Peloton Evolution in Road Cycling Races

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CFD & Peloton Aerodynamics (Theory)

- Aerodynamics dominates at racing speeds.
- CFD used in literature to study pelotons.

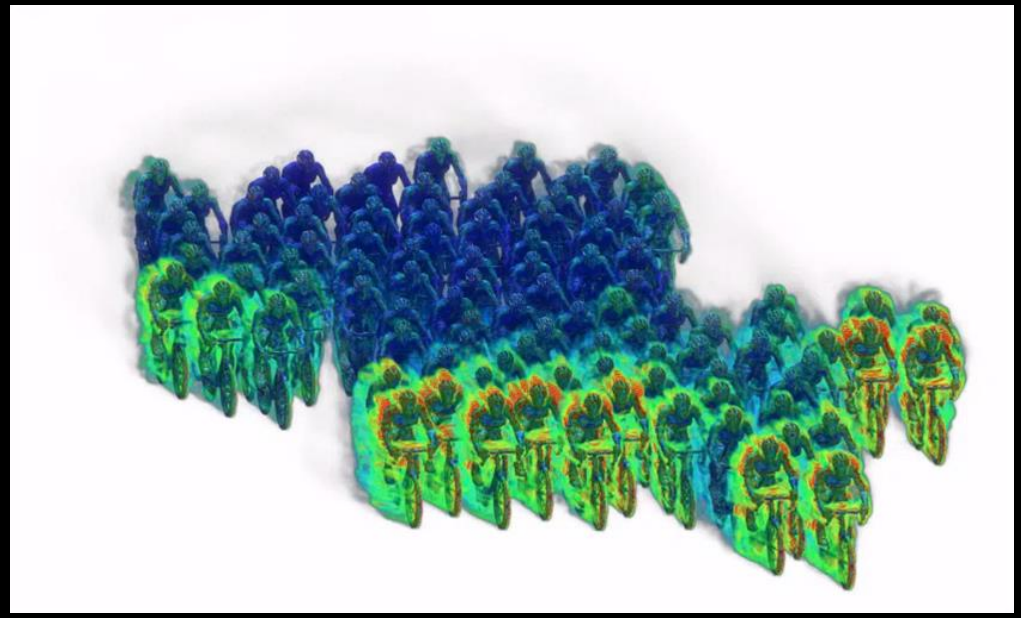


Figure 1: Peloton formation.
Ref: https://eolios.eu/

What CFD Studies Show

- High pressure and speed in front.
- Low-pressure and speed wake behind.
- Front rider = windbreak.

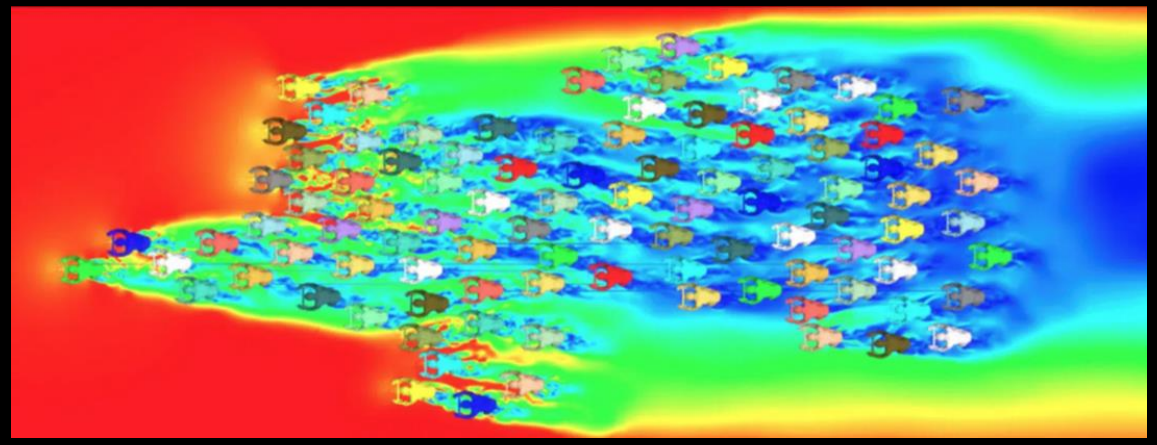


Figure 2: Horizontal plane of speeds within the peloton.
Ref: https://eolios.eu/

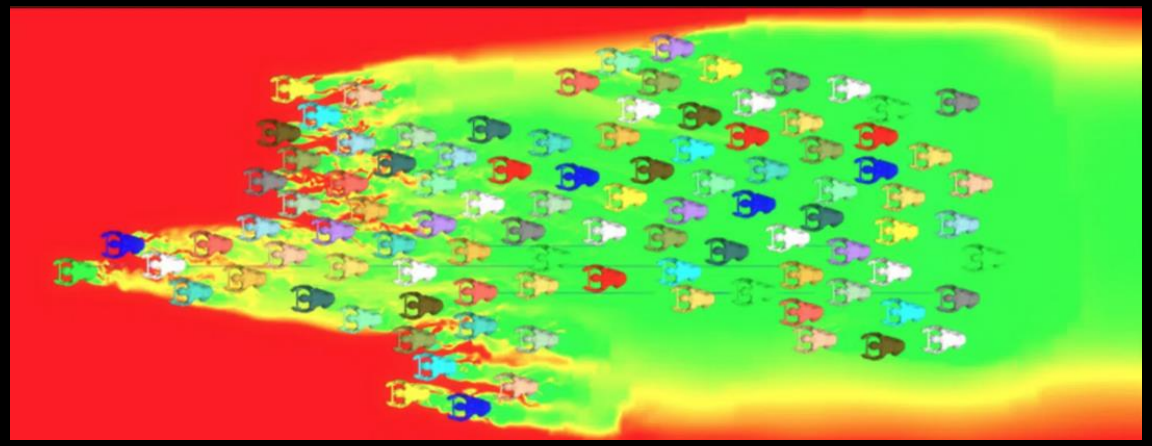


Figure 3: Horizontal pressure plane in the pack.
Ref: https://eolios.eu/

Drag Distribution in Peloton

- Leader ≈ 100% drag.
- Central riders ≈ 50% or less.
- Position determines energy cost.

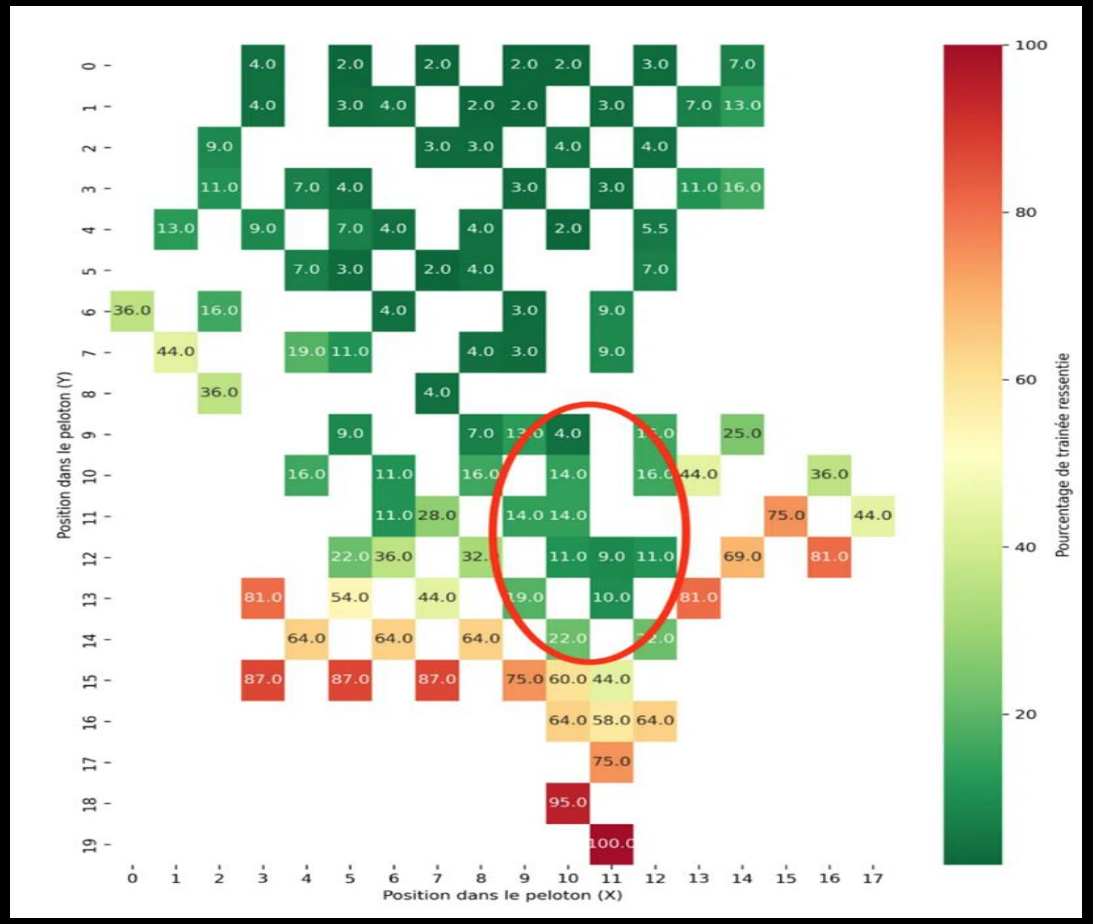
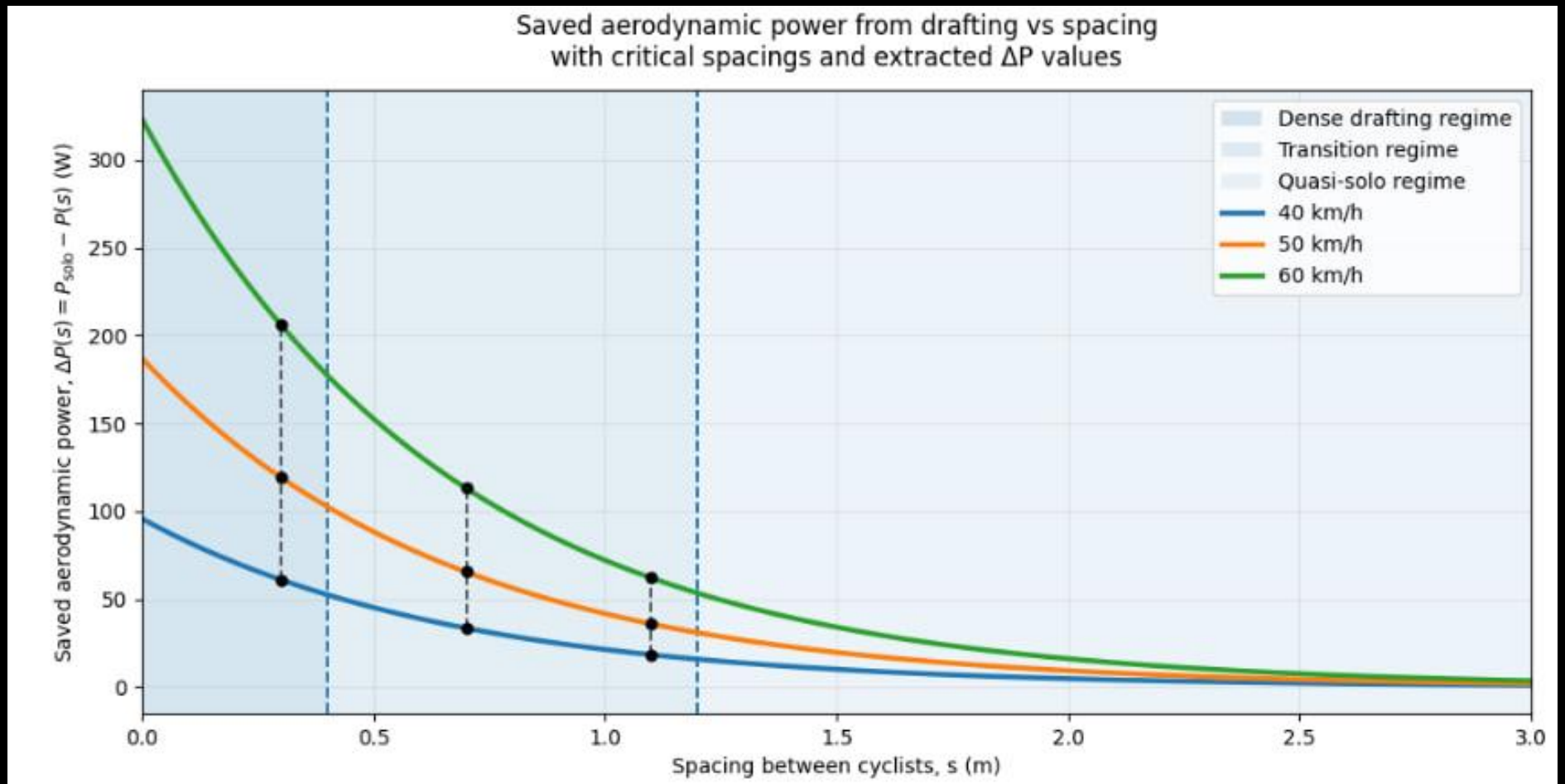
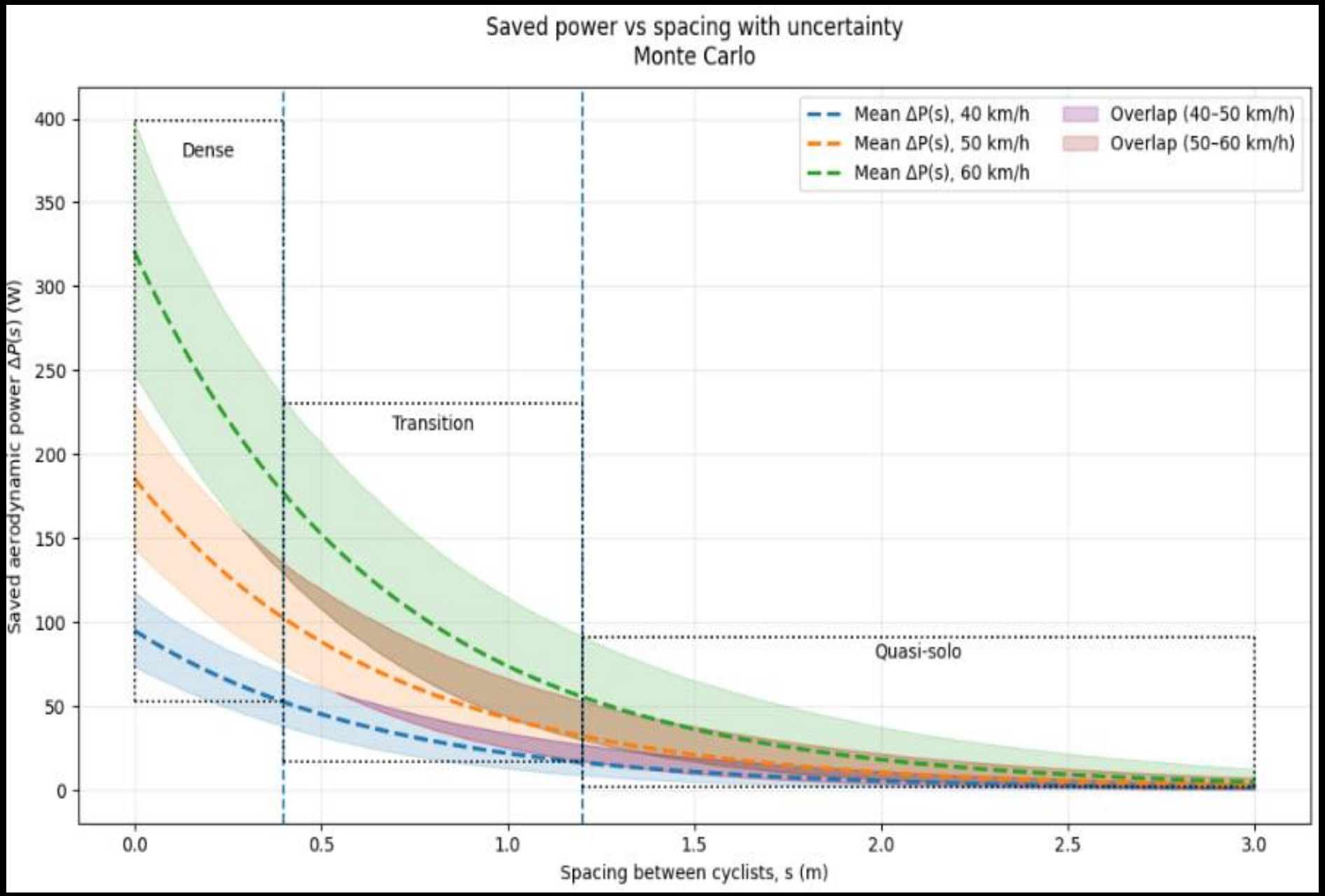


Figure 4: Percentage of drag felt compared to the drag felt by the leader (100%)
Ref: https://eolios.eu/

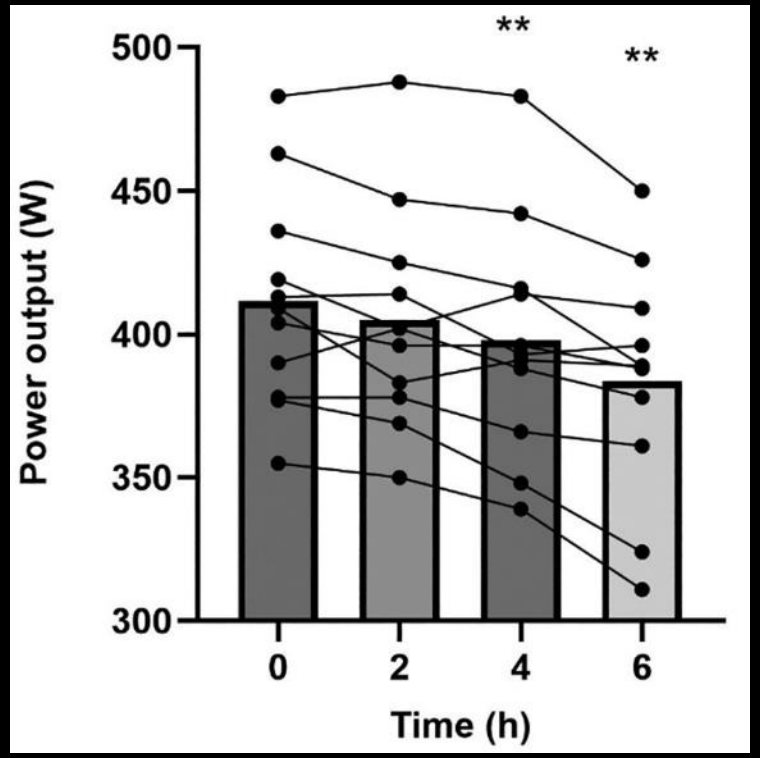


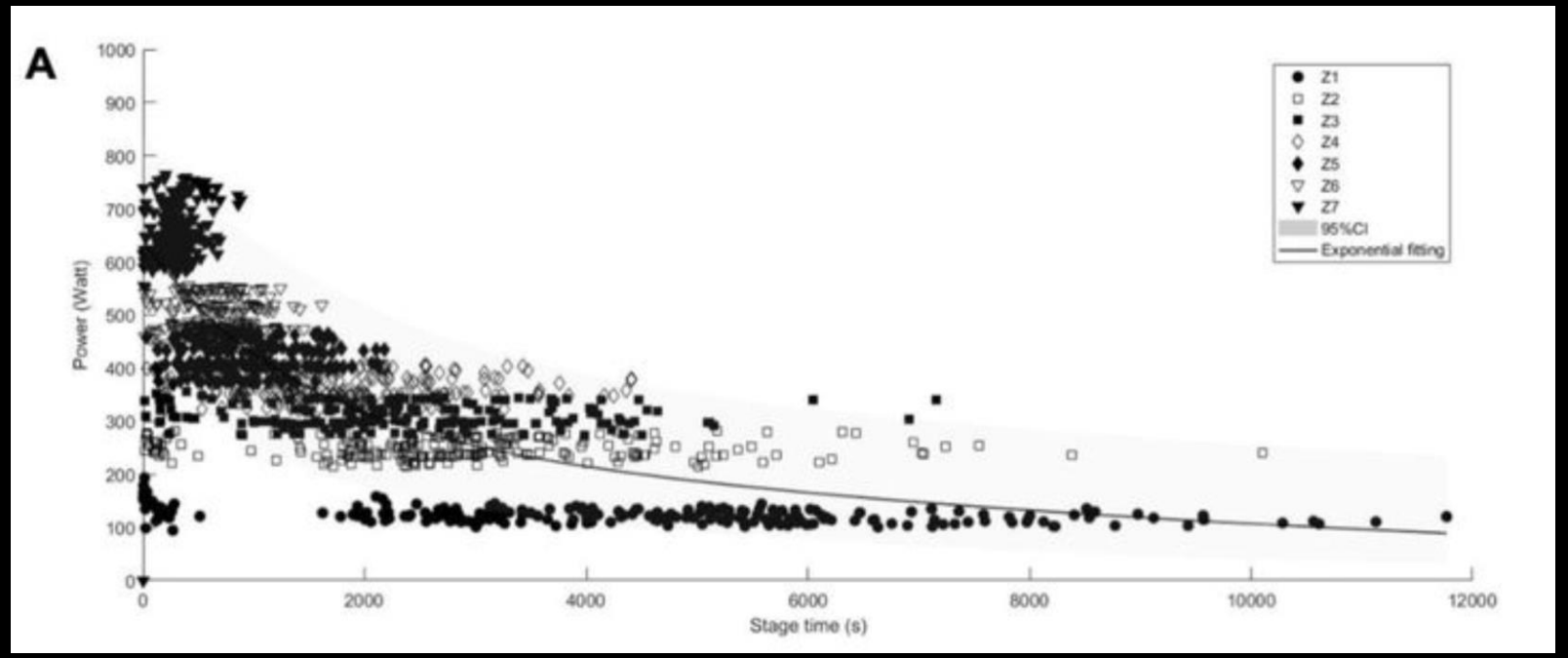
Extracted values of ΔP (W) at critical spacings

	40 km/h	50 km/h	60 km/h	Avg. ΔP per +10 km/h (W)
s = 0.3 m	61.1	119.3	206.1	72.5
s = 0.7 m	33.5	65.5	113.1	39.8
s = 1.1 m	18.4	35.9	62.1	21.8


Saved power vs spacing with uncertainty
Monte Carlo
Mean ΔP(s), 40 km/h
Mean ΔP(s), 50 km/h
Mean ΔP(s), 60 km/h
Overlap (40–50 km/h)
Overlap (50–60 km/h)
Dense
Transition
Quasi-solo
Saved aerodynamic power ΔP(s) (W)
Spacing between cyclists, s (m)
0
50
100
150
200
250
300
350
400
0.0
0.5
1.0
1.5
2.0
2.5
3.0

Fatigue Development and Power Dynamics in the Peloton





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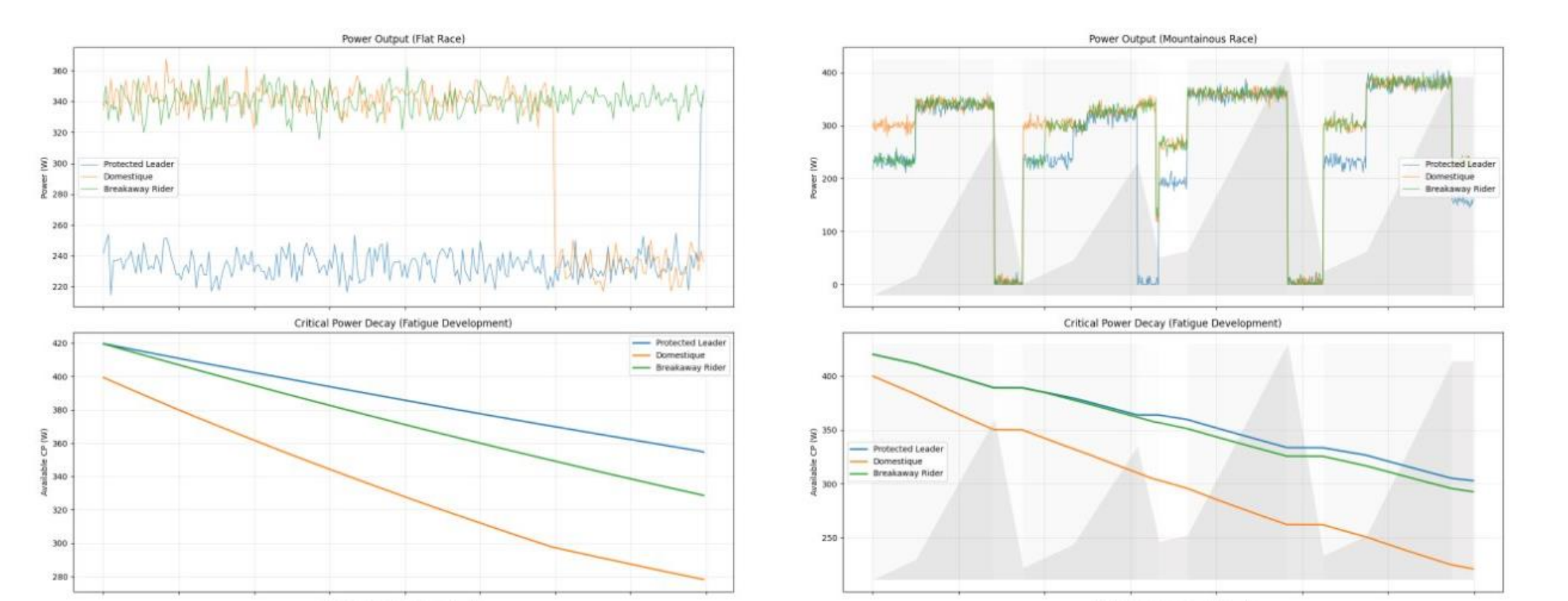
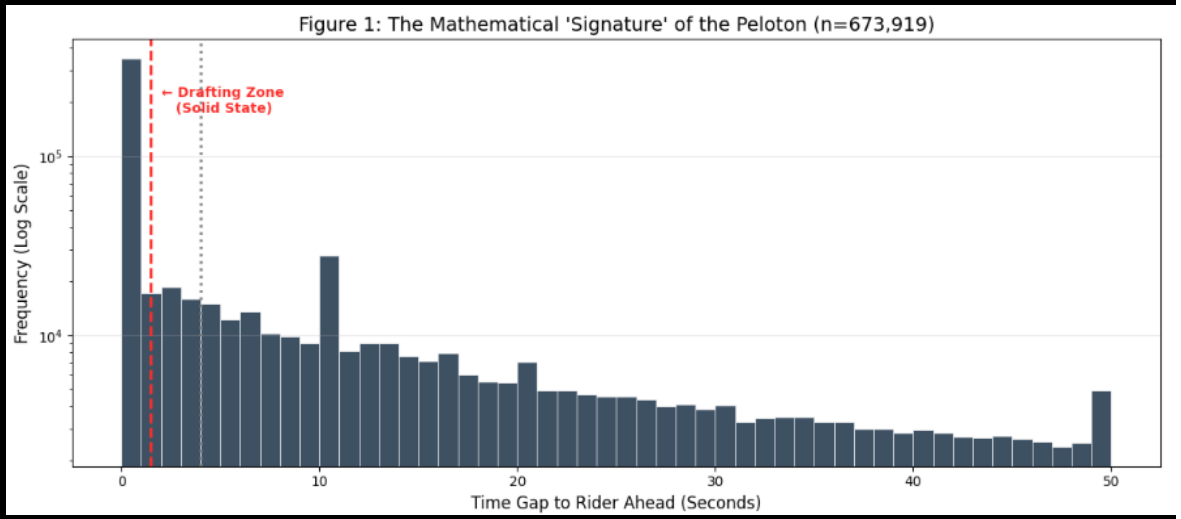
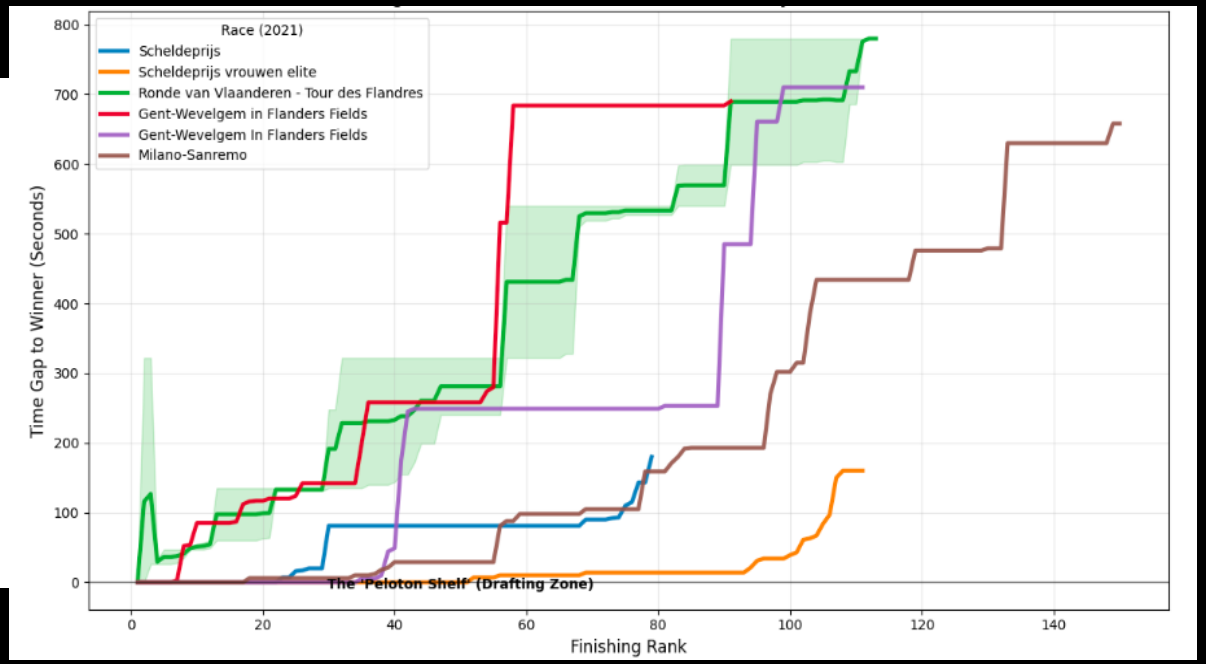


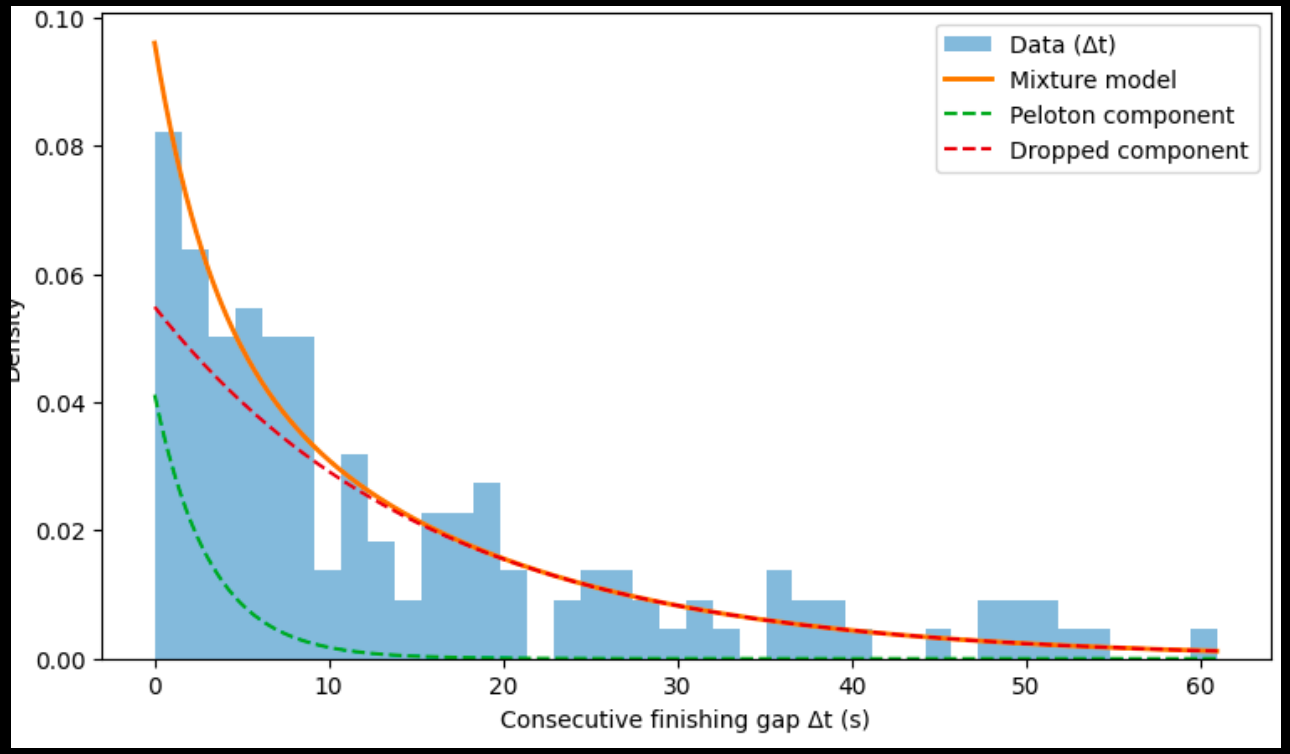
Statistical analysis of peloton finishing times





- **Non-random gaps:** Strong peak at near-zero gaps followed by a sharp transition and long tail
- **Peloton shelf:** Many riders share the same finishing time when plotted against rank
- **Collective behavior:** Peloton acts as a coupled system, not independent riders

Synthetic data model



$$p(\Delta t) = \pi \lambda_p e^{-\lambda_p \Delta t} + (1-\pi)\lambda_d e^{-\lambda_d \Delta t}$$

- **Minimal mechanism:** Two regimes peloton (small gaps) and dropped (large gaps)
- **Same structures reproduced:** Phase transition, peloton shelf, and long tail
- **Interpretation:** Patterns arise from coupling; conditions change parameters, not dynamics

Thanks for listening!