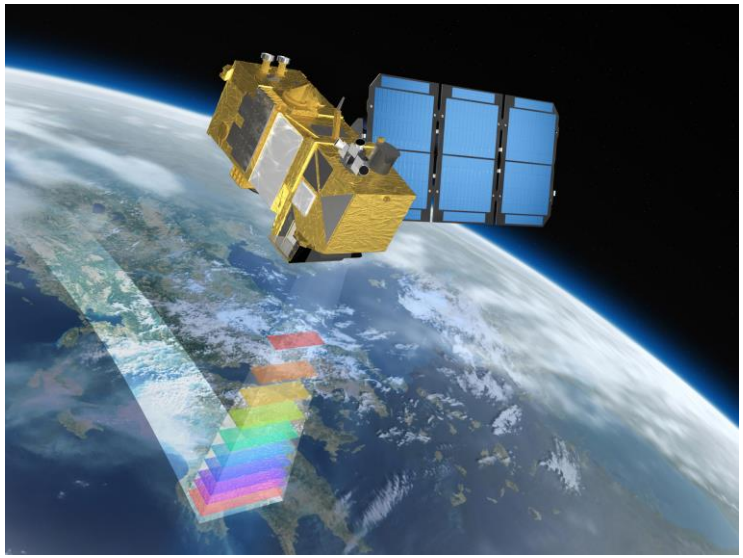
Centre Spatial de Liège

Why stray-light in optical instruments matters and what to do about it?

L. Clermont

Added values from space activities are crucial
(earth observation, science, etc.)

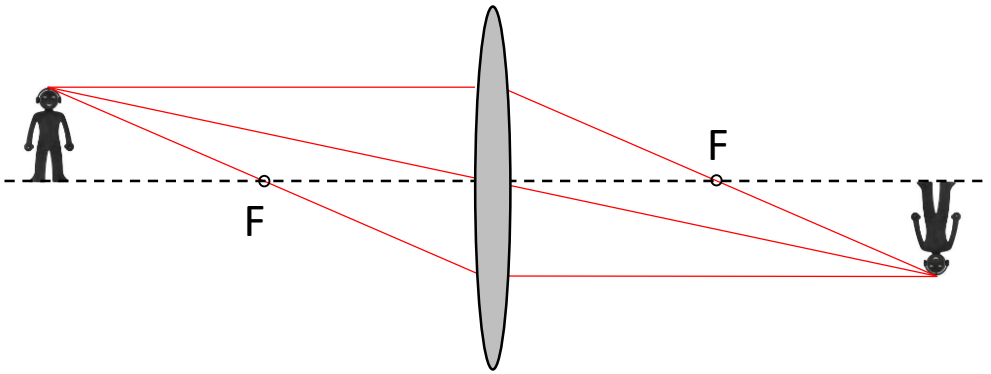


Just in case you didn’t knew it already …

Optics is at the core of space instruments

… says a totally unbiased optical guy

Optical elements (lenses, mirrors, diffractive elements) can bend rays to form an image

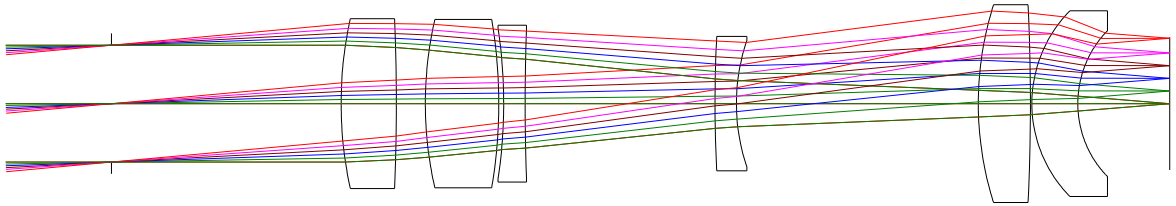


Optical designers build optical instruments by finding a configuration of optical elements which minimizes aberrations

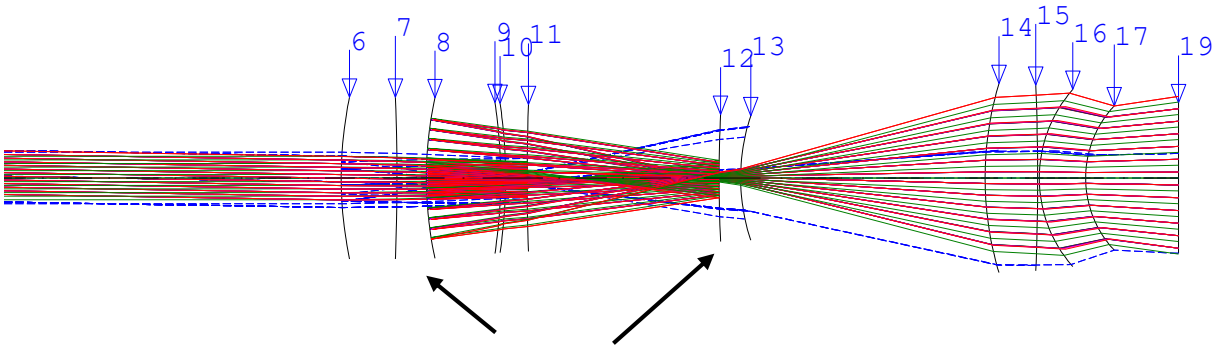
Minimizing aberrations is great …
but that's not the only driver of optical performance

stray-light is a critical concern for space optical instruments

Stray-light is light reaching the detector by following different paths or processes than the nominal beam



Nominal rays sequence



Ghost reflections

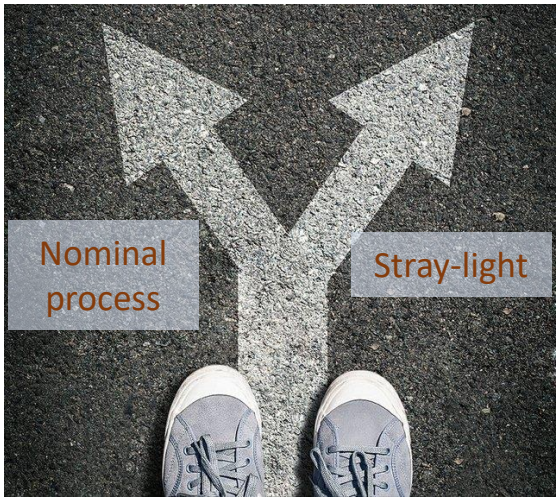
Stray-light decreases the image quality
and hence the added-values of spaceborne observations

- Broadening of the point spread function (PSF)
- Addition of unwanted features on the detector
- Decrease of the signal to noise ratio (SNR)
- Saturation of the detector

The ingredients of stray-light:

Source of light

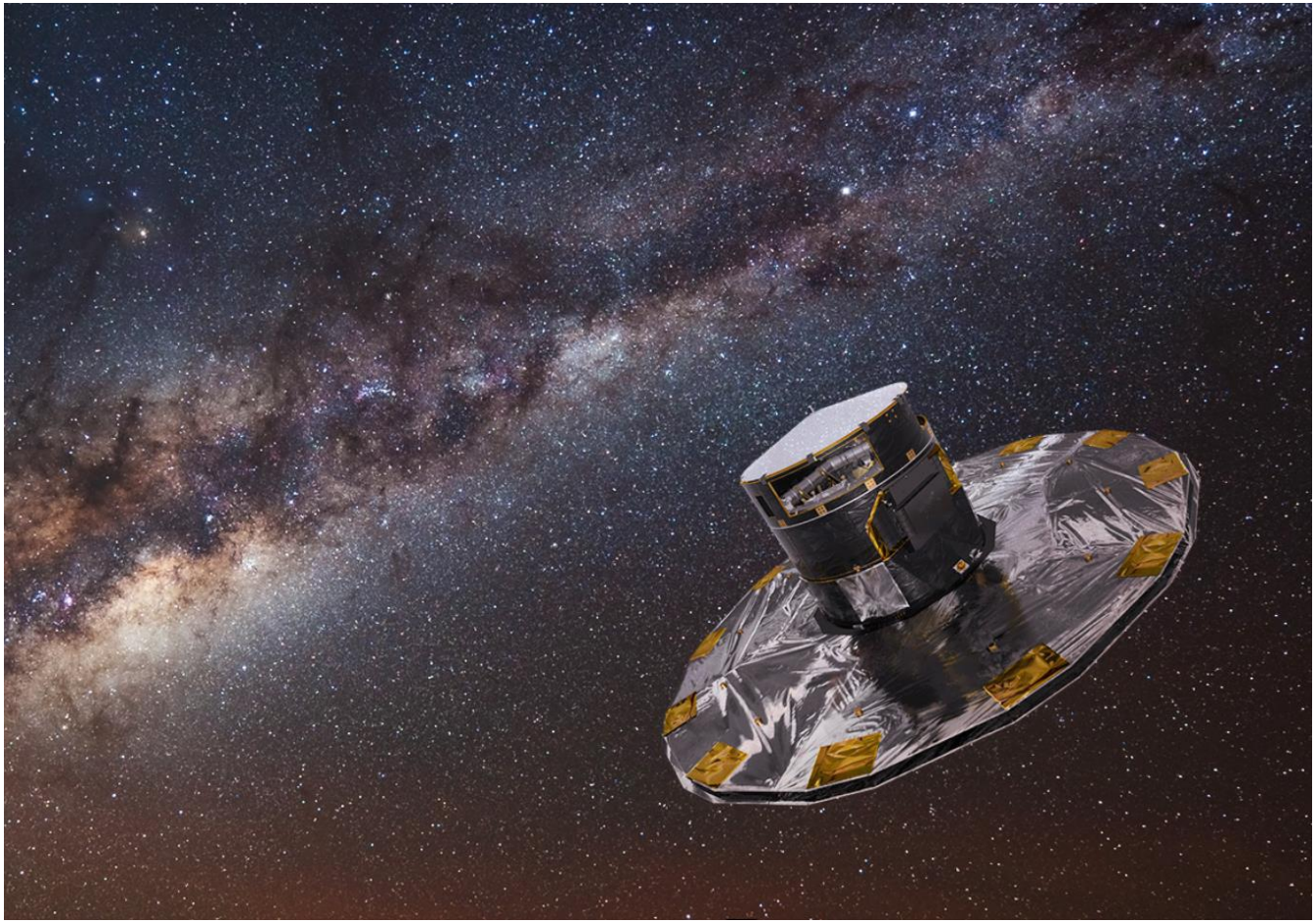
- External source
- Thermal self-emission
- Fluorescence



Non-nominal process

- Ghost reflection
- Scattering
- Diffraction
- Rogue paths

Stray-light even in the greatest …



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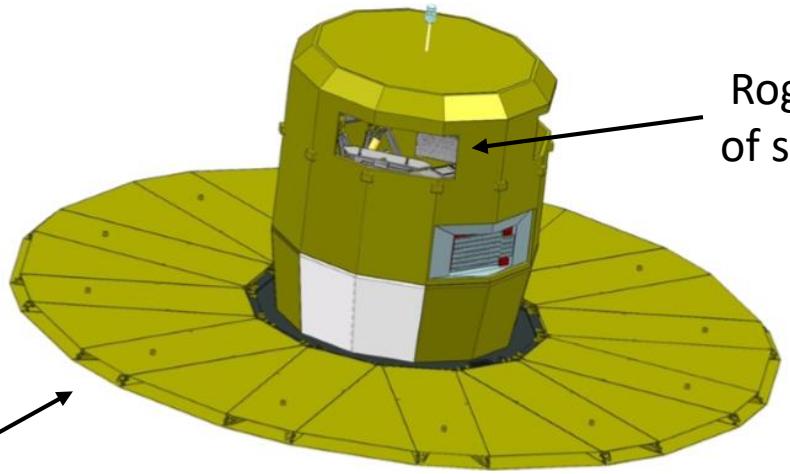
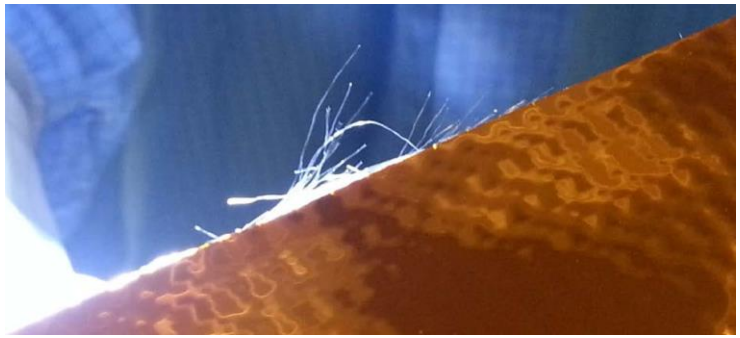


Rogue rays from edge of sun shield can enter



Nomex fibers sticking out of the sun shield

What to do against stray-light?

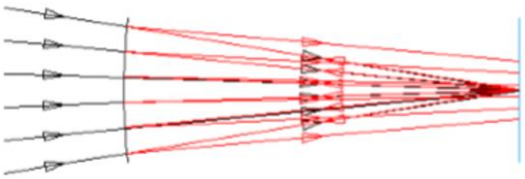
What to do against stray-light?

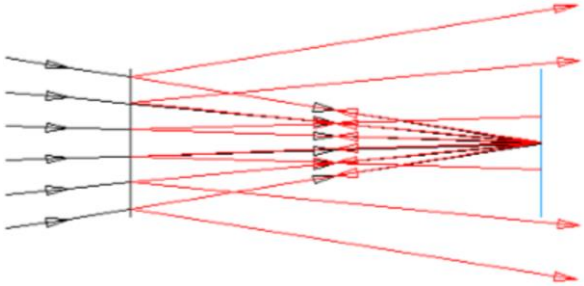
Design the instrument against stray-light (**control**)

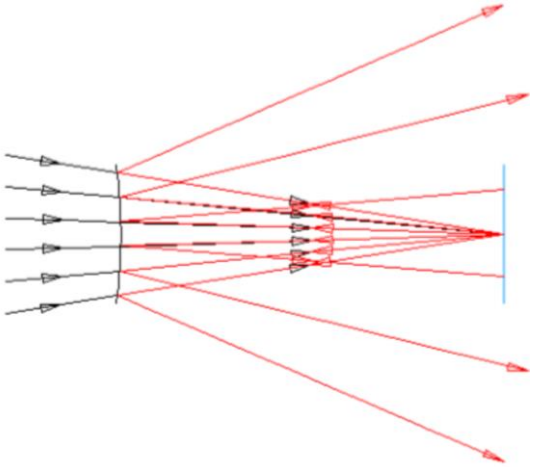
Predict the origin and level of stray-light (**analysis**)

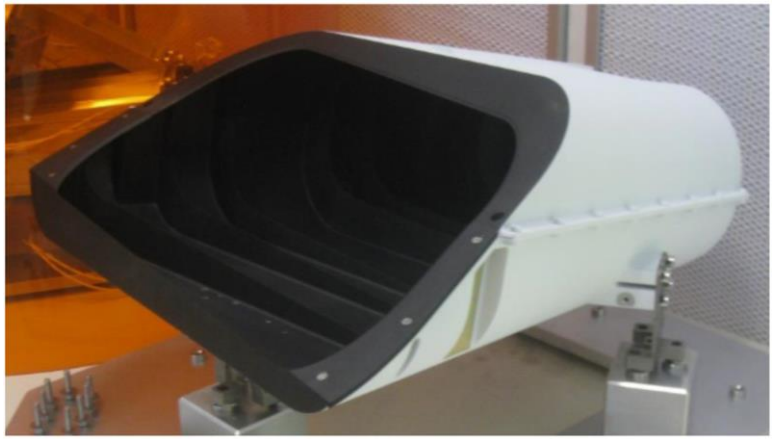
Verify the prediction experimentally (**measurement**)

Some examples of stray-light reduction tricks …

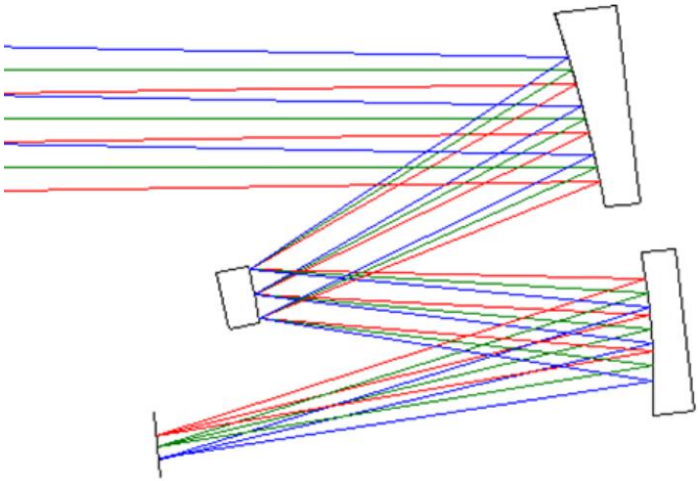




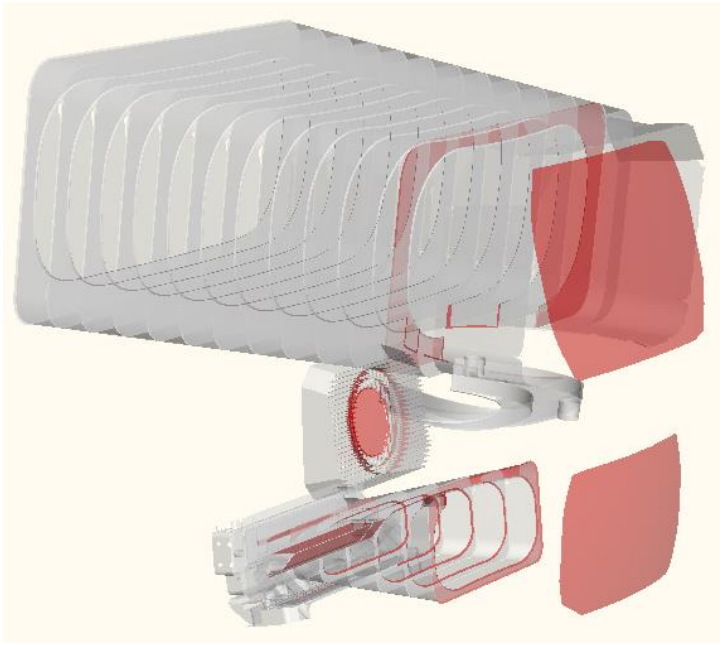




The stray-light engineering process is iterative and works as a feedback loop, it must consider also other aspects than optics



Optical design
Efficient against aberrations



System design
Efficient against stray-light

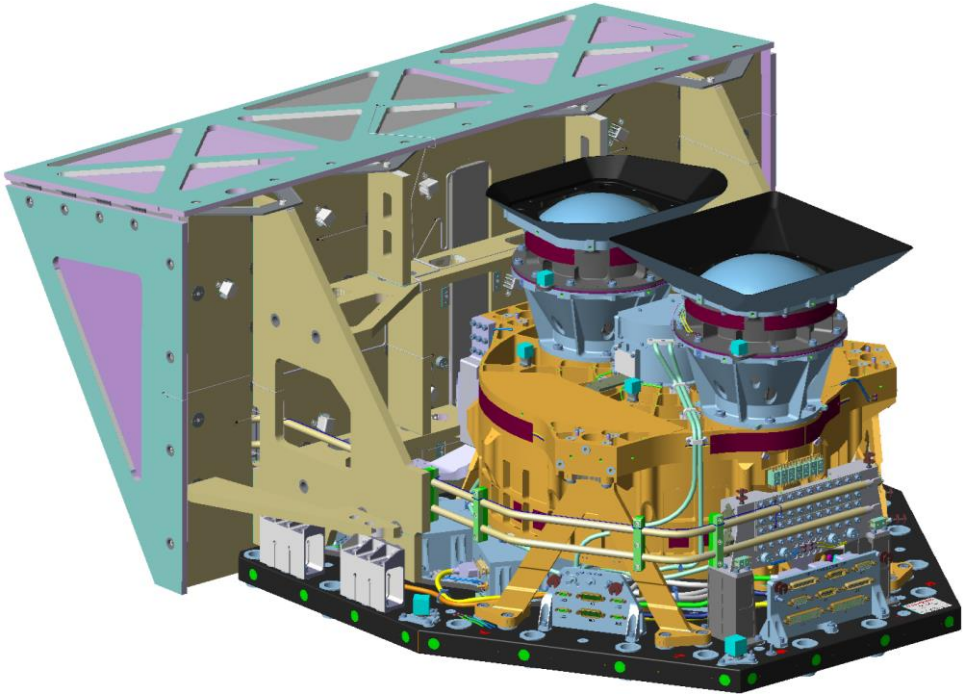
Experimental characterization requires dedicated facilities

FOCAL 3 facility @ CSL

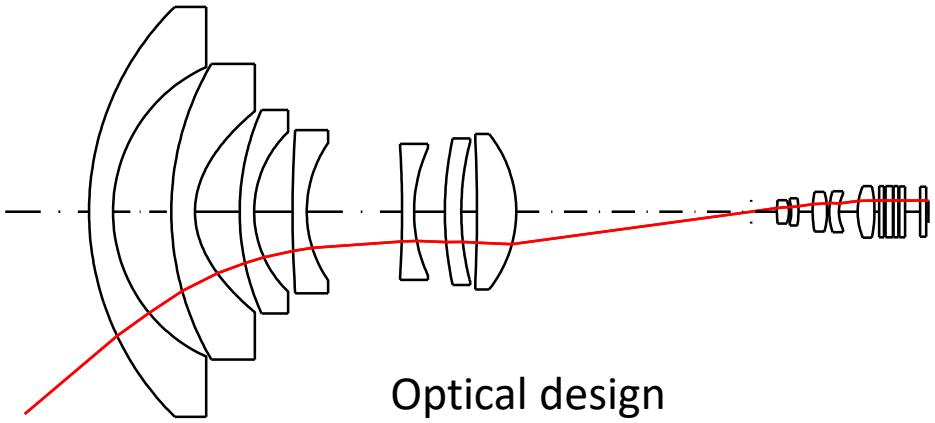
Stray-light requirements are always more stringent

Hardware optimization is not enough !

For METOP-3MI, we have developed a stray-light correction algorithm, which works together with an on-ground stray-light characterization



3D view of the payload



Optical design

What to remember?

Stray-light = critical concern (performance driver)

Need to be considered from early phase of mission @system level

Hardware is the first cure, post-processing is the second