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DEPARTMENT OF GEODESY AND GEOINFORMATION

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Technical challenges in VLBI observations of GNSS sources

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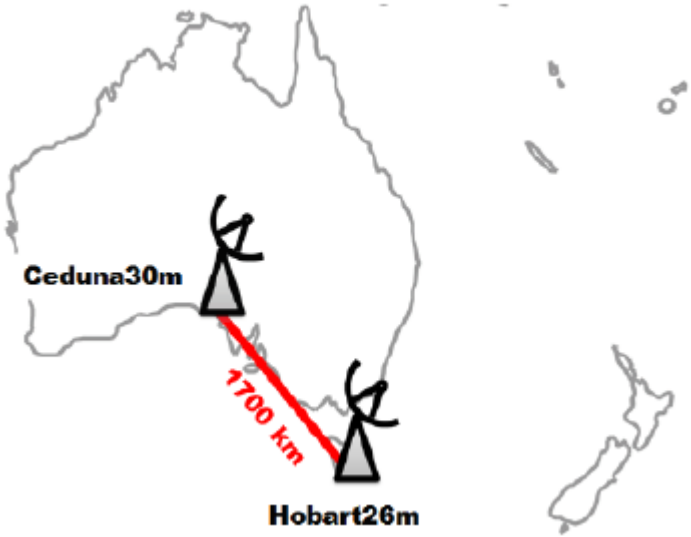
AuScope

Hobart-Ceduna observations

experiment code	date	time (UT)	targets GPS	targets GLONASS	comments
-	June 15	-	✓	✓	tracking tests
179a	28.6.15	18-20	✓	✓	16 satellites, change frequency for each satellite
236a	24.8.15	12-16	✓		fixed frequencies, dual polarisation
238a	26.8.15	12-16	✓	✓	fixed frequencies, dual polarisation
126b	5.5.16	17-23	✓		DBBC in Ho; no Mark4 data
131a	10.5.16	17-23	✓		redundant recording (DBBC + Mark4) in Ho
132a	11.5.16	17-23	✓		not observed due to high winds

- Lucia's talk has already shown you some results
- Aim here is to show how these were obtained
- Current status & future plans



Hobart-Ceduna observations

Operated by University of Tasmania

L-band receivers

Relatively slow (40 deg/s in each axis)

Equipped with VLBI recorders (DBBCs, mark4 rack, Mark5 recorders)

Linear polarisation. Quadrature hybrids available for conversion to circular polarisation

LNA saturation

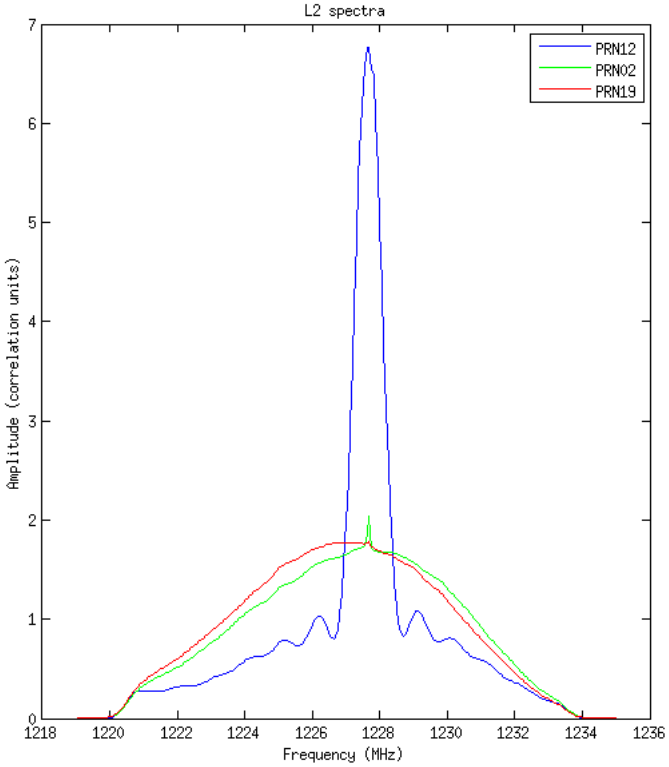
- GNSS signals vastly stronger than astronomical signals
- Can saturate LNAs, potentially damage them
- First tests tested analogue system performance for obvious signs of compression – none were present
- Hobart & Ceduna SEFDs ~400/1600 Jy at L-band.

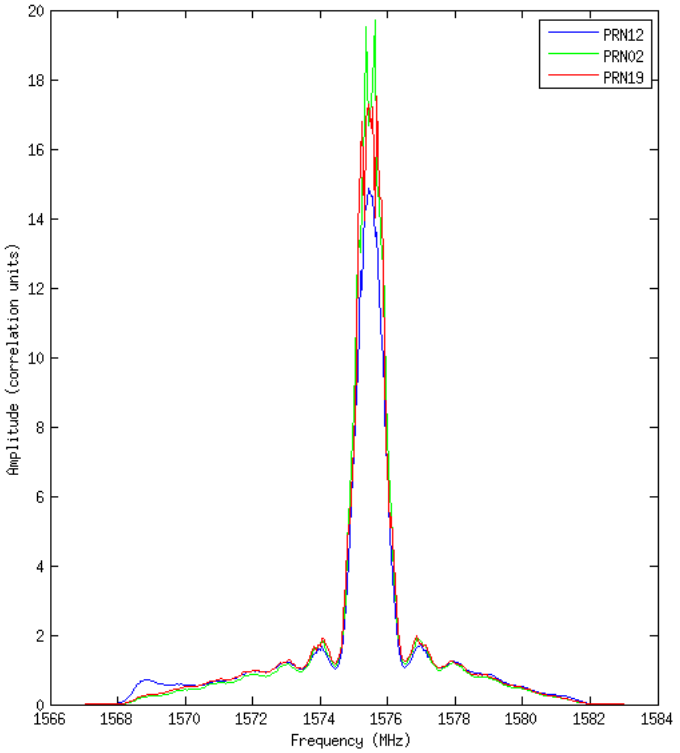
VLBI recording & Correlation

- Mark4/DBBC capable of recording at 2 bit resolution, up to 16 MHz bandwidth
- Chose to record dual (linear) polarisation, 16 MHz BW at 2-bit resolution
- Correlation using DiFX, with VEX and modified IM files for GNSS sources.
- Quasar scans used to determine a priori clock model.
- Time & Spectral resolution varied – final results opted for 0.1 second integration time, 62.5 kHz channel width (256 channels over 16 MHz).
- Output converted to FITS and mark4 format
- AIPS used for testing, main results from fourfit (Epoch considerations)

Notable differences

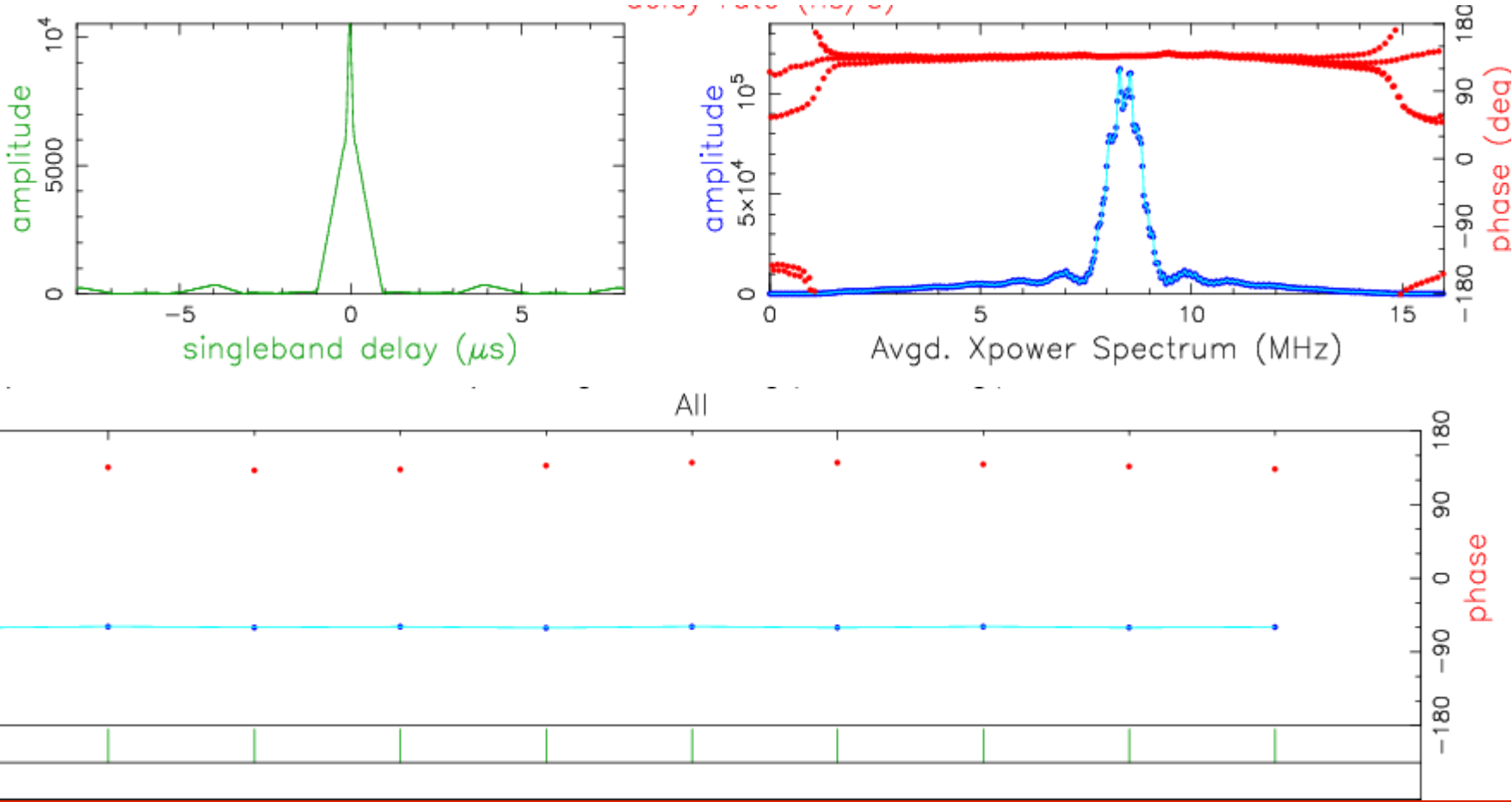
- Correlation amplitude ~1
- Approximately equal amplitude in all polarisation products
- L1 dominated by clear peak, L2 varies between satellites.





Fringe Fitting - Mark4

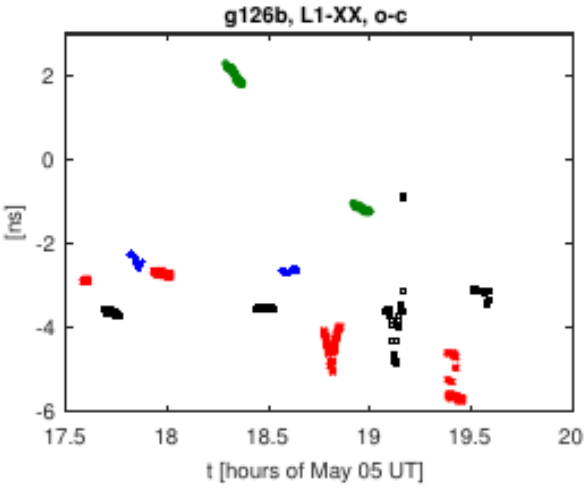
- Fourfit uses a scan-wise approach, taking each 10s observation
- Fitting performed in each band separately (single-band delay).
- Multiband delay on quasars failed due to to non-detections.

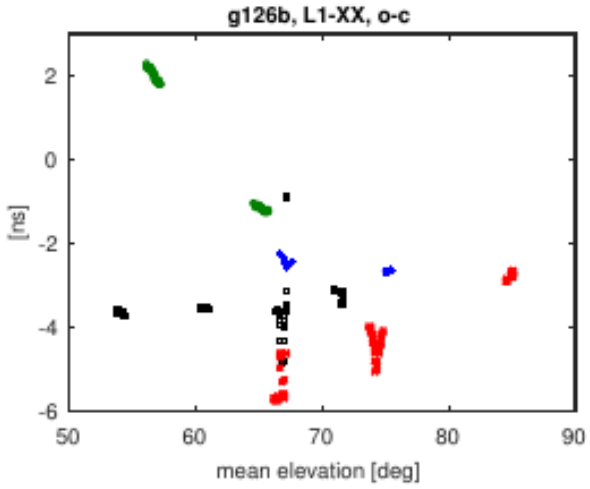


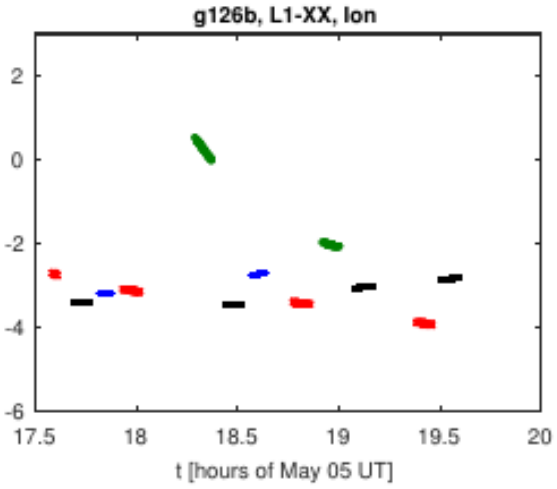
Fringe-fitting - AIPS

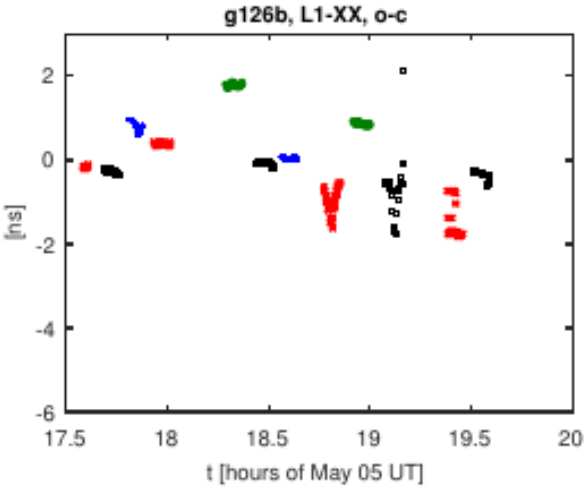
- Using FRING, entire bandpass but only single-band delays.
- Various solution intervals, defaulting to integration time.
- Fringe-fitting epoch differs from fourfit/mark4 definition & caused issues with near-field model.
- Used for high time resolution examination only, at this point.

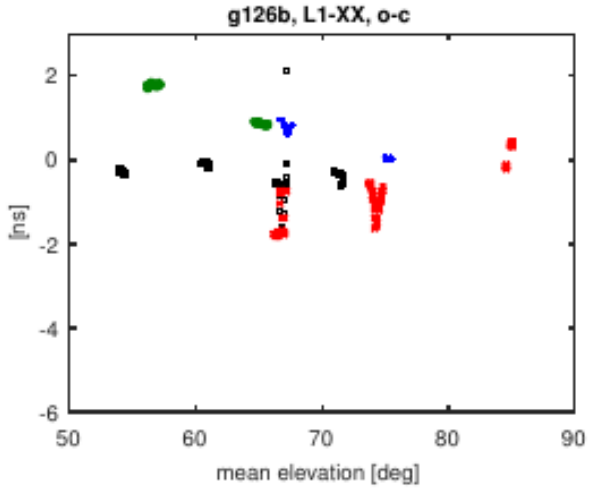
Residuals

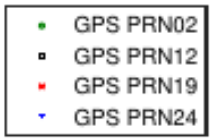

g126b, L1-XX, o-c
[ns]
t [hours of May 05 UT]


g126b, L1-XX, o-c
[ns]
mean elevation [deg]


g126b, L1-XX, Ion
t [hours of May 05 UT]


g126b, L1-XX, o-c
[ns]
t [hours of May 05 UT]

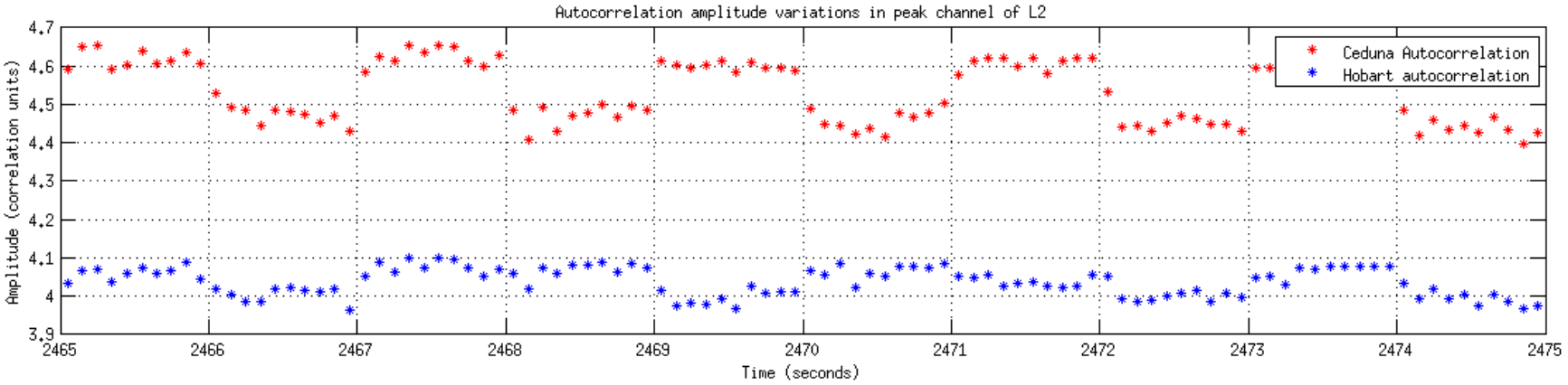

g126b, L1-XX, o-c
[ns]
mean elevation [deg]

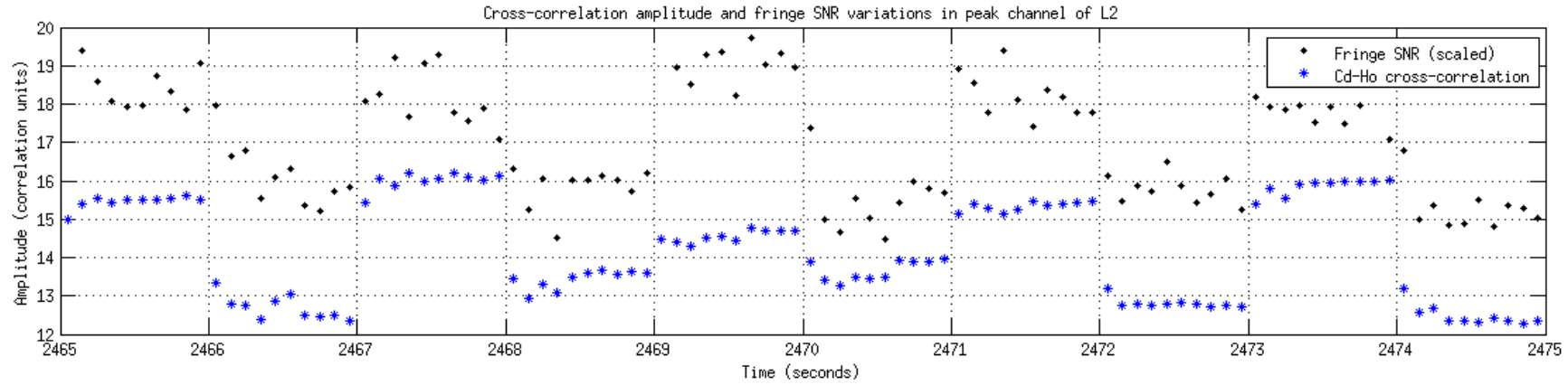

GPS PRN02
GPS PRN12
GPS PRN19
GPS PRN24

Residuals

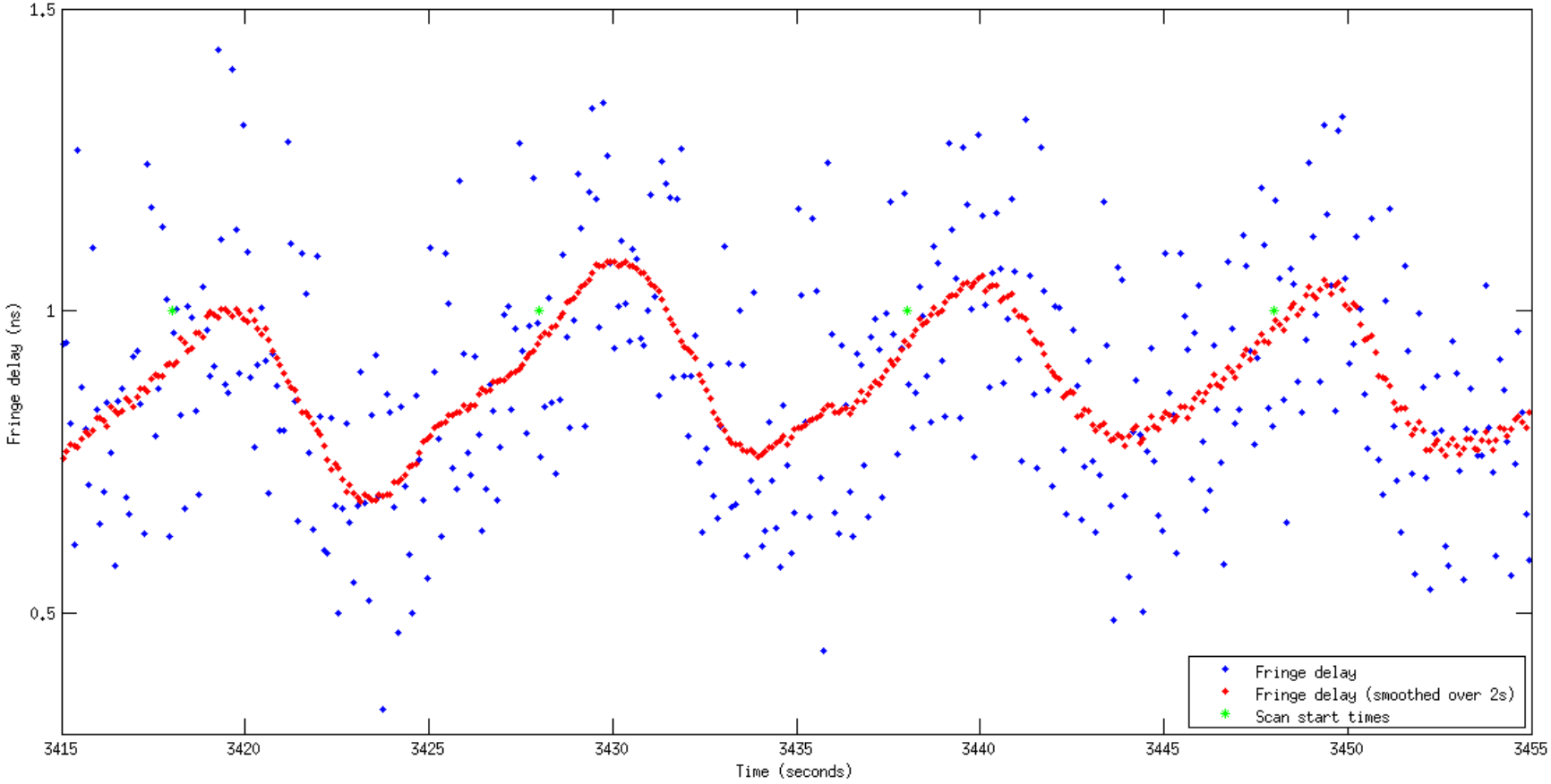
- Total residual ns in scale, improved with ionosphere corrections from global TEC maps.
- Residuals within scans typically 15-60 ps.
- High time resolution fringe-fitting shows significant residuals related to tracking & gain.

Gain & Delay – DBBC AGC loops

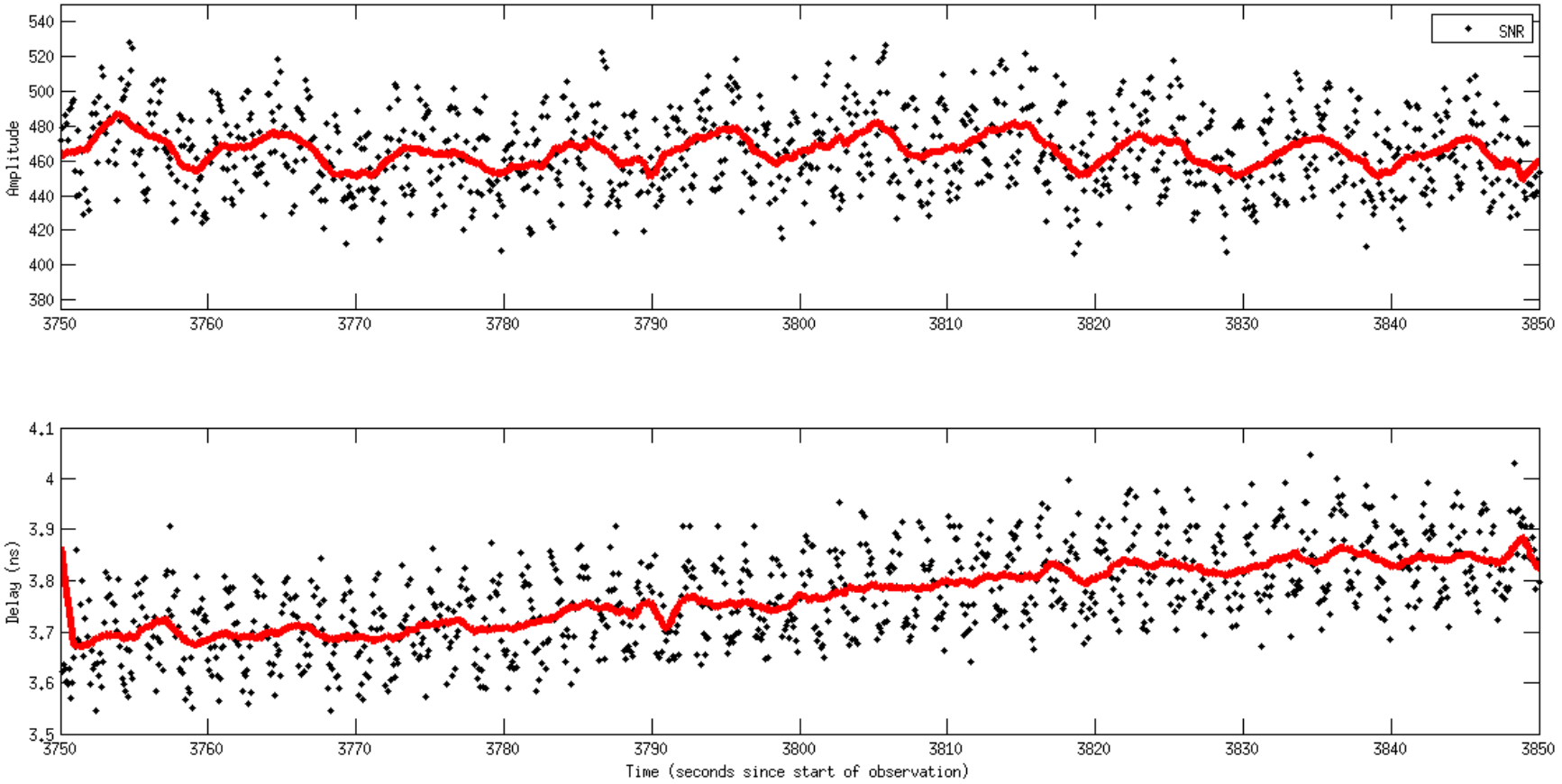




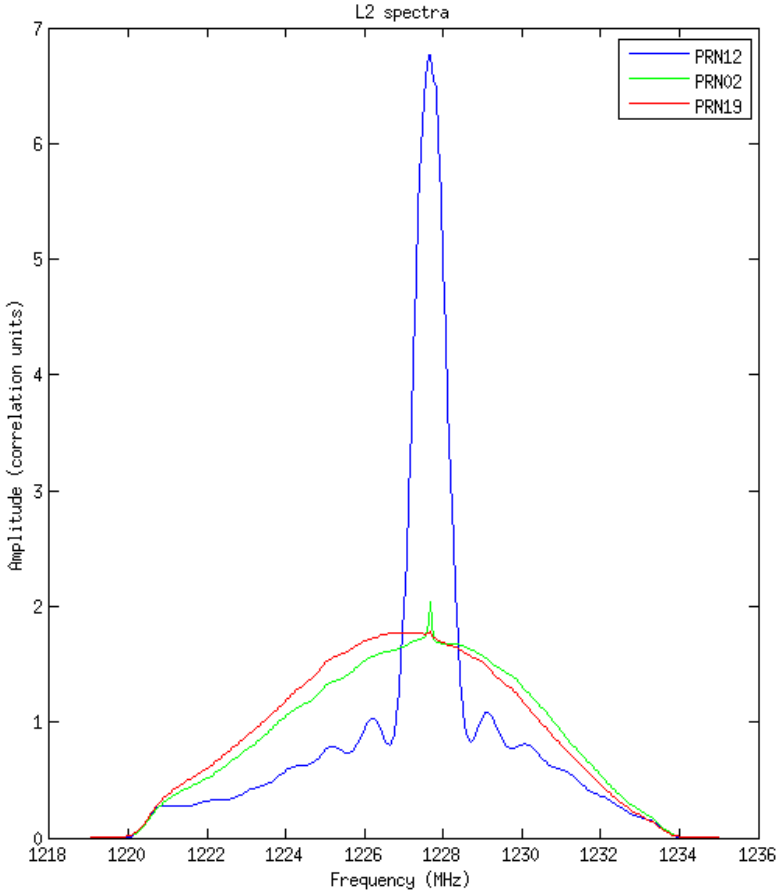
Gain & Delay – Tracking

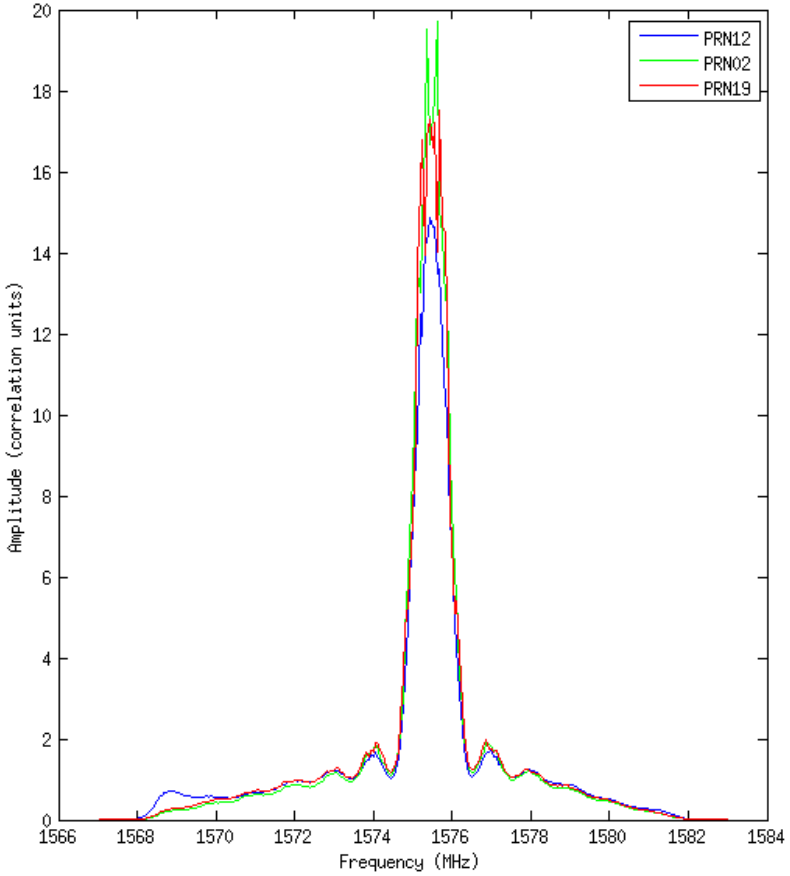


Gain and Delay



Gain “compression”





Polarisation

- Results shown here are for the XX correlation product.
- Polarisation calibration requires calibration of differential delay, gain, leakage terms.
- Neither Hobart or Ceduna is well calibrated, or well suited to calibration (different & unusual receiver mounting and likely high leakage terms, potentially variable gains)
- Quadrature hybrids known to only work over relatively small frequency range.
- GNSS observations likely to introduce some level of gain change – can a calibration be made?

Future plans

- Continuous tracking (challenging for Ho/Cd antcn)
- 8-bit recording - DBBC2
- AGC usage. Use pulsar mode and disable active AGC during recording
- Better use of quasar observations
- L1/L2 combination