Multi-frequency scatter broadening evolution of pulsars - I : Supplementary Material

This is the supplementary material for the paper titled "Multi-frequency scatter broadening evolution of pulsars - I". The following pages contain all the results of our observations and analysis as detailed in the paper. First two pages contain the table of τ_{sc} fit results. Table 1 includes measurements of τ_{sc} for pulsars from our new observations with the GMRT, those reported in KMNJM15 as well as from archival data available at EPN pulsar database. Table 2 shows the fit results of τ_{sc} obtained from the publicly available profiles in LWA1 data archive.

The plots of all the fits of τ_{sc} and α for all the pulsars we studied are given. Each page contain all the analysis plots of one pulsar. Each panel is divided into two panels as **left** and **right**.

(**left panel**): The plot shows the profiles of the pulsar at each frequencies and the fit. The observed profiles are plotted as **black continuous curve** and the best fit are in **red continuous curves**. The high frequency profile used for fitting is plotted at the top in **black continuous curve**. In the case of Multicomponent profiles, the high frequency profile is plotted as **black dotted curves** and the component of the profile fitted is given in **black continuous curve**. The centre frequency of observation and the observatory are given at the top right side of each profile.

(**right panel**): The plot shows the fit to the τ_{sc} measurements (black filled circles) as a function of observing frequency. The black continuous line shows the best fit model to the dataset and the dashed line shows the expected line for the Kolmogorov turbulence model. The pulsar name and the value of α obtained is also given in the right side of the panel along with confidence limits.

No.	PSR	150 MHz τ_{sc} (ms)	χ^2	235 MHz τ_{sc} (ms)	χ^2	327 MHz τ_{sc} (ms)	χ^2	408 MHz τ_{sc} (ms)	χ^2	436 MHz τ_{sc} (ms)	χ^2	610 MHz τ_{sc} (ms)	χ^2	658 MHz τ_{sc} (ms)	χ^2	α
1	J0502+4654	102 ± 60	1.2	27 ± 5	0.9	19 ± 1	1.2	11 ± 1	0.9	-	-	-	-	-	-	$2.1^{+0.4}_{-0.7}$
2	J0534+2200	25 ± 1	0.9	4.1 ± 0.2	1.0	2.25 ± 0.04	0.9	-	-	-	-	-	-	-	-	3.4 ± 0.2
						1.63 ± 0.01	0.9									
3	J0614+2229	23 ± 3	1.3	4.6 ± 0.6	0.7	1.74 ± 0.03	0.8	1.3 ± 0.1	1.2	-	-	-	-	-	-	2.9 ± 0.1
4	J1328-4921	19 ± 6	0.9	3.6 ± 0.5	1.2	0.8 ± 0.4	1.0	-	-	-	-	-	-	-	-	$4.0^{+0.7}_{-0.6}$
5	J1557-4258	-	-	55 ± 18	0.8	5.3 ± 0.3	1.1	-	-	1.3 ± 0.1	1.0	-	-	-	-	$6.0^{+0.4}_{-0.6}$
6	J1604-4909	42 ± 29.0	0.7	7.2 ± 0.6	0.8	1.77 ± 0.04	0.6	-	-	-	-	-	-	-	-	$4.0^{+0.6}_{-1.2}$
7	J1613-4714	100 ± 70	0.7	23 ± 3	0.9	6.8 ± 0.5	0.9	-	-	-	-	-	-	-	-	$3.6^{+0.6}_{-1.2}$
8	J1639-4604	-	-	259 ± 78	1.1	26 ± 2	1.1	-	-	-	-	-	-	-	-	-
9	J1651-5222	-	-	29 ± 4	0.9	6.7 ± 0.4	1.1	-	-	-	-	-	-	-	-	-
10	J1703-3241	76 ± 8	0.8	15 ± 2	1.5	4.7 ± 0.1	0.9	-	-	-	-	-	-	-	-	3.5 ± 0.1
11	J1705-3423	-	-	-	-	41 ± 3	0.9	23 ± 2	0.9	16 ± 1	1.1	5.3 ± 0.1	1.0	-	-	3.3 ± 0.1
12	J1722-3207	-	-	48 ± 2	0.9	13.9 ± 0.2	1.0	6.5 ± 1.4	0.8	-	-	-	-	-	-	3.6 ± 0.3
13	J1731-4744	13 ± 1	1.0	4 ± 2	0.8	8.8 ± 0.2	0.9	-	-	-	-	-	-	-	-	-
14	J1732-4128	-	-	-	-	26 ± 4	1.2	-	-	-	-	0.4 ± 0.3	0.7	-	-	-
15	J1741-3927	-	-	39 ± 8	1.0	17.2 ± 0.4	1.0	-	-	-	-	-	-	1.8 ± 0.1	0.8	$3.0^{+0.1}_{-0.2}$
16	J1743-1351	16 ± 3	0.8	2.3 ± 0.2	0.6	0.4 ± 0.1	1.0	-	-	-	-	-	-	-	-	$4.6^{+0.4}_{-0.3}$
17	J1745-3040	39 ± 14	0.7	12.1 ± 0.4	1.0	3.7 ± 0.2	1.1	-	-	-	-	-	-	-	-	$2.9^{+0.4}_{-0.5}$
18	J1759-2205	168 ± 126	1.3	44 ± 6	1.0	9.0 ± 0.3	1.0	-	-	-	-	-	-	-	-	$3.6^{+0.7}_{-1.3}$
19	J1801-0357	42 ± 7	0.9	2.0 ± 0.2	0.9	0.6 ± 0.1	1.0	-	-	-	-	-	-	-	-	5.4 ± 0.3
20	J1807-0847	38 ± 15	0.8	12 ± 1	0.6	4.3 ± 0.1	1.0	2.4 ± 0.2	0.9	-	-	-	-	-	-	$2.7^{+0.3}_{-0.4}$
21	J1807-2715	-	-	151 ± 46	1.0	37 ± 2	1.3	-	-	-	-	1.8 ± 0.1	1.5	-	-	$4.7^{+0.2}_{-0.3}$
22	J1808-0813	-	-	85 ± 14	0.6	12 ± 1	0.8	4.4 ± 0.4	0.7	-	-	-	-	-	-	5.4 ± 0.3
23	J1816-2650	55 ± 37	0.8	19 ± 6	1.1	7.5 ± 0.3	0.9	-	-	-	-	-	-	-	-	$2.5^{+0.6}_{-1.2}$
24	J1822-2256	-	-	66 ± 6	1.0	14.5 ± 0.2	1.0	-	-	-	-	-	-	-	-	-
25	J1823-0154	-	-	44 ± 5	0.9	5.9 ± 0.3	1.2	4.8 ± 0.1	1.3	-	-	-	-	-	-	4.1 ± 0.2
26	J1835-1106	-	-	25 ± 3	0.9	6.8 ± 0.4	1.0	4.5 ± 0.1	0.7	-	-	1.0 ± 0.1	1.0	-	-	3.3 ± 0.1
27	J1849-0636	593 ± 250	1.0	97 ± 3	1.0	24 ± 1	1.3	12.3 ± 0.5	1.0	-	-	-	-	-	-	$3.9^{+0.3}_{-0.4}$
28	J1854+1050	-	-	138 ± 48	1.1	46 ± 4	1.3	-	-	-	-	4.9 ± 0.1	0.8	-	-	$3.5^{+0.2}_{-0.3}$
29	J1854-1421	-	-	7.3 ± 0.6	0.8	3.0 ± 0.2	1.0	1.7 ± 0.1	1.2	-	-	-	-	-	-	2.6 ± 0.2
30	J1903-0632	-	-	66 ± 4	0.7	20.7 ± 0.3	0.9	8.3 ± 0.6	1.1	-	-	-	-	-	-	3.7 ± 0.1
31	J1904-1224	397 ± 250	0.8	24 ± 5	1.0	5.6 ± 0.2	0.9	-	-	-	-	-	-	-	-	$5.4^{+0.6}_{-1.0}$
32	J1905-0056	380 ± 280	1.4	39 ± 3	0.6	7.4 ± 0.4	0.5	-	-	-	-	-	-	-	-	$5.0^{+0.6}_{-1.3}$
33	J1910-0309	75 ± 33	1.1	16 ± 1	1.1	2.7 ± 0.1	0.9	-	-	-	-	-	-	-	-	$4.2^{+0.4}_{-0.6}$
34	J1910+0714	-	-	12 ± 2	0.8	4 ± 1	0.7	-	-	-	-	-	-	-	-	-
35	J1910+1231	-	-	-	-	52 ± 5	1.0	-	-	-	-	2.3 ± 0.2	0.6	-	-	-
36	J1916+1312	79 ± 60	0.8	24 ± 6	0.6	6 ± 1	1.0	-	-	-	-	-	-	-	-	$3.2^{+0.7}_{-1.4}$
37	J1926+0431	12 ± 1	0.7	4.0 ± 0.6	0.9	2.2 ± 0.1	0.9	0.9 ± 0.3	0.6	-	-	-	-	-	-	$2.4^{+0.3}_{-0.2}$
38	J1932+2020	-	-	71 ± 6	1.0	19 ± 1	1.1	12 ± 1	1.1	-	-	-	-	-	-	3.3 ± 0.2
39	J1932+2220	-	-	7 ± 2	0.7	0.65 ± 0.03	1.1	-	-	-	-	-	-	-	-	-
40	J1935+1616	20 ± 2	1.0	4.5 ± 0.2	1.0	3.2 ± 0.2	0.7	1.2 ± 0.4	1.1	-	-	0.4 ± 0.1	0.9	-	-	3.1 ± 0.1
41	J2004+3137	222 ± 105	0.7	38 ± 2	1.1	9.0 ± 0.2	1.2	-	-	-	-	-	-	-	-	$4.0^{+0.4}_{-0.7}$
42	J2029+3744	295 ± 81	0.7	49 ± 3	1.0	11.6 ± 0.3	1.1	-	-	-	-	-	-	-	-	$4.1^{+0.3}_{-0.4}$
43	J2055+3630	85 ± 50	1.0	23 ± 2	0.8	5.5 ± 0.3	0.9	3.0 ± 0.1	0.9	-	-	-	-	-	-	$3.4^{+0.4}_{-0.7}$
44	J2113+4644	50 ± 2	1.3	5.6 ± 0.2	1.2	1.8 ± 0.1	0.7	-	-	-	-	-	-	-	-	4.2 ± 0.1

| No. | PSR | τ_{sc} measurements | | | | | | | | | | | | | | | | | | α |
| | | 37.55 MHz | | 42.45 MHz | | 47.35 MHz | | 52.27 MHz | | 57.15 MHz | | 62.05 MHz | | 66.95 MHz | | 71.85 MHz | | 76.75 MHz | | |
		τ_{sc} (ms)	χ^2	τ_{sc} (ms)	χ^2	τ_{sc} (ms)	χ^2	τ_{sc} (ms)	χ^2	τ_{sc} (ms)	χ^2	τ_{sc} (ms)	χ^2	τ_{sc} (ms)	χ^2	τ_{sc} (ms)	χ^2	τ_{sc} (ms)	χ^2	
1	J0332+5434	50±5	1.0	29±2	0.7	21±1	0.8	13.8±0.5	1.0	9.3±0.4	0.9	5.7±0.2	1.0	4.0±0.1	1.0	3.4±0.2	0.8	-	-	4.3±0.1
2	J1825-0935	-	-	-	-	35±4	1.4	20±2	0.9	11±1	0.7	9±2	9	6±1	0.9	-	-	-	-	5.0±0.5
3	J2219+4754	-	-	83±10	0.9	64±5	1.0	37±2	0.9	28±2	1.0	19±1	0.8	14±1	0.8	9.2±0.4	0.9	7.0±0.4	0.9	4.2±0.1
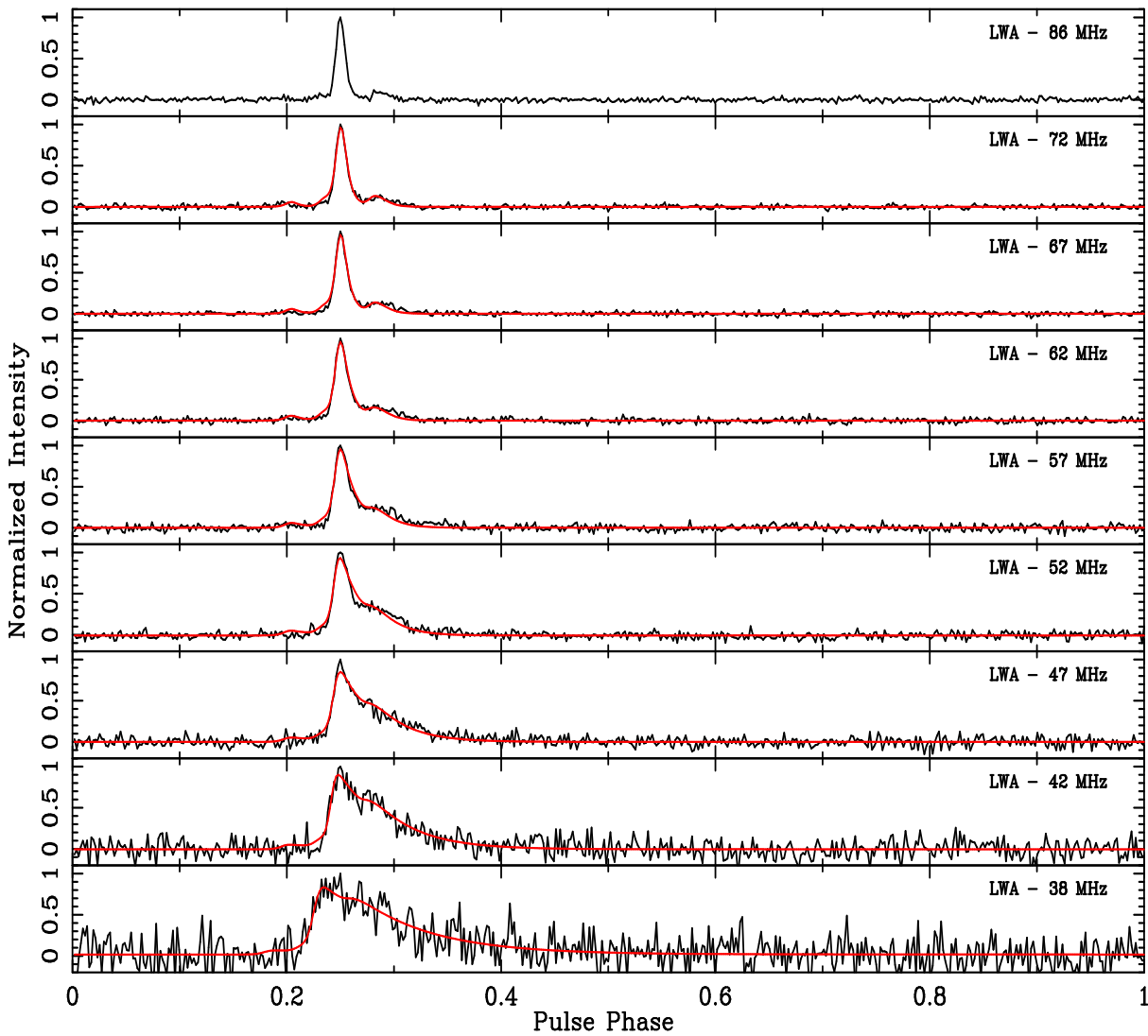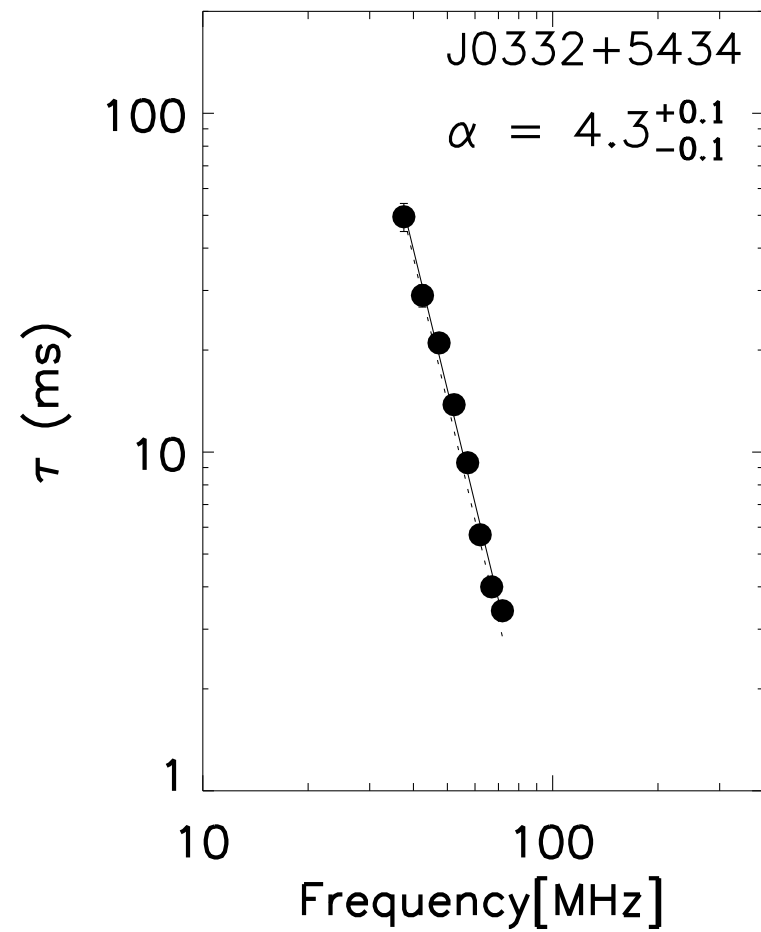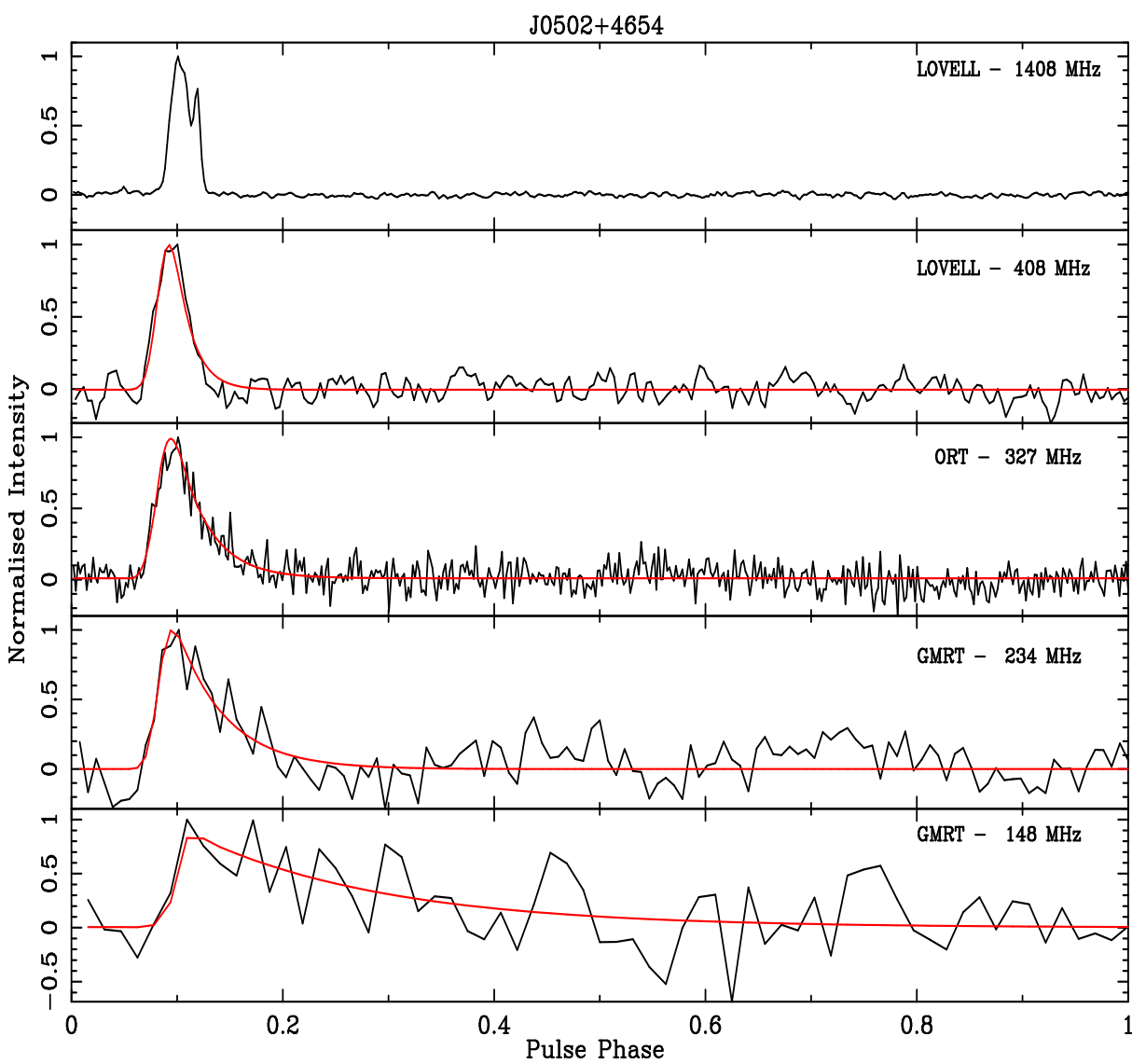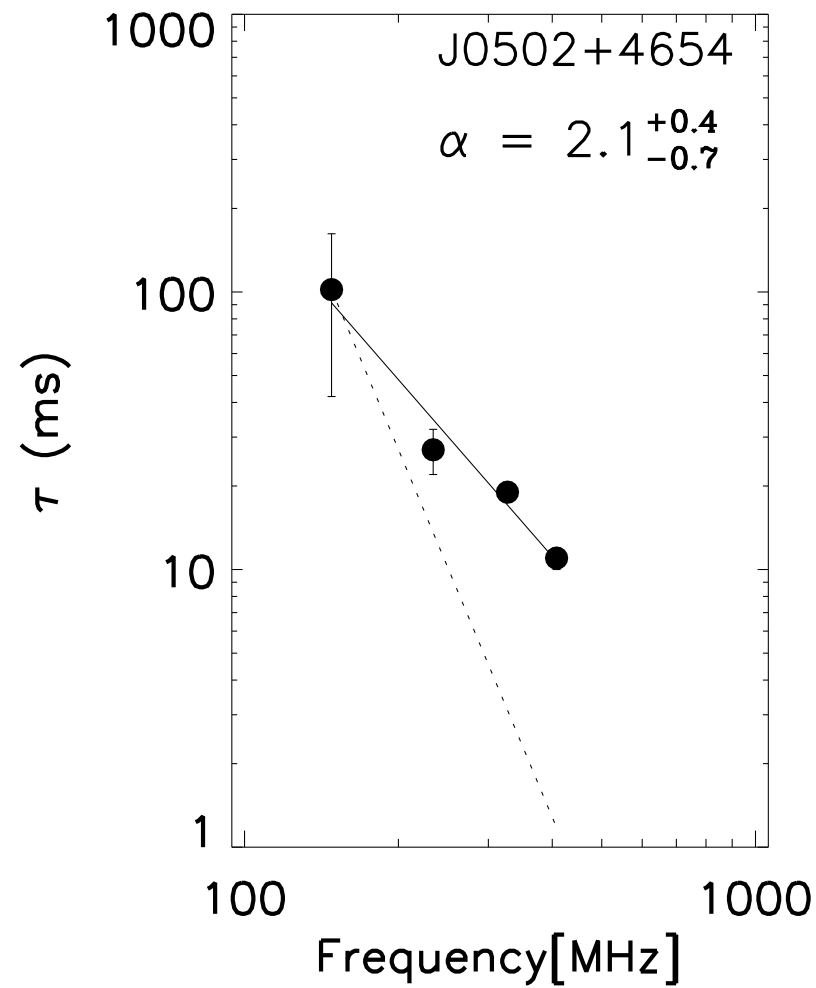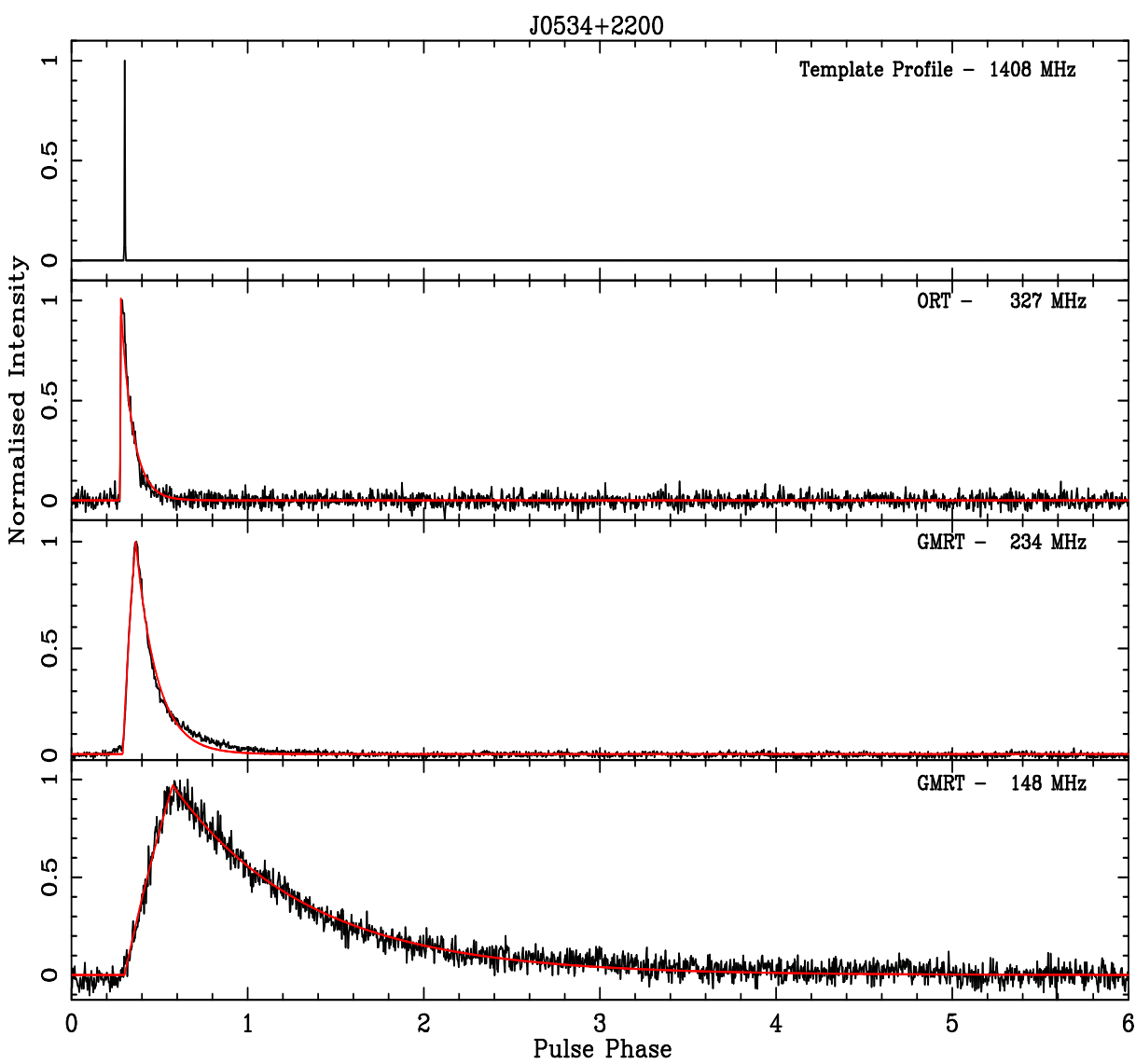
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Figure 2:

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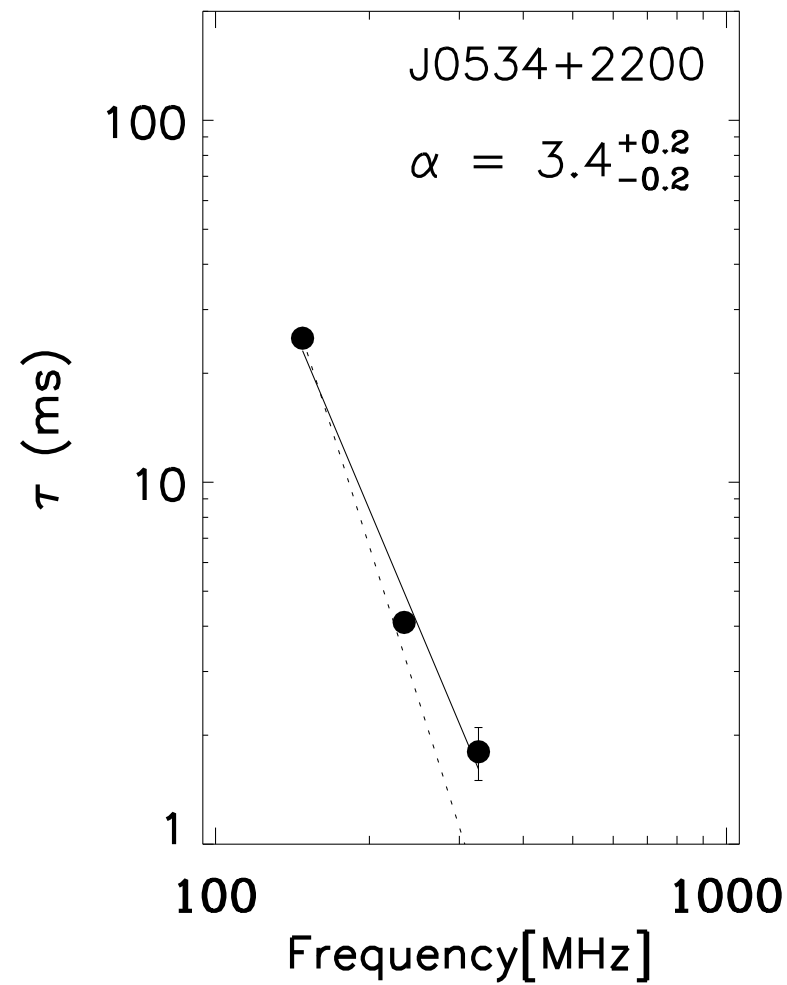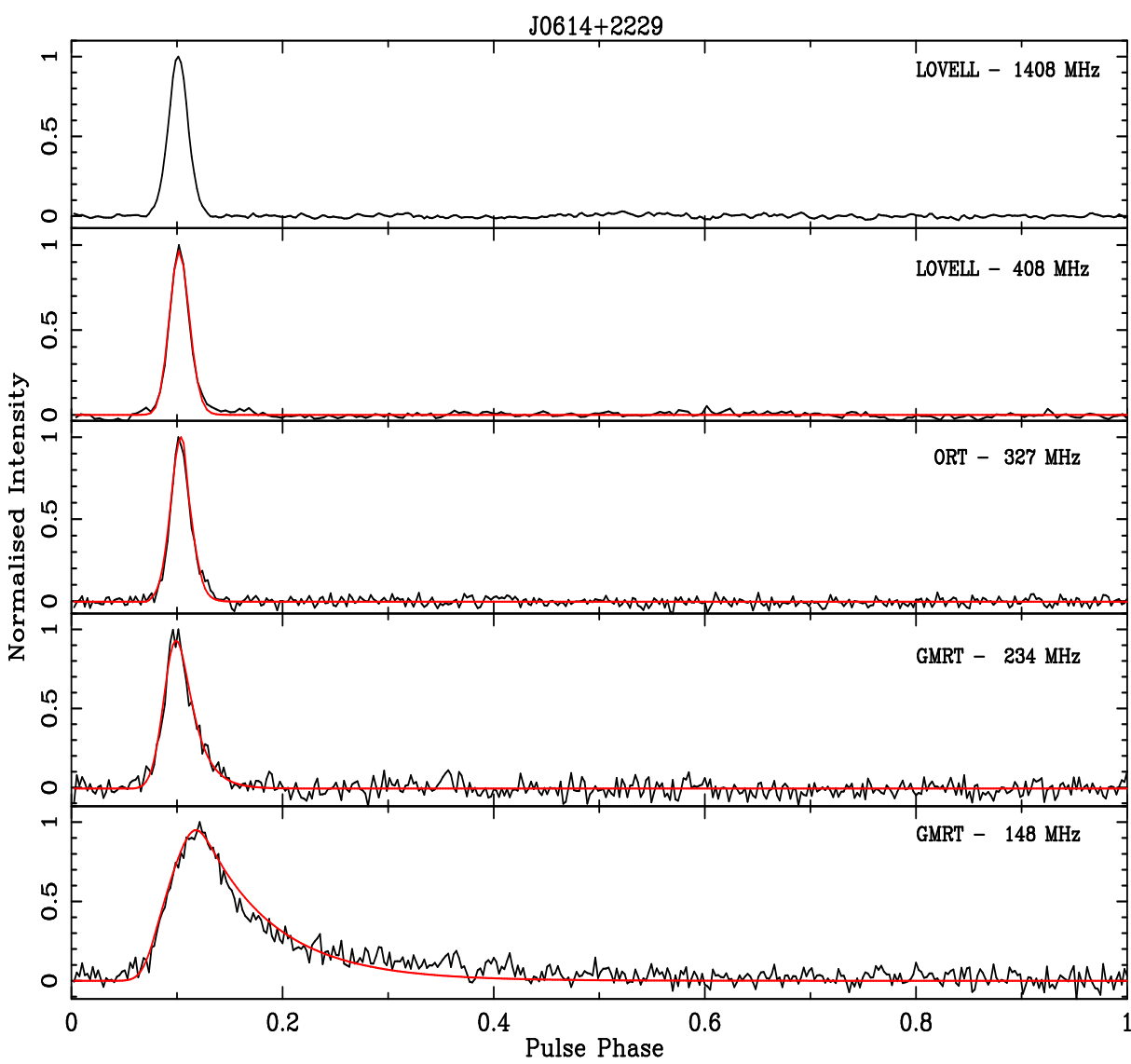
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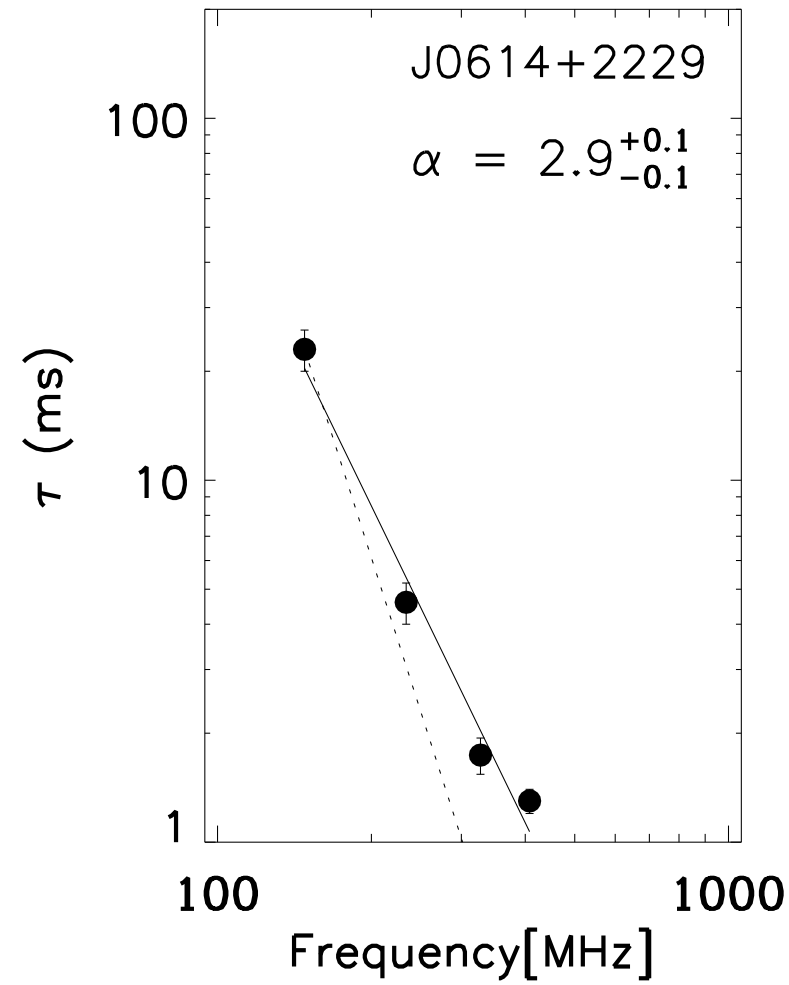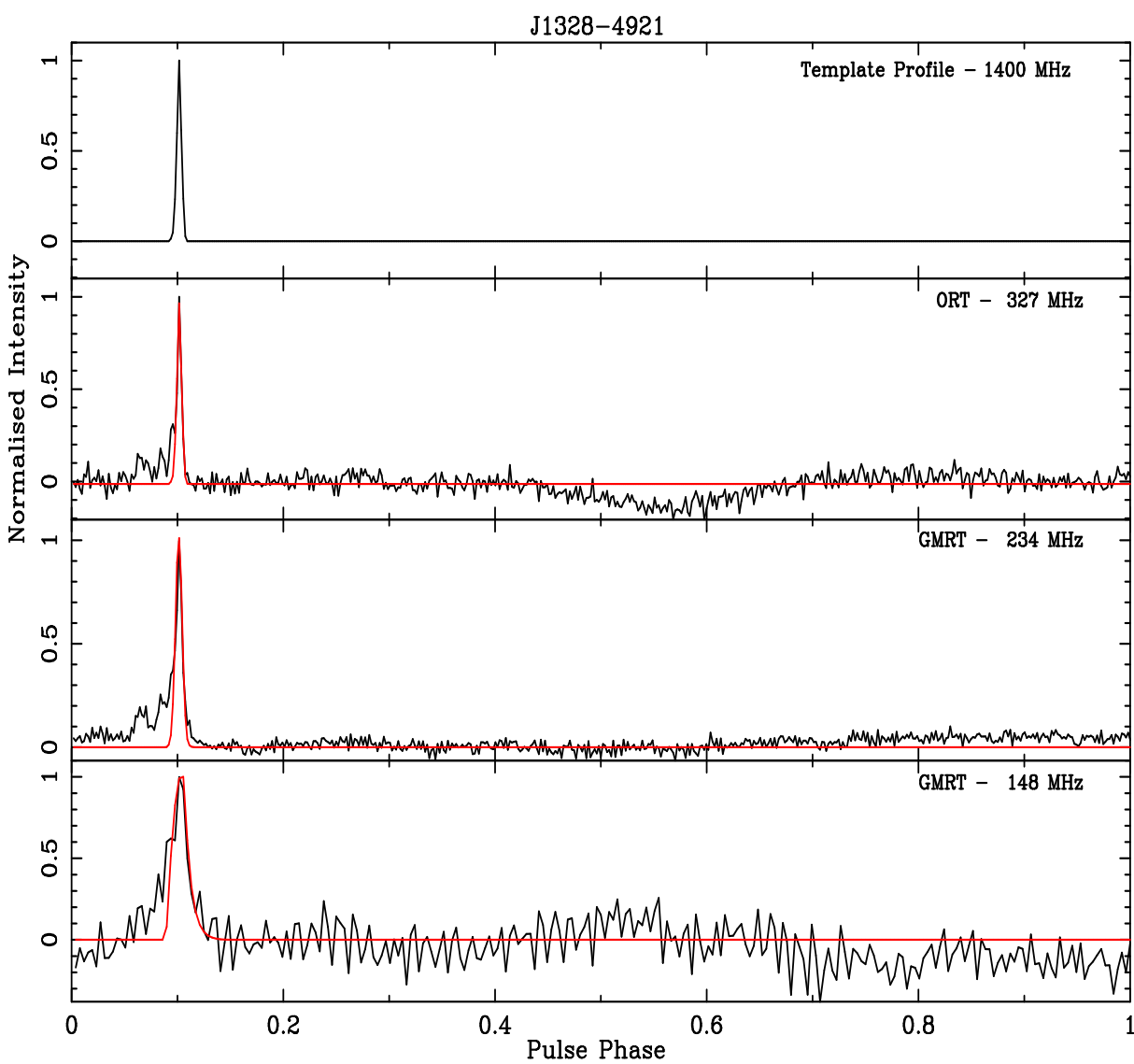
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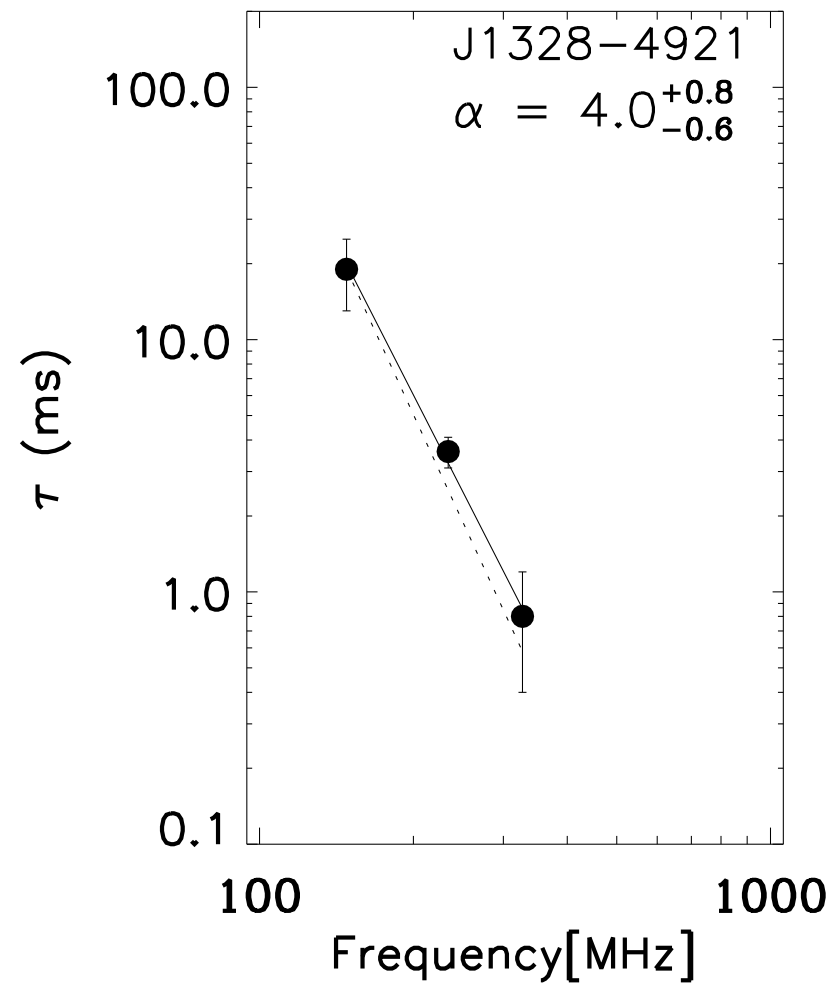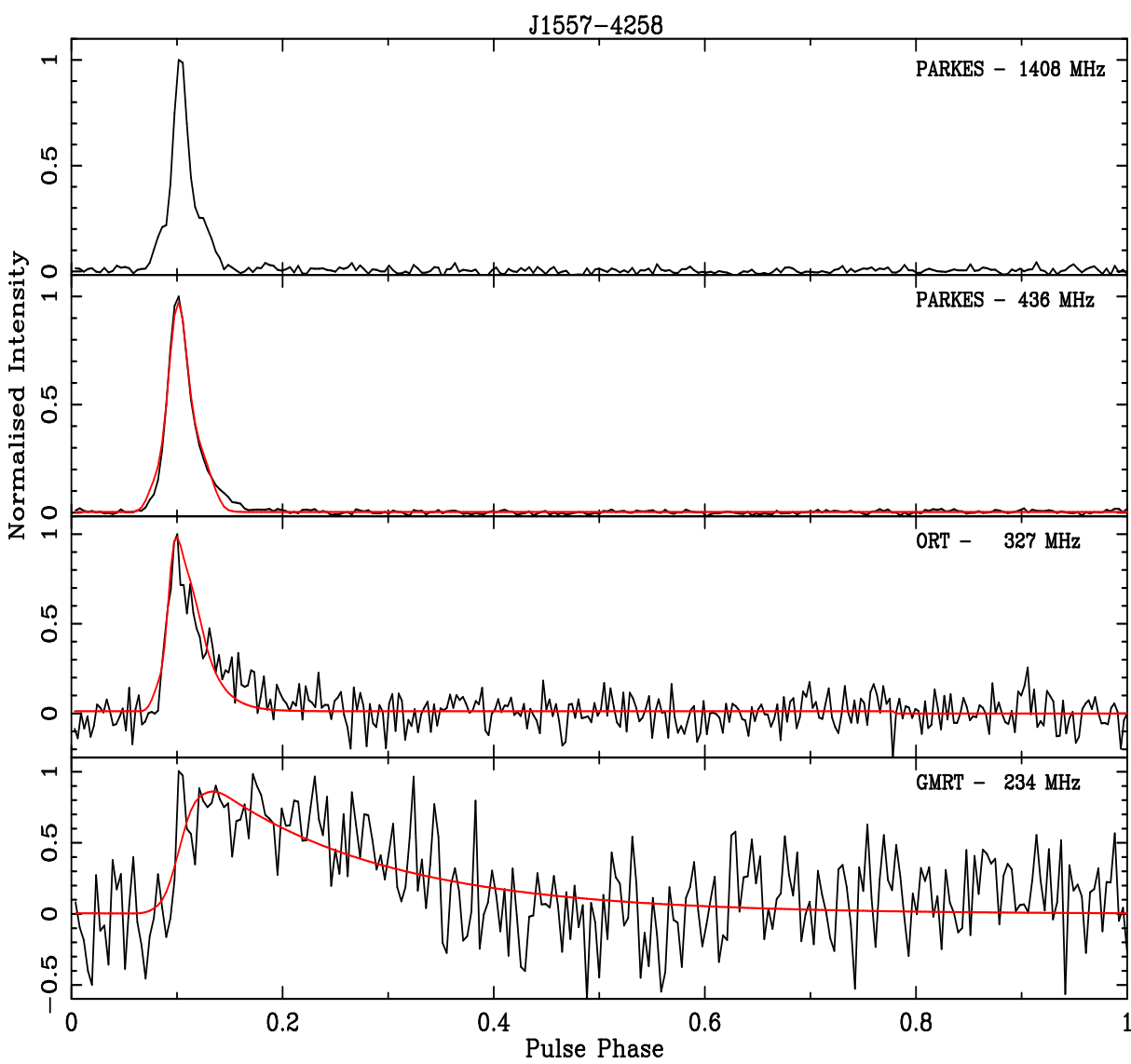
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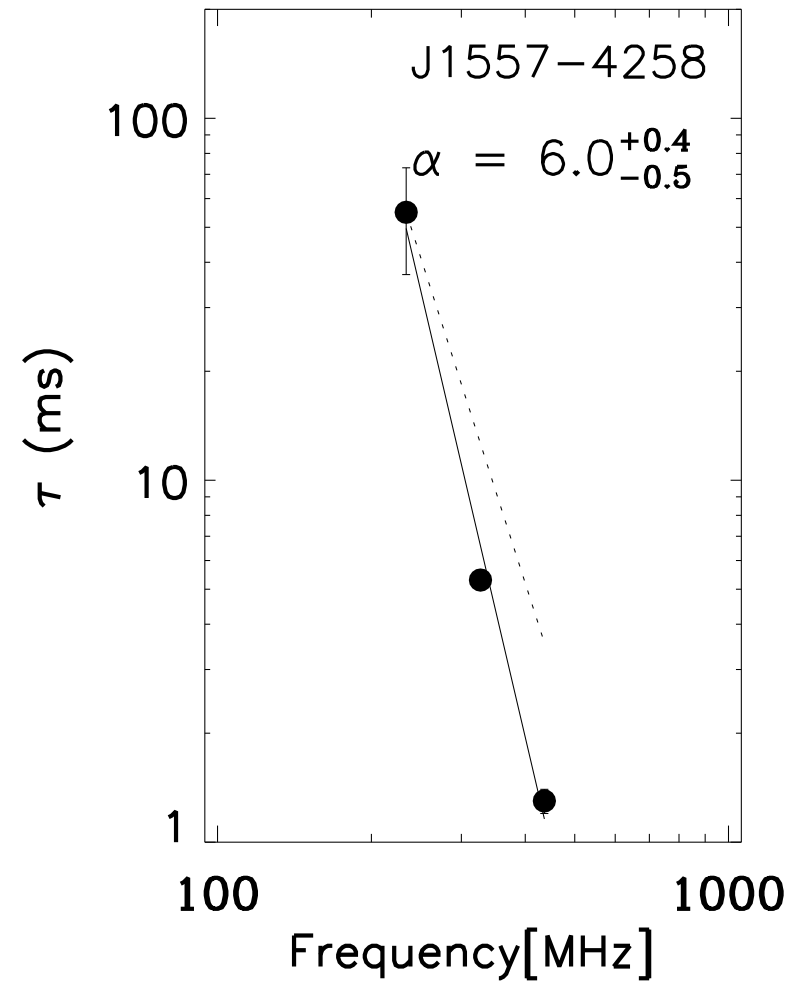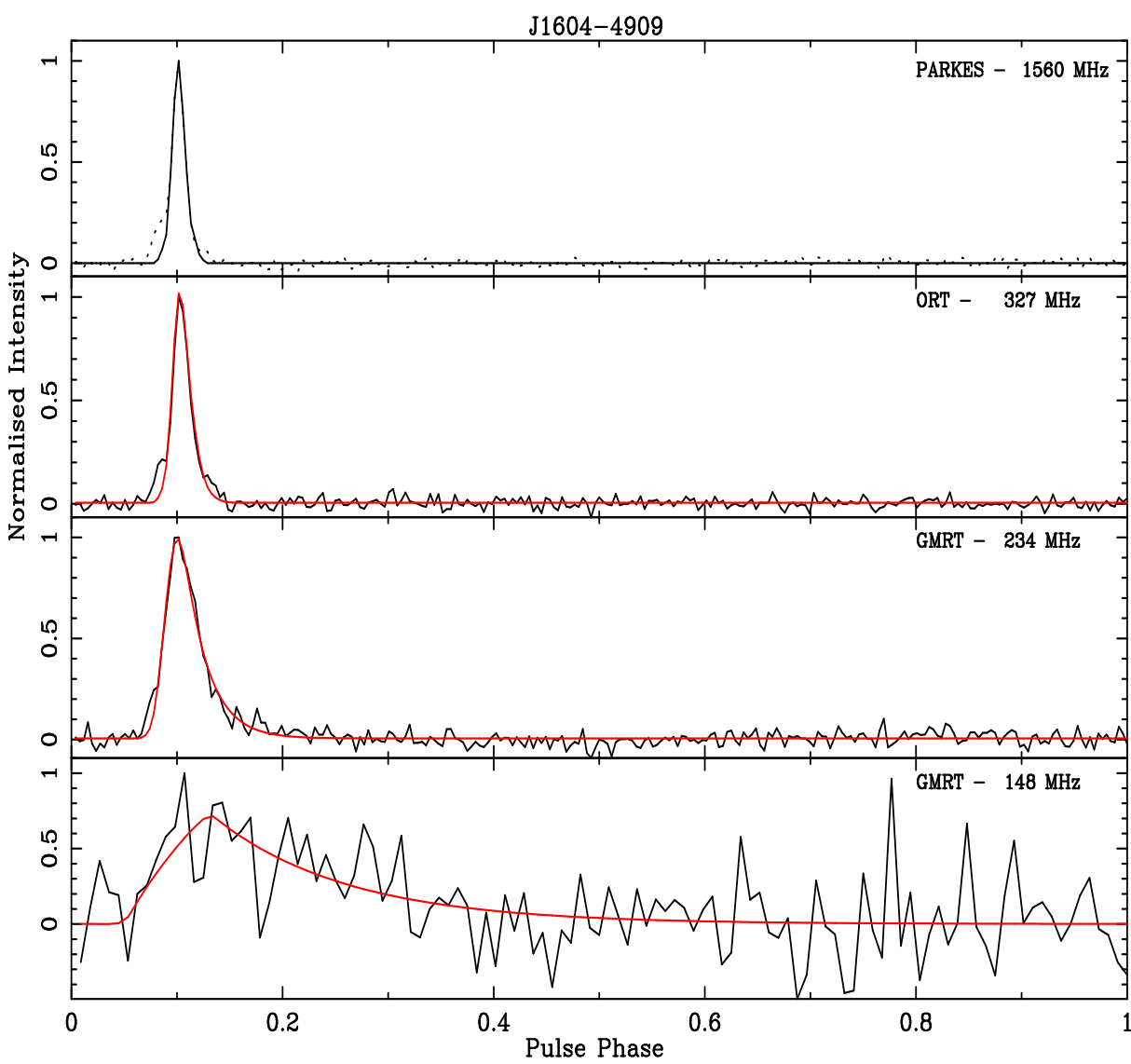
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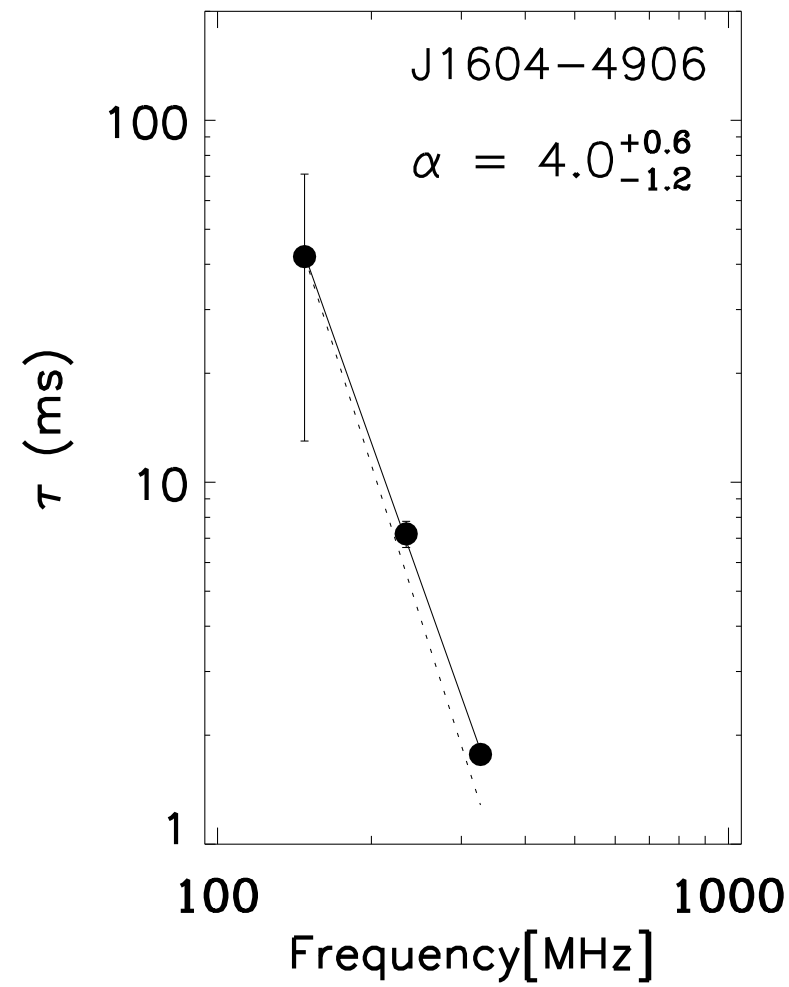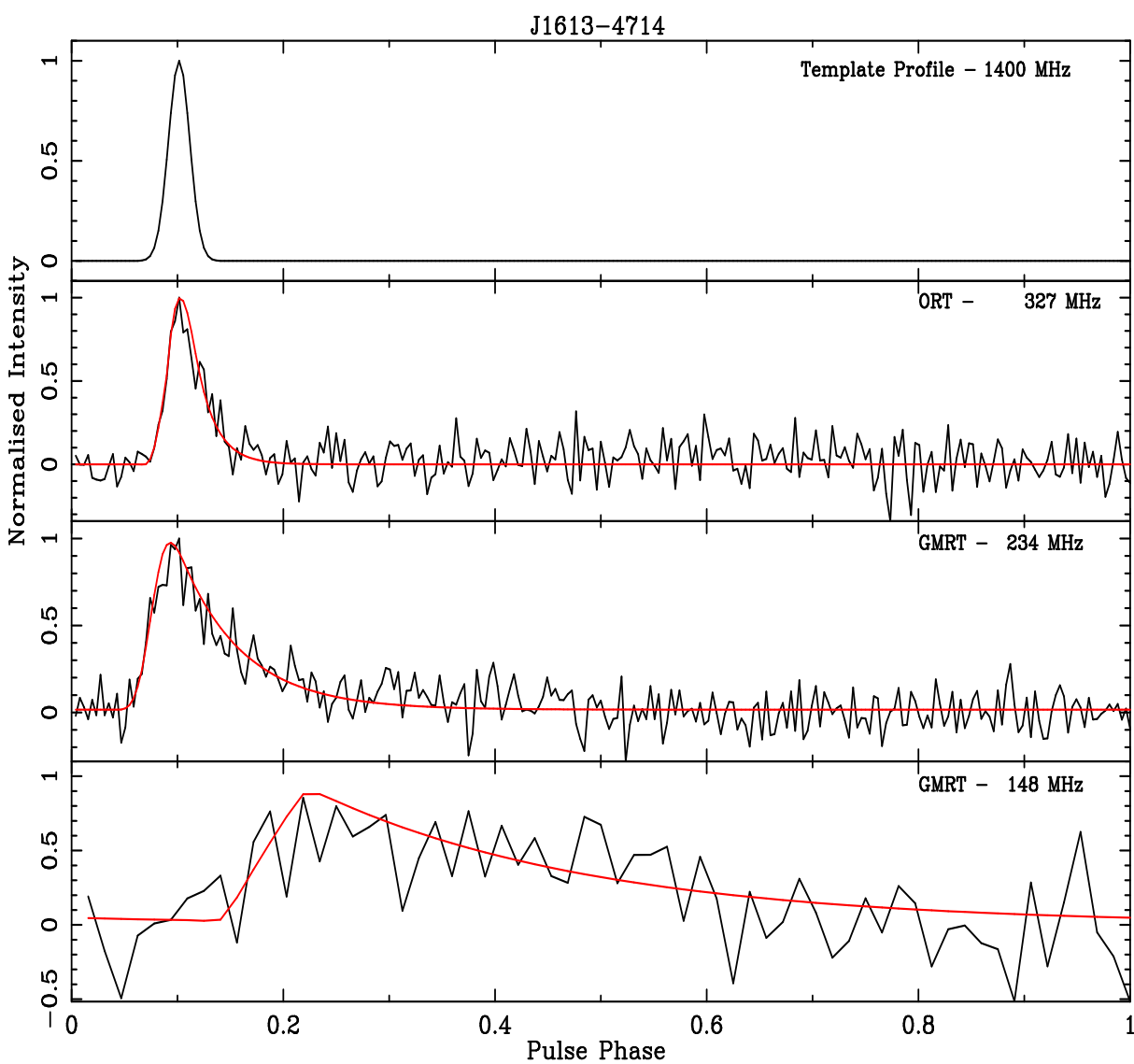
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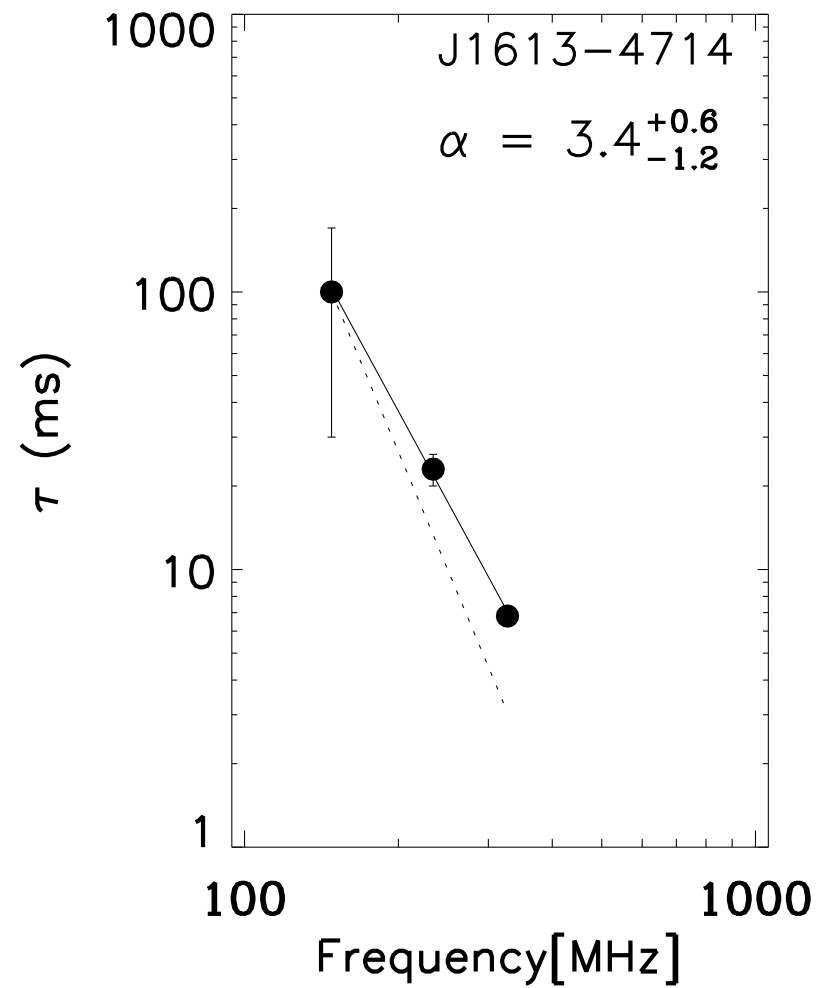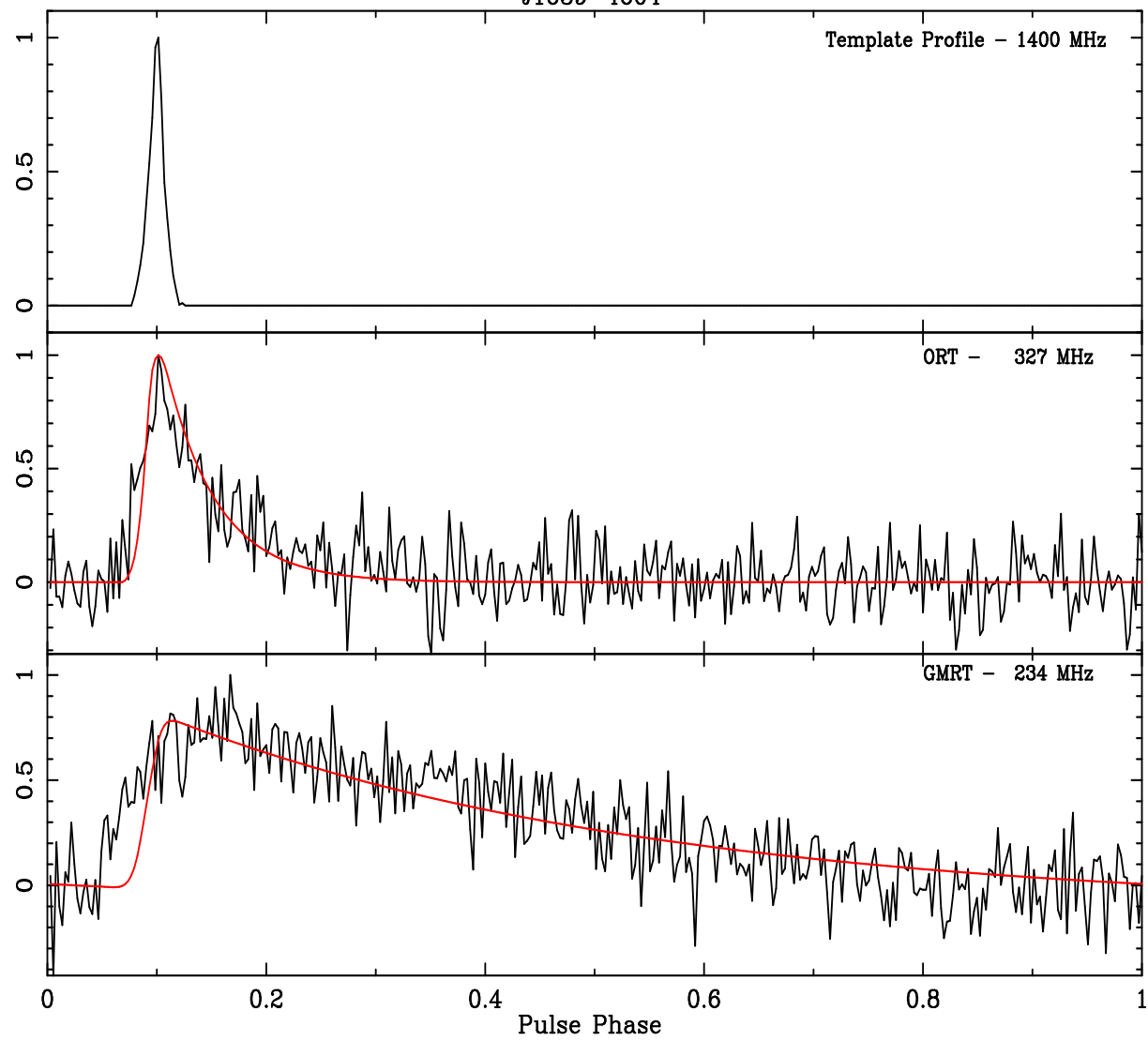
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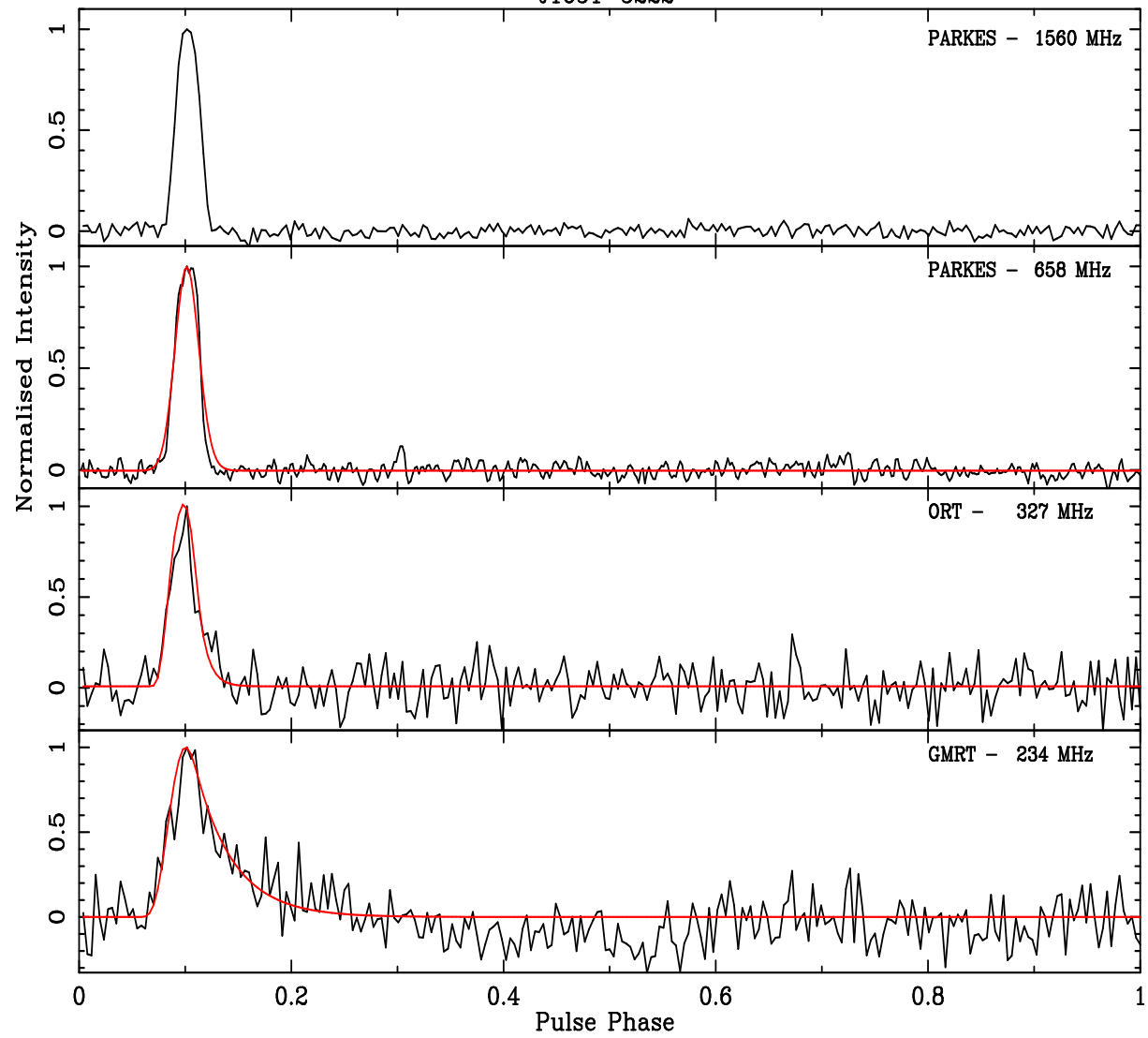
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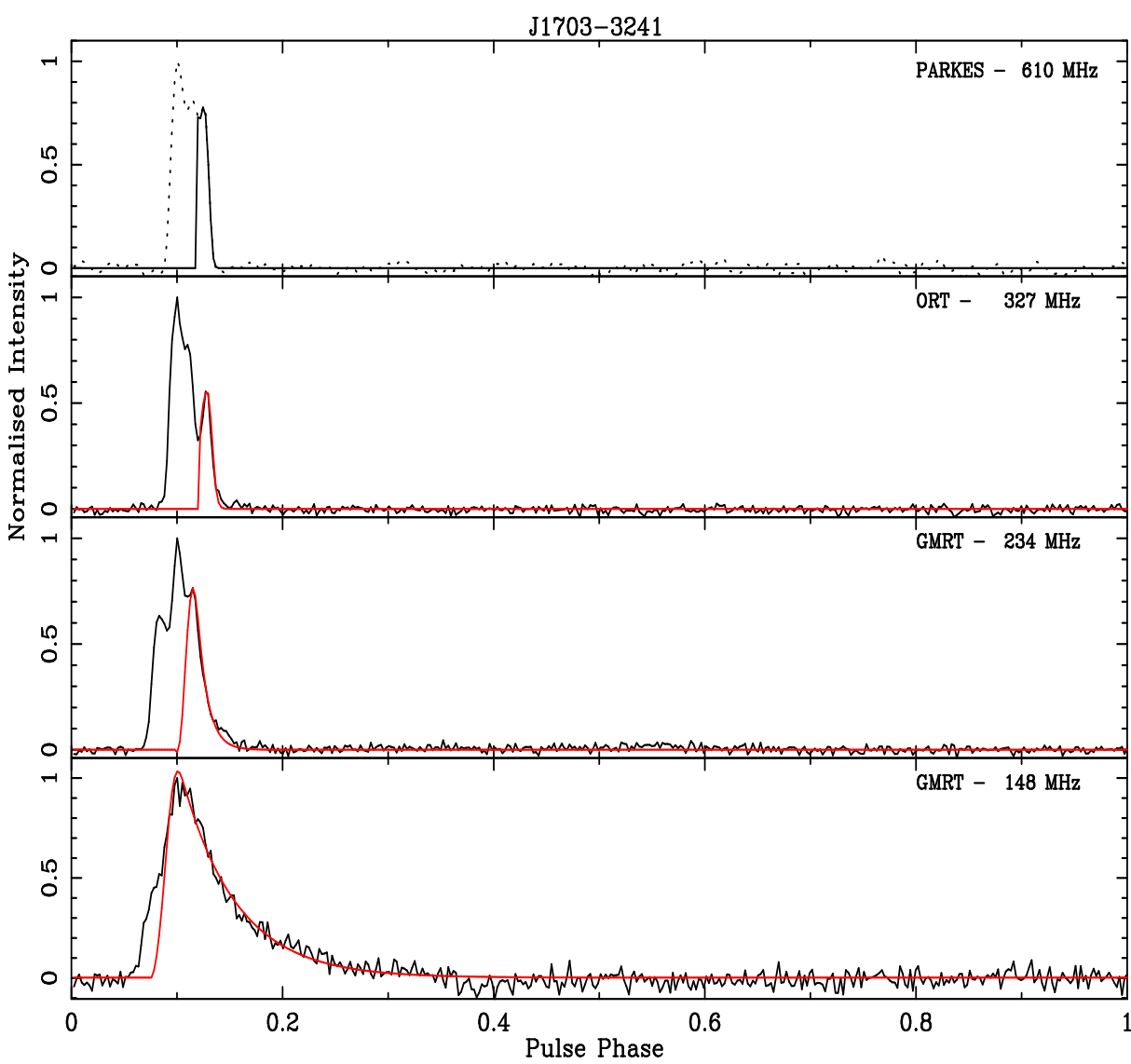
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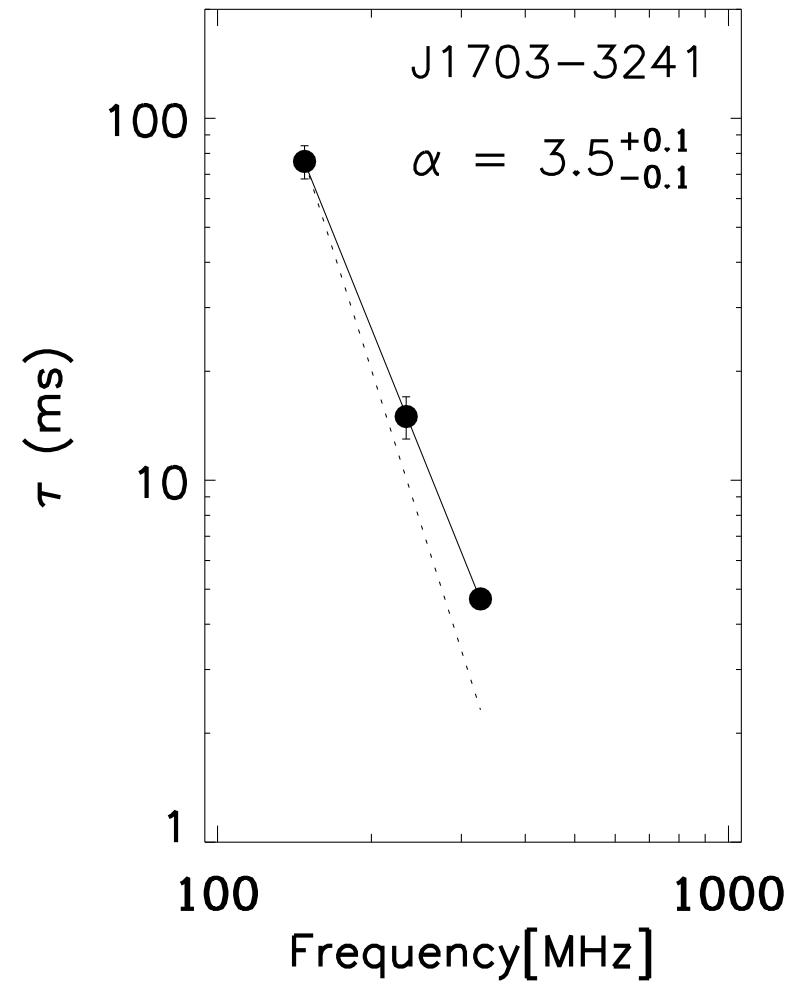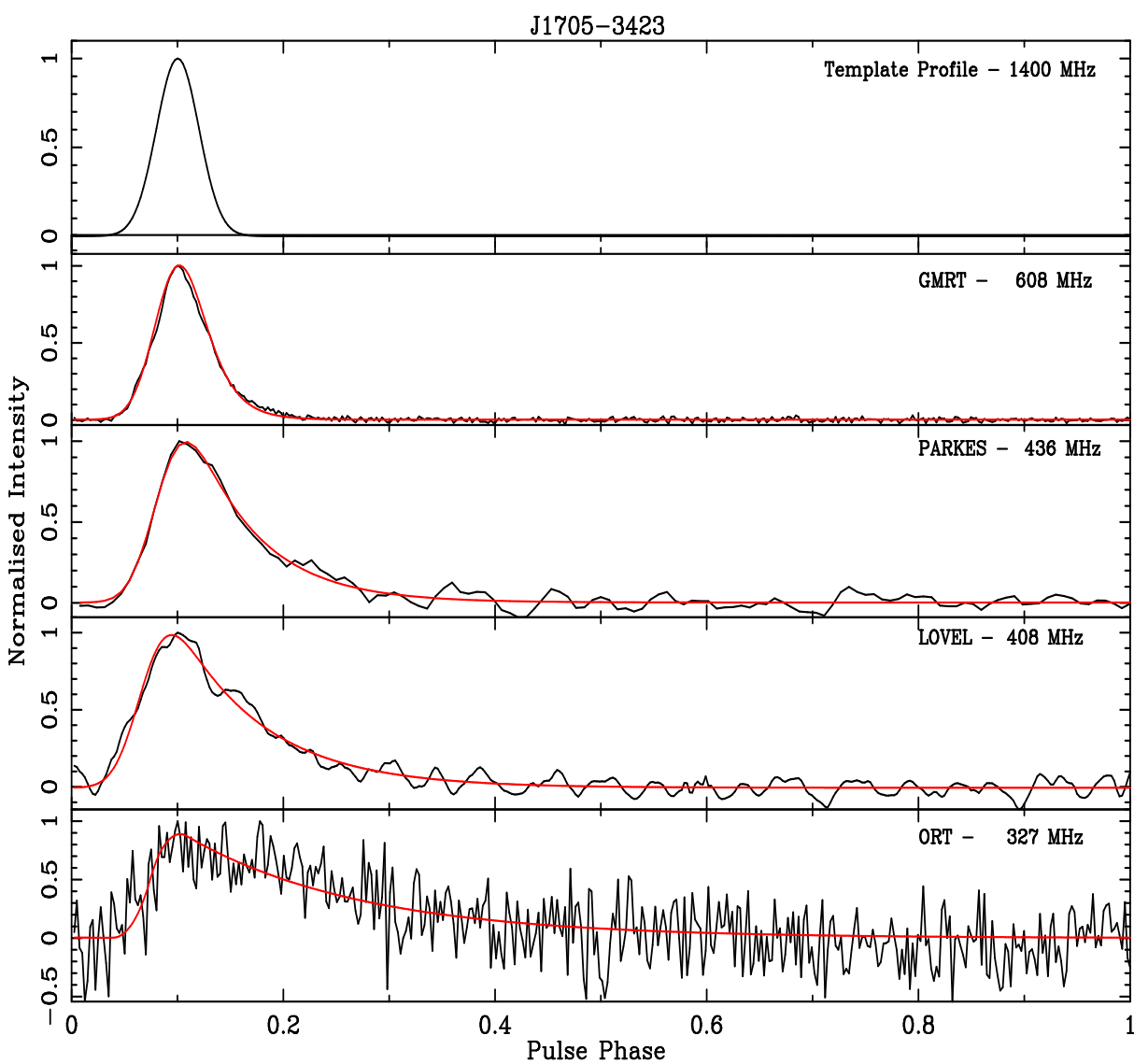
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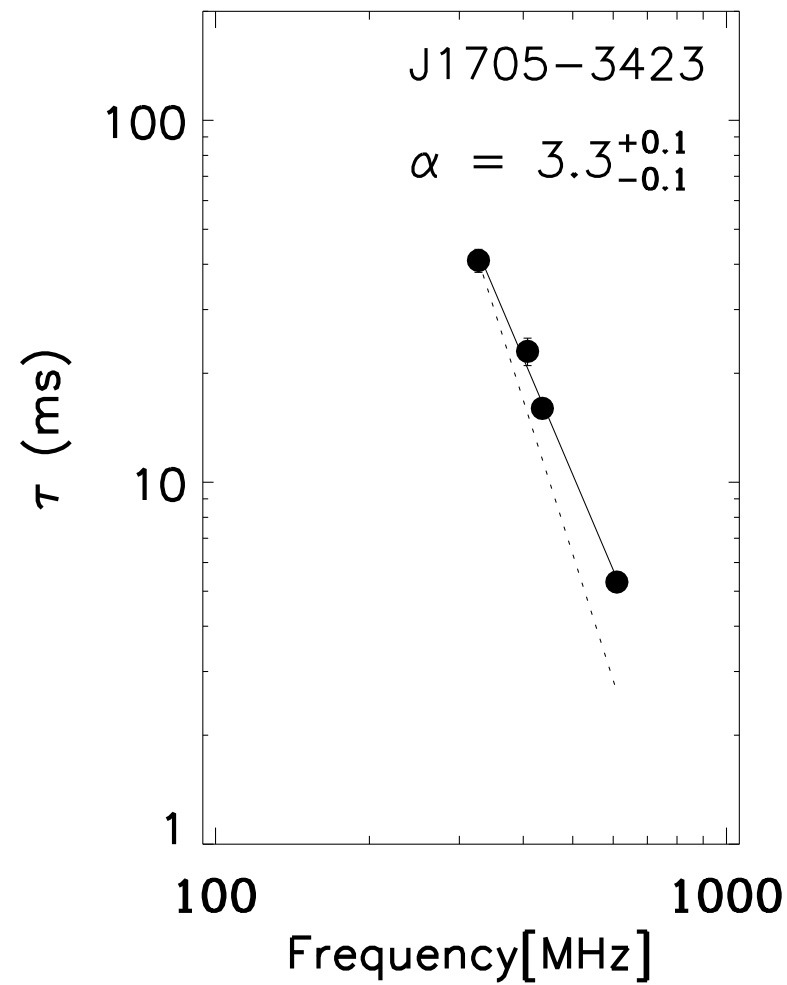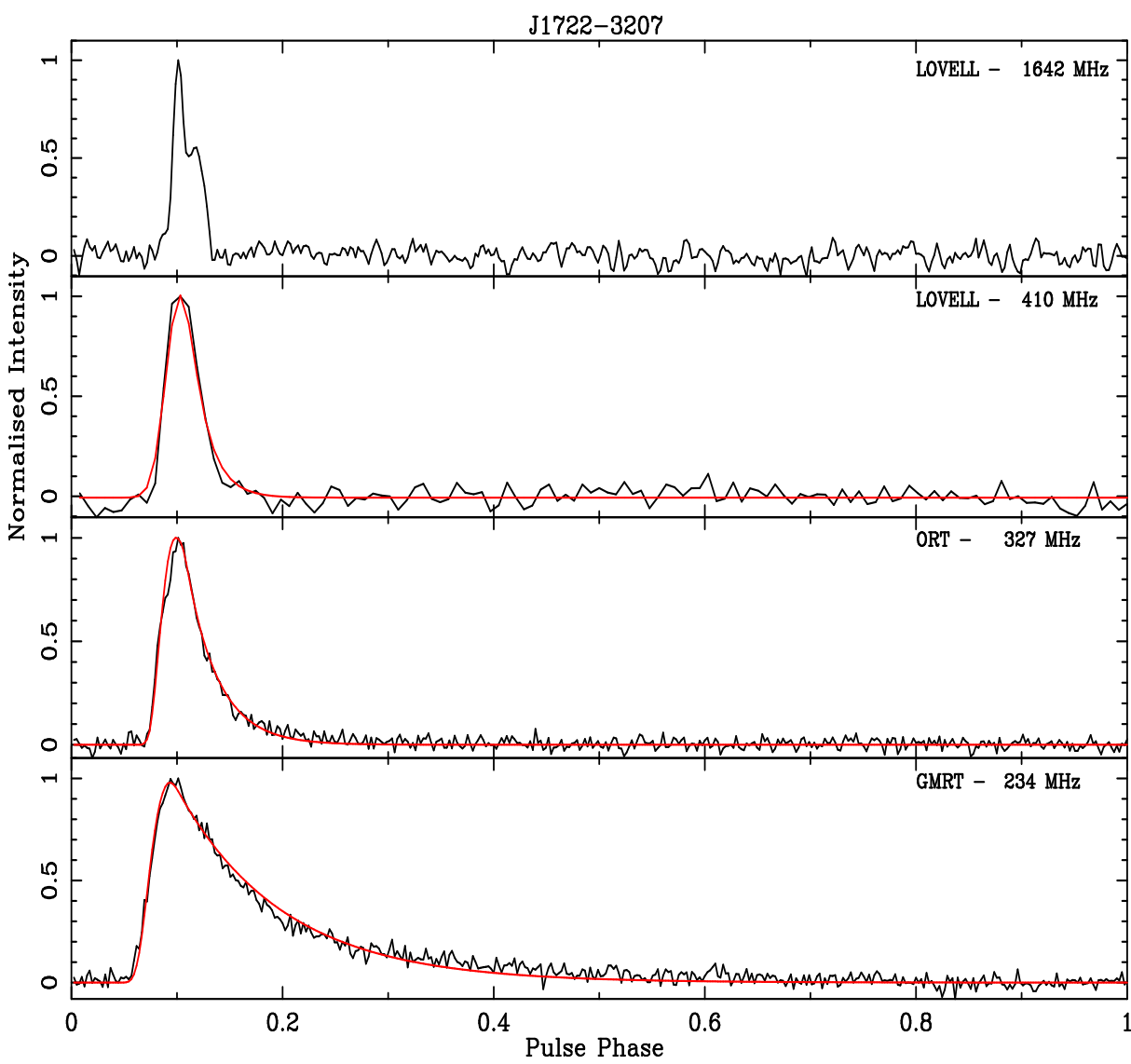
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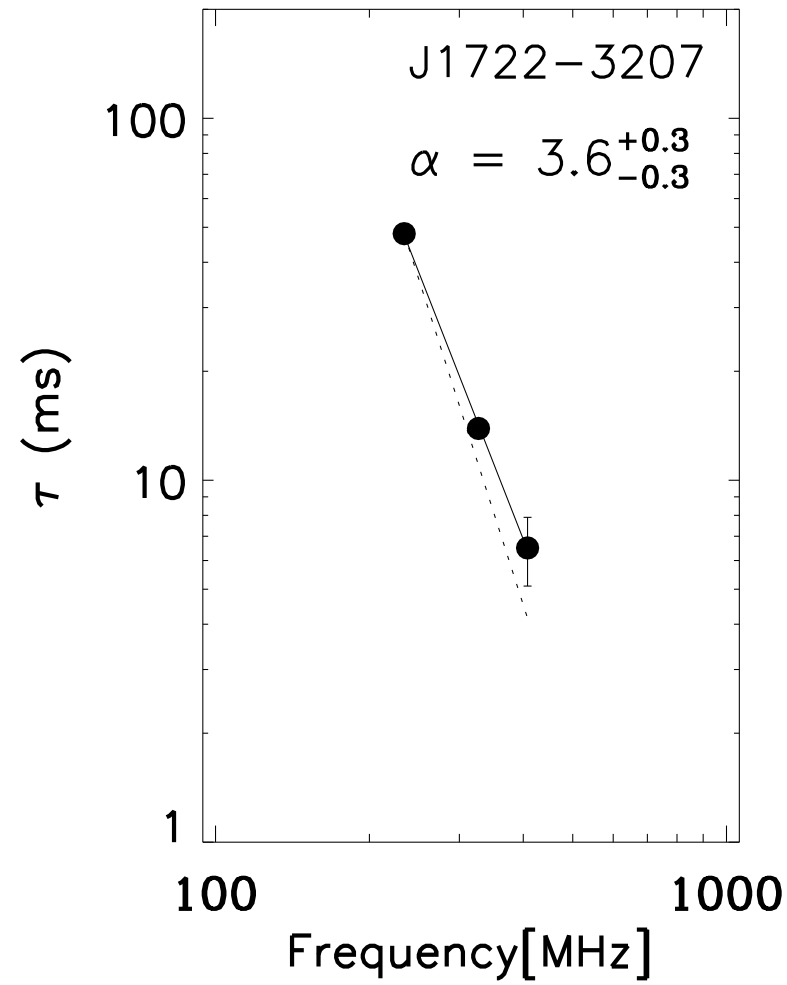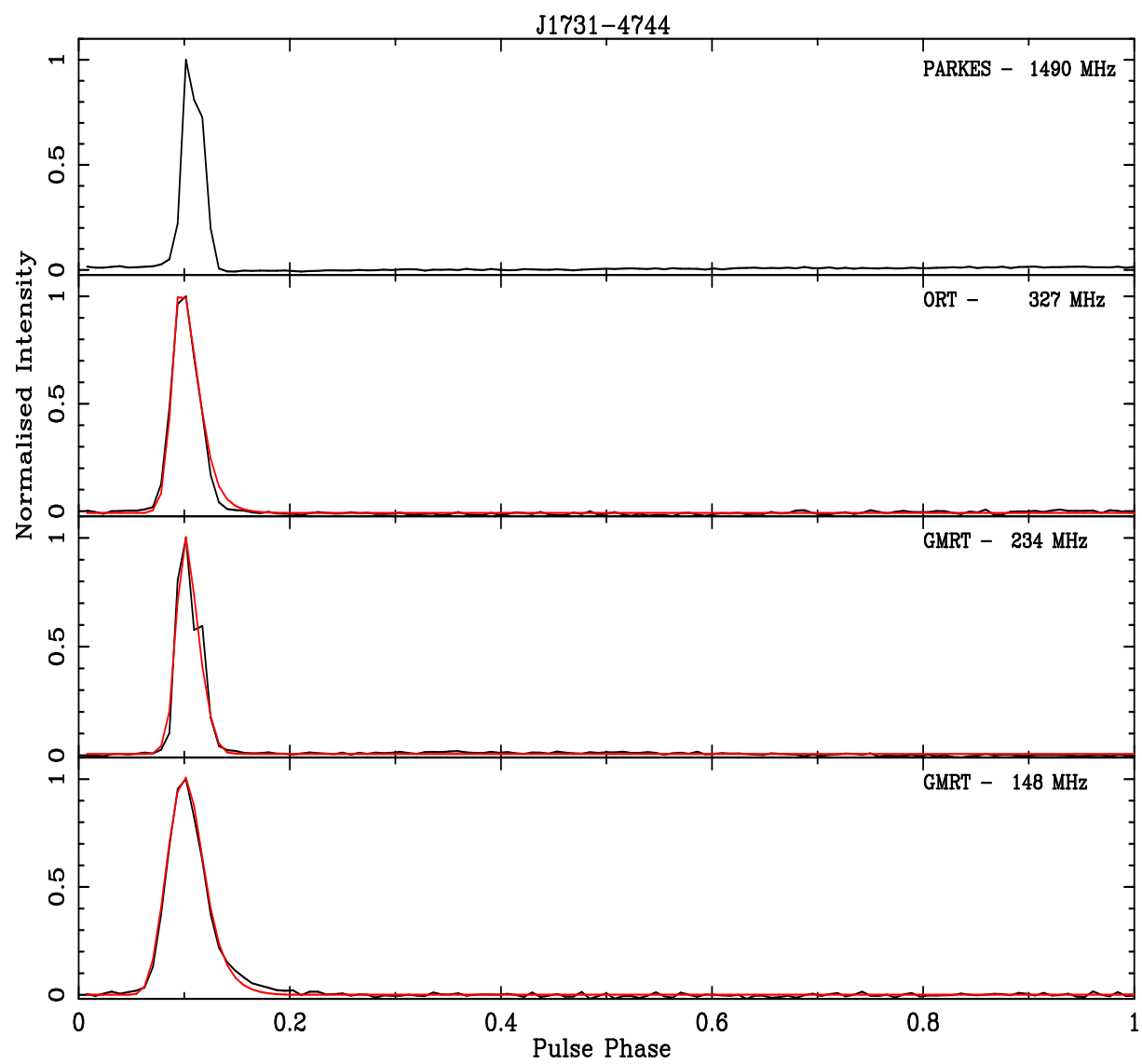
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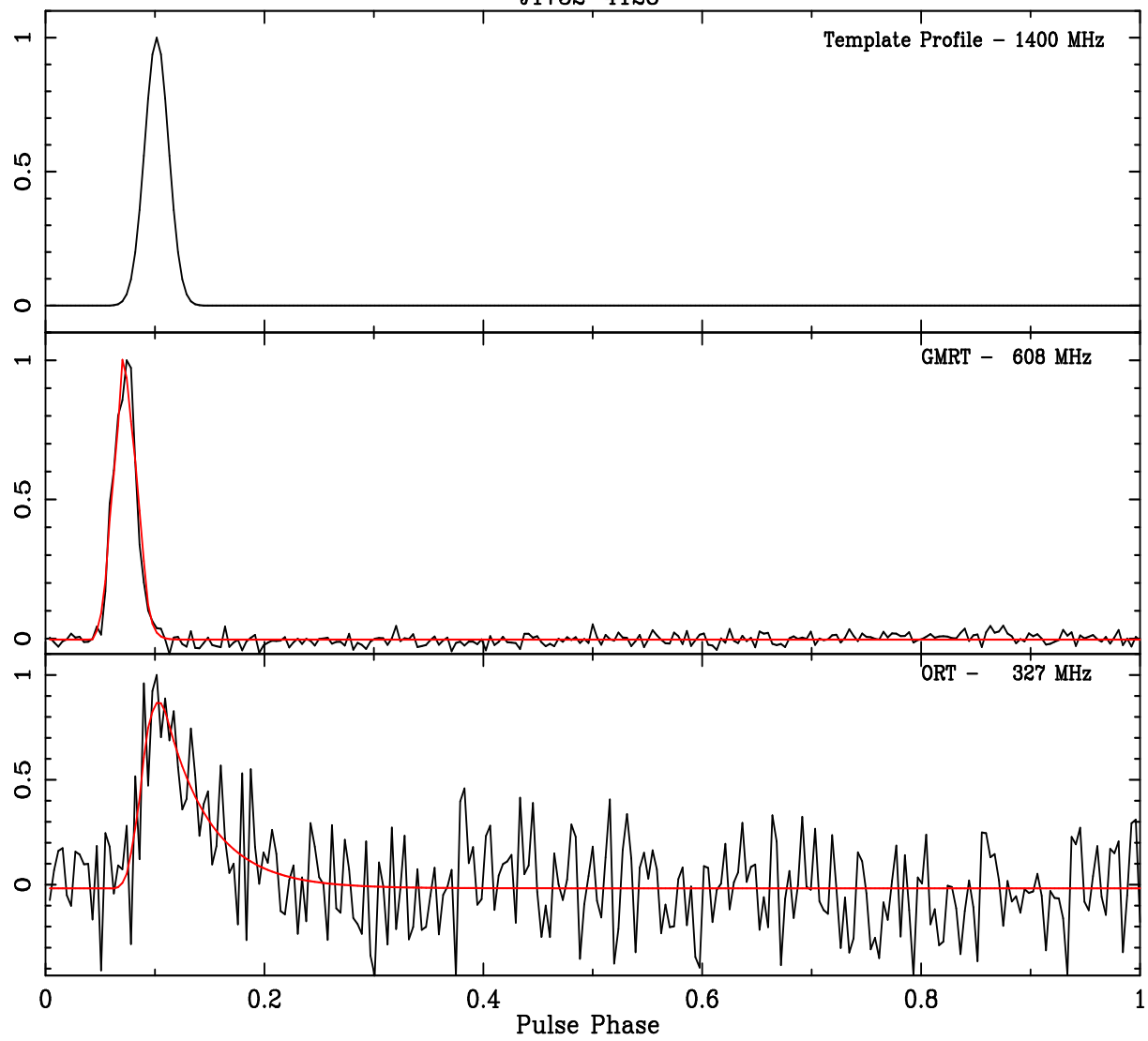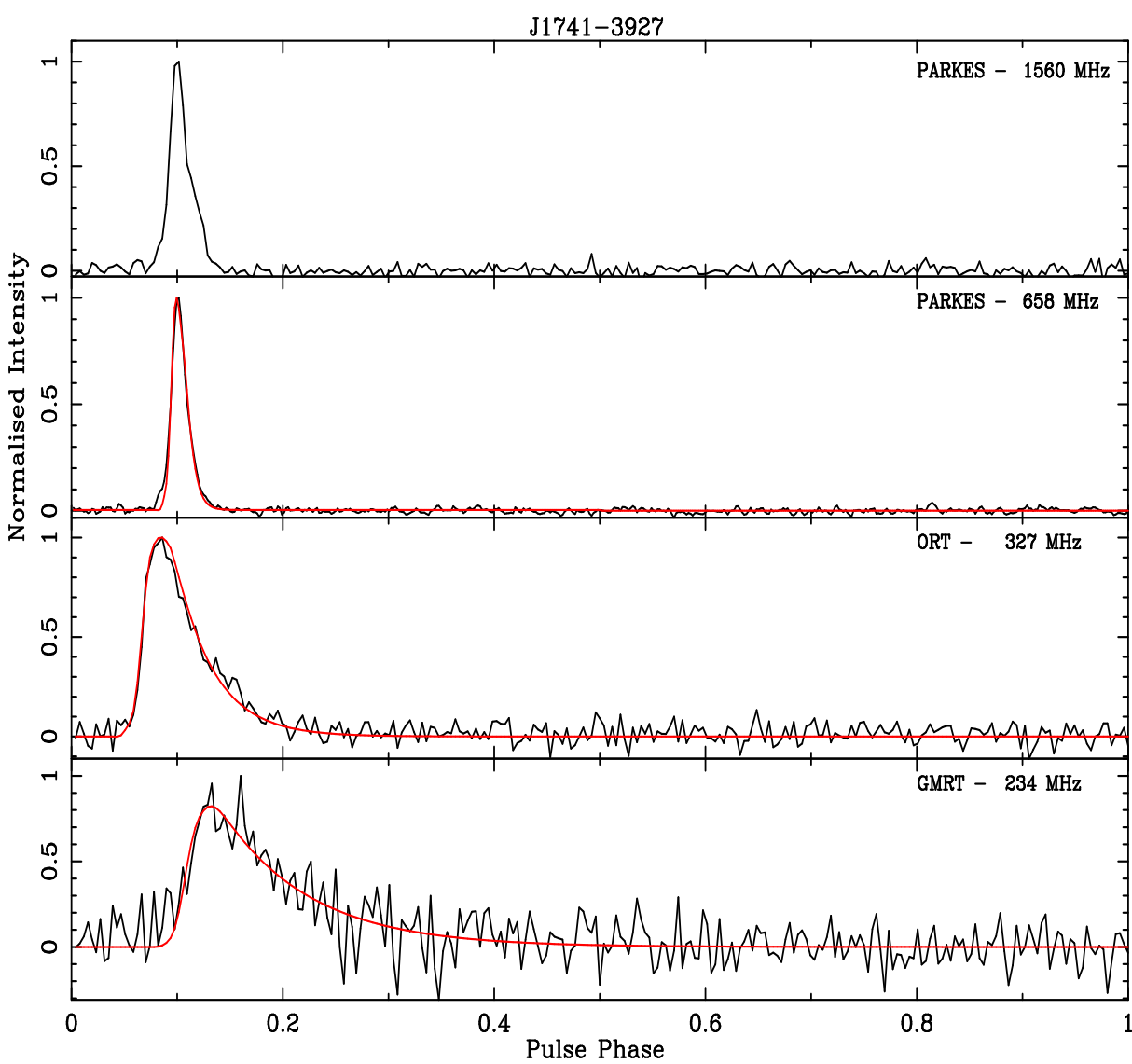
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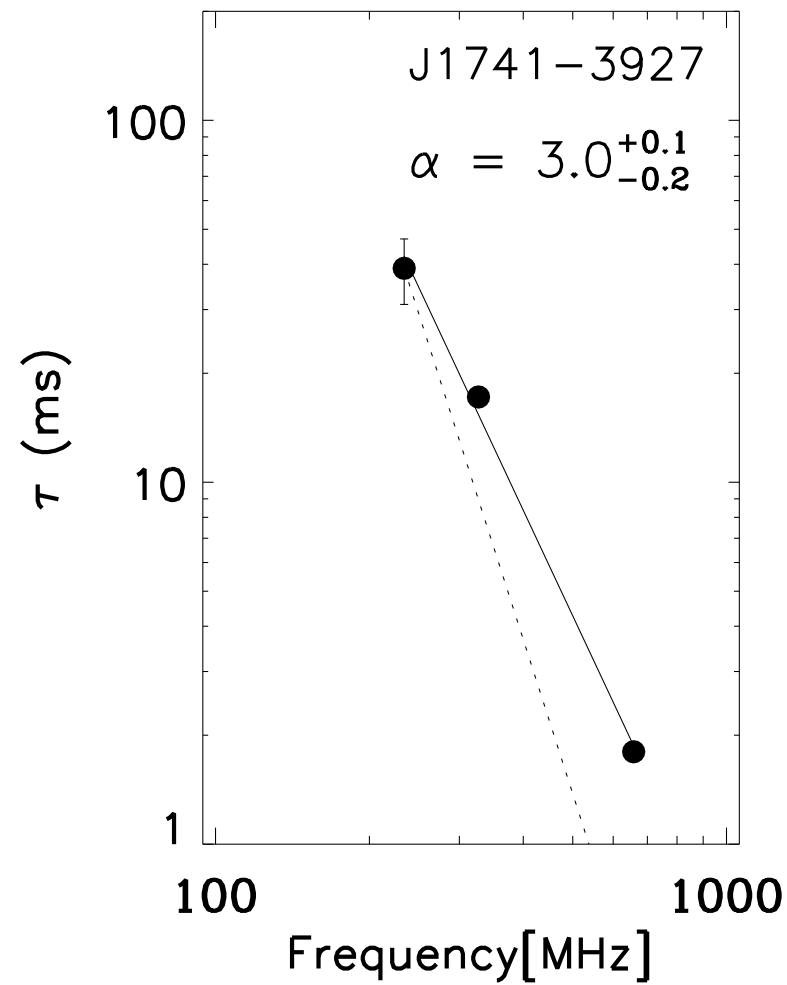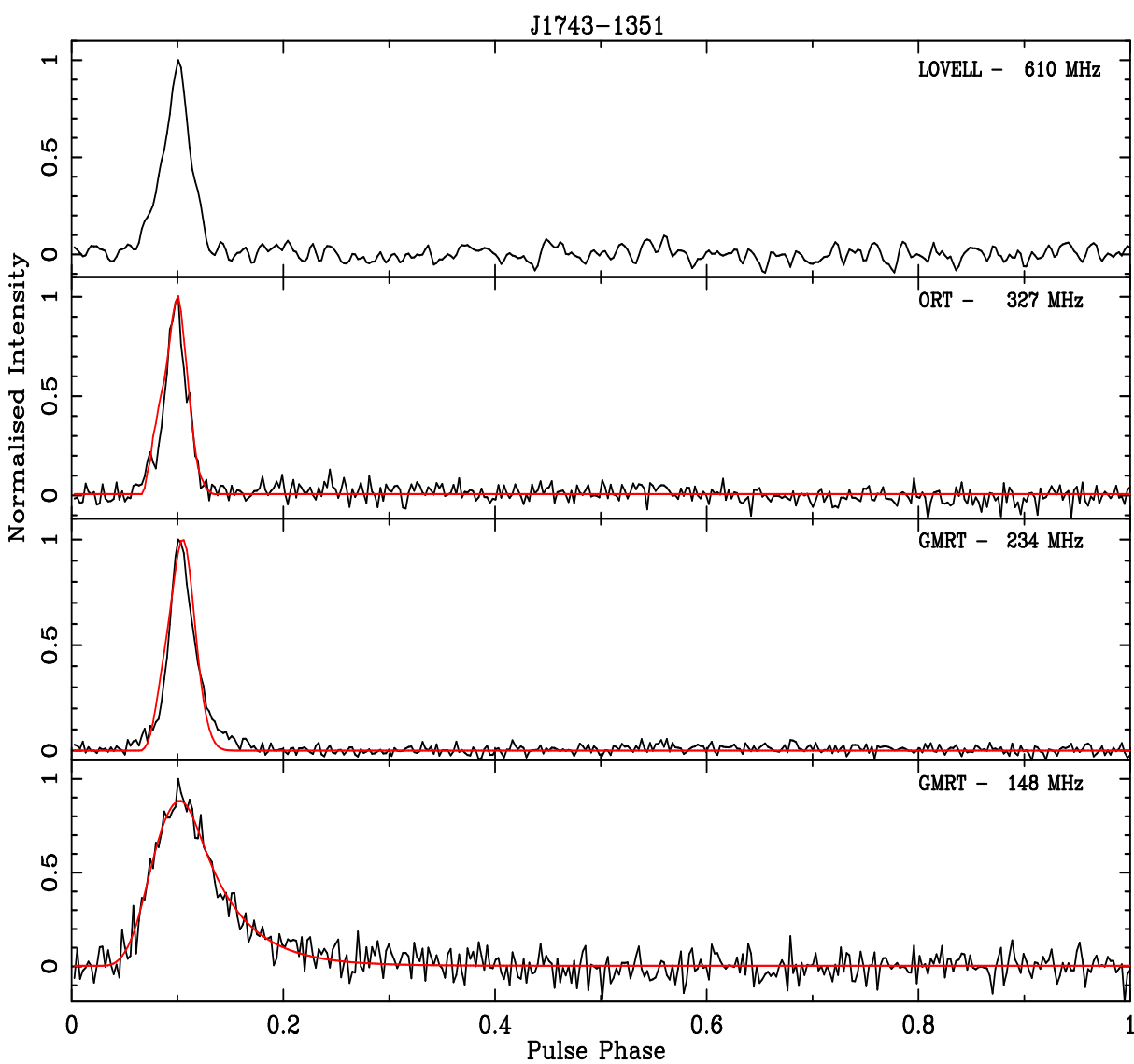
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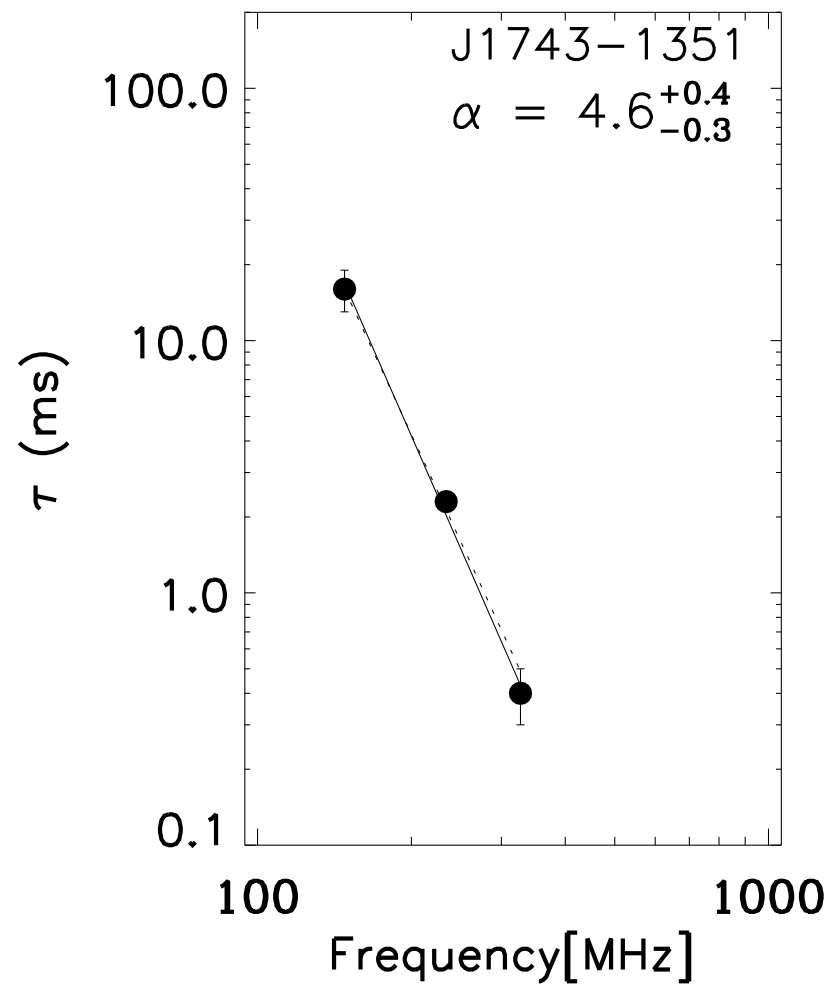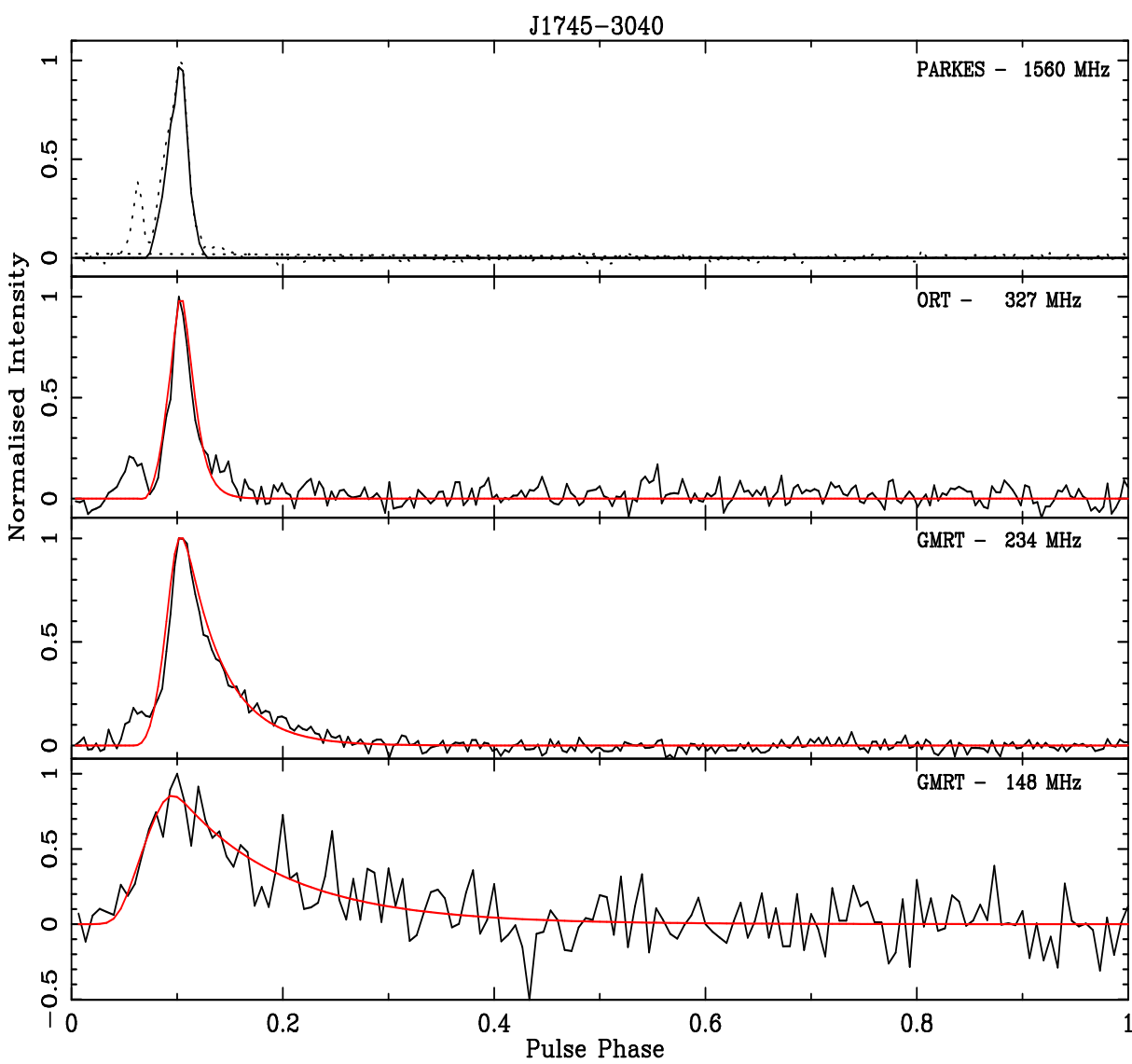
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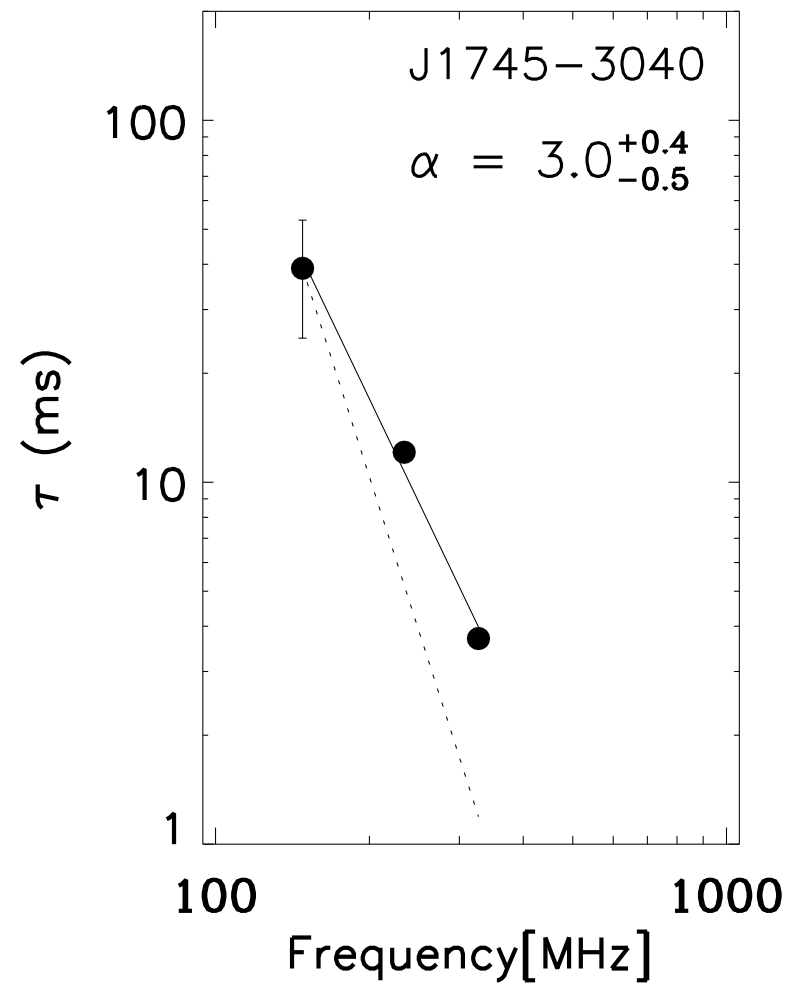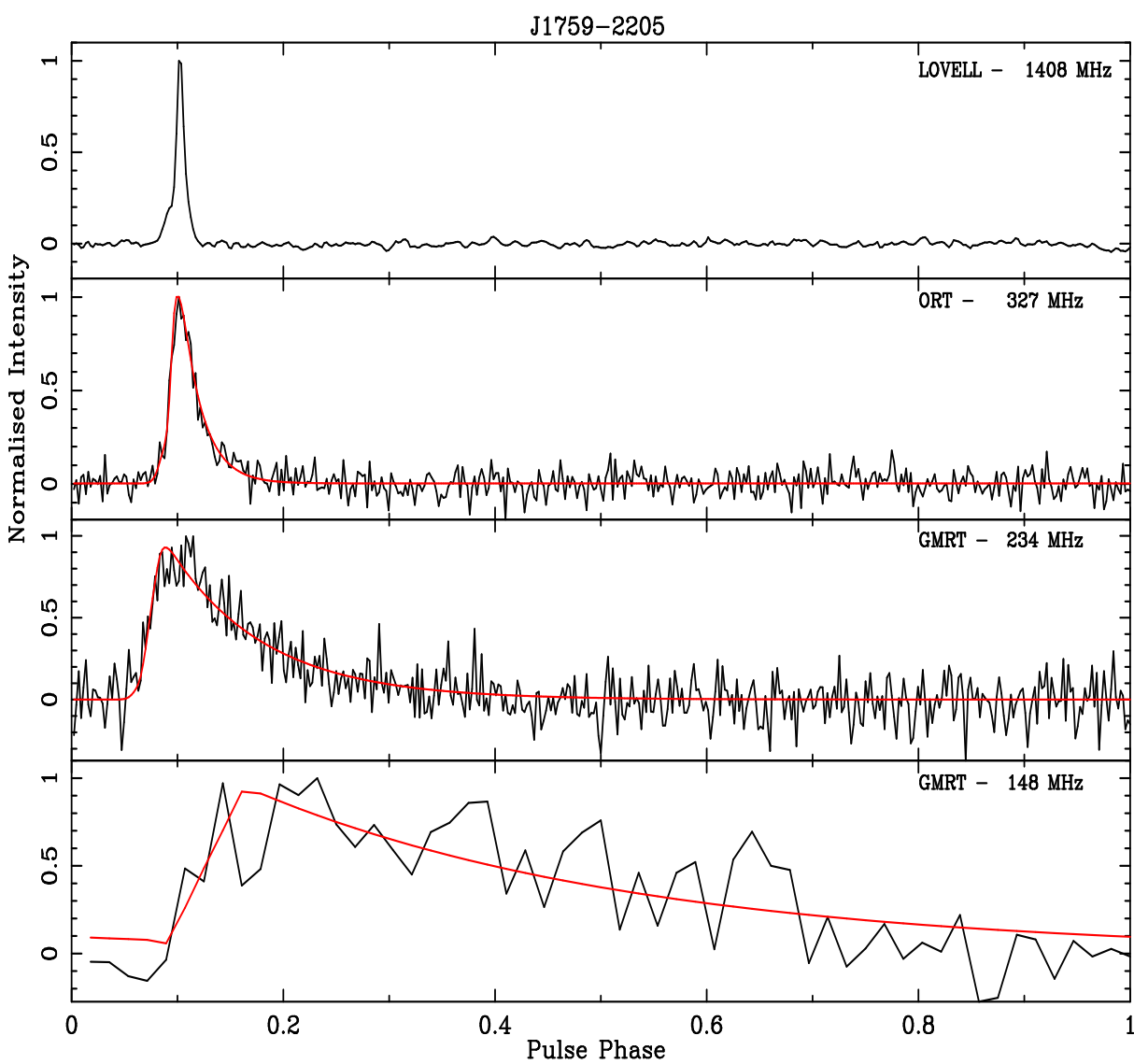
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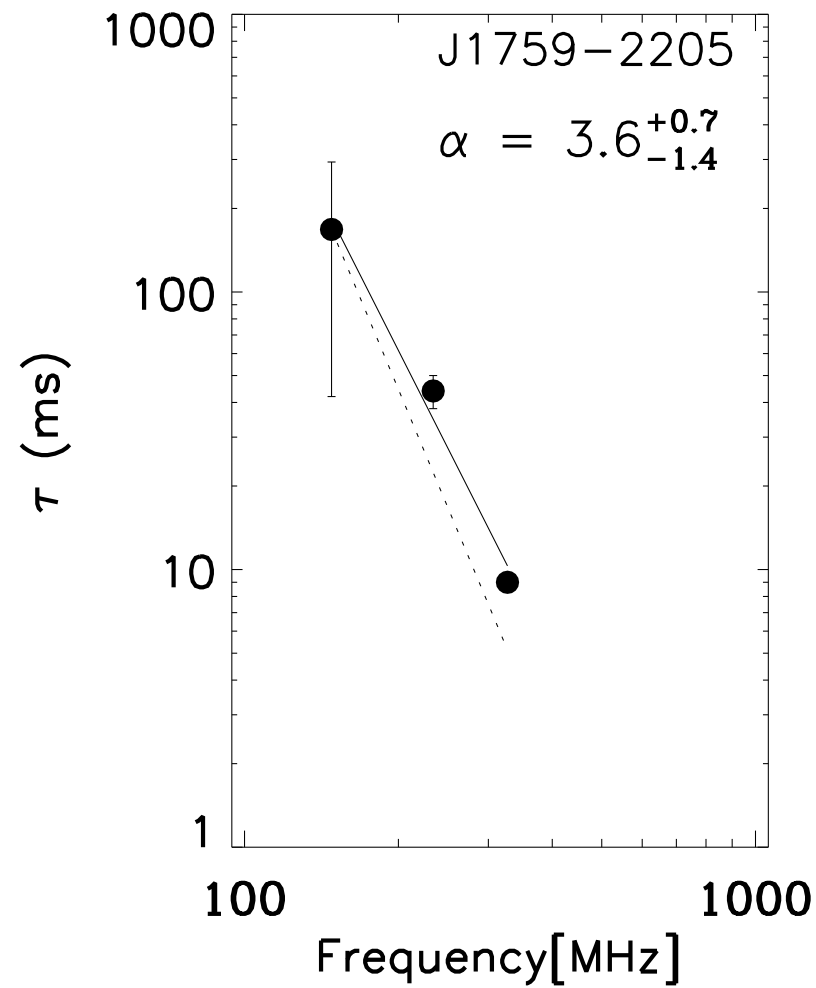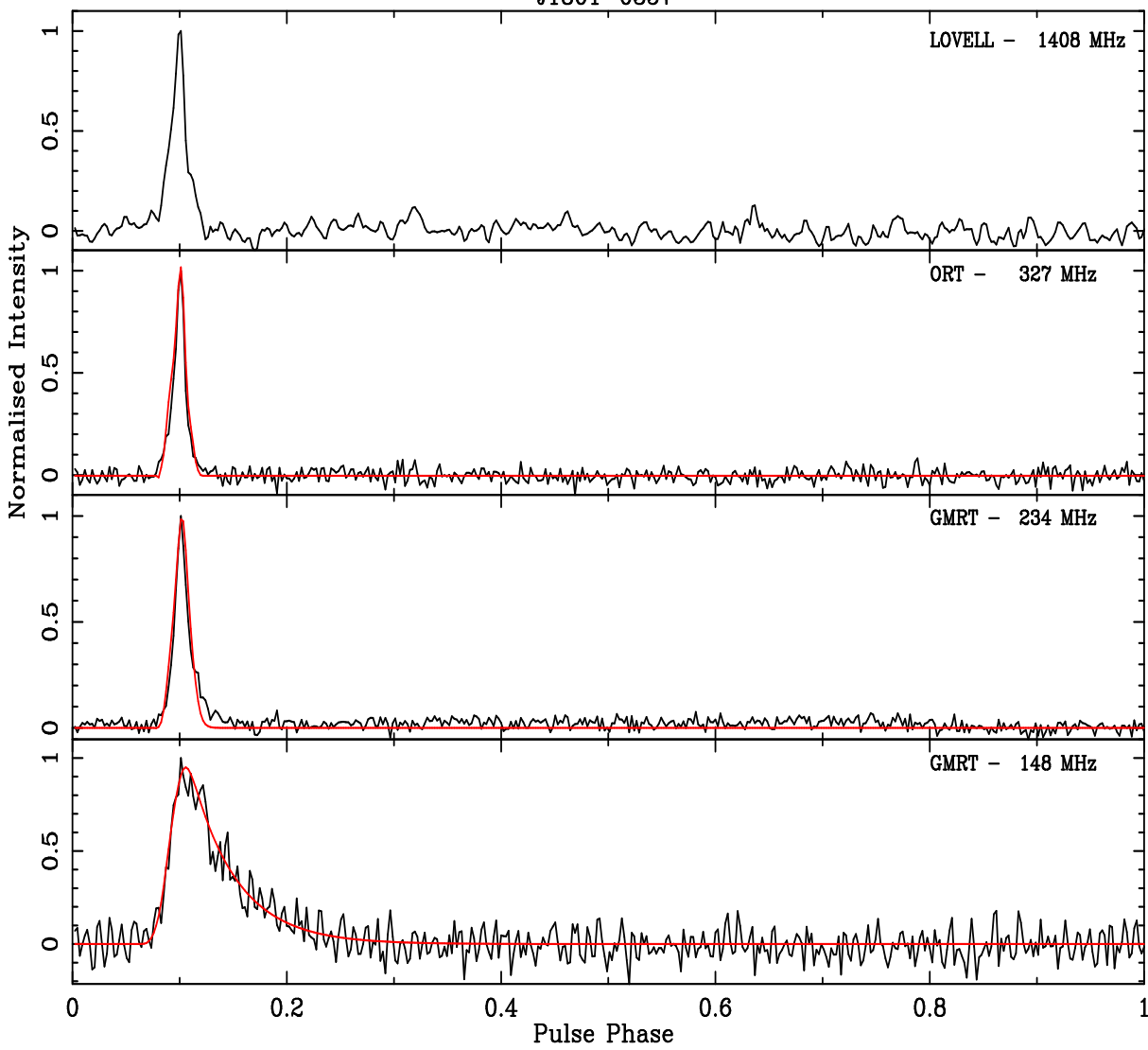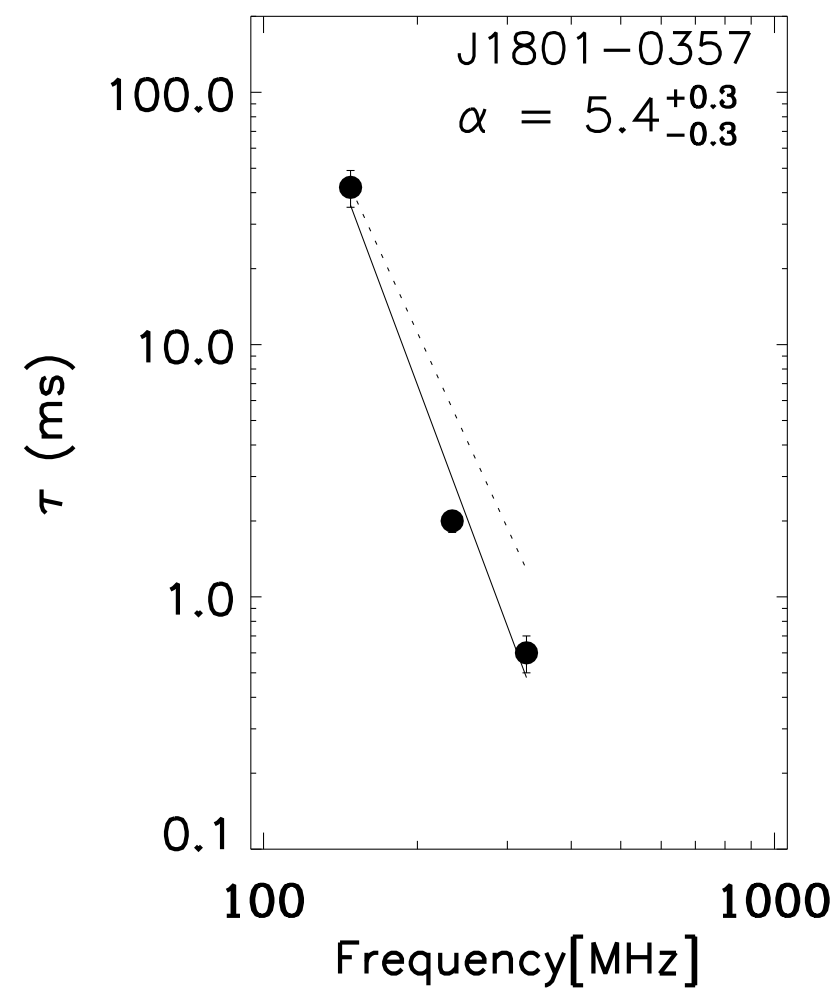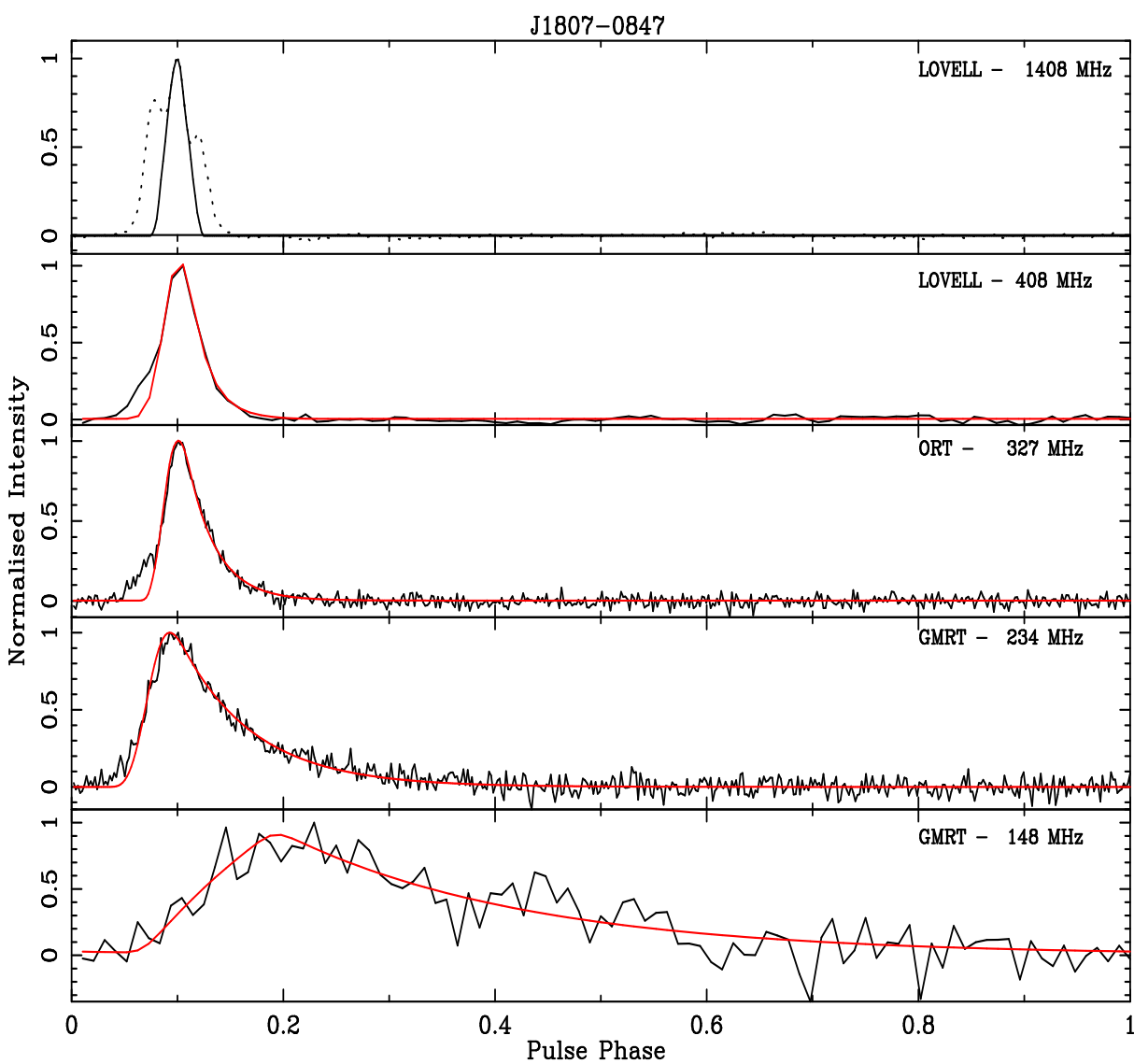
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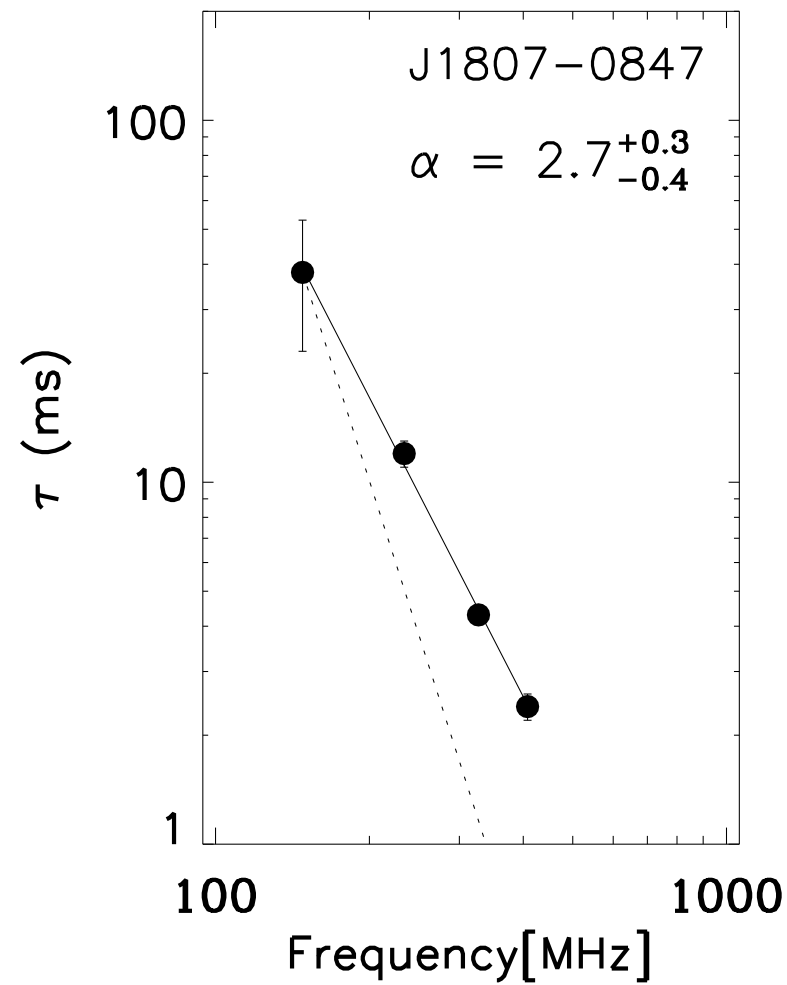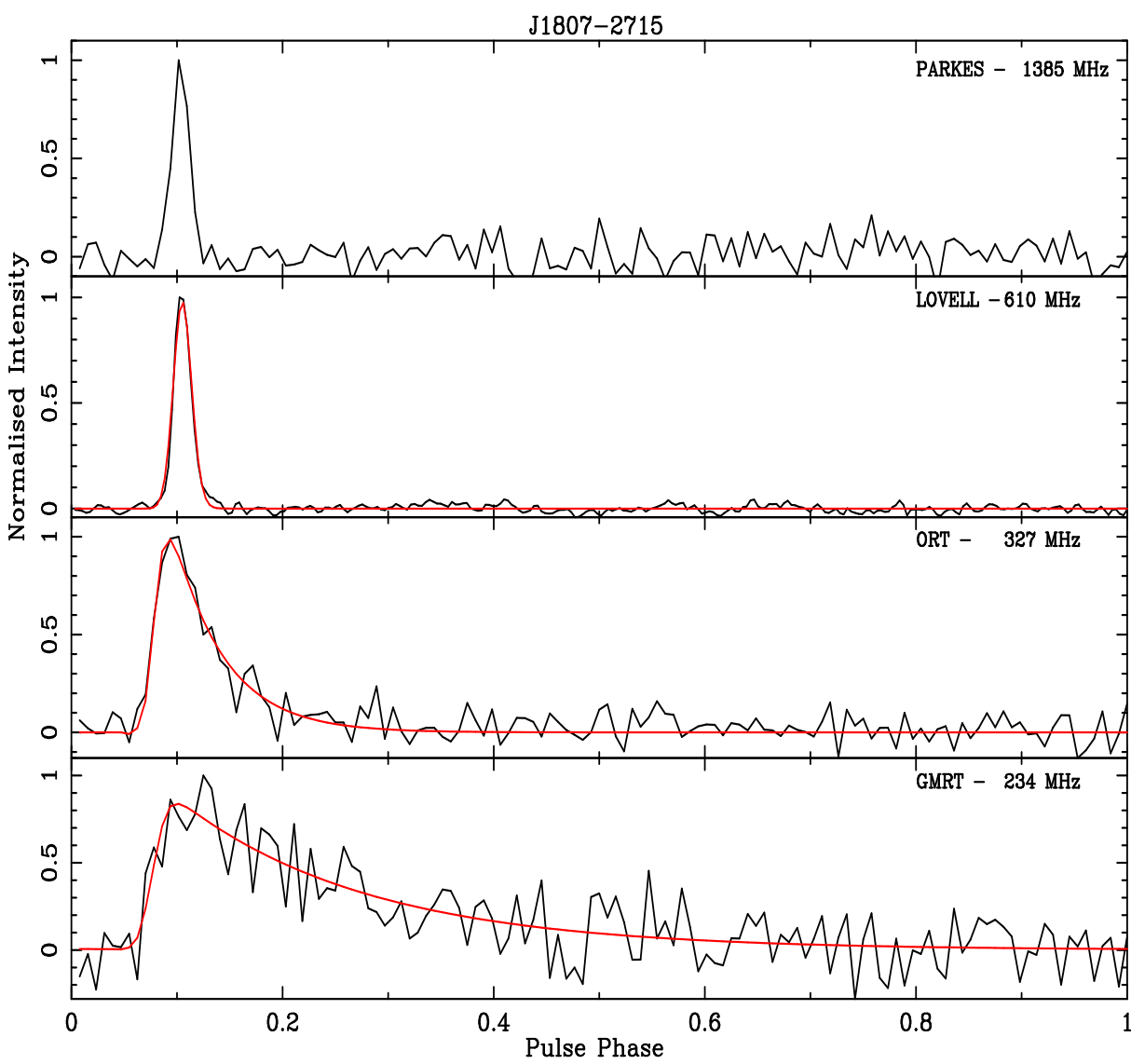
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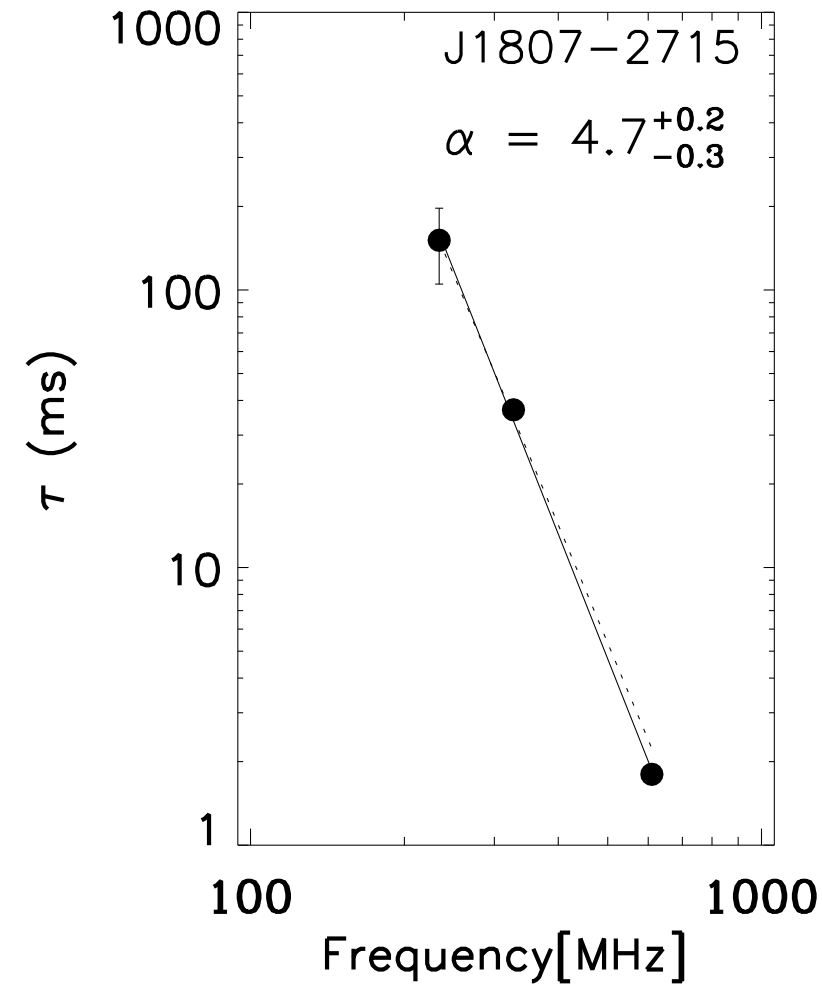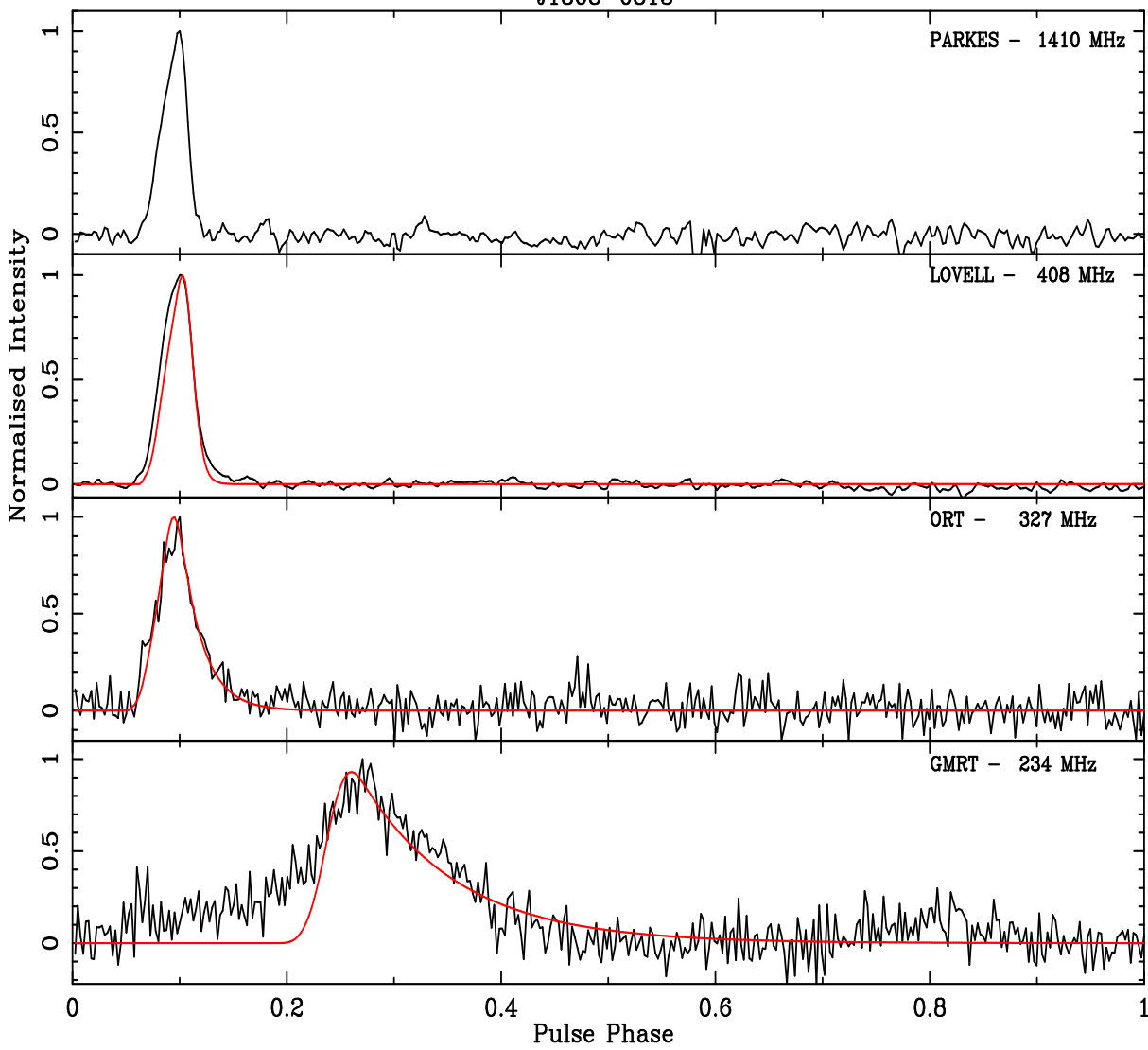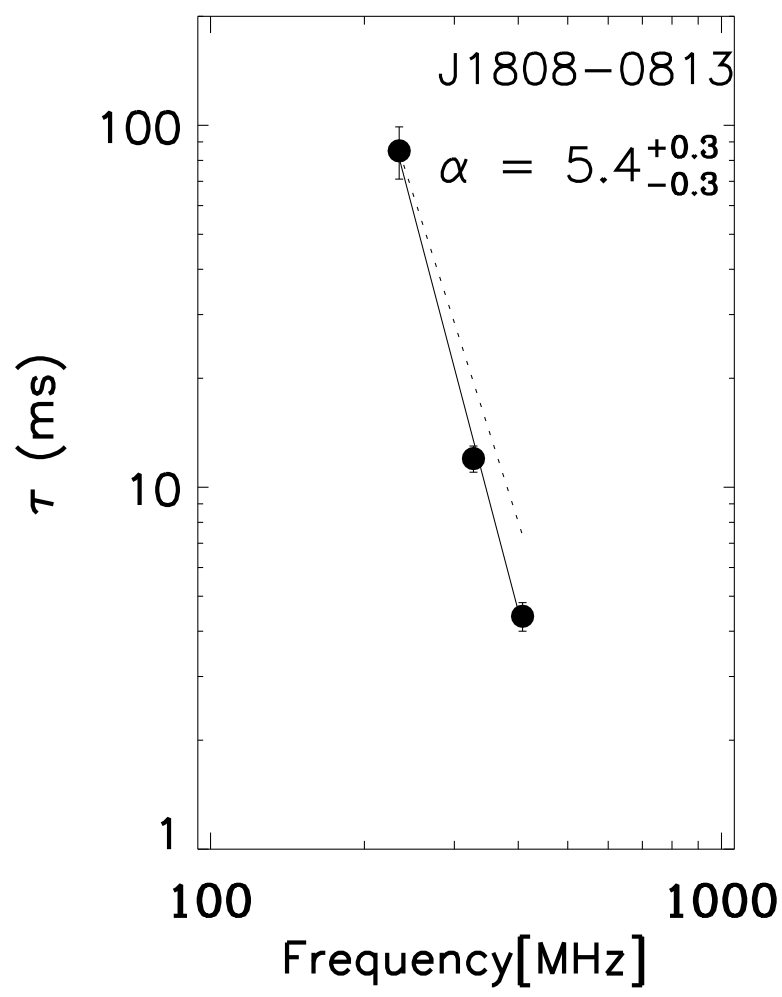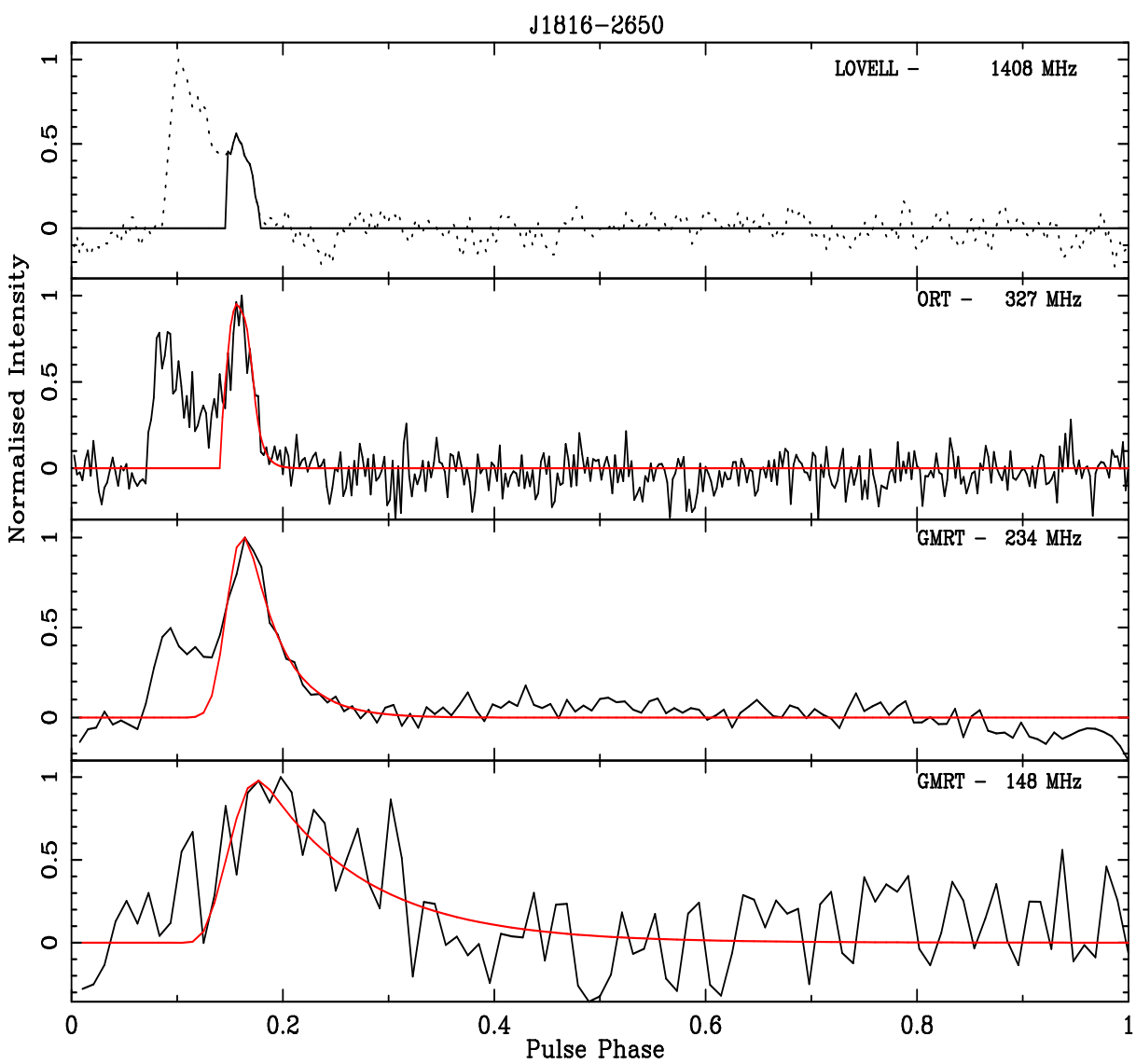
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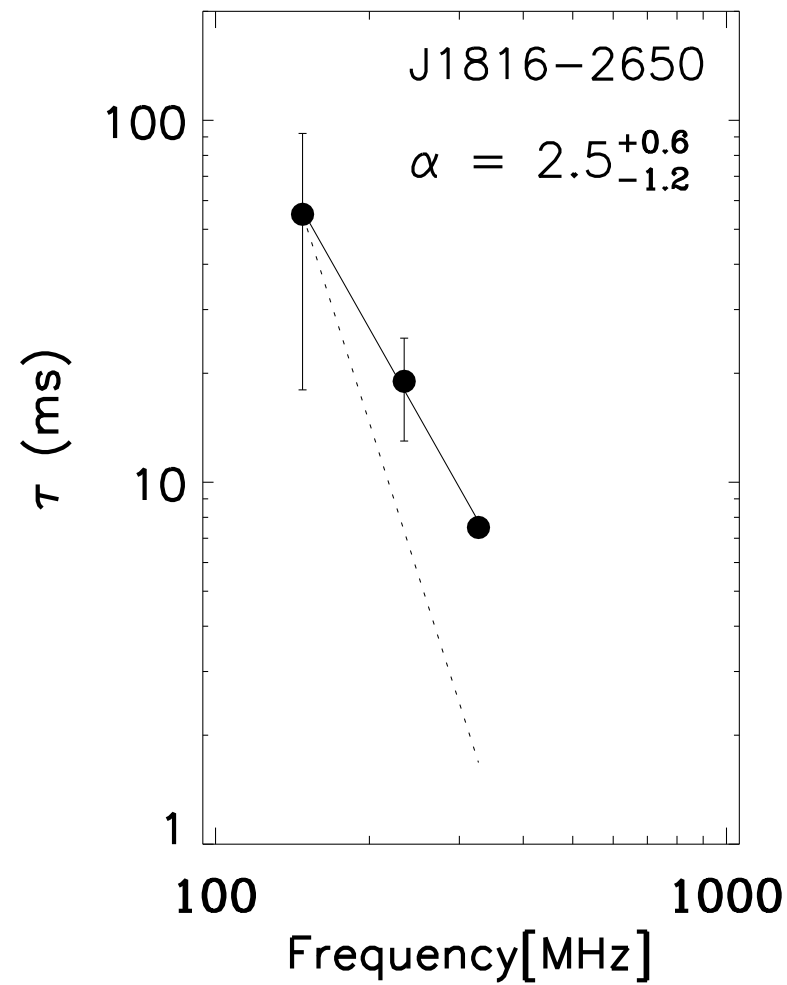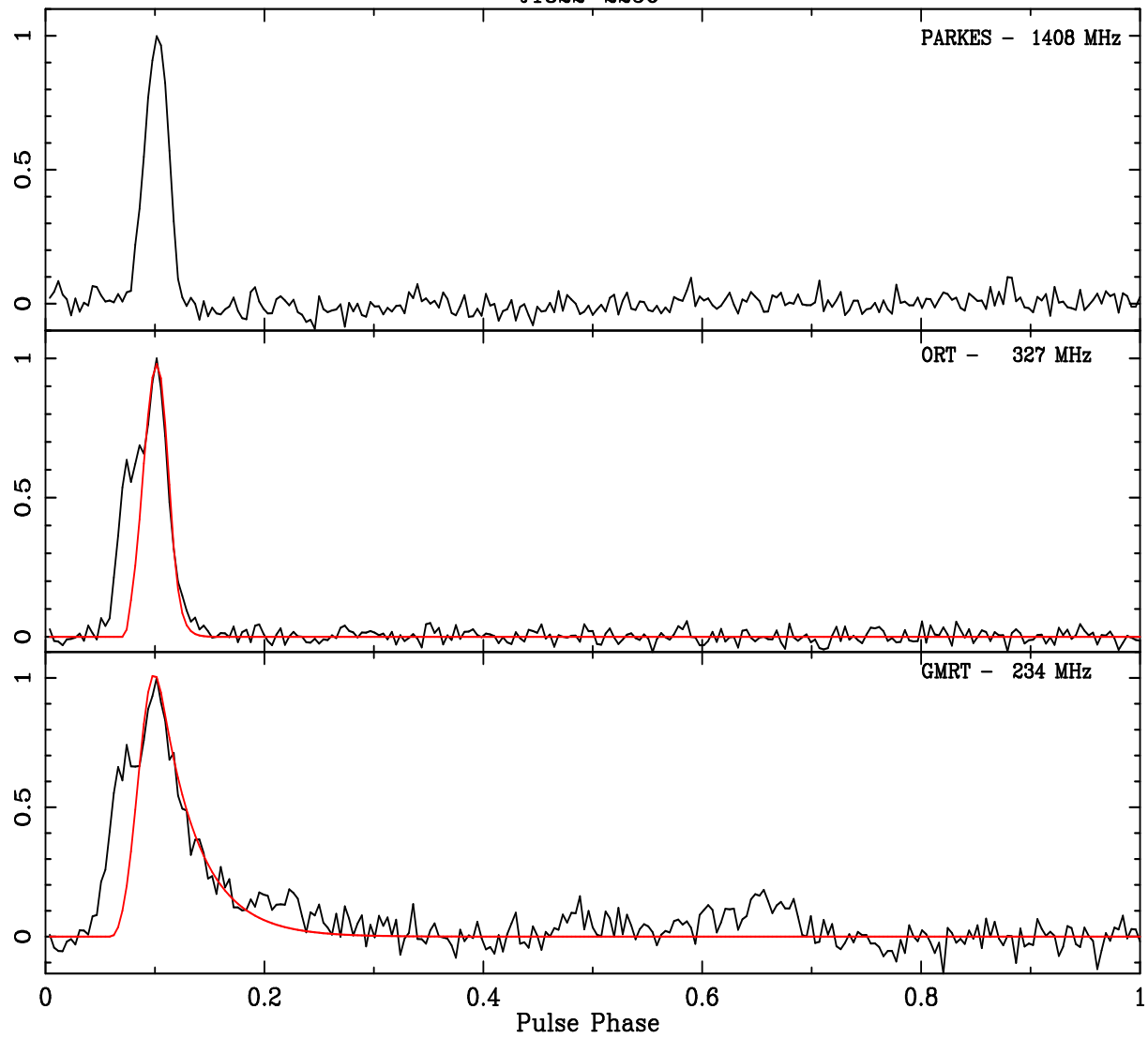
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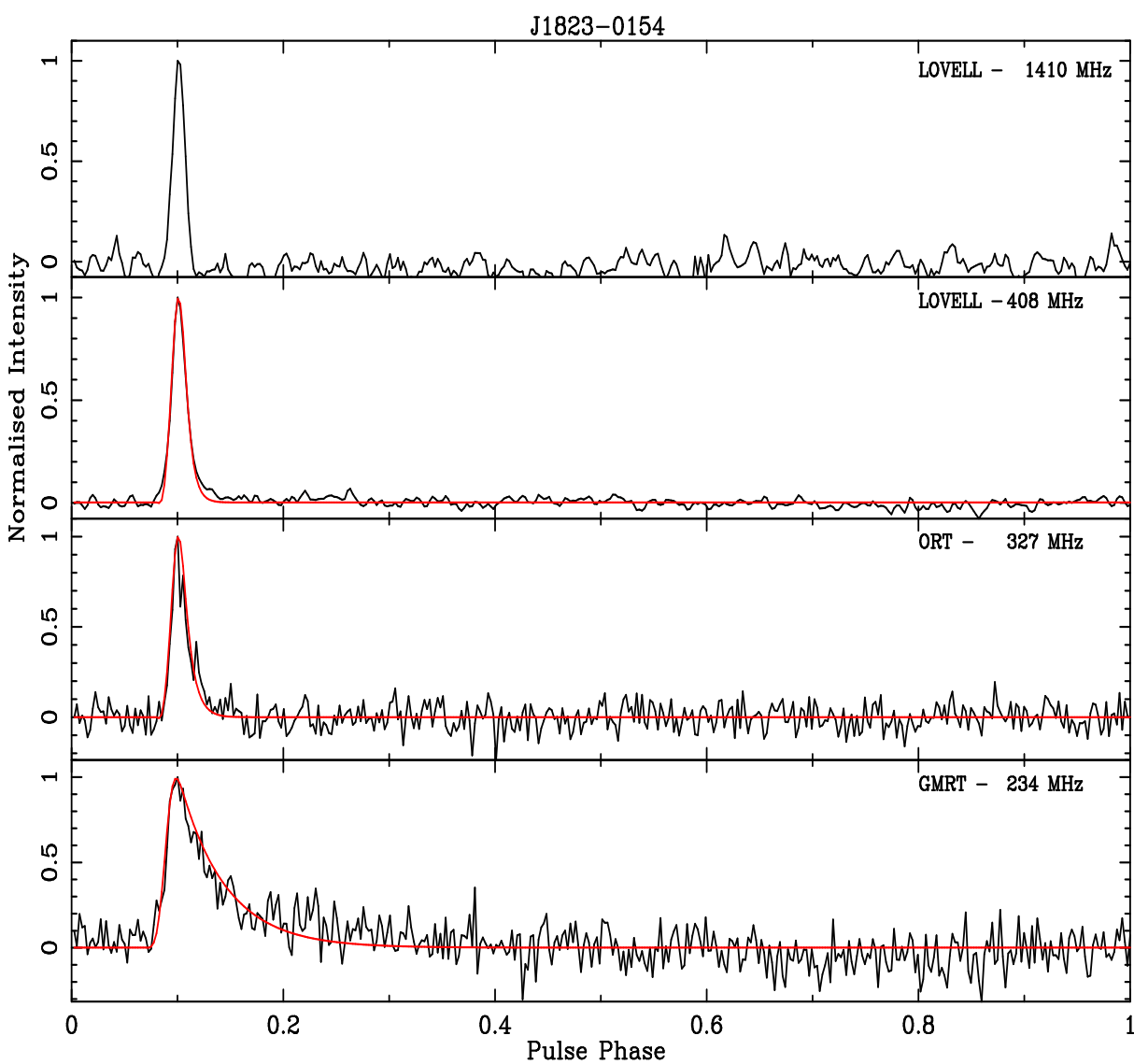
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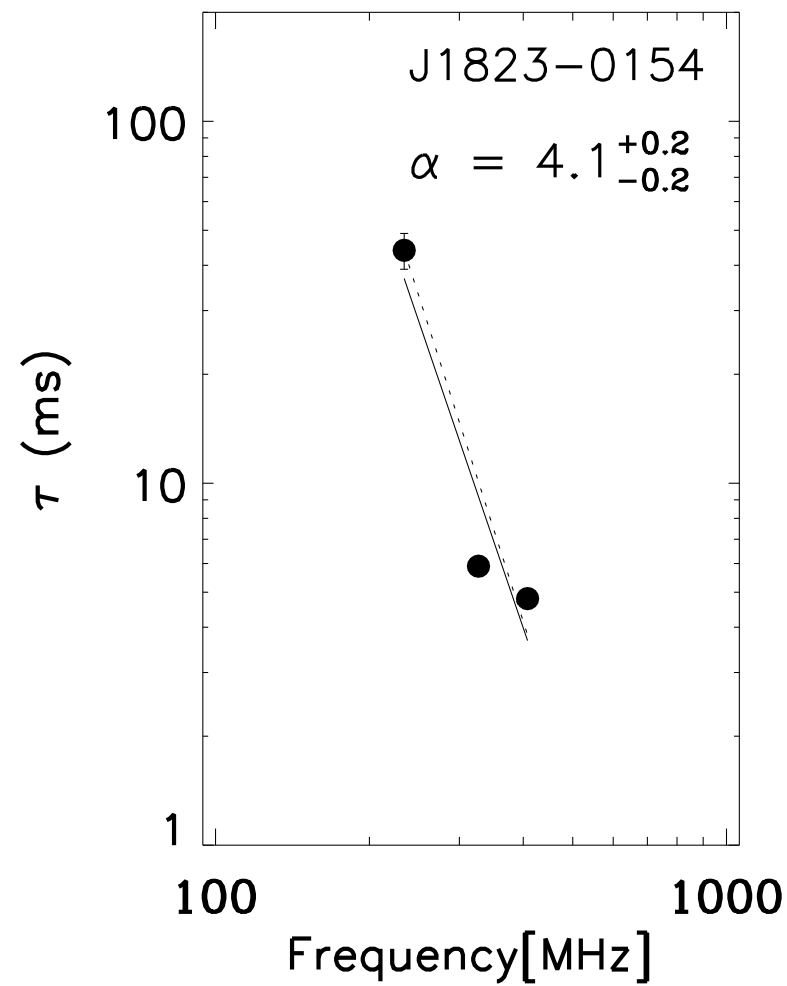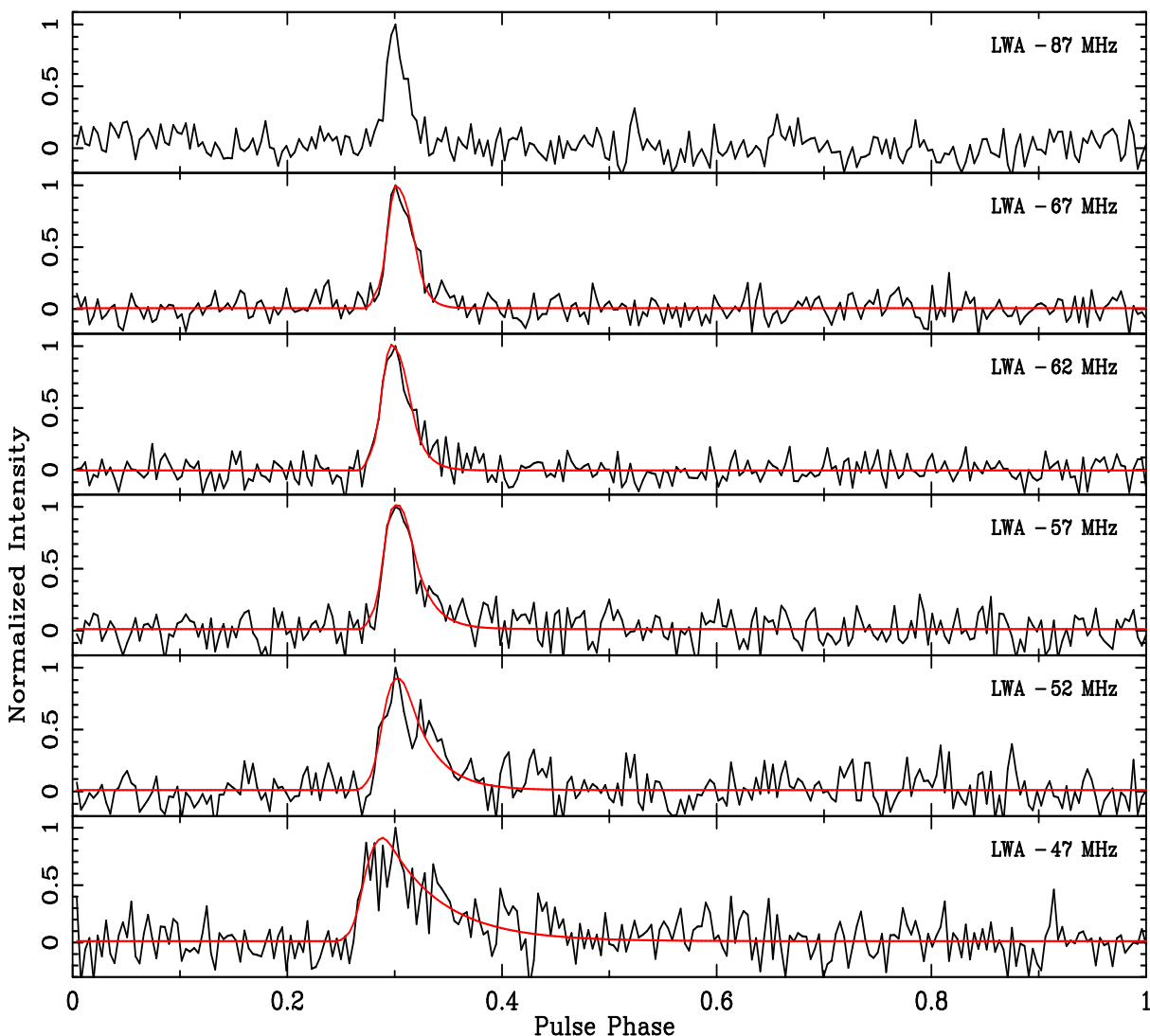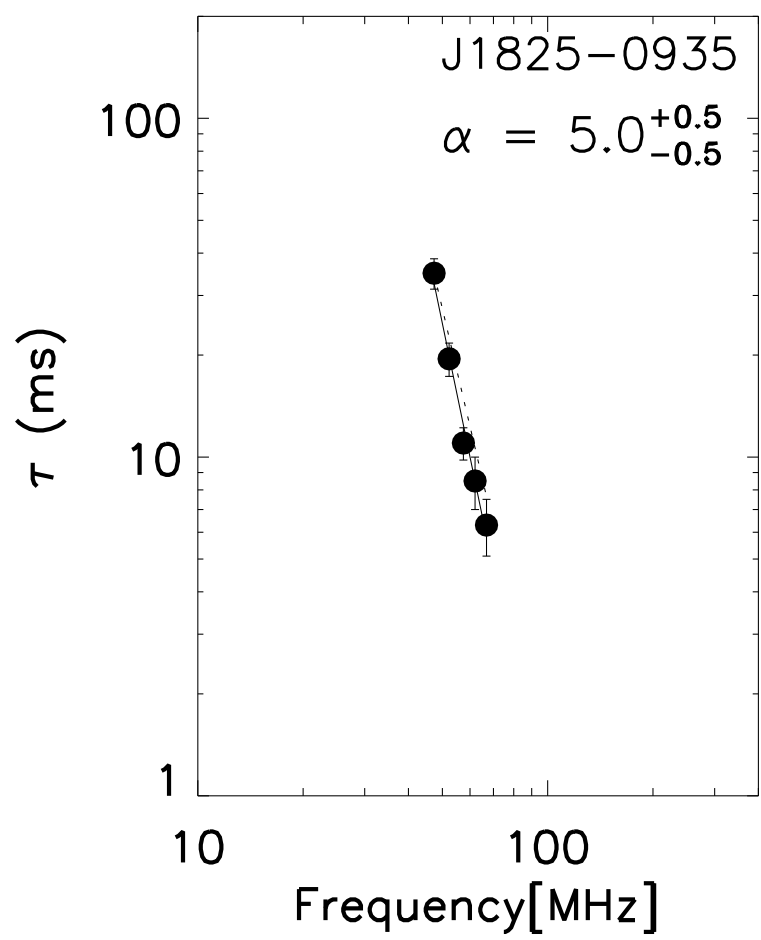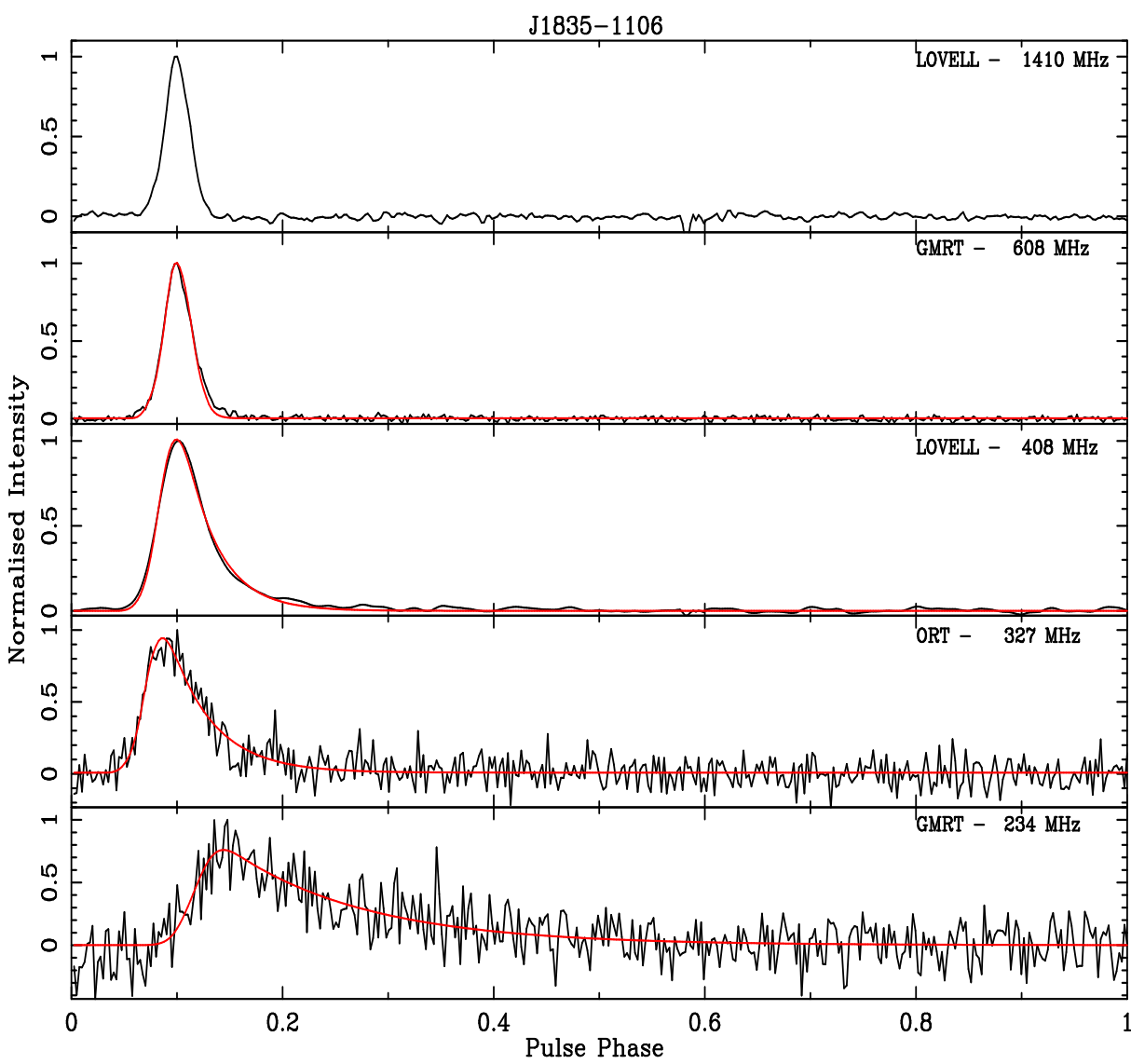
Figure 27:

Figure 28:
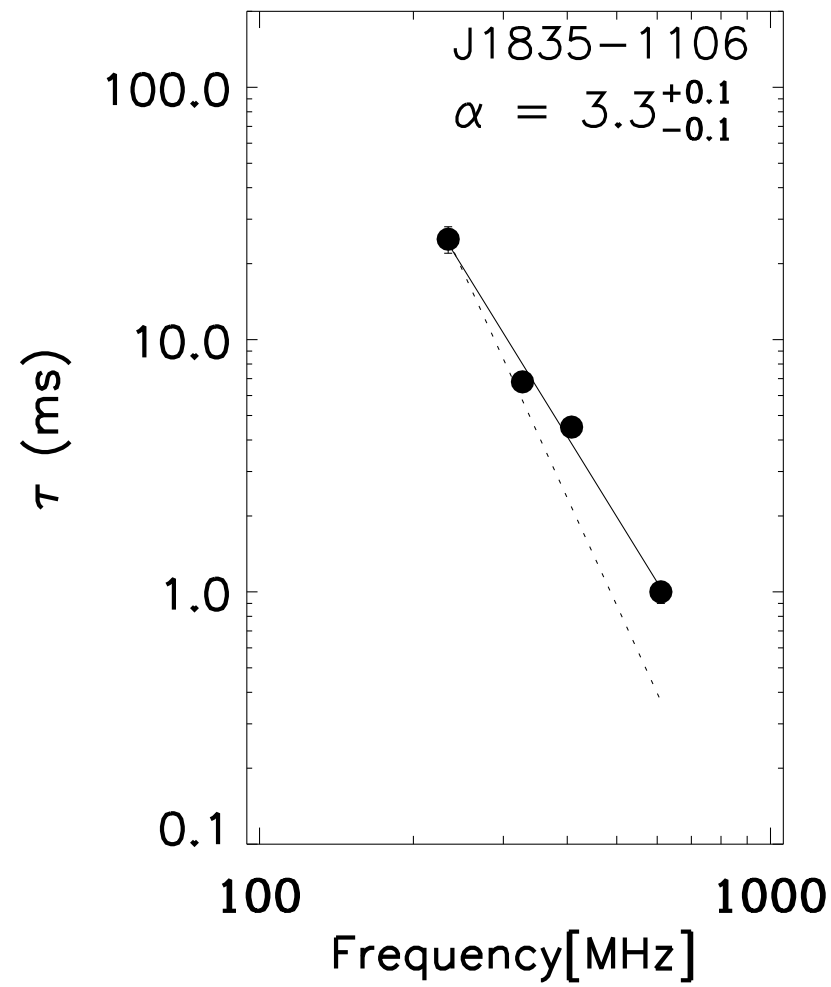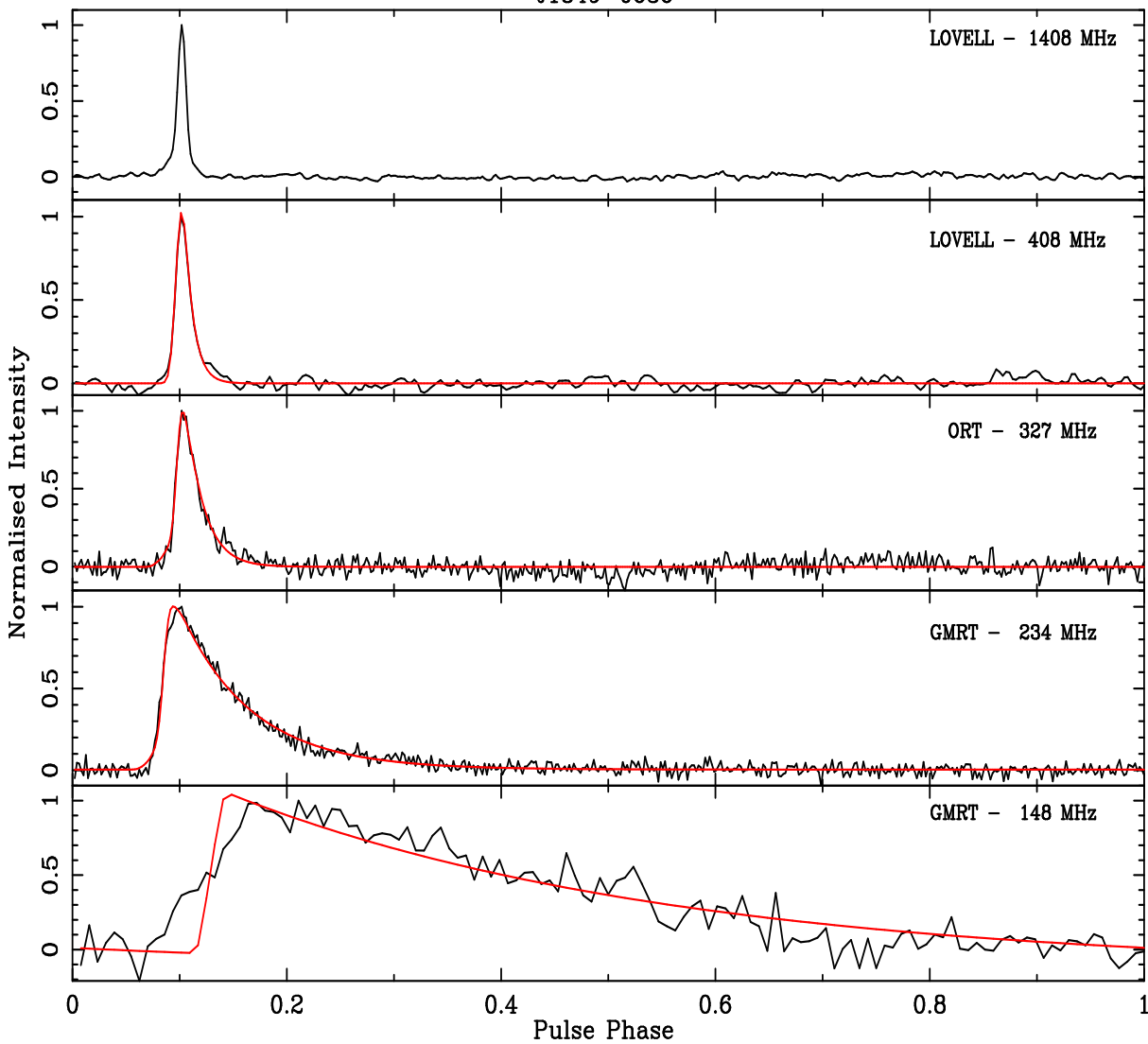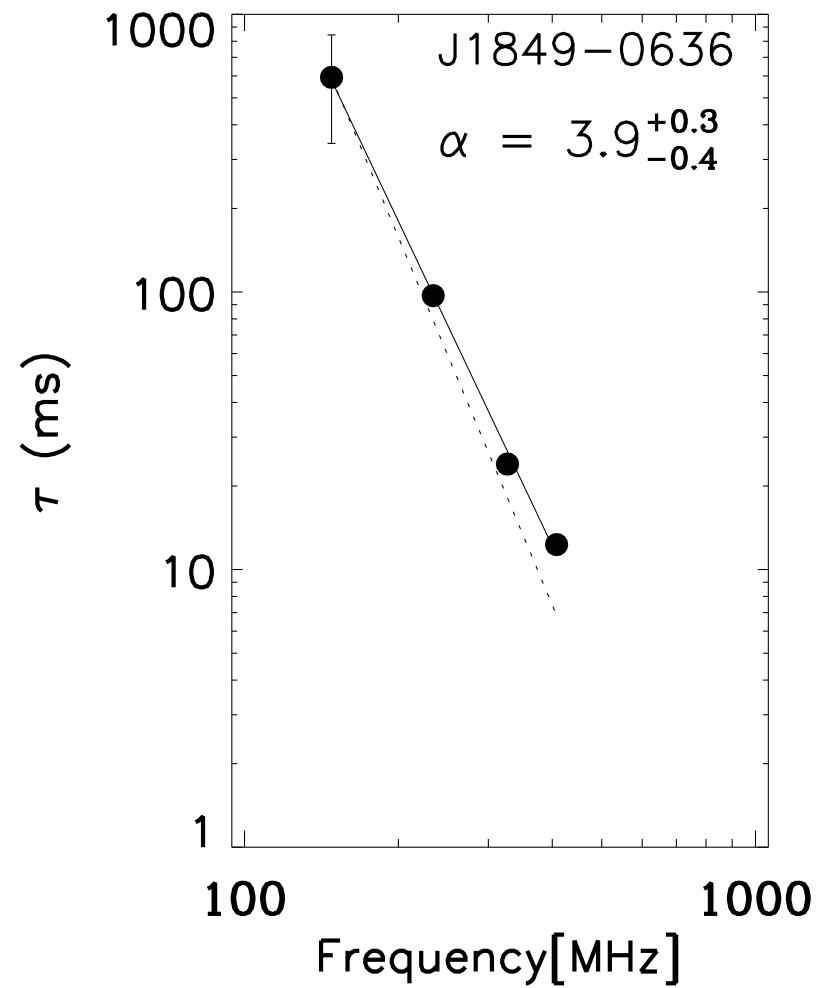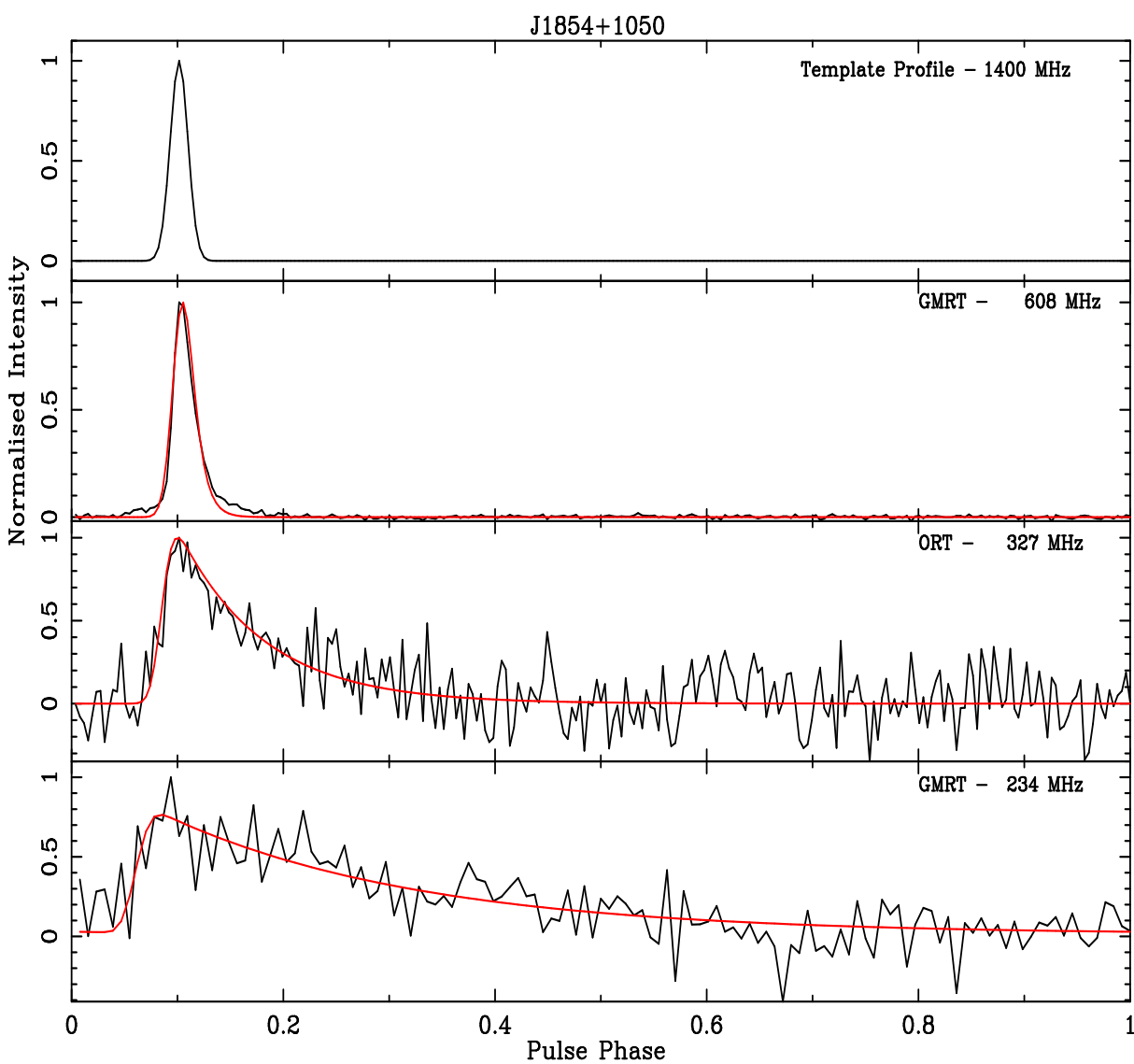
Figure 29:

Figure 30:
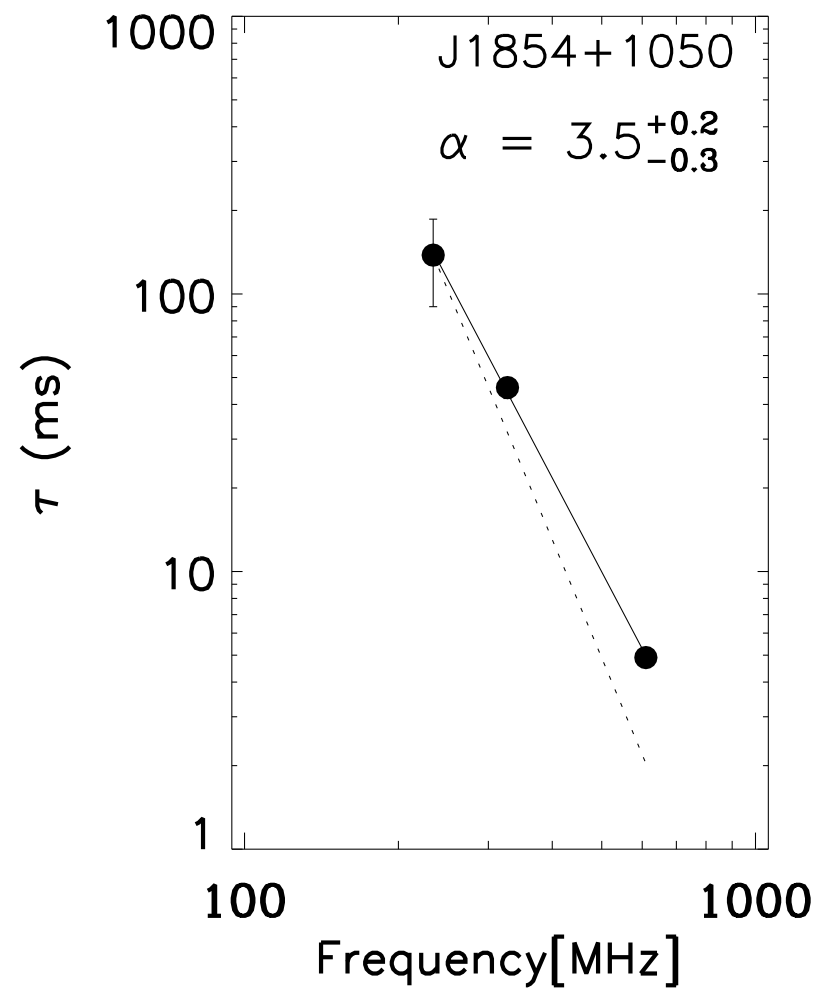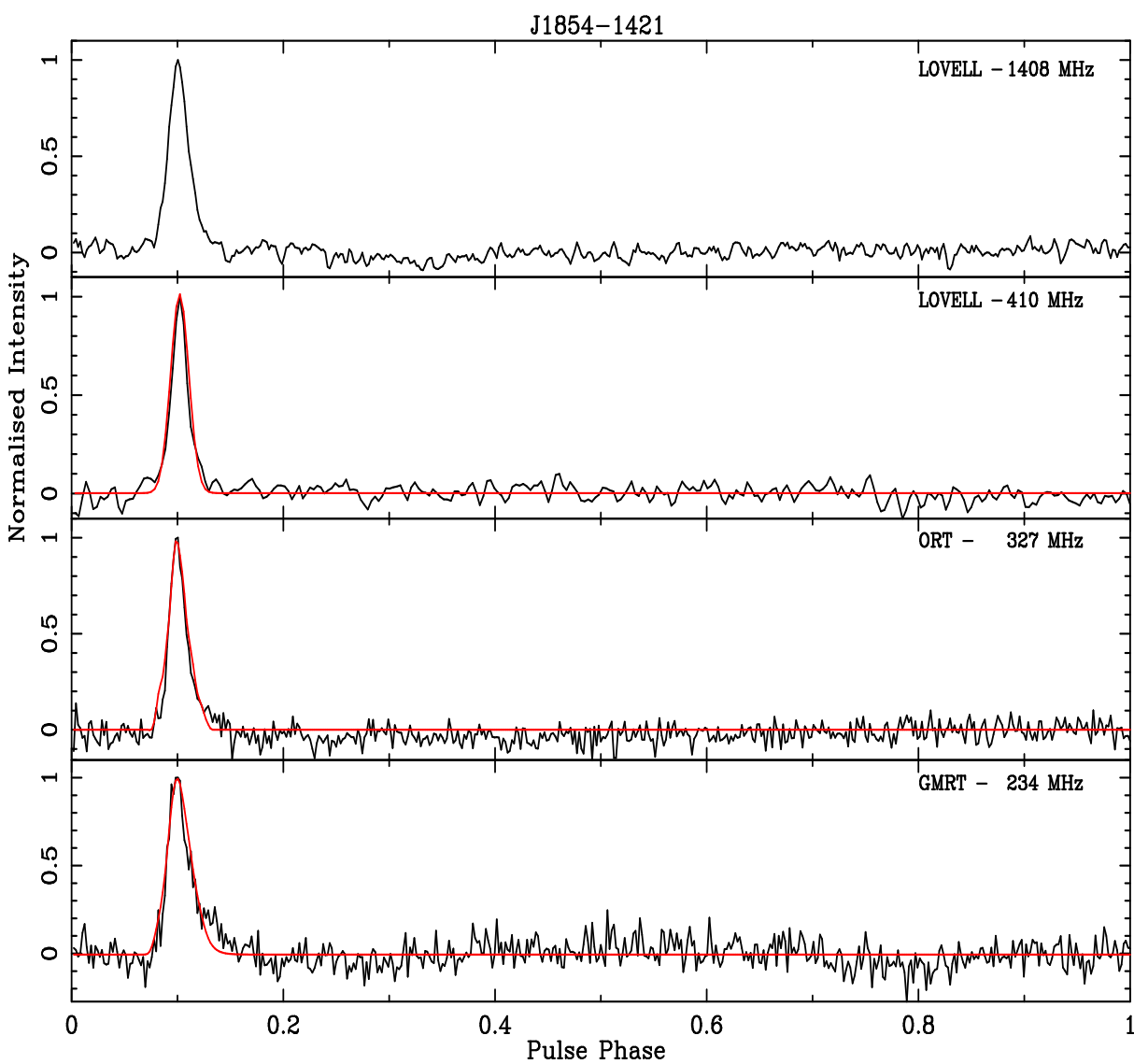
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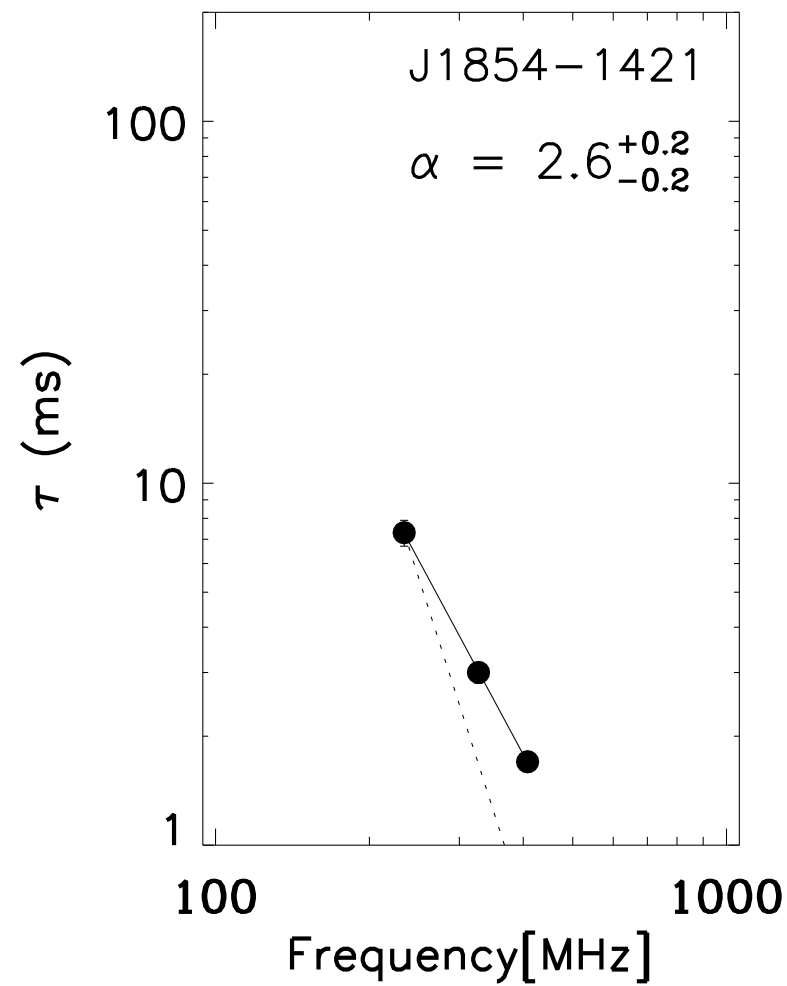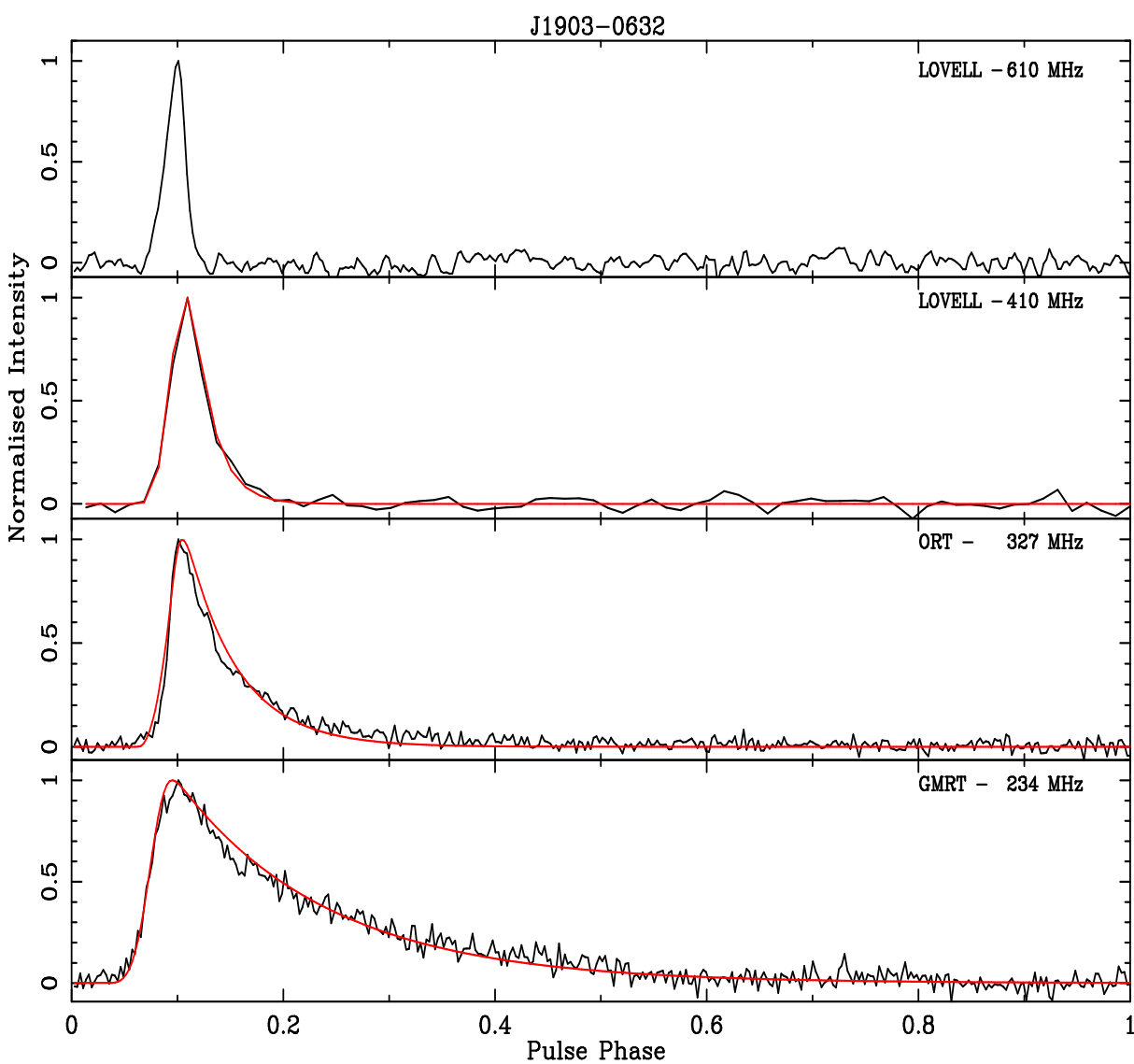
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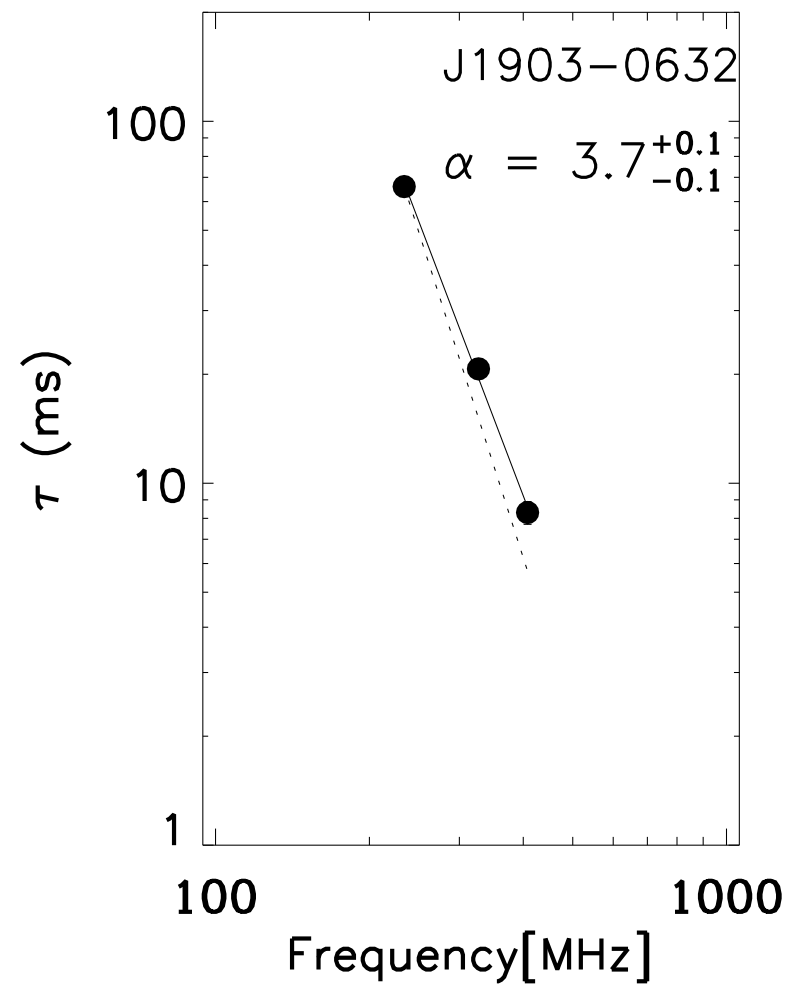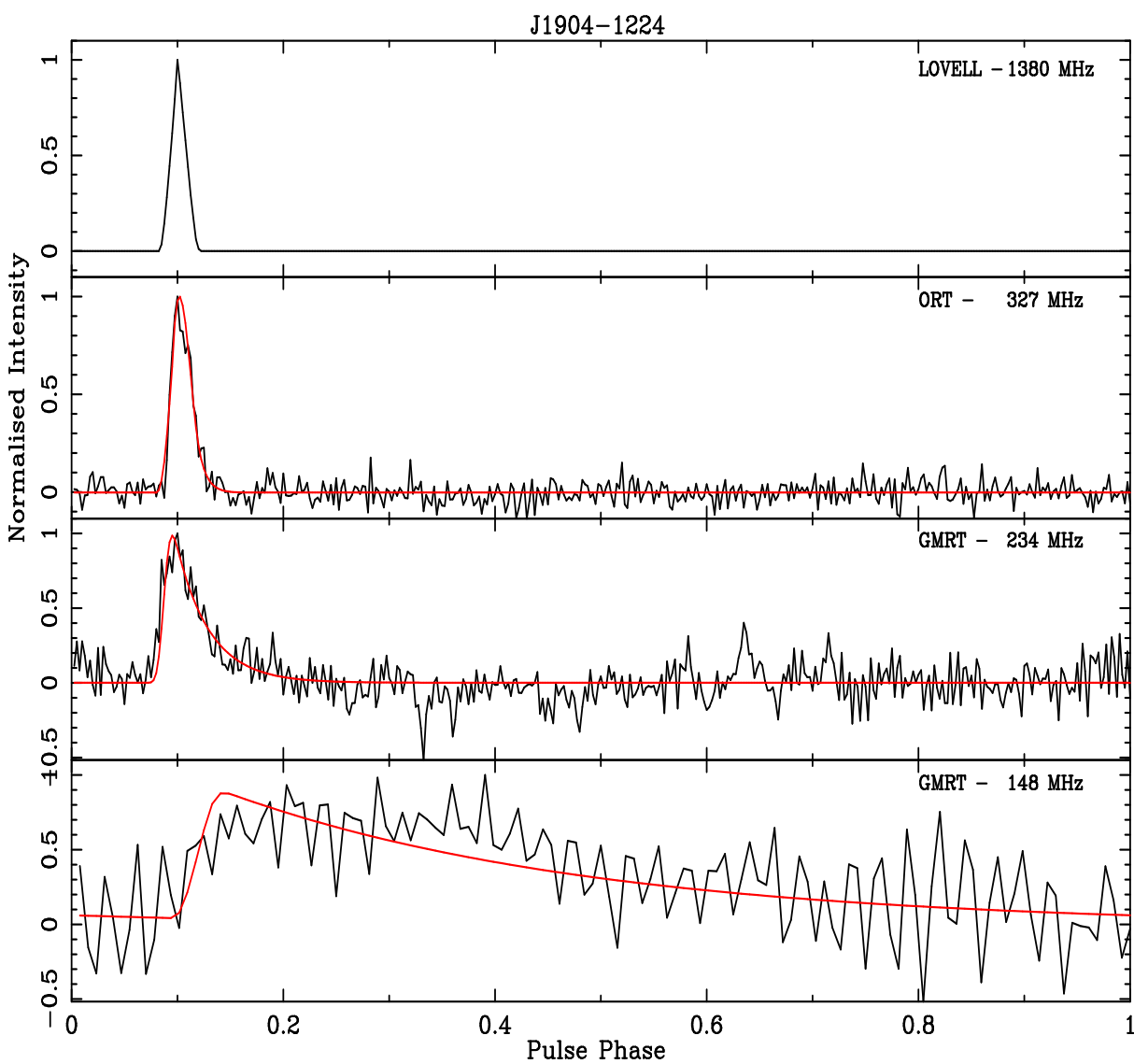
Figure 33:

Figure 34:

Figure 35:

Figure 36:

Figure 37:

Figure 38:

J1926+0431

LOVELL – 1408 MHz

LOVELL – 410 MHz

ORT – 327 MHz

GMRT – 234 MHz

GMRT – 148 MHz

Normalised Intensity

Pulse Phase

J1926+0431
$\alpha = 2.4^{+0.3}_{-0.2}$

τ (ms)
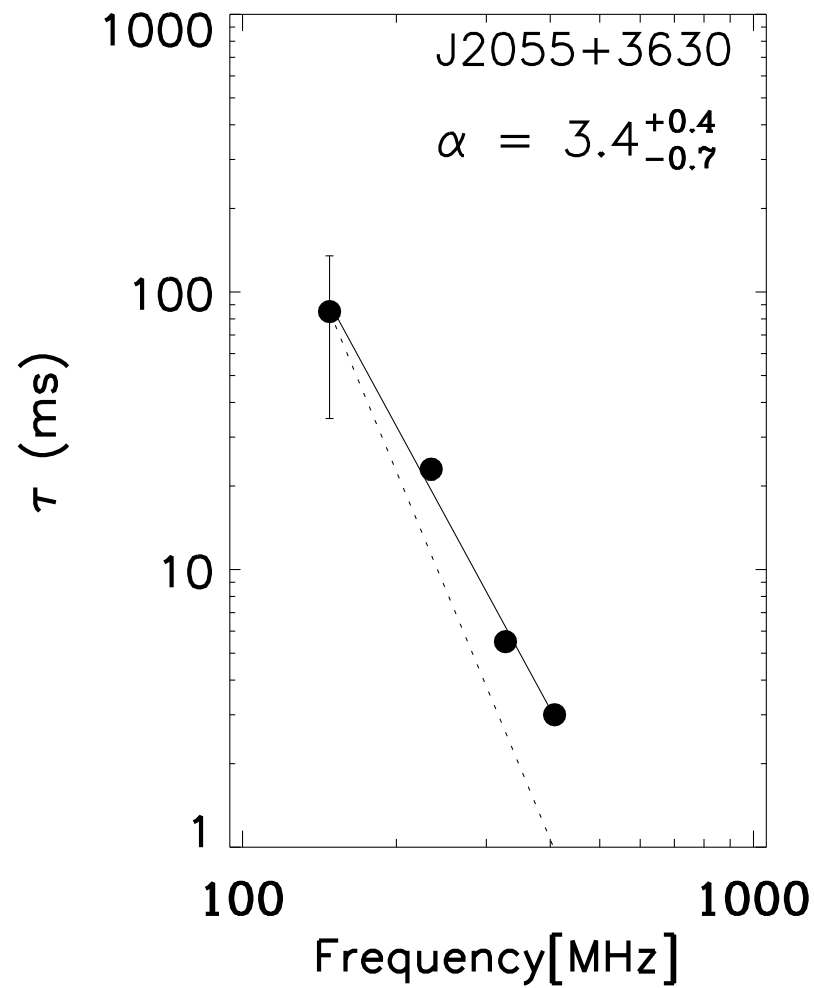
Frequency[MHz]
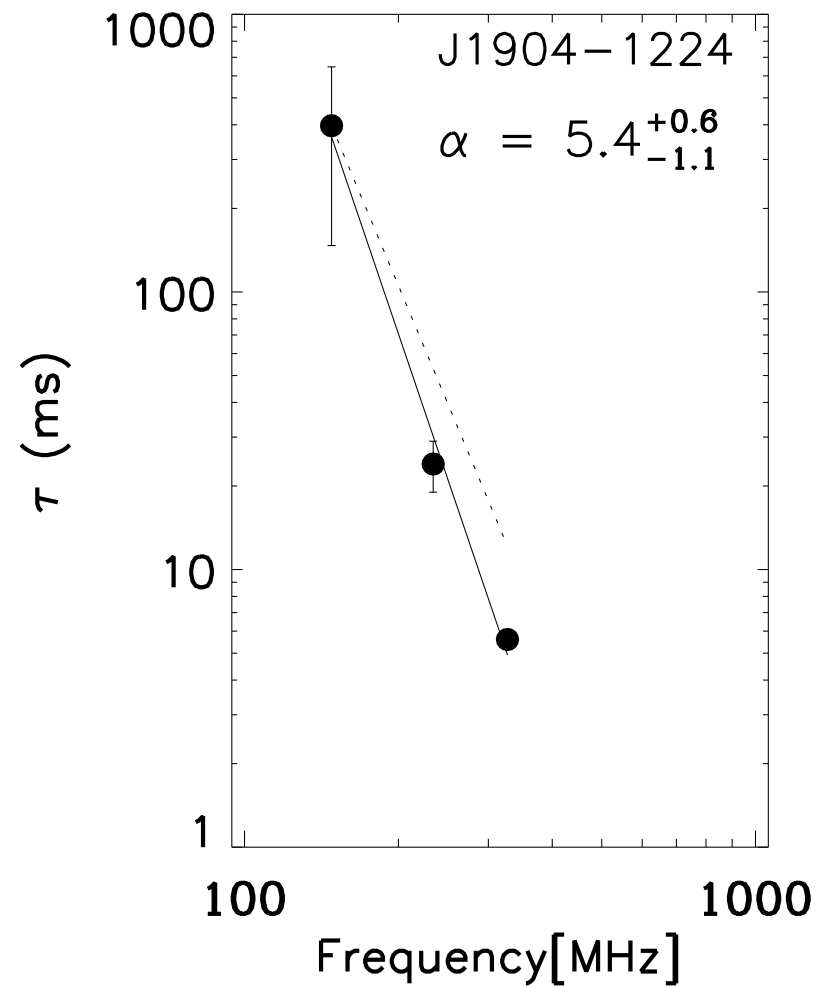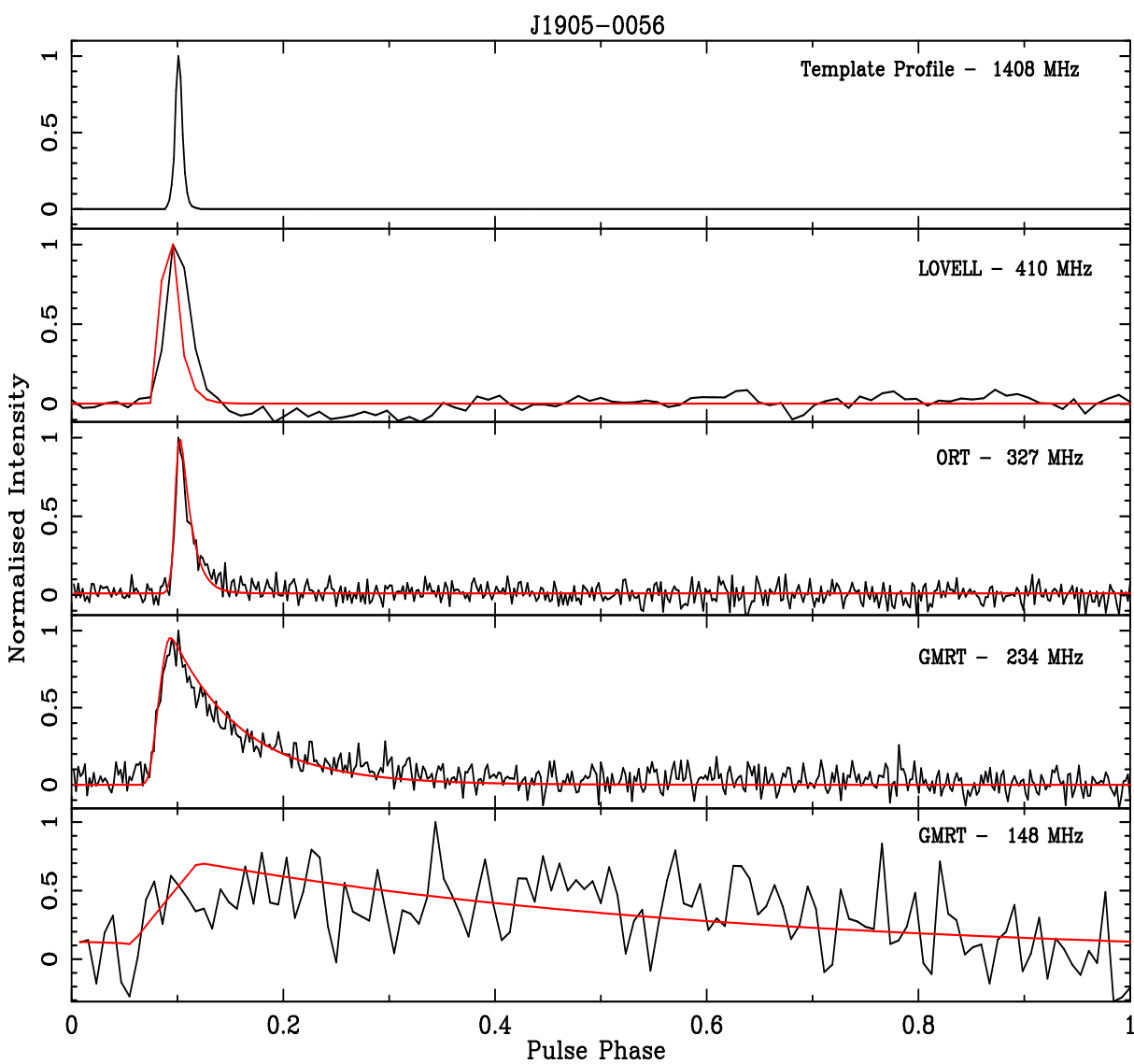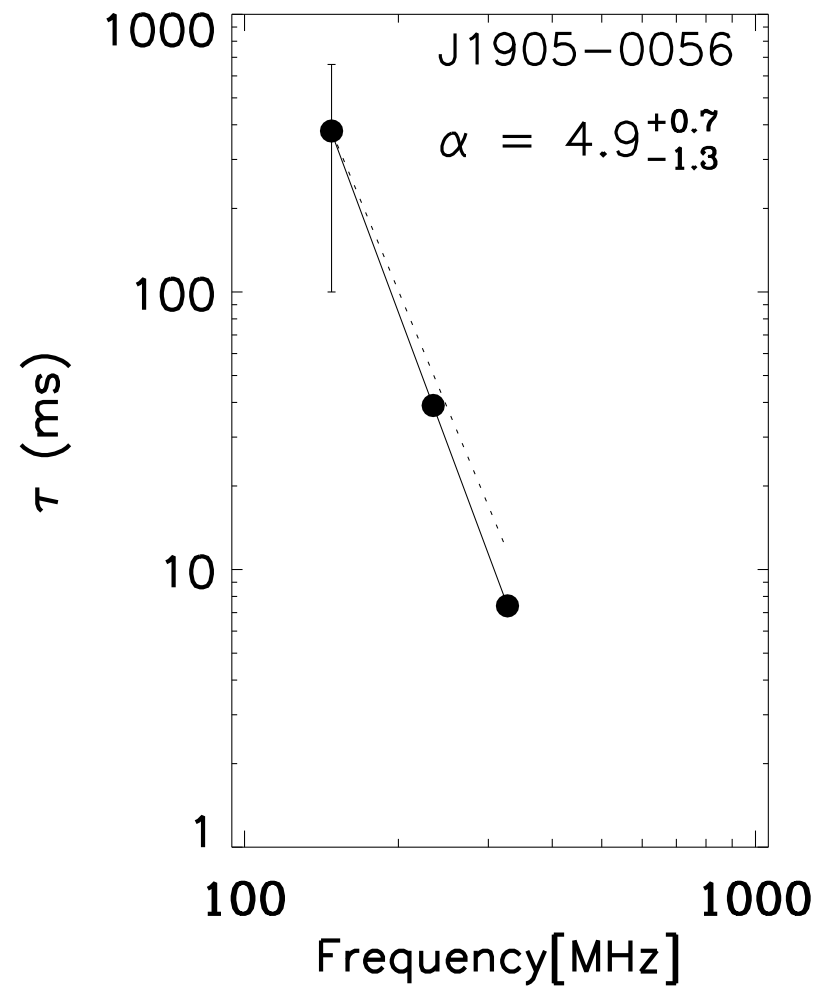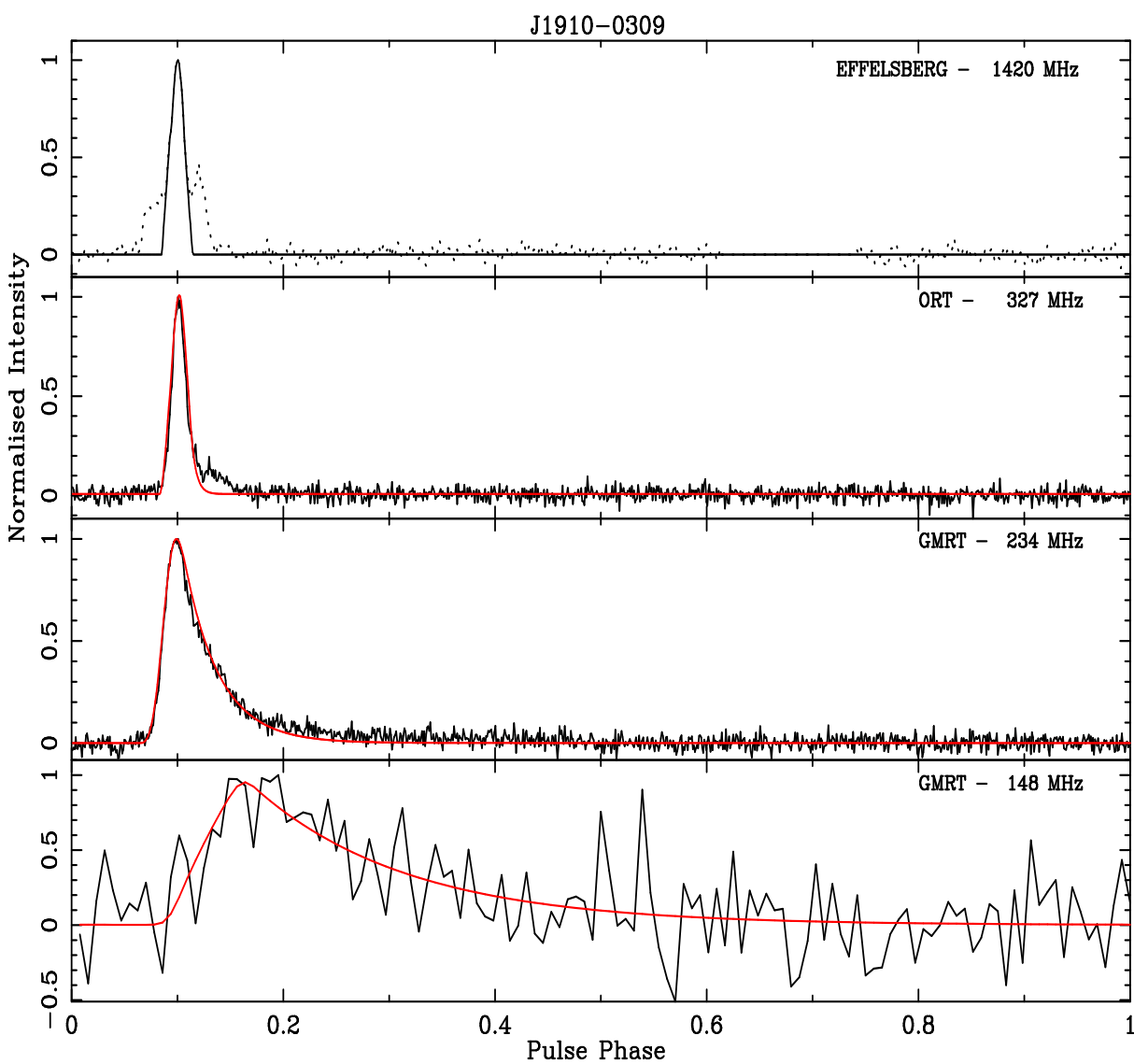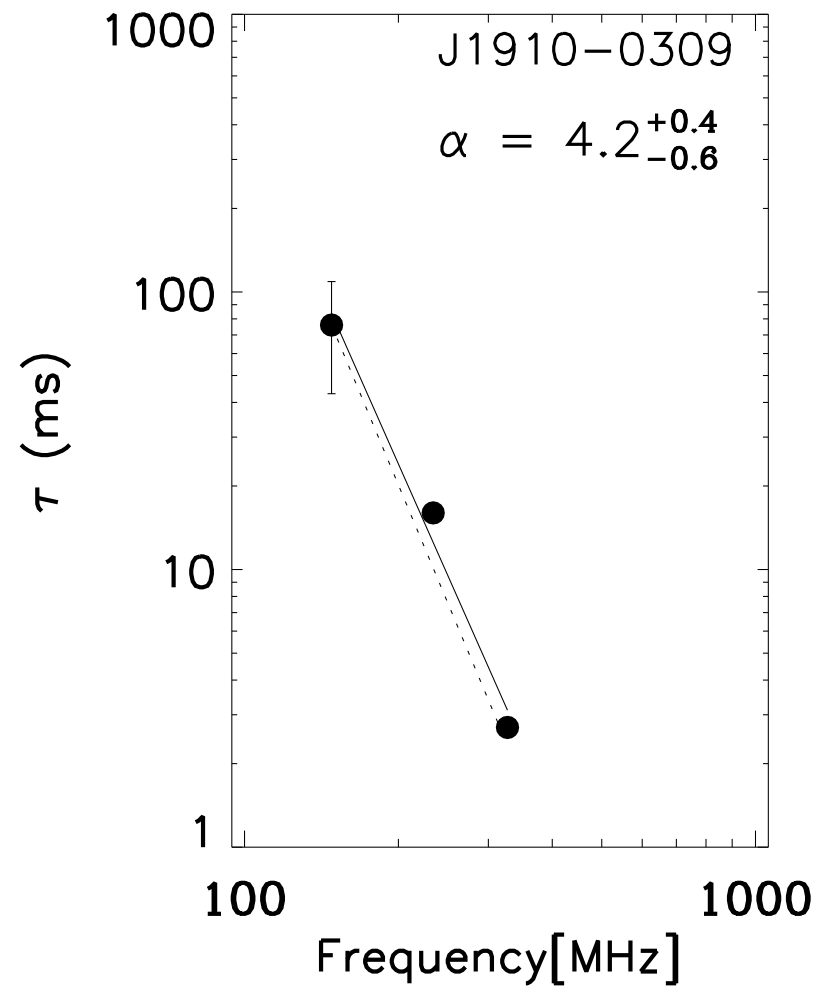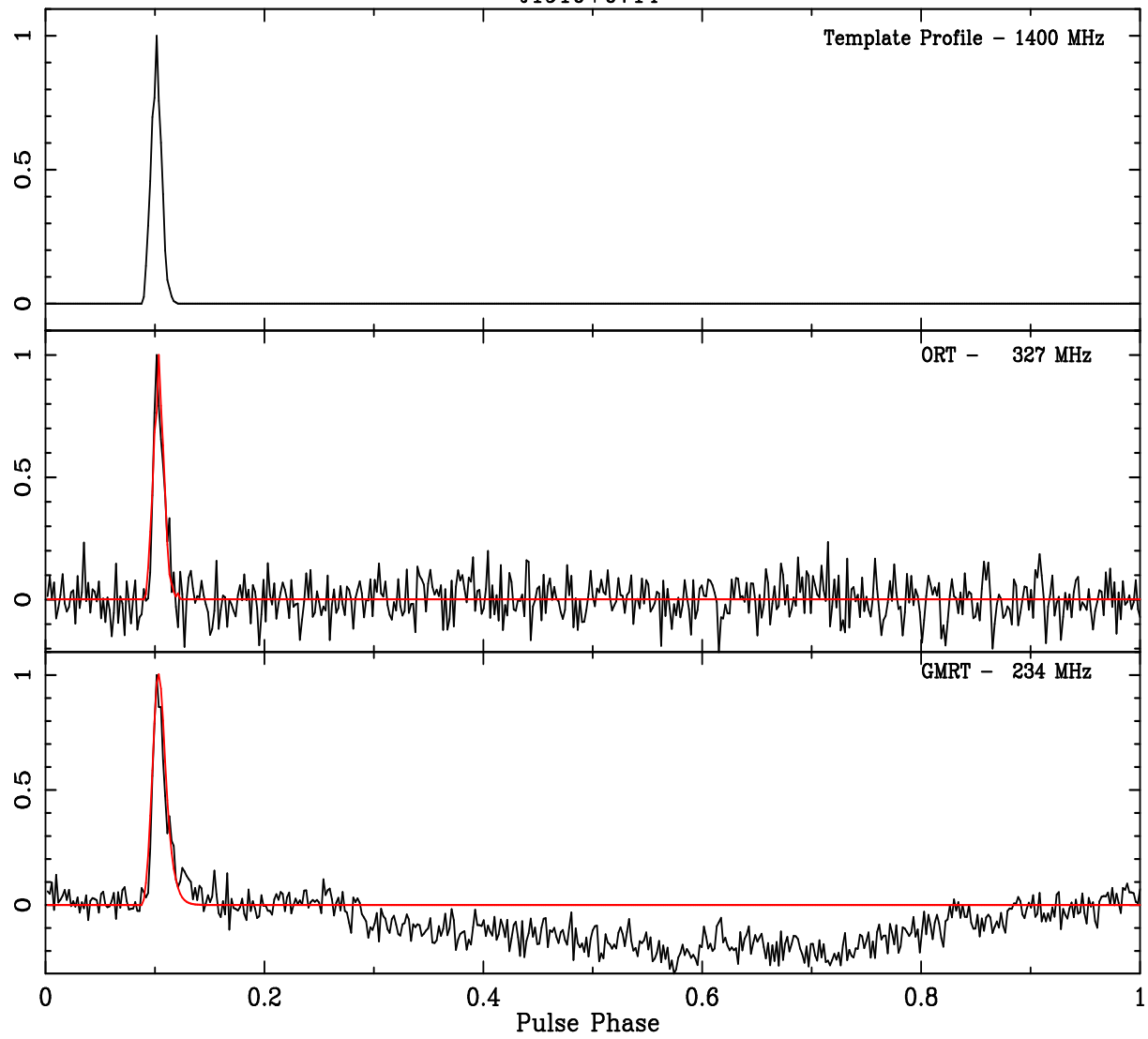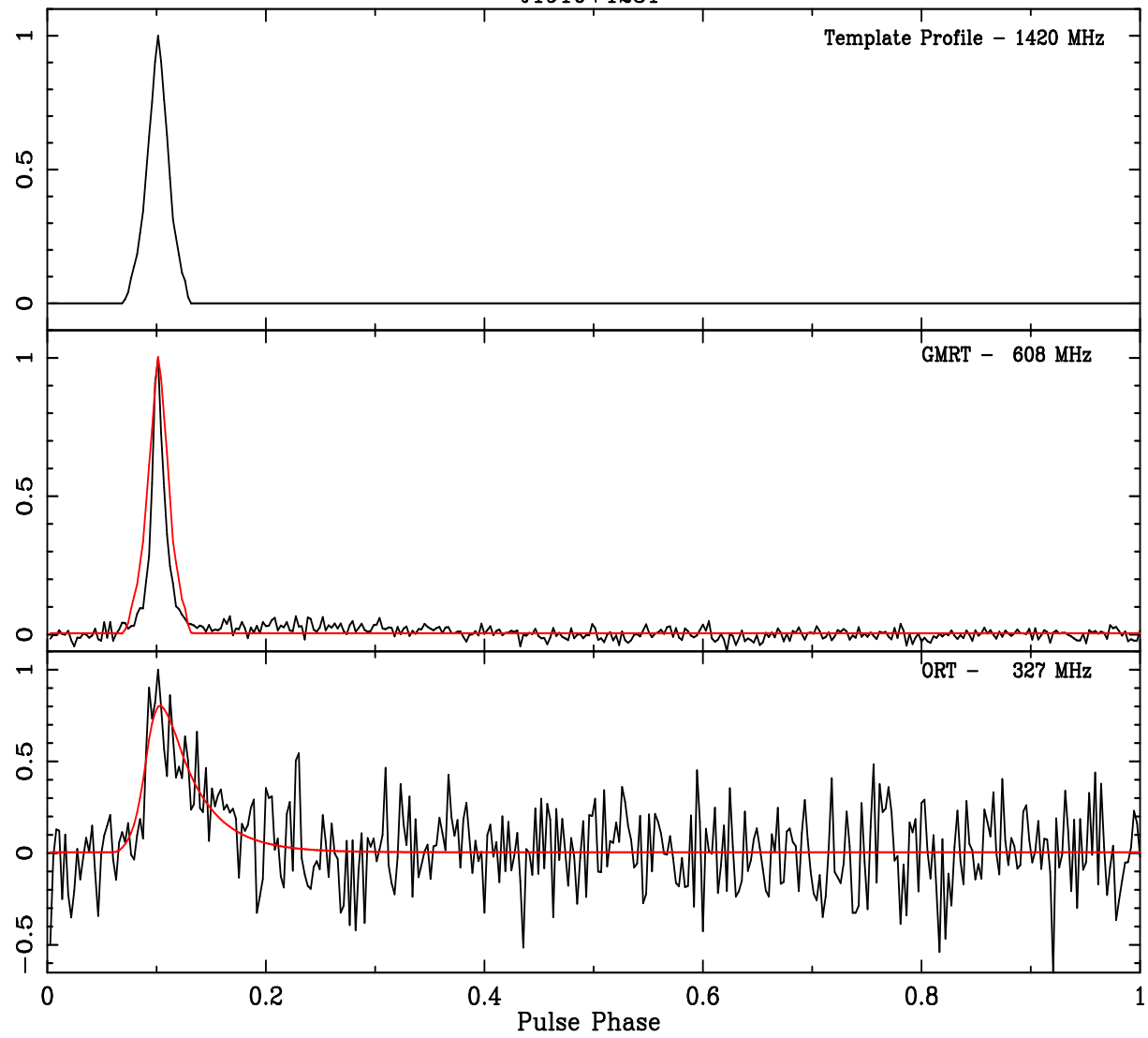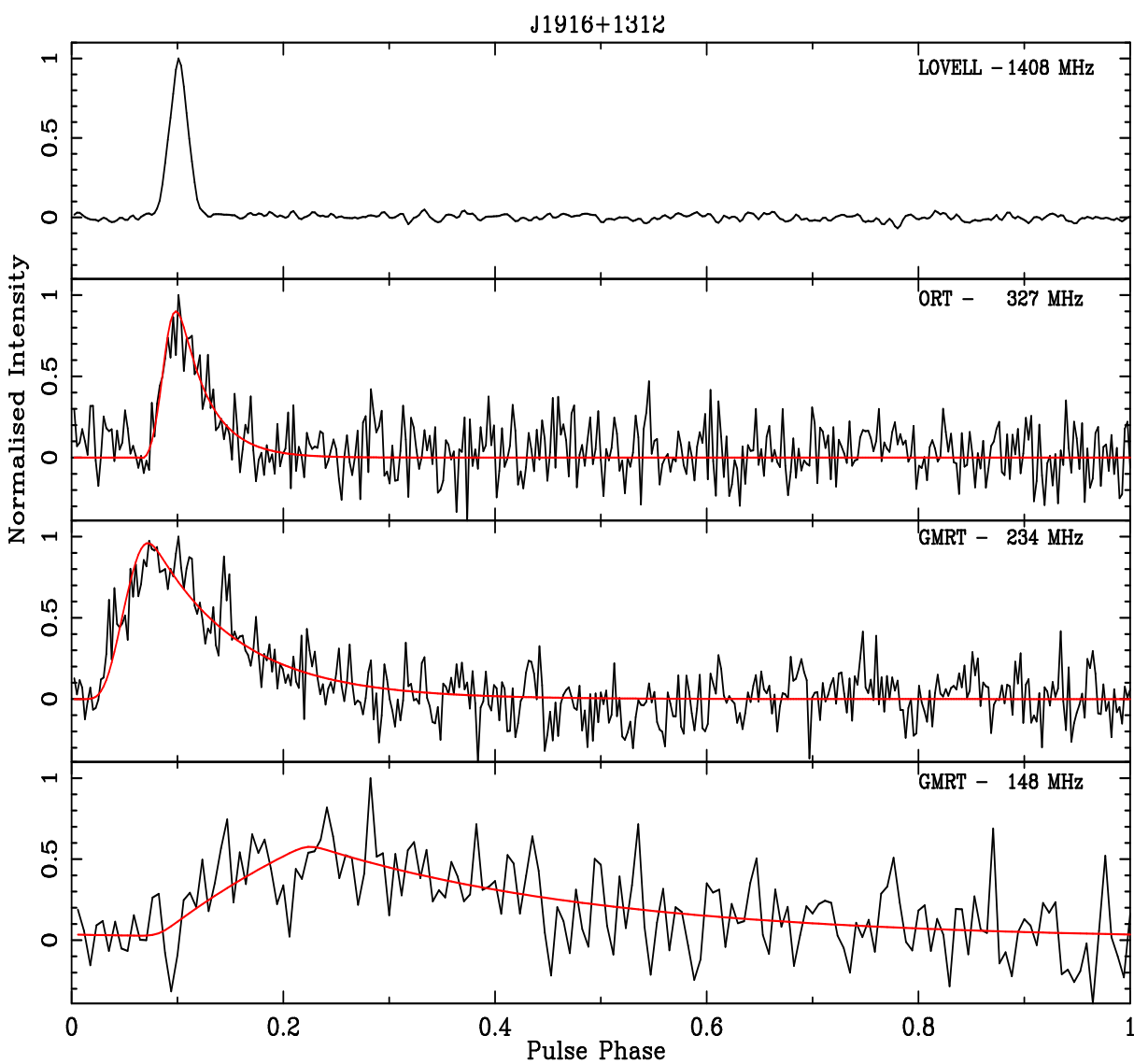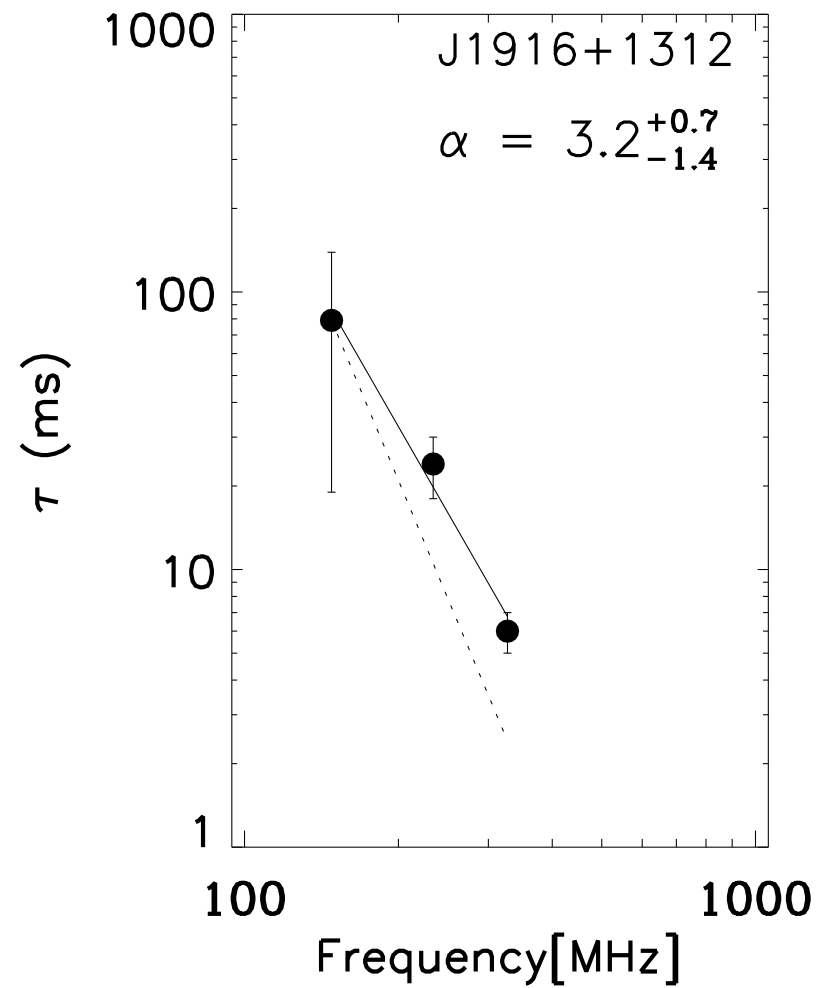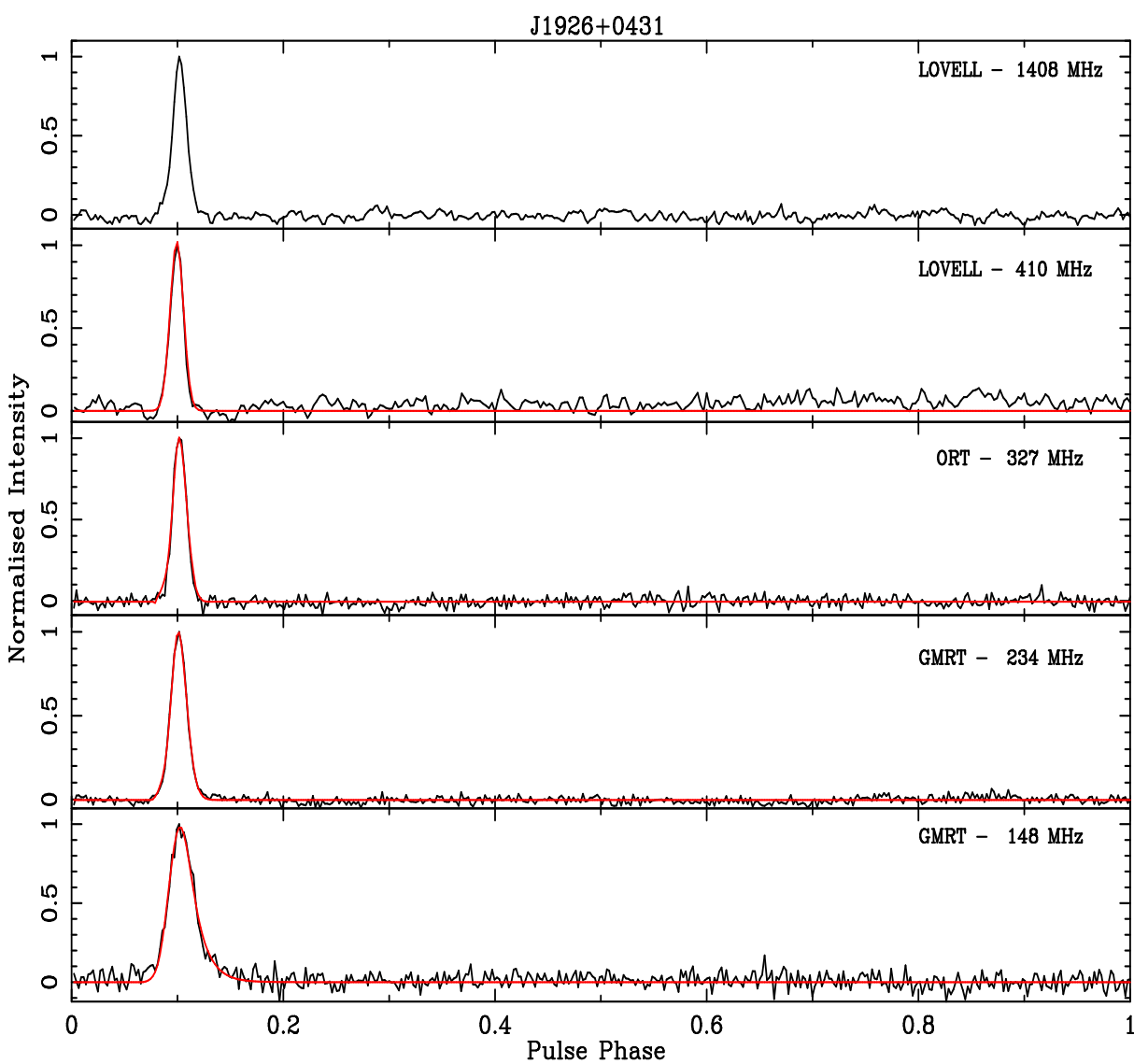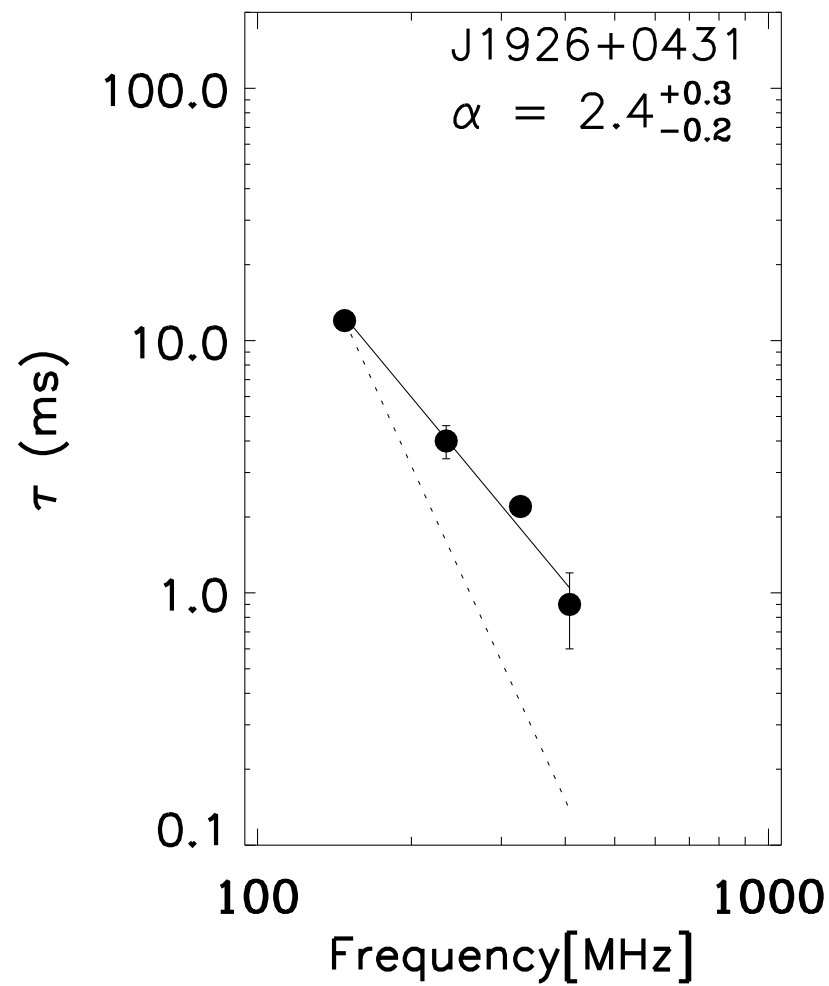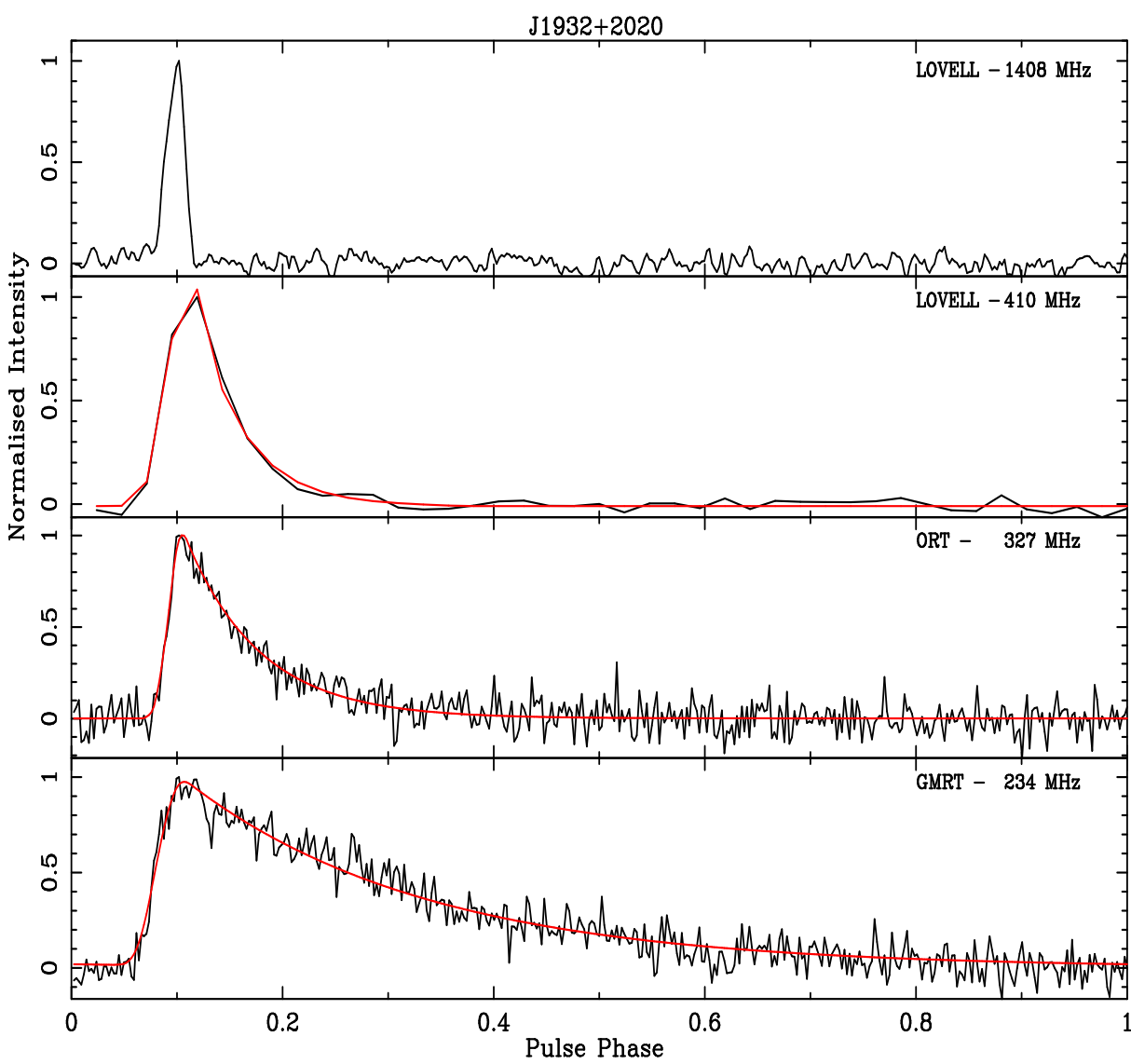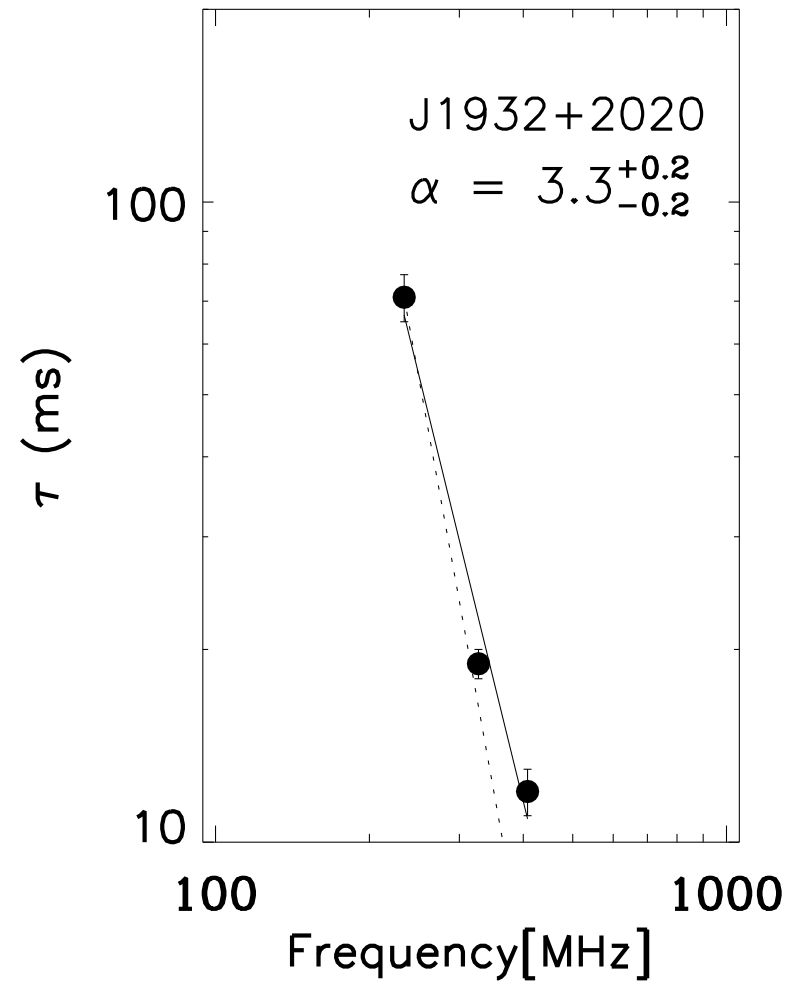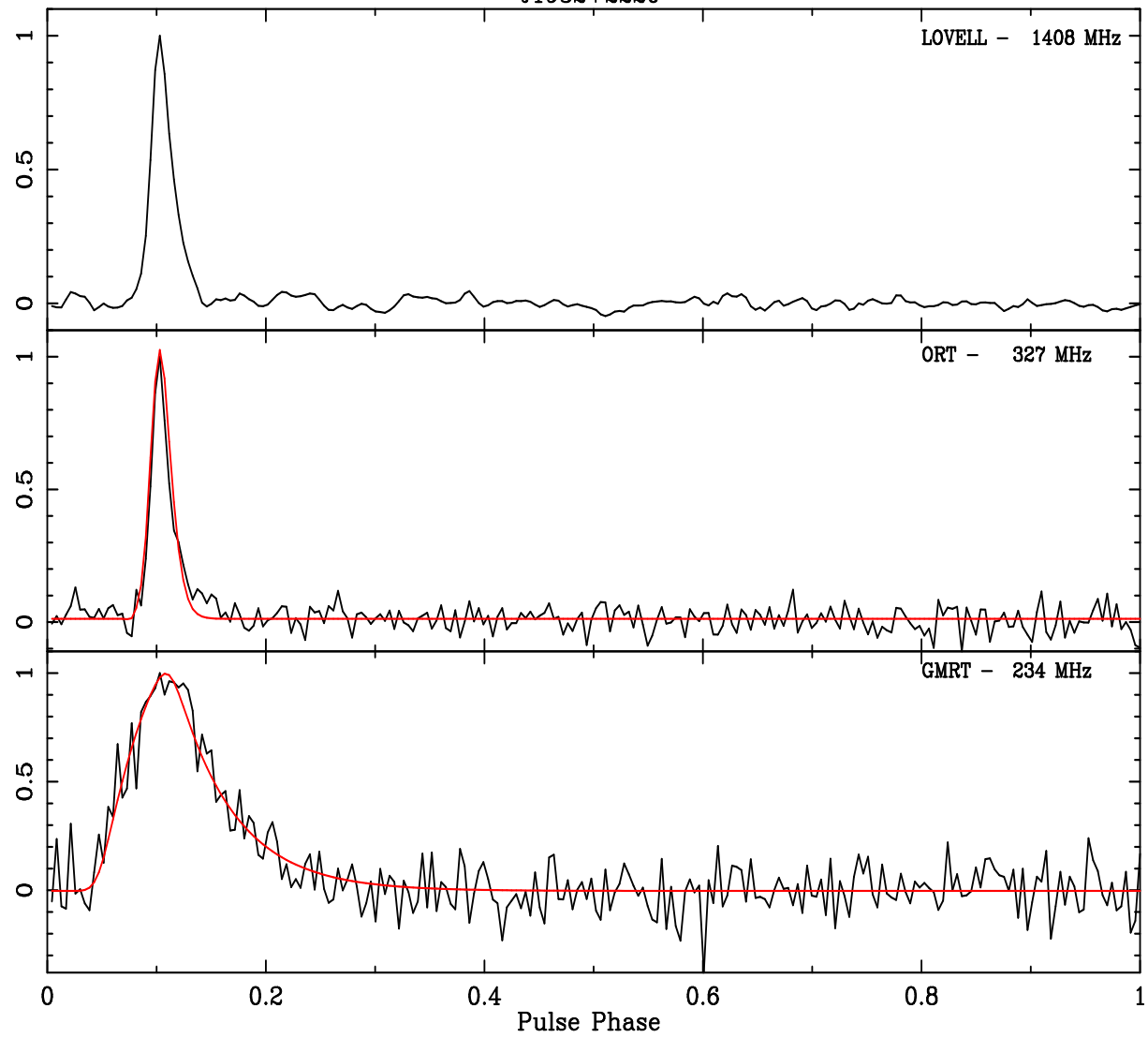
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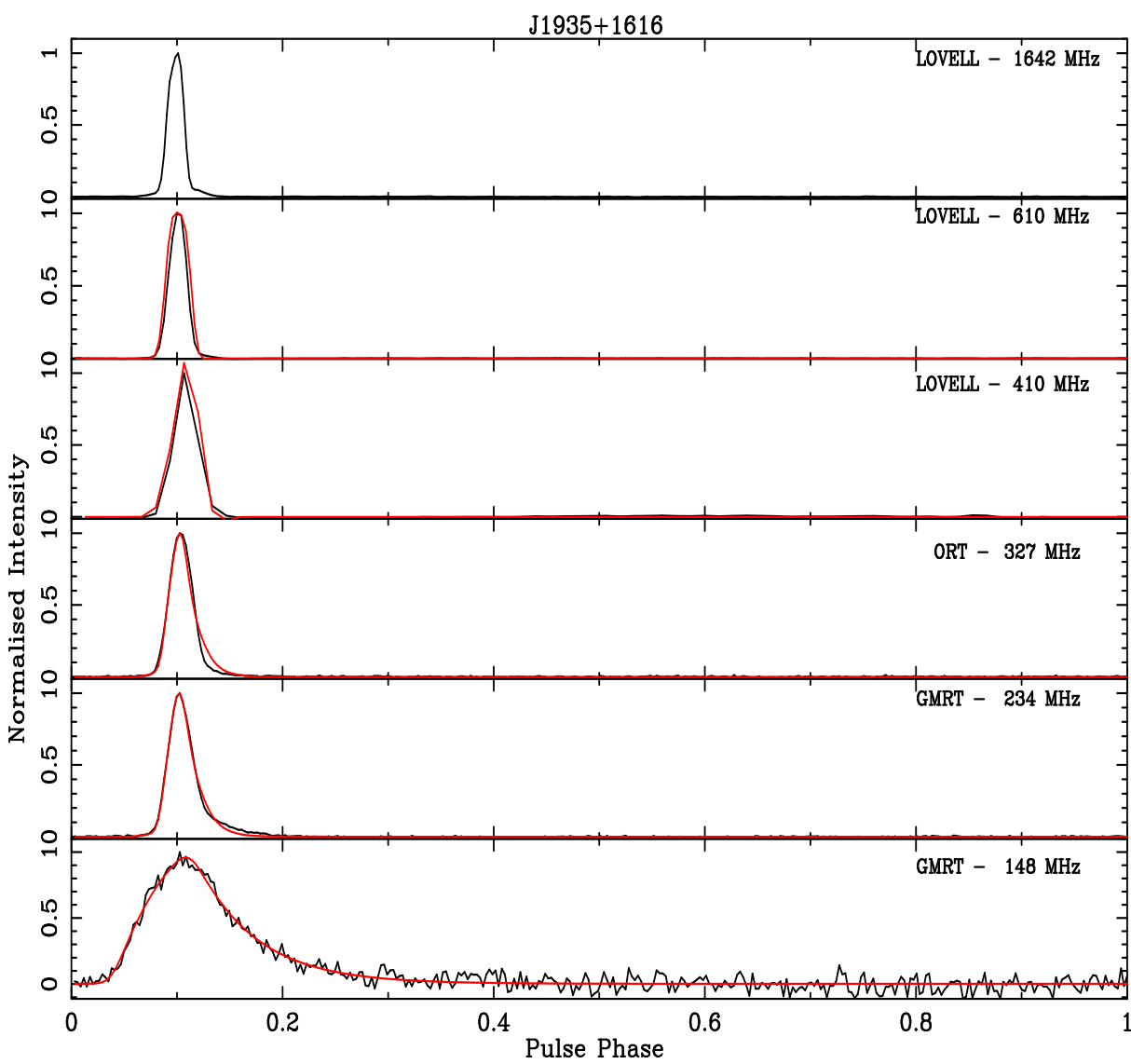
Figure 40:

Figure 41:

Figure 42:

Figure 43:

Figure 44:

Figure 45:

Figure 46:

Figure 47: