Future plans for the ACoRNE collaboration

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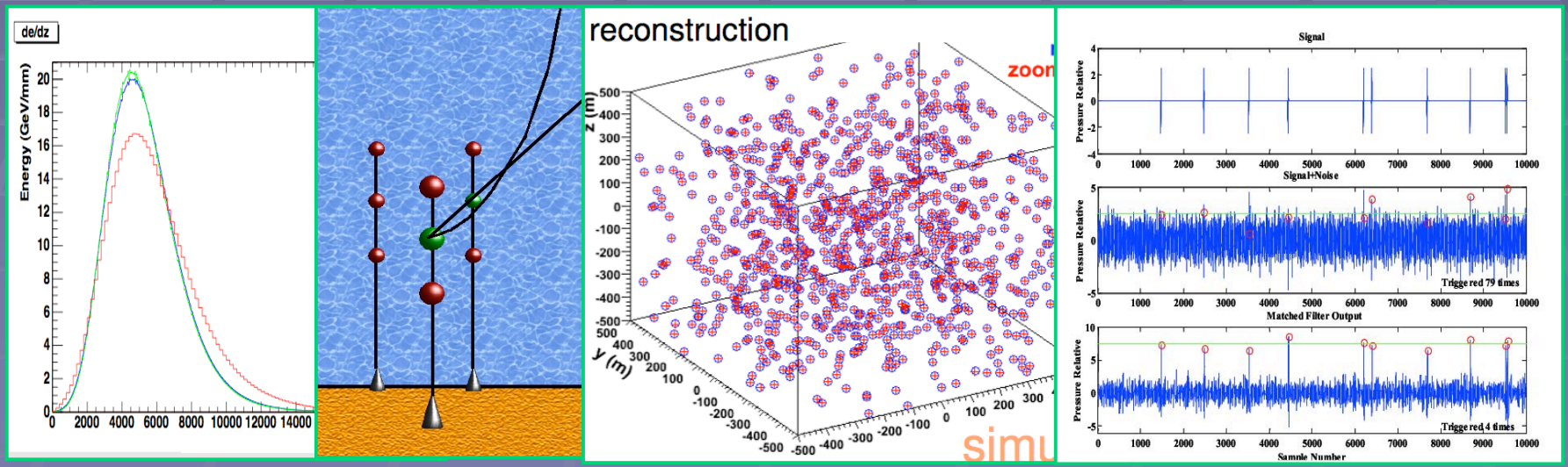
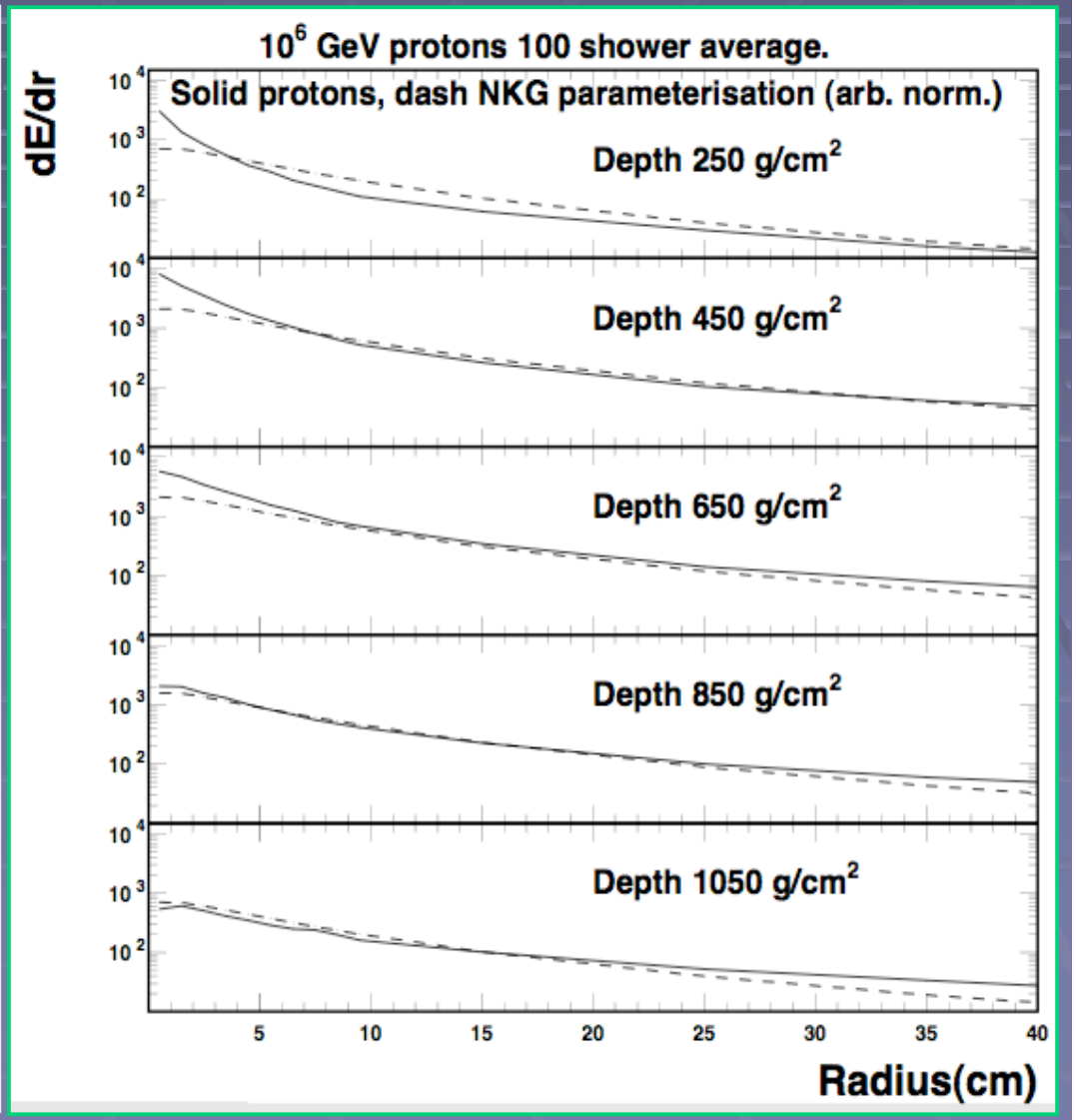
ACoRNE status reports at ARENA

- Simulating ν with CORSIKA (Terry Sloan)
- Sensitivity predictions (Jon Perkin)
- *Reconstruction (Simon Bevan)*
- *Analysis of Rona data (Sean Danaher)*



Simulating Neutrino Events

- The radial distribution of events generated with CORSIKA potentially important different radial profile (esp. when compared with NKG)
- Next steps:
  - Understand problems at E > 4 x 10^{16}eV (may be the HERWIG-CORSIKA interface)
  - *Generate UHE neutrino events and use these to predict acoustic signal using a full 3D simulation to include fluctuations*
  - Develop a CORSIKA parametrisation

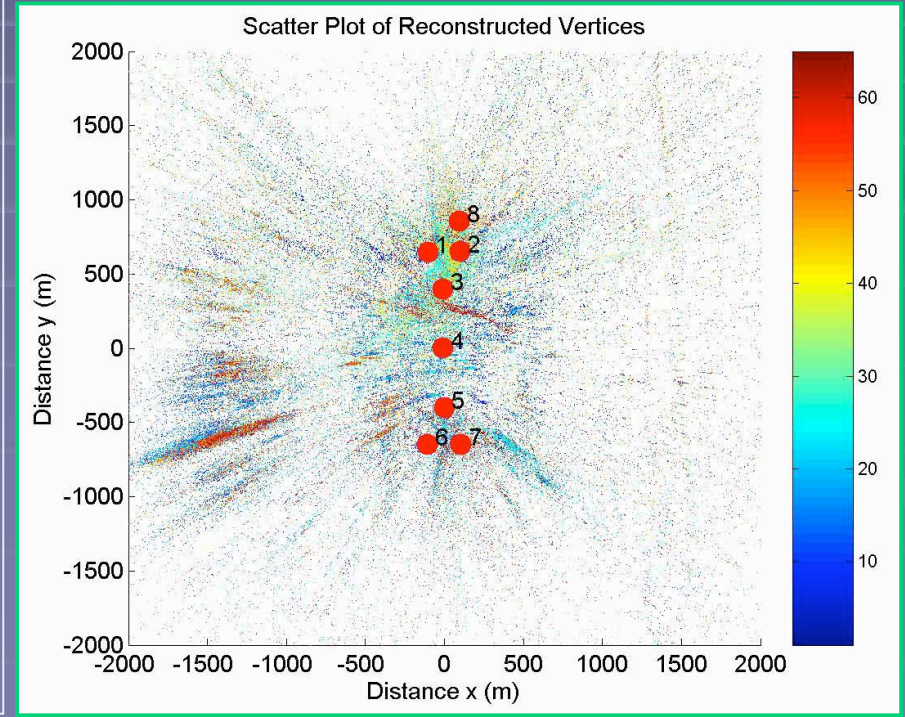


Analysis of first Rona data

- Initial data taken in Dec 2005 yielded 2.8Tb of unfiltered data over ~15 days (8 hydrophones @ 140kHz)
- *Subsequent analysis - 230k events. This is good! Data analysis is designed to keep lots of events in order to build up a large library of event classes that satisfy different selection criteria including that of a matched filter*

- Plans to use different signal processing techniques…

- Also we want to acquire more data to improve our understanding of hydrophone behaviour in e.g. different sea states and climate conditions



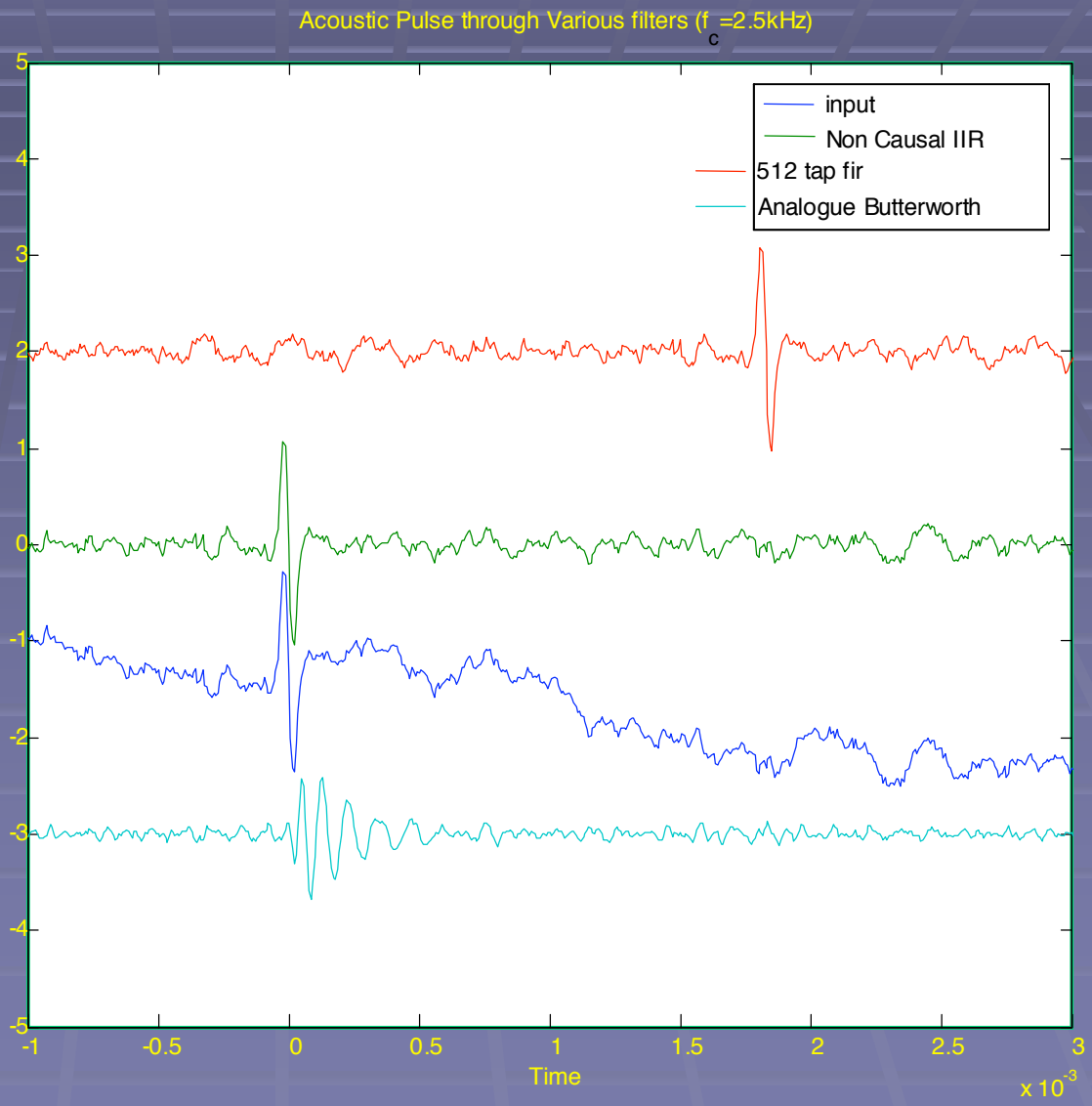
RONA Hydrophone Array -Plans

- Currently 8 wide-band hydrophones are available to be read out
- *December data run involved writing data to a disk (RAID) array which was subsequently shipped back to Sheffield*
- Decided this was inefficient and impractical
- *Over the summer a new Data Acquisition system will be installed based on an LT03 tape system with 6.4Tb of data capacity*
- Furthermore, we have discovered a freeware lossless audio compression utility that reduces our files to 0.46 of original size
- *Net result is ~60 days unattended capacity*
- Every 30 days a few tapes will be shipped
- *Continuous data-taking from 01/09*

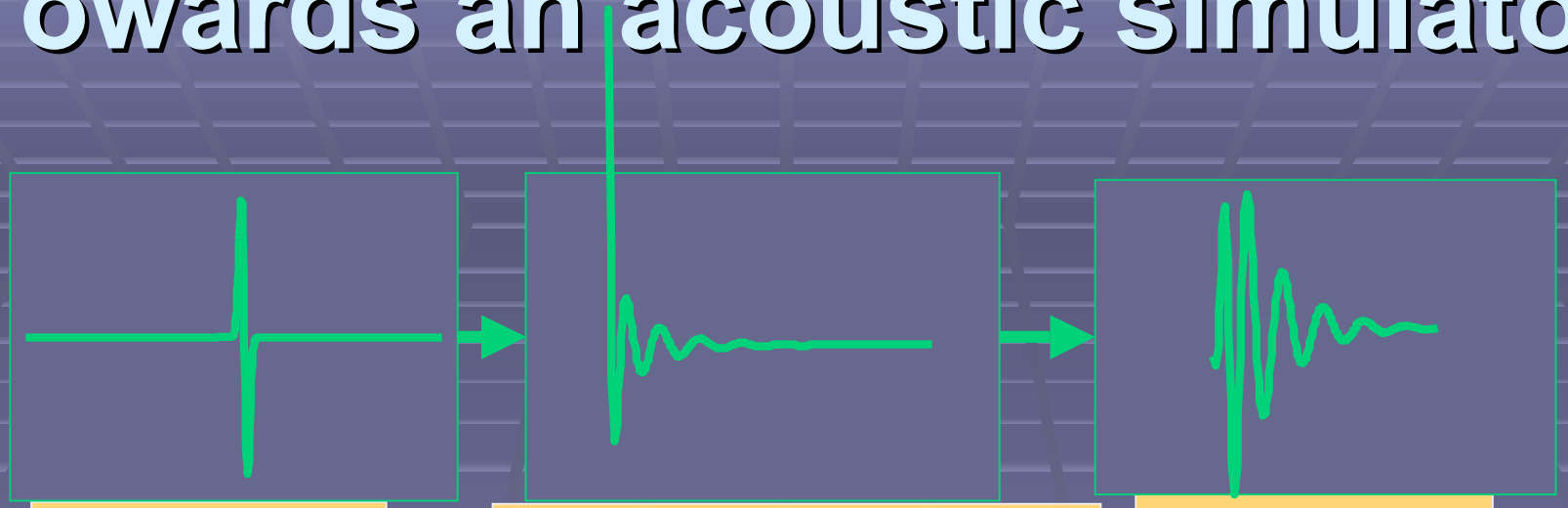
Importance of unfiltered data

Showing the response of various filters

- ***The 512 tap linear phase response filter gives a delay of half the filter length***
- ***The non causal filter has zero time delay (zero phase) Faster than FIR***
- ***The response of a 7.5kHz 100dB per octave Butterworth filter is shown for comparison***



Towards an acoustic simulator



s(t) Bipolar Acoustic Pulse

h(t) Impulse response of Hydrophone

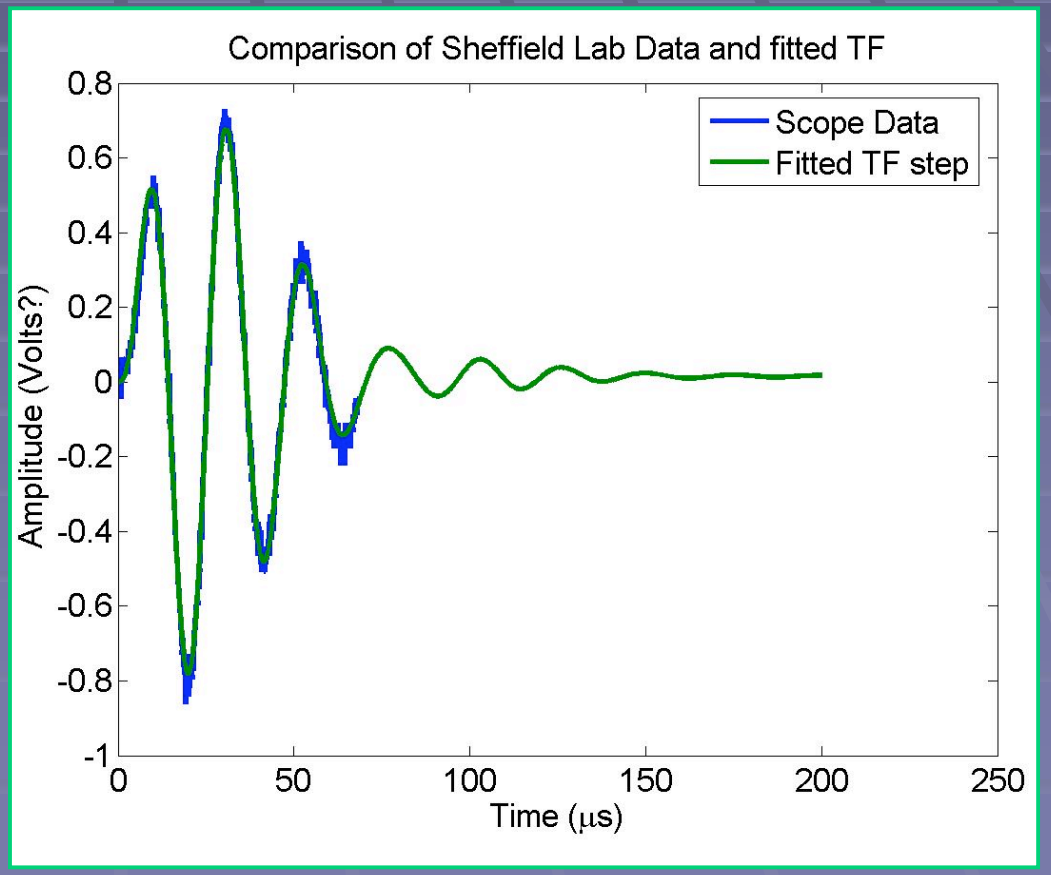
y(t) Electrical Pulse

- Can use this technique for transmit (reversed) and receive
- *Once 2 of s(t), h(t), y(t) are known the other can be calculated*
- Convolution in the time domain is equivalent to multiplication in the frequency domain
- *Deconvolution in the time domain is equivalent to division in the frequency domain*
- Simply use (Inverse) Fourier to transform between domains

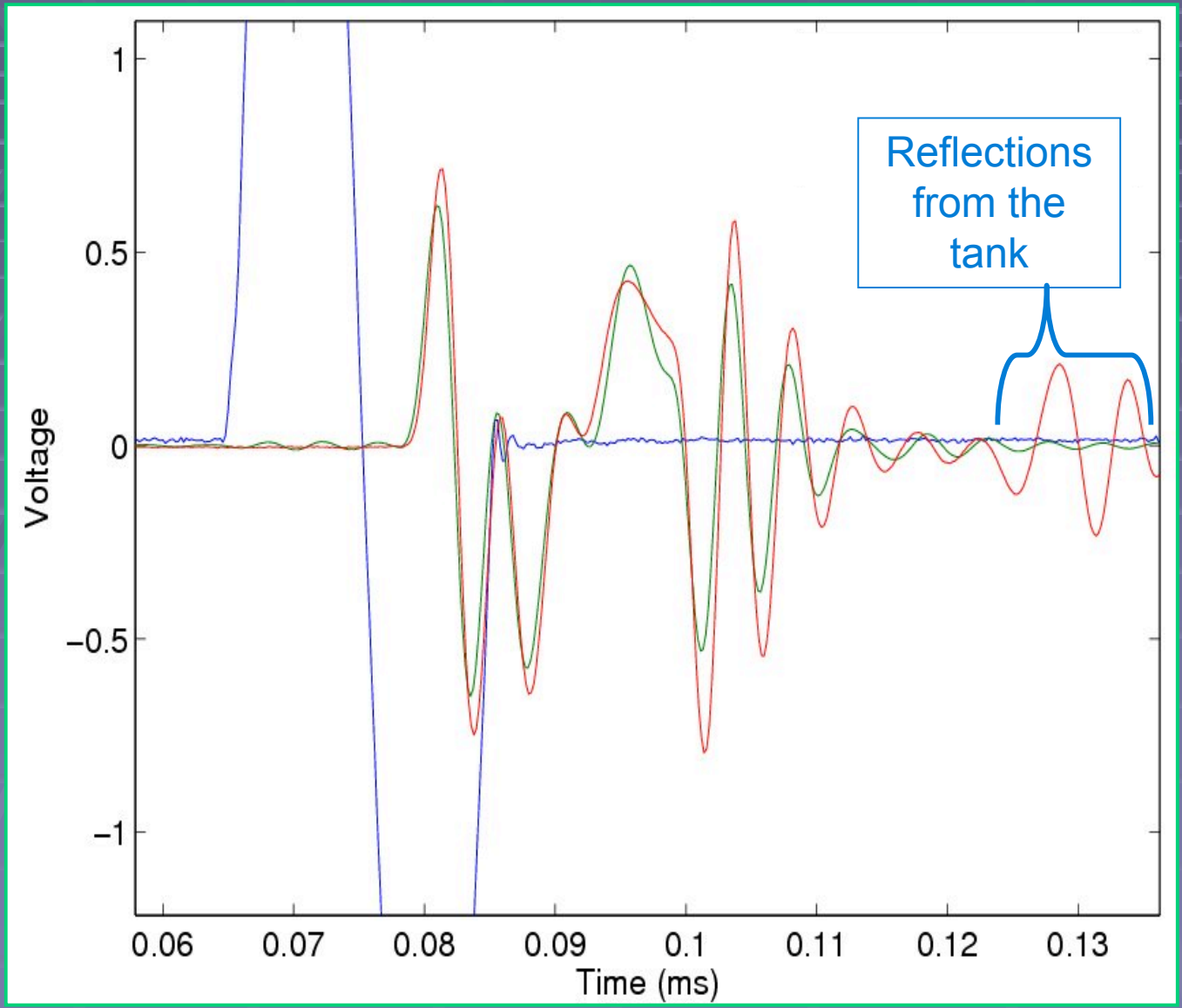
Towards an acoustic simulator

- We want to apply an electrical impulse to a hydrophone that will result in a bipolar pulse being created in a body of water
- Signal processing techniques allow us to first evaluate the hydrophone response, these steps are:

- *Apply a step function to the hydrophone and differentiate the observed output*
- The FT of this will be the frequency response of the system (including phase)
- *(Additional step of fitting a transfer function to the data using a 5th order LRC model)*
- Now take the hydrophone response and the desired output pulse and calculate the required electrical pulse needed

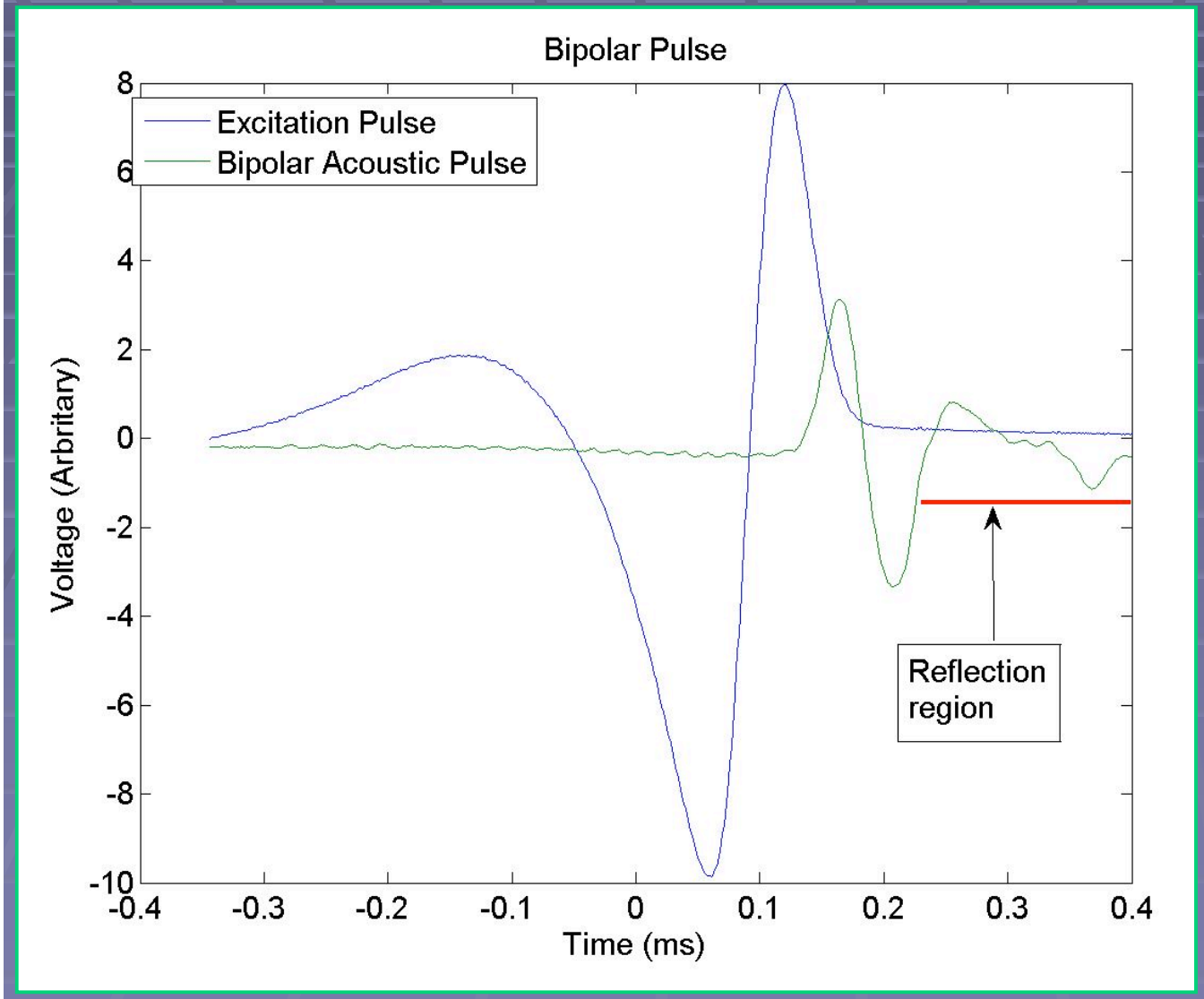


The technique in action



- Blue: single cycle 10kHz sine wave
- Green: predicted hydrophone response using 5th order LRC model
- Red: actual response measured in Sheffield "fish tank"

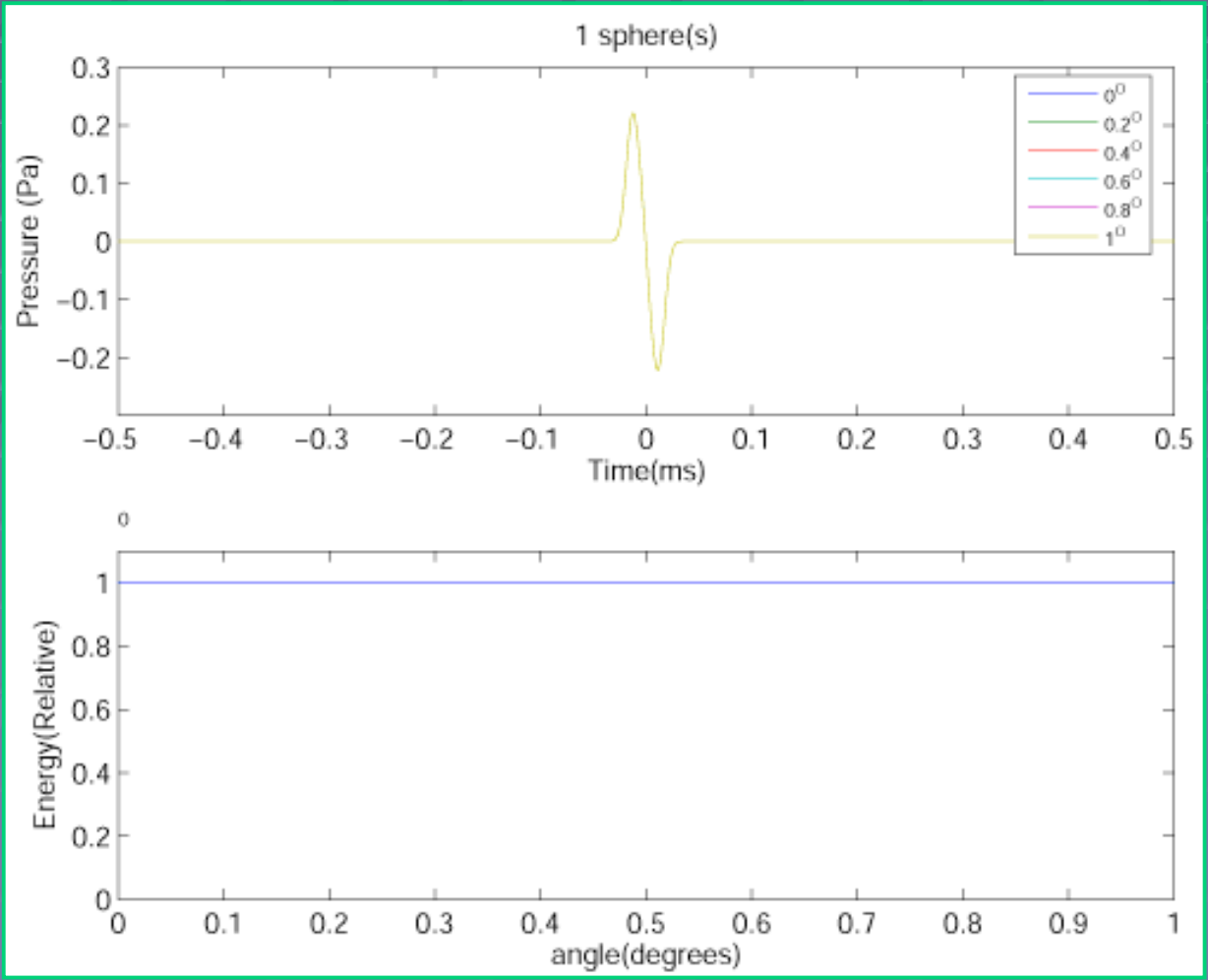
Creating a bipolar pulse



- Using the now known hydrophone response h(t) and the desired bipolar output y(t) the required electrical signal s(t) is derived
- Response of our hydrophone to s(t)

Creating a bipolar pancake

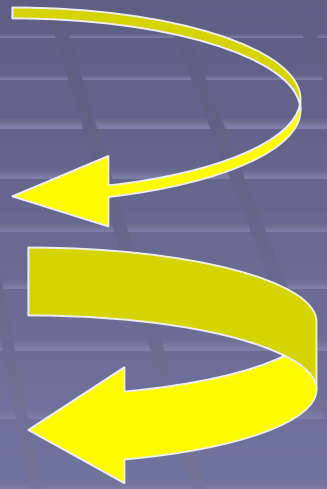
- How many individual bipolar sources do we need to generate a suitable pancake?



- 1.2×10^{20}eV pulse simulated
- *1km from source*
- N sources deployed over 10m with (10/N)m spacing
- *Study the angular profile as a function of the number of sources*
- Of order 6 to 10 hydrophones (minimum) are needed

Acoustic Simulator - Next Steps

- Increase power
- Test in increasingly larger water volumes
  - University swimming pool
  - Commercial shallow water site
  - Rona



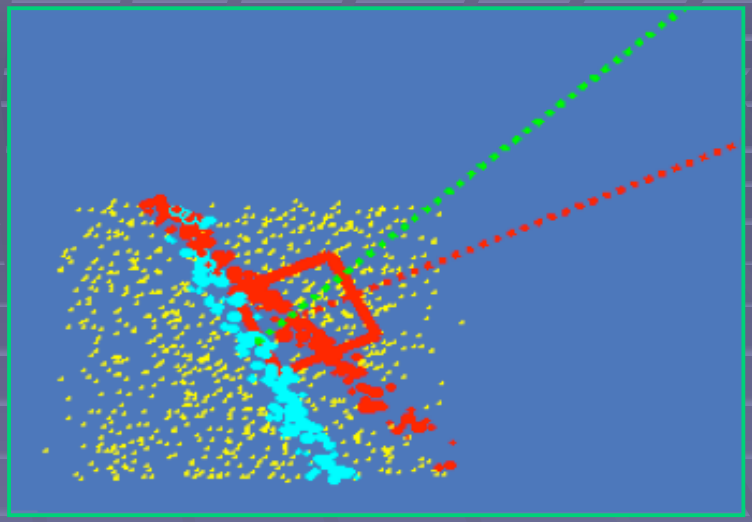
- Deployment at Rona could be in parallel with operation of a line array of hydrophones that we have procured from NATO

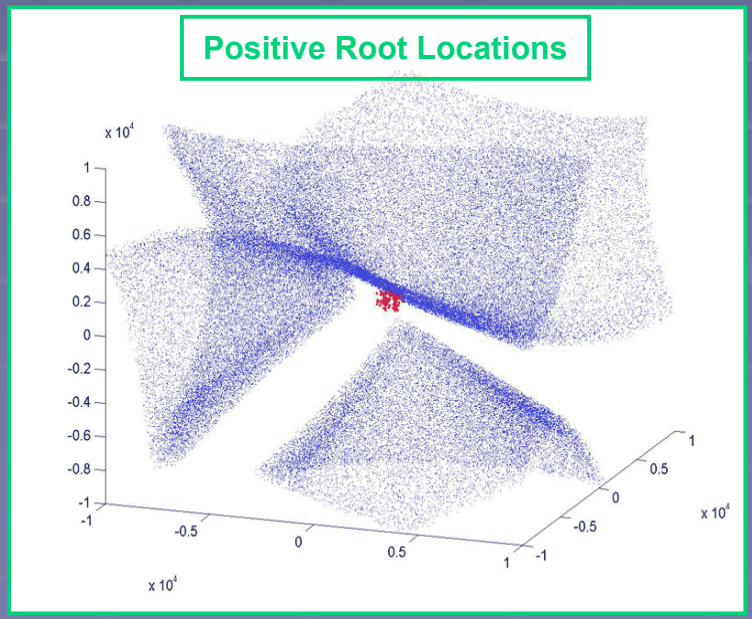
Summary

- The ACoRNE collaboration has made much progress in past year in areas of:
  - Simulating UHE neutrino events using CORSIKA
  - Inclusion of refraction into sensitivity/reconstruction code
  - Use of signal processing techniques in modelling hydrophones
  - Generation of bipolar acoustic signals for calibration purposes
  - Analysis of first data from Rona
- Future plans include
  - Continue broad R&D programme => large array
  - Move to continuous data-taking at Rona
  - Developing a full 3D simulation based on CORSIKA events
  - Evaluation of the pointing accuracy of large hydrophone arrays in the presence of refraction
  - Developing an acoustic (and possibly a laser-based) neutrino simulator
  - Deploying the simulator over the Rona array

Sensitivity and Reconstruction

- Refraction introduced (via ray tracing) to facilitate SVP studies
- First estimates of pointing accuracy for km^3-scale arrays
  - *Include refraction here*
- Investigated various reconstruction strategies
  - *Incorporation of refraction via look-up tables*
  - *Work on hydrophone location algorithm*





Towards a neutrino "simulator"