

# Low-Power Earring for Longitudinal Heart Rate and Activity Sensing



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## ABSTRACT

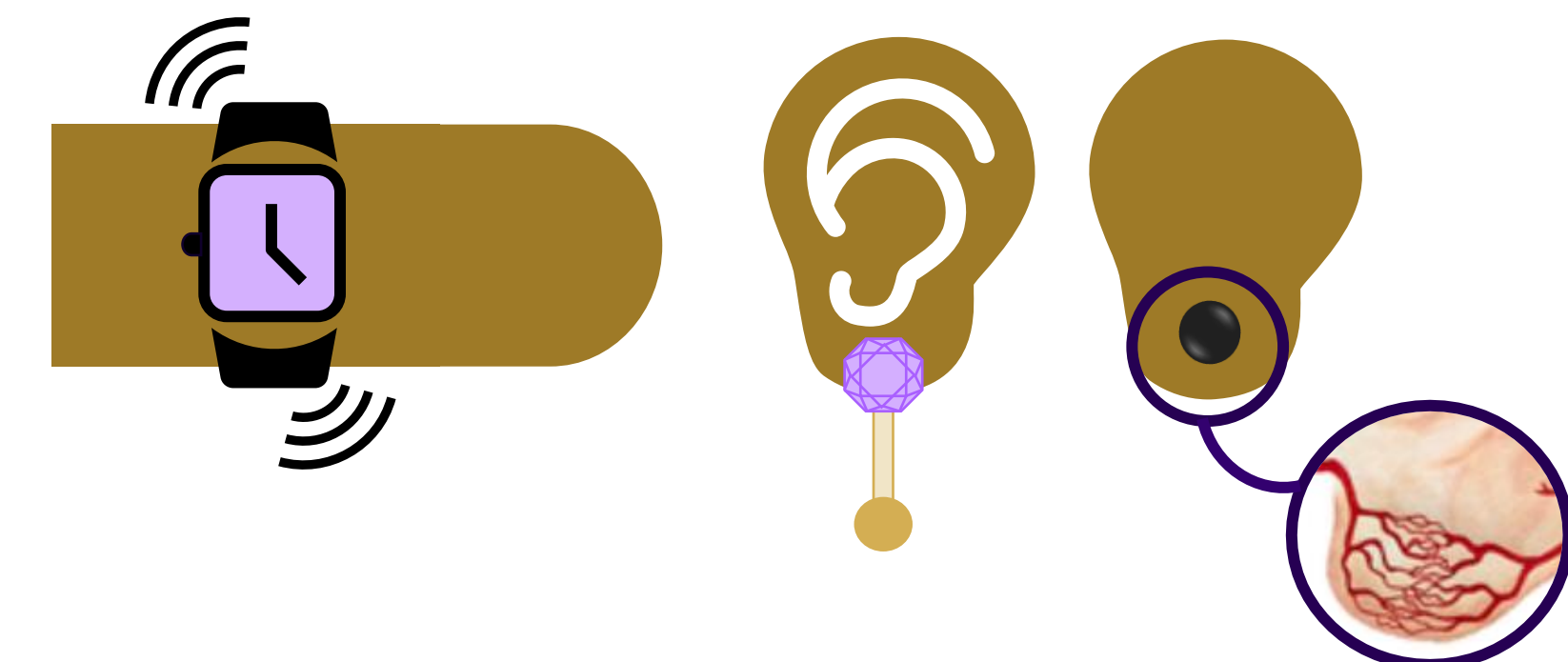
We present Earring++, a **first-of-its-kind smart earring** that enables a reliable non-invasive wearable solution for continuous heart rate and physical activity monitoring.



Earring++ takes advantage of the unique position of earrings on the earlobe, a region with **tight coupling to blood flow** unlike watches and other wearables which are more loosely worn on extremities of the body.

LOOSELY WORN - PRONE TO MOVEMENT

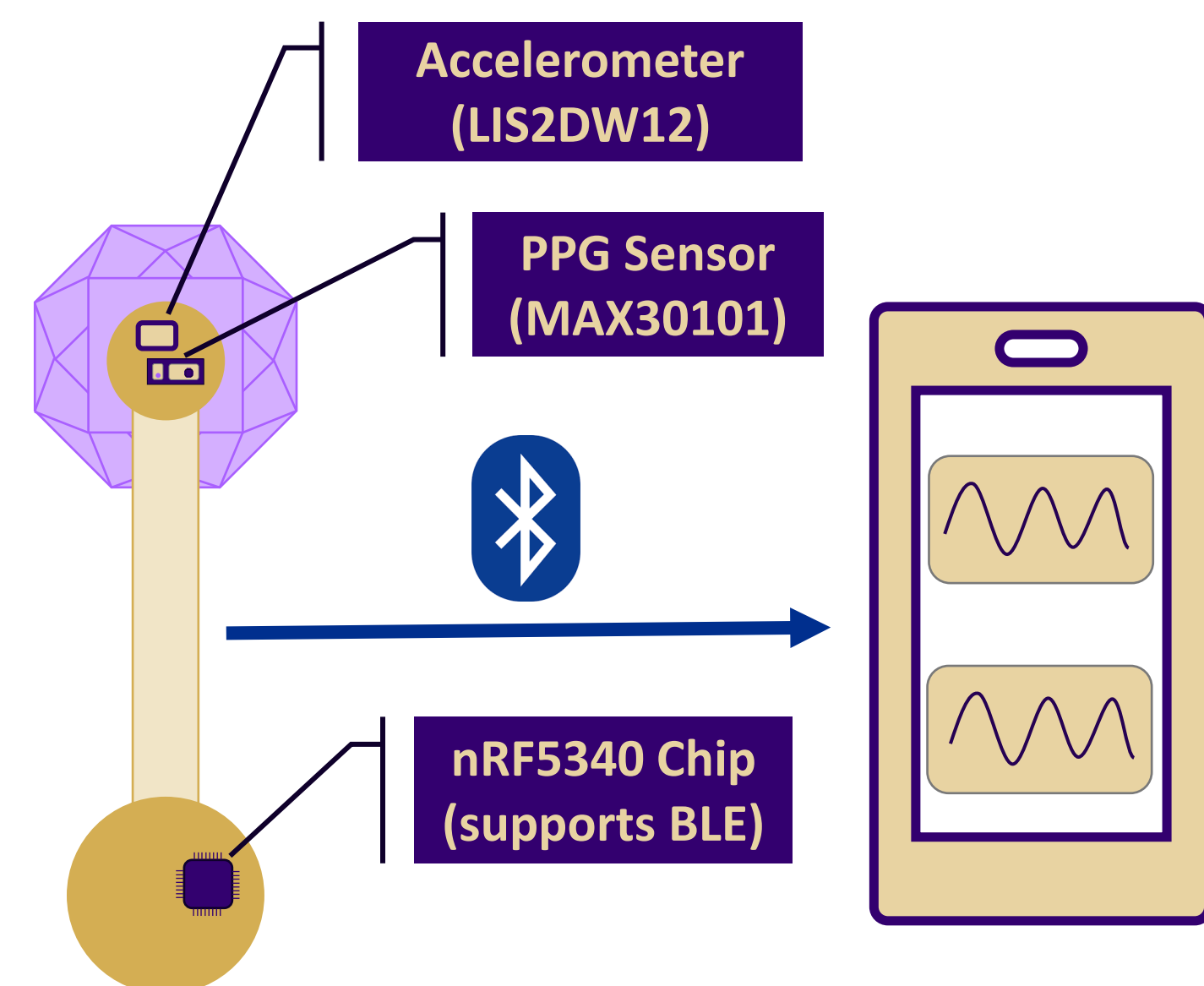
TIGHTLY SECURED & WORN EVERYDAY



Earring++ Low-Power Property:

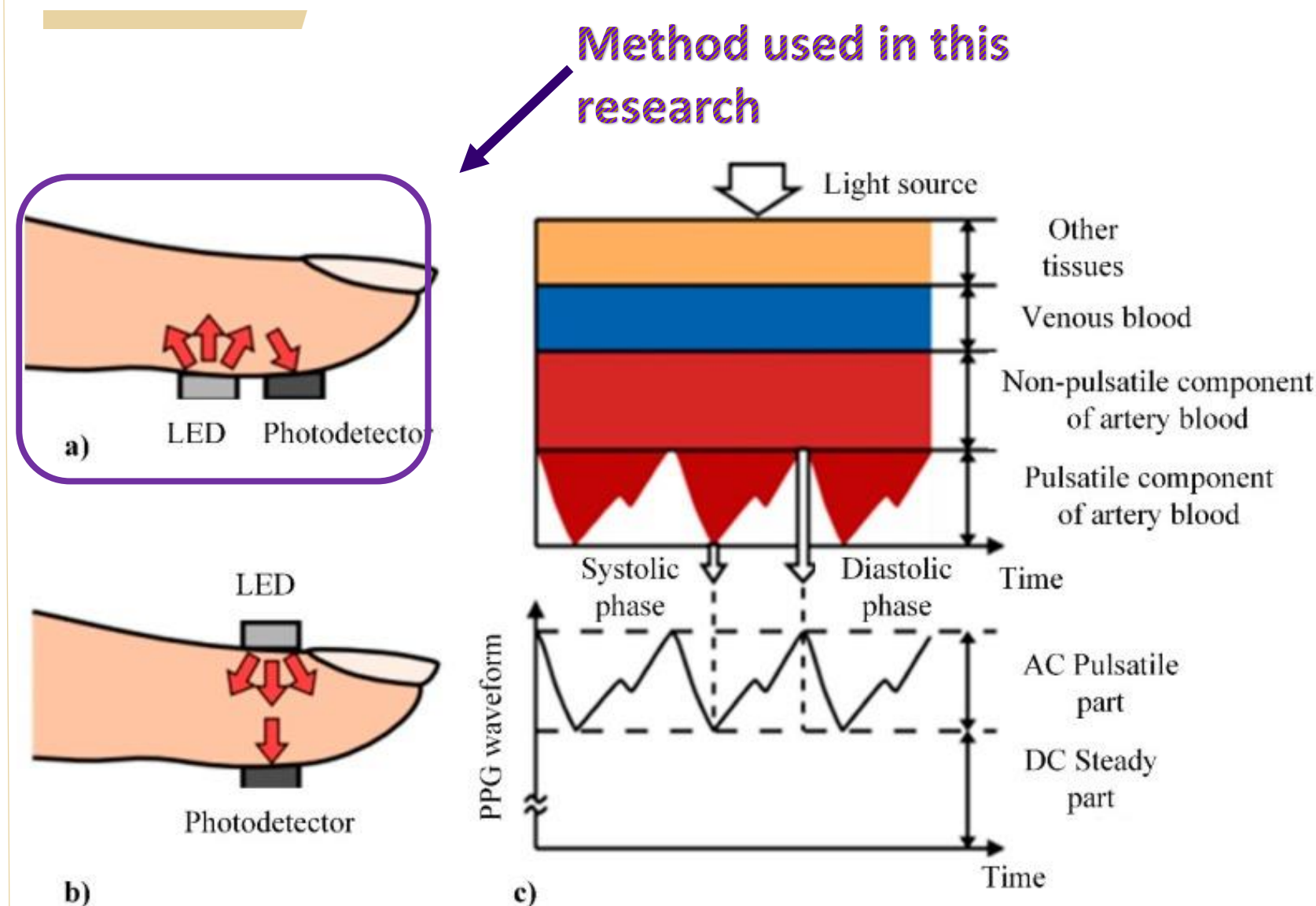
Transmission takes on average 650  $\mu$ A, enabling long battery life

## PIPELINE



- > nRF5340 collects data from MAX30101 (ppg) and LIS2DW12 (accel.) sensors
- > Transmit **240 byte buffer** of data over Bluetooth connection with phone
- > Data processes to measure heart rate and physical activity

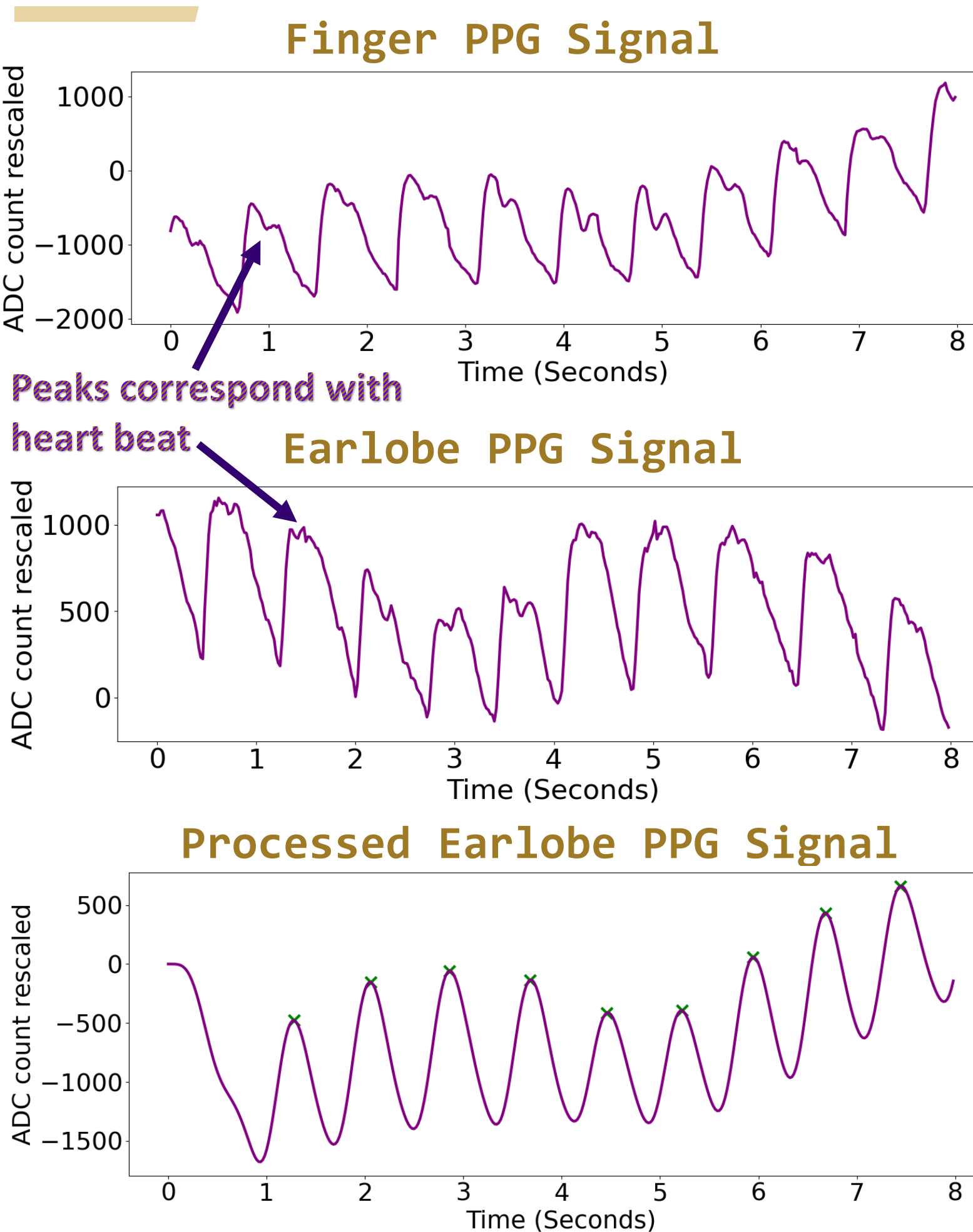
## PHOTOPLETHYSMOGRAPHY (PPG)



PPG usage (this research uses the reflective mode shown in part a) and example signal in part c

- > PPG sensor measures heart rate – variations of light absorbance as blood volume changes
- > Select IR because of deep penetration to reach deeper tissue
- > Medically, measure heart rate at earlobe and finger tip with a PPG sensor

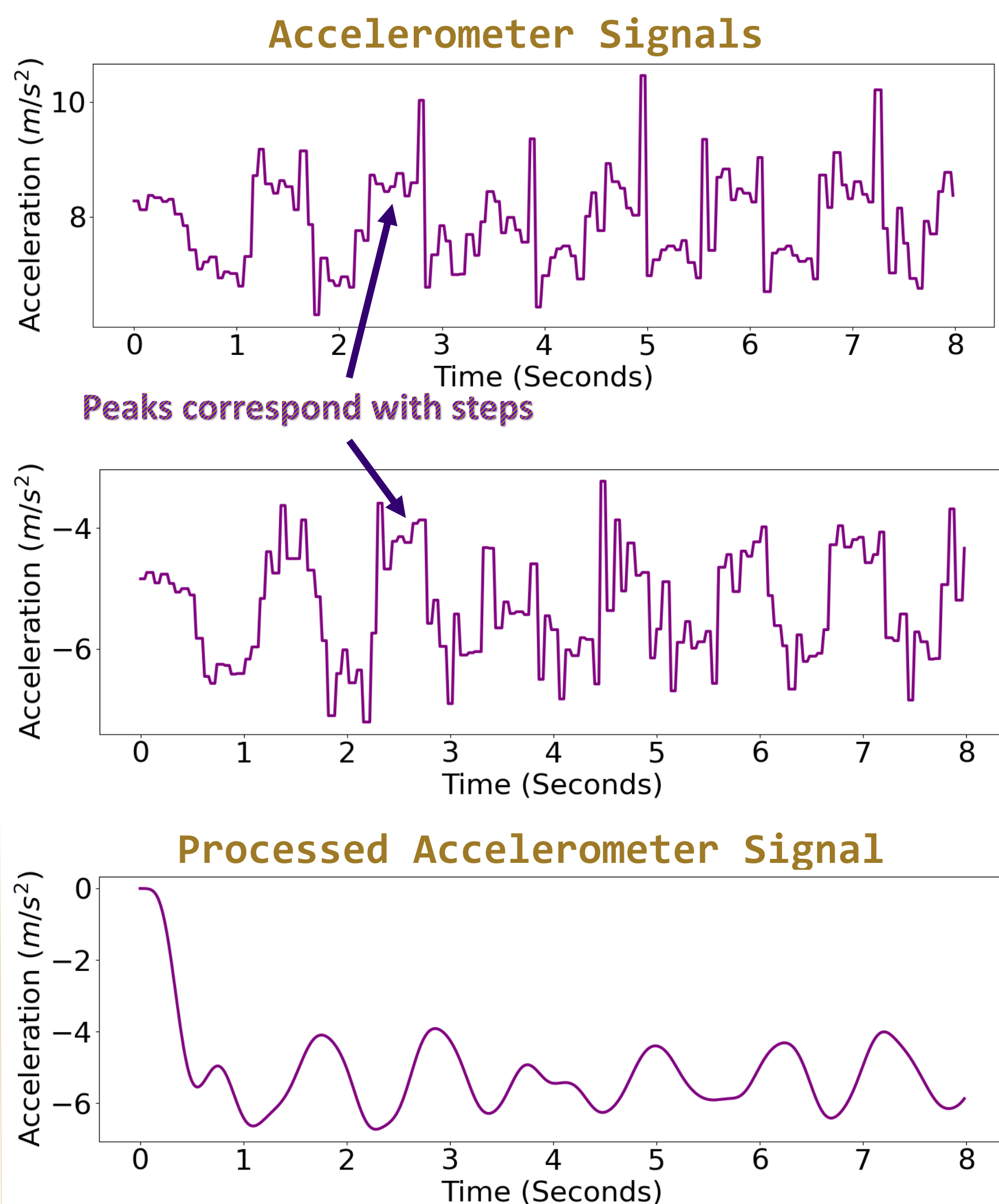
## PPG FOR PULSE DETECTION



PPG signal from fingertip used as ground truth (**error +/- 3bpm**)

- > Sampling rate of **50Hz** where PPG data peaks correlate with heart beats
- > Low pass filter and use number of peaks per time interval to calculate bpm
- > Heart rate variation – SD of PPG data

## ACCELEROMETER FOR ACTIVITY RECOGNITION



Earring is tightly secured to the ear making signals cleaner for activity tracking

- > Low pass filter for step counting
- > Count the number of steps while waking - used as ground truth value to detect peaks
- > Activity monitoring by recognizing workouts from accelerometer signals

## REFERENCES

Dzedzickis A, Kaklauskas A, Bucinskas V. Human Emotion Recognition: Review of Sensors and Methods. Sensors (Basel). 2020 Jan 21;20(3):592. doi: 10.3390/s20030592. PMID: 31973140; PMCID: PMC7037130.

Castaneda D, Esparza A, Ghamari M, Soltanpur C, Nazeran H. A review on wearable photoplethysmography sensors and their potential future applications in health care. Int J Biosens Bioelectron. 2018;4(4):195-202. doi: 10.15406/ijbsbe.2018.04.00125. Epub 2018 Aug 6. PMID: 30906922; PMCID: PMC6426305.