

Sensor	FS1-1	FS1-2	FS1-3	FS1-4	FS1-5	FS1-6	FS2-1	FS2-2	FS2-3	FS2-4	FS2-5	FS2-6	FS3-1	FS3-2	FS3-3	FS3-4	FS3-5	FS3-6	FS4-1	FS4-2	FS4-3	FS4-4	FS4-5	FS4-6
	#N/A	#N/A	IPO	#N/A	#N/A	IP1	#N/A	#N/A	IP2	#N/A	#N/A	IP6	#N/A	#N/A	#N/A	IP10	#N/A	IP14	#N/A	IP18	#N/A	#N/A	IP22	IP23
									RAKE						RAKE				RAKE			RAKE		

Sensor	NS1-1	NS1-2	NS1-3	NS1-4	NS1-5	NS1-6	NS2-1	NS2-2	NS2-3	NS2-4	NS2-5	NS2-6	NS3-1	NS3-2	NS3-3	NS3-4	NS3-5	NS3-6	NS4-1	NS4-2	NS4-3	NS4-4	NS4-5	NS4-6
	#N/A	#N/A	TC0	TC3	TC1	TC4	#N/A	TC2	KU3	#N/A	OP0	#N/A	KU6	TC6	#N/A	KU5	OP1	KU0	#N/A	OP2	TC15	#N/A	OP3	KU7
									TC9	RAKE			TC7		RAKE				RAKE			RAKE		

Further Instrumentation		
Location	Sensor	Working
TS1-1	TC8	
TS2-1	TC10	
TS3-1	TC12	
TS4-1	TC14	
R1-1	IP3	
R1-2	IP4	
R1-3	IP5	
R2-1	IP7	
R2-2	IP8	
R2-3	IP9	
R3-1	IP11	
R3-2	IP12	
R3-3	IP13	
R4-1	IP15	
R4-2	IP16	
R4-3	IP17	
R5-1	IP19	
R5-2	IP20	
R5-3	IP21	
KU3	TC9	
KU4	#N/A	
KU6	TC5	
pitot	TC11	

Ionisation Probe	Light Blue
Pressure Transducer	Yellow
Thermocouple	Orange
Optical Probe	Red

Item	Location	DAQ	Channel	Measurement	Instrument	Supplier	Range	Signal	Excitation	S/R
IP0	FS1-3	PXIe	PXI Slot2/ai0	Flame Presence	Ionisation Probe	Bruce Ewan	TBC	-5 to 5V	60V	100 kHz
IP1	FS1-6	PXIe	PXI Slot2/ai1	Flame Presence	Ionisation Probe	Bruce Ewan	TBC	-5 to 5V	60V	100 kHz
IP2	FS2-3	PXIe	PXI Slot2/ai2	Flame Presence	Ionisation Probe	Bruce Ewan	TBC	-5 to 5V	60V	100 kHz
IP3	R1-1	PXIe	PXI Slot2/ai3	Flame Presence	Ionisation Probe	Bruce Ewan	TBC	-5 to 5V	60V	100 kHz
IP4	R1-2	PXIe	PXI Slot2/ai4	Flame Presence	Ionisation Probe	Bruce Ewan	TBC	-5 to 5V	60V	100 kHz
IP5	R1-3	PXIe	PXI Slot2/ai5	Flame Presence	Ionisation Probe	Bruce Ewan	TBC	-5 to 5V	60V	100 kHz
IP6	FS2-6	PXIe	PXI Slot2/ai6	Flame Presence	Ionisation Probe	Bruce Ewan	TBC	-5 to 5V	60V	100 kHz
IP7	R2-1	PXIe	PXI Slot2/ai7	Flame Presence	Ionisation Probe	Bruce Ewan	TBC	-5 to 5V	60V	100 kHz
IP8	R2-2	PXIe	PXI Slot6/ai0	Flame Presence	Ionisation Probe	Bruce Ewan	TBC	-5 to 5V	60V	100 kHz
IP9	R2-3	PXIe	PXI Slot6/ai1	Flame Presence	Ionisation Probe	Bruce Ewan	TBC	-5 to 5V	60V	100 kHz
IP10	FS3-4	PXIe	PXI Slot6/ai2	Flame Presence	Ionisation Probe	Bruce Ewan	TBC	-5 to 5V	60V	100 kHz
IP11	R3-1	PXIe	PXI Slot6/ai3	Flame Presence	Ionisation Probe	Bruce Ewan	TBC	-5 to 5V	60V	100 kHz
IP12	R3-2	PXIe	PXI Slot6/ai4	Flame Presence	Ionisation Probe	Bruce Ewan	TBC	-5 to 5V	60V	100 kHz
IP13	R3-3	PXIe	PXI Slot6/ai5	Flame Presence	Ionisation Probe	Bruce Ewan	TBC	-5 to 5V	60V	100 kHz
IP14	FS3-6	PXIe	PXI Slot6/ai6	Flame Presence	Ionisation Probe	Bruce Ewan	TBC	-5 to 5V	60V	100 kHz
IP15	R4-1	PXIe	PXI Slot6/ai7	Flame Presence	Ionisation Probe	Bruce Ewan	TBC	-5 to 5V	60V	100 kHz
IP16	R4-2	PXIe	PXI Slot7/ai0	Flame Presence	Ionisation Probe	Bruce Ewan	TBC	-5 to 5V	60V	100 kHz
IP17	R4-3	PXIe	PXI Slot7/ai1	Flame Presence	Ionisation Probe	Bruce Ewan	TBC	-5 to 5V	60V	100 kHz
IP18	FS4-2	PXIe	PXI Slot7/ai2	Flame Presence	Ionisation Probe	Bruce Ewan	TBC	-5 to 5V	60V	100 kHz
IP19	R5-1	PXIe	PXI Slot7/ai3	Flame Presence	Ionisation Probe	Bruce Ewan	TBC	-5 to 5V	60V	100 kHz
IP20	R5-2	PXIe	PXI Slot7/ai4	Flame Presence	Ionisation Probe	Bruce Ewan	TBC	-5 to 5V	60V	100 kHz
IP21	R5-3	PXIe	PXI Slot7/ai5	Flame Presence	Ionisation Probe	Bruce Ewan	TBC	-5 to 5V	60V	100 kHz
IP22	FS4-5	PXIe	PXI Slot7/ai6	Flame Presence	Ionisation Probe	Bruce Ewan	TBC	-5 to 5V	60V	100 kHz
IP23	FS4-6	PXIe	PXI Slot7/ai7	Flame Presence	Ionisation Probe	Bruce Ewan	TBC	-5 to 5V	60V	100 kHz
OP0	NS2-5	PXIe	PXI1Slot4/ai0	Flame Presence	Optical Probe	Bruce Ewan	TBC	-5 to 5V	30V	100 kHz
OP1	NS3-5	PXIe	PXI1Slot4/ai1	Flame Presence	Optical Probe	Bruce Ewan	TBC	-5 to 5V	30V	100 kHz
OP2	NS4-2	PXIe	PXI1Slot4/ai2	Flame Presence	Optical Probe	Bruce Ewan	TBC	-5 to 5V	30V	100 kHz
OP3	NS4-5	PXIe	PXI1Slot4/ai3	Flame Presence	Optical Probe	Bruce Ewan	TBC	-5 to 5V	30V	100 kHz
OP4	NS4-5	PXIe	PXI1Slot4/ai4	Flame Presence	Optical Probe	Bruce Ewan	TBC	-5 to 5V	30V	100 kHz
OP5	NS4-5	PXIe	PXI1Slot4/ai5	Flame Presence	Optical Probe	Bruce Ewan	TBC	-5 to 5V	30V	100 kHz
TC0	NS1-3	PXIe	SC1Mod4/Wall	Gas Temperature (Wall)	K-Type Thermocouple	TC-Direct	1100°C	Conditioned	None	5 kHz
TC1	NS1-5	PXIe	SC1Mod4/ai1	Gas Temperature (Wall)	K-Type Thermocouple	TC-Direct	1100°C	Conditioned	None	5 kHz
TC2	NS2-2	PXIe	SC1Mod4/ai2	Gas Temperature (Wall)	K-Type Thermocouple	TC-Direct	1100°C	Conditioned	None	5 kHz
TC3	NS1-4	PXIe	SC1Mod4/ai3	Gas Temperature (Wall)	K-Type Thermocouple	TC-Direct	1100°C	Conditioned	None	5 kHz
TC4	NS1-6	PXIe	SC1Mod4/ai4	Gas Temperature (Wall)	K-Type Thermocouple	TC-Direct	1100°C	Conditioned	None	5 kHz
TC5	Ku6	PXIe	SC1Mod4/ai5	Gas Temperature (Wall)	K-Type Thermocouple	TC-Direct	1100°C	Conditioned	None	5 kHz
TC6	NS3-2	PXIe	SC1Mod4/ai6	Gas Temperature (Wall)	K-Type Thermocouple	TC-Direct	1100°C	Conditioned	None	5 kHz
TC7	NS3-2	PXIe	SC1Mod4/ai7	Gas Temperature (Wall)	K-Type Thermocouple	TC-Direct	1100°C	Conditioned	None	5 kHz
TC8	TS1-1	PXIe	SC1Mod4/ai8	Temperature (surface)	K-Type Thermocouple	TC-Direct	1100°C	Conditioned	None	5 kHz
TC9	KU3	PXIe	SC1Mod4/ai9	Temperature (kulite body)	K-Type Thermocouple	TC-Direct	1100°C	Conditioned	None	5 kHz
TC10	TS2-1	PXIe	SC1Mod4/ai10	Temperature (surface)	K-Type Thermocouple	TC-Direct	1100°C	Conditioned	None	5 kHz
TC11	pitot	PXIe	SC1Mod4/ai11	Temperature (kulite body)	K-Type Thermocouple	TC-Direct	1100°C	Conditioned	None	5 kHz
TC12	TS3-1	PXIe	SC1Mod4/ai12	Temperature (surface)	K-Type Thermocouple	TC-Direct	1100°C	Conditioned	None	5 kHz
TC13	NS3-1	PXIe	SC1Mod4/ai13	Temperature (kulite body)	K-Type Thermocouple	TC-Direct	1100°C	Conditioned	None	5 kHz
TC14	TS4-1	PXIe	SC1Mod4/ai14	Temperature (surface)	K-Type Thermocouple	TC-Direct	1100°C	Conditioned	None	5 kHz
TC15	NS4-3	PXIe	SC1Mod4/ai15	Temperature (pitot)	K-Type Thermocouple	TC-Direct	1100°C	Conditioned	None	5 kHz
KU0	NS3-6	PXIe	SC1Mod1/ai0	Pressure	Kulite					100 kHz
KU1	NS3-6	PXIe	SC1Mod1/ai1	Pressure	Kulite					100 kHz
KU2	NS3-6	PXIe	SC1Mod1/ai2	Pressure	XTEH-10L-190M-50BARA	Kulite		0-100 mV		100 kHz
KU3	NS2-3	PXIe	SC1Mod1/ai3	Pressure	Kulite					100 kHz
KU4	NS3-4	PXIe	SC1Mod1/ai4	Pressure	Kulite					100 kHz
KU5	NS3-4	PXIe	SC1Mod1/ai5	Pressure	Kulite					100 kHz
KU6	NS3-1	PXIe	SC1Mod1/ai6	Pressure	Kulite					100 kHz
KU7	NS4-6	PXIe	SC1Mod1/ai7	Pressure	Kulite					100 kHz
P81	TS3-6	PXIe	PXI Slot3/ai0	Pressure	113824	PCB	68 bar	0-5 V	20-30 V	1 MHz
P82	TS3-6	PXIe	PXI Slot3/ai0	Pressure	113825	PCB	68 bar	0-5 V	20-30 V	1 MHz

Date	14 April 2015
Time	15:53
Test Number	38
Mixture Composition	40%H2/60% CH4
Ambient Temperature	8 oC
Ambient Pressure	975 mbar
Wind Speed	0 m/s
Wind direction	
Relative Humidity	65.00%
Equivalence Ratio	0.60

### General Comments: (weather, rig configuration)

Weather: Cool but sunny and dry.  
 Tube configuration:  
 4 x 3m tube sections  
 igniter 250mm from beginning of tube section

Test with 15 rows of congestion (row 8 on central flange with 7 rows projecting upstream into tube 2 and 7 rows projecting downstream into tube 3. This is the lowest EQR used for this mixture. The combustion event is weak in intensity with a peak pressure of 363 mbar. Note that for this group of tests, the IPs sensor tips were treated to a blowtorch treatment raising them to yellow heat to attempt to remove any residual moisture. This was found in pre-checks to greatly improve their sharpness of performance. The results for this combustion test confirm this, with many more giving good flame transition signatures. The flame speeds are modest (~200 m/s at the exit) but there is also some evidence for this concentration that the flame propagation is complex with arrival times at some of the locations being out of the expected sequence. Flame speeds on the centreline are not always equal to the values measured with the wall sensors. For thi reason, the flame speeds based on the IPs are in two sets, one being based on the intervals between the wall sensors and the other based on the intervals between the array sensors within the body of the duct. The OPs provide an overall perspective across the tube diameter.

### Headlines

Max overpressure  
 mbar

Max. flame speed  
 m/s  
 [ionisation probes]

Max. temperature  
 °C

Mass Flow  
 kg/s

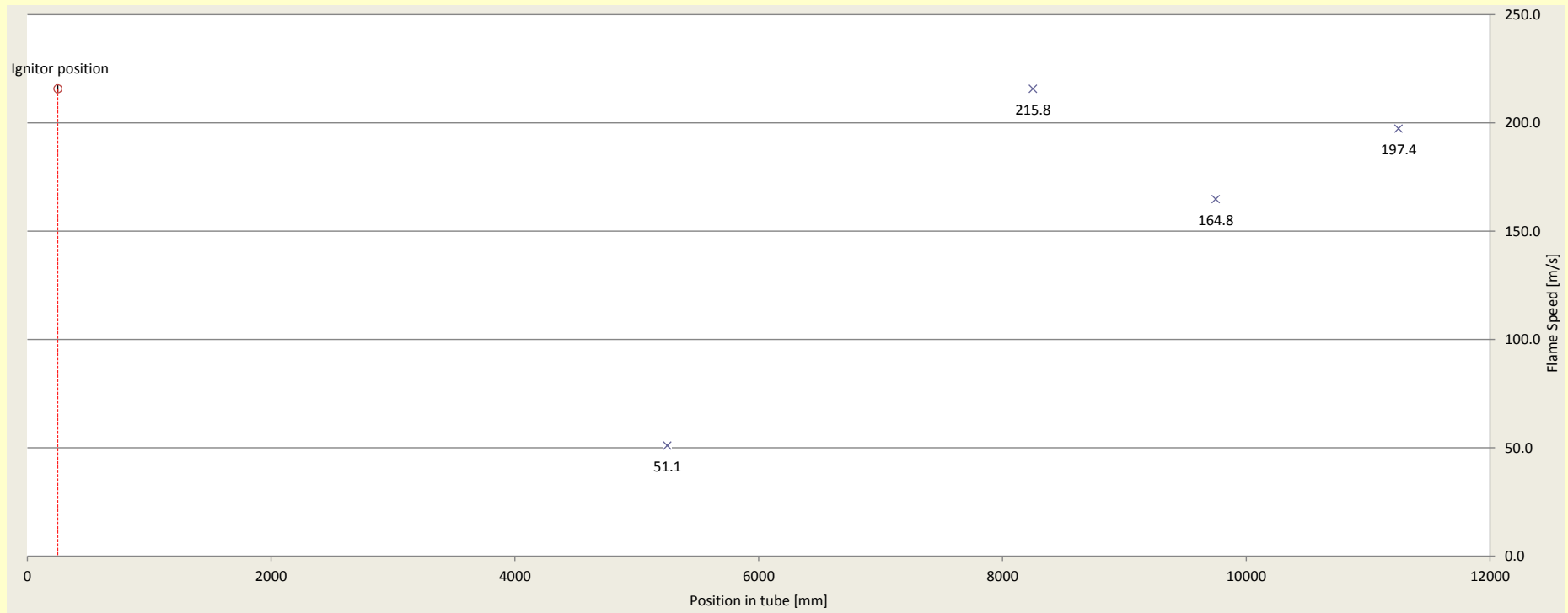
m/s  
 [optical probes]

Initial Temperature  
 °C

Location of igniter  mm

Time of ignition  seconds

OP Number	Location label	Position in tube (mm)	Flame arrival time (s)	Average flame speed (m/s)
OP0	NS2-5	5250	1.3864	51.1
OP1	NS3-5	8250	1.4003	215.8
OP2	NS4-2	9750	1.4094	164.8
OP3	NS4-5	11250	1.4170	197.4
OP4	0	#N/A		
OP5	0	#N/A		

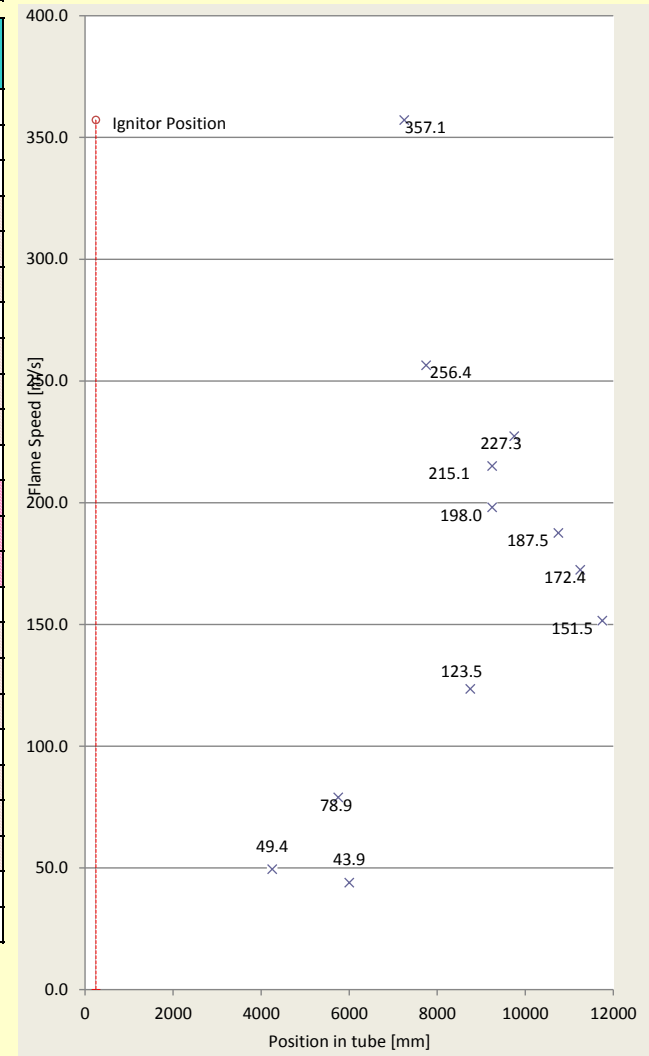


Location of igniter  mm

Time of ignition  seconds

IP Number	Location label	Data Name	Position in tube (mm)	Flame arrival time (s)	Avg Flame speed from last sensor (m/s)
REF	#N/A	Flameion_0	#N/A		
IP1	FS1-6	Flameion_1	2750		
IP2	FS2-3	Flameion_2	4250	1.3695	49.4
IP3	R1-1	Flameion_3	4750	NS	
IP4	R1-2	Flameion_4	4750	NS	
IP5	R1-3	Flameion_5	4750	NS	
IP6	FS2-6	Flameion_6	5750	1.3885	78.9
IP7	R2-1	Flameion_7	6000	1.3942	43.9
IP8	R2-2	Flameion_8	6000	NS	
IP9	R2-3	Flameion_9	6000	NS	
IP10	FS3-4	Flameion_10	7750	1.3963	256.4
IP11	R3-1	Flameion_11	7250	NS	
IP12	R3-2	Flameion_12	7250	1.3977	357.1
IP13	R3-3	Flameion_13	7250	NS	
IP14	FS3-6	Flameion_14	8750	1.4044	123.5
IP15	R4-1	Flameion_15	9250	1.4078	198.0
IP16	R4-2	Flameion_16	9250	1.4070	215.1
IP17	R4-3	Flameion_17	9250		
IP18	FS4-2	Flameion_18	9750	1.4088	227.3
IP19	R5-1	Flameion_19	10750	1.4150	187.5
IP20	R5-2	Flameion_20	10750	NS	
IP21	R5-3	Flameion_21	10750	NS	
IP22	FS4-5	Flameion_22	11250	1.4175	172.4
IP23	FS4-6	Flameion_23	11750	1.4208	151.5

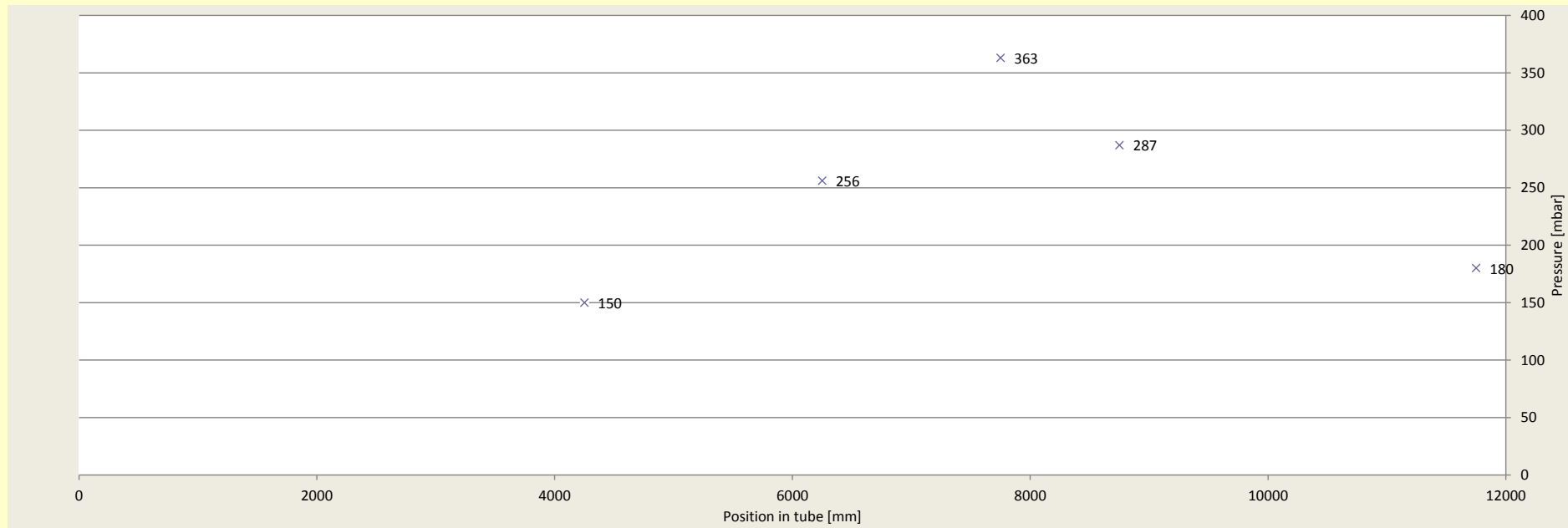
357.1



Location of igniter  mm

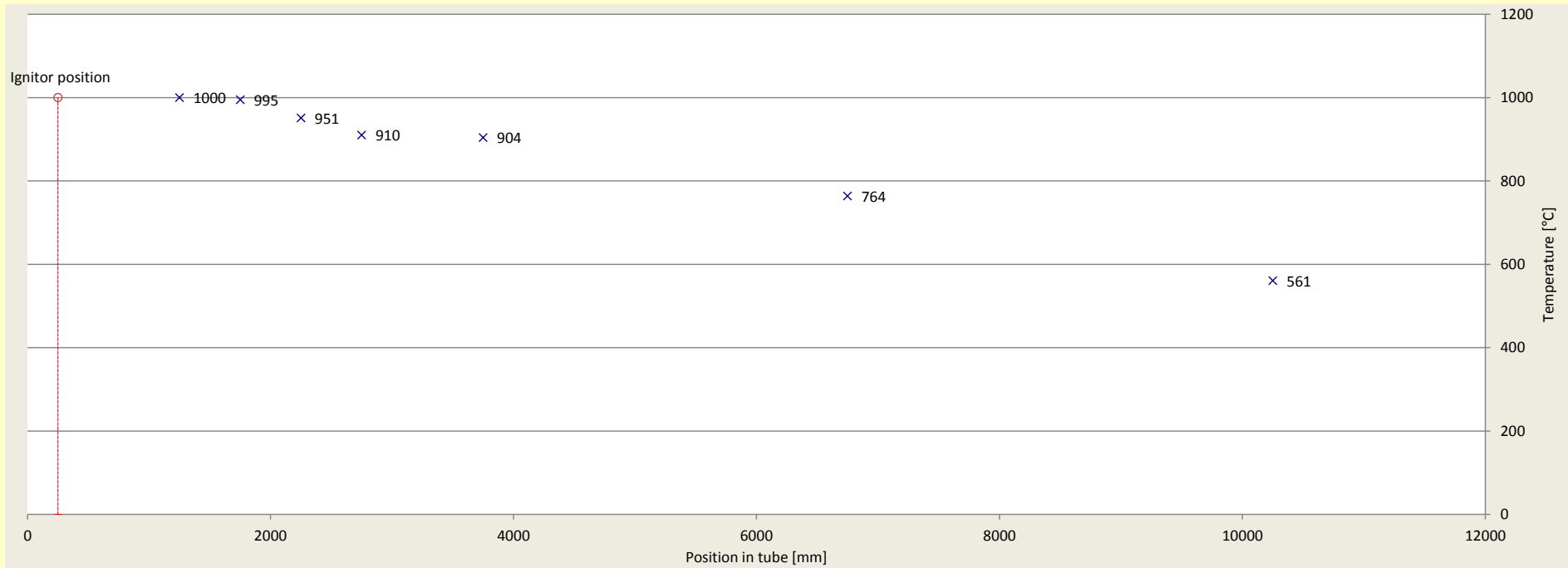
Transducer number	Location	Position in tube [mm]	$\Delta P_{max}$ [mbar]
KU0	NS3-6	8750	287
KU1	0	#N/A	
KU2	0	#N/A	
KU3	NS2-3	4250	150
KU4	0	#N/A	
KU5	NS3-4	7750	363
KU6	NS3-1	6250	256
KU7	NS4-6	11750	180

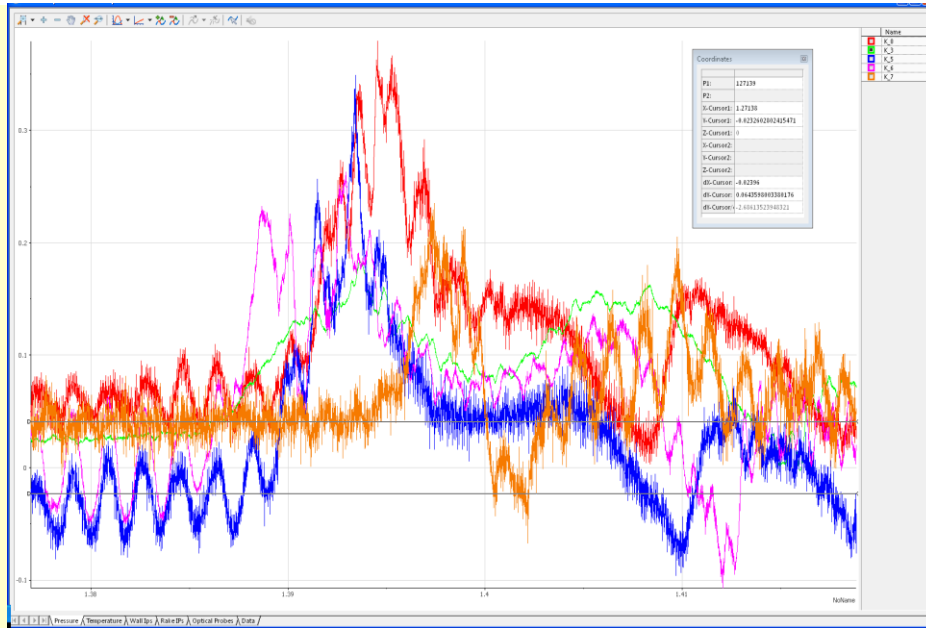
PCB = 0 mbar



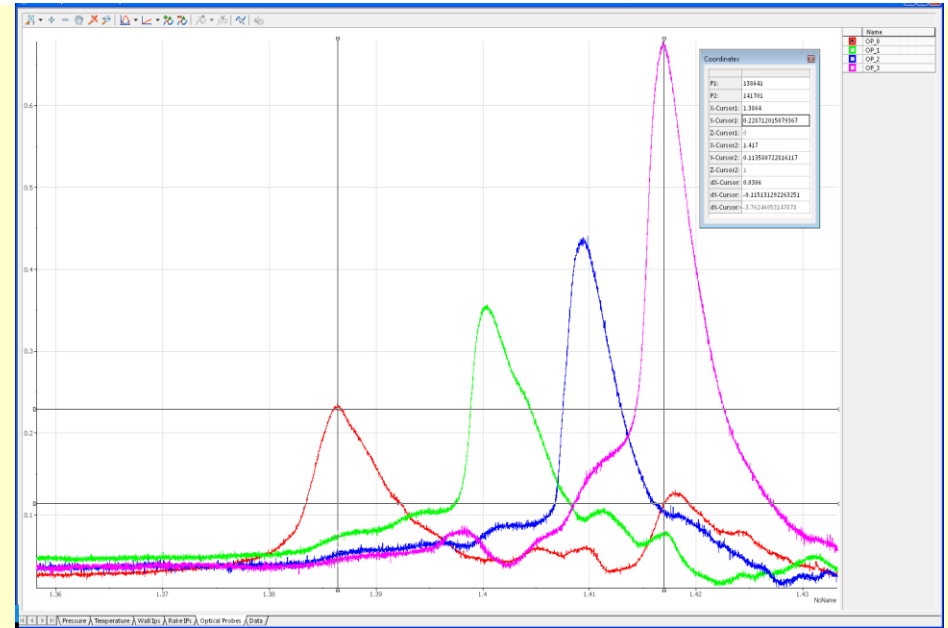
Location of igniter  mm

Thermocouple number	Location	Position in tube (mm)	T <sub>max</sub> (deg C)
TC0	NS1-3	1250	1000
TC1	NS1-5	2250	951
TC2	NS2-2	3750	904
TC3	NS1-4	1750	995
TC4	NS1-6	2750	910
TC5	Ku6	#N/A	
TC6	NS3-2	6750	764
TC15	NS4-3	10250	561

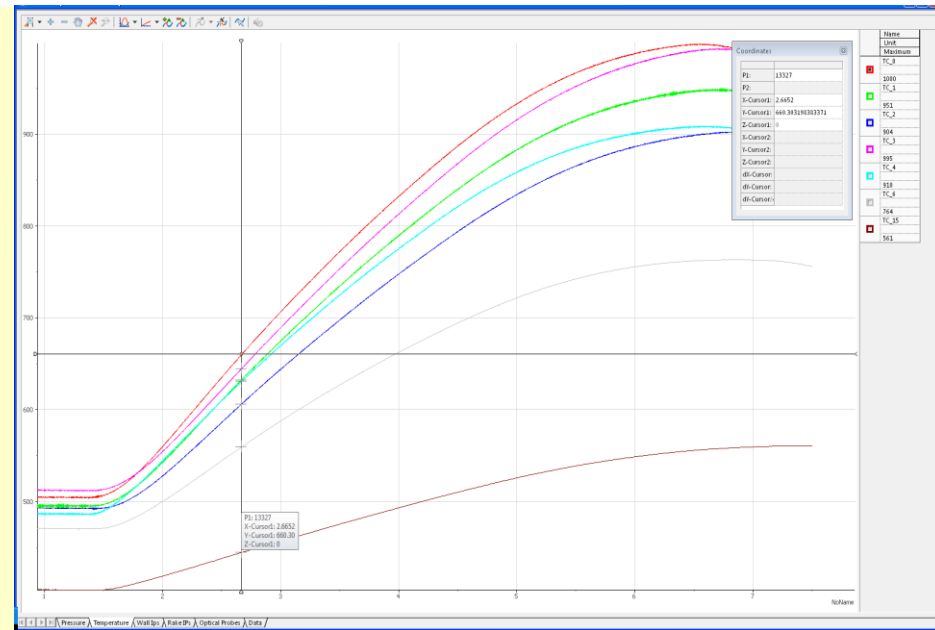
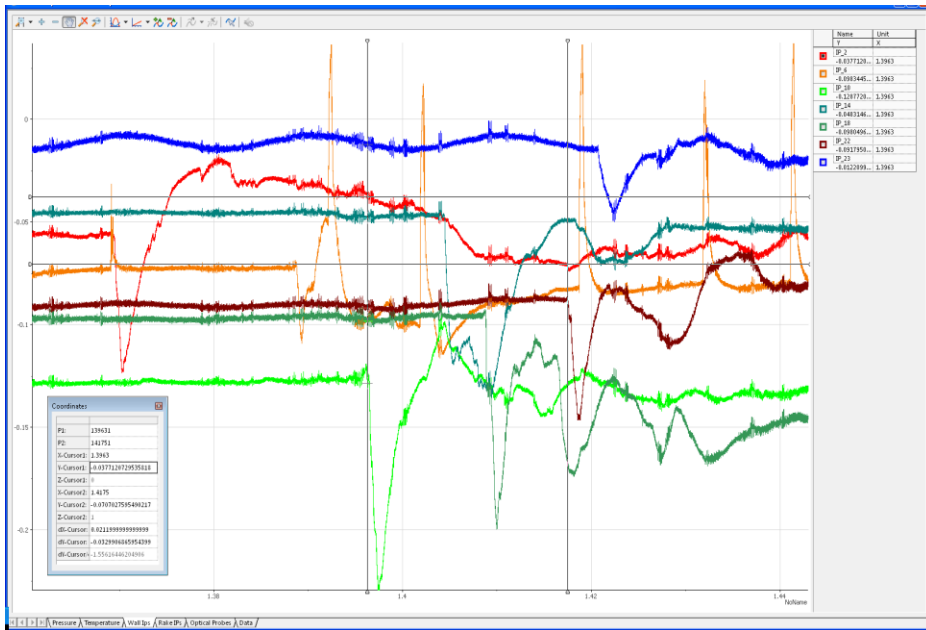




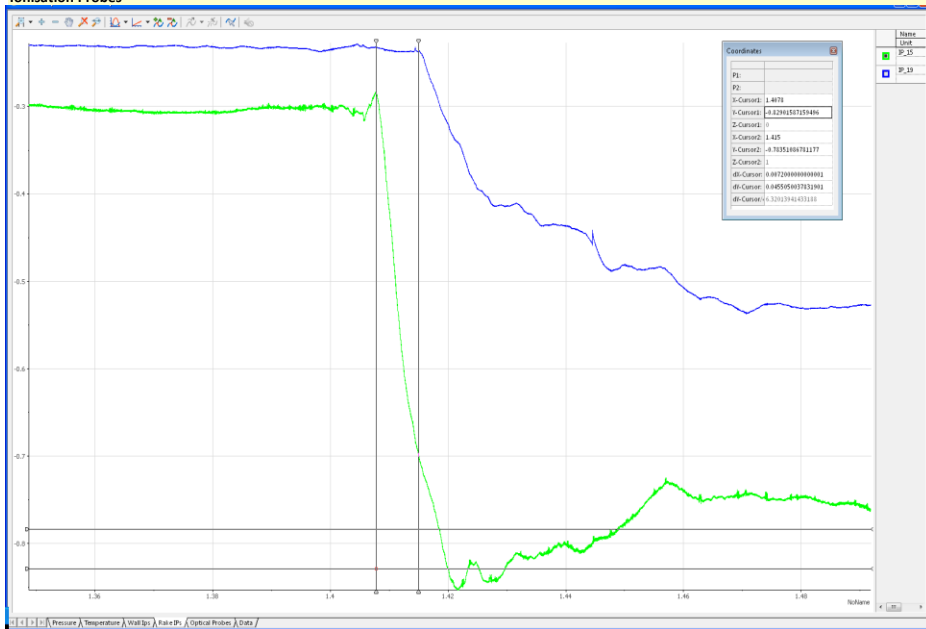
Pressure



Optical Probes



Ionisation Probes



Temperature