TWSTT Innovations at the USNO

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The Staff

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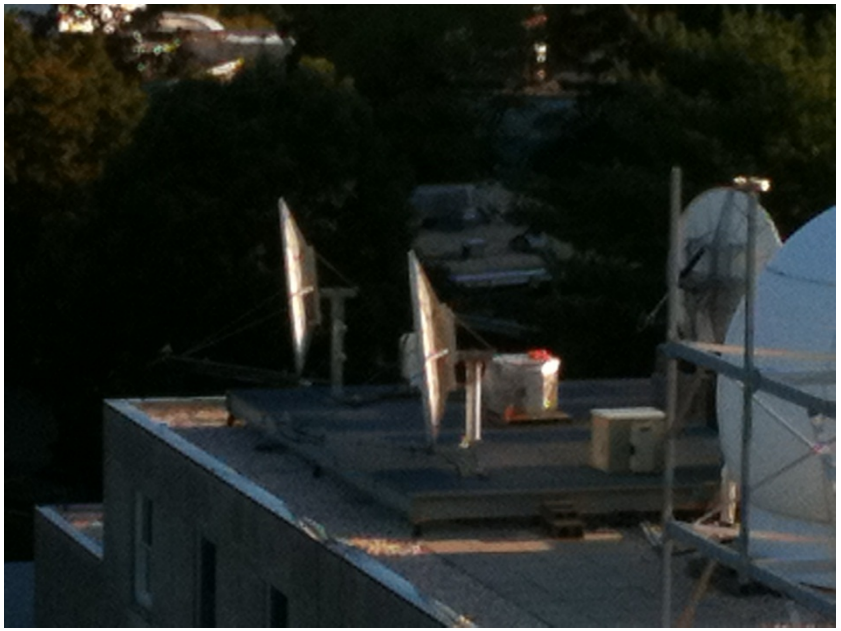
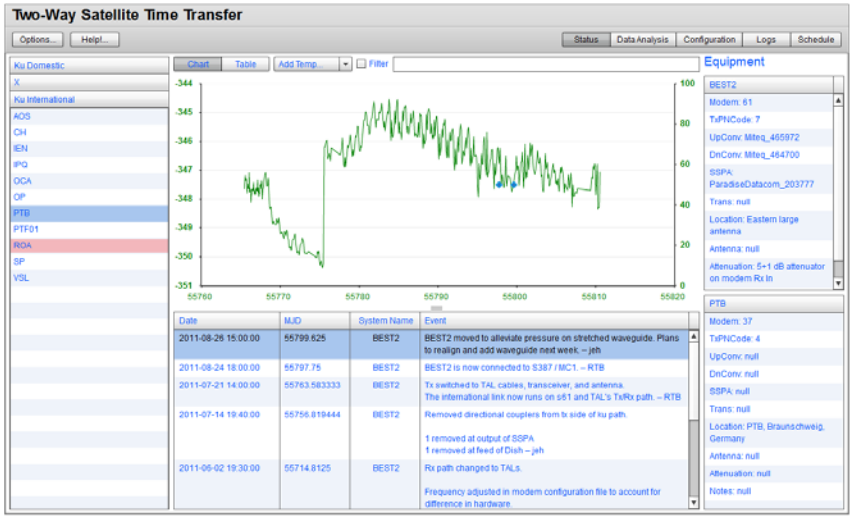
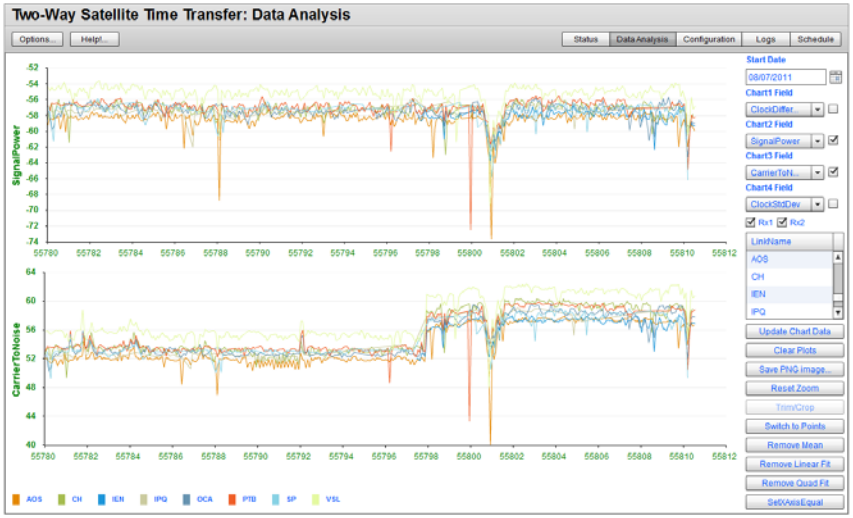
2010-2011

- Major Rebuild of Almost Every TWSTT system
  - At both USNO and AMC



TWSTT Web Interface





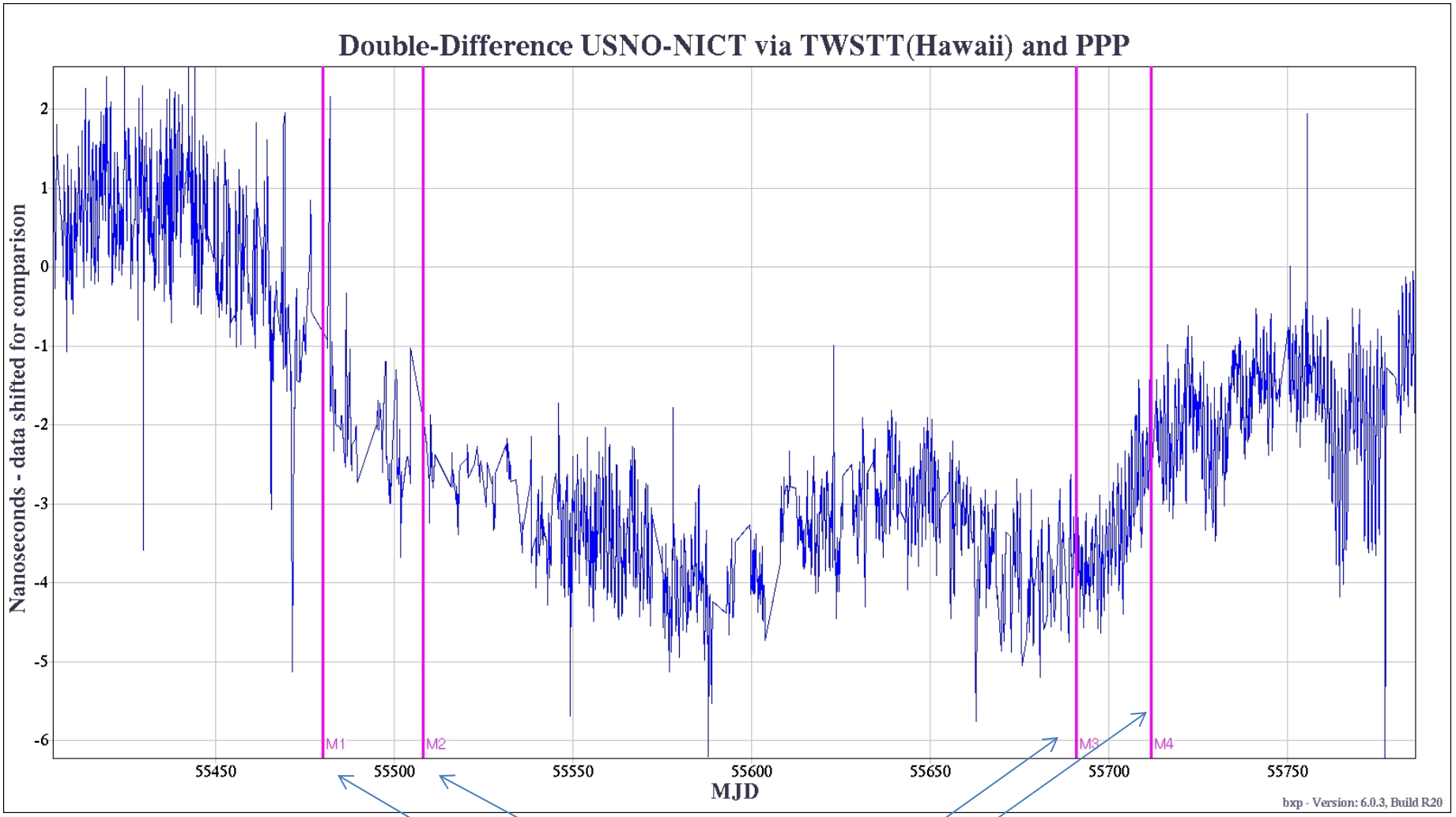
- Quick view of link info, status and logs
- Easy to log events and match events to data
- Quick plotting of signal power, frequency, carrier to noise, stddev, etc… for all links

Long-term Variations

- The next four slides suggest three different instances
  - USNO-NICT
  - USNO-PTB (probably at PTB)
  - USNO-AMC (probably at USNO)

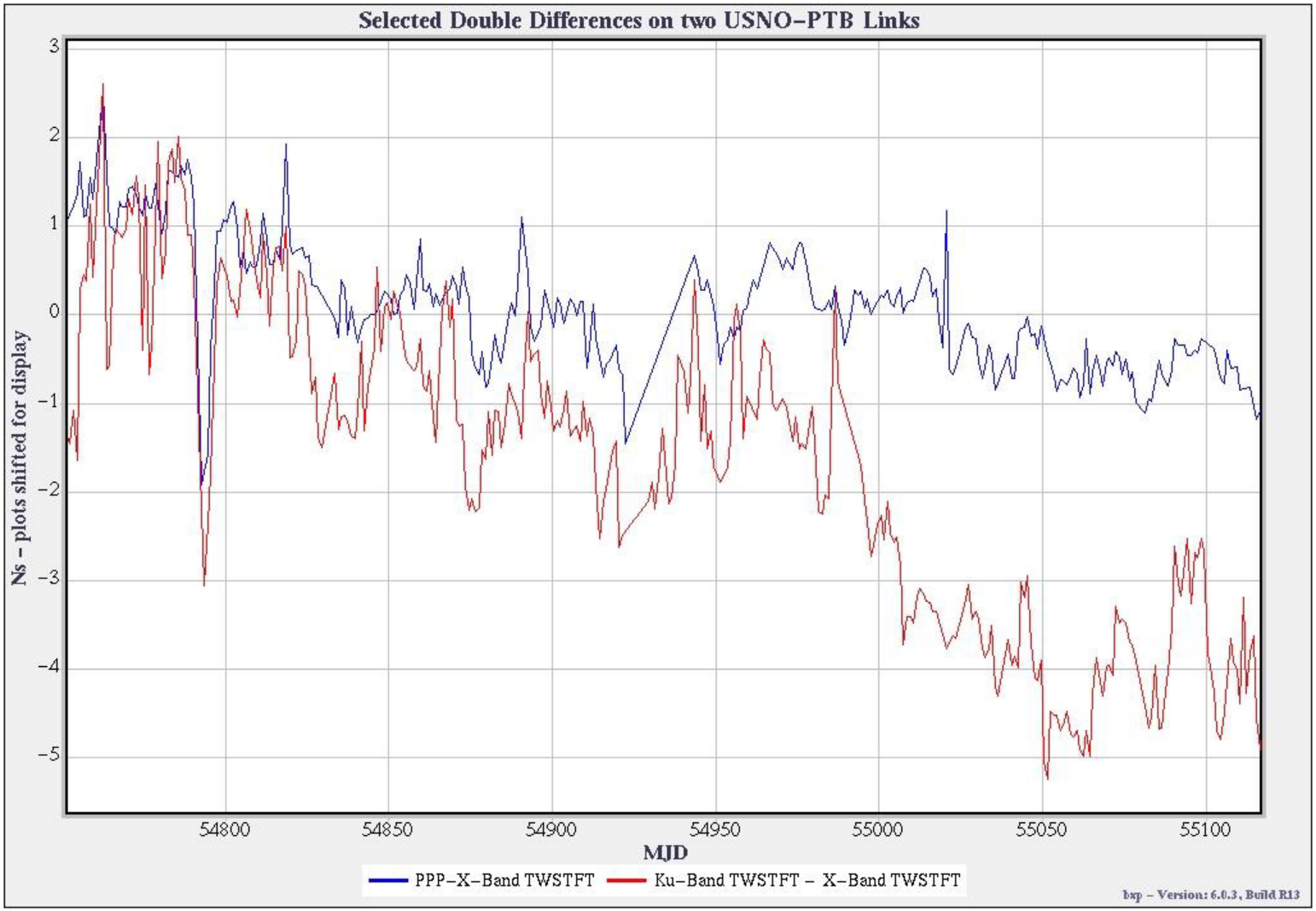
- Other events might exist unrecognized

USNO-NICT, PPP-TWSTT



Manual adjustments

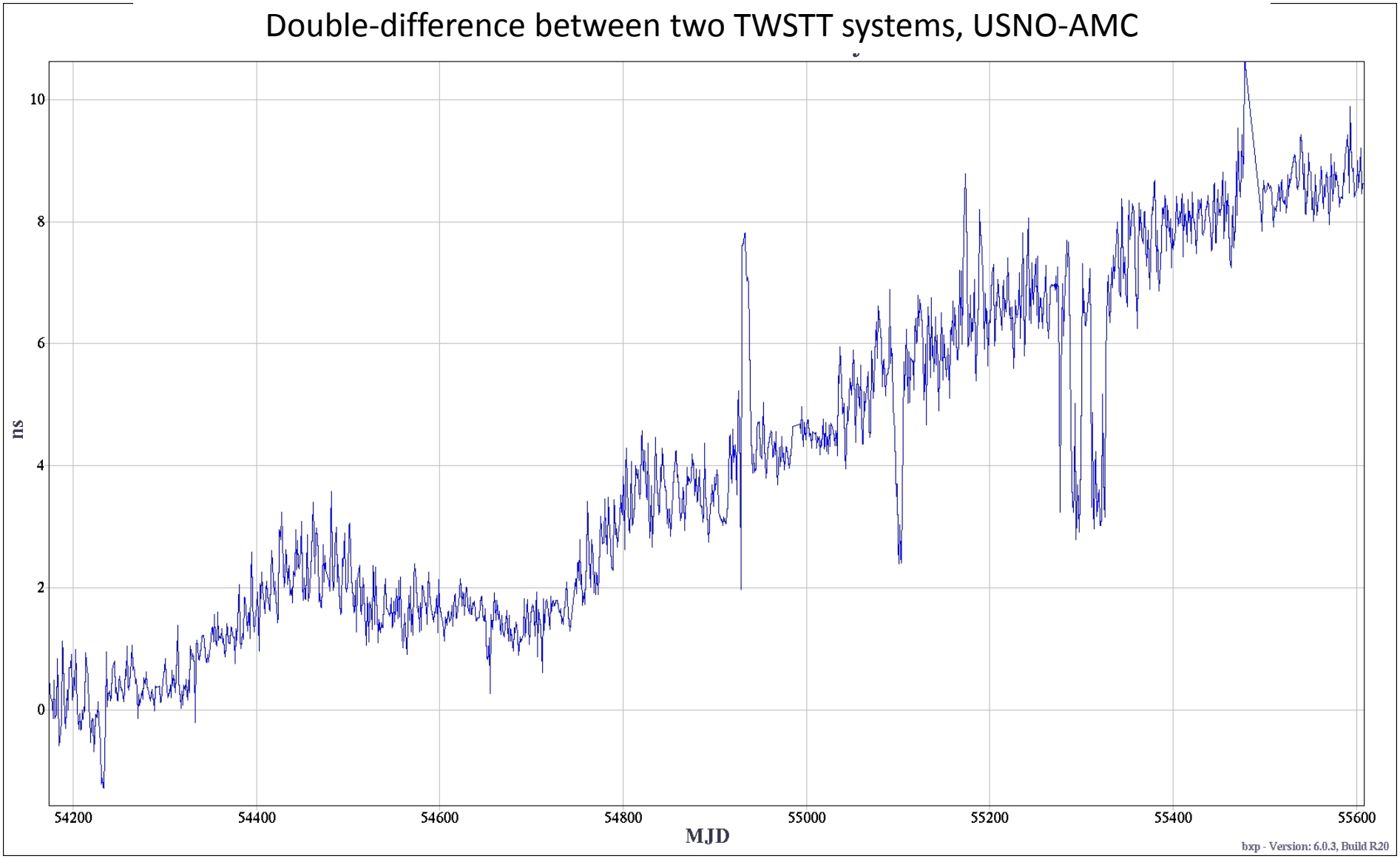
Shift of USNO-PTB, summer 2009



USNO-NIST Calibrations

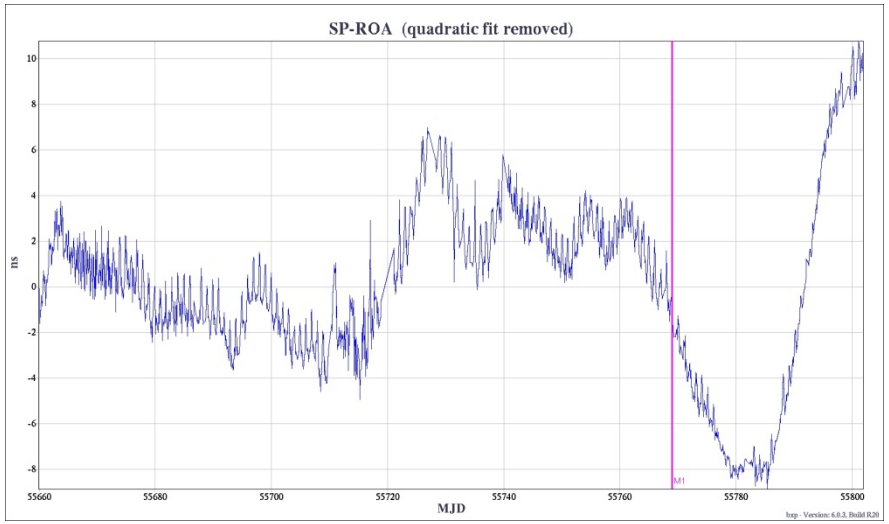
- Assume USNO TWSTT calibrations are perfect
  - PTB's GPS calibration consistent with TWSTT (PTTI-10)
- USNO-NIST calibrate with direct observations using USNO satellite
- Circular T vs. Direct USNO-NIST TWSTT
  1. 6 ns discrepancy before summer of 2009
     - *Given assumptions*, means miscalibration of NIST-PTB
  2. 3 ns after PTB calibration shift, summer 2009
     - See next viewgraph, and ppp comparisons
  3. 2 ns USNO Ku band cal shift starting summer 2010
     - Ku-band system worthless by November (since rebuilt)
     - Makes USNO-NIST discrepancy with Circular T to 3+2 = 5 ns
     - March, 2011 USNO-NIST TWSTT calibration 5.1 ns
     - July, 2011 USNO-NIST TWSTT calibration 4.1 ns off

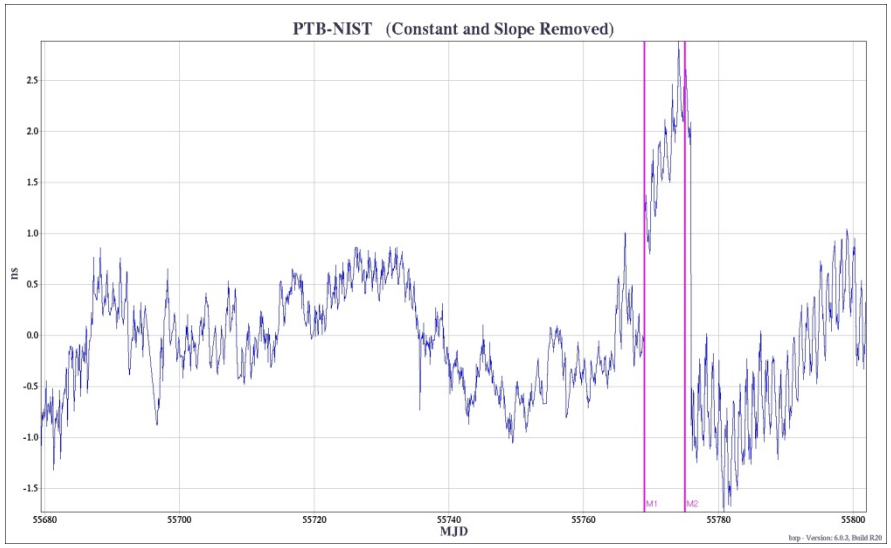
Double-difference between two TWSTT systems, USNO-AMC



Delay shift could be due to electronics or fiber-optics feeding the TWSTT hardware

Sat/Frequency changes of summer 2011
Some diurnals reduced, others enhanced





DIURNAL REDUCTION: USNO-PTB

- Configuration I: Original Hardware
  - Electronics indoors (except Low Noise Amplifier)
  - High-frequency waveguide to dish (~100ft) w/ low pressure dehydrator

- Configuration II: Exterior Receive Section
  - Transmit side unchanged - path to feed is via waveguide only
  - Receive is an Anasat on a different antenna at USNO-DC
    - 70 MHz to antenna
    - LNC to Anasat, both located on antenna
    - FACTOR OF 2 IMPROEMENT.

- Configuration III: Complete Anasat System
  - Anasat transceiver on dish, <1 meter waveguide to feed
    - 70 MHz exterior lines, transmit and receive
  - Same antenna for both

DIURNAL REDUCTION (other ways)

I. Enclosures – still untried in field

- Plan to test with just transceivers
  - Wide bandwidth outdoor amps may not contribute to diurnals
  - X-band 500 ps variation over 5 db gain chain (10=>35watts)

2. Spectral confusion
  - Odd hours did not help

3. Impedance matching
  - Removed directional coupler; made no difference
  - Ordered isolators and attenuators for Ku-band

An L-band Signal To Antenna?

- Cheaper or higher-bandwidth electronics
  - LNB ~$400, 4W BUC ~$700 (Ku ⇔ L band)
    - (additional cost to convert to L band)
  - UP/Down Converters 5K (low bandwidth) or 9K (high bandwidth)
  - For comparison: Anasat ~$10K
    - Converts 70MHz ⇔ Ku-band (with internal L-band step)
  - Question: Can TimeTech make an L-Band Transmitter Module?
- Another benefit: components are smaller
  - Easier to control temperature and/or humidity
  - Lighter for Ku-band calibrations

A Suggestion

- BIPM to host an extremely detailed listing of equipment
  - Manufacturer
  - Cost
  - Critical analysis of performance
- Info to be private – for players only
- USNO willing to do the work
  - Specifically, Jonathan Hirschauer

Summary

- Three TWSTT systems have independently shown calibration variations of several ns over several weeks/few months
- Diurnals and other instabilities need attention
- Calibrations via GPS useful if done with care
  - USNO uses a GPS receiver in every TWSTT calibration