Coherence of H1 and H2 ASQ channels with PEM channels

Vuk Mandic

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This note studies in more detail the features observed in the S4 H1ASQ-H2ASQ coherence plot. We use all of H1H2 coincident data in S4 with v04 data quality flags. We use the H1 and H2 ASQ channels, and a set of PEM channels including the LVEA microphone, ISCT1, 4, 7, and 10 microphones and accelerometers, LVEA and BSC1 magnetometers, and LVEA, EX, EY, MX, and MY voltage divider (on mains, phase 1; V1) channels.

Figure 1 shows the coherence γ^2 between H1ASQ and H2ASQ split into six 50 Hz bins, with the resolution of 0.1 Hz. Besides the 60 Hz harmonics, which we ignore here, we observe several structures that appear significant - i.e. $\gamma^2 > 4\sigma_{\gamma^2}$, where $\sigma^2_{\gamma^2} = 2\gamma^2(1-\gamma^2)^2/N$ is an estimate of the variance of the coherence and $N \approx 10^5$ is the number of averages. Figure 2 shows the time-trend for some of these features. Note that most of the features tend to plateau toward the end of S4, which is not the case for the "pure noise" band around 160 Hz. The discontinuous jumps in these trends are likely caused by glitches in one of the detectors, but we have not verified this explicitly for all jumps.

The remaining odd-numbered Figures in this note show γ^2 and σ_{γ^2} between the ASQ channels and various PEM channels at LHO. These Figures depict the significance of various coherence features. The remaining even-numbered Figures compare these coherences to the H1ASQ-H2ASQ coherence, in an attempt to match the various coherence features. Note that the shape of a given feature need not be the same in the ASQ-PEM coherences: the coherence levels may be very different, and the shapes may be distorted by coherences at nearby frequencies. We now list some of the conclusions that can be extracted based on these Figures.

- 107-108 Hz: Seems barely significant in H1ASQ-H2ASQ. We observe similar, but not identical, features in several ASQ-MIC channel-pairs. The best agreement of the feature shapes seems to be with the H1ASQ-ISCT4_MIC pair. The coherence of H2ASQ with MIC channels is significant at this frequency (especially for ISCT10_MIC), but the shapes are different. Coherence of ASQ channels with some of the ISCT_ACC channels is also significant.

- 133 Hz: This line seems very significant in H1ASQ-H2ASQ. Similar line can also be observed in coherences of ASQ with the MIC channels (LVEA and ISCT), as well as with most ISCT_ACC channels. It seems likely that the coupling for this line is acoustic.

- 191-195 Hz: This broad hump is barely significant in H1ASQ-H2ASQ. Coherence of ASQ channels with most MIC and ISCT_ACC channels seems significant at these frequencies, but the feature shapes are not always similar.

- 224-227 Hz: This feature contains a line at 224.6 Hz and a broader "hump" extending to 227 Hz. It seems fairly clear in H1ASQ-H2ASQ. Again, we observe such features in coherences of ASQ channels with most MIC and ISCT_ACC channels, although the observed features are not always similar.

- 258 Hz: This line seems fairly clear in H1ASQ-H2ASQ. Again, we see such feature in coherences of ASQ channels with most MIC and ISCT_ACC channels, although in some cases the line seems mixed with other structures.

- 266-268 Hz: This feature is barely significant in H1ASQ-H2ASQ coherence. Again, we observe significant coherence at this frequency between the ASQ channels and many MIC and ISCT_ACC channels, but the feature shapes are often significantly different.

- 277-283 Hz: This feature contains a broad hump at 277-280 Hz, followed by a clearer line at 282.6 Hz. It seems fairly significant in H1ASQ-H2ASQ. We observe features at these frequencies in coherences of ASQ channels with most MIC and ISCT_ACC channels, often of similar shape. It seems likely that the coupling of this feature is acoustic.

- 323-330 Hz: This feature contains a broad hump at 323-327 Hz, which is barely significant in H1ASQ-H2ASQ, followed by a much clearer line at 330 Hz. We observe similar features in coherences of H1ASQ with ISCT4_ACC channels and of H2ASQ with ISCT10_ACC channels (especially regarding the position of the 330 Hz line).

To conclude, it seems that the coupling for all of the observed features in the H1ASQ-H2ASQ coherence is acoustic/mechanical in nature. This is not obvious for the smaller, barely significant features, but seems clear for the largest (most significant) features. We could not observe features of similar shapes at the given frequencies in the coherences of the ASQ channels with the magnetometer channels nor with the V1 (voltage divider on mains, phase 1) channels. Finally, the coherences of the ASQ channels with the PEM channels reveal many other features (such as 3 Hz sidebands on 60 Hz; 16 Hz harmonics etc) - however, these features do not seem to appear in the H1ASQ-H2ASQ pair, so we do not pursue them here.

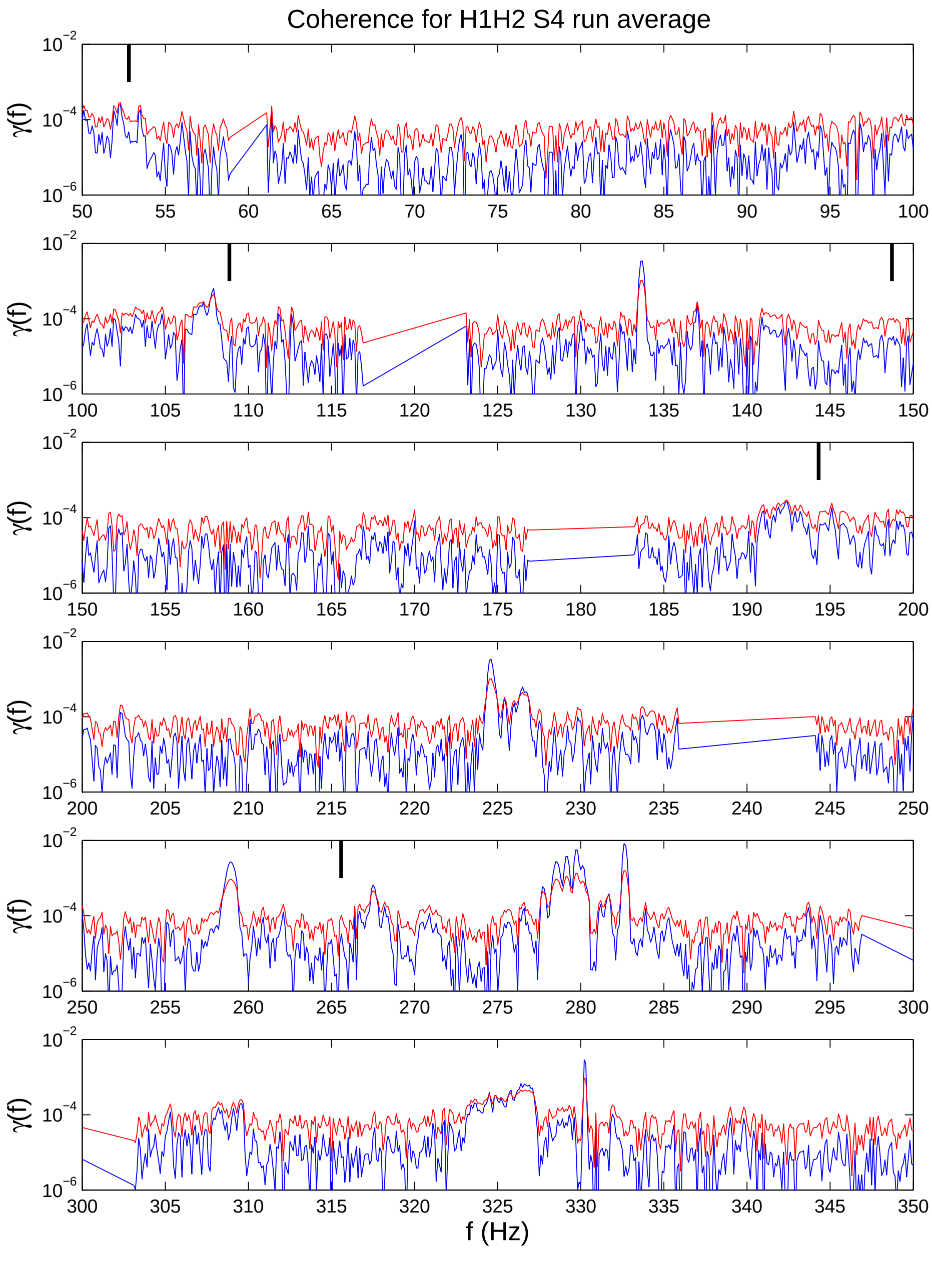


Figure 1: γ^2 (blue) and $4\sigma_{\gamma^2}$ (red). The 60 Hz harmonics have been removed by hand from the plot.

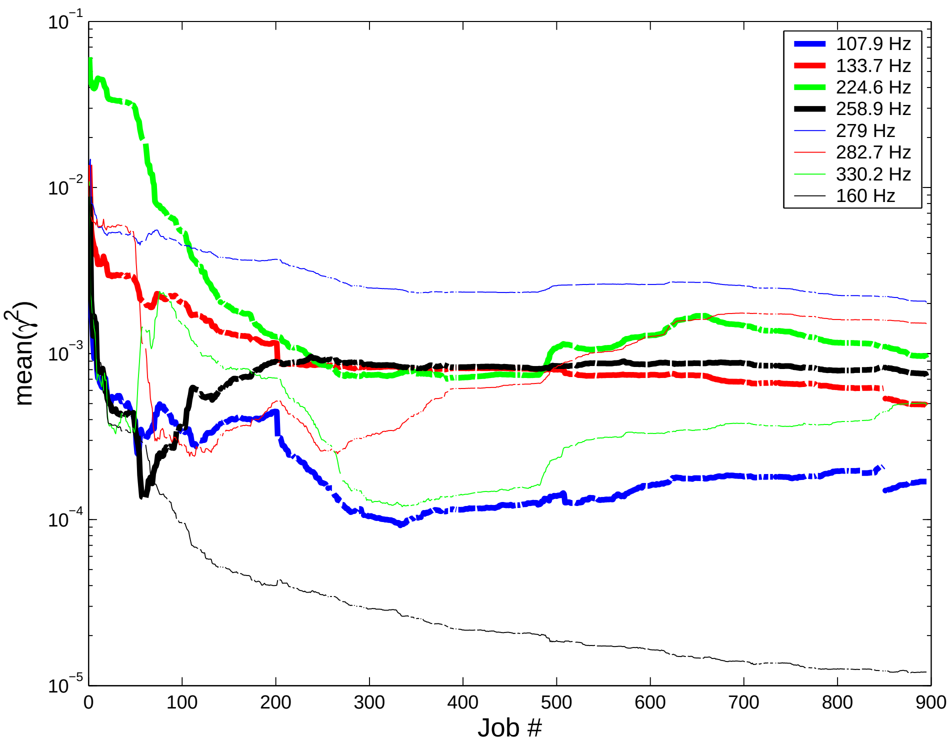
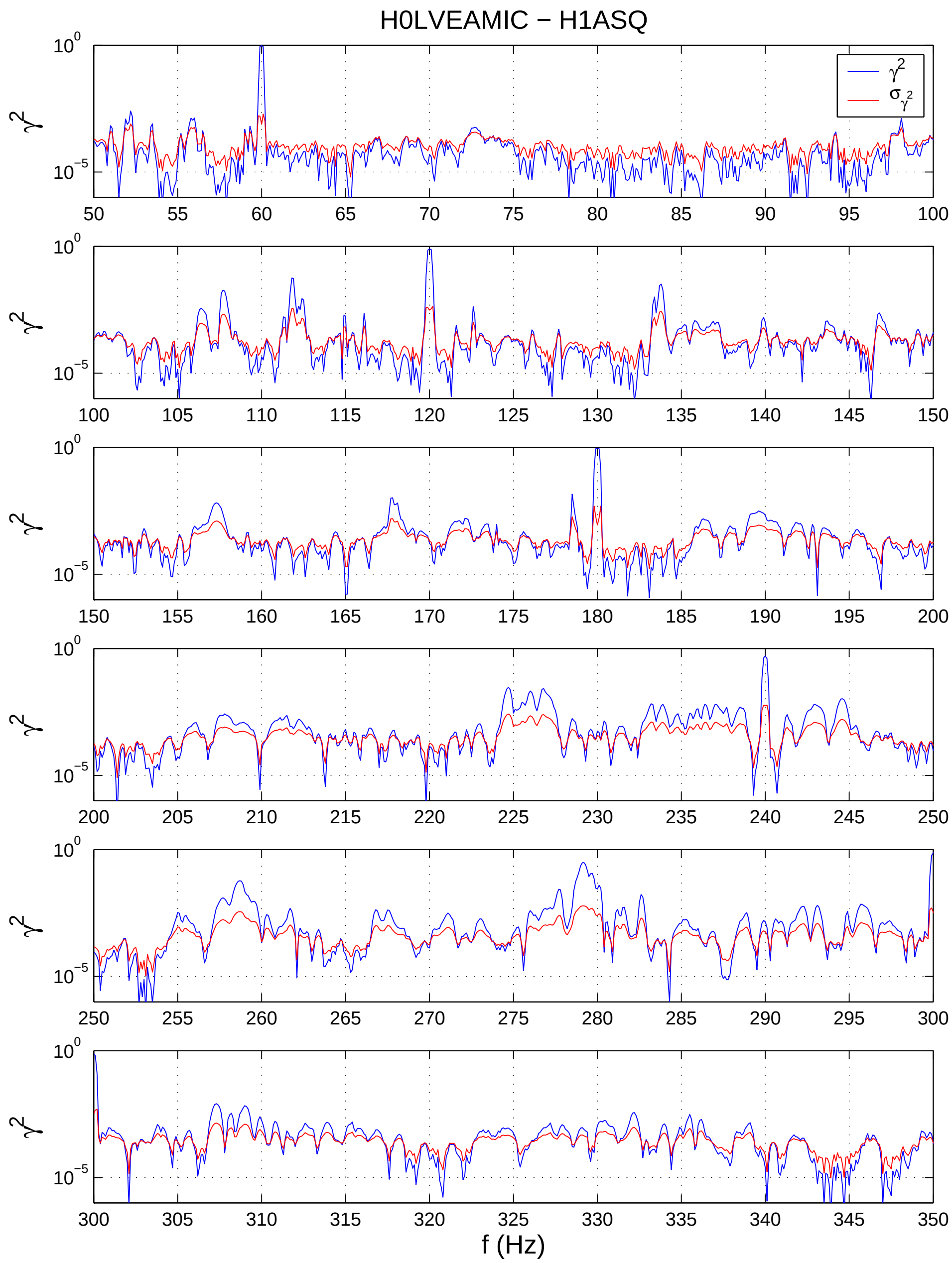


Figure 2: Time trend of the various H1ASQ-H2ASQ coherence features discussed in the text. Note that the 160 Hz line denotes a "pure noise" band 145-175 Hz.



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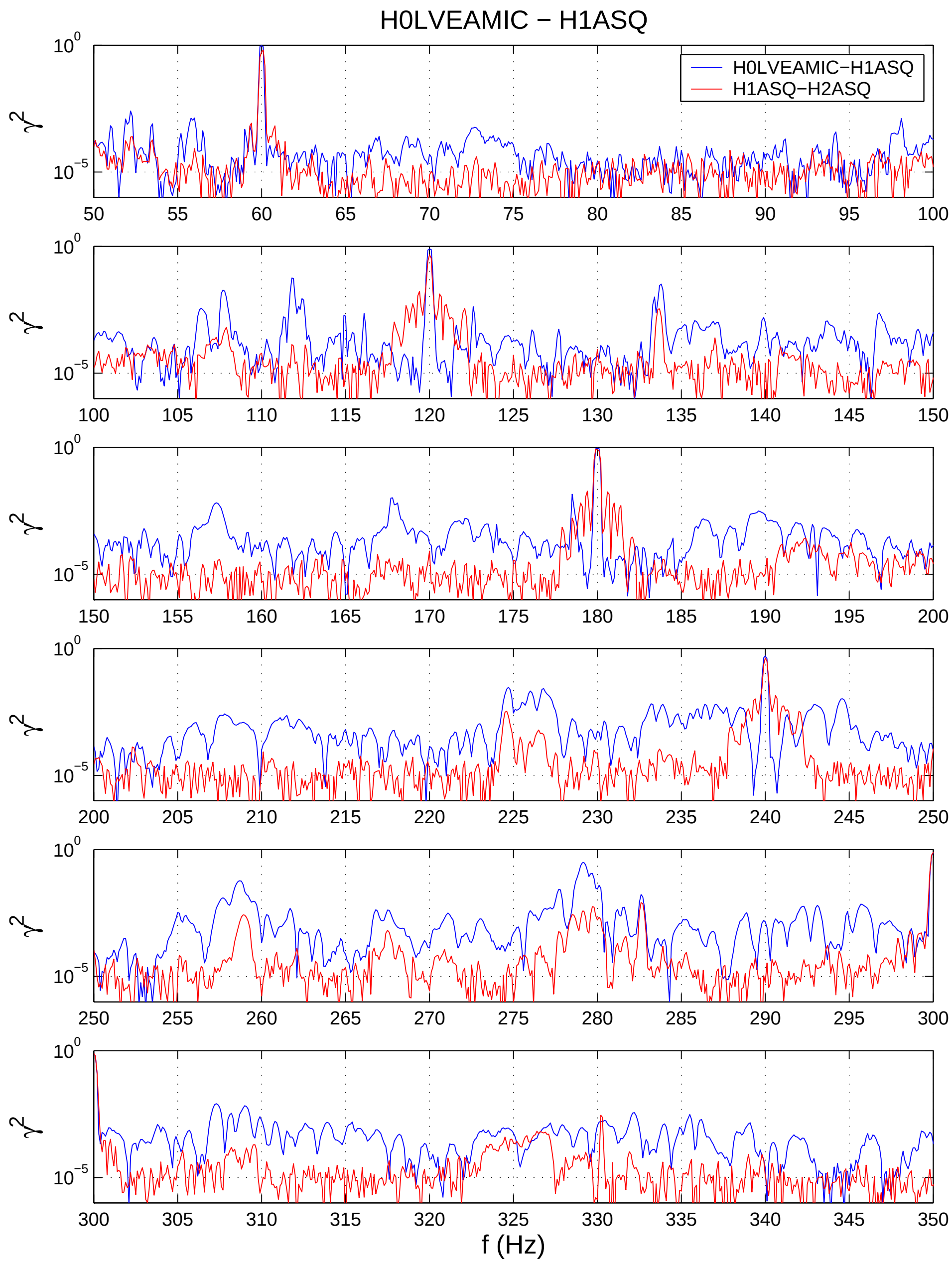

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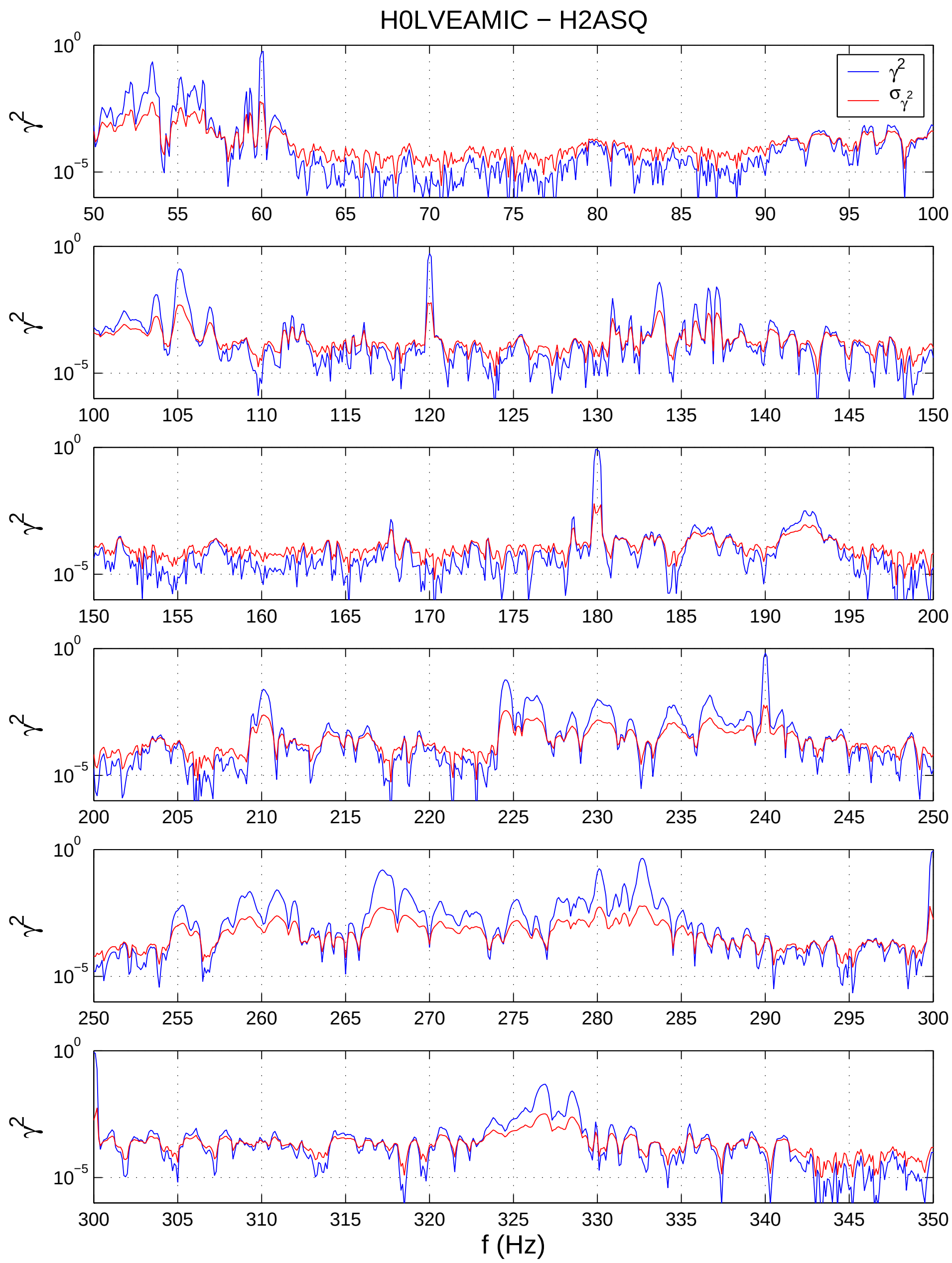

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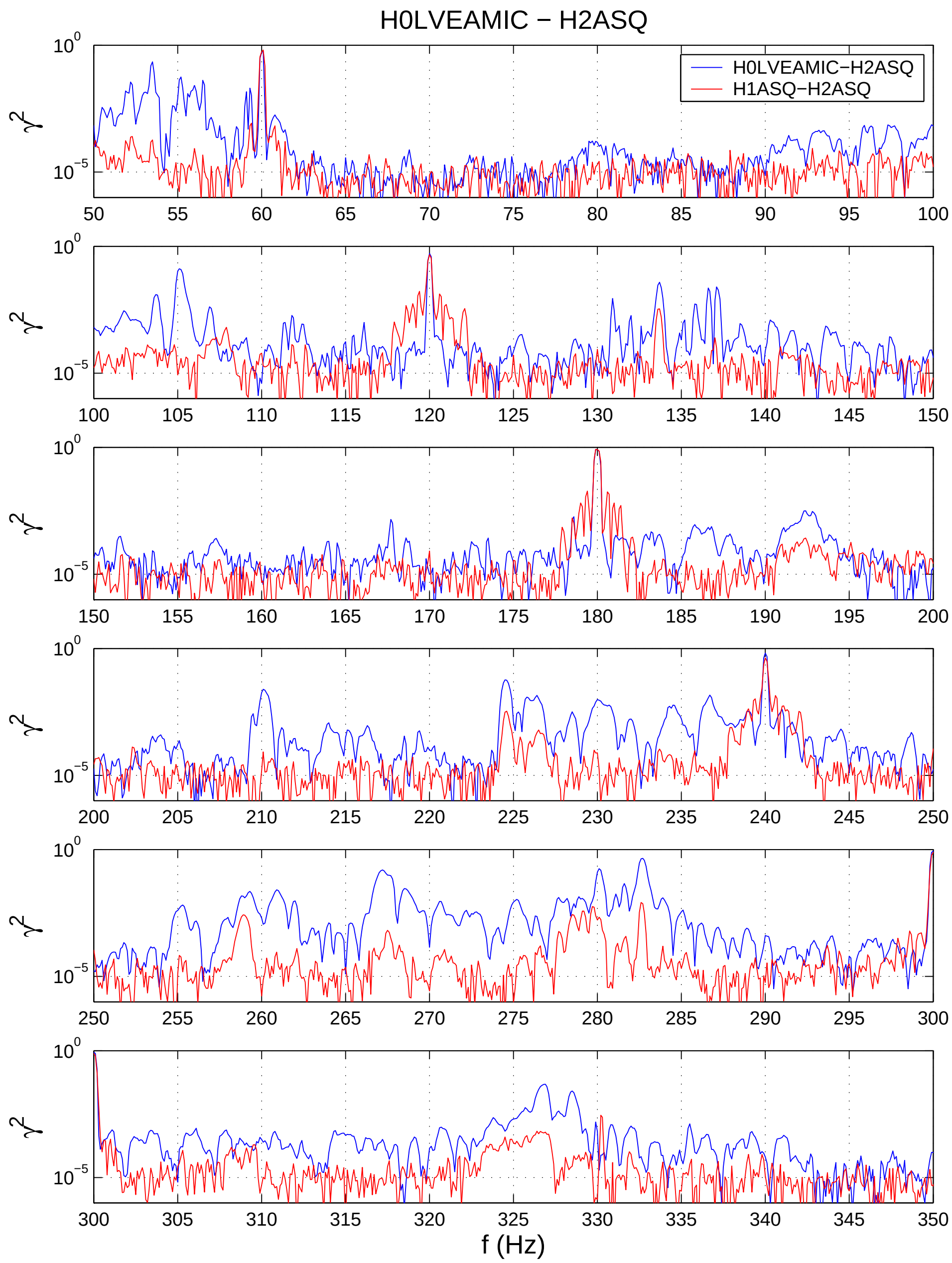
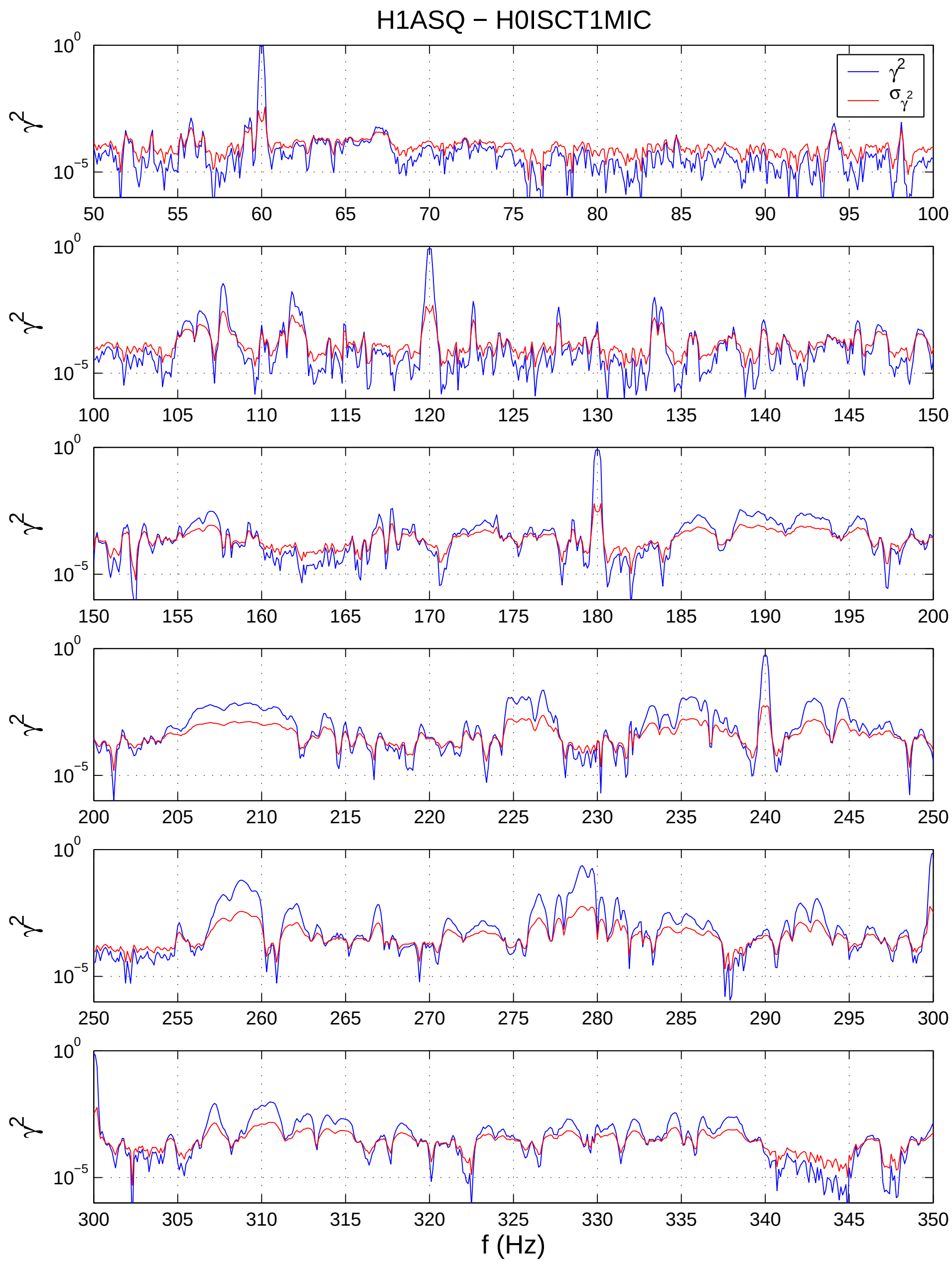

H0LVEAMIC − H2ASQ
H0LVEAMIC−H2ASQ
H1ASQ−H2ASQ
γ^2
10^0
10^{-5}
f (Hz)

Figure 6:



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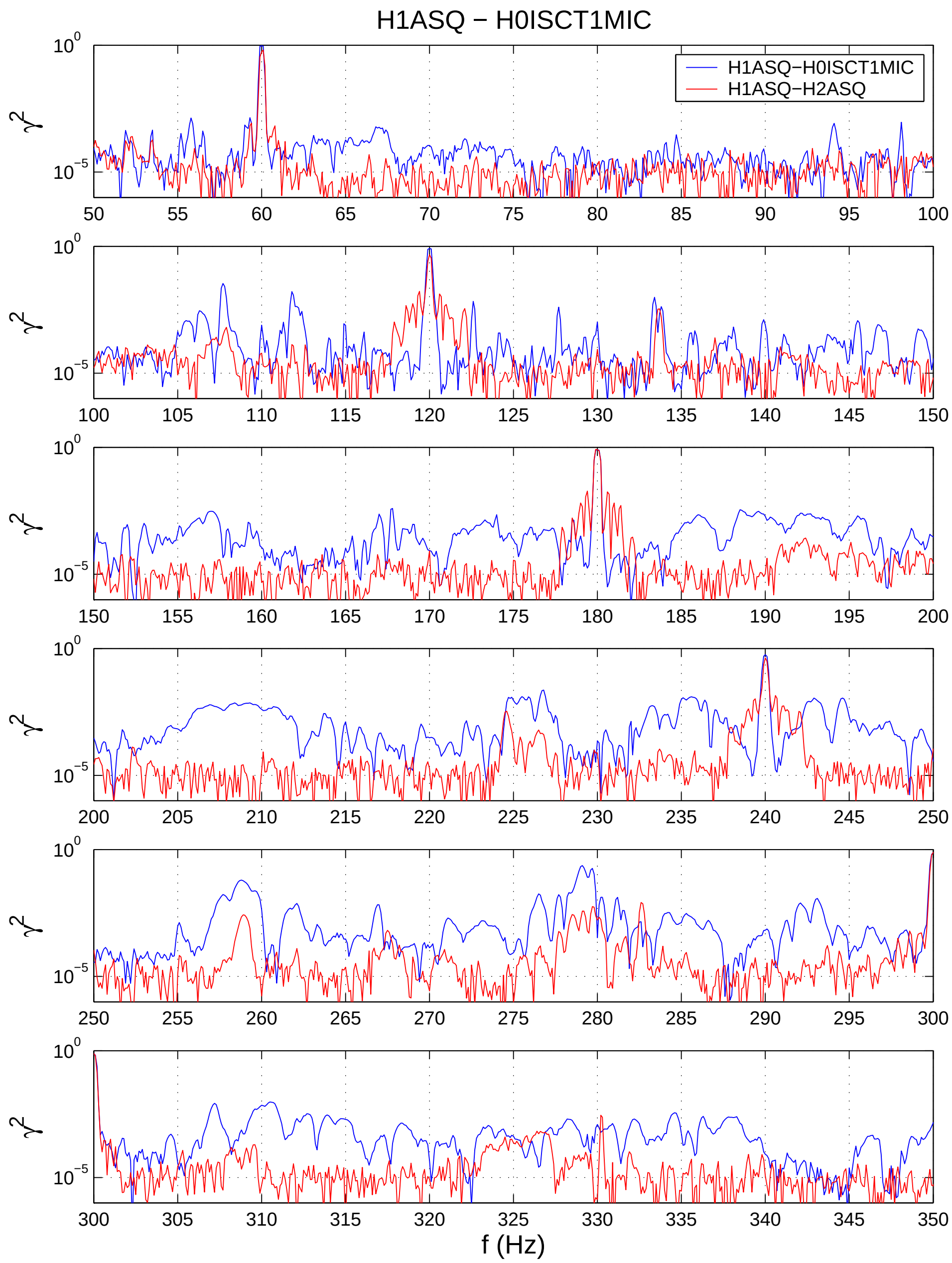

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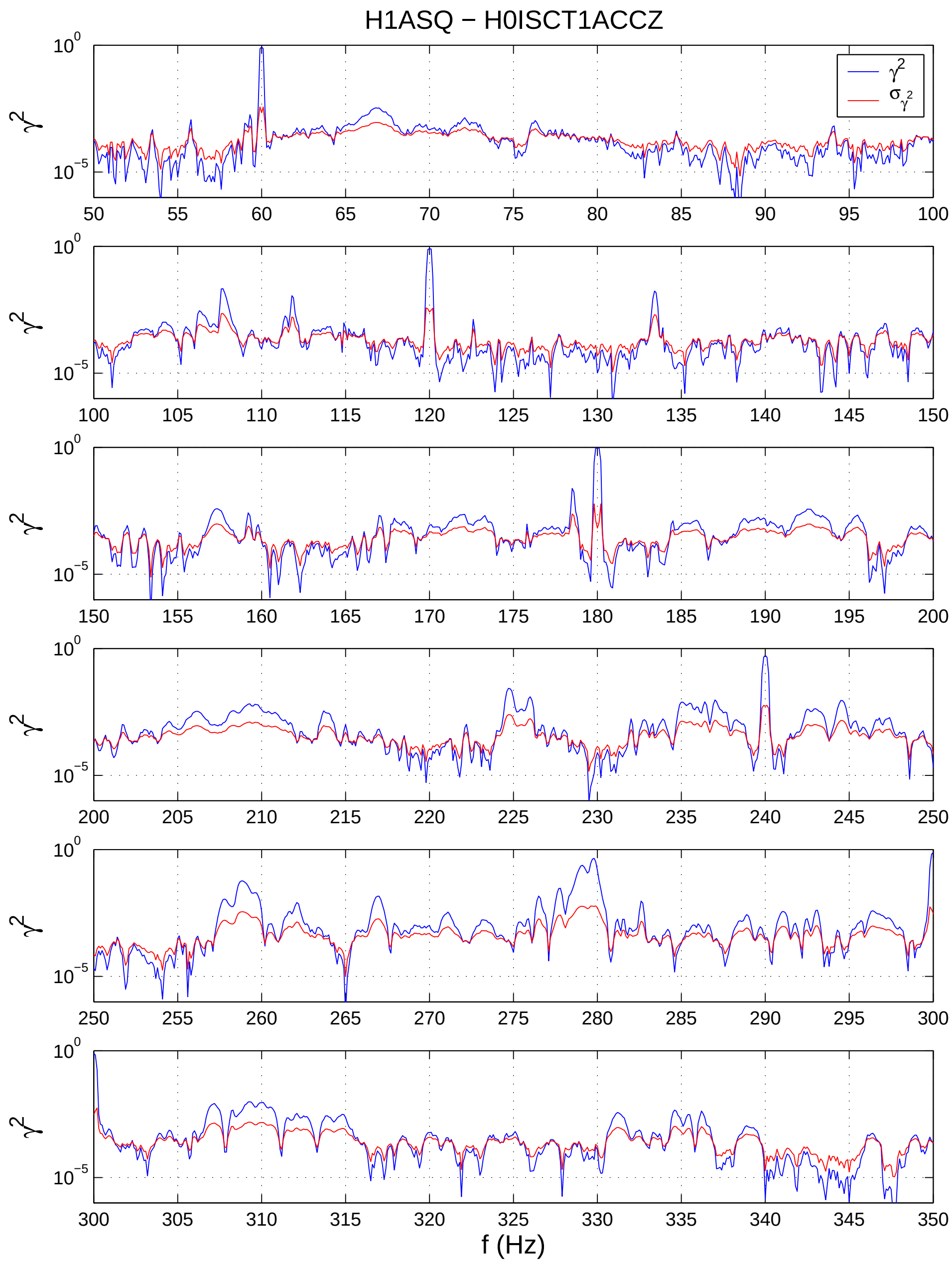

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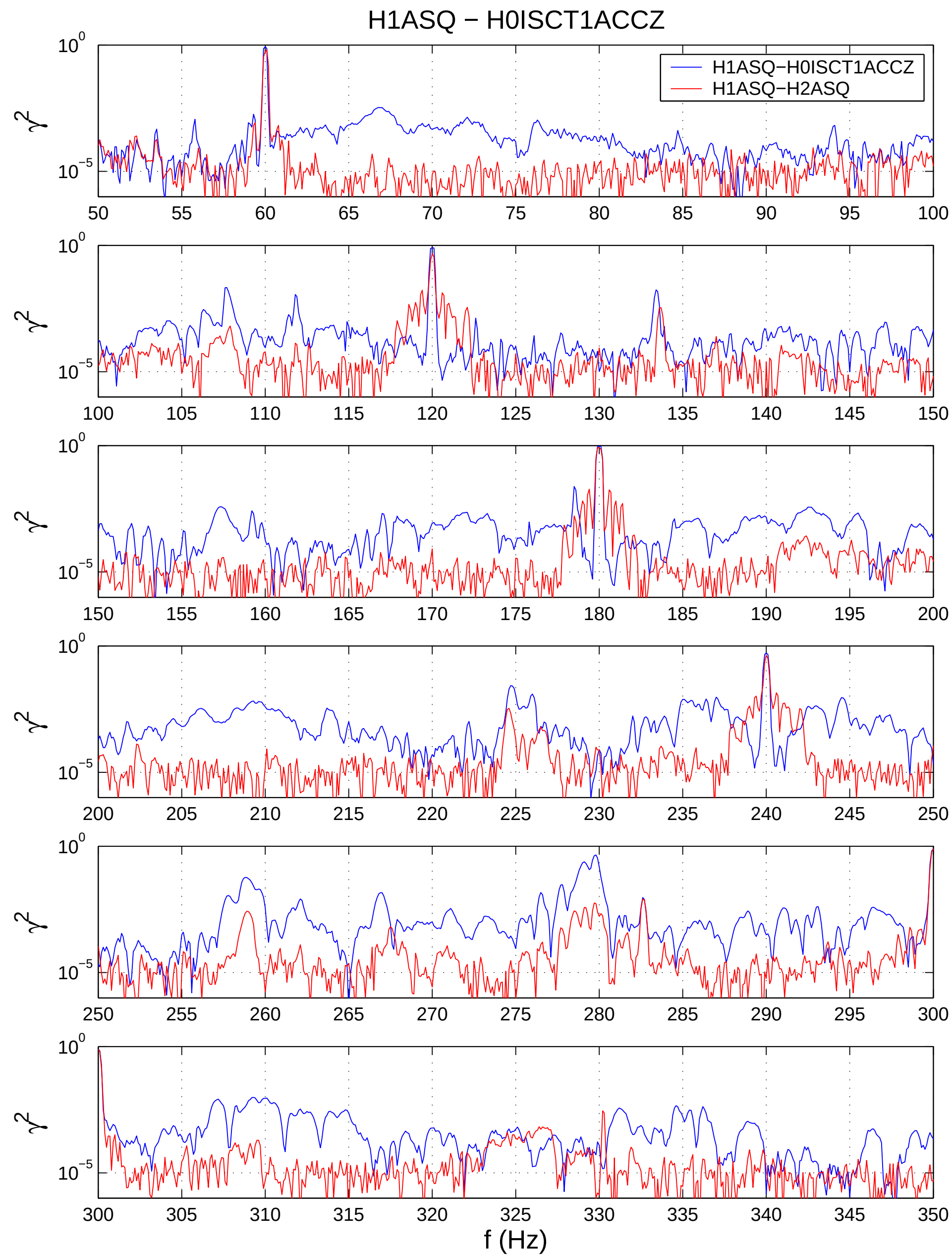
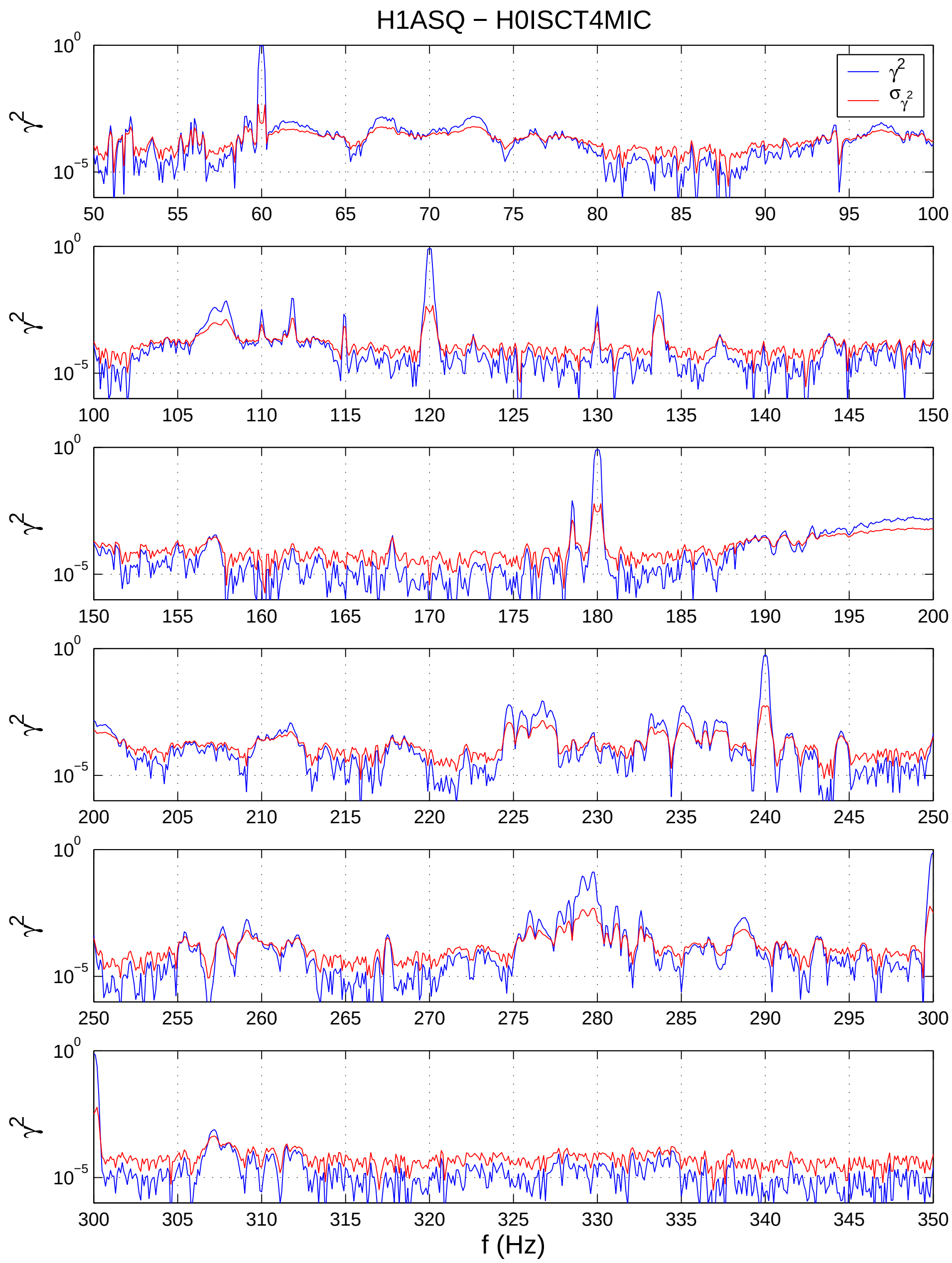

H1ASQ − H0ISCT1ACCZ
H1ASQ−H0ISCT1ACCZ
H1ASQ−H2ASQ
γ^2
10^0
10^{-5}
f (Hz)

Figure 10:



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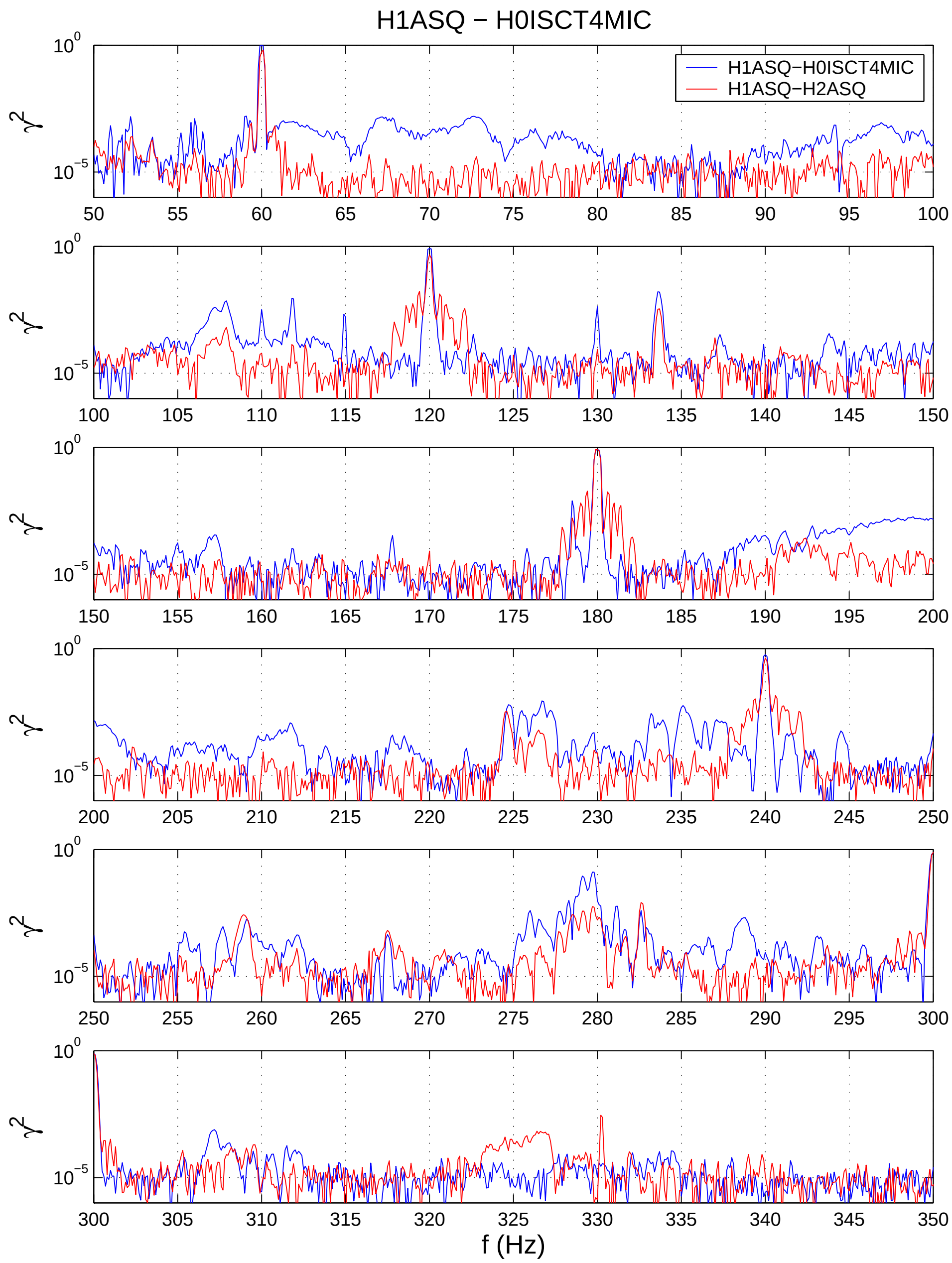

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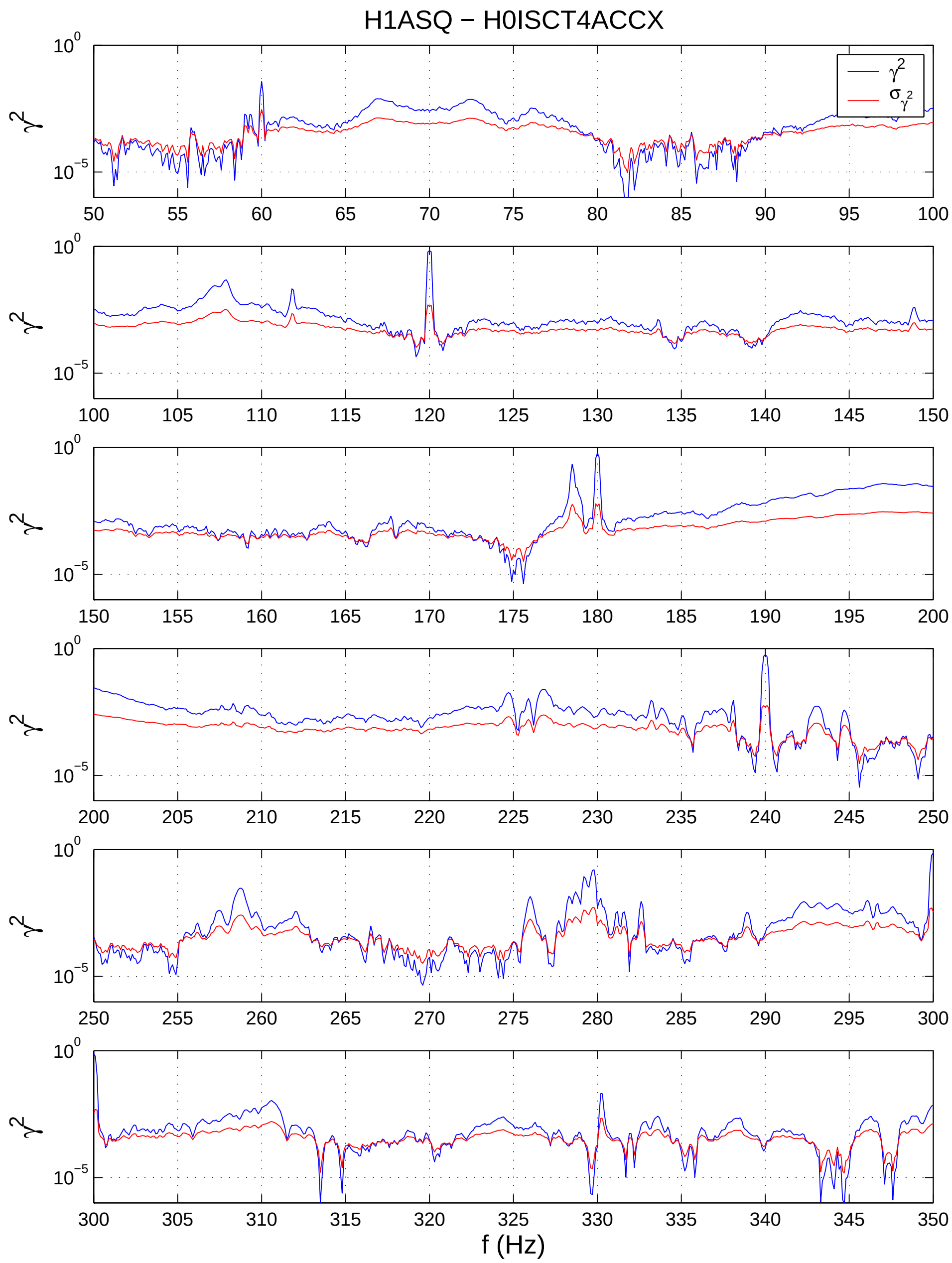

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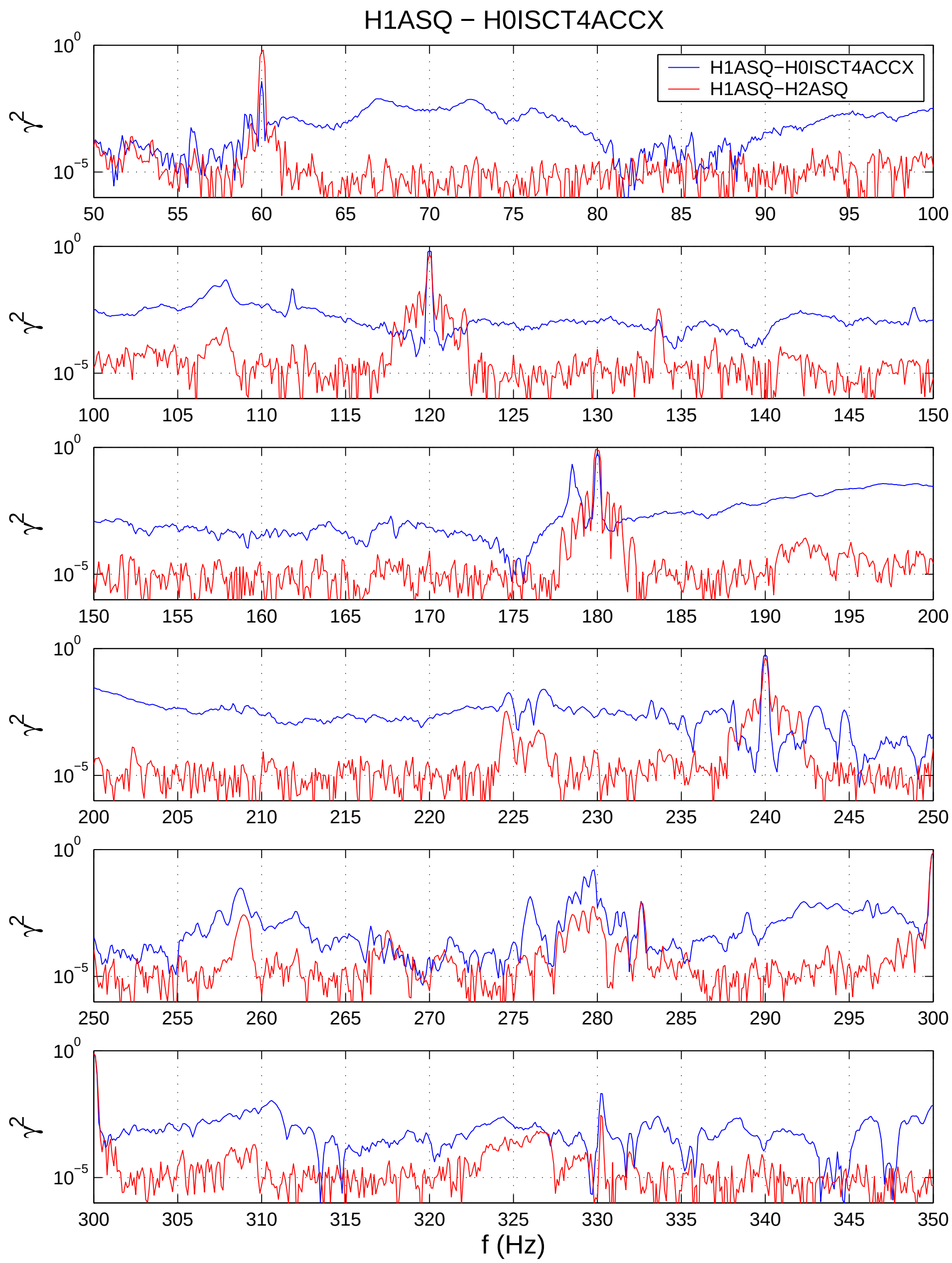
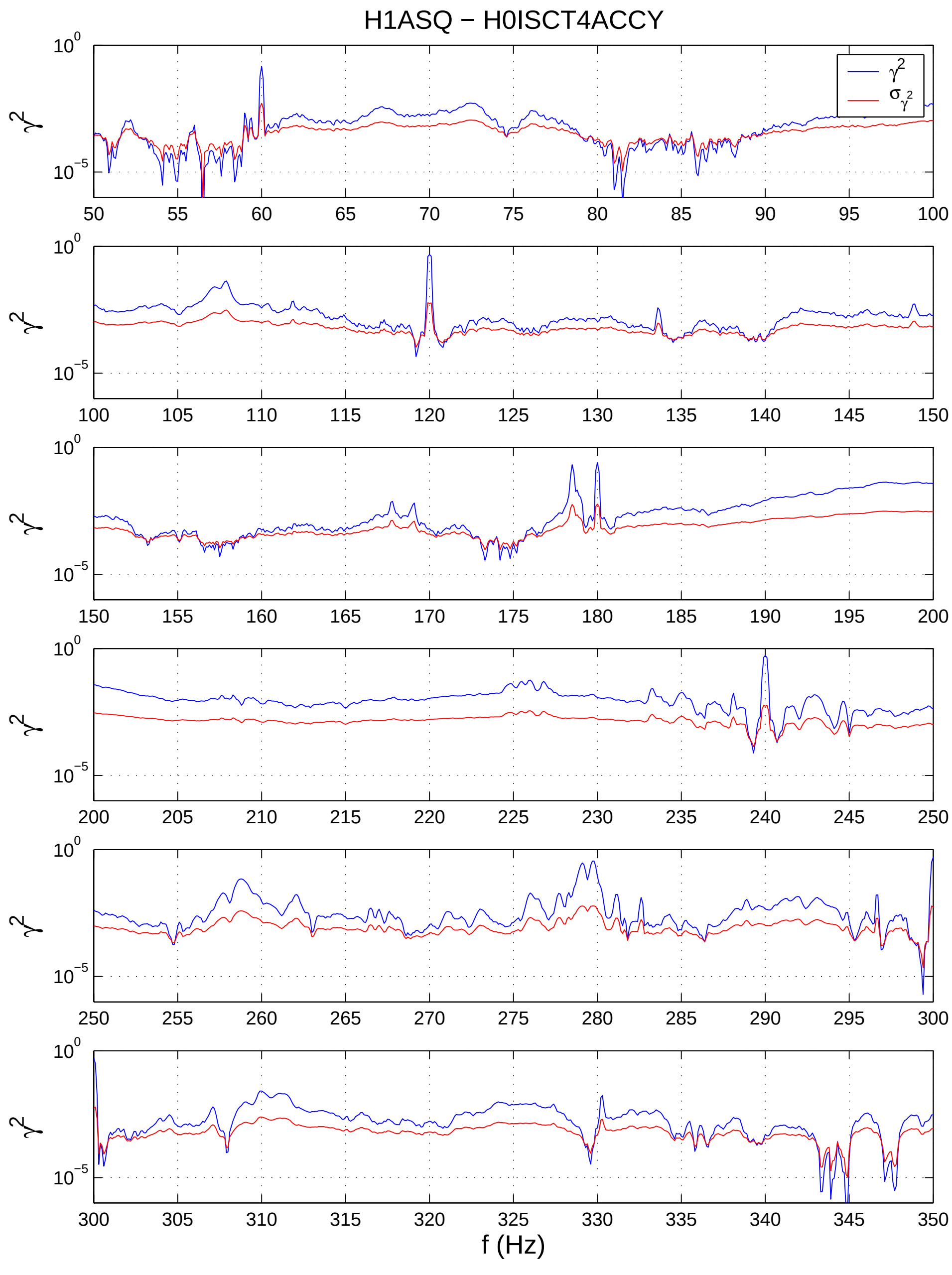


H1ASQ − H0ISCT4ACCX
H1ASQ−H0ISCT4ACCX
H1ASQ−H2ASQ
γ^2
10^0
10^{-5}
f (Hz)

Figure 14:



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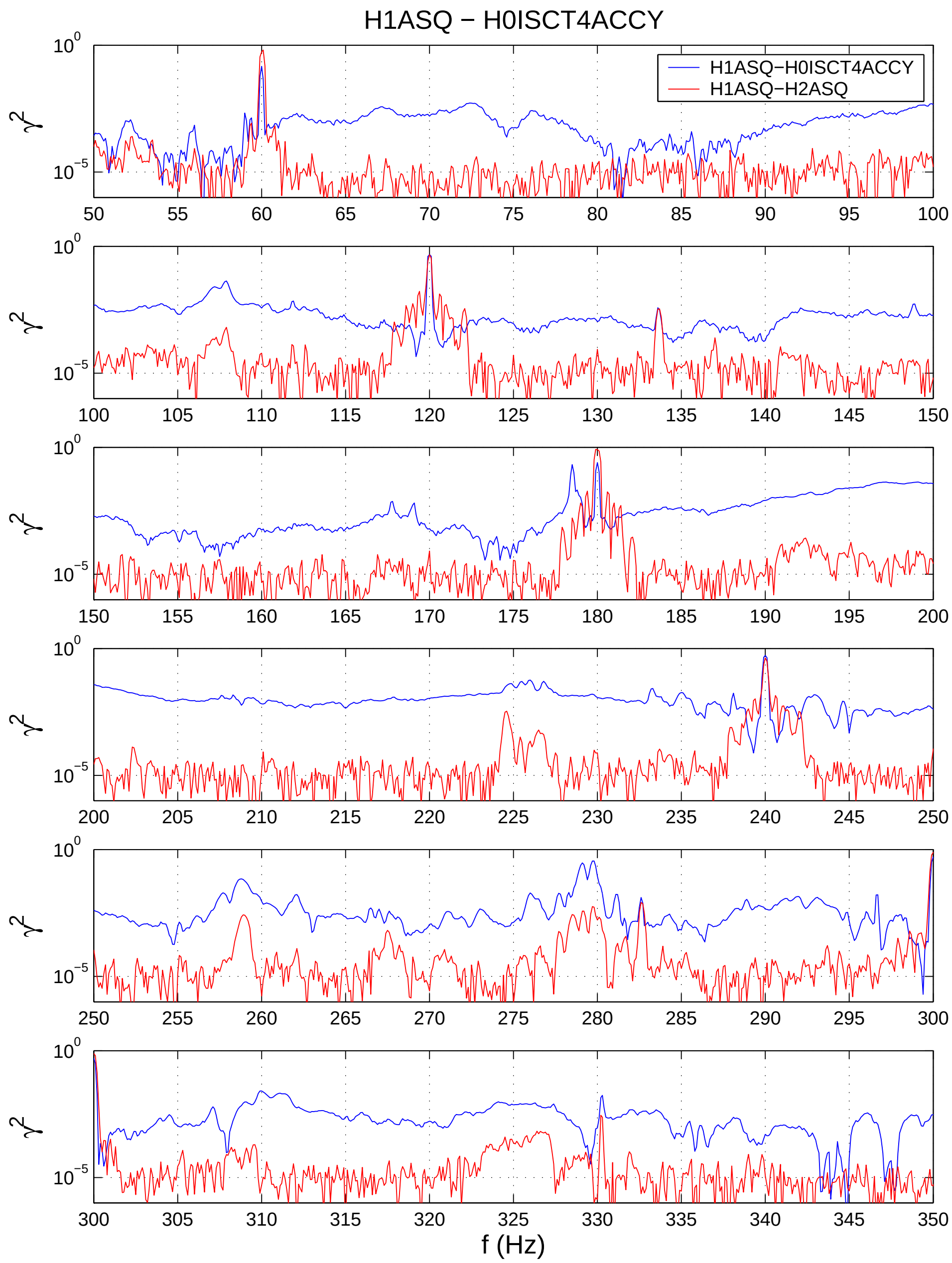
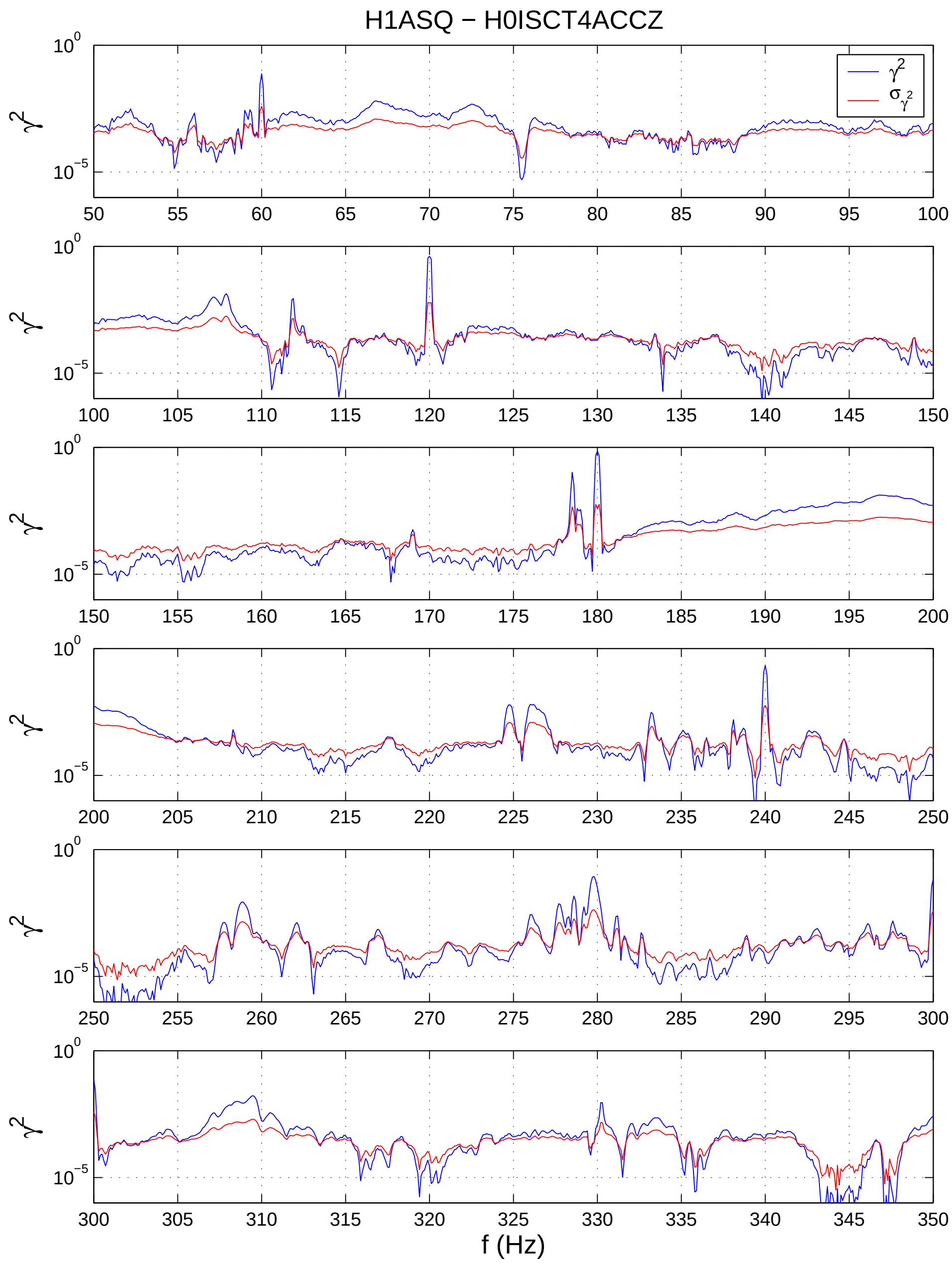

H1ASQ − H0ISCT4ACCY
H1ASQ−H0ISCT4ACCY
H1ASQ−H2ASQ
10^{0}
10^{-5}
γ^2
f (Hz)

Figure 16:



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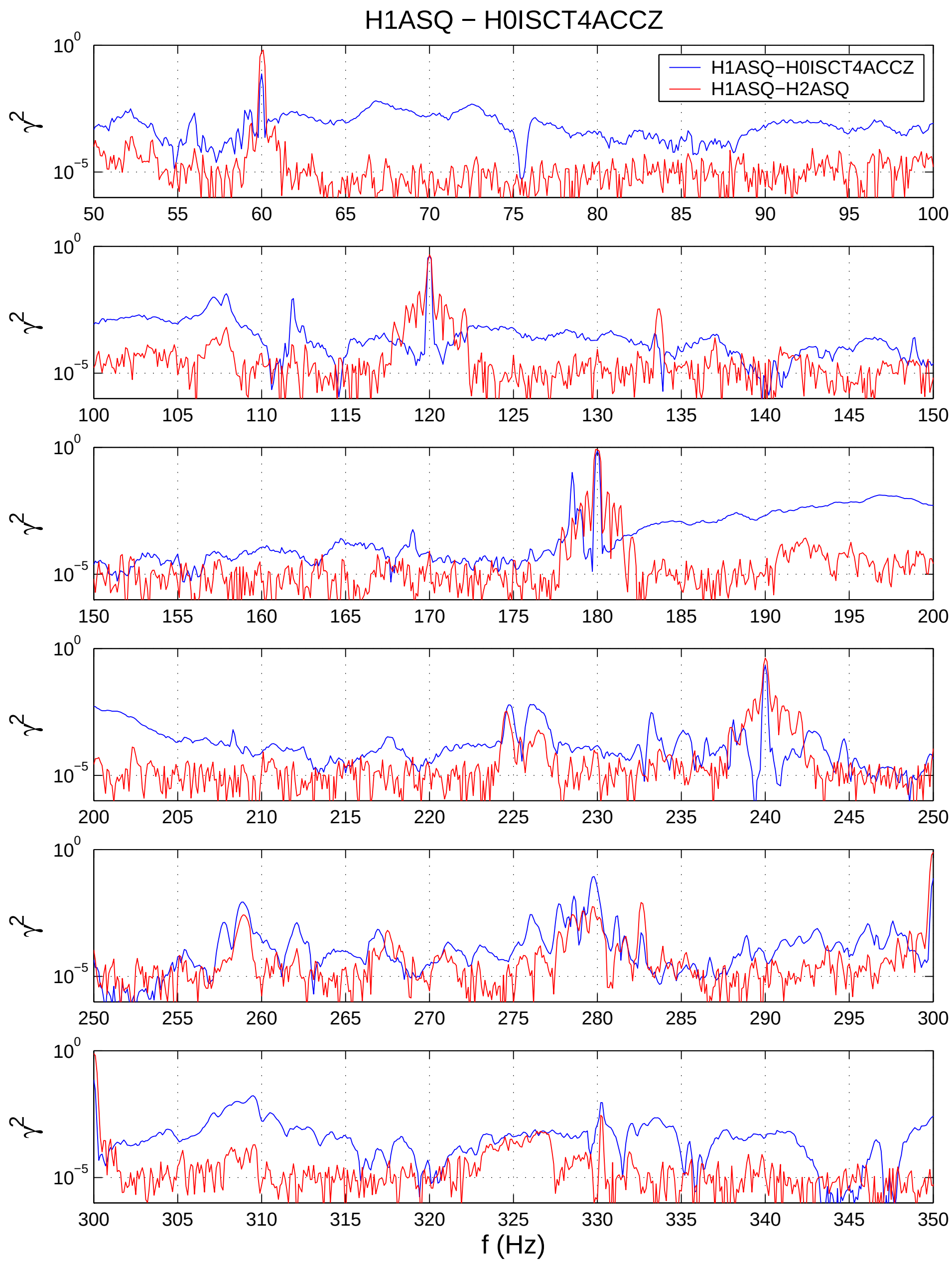

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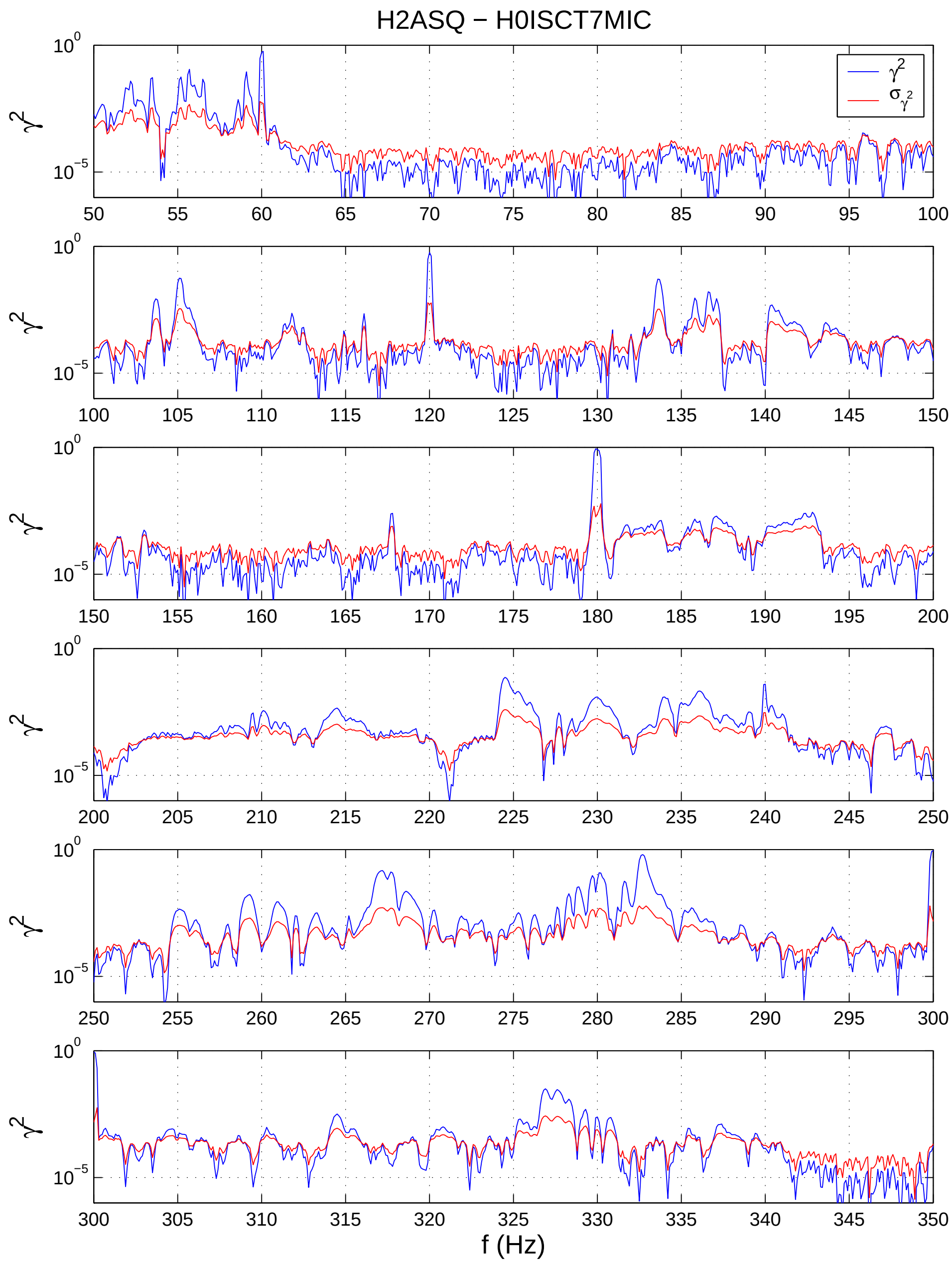

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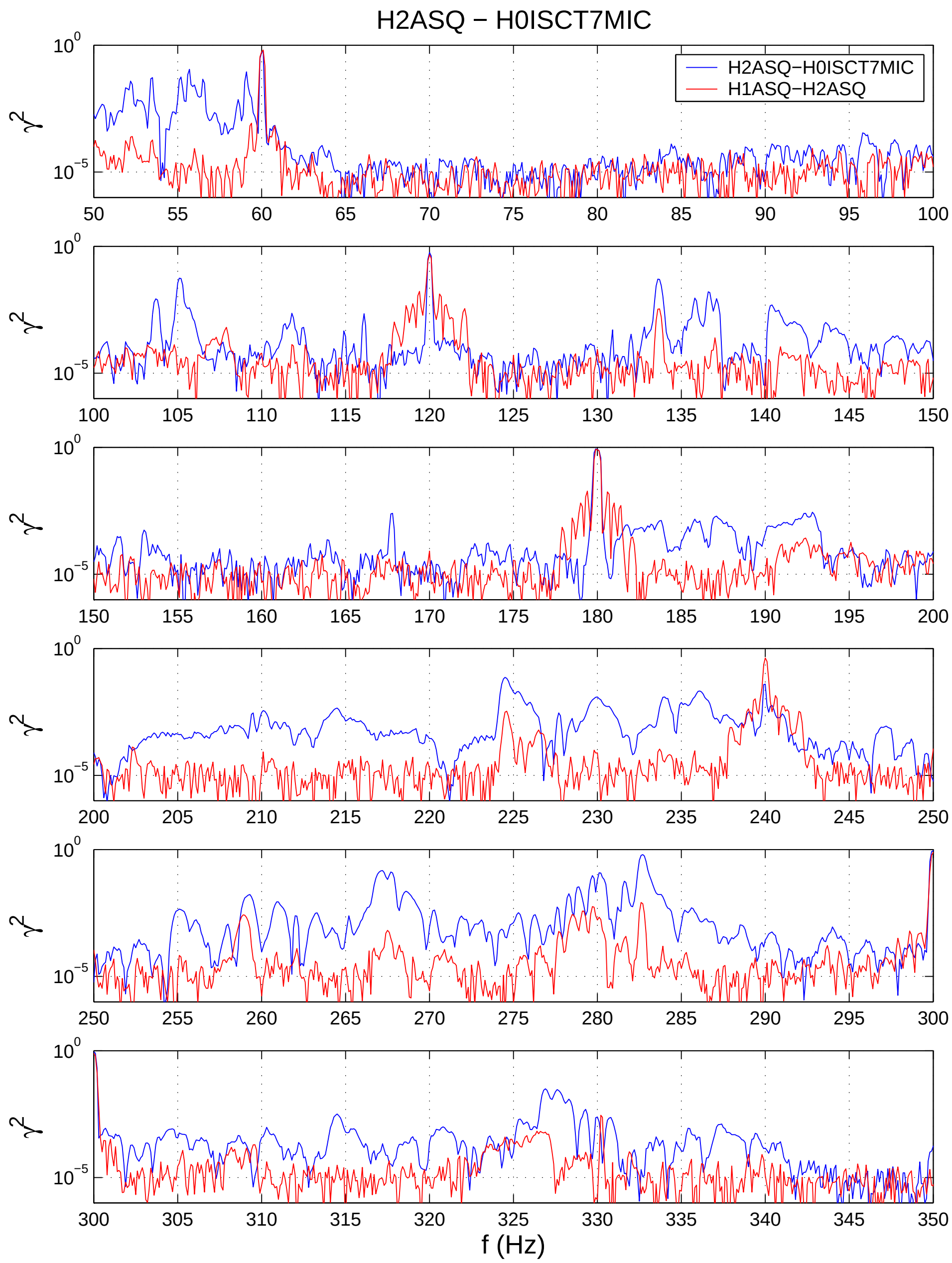
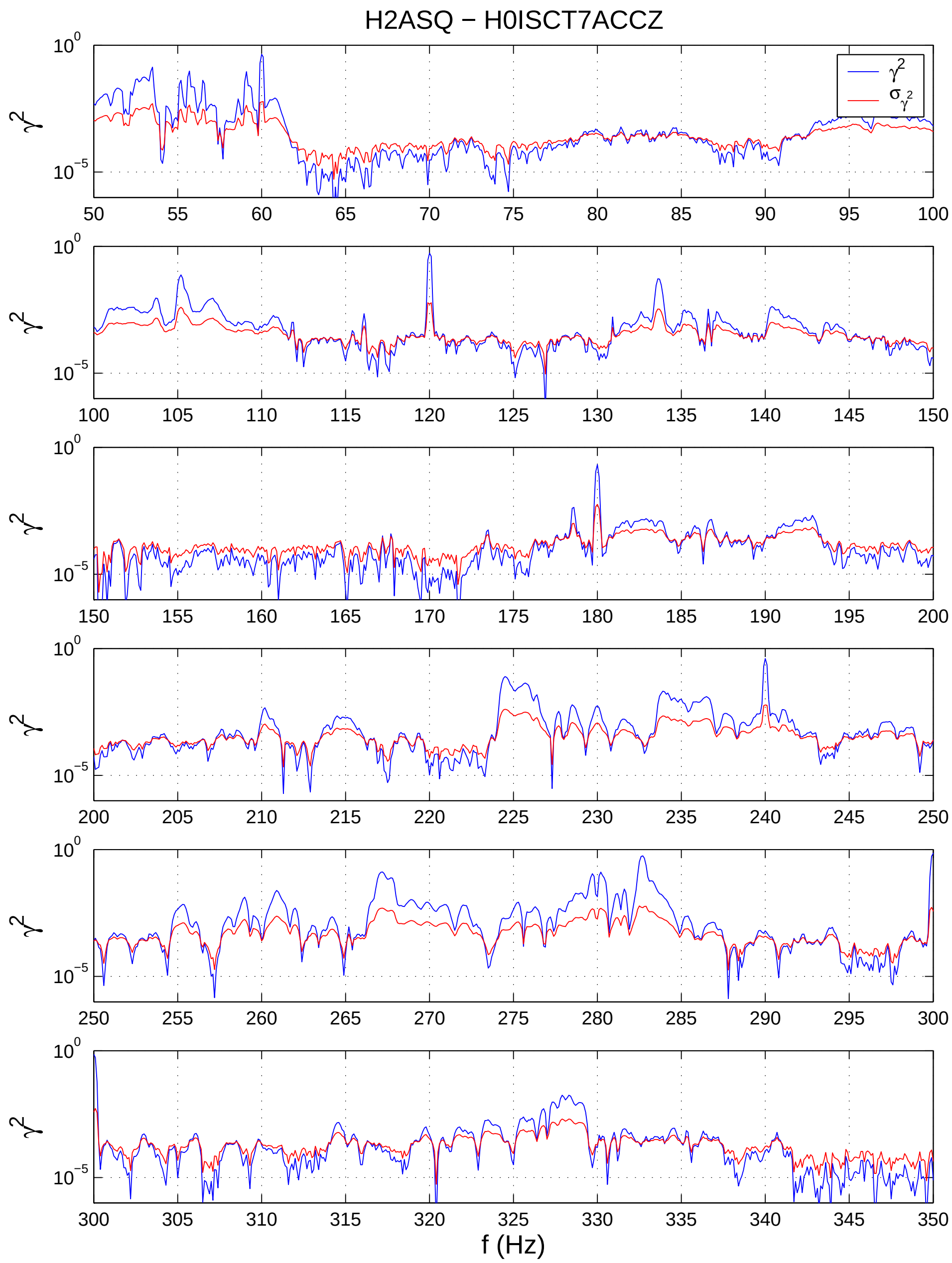


H2ASQ − H0ISCT7MIC
H2ASQ−H0ISCT7MIC
H1ASQ−H2ASQ
γ^2
10^0
10^{-5}
f (Hz)

Figure 20:



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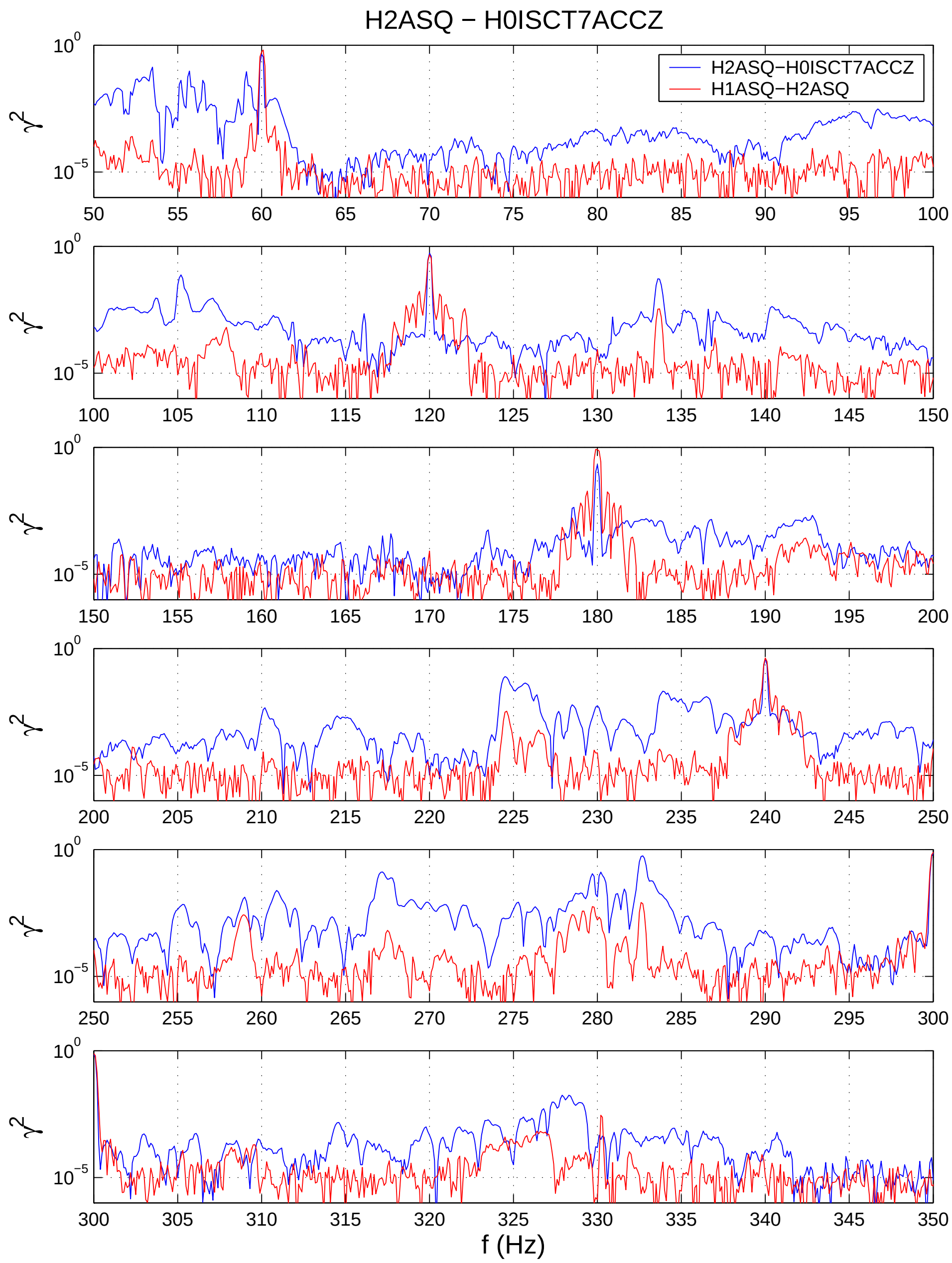

H2ASQ − H0ISCT7ACCZ
H2ASQ−H0ISCT7ACCZ
H1ASQ−H2ASQ
γ^2
f (Hz)

Figure 22:

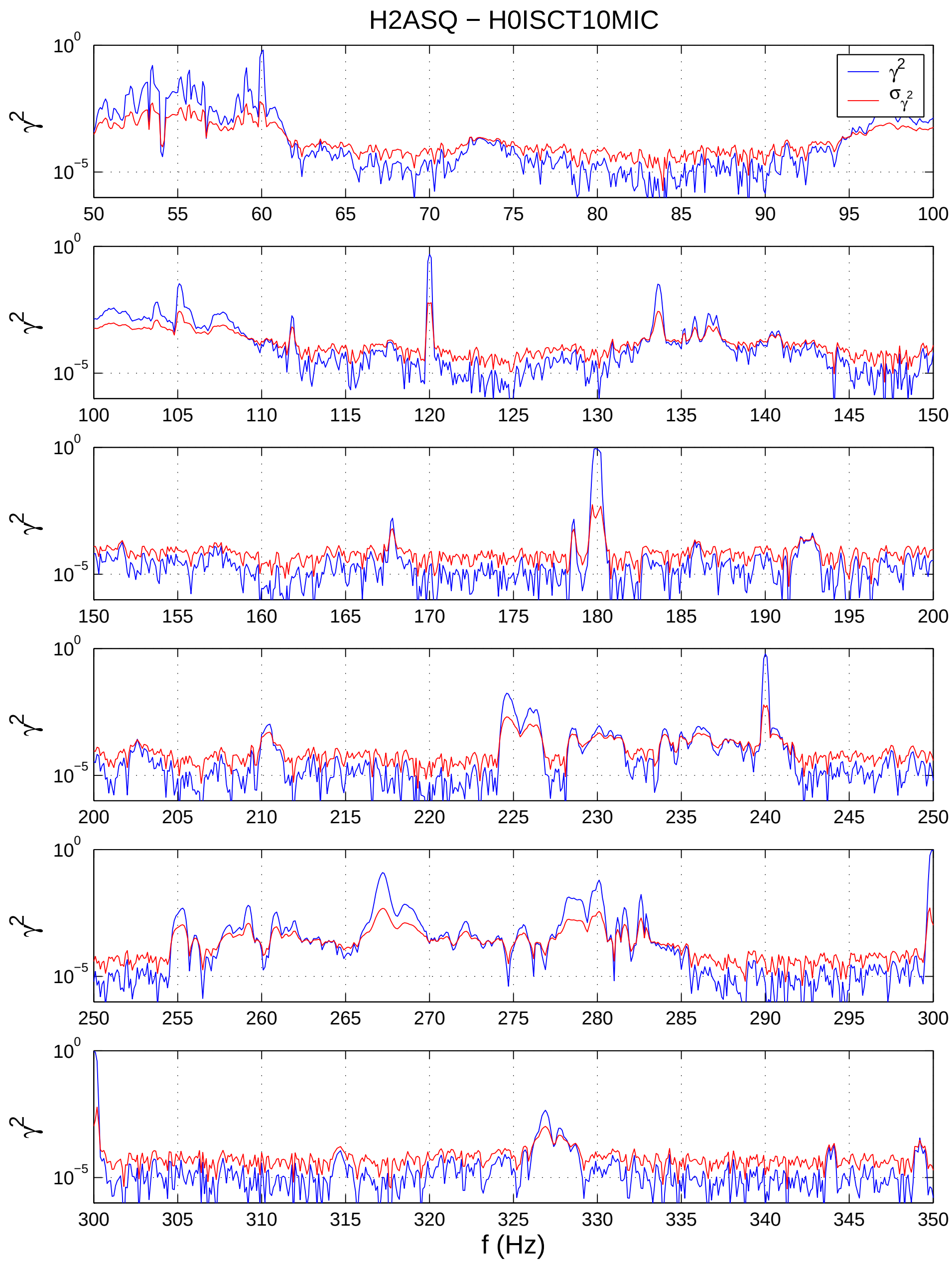
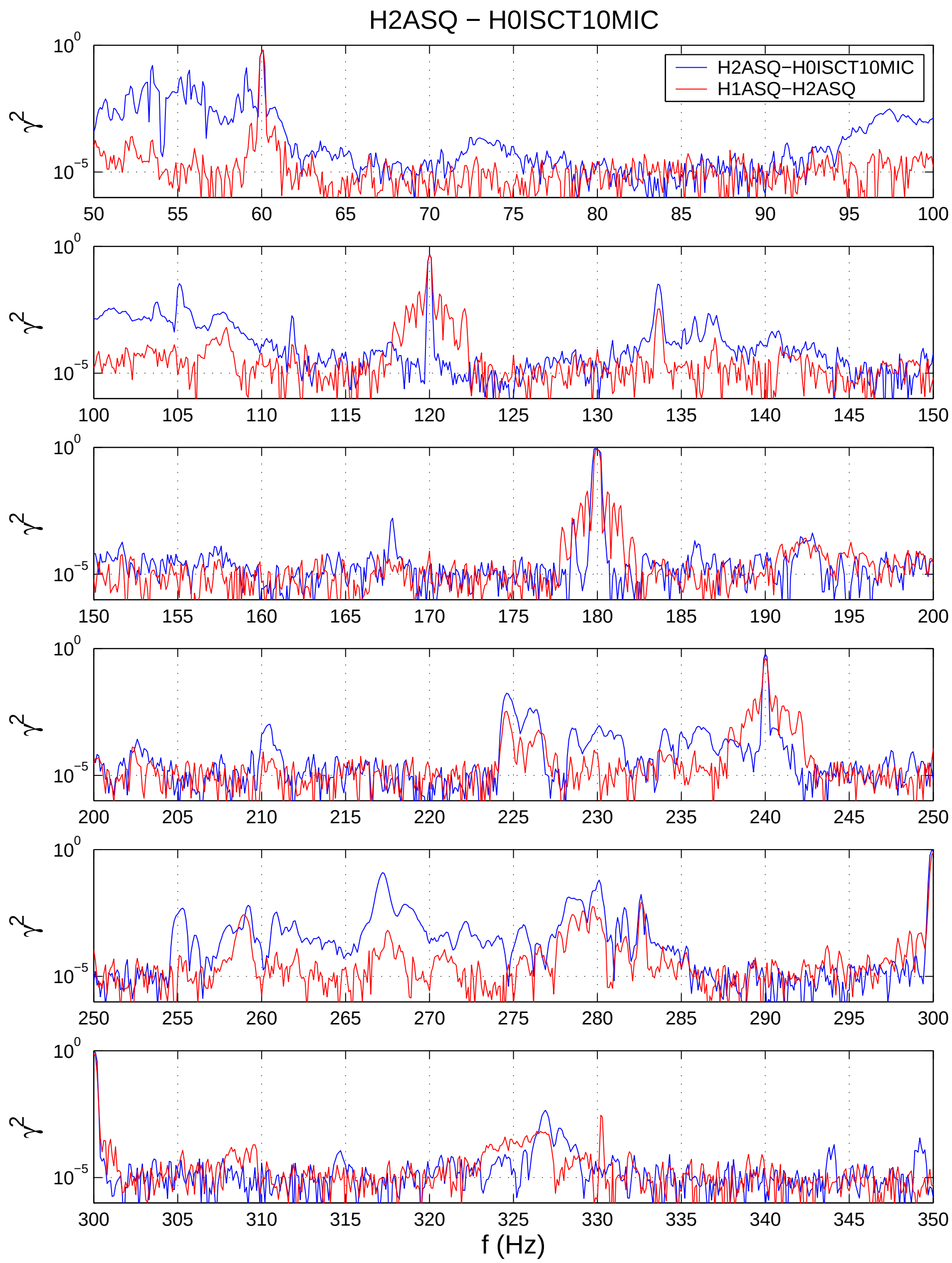
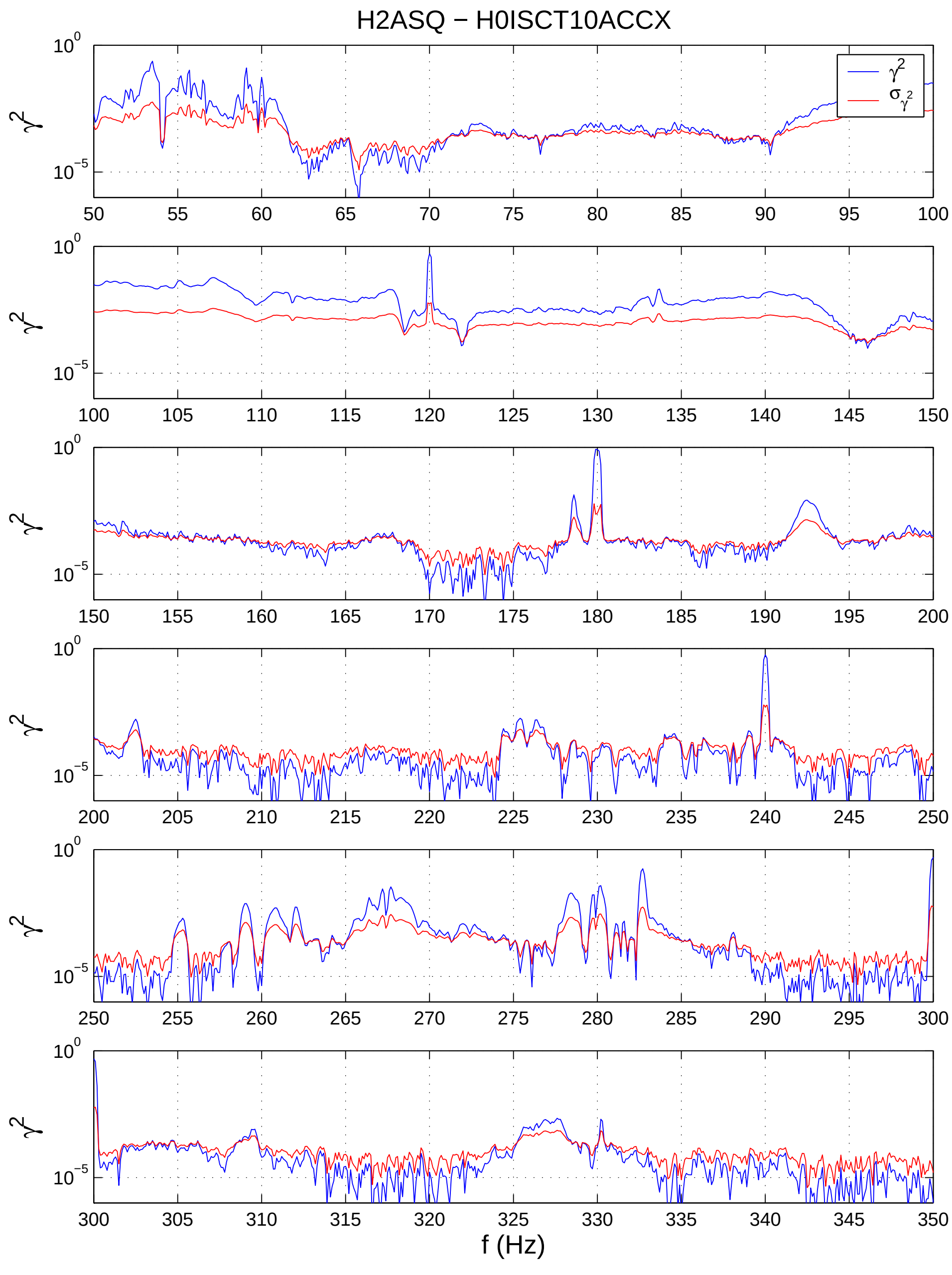

H2ASQ − H0ISCT10MIC
γ^2
σ_{γ^2}
10^0
10^{-5}
50 55 60 65 70 75 80 85 90 95 100
100 105 110 115 120 125 130 135 140 145 150
150 155 160 165 170 175 180 185 190 195 200
200 205 210 215 220 225 230 235 240 245 250
250 255 260 265 270 275 280 285 290 295 300
300 305 310 315 320 325 330 335 340 345 350
f (Hz)

Figure 23:



H2ASQ − H0ISCT10MIC
H2ASQ−H0ISCT10MIC
H1ASQ−H2ASQ
γ²
10^0
10^−5
f (Hz)

Figure 24:



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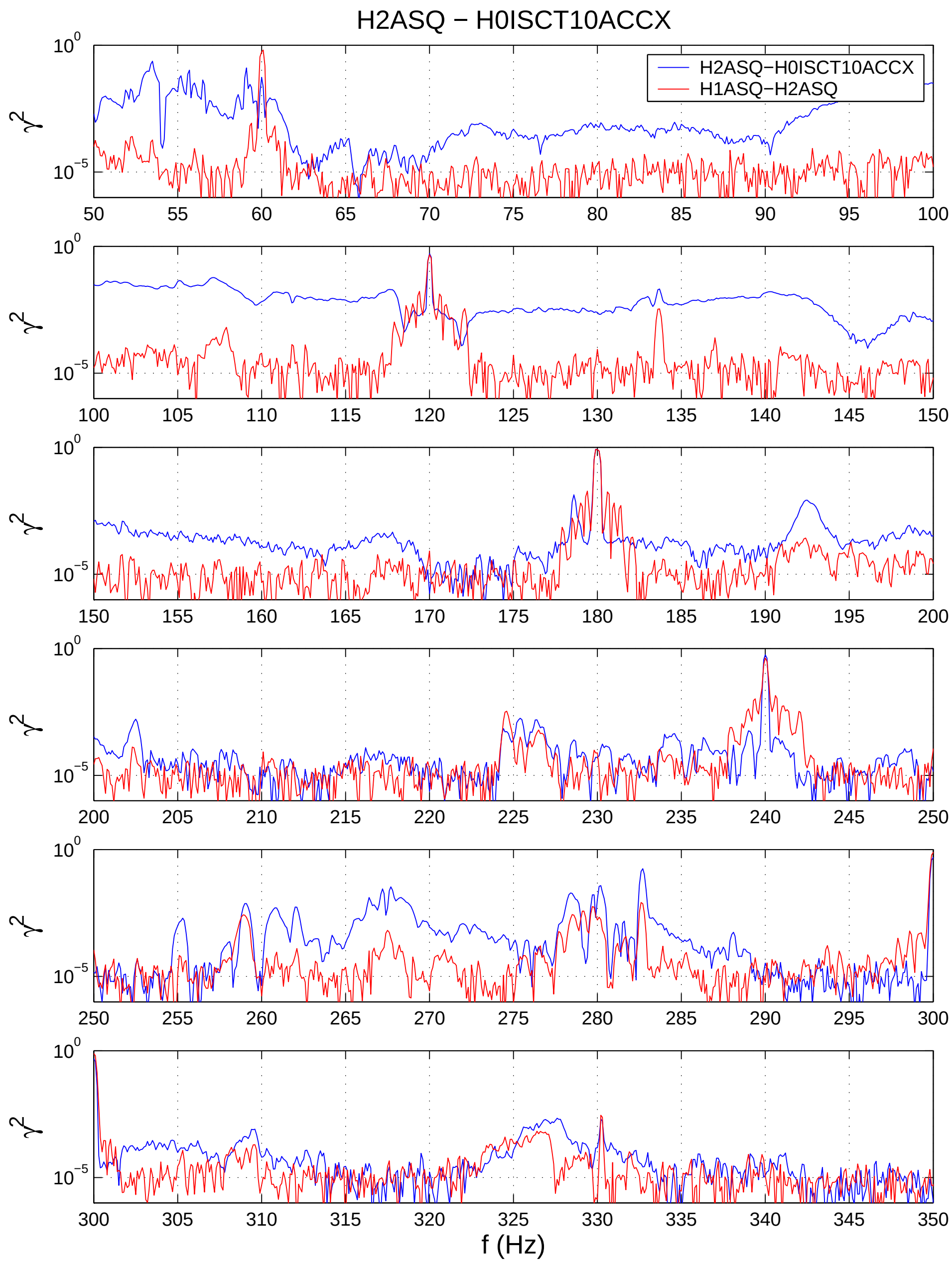

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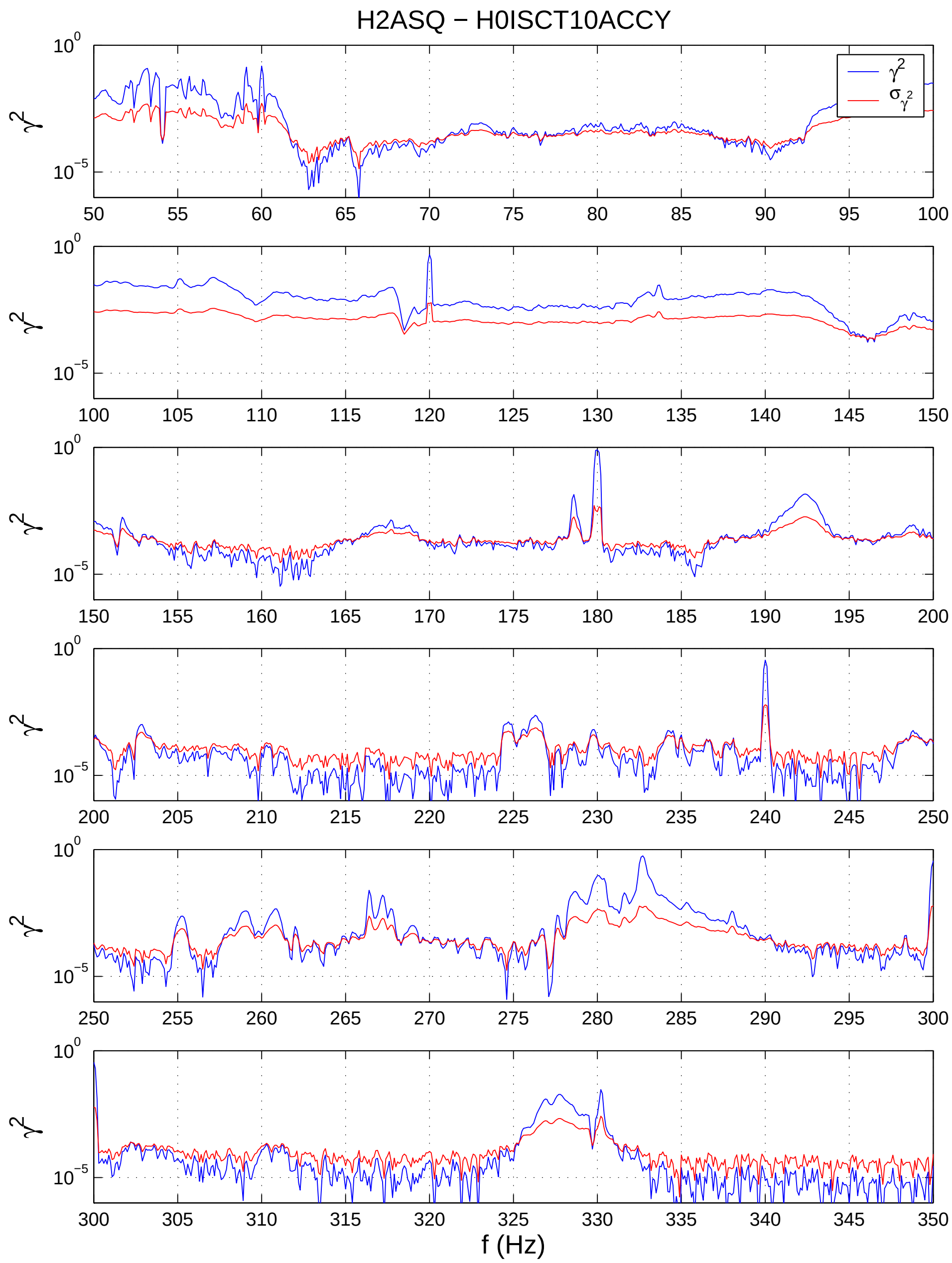

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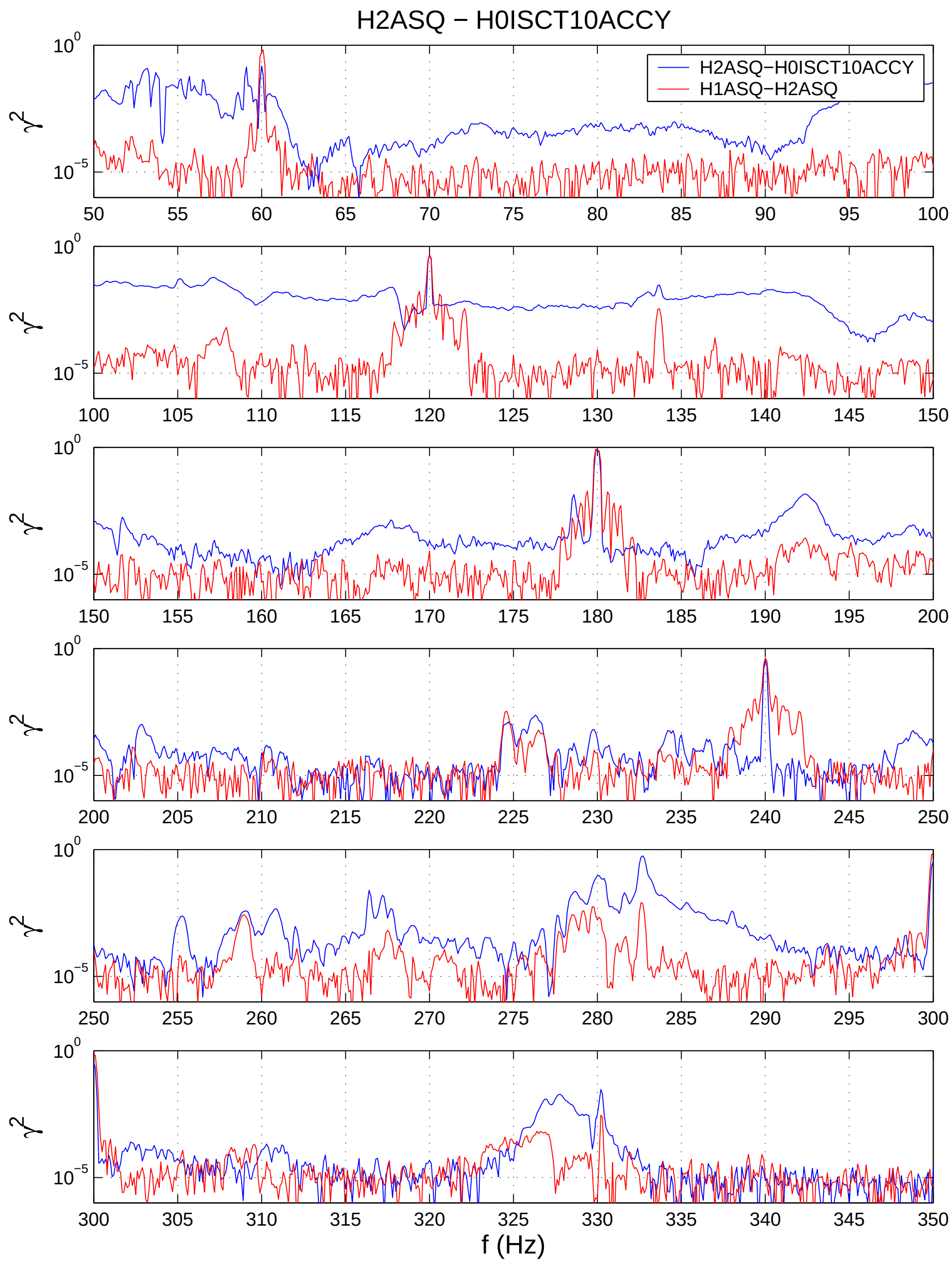
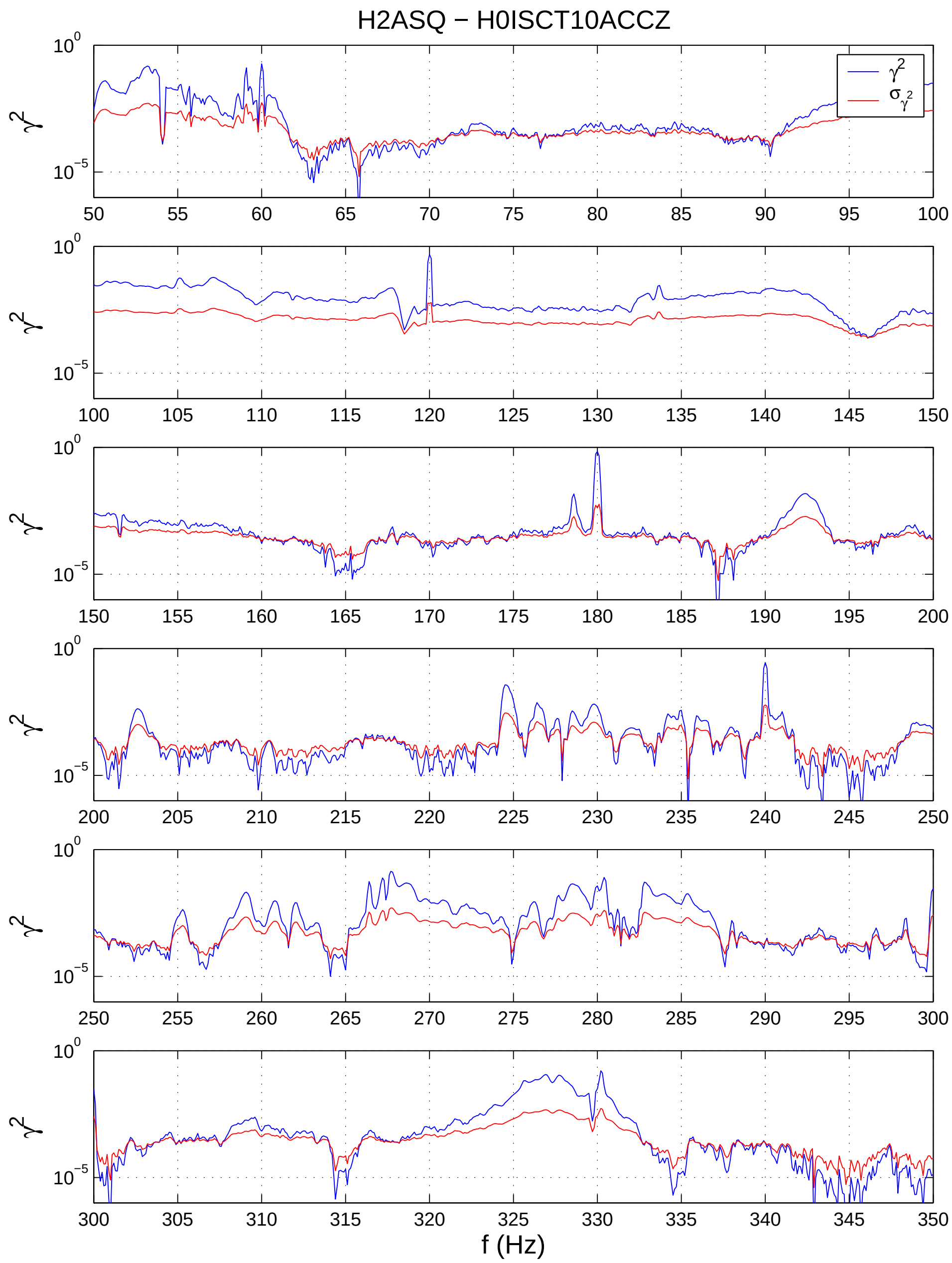

H2ASQ − H0ISCT10ACCY
H2ASQ−H0ISCT10ACCY
H1ASQ−H2ASQ
γ²
10^0
10^−5
f (Hz)

Figure 28:



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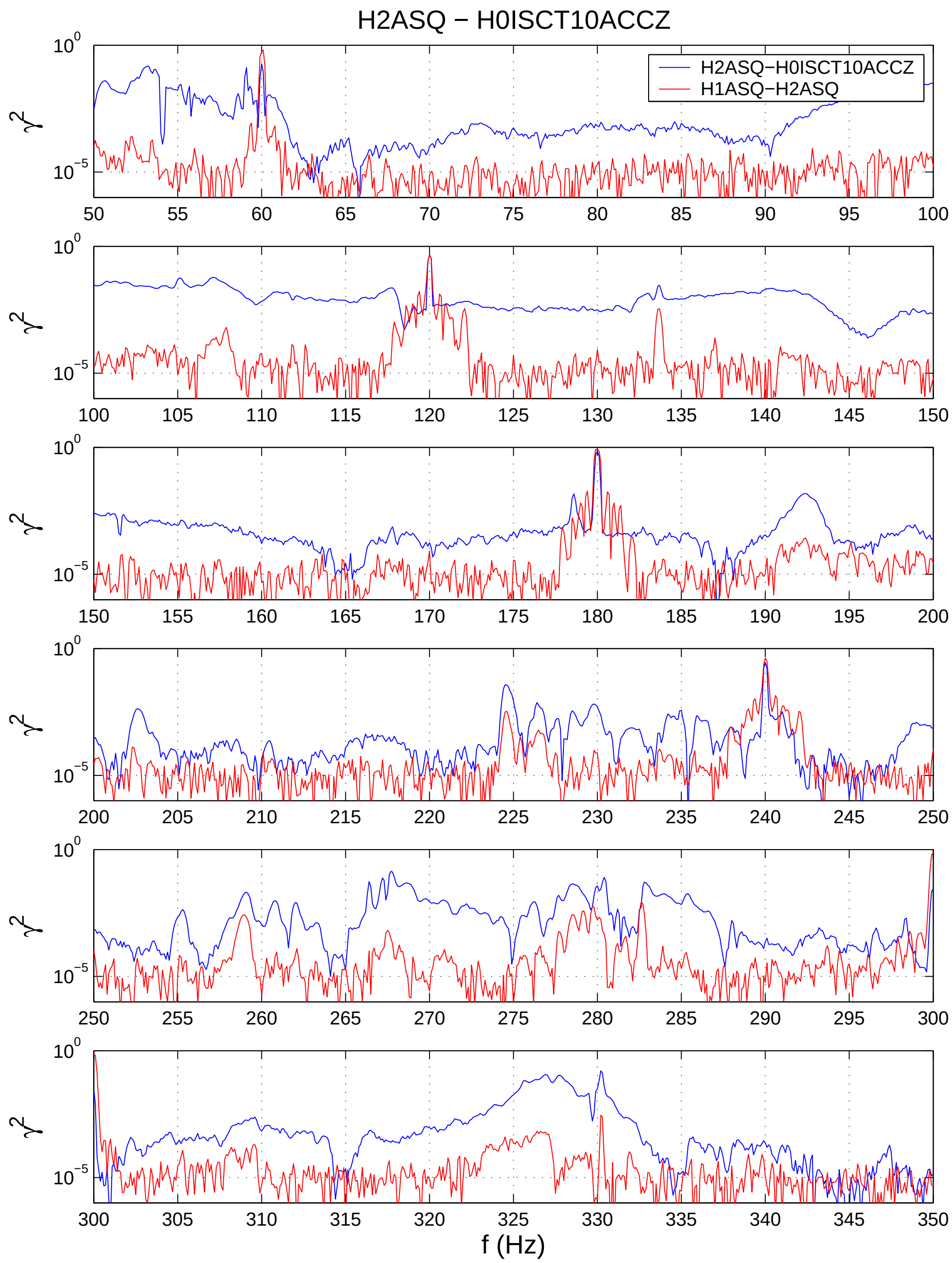
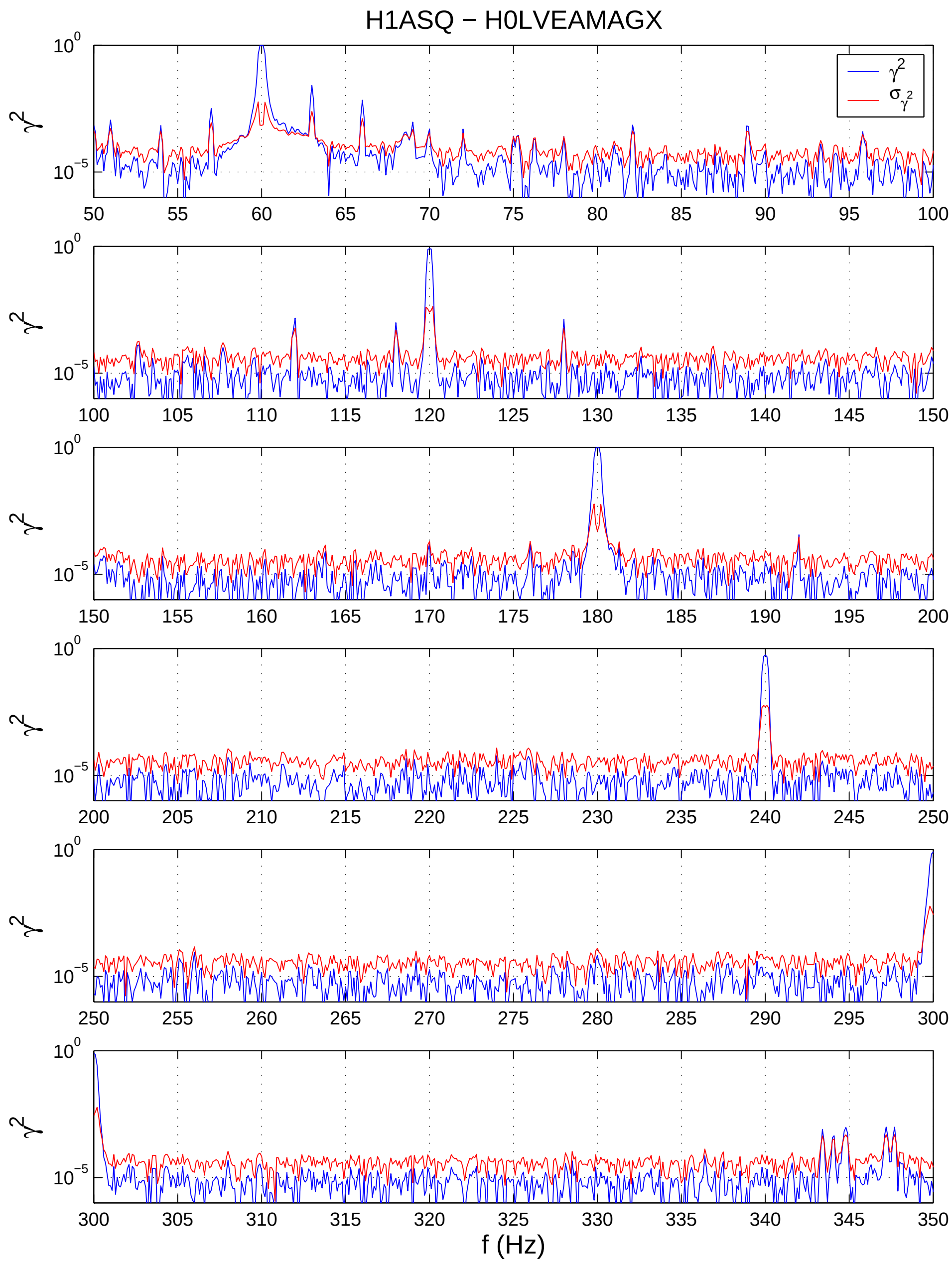

H2ASQ − H0ISCT10ACCZ
H2ASQ−H0ISCT10ACCZ
H1ASQ−H2ASQ
γ^2
10^0
10^{-5}
50 55 60 65 70 75 80 85 90 95 100
100 105 110 115 120 125 130 135 140 145 150
150 155 160 165 170 175 180 185 190 195 200
200 205 210 215 220 225 230 235 240 245 250
250 255 260 265 270 275 280 285 290 295 300
300 305 310 315 320 325 330 335 340 345 350
f (Hz)

Figure 30:



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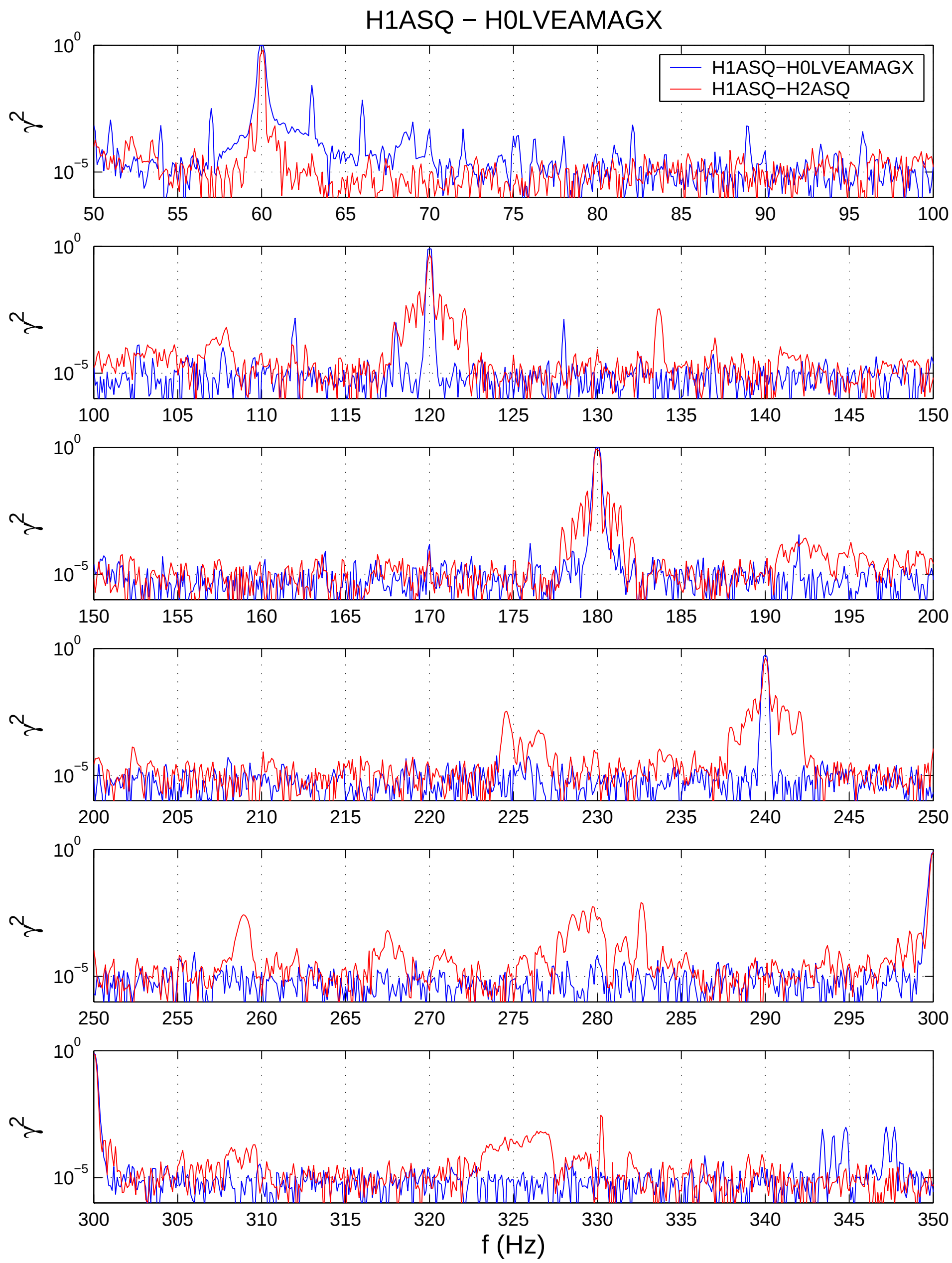

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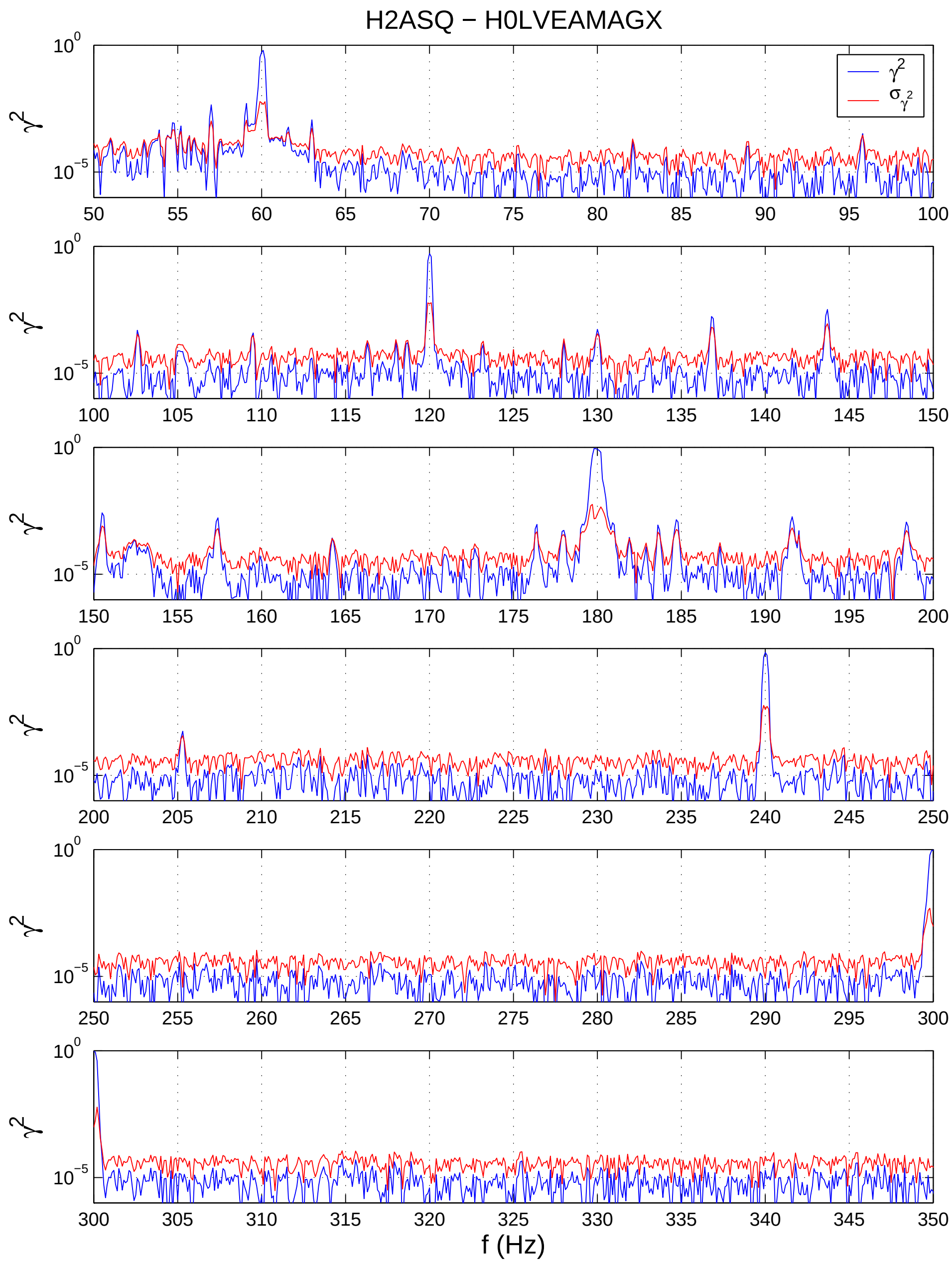

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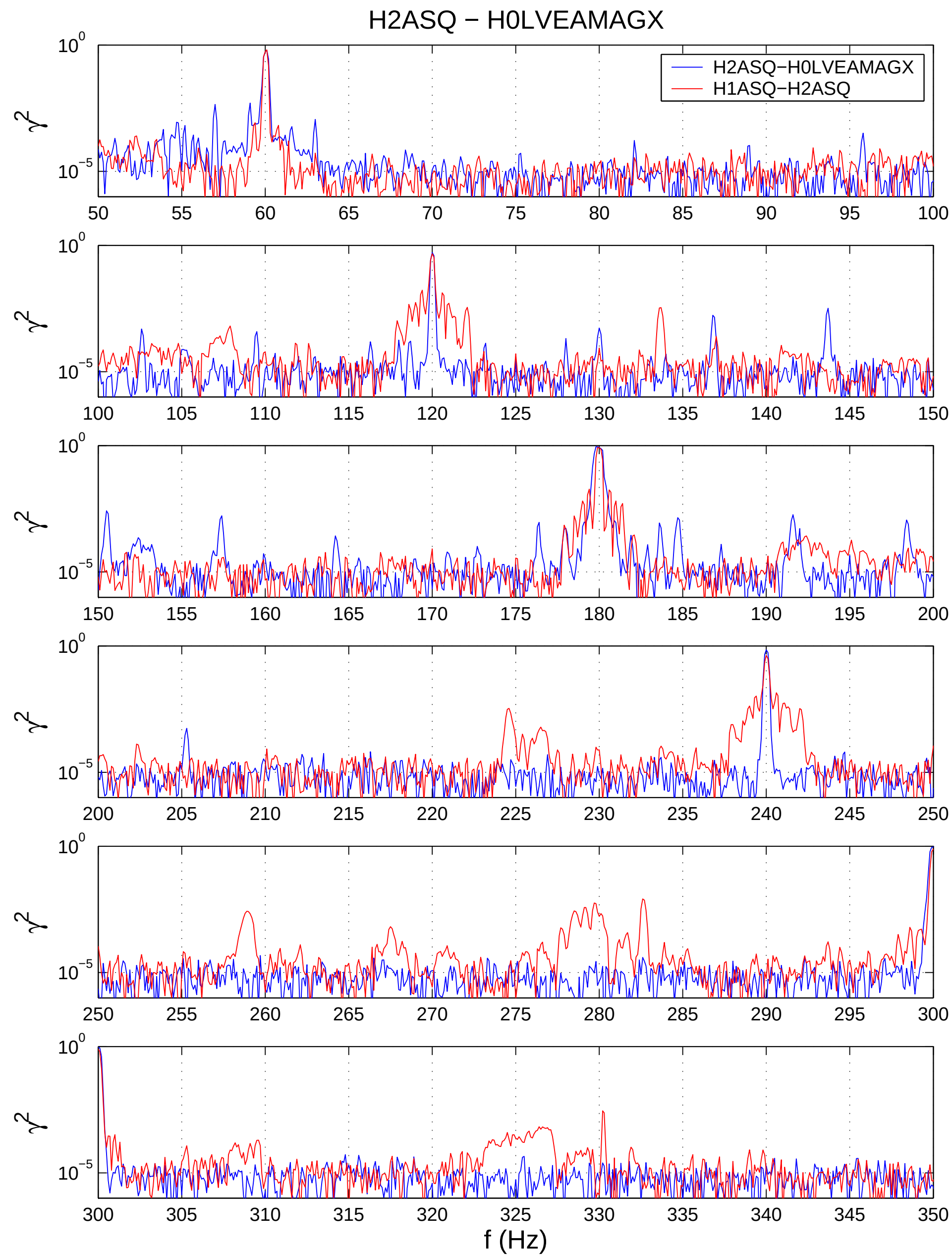

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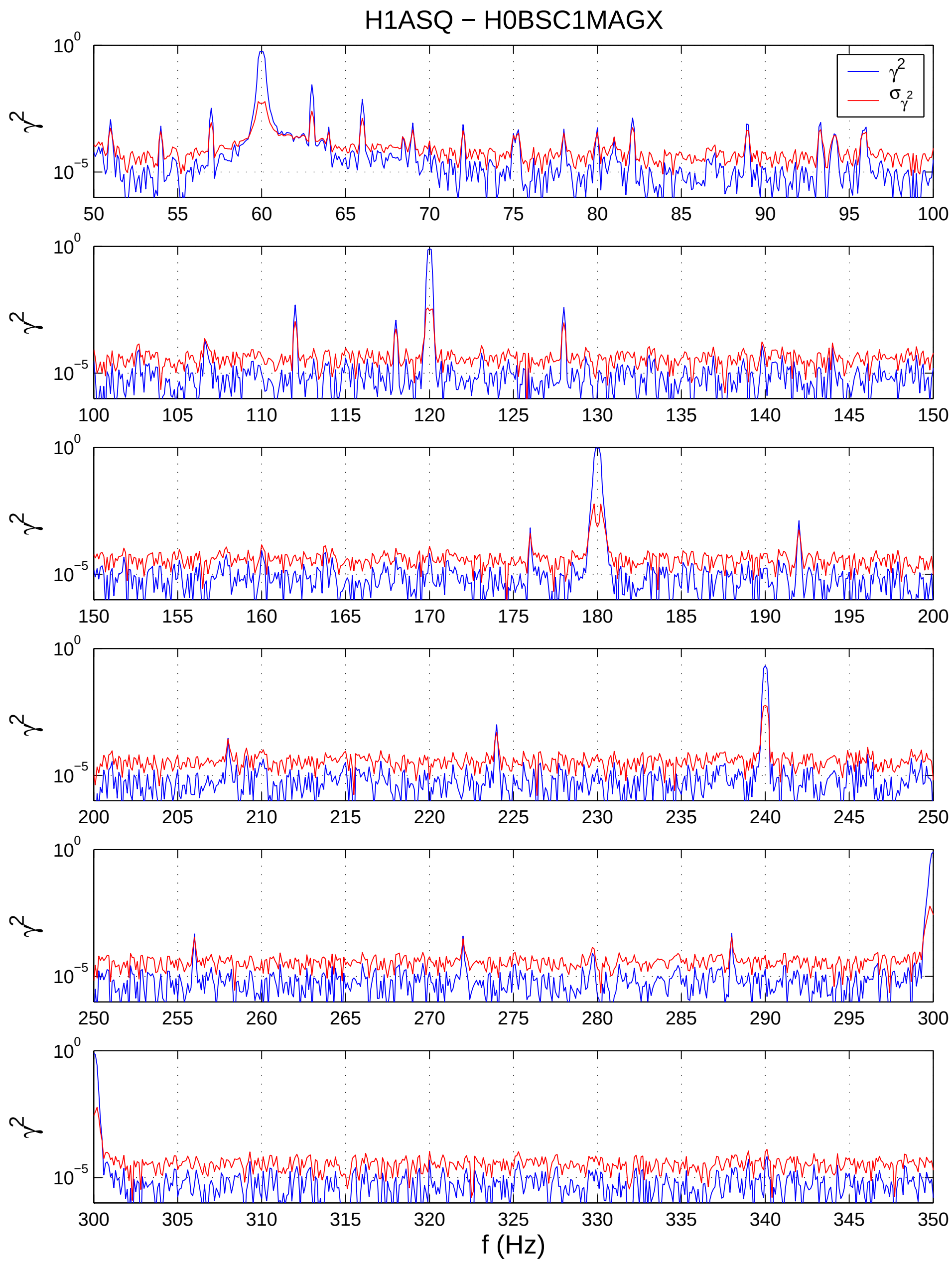

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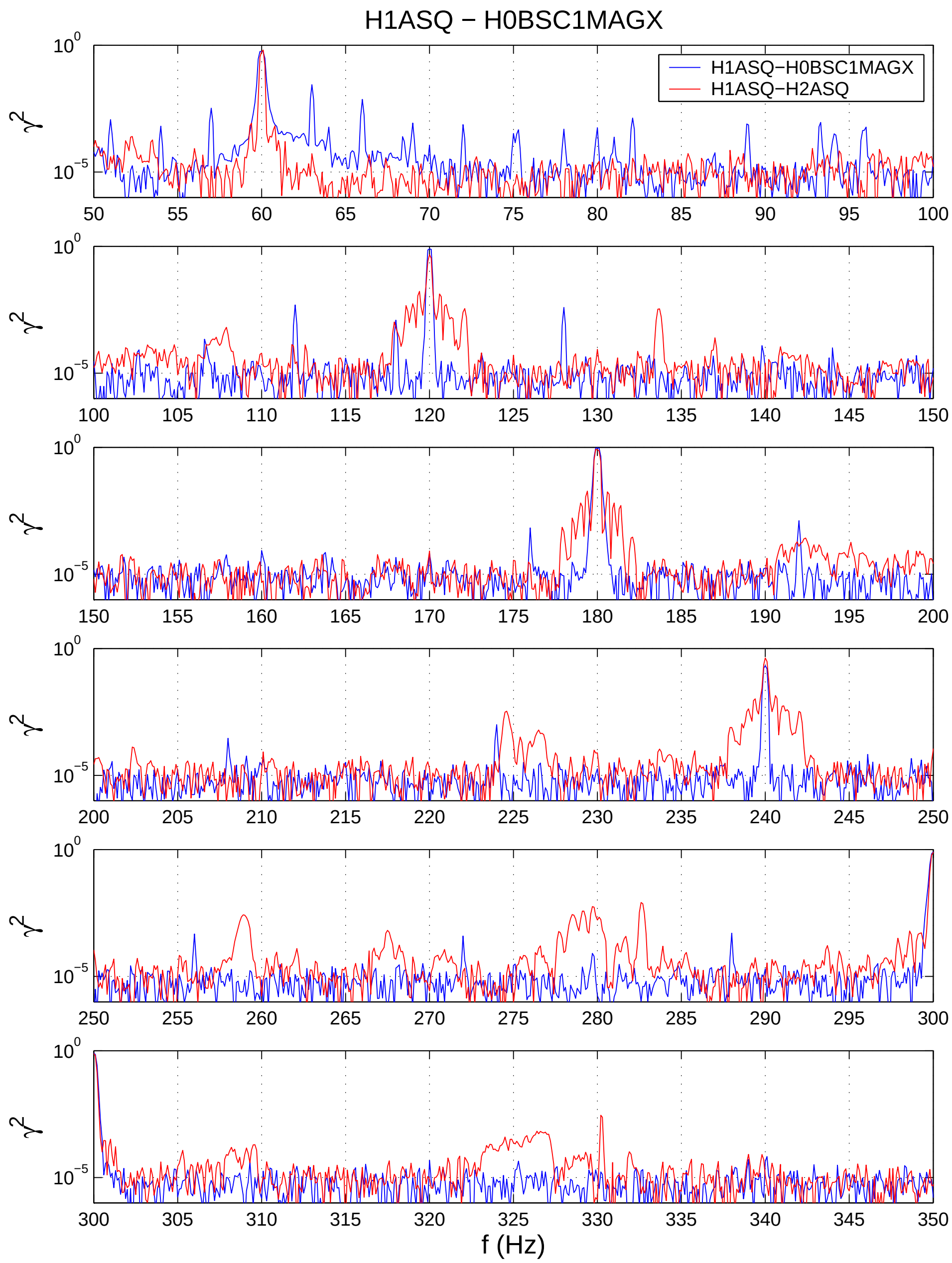
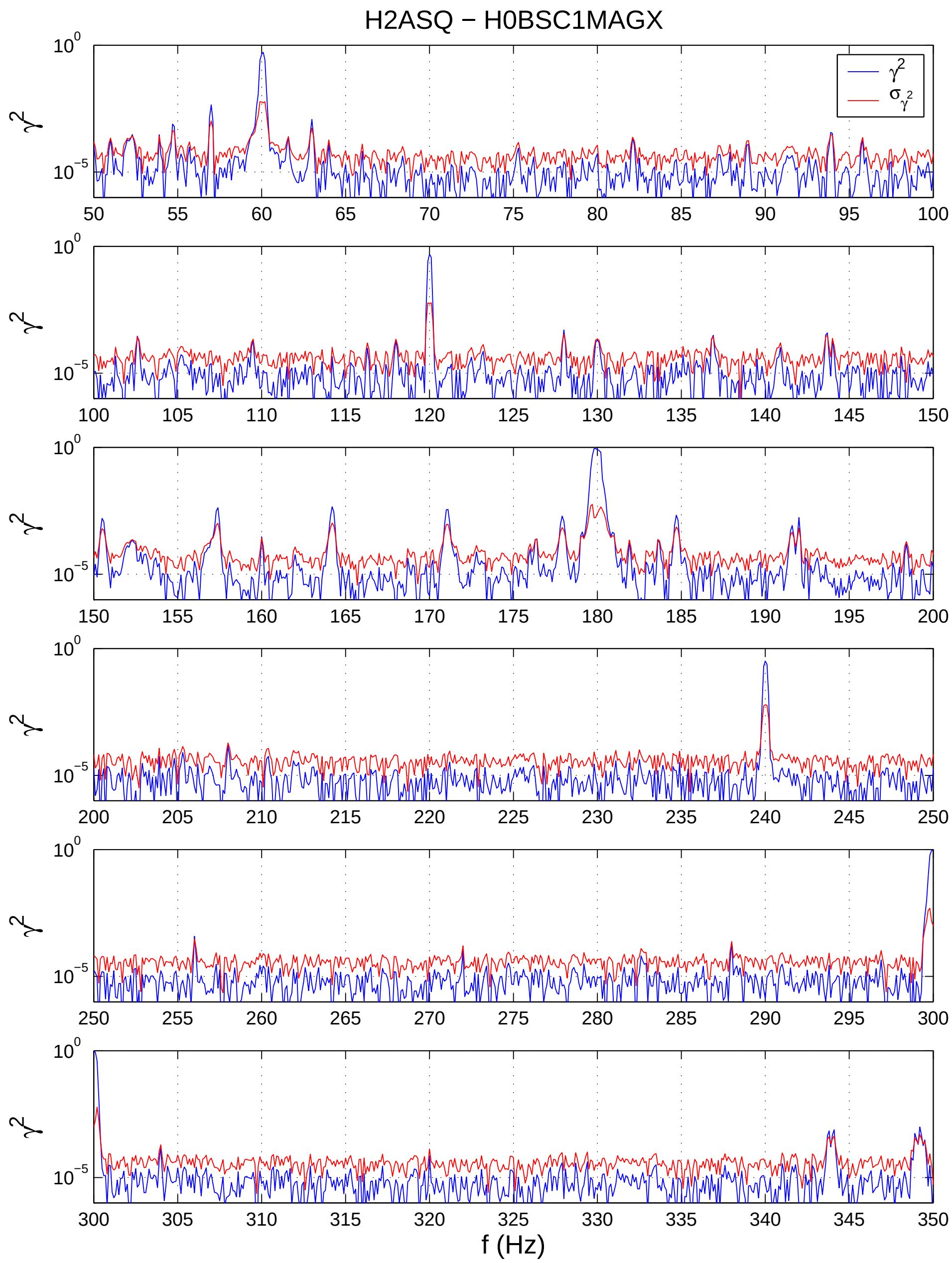


H1ASQ − H0BSC1MAGX
H1ASQ−H0BSC1MAGX
H1ASQ−H2ASQ
γ^2
10^0
10^{-5}
50 55 60 65 70 75 80 85 90 95 100
100 105 110 115 120 125 130 135 140 145 150
150 155 160 165 170 175 180 185 190 195 200
200 205 210 215 220 225 230 235 240 245 250
250 255 260 265 270 275 280 285 290 295 300
300 305 310 315 320 325 330 335 340 345 350
f (Hz)

Figure 36:



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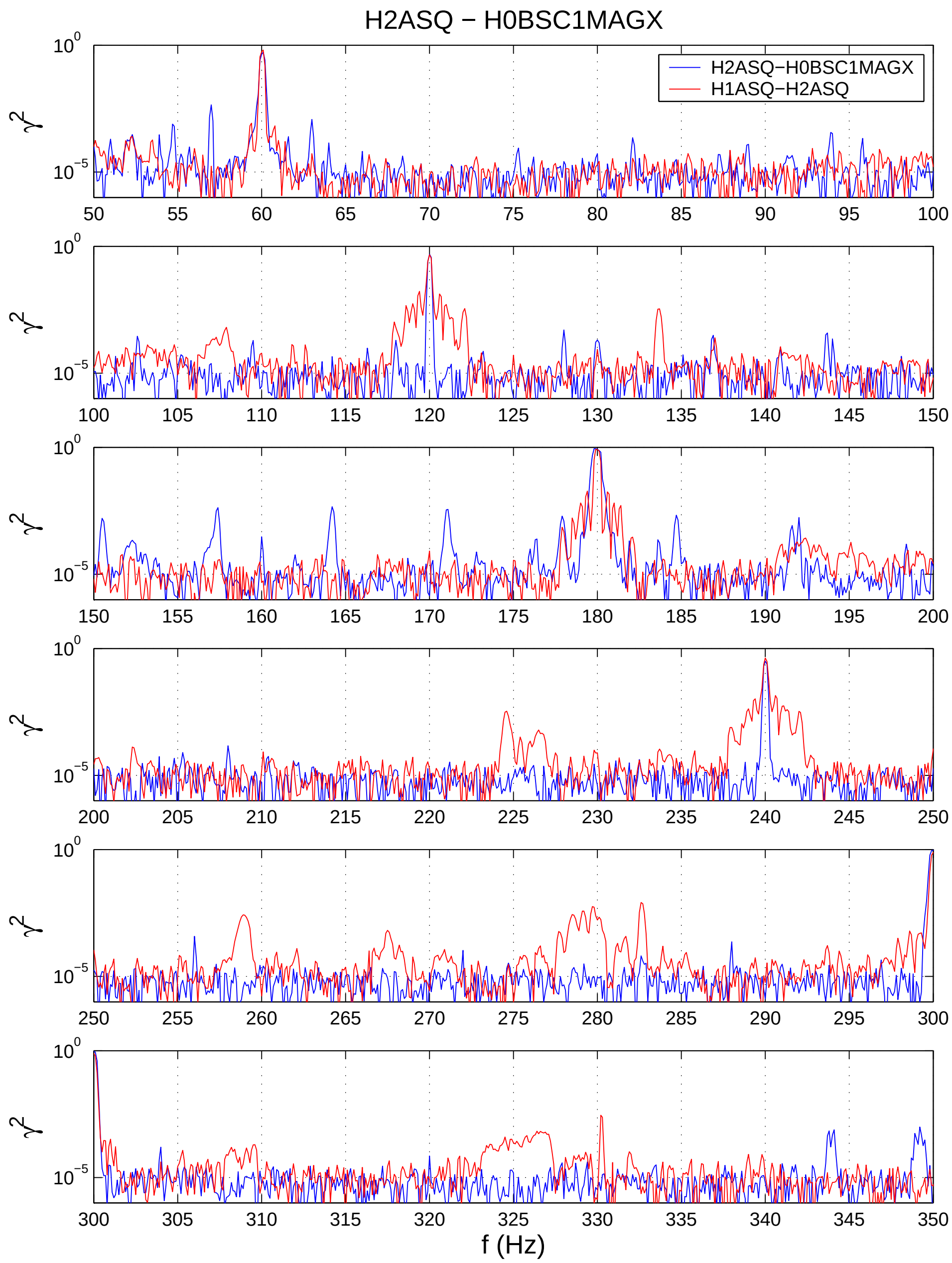
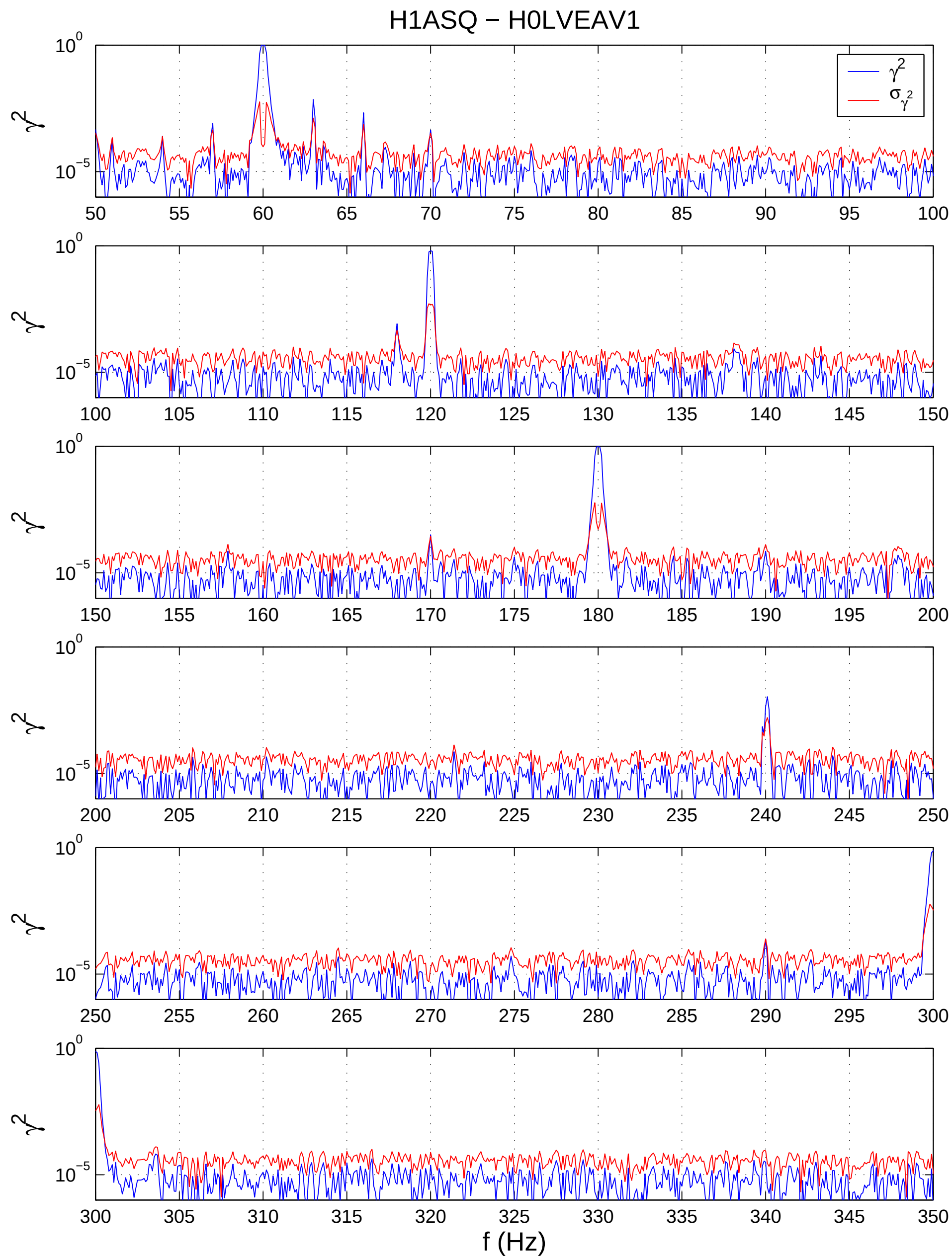


H2ASQ − H0BSC1MAGX
H2ASQ−H0BSC1MAGX
H1ASQ−H2ASQ
γ^2
10^0
10^{-5}
50 55 60 65 70 75 80 85 90 95 100
100 105 110 115 120 125 130 135 140 145 150
150 155 160 165 170 175 180 185 190 195 200
200 205 210 215 220 225 230 235 240 245 250
250 255 260 265 270 275 280 285 290 295 300
300 305 310 315 320 325 330 335 340 345 350
f (Hz)

Figure 38:



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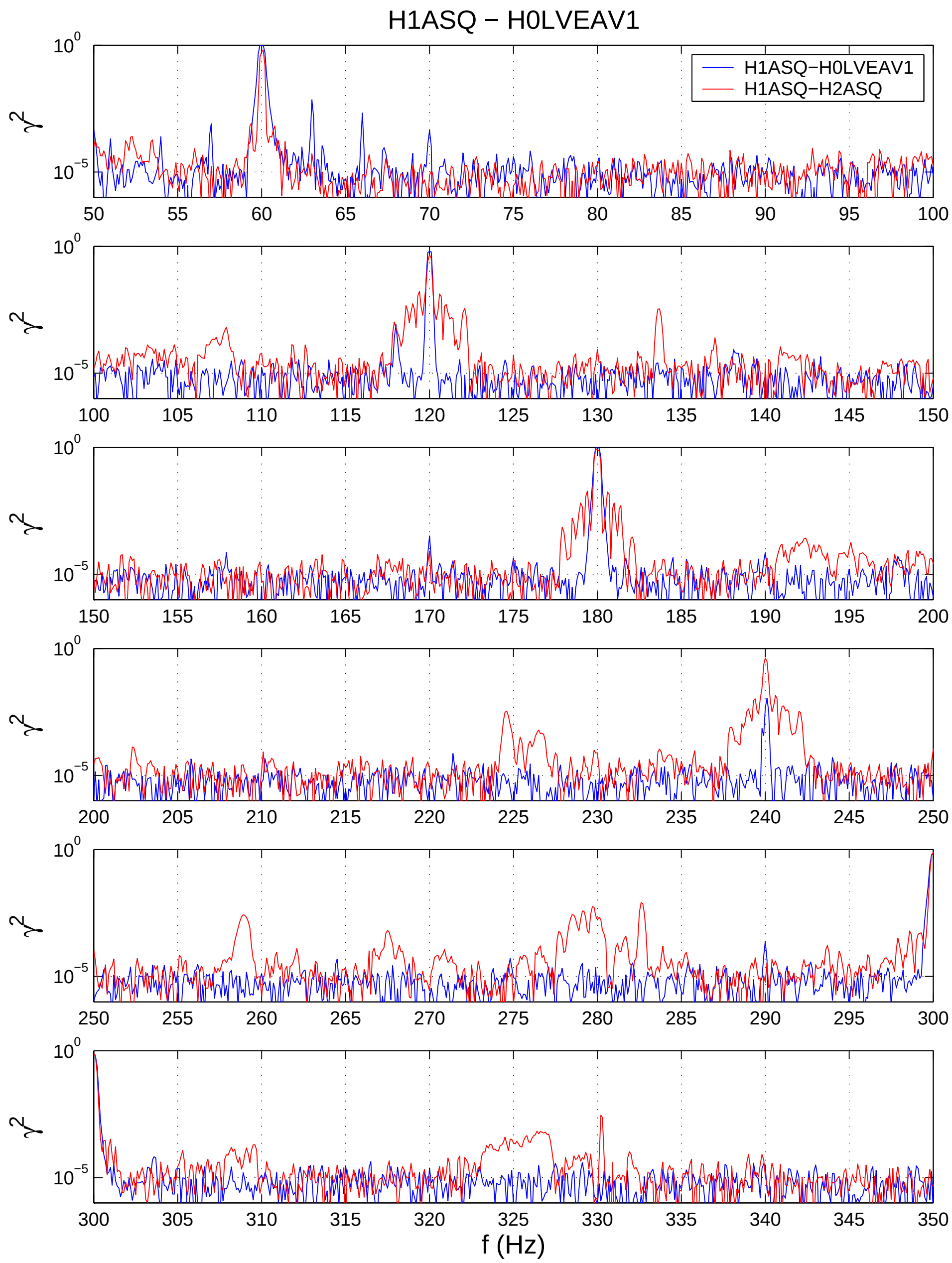

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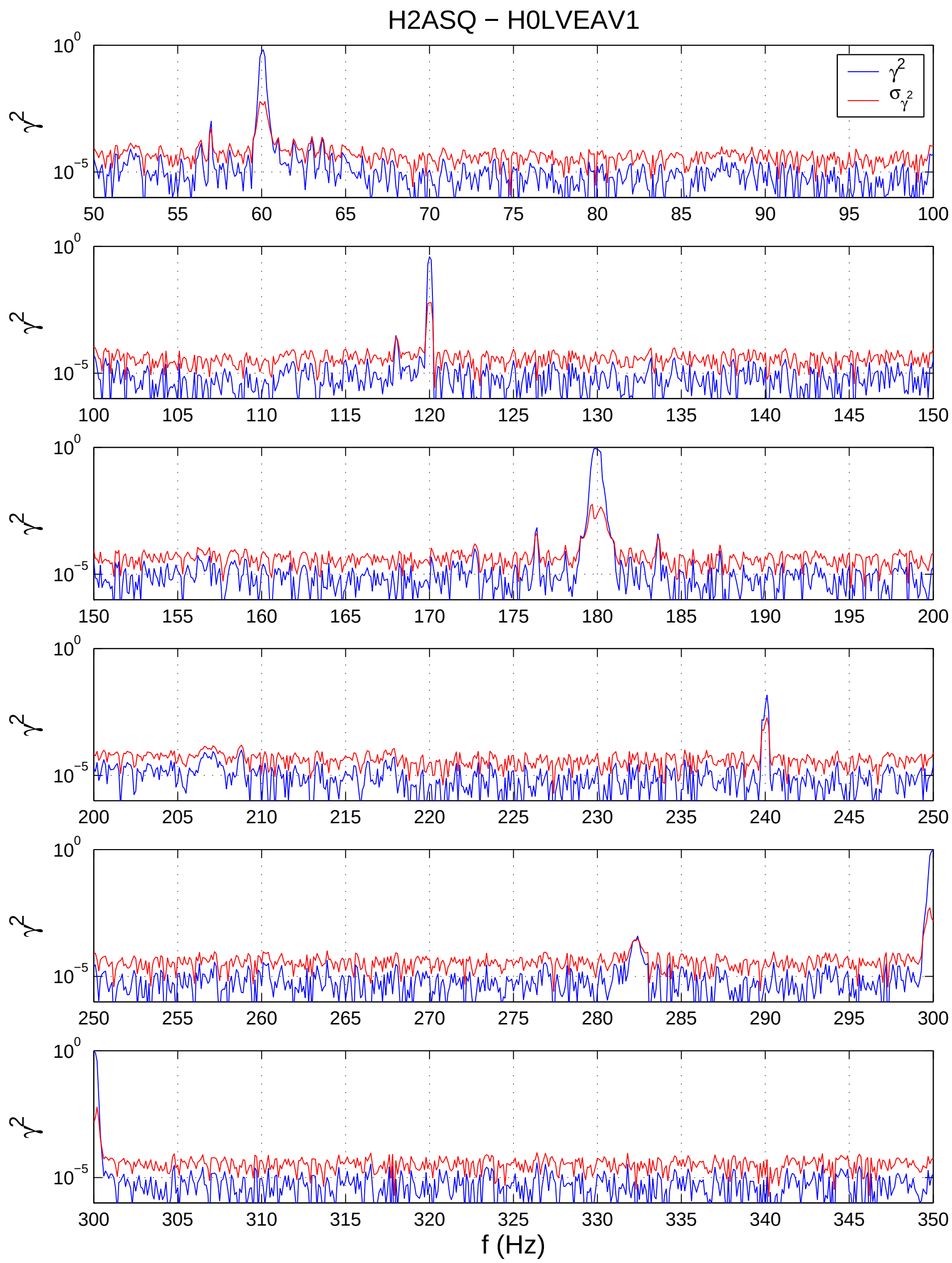

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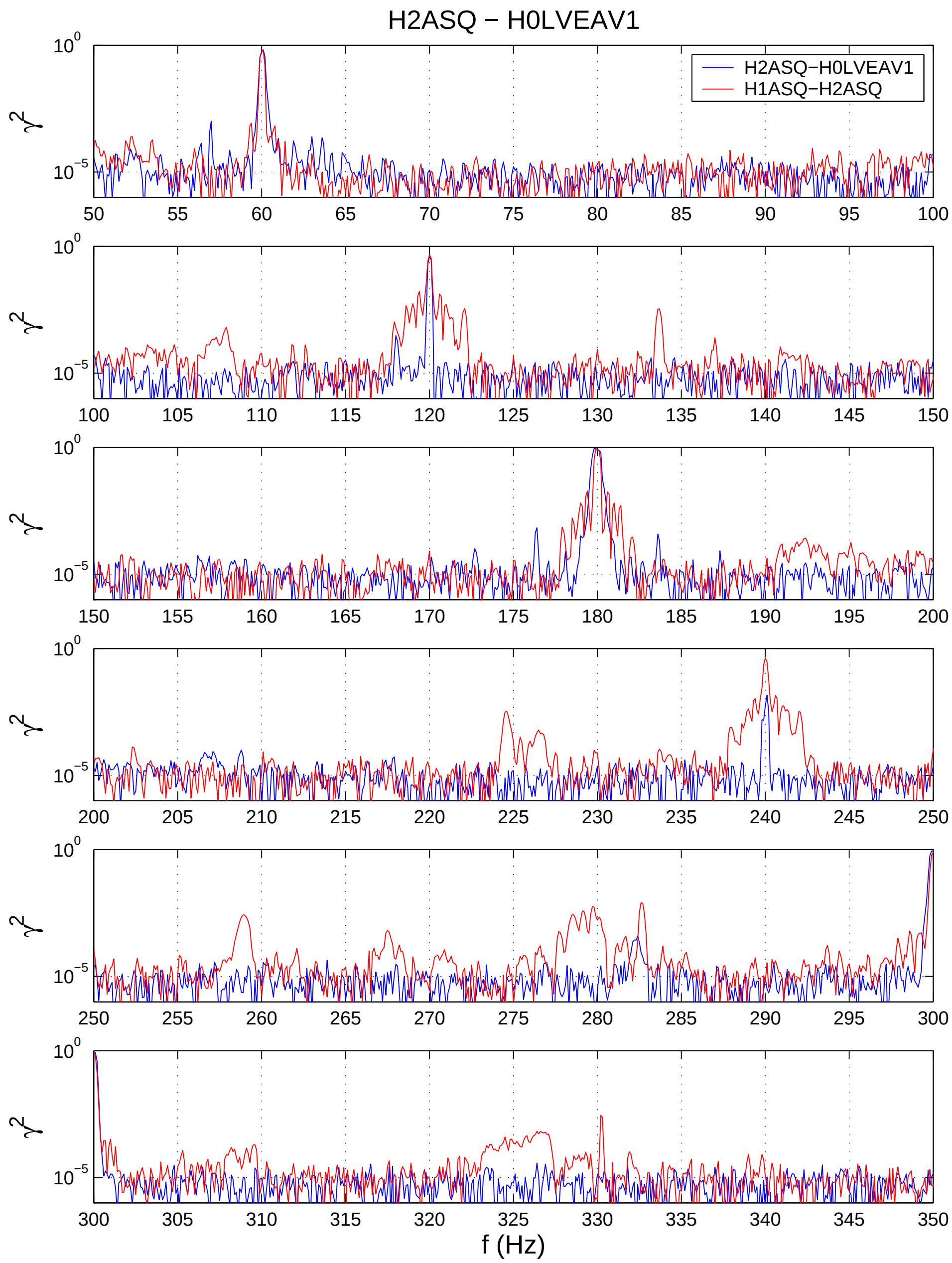

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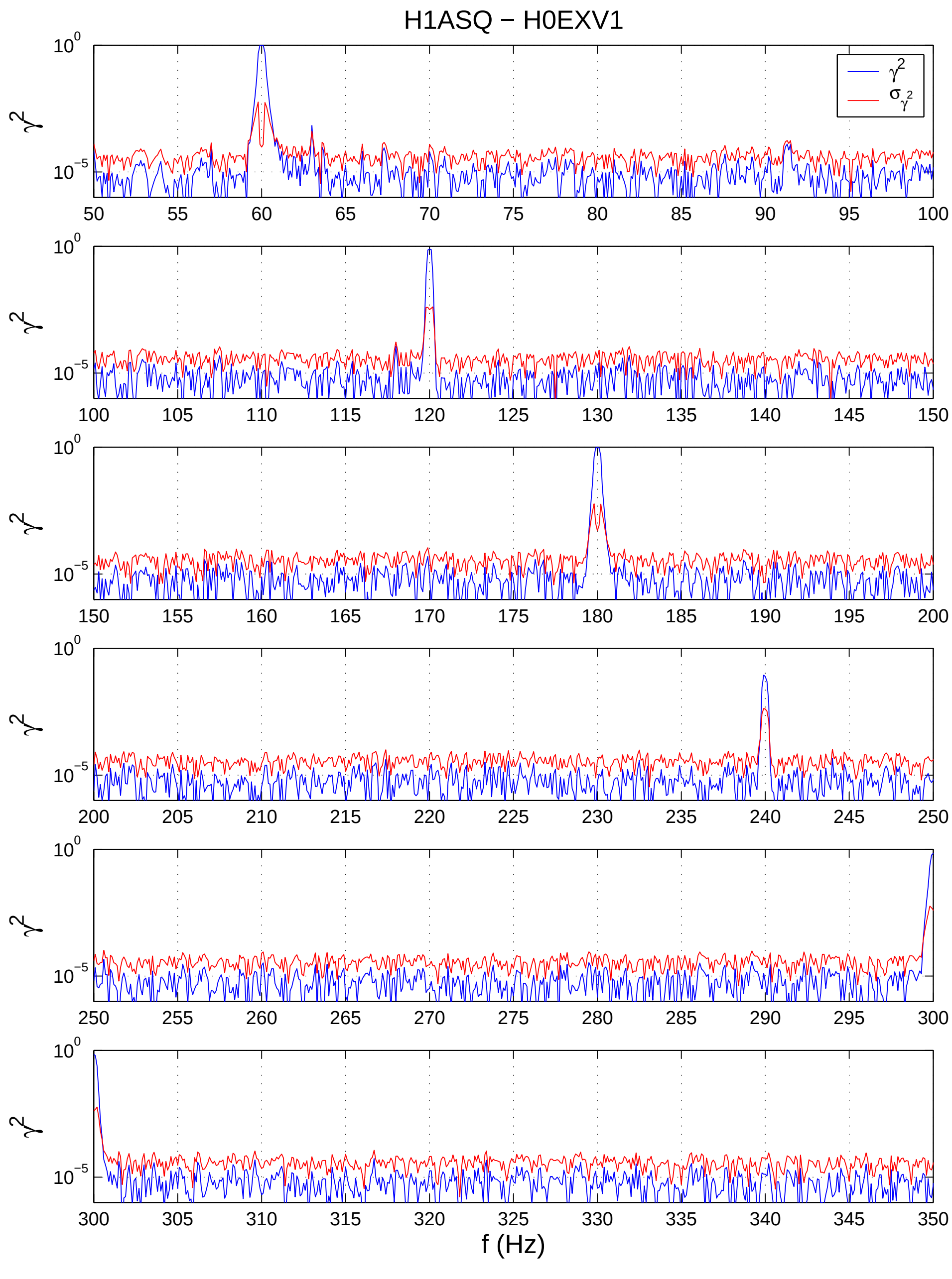

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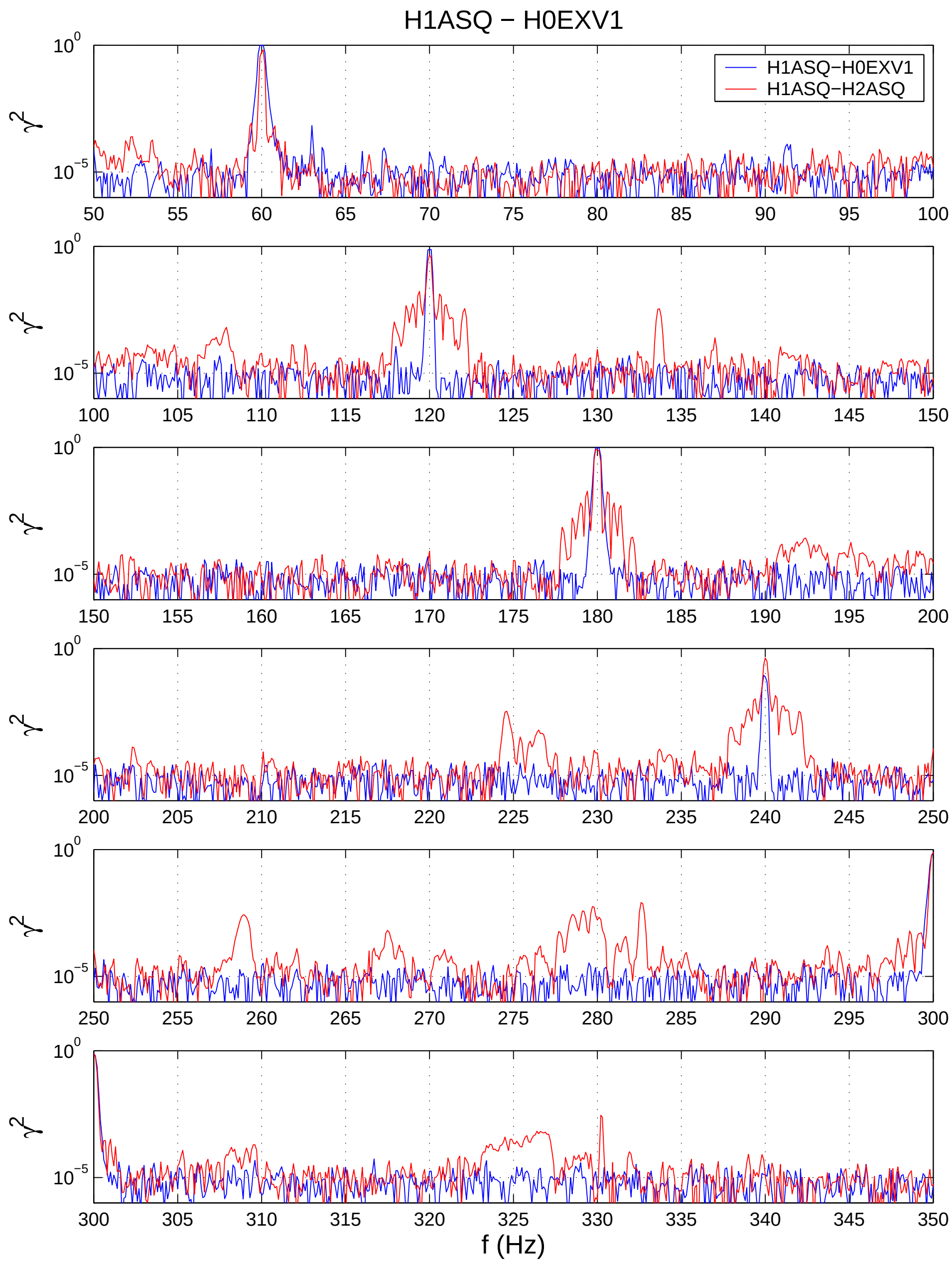

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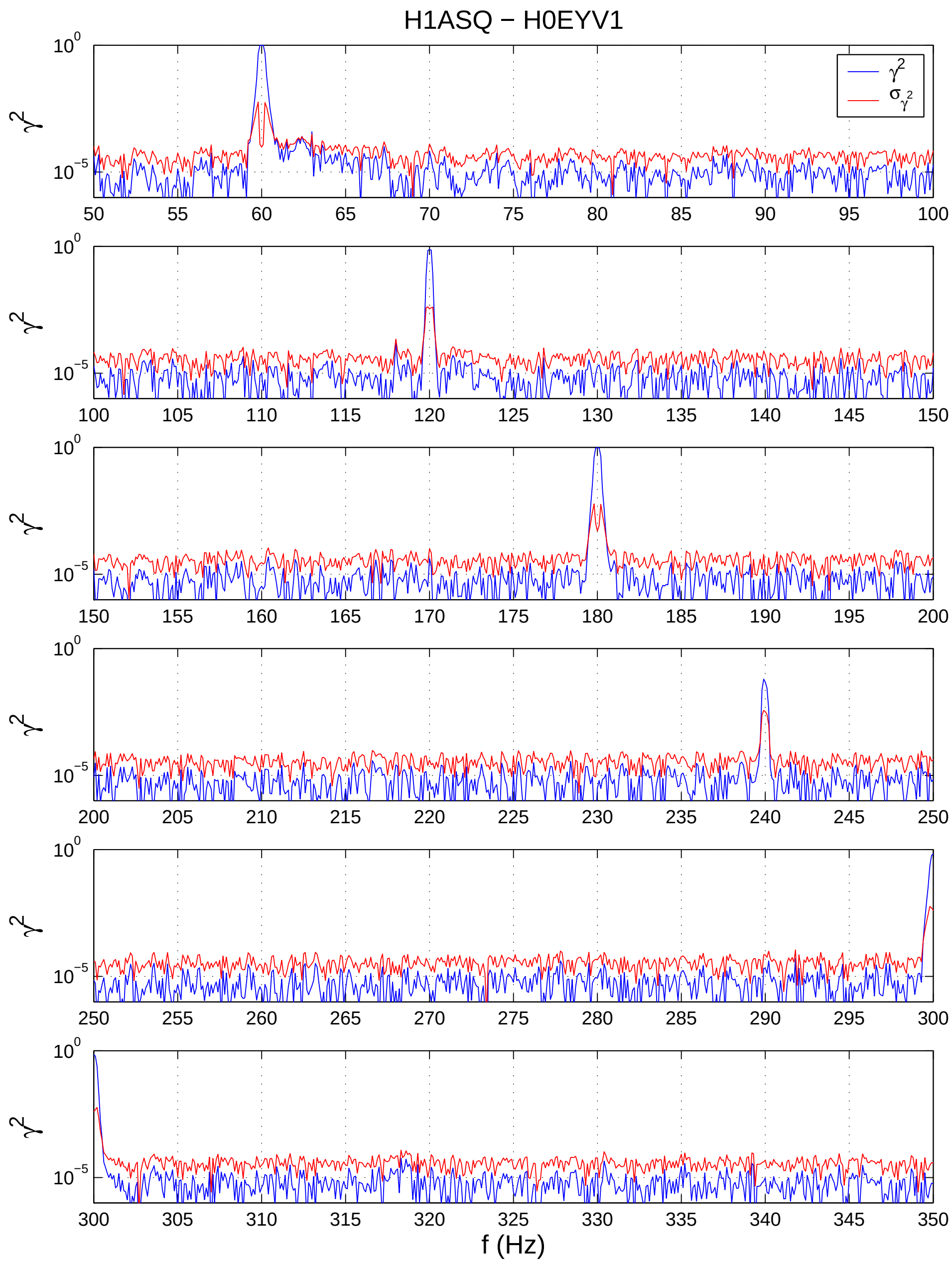

H1ASQ − H0EYV1
γ^2
σ_{γ^2}
10^0
10^{-5}
50
55
60
65
70
75
80
85
90
95
100
105
110
115
120
125
130
135
140
145
150
155
160
165
170
175
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185
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245
250
255
260
265
270
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310
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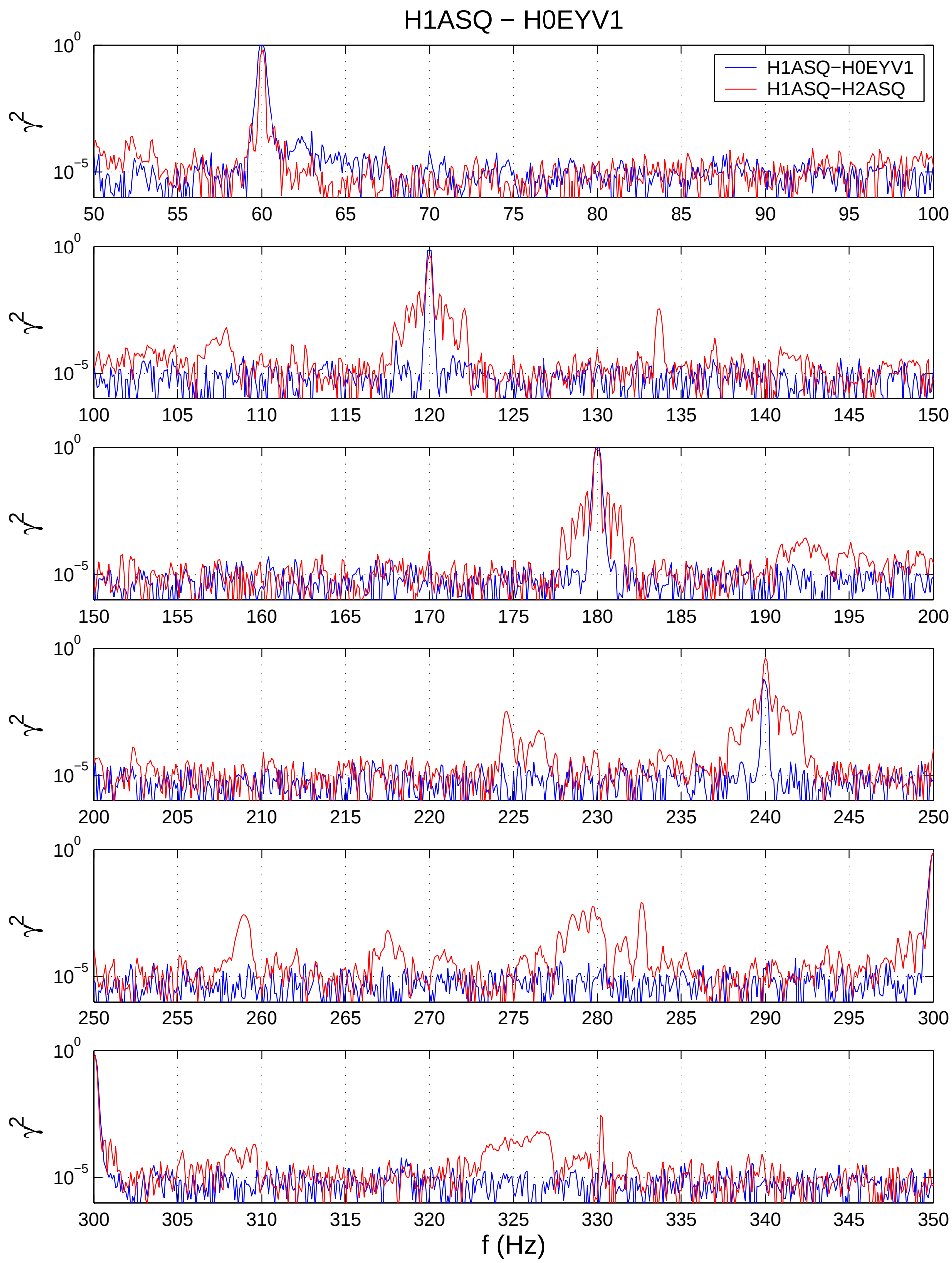
325
330
335
340
345
350
f (Hz)

Figure 45:



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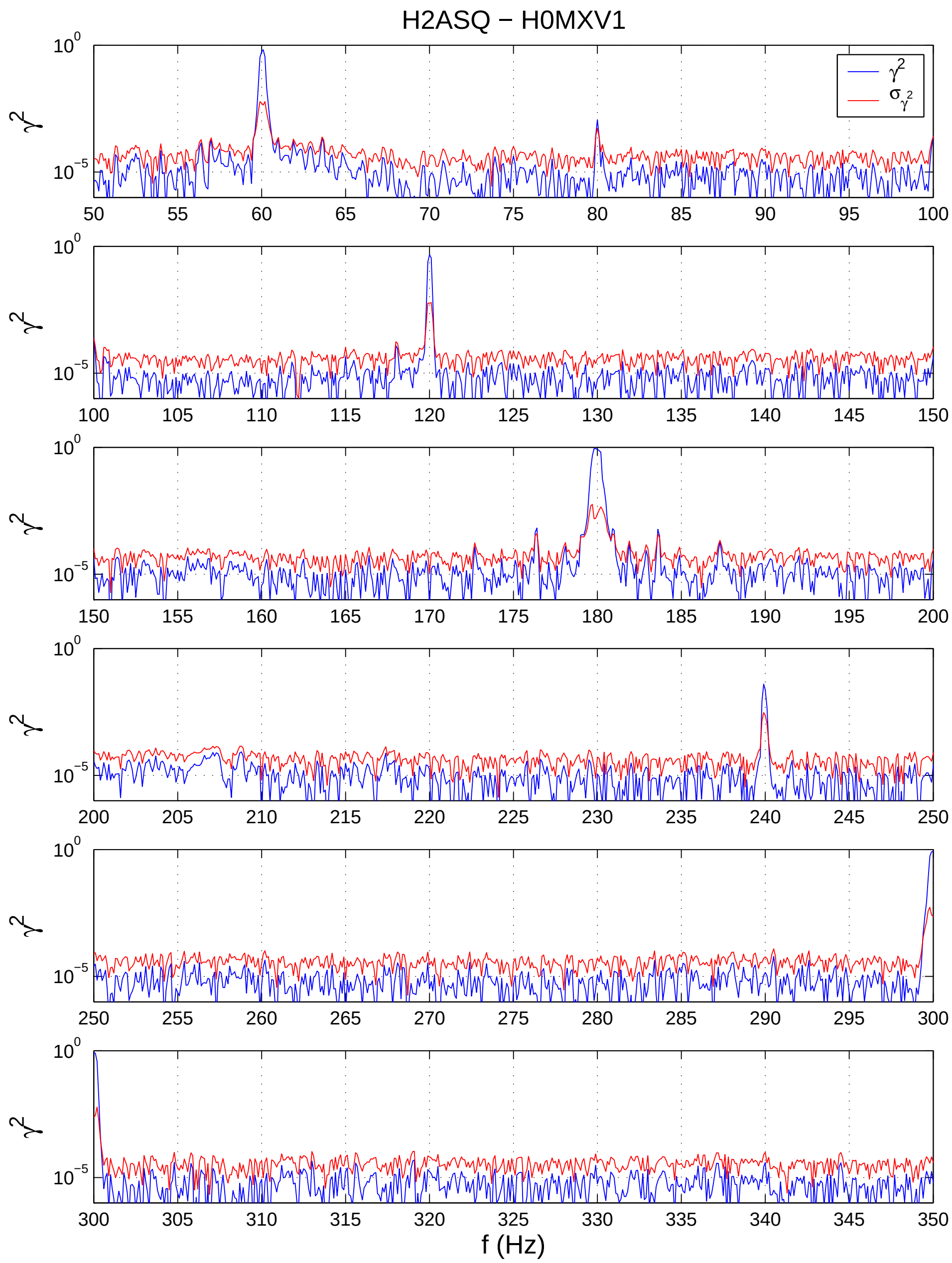

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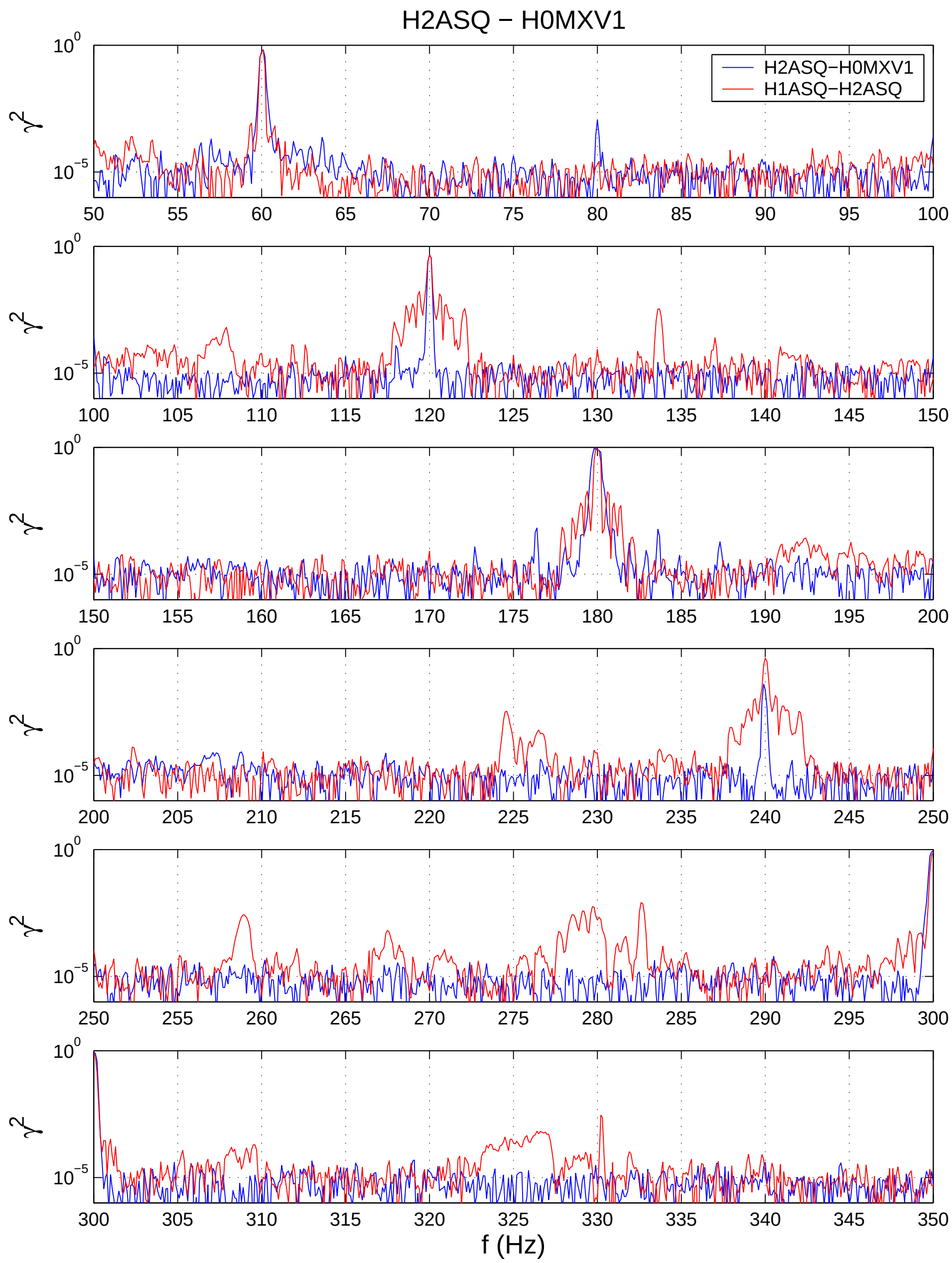

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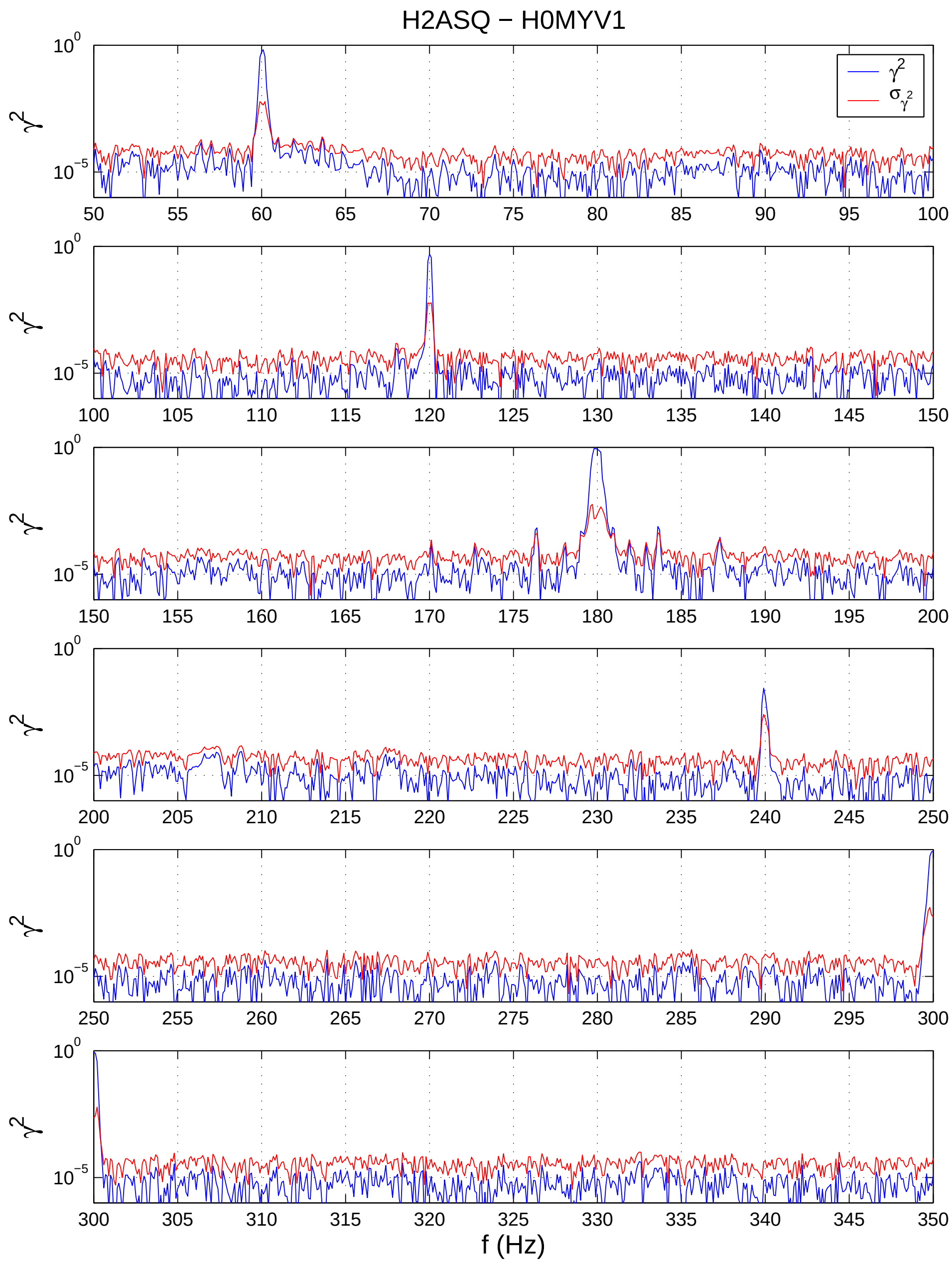

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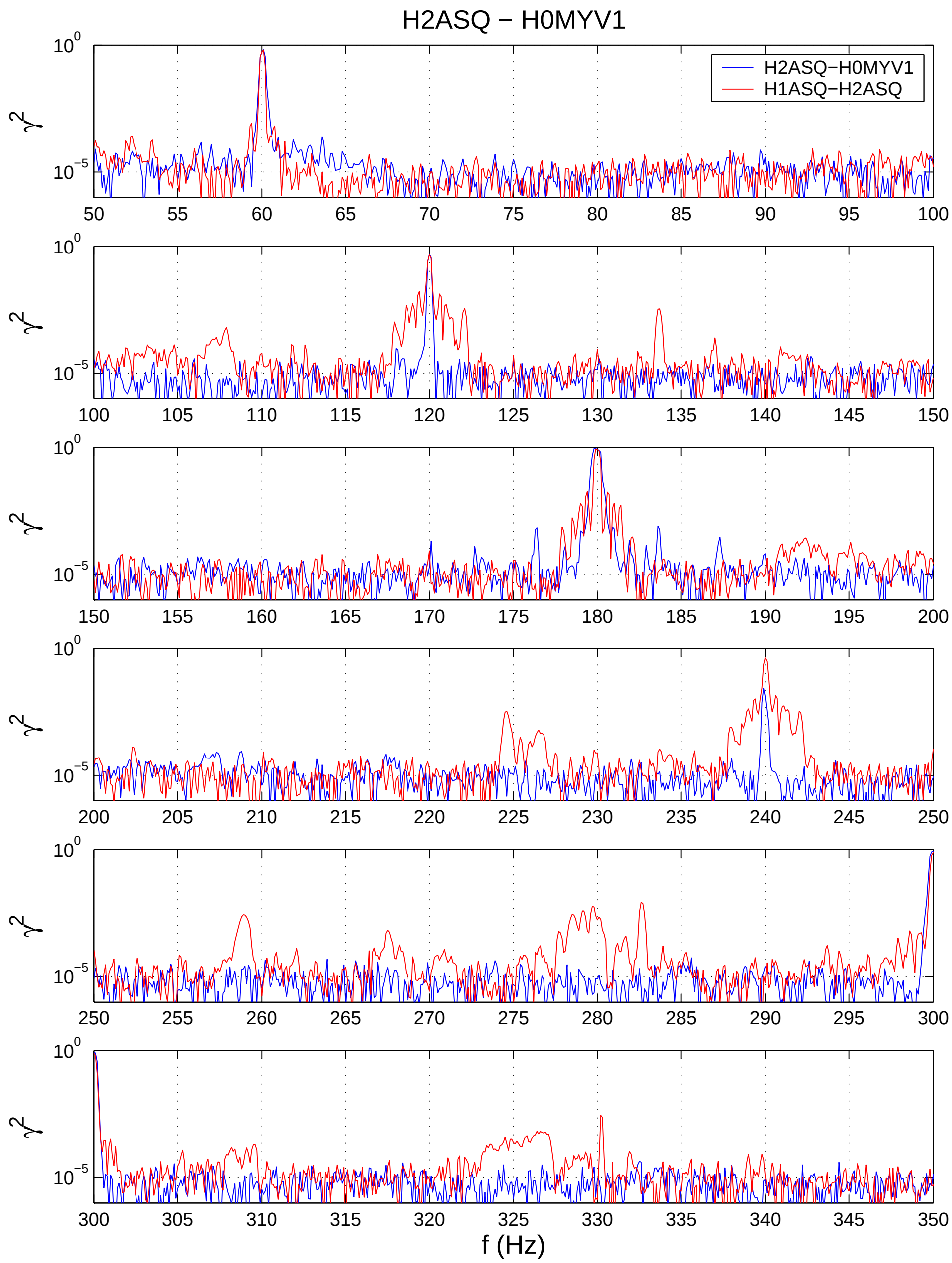

Figure 50: