

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	TC7	
KU4	TC9	
KU6	TC13	
pitot	TC11	

Ionisation Probe	
Pressure Transducer	
Thermocouple	
Optical Probe	

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	NS4-6	PXIe	PXI1Slot4/ai4	Flame Presence	Optical Probe	Bruce Ewan	TBC	-5 to 5V	30V	100 kHz
OP5	NS4-1	PXIe	PXI1Slot4/ai5	Flame Presence	Optical Probe	Bruce Ewan	TBC	-5 to 5V	30V	100 kHz
TC0	NS1-3	PXIe	SC1Mod4/ai0	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	NS2-1	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	KU3	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	KU4	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	KU6	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	NS2-3	PXIe	SC1Mod1/ai0	Pressure	Kulite					100 kHz
KU1	NS2-4	PXIe	SC1Mod1/ai1	Pressure	Kulite					100 kHz
KU2	NS3-1	PXIe	SC1Mod1/ai2	Pressure	XTEH-190M-50BARA			0-100 mV		100 kHz
KU3	NS3-2	PXIe	SC1Mod1/ai3	Pressure	Kulite					100 kHz
KU4	NS3-3	PXIe	SC1Mod1/ai4	Pressure	Kulite					100 kHz
KU5	NS3-4	PXIe	SC1Mod1/ai5	Pressure	Kulite					100 kHz
KU6	NS3-5	PXIe	SC1Mod1/ai6	Pressure	Kulite					100 kHz
KU7	NS4-6	PXIe	SC1Mod1/ai7	Pressure	Kulite					100 kHz
PB1	FS1-3	PXIe	PXI Slot3/ai0	Pressure	113B24	PCB	68 bar	0-5 V	20-30 V	1 MHz
PB2	FS1-6	PXIe	PXI Slot3/ai1	Pressure	113B25	PCB	68 bar	0-5 V	20-30 V	1 MHz

Date	04 November 2014
Time	15:54
Test Number	27
Mixture Composition	100 % H2
Ambient Temperature	6 oC
Ambient Pressure	946 mbar
Wind Speed	2.2 m/s
Wind direction	NE
Relative Humidity	88.00%
Equivalence Ratio	~0.50

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

Weather: Overcast with some light rain

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)

First test with 15 rows of congestion pure hydrogen only starting at EQR 0.50

This case represents an intermediate equivalence ratio for pure H2 to compare with the same equivalence ratio with 8 congestion tubes in place, in anticipation of a stronger event. Most signals on the IPs and OPs provide flame arrival information, although there is some ambiguity for some positions leading to some uncertainty with the flame speed behaviour. The peak pressures show a sharpening after the congestion with a decrease in peak pressure towards the exit and a Mach number of around 1.25. The flame speed is much lower than this as shown for both IPs and OPs. As noted for other tests, where the pressure wave sharpens, the same weak oscillation at 20 kHz is shown on the downstream pressure sensors.

**Headlines**

Max overpressure  
 mbar

Max. flame speed  
 m/s  
 [ionisation probes]

Max. temperature  
 °C

Mass Flow  
 kg/s

m/s  
 [optical probes]

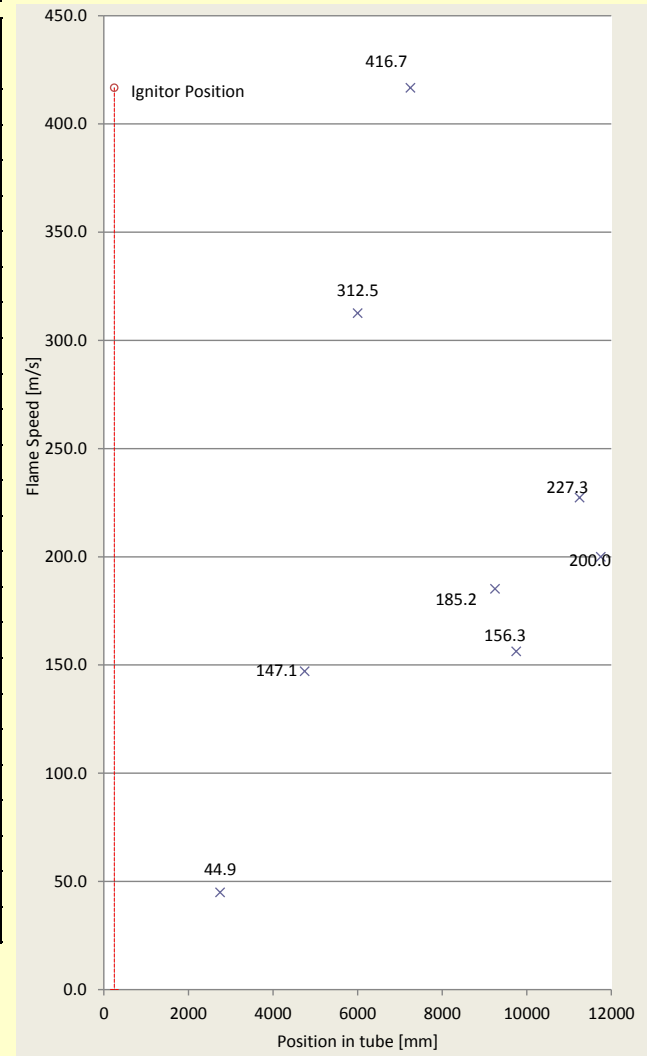
Initial Temperature  
 °C

Location of igniter  mm

Time of ignition  seconds

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	1.2944	44.9
IP2	FS2-3	Flameion_2	4250	NS	
IP3	R1-1	Flameion_3	4750	1.3080	147.1
IP4	R1-2	Flameion_4	4750	1.3050	
IP5	R1-3	Flameion_5	4750	1.3110	
IP6	FS2-6	Flameion_6	5750	NS	
IP7	R2-1	Flameion_7	6000	1.3120	312.5
IP8	R2-2	Flameion_8	6000	1.3120	
IP9	R2-3	Flameion_9	6000	1.3120	
IP10	FS3-4	Flameion_10	7750	1.3133	
IP11	R3-1	Flameion_11	7250	1.3150	416.7
IP12	R3-2	Flameion_12	7250	1.3128	
IP13	R3-3	Flameion_13	7250	1.3150	
IP14	FS3-6	Flameion_14	8750	NS	
IP15	R4-1	Flameion_15	9250	1.3271	
IP16	R4-2	Flameion_16	9250	1.3258	185.2
IP17	R4-3	Flameion_17	9250	1.3262	
IP18	FS4-2	Flameion_18	9750	1.3290	156.3
IP19	R5-1	Flameion_19	10750	NS	
IP20	R5-2	Flameion_20	10750	NS	
IP21	R5-3	Flameion_21	10750	NS	
IP22	FS4-5	Flameion_22	11250	1.3356	227.3
IP23	FS4-6	Flameion_23	11750	1.3381	200.0

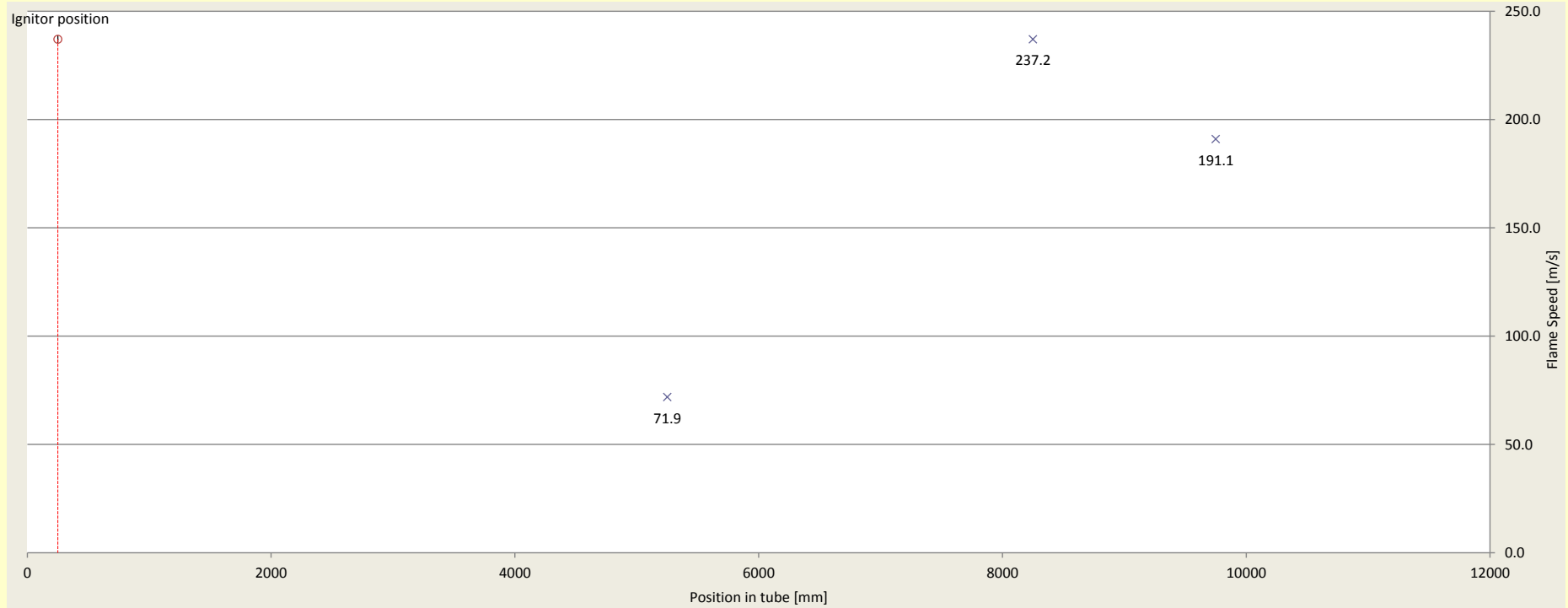
416.7



Location of igniter  mm

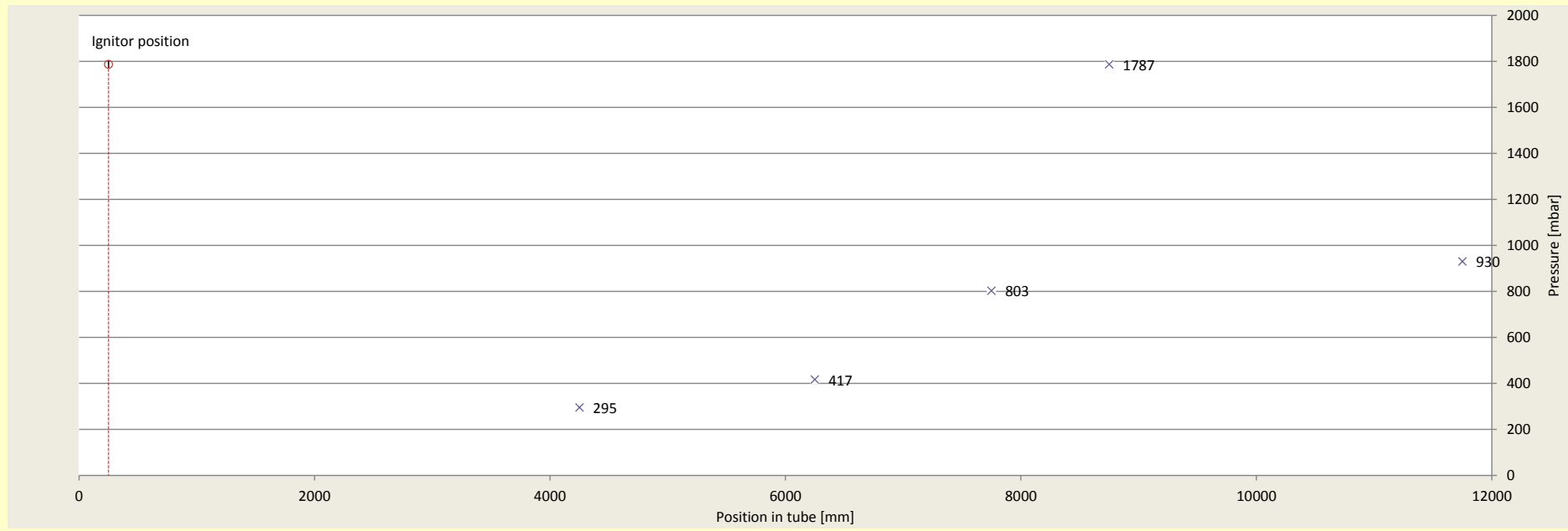
Time of ignition  seconds

OP Number	Location label	Position in tube (mm)	Flame arrival time (s)	Average flame speed (m/s)
OP0	NS2-5	5250	1.30823	71.9
OP1	NS3-5	8250	1.32088	237.2
OP2	NS4-2	9750	1.32873	191.1
OP3	NS4-5	11250	NS	
OP4	0	#N/A		
OP5	0	#N/A		



Location of igniter  mm

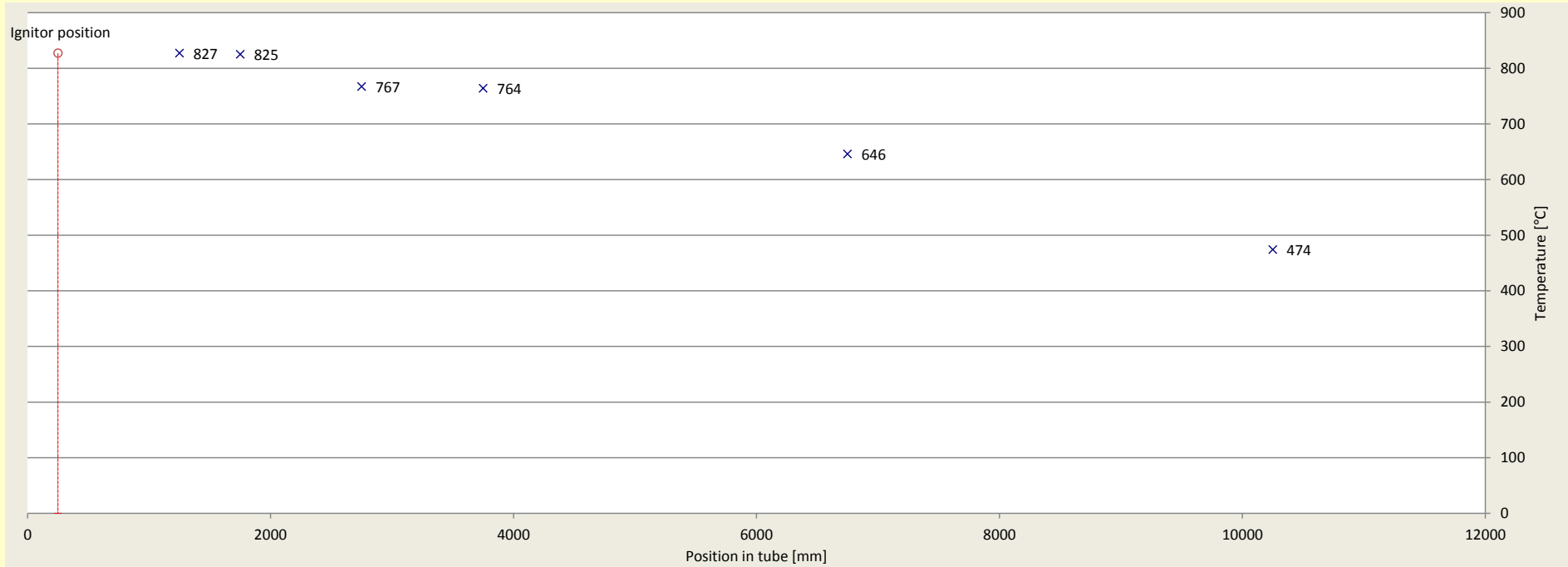
Transducer number	Location	Position in tube [mm]	$\Delta P_{max}$ [mbar]
KU0	NS2-3	4250	295
KU1	0	#N/A	
KU2	0	#N/A	
KU3	NS3-1	6250	417
KU4	0	#N/A	
KU5	NS3-4	7750	803
KU6	NS3-6	8750	1787
KU7	NS4-6	11750	930

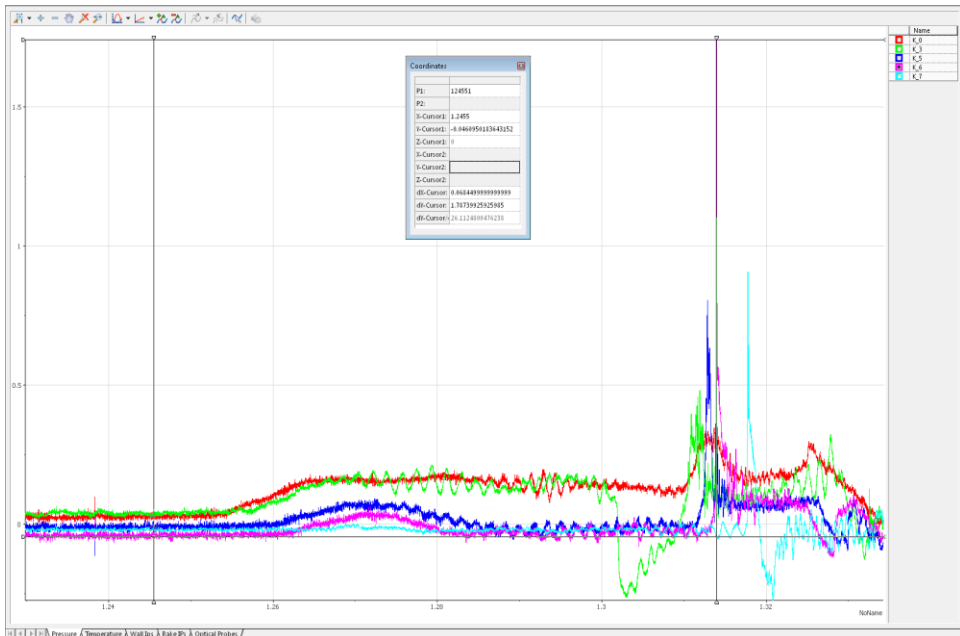


Location of igniter

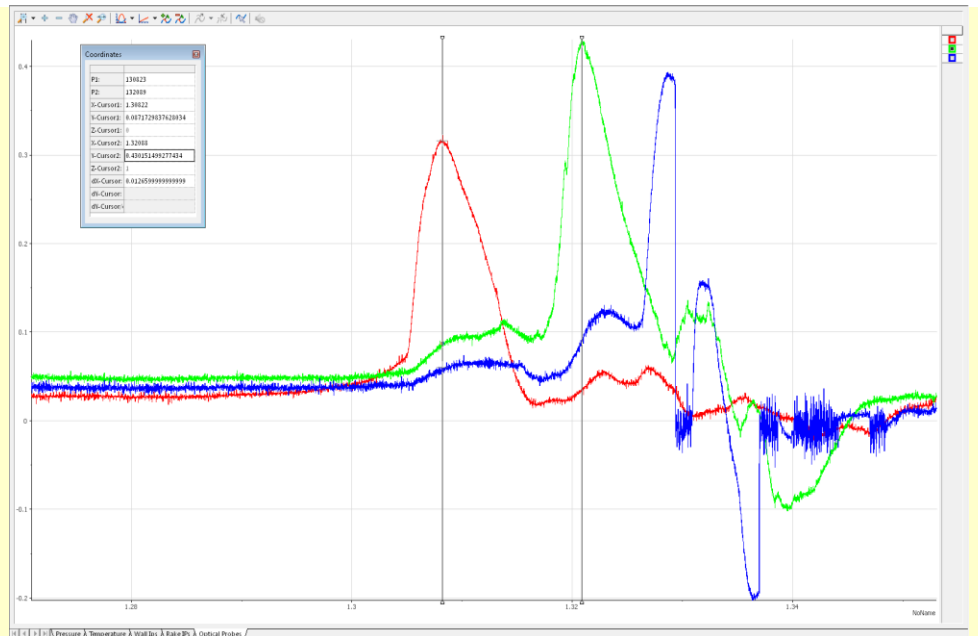
250 mm

Thermocouple number	Location	Position in tube (mm)	T <sub>max</sub> (deg C)
TC0	NS1-3	1250	827
TC1	NS1-5	2250	
TC2	NS2-2	3750	764
TC3	NS1-4	1750	825
TC4	NS1-6	2750	767
TC5	0	#N/A	
TC6	NS3-2	6750	646
TC15	NS4-3	10250	474

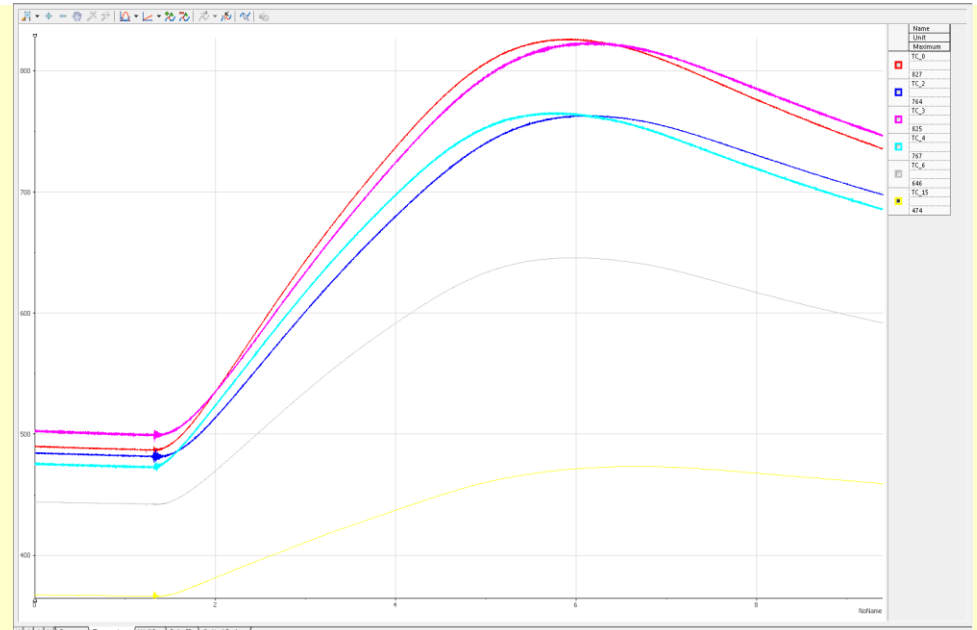
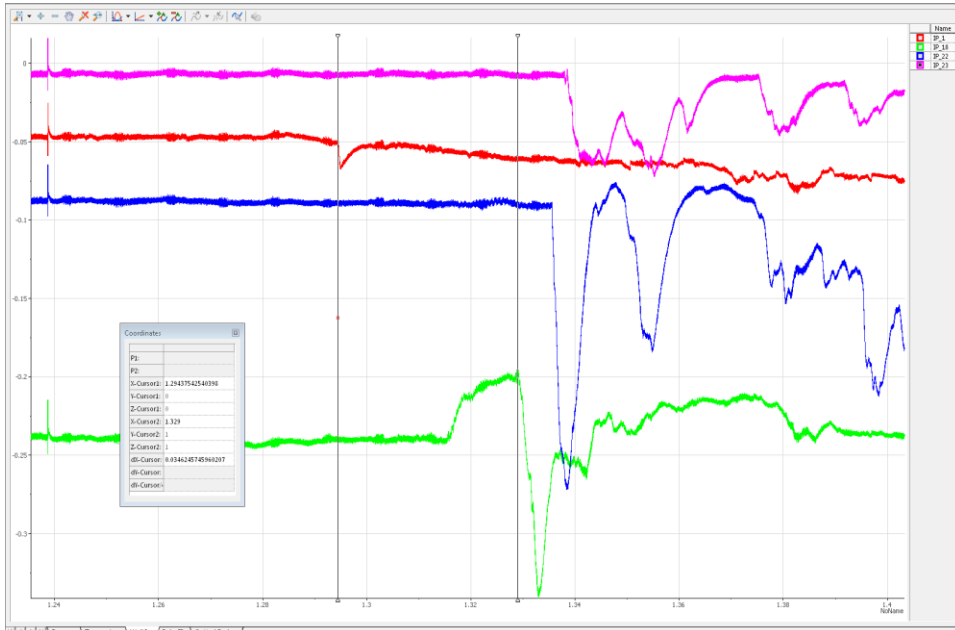




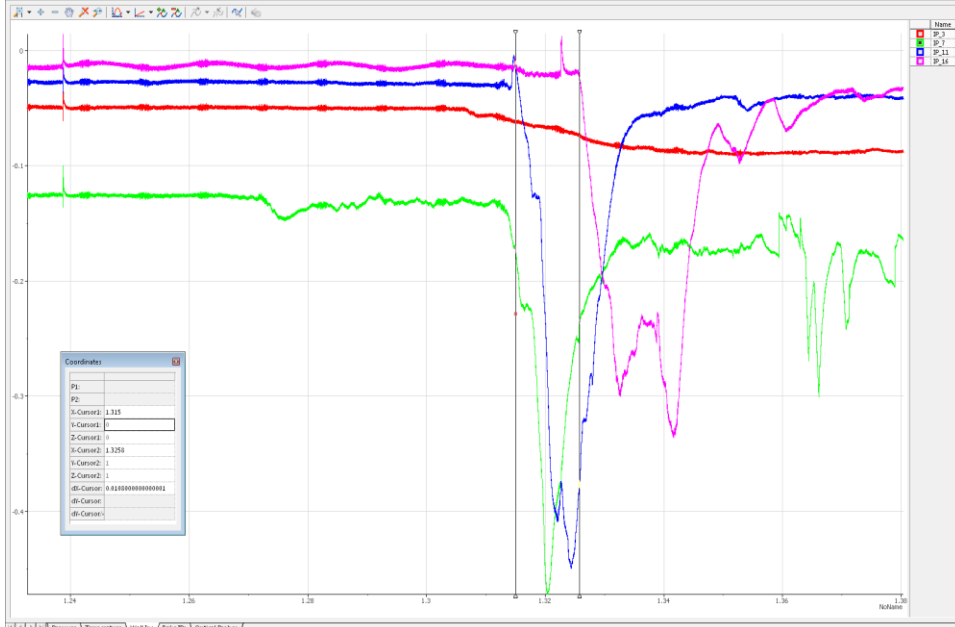
Pressure



Optical Probes



**Ionisation Probes**



**Temperature**

