions
  - We will try to monitor it, but please bring up questions are overlooked in our discussion





- Please always follow our NuFact2022 code of conduct
  - <https://indico.fnal.gov/event/53004/page/2913-code-of-conduct>
- Please remember we speak different languages, so explain abbreviations and technical terms that might be specific to your field

## CMB (disambiguation)

From Wikipedia, the free encyclopedia

**CMB** is the cosmic microwave background, the thermal radiation left over from the time of recombination in Big Bang cosmology.

**CMB** may also refer to:

### Science and technology [[edit](#)]

- **Core–mantle boundary**, lying between the Earth's silicate mantle and its metallic outer core
- **Continuous marine broadcast**, a type of radio station providing marine weather information to coastal areas of Canada



Look up **CMB** in Wiktionary, the free dictionary.

### Contents [[hide](#)]

- 1 [Science and technology](#)
- 2 [Arts and entertainment](#)
- 3 [Organizations](#)
- 4 [Other uses](#)
- 5 [See also](#)

# Speaker instructions

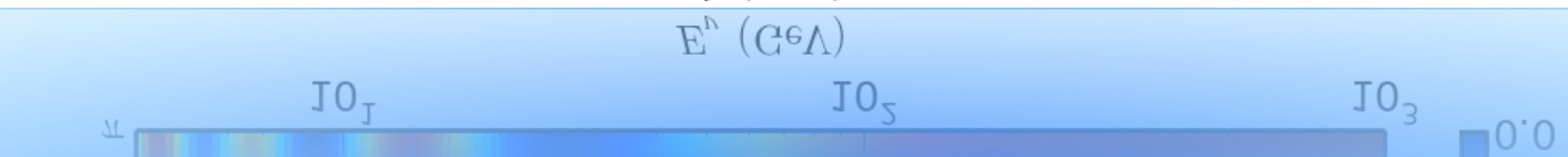
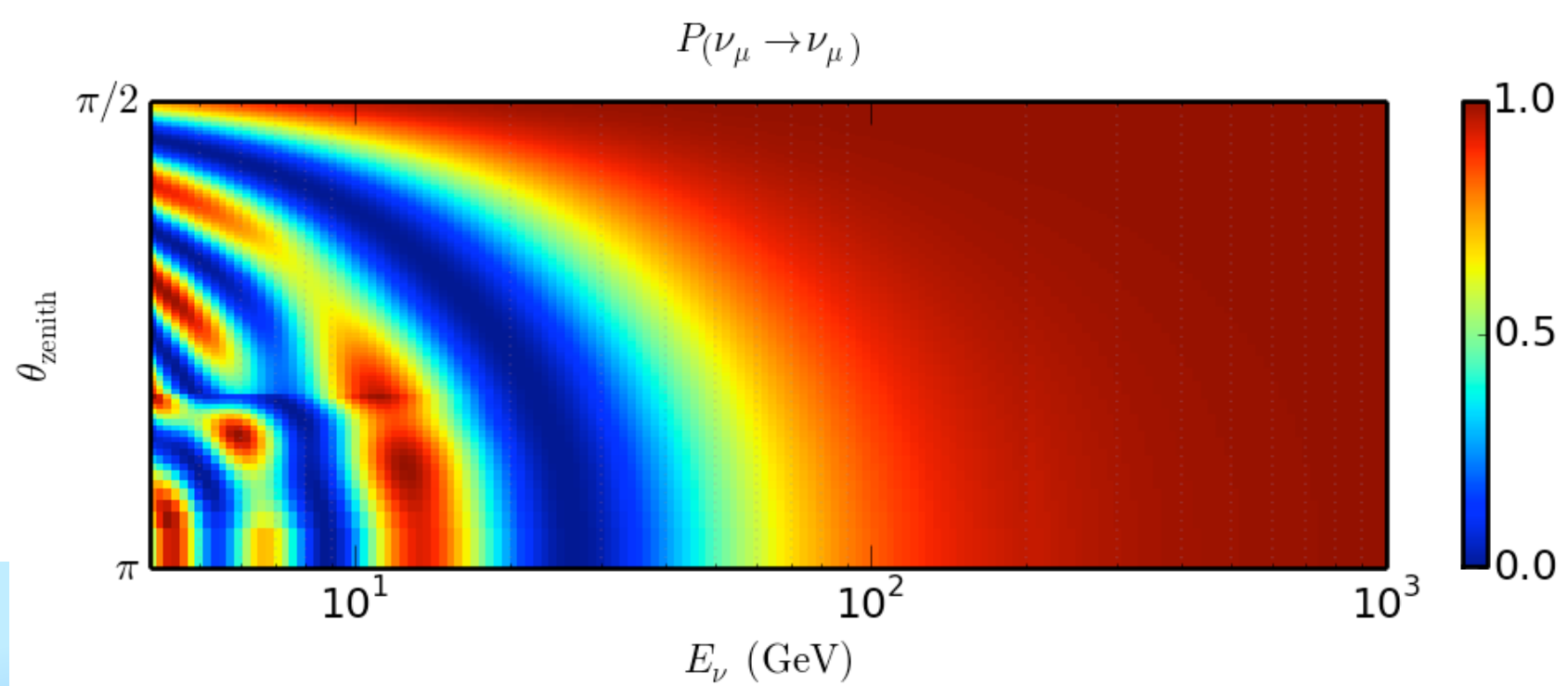
- **Presentations and uploading your contributions:**
  - Please upload your presentation before the start of the sessions. You can upload your slides directly to the indico page by clicking on your contribution. If you have any trouble please let us know and we can help. For parallel session talks, please contact the working group conveners of the session.
  - **All speakers need to upload their slides before the start of the session**
- **Allocated times for your presentation:**
  - The times shown for your presentation on indico includes the time for questions. So please prepare your talk such that you leave time for questions. We will need to be strict on the time to make sure that we stay on schedule, so that the in-person audience and remote participants can best interact. Virtual participants might connect for certain talks only.
  - **Please stay in time and remember allocated talk times include Q&A periods.**
- **Presentation Laptop:**
  - We will have a presentation laptop with the zoom session running for the presenters. All presenters shall use the presentation laptop. The presentation laptop will be running windows and can be used to display pdfs or power-point files. If necessary presenters could use their own laptop by connecting to the zoom session, however we strongly encourage you to use the presentation laptop.
- **Virtual presenters:**
  - Please join before the start of your session and test that screen sharing and your microphone works properly.

<https://indico.fnal.gov/event/53004/page/3011-instructions-for-presenters-session-chairs>

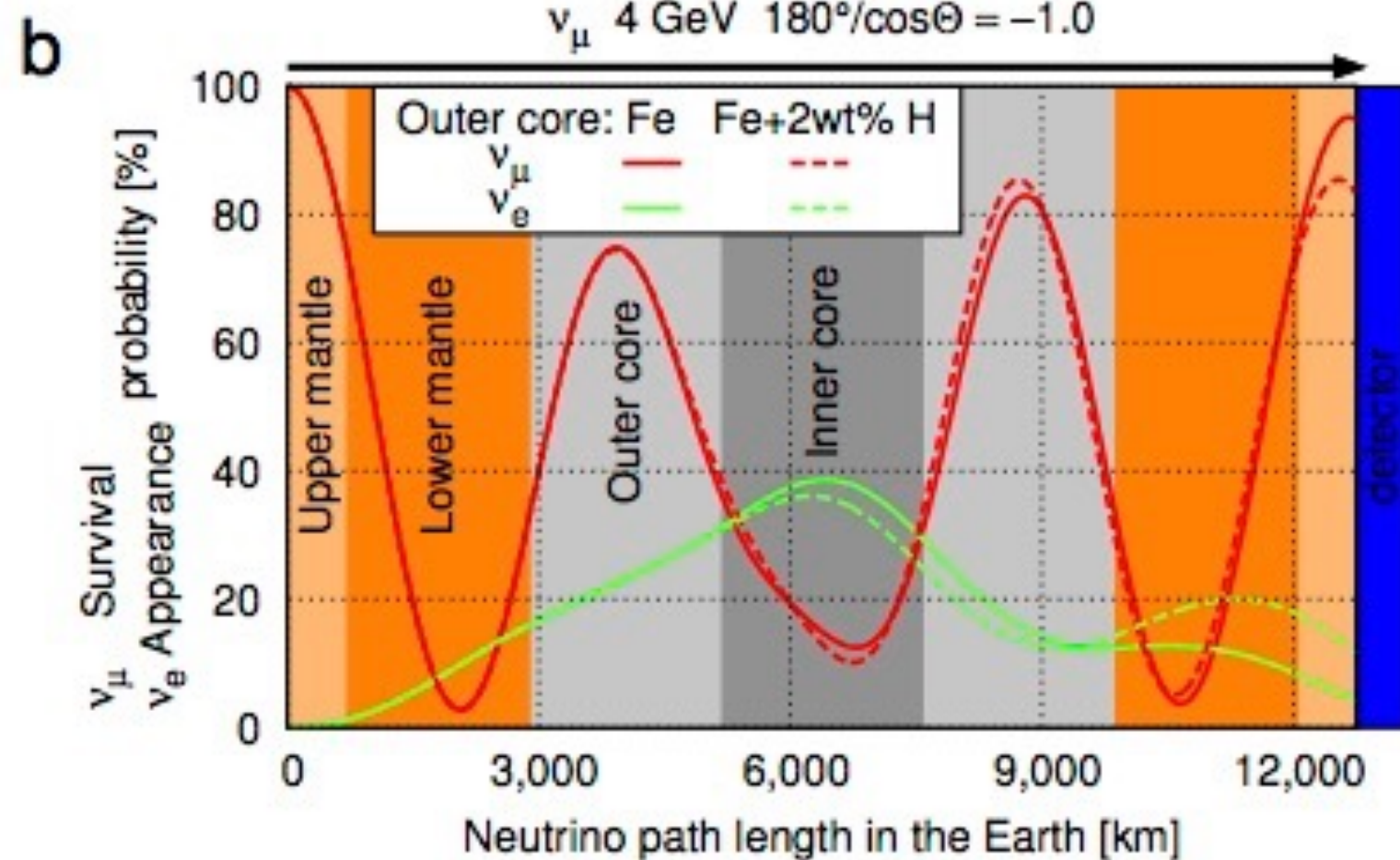
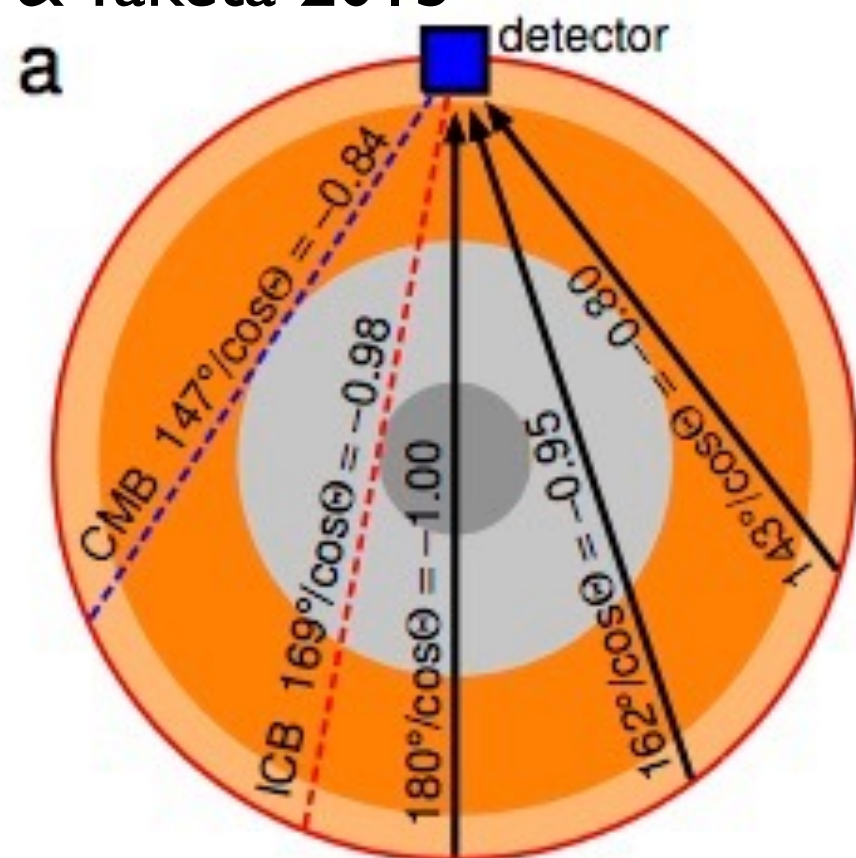
- We hope many new idea's and collaborations will come out of this workshop
- If you write a paper based on discussions you had here please acknowledge this workshop
- We also consider having a write up (white paper) from this workshop



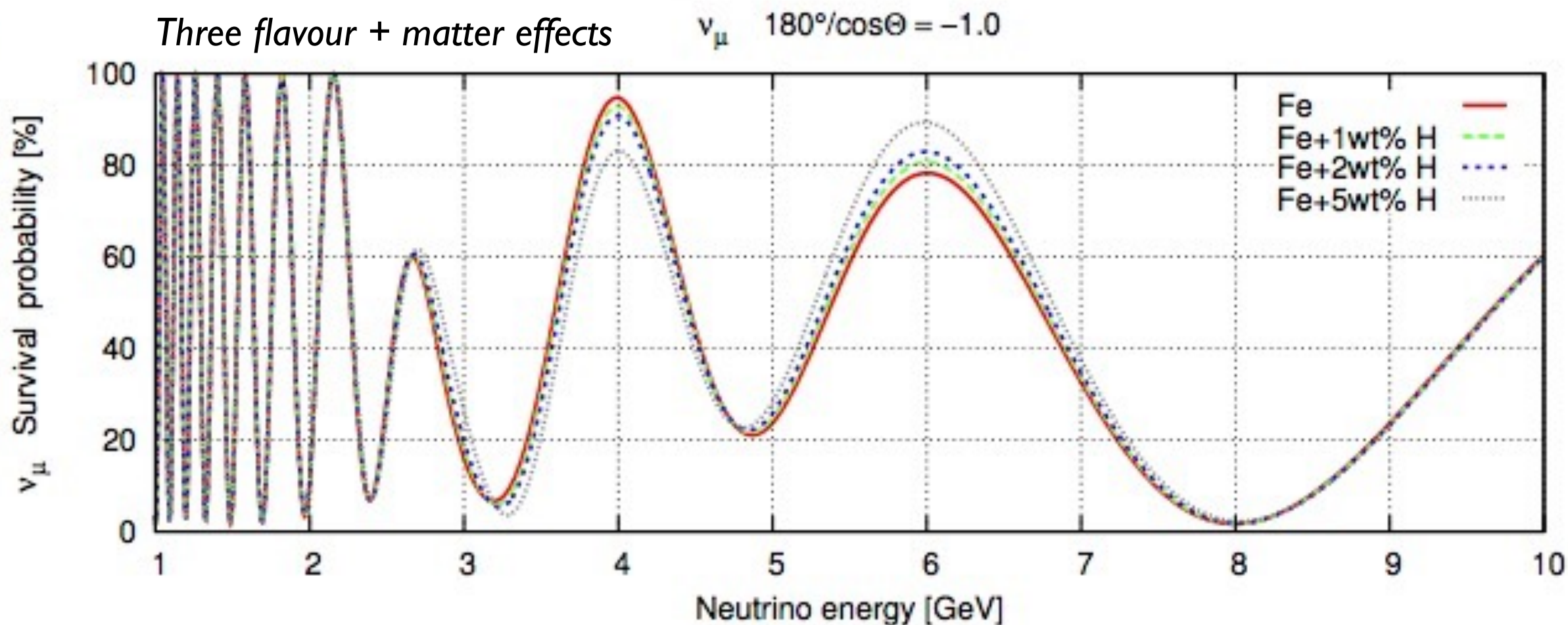
# Backup



# Neutrino Oscillations

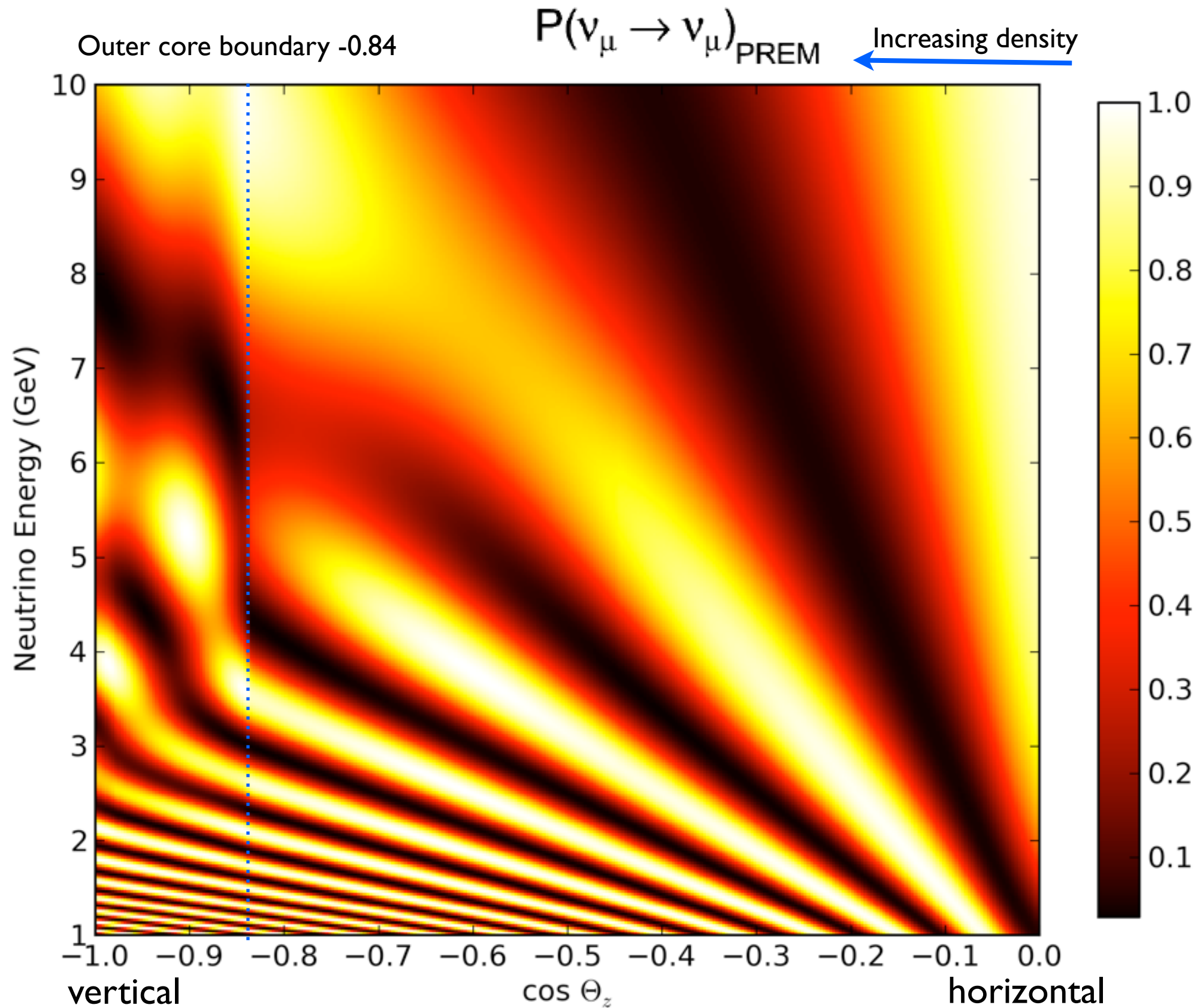


**c** *Three flavour + matter effects*



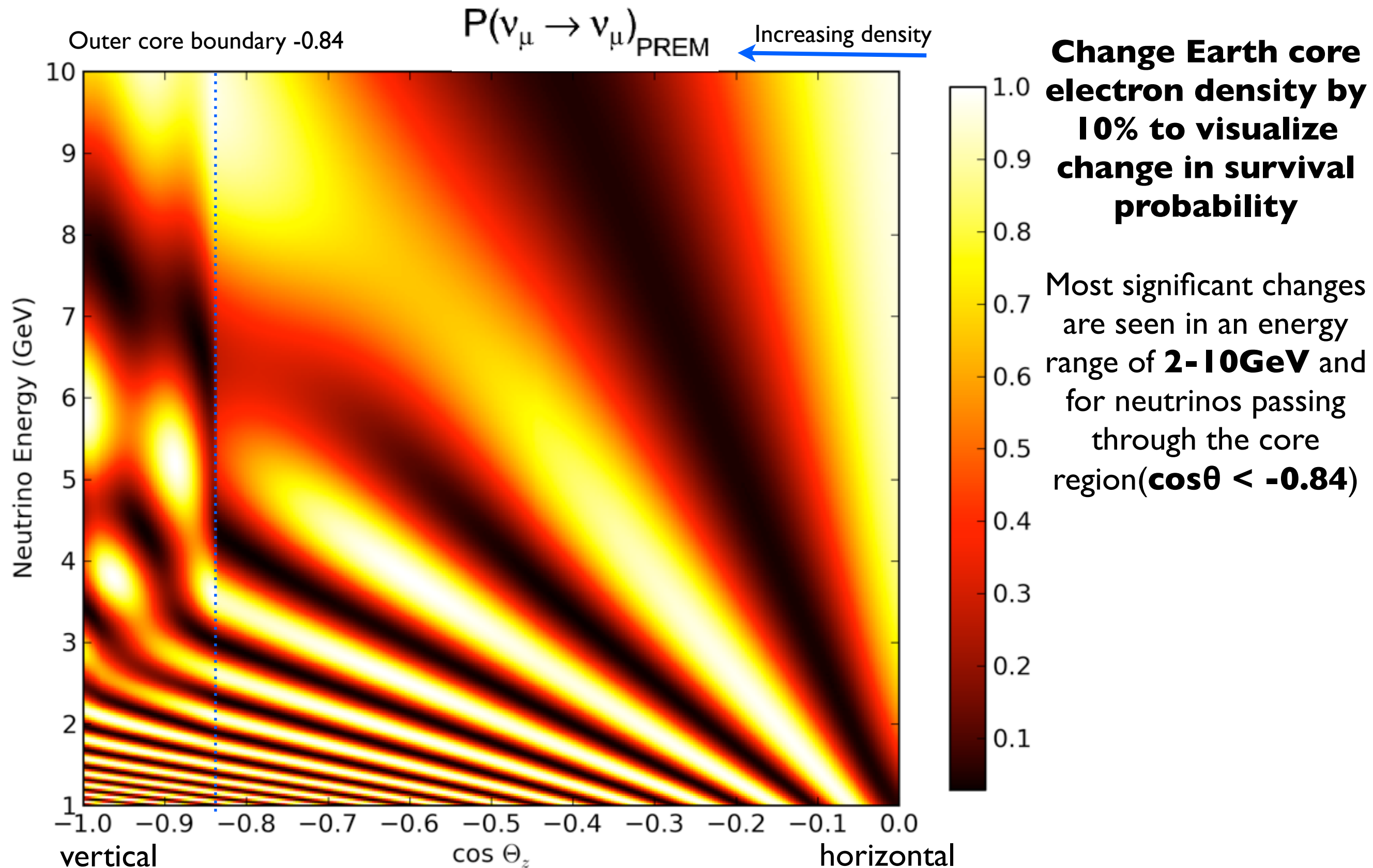


# Oscillogram (“normal” electron density)





# Oscillogram (enhance electron density)





# Oscillograms

