IGS Clock Products Working Group

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7th meeting of the representatives of Laboratories contributing to TAI

13 September 2006
Bureau International des Poids et Mesures
Sèvre, France

Clock RINEX Format Change

a. "RINEX VERSION / TYPE" header changed to 3.00 and to add satellite system designator.
b. "PGM / RUN BY / DATE" header date format elaborated.
c. "SYS / # / OBS TYPES" header added.
d. Added Galileo and Space-Based Augmentation System (SBAS) satellite designators in Section 5.
e. "TIME SYSTEM ID" header added.
f. The satellite antenna phase center offset information has been moved from a mandatory comment to the "SAT ANT PCO / PCV" header and now includes the associated phase center variation information also. It is expected that an external file will be referenced.
g. "SYS / DCBS APPLIED" header added. [NOTE: The format -- taken from RINEX 3.00 is not adequate to give DCBs for each satellite. Further changes are under discussion.]
h. Capability of handling inter-system timing biases (possibly as a new type of CR data record) are under consideration.

To view the pending revised version, please see:
ftp://www.ngs.noaa.gov/dist/jimr/rinex_clock.30aug06

Send any comments to:

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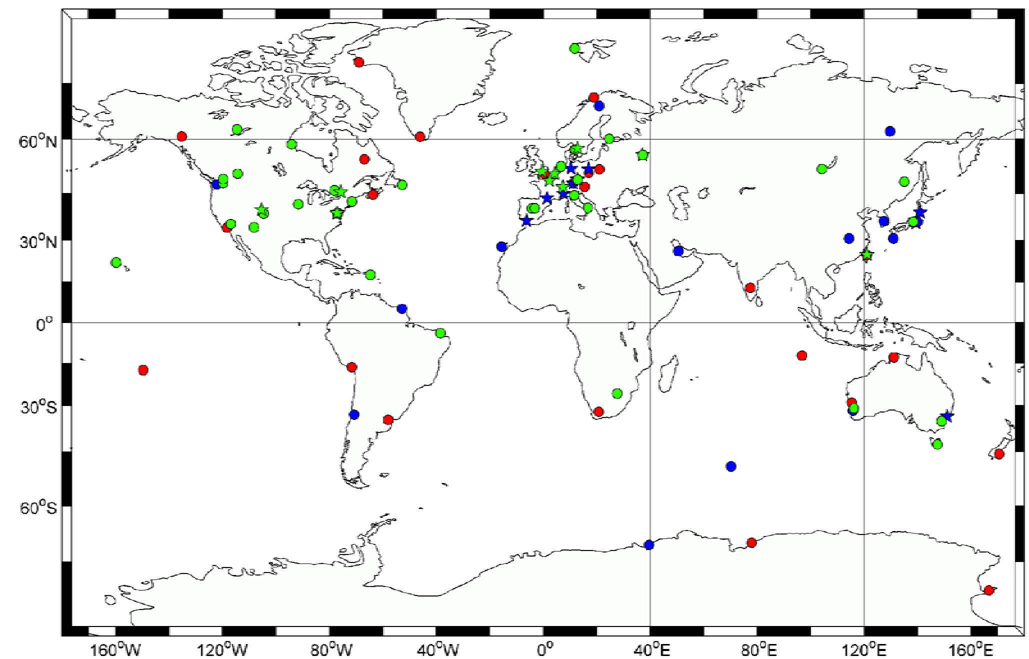
IGS High Performance Clocks

Time Labs

IGS Site	Time Lab	Freq. Std.	Location
AMC2	*AMC*	***H-Maser***	*Colorado Springs, CO USA*
BOR1	*AOS*	***Cesium***	*Borowiec, Poland*
BRUS	*ORB*	***H-Maser***	*Brussels, Belgium*
IENG	*IEN*	***Cesium***	*Torino, Italy*
KGN0	*CRL*	***Cesium***	*Koganei, Japan*
MDVJ	*VNIIM*	***H-Maser***	*Mendeleevo, Russia*
MIZU	*NAO*	***Cesium***	*Mizusawa, Japan*
NISU	*NIST*	***H-Maser***	*Boulder, CO USA*
NPLD	*NPL*	***H-Maser***	*Teddington, UK*
NRC1	*NRC*	***H-Maser***	*Ottawa, Canada*
NRC2	*NRC*	***H-Maser***	*Ottawa, Canada*
OBE2	*DLR*	***Rubidium***	*Oberpfaffenhofen, Germany*
OPMT	*OP*	***H-Maser***	*Paris, France*
PENC	*SGO*	***Rubidium***	*Penc, Hungary*
PTBB	*PTB*	***H-Maser***	*Braunschweig, Germany*
SFER	*ROA*	***Cesium***	*San Fernando, Spain*
SPT0	*SP*	***Cesium***	*Boras, Sweden*
SYDN	*NMI*	***Cesium***	*Sydney, Australia*
TLSE	*CNES*	***Cesium***	*Toulouse, France*
TWTF	*TL*	***Cesium***	*Taoyuan, Taiwan*
USNO	*USNO*	***H-Maser***	*Washington, DC USA*
USN3	*USNO*	***H-Maser***	*Washington, DC USA*
WAB2	*CH*	***H-Maser***	*Bern, Switzerland*
WTZA	*IFAG*	***H-Maser***	*Wettzell, Germany*
WTZR	*IFAG*	***H-Maser***	*Wettzell, Germany*



● masers (54)
● cesiums (32)
● rubidiums (27)

★ time lab stations (25)

+ GPS space clocks …

- IGS Reanalysis underway 2006/2007
  - Will reanalyze data back to 1994
  - Clock densification a high priority
  - PPP at BIPM w/ IGS products still probably necessary though

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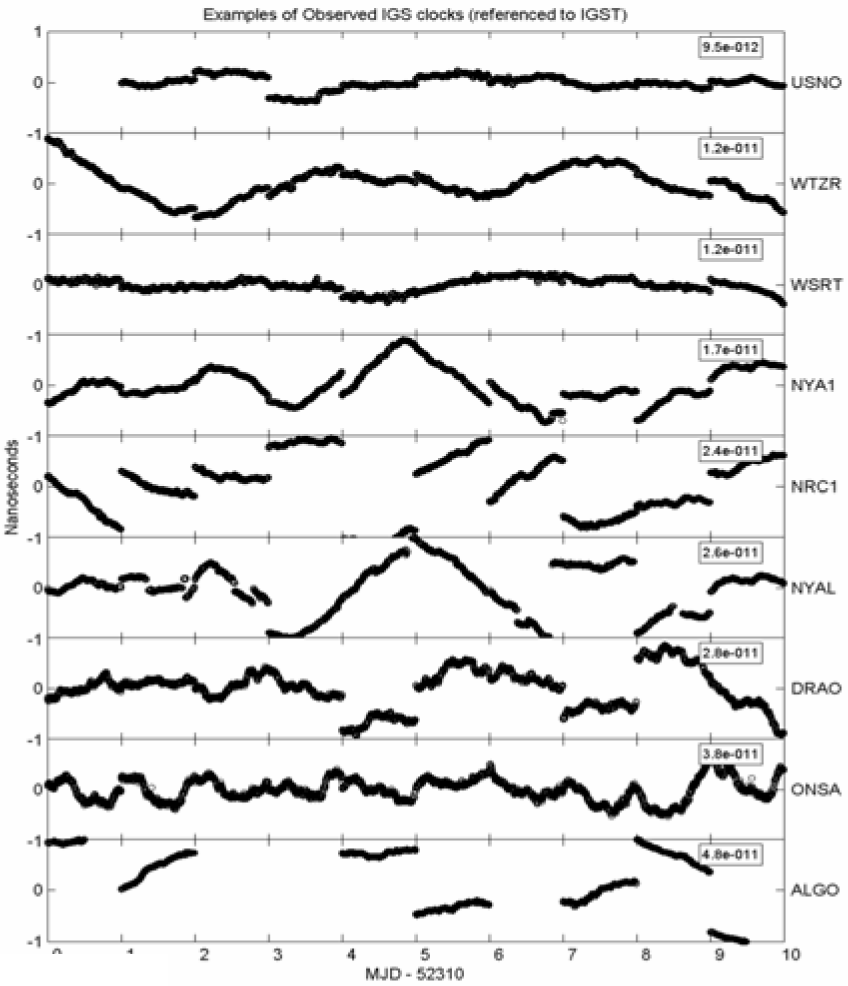
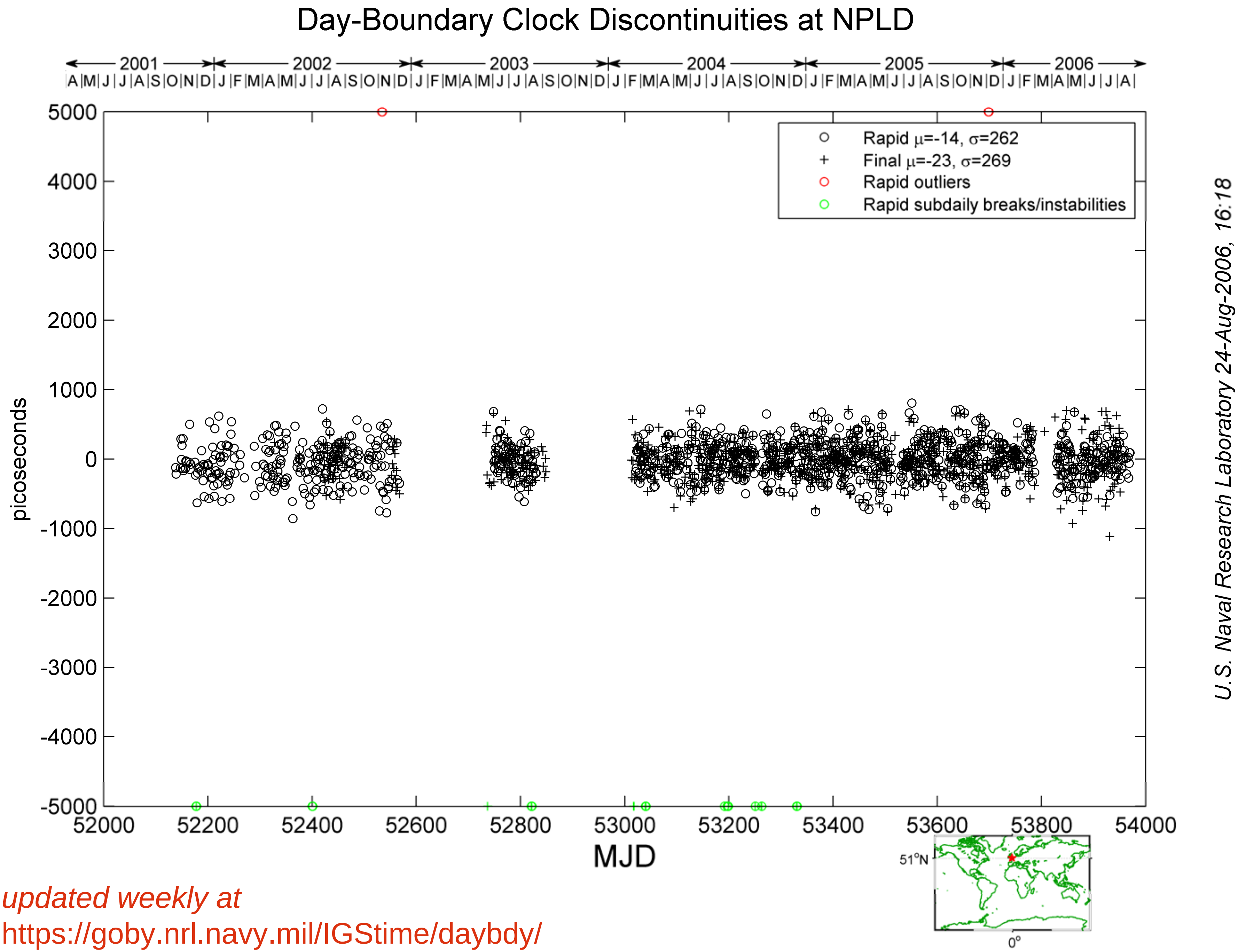
Day Boundary Clock Jumps

Metrologia, **40**(3), pp. S270-S288, (2003)

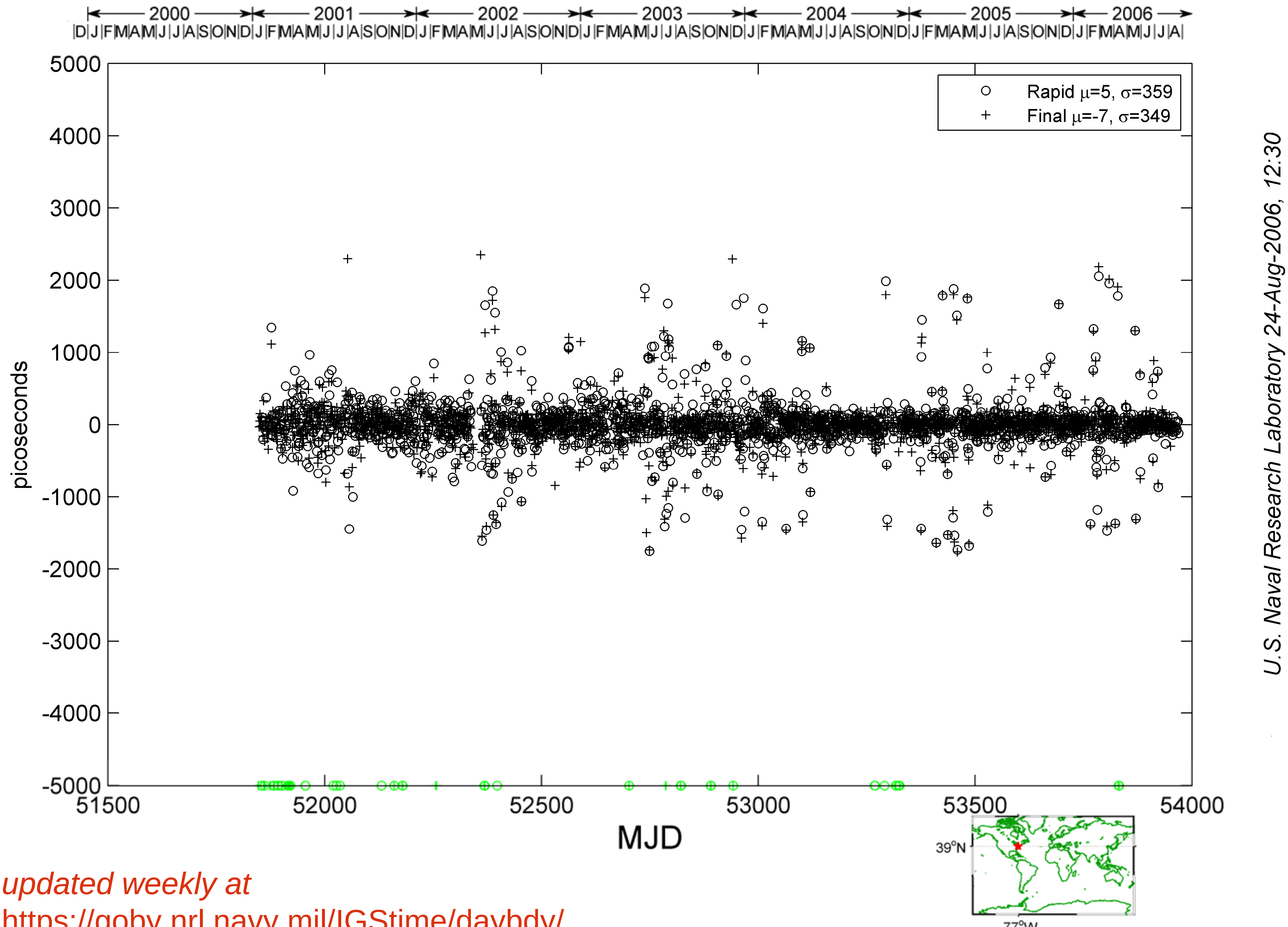
- **clock bias accuracy is determined by mean code noise per arc**
- **for 24-hr arc with code σ = 1 m, clock accuracy should be ~120 ps**
- ***independent* daily reductions can test accuracy by measuring clock jumps at day boundaries (H-maser stations only)**
- **observed clock accuracies vary hugely among stations (120 – 1500 ps)**
- **presumably caused by variable local code multipath conditions**
- **long-wavelength (*near-field*) code multipath most important**
- day-boundary jumps not an issue if station is constructed properly (e.g., ONSA & BRUS)





updated weekly at
https://goby.nrl.navy.mil/IGStime/daybdy/

Day-Boundary Clock Discontinuities for USNO



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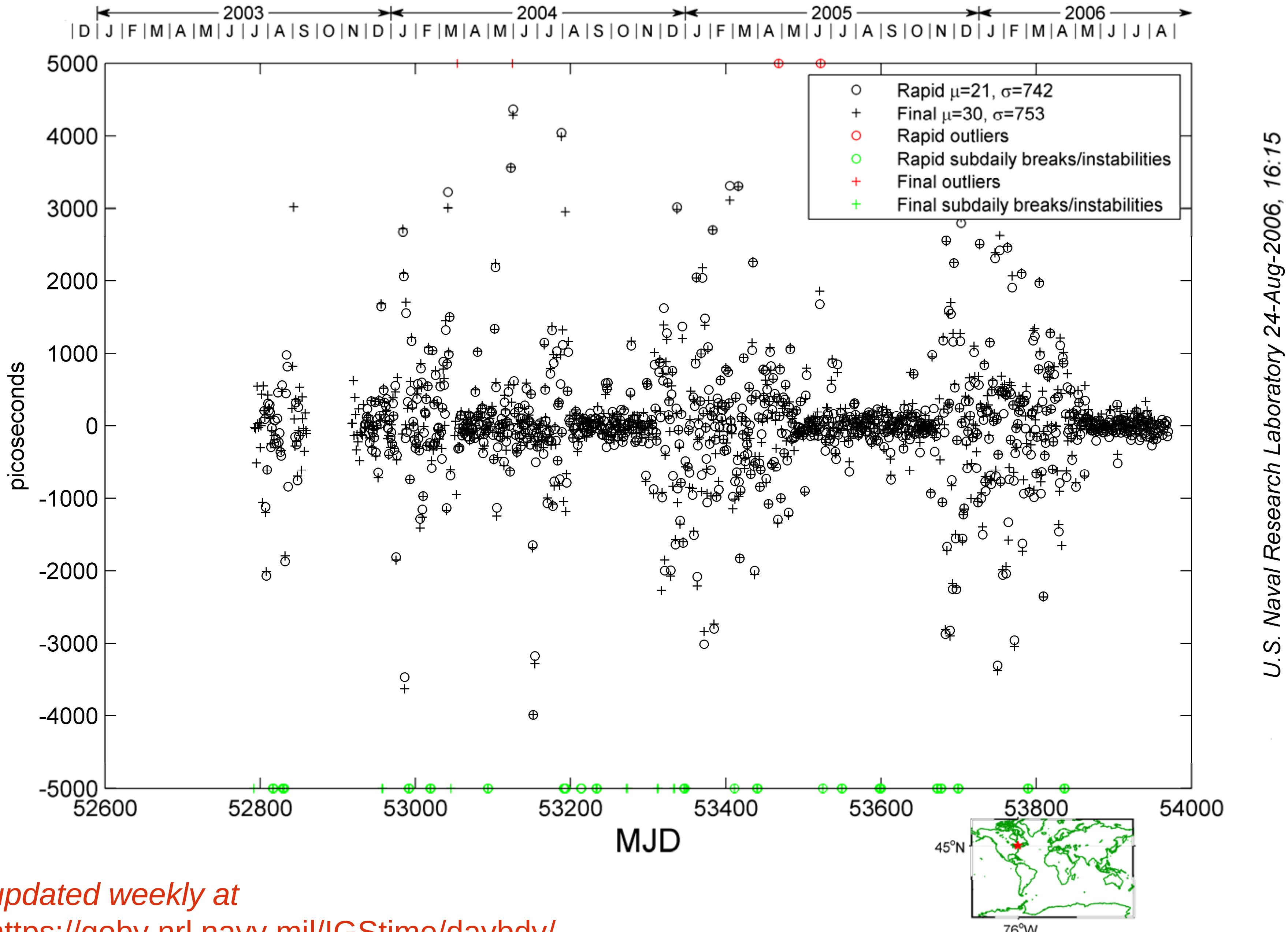
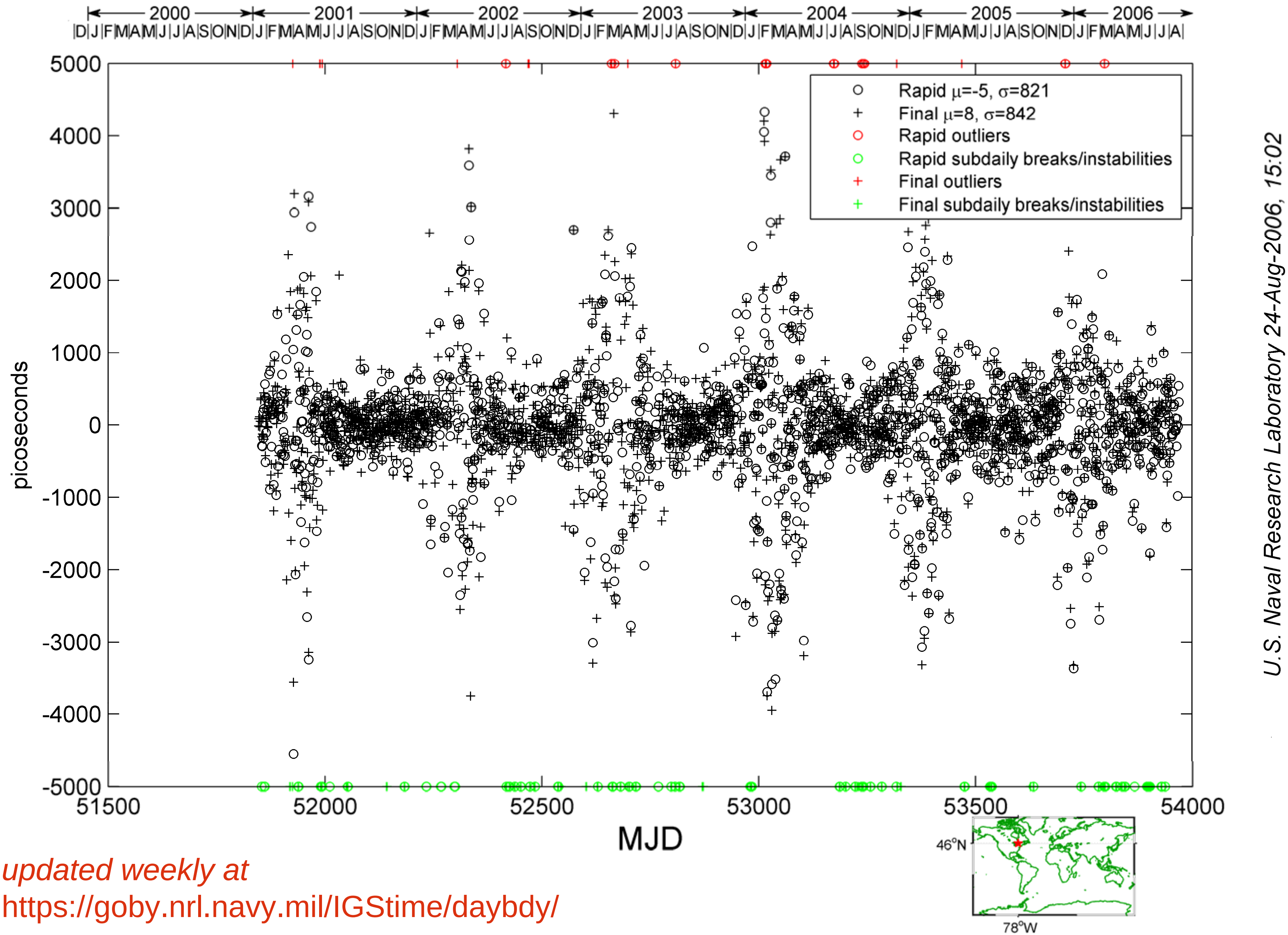
Day-Boundary Clock Discontinuities at NRC1



updated weekly at
https://goby.nrl.navy.mil/IGStime/daybdy/

Day-Boundary Clock Discontinuities at ALGO



updated weekly at
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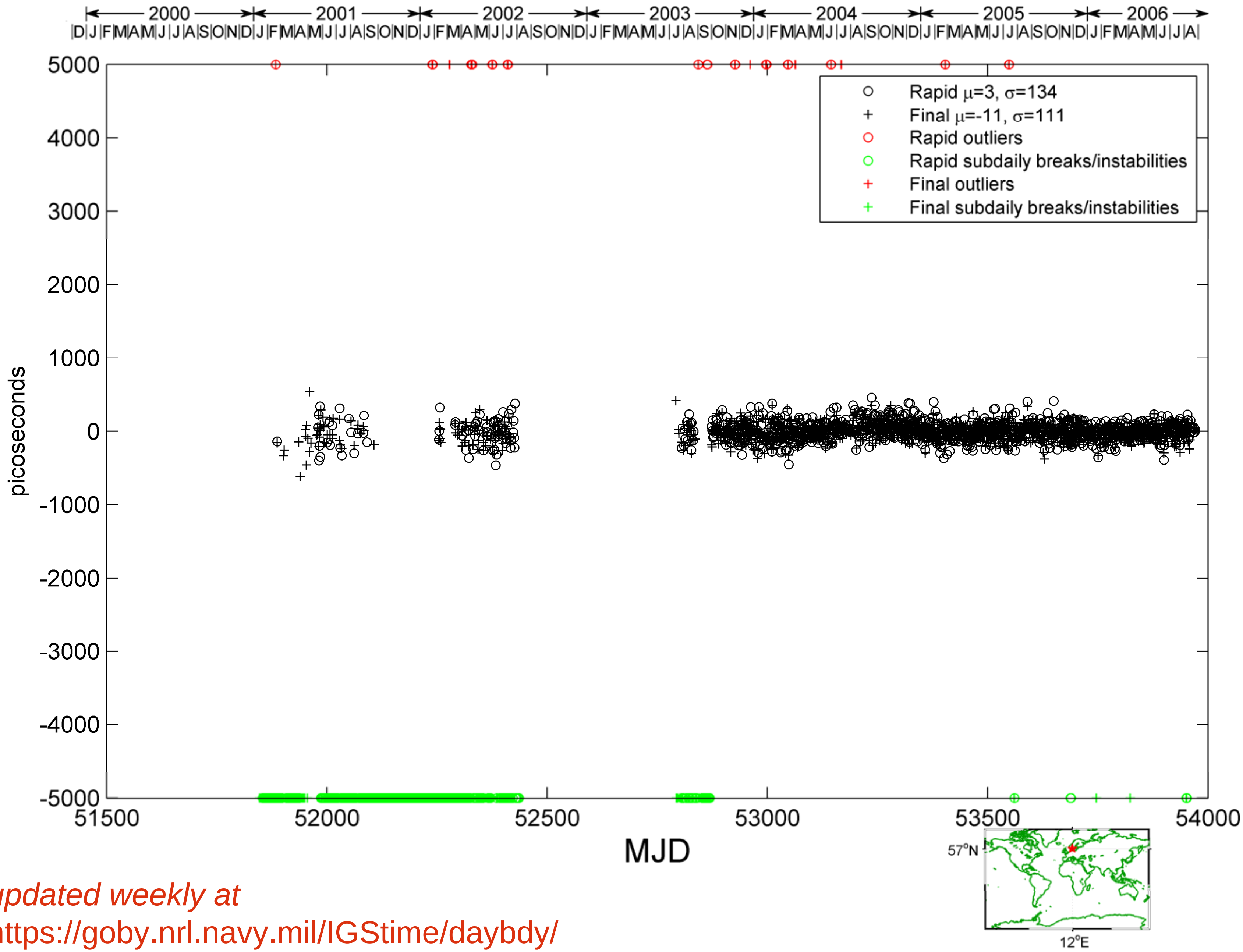
Day-Boundary Clock Discontinuities at ONSA



U.S. Naval Research Laboratory 25-Aug-2006, 16:32

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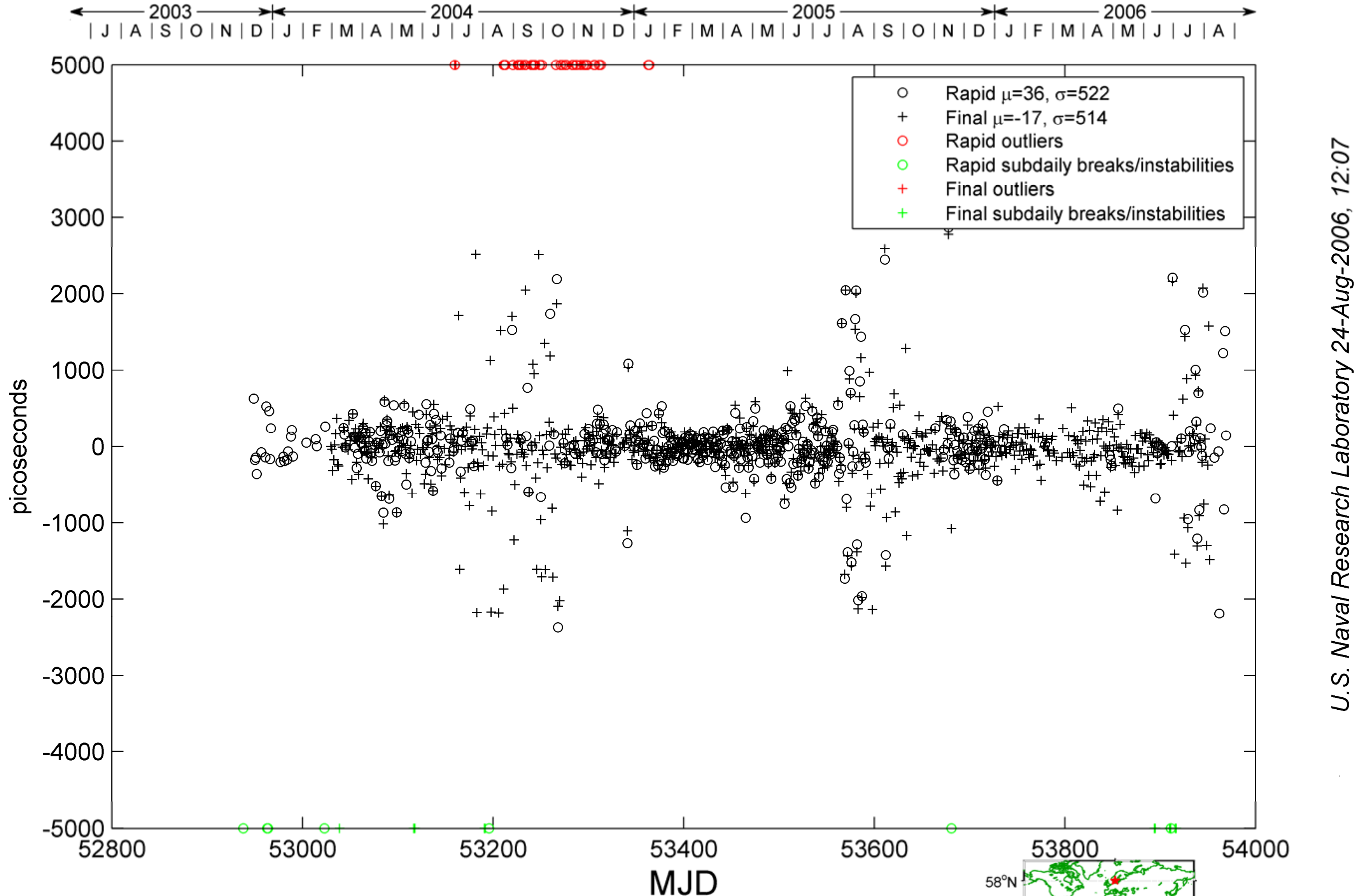
Day-Boundary Clock Discontinuities for SPT0



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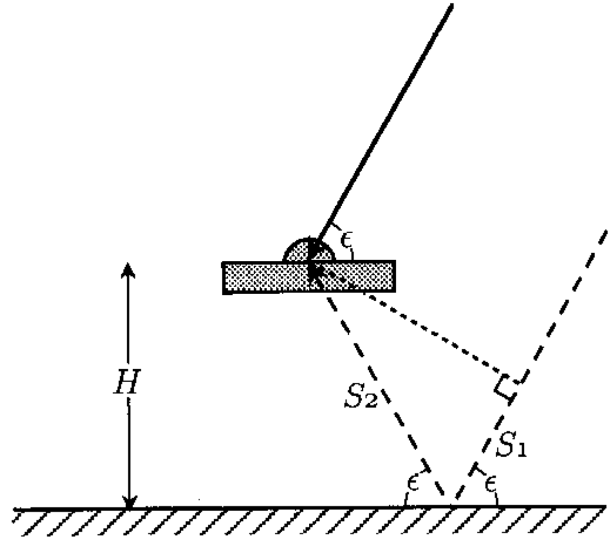
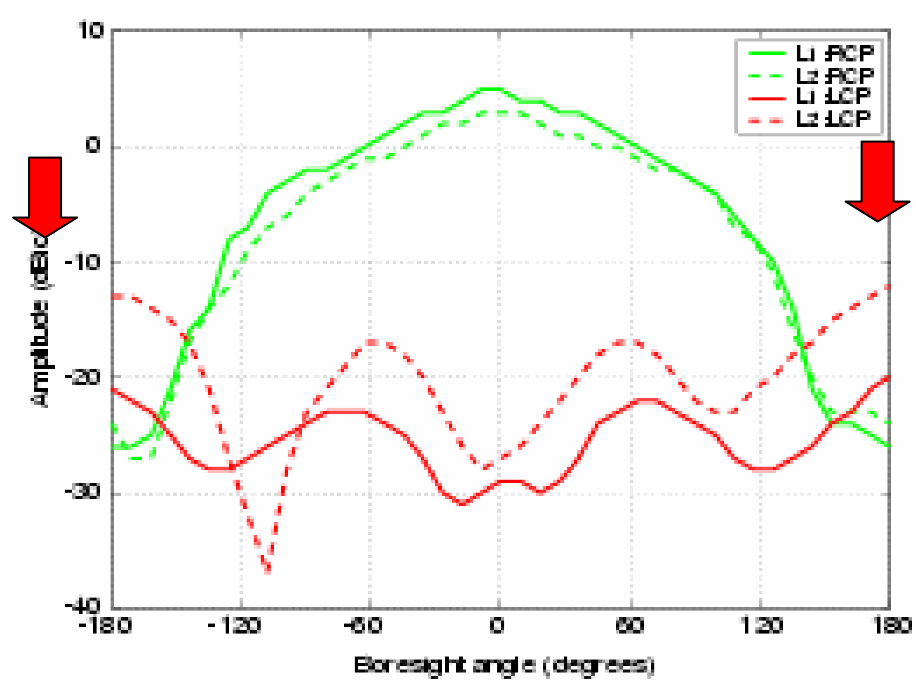
Near-field Multipath Hypothesis

- <u>Hypothesis</u>: (J. Ray, 2005) Near-field standing-wave back reflection a likely cause of day-boundary discontinuities at many sites
- Expect longest-period MP errors when H (phase center to back surface) is smallest [Elósegui et al., 1995]
- Choke-ring design esp sensitive to L2 reflections from below [Byun et al. 2002]
- Most IGS RF stations use antenna mount over surface!
- Other processing techniques may be studied, but we should determine what is already being done (instrumentally) correctly at sites like ONSA & BRUS



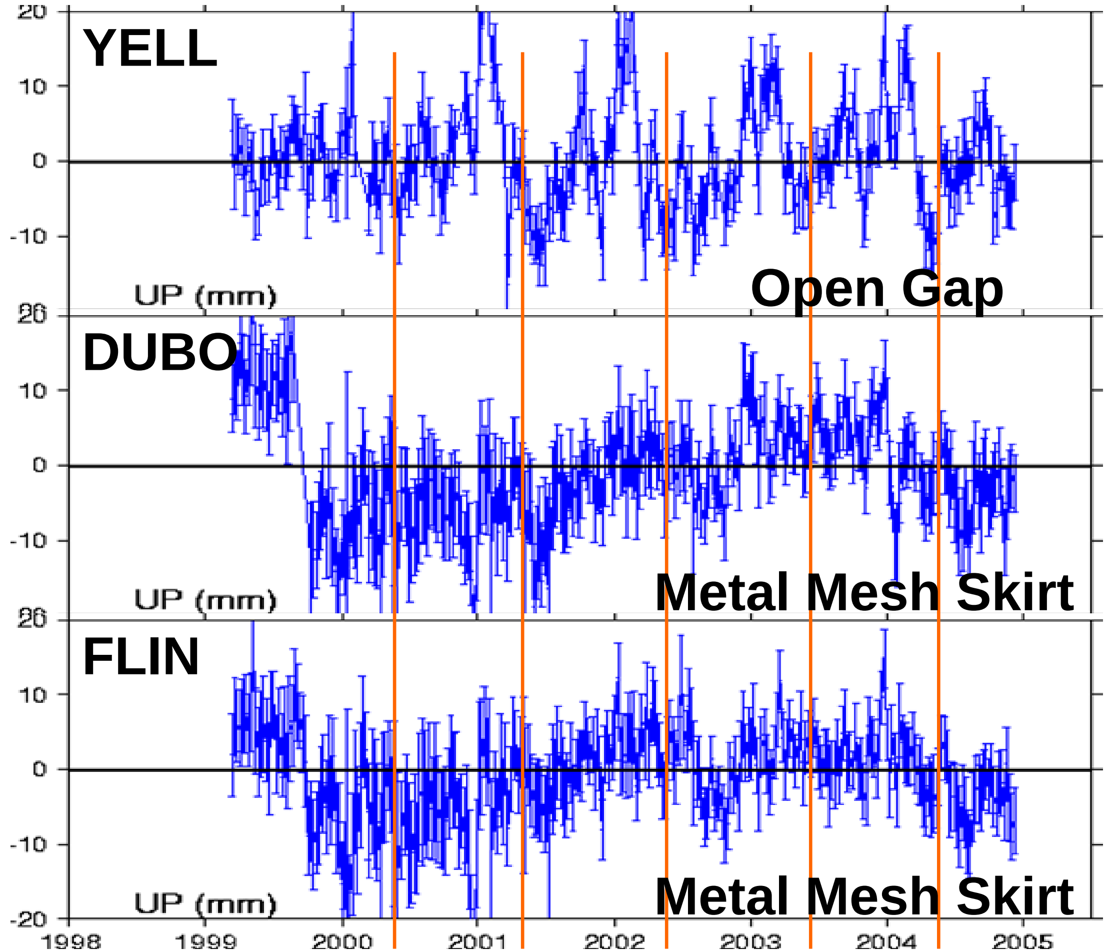


Empirical Test of Hypothesis

- **3 nearby, similar Canadian sites provide a test case**

- **YELL has *open gap* between antenna & pillar top**
  - **10-cm spacing**
  - **annual: 3.65 ± 0.30 mm**
    @ 93.3° ± 4.6°

- **DUBO & FLIN use *metal mesh shirts* to screen gap**
  - **DUBO: 10-cm spacing**
  - **annual: 1.59 ± 0.37 mm**
    @ 347.2° ± 14.1°
  - **FLIN: 15-cm spacing**
  - **annual: 1.74 ± 0.35 mm**
    @ 355.6° ± 12.7°



Poor Monumentation