Abstract

A nearby supernova will carry an unprecedented wealth of information about astrophysics, nuclear physics, and particle physics. Because supernova are fundamentally neutrino driven phenomenon, our knowledge about neutrinos – particles that remain quite elusive – will increase dramatically with such a detection. One of the biggest open questions in particle physics is related to the masses of neutrinos. Here we show how a galactic supernova provides information about the masses of each of the three mass eigenstates *individually*, at some precision, and is well probed at JUNO. This information comes from several effects including time delay and the physics within the supernova. The time delay feature is strongest during a sharp change in the flux such as the neutronization burst; additional information may also come from a QCD phase transition in the supernova or if the supernova forms a black hole. We consider both standard cases as dictated by local oscillation experiments as well as new physics motivated scenarios where neutrino masses may differ across the galaxy.

Individual Neutrino Masses From a Supernova

Peter B. Denton

BNL HET Lunch Discussion

January 10, 2025

2411.13634 with Yves Kini

Outline

1. Introduction
2. Possibility of spatially evolving neutrino masses
3. Neutrinos from a supernova
4. Time delay features
5. Detection
6. Sensitivities
7. Conclusions

Outline

1. **Introduction**
2. Possibility of spatially evolving neutrino masses
3. Neutrinos from a supernova
4. Time delay features
5. Detection
6. Sensitivities
7. Conclusions

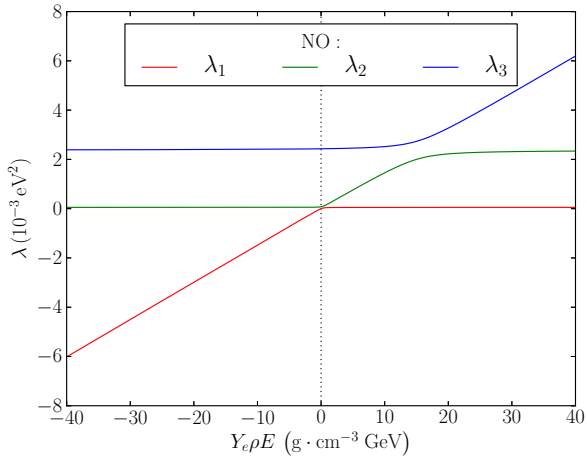
Outline

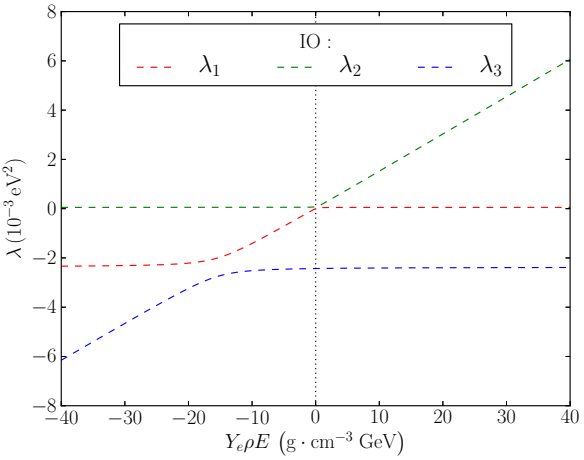
1. Introduction
2. **Possibility of spatially evolving neutrino masses**
3. Neutrinos from a supernova
4. Time delay features
5. Detection
6. Sensitivities
7. Conclusions

Outline

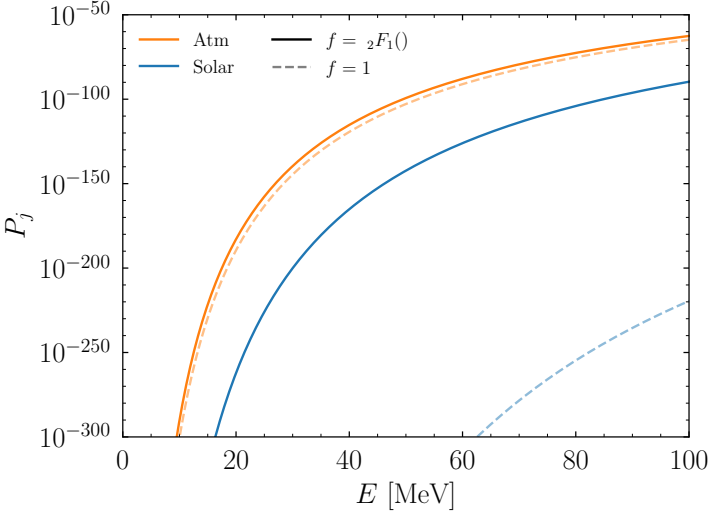
1. Introduction
2. Possibility of spatially evolving neutrino masses
3. **Neutrinos from a supernova**
4. Time delay features
5. Detection
6. Sensitivities
7. Conclusions

Eigenvalues

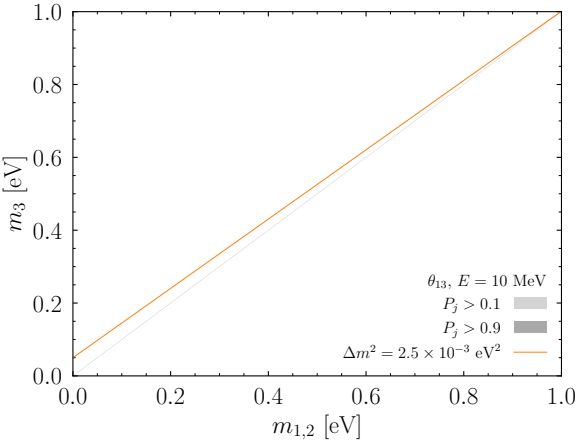


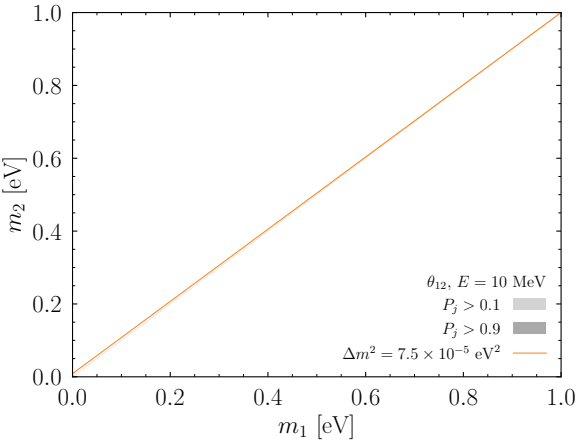


Jump Probabilities



Jump Probabilities





Outline

1. Introduction
2. Possibility of spatially evolving neutrino masses
3. **Neutrinos from a supernova**
4. Time delay features
5. Detection
6. Sensitivities
7. Conclusions

Outline

1. Introduction
2. Possibility of spatially evolving neutrino masses
3. Neutrinos from a supernova
4. **Time delay features**
5. Detection
6. Sensitivities
7. Conclusions

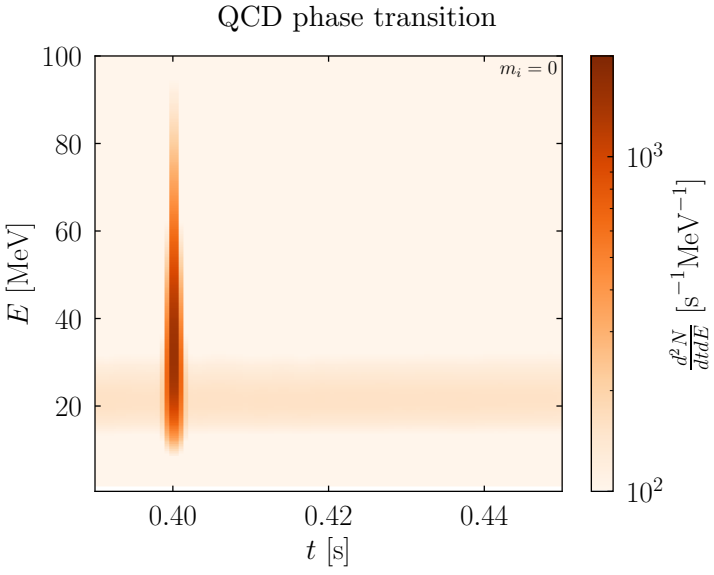
Outline

1. Introduction
2. Possibility of spatially evolving neutrino masses
3. Neutrinos from a supernova
4. Time delay features
5. **Detection**
6. Sensitivities
7. Conclusions

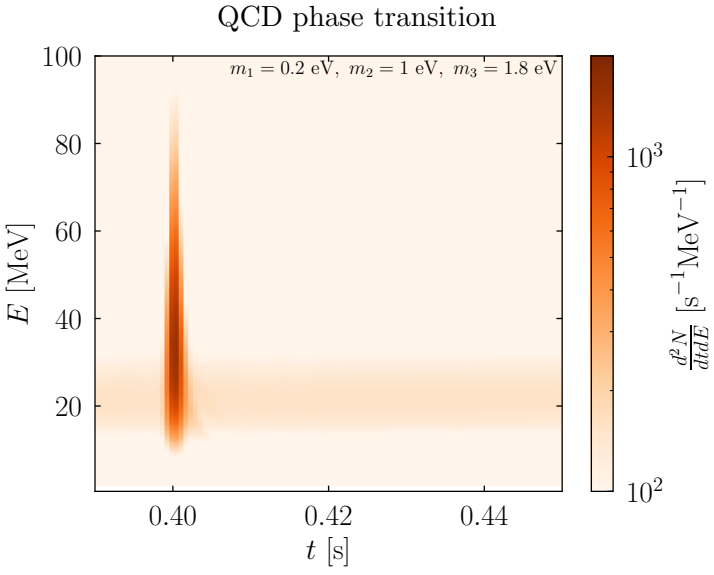
Outline

1. Introduction
2. Possibility of spatially evolving neutrino masses
3. Neutrinos from a supernova
4. Time delay features
5. Detection
6. **Sensitivities**
7. Conclusions

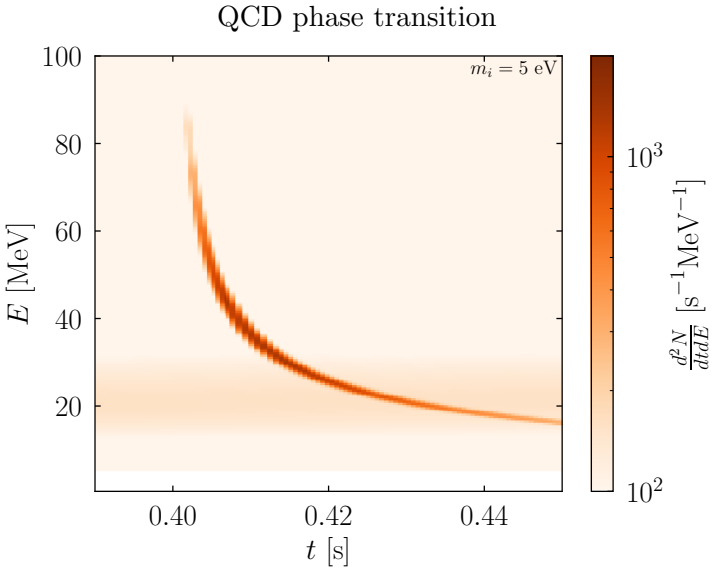
Events


QCD phase transition
$m_i = 0$
100
80
60
40
20
E [MeV]
0.40
0.42
0.44
t [s]
10^3
10^2
$\frac{d^2N}{dtdE}$ [s^{-1}MeV^{-1}]

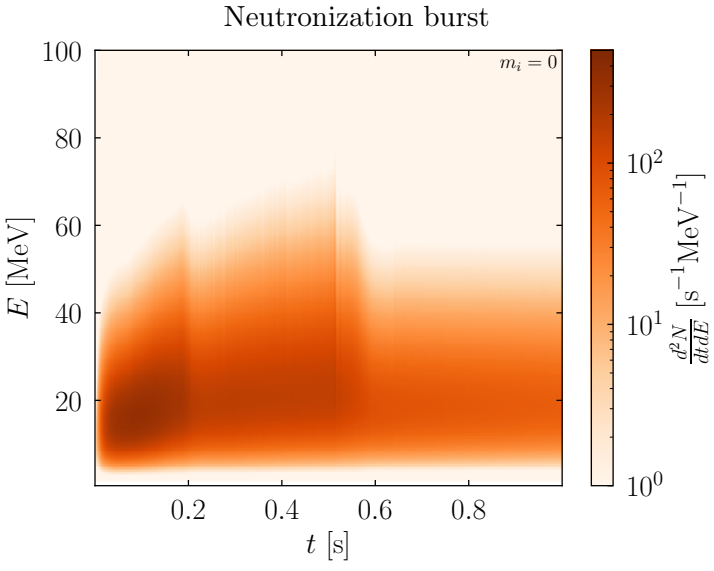
Events


QCD phase transition
$m_1 = 0.2$ eV, $m_2 = 1$ eV, $m_3 = 1.8$ eV
100
80
60
40
20
E [MeV]
0.40
0.42
0.44
t [s]
10^3
10^2
$\frac{d^2N}{dtdE}$ [s^{-1}MeV^{-1}]

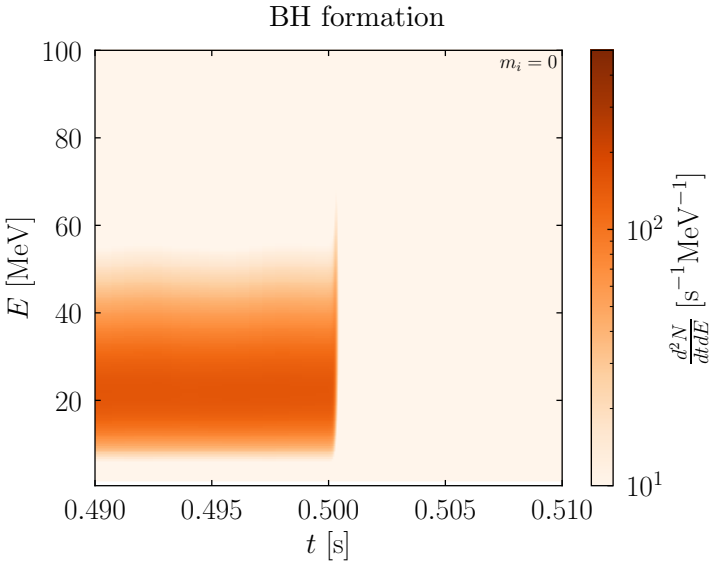
Events


QCD phase transition
$m_i = 5$ eV
100
80
60
40
20
E [MeV]
0.40
0.42
0.44
t [s]
10^3
10^2
$\frac{d^2N}{dtdE}$ [s^{-1}MeV^{-1}]

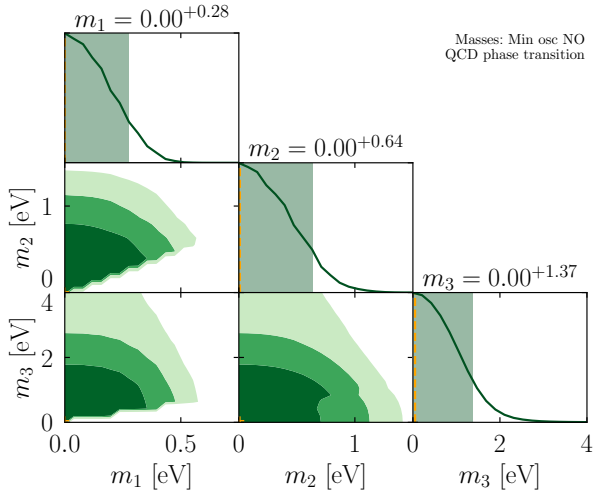
Events


Neutronization burst
$m_i = 0$
100
80
60
40
20
E [MeV]
0.2
0.4
0.6
0.8
t [s]
10^2
10^1
10^0
$\frac{d^2N}{dtdE}$ [s^{-1}MeV^{-1}]

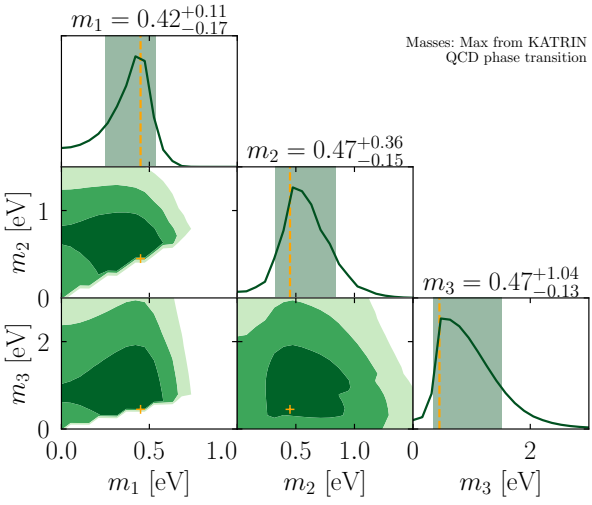
Events


BH formation
$m_i = 0$
100
80
60
40
20
E [MeV]
0.490
0.495
0.500
0.505
0.510
t [s]
10^2
10^1
$\frac{d^2N}{dtdE}$ [s^{-1}MeV^{-1}]

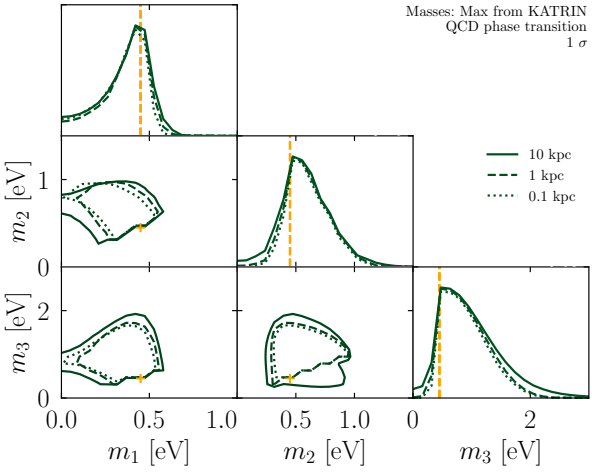
Sensitivities



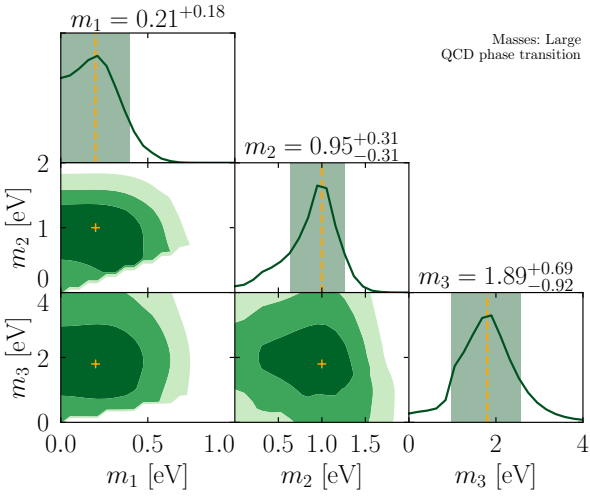
Sensitivities



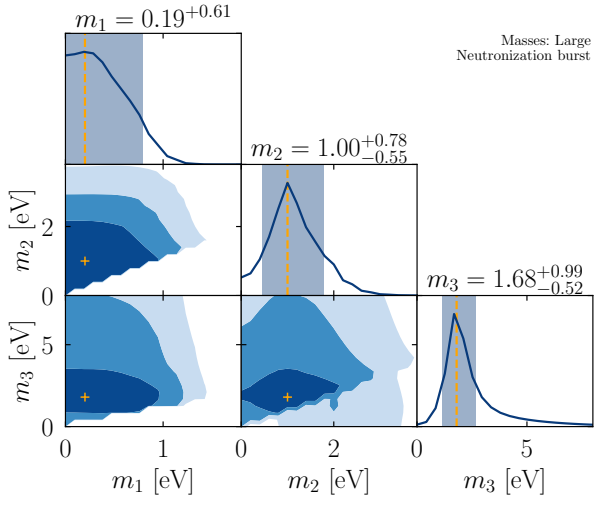
Sensitivities



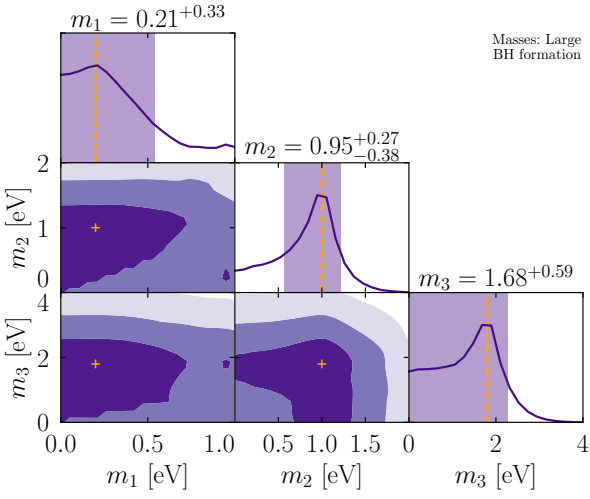
Sensitivities



Sensitivities



Sensitivities



Outline

1. Introduction
2. Possibility of spatially evolving neutrino masses
3. Neutrinos from a supernova
4. Time delay features
5. Detection
6. Sensitivities
7. **Conclusions**