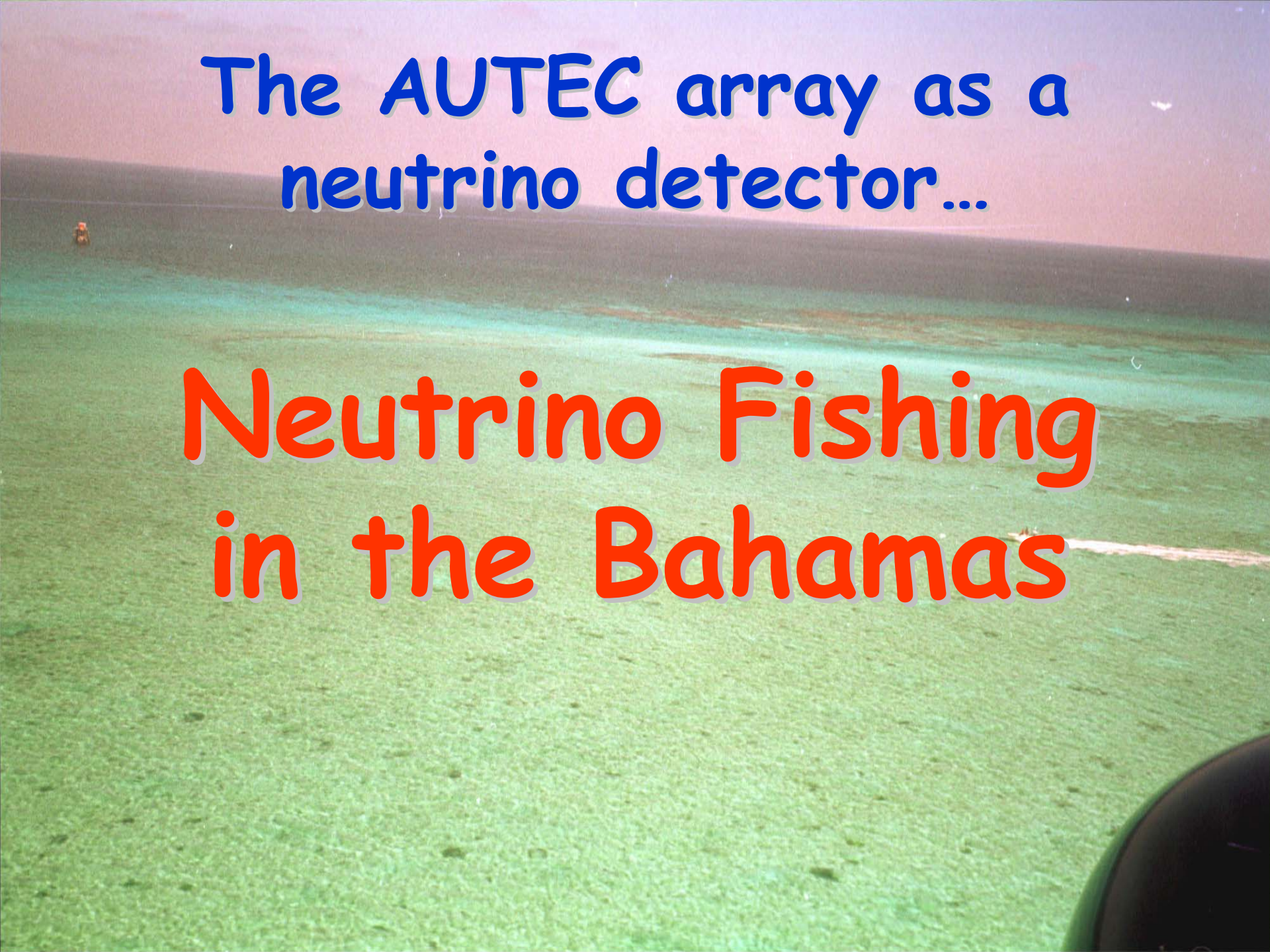

The AUTEC array as a neutrino detector…
Neutrino Fishing in the Bahamas

Study of
Acoustic
Ultra-high energy
Neutrino
Detection

At different times work contributed by:

Shaffique Adam[†], Giorgio Gratta,
Nikolai Lehtinen[§], Justin Vandenbroucke[$],
Yue Zhao
(Stanford University)
T.Berger[#], M.Buckingham
(SCRIPPS, UC San Diego)

[†]Now at Cornell University
[§]Now at University of Hawaii, Manoa
[$]Now at UC Berkeley
[#]Now at ???????

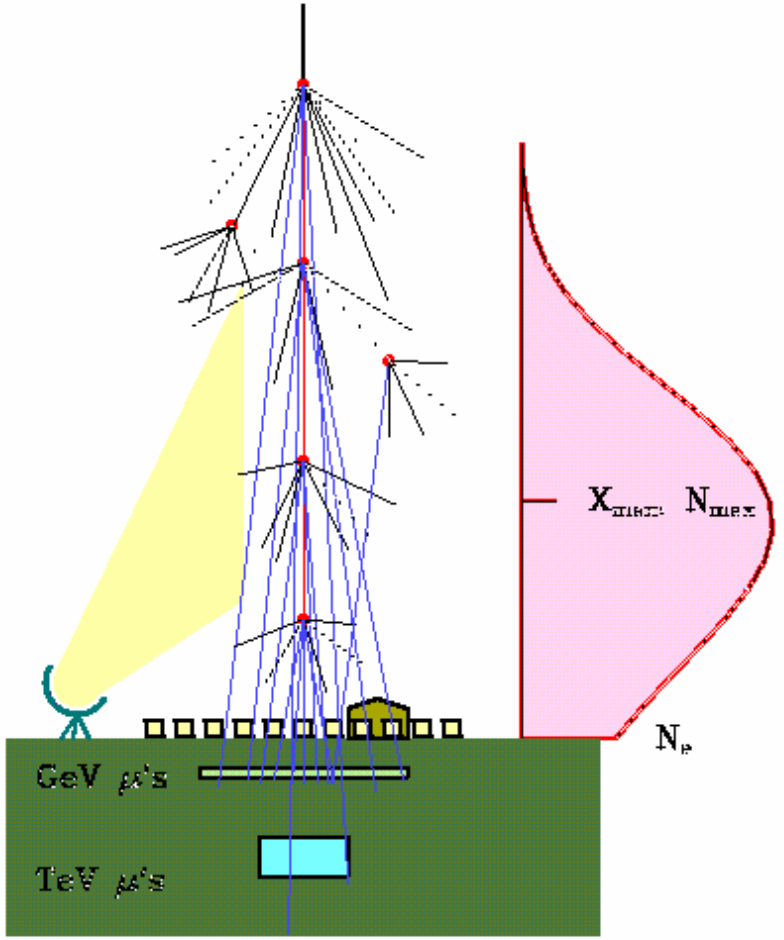
Many thanks to the US Navy and, in particular:

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

An acoustic array in sea water is only sensitive to neutrinos (and showering muons) since the atmosphere stops all other species

Merit: particle ID is automatic
Liability: (probably*) insensitive to the bulk of events

*Assuming the bulk of events are protons

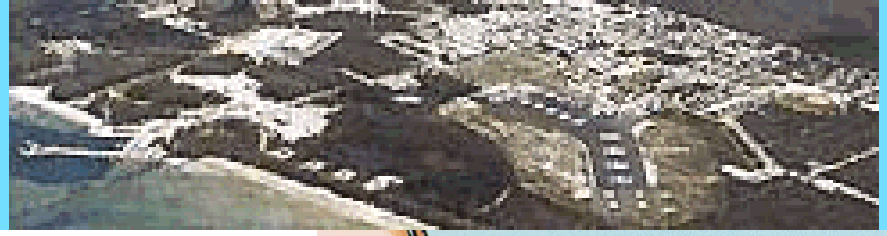


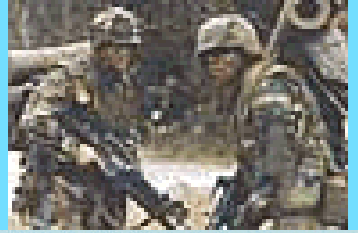
Look for an existing very large hydrophone array with lattice density and frequency response matching the needs of UHE neutrino detection

This is non-trivial: most military arrays are built for surveillance (make sure enemy subs don't come too close)

So they are:

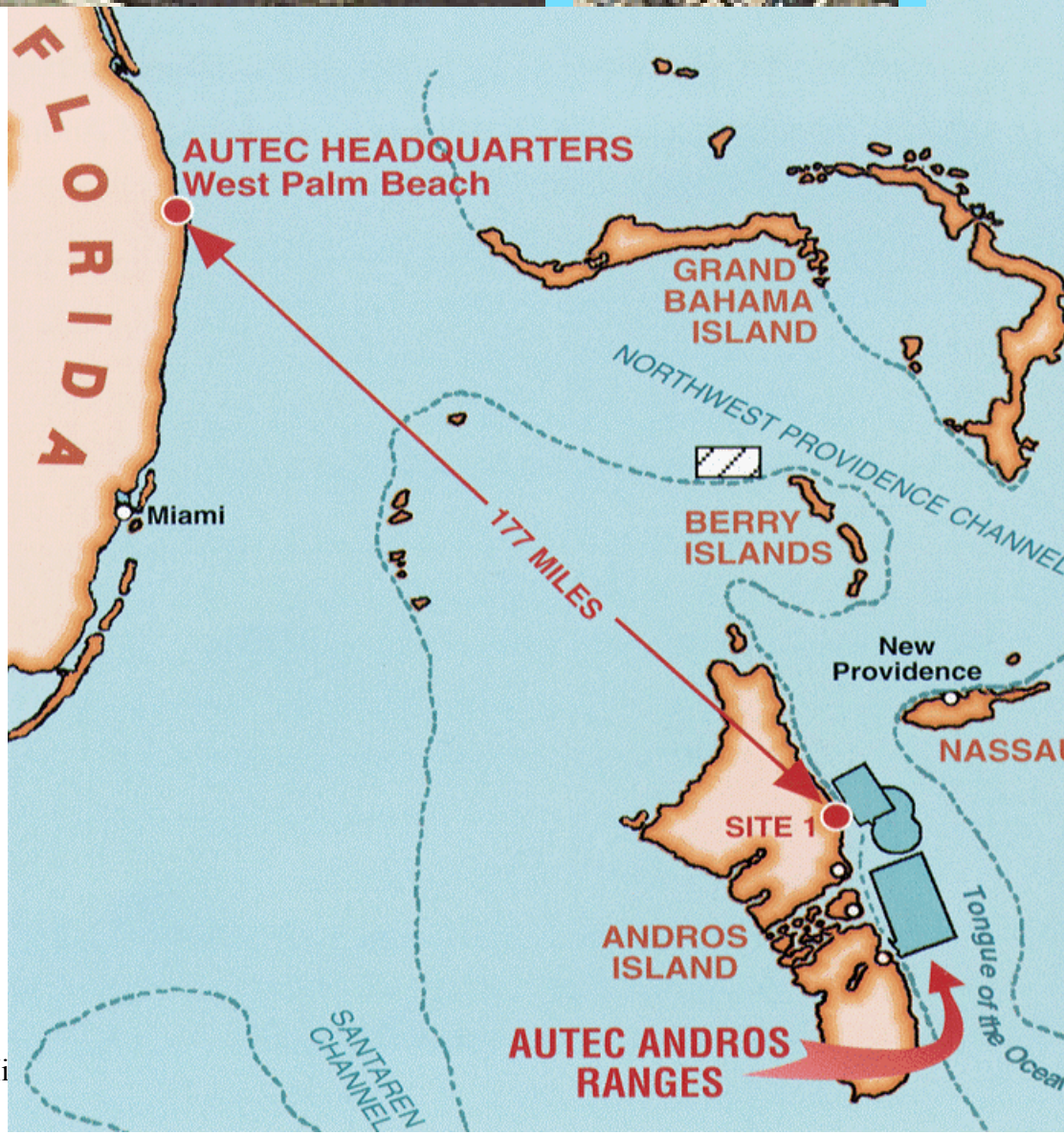
- sensitive at low frequency (~<100 Hz) because
  - subs produce mainly low frequency noise
  - high frequency noise does not propagate very far
- sparse (signals come from hundreds of km distance)
- very secret…





Atlantic
Undersea
Test and
Evaluation
Center

The largest USN high resolution, deep tracking array.



Tongue of the Ocean from space

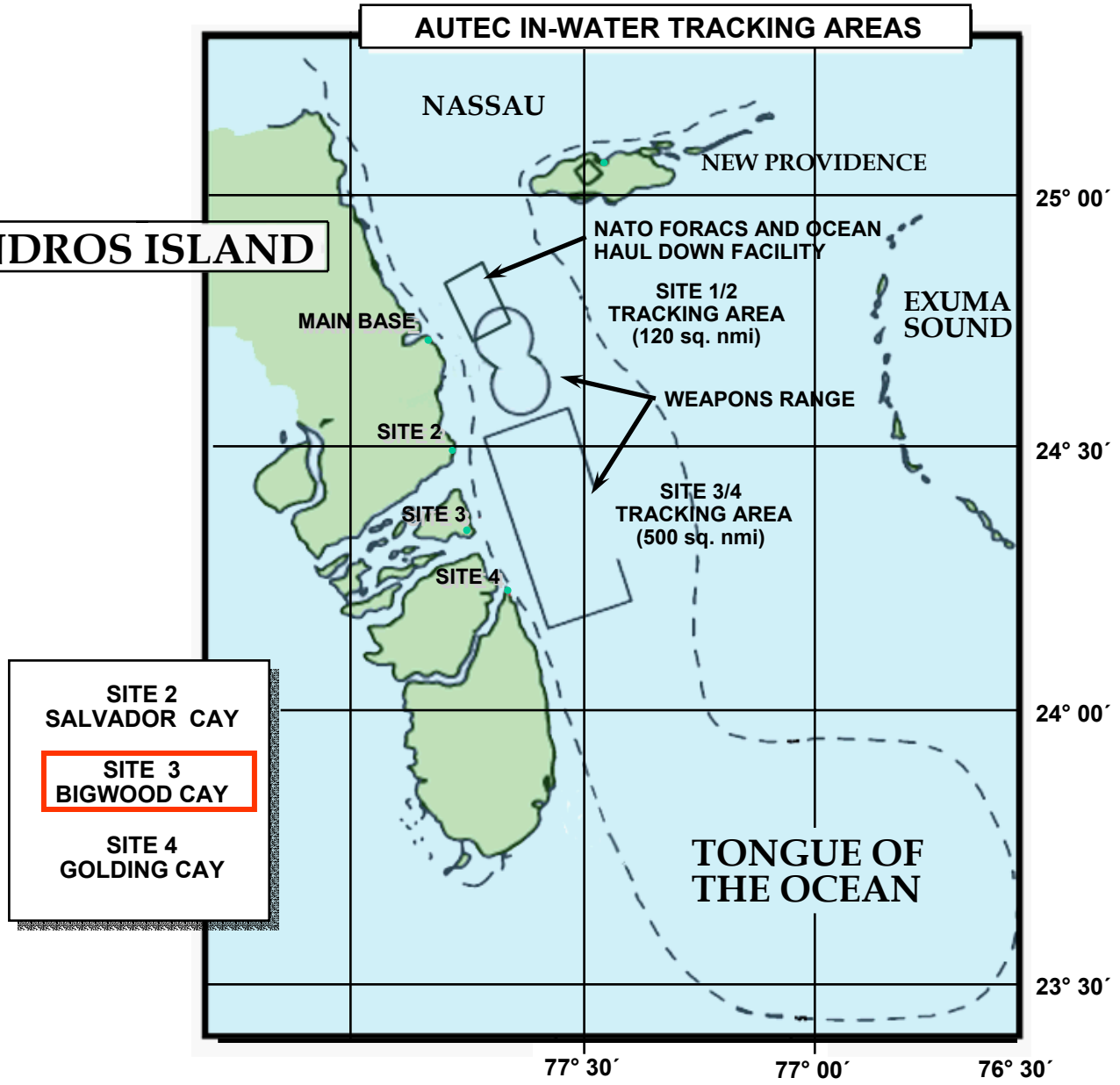
Sheltered
(islands and
~m deep shoals)

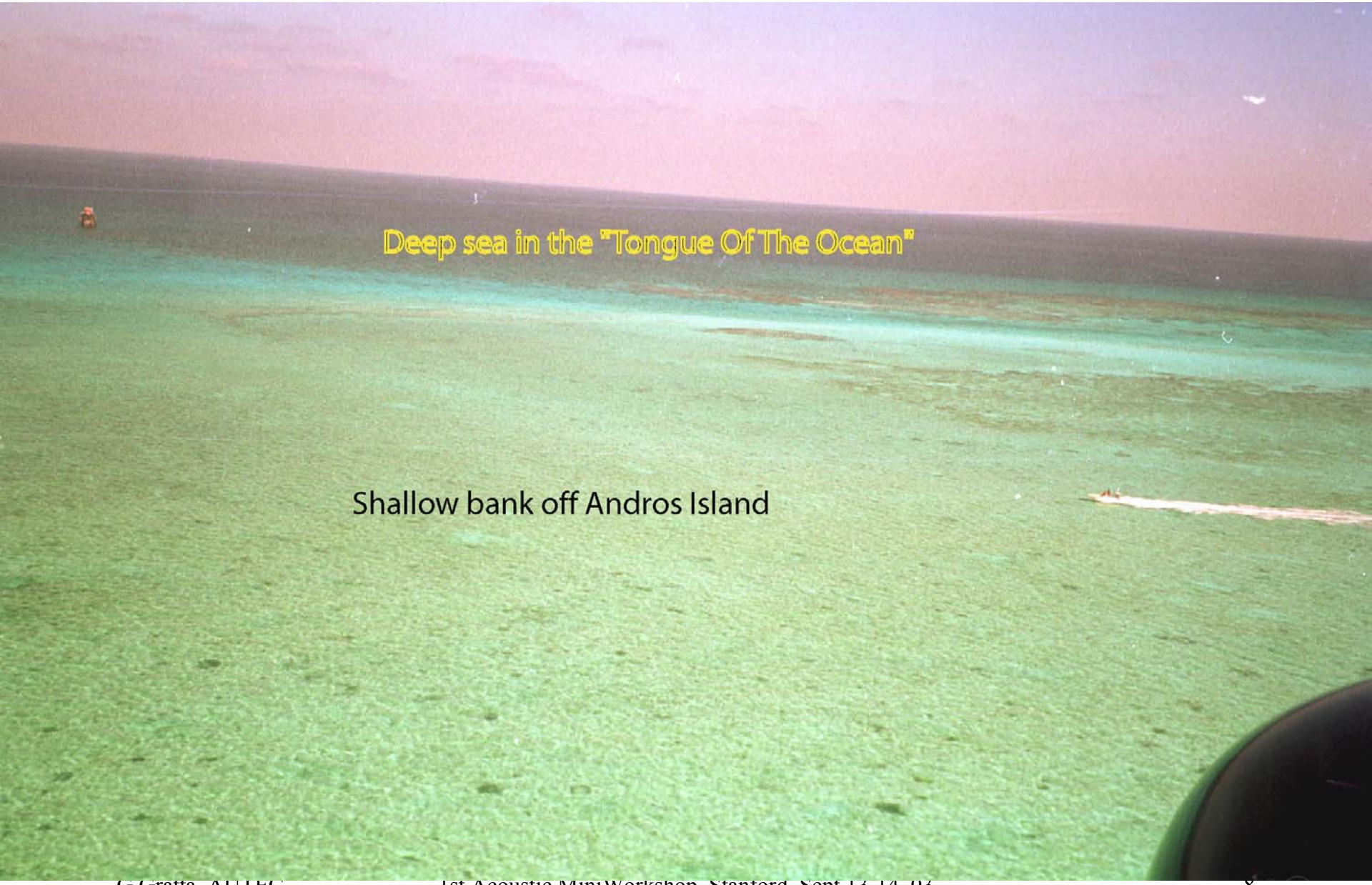
Deep (~1.5 km)
volume of water

Tongue
Of The Ocean

Very little shipping
traffic

Several hydrophone arrays
4 shore stations



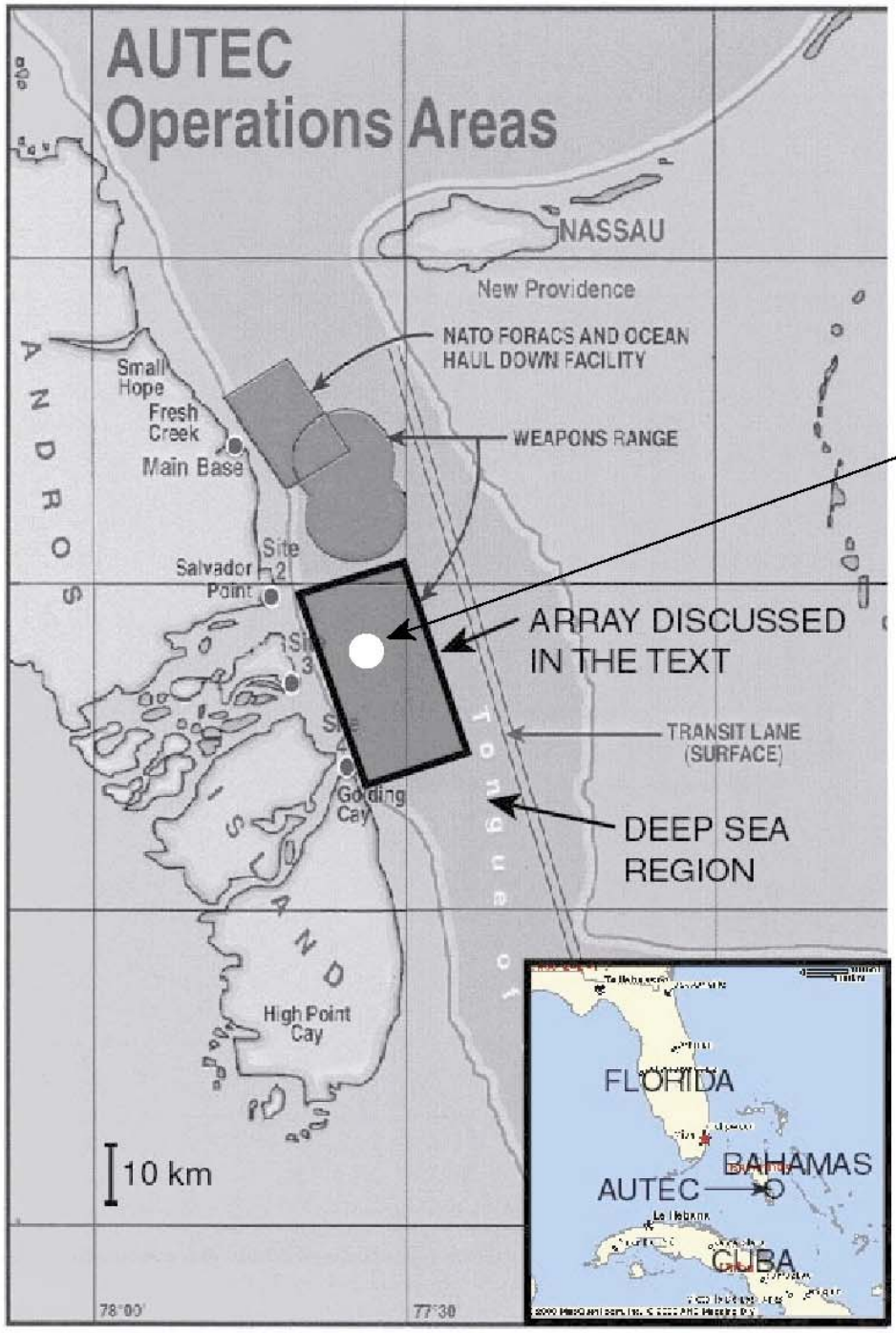

Deep sea in the "Tongue Of The Ocean"
Shallow bank off Andros Island

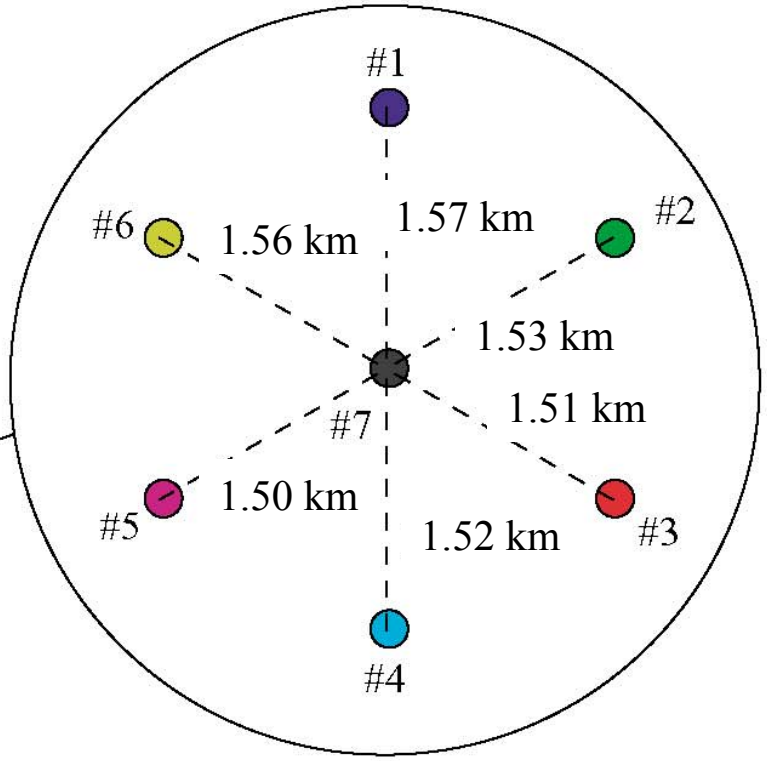
AUTEC Site 1 on Andros Island

Autec Site 3 (Bigwood Cay)

Range is large, helicopter is the favorite transportation (but boat is cheaper)

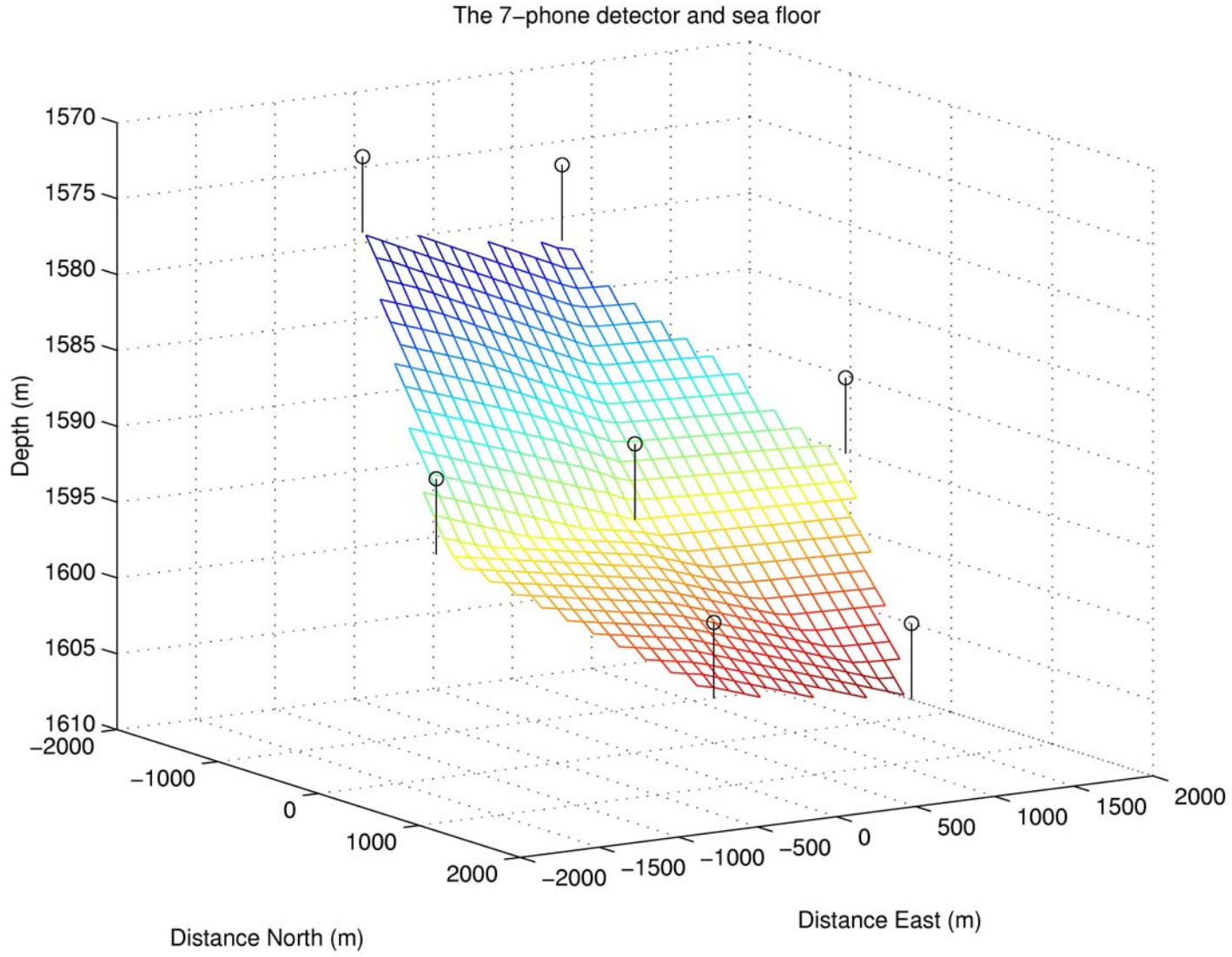
Range
Systems
Engineering
Company



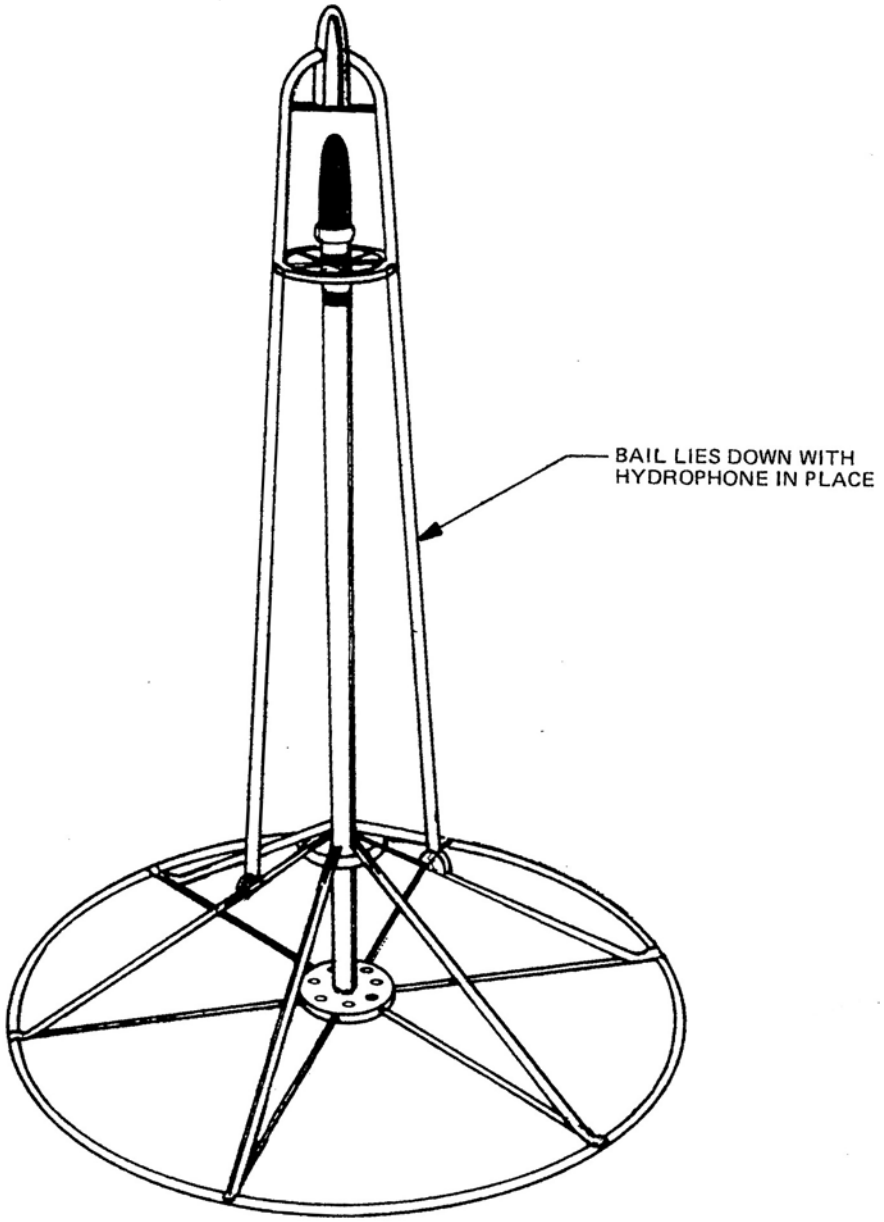


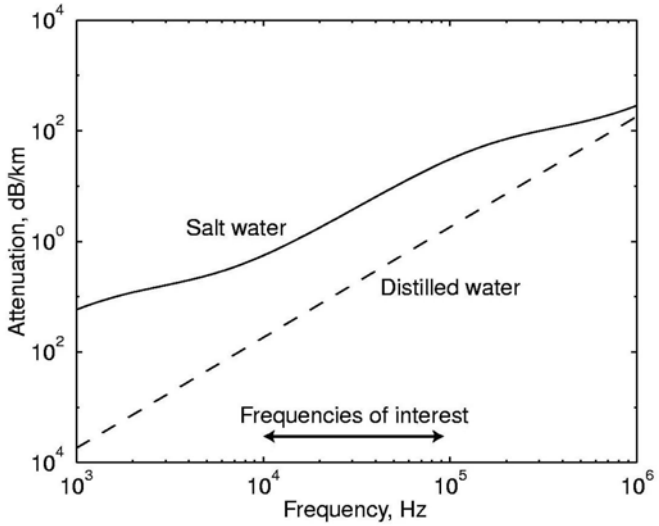
hydrophone subset used
in the experiment
(set up at Bahamas by
J. Vandenbroucke)

hydrophone depths are 1550-1600 m

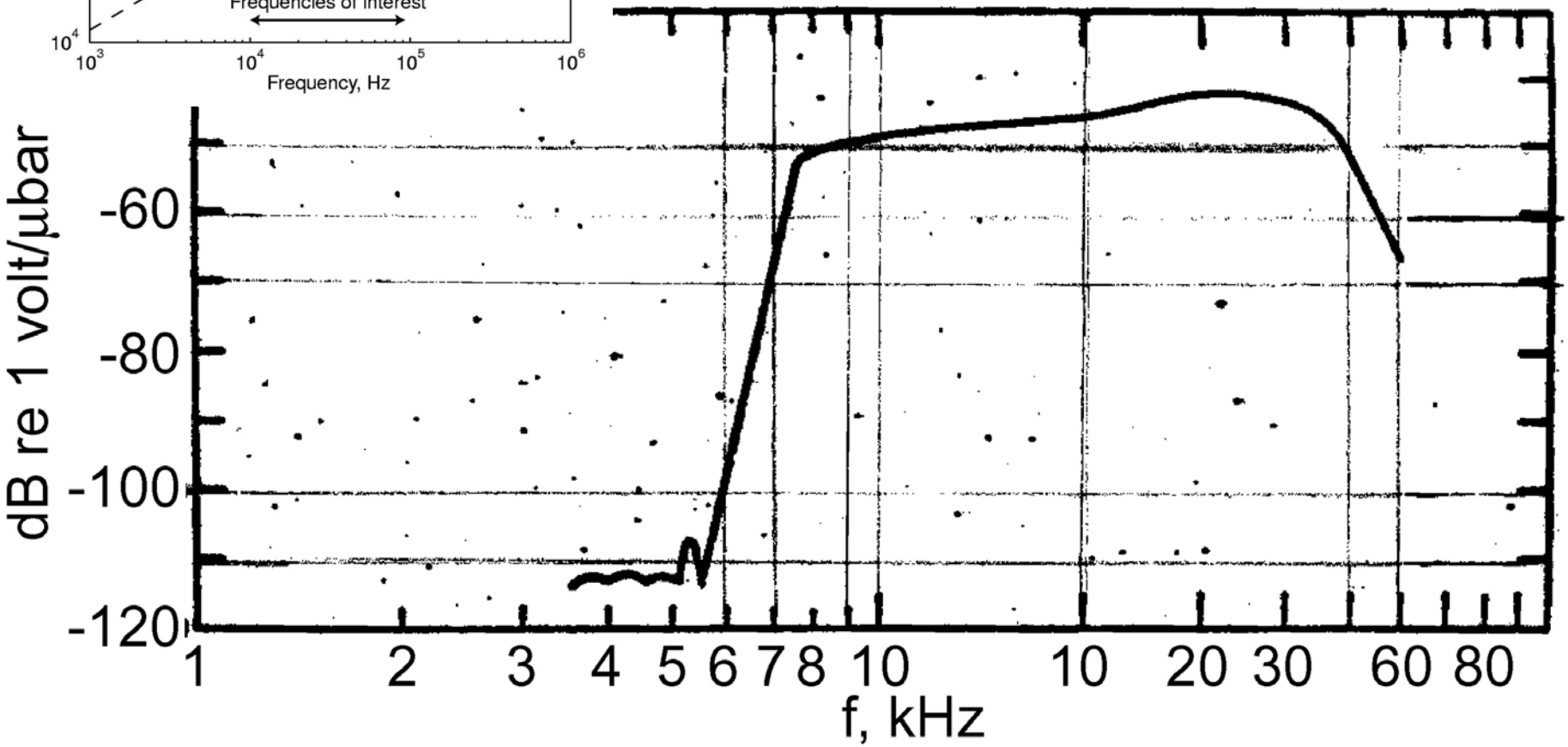

The 7−phone detector and sea floor
Depth (m)
1570
1575
1580
1585
1590
1595
1600
1605
1610
−2000
−1000
0
1000
2000
Distance North (m)
−2000
−1500
−1000
−500
0
500
1000
1500
2000
Distance East (m)

~4.5 m





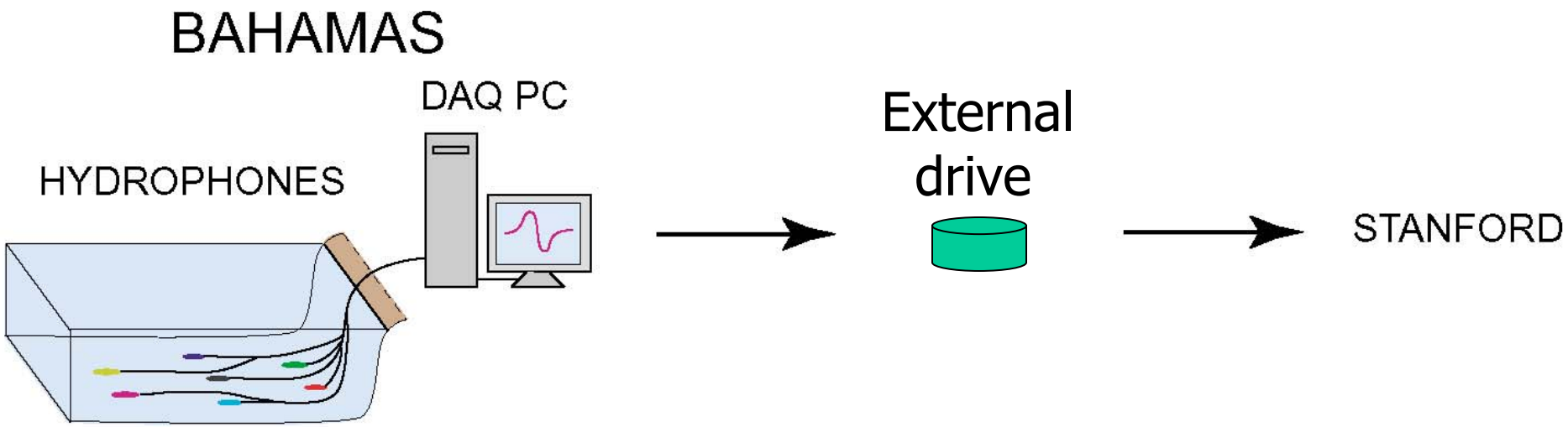
Autec phones are a good match to the problem but their lattice spacing in x,y and z is too coarse to be optimal



Very simple setup for cosmic-ray DAQ:

- 1.7 GHz Pentium IV
- Natl Inst sound card (digitize 7 channels at 179 kS/s)
- Trigger/digital filter coded in LabView
- 60 GB hot-swappable FireWire drive shipped back and forth to ferry data and program upgrades

Acquire 1 ms (179 Samples) for every event
Use adaptive threshold

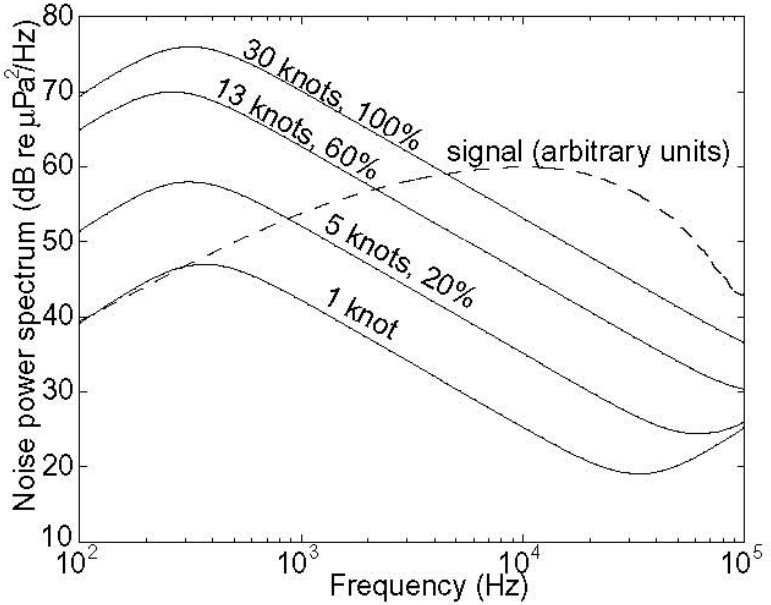


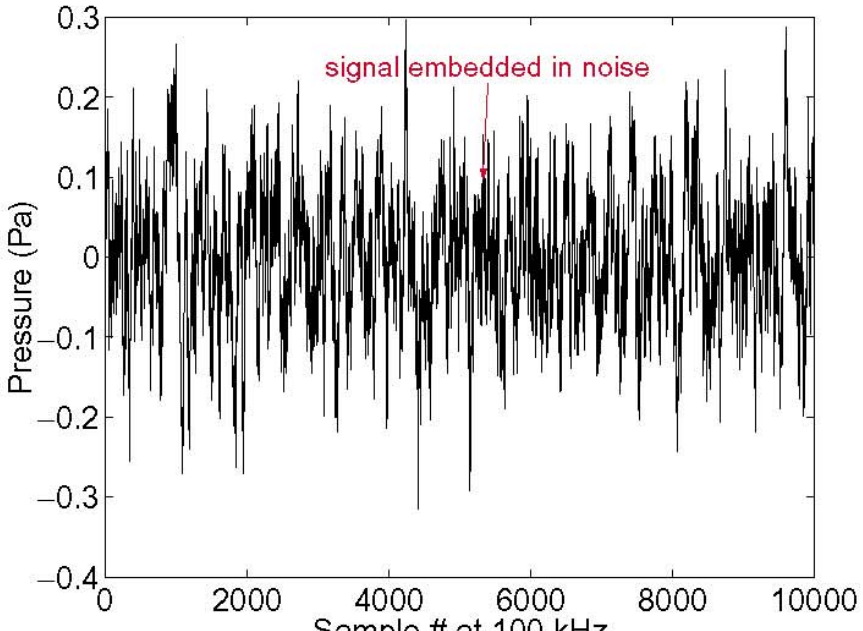
Matched filter as an optimal detection algorithm in Gaussian noise

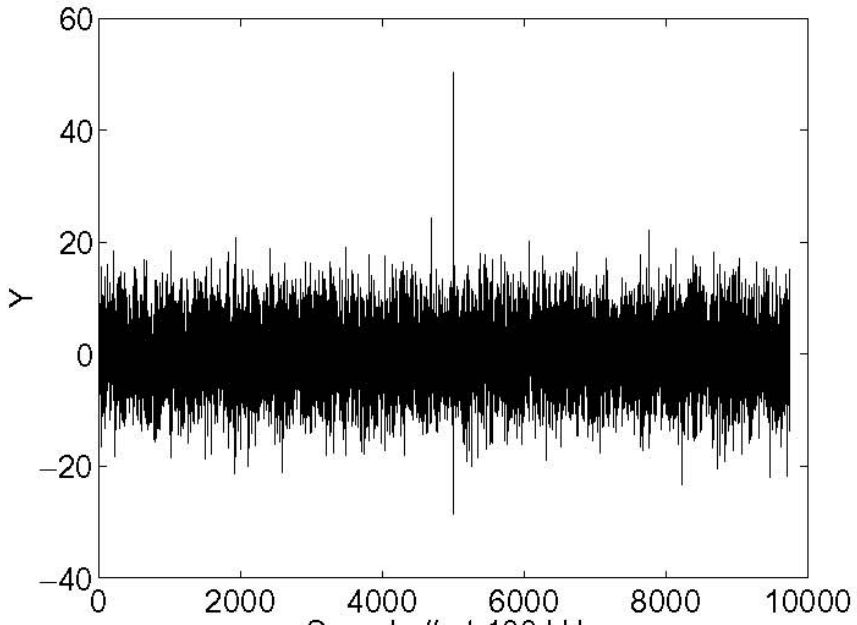
Matched filter technique is based on maximizing the likelihood of signal presence and uses the differences in noise spectrum and signal spectrum.

The matched filter which is used is a digital filter:

$$Y_k = \Sigma H_i X_{k-i}$$





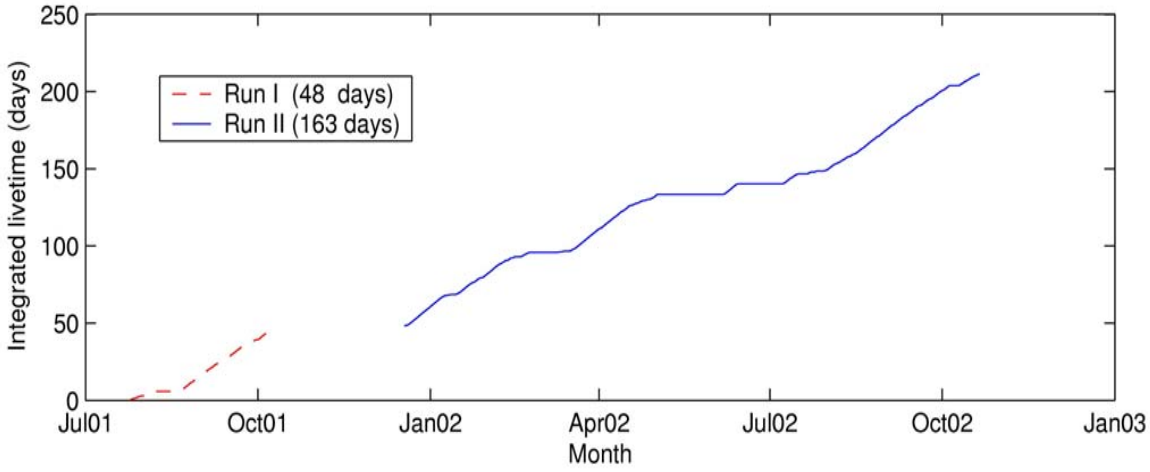


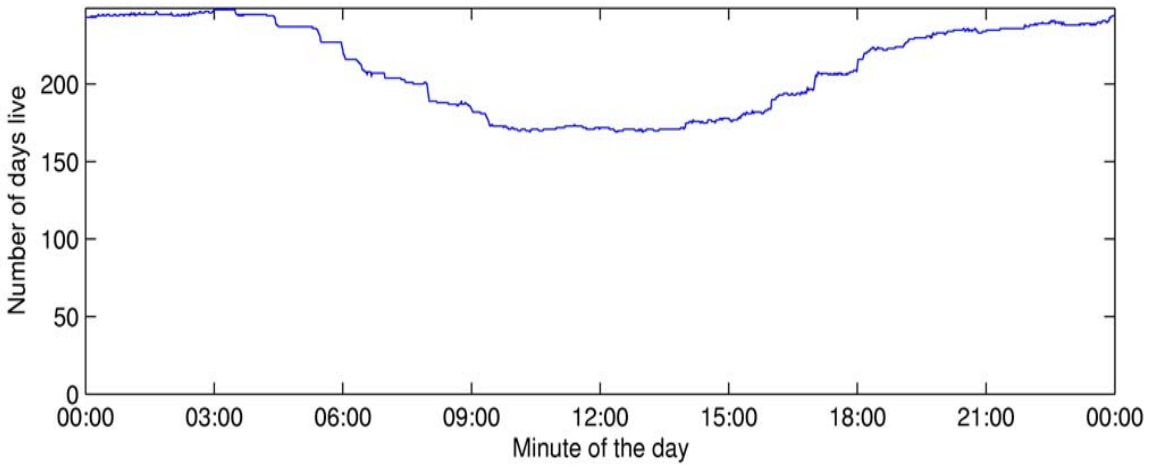
Present arrangement with the US Navy is very straightforward:

- Our DAQ is connected to their analog front-end via a multi-conductor cable
- During their tests they physically disconnect us

Overall 70% livetime is easy to obtain

- 16 months at the array
- 208 days livetime
- 25M triggers
- 350GB data





Status:

- *Properties of the AUTEC array relevant for UHE neutrinos published in*
  N.Lehtinen et al. Astropart. Phys. 17 (2002) 279
- *Largest data-set ever collected being analyzed, paper expected in the near future (see Justin's talk)*

Future plans:

- Equip entire array (~60 phones and 250 km^3)
- Possibly use new array (slightly larger with readout entirely at Site 1
- Improve adaptive threshold algorithm
- Introduce 2-level trigger, with online coincidence detection
- GPS time in data stream
- Collaborators would be welcome !