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# NEW LIGHTNING EXPERIMENTS AT THE PIC DU MIDI

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## ABSTRACT

**An experimental site devoted to the study of direct lightning impacts to lightning rods has been selected at the top of the Pic du Midi in the French Pyrénées. This site offers the exceptional opportunity of investigating lightning strokes to a complex structure of limited extension, intermediate between a large building at moderate altitude and a high-elevated structure such like the well-known instrumented telecommunication towers (Gaisberg, Peissenberg, Säntis or CN Tower). At the Pic du Midi, the famous astronomical Observatory offers an unique scientific environment for lightning observations (sprites, Météorage) in collaboration with astronomers.**

**Among various experiments, we will devote this paper to that installed at the top of the so-called DIMM platform. Several scientific sensors are here installed, such like measurements of lightning current, electric field, high-speed video and related recordings. This will enable to characterize both lightning attachment to an instrumented rod and lightning detection network efficiency at high altitude (about 2,900 m).**

## 1 INTRODUCTION

Lightning protection systems (LPS) may be investigated through various kinds of experiments, from high voltage laboratory testing to observations and measurements in nature. Of course, although difficult and slow in producing reliable data, only natural conditions may give a reliable assessment of the efficiency of a typical LPS.
An earlier analysis of lightning density in Indonesia has shown that even in countries with very high lightning density, it is not realistic to expect for a large number of lightning strikes to an instrumented LPS [1]. Some observers have noticed that in the Pyrénées Mountains, south of France, a substantial lightning activity with direct impacts exists, mainly during summertime. A general analysis of Météorage data has pointed out an interesting site at the Pic du Midi, a location at high altitude already occupied with an astronomical observatory, a telecommunication tall antenna and some intermediate building between two portions of cable car transportation.

The experimental site devoted to the study of direct lightning impacts to lightning rods has been selected at the top of the Pic du Midi in the French Pyrénées. This site offers the exceptional opportunity of investigating lightning strokes to a complex structure of limited extension, intermediate between a large building at moderate altitude and a high-elevated structure such like the well-known instrumented telecommunication towers (Gaisberg, Peissenberg, Säntis or CN Tower); see for example [2]. At the Pic du Midi, the famous astronomical Observatory offers an unique scientific environment for various lightning observations (sprites, lightning protection tests, Météorage) in collaboration with astronomers.

Our goal is to instrument some of these buildings to record lightning impacts and, if any, notice some possible LPS by-passes, a direct evaluation of the protected zone. In this paper, we will describe the DIMM platform (built on Turret 55) experimental equipments designed to record lightning currents, fields and light by means of a high-speed camera.

First, we will explain why we chose this test site in terms of lightning density and how results obtained at high altitude may be useful to test the lightning protection models. Then, a description of the diagnostics and related recording devices will be presented. Preliminary results will be discussed before conclusions.

## 2 LIGHTNING ACTIVITY AND CHOICE OF THE TEST SITE

As said earlier, the test site has been chosen for its special lightning density; but also because it is possible to express lightning parameters as functions of the air reduced density.

### 2.1 Choice of the test site at high altitude

Most of the lightning observation stations are built up at high altitude because of their performing values of

lightning density with respect to moderate altitude conditions. In general, these locations offer a good visibility for optical or electromagnetic sensors, being visible from far distance. When a lightning detection network is available to check the lightning detection and location efficiencies deduced from direct measurements, the location in altitude is a positive advantage. In temperate countries, quite all observation stations are built at altitudes above 2,000 m. In the USA, important results have been assessed about the competition between sharp and blunt rods in Socorro (Langmuir laboratory) at 3,000 m altitude.

One obvious concern is the significance of such conditions to study the attachment mechanisms. Some weather parameters such like air density, hygrometry and pressure may be easily recorded. As we know how to correct the effects of reduced density on the fields needed to form corona or leader discharges, on the minimum field needed for leader stable propagation, there is no unsolvable problem [3]. Meteorological storm conditions appear to be of greater concern because sometimes the relative distance between the cloud and the station may be small down to the case of a thunderstorm with the station fully inside the cloud.

### 2.2 Lightning activity as seen by Météorage

The Pic du Midi observatory is well located inside the Météorage network. One interesting feature of the test site is to stand at high altitude, at the top of a 3,000 m mountain. This offers an excellent opportunity to test both the detection and location efficiencies of such a large efficient network [4] in a region of different ground conductivity with respect to the low altitude surroundings.

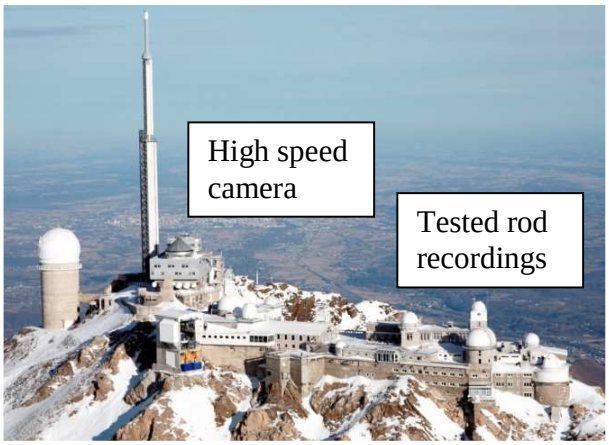


Figure 1. : Remote view of the test site

Figure 1 shows the test site, with the tested rod location (on top of major building at right) and h-s camera inside the building at the antenna foot.

Surveying 10 years of Météorage data gives an interesting confirmation of the site choice. Overall lightning density inside a 25 km radius circle is about 2-4 strokes per year per square km; at the site itself, this density averages 40. Figure 2 shows a map of lightning impacts around the site for a 10 years period, for 2000-2009. There is no doubt to guess where the tested site location is…

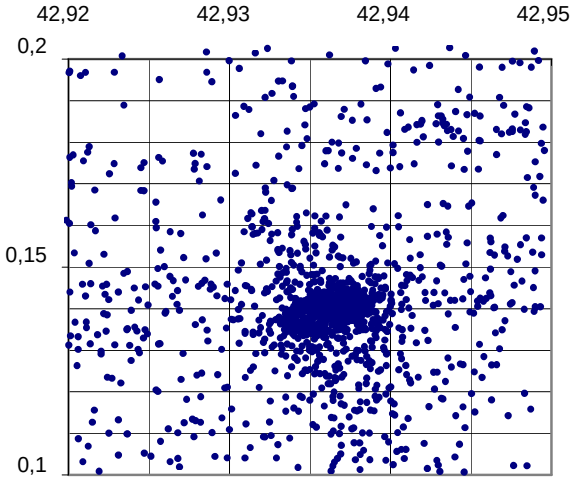


Figure 2. : Map of lightning impacts around the site for a 10 years period, for 2000-2009. Latitude is in abscissa and longitude in ordinate. From Météorage.

An overall survey of the lightning data shows that the lightning current distribution is shifted to the lower intensities (current intensities are lower than in the valley). It is expected that the network would not detect low intensity leaders, which can be done by means of current recorders or probes. At last, most of the flashes are negative.

## 3 LIGHTNING RECORDING DEVICES

A lightning rod is susceptible to be struck by incoming downward leaders or to initiate upward leader triggered by close CG flashes or downward leaders. The general purpose of our experiments is to characterize lightning impacts on and around an instrumented lightning rod installed on Turret 55 (42, 93652°N; 0, 14261°E) of the Observatory. The test site is limited to the “flat” top of the mountain, with a tall telecom antenna on one side, and some astronomical towers on opposite side (see also figure 4). DIMM platform is located out of the “shadow” of the tall antenna.

### 3.1 Diagnostics means used around the lightning rod

Several lightning and environmental parameters are simultaneously recorded:

- The lightning rod current is measured by means of a current probe and monitored by a digitizer.

- Independently, the current and field are detected by means of a new Rod Links® unit. This unit records both the exact date of lightning event, polarity, crest amplitude, rise time and decay time of the current, specific energy too. All these data are sent by SMS.

- The electric field may be measured either by a field-mill or by a capacitive plate

- Upward and downward leaders may be recorded by a high-speed video camera, located far enough from DIMM platform, viewing at least the last 200 m of the down leader trajectory; see figure 3 (in reality, camera is set indoors).

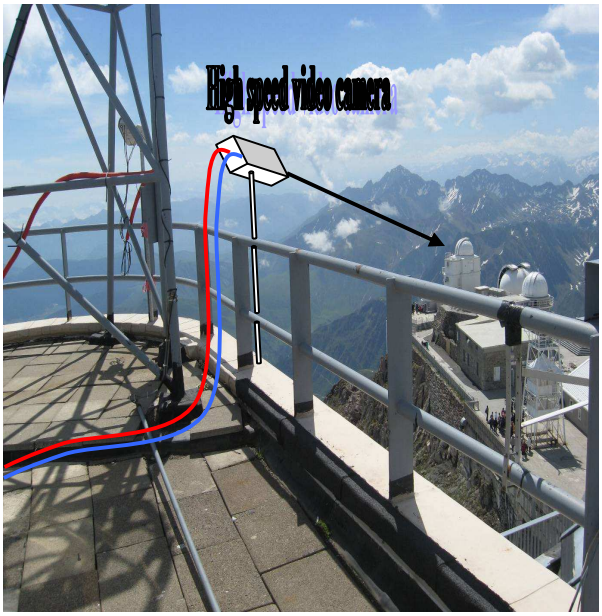


Figure 3. : Field of view of the HS video camera

- Lightning dating counters are used to get evidences of the lightning activity of the rod.

### 3.2 Further details about the recording equipment

The lightning current is measured by means of a Rogowski probe. The galvanic insulation is made using a optical fibre system. Recorded current waveforms are kept in the oscilloscope memory, transferable to the researchers at distance.
Independently, data obtained by the Rod Links® unit (electric field, lightning current) is processed and also accessible at distance.
A field-mill (Previstorm) is installed close to the rod. Data is sent by optical fibre to a computer indoors.

A high-speed camera is set inside a room of the ministerial building built at the antenna foot. So, its surrounding ambiance will stay acceptable to a convenient functioning. This video camera (Photron SA4) is able to give data such like the occurrence of corona or leader discharges, to give temporal (and of course spatial) information. We hope to use it to exhibit direct strokes to the rod but also by-passes, in correlation with Météorage data. Resolution of this camera is 3,600 frames per second at the highest resolution of 1024x1024.Its triggering will be done by a radio signal (869 MHz) emitted at the rod site from the oscilloscope. Its memory (32Go) is large to be able to record four different flashes without data transfer.

In addition, lightning counters have been installed along the down conductors of the rod. Their data may be also compared to Météorage data. Of course, the reference time will be controlled using GPS.

### 3.3 Special problems due to weather parameters

At such altitude, the experiment maintenance is very tough. The observatory is covered by huge snow during a large part of the year. Extreme cold (-30°C and strong winds (velocities higher than 200 km per hour) are frequently recorded (see figure 5). So, a special care about the rod fittings is highly recommended. End of February 2010, wind bursts of 240 km per hour have been recorded, without damage to the experiment.

## 4 CONCLUSIONS

A comparative study of lightning counters data with Météorage allowed to identify some of the flashes involved in striking the lightning rod. At DIMM platform, several events have been recorded inside a period of one year (some of them are non-connecting upward leaders created at the lightning rod tip). This appeared to become an excellent site for lightning studies, especially for featuring the lightning attachment to a lightning rod. In figures 1,4,5, Turret 55 is visible with its surrounding buildings.

Lightning dating counters have been installed for years on a cable-car intermediate station building and on the down conductors of the rod at DIMM platform. The

number of recorded small events is about 15 per year versus 400 per year at DIMM platform, corresponding to their relative estimated lightning density as derived from data recorded over a 10 year time period. Generally, they are of low intensity (up to 6 kA) and are assumed to be similar to non-connecting leaders.

At the time of ICLP 2010 conference, summertime results will be presented. Present results lead to the assumption that such a site is more producing data than other sites we experienced in Indonesia.

## 5 REFERENCES


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Figure 4. : Turret 55 with DIMM platform at left

Figure 5. : Turret 55 with DIMM platform in winter