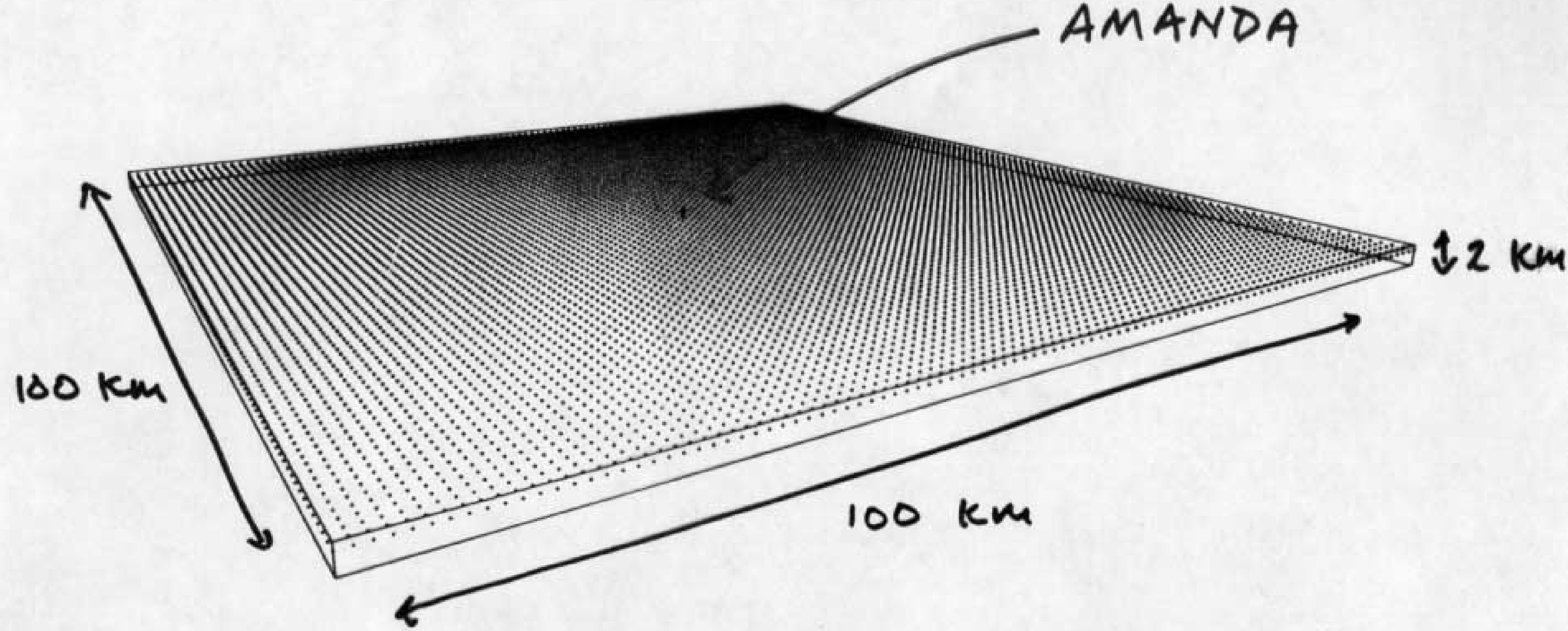
LARGE SCALE RADIO DETECTORS in ICE

Dave Seckel

@ RADHEP 2000

X-RICE



10^4 Radio Antennas @ 1 km spacing

(similar in scale to PIERRE AUGER project)

1. Confession

2. UHE CR + GZK ν

3. Event Rates + Detector Mass

4. RICE ⟶ X- RICE

5. Alternate Technologies

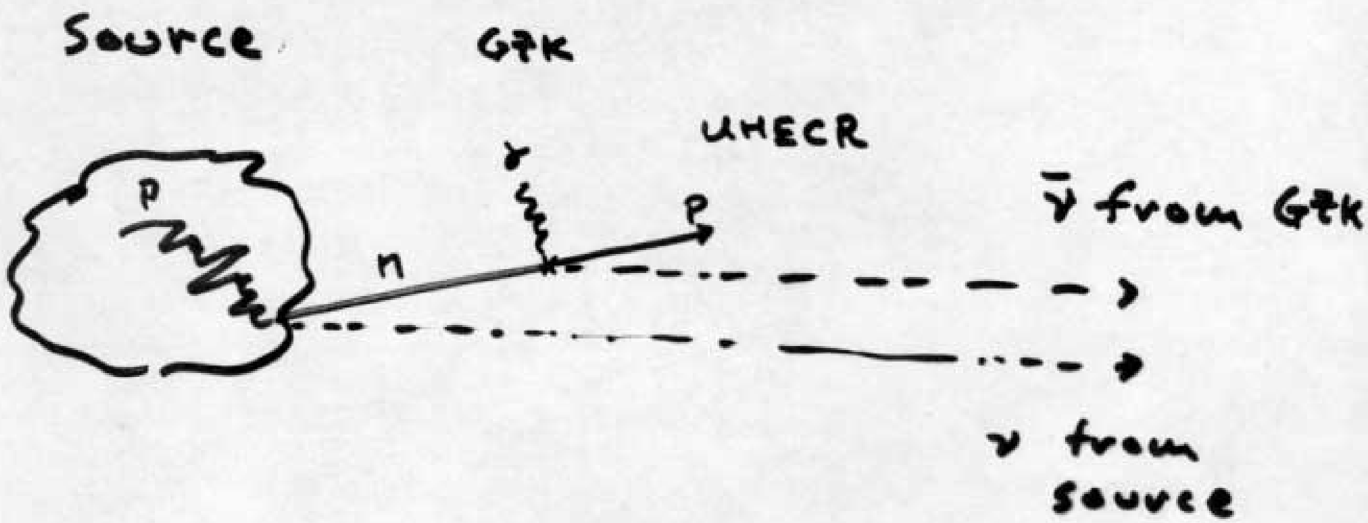
   ICECUBE

   Air showers - ground

   Air flourescence - ground/space

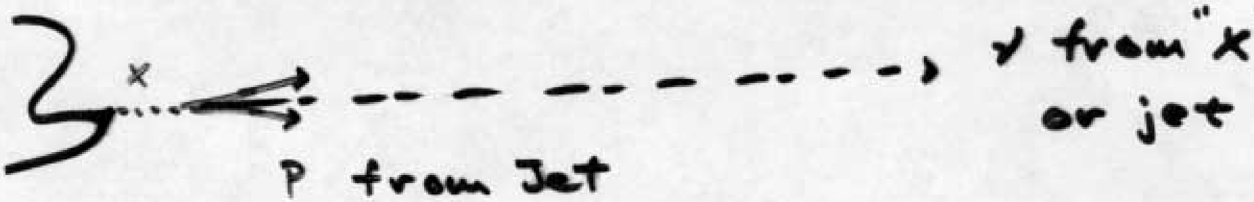
   LUNAR

6. Feasibility



- protons primary
- ν's secondary
- γ's

Cosmic String



- ν's primary
- Protons suppressed

• GZK $\Rightarrow$ 1 proton $E_p > 10^{19}$ eV

$\hookrightarrow$ 1 ν w/ $E > 10^{18}$ eV

• $$R = \frac{\int_{10^{18}} \phi_\nu \, dE_\nu}{\int_{10^{19}} \phi_{CR} \, dE_{CR}} = 1 + \alpha$$

• If

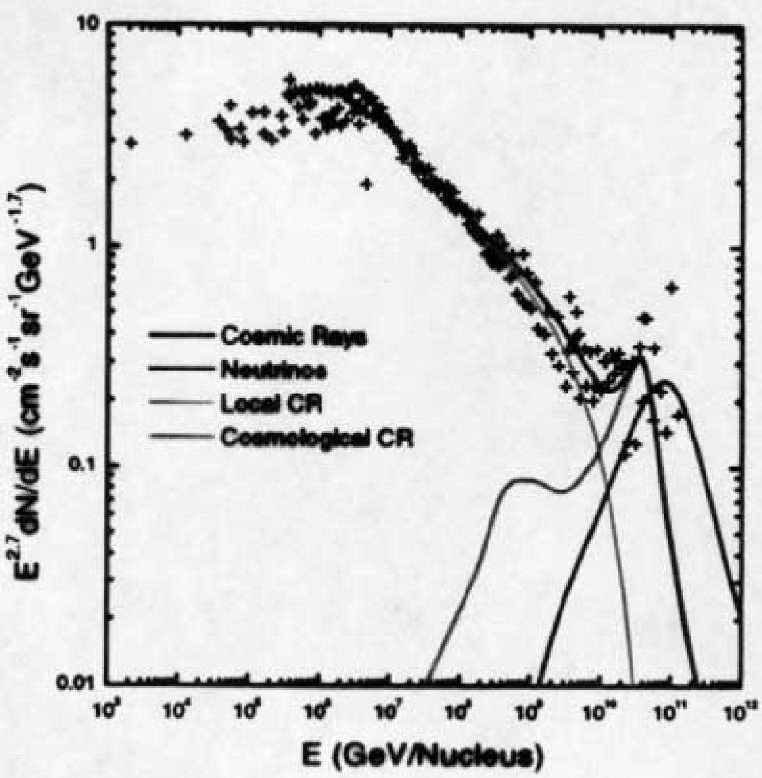
$\alpha \approx 1$ Astrophysical Source w/ ν production (AGN, GRB ...)

$\alpha \ll 1$ Astrophysical Source with NO ν's (Hot spots)

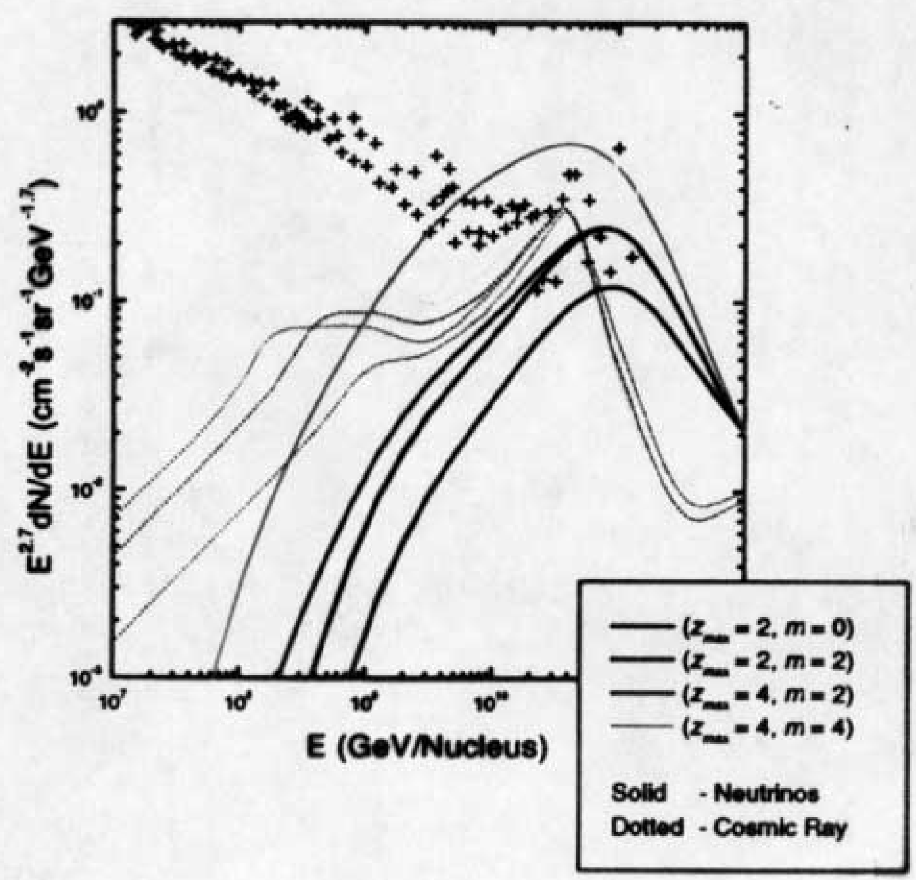
$\alpha \gg 1$ Top Down (Defects)

Model 2 from Yoshida and Teshima

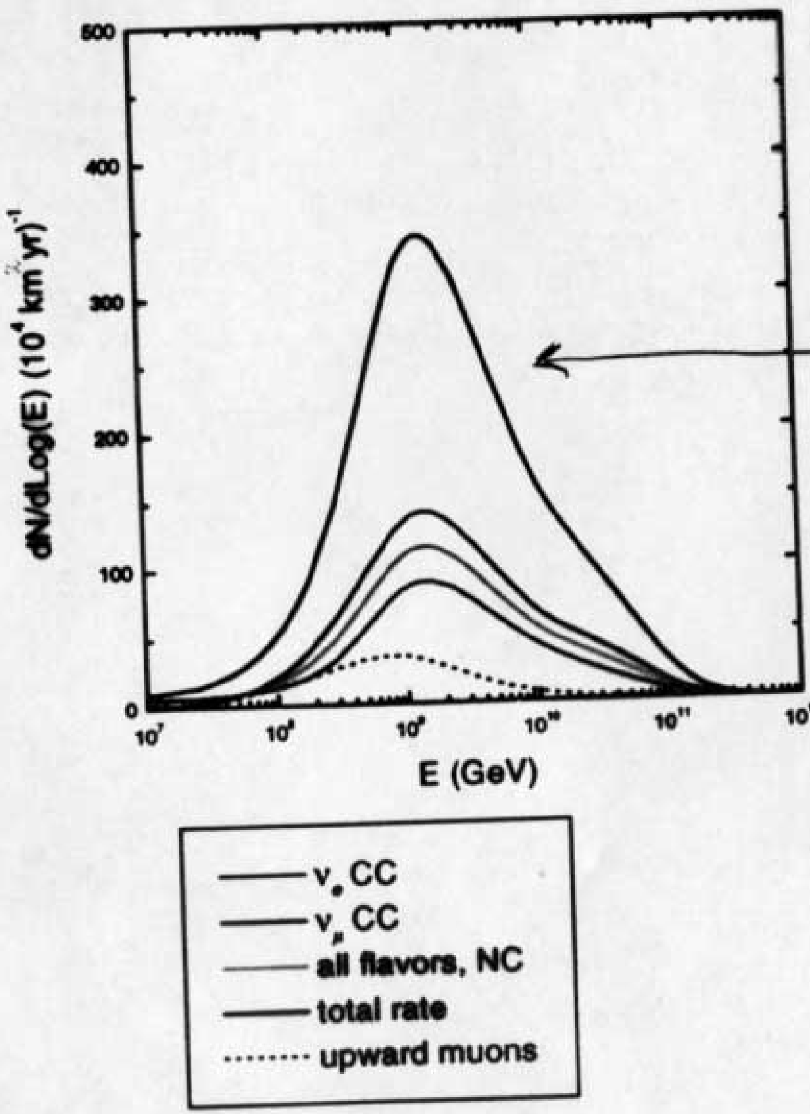
(z_{max} = 2, m = 2)



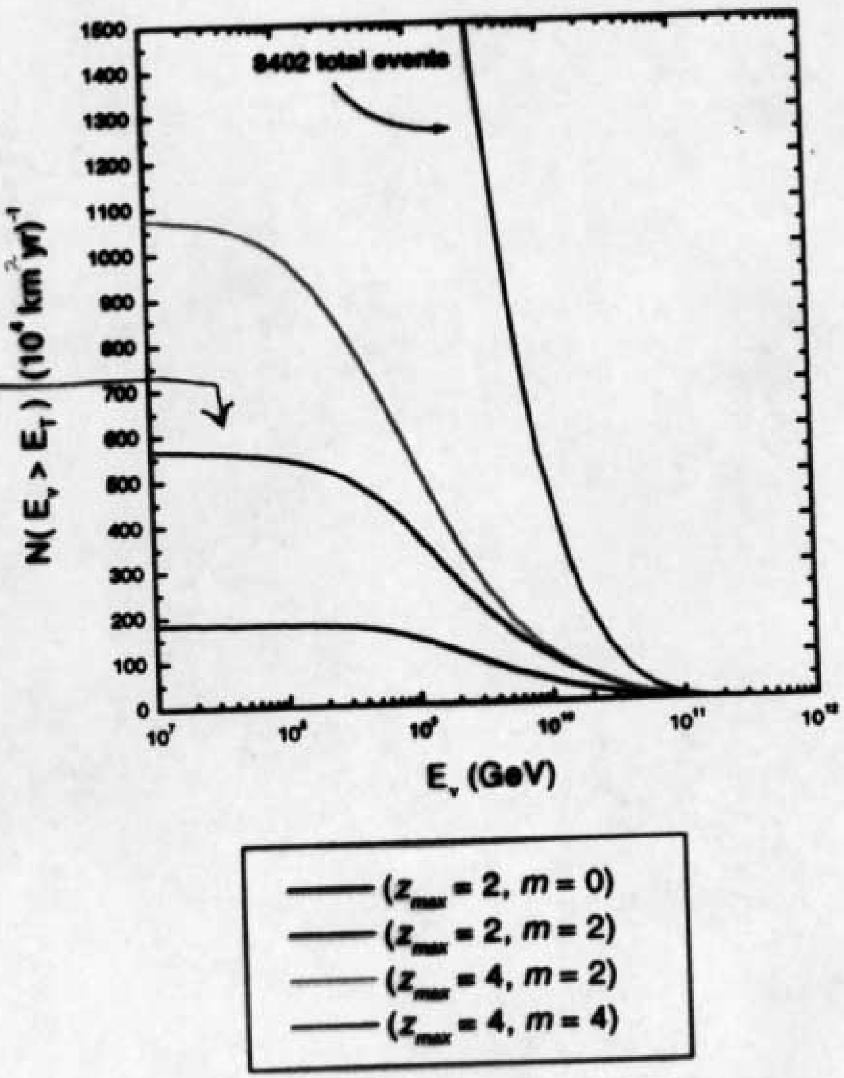
Variation of Neutrino Flux with Model



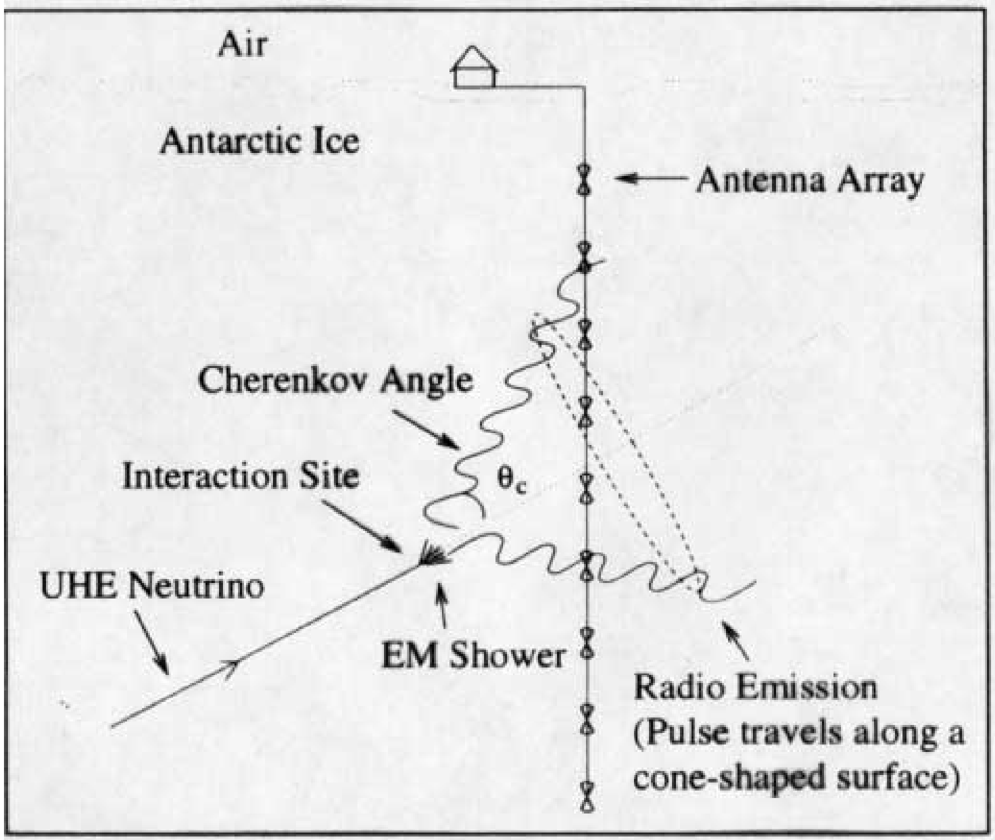
Diferrential Event Rate for YT Model 2
in 2 km ice



All Events above Threshold
in 2 km ice, for YT models



RICE Concept



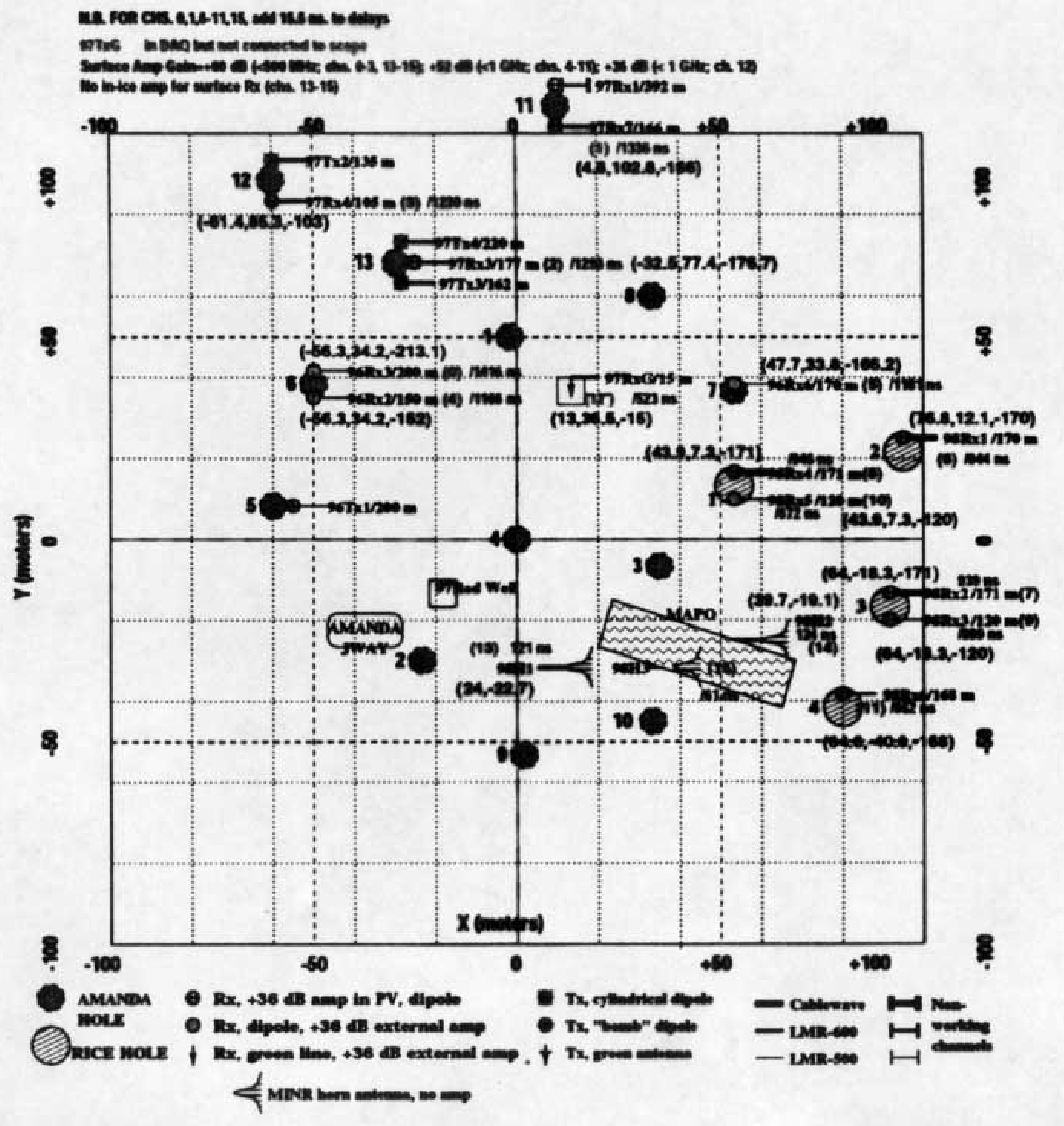
- **An UHE ν_e interacts in Antarctic ice, producing an EM shower**
- **At wavelengths longer than the shower size, coherent Cherenkov emission is produced (100 MHz - 1 GHz)**
- **The resulting radio pulse is detected by a buried array of receivers**

3 Versions of RICE

- RICE
  - FEASIBILITY
  - BACKGROUND SURVEY
  - ~ 20 Antennas (Rx)
    ~ $(100\,m)^3$ 10-100 PeV
  - LIMITS

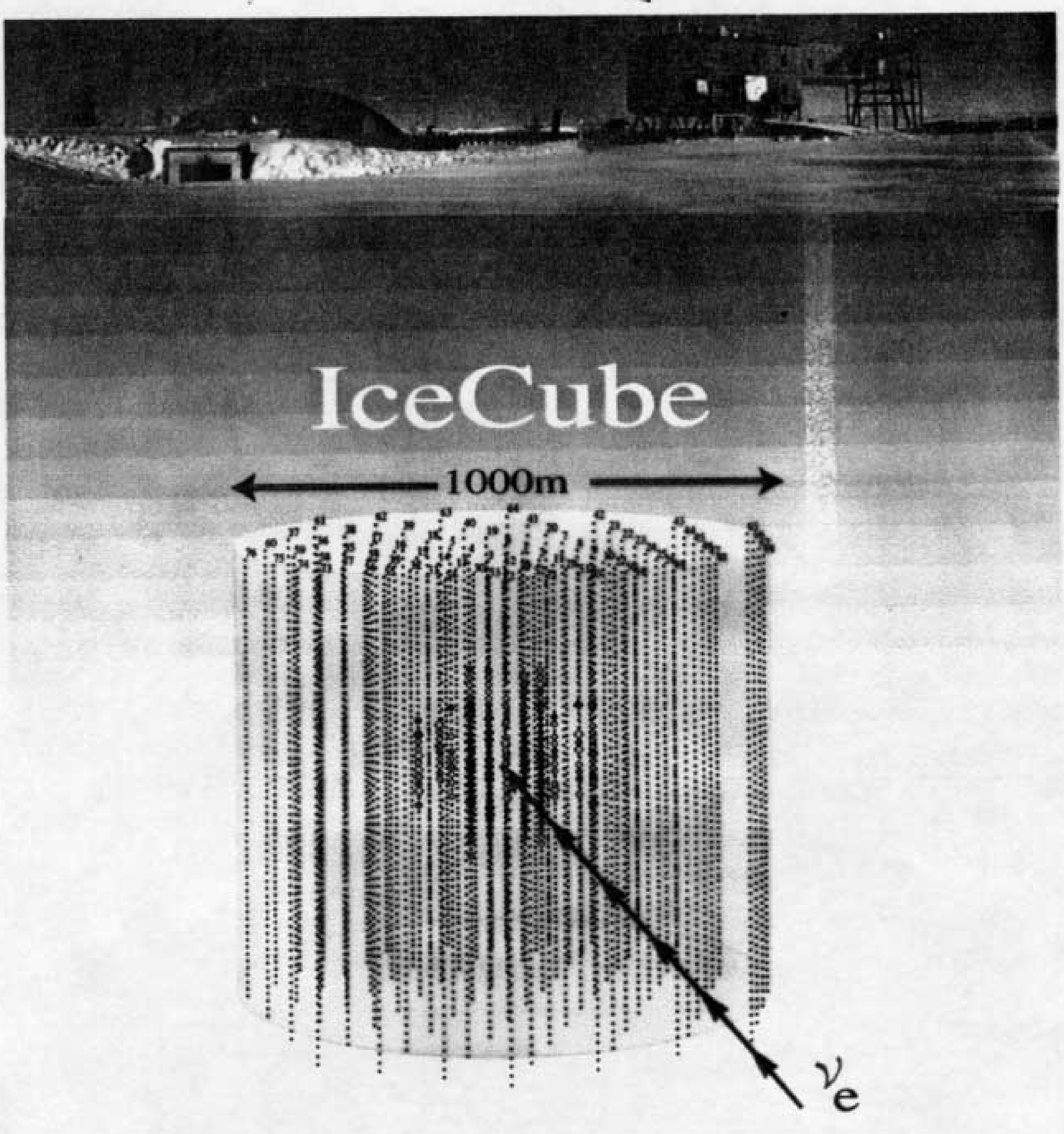
- $RICE^3$
  - few hundred Rx
  - $(km)^3$ 1-10 PeV
  - Limits
    Test models
    Events
    Calibrate

- X-RICE
  - 10^3-10^4 Rx
  - 10^3-10^4 km^3 1 EeV
  - 100 GZK ν's per yr
    "GUARANTEED"



X (meters)
Y (meters)
-100
-50
0
+50
+100
AMANDA HOLE
RICE HOLE
Rx, +36 dB amp in PV, dipole
Rx, dipole, +36 dB external amp
Rx, green line, +36 dB external amp
Tx, cylindrical dipole
Tx, "bomb" dipole
Tx, green antenna
Cablewave
LMR-600
LMR-500
Non-working channels
MINR horn antenna, no amp
AMANDA
MAPO

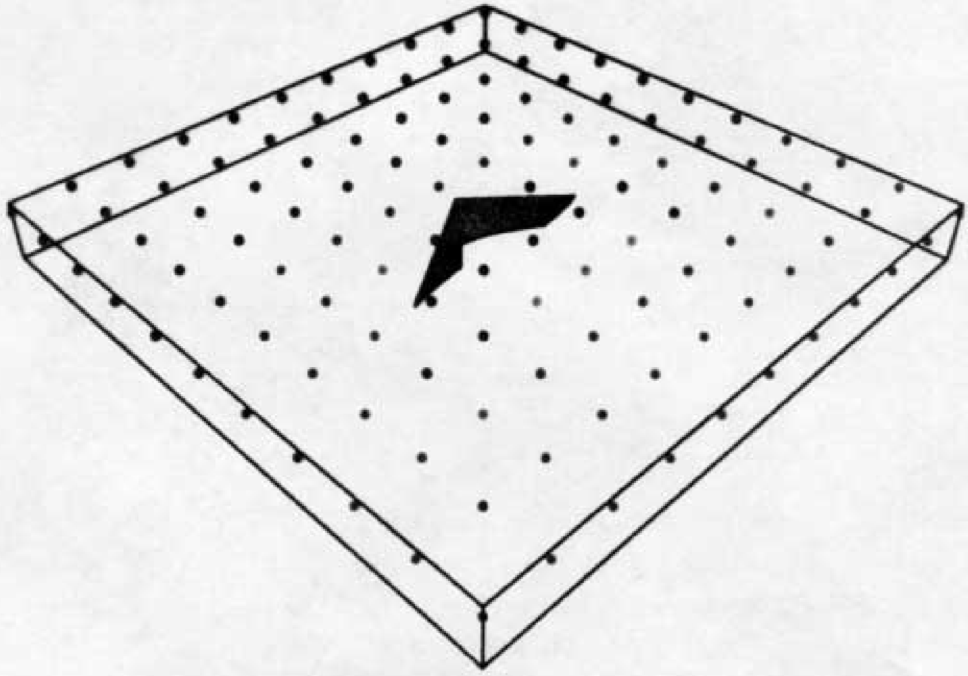
MAPO - Martin A. Pomerantz observatory



- A "small" array of antennas, $V_{thresthold} = 30\ mV$

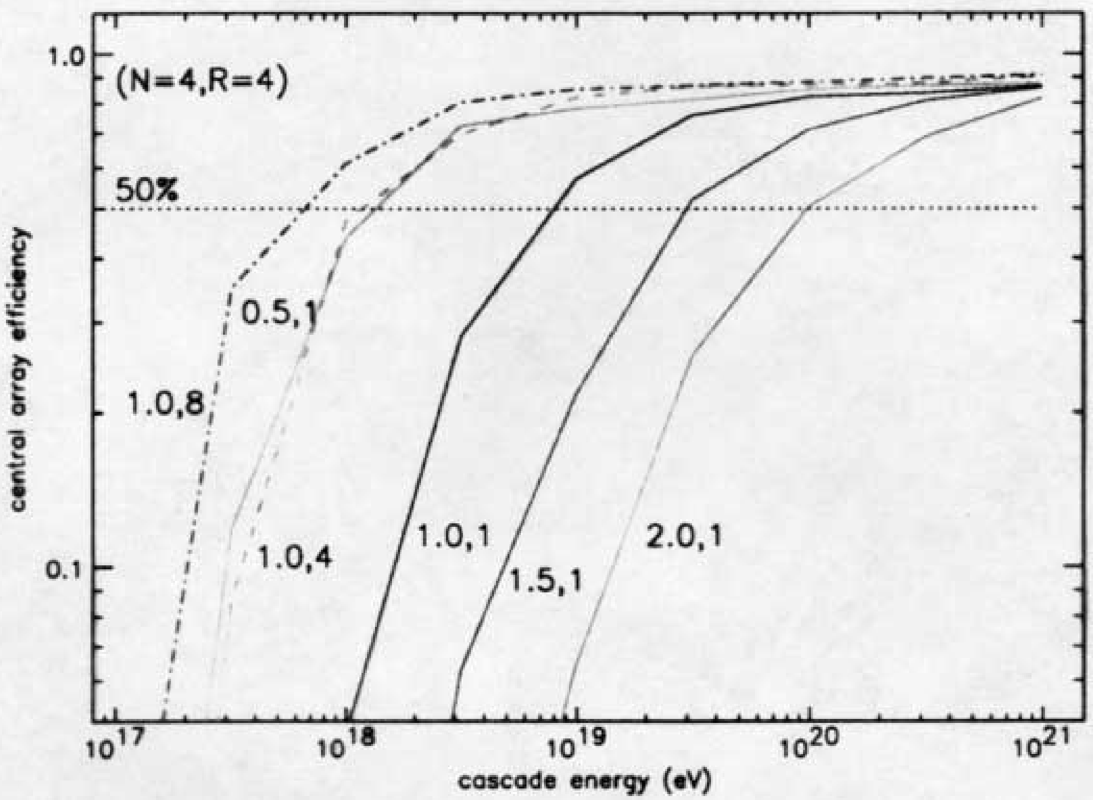
- 11*11, 2 km spacing, 300 m depth

- $E = 10^{10}$GeV

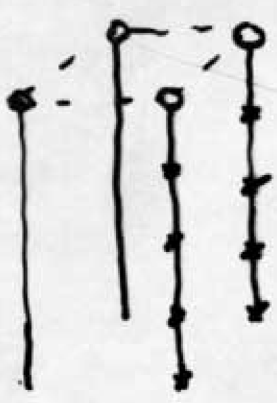


w/ G Frichter

Array efficiency:



#,# = Horizontal spacing,
# of antennas/hole



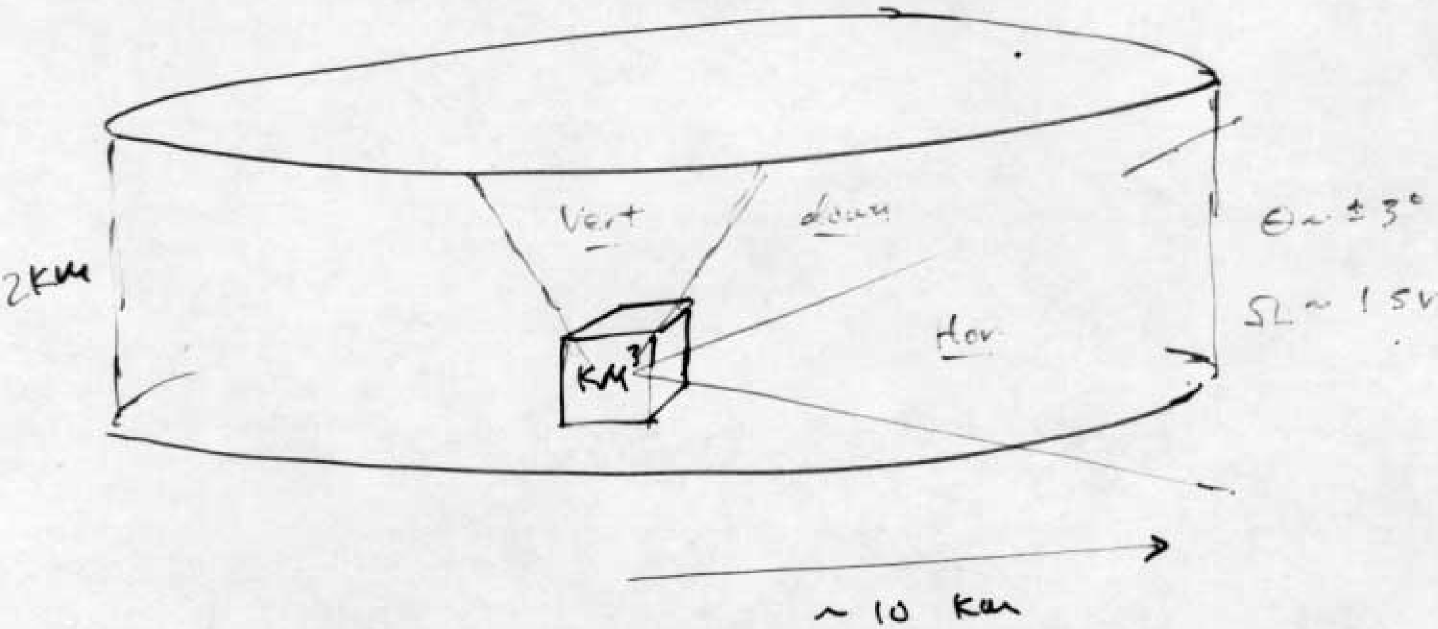
Experiments

Technique

Optical Č	AMANDA, ANTARES NESTOR, BAIKAL ICE^3
Radio	RICE, RICE^3, X-RICE LUNAR REMOTE orbit VENUS
Air Flouvescence	Fly's Eye, Hi Res I, II Telescope Array Project AUGER, OWL/Airwatch
Ground	AGASA, AUGER

GZK at ICECUBE

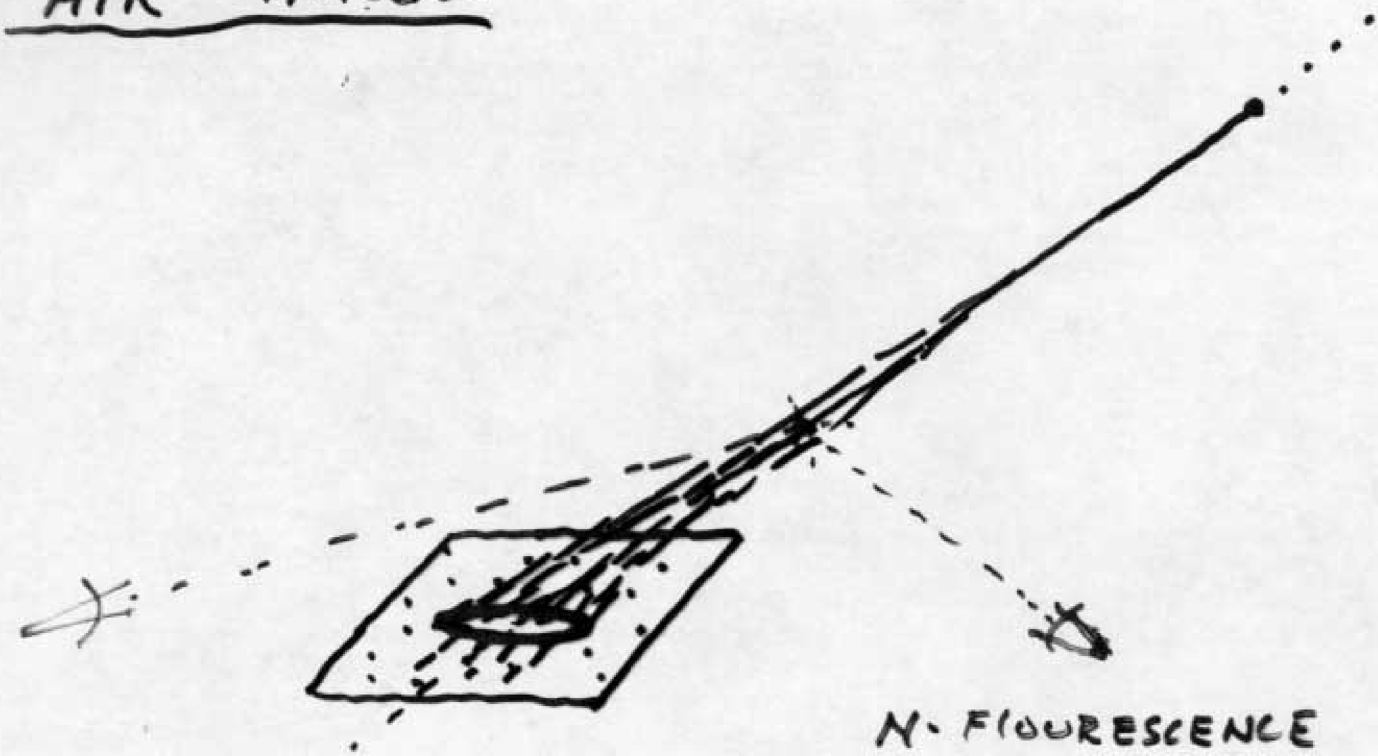
- CONTAINED EVENTS $1\ km^3$, 2π sr
  R ~ .01 - .1 / yr   <u>ΔE good</u>



- External μ's (ΔE not so good)
  R ~ 1-2 / yr (private comm. Francis)

contained = 6 km^3 sr
Horizontal ≈ 10 km^3 sr   ? 6x Contained
Down ≈ [redacted] ? 15
Vertical ≈ 2

AIR TARGET

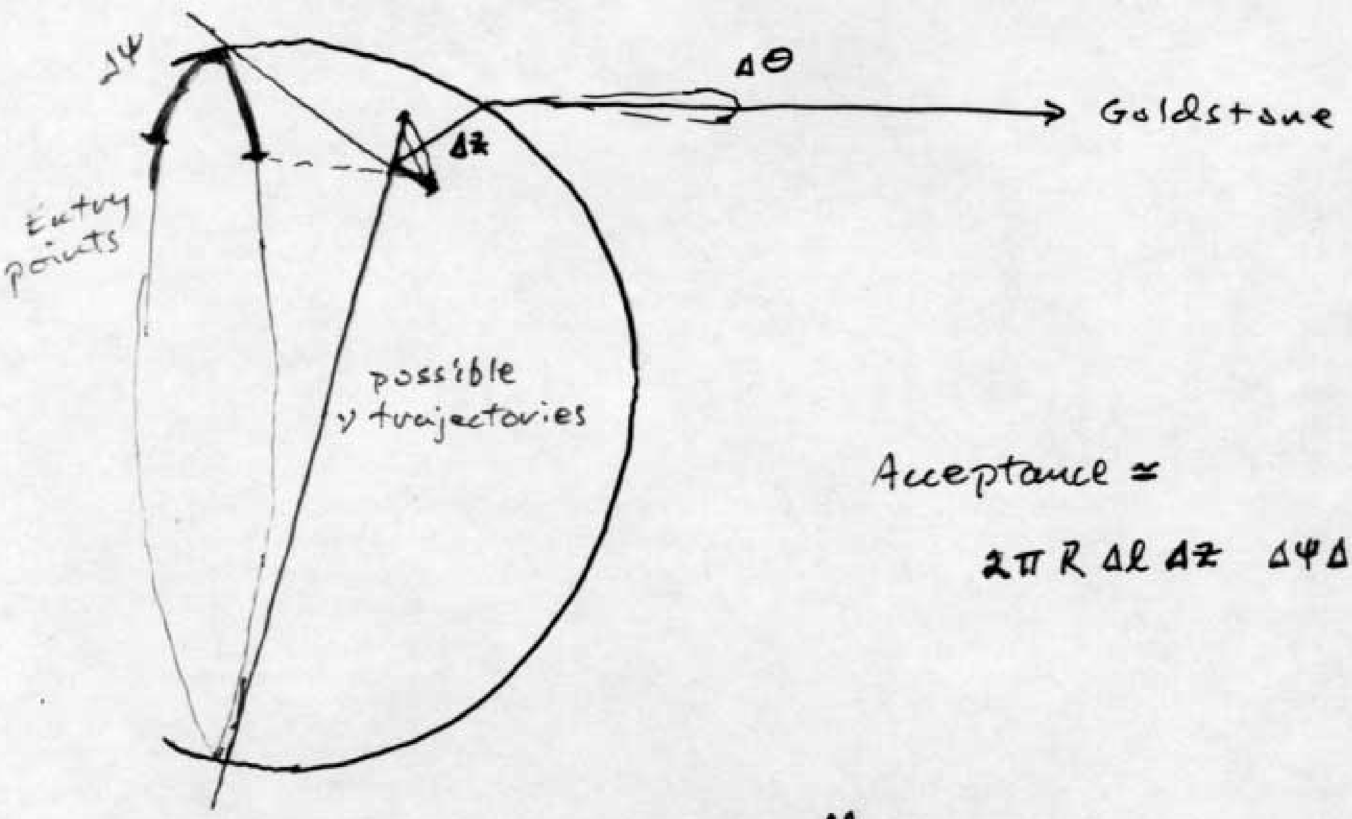


- PROVEN TECHNOLOGY
- COS RAY BACKGROUND ($\gamma + \mu$)
- HIGH THRESHOLD
- LOW TARGET MASS/AREA

equiv. 10 m H_2O

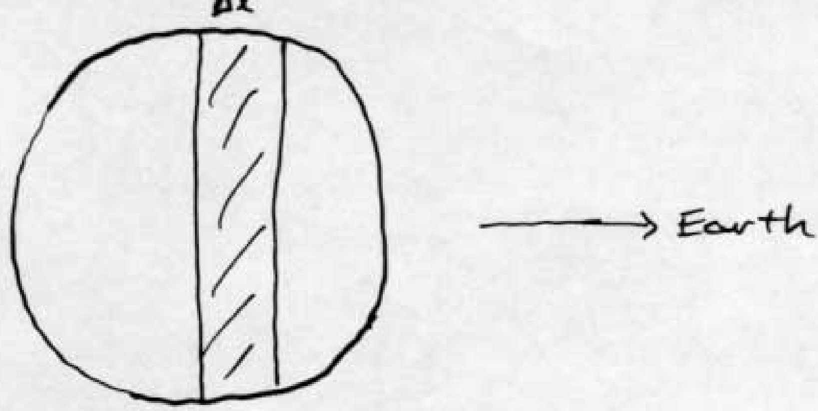
SHOWER PROFILE
+ VERTEX

LUNAR

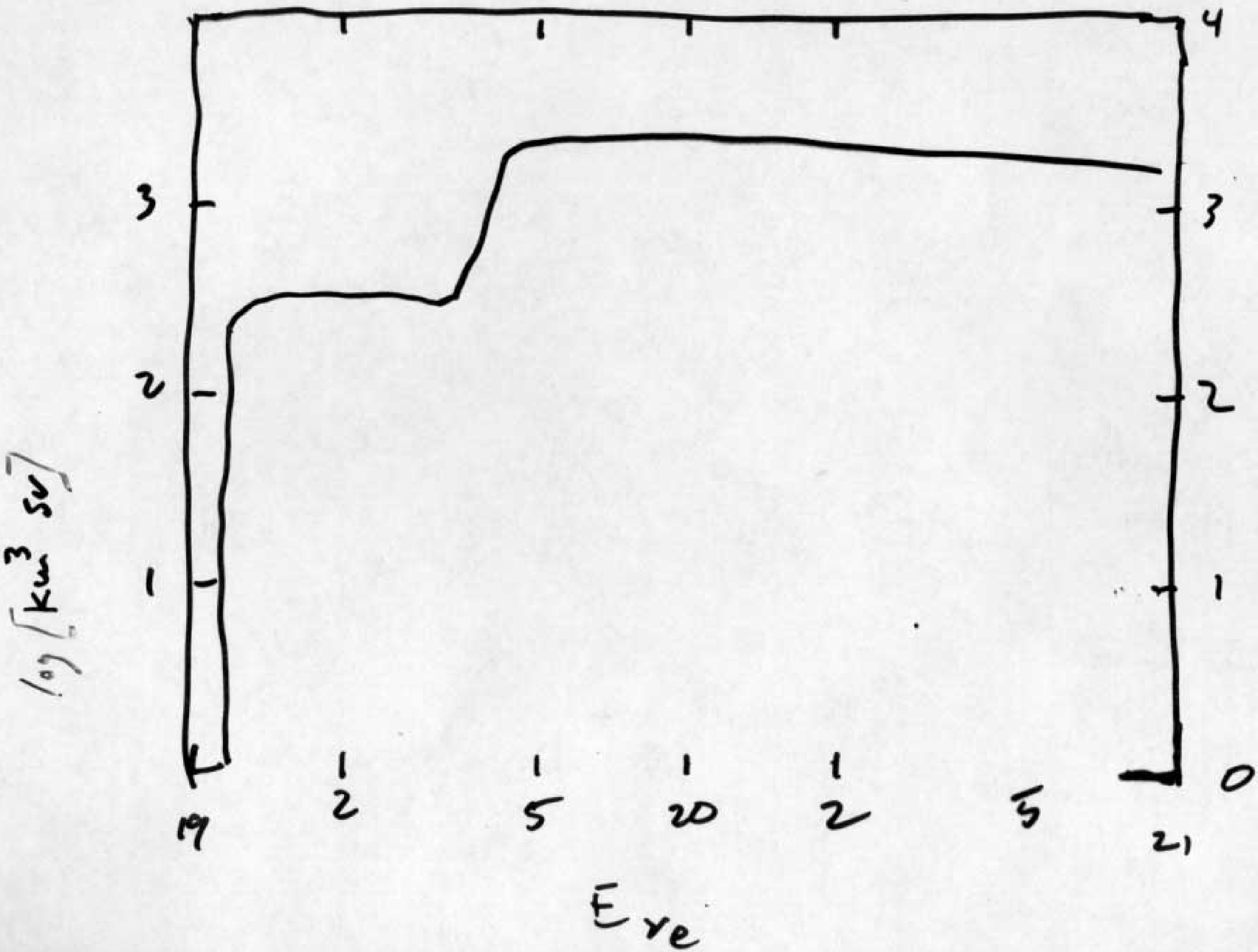


Acceptance ≈

$$2\pi R \, \Delta l \, \Delta z \quad \Delta\Psi \, \Delta\theta$$

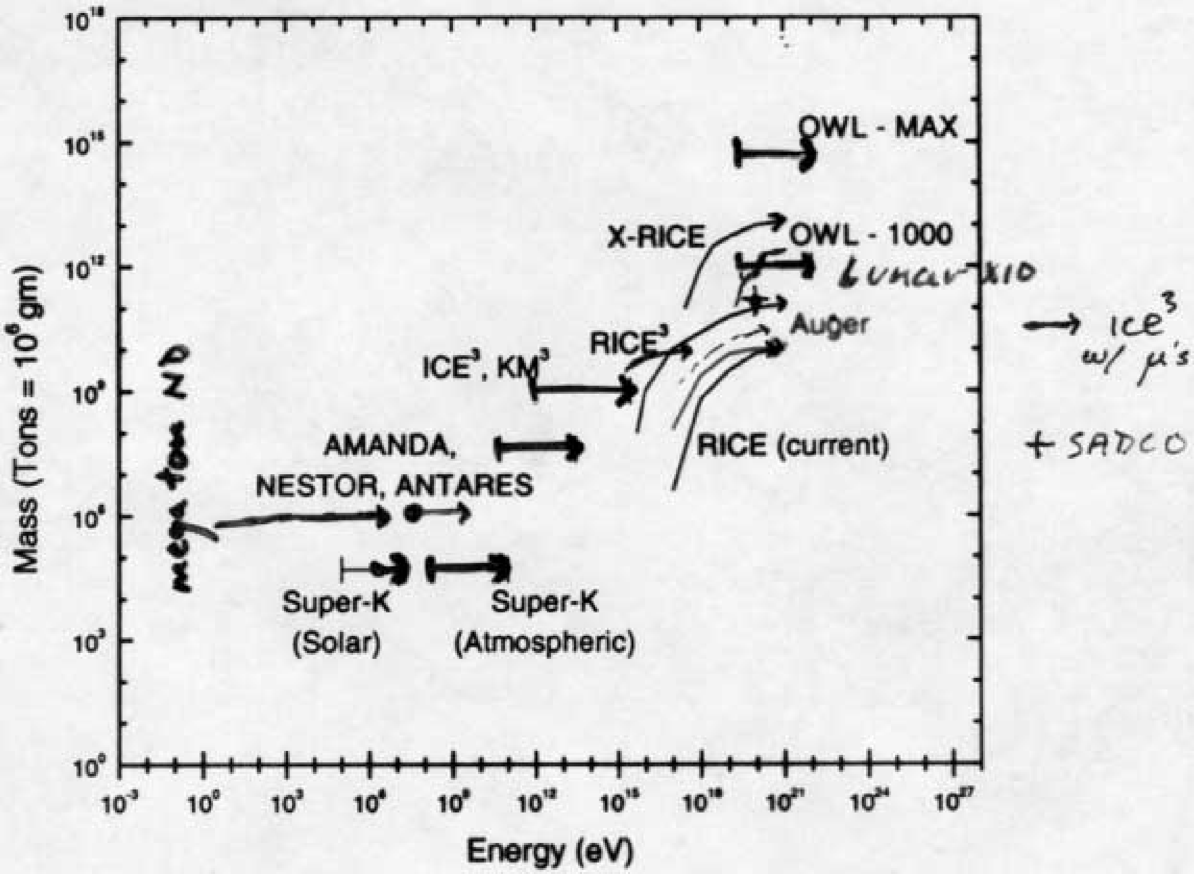


Alvarez-Muñiz



D. SECKEL

Neutrino Detector Characteristics



Lower E Limit: Detector Threshold (Sensitivity)

Upper E Limit: Detector Size (Flux)

Feasibility

- All the problems of ICECUBE
- All the problems of AUGER
- But the real problem is

  CONVINCING people that it works

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