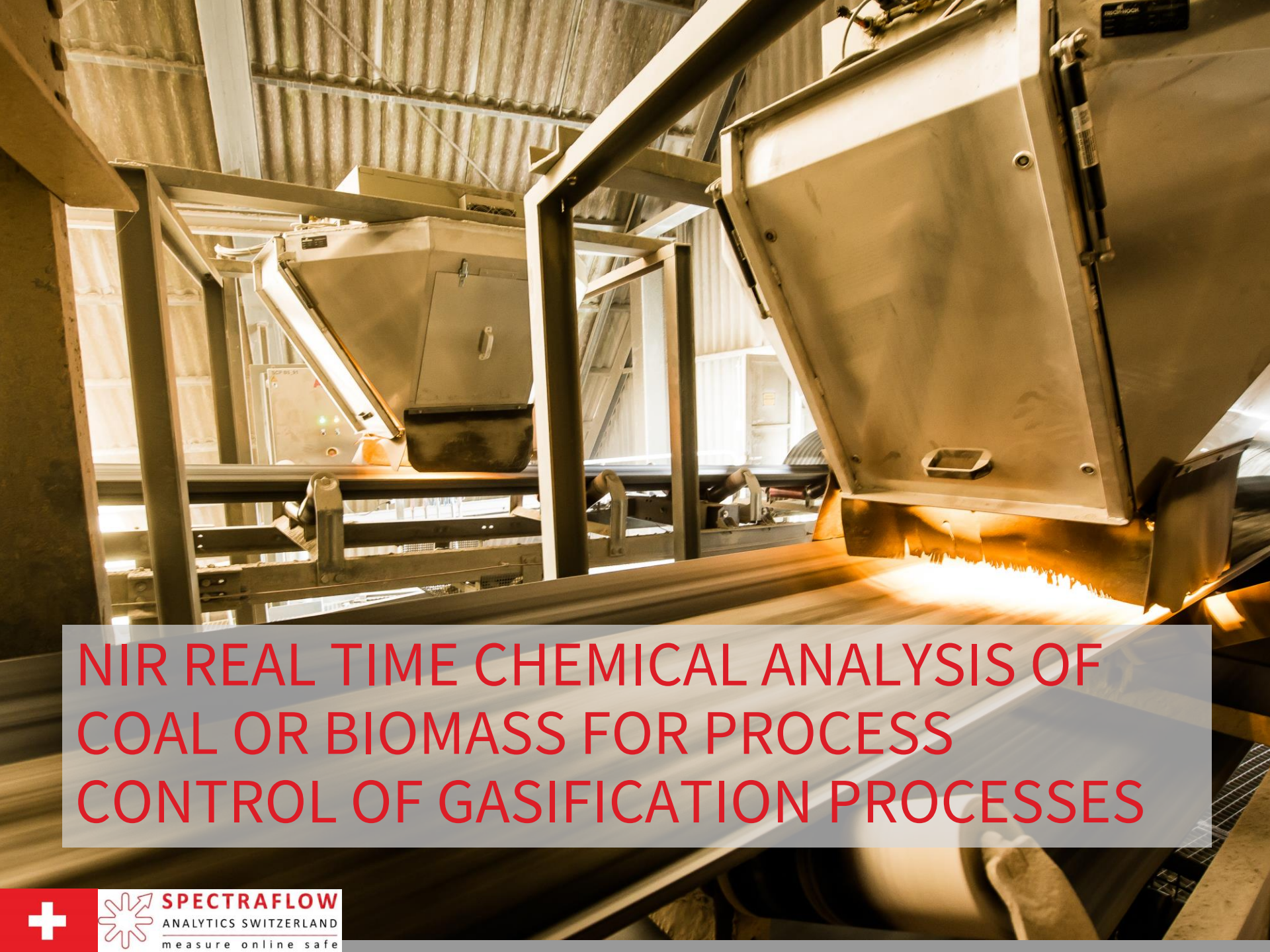

NIR REAL TIME CHEMICAL ANALYSIS OF COAL OR BIOMASS FOR PROCESS CONTROL OF GASIFICATION PROCESSES

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WHO WE ARE

ABB

SPECTRAFLOW
ANALYTICS SWITZERLAND
measure online safe

Installations & Partners

Holcim

AngloAmerican

TATA STEEL

FLSmidth

EGA

HOW MIGHT GASIFICATION PRODUCTIVITY AND PROFITABILITY BE OPTIMIZED?

- Accurate stockpile quality
- Stable resp. controlled feed
- Detection and reduction of contaminants
- Zero unwanted waste
- Active process control

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OUR SOLUTION: CROSSBELT & AIRSLIDE NIR ANALYSERS

SEEMLESS INTEGRATION INTO YOUR PROCESS IN MINE, FEED STOCK BLENDING, FEED & PROCESS CONTROL

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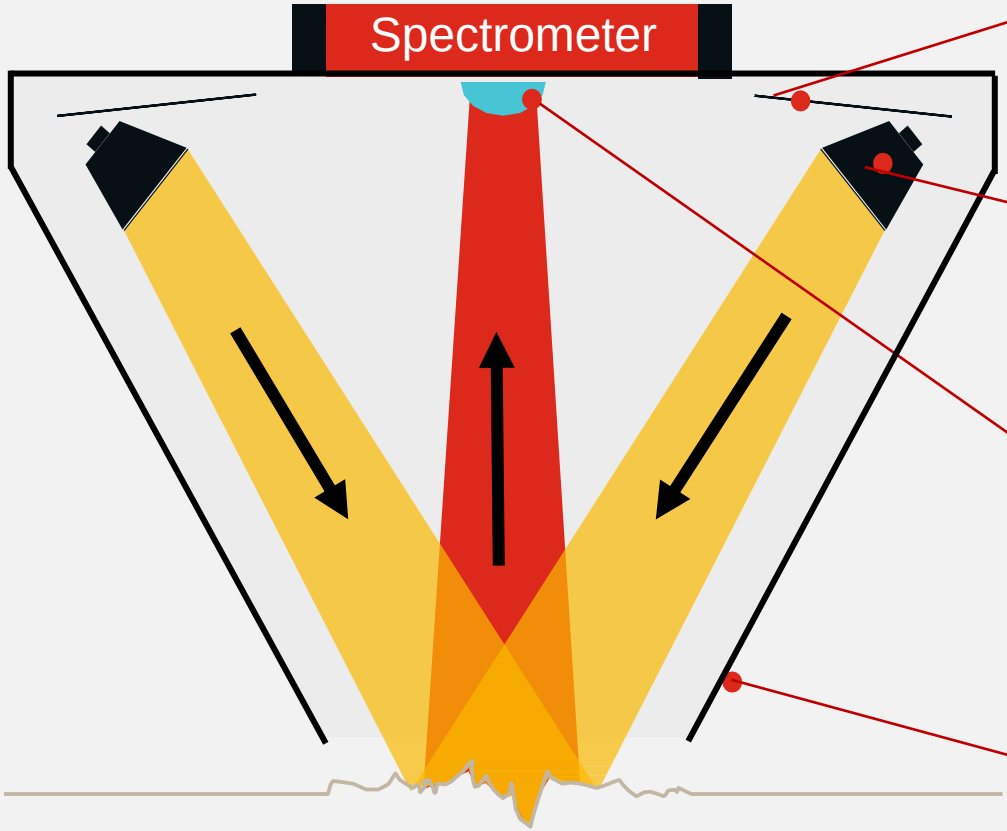
NIR SENSING IS SIMPLE IN PRINCIPLE YET ROBUST IN PRACTICE



Bulk Material

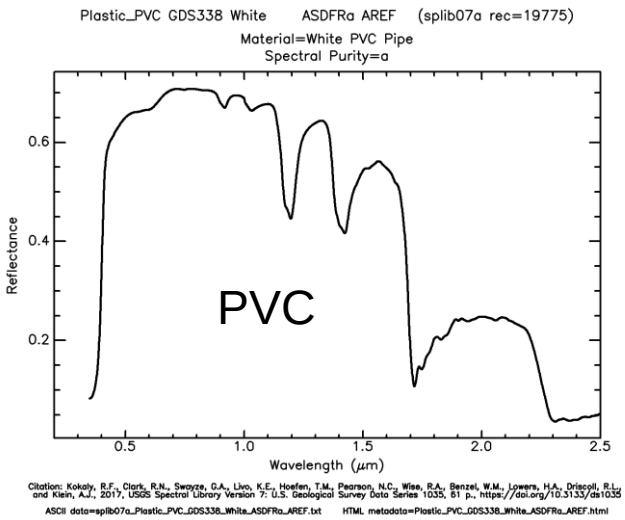
Rails for lamp positioning

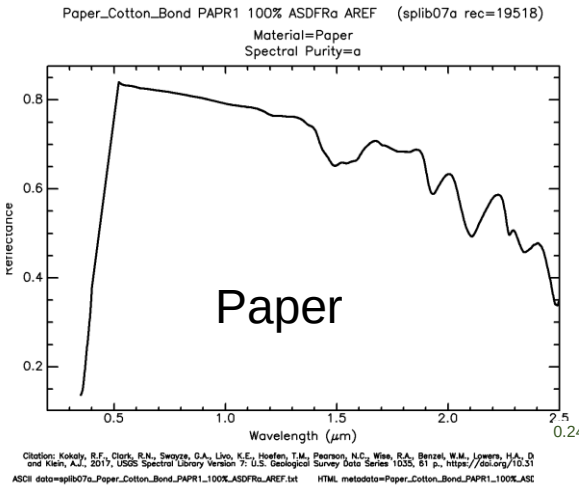
- Halogen bulb
- 2 - 8 lamps
- 50 Watt each

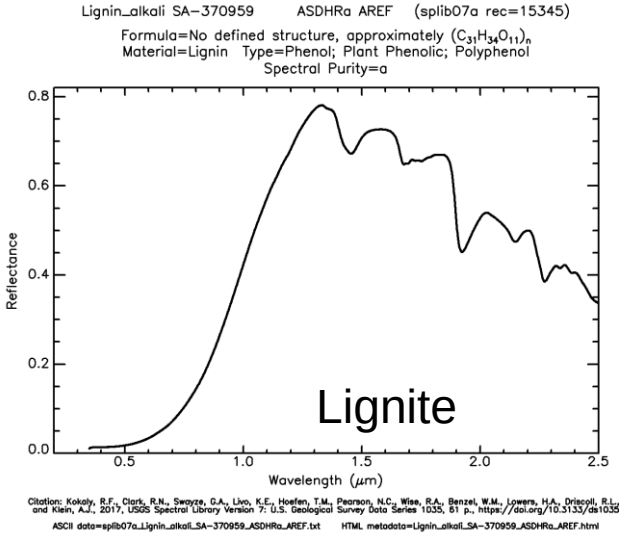
Entry lens of spectrometer

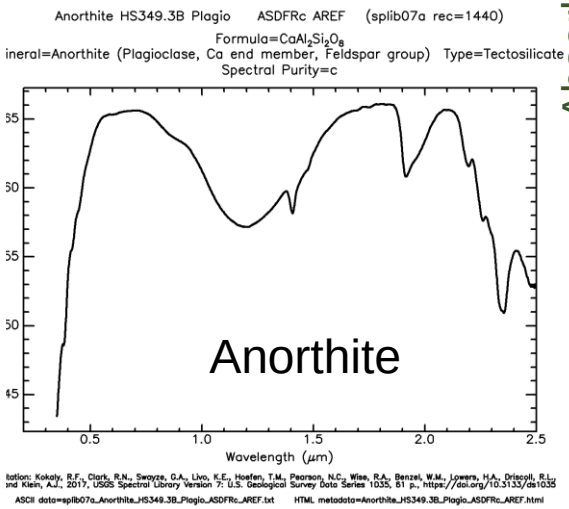
Light and dust shield

NIR FOR ORGANICS AS WELL AS MINERALS & MOISTURE

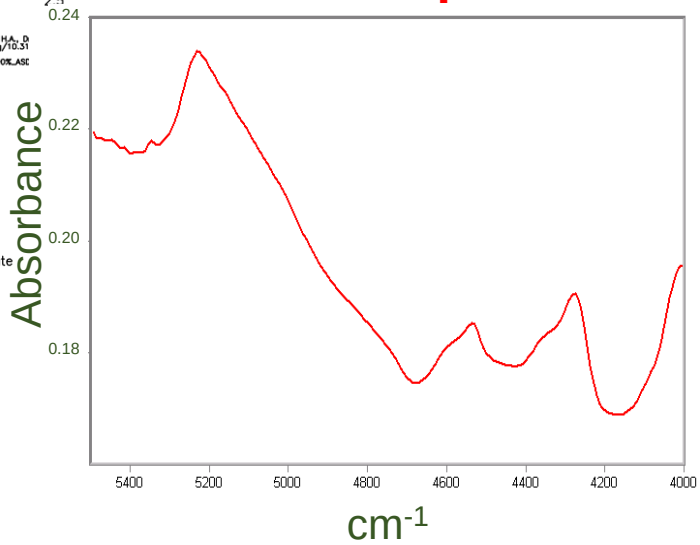




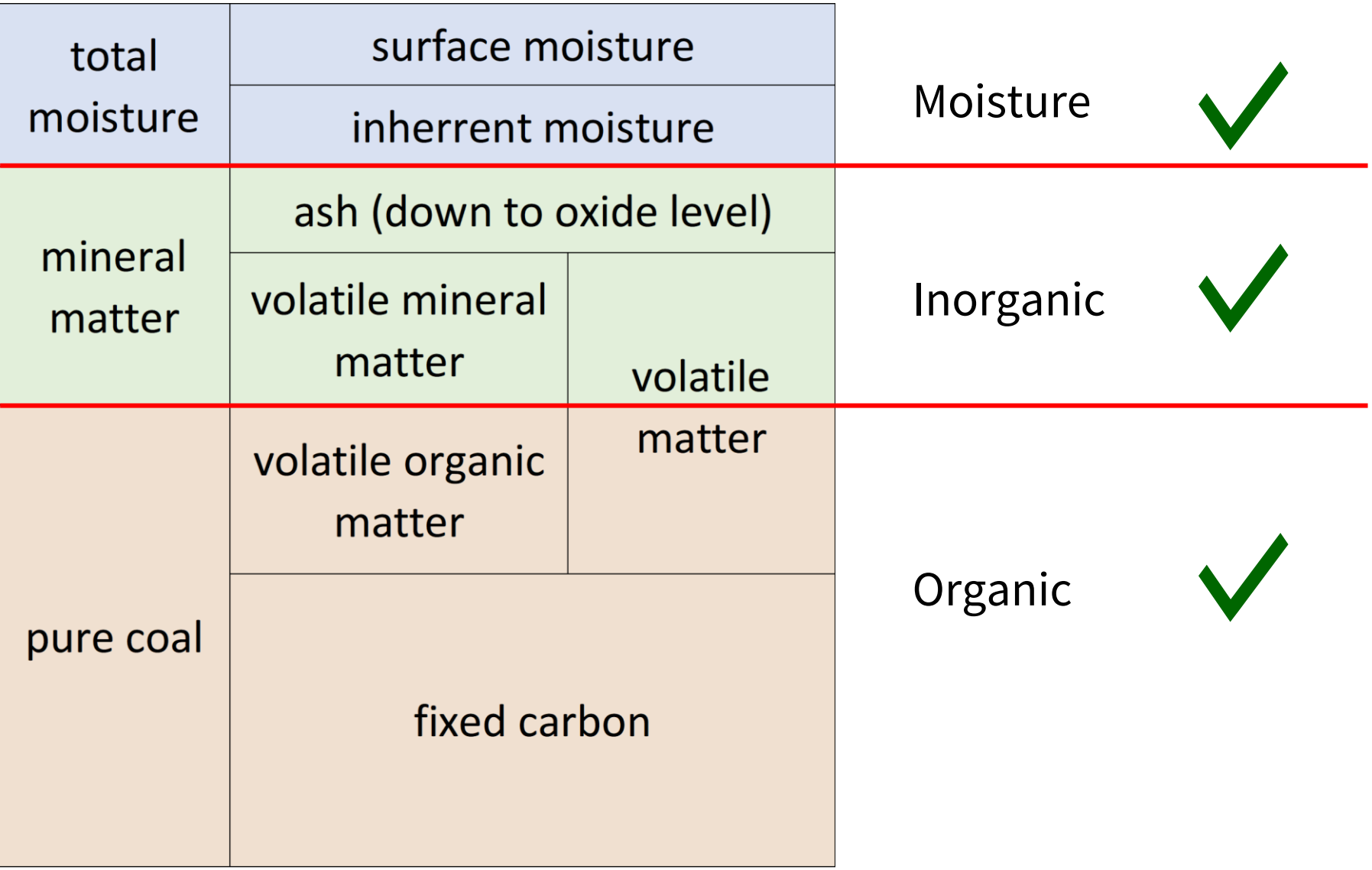




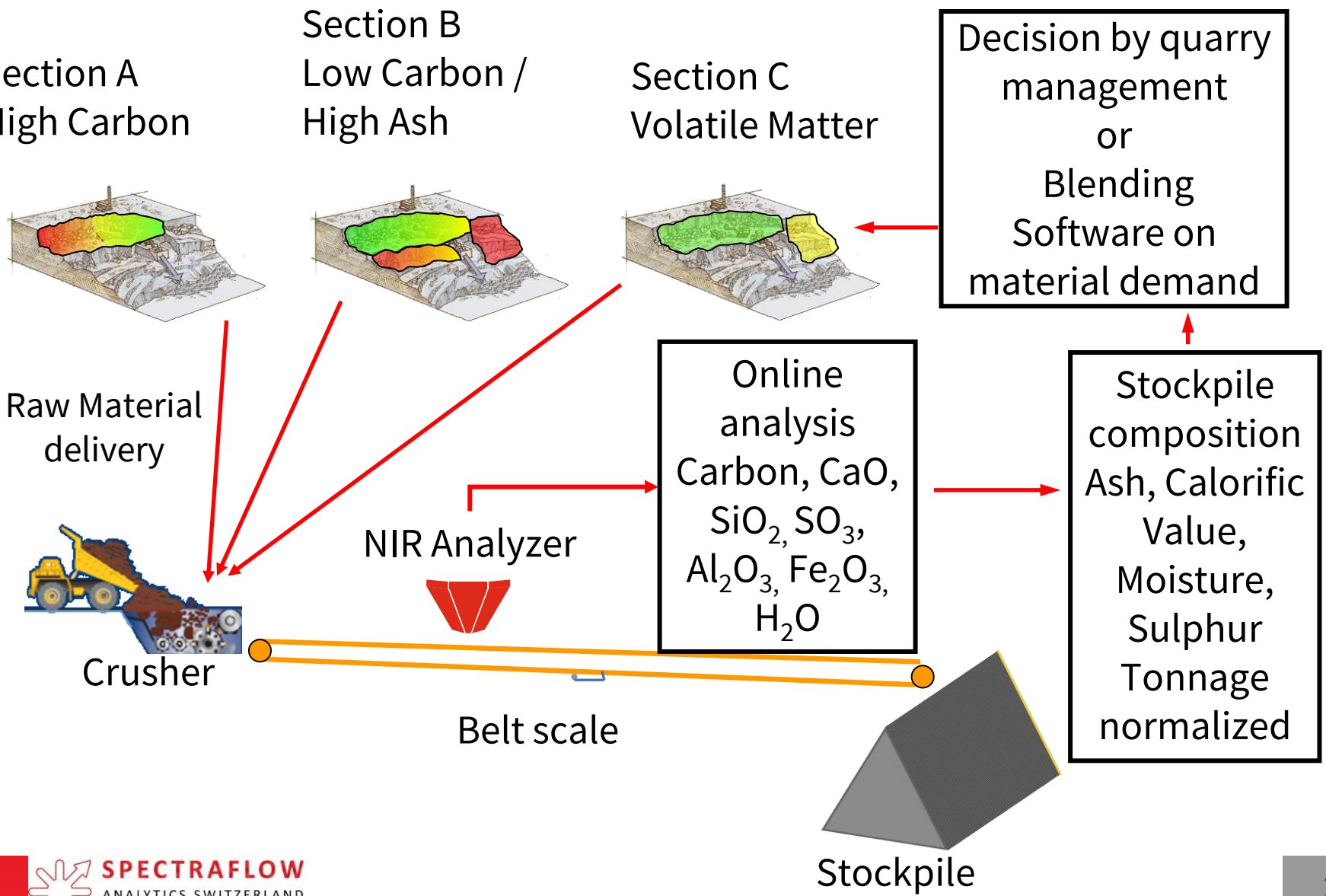
SFA NIR Spectra



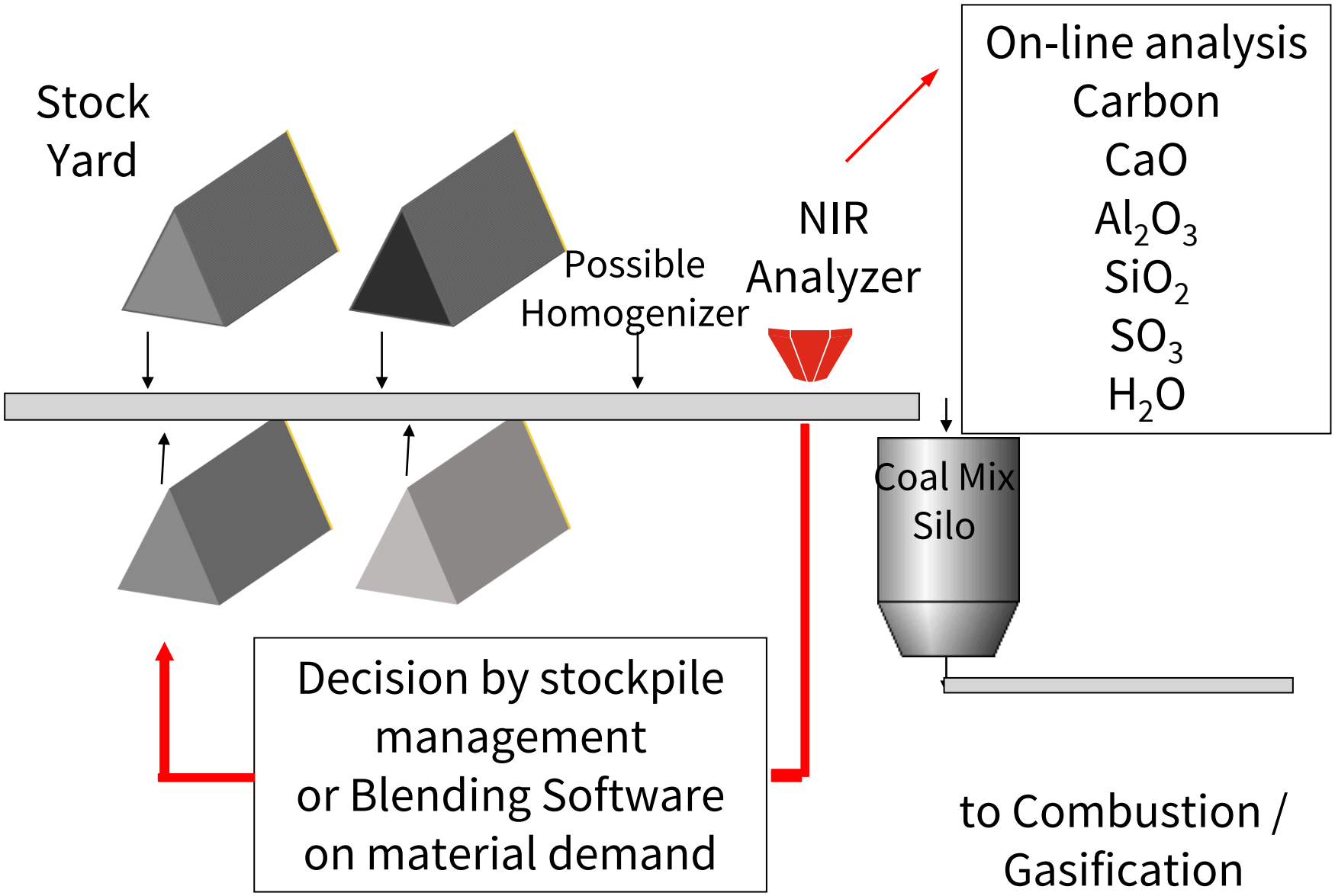
FULL COAL, MSW OR BIOMASS ANALYSIS BY NIR



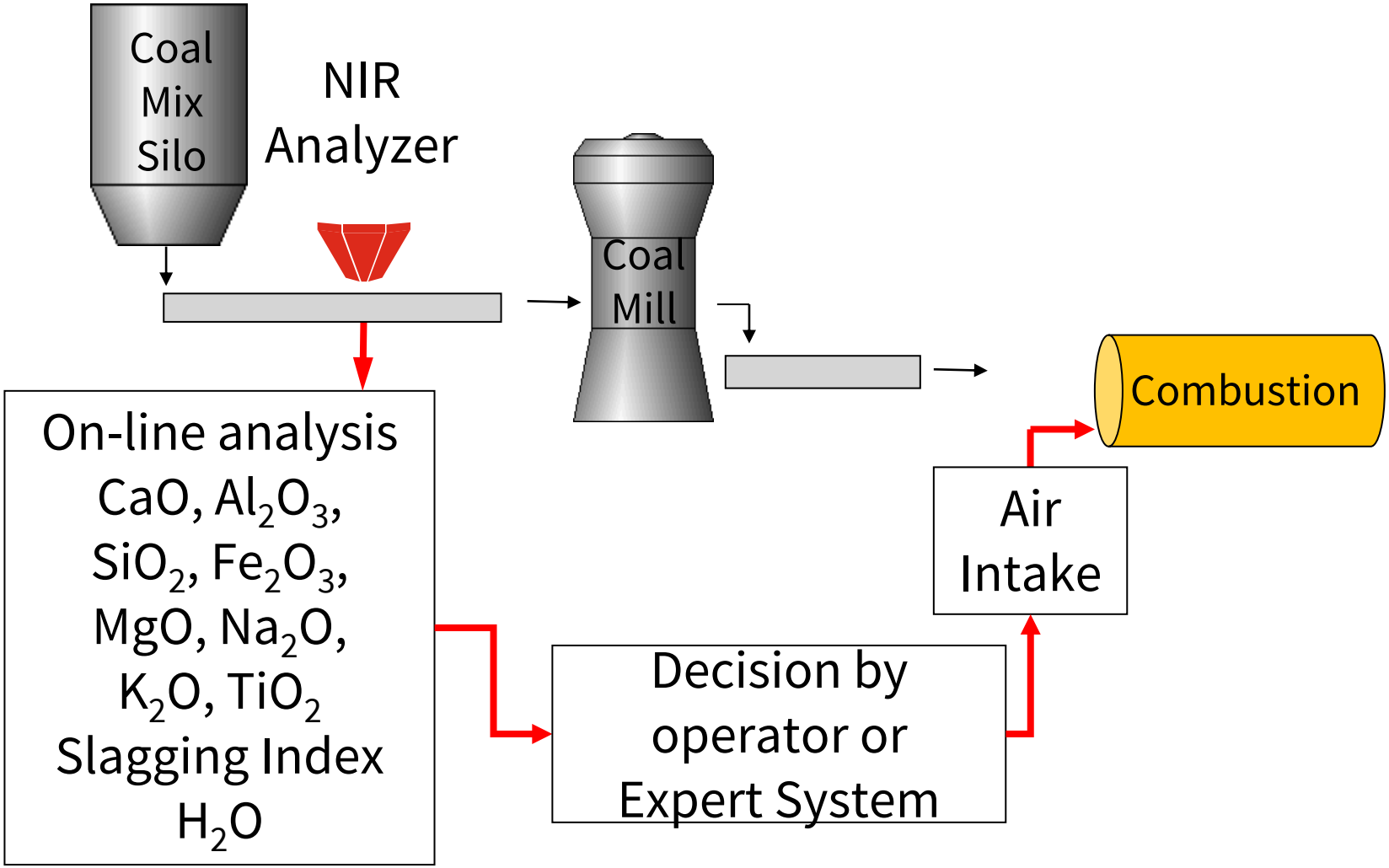
QUARRY / FEED STOCK OPTIMIZATION / BLENDING



COAL / FEED STOCK BLEND



PROCESS CONTROL



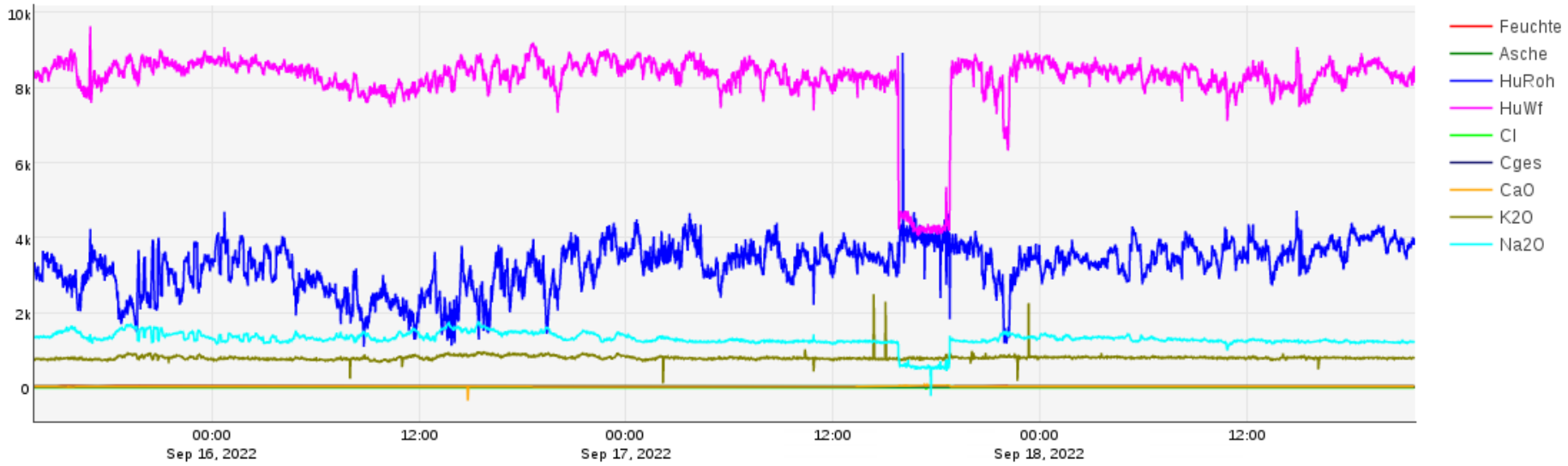
SPECTRAFLOW CASE STUDY 1 – ALTERNATIVE FULES @ UPM

- UPM: Paper Manufacturing plant in Germany
- Paper waste
- + other municipal waste
- Control of feed to combustion
- Main Constituents: Calorific value, Moisture, Cl

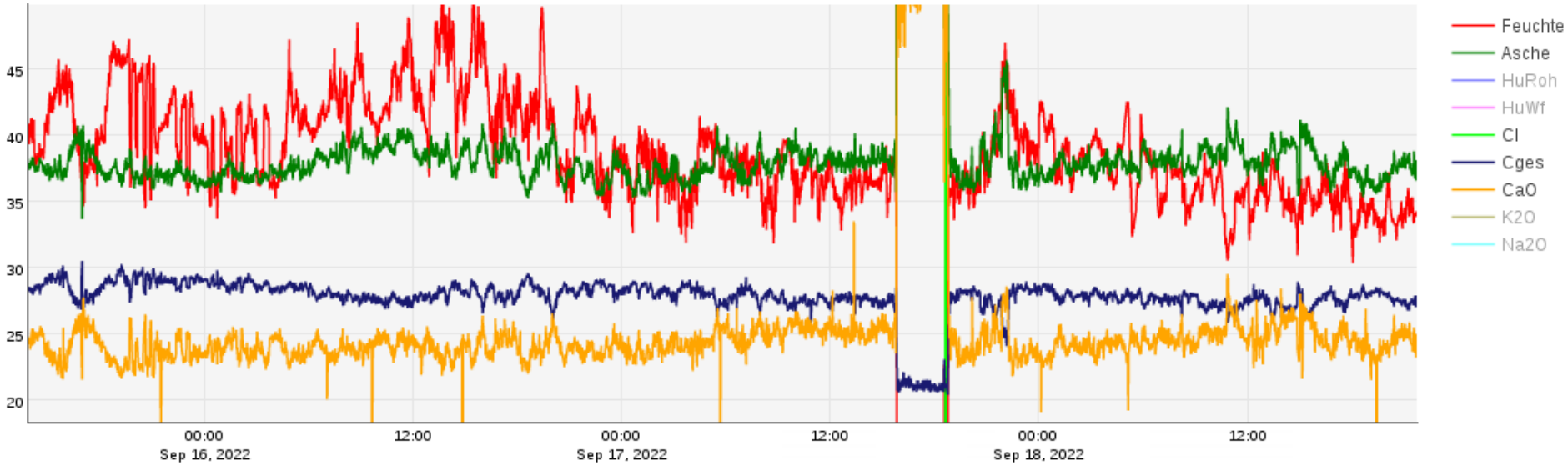
SPECTRAFLOW CASE STUDY 1 – ALTERNATIVE FULES @ UPM

		Min	**Max**	**Min**	**Max**	**± absolut 1 Sigma**	**± % deviation***	**Target range**
		Measurement range (for calibration)		Typical measurement range		Performance guarantee		± 1 Sigma
Chlor, ges.	%	0,00	1,50	0,00	0,60	0,06	10,0	0,04
Lower heating value $_{raw}$	kJ/kg OS	1.800	10.000	2.500	6.500	360	9,0	250
Dry mass	%	40,0	80,0	55	75	2,0	10,0	1,5
Ash 950°C	%	25,0	55,0	25	50	2,0	8,0	1,5
C(total)	%	20,0	40,0	20	40	1,5	8,0	1,5
CaO	%	10,0	50,0	15	45	3,0	10,0	
Potasium	mg/kg	0	6000	300	5.00	250	5,0	200
Sodium	mg/kg	0	3000	500	2.60	250	12,0	

SPECTRAFLOW CASE STUDY 1 – ALTERNATIVE FULES @ UPM



SPECTRAFLOW CASE STUDY 1 – ALTERNATIVE FULES @ UPM



SPECTRAFLOW CASE STUDY 1 – ALTERNATIVE FULES @ UPM

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SPECTRAFLOW CASE STUDY 1 – ALTERNATIVE FULES @ UPM

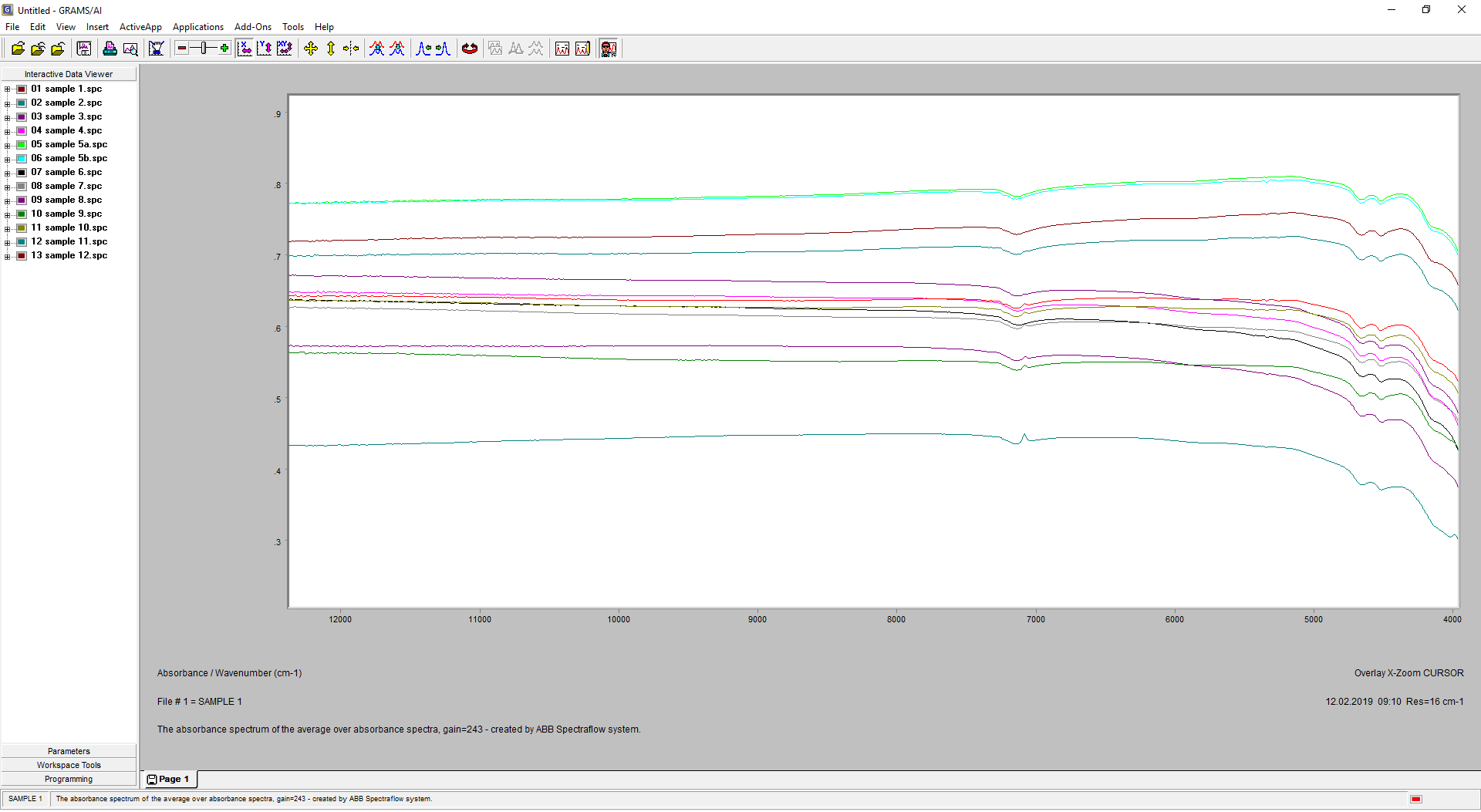
SPECTRAFLOW CASE STUDY 2 – Minerals in Fly Ash @ India client

- plant was using fly ash as a flux in 2018 for their gasification project
- Question was the mineral content of the ash to be able to automate the calculation of slag & viscosity in FactSage
- Amorphous vs. Crystaline content?
- CaO vs. Anhydrite / Gehlenite / Anorthite / Calcite

SPECTRAFLOW CASE STUDY 2 – Minerals in Fly Ash @ India client

Component and Formula	FlyAsh Sample 6 F-IC (Indonesian) 17/09/2018	FlyAsh Sample 8 F-IC (Indonesian) 14/09/2018	FlyAsh Sample 7 F-IC (Indonesian) 10.09.2018	FlyAsh Sample 4 F-IC (Indonesian) 07.09.2018	FlyAsh Sample 3 F-IC (Indonesian) 03.09.2018	FlyAsh Sample 2 F-IC (Indonesian) 31/08/2018	FlyAsh Sample 5 F-SA (S. African) 24/09/2018	FlyAsh Sample 1 F-SA MV-C (S. African MV Catherina) 27/08/2018	FlyAsh Sample 10 F-SA (S. African) 24/08/2018	FlyAsh Sample 9 F-SA (S. African) 17/08/2018	FlyAsh Sample 11 F-CCPP-AHP 24/09/2018	FlyAsh Sample 12 CCPP-AHP 20/08/2018
Amorphous Fraction (%)	**52.53**	**46.82**	**29.13**	**51.12**	**25**	**21.69**	**44.45**	**29.58**	**37.28**	**10.43**	**32.49**	**41.25**
Crystalline Fraction (Total %)	**47.47**	**53.18**	**70.87**	**48.88**	**75**	**78.31**	**55.55**	**70.42**	**62.72**	**89.57**	**67.51**	**58.75**
Iron Silicate (Fe_7SiO_{10})	**1.51**	**3.45**	3.35	2.78	2.43	2.31	**2.98**	**2.78**	2.58	1.58	2.12	1.85
Lime (CaO)	0.81	1.48	5.89	1.25	4.86	8.13	4.16	5.68	6.04	11.26	3.15	2.63
Quartz (SiO_2)	17.28	19.11	23.76	17.95	27.38	24.63	14.59	18.67	14.94	21.17	26.72	23.2
Calcite ($CaCO_3$)	1.5	1.18	1.18	1.5	2.73	1.19	-	-	-	17.71	-	-
Nepheline ($Na_{7.11}Al_{7.2}Si_{8.8}O_{32}$)	3.46	3.5	0.86	1.9	5.3	2.12	0.88	1.15	0.82	3.16	3.18	3.31
Mullite ($Al_{4.64}Si_{1.36}O_{9.68}$)	2.86	4.55	6.57	2.6	6.52	9.27	6.56	7.78	5.37	5.56	5.93	6.72
Hematite (Fe_2O_3)	2.62	2.3	3.57	2.51	3.19	3.21	3.02	3.78	3.39	3.56	3.27	3.03
Titanium Oxide (TiO_2)	1.78	1.48	3.43	1.63	3.62	5.72	2.04	1.89	1.82	1.89	1.58	1.33
Phosphide Oxide (P_2O_5)	2.13	0.6	1.9	2.47	1.78	7.17	-	-	-	-	-	-
Anhydrite ($CaSO_4$)	1.11	1.57	6.21	1.94	4.58	7.9	4.23	6.51	6.4	6.12	3.99	3.84
Anorthite ($Na_{0.14}Ca_{0.85}Al_{1.83}Si_{2.16}O_8$)	4.06	5.85	6.12	5.75	7.32	7.25	8.33	7.36	8.98	5.44	6.95	6.15
Sodium Silicon Oxide ($Na_6Si_8O_{19}$)	4.61	4.19	3.33	2.63	2.11	-	-	-	-	-	-	-
Gehlenite ($Ca2Al_2SiO_7$)	3.79	3.92	2.88	3.99	5.3	3.11	1.93	3.13	3.15	3.03	1.89	0.61
Periclase (MgO)	-	-	0.59	-	1.16	0.91	1.99	2.06	1.86	2.15	1.31	1.67
Potassium Oxide (K_2O)	-	-	1.16	-	0.94	1.53	2.15	3.95	3.48	3.27	2.91	2.65
Potassium Sodium Oxide (KNaO)	-	-	-	-	-	-	0.55	1.11	0.98	-	-	-
Calcite (Mg)	-	-	-	-	-	-	2.18	1.74	1.63	2.39	2.51	1.23
Portlandite $Ca(OH)_2$	-	-	-	-	-	-	-	-	1.27	1.27	2	0.53

SPECTRAFLOW CASE STUDY 2 – Minerals in Fly Ash @ India client



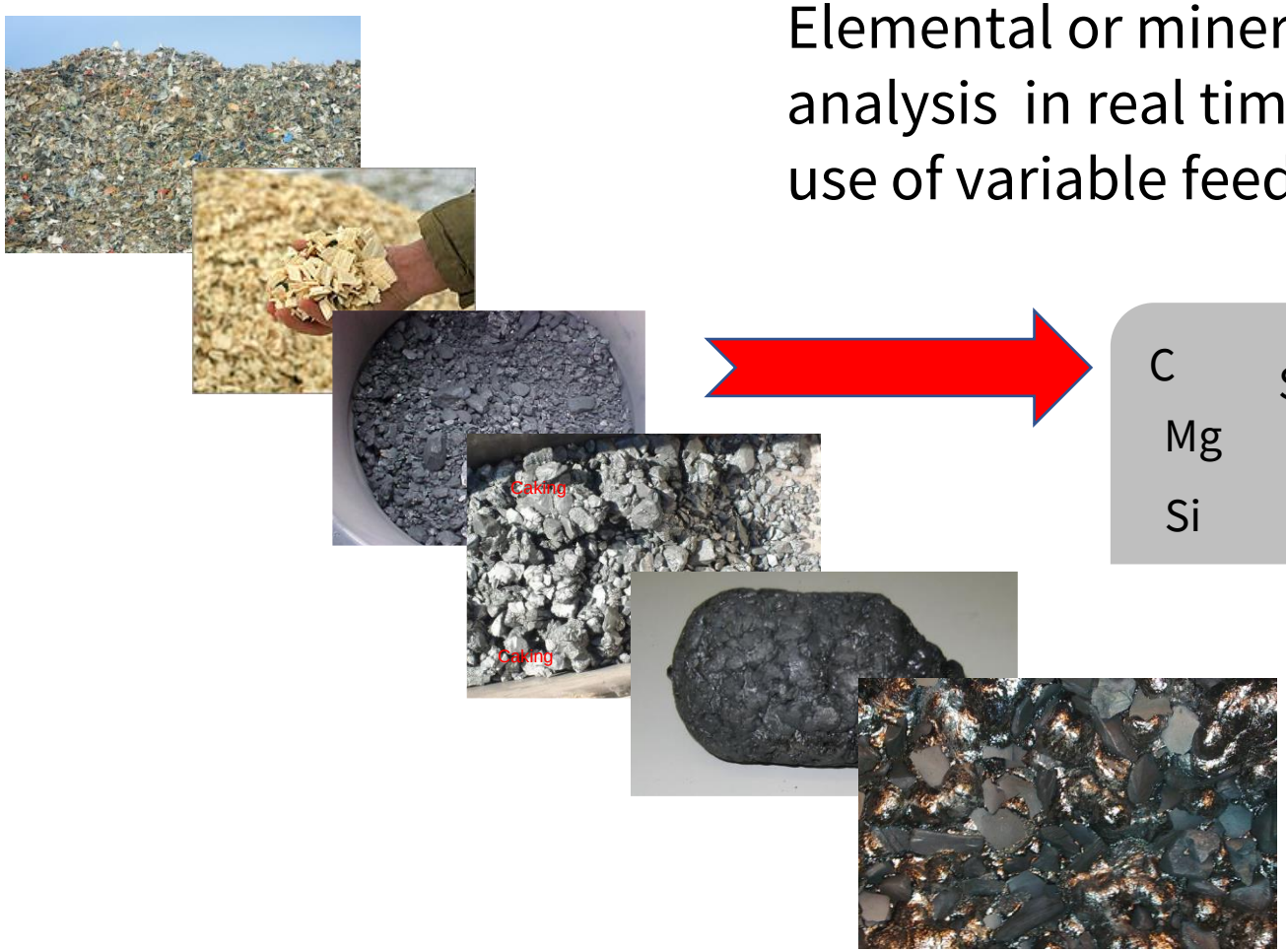
SPECTRAFLOW CASE STUDY 2 – Minerals in Fly Ash @ India client

Component and Formula	Amorphous Fraction (%)	Crystalline Fraction (%)	Lime (CaO)	Anhydrite (CaSO4)
min	21.69	47.47	0.81	1.11
max	52.53	78.31	8.13	7.90
Range	30.84	30.84	7.32	6.79
Calibration R^2	0.95	0.94	0.98	0.99
Test RMSEP	2.30	2.10	0.69	0.35
% RMSEP	7.4	6.8	9.4	5.1
Prediction				
Sample 1 (Lab %)	29.58	70.42	5.68	6.51
Sample 1 - SFA Prediction	*32.85*	*68.15*	*6.59*	*7.02*
delta in % of range	*0.11*	*0.07*	*0.12*	*0.08*
delta absolut	*3.27*	*2.27*	*0.91*	*0.51*
Sample 5b	44.45	55.55	4.16	4.23
Sample 5b - SFA Prediction	*46.00*	*53.81*	*4.31*	*4.51*
delta in % of range	*0.05*	*0.06*	*0.02*	*0.04*
delta absolut	*1.55*	*1.74*	*0.15*	*0.28*

SPECTRAFLOW CASE STUDY 2 – Minerals in Fly Ash @ India client

Component and Formula	Anorthite (Na0.14Ca0.85 Al1.83Si2.16O8)	Gehlenite (Ca2Al2SiO7)	Calcite combined (CaCO3 & Mg)	Calcite (CaCO3)	Calcite (Mg)
min	4.06	0.61	1.18	1.18	1.23
max	8.98	5.30	2.73	2.73	2.51
Range	4.92	4.69	1.55	1.55	1.28
Calibration R^2	0.96	0.99	0.92	0.98	0.98
Test RMSEP	0.98	0.17	0.22	0.06	0.06
% RMSEP	20	3.6	14.6	3.8	4.7
Prediction				*s. 2*	
Sample 1	7.36	3.13	1.74	1.19	1.74
Sample 1 - SFA Pred.	*8.53*	*3.17*	*1.80*	*1.21*	*1.73*
delta in % of range	*0.24*	*0.01*	*0.04*	*0.01*	*0.01*
delta absolut	*1.17*	*0.04*	*0.06*	*0.02*	*0.01*
				s. 6	
Sample 5b	8.33	1.93	2.18	1.50	2.18
Sample 5b - SFA Pred.	*7.59*	*2.11*	*1.95*	*1.51*	*2.16*
delta in % of range	*0.15*	*0.04*	*0.15*	*0.01*	*0.02*
delta absolut	*0.74*	*0.18*	*0.23*	*0.01*	*0.02*

FROM ANALYTICS TO ACTIVE PROCESS CONTROL



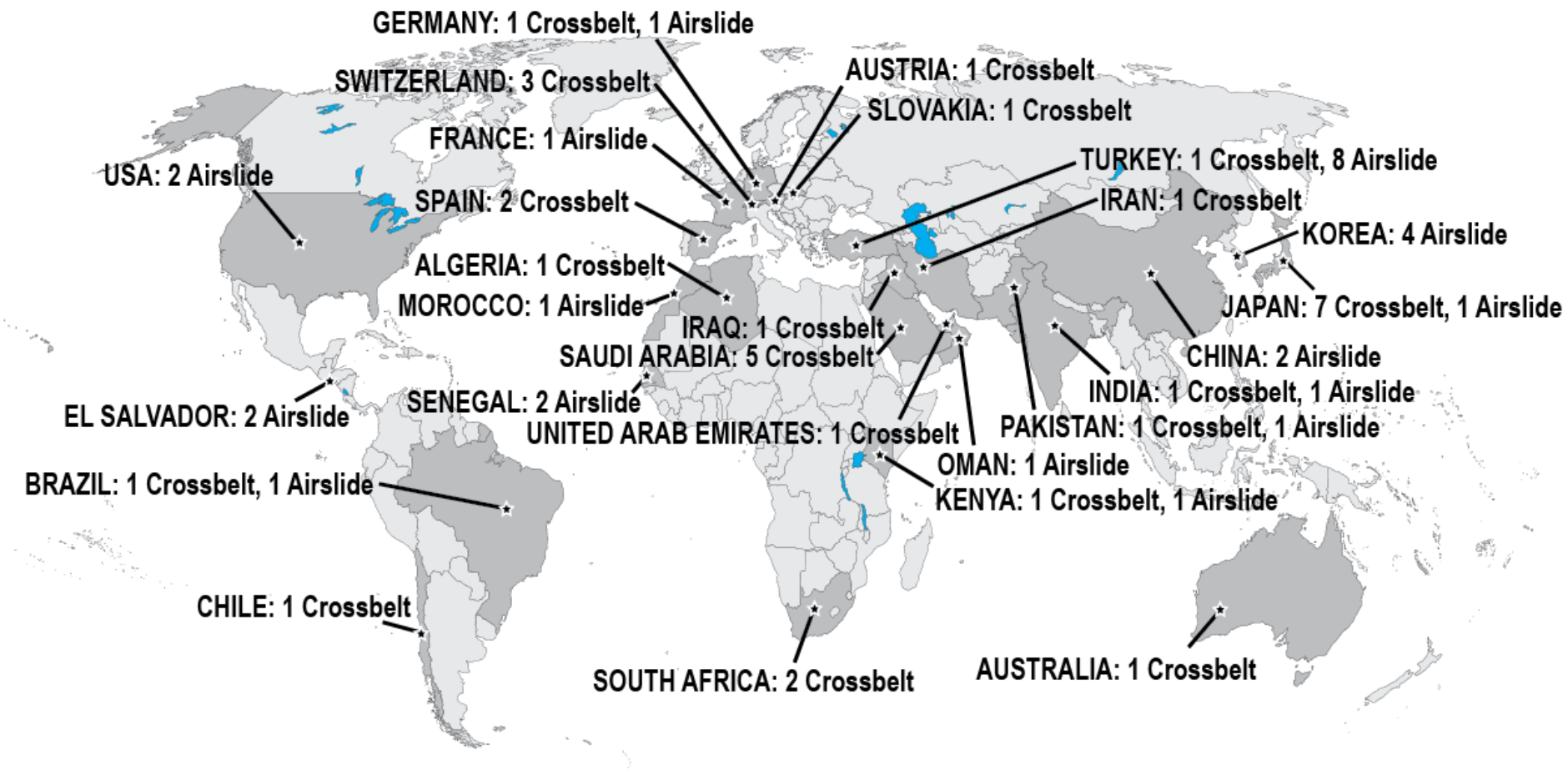
Elemental or mineral phase analysis in real time allowing the use of variable feed stock

C Al S Cr O V Mg Fe N Si Ca H

FROM ANALYTICS TO ACTIVE PROCESS CONTROL

- Elemental or mineral phase analysis in real time allowing the use of variable feed stock
- Ability to reject, recirculate or flux the feed
- Ability to adjust process parameters at the gasifier in real time, e.g. with the model in FactSage

INSTALLED BASE THROUGH VARIOUS INDUSTRIES



SUMMARY

- NIR is a proven industrial real time analytical method for minerals and organics
- NIR is sensitive to organics, minerals and moisture
- Real time analysis opens the opportunity to
  - Prepare stable feed
  - Balance variations with fluxes or by mixing feeds
  - Enable active real time process control for combustion or gasification e.g. by use of FactSage

PETRA.MUEHLEN@SPECTRAFLOW-ANALYTICS.COM

THANK YOU VERY MUCH FOR YOUR ATTENTION

NA MEASUREMENT IN PPM RANGE @EGA RECYCLE ANODES