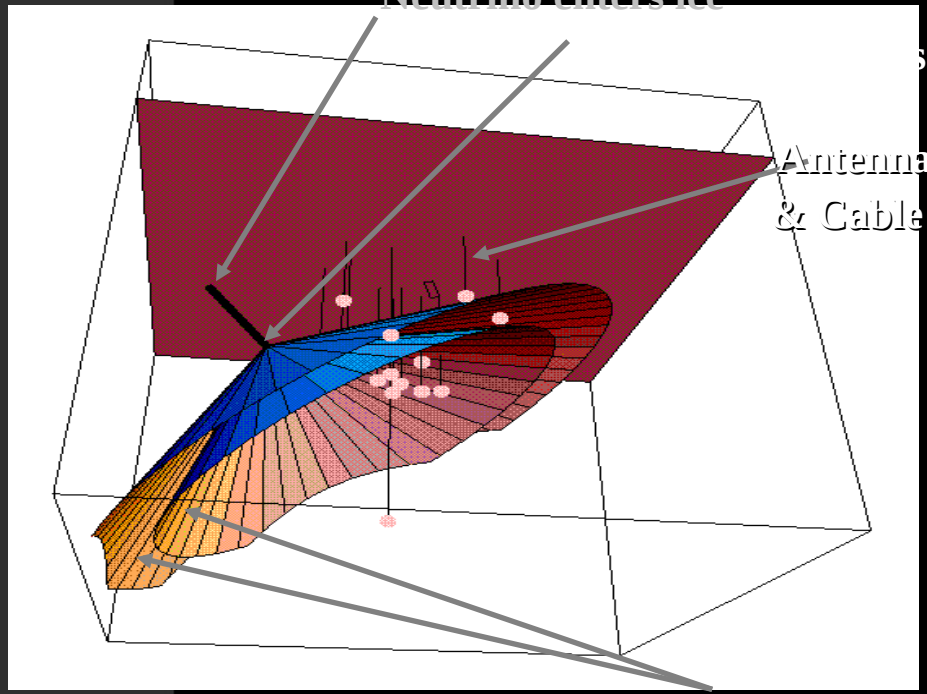
Radio-wave detection of neutrinos
Current Antarctic Experiments:
ARA (South Pole) &
ARIANNA (Moore's Bay)

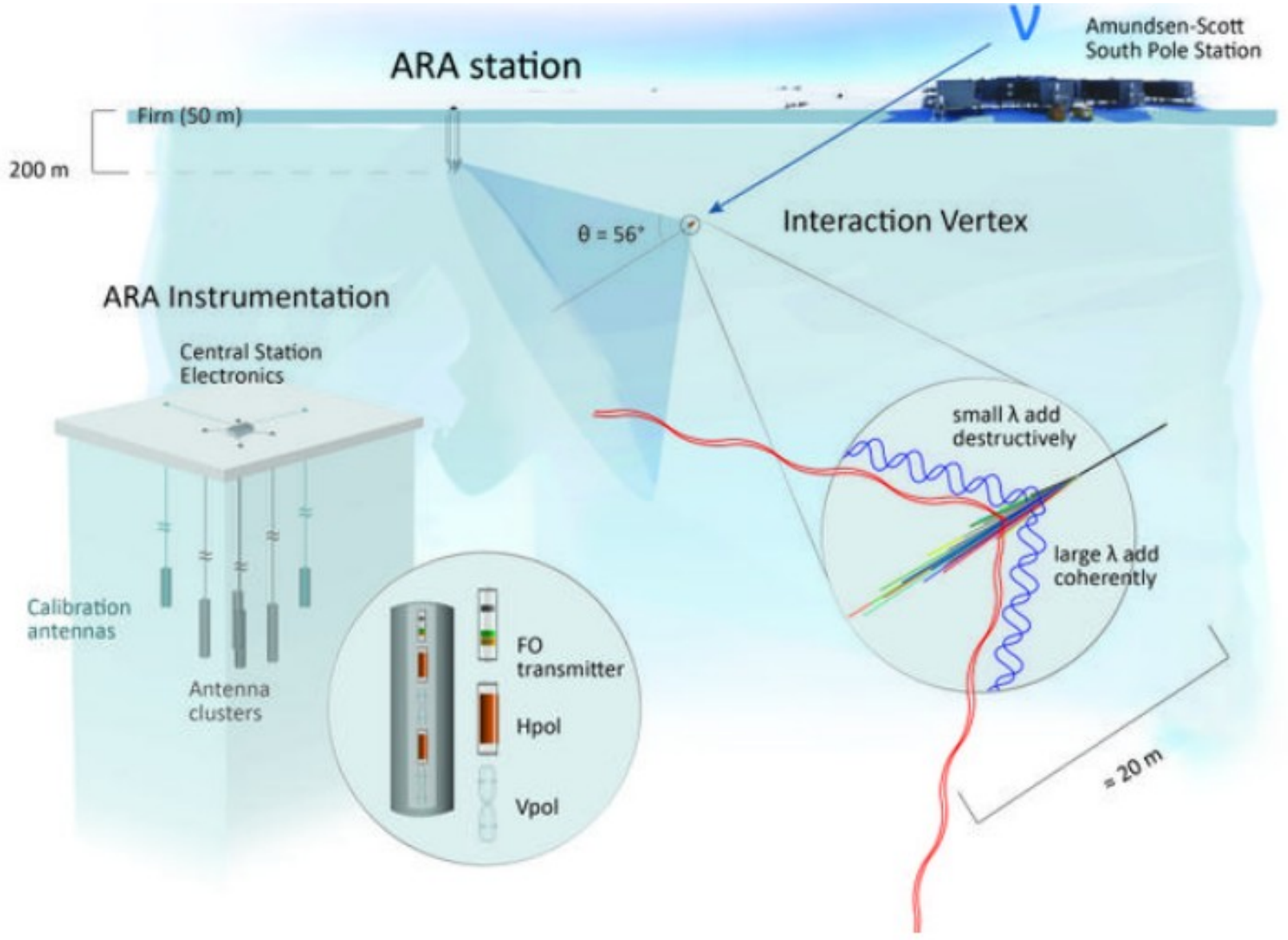
UHE ν:
ARA,
ARIANNA,
ANITA

Radio Detection in South Pole Ice

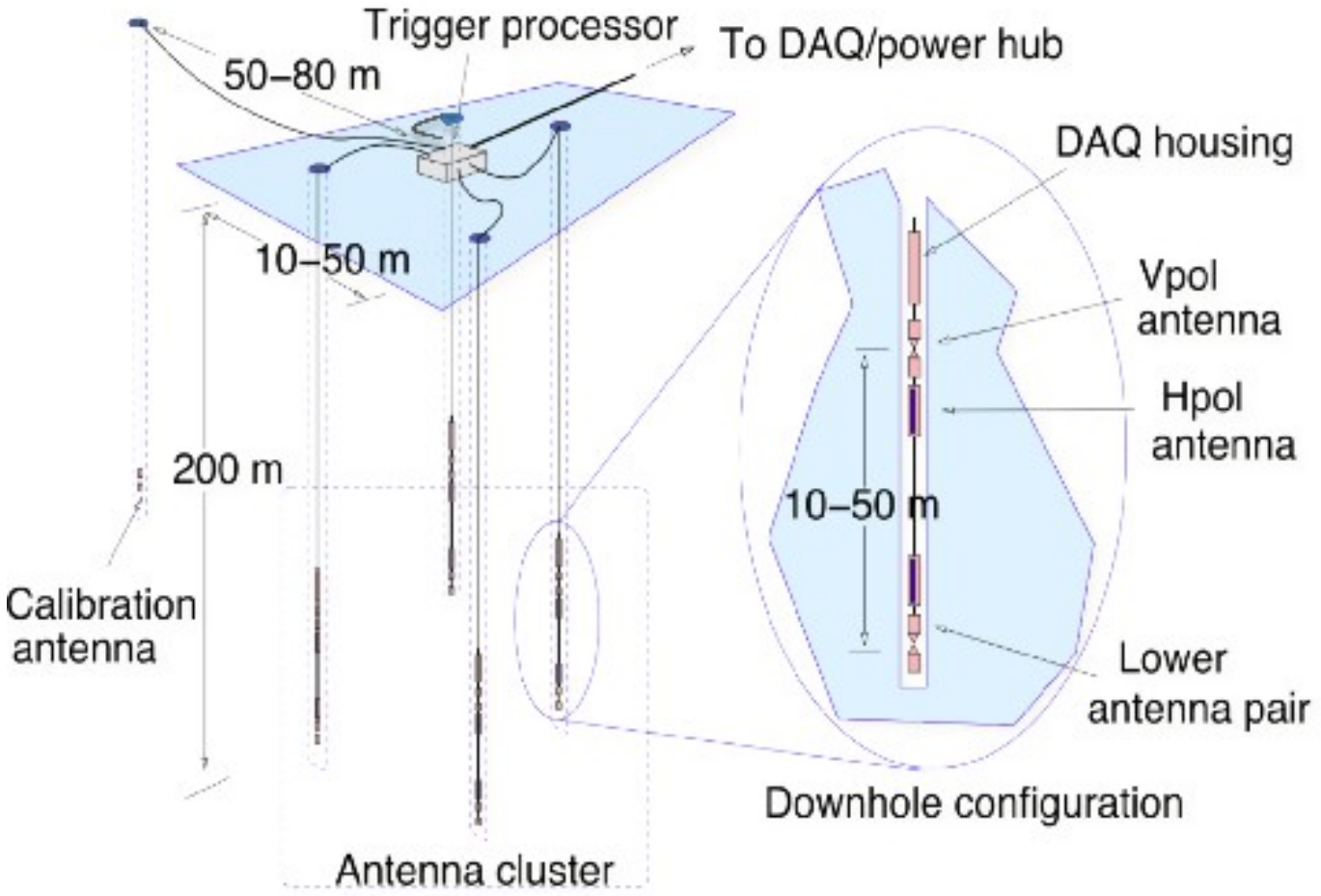


Two cones show 3 dB signal strength

- installed 15 antennas few hundred m depth with AMANDA strings.
- tests and data since 1996.
- most events due to local radio noise, few candidates.
- Askaryan Radio Array near IceCube : first deployments December 2010


ARA station
Amundsen-Scott
South Pole Station
Firn (50 m)
200 m
θ = 56°
Interaction Vertex
ARA Instrumentation
Central Station
Electronics
Calibration
antennas
Antenna
clusters
FO
transmitter
Hpol
Vpol
small λ add
destructively
large λ add
coherently
≈ 20 m

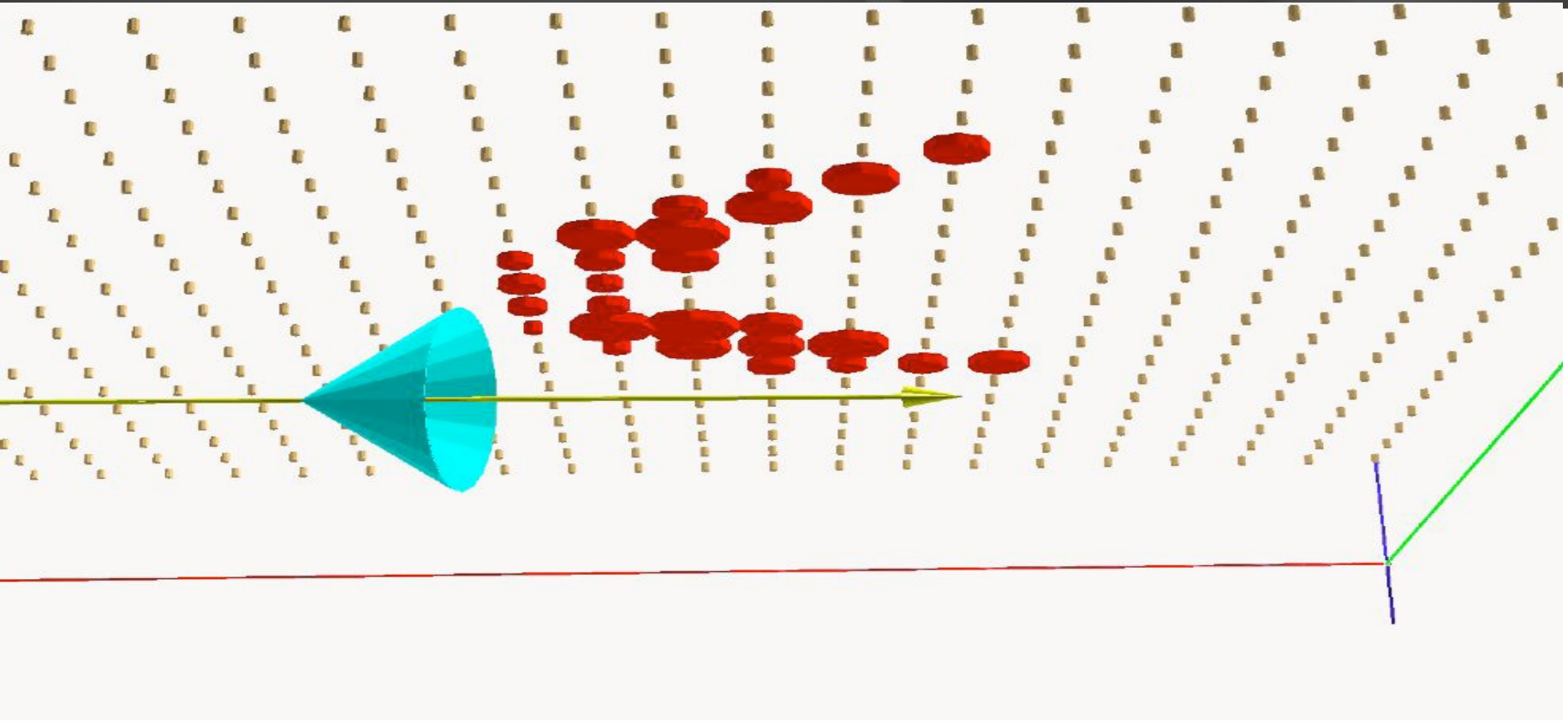
ARA Station & Antenna Cluster



in-ice view of radio detection with antennas

→ 200m deep for ARA

→ at the surface for ARIANNA



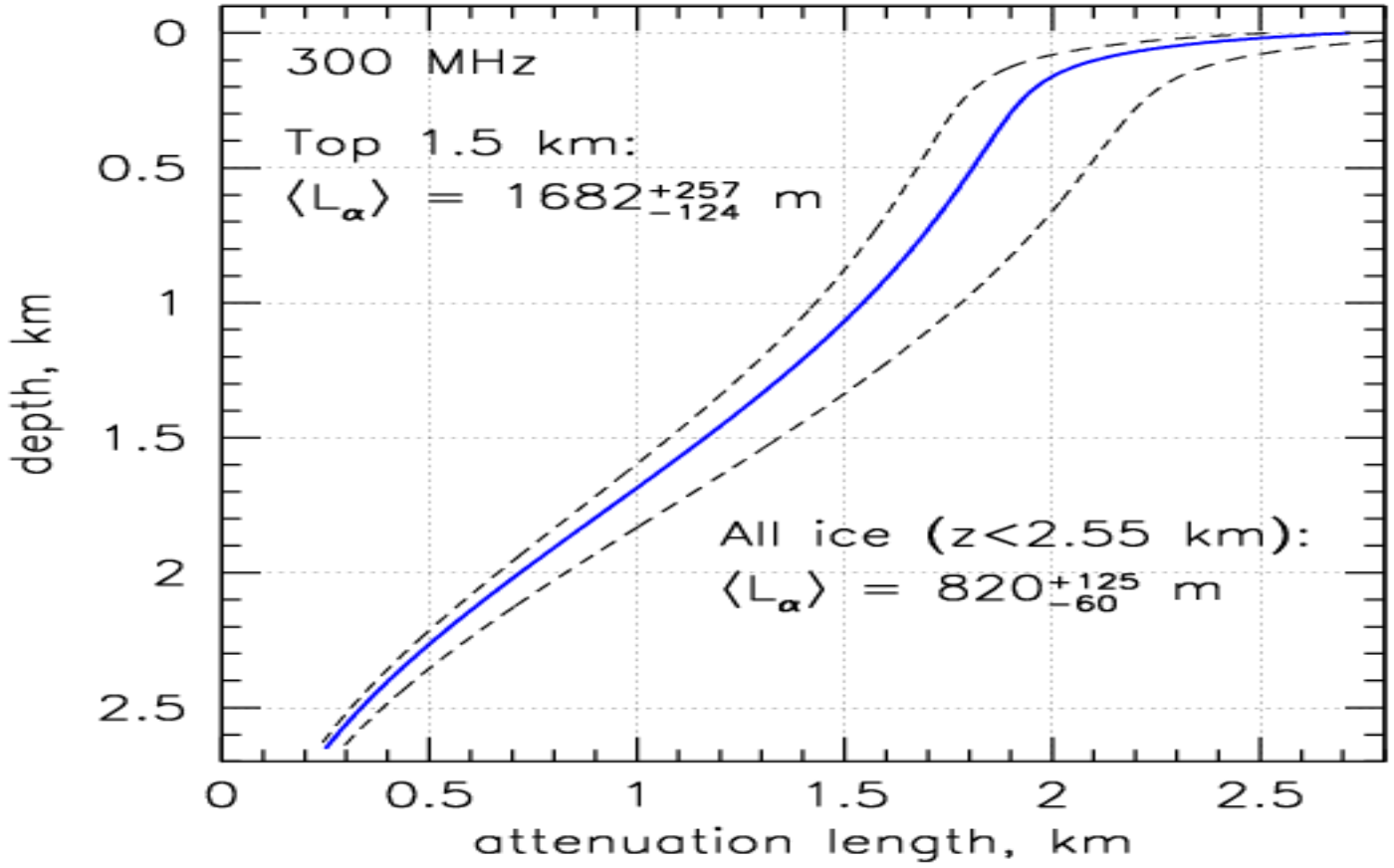
Deployed Antennas (Jan 2011); wire bicones and bicone slot-cylinders

NOTE: Cable runs through center to preserve azimuthally symmetric response

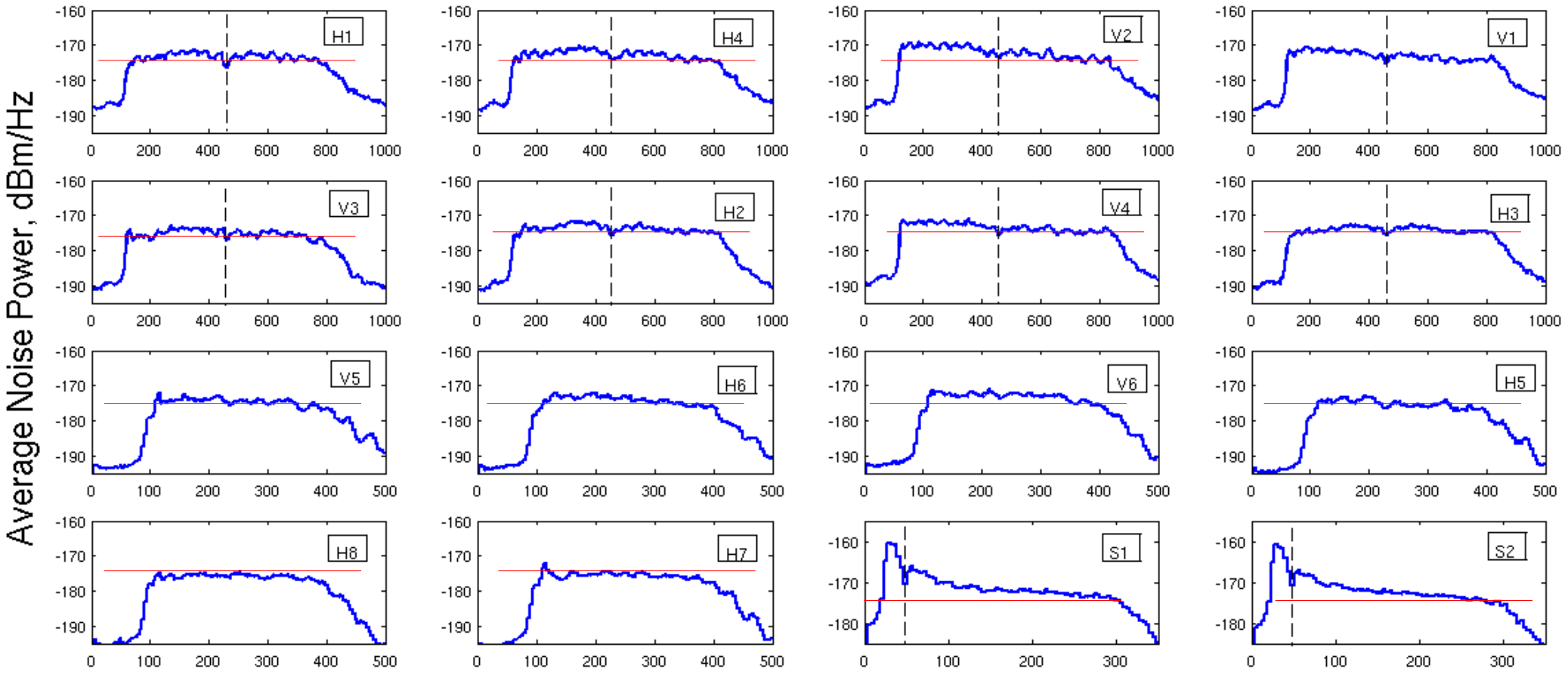



Analyze signals received @testbed from Buried Pulser: Δz=2450 m; Δr~2000 m
Calculate $\langle L_{atten} \rangle$ via: $P_{rx}=P_{Tx}G_{Tx}G_{Rx}\,\lambda^2/4\pi r^2 \exp(-2r/L_{atten})$; Unfold depth dependence via lab $L_{atten}(T(z))$, using IceCube T(z)

Attenuation length (depth)



Measured Noise floor=-174 dBm/Hz+2 dBm/Hz system

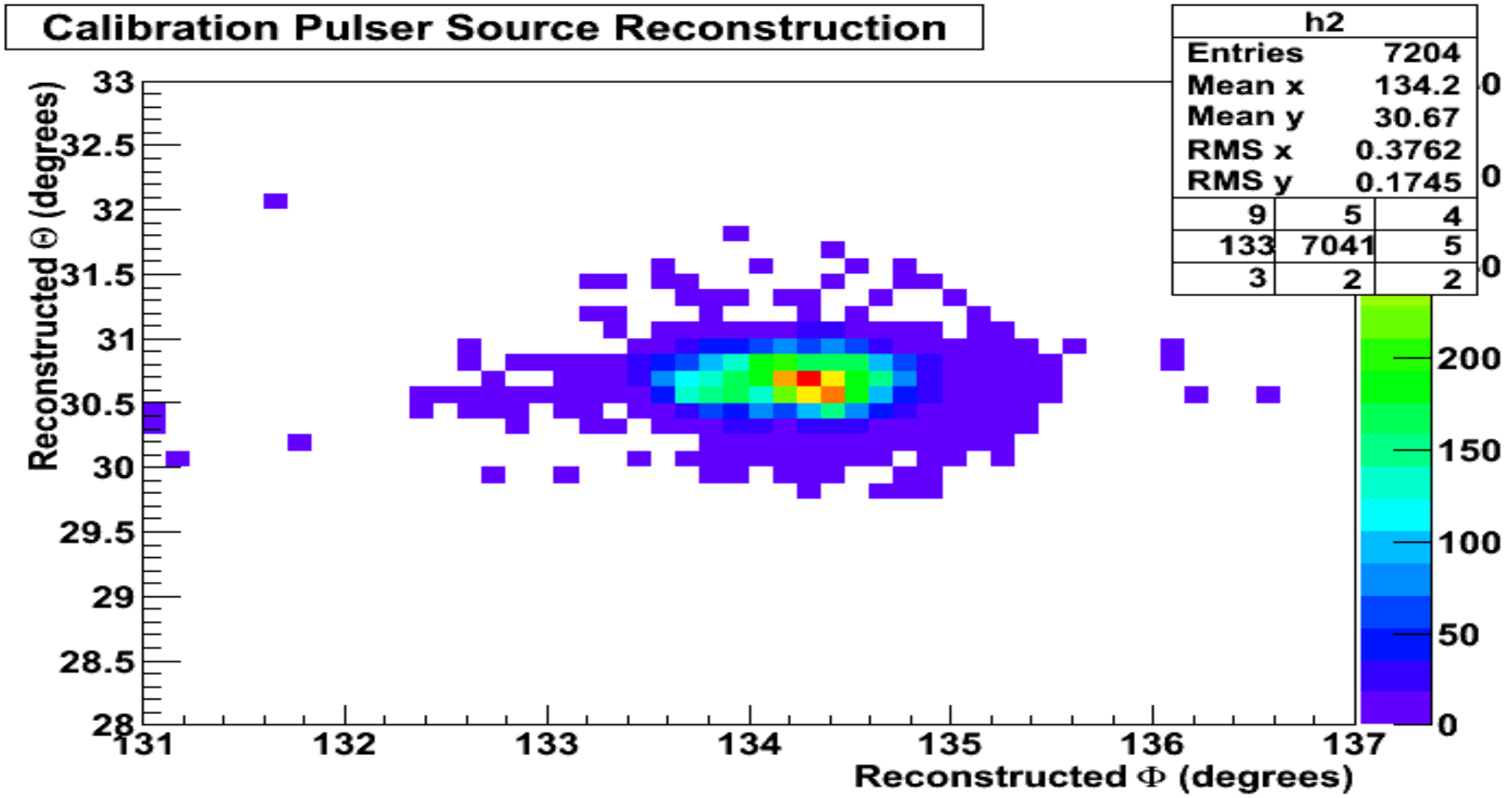


(resistive losses in QSC)

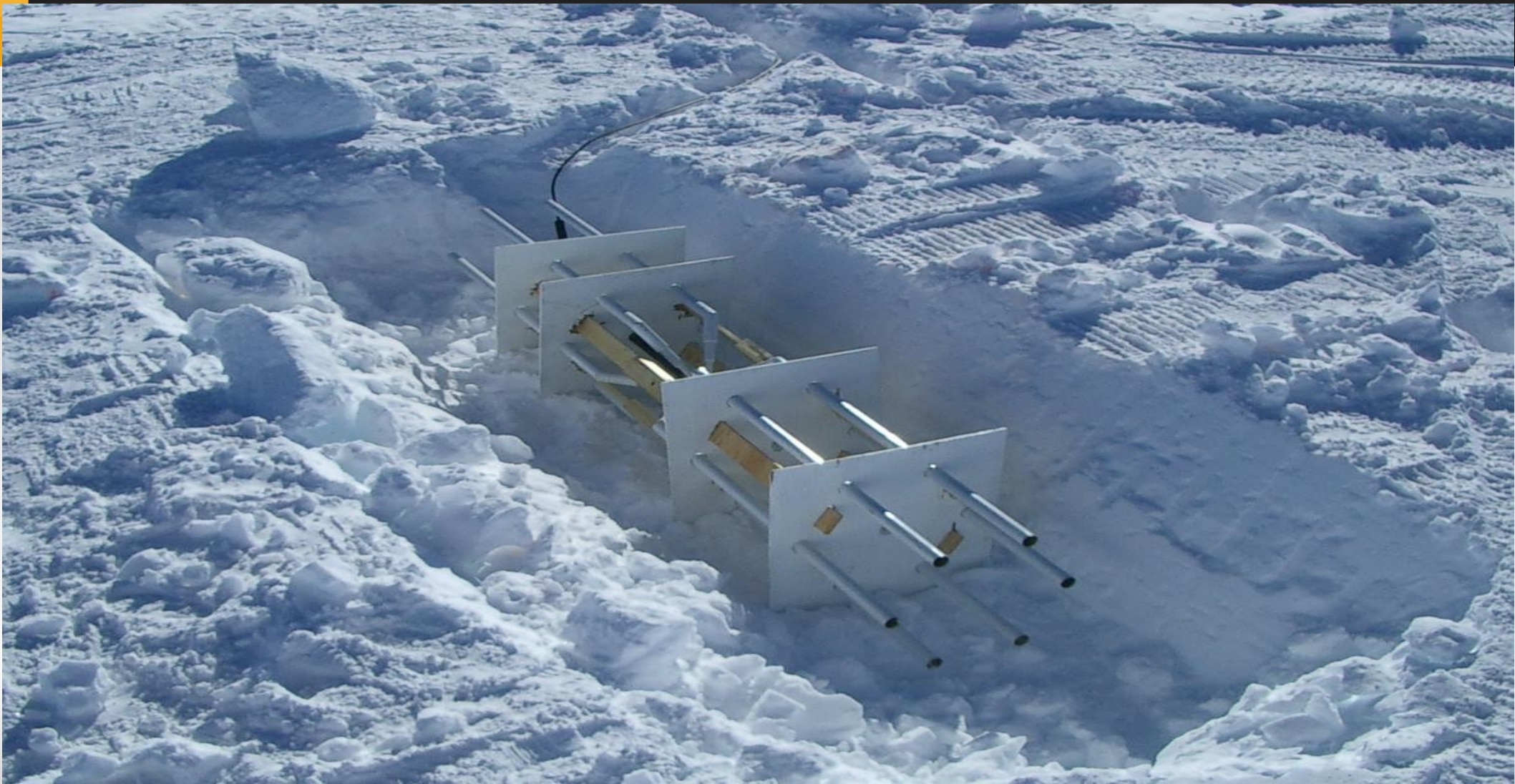
Thermal noise from a source at temperature T

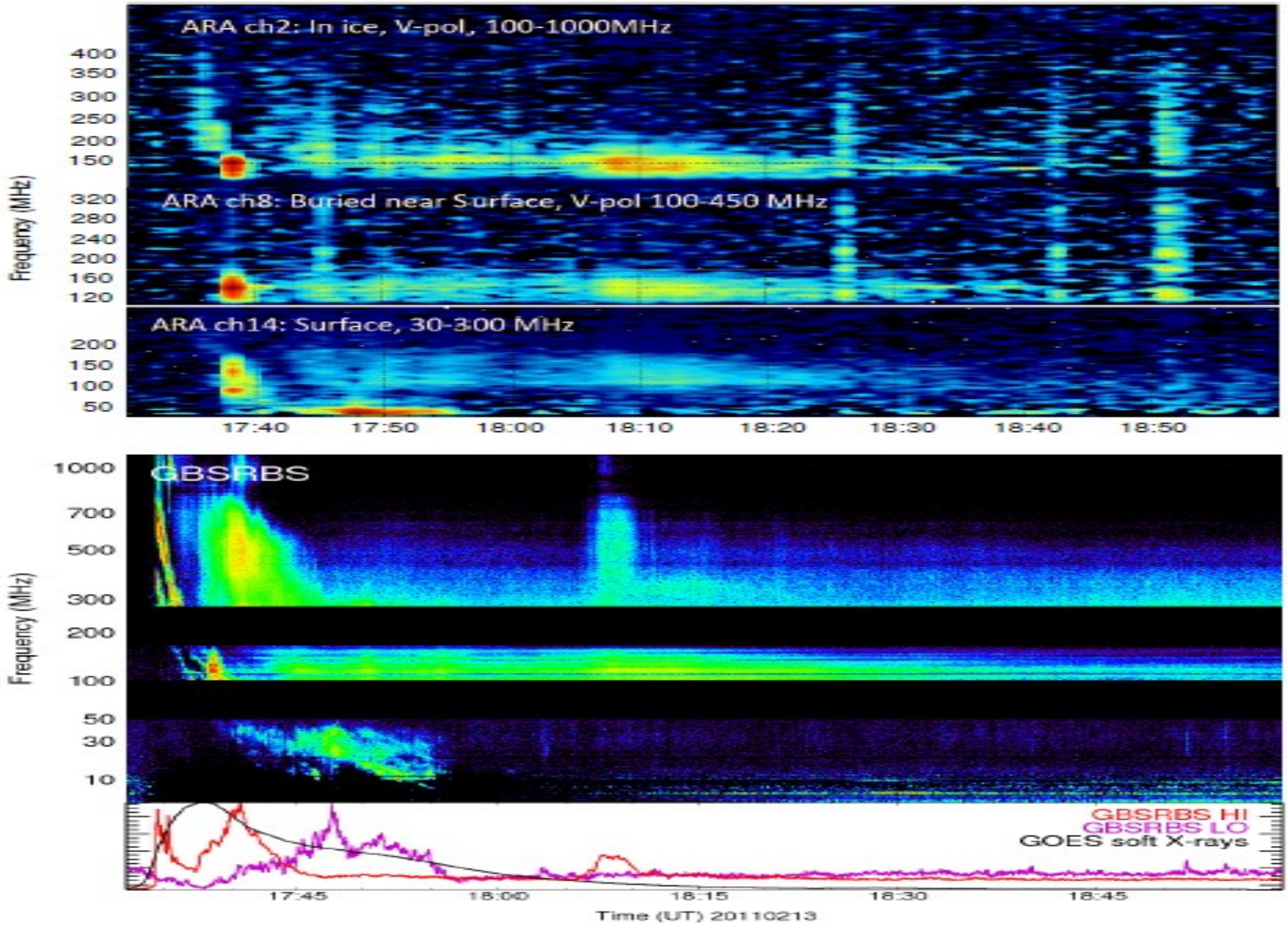
- Noise power=$k_B T(^O K)$Bandwidth (Hz)
  - For one Hz, $kT=3.31 \times 10^{-21}$ W=3.31×10^{-18} mW
    - $=10\log_{10}(3.31 \times 10^{-18})$ dBm=-174.8 dBm
- Typical numbers:
  - 500 MHz bandwidth
  - Temperature=240 K
  - $P=1.38 \times 10^{-23} \times 5e8 \times 240=1.66 \times 10^{-12}$ Watts
  - Coupled to 50Ω antenna: $V^2/50=1.66 \times 10^{-12}$
    - =>10 microVolts

ARA angular resolution~22'/10' in θ/ϕ



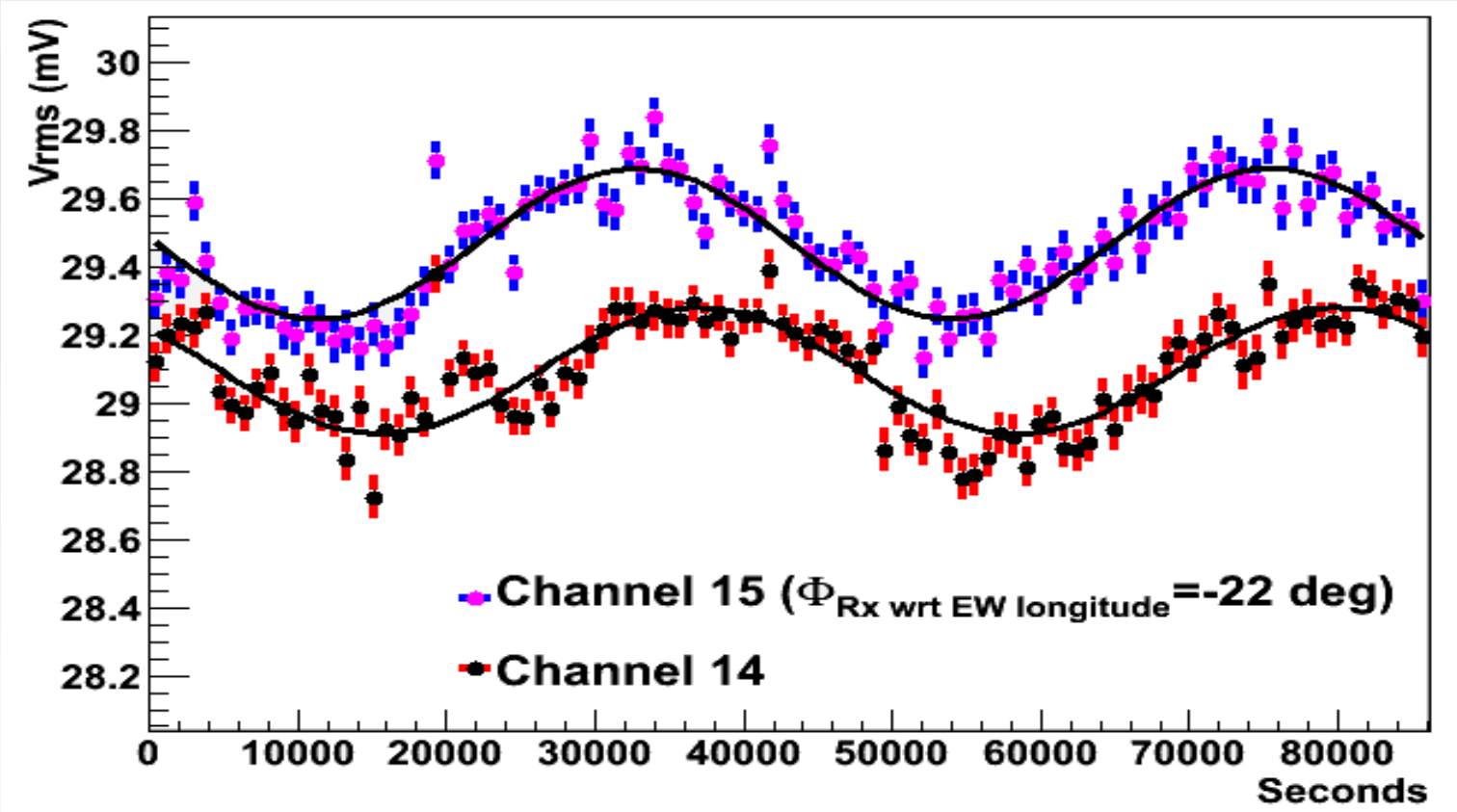
Surface Antennas - “fat dipoles”





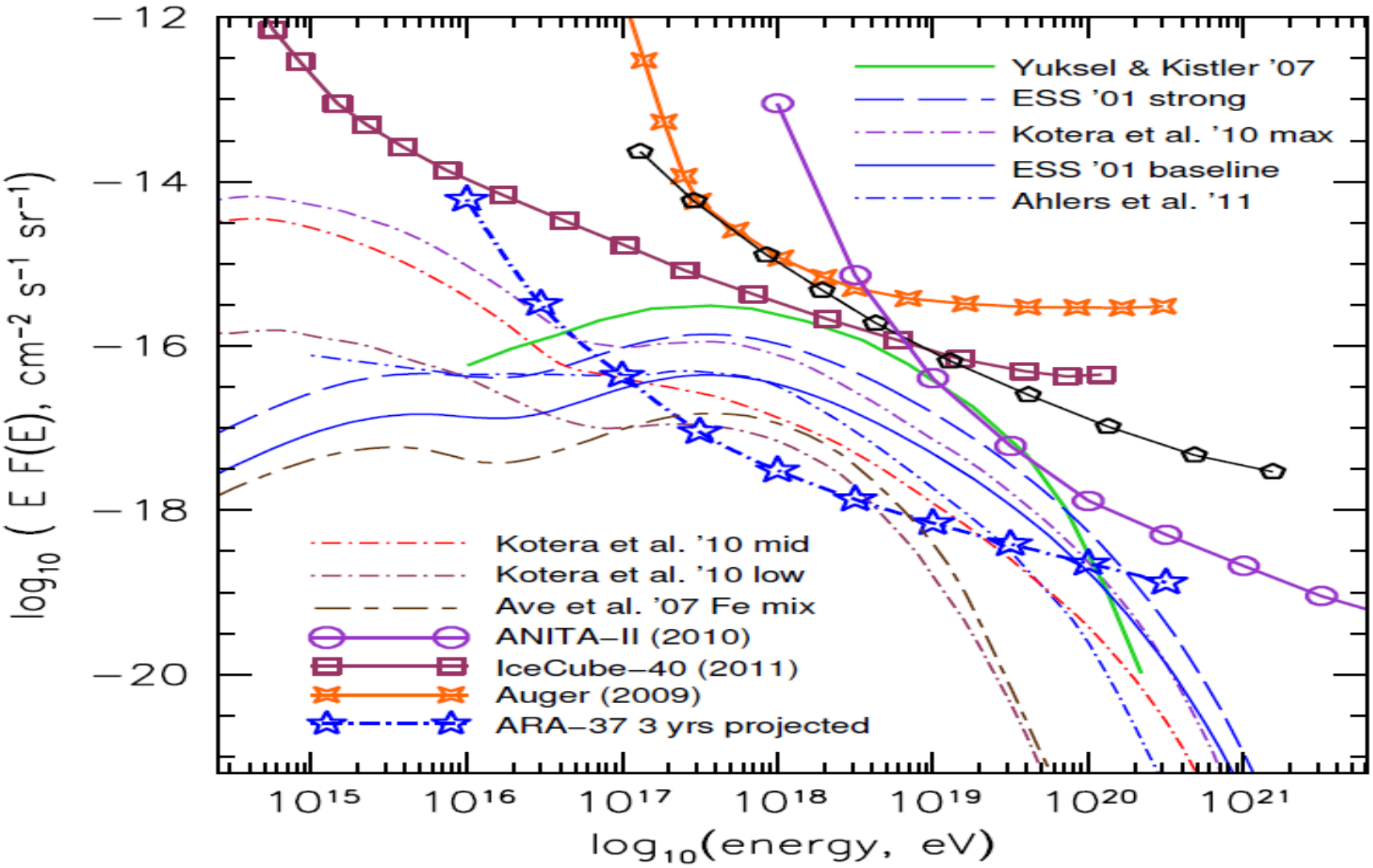
Feb 11, 2011 solar flare obser-vation

Cross-check phase offset of galactic signal...

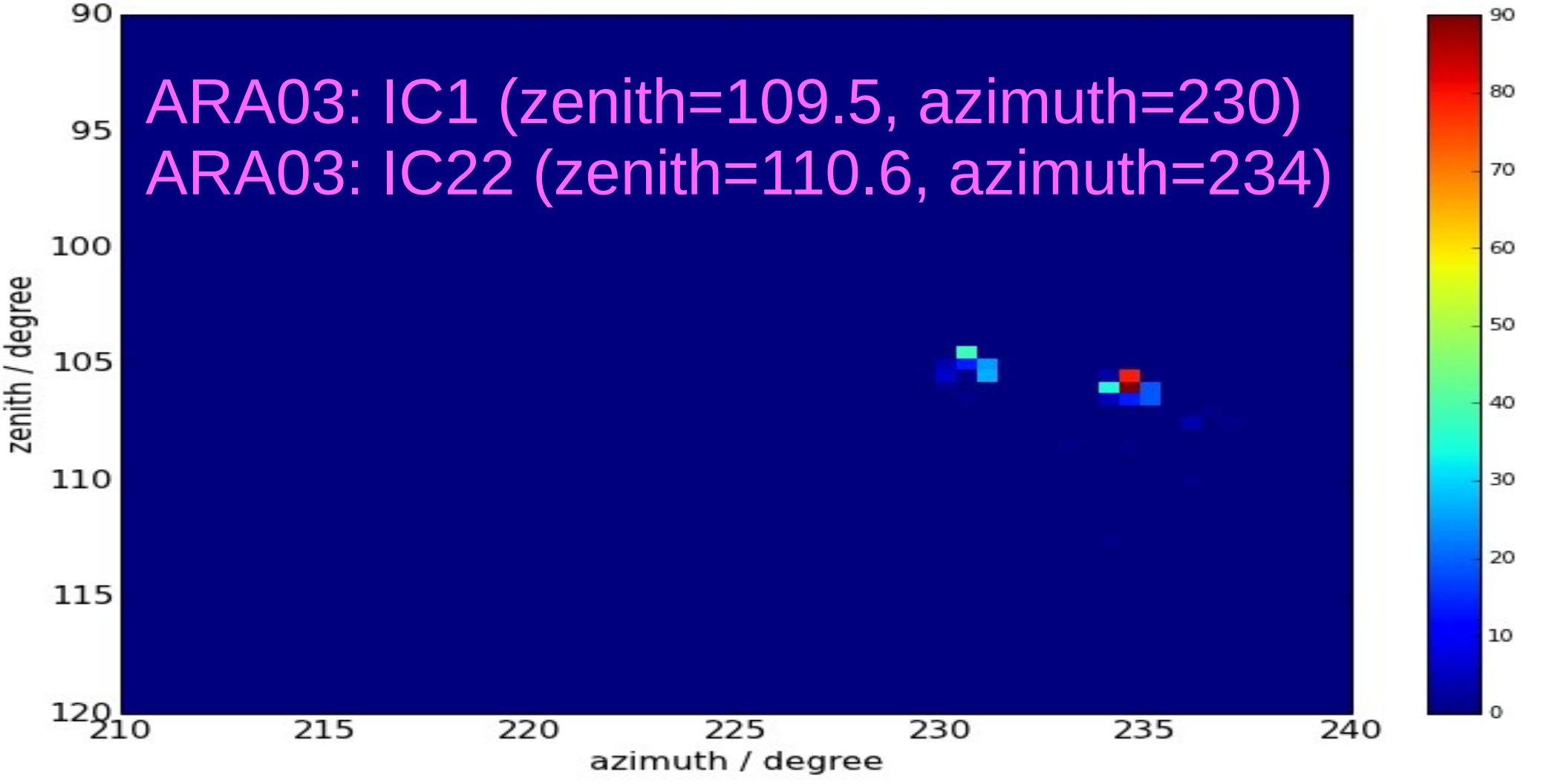


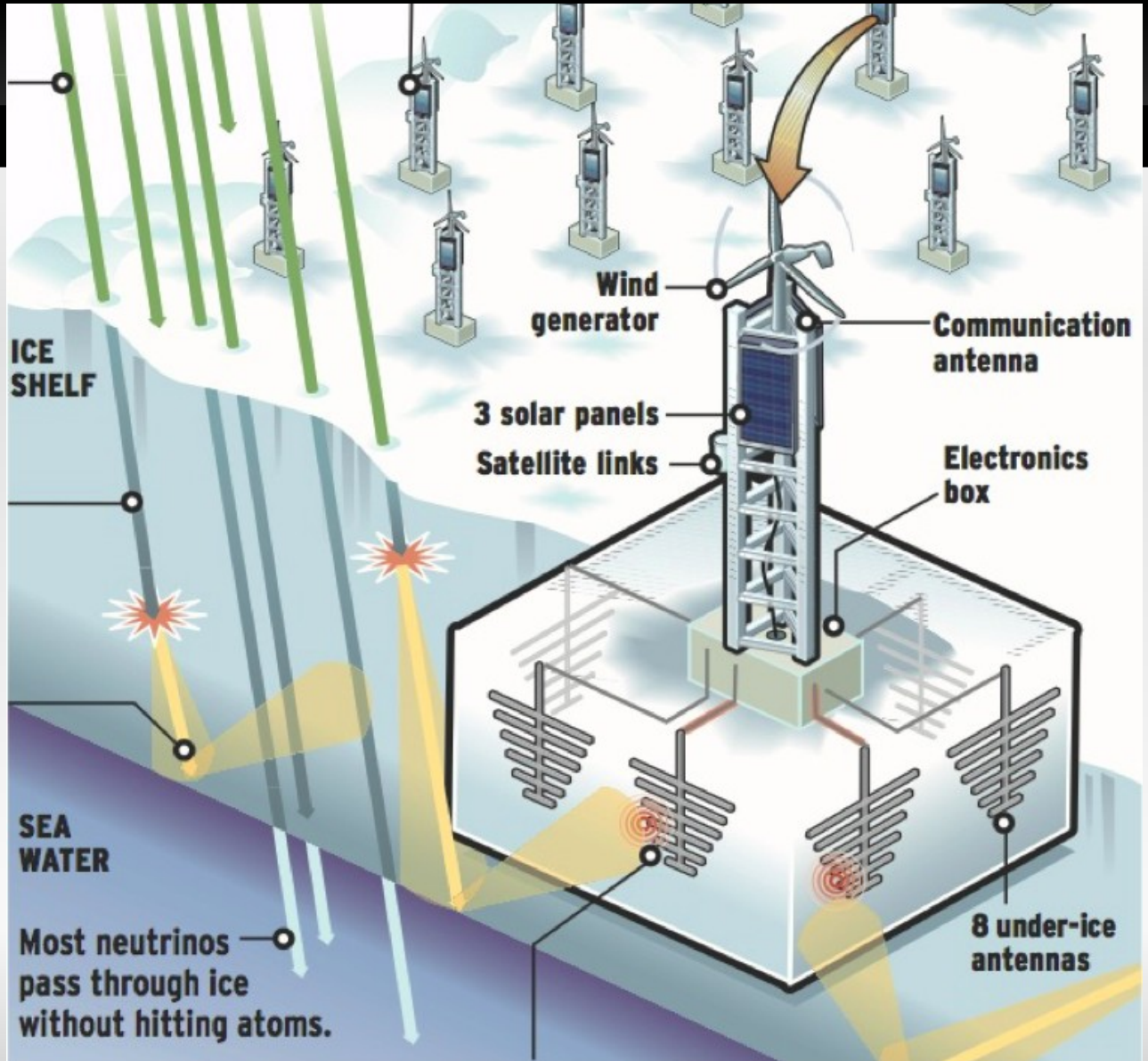
Sidereal Variation as Surface Rx Rotate under Galactic center

Projected Performance – ARA-37

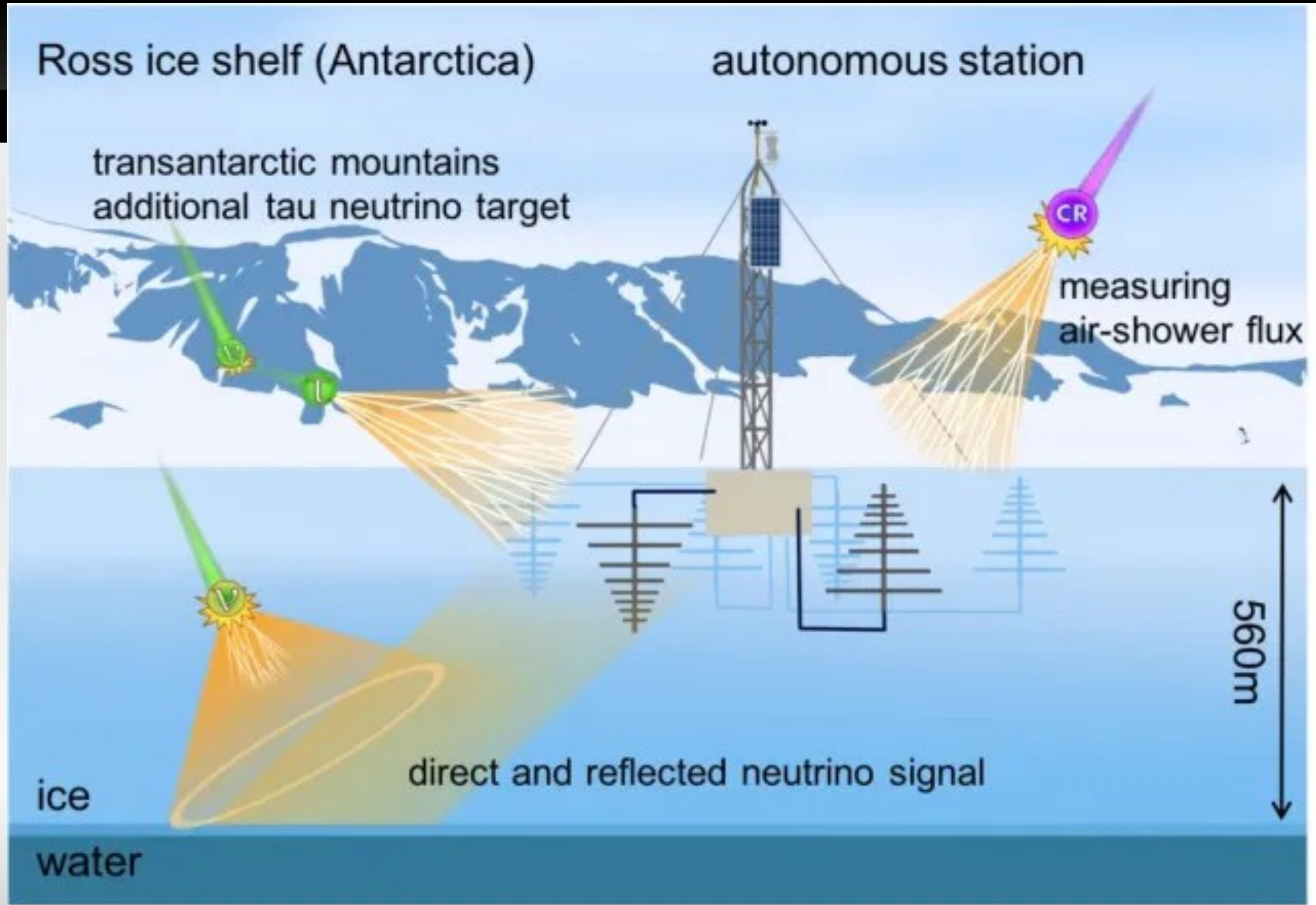


ARA03 reconstruction





ARIANNA experiment


Ross ice shelf (Antarctica)
autonomous station
transantarctic mountains
additional tau neutrino target
CR
measuring
air-shower flux
560m
direct and reflected neutrino signal
ice
water