A detailed characterization of the atmospheric aerosols and precursors at the Pierre Auger Observatory

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Letter Of Intent to the Pierre Auger Collaboration

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[3]LISA, UPEC–Paris Diderot, CNRS/INSU, Créteil, France.

3 laboratories involved in the project

- Laboratory of Physics Meteorology (LaMP)
  → Aurélie Colomb (trace gases),
  → Karine Sellegri (precursors / aerosols),

- Laboratory Inter-universitary of Atmospheric Systems (LISA)
  → Rémi Losno (aerosols),
  → participant to the IS@AO workshop,

- Laboratory of Subatomic Physics and Cosmology (LPSC)
  → François Montanet (Auger member),
  → Karim Louedec (Auger member),
  → intermediary between the Auger experiment and the two atmospheric labs.

(in a close scientific collaboration with MI Micheletti)

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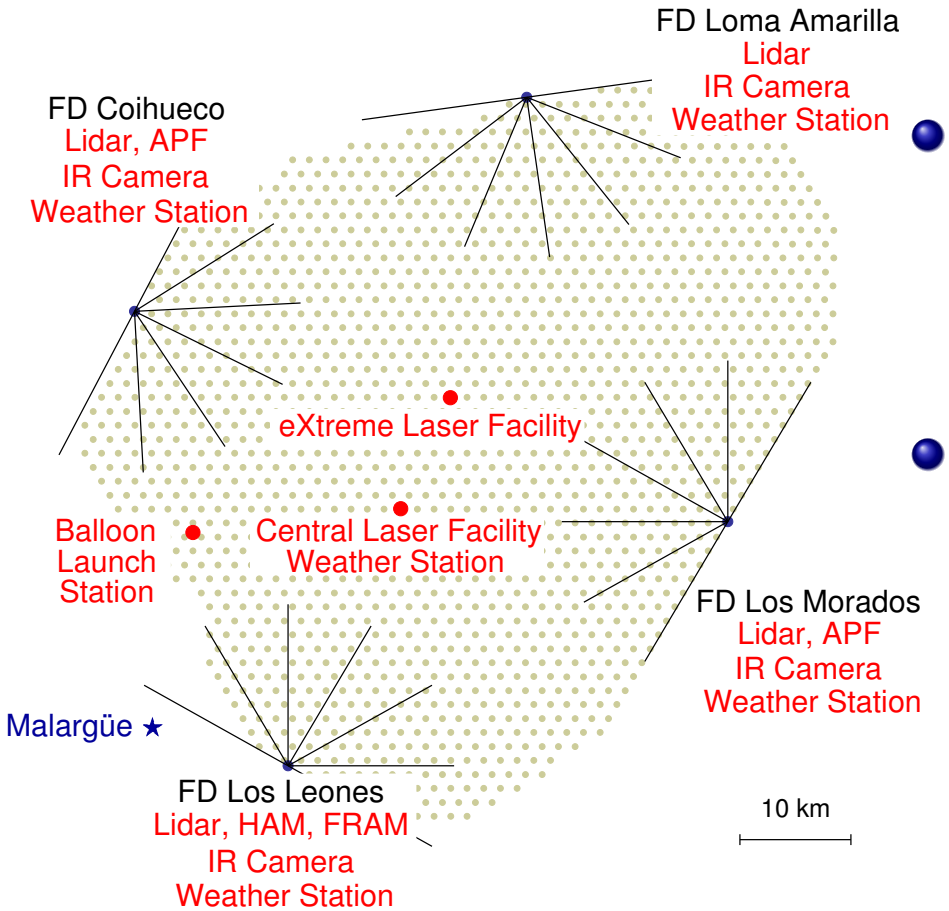
Objectives

The Pierre Auger Observatory has developed during the last years a large program to monitor the atmospheric aerosols. We propose to extend this monitoring program with the installation of several facilities to improve our knowledge about aerosols. In fact, some studies done in the collaboration have highlighted possible systematic errors coming from the aerosol size or some trace gases. The goal of this project is hybrid: for the Pierre Auger Collaboration, a better knowledge of the atmospheric aerosols and the pollutants, and for our groups, specific studies to better understand the link between aerosols and climate evolution.

An extensive atmospheric monitoring @ the Pierre Auger Observatory



- Atmospheric state variables
  - → 5 ground-based weather stations,
  - → more than 300 balloon lunches,
  - → now the GDAS model too.
- Aerosol and cloud monitoring
  - → 4 ‘elastic’ lidars,
  - → 2 central lasers (CLF/XLF),
  - → 2 optical telescopes (HAM/FRAM),
  - → 4 IR cameras,
  - → ... and soon, a Raman lidar.

Some remaining questions on atmospheric effects

Aerosol size affects the contribution of multiple scattered light

- not yet taken into account in the $\overline{\text{Off}}\underline{\text{line}}$ reconstruction,
- systematic uncertainties not negligible compared to the total systematics: $\Delta E/E \sim 4\% - \Delta X_{\max} \sim 5\ g/cm^2$,
- more details in GAP-2011-073.

Ultraviolet and visible absorption by atmospheric trace gases

Atmospheric gas	Cross section at 350 nm [cm^2]	Concentration [$\mu g/m^3$]	Λ_{abs} [km]
Ozone O_3	2×10^{-22}	80 µg/m3	50 000
Nitrogen dioxide NO_2	4×10^{-19}	30 µg/m3	64
Sulfur dioxide SO_2	8×10^{-23}	8 µg/m3	2×10^6
Nitric acid HNO_3	1×10^{-24}	2 µg/m3	5×10^8

- photoabsorption cross section is the key parameter,
- NO_2 (& Co.) should be monitored to estimate really its effect.

1st project: modelling of the evolution of aerosols in South America (LISA)

- Austral region from $40°$ to $65°$ South is one of the major CO_2 sink,
- trace metals (aerosols) $\rightarrow$ growth of phytoplankton $\rightarrow$ trap CO_2,

$\rightarrow$ characterize chemical properties of aerosols (dust) in Argentina.

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Method and plans

- aerosol collections to increase the existing aerosol samplings,
  $\rightarrow$ *field campaigns and pumping system*
- chemical measurements
  $\rightarrow$ *estimation of light absorption*
- Lidars to retrieve the vertical shape of aerosol layers,
  $\rightarrow$ *using as frequent as possible*

2nd project: link between ionic precursors, aerosols and galactic cosmic rays (LaMP)

basic idea: the CLOUD experiment in the real atmosphere

- formation of nanoparticles from gaseous molecules/ions by nucleation,
  → *influence of ions on the formation of new particles ?*
  → *influence of GCRs on the formation of new particles ?*
- the LaMP group is already involved in experiments in Bolivia and Nepal,
  → *interest: collaborate with scientists experts on CR physics*

Method and plans

- Neutral Air Ion Spectrometer (NAIS),
  → *characterization of ions, SO_2 and Volatile Organic Compounds*
- Scanning Mobility Particle Sizer (SMPS),
  → *particle size distribution from 0.4 nm to 800 nm*
  → *optical properties of aerosols*

Benefits for the Pierre Auger Collaboration

- new facilities installed at the observatory to understand the atmospheric effects,
  → *size, shape and chemical composition of atmospheric aerosols*
  → *measurement of trace gases*
    → reduction of systematics on aerosols (size effect)
    → validity of the assumption that absorption is negligible in Auger
- the observatory is installed where only a few meteo stations are installed,
  → *the Auger Observatory could join international networks as GAW / AERONET (maybe a possibility to get a sun photometer → needed to be confirmed)*

Request to the Pierre Auger Collaboration

- access to Lidar data and SD scaler data,
- possibility to install detectors on site,
- help from the local staff (depends on facilities installed).

Thanks for your attention !