

RAuger: a fully autonomous station for radio detection at Auger

Les savoir-faire et les connaissances acquis par notre équipe sur CODALEMA pour la radiodétection des rayons cosmiques autour de 10^{17} eV nous ont permis d'envisager d'étendre la méthode à des énergies supérieures. Nous avons donc implanté un petit réseau d'antennes complètement autonomes et auto-déclenchées sur le site de l'Observatoire Pierre Auger (Argentine). Pour la première fois au monde, ces antennes ont permis la détection complètement indépendante d'événements radio associés à des gerbes atmosphériques générées par des rayons cosmiques.

The CODALEMA experiment has demonstrated the possibility to detect radio signals associated with high energy cosmic rays air showers and use them to determine some important air shower characteristics [1, 2]. However, the current size of CODALEMA limits exploration to energies around some 10^{17} eV. To get a better knowledge of these radio signals and their dependences on other primary characteristics at higher energies, a natural subsequent stage is to associate antennas to larger ground detector arrays as the Pierre Auger Observatory, in Malargüe, Argentina. Besides our own processes, the Auger collaboration has also engaged a reflection in this way, permitting both requirements to meet.

In December 2006, we have installed an array of 3 autonomous, self triggered radio detectors (stations) [3]. Each of these stations is solar powered and automatically transmits its data by a WiFi link to a central acquisition system located 1 km away from the array. On each station, the trigger is made on a simple voltage threshold set on a filtered part of the EW signal. Taking advantage of the great purity of the radio sky over Auger's site, very broadband (1-100 MHz) signals can be recorded on both the East-West and North-South polarizations. In order to keep maximum of flexibility, the station is built as simple as possible using off-the-shelf equipments. The complete setup of this pre-prototype is as follow:

- two dipolar active antennas identical to the ones used on CODALEMA, one in the North-South direction, the other in the East-West direction to study the polarization in the horizontal plane,
- a trigger board with a tunable radiofrequency

filter to get rid of frequencies due to human activities,

- 8-bit Analog to Digital converter electronics adapted to large band wave form analysis, working at 500 MS/s for a $5 \mu\text{s}$ registered waveform; the ADC is a Tektronix THS730A handheld scope, 1 GHz bandwidth,
- GPS receiver for event time tagging at the 10 nanoseconds level,
- 100 W solar panels and 100 A.h, 12 V batteries for power supply,
- the local acquisition system is the standard Unified Board developed for the Cerenkov tanks in Auger; it masters the local data streams and manages the communication with the distant Radio Central Data Acquisition System (RDAS),
- standard WiFi system (115 kb/s) to send antenna data to the RDAS.

The total power budget is 18 W. A synoptic sketch of a single station is given Fig. 1.

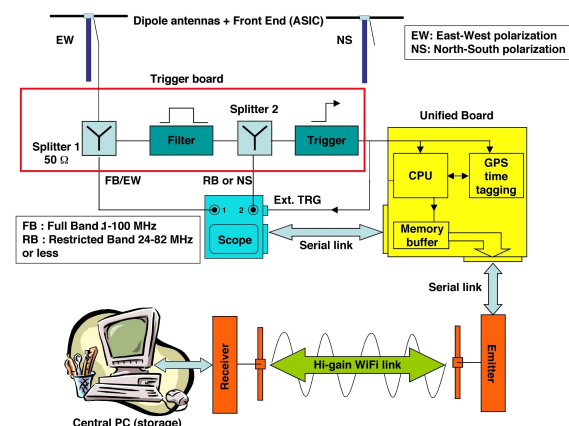


Fig. 1: Sketch of the electronics of a single station.

The complete array (called RAuger, for Radio@Auger) is depicted on Fig. 2. It is located in the middle of the surface detector (SD) array of Auger, and in the middle of an elementary mesh of the 1600 water tanks whose it is constituted. The RDAS PC is located on side of the Central Laser Facility (CLF) shelter, where an internet link to the outer world allows to download the data from France. Fig. 3 shows a picture of one of the stations, surrounded by a fence protecting them against animals.

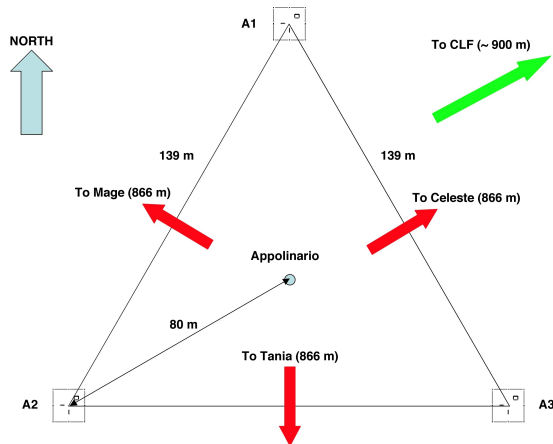


Fig. 2: Location and set up of the 3-radio detector array. The radio stations named A1, A2 and A3 surround the central tank Appolinario added specifically in the middle of the elementary mesh of tanks Mage-Tania-Celeste.



Fig. 3: Picture of a station. The electronics is placed inside the box on side of the solar panel in background. On foreground, the two dipoles in crossed polarization, identical to those used in CODALEMA.

Radio events are time-tagged by the same GPS system as in Auger. This allows recognizing real cosmic ray events from noise by searching time coincidences between

particle events detected by Auger's SD and radio events.

Main results obtained with RAuger are described in the next contribution to this report. Operation of this prototype array has been stopped in 2008, but the goal was achieved to demonstrate the ability of self triggered radio detection [4]. For the coming years, a new generation of autonomous stations (described elsewhere in this report) will be installed on the CODALEMA and RAuger sites, with the mid-term objective of covering a 20 km² array at Auger, opening the way to a super-hybrid (SD, fluorescence and radio) cosmic ray detector.

La démonstration de la radiodétection des gerbes cosmiques autour de 10^{17} eV ayant été faite par CODALEMA, l'étape suivante concerne la gamme d'énergie supérieure (à partir de 10^{18} eV). La conception et la construction d'un réseau d'antennes travaillant à ces énergies nécessite des phases de tests auprès d'un détecteur permettant la validation et la calibration des signaux radio obtenus, tel l'Observatoire Pierre Auger (Malargüe, Argentine). Après avoir validé la qualité radio du site d'Auger grâce à des mesures de bruits effectuées en janvier 2005, nous avons installé sur le site de l'Observatoire un petit réseau de 3 stations de radio détection entièrement autonomes, dont l'objectif était la détection indépendante des signaux radio à haute énergie. Ces tests ont été concluants et ont pour la première fois au monde permis de démontrer la faisabilité de la détection radio non déclenchée par un détecteur de particules. Une version évoluée de ce prototype de station autonome est en cours de construction et sera installée d'une part sur le site de CODALEMA, d'autre part sur le site d'Auger en vue d'une extension future à une centaine d'antennes sur une vingtaine de km²

[1] D. Ardouin et al, 2006, *Astroparticle Physics* 26, p. 341-350, astro-ph/0608550.

[2] O. Ravel and the CODALEMA collaboration, 2007, *Proceedings of the XXXth ICRC, Merida, Mexico*

[3] B. Revenu and the CODALEMA collaboration, 2007, *Proceedings of the XXXth ICRC, Merida, Mexico*

[4] S. Acounis et al., 2007: "First detection of radio signals from cosmic ray air showers with a self triggered, fully autonomous system", Auger internal note GAP-2007-130