# MEGHA - TROPIQUES

## Scarab, First Calibration Results

## SCARAB first result

### On-ground :

- Long wave calibration
- Short wave calibration

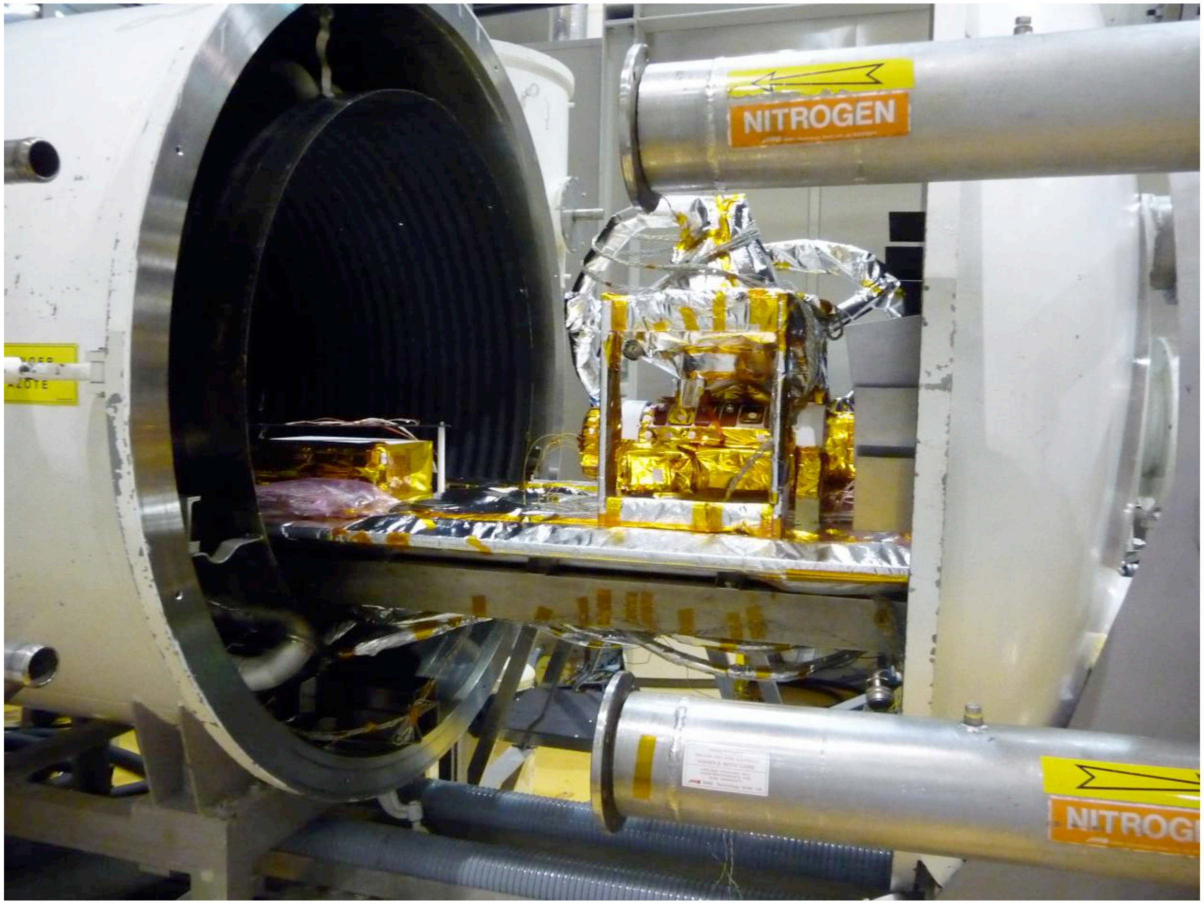
### In-orbit :

- Radiometric noise
- Thermal leak
- Gain
- A’ factor
- Location
- Registration
- LA/LA2 comparison

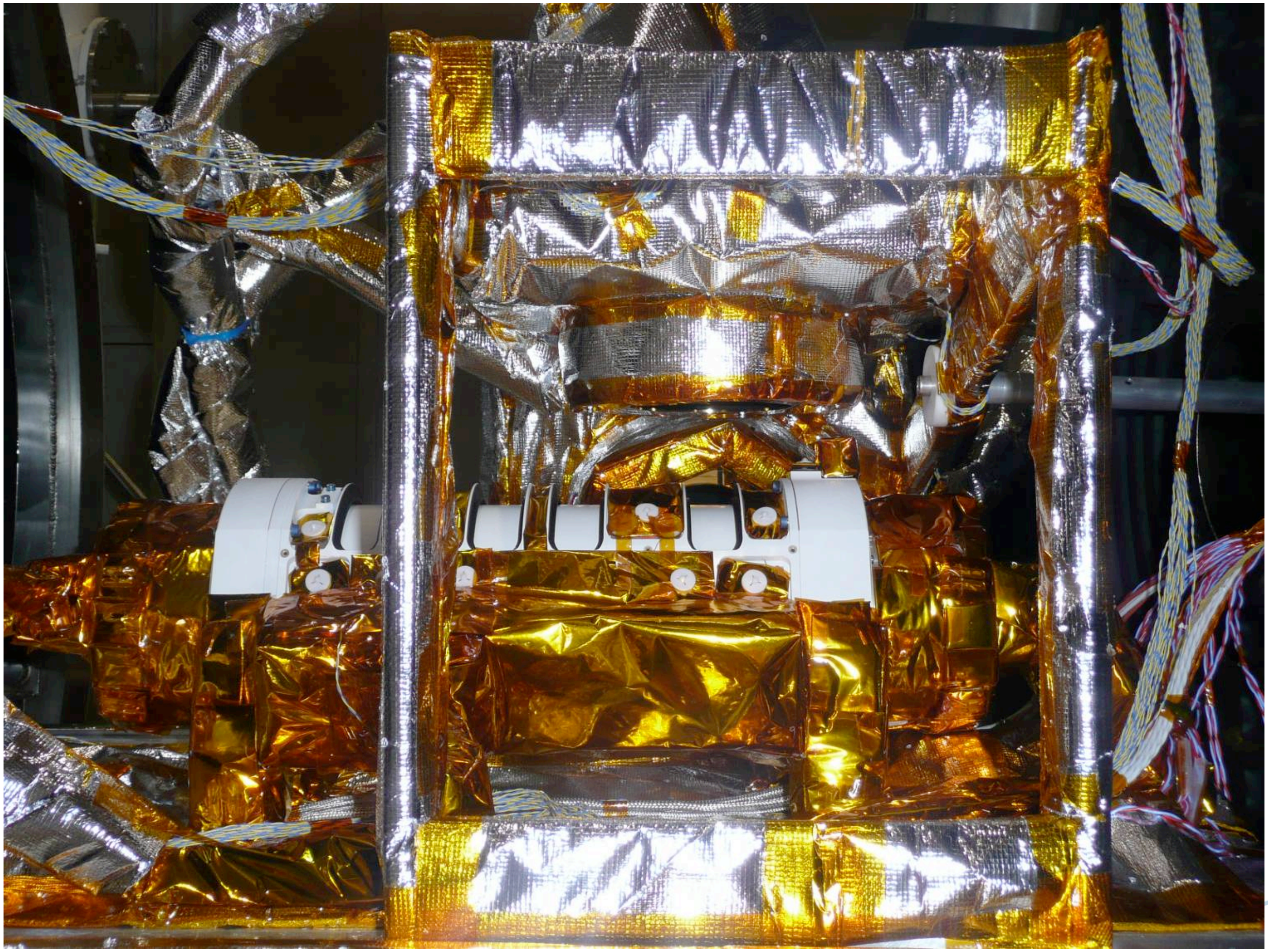
# SCARAB / on ground calibration

**Long wave calibration**

**Intespace facility**



# SCARAB / on ground calibration



# SCARAB / on ground calibration

## Two high performance Black Bodies (HGH)

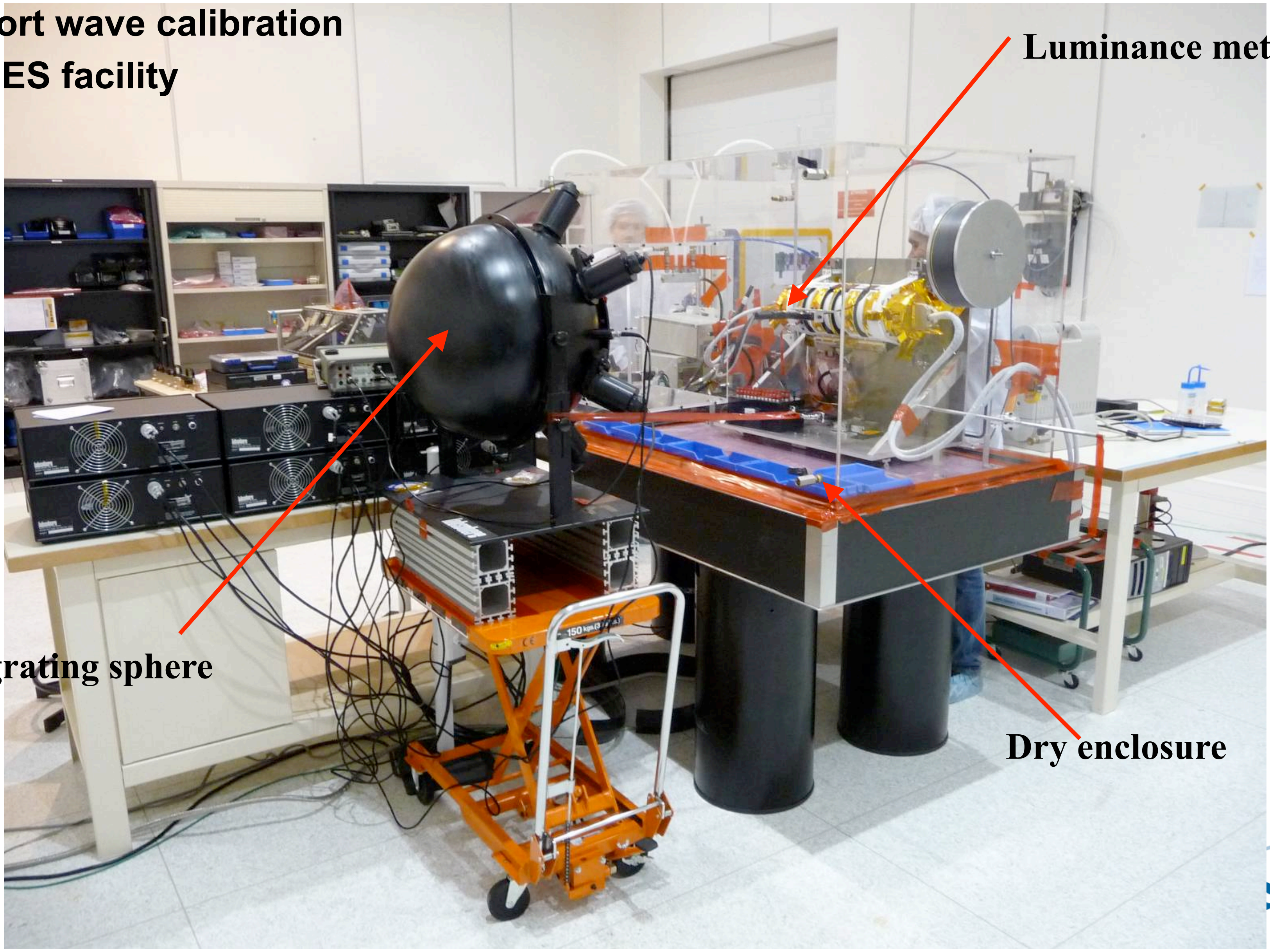
Theorical emissivity
>0.9993

Hot BB temperature :
223° / 323°K

Cold BB filled with
Liquid nitrogen

# SCARAB / on ground calibration

- Short wave calibration
- CNES facility



# SCARAB first result / noise

**Method :**

**Uniform data :** **use of « space » pixels**

**Standard deviation of 3pixels x 500 scans**

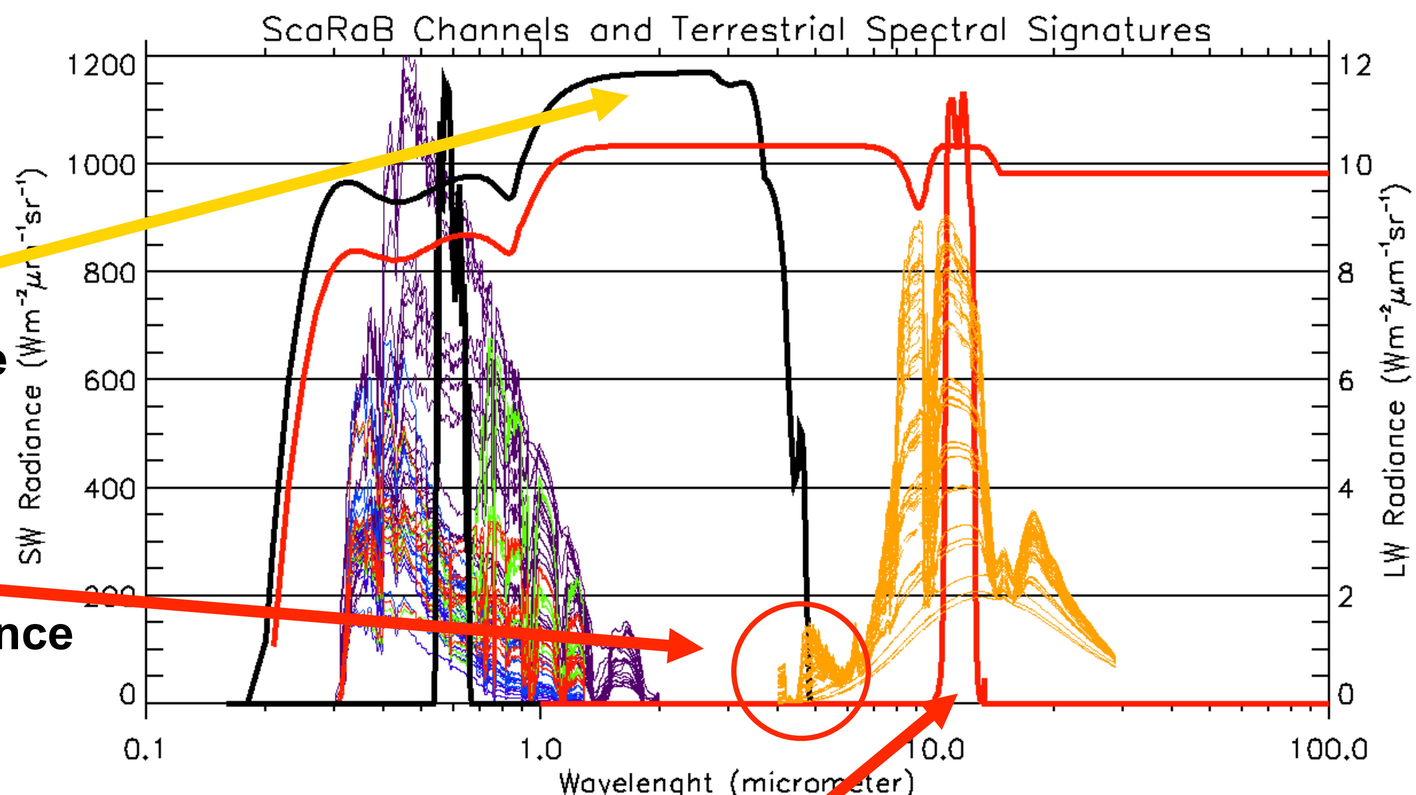
**MS mode only (channel 2&3 with solar filter), once per month**

**Results :**

| | | Channel 1 visible | Channel 2 solar | Channel 3 total | Channel 4 IR window |
|---|---|---|---|---|---|
| Max radiometric noise | LSB | 6LSB | 2.5LSB | 2.1LSB | 30LSB |
| Max radiometric noise | W/m²/sr | 0.2 W/m²/sr | 0.09 W/m²/sr | 0.07 W/m²/sr | 0.14 W/m²/sr |
| Noise requirements | W/m²/sr | 1 W/m²/sr | 0.5 W/m²/sr | 0.5 W/m²/sr | 0.5 W/m²/sr |

# SCARAB first result / thermal leak

**<u>Thermal leak :</u>**




**Channel 2**

**=> Solar radiance**

**Thermal leak**

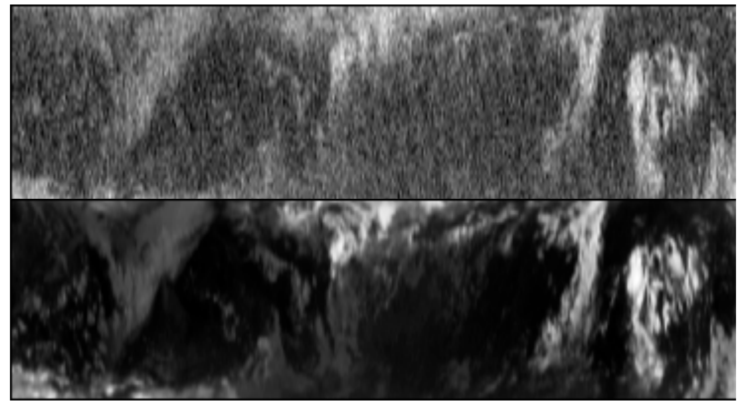
**=> Thermal radiance**

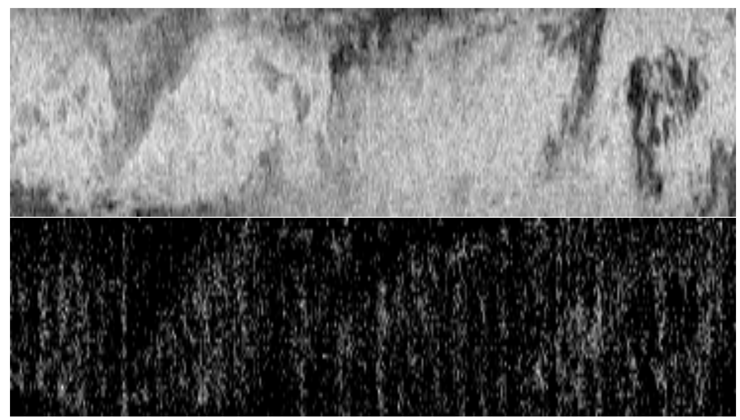
**Thermal leak must be evaluated and substracted to deliver Channel 2 solar radiance.**

**Thermal leak is estimated from Channel 4**

# SCARAB first result / thermal leak

| | |
|---|---|
| Channel 2<br>Level 0 | **Night area** |
| Channel 4<br>Level 0 | |
| Channel 2<br>Level 1<br>(not corrected) | STD value : 0.13 W/m²/sr |
| Channel 2<br>Level 1<br>(corrected) | Mean value : 0.03W/m²/sr<br>STD value :<br>0.06 W/m²/sr ≈2 LSB |





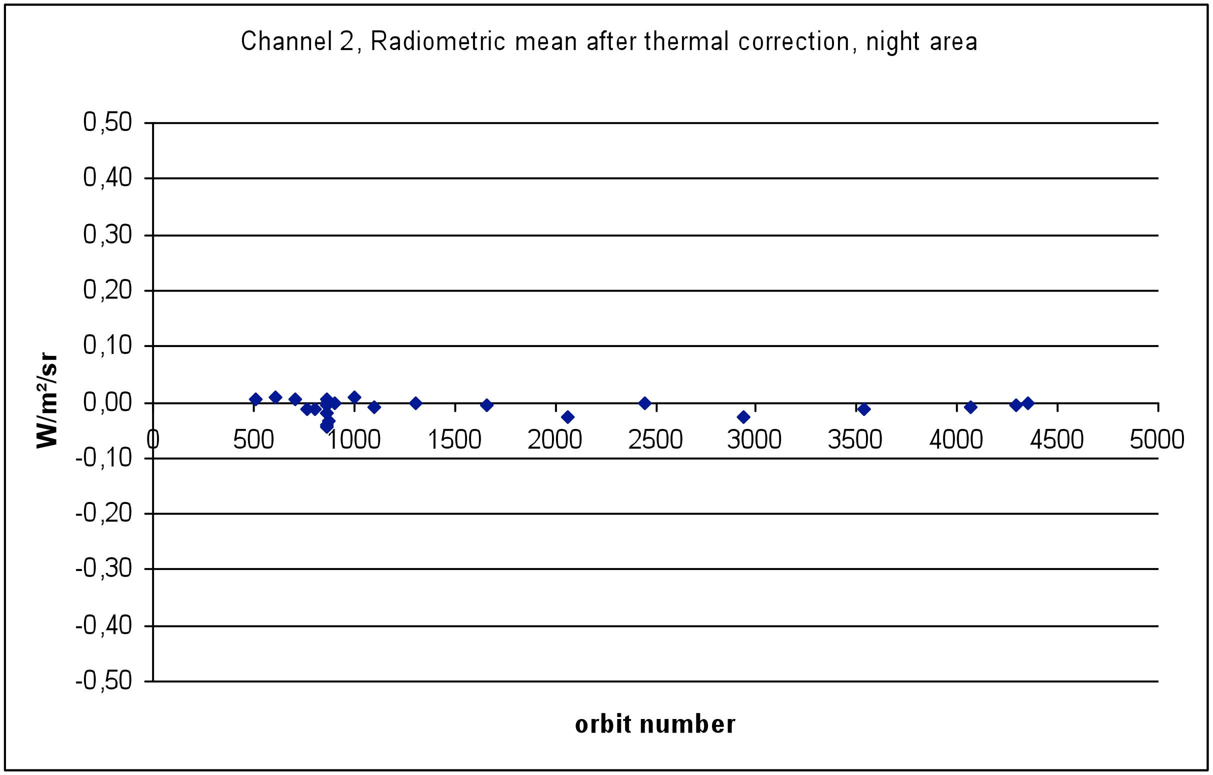
$$L_{2\_SW} = \frac{N_2}{G_{2\_sw}} - \left\{a_2.(L_{4\_IRW})^2 + a_1.L_{4\_IRW} + a_0\right\}$$

# SCARAB first result / thermal leak

## Thermal leak – Evaluation of the efficiency

**Night area of 300 scans**

**Calculation of the mean**



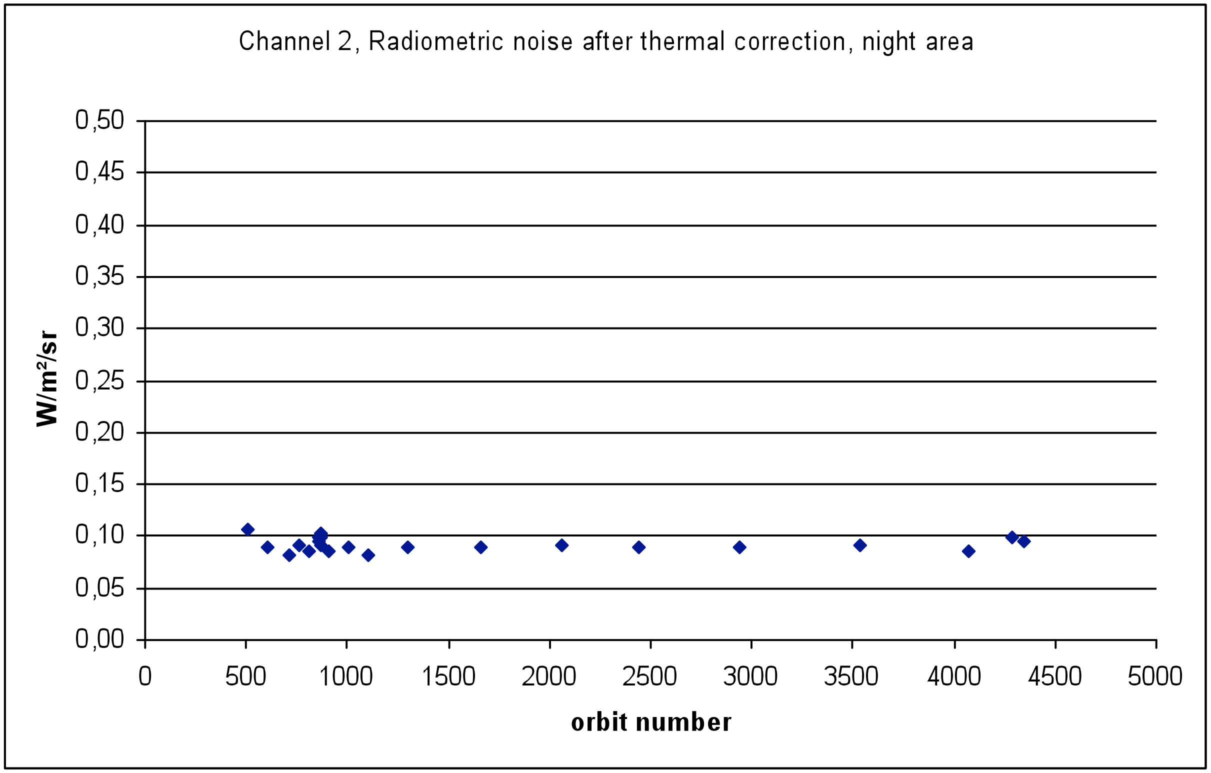

**Mean < 0.05W/m²/sr**

# SCARAB first result / thermal leak

## Thermal leak – Evaluation of the efficiency

**Night area of 300 scans**

**Calculation of the standard deviation**




**STD < 0.11W/m²/sr**

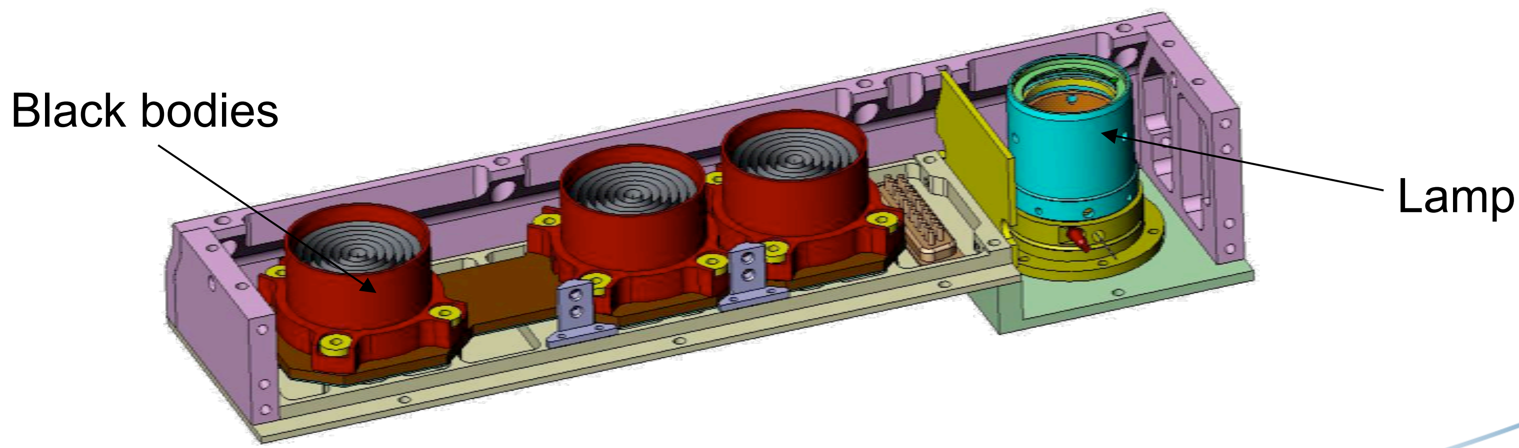
**< 3LSB**

# SCARAB first result / gain

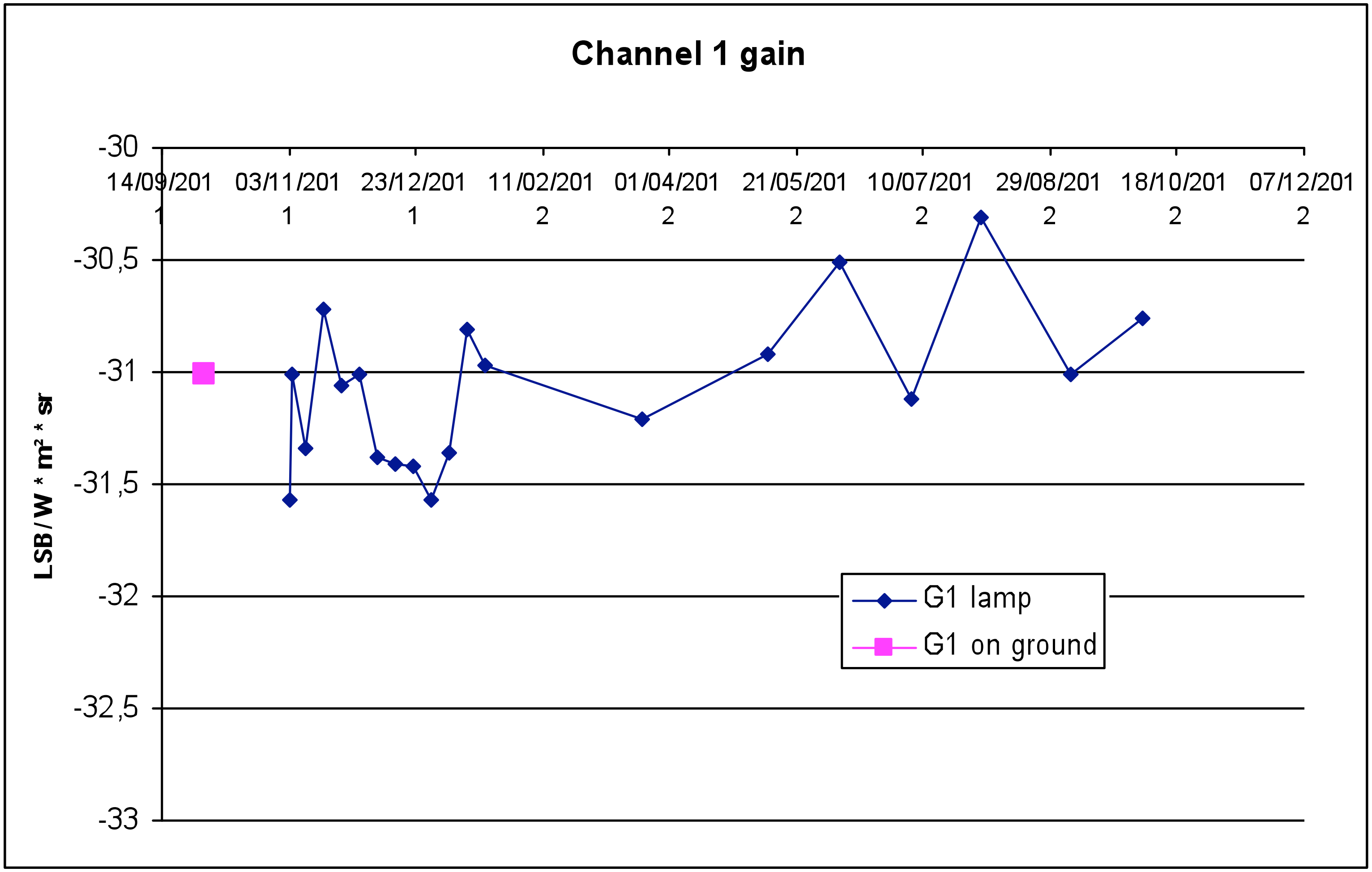
**Gain**

**Measured with the CALibration Module (CALM)**

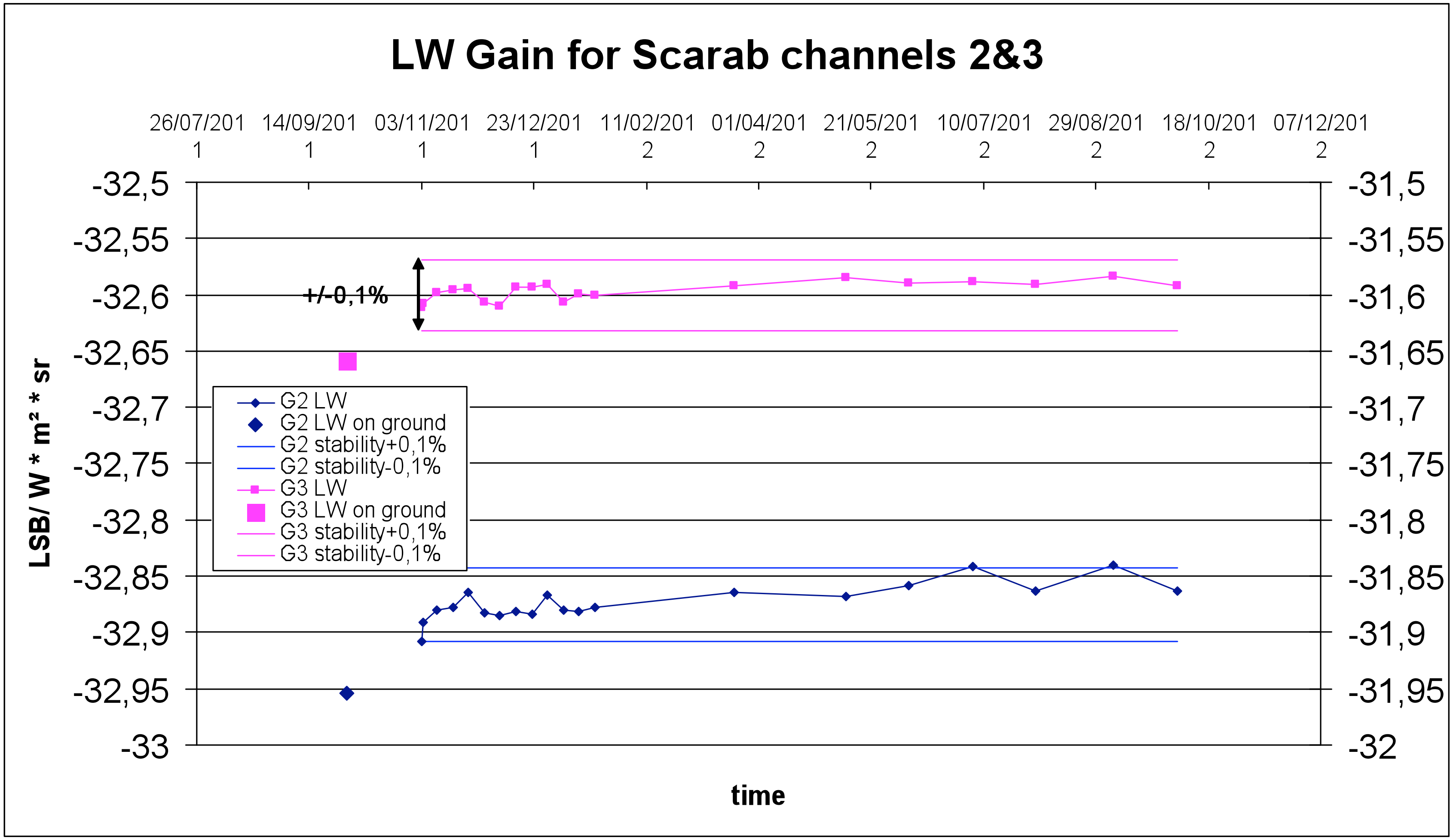
- **1 lamp for channel 1**
- **3 black bodies for channel 2-3-4**
- **No solar filter on channel 2 (filter wheel)**
- **CALM mode once per month**



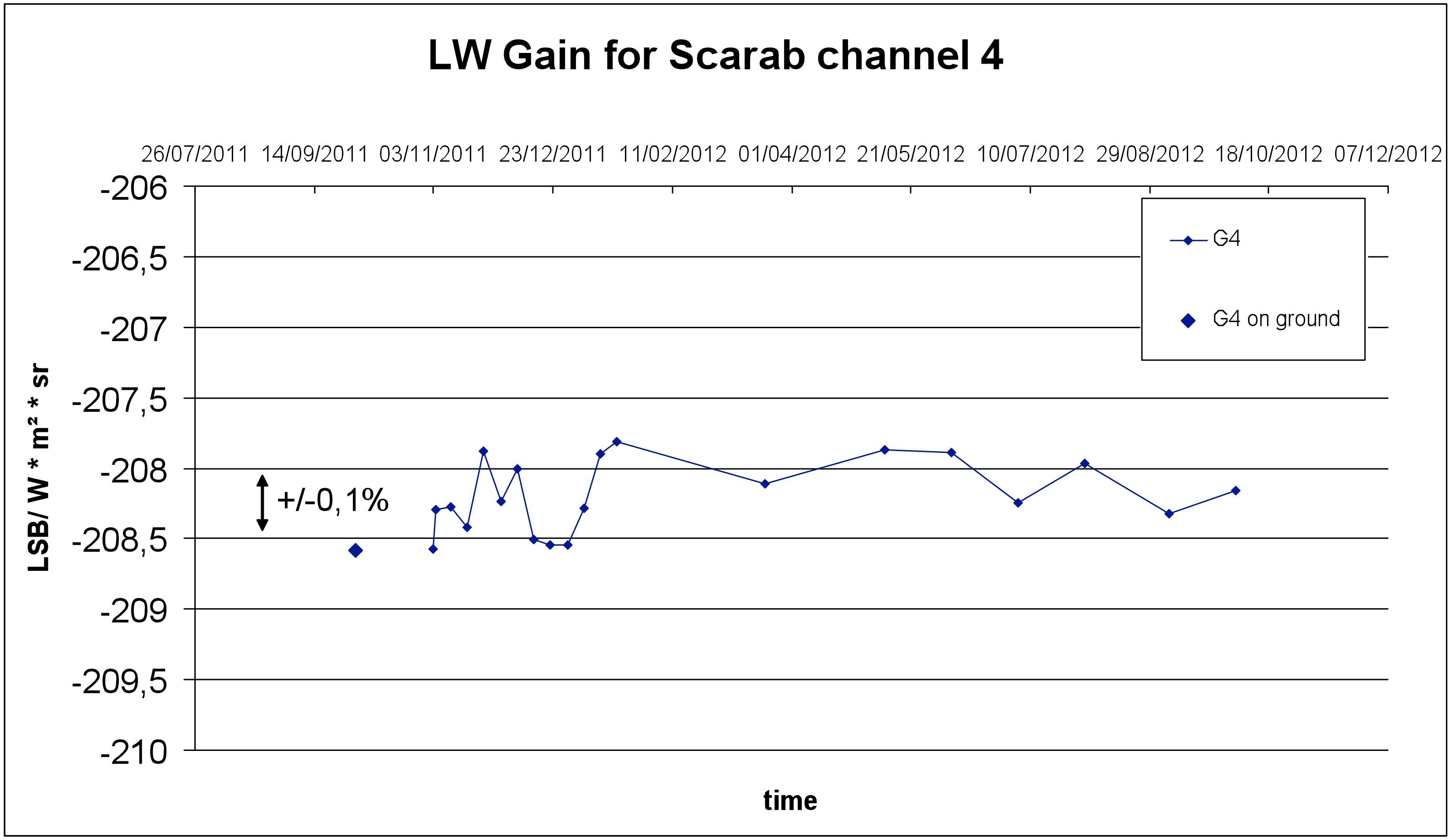
# SCARAB first result / gain



# SCARAB first result / gain



# SCARAB first result / gain



# SCARAB first result / gain

**Gain**

**Difference between last ground value and in-orbit value ≈ 0.2%**

**Gain stability is better than +/-2% for channel 1, mainly due to lamp instability.**

**Gain stability is better than +/-0.1% for channels 2&3.**

**Gain stability is better than +/-0.2% for channel 4.**

# SCARAB first result / A' factor

**Channel 2 :** Solar channel 0.2-4µm Short wave radiance $L_{sw}$

**Channel 3 :** Total channel 0.2-200µm Total radiance $L_{total}$

**Channel 5 :** Infrared channel 4-200µm long wave radiance $L_{lw}$

Channel 5 is computed with :

$$L_{lw} = L_{total} - A' \times L_{sw}$$

When channels 2&3 observe a same pure SW source, A' can be evaluated by :

$$A' = L_{total} / L_{sw} = L_3 / L_2$$

A' represents the difference of sensibility in the SW domain, between channel 2 and channel 3.

# SCARAB first result / A' factor

**MS Mode :**

**Channel 2 AND Channel 3 have an identical silica filter**

**=> Both observe the same pure SW source**

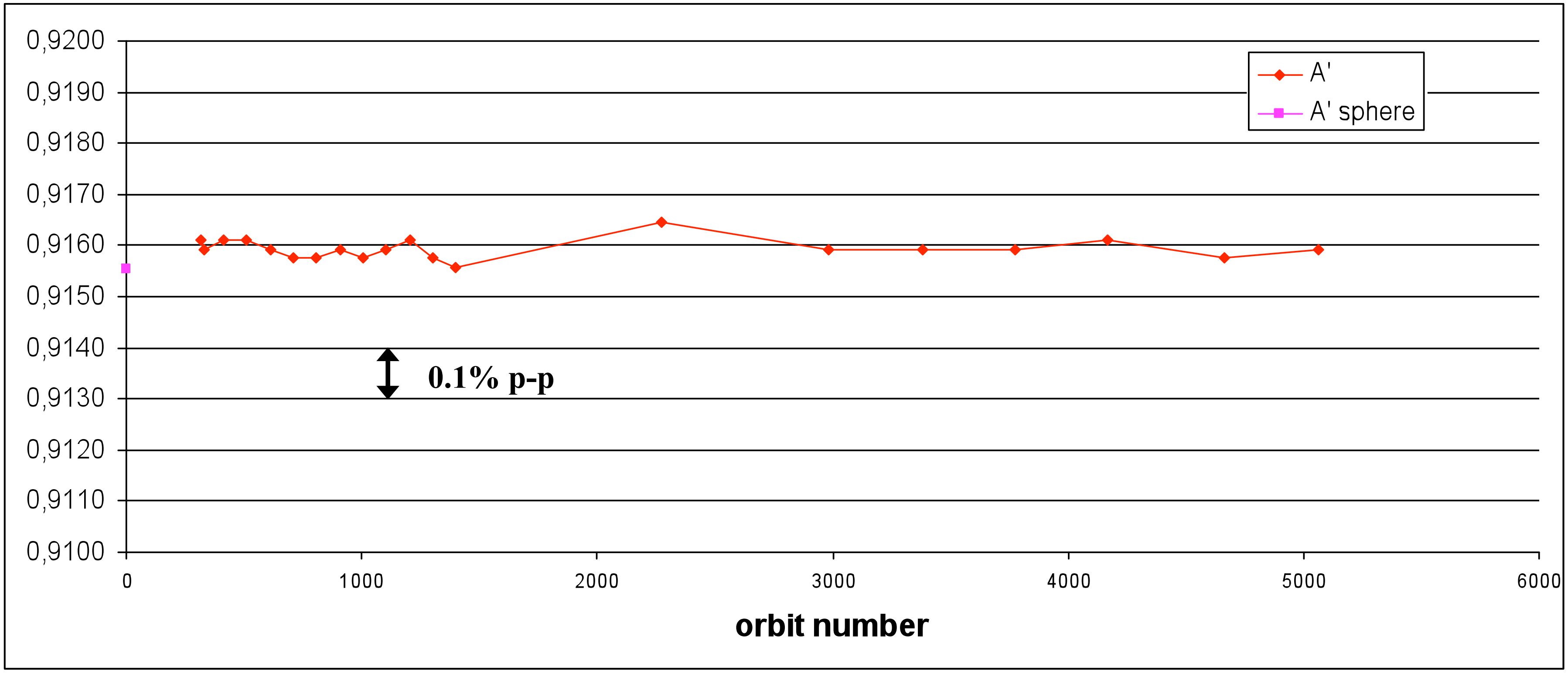
**=>** $A_{ms} = N_3 / N_2$

**=>** $A' = Ams * G_{2\_sw} / G_3 / T_{filter}$

$T_{filter}$ **must be known accurately with on-ground measurements !**

# SCARAB first result / A’ factor

## MS Mode :




The difference between the in orbit value and the sphere value is less than 0.2%.

The stability of the A’ms factor is about +/-0.05% for this first year.

# SCARAB first result / A' factor

**Nominal Mode :**

**Selection of bright clouds :** $L_{sw} > 250$ W/m²/sr

$L_{ir_window} < 5$W/m²/sr (223K)

**Selection of homogenous area** 10%

**Evaluation of LW radiance with Channel 4, with a polynomial P**

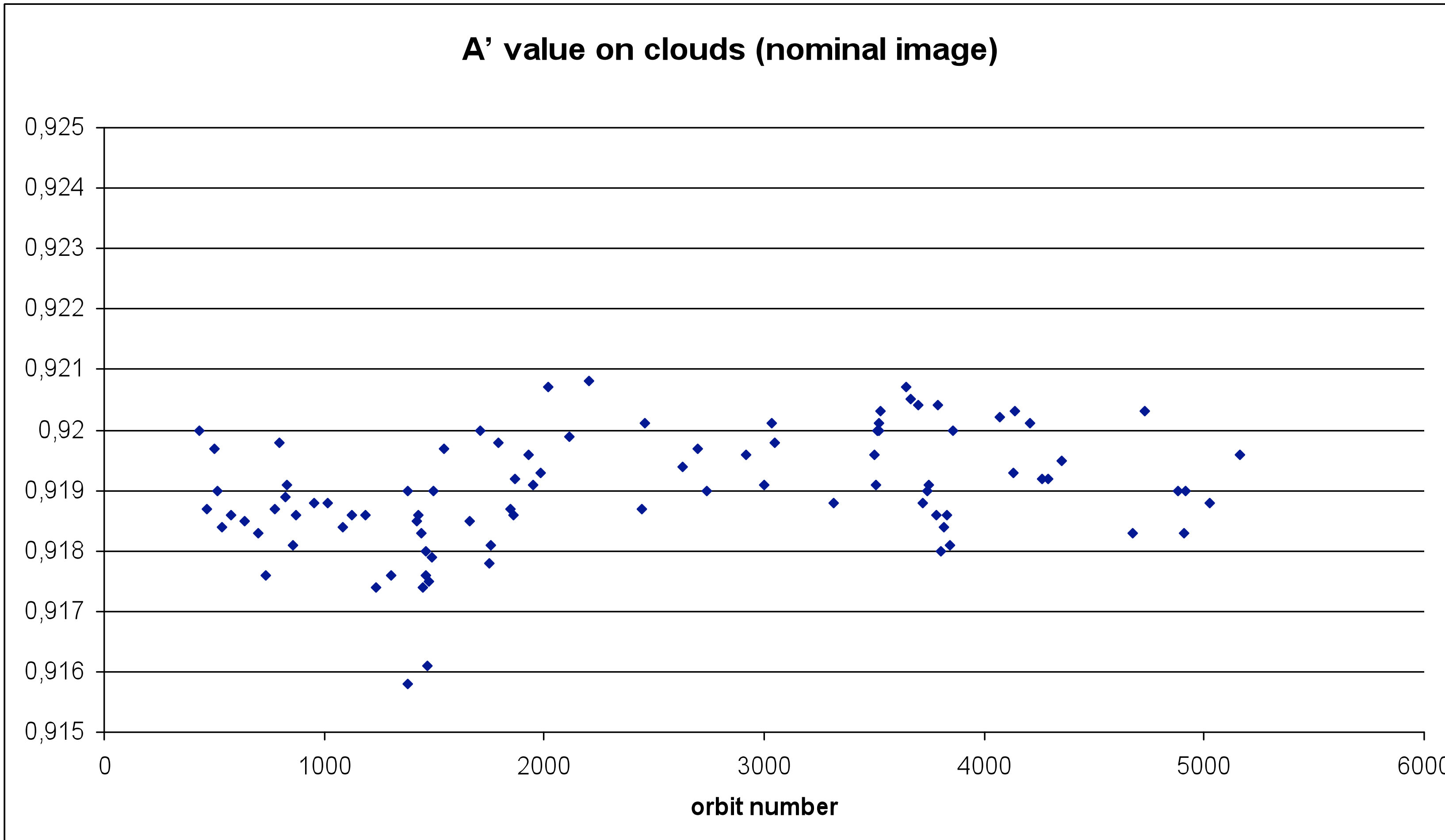
$L_{LW\_estimated} = P(L_{ir\_window})$

**Evaluation of A'**

$$A' = \frac{L_{3\_total} - L_{lw\_estimated}}{L_{2\_sw}}$$

# SCARAB first result / A' factor

## Nominal Mode :



# SCARAB first result / A’ factor

## Comparison for the first three months

| | |
|---|---|
| A’ from MS mode | 0.9159 |
| A’ nominal | 0.9180 |

**The difference is around 0.2%**

# SCARAB first result / Absolute pointing location

**Absolute pointing location**

**Comparison by massive correlation between Scarab and VeGeTation images.**

**VGT images :** **geolocation accuracy of less than 1km**
**resolution is 1 km**
**VGT Band 2 is used**
**cloud free images**

# SCARAB first result / Absolute pointing location

## Absolute pointing location

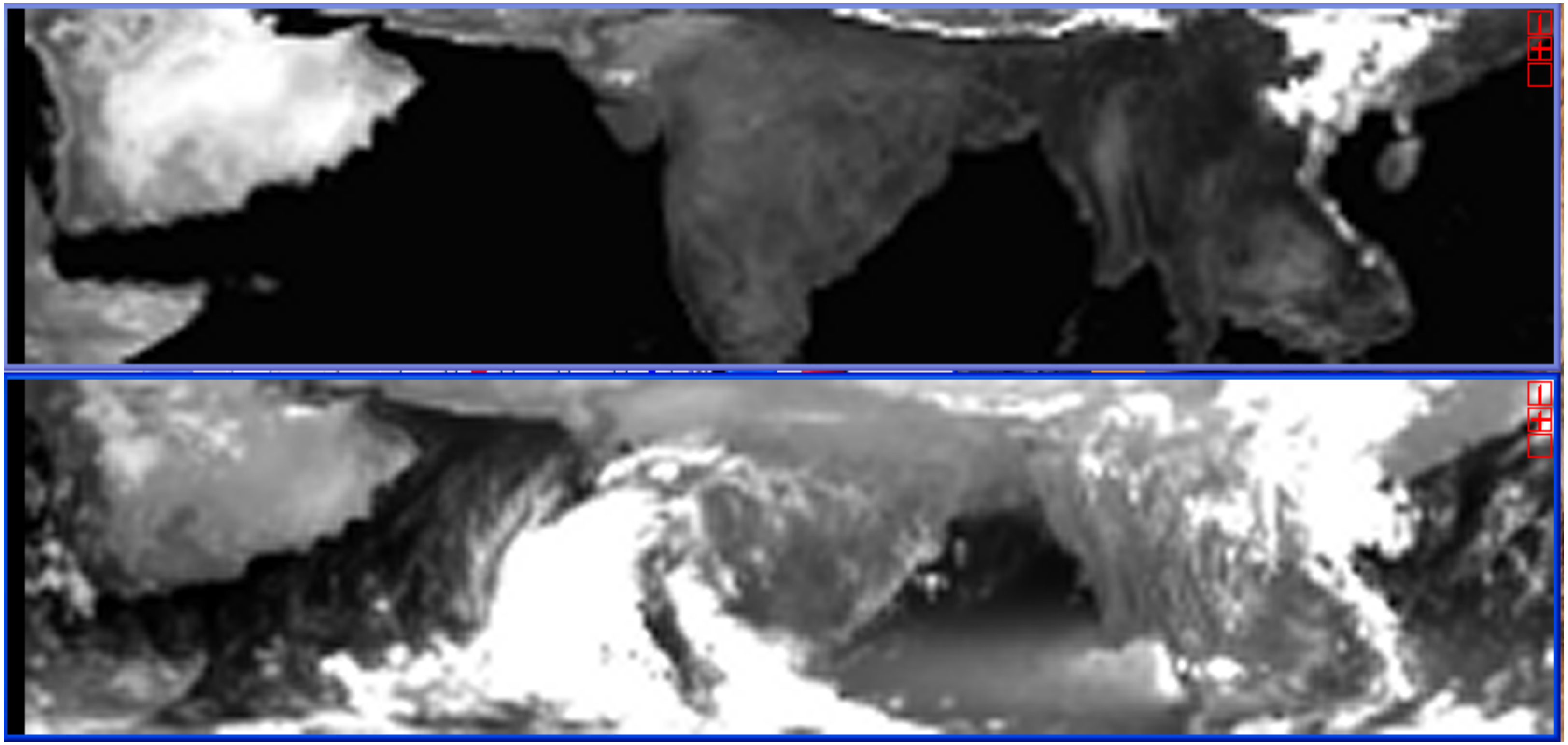


**Figure 1 : Orbit 666 extract from scan 1 to scan 221,**

**Resampled VGT on the top, SCARAB C2 below**

# SCARAB first result / Absolute pointing location

## Absolute pointing location

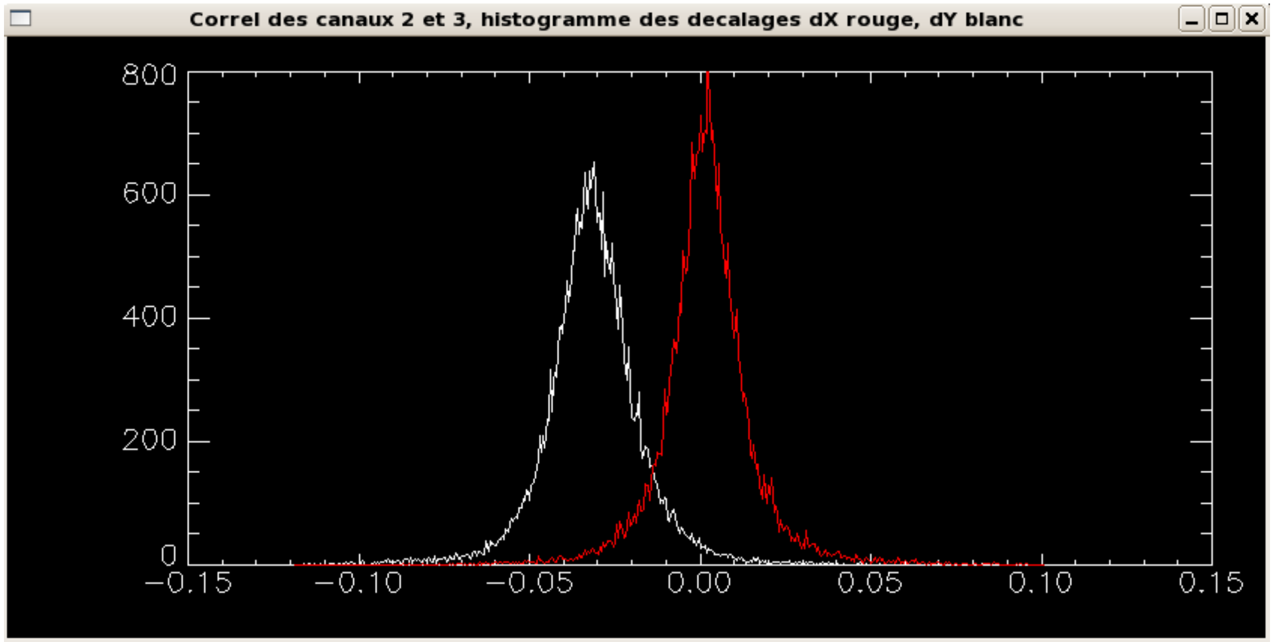
| | Nadir | | Swath border | |
|---|---|---|---|---|
| | across track | along track | across track | along track |
| Maximum bias measured | 0.4 km | 1.3 km | 1.5 km | 2.3 km |
| Uncertainty | 1 km | 1 km | 1 km | 1 km |
| VGT geolocation accuracy less than 1km | 1 km | 1 km | 1 km | 1 km |
| Total | 2.4 km | | 3.4 km | |
| Requirement | 5 km | | 5 km | |

# SCARAB first result / Registration

## Registration

## Massive correlation between channels

## Nominal mode and MT mode




Across track and along track shifts histograms between C3 and C2 respectively in red and white for MT mode products

# SCARAB first result / Registration

## Registration for level 1A

| | C1/C2 | C3/C2 | C4/C3 |
|---|---|---|---|
| Anticipated surface registration (on-ground measurement) | 89 % | 97.4 % | 93 % |
| In orbit measured value Level 1A | 92.1 % | 97.3-97.8% | 98 % |

## Level 1A2 : All channels are resampled on channel 2

| | C1/C2 | C3/C2 | C4/C3 |
|---|---|---|---|
| In orbit measured value Level 1A2 | 98.2 % | 99.3 % | 99.4 % |

# SCARAB first result / L1A-L1A2 comparison

To compute synthetic channel 5 :

$$L_{lw} = L_{tot} – A' L_{sw}$$

Channel 3 ($L_{tot}$) and Channel 2 ($L_{sw}$) must aim at the same location.

At level 1A, the covering of channel 2 by channel 3 is around 98% (0.05°)

As Scarab respects Shannon theorem, it is possible to resample channel 3 on channel 2 with a low level of artifacts, to generate L1A2 products

How to compare the 2 products ?

=> With MS mode, Channel 2 and Channel 3 are identical !

=> C5 should be equal to 0

# SCARAB first result / L1A-L1A2 comparison

**MS mode 3775**

**Ch 2**

**Ch 3**

**Ch 5**
**L1A**

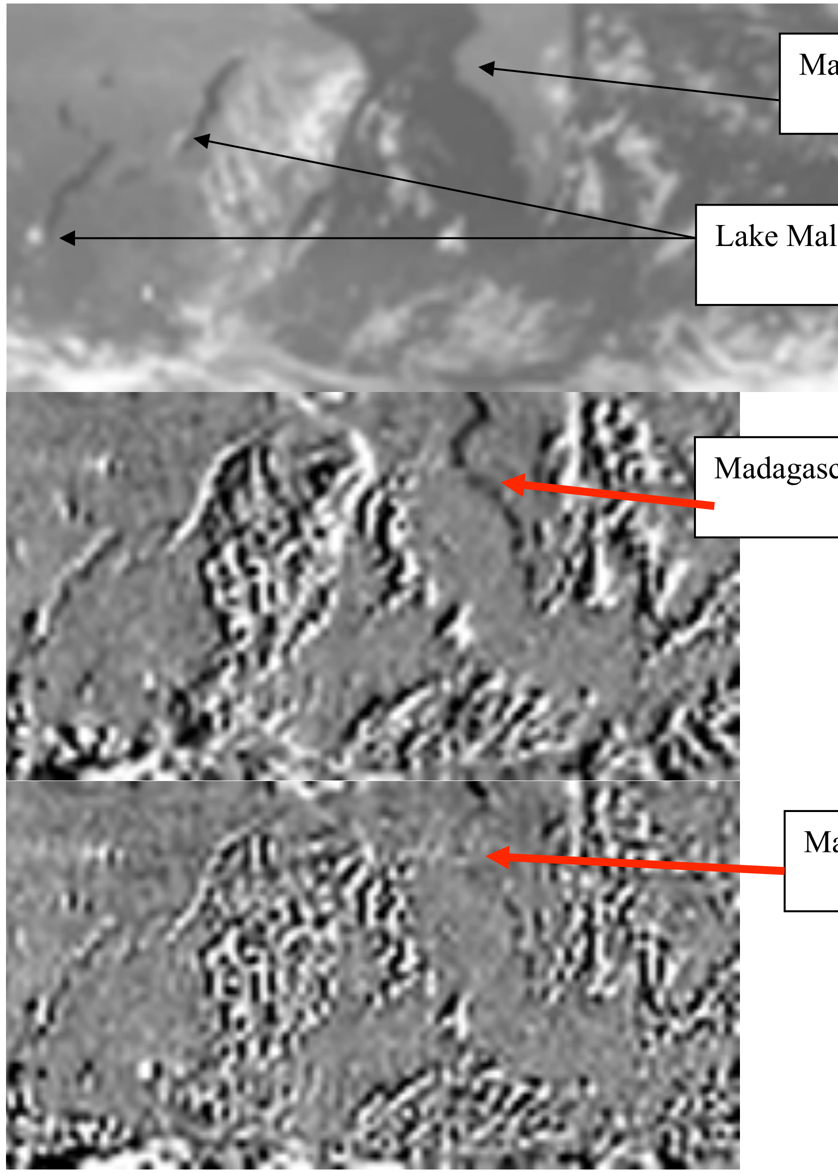
**CH5**
**L1A2**

# SCARAB first result / L1A-L1A2 comparison

Ch 2

Ch 5
L1A

CH5
L1A2



# SCARAB first result / L1A-L1A2 comparison

| | Standart deviation W/m²/sr | Min W/m²/sr | Max W/m²/sr | Mean W/m²/sr |
|---|---|---|---|---|
| C2 | | | | 48 |
| C5_A | 0.57 | -3.8 | 7.8 | |
| C5_A2 | 0.41 | -2.9 | 7.6 | |

**=> No artifacts on level A2**

**=> Better performances on level A2**

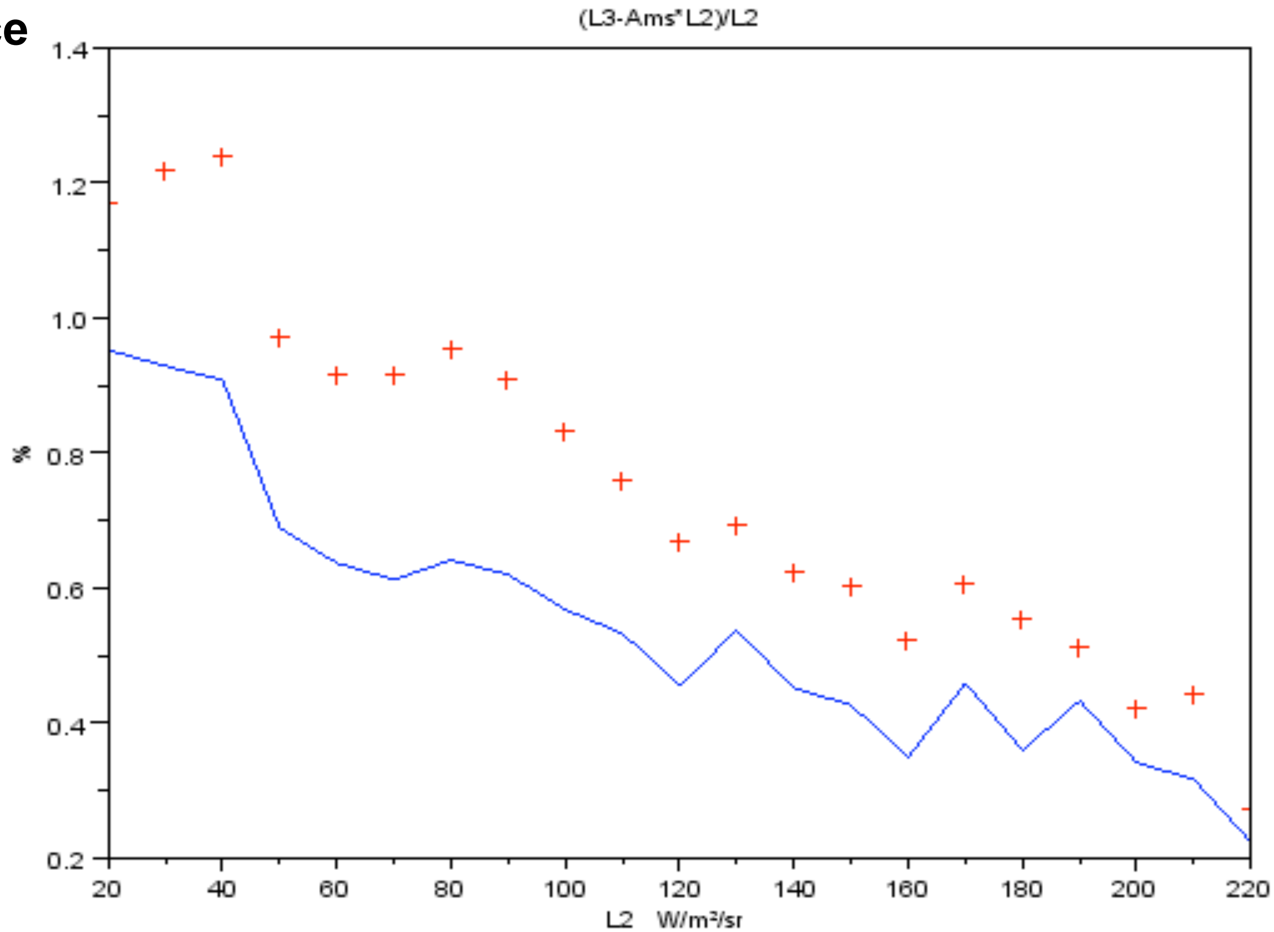
## SCARAB first result / L1A-L1A2 comparison

**Estimation of the absolute calibration error for Channel 5 (LW channel), function of the short wave radiance :**

$$e_{A1}(L_{2\_sw}) = \frac{\sigma_{C5\_A1}(L_{2\_sw})}{L_{2\_sw}}$$

# SCARAB first result / L1A-L1A2 comparison

This value is calculated for the MS mode orbit 3775 for each interval of SW radiance




- For L1A : 0.4% at 220 W/m²/sr to 1.2% at 20 W/m²/sr
- For L1A2 : 0.3% at 220 W/m²/sr to 0.9% at 20 W/m²/sr

# SCARAB first result / Absolute calibration budget (LW)

## The absolute calibration budget can be established :

| **L1A2** | | Bright cold clouds | Hot / bright scene | Night scene |
|---|---|---|---|---|
| | | 250 SW + 50 LW | 210 SW + 130 LW (20°) | 0 SW + 80 LW |
| Instrumental noise | Random | 0.21% | 0.11% | 0.14% |
| Calibration CALM | Bias | 0.12% | 0.12% | 0.12% |
| **A' factor** (0.2%) | Random | 1% | 0.3% | 0% |
| **Registration and spectral effects** | Random | 1.5% | 0.55% | 0% |
| Location | Random | 0.4% | 0.40% | 0.40% |
| | | | | |
| Budget @1σ % | | **1.9%** | **0.8%** | **0.45%** |
| Budget @1σ W/m²/sr | | **0.95** | **1.0** | **0.35** |
| Requirement | | | **1%** | |

# SCARAB / Absolute calibration budget (SW)

| Items | Value | Type | |
|---|---|---|---|
| Short wave calibration (sphere) | 3% @2σ | Biais | 1.5% |
| Error on spectral response | | Biais | 0.4% |
| Thermal gain correction | 0.08%/° dT= 0.04° @1σ | Random | 0.03% |
| Thermal leak correction | 20% of the thermal leak@1σ | Random | 0.04% |
| Location | 0.06°@1σ | Random | 0.4% |
| Budget at 1 sigma | | | 1.6% |

**Absolute calibration of channel 2 was made in front of an integrating sphere at CNES facilities**

# SCARAB first result / Conclusion

| | |
|---|---|
| Radiometric noise | => Very low |
| Thermal leak | => Coherent with on-ground value |
| Gain value | => Very stable<br>=> Coherence with on-ground value 0.2% |
| A' factor | => Very stable<br>=> Coherence with on-ground value 0.2% |
| Location | <5 km as required |
| Registration | => Coherent with on-ground value<br>=> Very good for L1A2 product |