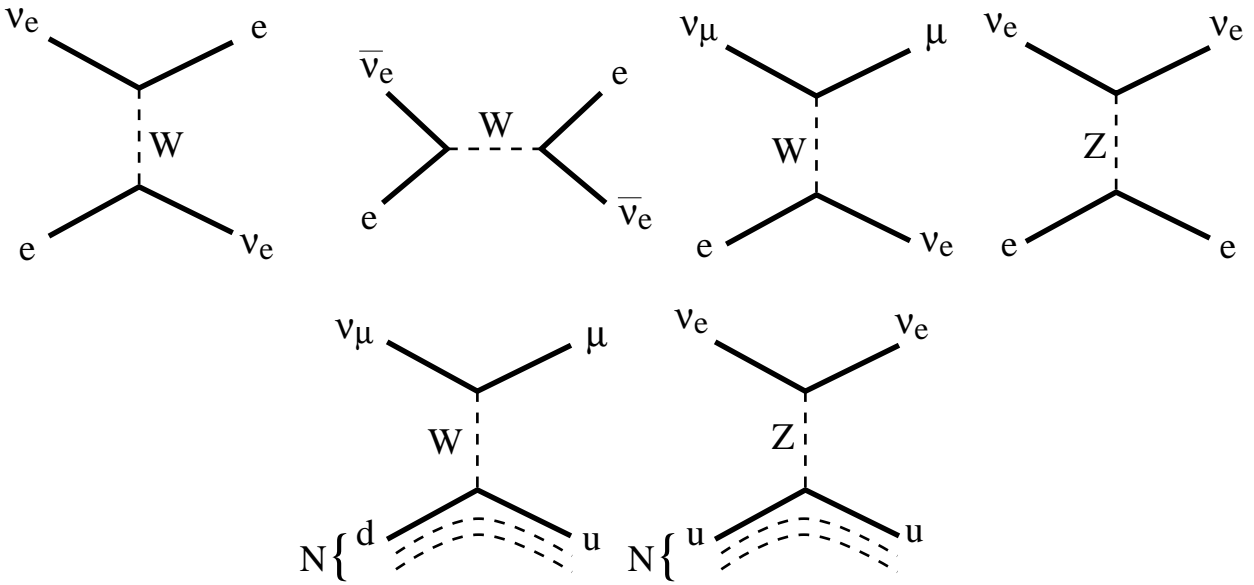


Neutrino shower physics

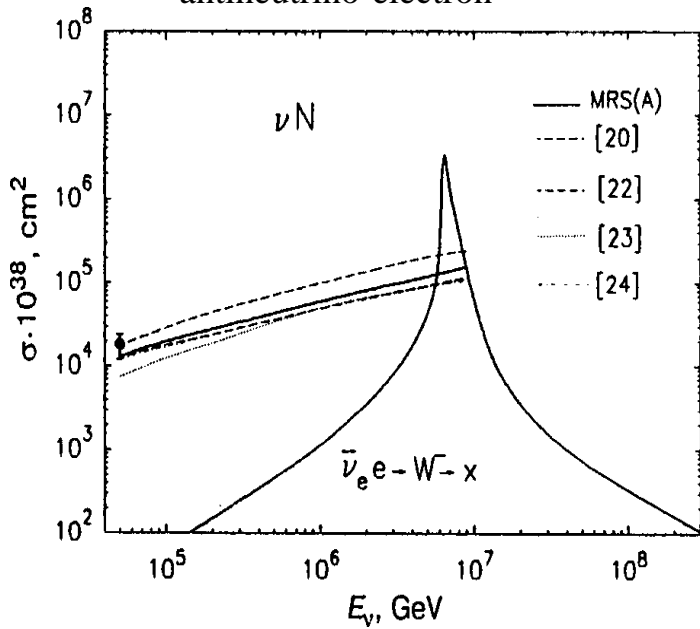
Shower consists of the following components:

- hadronic (pions, kaons etc.)
- electromagnetic (electrons, positrons, gamma photons)
- muons

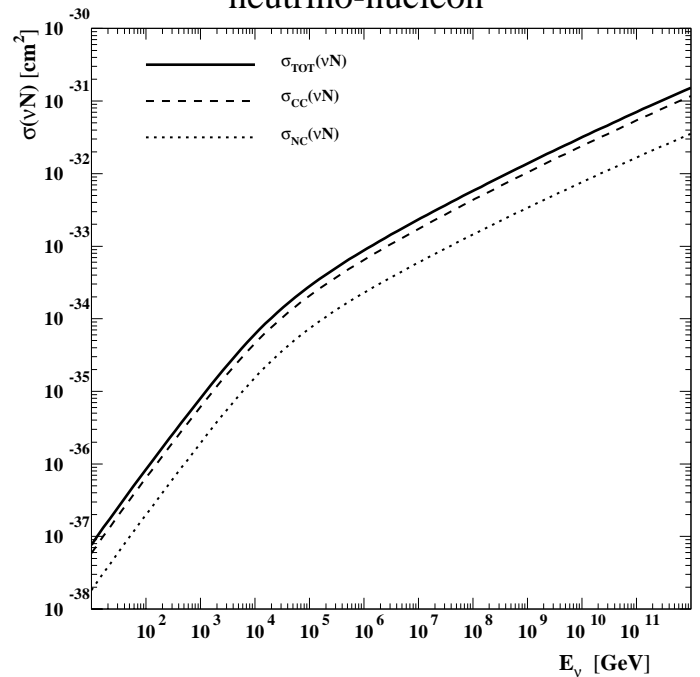
Neutrino cross-section



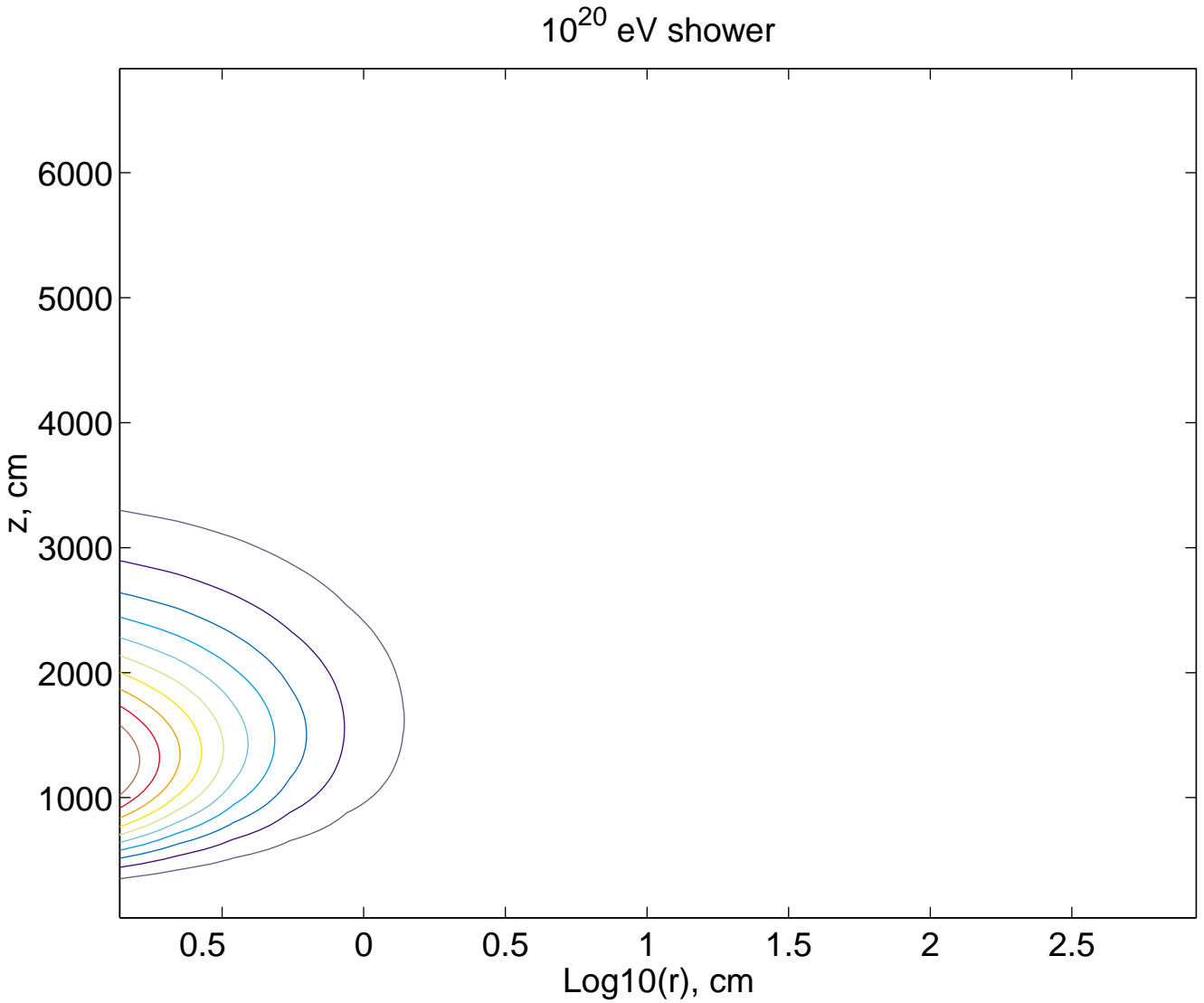
Butkevich et al., 1998:
neutrino/antineutrino-nucleon
antineutrino-electron



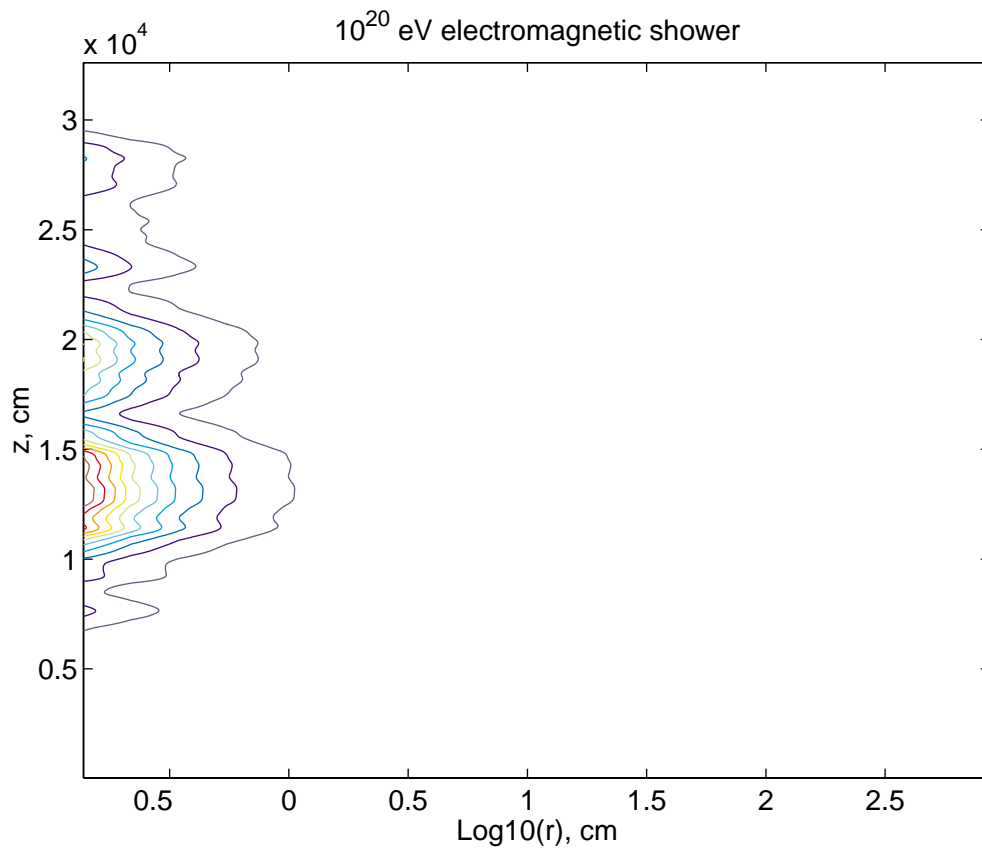
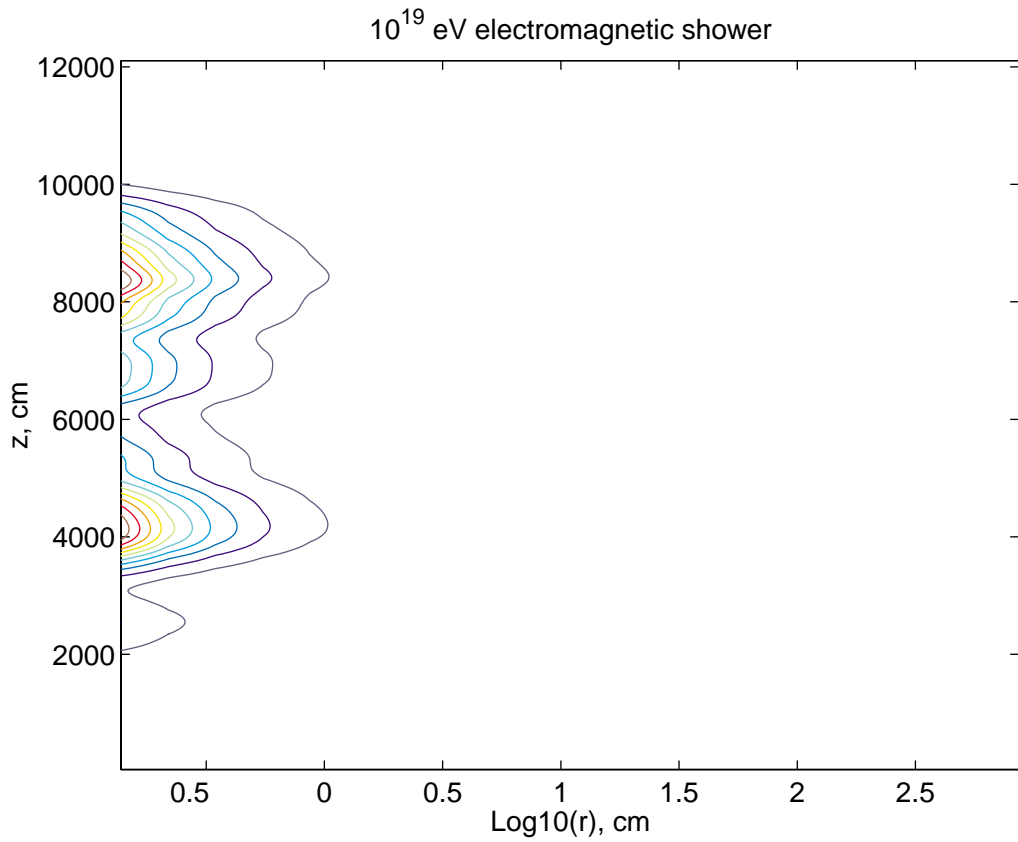
Kwiecinski et al., 1998:
neutrino-nucleon



Analytical shower parametrization [Learned, 1979]

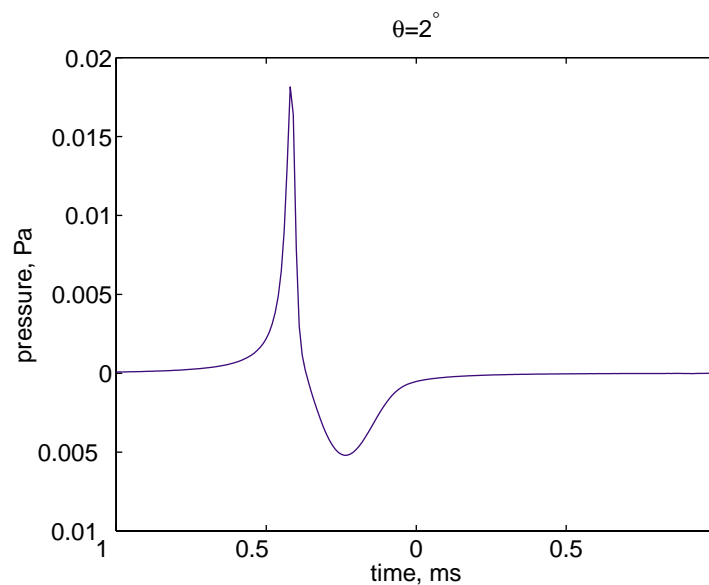
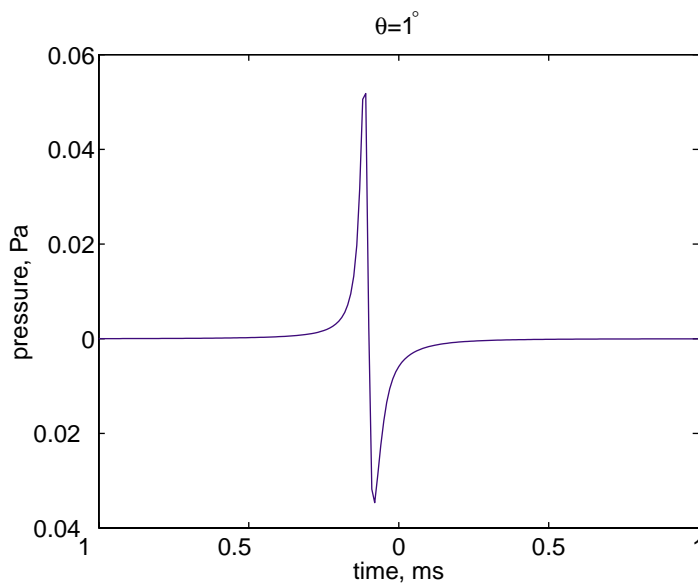
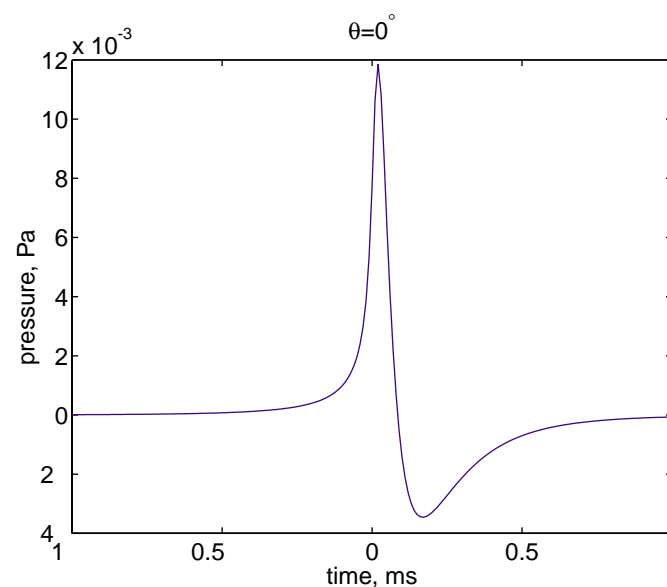
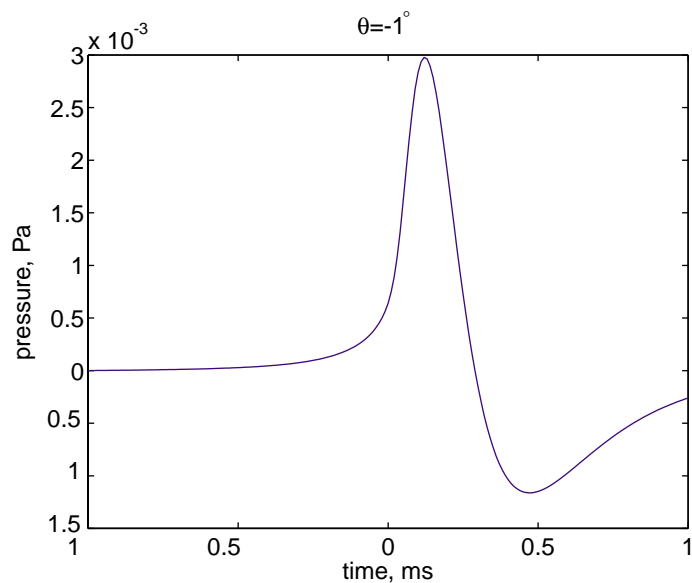
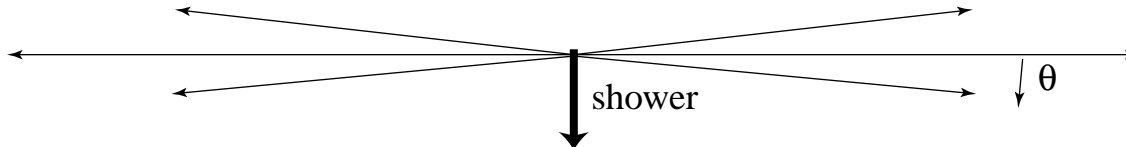


Alvarez-Muniz et al. model results

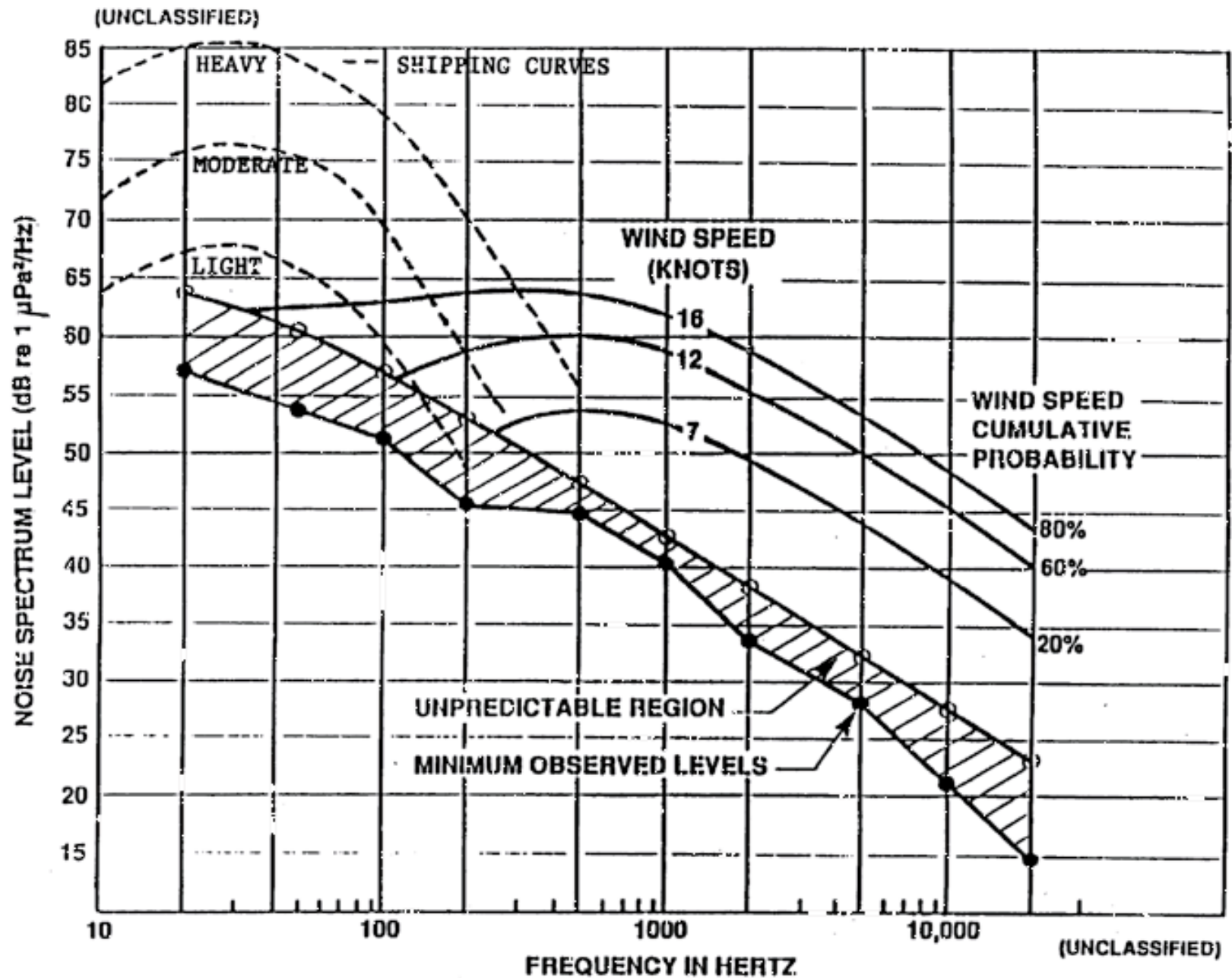


Sound pulse simulation results (for Learned parametrization)

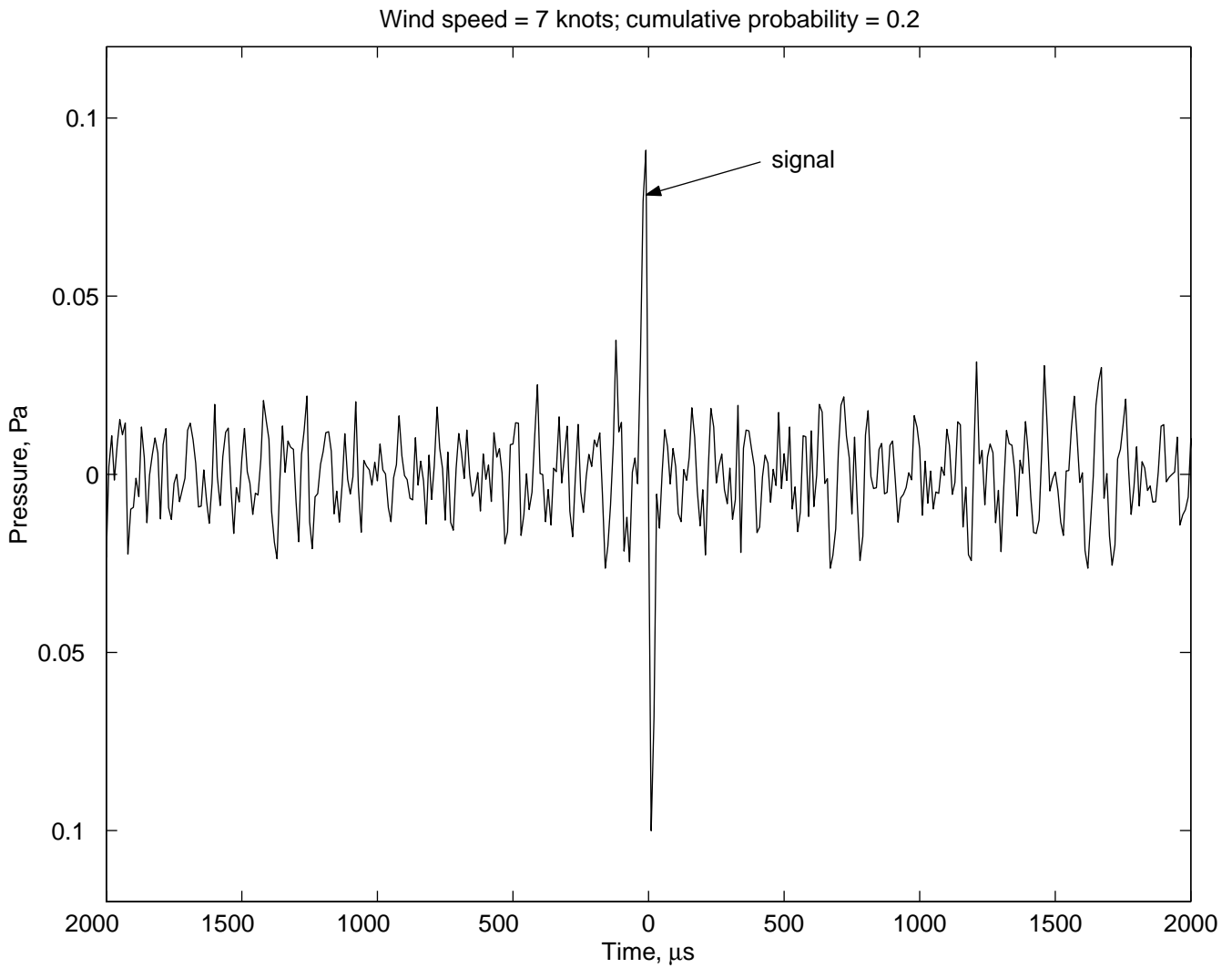
The acoustic radiation is in a narrow disk perpendicular to shower axis



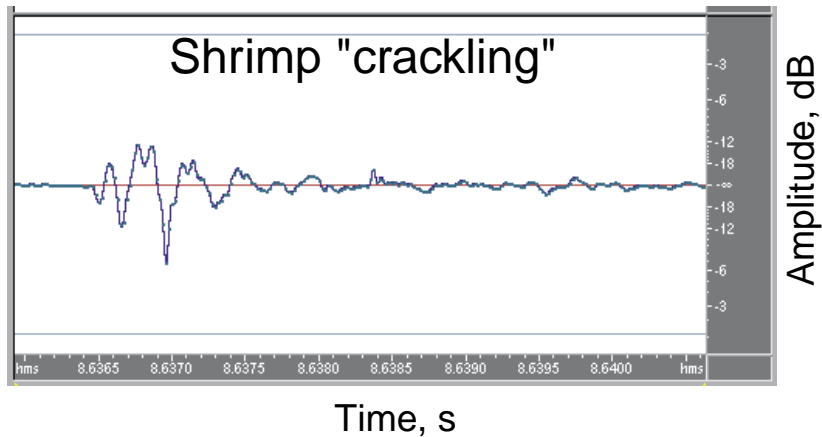
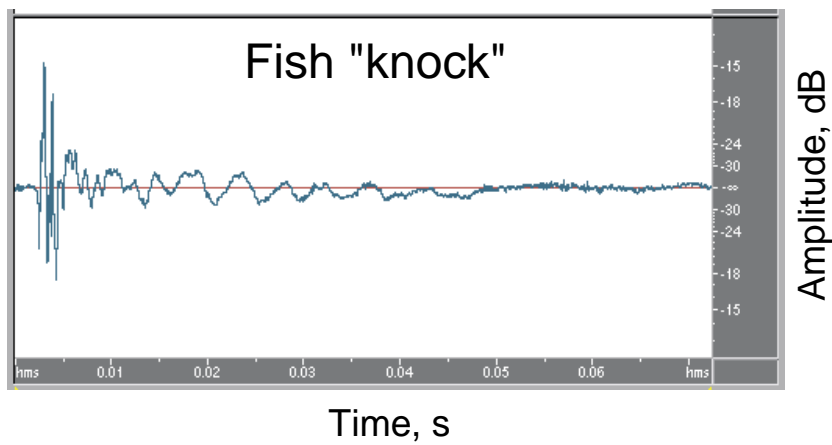
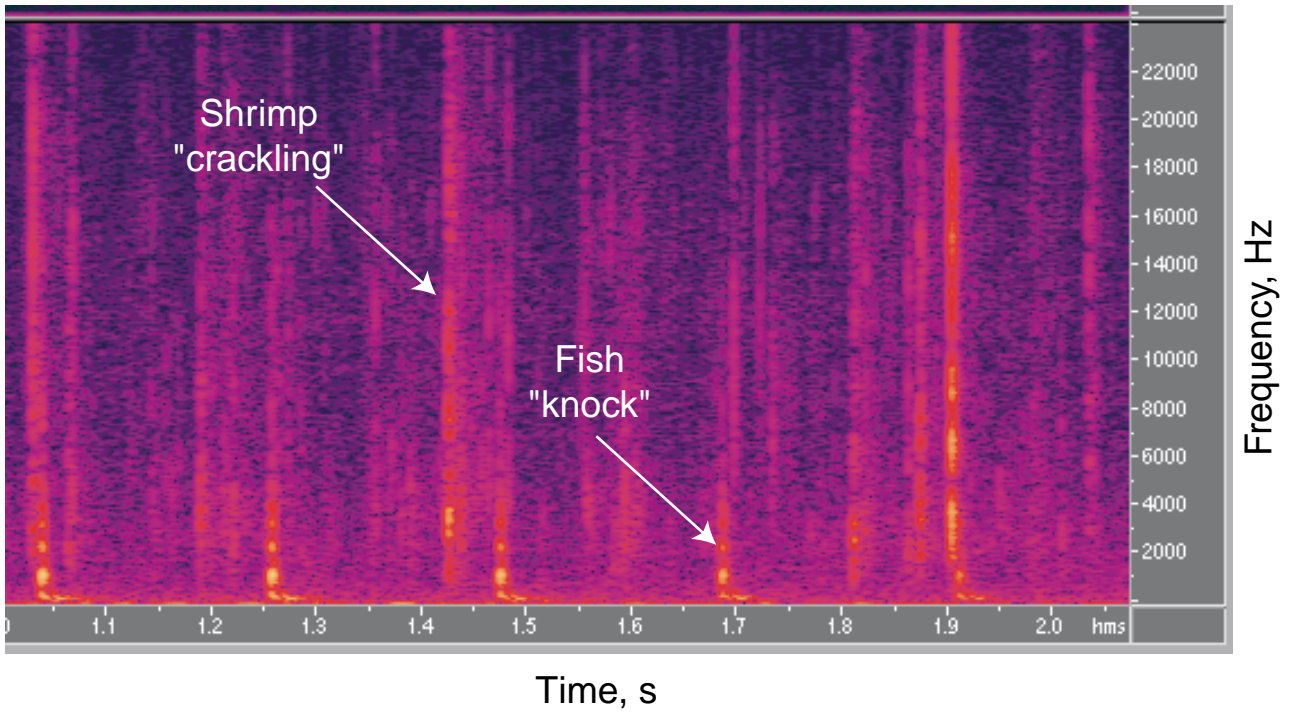
AMBIENT NOISE LEVELS AT AUTEC, TOTO, BAHAMAS



The pulse of 10^{20} eV neutrino recorded at 1 km distance super-imposed on the statistical noise

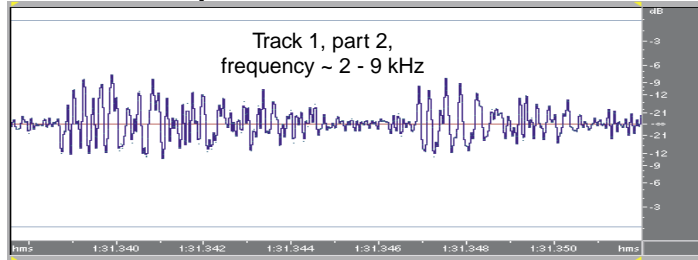


Examples of animal noise (from UCSD tape)

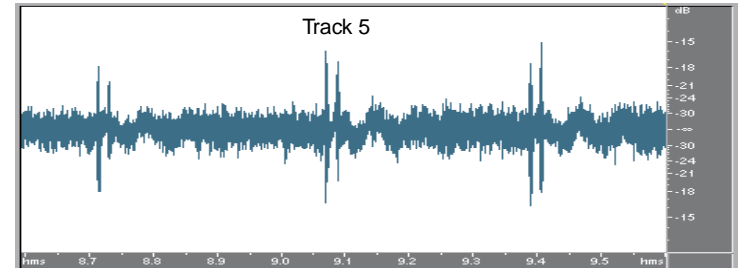


More examples of animal noise (from AUTECD CD)

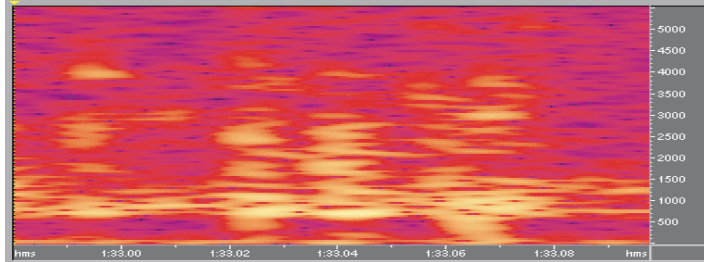
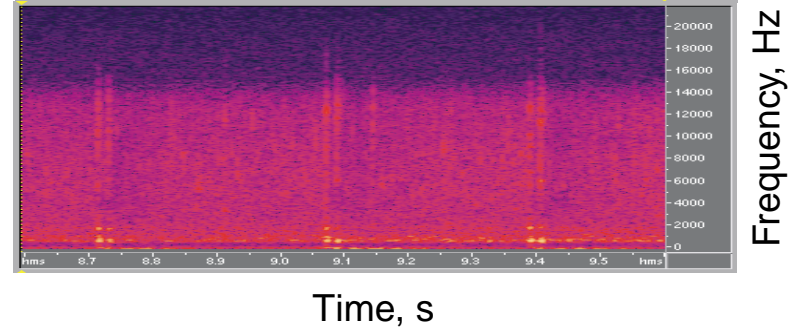
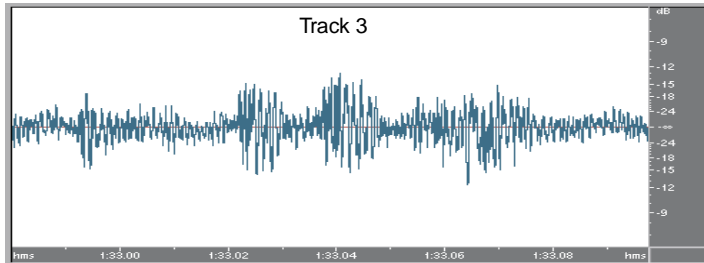
Sperm whale "click"



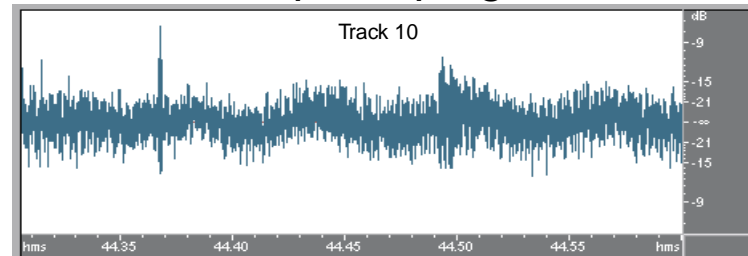
Pilot whale "knocks"



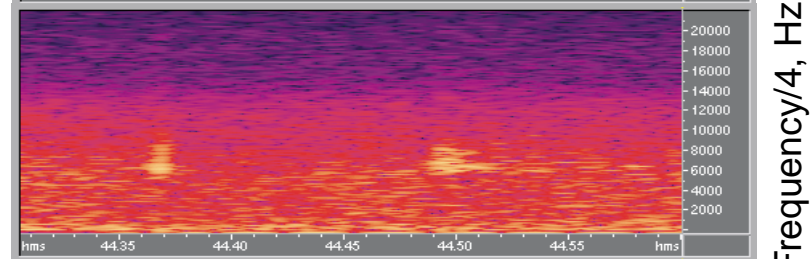
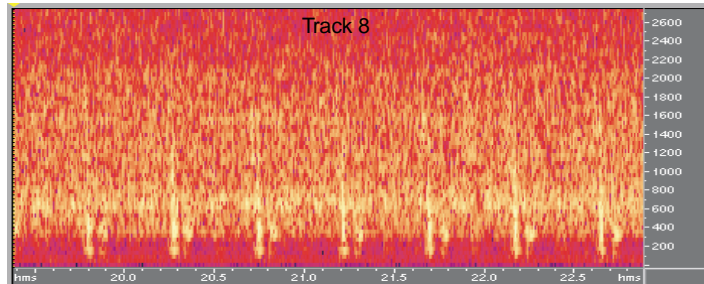
Pilot whale "rattle"



Dolphin "pinger"

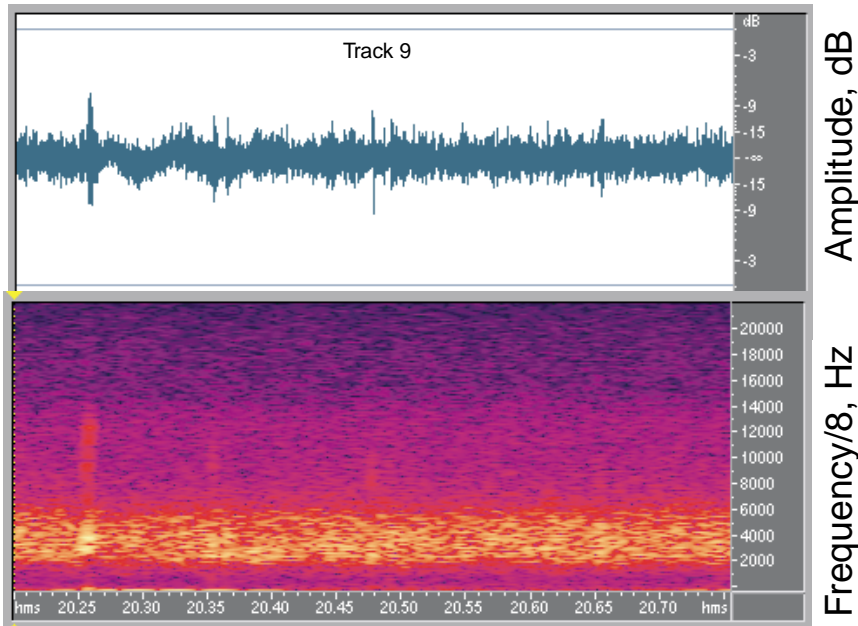


Minke whale "thump"

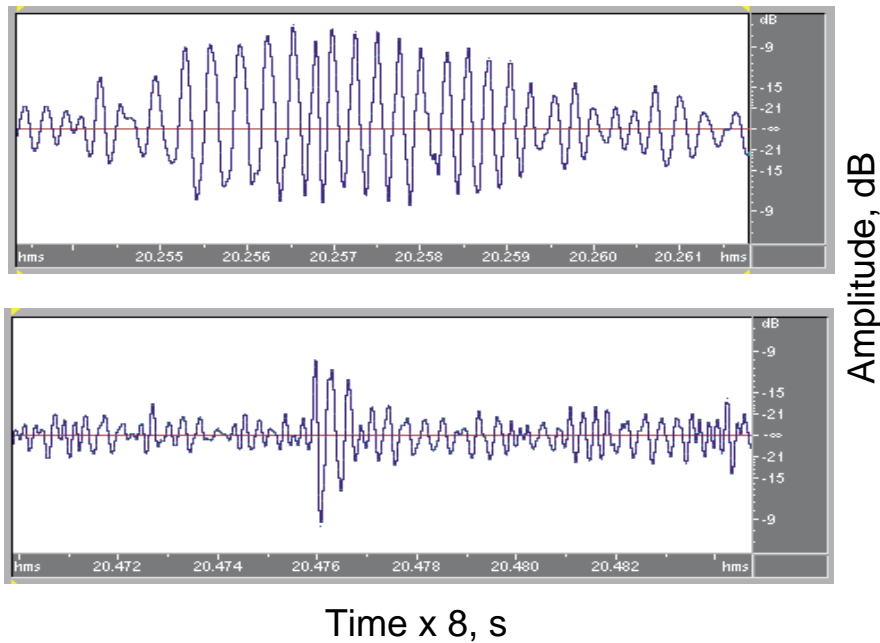


Still more examples from AUTECD CD

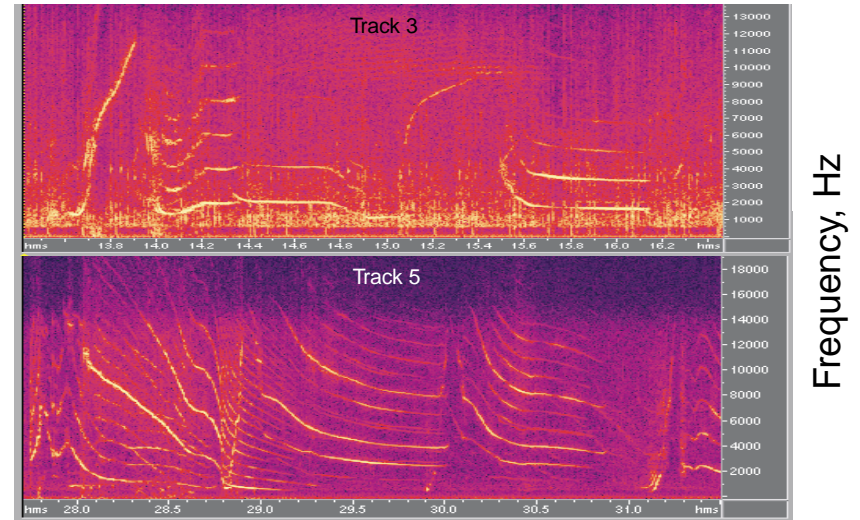
Whale "pinger"



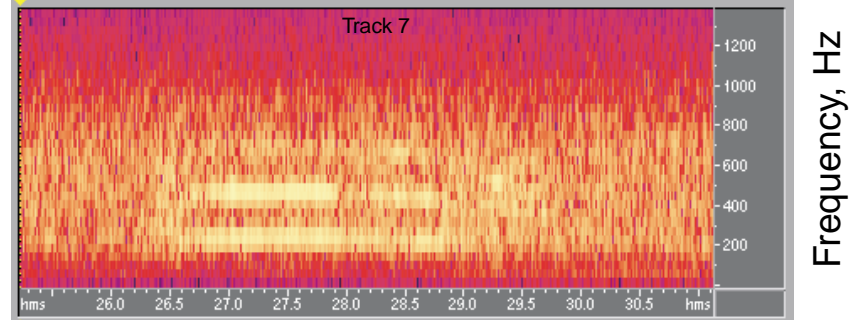
Separate pinger trains



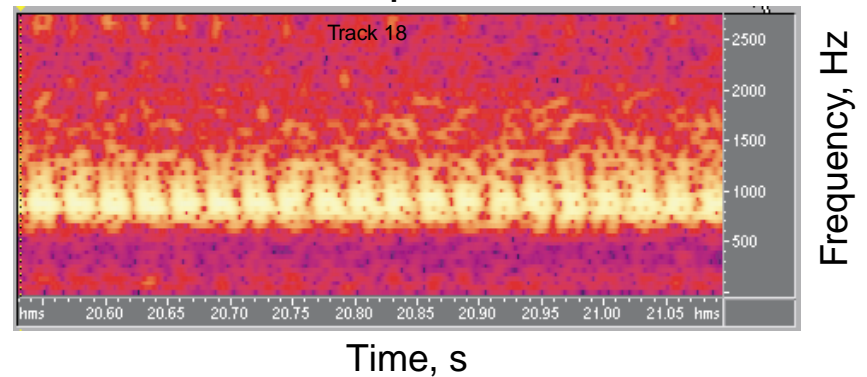
Non-pulsed sounds: Pilot whale "whistle"



Humpback whale

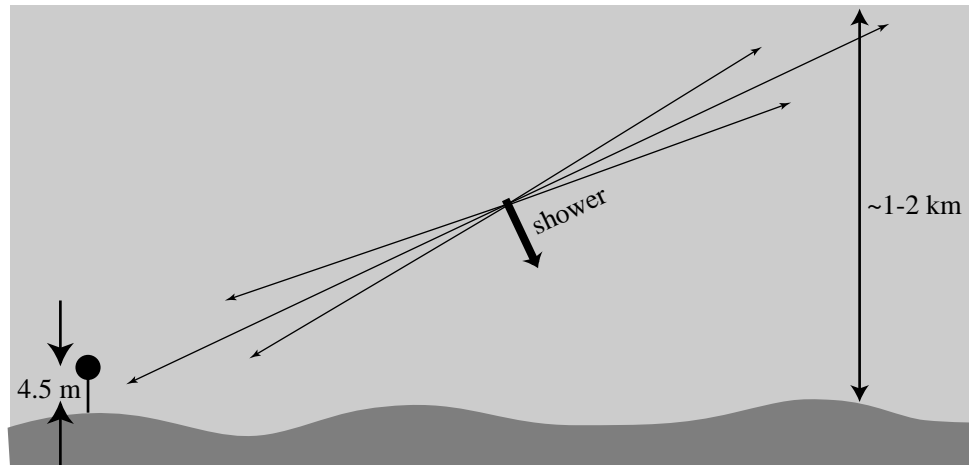


Squid



Problems with acoustic detection of neutrinos to be solved

1. Narrowness of the detection volume => hard to correlate between hydrophones.



2. Ambient Gaussian noise =>

a. only detection of the highest energies neutrinos?

b. use of a sophisticated detection technique (wavelet analysis).

Note that another analogous proposed experiment, namely SADKO [Sea Acoustic Detector of Cosmic Objects, Butkevich et al., 1992], to be located in Mediterranean at 4 km deep, has ~10 times smaller amplitude of ambient Gaussian noise [Dedenko et al., 1994].

3. The variable temperature profile => the amplitude depends on the location of the shower.
Possible use of the nonthermal acoustic emission mechanisms.

(temperature profiles)

4. How to infer the location of the shower:

The direction can be guessed using both direct signal and the signal reflected from the bottom (the hydrophone is located at ~4.5 m from the bottom).