

**EXPERIMENTAL STUDY OF VENTED
HYDROGEN DEFLAGRATION
WITH IGNITION INSIDE AND OUTSIDE THE
VENTED VOLUME**

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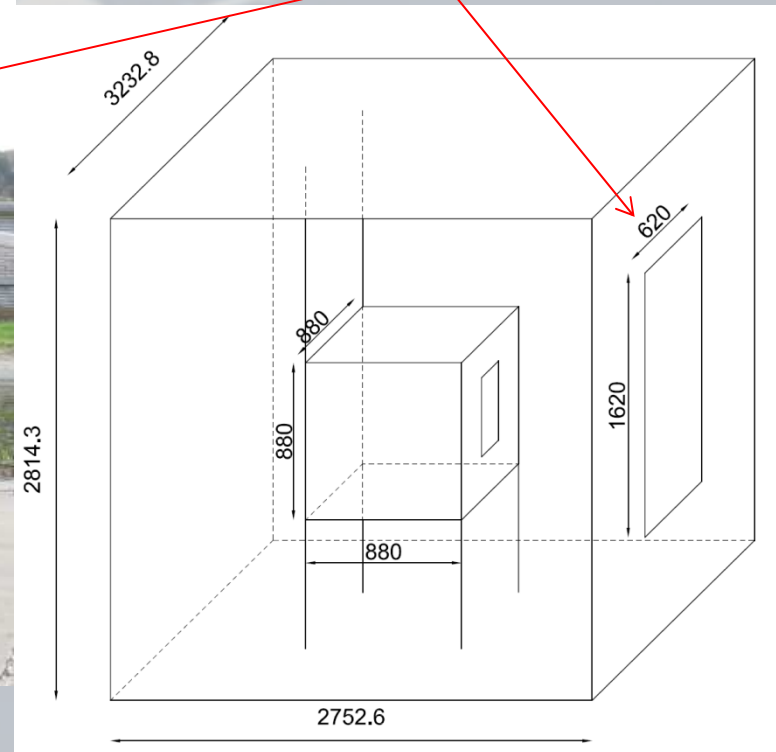
Presentation outline:

- CVE Test facility
- RED-CVE box experimental campaign
- Results
- Preliminary data analysis



CVE Test Facility
(Chambre View Explosion)

CVE Vent



Internal volume $\sim 25 \text{ m}^3$
Design to withstand up to 350
mbar overpressure

Errata corrige: CVE Dimensions



CVE Test Facility
(Chambre View Explosion)

RED-CVE Characteristics:
Cubic shape – 0,88 m side
Internal volume 0,6814 m³

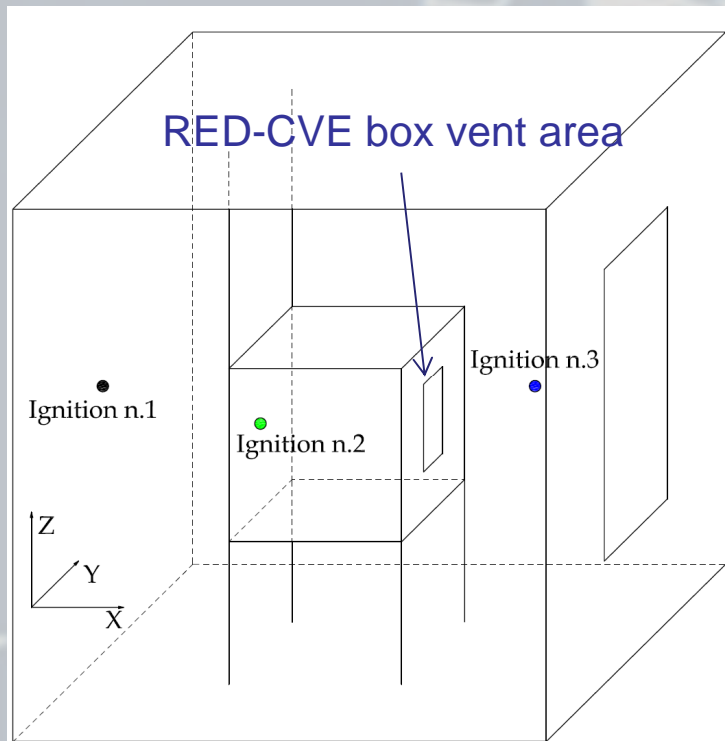


Internal volume ~25 m³

RED-CVE Experimental Campaign:

Fixed Parameters:

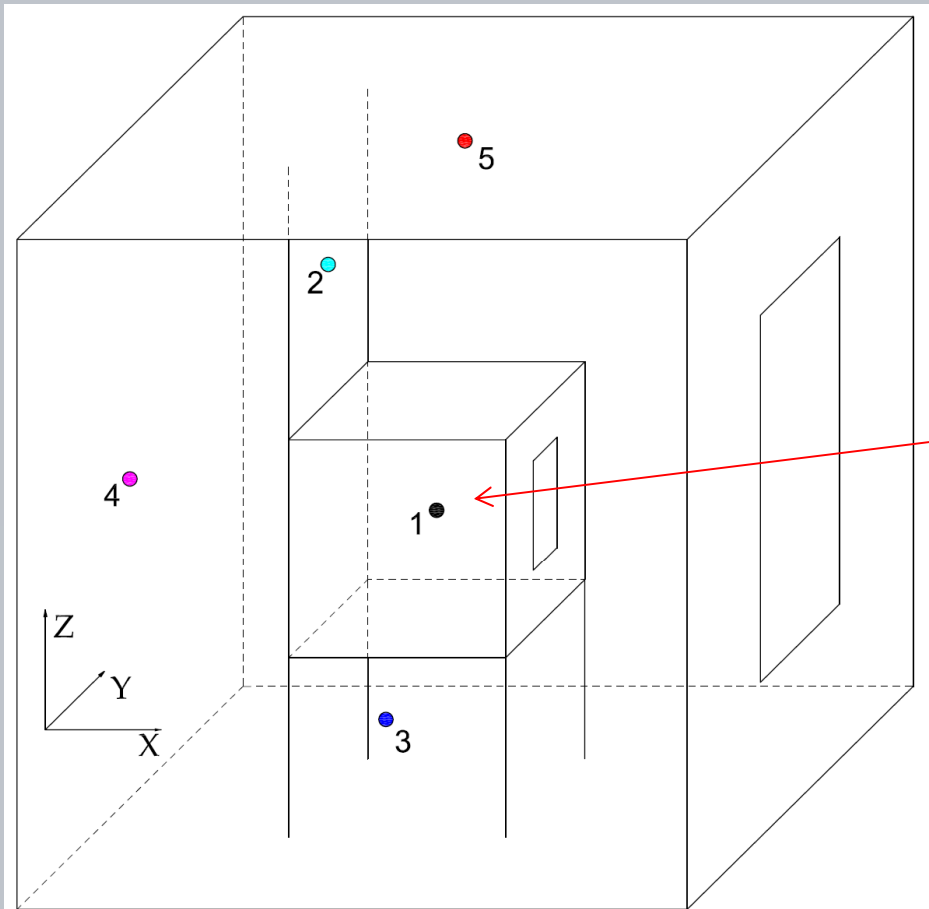
- Test facility vent area 1,12 m²
- Internal obstacles configuration (RED-CVE box – Ventilation Fans)



Parameters under investigation:

- Homogeneous hydrogen-air concentration in the range 8%vol. -13% vol.
- RED-CVE box vent area
- Ignition location

RED-CVE vent dimensions			
	Y [mm]	Z [mm]	Area [m ²]
Vent 1	205	135	0,027675
Vent 2	205	205	0,042025
Vent 3	205	270	0,05535



- Concentration sampling point n.1 ●
- Concentration sampling point n.2 ●
- Concentration sampling point n.3 ●
- Concentration sampling point n.4 ●
- Concentration sampling point n.5 ●

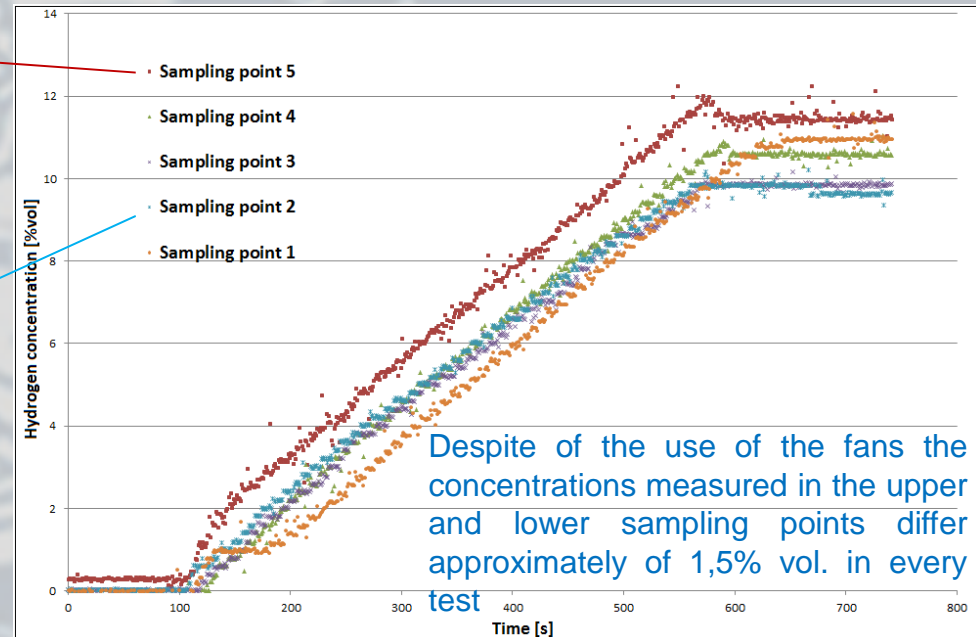
Concentration analyzers
MSA model TC9010B (0-20%vol.)

Concentration sampling points:

- 4 sampling points in the CVE test facility volume
- 1 sampling point placed inside the RED-CVE box



RED-CVE Experimental Campaign: “Nearly” Homogeneous concentrations



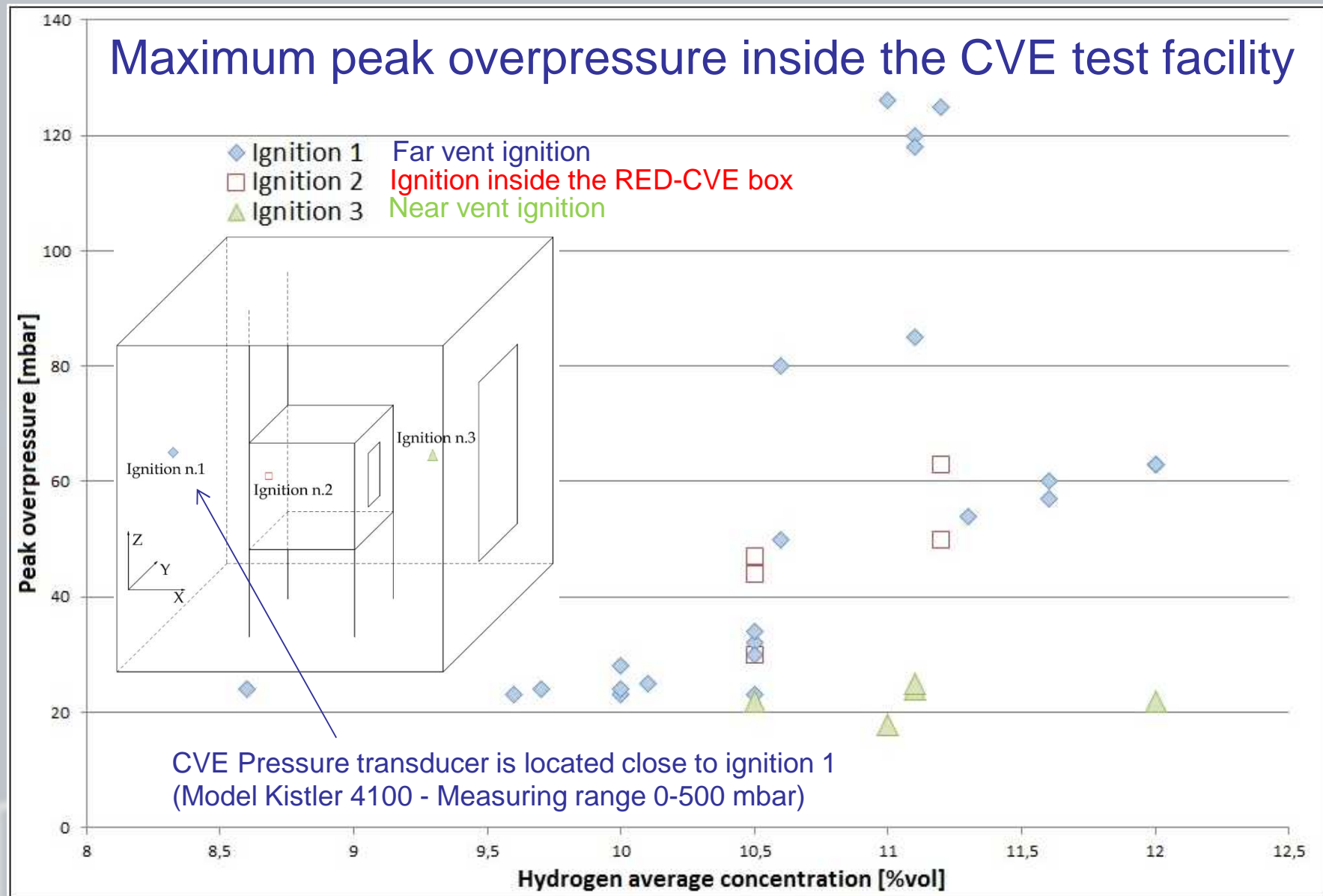
Secondary fan
(Dedicated to the recirculation inside the RED-CVE internal volume)

Main fan (CVE test facility atmosphere homogenization)

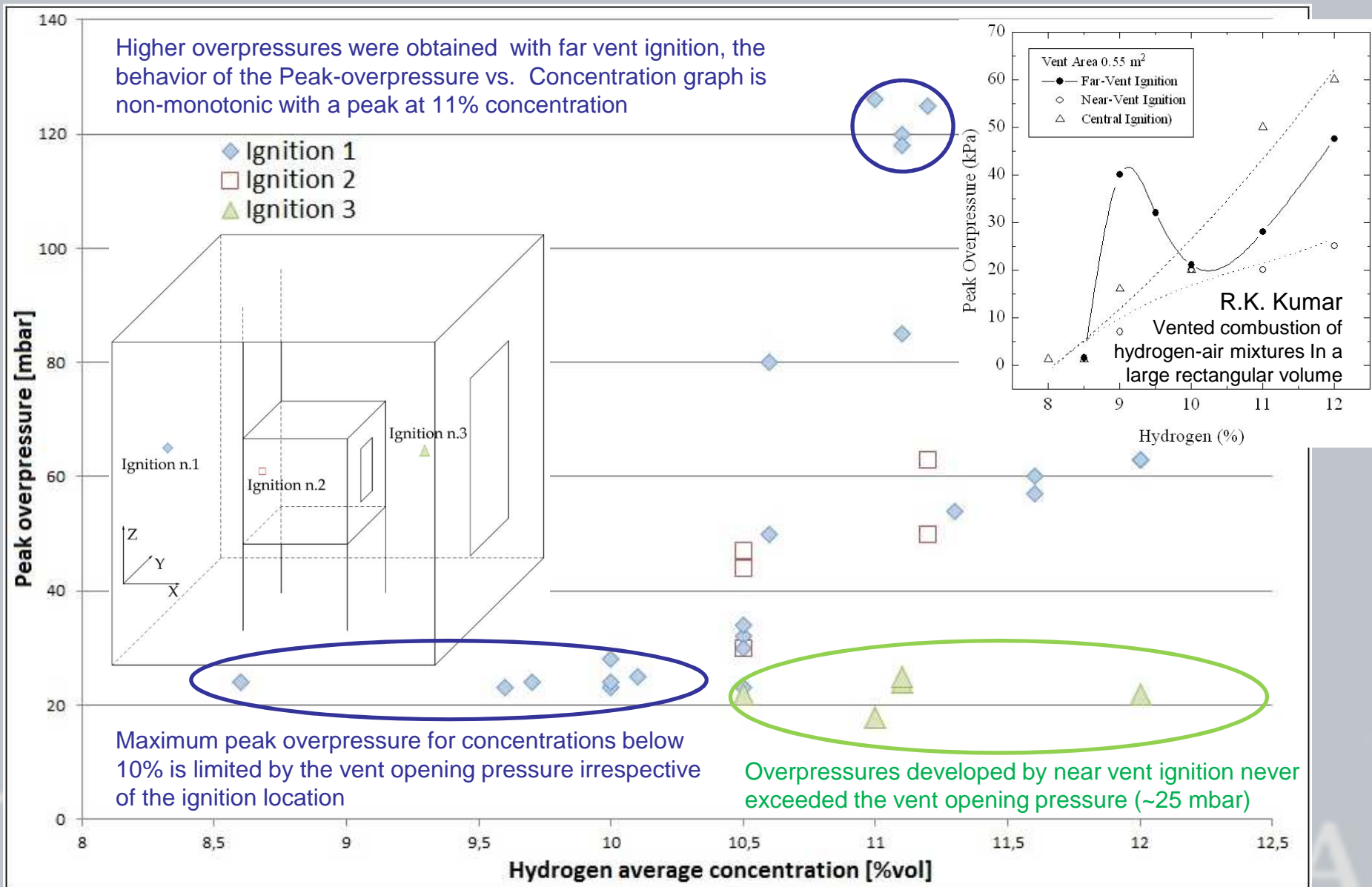
RED-CVE Campaign - Results

- 1. Overpressures inside the CVE Test facility*
- 2. Overpressures inside the RED-CVE box*



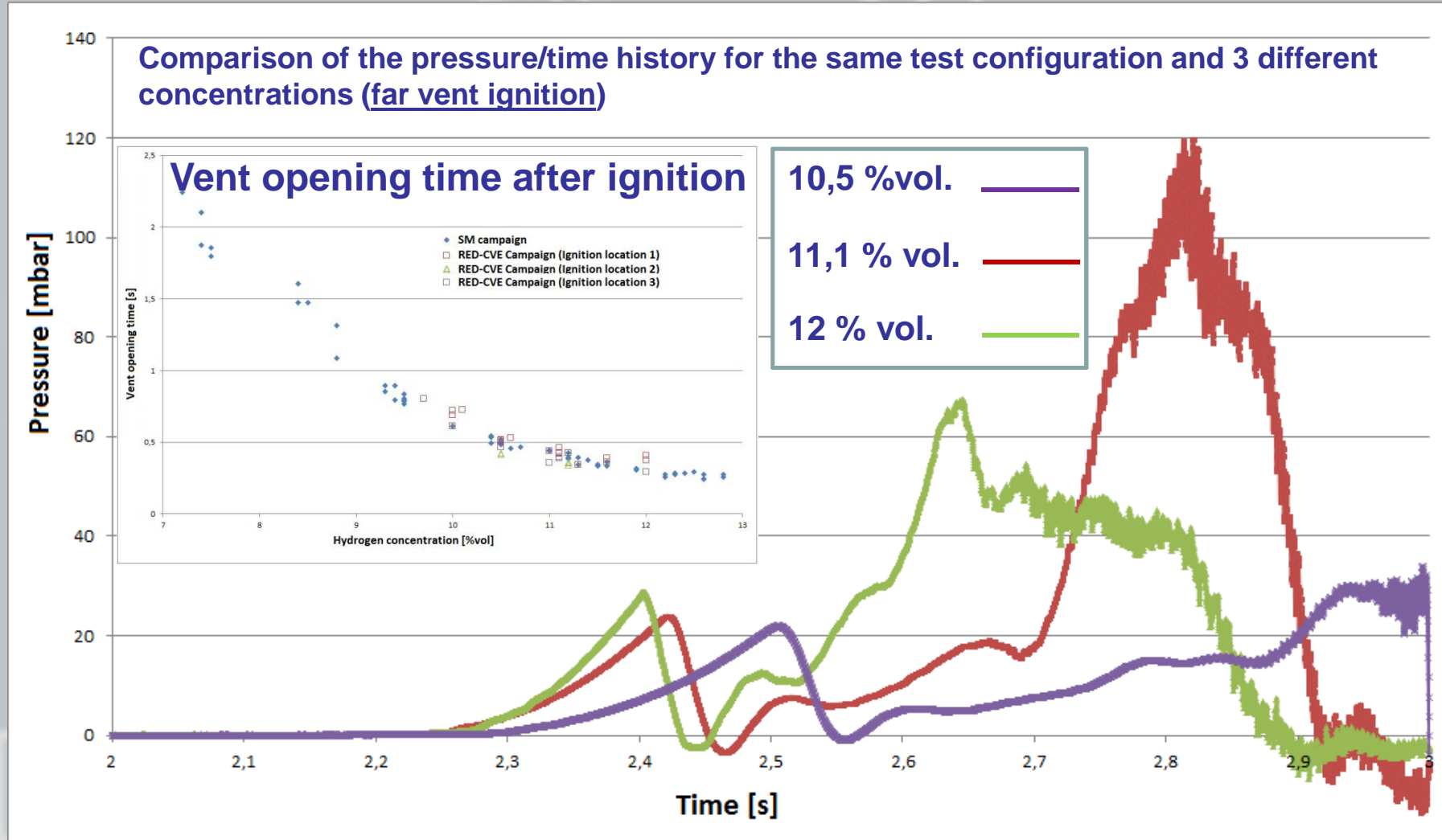


EXPERIMENTAL STUDY OF VENTED HYDROGEN DEFLAGRATION WITH IGNITION INSIDE AND OUTSIDE THE VENTED VOLUME



RED-CVE Campaign - Results

Pressure build-up in the CVE Test Facility – Far vent ignition



RED-CVE Campaign - Results

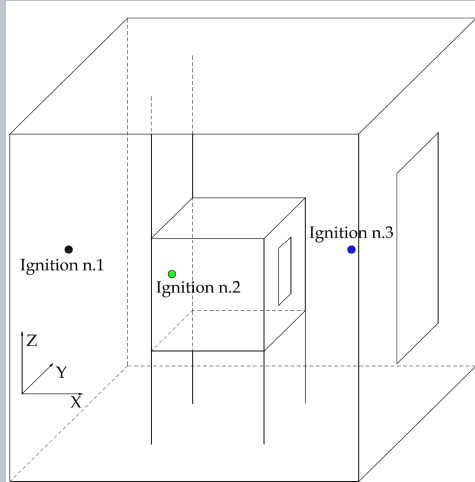
Overpressures inside the CVE Test facility

Summary:

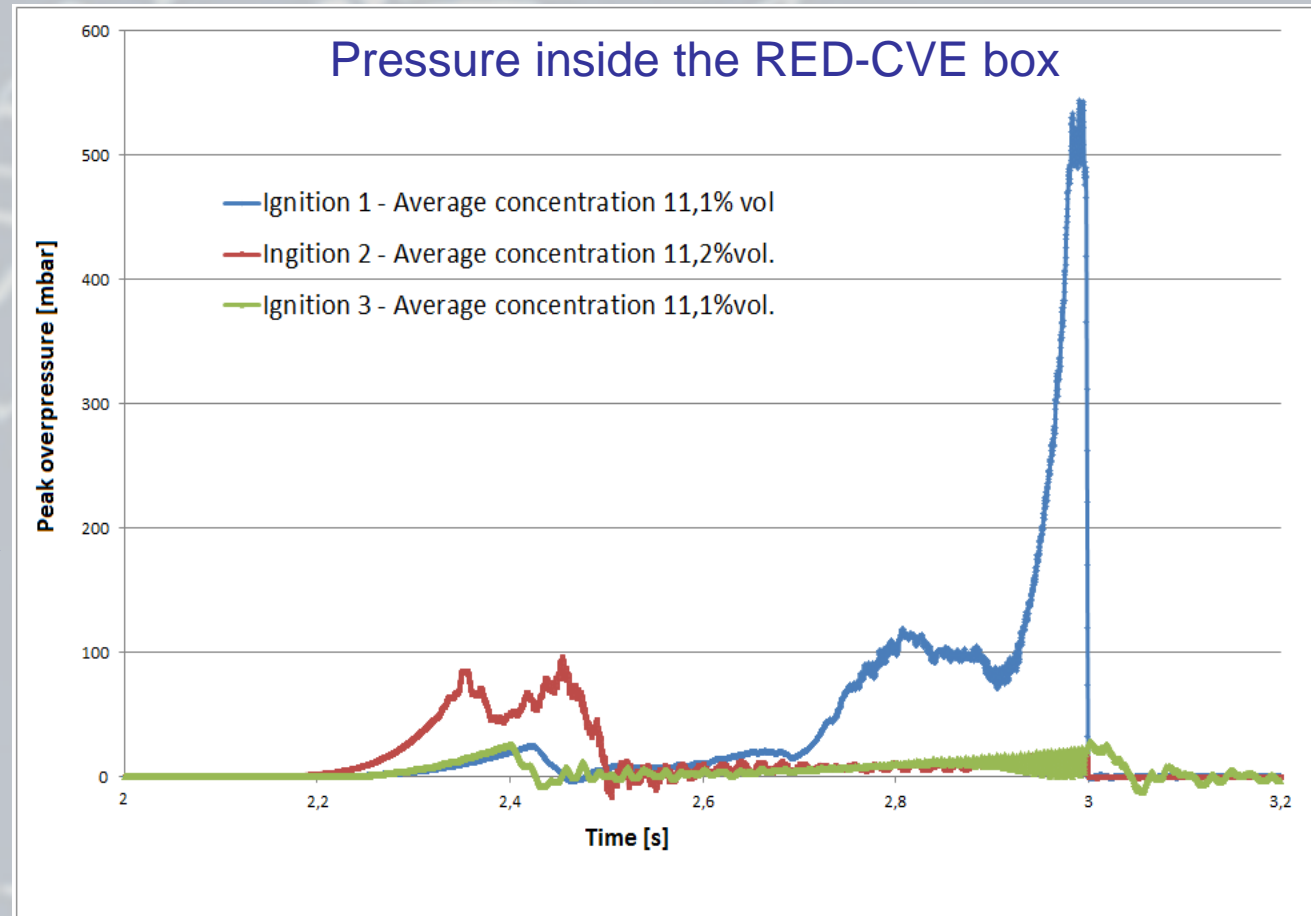
- Vented deflagrations were performed in a 25 m³ volume facility, having a vent area of 1,12 m², with a homogeneous hydrogen concentration ranging from 8,5% to 12,5%.
- For average concentrations below 10% the peak overpressure was limited by the opening pressure of the vent (~25 mbar) independently of the ignition position (ignition inside the test facility volume).
- When the mixture was ignited inside the RED-CVE box the opening pressure of the vent was higher and dependent of the RED-CVE vent dimensions.
- In far vent ignition tests the peak overpressure vs. concentration behavior showed a non-monotonic growth with a peak at around 11% concentration. (The same non-monotonic behavior was described by Kumar for deflagration tests in a rectangular 120 m³ facility, with a peak at 9% vol.)

RED-CVE Campaign - Results

Pressure build-up in the RED-CVE box

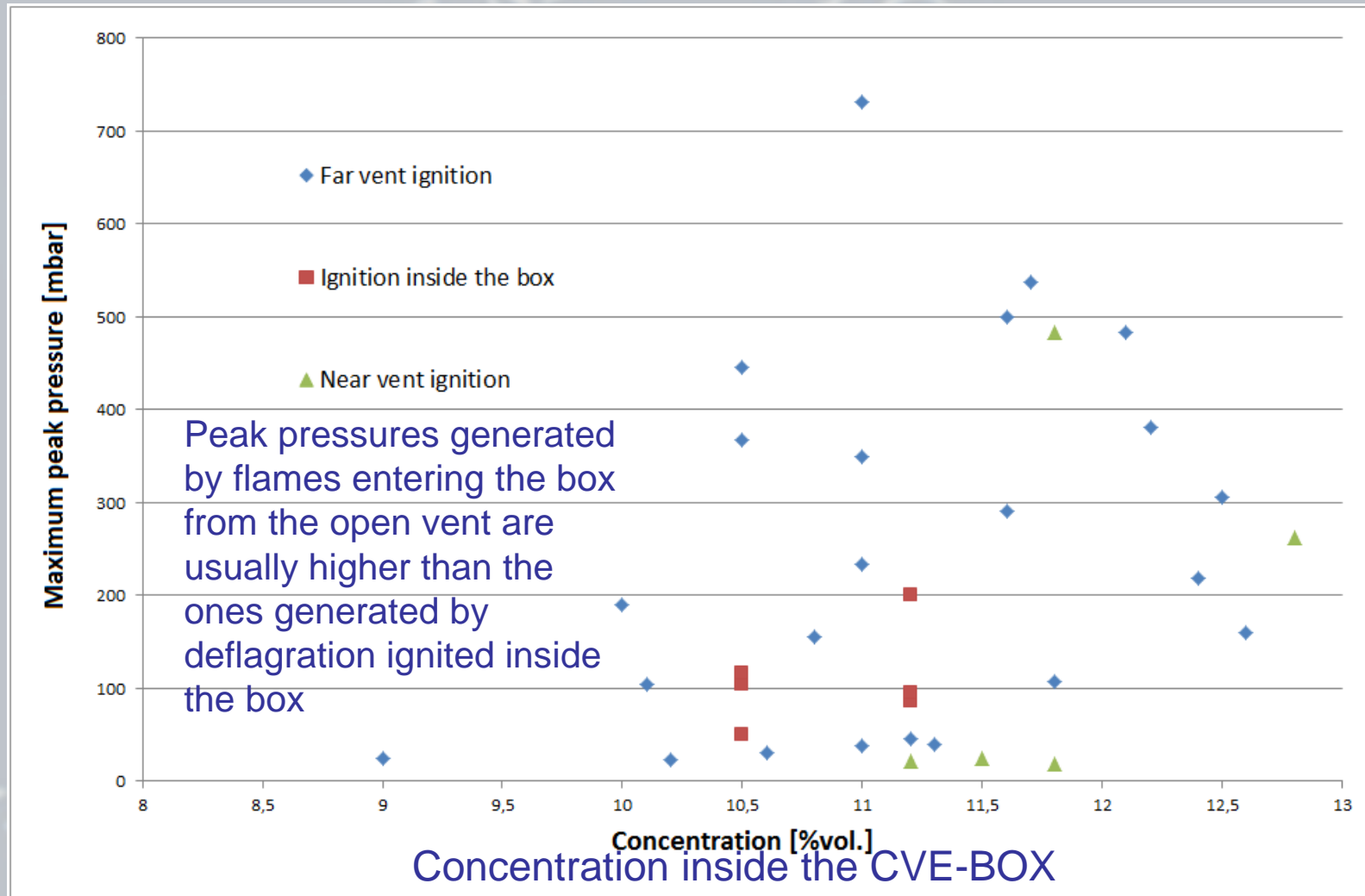


The comparison of the pressure-time history inside the RED-CVE box for the same measured concentration varying the ignition position showed that maximum peak pressure is obtained during deflagration generated by far vent ignition



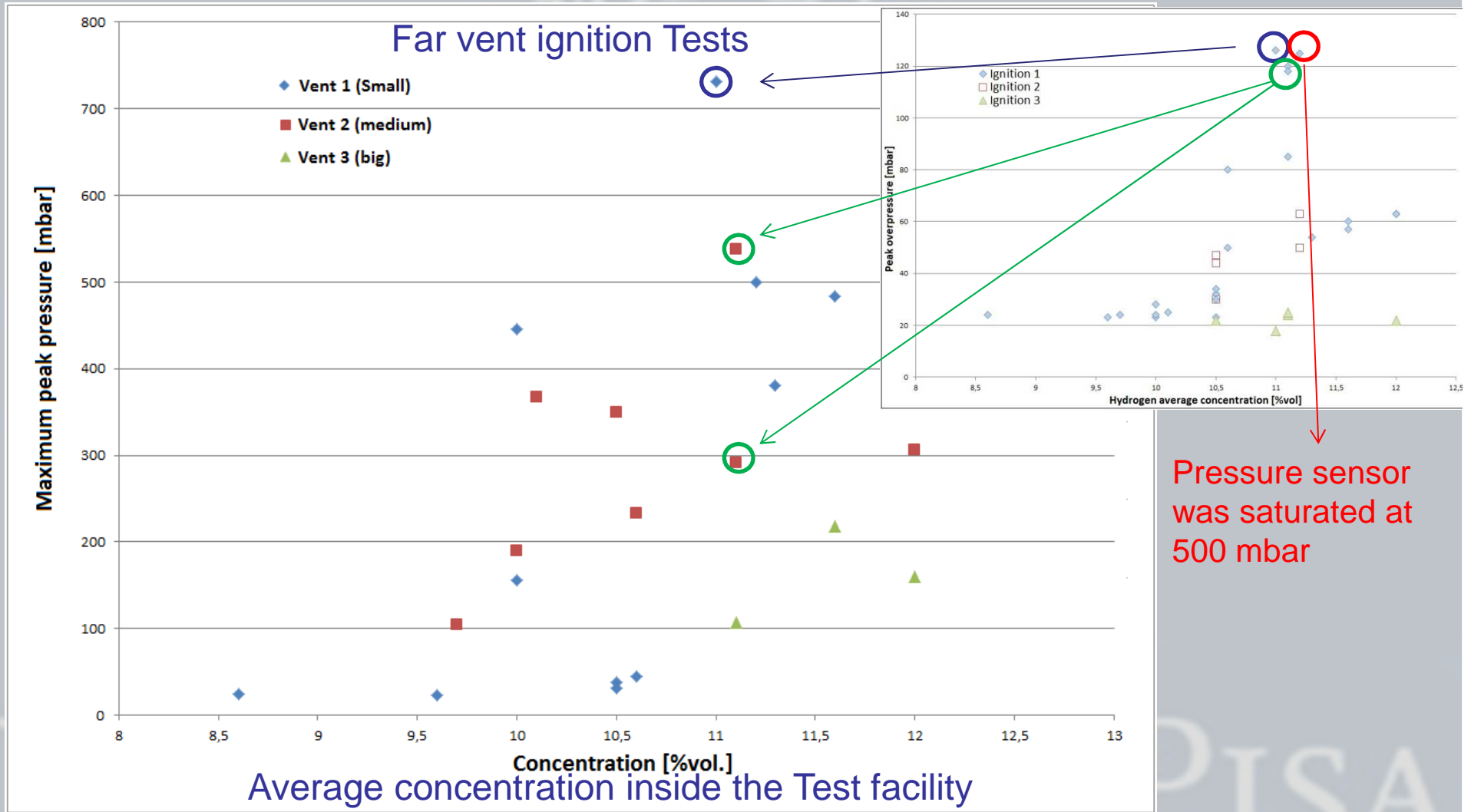
RED-CVE Campaign - Results

Maximum peak overpressure inside the RED-CVE box



RED-CVE Campaign - Results

Maximum peak overpressure inside the RED-CVE box



RED-CVE Campaign - Results

Overpressures inside the RED-CVE box

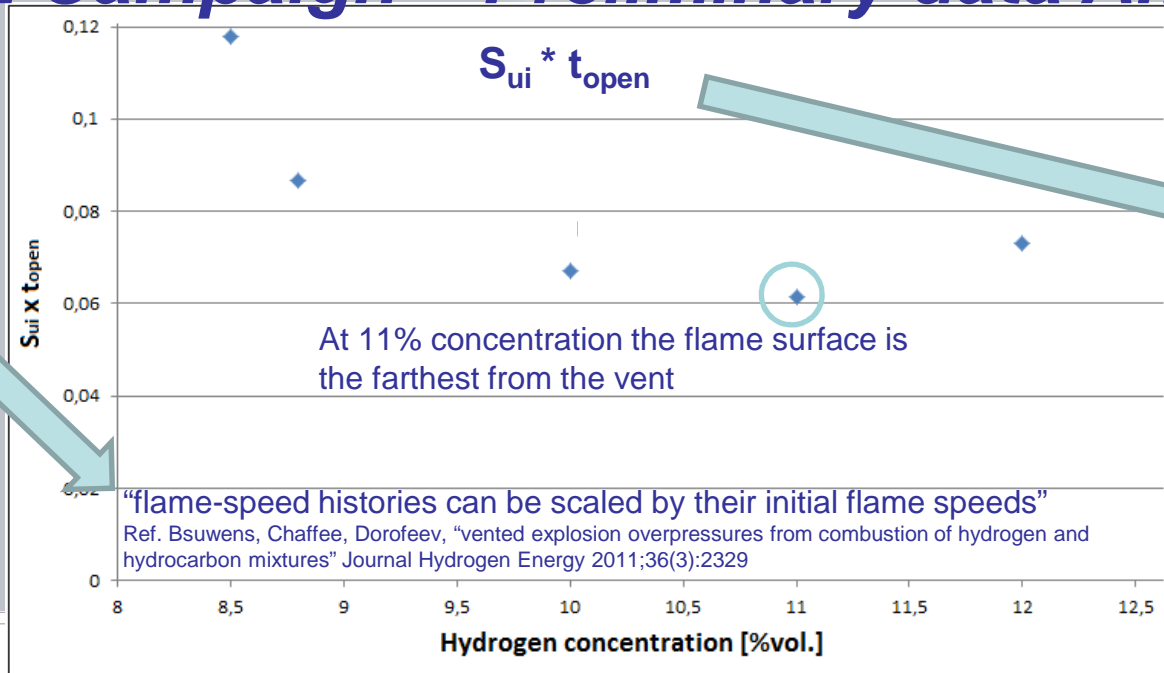
Summary:

- Vented deflagrations were performed in a 25 m³ volume facility, hosting a smaller vented chamber characterized by a volume of 0,6814m³.
- Maximum peak overpressure measured inside the RED-CVE, over the range condition investigated, was about 700 mbar (70 kPa).
- For a given concentration the peak overpressure produced inside the box was higher when the ignition location was external to the box.
- Higher overpressures were generated by far vent ignition.
- The maximum peak overpressure was obtained with the smaller vent for an average concentration of 11%, for the same tests that produced a maximum peak overpressure inside the test facility.

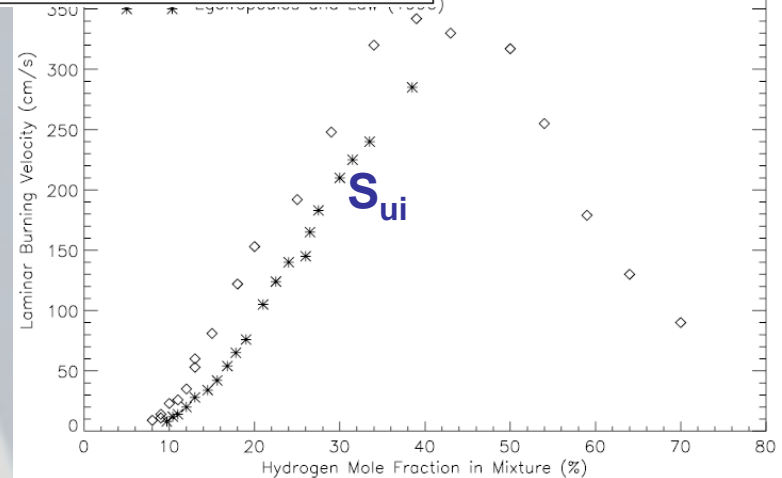
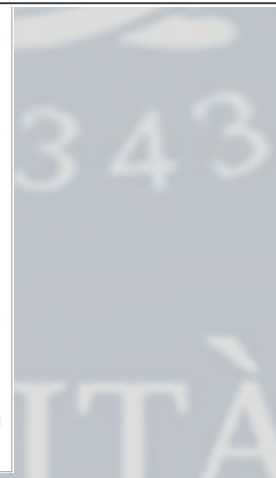
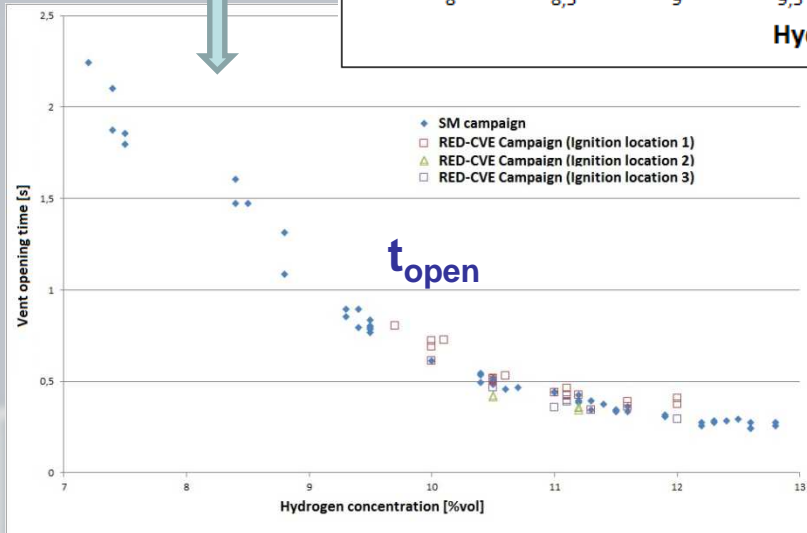
RED-CVE Campaign – Preliminary data Analysis

$$V_f = S_{ui} + U_u$$

T_{open} is not influenced by the obstacle, usually the vent opens when the flame front has not reached the obstacles yet



Relative position of the flame at the vent opening's time for different concentrations

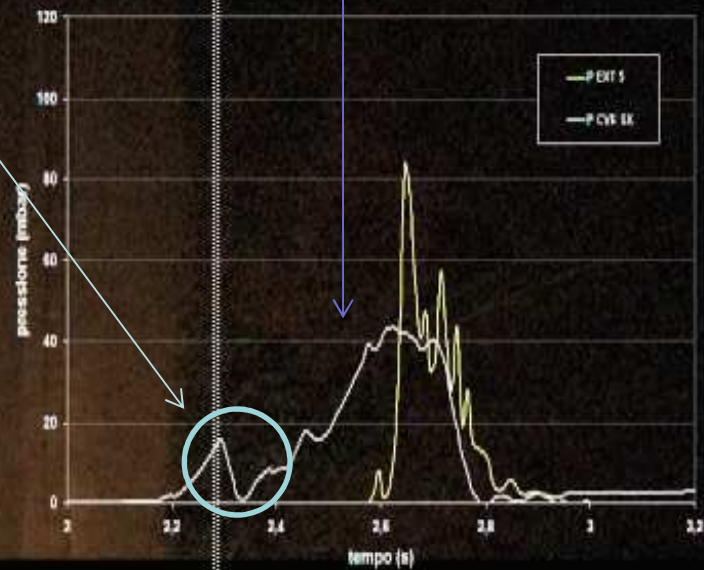
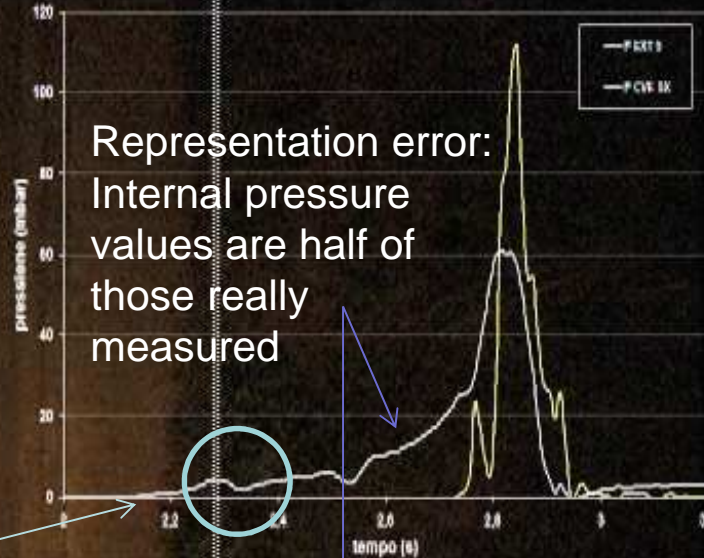


Ref. Chao, Bsuwens, Dorofeev, 'An analysis of peak overpressure in vented gaseous explosion' Proceedings of the combustion institute 33 (2011) 2367-2374

- A first peak was observed when the flame reached the vent igniting the vented un-burned mixture
- A second pressure peak is observed as the flame approaches the walls

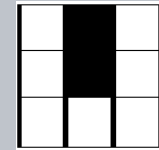
Flame recorded with a commercial camera 25 Hz (Semi-frame 50 Hz)

Initial vent opening



Average concentration
11,3%

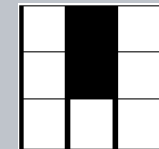
Test ISP23



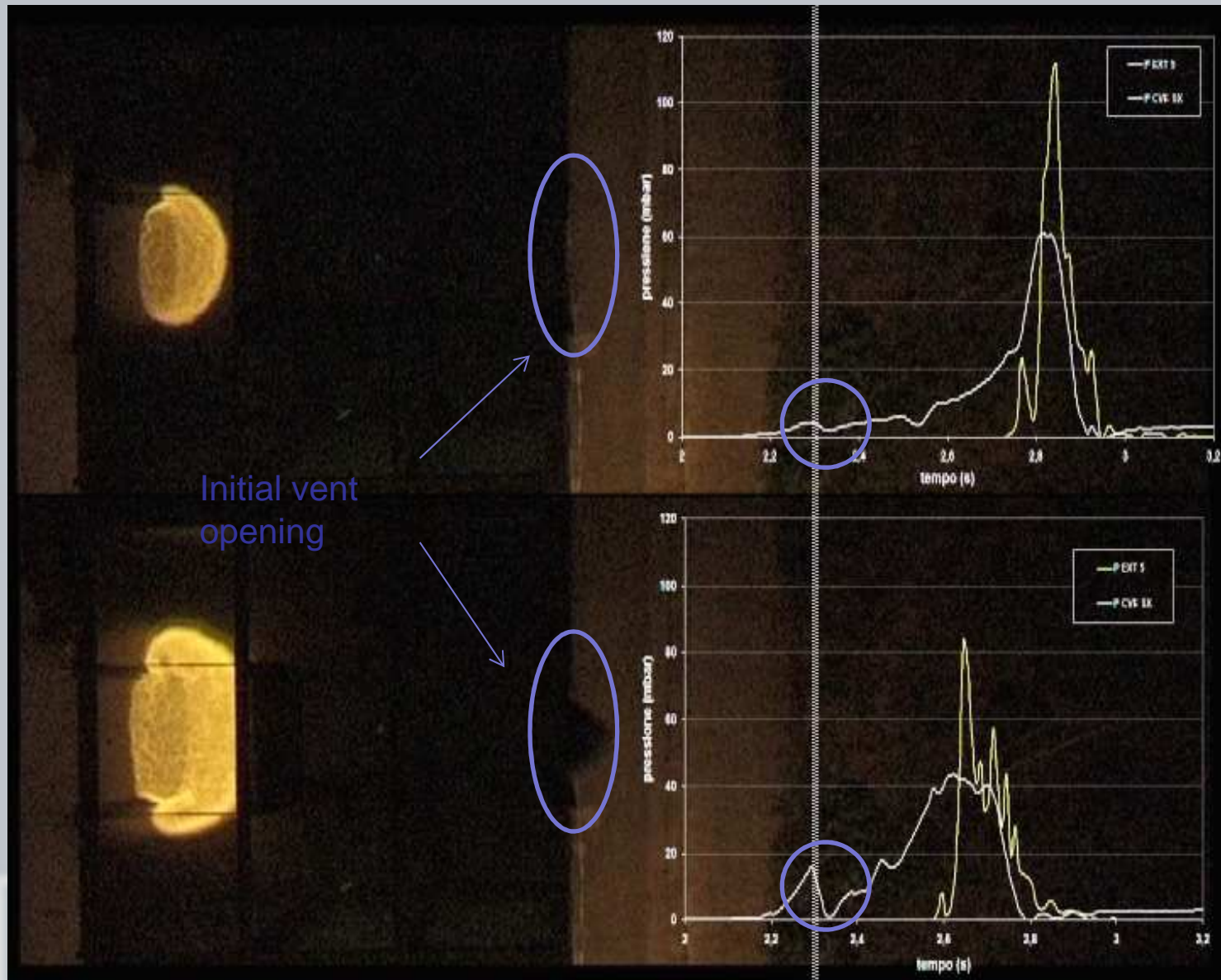
Obstacle configuration

Average concentration
12,3%

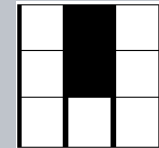
Test ISP24



Obstacle configuration

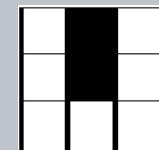


Average concentration
11,3%
Test ISP23

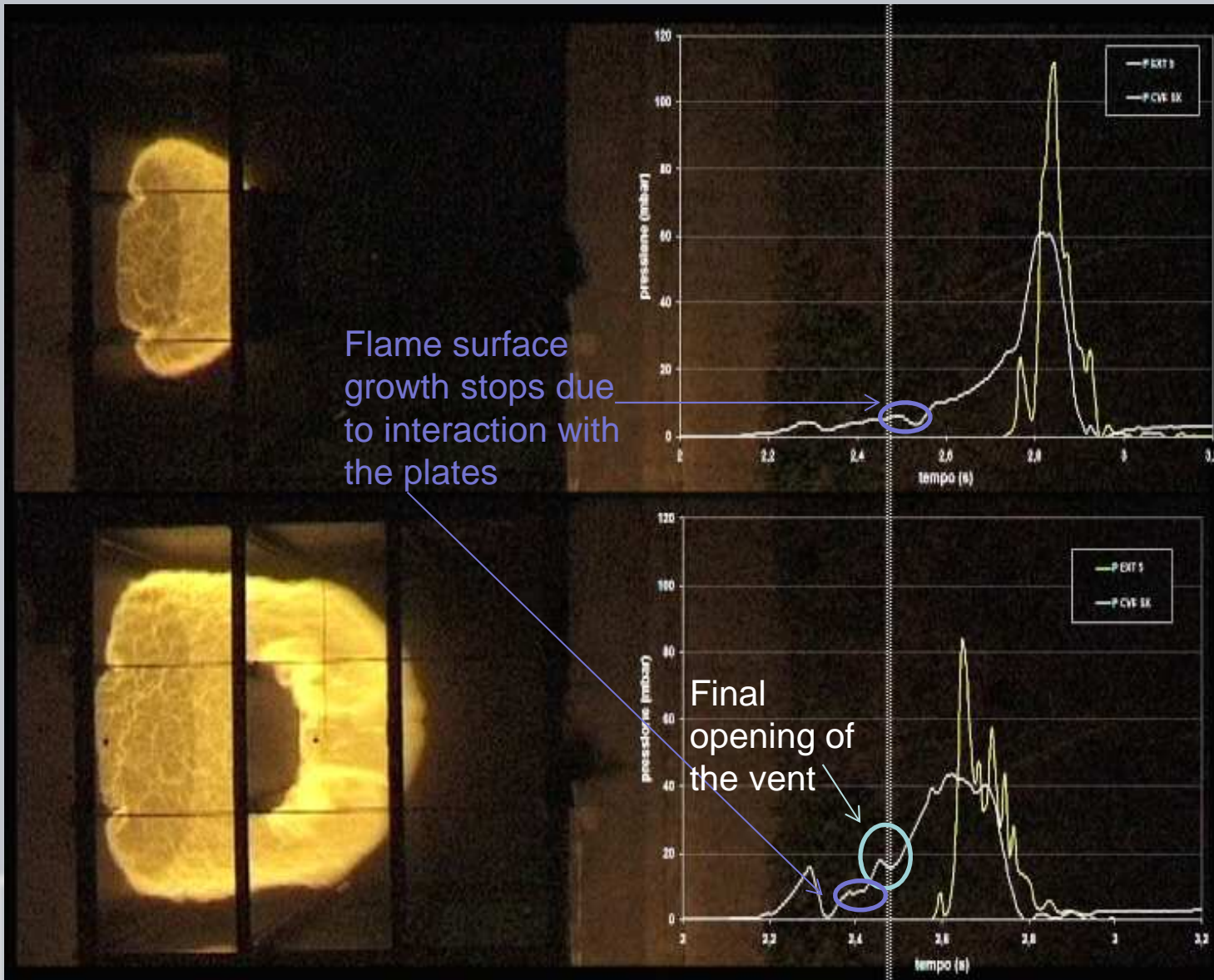


Obstacle configuration

Average concentration
12,3%
Test ISP24



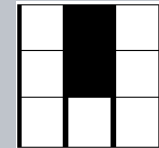
Obstacle configuration



Average concentration 11,3%

Test ISP23

Obstacle configuration

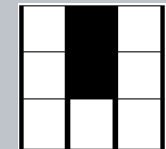


Obstacle configuration

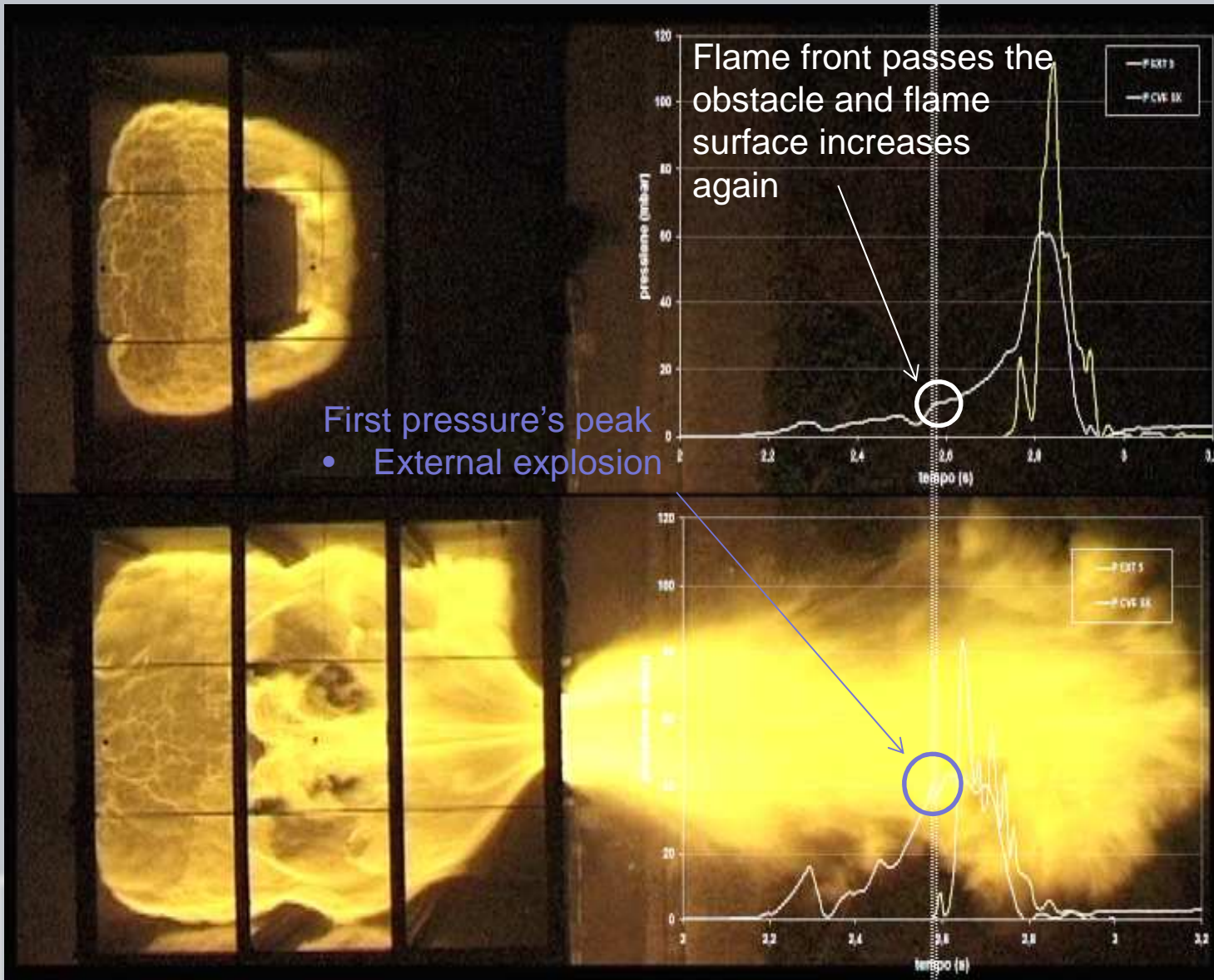
Average concentration 12,3%

Test ISP24

Obstacle configuration

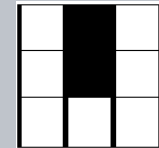


Obstacle configuration



Average concentration
11,3%

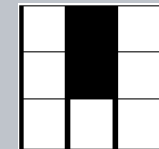
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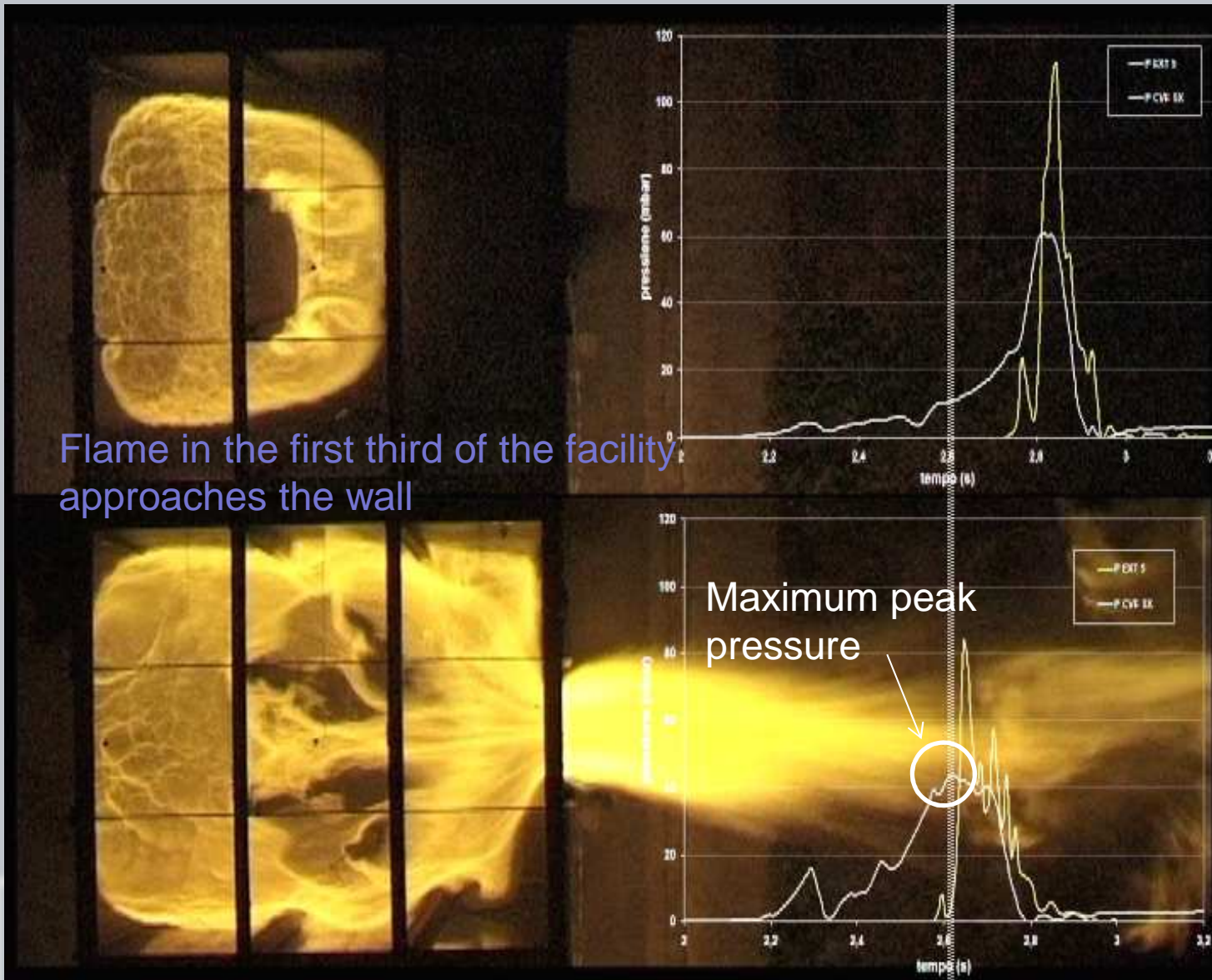
Obstacle configuration

Average concentration
12,3%

Test ISP24

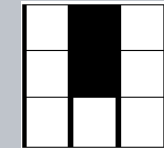


Obstacle configuration



Average concentration
11,3%

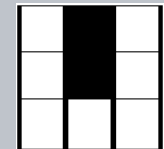
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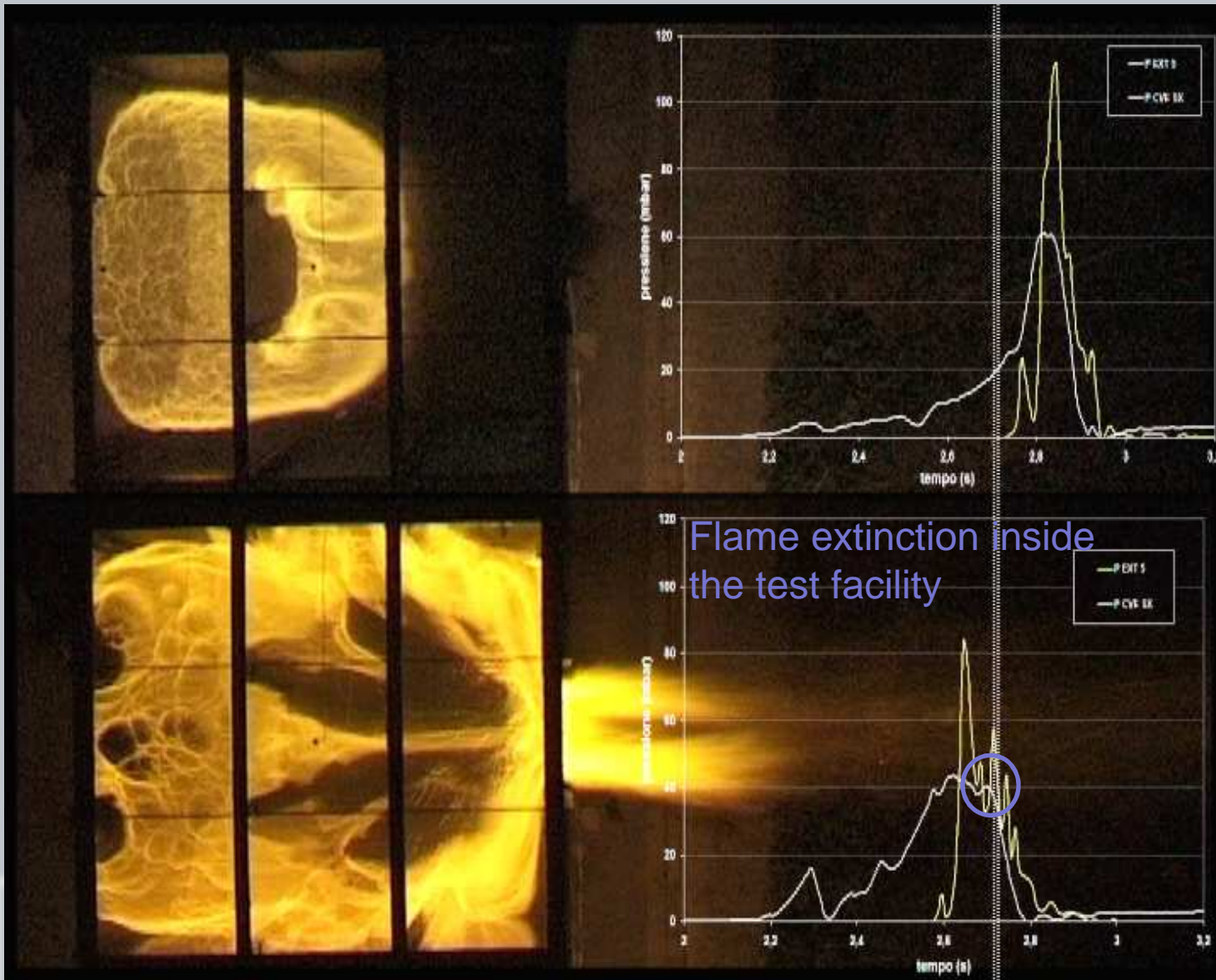
Obstacle configuration

Average concentration
12,3%

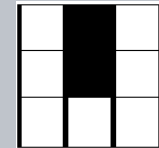
Test ISP24



Obstacle configuration

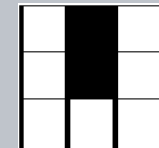


Average concentration
11,3%
Test ISP23

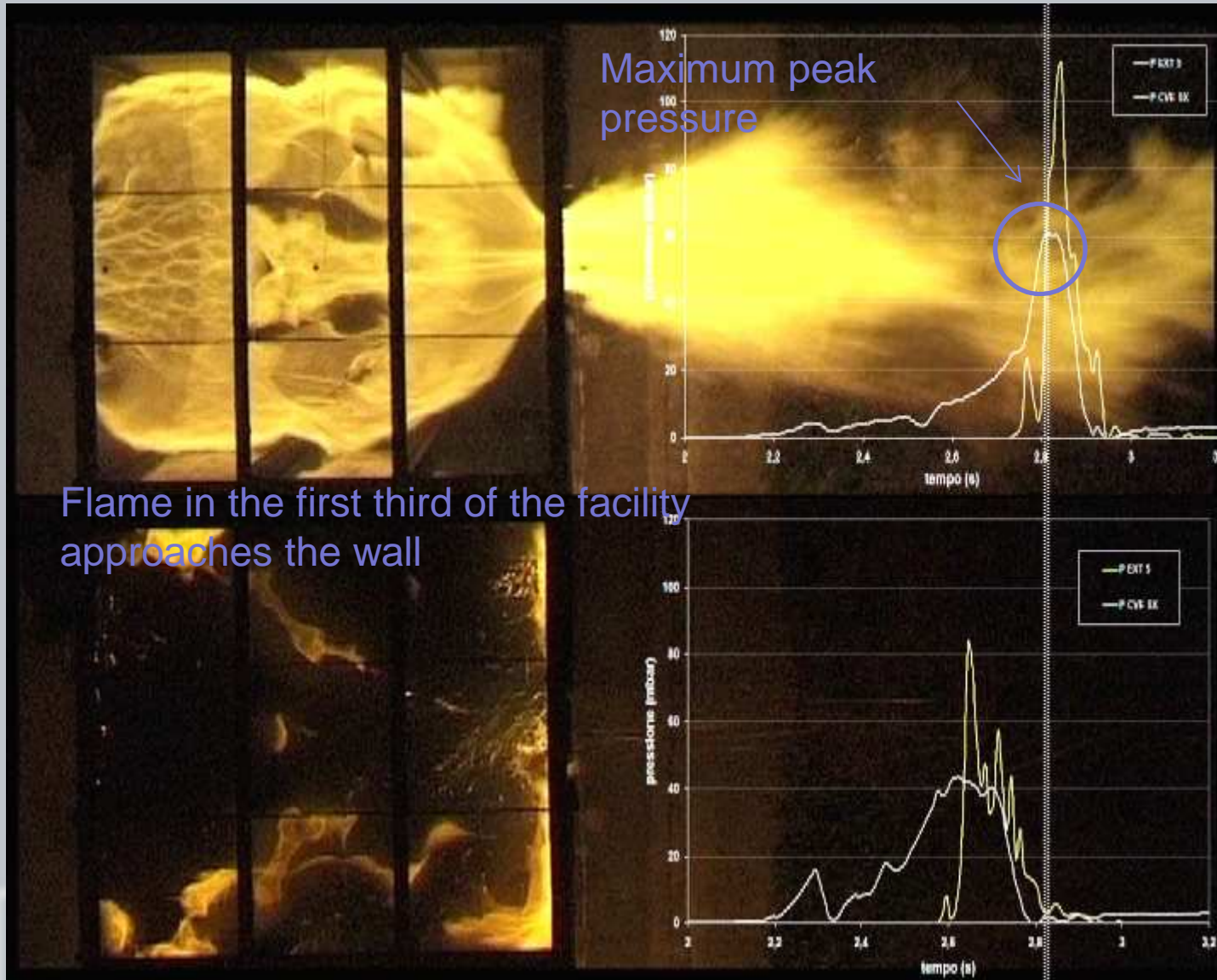


Obstacle configuration

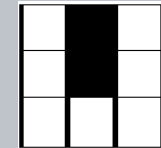
Average concentration
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Test ISP24



Obstacle configuration

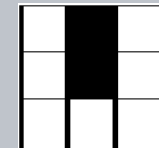


Average concentration 11,3%
Test ISP23

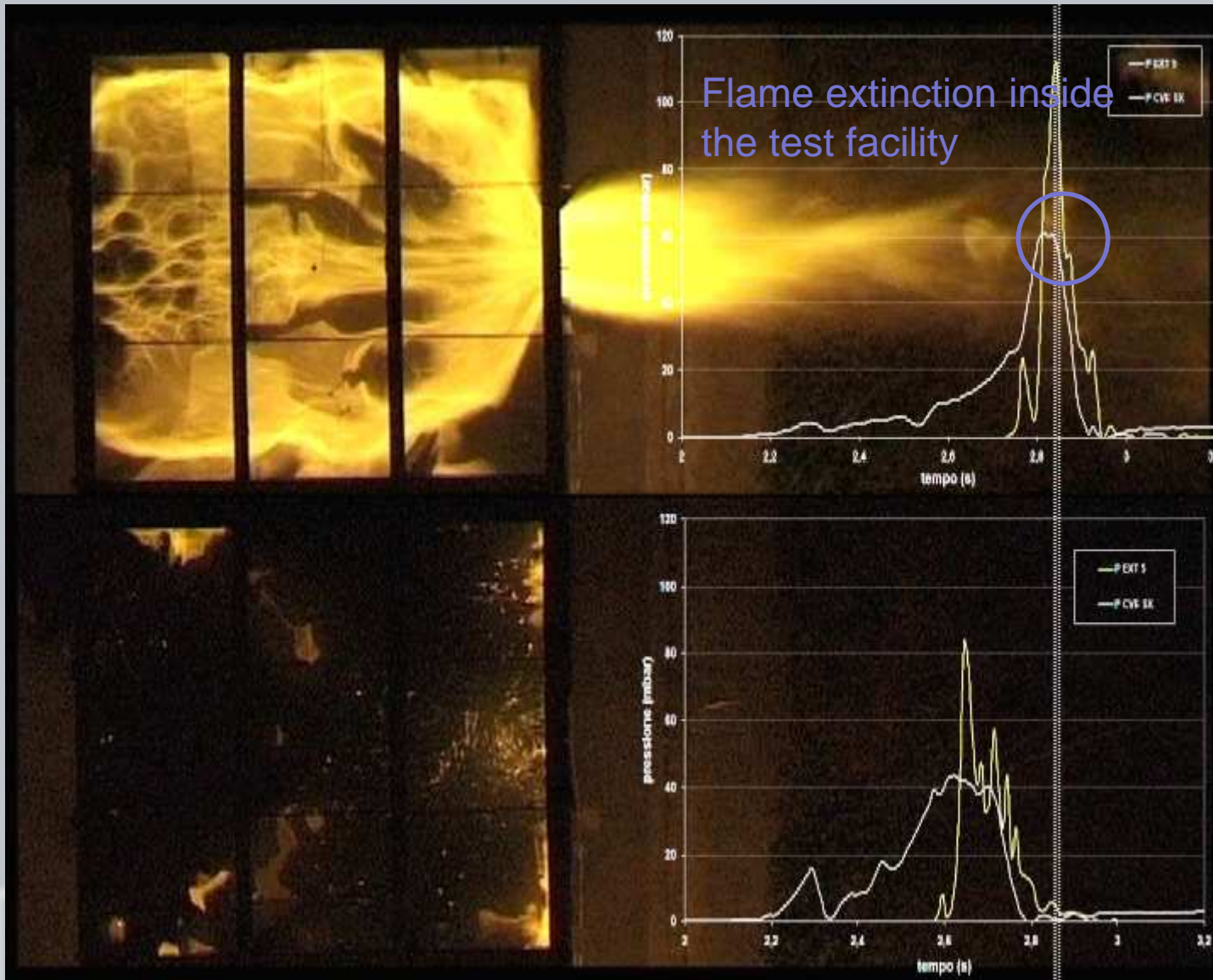


Obstacle configuration

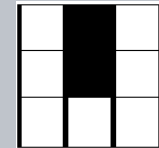
Average concentration 12,3%
Test ISP24



Obstacle configuration

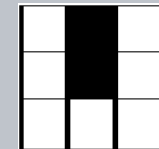


Average concentration 11,3%
Test ISP23



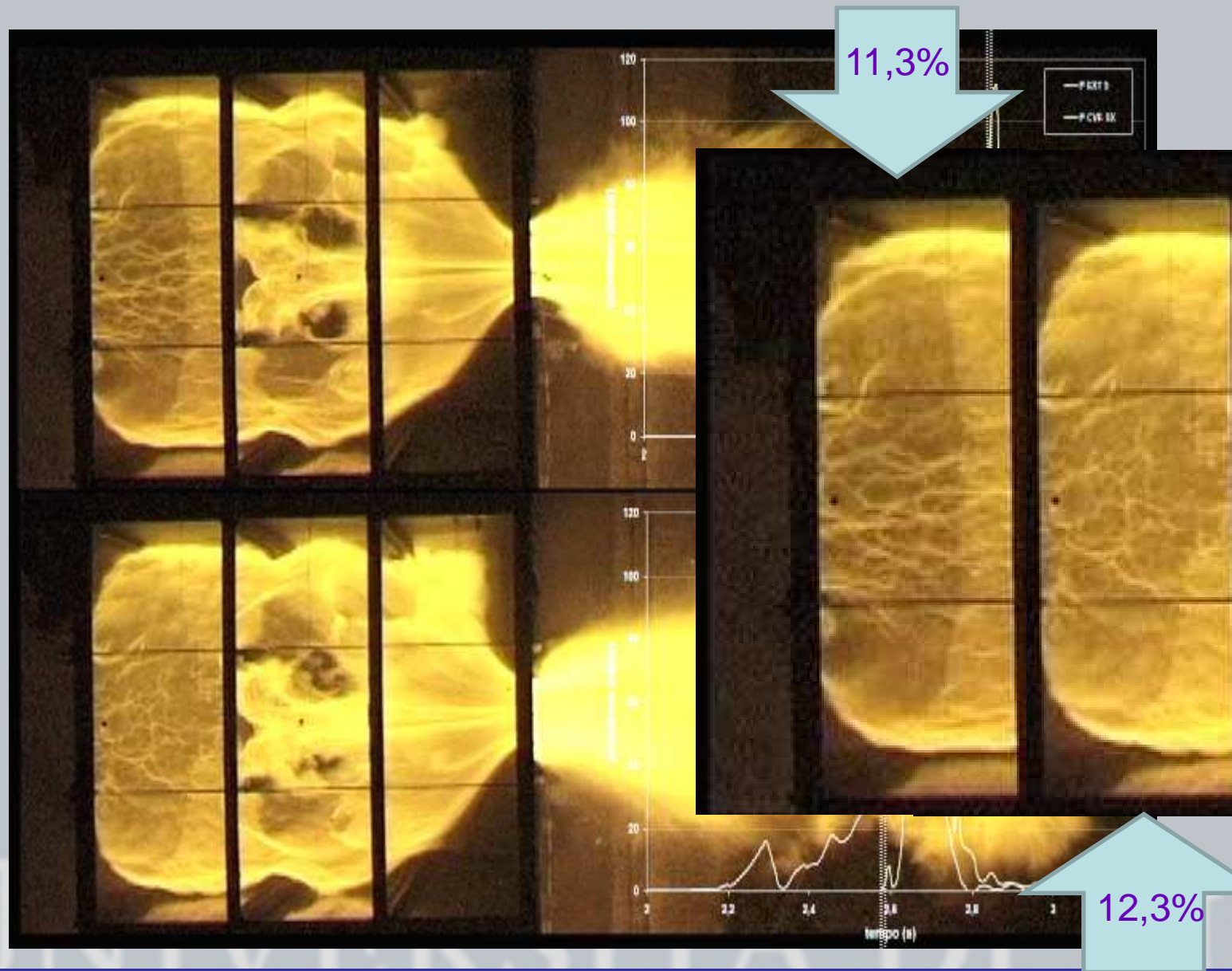
Obstacle configuration

Average concentration 12,3%
Test ISP24



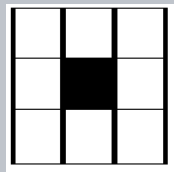
Obstacle configuration

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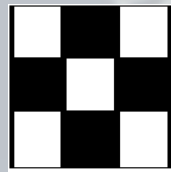


The non-monotonic behavior was not observed in all the obstacle configurations

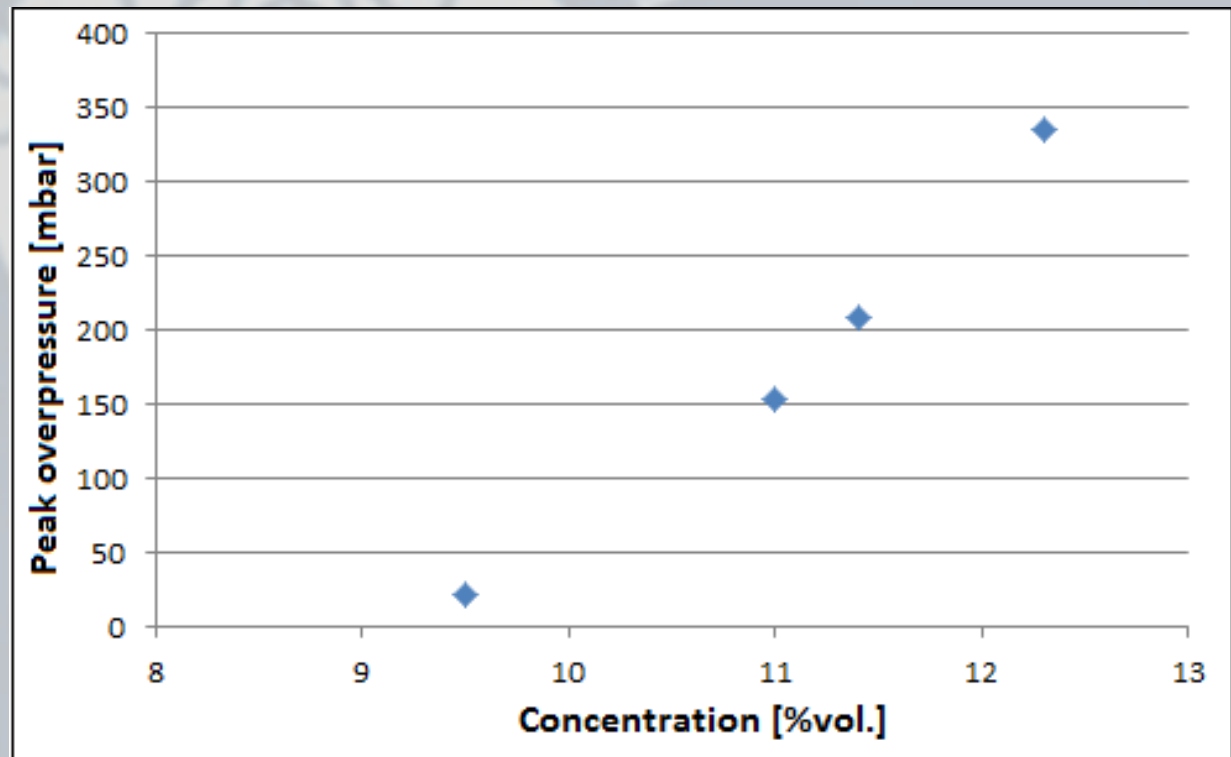
Obstacle configuration



1st set



2nd set



RED-CVE Campaign – Preliminary data Analysis

Maximum peak overpressure inside the CVE test facility

Summary:

- Vented deflagration were performed in a 25 m³ volume facility, having a vent area 1,12 m², with a homogeneous hydrogen concentration ranging from 8,5% to 12,5%.
- The pressure time behavior showed a non-monotonic behavior with a peak at 11% concentration.
- 11% concentration was found to be the configuration in which the vent opens when the flame position is the farthest from the vent.
- Comparison between the flame propagation in 11,3% vol. against 12,3% vol. shows that the first peak overpressure is generated during the venting of the flame outside the vent area (external explosion)
- In the 12,3% vol. deflagration a second peak (very close to the first) is generated when the flame reaches it's maximum area approaching the walls
- In the 11,3% vol. deflagration the flame surface is already approaching the walls at the same time that the external explosion is undergoing, hence the overlap of the two phenomena can be responsible for the non-monotonic behavior

***Thank you
for your attention***

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