Radar detection of air showers?

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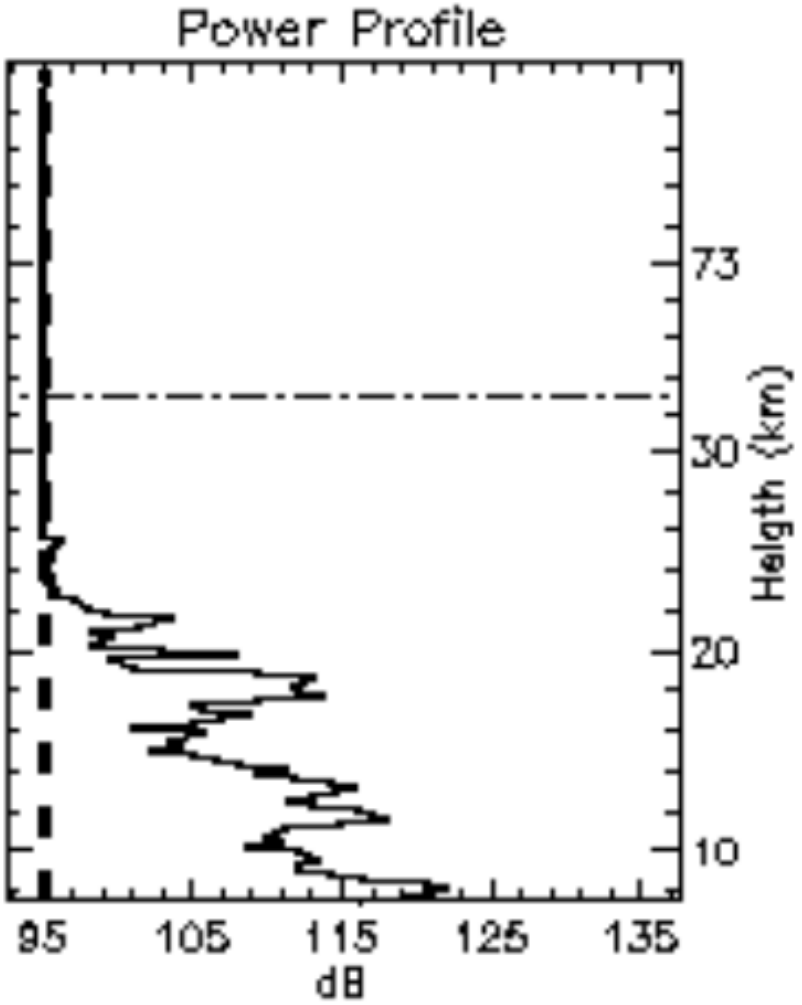
In 1940, Lovell y Blackett suggested that the sporadic echoes detected in the ionosphere could come from extended air showers (these turned out to be micro-meteors as studied currently in Jicamarca).

Signal to Noise Ratio (SNR)

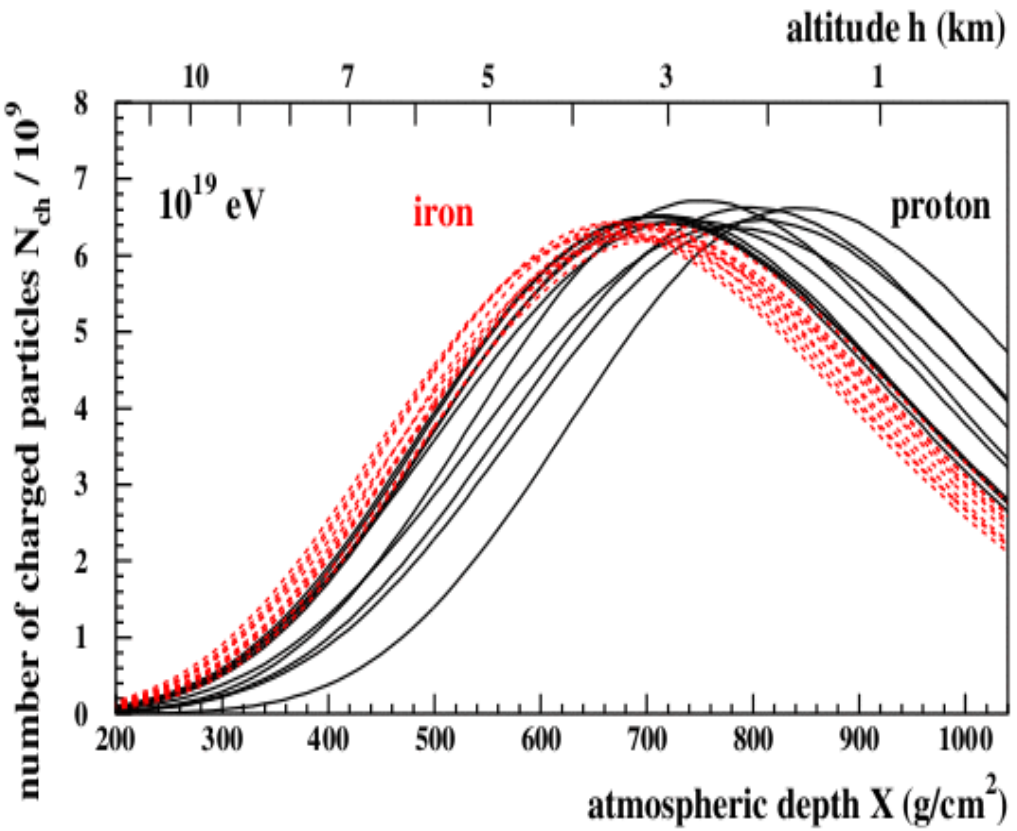
The sensitivity of the radar depends on the signal to noise ratio

Noise is caused by fluctuations in the refractive index of the atmosphere. Broadly speaking, more molecular density = more noise

A typical noise profile is shown for Jicamarca (see figure). Between 5-10km the noise decreases by ~1 order of magnitude, compensating signal loss



Typical noise profile at Jicamarca. The 95dB limit is from galactic noise at 50MHz



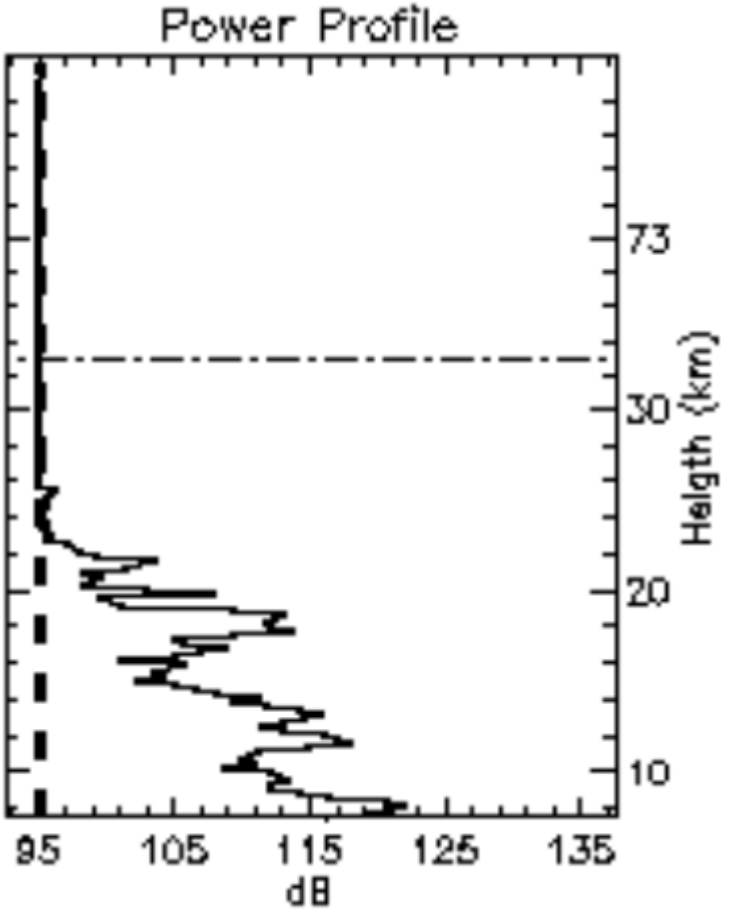


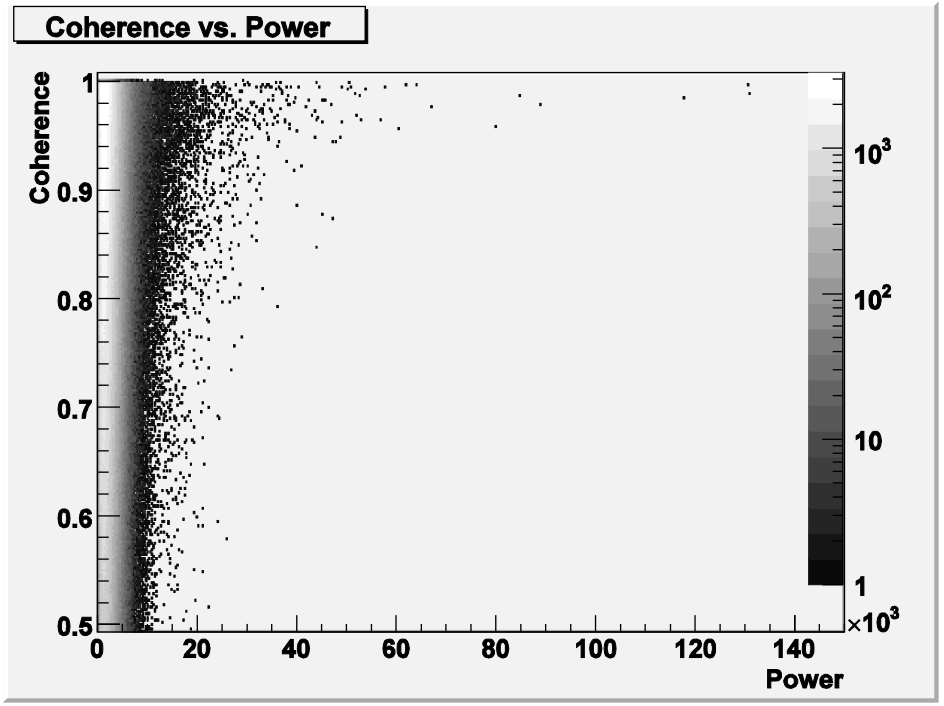
Fig. 5. Individual longitudinal shower profiles (vertical incidence).

Search for anomalous signals

No clear theoretical picture yet, alternative is to look for any unidentified signals in the radar data

Procedure: examine any coherent points (= signal) that have a high power

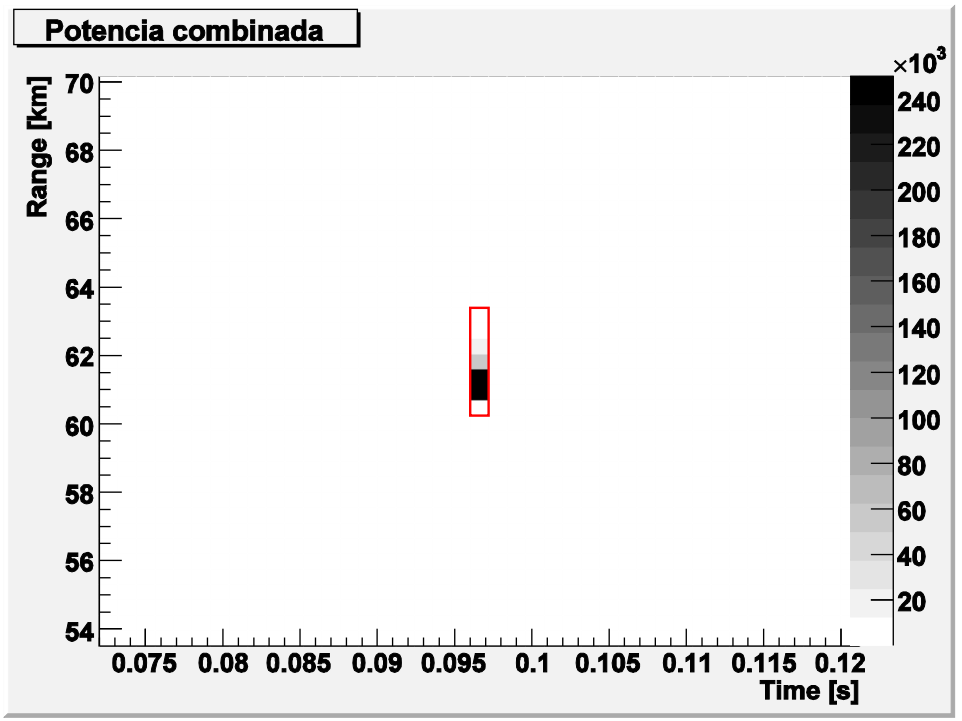
Define high power (in a.u.) as power > 100 (see figure), and coherent events as coherence > 0.95



Coherence vs. Power (in a.u.)
3 points have power > 100 and coherence > 0.95

Typical “anomalous” signals

Using this method, a new type of event was identified

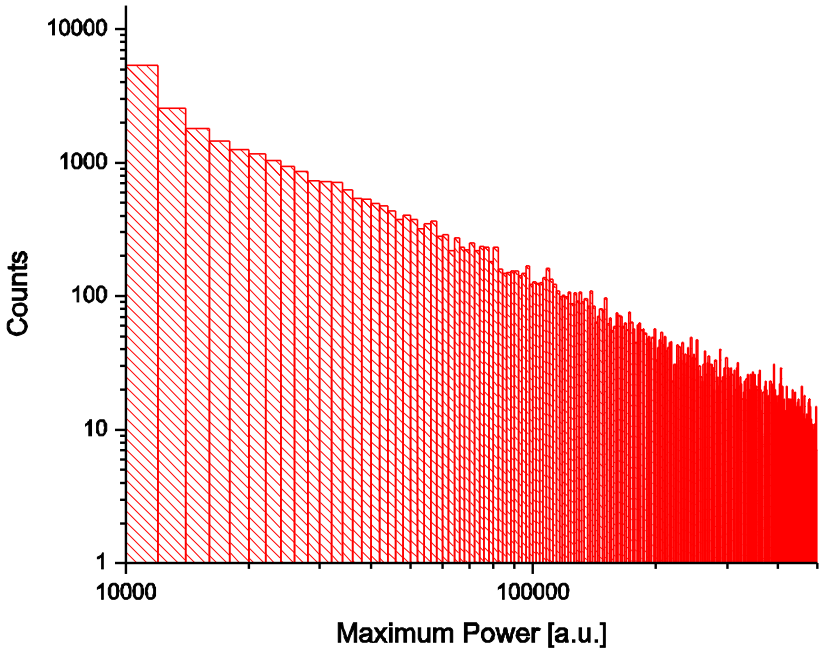


Could these be HAHAS?

The energy distribution (figure) needs to be "corrected" with respect to altitude to be compared with CR spectrum

Directional distribution to be analyzed for further hints as to possible sources

Most other known possible sources (elves, sprites, meteors) are not compatible with observations



Histogram of maximum power of events

Conclusions

Theory predicts that high altitude horizontal air showers (HAHAS) should exist.

The Jicamarca 50 MHz radar is an ideal place to search for these events as conventional detection methods cannot observe HAHAS

Toy model predicts significant flux of HAHAS. Full SNR calculations needed to make clearer prediction

Direct search through data has revealed a new event class with interesting characteristics. Need to analyze if data matches expected EAS properties

Other candidate events with different profiles have been observed at Jicamarca and are to be analyzed for potential match to EAS

The search for HAHAS at Jicamarca goes on…

Bibliography

Initial idea at Jicamarca was to focus on near vertical air showers (i.e. those detected by

Recent activity

Theoretical Papers (RADHEP 2000):

Peter Gorham *On Radar Detection of EeV Air Showers*

Tatiana Vinogradova *A Proposed Experiment to Detect Air Showers with the Jicamarca Radar System*

Experimental Papers:

A. Iyono et al., *Radar echo detection of EAS at the LAAS*, 28th ICRC

50W continuous wave transmitter @ 54MHz in 3 arrays

3 arrays of 8 counters of 20x30m^2 scintillators

~3 months data, no sign of coincidence. No sign of coincidence reported in 29th ICRC