

# Single-Beat ECG Template Generation: From RR-Interval to a Fiducial Point-Informed Approach

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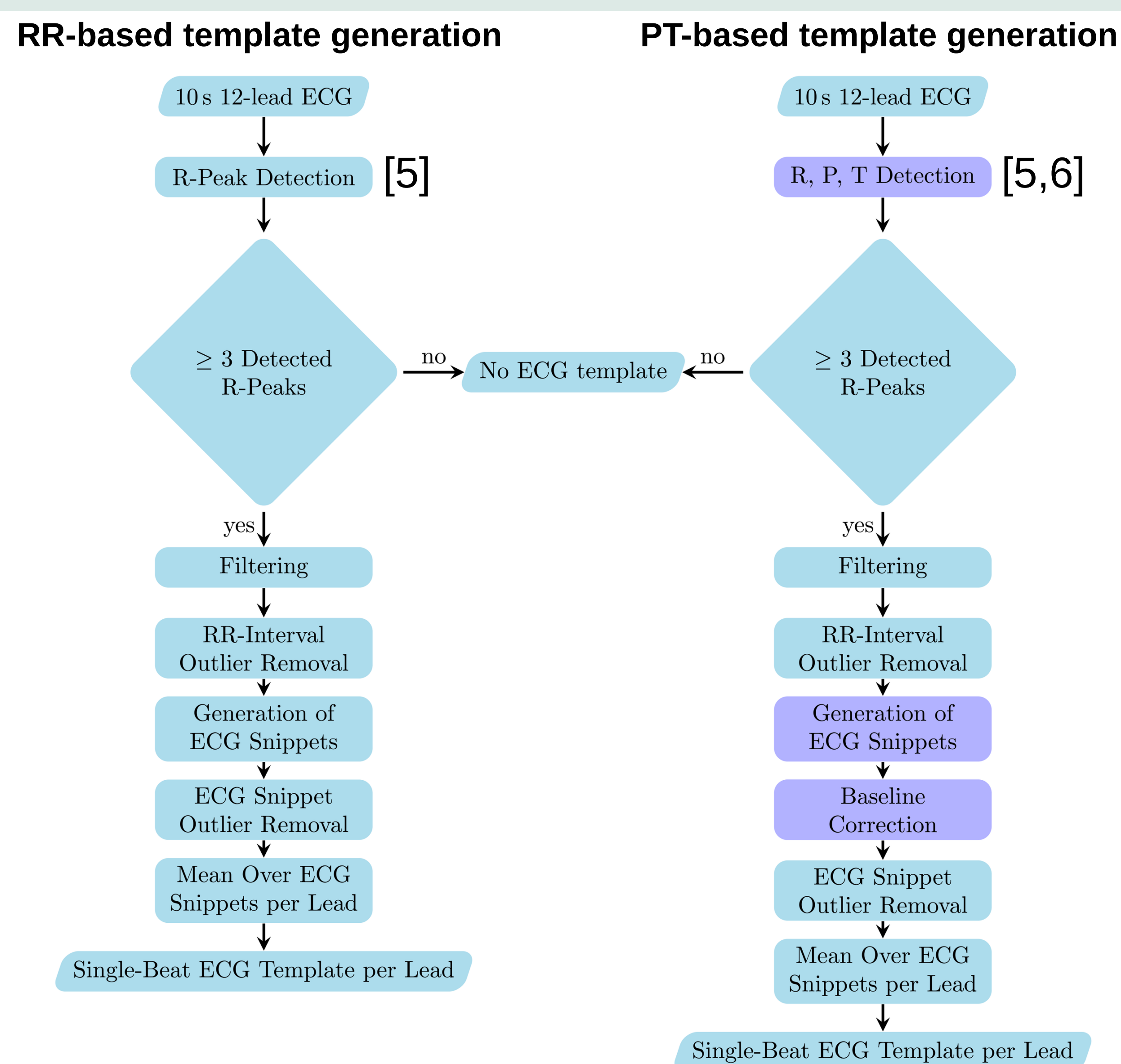
## Introduction

In certain **electrocardiogram (ECG) analysis** scenarios, a condensed representation of a 10 s 12-lead recording that minimizes inter-beat variability is required. Applications include analyzing associations between amplified P-wave duration and low-voltage extent, outcome after pulmonary vein isolation, and new-onset atrial fibrillation [1,2].

This work extends an existing **template generation method** based on RR-intervals for extracting the single heartbeats, therefore called RR-based approach [3]. The proposed template generation utilizes the information of P-wave onset and T-wave offset in the ECG snippet extraction and is therefore called PT-based approach [4].

## Methods

### Template Generation Workflow



### Data

- For the comparison 200 ECGs from the MIMIC-IV dataset were used [7]
- Heart rates (HR):  $90.2 \pm 24.4$  bpm (38 - 238 bpm)

### Signal-to-Noise Ratio Calculation

- Signal-to-Noise Ratio (SNR) was computed as the averaged ratio of template power to mean residual power (template vs. beats)

## Discussion & Conclusion

- PT-based approach **more robust for ECGs with high HR**
  - Preventing leakage of neighboring beats into the template
- SNR improvement** was significantly larger for ECGs with  $HR \geq 100$  bpm
- Negative correlation between baseline SNR and SNR change
  - Indicates that recordings with poorer initial quality benefit most from PT-based approach
- Improvements due to method and not the amount of used data

## Results

### Template Robustness

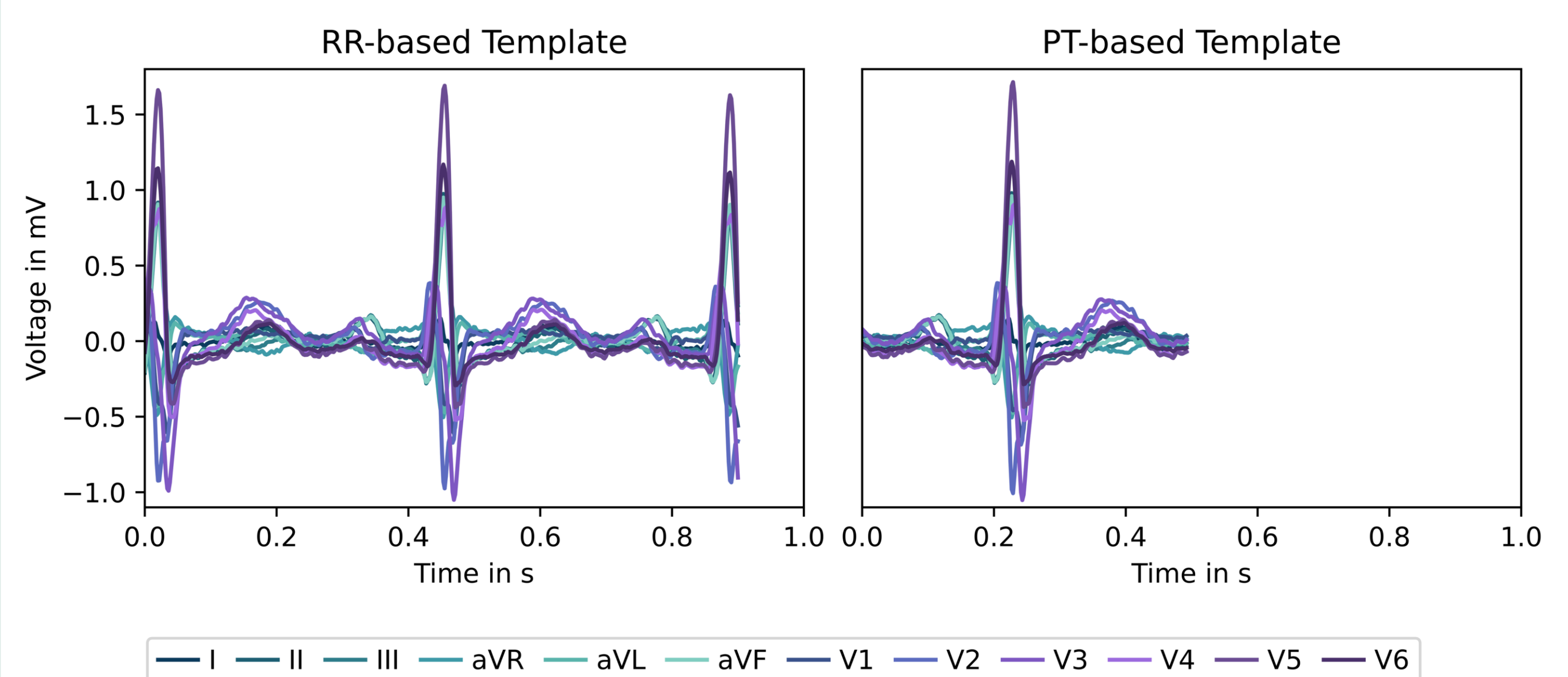
- No failed template generation in both methods
- Mean number of beats retained per method:
  - RR:  $9.4 \pm 3.31$
  - PT:  $9.5 \pm 3.45$

### Open-Source Code

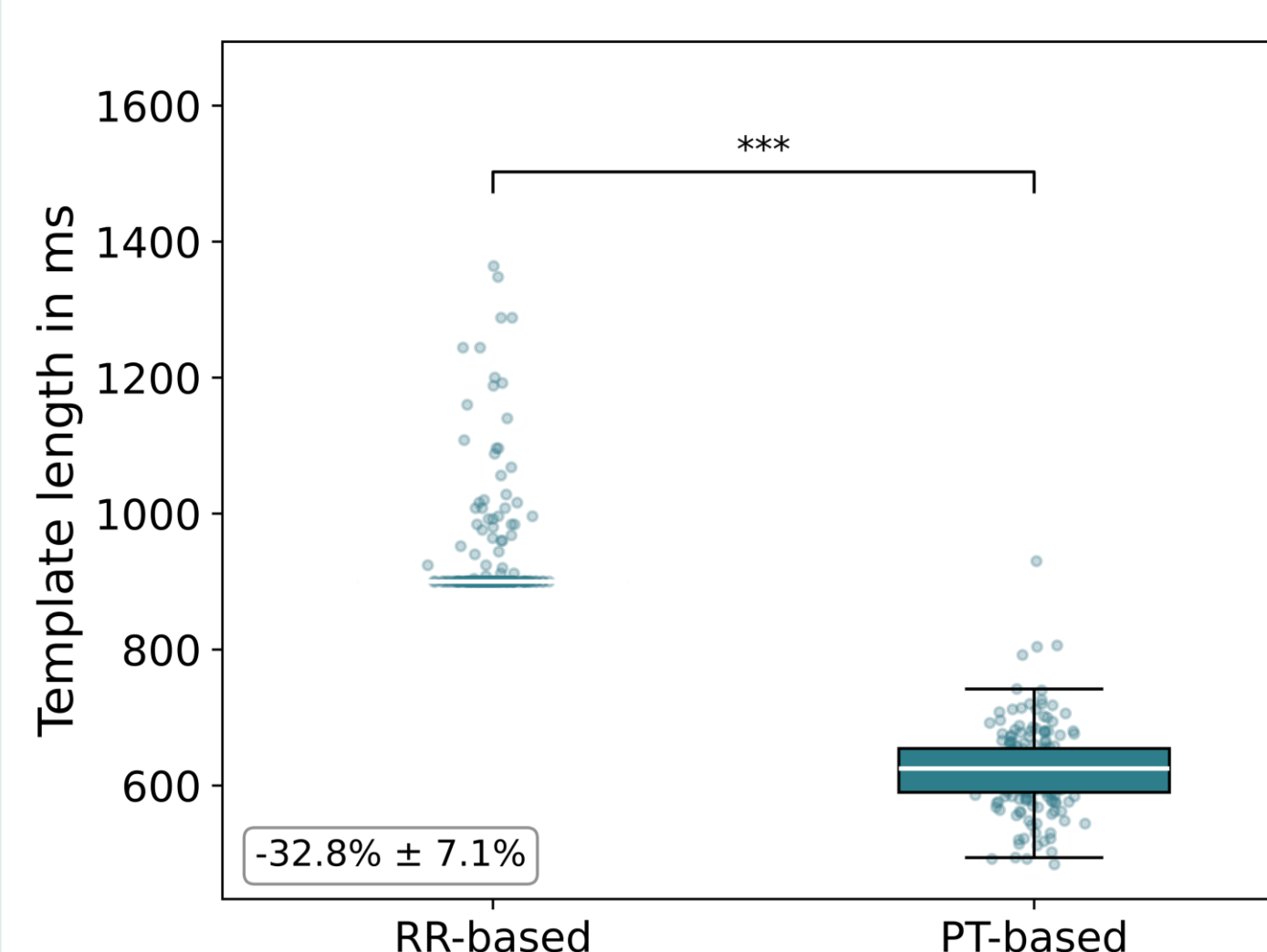


Single-beat-ecg-template-generation

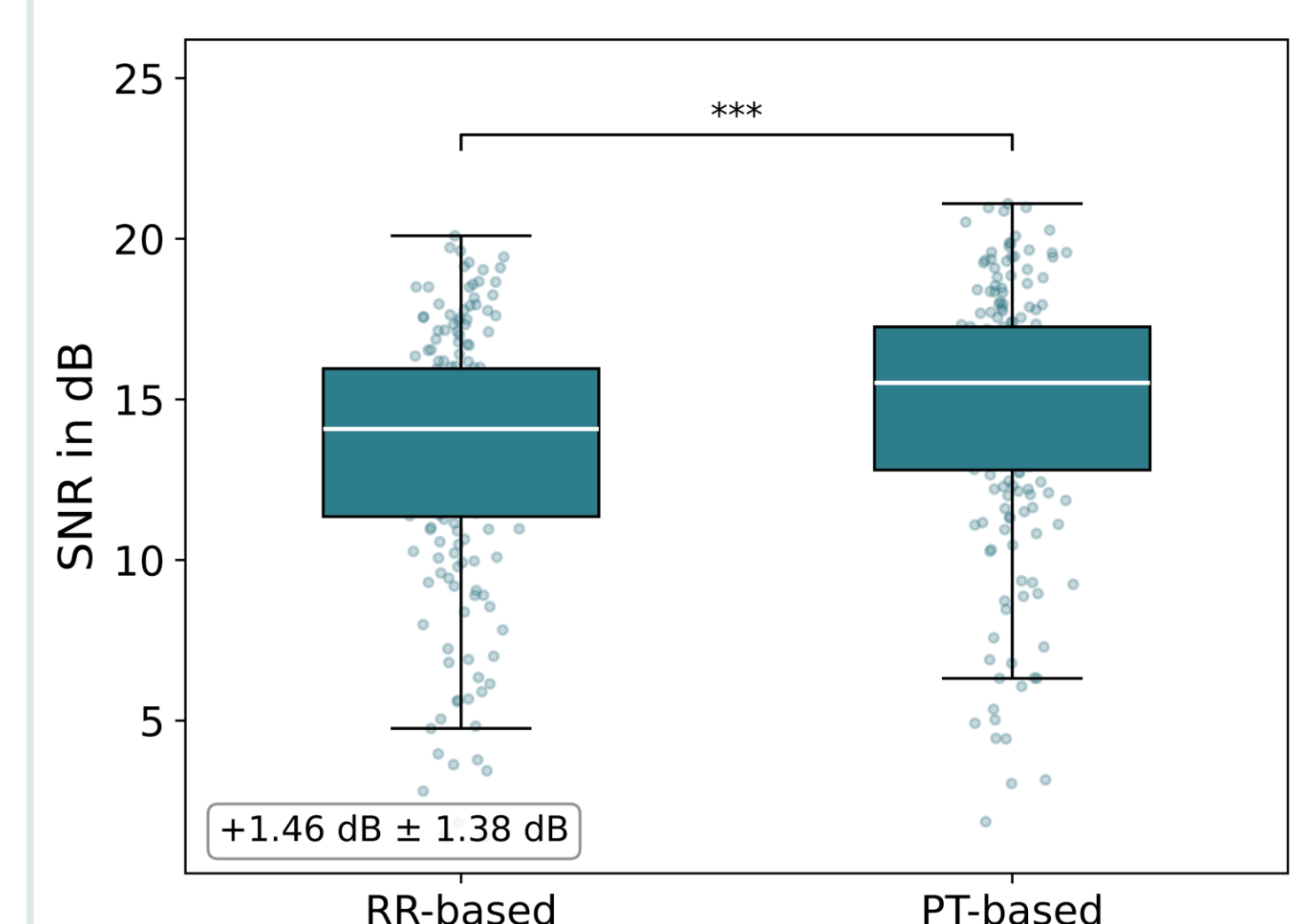
### Example Sinus Tachycardia



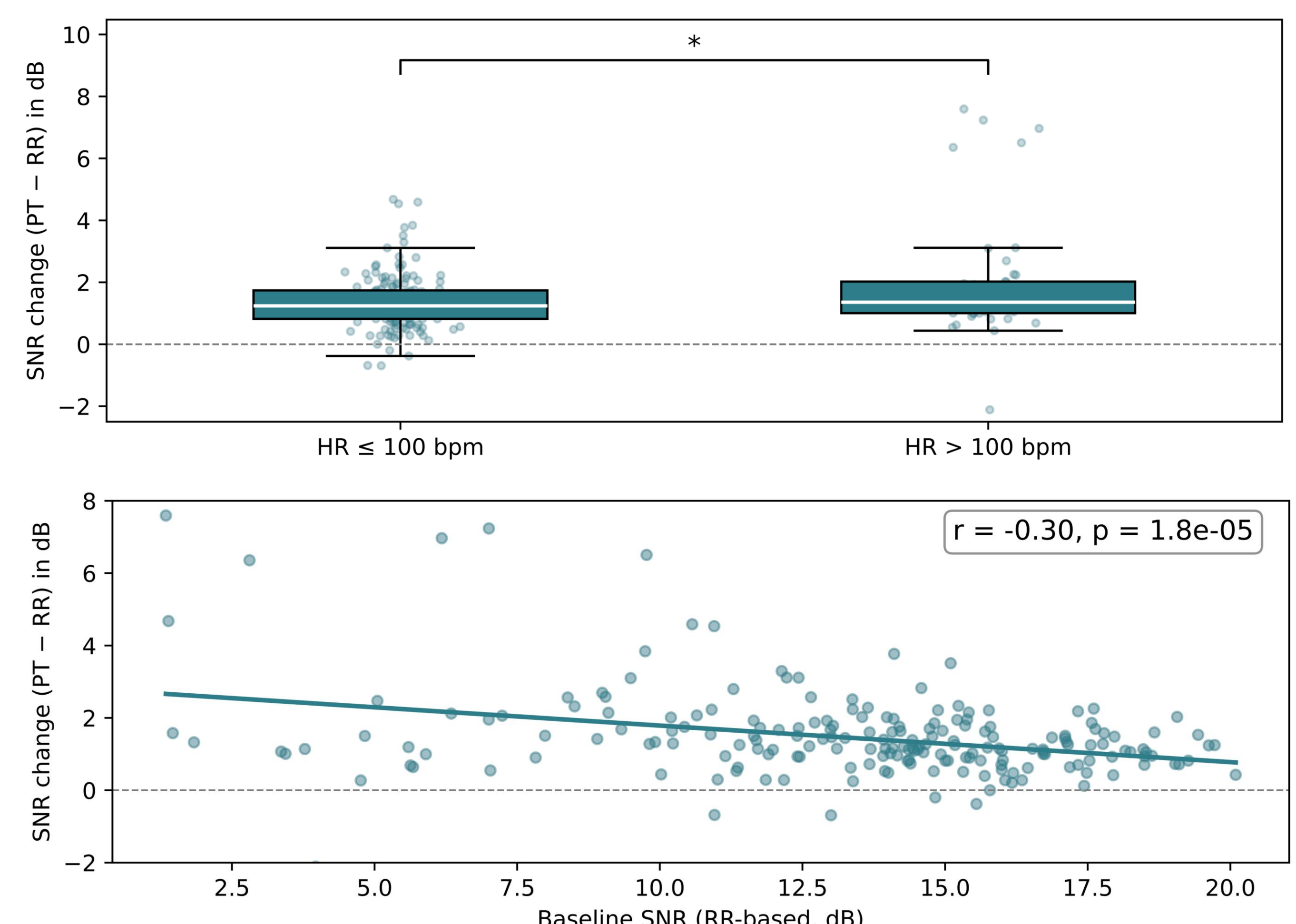
### Length Reduction



### SNR Improvement



### SNR Improvement at High Heart Rates



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