Detection of aerosols in planetary atmospheres using the new light aerosol counter LOAC

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Liquid and solid particulates in suspension in atmosphere

On Earth :

- Liquid sulfate aerosols, soot , meteoric debris in the stratosphere
- Soot, minerals, biomass particulates, … in the troposphere

On other solar system bodies :

- Martian dust
- Droplets on Venus
- Titan aerosols

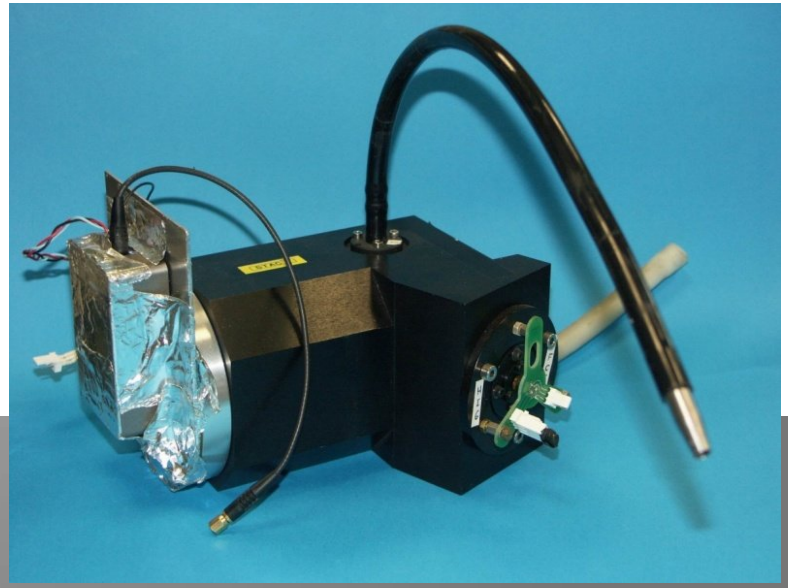
Among the physical properties of aerosols, need to determine

- The size distribution (from hundreds of nm to tens of mm)
- The concentration (number . cm^{-3})
- Their nature (liquid, solid, main composition)

Aerosol counters can be used more or less for such purpose

But with conventional counters:

- Size distribution is often retrieved assuming liquid aerosols (Mie scattering)
- The nature of the (solid) aerosols must be known in advance
- Aerosols with irregular shape cannot be accurately detected



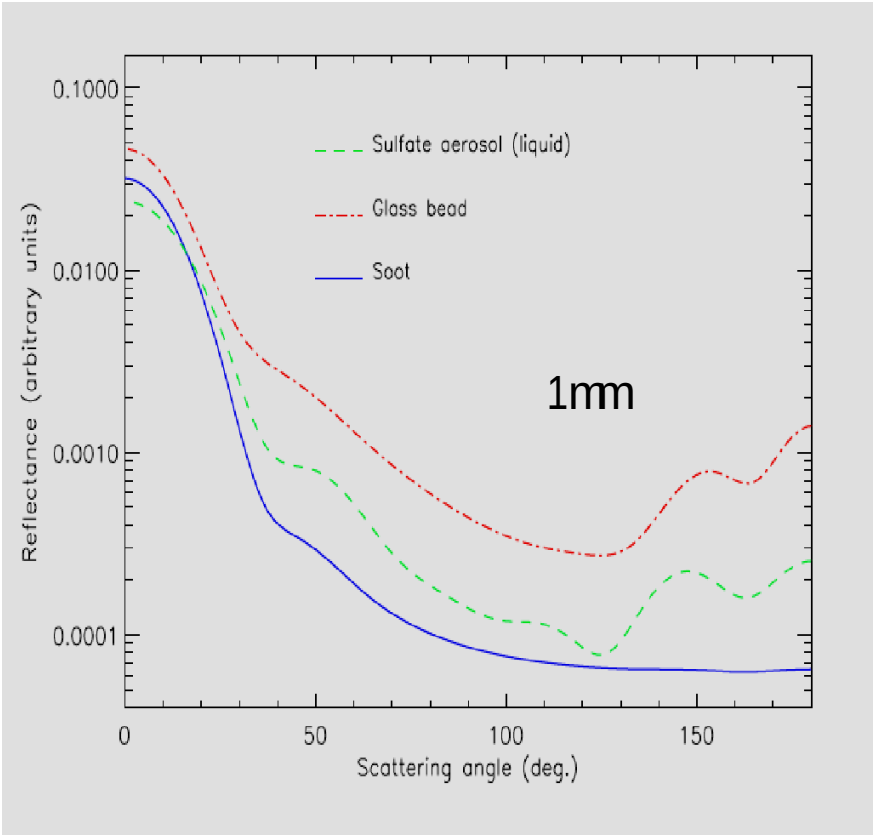
STAC aerosol counter onboard stratospheric balloon

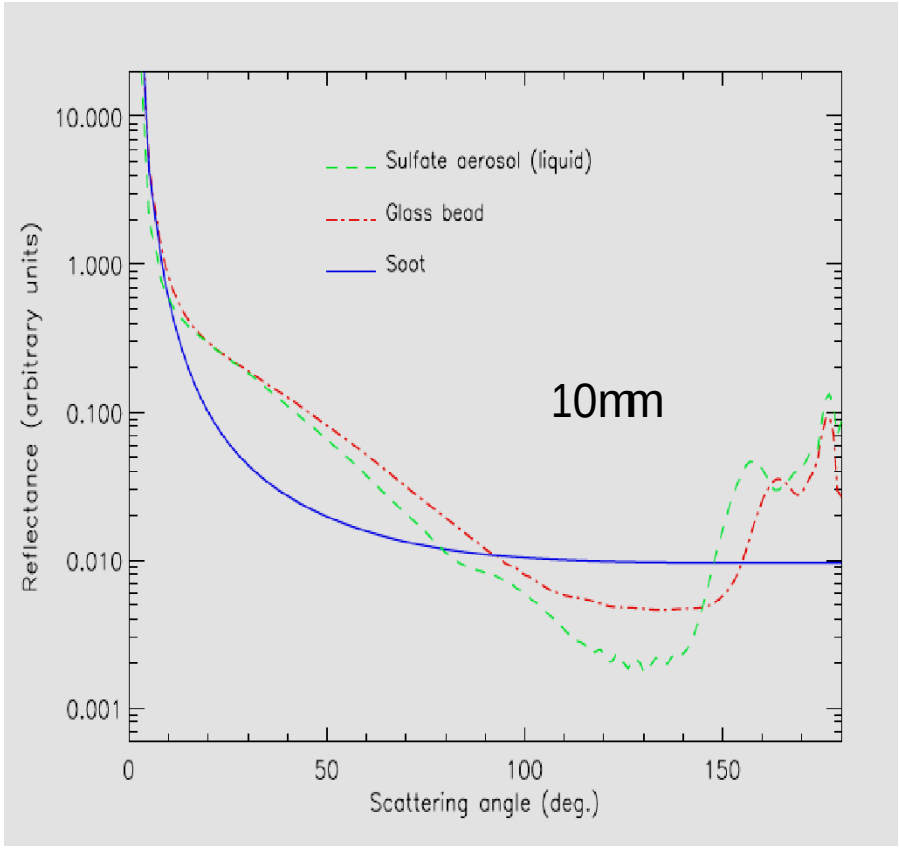
Counters performed measurements usually at scattering angles around 90°

Different natures of aerosols give different optical response

=> the retrieval of size is difficult even if they are spherical

Example of optical response for various kinds of spherical aerosols (assuming spherical aerosols)



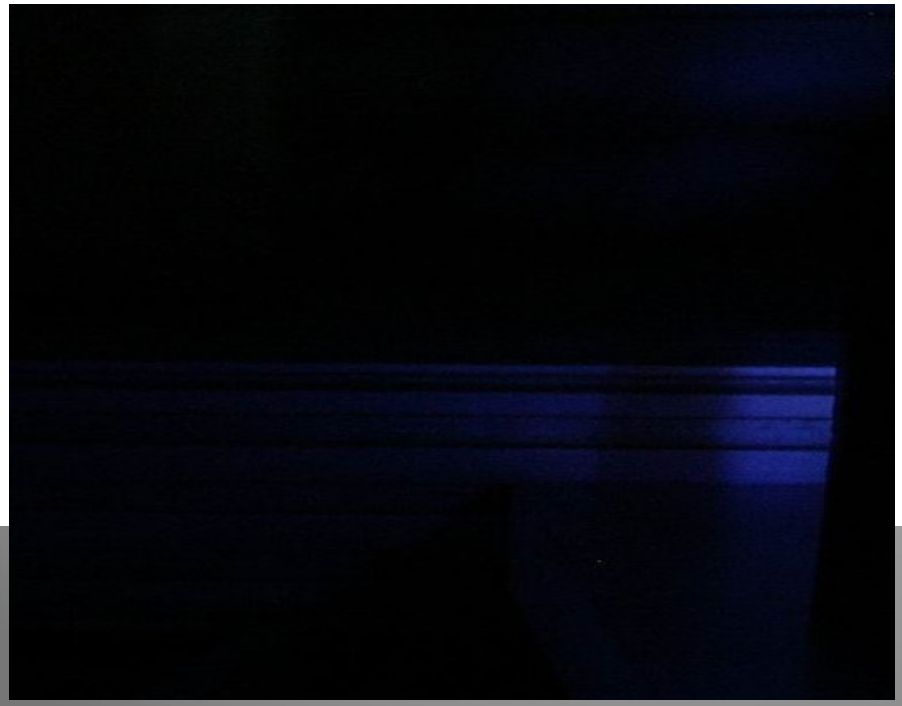


At small scattering angles (>20°), scattered light is less dependent on the nature of the aerosols

But the main problem is the strong stray light contamination (light source close to the field of view)

Ex: dust in ambient air

scattering angle of 90°



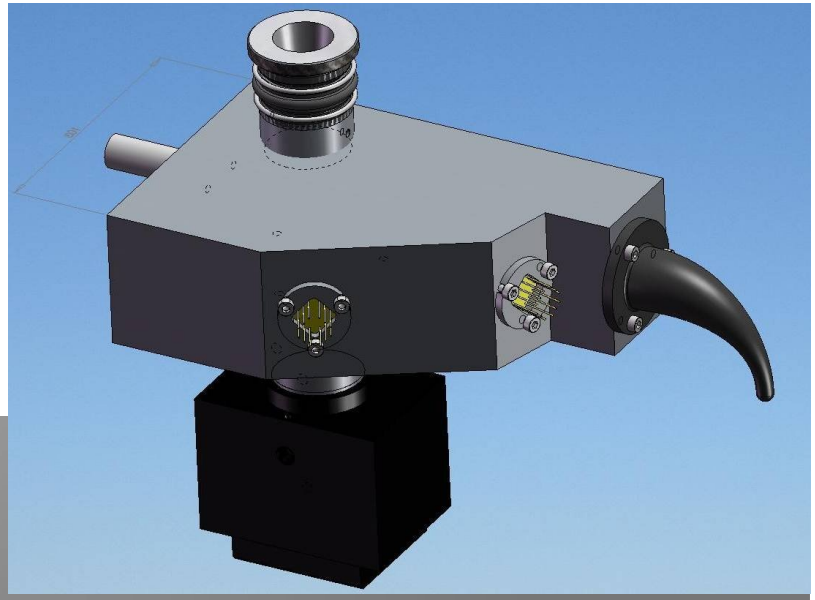
scattering angle of 10°

We have developed, with the Environnement-SA Company, a new concept of aerosol counter (CPM) with:

- Measurement at two angles:10° and 60°
- No lenses in front of the detection system (=> no need of optical alignment)
- Small field of view
- Real-time correction of the stray light (avoiding the problem of the stray light evolution with time)

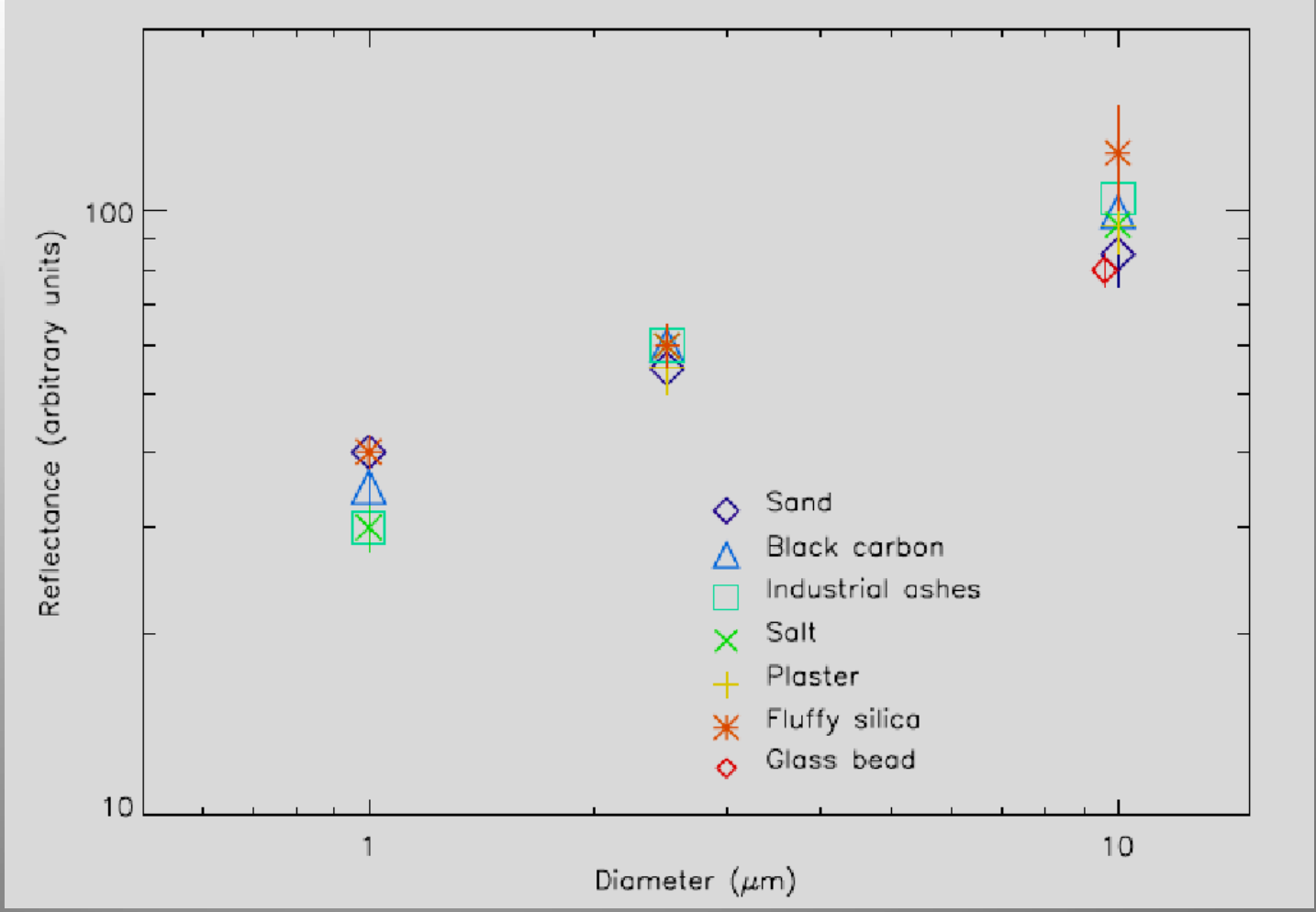
The 10°angle, to count the aerosols per size classes

The 60° angle, to identify the main nature of the aerosols (the light scattered at 60° is very sensitive to the nature of the aerosols)



CPM instrument (Environnement-SA)

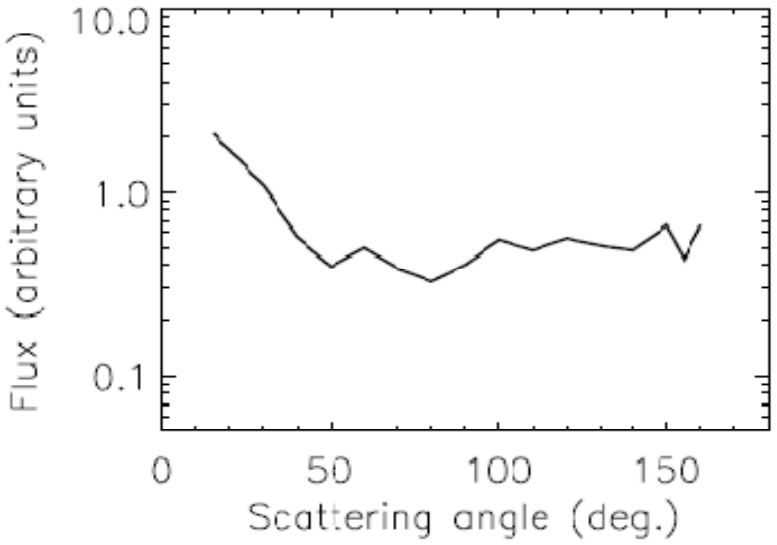
Laboratory tests on various kinds of solid (and irregular) particles has confirmed that the scattered light is similar at small scattering angles, at least for particles below 10 mm



Example of scattering curves
(obtained in laboratory a polarimeter)

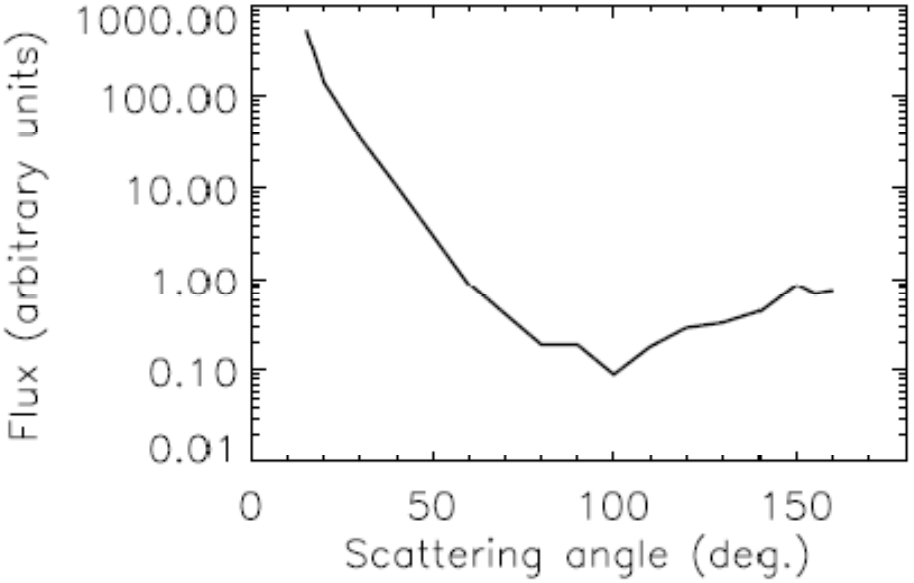
Tholins

ratio 10°/60° ~10

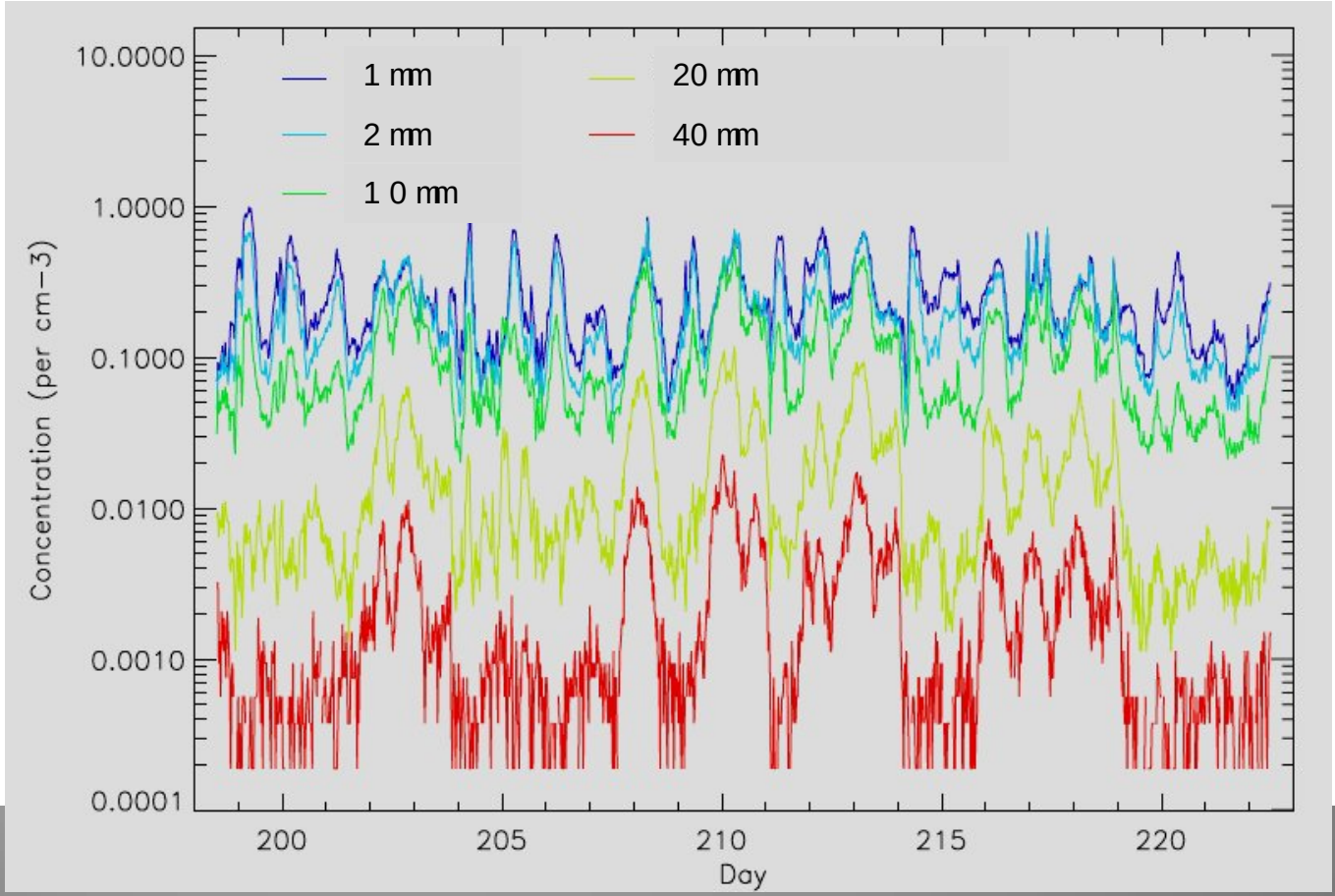


Black carbon

ratio 10/60° ~ 1000

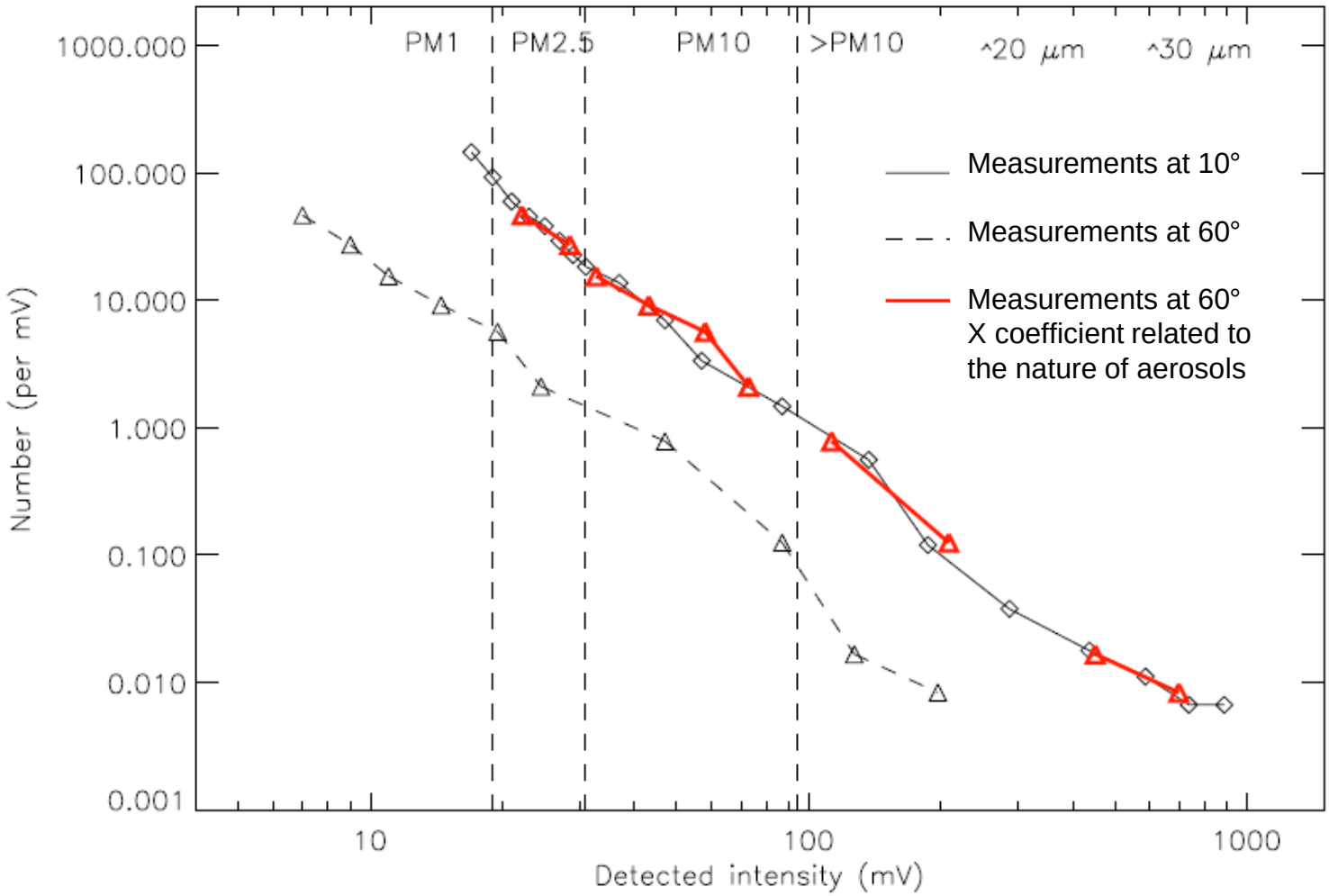


Example of measurements in ambient air on July-August 2009

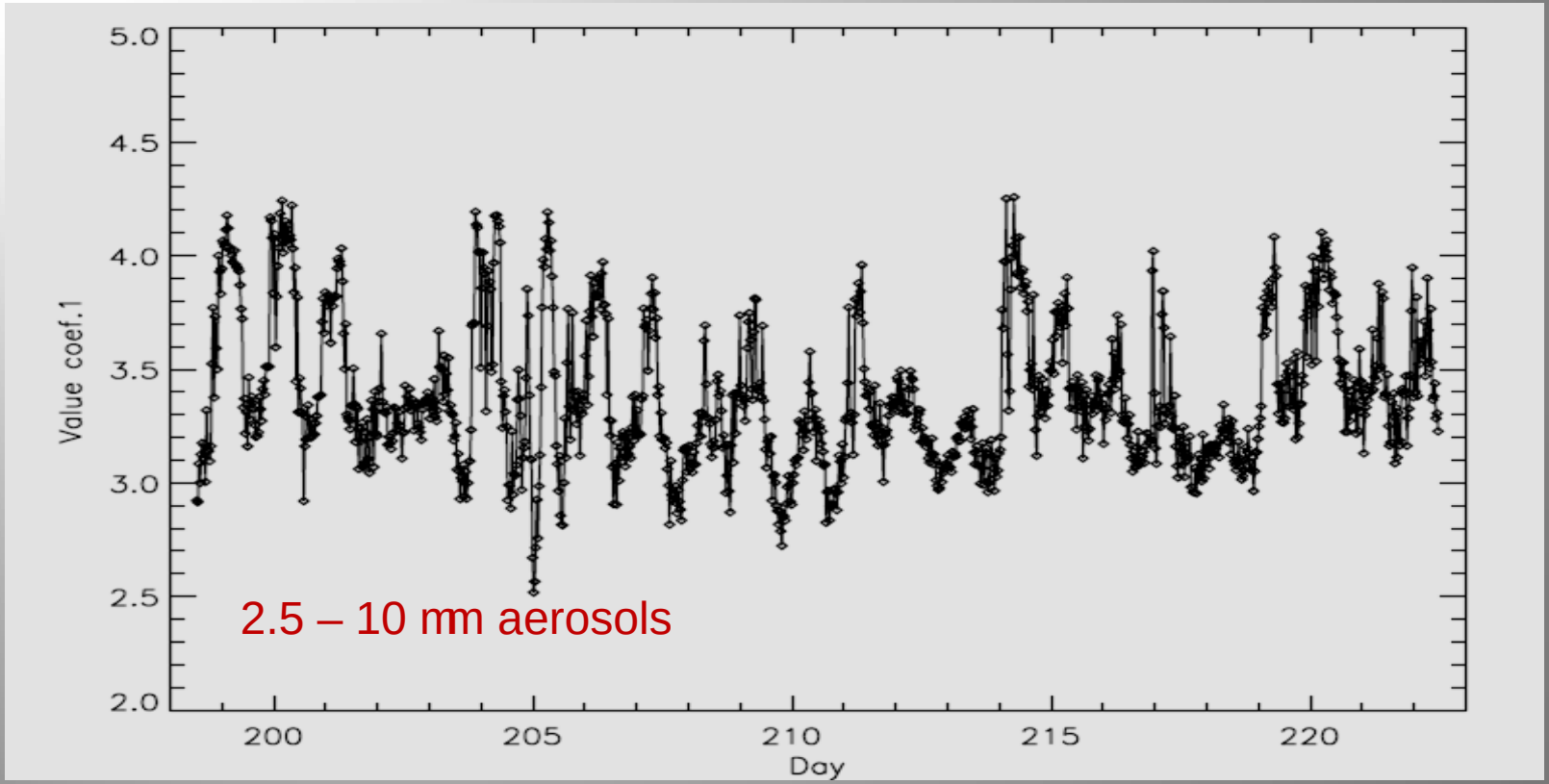


Size distribution at 10° and 60°

Flux range (mV) vs. number of particulates per mV



The ratio of the curves for different sizes, and its evolution with time, is linked to variation of the aerosol nature(in this case, diurnal cycle of aerosol moisture)



The data are compared to a data base obtained in laboratory with this instrument for various natures of aerosols

LOAC (Light Optical Aerosols counter) is the light version of this new concept of aerosol counter

Characteristics:

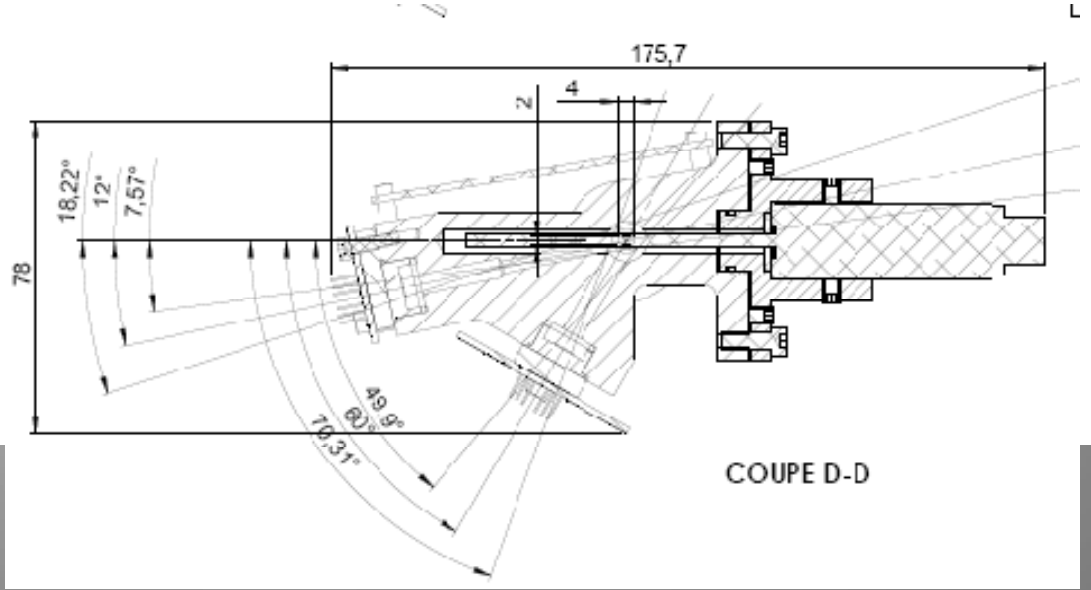
Weight : ~200 g (excluding batteries)

Size = ~20 cm x 10 cm

Detection at 2 angles, for aerosols in the 0.5-20 mm size range

No lenses in front of the detector

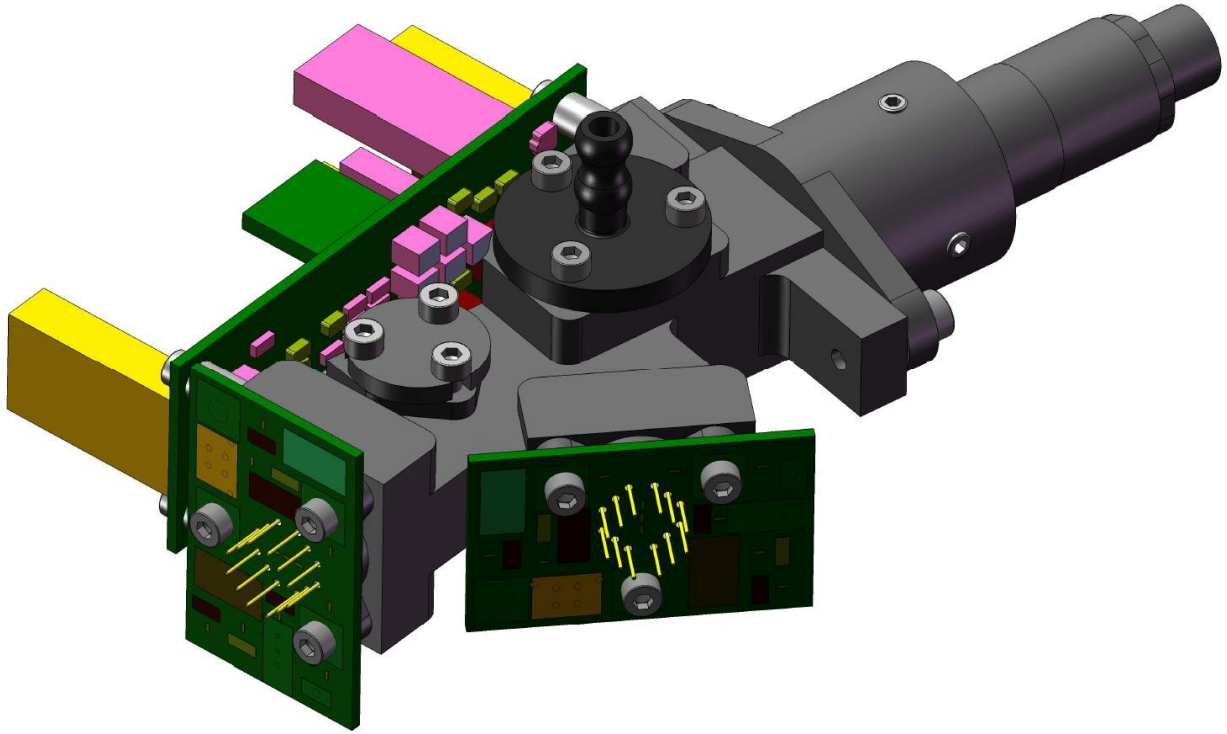
Real-time stray light correction



No real lower detection limit for concentration …

Smaller aerosols could be detected by increasing the power of the light source

Open data base for measurements interpretation



LOAC is firstly designed to be operated during flights under meteorological balloons, onboard stratospheric gondolas, and onboard long-duration tropospheric balloons

First flights expected in September 2010

Such light instrument could be put onboard space probes to better document some physical properties of planetary atmosphere aerosols during lander descent

LOAC could be also put on planetary balloons, as well as on landers and rovers for long term monitoring of surface aerosols