

# GAMBLE FINAL MEETING

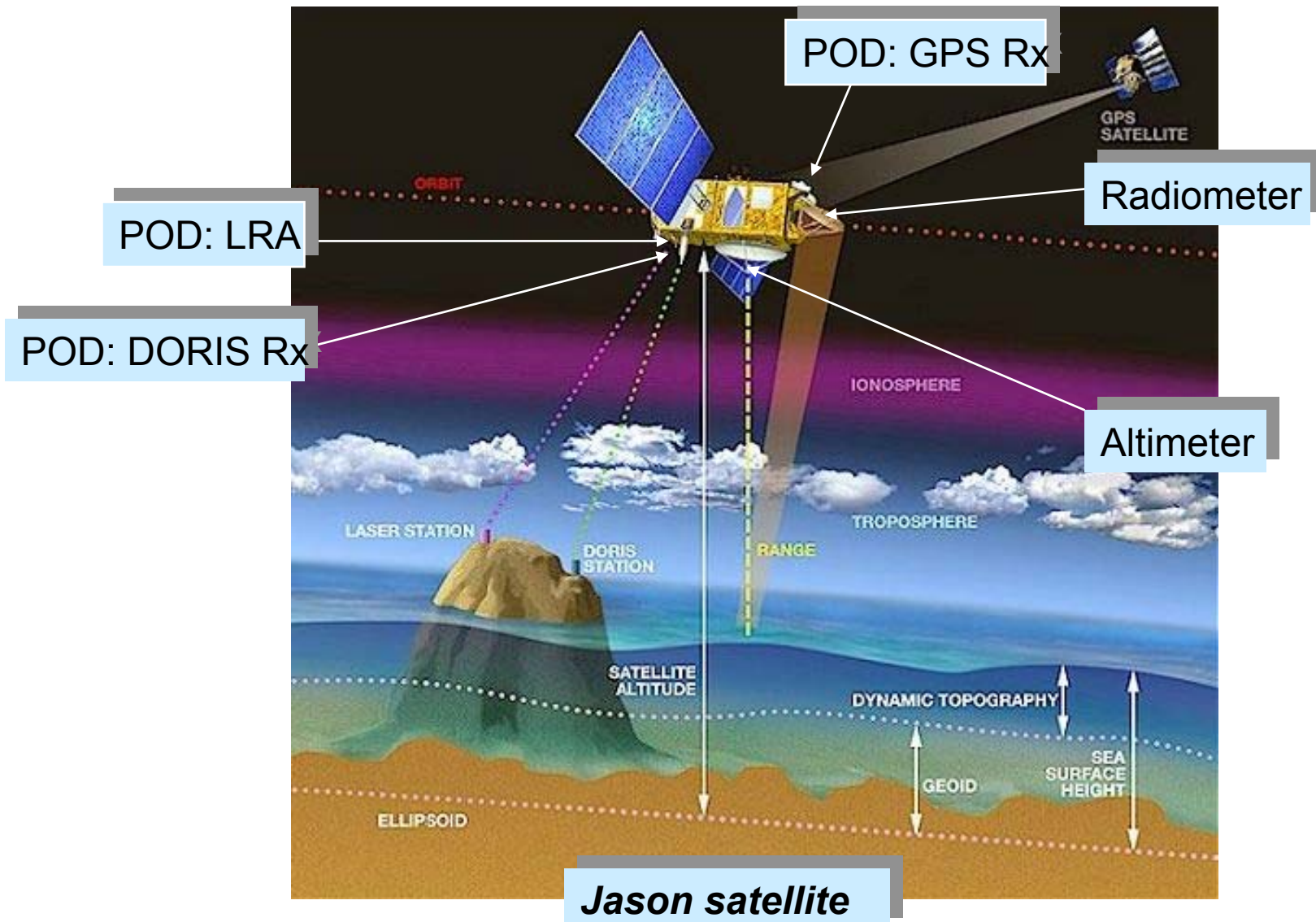
## RADAR ALTIMETRY REVIEW AND STATE OF THE ART

*L. Phalippou, Alcatel Space*

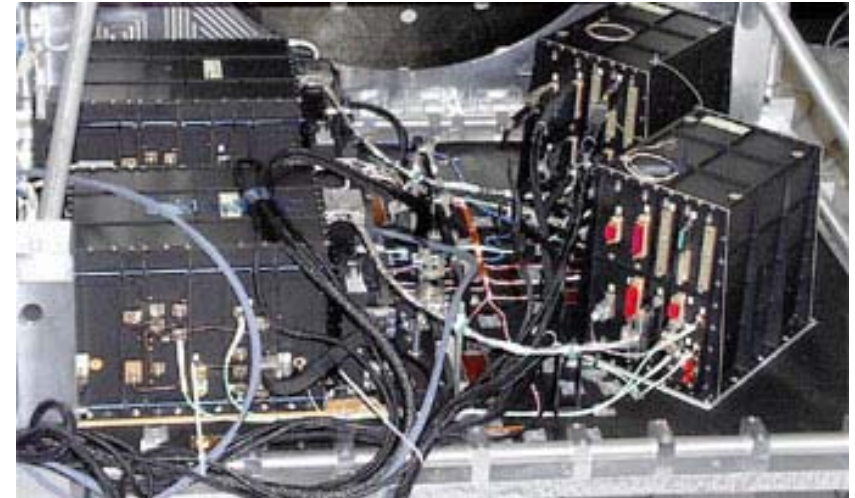
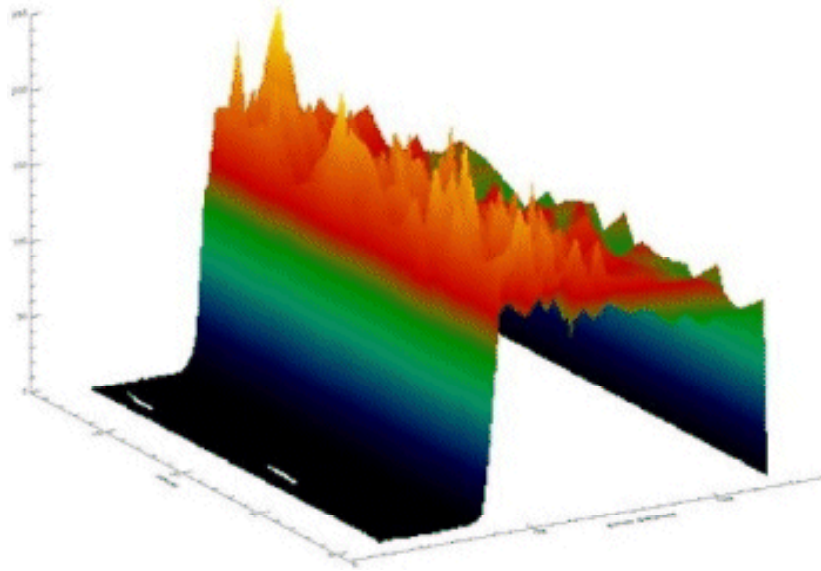
Arles, 17/11/03

- ◆ NADIR ALTIMETERS (conventional altimetry)
- ◆ NADIR SAR INTERFEROMETRIC RADAR ALTIMETER:  
SIRAL/CRYOSAT
- ◆ IMAGING ALTIMETER (e.g. WSOA)
- ◆ WAVE SPECTRA MEASUREMENTS (SWIMSAT)

# OCEAN ALTIMETRY PAYLOAD



## NADIR ALTIMETRY MEASUREMENTS

***First echoes from Poseidon 2 on Jason***

*The echo shape (waveform) contains the geophysical signals*

*Return time of the leading edge :*

*Sea Surface Height*

*Slope of the leading edge :*

*Significant Wave Height*

*Maximum of echo power :*

*Surface Wind Speed ( $\sigma_0$ )*

## NADIR ALTIMETERS FEATURES

	Poseidon 2 / 3	RA-2	GeoSat-FO	Alti-Ka ( with radiometer)
Mission	Jason-1	Envisat	GFO	Alti-Ka <sup>3</sup>
Altitude (km)	1330	800	800	Up to 800 km
Frequency (GHz)	13.6 (Ku) / 5.3 (C)	13.6 (Ku) / 3.2 (S)	13.5 (Ku)	35.75 (Ka)
Tx Bandwidth (MHz)	320 / 100-320	320-80/160	320	480
Pulse width	105.6 $\mu$ s	20 $\mu$ s	102.4 $\mu$ s	105.6 $\mu$ s
PRF (kHz)	1.8/0.3-0.45	1.8/0.45	1 (Geosat)	4
Best Vertical Resol. (cm)	46	46	46	30
Pulse Limited	Yes	Yes	Yes	Yes
Tx power (W)	7 / 19 (SSPA)	60 (TWT) / 63 (SSPA)	7 (SSPA)	2 (SSPA)
Range noise over ocean	2.2 cm (C+ Ku) SMH= 2m Rate= 1Hz	< 4.5 cm	$\leq$ 3.5 cm SMH= 2m Rate= 1Hz	0.8 cm SMH= 2m Rate= 1 Hz
Power consumption (W)	69	161	71	76 (including radiometer)
Total Mass (kg)	58 with redundancy	110 with redundancy	28 partial redundancy	33 (including radiometer)
Data rate	20 kb/s	100 kb/s	?	21 kb/s

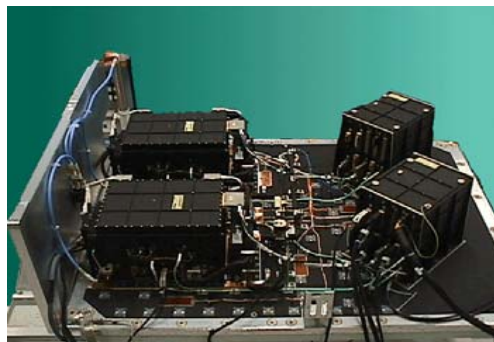
# NADIR ALTIMETER PRODUCT LINE



**Poséidon 1 Ku**

3.5 cm

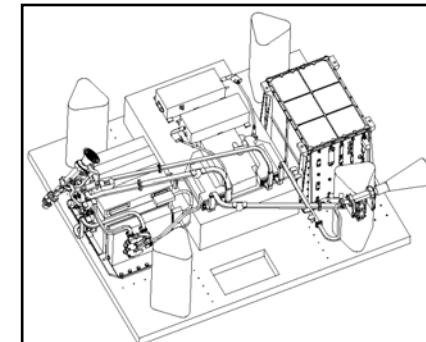
25 kg, 50 W, 14 kb/s



**Poséidon 2-3 Ku+C**

2 cm

58 kg, 69 W, 22 kb/s  
Redunded

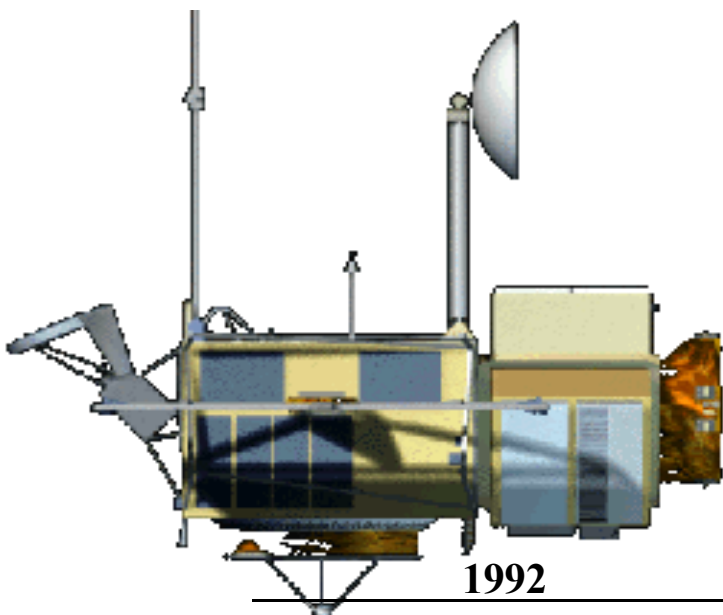


**Alti-Ka + radiometer**

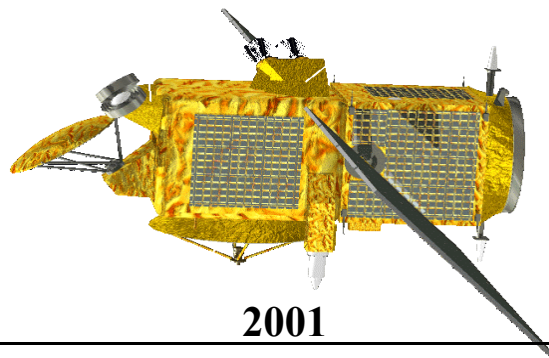
0.8 cm

33 kg, 76 W, 20 kb/s

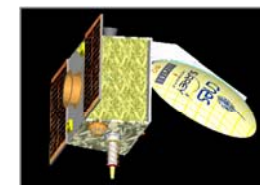
TOPEX/POSEIDON (2500 kg), JASON-1 (500 kg) and AltiKa  $\mu$ sat (125 kg) shown at the same scale



1992



2001



200x

## ◆ PRO's

- 3 Products : SSH, SWH, Ocean Surface Wind Speed
- Operational status (S, C, Ku band)
  - Physics of the measurement is well understood
  - Performances are demonstrated
  - Ground processing (algorithms) are operational
  - Maturity of the technology is very good
- Short development plan (C/D phase) from 20 months (recurrent altimeter) to ~ 32 months

## ◆ CON's

- Measurements are limited to nadir: a constellation is necessary to improve the ocean coverage

◆ Priority (GODAE ...): Continuity of service of Jason/Envisat

◆ Jason 2

□ Provides mission continuity with Jason 1

□ Payload

→ Poseidon 3 (funct. & perf. =Poseidon 2)

→ DORIS/Diode

→ LRA

→ Advanced Microwave Radiometer

→ Passenger : Wide Swath Ocean Altimeter

□ B/C/D phase for Jason 2/Poseidon 3 (start early 2004)

□ Launch: end 2007 (tbc)

□ Opportunity for a recurring Satellite/Poseidon 3 (Jason 2B)



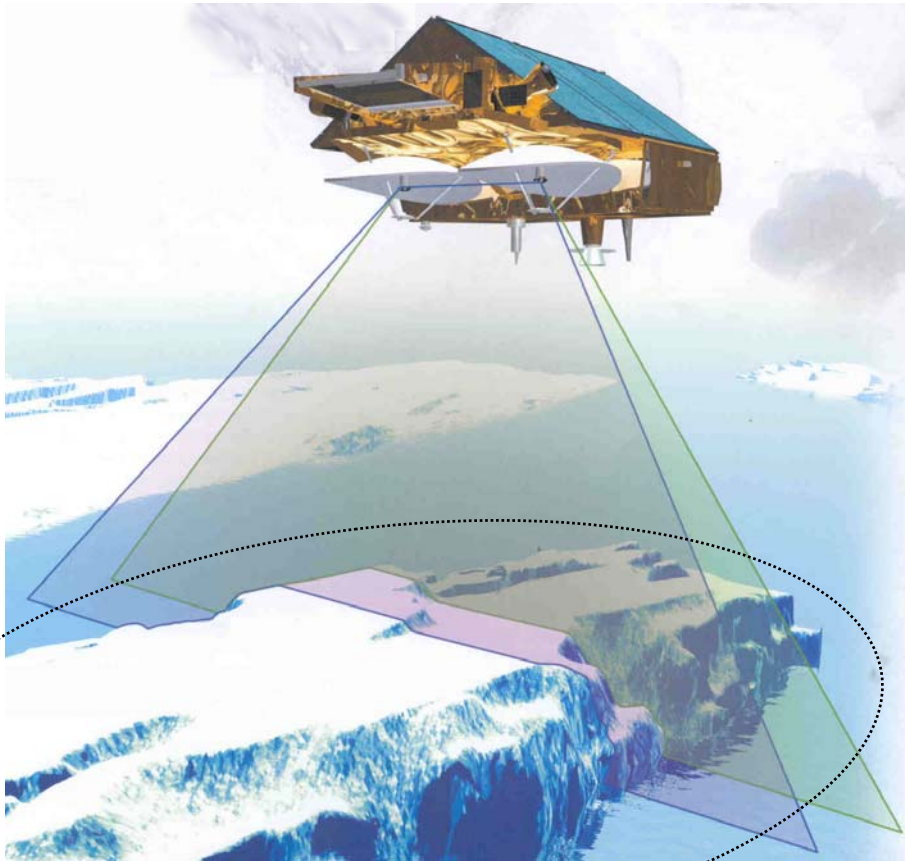
## ◆ PRIMARY SCIENTIFIC OBJECTIVES

- Trends in perennial arctic sea ice thickness (**1.6 cm/yr**) and mass
- Determination of regional and total contributions of Antarctica (**0.17 cm/yr**) and Greenland ice sheets to sea level rise

## ◆ MISSION

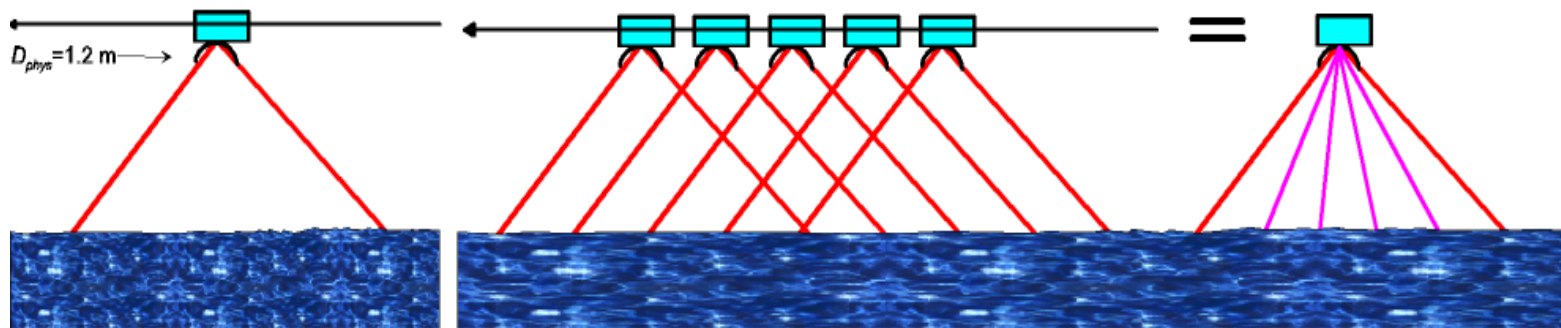
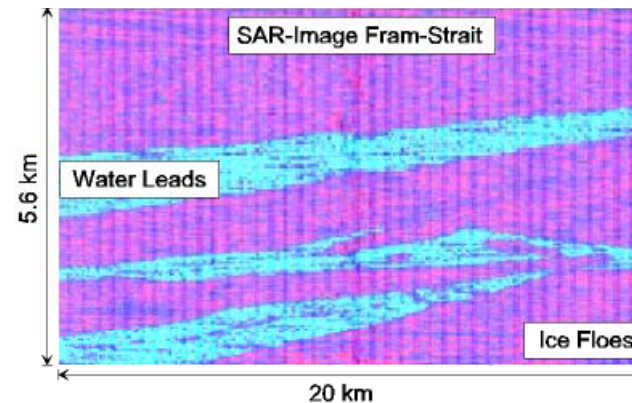
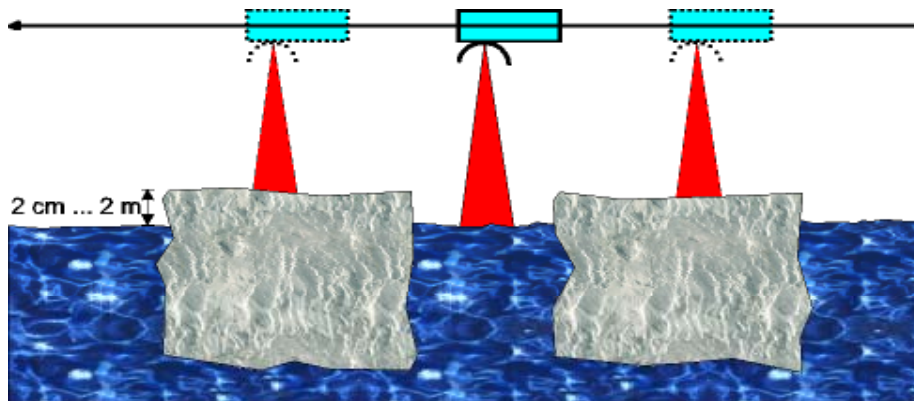
- 3 years ESA mission to be launched in 2004
- Orbit 717 km at 92 degree inclination (non SSO)
- Astrium is satellite prime
- Alcatel is prime for the SIRAL radar altimeter
- Payload :
  - SIRAL
  - Star trackers
  - DORIS receiver
  - Laser reflector

**SIRAL**, **S**ar **I**nterferometric **R**Adar **A**ltimeter, is the main instrument of the CRYOSAT mission



- *Ku band Radar (13.5 GHz)*
- *Chirp radar (coherent)*
- *320 MHz bandwidth*
- *25 W SSPA RF Tx Power*
- *Unfocussed SAR Mode*
- *SAR Interferometric Mode*

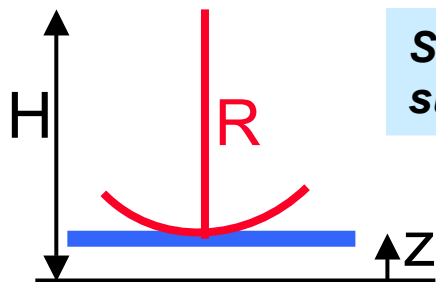
## SEA ICE : SIRAL SAR MODE



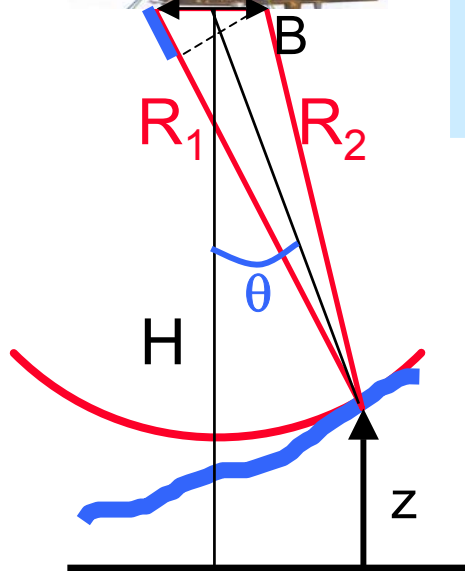
Spatial Resolution  
before unfocused SAR  
processing ~ 16 km

After unfocused SAR  
processing, along-track  
spatial resolution ~ 250 m

# ICE SHEET SLOPES : SARIn MODE



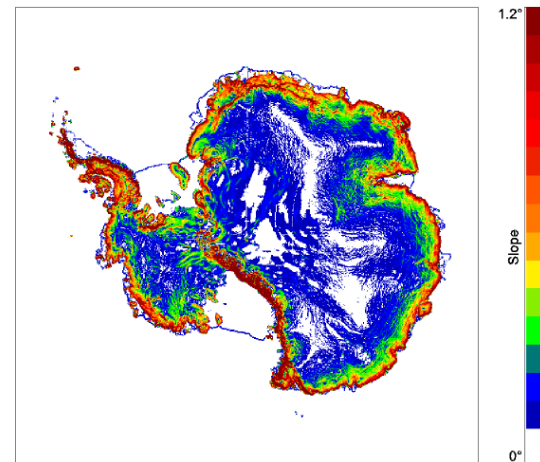
**Surface Slope=0 : range measurement is sufficient to determine surface elevation**



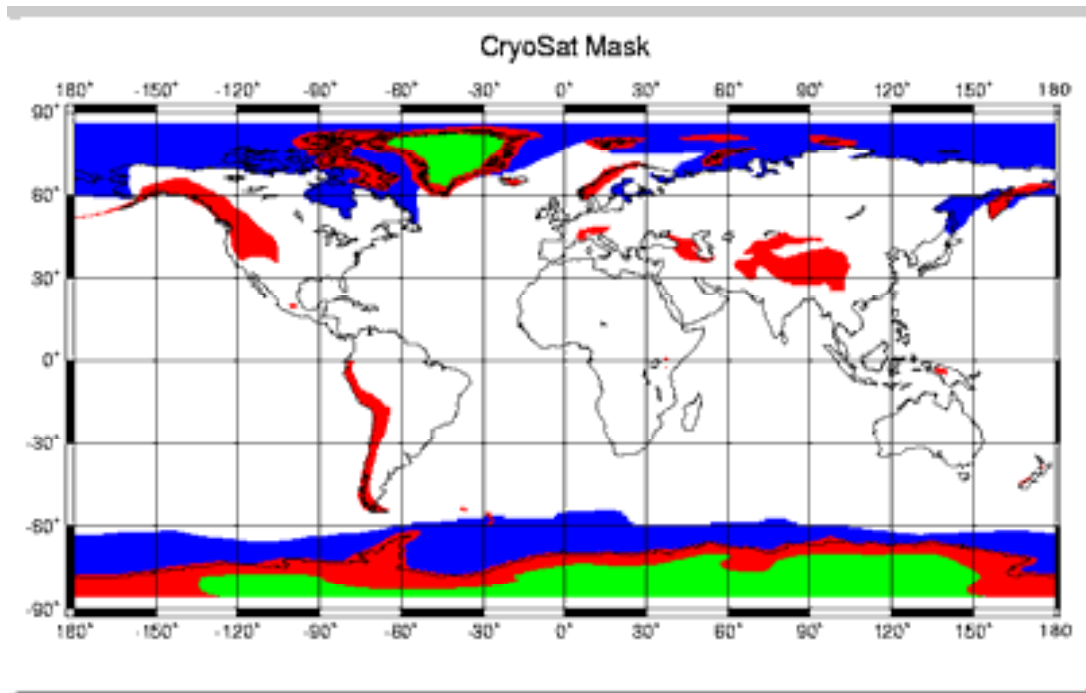
**For sloppy surface SAR / interferometry mode is required to locate the point of first return on the surface.**

$$\phi = \frac{2\pi(R_2 - R_1)}{\lambda} \approx \frac{2\pi B \sin \theta}{\lambda} \approx \frac{2\pi B}{\lambda} \theta$$

$$z = H - R \cos \theta$$



*Antarctica slope model*



*Operation of SIRAL LRM over ocean is under discussion at ESA level*

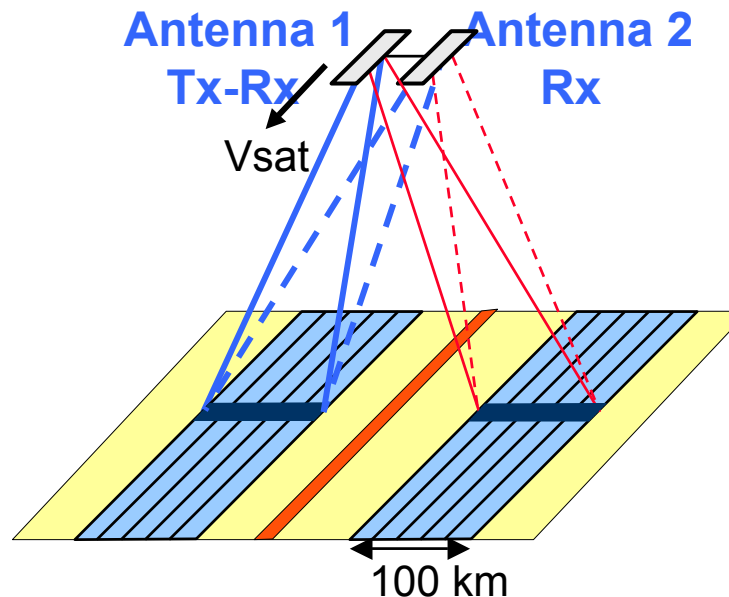
### SCIENCE MODES:

- Low Resolution Mode
- SAR mode
- SARIN mode

### CALIBRATION MODES

- Range Impulse Response
- Transfer function
- Attitude of Interferometric Baseline ( internal and external calibrations )

- ◆ Solutions for improving spatial sampling and coverage
  - Constellations: T/P-ERS, Jason-Envisat, Alti-Ka<sup>3</sup>, WITTEX
  - Imaging altimeters: Interferometric SLAR or SAR
    - Provides SSH only (tbc)
    - First implementation will be WSOA (JPL) on Jason 2
    - Concept alternatives to WSOA are under study by Alcatel (ESA contract)



## ◆ PRO's

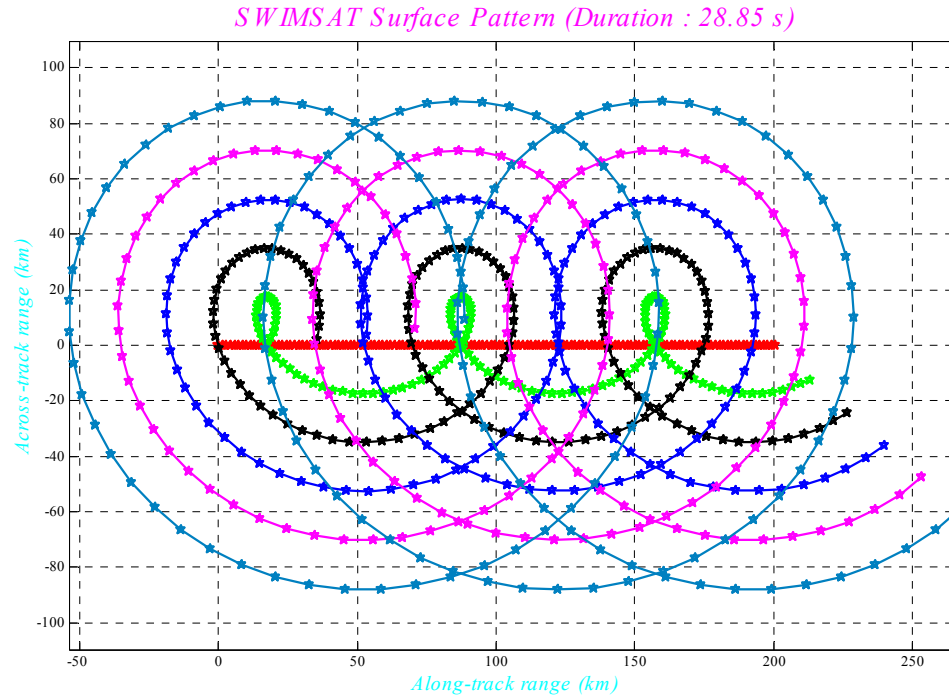
- Improved coverage (typically  $\sim 2 \times 100$  km swath)

## ◆ Technical Difficulties

- size of antennas sub-system
- complex design and critical technology (e.g. antenna)
- calibration of the baseline (length and orientation) : external calibration requires complex ground processing
- trade off between large data rate ( $\sim 30$  Msamples/s) and heavy on board processing
- complex error budget
- best suited on a platform without yaw steering

## ◆ SWIMSAT MISSION

- ❑ Surface Wave Investigation and Monitoring from SATellite
- ❑ Sciences Main Objectives : see D. Hauser presentation
- ❑ Platform : mini-satellite
- ❑ Sun synchronous orbit
- ❑ Mission duration : 3 years
- ❑ Global ocean coverage
- ❑ Payload : Ku-band radar ( 75 kg, 190 W )
- ❑ Ground segment : X band receiving stations



$$\underbrace{P_m(k, \phi)}_{\text{RCS modulation spectrum}} = \frac{\sqrt{2\pi}}{L_y} \underbrace{\alpha^2(\theta)}_{\text{Scaling factor related to the slope pdf at incidence angle } \theta} \underbrace{k^2 F(k, \phi)}_{\text{Wave-slope spectrum}}$$

Footprint in azimuth direction      Scaling factor related to the slope pdf at incidence angle  $\theta$

- ★ Nadir
- ★ 2° Incidence
- ★ 4° Incidence
- ★ 6° Incidence
- ★ 8° Incidence
- ★ 10° Incidence

## ◆ Instrument Main Characteristics

- ❑ Preliminary definition of SWIMSAT completed (Alcatel study under CNES contract)
- ❑ An instrument Phase A is required.
- ❑ Radar Key points

<b>Radio-Frequency Part</b>	
Frequency	13.575 GHz
Peak power	120 W
Bandwidth	200 to 320 MHz depending on incidence
Pulse duration	50 $\mu$ s
PRF	2 to 6.5 kHz depending on incidence
<b>Antenna (nadir antenna)</b>	
Design	40 cm passive parabole
3 dB Beamwidth	4 °
<b>Antenna (offset beams)</b>	
Design	80 cm passive offset parabole, with 5 rotating feeding horns
Incidence	2, 4, 6, 8, and 10°
3 dB Beamwidth	2 °
Rotation	6 rotations/minute