NURC Facilities/capabilities and NURC/SMID expertise on Neutrinos

A.Maguer

OUTLINE

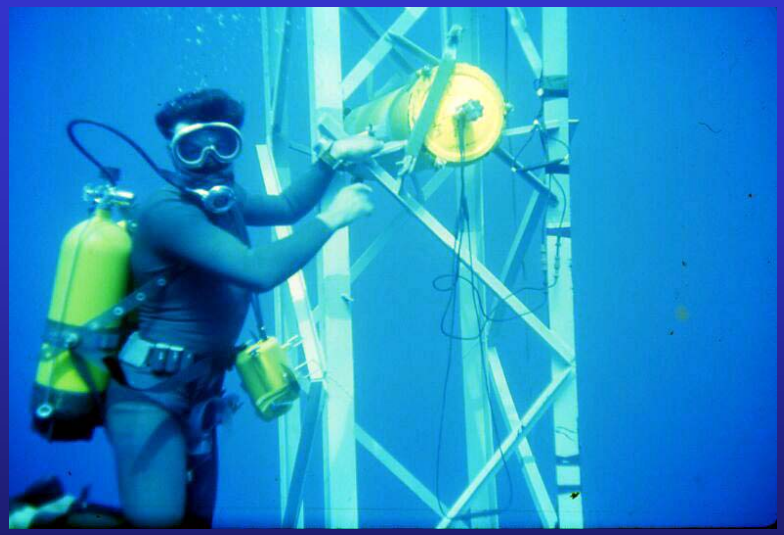
- Introduction
- SMO (Ship Management Office) facilities
- ETD (Engineering and technology Department) facilities and expertise
- ETD current developments
- NURC/SMID developments for neutrinos project
- NURC/SMID potential ideas for enhancement and collaboration

ETD and SMO

- ETD: Engineering and technology Department
- SMO: Ship Management Office
- Experience in performing controlled measurements at sea since 1959
- Offer expertise in development, testing and evaluation of ocean and maritime equipment

Ship Management Office (SMO)

60's: Oceanographic Experiments



- Meteo-oceanographic buoy for air-sea interaction studies
- R.V. Aragonese

Upper layer variability studies
(internal waves-microstructure)

Gulf of Lions Buoy (1969-1976)

MAGNAGHI
&
MARIAPAOLINA
off
BORA II

Engineering developments :

- yo-yo and towed oscillating CTD
- Thermistor buoys
- Deep sea taut mooring techniques

Calibration of a towed array at sea

- Calibration on board of R.V. Maria Paolina
- 32 elements acoustic array

Towed Sound Source

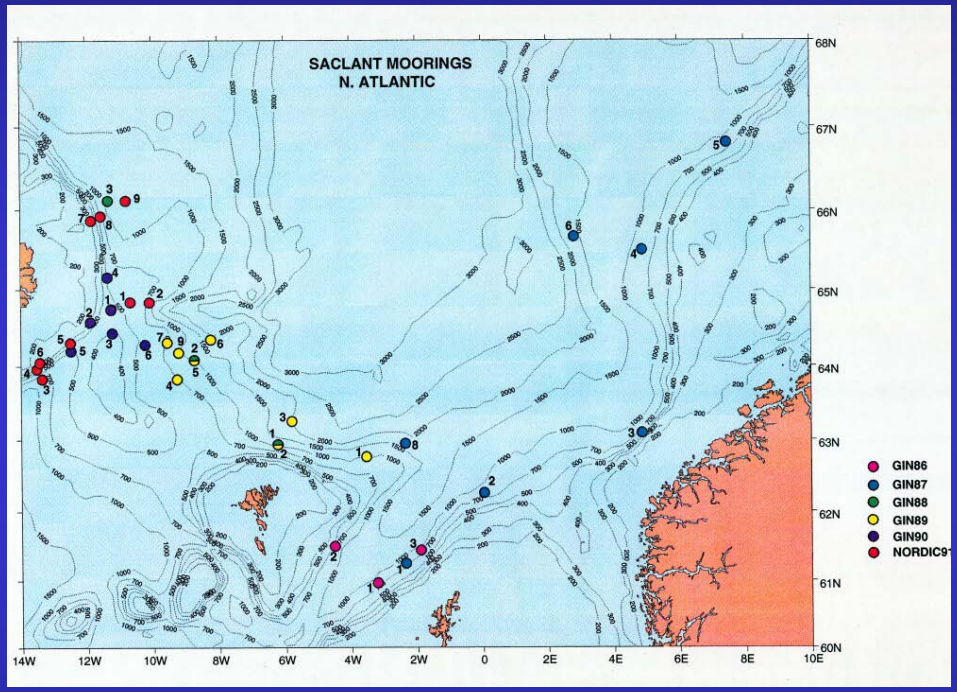
Vertical array of low frequency flextensional projectors
Early 1985 version

The body is launched,recovered and handled vertically but ,once streamed,it assumes a horizontal position and the array deploys automatically to become vertical

Projector body,towing winch and chute designed by Ocean Engineering
Larger commercial version of similar concept made later in USA

Development of buoy & mooring technology for long -term sea deployments in severe weather conditions

1986-1991



31buoys, 118 instruments
up to one year of deployment
less than 5% of loss

NURC designed ADCP flotation package

1988: NRV ALLIANCE

Characteristics:

- LOA 93m
- Beam 15,2m
- Draft 5.2m
- Gross Tonnage 3180t
- Shaft power 2970kw giving sustained speed of 16.3 kts
- Effective range 7200nm with 26 day endurance
- Diesel / Gas turbine electric drive with 2 screws and bow thruster
- Complement 24 crew and 25 scientific staff

NRV ALLIANCE

Characteristics:

- Designed as acoustically silent platform with 8 different noise states ranging from silent battery operation to main diesel propulsion.
- Gas turbine operation for silent towing speeds up to 6 kts.
- Large scientific laboratory
- Fully integrated electronic navigation, engine automation and station keeping capability.
- Extensive suite of deck handling equipment
- 2 offshore RIB’s capable of 35+ kts
- Full satellite communications with advanced networks and broadband internet access.

2002: CRV LEONARDO

Characteristics:

- LOA 28.6m
- Beam 9.0m
- Draft 2.5m
- Displacement 393t
- Power 1170 kw
- Max speed 10.5kts
- Diesel electric drive
- 2 Azimuth pod thrusters
- Water pump jet bow thruster
- Full dynamic positioning (SDP11)
- 5 kt low noise configuration

CRV LEONARDO

Characteristics:

- Crew of 5
- 7 scientific staff
- Sleeping berths for 12 with maximum lifesaving capacity of 15
- HiPap acoustic positioning and moonpool

Engineering and Technology Division (ETD)

ETD Mission and Assets

Mission

1. To conduct the cruise and experimental component of NURC's Scientific Programme of Work
2. To design, construct and operate equipment in support of NURC's Work Programme including Ship Charter
3. Provide a long term view of the applicability of new technology to all NURC's activities

Assets

- Staff of 40 people
  - 11 A-grade Engineers
  - 29 B/C-grade Technicians
- Facilities
  - Laboratories
  - Test facilities
  - Calibration facilities
  - Workshops

Capabilities

- Acoustic and Oceanographic Calibration
- Ocean Engineering –Buoys, moorings etc.
- Provision of High Reliability maritime systems
- Mechanical, Optical and Electrical Cable Termination
- Data Acquisition and Telemetry
- System architecture design
- Full system testing

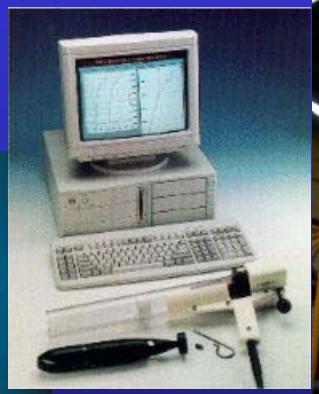
Technologies

- Materials – high strength, low corrosion
- Electronic circuit design and production
- Hydrodynamic design
- Power generation – fuel cells, batteries etc
- Chemical analysis
- Reliability monitoring and control

Laboratories and Infrastructures to Support Research

NURC has advanced laboratories and infrastructures

- acoustic and oceanography Labs
- calibration systems
- electronic design labs
- mechanical design labs
- autonomous underwater systems
- real time data processing capabilities



Acoustic Calibration Facility

Towed arrray Calibration Facility

- Frequency range: 50 to 3000Hz
- Amplitude and phase response measurement
- Cost effective: 128 hydrophone array can be calibrated in one day

TA Hosing/dehosing facility

Acoustic tank Calibration Facility

Deep water Acoustic Calibration Facility

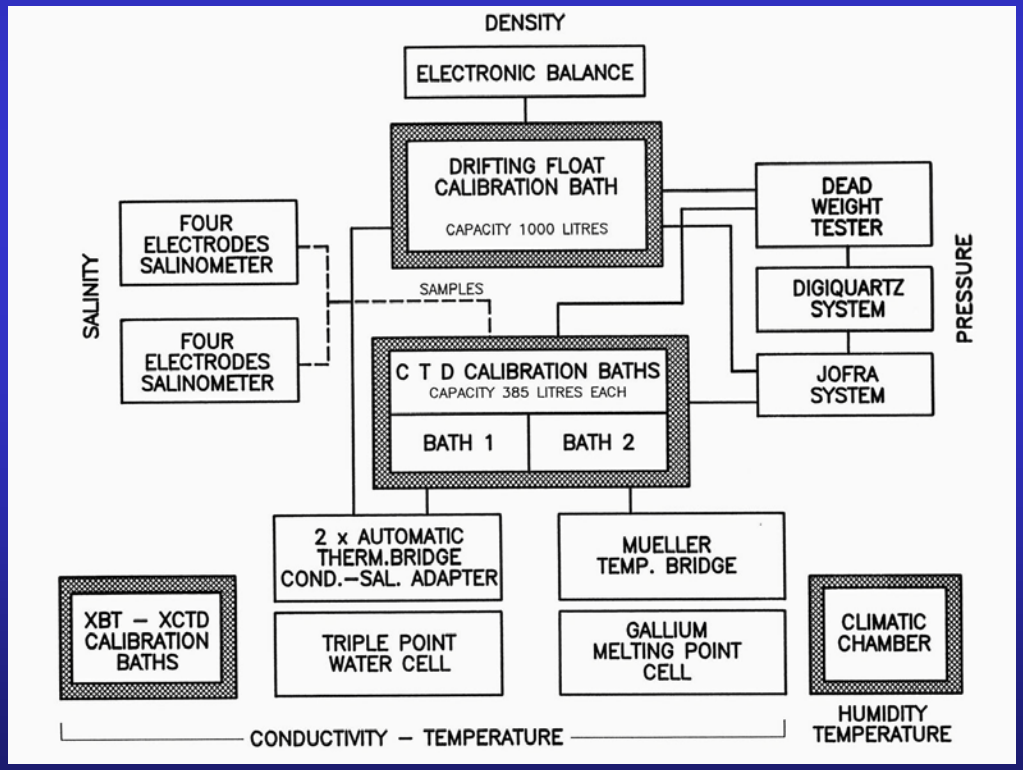
- Frequency range:10 kHz to 80 kHz (before only good around 20-30 KHz)
- up to 4000 meters
- hydrophone dimension: 40 mm diam.
- Work in progress: Transducer TVR versus pressure calibration, 150 mm diameter

Pressure Tank and Rope Test Bench

- Pressure up to 6000 meters
- Fatigue and stress test

Oceanographic Calibration Facilities
WOCE Standard

- Thermally controlled salt water baths
- Fully automated data acquisition
- Evaluation of secondary effects on sensors



Oceanographic Instruments

- ADCP's
- CTD's
- Wave Sensors
- Expendable Devices
- Thermistor & CTD Chains
- Meteo Stations
- Acoustic Release Systems
- Current Meters
- Drifters
- Other Oceanographic Instruments

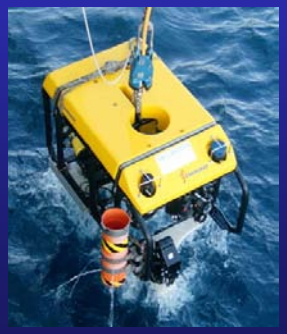
Acoustic Instruments

- Towed Arrays
- Vertical Arrays
- Transducers
- Source Arrays
- Parametric Sonars
- Echo Repeaters
- Hydrophones & Tranducers
- Multibeam Systems

NURC UxVs ASSETS (1)

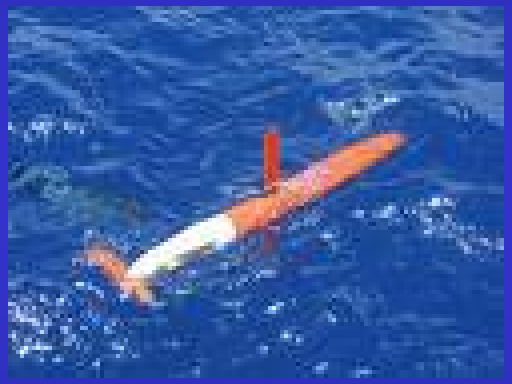
- **AUV Systems**
  - 2 OEX with Payloads: sidescan, LF Tx, towed Rx
  - 2 REMUS 100
  - 1 MUSCLE with HF sonar
  - 5 FOLAGA (hybrid glider-AUV)

- **ROV's**
  - Cherokee
  - SCALLOP mini ROV
  - Video Ray pro



NURC UxVs ASSETS (2)

- **GLIDER**
  - **Bluefin Spray Glider (deep water)**
  - **6 slocums (shallow water)**
  - **1 slocum (deep water)**



- **USvs**
  - **H-scientific**
  - **Sea Robotics**

Geophysical Equipment

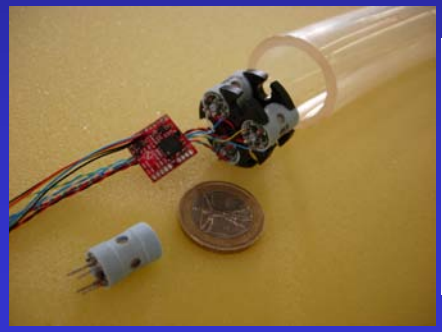
- Sub bottom
  - Uniboom
  - Chirp Edgetech
- Sidescan Sonars
  - Edgetech *2
  - Marinesonics
- Corers

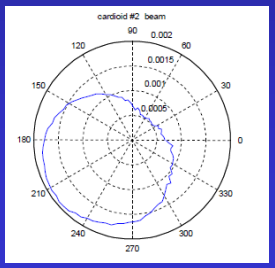
SLIM TOWED ARRAYS for AUVs

SLITA Towed arrray

- ✓ 48 hydrophones, 31mm diameter array
- ✓ 3 x 32 hydrophones octaves (900 Hz, 1800 Hz, 3200 Hz)
- ✓ 32 channel, 24-bit, 100kHz continuous acquisition (9.6Mbyte/s)
- ✓ Integrated with OEX AUV
- ✓ Developed in 2007

TriBENS Towed arrray with triplet hydrophones

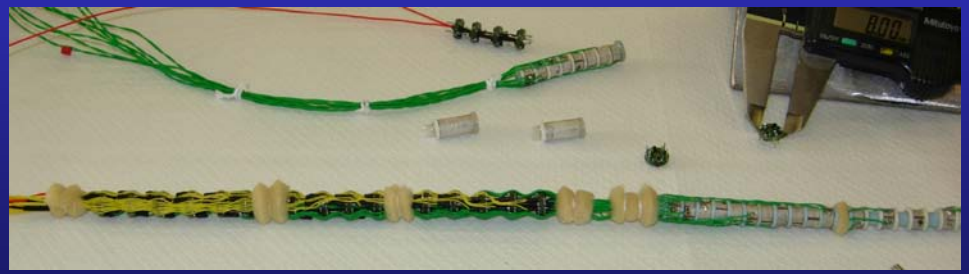




- ✓ Same as SLITA + extension with triplet hydrophones (L/R ambiguity)

Micro SLITA arrray (12 mm diameter)

- ✓ 32 hydrophones, 12mm diameter array
- ✓ 1 octave (3200 Hz)
- ✓ Same acquistion system as SLITA and TriBENS
- ✓ Integrated with OEX AUV
- ✓ Under construction



AUV source (Tx) capability for ASW

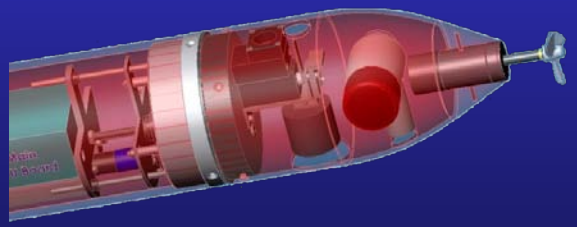
- **Transmitting source in 800 – 3200 Hz towed by OEX AUV**

Engineering UUV development (3)

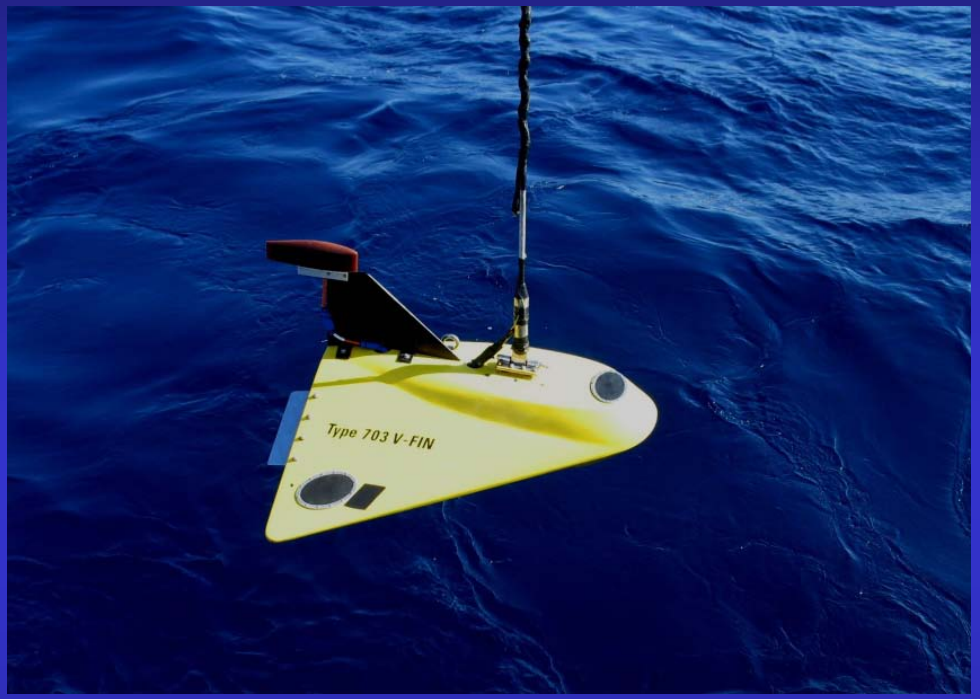
- Low-cost Hybrid (AUV-Glider) FOLAGA

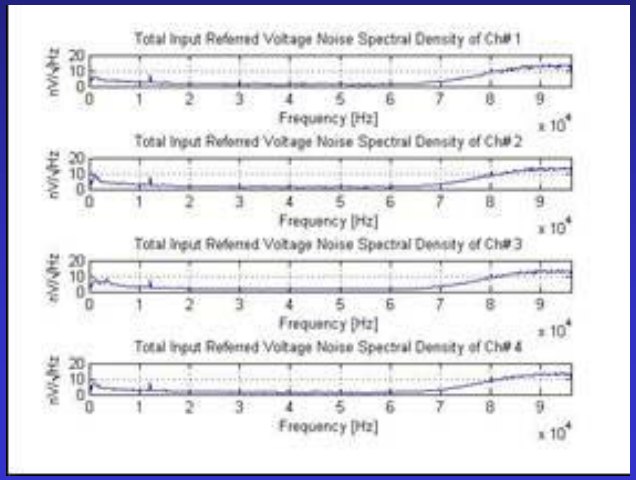
Technical Data

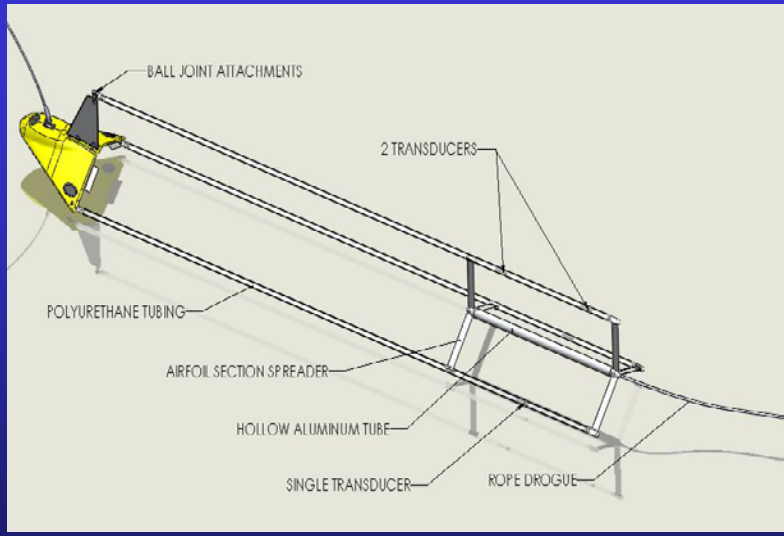
length:	~200 cm
diameter:	15 cm
weigth (in air) :	30 kg
autonomy (at max speed):	6 hours
max speed:	2/3 knots
max depth:	80 meters
Payload	Sidescan sonar, optical sensor, acoustic modem



CPAM: Tetrahedral Array for Marine Mammals detection and localization

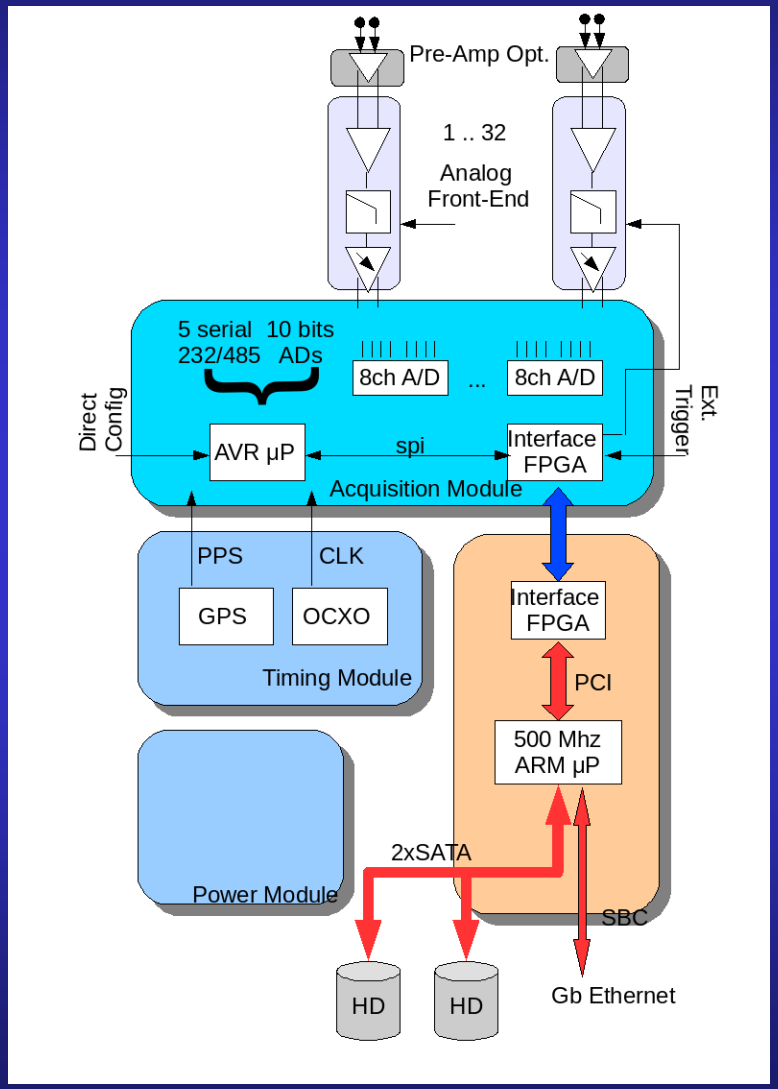






- ✓ **4 hydrophones sampled at 192 KHz (80 kHz acoustic bandwidth)**
- ✓ **Digital compass, pressure and temperature sensors**
- ✓ **Low noise pre-amplifier. Very low consumption**
- ✓ **Hydrophones (3 over 4) mounted flush into body to reduce flow noise**

32 channel low-consumption digital acquisition system



- 32 simultaneous channels
- 24 bit Sigma-delta converters up to fs=52 KHz
- Input noise 5nV/√Hz (10kHz, VGA = 40dB)
- 16.5 W power consumption

APPLICATIONS

- Acoustic array system on AUV / gliders

4 channel low-consumption digital acquisition system

- 4 simultaneous channels
- 24 bit Sigma-delta converters up to fs=300 KHz (B=140 KHz)
- Input noise 5nV/√Hz (10kHz, VGA = 40dB)
- 4 W power consumption
- Electronic dimension 120 * 70 * 50 mm
- 7 days continuous time recording

APPLICATIONS

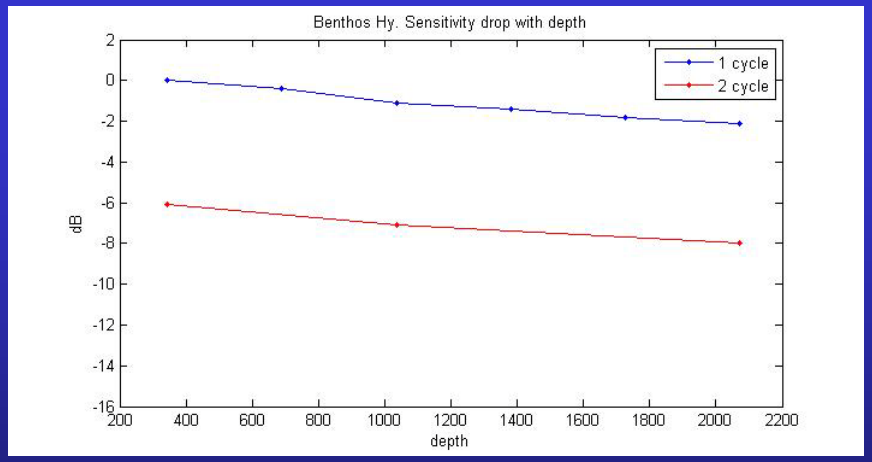
- Acoustic system on gliders
- Self-recording system for natural parks

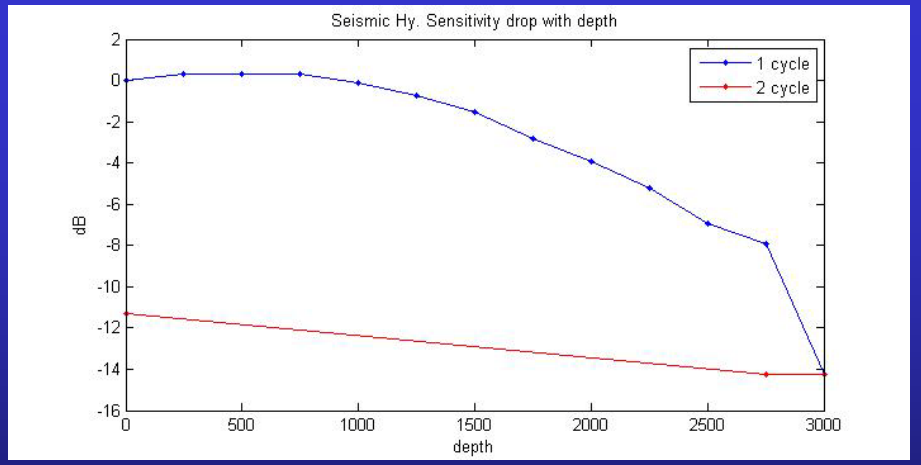
NURC/SMID hydrophone development for neutrinos project

NURC Experience on deep water hydrophone calibration

Benthos

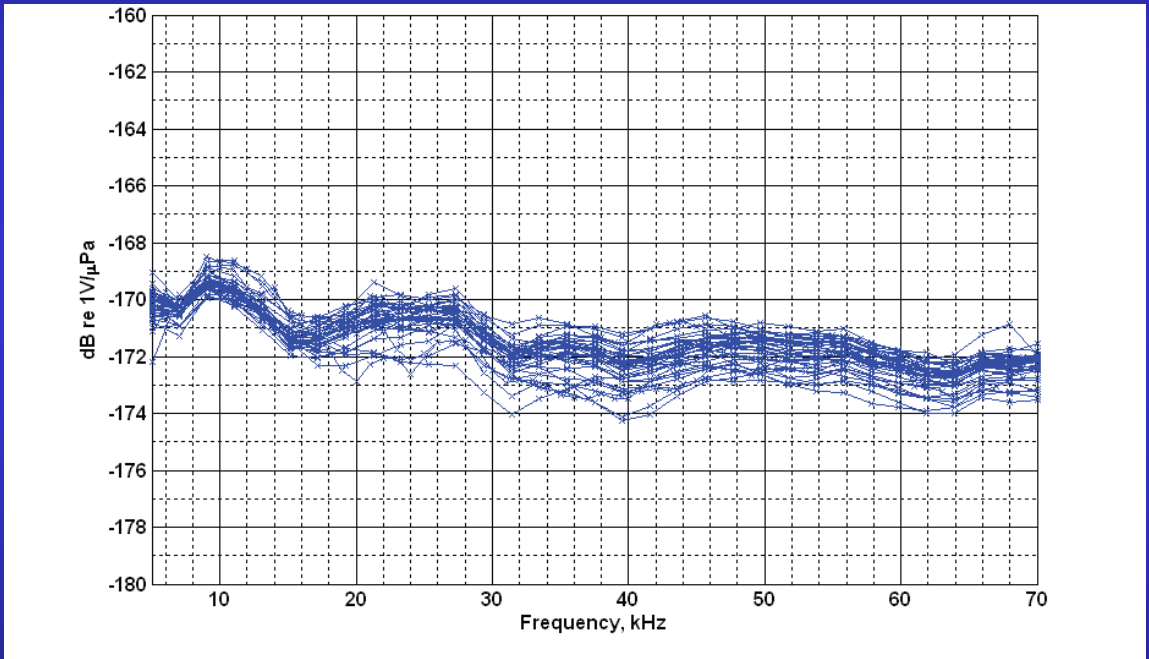
Seismic



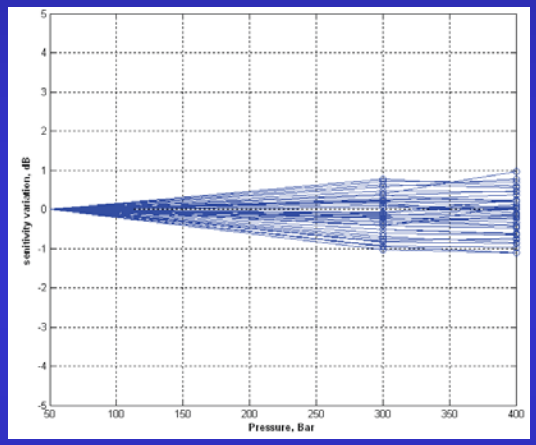


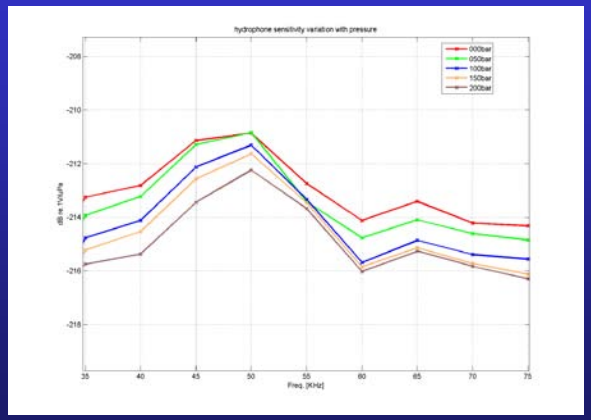
NURC measurements for INFN hydrophones

Pressure sensitivity versus frequency



Pressure sensitivity variation versus depth





39 hydrophones have been tested

INFN Deep-water Hydrophone
Main characteristics

Hydrophone and Preamplifier

• Sensitivity	-207 dB re. 1V/μPa @ 30 kHz
• Electronic Input Noise	-181 dB re. 1V/√Hz @ 30 kHz
• Acoustic equiv.noise level	26 dB re. 1μPa /√Hz @ 30 kHz
• Gain	38 dB
• Max input voltage level	50 mV ptp
• Frequency range	4 Hz to 80 kHz

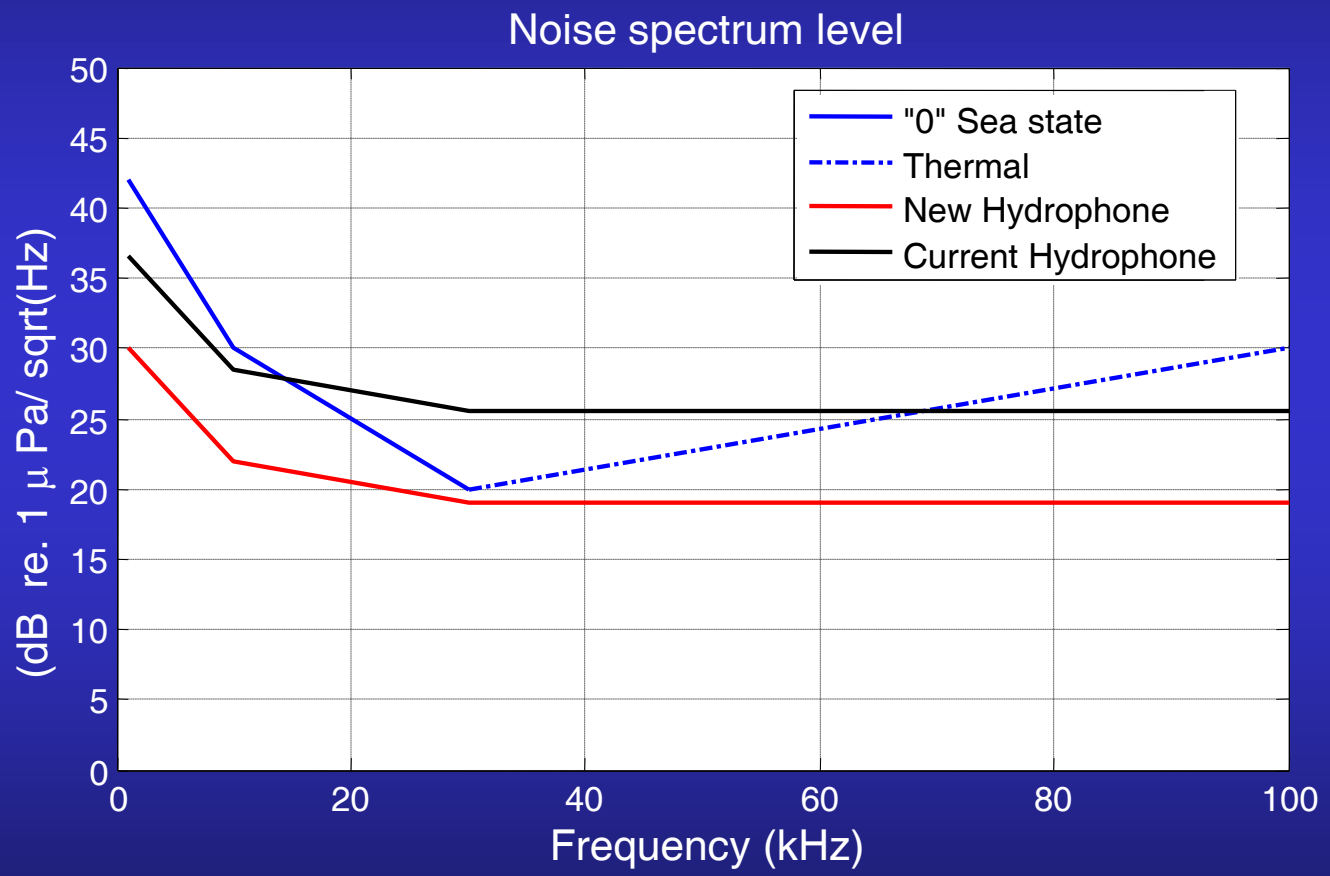
Improved Deep-water Hydrophone

Main characteristics

Hydrophone and Preamplifier

• Sensitivity	-200 dB re. 1V/μPa @ 30 kHz
• Electronic Input Noise	-181 dB re. 1V/√Hz @ 30 kHz
• Acoustic equiv.noise level	19 dB re. 1μPa /√Hz @ 30 kHz
• Gain	32 dB
• Max input voltage level	220 mV ptp
• Frequency range	0.4 Hz to 80 kHz

Deep-Water Hydrophone
Acoustic Noise Spectrum



Improved Deep-water Hydrophone for seismic/ marine mammals measurements

New Front End and A/D converter

- VGA — 0-20-40 dB
- VGF — 0.1 Hz, 100 Hz, 1 kHz
- Frequency range — 0.1 Hz to 80 kHz
- Electronic noise level — -150 dB re. 1V /√Hz at 0 dB gain flat on full band

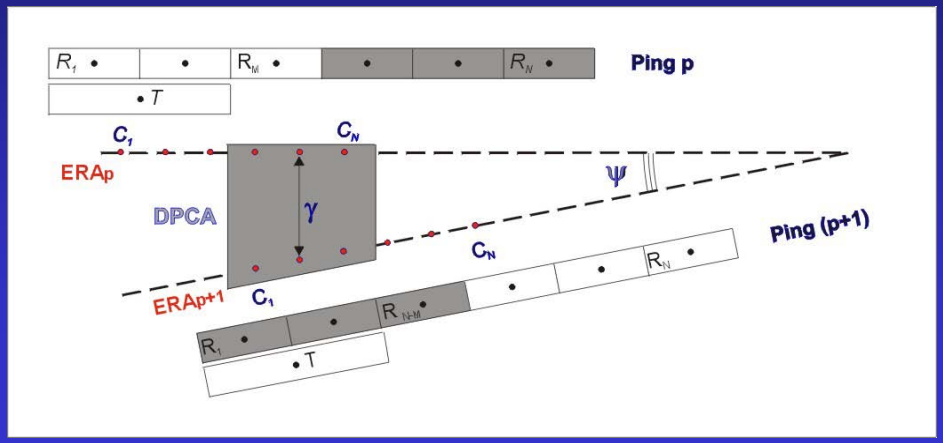
Improved Deep-water Hydrophone acquisition system for acoustic positioning

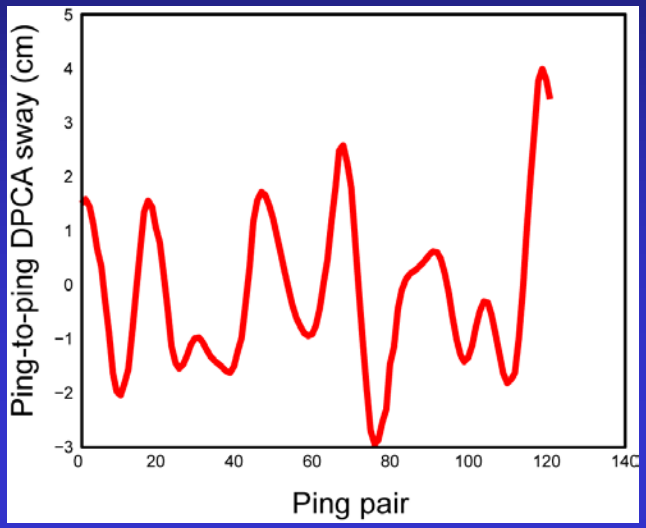
New acquistion system

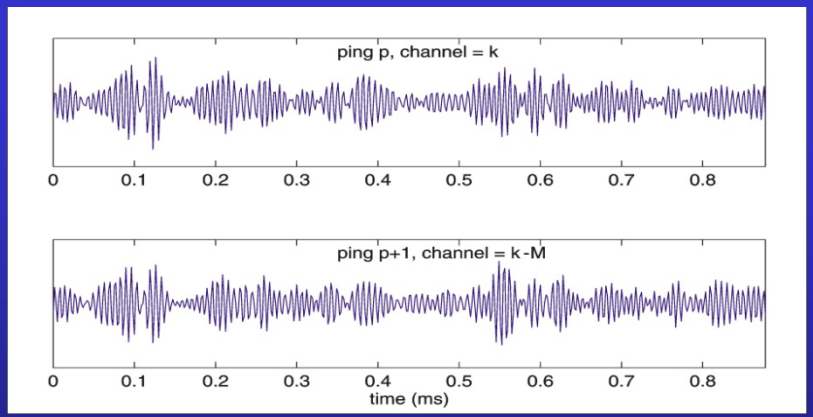
- Communication protocol — SPI with external absolute time
- Electronic latency — 150 µs
- Maximum latency jitter — 100 ns (with clock jitter less than 100 ps)

Other NURC expertise with potential relevance to Neutrino project

New navigation concept
Displaced Phase Centre Antenna (DPCA)







NURC has demonstrated centimetric AUV navigation accuracy using the DPCA concept.

The same principle could be used to accurately monitor in real time the position of the hydrophones of the neutrino telescope

Andrea Bellettini & Marc Pinto

"Design and Experimental Results of a 300 kHz Synthetic Aperture Sonar Optimized for Shallow Water Operations"

IEEE Journal of Ocean Engineering, July2009, Volume 34, Number 3

Conclusions

- Together, ETD (Engineering Technology Division) and SMO (Ship Management Office) offer an unparalleled capability of experimental support