Critical Confusion

Charles Dauwe D. Sc.

Science & Cycling – Nantes 4 – 5 July 2018

THE WORK CAPACITY OF A SYNERGIC MUSCULAR GROUP

By H. Monod and J. Scherrer

Laboratoire de Physiologie du Travail du C.N.R.S., Paris

$$P(t_{lim}) = CP + \frac{W'}{t_{lim}}$$

CP is the highest steady state level of power

P < CP is non-fatigable

W’ is a constant amount of anaerobic work

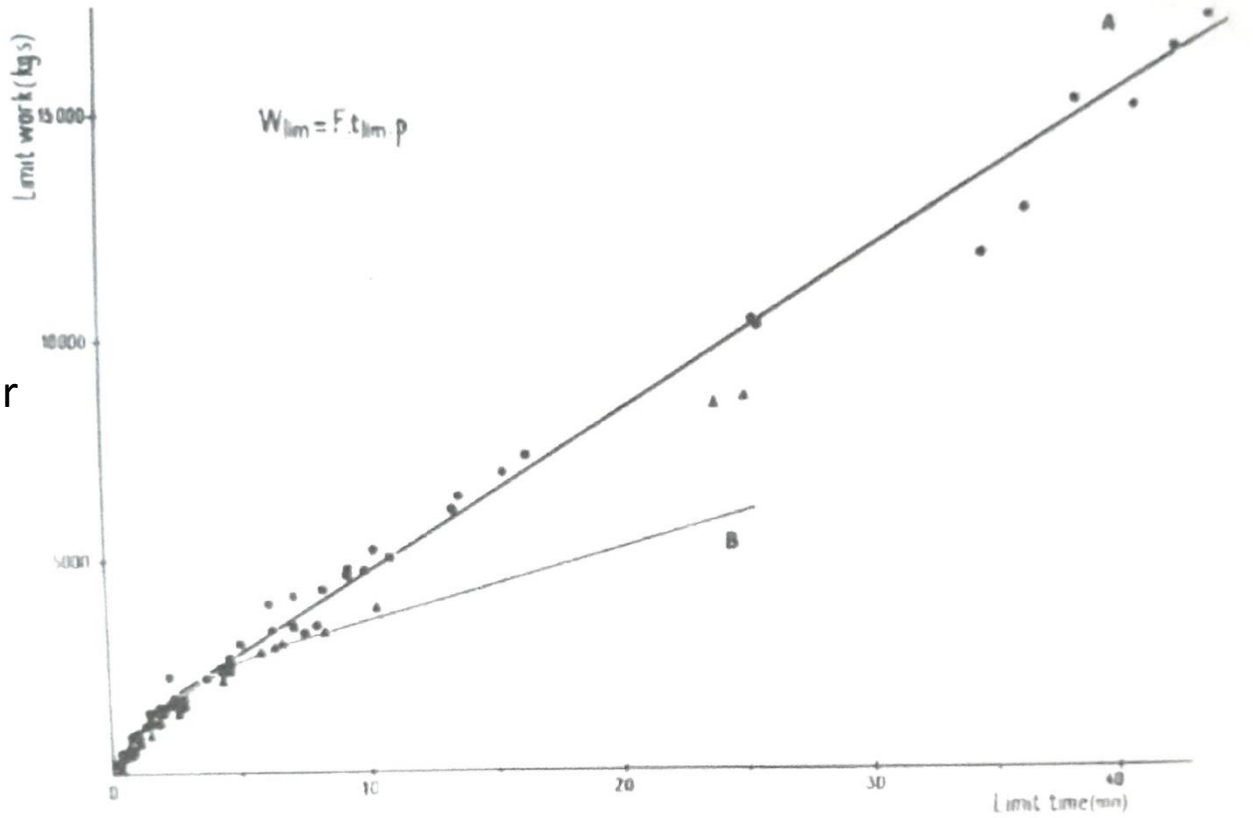


Figure 6. The *limit work*, product of the contraction time and the force, is plotted versus *limit time*. Curve A and the experimental points concern intermittent static work at 50% activity; curve B, obtained by transforming the curve plotted on Figure 3, concerns total static work.

How to measure CP and W' ?

$$P(t_{lim}) = CP + \frac{W'}{t_{lim}}$$

Short durations In the testing lab

MEX: Multiple exhaustion
4 or more bouts at 85 – 105% of VO2max
Durations ~ 2' to ~ 12'
Zero intersection is CP, Slope is W'

3' All out test
Last 30" are equaled to CP
Surface under curve is W'

Long durations In the field

Exhaustive climbs modelling and computation
Durations 10' to 60'

Power meters
Power-Duration, Power Profile
Durations 5" to > 60'
Extended CP modelling

Conflict and confusion !

In the testing lab

High CP
Low W’
Sustainabilty at CP is < 20 ‘

CP threshold between hard and extremely hard

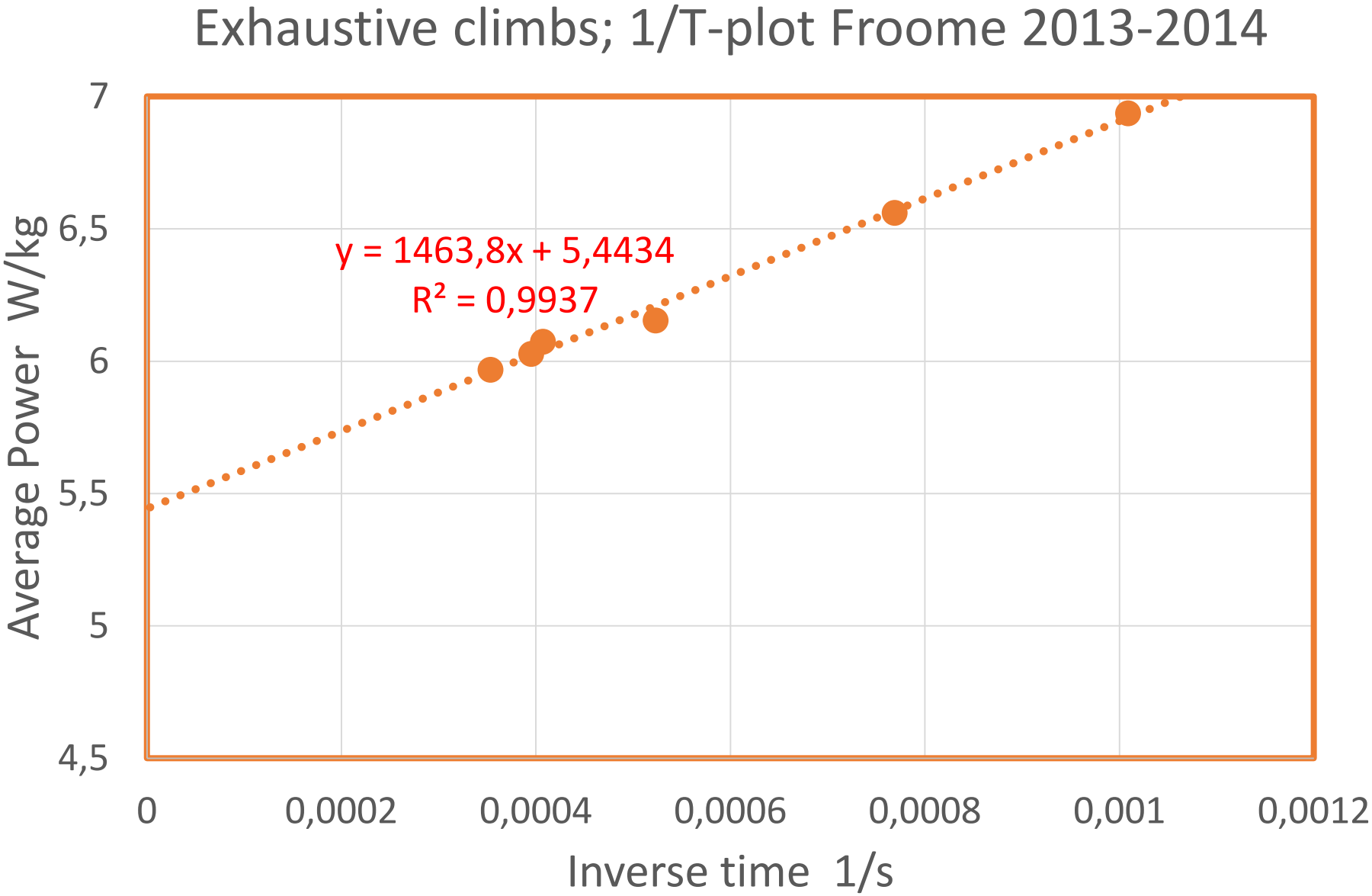
In the field

Low CP
High W’
Sustainability at CP is infinite

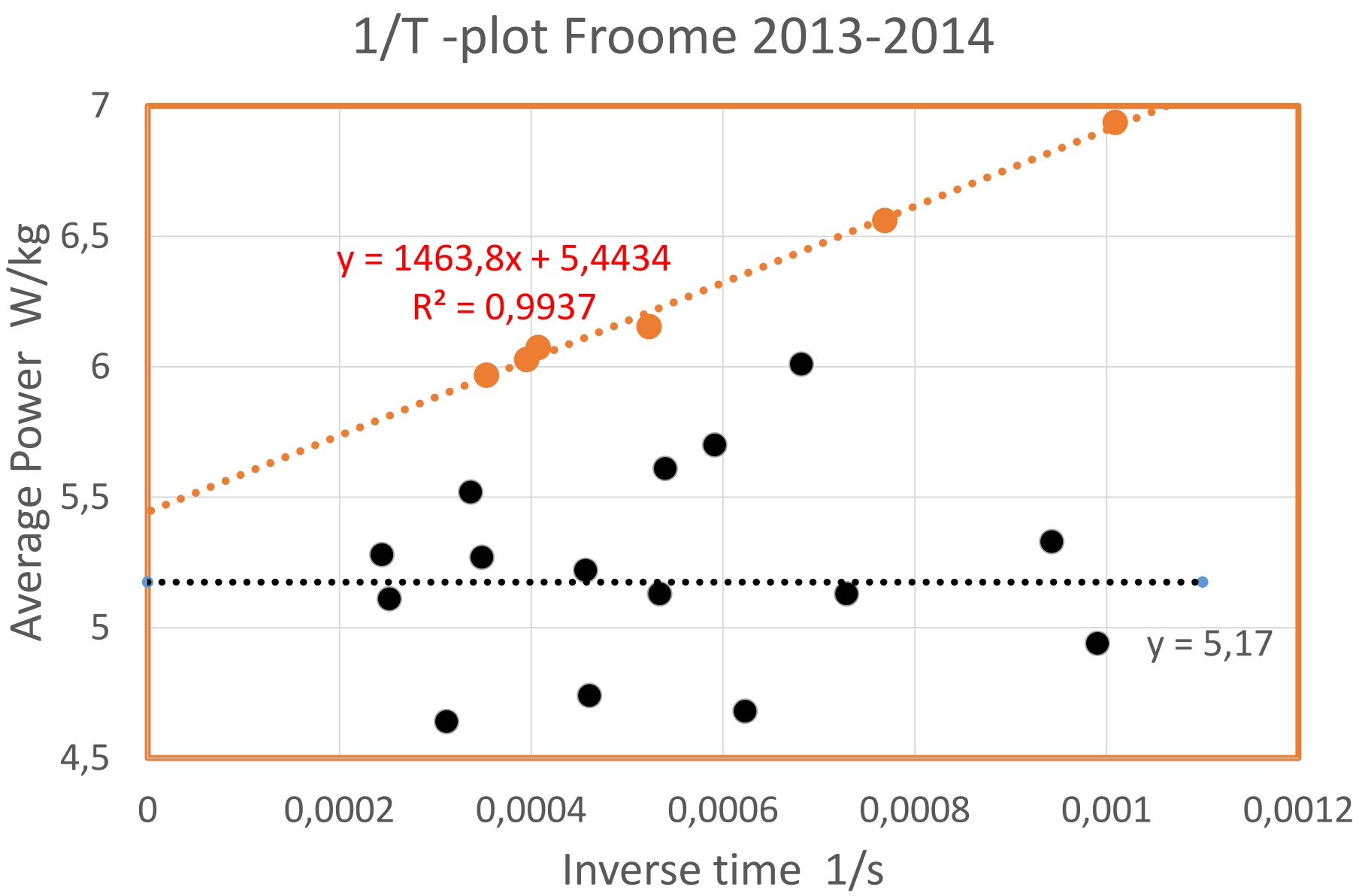
CP threshold between easy and hard

$$P(t_{lim}) = CP + \frac{W'}{t_{lim}}$$

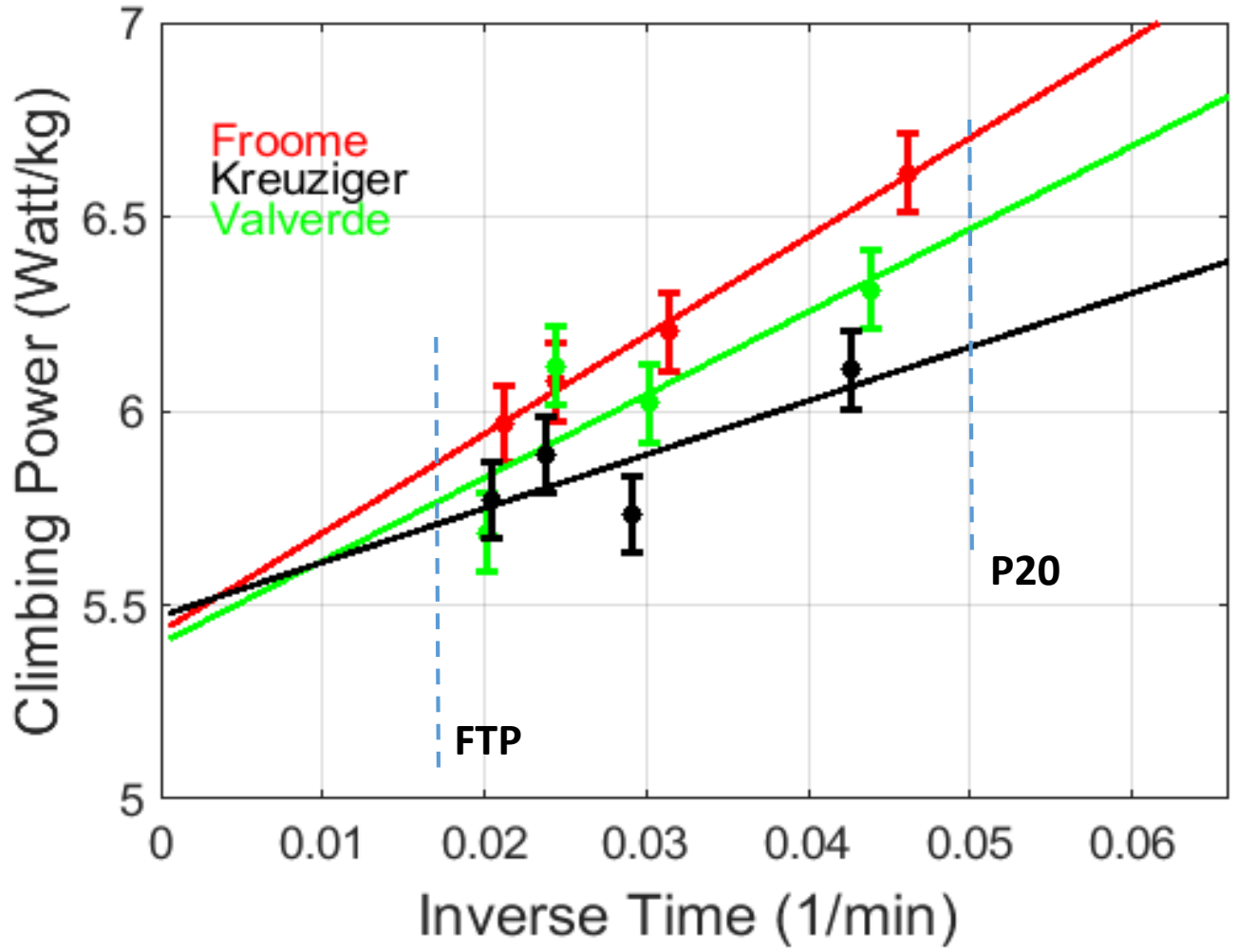
ECP model consolidates it all



Belles Filles
Ax 3 Domaines
Semnoz
Huez
La Toussuire
Ventoux (15 km)


1/T -plot Froome 2013-2014
y = 1463,8x + 5,4434
R² = 0,9937
y = 5,17
Average Power W/kg
7
6,5
6
5,5
5
4,5
0
0,0002
0,0004
0,0006
0,0008
0,001
0,0012
Inverse time 1/s

	CP W/kg	W' kJ/kg	FTP	P20	P20/FTP
Froome	5.44	1.46	5.85	6.70	1.14
Valverde	5.40	1.28	5.75	6.47	1.12
Kreuziger	5.47	0.83	5.70	6.16	1.08



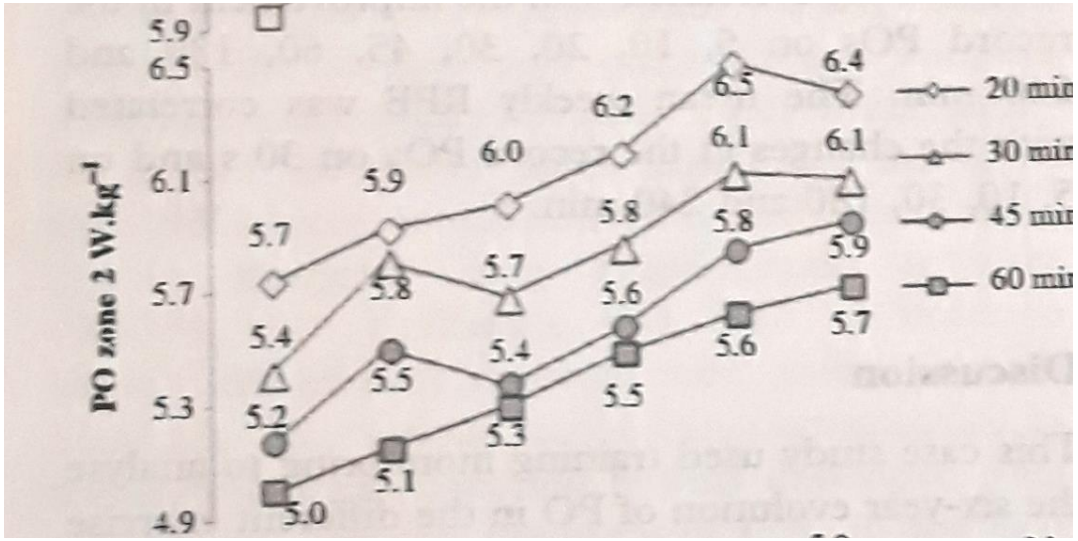
~~FTP = 0.95 P20~~

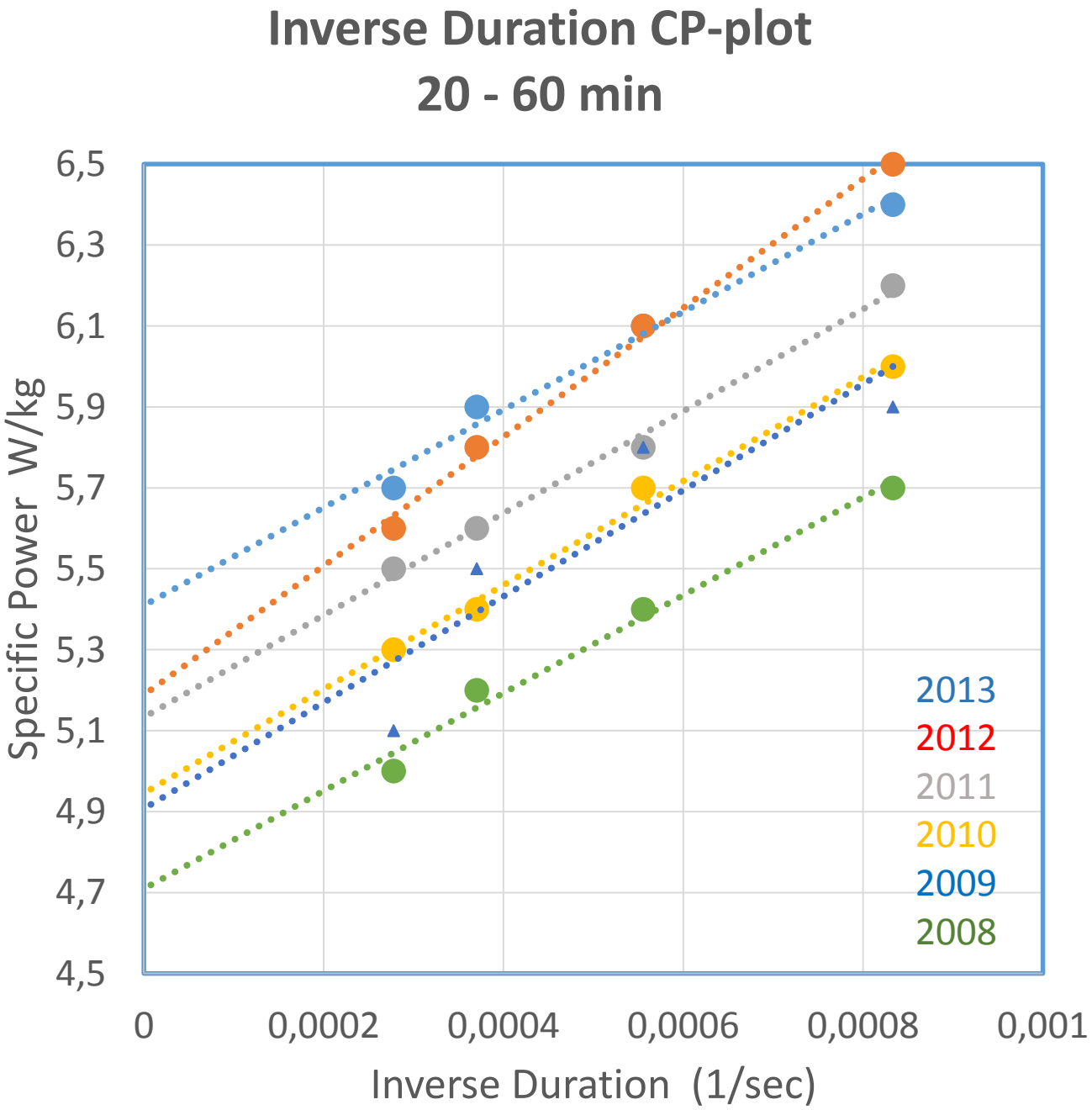
~~$P(t_{lim}) = CP\left(1 + \frac{97.3}{t_{lim}}\right)$~~

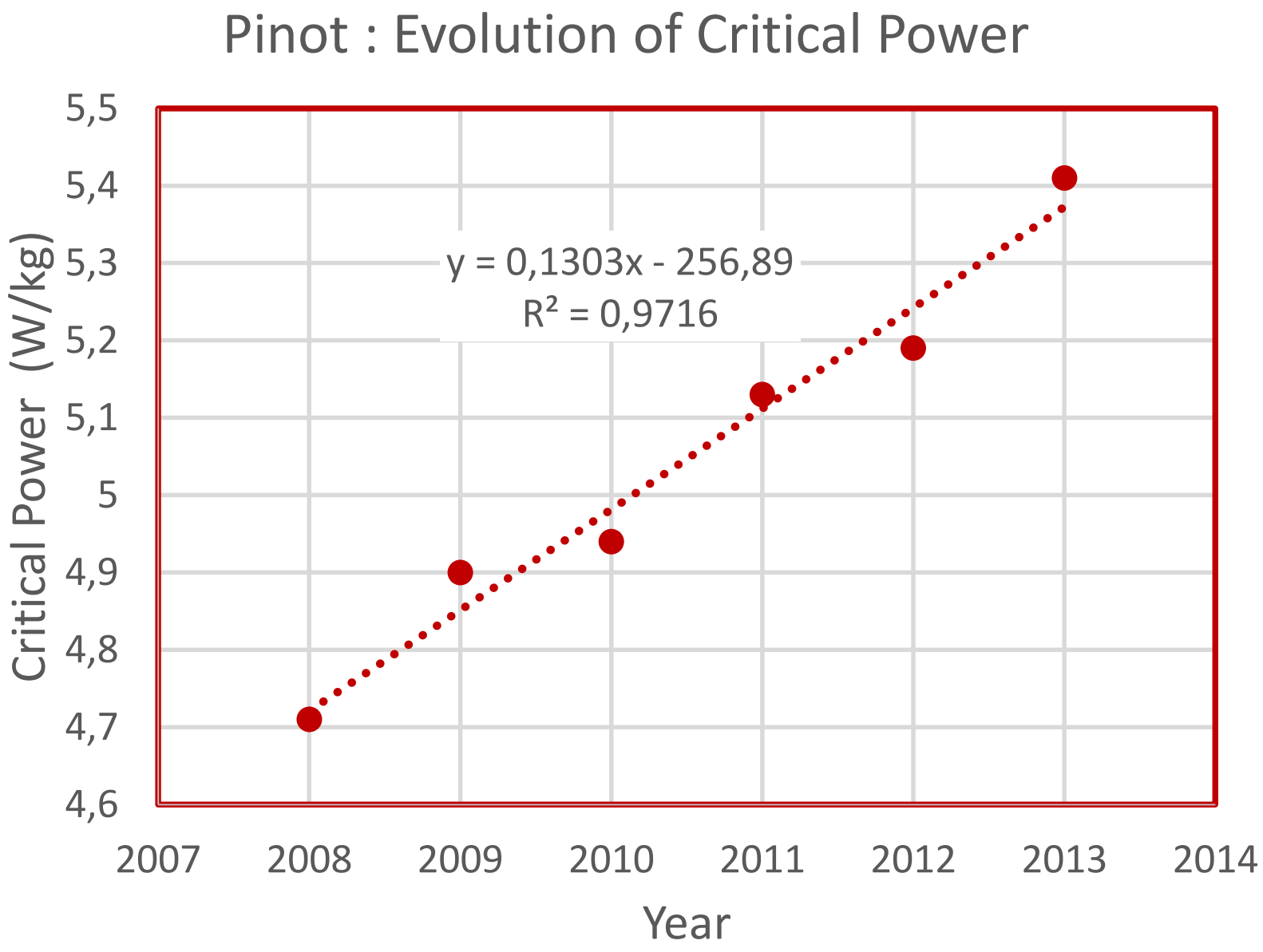
Are all cyclists created equal ???

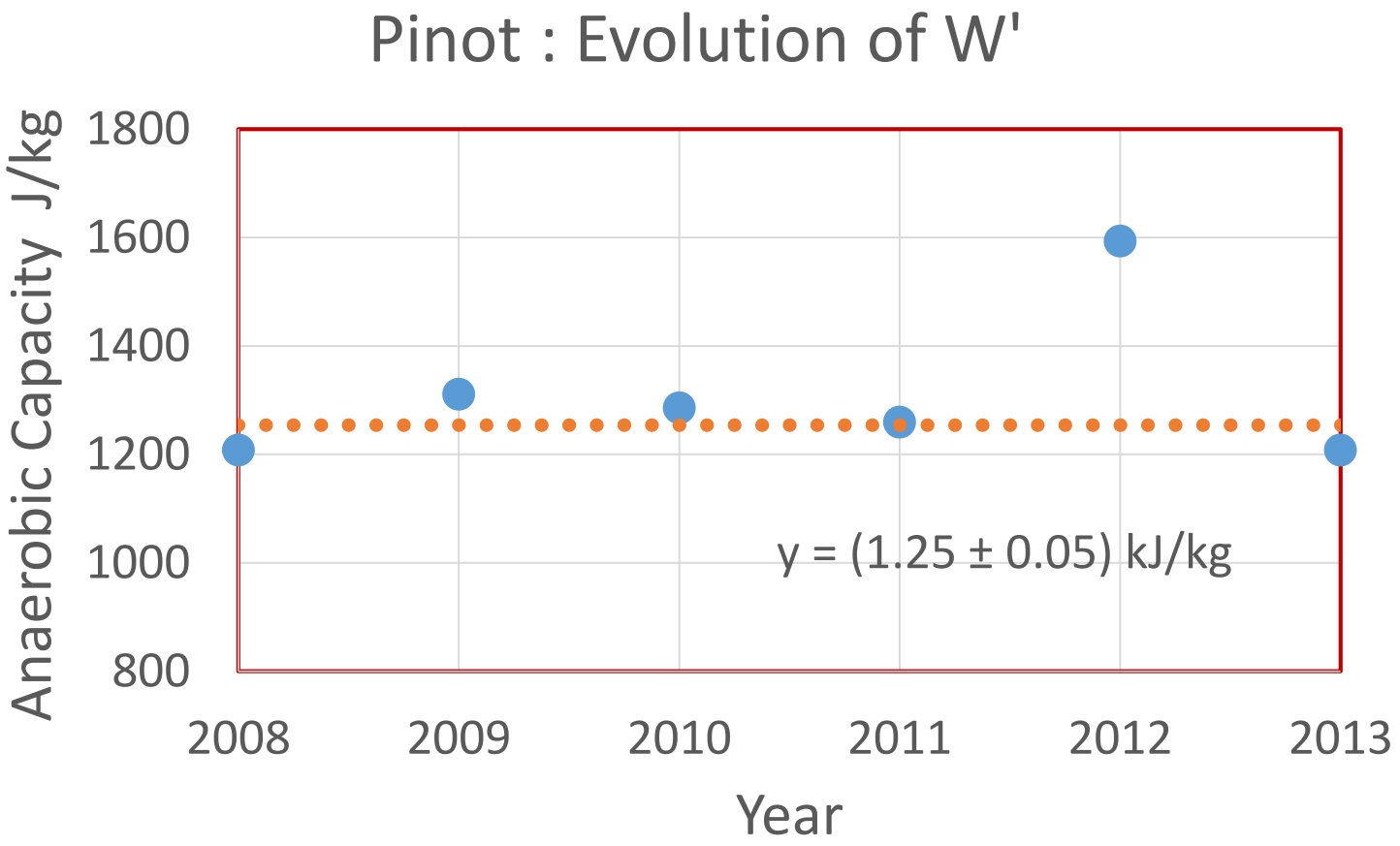
Power profile with powermeters

Data; Pinot J. Grappe F. (2014)
http://dx.doi.org/10/1080/02640414.2014.969296
A six-year monitoring case study of a top-10 cycling Grand Tour finisher

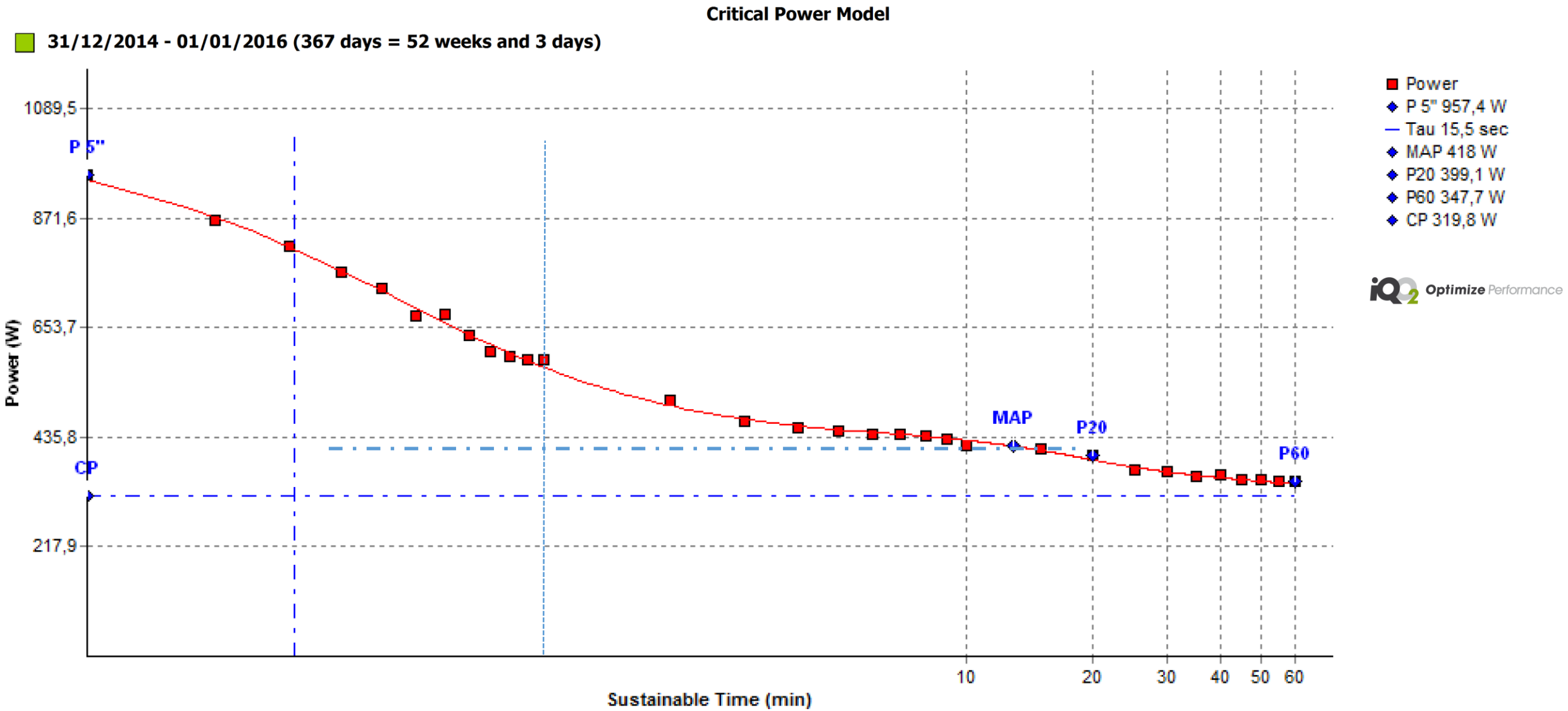


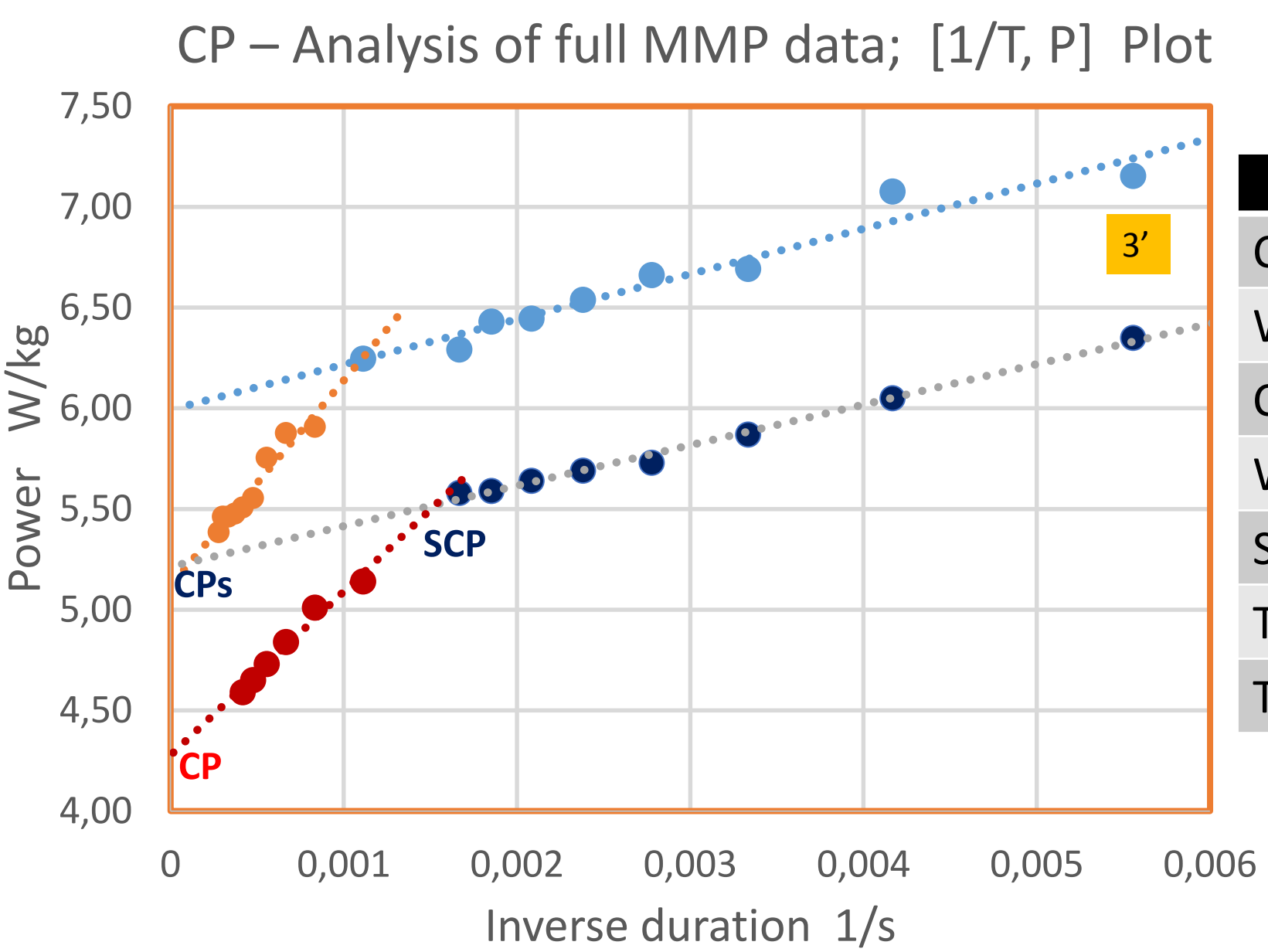



Pinot : Evolution of Critical Power
y = 0,1303x - 256,89
R² = 0,9716
Critical Power (W/kg)
5,5
5,4
5,3
5,2
5,1
5
4,9
4,8
4,7
4,6
2007
2008
2009
2010
2011
2012
2013
2014
Year


Pinot : Evolution of W'
Anaerobic Capacity J/kg
1800
1600
1400
1200
1000
800
2008
2009
2010
2011
2012
2013
Year
y = (1.25 ± 0.05) kJ/kg

Including short sustainability ?
Using full range MMP, RP, t-P data





	Male	Female
CP (W/kg)	5,11	4,28
W’ (kJ/kg)	1,02	0,81
CPs (W/kg)	6,00	5,21
W’s (kJ/kg)	0,22	0,20
SCP (W/kg)	6,24	5,51
T SCP (min)	15	10,9
T CPs	19.1	14.5

Avoid confusion: Splitting the CP – model
ECP = Extended Critical Power model

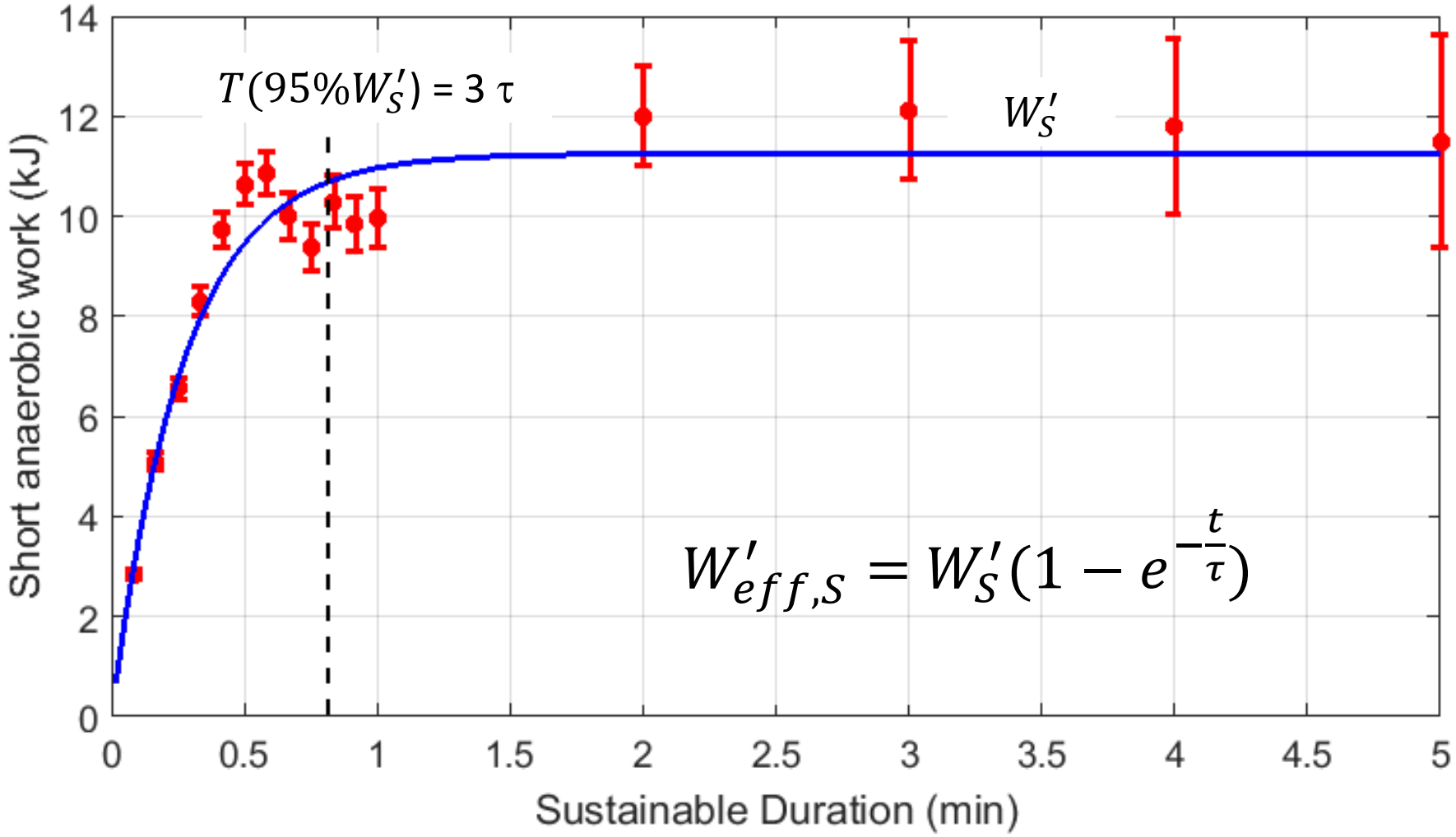
- Critical power obtained from short lab tests is CPs
- 95% of studies are about CPs, mistakenly called CP
- Threshold Easy:Hard is at CP
- CPs is no threshold at all
- SCP is the intersection of 2 linear segments in the [1/T , P] relation
- Threshold Hard:Extreme is not at CPs but at Supercritical Power SCP

- What about short bursts at sustainability < 1’

SCP first mentionned by M. Puchowicz - Veloclinic

Short Bursts: Effective Anaerobic work available in excess of SCP

$$W'_{eff,s}(t_{lim}) = (P(t_{lim}) - CP_s).t_{lim} \qquad \forall \text{ P} > \text{SCP}$$



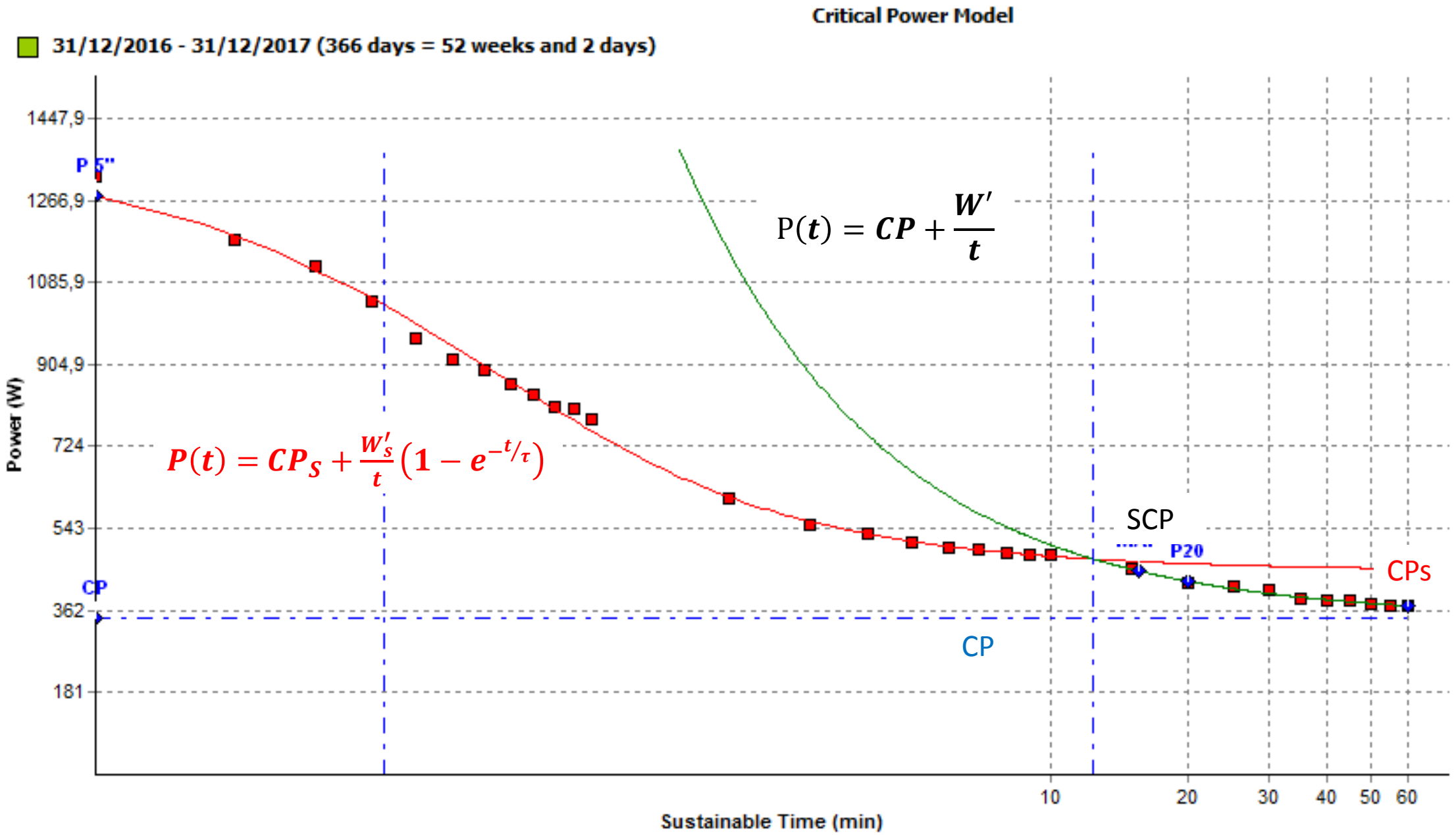
Max sprint power

$$P_{max} = CP_S + \frac{W'_S}{\tau}$$

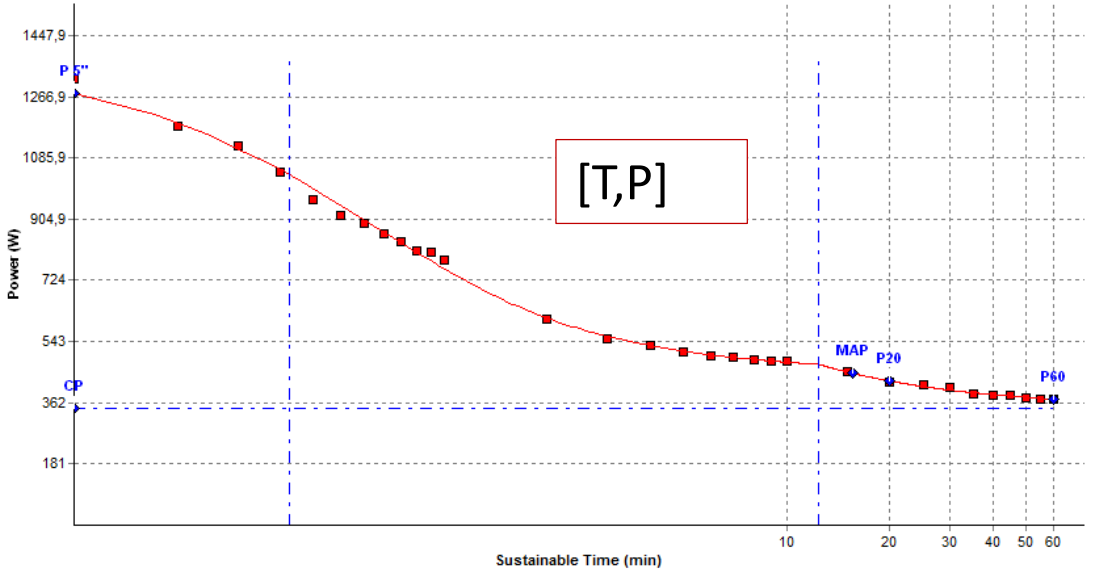
$\tau \cong 10" - 20"$

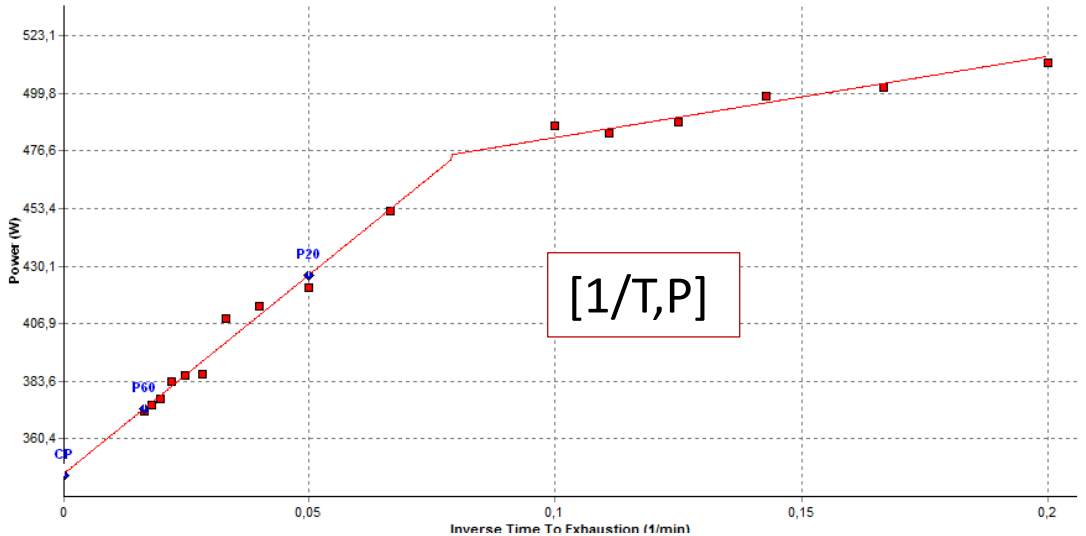
Sprint time constant

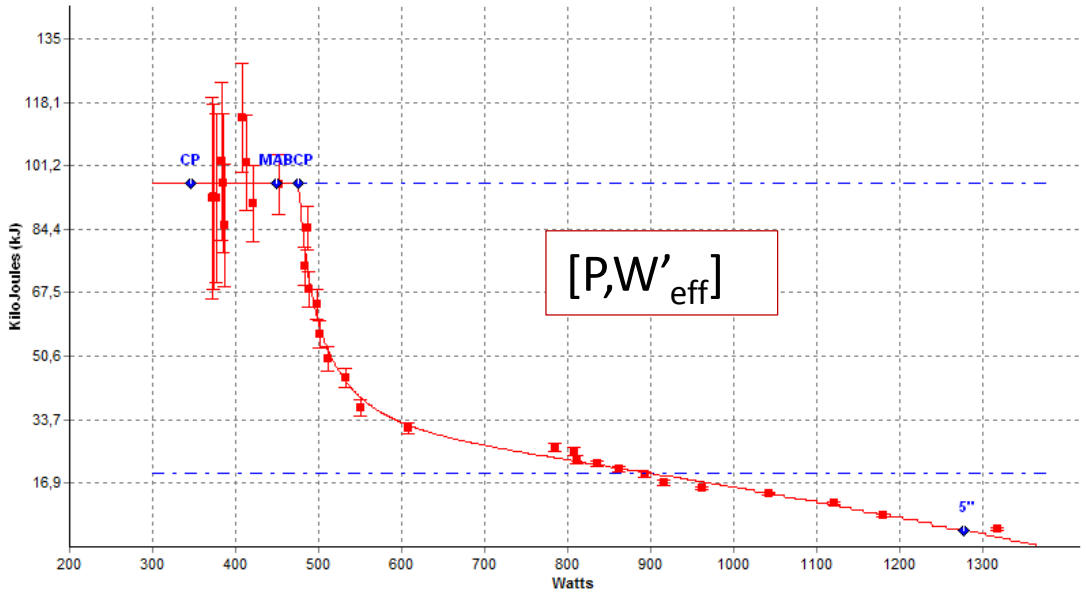
The MMP, RP, P-t data has it all

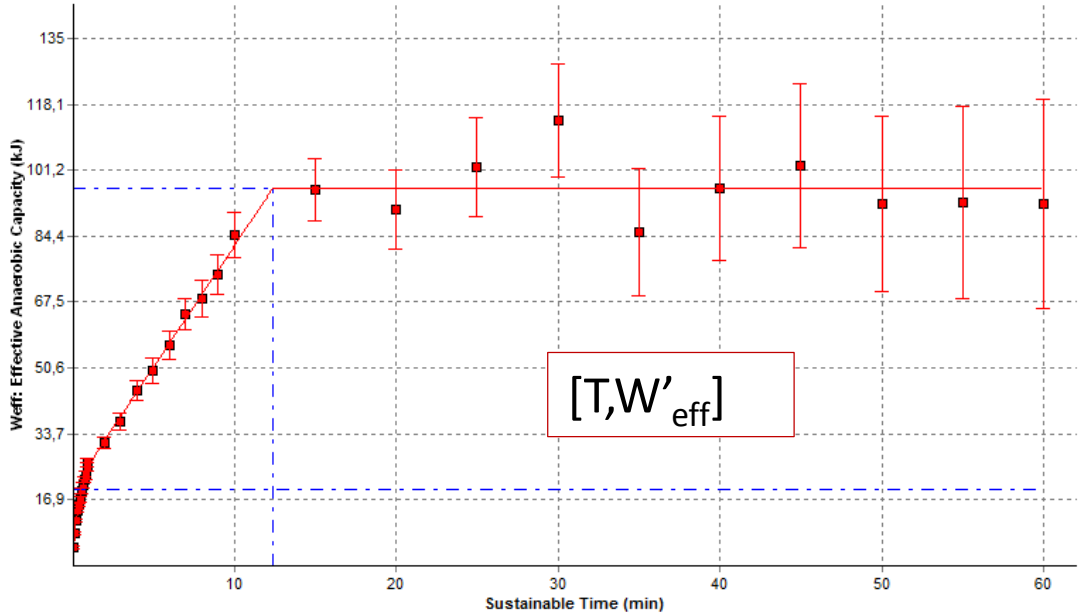


4 Presentations of Power and $W'_{eff} = (P_{lim}\text{-}CP)\ T_{lim}$









Some typical ECP model parameters

	CP W/kg	CPs W/kg	SCP kJ/kg	W' kJ/kg	Ws' kJ/kg	τ sec	Pmax W/kg
F1 2014	5,09	5,49	6,16	0,34	0,21	21,6	15,3
F2 2014	4,27	5,24	5,53	0,82	0,19	16,3	16,2
GT1 2013	4,96	6,37	6,57	1,25	0,15	15,9	15,9
GT1 2014	5,11	6,21	6,40	1,01	0,15	13,6	17,4
GT1 2015	4,91	6,40	6,56	1,35	0,13	11,1	18,1
P 2008	4,70	5,60	5,80	1,21	0,24	18,7	18,6
P 2013	5,41	6,43	6,70	1,21	0,25	18,9	19,9
S1 2017	3,79	5,51	5,67	3,81	0,33	19,1	23,1
S2 2016	4,60	5,40	5,79	1,00	0,33	19,6	22,1

Anaerobic depletion and recovery

Skiba et al. 2012,2013,2014,2015

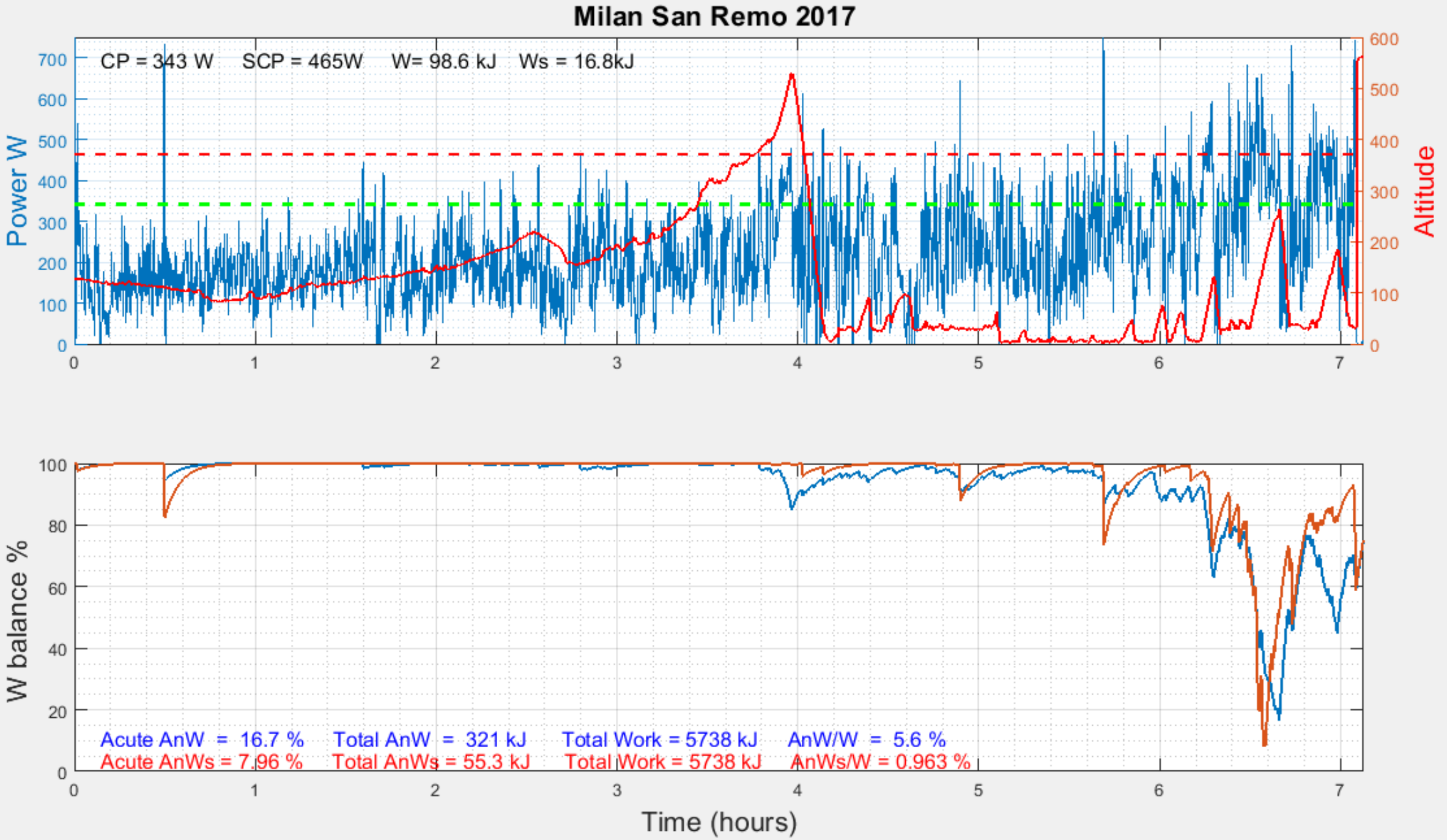
$$W'_{bal}(t) = W' - \int_0^t W'_{exp}\,(u).\exp(-(t-u)/\tau_r)\,du$$

$$\Delta W'_{bal} = (W' - W'_{bal})\left(1 - e^{-\Delta t/\tau}\right).U(D_{CP}) + D_{CP}\Delta t.U(-D_{CP})$$

$$W'_{bal}(t=0) = W' \qquad D_{CP} = CP - P$$

Time constant for recovery $\tau_r = 316 + 546 \exp(-0.01\ Dcp)$ Skiba 2014

Equally useful for depletion-recovery of (CP, W') and of (SCP, Ws') albeit with proper recovery constants


Milan San Remo 2017
CP = 343 W
SCP = 465W
W= 98.6 kJ
Ws = 16.8kJ
Power W
Altitude
W balance %
Acute AnW = 16.7 %
Total AnW = 321 kJ
Total Work = 5738 kJ
AnW/W = 5.6 %
Acute AnWs = 7.96 %
Total AnWs = 55.3 kJ
Total Work = 5738 kJ
AnWs/W = 0.963 %
Time (hours)

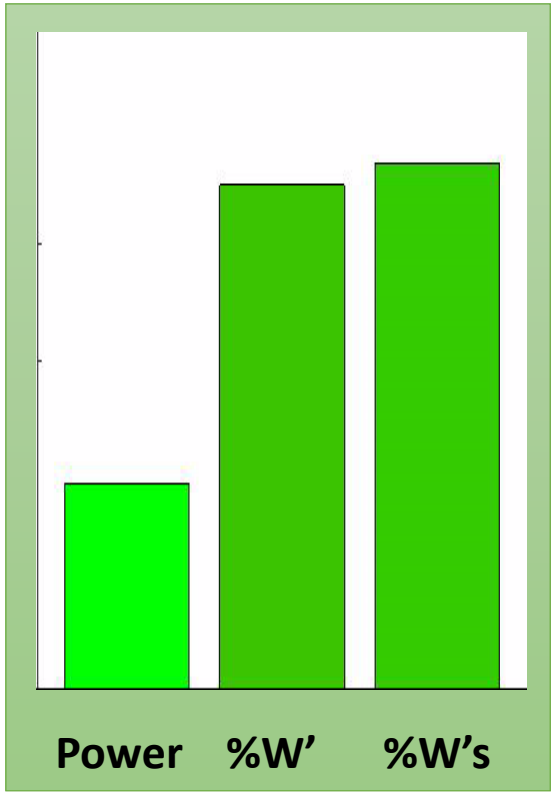
Towards an on-bike $W_{balance}$ app ?

Many details need to be adressed

- Raw data must be smoothed to avoid “stochastic” depletion
- Which CP, SCP, W’, Ws’ and τ_r to be used ?
- Updating parameters, Yearly? Quarterly? Monthly?
- Expected errors SD on parameters
- Minimal balance may be negative
- Time constant for recovery τ_{rec}
  - Personalized
  - Temperature and humidity
  - Days of good legs and of bad legs
  - Accumulated fatigue
  - Nutrition, nitrate loading
  - Illness
  - Doping….

Anaerobic Energy Balance
Ultimate 37’ of Milan – San Remo

CP	343	W
SCP	465	W
W’	98.6	kJ
W’s	16.8	kj



Foot Cipressa

Top Cipressa

Foot Poggio

Top Poggio

Accelerated Motion 60x 1” is 1’

Time for Questions

Charles Dauwe D. Sc.

Science & Cycling – Nantes 4 – 5 July 2018