Ignition of Hydrogen Jet Fires from High Pressure Storage

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ICHS-5

09.09.2013

European Commission, Bruxelles, B

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Outline

- **Description of release setup & behaviour**
- **Induction of spontaneous ignition**
- **Investigation of the combustion regime**
- **Conclusion**

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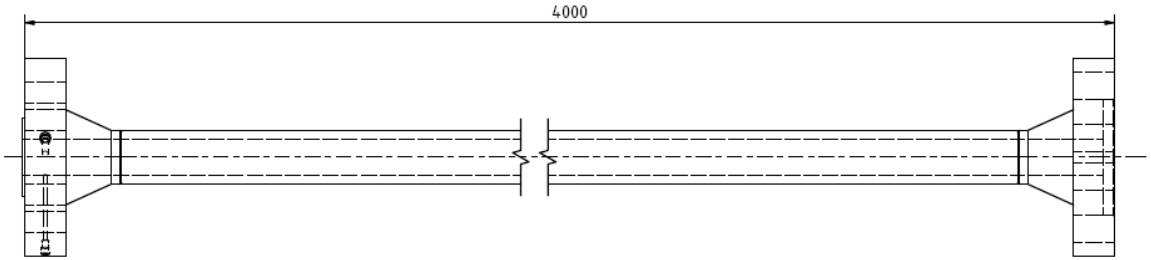
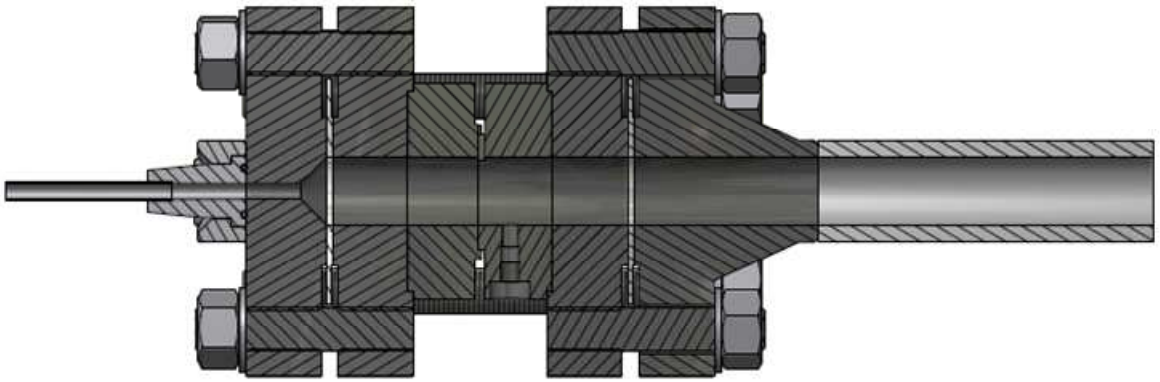
Storage Pipe / Release Configuration



l = 4m d_i = 40.3mm ; V ~ 5l



Reflection contour inclination 45° (Nozzle)

Release tube d_i = 10mm

Rupture disk

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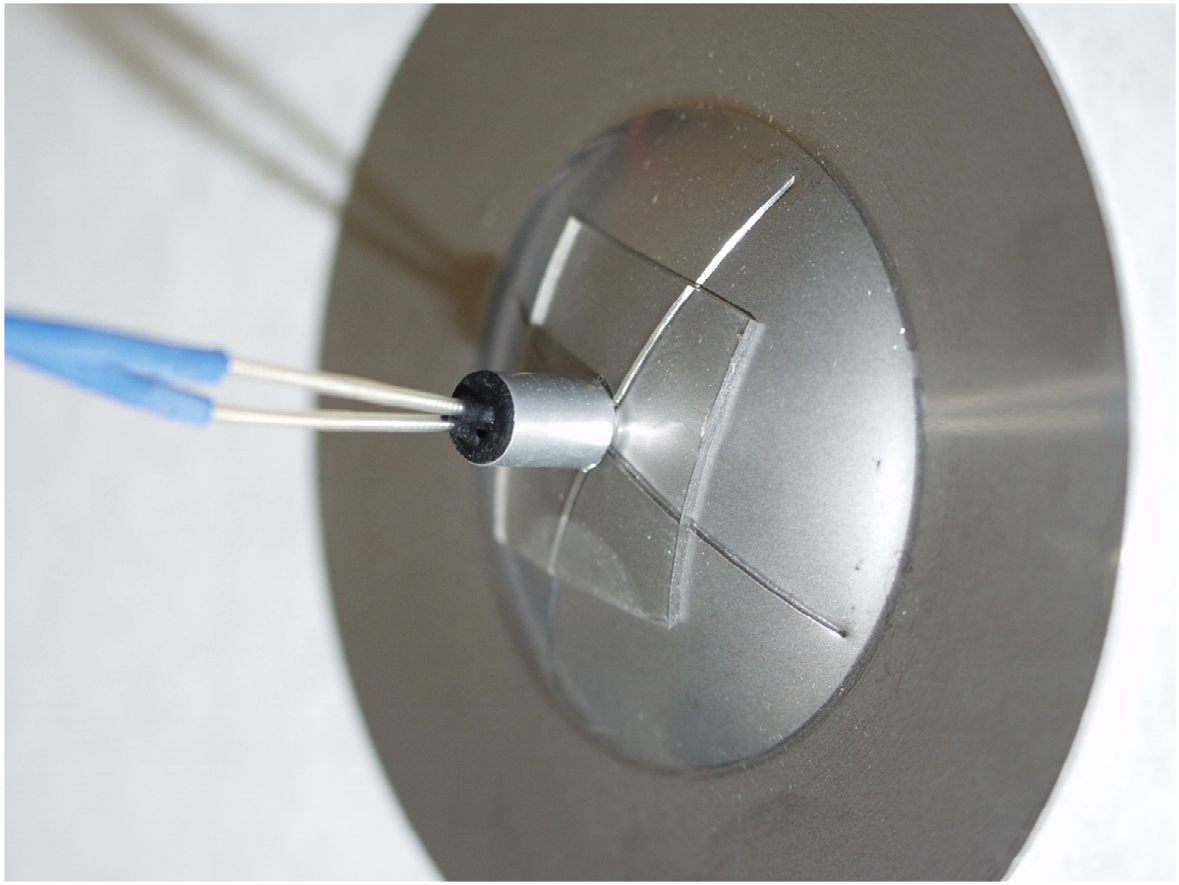
Rupture Disk Arrangement with Microdetonator



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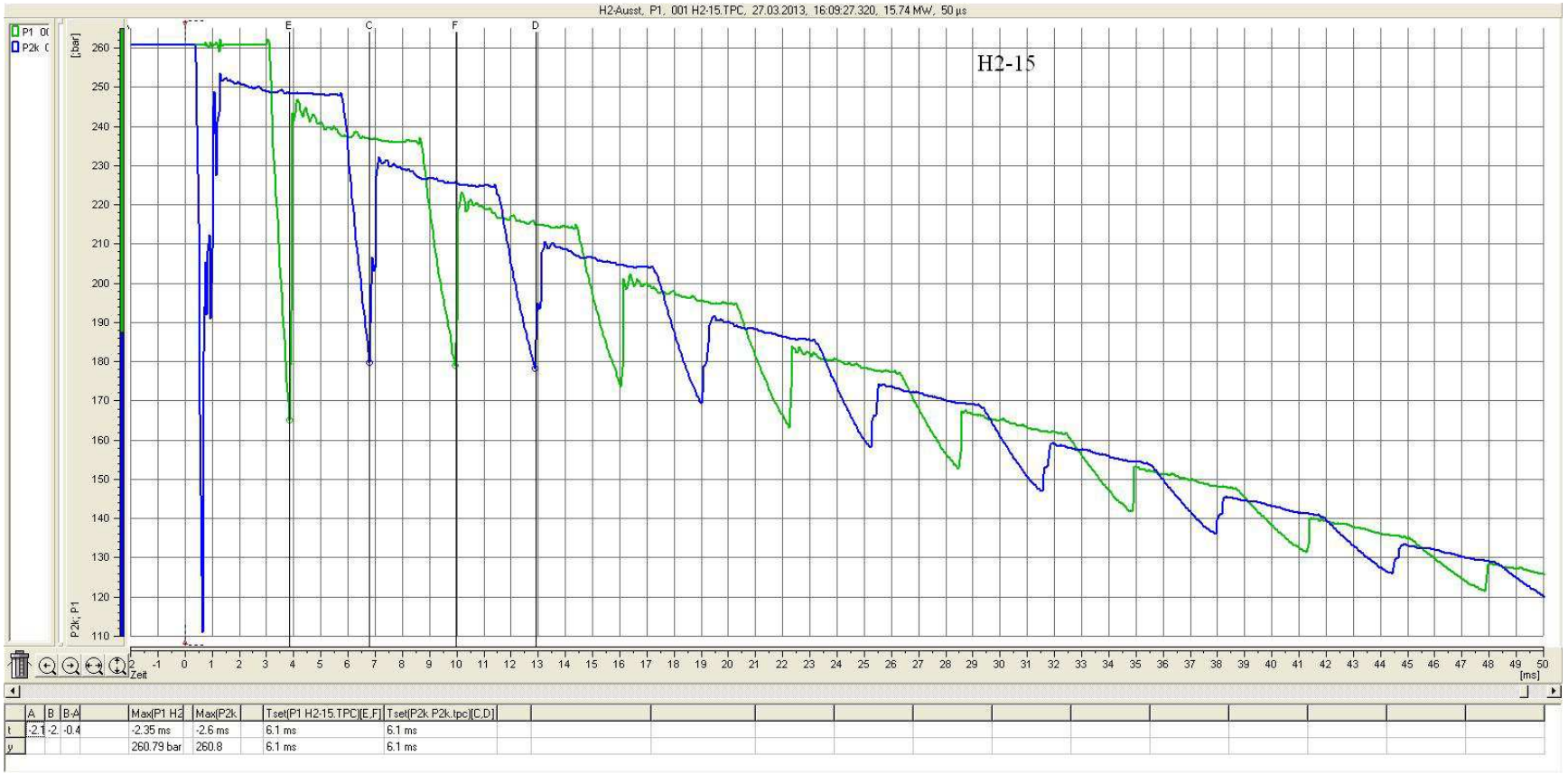
Pipe pressure decay



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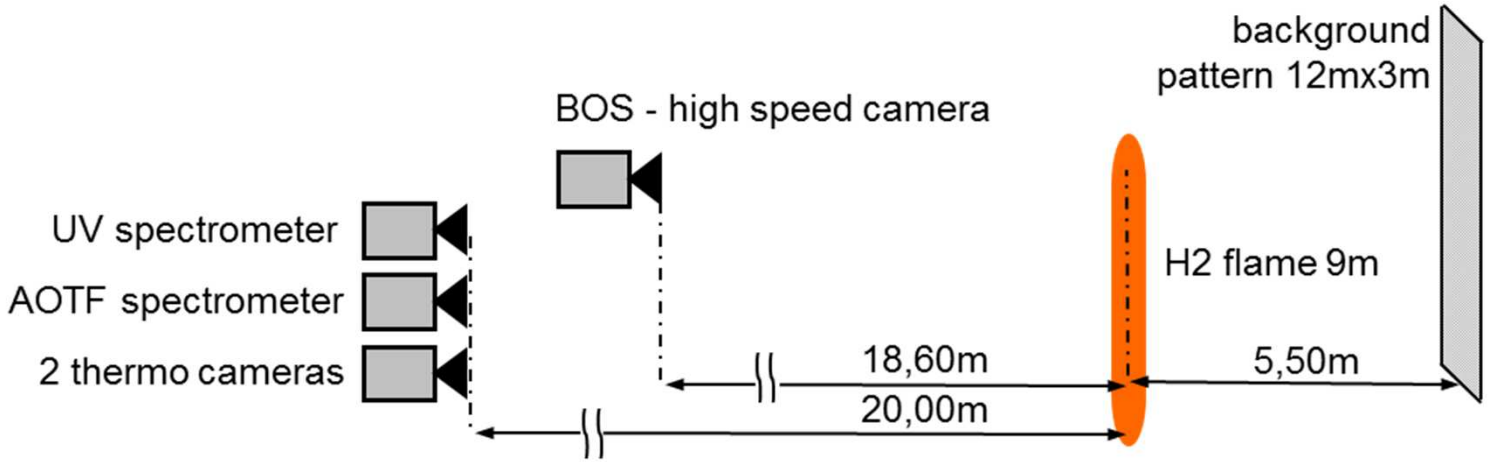
High pressure H_2 release setup at Fh-ICT rocket test stand



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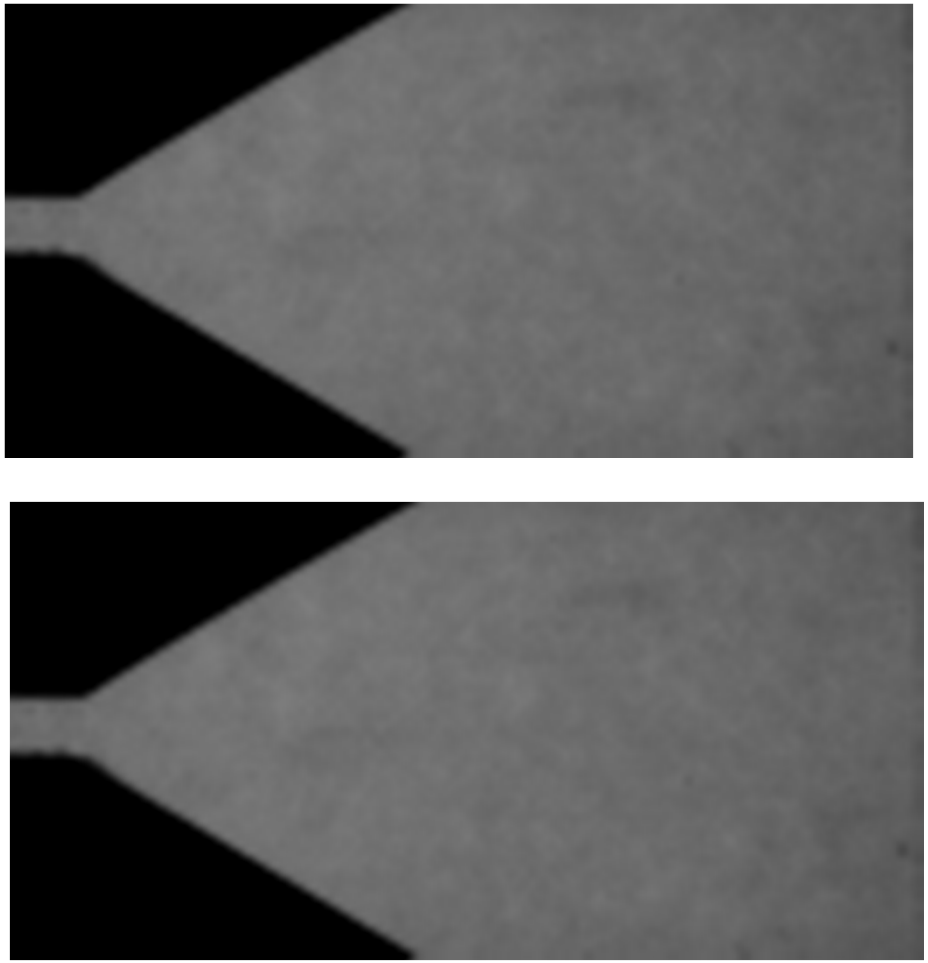
Spontaneous Ignition in the nozzle



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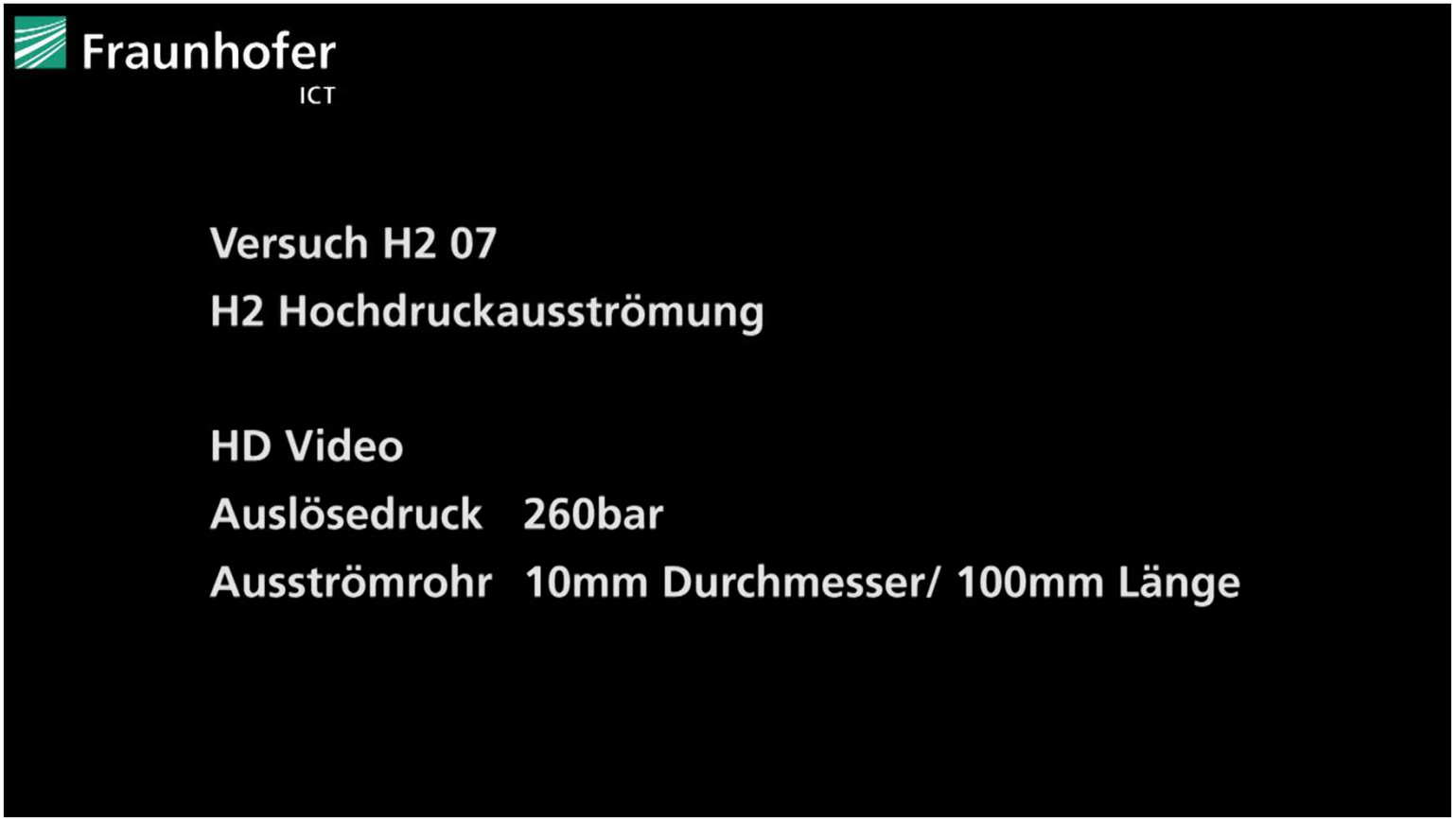
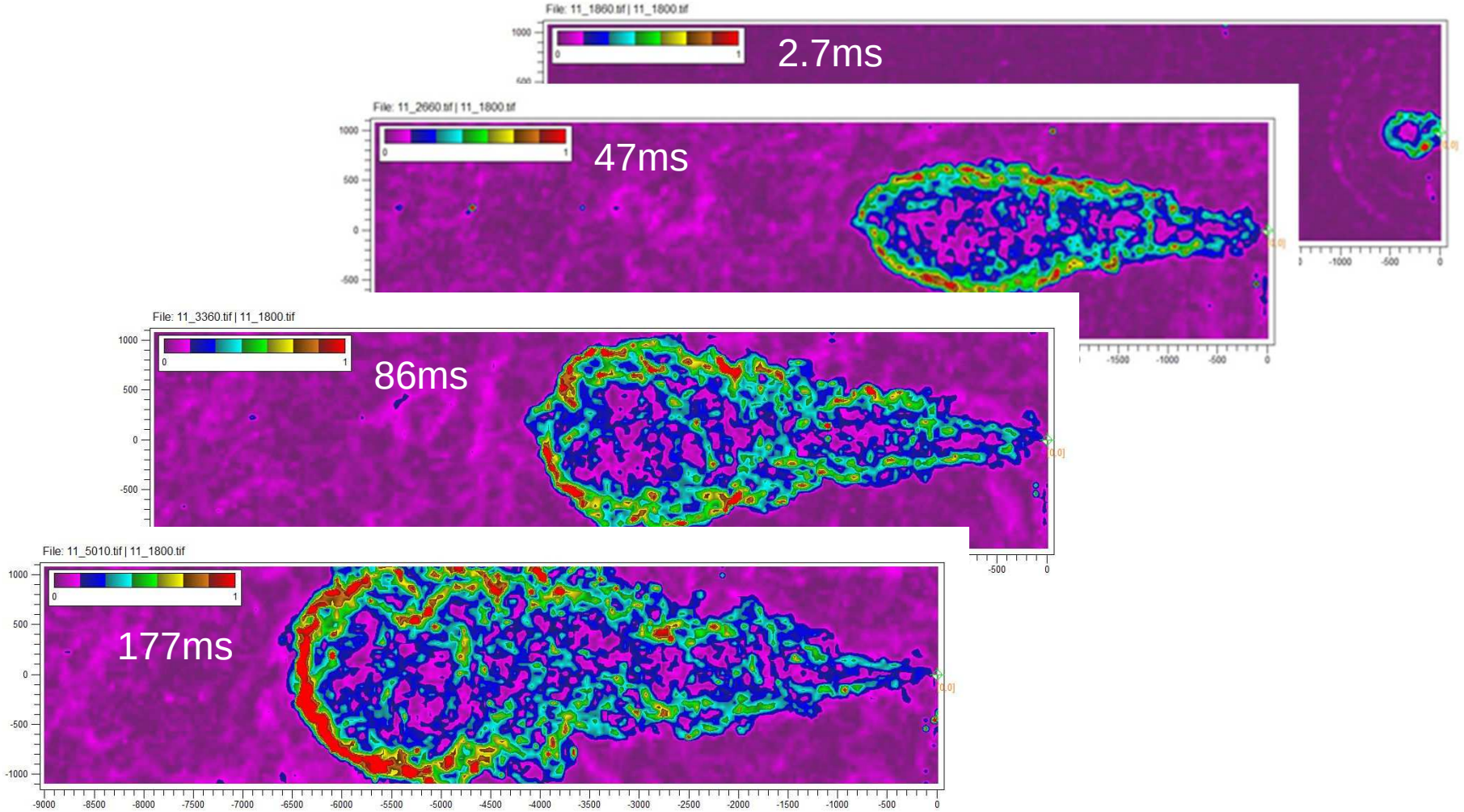
Real video of 260bar release experiment



BOS images from different stages of the flame jet deployment which make the structures clearly visible



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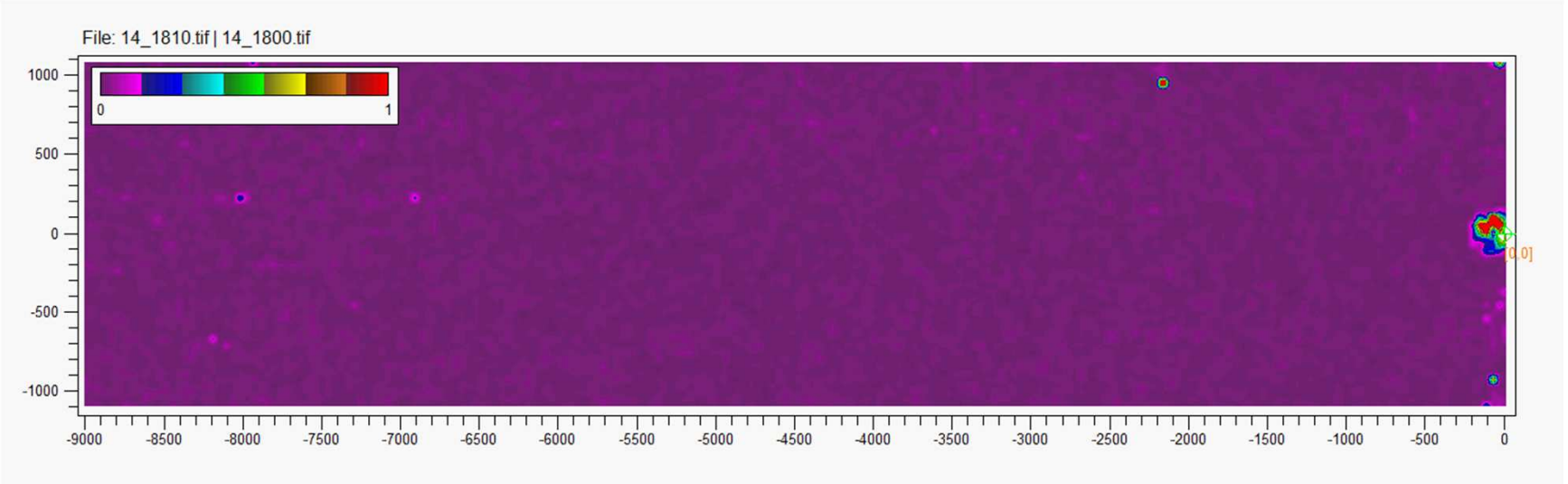
BOS Visualisation of Flame Propagation



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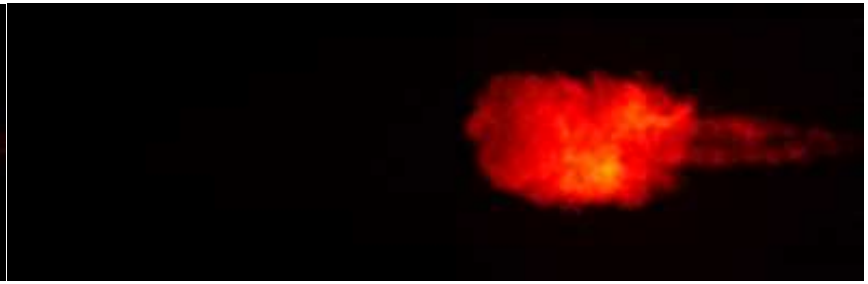
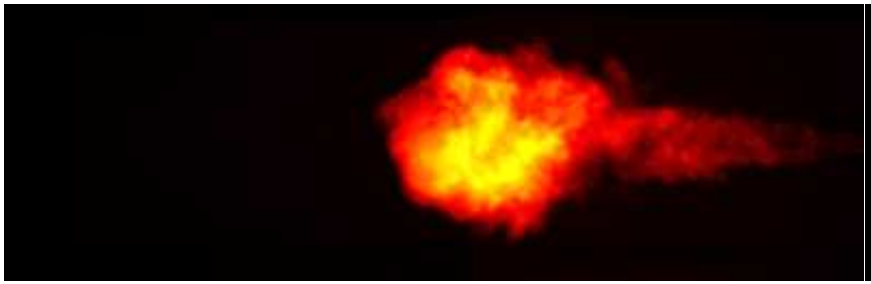
IR images at different stages from the opening of the flame jet

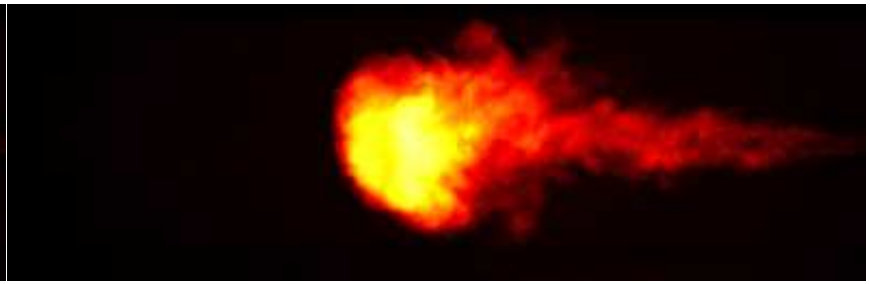
0.025 s



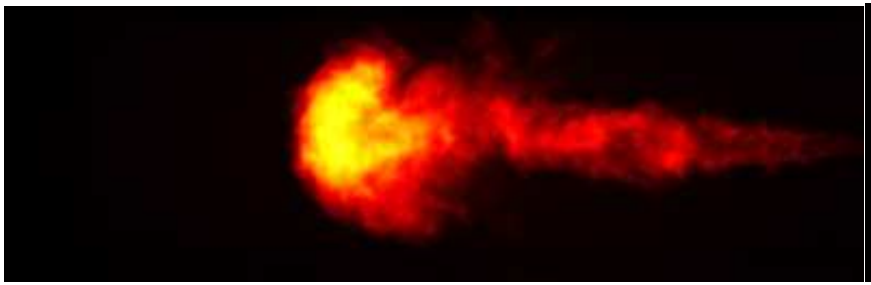
0.062 s



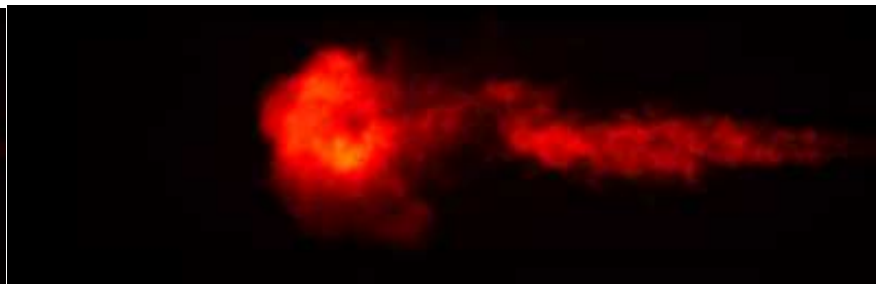
0.099 s



0.136 s



0.173 s



0.210 s

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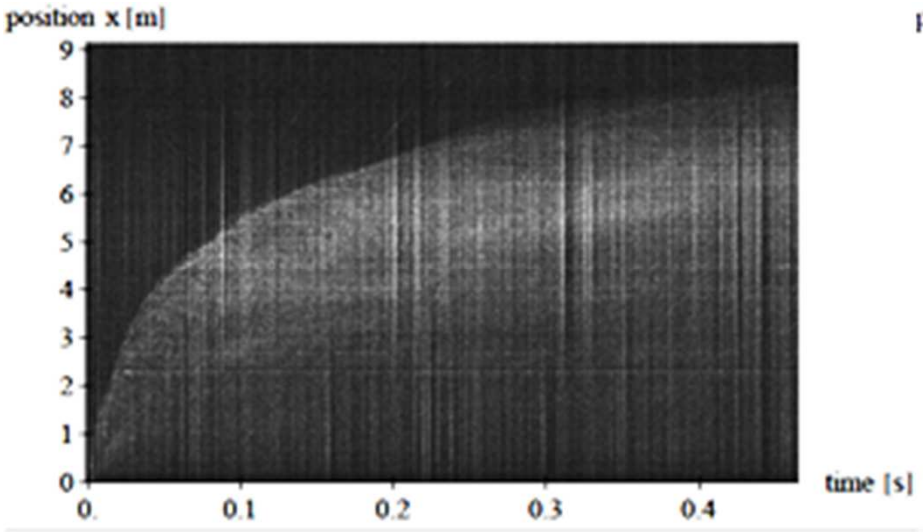
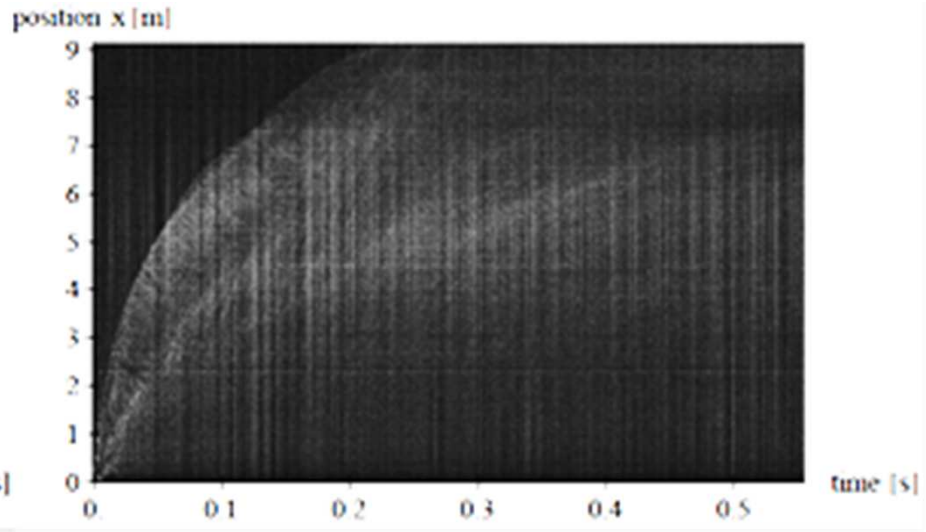
Visualization of flame head:
1-D contraction from different images



100 bar initial pressure



260 bar initial pressure

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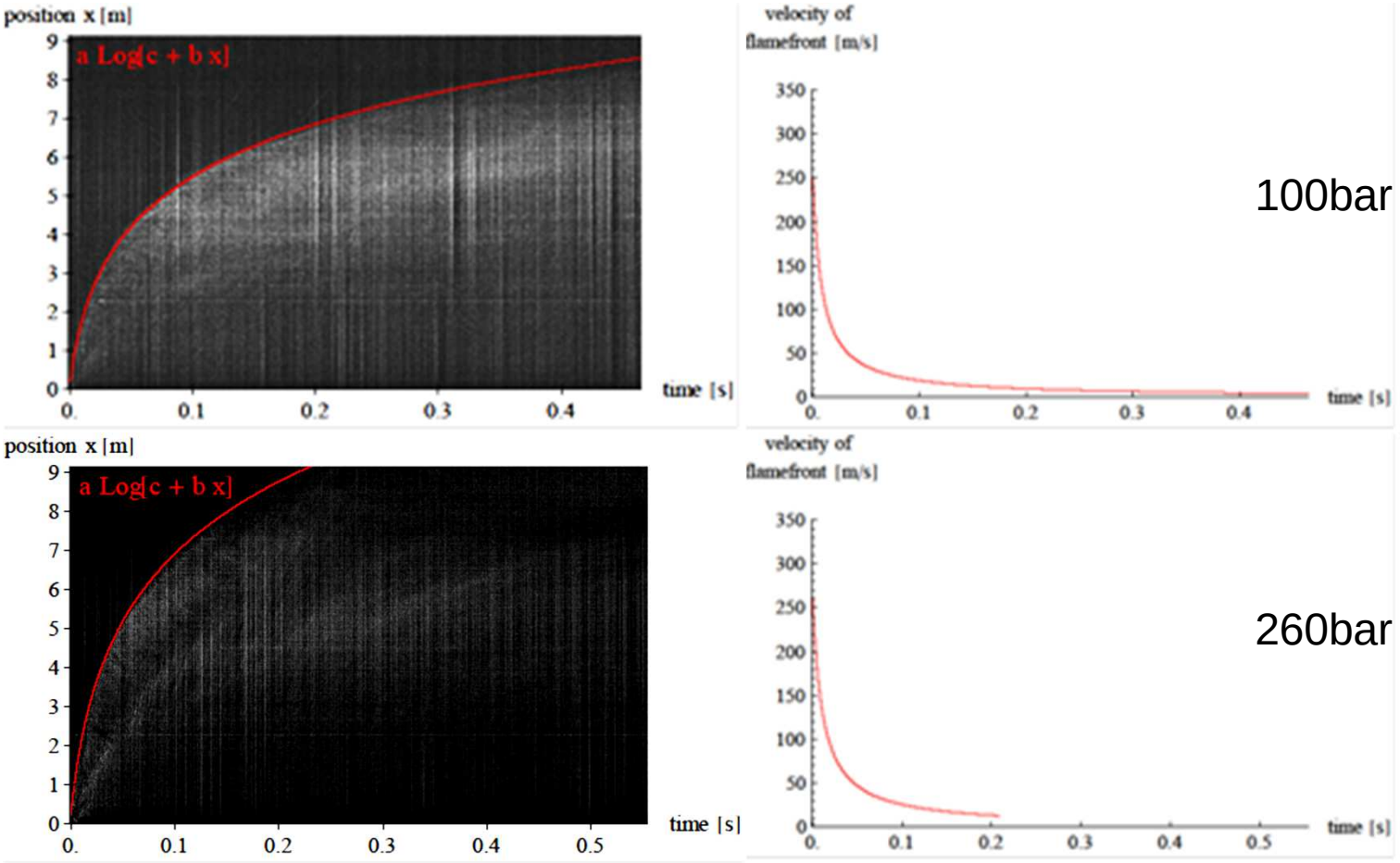
Flame jet head profile
decelerated movement by a drag / transient velocity



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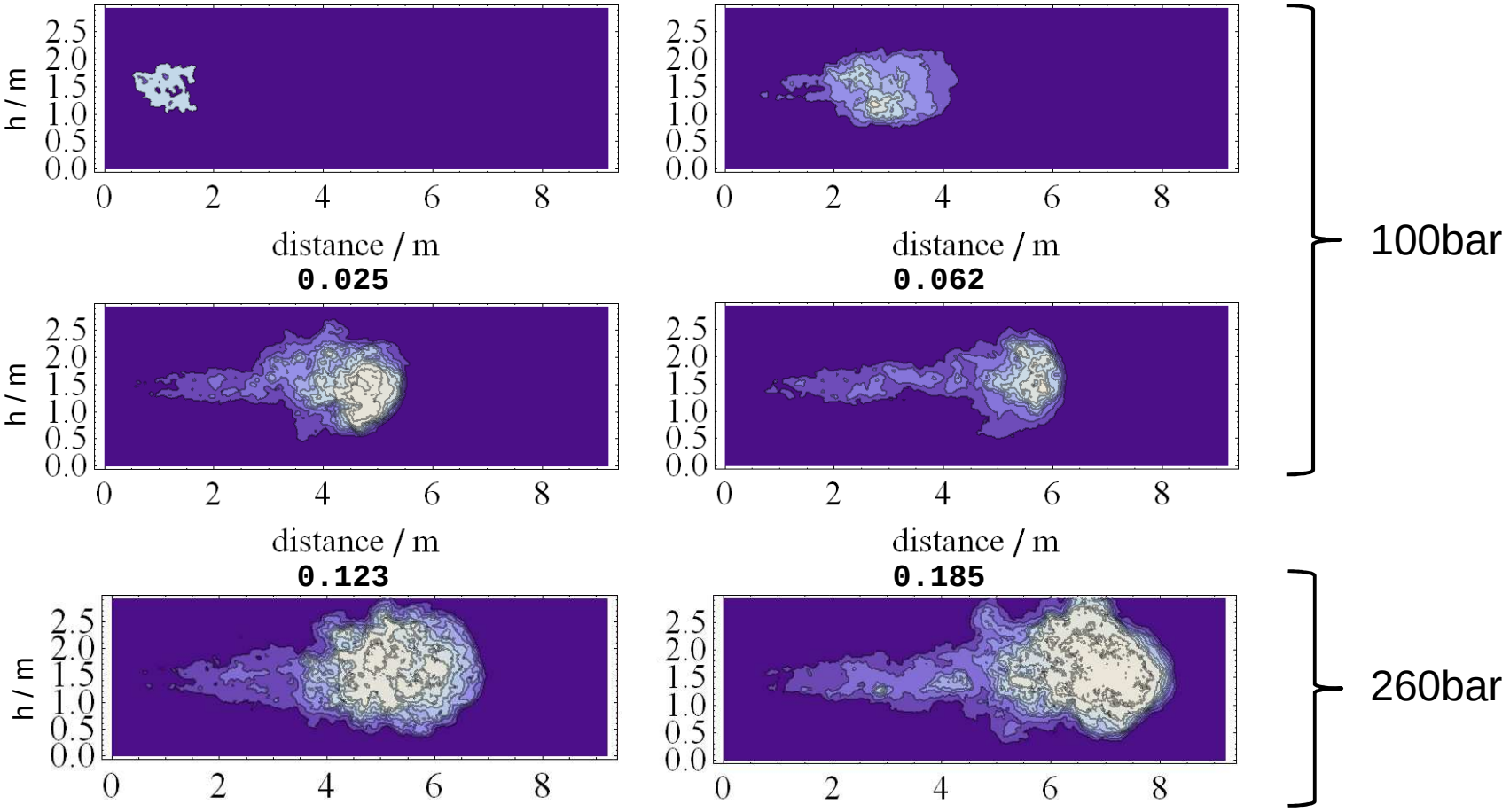
Contour plots of IR images
at different stages from the opening of the flame jet



→ Bright zone of flame head fully deployed @260bar

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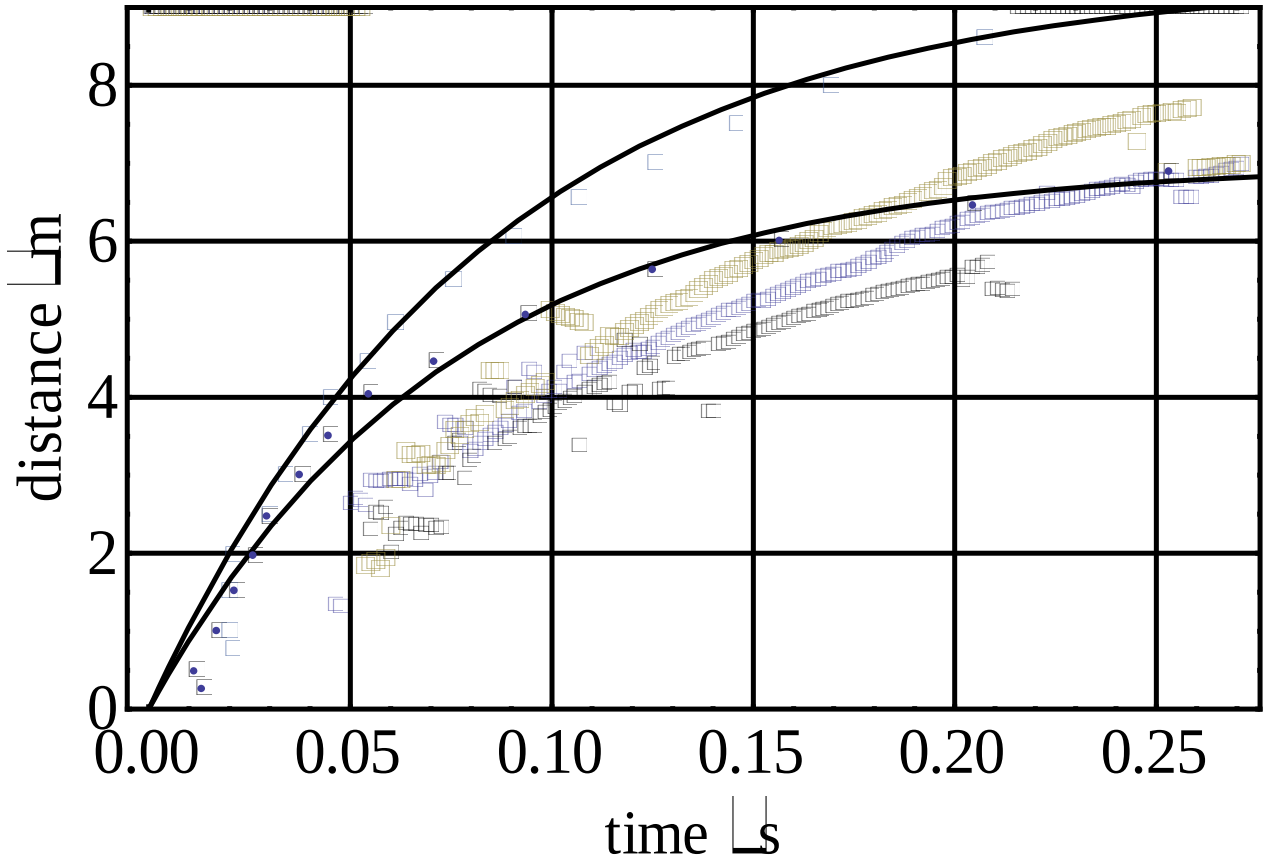
The position of the centroid of the bright zone vs. time moves similar to the advanced fronts of the jet heads



Dense plot markers:
Centroid

Spares plot markers:
Front of head

Solid lines:
Calculated curves

Higher distances =
Higher pressures

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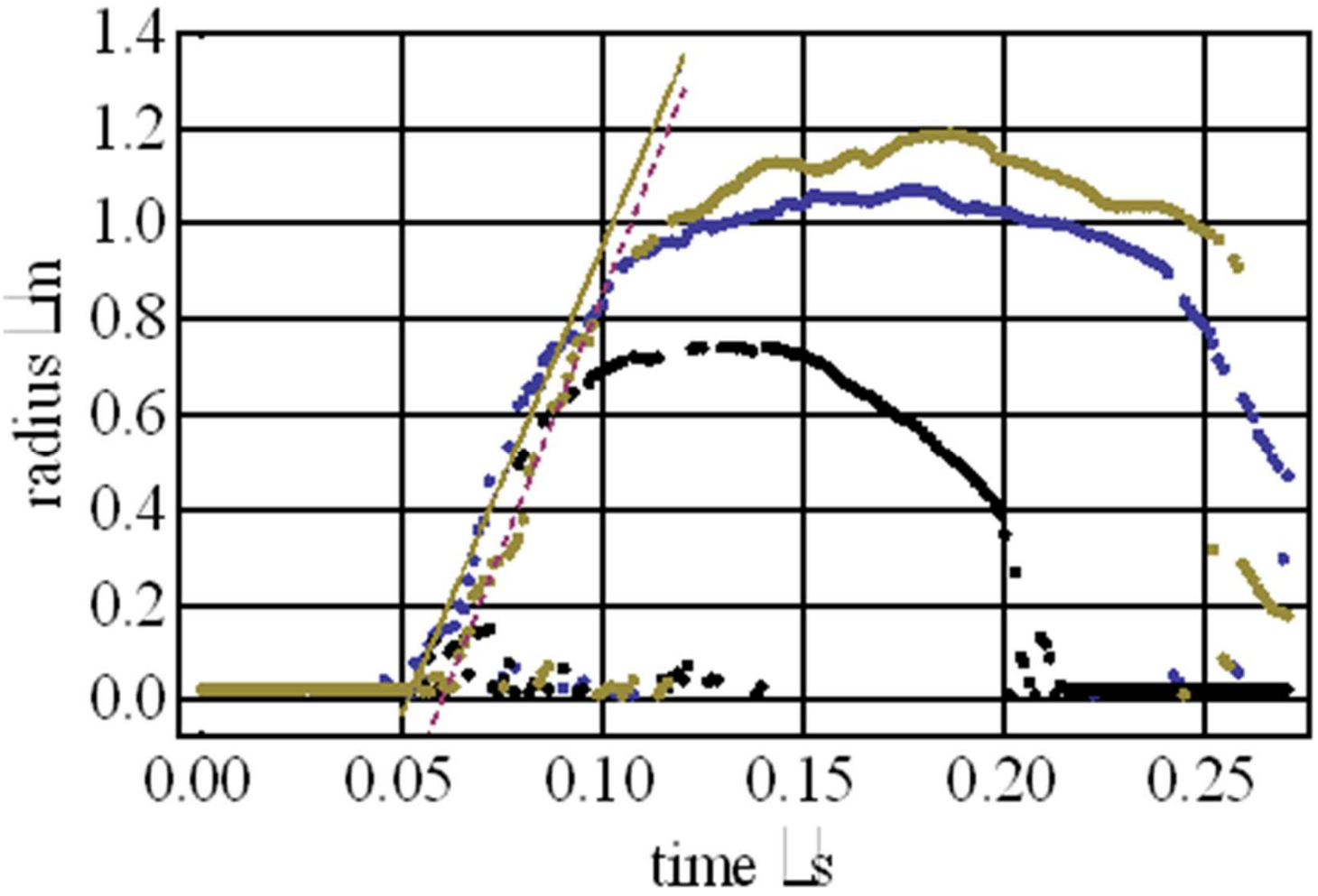
Equivalent radii for the deployment of the bright zone with linear rise of radii



initial pressure

260bar

180bar

100bar

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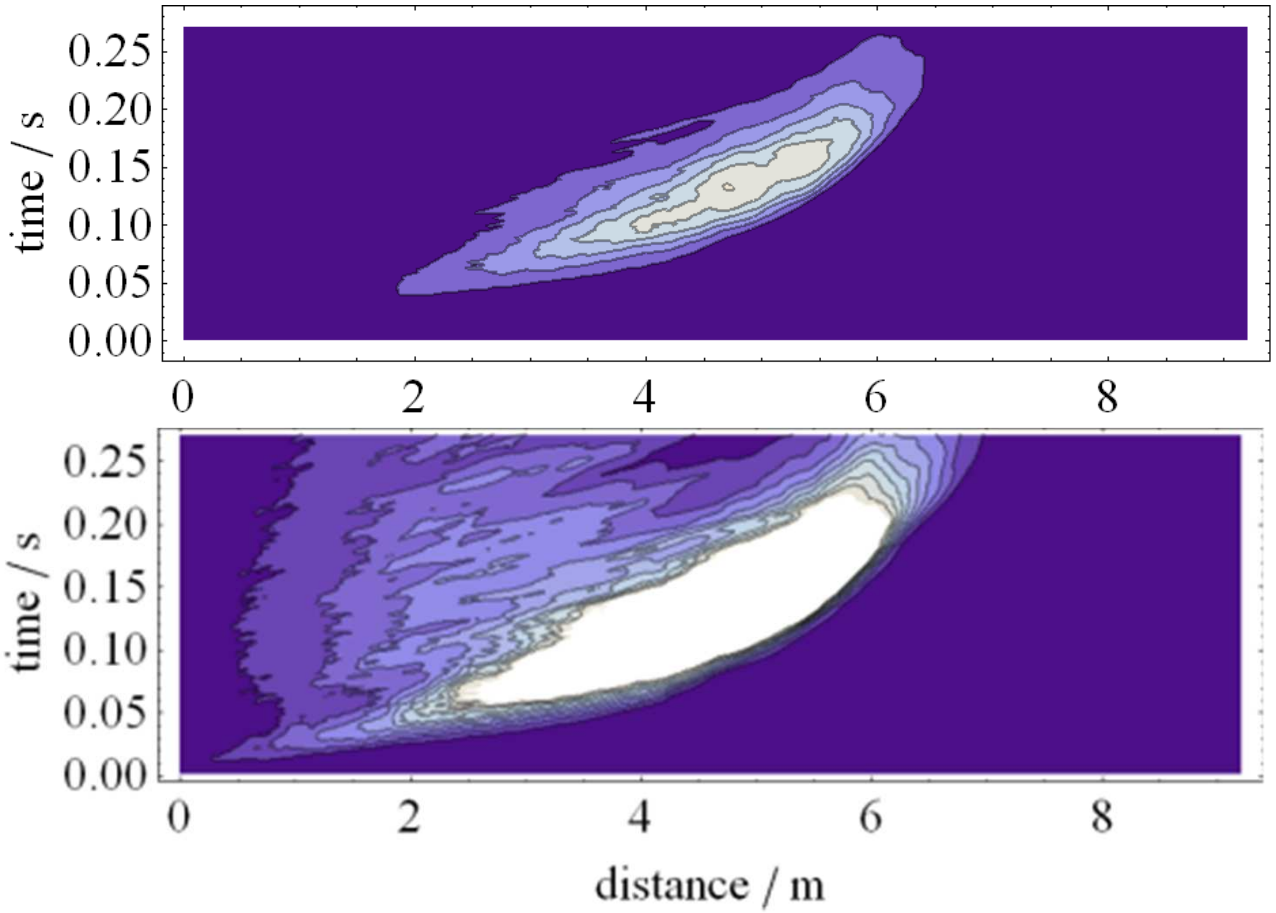
Contracted images in direction of the height (100 bar) full scale & cut-off at half scale



Contour Plot:

Full scale

Half scale

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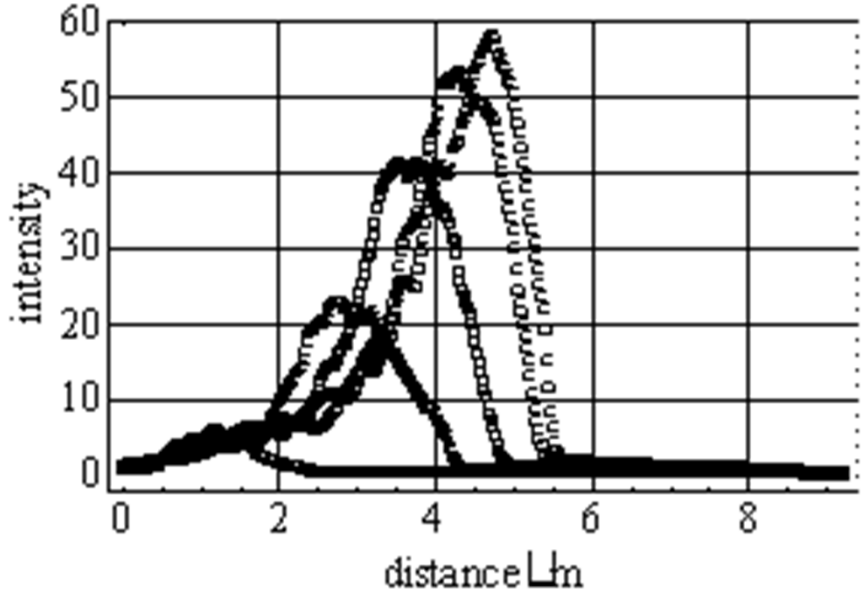
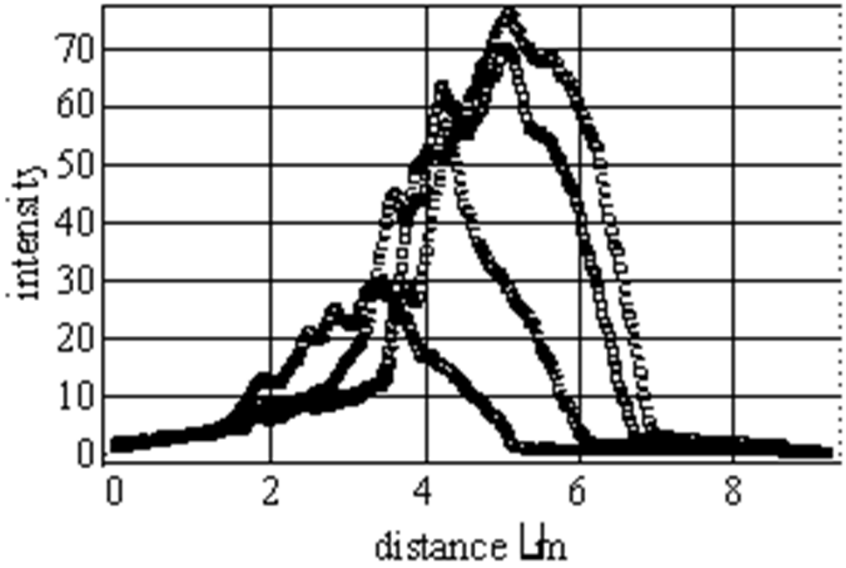
Selected slices of the contracted images from 0.025s to 0.123s



100bar initial pressure



260bar initial pressure

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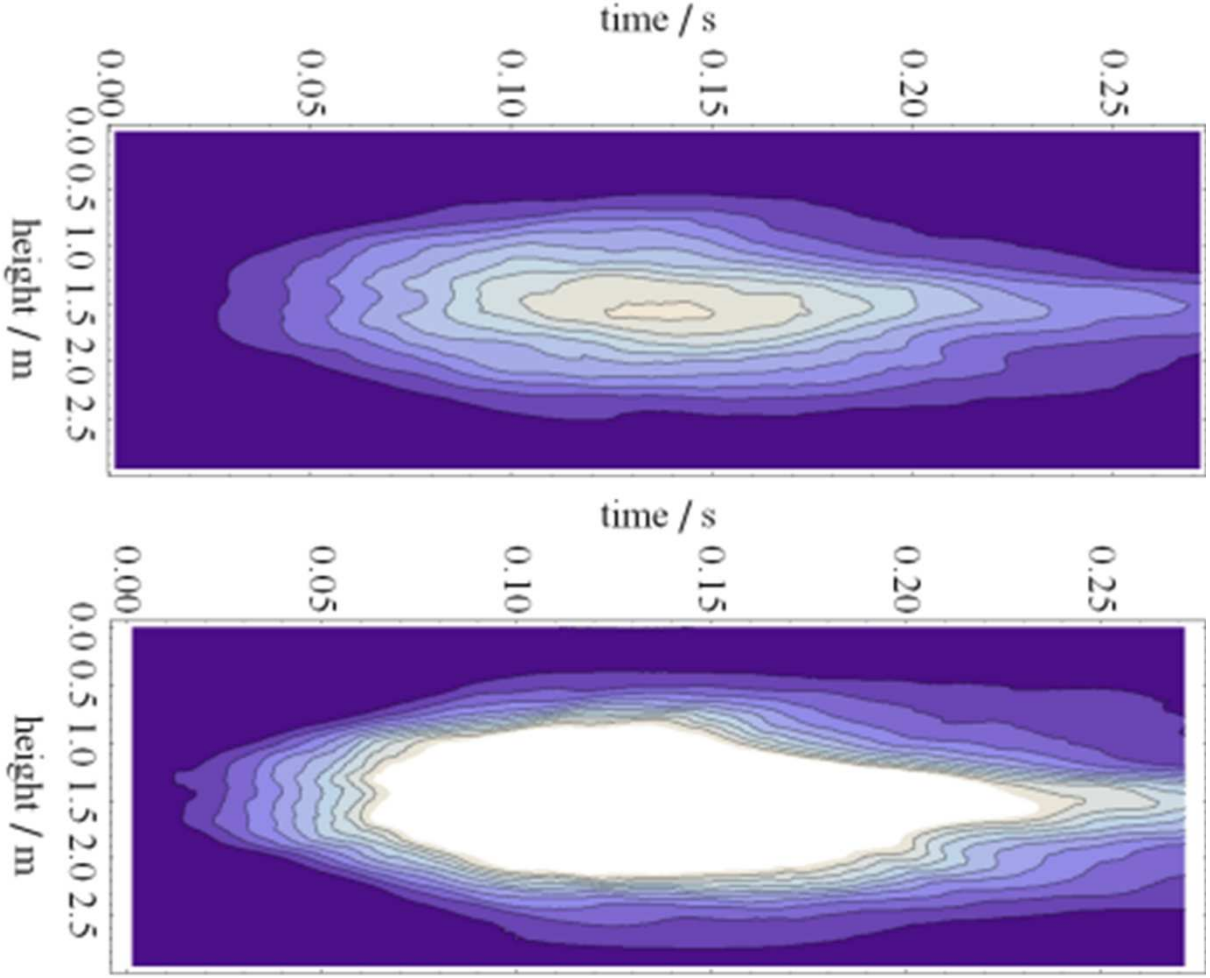
Contracted images in direction of the jet propagation corresponding to the height of it



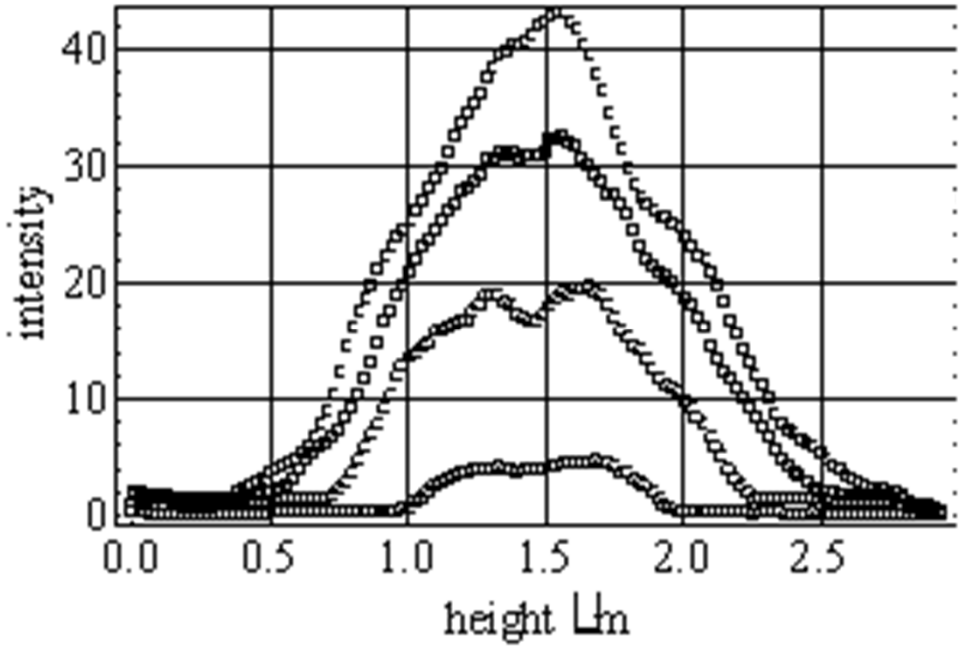
Contour Plot:

Full scale

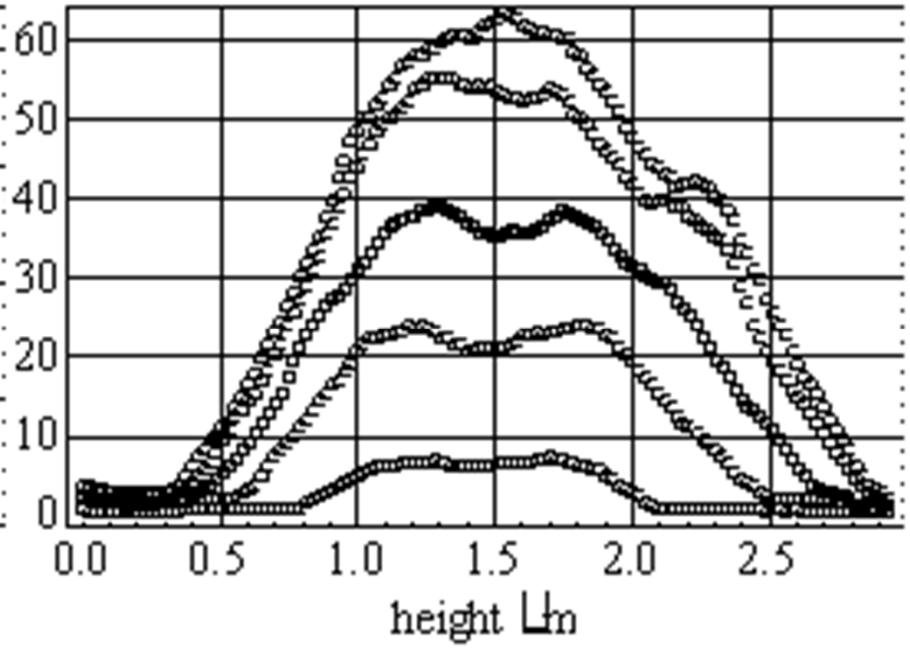
Half scale

Fraunhofer ICT

Selected slices of the contracted images in direction of the jet propagation from 0.025s to 0.123s



100bar initial pressure



260bar initial pressure

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Conclusions

- Openings of high pressure tanks with a low volume related to the gas flow rate form transient hydrogen jets.
- The jet starts burning close to the opening at the outer shell and changes to a volume reaction forming a bright zone.
- Approximation by an expanding sphere like a spherical gas explosion.
- The centroid of the bright zone moves parallel to the jet head.
- Move downstream to nearly rest
- Deceleration with a nearly constant drag coefficient
- Separation from the jet cone at the end.
- Apparent flame velocity was found to be close to 20m/s.
- Emission of radiation dominated by this combustion regime

→ Radiation estimation discussed in separate paper
based on these results on the jet shapes

→ Presented by S. Knapp on Wednesday: Fires Session / Paper ID #104

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Thank you for your attention!

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