



Crank-based cycling powermeter — construction and validation

September 30, 2021

Jan Heczko, Tomáš Kroupa, Jan Krystek

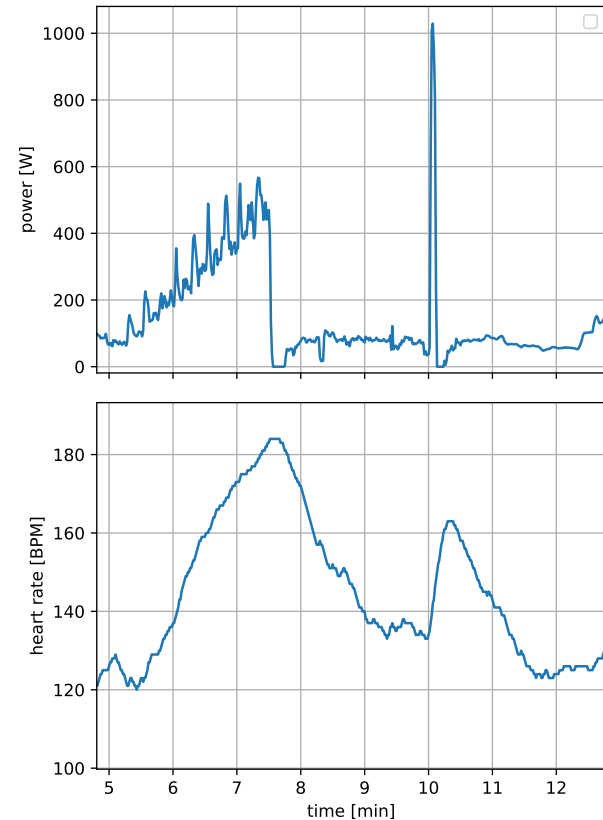
jheczko@ntis.zcu.cz

NTIS - New Technologies for the Information Society, Faculty of Applied Sciences,
University of West Bohemia, Pilsen, Czech Republic



Introduction – Power measurement in cycling

- Motivation: Competitive cycling
 - People are bad at perceiving effort
- Power – good metric of effort [1]
 - Instantaneous (contrary to heart rate)
 - Objective
 - Pedalling dynamics (cadence, asymmetry, pedaling smoothness, torque effectiveness, etc.)
- Frequent testing in the field
- Evaluation and modelling (TSS, CP)

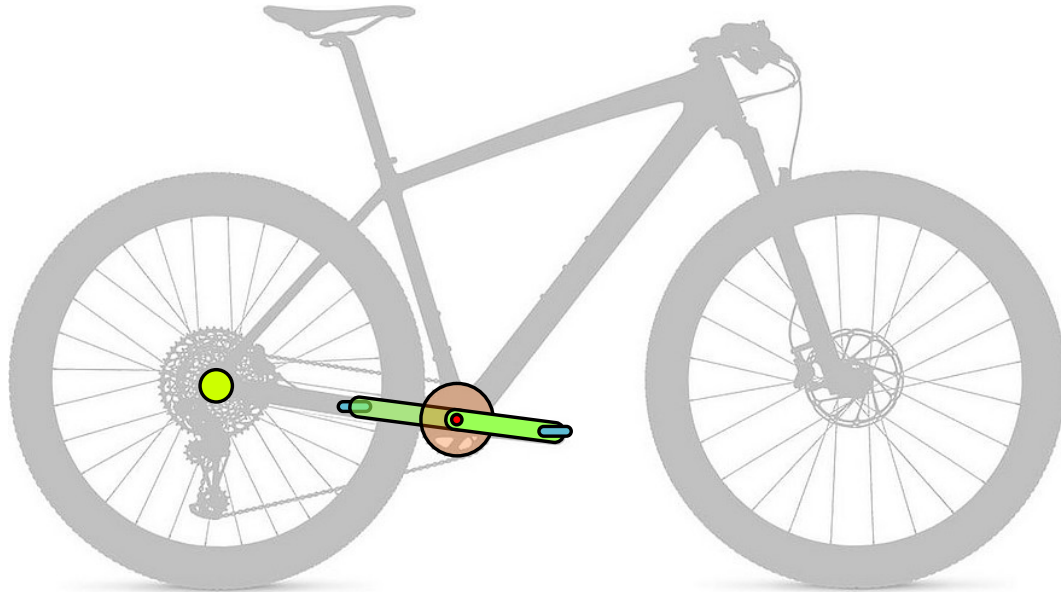


[1] Allen, Coggan, McGregor. Training and Racing with a Power Meter. 2018.

[2] Jobson, Irvine. Ultra-Distance Cycling: An Expert Guide to Endurance Cycling. 2017.

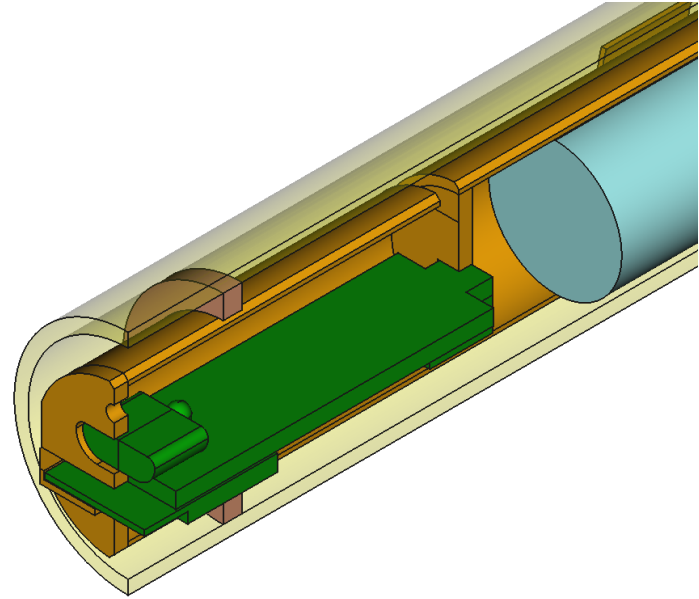
Introduction – Powermeter construction

- Location: pedals, crank arm(s), crank axle, chainring/spider, rear hub
- Single-sided: pedal, crank arm, crank axle
- Dual-sided (independent left/right): both pedals/crank arms, combination of locations (chainring + crank arm/axle)
- Combined: chainring, rear hub



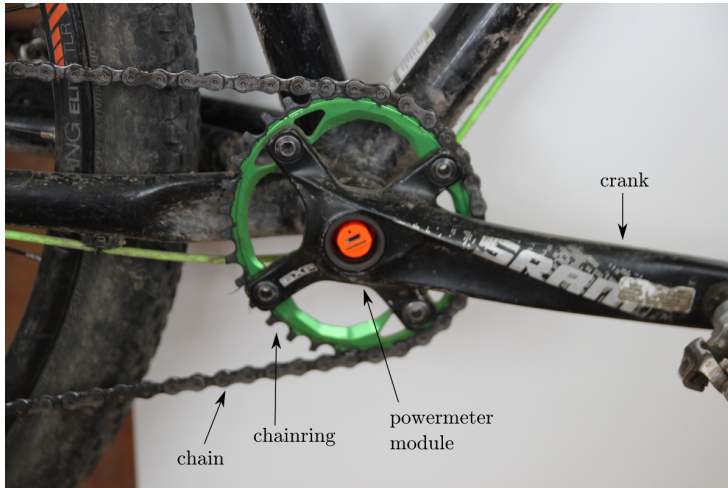
Outline

- Design
 - Supplied parts
 - Constraints
 - Enclosure
 - Watertight cap
- Assembly
 - Strain gauges application
- Calibration
- Validation and testing
- Summary and outlook

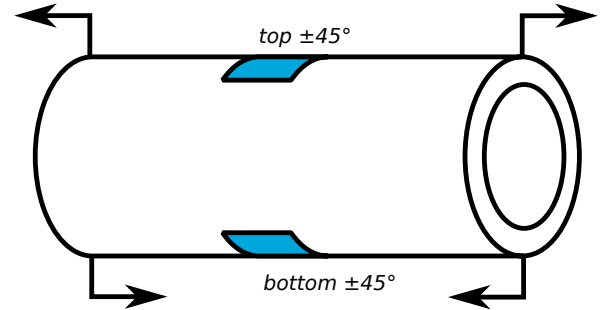


Operating principle

- Strain gauges (force/torque)



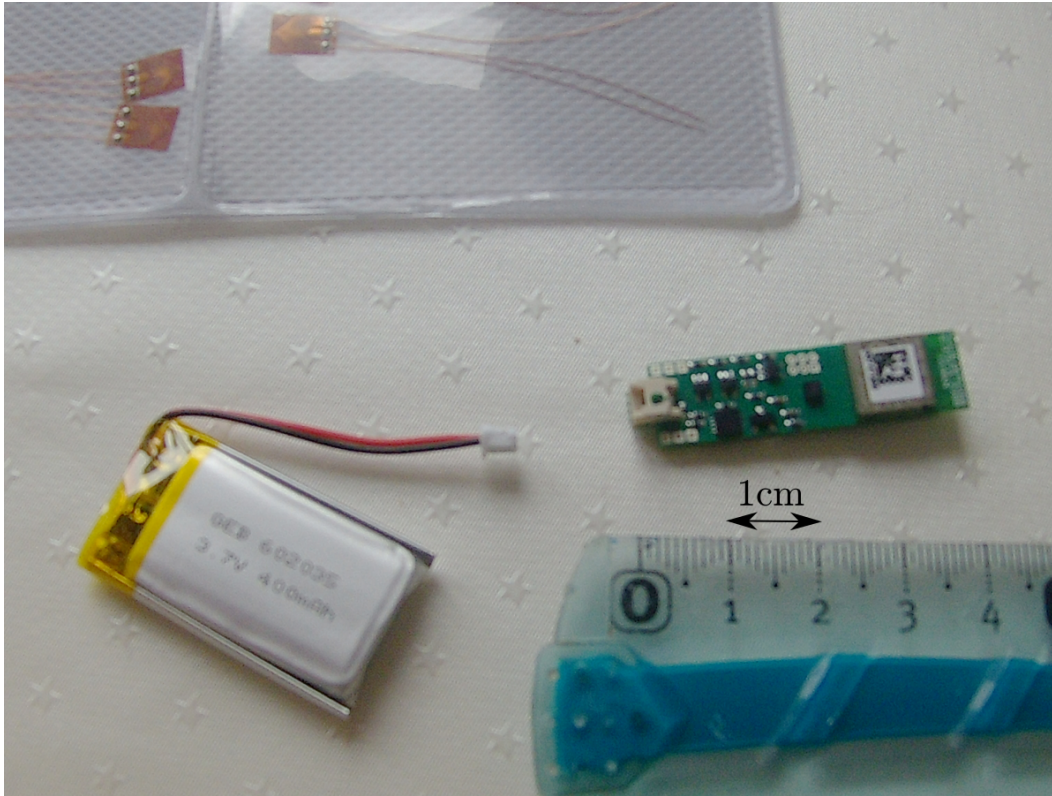
- Accelerometers (angular velocity)



- $\pm 45^\circ$ gauges on opposite sides of axle \Rightarrow temperature, bending, and axial strains compensated

Design – Supplied parts

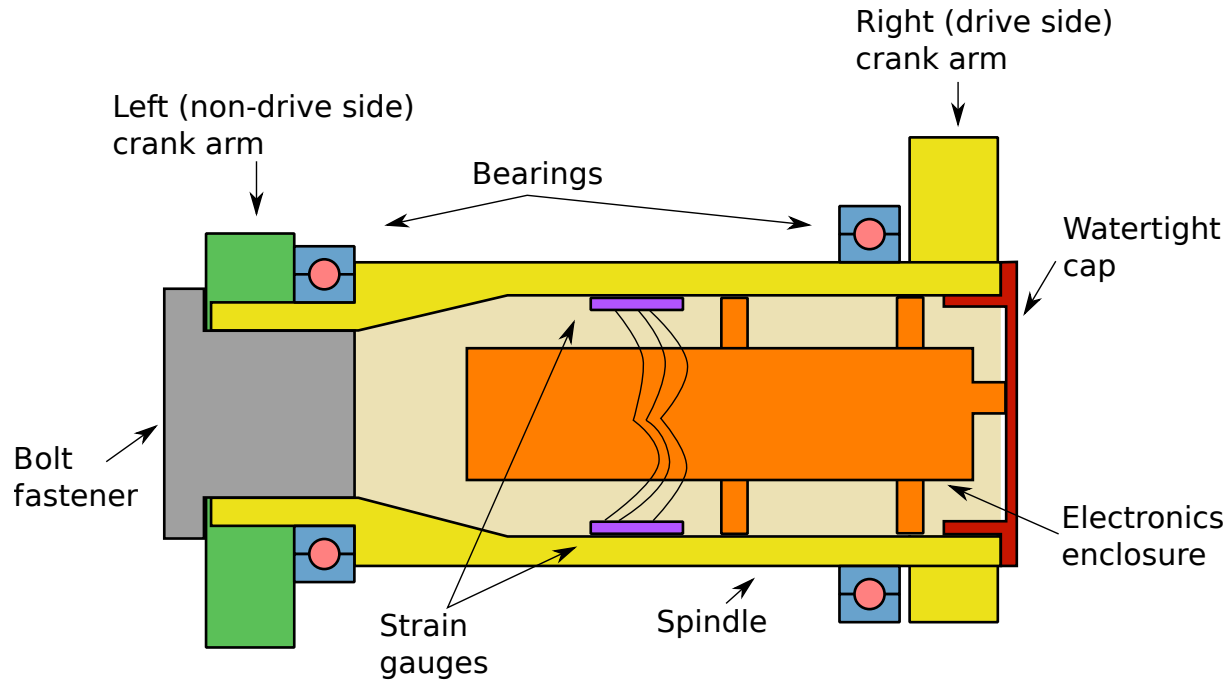
- Manufacturer: Sensitivus Gauge
- SG53 electronics module
- Strain gauges
- Battery (not used – wrong dimensions)



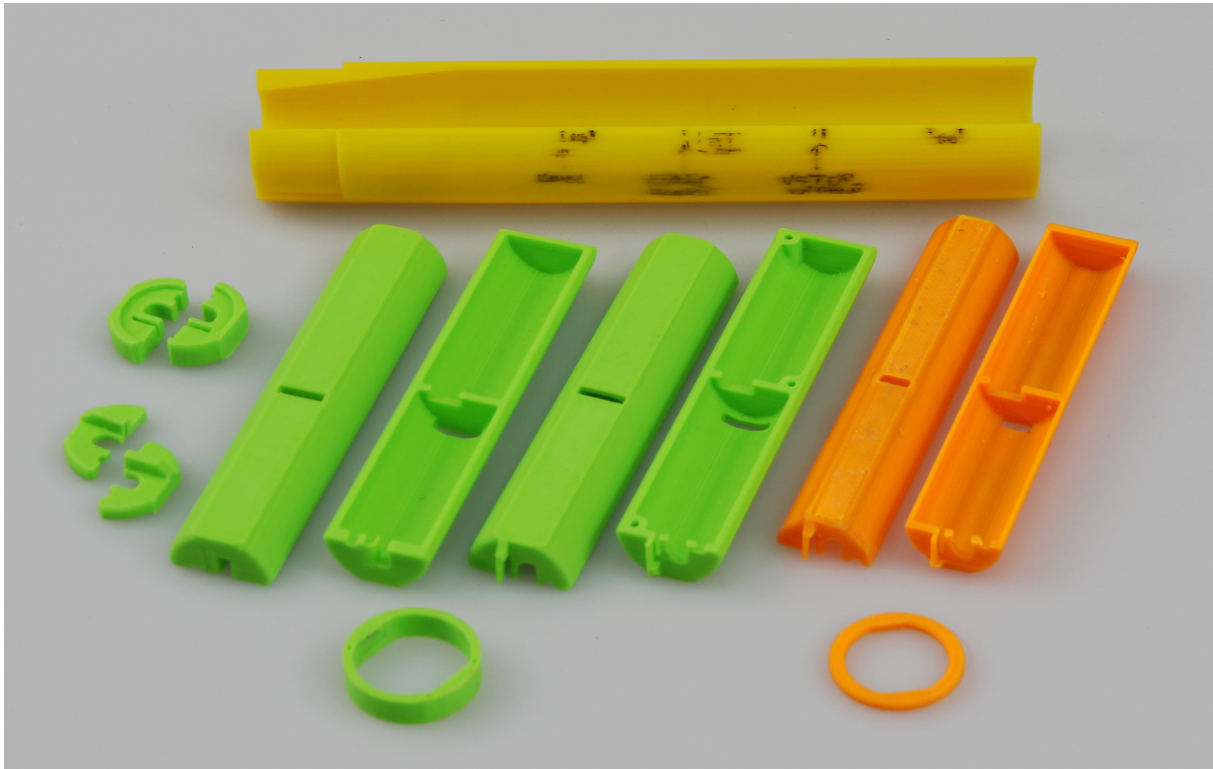
[3] Sensitivus Gauge. DIY Power Meter. 2021. <https://sensitivus.com/products/diy-power-meter/>

Design – Constraints

- Sram GXP crankset
 - 20 mm inner diameter
- Antenna must stick out
- USB port for charging
- Strain gauges applied to the inside of crank axle
 - How to?
 - Wiring has to fit

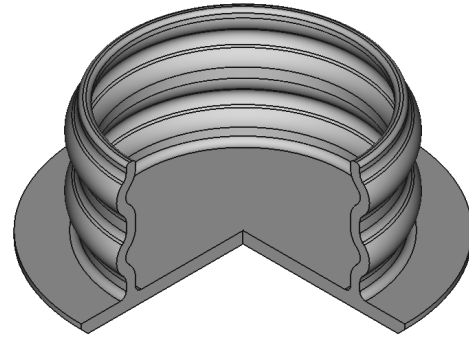
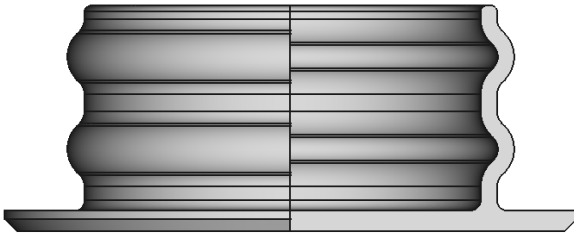


Design – Enclosure



Design – Watertight cap

- 3D printed, TPE 32D



- other options: o-rings, silicone casting



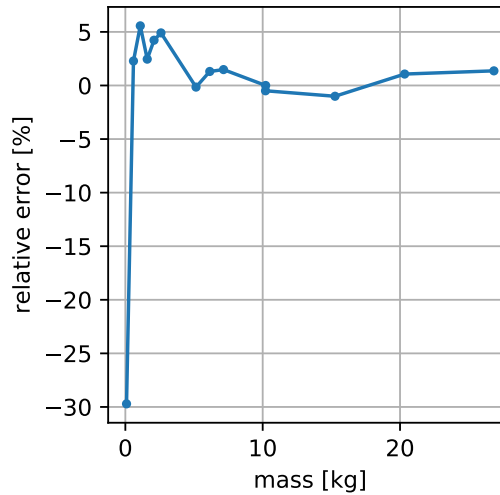
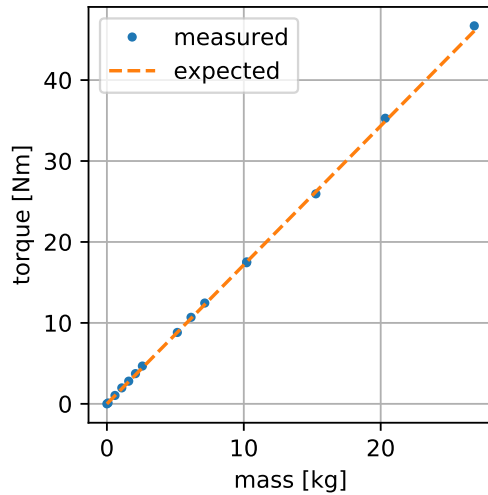
Assembly – Strain gauges application

- Soft padding, double-sided tape
- Clamps fit crank axle
- Ensures precise positioning of strain gauges



Calibration

1. Hang known weight to crank arm in horizontal position
2. Measure torque
3. Set parameter in firmware



Validation

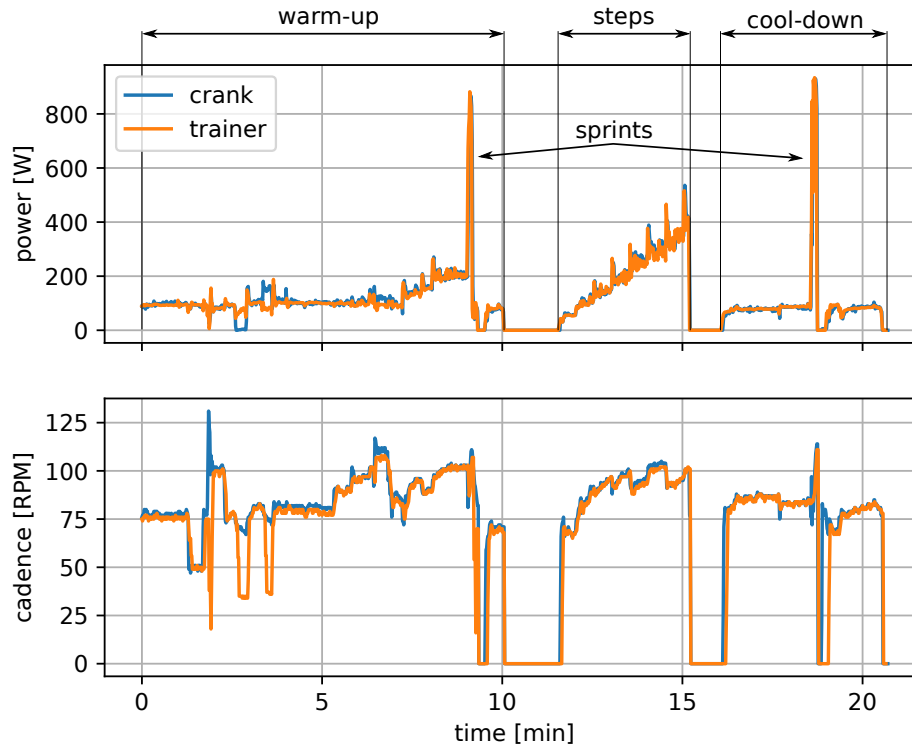
- Wahoo Kickr indoor trainer



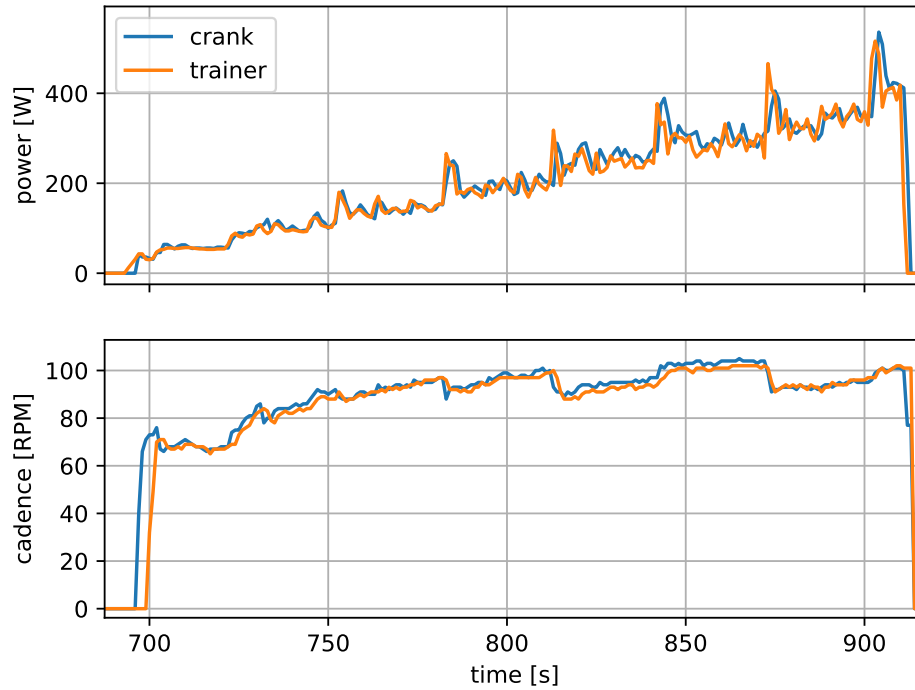
Validation

- Single leg pedalling
- Seated/standing

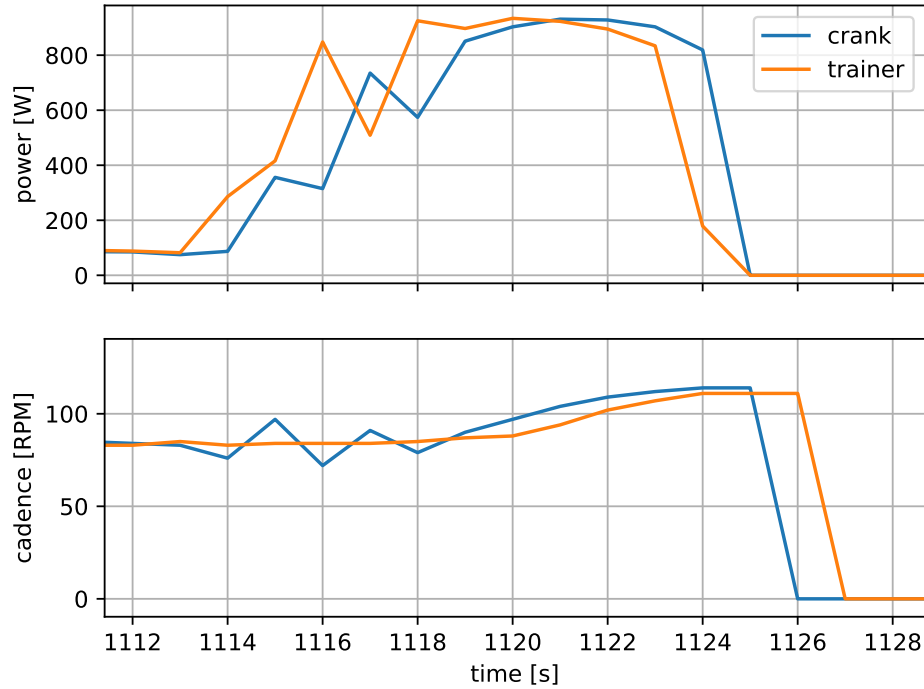
- Cadence variation
- Steps, sprint



Validation – steps

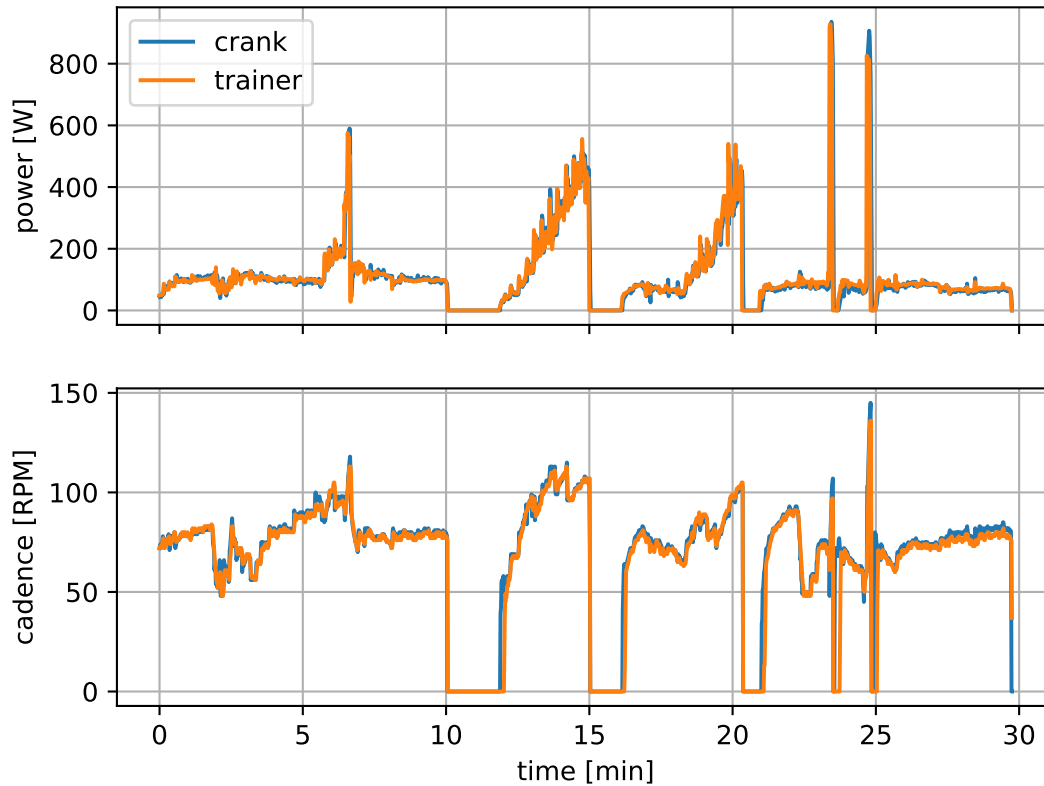


Validation – sprint



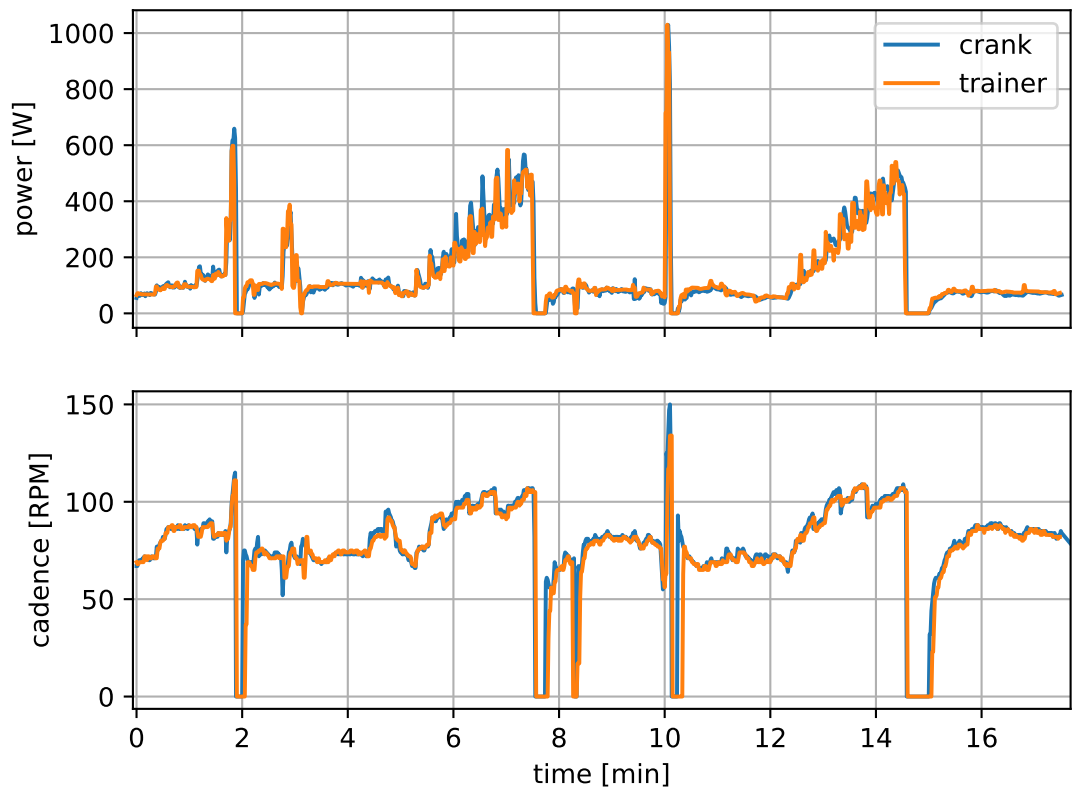
Validation – other rides

- Increased power range



Validation – other rides

- Averaging (0-16 pedal strokes)



Summary

- Working device, reliable readings, useful in training and racing
- Complex but doable project
 - Learn mechanics
 - Learn other fields (electronics, design, manufacturing techniques)
 - Real-world application, consumer-grade product
 - Encourages learning, creativity, problem solving

Ongoing and future work

- Continuous field testing
- Better waterproofing
- Use of data in other projects
- Use in teaching of experimental mechanics

References

- [1] H. Allen, A. Coggan and S. McGregor. Training and Racing with a Power Meter. 2018.
- [2] S. Jobson and D. Irvine. Ultra-Distance Cycling: An Expert Guide to Endurance Cycling. 2017.
- [3] Sensitivus Gauge. DIY Power Meter. 2021. <https://sensitivus.com/products/diy-power-meter/>