Real Time Respirable Dust

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RingIR, Inc.
Breakthrough in Molecular Fingerprinting

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A PILOT STUDY

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Acknowledgements

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Mr Bruce Yoshioka; CSM

New Mexico Tech

ACARP

Queensland Government

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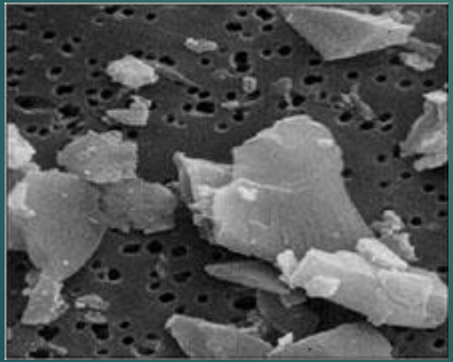
Introduction

- Real time is possible
- Further research is necessary
- Once developed it is a “game changer”
  - Detect and mitigate sources
  - PPE becomes second line of defence rather than only protection
- Other uses for the device can be developed
  - DPM, Asbestos, fire detection/ smoke, gas and combinations of them.

Respirable Dust

- Dust is produced when rocks are broken crushed, ground, scraped or impacted.
- The nature of this dust is that there can be a fraction that is invisible,(0.5-10μm), harmful and can remain in the air for long periods of time.



Respirable Crystalline Silica
<10 microns

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Rationale for Development

- Current methods "allow" a person to be exposed to silica even though they may be below the total mass limit
- Exposure is unknown for at least 14 days
  - Potentially many days of exposure
- Devices are not able to located sources

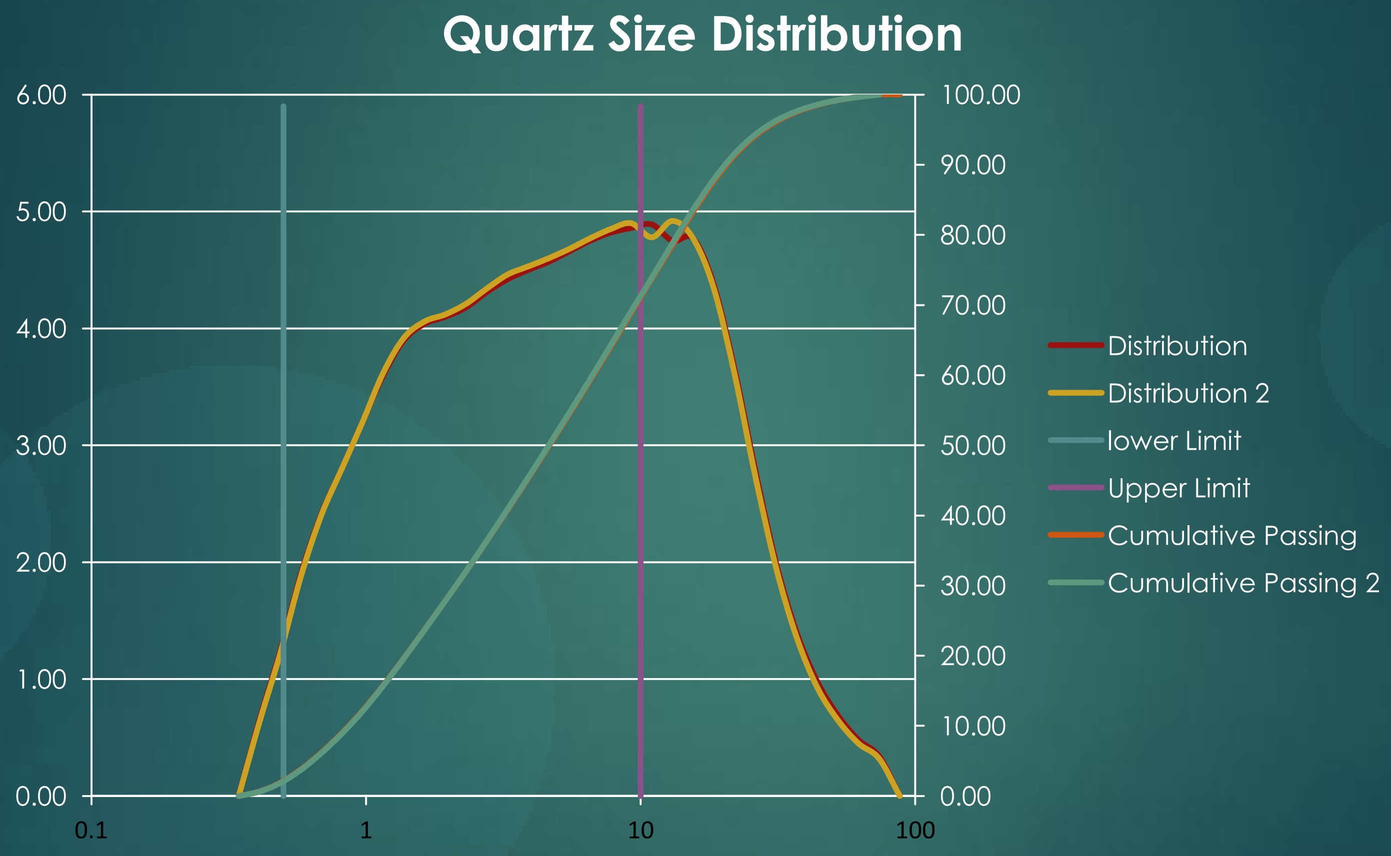
Ring Down Spectrometer

- Originally designed for IED detection
- Configured to detect low concentrations of Methane
- Can be configured to detect any substance with an IR signature
- Silica tests show that it is possible.

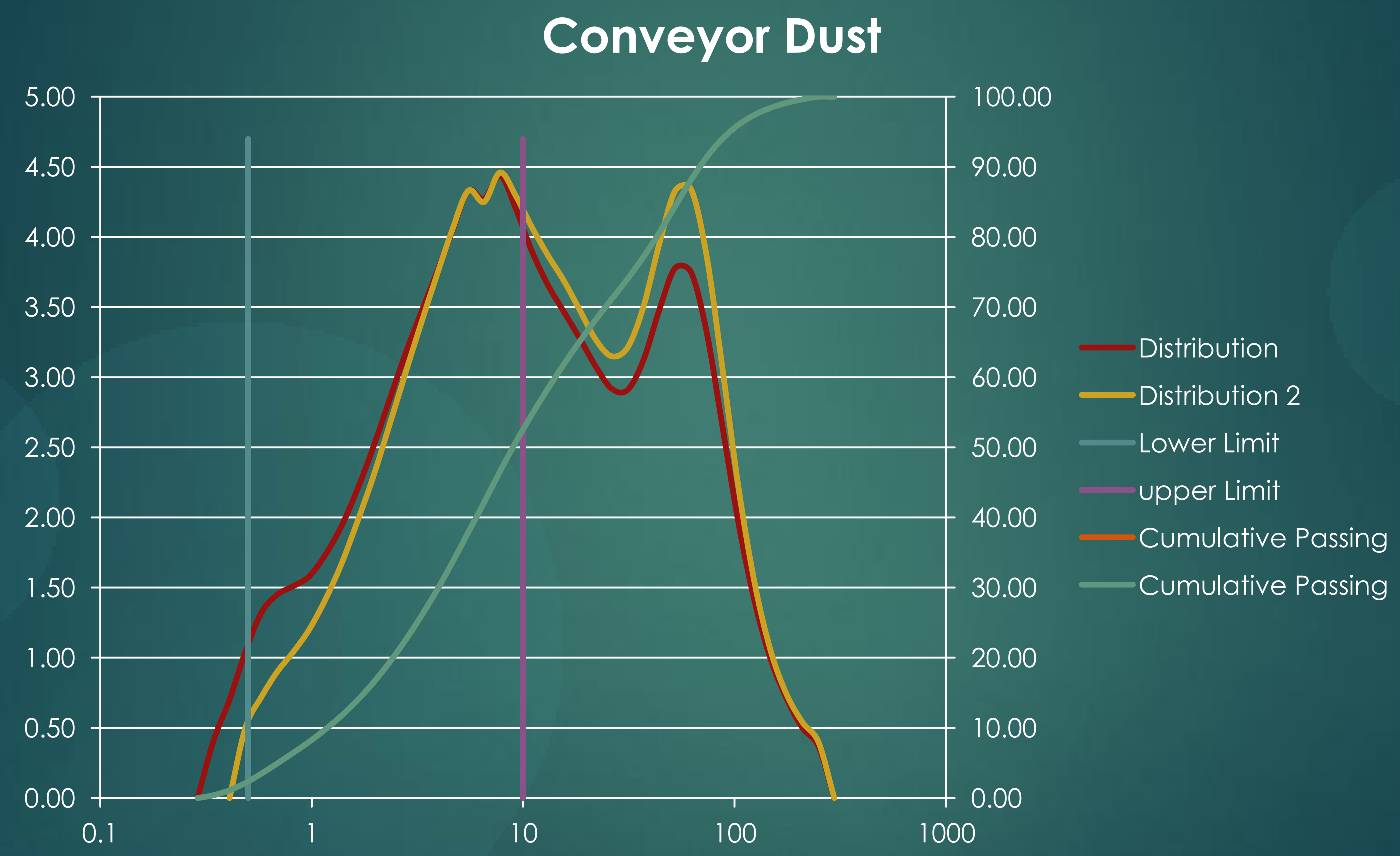
Initial proof of concept tests

- Three types of dust samples
- Pure Silica
- Metal mine dust
  - Conveyor Dust
  - Rib Side Dust

Silica


Quartz Size Distribution
6.00
5.00
4.00
3.00
2.00
1.00
0.00
100.00
90.00
80.00
70.00
60.00
50.00
40.00
30.00
20.00
10.00
0.00
0.1
1
10
100
Distribution
Distribution 2
lower Limit
Upper Limit
Cumulative Passing
Cumulative Passing 2

Conveyor Dust



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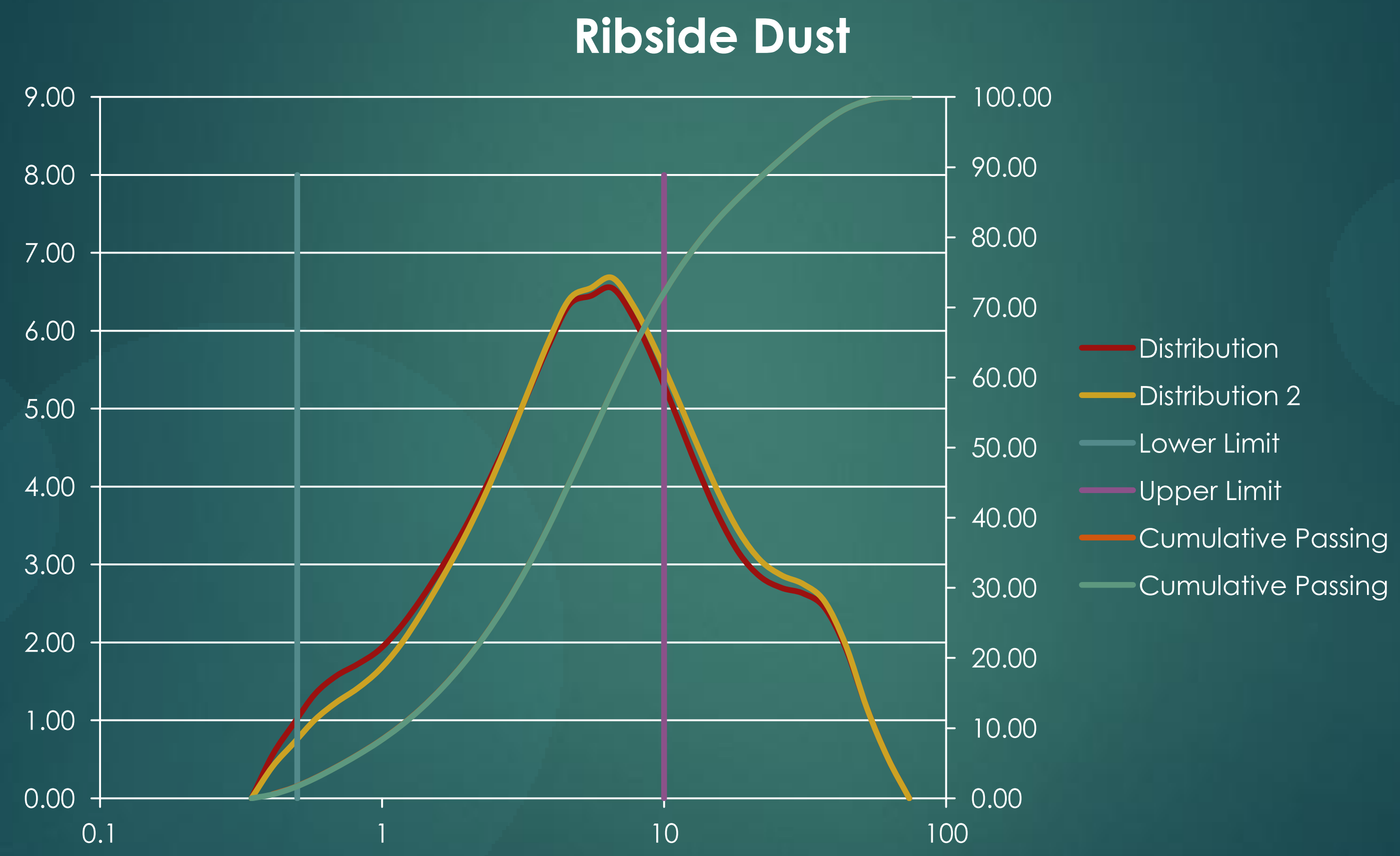
Conveyor Dust Analysis

Phase	Weight %	Error Of Fit
Illite	27.8	0.47
Albite	16.6	0.34
Quartz	16.3	0.22
Muscovite	14.3	0.64
Dolomite	10.4	0.29
Kaolin	8.8	0.56
Chalcopyrite	2.3	0.09
Chlorite	1.8	0.26
Gypsum	1.7	0.16

Rib Side Dust



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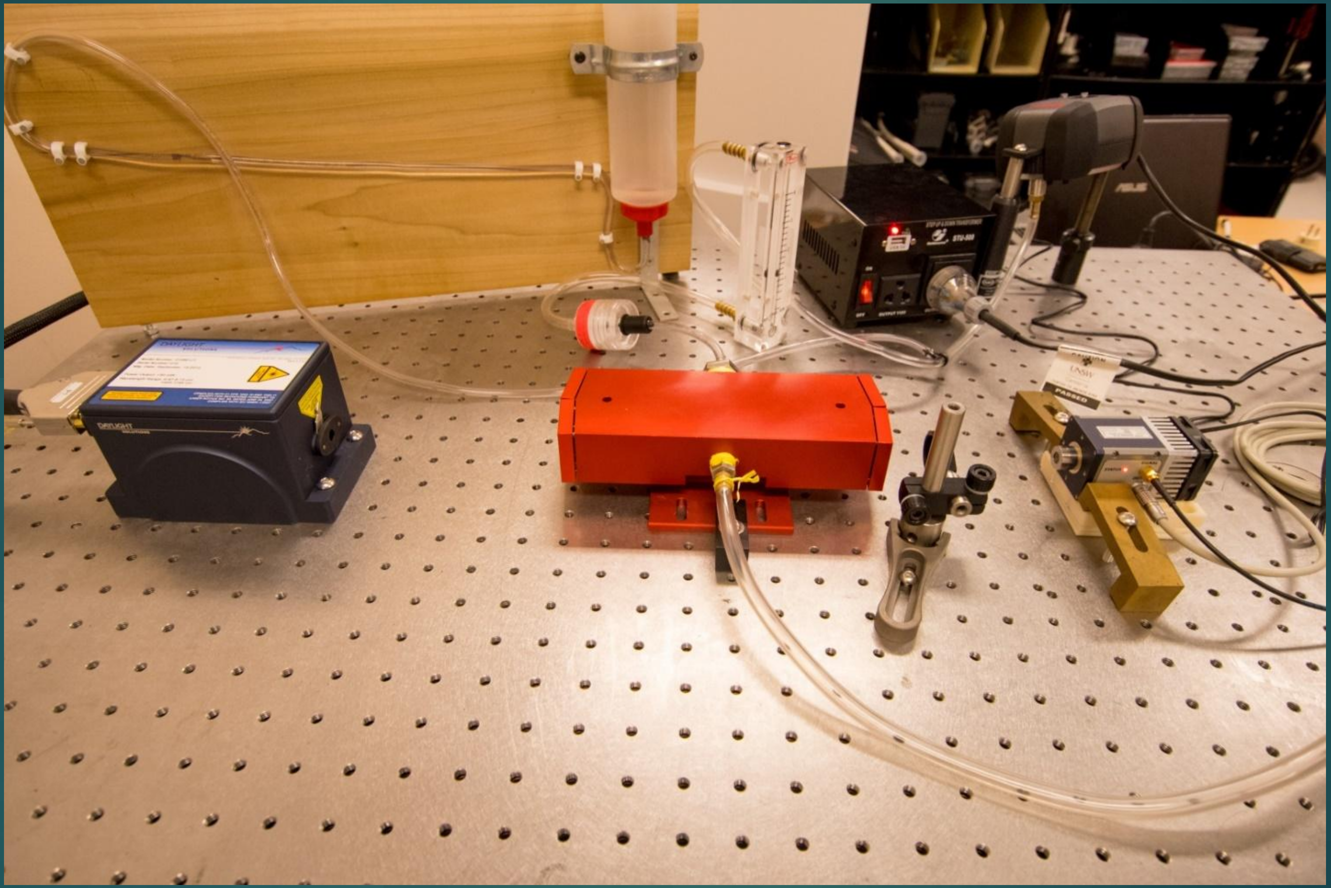
Rib Side Dust Analysis

Phase	Weight %	Error Of Fit
Illite	20.9	0.47
Quartz	20.1	0.27
Muscovite	18.4	0.64
Albite	16.6	0.35
Dolomite	11.4	0.30
Kaolin	7.2	0.59
Gypsum	2.2	0.17
Chalcopyrite	1.9	0.09
Chlorite	1.3	0.27

Experimental Setup

- The device was set up on a test bed
- Dust was placed in front of the cyclone and brushed into the air
- An ambient run was conducted
- A series of measurements taken until the dust was collected
- Repeated for each dust
- Results analysed.

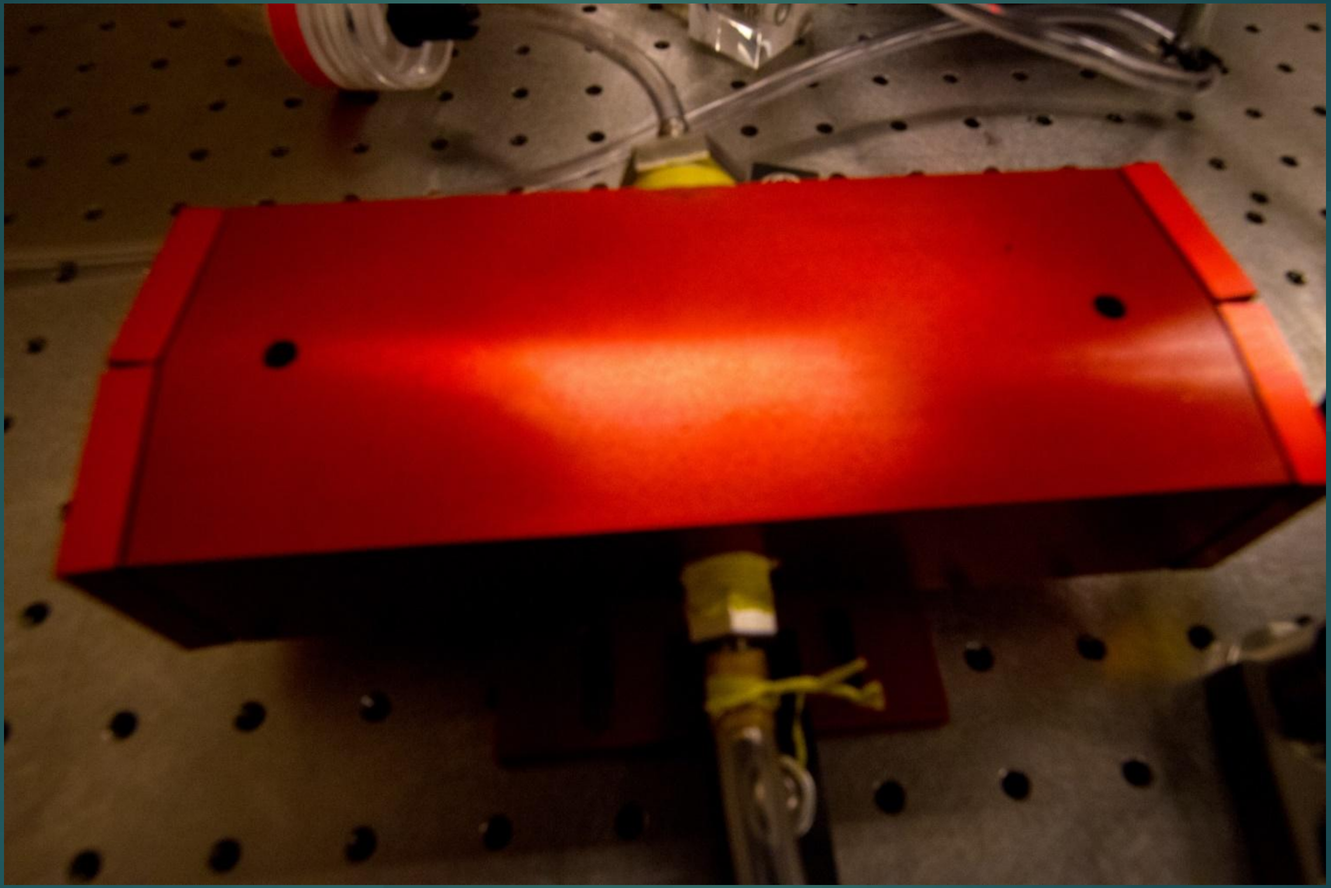
Setup



Laser


DAYLIGHT
SOLUTIONS
15378 Avenue of Science, Suite 200 - San Diego, CA 92128
Made in USA
Model Number: 31080-UT
Serial Number: 015
Mfg. Date: September, 19 2012
Power Output: <50 mW
Wavelength Range: 6.87-8.73 µm
1455-1145 cm-1
LASER APERTURE
INVISIBLE LASER RADIATION
AVOID EXPOSURE TO THE BEAM
CLASS 3B LASER PRODUCT
COMPLIES WITH 21 CFR 1040.10 AND 1040.11
EXCEPT FOR DEVIATIONS PURSUANT TO
LASER NOTICE NO. 50, DATED JUNE 24, 2007
COMPLIES WITH IEC 60825-1:2007
P1
DAYLIGHT
SOLUTIONS

Cavity



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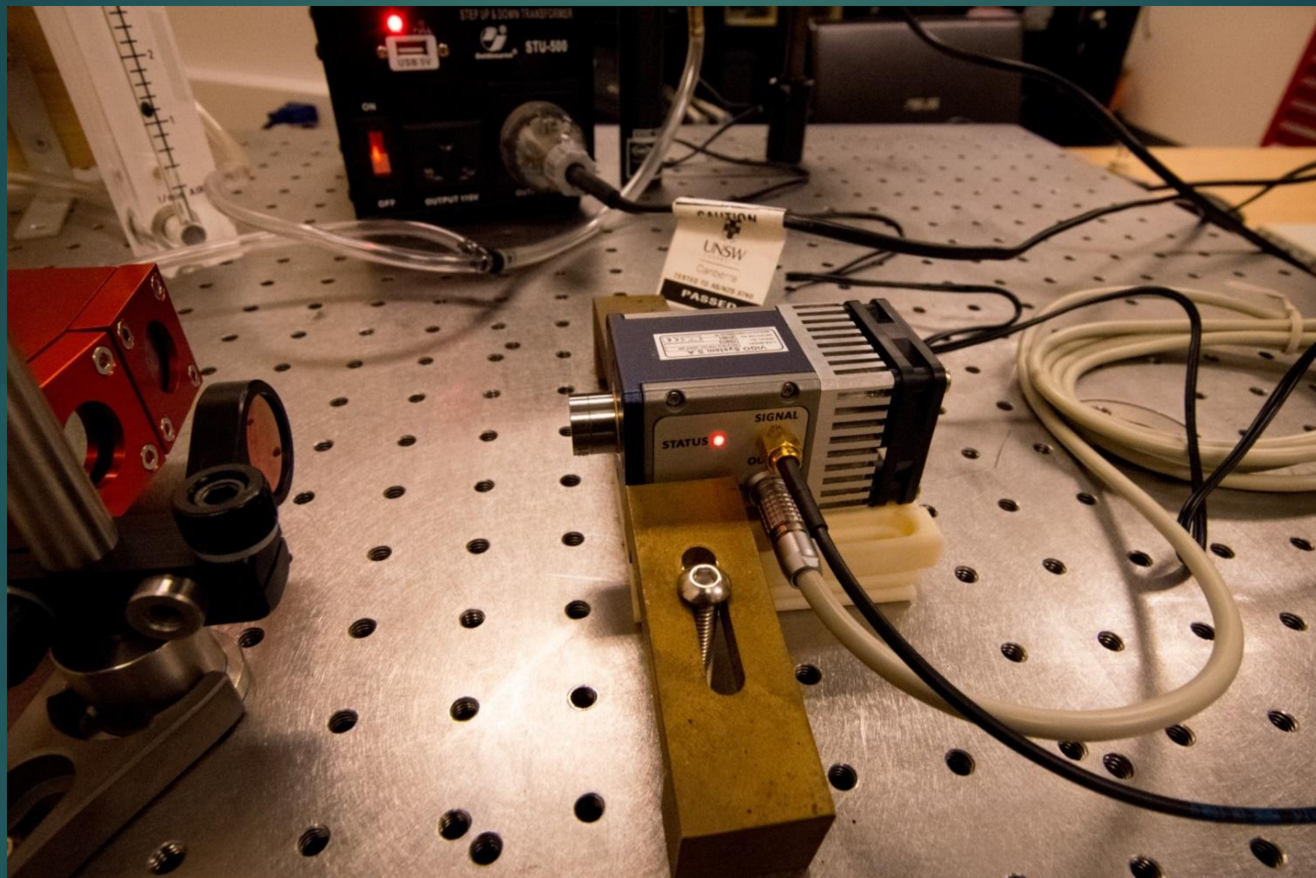
Detector



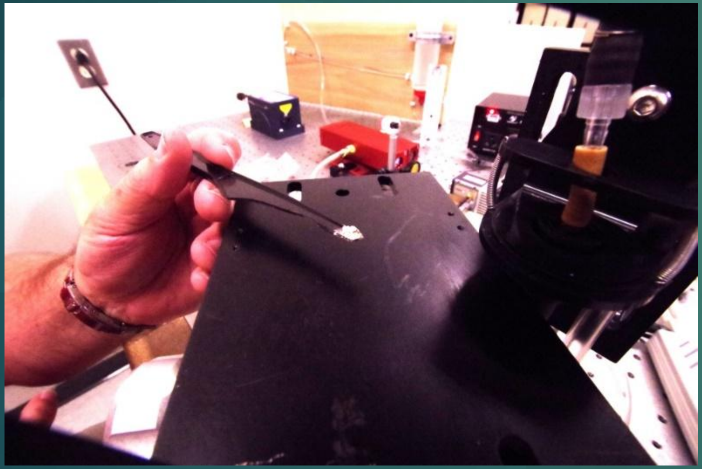
Dust Management

Cyclone

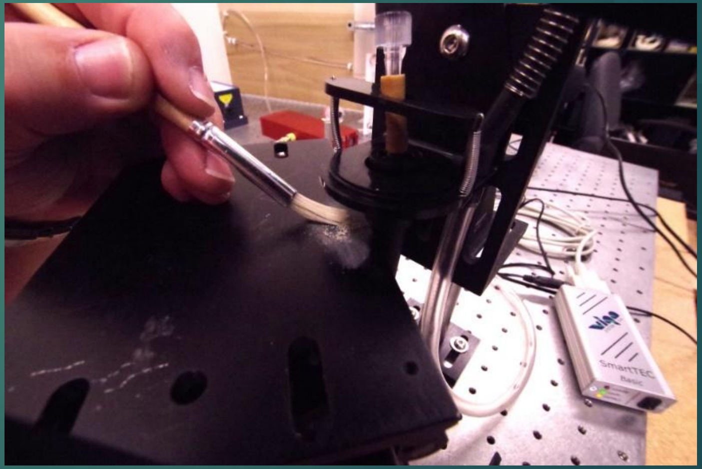
Filter

Dust Delivery

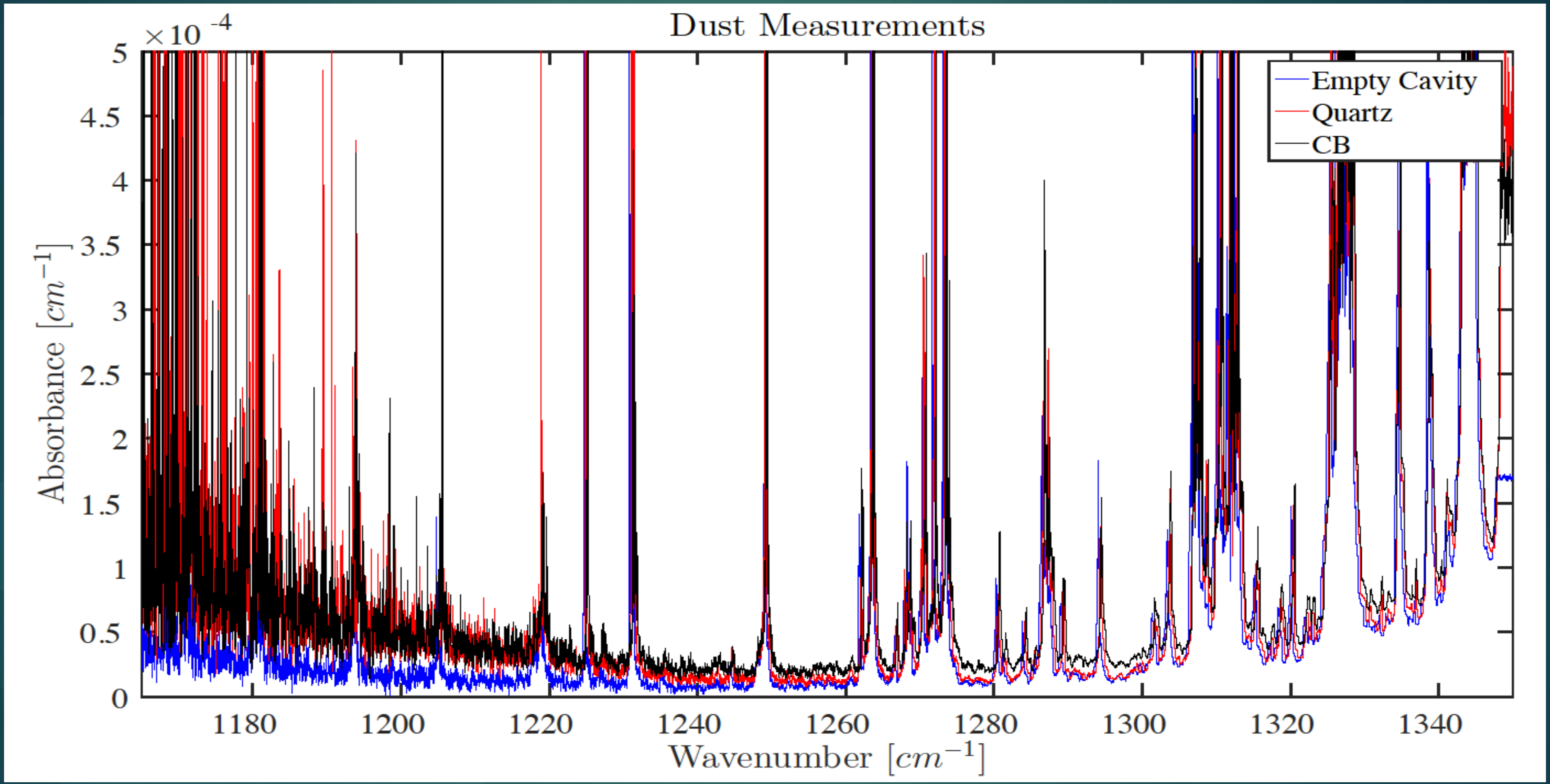
Sample



Delivery



Results



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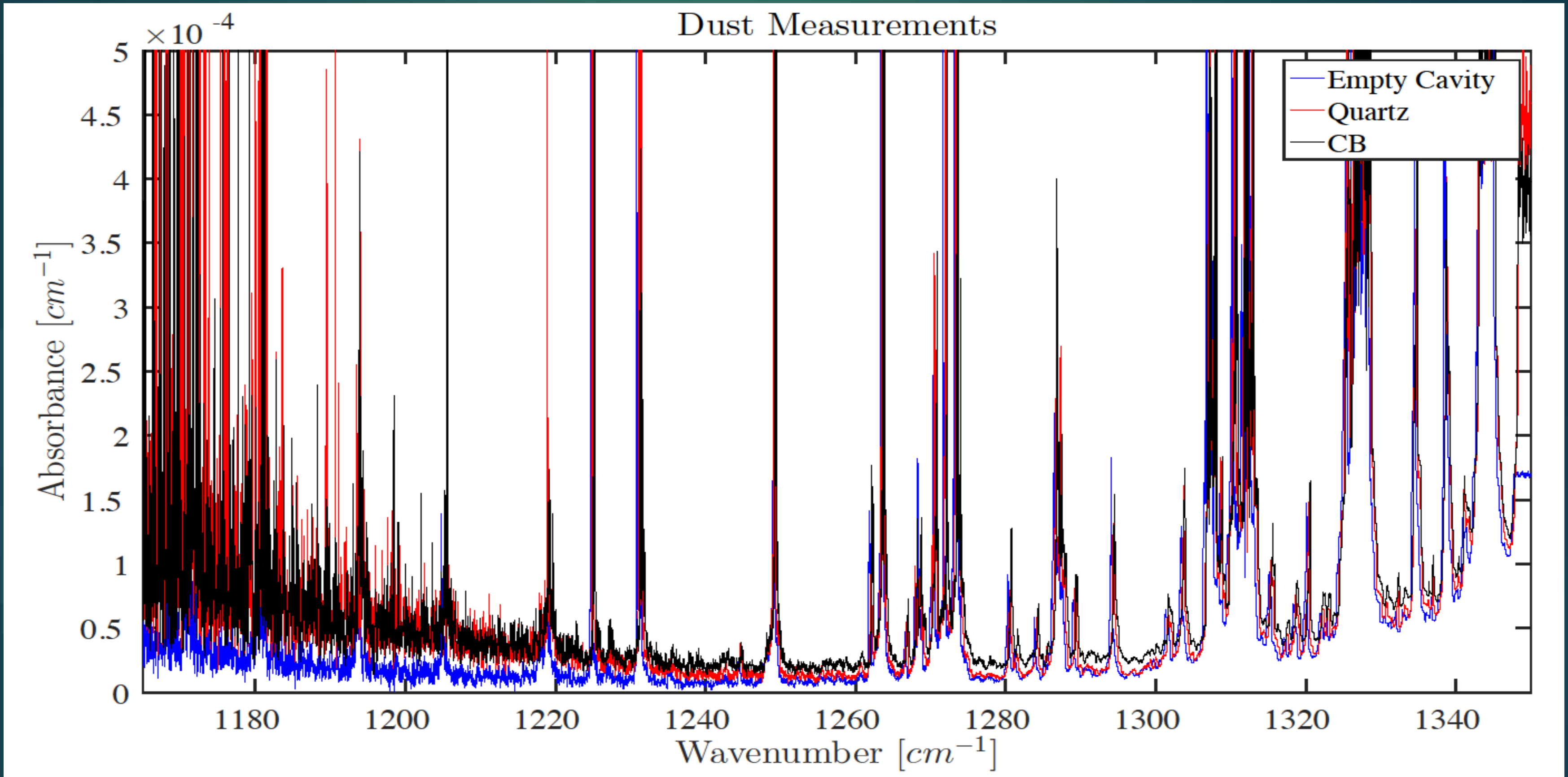
Results



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Outcomes and Questions

- Device “saw” silica dust in real time
- Device discriminates silica from other dusts
- Response was in seconds
- What is the most appropriate wavelength for Silica?
- What is the most appropriate wavelength for Coal?

Testing with Coal

- Next Step
- Doping with silica
- Modified method
- Sample preparation
- Results
- Additional conclusions

Doping with silica

- Samples prepared for testing
- ROM Coal
- ROM Coal +5%respirable Silica
- ROM Coal +10% respirable Silica

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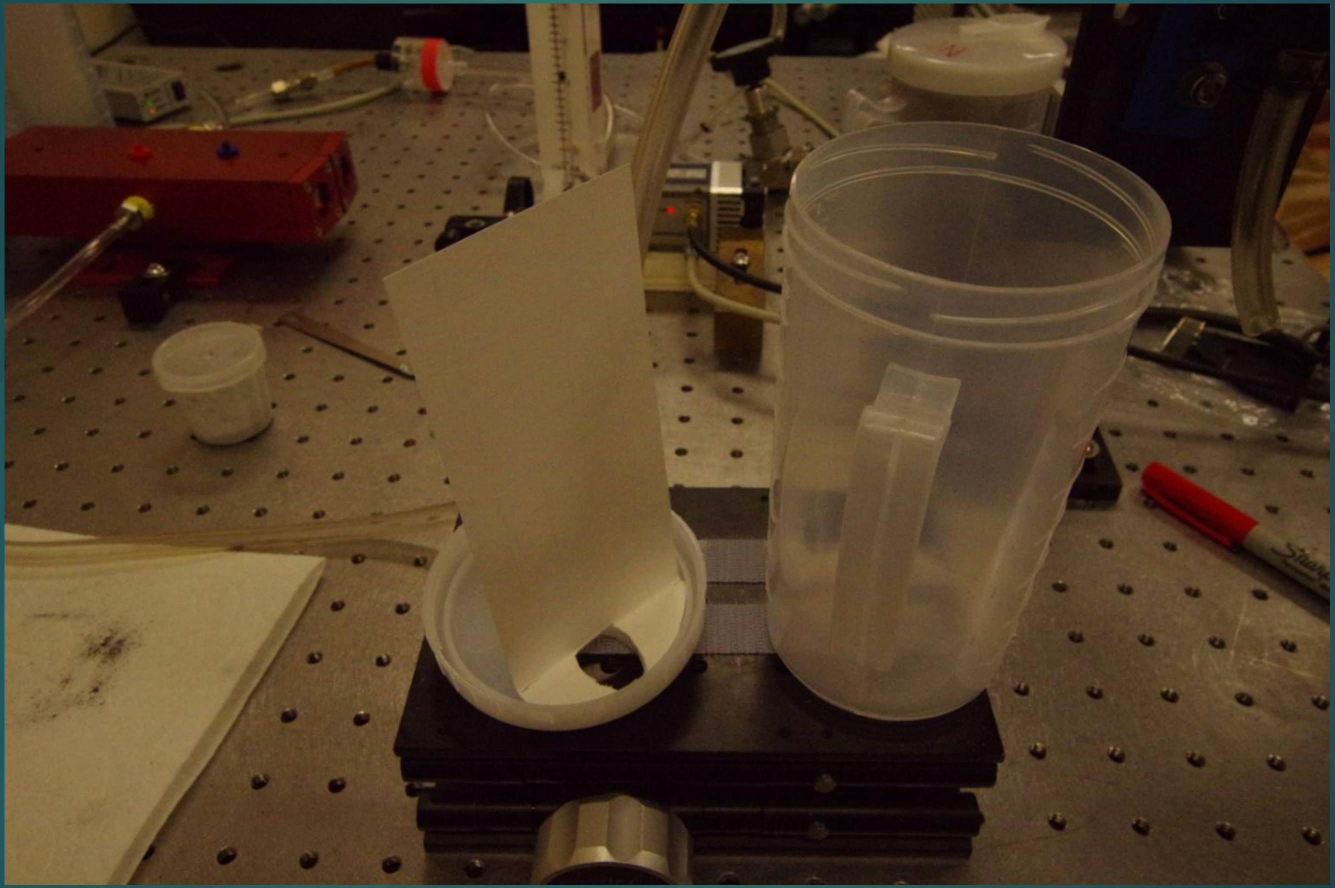
Modified method

- Coal Dust is lighter than Silica
- Protection from Respirable Dust
- Control of Sample Size

Sample Preparation



Sample Preparation

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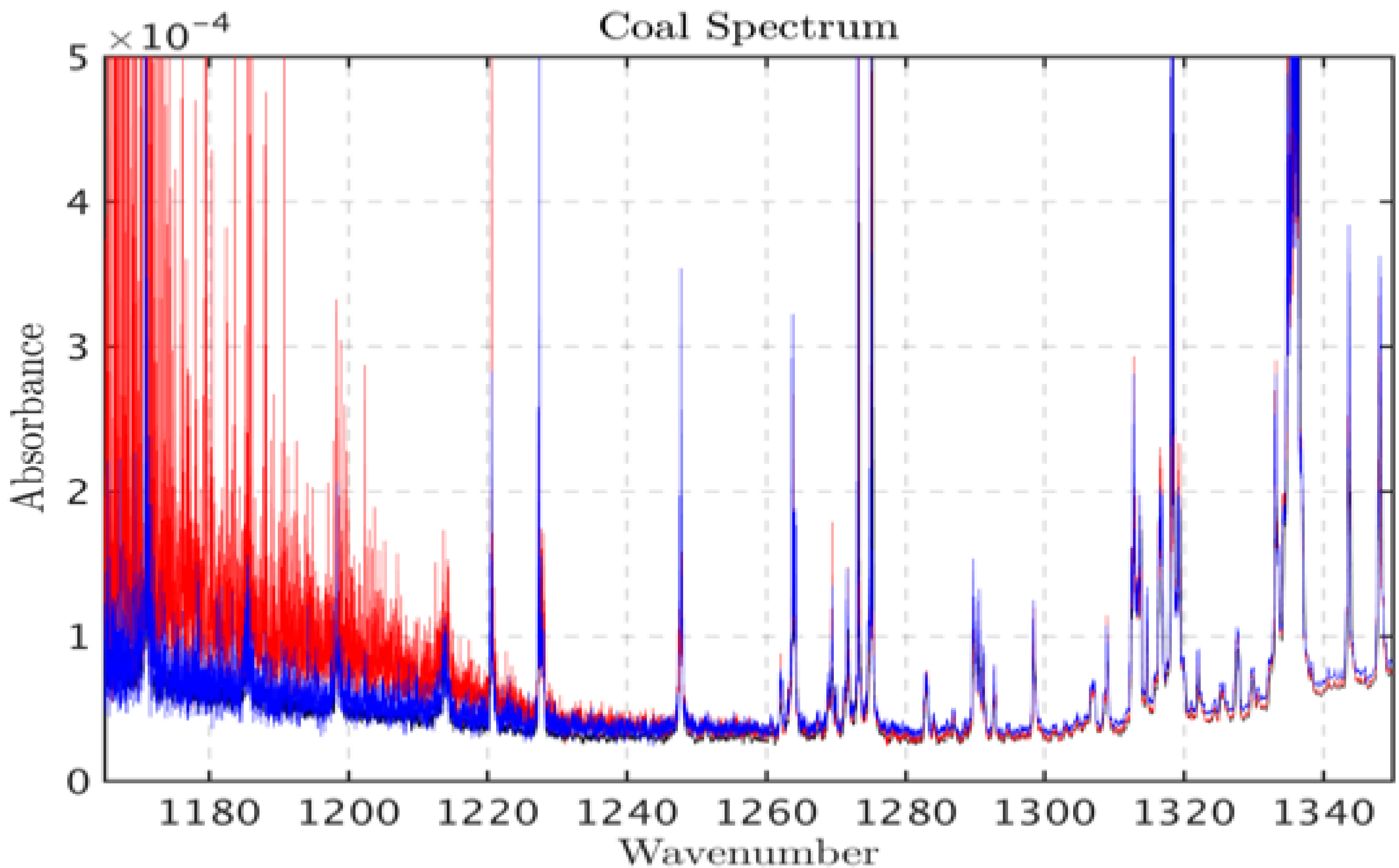
Sampling

Results



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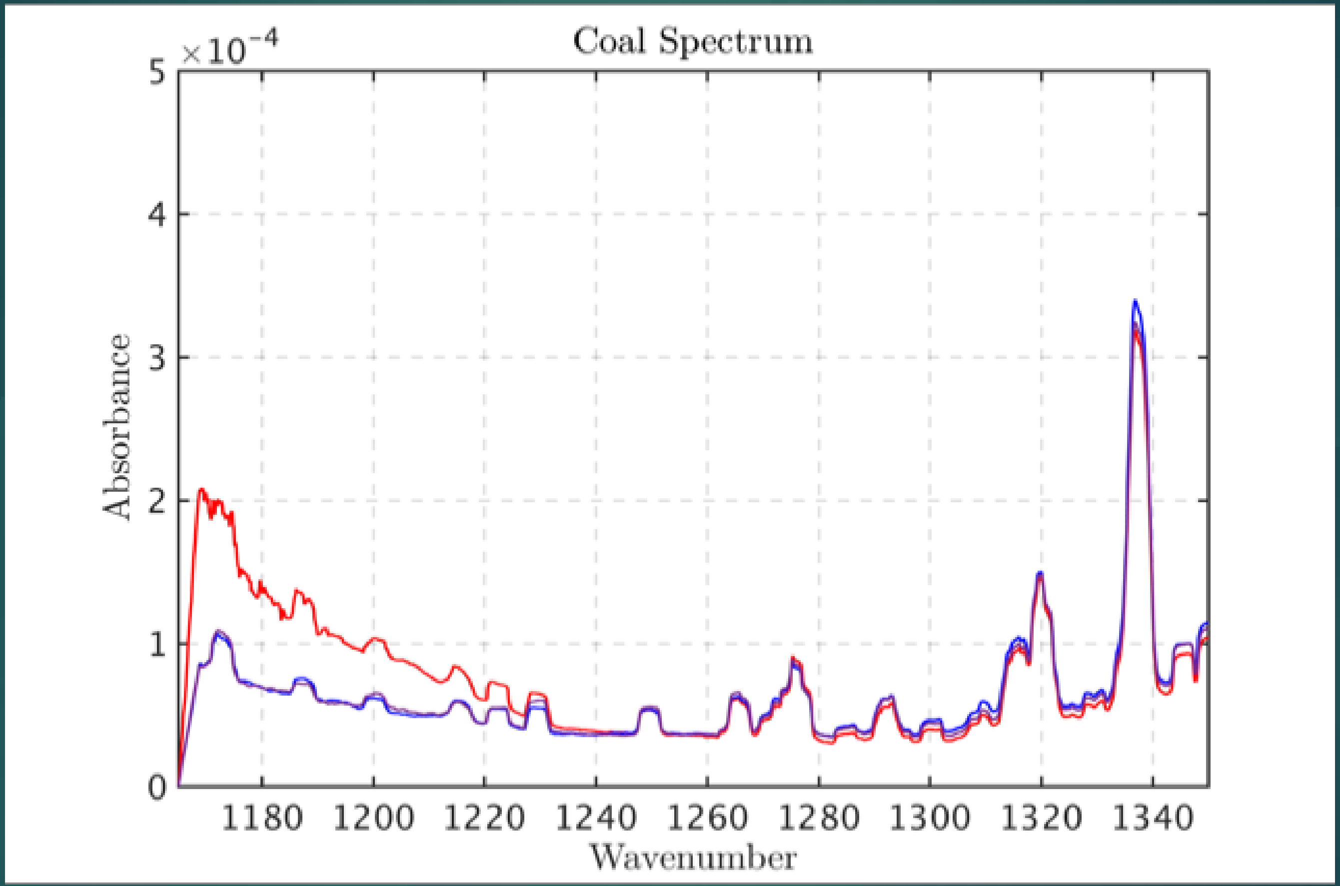
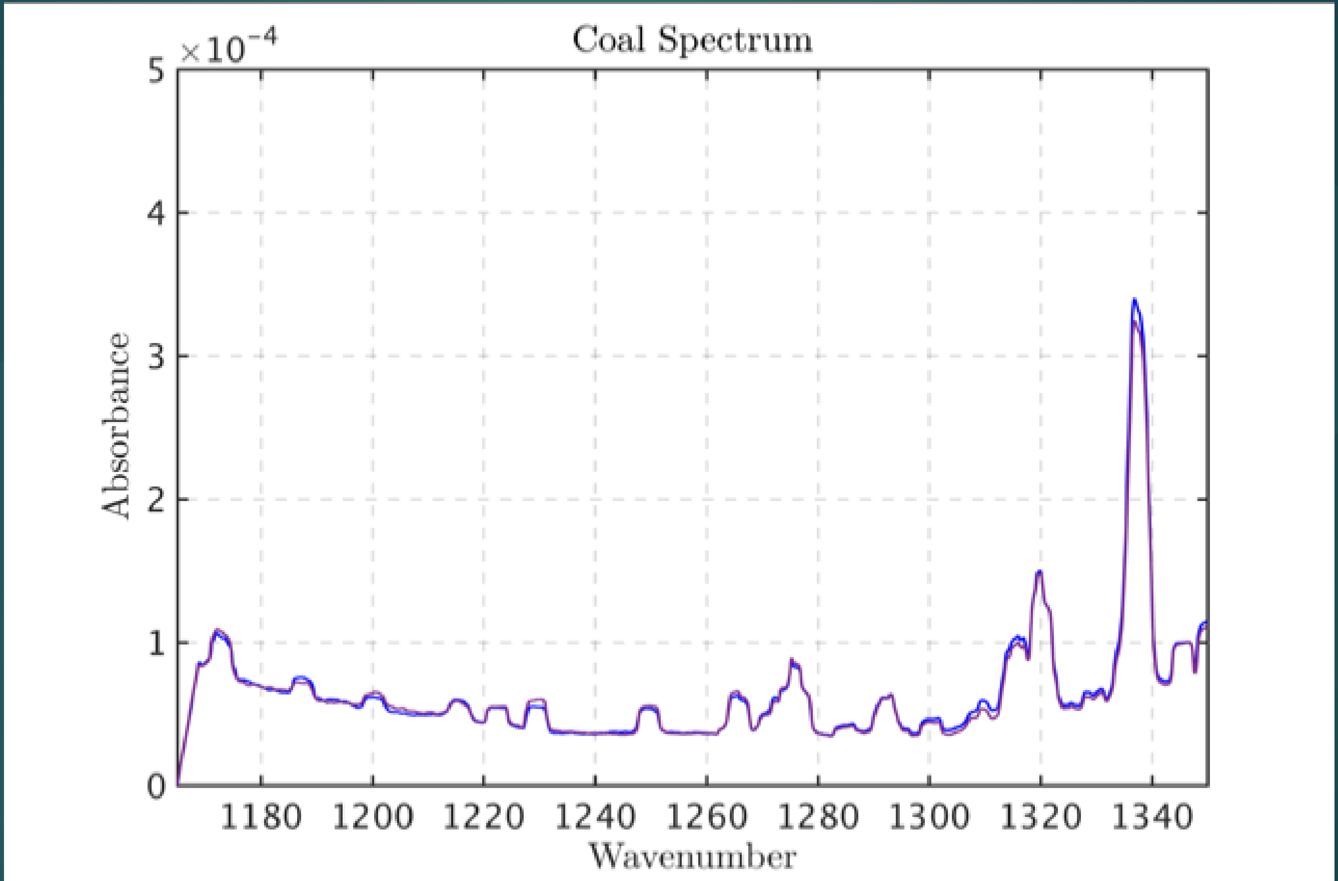
Results



Coal Spectrum
×10^-4
5
4
3
2
1
0
Absorbance
1180
1200
1220
1240
1260
1280
1300
1320
1340
Wavenumber

Results



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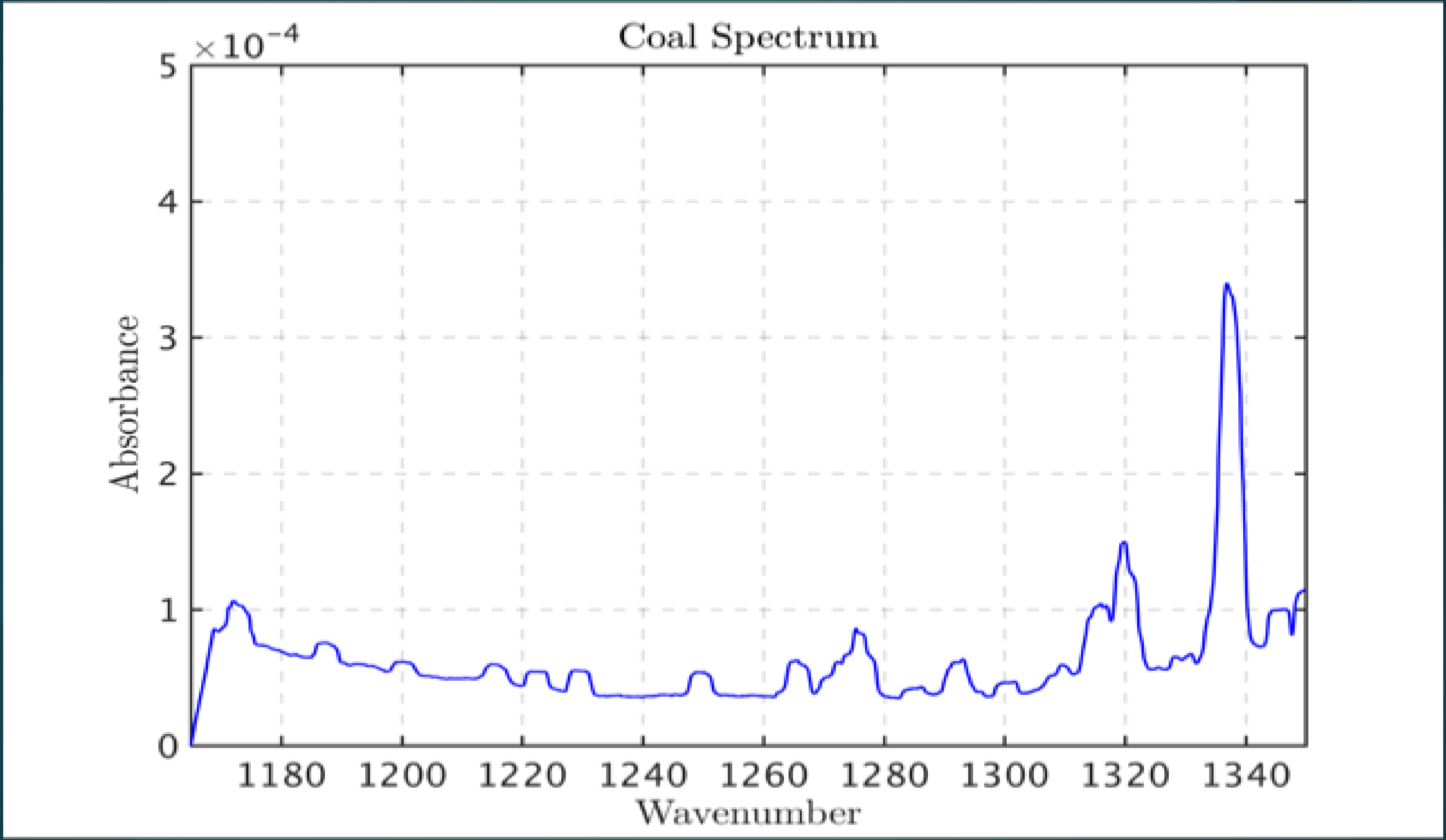
Results



Coal Spectrum
×10⁻⁴
5
4
3
2
1
0
Absorbance
1180
1200
1220
1240
1260
1280
1300
1320
1340
Wavenumber

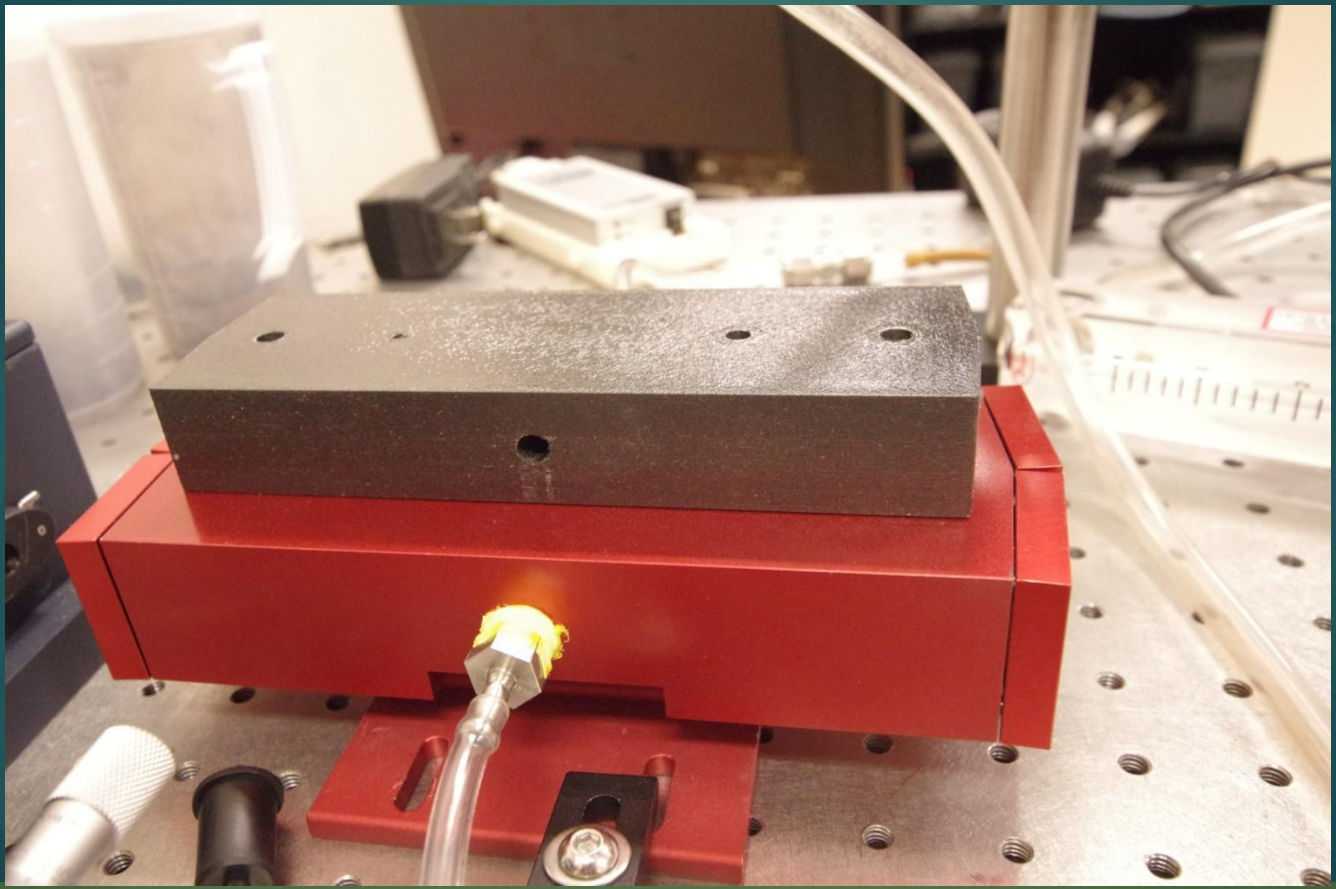
Selection of Frequencies

- Two Wavelengths are required 7.4microns & 9.4 microns
- One that sees all dust
- One that does not see silica
- Subtracting one from the other would allow the determination of the silica content

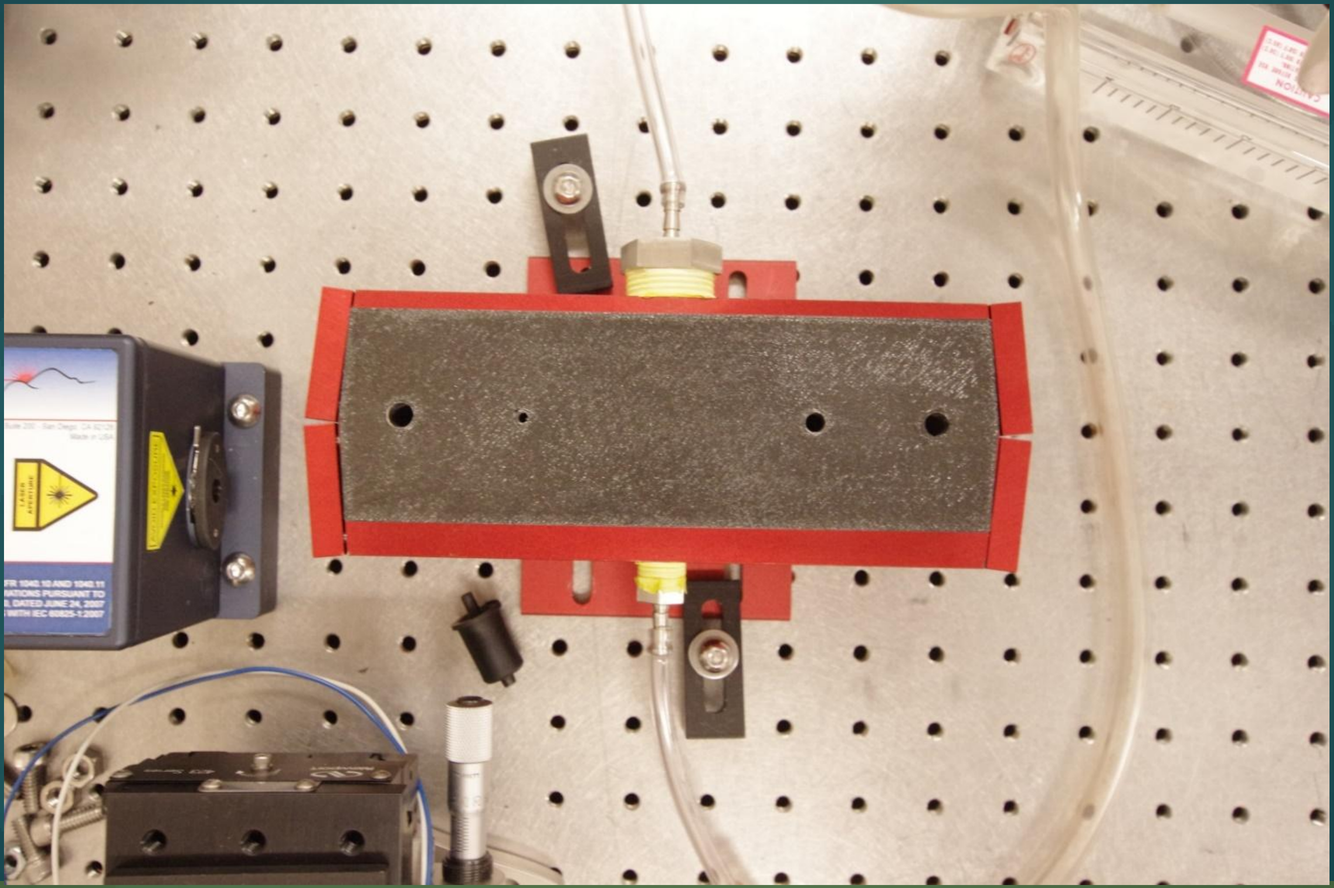
New Materials

- Step1 Miniaturisation
  - Graphite composite
  - 3D Printed
  - Maintaining vacuum
  - Testing
- Step 2 Further Miniaturisation

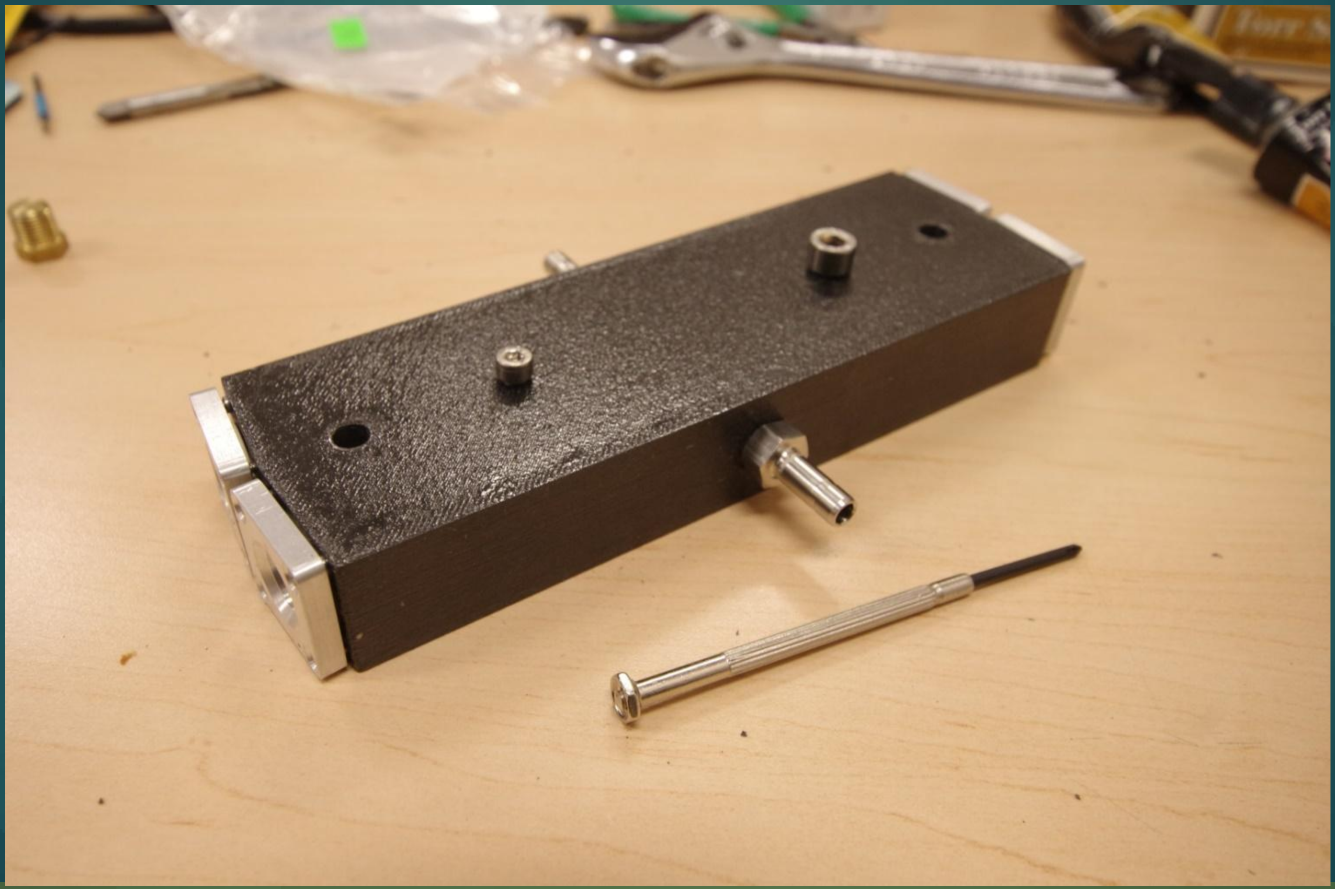
Step 1 miniaturisation



Minaturisation



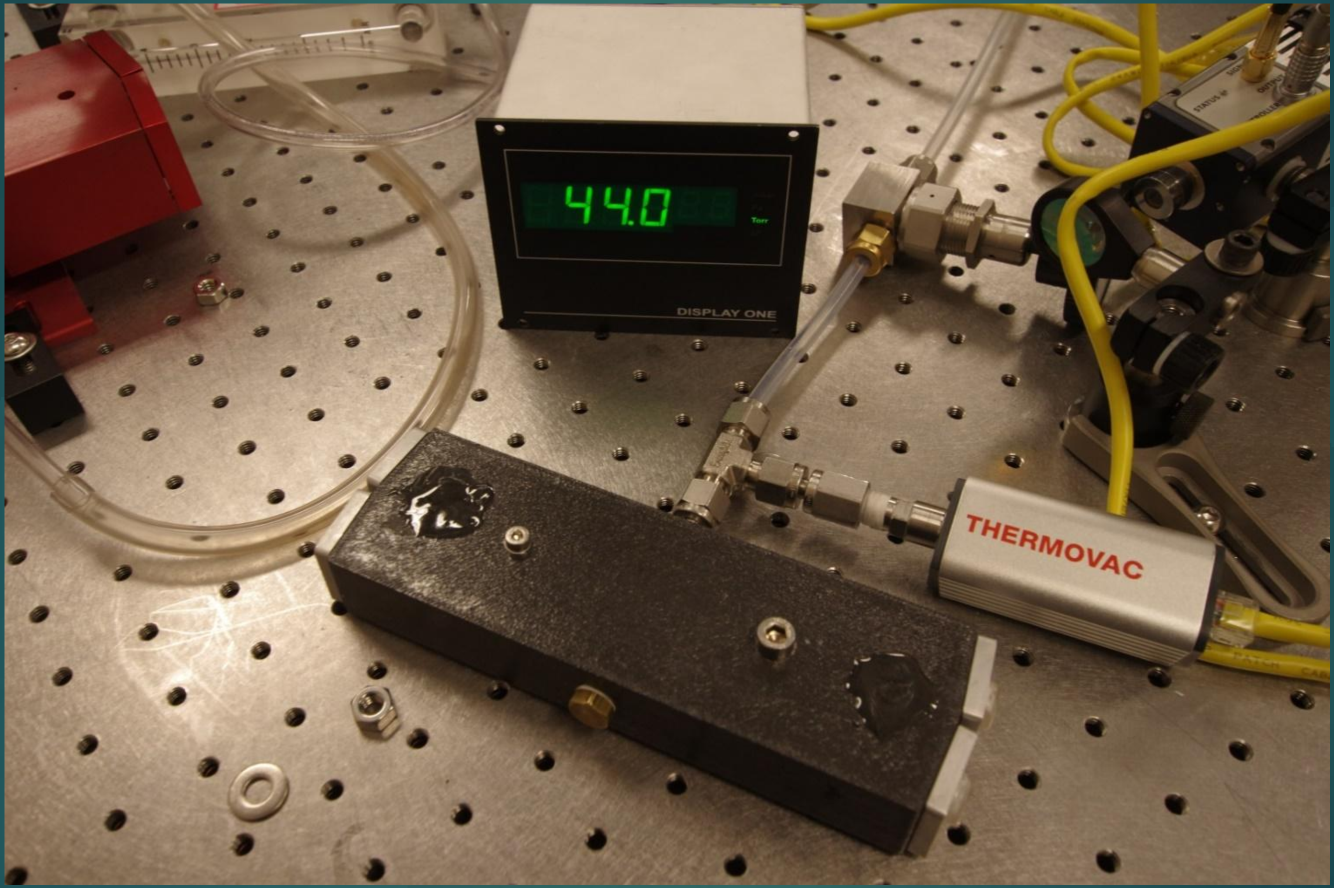
Assembly



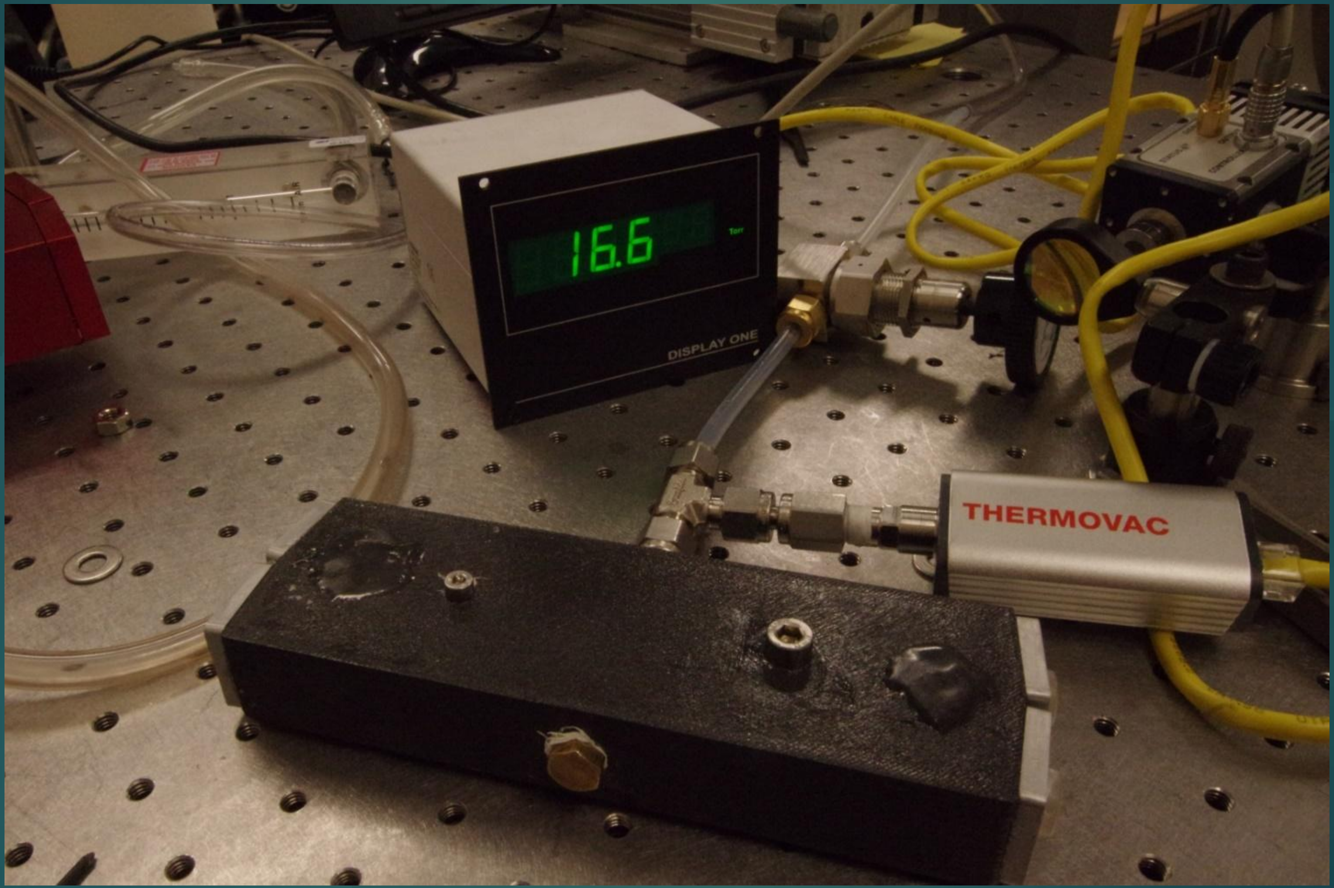
Vacuum Testing

- Atmospheric pressure
  - 100kPa =750 torr
  - 2.2kPa=16.6 torr

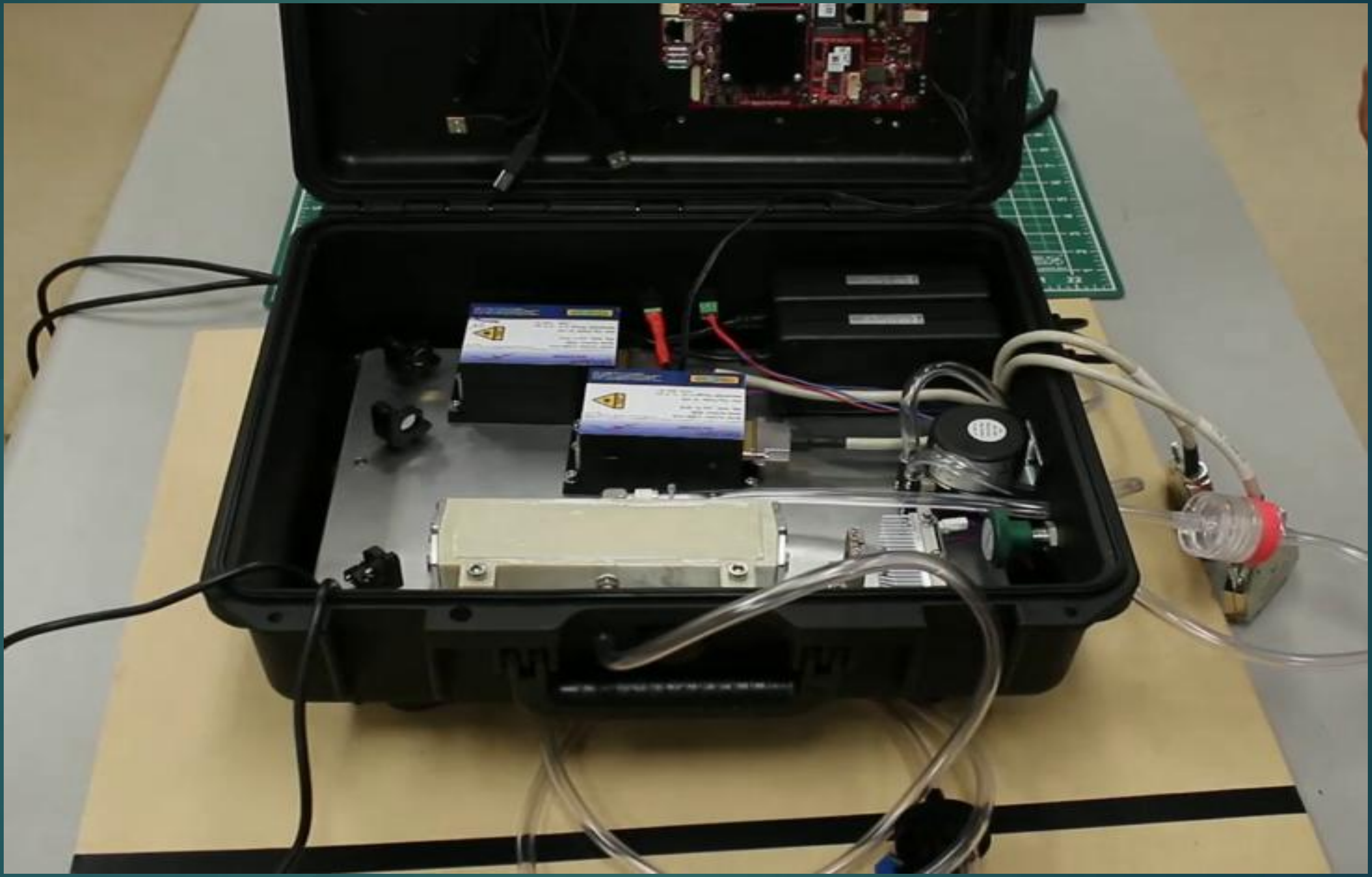
Initial sealing



Leak chasing



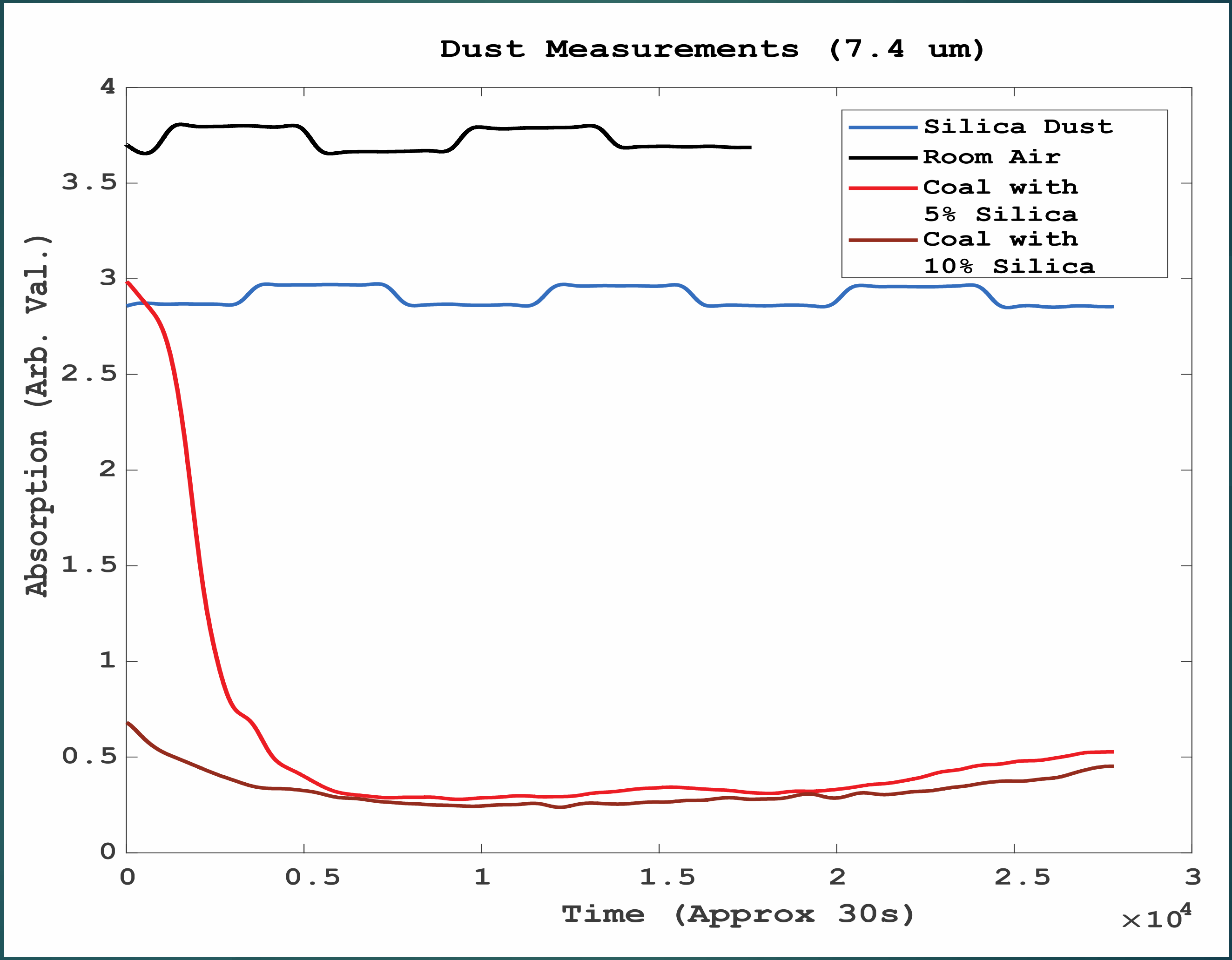
New Prototype



New Prototype

New Prototype

Initial Dust Measurements



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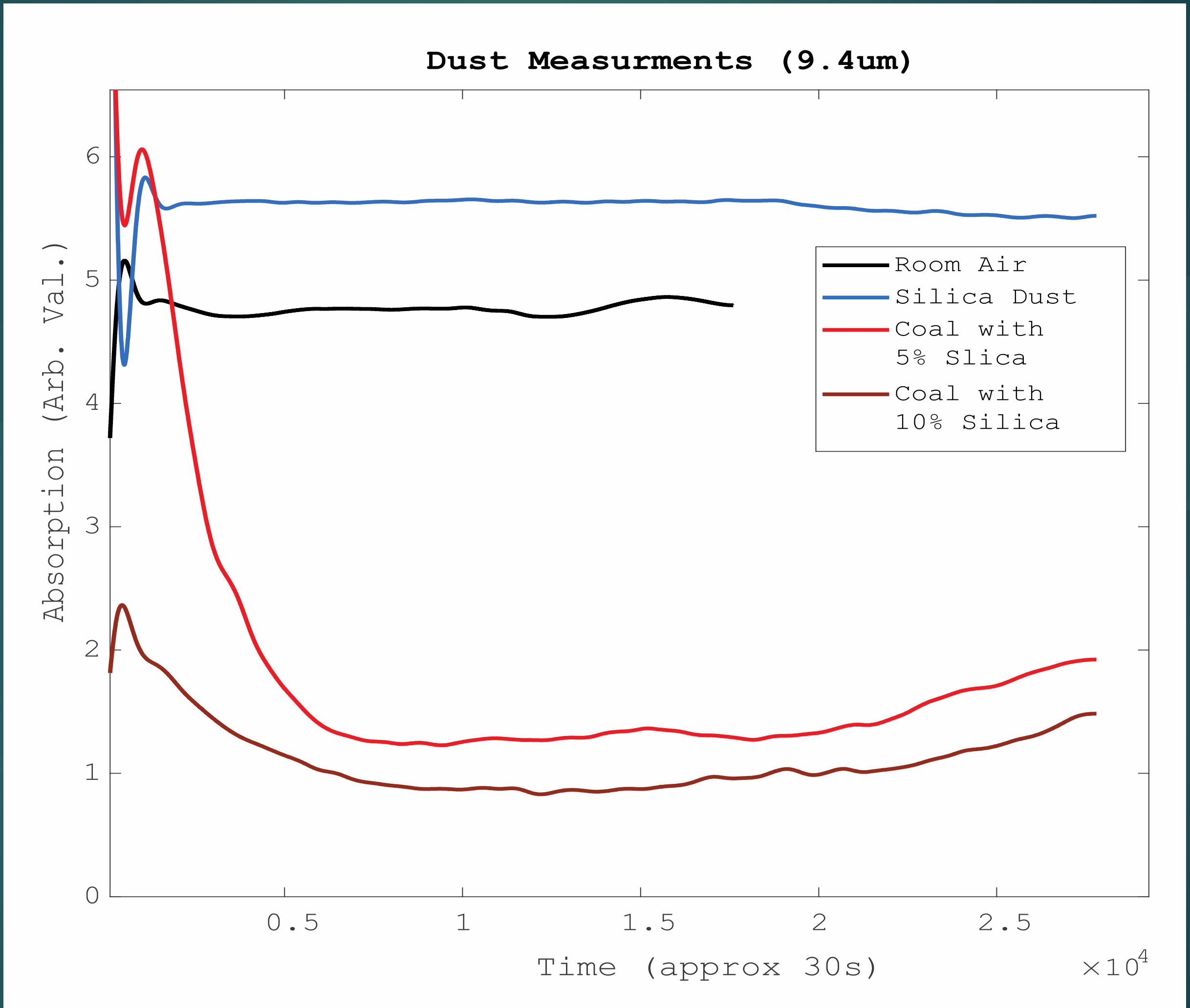
Initial Dust measurements



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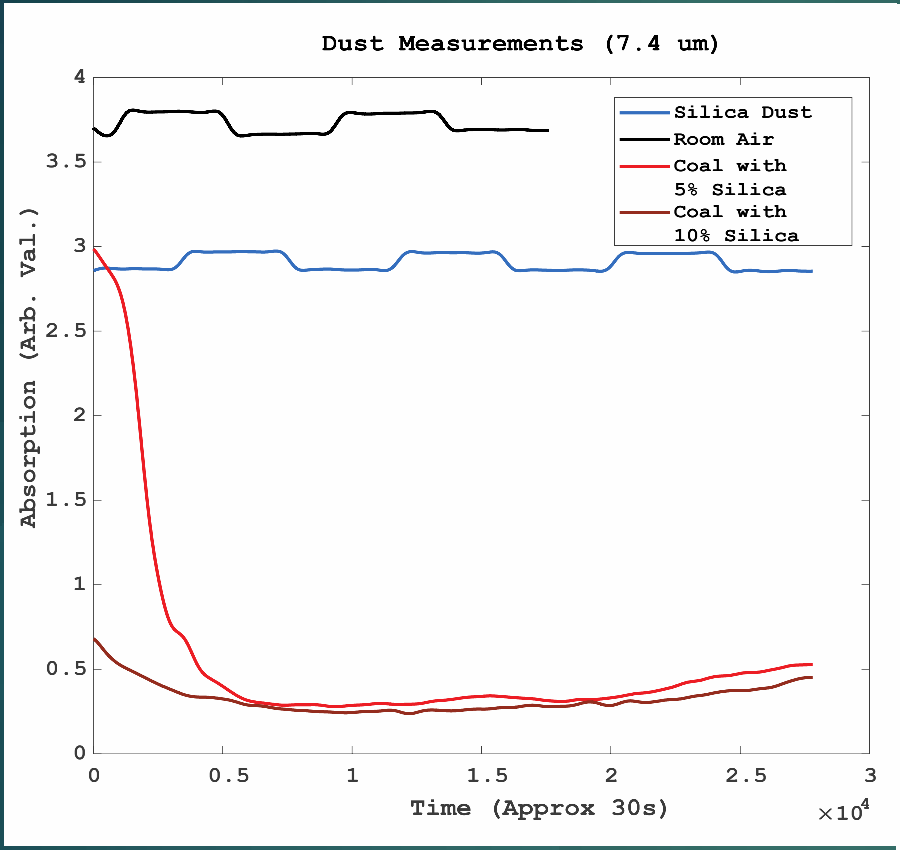
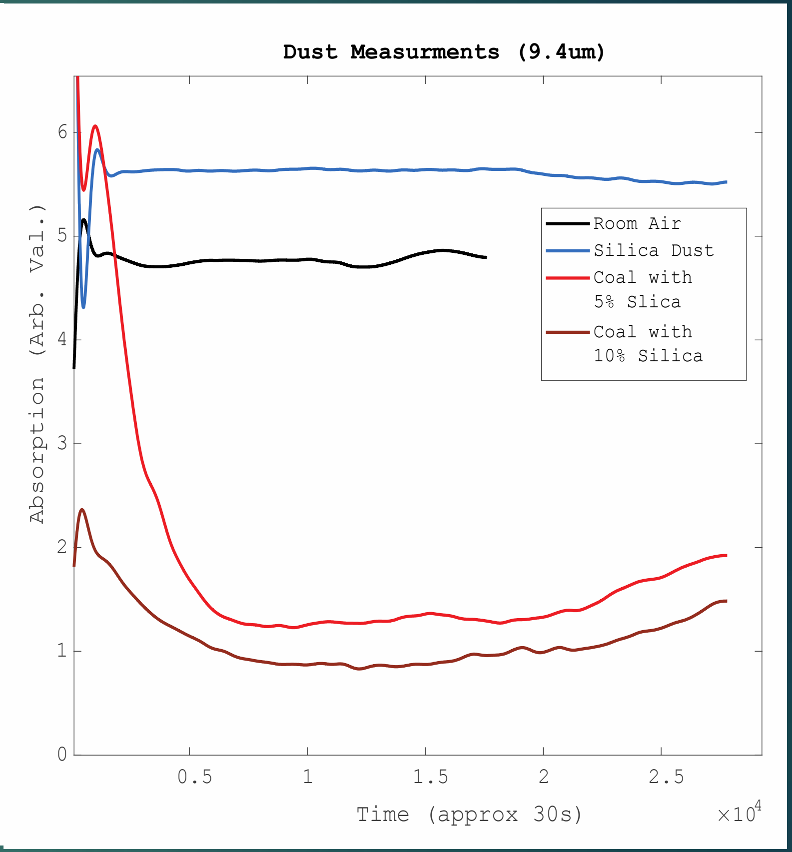
Initial Dust measurements





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Dust Analysis

Table 2: Composition of Coal Ash Used in Trials for Size Distribution of Coal G Mine Figure					
24th August, 2017	OXIDE WT.%	Coal Ash			Ash Content* %
	SiO2	53.98		Coal	13.58
	TiO2	1.41			
	Al2O3	30.33			
	Fe2O3	5.56			
SAMPLE TYPE	Mn_3O_4	0.03			
1 coal sample	MgO	0.89			
	CaO	2.15			
	Na2O	1.06			
	K2O	1.83			
SAMPLE PREPARATION	P2O5	0.92			
40 mm GLASS DISK.	SO3	0.58			
Crushing in WC mill	Cr_2O_3	<0.01			
Ashing at 815 °C	ZrO_2	0.09			
	SrO	0.08			
REQUESTED BY	CuO	0.02			
Duncan Chalmers	ZnO	0.01			
School of Mines	NiO	<0.01			
	BaO	<0.01			
	PbO	<0.01			
ANALYST: I.W. / S.K.	L.O.I.	1.09			
	TOTAL	100.03			
INSTRUMENT: **PHILIPS PW2400 XRF** **Rh end-window tube** **"SUPERQ" SOFTWARE.** **WROXI calibration**	NOTE: (i) L.0.I. = loss on ignition at 1,050°C. (ii) ND = not determined *This sample was ashed at 815 °C before analysis. Back-calculation required for results on a whole-basis				

Cumulative dust analysis

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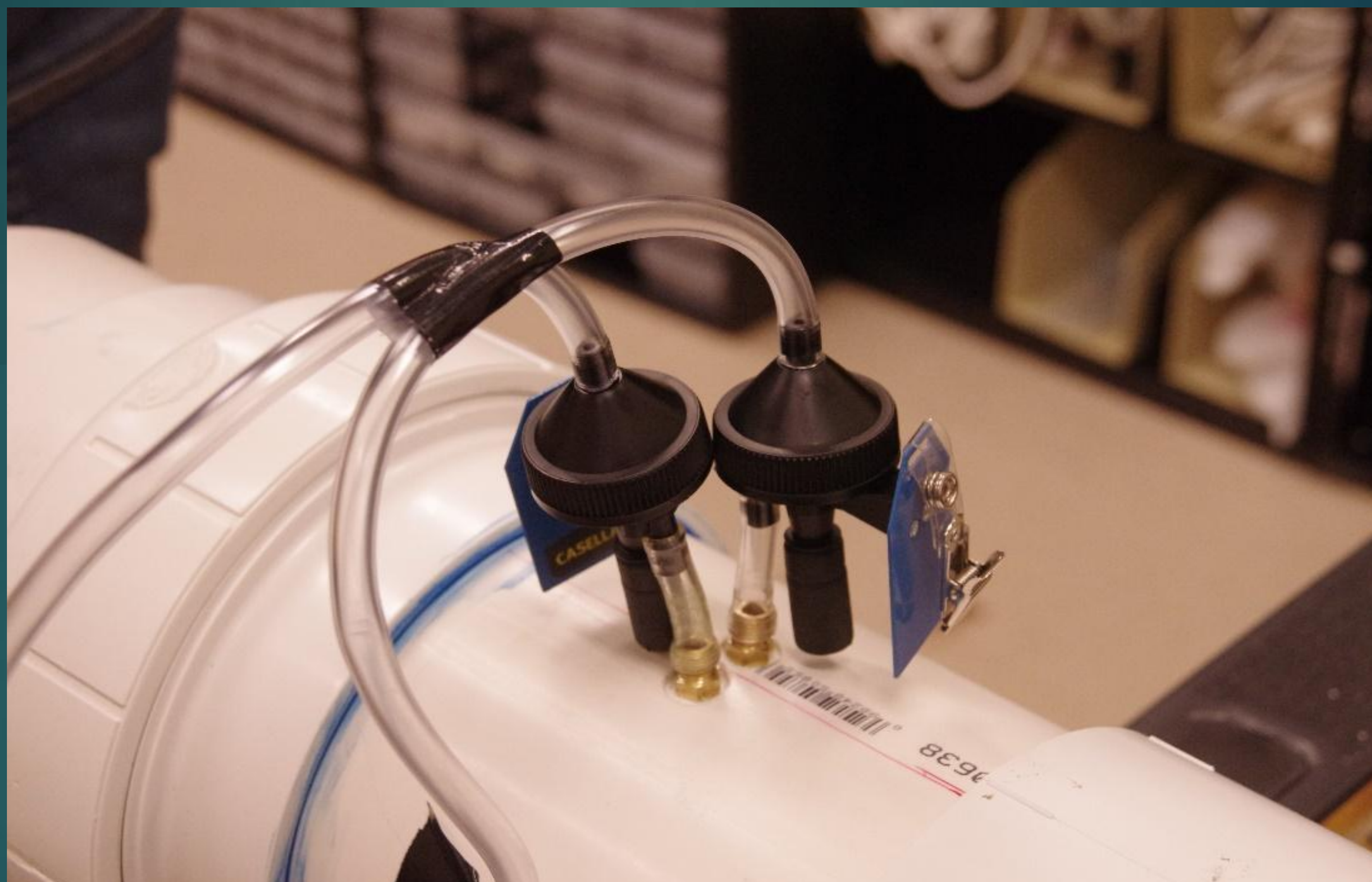
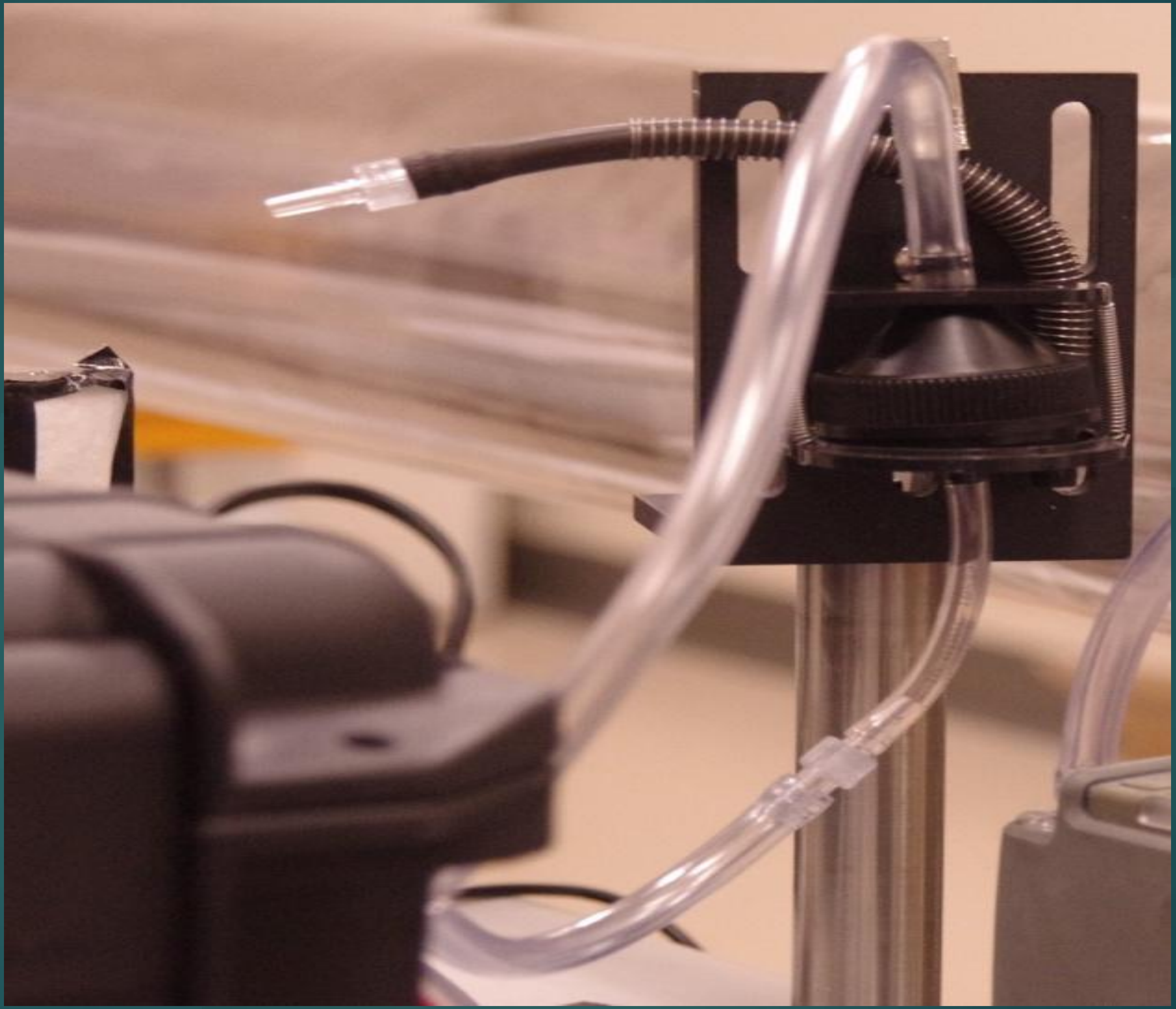
Dust sampling points



Post analysis Filter



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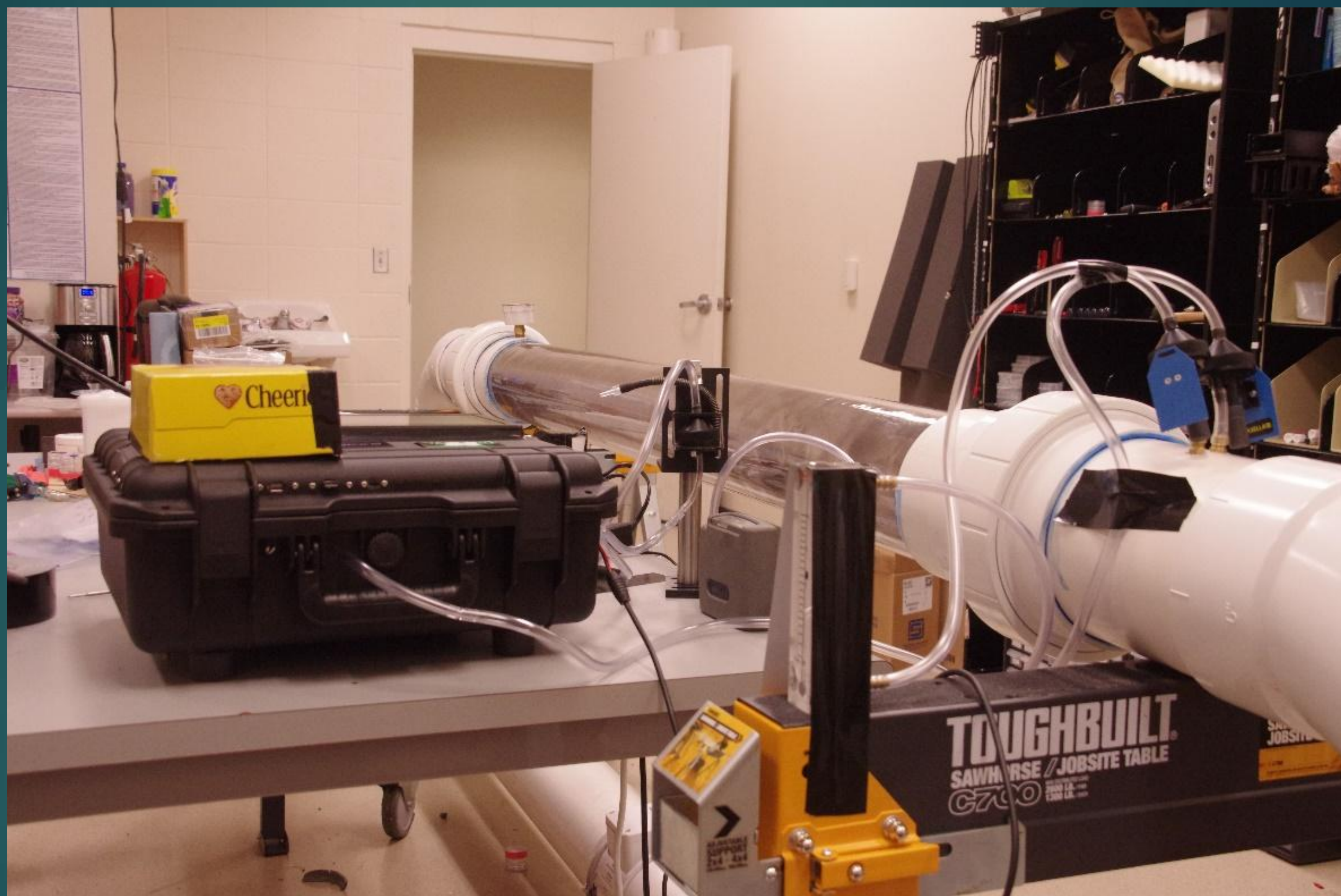
Test Setup



Circulating Fan

Laser Setup

- Laser 1:
  - Wavelength = 7.32um;
  - Pulse Rate = 166667Hz;
  - Pulse Width = 40ns;
- Laser 2:
  - Wavelength = 9.34um;
  - Pulse Rate = 156250;
  - Pulse Width = 40ns;

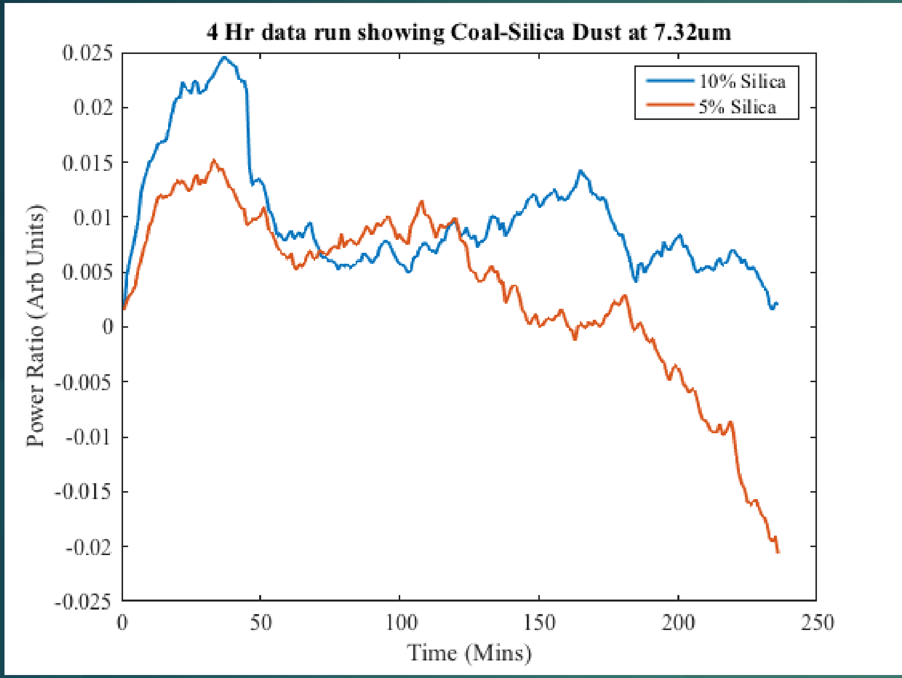
Test Conditions

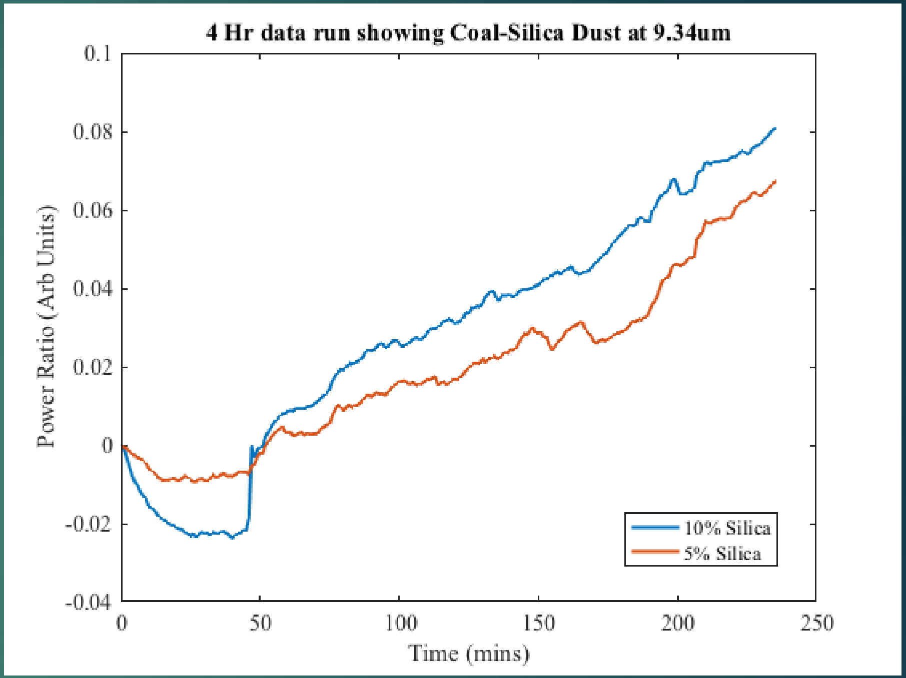
- Both lasers were operating simultaneously, and the wavelength data was multiplexed in the data stream. The saved data was analysed (demultiplexed) after each run to produce the figures shown in this section.
- The flow rate was set to 2.2l/min for both the personal dust sampler and the prototype.

Test Setup

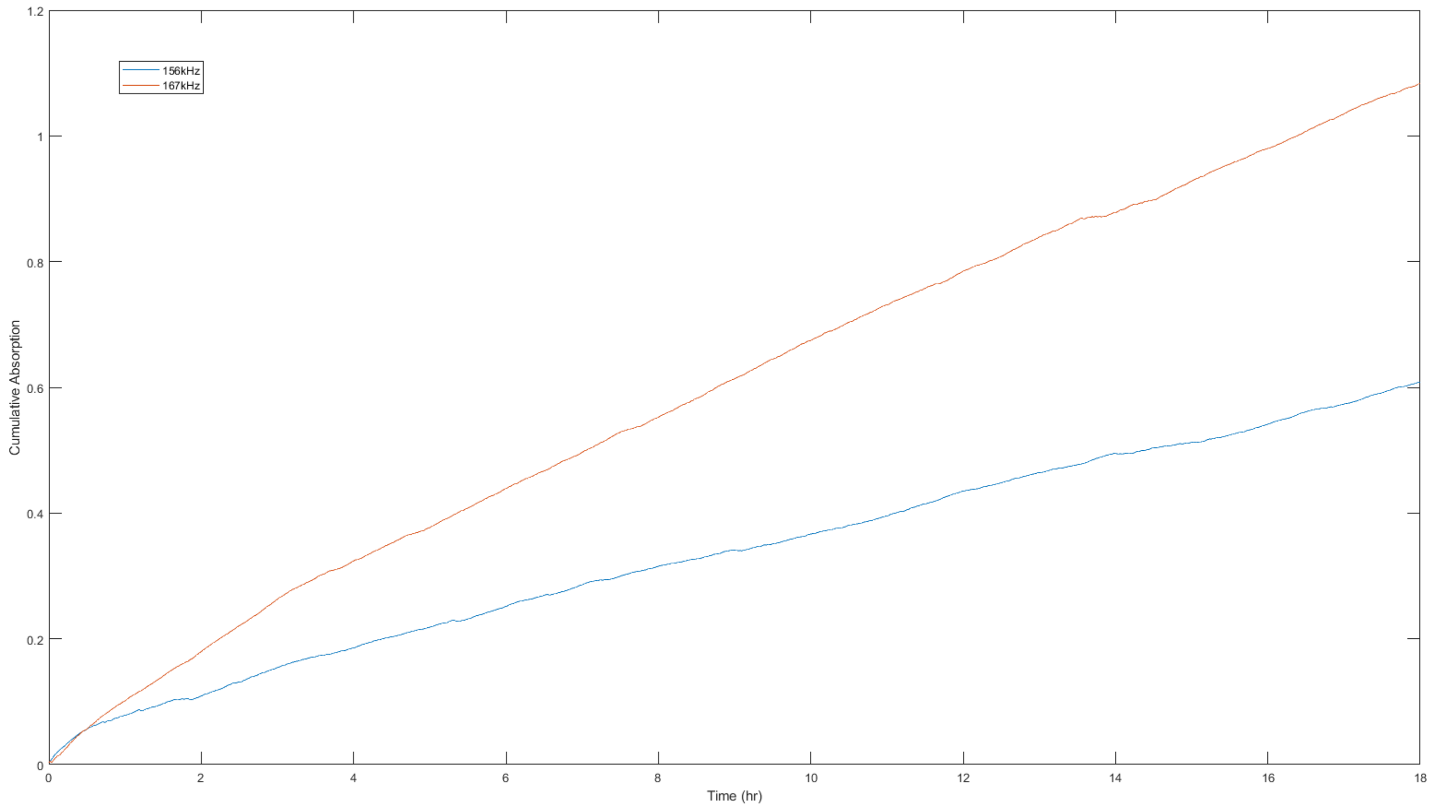
- Four, 4-hour data runs performed:
- **Background:** 4 Hrs data with no dust in system
- **Run 1:** Coal dust plus 5% silica dust: 4 Hrs data with a coal-dust mixture in system – The dust was 5% of the coal dust. Chamber velocity 4.8m/s
- **Run 2:** Coal dust plus 5% silica dust: 4 Hrs data with a coal-dust mixture in system – The dust was 5% of the coal dust. Chamber velocity 3.5m/s.
- **Run 3:** Coal dust plus 10% silica dust: 4 Hrs data with a coal-dust mixture in system – The dust was 10% of the coal dust. Chamber velocity 3.5m/s.

Results


4 Hr data run showing Coal-Silica Dust at 7.32um
10% Silica
5% Silica
Power Ratio (Arb Units)
Time (Mins)
0.025
0.02
0.015
0.01
0.005
0
-0.005
-0.01
-0.015
-0.02
-0.025
0
50
100
150
200
250


4 Hr data run showing Coal-Silica Dust at 9.34um
10% Silica
5% Silica
Power Ratio (Arb Units)
Time (mins)
0.1
0.08
0.06
0.04
0.02
0
-0.02
-0.04
0
50
100
150
200
250

Two long duration runs



Conclusions

- Using two wavelengths allows discrimination between coal and silica.
- The unit is very responsive to changes in dust concentrations
- The cumulative exposure to respirable dust can be calculated
- The unit was continuously run for 18hrs

Conclusion

- Real time appears possible
- Further research is necessary
- Once developed it is a “game changer”
  - Detect and mitigate sources
  - PPE becomes second line of defence rather than only protection
- Other uses for the device can be developed

Questions?

- Thank you for the opportunity to present our work.

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President and CEO
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