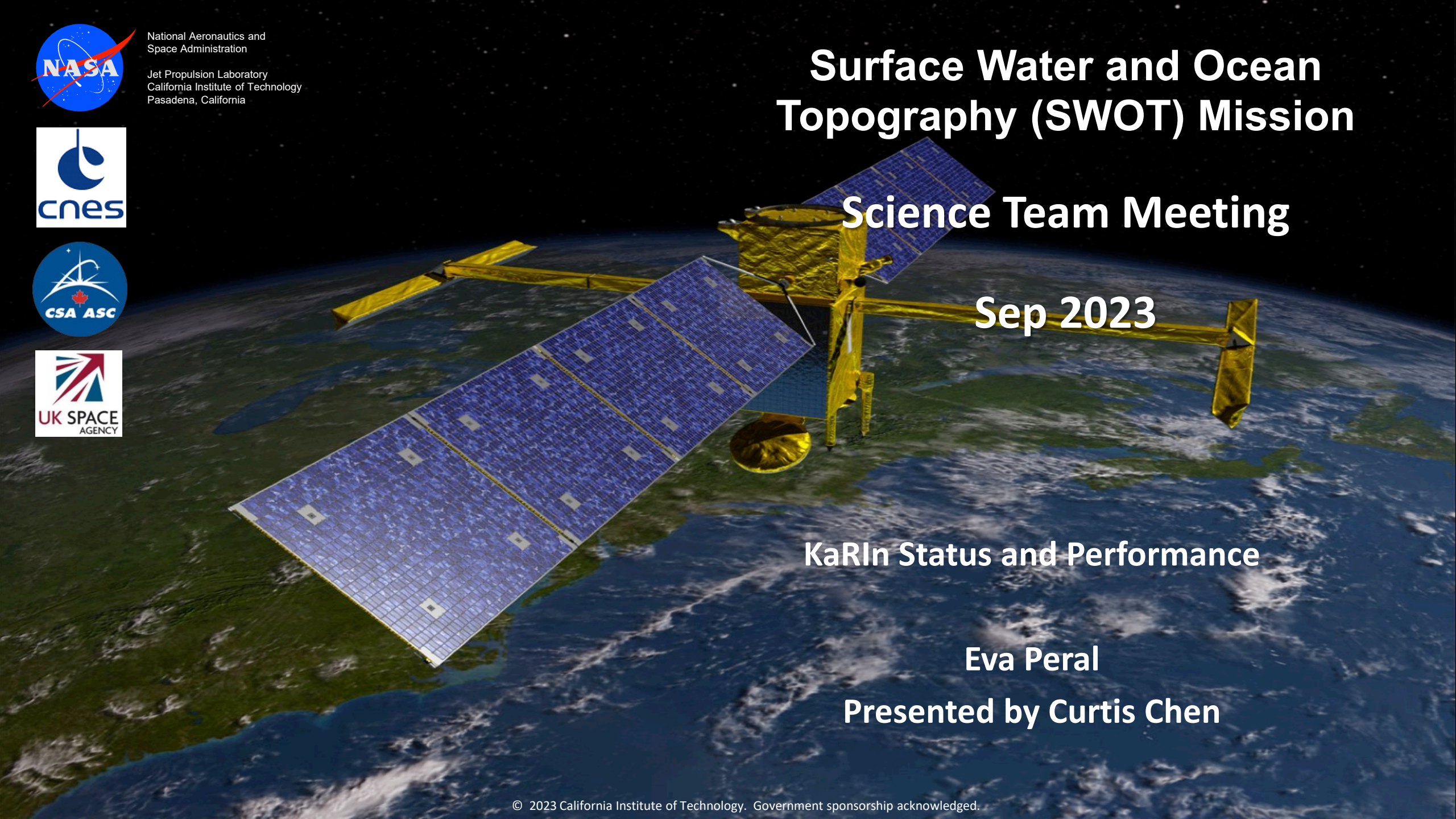


National Aeronautics and Space Administration

Jet Propulsion Laboratory
California Institute of Technology
Pasadena, California

Surface Water and Ocean Topography (SWOT) Mission

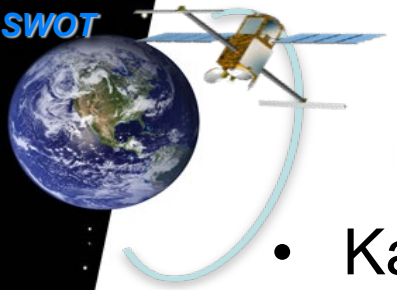
Science Team Meeting

Sep 2023

KaRIn Status and Performance

Eva Peral

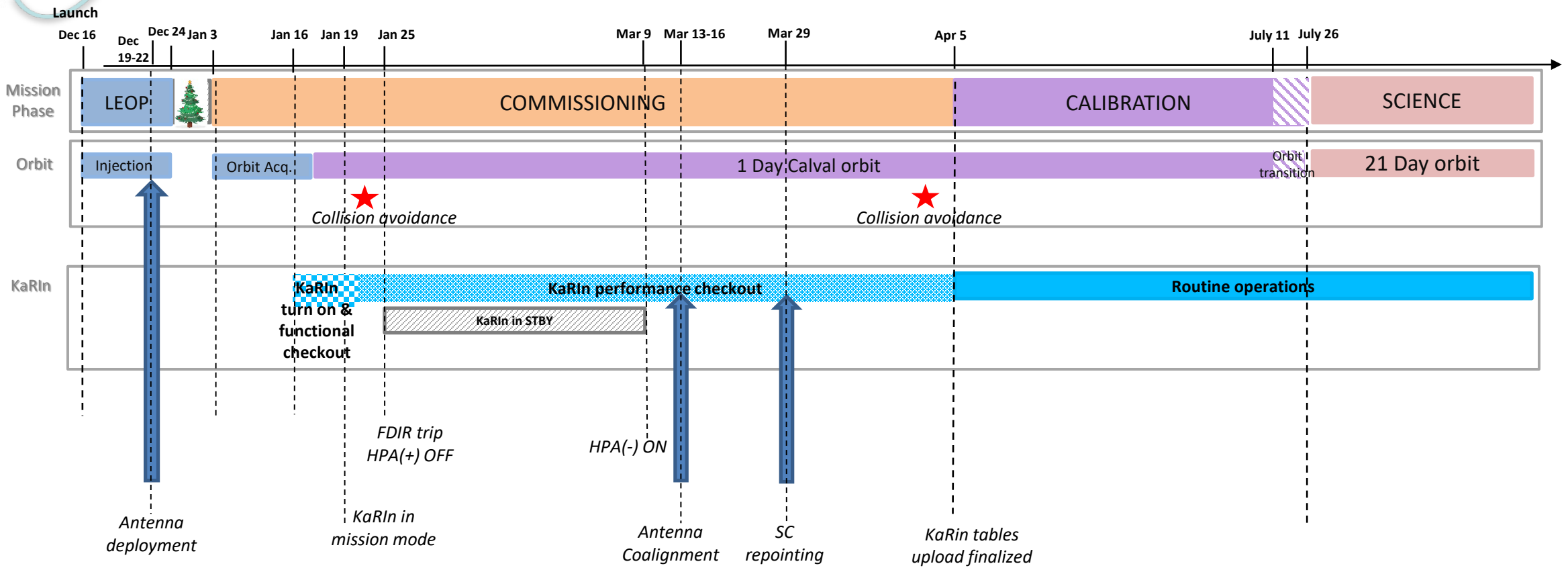
Presented by Curtis Chen



Outline

- KaRIn timeline since launch
- KaRIn random performance
  - KaRIn SNR budget
  - KaRIn height random performance
  - KaRIn ocean performance with waves
- KaRIn systematic performance
- KaRIn pointing performance

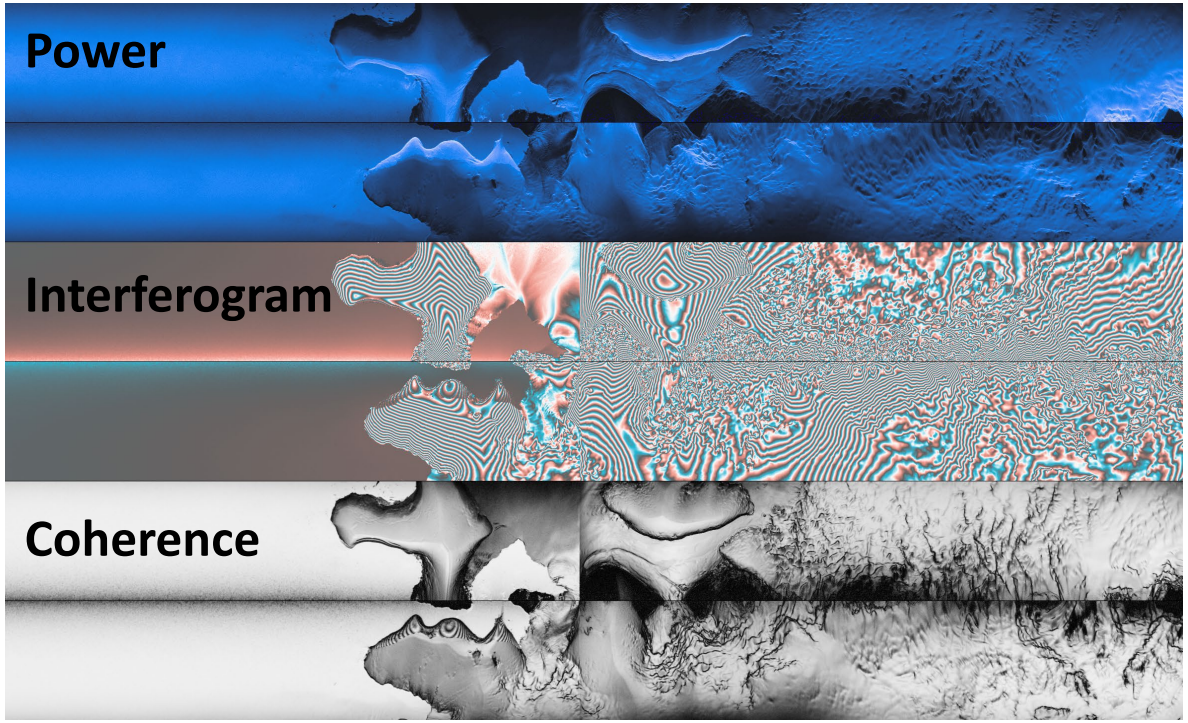
KaRIn timeline since launch



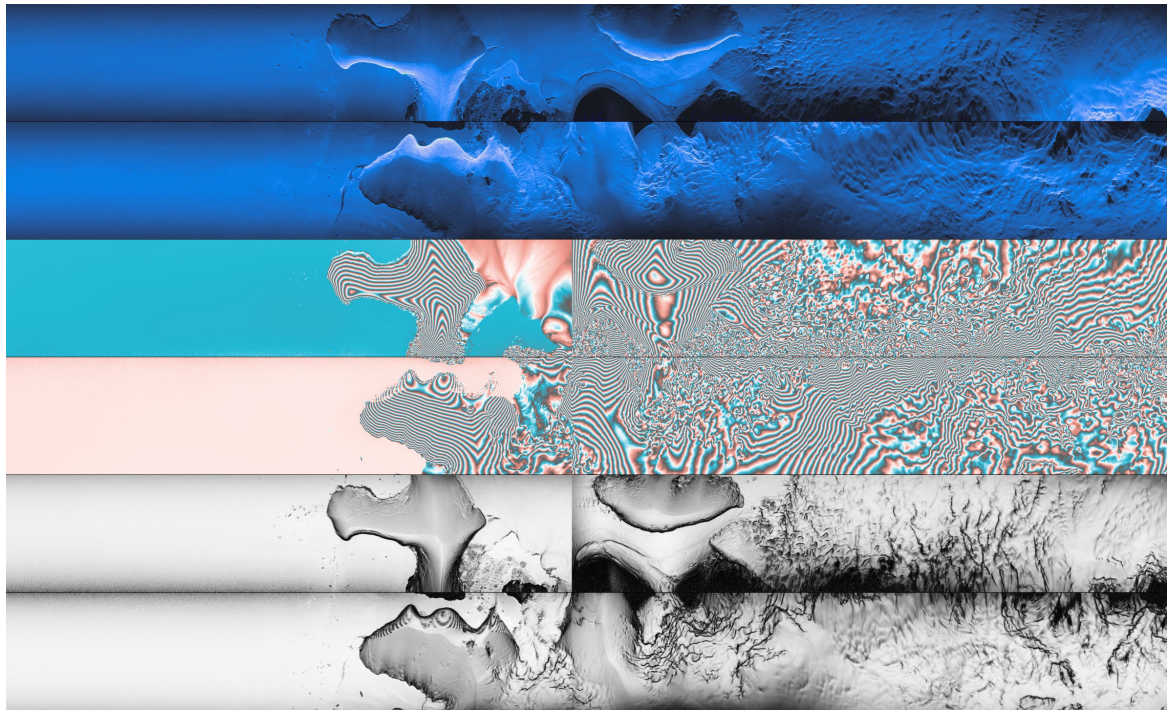
KaRIn health and status is nominal

KaRIn first light

01/19/2023: Beginning of performance checkout

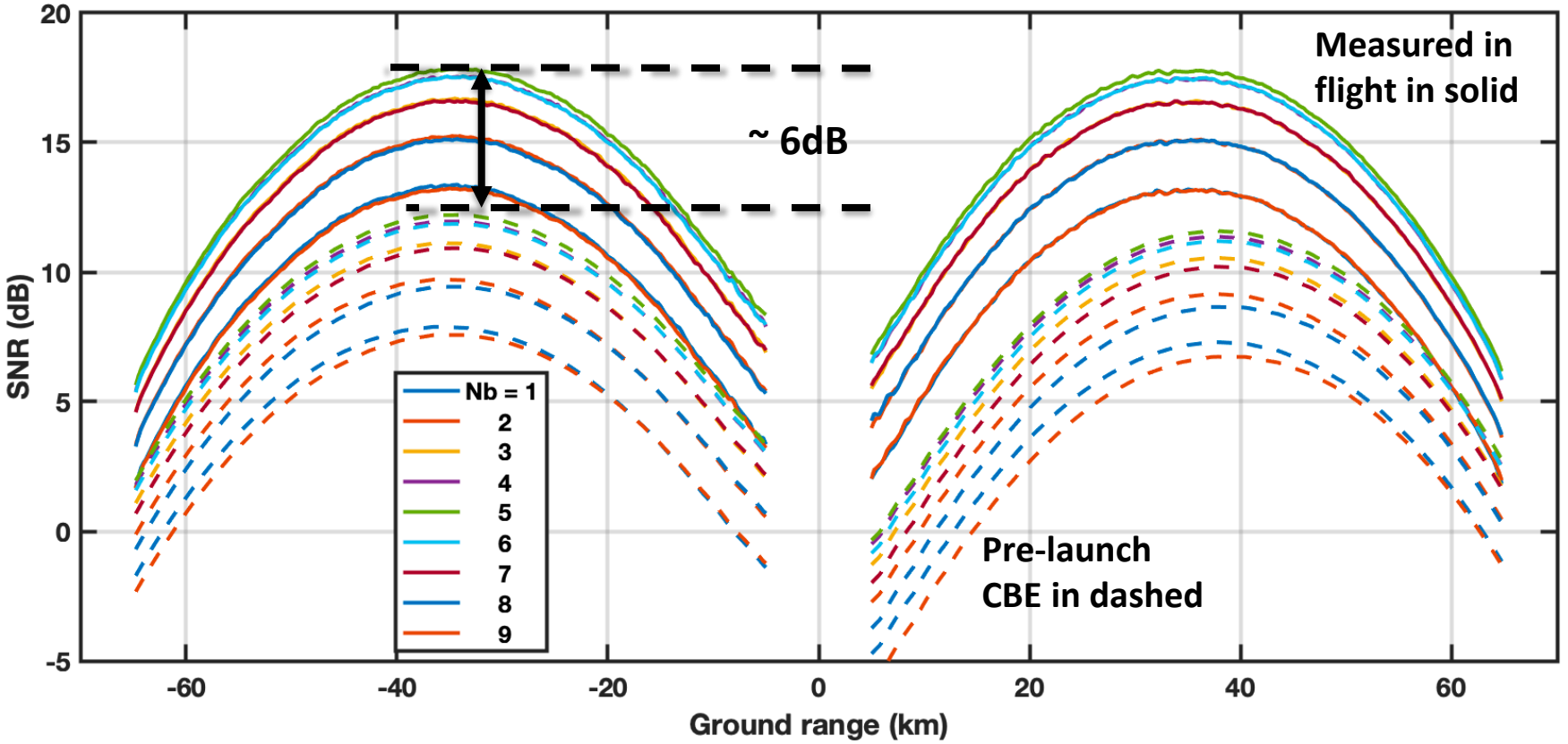


04/03/2023: End of performance checkout

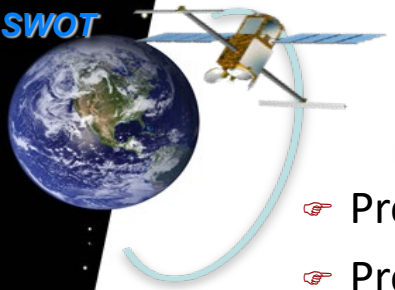


- Images shows the LR power image, interferogram and coherence without any further processing.
- LR product was very good out of the box, but small improvements were made to flatness and coherence during performance checkout.
- **To our knowledge, this is the first ever radar interferogram computed on board a satellite.**

KaRIn performance SNR (signal to noise ratio) budget compared to pre-launch CBE (current best estimate)



- Using data set with SWH ~2m and windspeed ~ 8.9m/sec per the requirements
- The different shape vs. xtrack for pre-launch CBE and flight is due pre-launch CBE using edge case elevation pointing
- Measured flight SNR for cal orbit over rain free ocean is about 6dB above pre-launch CBE.
- We had 4dB SNR margin at launch
- This translates to **~ 10dB SNR margin above the requirement for rain free ocean**



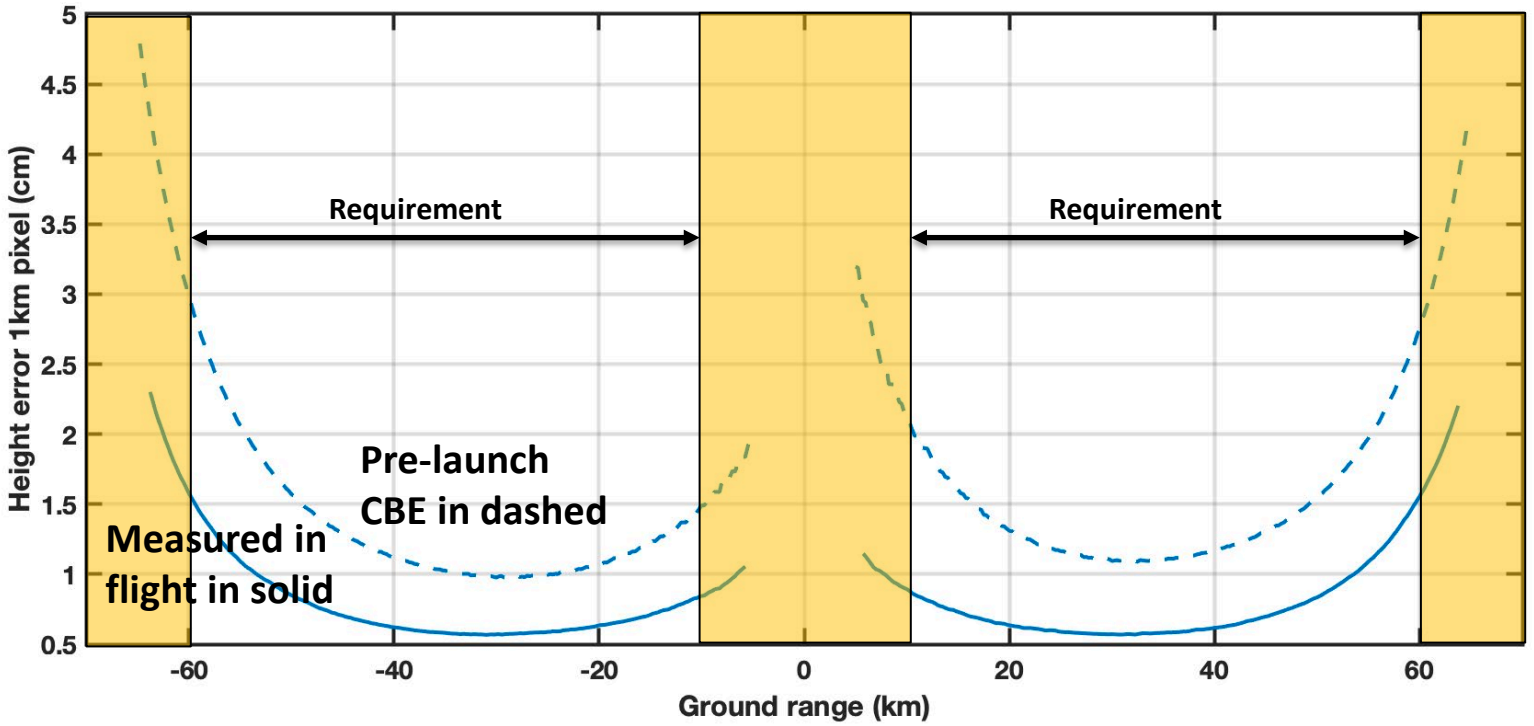
SNR margin (ΔSNR) explained

- Pre-launch SNR margin was ΔSNR = 4dB
- Pre-launch CBE uses EOL (end of life) transmit power and antenna gain
  - δΔSNR = 1.1dB
- Pre-launch CBE noise figure assumes operation at hot AFT (allowable flight temperature)
  - δΔSNR = 0.5dB
- Pre-launch CBE includes 0.5dB antenna gain uncertainty
  - δΔSNR = 1dB
- Pre-launch CBE noise figure assumes land brightness temperature
  - δΔSNR = 0.5dB
- Per the requirements, using Vandemark 2009 model at 8.9m/sec windspeed for sigma0
  - The measured sigma0 is ~1.9dB higher (at 8.9m/sec, varies with wind speed)
  - δΔSNR = 1.9dB
- Per the requirements, assuming 1dB atmospheric attenuation
  - In practice, this varies. Using rain free ocean for requirement assessment.
  - δΔSNR = 1dB

Total BOL (beginning of life) ΔSNR ~ 10dB over rain free ocean

Expected Total EOL (end of life) ΔSNR > 8.4dB over rain free ocean

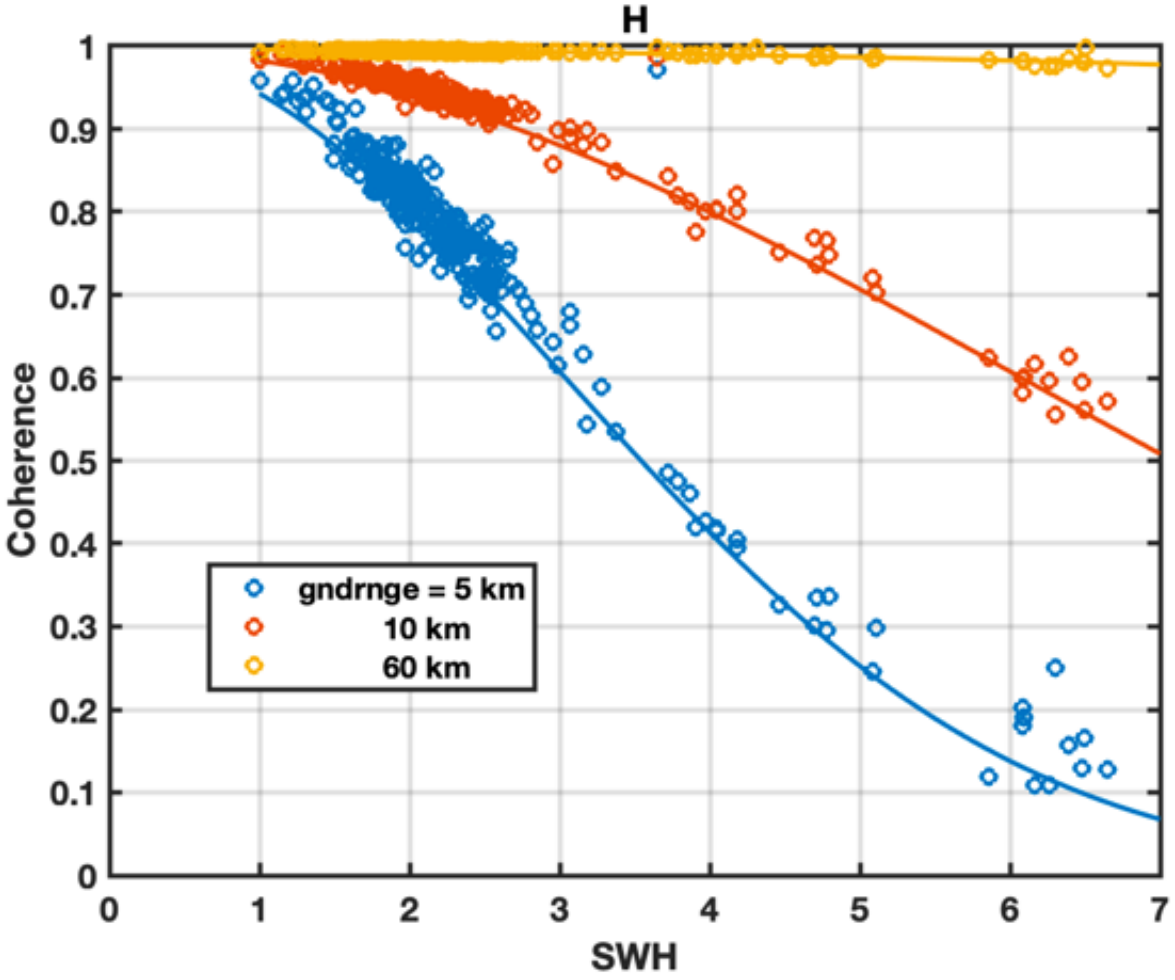
KaRIn random height error performance (science orbit)



- Using data set with SWH ~2m and windspeed ~ 8.9m/sec per the requirements.
- Rain free ocean
- Estimating random height error from measured coherence and estimated number of looks.

Height error (cm)	Pre-launch CBE	Flight
Random (w/o surfboard)	1.5	0.8
Requirement	2.5	2.5

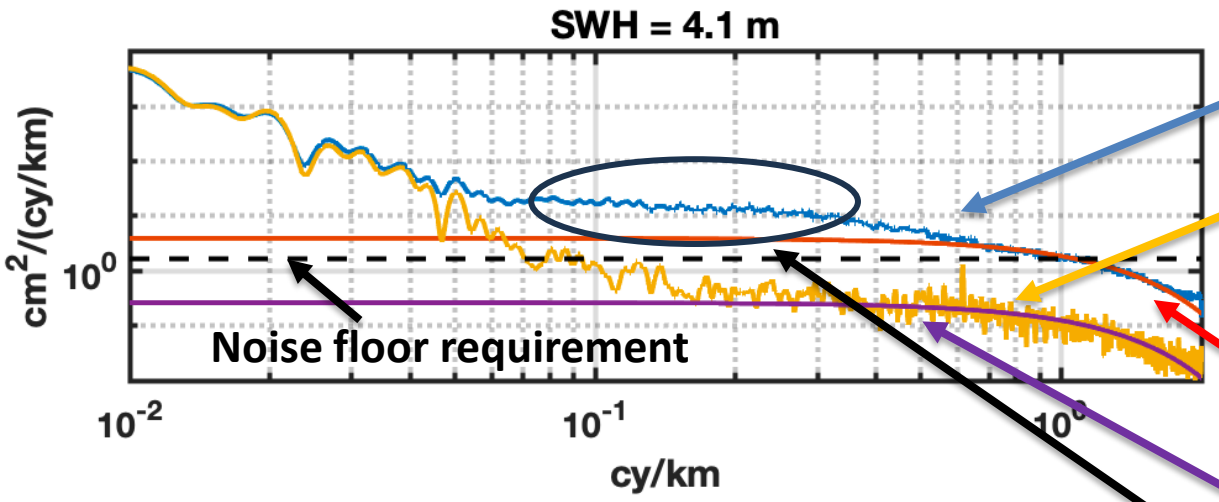
KaRIn coherence vs. SWH

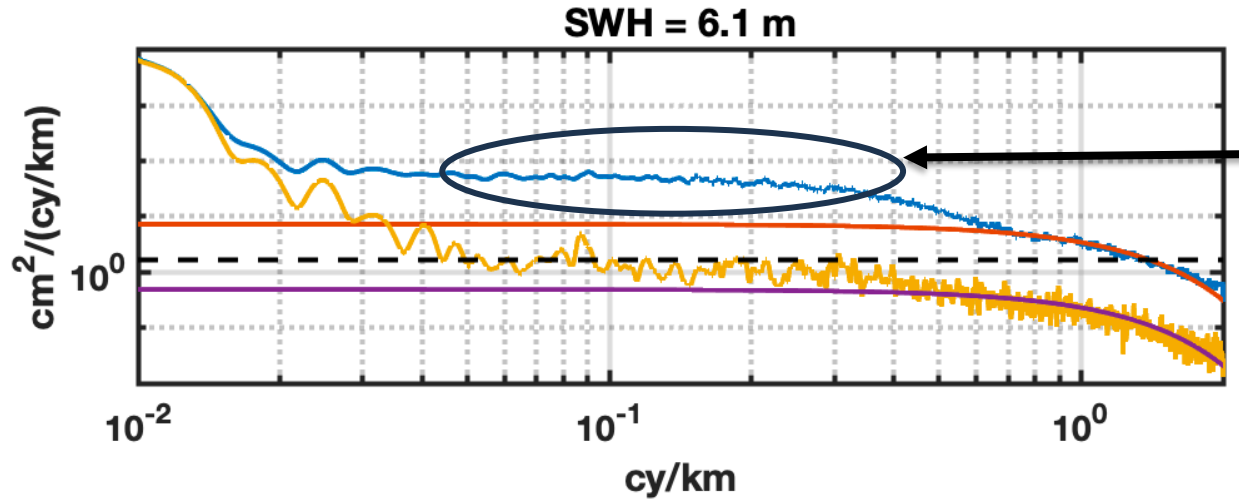


- Plot shows measured coherence in open ocean (circles) as a function of SWH (as reported by nadir altimeter) at three different cross track distances.

- **Measured coherence matches well the theoretical prediction** (solid) using the volumetric decorrelation introduced by the SWH.

Ocean PSD with waves





PSD at native 500m resolution

PSD at 7.5km resolution

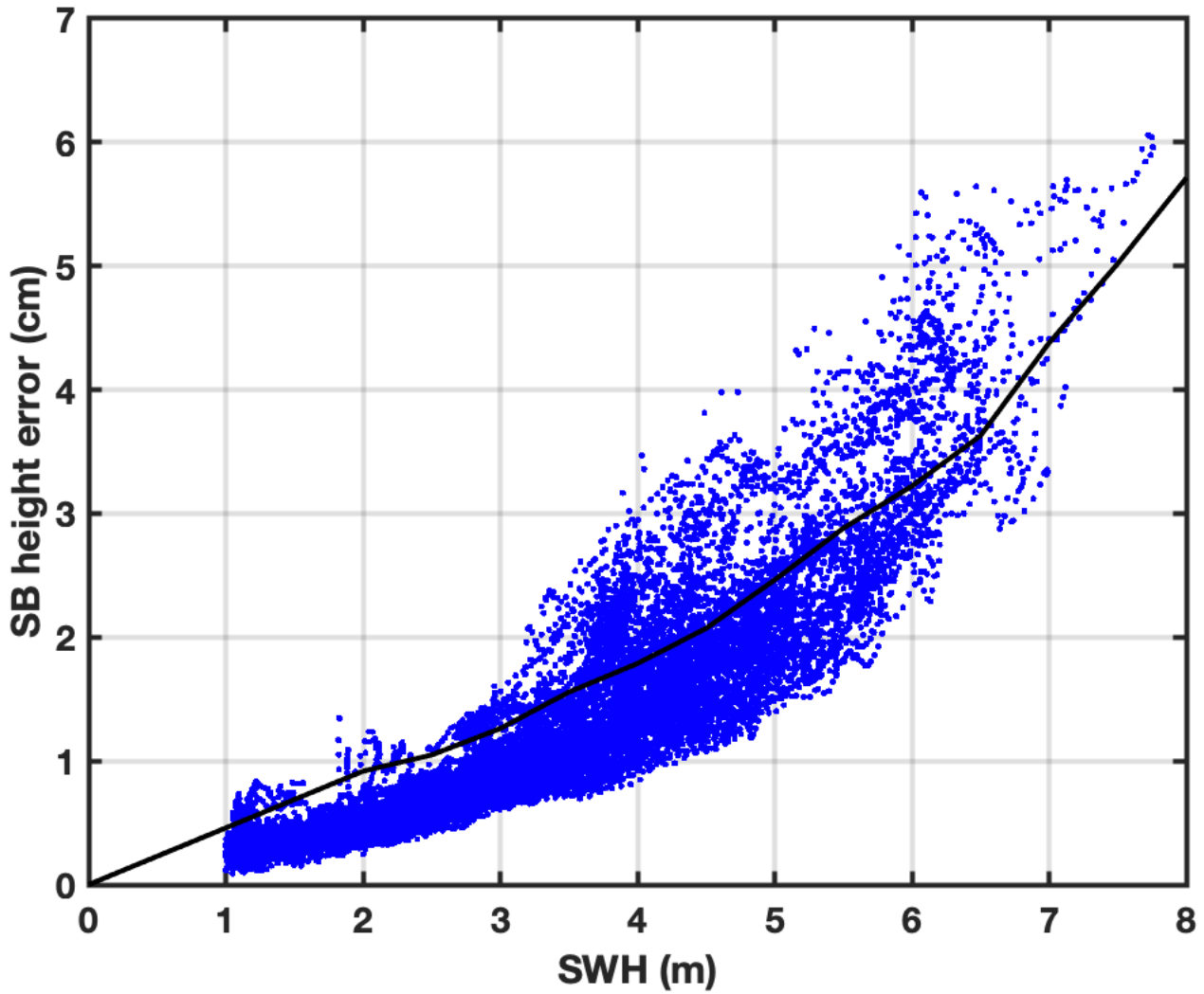
Random error (w/o surf-board) at native 500m resolution

Random error (w/o surf-board) at 7.5km resolution

Surf-board error

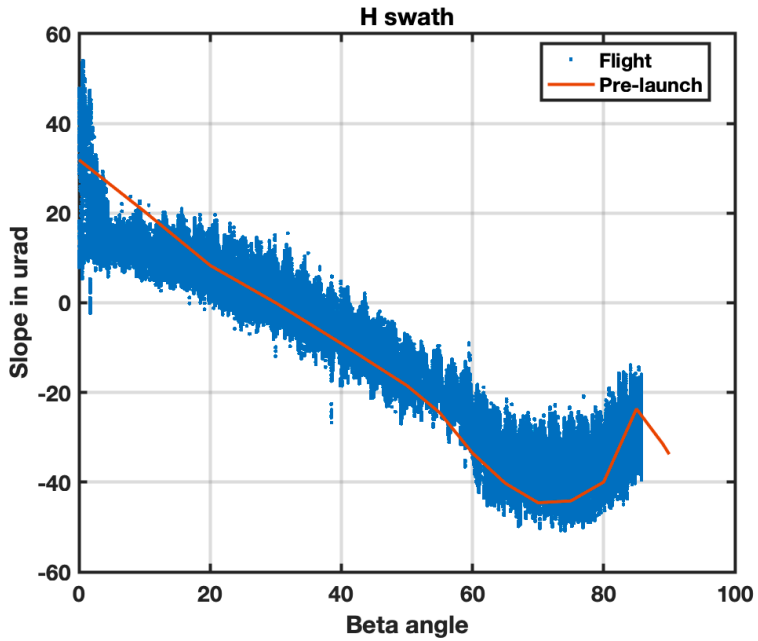
Noise floor requirement is met even at SWH = 6m for this dataset.

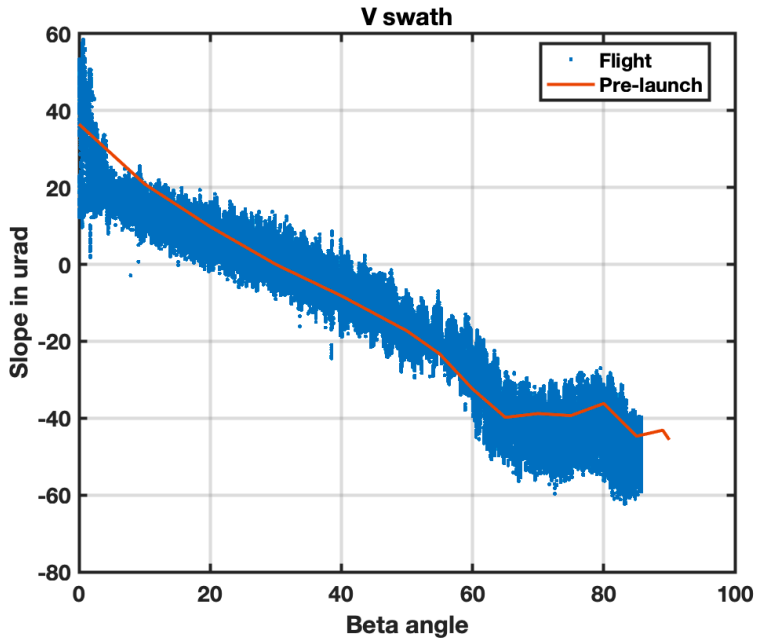
Performance vs. SWH: Surf-board effect



- Excellent match between flight data (circles) and pre-launch model/simulation (solid black).

KaRIn systematic performance

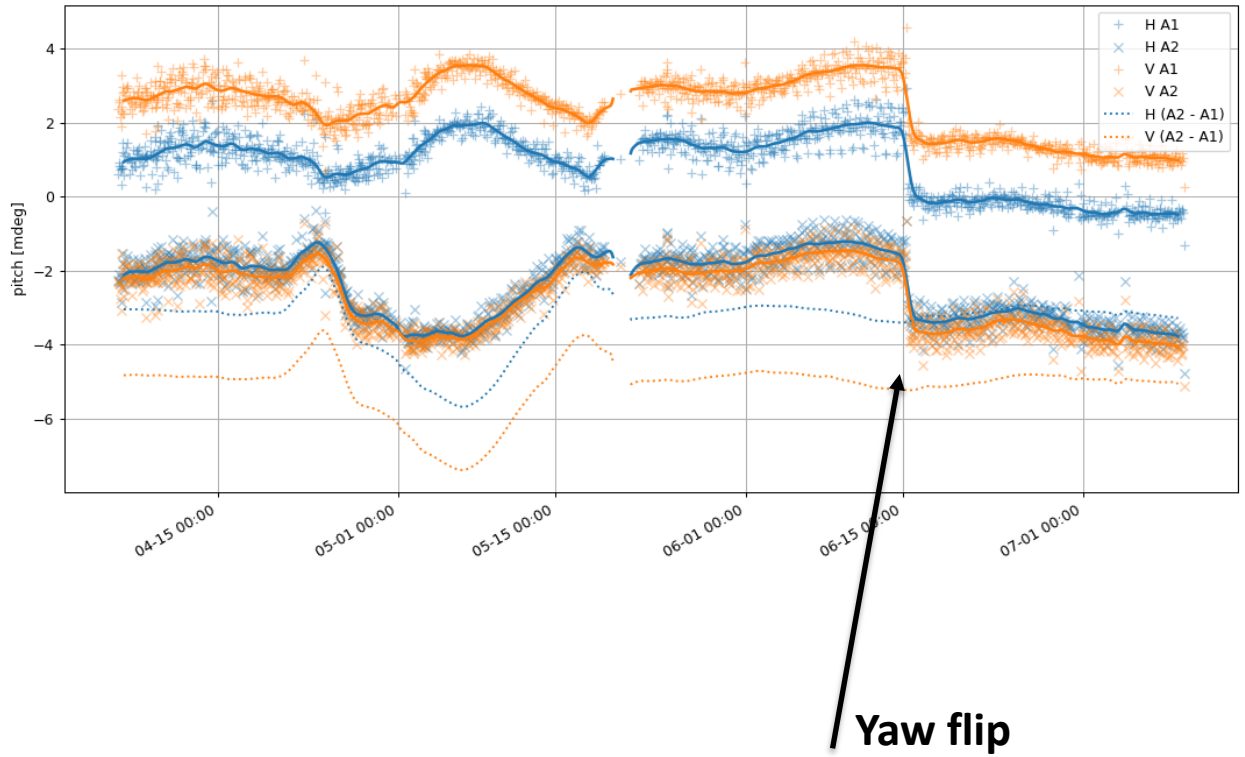


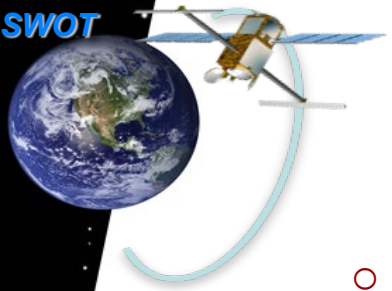


- Height slope as a function of beta angle compared to pre-launch simulations
  - *1 microradian slope = 6 cm height error at 60 km cross-track*
- **Good agreement between expected and measured systematic error performance**
- The stronger orbital variability near beta 0 has been correlated with star tracker thermoelastic distortions

Antenna pointing (pitch and diff pitch)

- Pitch for each antenna (solid) and differential pitch (dotted)
- Variations with beta of +/-3 mdeg and small discontinuity at yaw flip.
- **All pointing performance requirements are met with margin**





Conclusions

- KaRIn SNR is well understood and higher than error budget assumed
- KaRIn pointing requirements met with significant margin
- KaRIn hardware stability is good and is consistent with pre-launch predictions