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VLBI observations of GNSS signals on the baseline Hobart-Ceduna - First results

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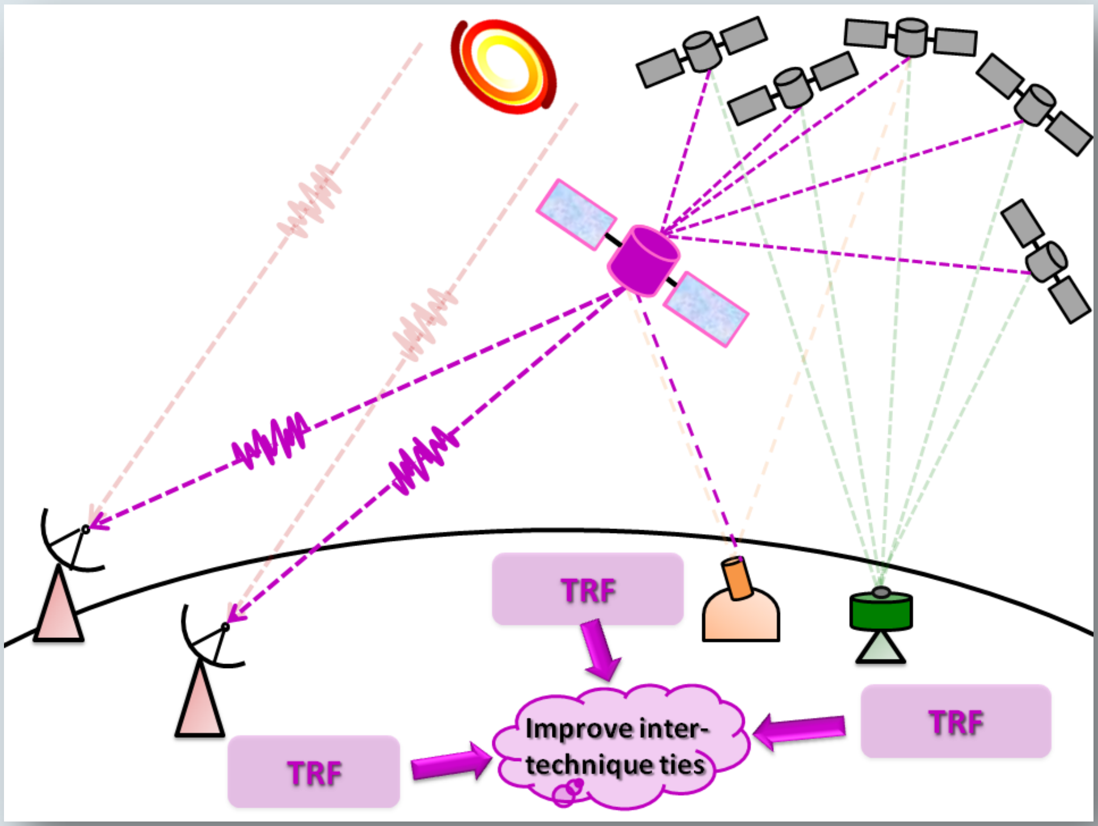
Satellite observations with VLBI

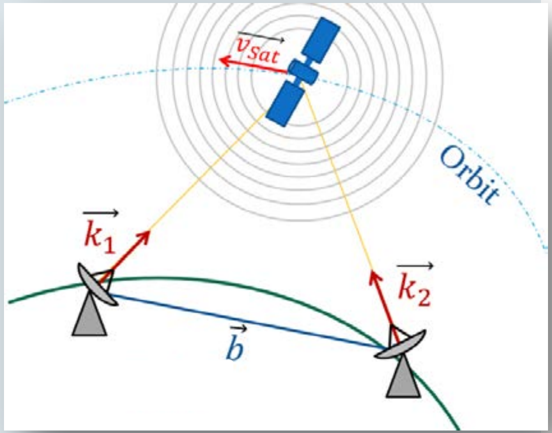
- Motivation
  - Establish inter-technique ties in space
  - Improved future ITRF realizations



„Co-Location in space “ *(Plank L, 2014)*

VLBI GNSS observations

- **Observation approach**
  - Apply observation strategies common in geodetic VLBI
  - Baseline delays = main observables
  - Direct observations of GNSS satellites



- **Previous VLBI satellite observations**, e.g.
  - Tornatore et al. (2010a/b, 2014)
  - Hellerschmied et al. (2014)

➢ **Clear strategies for data acquisition and the geodetic analysis are still missing**

➢ Established procedures to plan, observe, correlate and analyze VLBI observations to GNSS satellites

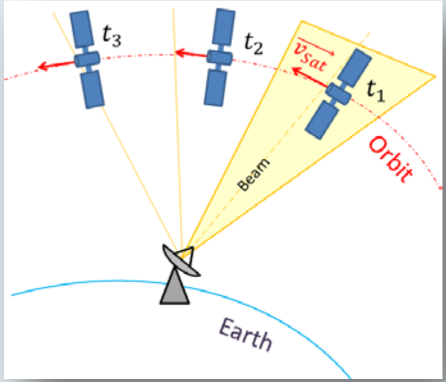
➢ Realized several experiments in 2015, baseline Ceduna-Hobart (Australia)

Data acquisition

- **Observation planning** with **VieVS satellite scheduling program** *(Hellerschmied et al., 2015)*
  - Module of the Vienna VLBI Software (VieVS, *Böhm et al., 2012*)
  - Generation of schedule files (VEX format)

- No dedicated satellite tracking features at Cd and Ho

- **"Stepwise" satellite tracking**
  - Satellite orbits converted to sequences of discrete positions (Ra/Dec)
  - 10 sec antenna reposition interval



Principle of stepwise satellite tracking

Correlation and analysis

- VieVS upgraded with **near field delay model** *(Plank et al., 2014)*
  - A priori delays for GNSS satellites observations
  - Iterative solution of the light time equation (e.g. Klioner, 1991)
  - IGS final orbits (SP3 files)

- **Correlation** with DiFX (2.4.1)
  - Correlator input model for near field observations to satellites calculated in VieVS

- **Fringe fitting** with the FRING task in AIPS and with fourfit

- Preliminary **data analysis** with VieVS

Experiments at Cd-Ho

- **Stations**
  - HOBART26 (26m), Mk4
  - CEDUNA (30m), DBBC
  - Operated by UTAS
  - Equipped with L-band receivers (1.35 – 1.65 GHz)

Baseline Cd-Ho
(~ 1700 km)

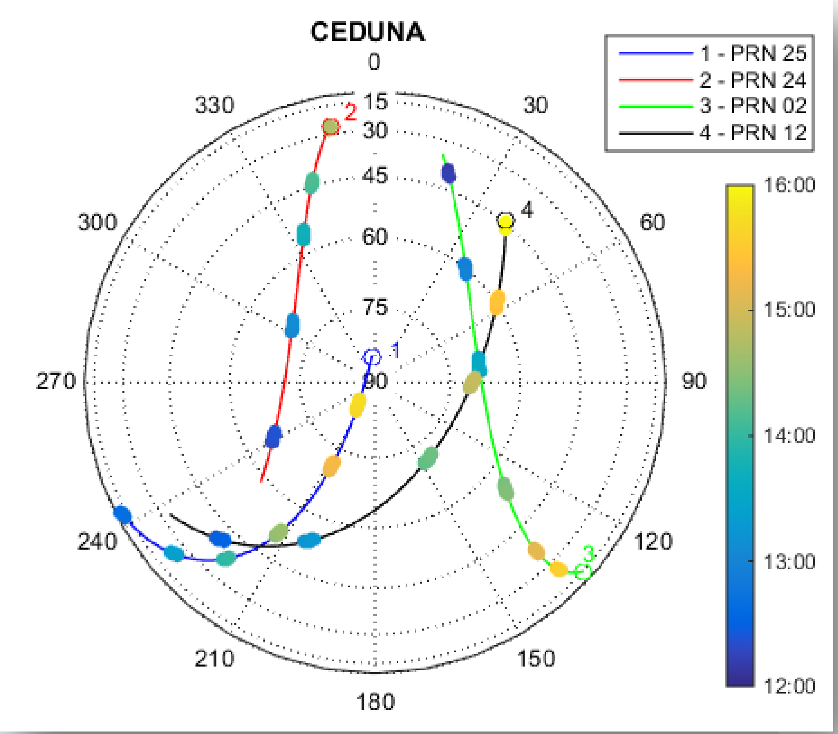
- **GNSS-VLBI Experiments**
  - Several test sessions in June 2015
  - g179a: 2015-06-28, 2 hours
  - g236a: 2015-08-24, 4 hours
  - g238a: 2015-08-26, 4 hours

➢ GLONASS and GPS satellites + quasars (calibrators)

➢ L1 and L2 band

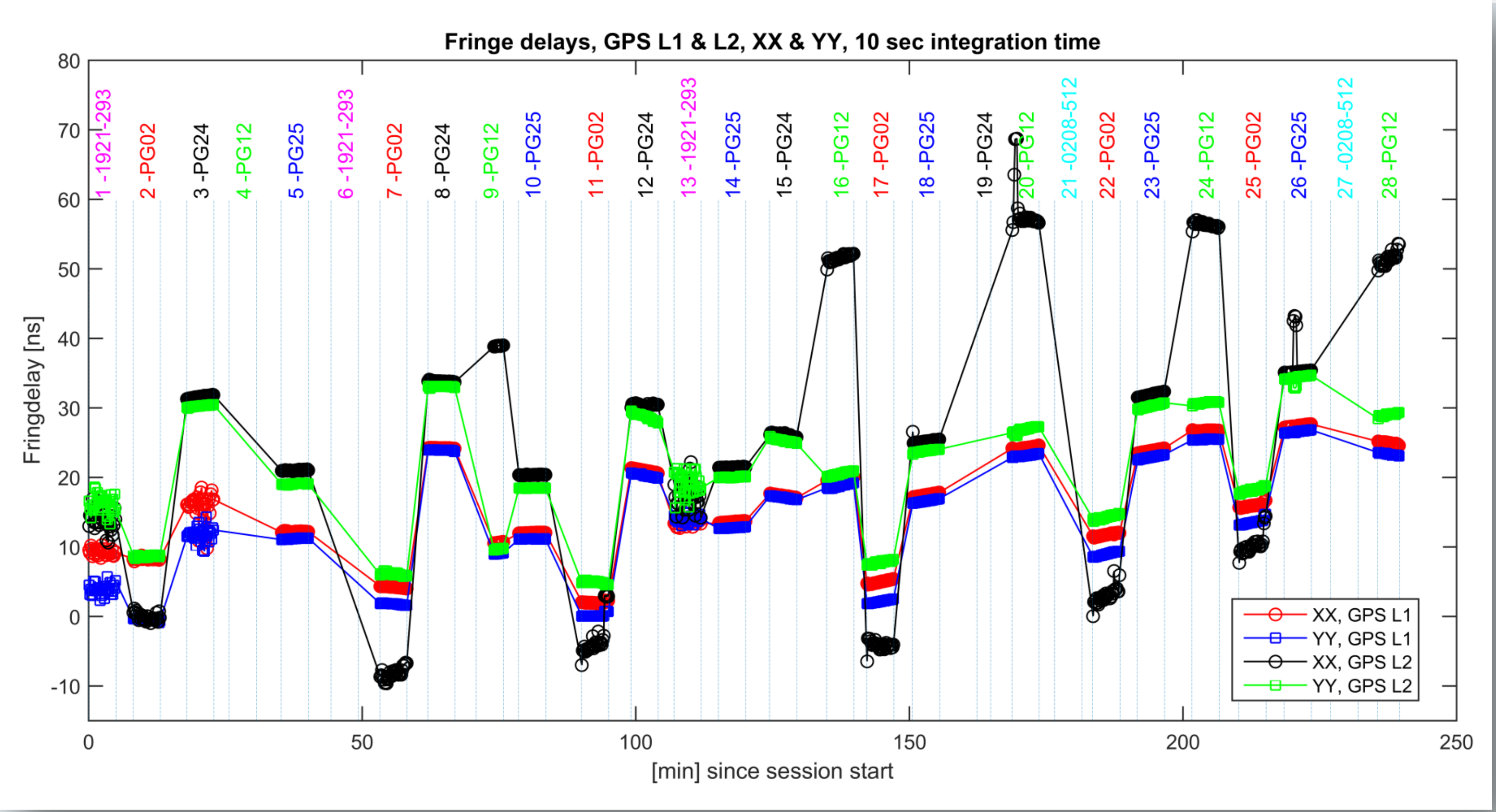
The g236a experiment

- 24th Aug. 2015, 12:00 – 16:00 UT
- GPS satellites (+ quasars)
  - PRN: 02, 12, 24, 25
- 23 satellite scans @ 5 min duration
- 4 channels, BW = 16 MHz
  - L1 (1,57542 GHz) + L2 (1,2276 GHz)
  - X + Y linear polarization
- 10 sec integration time in DiFX
- SNR in fourfit
  - L1: > 7000
  - L2: ~ 500-700



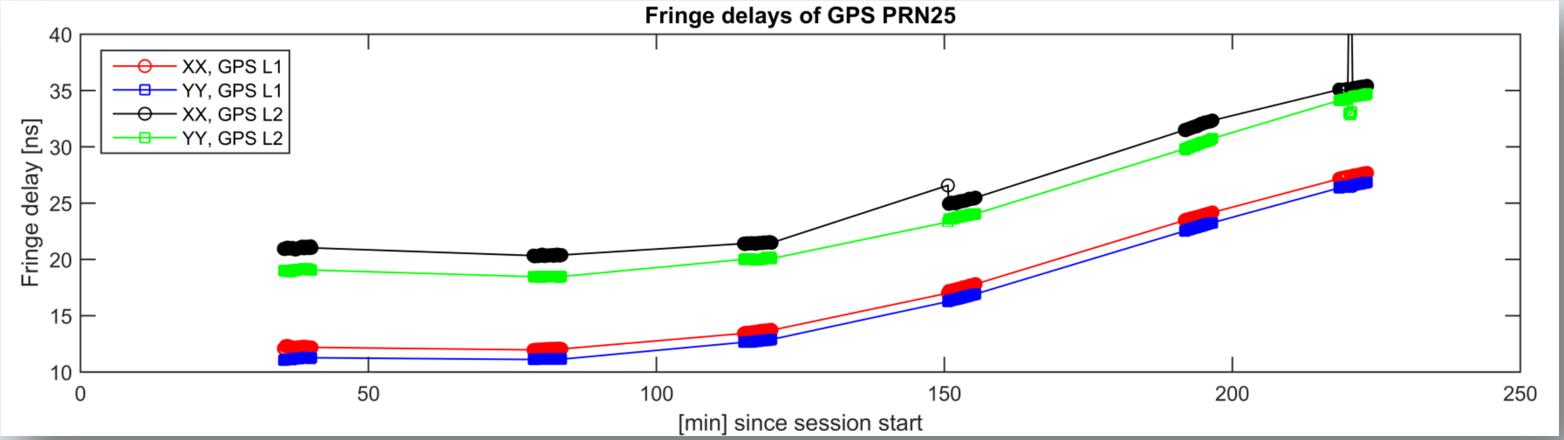
Skyplot for Cd, g236a experiment, (2015-08-24, 12:00 – 16:00 UT) Duration of individual scans = 5 min; the observation time is color-coded

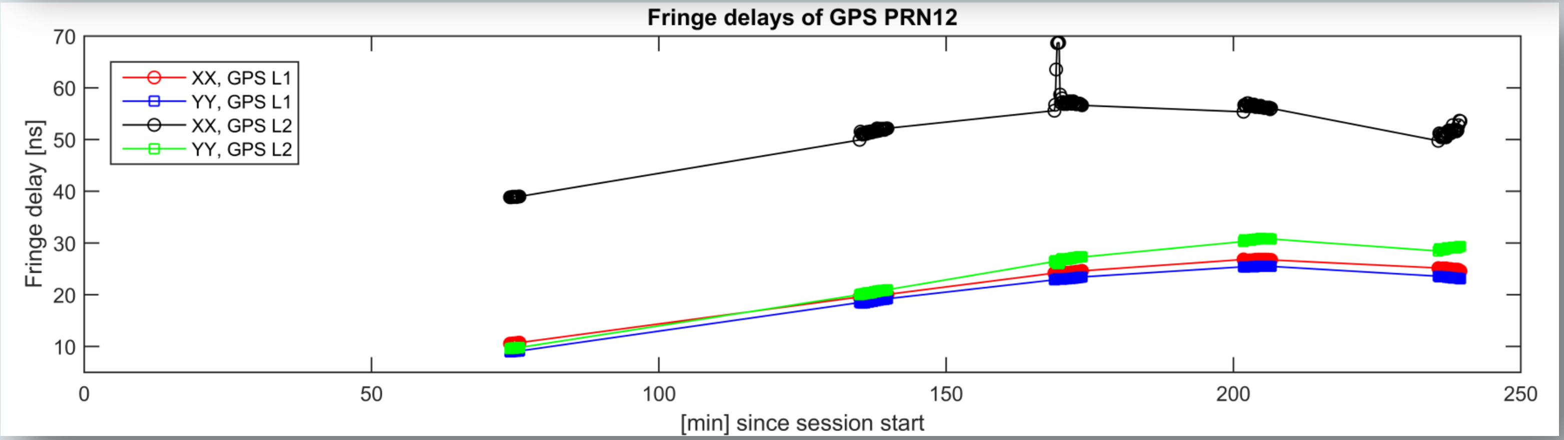
Fringe delays (1)



- **Fringe delays** = Deviation from the a priori delays (correlator input model)
- Single band delays
- ➢ Offsets between recorded channels (up to 40 ns)

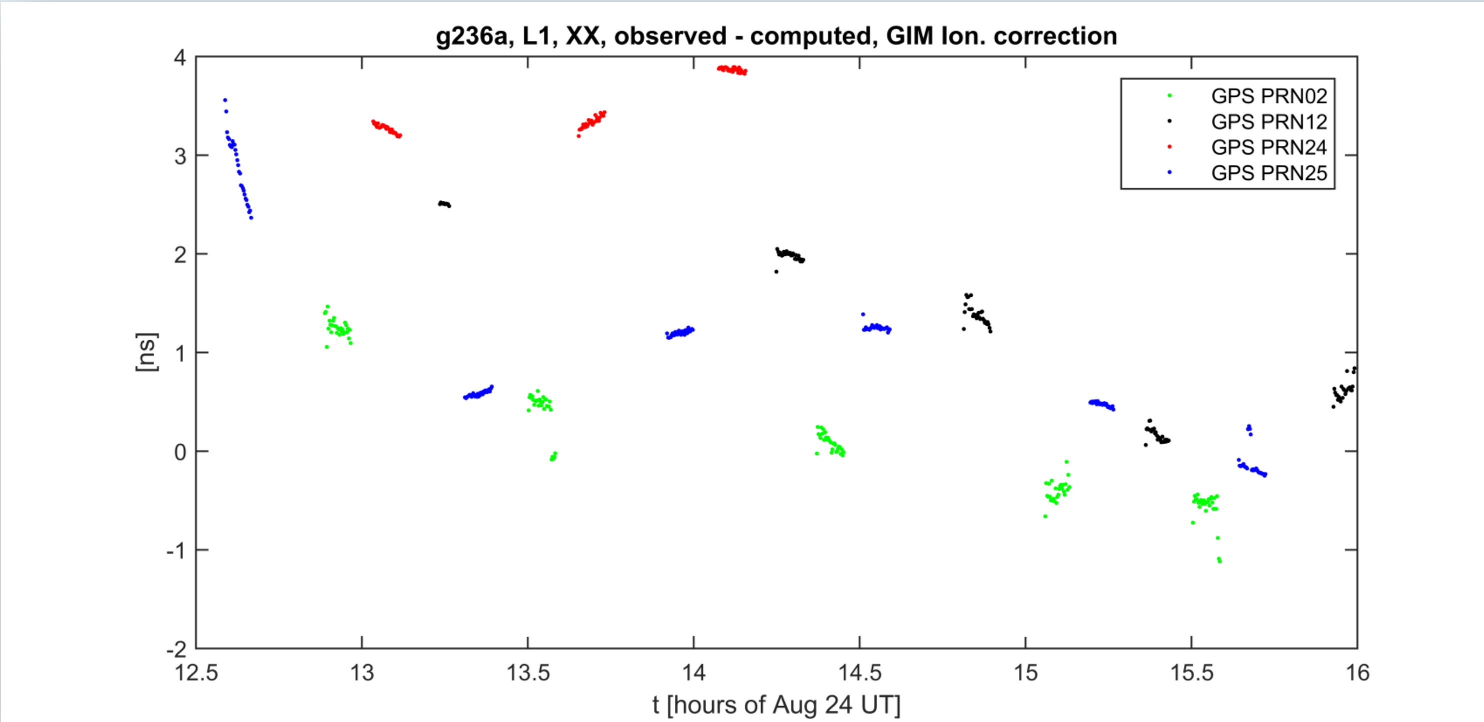
Fringe delays (2)





- Offsets between recorded channels are…
  - Characteristic for specific satellite
  - quite stable over the entire session

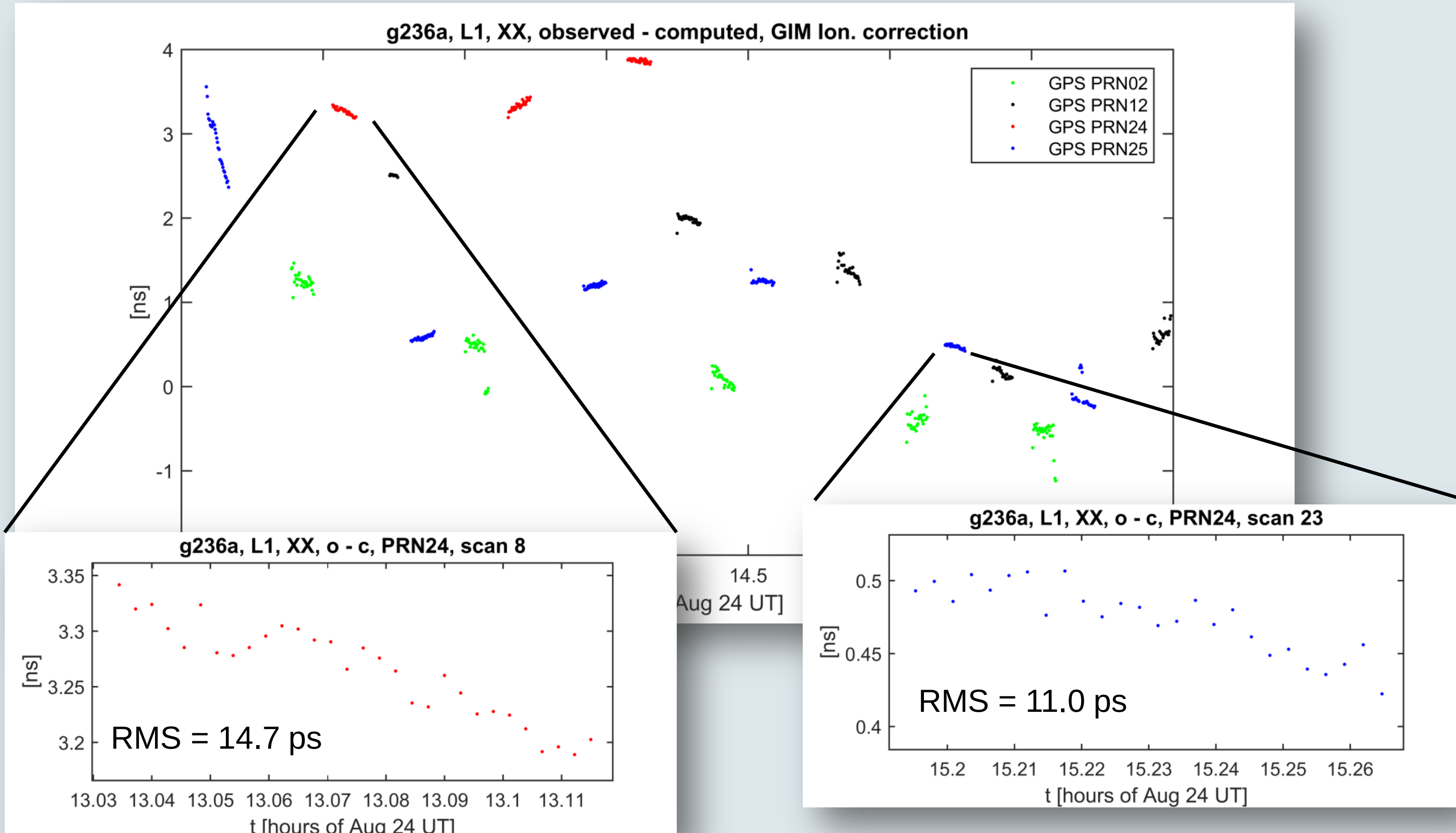
Observed – Computed (1)



- **Observed**: Total delays (= Fringe delays + correlator input model)
- **Computed**: Near field delay modelling in VieVS

- Ionospheric delay corrections from IGS TEC Maps (range: 1-5 ns) *(Tierno Ros et al., 2011)*
- ➢ Variations between 1 and 4 ns per satellite track

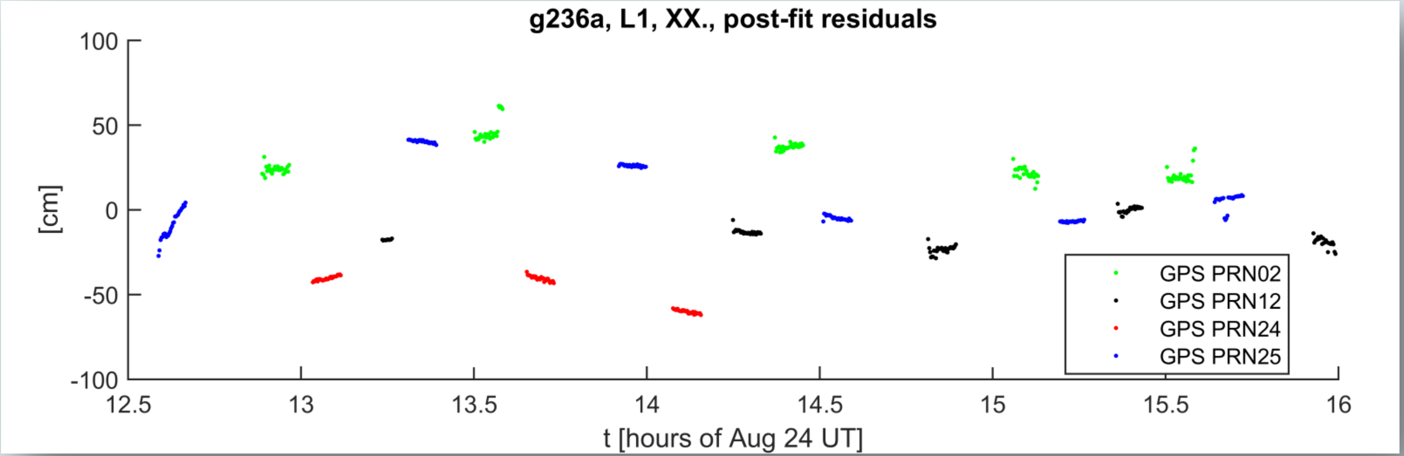
Observed – Computed (2)



RMS within 5 min. scans: ~ 10-100 ps

Parameter estimation

- **Parameter estimation in VieVS**
  - Only clock for HOBART26 (fixed for Cd)
  - Hourly clock offsets + rate + quadratic term



WRMS = 29,6 cm

➢ Models and observations have to be improved to estimate further parameters meaningfully, but in principle it works!

Summary

- **Successfully established procedures to plan, observe and correlate VLBI satellite data**
  - Observation planning, a priory delay modelling and parameter estimation with VieVS
  - Correlation with DiFX
  - Fringe fitting in AIPS and fourfit
- **UTAS VLBI antennas are a great test bed for VLBI GNSS observations**
- **Several successful GNSS-VLBI experiments in 2015 on the baseline Cd-Ho**
  - Acquired several consistent data sets which serve as basis for our research and studies

Questions?

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