MINE ATMOSPHERE REAL TIME PERSONAL RESPIRABLE DUST AND DIESEL PARTICULATE MATTER MONITORING

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Stewart Gillies & Hsin Wei Wu

Queensland Mining Industry Health and Safety Conference

August 2007

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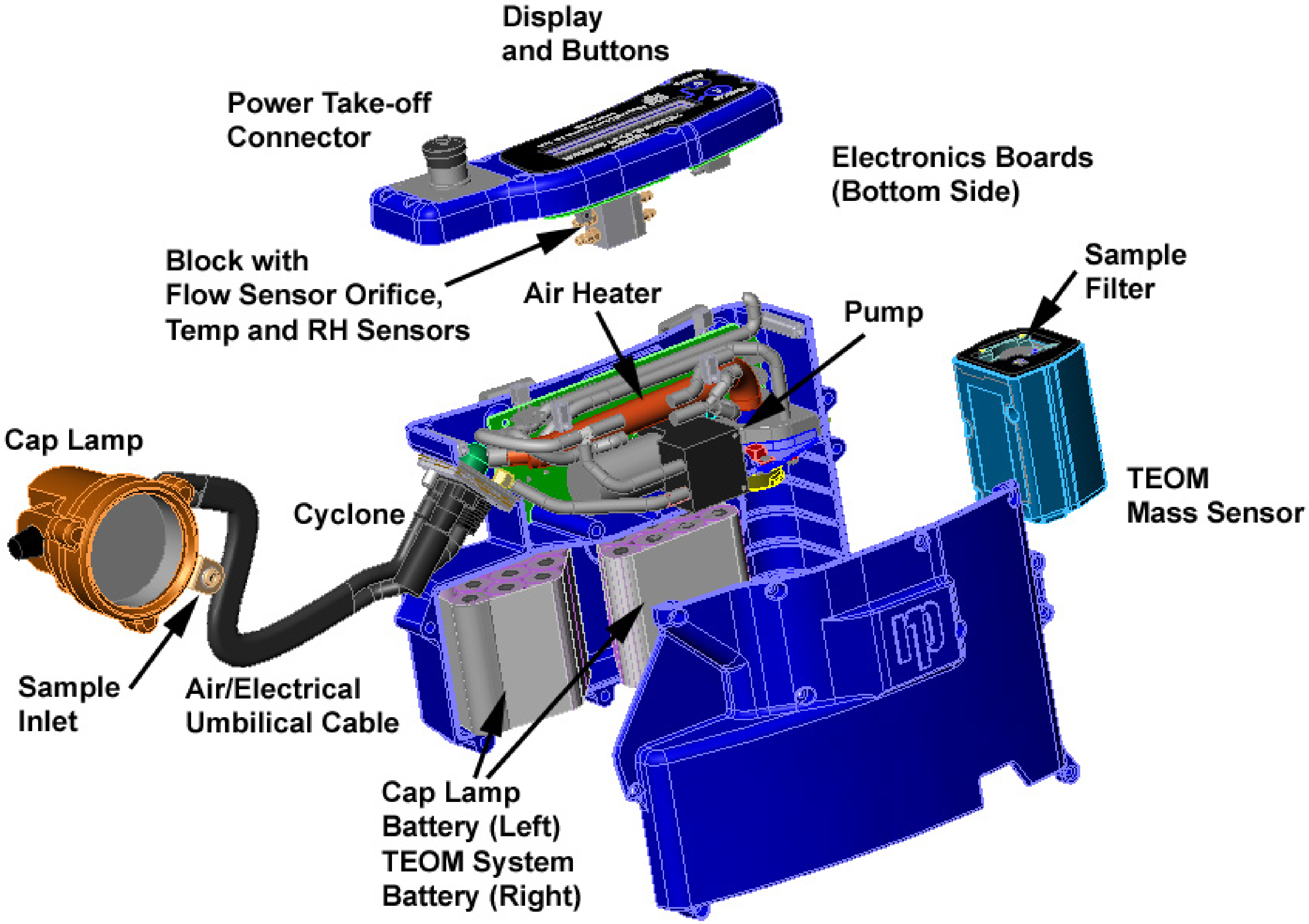
Real Time Respirable Dust Monitoring

NIOSH contracted with Rupprecht & Patashnick Co. Inc (now Thermo Fisher Scientific Co. Inc) for the development of a one-piece personal dust monitor (PDM), with the objective of miniaturizing the firm's TEOM® microbalance technology into a person-wearable form for accurate end-of-shift exposure information.

Main System Components



Australian Engineering Evaluation

- NIOSH invited Gillies Wu Mining Technology to undertake comparison respirable dust Australian tests to those done in US.
- The Australian Coal Association Research Program under ACARP Grant C14010 and various test mines supported a project to evaluate the PDM instrument for assessing engineering improvements in dust conditions.
- Since the project's completion a large number of Australian mines have had high dust situations evaluated using PDM monitors.

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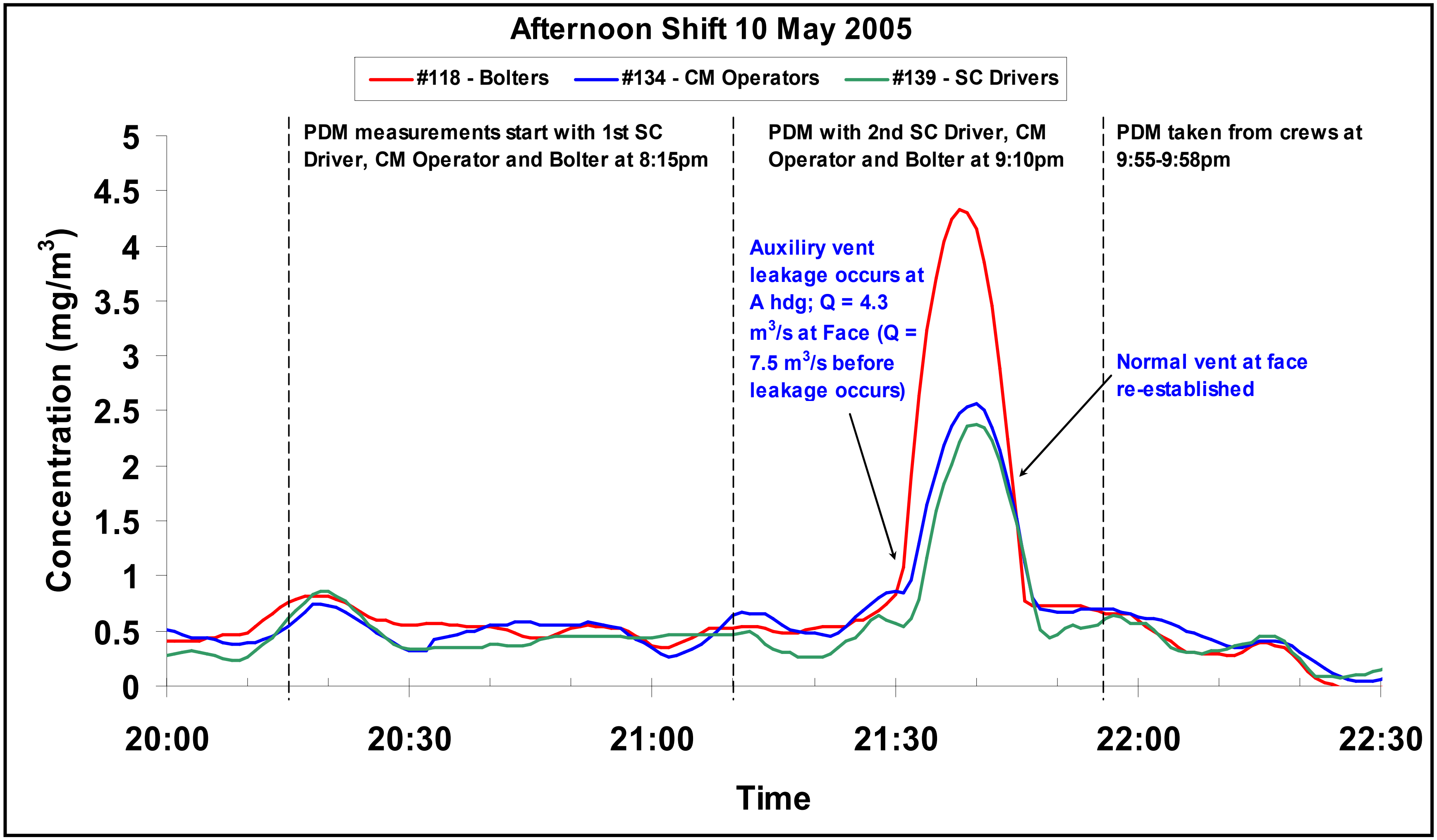
Dust - Medium Seam, Development Section, 3 Operators, Ventilation change



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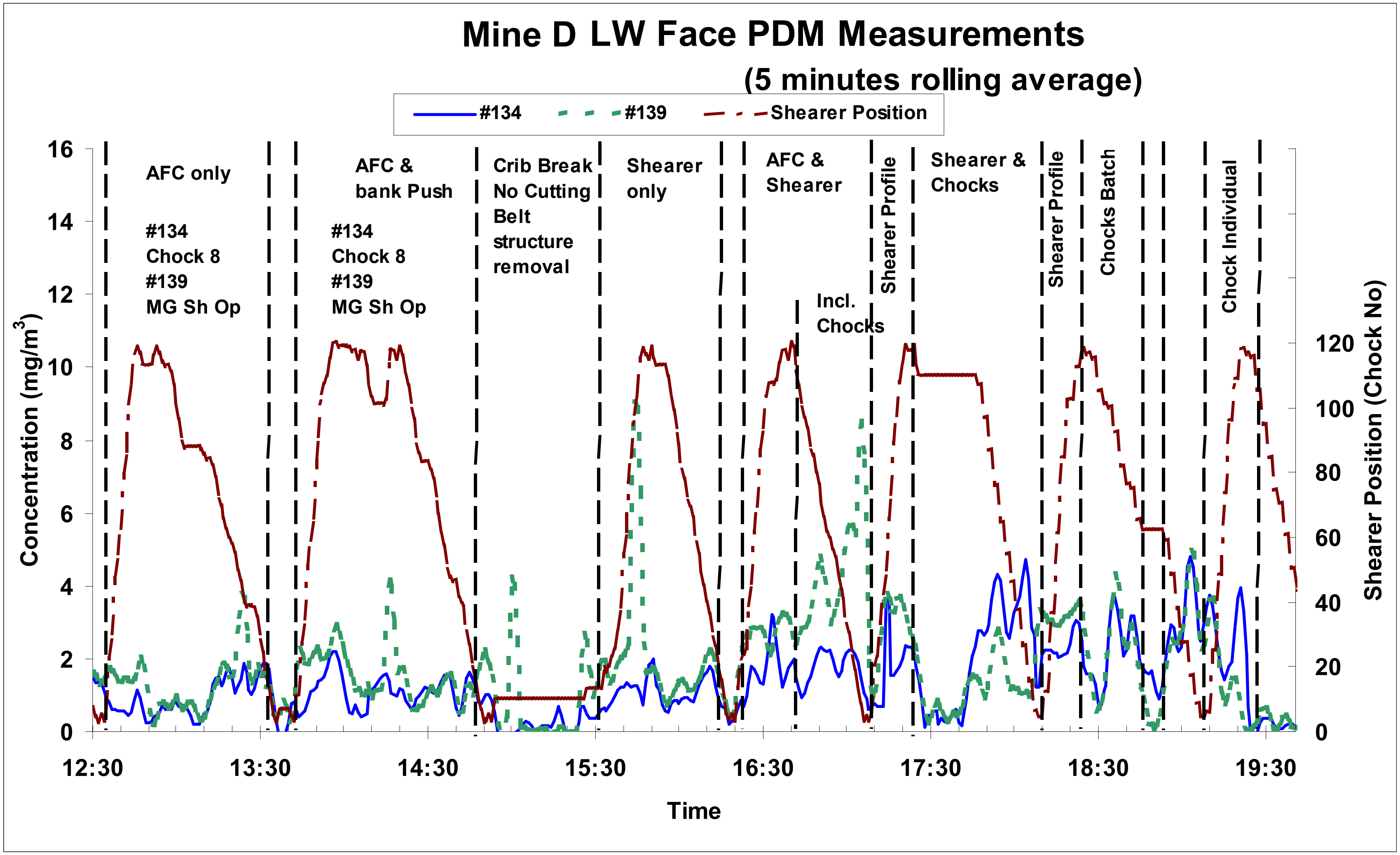
LW Face Dust Surveys
Shearer Position and Dust Levels



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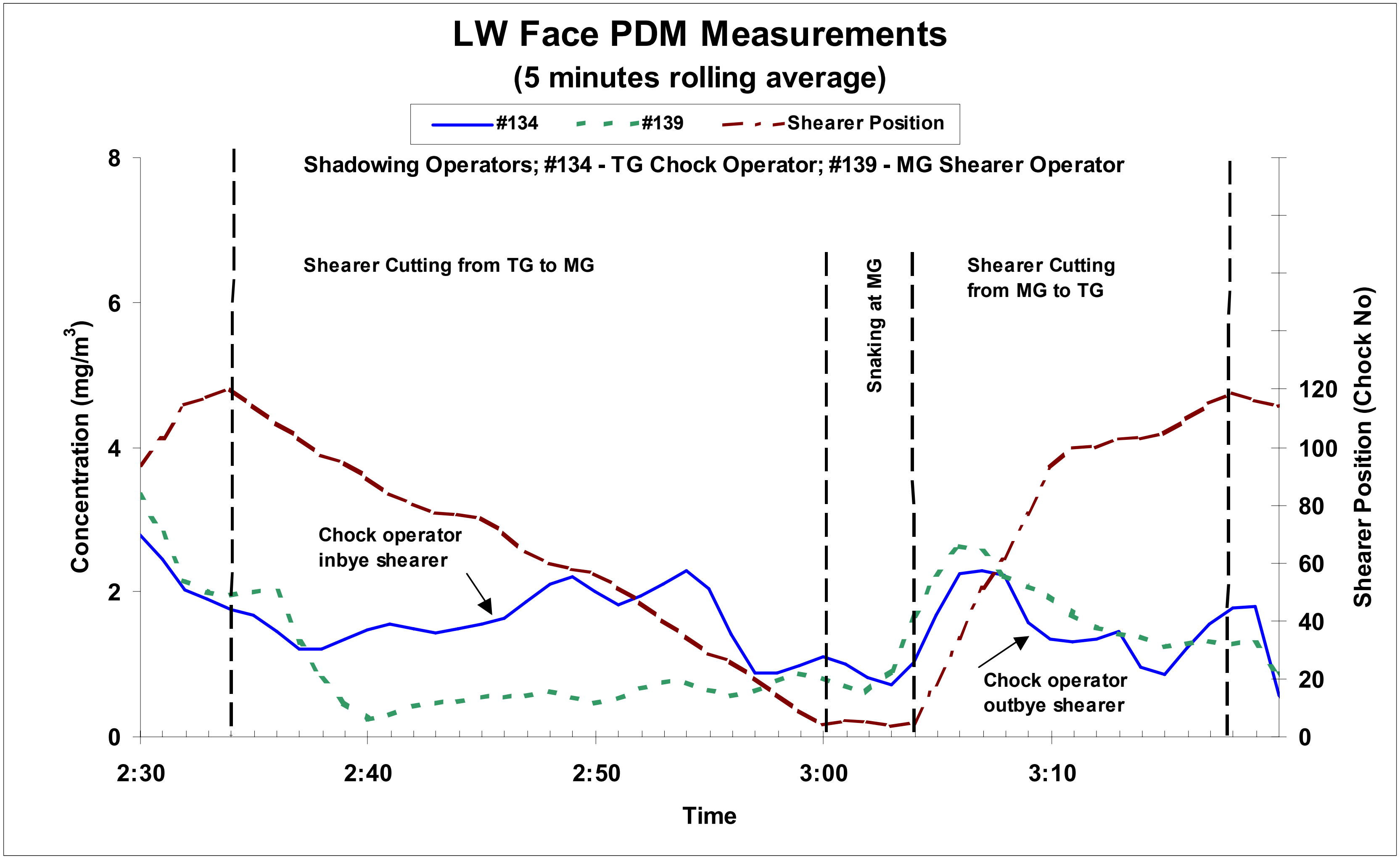
LW Face Dust Surveys
Chock Advance Dust-Unidi Cutting



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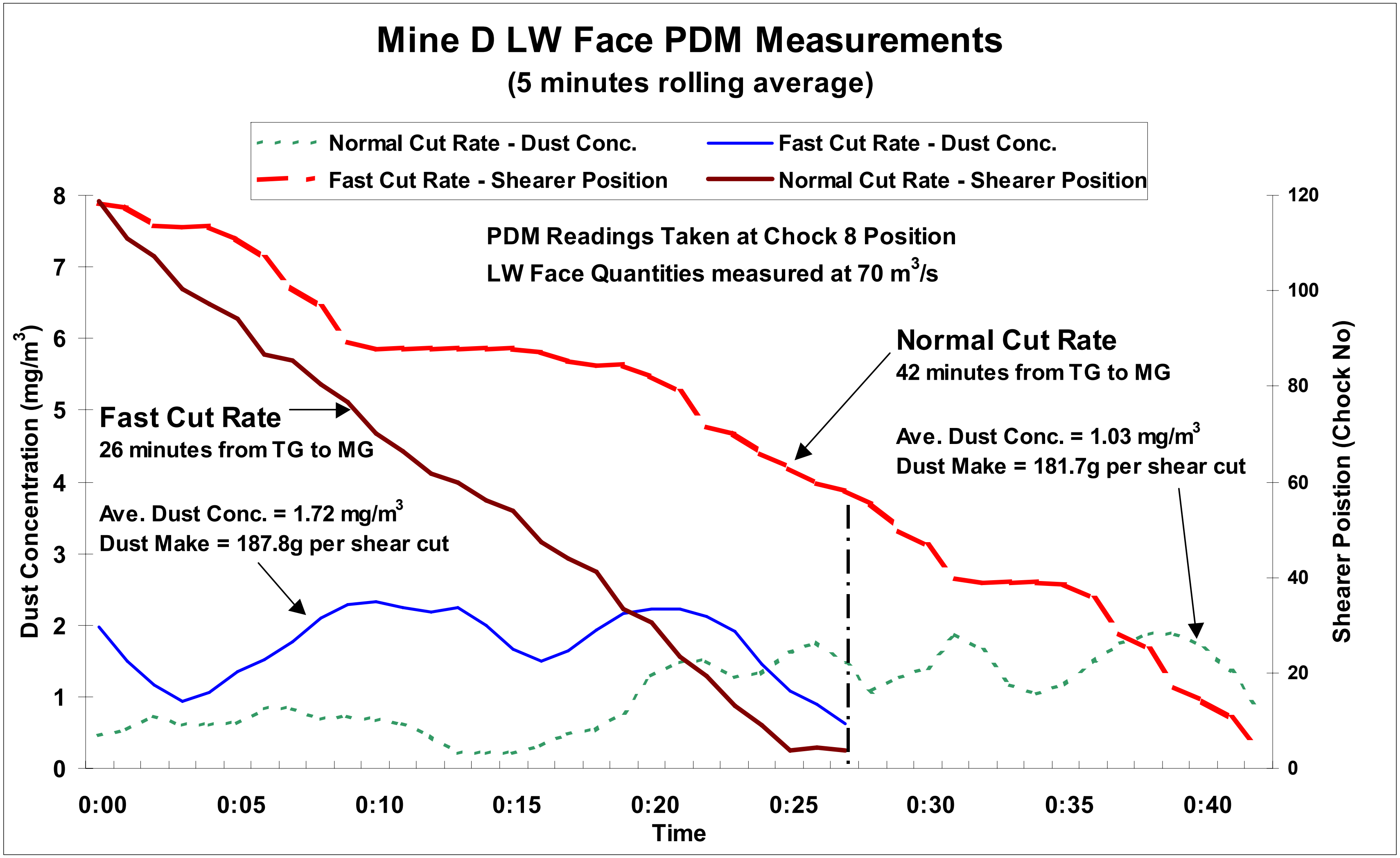
LW Face Dust Surveys
Variation of Dust with Shearer Advance Rate



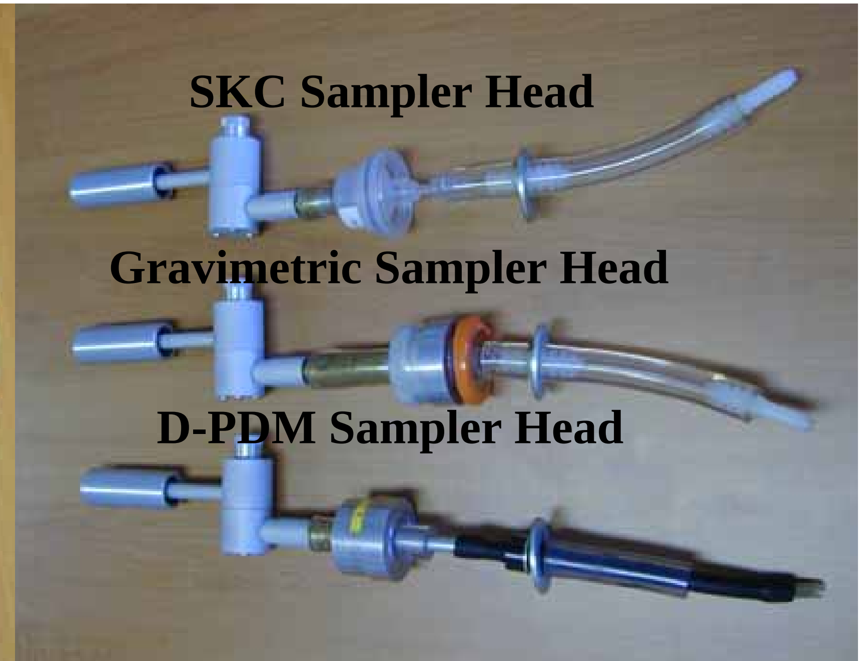
DPM Grant & Australian Limits

- ACARP funding under Grant C15028 to develop/test/mine prove a DPM real time **atmospheric** monitoring unit.
- Moves to broad international acceptance of USA DPM MSHA metal mine limits (originally pub 2001) of submicron 0.20 mg/m^3, TC 0.16 mg/m^3 and EC 0.10 mg/m^3.
- NSW Minerals Council 2005 Guideline for DPM is specified at 0.20 mg/m^3. This equates to 0.16 mg/m^3 TC or 0.10 mg/m^3 EC. Recommended Queensland approach.
- The real time DPM monitor is being developed from the base of the successful Personal Dust Monitor.

Objective steps in the Grant

1. PDM Instrument Reconfiguration to finalise DPM design.
2. NIOSH Pittsburgh Laboratory comprehensive and internationally recognised testing to evaluate the new design.
3. Australian mine underground series of tests to establish the robustness and reliability of the new approach.

NIOSH Marple Chamber



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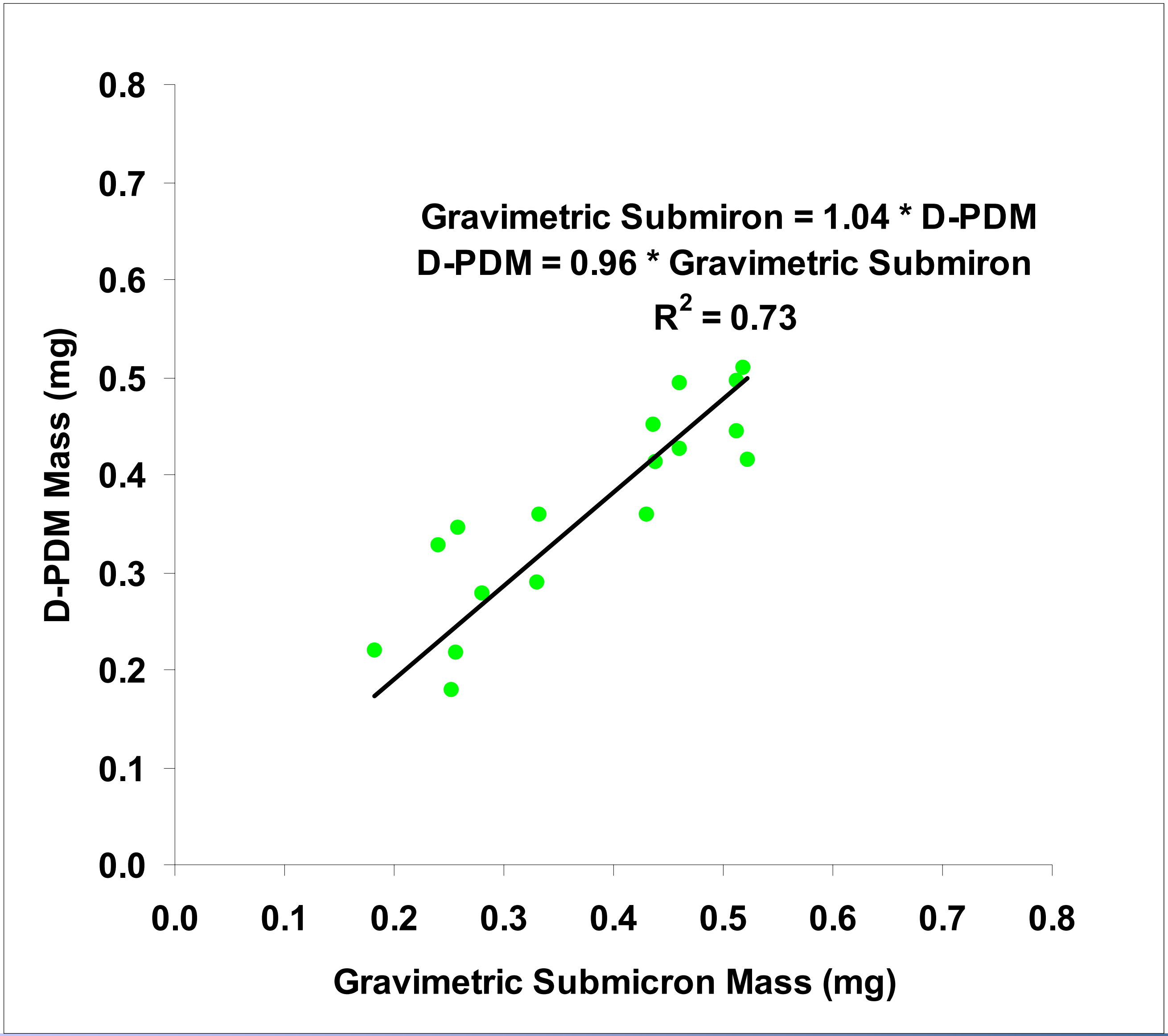
Comparison of D-PDM to Reference Gravimetric, TEOM Measurements and SKC

Test No	Sub µm Grav (mg)	D-PDM (mg)	TC (µg)	EC (µg)	D-PDM/sub µm ratio	EC/Sub µm ratio	TC/sub µm ratio
Test 1 Interval 1	0.251	0.179	185.21	164.10	0.715	0.654	0.738
	0.181	0.221	179.49	159.23	1.221	0.880	0.992
	0.256	0.219	181.54	166.12	0.855	0.649	0.709
Test 1 Interval 2	0.430	0.36	349.70	308.86	0.837	0.718	0.813
	0.435	0.451	339.72	271.47	1.037	0.624	0.781
	0.460	0.426	351.66	313.67	0.926	0.682	0.764
Test 2 Interval 1		0.293	250.48	228.98			
	0.331	0.359	232.63	212.84	1.084	0.643	0.703
	0.257	0.347	205.09	176.60	1.350	0.687	0.798
Test 2 Interval 2	0.522	0.416	423.73	374.43	0.797	0.717	0.812
	0.517	0.510	348.43	364.88	0.986	0.706	0.674
	0.459	0.494	323.56	295.09	1.076	0.643	0.705
Test 3 Interval 1	0.329	0.291			0.883		
	0.239	0.329	248.55	227.11	1.378	0.950	1.040
	0.280	0.278	248.35	197.30	0.994	0.705	0.887
Test 3 Interval 2	0.512	0.444	399.99	364.07	0.867	0.711	0.781
	0.512	0.496	378.99	358.71	0.969	0.701	0.740
	0.438	0.413	368.52	331.51	0.943	0.757	0.841
				Average	**0.995**	**0.714**	**0.799**

Relationship between Gravimetric Submicron and D-PDM from NIOSH



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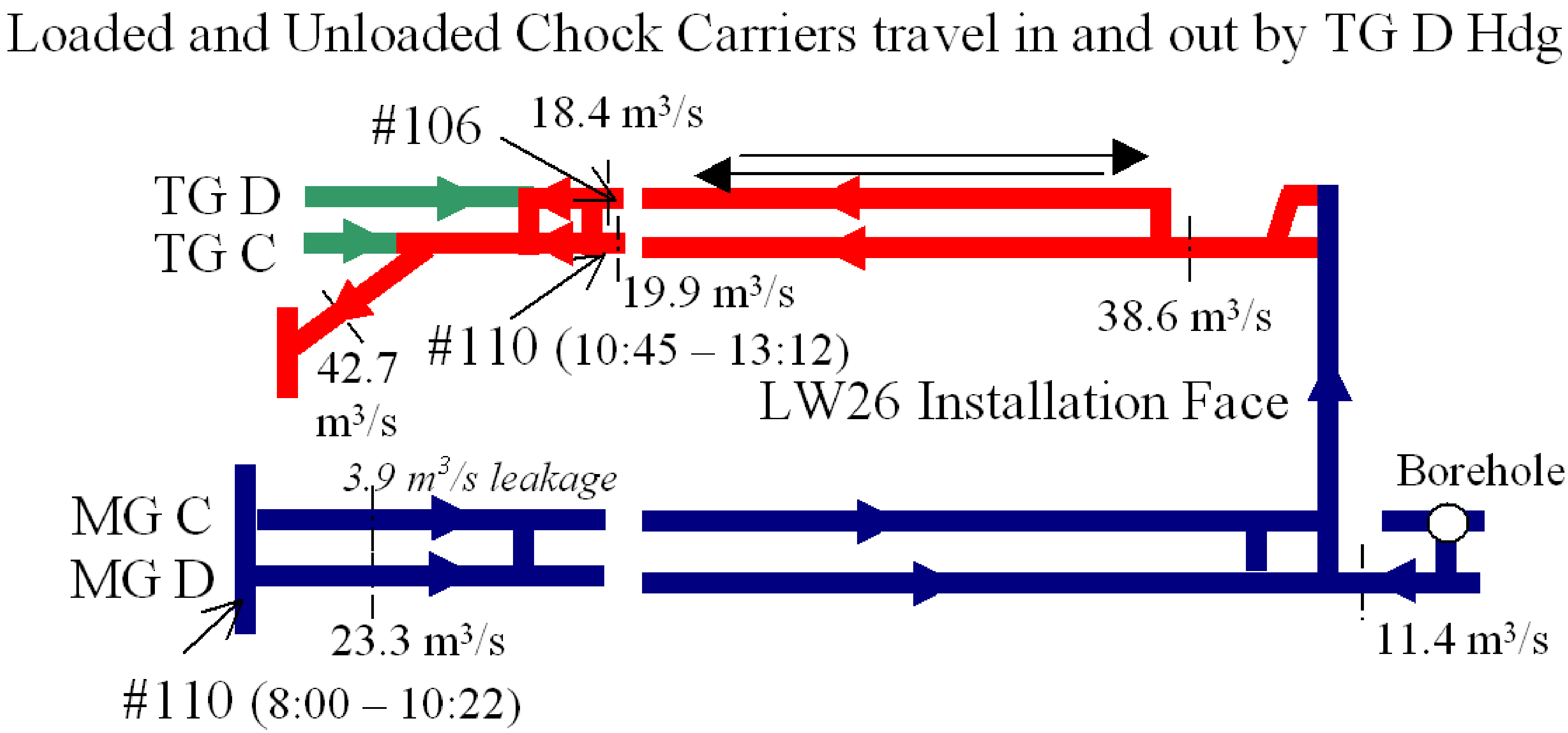
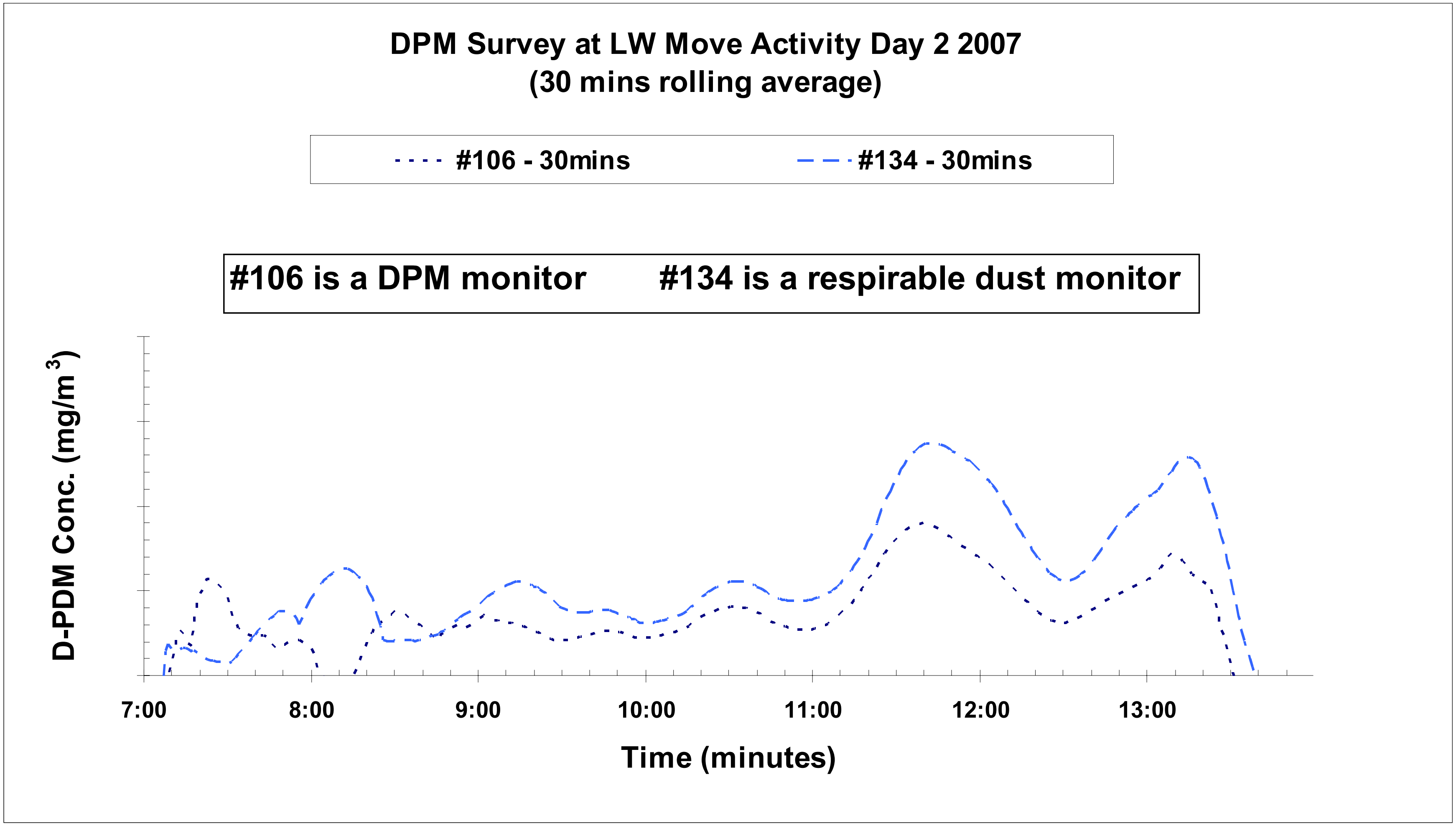
Mine 3 Ventilation Strategy Chock Carrier Air Goes to Dogleg Return

Day 2



Submicrometre DPM & PDM Respirable Dust Results in Longwall Move (no face coal cutting)



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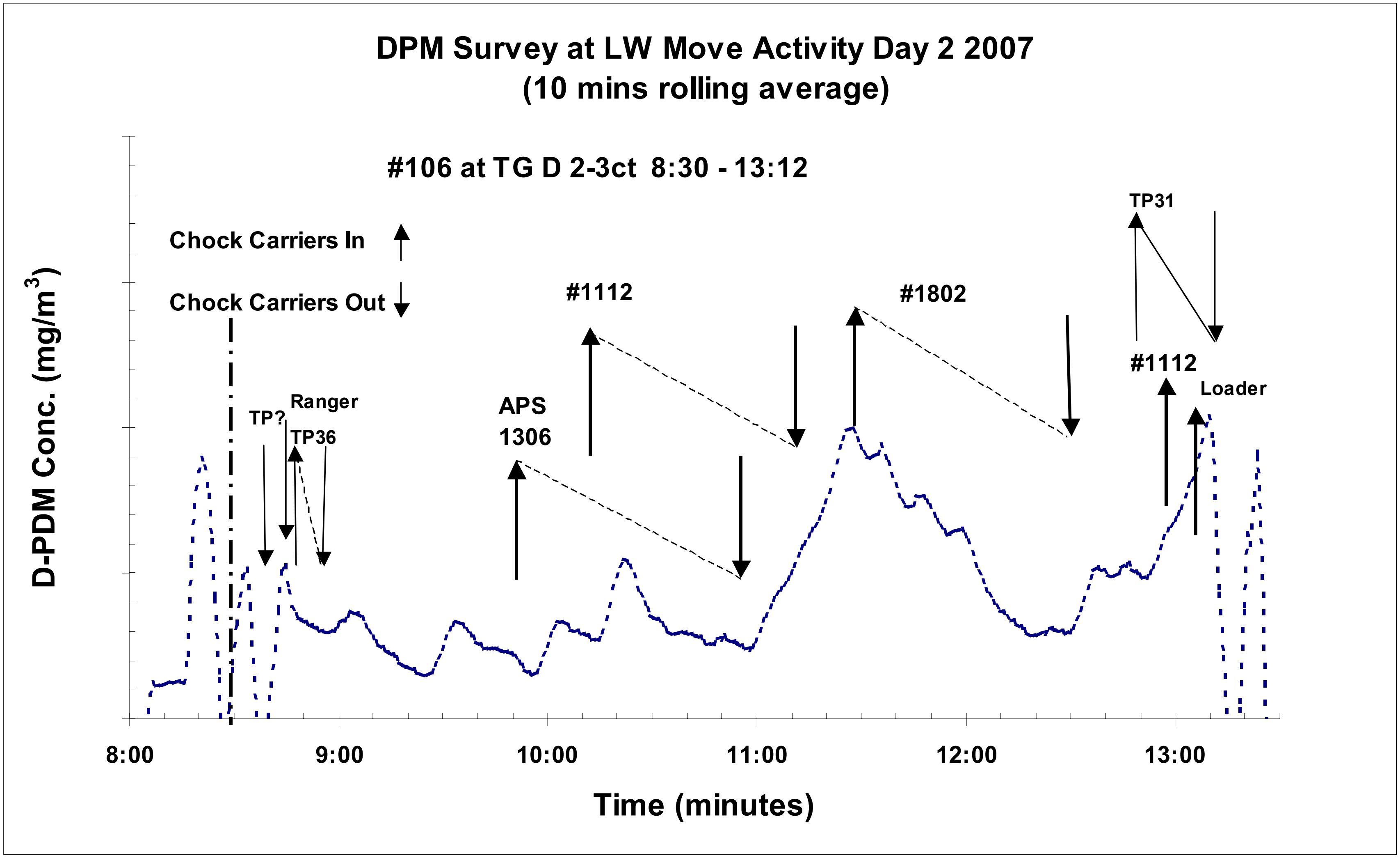
Submicrometre DPM in Longwall Move



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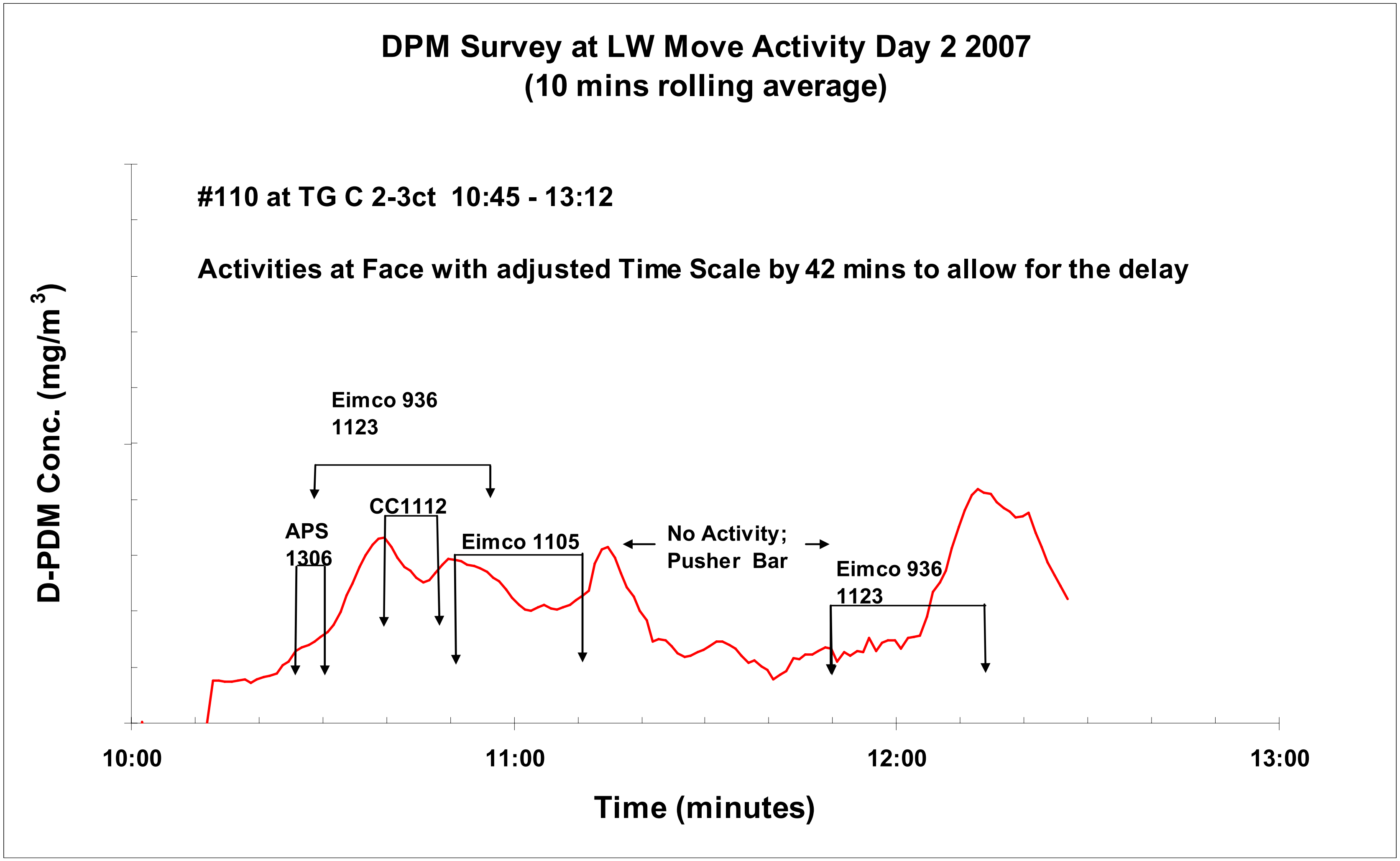
Submicrometre DPM in Longwall Move. DPM make from LW face activity



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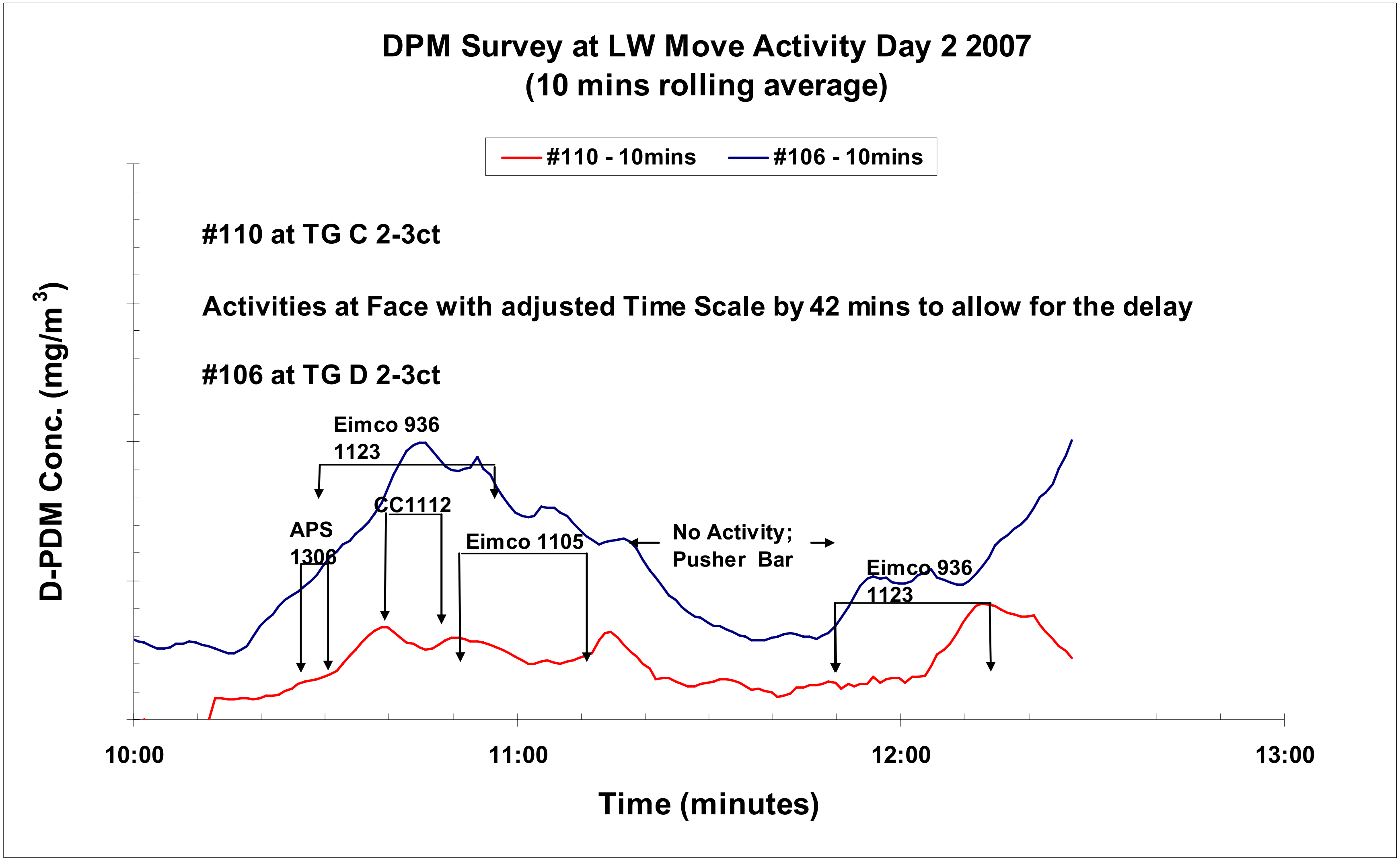
DPM make from LW face activity compared with DPM make from both face and TG transport activities



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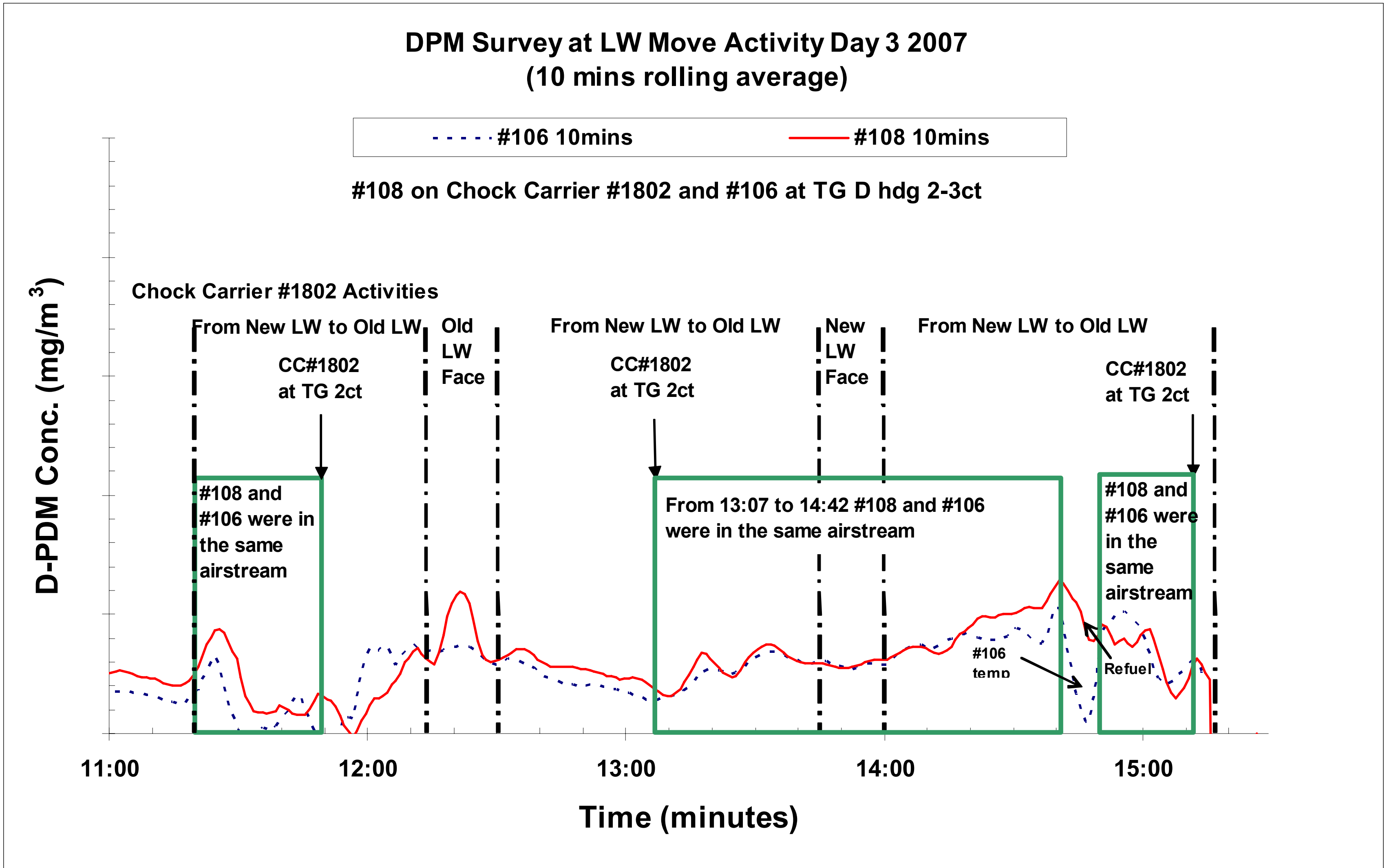
Submicrometre DPM in Longwall Move. Comparison of monitor on machine with monitor hanging on rib bolt



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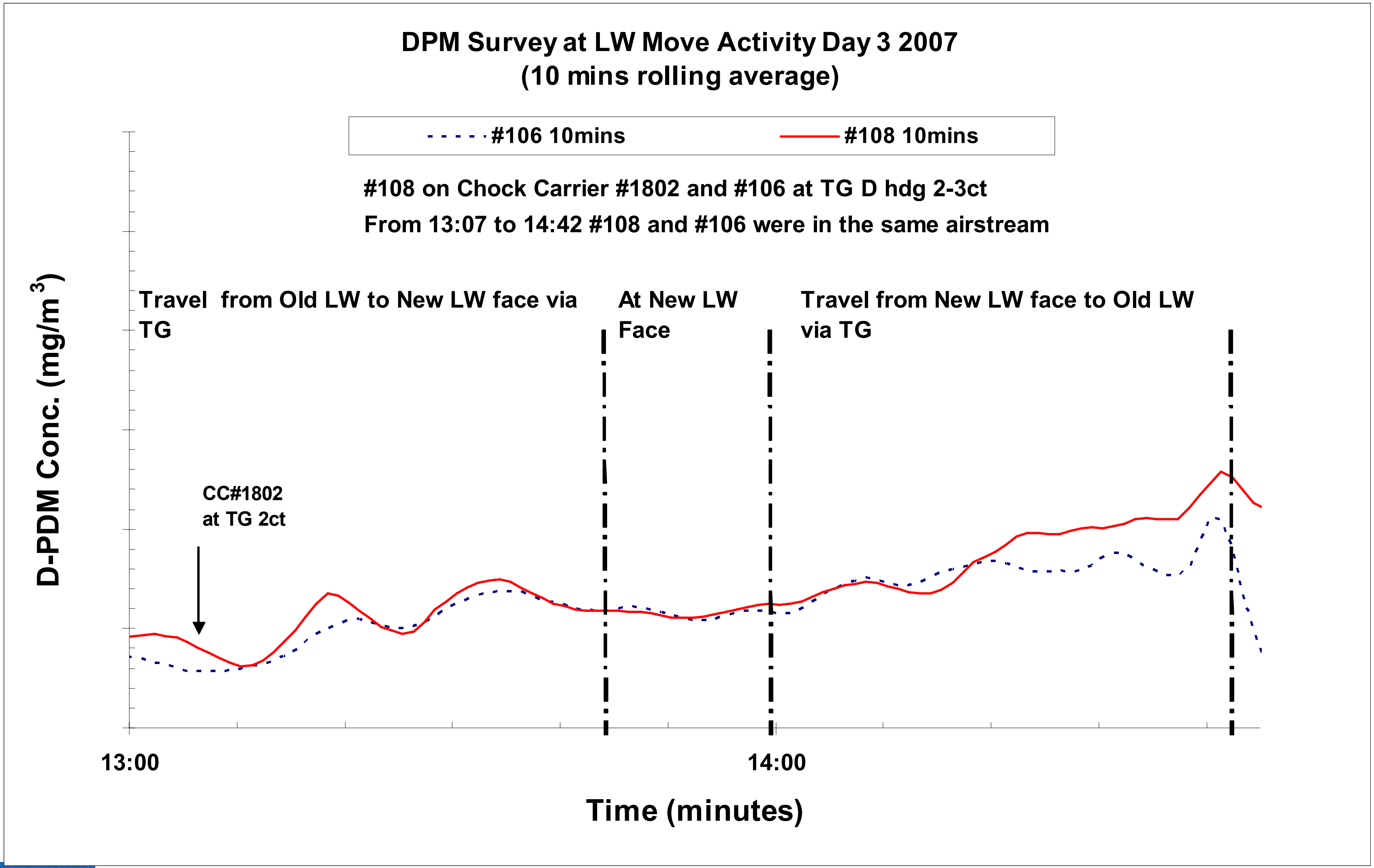

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Submicrometre DPM in Longwall Move, Panel Sources

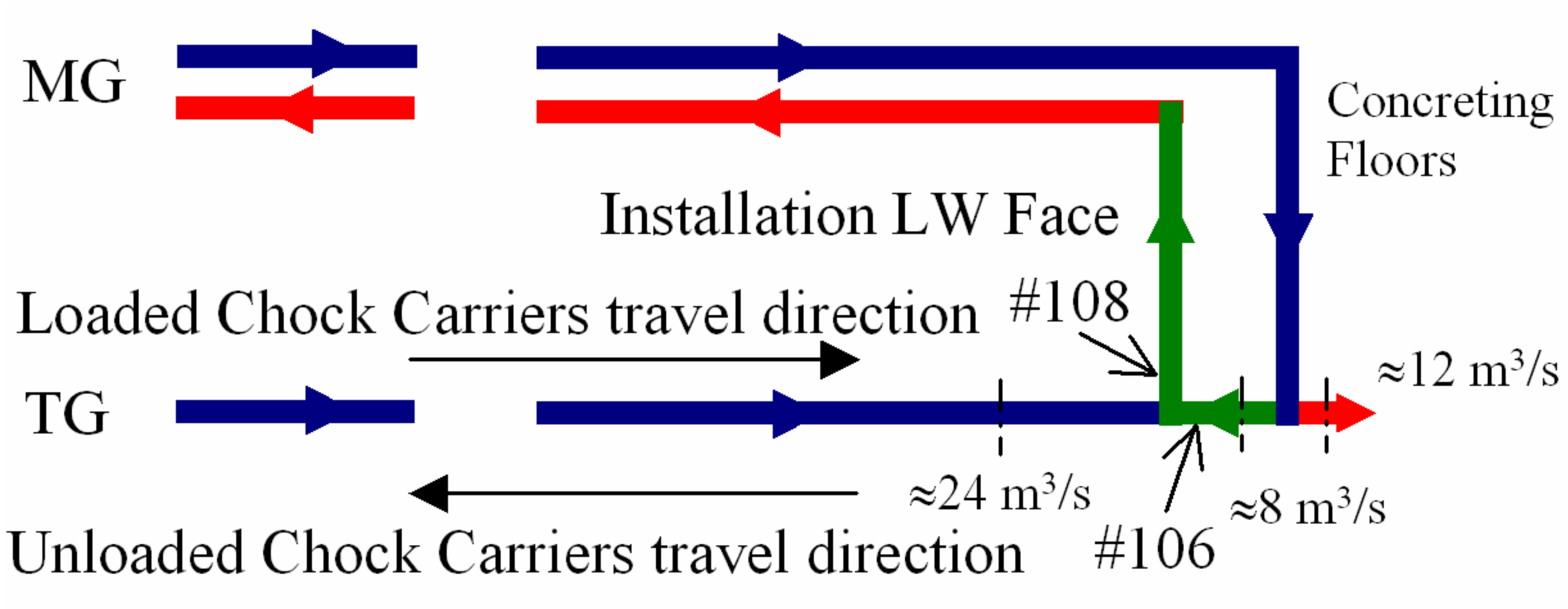
Location	Sources ug/s	%	Comments
MG, C & D Hdgs	3.03	18.6	Mains Air at MG Panel Entrance
Borehole	0.00	0.0	Back of MG26
LW Face	4.77	29.2	Eimco 396 & Shunting LHDs
TG D Hdg	6.96	42.6	Chock Chariots Travel Way
TG C Hdg	0.00	0.0	No Diesel Activity
Leakages	1.57	9.6	Mains Air; Coffin Seal & Ddbl Doors
Measured Total	**16.32**	**100.0**	

Observations on Mine 3 Results

- Results from monitoring clearly demonstrated the ability of the D-PDM units to detect variations of DPM levels in atmosphere as the Chock carriers travel into the LW face and out.
- High submicron DPM readings were recorded due to the large number of chocks that were transported during the shifts.
- High submicron DPM readings were also found due to the relatively high DPM in air entering panel from Outbye and also from face activity.

Mine 2 Ventilation Strategy Chock Carrier Air Goes to Face Day 1

Chock carriers travel in and out only from TG



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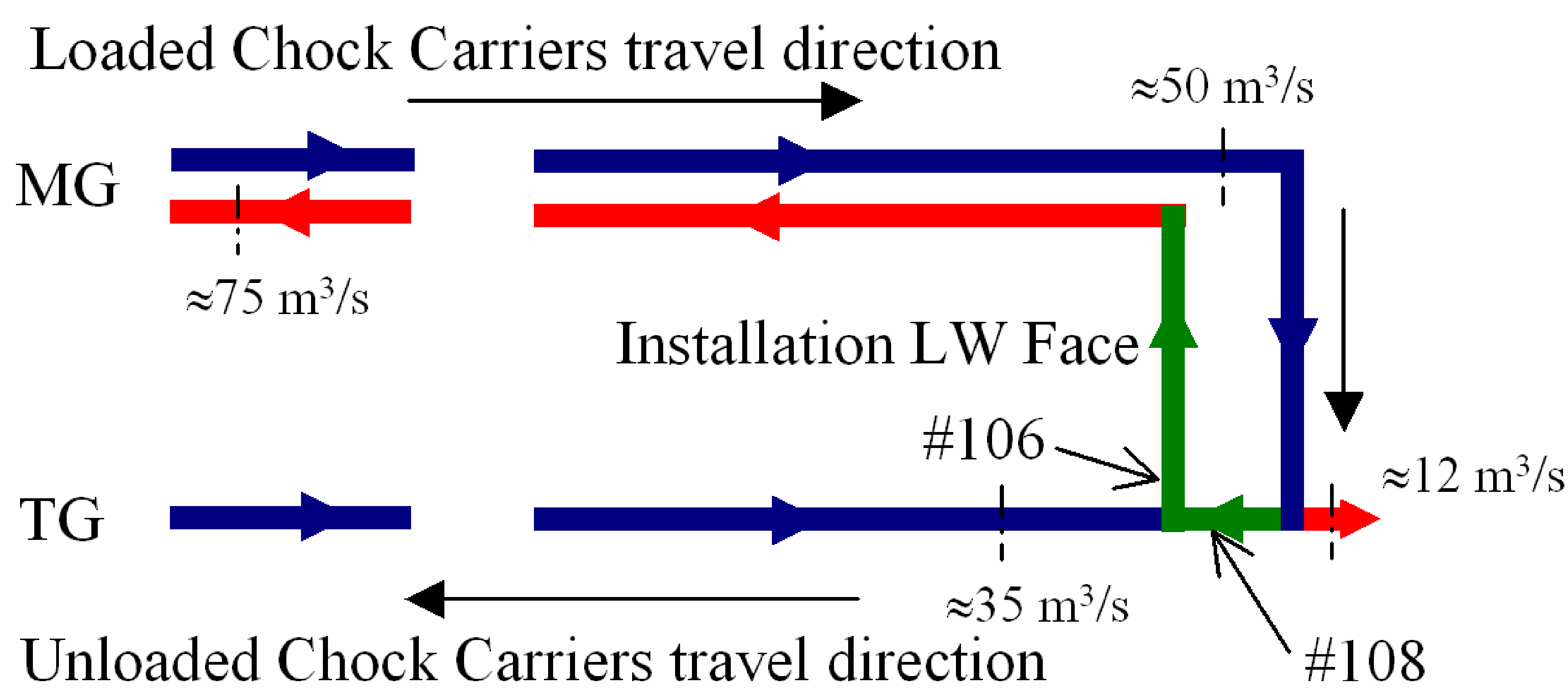
Mine 2 Ventilation Strategy Chock Carrier Air Goes to Face Day 2

Chock carriers travel in on MG and out on TG



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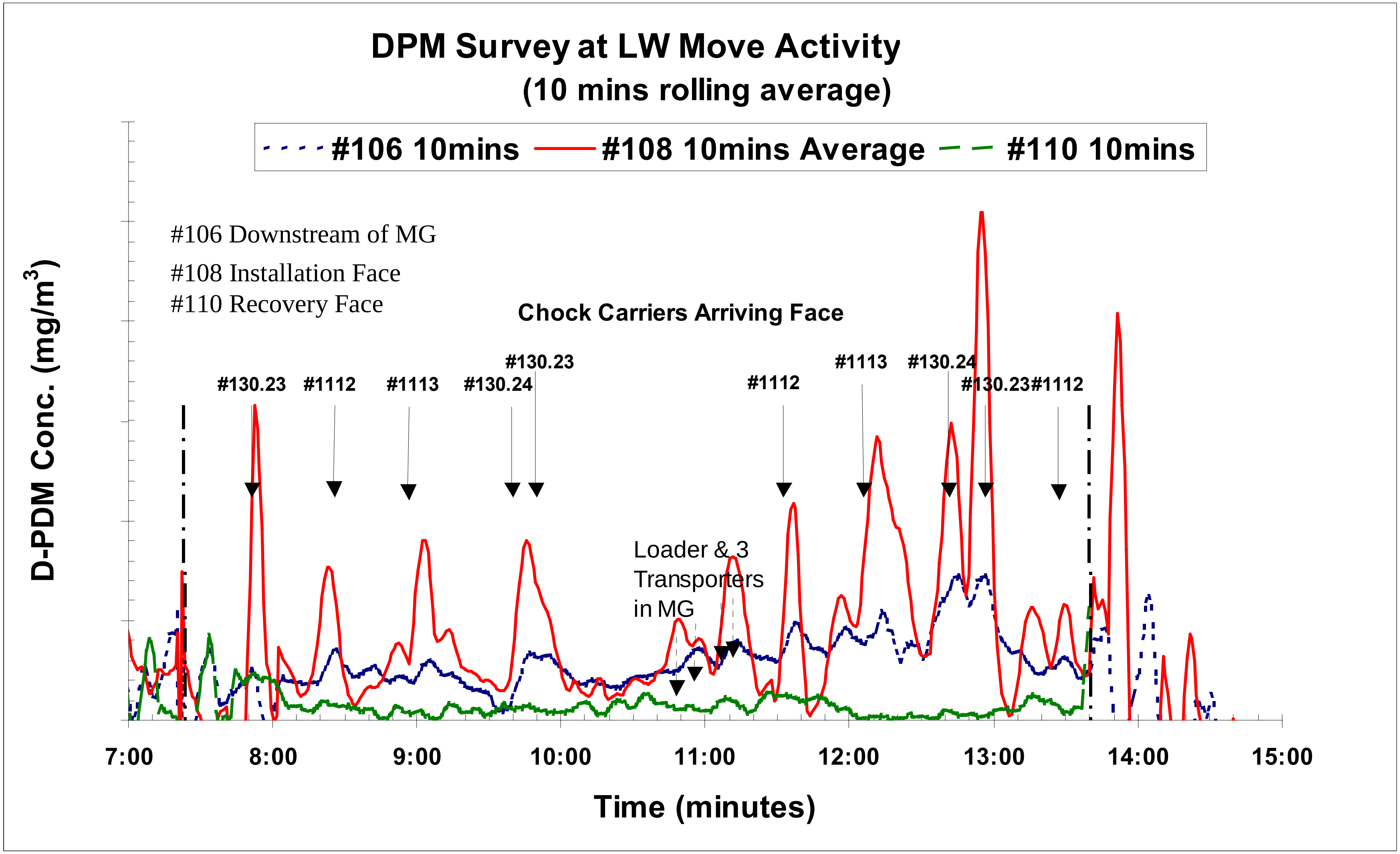
Mine 2 Submicrometre DPM in Longwall Move, Day 2



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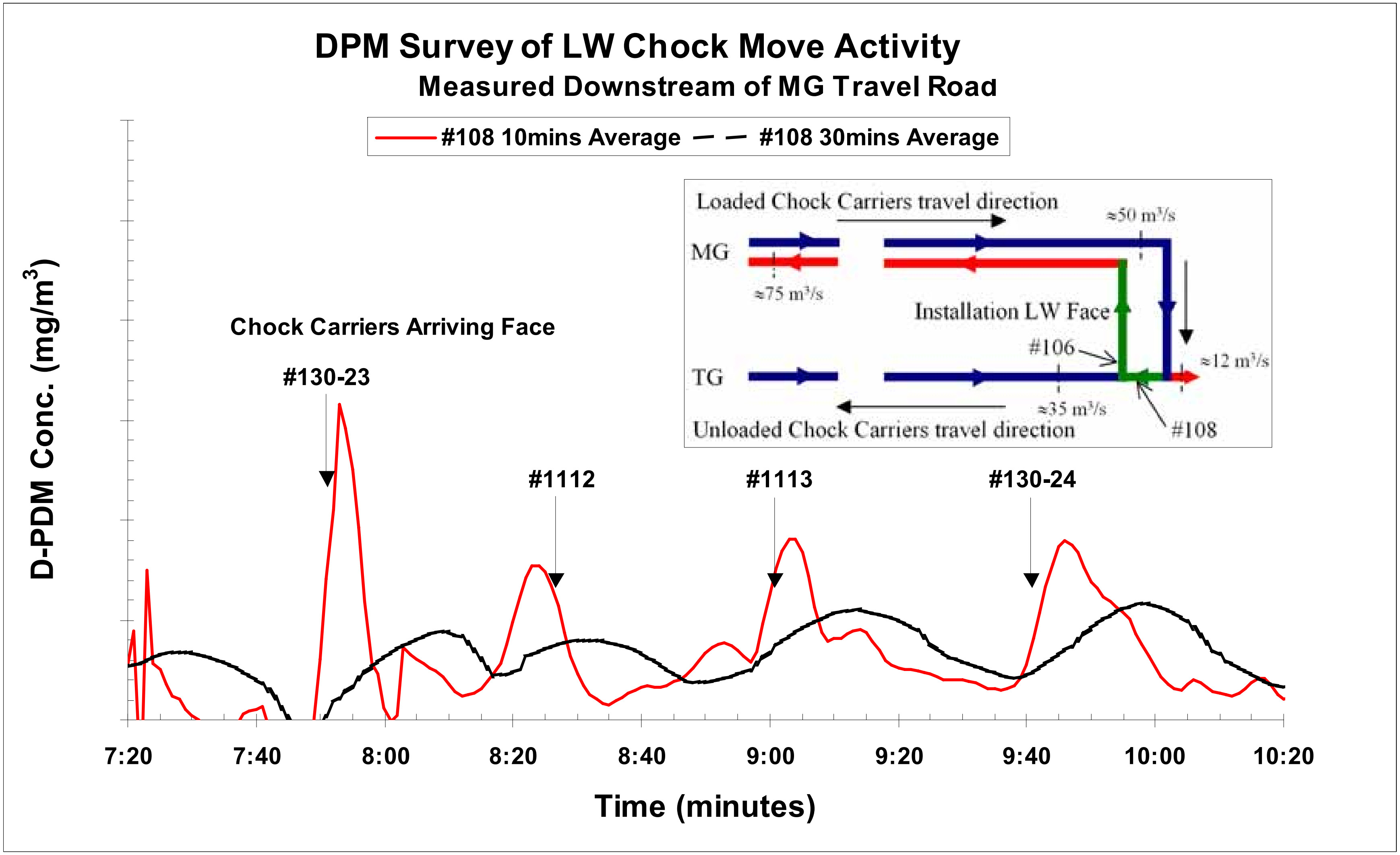
Mine 2 Submicrometre DPM in Longwall Move, Day 2



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Air Velocity vs Vehicle Speed

- Closer examination of these results indicates that sometimes chock carriers travel at higher average speed than air velocity.
- On occasions there is slower machine travel speed than air velocity.
- Slower machine speed results from poor road surface or steep gradients.

Air Velocity vs Vehicle Speed

- The time difference and also the peak concentration will depend on the air route, whether the air is travelling with or against the carrier direction, the air velocity as a function of the air quantity and chock carriers' travel speeds.
- Best if vehicle travels against airflow direction.
- For vehicles travelling against the ventilation always ensure the engine exhaust outlet is trailing the driver.
- In theory if the chock carrier travels with the air at the same speed as air velocity the peak concentration will be extremely high and the carrier will arrive at the same time as the concentration peak.

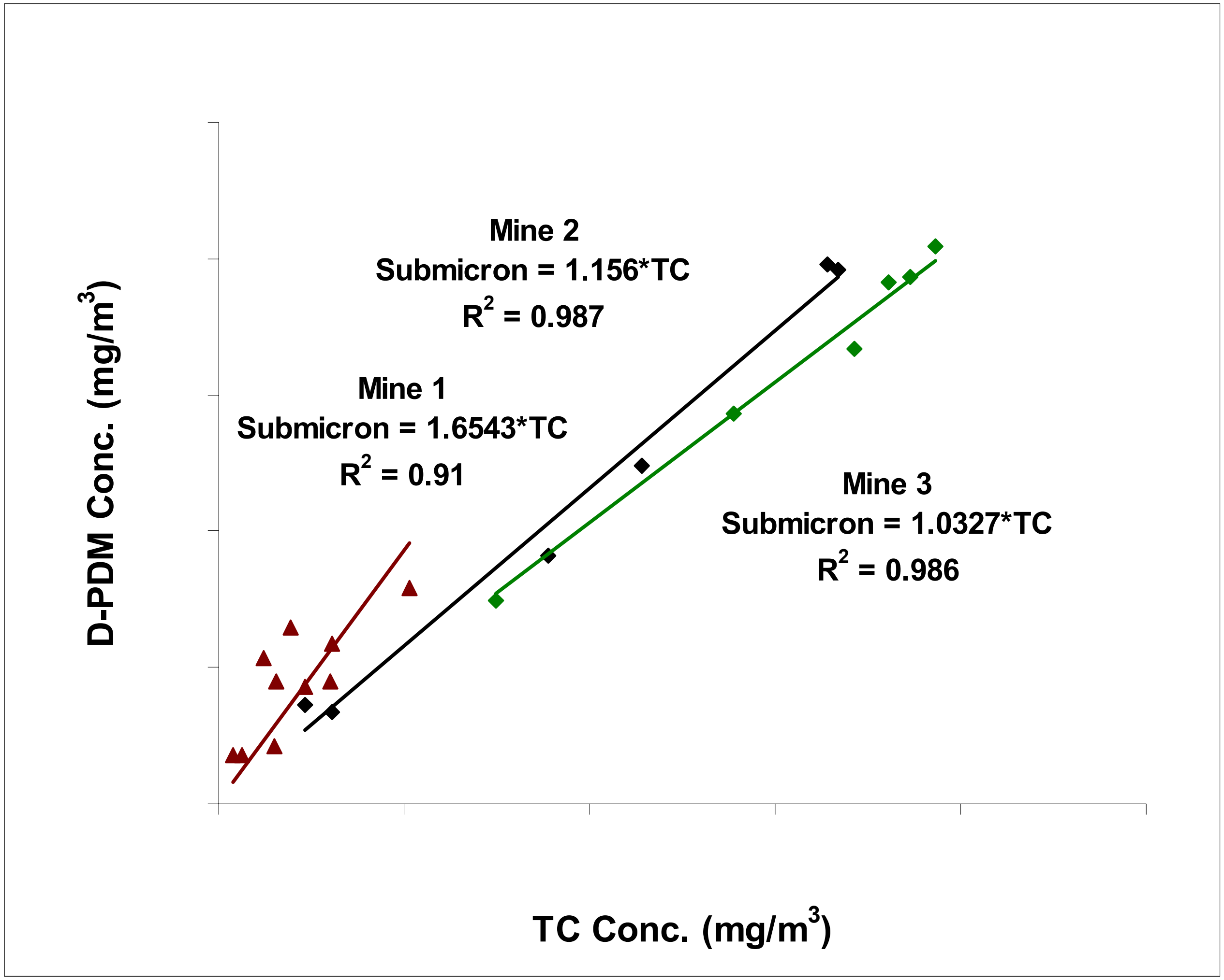
Air Velocity vs Vehicle Speed, Mine 3

Time	Location	In/Out	Distance m	Time mins	Speed, m/s	Air Vel m/s	Air Travel Time mins
Chock Carrier APS 1306							
9:53	TG26 2ct	In	3,400	34	1.66	1.29	43.9
10:27	Face						
	Machine Against Air			**Machine/Air Rel Velocity, m/s = 2.95**			
10:31	Face	Out	3,400	26	2.18	1.29	43.9
10:57	TG26 2ct						
	Machine With Air			**Machine/Air Rel Velocity, m/s = 0.89**			
Chock Carrier CC 1112							
10:12	TG26 2ct	In	3,250	28	1.93	1.29	41.9
10:04	TG26 36ct						
	Machine Against Air			**Machine/Air Rel Velocity, m/s = 3.22**			
10:05	TG26 36ct	Out	3,250	17	3.18	1.29	41.9
11:07	TG26 2ct						
	Machine With Air			**Machine/Air Rel Velocity, m/s = 1.89**			

Issues from Air Velocity vs Vehicle Speed, Mine 3

- Here chock carriers travel at higher average speed than air velocity.
- To reduce DPM in Mine 3 TG travel route panel air quantity could be increased.
- This increase in air velocity may result in relative air velocity and vehicle speed being very similar. This is to be avoided if vehicle travels in direction with air.
- Alternatively TG air could be re-routed, eg Air into panel up C Heading and return down D Heading.
- If air into panel up C Heading and return down D Heading and traffic is the opposite and up D and down C then vehicle always travel against air so this issue is avoided.

Mine Individual Relationships between TC and Submicron DPM results



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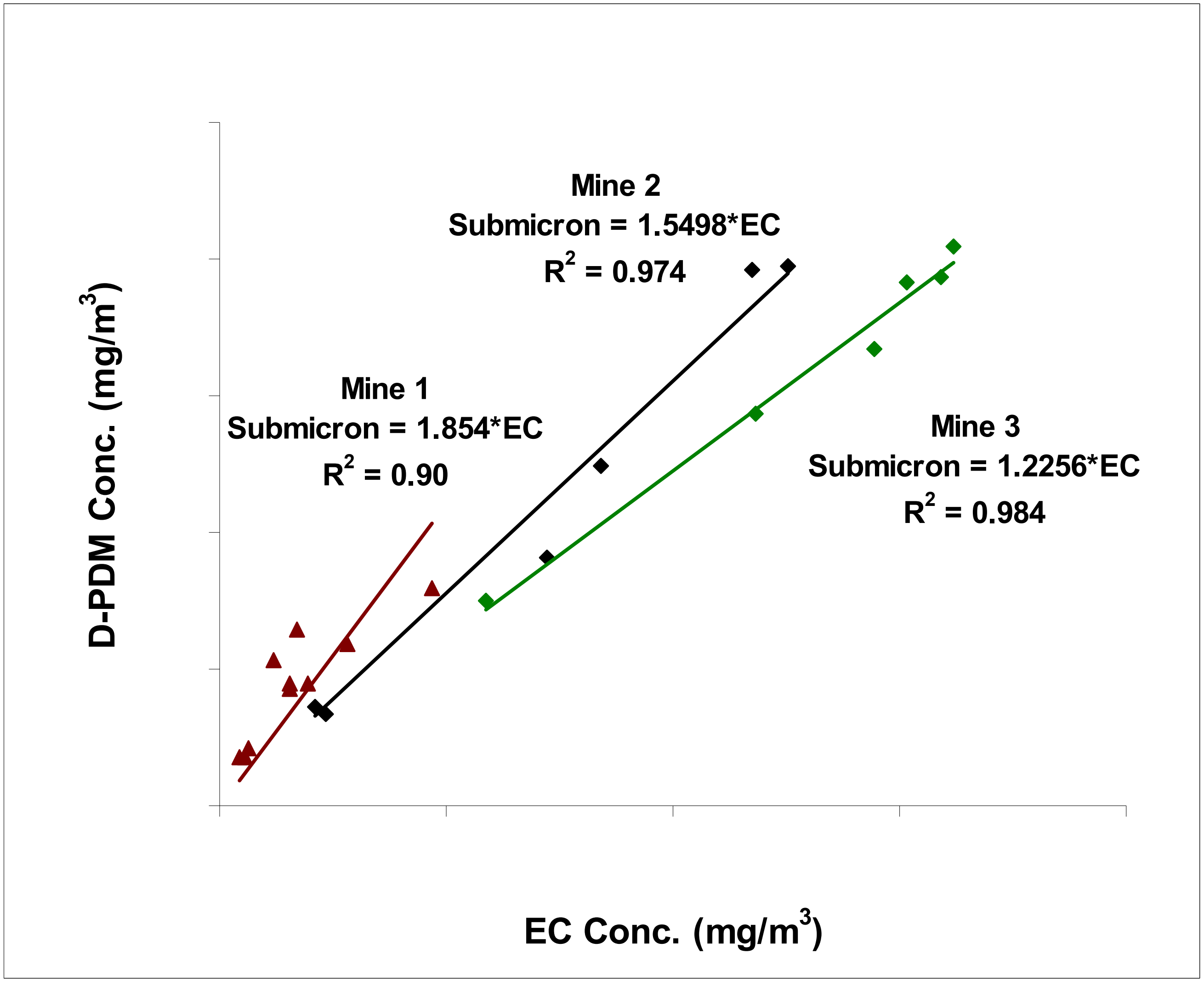
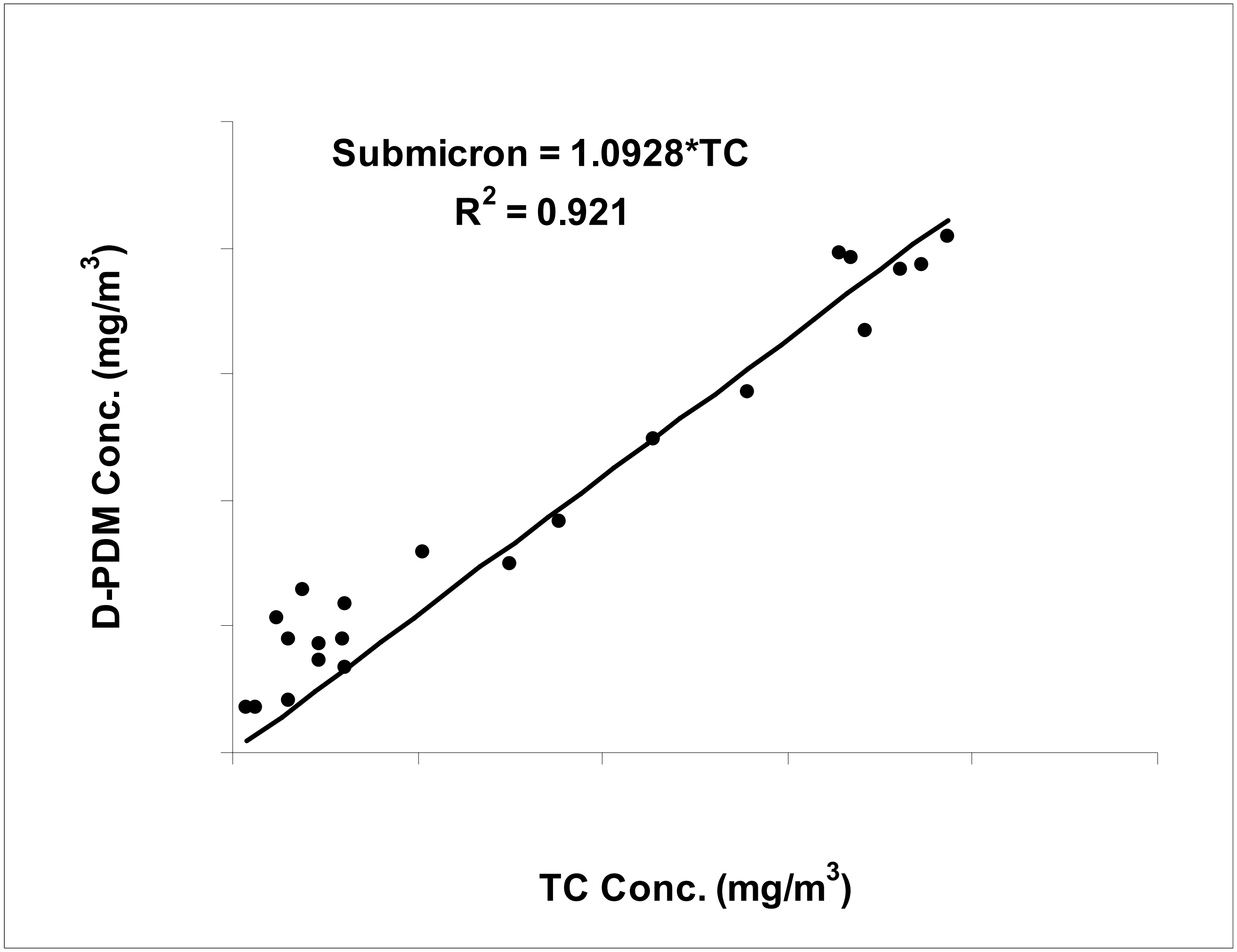
Mine Individual Relationships between EC and Submicron DPM results



Combined Mines Relationship between TC and Submicron DPM results



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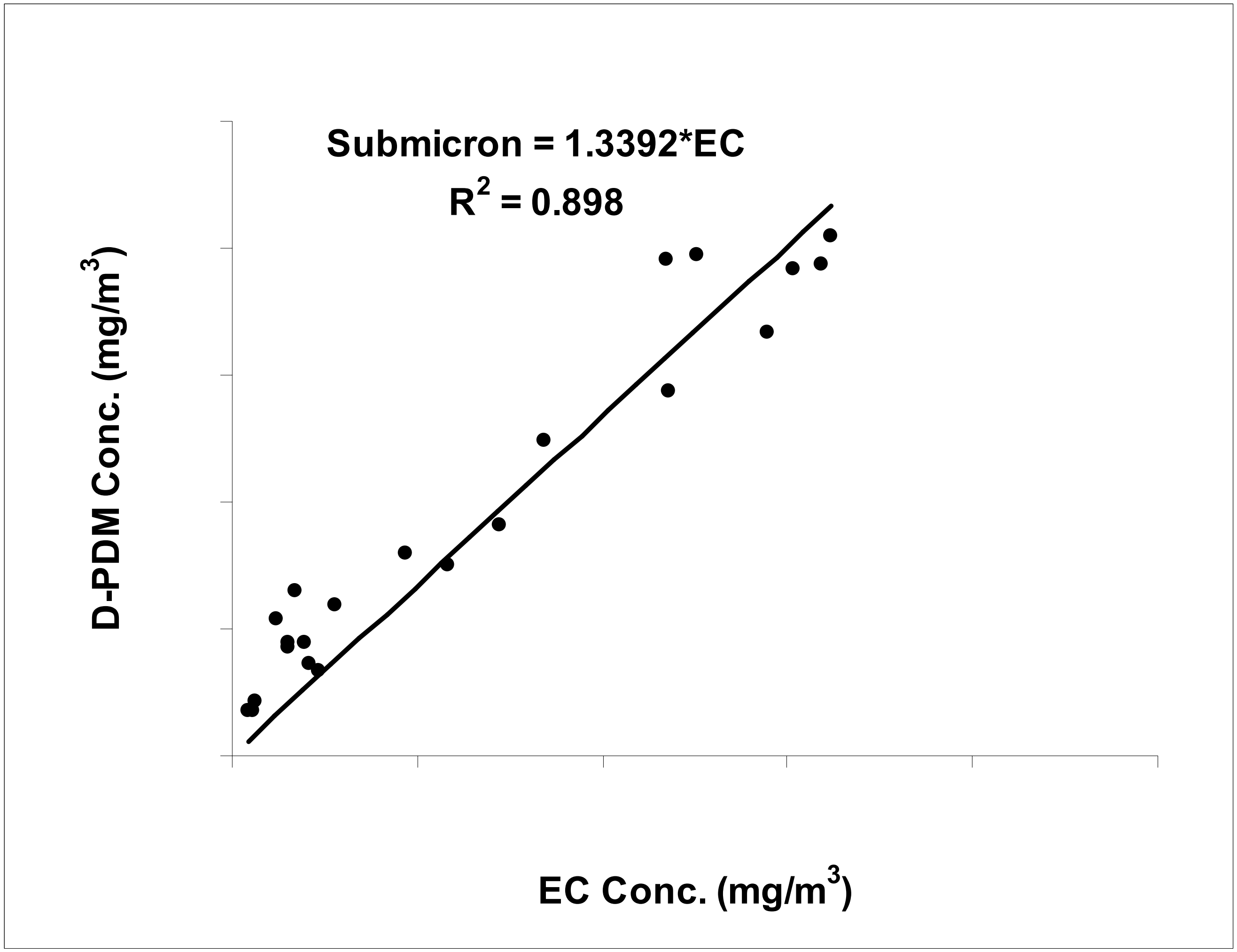
Combined Mines Relationship between EC and Submicron DPM results



Reporting DPM levels

- D-PDM directly gives submicron DPM reading.
- SKC impactor shift average results are taken in many mines and analysed by Coal Services in Singleton NSW using NIOSH 5040 method.
- DPM results from SKC are a DPM surrogate reported as Total Carbon (TC) or Elemental Carbon (EC)
- What is relationship between D-PDM measurement and the TC/EC levels measured by SKC sampler?

Reporting DPM levels

- DPM = TC + inorganics.
- TC = EC + hydrocarbons
- TC is consistently over 80% of DPM (Volkwein 2006)
- Does this calibration relationship vary mine to mine?
- Calibration relationships presumably vary mine to mine due to differences in aspects such as mine atmospheric contamination, fuel type, engine maintenance and engine behaviour.

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