Detrusor Pressure Estimation from Single Channel Bladder Pressure Recordings

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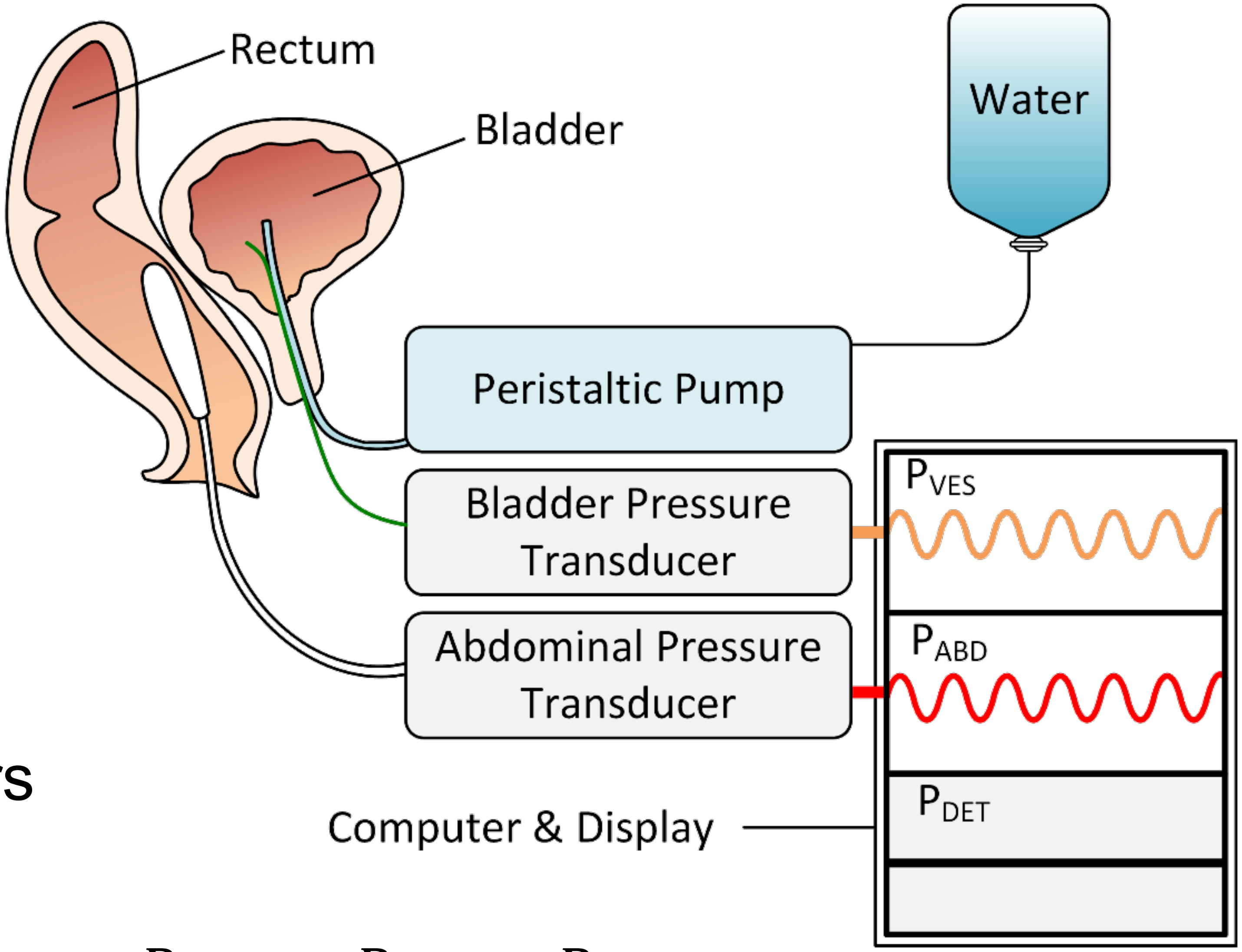
Introduction

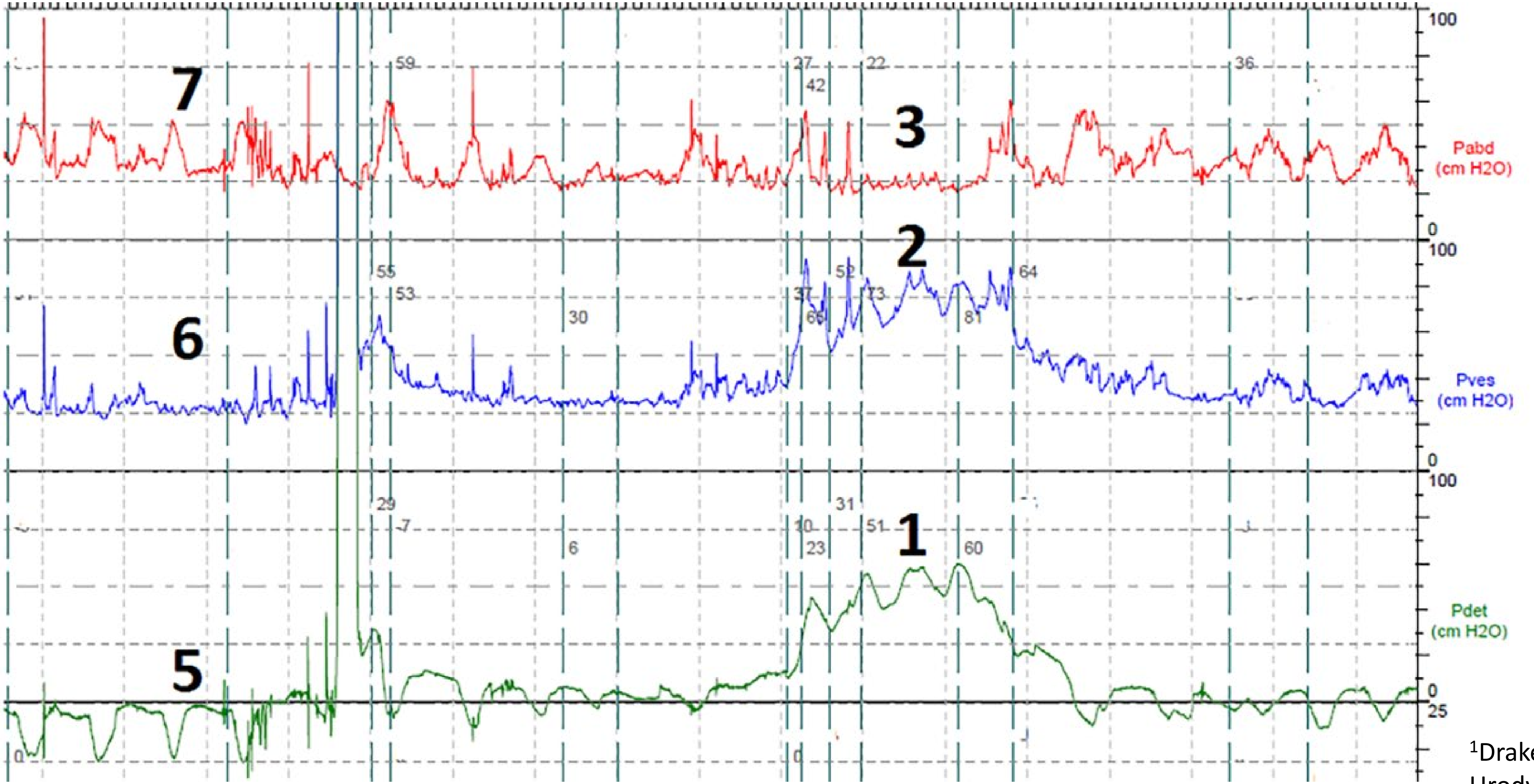
- Clinical urodynamics
  - Simulate filling and voiding of bladder
  - Detrusor pressure (P_{DET})

- Insertion of **two** catheters
  → Discomfort
  → Artifact



$$P_{DET} = P_{VES} - P_{ABD}$$

Urodynamics Signals



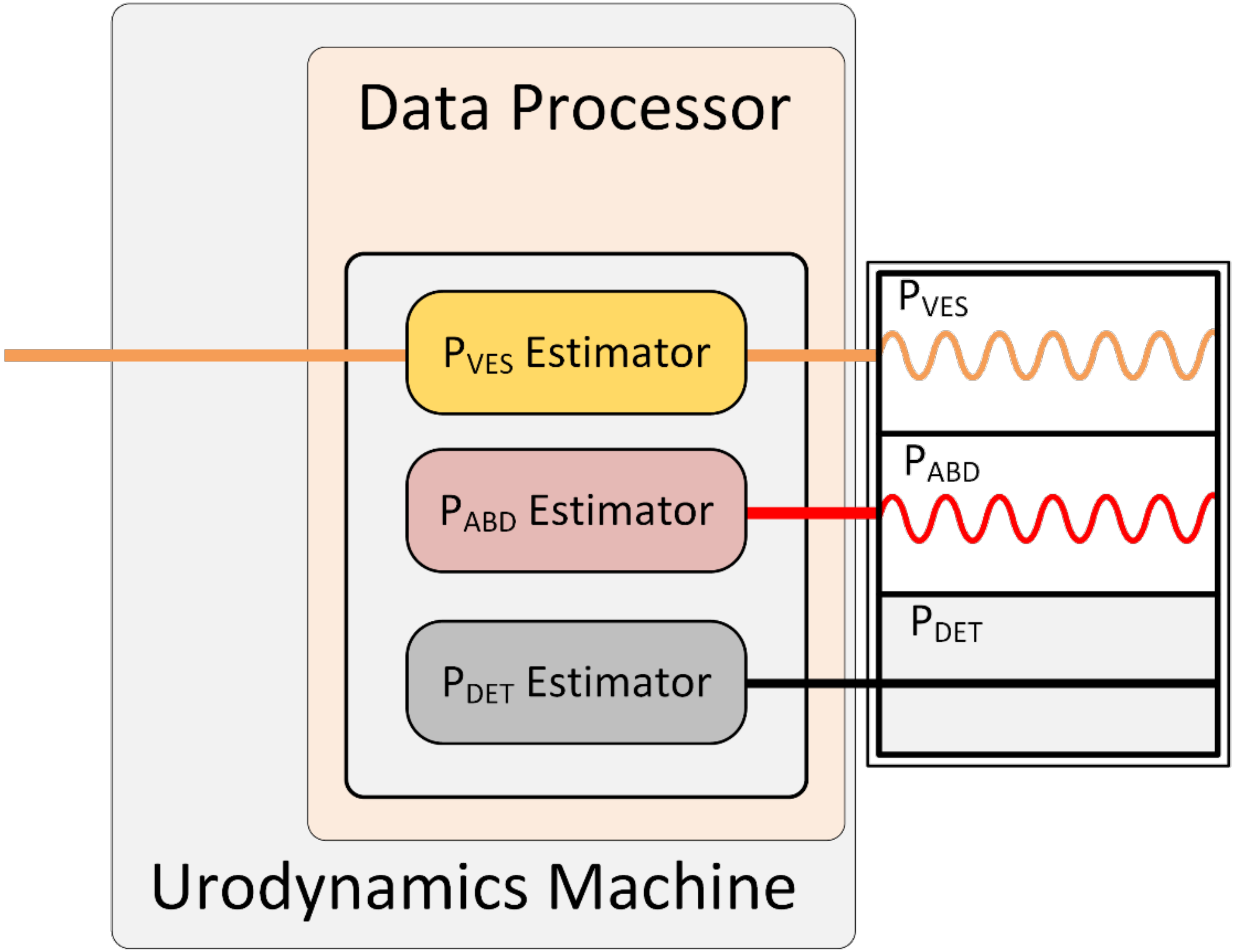
[1]Drake, Neurourology & Urodynamics, 2018

Goals

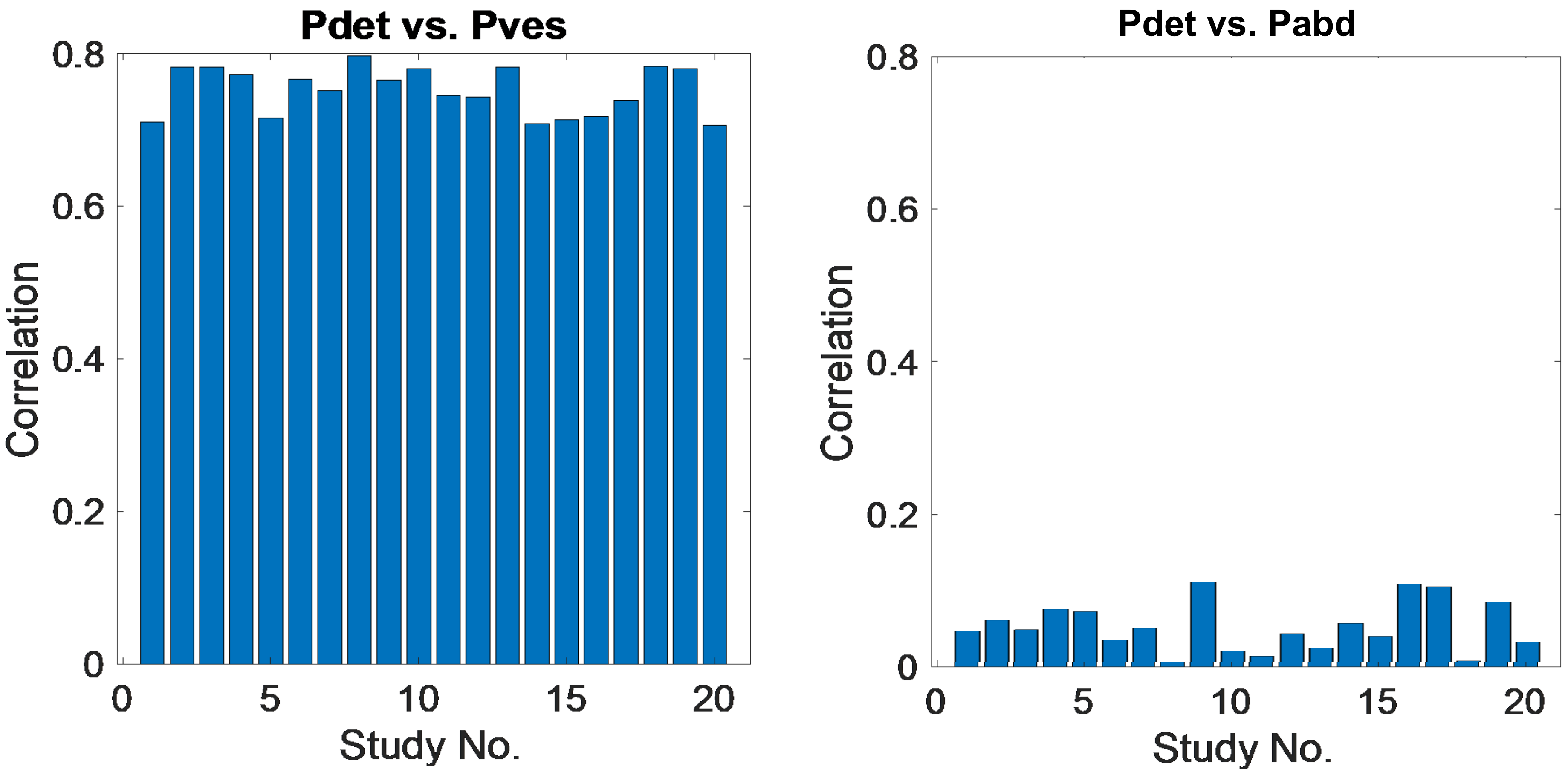
1. Use one catheter

2. Extract P_{DET} from vesical pressure (P_{VES})

3. Reconstruct P_{VES}, P_{ABD}, and P_{DET} traces with minimal delay



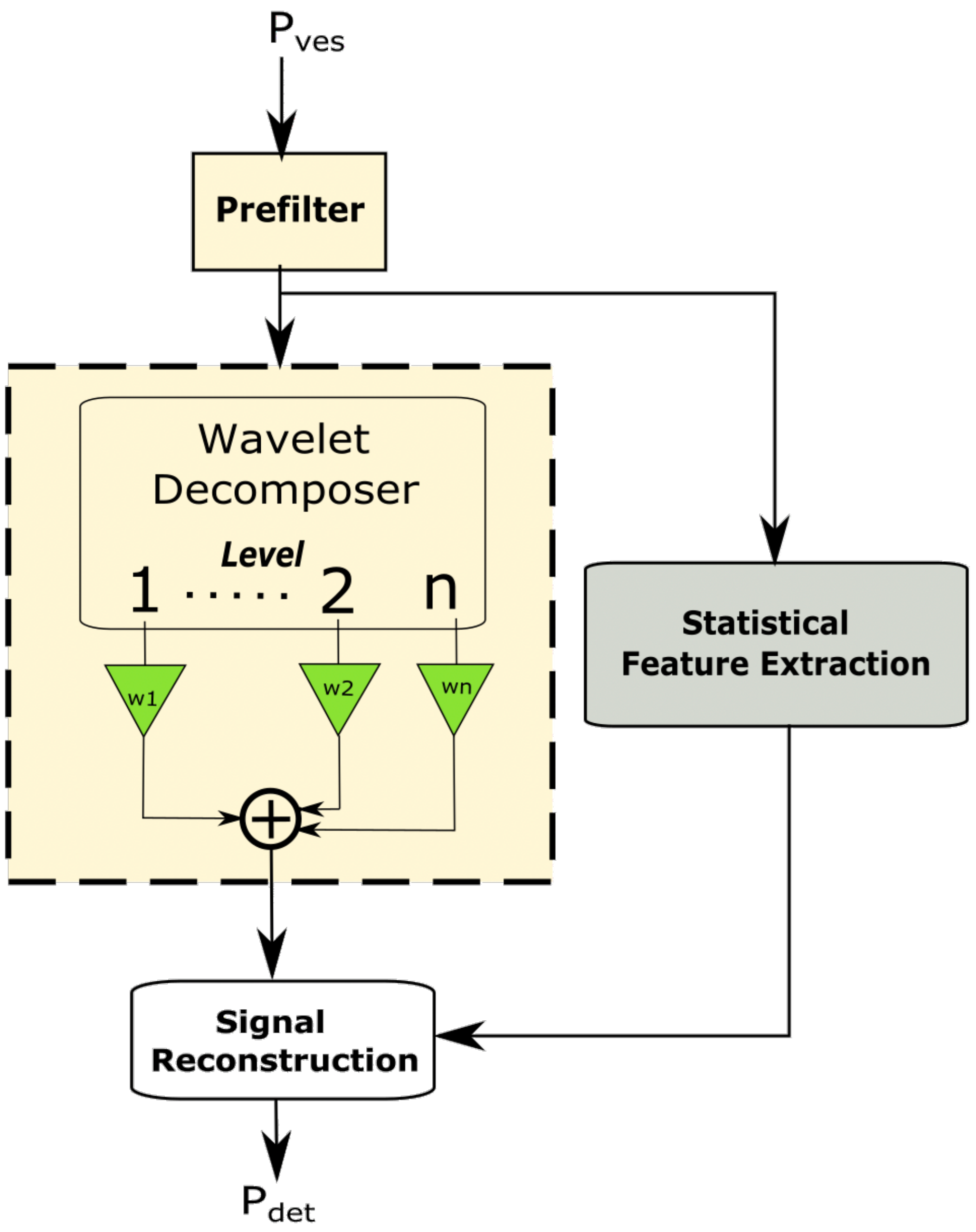
Which catheter?



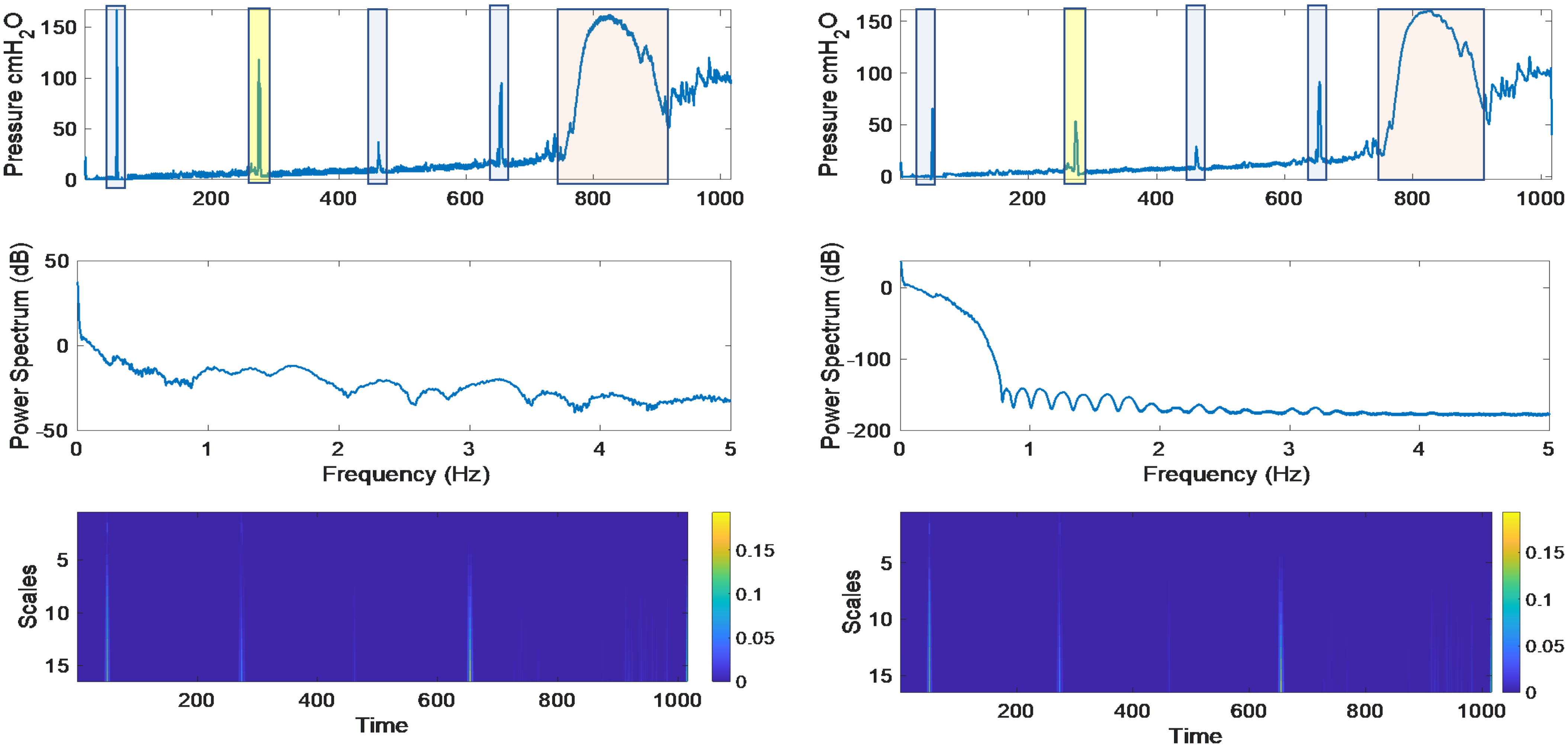
Unsurprisingly the bladder catheter correlates strongly with detrusor pressure

Single Channel Pipeline

1. Prefiltering
2. Wavelet decomposer
3. Statistical feature extraction
4. Signal reconstruction

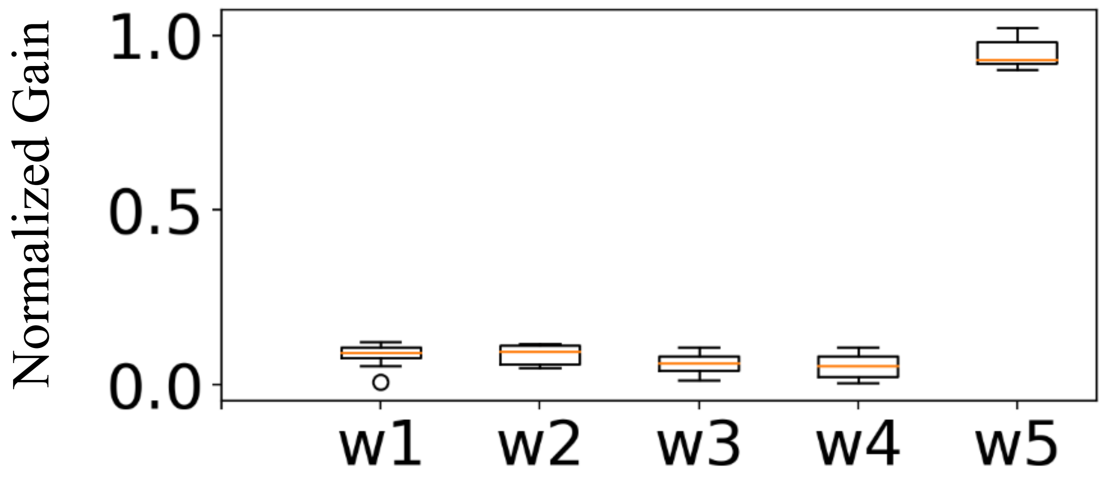


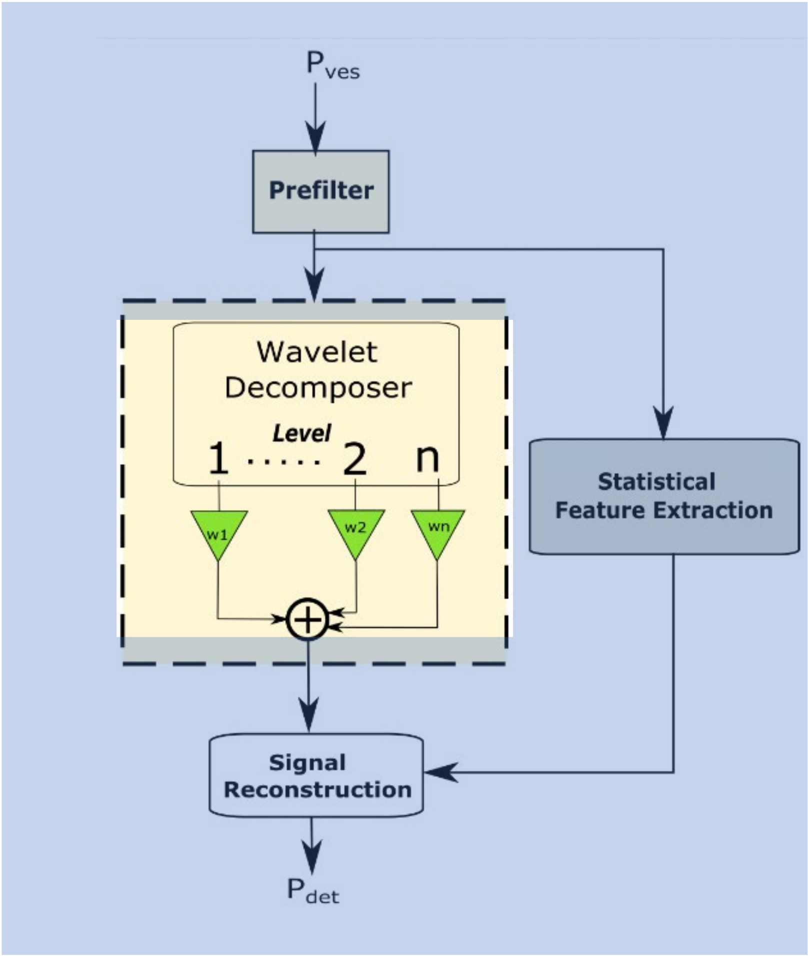
3rd-order Savitky Golay prefilter



Wavelet reconstruction weights

- Pves decomposed to 5 levels
- Least mean square fitting used to calculate average weights (n=20)





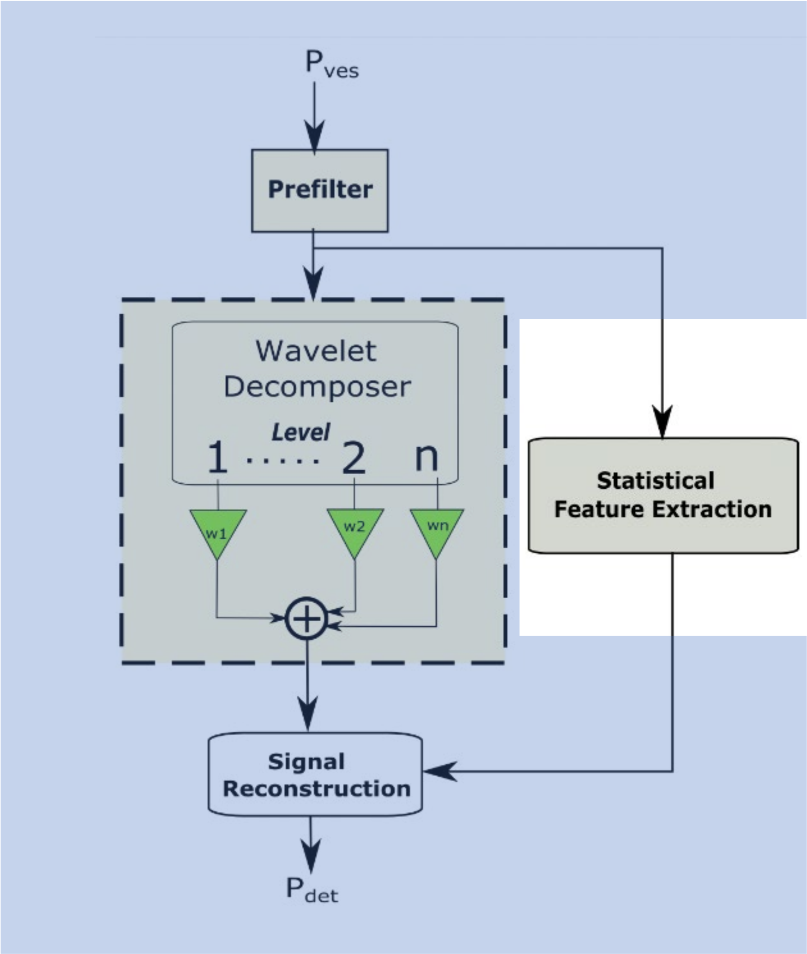
Selecting wavelet function

- Wavelets tested by reconstructing urodynamics signals (n=20)
  - **Reconstruction computation time (RT)**
  - **Reconstruction error (RE)**
- Symlet with four vanishing points (Sym4) achieved the best RT/RE balance

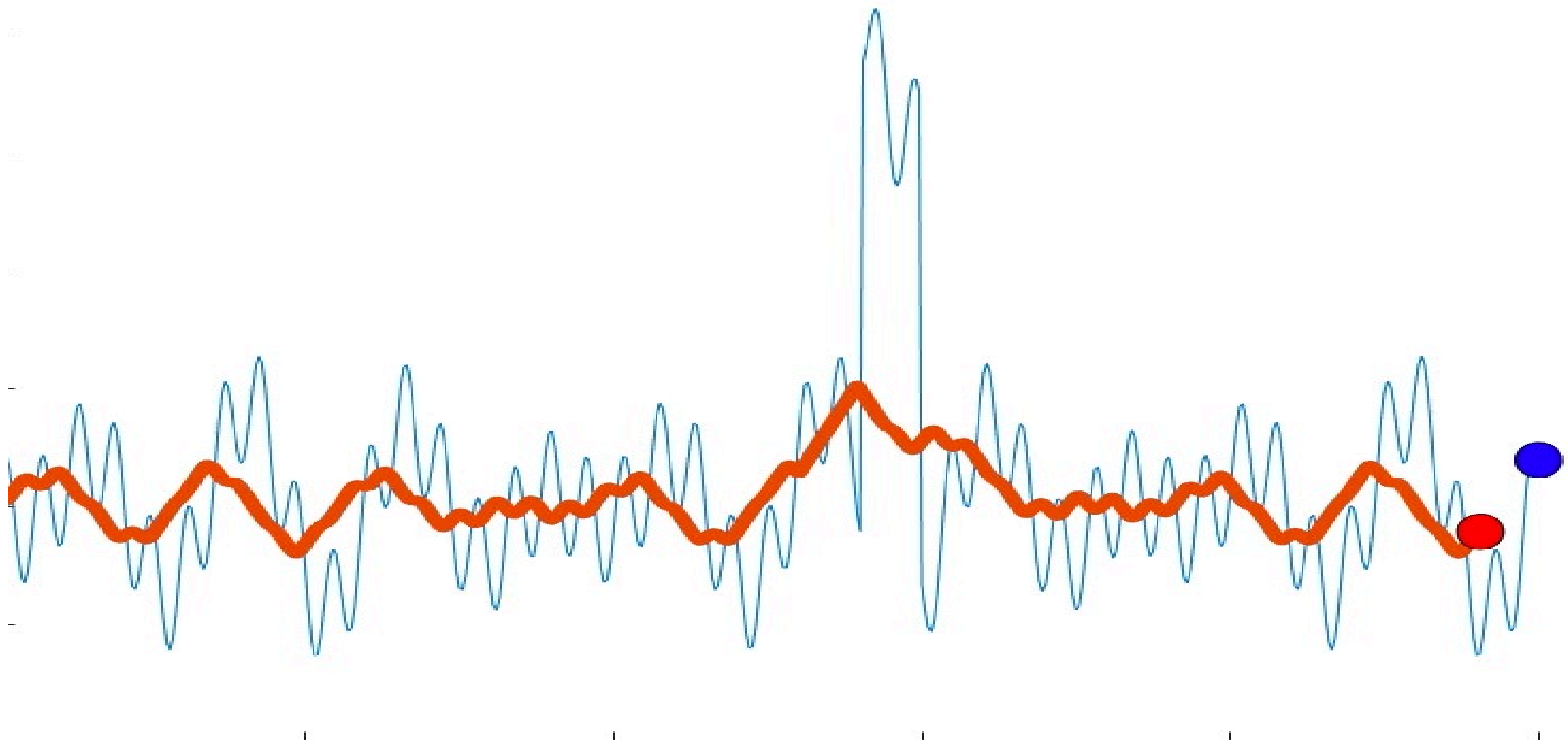
	Haar	DB4	Sym4	Dmey	Coif4
RT (msec)	1.9	3.7	3.4	8.7	14
RE	1e-5	1e-12	1e-12	1e-12	1e-12

Event Detection

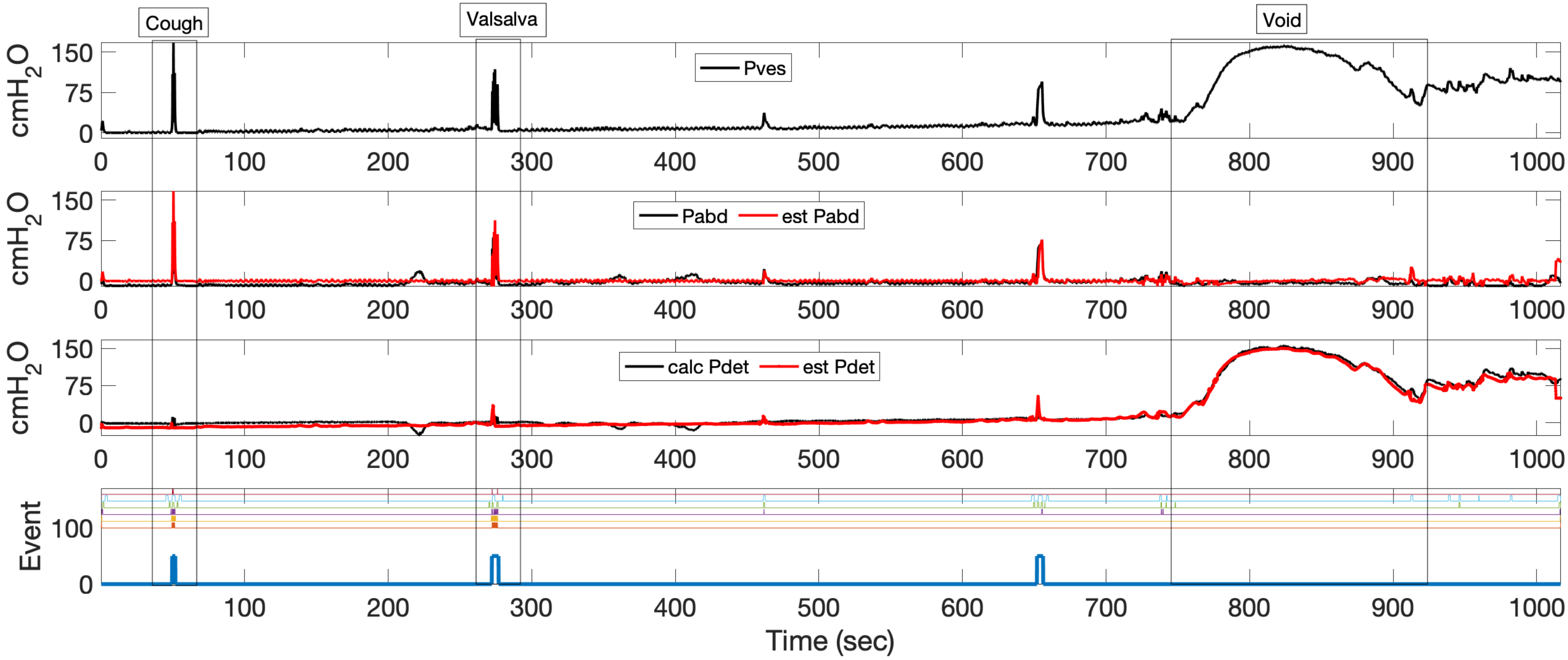
- Prefiltering and wavelets attenuated P_{ABD} artifacts feeding through to P_{DET}
- Frame-based on 32-sample window
- Event detection replaces the wavelet reconstruction with the frame mean
  - 2 events: cough and valsalva
  - 4 features per frame



Example of adaptive reconstruction



Event detection and signal reconstruction



Results and conclusion

- Overall estimation performance showed $RMSE = 10.7 \pm 2.1\ \mathrm{cmH_2O}$ and $R = 0.88 \pm 0.6$ (n=20)
- Detection accuracy for cough and valsalva were 99.5% and 84.3% respectively
- Future work on higher sample rate systems (100 to 1,000 Hz) for longer wavelet lengths and real-time implementation

Thank you!

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Drs. Damaser and Majerus are inventors on IP and have significant financial interests in the outcome of this project. Mr. Brody is employed by SRS Medical and has significant financial interests in this project.

This work does not represent the views of the US Dept of Veterans Affairs or the US Government.

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