

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	IP0	#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					

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
												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		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	NS4-6	PXIe	PXI1Slot4/ai4	Flame Presence	Optical Probe	Bruce Ewan	TBC	-5 to 5V	30V	100 kHz
OP5		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		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		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		PXIe	SC1Mod1/ai1	Pressure	Kulite					100 kHz
KU2		PXIe	SC1Mod1/ai2	Pressure	XTEH-190M-50BARA	Kulite		0-100 mV		100 kHz
KU3	NS2-3	PXIe	SC1Mod1/ai3	Pressure	Kulite					100 kHz
KU4		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
PB1	TS3-6	PXIe	PXI Slot3/ai0	Pressure	113B24	PCB	68 bar	0-5 V	20-30 V	1 MHz
PB2		PXIe		Pressure	113B25	PCB	68 bar	0-5 V	20-30 V	1 MHz

Date	08 April 2015
Time	15:49
Test Number	33
Mixture Composition	100% CH4
Ambient Temperature	3 °C
Ambient Pressure	983 mbar
Wind Speed	5 m/s
Wind direction	N
Relative Humidity	97.00%

General Comments: (weather, rig configuration)

Weather: Cold but fairly settled.
 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. A moderately strong combustion event at an EQR of 0.86 and showing a peak pressure of 2.6 bar. This should be contrasted with the corresponding pure methane case with no obstacles where the peak pressure was around 0.2 bar. Note that OP3 was later found to have loosened in its mounting, resulting in no signal for this sensor.

Equivalence Ratio

Headlines

Max overpressure mbar

Max. flame speed m/s
 [ionisation probes]

Max. temperature °C

Mass Flow kg/s

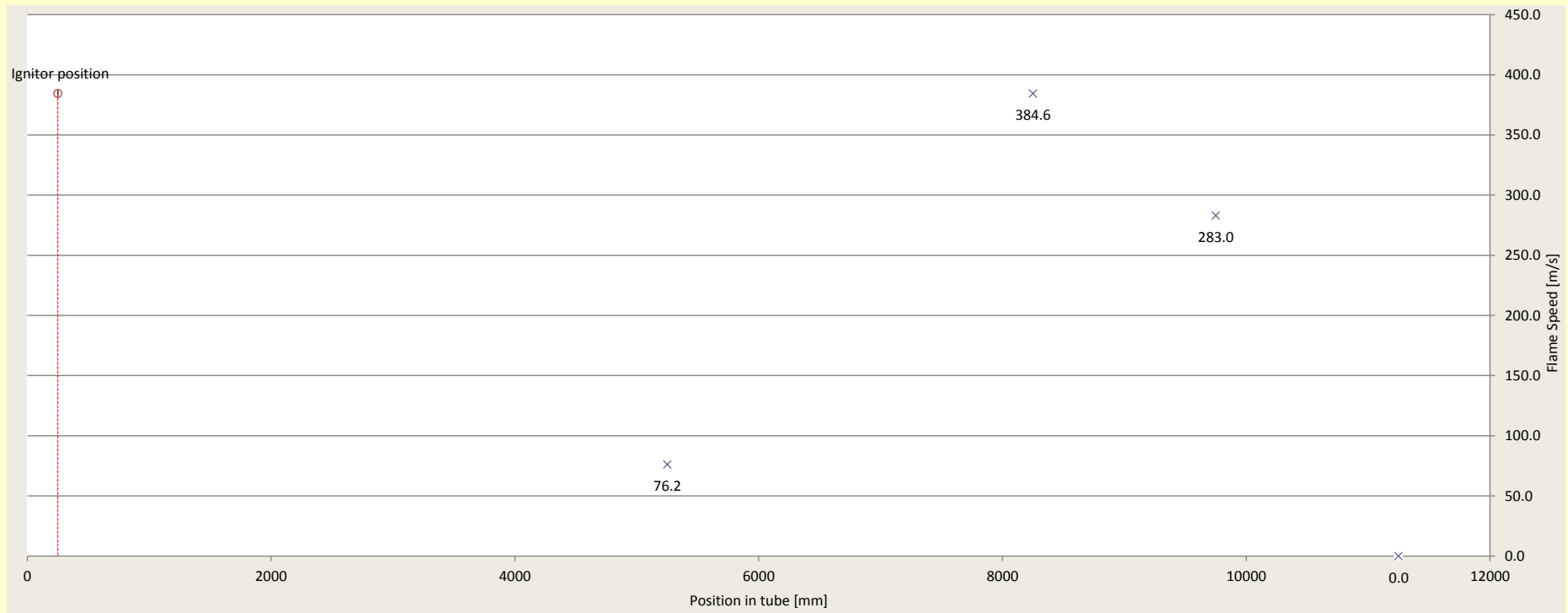
m/s
 [optical probes]

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	1.34450	76.2
OP1	NS3-5	8250	1.35230	384.6
OP2	NS4-2	9750	1.35760	283.0
OP3	NS4-5	11250	NS	NS
OP4	0	#N/A		
OP5	0	#N/A		

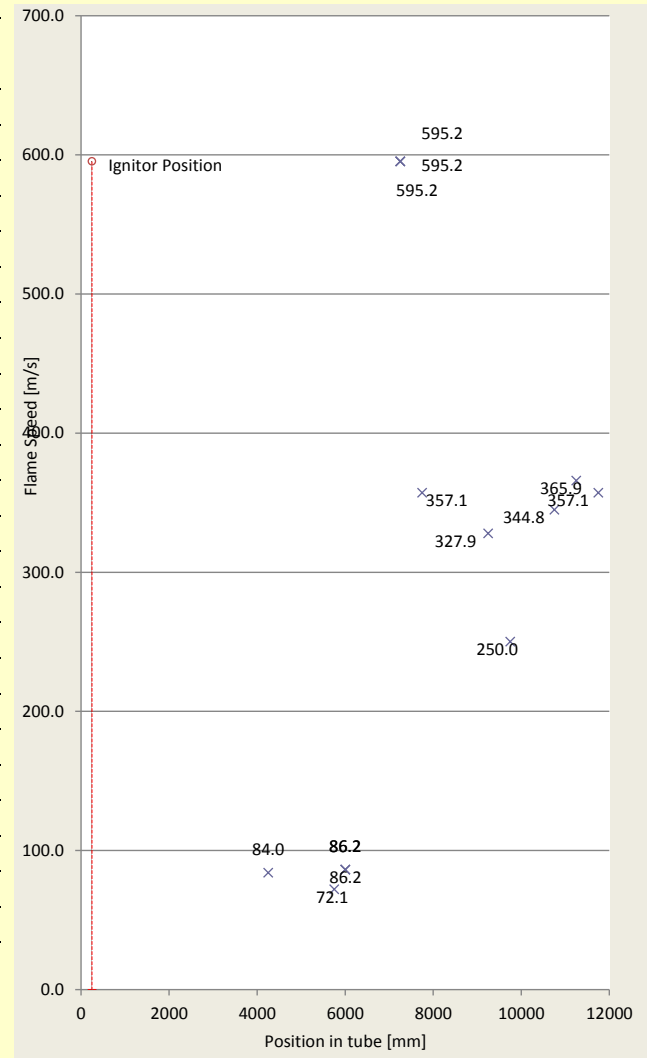


Location of igniter mm

Time of ignition seconds

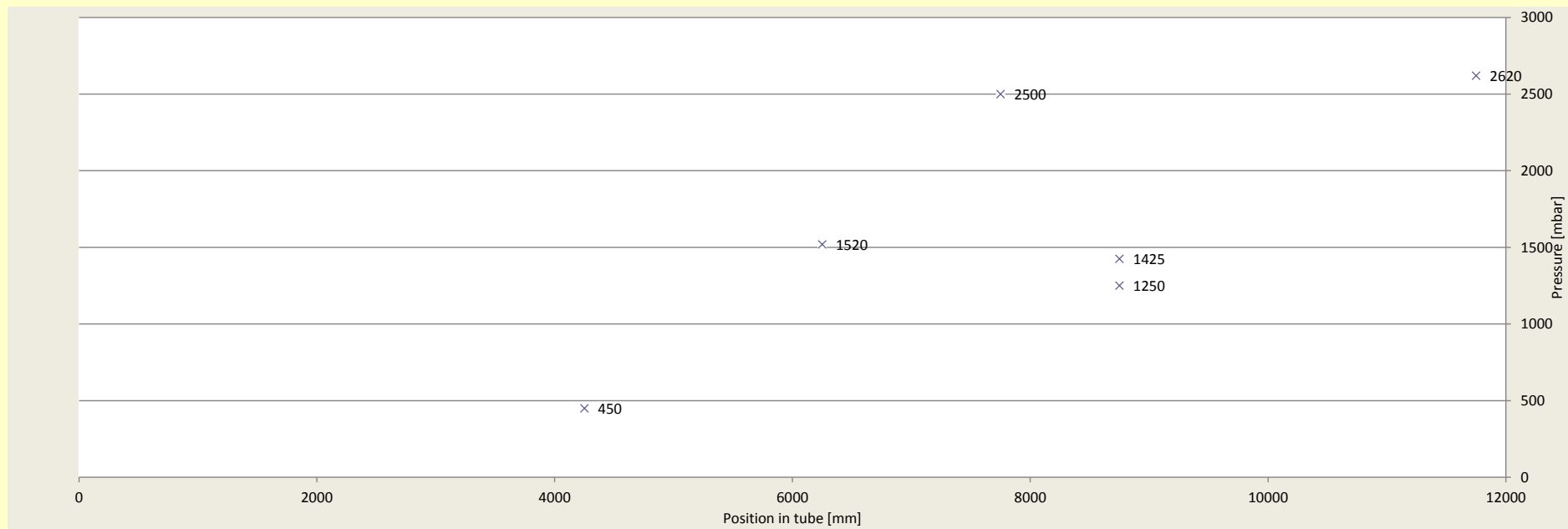
IP Number	Location label	Data Name	Position in tube (mm)	Flame arrival time (s)	Avg Flame speed from last sensor (m/s)
REF	#N/A	Flameion_0	#N/A		
IP1	FS1-6	Flameion_1	2750	NS	
IP2	FS2-3	Flameion_2	4250	1.3265	84.0
IP3	R1-1	Flameion_3	4750	NS	
IP4	R1-2	Flameion_4	4750	NS	
IP5	R1-3	Flameion_5	4750	NS	
IP6	FS2-6	Flameion_6	5750	1.3473	72.1
IP7	R2-1	Flameion_7	6000	1.3468	86.2
IP8	R2-2	Flameion_8	6000	1.3468	86.2
IP9	R2-3	Flameion_9	6000	1.3468	86.2
IP10	FS3-4	Flameion_10	7750	1.3503	357.1
IP11	R3-1	Flameion_11	7250	1.3489	595.2
IP12	R3-2	Flameion_12	7250	1.3489	595.2
IP13	R3-3	Flameion_13	7250	1.3489	595.2
IP14	FS3-6	Flameion_14	8750		
IP15	R4-1	Flameion_15	9250	NS	
IP16	R4-2	Flameion_16	9250	NS	
IP17	R4-3	Flameion_17	9250	1.3550	327.9
IP18	FS4-2	Flameion_18	9750	1.3570	250.0
IP19	R5-1	Flameion_19	10750	1.3599	344.8
IP20	R5-2	Flameion_20	10750	NS	
IP21	R5-3	Flameion_21	10750	1.3599	
IP22	FS4-5	Flameion_22	11250	1.3611	365.9
IP23	FS4-6	Flameion_23	11750	1.3625	357.1

595.2



Location of igniter mm

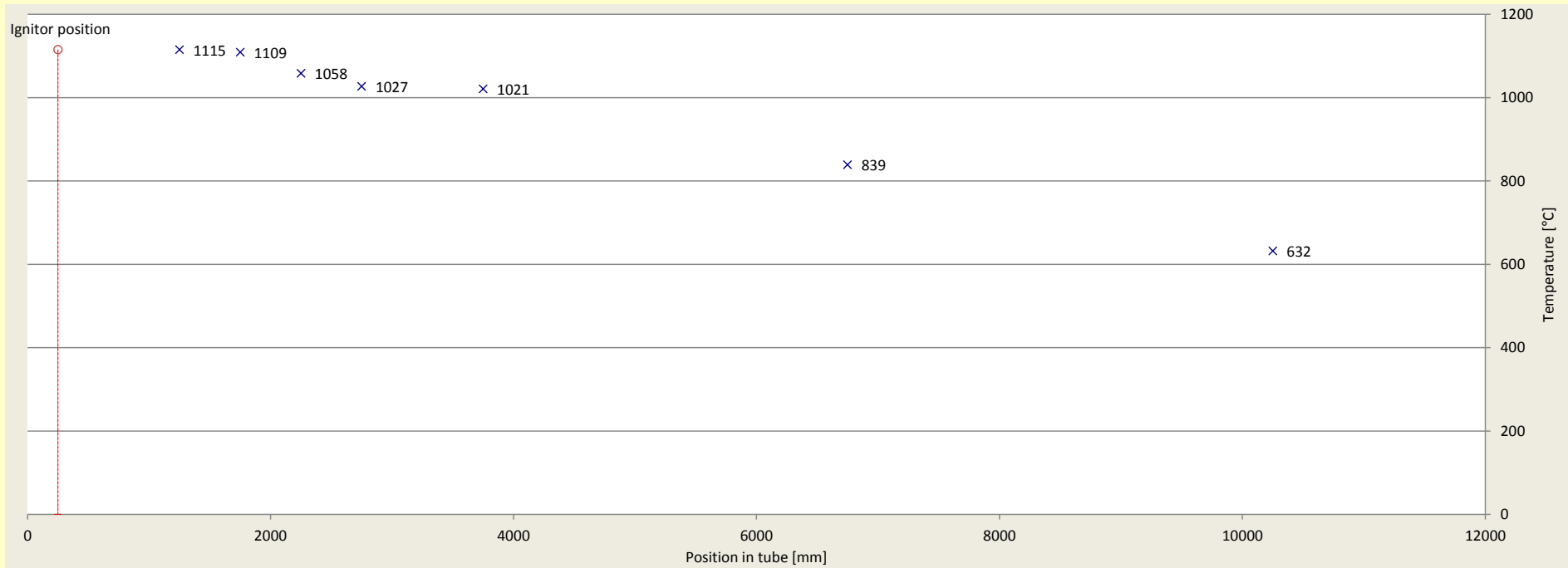
Transducer number	Location	Position in tube [mm]	ΔP_{max} [mbar]
KU0	NS3-6	8750	1250
KU1	0	#N/A	
KU2	0	#N/A	
KU3	NS2-3	4250	450
KU4	0	#N/A	
KU5	NS3-4	7750	2500
KU6	NS3-1	6250	1520
KU7	NS4-6	11750	2620
PB1	TS3-6	8750	1425

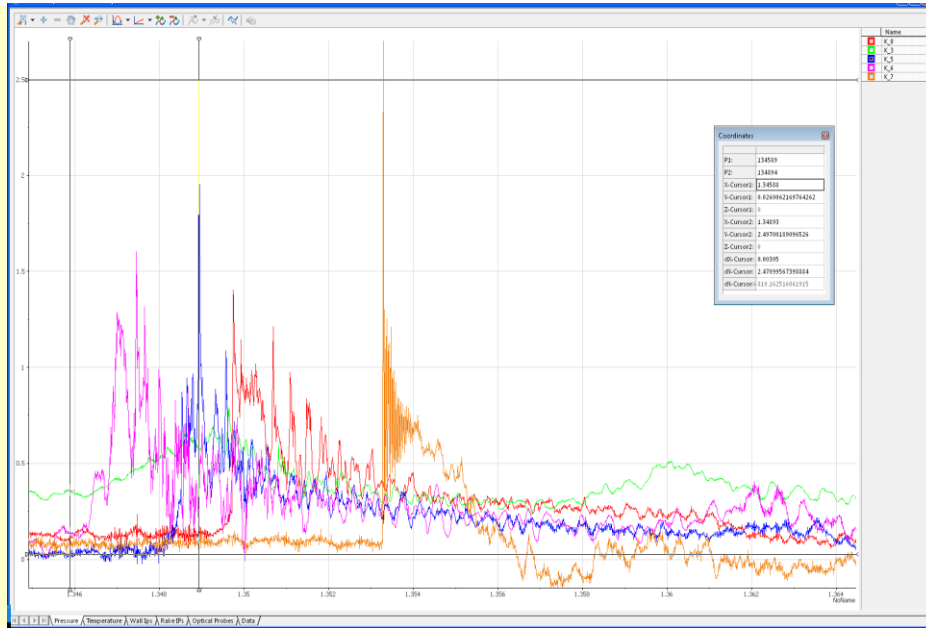


Location of igniter

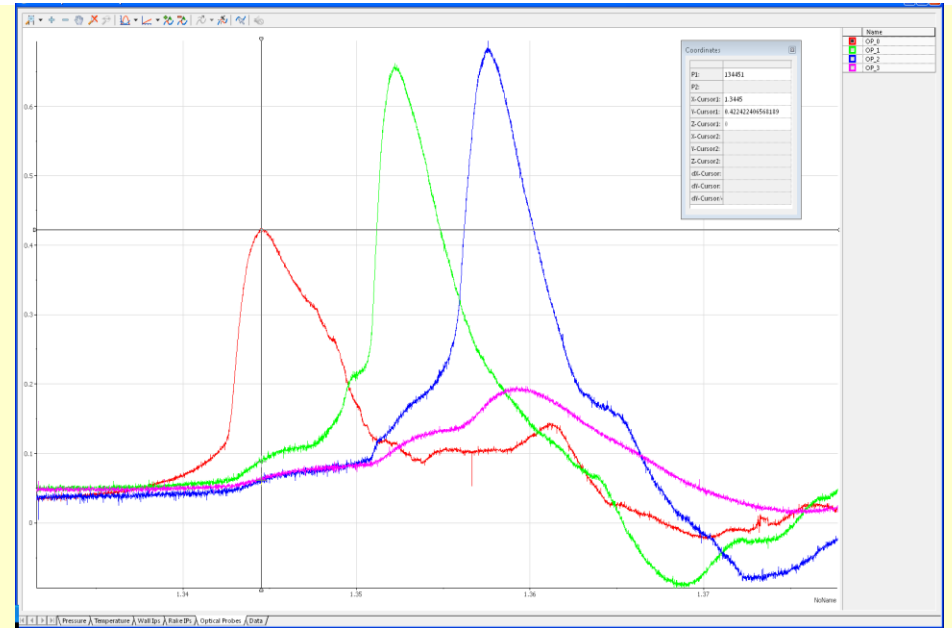
250 mm

Thermocouple number	Location	Position in tube (mm)	T _{max} (deg C)
TC0	NS1-3	1250	1115
TC1	NS1-5	2250	1058
TC2	NS2-2	3750	1021
TC3	NS1-4	1750	1109
TC4	NS1-6	2750	1027
TC5	Ku6	#N/A	
TC6	NS3-2	6750	839
TC15	NS4-3	10250	632

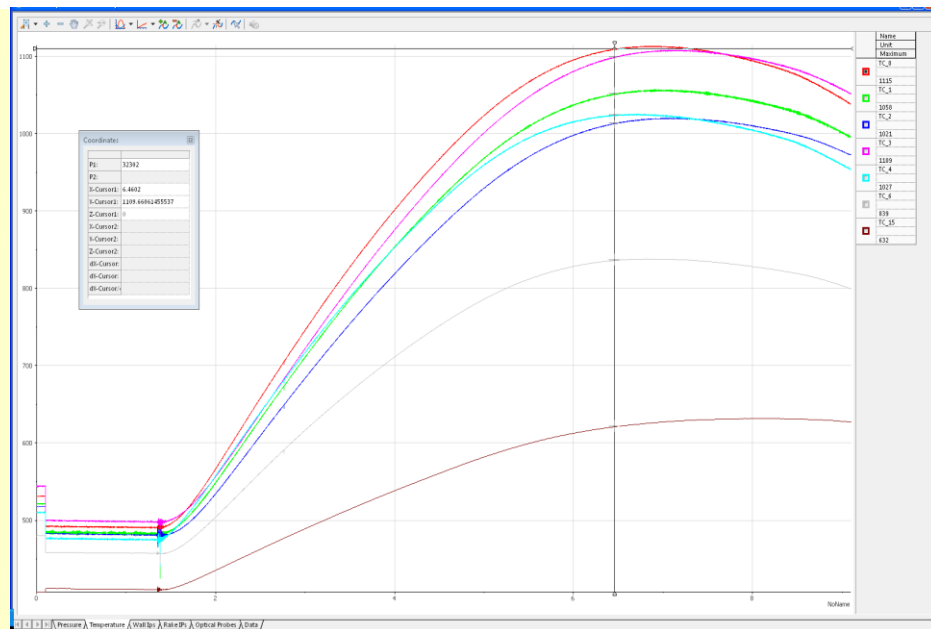
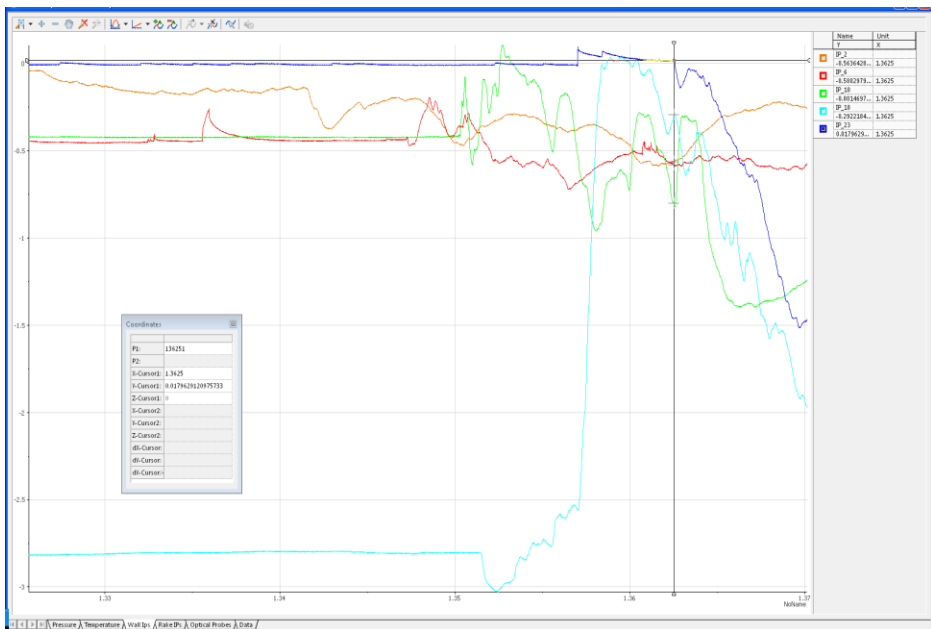




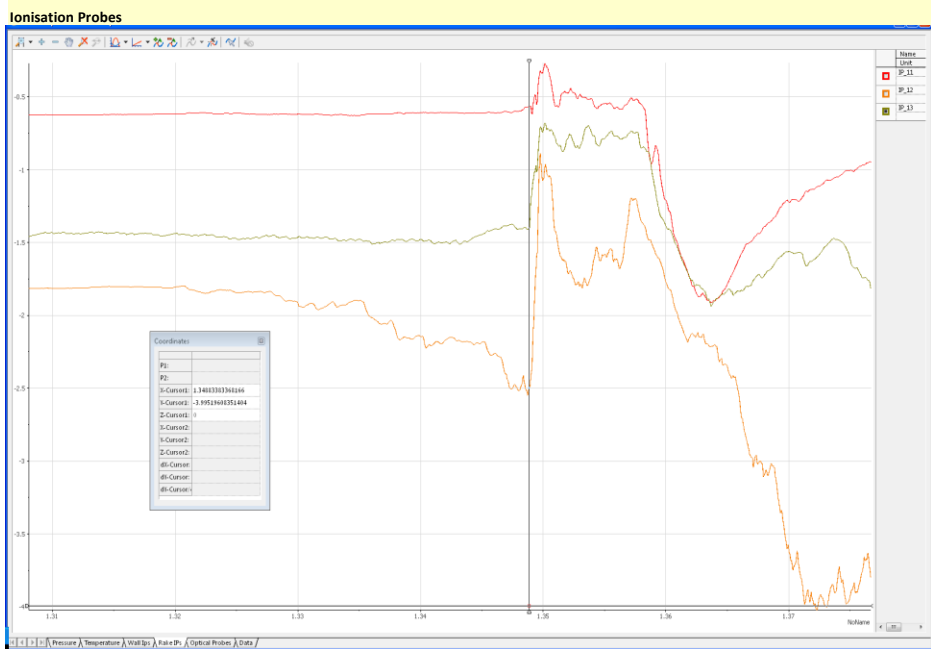
Pressure



Optical Probes



Temperature



Ionisation Probes