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Meter and nanosecond precision lightning imaging in 3D

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We report on a lightning imaging technique that can map lightning in 3D using fully coherent interferometry in broadband VHF (30 — 80 MHZ). This is made possible by the infrastructure offered by LOFAR (LOw Frequency Array), a modern radio telescope used primarily for astronomical observations.

Through LOFAR, we utilize a large number of simple dual-polarized dipole antennas arranged in stations of 48 antennas with a diameter of about 60m. We primarily use the Dutch stations, which have baselines up to 100 km. The data are sampled at 200 MHz giving 5 nanoseconds time between samples. Upon a trigger the data for all Dutch stations is stored for later off-line processing. Upon triggering, LOFAR saves out the full time-series spectra for five seconds for every antenna in the array.

This unique capability of LOFAR, the nanosecond precision over 100 km baselines, allows us to image the sources in 3D and paves the way for ultra-precise imaging of lightning discharges with a precision of meters. We now reach a precision that is primarily limited by the finite extent of the VHF sources. In the presentation we discuss the procedures we use to perform imaging in 3D at this scale using interferometric techniques.

We will present a few of the most interesting new structures we observe in the lightning discharge. The needles along a positive leader are evidence that the positive and negative leaders have gotten disconnected and the charge collected by the tip of the positive leader is being dumped at its base. The negative leader shows as a rather continuous sequence of VHF sources with no clear signature of any stepping process. This is an indication that the source of VHF emission lies on the streamers rather than being associated with the stepping process.