Acoustic Cosmic Ray Neutrino Experiment

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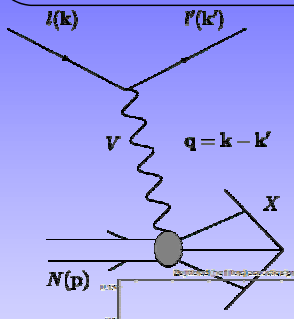
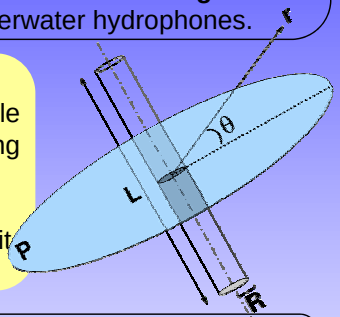
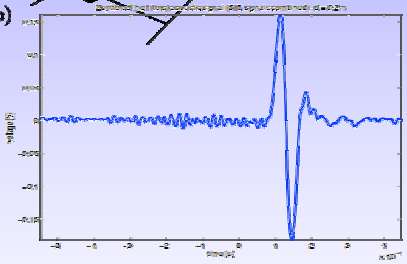
The Acoustic Detection of Ultra High Energy Neutrinos: (E>10^{18}eV) is **Neutrino Astronomy** at the highest energies. Cosmic Ray **air shower** experiments such as **AUGER** have reported several **CR** events in excess of **1EeV**. It is likely that there will be a **neutrino counterpart** to such a signal, which is in principle energetic enough to **thermally heat** the medium in which it may interact, producing a **coherent** pressure wave detectable on **commercially available**, broad band transducers. The **ACORNE** collaboration utilises the **RONA** underwater acoustic range off the coast of Northwest Scotland as a 'test bench' for development of **readout** and **analysis**. Furthermore the collaboration is developing **sensor calibration technologies** and **Monte Carlo** simulation tools for **predicting** the **performance** of **large-scale** (>1km^3) arrays of underwater hydrophones.

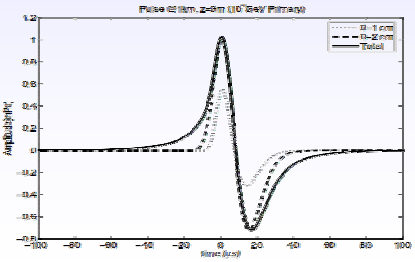


Neutrinos Interacting on Earth: can scatter off the constituent quarks in nucleons of seawater or ice **(left)**. The development of the resulting particle cascade **X** is **instantaneous** with respect to the signal transit time resulting from **thermoacoustic** emission. Hence the pressure wave is **coherent** along the cascade **axis** and thus **confines** the signal region to a **narrow pancake (right)** in analogy with the diffraction of light through a narrow slit (**99%** of the energy at **1EeV** is deposited within **L**~20m, **R**~10cm)

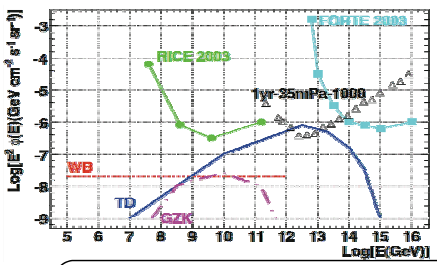




The RONA underwater acoustic range: comprises 8 wideband hydrophones with a flat -158dB/V/μPa response from 0.01-65kHz distributed about a rectangle of dimensions 1.2x0.2km. Readout is 16bit @ 140kHz. Omnidirectional sensitivity.



Hydrophone Calibration: relies on production of the characteristic bipolar signal. A **single element** has been used to generate an omnidirectional neutrino-like pulse **(above left)** via a **5th order RC circuit model** of the emitting transducer. The next phase of calibration development is to use between 8 and 10 transducers in a line array to recreate the 'pancake'.

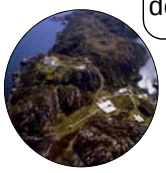


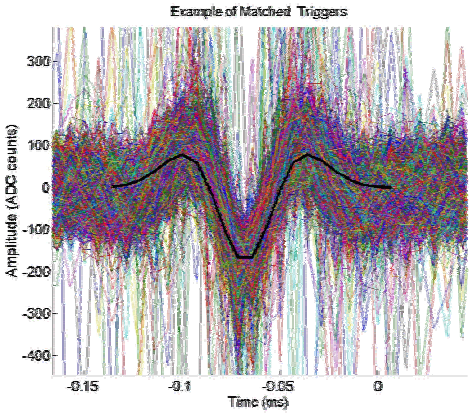
ACORNE Simulation work: A modification has been made to the **CORSIKA** air shower program for simulation of **UHE neutrino induced particle cascades** in water and ice. **[arxiv:0704.1025]**. Integrating the cascade energy density yields the resultant **thermoacoustic pressure pulse (left).** Understanding the energy deposition close to the cascade axis is vital since this is where the bulk of the pressure signal comes from (~90% within 2cm@ E_ν=1EeV)

Large-scale hydrophone array simulations: For a hypothetical array, one can interpret the performance (i.e. the ratio of events detected to events generated) as a limit on the neutrino flux based on there being no detections made for a given period of observation. The flux limit for a cubic kilometre array of 1000 hydrophones is shown **(left)** with along with some measured and model fluxes.

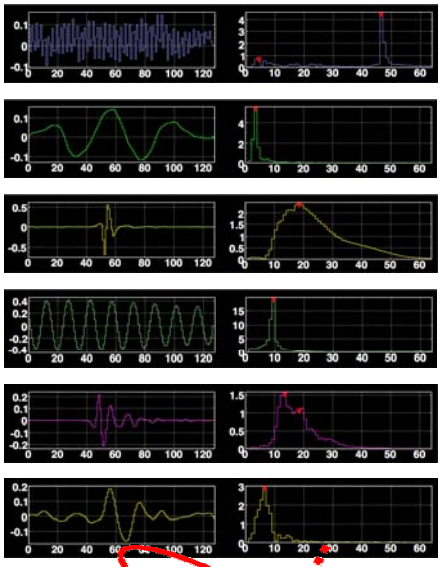
STATUS REPORT…

The ACORNE DAQ philosophy: is **all unfiltered data to shore**. This permits the greatest flexibility for **digital linear phase** filtering and **matched filter** development. **18TB** of (**FLAC** compressed) raw data are under analysis

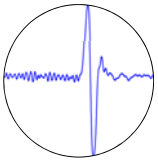




Left: An example of triggers **pattern matched** to the **bold** signal shape (derivative of bipolar) by the **matched filter**. **Right:** An example of recurring signal types identified (from top): 50kHz oscillating low freq. oscillating impulsive 10kHz sinusoidal ringer 'bipolar' **[y-axis: P(Pa); x-axis: sample №]**



Offline analysis: 13 dimensional phase space to explore: Pulse Width Pulse Periodicity Relative Energy Pulse Multiplicity Dominant Frequency Sinusoidalness Bipolarity Standard Deviation Skewness Kurtosis Asymmetry of Standard Deviation Asymmetry of Skewness Asymmetry of Kurtosis Prioritisation/optimisation of parameters underway….



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