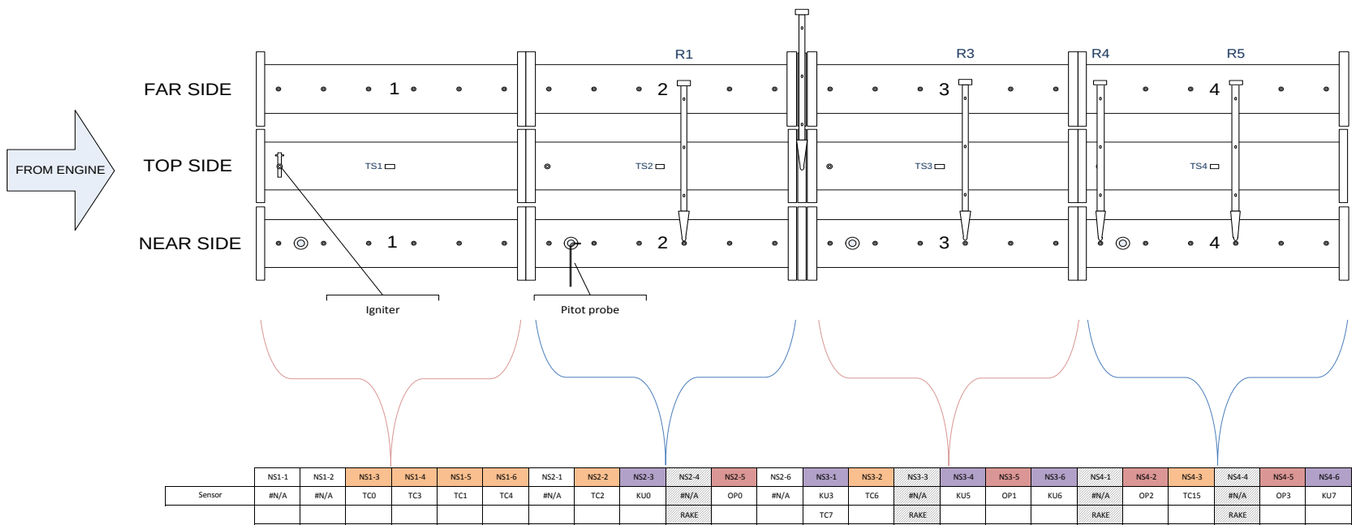
	FS1-1	FS1-2	FS1-3	FS1-4	FS1-5	FS1-6	FS2-1	FS2-2	FS2-3	FS2-4	FS2-5	FS2-6	FS3-1	FS3-2	FS3-3	FS3-4	FS3-5	FS3-6	FS4-1	FS4-2	FS4-3	FS4-4	FS4-5	FS4-6
Sensor	#N/A	#N/A	IP0	#N/A	#N/A	IP1	#N/A	#N/A	IP2	#N/A	#N/A	IP6	#N/A	#N/A	#N/A	IP10	#N/A	IP14	#N/A	IP18	#N/A	#N/A	IP22	IP23
										RAKE					RAKE				RAKE			RAKE		



	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
Sensor	#N/A	#N/A	TC0	TC3	TC1	TC4	#N/A	TC2	KU0	#N/A	OP0	#N/A	KU3	TC6	#N/A	KU5	OP1	KU6	#N/A	OP2	TC15	#N/A	OP3	KU7
										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	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		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		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/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		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		PXIe	SC1Mod1/ai1	Pressure		Kulite				100 kHz
KU2		PXIe	SC1Mod1/ai2	Pressure	XTEH-10L-190M-50BARA	Kulite		0-100 mV		100 kHz
KU3	NS3-1	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	NS3-6	PXIe	SC1Mod1/ai6	Pressure		Kulite				100 kHz
KU7	NS4-6	PXIe	SC1Mod1/ai7	Pressure		Kulite				100 kHz
PB1		PXIe	PXI Slot3/ai0	Pressure	113824	PCB	68 bar	0-5 V	20-30 V	1 MHz
PB2		PXIe		Pressure	113825	PCB	68 bar	0-5 V	20-30 V	1 MHz

Date	29 October 2014
Time	15:08
Test Number	26
Mixture Composition	100 % H2
Ambient Temperature	6 oC
Ambient Pressure	946 mbar
Wind Speed	1.5 m/s
Wind direction	NE
Relative Humidity	84.00%
Equivalence Ratio	~0.6

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 congestion in place. Eight (8) rows of congestion in place from central flange (between tube sections 2 and 3).

This case represents an intermediate equivalence ratio for pure H2 to explore the region prior to the strong combustion event with equivalence of 0.7. There is clear evidence of a rapid combustion and a significant pressure wave development following flame impingement on the congestion region. Signals on most IPs and all OPs give a good indication of flame speed along the duct. These however are lower in the 200-300 m/s range.

The peak pressures show a sharpening to shock behaviour downstream with a shock speed of around 900 m/s. The flame speed is much lower than this as shown for both IPs and OPs. As noted for test 21, the some weak oscillation at 20 kHz shown on the downstream pressure sensors awaits further explanation.

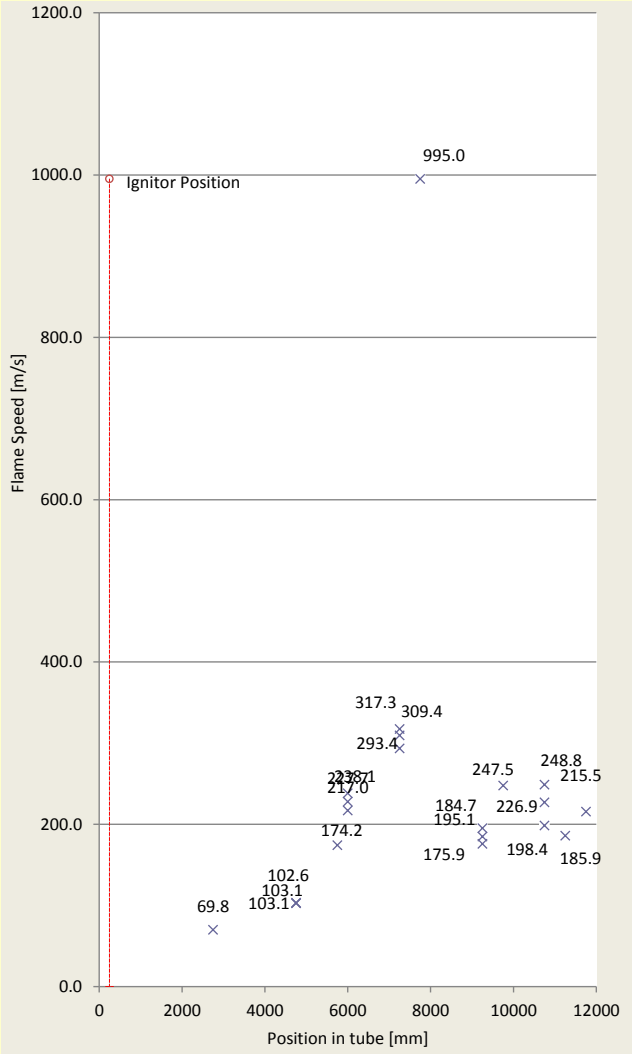
Headlines

Max overpressure	Max. flame speed	Max. temperature
1970 mbar	995 m/s [ionisation probes]	876 °C
Mass Flow		Initial Temperature
kg/s	288 m/s [optical probes]	°C

Location of igniter 250 mm **Time of ignition** 1.11144 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	1.147240	69.8
IP2	FS2-3	Flameion_2	4250	NS	
IP3	R1-1	Flameion_3	4750	1.166640	103.1
IP4	R1-2	Flameion_4	4750	1.166640	103.1
IP5	R1-3	Flameion_5	4750	1.166730	102.6
IP6	FS2-6	Flameion_6	5750	1.172380	174.2
IP7	R2-1	Flameion_7	6000	1.172130	227.7
IP8	R2-2	Flameion_8	6000	1.171890	238.1
IP9	R2-3	Flameion_9	6000	1.172490	217.0
IP10	FS3-4	Flameion_10	7750	1.174390	995.0
IP11	R3-1	Flameion_11	7250	1.176070	317.3
IP12	R3-2	Flameion_12	7250	1.175930	309.4
IP13	R3-3	Flameion_13	7250	1.176150	293.4
IP14	FS3-6	Flameion_14	8750	NS	
IP15	R4-1	Flameion_15	9250	1.186900	184.7
IP16	R4-2	Flameion_16	9250	1.187300	175.9
IP17	R4-3	Flameion_17	9250	1.186400	195.1
IP18	FS4-2	Flameion_18	9750	1.188920	247.5
IP19	R5-1	Flameion_19	10750	1.193510	226.9
IP20	R5-2	Flameion_20	10750	1.193330	248.8
IP21	R5-3	Flameion_21	10750	1.193960	198.4
IP22	FS4-5	Flameion_22	11250	1.196200	185.9
IP23	FS4-6	Flameion_23	11750	1.198520	215.5

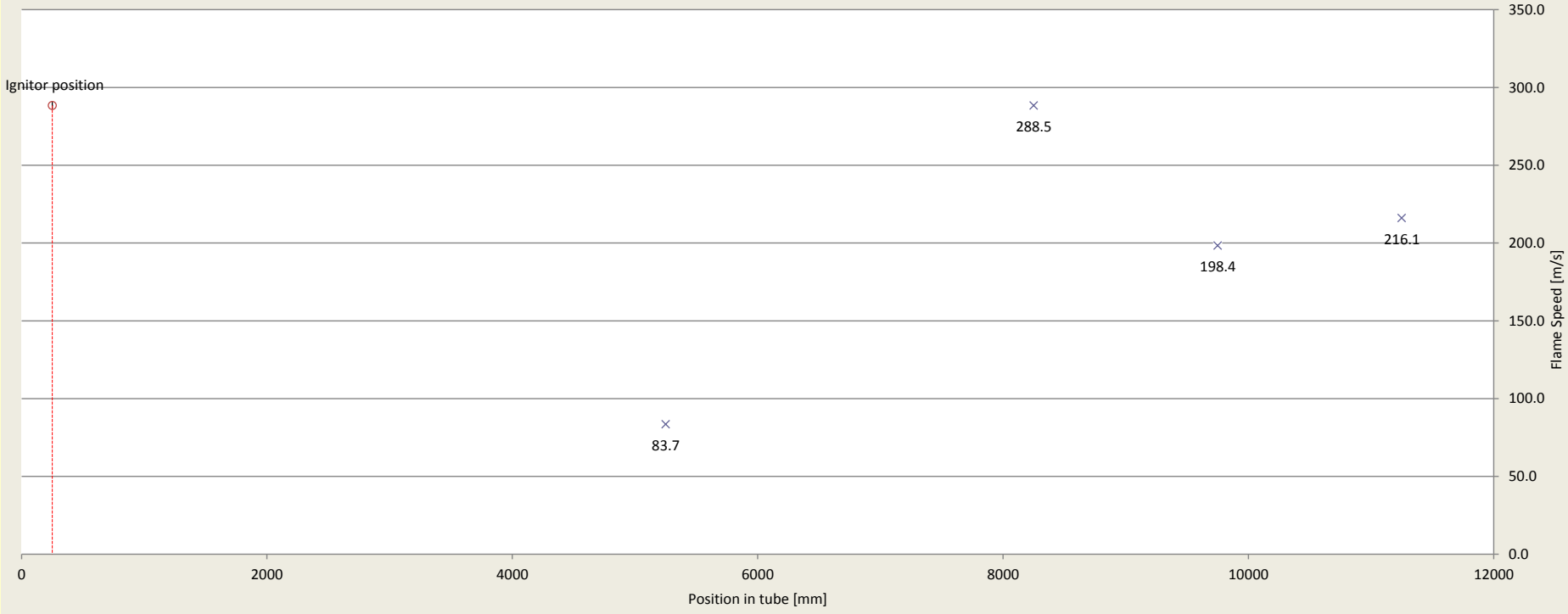
995.0



Note - IP10 signal may contain artefacts

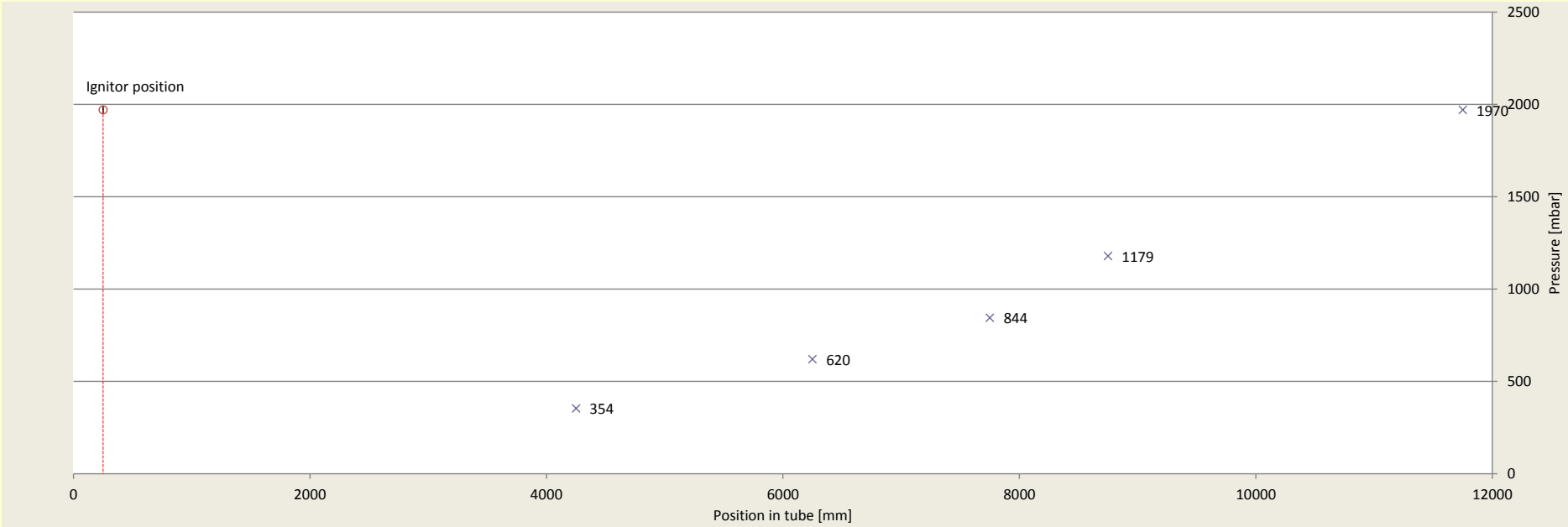
Location of igniter 250 mm **Time of ignition** 1.11144 seconds

OP Number	Location label	Position in tube (mm)	Flame arrival time (s)	Average flame speed (m/s)
OP0	NS2-5	5250	1.17120	83.7
OP1	NS3-5	8250	1.18160	288.5
OP2	NS4-2	9750	1.18916	198.4
OP3	NS4-5	11250	1.19610	216.1
OP4	0	#N/A		
OP5	0	#N/A		



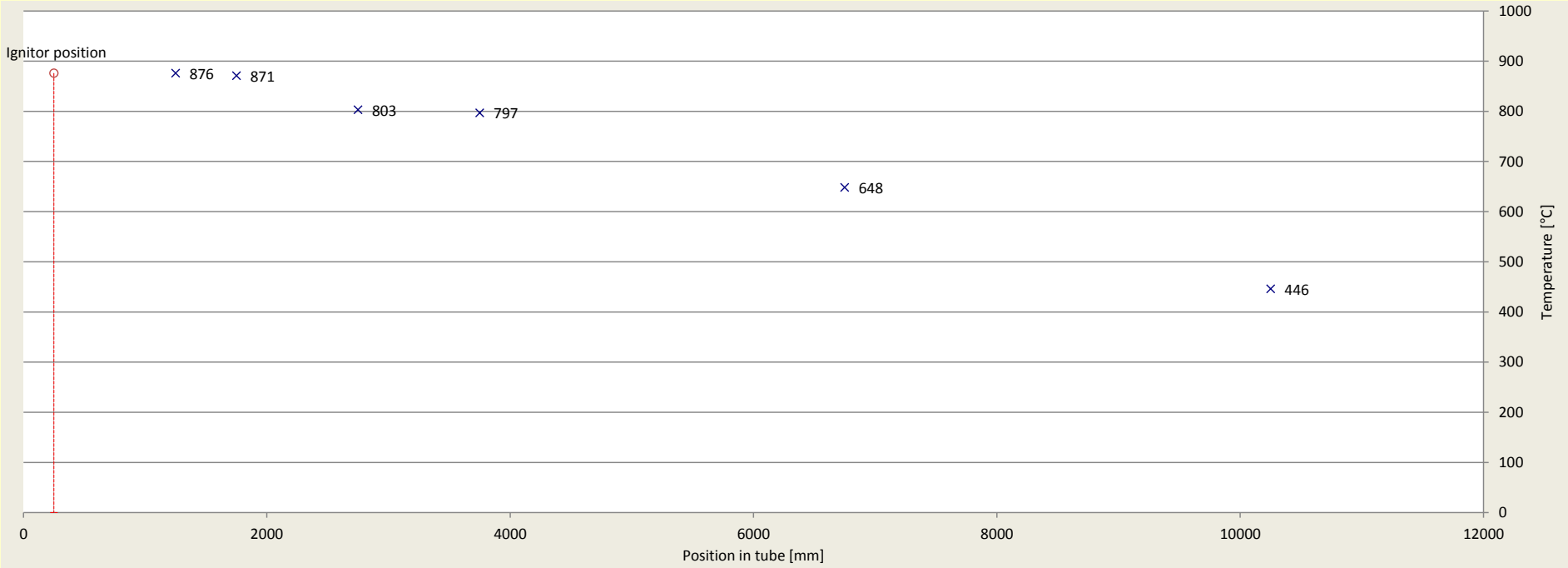
Location of igniter 250 mm

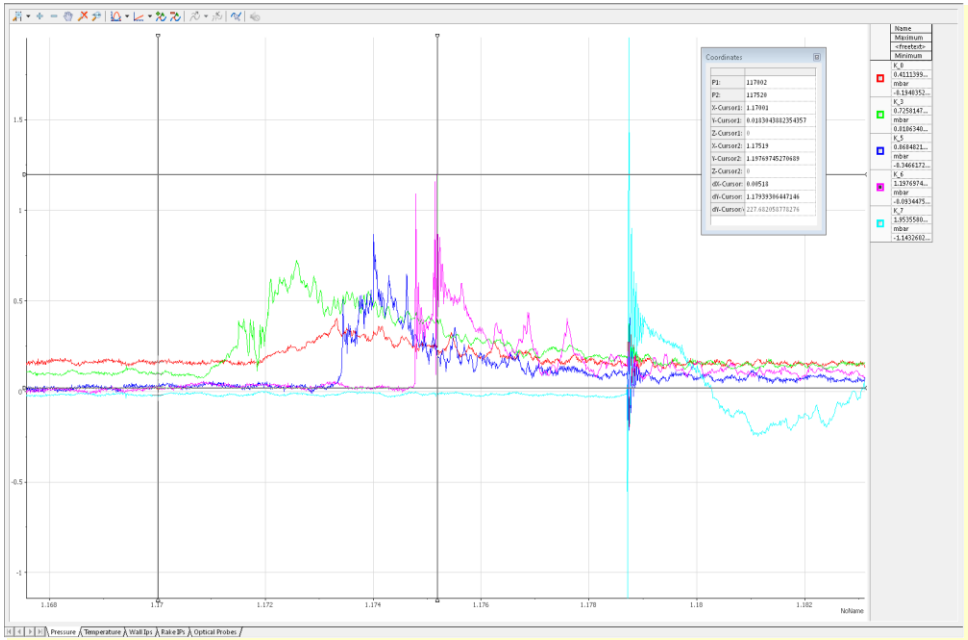
Transducer number	Location	Position in tube [mm]	ΔPmax [mbar]
KU0	NS2-3	4250	354
KU1	0	#N/A	
KU2	0	#N/A	
KU3	NS3-1	6250	620
KU4	0	#N/A	
KU5	NS3-4	7750	844
KU6	NS3-6	8750	1179
KU7	NS4-6	11750	1970



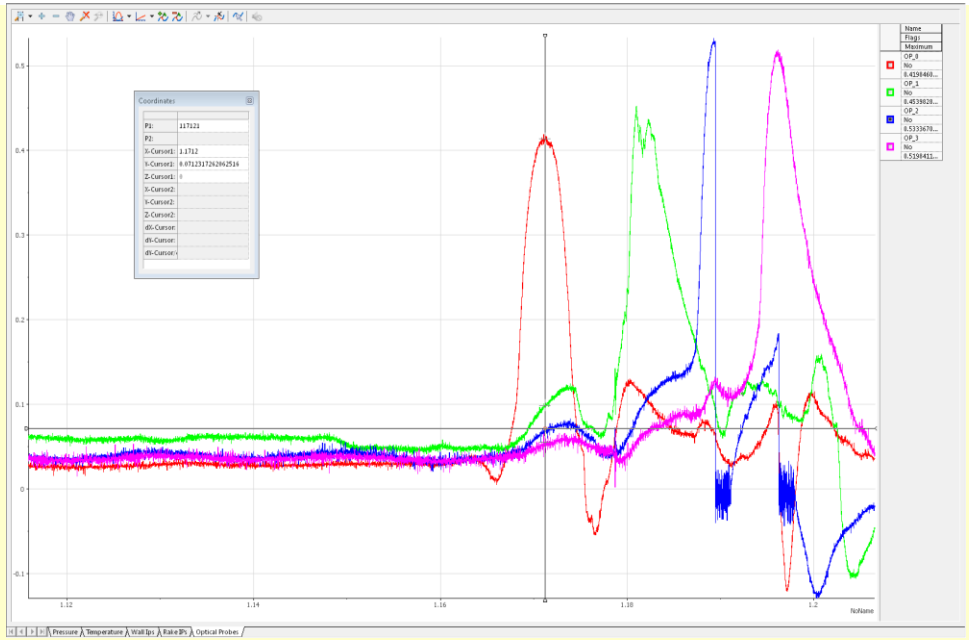
Location of igniter 250 mm

Thermocouple number	Location	Position in tube (mm)	T_{max} (deg C)
TC0	NS1-3	1250	876
TC1	NS1-5	2250	
TC2	NS2-2	3750	797
TC3	NS1-4	1750	871
TC4	NS1-6	2750	803
TC5	0	#N/A	
TC6	NS3-2	6750	648
TC15	NS4-3	10250	446

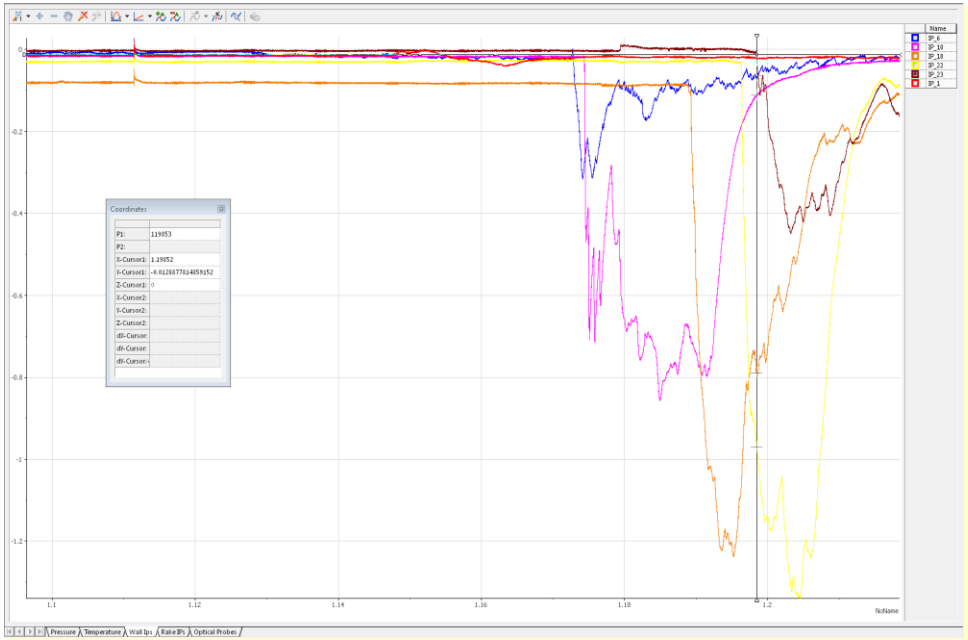


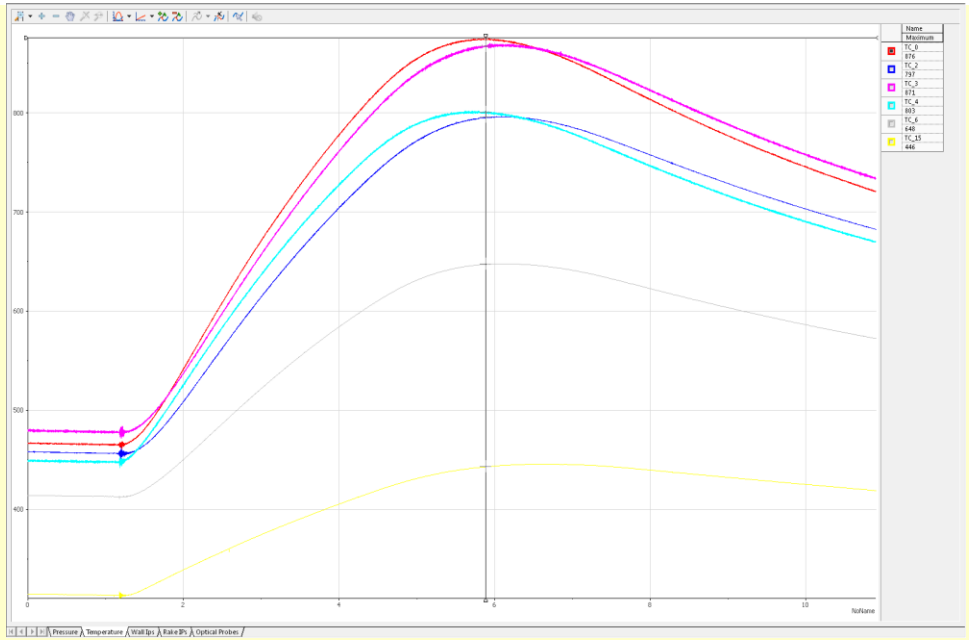


Pressure

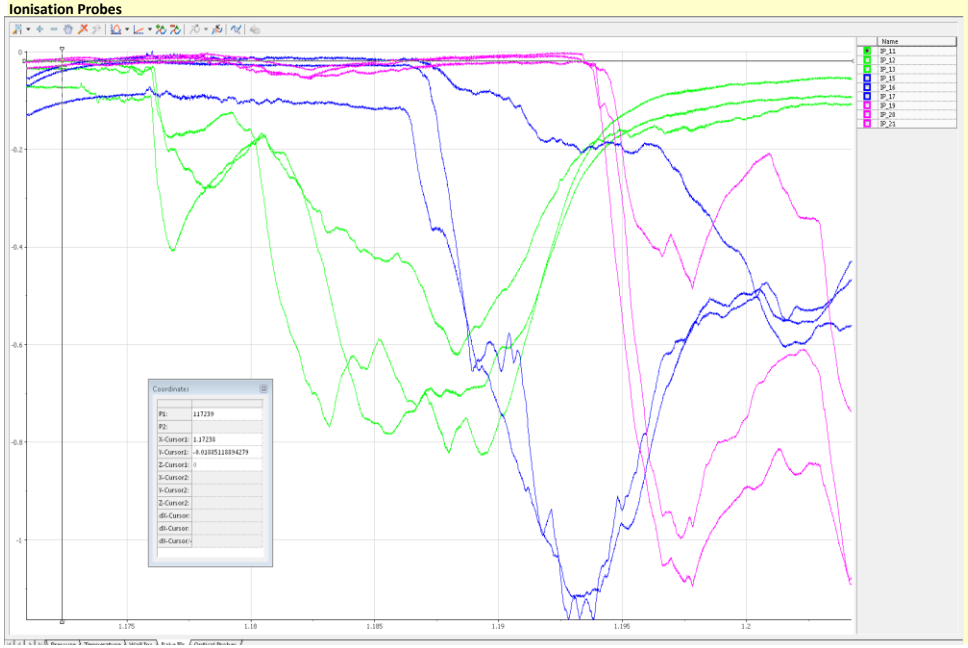


Optical Probes





Ionisation Probes



Temperature

|◁ ◁ ▷ ▷| Pressure Temperature Wall Bps Fake IPs Optical Probes