A New VLBI Intensive Series Using the Mauna Kea and Pie Town Stations of the VLBA

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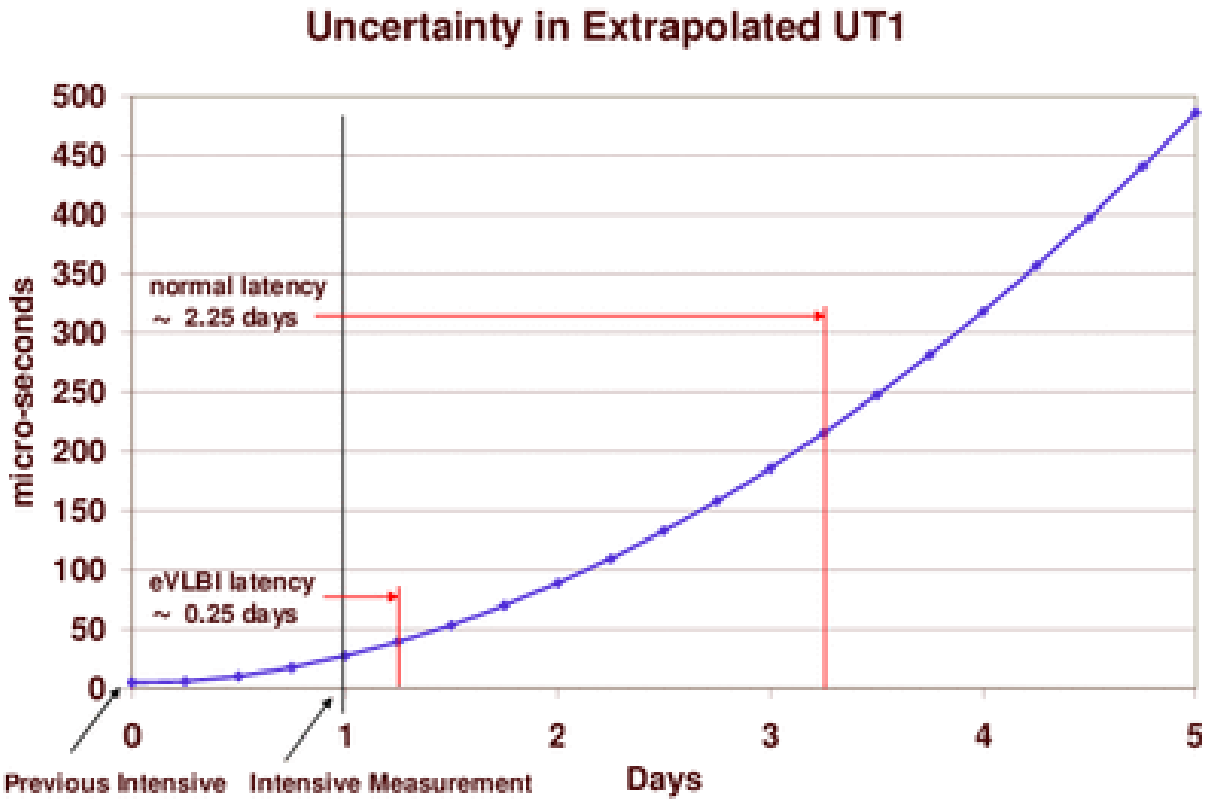
Outline

- Background
- UT1 tests with the VLBA
- VLBA MK-PT Intensive series
- Fine tuning the sessions
- Future plans

The USNO Astrometric/Geodetic Mission

- USNO is the IERS Rapid Service/Prediction Center for Earth Orientation and co-chairs the ICRS Product Center.
- USNO has several functions within the IVS.
  - Correlator Operations Center.
  - VLBI Data Analysis Center.
  - Special Analysis Center for Source Structure.
- USNO provides several levels of data products to the international community and to other U.S. Federal agencies.
  - Daily EOP (rapids).
  - Weekly EOP updates (Bulletin A).
  - Long-term (periodic EOP, TRF, CRF solutions).

How Can UT1 Product be Improved?



- Reducing data latency from 2.25 days to 6 hours results in:

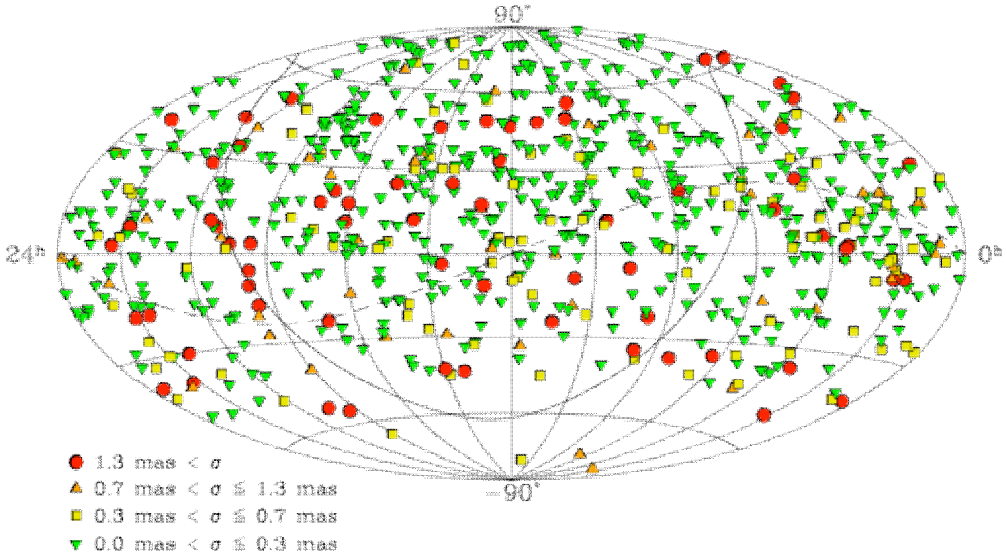
  Factor of 5 reduction in UT1-UTC prediction uncertainty

  40% reduction UT1-UTC prediction errors 7 days out.

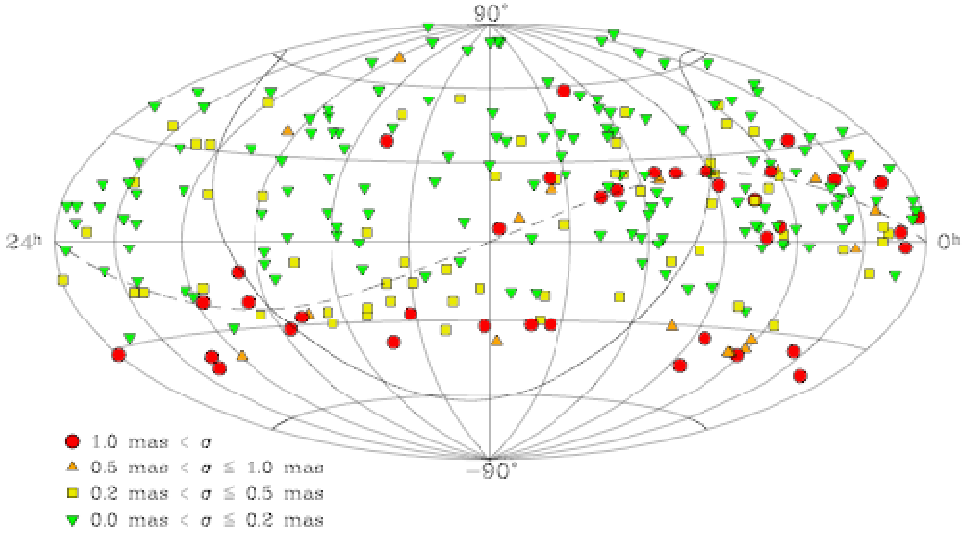
Astrometry/Geodesy with the VLBA

- VLBA already heavily used for astrometric CRF observations.
- RDV experiments.
  - Six 24-hr sessions per year.
  - 1997 – present.
  - RDV 91 (Feb. 2012)
- High-Frequency Reference Frame
  - K (24 GHz) / Q (43 GHz) bands
  - Twelve 24-hr VLBA sessions
  - 2002 to 2009
- USNO interest in using VLBA for geodesy.

RDV reference frame

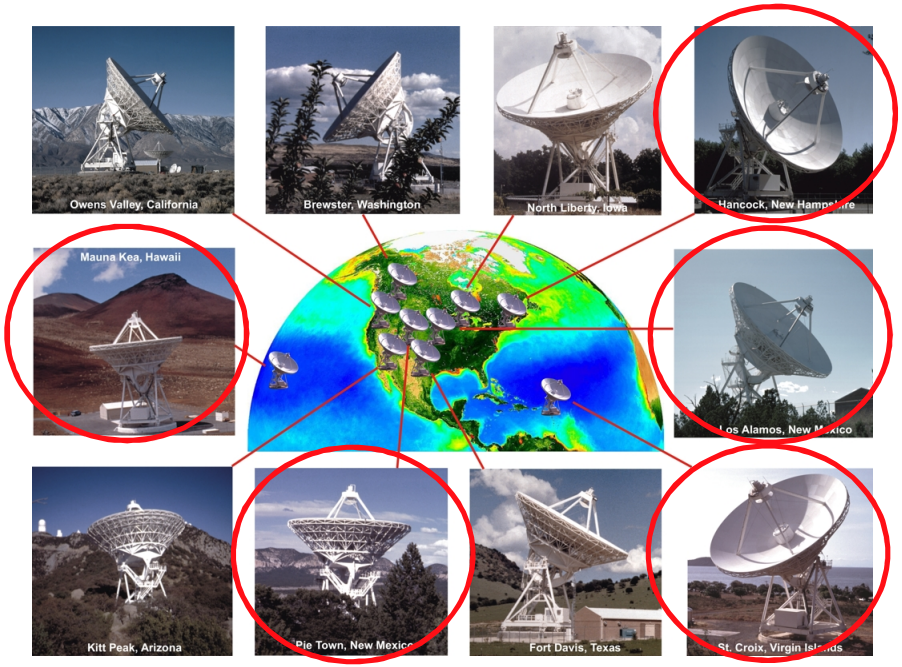


High-freq. reference frame



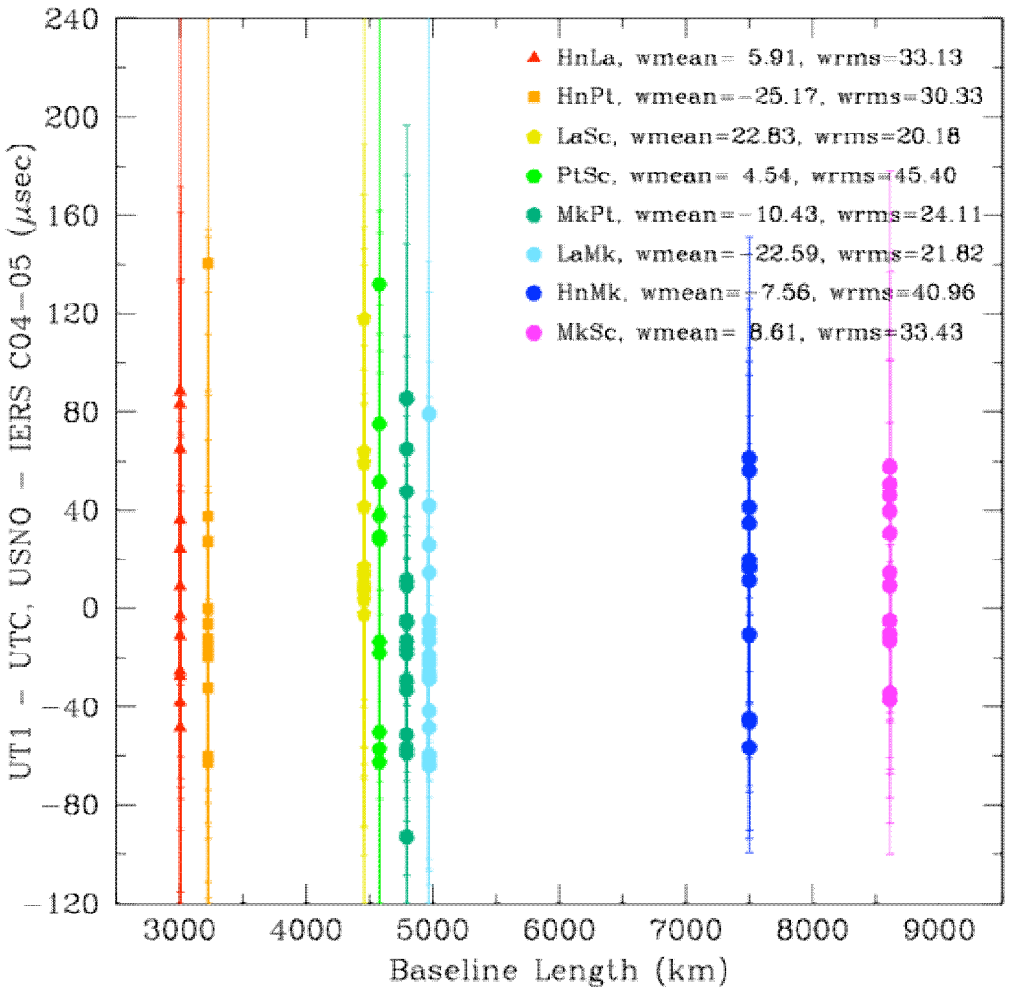
UT1-UTC Testing With the VLBA

- NRAO and USNO began a series of “Pseudo” Intensives to measure UT1-UTC.
- Feb. 2009 – Mar. 2010
- TC015
  - 5 stations (HN, LA, MK, PT, SC)
  - 13 sessions
  - Optimized for MK-SC baseline
- TB014
  - 3 stations (MK, LA, PT)
  - 5 sessions
  - Optimized for MK-PT baseline



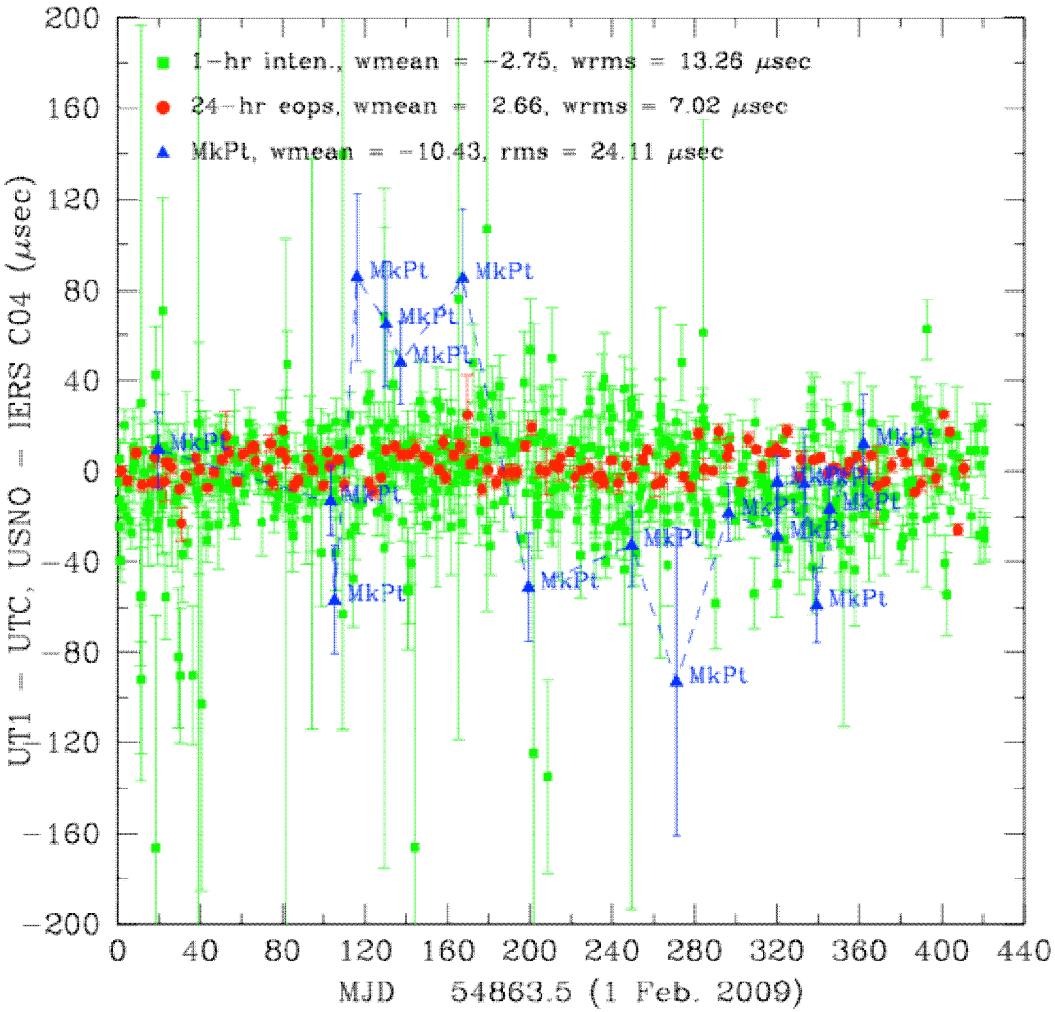
Results from Pseudo-Intensive Experiments

- Differences between VLBA UT1-UTC and IERS C04 as a function of baseline length
- Longer baselines more tightly distributed
- Despite shorter baselines, VLBA measurements meet operational requirements for UT1-UTC



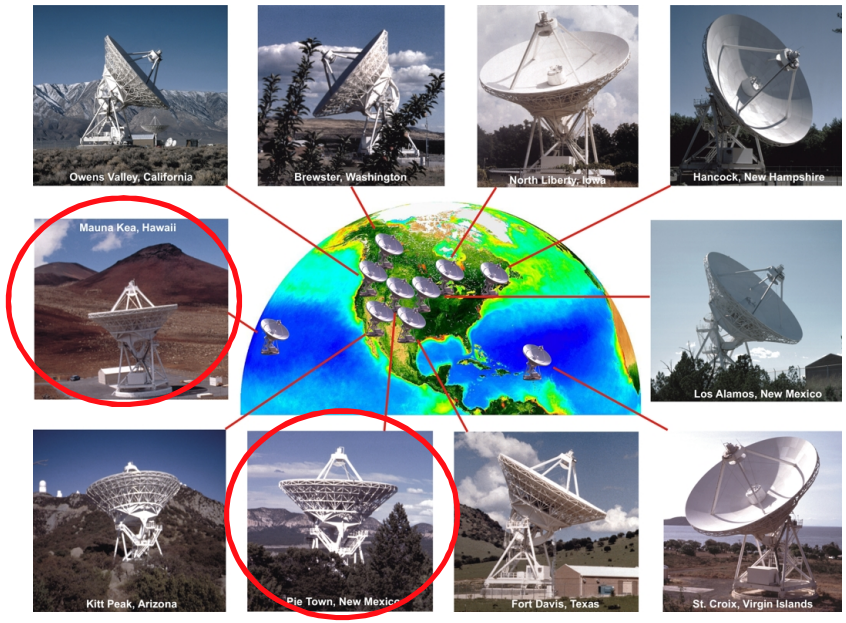
Why the MK-PT Baseline for UT1-UTC?

- Mauna Kea, Hawaii
  - Provides long east-west baseline necessary for UT1.
  - Network infrastructure mostly there except for last mile.
  - Redundancy with Kokee Park geodetic VLBI station.
- Pie Town, New Mexico
  - Network infrastructure already in place (VLA-PT).
  - Cost sharing for some legs between station and 10 Gb/s Internet2.
  - Proximity to NRAO-AOC.



Agreement with the NRAO

- Goal: Perform daily UT1-UTC measurements using the VLBA.
- Mauna Kea, HI - Pie Town, NM
  - Baseline: 4795 km
- USNO-NSF-NRAO MOU signed.
  - USNO to provide funding for daily “Intensive” observations.
  - Continued VLBA RDV participation.
- Intensives require high-speed network connections to both stations for e-VLBI.



Installation of MK-PT Fiber Links

- Pie Town link (1 Gbps).
  - Available March 2011.
  - Multiple test transfers of VLBI data
  - 100 - 400 Mb/s to USNO.
- Mauna Kea link (1 Gbps).
  - Contract with University of Hawaii.
  - Installed and available July 2011.
  - Multiple test transfers of VLBI data
  - 100 - 400 Mb/s to USNO.

VLBA MK-PT Observations

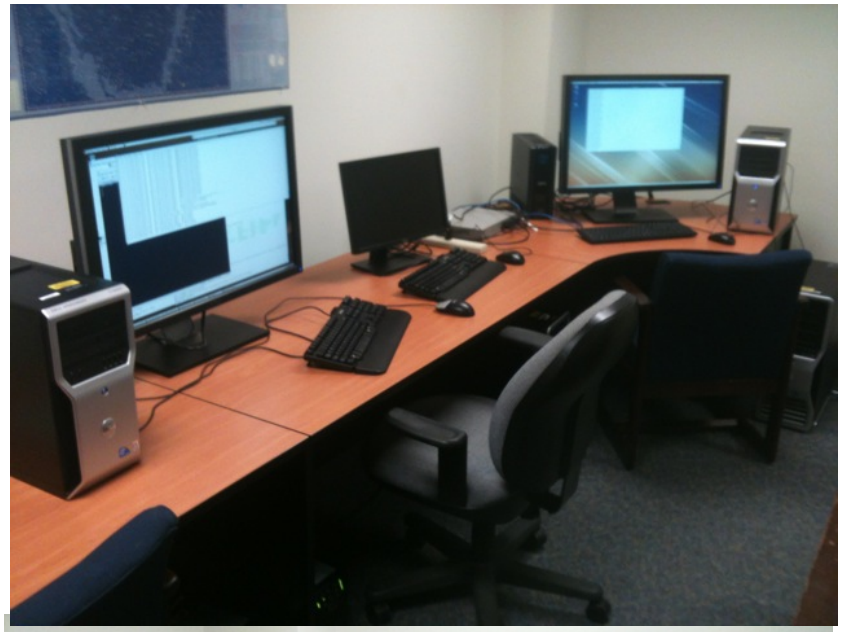
- Using new RDBE system at MK and PT stations.
- Dual S/X Band
  - 32 MHz/channel
  - 6 Contiguous S-band channels: 2156 – 2348 MHz
  - 10 X-band channels: 8430 – 8908 MHz
- 2 Gb/s data rate
- 45 minutes / experiment, 30-35 scans
- 12 seconds scan lengths
  - Helps limit data to be transferred (~100 GB/station).
  - Source lists from USNO, ICRF2 defining sources.
- Separate USNO Mark5C recorders.

VLBA MK-PT Data Path

- Schedule generated by NRAO: SCHED
  - Gives NRAO flexibility to break into astronomy obs.
  - Automated e-mail notification to exploder: ut1@nrao.edu
- Observations occur.
  - Notification (observing log) to exploder.
- Data copied from Mark5C module to Mark5C internal disk.
- Data e-transferred from stations to USNO.
  - ~100GB per station transferred via TSUNAMI
  - Data written to 48 TB Storage Area Network (SAN) at USNO.
- Data written from SAN to Mark5 modules at USNO.
- Data correlated on USNO Software Correlator.
- Data converted from DiFX format to FITS and MARK4 formats.
- Data post-processed and geodetic databases created.

Correlation on USNO DiFX Software Correlator

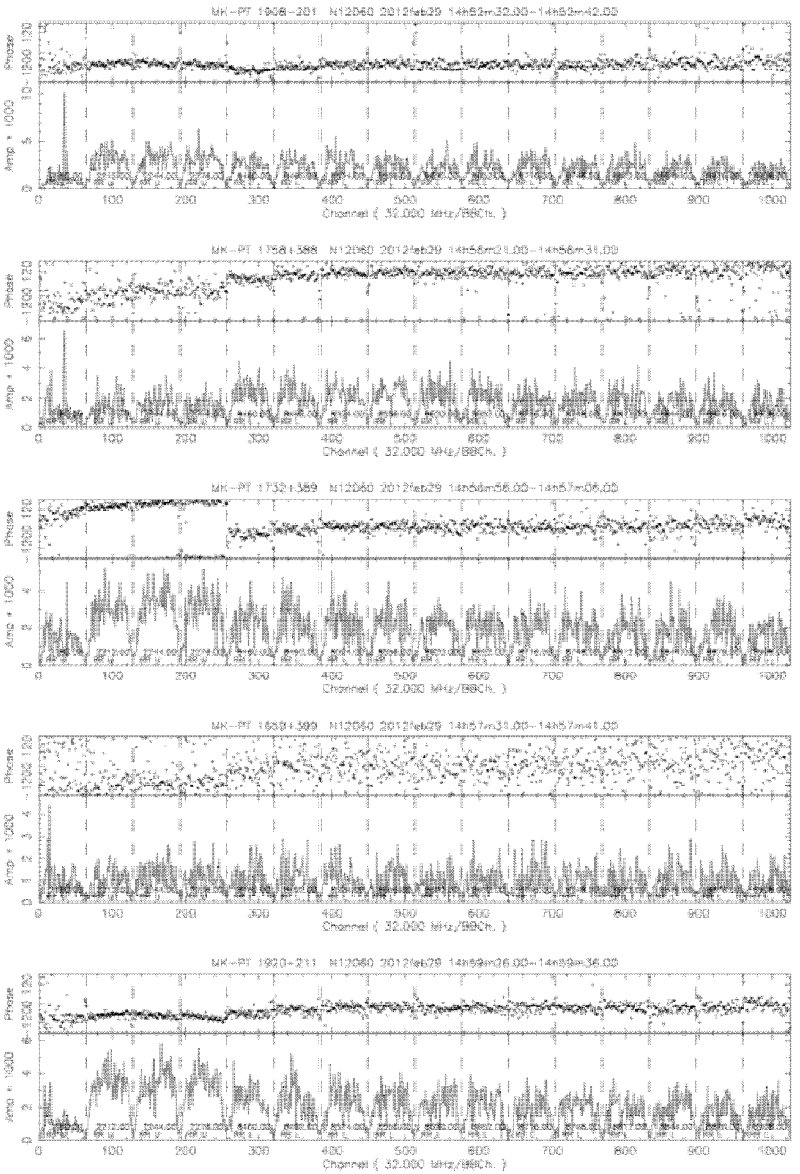
- Heterogeneous cluster.
  - 4 nodes (workstations)
  - 28 cores
  - 2 Mark5B+ units
- 1 Gb/s ethernet switch.
- Red Hat Enterprise Linux operating system.
  - Mixed 32 and 64-bit operating system
- DiFX package installed.
- Procurement of full software correlator cluster underway.



VLBA MK-PT INT4 Sessions

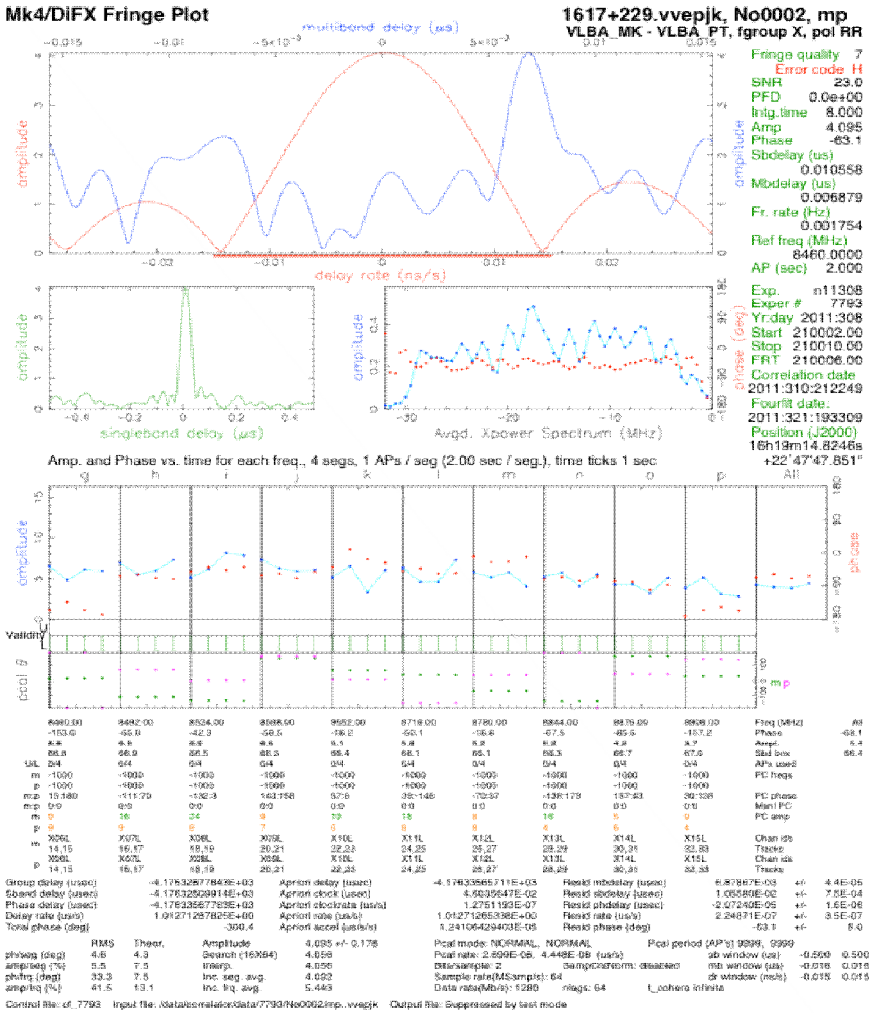
- Designated IVS Intensive4 (INT4)
  - IVS Session: Nyyddd
  - Databases: yymmmddXV_V001
- Some growing pains with new series.
- Fringes/Experiments
  - Sept. – 1/3
  - Oct. – 4/11
  - Nov. – 5/13
  - Dec. – 5/13
  - Jan. 2012 – 16/16
  - Feb. 2012 – 21/24
  - Mar. 2012 – 3/3 so far

N12069 – 29 Feb. 2012



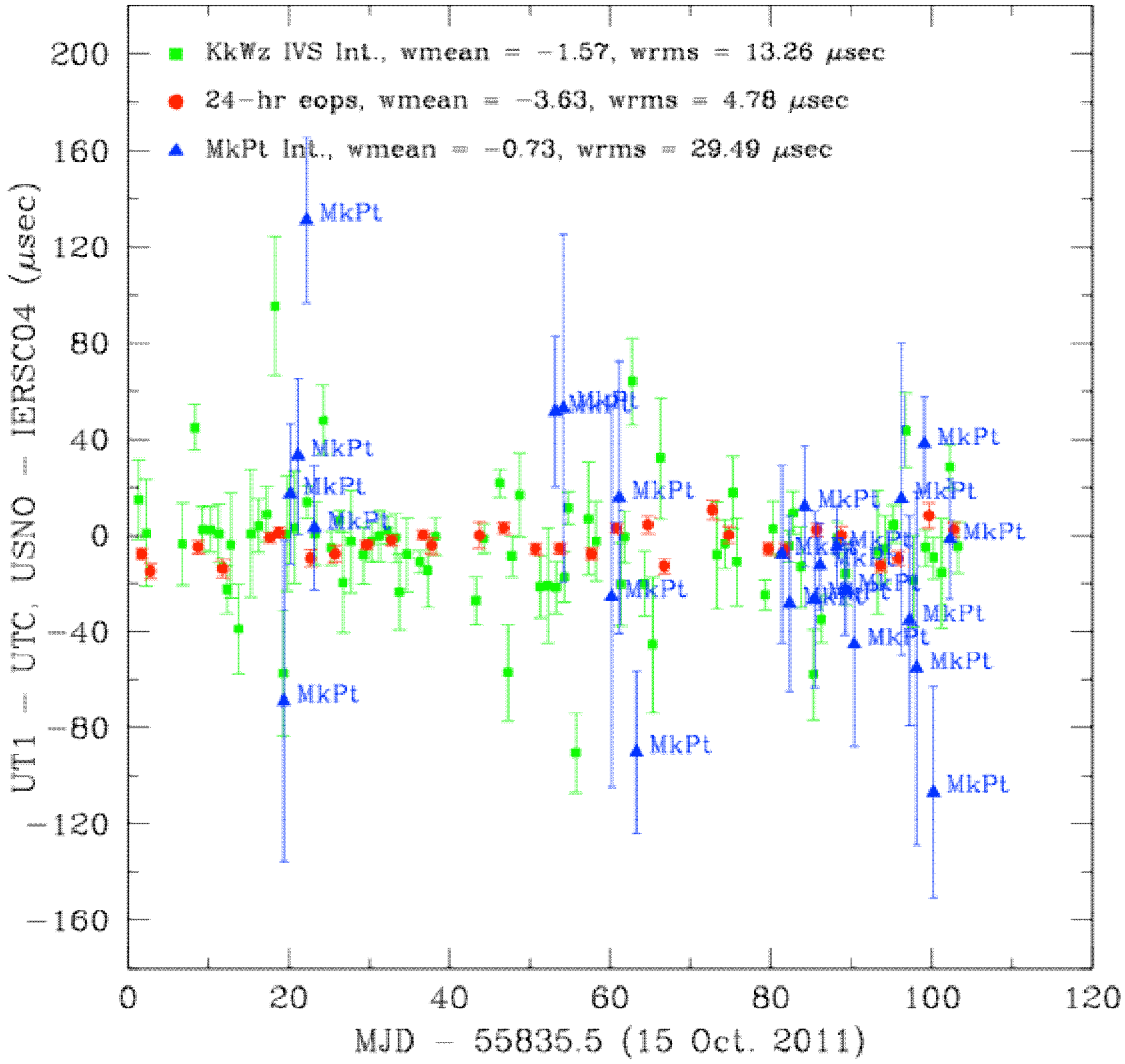
Post-processing and Analysis

- Geodetic post-processing path exercised through completion.
  - Nov. 2011 – 5 sessions
  - Dec. 2011 – 5 sessions
  - Jan. 2012 – 16 sessions
- Mark4 style databases produced with DiFX2Mark4.
- Fringe-fitting and calibration within HOPS.
- Geodetic database creation and distribution with DBEDIT.
- Database analysis with SOLVE.
- Global solution and UT1–UTC time series generation with SOLVE.



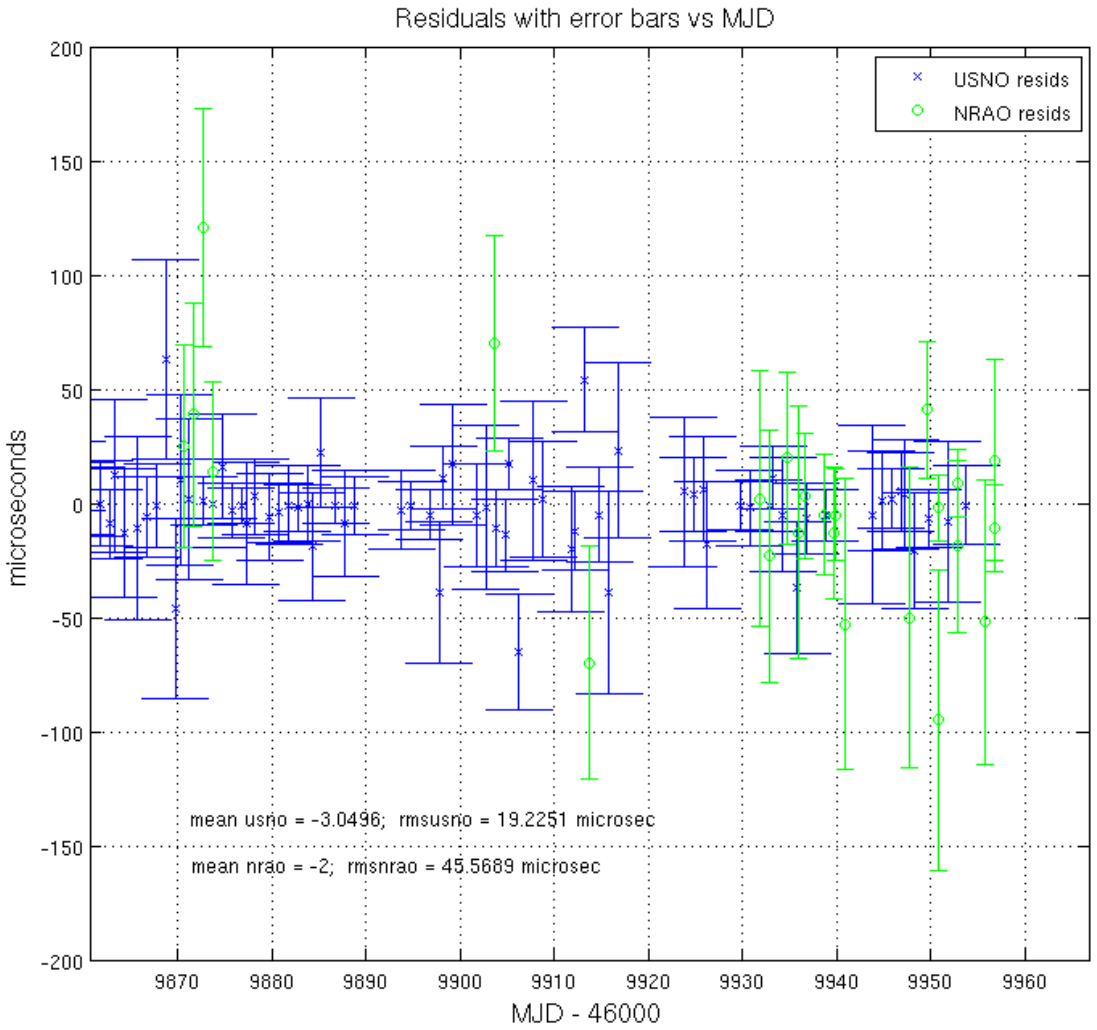
UT1–UTC Results: Comparison IERS C04

- Oct. 2011 – Jan. 31, 2012
- IVS 24-hr sessions (red)
- KkWz Intensives (green)
  - wrms = 13.3 μsec
- MkPt Intensives (blue)
  - wrms = 29.5 μsec



UT1–UTC Results: Comparison with Bulletin A

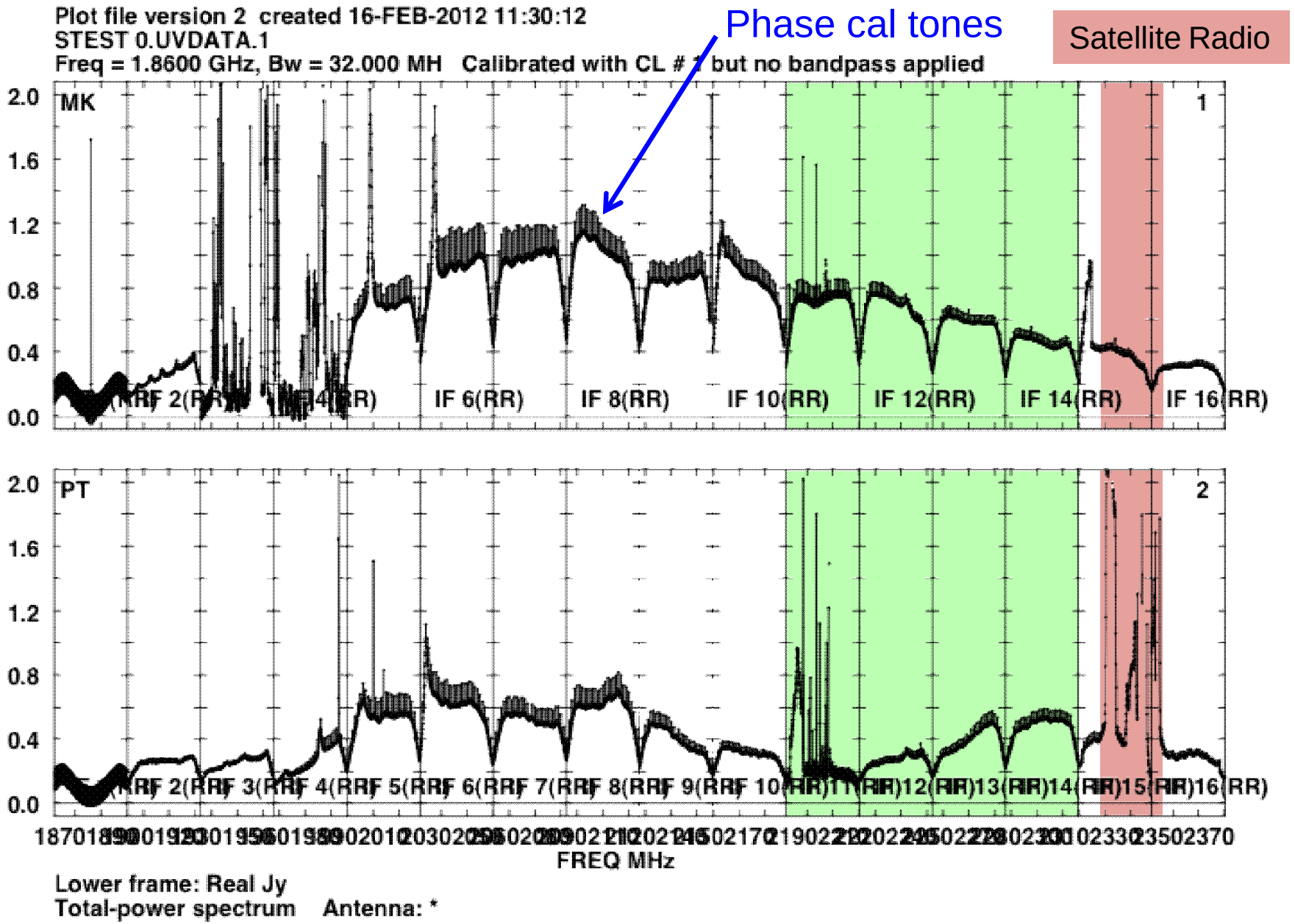
- Oct. 2011 – Jan. 31, 2012
- KkWz Intensives (blue)
  - rms = 19.2 μsec
- MkPt Intensives (green)
  - rms = 45.6 μsec



Fine Tuning: S-Band Tests

- USNO working with NRAO to optimize frequency bands for MK-PT Intensives.
- Started with 6 S-band channels and 10 X-band.
- Two S-band channels in satellite radio band 2320-2345 MHz.
  - These channels dropped.
  - Replaced with X-band channels.
- Current setup: 4 S-band and 12 X-band.
- Some RFI still in S-band channel 1.
- 15-25 observations at S-band make it through fringing/post-processing typically.
- Prompted tests to map the entire S-band frequency range.

S-Band Test: 1860–2372 MHz



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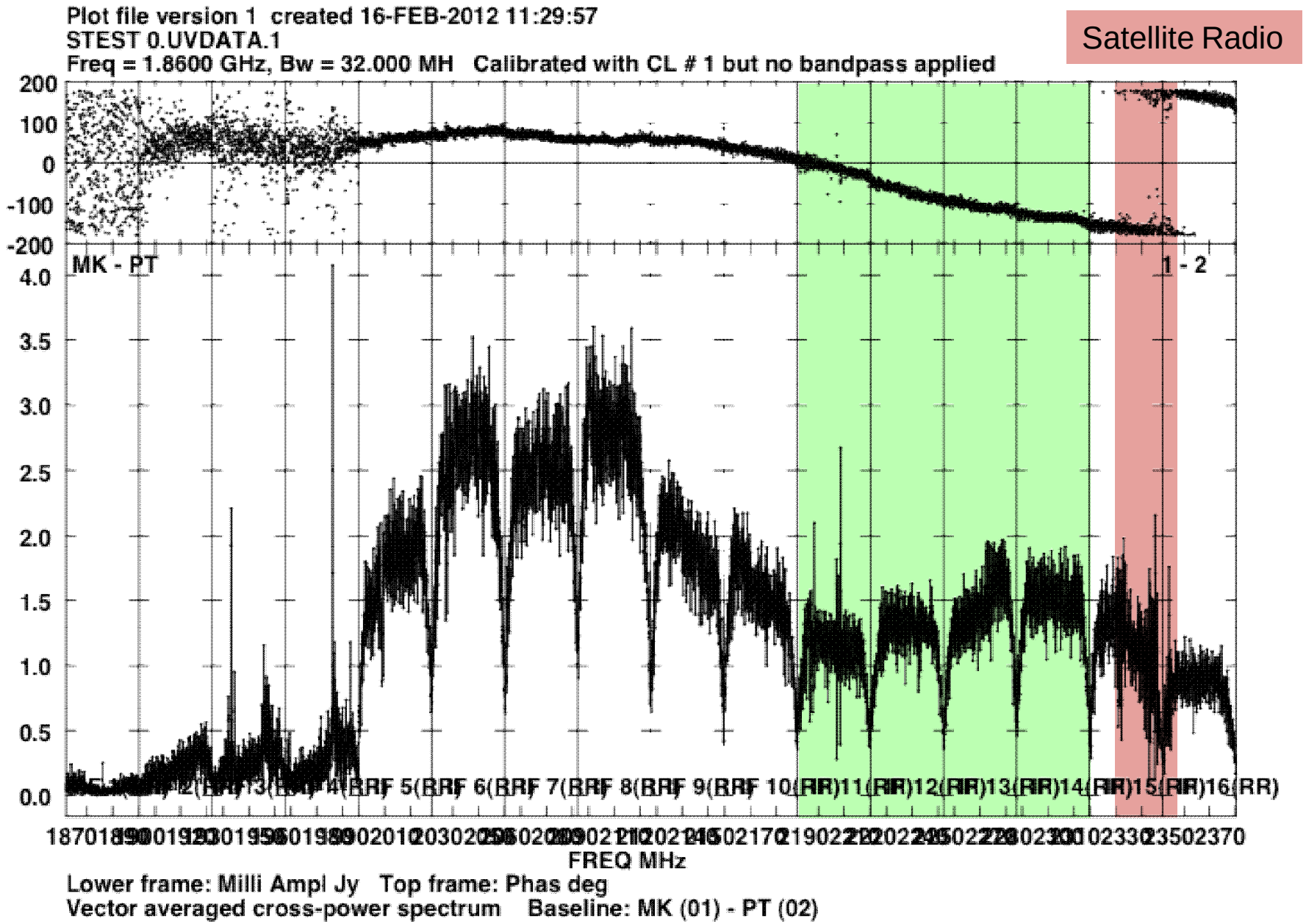
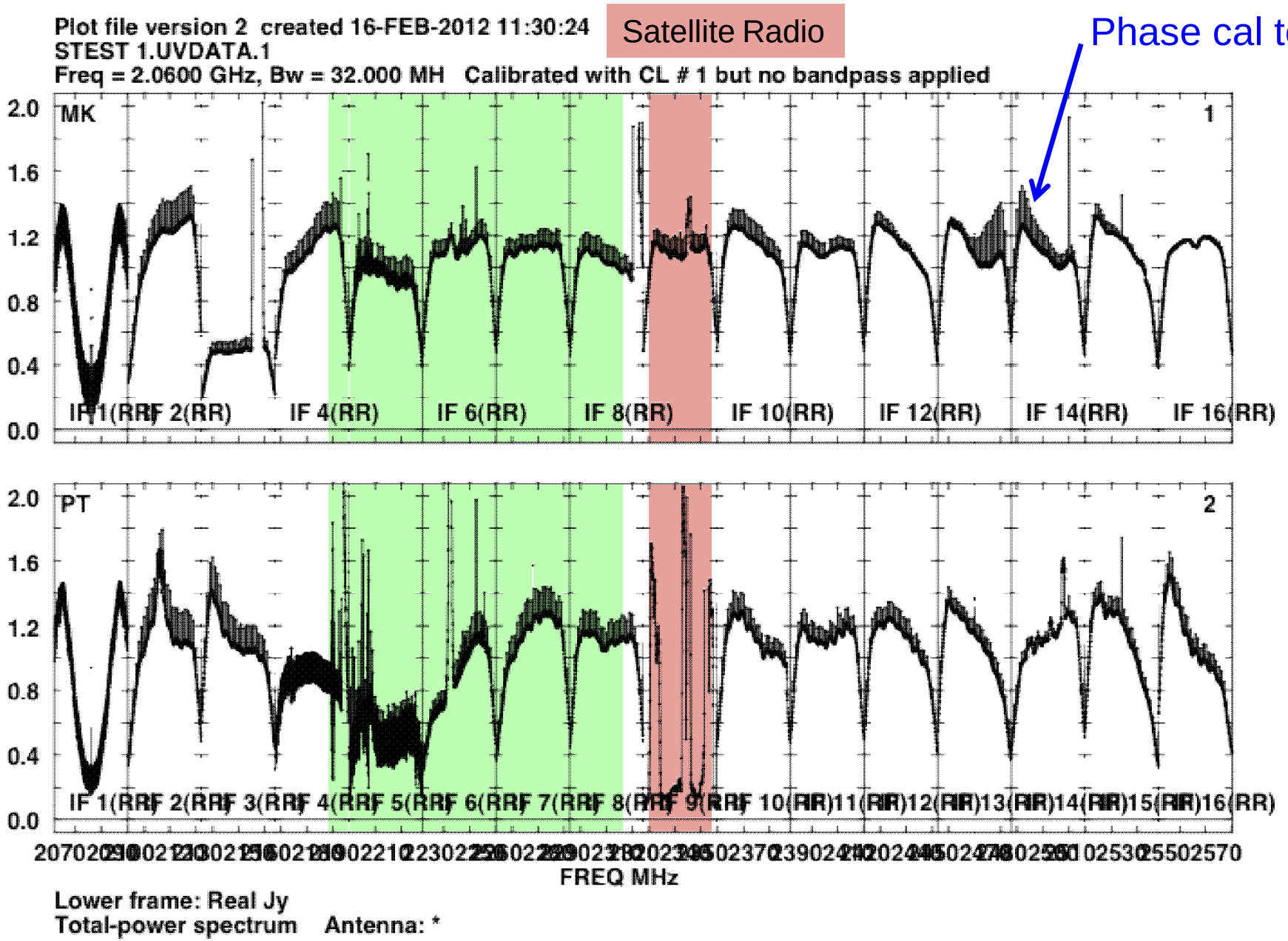
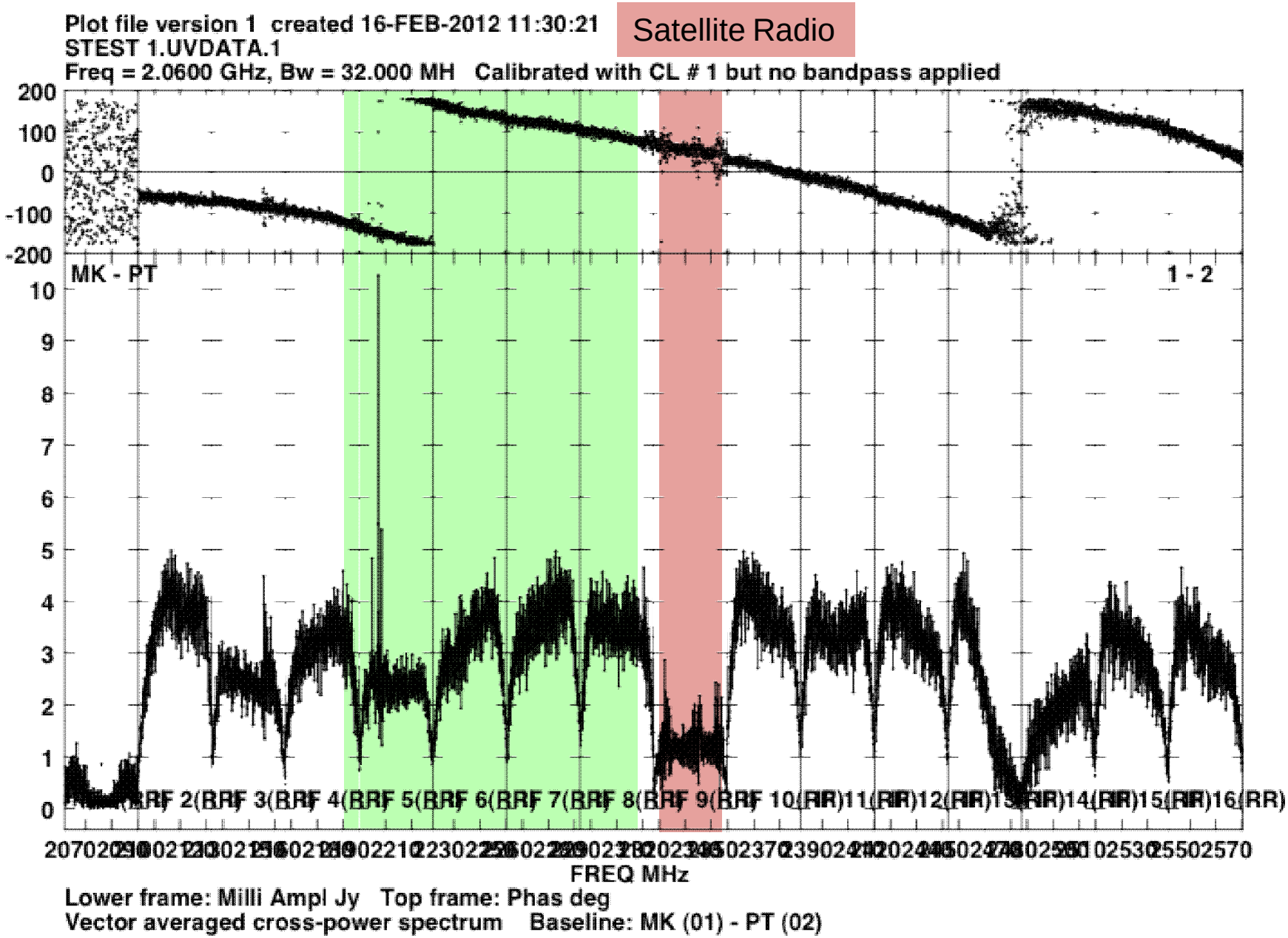


S-Band Test: 2060–2572 MHz



S-Band Test: 2060–2572 MHz



Future Plans

- Get INT4 data into IVS system.
- Move MK-PT INT4 sessions from tests to operations.
- Automate e-transfers of the data.
- Streamline post-processing.
- Scheduling/Frequency optimization.
- Move to file-based correlation.
  - Eliminate USNO data write to Mark5 module.
- New software correlator at USNO.
  - 30 Node (360 core) cluster running DiFX.
  - Capable of correlating 15 stations at ~2 Gb/s.