

Implementation of Large Scale Shadowgraphy in Hydrogen Explosion Phenomena

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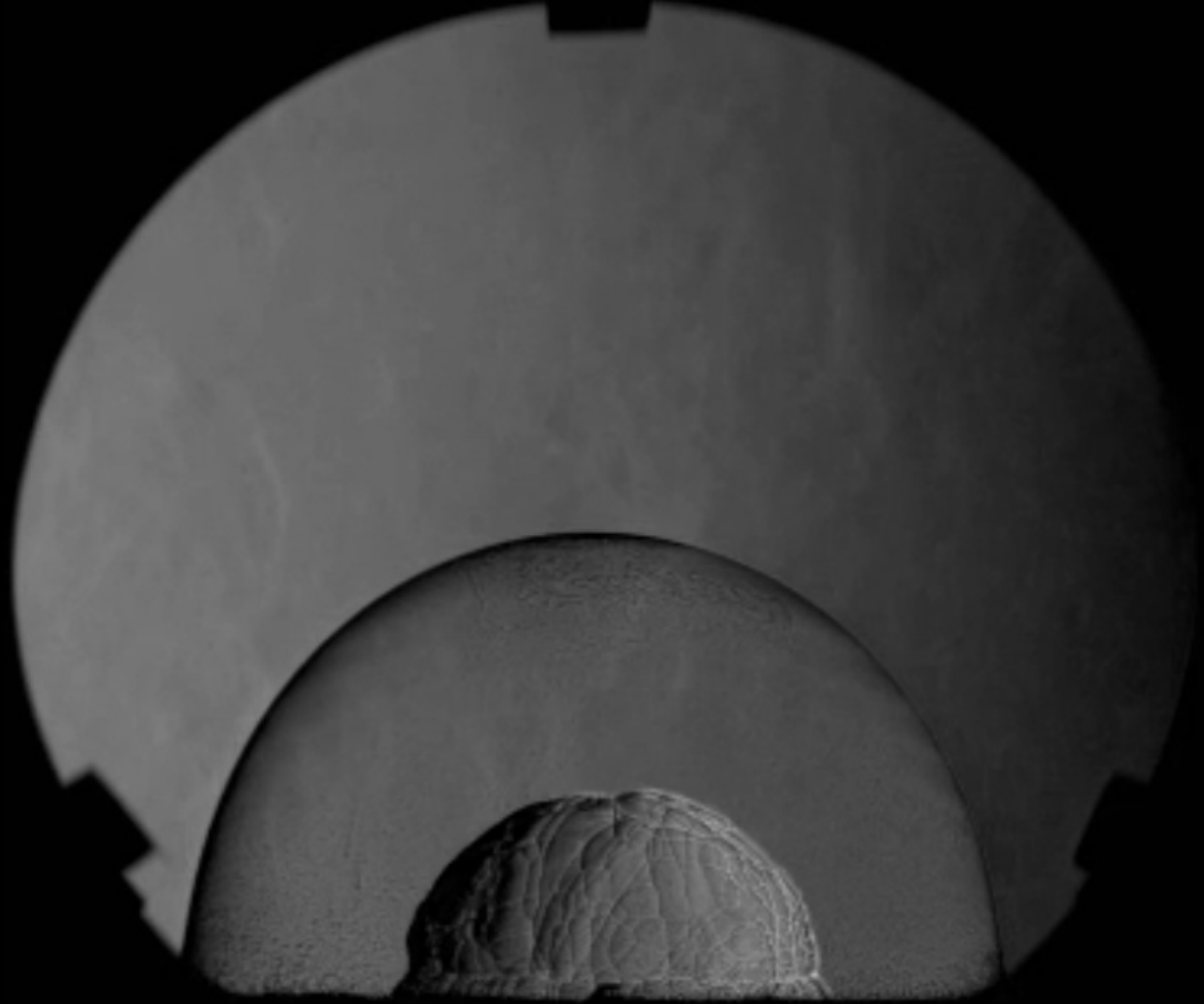
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Purpose

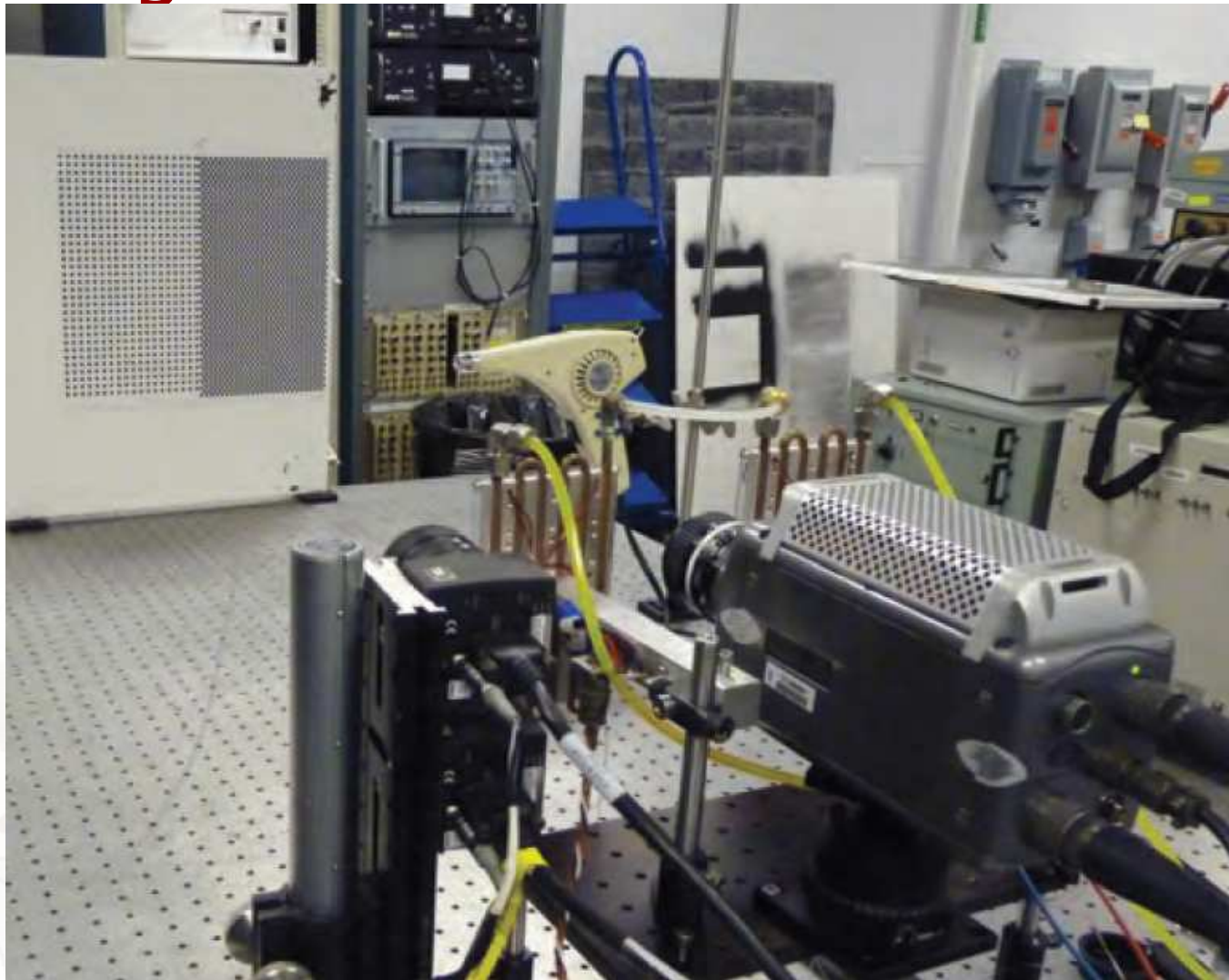


- We want to visualize laboratory combustion experiments
- One meter length scale





Background-oriented Schlieren



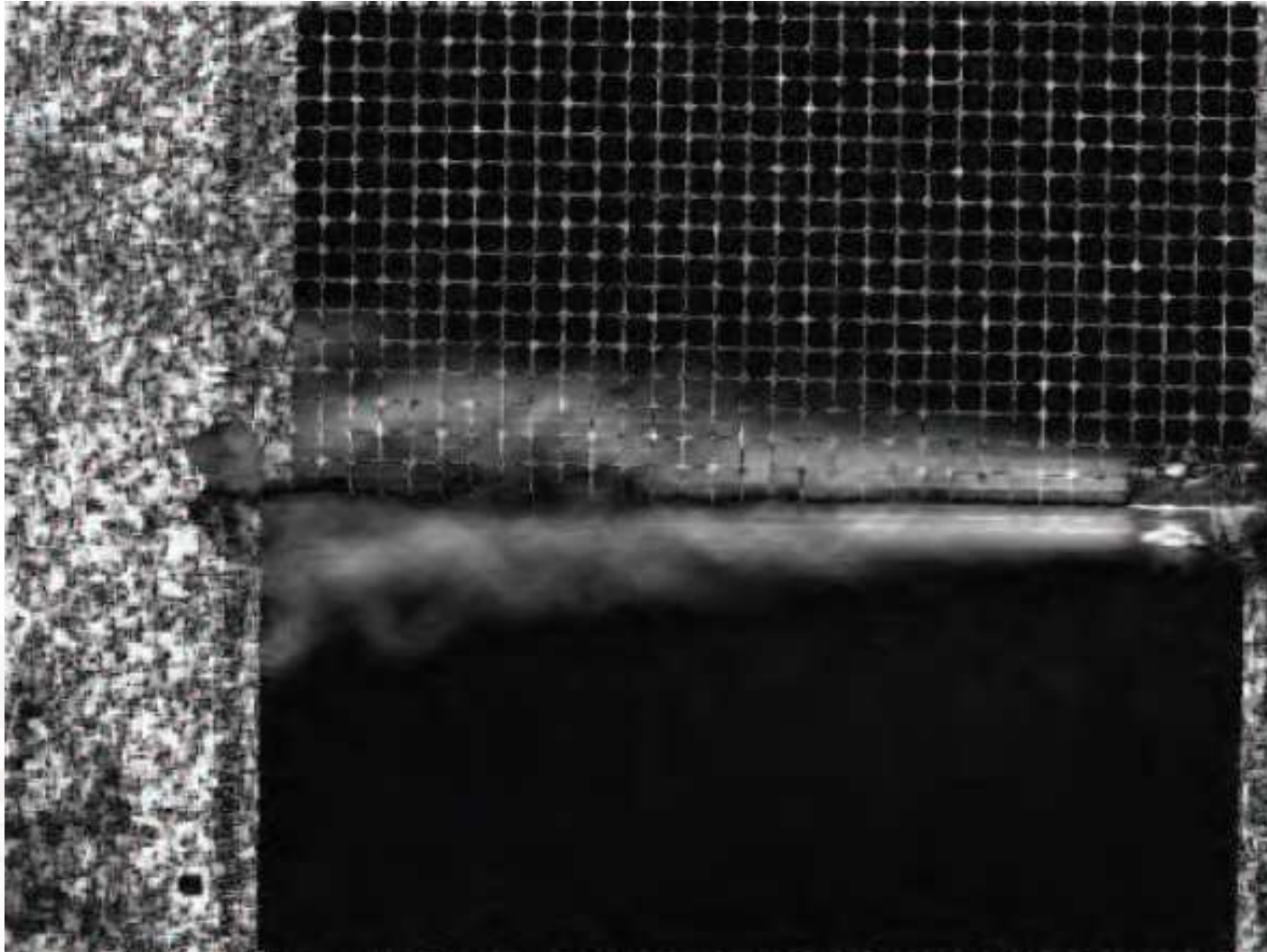
J. Hartberger, "BACKGROUND-ORIENTED SCHLIEREN PATTERN OPTIMIZATION," Air Force Institute of Technology. M.Sc Thesis, 2011.

Background-oriented Schlieren



J. Hartberger, "BACKGROUND-ORIENTED SCHLIEREN
PATTERN OPTIMIZATION," M.Sc Thesis, 2011.

Background-oriented Schlieren

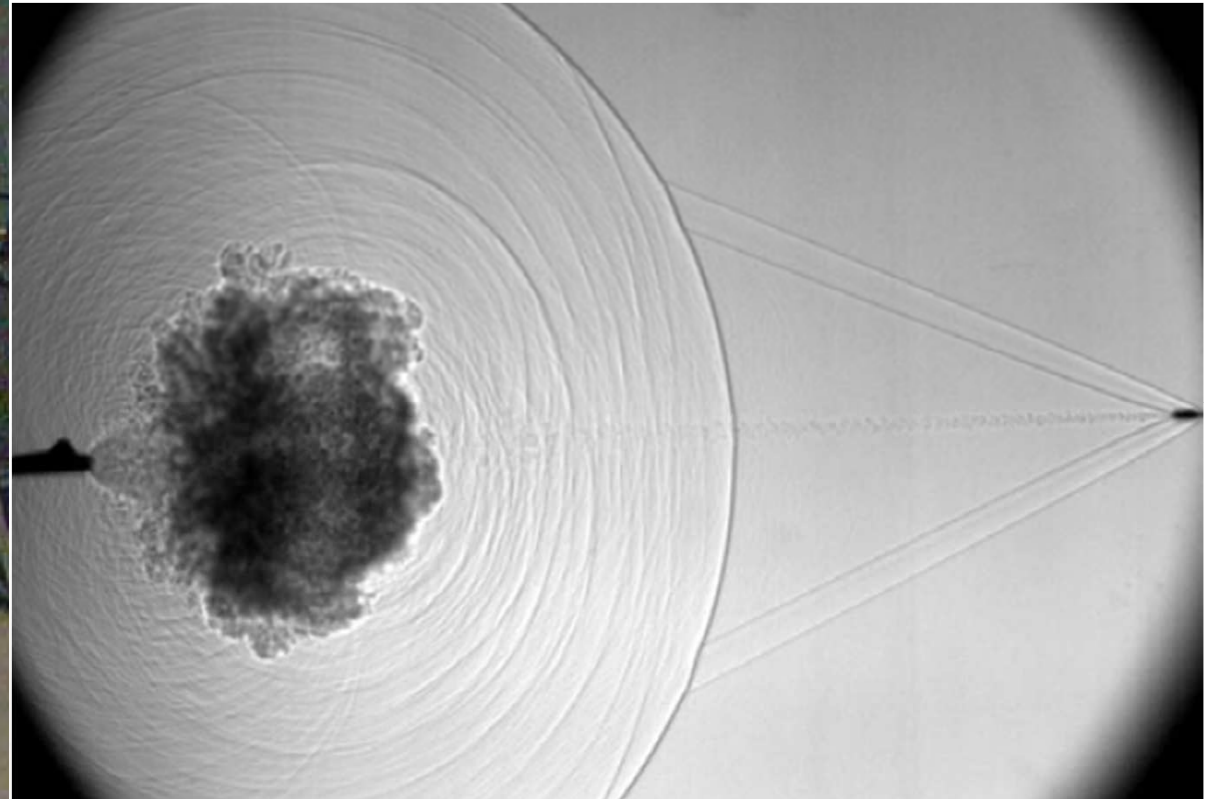


J. Hartberger, "BACKGROUND-ORIENTED SCHLIEREN
PATTERN OPTIMIZATION," M.Sc Thesis, 2011.



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Large-scale Shadowgraphy

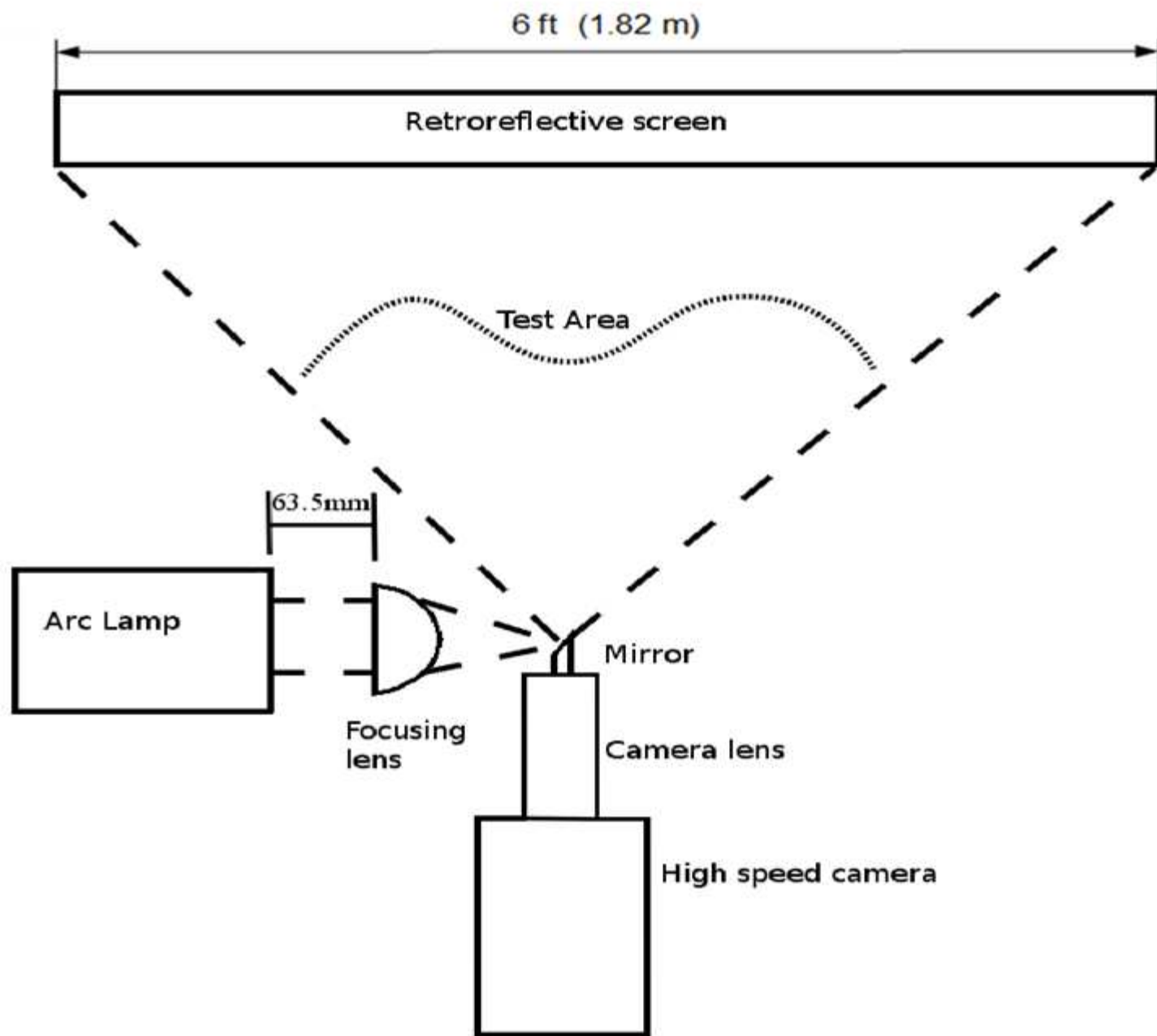


This study



- Implement Settles' large-scale shadowgraph technique
- Combustion experiments where self-luminosity may be an issue
- Gas dynamics experiments



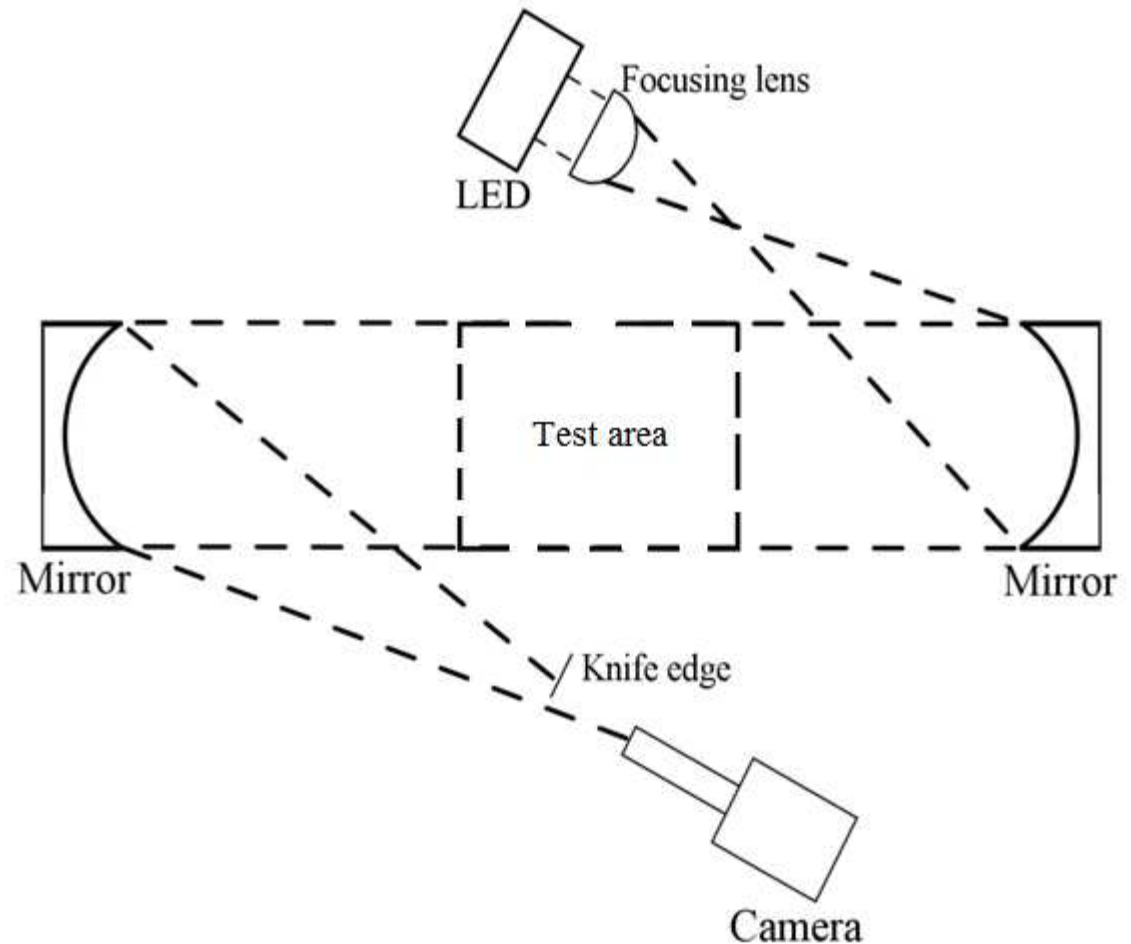


- Phantom v1210 1,000,000 fps

Schlieren Visualization



- Z-schlieren
- 300W LED
- 16500 lm
- 32cm parabolic f/8 mirrors



Experiments



Jet Releases

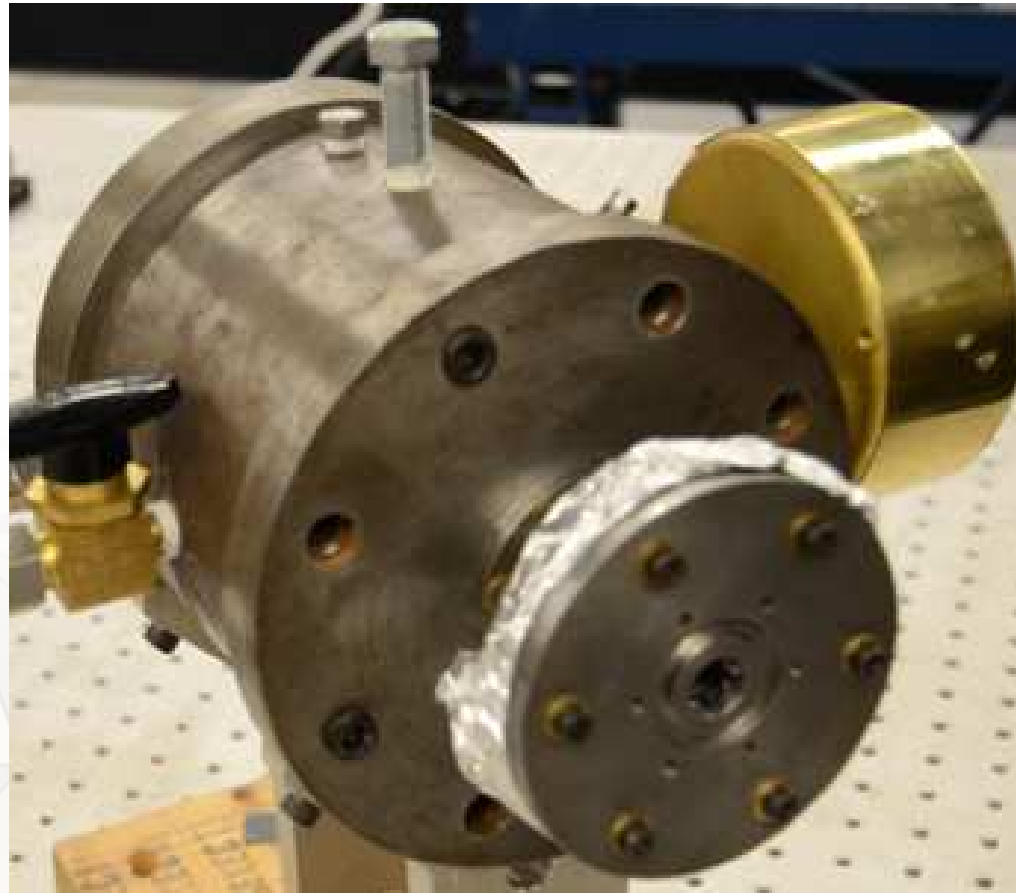
Unconfined Flames

Detonations

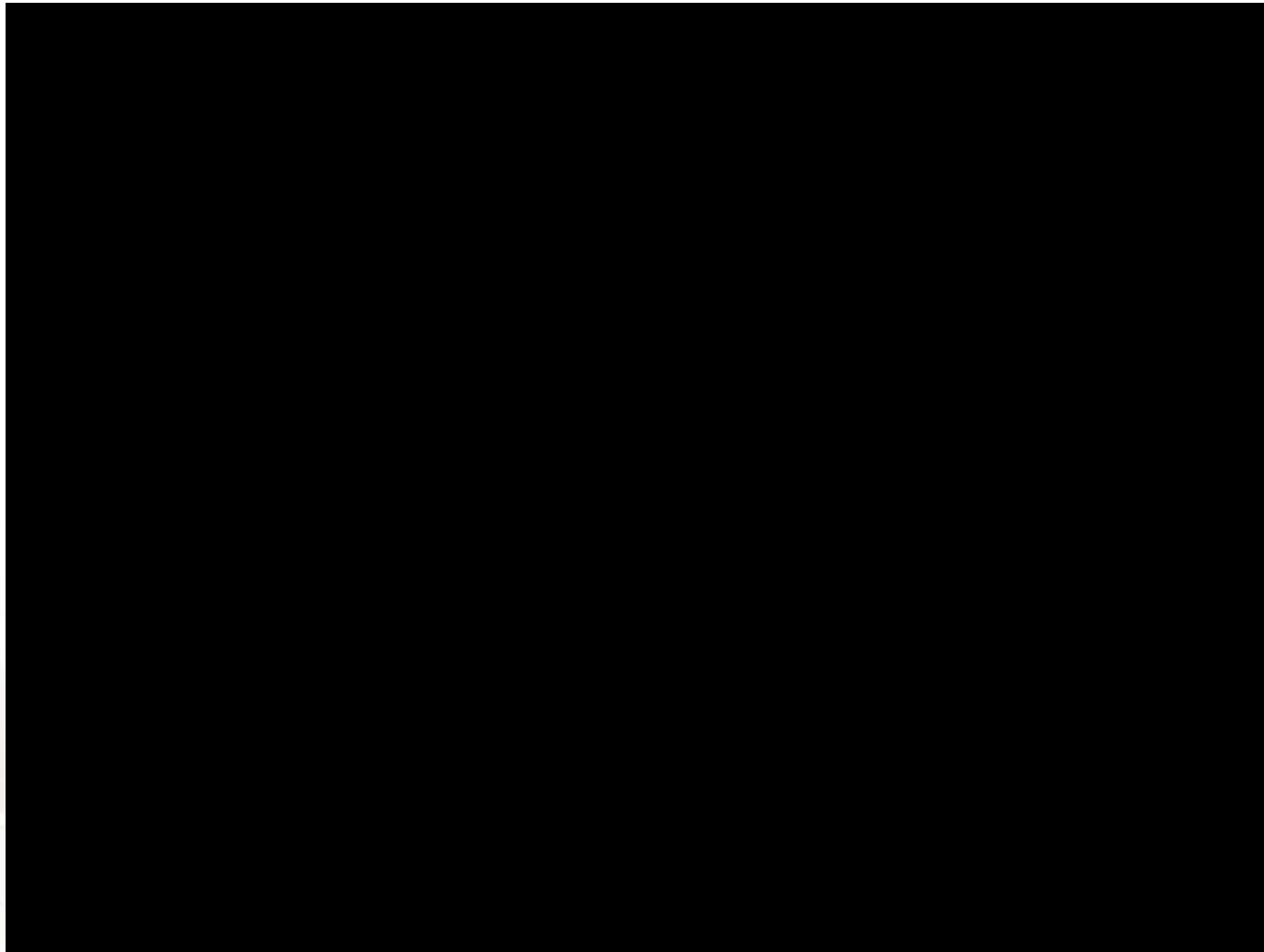


Jet Releases

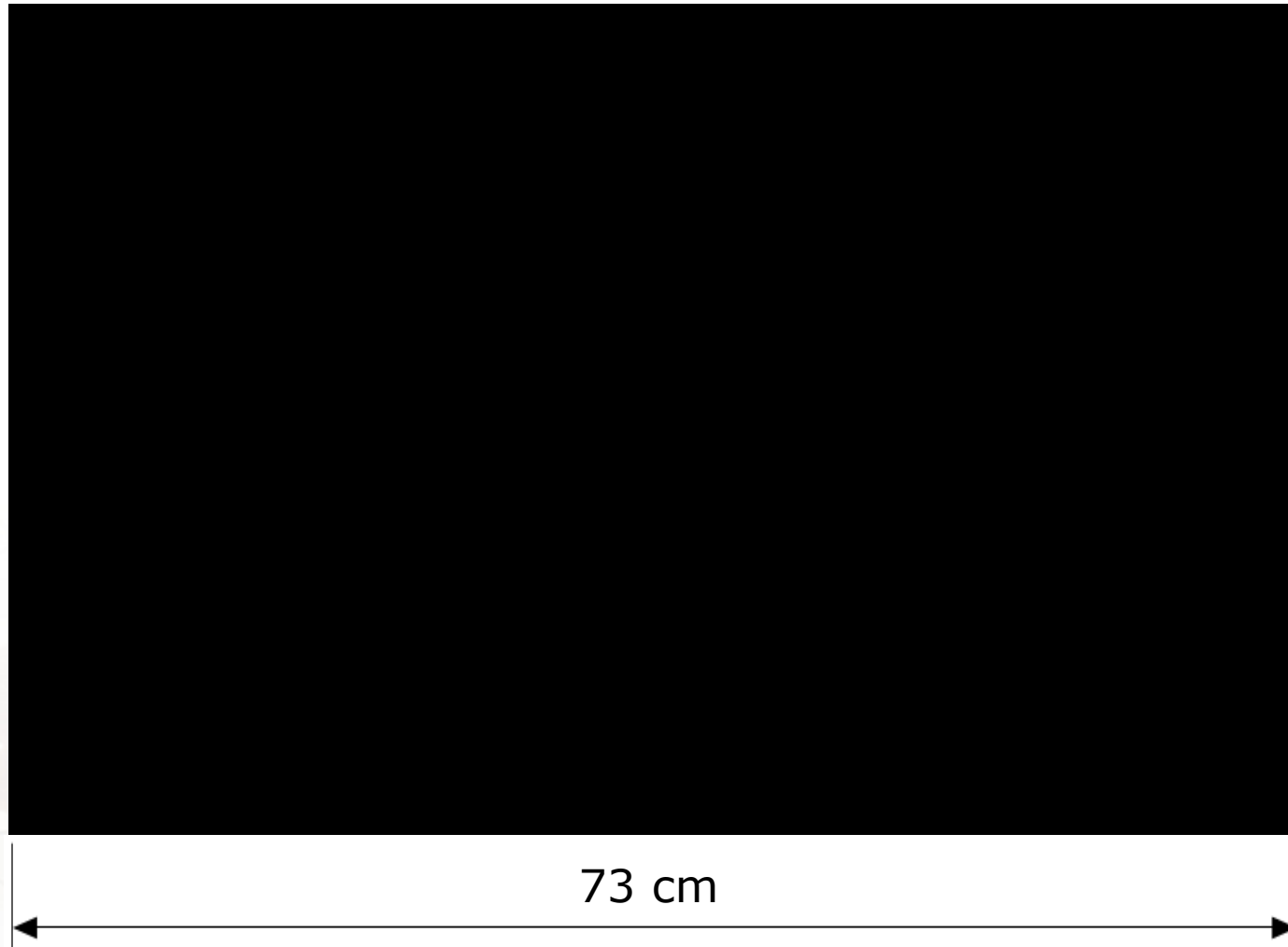
- 850 cm³ volume

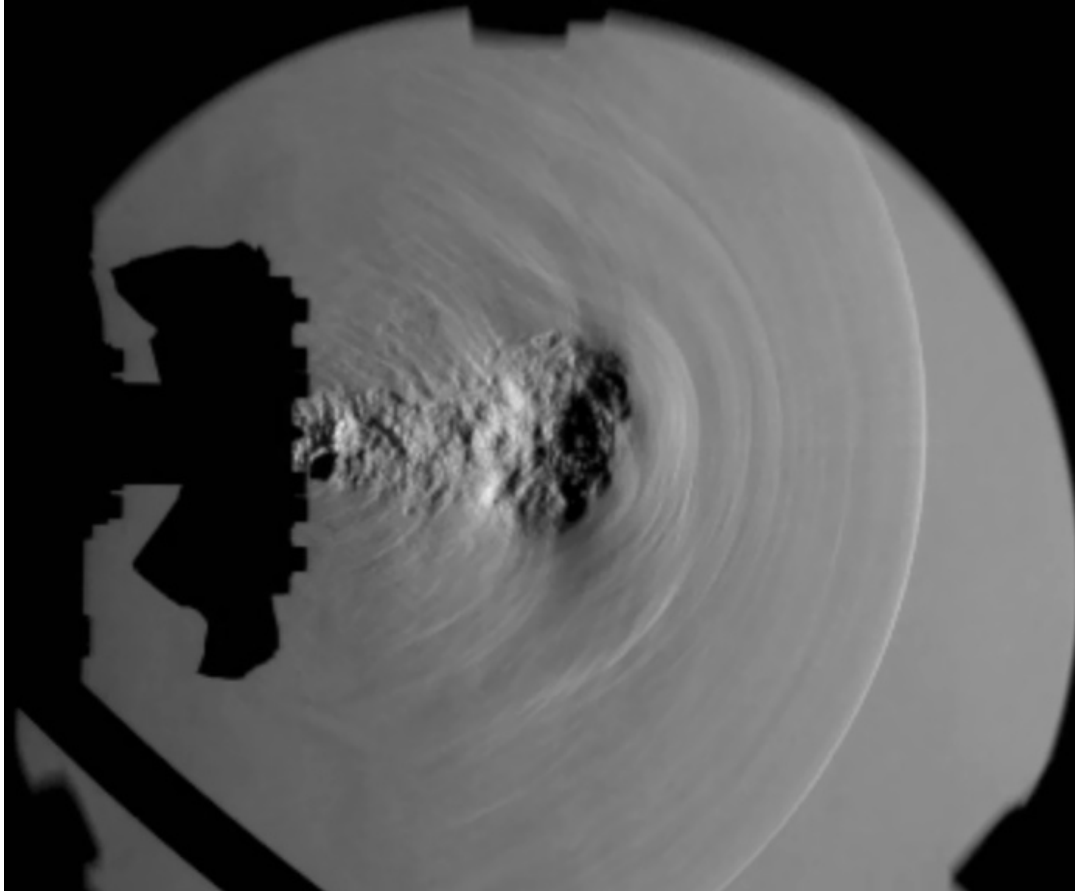


Jet Release - Schlieren

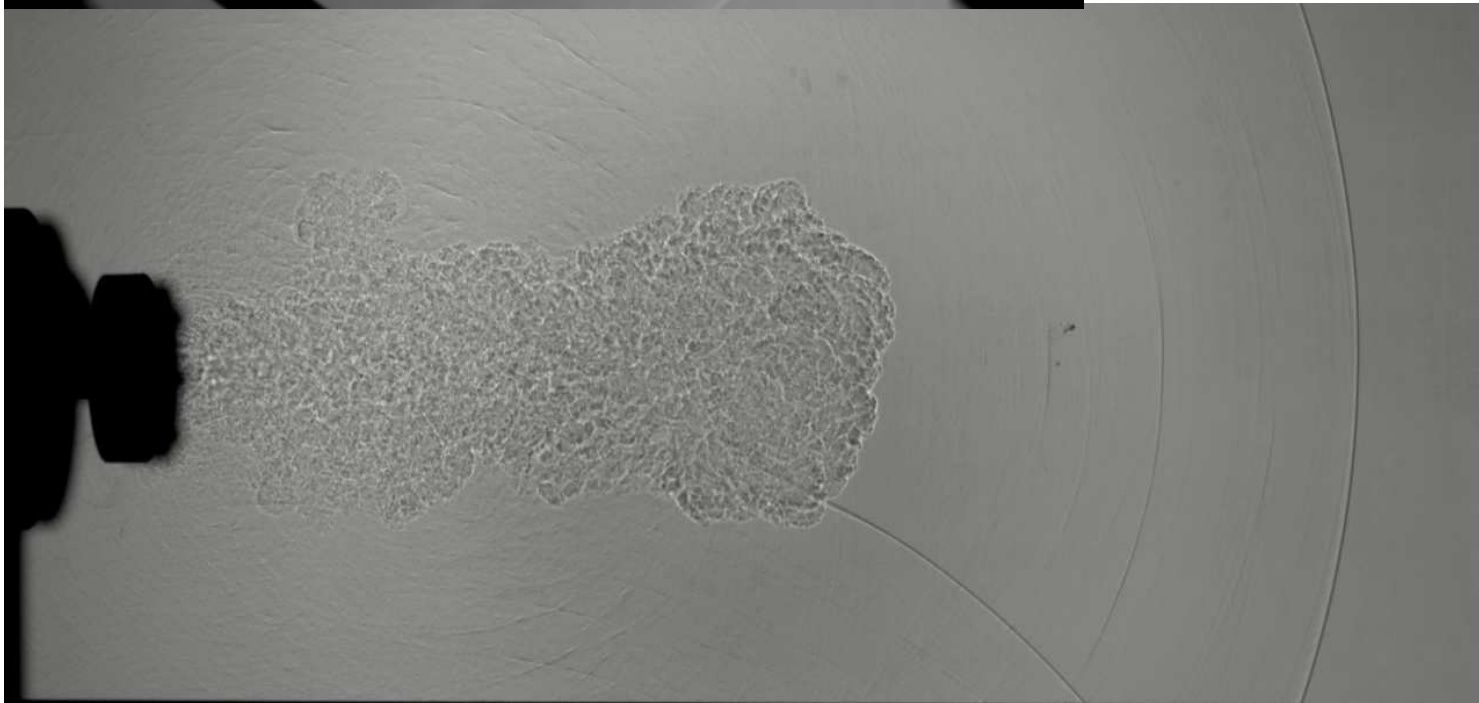


Jet Releases - Shadowgraph





Jet Releases - Comparison

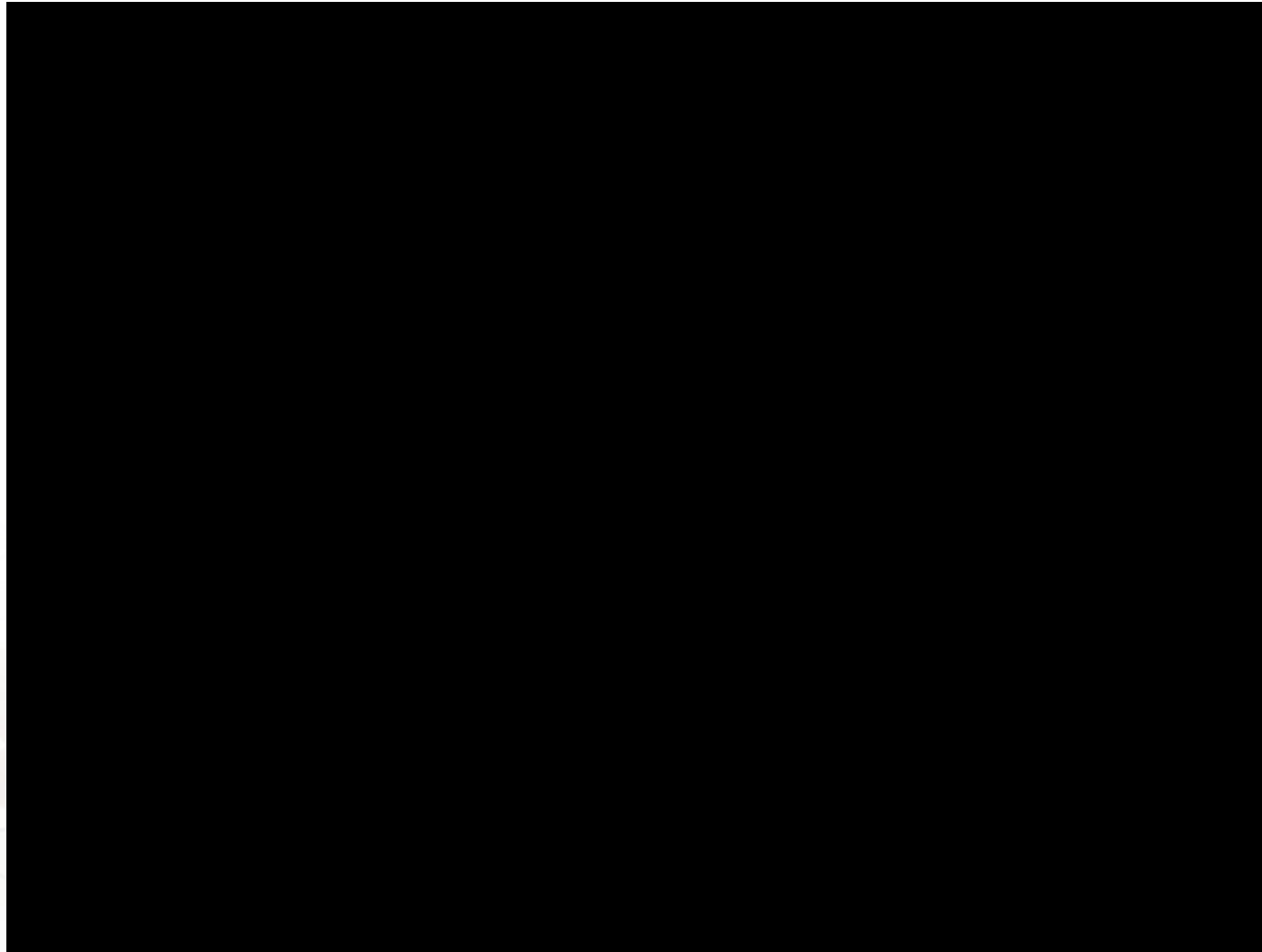


Soap Bubble Technique



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Unconfined Flames - Schlieren

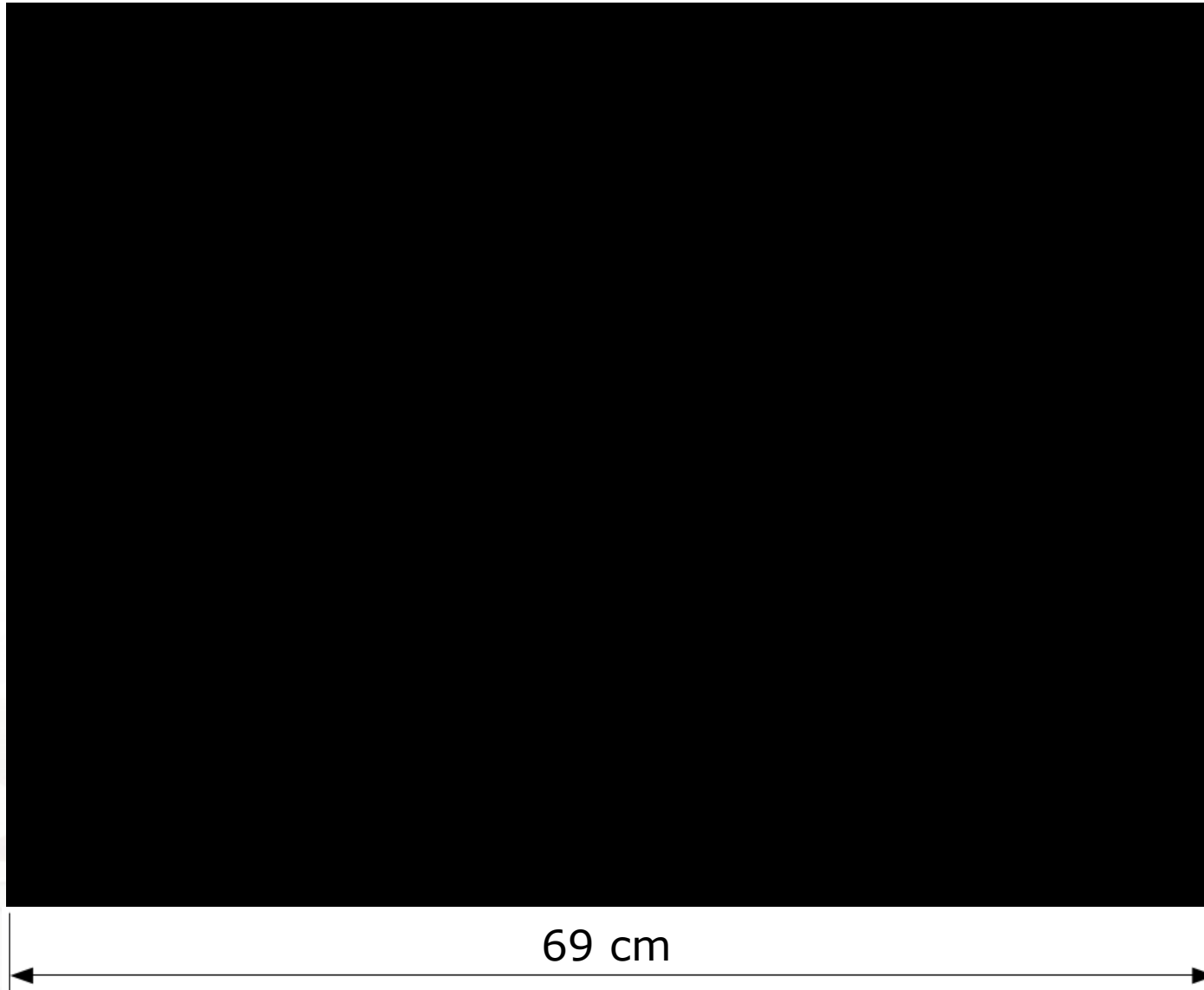


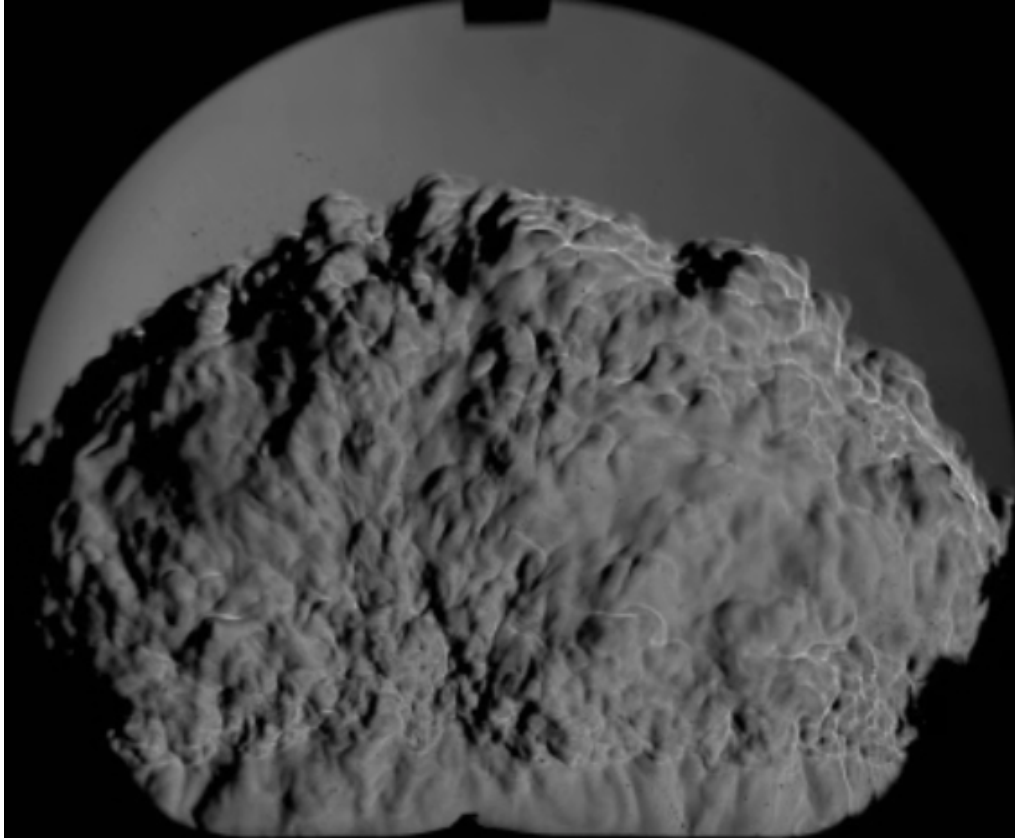
15% H₂ - Air

$\Phi = 0.42$

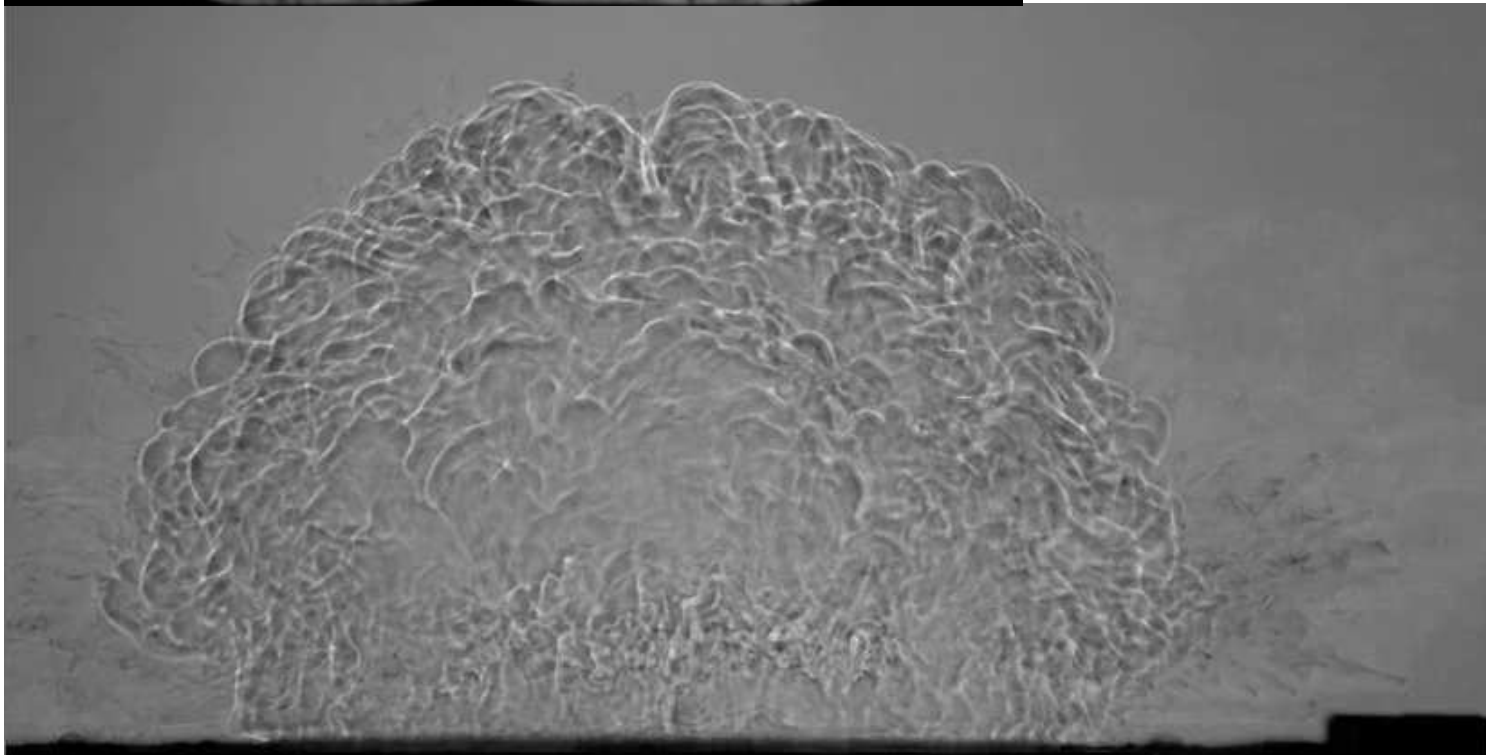
Soap bubble diameter 22 cm

Unconfined Flames - Shadowgraph

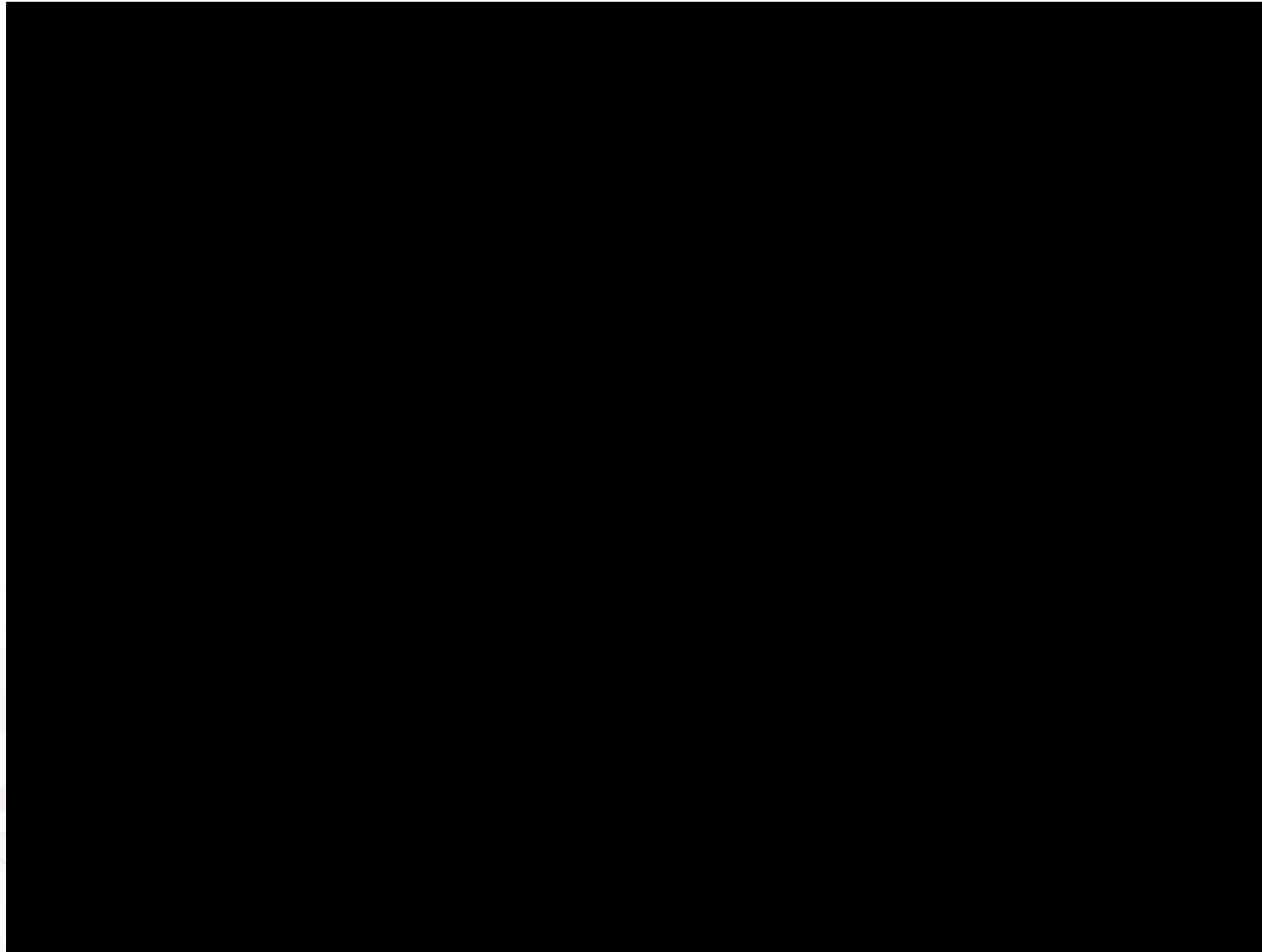




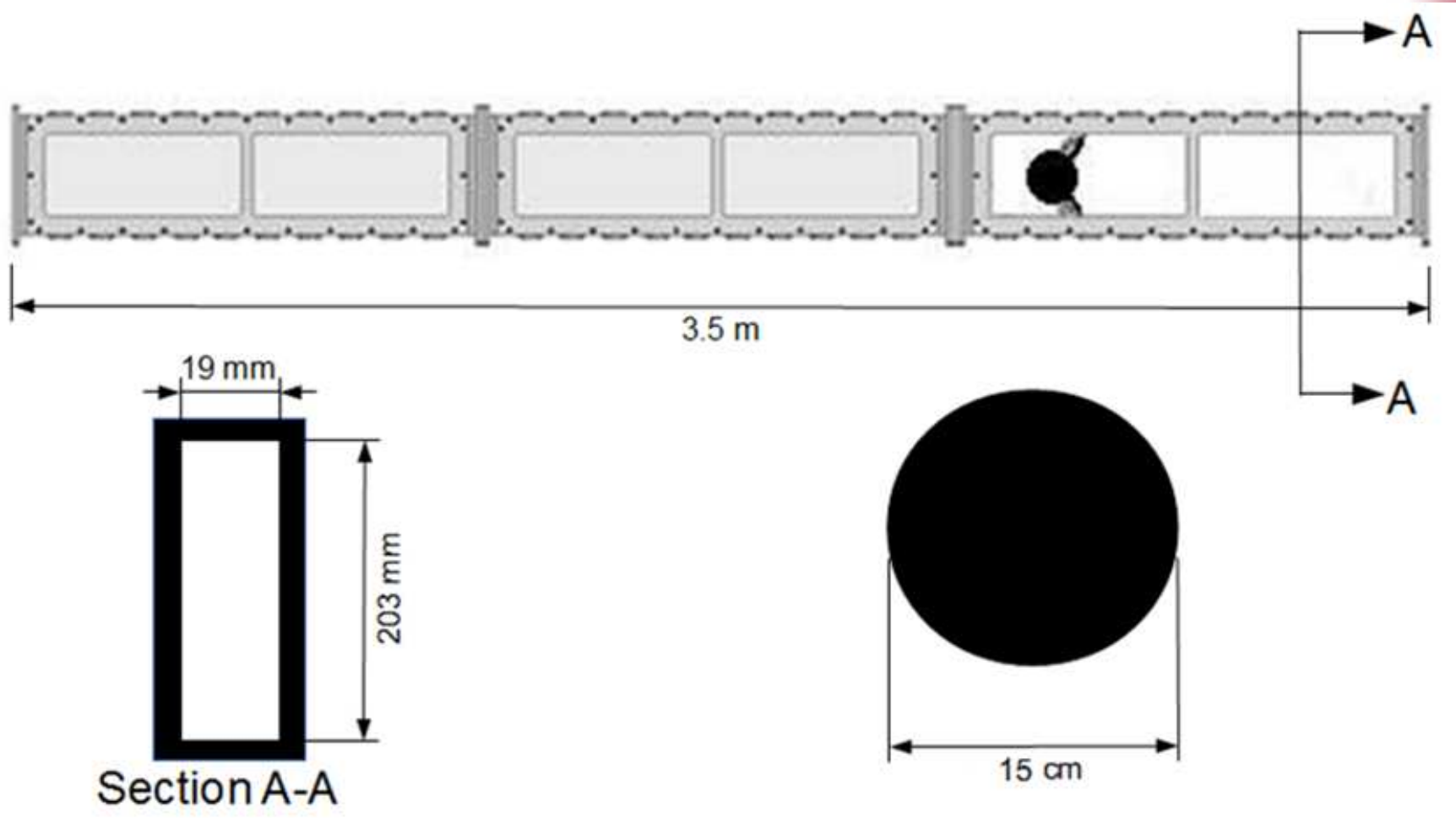
Unconfined Flames Comparison



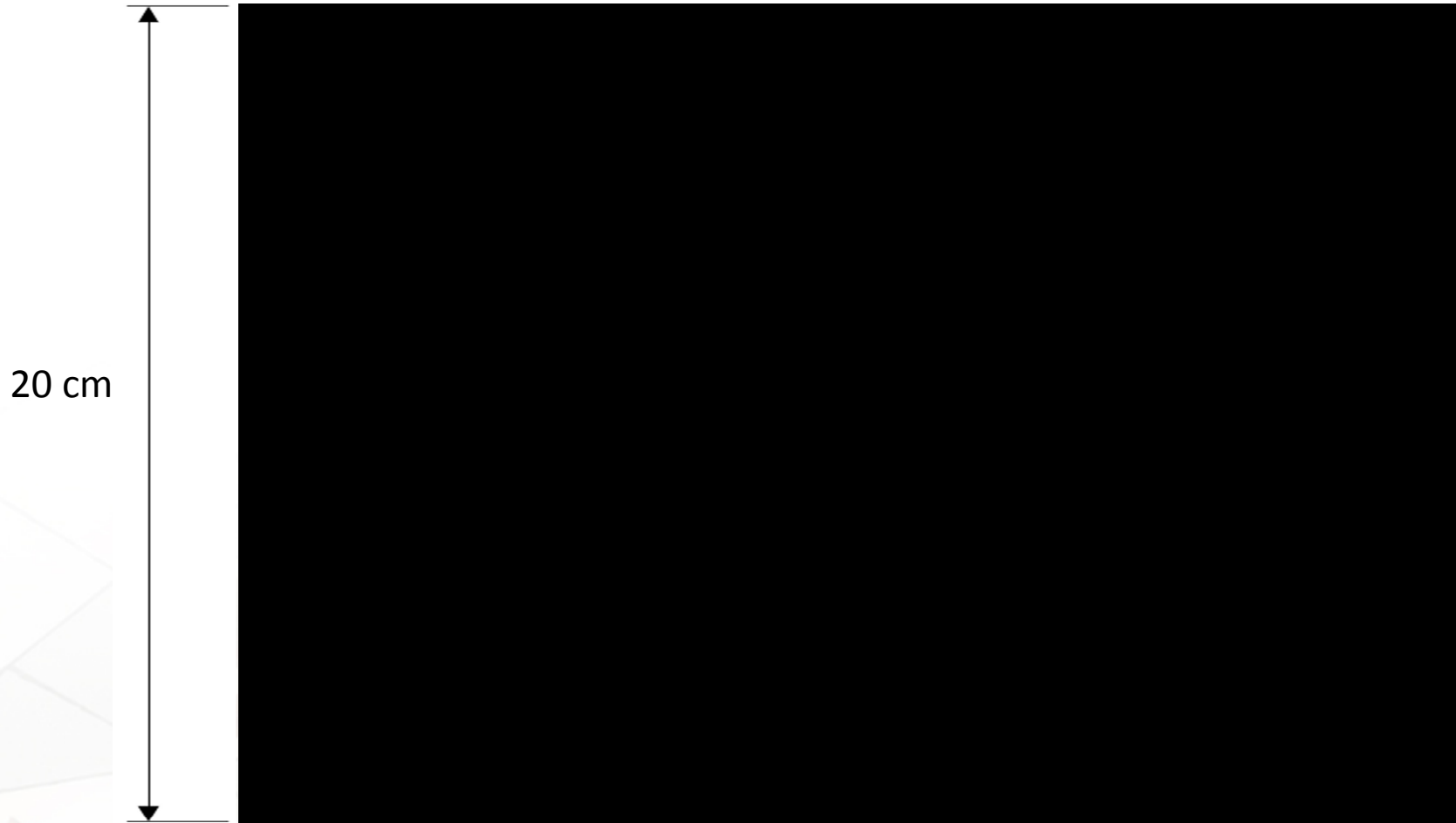
Unconfined Flames - Methane



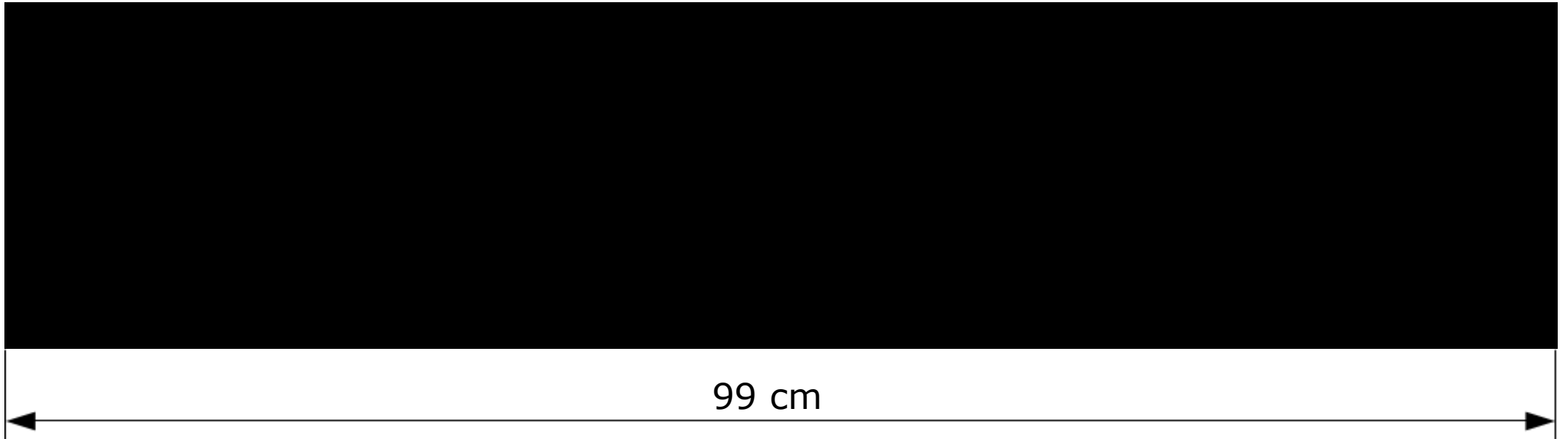
Shock Tube



Methane Detonations - Schlieren



Methane Detonations - Shadowgraph



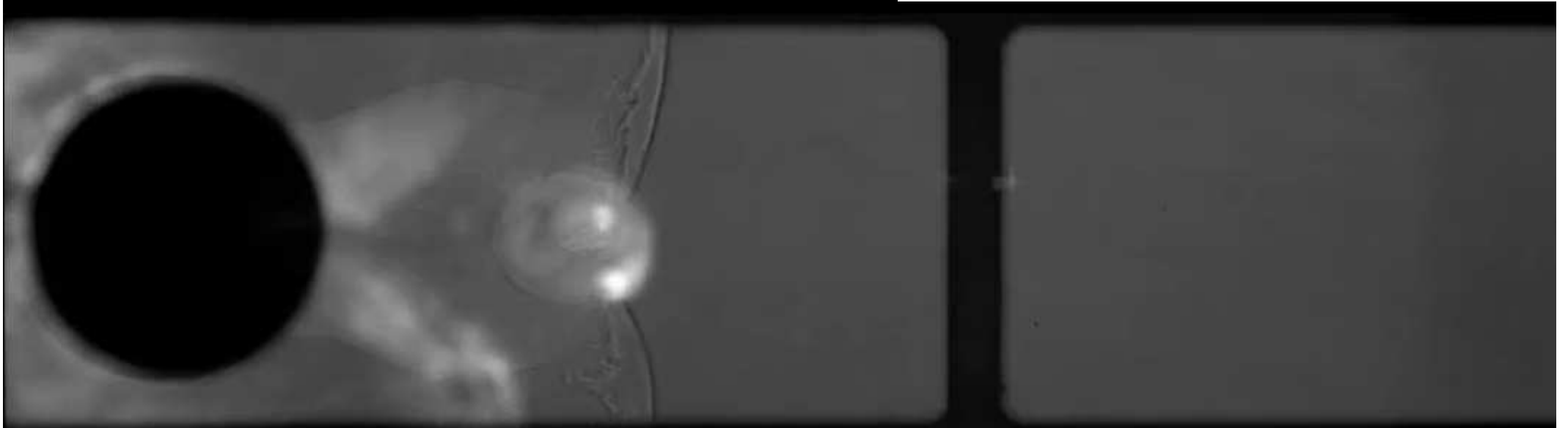
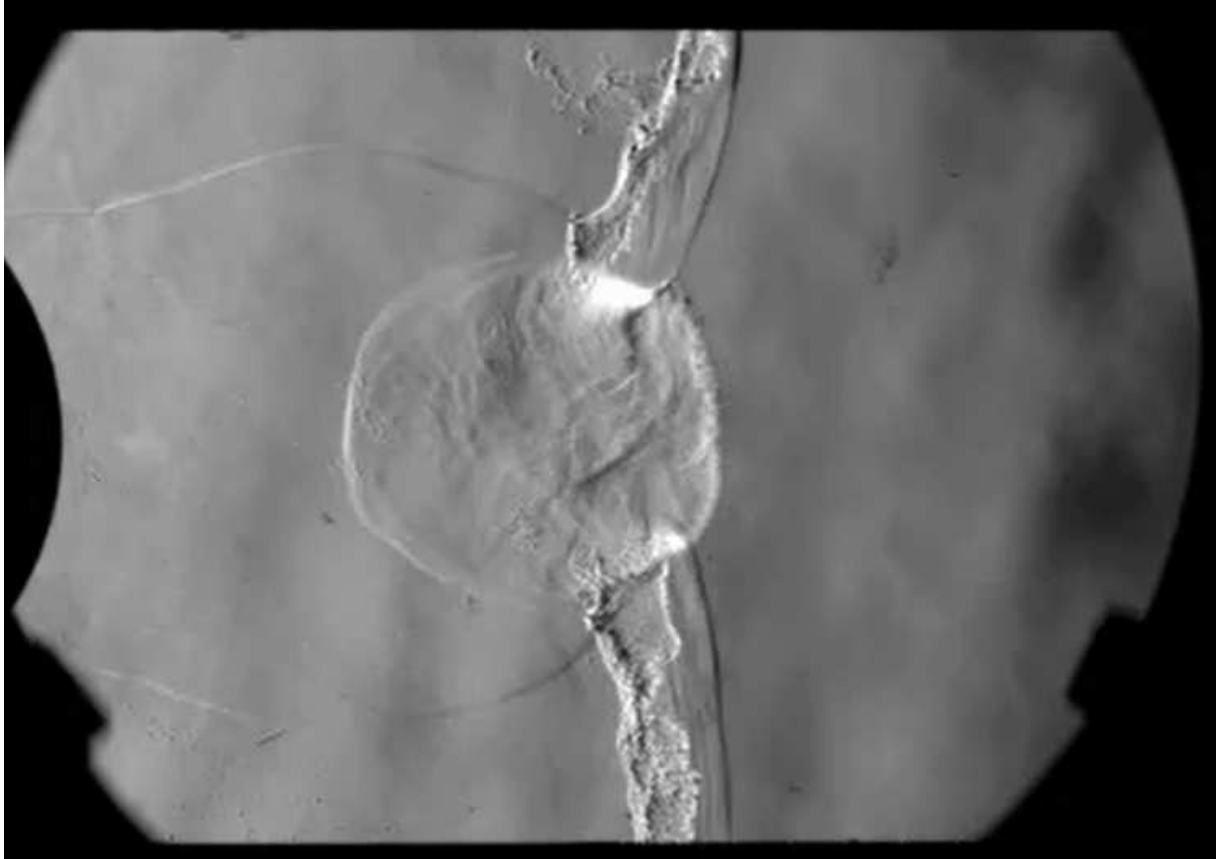
99 cm



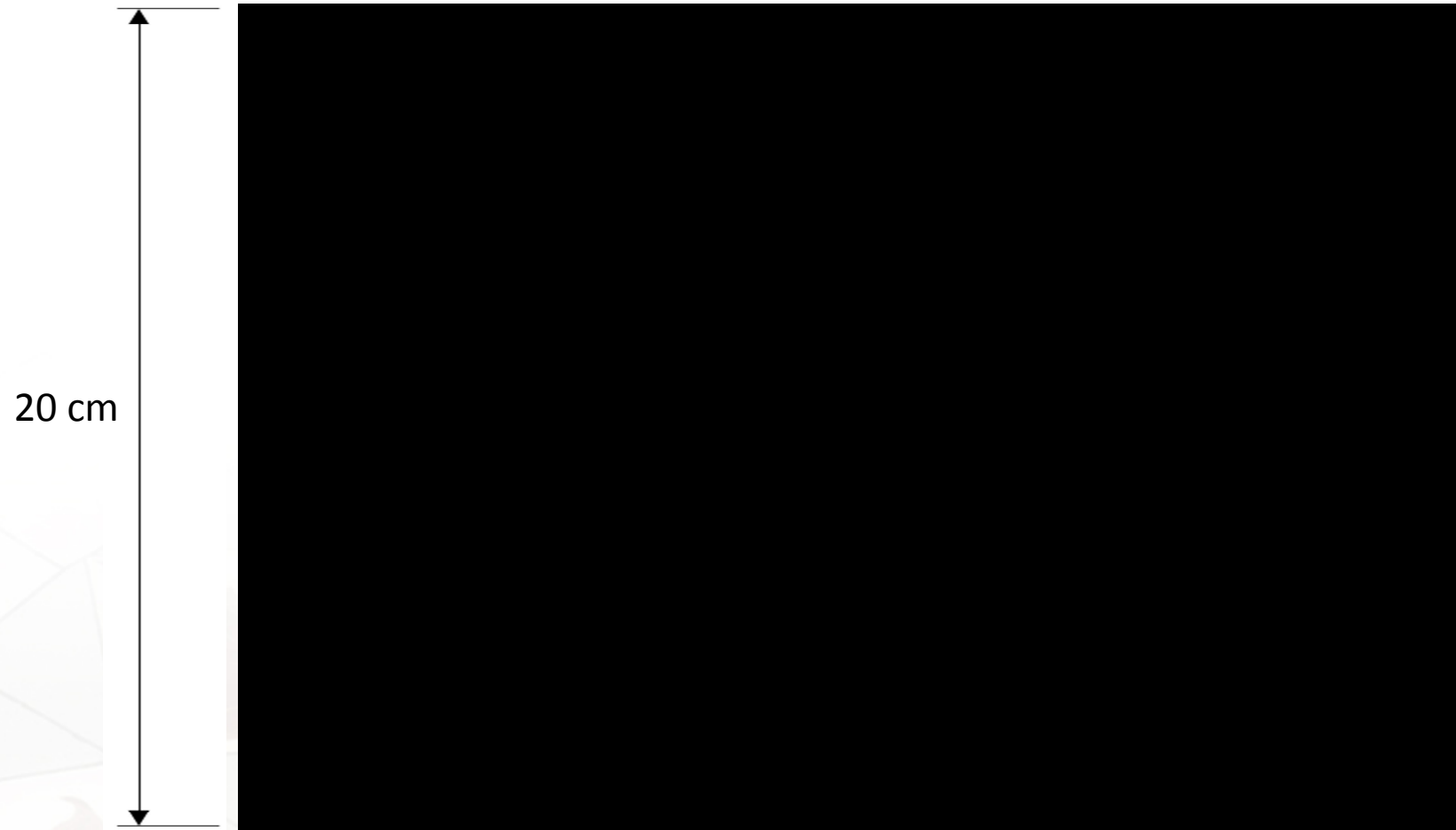
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$\text{CH}_4 + 2\text{O}_2$
14 kPa

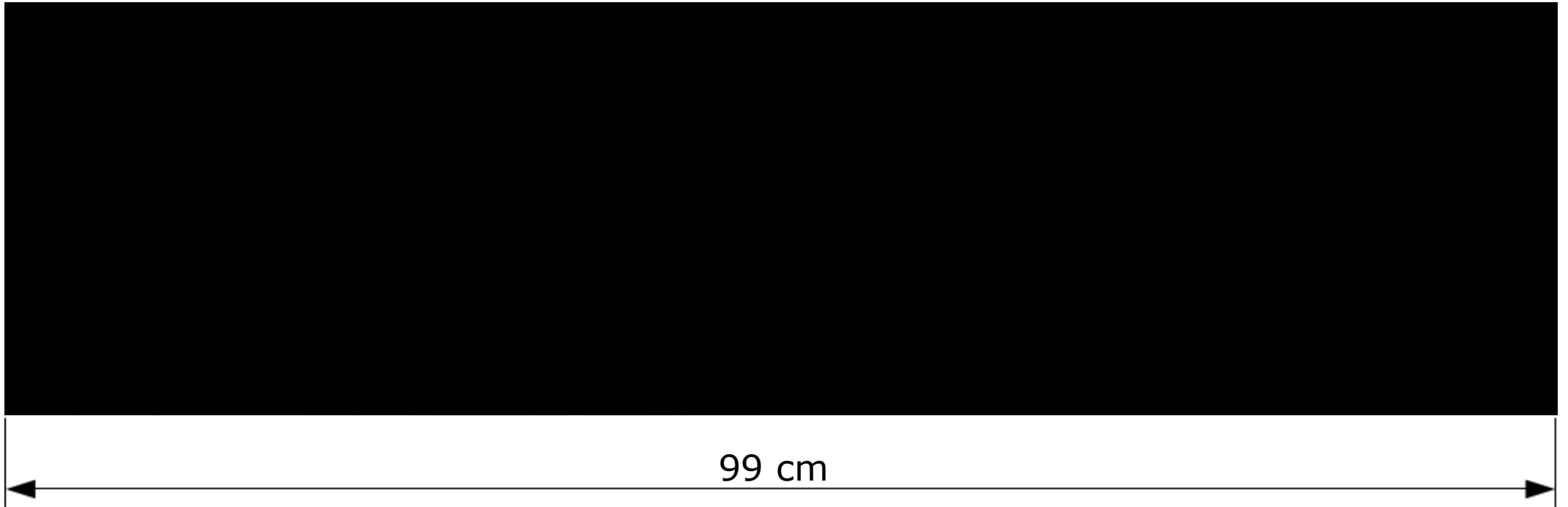
Methane Detonations - Comparison



Hydrogen Detonations - Schlieren

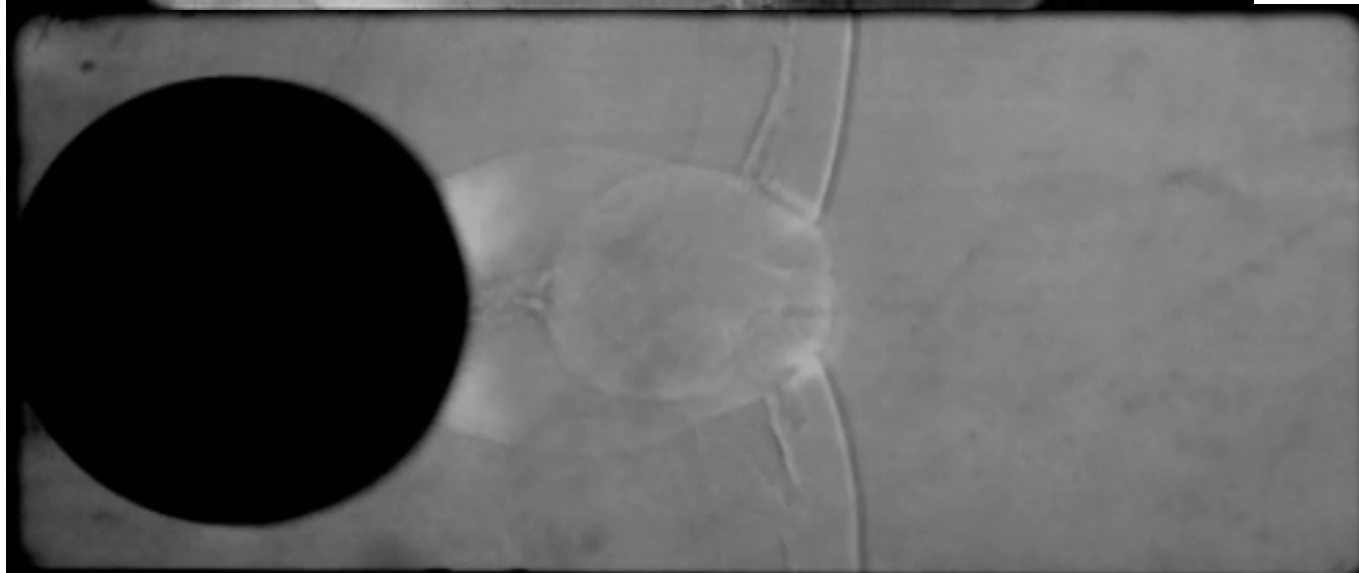
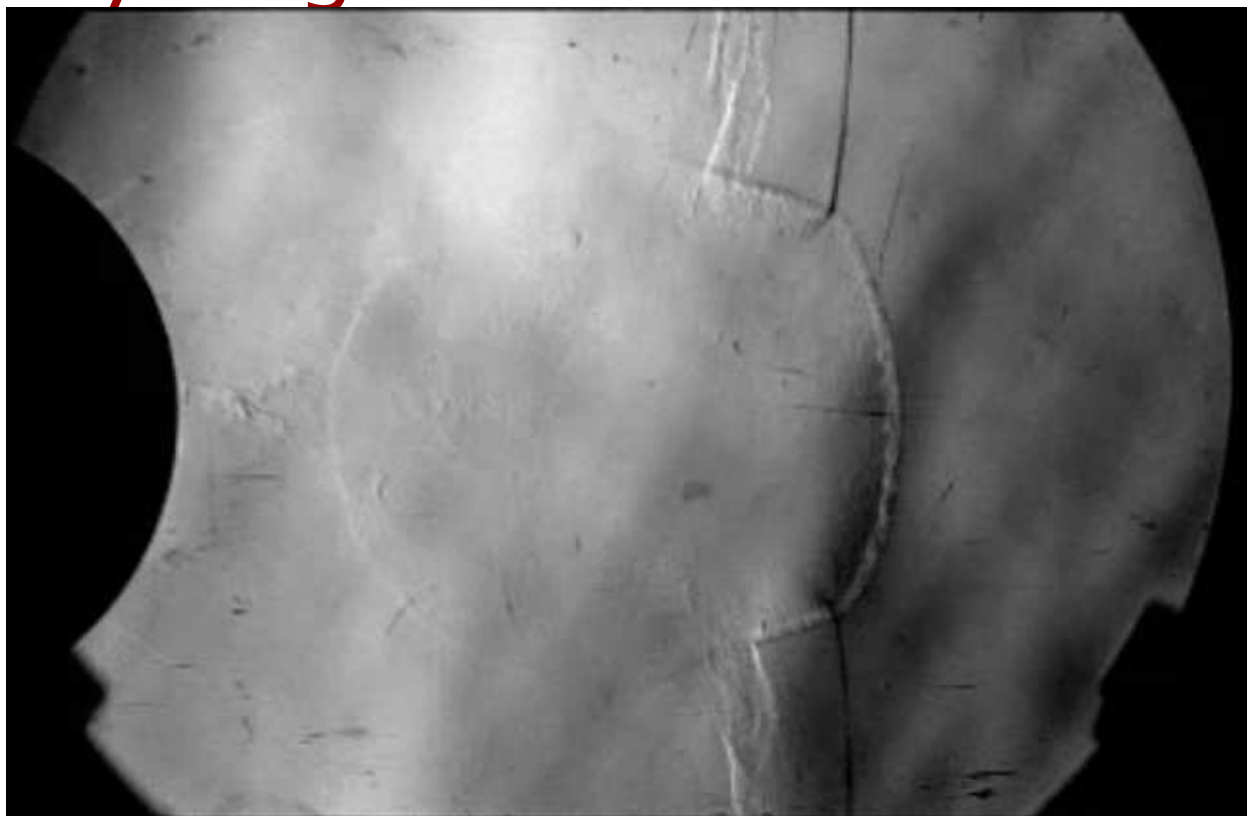


Hydrogen Detonations - Shadowgraph



99 cm

Hydrogen Detonations - Comparison



Conclusions



- Strong in all experiments
- Applicable outside of combustion experiments
- Low-cost
- Large-scale analysis
- Loss of detail



Future Work



- Flash light source
- Self-luminosity issues

Acknowledgements



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