Testing Radio Detection of Neutrinos with IceCube

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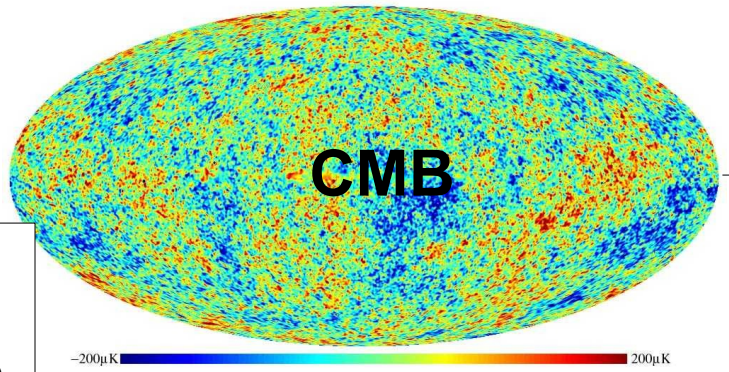
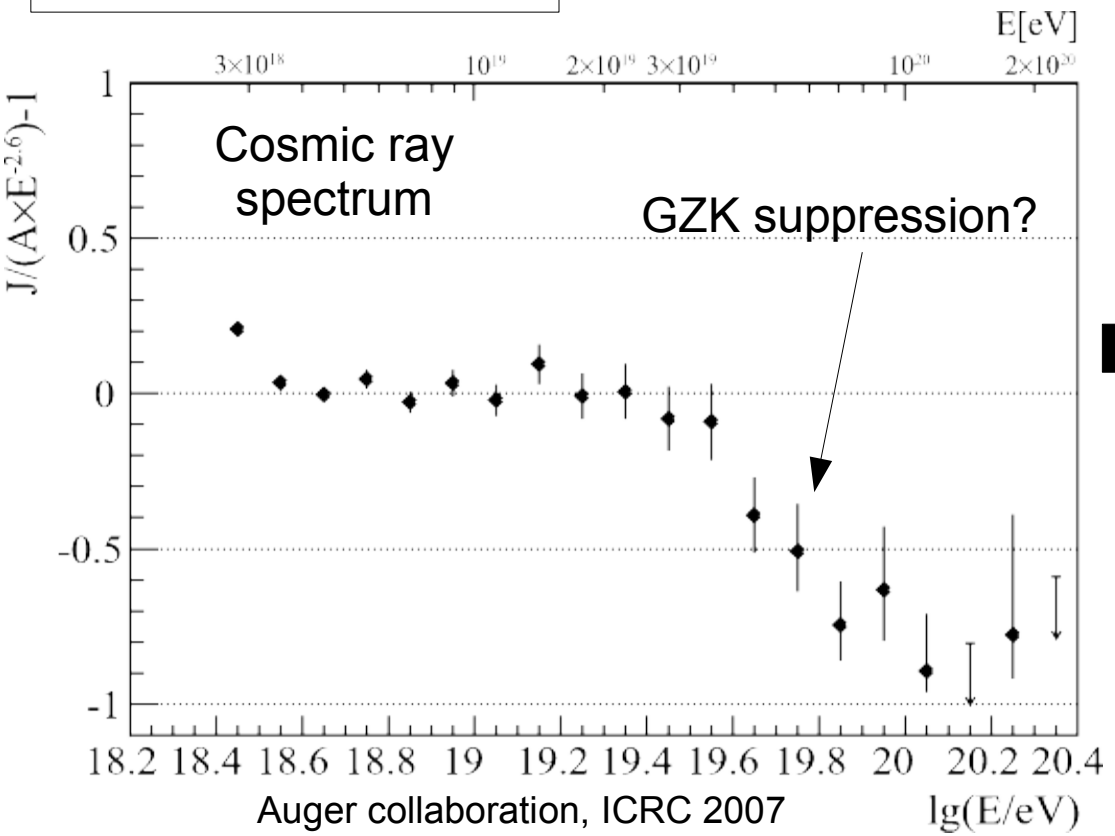
GZK Neutrinos

p → CMB → ν



Cosmic ray protons above $10^{19.5}$ eV interact within 50 Mpc



Auger collaboration, ICRC 2007

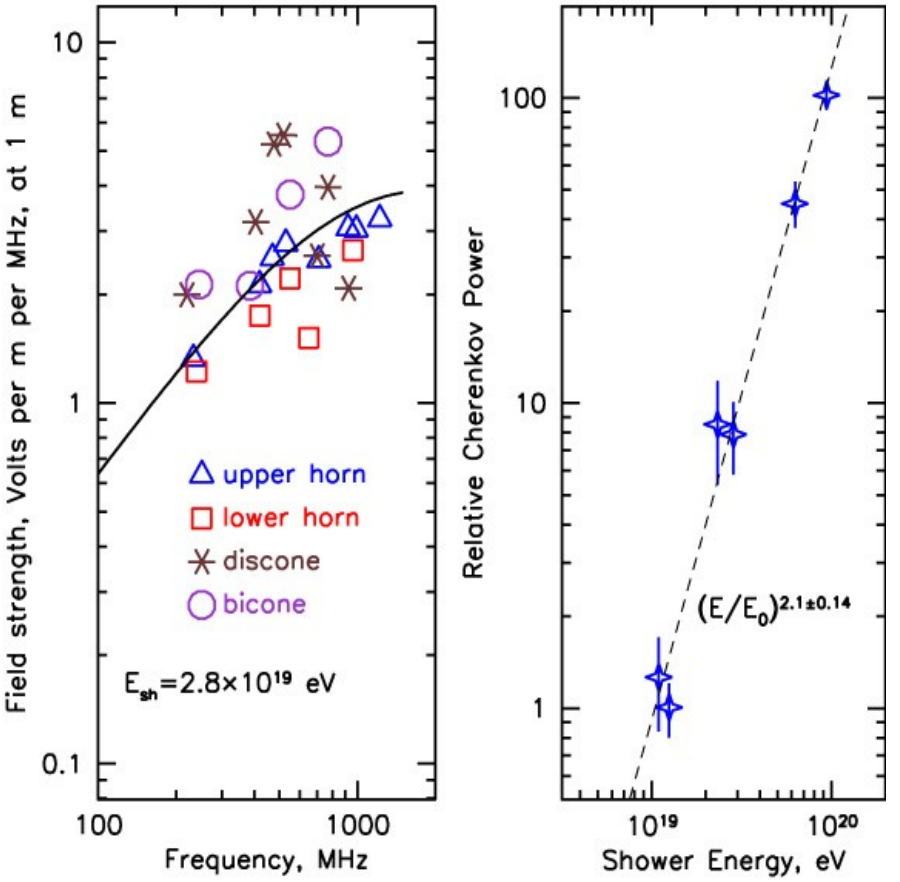
"Guaranteed" flux of neutrinos

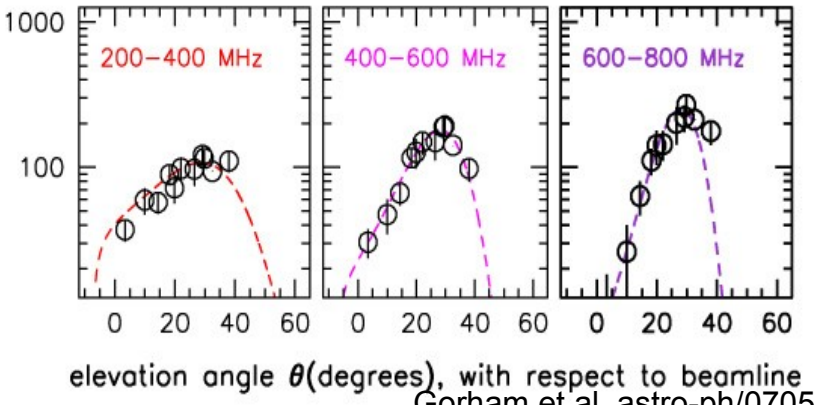
However, fewer than 1/km^3/yr

Optical detectors ~ 1km^3, not big enough

Radio Detection

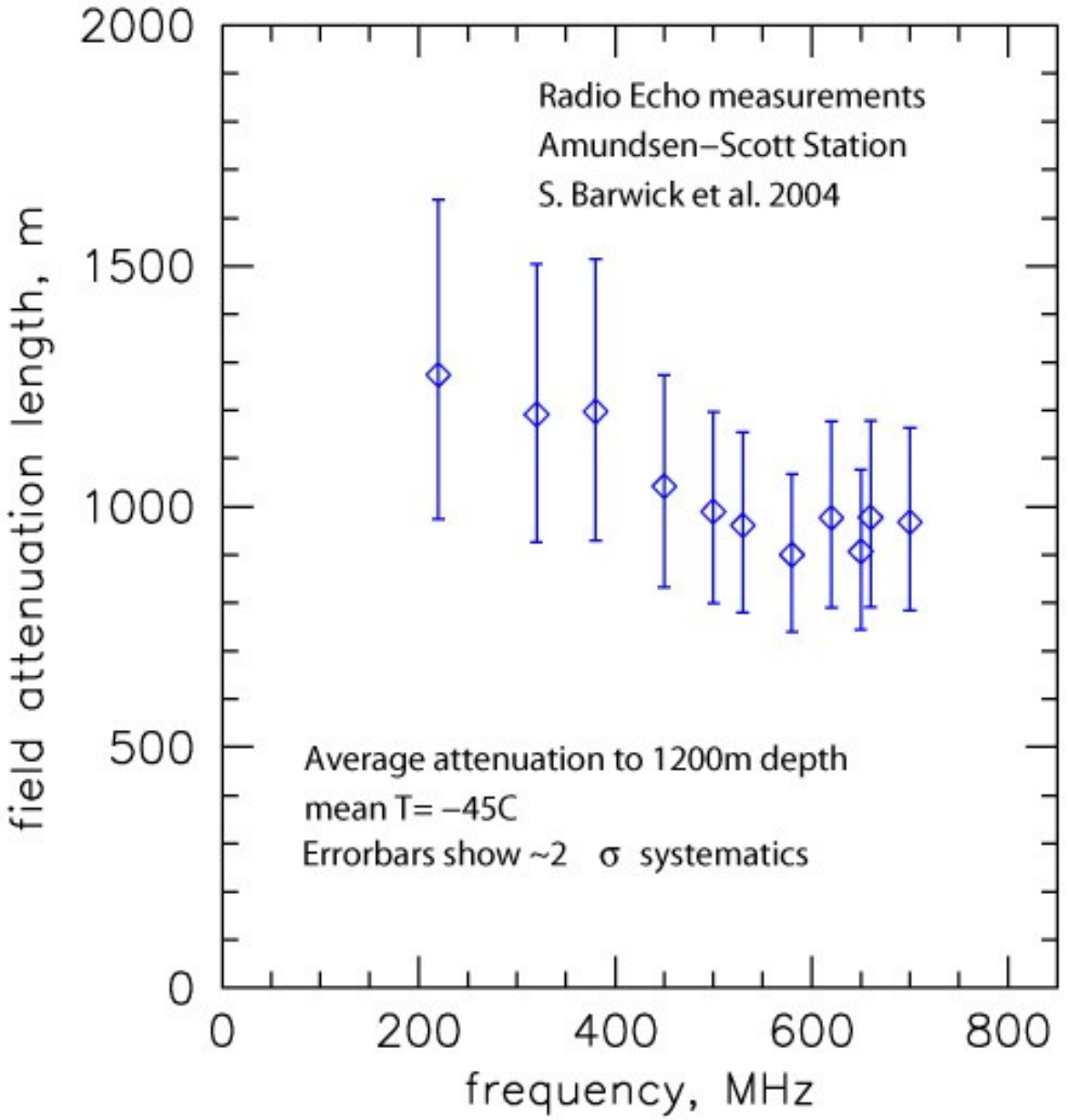
- G. Askar'yan, 1962
  - Neutrino interacts in solid dielectric
    - Ice, sand, salt
  - Shower develops negative charge excess
  - Charge excess => Cherenkov radiation
  - Coherent at wavelengths longer than shower bunch size
    - Frequencies up to ~ 1 GHz in ice
  - Properties of Askar'yan effect confirmed in beamtests at SLAC





Gorham et al, astro-ph/0705.2589

South Pole Ice

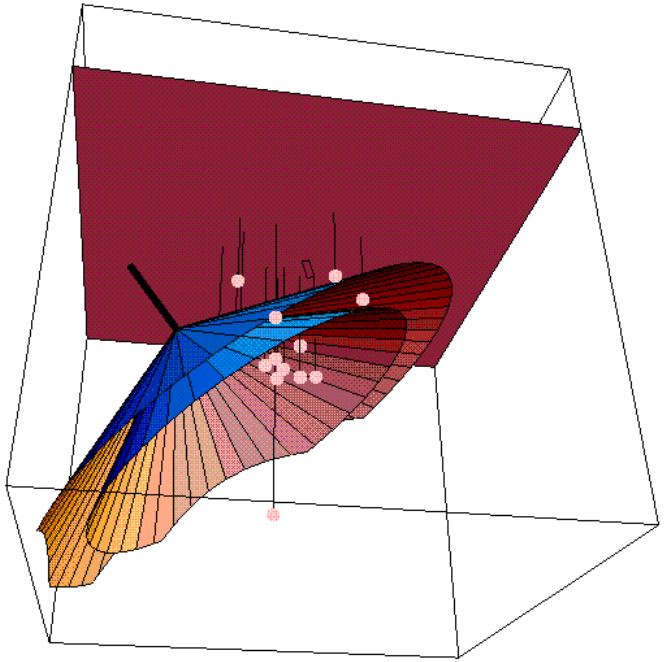


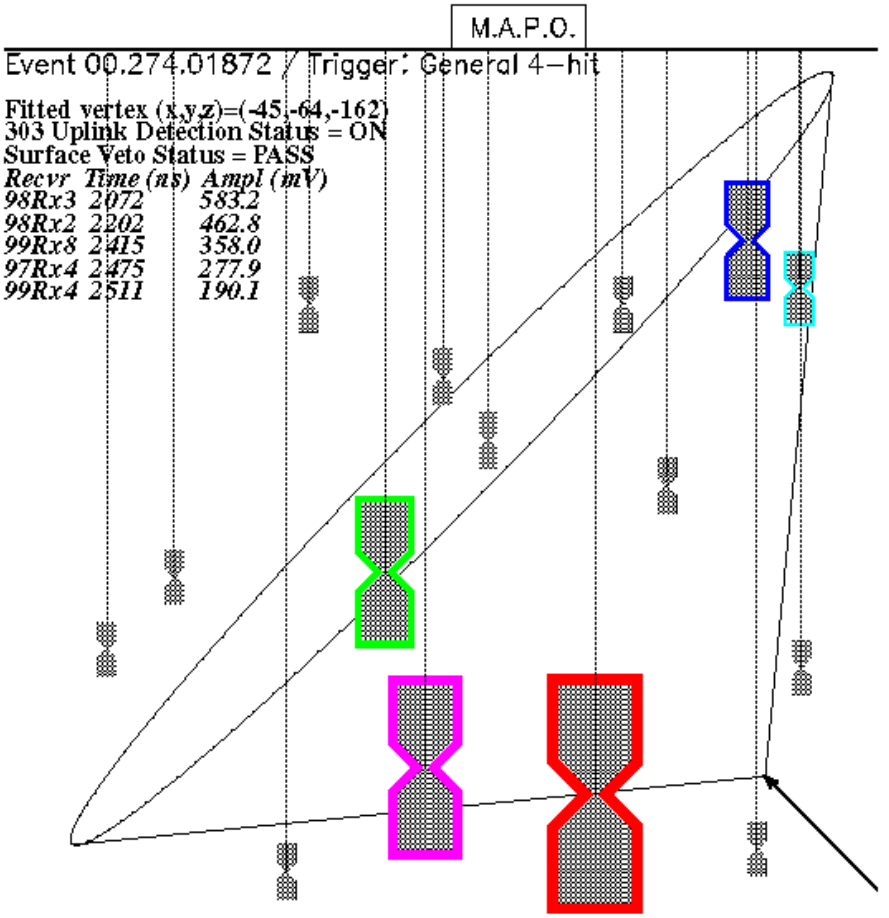
Attenuation length ≥ 1 km from 200 to 700 MHz

Deployment of AMANDA and IceCube offers unique opportunity for radio and optical methods to occupy the same space (and also acoustic!)

Test radio detector elements without incurring additional drilling costs

RICE
Radio Ice Cherenkov Experiment

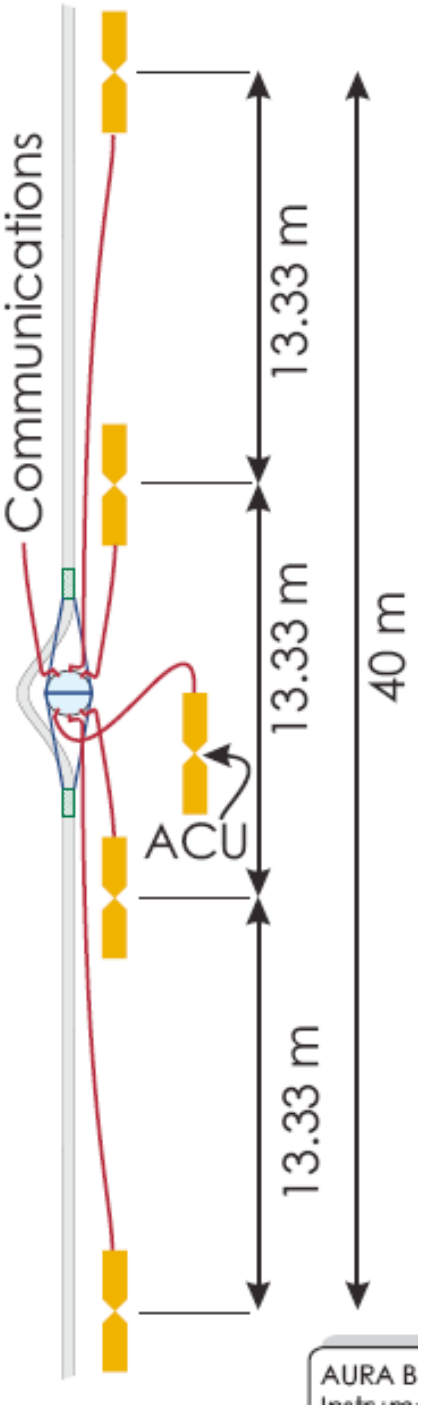




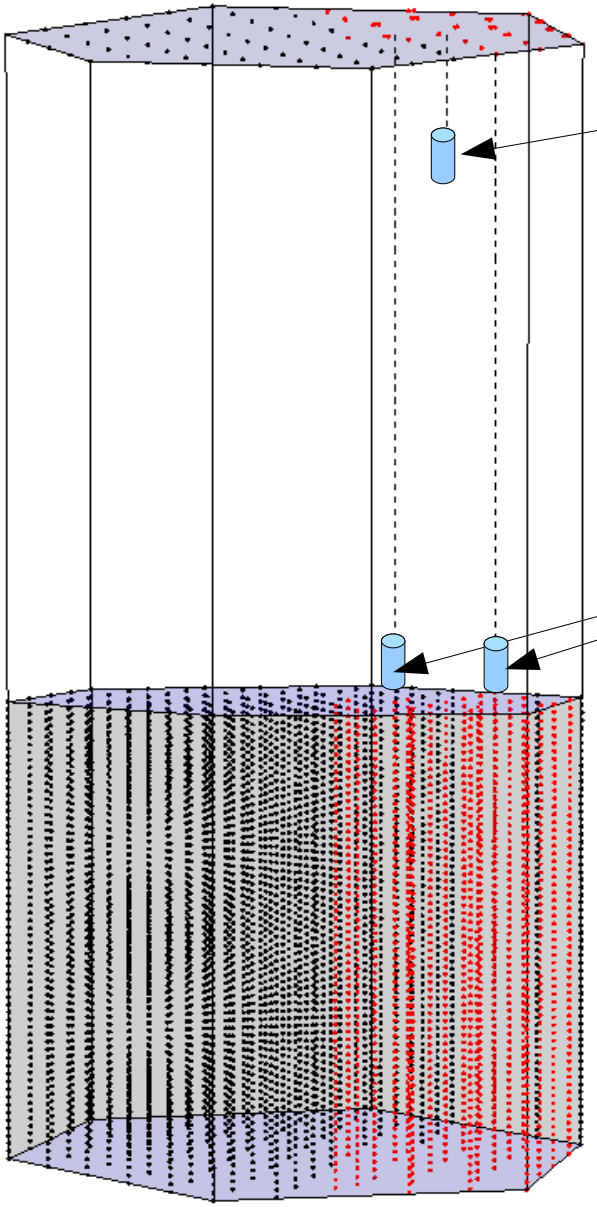
- 17 dipoles
  - 200x200x200 m cube above AMANDA
  - All electronics on the surface, like AMANDA
  - Data-taking since 1999, upper limits on flux from 10^{17}-10^{19} eV

AURA
Askaryan Underice Radio Array

- Combines technology and design from IceCube, RICE and ANITA (balloon-borne radio neutrino detector)
  - IceCube communications motherboard, cables, DAQ... and drilling!
  - ANITA digitization and triggering electronics
  - RICE antennas
    - 200-1000 MHz dipoles



AURA Status: 2006/7 deployment



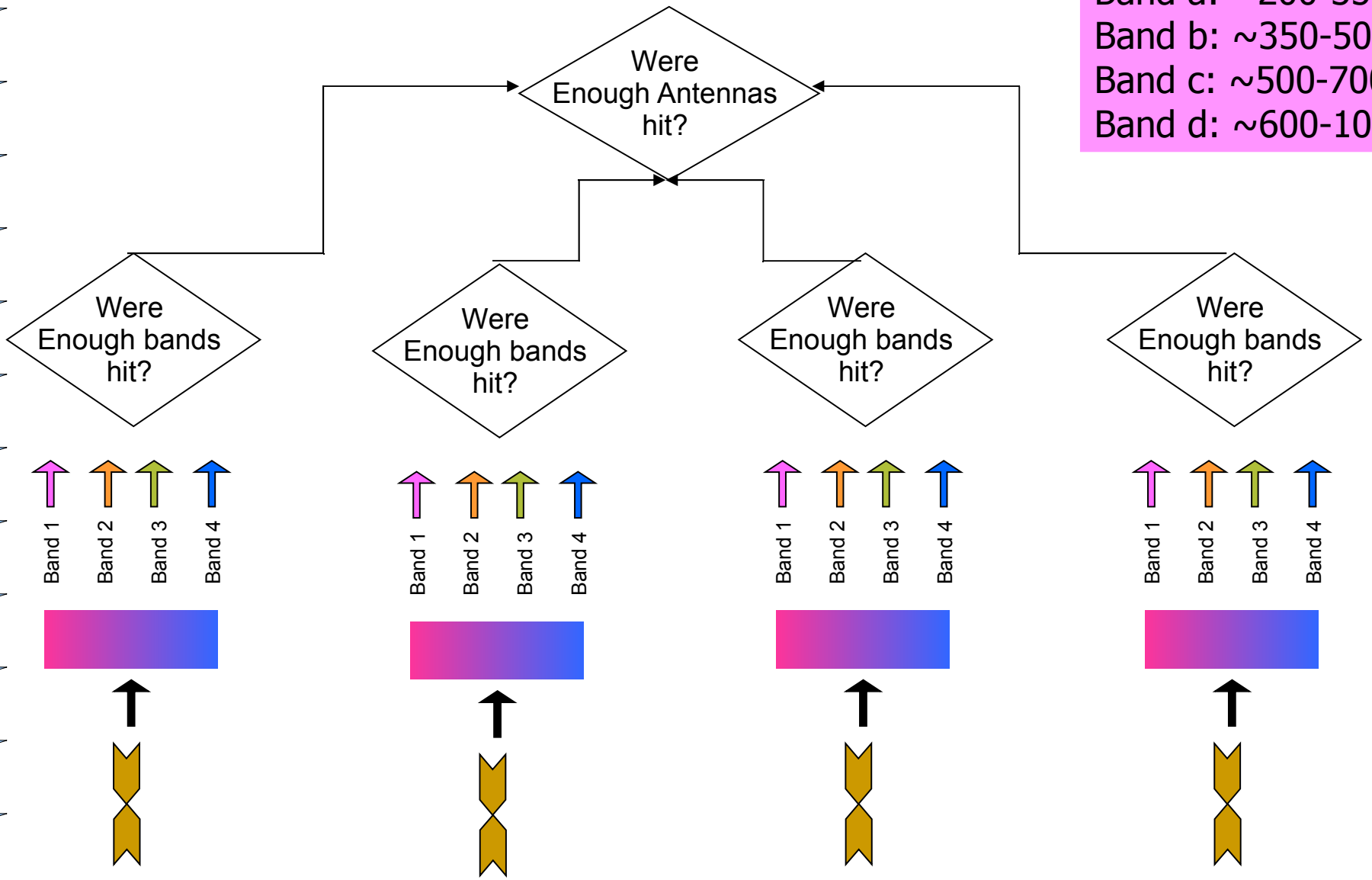
One module at 200 m depth, near RICE

Two modules at 1450 m depth, 600 m apart

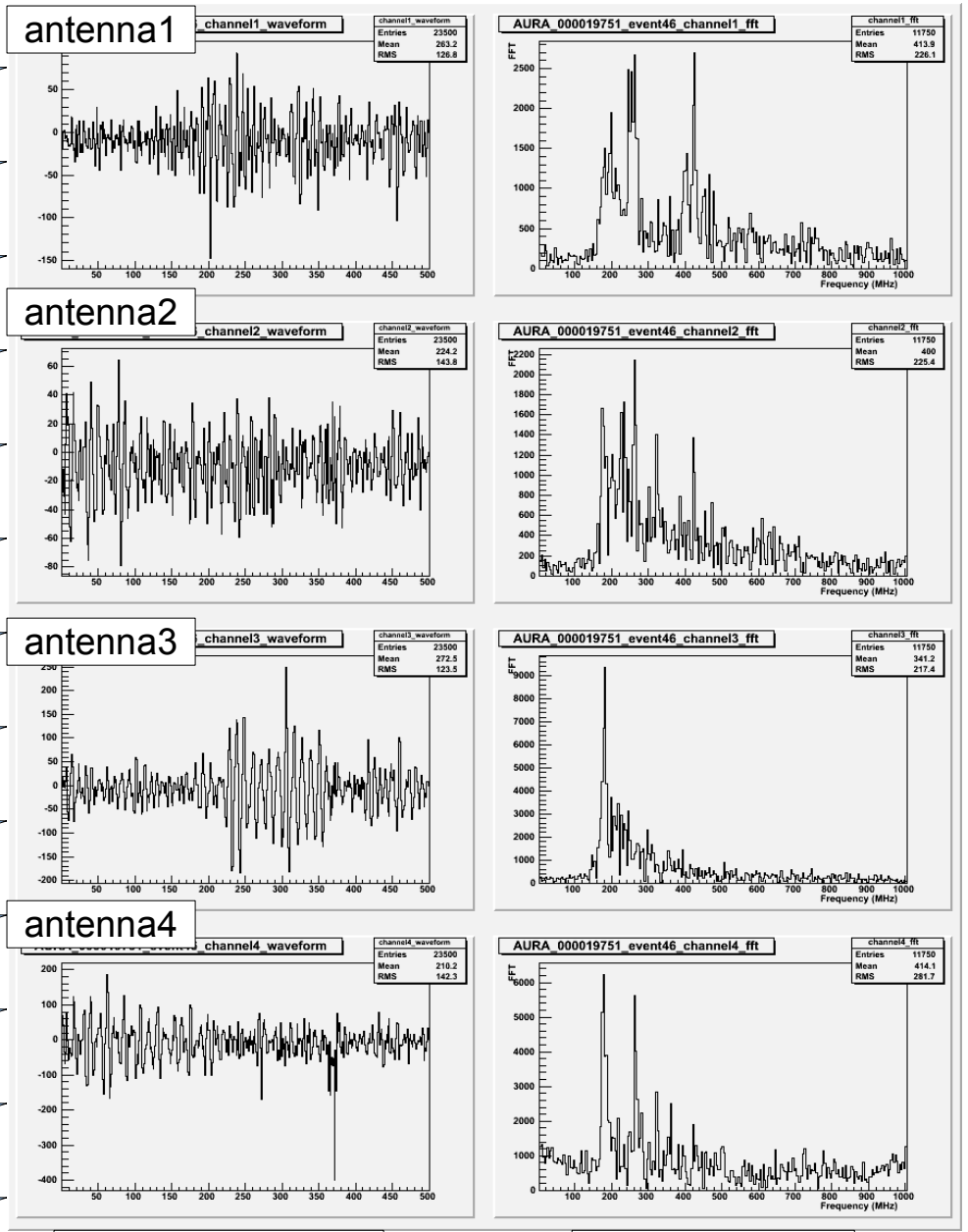
1 module has transmitter only

AURA in-ice trigger

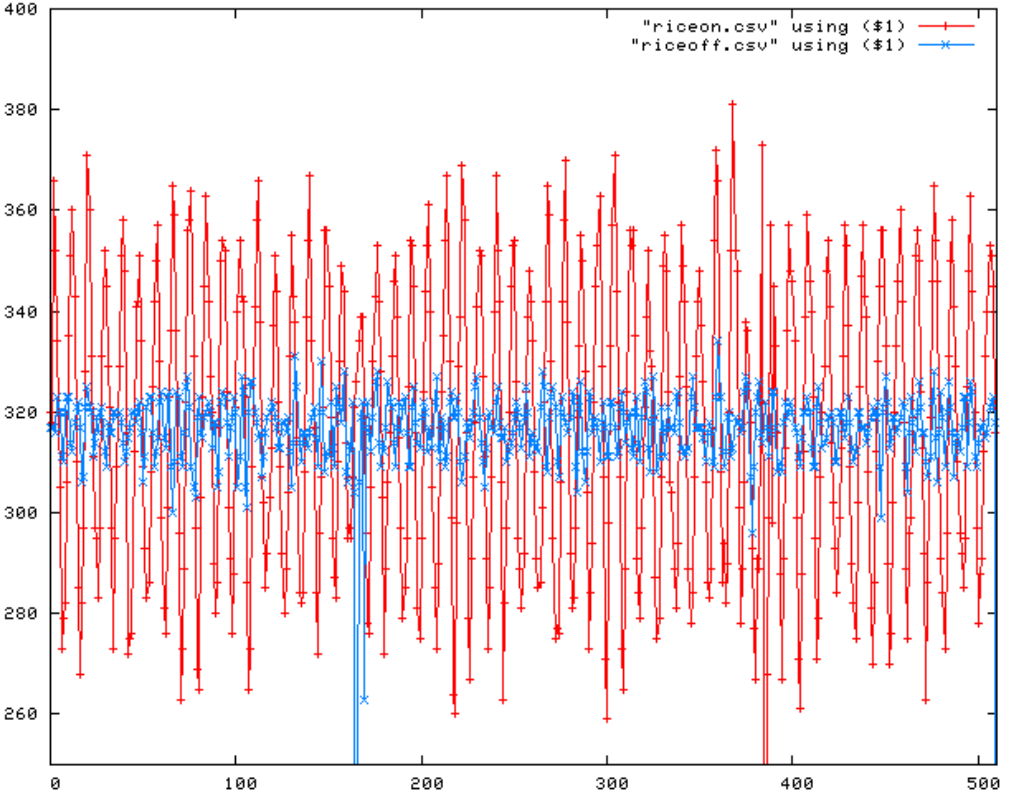
Band a: ~200-350 MHz
Band b: ~350-500 MHz
Band c: ~500-700 MHz
Band d: ~600-1000 MHz



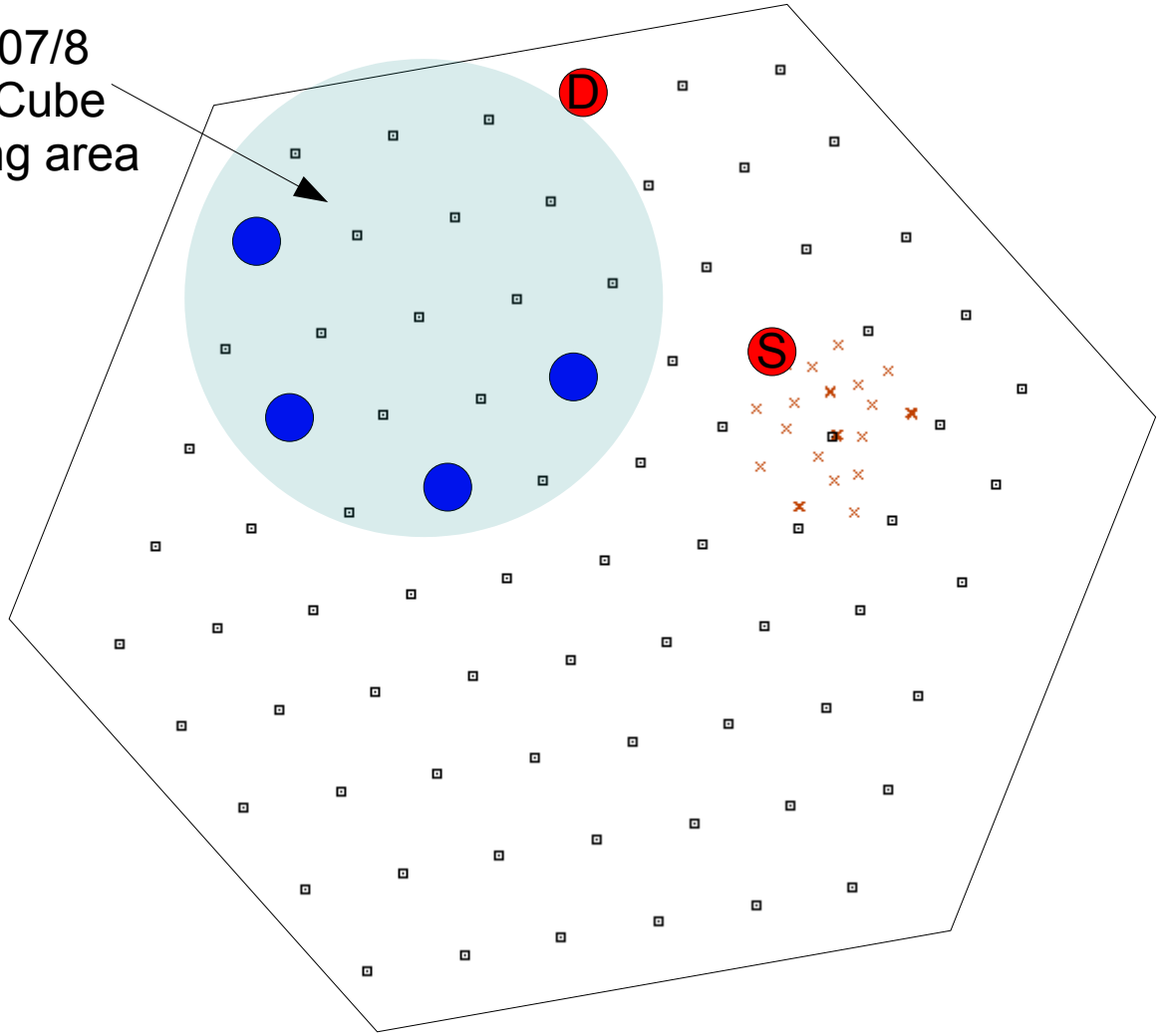
AURA Waveforms & FFTs



AURA receiving 250 MHz sine wave from RICE transmitter



AURA 2007/8 plans



Full IceCube footprint

2006/7 receivers

2007/8 receivers

Same basic design as last year

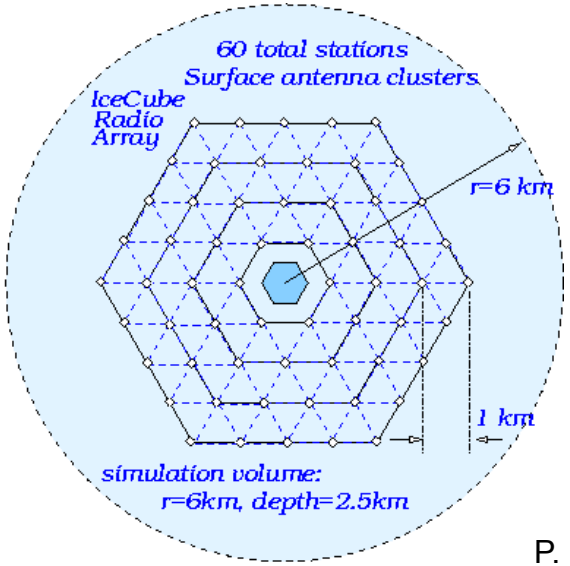
new shielding, power supply, stronger transmitter

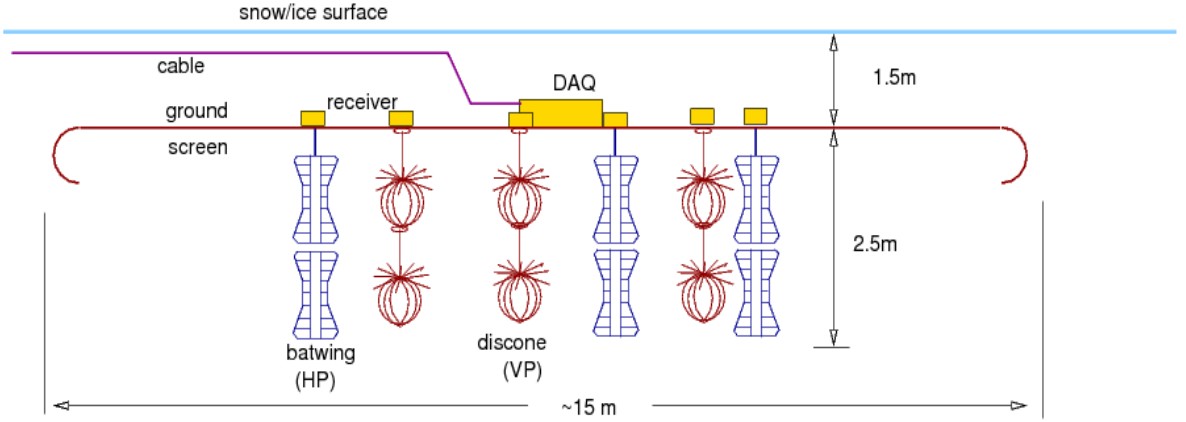
Conclusions

- Radio detection is a promising method for GZK neutrino detection
- South Pole ice radio properties and Askar'yan effect in ice have been studied
- Radio detectors can take advantage of existing South Pole and IceCube infrastructure... possibility for coincident detection
- AURA following RICE, total of 6 receivers in ice after 2007/8 season

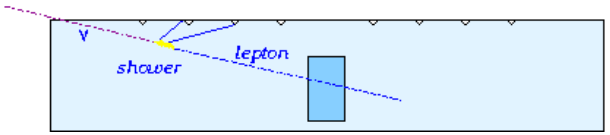
Backup slides

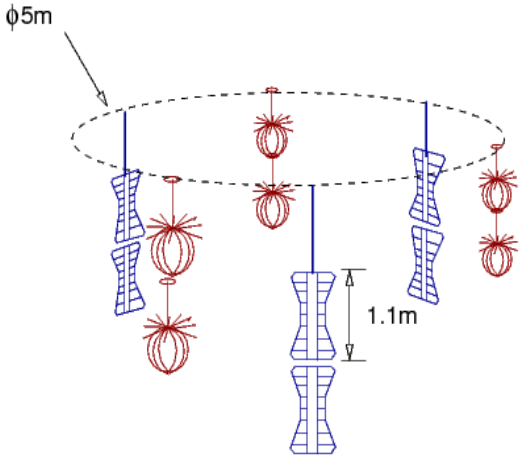
Future possibilities: IceRay





P. Gorham

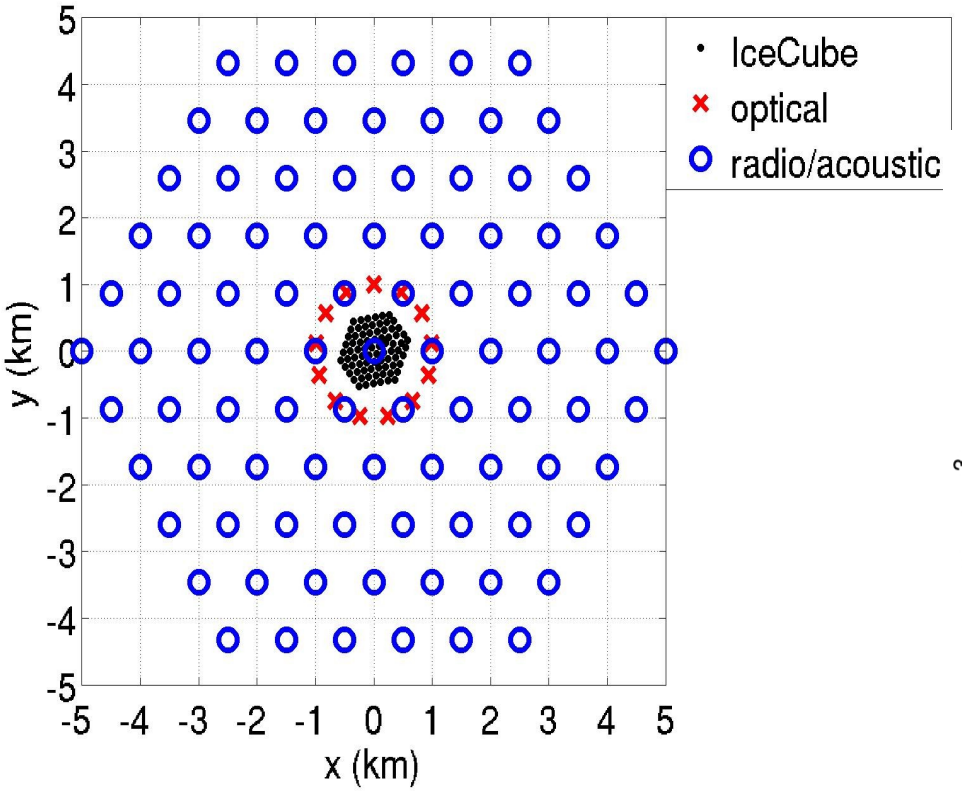




Subsurface array... no drilling!
1 Prototype station to be tested 2007/8, 1.5 km from IceCube

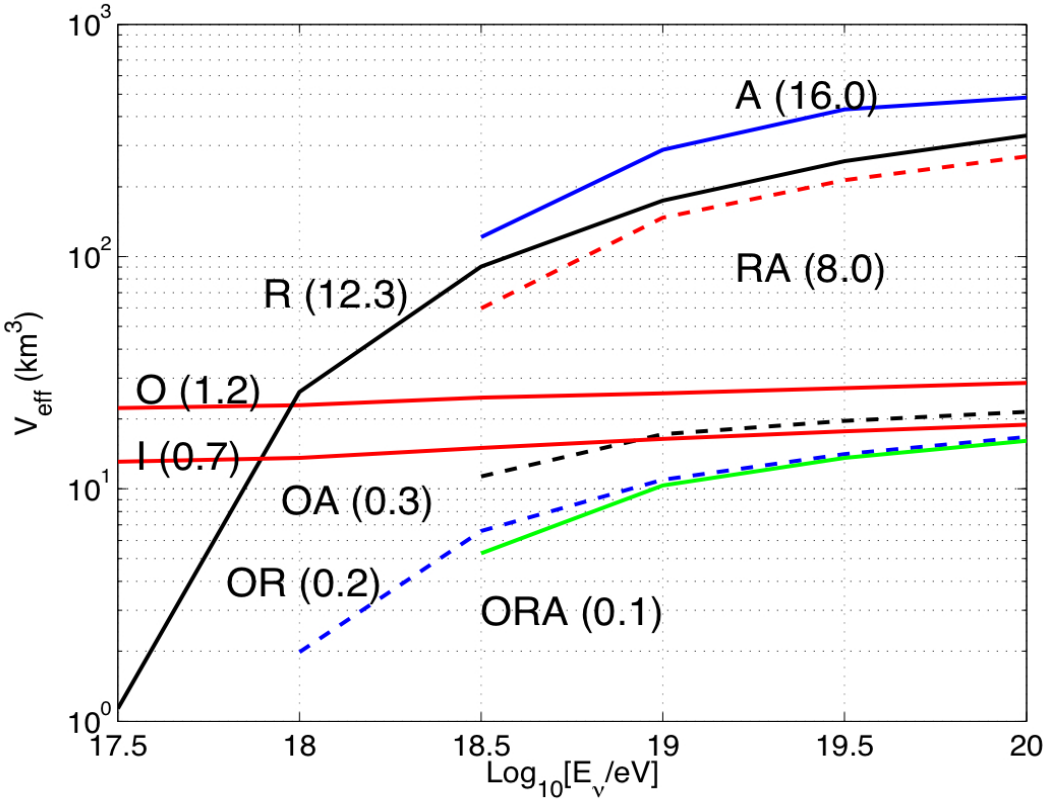
Simulated subsurface array as shown sees a few GZK neutrinos/year

Hybrid array simulations



J. Vandenbroucke

O=optical
A=acoustic
R=radio



See Freija's talk later this session for acoustic activity at Pole!