

# Sampling to Quantify Respirable Dust Generation

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# Presentation topics

- Current respirable dust standards and sampling requirements
- Dust sampling instruments approved for use in underground US coal mines
- Sampling methods to quantify dust sources

# Respirable dust standard for coal mining

( Federal Coal Mine Health and Safety Act of 1969)



**2.0 mg/m<sup>3</sup>**

If silica > 5%, reduced standard = 10 / (% silica)

# Gravimetric dust sampler

- Provides time-weighted-average respirable dust concentration
- Dorr-Oliver cyclone separates respirable and oversize dust
- Pump operated at 2.0 liters per minute in coal mines



# Sampling with gravimetric sampler

- Filter is pre- and post-weighed to determine mass gain and is used to calculate an average dust concentration over sampling period
- Filter processed using MSHA P7 infrared analytical technique for silica content
- Sufficient mass must be collected to have confidence in measurement
- NIOSH typically uses multiple gravimetric samplers and averages data



# Personal DataRAM (pDR)

- Uses light scattering as measurement technology
- Instantaneous readings correlated with time and stored in internal memory
- Relative concentrations impacted by:
  - size distribution of dust
  - composition of dust
  - water mist in air
- PRL adjusts readings with ratio obtained from adjacent gravimetric samplers

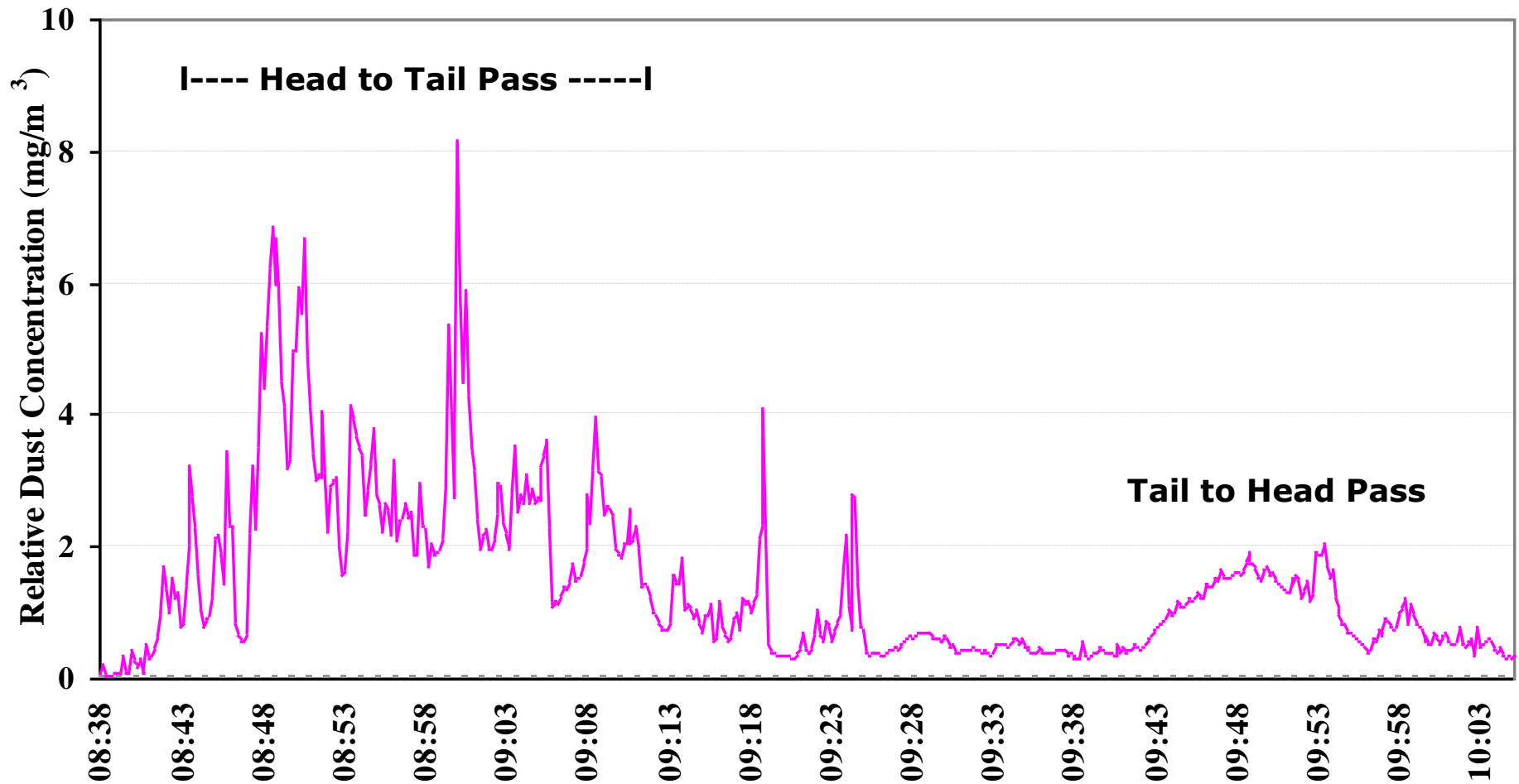


# pDR field calibration

- Divide average gravimetric concentration by average pDR concentration for same sampling period
- Multiply all individual pDR readings by ratio
- Example:  
gravimetric average =  $1.4 \text{ mg/m}^3$   
pDR average =  $1.1 \text{ mg/m}^3$   
grav/pDR ratio =  $1.4/1.1 = 1.27$   
pDR concentrations \* 1.27 = adjusted pDR concentrations

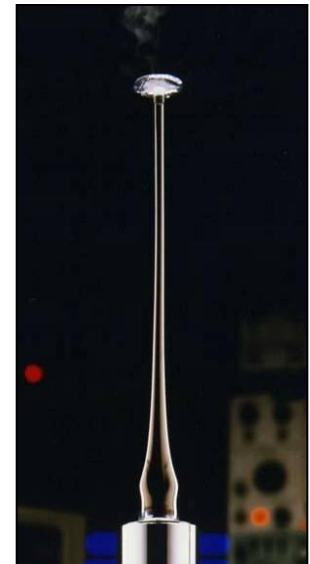
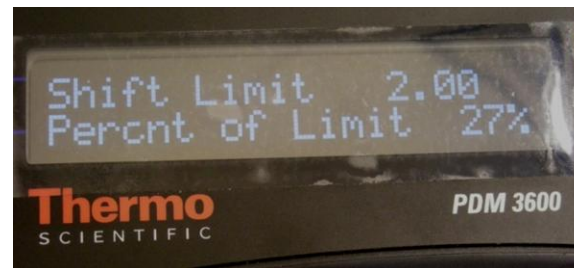


# pDR provides time record of dust levels



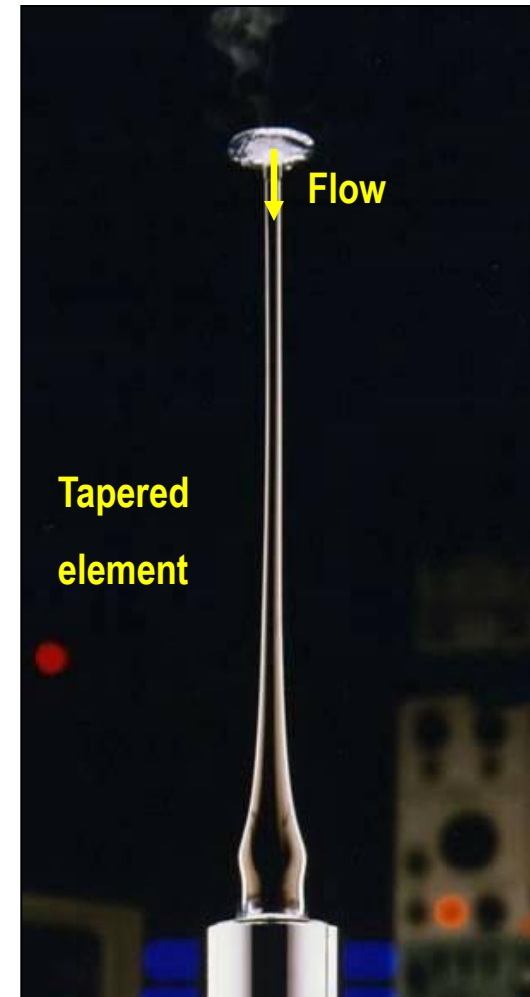
# Personal Dust Monitor (PDM)

- Real-time measurement of respirable dust
- Combines dust sampler and cap lamp into one unit
- Sample inlet is mounted on cap lamp
- Utilizes mass-based measurement to quantify dust concentration (TEOM)
- Dust measurements are displayed on screen and stored internally for later analysis



# Principle of operation

- Exchangeable filter cartridge mounted on the end of the tapered element collects particles as sample stream flows through hollow tube
- Tapered element oscillates at its harmonic frequency -- like a tuning fork
- Frequency changes in *direct* relation to the mass collected on the filter
- Measurement principle does *not* respond to other particle characteristics such as size distribution or composition (heated circuit removes moisture)



# PDM status:

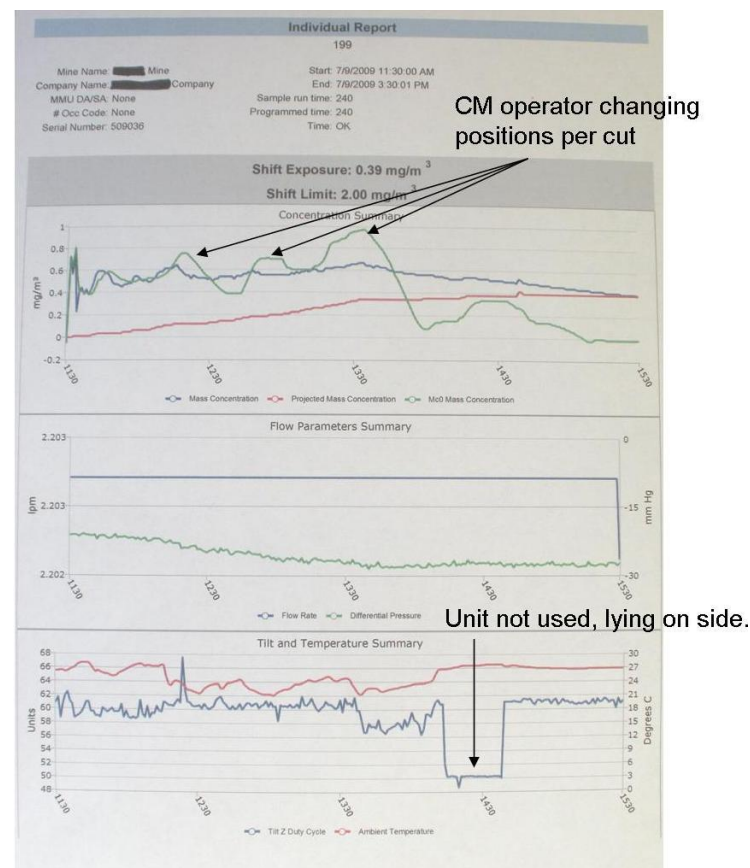
- Meets NIOSH sampling accuracy requirements (NIOSH RI 9669)
- Equivalency to CMPDSU (gravimetric sampler) published in peer-review journal
- MSHA IS approval granted for use in underground coal mines
- CFR 30, Part 74 modified rule published April 6, 2010
- Thermo Scientific began delivery of commercial units in July 2009
- Two ongoing NIOSH research efforts (software and silica)



# PDM analytical software

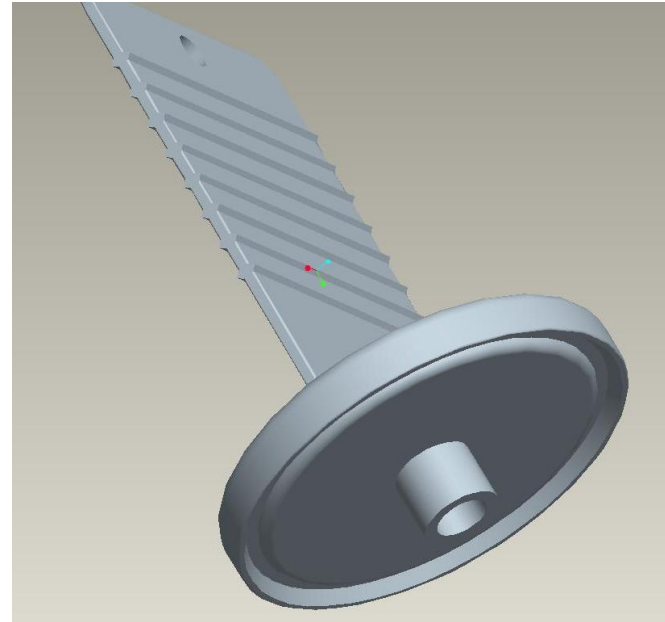
- Compile output from PDM samplers
- Provide user-selected summaries for multiple samplers (foreman, mine superintendent, etc.) or engineering evaluations
- Provide graphing capabilities

A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q
1	Start Time: 07/30/2008															
2	End Time: 16:00:01/30/2008															
3	Wearer ID: 1012															
4	Mine ID Number: 151216															
5	Contractor Code:															
6	Mine Name: Acme															
7	Company Name: Coal LLC															
8	Sample Type: 0															
9	MMU DA/SA: 000															
10	Occ Code: 012															
11	Part 90 Miner Sampled:															
12	Certified Person:															
13																
14	Time	SERIAL N°	AIR HEAT	TE HEATE	FLOW RA	MASS KO	MASS FO									
15	7/30/2008 7:00	105	43	46	2.2	13846	288.3122									
16	7/30/2008 16:00	105	43	46	2.2	13846	288.3122									
17																
18	Time	STATUS C	AIR HEAT	TE HEATE	AMBIENT	DIFFEREN	FLOW RA	AMBIENT	RH PERC	MASSO TC	MASSO CY	MASSO CI	PROJECT	MASSO TC	MASSO CI	TILT Z DUTY CYCL
19	7/30/2008 7:00	43.07023	46.02931	742.2017	-45.94559	2.199398	25.3373	38.57457	0	1.957658	1.703396	0	0	1.957658	1.703396	63.33999
20	7/30/2008 7:01	43.07023	46.02931	742.2017	-46.10029	2.199398	25.3373	38.57457	0	1.655445	1.38272	0	0	1.655445	1.38272	65.09545
21	7/30/2008 7:02	43.07023	46.02931	742.2017	-46.10029	2.199398	25.3373	38.57457	0	1.655445	1.38272	0	0	1.655445	1.38272	65.09545
22	7/30/2008 7:03	43.07023	46.02931	742.2017	-46.61493	2.199398	25.3373	38.57457	0.011283	2.035846	1.736231	0	0.011283	2.035846	1.736231	62.31209
23	7/30/2008 7:04	43.07023	46.02931	742.2017	-46.55847	2.199398	25.20537	38.57457	0.011283	2.035846	1.864717	0.01364	0.011283	1.995951	1.864717	63.33088
24	7/30/2008 7:05	43.07023	46.02931	742.2017	-46.64362	2.199398	25.20537	38.57457	0.011283	1.961956	1.711413	0.01364	0.011283	1.961956	1.711413	63.33088
25	7/30/2008 7:06	43.07023	46.02931	742.2017	-47.28967	2.199398	25.36383	38.57457	0.022856	1.869375	1.747324	0.01364	0.022856	1.869375	1.747324	63.33088
26	7/30/2008 7:07	43.07023	46.02931	742.2017	-47.40216	2.199398	25.36383	37.37875	0.022856	1.869375	1.685616	0.01364	0.022856	1.823317	1.685616	63.33088
27	7/30/2008 7:08	43.07023	46.02931	742.2017	-47.91956	2.199398	25.36383	35.98792	0.022856	1.733021	1.650241	0.024295	0.022856	1.733021	1.650241	62.01268
28	7/30/2008 7:09	43.07023	46.02931	742.2017	-48.0039	2.199398	25.25729	35.98792	0.033648	1.733021	1.709777	0.024295	0.033648	1.733021	1.709777	63.4618
29	7/30/2008 7:10	43.07023	46.02931	742.2017	-48.21472	2.199398	25.25729	37.26128	0.033648	1.733021	1.75812	0.035651	0.033648	1.75812	1.75812	53.28996
30	7/30/2008 7:11	43.07023	46.02931	742.2017	-48.59722	2.199398	25.42719	37.26128	0.033648	1.733021	1.75812	0.035651	0.033648	1.75812	1.75812	63.10898
31	7/30/2008 7:12	43.07023	46.02931	742.2017	-48.85986	2.199398	25.58787	37.26128	0.050044	1.806322	1.906455	0.035651	0.050044	1.806322	1.906455	63.10898
32	7/30/2008 7:13	43.07023	46.02931	742.2017	-48.97601	2.199398	25.70879	37.26128	0.050044	1.867195	1.906455	0.035651	0.050044	1.867195	1.906455	63.10898
33	7/30/2008 7:14	43.07023	46.02931	742.2017	-49.92926	2.199398	25.70879	37.26128	0.050044	1.867195	1.957527	0.050569	0.050044	1.902353	1.957527	63.10898
34	7/30/2008 7:15	43.07023	46.02931	742.2017	-49.55591	2.199398	25.70879	37.26128	0.062221	1.928447	1.891094	0.050569	0.062221	1.928447	1.891094	63.10898
35	7/30/2008 7:16	43.07023	46.02931	742.2017	-50.43732	2.199398	25.70879	37.26128	0.062221	1.928447	1.924207	0.050569	0.062221	1.928447	1.924207	63.10898
36	7/30/2008 7:17	43.07023	46.02931	742.2017	-49.99609	2.199398	25.70879	37.26128	0.062221	1.928447	1.924207	0.050569	0.062221	1.928447	1.924207	63.10898
37	7/30/2008 7:18	43.07023	46.02931	742.2017	-50.612	2.199398	25.70879	38.5776	0.076476	1.928447	1.935487	0.064337	0.076476	2.017298	1.935487	63.10898
38	7/30/2008 7:19	43.07023	46.02931	742.2017	-50.65167	2.199398	25.54123	38.5776	0.076476	1.928447	1.89249	0.064337	0.076476	2.040288	1.89249	65.10558
39	7/30/2008 7:20	43.07023	46.02931	742.2017	-51.01233	2.199398	25.54123	37.19453	0.076476	1.928447	1.92818	0.064337	0.076476	2.057286	1.92818	62.45758
40	7/30/2008 7:21	43.07023	46.02931	742.2017	-51.59625	2.199398	25.54123	37.19453	0.087974	1.928447	1.93091	0.064337	0.087974	2.057286	1.93091	62.45758
41	7/30/2008 7:22	43.07023	46.02931	742.2017	-51.71686	2.199398	25.54123	37.19453	0.087974	1.928447	1.93091	0.077344	0.087974	2.057286	1.93091	62.45758
42	7/30/2008 7:23	43.07023	46.02931	742.2017	-52.20038	2.199398	25.54123	37.19453	0.087974	1.928447	1.849045	0.077344	0.087974	2.004	1.849045	62.45758
43	7/30/2008 7:24	43.07023	46.02931	742.2017	-52.08337	2.199398	25.64989	36.06315	0.087974	1.928447	1.80204	0.077344	0.087974	1.920922	1.80204	63.53312
44	7/30/2008 7:25	43.07023	46.02931	742.2017	-52.33838	2.199398	25.53248	36.06315	0.099899	1.928447	1.820008	0.077344	0.099899	1.826481	1.820008	63.53312
45	7/30/2008 7:26	43.07023	46.02931	742.2017	-52.22467	2.199398	25.53248	36.06315	0.099899	1.928447	1.779111	0.077344	0.099899	1.732232	1.779111	63.53312

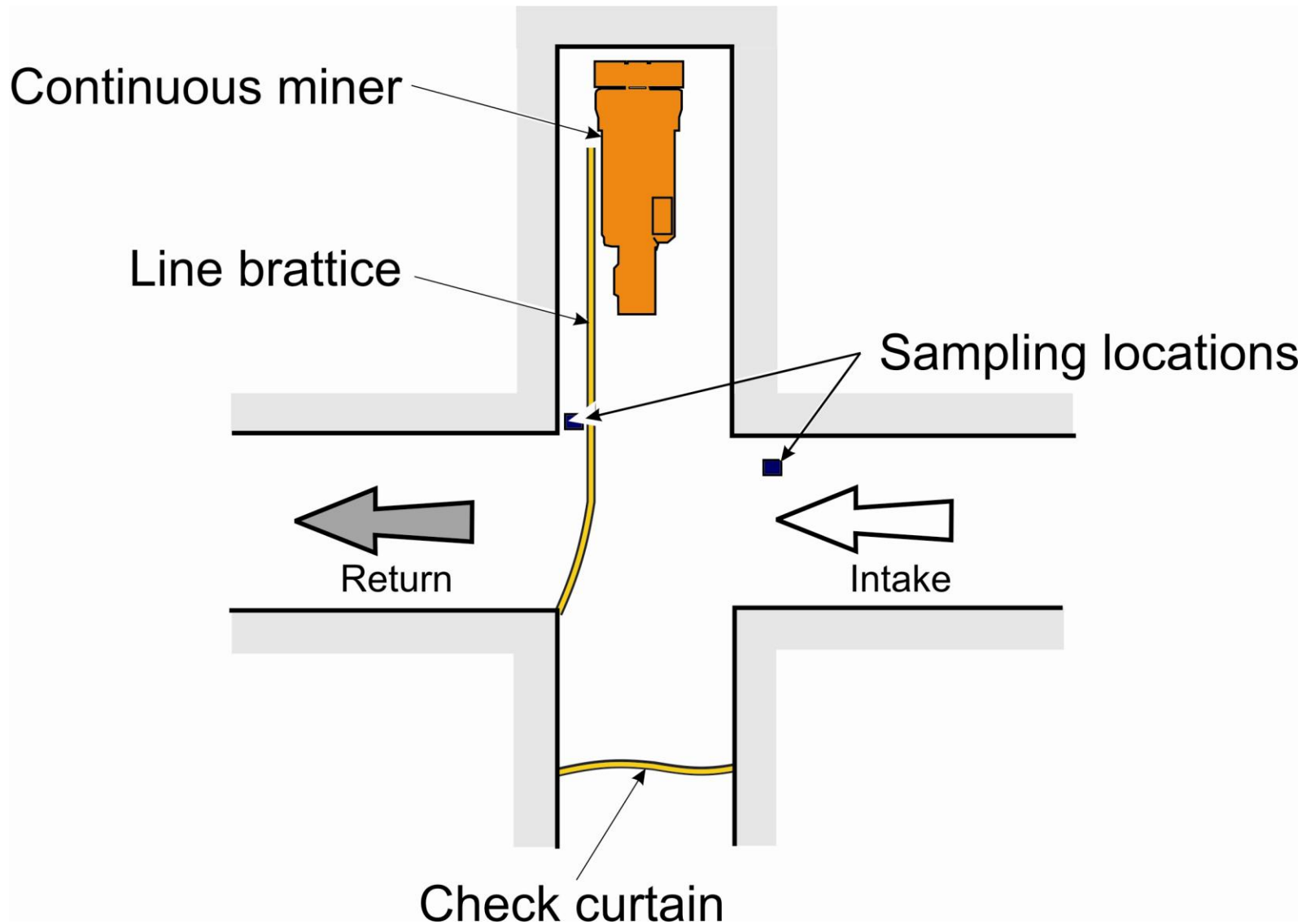


# PDM filter capsule for maintaining sample integrity for quartz analysis

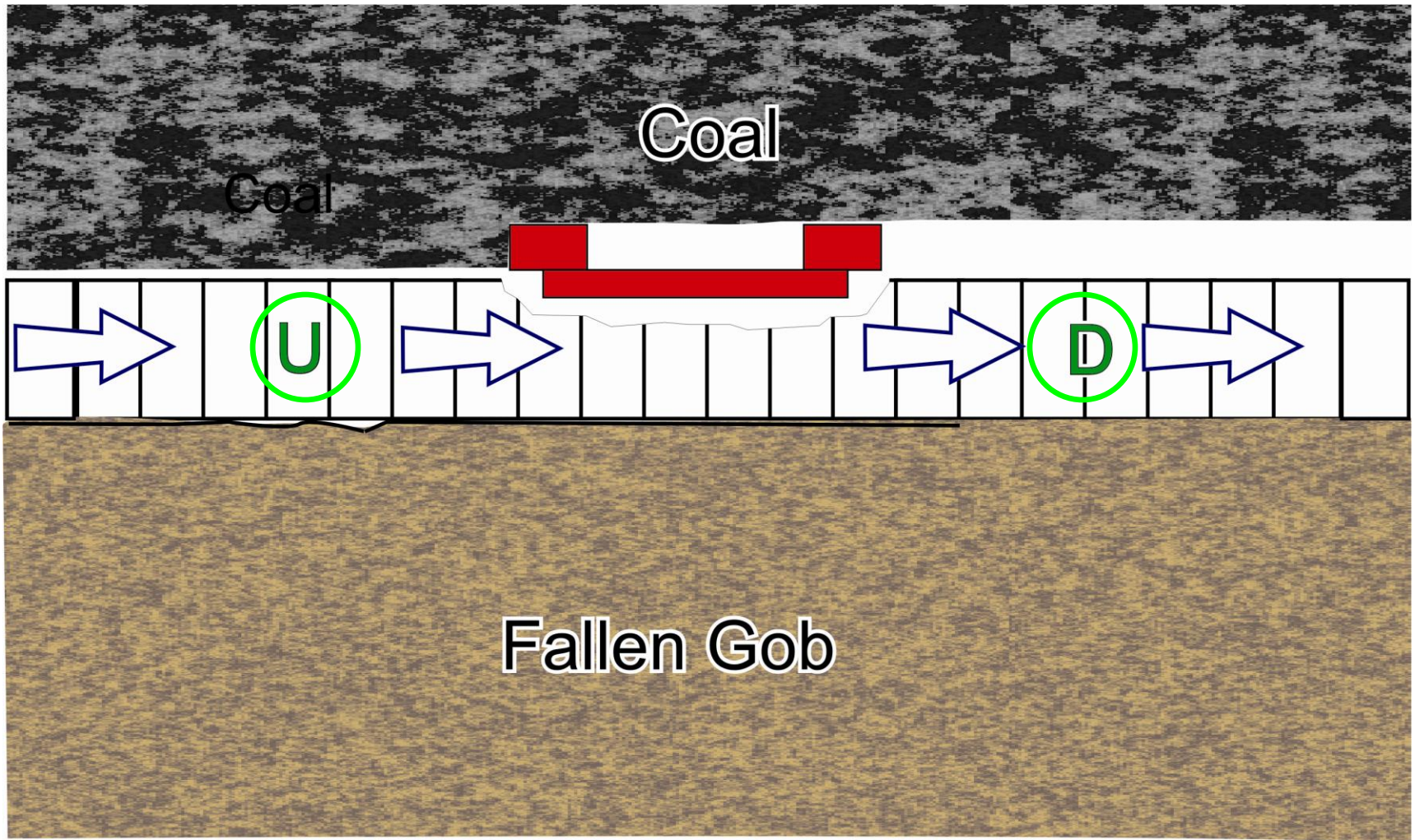
- Place capsule over PDM filter when TEOM unit removed from PDM
- Use capsule as filter removal tool and to secure dust
- Send to lab, remove finger tab, ash capsule
- Plan to conduct mine surveys to complete side-by-side testing with current silica analysis method



# Sampling to isolate a fixed dust source



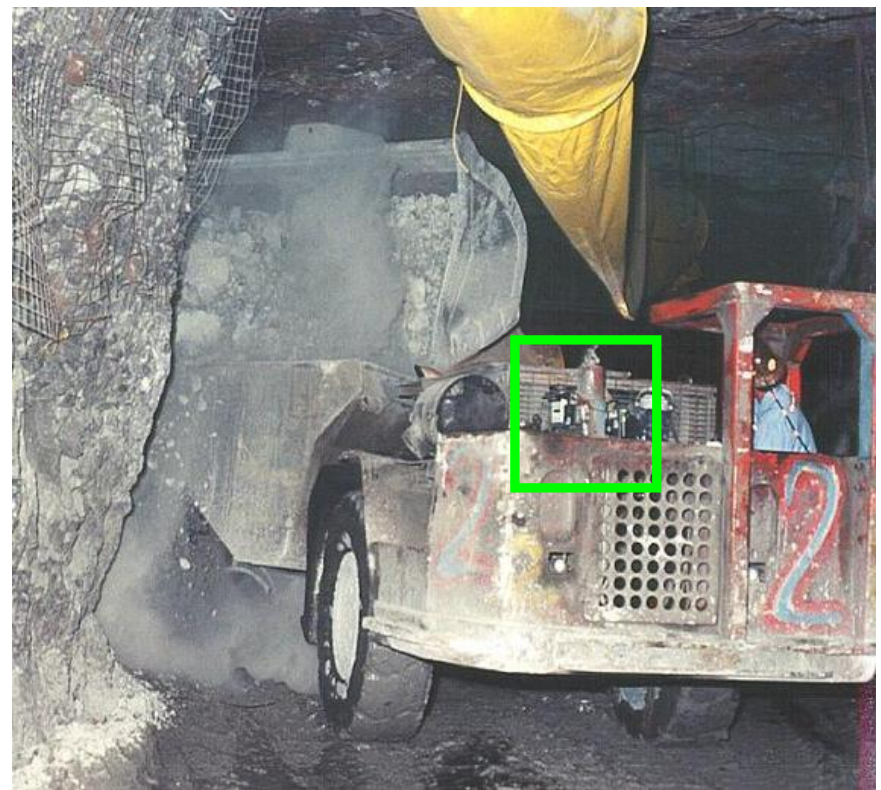
# Sampling to isolate a mobile dust source



U - Upwind location D - Downwind location

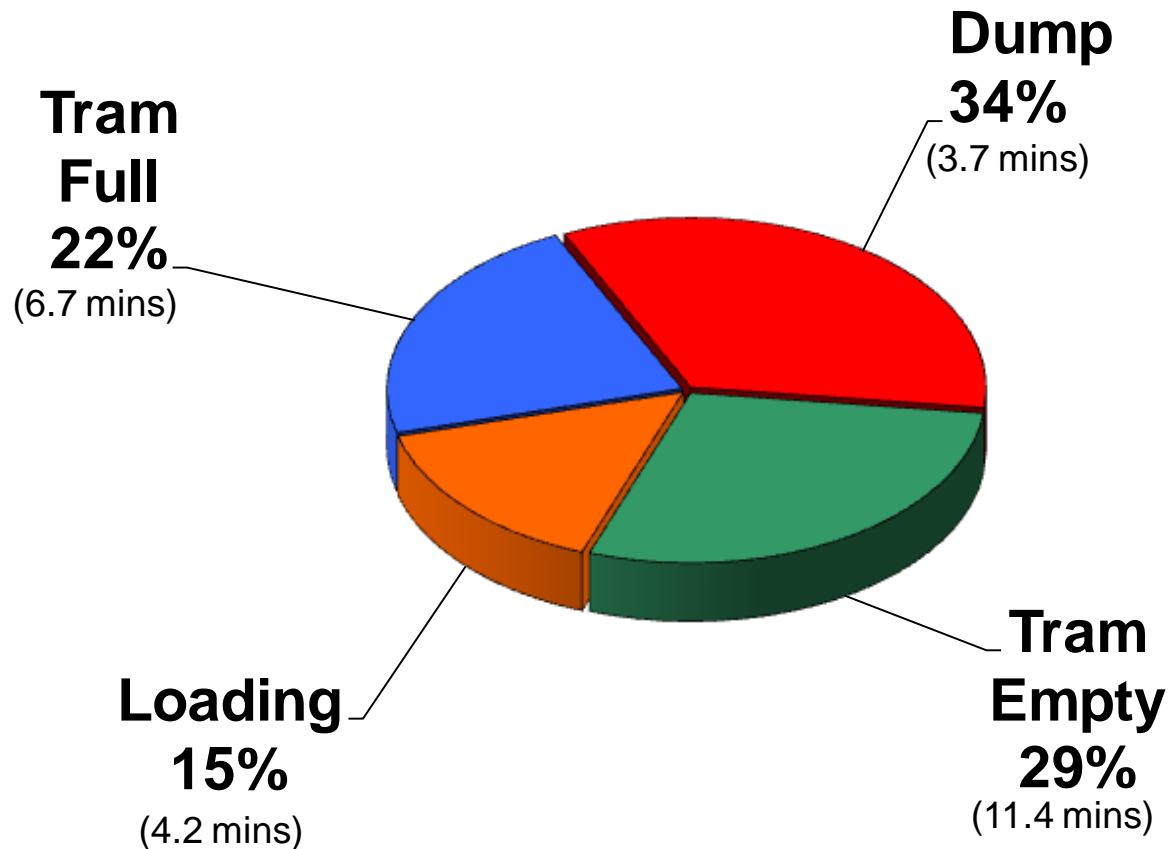
# Using real-time data to quantify mobile dust sources

- Evaluate dust levels during truck haulage cycle at an underground gold mine
- Use pDR samplers and time study data to quantify dust generation for different parts of cycle
  - loading
  - hauling full
  - dumping
  - hauling empty
- Two researchers conducting time studies



# Time-weighted-average dust contributions

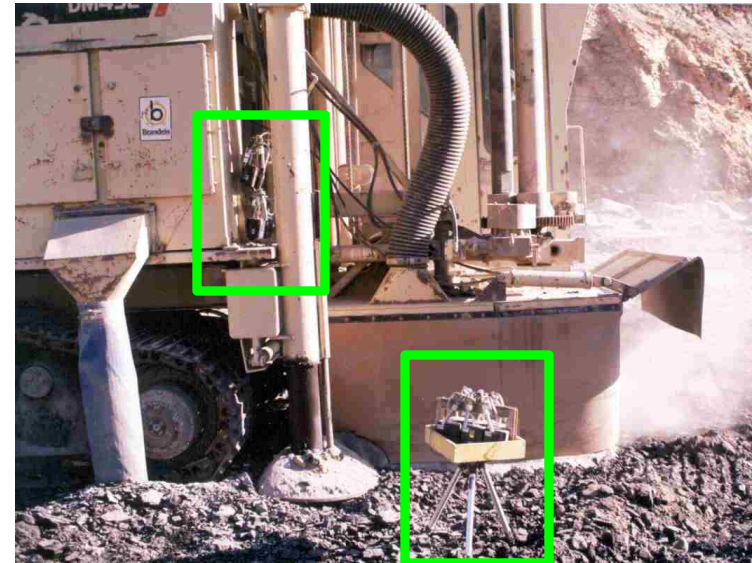
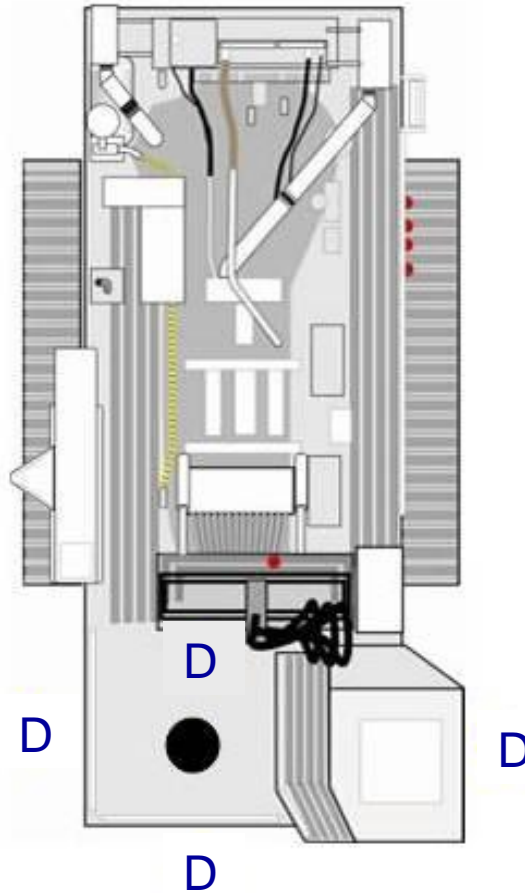
Dump location had highest dust contribution despite having the shortest duration... (14% time vs 34% dust)



# Sampling to isolate an unconfined dust source

A

Wind direction



A – Ambient sampling location

D – Drill sampling locations

# Thank you!

## Questions??

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