Comparison of Line Removal Techniques

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This Report Includes Work From:

- Philip Charlton (ANU & CalTech)
- Bob Coldwell (UF)
- Gordon Deane (ANU)
- Chris Hawkins (UF)
- Sergei Klimenko (UF)
- Bernard Whiting (UF & ANU)

Nature of Lines

- Mains (Line) Harmonics
- Large Amplitude (Coherent)
- Highly Non-Gaussian
- Violin Resonances
- Others (Known and Unknown)

Benefits of Line Removal

- Reduces Data Volume
- Improves Gaussianity
  - Better Matched Filter Implementation
  - Enables Better Use of Wavelets

Catalog of Methods

	Mains Harm	Violin Res	Other	Comments
Multi-Taper (Allen – Ottewill: GRASP) GRG 32, 385-98 (2000)	Y	Y	Y	
CLR (Sintes – Schutz: LAL) PRD 58, 122003 (1998), see also PRD 60, 062001 (1998)	Y			
Kalman (Finn – Mukherjee: PSU) GR-QC 9911098		Y		Needs Model
Adaptive Filter (Chassande-Mottin – Dhurandhar) INT.J.MOD.PHYS.D9, 275-9 (2000)	Y	Y		
Magnetometer (Finn – Mohanty: PSU) 3rd Amaldi Proceedings, AIP Conf. Proc. 523, 451-458 (2000)	Y			
QMLR (Klimenko: DMT) LSC: Livingston (2000), Hanford (2000)	Y	P		
CLR' (Charlton – Deane: dctools) B. Eng thesis, ANU, June (2000)	Y			
Cross Correlation (Allen – Ottewill: GRASP) GR-QC 9909083				Removes Other Noise

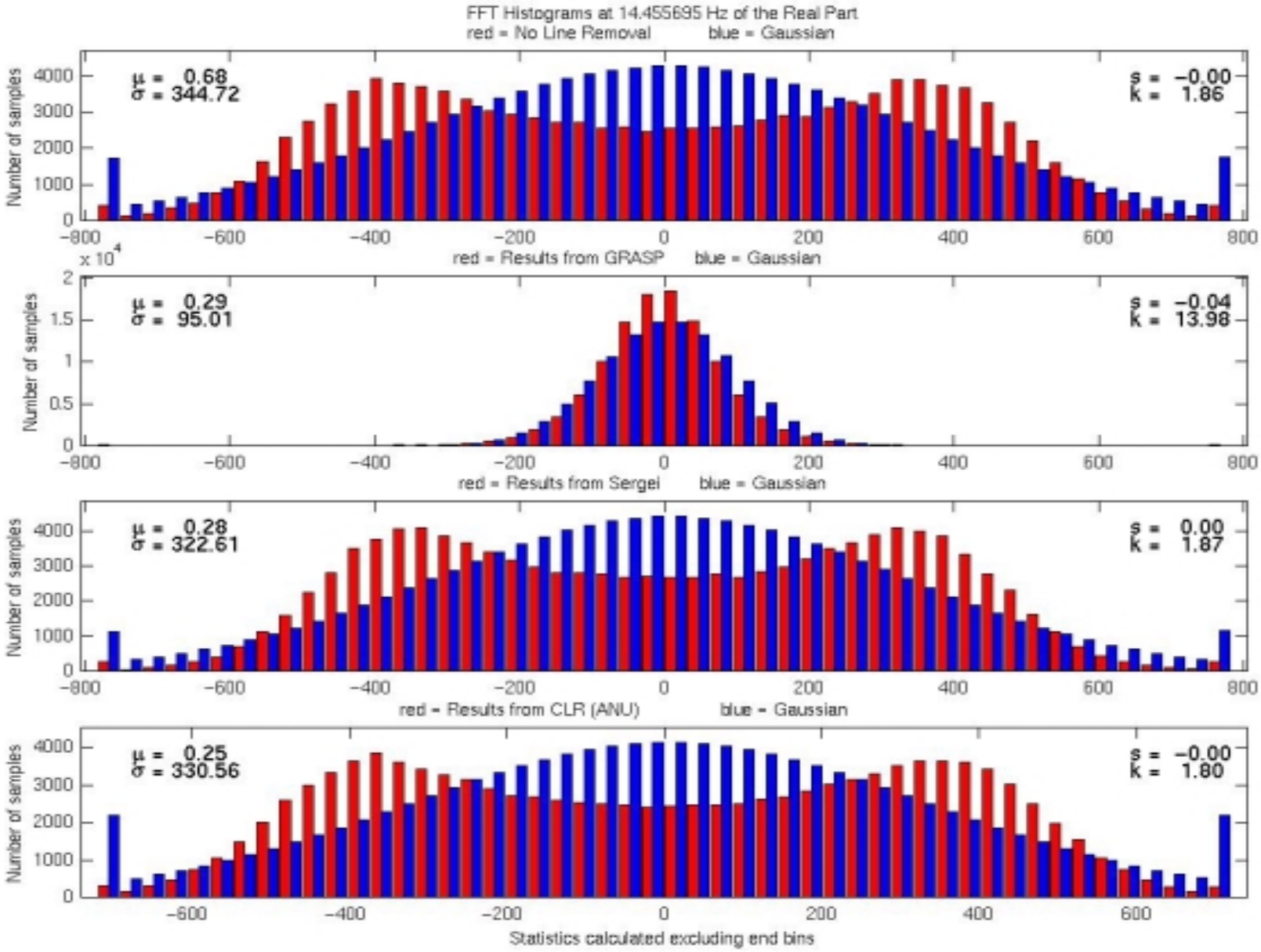
Comparison via:

- Statistical Properties
  - expect Gaussianity to be improved
  - actually find residual non-Gaussian components
- Spectral Properties
  - “complete” removal of a line introduces artificial “glitch” in spectrum, whereas
  - “cleaned” data should have residual noise which is not strongly dependant on frequency
- Signal Detect Ability
  - Filter banks trigger even without GW signal (false detection due to noise)
  - Filter banks may fail to trigger on embedded signal (false rejection due to “threshold”)
  - How do line removal techniques affect false rejection rate for a given SNR threshold?

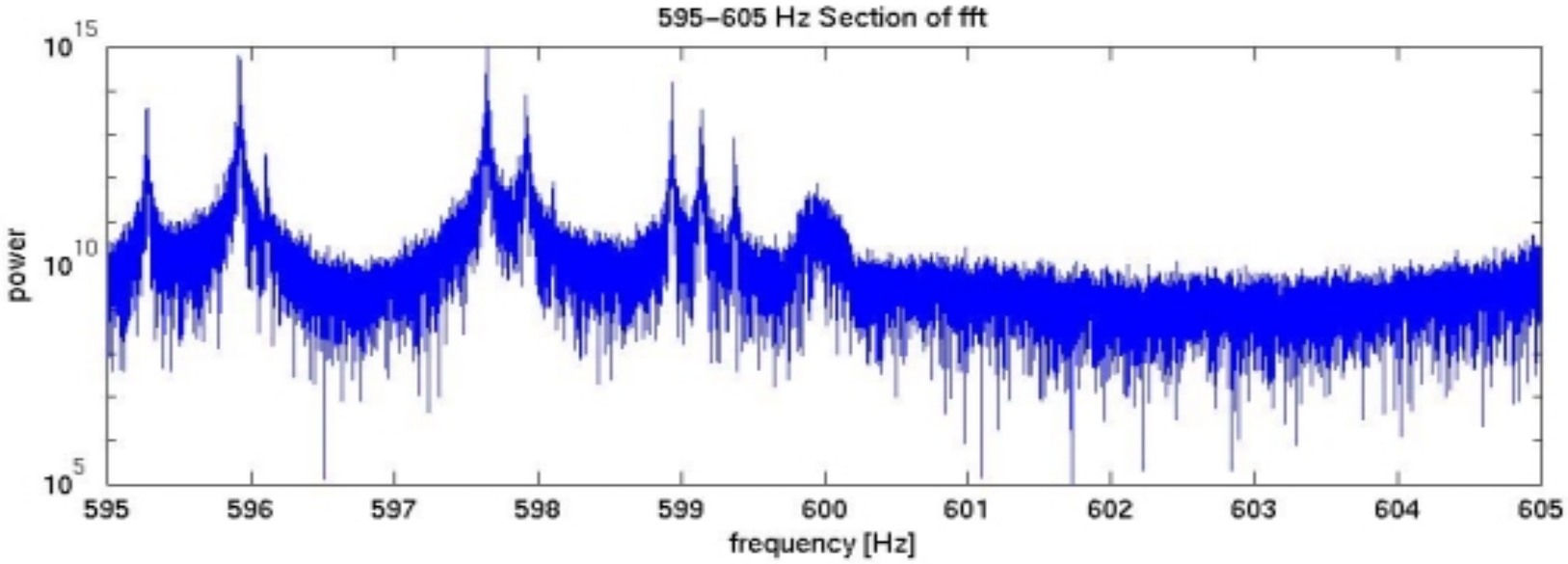
Following Pages Show:

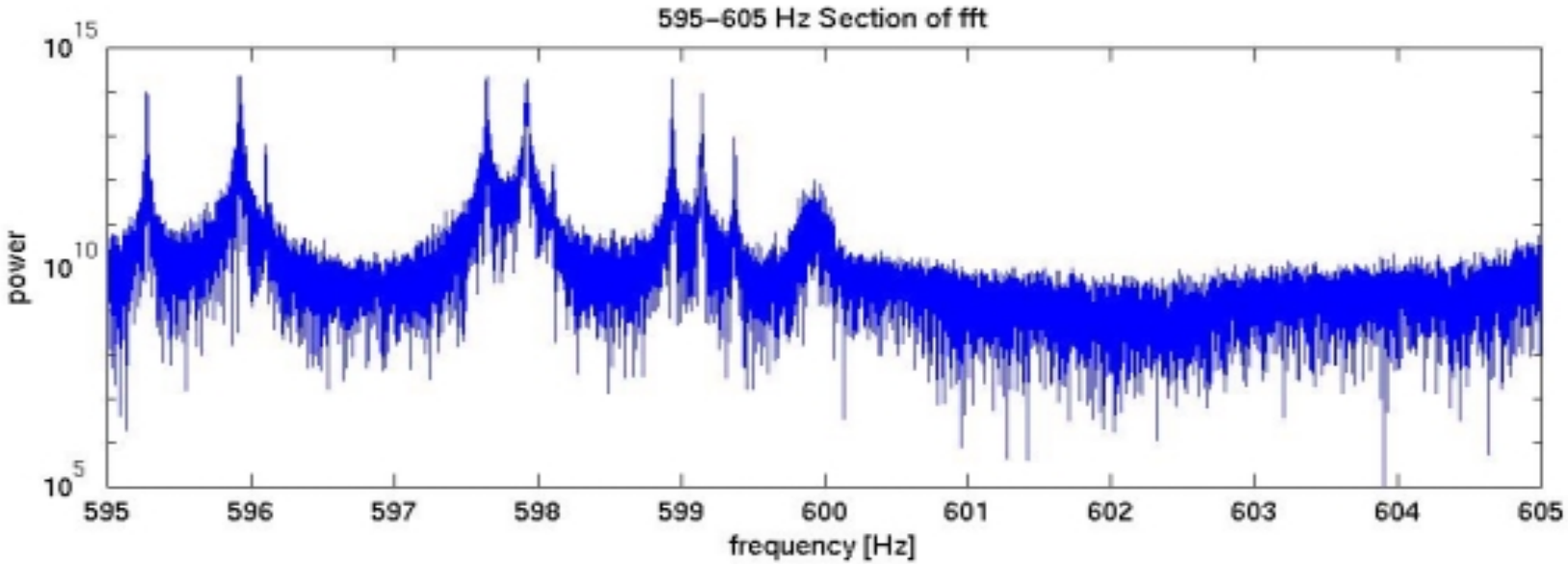
- “Other” Coherent Line Removal by GRASP code.
- “Incoherent” mains noise at 600 Hz, and comparison with line removal codes at that frequency.
- “Other” lines near 180 & 300 Hz mains lines.
- Superimposed effects of removal in Klimenko code.
- Different levels of removal in Klimenko code.
- Spectral properties of Sintes LAL code.
- Superimposed effects of Sintes LAL & GRASP codes.
- Non-Gaussian residual at 180 & 300 Hz.

A. “Other” Coherent Line Removal by GRASP code.

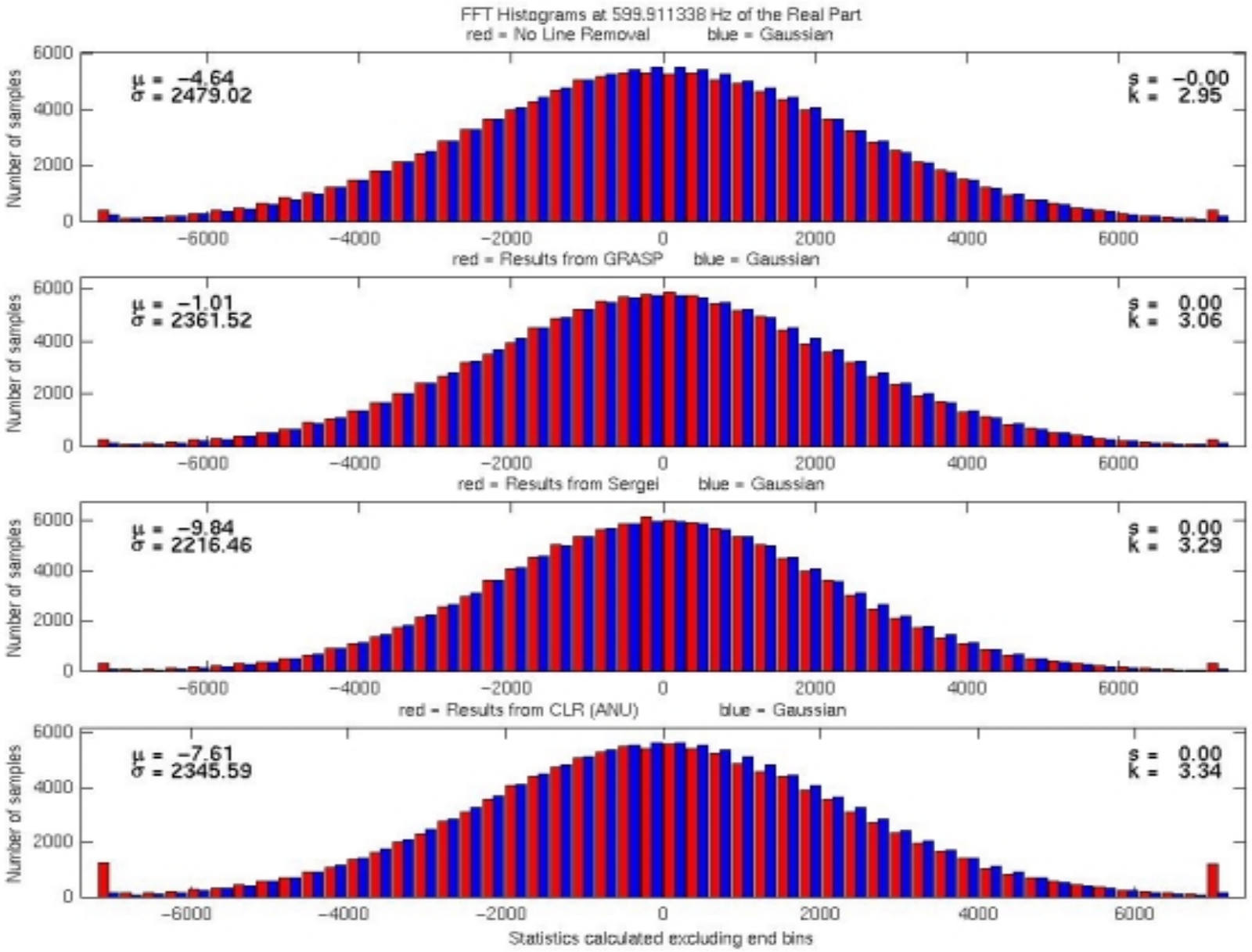


B.i) “Incoherent” mains noise at 600 Hz.

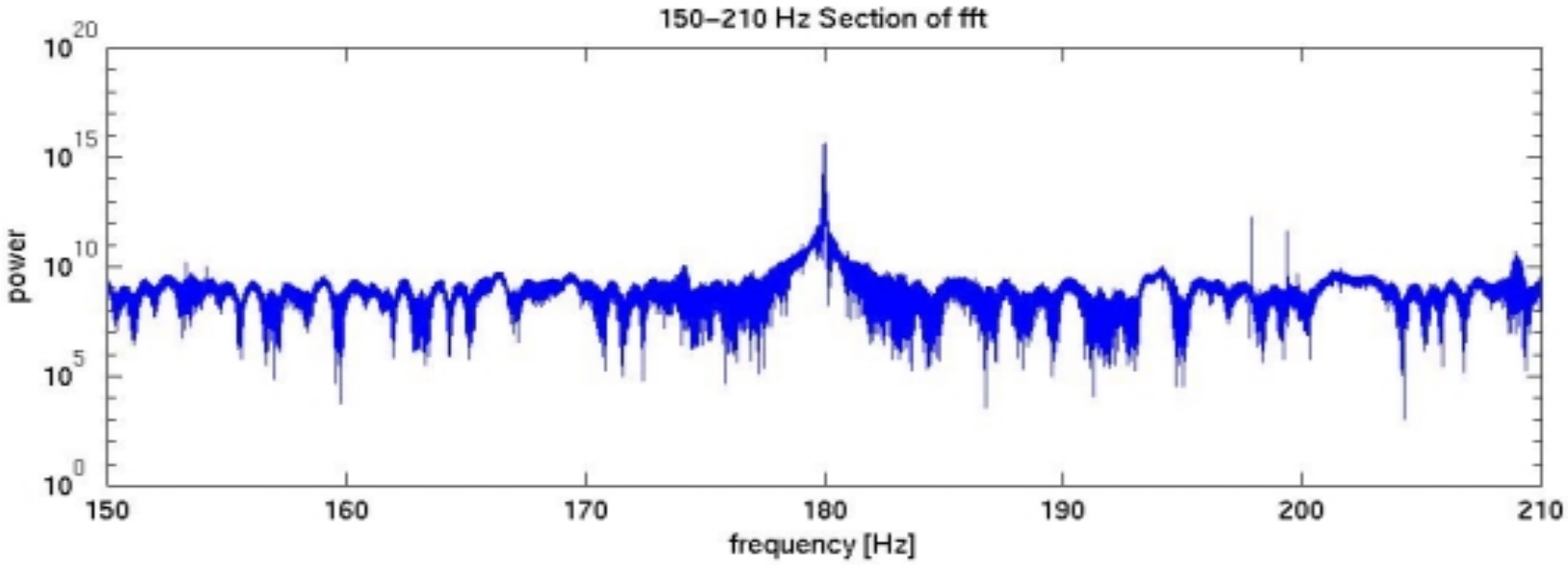


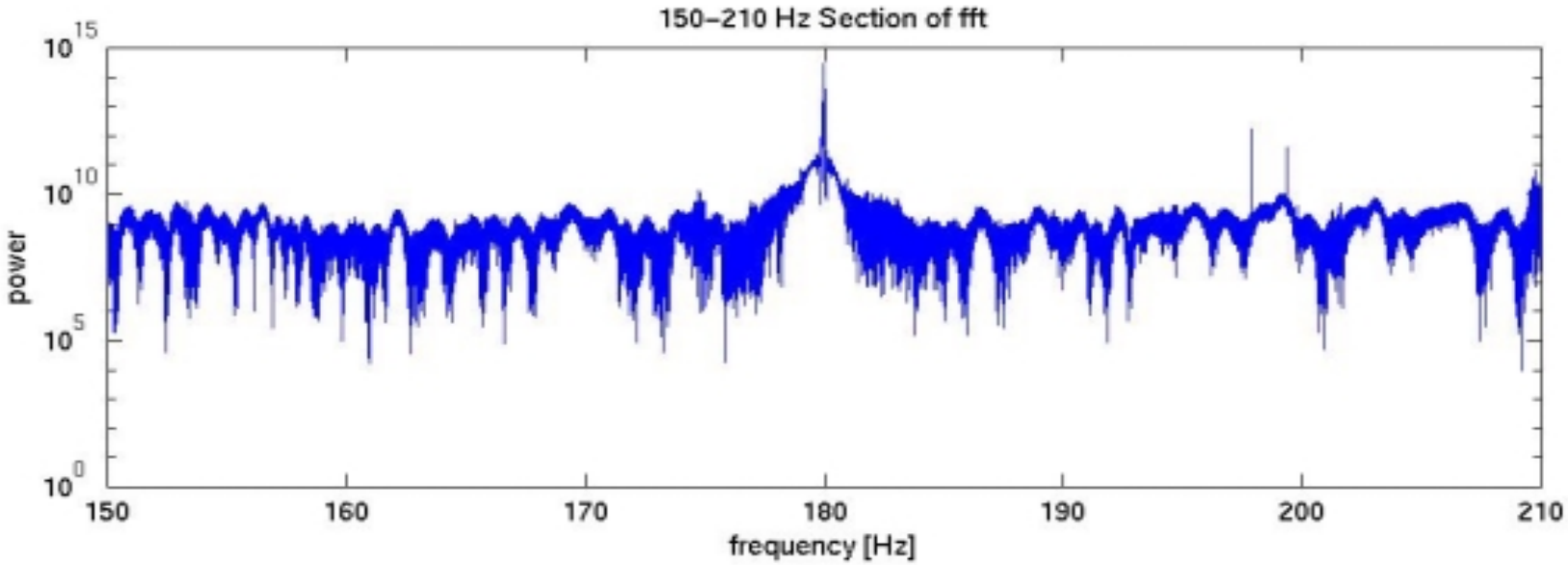


B.ii) Comparison of line removal codes at 600 Hz.

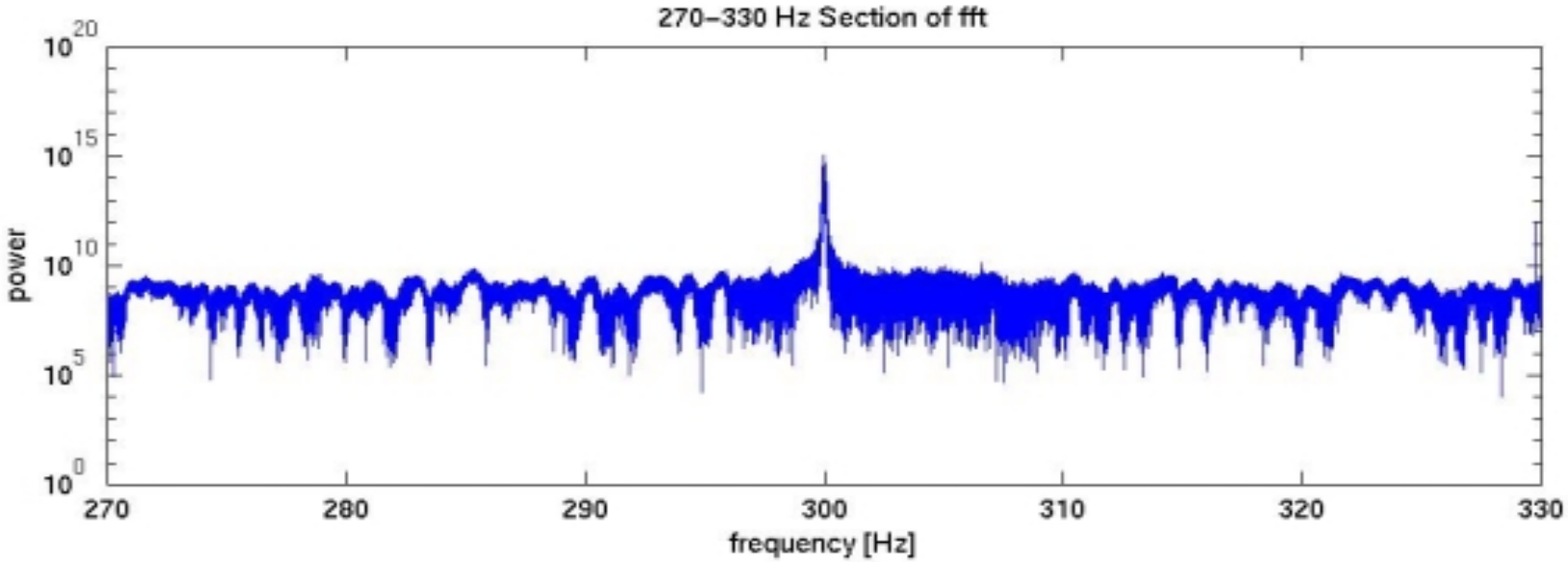


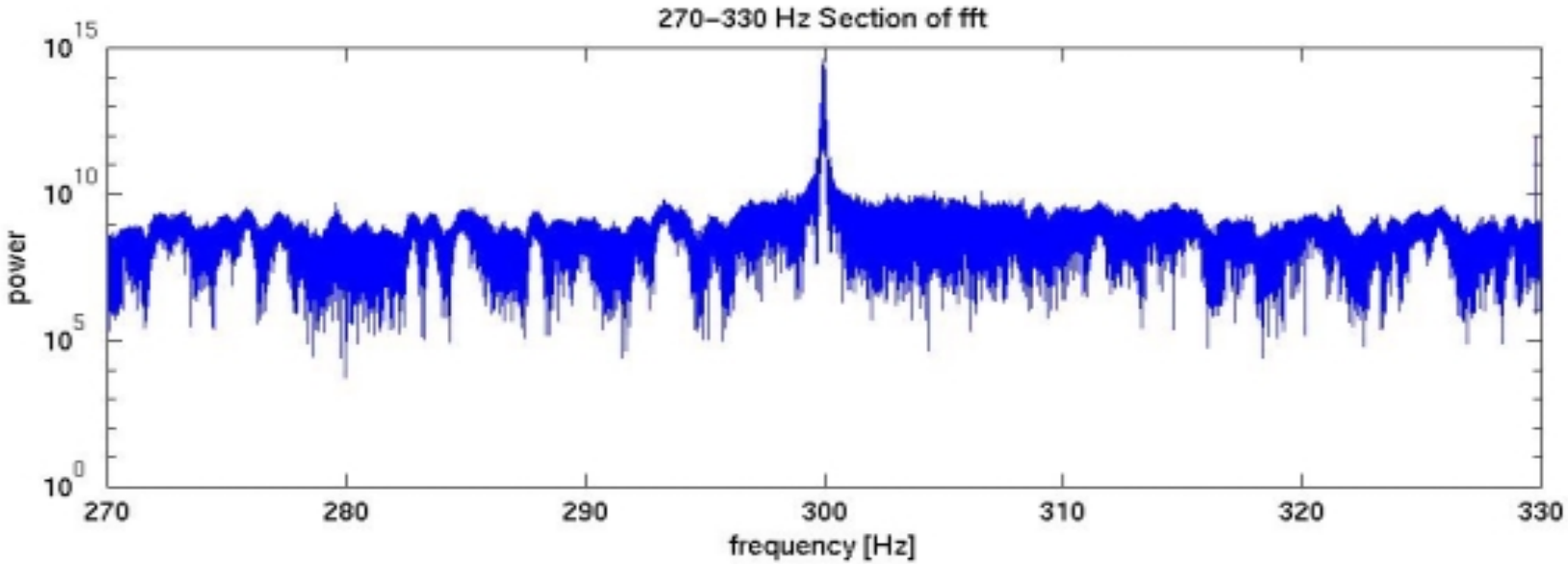
C.i) “Other” lines near 180 Hz mains lines.



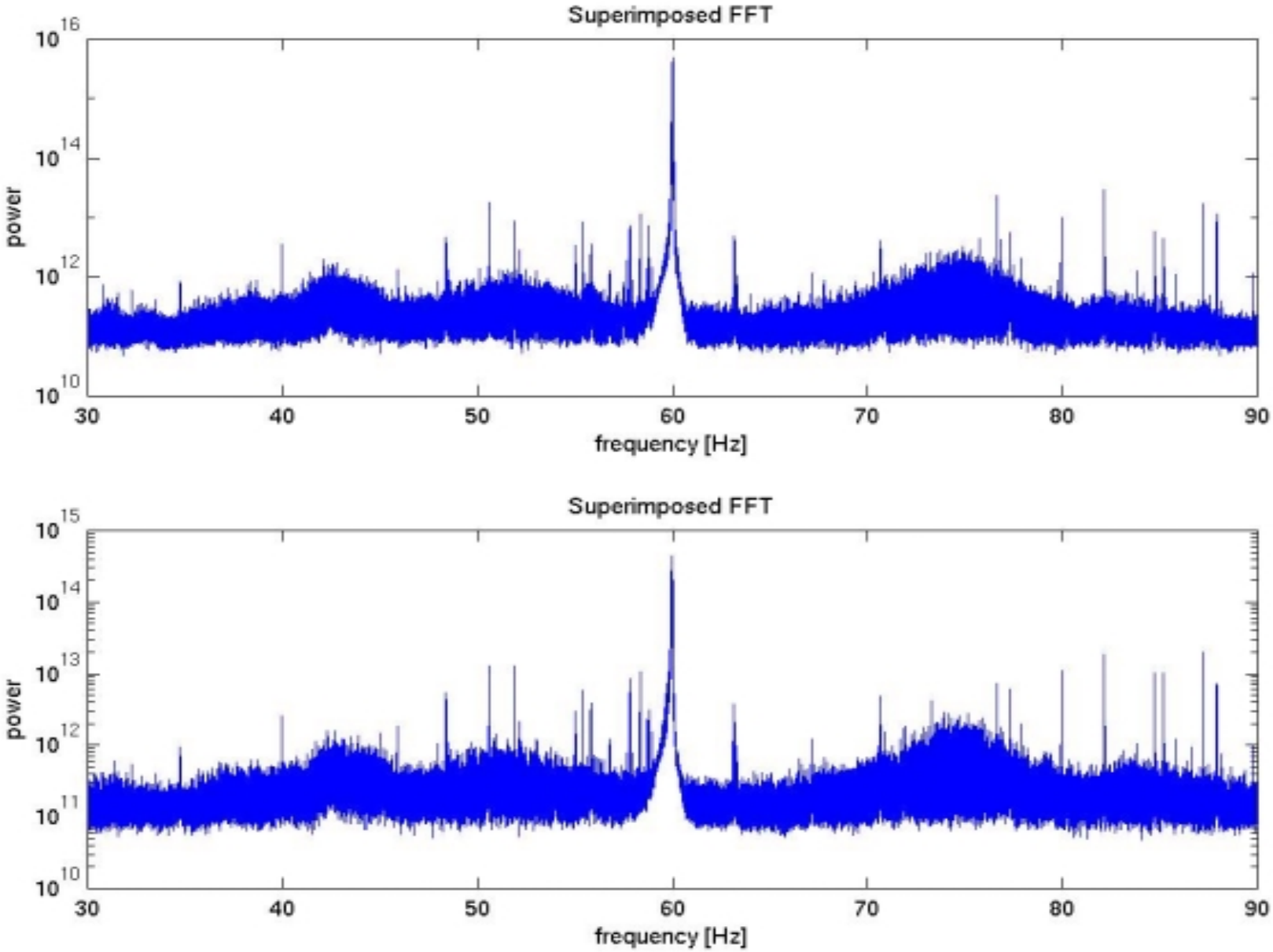


C.ii) “Other” lines near 300 Hz mains lines.

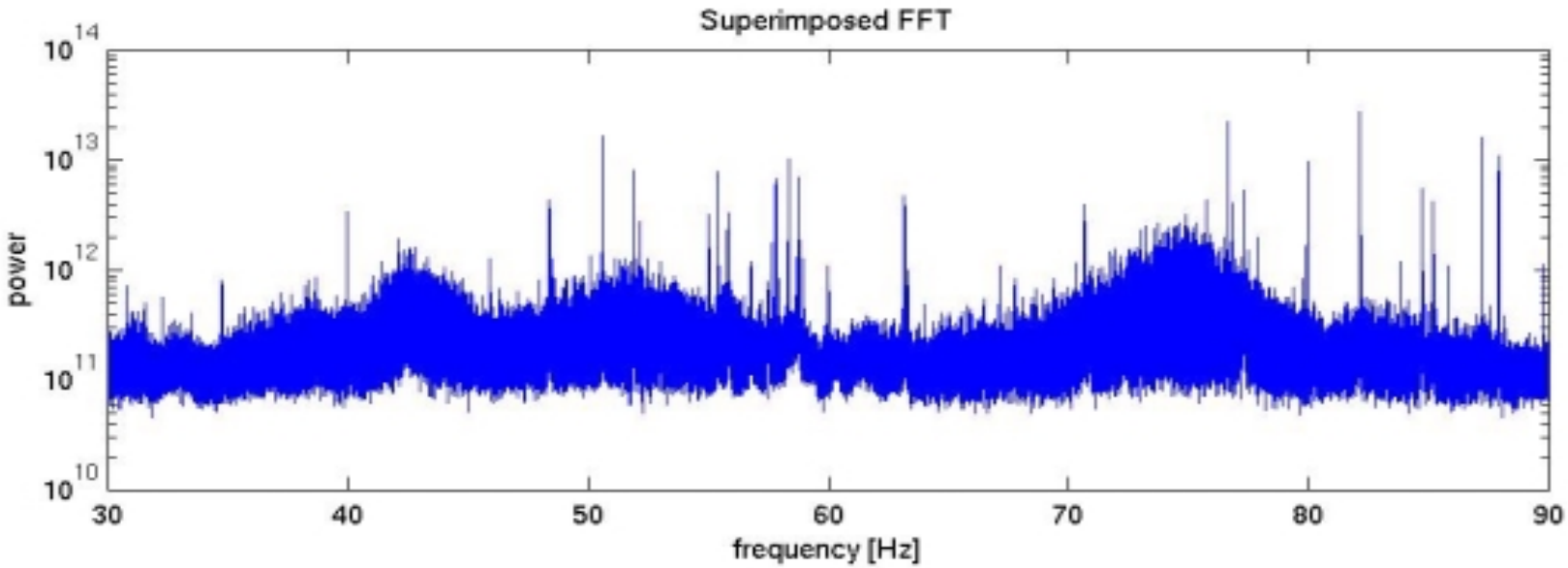


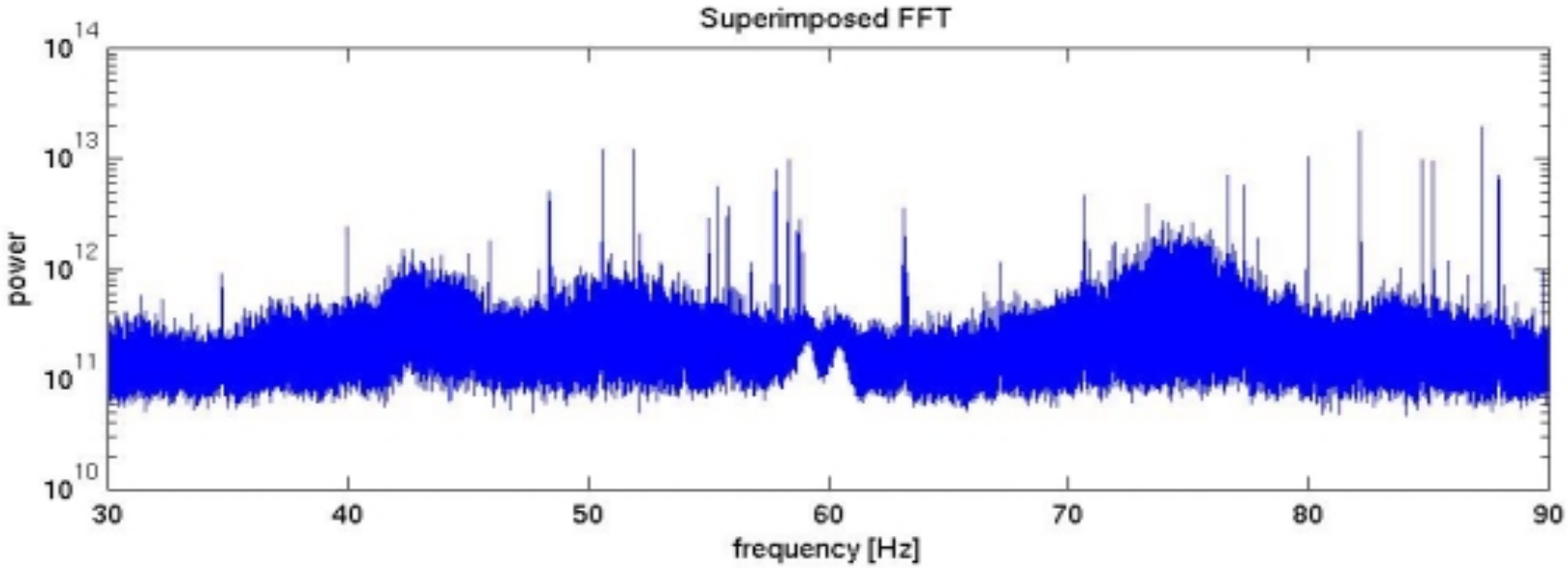


D.i) Superimposed with no removal.

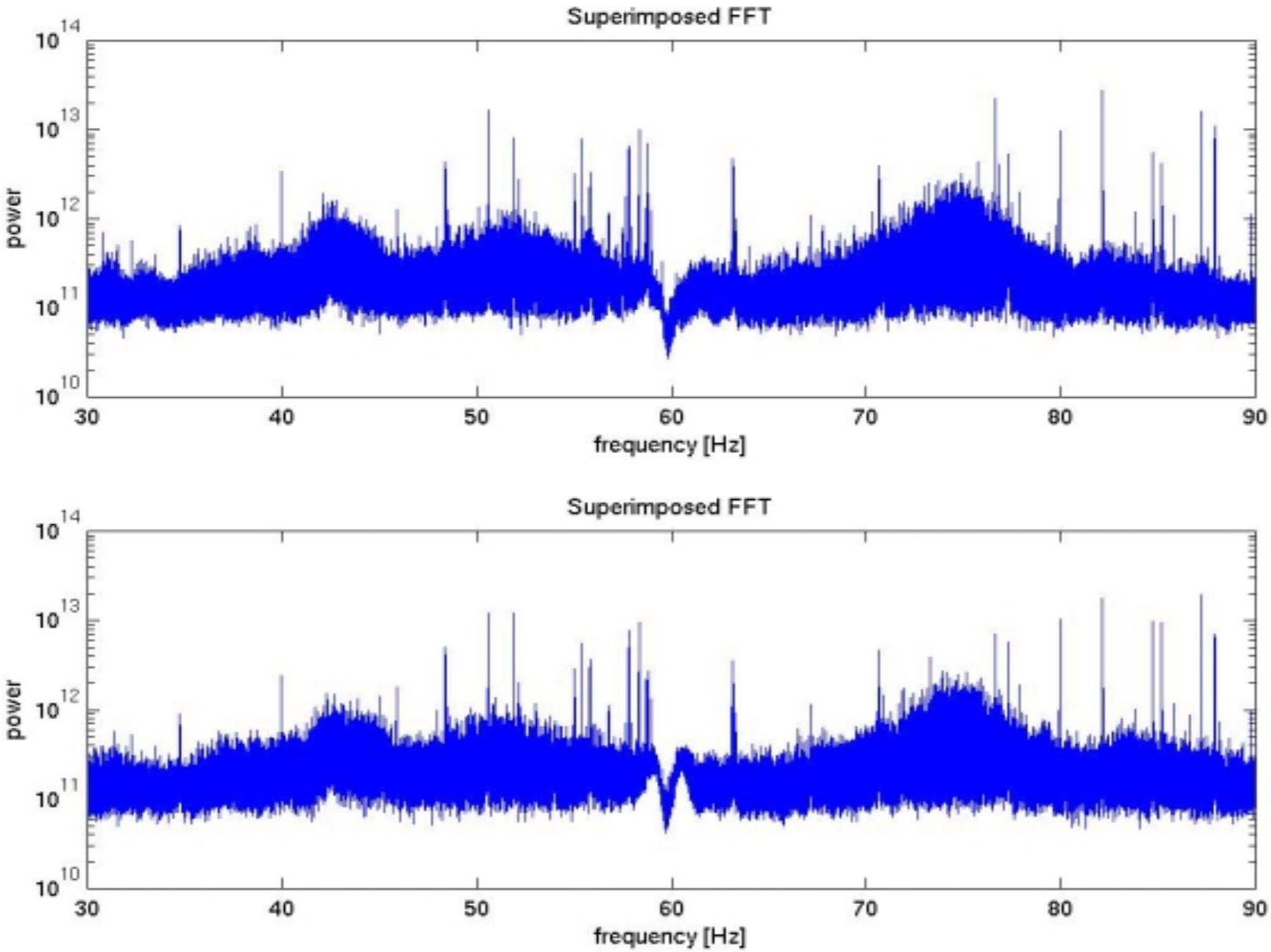


D.ii) Superimposed effects of removal in Klimenko code.

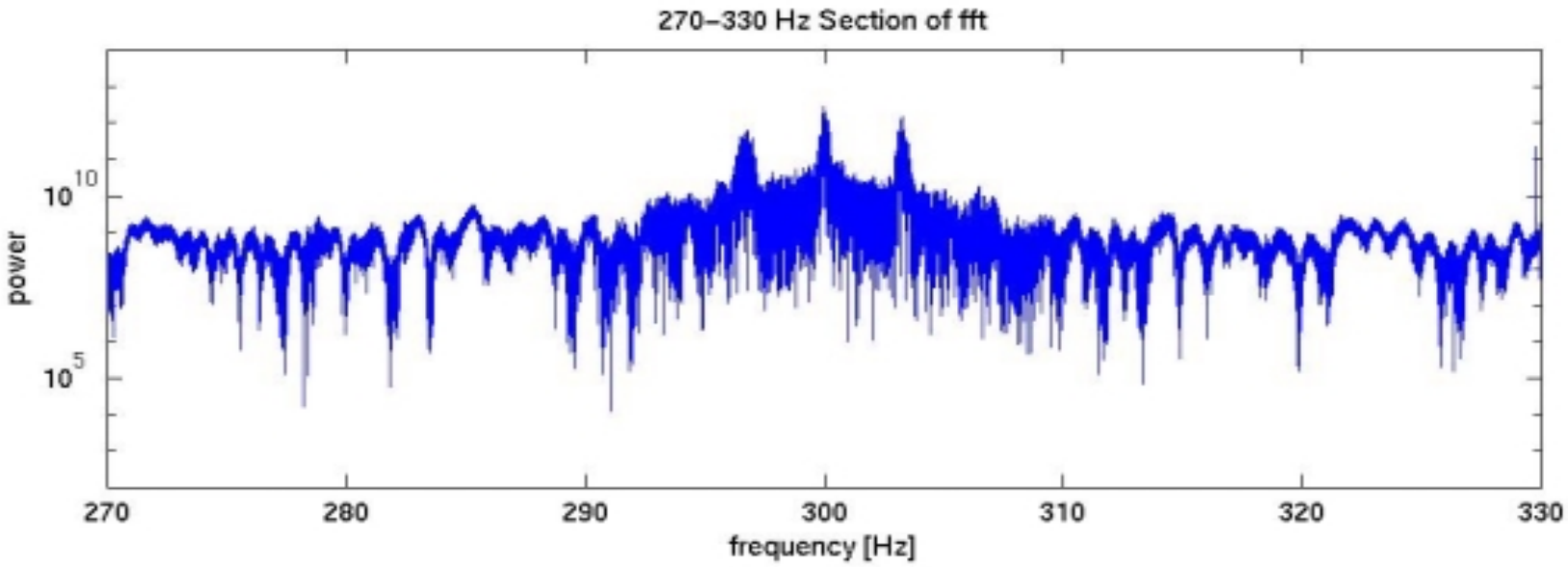


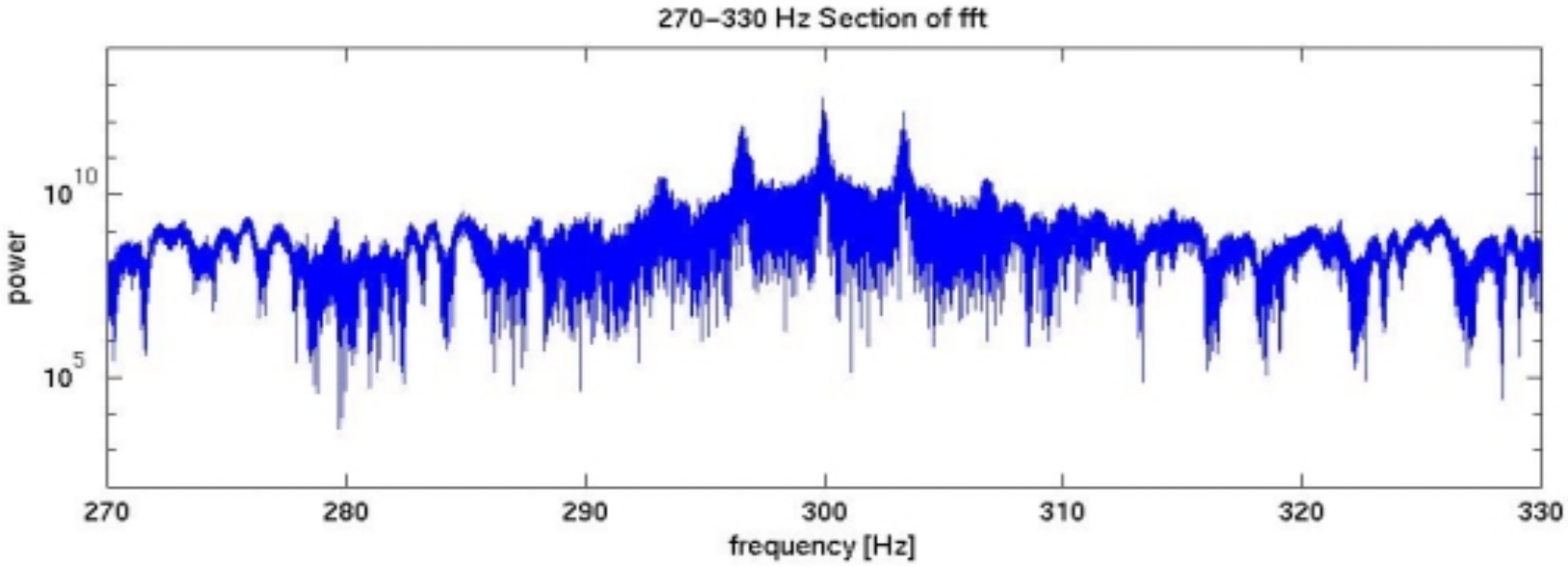


E. Different levels of removal in Klimenko code (full).

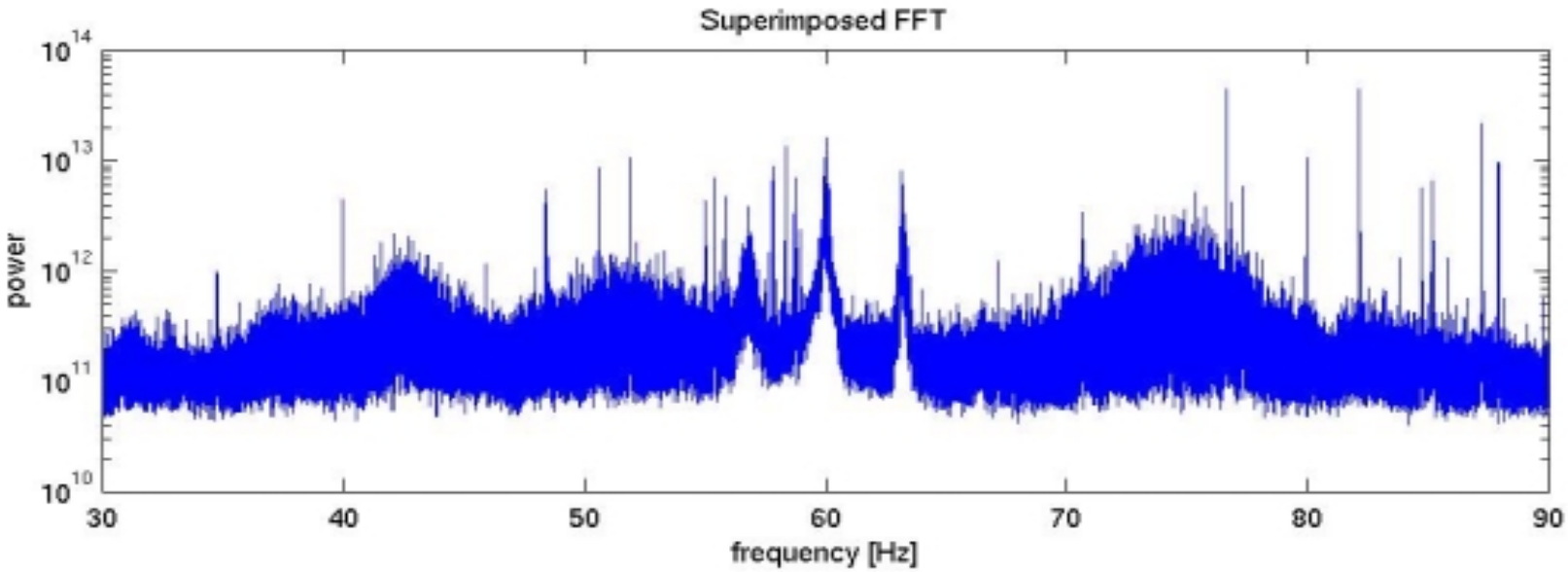


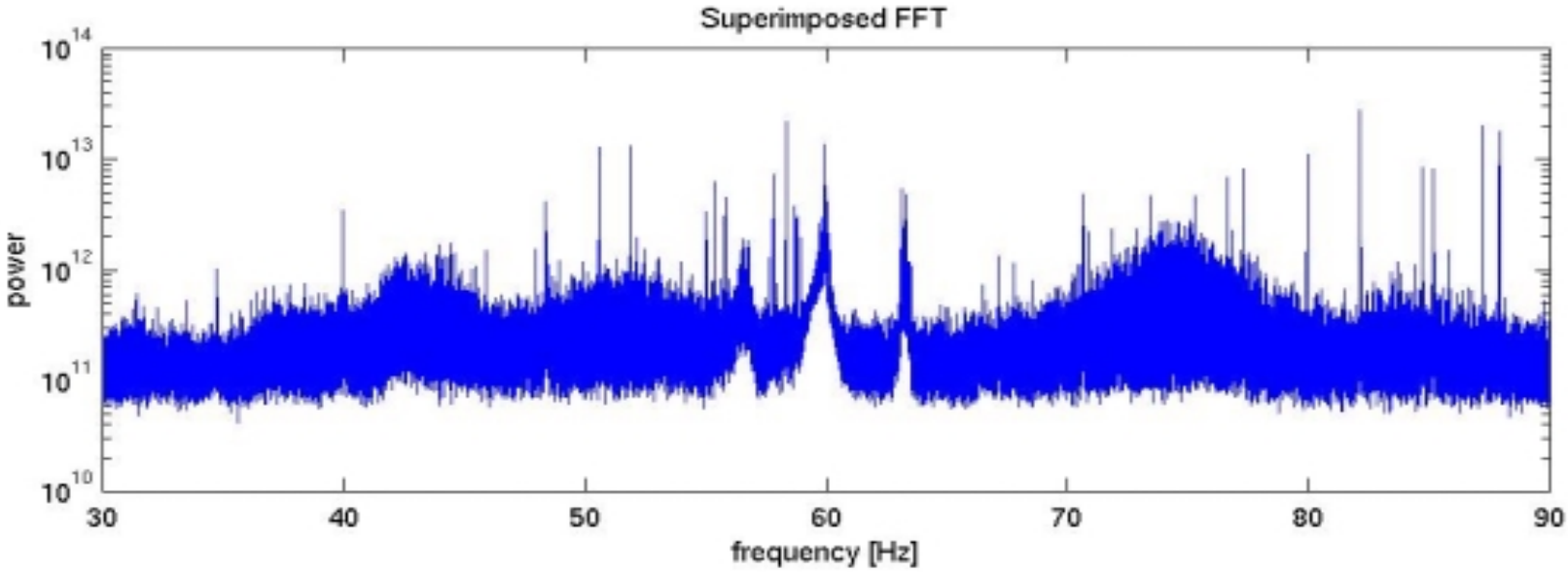
F. Spectral properties of Sintes LAL code.



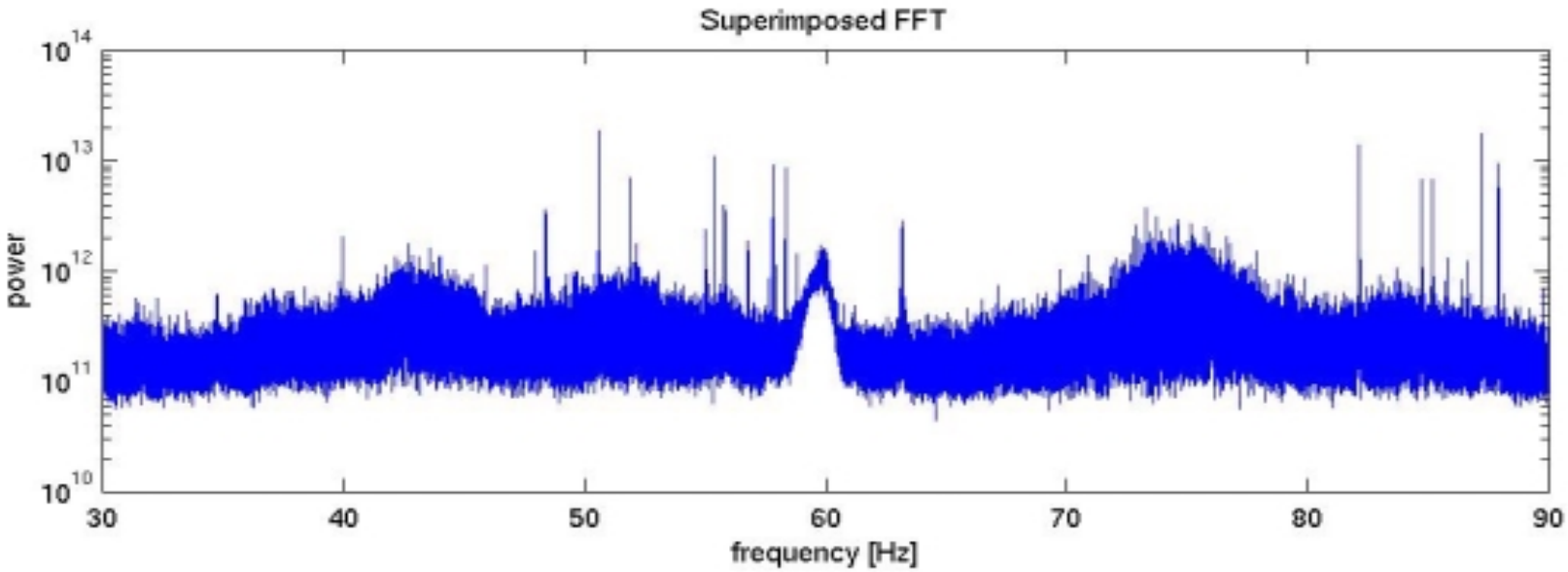


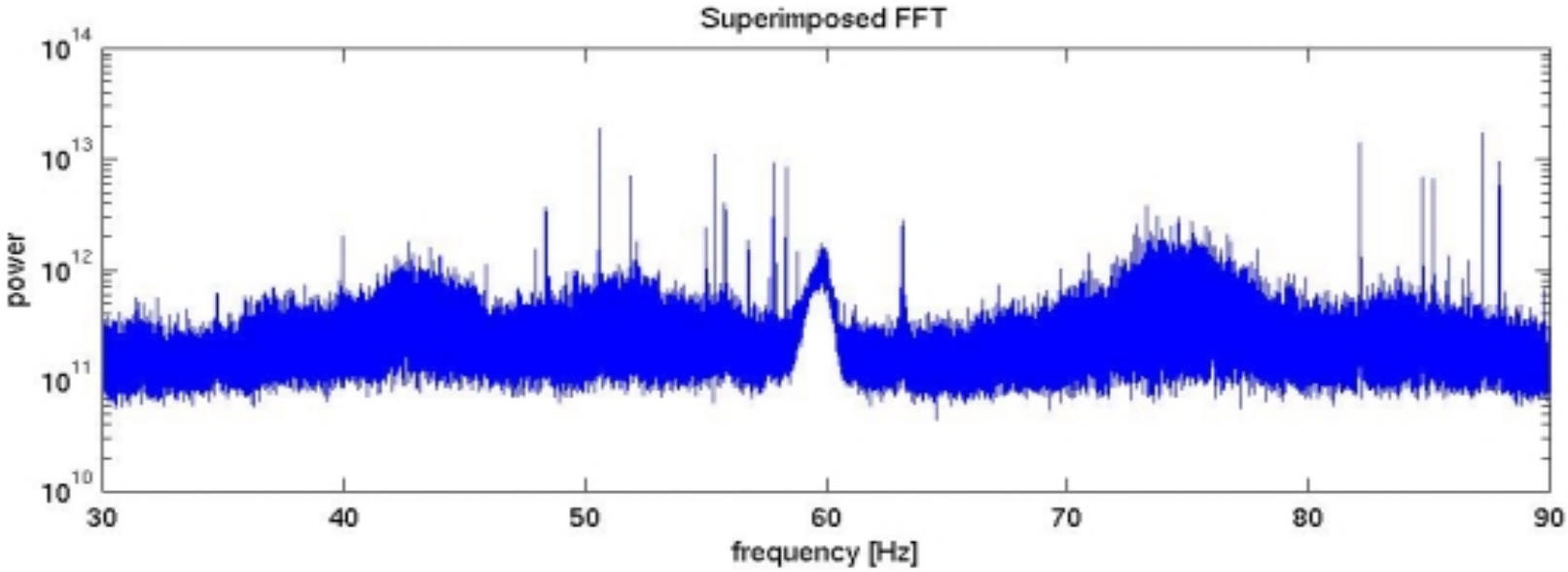
G.i) Superimposed effects of Sintes LAL code.



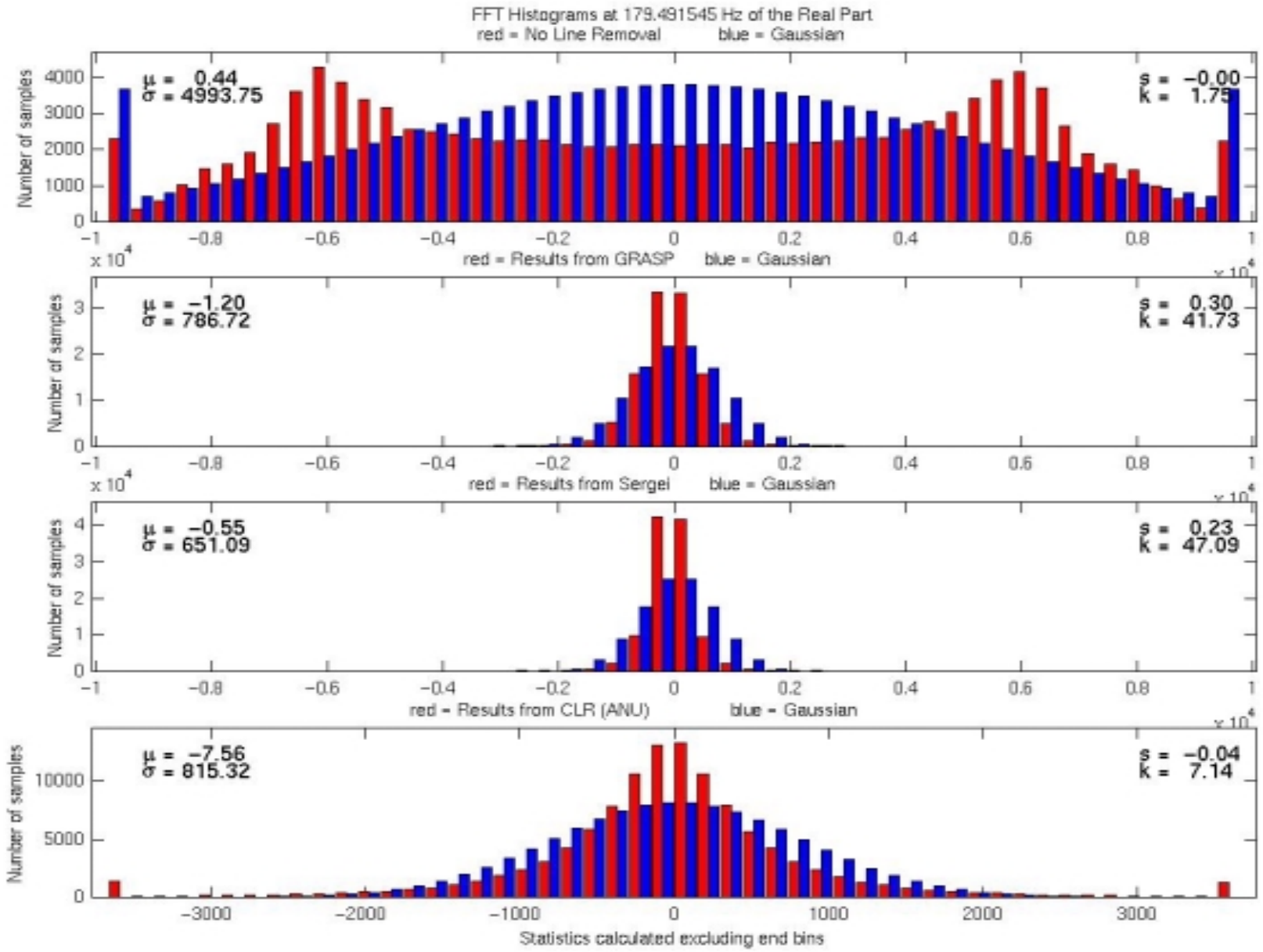


G.ii) Superimposed effects of GRASP code.

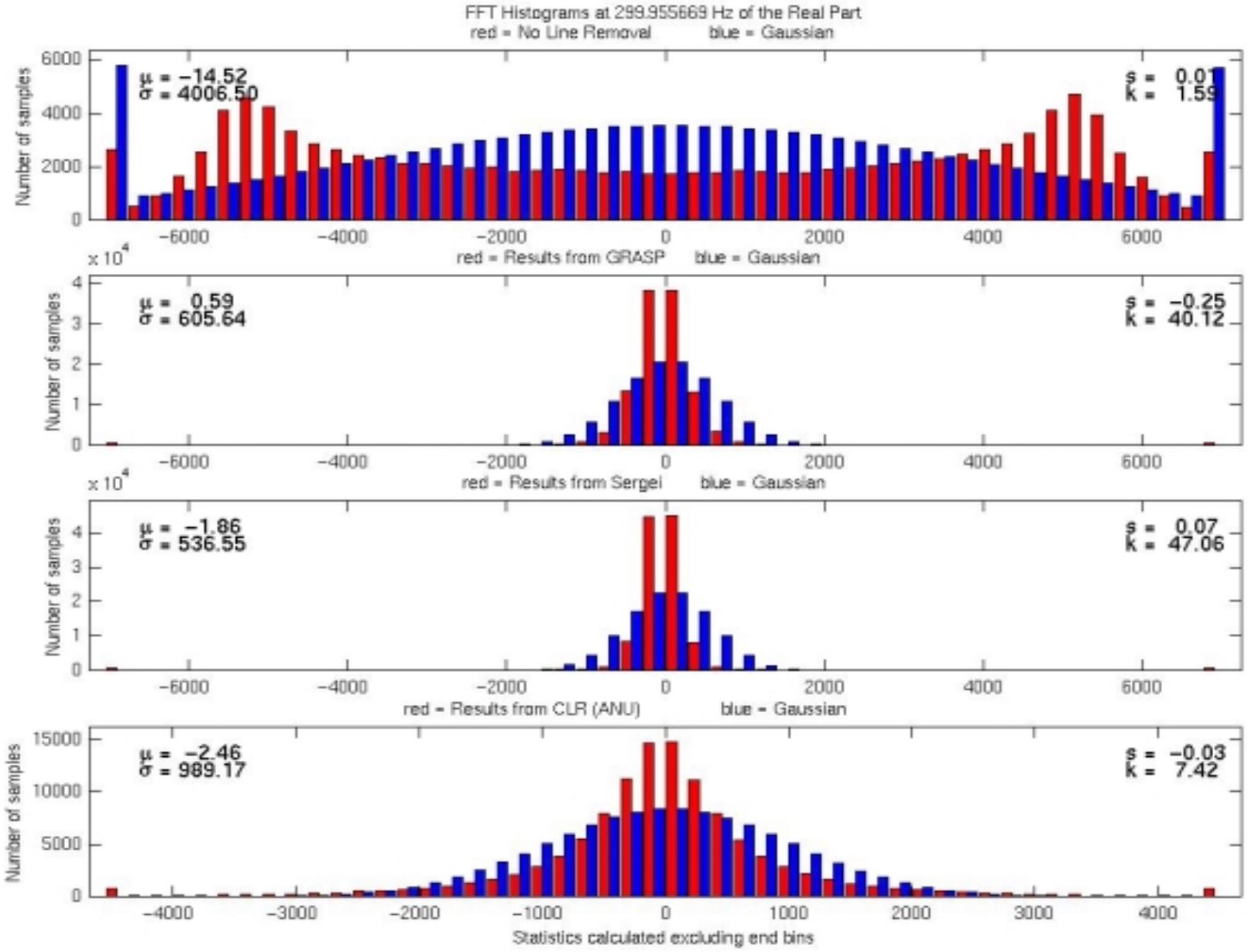




H.i) Non-Gaussian residual at 180 Hz.



H.ii) Non-Gaussian residual at 300 Hz.



Future Plans:

- Capitalize on correlation technique benefits.
- Inspect engineering run data.
- Prepare for short science run next year.

Conclusions:

- There is a need for search algorithms to implement and compare line removal techniques.
- Need more uniform treatment for bad data.
- Short blocks currently give better results.