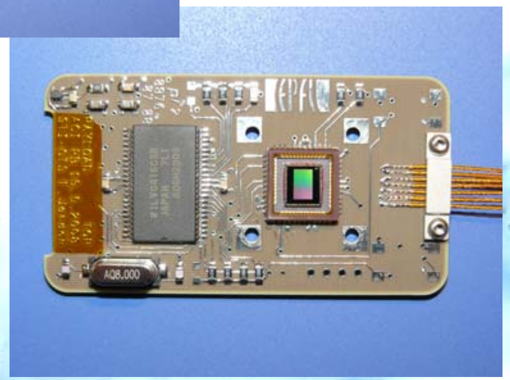
SwissCube Project Phase D

Qualification and Flight Acceptance Review, March 9, 2009

Noémy Scheidegger

Systems Engineering Team



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Sience Mission and Payload Design

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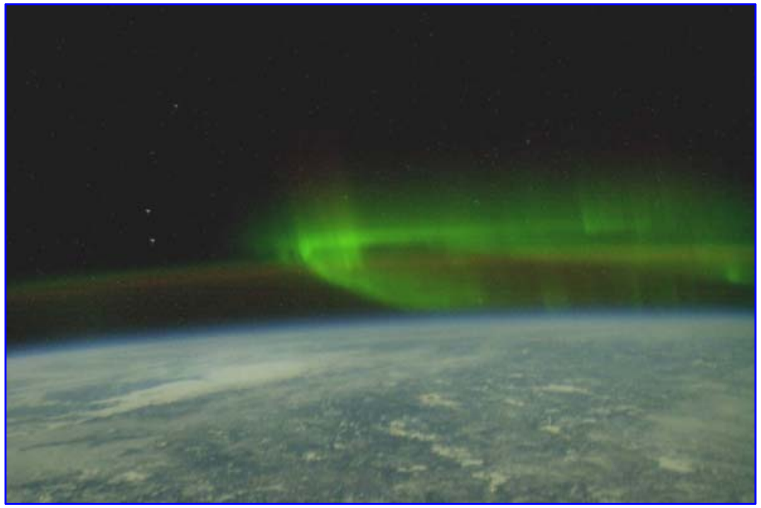
- Optical Alignment Tests

Science Objectives

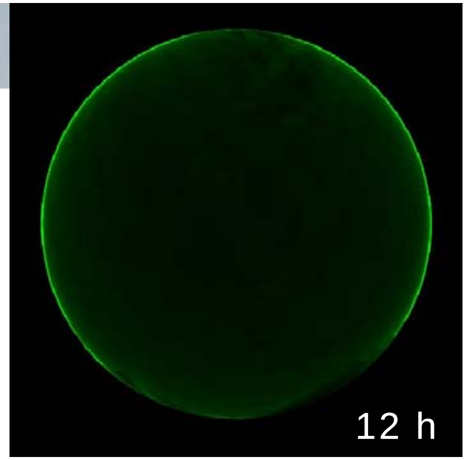
Measure the airglow emission in the upper atmosphere at 100 km altitude to :

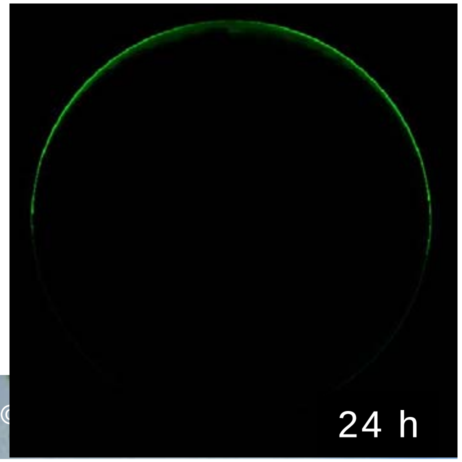
- Demonstrate the feasibility of using airglow as a basis for a low-cost earth sensor
- Validate the established airglow model or bring additional information about airglow dependence on

→ latitude
→ altitude
→ local solar time

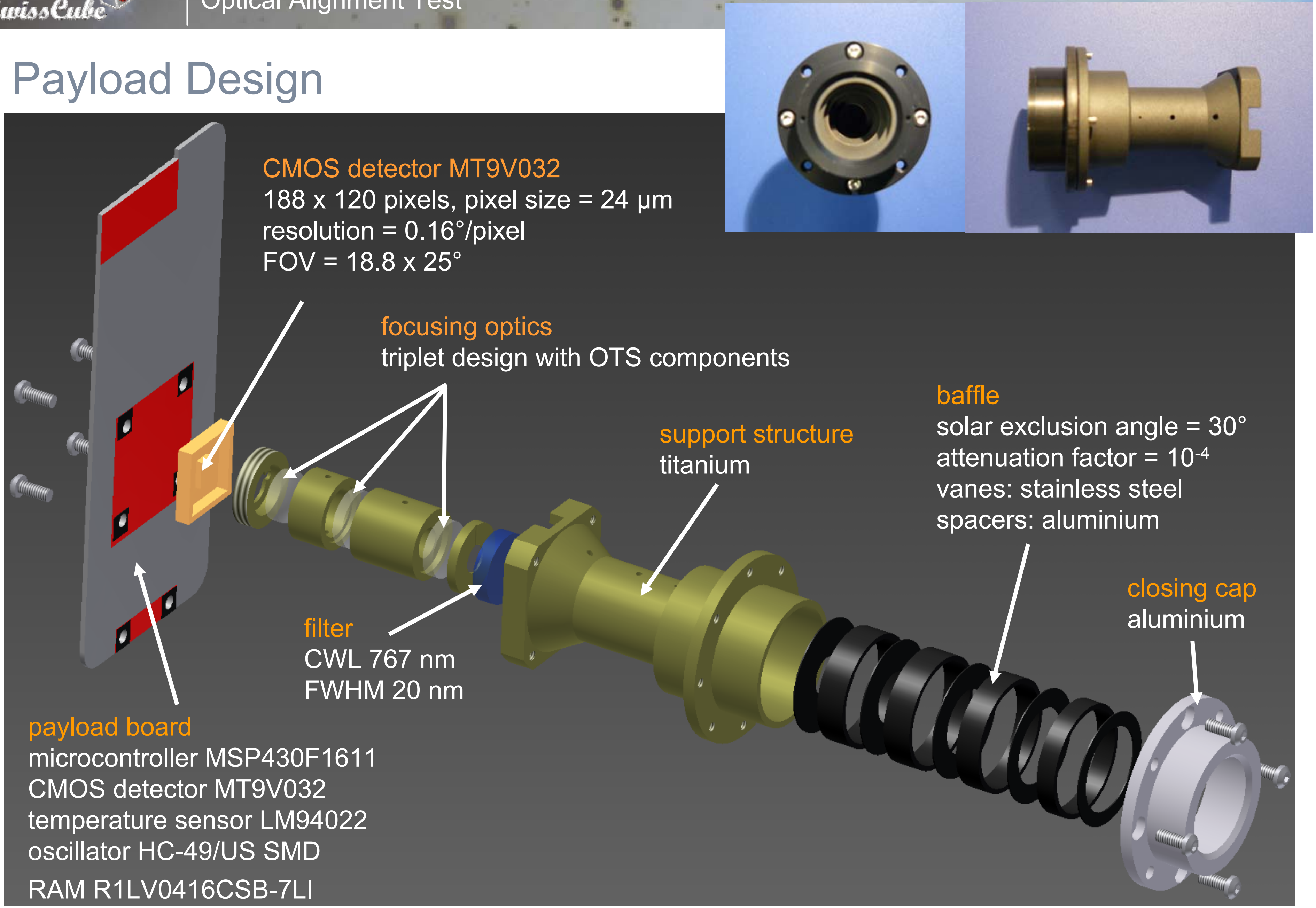


nightglow and aurora borealis





Payload Design



Test: Payload Alignment Test

- Purpose: test robustness of the opto-mechanical system of the payload against vibrations, shocks and temperature variations
- Tested Requirement:

Field of view

The payload may have a FOV of at least 20°.

Angular resolution

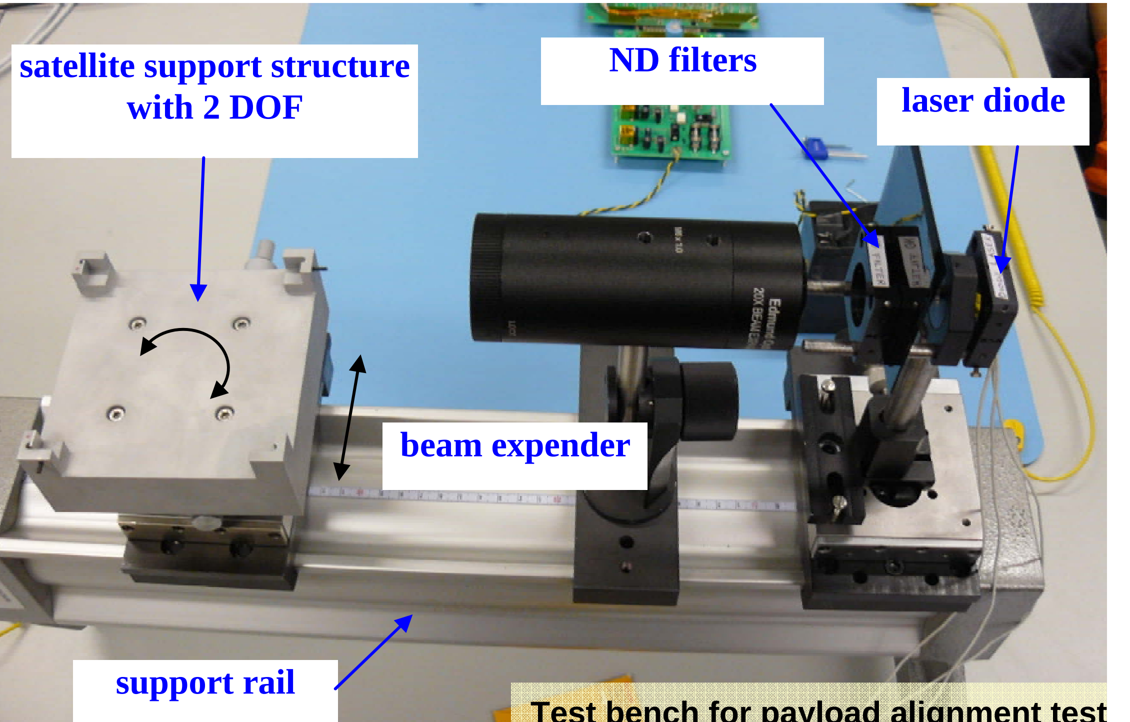
The payload may measure airglow with an angular resolution of at least 0.3°.

→ Maximum spot diameter = 48 μm (2 pixels)

Test: Payload Alignment Test

- Test Setup:
  - Test bench for payload alignment test
- Limitations of the PL test bench
  - intensity of the laser spot
  - angle of incidence of the laser
- Updated success criteria

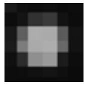
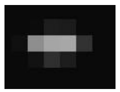
  → spot size and intensity distribution have to remain constant



Test bench for payload alignment test

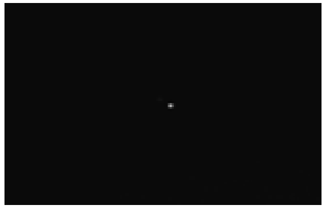
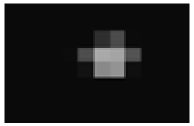
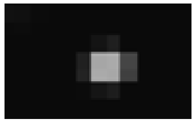
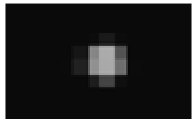
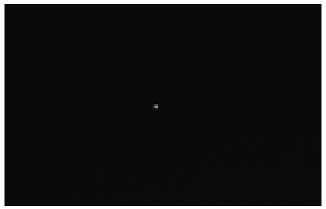
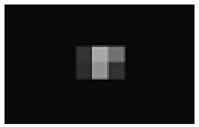
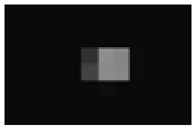
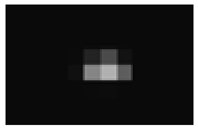
Test: Payload Alignment Test

- Test results for the QM:
  - variation of the spot diameter ≤ pixel
  - variation of the intensity distribution ≤ pixel

Angle of incidence	-8.5 [deg]	0 [deg]	8.5 [deg]
Full image after optical calibration			
Spot after optical calibration			
Full image after QM test campaign			
Spot after QM test campaign			

Test: Payload Alignment Test

- Test results for the FM:
  - variation of the spot diameter ≤ pixel
  - variation of the intensity distribution ≤ pixel

Angle of incidence	-8.5 [deg]	0 [deg]	8.5 [deg]
Full image after optical calibration			
Spot after optical calibration			
Full image after QM test campaign			
Spot after QM test campaign			

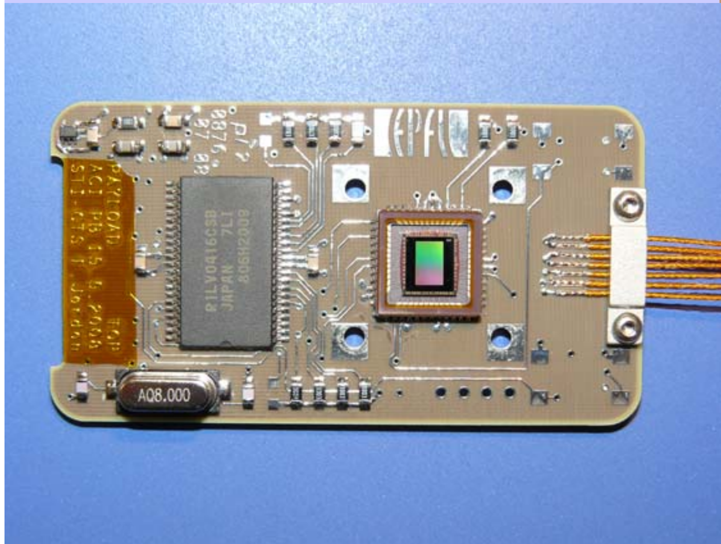
Design Issues and Open Questions / Risks, Potential Solutions

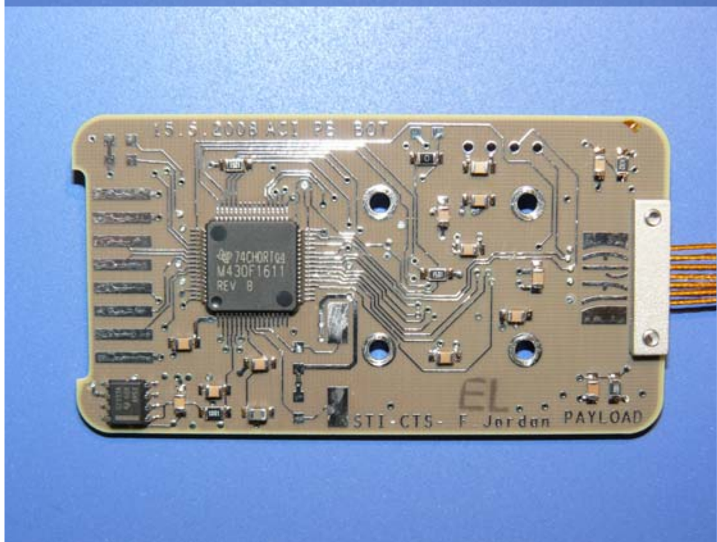
- First image after power up is grey (noise)
  - After each power up of the payload, two pictures will be taken and only the second one will be downloaded.
- Analysis of the spot for PL alignment tests should be done more accurately
  - Intensity distribution of the spot should be done to determine the RMS spot diameter
- Characterisation of the CMOS detector has been done on a DM, but should be repeated for the FM prior to the launch

Conclusions and Future Work

- Payload QM and FM successfully passed their test campaign
- Additional work related to the payload and science mission :
  - programming of a tool to analyse the images (ongoing)
  - programming of a tool to determine when an image has to be taken

Questions ?





Test: Performance of the CMOS Detector vs. Temperature

- Purpose: characterise the dark signal of the CMOS detector vs. temperature
- Tested Requirement:

  Signal-to-Noise-Ratio
  The payload shall allow taking science measurements with a SNR of at least 3 for limb measurements.

  → Maximum mean dark signal = 350 kHz

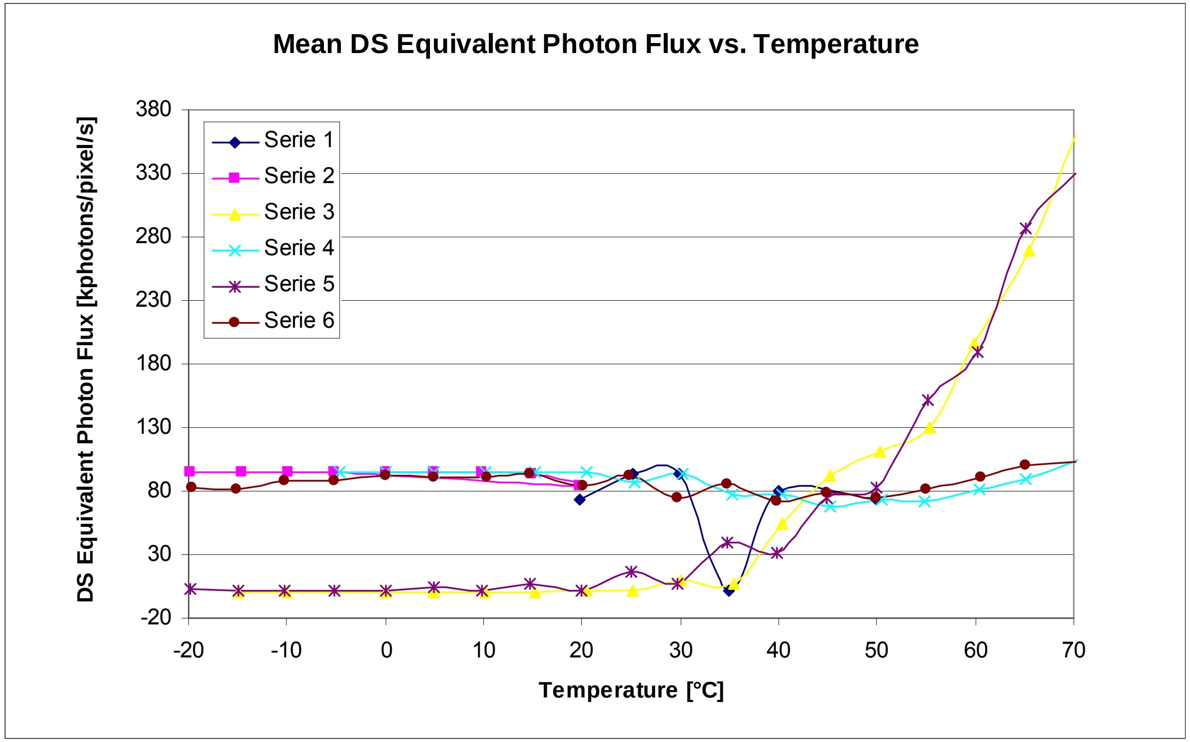
- Test Setup:
  - Thermal Chamber
  - Dark room

Test: Performance of the CMOS Detector vs. Temperature

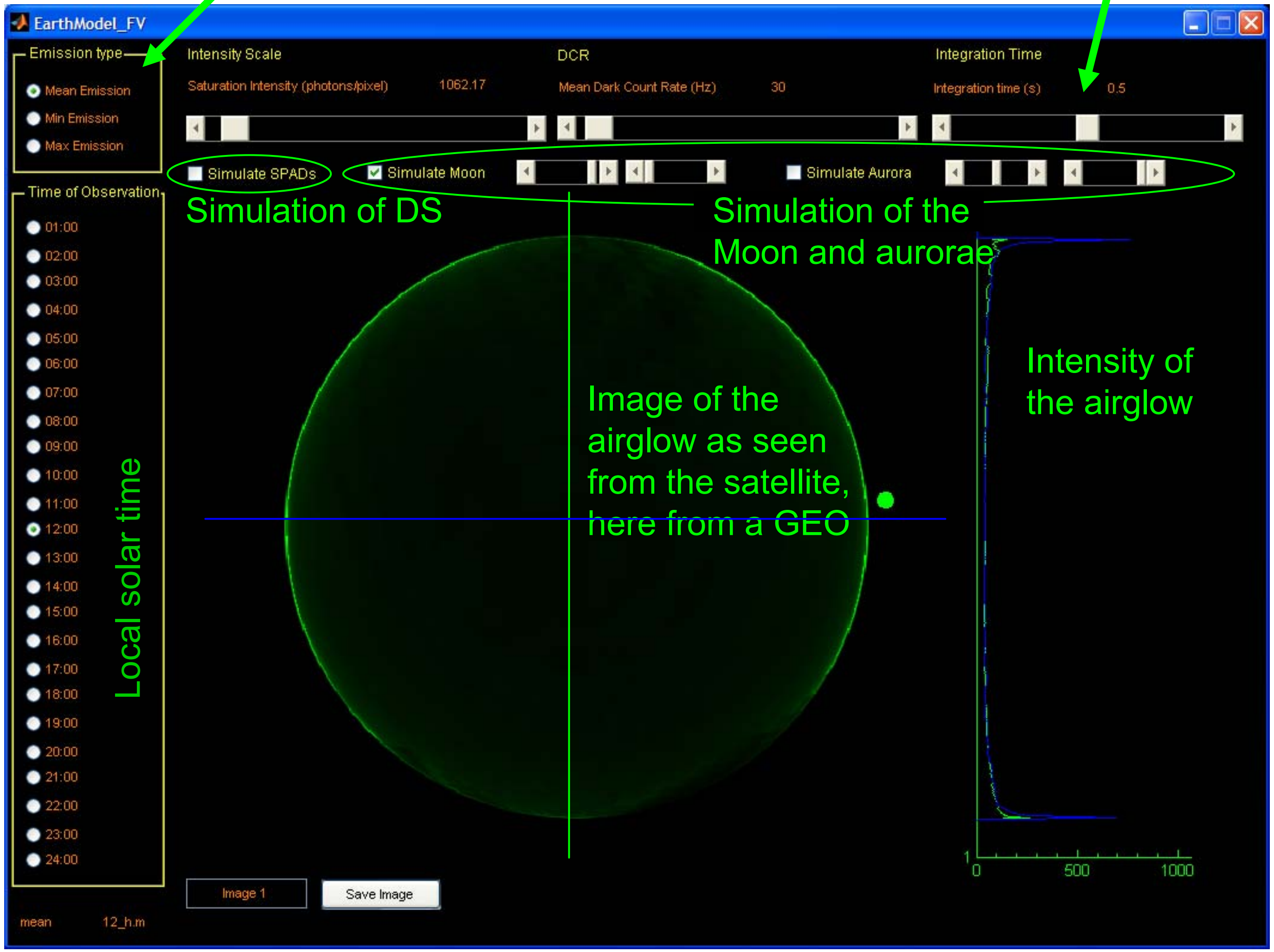
- Test condition:
  - -15°C to °70°C
  - 2 different register configurations of the detector

airglow signal
at night: 8k - 40k e⁻/s at day: 470k – 4M e⁻/s

- Test results:
  - mean DS < min airglow signal if T < 40°C,
  - PL board is operational between -15° and 70°C



Aiglow Model

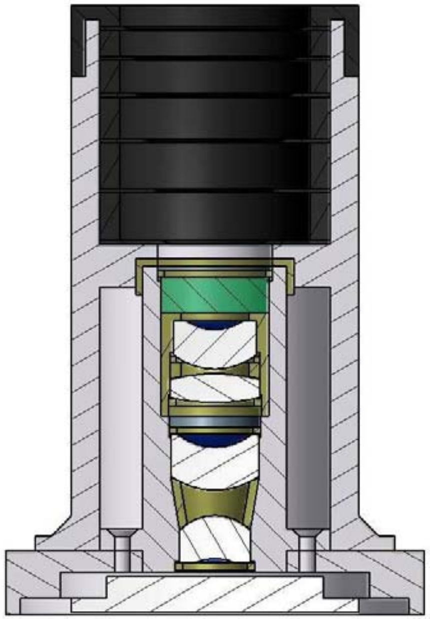


Driving Requirements for the SwissCube Payload

- Payload may be a technology demonstrator of an earth sensor based on airglow
  - Observes the emission at 762 nm with a bandwidth between 10 nm and 40 nm
  - Has a spatial resolution of at least 0.3° and a FOV of 20°
  - Can perform science mission with the sun no closer than 30° from its boresight.

- Physical and electrical constraints
  - Volume: 30 x 30 x 65 mm^3 for the optics
80 x 35 x 15 mm^3 for the payload board
  - Mass: < 50 g
  - Peak Power: < 450 mW during 30 s for each image

- Additional design driver
  - The PL board is not a critical element of the SwissCube satellite
→ no redundancy has been taken into account for this subsystem



optics of the AIRES earth sensor

Operational Scenario: Frequency of Measurements

- During the first 3 month one image each 4.5 days:
  - 5 images of dayglow/nightglow measured at limb/nadir
  - Total: 20 measurements, cycle repetition of 18 days
- After 3 month: observation of variation of emission intensity depending on latitude
  - Dayglow/nightglow above 85° N/S
  - Dayglow/nightglow between 40° and 50° N/S
  - Dayglow/nightglow between 5° N and 5° S
  - Total : 10 measurements, cycle of repetition of 45 days

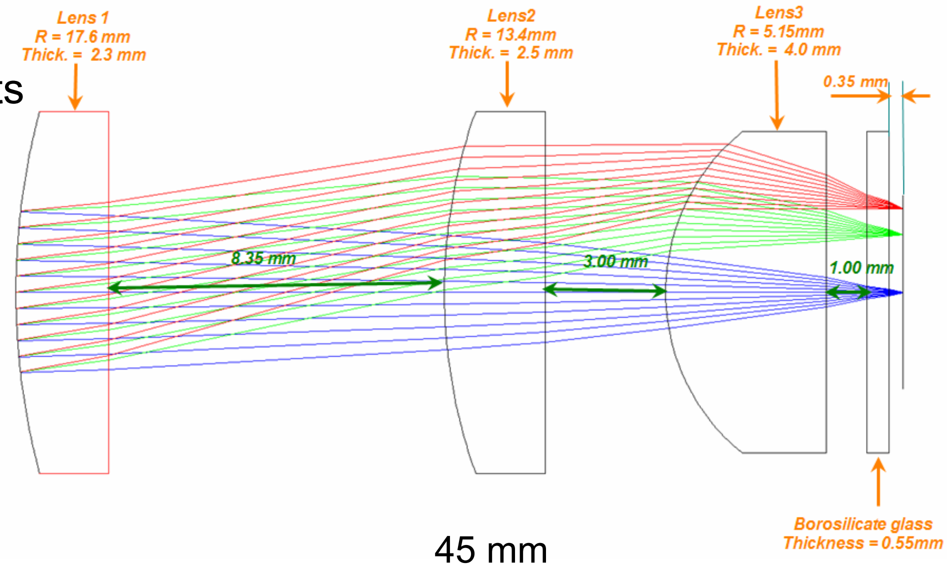
    8 measurements per latitude in one year

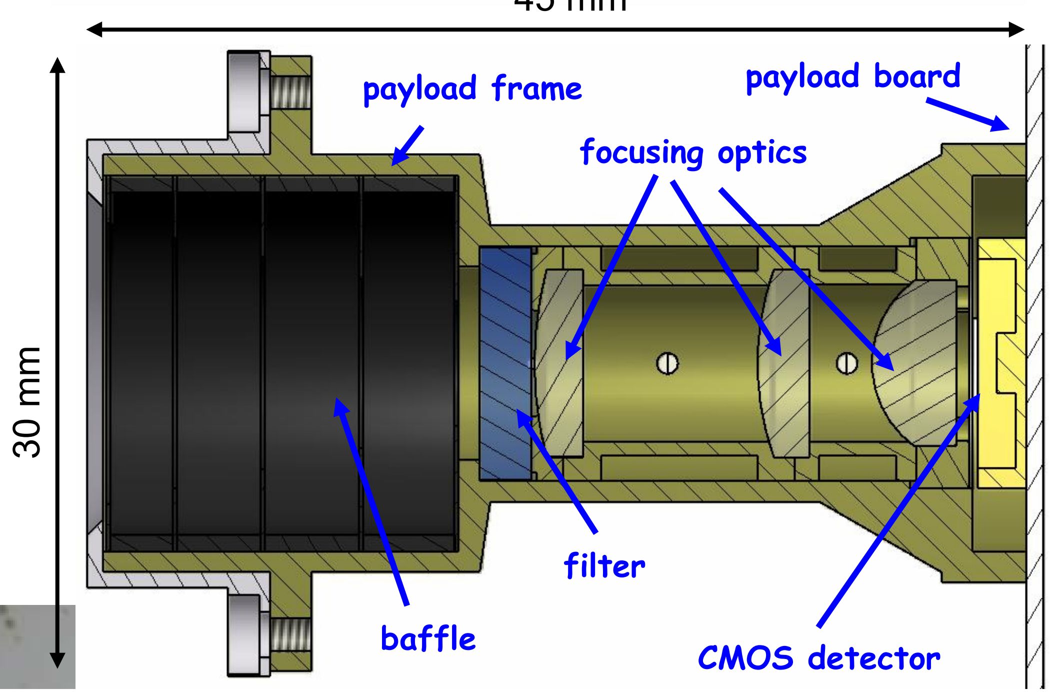
Operational Scenario: PL Board

- PL board always turned on for housekeeping
- Detector turned on only when science observations are carried out
- Science observations are triggered by EPS
- Power consumption:
  - 8 mW when no science observations are performed
  - < 450 mW during science observations

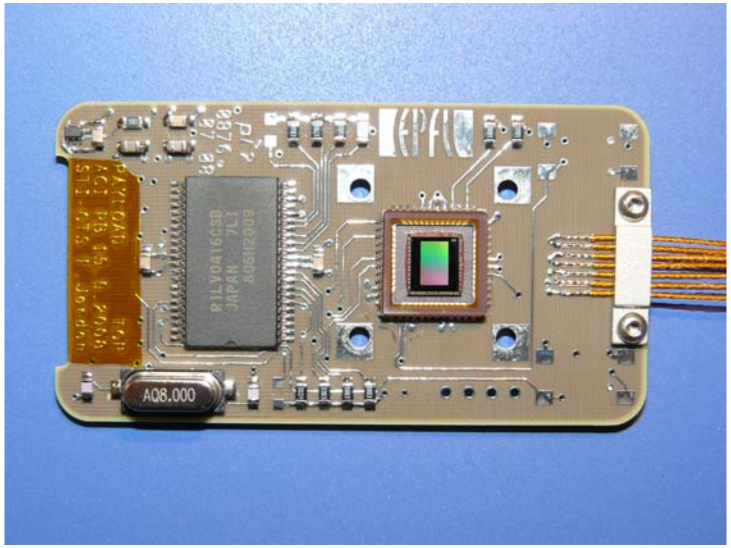
Design Description: Optical System

- Triplet design with off-the-shelf components
- FOV 18.8° x 25°
- Resolution 0.16°/pixel
- Baffle for a solar exclusion angle of 30° with an attenuation factor of 10^{-4}
- Filter with a central wavelength at 767 nm and a bandwidth of 20 nm

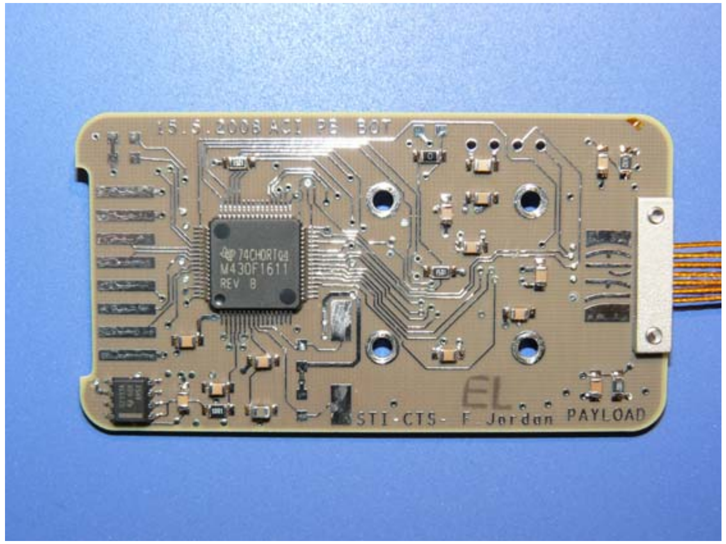




Design Description: Payload Electronics

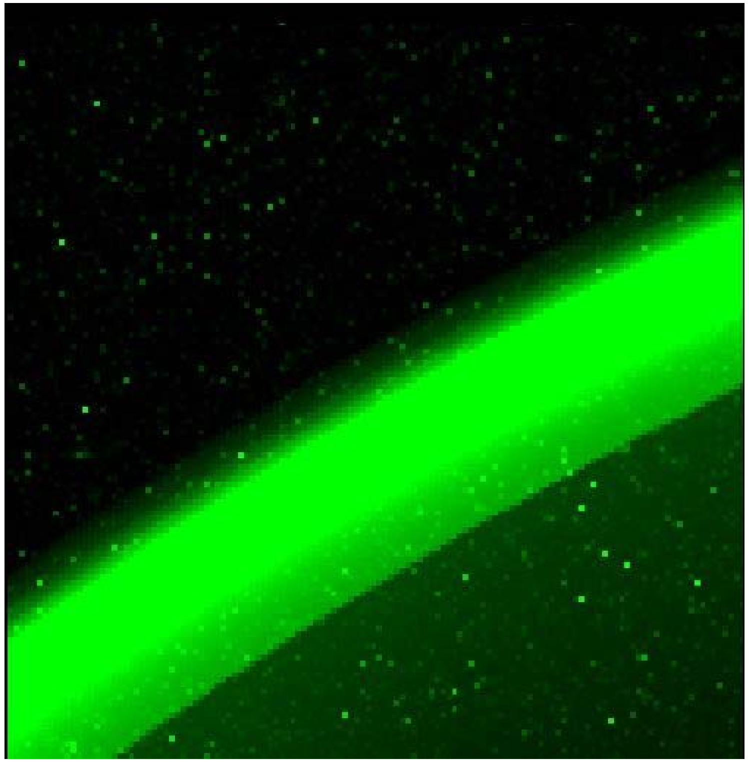


- Microcontroller MSP430F1611
  - Operate the detector
  - Communicate with the EPS
  - Read temperature sensors
- CMOS Detector MT9V032
  - Capture images of the airglow
- Temperature Sensor LM94022
  - Used for dark signal correction
- Oscillator HC-49/US SMD
  - Provide clock reference for the CMOS detector
- RAM R1LV0416CSB-7LI
  - Store images until transmission to ground station



Design Description: Expected Airglow Images

Limb Observations



Zenith Observations