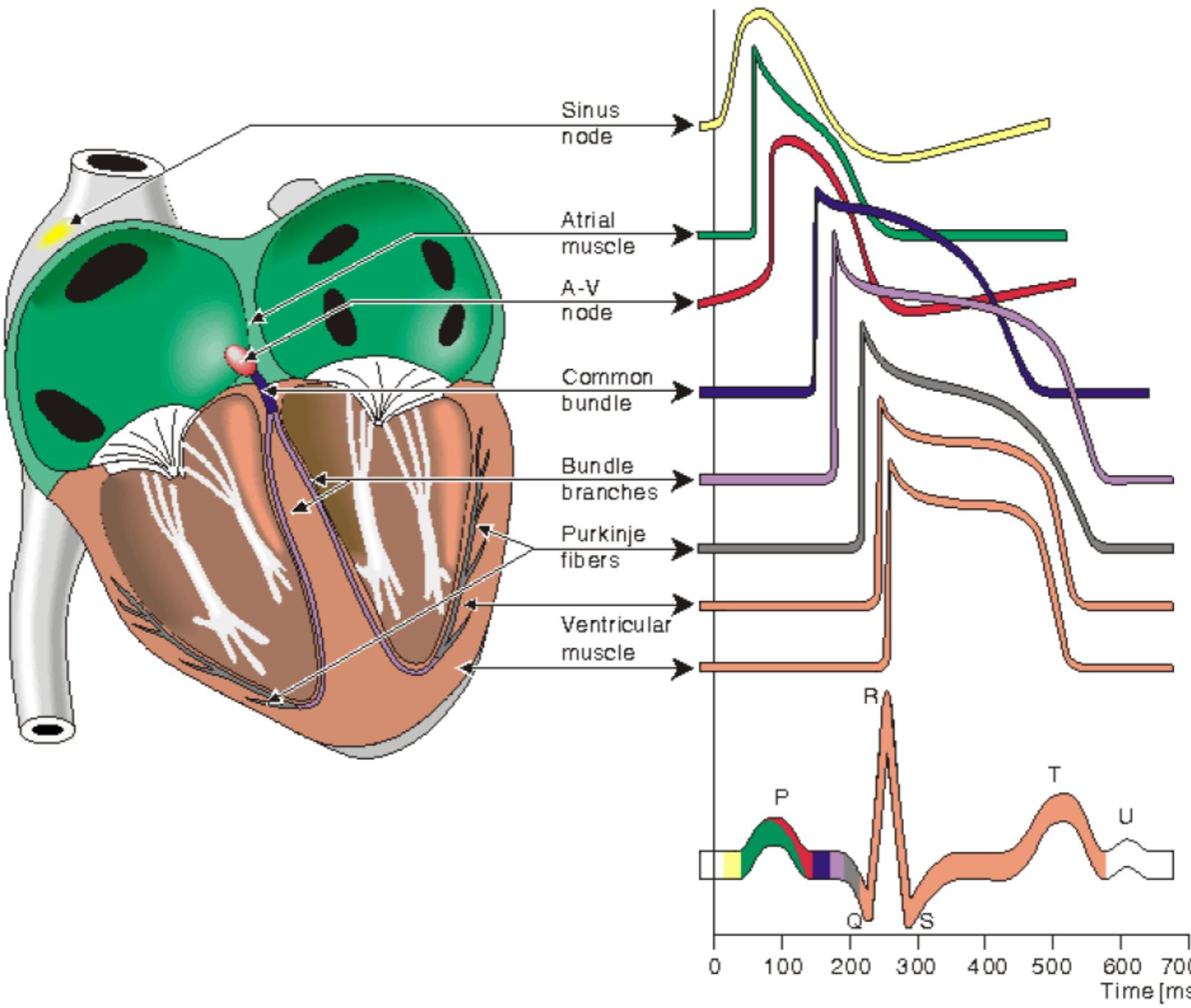


Lab 2: ECG Circuits, Signal Sampling and Digitization

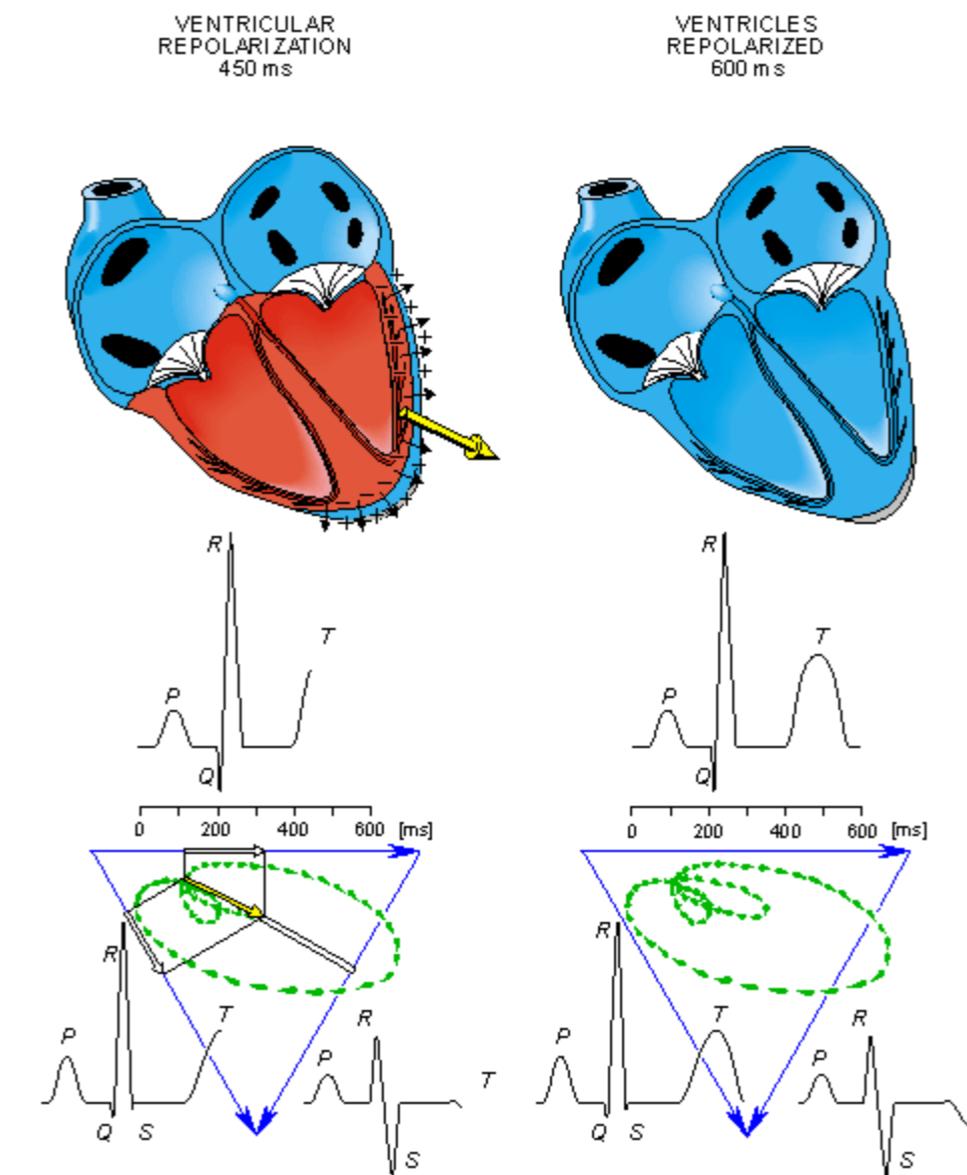
Formation of the ECG Signal(1/2)



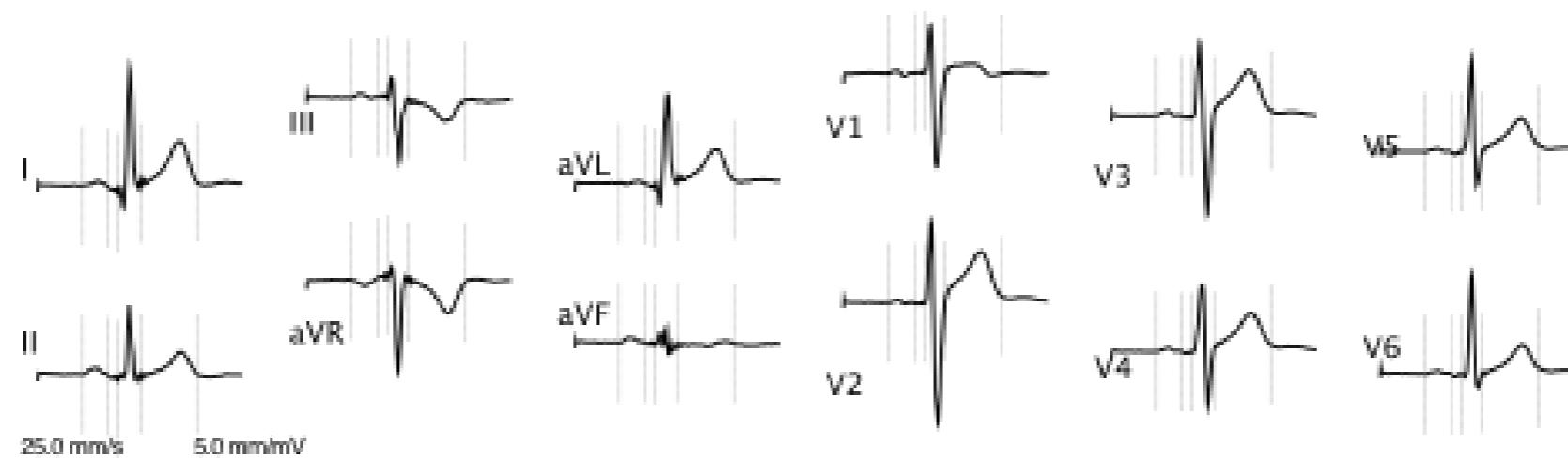
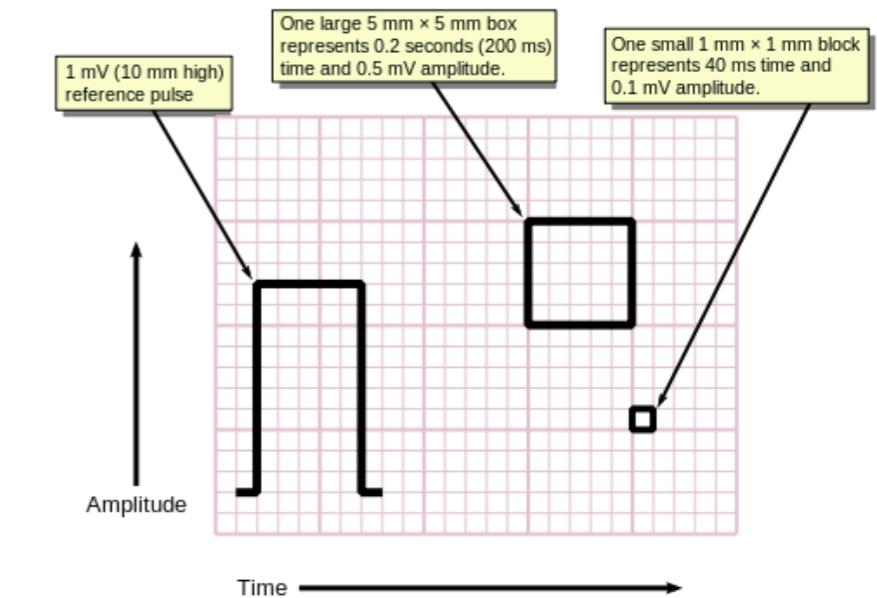
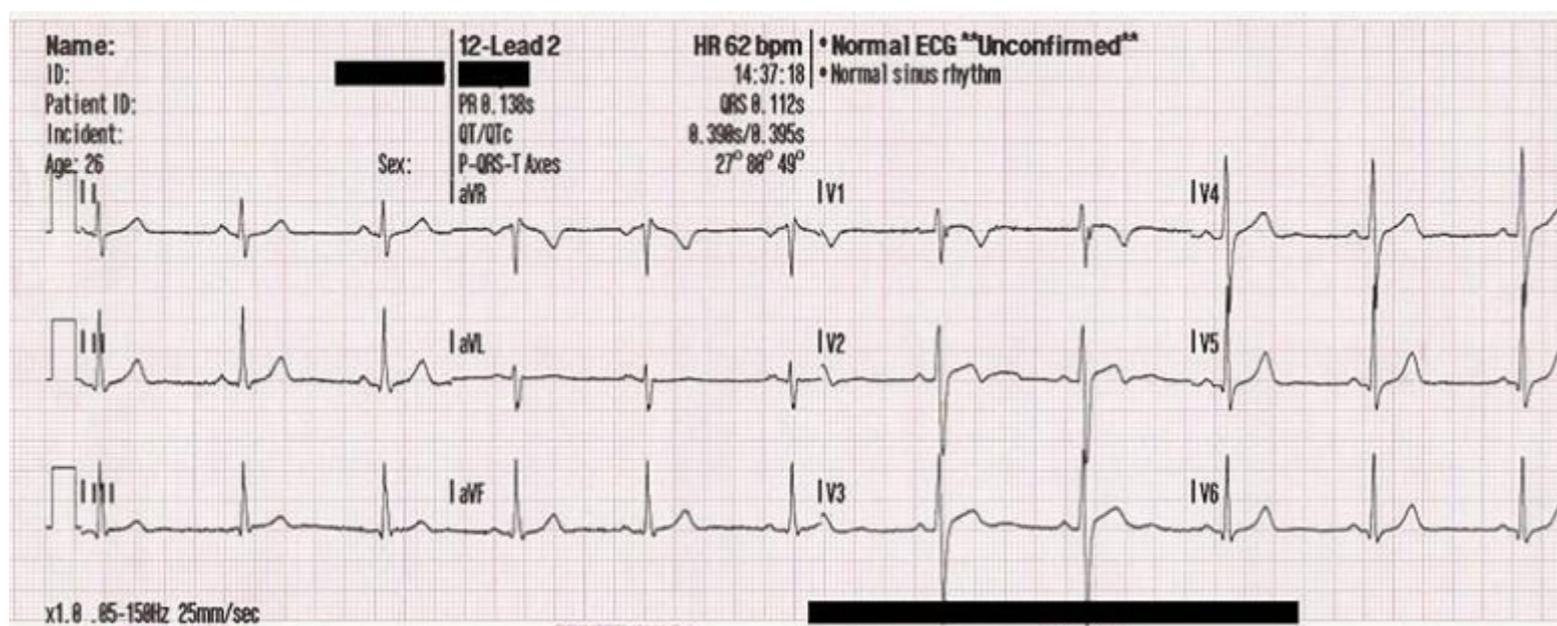
Please see <https://en.wikipedia.org/wiki/Electrocardiography>

BPM biosignals: <https://www.youtube.com/channel/UCCJ27SbGrOIIQ AeUEhRy1fg>

Formation of the ECG Signal(2/2)

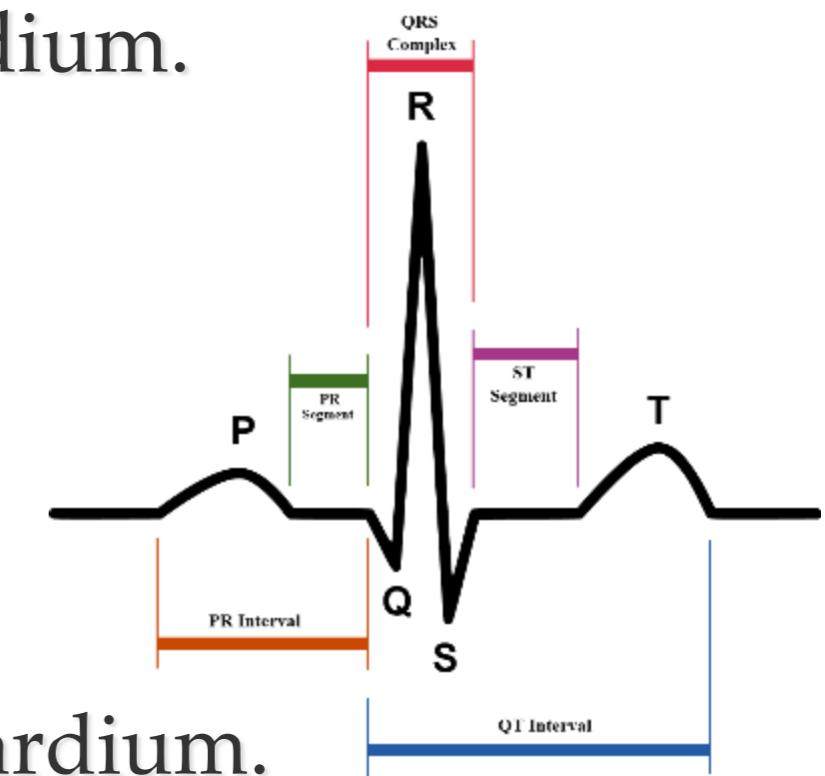


12-lead ECG



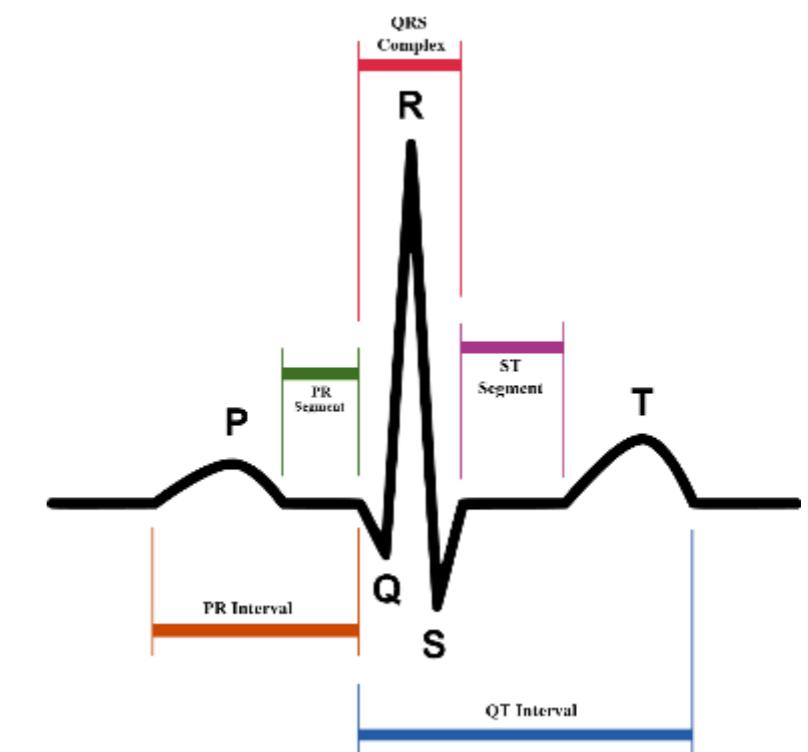
Normal ECG Signal (1/2)

- P waves
 - The depolarization of the atrial myocardium.
- PR interval
 - Between the beginning of the P wave and the beginning of QRS complex.
- QRS complex
 - The depolarization of ventricular myocardium.
 - Before the onset of ventricular systole.
 - R peaks are important for heart rate monitoring



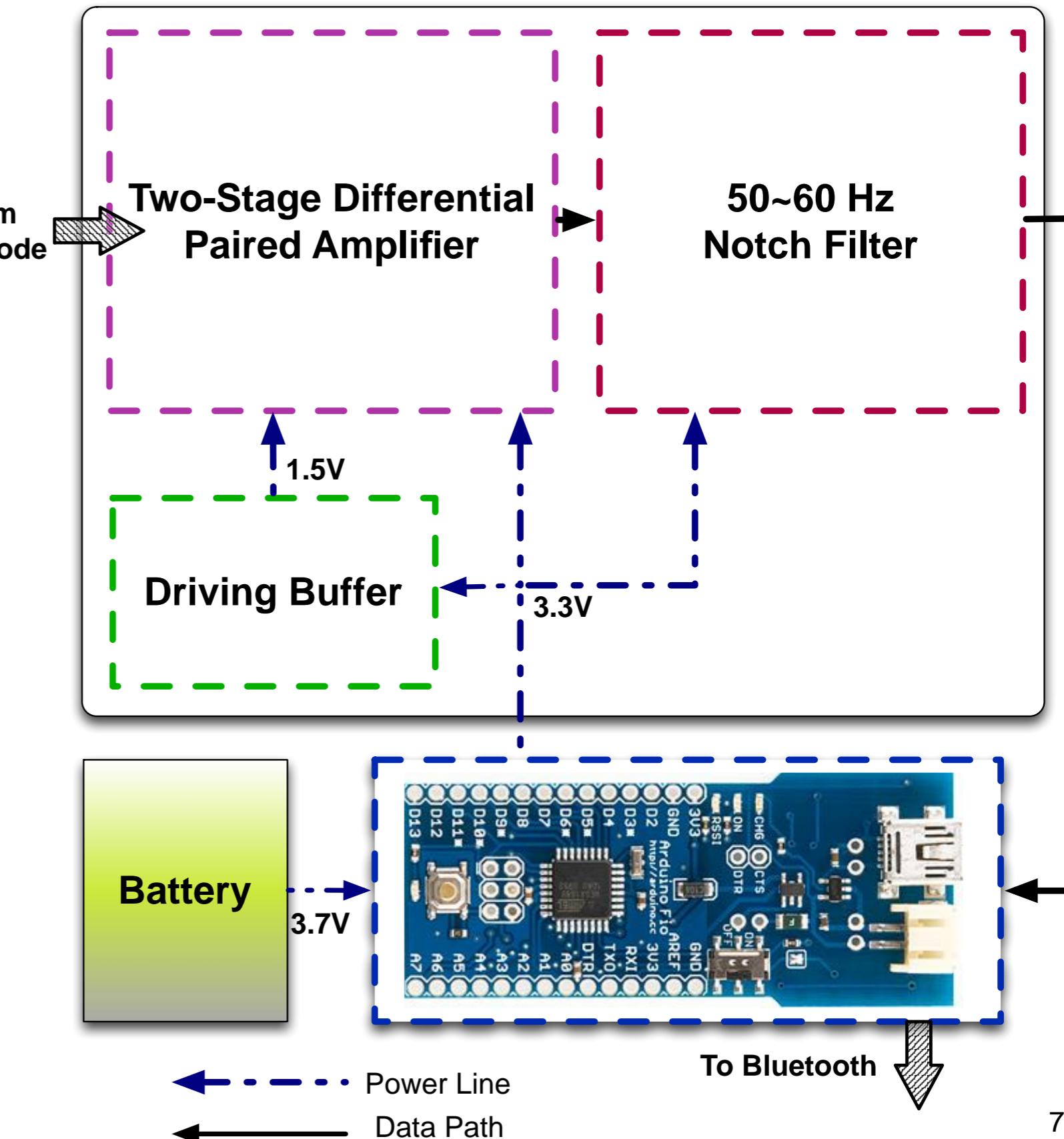
Normal ECG Signal (2/2)

- T waves
 - The repolarization of the ventricular myocardium.
- QT interval
 - Between the beginning of the P wave and the beginning of QRS complex.
- Corrected QT interval
 - $QT_c = \frac{\text{time interval from Q onset to T peak}}{\sqrt{\text{Previous RR interval}}}$



Front-End Circuits and Power Supply

- **Amplifier**
 - 1500X for ECG
 - -3dB frequencies at 1 Hz and 1.1 kHz
 - **Notch Filter**
 - Cut off at 59.9 Hz
 - Depth of the null is -29dB
 - **Driving Buffer**
 - Convert 3.3 V to 1.5 V



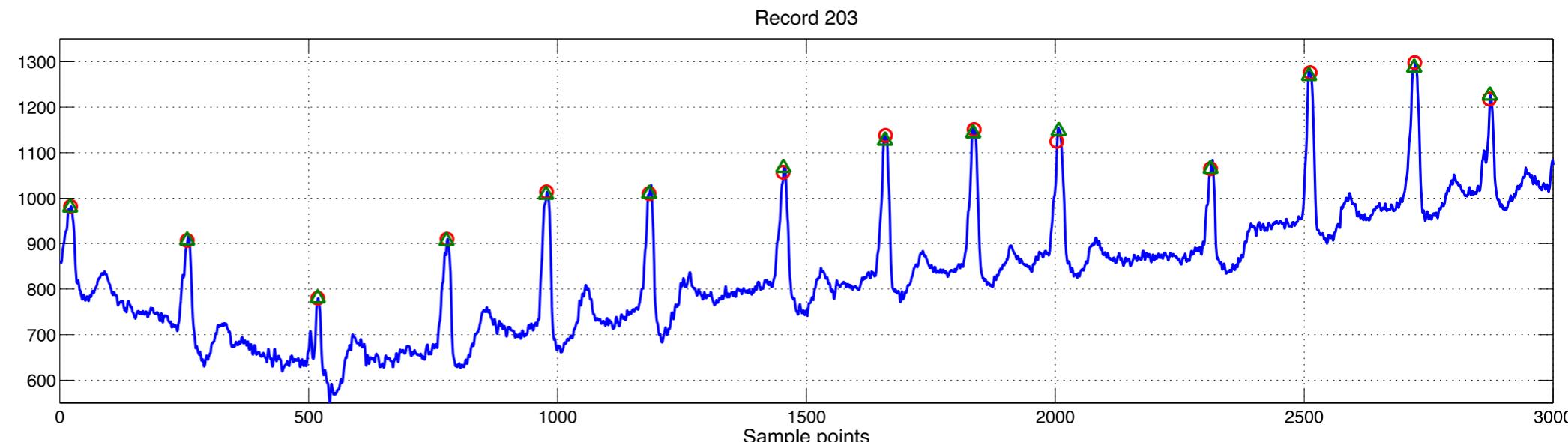
ECG Noise Reduction

- Noise types:
 - Baseline wander (BW) (below 1Hz)
 - 50 or 60 Hz power-line interference (PLI)
 - Electromyogram (EMG)
 - Motion artifact (MA)

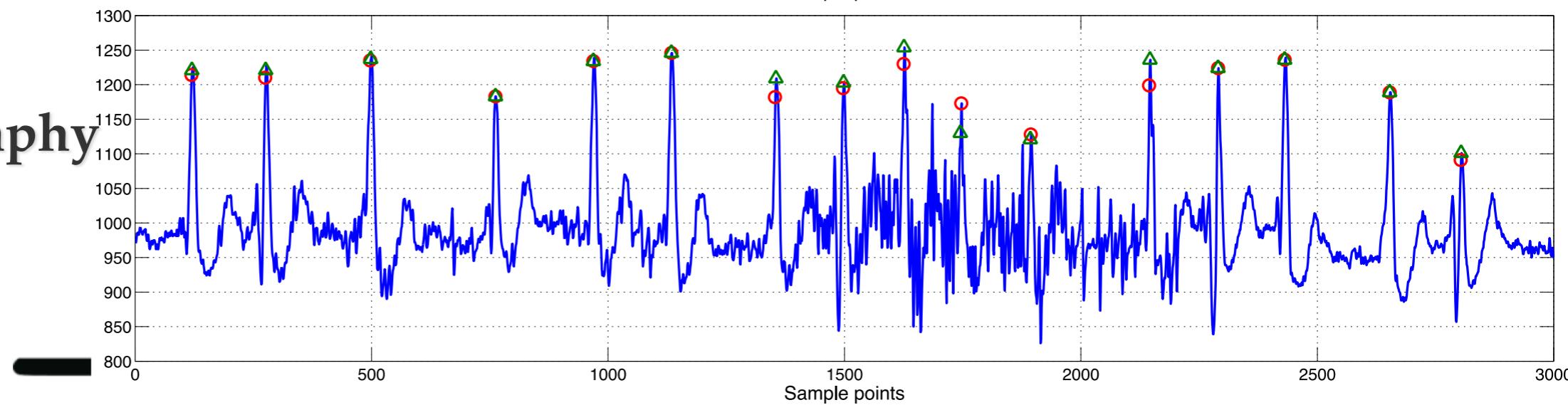
Method	Noise Type
Adaptive Filter	BW, PLI, MA
Wavelet Transform	BW, EMG, MA
Empirical Mode Decomposition	BW, EMG, MA
Independent Component Analysis	MA
Moving Average	BW, MA

ECG Signal and Interferences

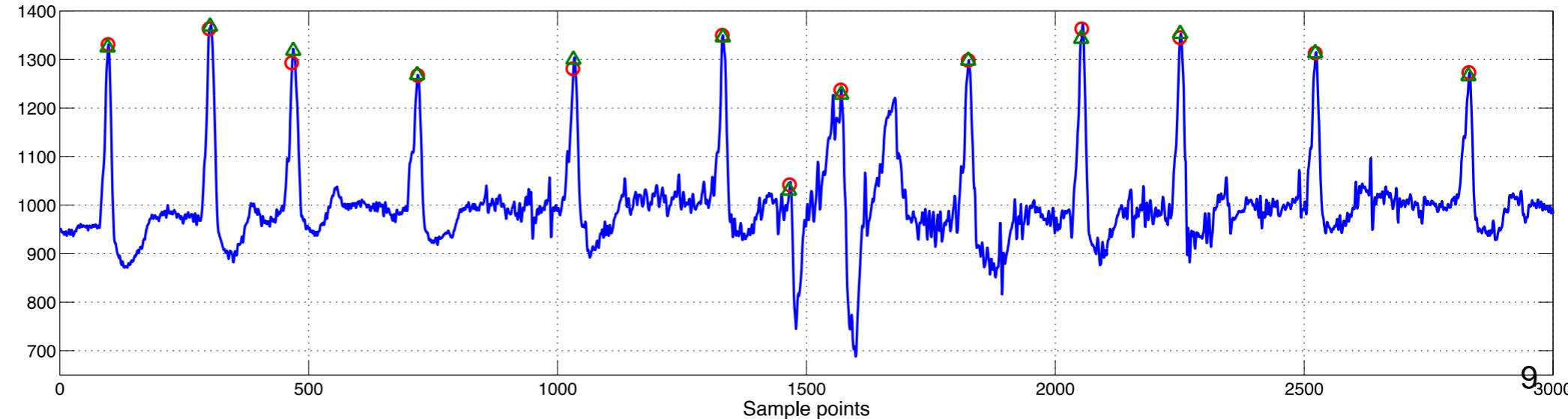
Baseline Noise



Electromyography
Noise



Motion Artifact



60-Hz Power-Line Interference

