

# Comparison of P3 time links from geodetic GPS receivers with other techniques

G. Petit, Z. Jiang (BIPM)



TAI labs meeting, 31 March 2004

# The TAI P3 pilot experiment

- Pilot experiment proposed in April 2002: Compute time links with P3 (ionosphere free) measurements from [preferably calibrated] Z12-T receivers [or equivalent]:
  - Maintain receiver in a constant set-up, with reference to UTC(k).
  - Calibrate it vs. travelling Z12-T from BIPM.
  - [Possible to include Z12 and others (Javad) for studies]
- Transform Rinex data to CGGTTS format with adequate program (Defraigne et al. 2001), using broadcast ephemerides, and post the data on BIPM ftp site at regular intervals (typical: 1-day or 5-day automatic transmission)
- If reference is not UTC(k), report the difference in a defined format.
- Possible to re-consider the issues of data management in the future
  - (e.g. transfer Rinex data, use IGS rapid orbits ??)



## TAIP3: participating laboratories

- ORB (Belgium): Z12-T operational since June 2002
- [NPL (UK): Z12-T operational June-October 2002]
- CRL (Japan): Z12-T operational since July 2002
- IEN (Italy): Z12-T operational since July 2002
- BNM-SYRTE (France): Z12-T operational since July 2002
- USNO (USA): Z12-T operational July-November 2002, back March 2003
- [SP (Sweden): Z12 operational since July 2002-June 2003]
- DLR (Germany): Z12-T operational July-December 2002, back May 2003
- METAS (Switzerland): GeTT operational since October 2002
- PTB (Germany): Z12-T operational since October 2002
- NMIJ (Japan): Z12-T operational since November 2002
- TL (Japan): Z12-T operational since December 2002
- IFAG (Germany): Z12-T operational since December 2002
- NRC (Canada): Z12-T operational since March 2003
- NTSC (China): Z12-T under test



# Comparison of P3 time links with different techniques

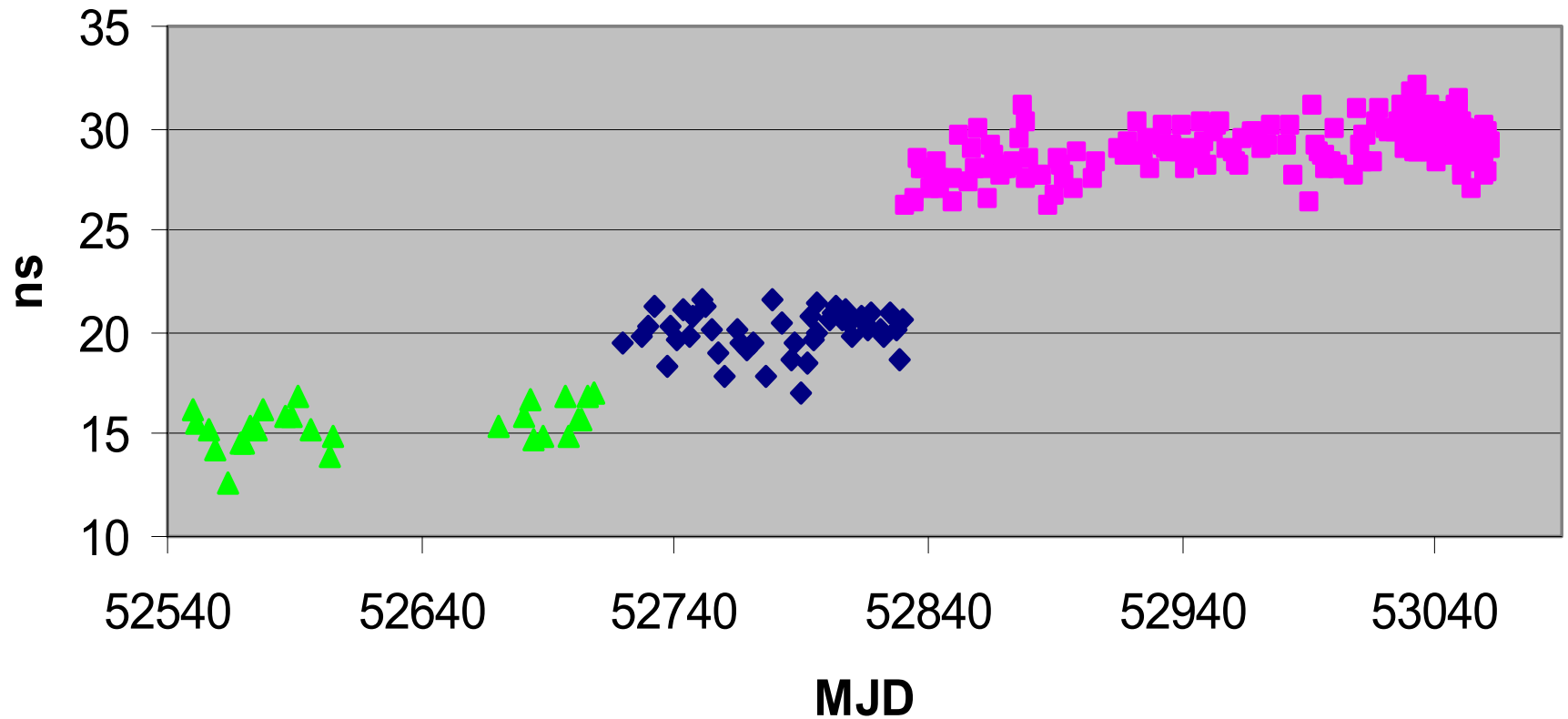
- P3, TW(Ku), C/A MC/SC
- For all comparisons: GPS data are corrected using IGS precise ephemerides. C/A data are corrected for ionosphere using IGS Ionex maps
- All comparisons with TW: GPS link evaluated at the dates of the TW measurements
- Comparisons P3-C/A only: Links evaluated at TAI standard dates
- Short-term stability ( $<0.5$  day): Not shown here (but dozens of plots exist)
  
- **P3-TW-C/A**
  - IEN-PTB, USNO-PTB, OP-PTB, NMIJ-CRL, TL-CRL
  
- **P3-C/A**
  - CRL-PTB, CH-PTB + a few others (not shown here)



# Comparison of P3 and TW for IEN-PTB over 17 months

## UTC(IEN) - UTC(PTB): 2002/10-2004/02

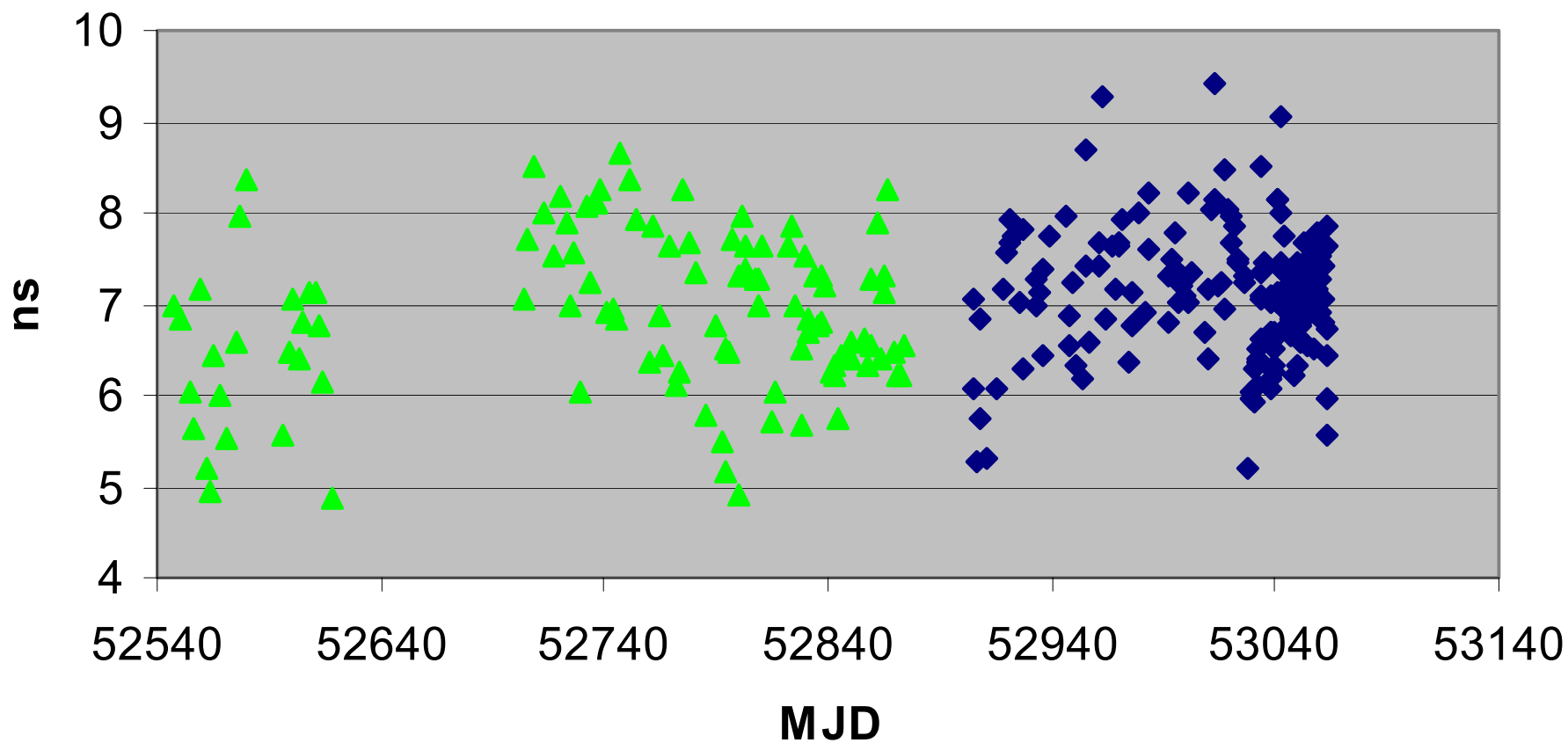
▲ P3-TW: RMS = 1.0 ns    ◆ : RMS = 1.1 ns    ■ : RMS = 1.2 ns



# Comparison of P3 and TW for USNO-PTB over 17 months

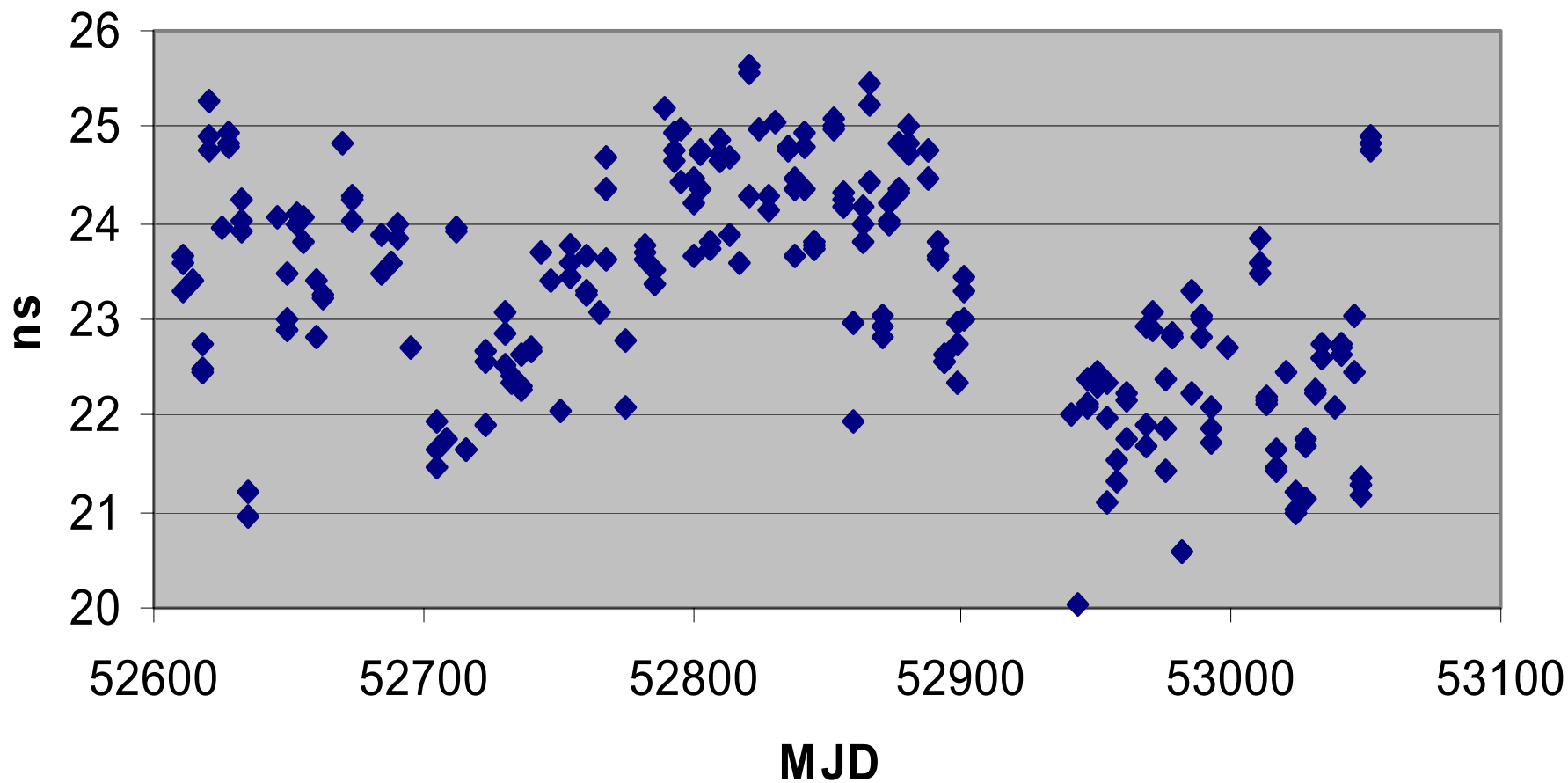
## UTC(USNO) - UTC(PTB): 2002/10-2004/02

▲ P3-TW(Ku): RMS = 0.8 ns    ◆ after TW gap bridged with P3



# Comparison of P3 and TW (outliers edited) for NMIJ-CRL over 15 months

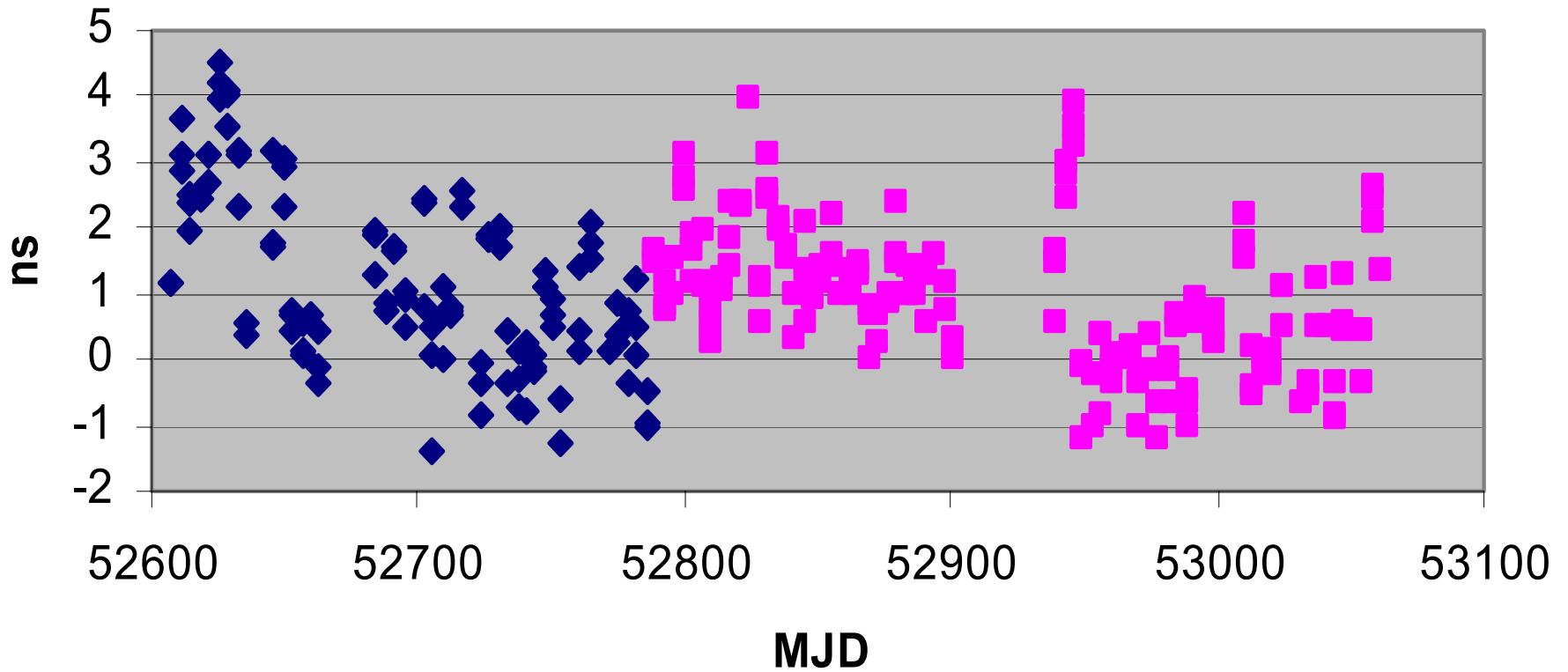
UTC(NMIJ)-UTC(CRL) P3-TW(edited) 2002/12-2004/02: RMS=1.2 ns



# Comparison of P3 and TW for TL-CRL over 15 months

UTC(TL)-UTC(CRL) P3-TW: 2002/12-2004/02

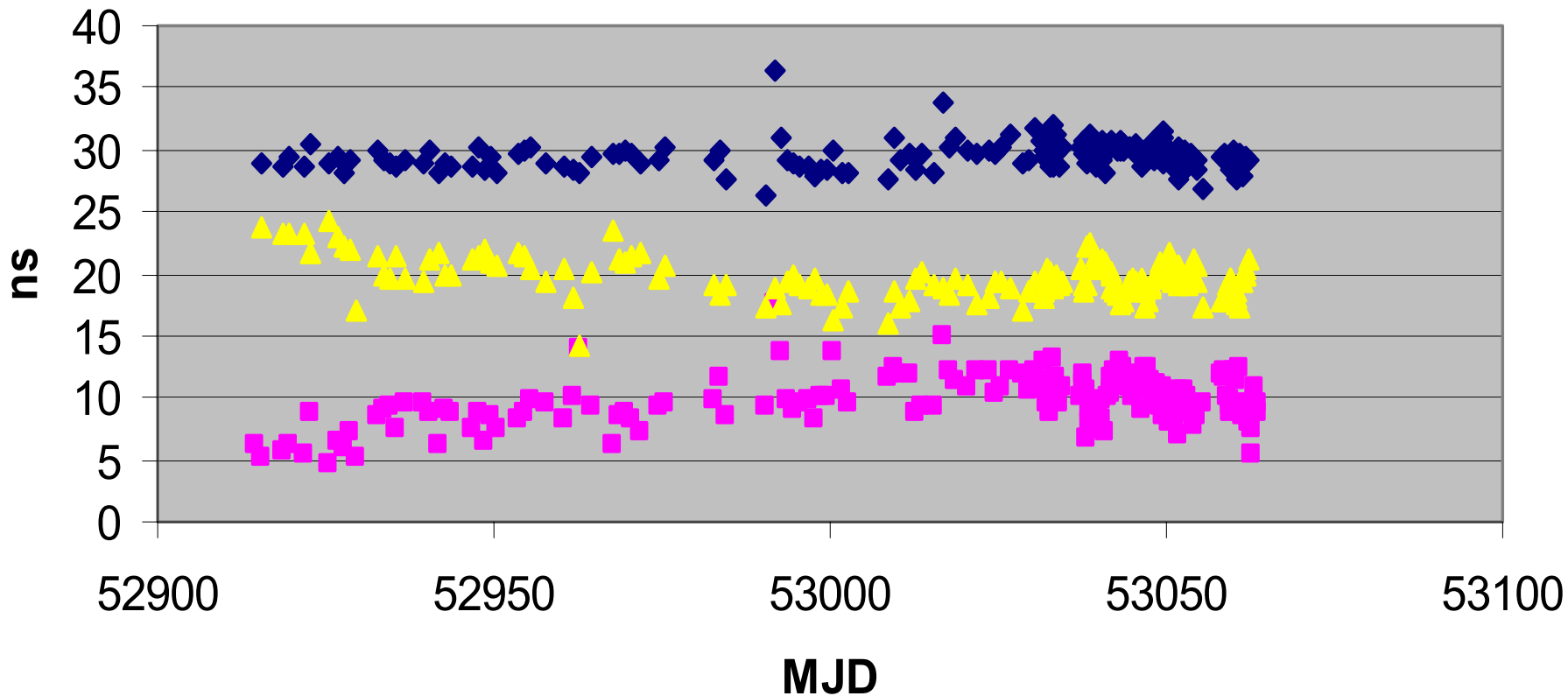
◆ P3-TW: RMS = 1.3 ns    ■ : RMS = 1.1 ns



# Comparison of P3, C/A MC and TW for IEN-PTB over 5 months

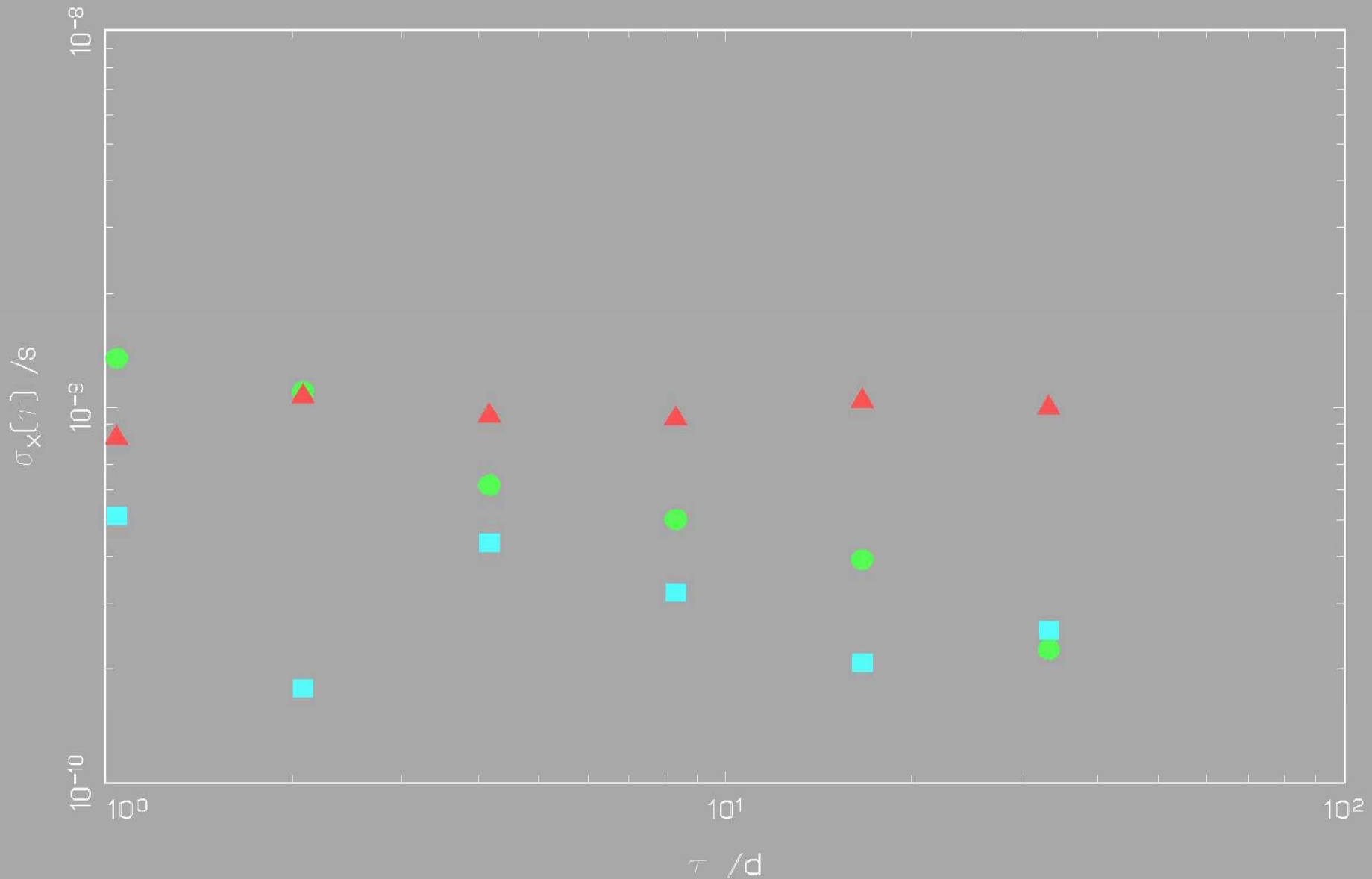
## UTC(IEN) - UTC(PTB): 2003/10-2004/02

◆ P3-TW: RMS=1.1ns    ■ MC-TW (+10ns): 2.0ns    ▲ P3-MC (-10ns): 1.5ns



# IEN-PTB: 3-corner hat analysis over 08/2003-02/2004

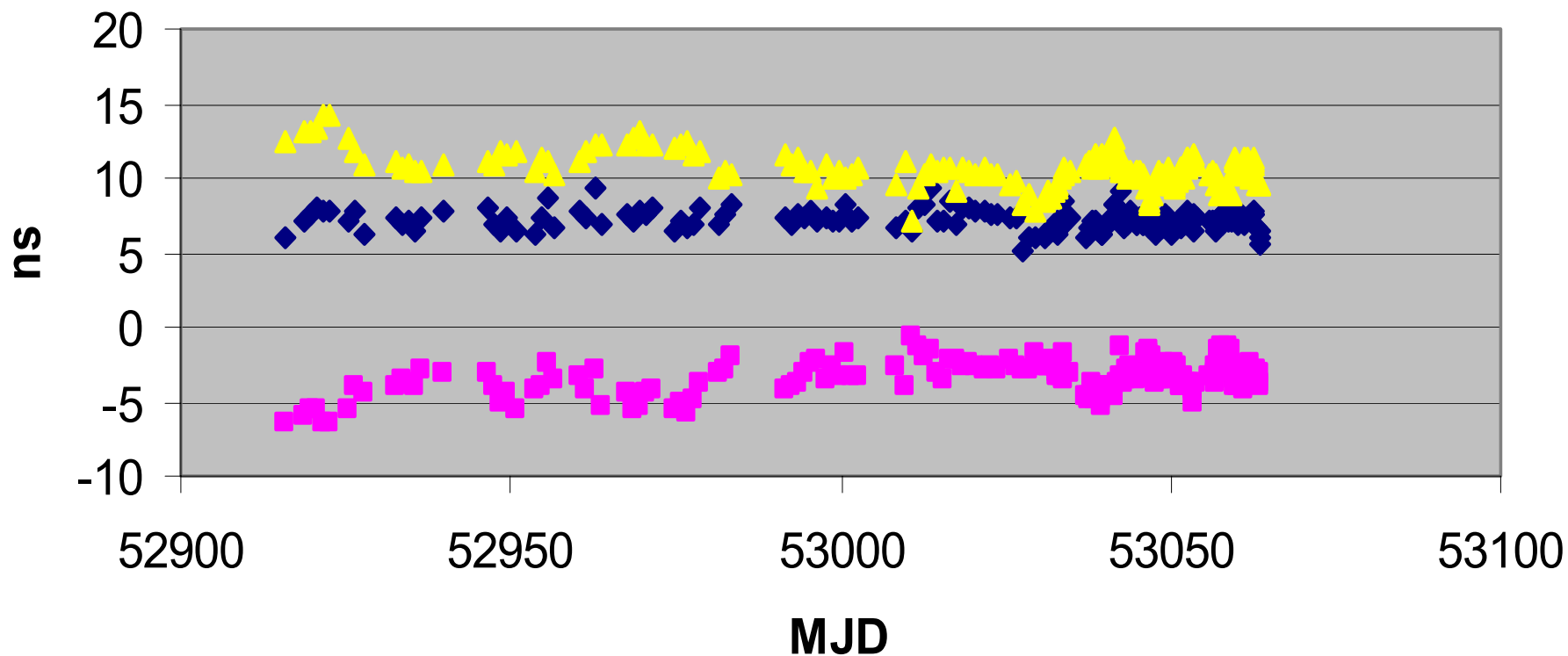
IEN-PTB 52859-53062: circle=TW square=P3 triang=MC



# Comparison of P3, C/A MC and TW for USNO-PTB over 5 months

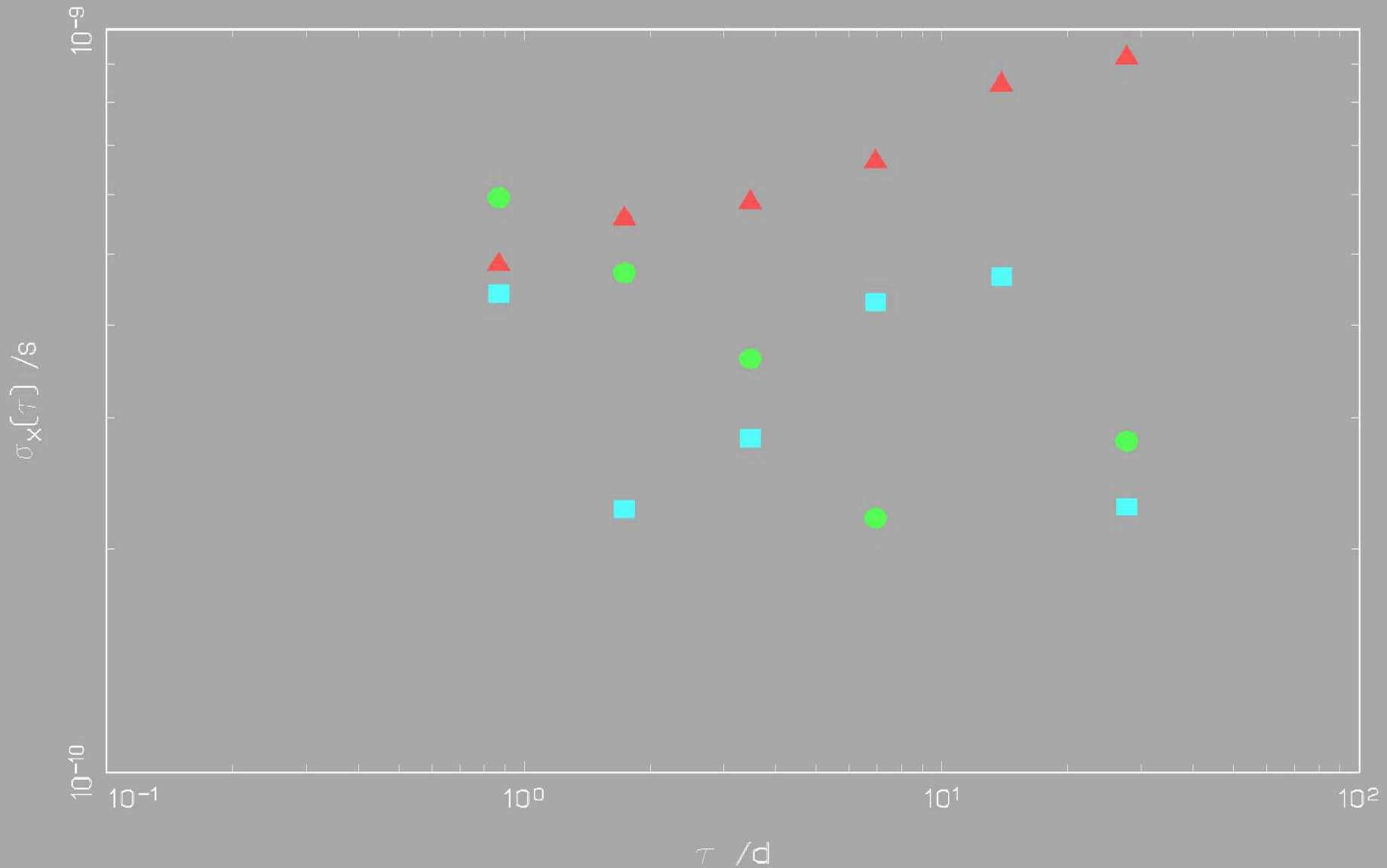
## UTC(USNO) - UTC(PTB): 2003/10-2004/02

◆ P3-TW(Ku): RMS = 0.6 ns    ■ MC-TW(Ku): 1.2 ns    ▲ P3-MC: 1.1 ns



# USNO-PTB: 3-corner hat analysis over 10/2003-02/2004

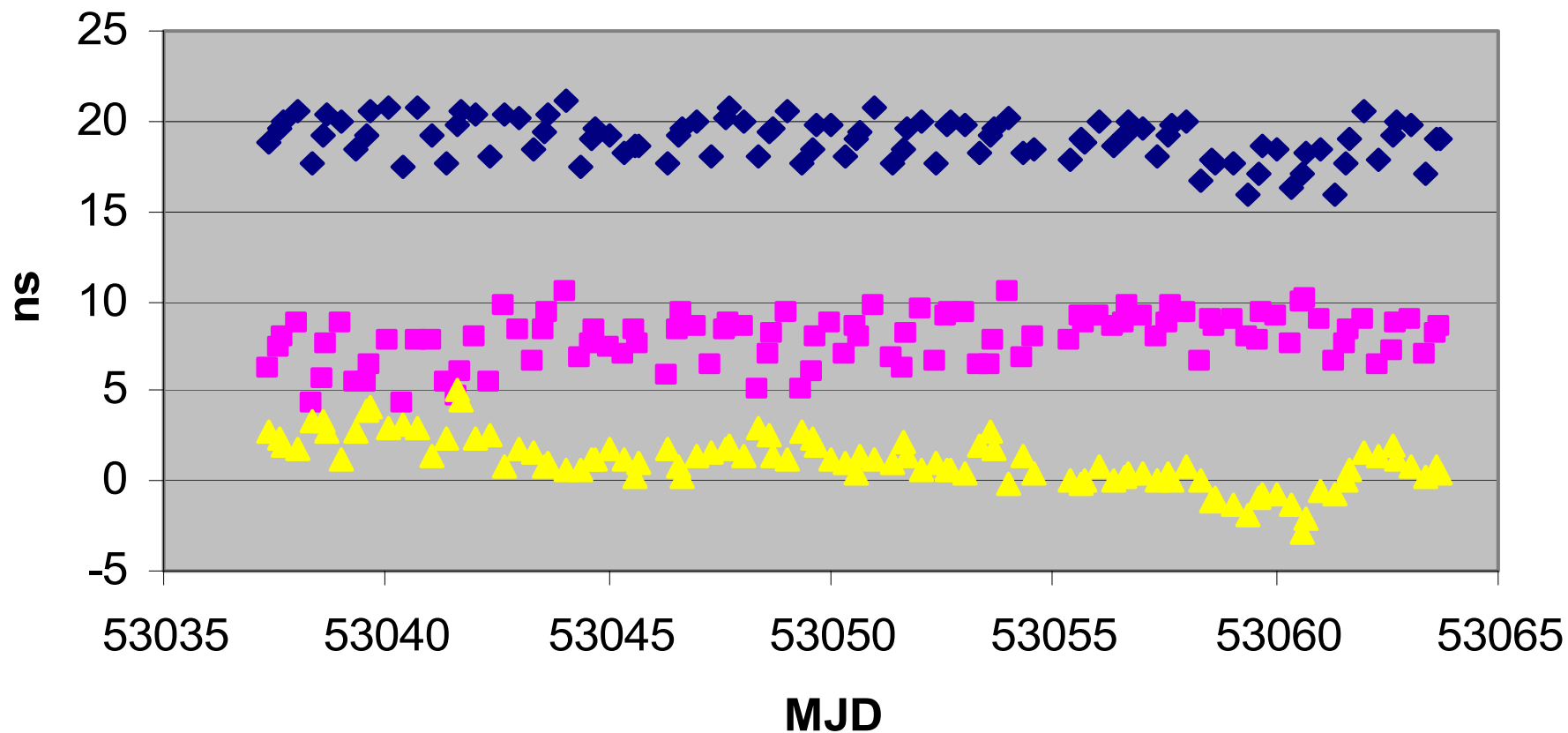
USNO-PTB 52915-53063: circle=TW square=P3 triang=MC



# Comparison of P3, C/A SC and TW for OP-PTB over 1 month

## UTC(OP) - UTC(PTB): 2004/02

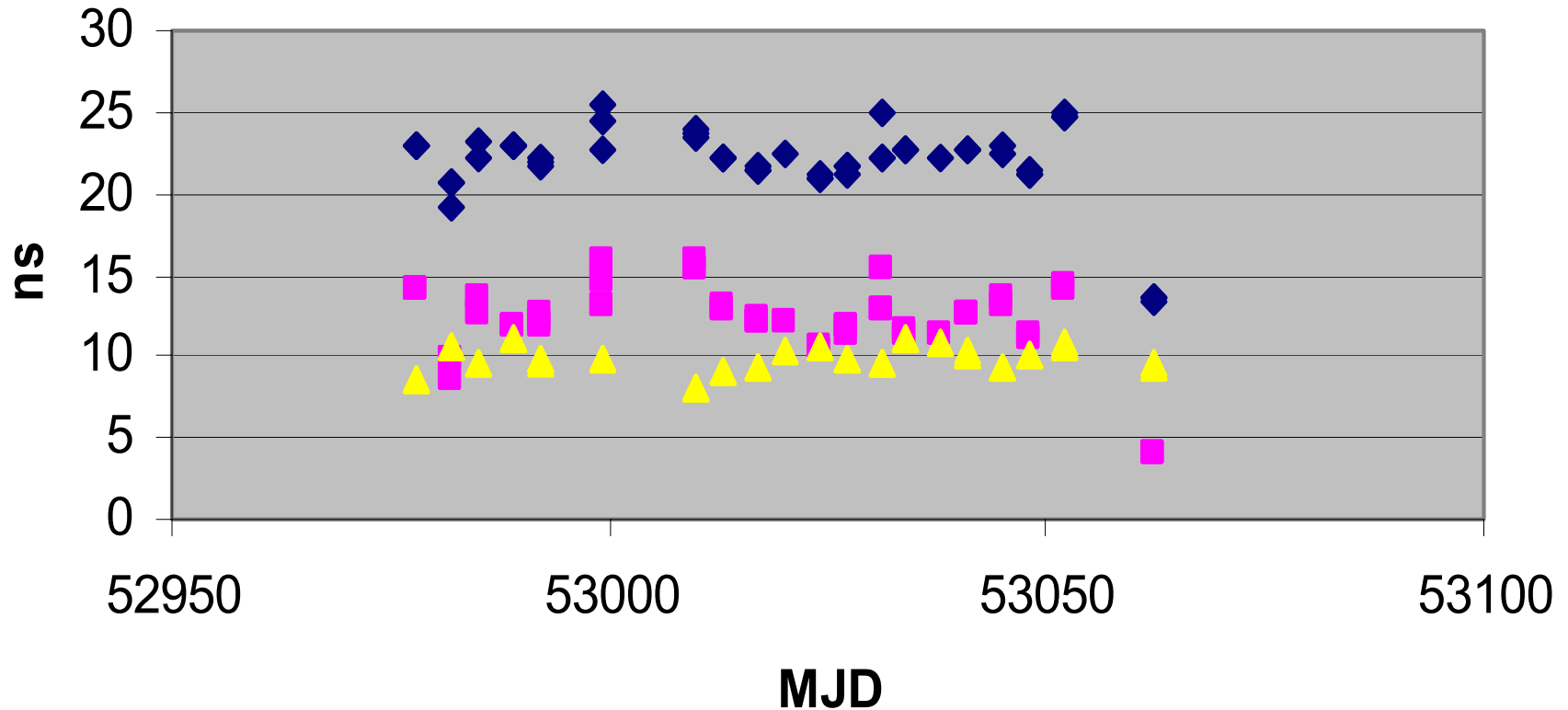
◆ P3-TW: RMS = 1.2 ns    ■ C/A-TW: 1.4 ns    ▲ P3-C/A: 1.4 ns



# Comparison of P3, C/A SC and TW for NMIJ-CRL over 3 months

## UTC(NMIJ)-UTC(CRL) 2003/12-2004/02

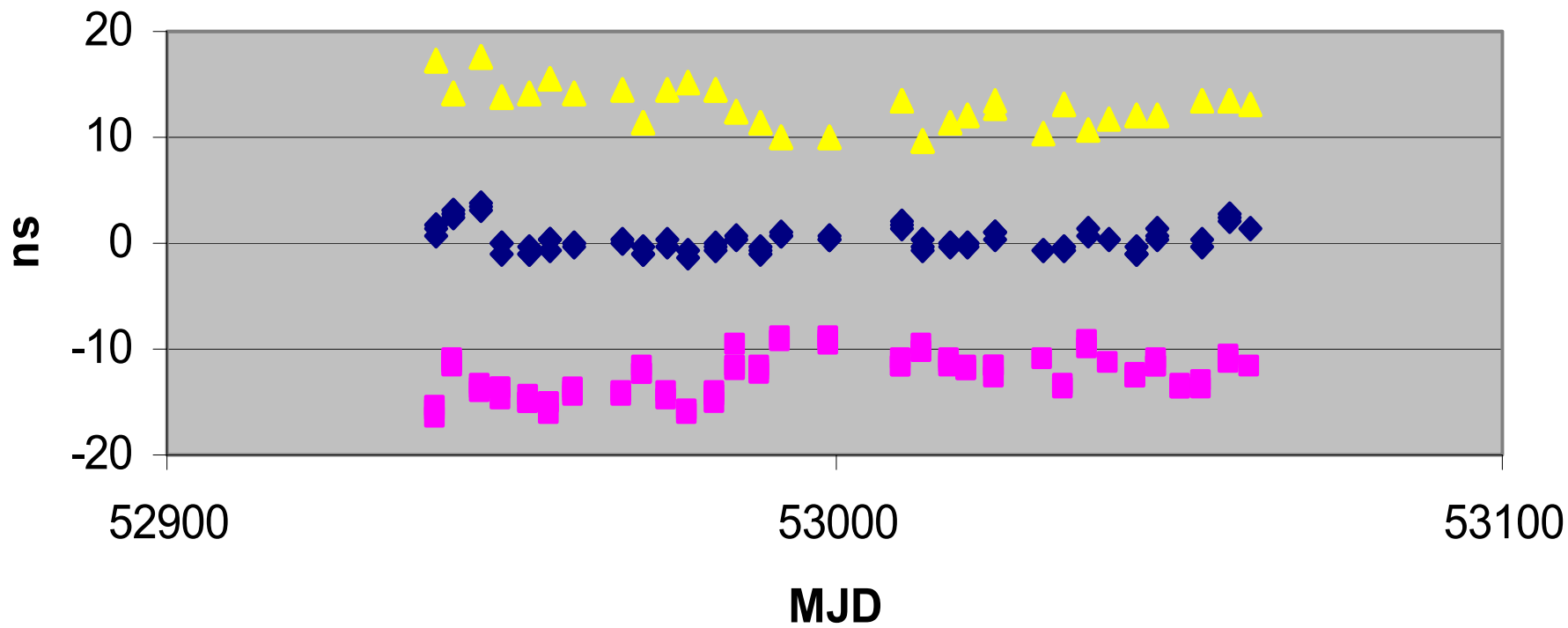
◆ P3-TW: RMS=2.4ns    ■ SC-TW (+15ns): 2.5ns    ▲ P3-SC (-15ns): 0.8ns



# Comparison of P3, C/A SC and TW for TL-CRL over 4 months

UTC(TL)-UTC(CRL): 2002/11-2004/02

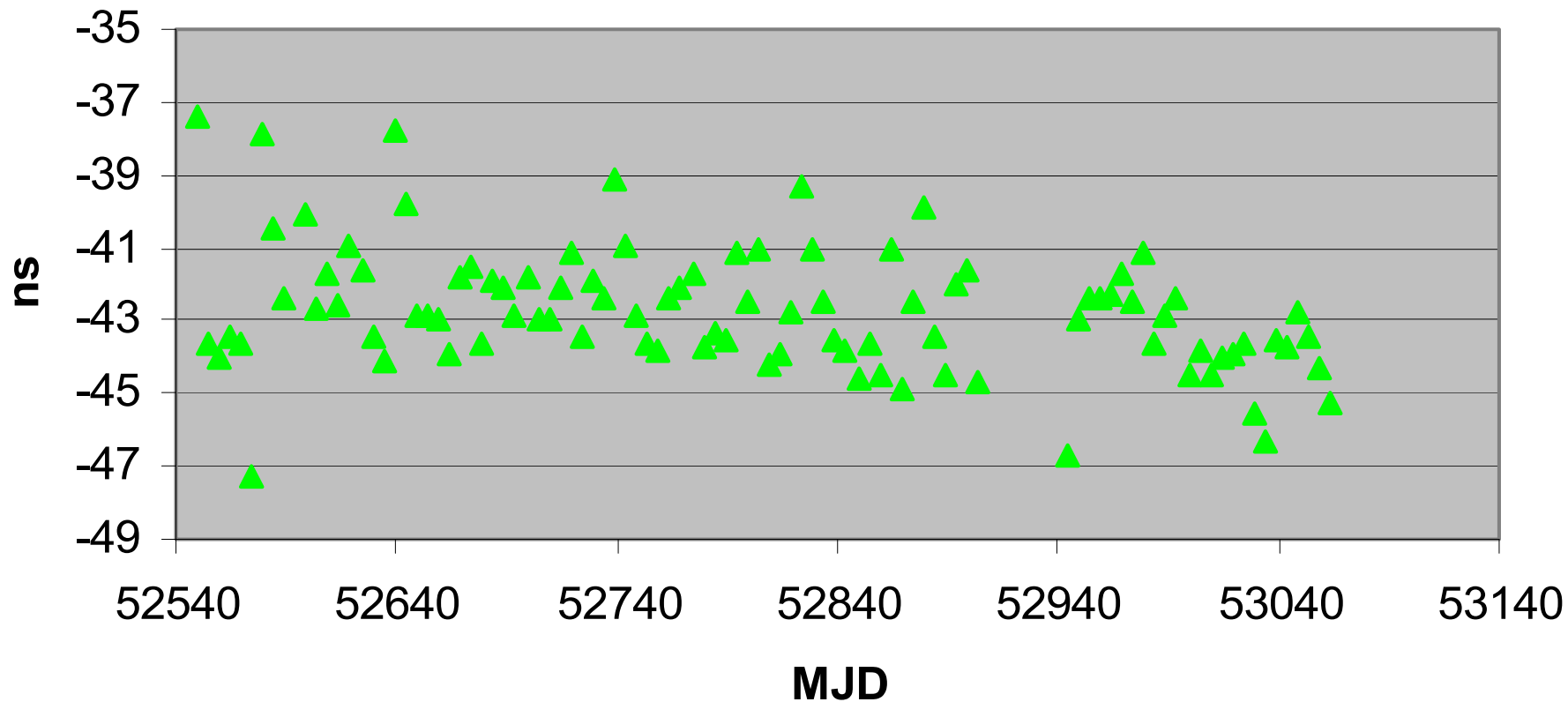
◆ P3-TW: RMS = 1.2 ns    ■ SC-TW: 2.0 ns    ▲ P3-SC: 2.0 ns



# Comparison of P3 and C/A SC CRL-PTB over 18 months

## UTC(CRL) - UTC(PTB): 2002/09-2004/02

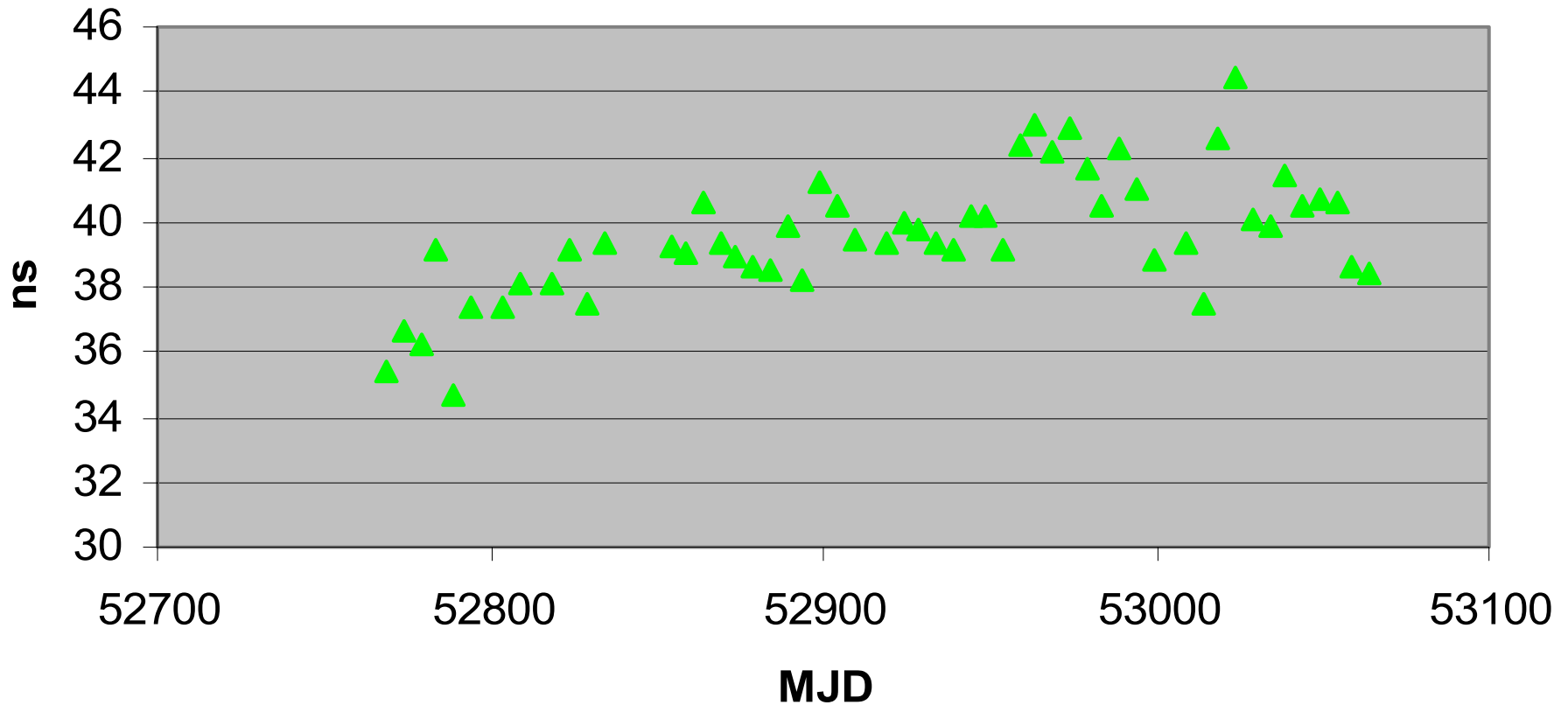
▲ P3-C/A SC: RMS = 1.7 ns



# Comparison of P3 and C/A SC CH-PTB over 10 months

## UTC(CH) - UTC(PTB): 2003/05-2004/02

▲ P3-C/A SC: RMS = 1.9 ns



# Comparison of P3 links with different techniques: results

- Long term time stability
  - P3-TW comparisons over several months: **typical RMS is 1 ns** (values ranging from 0.8 ns to 1.3 ns).
  - 3-corner hat analysis: **P3 time stability well below 1 ns** for averaging times between 1 and 30 days.
  - P3-C/A (and TW-C/A) over several months: typical RMS is 1.5-2 ns. Due to significant long-term variations (up to a few ns) attributed to C/A.
- Short term time stability
  - Measurement noise (observed from regular statistical analysis): **0.2-0.3 ns** for averaging a few hours.
  - no evidence of significant (1 ns) short term, notably diurnal, noise in P3.
  - When dense TW measurements are available: Some links display significant (1 ns or larger) short term, mostly diurnal, noise in the TW data. Some TW outliers are also evidenced by comparison to the P3 link.

