

# ALTIKA INSTRUMENT : IN-FLIGHT STABILITY AND PERFORMANCES



N. Steunou, P. Sengenès, J. Noubel, N. Picot, J.D. Desjonquères (CNES)

J.C. Poisson, P. Thibaut (CLS)

F. Robert, N. Taveneau (TAS-F)

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# ALTIKA : A NEW CONCEPT

- First Altimeter in Ka-band
- Saral, cooperation with ISRO, was launched on the February 25th, 2013
- Single frequency Ka-band altimeter with an enhanced bandwidth
- Includes a radiometer instrument
  - ◆ Dual-frequency radiometer ( 23.8 GHz +/- 200 MHz & 37 GHz +/- 500 MHz )
  - ◆ Embedded within the altimeter, shares the DPU and the antenna



# The Saral/AltiKa mission and altimeter characteristics

- The AltiKa altimeter :
  - ✓ is the **first in-flight altimeter in Ka-Band** → reduced ionosphere impacts → Mono frequency instrument
  - ✓ has a higher bandwidth → improved vertical resolution (~ 30 cm w.r.t. 47cm for J2) and thus error budget
  - ✓ operates at 4 KHz → improved spatial sampling
  - ✓ has a smaller footprint (5.7 km w.r.t. 9.6 km for J2) → improved coastal approach
  - ✓ has higher sensitivity to atmospheric water

	AltiKa	Jason-2 (Ku)
Frequency	35.75 GHz	13.575 GHz
Bandwidth	480 MHz	320 MHz
PRF	~4 KHz (variable)	2 KHz
Antenna Beam	0.6°	1.29°
WF rate	40 Hz	20 Hz

# In flight assessment phase : altimeter activities

## □ Calibrations

- ✓ In routine 3 calibrations per day (PTR and LPF)
- ✓ 20-March-2013 : Succession of PTR during 200 minutes
- ✓ 27-March-2013 : Expertise LPF (long acquisition)
- ✓ Several calibrations of the gain steps used in AGC loop

## □ Tracking modes

- ✓ All the tracking modes have been tested successfully
- ✓ Recommendation :

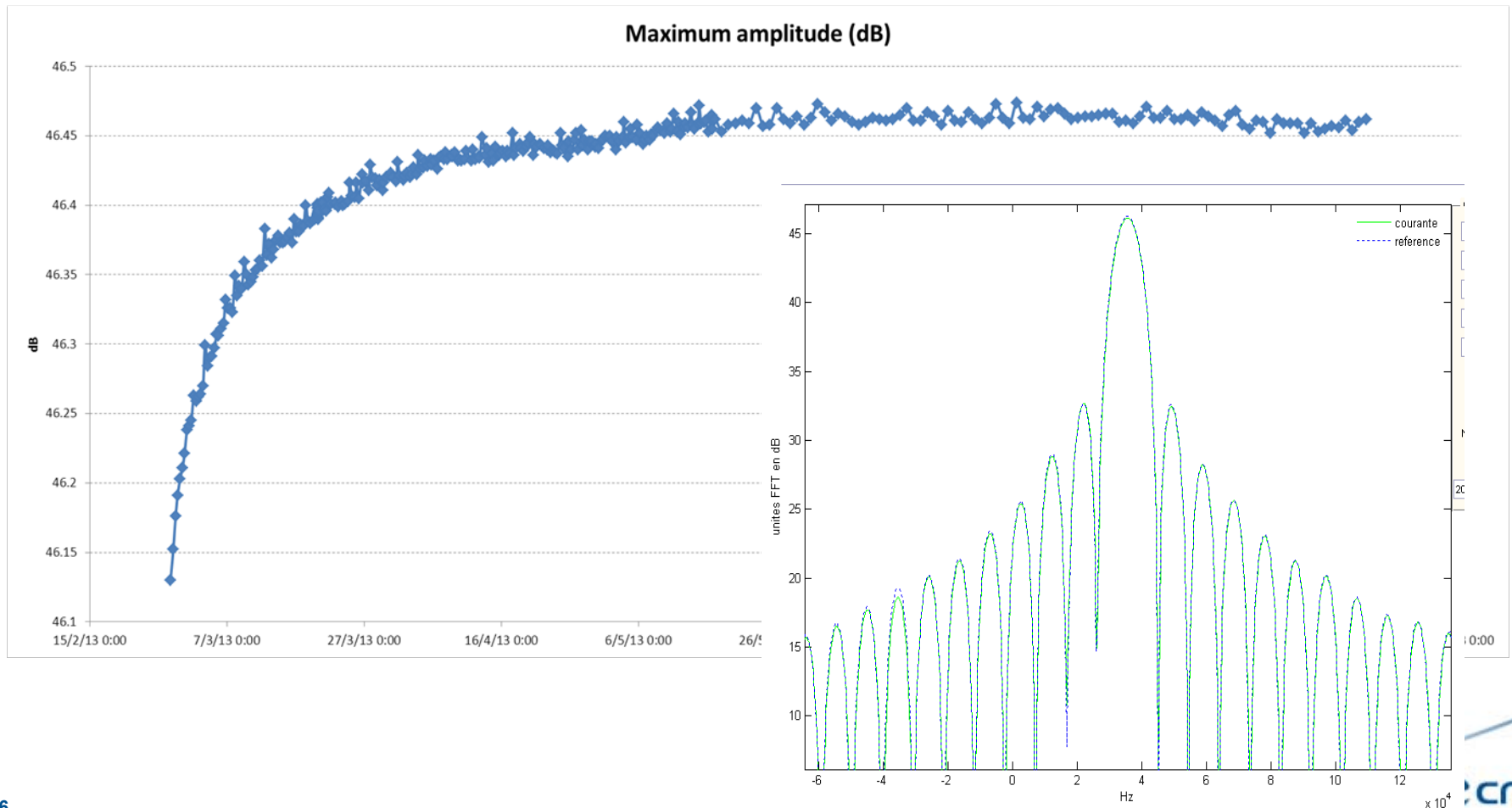
Operational mode = acquisition Diode with median tracker

## □ Cross maneuvers

# PTR analysis

Routine PTR : observed evolutions as expected

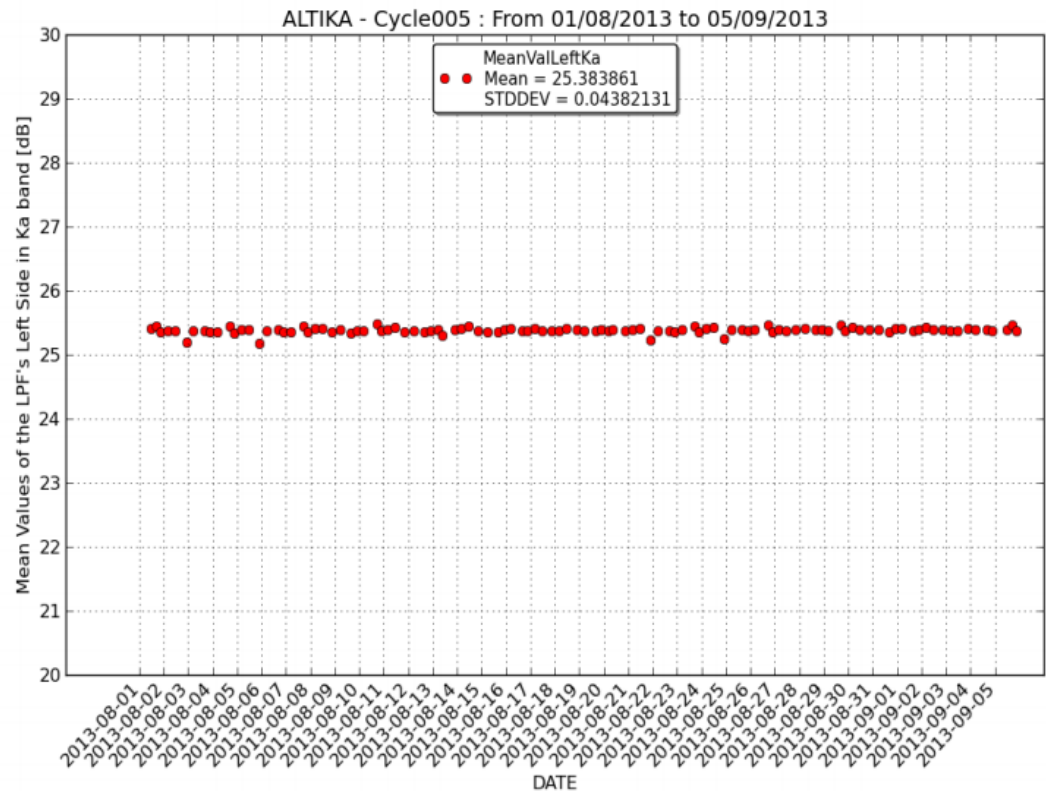
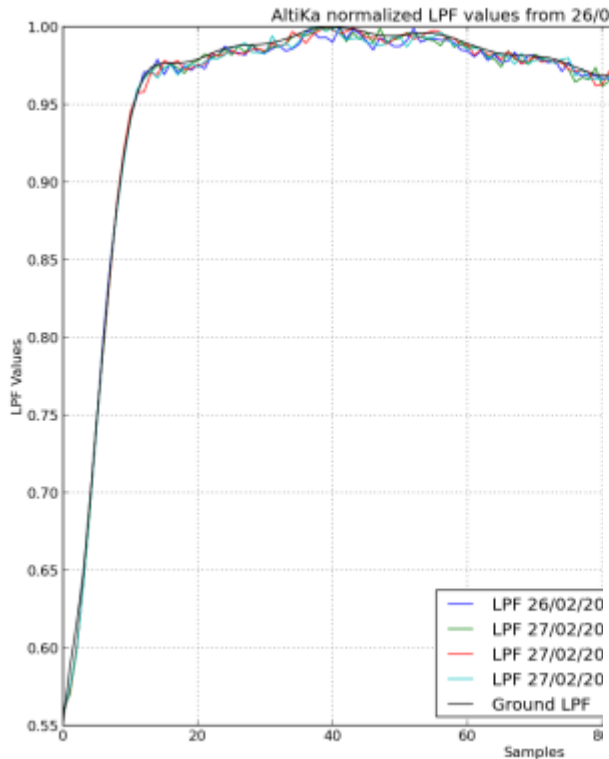
In the ground processing (P1) PTR parameters are averaged on 3 days basis to reduce the noise



# LPF analysis

Routine LPF : Very good stability since launch

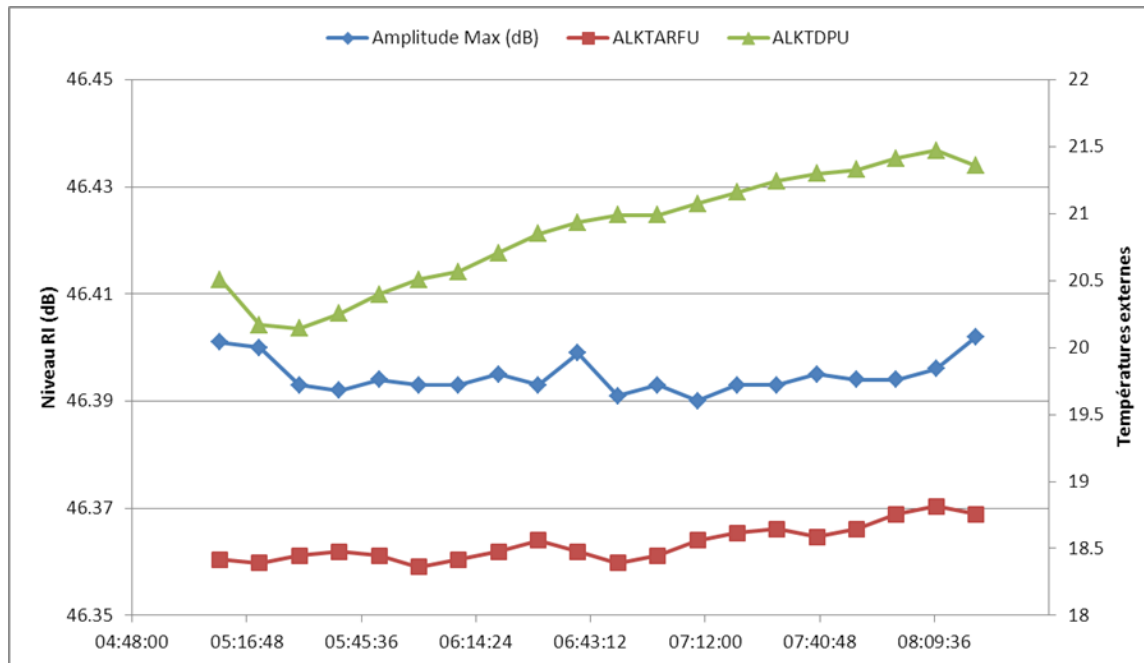
In the ground processing (P1) LPF parameters are averaged on 7 days basis to reduce the noise



# Expertise calibrations : 200 min PTR

Objective : to assess the altimeter stability within temperature range

Principle = 1 calibration every 10 minutes during 200 minutes



Legend :  
Amplitude of the PTR  
ARFU temperature  
DPU temperature

0.02 dB

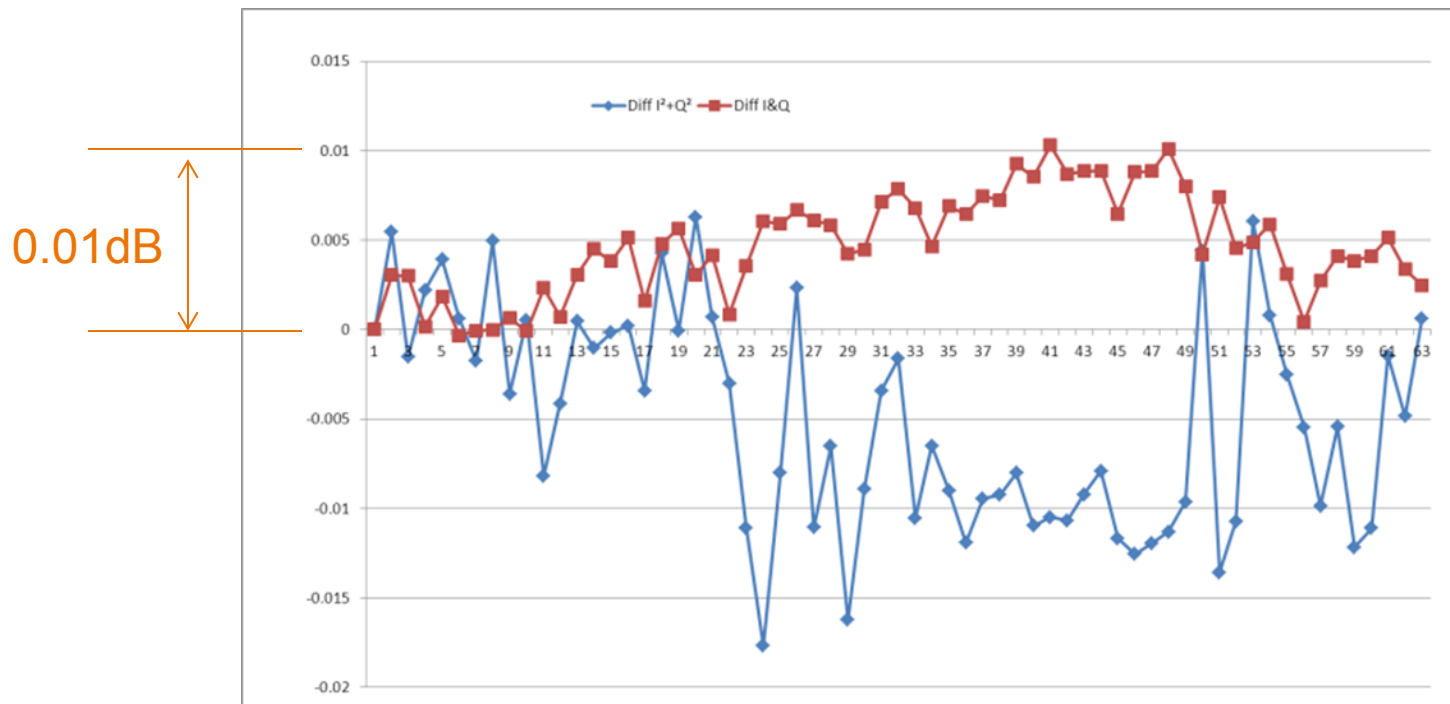
## Conclusion :

- Very good stability of the PTR characteristics



## Expertise calibrations : CNG

Objective : to estimate the 62 gain steps values (2 adjustable amplifiers on board)  
Used in the scaling factor for Sigma0 retrieval



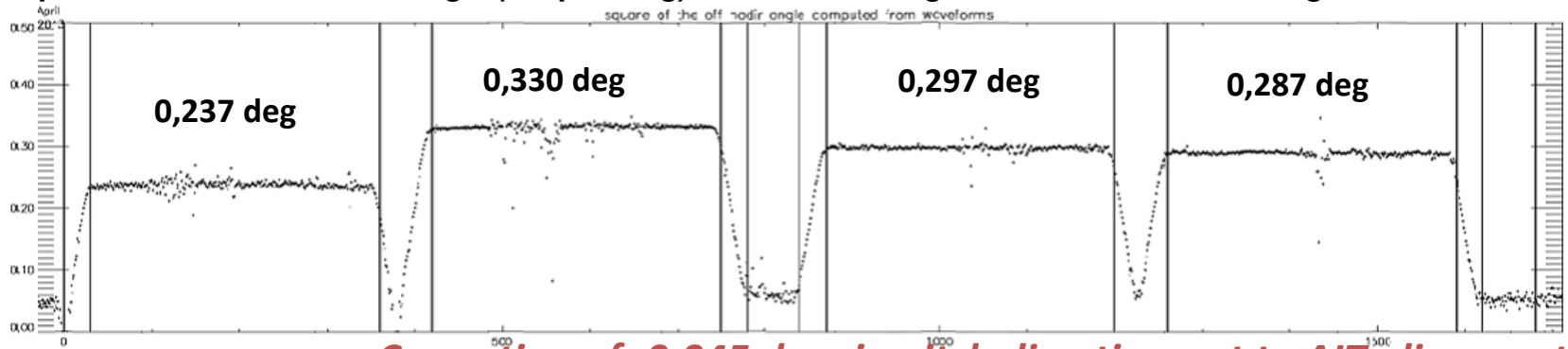
- Very good stability (of the order of 0.01 dB !!).
- Will be performed every 3 months in routine and the values will be updated in the altimeter characterization file

# NADIR POINTING OF ALTIKA RF BEAM : X-CROSS CALIBRATION MANEUVERS

3 X-cross calibration maneuvers have been performed

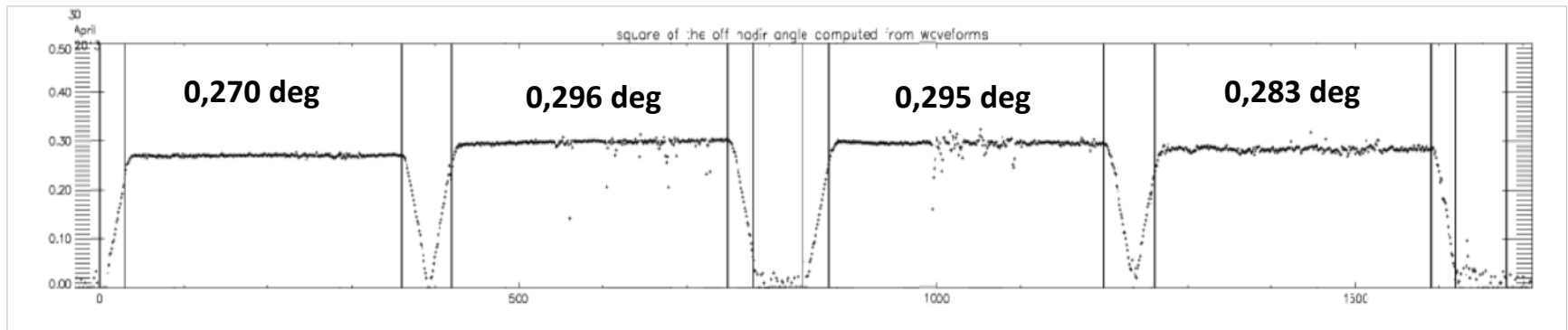
- ❑ 1<sup>st</sup> X-cross maneuver on April 19<sup>th</sup> : sequencer test over BIAK
- ❑ 2<sup>nd</sup> X-cross maneuver on April 22<sup>nd</sup> :  $-0,3^{\circ}/+0,3^{\circ}$  in pitch then  $-0,3^{\circ}/+0,3^{\circ}$  in roll

*Square root of the off-nadir angle (mispointing) estimated through AltiKa echoes retracking*



*=> Correction of  $-0.045$  deg. in pitch direction wrt to AIT alignments*

- ❑ 3<sup>rd</sup> X-cross maneuver on April 30<sup>th</sup> :



**Very good pointing accuracy achieved : estimated to be less than 0.02 deg !**

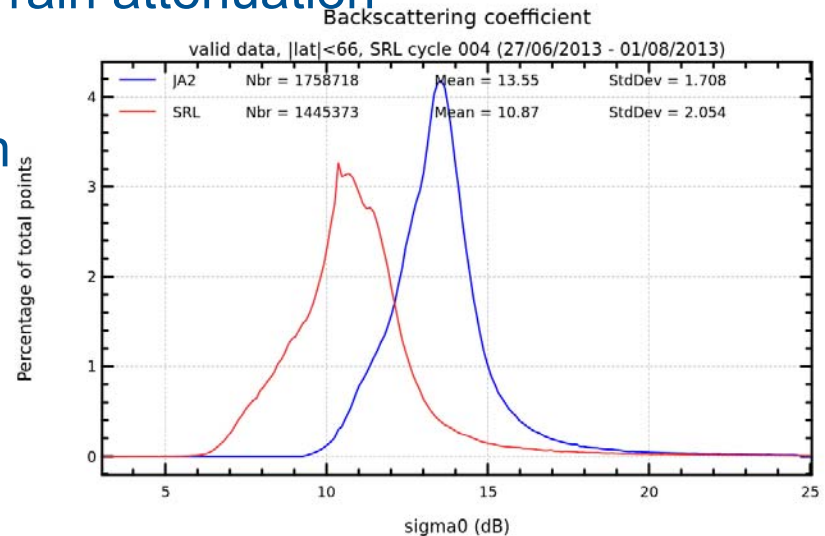
# SNR considerations

- Several studies have been made during AltiKa development to assess hypothesis on  $\sigma_0$  and atmospheric attenuations
  - $\sigma_0$  Ka =  $\sigma_0$  Ku [Topex] – 1,5 dB  $\approx$   $\sigma_0$  Ku [Jason] – 3,5 dB
- Some margins have been considered in link budget during development : system margin, ageing, mispointing and rain attenuation

- In flight assessment : better SNR than expected

- The 3,5 dB margins allocated to mispointing, system margin and ageing provide additional capacity to withstand higher rain rates than targeted

⇒ Thus, a few data are lost due to atmospheric attenuations



Measured AltiKa  $\sigma_0$  :

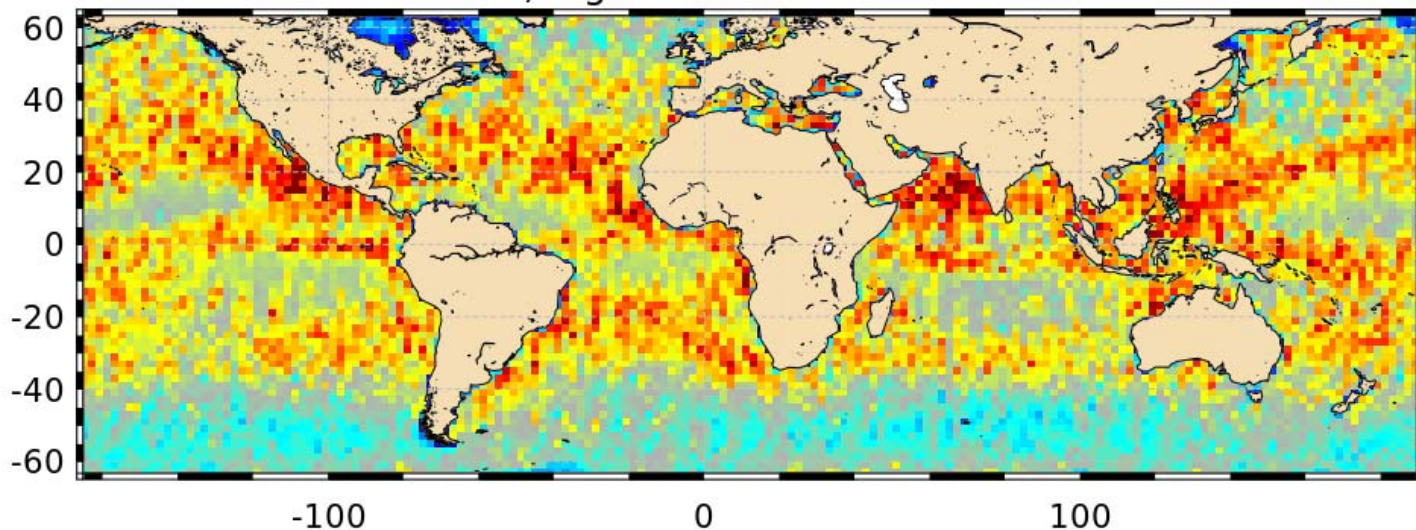
$\sigma_0$  Ka  $\approx$   $\sigma_0$  Ku [Jason] – 2,5 dB

⇒ i.e. 1 dB greater than  $\sigma_0$  hypothesis considered during development

# SNR considerations

AltiKa Cycles 2-2

Mean, Signal to Noise Ratio MLE-4



SNR\_MLE4

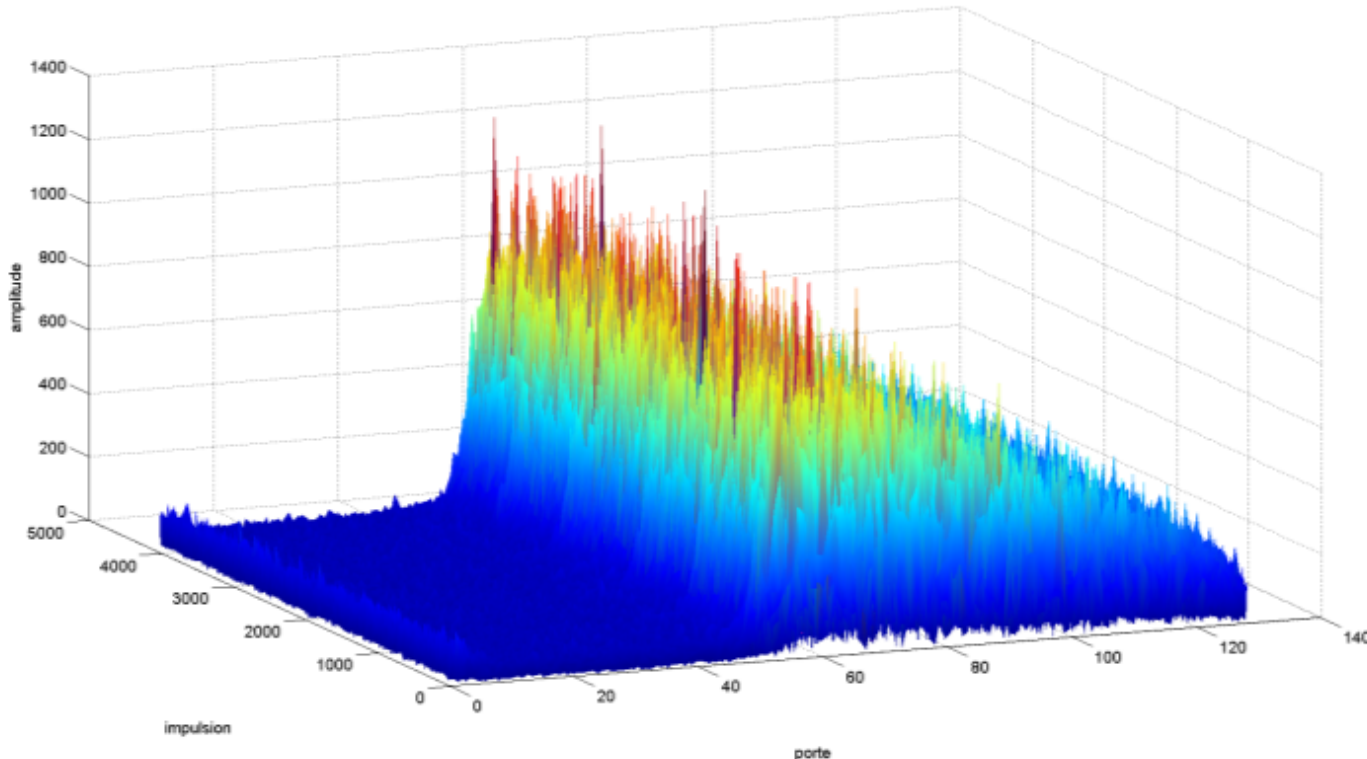


<i>Nbr :</i>	11880	<i>Std Dev :</i>	5.8847036	<i>Min :</i>	3.5505074
<i>Mean :</i>	20.51305	<i>Median :</i>	22.676992	<i>Max :</i>	32.288367

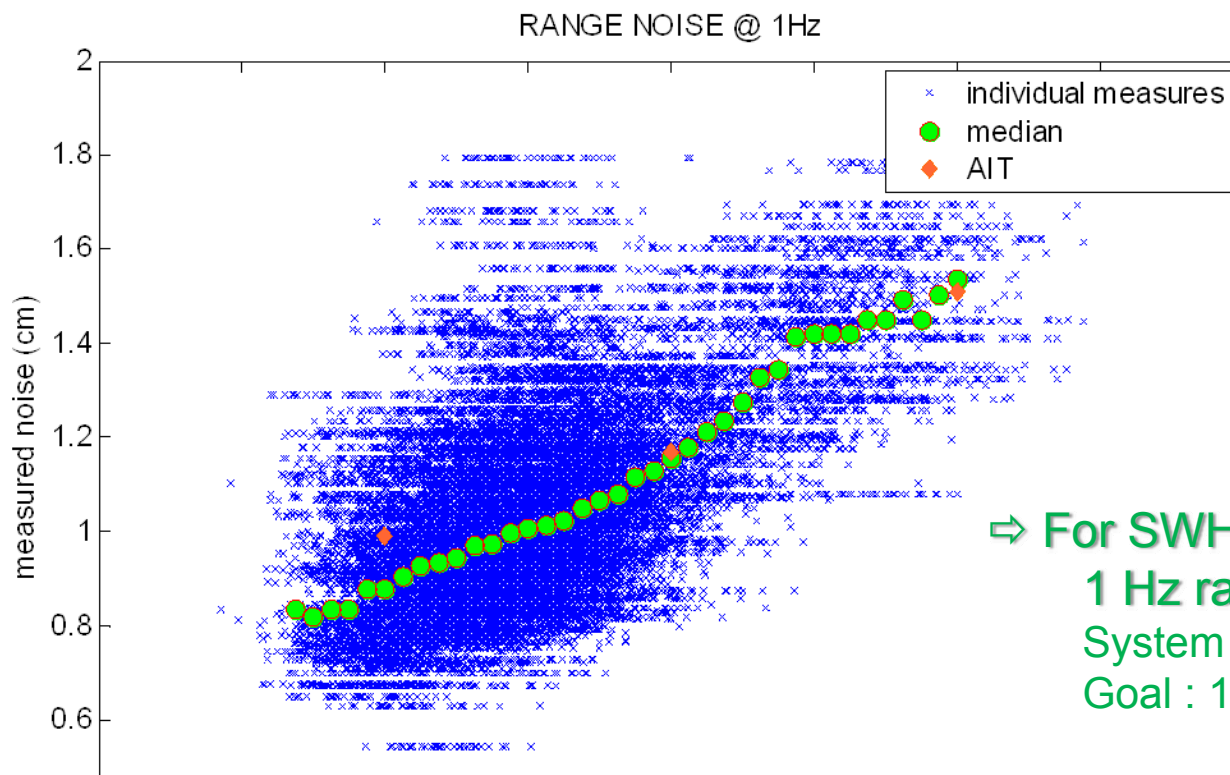
## High rate data (“HD mode”)

- Principle : to record data at the PRF rhythm – limited to about 1 second of data.
- Time tag precision : about 1 second (difference between the command and the actual waveforms dates)
- Have be performed again for expertise :
  - For correlation analysis in Ka-band (for different wave and wind conditions)
  - For analysis on transitions areas (coast, ice ...)

echos HD à la PRF



# Altimeter performances – range noise



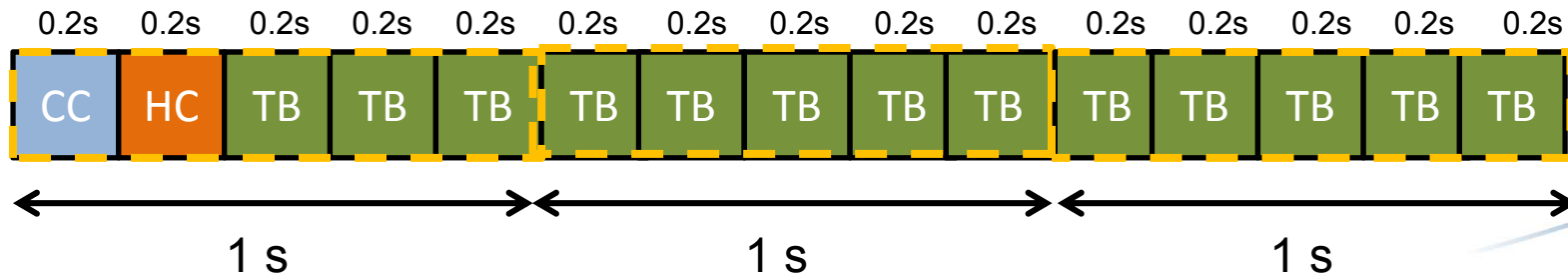
⇒ For SWH = 2 m  
 1 Hz range : 0,9 cm  
 System requirement : 1,5 cm  
 Goal : 1 cm

Altimeter parameter	Specifications	Measured on ground	In flight data
1 Hz range	1.5 cm	0.9 cm	0.9 cm
1Hz SWH	6.3 cm	5.7 cm	5 cm
1 Hz Sigma0	0.2 dB*	N/A	0.012 dB

# RADIOMETER : MAIN FEATURES

## Radiometer is embedded within the altimeter

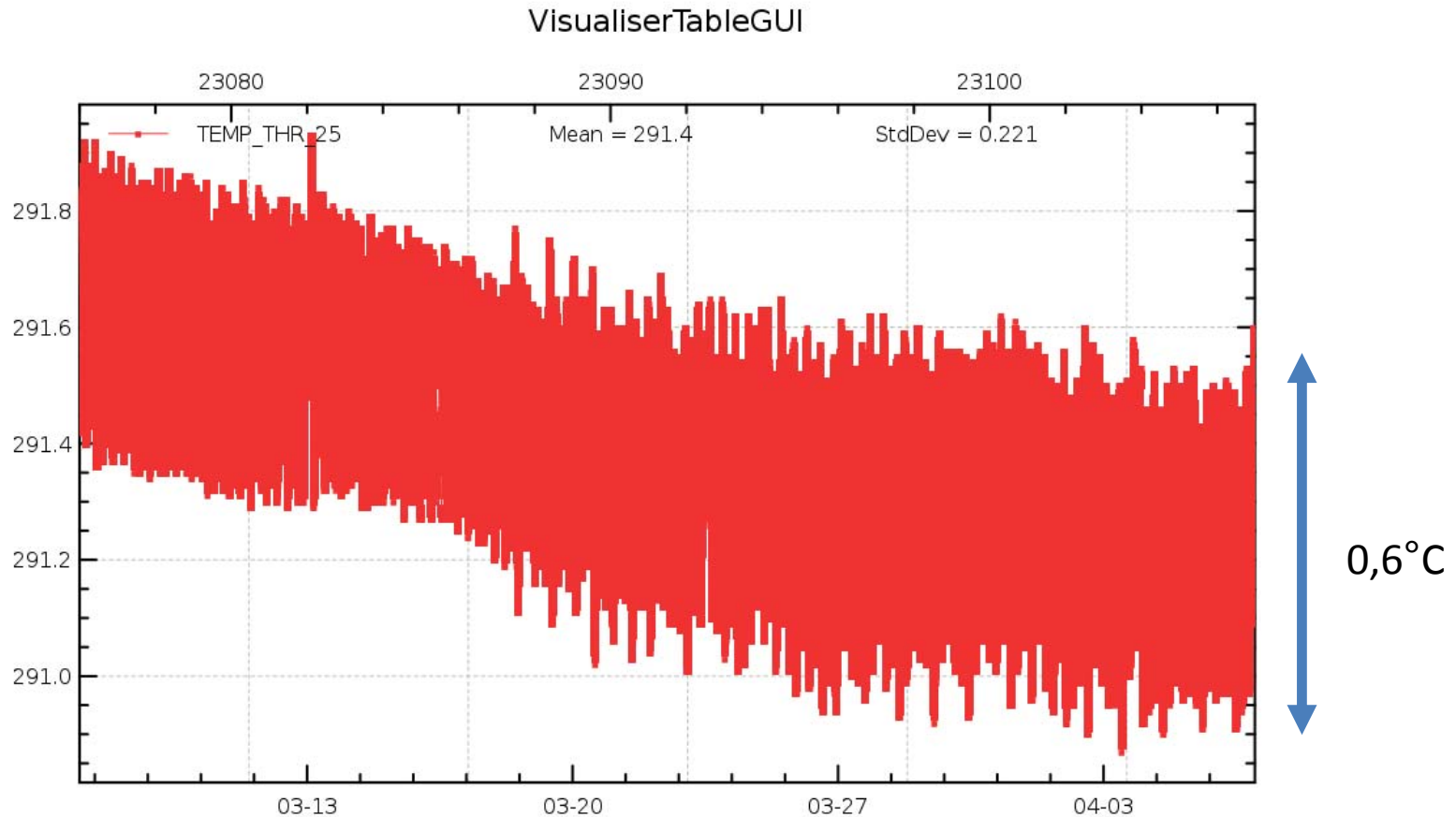
- ❑ Antenna and processing units are shared between altimeter and radiometer.
- ❑ Radiometer : dual frequency, in K (23,8 GHz) and Ka bands (37 GHz)
- ❑ Footprint size (half-power beam width) diameter : 8 kms in Ka band and 12 kms in Ku band.
- ❑ The radiometer is operational in all altimeter modes (except init mode)
- ❑ No particular operations in assessment phase, it has been working since Altika switch ON
  - ◆ 1 measurement every 200 ms
  - ◆ Calibrations are done continuously, every 3 sec
    - » 2 sources for calibration : 1 cold (sky horn) and 1 hot (internal load)



# THERMAL STABILITY

Very good thermal on-board stability

Example : hot load temperature (measured) over 1 month





# STABILITY AND PERFORMANCE ASSESSMENT

## Radiometer performances : sensitivity estimation on calibration counts

- $\Delta T \cong G_{mean} \times \Delta V$ , G : radiometer gain estimated through calibrations, expressed in V/K

Parameter	Flight data
Sensitivity on cold source in K band	0,072 K
Sensitivity on cold source in Ka band	0,101 K
Sensitivity on hot source in K band	0,125 K
Sensitivity on hot source in Ka band	0,139 K

- During ground assessment tests, sensitivity was estimated
  - ✓ Between 0,12 and 0,16 K in Ka band for TB between 125 and 300 K
  - ✓ Between 0,1 and 0,14 K in K band for TB between 125 and 300 K

## Conclusion

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- AltiKa has a very good behavior
- Instrument stability and performances are very good and fully compliant with the system requirements
- Each mode has been tested successfully during assessment phase
- No functioning anomaly detected.
- Dedicated calibrations demonstrated a very stable behavior on orbit
- A very few data are lost by loss of tracking due to atmospheric attenuation