ONTIE: Short-baseline interferometry at Onsala Space Observatory

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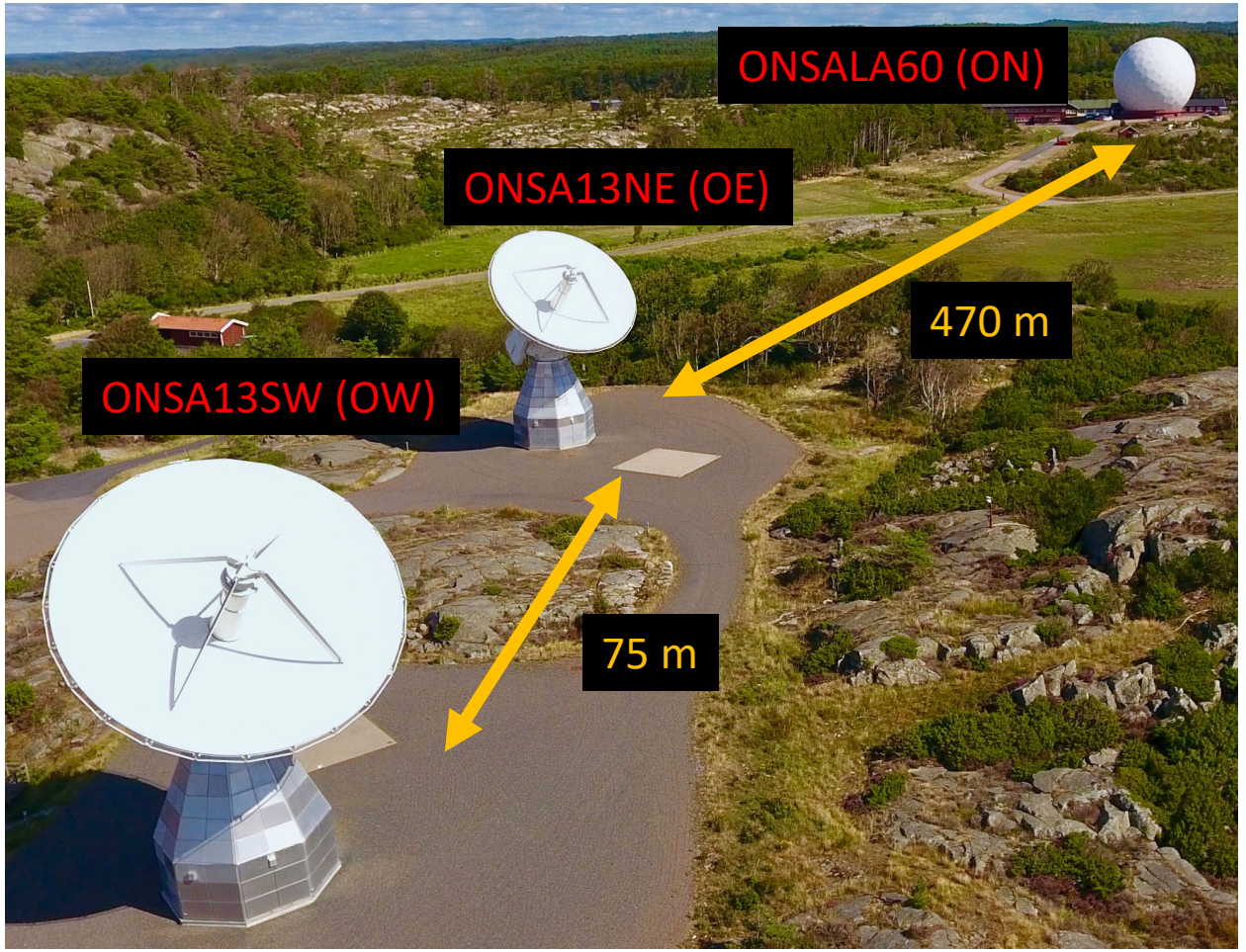
Outline

- Antennas, scheduling and observations
- Correlation and post-processing
- Geodetic analysis with *ASCOT*
- Results: Group- and phase delays
- Summary and outlook

ONSALA60 and the Onsala twin telescopes

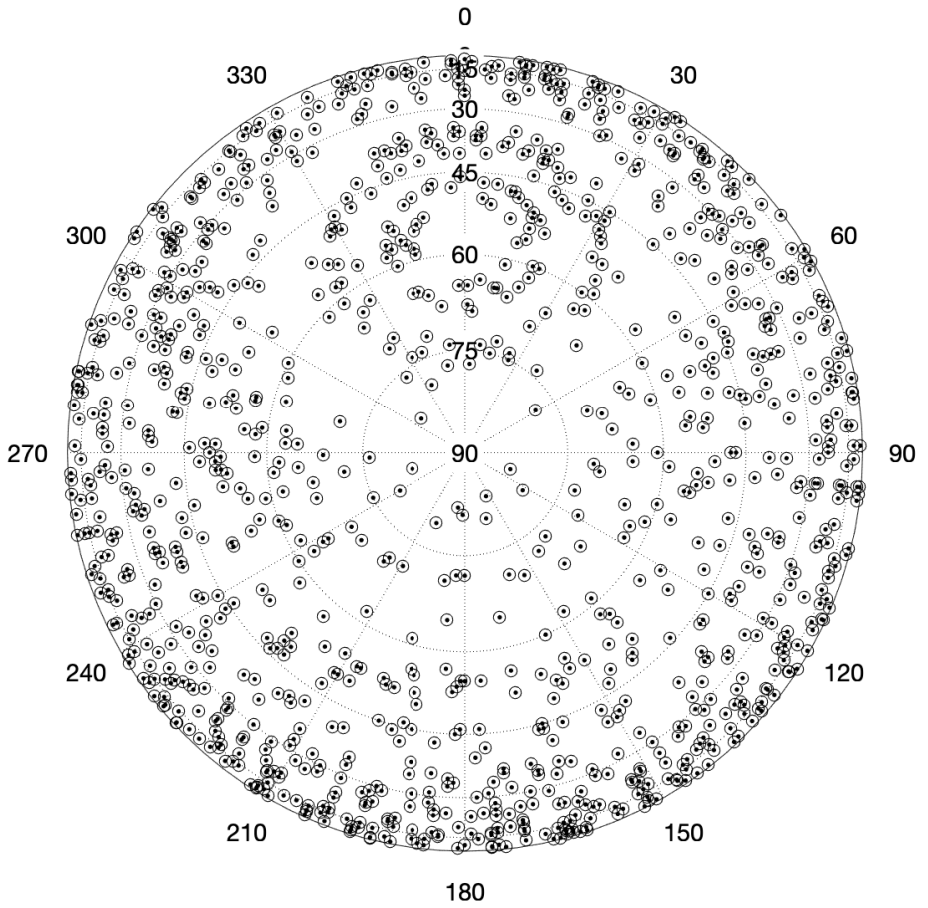
- ON: 20m S/X, RCP. Known pos.
- OE & OW: 13m VGOS, H+V.
- Common band: 8.2-9 GHz (X)
- **Goal:** Find local-tie vectors OE-ON and OW-ON using X-band interferometry.



Credit: Onsala Space Observatory/Roger Hammargren.

Scheduling

- sked software (Gipson, 2010)
- VGOS VO-source list > 5° el
- All three antennas observe all scans together
- Most sessions 24 h long: about 120 sources with 1200 scans (min 30 sec)



Example sky plot for 24 h ONTIE experiment.

Credit: Varenius et al., submitted, arxiv.org/abs/2010.16214.

Observations

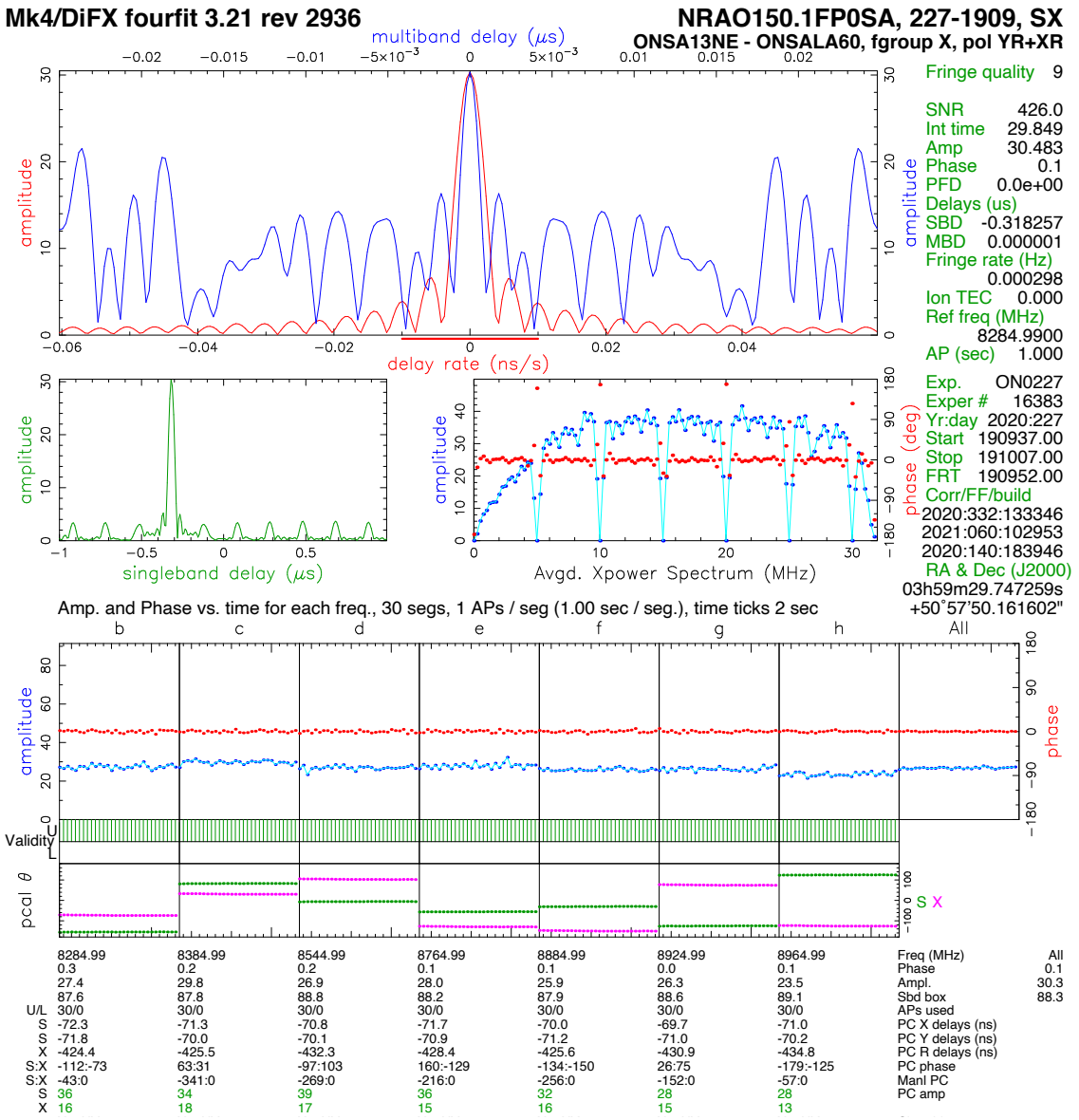
- 25 sessions, April 2019 to November 2020
- Available via IVS
- Phase-calibration (PCAL) used in most (not all) obs.

Exp. code	vgosDB	Dur. [h]	Stations	Manual PCAL
ON9114	19APR24VB	4	ON, OE	ON
ON9120	19APR30VB	29	ON, OE, OW	ON, OW
ON9122	19MAY02VB	29	ON, OE	ON
ON9135	19MAY15VB	4	ON, OE, OW	ON, OW
ON9136	19MAY16VB	26	ON, OE, OW	ON, OW
ON9142	19MAY22VB	6	ON, OE, OW	ON, OW
ON9323	19NOV19VB	21	ON, OE, OW	-
ON9327	19NOV23VB	24	ON, OE ,OW	-
ON9328	19NOV24VB	24	ON, OE, OW	-
ON0010	20JAN10VB	20	ON, OE, OW	-
ON0011	20JAN11VB	20	ON, OE, OW	-
ON0012	20JAN12VB	20	ON, OE, OW	-
ON0079	20MAR19VB	24	ON, OE, OW	-
ON0080	20MAR20VB	24	ON, OE, OW	-
ON0081	20MAR21VB	24	ON, OE, OW	-
ON0082	20MAR22VB	24	ON, OE, OW	-
ON0177	20JUN25VB	23	ON, OE, OW	-
ON0178	20JUN26VB	23	ON, OE, OW	-
ON0179	20JUN27VB	23	ON, OE, OW	-
ON0180	20JUN28VB	23	ON, OE, OW	-
ON0223	20AUG10VB	24	ON, OE, OW	ON
ON0227	20AUG14VB	24	ON, OE, OW	-
ON0228	20AUG15VB	24	ON, OE, OW	-
ON0317	20NOV12VB	24	ON, OE, OW	-
ON0318	20NOV13VB	23	ON, OE, OW	-

Credit: Varenius et al., submitted, arxiv.org/abs/2010.16214.

Data processing

- DiFX correlation: one 12-core node.
- HOPS fourfit fringe-fitting. ”notches” for PCAL.
- vgosDbMake, vgosDbCalc, vgosDbProcLogs→ vgosDb
- nuSolve → basic editing + ambiguity resolution (group and phase-delays)



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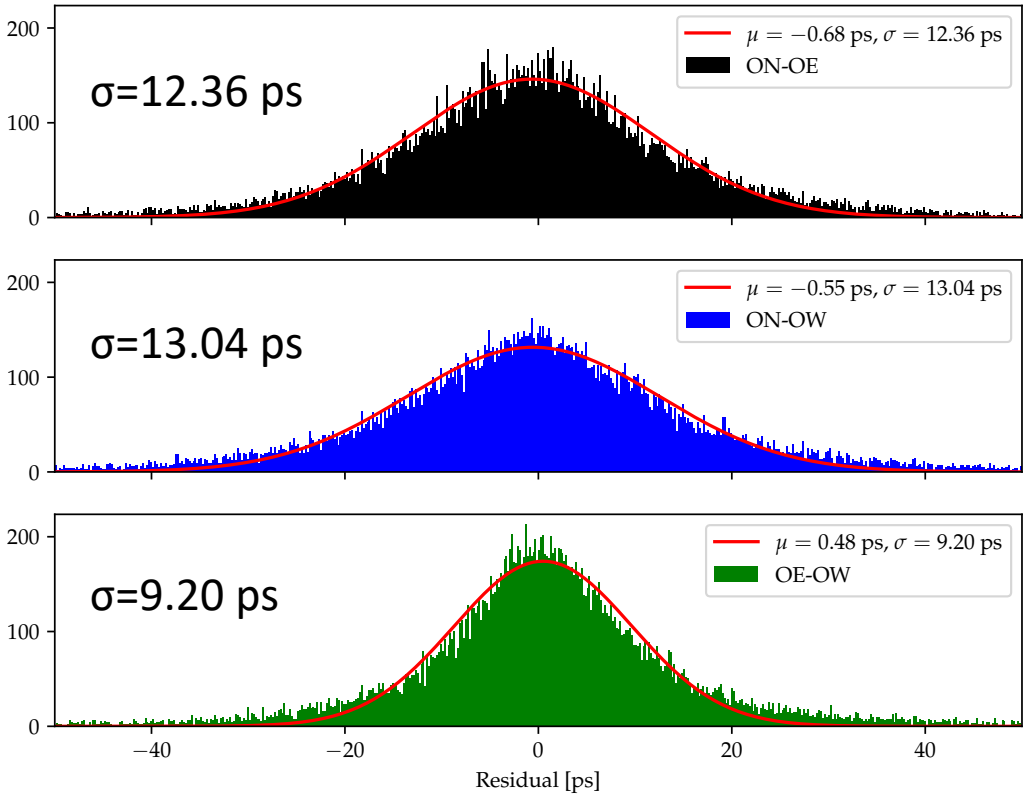
Geodetic analysis with ASCOT (Artz et al. 2016)

- ICRF3 source positions, VMF3 mapping function, IERSC04 EOP
- Group- and phase-delay analysis for each vgosDb → positions vs time.
- Combined “global” solution (stack normal equations) for all vgosDbs.

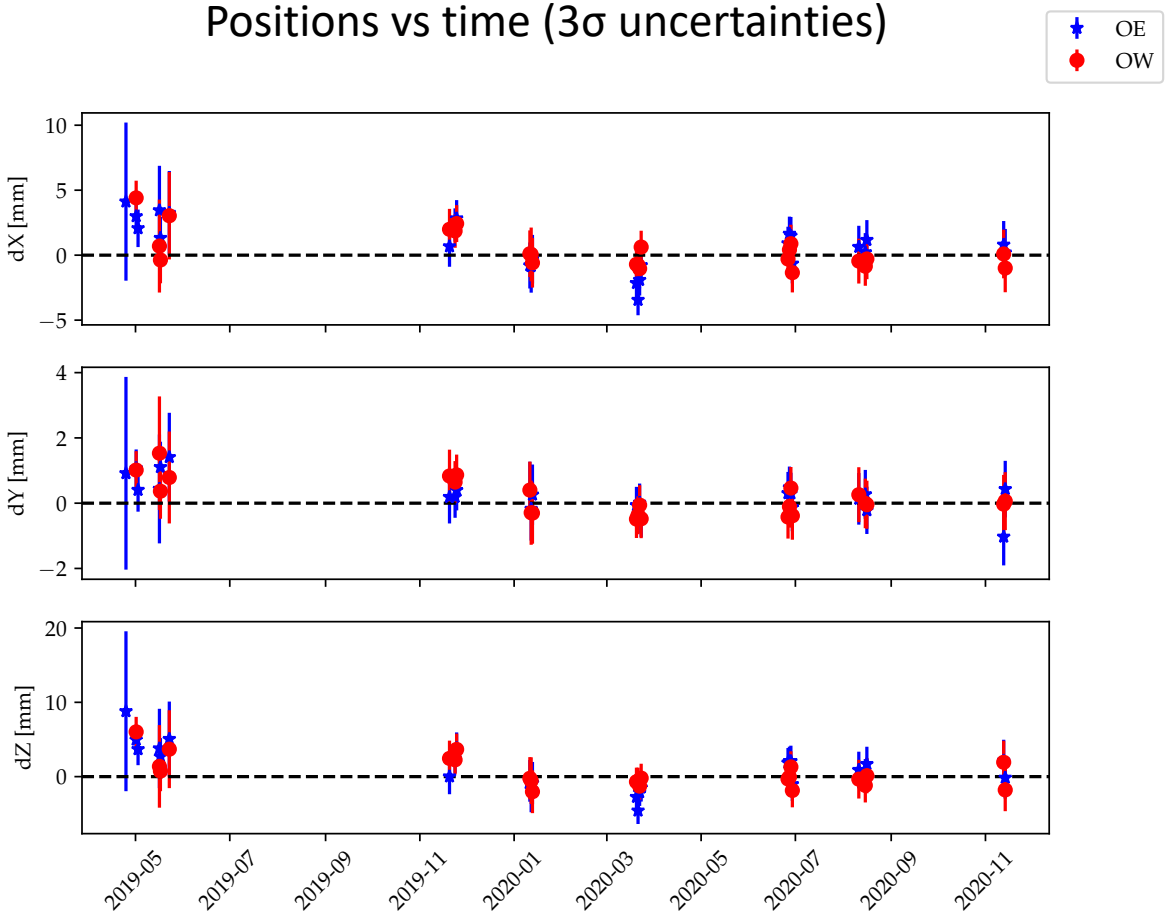
  → final (group- and phase-delay) OE and OW positions.

Results: Group-delay residuals and positions

Post-fit residuals for all data



Positions vs time (3σ uncertainties)



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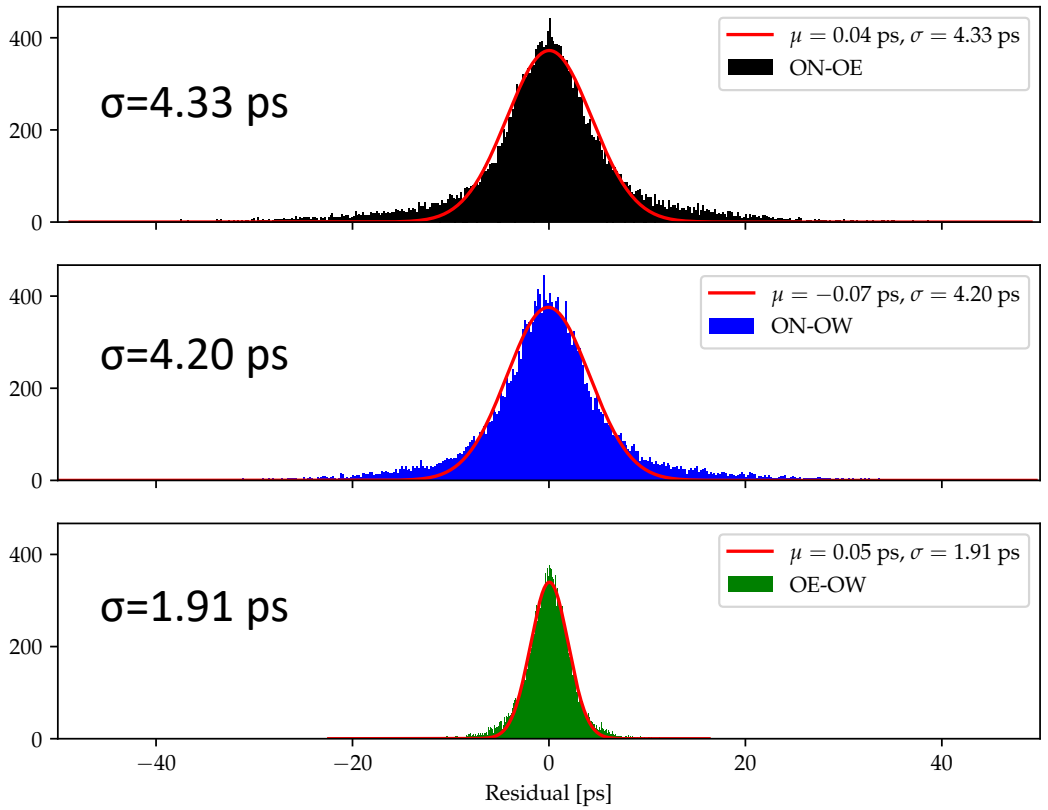

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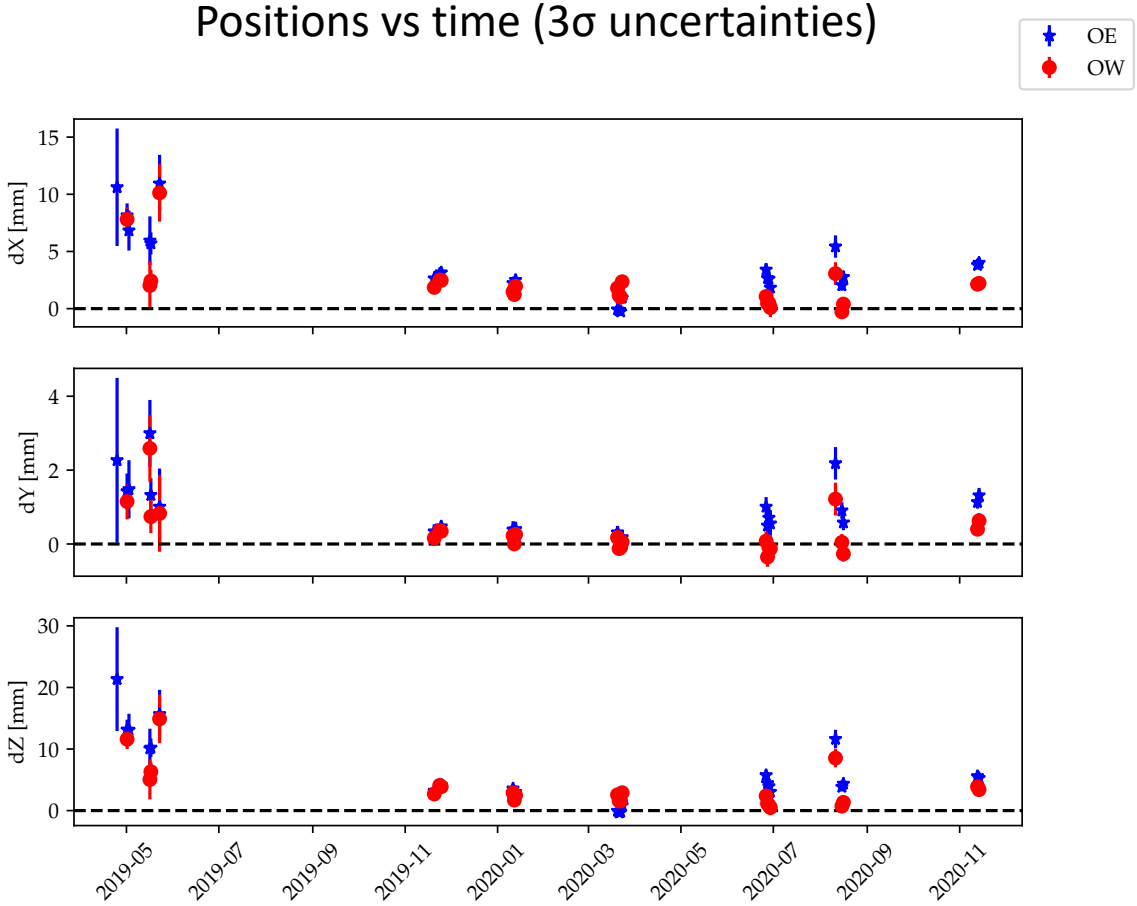

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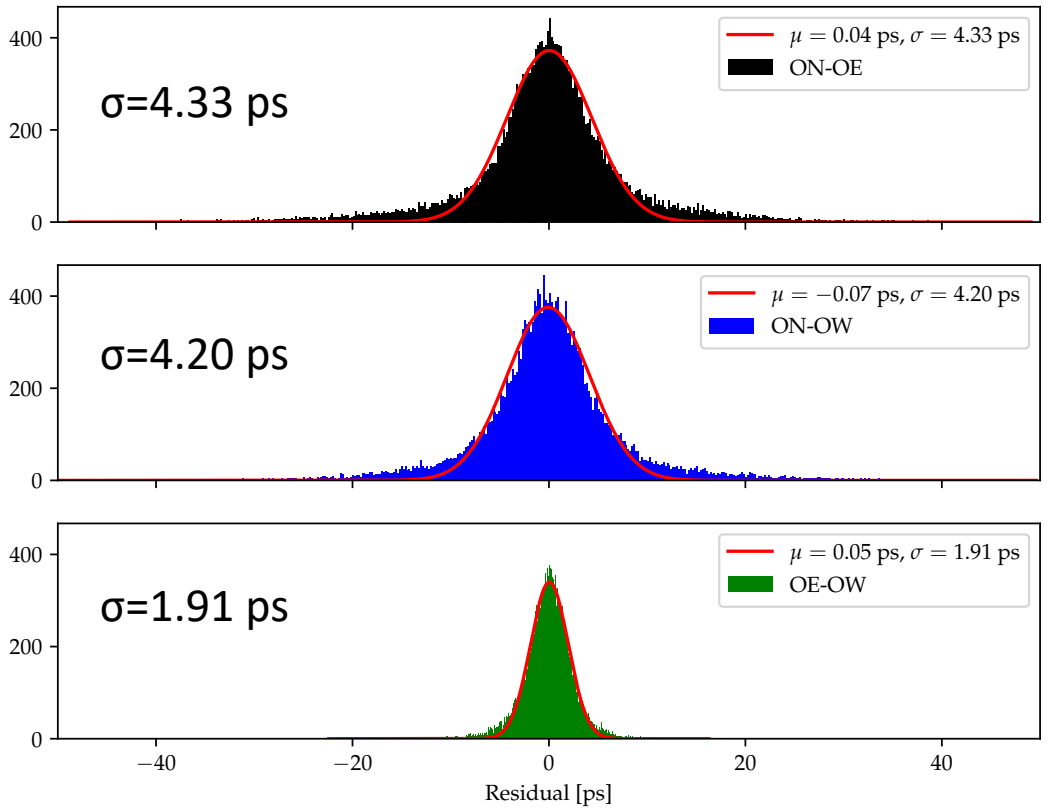

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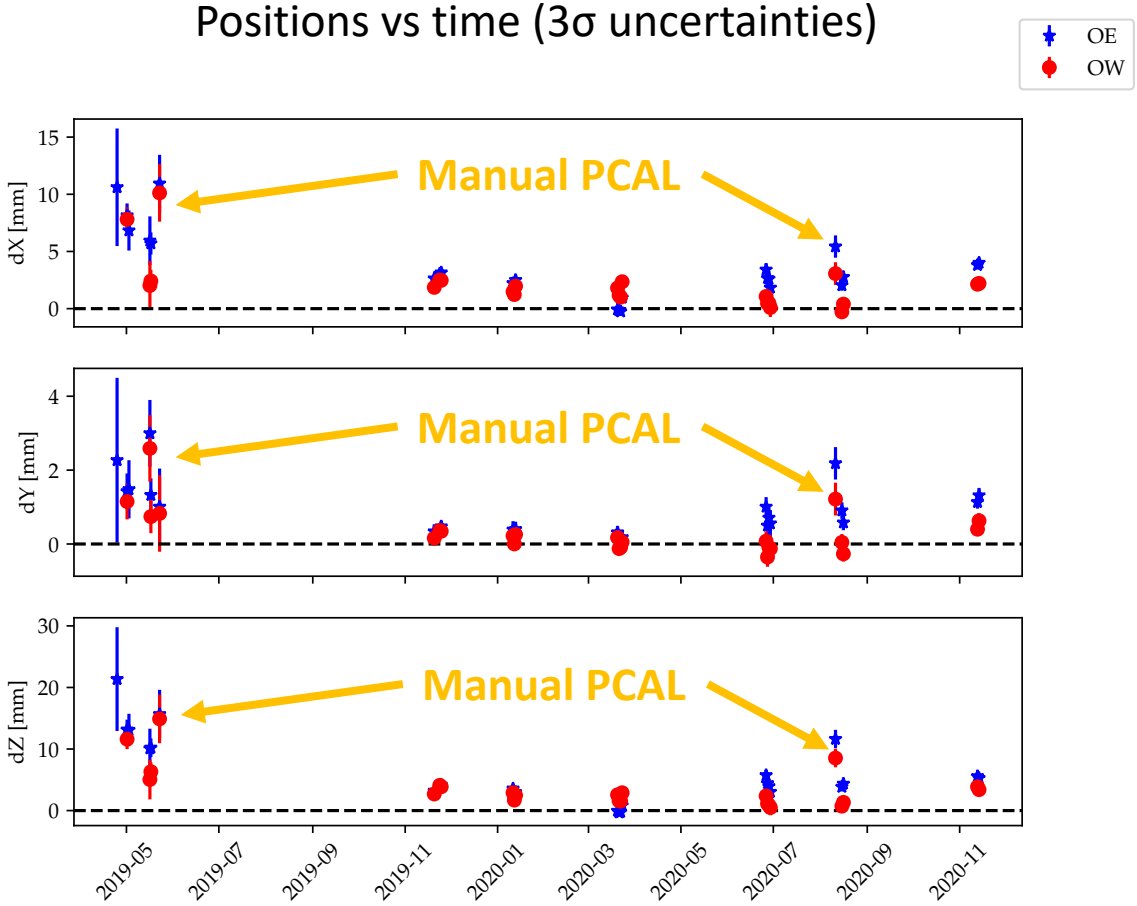

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Results: Group- and phase delay positions

VTRF2020b (epoch 2010.0) group-delay positions (in m) and their formal standard deviations (in mm) for OE and OW

antenna	X	Y	Z	σ_X	σ_Y	σ_Z
OE	3370889.29717	711571.19876	5349692.04692	0.11	0.05	0.17
OW	3370946.77840	711534.50648	5349660.92411	0.11	0.05	0.17

VTRF2020b (epoch 2010.0) phase-delay positions (in m) and their formal standard deviations (in mm) for OE and OW

antenna	X	Y	Z	σ_X	σ_Y	σ_Z
OE	3370889.29933	711571.19930	5349692.05005	0.04	0.02	0.06
OW	3370946.77978	711534.50658	5349660.92639	0.04	0.02	0.06

Credit: Varenius et al., submitted, arxiv.org/abs/2010.16214.

Results: Phase-delay vs group-delay

- We find a systematic shift in positions determined using phase-delays vs group-delays. In local East-North-Up coordinates, the shift is:

antenna	ΔE (mm)	ΔN (mm)	ΔU (mm)
OE	$+0.07 \pm 0.04$	-0.19 ± 0.01	$+3.77 \pm 0.28$
OW	$+0.11 \pm 0.04$	$+0.07 \pm 0.01$	$+2.52 \pm 0.28$

Credit: Varenius et al., submitted, arxiv.org/abs/2010.16214.

- The reason for this is not understood. It may be related to gravitational deformation effects, significant for ONSALA60.

Summary

- Observed, correlated and analysed 25 ONTIE X-band sessions.
- Obtained (submm) group- and phase delay positions for OE/OW.
- No GNSS local-tie yet (due to covid-19) but:

  VGOS-B dUT1 analysis works, and preliminary rd2005 results are close

→ Short-baseline interferometry can be used to tie VGOS and S/X!

- Unexplained shift of about 3 mm in phase- vs group delay positions.

Outlook

- Shift in phase vs group-delay results needs additional investigation.
- Comparison with GNSS local-tie data will be done soon.
- Will try similar measurements for OE/OW to ONSALA85 at C-band.
- ONTIE can also be used for flux-density monitoring → try this.
- Regular ONTIE monitoring (roughly every 3 months) continues.