# INVESTIGATION OF SWH BIAS IN SAR ALTIMETRY MODE

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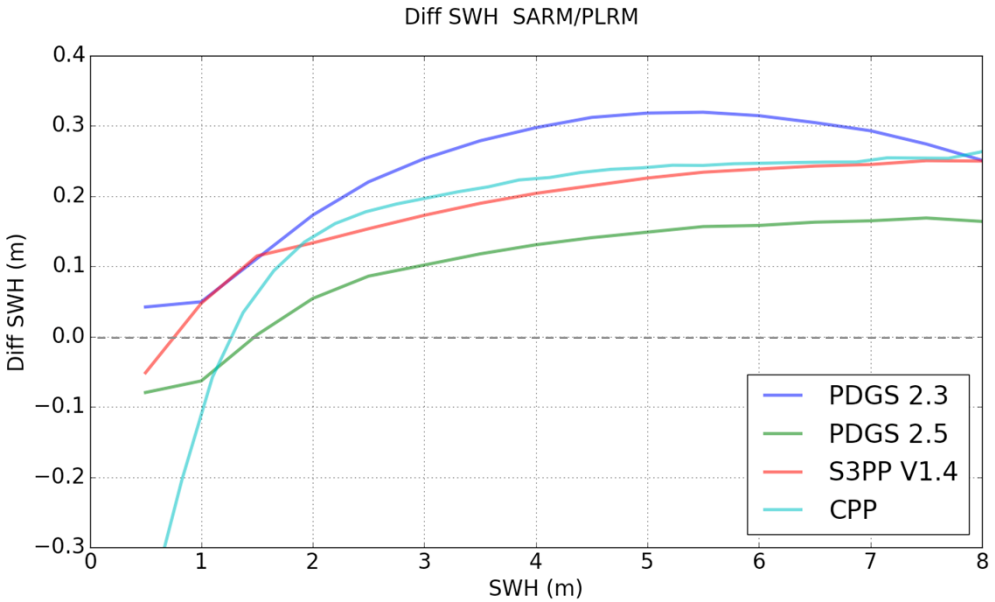
# CONTEXT

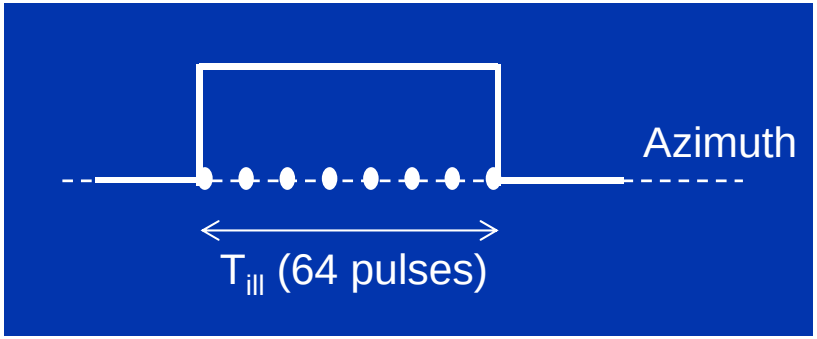
## Objective of this CNES/ESA/CLS study:

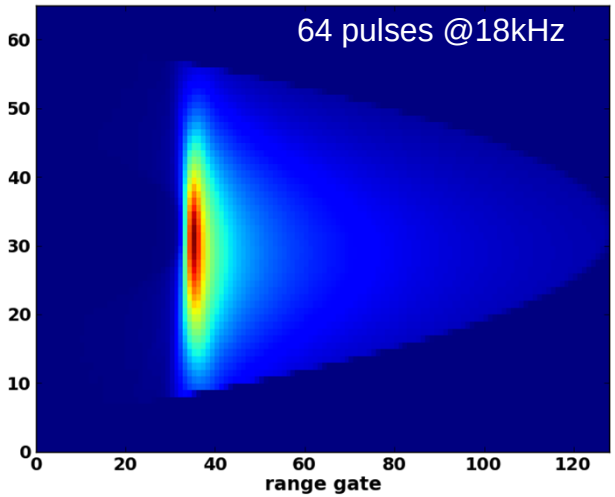
- To understand the >10cm discrepancy between LRM and SAR mode
- To mitigate it for improving quality of the data continuity LRM-SARM (for the follow-on S-3 and S-6 missions)




*[see M.Raynal et al., poster CVL_016]*

# FINDINGS FROM PREVIOUS ANALYSES



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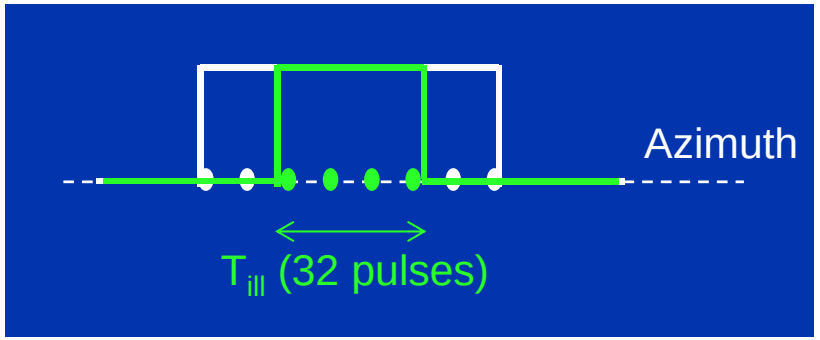
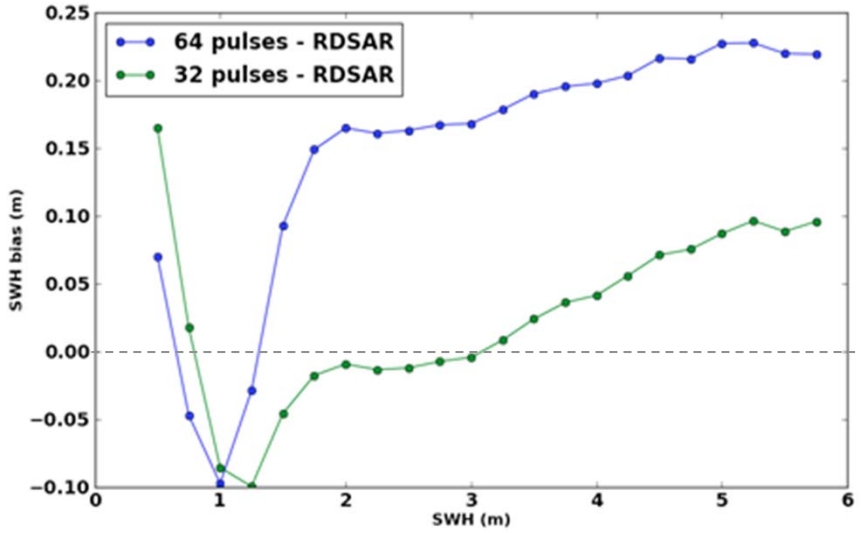
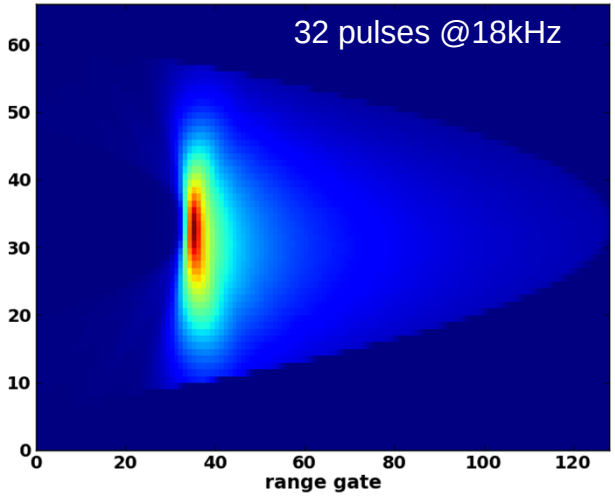
- Reducing the illumination time ($T_{ill}$)

➔ **Reduced SWH bias with LRM**



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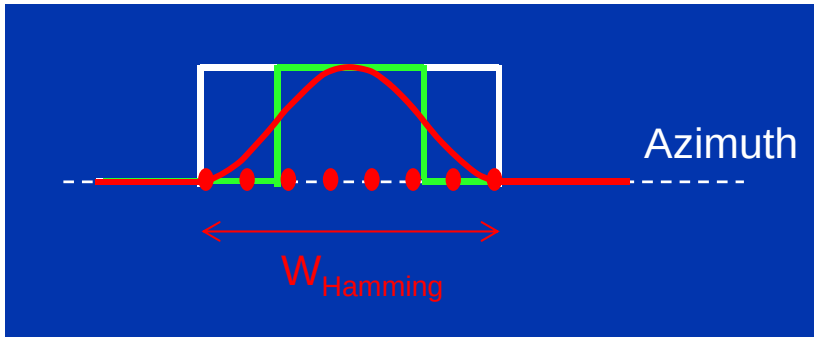


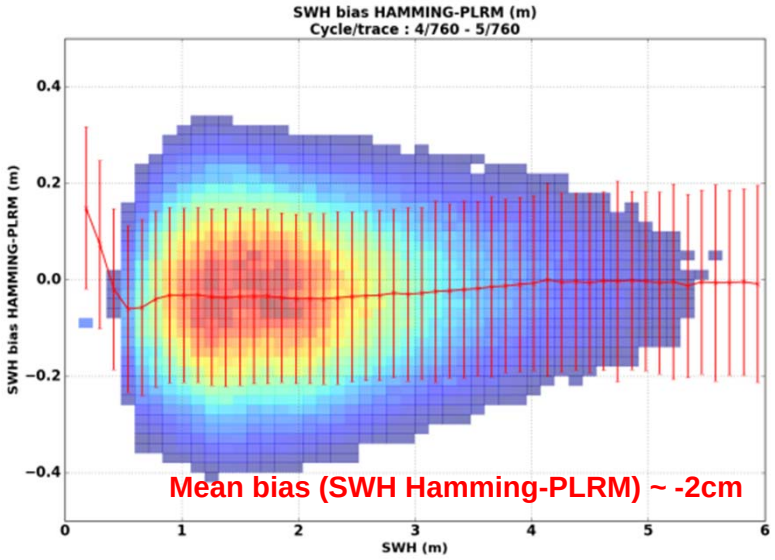


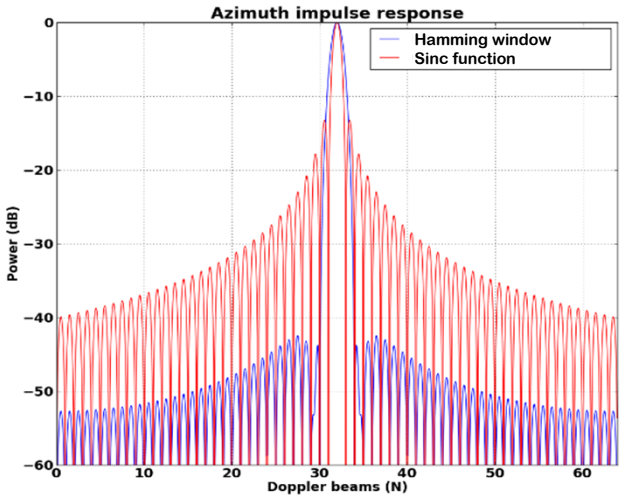

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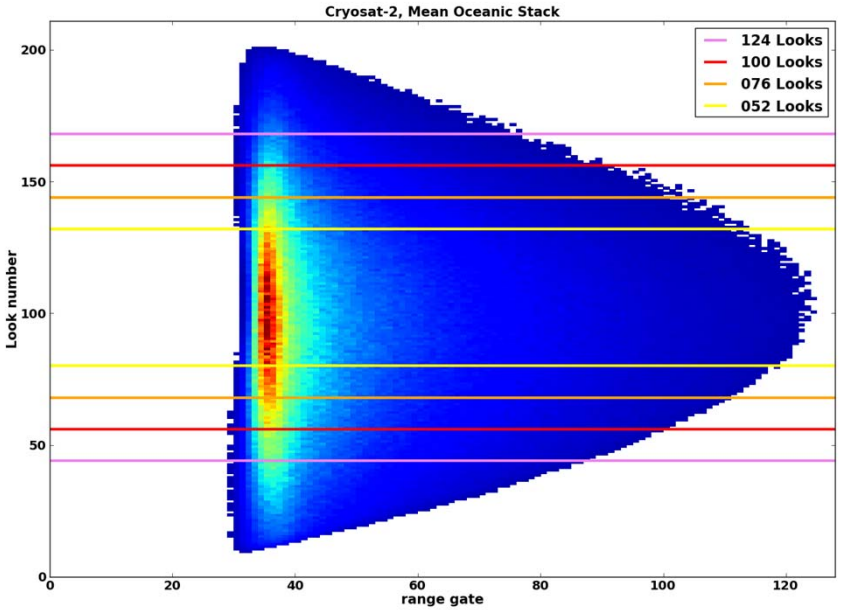

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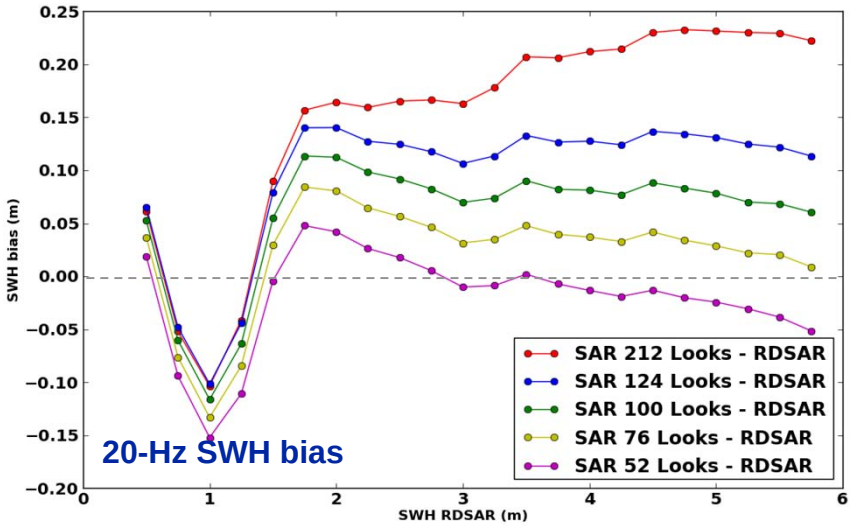

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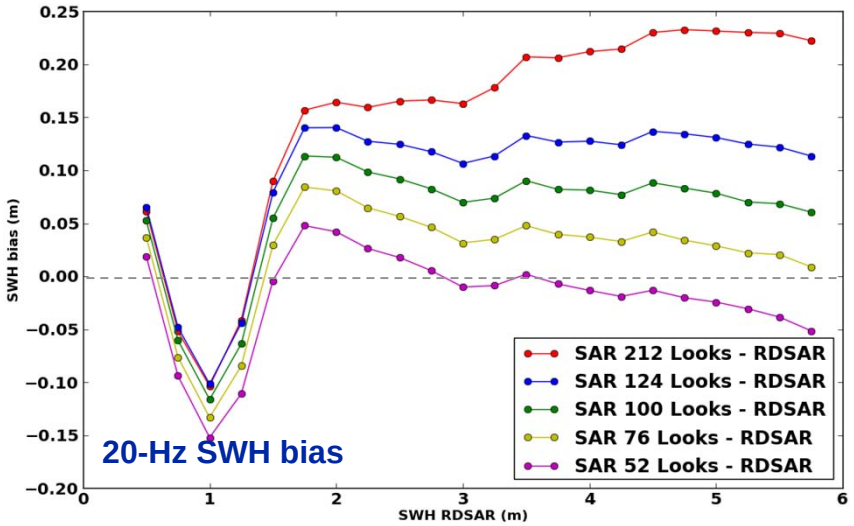
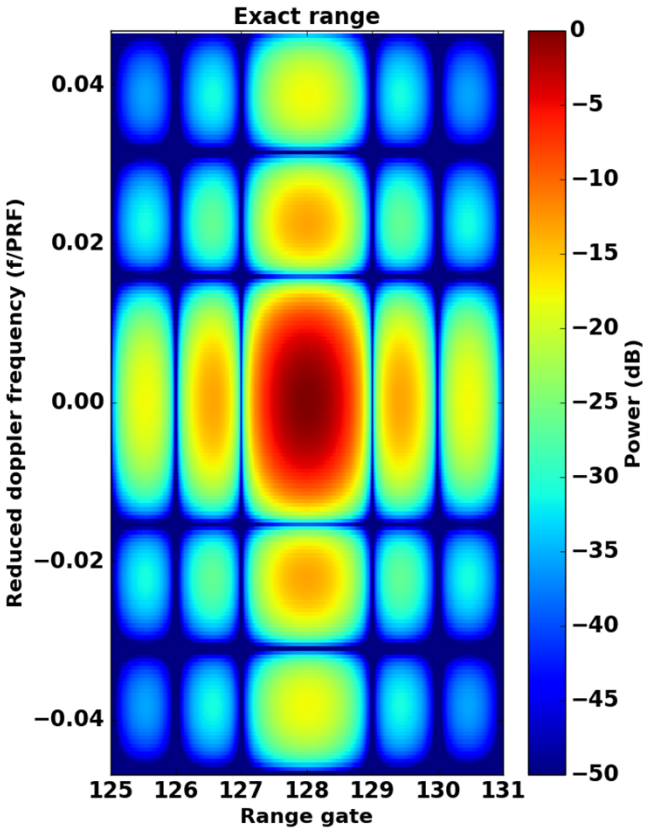
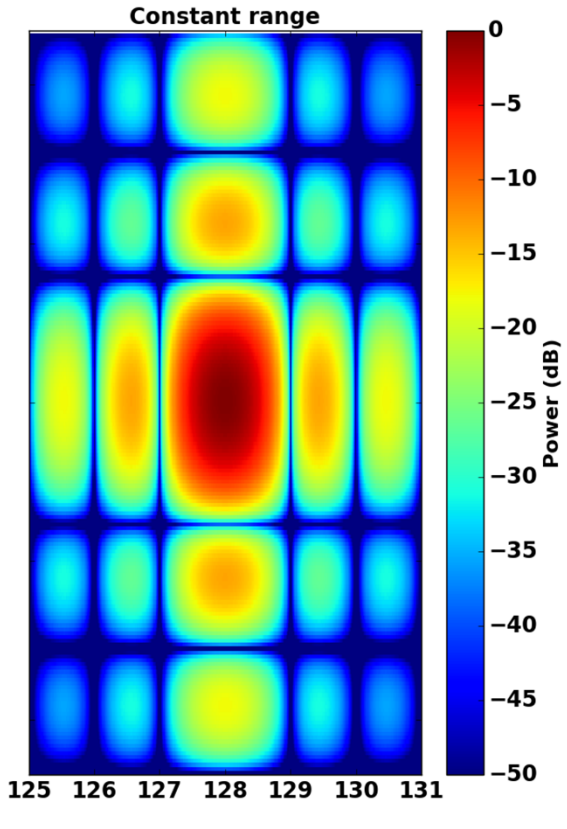


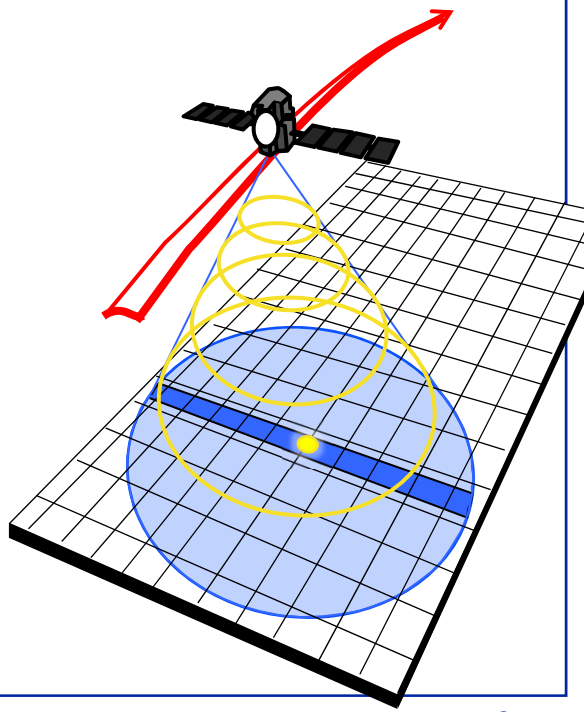

- Both improved consistency model/data
- Data analysis over transponder may help to better characterize this behaviour

# SAR-MODE SIMULATION: TRANSPONDER




**- BURST #00 -**
**(nadir)**



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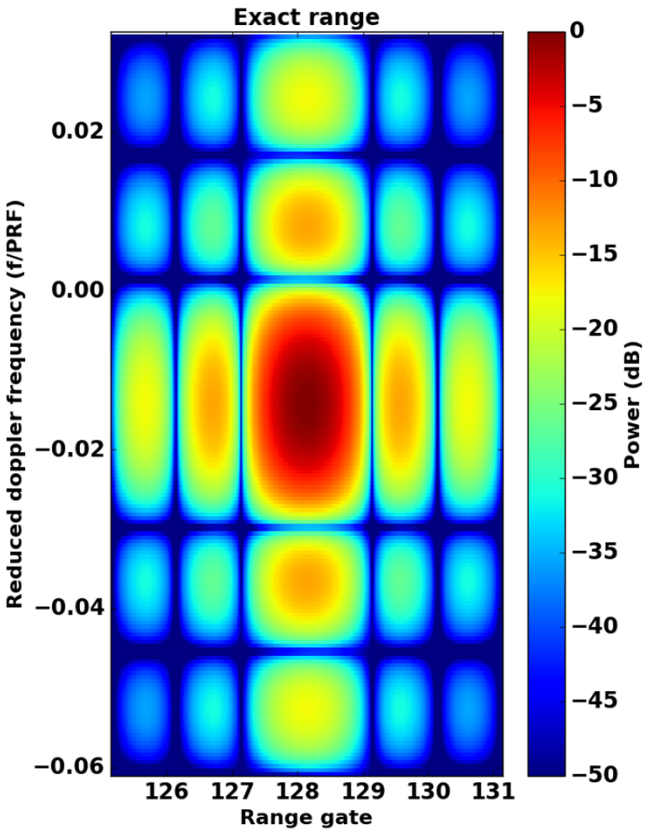
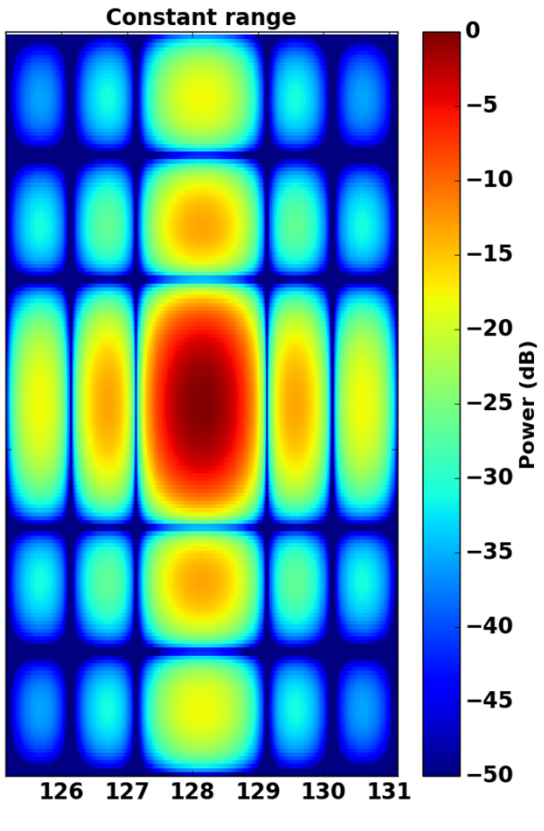
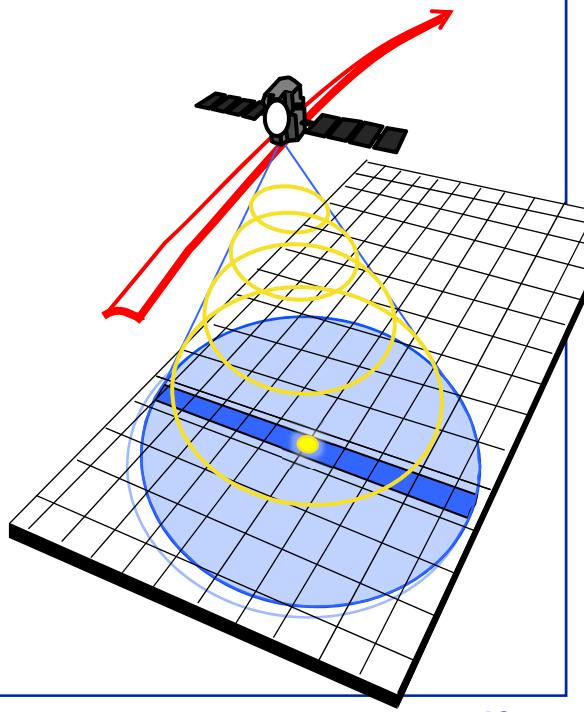



**- BURST #04 -**



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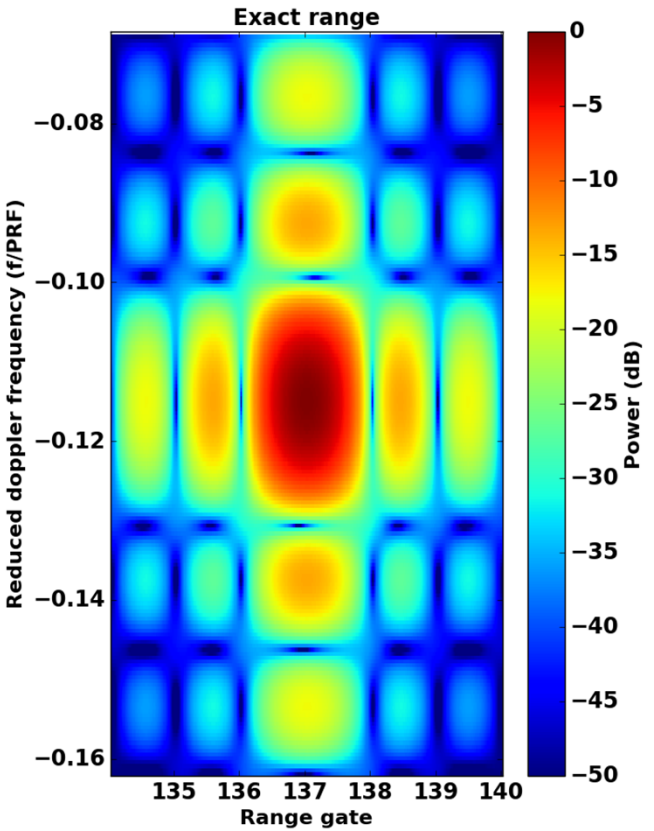
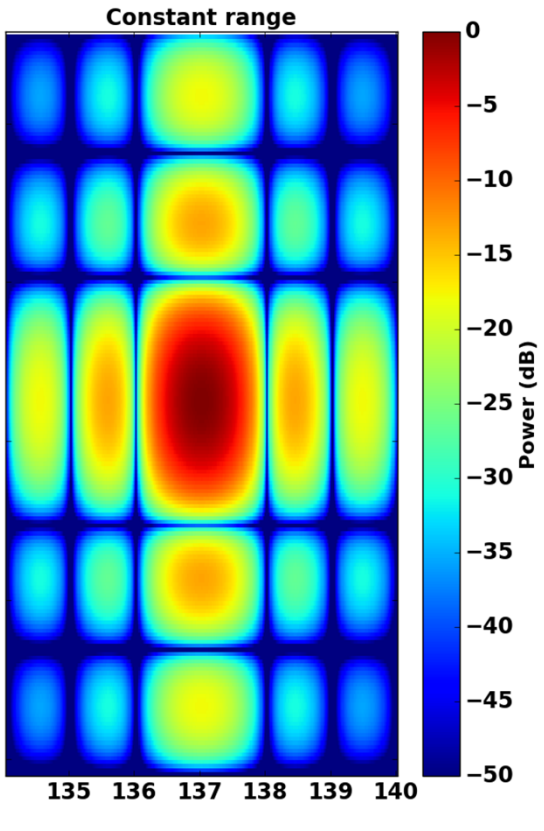
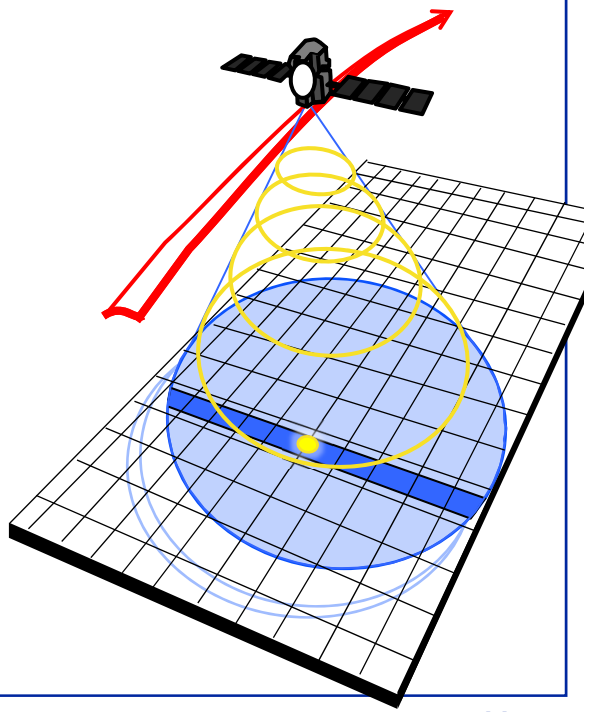



**- BURST #32 -**



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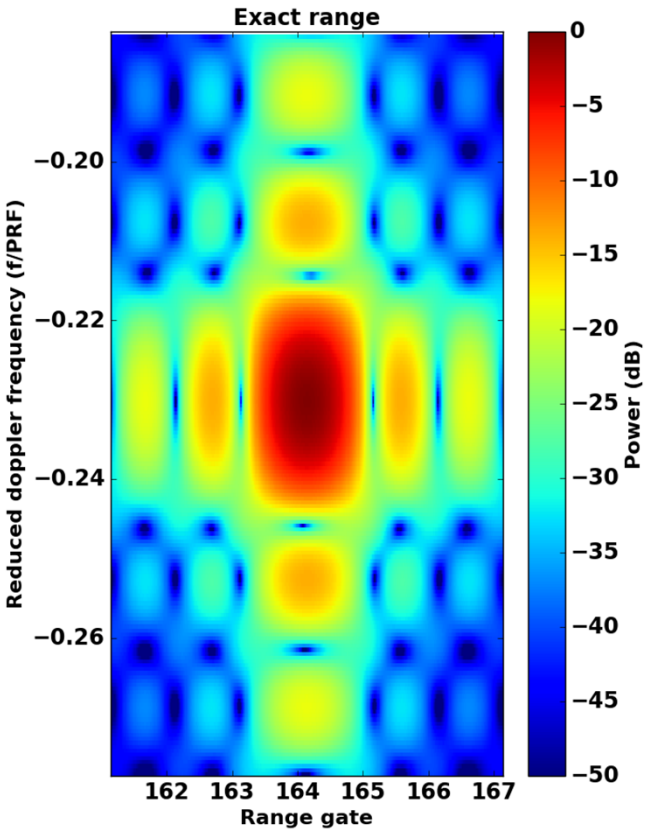


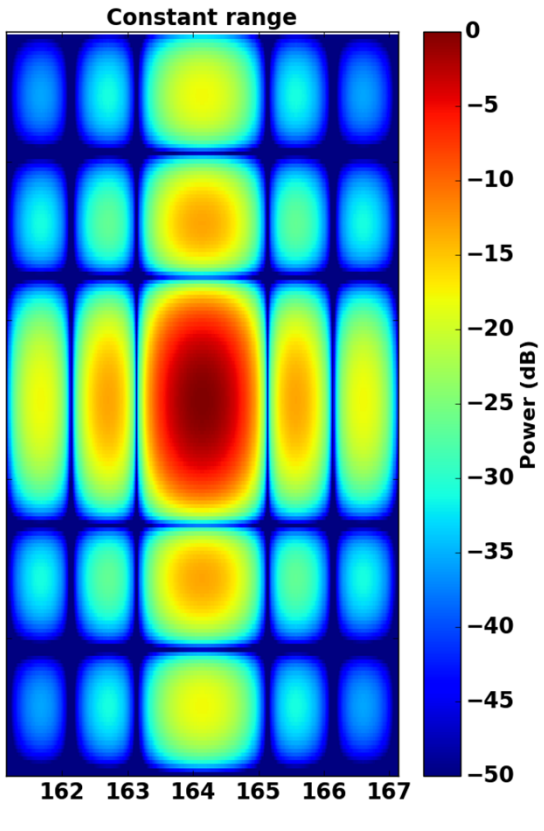


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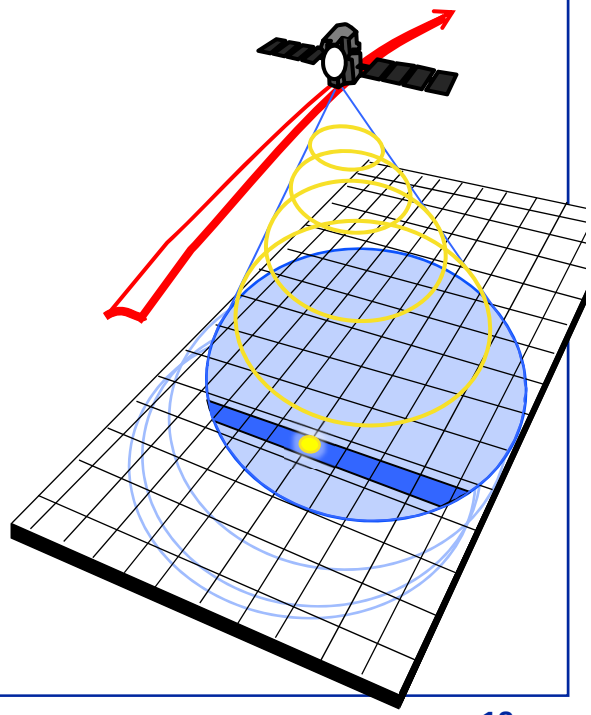

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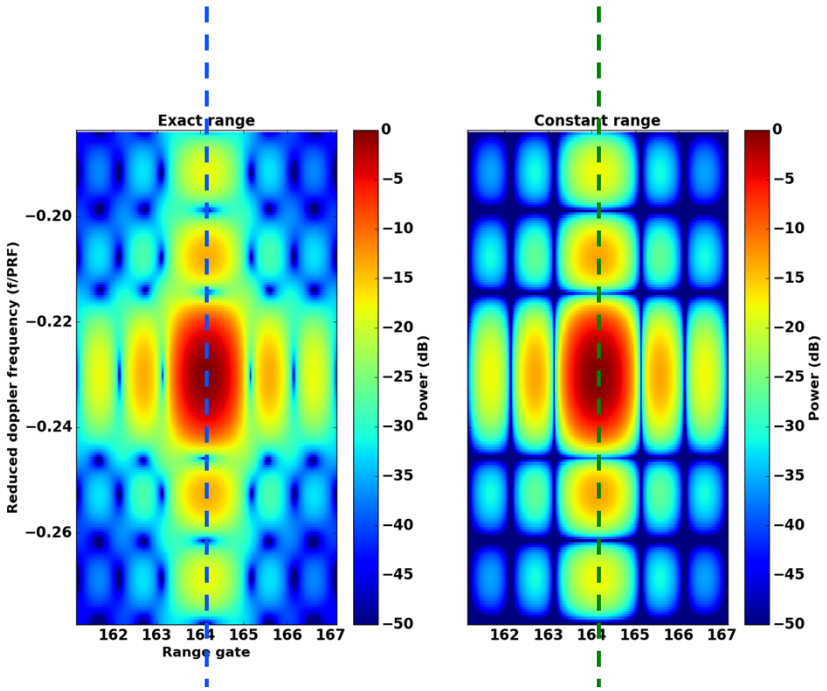


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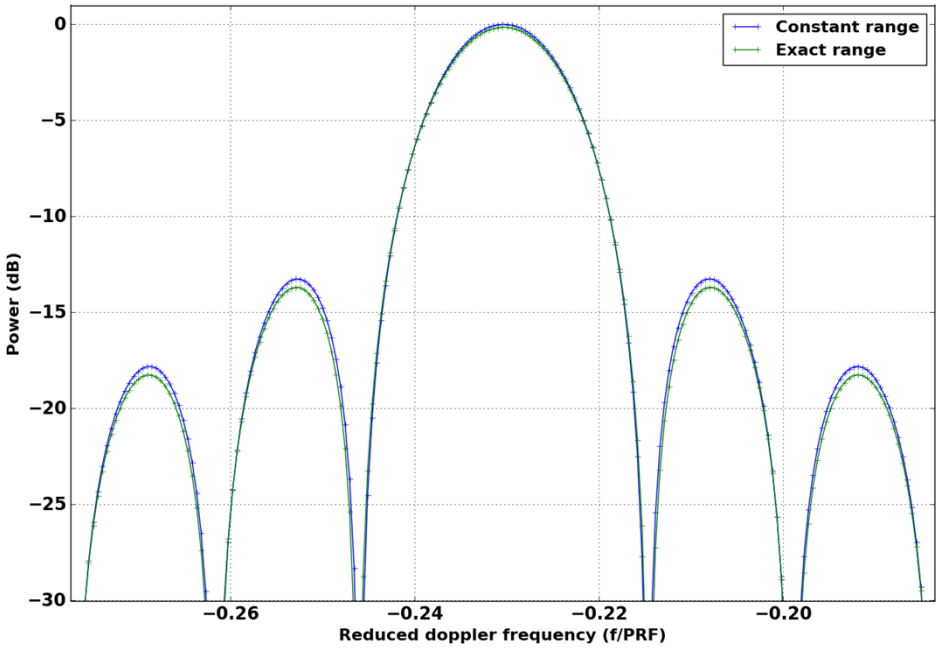

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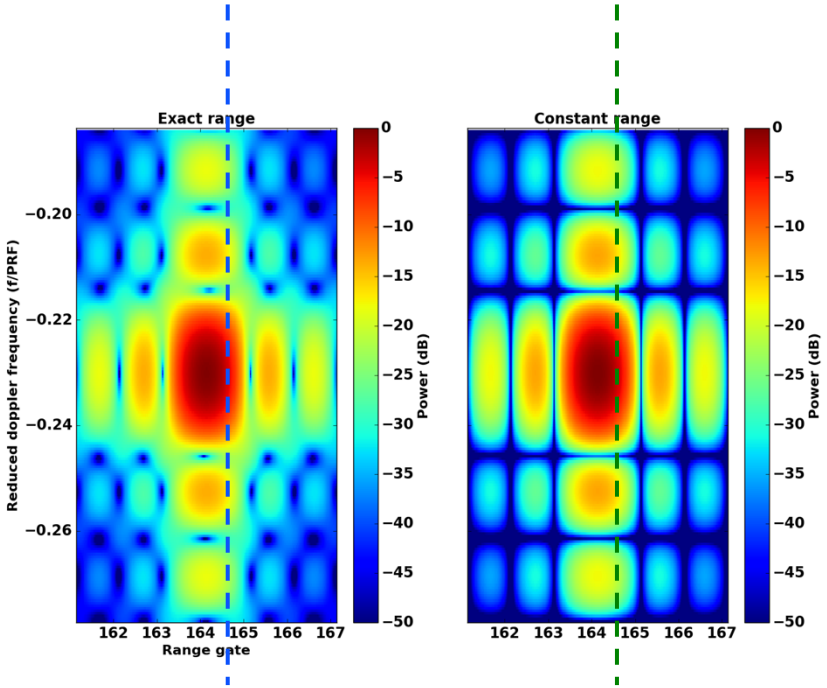


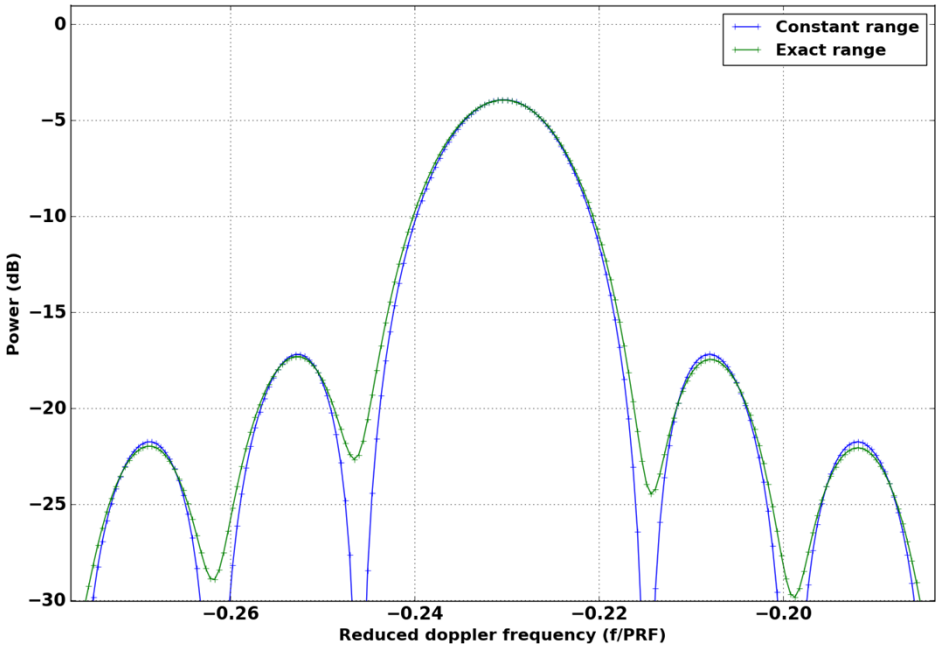


- Non-null values and wider IR lobes compared to sinc function (considered in nominal SAR-mode retracking)

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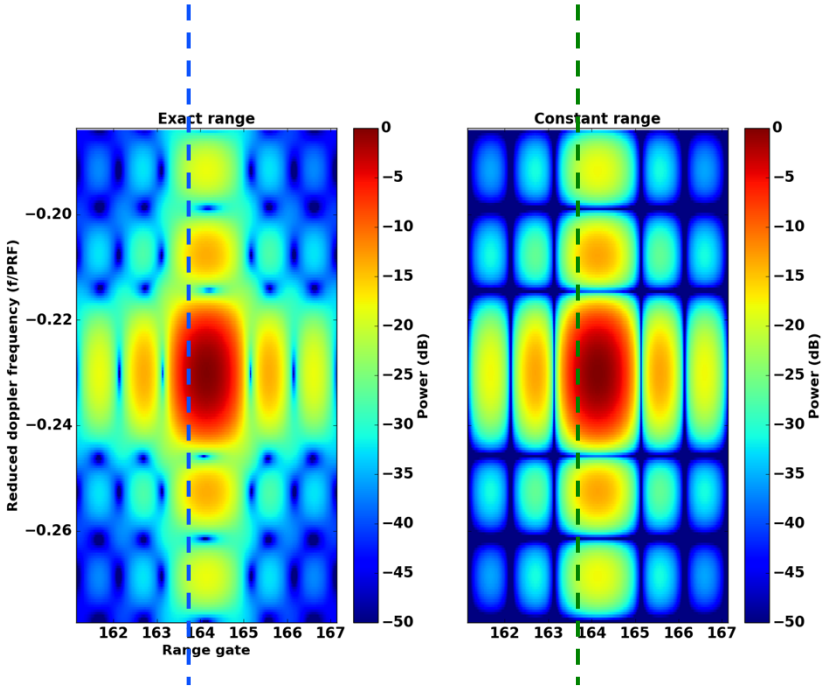


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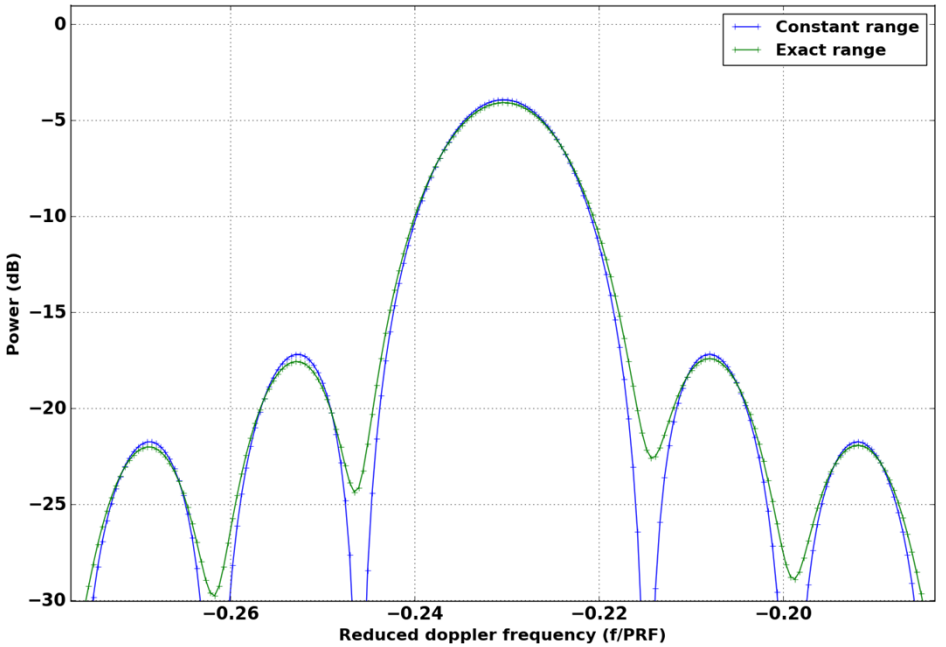


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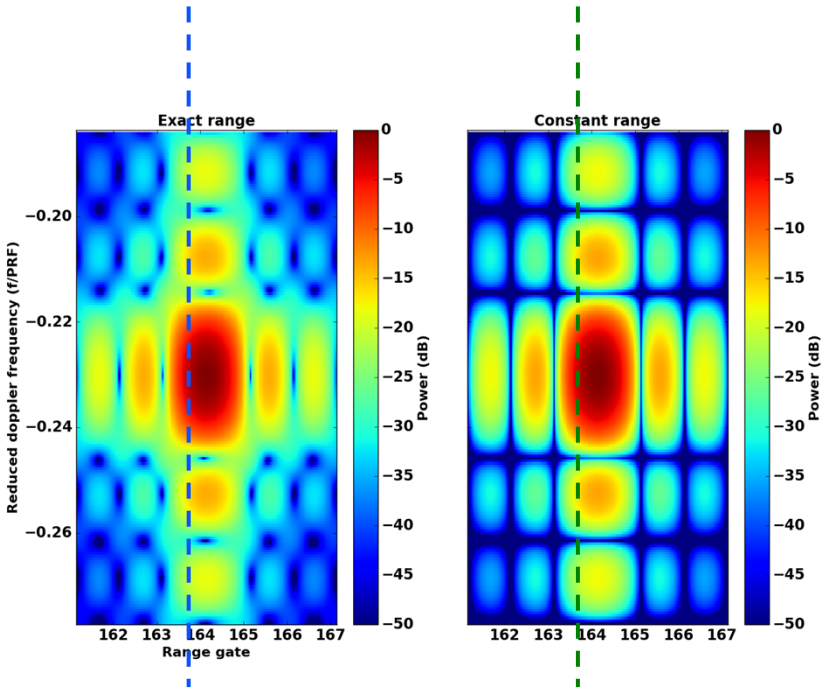


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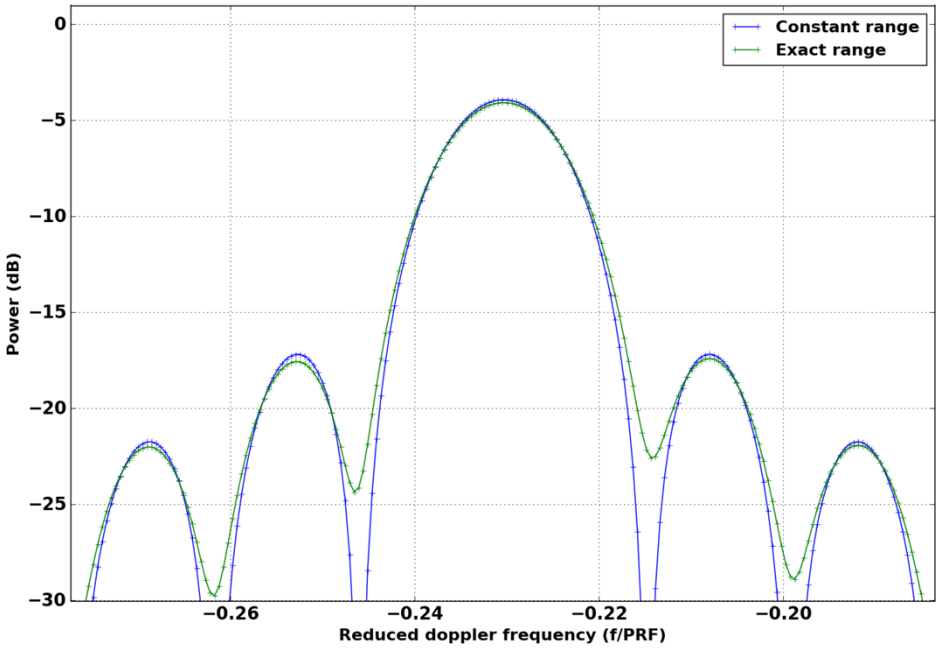
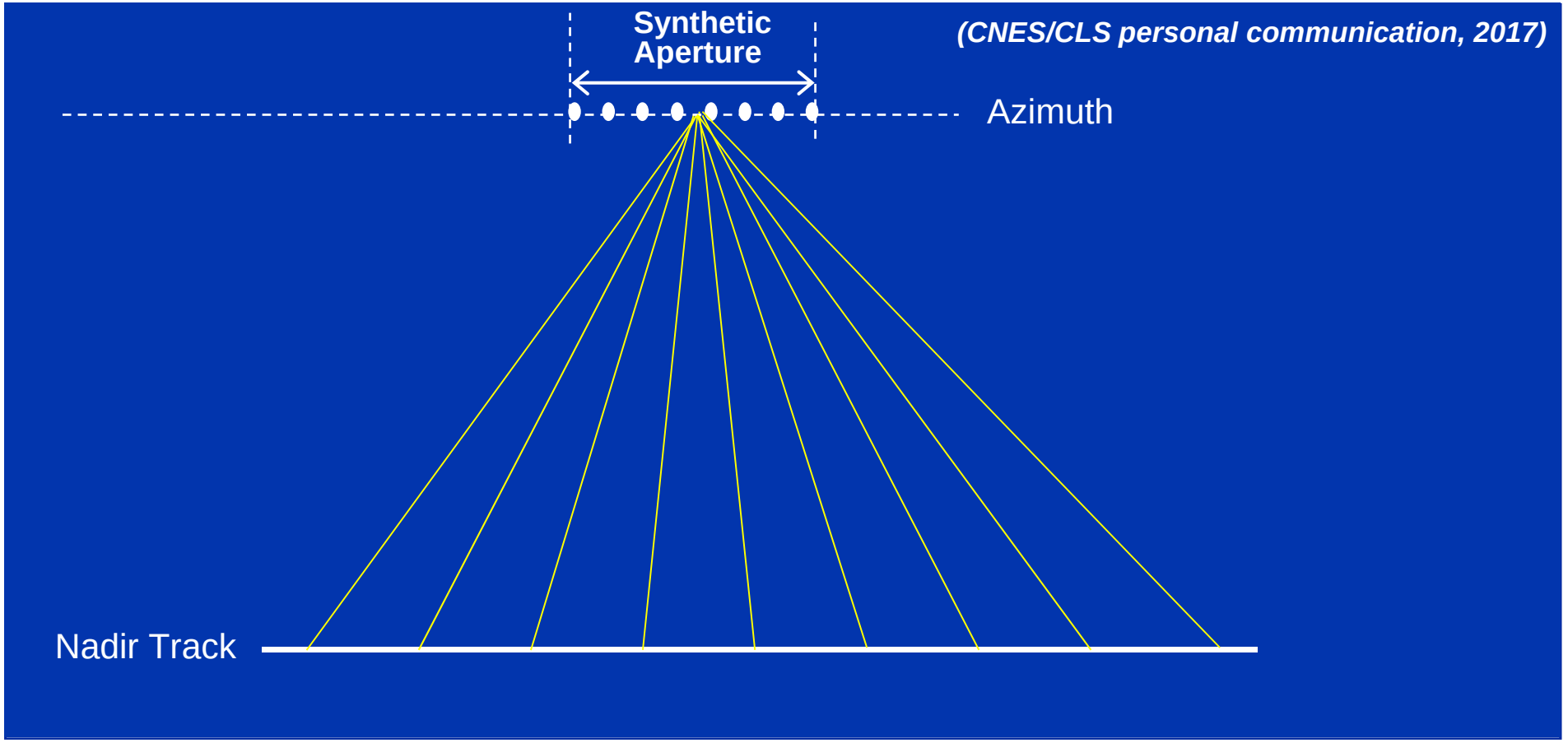



**Widening lobes ➔ increase in SWH by retracking with sinc IR model**

# THEORETICAL ANALYSIS




*(CNES/CLS personal communication, 2017)*

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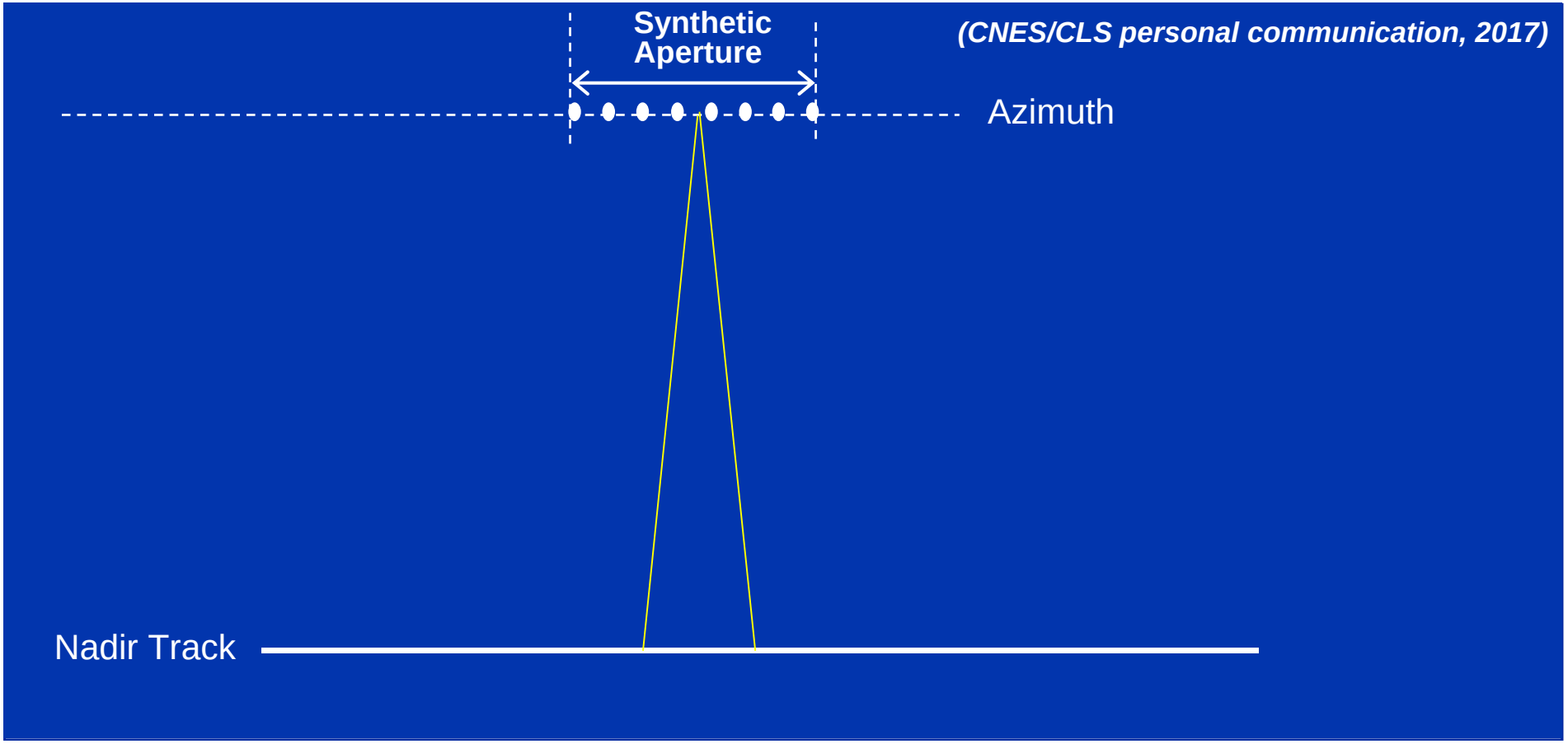


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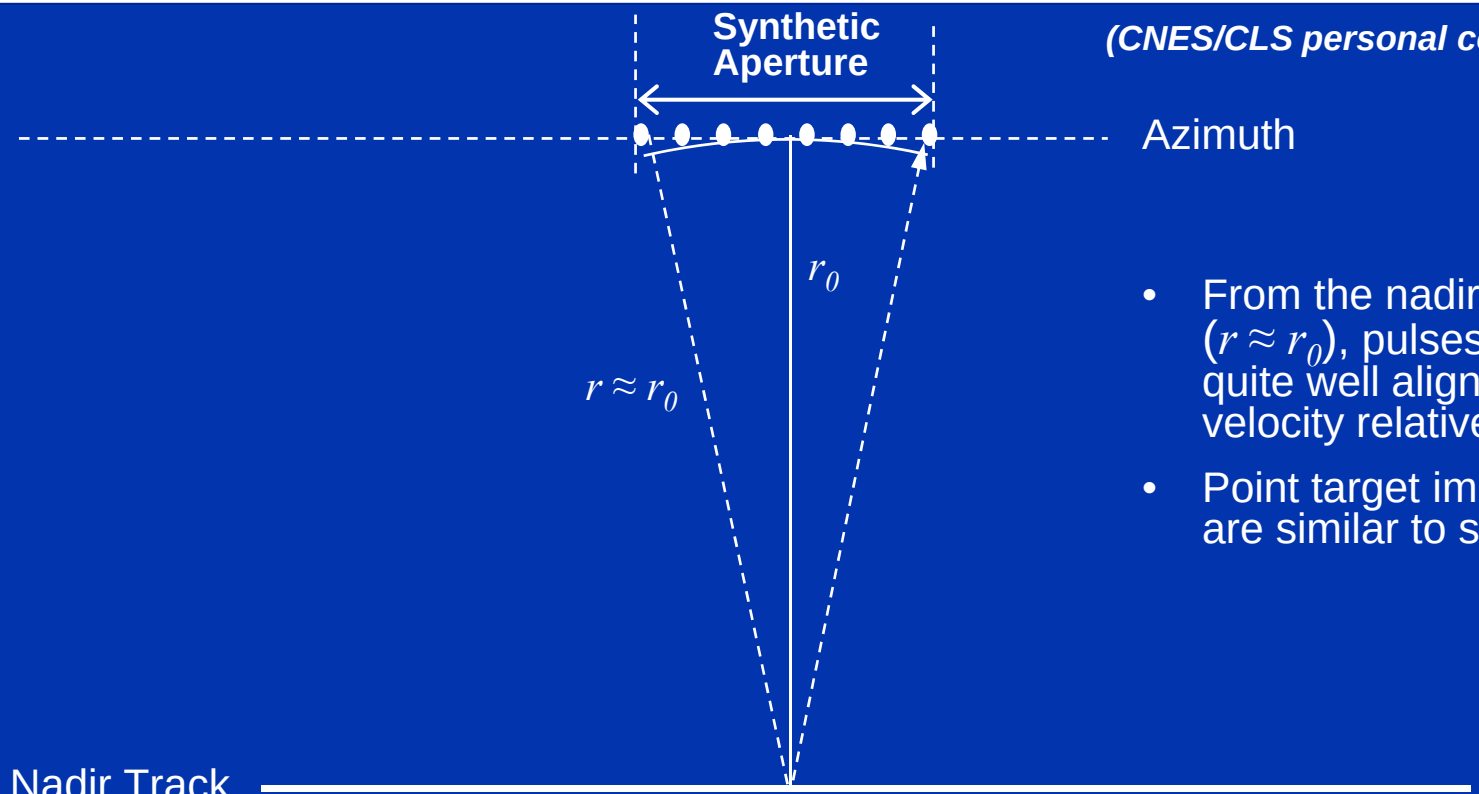
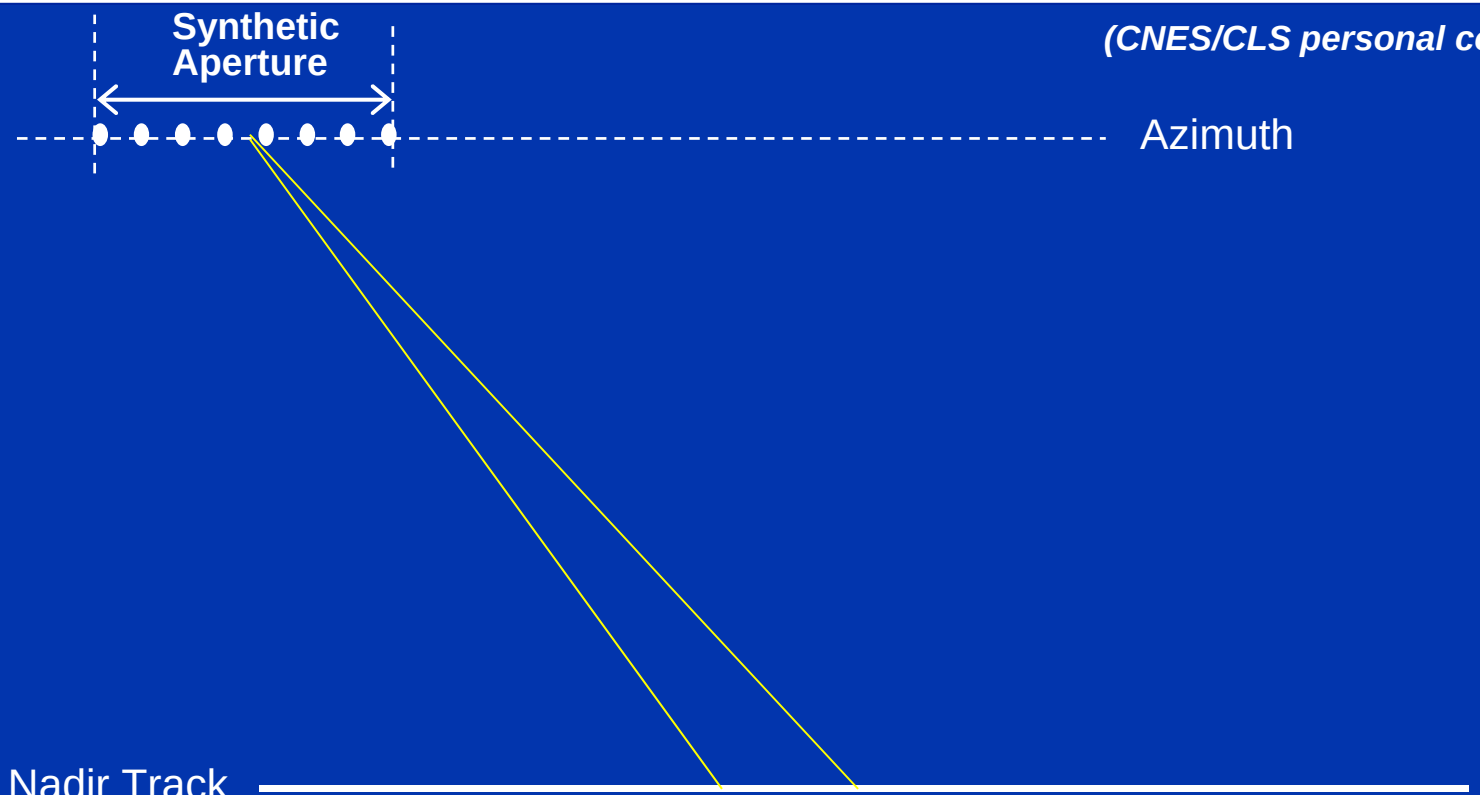



*(CNES/CLS personal communication, 2017)*

- From the nadir surface point ($r \approx r_0$), pulses in a burst are quite well aligned (no radial velocity relative to this point)
- Point target impulse responses are similar to sinc functions

# THEORETICAL ANALYSIS

*(CNES/CLS personal communication, 2017)*



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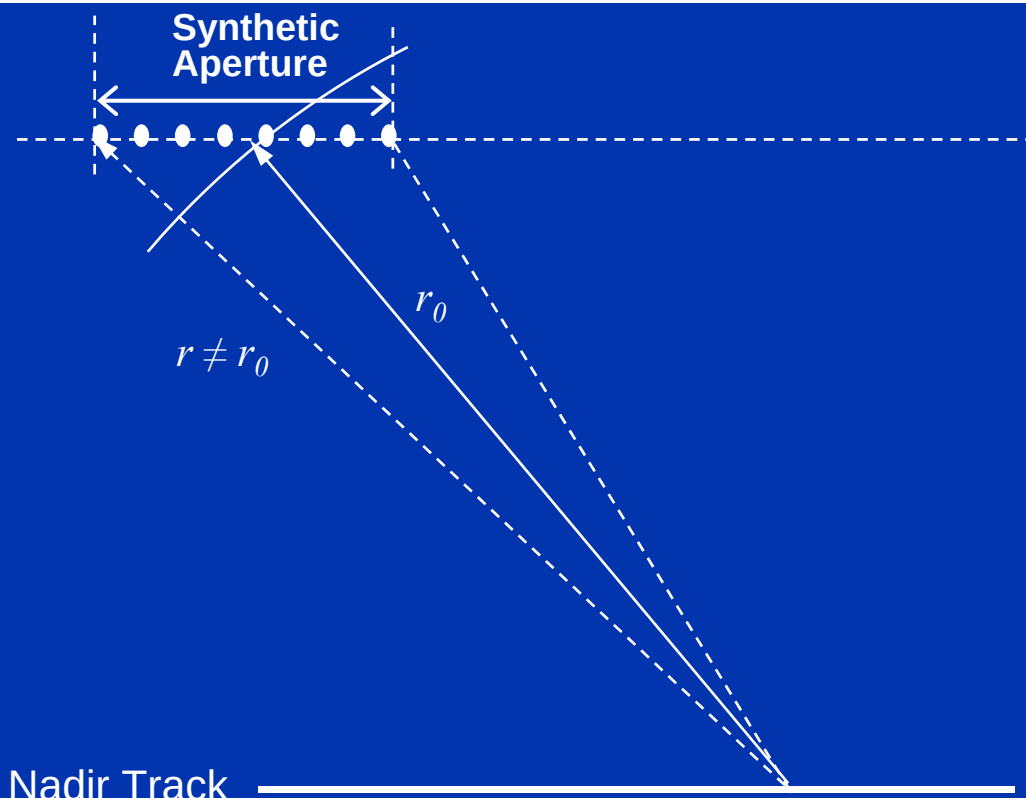


***(CNES/CLS personal communication, 2017)***

- At off-nadir, pulses have different velocity relative to the surface point and slide in the burst from each other wrt to this point

  **➔ L1 unfocussed SAR-mode processing does not account for this effect**

- Misalignement of pulses are messing up the impulse responses

  **➔ L2 SAR-mode processing does not account for the distorted 2D-IR**

- $(r\text{-}r_0)$ varies with $f_d t$ at first order (very low variation in across-track)

*(CNES/CLS personal communication, 2017)*

- Spectrum of the Point Target Impulse Response is given by its transform:

$$IR^*(r,f) = PRF/N \int_{-N/(2\,PRF)}^{N/(2\,PRF)} e^{-2j\pi(f_d - f)t}\ sinc\left((r - r_0 + (f_d\,\lambda)\,/\,2\,t)\ \ 2B/c\right)dt$$

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**Phase component**

**Characteristic of the impulse response**
with
$f_d$ the Doppler frequency at the centre of the burst
$r_o$ the distance surface point - centre of burst

*(CNES/CLS personal communication, 2017)*

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$$IR^2 = |IR^*|^2$$

$$If\ \ f_d \approx 0\ (nadir):\quad IR^*(r,f) = sinc\left((r - r_0)\ 2B/c\right)PRF/N \int_{-N/(2\,PRF)}^{N/(2\,PRF)} e^{-2j\pi(f_d - f)t}\,dt$$

$$\boxed{IR^*(r,f) = sin\,c\left((r - r_0)\frac{2B}{c}\right)sinc\left((f - f_d)\frac{N}{PRF}\right)}$$

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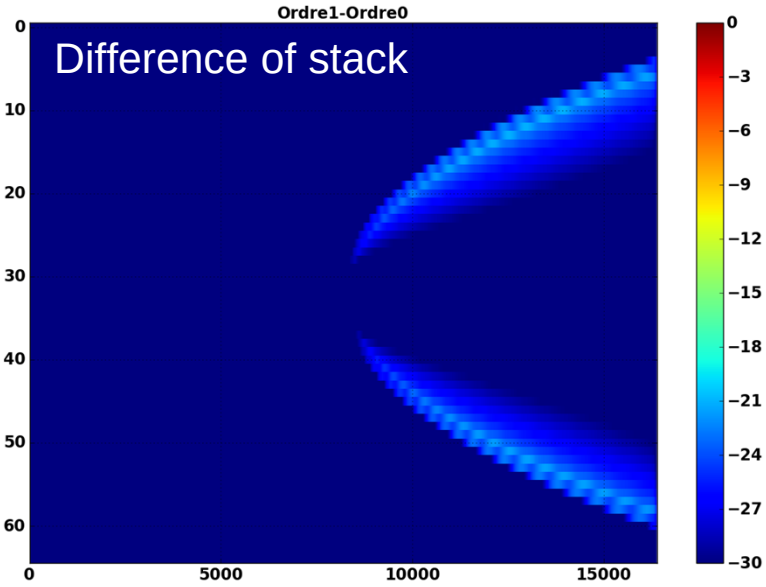
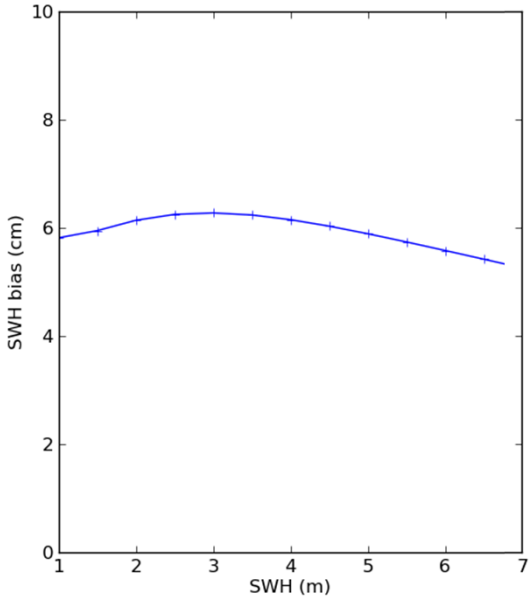
$If\ \ f_d \neq 0\ \ (off - nadir)$: sinc function expanded up to first order

# THEORETICAL ANALYSIS

*(CNES/CLS personal communication, 2017)*

- Impact on estimates (retrieved from conventional SAR model accounting for 2D-IR sinc function) – Mostly impacting far looks

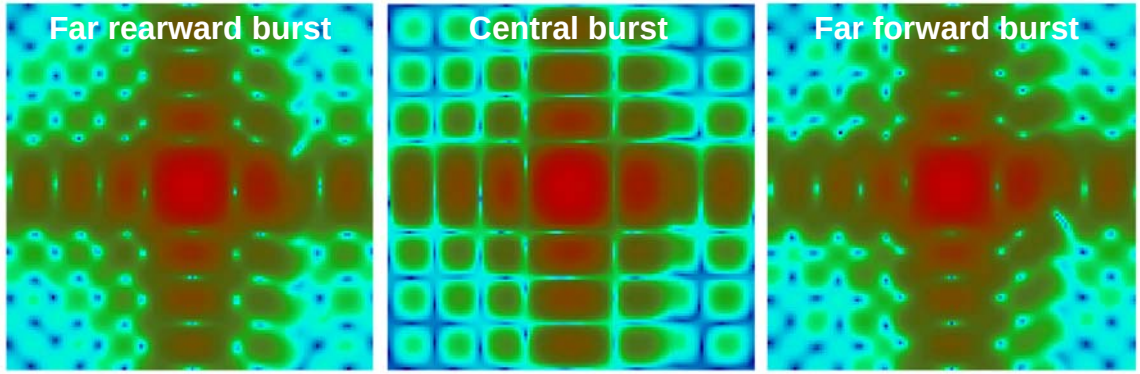



- Preliminary analyses done with real S3A data also confirmed those results

# S3A ANALYSIS OVER TRANSPONDER

**2D-IR measured using nominal L1 SAR processing:**




- 2D-IR as sinc functions at nadir
- 2D-IR is getting more and more distorted with distance from the surface point

***(F.Boy, internal communication, 2017)***

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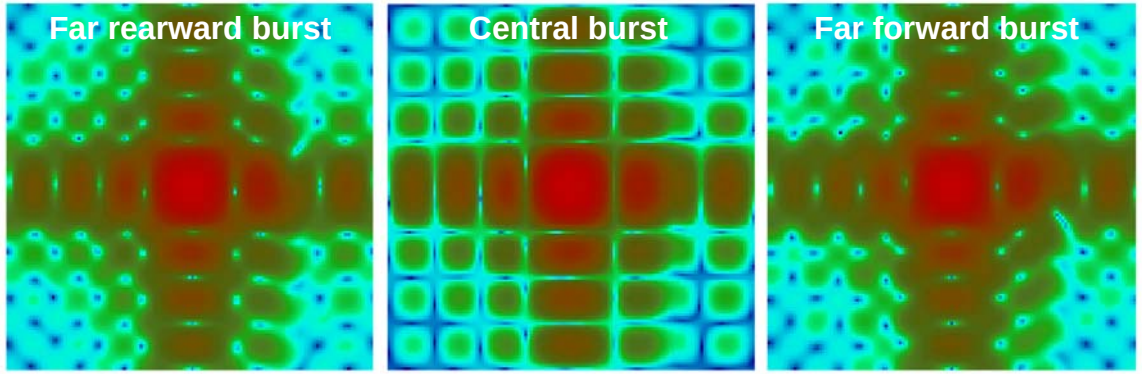
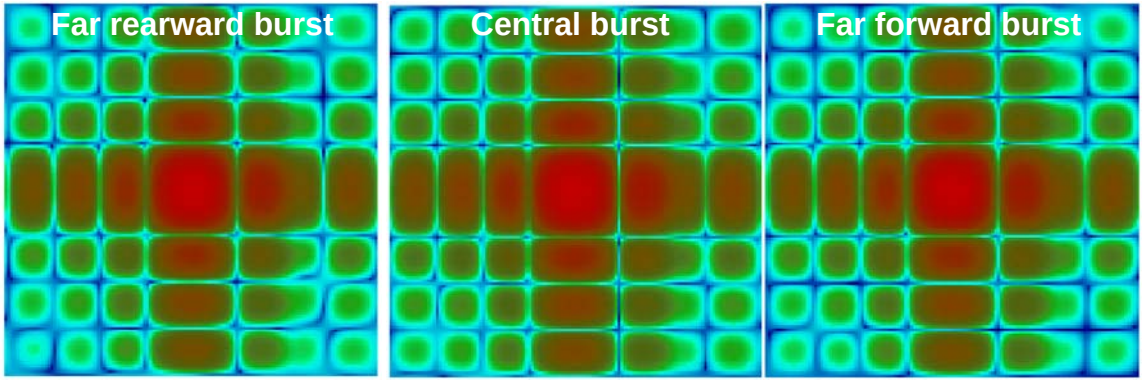



**2D-IR after correcting pulses misalignment:**




- 2D-IR as sinc functions at nadir
- 2D-IR is getting more and more distorted with distance from the surface point
- Aligning pulses in a burst wrt the surface point (correcting L1 processing)

➔ **2D-IR as sinc functions everywhere**

***(F.Boy, internal communication, 2017)***

# CONCLUSIONS & PERSPECTIVES

- Nominal ocean SAR-mode processing uses inappropriate 2D-IR model => overestimation of the SWH
- On-going investigations would confirm those results and assess the impact of this inconsistency on estimates
- Correction may be done at different processing levels
  - at level-1: by correcting the misalignment of pulses in burst wrt the surface point (as done in Egido & Smith fully focused processing but done here over the illumination time of a burst)
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  - or, at level-2: by accounting for this distorted 2D-IR in the retracking ocean model (through semi-analytical or numerical approach)
- We expect to improve the consistency data/model to make possible the use of maximum-likelihood method (Adaptive retracker) with SAR-mode data and individual Doppler echoes

# THANK YOU !!

tmoreau@cls.fr