Measuring the antenna response of LOFAR

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Instead of observing astronomical sources, in Autum of last year LOFAR had a look at a flying octocopter.

Since June 2011, the LOFAR telescope has been used to measure cosmic rays from space. These atomic nuclei have such a high energy that when they collide with particles in the atmosphere, they generate a cascade of millions of secondary particles that travel as a so called air shower towards the Earth's surface. Charged secondary particles travel along a bent trajectory in the Earth's magnetic field. They thereby emit radiation, mostly in the MHz frequency regime.

LOFAR has been delivering beautiful data of cosmic rays with an unprecedented number of antennas. However, in order to understand the physics behind the phenomenon, every single signal has to be corrected for the direction-dependent sensitivity of the LOFAR antenna. The understanding of the antennas is therefore crucial.

So far, we have been building on the expertise at ASTRON, where a considerable amount of work has been put into describing the response of the low-band antenna. However, as the radiation from air showers is created in the Earth's atmosphere, ➔

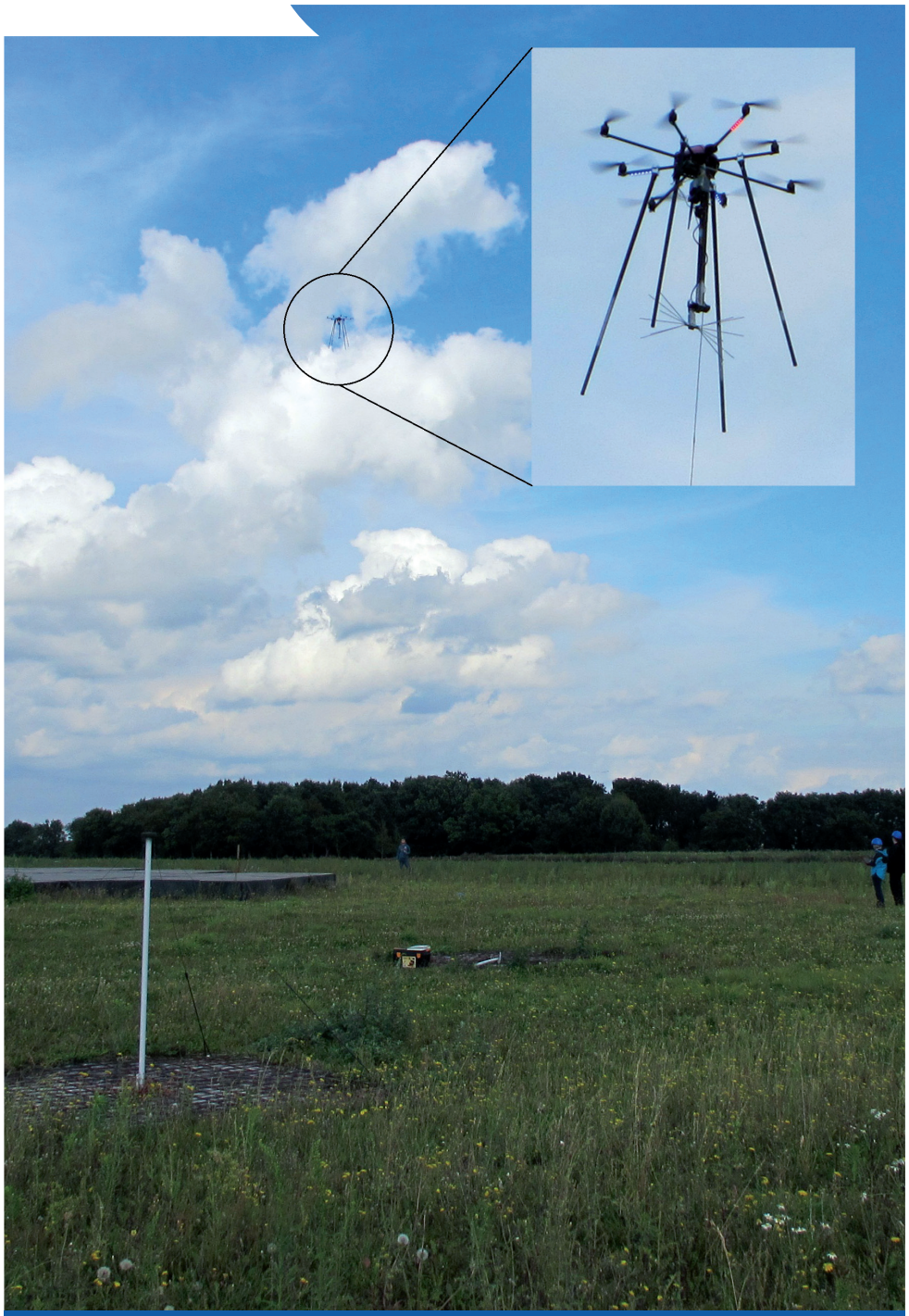

Figure 1: The octocopter with the artificial source above LOFAR.

none of the usual calibration tools of LOFAR can be used to verify our results. There is no natural steady source within the atmosphere to calibrate on. Thus, an artificial source is needed, which can be measured with a single antenna.

A calibrated antenna was flown on an octocopter (Fig. 1) over several LOFAR antennas to measure their response pattern in situ. So far, the pattern has only been simulated. The response was measured with respect to the direction and for all frequencies. A nice dipole response was observed (Fig. 2), which can now be compared in detail to simulations and will help to improve them.

Additionally, a pulse generator was flown. The corresponding measurements can be used as an independent crosscheck of the timing calibration of the system.

The results from this campaign will be fed back into the standard LOFAR reconstruction pipelines.

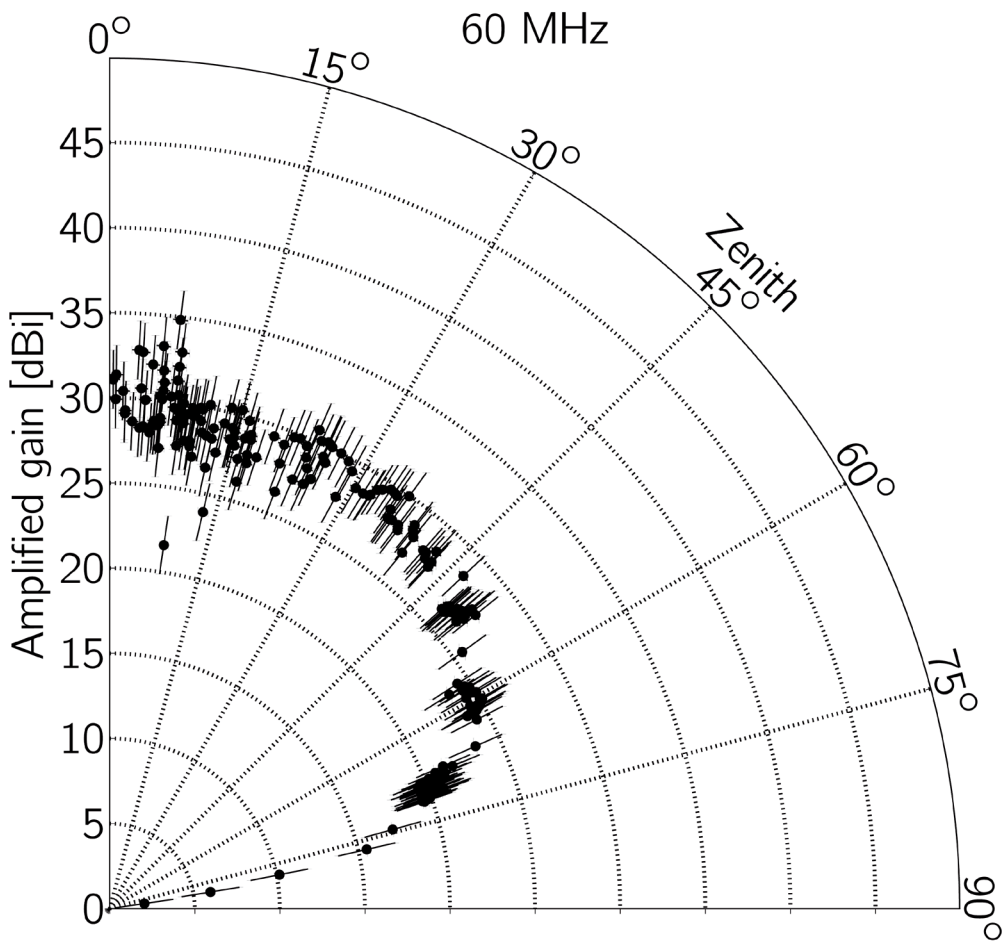

Figure 2: The antenna gain response as a function of direction at 60 MHz as measured with the octocopter above LOFAR.