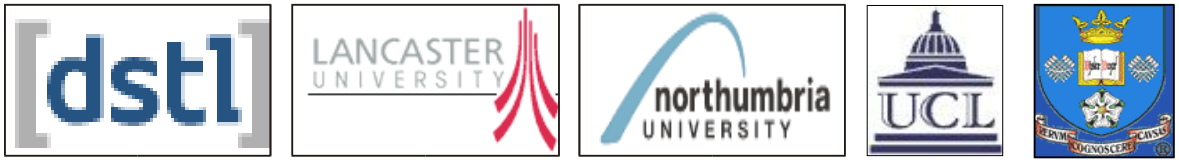


ACoRNE

STATUS OF SENSITIVITY PREDICTIONS

PPARC

Overview

- Summary of 2005 status
- Pointing
- Refraction and Reconstruction
- Input from CORSIKA
- Summary

simulation…

Summary of simulation 2005

ACoRVE

SENSITIVITY PREDICTIONS

- Simulation chain:
  - event generator (ANIS)
  - shower program (GEANT4)
  - integrate cascade energies for acoustic radiation
  - simulate signal propagation and detection
  - sensitivity calculation
- Extrapolate to Ultra High Energy
  - Use the fact that cascade energy density scales with energy of primary particle to extrapolate acoustic pulse formation to UHE ($E>10^{18}$GeV)

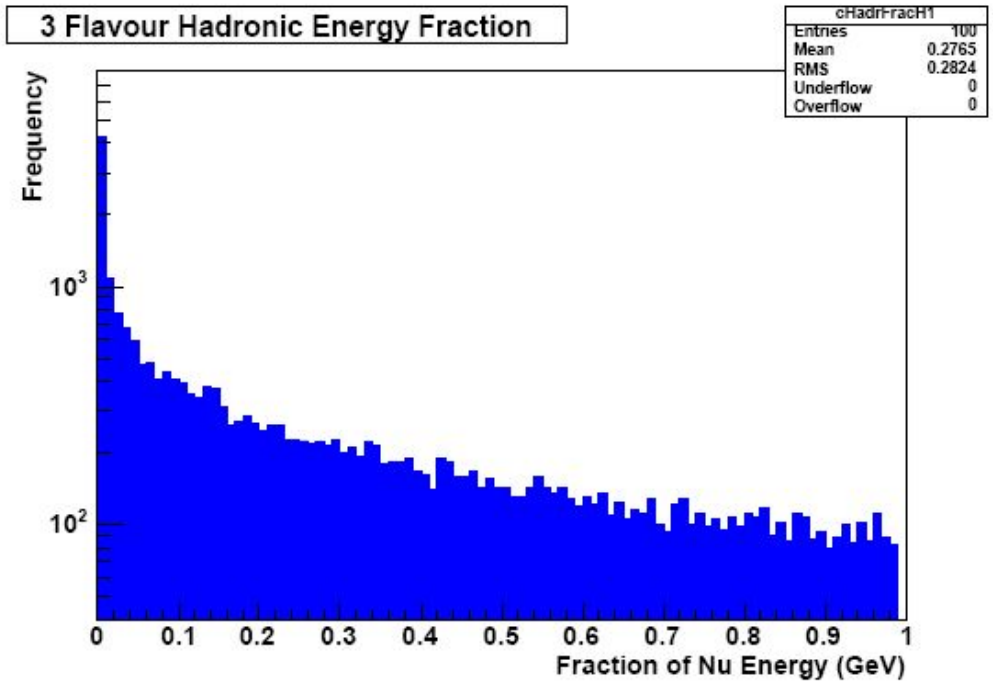
simulation…

The simulation chain...

ACoRNE

SENSITIVITY PREDICTIONS

- Simulation chain:
  - event generator (ANIS) – use to generate hadronic energy fraction (Bjorken y)



- **mean of ~27% of neutrino energy taken by hadron shower (10^{19}eV)**
- **sensitivity code uses constant 25% at all energies (will really be energy dependant – waiting for input from CORSIKA)**

NB/ mean ~25% but, big variations – can be 0% or 100% - large shower fluctuations (c.f. talk by Terry Sloan)

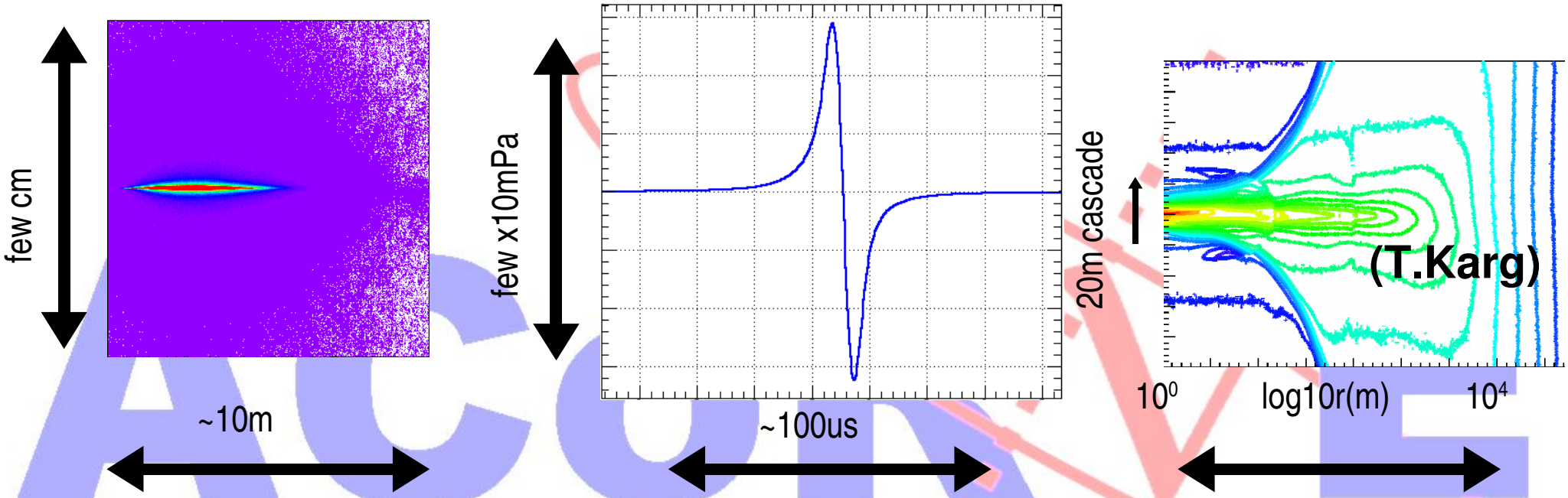
simulation...

The simulation chain...

ACoRNE

SENSITIVITY PREDICTIONS

- Simulation chain:
  - shower simulation up to 10^5GeV (Geant4)



- integrate quasi-instantaneous thermal energy deposition
- adds up to bipolar acoustic pulse
- coherent emission along cascade leads to formation of acoustic pancake
- for purposes of "detection" just interested in timing and magnitude of pulse

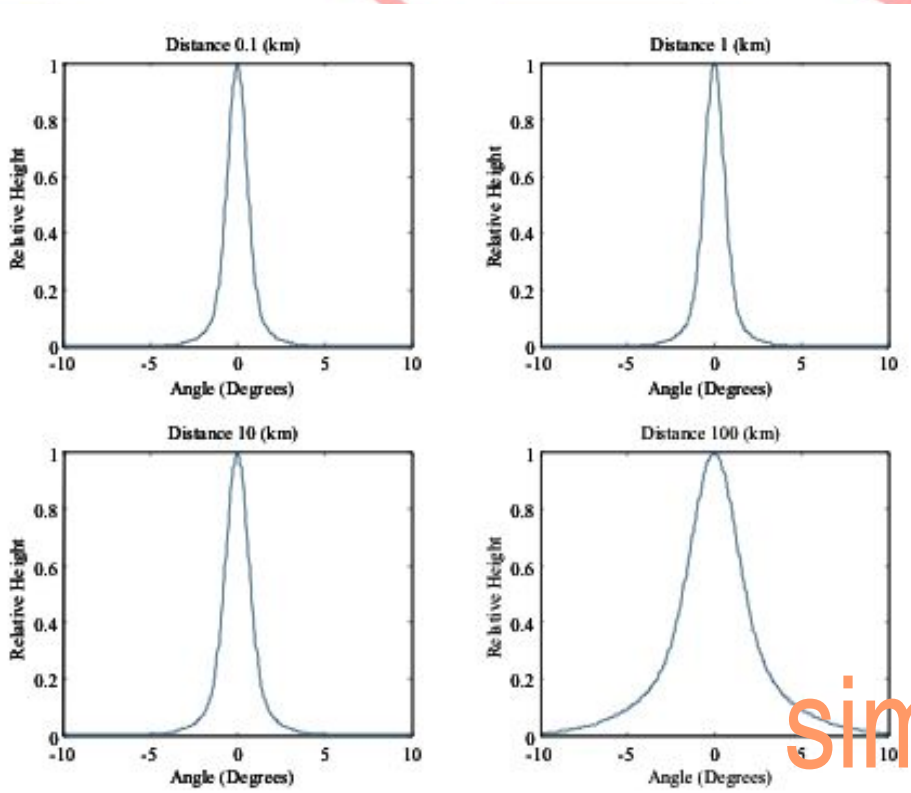
simulation...

The simulation chain...

ACoRVE

SENSITIVITY PREDICTIONS

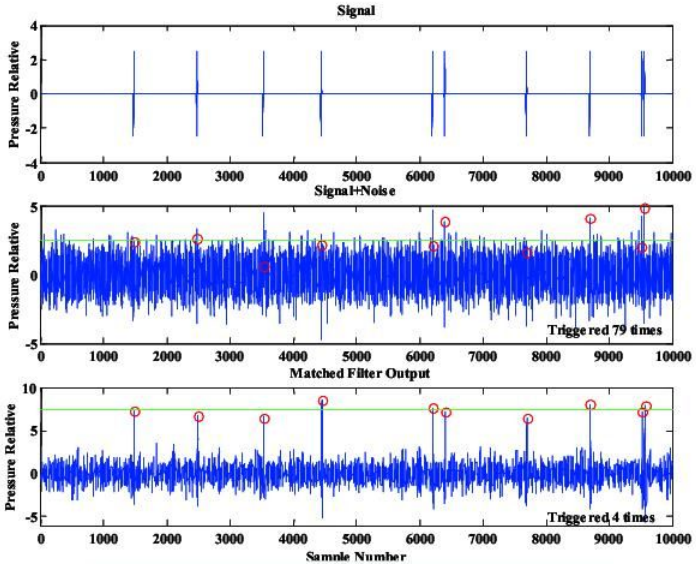
- Simulation chain:
  - propagation and detection of signal
    1. geometric (1/r) attenuation,
    2. angular spread using Fraunhofer diffraction theory (hydrophones more than 5 degrees out of the pancake plane are not considered – this does not cut hydros, it just speeds up computation)

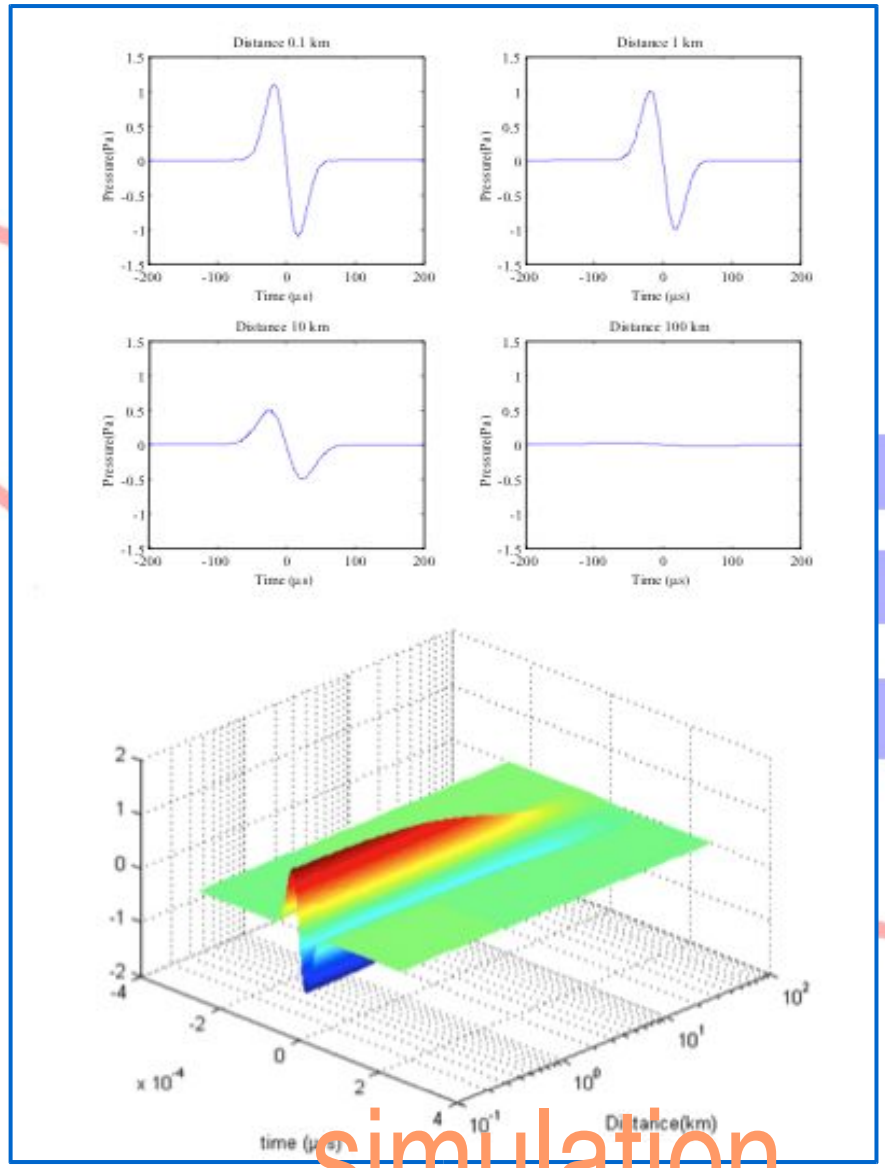


simulation...

The simulation chain...

- Simulation chain:
  - propagation and detection of signal
    3. attenuation due to the medium - again from studying the acoustic signal as a function of the distance from the source and the water properties. Coupled to matched filter output (see talk by S.Danaher)





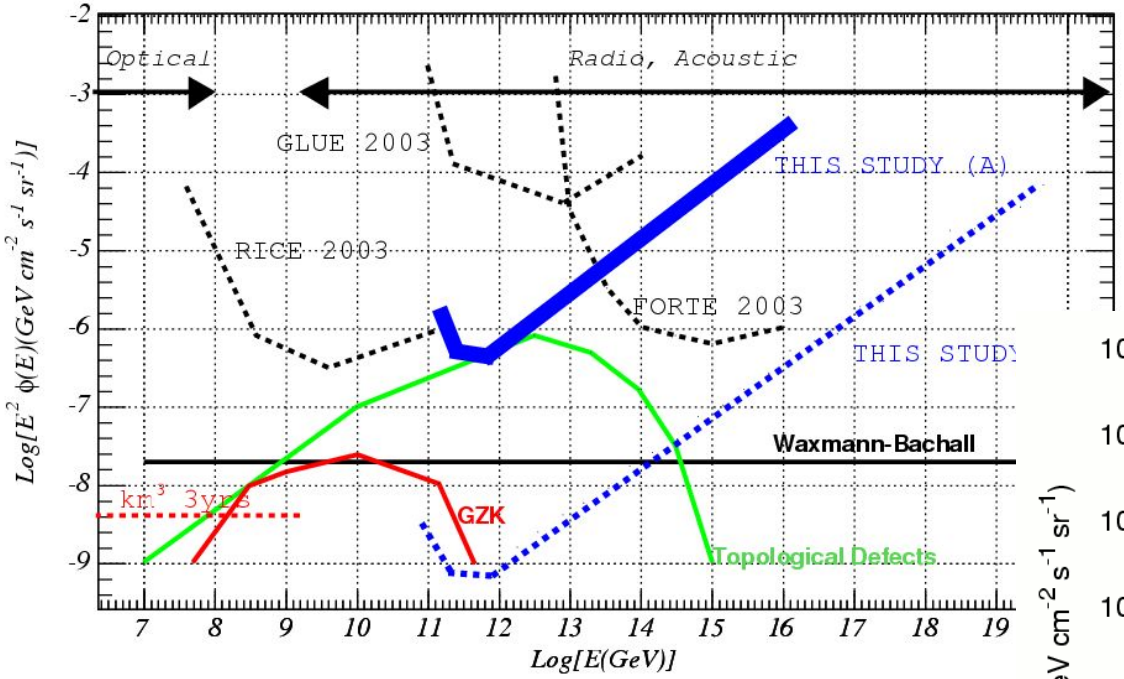
simulation...

Summary of results from 2005

ACoRNE

SENSITIVITY PREDICTIONS

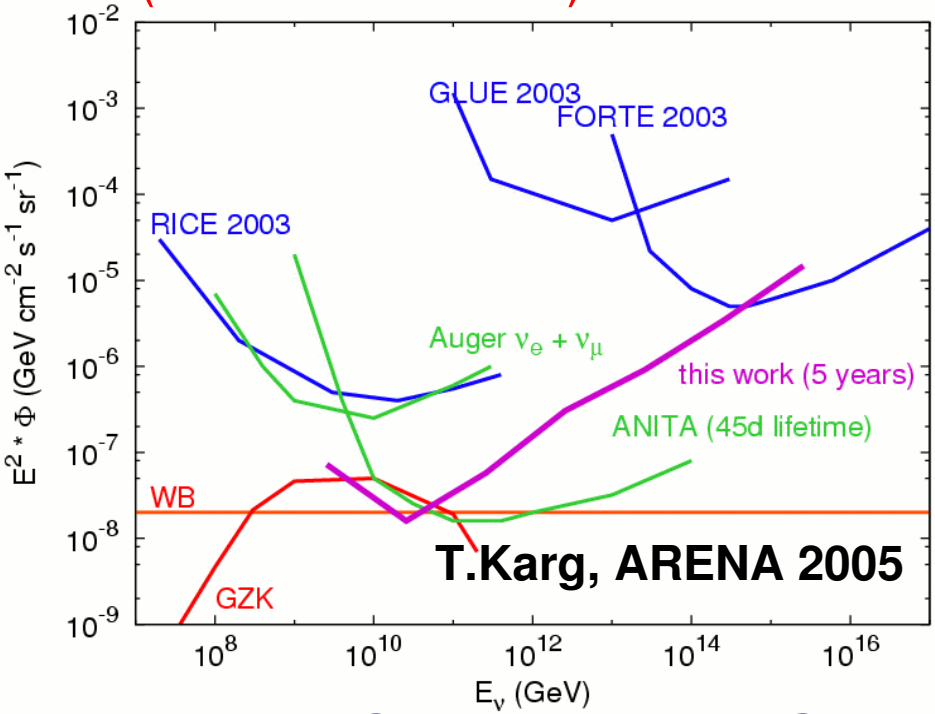
Acoustic technique can be sensitive to (proposed) GZK neutrinos



- 30x50x1km³ instrumented volume
- 200 AM per km³
- 5yrs operation
- 5mPa threshold

Think **BIG!**

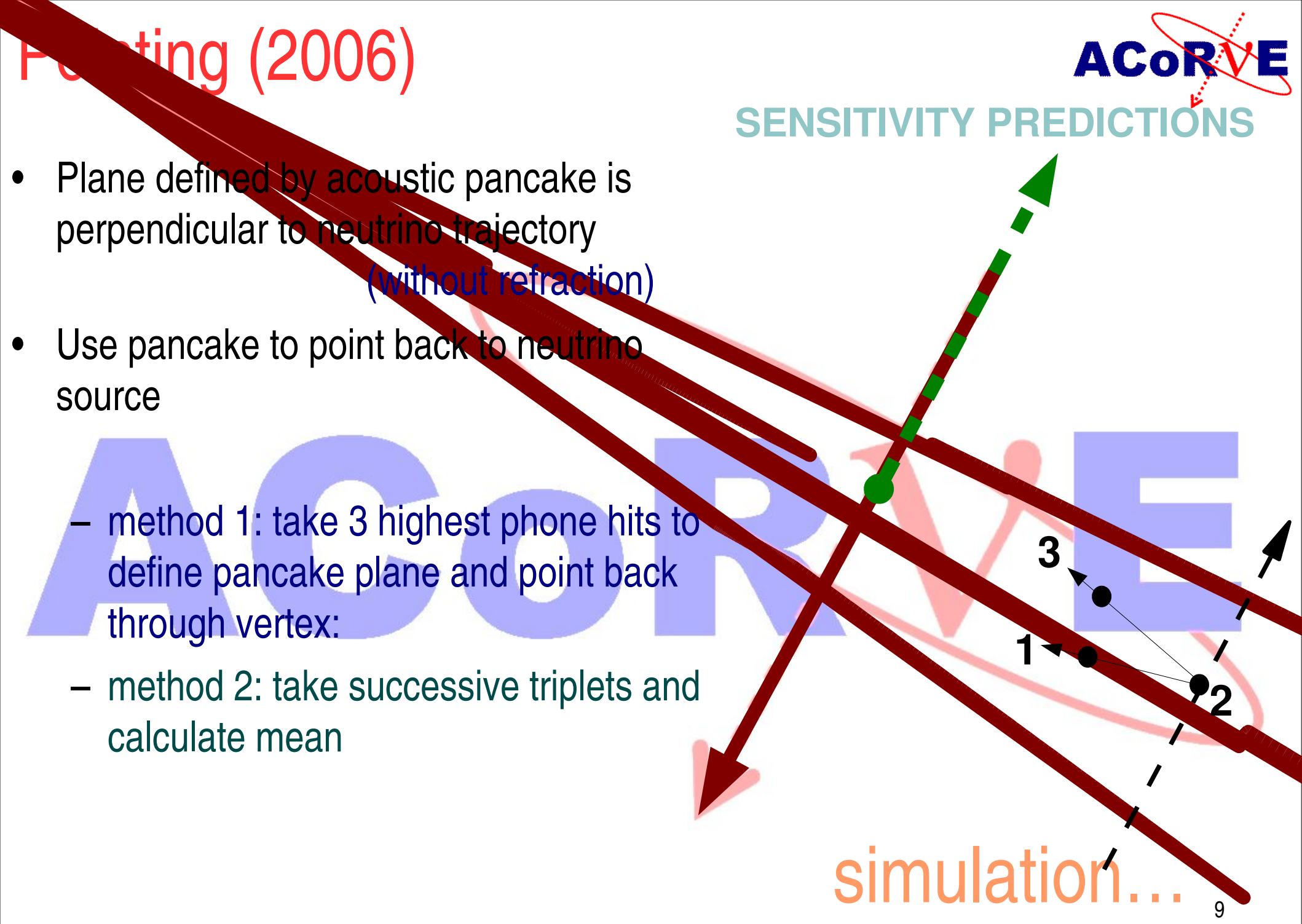
events are detected if they pass vertex reconstruction (no refraction here)



simulation…

Pointing (2006)

- Plane defined by acoustic pancake is perpendicular to neutrino trajectory (without refraction)
- Use pancake to point back to neutrino source
  - method 1: take 3 highest phone hits to define pancake plane and point back through vertex:
  - method 2: take successive triplets and calculate mean



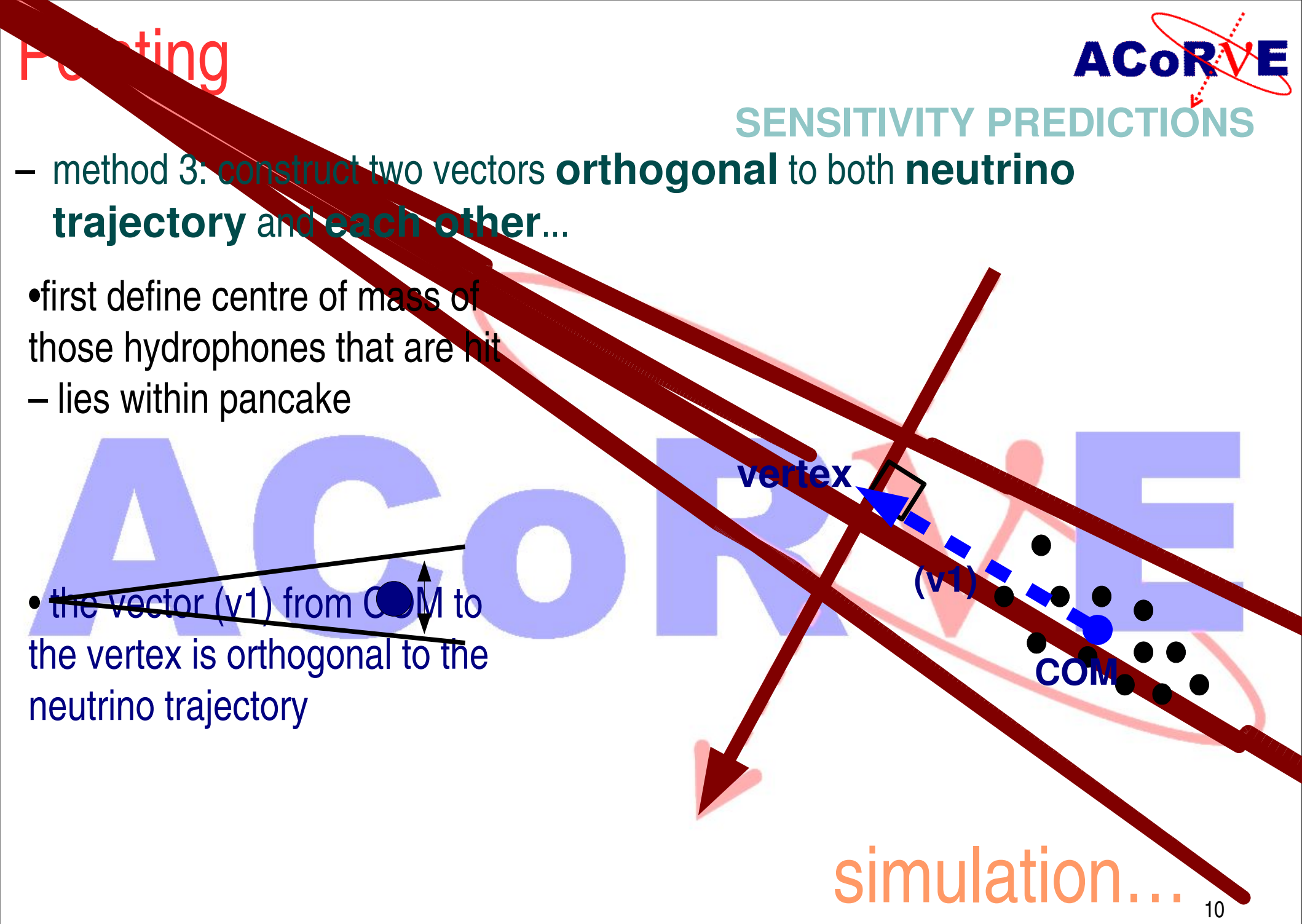
simulation...

Pointing

– method 3: construct two vectors **orthogonal** to both **neutrino trajectory** and **each other**...

•first define centre of mass of those hydrophones that are hit
– lies within pancake

• the vector (v1) from COM to the vertex is orthogonal to the neutrino trajectory



simulation...

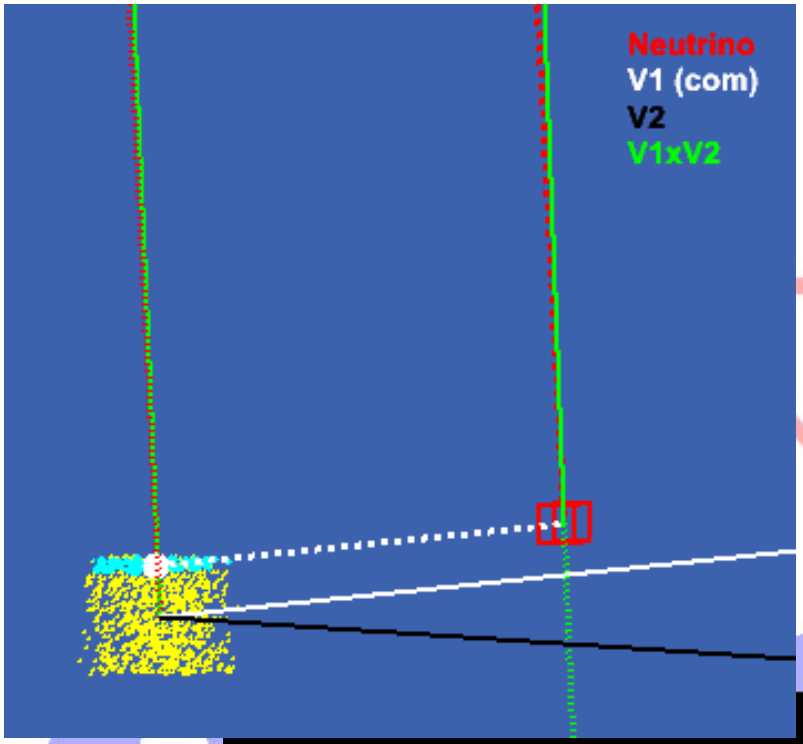
Pointing

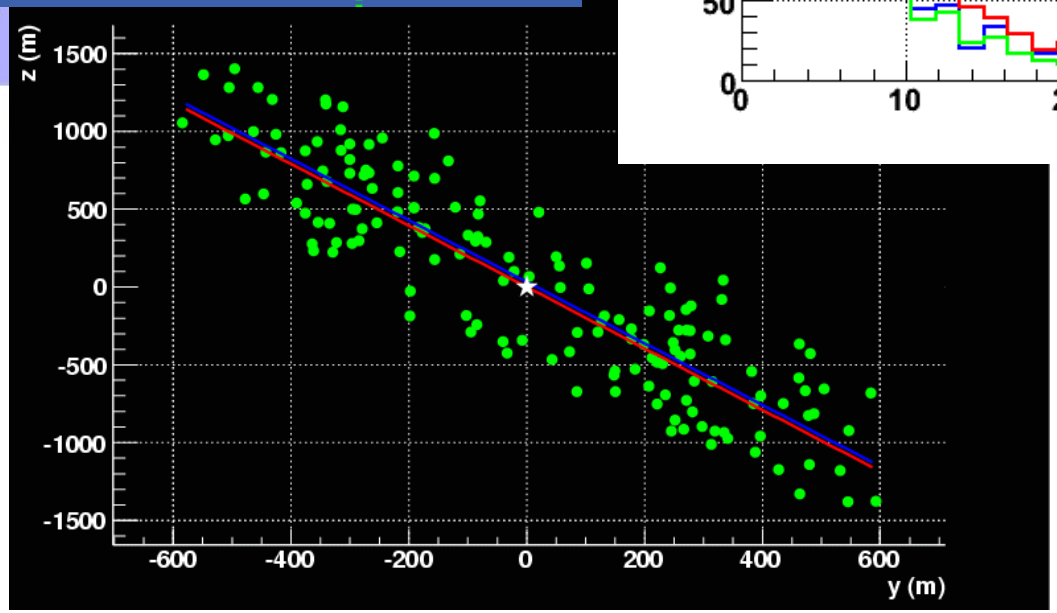
- method 3: construct two vectors **orthogonal** to both **neutrino trajectory** and **each other**...
  - next, translate the system so the origin is at the COM and rotate system such that vector v1 is aligned with the x-axis
  - now, collapse the system into 2D by discarding x-coordinates and find the COM in the collapsed y-z plane
  - define a vector v2 from the origin through the collapsed COM – this is both orthogonal to v1 and the neutrino trajectory
  - finally back rotate v2 around z and y then **v1 x v2 = pointing**

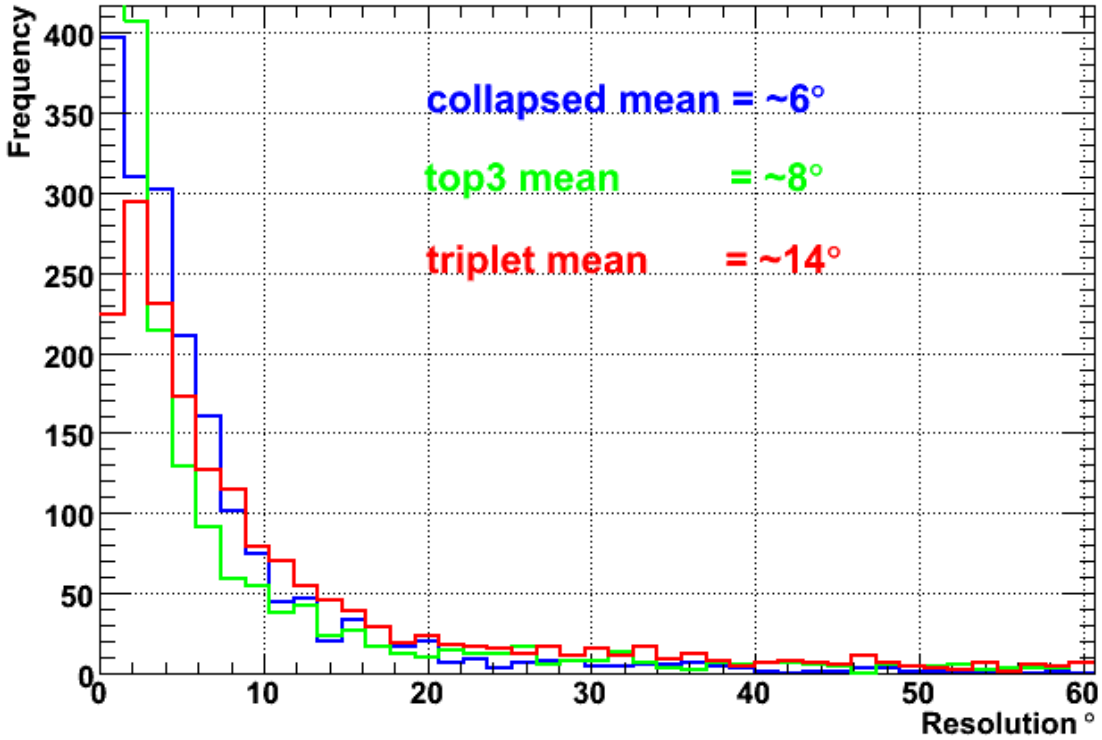
simulation...

Pointing

SENSITIVITY PREDICTIONS



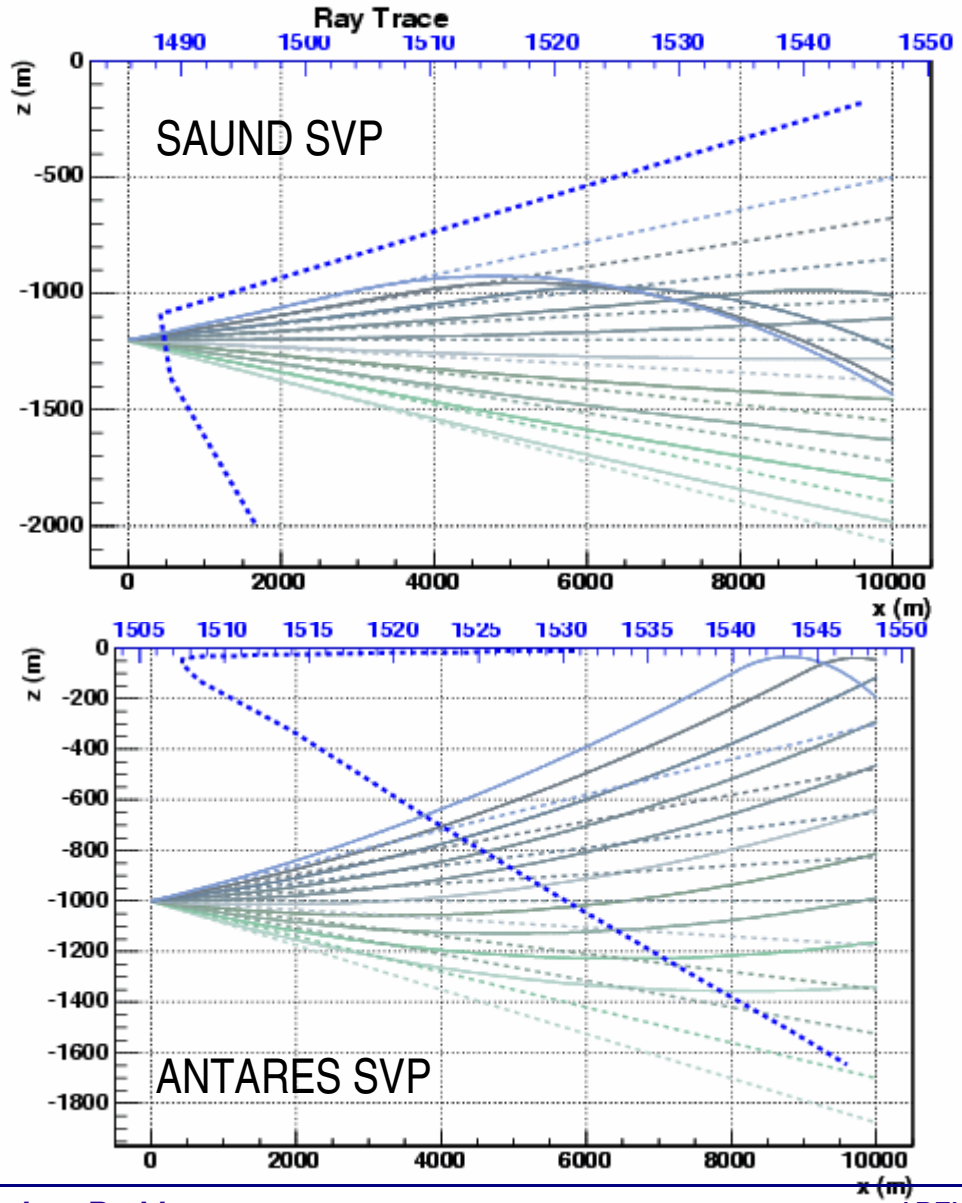


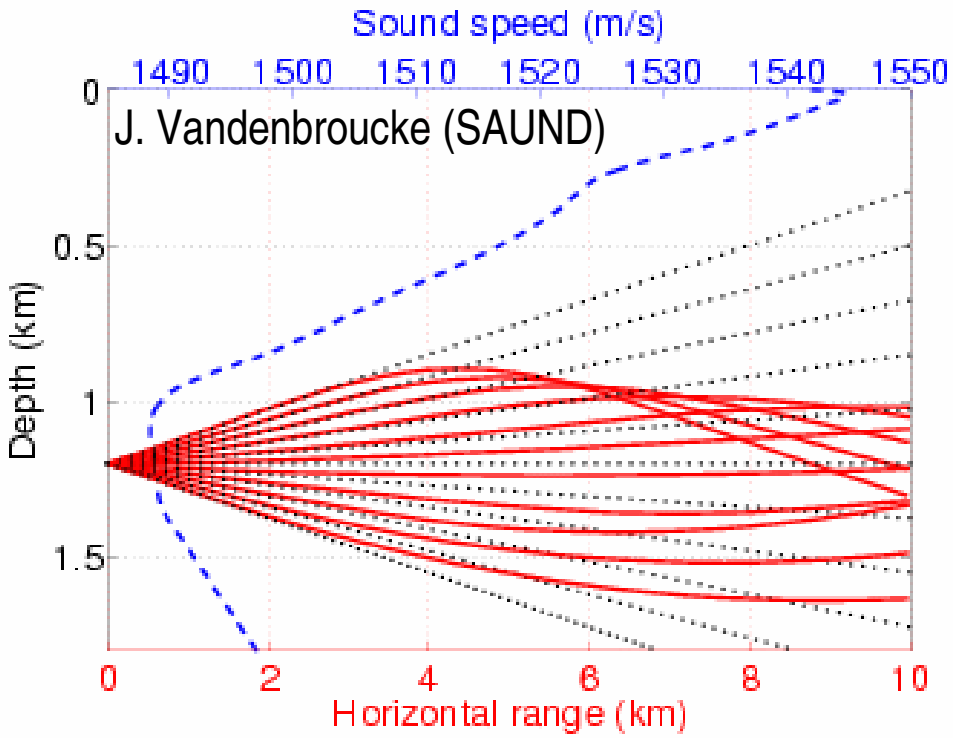


simulation…

Refraction

- Can use ray tracing to simulate refraction:

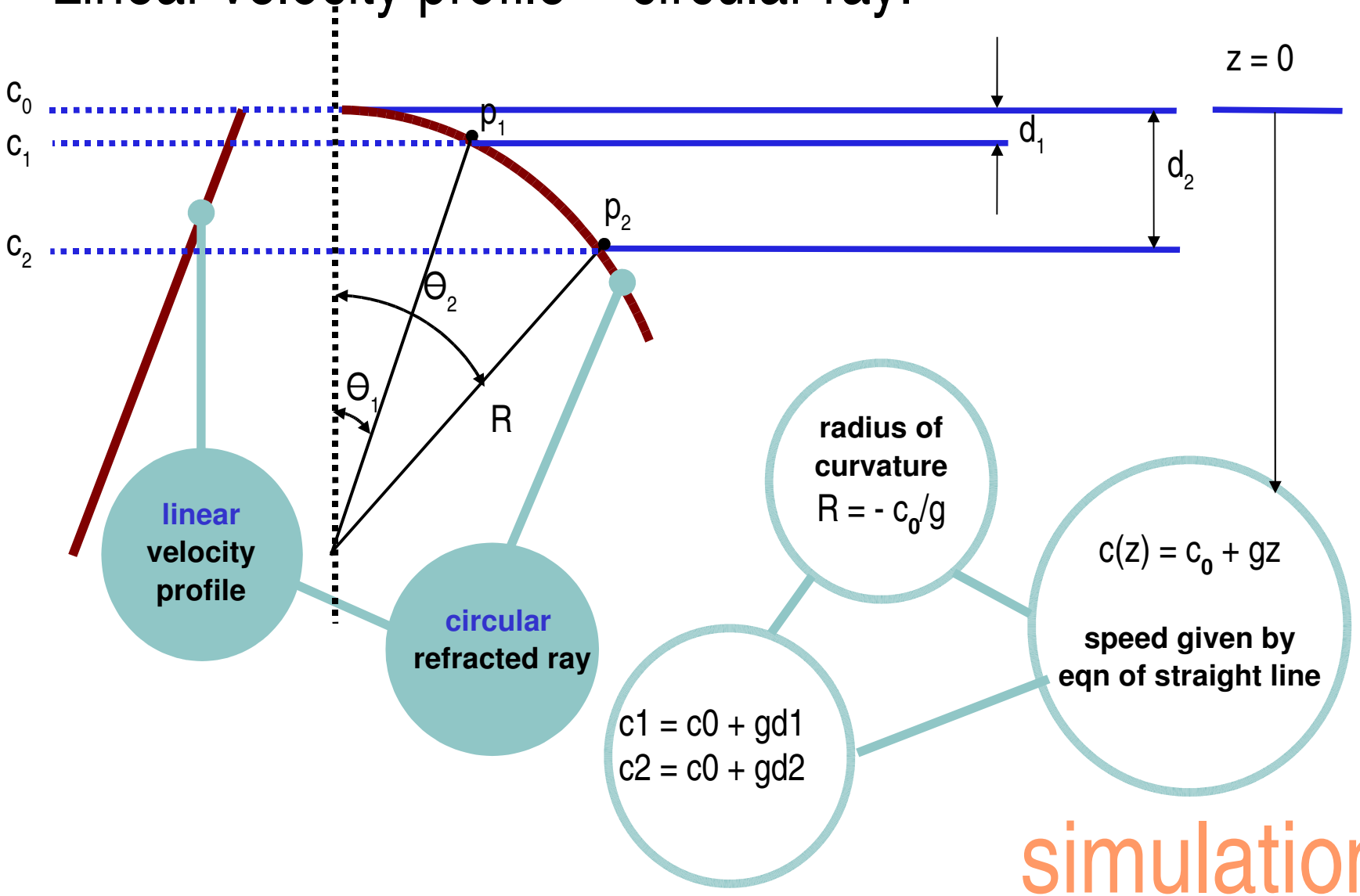




simulation…

Refraction

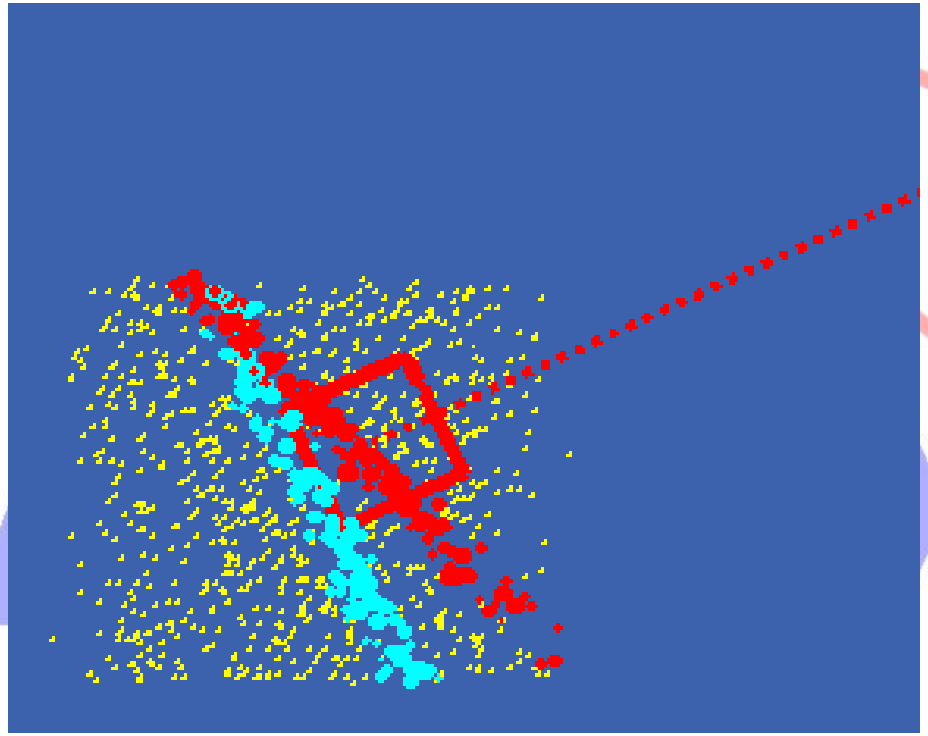
- Linear velocity profile = circular ray:



simulation…

Refraction

- Refraction warps (deforms) the acoustic pancake:



Preliminary!

blue = unwarped pancake
red = warped pancake

show simulation here...

simulation...

Reconstruction

- Refraction warps the acoustic pancake
- No analytical solution to reconstruct vertex location from signal arrival times
- Use precomputed look up tables
  - calculate hit times for a 3D lattice within fiducial volume
- and, off lattice interpolation to find vertex (c.f. RICE)
  - generate sub-lattice of 4^3 points per ½ lattice spacing surrounding best lattice point, find next best point
  - repeat until desired accuracy reached

simulation…

Reconstruction

- reconstruction accuracy in principle then limited by CPU time
  - how ever this doesn't include real uncertainties in hydrophone locations and timing errors
  - also, relies on good knowledge of **SVP** (here we use linear gradient)
  - so far this has been implemented for point sources of sound, have yet to integrate with formation of pancake (will increase CPU time, currently ~10s per event)
  - now pointing reconstruction doesn't work!

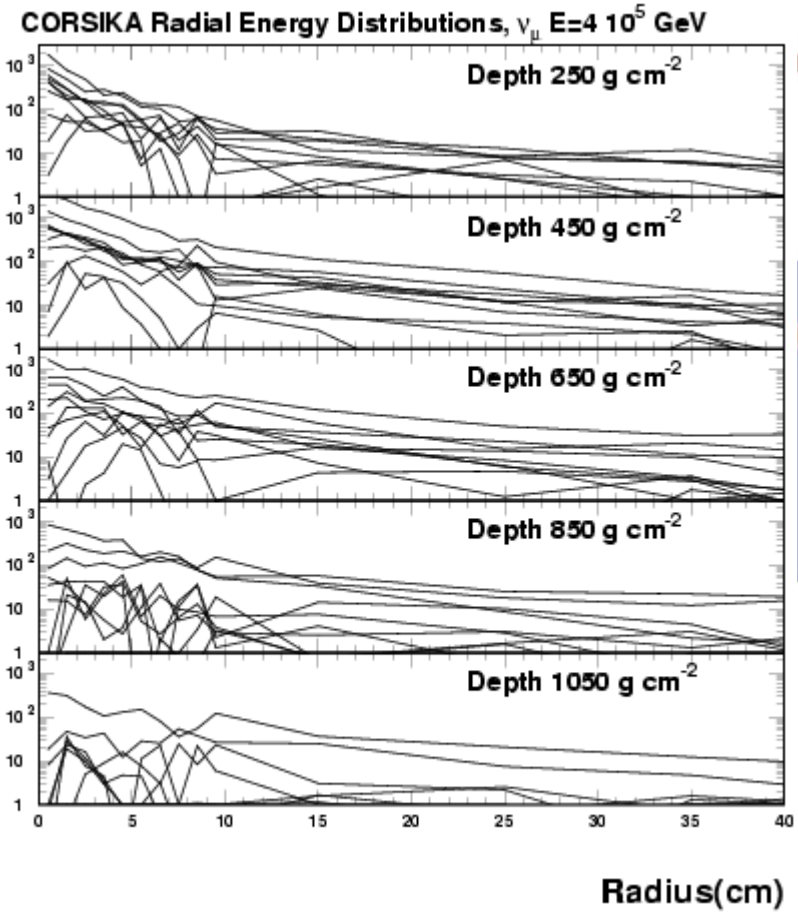
Reconstruction

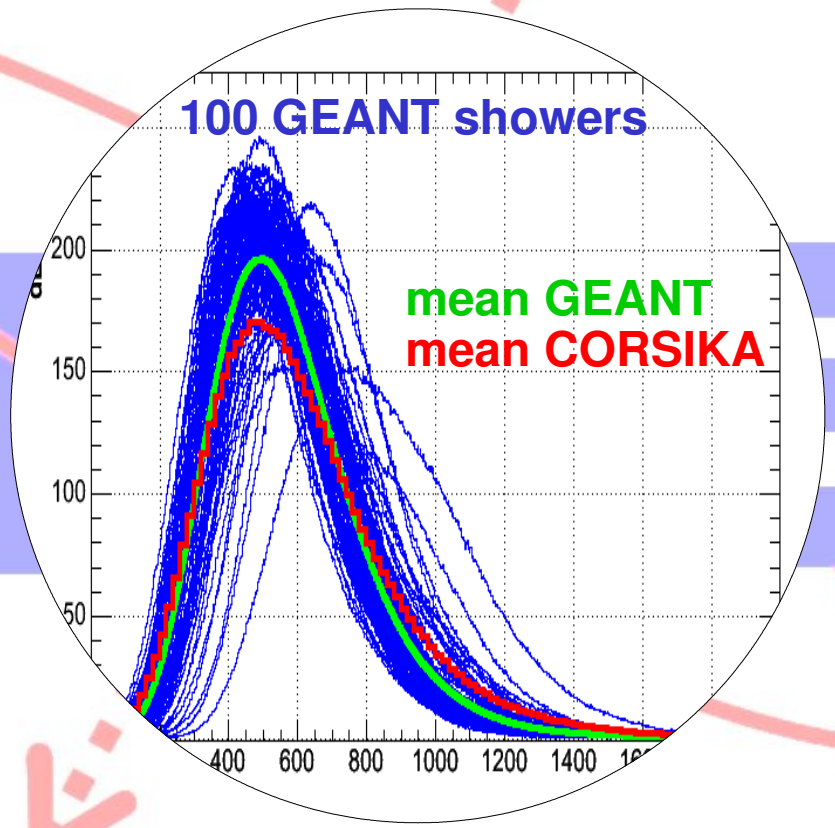
- vertex reconstruction – what next?
  - new RONA data will provide input to hydrophone timing and position uncertainties and threshold levels
  - with ray tracing we can now ask the question of how well we need to know the SVP in order to successfully reconstruct events – this will effect sensitivity

simulation…

CORSIKA

- T. Sloan has shown, you can use CORSIKA to produce neutrino induced showers in water:





simulation…

CORSIKA

- T. Sloan has shown, you can use CORSIKA to produce neutrino induced showers in water
- Awaiting Herwig interface or "plan B" then:
  - No radial or longitudinal parameterisations
  - LPM effect included
  - jet multiplicities
  - shower fluctuations
- Use signal processing (SVD) to quickly reproduce CORSIKA data

simulation…

Summary 2006

- **In 2005 we learnt the acoustic technique can be sensitive to (proposed) GZK neutrinos but refraction was not included**
- Unrefracted pancakes facilitate pointing reconstruction ~6°
  - now need to develop pointing in presence of refraction
- Use ray tracing to simulate the warping of the acoustic pancake
  - can begin to investigate effects of knowledge of SVP
- Developed look up table and interpolation algorithms to reconstruct point sources in presence of refraction
  - must now extend to include the pancake
- CORSIKA is almost ready to provide input to simulation
  - extrapolated energy densities can be discarded and the effect of shower fluctuations can be investigated

simulation…