MTG LI instrument and mission status

ESA LI team

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9th MTG LI Mission Advisory Group workshop
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Contents

- Instrument Engineering Model status and re-design aspects
- Instrument proto-flight model (PFM) design, procurement, assembly, integration and testing status

Engineering Model (EM) status

- The EM debugging activities have been completed: all Front End Electronics (FEE) and Main Electronic (LME) tests have been finished
- All identified mitigation & workarounds have been implemented in the flight hardware design:
    - a new FPGA design is implemented in the Front End Electronics: it has been integrated on flight hardware and successfully tested
    - the SW specification was updated - the new SW is available and has already been successfully tested
- The EM is now in a stable configuration allowing in-depth functional testing

LI PFM instrument design and procurement status

- The LI CDR has been closed. All lower level CDRs are closed.
- The expected LI PFM delivery is in autumn 2020 – there is an incentive scheme for industry to achieve this target.

Design

- the overall LI PFM design is complete
- the EMC shield around the Front End Electronics is currently optimized / preliminary tests on a validation model showed that the current design must be improved to be compliant with the radiated emission.

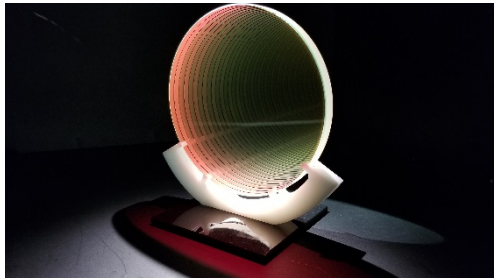
LI PFM instrument design and procurement status

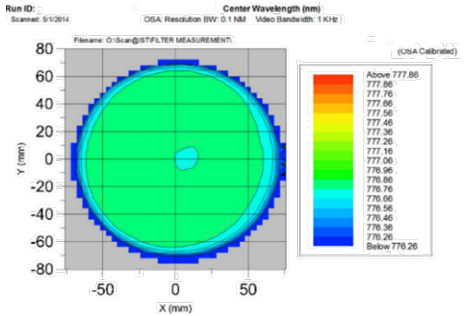
Flight Hardware procurement status

- the largest part of the flight hardware is already available in house at Leonardo or is short of being delivered

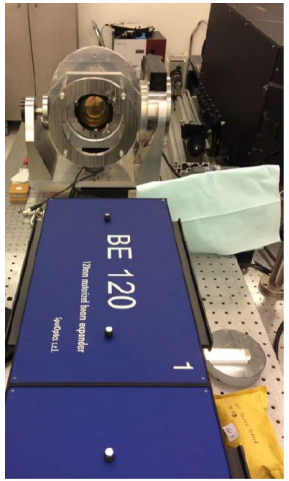
→ this is a very busy period organizing lower level Test Reviews

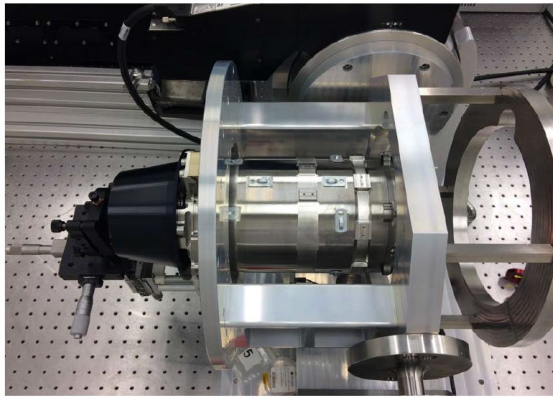
- the optical filters have been delivered
- The single board computer (SBC) flight units have been delivered
- the harness is being manufactured
- The SW has been updated considering all issues / bugs found so far





Sun Rejection Window – courtesy Iridian





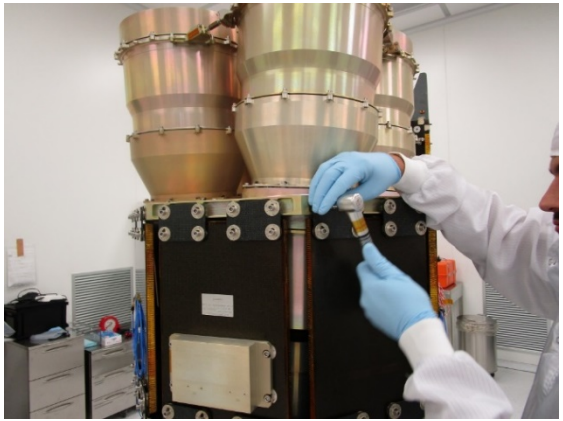
Telescope Wave Front Error test set-up - courtesy Leonardo

LI instrument design and procurement status

Assembly / Integration

- the PFM integration has started
- all four telescopes have been integrated – the wave front error test results are very good, well within the specs
- the population of the Optical Channel (OC) printed circuit boards is on-going. Some soldering risks have been identified which are currently assessed.
- the Main Electronics (ME) unit is ready, waiting for the completion of the power distribution printed circuit boards. A soldering issue has been identified and is currently investigated.
- The Telescope – to Focal Plane Array (FPA) alignment set-up has been commissioned and is ready for integration the flight hardware

Thermal model optical channels - courtesy Leonardo

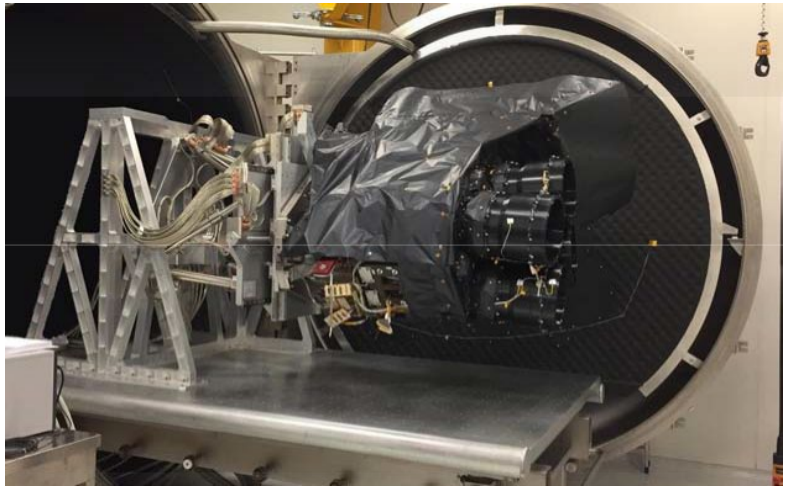


Structural model - courtesy Leonardo

LI instrument design and procurement status

Testing

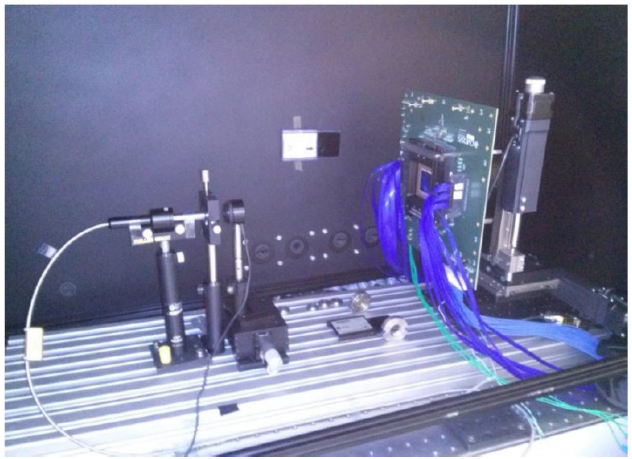
- Thermal and structural testing at LI level completed
- The lower level functional testing of the Front End Electronics has been completed.
- LME electronics board testing has been completed
- The LME PFM environmental test and functional test campaigns are currently prepared.
- Next steps: LME flight Hardware and LOH flight hardware testing

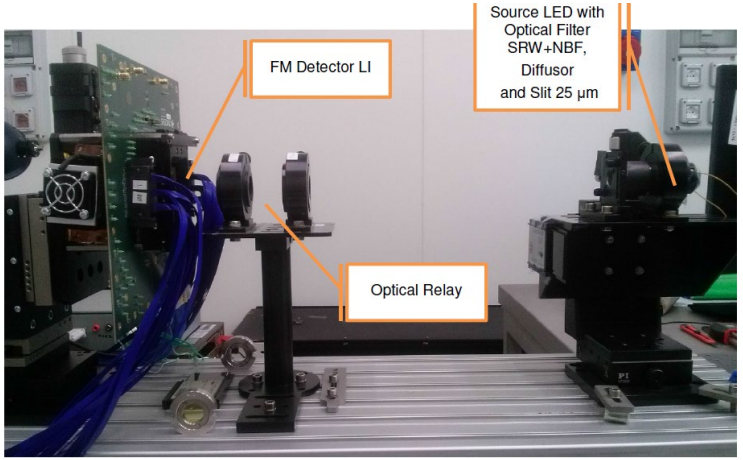


Thermal Model - courtesy Leonardo

LI detector status

- Flight units already delivered to Leonardo.
- Characterisation tests completed – the Quantum Efficiency is well within the specification (actually exceeding the specification of 70 %)
- Noise parameters well within specification
- Qualification campaign completed.
- Sun spot characterization tests completed: no functional / performance loss observed when illuminating the non-active pixel area. For the active area, the correct functioning of the anti-blooming has been confirmed.





Detector characterization set-ups - courtesy Leonardo

Instrument status summary

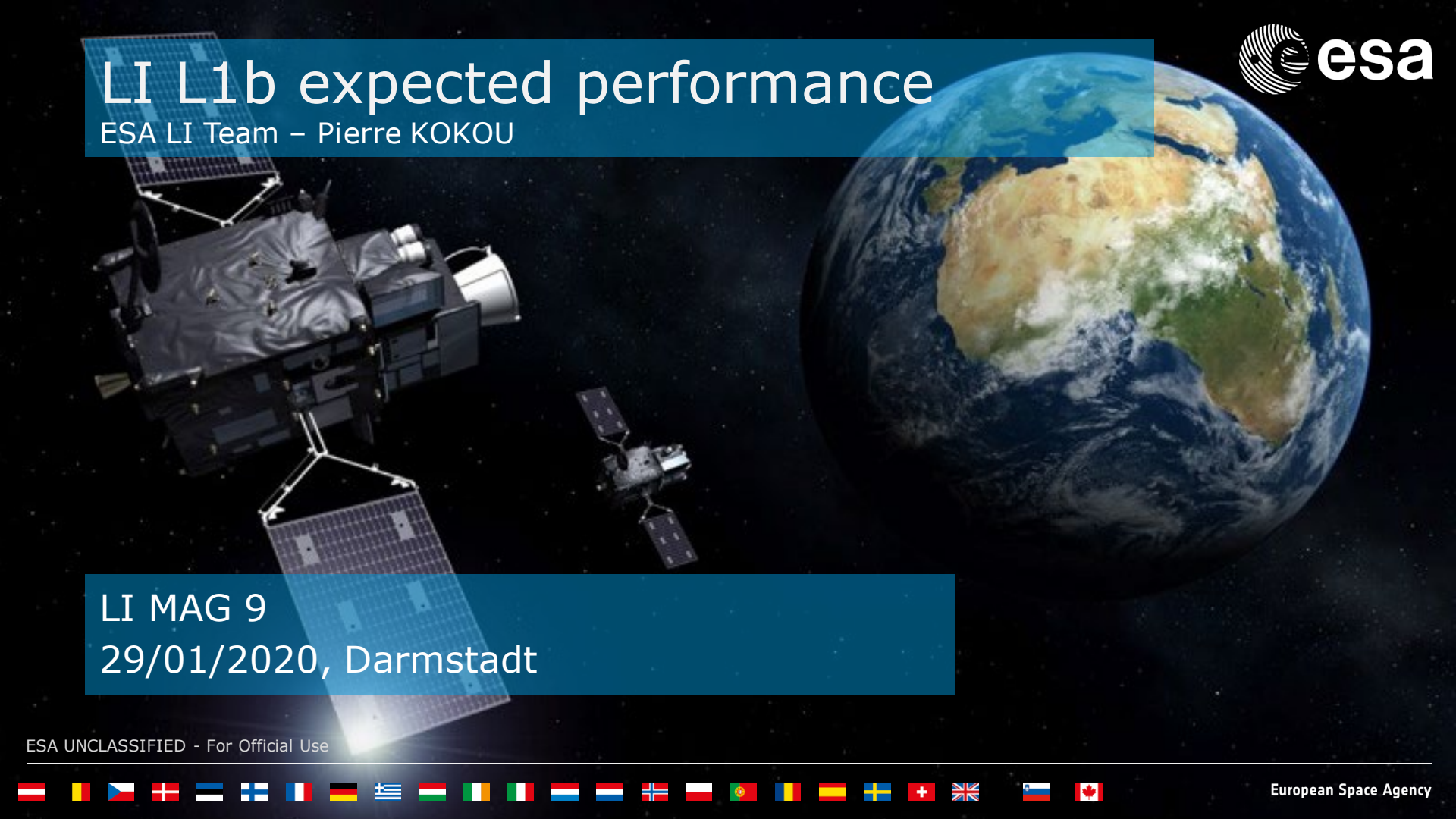
- All major design issues have been solved.
  The focus is now on the PFM manufacturing and testing.

- The PFM is foreseen to be delivered in autumn this year

- The L1b performances are in line with the expectations (see next slides)

LI L1b expected performance

ESA LI Team – Pierre KOKOU



LI MAG 9

29/01/2020, Darmstadt

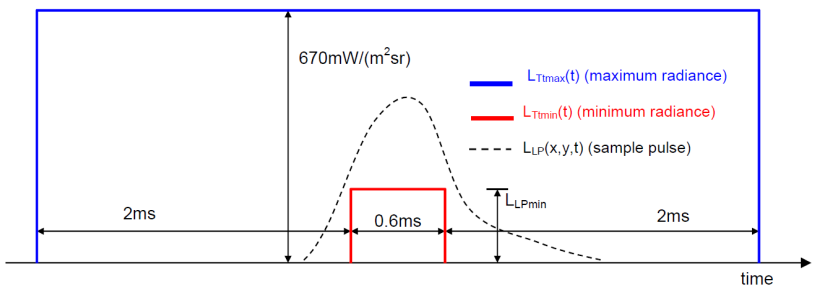
Content

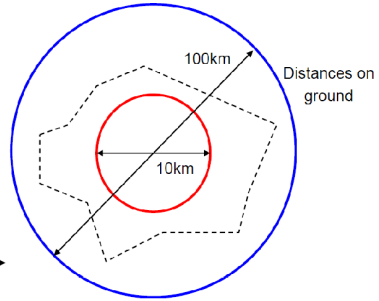
1. General L1b expected performance
2. Expected behavior at night with sun near the FOV

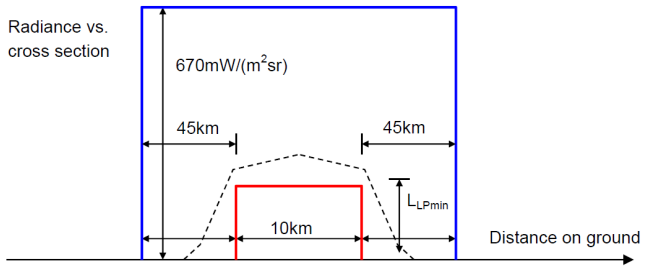
LI Detection requirement - reminder

Lightning signal characteristics used to assess the performance at L1b: "engineering pulses"

- 10 km diameter
- Duration 0.6 ms
- Minimum energy of the specified pulses is tied to the (local) background level on which the lightning is simulated by: $L_{LP\min} = 6.7\sqrt{1+0.02L_{bkg}}\, mW/(m^2 sr)$, with L_{bkg} in $Wm^{-2}sr^{-1}\mu m^{-1}$







General LI L1b expected performances

Based on latest performance report:

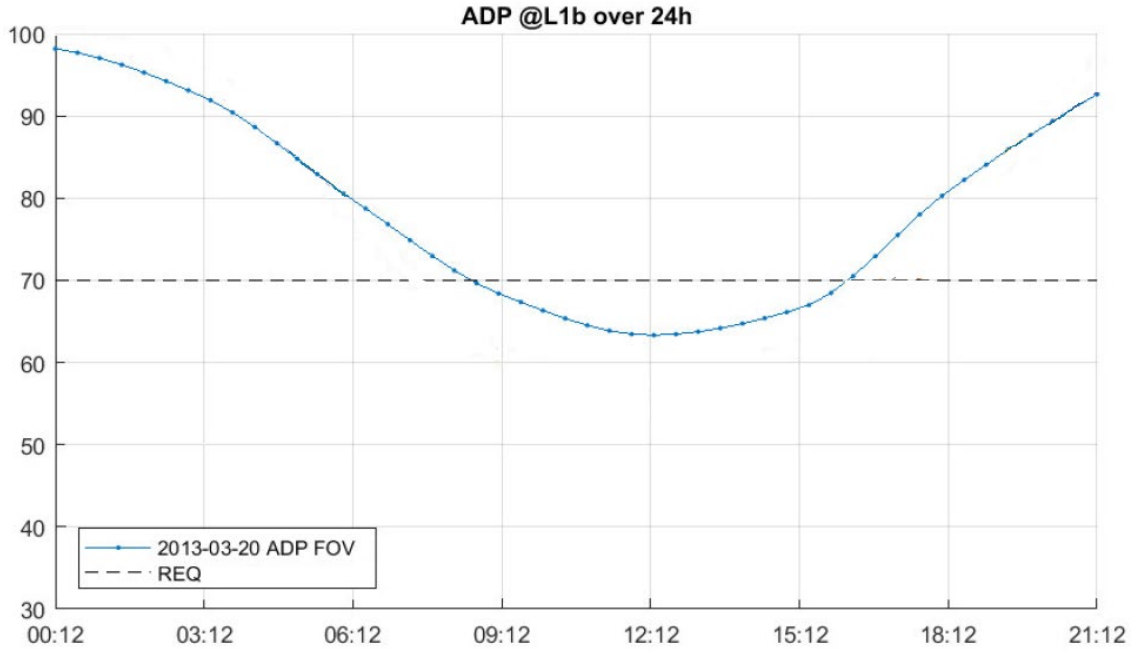
Scenario	FAR	IADP	DE
Day - noon	34k/s	64%	98%
Night	2k/s	96%	100%

- False alarm rate (FAR): number of undesired events per second => Req = 35k/s at L1b
- Detection Efficiency (DE): capability of a pixel to detect a pulse that 'fills' its full spatial coverage during a complete integration period => Req = 70% average over full FOV at L1b
- Detection Probability (IADP): capability of the instrument to detect a small pulse placed randomly in space and time => Req = 70% average over full FOV at L1b

- Very good behavior at night (better contrast than during daylight => see next slide)
- Performance expected to evolve (favorably) in the next simulation loop, incorporating actual sub-system measurements data rather than specified values.

General LI L1b expected performances

- Behavior over the reference day



Content

1. General L1b expected performance
2. Expected behavior at night with sun near the FOV

Reminder – Reasons for a 4 OCs design

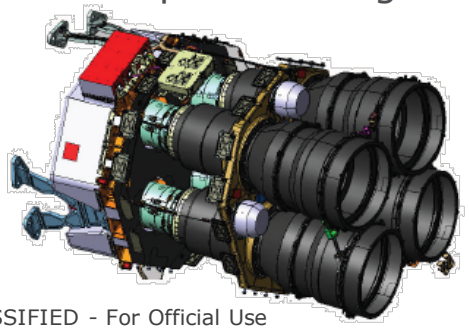
At the beginning of the project, a key requirement was the full disc coverage:

PL-LI-010

The Lightning Imager (LI) full disc coverage shall include the Earth within a circle of 16° in diameter, shifted northward to cover high latitude regions.

Note: If for design optimisation the coverage is not circular then it must cover at least 84% of the visible earth disc (a circle of 17.54° in diameter centred at SSP) and the European territories of all the EUMETSAT member states, when the satellite is positioned at 0° longitude, with the requirement SA-ORB-110 not being applicable for the calculation of the coverage.

Due to technological limitations (e.g. spectral behavior of optical filters at high incidence angles, detector constraints…), it was decided to go from a 1-optical channel (OC) design to a more complex multiple-OC design.

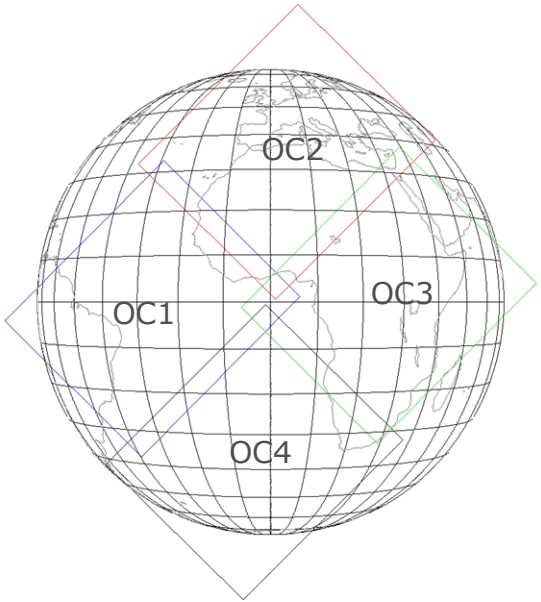


This brought many advantages (larger coverage while keeping fine spatial resolution and spectral performance, better configurability…) but it also means the field of view is more open to sun intrusions.

Field of view (FOV) from geostationary orbit

Sun trajectory over the day is an 'horizontal' line

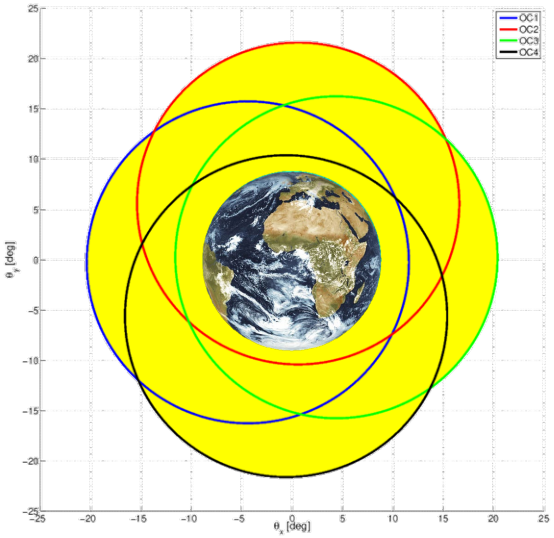
sun



Over the year the 'horizontal' sun trajectory goes from 'above' the Earth (summer) to 'below' the Earth (winter)

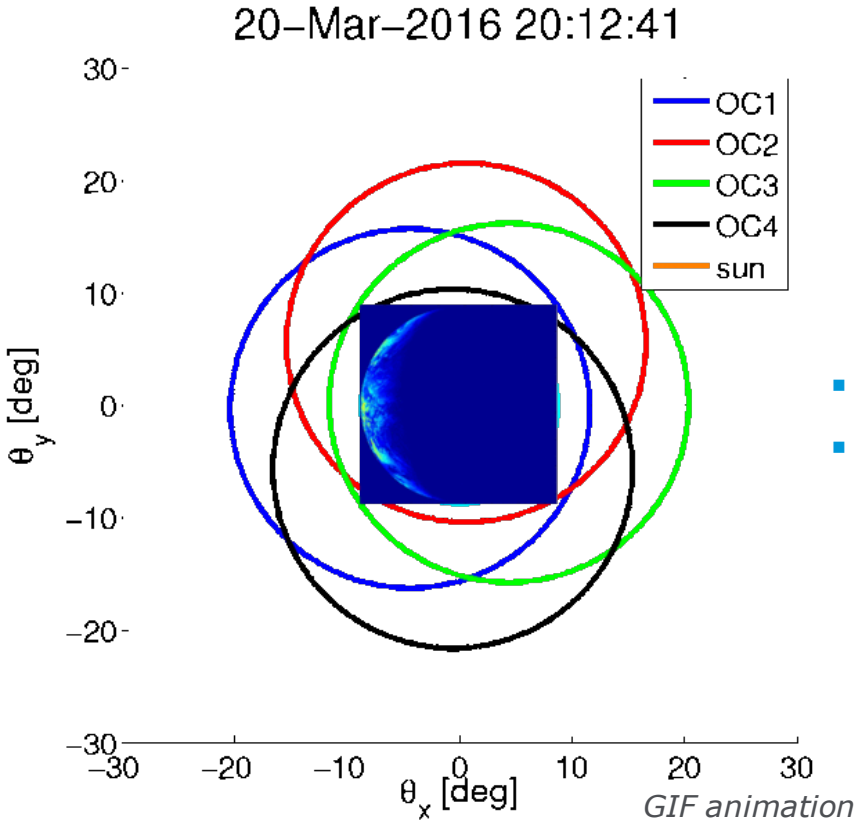
Effects of the sun near the FOV

- When the sun is near the FOV of an optical channel, its direct and stray light shines in the instrument.
  This increases the level of the measured background, which reduces the contrast (lower detection probability) and increase the noise (higher FAR)
- With respect to requirements, this inevitable phenomenon is addressed by the definition of Sun Restricted Zones



Sun Restricted Zone of an optical channel = circle of 16 degrees radius centered on the center of the FOV of the optical channel

Simulation of a night at equinox

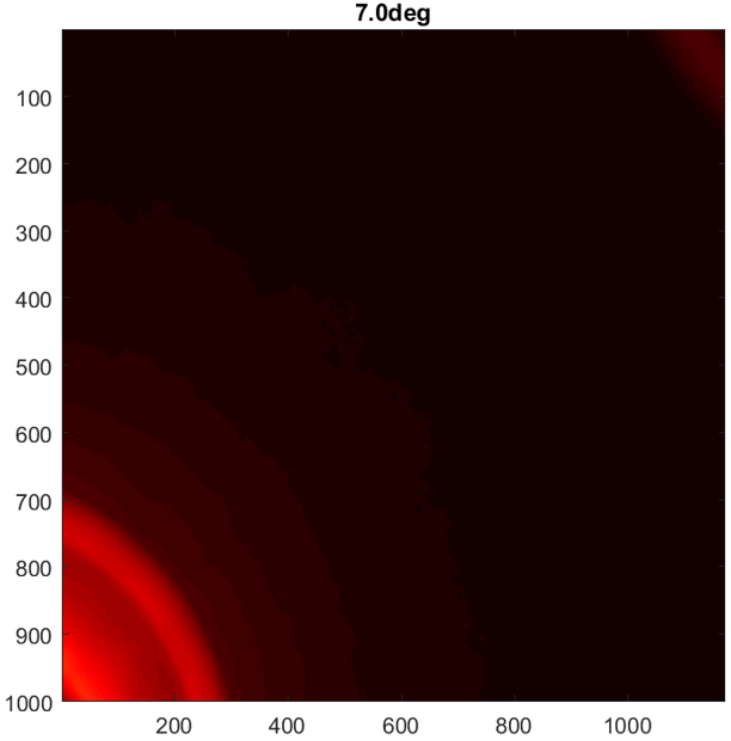


GIF animation

- At night, Earth is dark.
- Picked-up signal would be sun stray light

Expected behaviour at night (1/2)

Example of an expected sun straylight scene (model)



Sun straylight localised in one corner
(+ fainter ghost in opposite corner)

Sun spot on detector

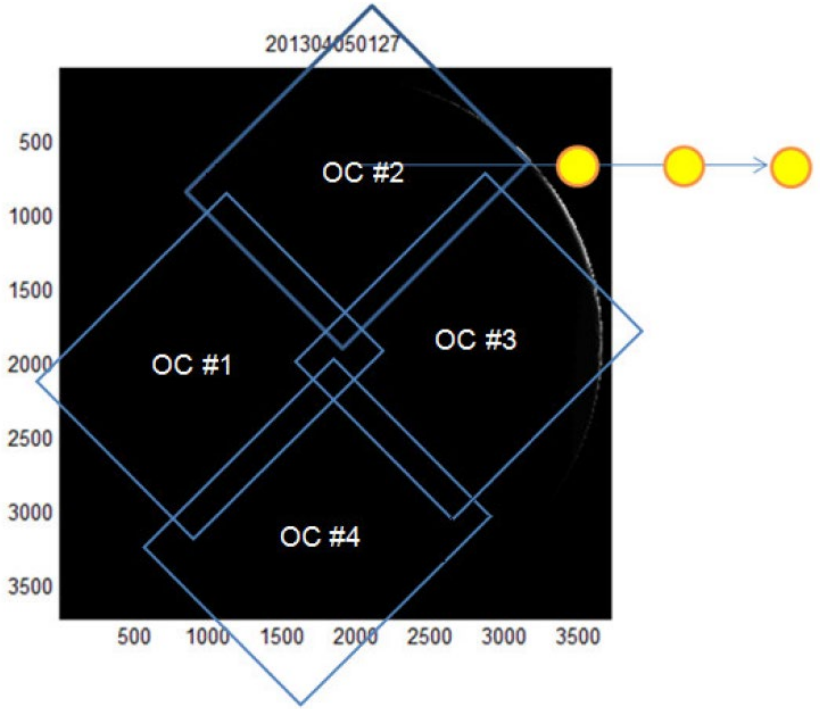
Tests at detector level show that the sun spot stays localised at the incoming light beam position (=> no leakage to other parts of the detector)

Expected behaviour at night (2/2)

Example of a night with sun near the FOV:

30 min

daytime	θ_{sun_SSP}	θ_{sun_ZOC1}	θ_{sun_ZOC2}	θ_{sun_ZOC3}	θ_{sun_ZOC4}	ADP	ADP	ADP	ADP	ADP
(h)	(deg)	(deg)	(deg)	(deg)	(deg)	OC#1	OC#2	OC#3	OC#4	LI
0.5	9.3	13.2	6.9	6.1	13.7	77.1	44.9	46.5	82.1	62.7
0.55	9.9	13.9	7.6	6.5	14.2	87.2	54.6	47.9	83.3	68.3
0.6	**10.5**	14.6	8.4	7.0	14.7	87.7	52.3	47.6	84.2	68.0
0.65	**11.2**	15.3	9.1	7.5	15.2	88.6	64.6	52.0	85.6	72.7
0.7	11.8	15.9	9.9	8.0	15.7	89.0	64.9	55.7	89.4	74.8
0.75	12.5	16.6	10.6	8.6	16.2	89.1	75.9	57.2	88.7	77.7
0.8	13.2	17.4	11.3	9.2	16.8	90.0	76.0	64.9	89.5	80.1
0.85	13.8	18.1	12.1	9.9	17.3	89.9	75.0	67.3	88.5	80.2
0.9	14.6	18.8	12.8	10.5	17.9	94.2	75.4	74.4	93.5	84.4
0.95	15.3	19.5	13.6	11.1	18.5	93.5	75.9	72.7	94.1	84.1
1	16.0	20.2	14.3	11.8	19.1	94.8	84.0	73.4	93.9	86.5



Each OC has its own performance behavior:

- OC1 & OC4 FOV are far from the sun => OK
- When the sun is close to OC2 & OC3 FOV
  => degraded performance, quickly recovered when the sun gets further away