1 – Are neutrinos Dirac or Majorana particles?	3 – CP violation from flavor fractions	4 – Coherence in neutrino oscillations	11 – Statistical test for discovery
10 – Sensitivity studies with GLoBES	5 – Cross sections for long-baseline experiments	14 – The future of long-baseline neutrino physics	8 – Neutrino telescopes meet neutrino beams
2 – Atmospheric neutrinos from Earth, Sun and planets	6 – Find the Supernova!	9 – Pre-Supernova Neutrinos	12 – The Hunt for Red October
7 – Low-energy neutrino target isotopes	13 – Vertex reconstruction in scintillator	15 – Neutrino detection at 30 PeV	16 – Separation of hadronic and electromagnetic cascasdes

## **Neutrino Physics & Oscillations**

**1)** Are neutrinos Dirac or Majorana particles?

Invent novel experimental approaches to determine whether neutrinos are Dirac or Majorana particles. Focus: Neutrino physics Requirements: Analytical calculations Author: Boris Kayser

#### 3) CP violation from flavor fractions

Analyze the structure of the leptonic mixing matrix and of neutrino oscillation probabilities to understand the conditions under which CP is violated in the neutrino sector. **Focus:** Oscillation physics **Requirements:** Analytical calculations **Author:** Boris Kayser

#### 4) Coherence in neutrino oscillations

A project about the subtle quantum mechanics of neutrino oscillations, including several potential brain-teasers. Focus: Neutrino oscillations Requirements: Analytical calculations Author: Joachim Kopp

## Long-baseline oscillations

10) Sensitivity studies with GLoBES
Learn to use the software package GLoBES
and study the sensitivity of current and
future experiments.
Focus: Neutrino oscillations
Requirements: Numerical
calculation/GLoBES software
Author: Joachim Kopp

14) The future of LBL neutrino physics
Perform a MC-based study to project the
final sensitivity of the T2K experiment
Focus: Neutrino oscillations
Requirements: Numerical calculations
Author: Hiro Tanaka

5) Cross sections for LBL experiments

In this activity, you will learn the steps necessary to calculate the neutrino interaction total cross section as function of the neutrino energy. Focus: Neutrino physics Requirements: Numerical calculation Author: Minerba Betancourt 8) Neutrino telescopes meet v beams Explore the potential of the future lowenergy neutrino telescopes PINGU and ORCA to study oscillations from atmospheric and beam neutrinos. Focus: Oscillation physics Requirements: Numerical calculation / PISA Author: Sebastian Böser

# **Observation of neutrinos**

### 6) Find the Supernova

In this activity, you will learn the steps necessary to calculate the neutrino interaction total cross section as function of the neutrino energy. Focus: Supernova and detector physics Requirements: Toy MC Author: Basudeb Dasgupta

### 9) Pre-Supernova Neutrinos

Be the first one to see the next Supernova coming! Learn to distinguish the faint neutrino signal of remote sSi-burning stars from other neutrino background fluxes. **Focus:** Low-energy v's, stellar physics **Requirements:** Analytical and numerical calculations **Author:** Michael Wurm

# 2) Atmospheric neutrinos from Earth, Sun and planets

Learn about the physics of atmospheric neutrinos and its dependence on atmospheric properties. Focus: Atmospheric showers, particle decay and absorption Requirements: analytical calculations Author: Lutz Köpke

### **12)** The Hunt for Red October

Come up with a neutrino-based scheme to pinpoint nuclear submarines or an evasion strategy for detection. Focus: Reactor neutrinos, applied neutrino physics Requirements: simple analytical and numerical estimates Author: Patrick Huber

### **Neutrino detectors & analysis**

7) Low-energy neutrino target isotopes
Select a suitable target isotope for a lowenergy neutrino detector.
Focus: Low-energy neutrinos, nuclear physics
Requirements: Analytical calculation
Author: Jonathan Link

15) Detection of 30 PeV neutrinos
Assess a possible detector design for cosmic neutrinos at the very highest energies
Focus: High- energy neutrinos, detector physics
Requirements: analytical and numerical calculations
Author: Dave Seckel

13) Vertex reconstruction in scintillator
Build your own virtual solar neutrino
detector! Learn to reconstruct the position
of neutrino events in your liquid scintillator
target to reject external background.
Focus: Low-energy neutrinos,
event reconstruction algorithms

event reconstruction algorithms Requirements: Toy Monte Carlo Author: Michael Wurm

# 16) Separation of hadronic and electro-magnetic cascades

Explore methods to separate hadronic from electromagnetic cascades in a high-energy neutrino telescope Focus: High- energy neutrino detectors Requirements: analytical calculation

or GEANT Author: Dave Seckel

Michael Wurm (Mainz)

#### **11) Statistical test for discovery**

Design a statistical test for discovery of a signal process such as dark matter by counting events in a detector. Focus: High-level analysis, statistics Requirements: analytical calculation Author: Glen Cowan