WG 1 Introduction
Neutrino Oscillations

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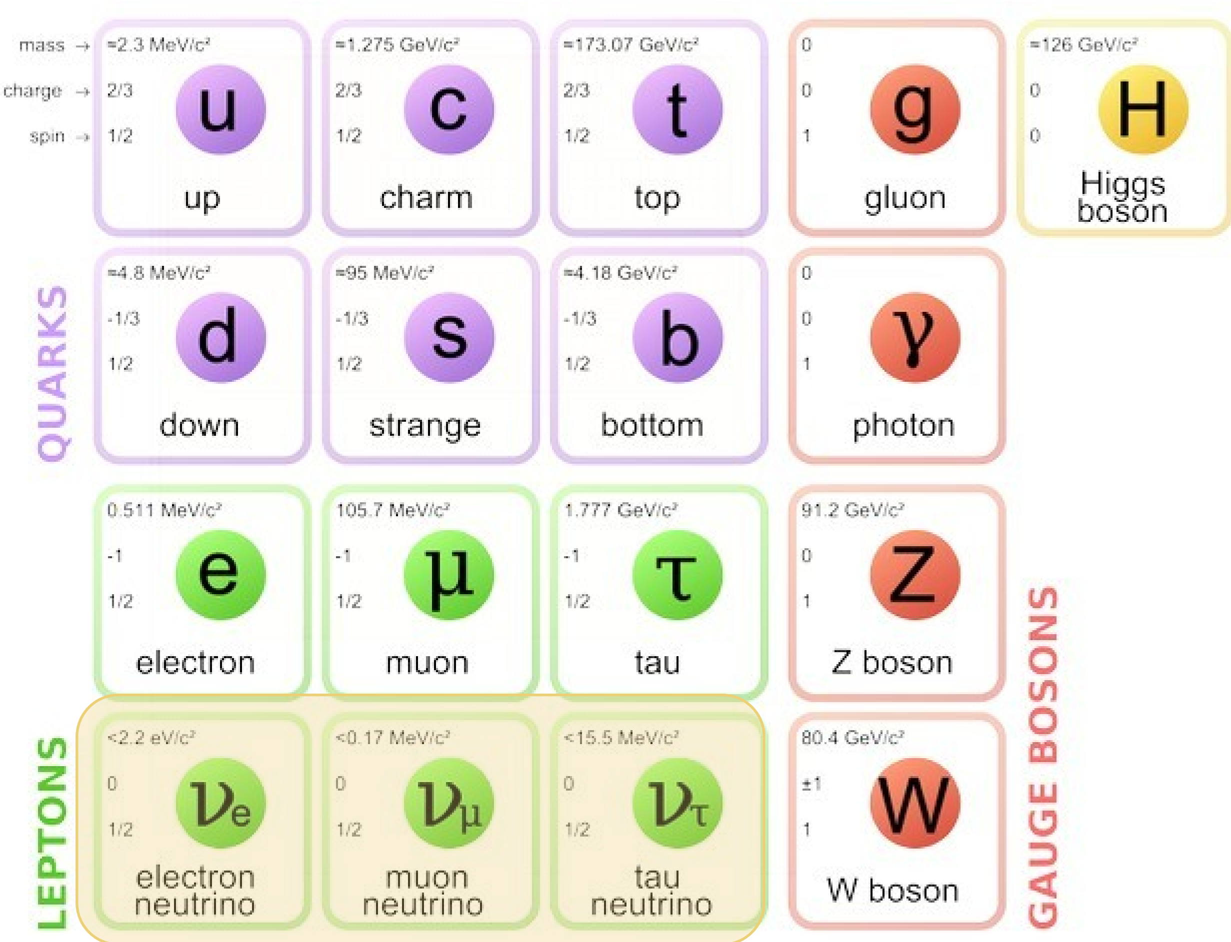
23rd International Workshop on Neutrinos from Accelerators

Salt Lake City, Utah

1 August 2022

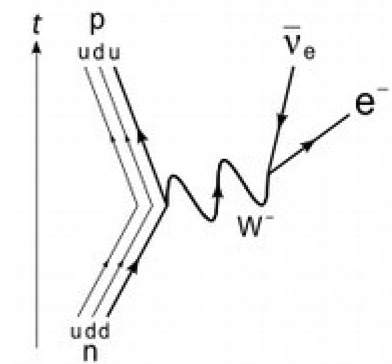
Neutrinos in the Standard Model



Neutrinos only feel the weak force

In the SM neutrinos are massless

1930: Wolfgang Pauli proposed neutrinos to make β decays conserve energy

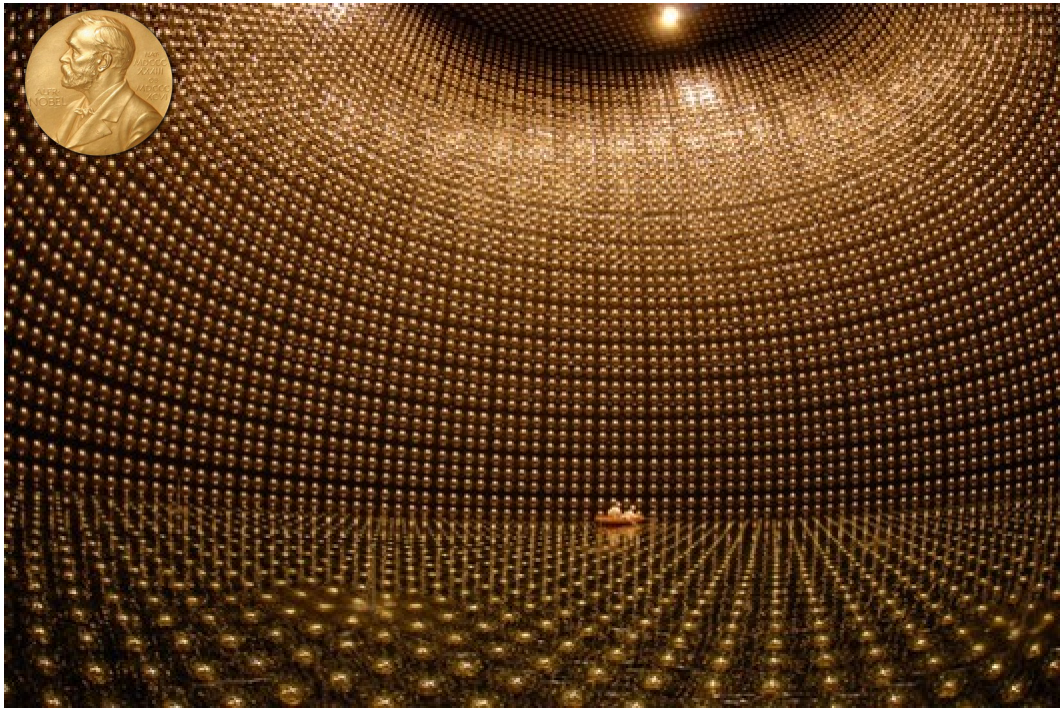


1956: Cowan and Reines discovered the ν_e

1962: Lederman, Schwartz, and Steinberger discovered the ν_μ

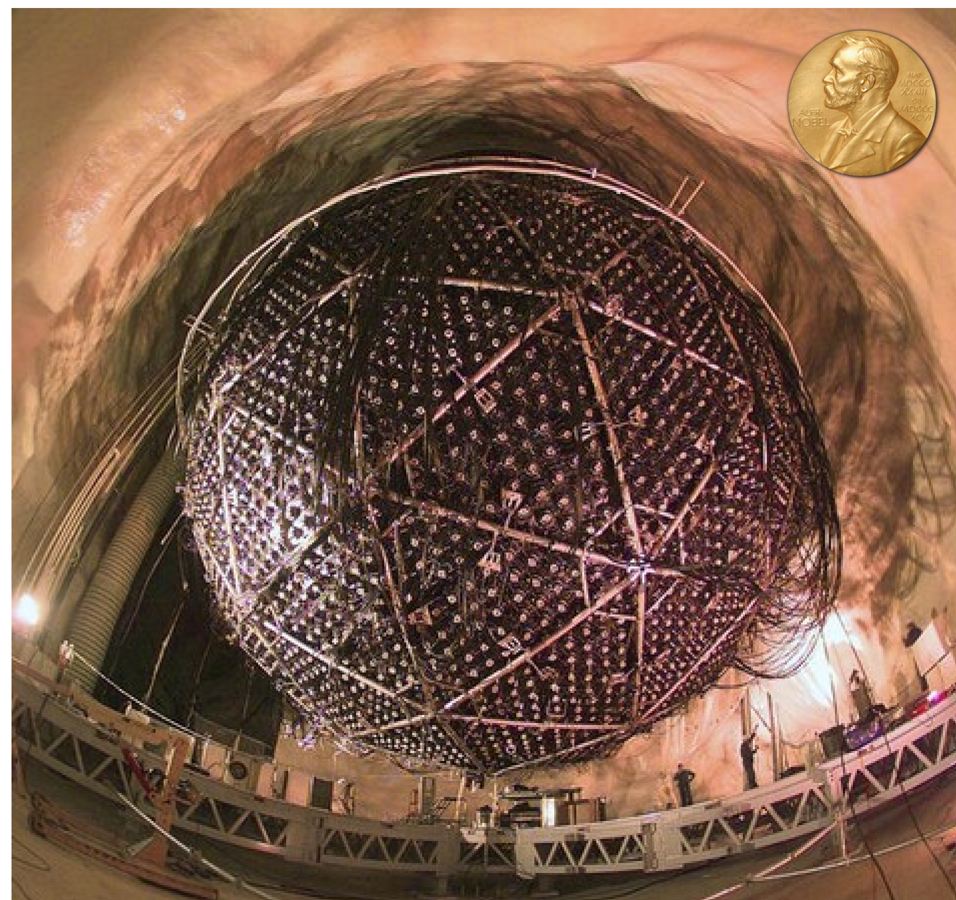
2000: DONUT collaboration discovered the ν_τ

Neutrinos Oscillate!

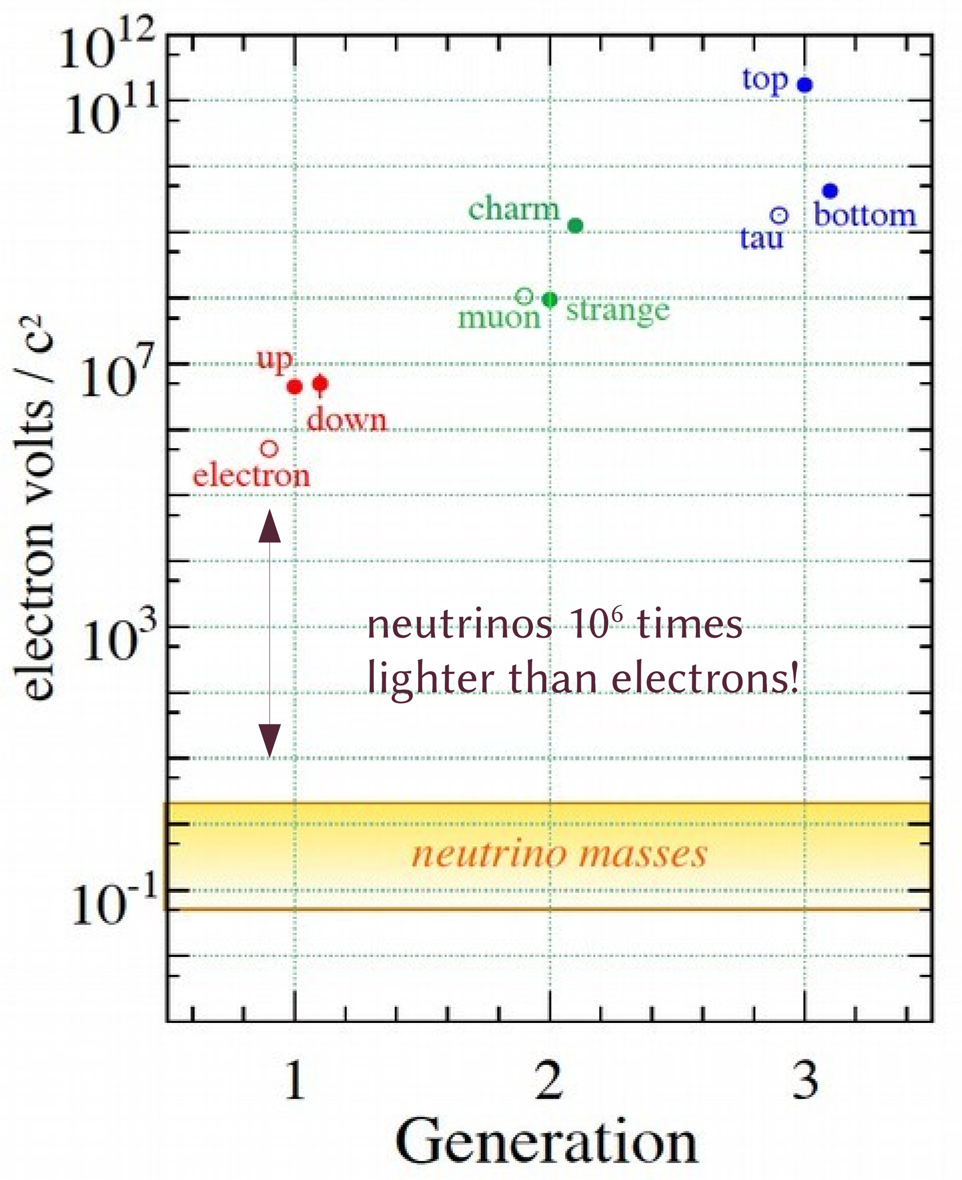


- Super-Kamiokande
  - Looked for ν_μ produced in the atmosphere by cosmic rays
  - Deficit of ν_μ going up through the earth compared to those coming down from the sky.

- SNO
  - Showed that ν_e from the sun less than expected
  - Total number of neutrinos agreed with expectations



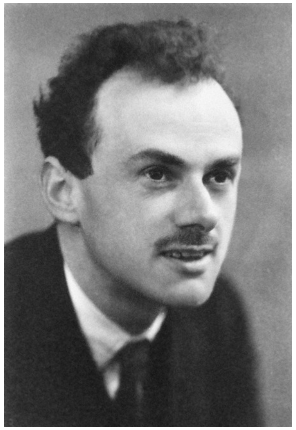
Oscillations are New Physics



Oscillations imply neutrinos have mass (but very little)

Dirac:

- All massive SM particles get this type of mass
  - Generated by Higgs mechanism
- Requires right-handed neutrinos



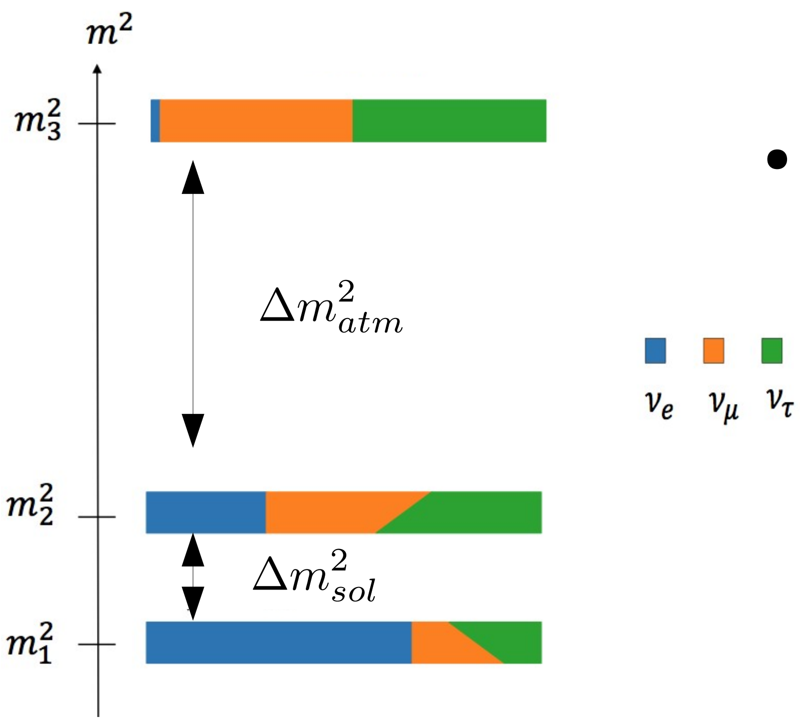
Majorana:

- Couples particle to its antiparticle
- No fundamental particles are known to have this type of mass

Three-Flavor Oscillations

$s_{ij} = \sin\theta_{ij} \quad c_{ij} = \cos\theta_{ij}$

$$\begin{bmatrix} \nu_e \\ \nu_\mu \\ \nu_\tau \end{bmatrix} = \begin{bmatrix} 1 & 0 & 0 \\ 0 & c_{23} & s_{23} \\ 0 & -s_{23} & c_{23} \end{bmatrix} \begin{bmatrix} c_{13} & 0 & s_{13}e^{-i\delta} \\ 0 & 1 & 0 \\ -s_{13}e^{i\delta} & 0 & c_{13} \end{bmatrix} \begin{bmatrix} c_{12} & s_{12} & 0 \\ -s_{12} & c_{12} & 0 \\ 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} \nu_1 \\ \nu_2 \\ \nu_3 \end{bmatrix}$$



- 3-flavor oscillations parameterized by:
  - Three mixing angles (θ_{12}, θ_{13}, θ_{23})
  - One CP-violating phase (δ)
  - Two mass splittings (Δm^2_{sol} and Δm^2_{atm})

Measuring Parameters

$s_{ij} = \sin\theta_{ij} \quad c_{ij} = \cos\theta_{ij}$

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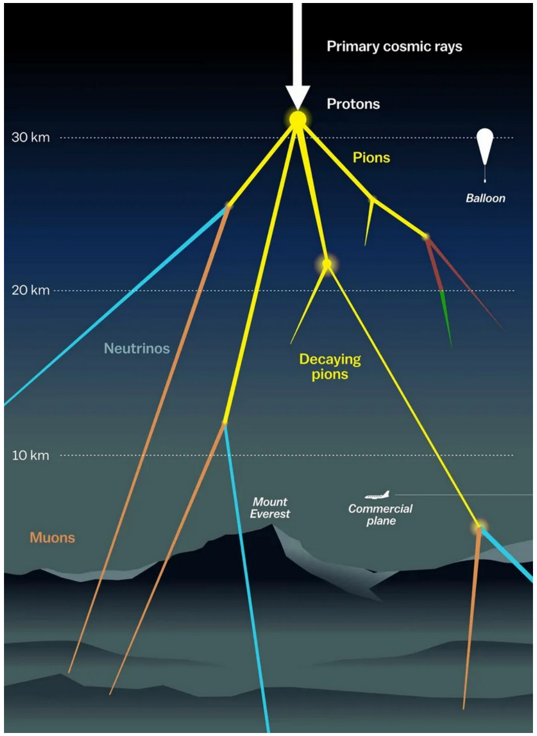
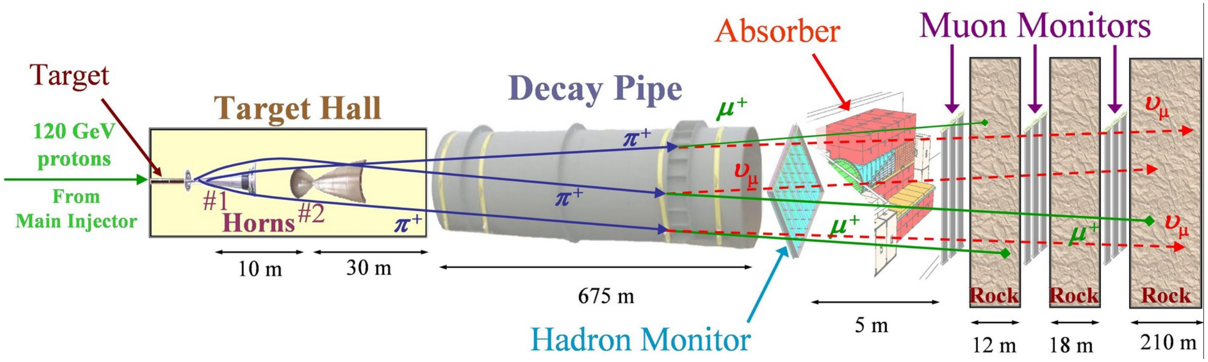
Atmospheric
Accelerator ν_μ





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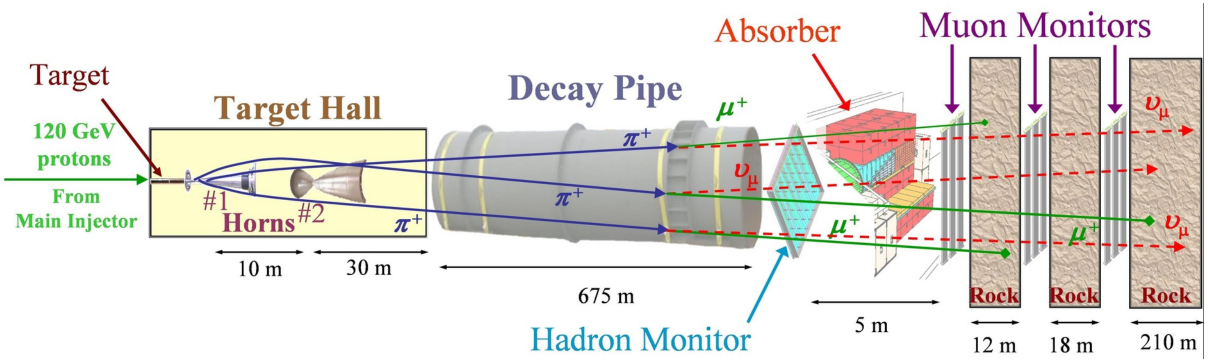
Short-baseline reactors
Accelerator ν_e



Measuring Parameters

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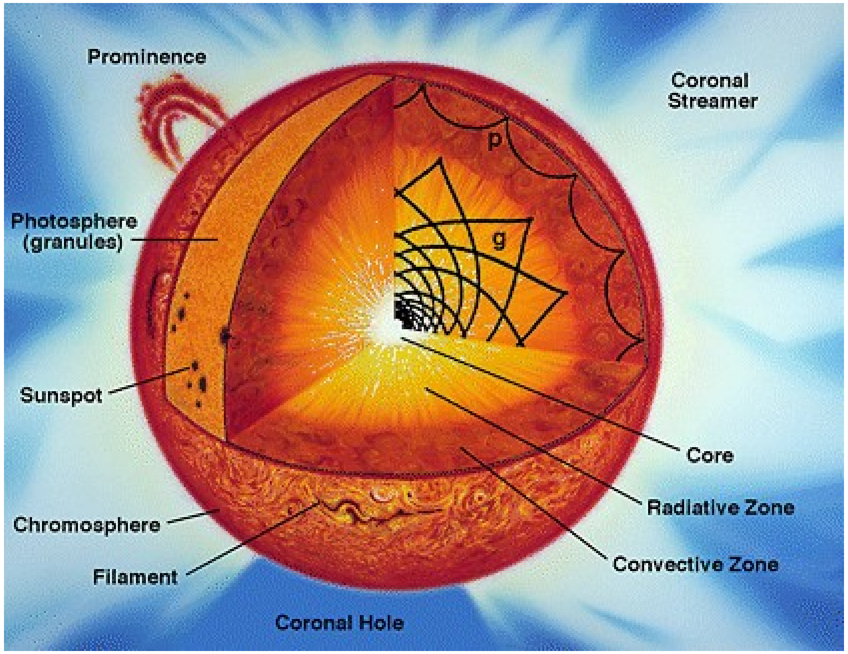
Solar
Long-baseline reactors



Open Questions

$s_{ij} = \sin\theta_{ij} \quad c_{ij} = \cos\theta_{ij}$

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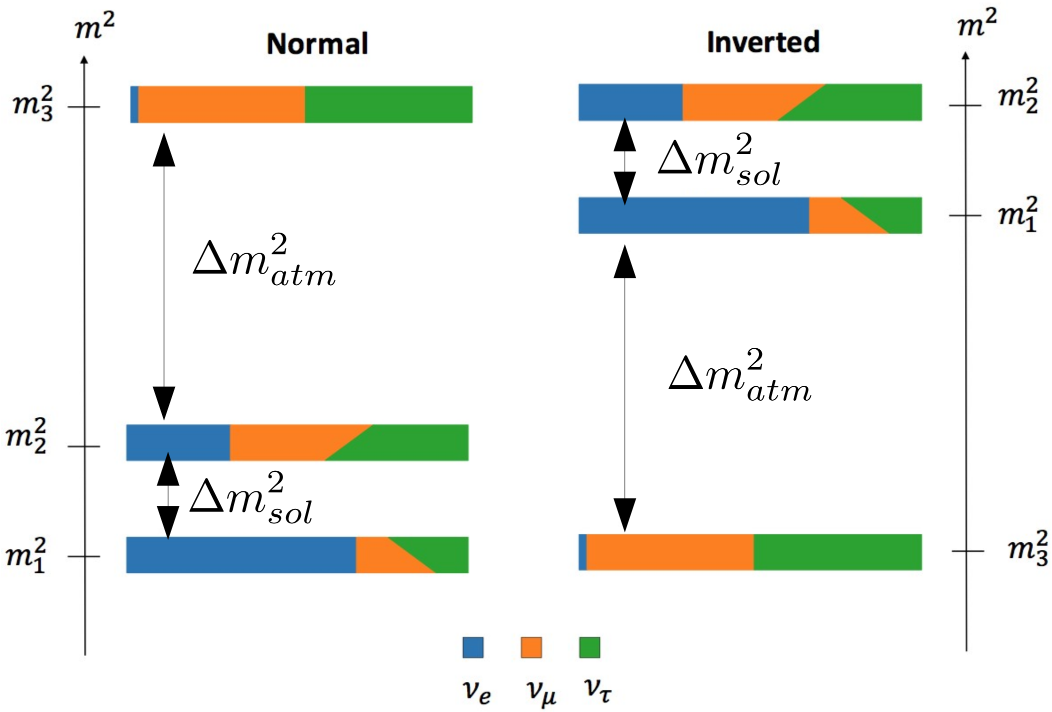

- Is θ_{23} exactly 45°?
- Is ν_3 the heaviest or lightest neutrino?
- What is the value of sinδ?
- Is the PMNS matrix unitary?
- Are there only three neutrinos?
- Is this the whole picture?

WG1 Program

- 44 total talks/virtual posters
- Plenary talks
  - Current and future experiments
- 4 joint sessions
  - WG1+WG2: constraining cross-section uncertainties/cross-section tuning
  - WG1+WG5: near-term BSM oscillation measurements
  - WG1+WG2+WG6: near detector constraints
  - WG1+WG6: machine learning strategies for reconstruction/selection
- 4 WG1-only sessions
  - Details of current and future experiments
  - Programs to improve oscillation experiments
  - Exploration of BSM oscillation scenarios

Plenary Talks

Monday		
13:50	Status of IceCube	Kayla Leonard
14:20	Status of T2K	Laura Kormos
14:50	Status of NOvA	Jeremy Wolcott
15:40	Status of DUNE	Sowjanya Gollapinni
16:10	Status of Hyper-Kamiokande	Michael Smy
16:40	Status of JUNO	Livia Ludhova

Tuesday		
11:00	Status of ESSnuSB	Marcos Dracos

Tuesday Parallel Sessions

14:00	WG1+WG2: Constraining xsec systs	Ballroom 2
	T2K improved neutrino-nucleus interaction model tuned to global data	Stephen Dolan
	Cross-section tuning from a NOvA perspective	Kirk Bays
	Structure functions and tau neutrino cross-sections at DUNE far detector	Barbara Yaeggy
	Current need for simulation tuning based on new experimental results in nu-A scattering	Jonathan Paley

16:00	WG1+WG5: BSM oscillations	Ballroom 2
	Status of the SBND at Fermilab	Miquel Nebot-Guinot
	Short-baseline neutrino oscillations with the ICARUS detector	Alessandro Menegolli
	Beyond the Standard Model searches with SBND	Supraja Balasubramanian
	New sensitivities for eV-scale sterile neutrino searches with IceCube	Alfonso Andres Garcia Soto
	Beyond Standard Model neutrino oscillation results from NOvA	V Hewes

Thursday Parallel Sessions

11:20	WG1+WG2+WG6: Near detector constraints	Ballroom 2&3
	The path to precision: Role of the DUNE near detectors	Zoya Vallari
	SBND-PRISM: Sampling multiple off-axis neutrino fluxes with the same detector	Marco Del Tutto
	Latest results on T2K near detector constraints for neutrino oscillation measurements	Callum Wilkinson
	The T2K near detector upgrade	Aoi Eguchi
	Total neutron cross section measurement on CH with a novel 3D-projection scintillation detectors	Ciro Riccio
14:20	WG1+WG6: Machine Learning for reco	Ballroom 2&3
	Machine learning techniques to enhance event reco in water Cherenkov detectors	Nick Prouse
	Measurement of atmospheric muon neutrino disappearance using CNN reconstruction with IceCube	Shiqi Yu
	Machine learning methods for solar neutrino classification	Alejandro Yankelevich
	Panoptic segmentation for particle identification in ProtoDUNE-SP	Carlos Sarasty

Thursday Parallel Sessions (cont)

16:10	WG1	Ballroom 2
	Exploring new physics effects of scalar NSI at long baseline experiments	Abinash Medhi
	Oscillation and decay of neutrinos in matter: an analytic treatment	Dibya S. Chattopadhyay
	KM3NeT/ORCA calibration procedures and capabilities	Antonio De Benedittis
	Influence of Lorentz invariance violation on oscillation probabilities in LBL experiments	Arnab Sarker
	Status of the KDAR neutrino search with JSNS2 experiment	Hyoungku Jeon

Friday Parallel Sessions

11:15	WG1	Ballroom 2
	Neutrino oscillation measurement with KM3NeT/ORCA	Johannes Schumann
	Neutrino mass ordering with IceCube DeepCore	Maria Prado Rodriguez
	New results from the atmospheric neutrino oscillations at Super-Kamiokande	Magdalena Posiadala-Zezula
	The NOvA test beam program	Michael Wallbank
14:20	WG1	Ballroom 2
	Neutrino mass scale from cosmological constraints	Olga Mena
	Three-flavor oscillation results for the NOvA experiment	Richa Sharma
	Long-baseline neutrino oscillation physics sensitivities of the Hyper-Kamiokande Experiment	Megan Friend
	DUNE long-baseline oscillation physics sensitivity	Callum Wilkinson
	NA61/SHINE proton-carbon hadron production measurements for neutrino oscillation experiments	Brant Rumberger

Friday Parallel Sessions (cont)

16:10	WG1	Ballroom 2
	Oscillation physics potential of JUNO	Jinnan Zhang
	Ability of DUNE to establish deviation from maximum θ_{23}	Masoom Singh
	Tau Neutrino Studies at ICAL Detector in INO	Thiru Senthil
	Tension between the T2K and NOvA appearance data and hints to new physics	Ushak Rahaman
	T2K oscillation analysis results: latest analysis improvements at the far detector	Kenji Yasutome

Summary

- Packed program covers broad range of topics relating to neutrino oscillations
- Plenary talks will provide an overview of the current and future state of the field
- Joint sessions will be an excellent opportunity to better understand issues that require a broader view to resolve
- WG1-only parallel sessions will provide a chance to understand the details of experiments