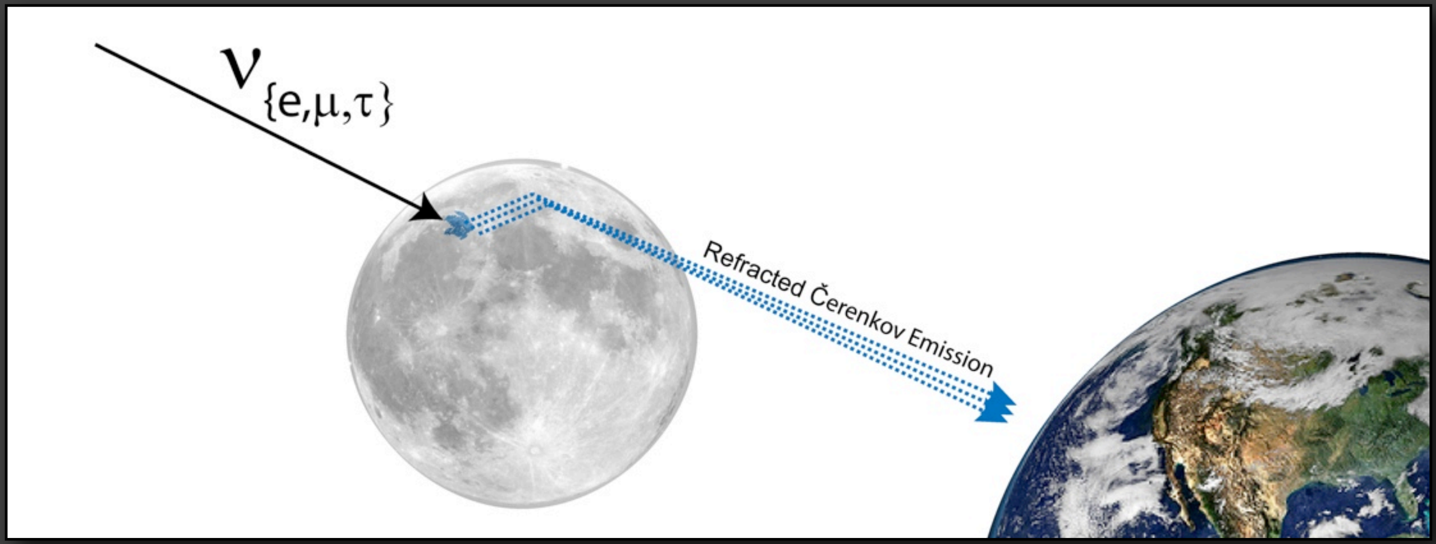
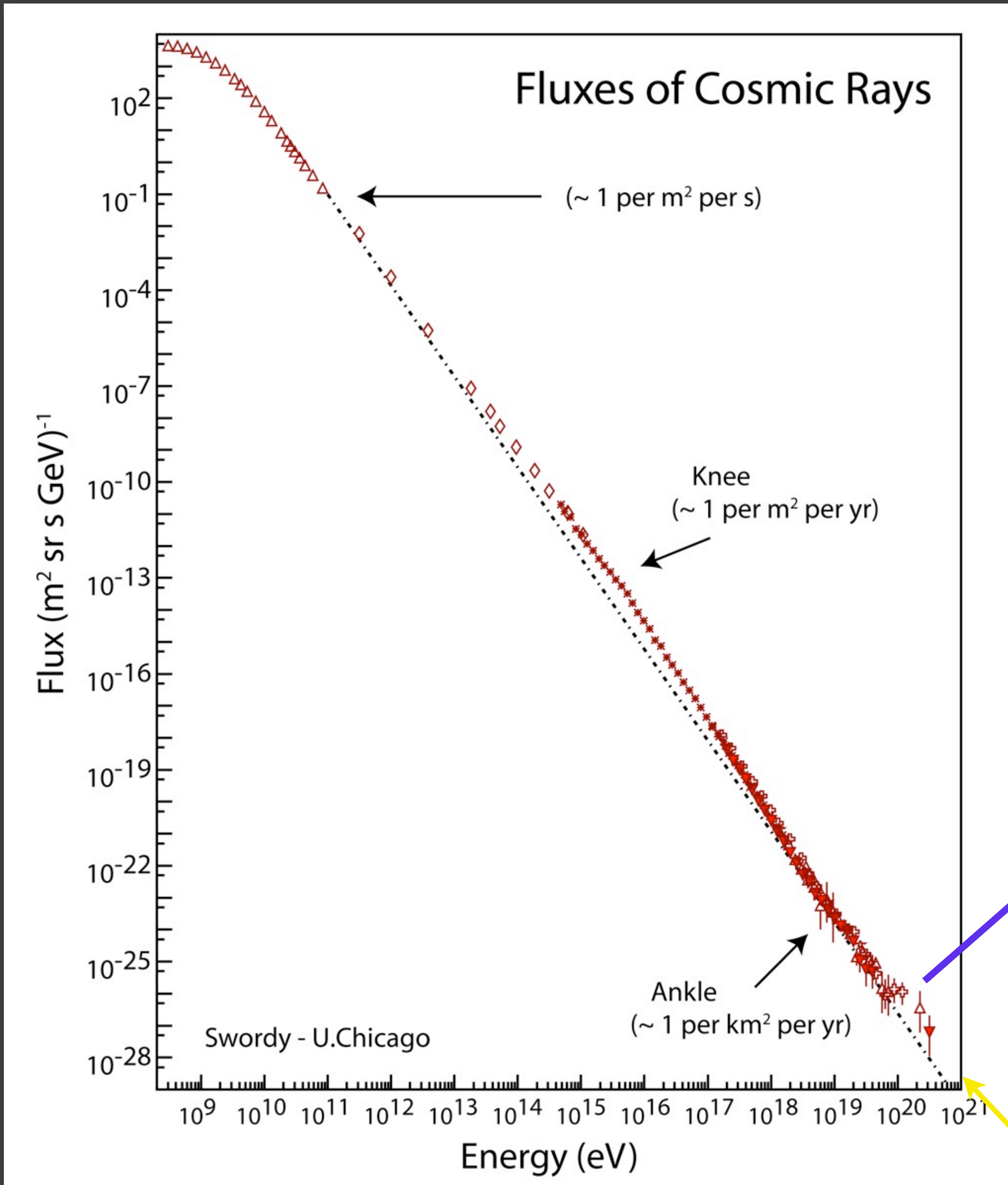
THE UNIVERSITY OF IOWA

Radio EVLA Search for UHE Neutrinos (RESUN)

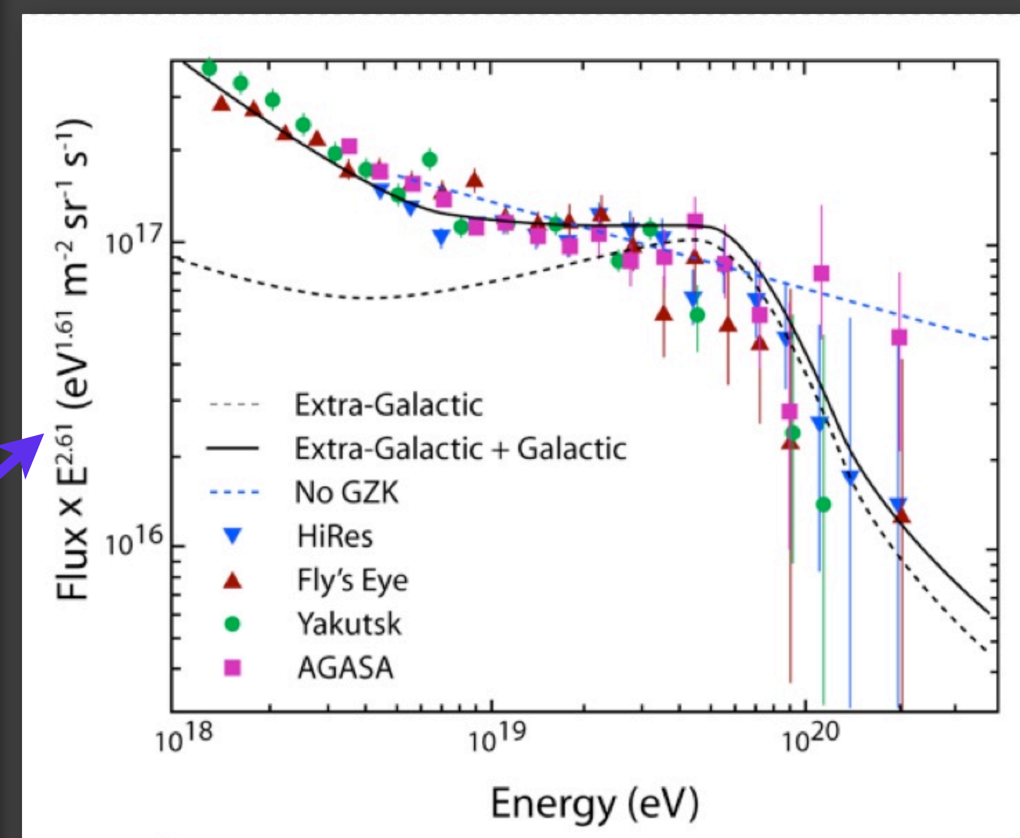
Robert Mutel, Ted Jaeger, Ken Gayley
University of Iowa



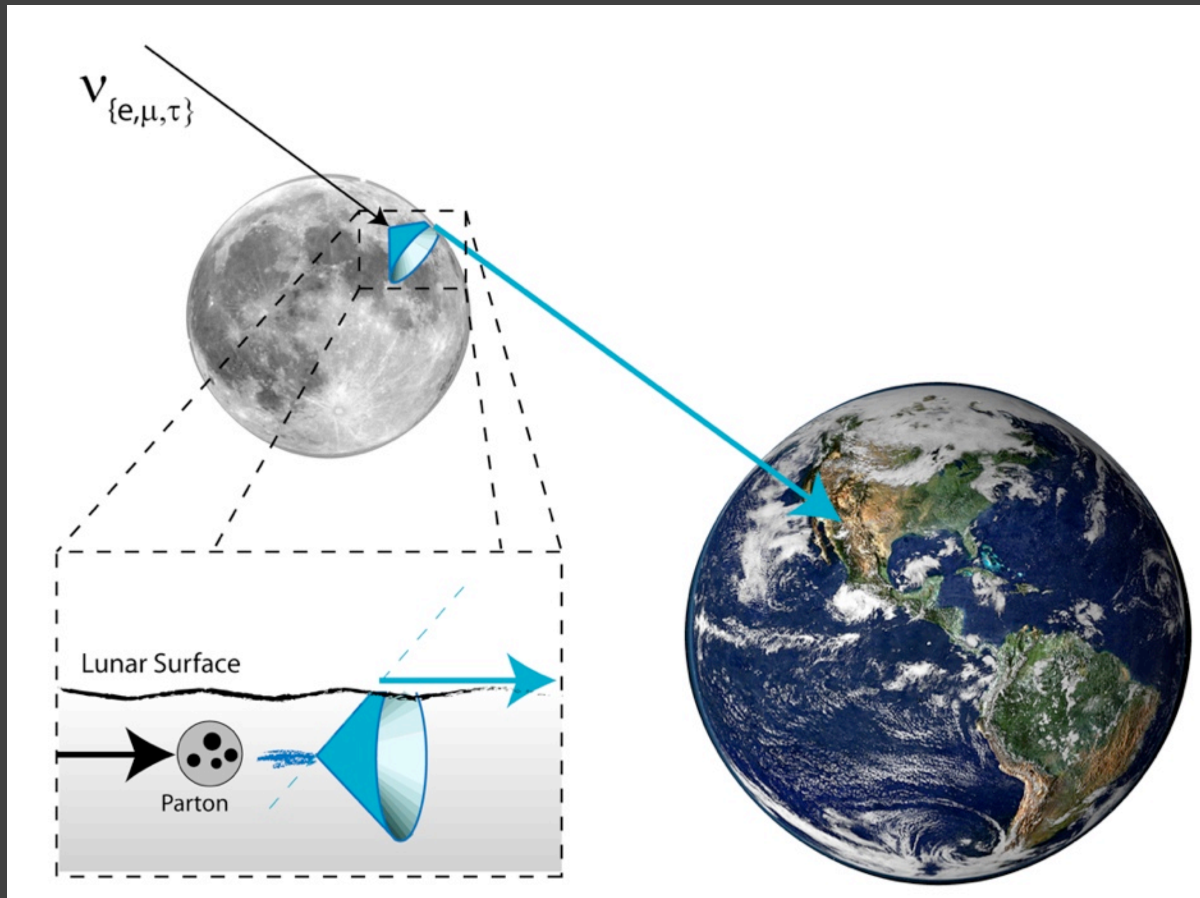


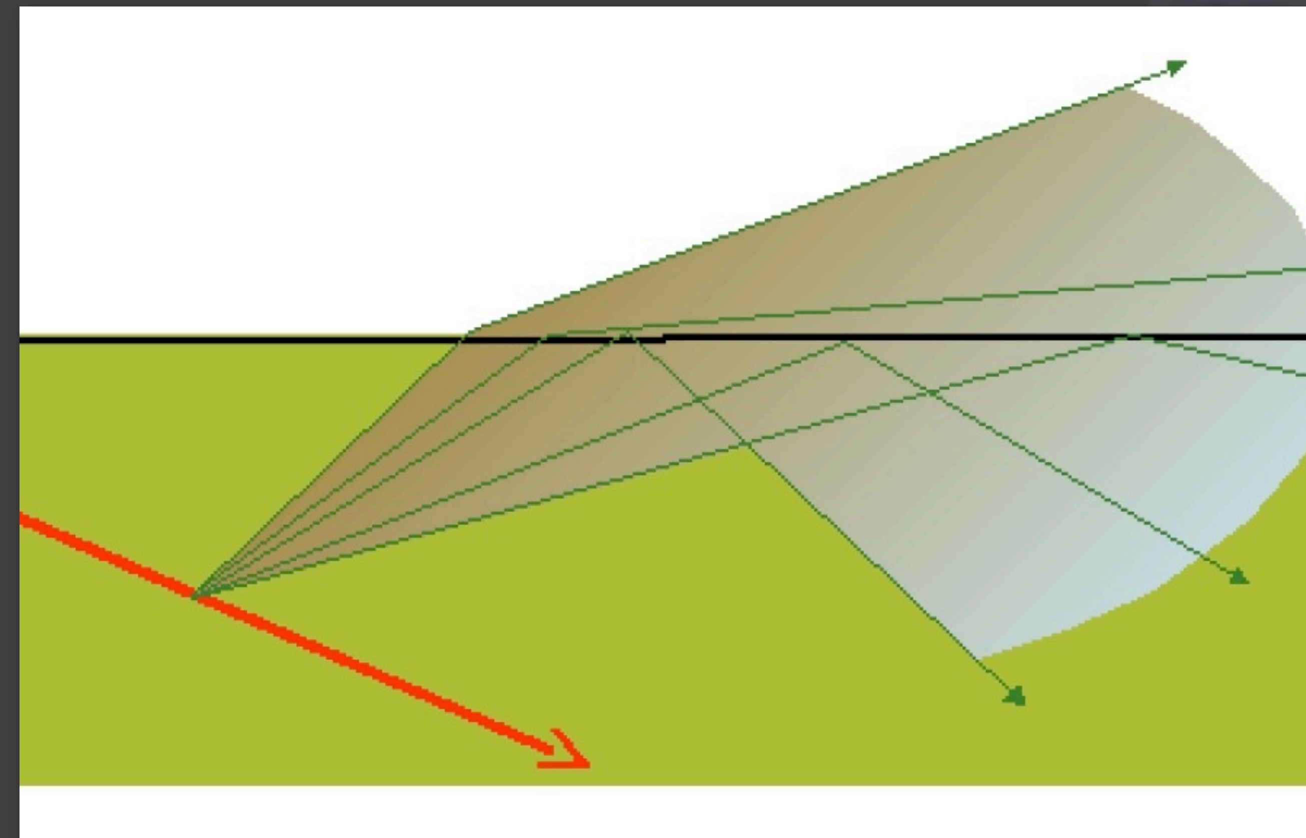
COSMIC RAY SPECTRUM

RESUN SEARCHES FOR UHE NEUTRINOS ABOVE GZK LIMIT ($E > 10^{19.5}$ EV)



TERRA INCOGNITA

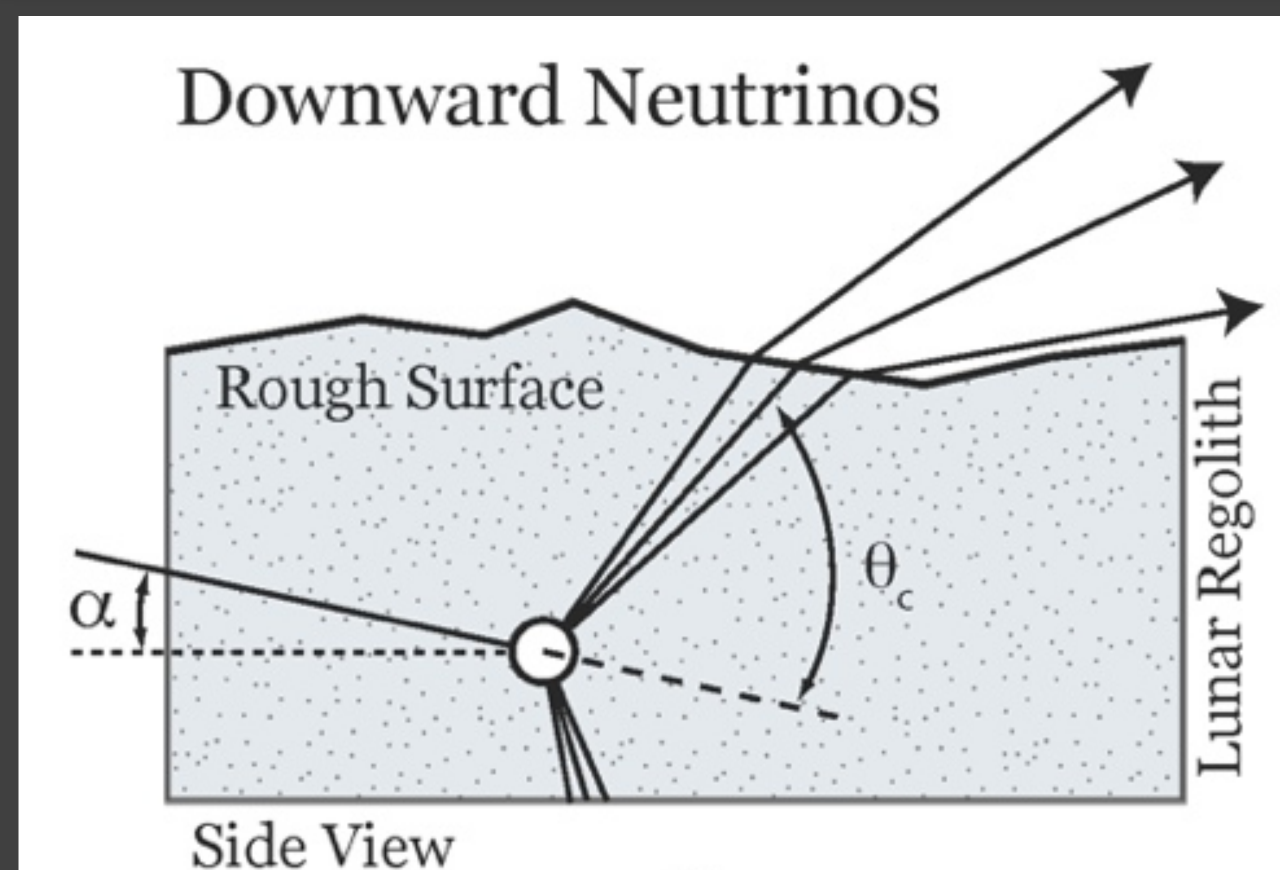




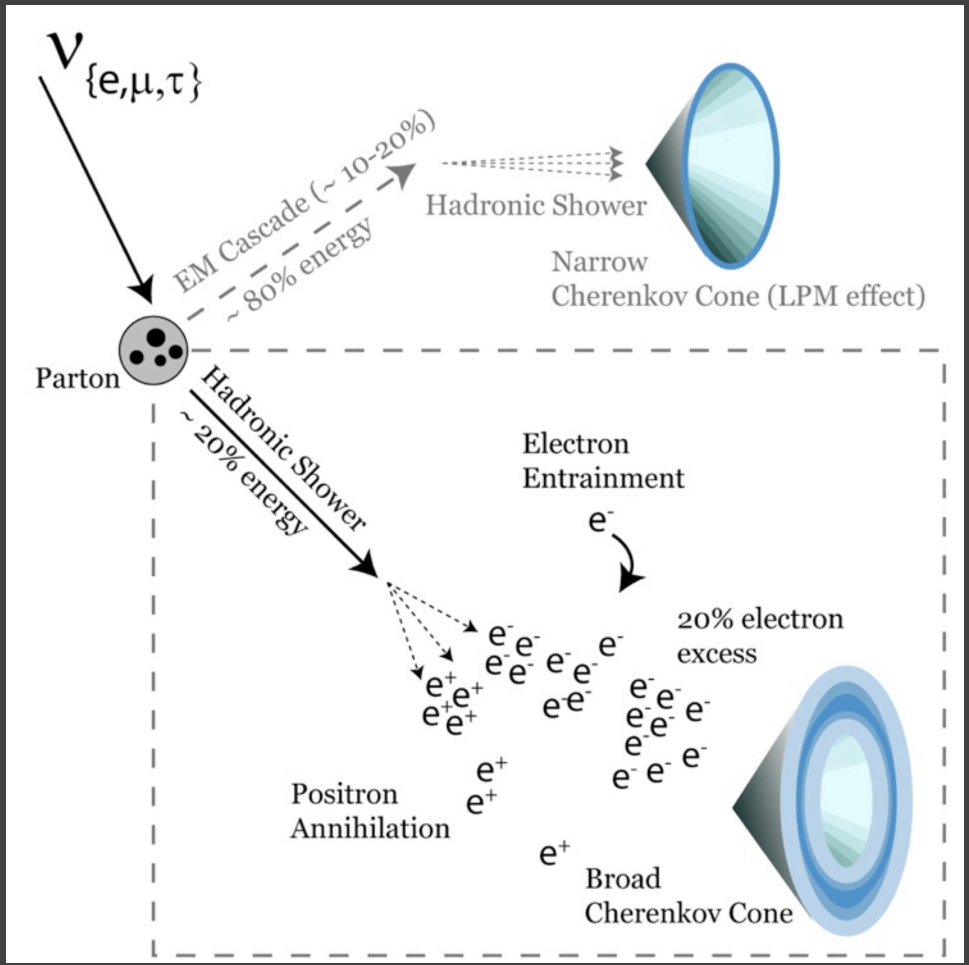
CERENKOV RADIATION CONE ESCAPE GEOMETRY

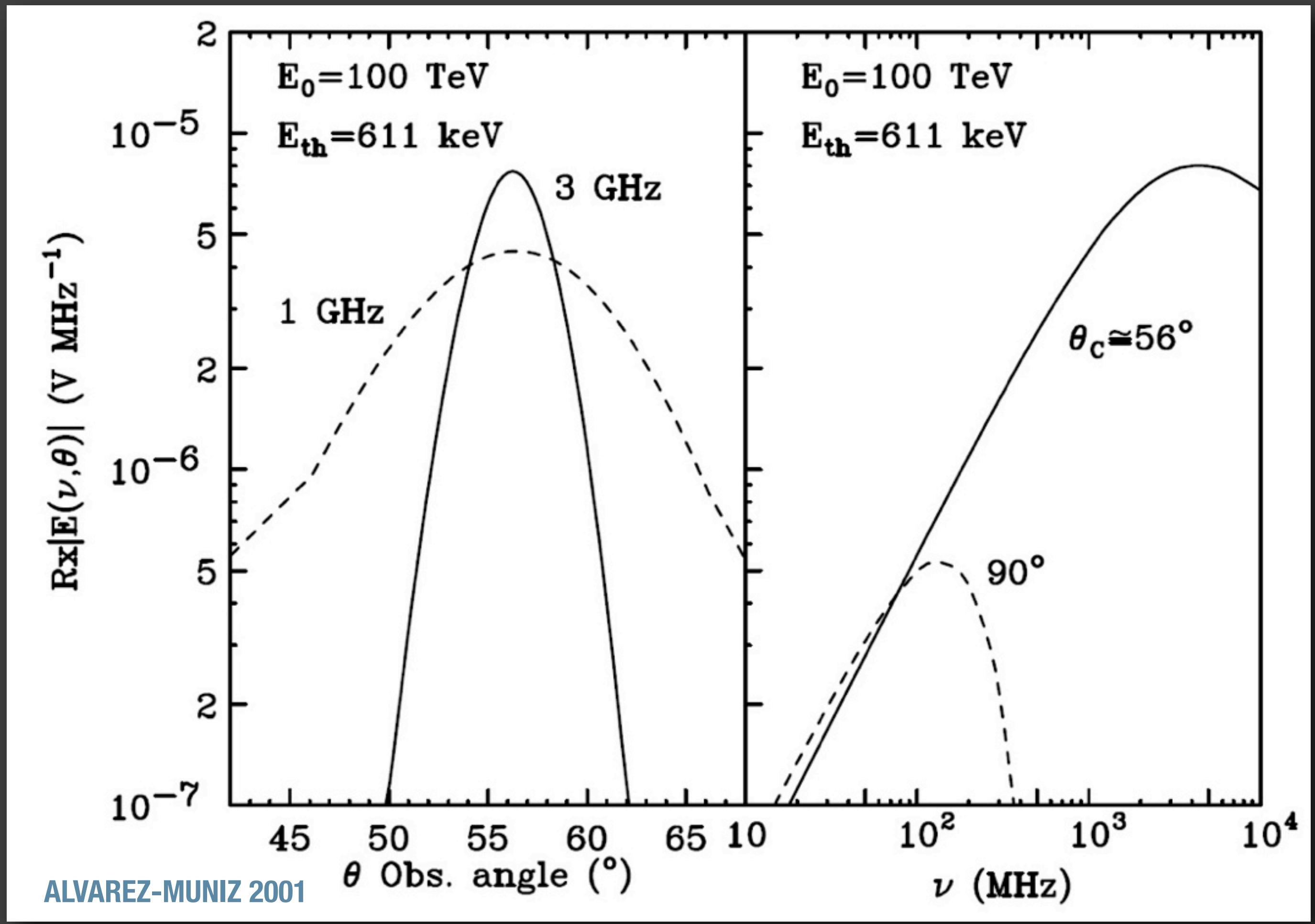
ONLY GLANCING TRAJECTORIES PRODUCE ESCAPING RADIATION

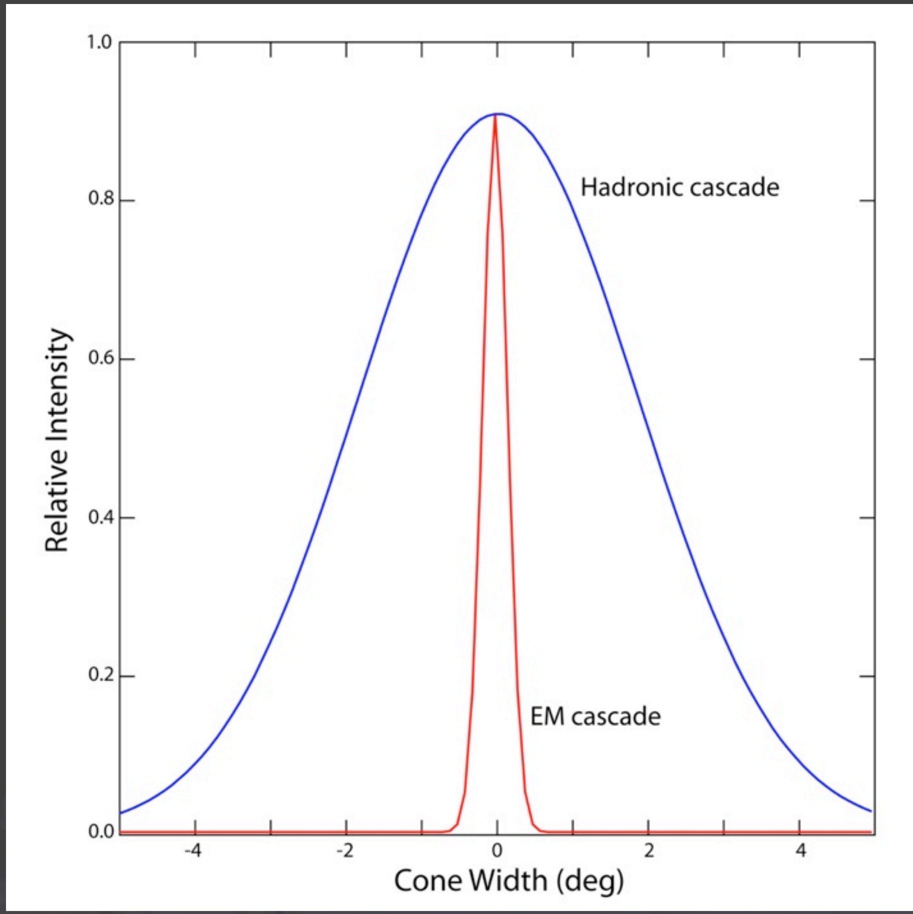
LUNAR SURFACE ROUGHNESS GREATLY INCREASES ESCAPE PROBABILITY



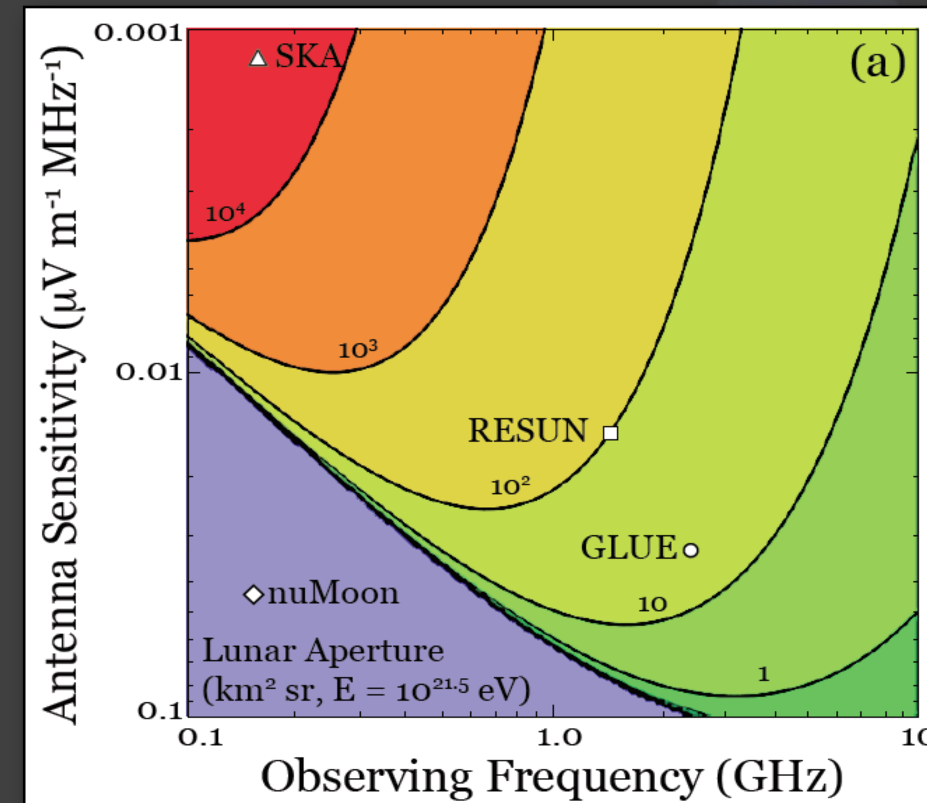
CERENKOV BEAM CHARACTERISTICS







ANALYTIC APERTURE IS A FUNCTION OF LUNAR INTERACTIONS PARAMETERS, FREQUENCY, DETECTOR SENSITIVITY



$$P(E) = \frac{2}{\pi^{5/2}} \frac{(n_r^2 - 1)}{n_r^2} f_o^2 \left(\frac{L_\gamma}{L_\nu}\right) \int_{-\infty}^{\infty} dw\, e^{-w^2} \int_0^{\pi/2} d\phi' \times \int_{-\infty}^{\infty} d\Delta\, \Upsilon\left(1 - \frac{\Delta^2}{f_o^2 \Delta_o^2}\right) \int_{-\infty}^{\infty} d\alpha\, e^{-\tau_\nu} \int_0^{\phi_R} d\phi\, \xi(\beta) \mathcal{H}_R(\phi_R)$$

$$A(E) \cong A_o \frac{(n_r^2 - 1)}{8 n_r} \frac{L_\gamma}{L_\nu} f_o^3 \Delta_o (\Psi_{ds} + \Psi_{dr} + \Psi_u) ,$$

where

$$\Psi_{ds} = f_o \Delta_o$$

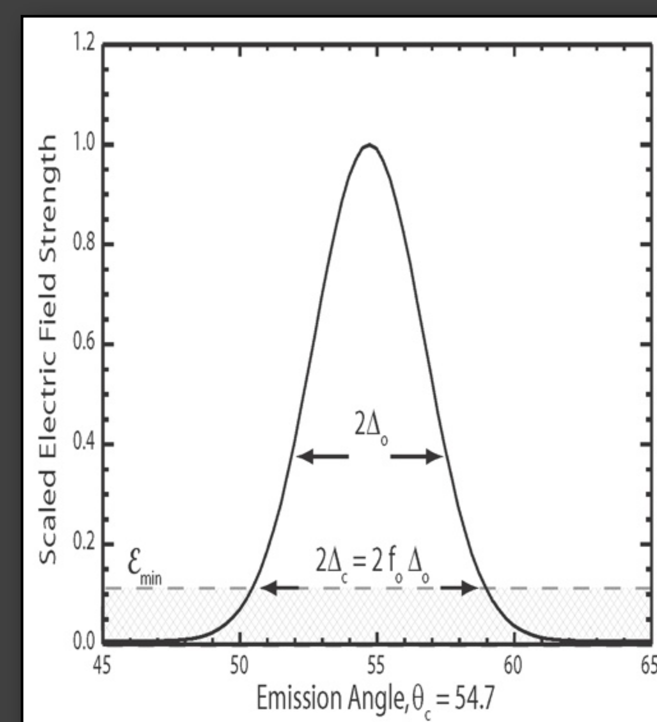
accounts for downward detections without help from roughness,

$$\Psi_{dr} = \frac{16}{3\pi^{3/2}} \sigma_o = 0.96\, \sigma_o$$

accounts for downward detections assisted by roughness, and

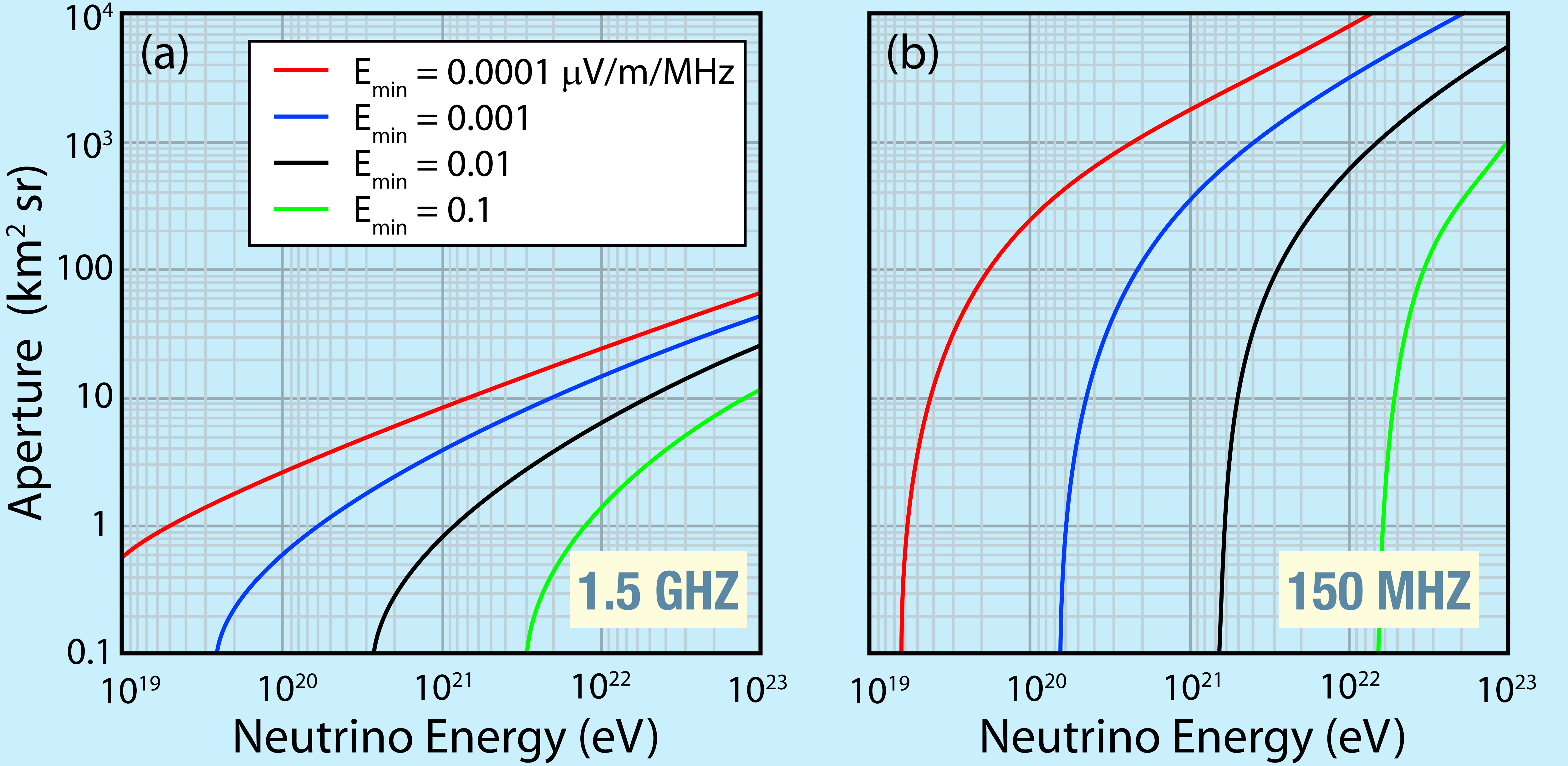
$$\Psi_u = \frac{16}{3} \alpha_o = 5.3\, \alpha_o$$

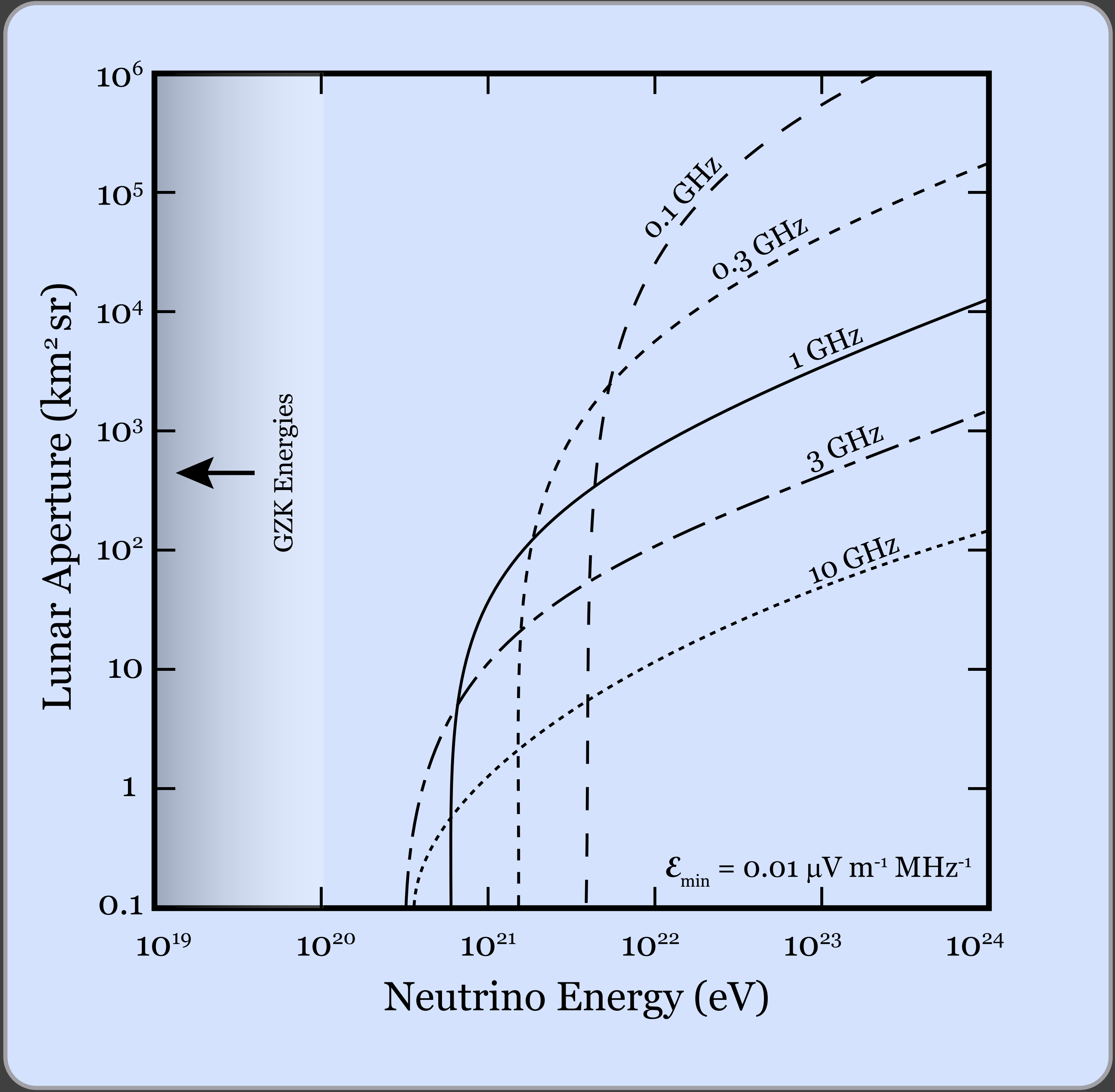
accounts for the detection of upward neutrinos.



DETAILS: GAYLEY, MUTEL, AND JAEGER APJ 2010

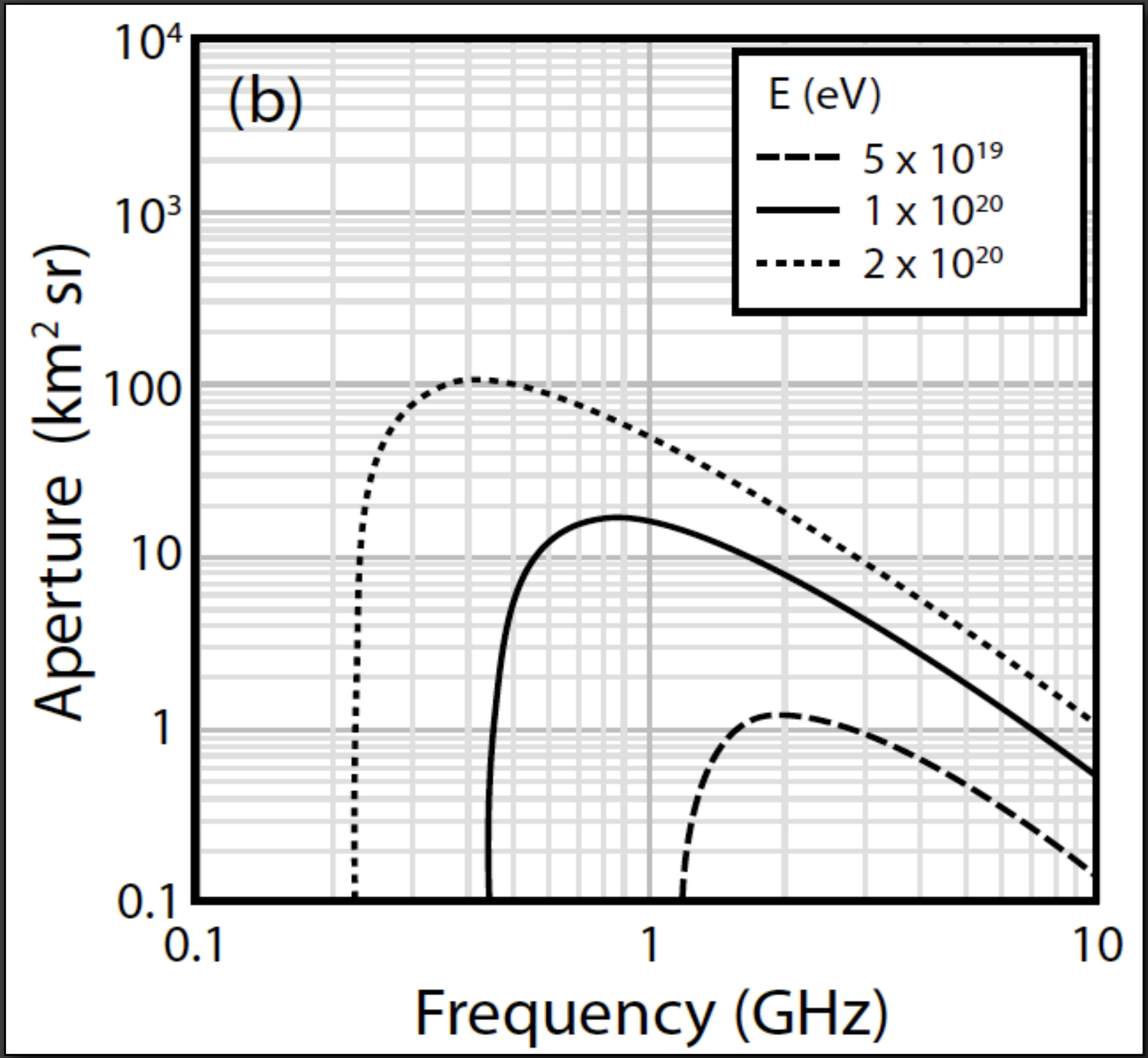
APERTURE DEPENDENCE ON NEUTRINO ENERGY, FREQUENCY





APERTURE VS ENERGY

FREQUENCIES NEAR 1 GHZ MAXIMIZE ENERGY SENSITIVITY x APERTURE

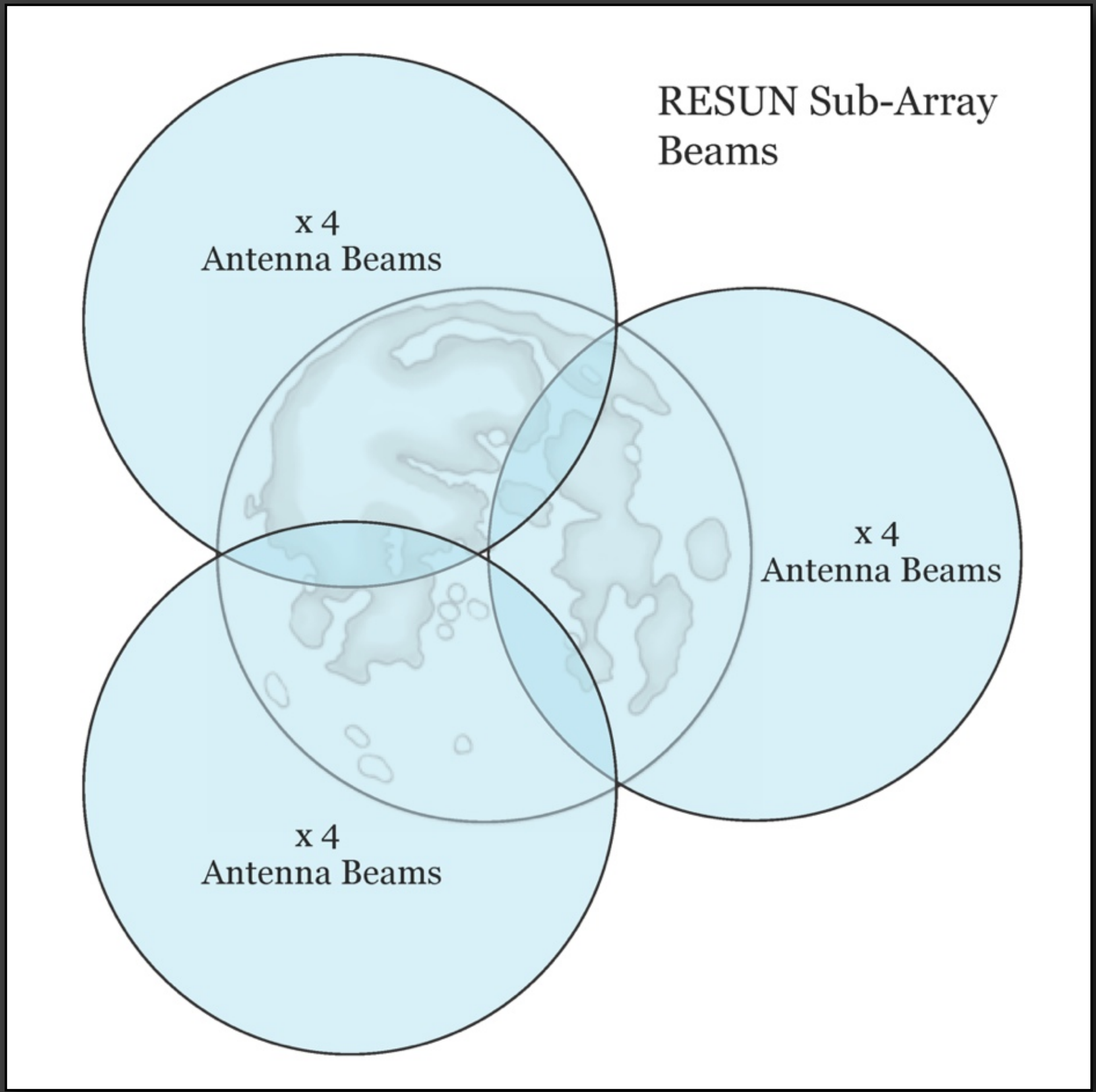


APERTURE VS. FREQUENCY

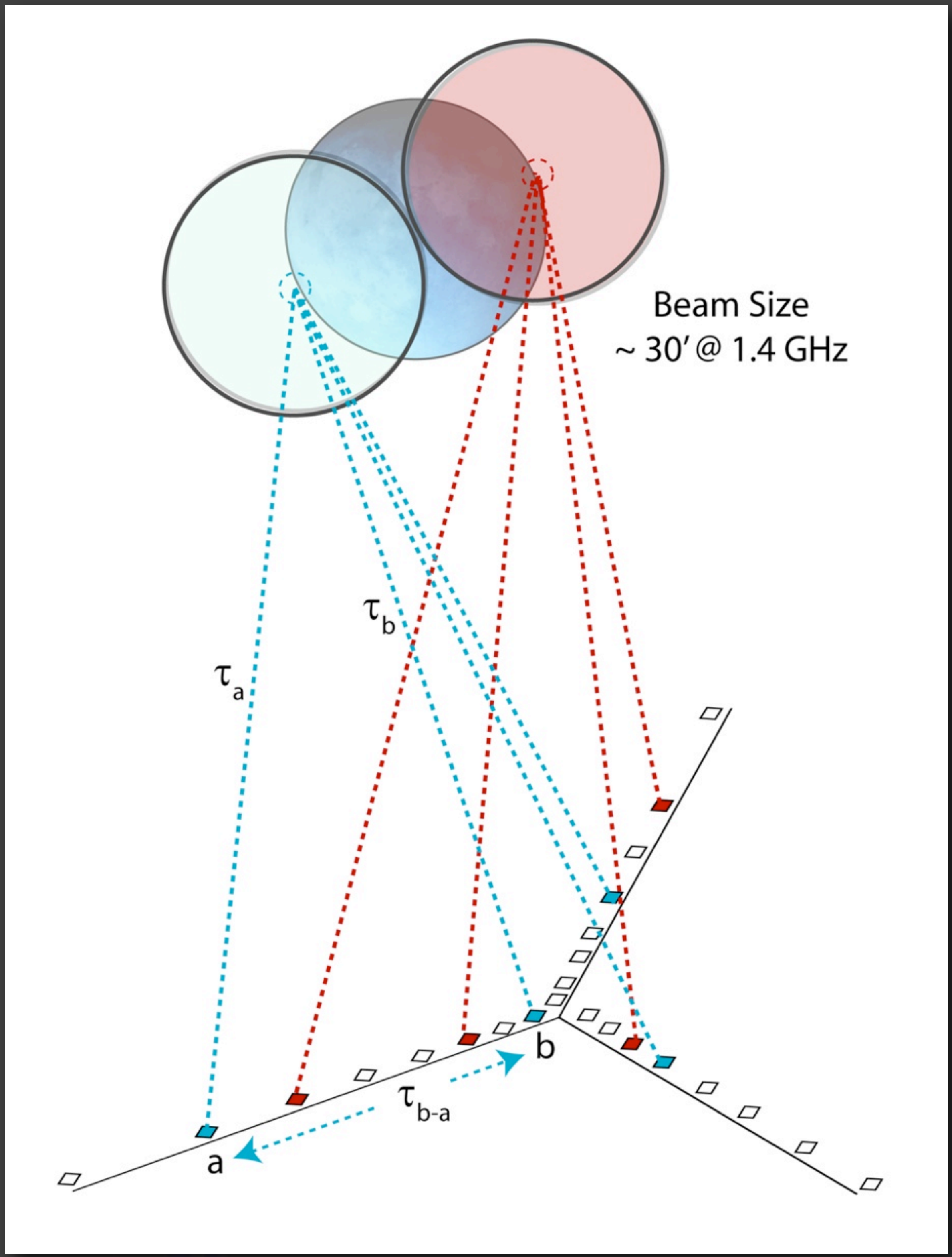
FOR FIXED TARGET ENERGY, THERE IS AN OPTIMAL OBSERVING FREQUENCY

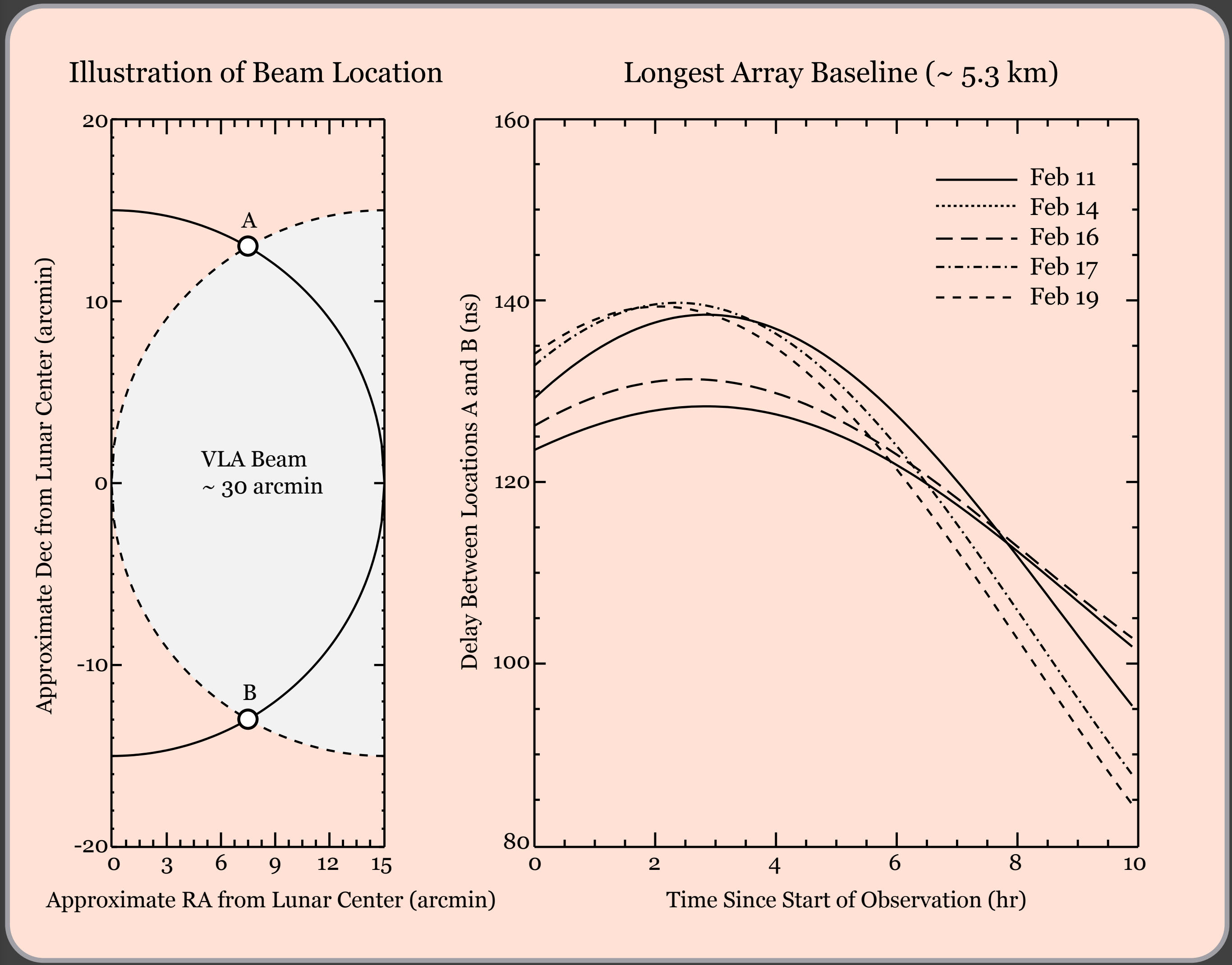
RESUN Experiment Overview

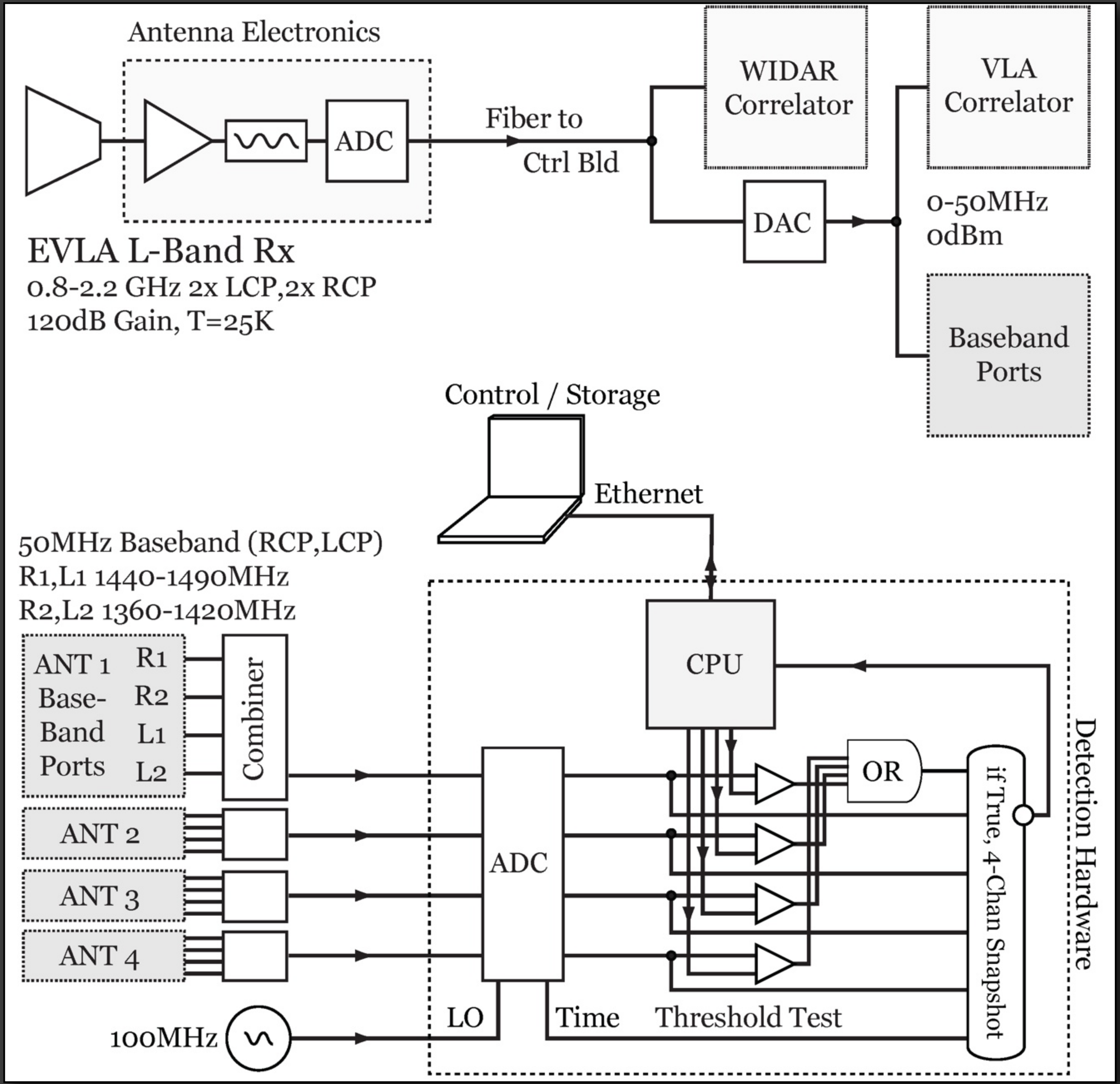
- 250 hours, 1.4 GHz, 4x50 MHz bandwidth 9combine RCP, LCP)
- Use **three subarrays of 4** EVLA Antennas spaced around lunar limb
- 10 ns sampling, real-time 4 sigma threshold pulse detection (FPGA)
- Post-processing: Check for coincident pulses (with correct geometric delay).

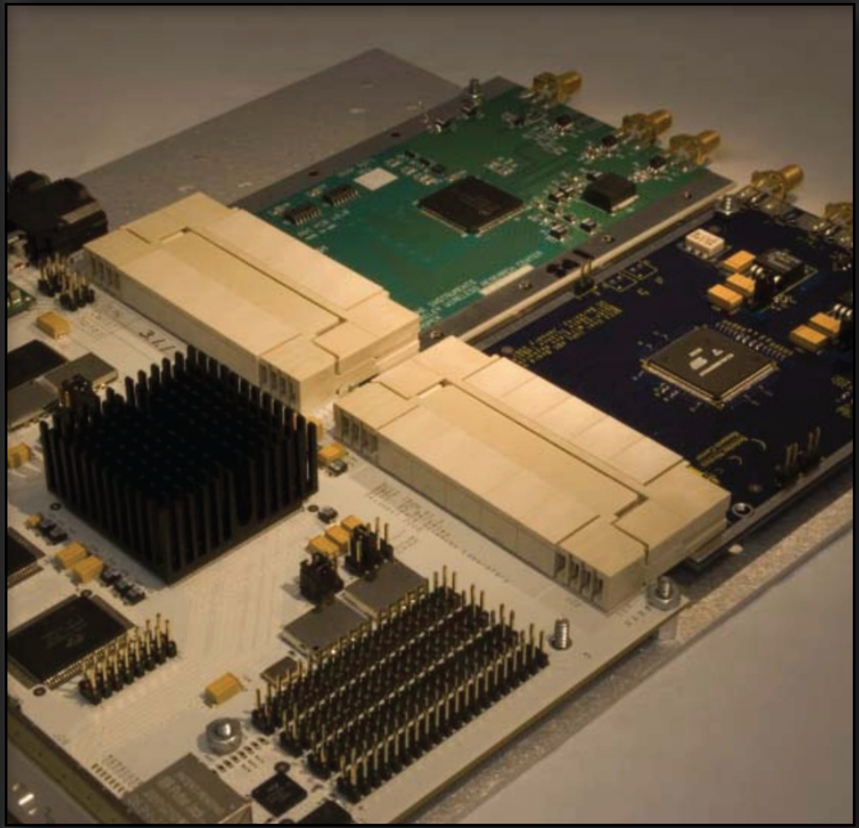


RESUN BEAM GEOMETRY: DIFFERENTIAL DELAY WINDOW



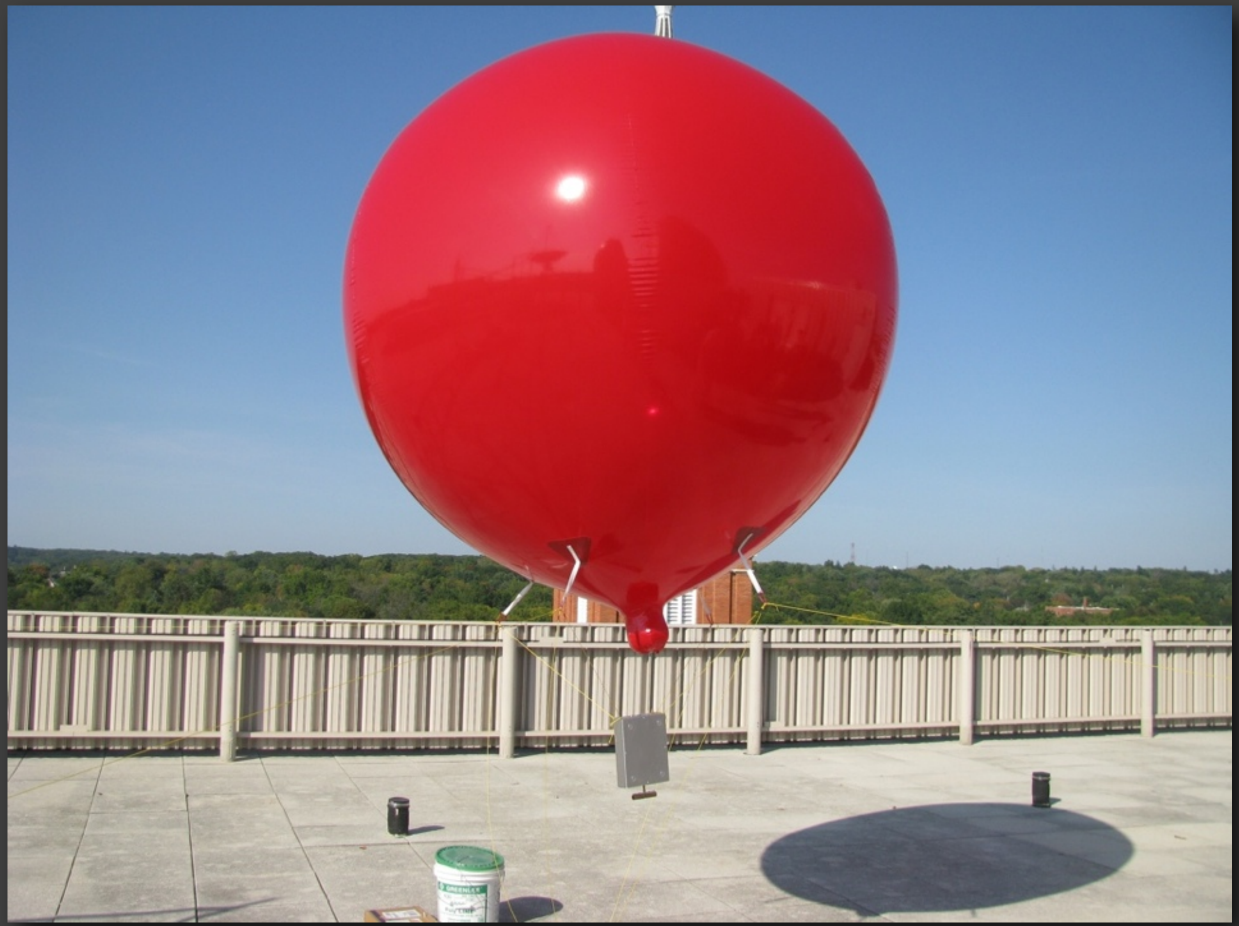


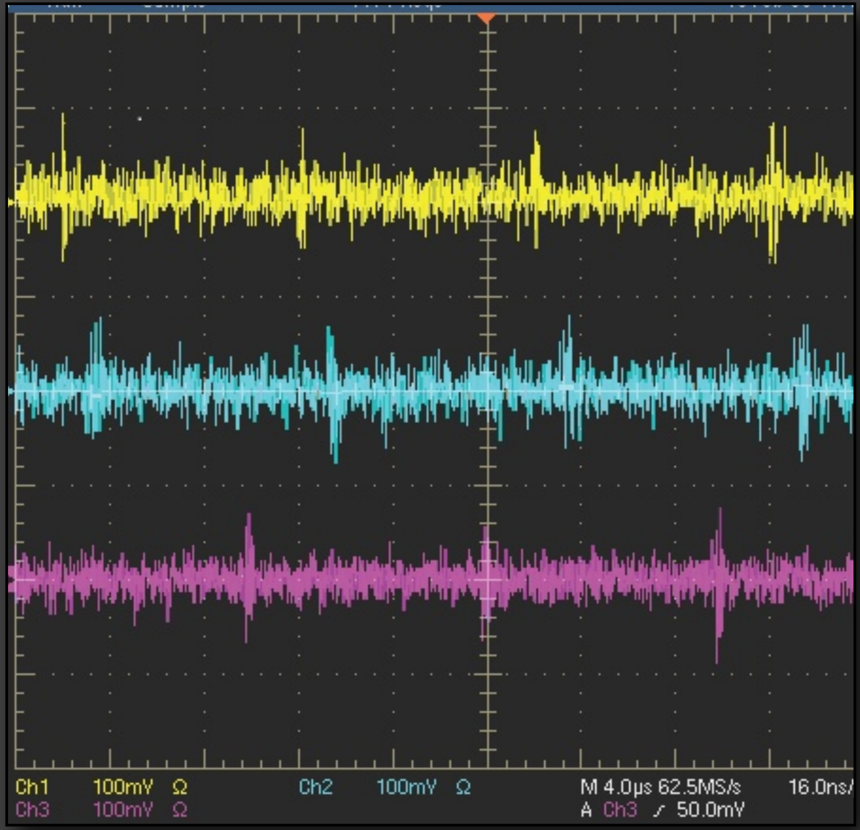




RESUN OBSERVATIONS

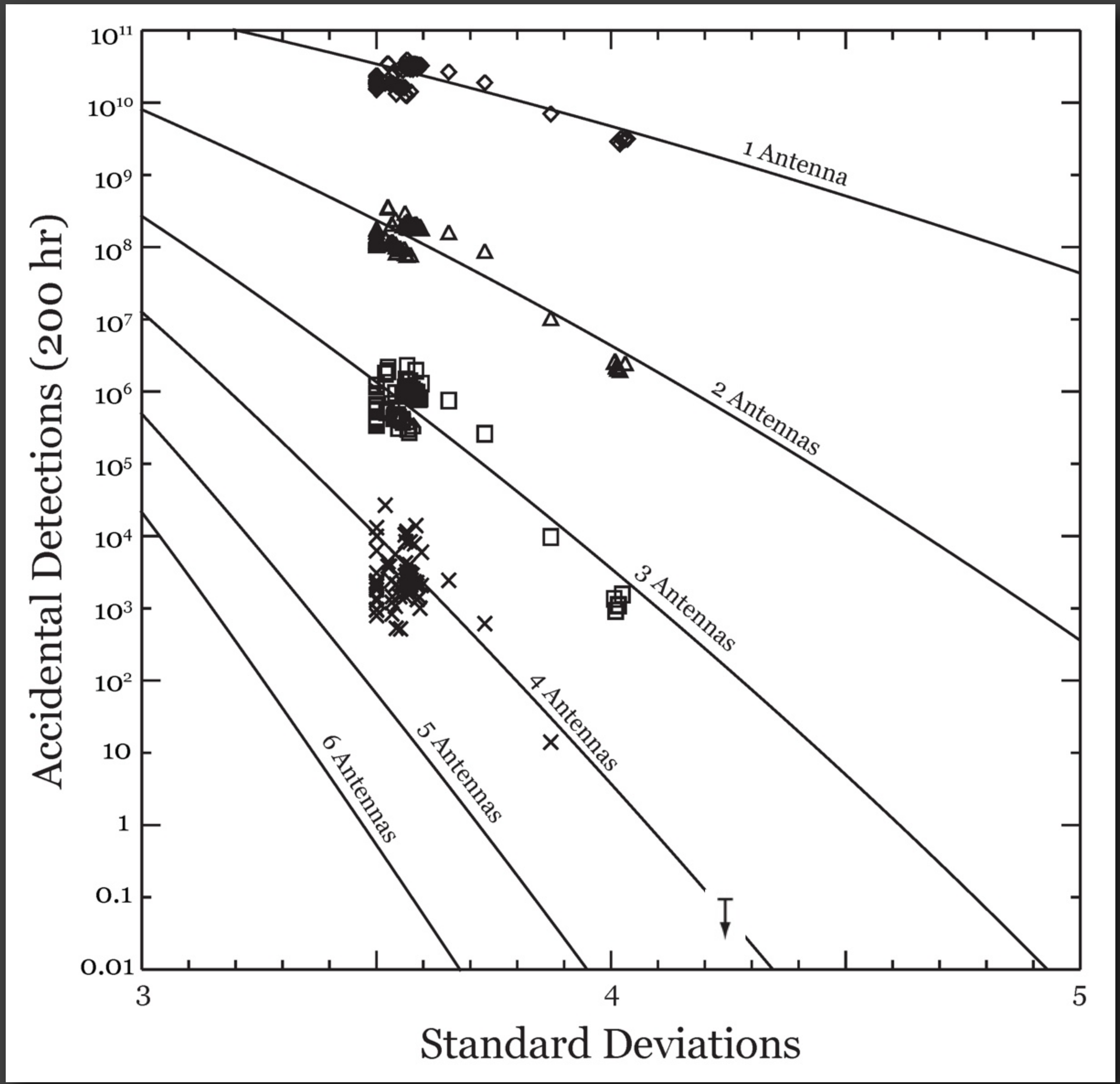
DETECTION HARDWARE





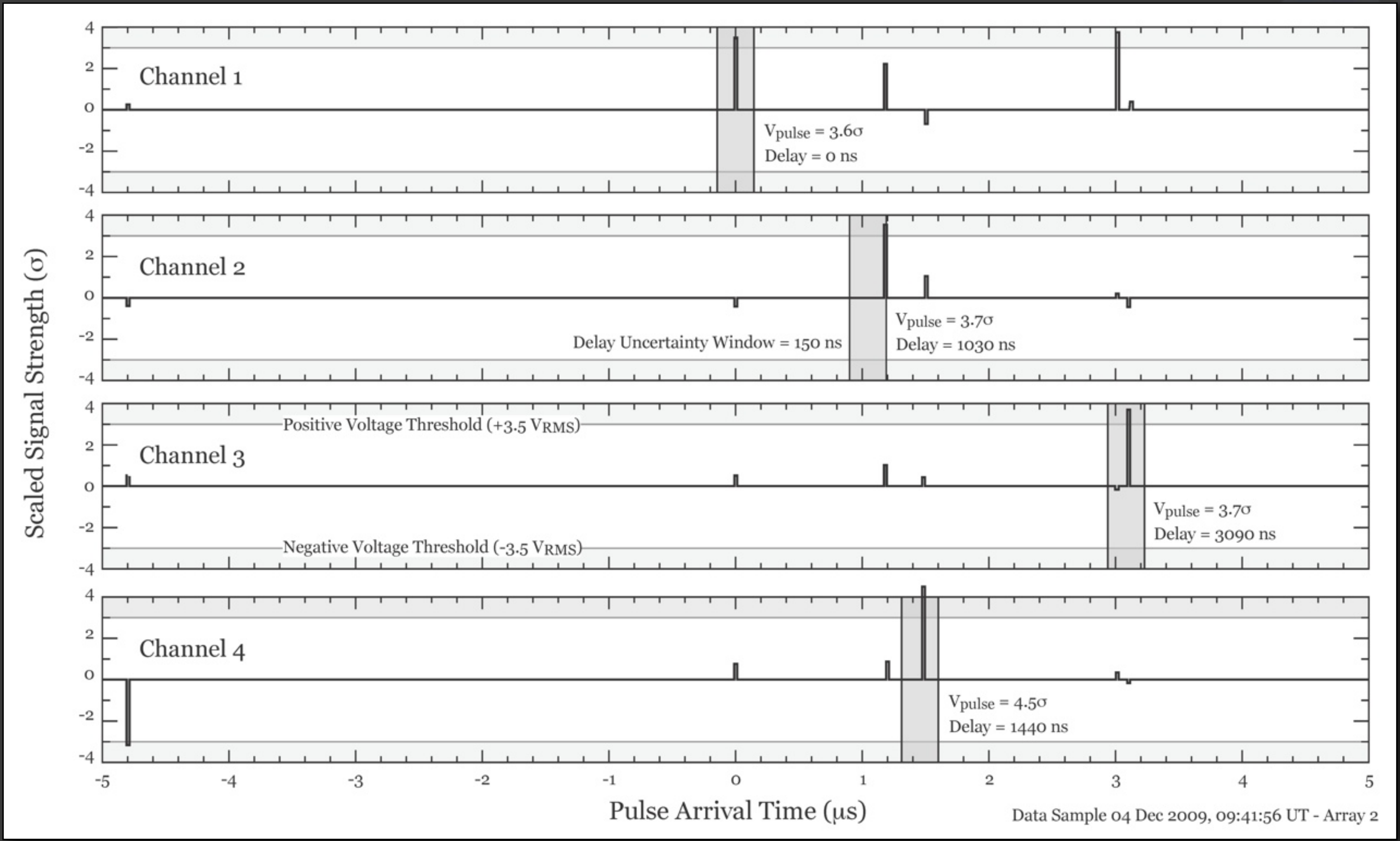
RESUN CALIBRATION

BALLOON-BORNE TRANSMITTER: PULSE DETECTION VERIFICATION



OBSERVED PULSE COINCIDENCES

CONFIRMS EXPECTED GAUSSIAN STATISTICS, NO 4-ANTENNA DETECTIONS ABOVE THRESHOLD

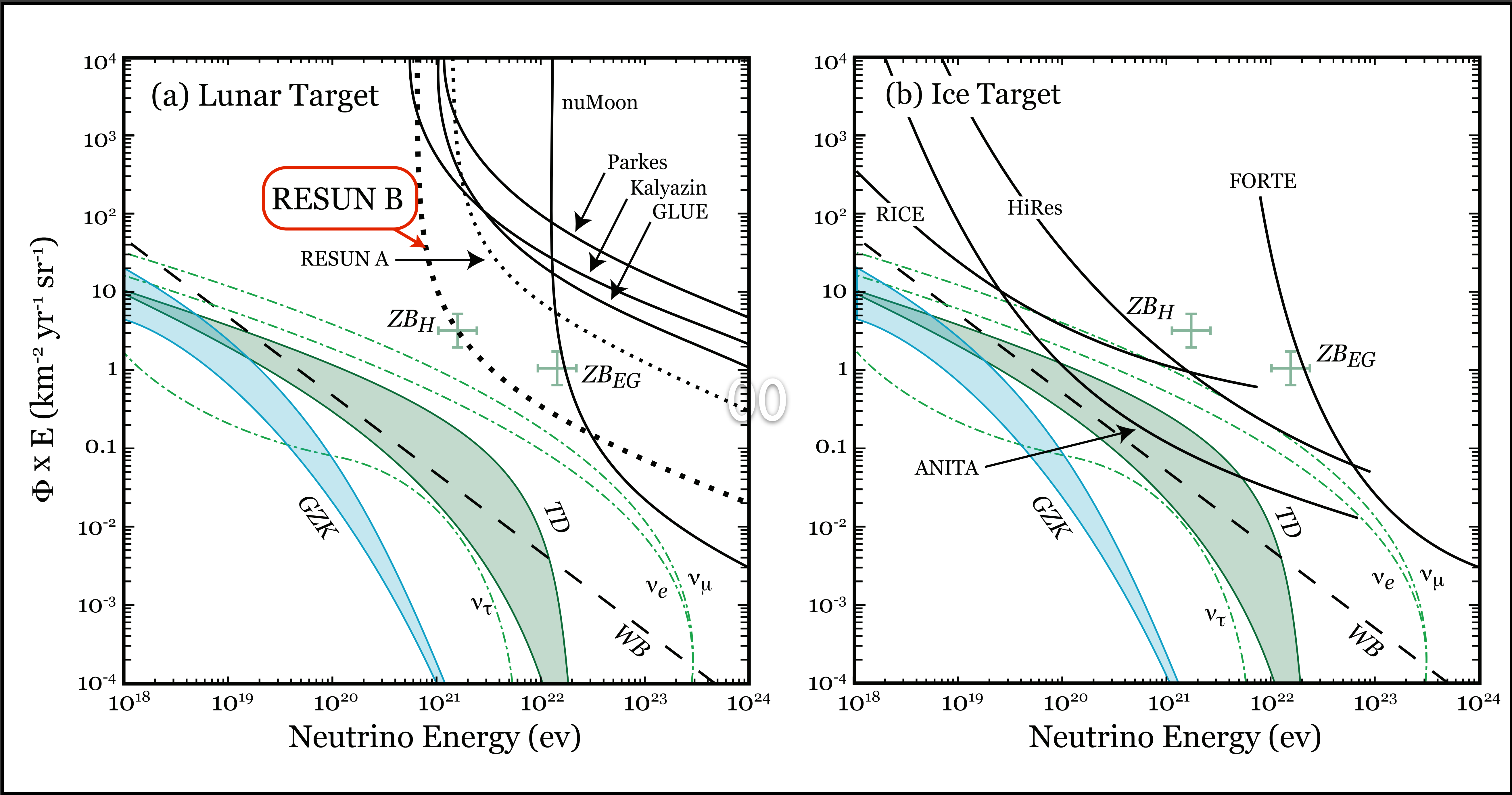


RESUN OBSERVATIONS

EXAMPLE OF ACCIDENTAL COINCIDENT PULSE DETECTION WITH WIDE DELAY WINDOW

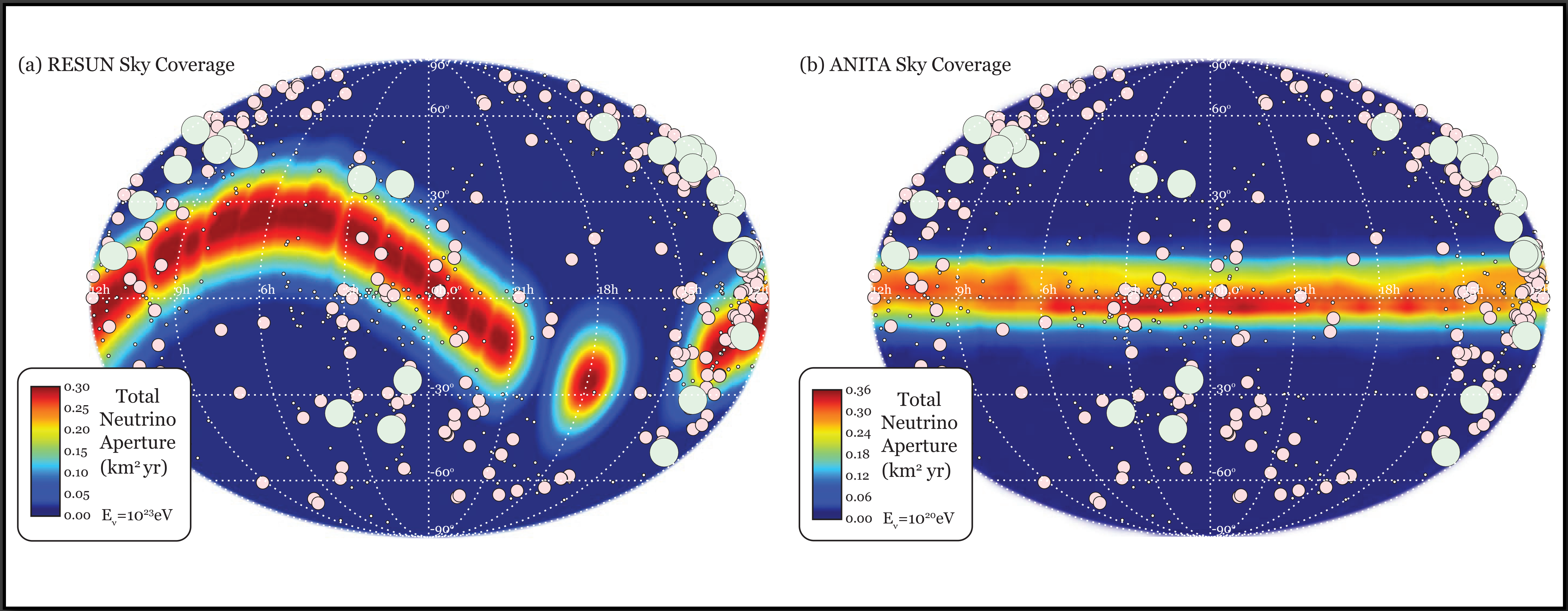
RESUN RESULTS

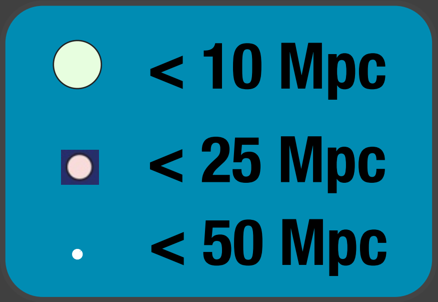
- No Pulses of Lunar Origin (250 hr)
  - Lowest Upper Limit from Lunar-Target Observations
    - $E\ dN/dE < 1\ km^{-2}\ yr^{-1}\ sr^{-1}$ for $E > 10^{21.2}$ eV
  - Point Source Upper Limits for 41 AGN within 50 Mpc



RESUN RESULTS

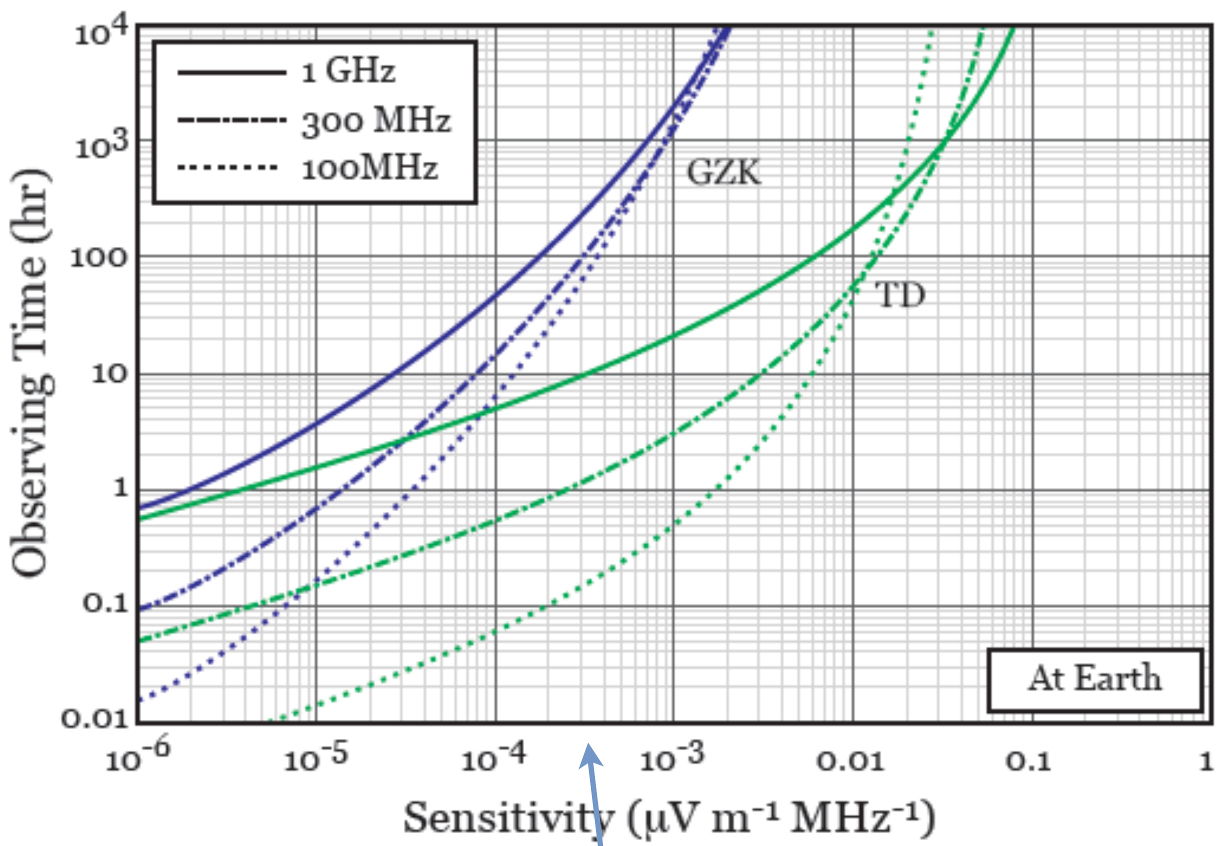
UHE NEUTRINO ISOTROPIC FLUX UPPER LIMITS

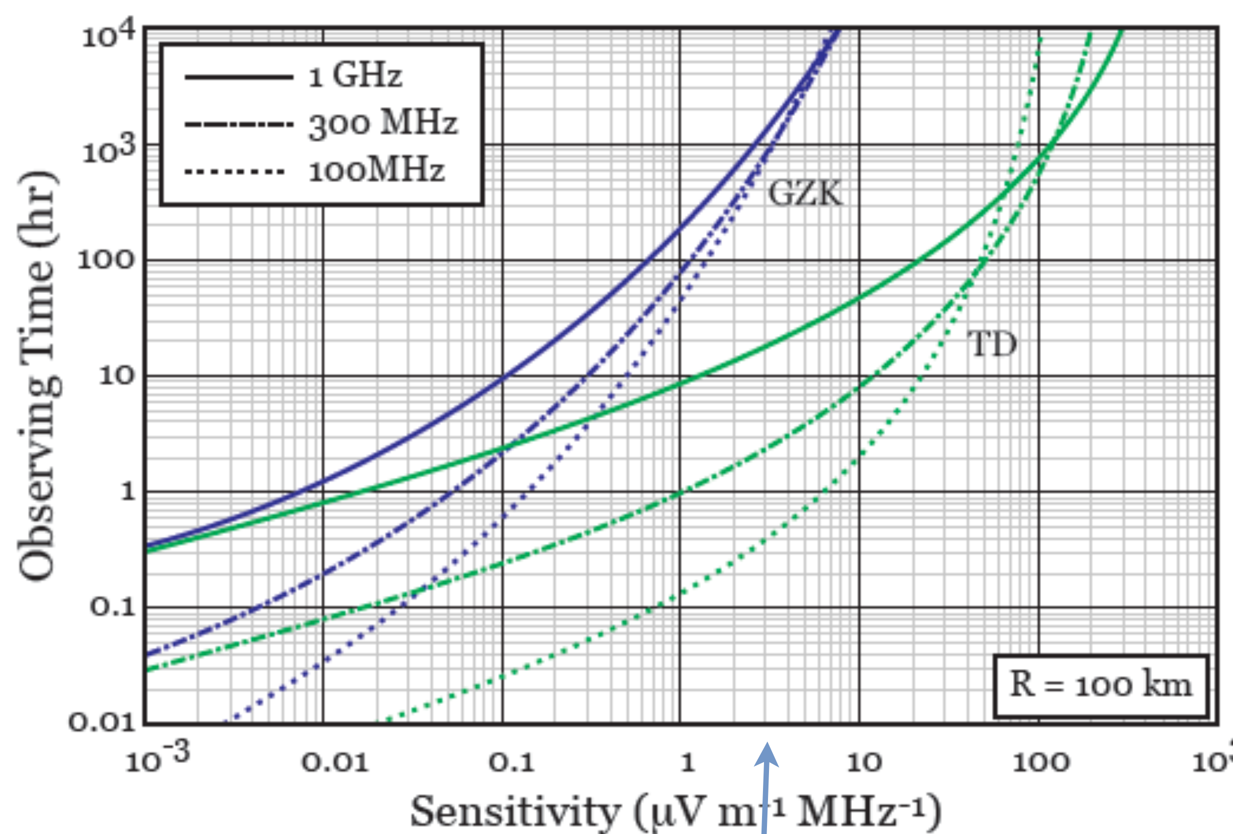




RESUN RESULTS

SKY COVERAGE OF DISCRETE AGN SOURCES - LOCAL AGN



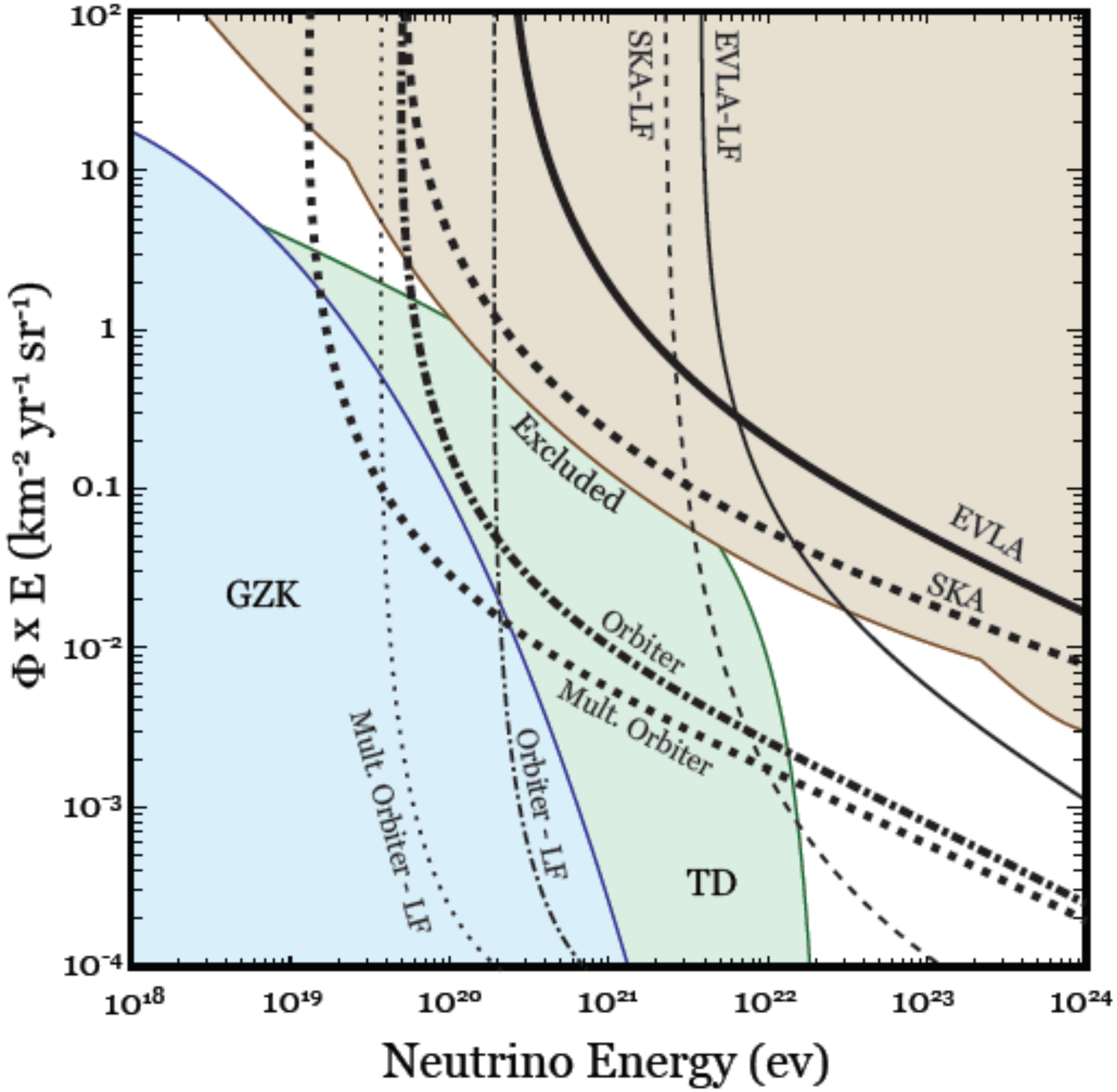


SKA

LUNAR ORBITER (E.G. LORD)

FUTURE DETECTION EXPERIMENTS

ANTICIPATED DETECTION RATE



FUTURE DETECTION EXPERIMENTS

ANTICIPATED UHE NEUTRINO FLUX UPPER LIMITS