Protea Ltd.

HCHO Measurement in Ambient Air

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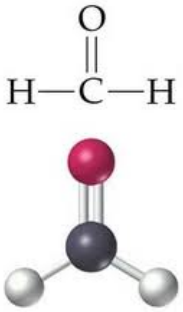
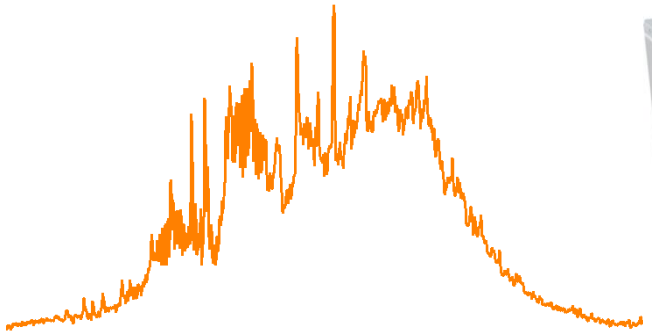
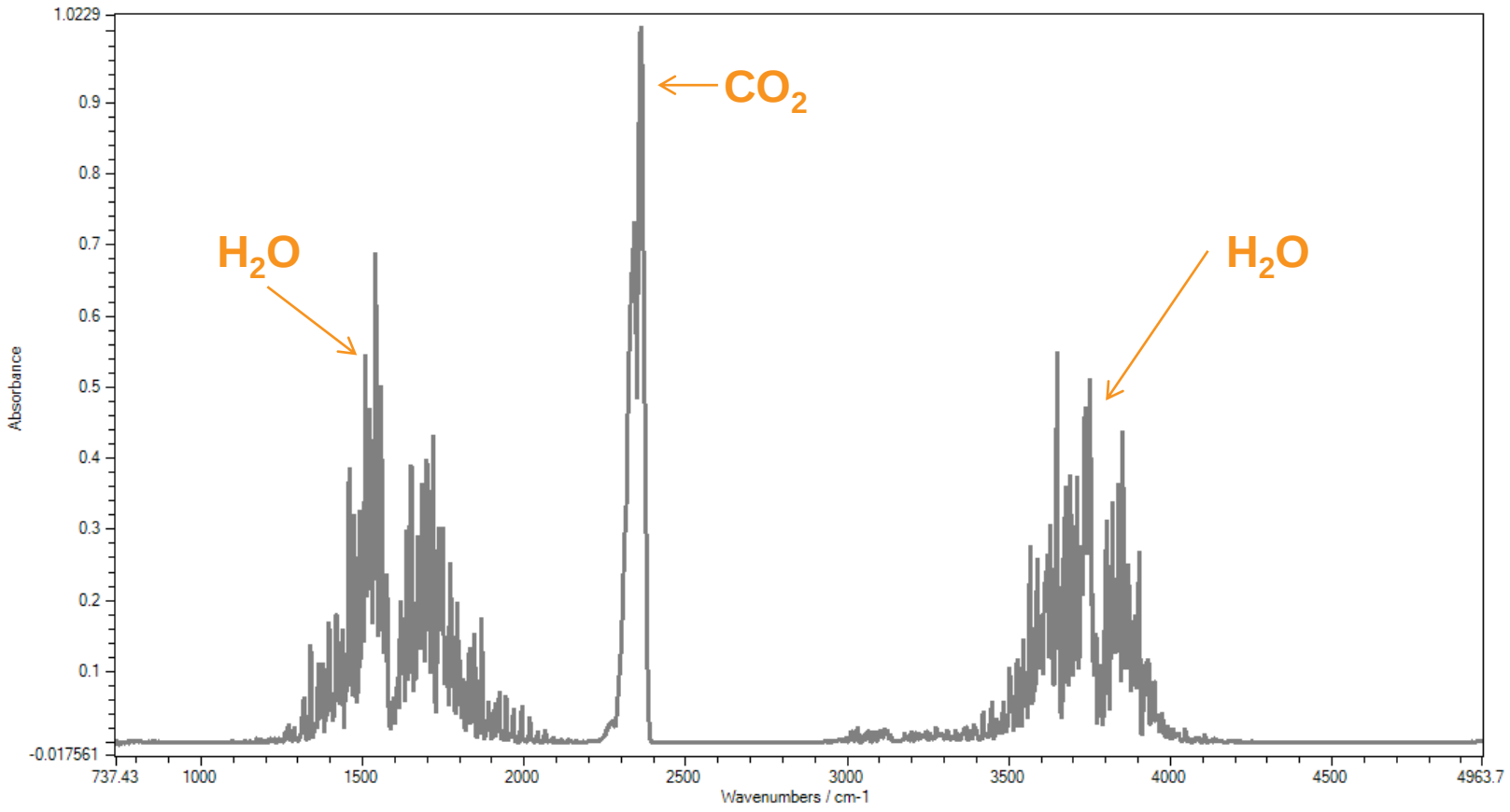




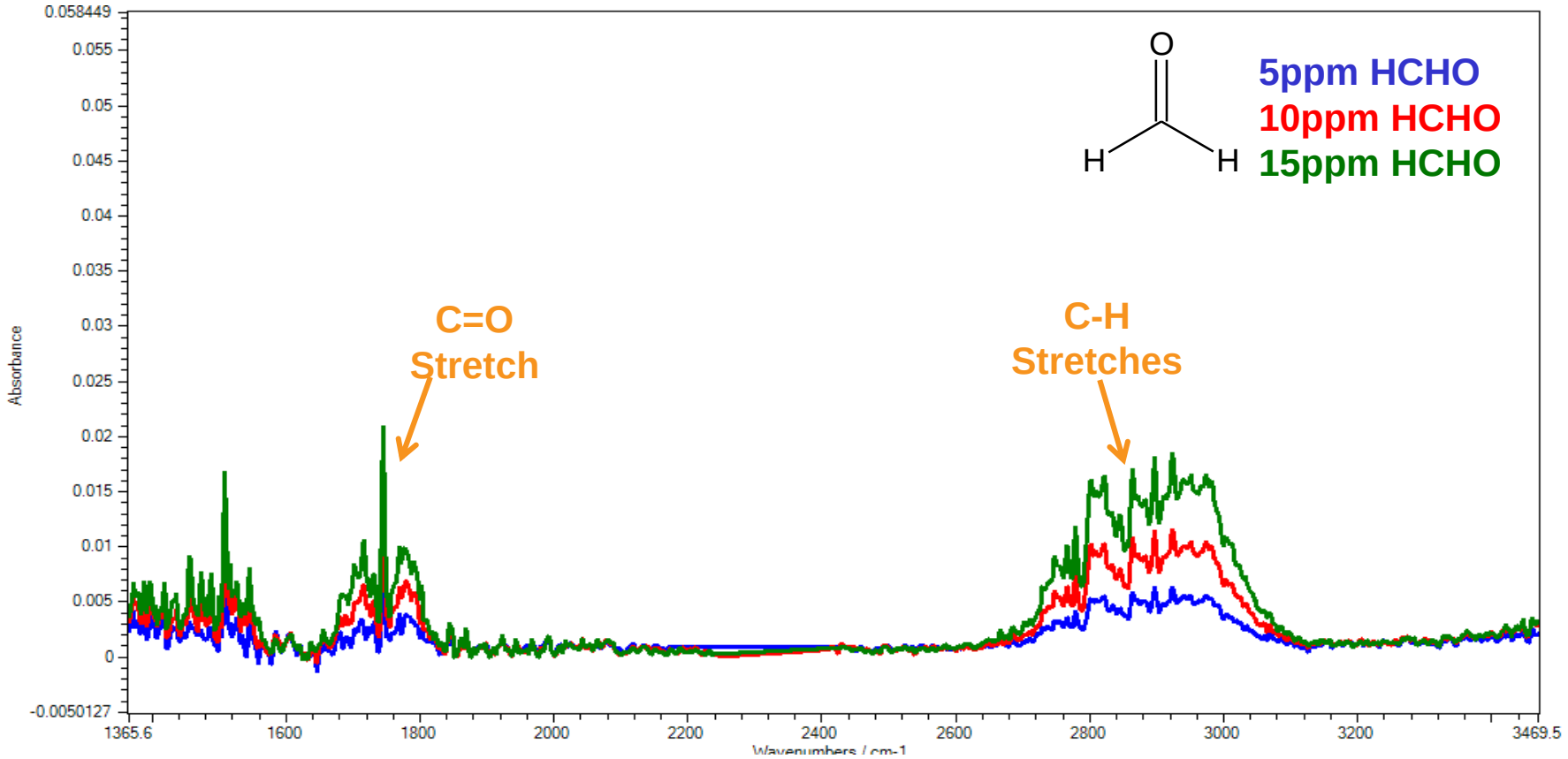
Typical Background Composition (Air)

Species	Typical Concentration	Can it be measured by FTIR?	Detection Limit
Oxygen	20.9 %	No	N/A
Nitrogen	78.1 %	No	N/A
Carbon Dioxide	0.03 %	Yes	0.001%
Water	~1-2 %	Yes	0.005%

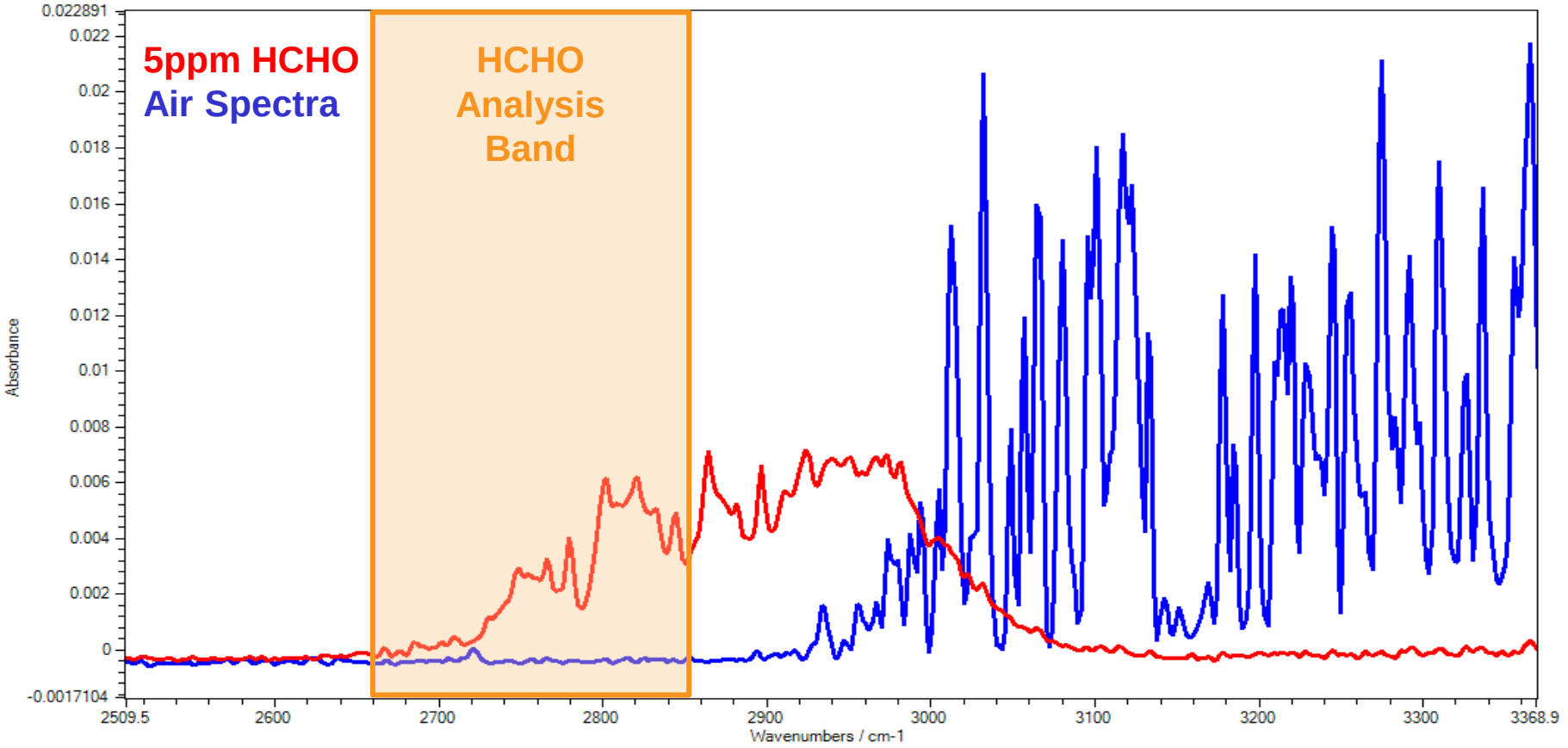
Typical Background Spectra



Typical Formaldehyde spectra

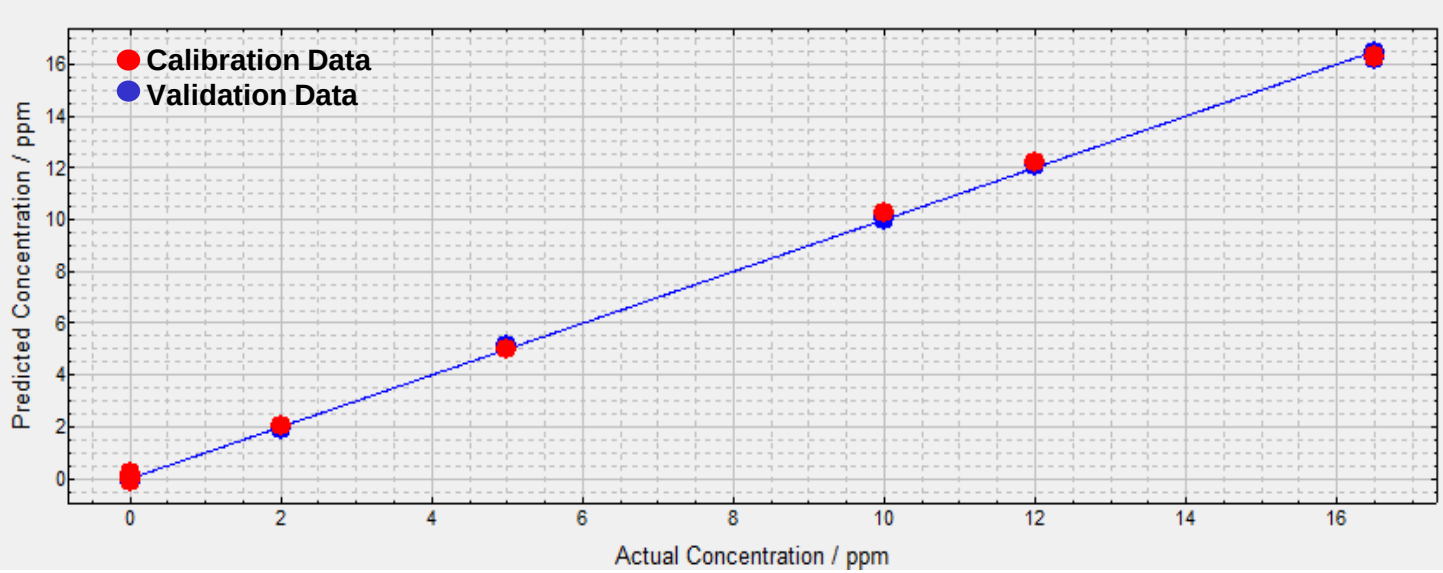


Typical Formaldehyde Spectra



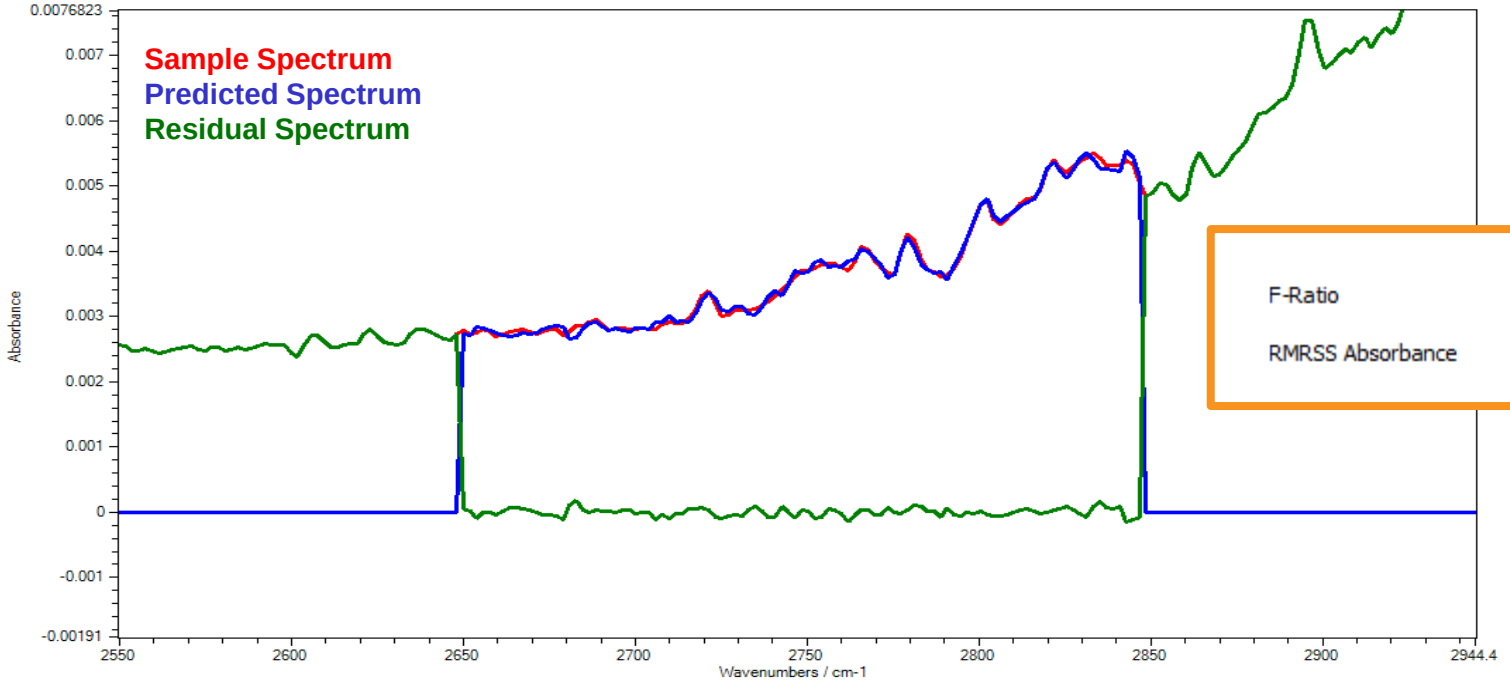
Analysis Models

- Protea uses chemometric models, specifically PLS, to create an analytical model which targets each measurement species individually.
  - Accurate quantification of HCHO
  - Minimise the effects of interfering species



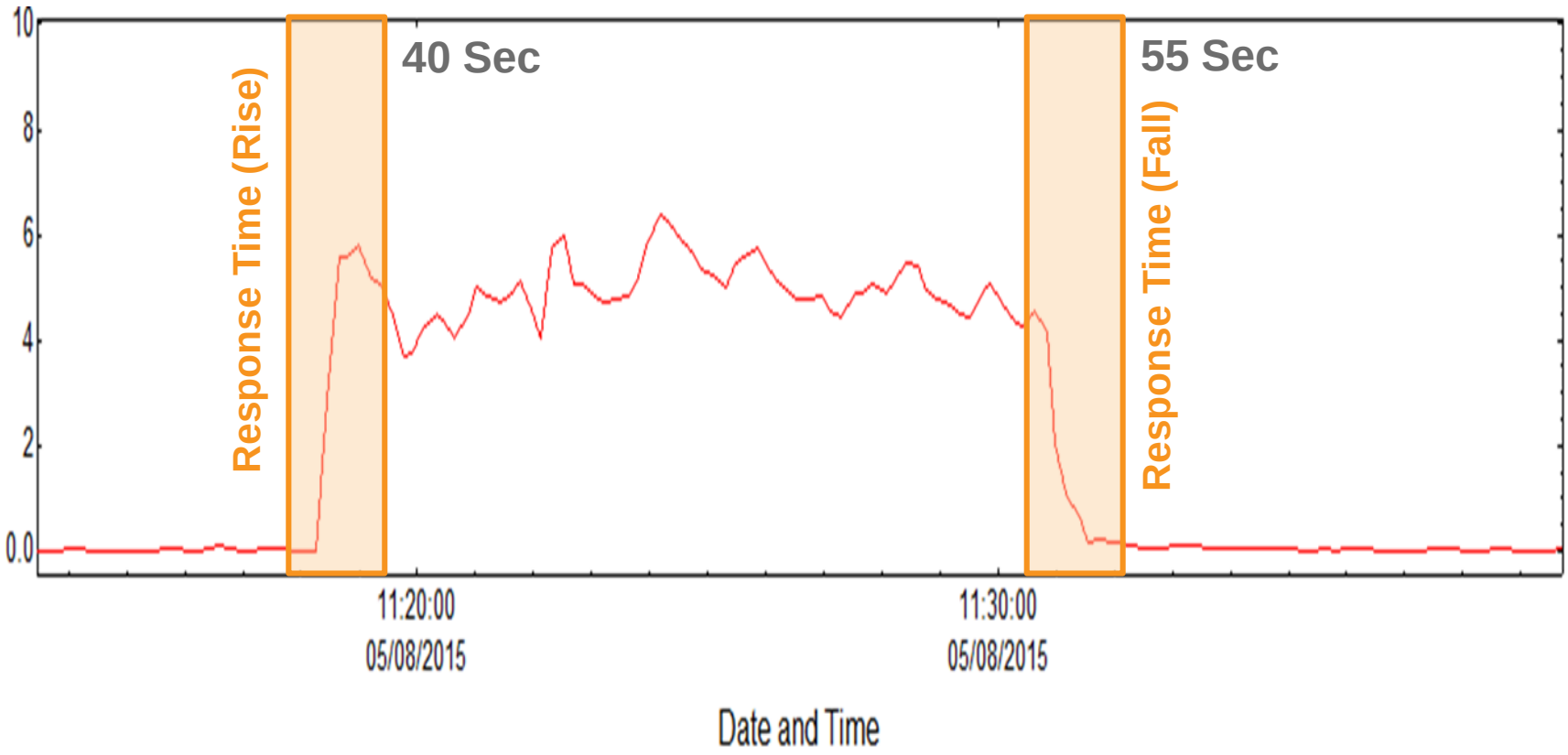
Analysis Models

- Residual Analysis- Check quality of analysis



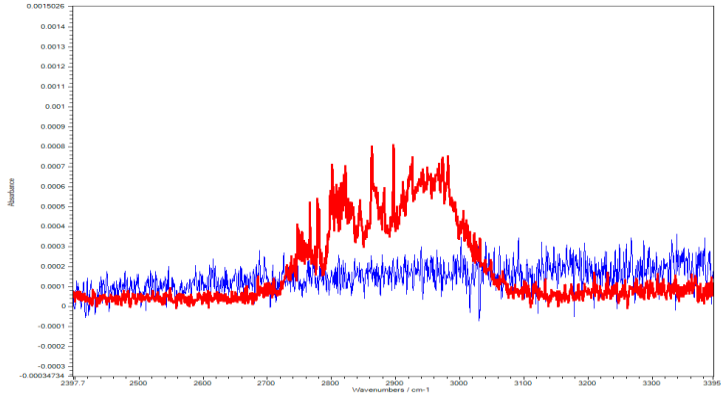
F-Ratio	0.000	
RMRSS Absorbance	0.001	Abs

Response Time to ambient air sample



Detection Limits

- Typical detection limit are calculated as 2 times the standard deviation of concentration readings on zero data (N2).
- This analysis was performed using at AtmosFIRs with 4.2M pathlength at 40oC and a 10 minute measurement time
- As the detection limits are dependent on the signal to noise ratio they can be improved by averaging more scans into each spectrum.



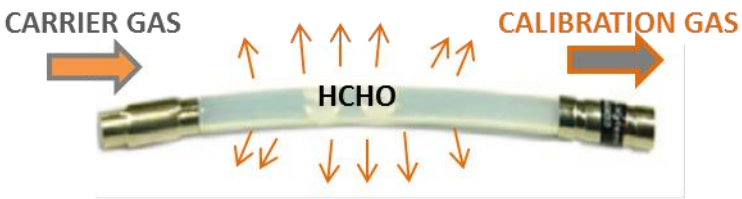
120ppb HCHOSpectrum
ZeroSpectrum

Detection Limits

	Scan Rate/ Measurement Time		
	5 Scan	10 Scan	50 Scan
Measurement Time (Min)	1	2	10
HCHO LDL (ppb)	40	16	8

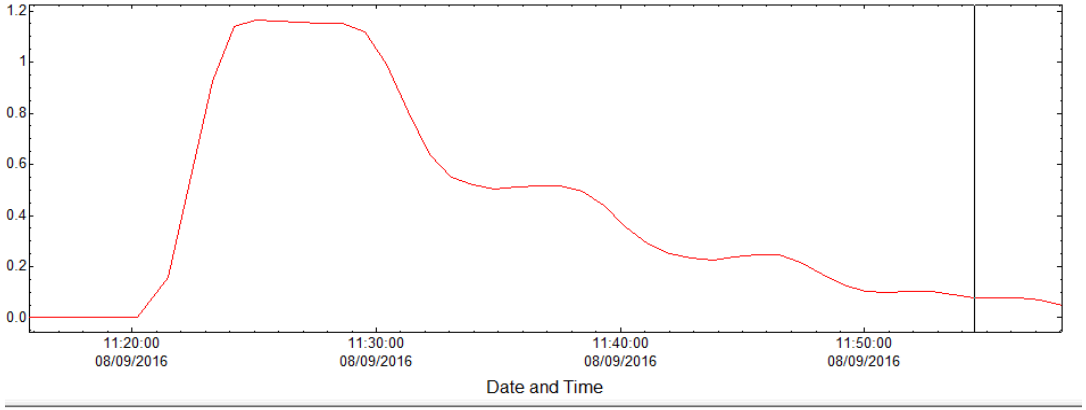
Generation of Calibration Data

- We used a number of different methods to calibrate HCHO analysers depending on the range required.
  - <20ppm HCHO gas cylinder standards
  - <100ppm Permeation tubes
  - >100ppm calculated synthetic spectra (Proprietary algorithm used to calculate IR spectra from HITRAN line data)



Generation of Calibration Data

- Calibration linearities are produced over the required range



RANGE/ Units	1000	ppb								
Calibrated Conc.	Analyser Conc (Min of 3 readings)							Span Factors	Spanned for Range	Linearity % Range
	1	2	3	4	5	6	Ave			
1150	1138	1165	1160	1154	1153	1148	1153.000	0.9974	1150.0000	0.00%
500	519	503	508	516	515	496	509.500	0.9814	508.1743	0.82%
240	251	233	226	236	248	244	239.667	1.0014	239.0431	-0.10%
120	129	111	115	114	119	118	117.667	1.0198	117.3605	-0.26%
60	68	69	59	67	68	50	63.500	0.9449	63.3348	0.33%
0	2	5	7	7	4	5	5.133	0.0000	5.1200	0.51%

Error on full scale
-0.30%

CASE STUDY: Medical School

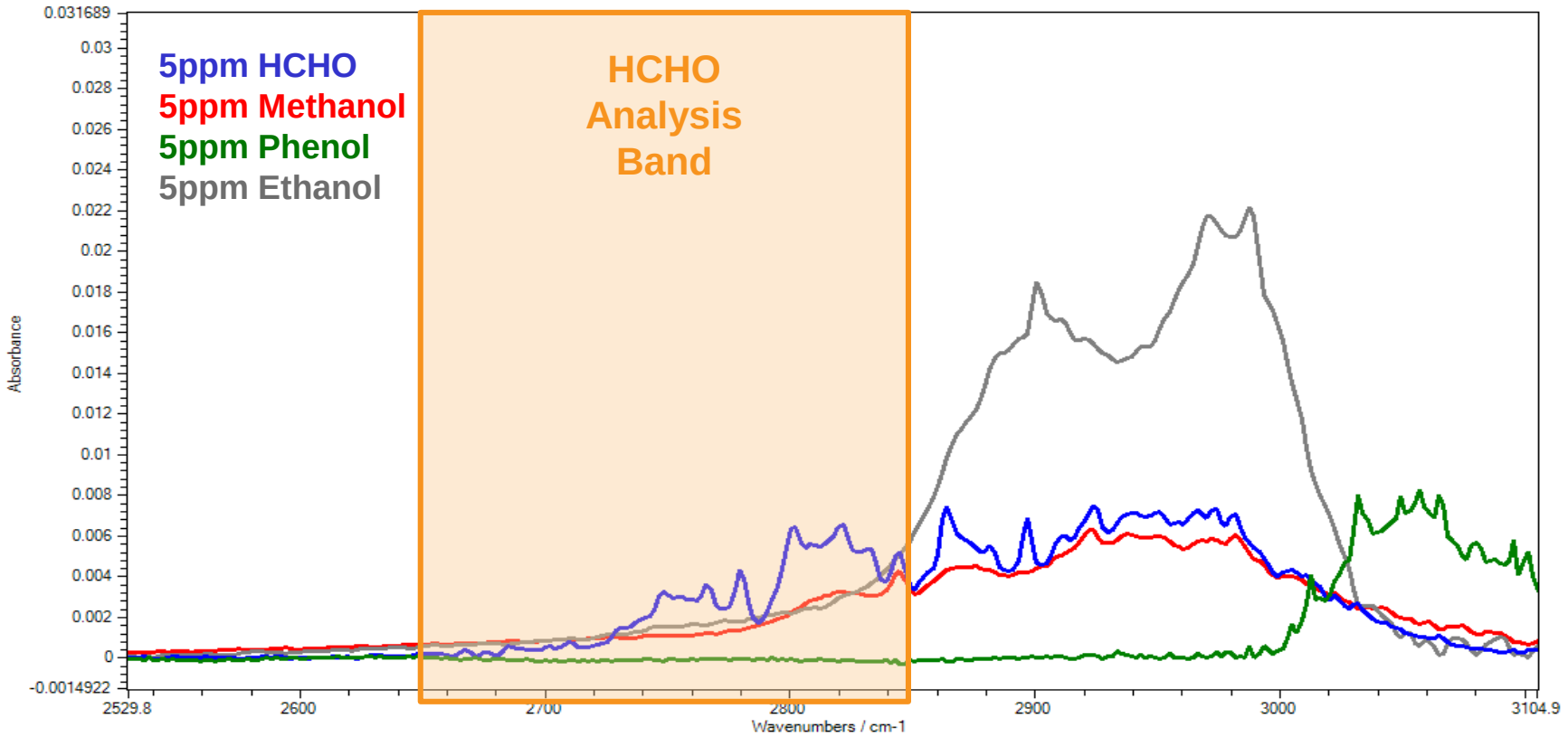
- For many years, phenol-formaldehyde has been used as an embalming fluid in hospital and medical research
- Persons working in such an environment need to be protected from HCHO emissions from the fluid.
- Workplaces have a duty of care to monitor and reduce HCHO levels in ambient to save levels.
- Protea participated in a case study at a medical school to demonstrate the power of FTIR in such an application

CASE STUDY: Background Gases

- A number of other interfering species were found present in the analysed air
- These were all components originating from the embalming fluid

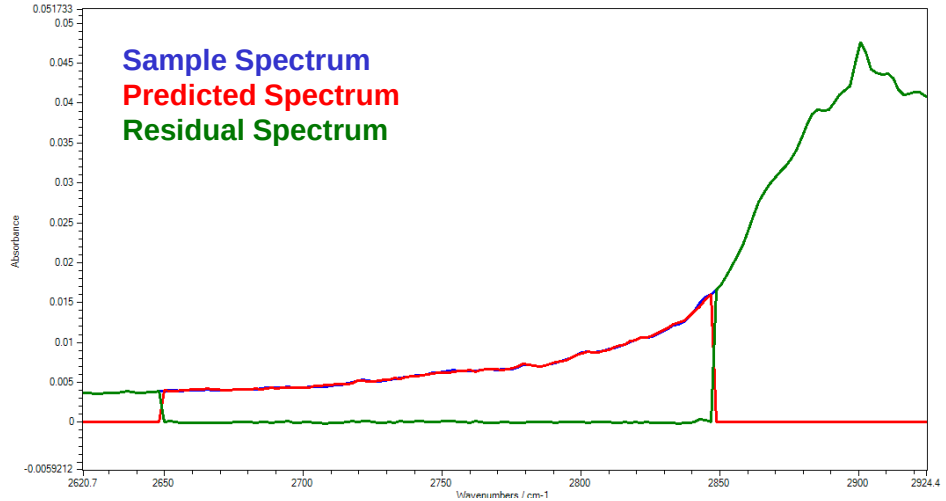
Species	Typical Concentration	Can it be measured by FTIR?	Detection Limit
Phenol	0.2 ppm	Yes	0.05
Methanol	15 ppm	Yes	0.10
Ethanol	0.8 ppm	Yes	0.10

CASE STUDY: Background Gases



CASE STUDY: Data Analysis

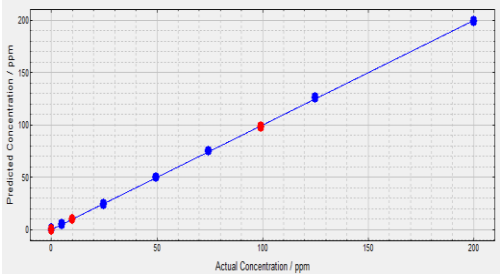
- By adding spectra of these known interferences to the PLS model we can train the model on the difference between HCHO spectra and other species.
- This way we can still accurately measure formaldehyde in the presence of other gases.
- Residuals indicate that all species are correctly being accounted for….



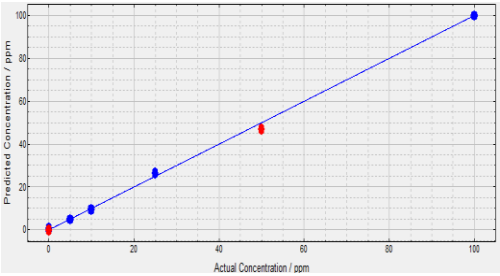
CASE STUDY: Data Analysis

- We can measure the other species too!!

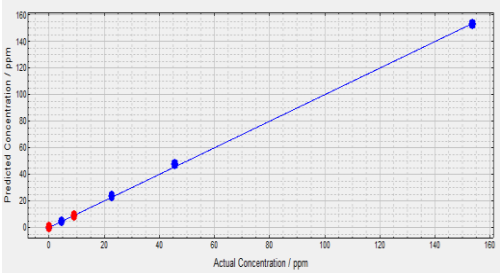
Ethanol

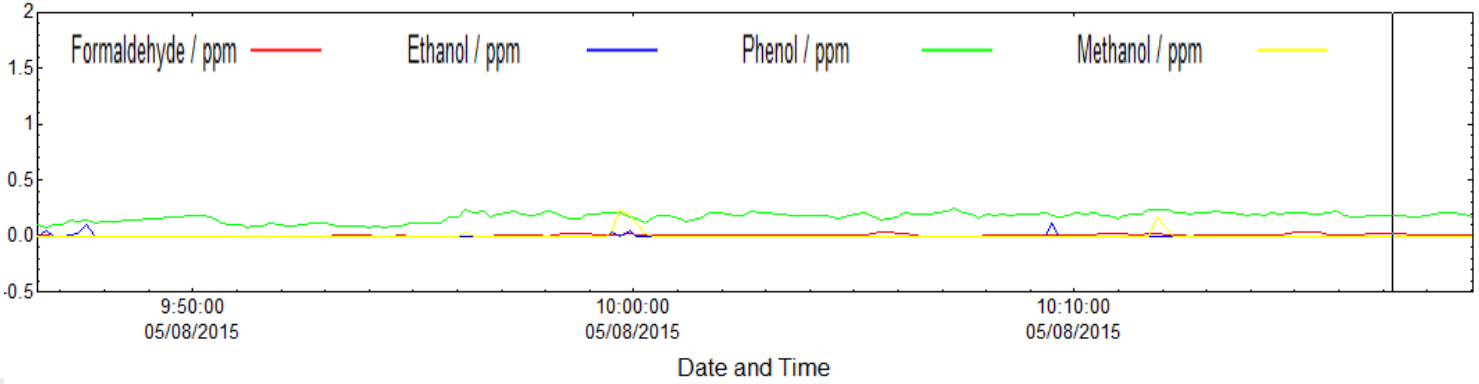


Methanol



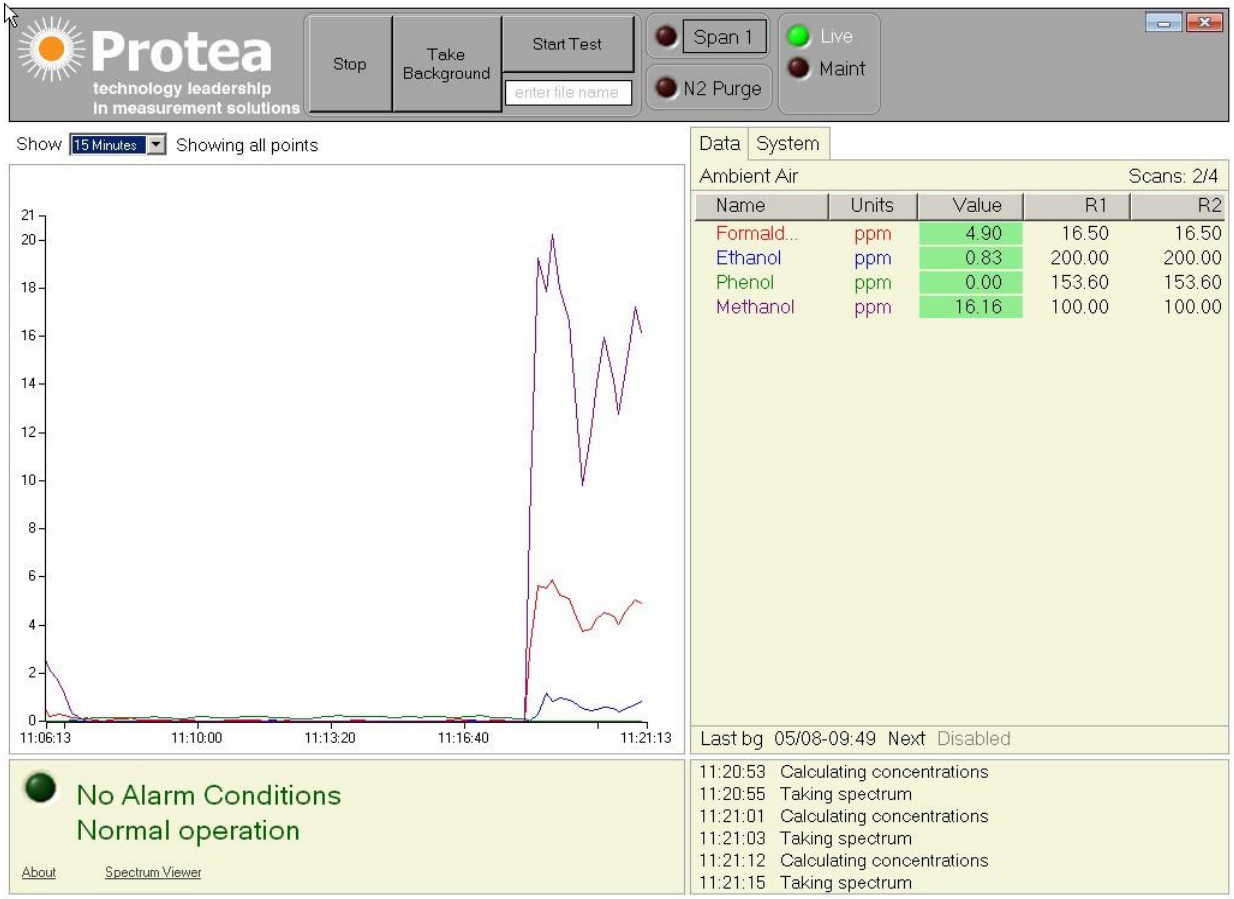
Phenol



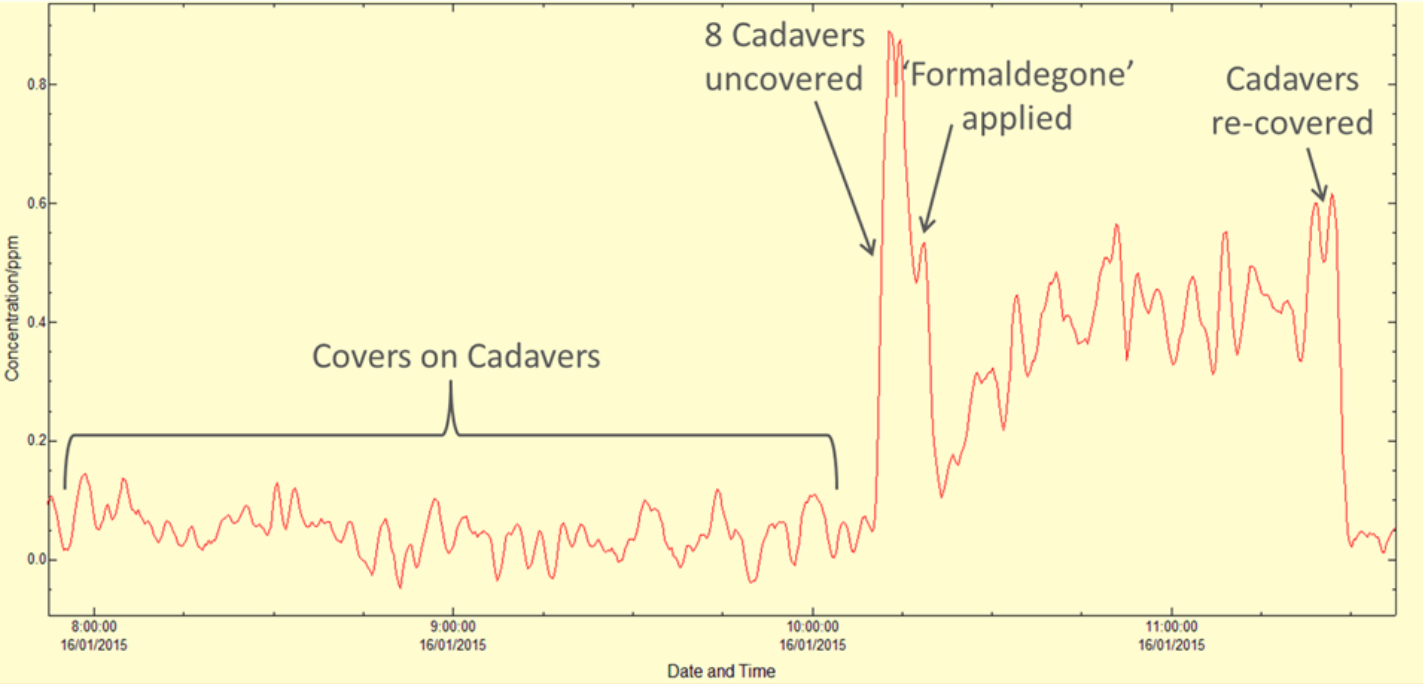


Formaldehyde / ppm	0.02	PASS
Ethanol / ppm	0.00	PASS
Phenol / ppm	0.17	PASS
Methanol / ppm	0.00	PASS

CASE STUDY: Real Time Results



CASE STUDY: Results



HCHO trend as measured my the software over the course of a day. A clear response to activity in the dissecting room can be seen.