

Radiodetection of Cosmic Ray Extensive Air Showers: upgrade of the CODALEMA experiment

D. Ardouin, A. Belletoile, Didier Charrier, Richard Dallier, L. Denis, P. Eschstruth, Thierry Gousset, Fayrouz. Haddad, J. Lamblin, Pascal Lautridou, et al.

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RADIODETECTION OF COSMIC RAY EXTENSIVE AIR SHOWERS : PRESENT STATUS OF THE CODALEMA EXPERIMENT.

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- ^{a)}D.ARDOUIN¹ , ^{a)}BELLETOILE A., ^{a)}CHARRIER D., ^{a)}DALLIER R.,
^{b)}DENIS L., ^{d)}ESCHSTRUTH P., ^{a)}GOUSSET T., ^{a)}HADDAD F.,
^{a)}LAMBLIN J., ^{a)}LAUTRIDOU P., ^{c)}LECACHEUX A.,
^{d)}MONNIER-RAGAIGNE D., ^{a)}RAHMANI A., ^{a)}RAVEL O.
^{a)}SUBATECH, La Chantrerie, 4 rue Alfred Kastler, BP 20722, 44307
Nantes-cedex 3
^{b)}Observatoire de Paris - Station de radioastronomie, 18330 Nançay
^{c)}LESIA, Observatoire de Paris, Section de Meudon, 5 place Jules Janssen,
92190 MEUDON
^{d)}LAL, Université Paris-Sud, Bâtiment 200, BP 34, F-91898 Orsay cedex

Abstract

The CODALEMA experiment uses 6 large frequency bandwidth antennas of the Nançay Radio Observatory Decametric Array (France). In a first configuration, one antenna narrowed band filtered acting as trigger, with a 4σ threshold above sky background-level, was used to tag any radio transient in coincidence on the antenna array. Recently, the addition of 4 particle detectors allowed us to observe cosmic ray events in coincidence with antennas.

keywords:ultra high energy cosmic rays ; radiodetection.

¹daniel.ardouin@sciences.univ-nantes.fr

1 The CODALEMA experiment.

We present the characteristics and performances of a demonstrative experiment devoted to the observation of ultra high- energy cosmic rays extensive air showers using a radiodetection technique. The CODALEMA (COsmic ray Detection Array with Logarithmic Electromagnetic Antennas) experiment was set up at the Nançay Radio Observatory in 2003. It uses 6 of the 144 log-periodic antennas (in the 1-100 MHz frequency band for CODALEMA) constituting the DecAMetric array (DAM) [1].

In the first period of observation [2], the setup (see Fig. 1) was self-triggered using one devoted antenna: its signal was filtered in an appropriate noise-free frequency band (33-65 MHz) chosen after an exhaustive study in the observed local noise frequency spectrum, before entering the ADC. The wide band waveform signals (1 - 100 MHz) of the other antennas were registered when a voltage threshold was reached on the trigger antenna. The trigger threshold was set at $4 \sigma_{sky}$ (σ_{sky} : the rms sky background noise), leading to an electric field sensitivity of $4 \mu\text{V/m}$.

On figure 2 the evolution of the average counting rate at Nançay is presented as a function of the trigger level expressed in unit of σ_{sky} . The counting rate evolves greatly with the anthropic activities in the vicinity of the station of Nançay and with the weather conditions.

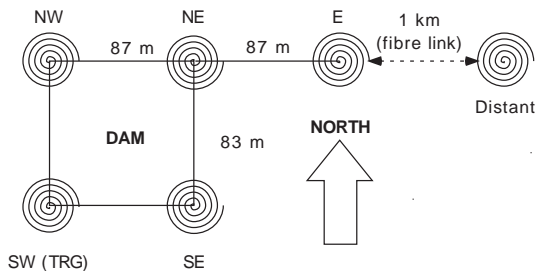


Figure 1: First CODALEMA setup: the SW antenna acted as a trigger.

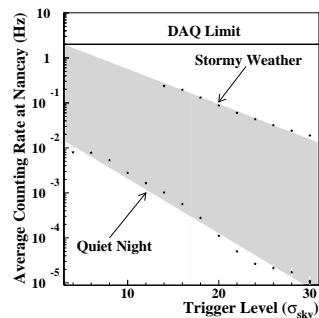


Figure 2: The shaded area corresponds to the measured counting rate. The lower limit has been measured during quiet night runs whereas the upper limit corresponds to stormy weather.

Except for the trigger antenna, transient signals on the antennas were hidden by radio transmitters signals. Consequently, a numerical passband

filter (same as trigger frequency band) was applied, offline, in order to observe coincidences involving several antennas [3]. Using the position and the timing differences between antennas, it was also possible to perform the trajectory reconstruction of the electromagnetic plane wave using a triangulation techniques across the array [4]. This level of analysis enables us to bring in light several cosmic ray air shower candidates.

2 Coincident particle data: Preliminary results

In the second phase operating since mid 2004, the above setup (see Fig. 3) has been completed with four double plastic scintillators [5] placed at the corner of the DAM array ($\simeq 100 * 100m^2$). The trigger of the experiment is made of the four particle detectors in coincidence, resulting on an event rate of 0.8 event/mn. All the antennas have now the same role and are passband filtered (24-82 MHz) in order to increase the signal to noise ratio.

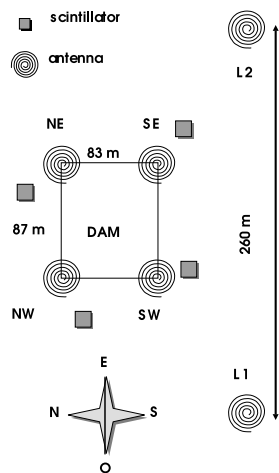


Figure 3: Actual CODALEMA setup: the particle detectors act as a trigger.

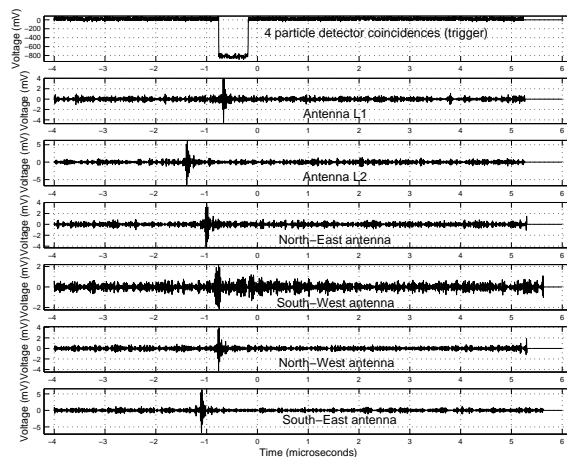


Figure 4: Filtered antenna signals obtained for a cosmic ray event triggered by the particle detectors.

The observation of coincident events on antennas and charged particle detectors (Fig. 4) demonstrates the association of antenna transient signals with the occurrence of extensive air showers. This unambiguous evidence of radio signals through the simultaneous detection of shower particles will

allow, for the first time, the characterisation of the shape and amplitude of air showers associated radio pulses. A preliminary event rate of 1/(8 hours) is observed with antenna multiplicity ranging from 3 to 6.

From the corresponding deposited energy distribution in scintillators, one can infer the location of the air shower core. The time delays between the particle detectors allow the reconstruction of the shower axis. From these information, impact parameter effects can be studied especially those related to non vertical showers. The latter are expected [6] to generate amplitude and shape field variations which will better show up in large atmosphere volumes accessible with radiodetection method. Purposely, 5 antennas will be installed (up to 400 m from the DAM) on a east-west line crossing the existing array.

Two effects, namely Cerenkov emission and the classical far field, contribute to the radio emission of a shower [6]. The line will also allow to study their respective influences and asseses the interest for designing a larger antenna array dedicated to Ultra High Energy Cosmic Rays.

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