Fermilab U.S. DEPARTMENT OF ENERGY | Office of Science

Welcome to INSS 2023

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International Neutrino Summer School, August 7 - 18, 2023

Curriculum and Lectures

Neutrino Oscillation Theory	Concha Gonzalez-Garcia (YITP Stony Brook)
Dark Sector Theory	Brian Batell (U. Pittsburgh)
Dark Sectors at Neutrino Experiments	Bill Louis (Los Alamos)
Neutrinos in the Standard Model	Julian Heeck (U. Virginia)
Introduction to Leptogenesis	Mu-Chun Chen (UC Irvine)
Accelerator Neutrino Oscillations	Mark Messier (Indiana U.)
Neutrino Cosmology	Joel Meyers (Southern Methodist U.)
Statistical methods in HEP	Scott Oser (U. British Columbia)
Neutrinoless double beta decay experiments	Walter Petus (Indiana U.)
Neutrino Detectors	Sowjanya Gollapinni (Los Alamos)
Experimental Neutrino Cross Sections	Deborah Harris (York U.)

Neutrino Mass Models	Goran Senjanovic (LMU Munich)
Theory of Neutrino Cross Sections	Noemi Rocco (Fermilab)
Neutrino Beams and Fluxes	Joshua Spitz (U. Michigan)
Solar and reactor oscillations	Jelena Maricic (U. Hawaii)
Neutrinoless double beta decay and lepton number violation	Jordi deVries (Nikhef & U. Amsterdam)
Atmospheric oscillations	Ed Kearns (Boston U.)
Neutrino Astrophysics	Irene Tamborra (Niels Bohr Inst.)
Neutrino Simulation	Stephen Dolan (CERN)

First Week Agenda

- Full agenda on the Indico page: https://indico.fnal.gov/event/57378/timetable/#20230807

	Monday, August 7	Tuesday, August 8	Wednesday, August 9	Thursday, August 10	Friday, August 11
09:00 - 09:30	Welcome Meet and Greet	0νββ Experiments *Walter Petus*	Theory of Neutrino Cross Sections I *Noemi Rocco*	Neutrino Detectors II *Sowjanya Gollapinni*	Neutrino Mass Models I *Goran Senjanovic*
09:30 - 10:00					
10:00 - 10:30	Break	Break	Break	New results from the Muon g-2 experiment	Break
10:30 - 11:00	Neutrinos in the Standard Model I *Julian Heeck*	Neutrino Interaction Simulation I *Stephen Dolan*	Neutrino Detectors I *Sowjanya Gollapinni*		Neutrino Astrophysics II *Irene Tamborra*
11:00 - 11:30				Break	
11:30 - 12:00	Phenomenology of Massive Neutrinos I *M.C. Gonzalez-Garcia*	Phenomenology of Massive Neutrinos II *M.C. Gonzalez-Garcia*	Phenomenology of Massive Neutrinos III *M.C. Gonzalez-Garcia*	Theory of Neutrino Cross Sections II *Noemi Rocco*	Neutrino Mass Measurements *Walter Petus*
12:00 - 12:30					
12:30 - 13:00	Lunch	Lunch	Lunch	Lunch	Lunch
13:00 - 13:30					
13:30 - 14:00	Neutrino Beams and Fluxes I *Joshua Spitz*	Solar and Reactor Neutrino Oscillations II *Jelena Maricic*	Accelerator Neutrino Oscillations I *Mark Messier*	Neutrino Astrophysics I *Irene Tamborra*	Neutrinos in the Standard Model II *Julian Heeck*
14:00 - 14:30					
14:30 - 15:00	Break	Break	Neutrino Interaction Simulation II *Stephen Dolan*	Accelerator Neutrino Oscillations II *Mark Messier*	Break
15:00 - 15:30	Solar and Reactor Neutrino Oscillations I *Jelena Maricic*	Neutrino Beams and Fluxes II *Joshua Spitz*			Homework
15:30 - 16:00			Break	Break	
16:00 -16:30	Welcome Reception	Homework	Colloquium: Neutrinos in the Era of Multi-Messenger Astronomy *Irene Tamborra*	Poster Session	
16:30 - 17:00					
17:00 - 17:30			Fajita Night		
17:30 - 18:00					
18:00 - 18:30					
18:30 - 19:00					

Fermilab

Second Week Agenda

- Full agenda on the Indico page: https://indico.fnal.gov/event/57378/timetable/#20230807

	Monday, August 14	Tuesday, August 15	Wednesday, August 16	Thursday, August 17	Friday, August 18
09:00 - 09:30	Neutrino Mass Models II *Goran Senjanovic*	Introduction to Leptogenesis I *Mu-Chun Chen*	Neutrino Mass Models III *Goran Senjanovic*	Experimental Neutrino Cross Sections II *Deborah Harris*	Neutrino Cosmology II *Joel Meyers*
09:30 - 10:00					
10:00 - 10:30	Break	Break	Break	Break	Break
10:30 - 11:00	0νββ and Lepton Number Violation I *Jordi deVries*	Statistical Methods in HEP II *Scott Oser*	Experimental Neutrino Cross Sections I *Deborah Harris*	Neutrino Cosmology I *Joel Meyers*	Neutrino Mass Models IV *Goran Senjanovic*
11:00 - 11:30					
11:30 - 12:00	Atmospheric Neutrino Oscillations I *Ed Kearns*	Group Photo	0νββ and Lepton Number Violation II *Jordi deVries*	Dark Sector Theory I *Brian Batell*	Dark Sector Theory II *Brian Batell*
12:00 - 12:30		Lunch			
12:30 - 13:00	Lunch		Lunch	Lunch	Lunch
13:00 - 13:30		Introduction to Leptogenesis II *Mu-Chun Chen*			
13:30 - 14:00	Statistical Methods in HEP I *Scott Oser*		Statistical Methods in HEP III *Scott Oser*	Dark Sectors at Neutrino Experiments I *Bill Louis*	Dark Sectors at Neutrino Experiments II *Bill Louis*
14:00 - 14:30		Break			
14:30 - 15:00	Break	Atmospheric Neutrino Oscillations II *Ed Kearns*	Break	Break	Break
15:00 - 15:30	Neutrinos in the Standard Model III *Julian Heeck*		Homework	Homework/Tours	Homework/Tours
15:30 - 16:00		Homework			
16:00 -16:30	Homework		Colloquium: Phenomenology with Massive Neutrinos in 2023 *M.C. Gonzalez-Garcia*		
16:30 - 17:00					
17:00 - 17:30		Pizza Night		BBQ Dinner	
17:30 - 18:00					
18:00 - 18:30					
18:30 - 19:00					

Logistics

- **Welcome Reception:** Monday, August 07

- **Poster Session and Reception:** Thursday, August 10

- **Social Dinners:**
  - Wednesday, August 09 (Fajita Night)
  - Tuesday, August 15 (Pizza Night)
  - Thursday, August 17 (BBQ)

- **Daily Coffee Breaks:** Two breaks one in the morning session and one in the afternoon session

- **Lunch:** On your own at the cafeteria
  - Fermilab cafeteria orders can be placed in advance via the website or pay at the cashier before 11:30 am: https://www.clover.com/online-ordering/fermilab-caf---taher-batavia

- Dinner the remaining days on your own

Logistics

- **ID Badge Appointments:**

  - We have scheduled 10 students every hour today and every half an hour on Tuesday, please check the schedule to see your appointment: https://drive.google.com/file/d/1eyyNRbIOdVBYrs3w621LxqFIdbX2brek/view

- **Bus to/from Hotel:**

  - Bus will leave your hotel at 8:15 am every day of the school to bring you to Fermilab. On the way back, the bus will take you back to the hotel at 5:15 pm (except the days when we have additional activities until late, on those days the bus will leave at the hour when the activity finishes).

Homework Exercises

- You should complete 5-6 of the assigned homework sets. They should take ~3 hours each.

- There is time allocated in the school to work together with other students on the homework & to discuss with lecturers.

- Homework areas are organized by interest (see next slide)

- Some of the neutrino experiment exercises involve ROOT and a personal laptop.

- Homework exercises are available at this google drive link : https://drive.google.com/drive/folders/1ZnRf8OhRbhQKg7H7dhJfGwtE84a5Xhmn?usp=drive_link

- Some of the exercises will only be posted next Monday.

Homework Exercises

Homework exercises are available at this google drive link

https://drive.google.com/drive/folders/1ZnRf8OhRbhQKg7H7dhJfGwtE84a5Xhmn?usp=drive_link

Homework Topics/rooms

- **Neutrino oscillation experiment** (Oscillation theory, Oscillation experiment, Neutrino detection, Statistics, Beams and fluxes): One West room

- **Neutrino oscillation theory** (Oscillation theory, Neutrino mass models, Oscillation experiment, Neutrino Astrophysics, Neutrino cosmology): Hornest (8 floor) first week and second week Comitium (2 floor)

- **Physics beyond the SM** (Dark sectors (Expt + Theory), Neutrino mass models, Leptogenesis, LNV + neutrinoless theory, Neutrinoless beta decay experiment): Oscillatorium room (13 floor)

- **Neutrino-nucleus cross sections**(Cross section theory, Cross section experiment, Neutrinos in SM (Heeck), Neutrino detection, Neutrino simulation: Nus room (12 floor)

- **Astro/Cosmology & neutrinos** (Neutrino cosmology,Neutrino astro, Oscillation theory, Oscillation experiments, Statistical methods in HEP): Disappearance room (13 floor)

Posters

- Poster presentation is scheduled for Thursday August 10 at 4:00 pm

- We have scheduled 84 poster presentations

- Poster could be printed at Fermilab with a fee, if you need to print please email Cindy Arnold at carbold@fnal.gov

Tours

- Thursday Aug 17 and Friday Aug 18, 3:00 to 5:00 PM
- There are two tour options, due to space limitation you will have to pick one. A google form will be sent later today for you to pick your option (first come first serve basis).

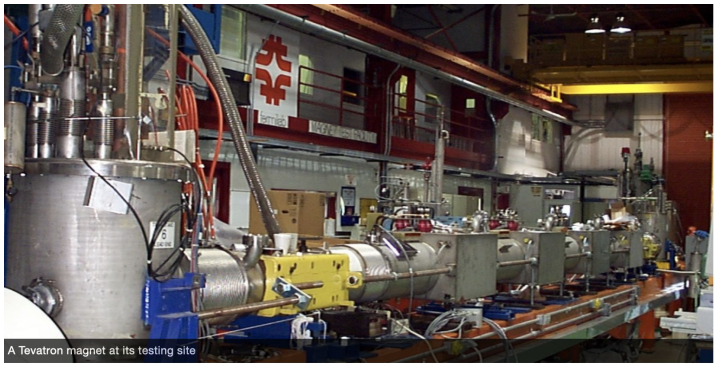
https://docs.google.com/forms/d/e/1FAIpQLSeBAcqQHs_vbbL5JW9supVB8J5BVbBu4csHL4vtVt8gZe4Ebw/viewform

***Neutrino Campus Tour*: (max 80 students)**

Fermilab is the neutrino capital of the world and hosts a suite of neutrino experiments to study several standard and beyond the standard model physics questions. Before being detected, neutrinos from Fermilab experiments travel over short distances (several hundred meters) and over long distances (several hundred miles). In this tour, we will visit the Short Baseline Near Detector (SBND) facility, a Liquid Argon Time Projection Chamber (LArTPC) detector which is part of the Short Baseline Neutrino (SBN) program at Fermilab.

***SRF and SC Magnet Facility Tour*: (max 60 students)**

Fermilab is a leading center for the development of high gradient superconducting RF cavities to drive particle accelerators, and the high-field superconducting magnets used to control and contain high energy particle beams. This tour will visit several of the main facilities used in the research, development and production of these technologies.



A Tevatron magnet at its testing site