A Study of Acoustic Ultrahigh-energy Neutrino Detection (SAUND)

http://hep.stanford.edu/neutrino/SAUND/

Justin Vandenbroucke

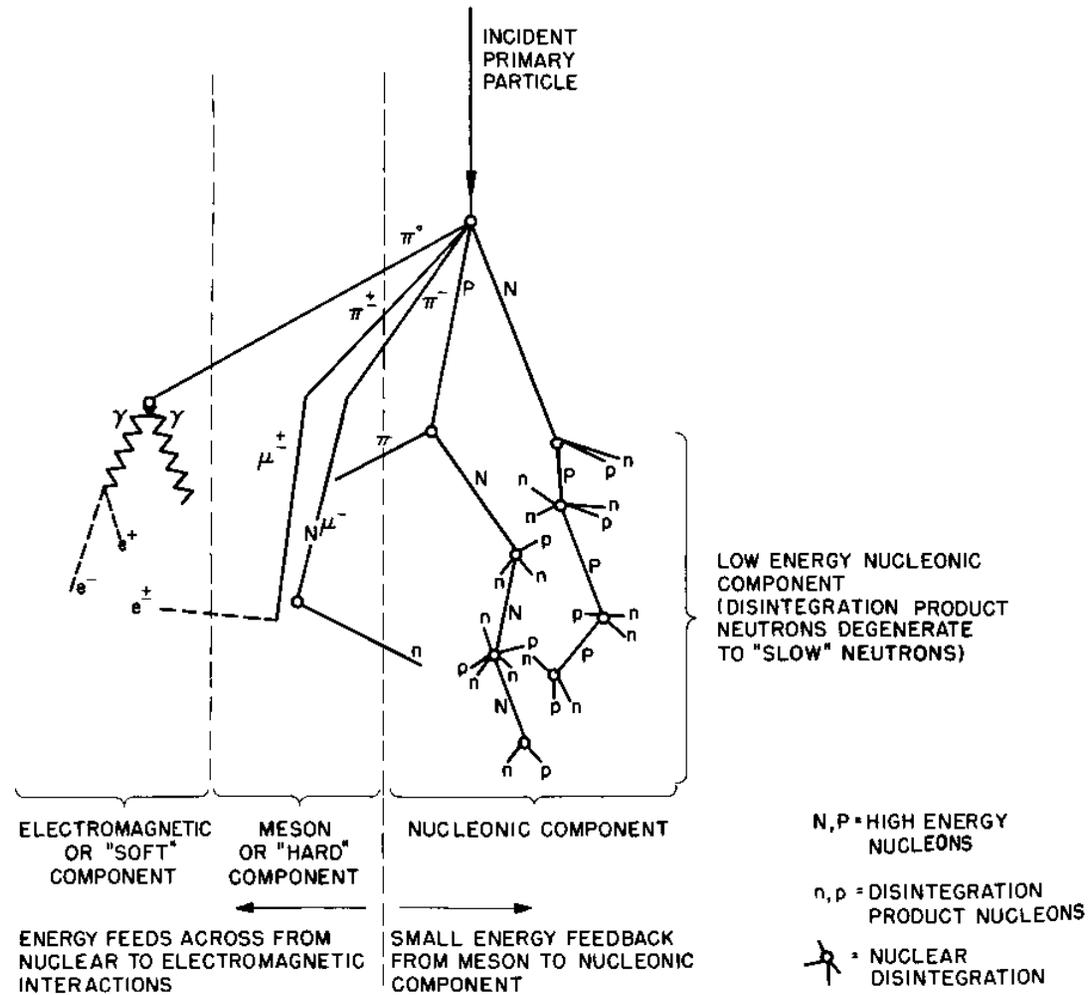justinav@socrates.berkeley.edu

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Oceans 2003
San Diego

SAUND Collaborators:

S. Adam (Stanford/Cornell)
T. Berger (Scripps)
M. Buckingham (Scripps)
G. Gratta (Stanford)
N. Lehtinen (Stanford/Hawaii)
J. Vandenbroucke (Stanford/Berkeley)
Y. Zhao (Stanford)

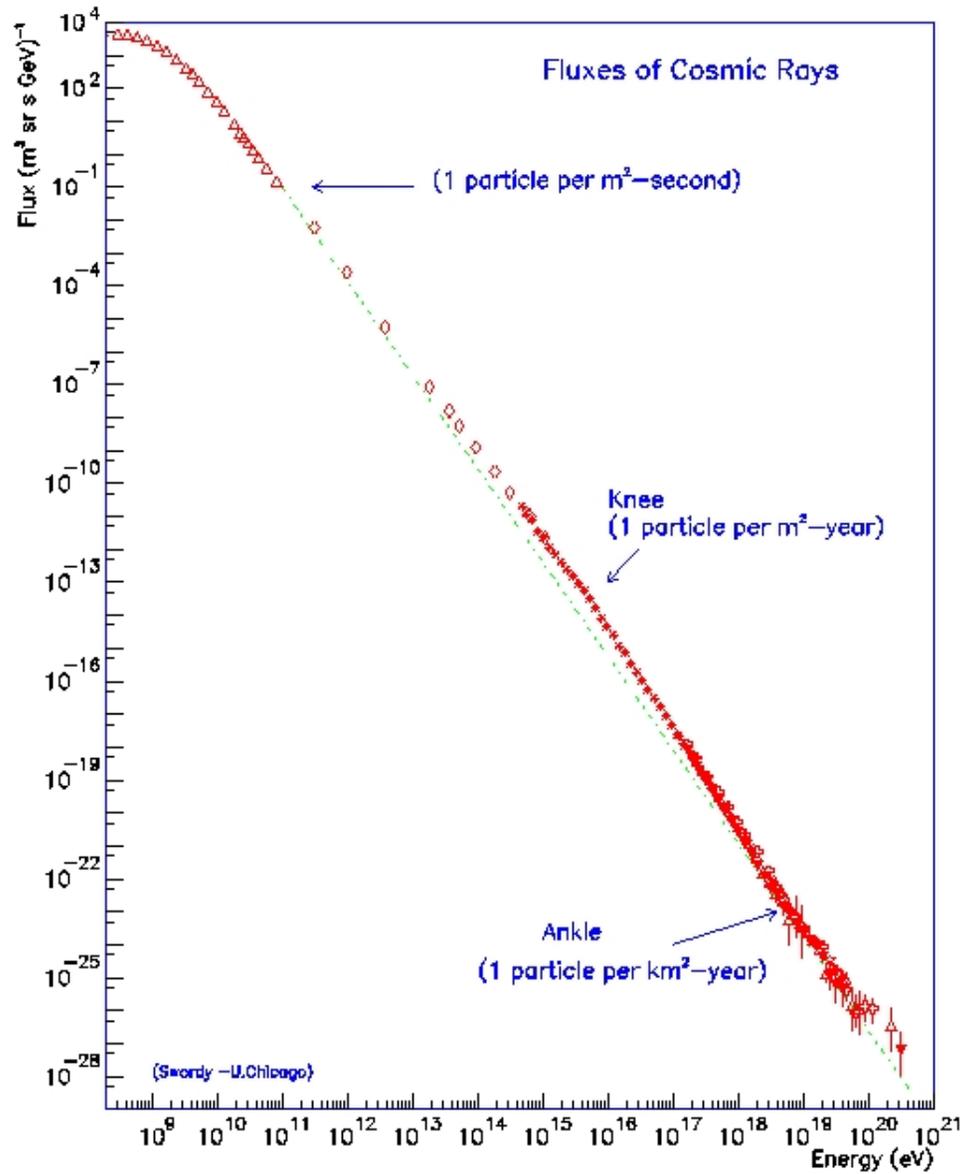## Many thanks to AUTEC and the U. S. Navy:

D. Belasco
J. Cecil
D. Deveau
D. Kapolka
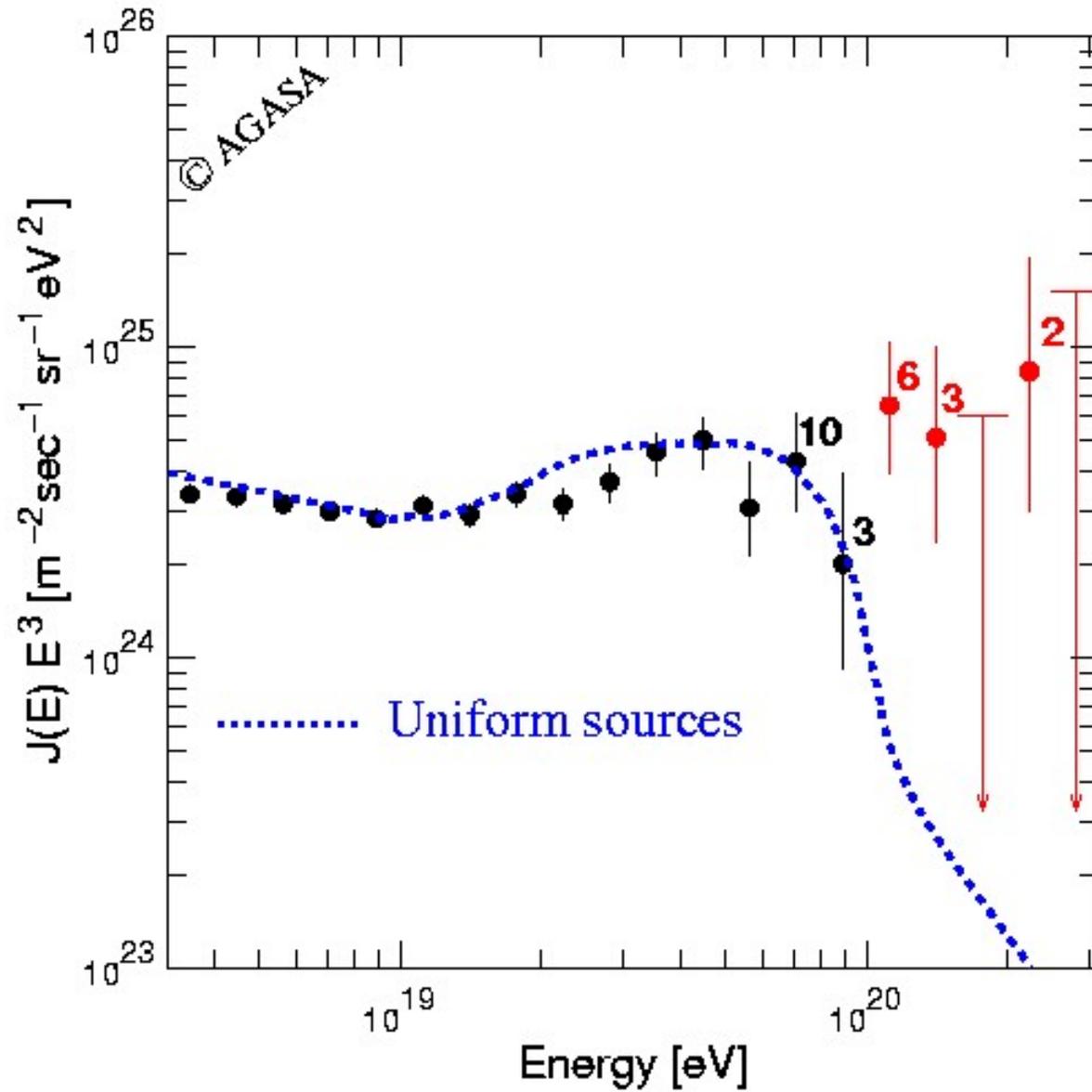T. Kelly-Bissonnette

Cosmic rays: subatomic particles from space

Schematic Diagram of Cosmic Ray Shower

Cosmic ray energy spectrum

Fluxes of Cosmic Rays

10^4

10^2

10^{-1} — (1 particle per m²−second)

10^{-4}

10^{-7}

10^{-10}

10^{-13} — Knee (1 particle per m²−year)

10^{-16}

10^{-19}

10^{-22}

10^{-25} — Ankle (1 particle per km²−year)

10^{-28}

(Swordy −U.Chicago)

Flux (m³ sr s GeV)⁻¹

10^9 10^{10} 10^{11} 10^{12} 10^{13} 10^{14} 10^{15} 10^{16} 10^{17} 10^{18} 10^{19} 10^{20} 10^{21}

Energy (eV)

GZK: An unsolved mystery

So What?

A crossroads of exciting physics
- active galactic nuclei
- gamma ray bursts
- grand unified theories
- topological defects (magnetic monopoles, cosmic strings, domain walls)
- supersymmetry
- dark matter
- Lorentz invariance violation
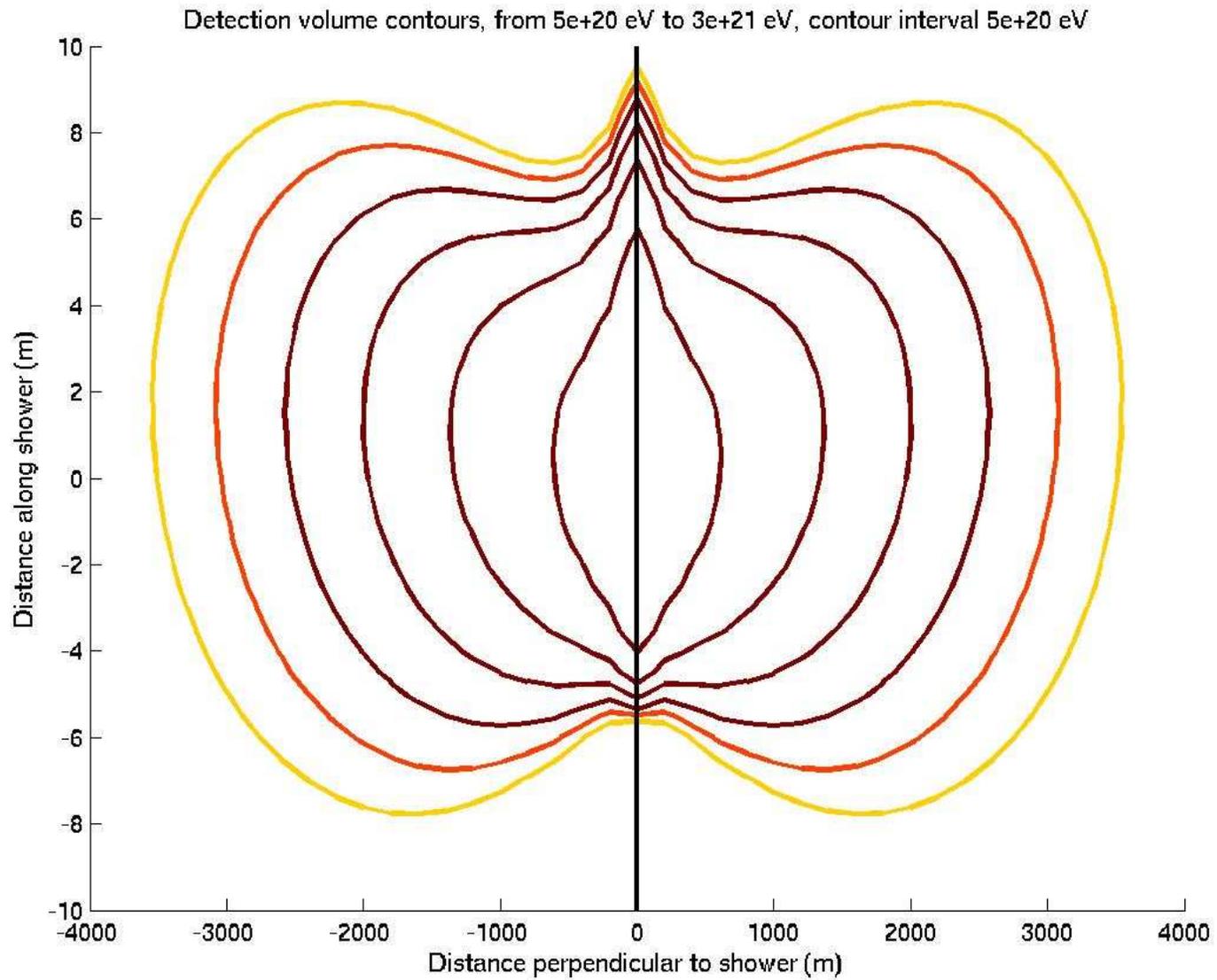- extra dimensions
- gravity at a TeV

All key to understanding the universe!

Ocean as particle detector

surface
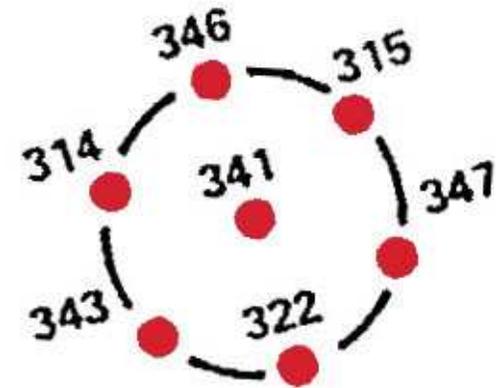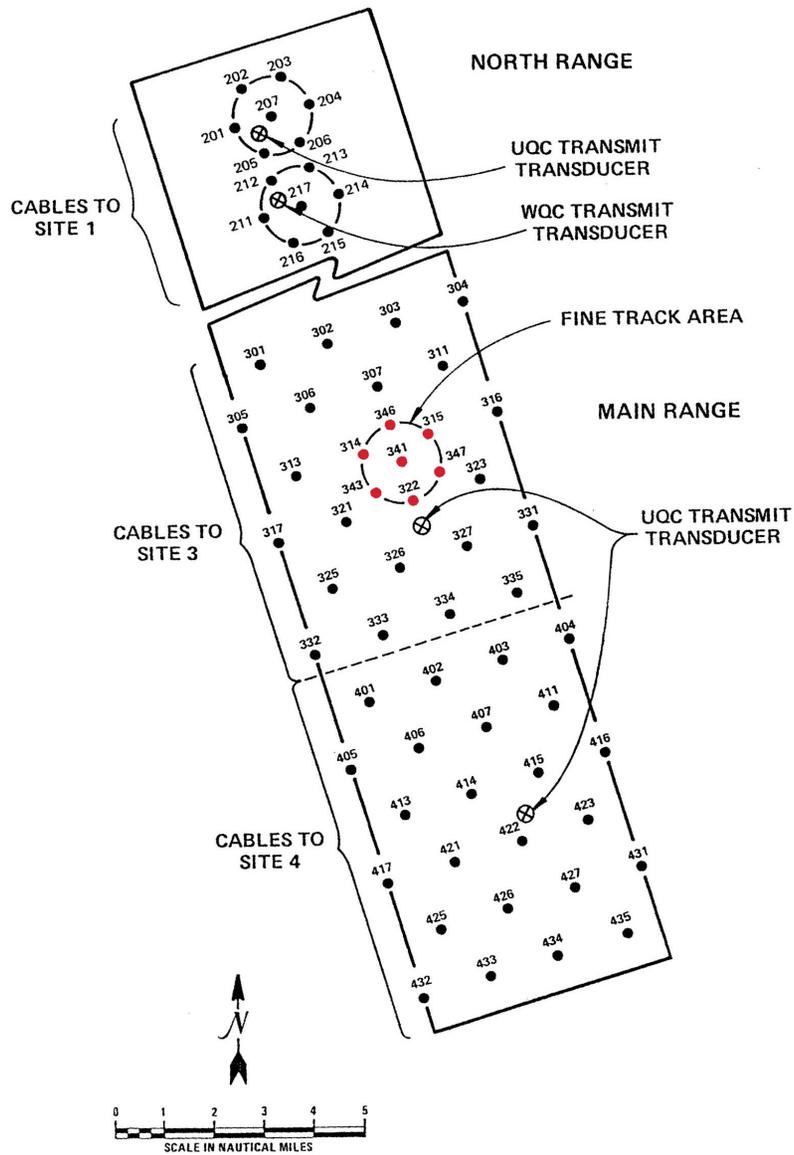
ocean water

shower

~1-2 km

θ

hydrophone

bottom
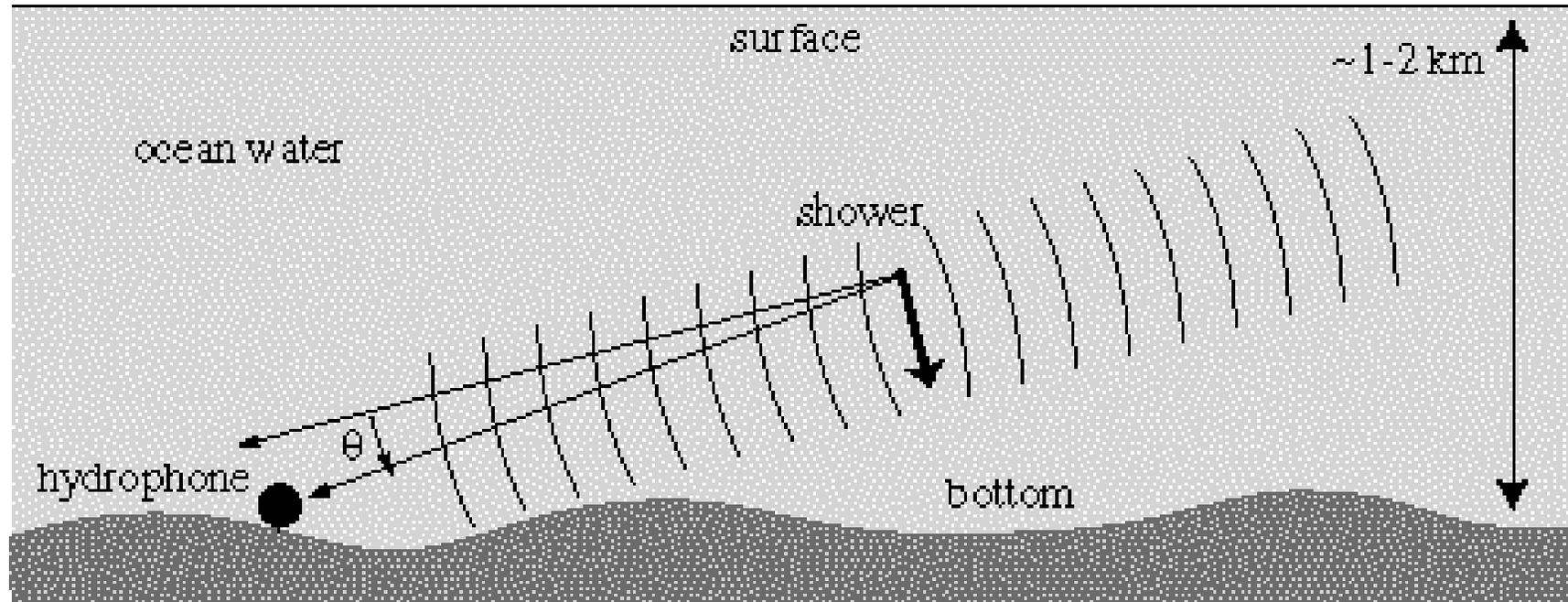
N. Lehtinen

Extreme pancakes

Detection volume contours, from 5e+20 eV to 3e+21 eV, contour interval 5e+20 eV
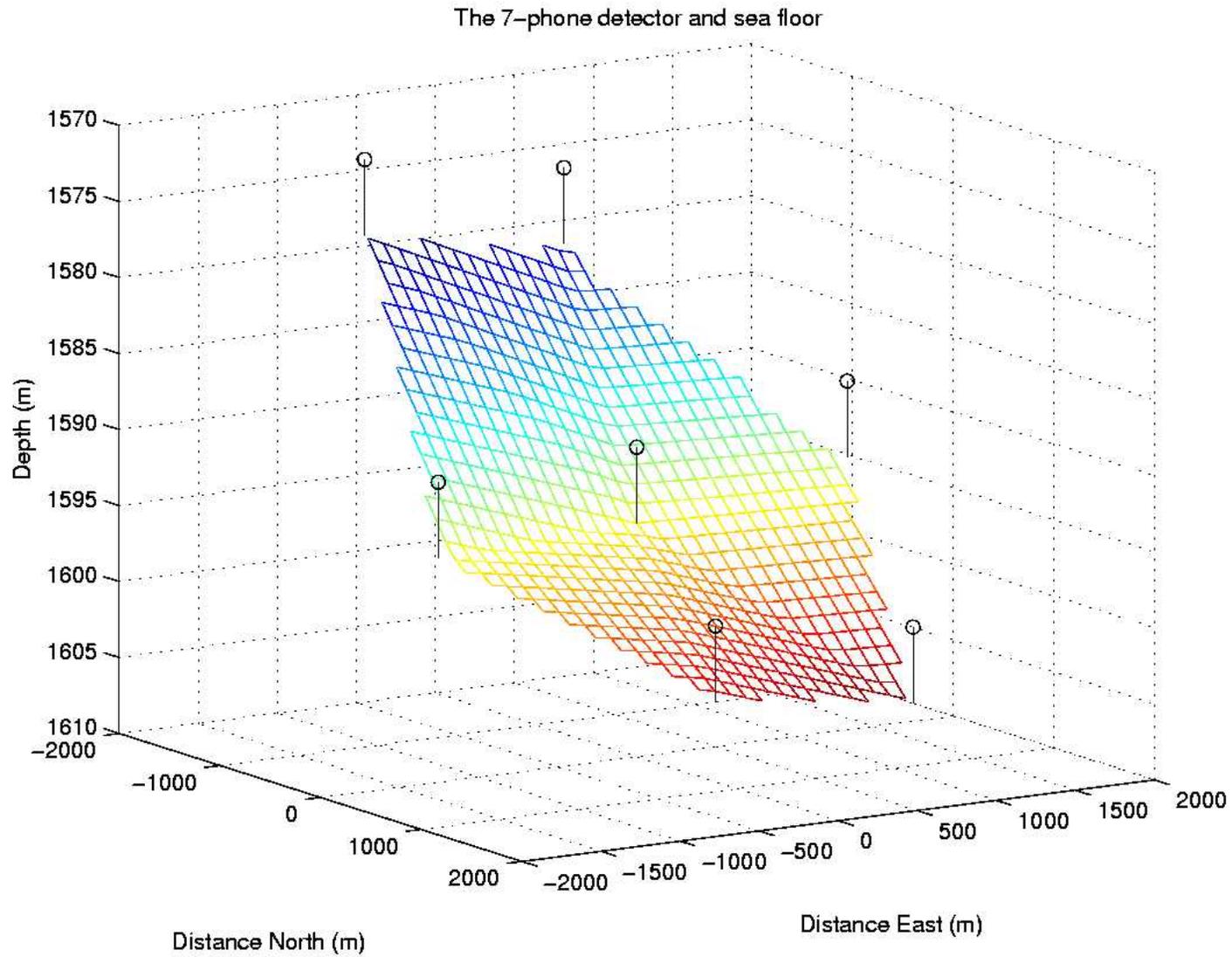
The Atlantic Undersea Test and Evaluation Center (AUTEC)

AUTEC hydrophones
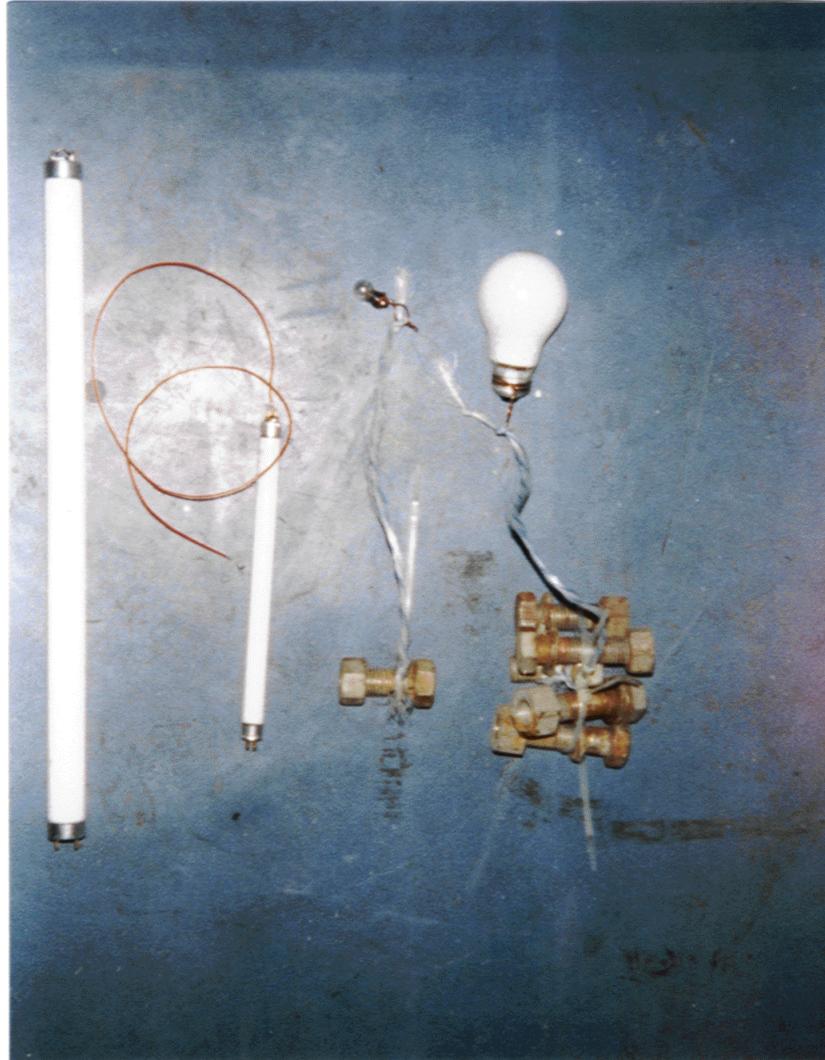

SAUND

The SAUND array

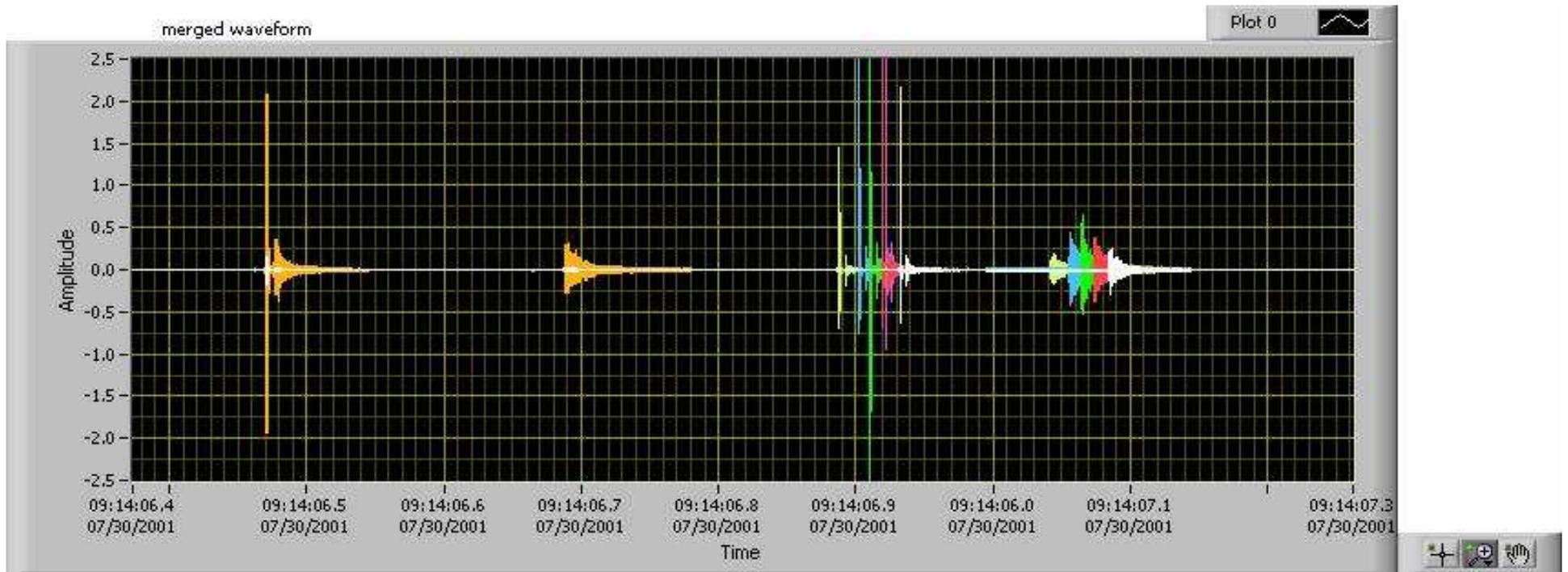The 7-phone detector and sea floor

Site 3

Calibration sources

21 Events per lightbulb

Light bulb positions and energies reconstructed

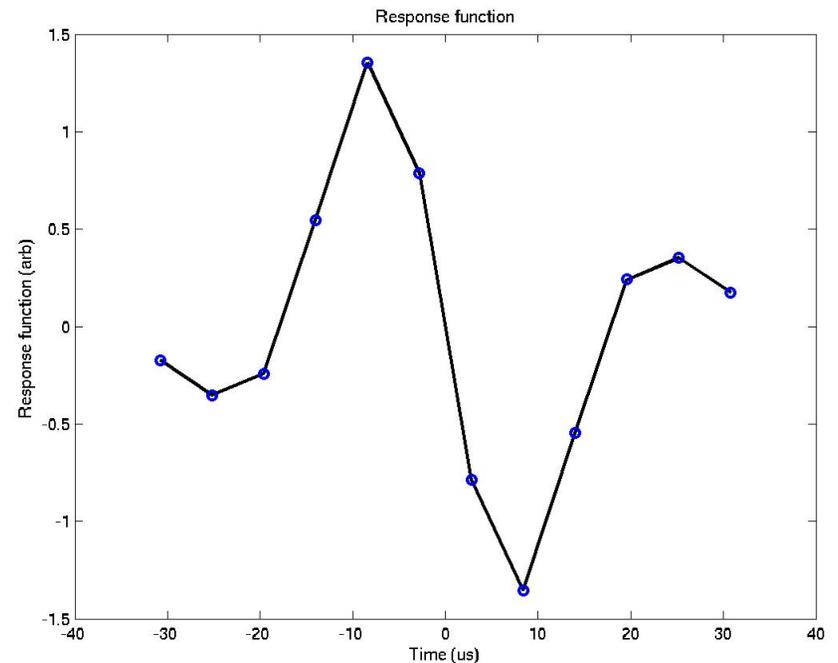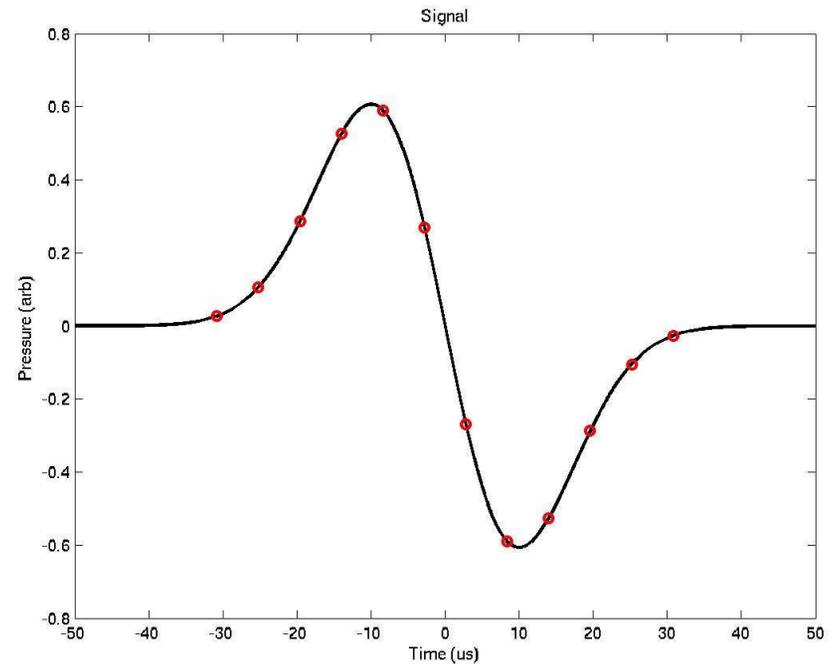Location of boat (GPS) and bulbs (reconstructed)
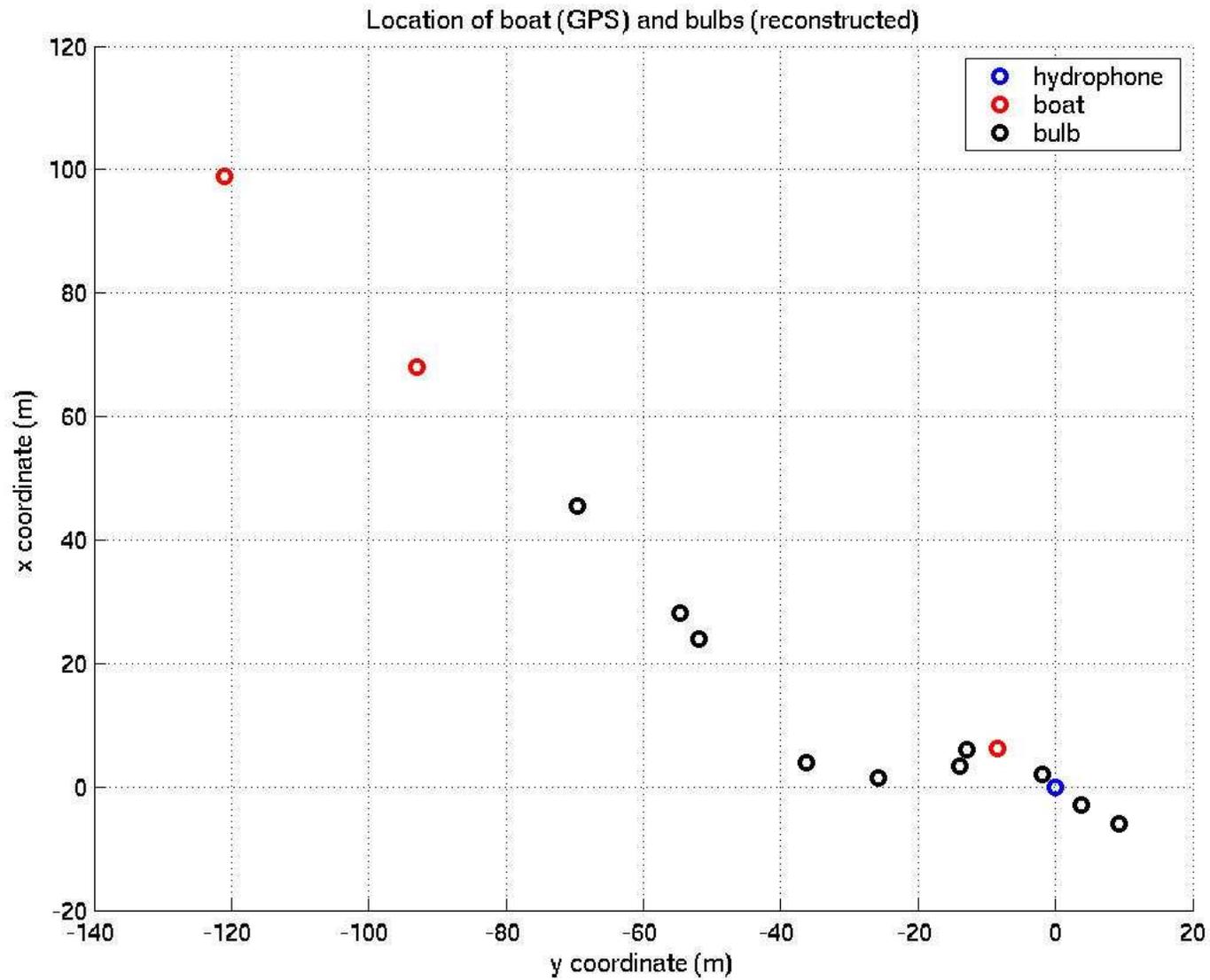
DAQ

Hardware
- Dell 8100 (1.7 GHz Pentium 4)
- NI ADC card
    (PCI-MIO-16E, interface BNC 2110)
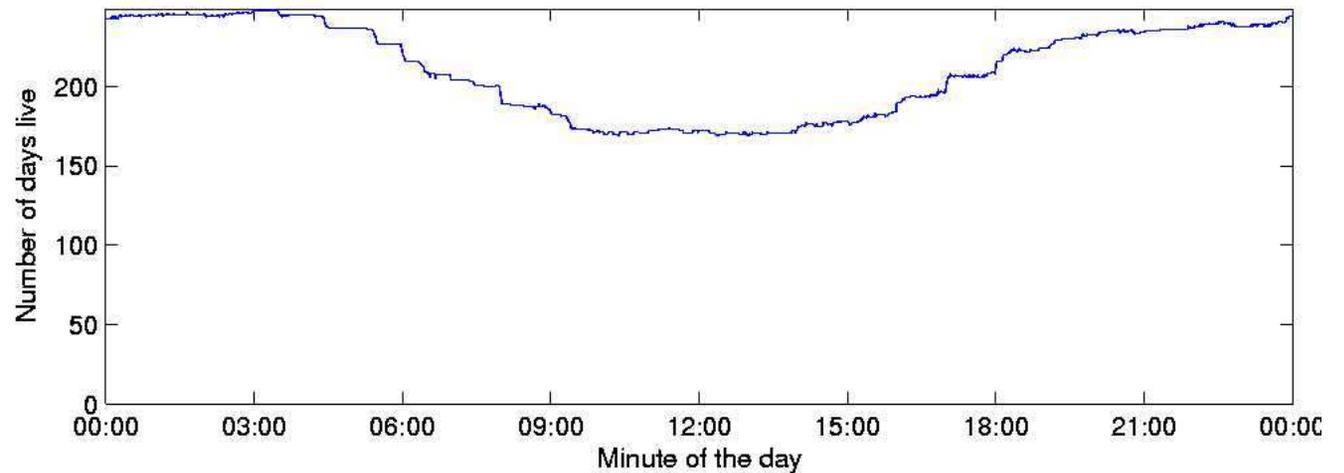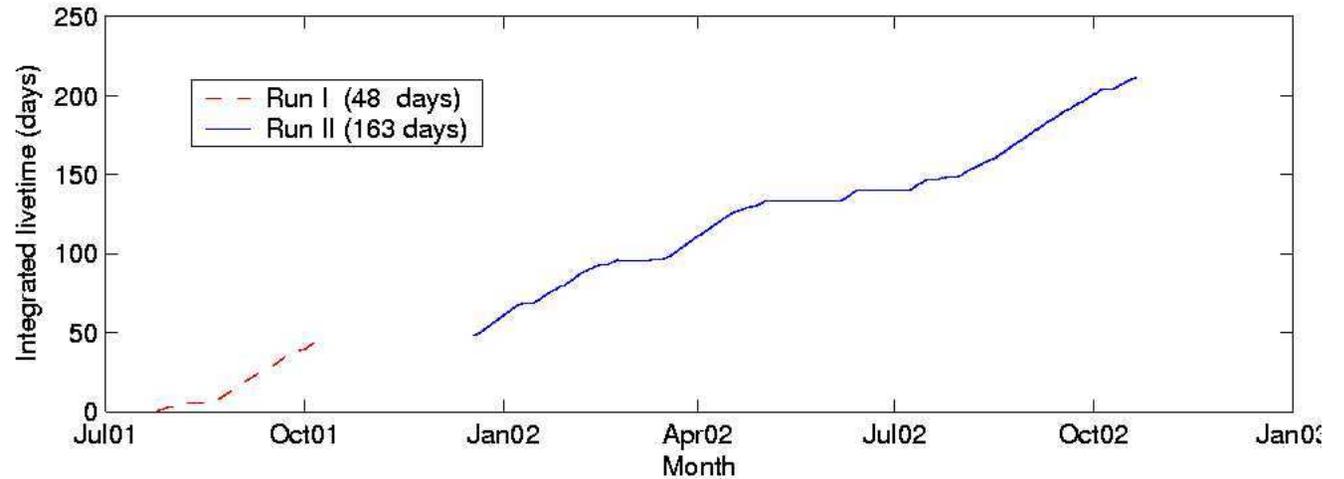- 60 GB external hard drive for data transfer

Software
- digital matched filter
- variable threshold
- 179 kHz sampling
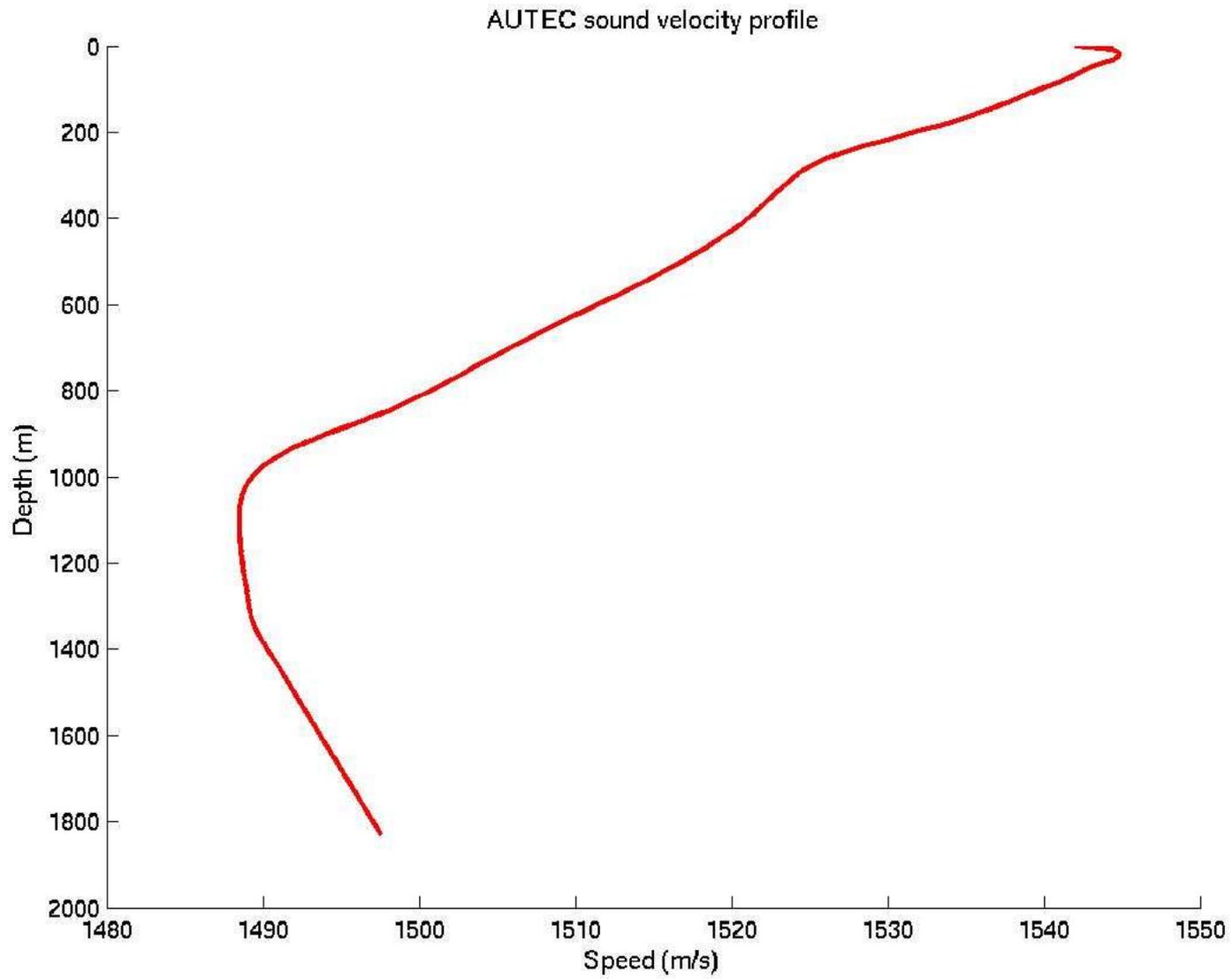- 60 events/minute target
- 1-2 GB / 24 hrs

Accumulated data

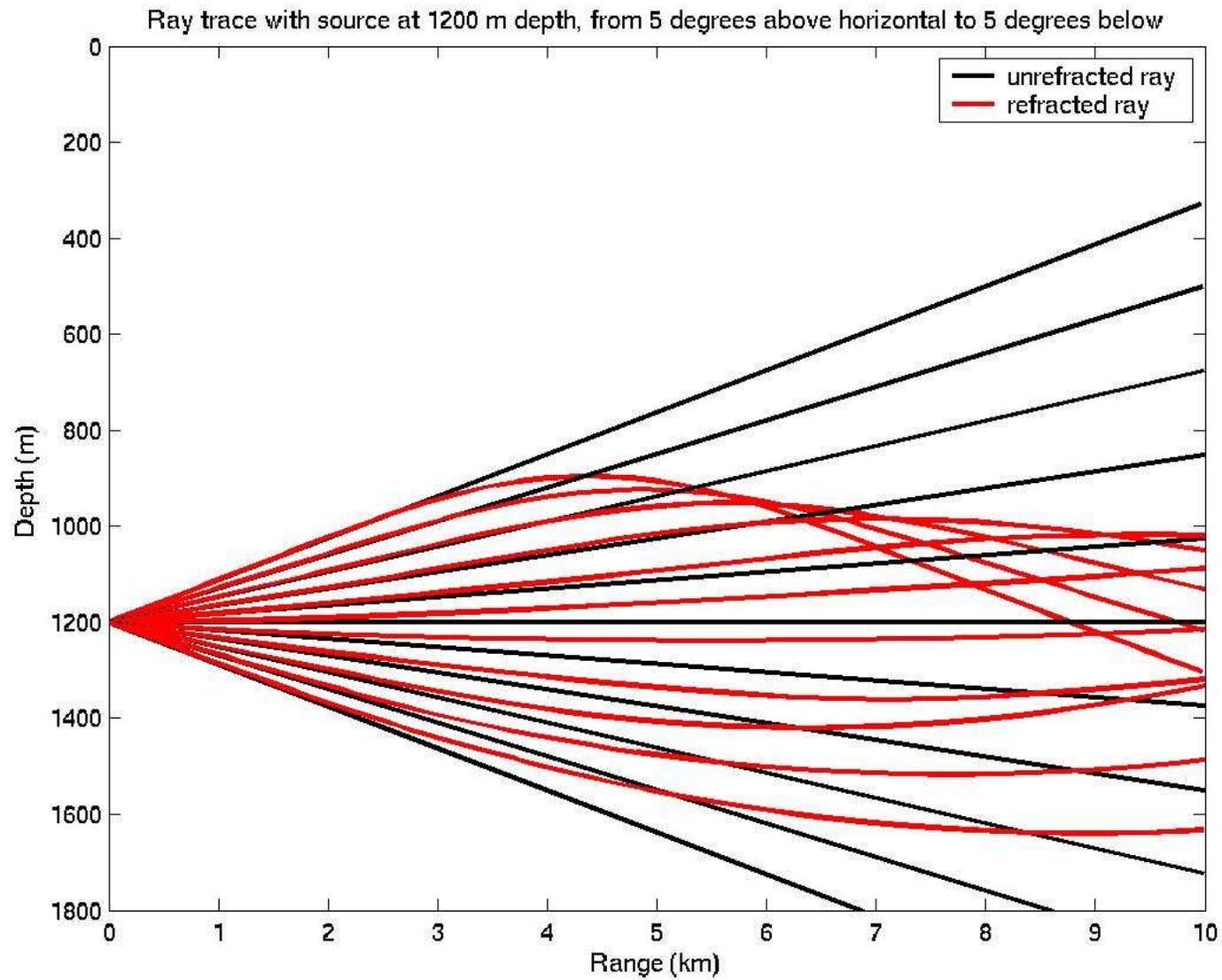- 70% duty cycle
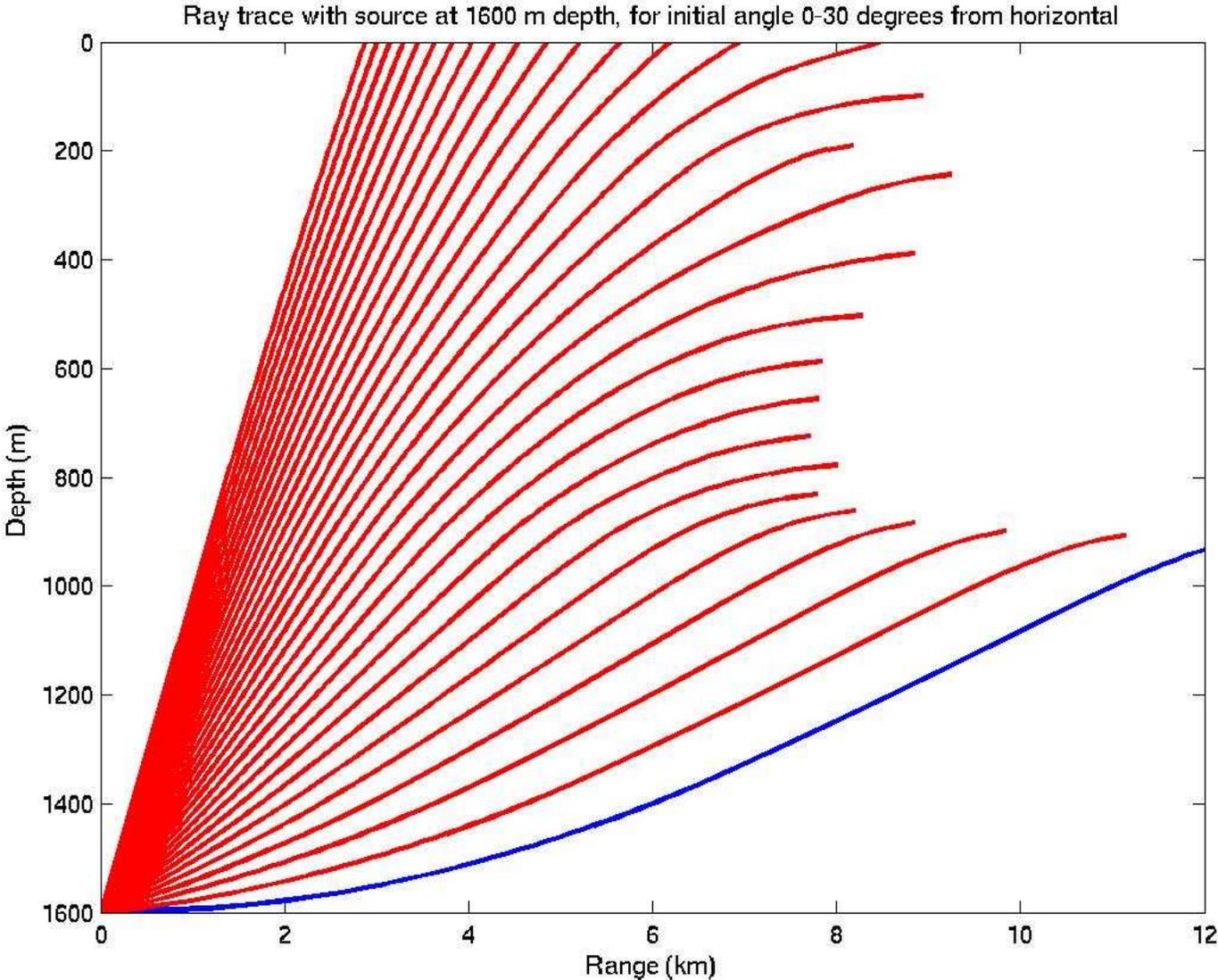- 211 days live
- 25 million events
- 350 GB

AUTEC SVP

AUTEC sound velocity profile

Refraction

Ray trace with source at 1200 m depth, from 5 degrees above horizontal to 5 degrees below

Legend:
- unrefracted ray
- refracted ray

Refraction shadow

Ray trace with source at 1600 m depth, for initial angle 0-30 degrees from horizontal

Refracted pancake

Refracted acoustic radiation disk cross section for a 1e+21 eV neutrino at zenith 0.5 deg

- ○ hydrophone
- unrefracted pancake
- refracted pancake
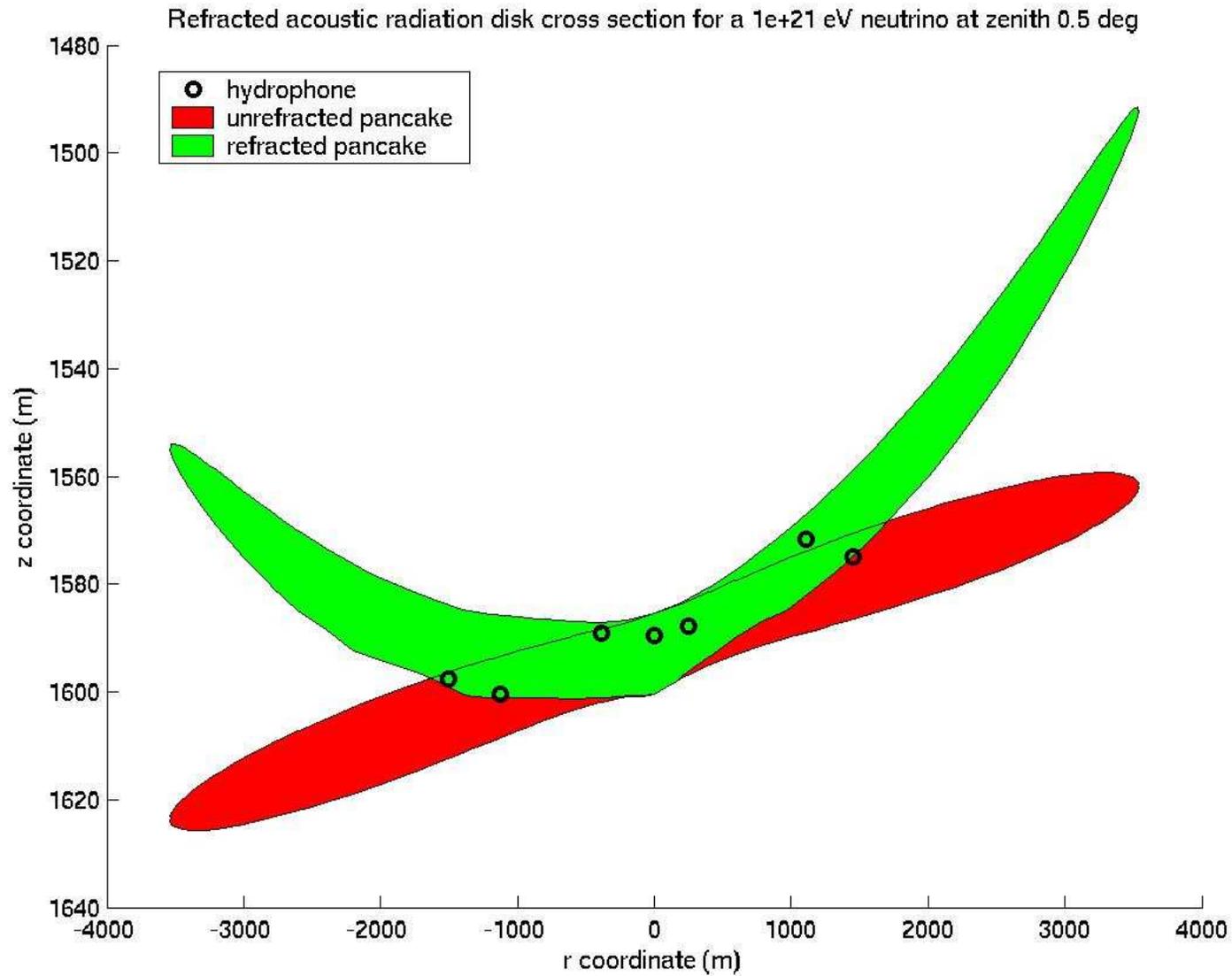
Time difference of arrival (TDOA) localization achieved

Radial coordinate vs. depth of reconstructed events
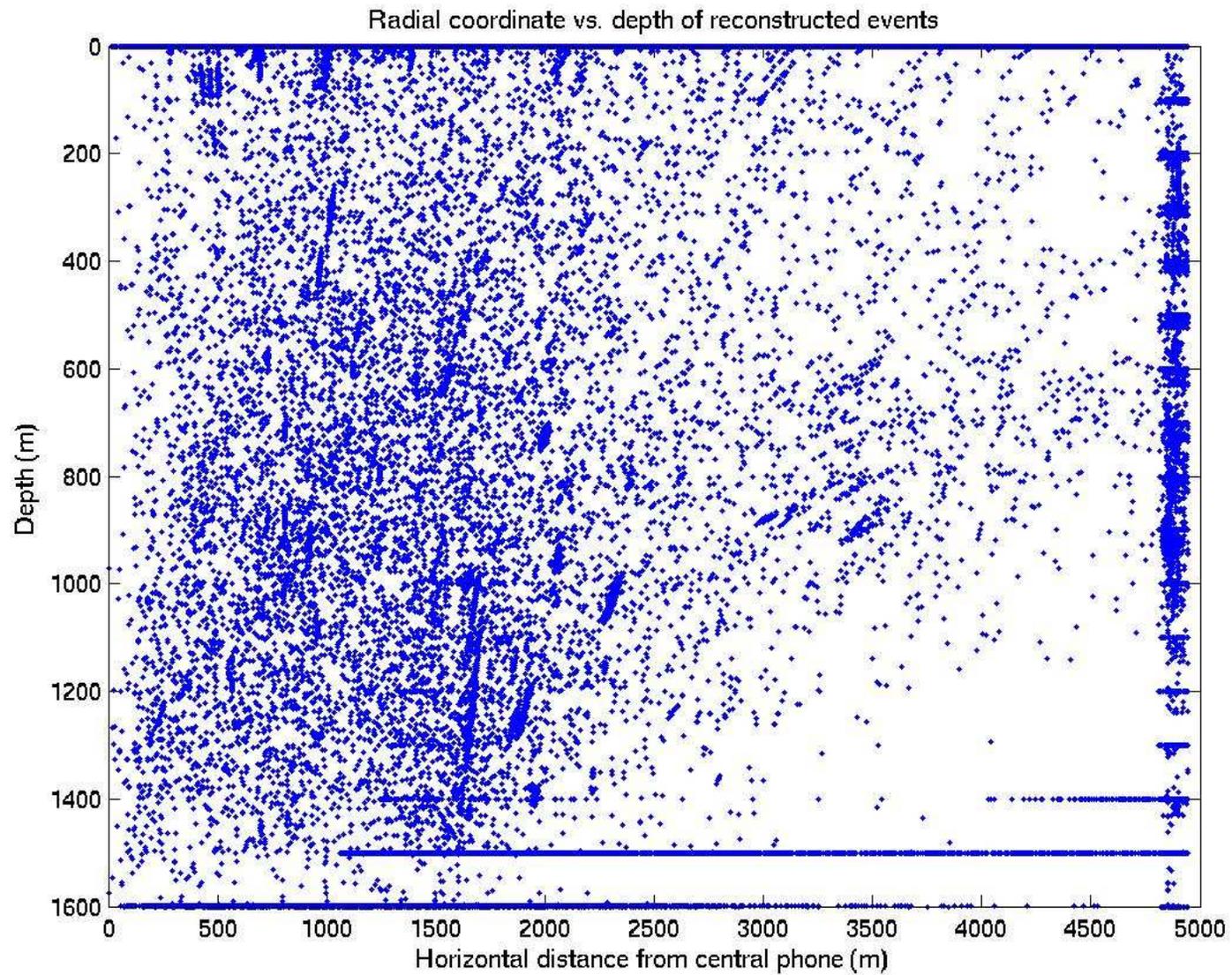
Example of a five-phone event
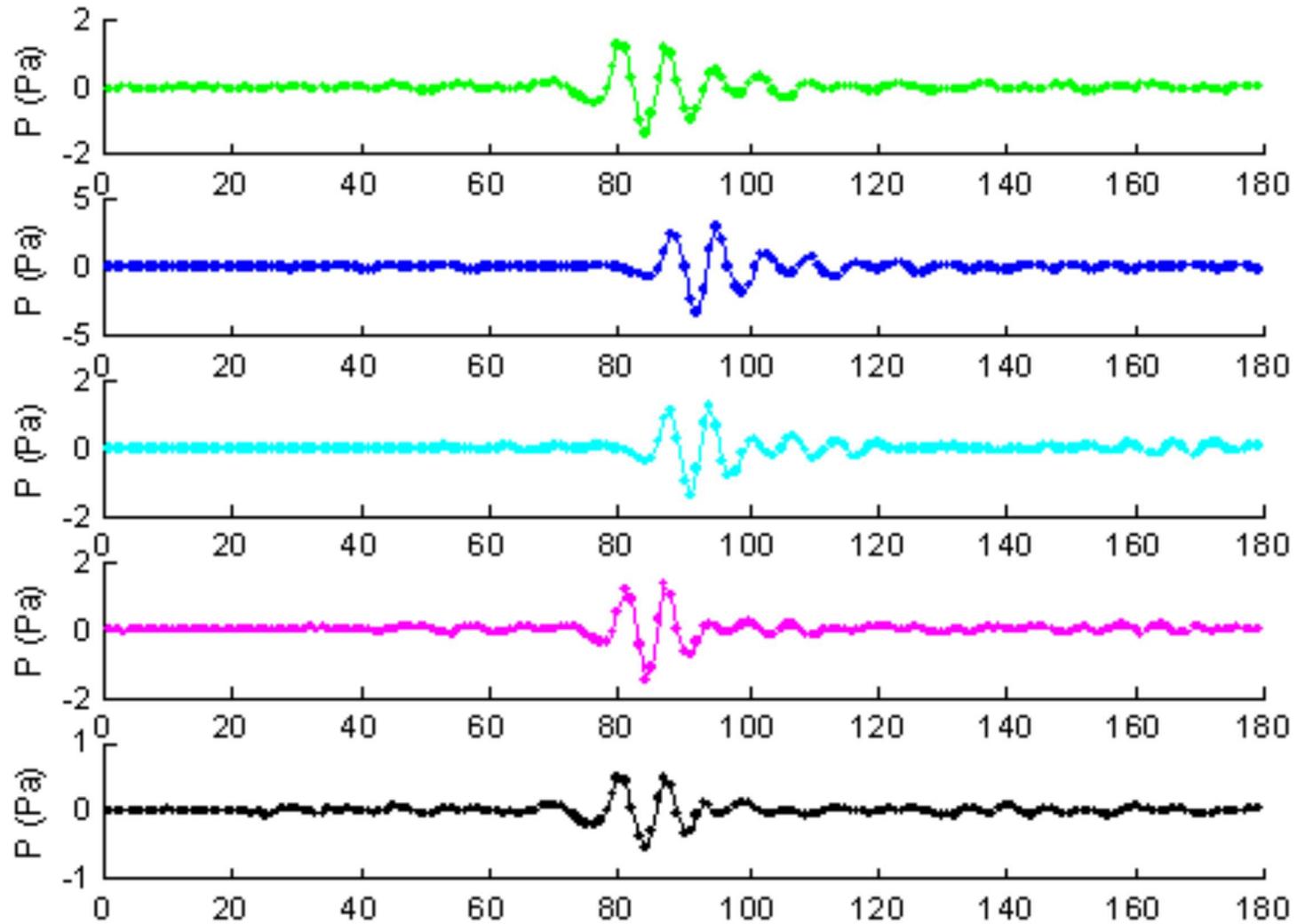
Example of a five-phone event
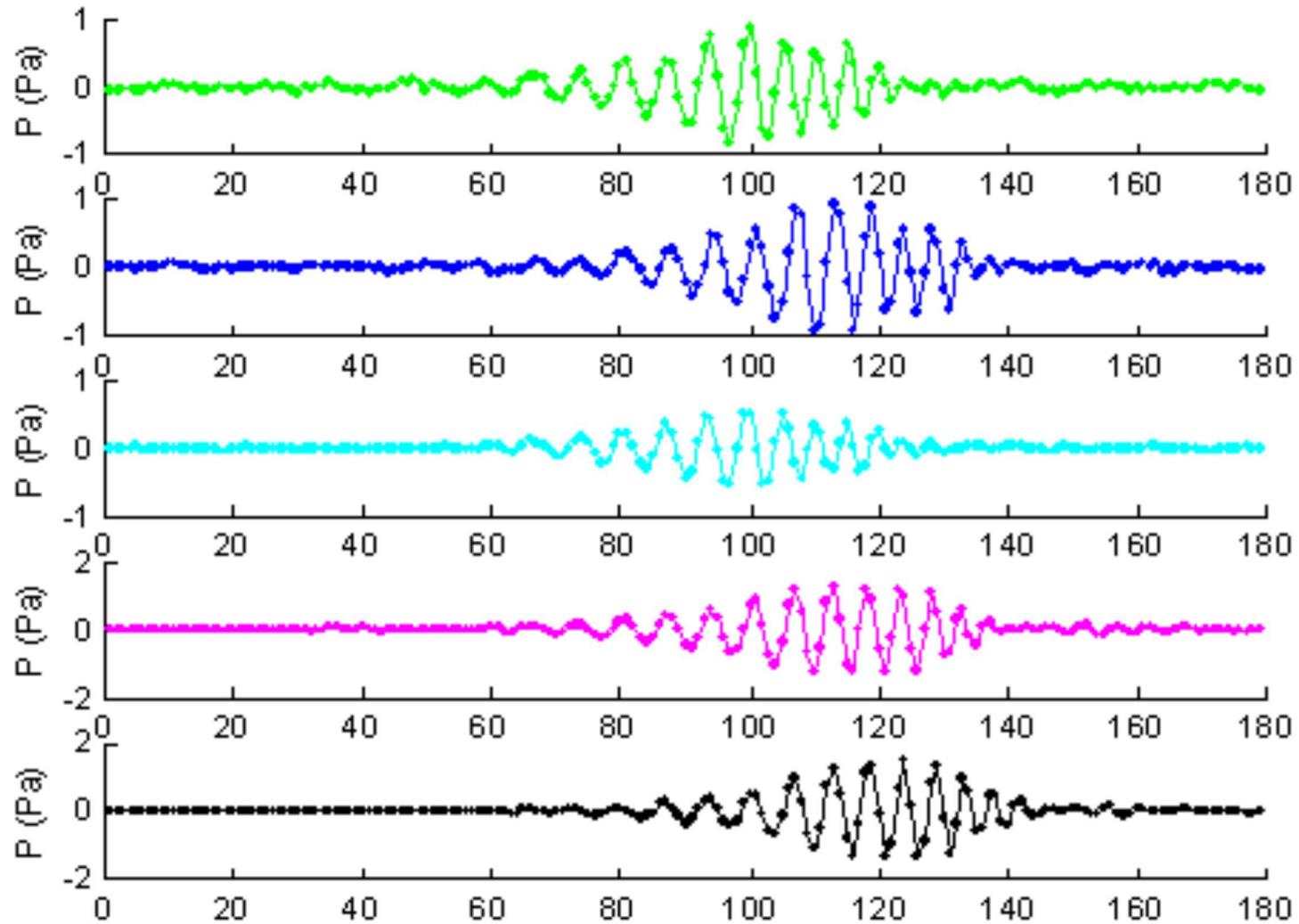
Onward

Unanswered questions
- Backgrounds distinguishable?
- Lowest energy threshold?
- Adapt to noise how?
- Pancake backgrounds?
- Best array geometry?

SAUND-II
- More hydrophones, water volume, CPU power
- Improved thresholding
- Sophisticated online data reduction

More collaborators welcome!!

http://hep.stanford.edu/neutrino/SAUND/
justinav@socrates.berkeley.edu