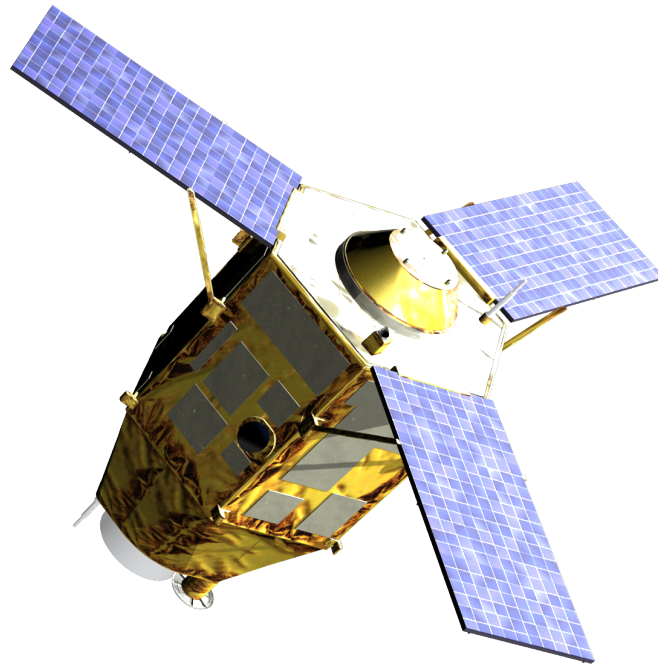


PLEIADES LINE OF SIGHT STEERING MODES FOR CAL/VAL



Laurent LEBEGUE, Philippe KUBIK,
[Aimé MEYGRET](#)

PLEIADES MISSION



Spatial resolution:

- Panchromatic: 0,70 m (product resampled @ 0.5m to improve robustness to ground processing)
- XS (B, G, R, NIR): 2.80 m

Swath: 20 km

Revisit Capability: 1 day with 2 satellites



Mode	Band	Spectral characteristics
Multi spectral	1	430 – 550 nm
	2	490 – 610 nm
	3	600 – 720 nm
	4	750 – 950 nm
Panchromatic	P	480 – 830 nm

- **PHR1A launch: December 17, 2011**
- **PHR1B launch: December 2, 2012**

PLEIADES SATELLITE

A new concept compared to Spot

A small and very agile satellite to improve operational capability and minimize the conflicts between users

Designed for high agility

Compact <1000 kg satellite with low inertia

Rigid satellite with fixed solar array

Attitude control system with 4 powerful CMG (Control Moment Gyros) actuators

☞ agility (roll and pitch):

5° in 8 seconds

10° in 10 seconds

60° in 25 seconds



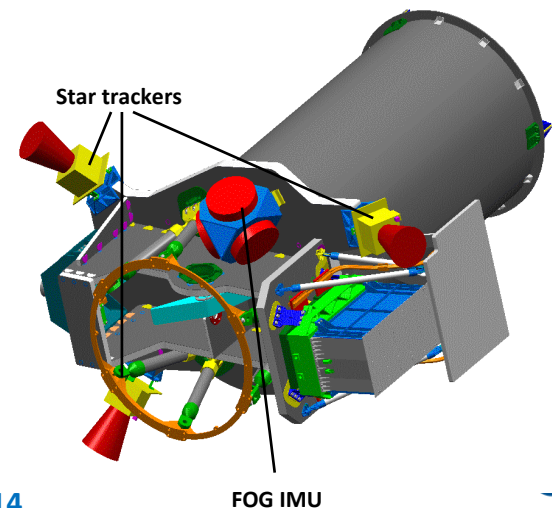
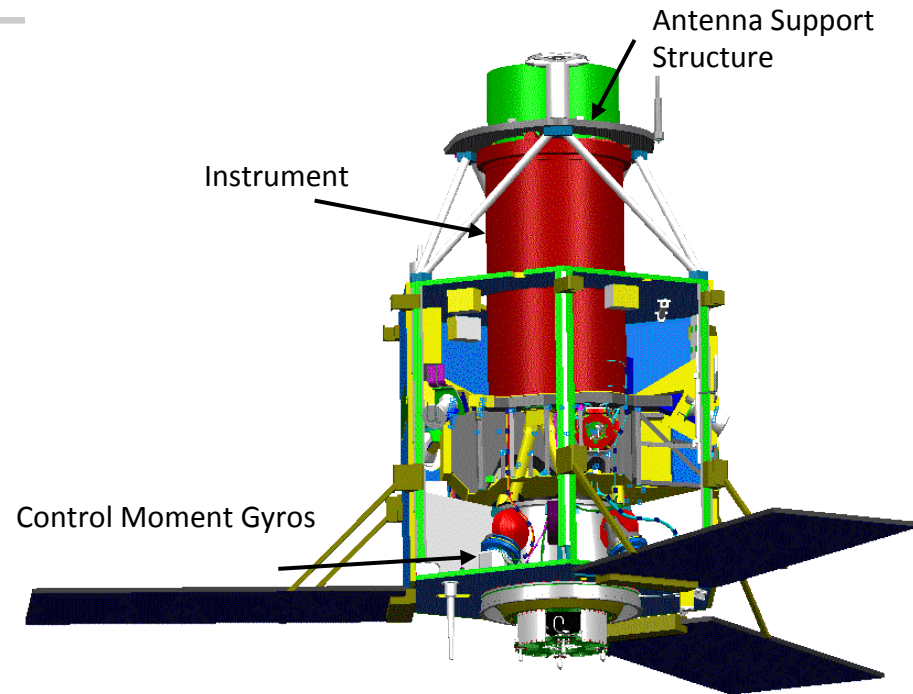
Designed for high geometric image quality

Very stable instrument with very accurate sensor heads mounted on the optical bench:

- 3 star trackers

- an Inertial Measurement Unit made of 4 Fiber Optical Gyrometers

Autonomous navigation with DORIS/DIODE system



PLEIADES INSTRUMENT



Korsch camera:

focal length = 13 m

input diameter = 0.65 m

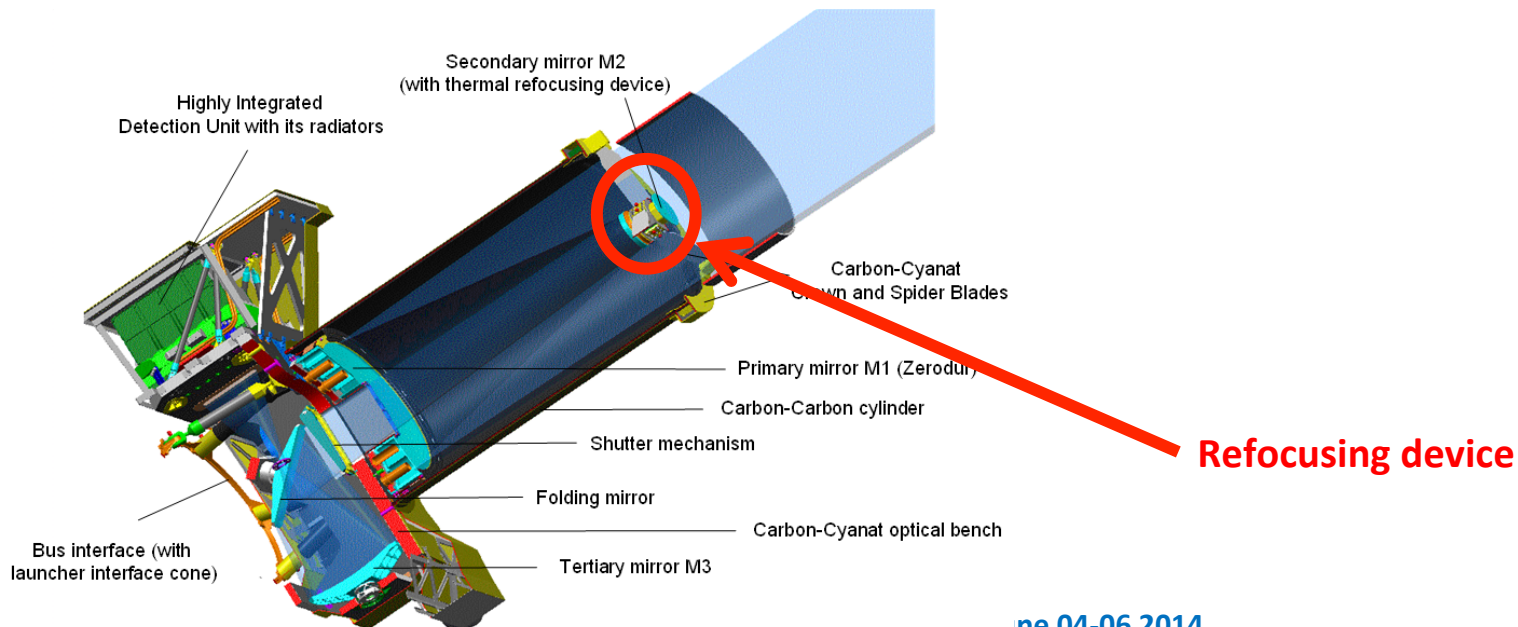
PA retina : 5 TDI detectors

XS retina : 5 four-color CCD

Radiometric resolution: 12 bits

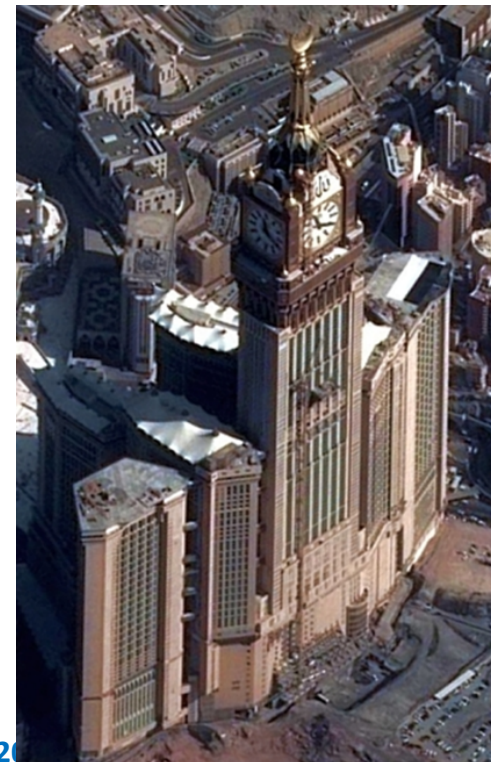
On-board detectors normalization

Wavelet compression: from 1.4 to 3.33 bits/pixel



AN EXAMPLE OF PLEIADES AGILITY

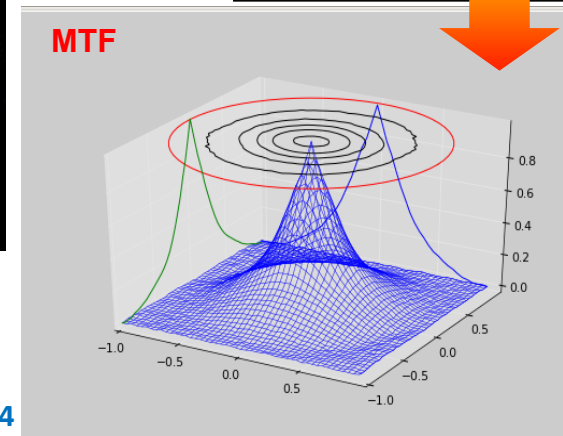
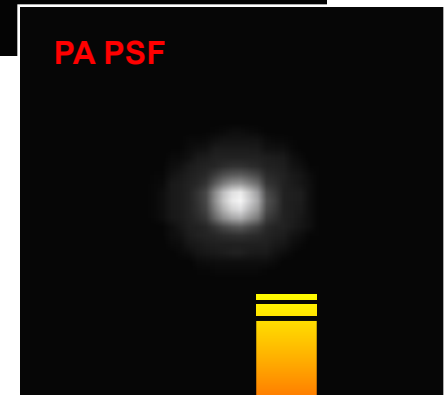
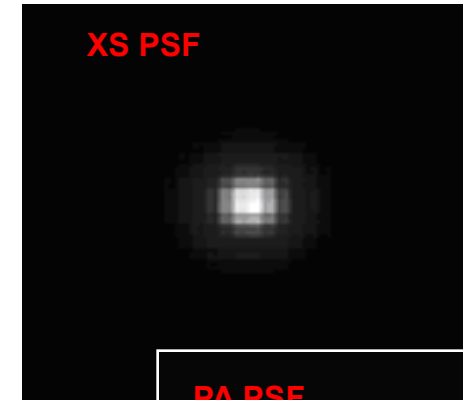
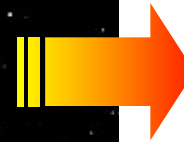
**Mecca "tower clock" viewed by
PLEIADES 1B every 90 sec in a single
pass to see the 3 faces of the building ...
and the minutes needle moving!**



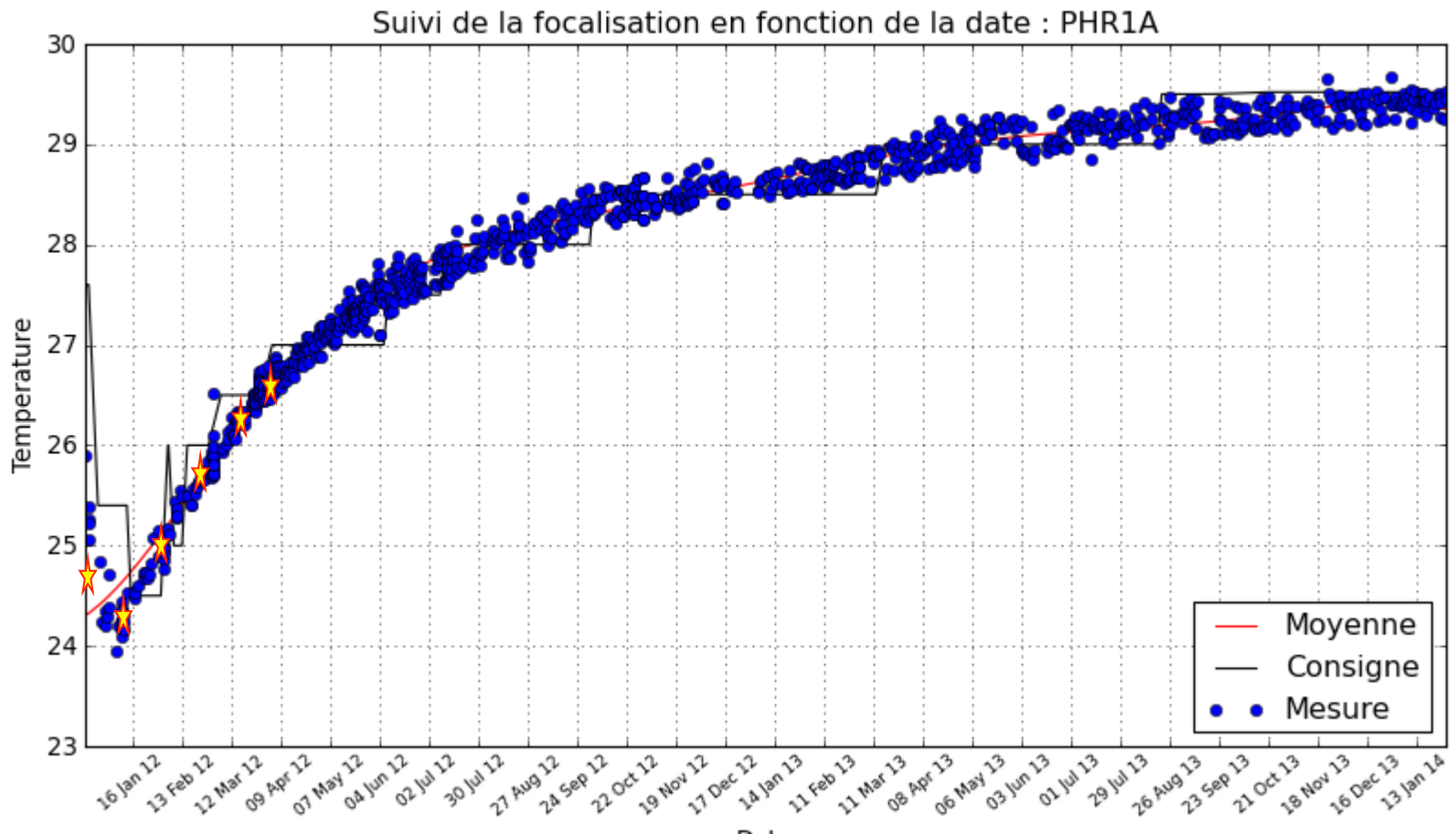
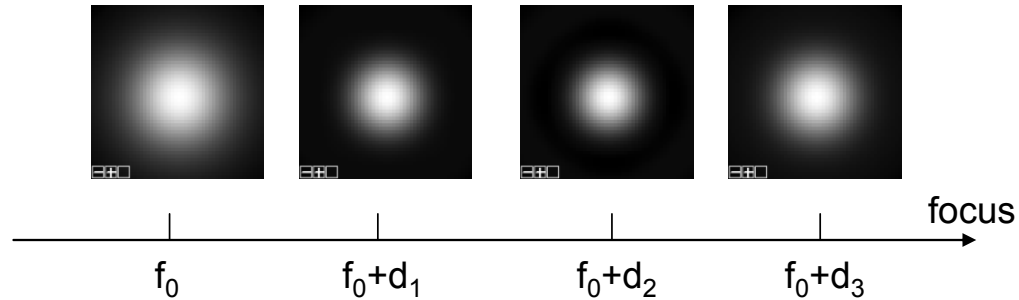
TAKING ADVANTAGE OF THE AGILITY TO VIEW STARS FOR RESOLUTION (MTF) ASSESSMENT AND INSTRUMENT FOCUSING



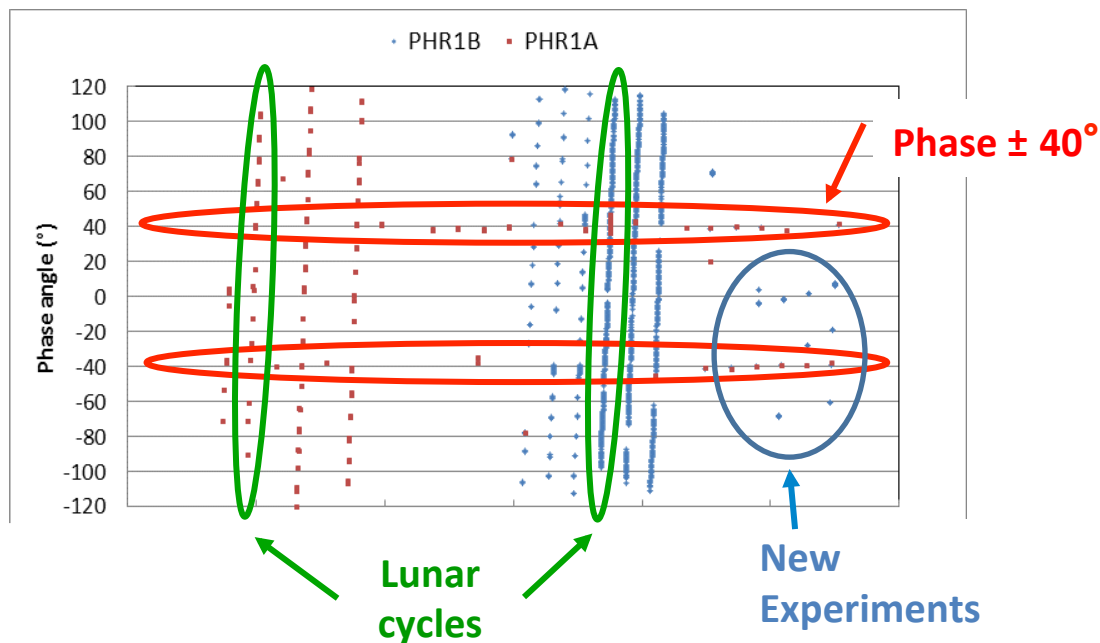
- Few images are needed
- No atmosphere
- Good accuracy
- 2D MTF assesment



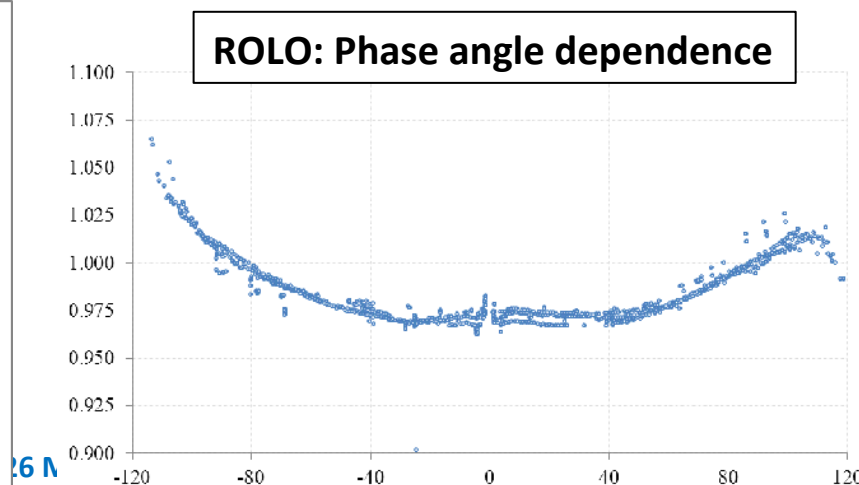
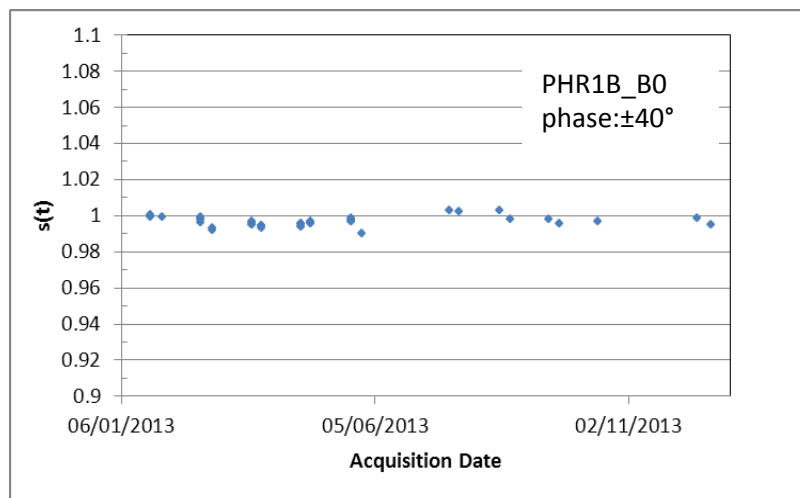
MONITORING THE BEST FOCUS



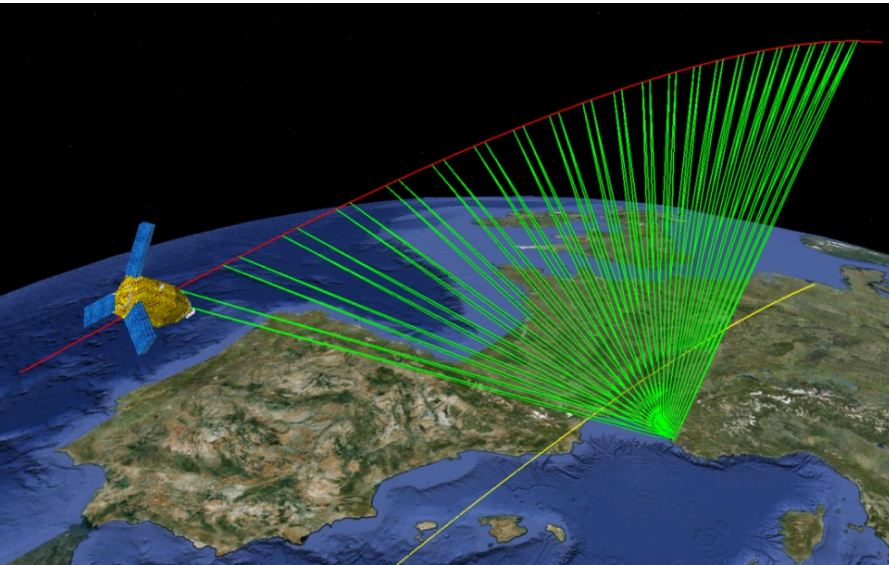
TAKING ADVANTAGE OF THE AGILITY TO VIEW THE MOON FOR ABSOLUTE RADIOMETRIC CALIBRATION



POLO dataset : more than 1200 images to enhance the Lunar radiometric calibration model



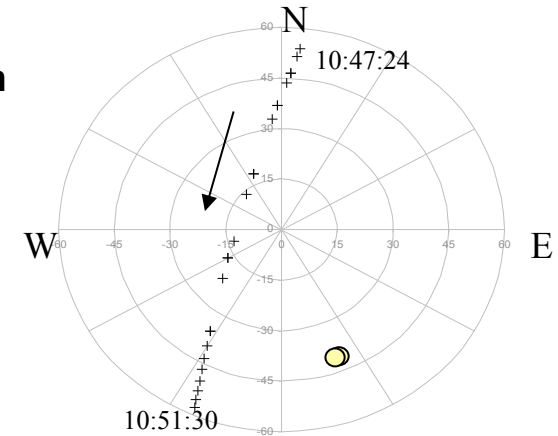
THE VIDEO MODE FOR RADIOMETRIC ABSOLUTE CALIBRATION AND BRDF VALIDATION



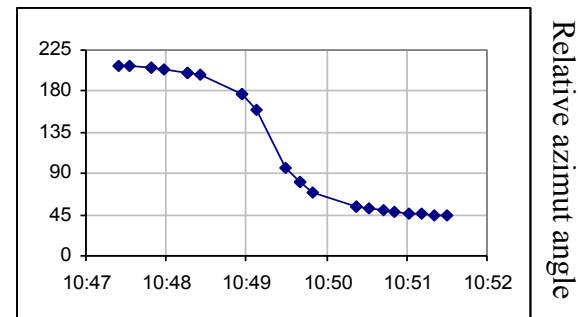
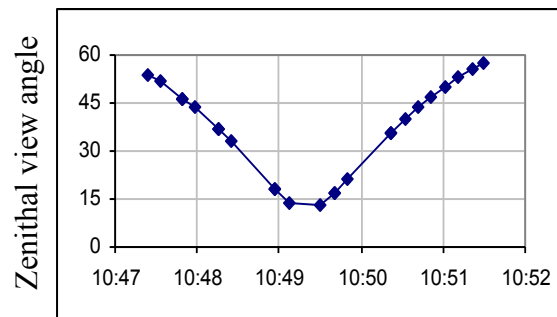
**Directional effects: video of PHR1-A
acquisitions on Crau March 28, 2012**

**19 measurements
4 minutes total duration**

**$\theta_s \approx 42$ deg
 θ_v min = 13.2 deg
 θ_v max = 57.7 deg**



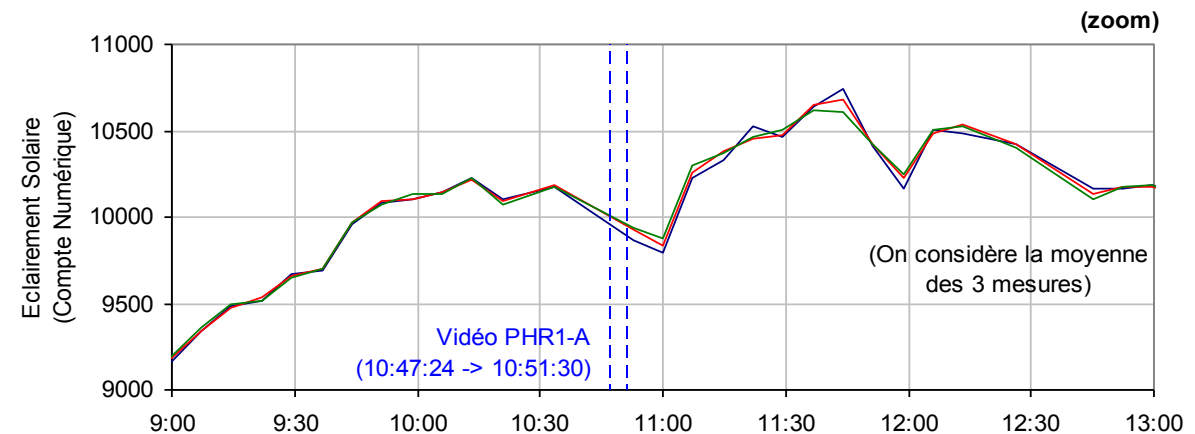
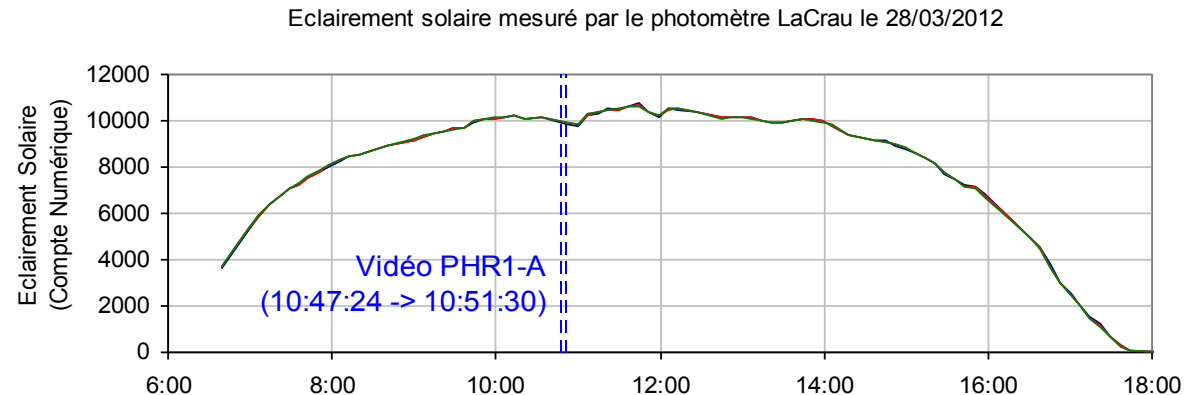
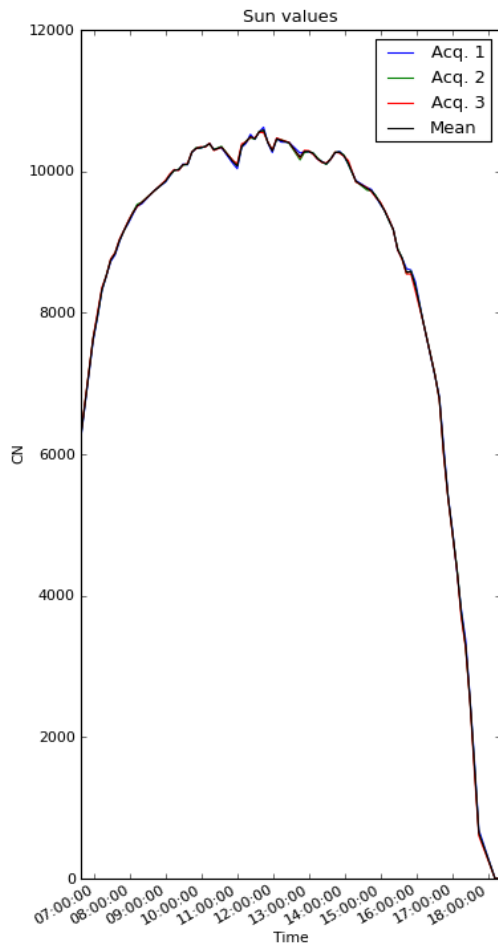
Absolute azimuths



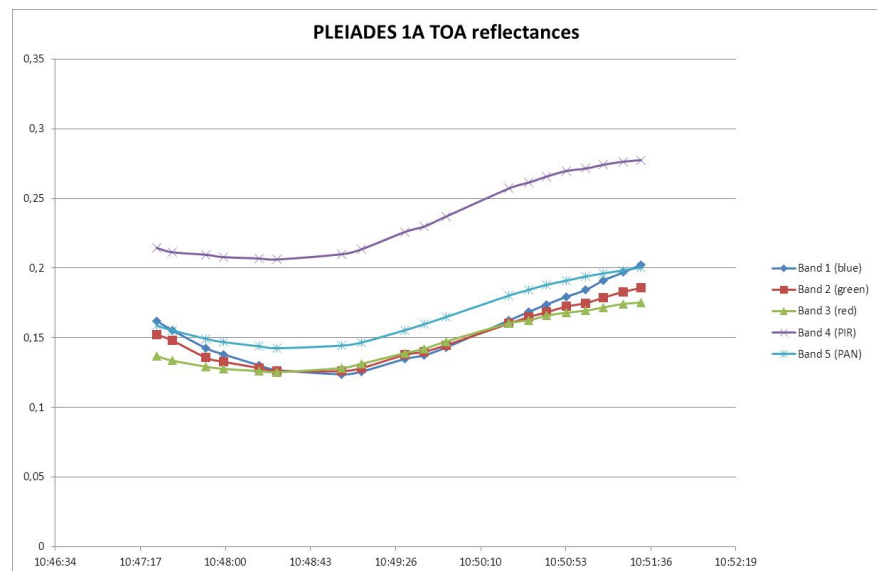
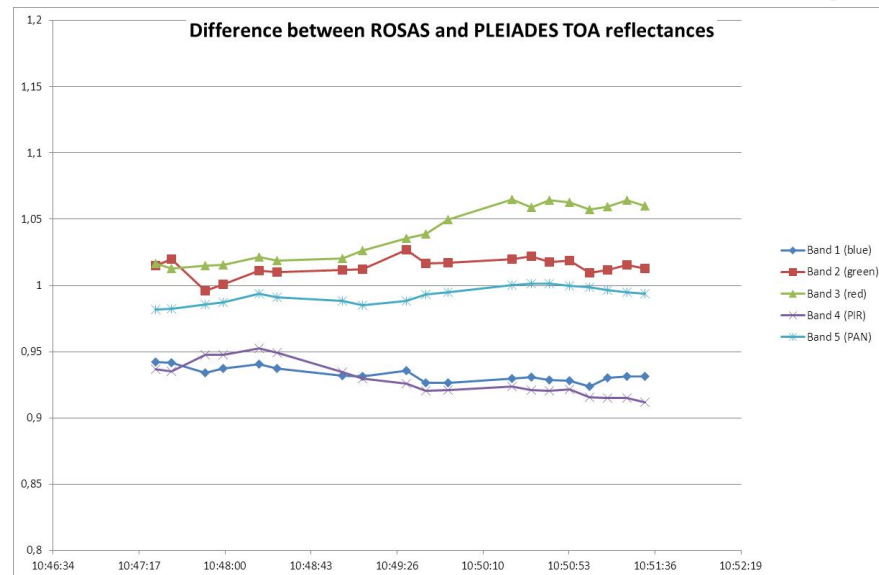
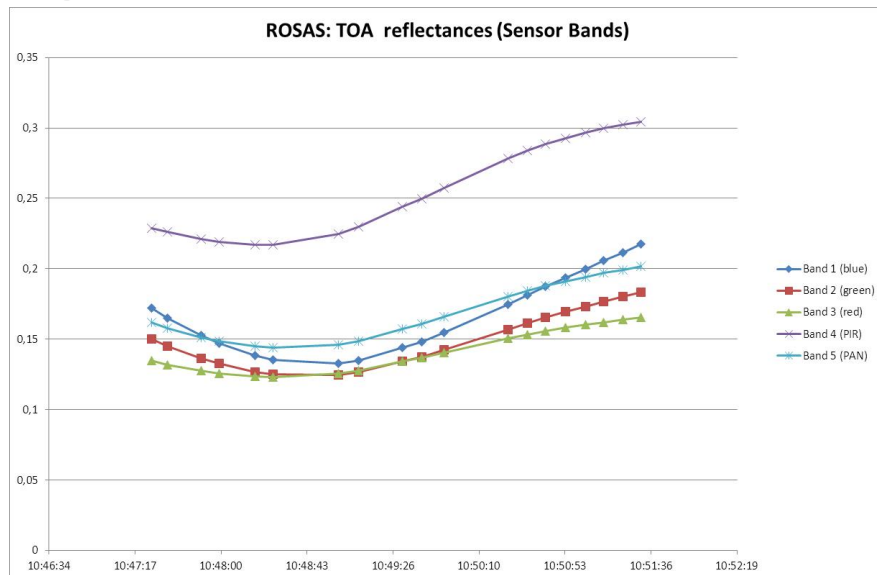
On-orbit PHR1A calibration over Crau site: video (28 march 2012)



- SUN irradiance measurements:



On-orbit PHR1A calibration over Crau site: video (28 march 2012)



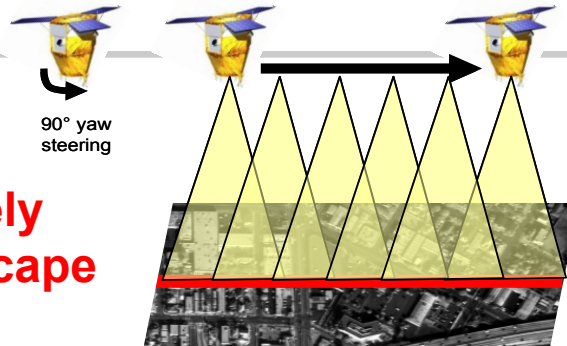
Bands	Ak ROSAS / Ak Ground (mean)	Standard deviation	Max-Min	Ak Official / Ak Ground	Ak ROSAS / Ak Official
B1 (blue)	0.92	0.0053	0.0183	1.05	12.5%
B2 (green)	1	0.0060	0.0308	0.95	5%
B3 (red)	1.025	0.0031	0.0522	0.96	6.5%
B4 (PIR)	0.915	0.0029	0.0406	0.94	2,5%
B5 (PAN)	0.975	0.0045	0.0198	0.95	2,5%

BRDF assesment:

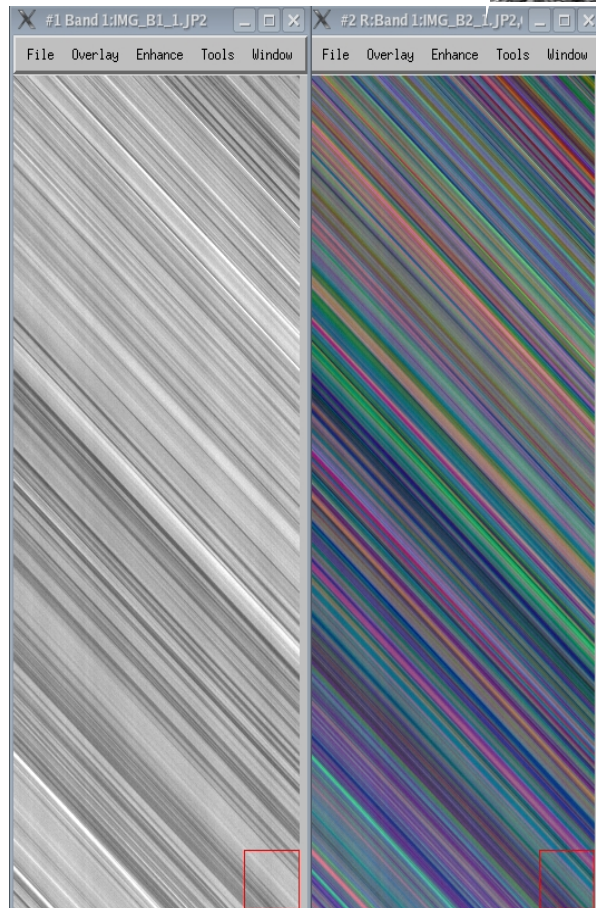
- Weak standard deviation (19 measurements)
- Good agreement for B1, B2 and B5
- Max-min difference to be understood for B3 (4%) and B4 (5%): azimuth dependence?

➤ Large bias for band B1 to be understood... not completely explained by the high aerosol optical thickness (~0.3 at 550nm)

AMETHIST MODE FOR NON UNIFORMITY CALIBRATION

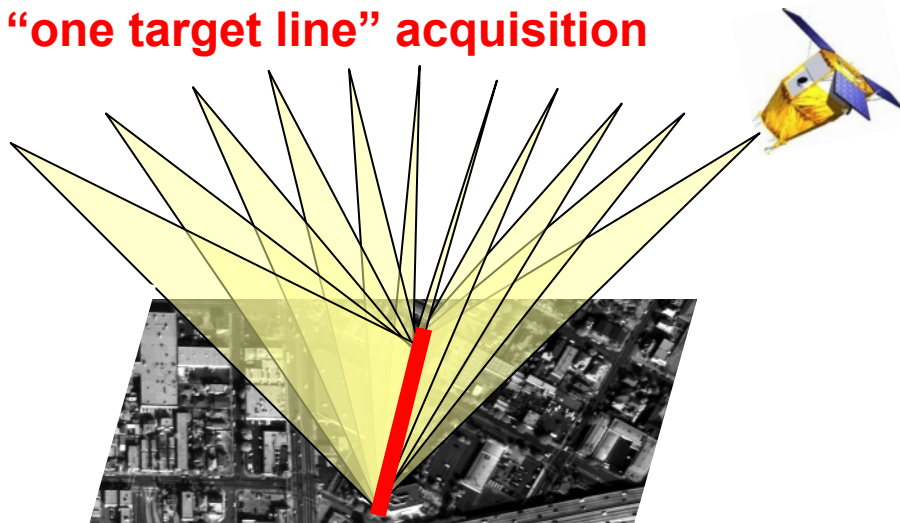


**Each pixel successively
views the same landscape**



STEADY MODE FOR SIGNAL-TO-NOISE RATIO ASSESSMENT

“one target line” acquisition

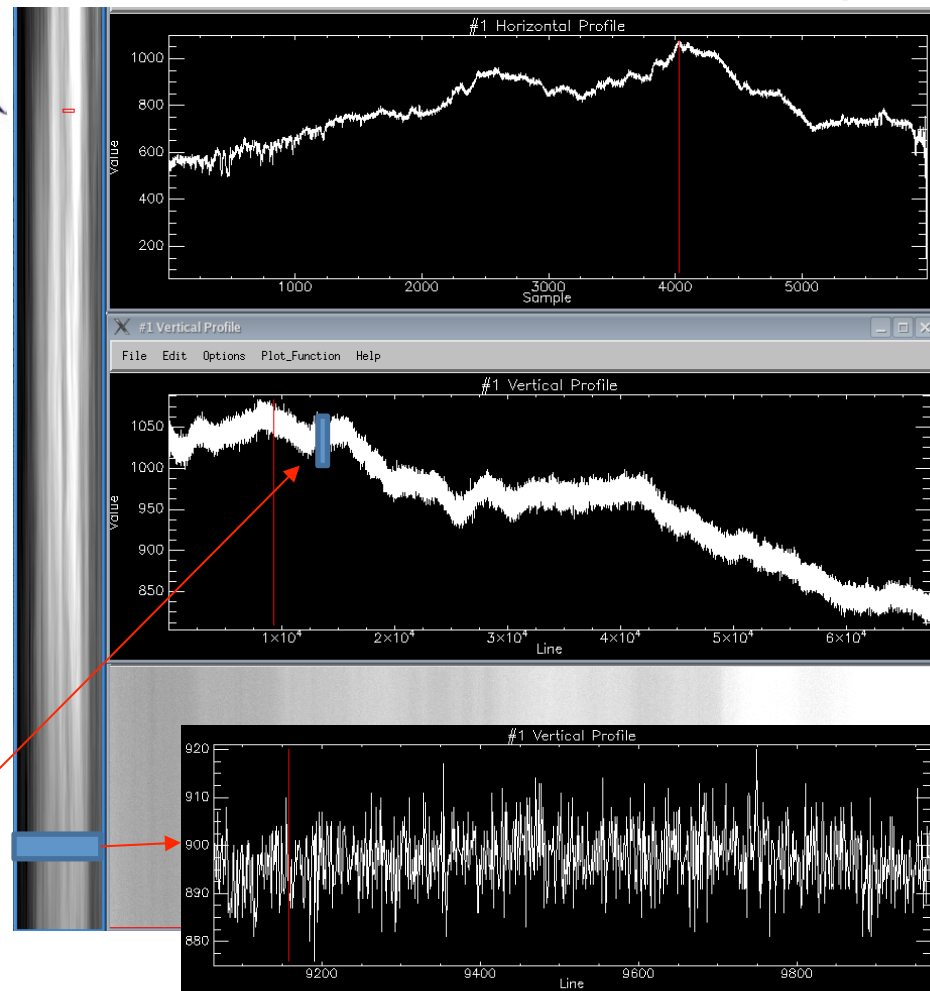
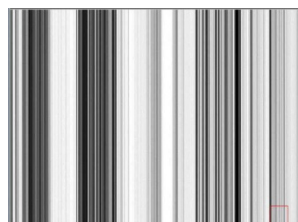


Acquisition duration

- a few seconds
- about 60000 rows

Relative line-of-sight good stability

- use of 1000 rows

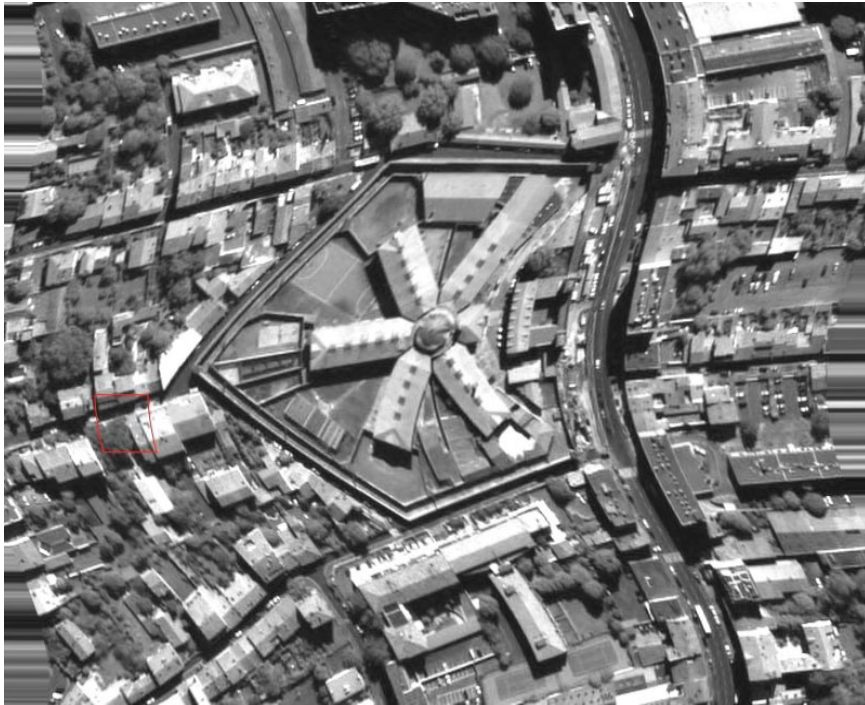


Vertical profile of 1 column and for 1000 rows

PHR1B	PA-NTDI 10	PA-NTDI 13	PA-NTDI 16	B0	B1	B2	B3
S/B(L1)	38	47	53	69	63	48	35
S/B(L2)	138	162	178	150	164	158	187
S/B(L3)	208	242	266	220	243	233	273

IN-FLIGHT MICROVIBRATIONS ASSESSMENT

Simulation of microvibration geometric effects on the image

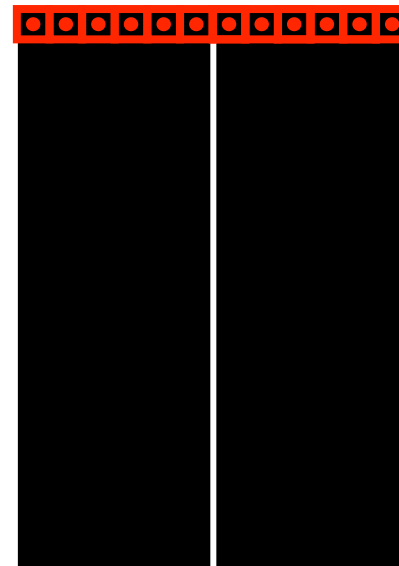


with microvibrations

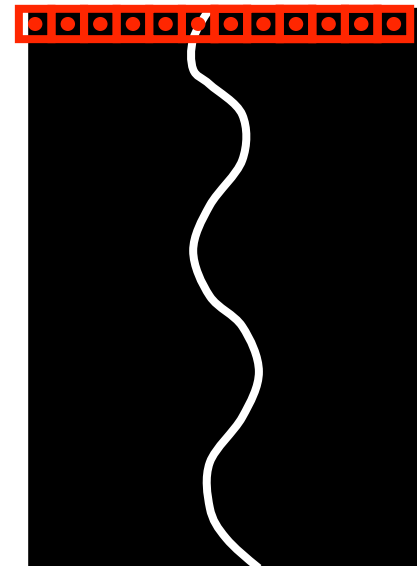


without microvibrations

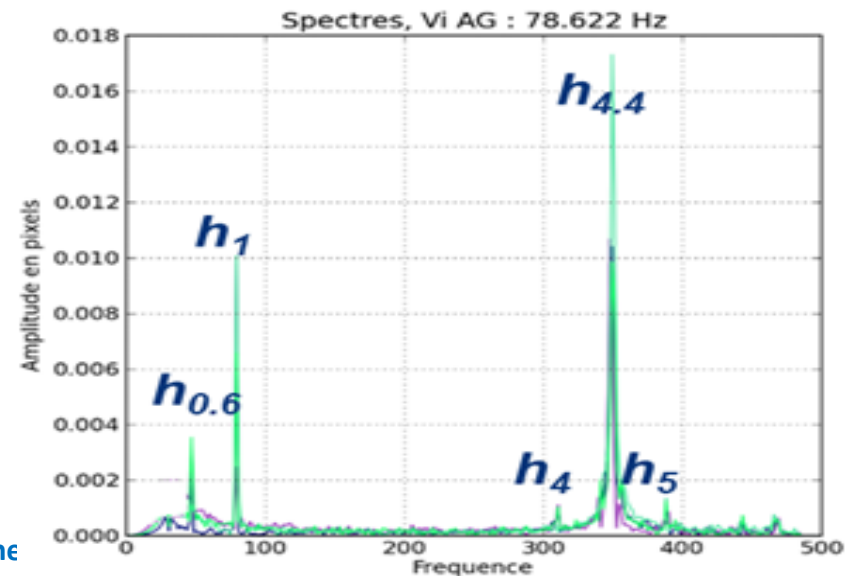
STAR ACQUISITION IN STEADY MODE FOR IN-FLIGHT MICROVIBRATIONS ASSESSMENT



without μ vib



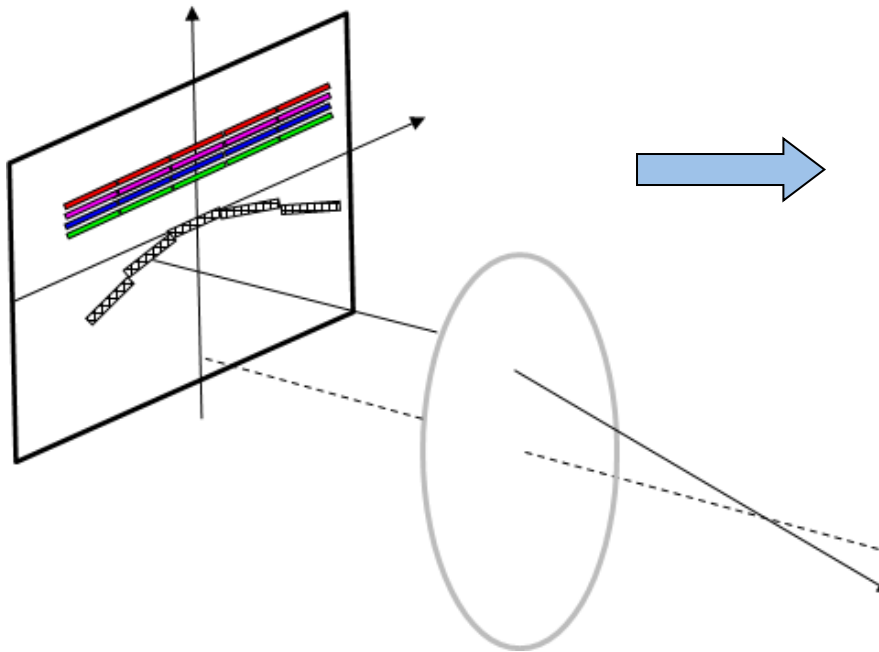
with μ vib



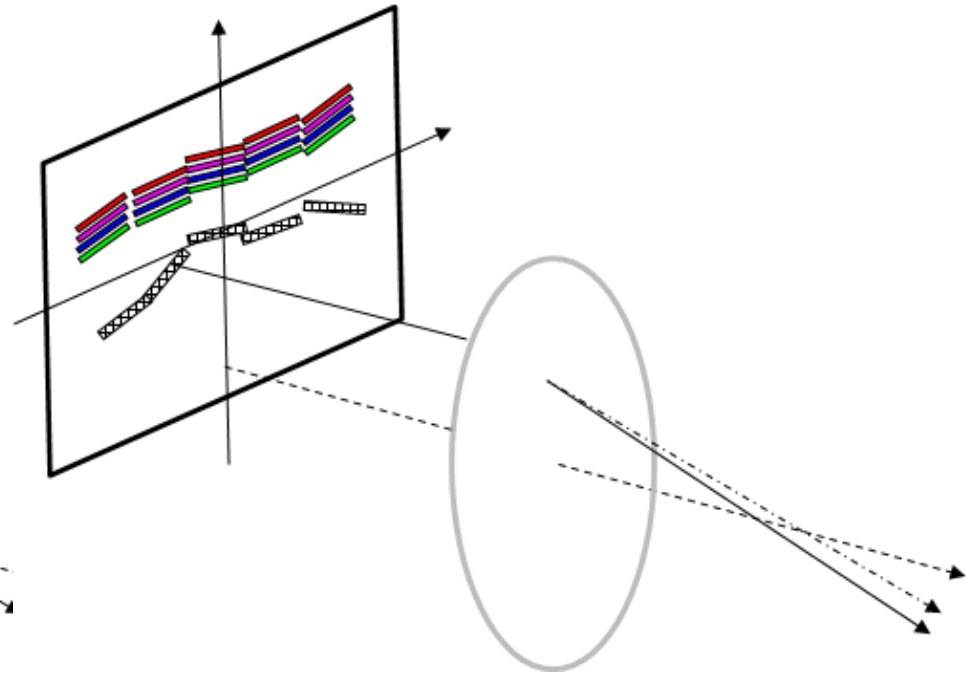
- ➡ Microvibration amplitude < 0.02 pixels
- ➡ Accuracy: few nrad

FOCAL PLANE CARTOGRAPHY CALIBRATION

Ground model



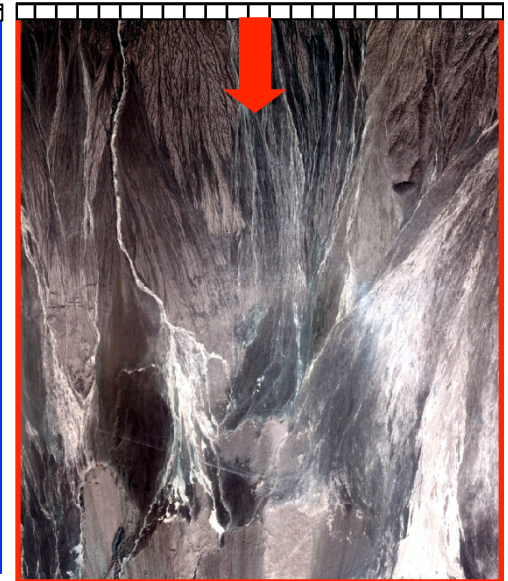
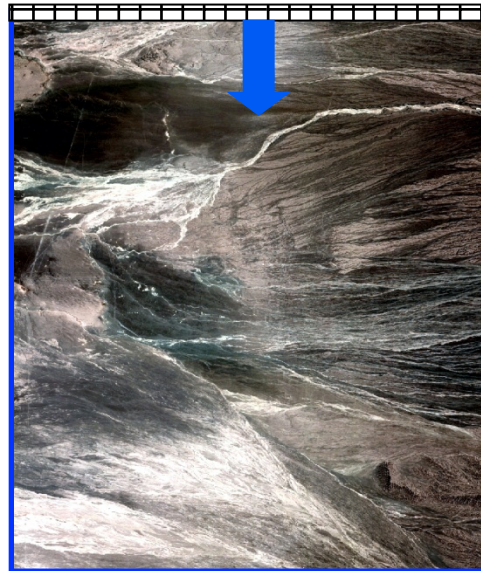
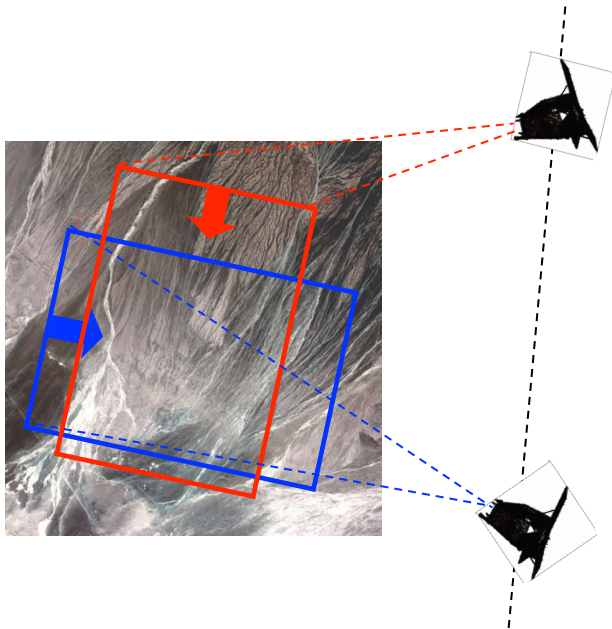
In-orbit model



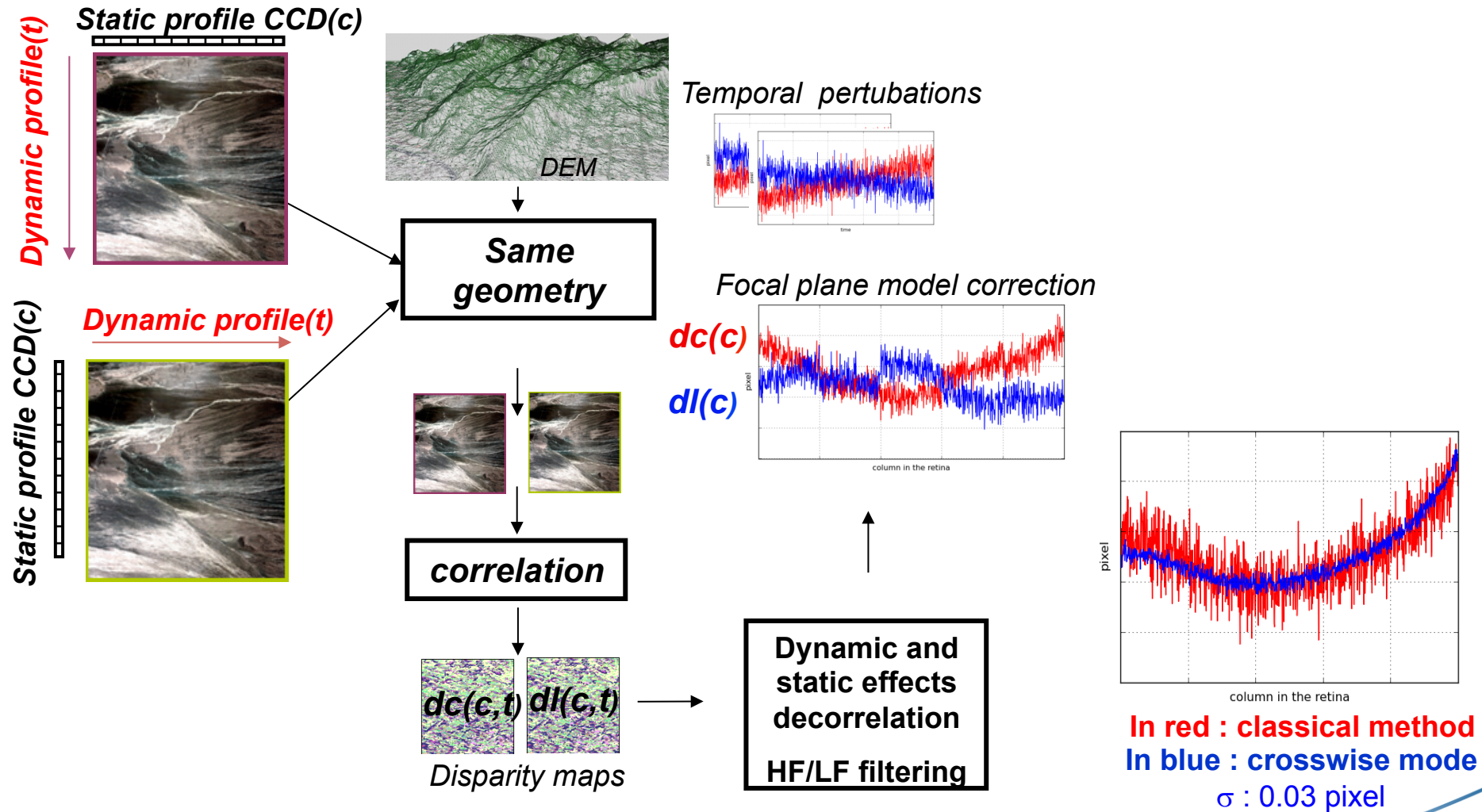
Geometric model enhancement: arrays alignments, tilts, magnification, ...

CROSSWISE MODE FOR FOCAL PLANE CARTOGRAPHY

Use of images taken in a crosswise mode (LOS orientation variation = 90°) to separate dynamic and static phenomenon which are specific to the push-broom acquisition principle



CROSSWISE MODE FOR FOCAL PLANE CARTOGRAPHY

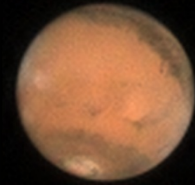
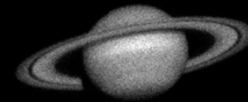


THE OPPORTUNITY TO VIEW OTHER ORBITING OBJECTS...

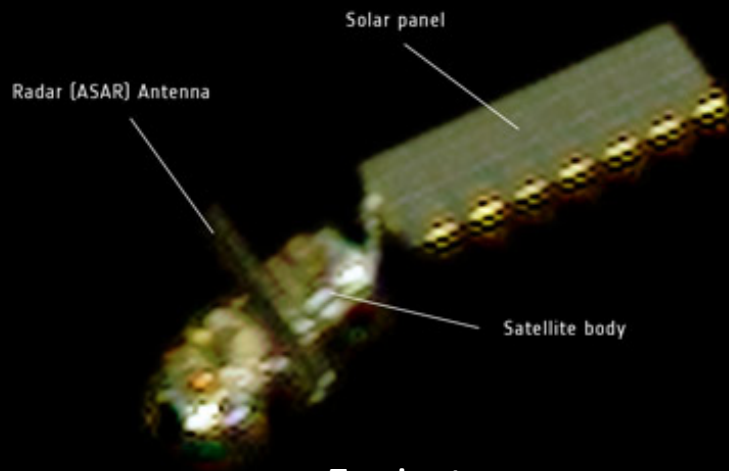


Jupiter

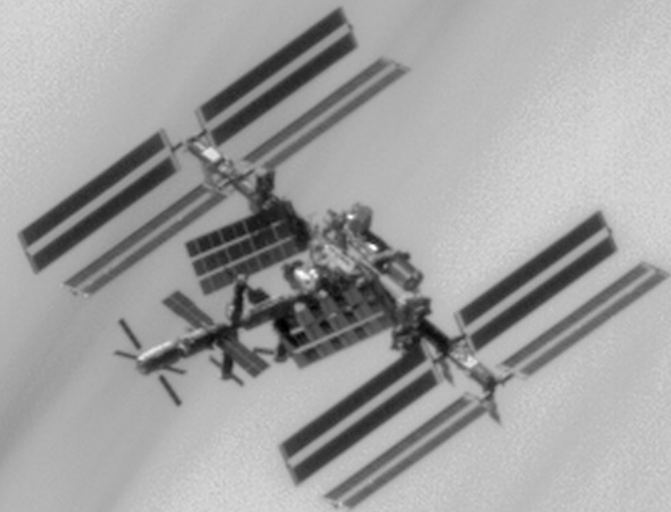
Saturne



Mars



Envisat



ISS and ATV

MAIN PERFORMANCE

Excellent performance for both satellites

- All requirements are fulfilled with a comfortable margin after 2.5 years in flight for PHR-1A and 1.5 year for PHR-1B
- Very similar performance between 1A and 1B (coherent constellation)

Image Quality criteria		Performance
Location CE90 (with accurate attitude and for depointing < 30°)	All bands	6.5 m
PAN/XS registration in XS pixels (90%)	PA/XS	0.20
XS/XS registration in XS pixels (90%)	XS	0.18
Planimetry in PAN pixels (90%)	All bands	0.42
Altimetry for a stereo pair with a b/h of 0.15 (RMS)	PA	1 m
Absolute calibration accuracy	All bands	<5 %
Multi-temporal calibration accuracy	All bands	1%
Inter-Pleiades accuracy	All bands	2%
MTF @ Nyquist	PA	0.15
	XS (X axis)	0.31
	XS (Y axis)	0.26
SNR @ L2	PA	156
	B0/B1/B2	158
	B3	190



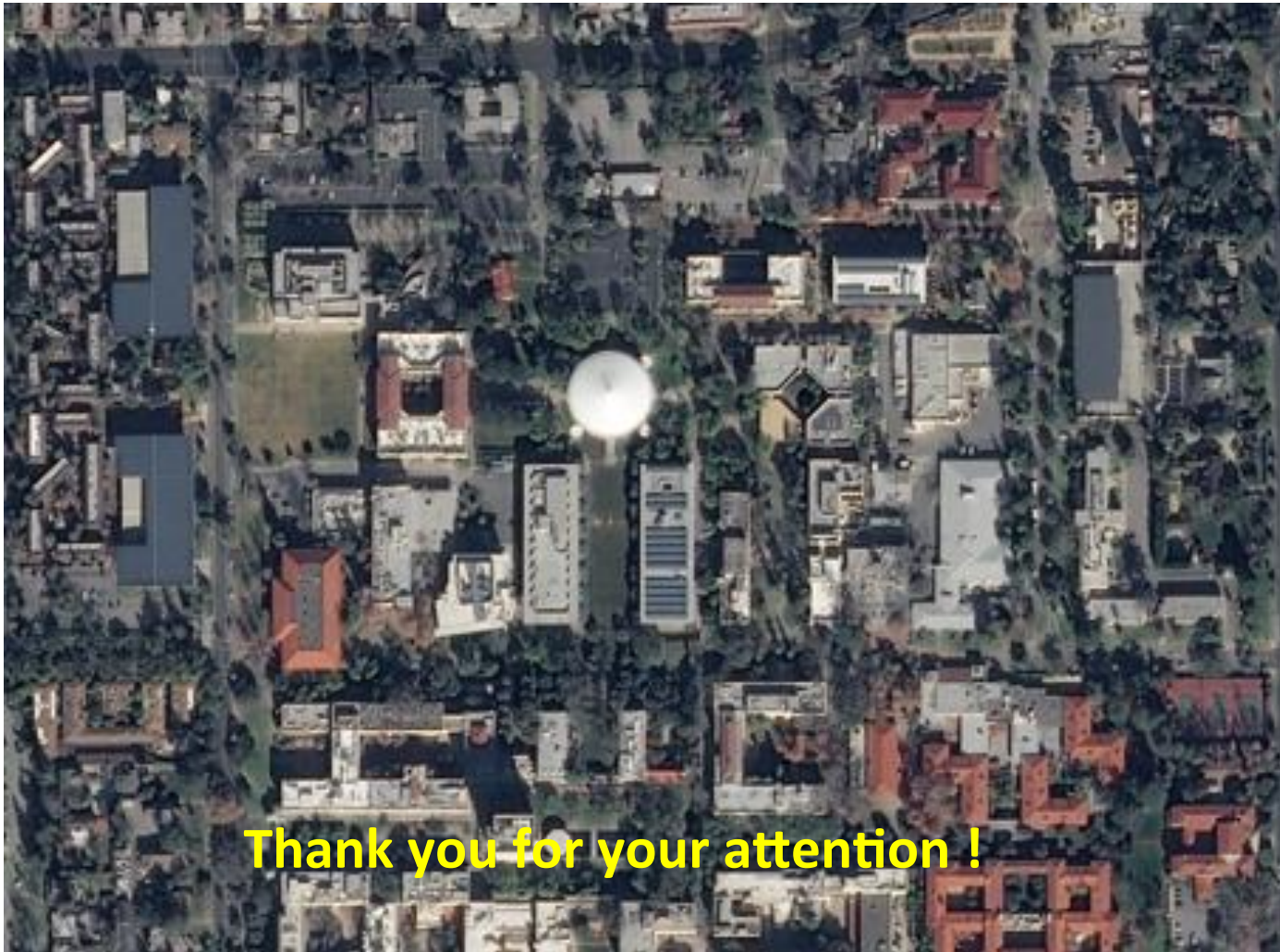




CALTECH SEEN BY PLEIADES



CALTECH SEEN BY PLEIADES



Thank you for your attention !