Alignment of NICT-PTB TW link to the GPS P3 link

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The TWSTFT link, with the new NICT modern, between NICT and PTB was installed between Oct. 2004 and July 2005 [2,4]. The NICT supports the substantial techniques, including provision of hardware Earth-station design and remote operation of the station. Operational timing link tests started on 22 July 2005. Regular operation is performed since 1 Nov. 2005. The NICT-PTB is the longest baseline of about 10 000 km in the TAI world-wide network.

The data in the ITU standard format is reported to the BIPM since Jan. 2006 except for some short periods. A first BIPM analysis of this link was reported in [2].

This TW link is not absolutely calibrated. In order to introduce this link into circular T computation, the calibration and uncertainty information is essential. [1] gives an estimation using the 7 values on the standard MJD published in Circular T 228. The result has been integrated in the TW ITU data files. This TM gives a rigorous estimation of the differential calibration by the comparison between the TW and GPS P3 time link observations. The TAI data 0702 and 0703 are used. We first interpolate the P3 values onto the TW measuring epochs and then compare them with the TW measuring values. From MJD 54129 to 54191, totally 1315 epochs were used.

Fig.1a, 1b, 2a and 2b present separately the TW and P3 link for TAI 0702 and 0703. The related results can also be found on the monthly updated BIPM ftp site: ftp://tai.bipm.org/TimeLink/LkC. A careful look at the sigma and the Time Deviations of the Fig. 1a and 2a, we know that the short term stability of this link is comparable with other TW links of inter-Europe and Europe-America. In consequence, we can estimate the uA of the NICT-PTB TW link is identical as that of the others, that is, 0.5 ns.

Fig. 3 shows the two months' comparison between TW and P3. For reference, it is given in Fig. 4 and 5 the related GPS MC link comparisons.

The following table gives a resume of the TW-P3 comparison:

Tab. 1 Differences between TW and GPS P3 links for NICT-PTB (ns)

MJDs	Total compared epochs	Mean values of TW – P3	Standard Deviation
54129-54191	1315	-1.501	±1.044

The uB of the TW NICT-PTB can be estimated as:

$$(uB)^2 = [uB(P3)]^2 + [uA(P3)]^2 + [uA(TW)]^2 = (5.0)^2 + (0.7)^2 + (0.5)^2 = (5.07)^2$$

or:

$$(uB)^2 = [uB(P3)]^2 + [\text{Std in Tab. 1}]^2 = (5.0)^2 + (1.044)^2 = (5.11)^2$$

The two estimations are of similar result : 5.1 ns.

Remarks:

- Comparing the Time Deviations in the Fig. 1a, 1b, 2a and 2b, we know that the time stability of the two techniques are almost identical. However, due the advantage of the TW technique w.r.t. GPS, it is expected the middle and long term stability of the TW is better than that of GPS
- A closer look at the Time Deviations in the Fig. 1a and 2a, we see still the diurnal disturbances in the TW link, as pointed out in the TM144. If we compare the related plots in TM144 and TW144Bis, the amplitude of the diurnal disturbances reduced since one year, due to the efforts of the NICT colleagues
- The differences between GPS P3 and MC is important: 3.4 ns. This is caused probably by the differential calibration of the PTB P3 GPS receiver (cf. the Cirt T reports).

Reference

[1] NICT and PTB: Calibration result of the NICT-PTB TWSTFT Link, 20/2/2007, email Maeno 20/7/2007
[2] Z Jiang and G. Petit: BIPM first analysis of NICT-PTB TW link and comparison with GPS CV-AV P3 links, ftp://tai.bipm.org/TimeLink/LkC/Doc/TM144.prn.pdf

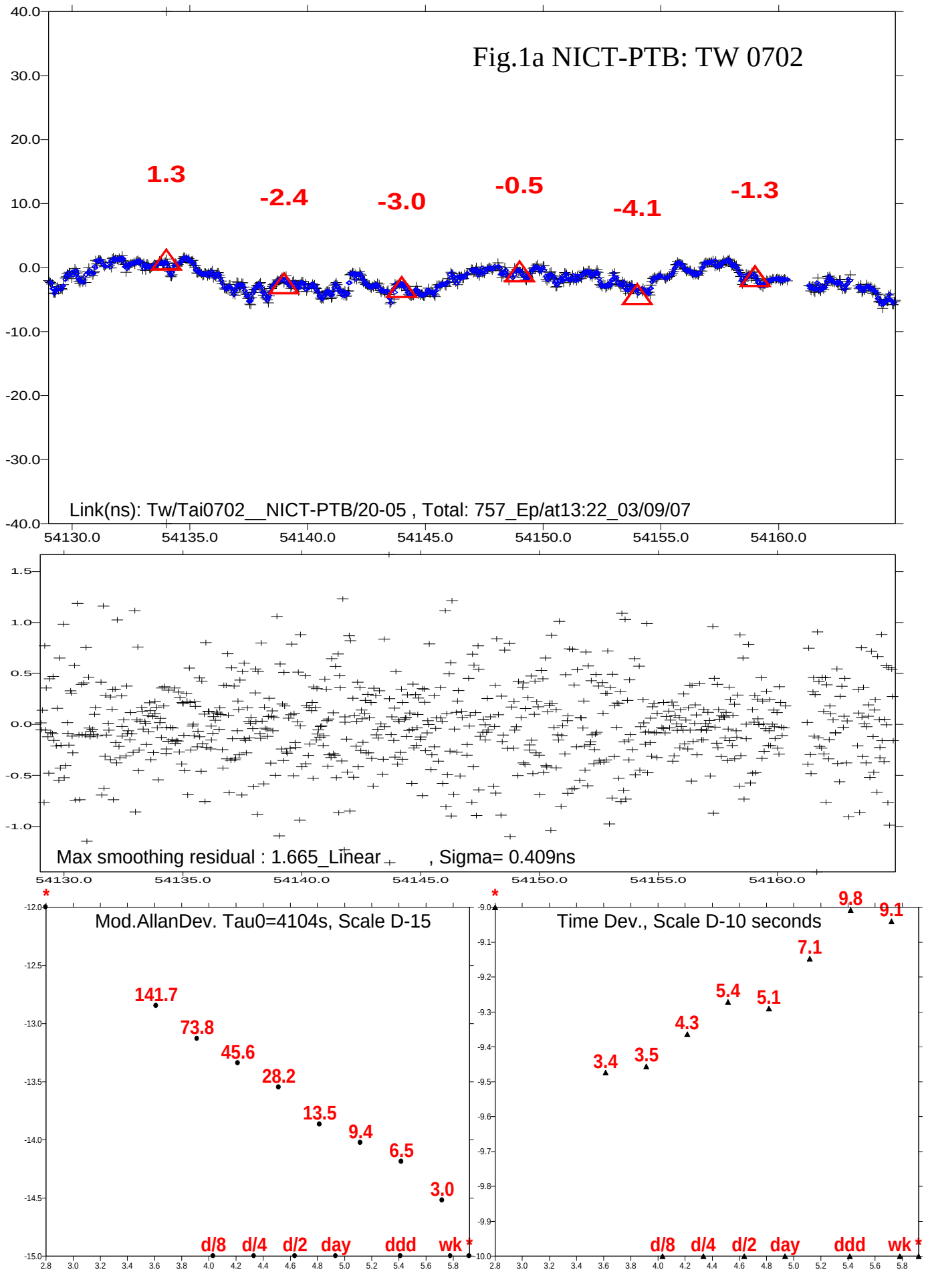


Fig.1a NICT-PTB: TW 0702
1.3
-2.4
-3.0
-0.5
-4.1
-1.3
Link(ns): Tw/Tai0702__NICT-PTB/20-05 , Total: 757_Ep/at13:22_03/09/07
Max smoothing residual : 1.665_Linear , Sigma= 0.409ns
Mod.AllanDev. Tau0=4104s, Scale D-15
141.7
73.8
45.6
28.2
13.5
9.4
6.5
3.0
d/8 d/4 d/2 day ddd wk *
Time Dev., Scale D-10 seconds
9.8
9.1
7.1
5.4
5.1
4.3
3.4
3.5
d/8 d/4 d/2 day ddd wk *

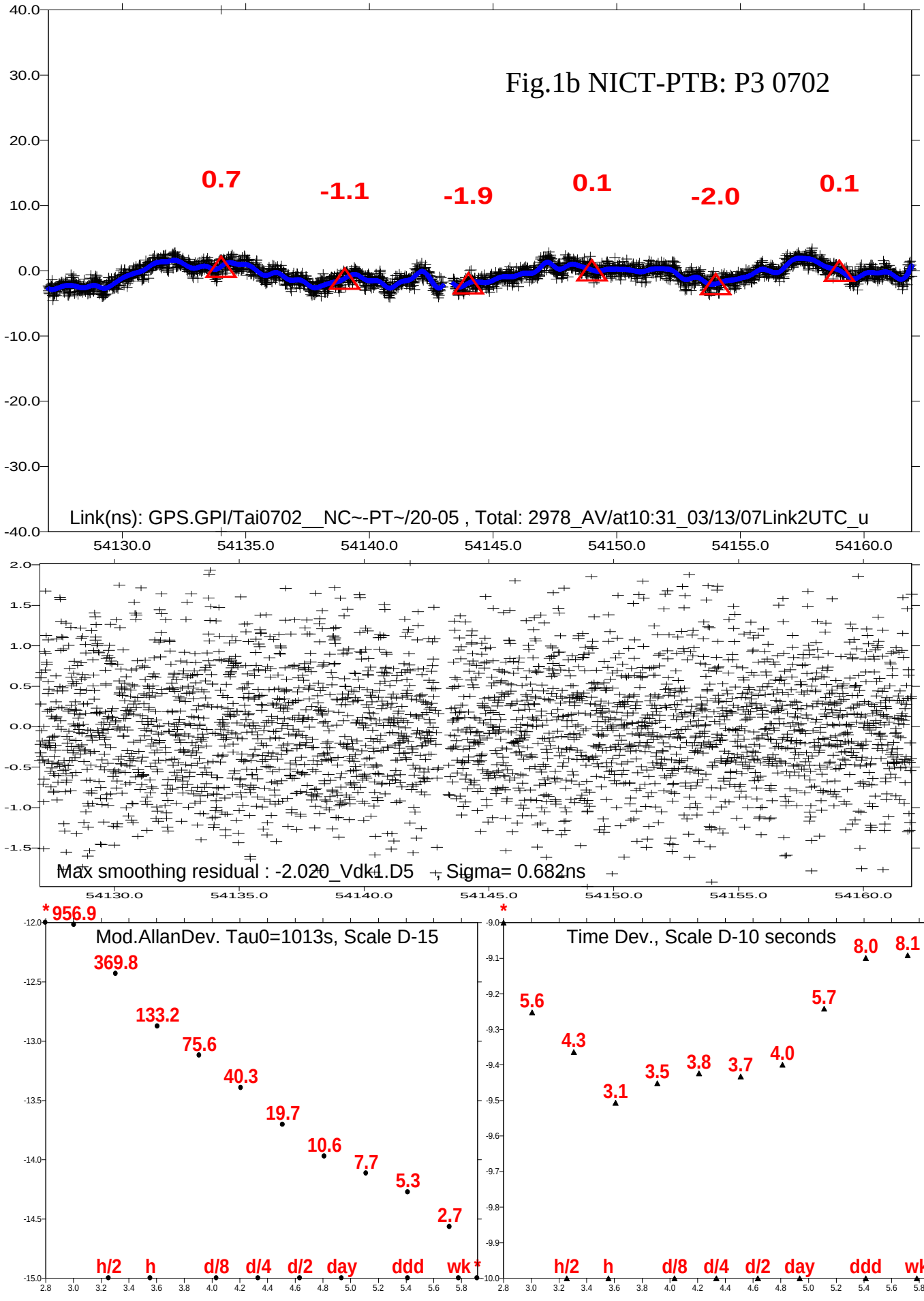


Fig.1b NICT-PTB: P3 0702
0.7
-1.1
-1.9
0.1
-2.0
0.1
Link(ns): GPS.GPI/Tai0702__NC~-PT~/20-05 , Total: 2978_AV/at10:31_03/13/07Link2UTC_u
Max smoothing residual : -2.020_Vdk1.D5 , Sigma= 0.682ns
Mod.AllanDev. Tau0=1013s, Scale D-15
*956.9
369.8
133.2
75.6
40.3
19.7
10.6
7.7
5.3
2.7
h/2 h d/8 d/4 d/2 day ddd wk*
Time Dev., Scale D-10 seconds
5.6
4.3
3.1
3.5
3.8
3.7
4.0
5.7
8.0
8.1
h/2 h d/8 d/4 d/2 day ddd wk*

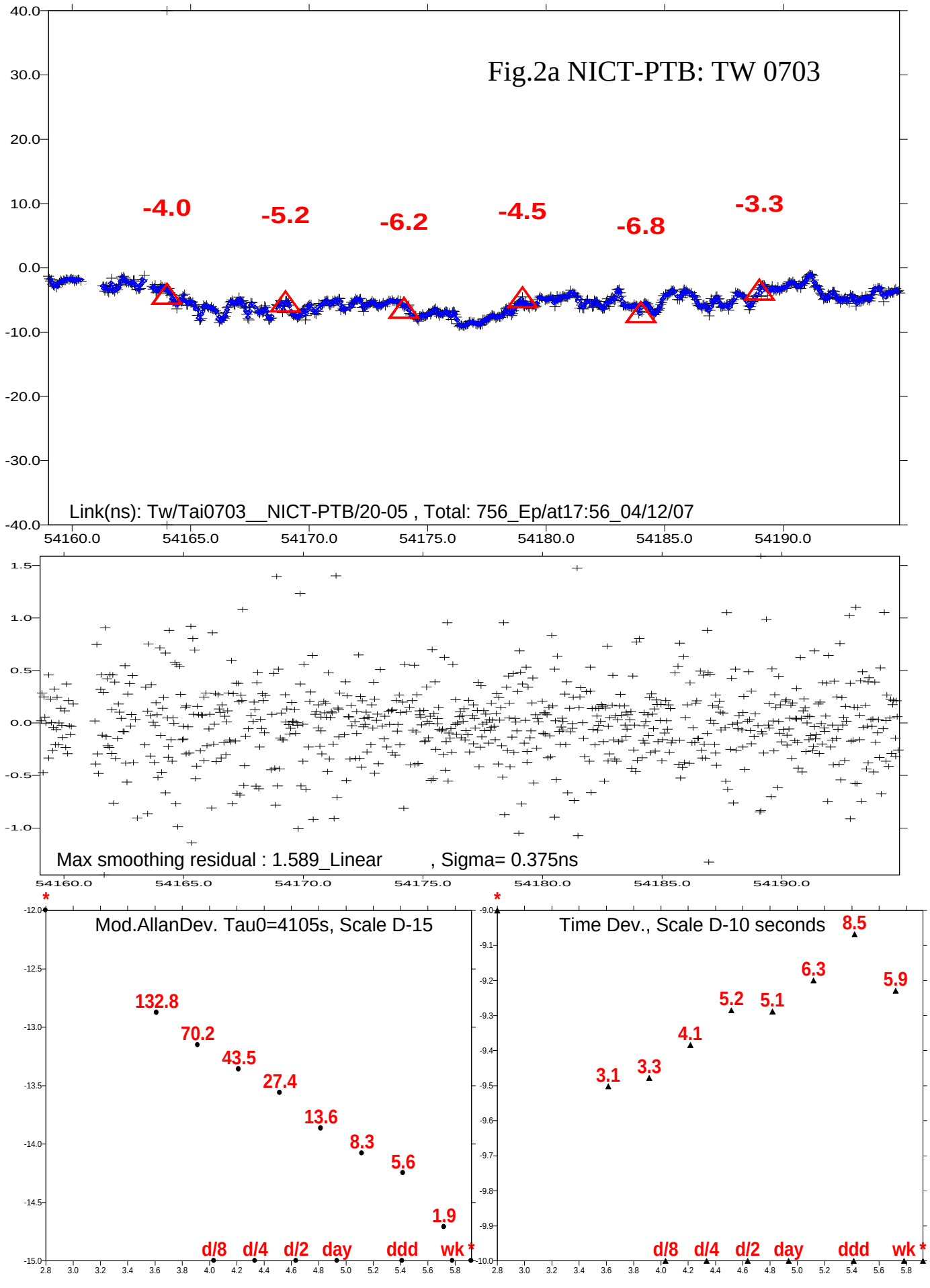


Fig.2a NICT-PTB: TW 0703
-4.0
-5.2
-6.2
-4.5
-6.8
-3.3
Link(ns): Tw/Tai0703__NICT-PTB/20-05 , Total: 756_Ep/at17:56_04/12/07
Max smoothing residual : 1.589_Linear , Sigma= 0.375ns
Mod.AllanDev. Tau0=4105s, Scale D-15
132.8
70.2
43.5
27.4
13.6
8.3
5.6
1.9
d/8 d/4 d/2 day ddd wk *
Time Dev., Scale D-10 seconds
8.5
6.3
5.9
5.2
5.1
4.1
3.1
3.3
d/8 d/4 d/2 day ddd wk *

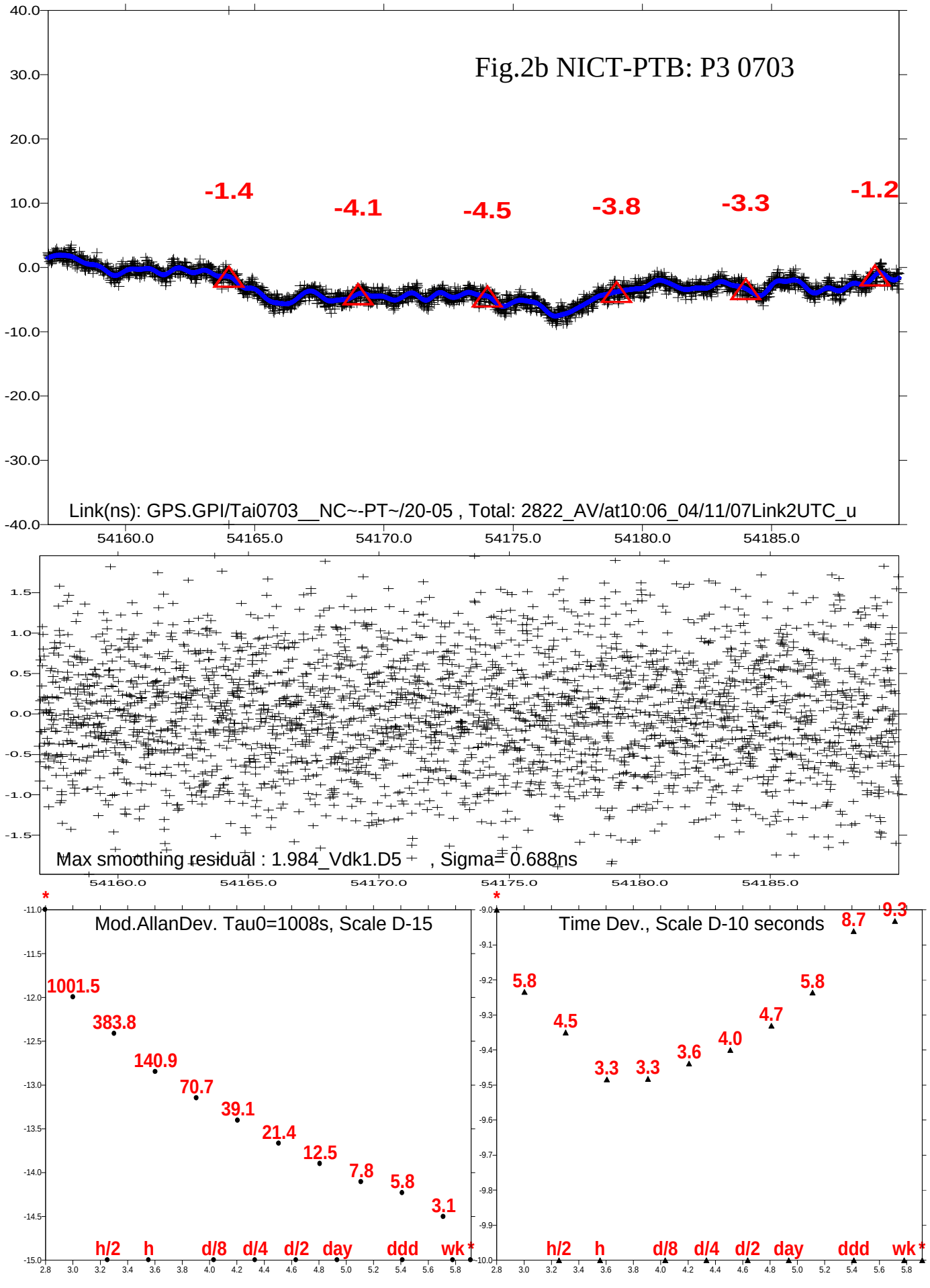


Fig.2b NICT-PTB: P3 0703
-1.4
-4.1
-4.5
-3.8
-3.3
-1.2
Link(ns): GPS.GPI/Tai0703__NC~-PT~/20-05 , Total: 2822_AV/at10:06_04/11/07Link2UTC_u
Max smoothing residual : 1.984_Vdk1.D5 , Sigma= 0.688ns
Mod.AllanDev. Tau0=1008s, Scale D-15
1001.5
383.8
140.9
70.7
39.1
21.4
12.5
7.8
5.8
3.1
h/2 h d/8 d/4 d/2 day ddd wk*
Time Dev., Scale D-10 seconds
5.8
4.5
3.3
3.3
3.6
4.0
4.7
5.8
8.7
9.3
h/2 h d/8 d/4 d/2 day ddd wk*

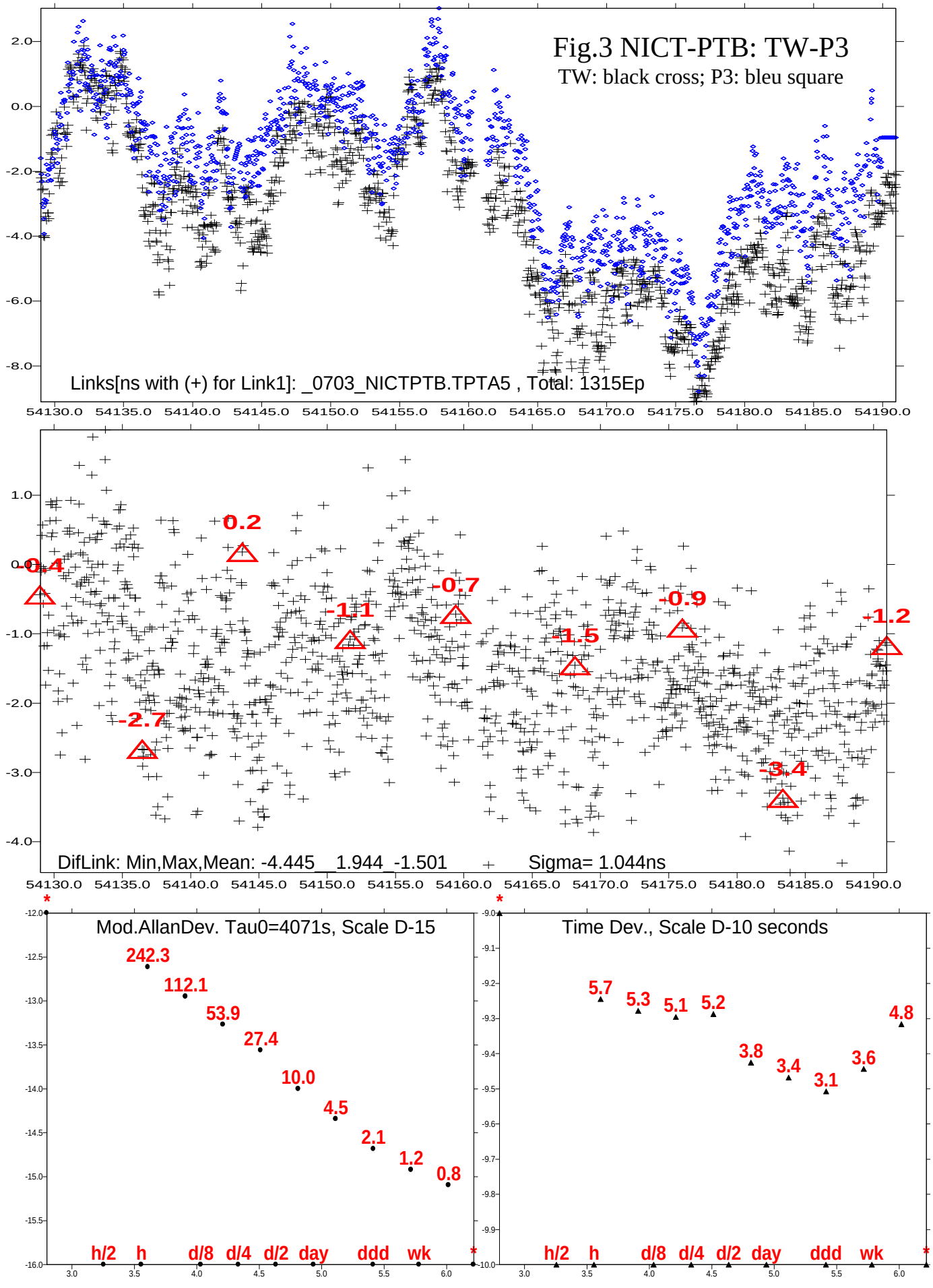


Fig.3 NICT-PTB: TW-P3
TW: black cross; P3: bleu square
Links[ns with (+) for Link1]: _0703_NICTPTB.TPTA5 , Total: 1315Ep
DifLink: Min,Max,Mean: -4.445 _ 1.944 _-1.501
Sigma= 1.044ns
Mod.AllanDev. Tau0=4071s, Scale D-15
242.3
112.1
53.9
27.4
10.0
4.5
2.1
1.2
0.8
Time Dev., Scale D-10 seconds
5.7
5.3
5.1
5.2
3.8
3.4
3.1
3.6
4.8
h/2 h d/8 d/4 d/2 day ddd wk

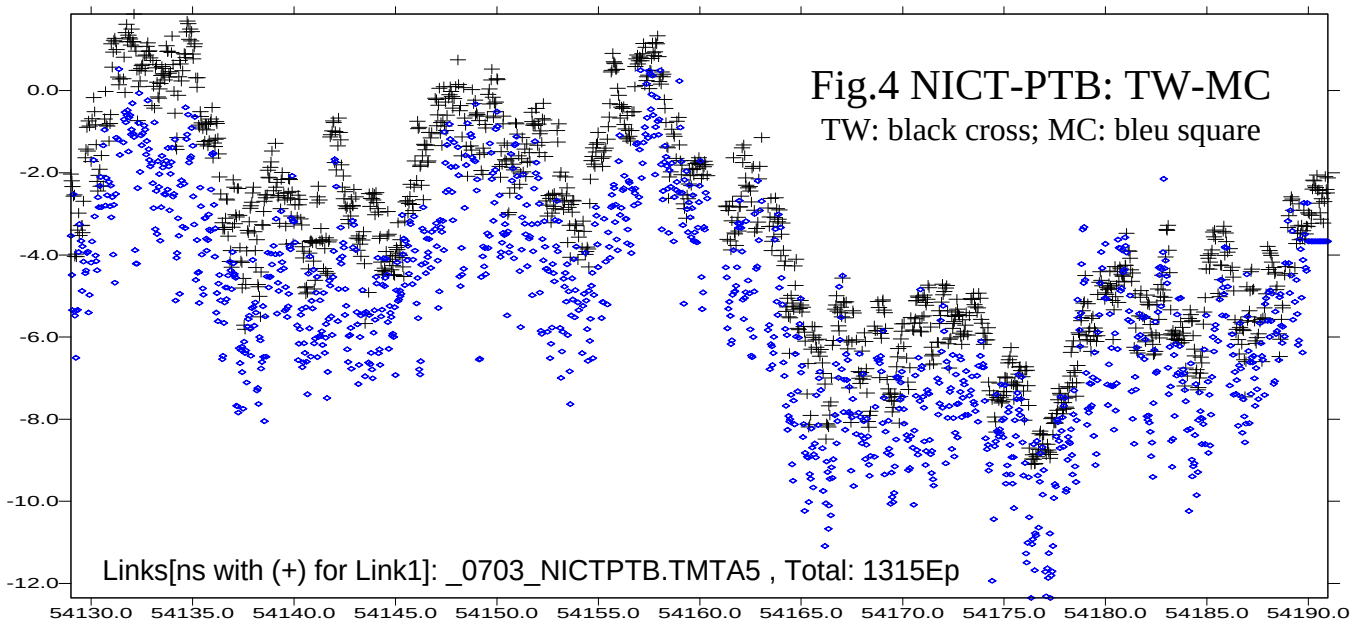
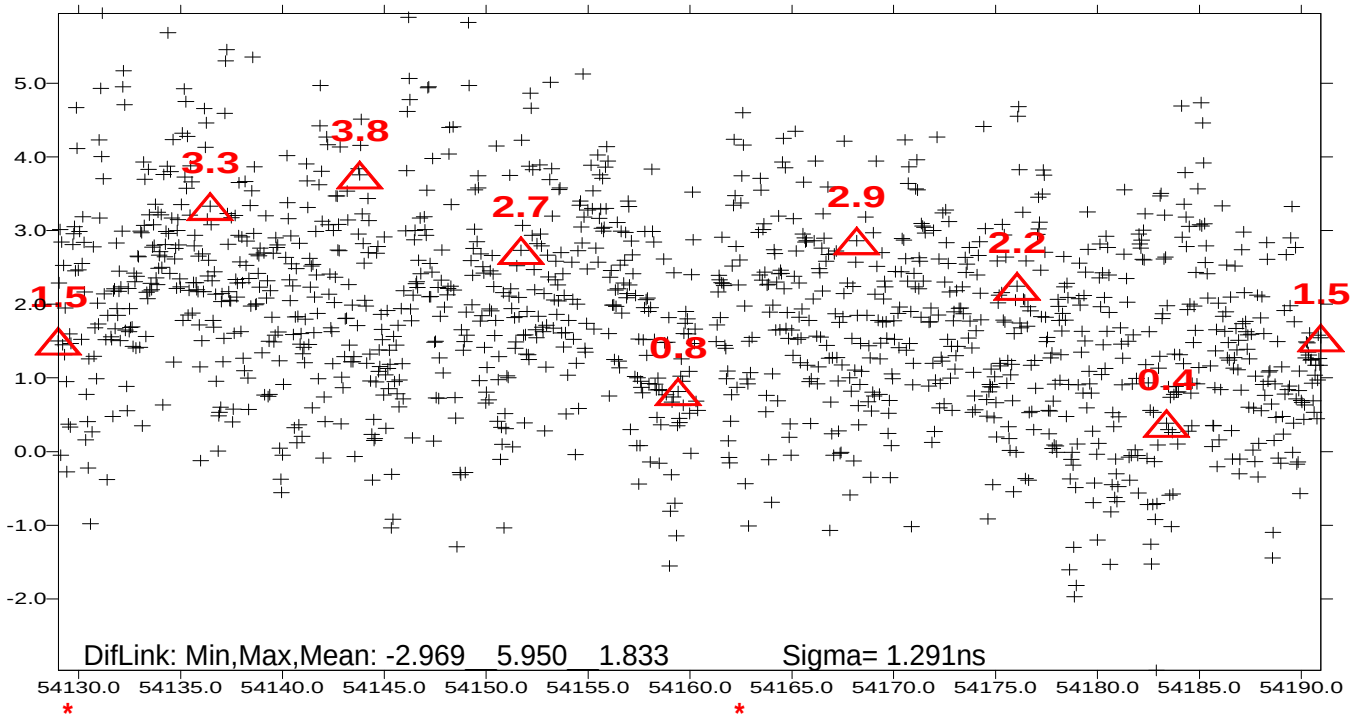
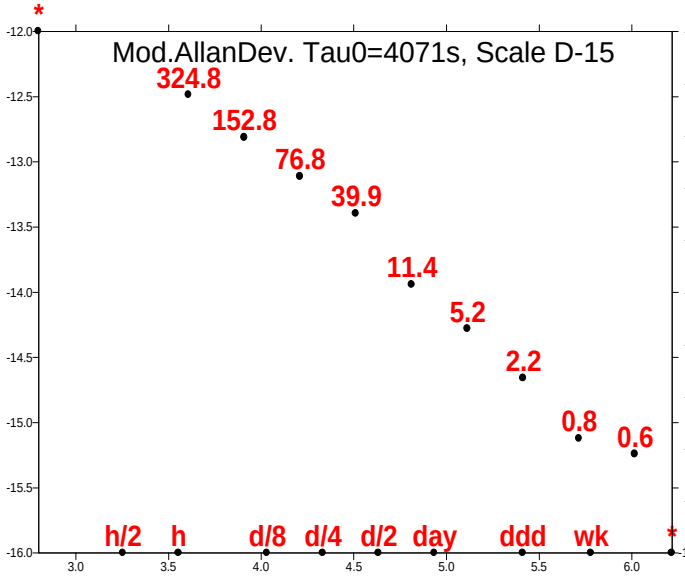
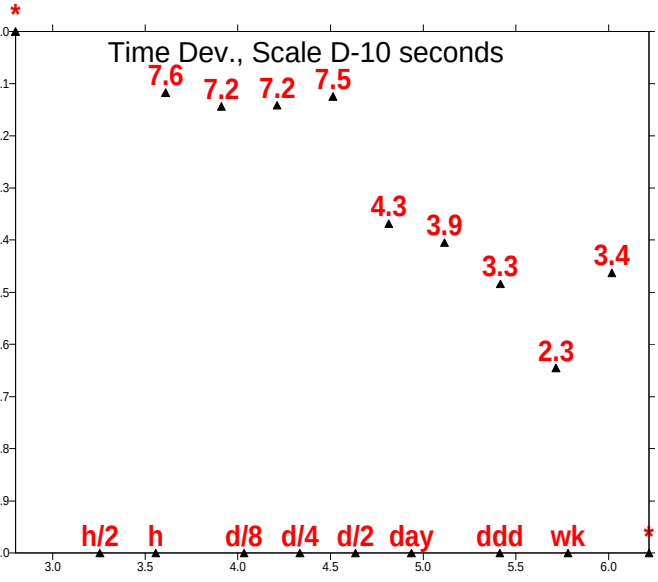


Fig.4 NICT-PTB: TW-MC
TW: black cross; MC: bleu square
Links[ns with (+) for Link1]: _0703_NICTPTB.TMTA5 , Total: 1315Ep
0.0
-2.0
-4.0
-6.0
-8.0
-10.0
-12.0
54130.0 54135.0 54140.0 54145.0 54150.0 54155.0 54160.0 54165.0 54170.0 54175.0 54180.0 54185.0 54190.0


DifLink: Min,Max,Mean: -2.969 5.950 1.833
Sigma= 1.291ns
5.0
4.0
3.0
2.0
1.0
0.0
-1.0
-2.0
3.3
3.8
2.7
2.9
2.2
1.5
1.5
0.8
0.4
54130.0 54135.0 54140.0 54145.0 54150.0 54155.0 54160.0 54165.0 54170.0 54175.0 54180.0 54185.0 54190.0


Mod.AllanDev. Tau0=4071s, Scale D-15
324.8
152.8
76.8
39.9
11.4
5.2
2.2
0.8
0.6
h/2 h d/8 d/4 d/2 day ddd wk
-12.0
-12.5
-13.0
-13.5
-14.0
-14.5
-15.0
-15.5
-16.0
3.0 3.5 4.0 4.5 5.0 5.5 6.0


Time Dev., Scale D-10 seconds
7.6
7.2
7.2
7.5
4.3
3.9
3.3
3.4
2.3
h/2 h d/8 d/4 d/2 day ddd wk
-9.0
-9.1
-9.2
-9.3
-9.4
-9.5
-9.6
-9.7
-9.8
-9.9
-10.0
3.0 3.5 4.0 4.5 5.0 5.5 6.0

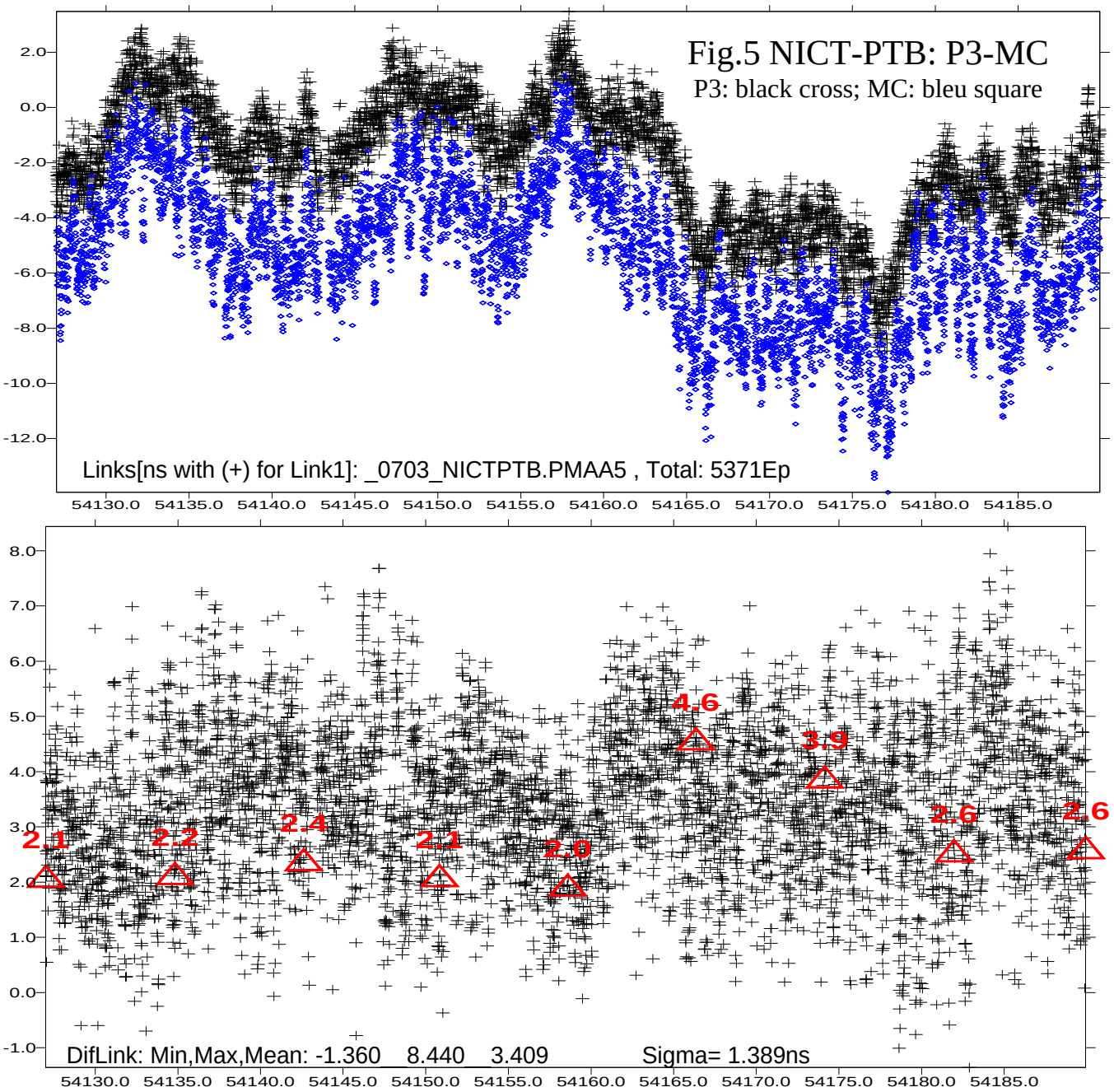


Fig.5 NICT-PTB: P3-MC
P3: black cross; MC: bleu square
Links[ns with (+) for Link1]: _0703_NICTPTB.PMAA5 , Total: 5371Ep
DifLink: Min,Max,Mean: -1.360 8.440 3.409
Sigma= 1.389ns
Mod.AllanDev. Tau0=1012s, Scale D-15
Time Dev., Scale D-10 seconds
h/2 h d/8 d/4 d/2 day ddd wk