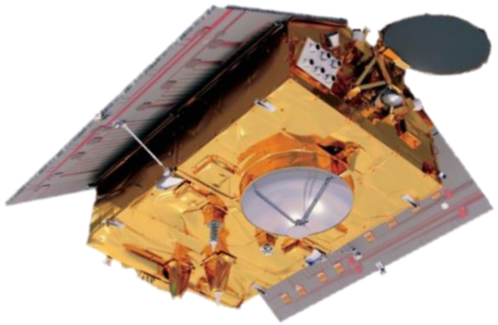
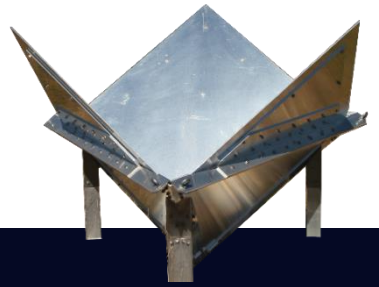


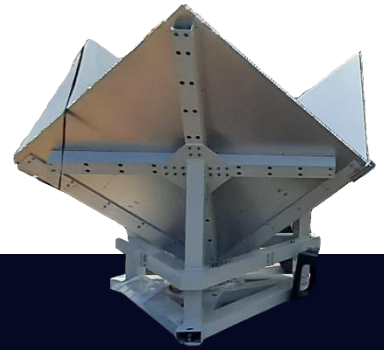
Sentinel-6 Validation Team

SENTINEL-6 PERFORMANCE FROM TRANSPONDER GROUP

A. Garcia-Mondéjar [1], C. Donlon [6], M. Fornari [8], S. Mertikas [2], L. Fioretti [3], A. Flores [1], A. Gómez [1], F. Gibert [1], S. Hernández [1], A. Recchia [3], K. Kokolakis [5], D. Piretzidis [5], E. Ferrer [4], T. Moreau [4], S. Amraoui [4], R. Cullen [6], P. Féménias [7], L. Giulicchi [6], A. Egido [6], M. Scagliola [8], F. Boy [9], C. Maraldi [9], M. Meloni [10], C. Martín-Puig [10], J. D. Desjonqueres [11], R. Scharroo [10], W. Smith [12]

[1] isardSAT, [2] Technical University of Crete, [3] Aresys, [4] CLS, [5] Space Geomatica, [6] ESA/ESTEC, [7] ESA/ESRIN, [8] RHEA for ESA, [9] CNES, [10] EUMETSAT, [11] JPL/CalTech, [12] NOAA

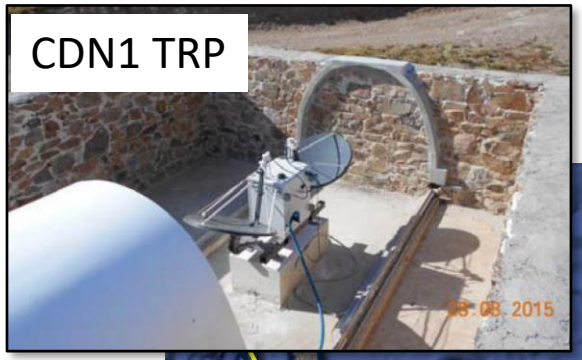


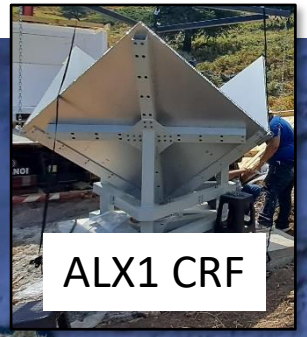


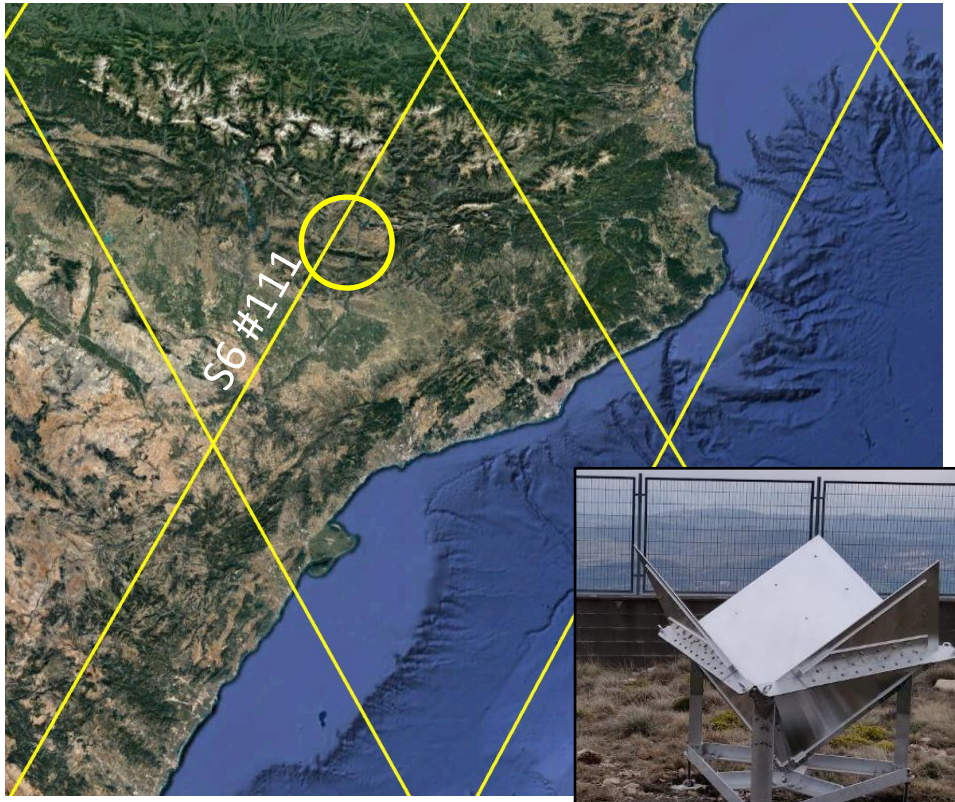
Transponder Group Overview

- S6TPX group was convened by ESA to work openly and collaboratively with transponder specialists (as part of the ESA FRM4S6 project – the ESA contribution to S6 Cal/Val)
- S6TPX group coordinates results with same input data (PDAP & GPP) collected:
  - By different teams,
  - Different independent processing systems,
  - Different statistical analyses,
  - Cal/Val infrastructures (Transponders: CDN1, GVD1, JPL; Corner reflectors)
- Met 31 times in about 3 years,
- Full and open exchange of data, results, processing, corrections etc.,
- Aim of S6TPX group to confirm & monitor Sentinel-6 in flight performance,
- Results on Datation, Range bias and PTR characteristics.

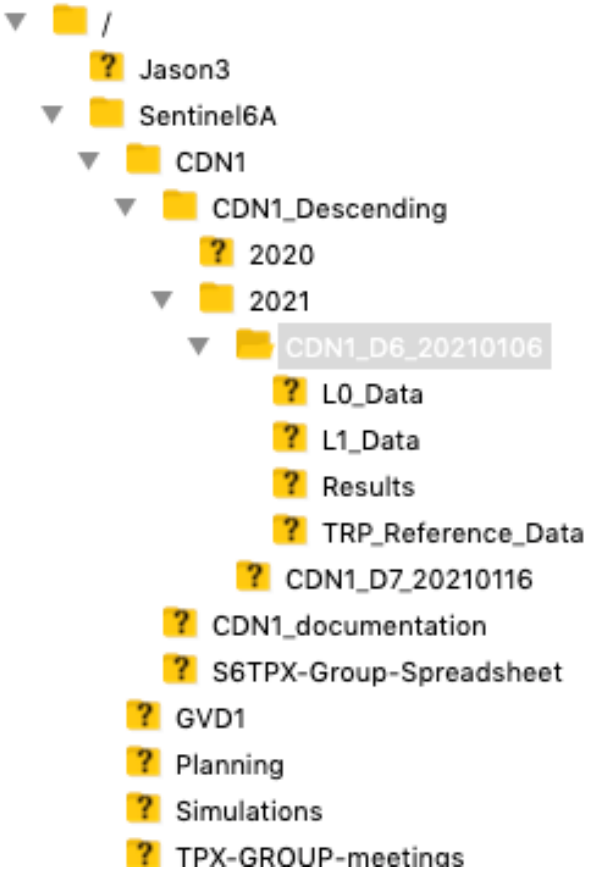
Transponder Group Overview



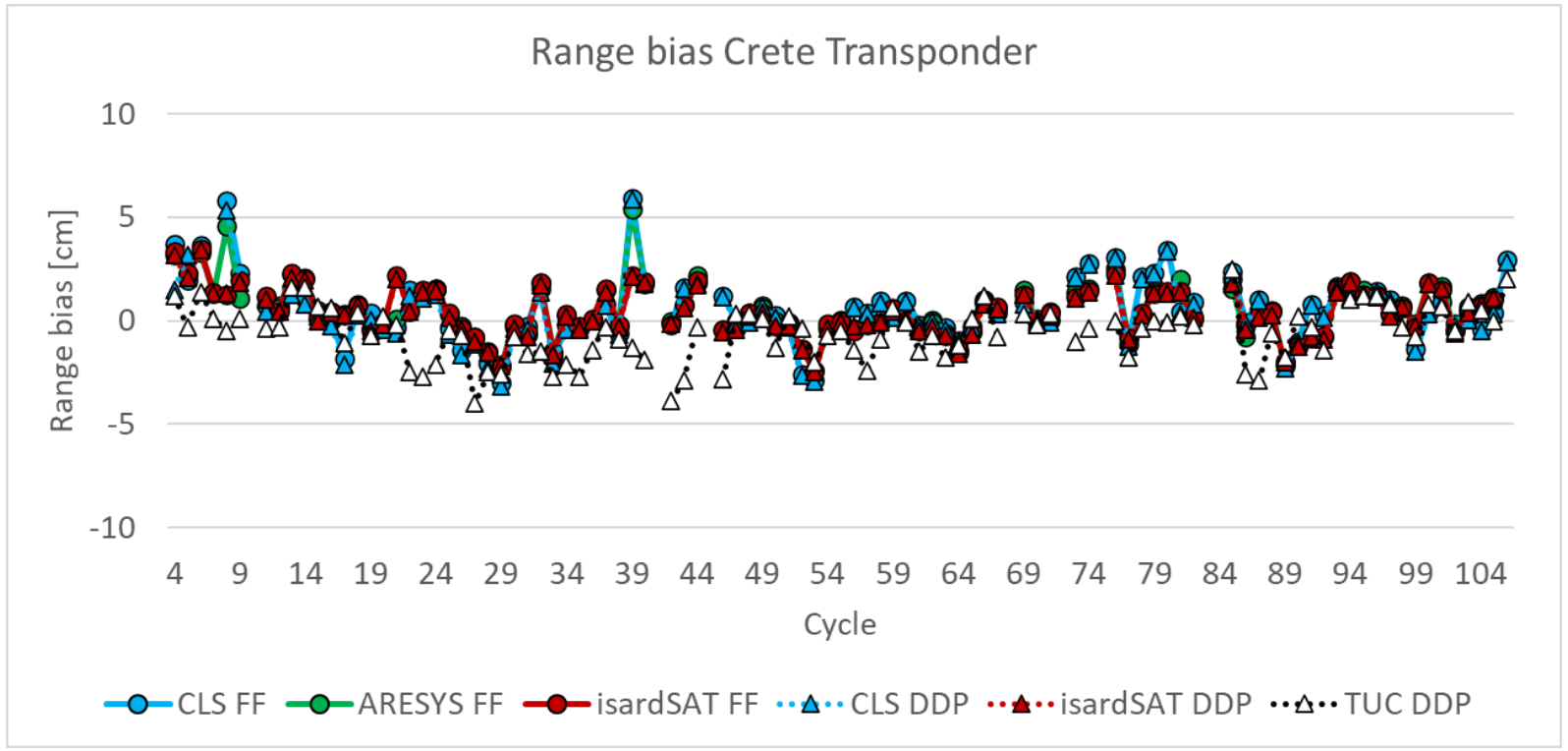




- Input data
  - EUMETSAT PDAP L1A and L2.
  - ESA GPP L1A.
  - Auxiliary data from in-situ equipment.
- Analysis Tools
  - In house dedicated processors (UFSAR, FFSAR)
  - Retrievals



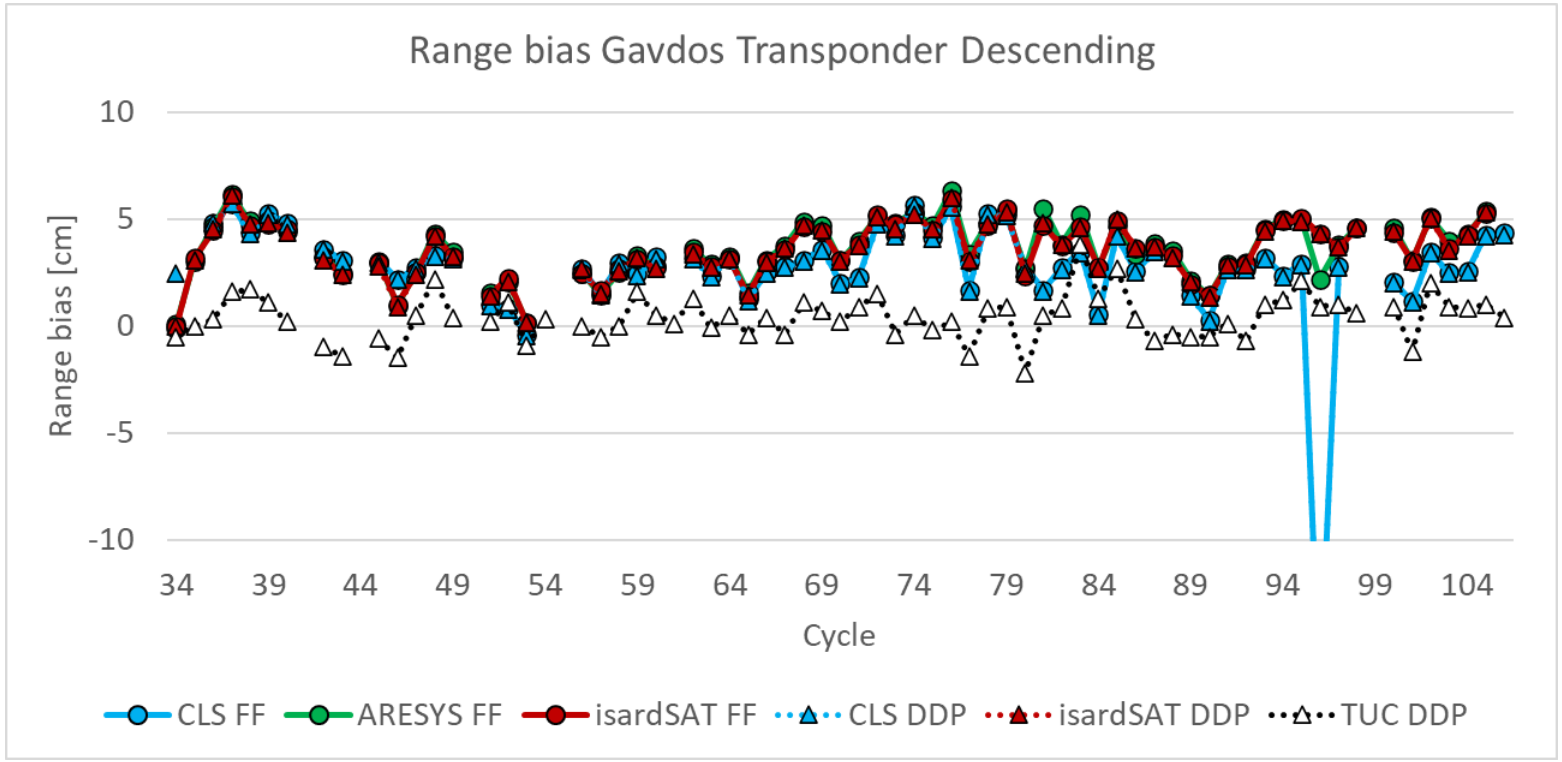
Range results S6 #018



CLS FF	0.57 ± 1.55 cm
CLS DDP	0.39 ± 1.51 cm
isardSAT FF	0.45 ± 1.16 cm
isardSAT DDP	0.38 ± 1.15 cm
ARESYS FF	0.52 ± 1.30 cm
TUC DDP	-0.62 ± 1.28 cm

Very good agreement between processing methods and analysis techniques

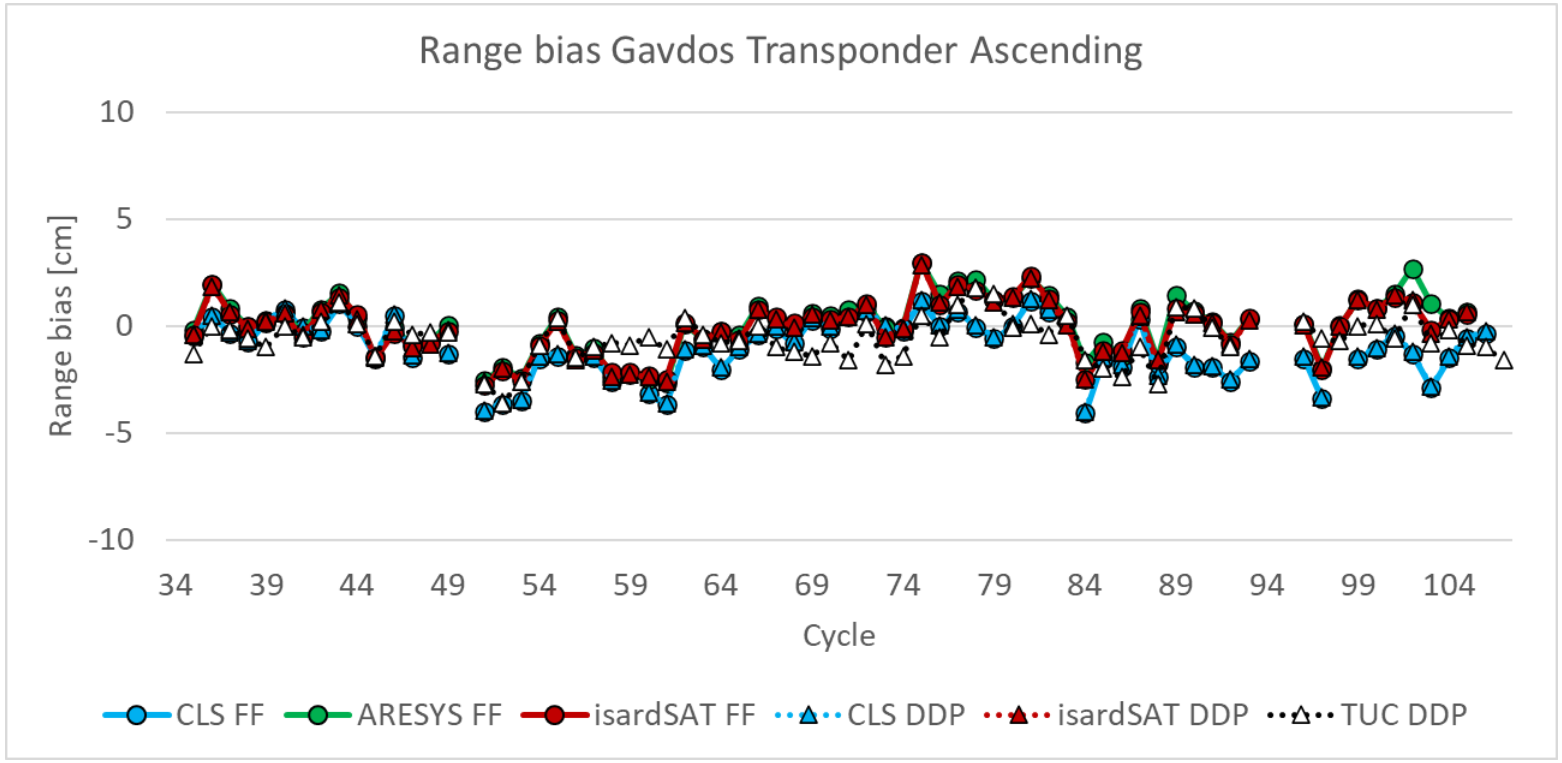
Range results S6 #018



CLS FF	2.96 ± 1.40 cm
CLS DDP	2.95 ± 1.34 cm
isardSAT FF	3.53 ± 1.32 cm
isardSAT DDP	3.51 ± 1.32 cm
ARESYS FF	3.59 ± 1.36 cm
TUC DDP	0.41 ± 1.03 cm

Mismatch between TUC and the rest related to an additional range correction applied to the GVD #1 descending pass

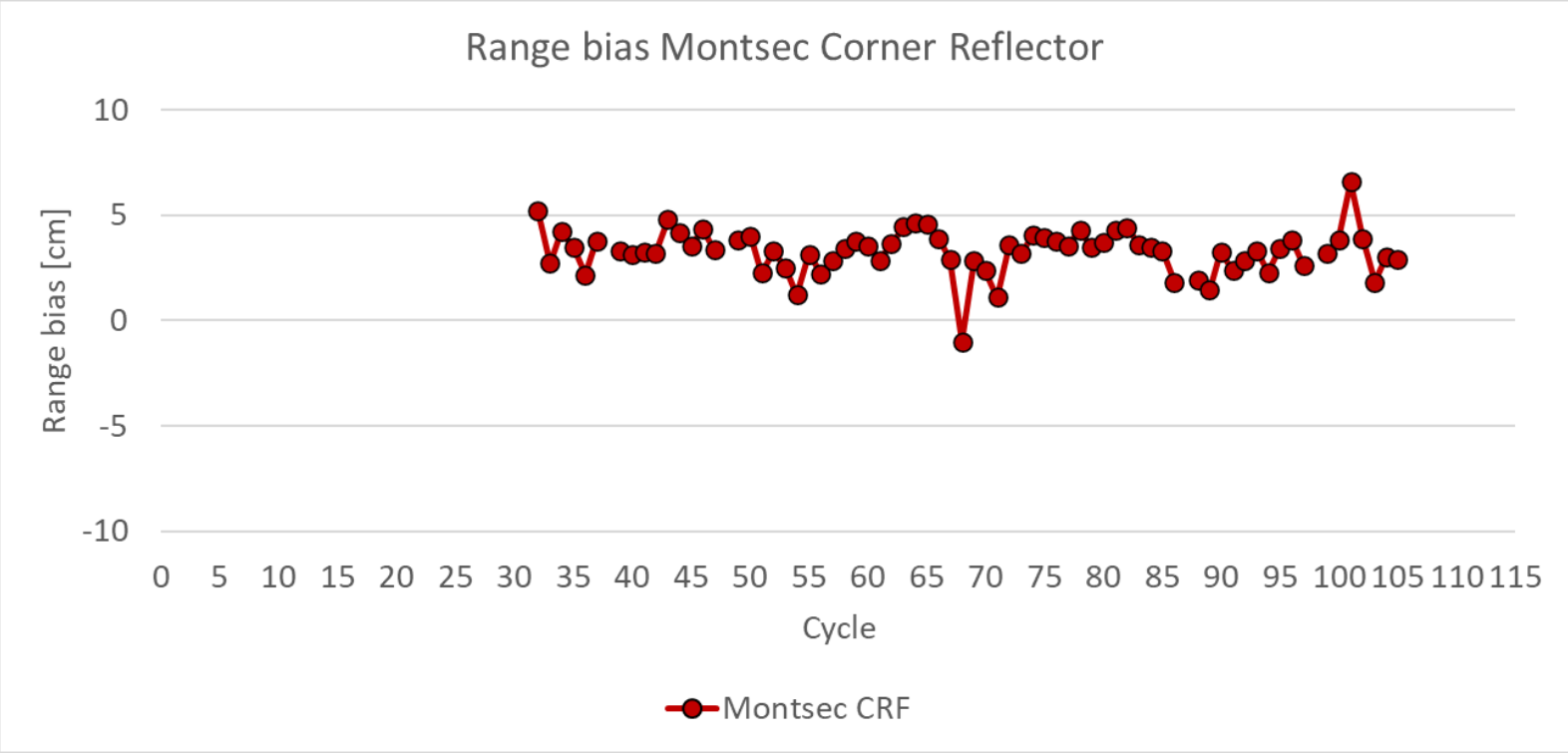
Range results S6 #109

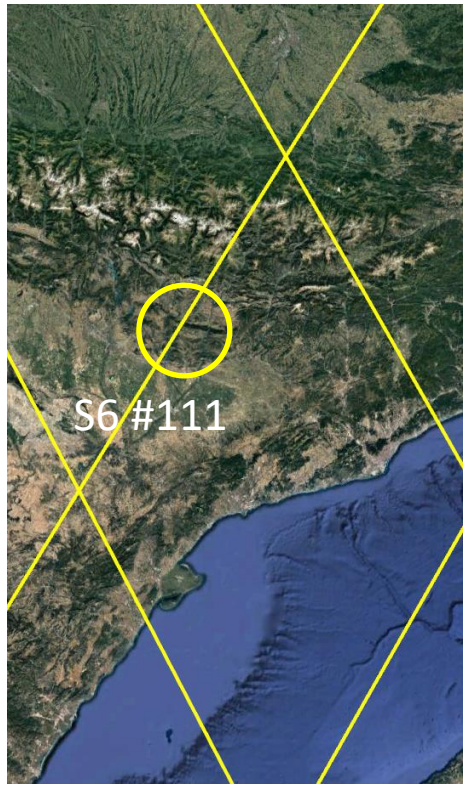


CLS FF	-1.04 ± 1.34 cm
CLS DDP	-0.96 ± 1.34 cm
isardSAT FF	-0.07 ± 1.27 cm
isardSAT DDP	-0.09 ± 1.26 cm
ARESYS FF	0.08 ± 1.32 cm
TUC DDP	-0.56 ± 1.01 cm

Very good agreement between processing methods and analysis techniques

Range results S6 #111

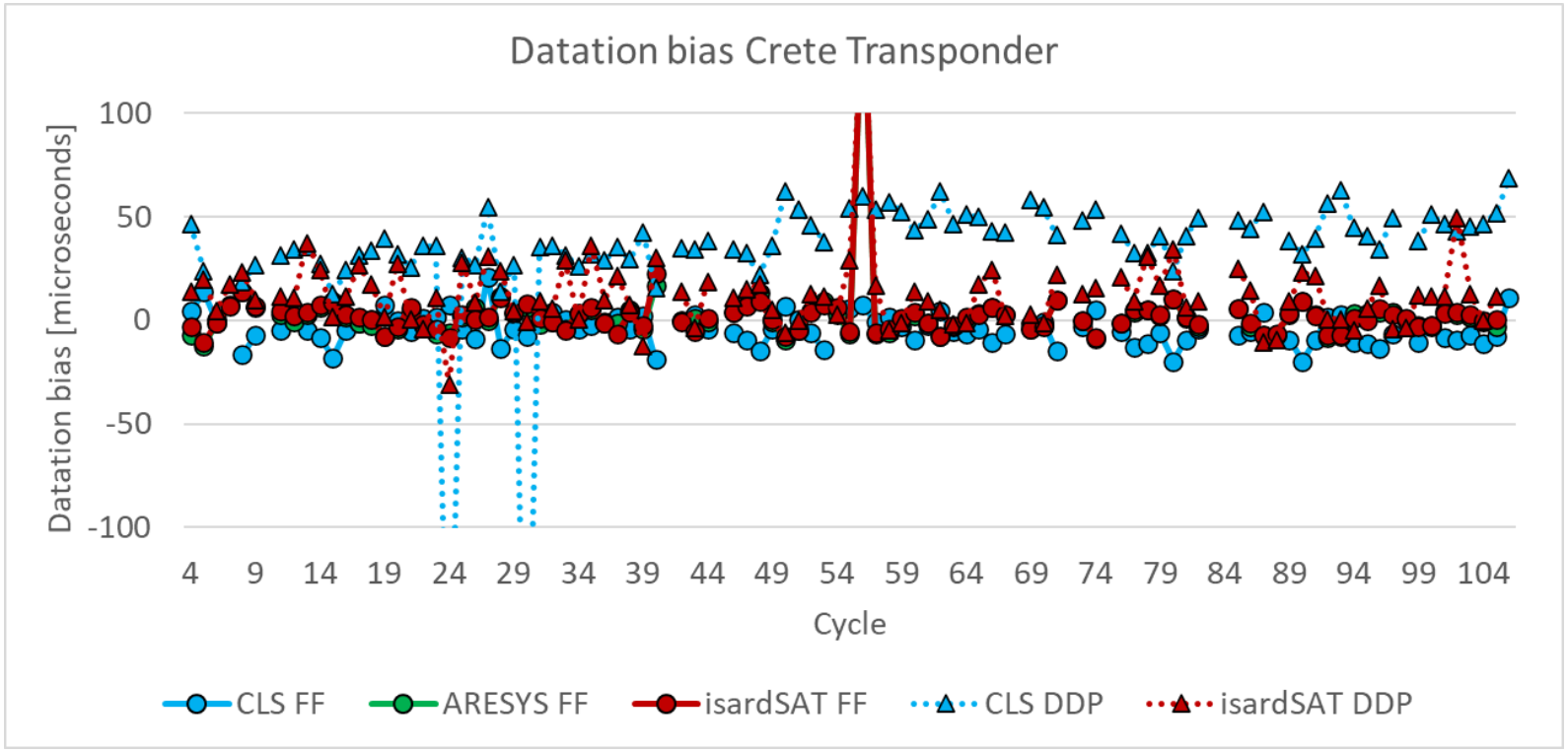




isardSAT FF	3.29 ± 1.07 cm

- Good stability for the Corner Range results
- Overall bias due to preliminary reference height determination

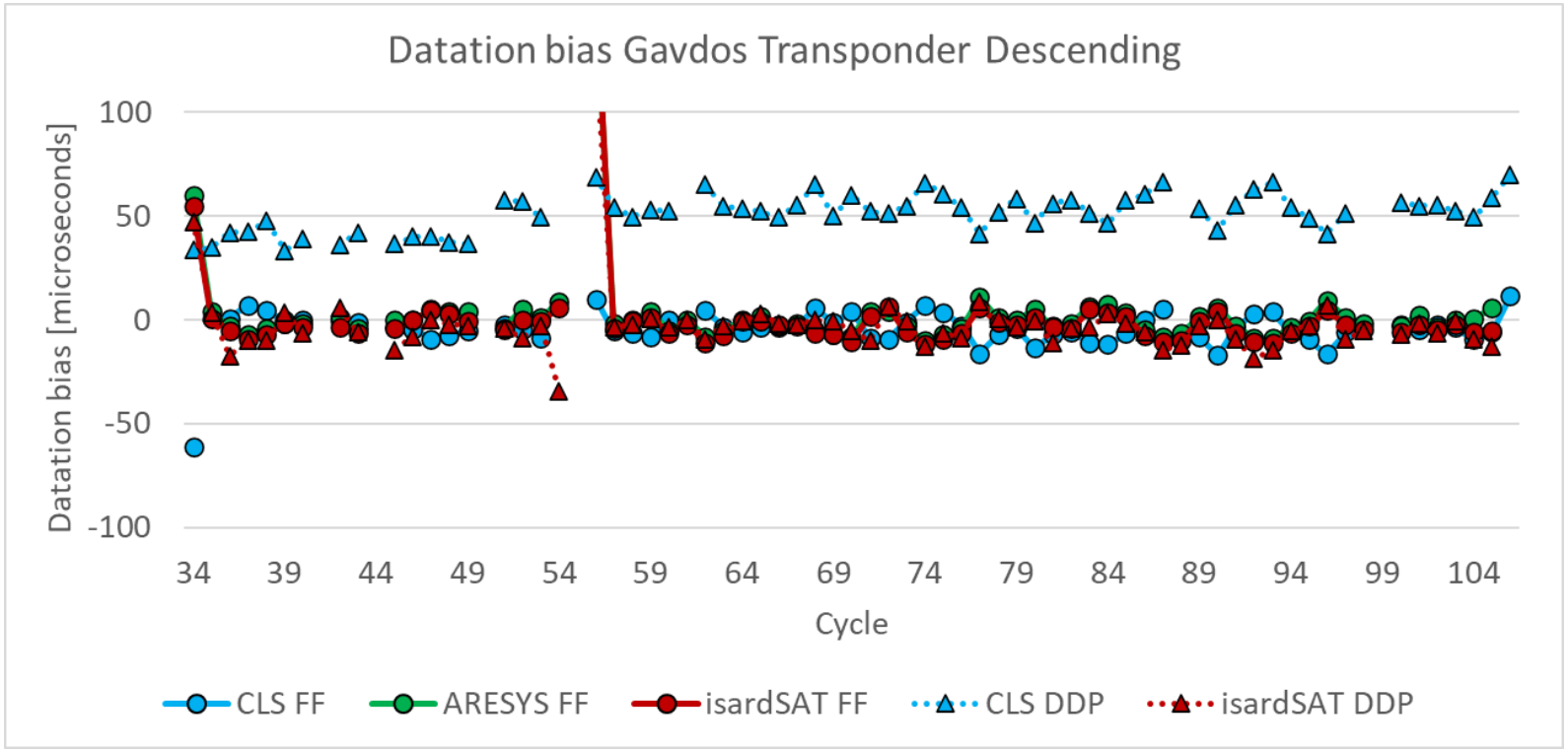
Datation results S6 #018

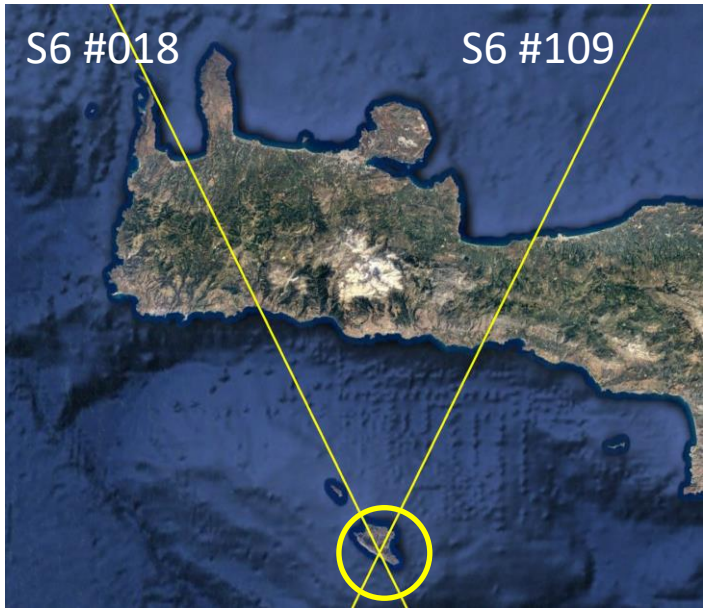


CLS FF	-4.22 ± 7.23 µs
CLS DDP	40.04 ± 11.77 µs
isardSAT FF	1.15 ± 5.60 µs
isardSAT DDP	11.22 ± 12.62 µs
ARESYS FF	0.76 ± 5.65 µs

Datation requirement < 100µs ☑

Datation results S6 #018

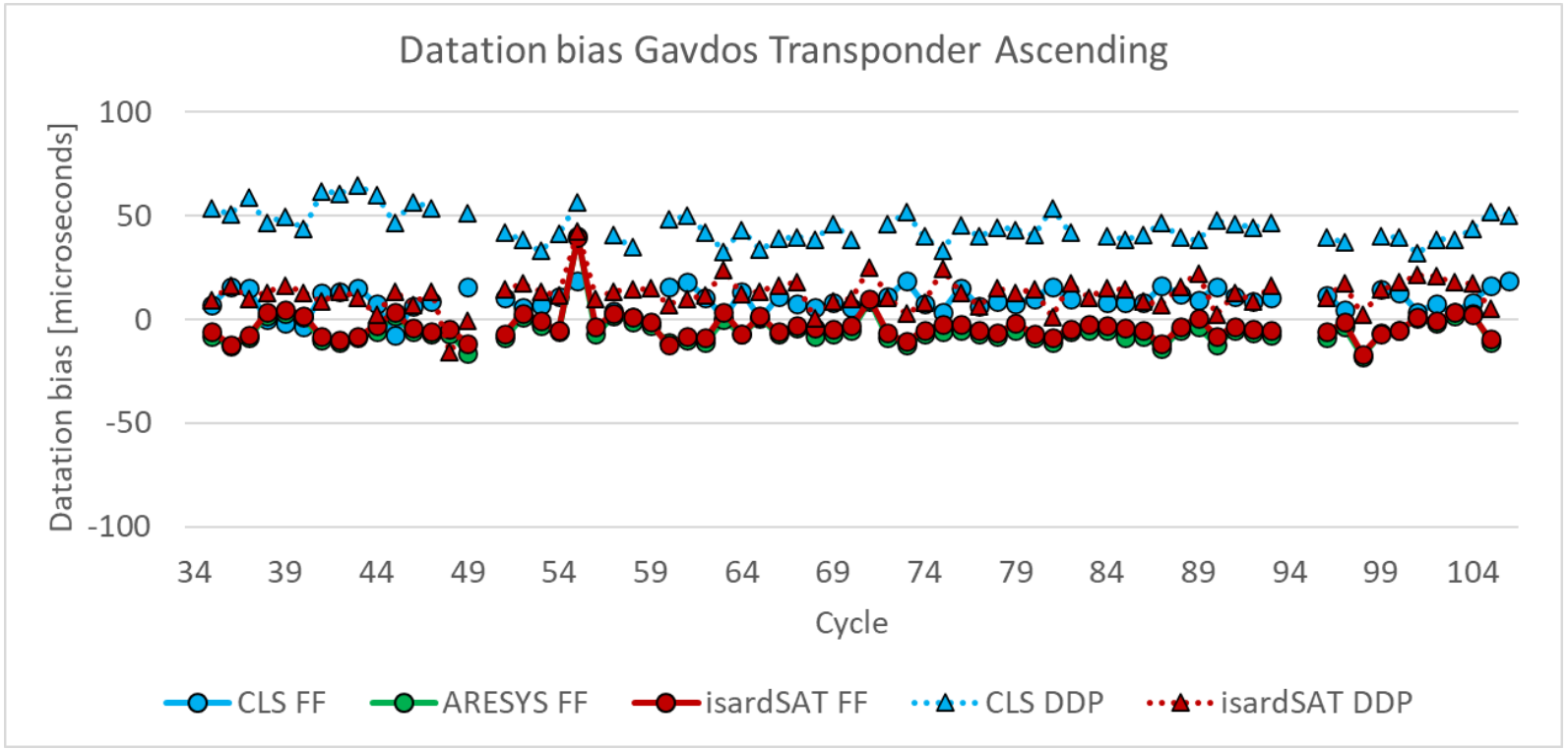


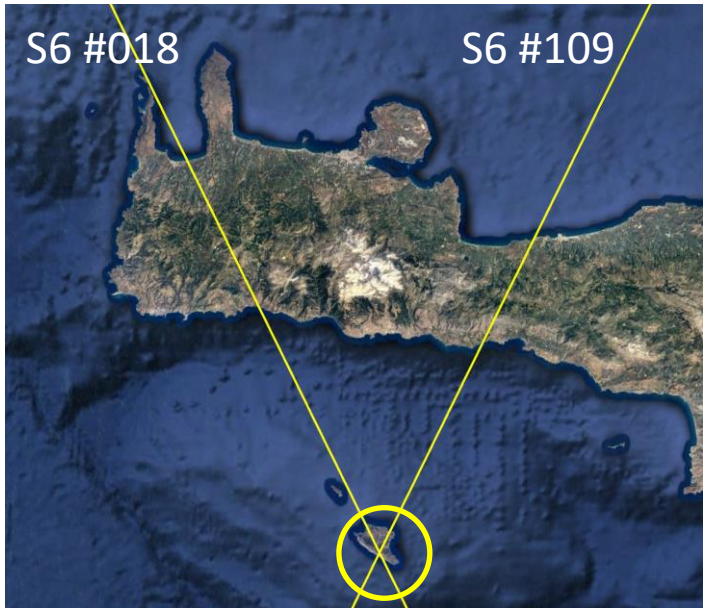


CLS FF	-3.47 ± 6.07 µs
CLS DDP	51.60 ± 9.09 µs
isardSAT FF	-3.07 ± 4.65 µs
isardSAT DDP	-4.88 ± 6.88 µs
ARESYS FF	-0.63 ± 4.85 µs

Datation requirement < 100µs ☑

Datation results S6 #109

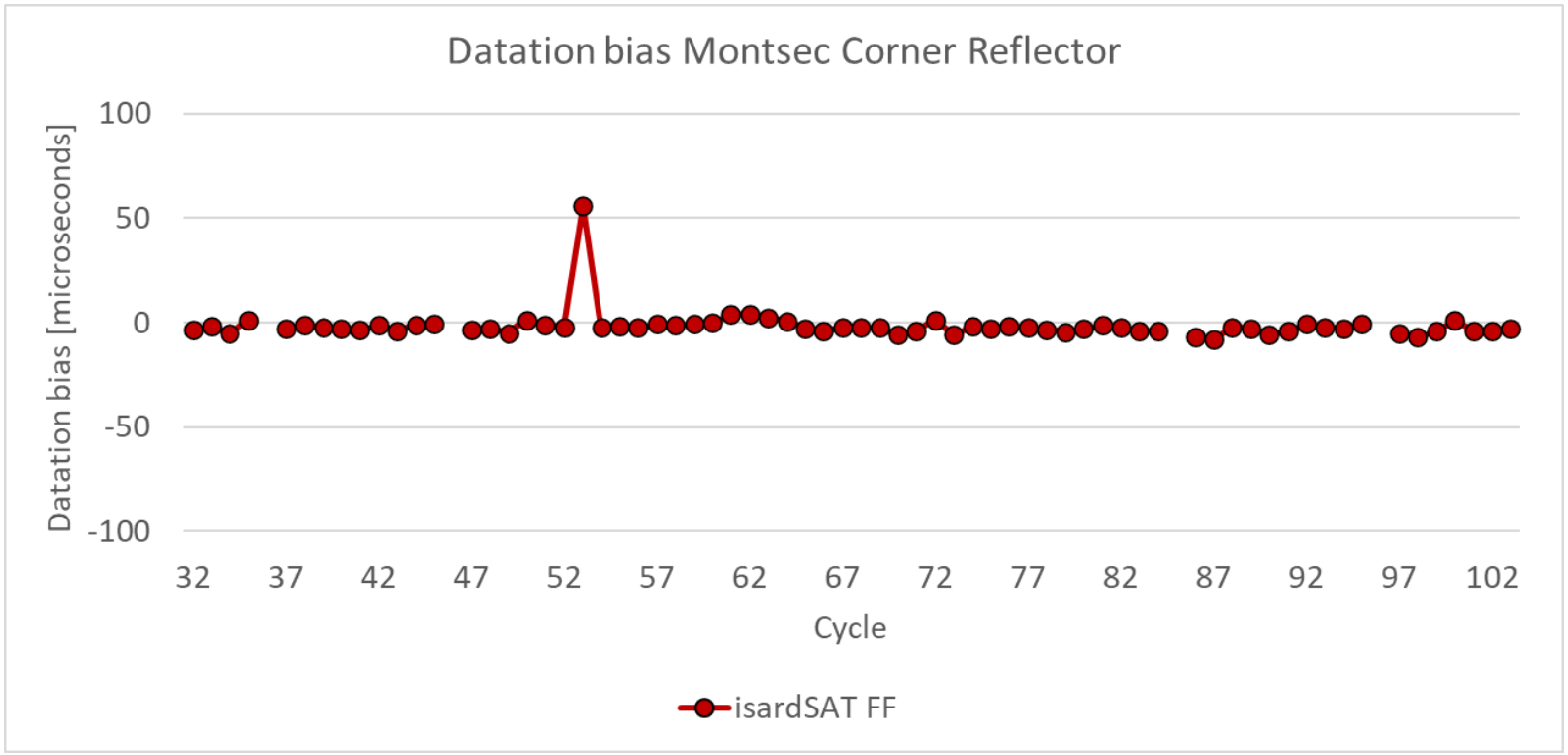


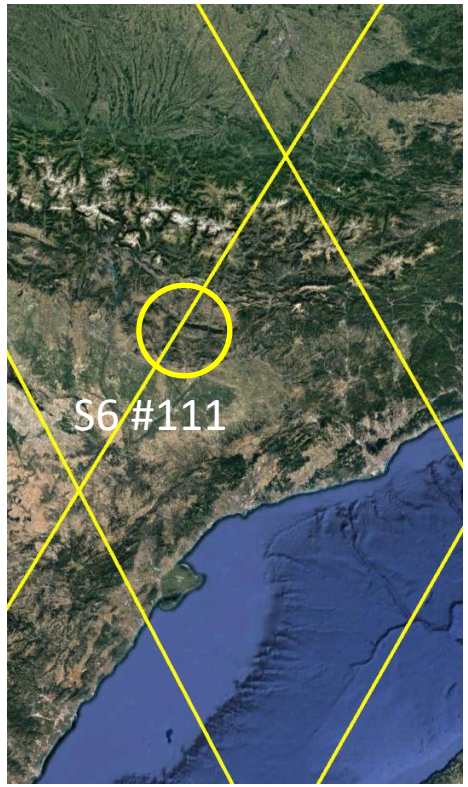


CLS FF	9.15 ± 5.54 µs
CLS DDP	44.65 ± 7.63 µs
isardSAT FF	-4.02 ± 4.81 µs
isardSAT DDP	12.01 ± 6.60 µs
ARESYS FF	-5.88 ± 4.90 µs

Datation requirement < 100µs ☑

Datation results S6 #111

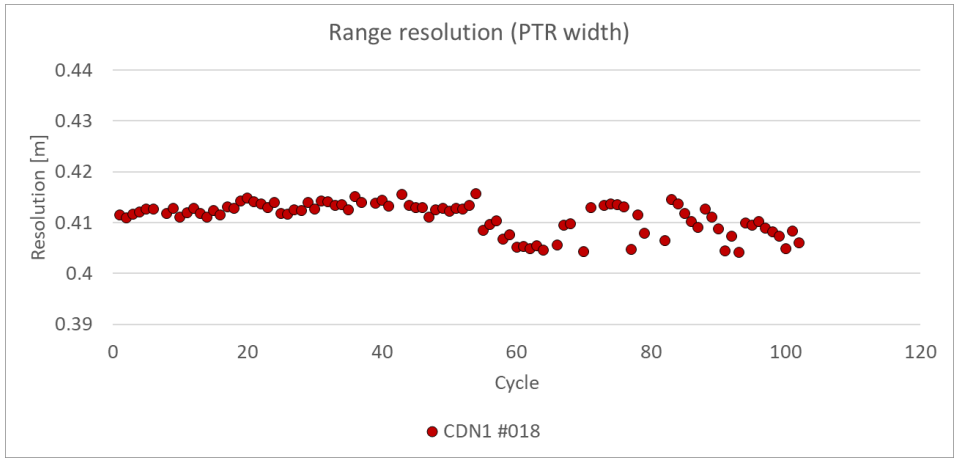




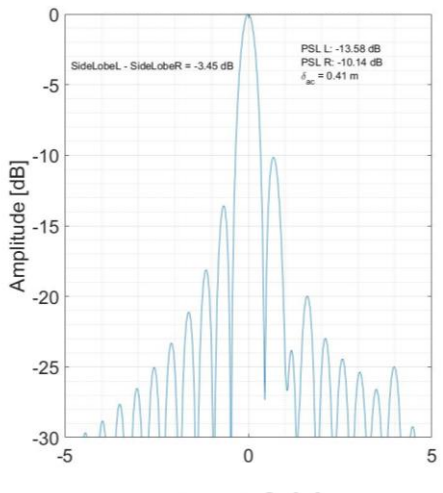
isardSAT FF	-2.44 ± 3.31 µs

Datation requirement < 100µs ☑

Range resolution (PTR width) results

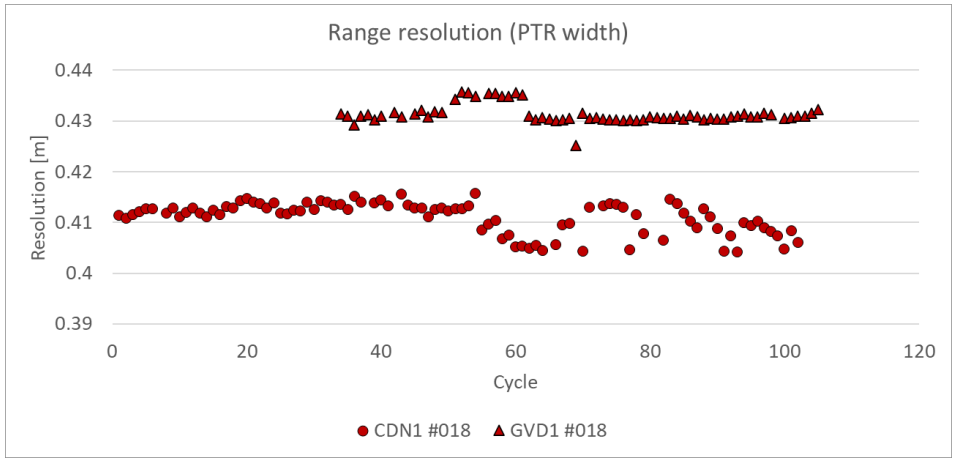


CDN1 #018	41.1 ± 3.1 mm

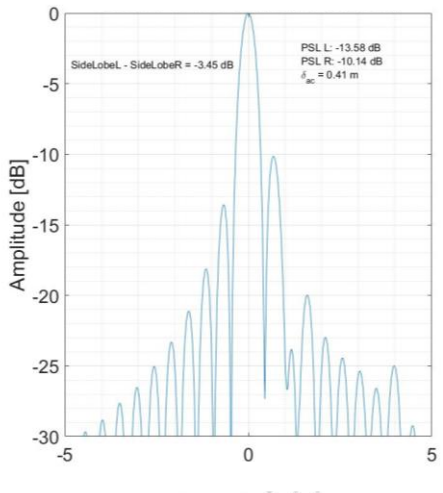


CDN1 #018

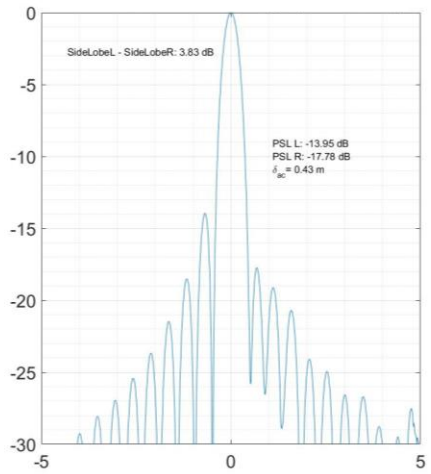
Range resolution (PTR width) results



CDN1 #018	41.1 ± 3.1 mm
GVD1 #018	43.1 ± 1.8 mm

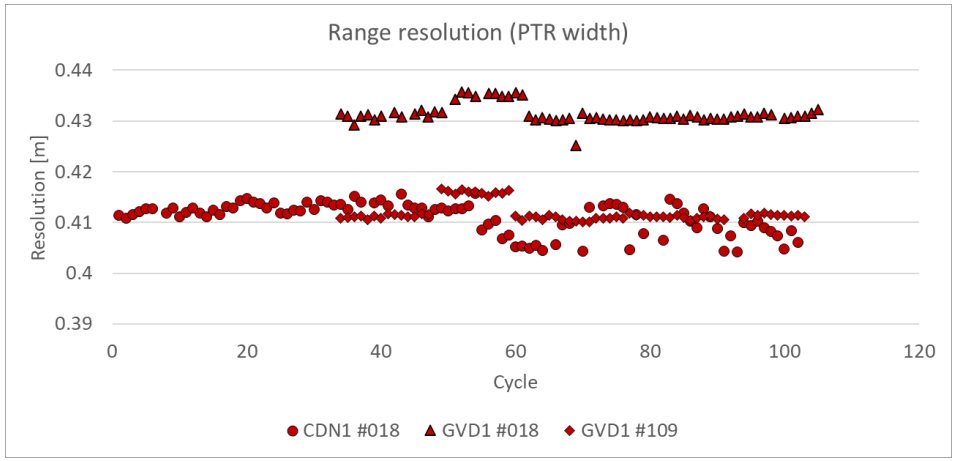


CDN1 #018

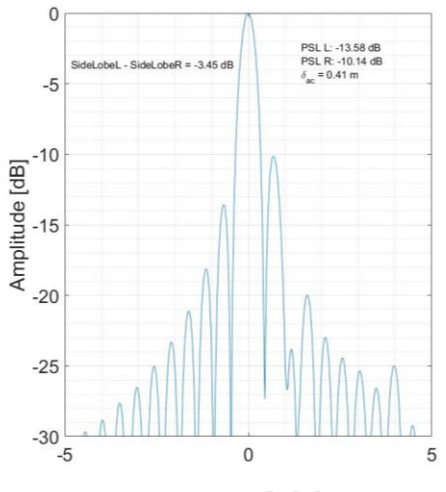


GVD1 #018

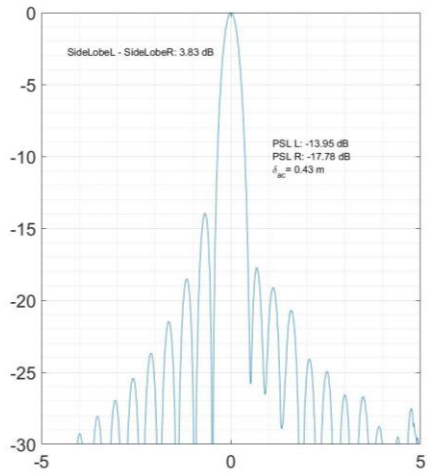
Range resolution (PTR width) results



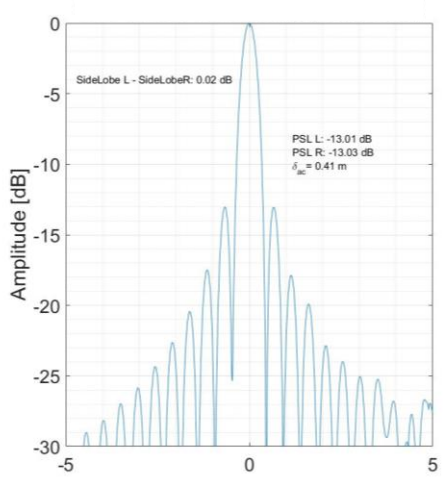
CDN1 #018	41.1 ± 3.1 mm
GVD1 #018	43.1 ± 1.8 mm
GVD1 #109	41.2 ± 1.9 mm



CDN1 #018

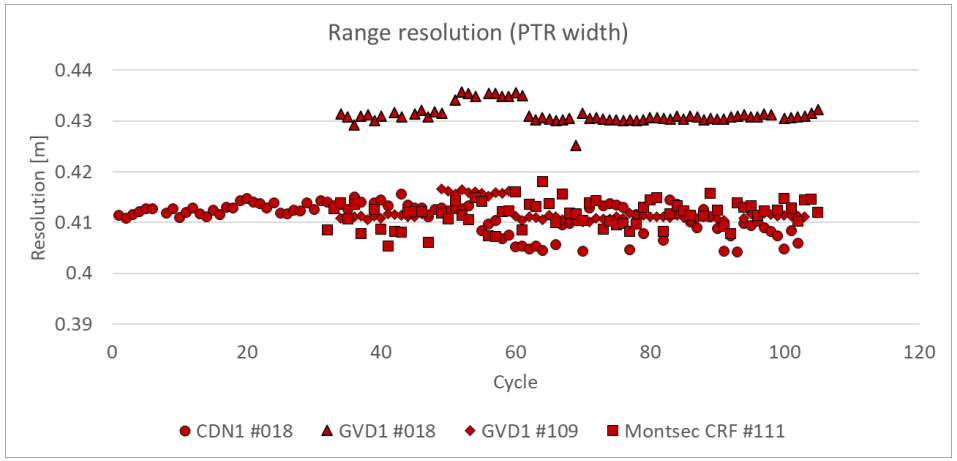


GVD1 #018

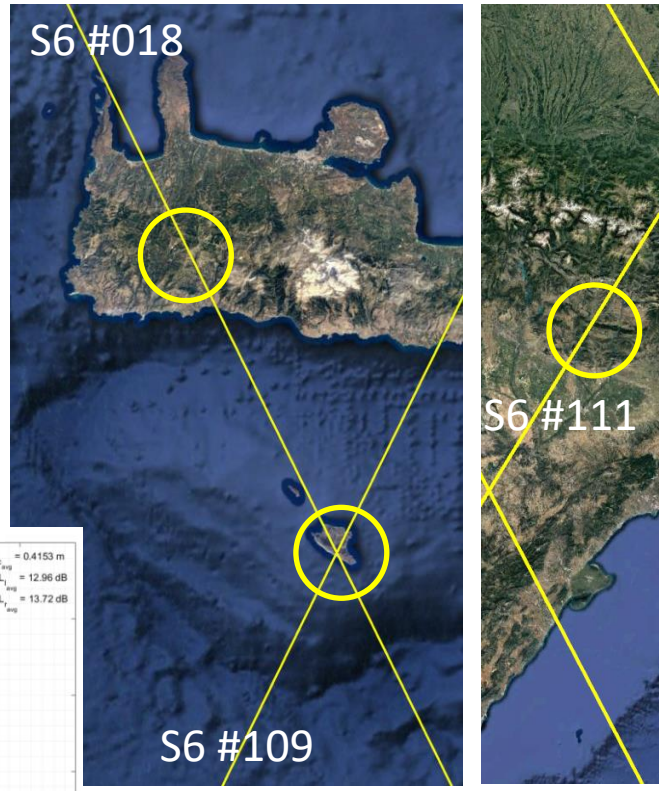


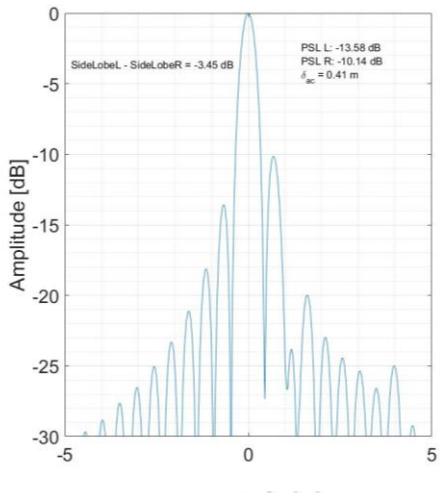
GVD1 #109

Range resolution (PTR width) results

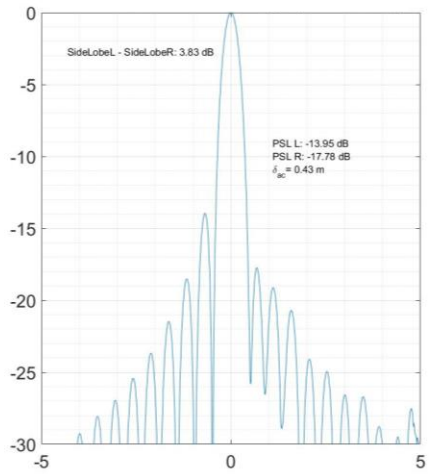


CDN1 #018	41.1 ± 3.1 mm
GVD1 #018	43.1 ± 1.8 mm
GVD1 #109	41.2 ± 1.9 mm
Montsec CRF #111	41.1 ± 2.5 mm

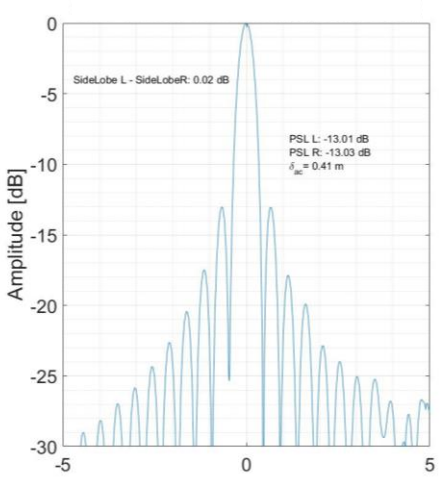




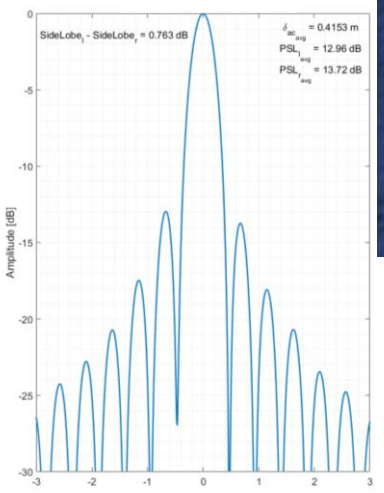
CDN1 #018



GVD1 #018

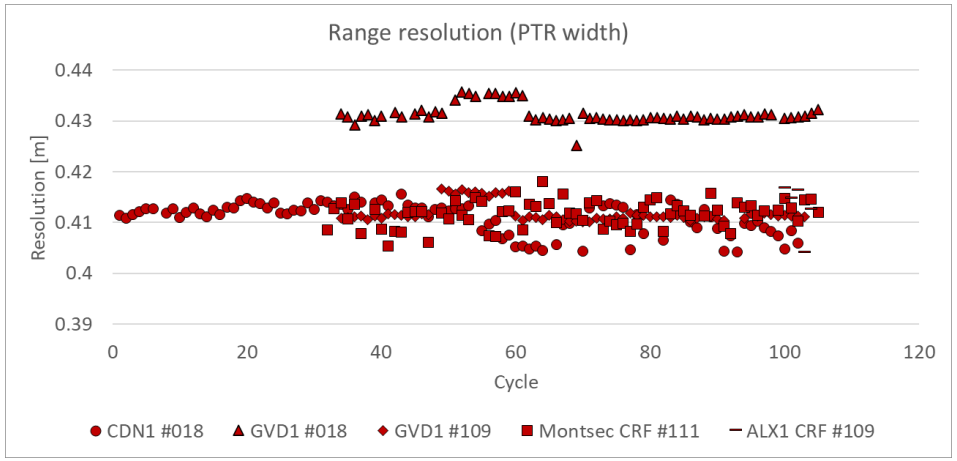


GVD1 #109

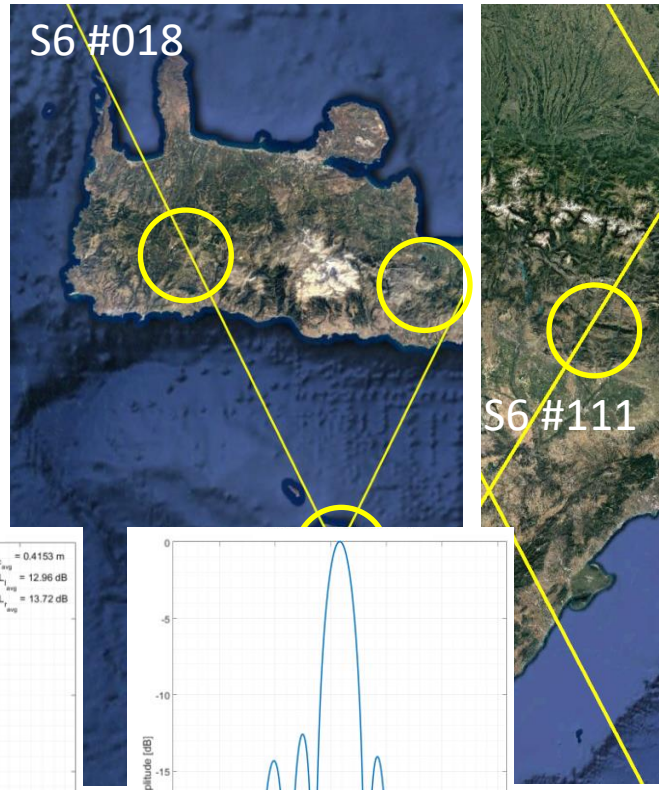


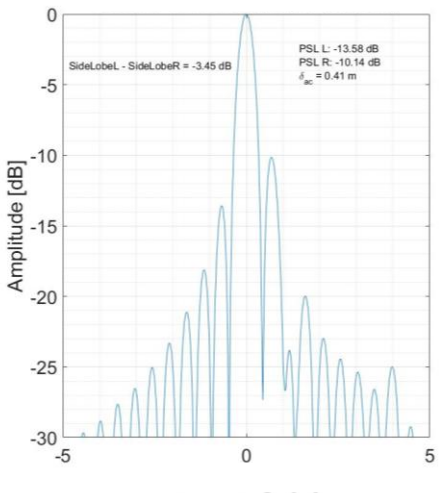
Montsec CRF #111

Range resolution (PTR width) results

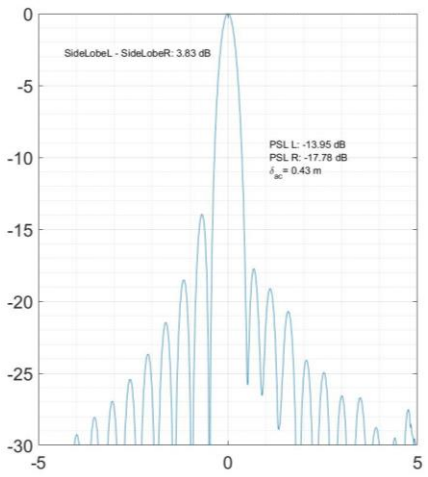


CDN1 #018	41.1 ± 3.1 mm
GVD1 #018	43.1 ± 1.8 mm
GVD1 #109	41.2 ± 1.9 mm
Montsec CRF #111	41.1 ± 2.5 mm
ALX1 CRF #109	41.5 ± 6.7 mm

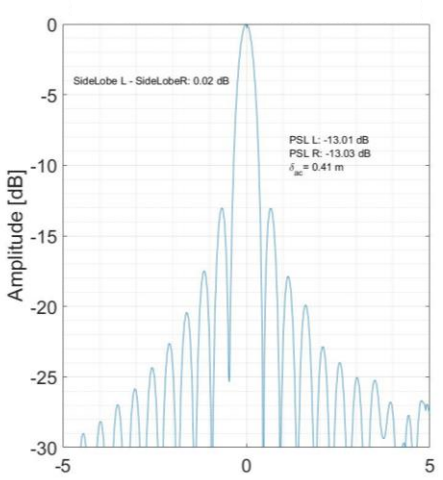




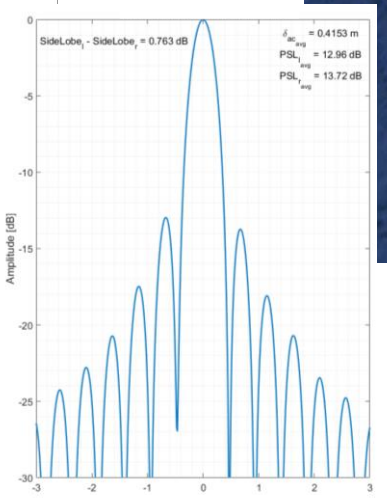
CDN1 #018



GVD1 #018



GVD1 #109

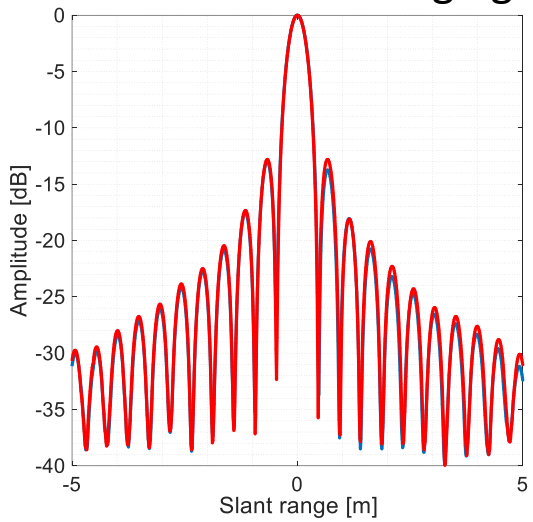


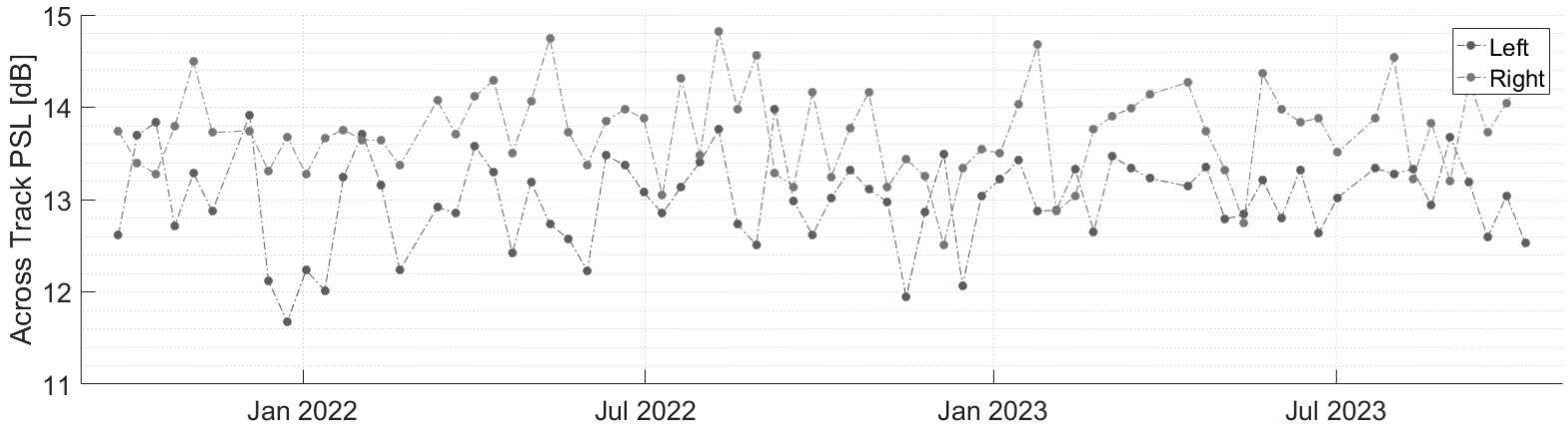
Montsec CRF #111

ALX1 CRF #109

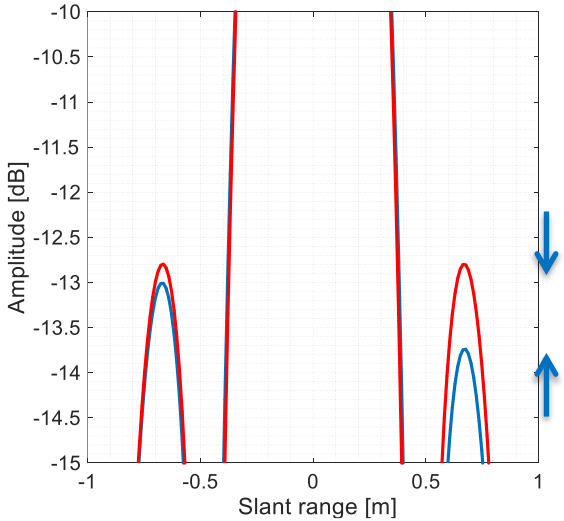
Range resolution (PTR width) results

Montsec CRF averaging all passes





0.73 dB

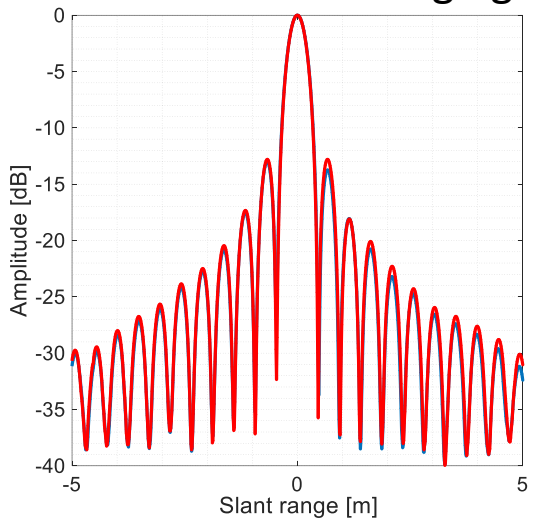


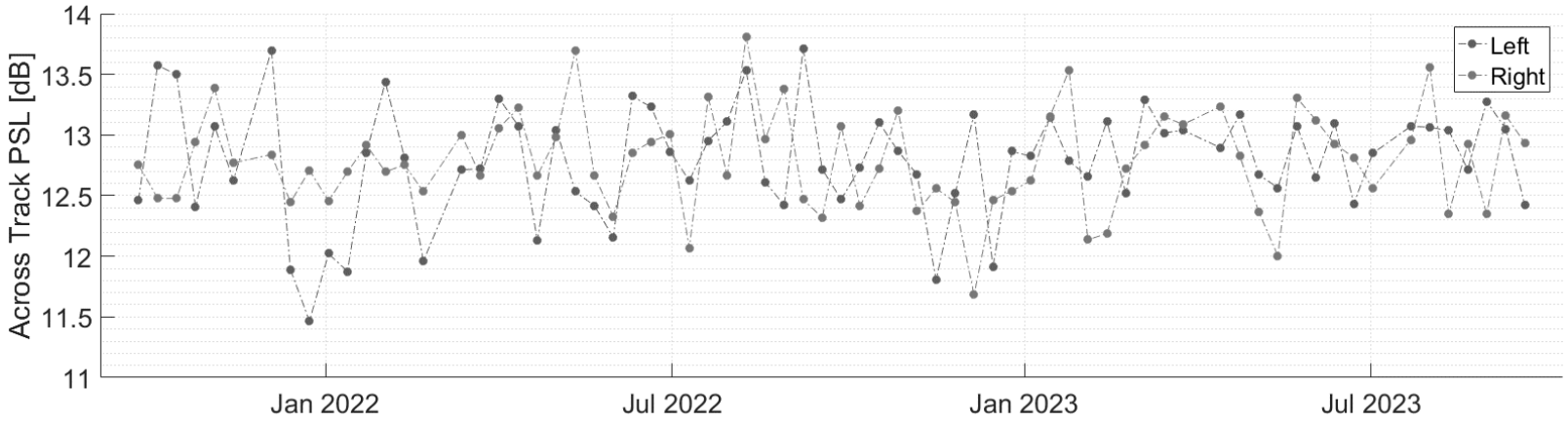
0.73 dB

Similar asymmetry provided in the pre-launch POS-4 antenna characterisation done by Thales

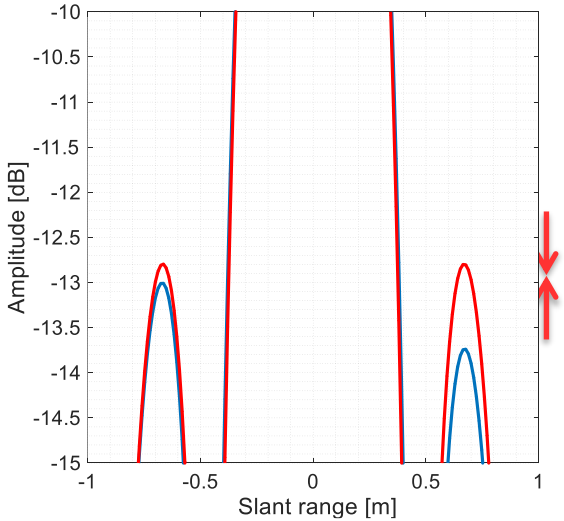
Range resolution (PTR width) results

Montsec CRF averaging all passes





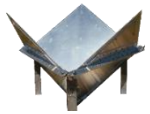
0.01 dB



0.01 dB

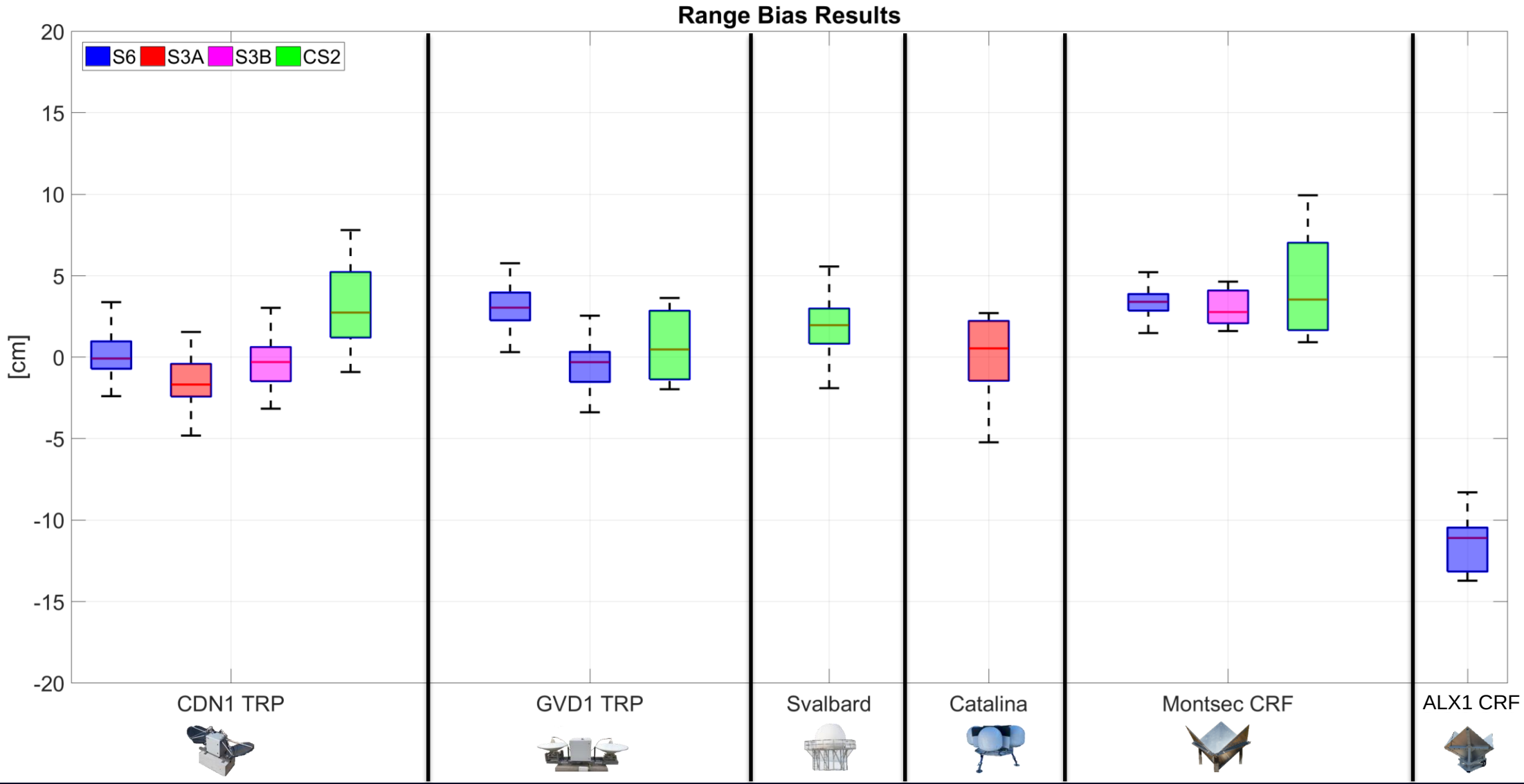
The asymmetry is reduced to residual values after applying the correction designed by S. Dinardo (see poster S6VT2023_001)

Comparison between missions

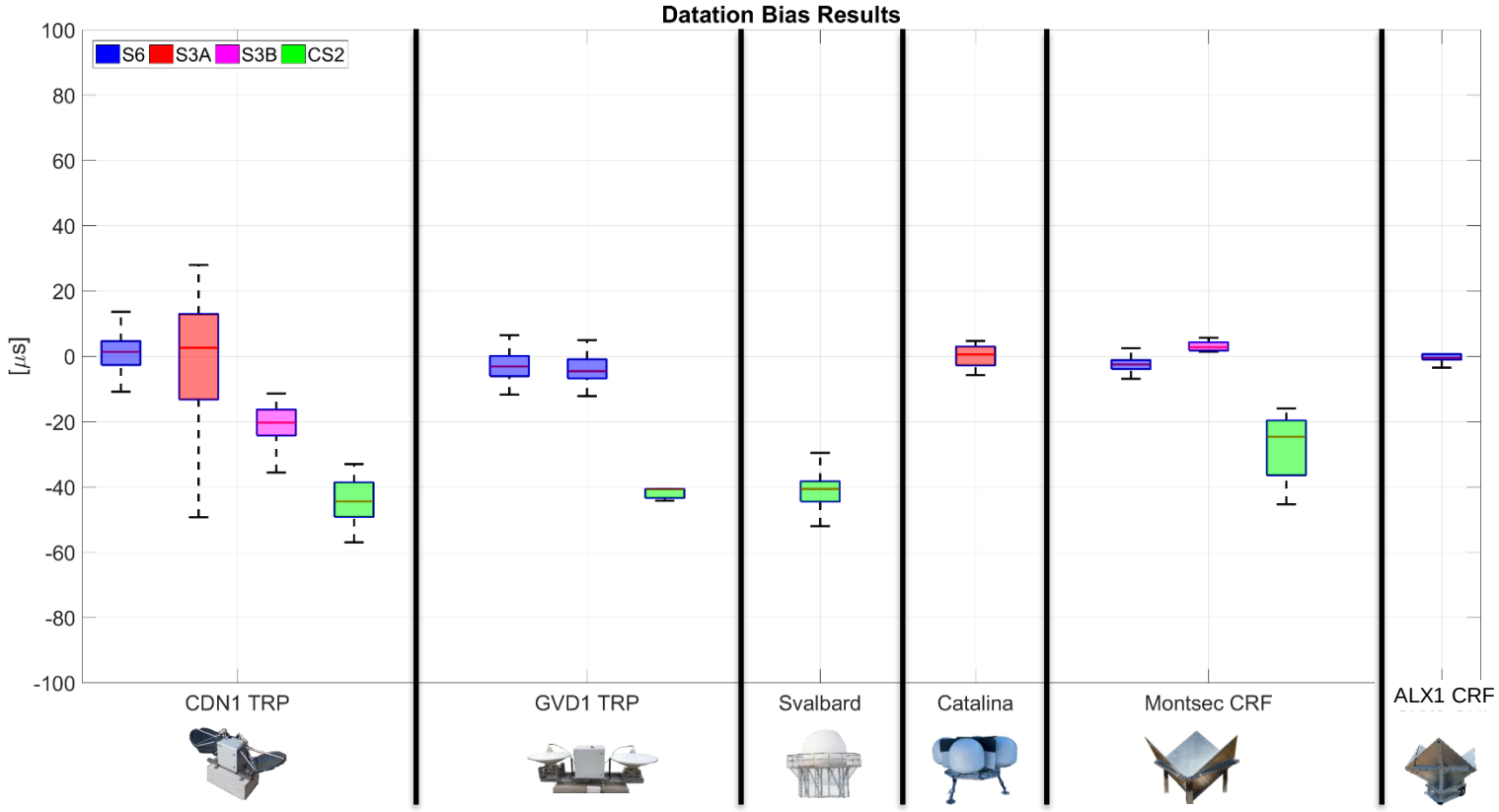
	 CDN1				 GVD1			 Svalbard	 Leonessa		 Catalina			 Montsec[3]			 ALX1[3]
	S6	**S3A**	**S3B**	**CS2**	**S6 D.** [2]	**S6 A.**	**CS2**	**CS2**	**S3A**	**S3B**	**S6-Ku**	**S6 -C**	**S3A**	**S6**	**S3B**	**CS2**	**S6**
Range Bias [cm]	0.45	-1.45	-0.39	2.87	3.53	-0.07	4.79	1.79	--	--	-2.5[4]	-0.3[4]	--	3.29	3.08	3.05	-11.32
Range STD [cm]	1.16	1.54	1.66	2.26	1.32	1.27	2.09	2.09	--	--	0.68	1.98	1.82	1.07	1.08	2.16	1.82
Datation Bias [µs]	1.15	2.54	-19.87	-44.20	-3.07	-4.02	-41.6	-41.6	--	--	19	-36	--	-2.44	2.48	-31.90	248.5
Datation STD [µs]	5.60	18.10	16.59	7.22	4.65	4.81	5.16	5.16	--	--	3.6	107	16.56	2.31	1.13	3.57	2.60
Sigma0 [dB]	--	--	--	--	--	--	--	--	-3.05	-0.20	--	--	--	0.89	1.10	--	--
Sigma0 STD [dB]	--	--	--	--	--	--	--	--	0.60	0.45	--	--	--	0.37	0.34	--	0.56
#Passes	94	91	64	27	67	68	3[1]	74[1]	8	7	40		10	70	8	5[1]	9

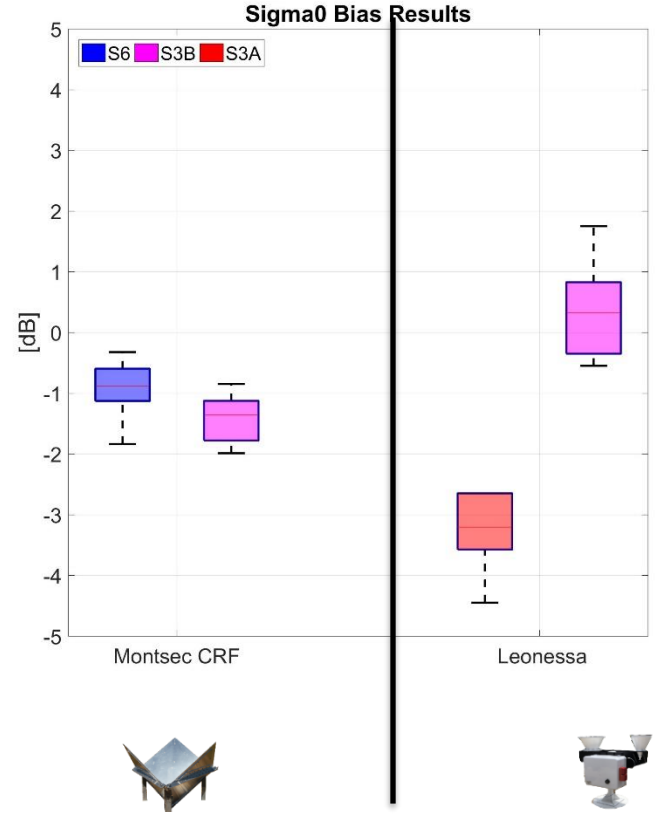
[1]Only SAR passes included for CS2, no SARIn
[2]Asymmetry observation
[3]Preliminary reference height determination
[4] Referenced to Jason-3

Comparison between missions



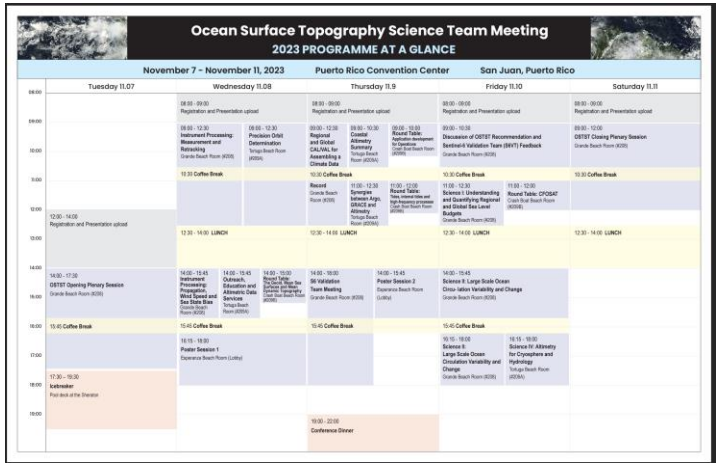
Comparison between missions





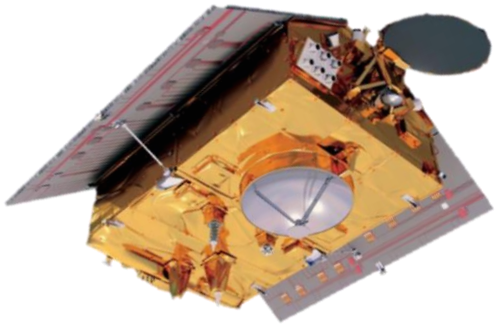
Related talks and posters at OSTST 2023

- The ESA Permanent Facility for Altimetry Calibration in Crete: Advanced Services and Results
  - Thu, 09:45-10:00 S. Mertikas
- Using corner reflector for altimetry calibration
  - Thu, 10:00-10:15 F. Gibert & C. Maraldi
- S6 MPWG Cal/Val Activities Status ad Roadmap
  - Thu, 14:20-14:40 C. Martin-Puig
- Catalina Island Dual Band Transponder
  - *CVL2023_003* JD. Desjonqueres
- Calibration of S3 with corner reflector
  - *CVL2023_004* C. Maraldi
- Radar altimetry calibration with Corner Reflectors: Current Status and Future Plans
  - *CVL2023_005* F. Gibert
- A complex correction for the End to End Range Impulse Response of S6
  - *S6VT2023_001* S. Dinardo



Conclusions

- Strong **collaboration** between different actors (ESA, TUC, Aresys, isardSAT, CNES, CLS, NOAA, JPL,…) with 31 meetings since the beginning of Sentinel-6.
- **Sentinel-6 performances** over point targets present better precision and stability than other altimetry missions.
- Assessment of different sites allowed to **understand** differences in the results.
- **Corner Reflector**, when suitable site, becoming an excellent transponder alternative.
- Coming up: **Publication** with methodologies and results from Transponder Group.



Sentinel-6 Validation Team

SENTINEL-6 PERFORMANCE FROM TRANSPONDER GROUP

THANKS!!!