Future prospects for large area ground & space-based neutrino detectors

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JPL Tracking & Applications Section 335

RADHEP 2000

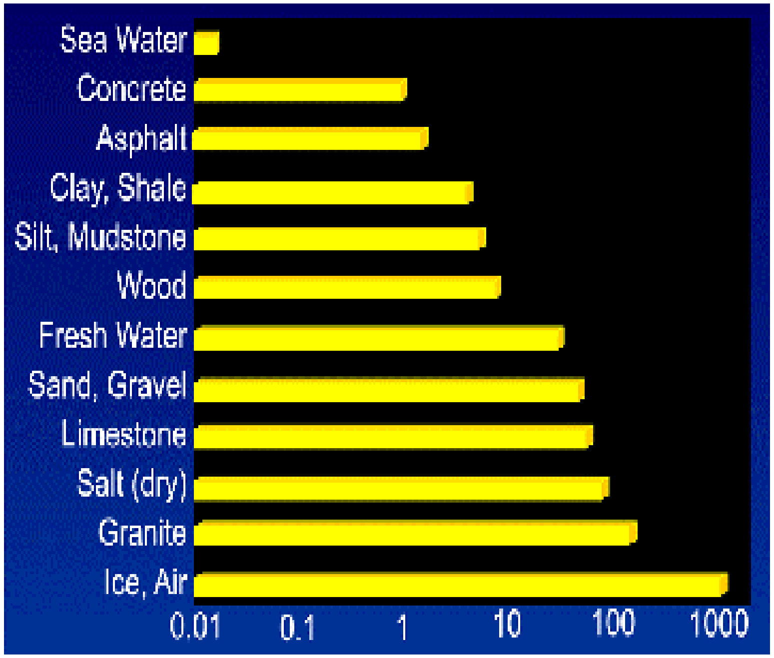
UHE/EHE Neutrino Detector Possibilities

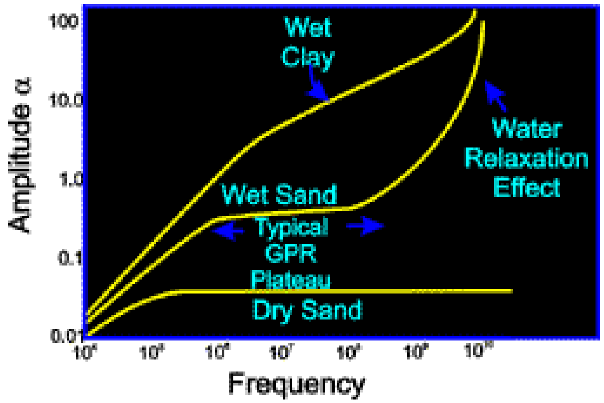
- Of order 10^43 nucleons if we want ~100 GZK nu events per year at >10^18 eV
  - Muon tracking no longer helps above ~ 1 PeV because the range grows slowly
  - ~10^4 km^3 of ice
- Detectors fall into 3 classes:
  - <u>VOLUME ARRAYS (VAs):</u>
    - Traditional approach to particle detection: instrument a fiducial volume with detector elements of sufficient number density to track the cascade Cherenkov emission
    - RICE (radio), AMANDA, ANTARES, NESTOR (optical) are examples
    - Lowest energy threshold, but most expensive
  - <u>SURFACE ARRAYS (SAs):</u>
    - For these types, the Cherenkov is detected at the outer surface of the fiducial volume
    - SuperKamiokande is the primary example for optical Cherenkov
    - A saltbed or ice array could follow this or the previous approach
    - Radio air shower arrays are also in this category
    - Can get large volumes for modest cost in very clear media
  - <u>EXTERNAL ARRAYS (EAs):</u>
    - Radiation exits the fiducial volume and is detected at a distance
    - Lunar Radio experiments are the prototype
    - largest volume for lowest cost, but high energy threshold

UHE/EHE Neutrino Detector possibilities

medium	area	depth	solid angle	E_thr	type	description	reference
Antarctic ice	(see results at this conference)					present RICE array	this conf.
Antarctic ice	1e4 km^2	2 km ice	~2pi	1e18	VA	super-RICE array	RICE collab.
Antarctic ice	1.2e6 km^2	~150m	~0.1	1e19	EA	balloon at 30km altitude	...
Greenland ice	1.8e6 km^2	~90m	~0.05	1e20	EA	geostationary orbiter	...
Earth atmosphere	1.6e7 km^2	10mwe	~1	~1e20	EA	Space station array	...
Dry lake array	160km^2	10mwe	~0.1	3e16	SA/EA	lakebed surface array	...
Auger array	5e3 km^2	10mwe	~3	1e19	SA	deep EAS, in constr.	Zas et al. 98
Goldstone	2e6 km^2	10mwe	0.05	1e20	EA	existing experiment	this conf.
super-Goldstone	7.5e6 km^2	20mwe	0.05	2e19?	EA	bigger beam, more BW	...
Compact salt array	10 km^2	100m salt	2pi	1e16	VA	instrument existing mines	M. Chiba, RICE grp.
Giant Salt array	3e4 km^2	300m salt	2pi	1e18	VA	0.5% US evaporite area	M. Chiba, RICE grp.
Lunar orbiter	1.2e7 km^2	20mwe	0.1	1e18	EA	h ~ 2 lunar radii	...

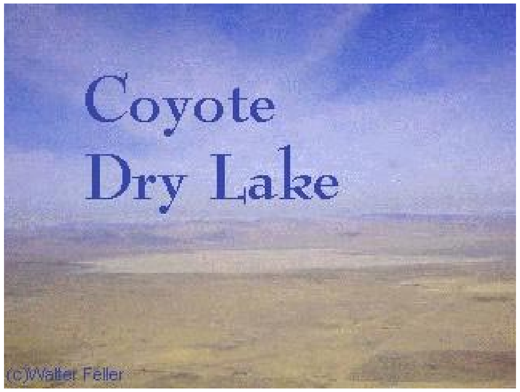
RF Propagation in natural dielectric solids



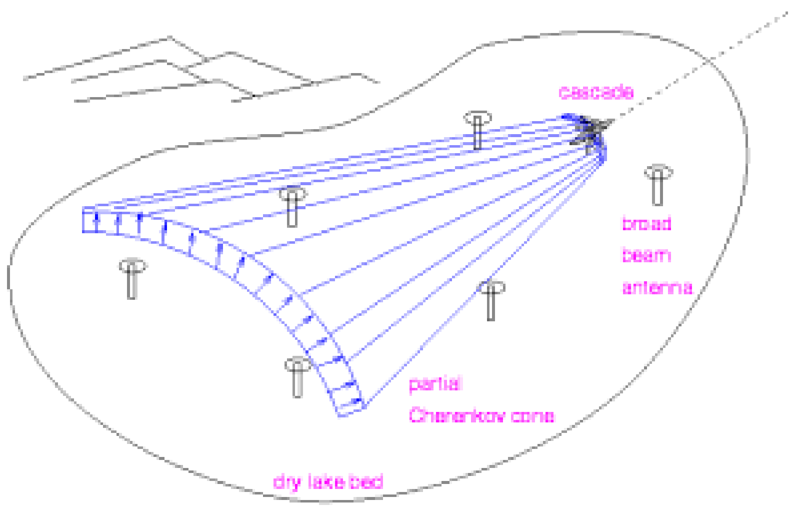


- Volume and surface arrays:
  - Require 10's to hundreds of m attenuation length for low detector number density
  - Probably limited to ice and clear salt due to L_atten & ease of penetration
  - Volume/surface arrays generally get large solid angle coverage
- External arrays
  - sand, dry clays, limestone, & granite are all additional possibilities giving reachable depths of ~10-20 m
- Array limitations:
  - Volume: requires several antennas per attenuation volume, more for high efficiency
  - External arrays are limited in solid angle, and effective volume must lie within the antenna beam

Desert Playas (Dry lakes): RF surface Array



Area: ~160 km^2, near Barstow



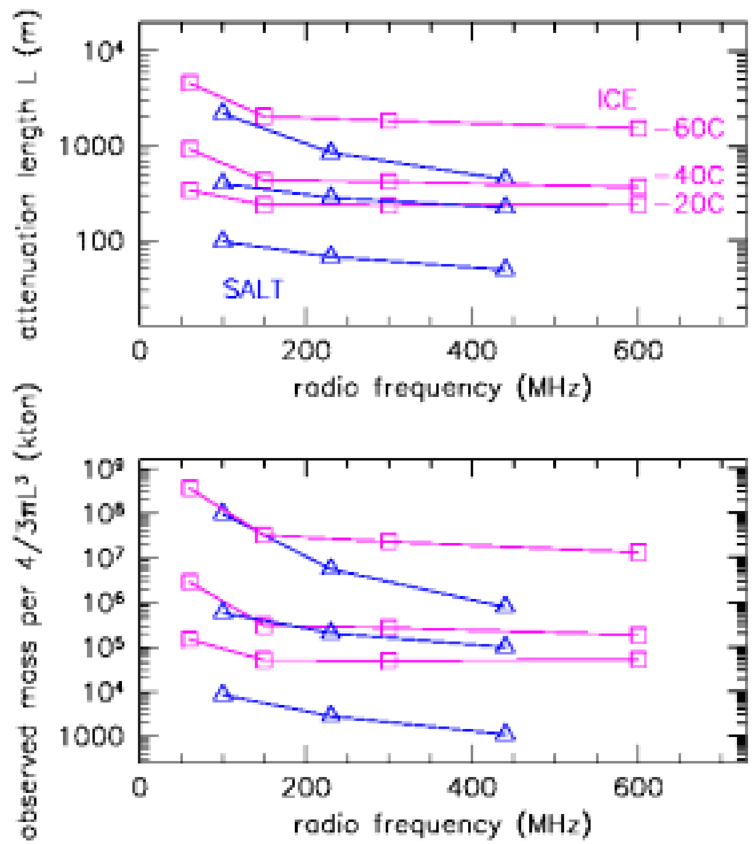
CASCADE IN ~10 m SURFACE LAYER + RF REFRACTION

Tracking possible by use of polarization measurements:

Plane of polarization preserves projected track direction

~3 cubic kmwe possible for modest array at Coyote Lake!

RF properties of Halite



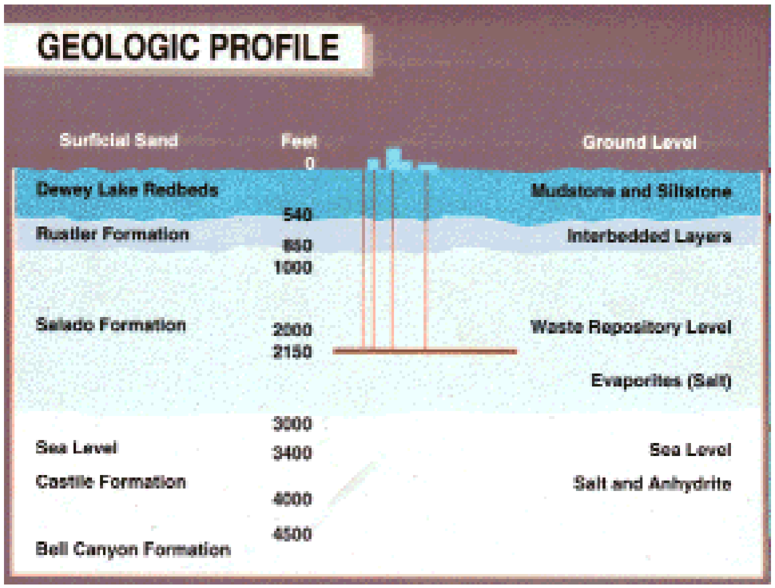
- Natural salt can be extremely low loss: ~ as clear as very cold ice, nearly 2 1/2 times as dense

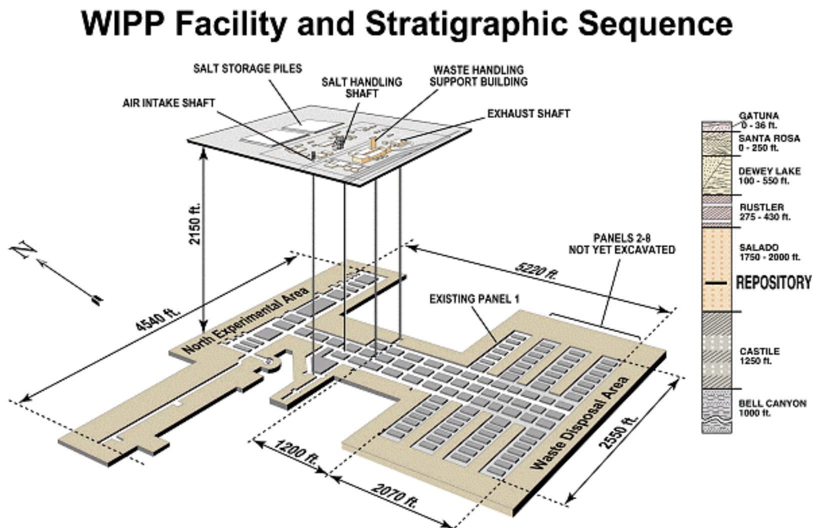
- Typical salt dome halite is comparable to ice at -40C

- Good evaporite halite (salt beds) is still comparable to clearest seawater/ice in optical

SALT curves are for (top): purest natural salt; (middle): typical good salt dome; (bottom) typical good salt bed halite.

Waste Isolation Pilot Plant: Potential Salt Detector Testbed





- GPR measurements (Roggenthen 97) indicate L_att ~ 100m at 100MHz
- New measurements planned for early December
- DOE site -- mandate for science support (Richardson 2000)

ISS Radio Neutrino Array: transition & Cherenkov radiation detector utilizing ocean reflectivity

- Geosynchrotron & radio Cherenkov from extensive air showers
- Backward TR from EAS that impact the ocean
- Threshold ~ 1e20 eV
- ~2000 km to horizon from 350km LEO
- Requires 3 or more elements
  - ~ 80m separation possible
  - ~ 5 deg resolution @ 50MHz
  - Dual polarization necessary
  - RFI an issue