Line of sight measurements in sprays

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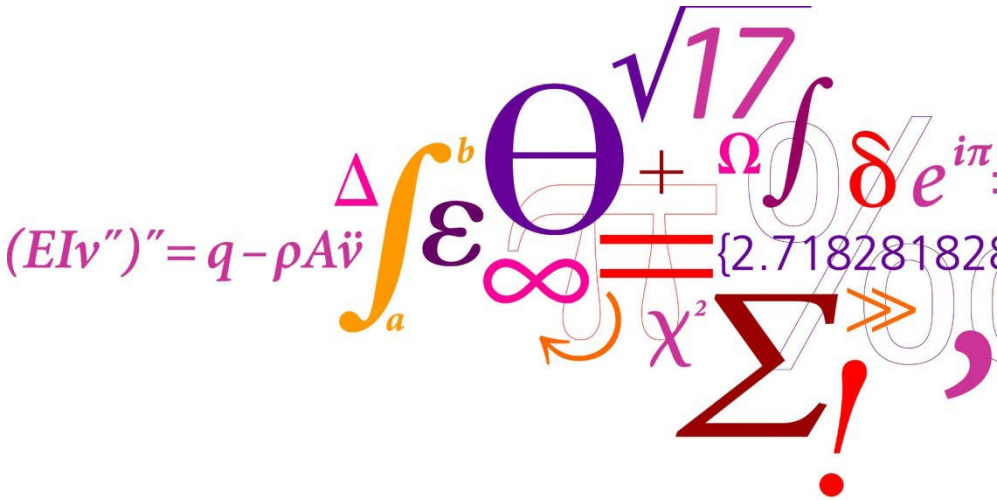
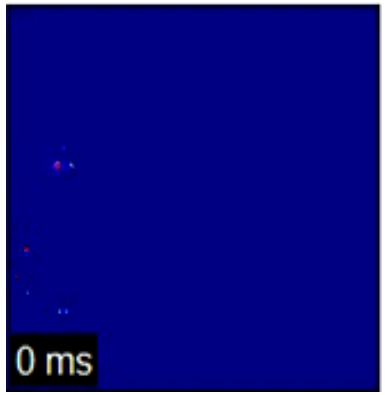
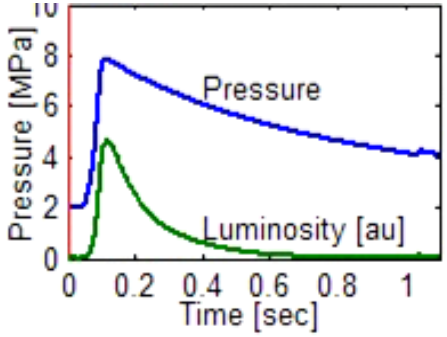


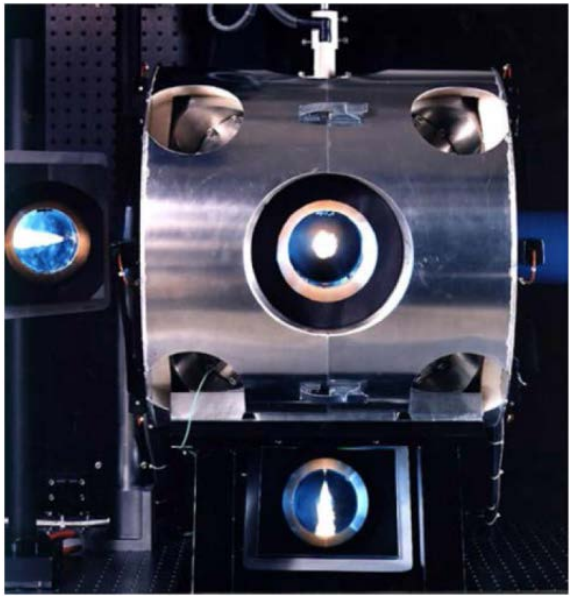
DTU Mechanical Engineering
Department of Mechanical Engineering

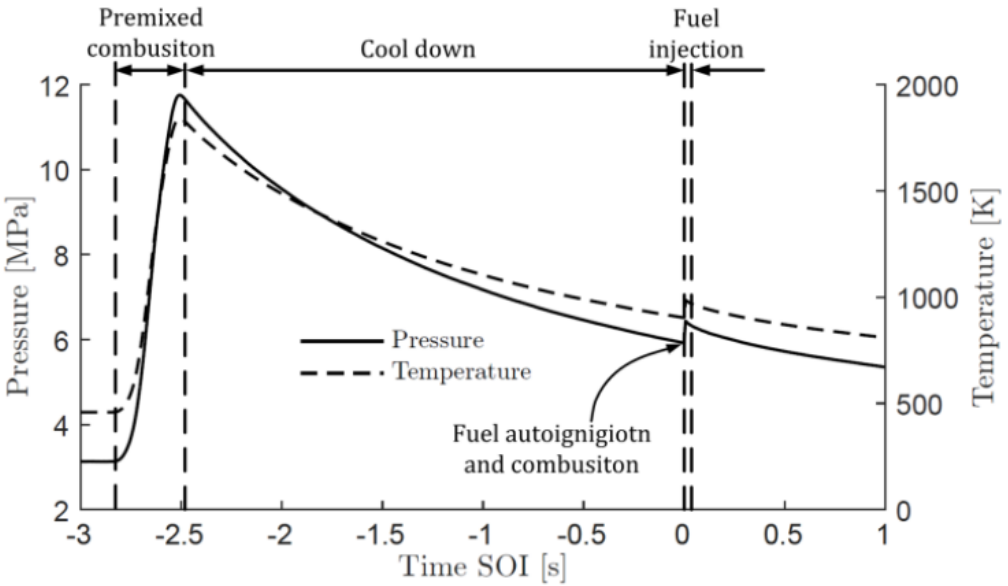
Spray flame experiments

- Experimental validation of computational modelling
- High pressure and temperature environment generated in CVC vessel









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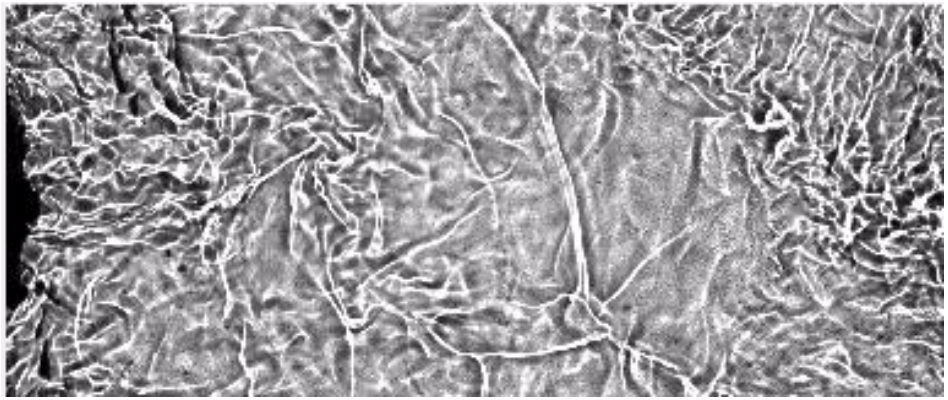
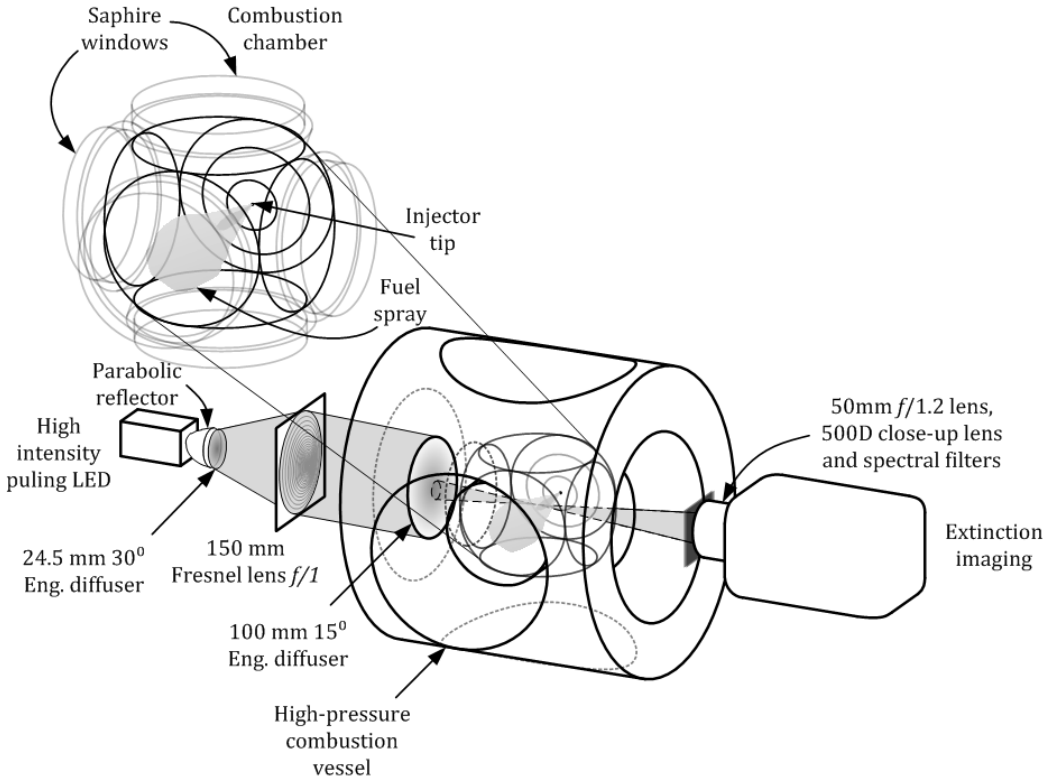
Optical diagnostics

- Imaging techniques advantageous
- Challenges:
  - High temporal resolution
  - Distortions from optically harsh environment



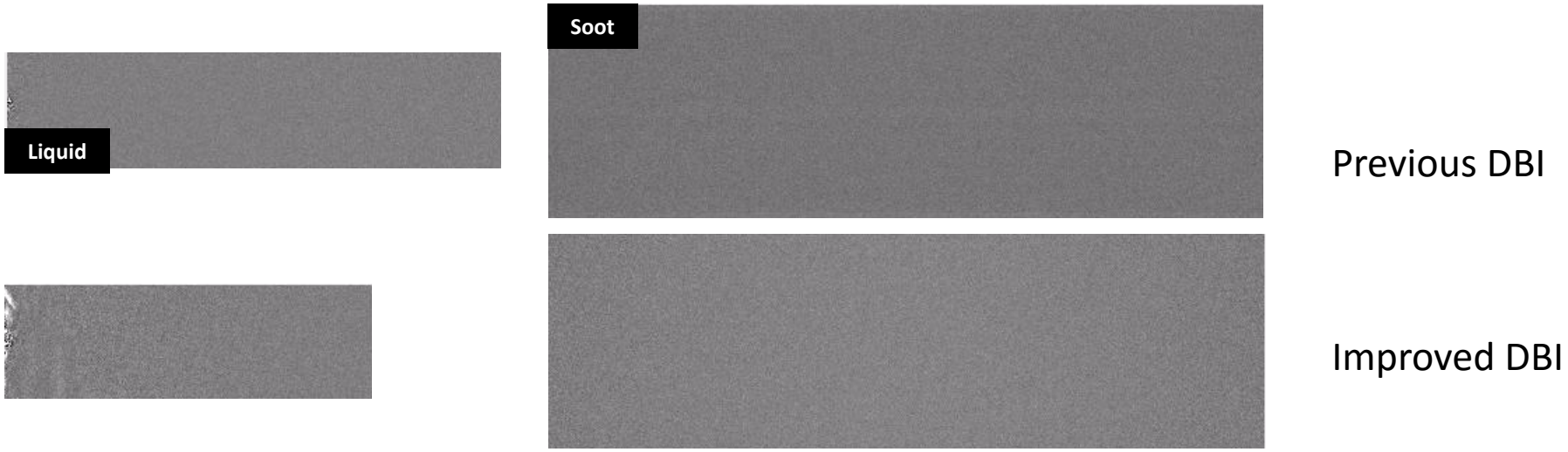
Schlieren imaging

Experimental setup



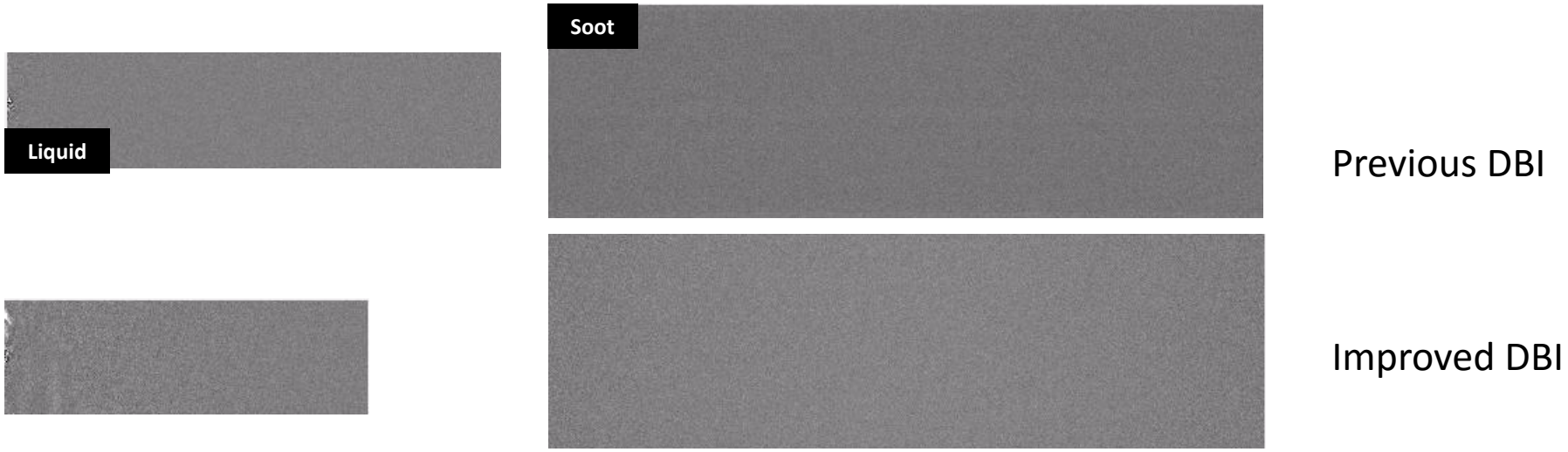
Extinction imaging

- Lighting characteristics can isolate scattering and absorption
- Severely reduced light throughput
- Attempts to achieve diffused lighting with high light throughput



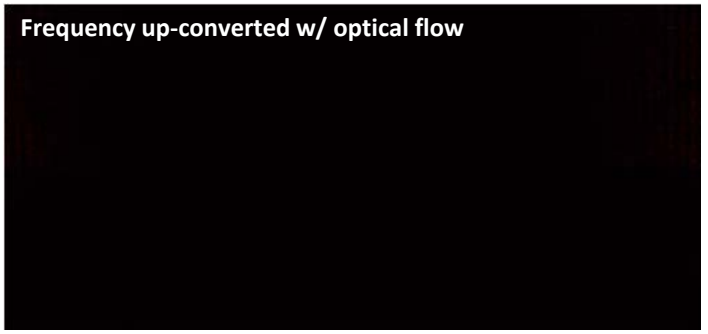
Extinction imaging

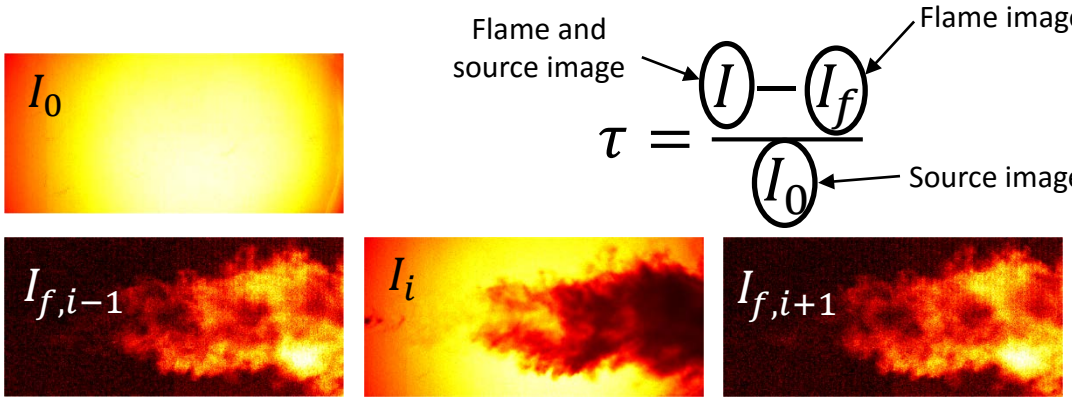
- Lighting characteristics can isolate scattering and absorption
- Severely reduced light throughput
- Attempts to achieve diffused lighting with high light throughput
- Enhanced setup maintain high light throughput of well characterized diffused lighting



Extinction imaging of soot

- Transmission consists of sequential and reference images
- Moving flame luminosity introduces error
- High temporal resolution and spectral filtering reduces error
- Clever post processing can further reduce error

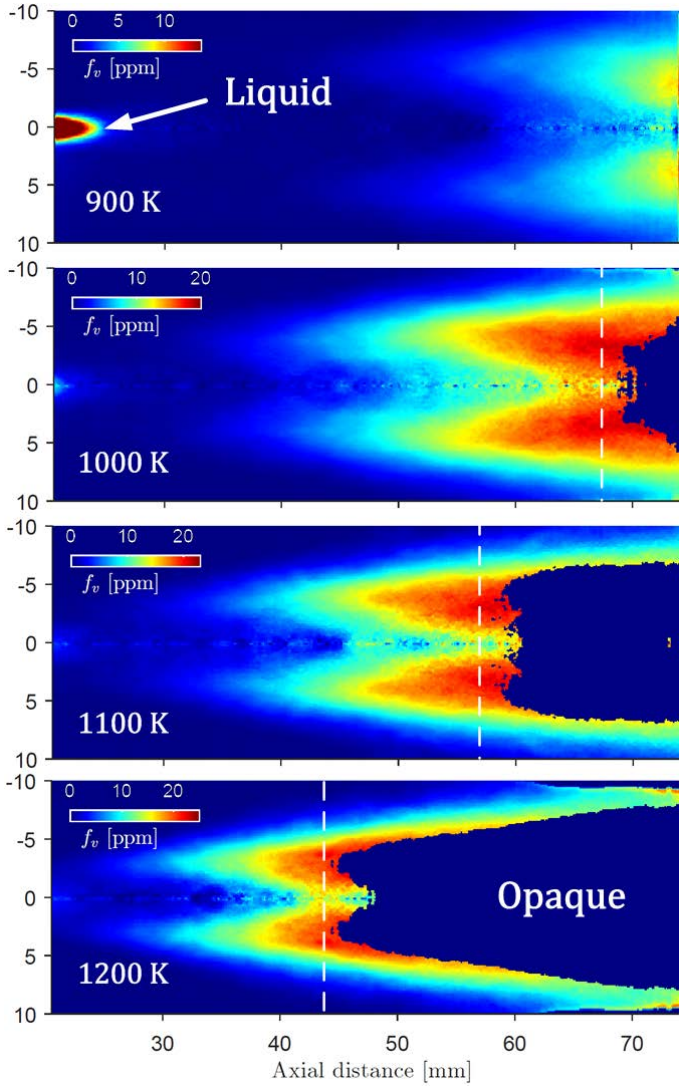




Extinction imaging of soot

- KL is a projection
- K obtained by tomographic reconstruction
- Soot volume:
  - Optical properties
  - Fractal dimensions
  - Small particle Mie theory coupled with Rayleigh-Debye Gans theory

$$K_{abs} = -\frac{6\pi}{\lambda} f_v E(\tilde{m})$$



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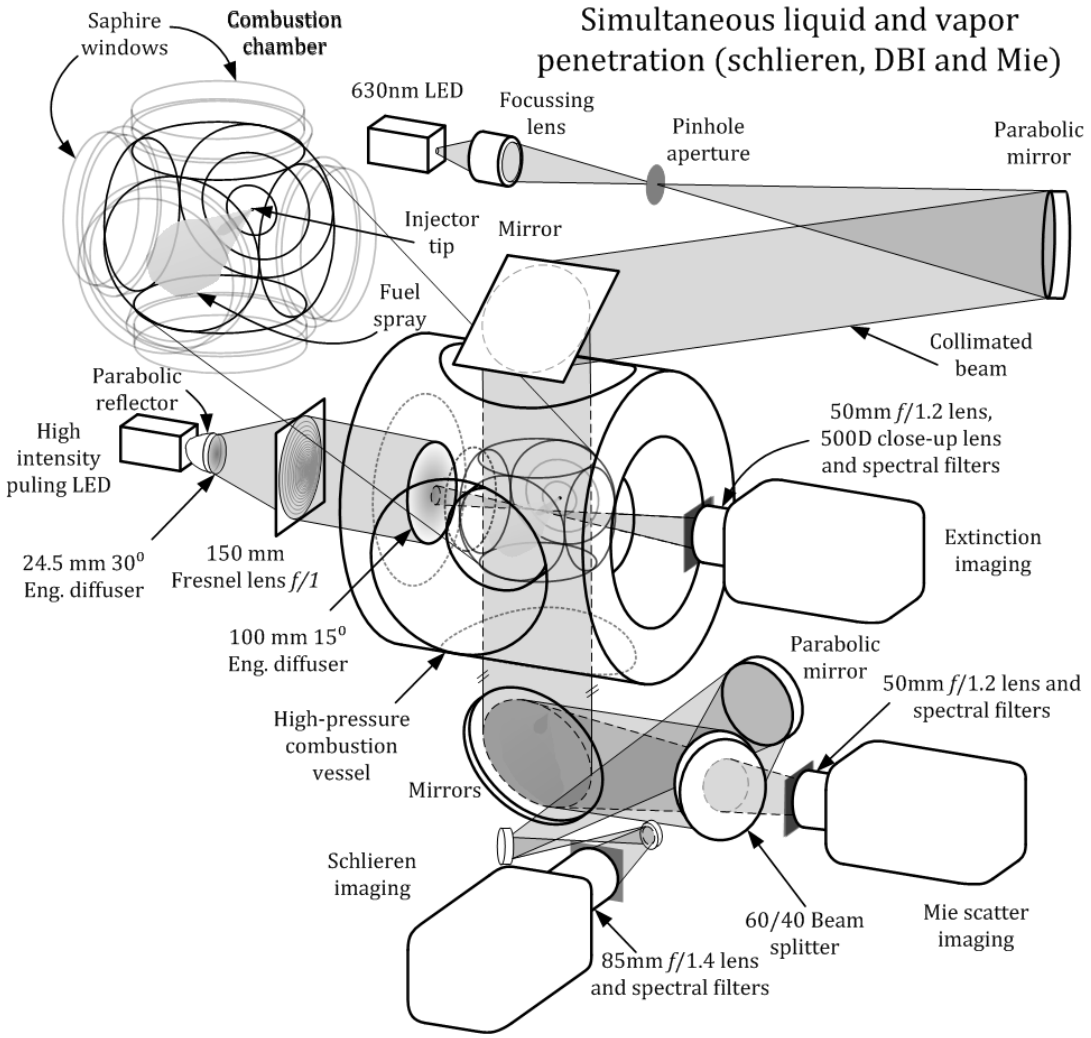
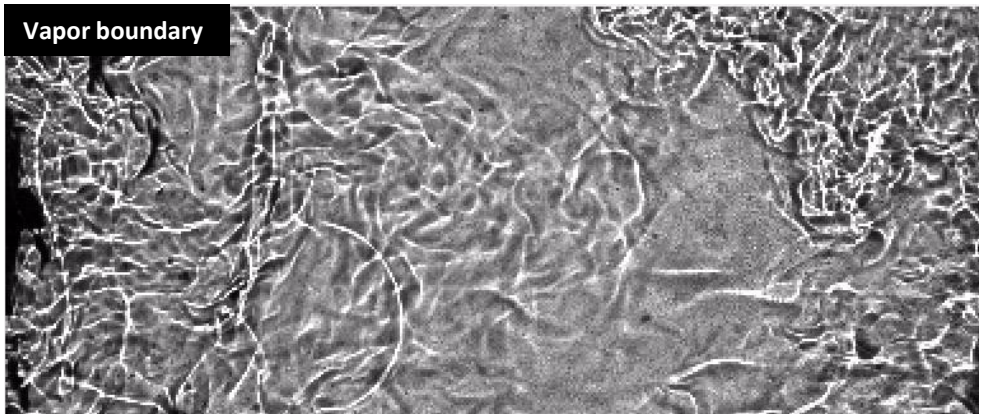
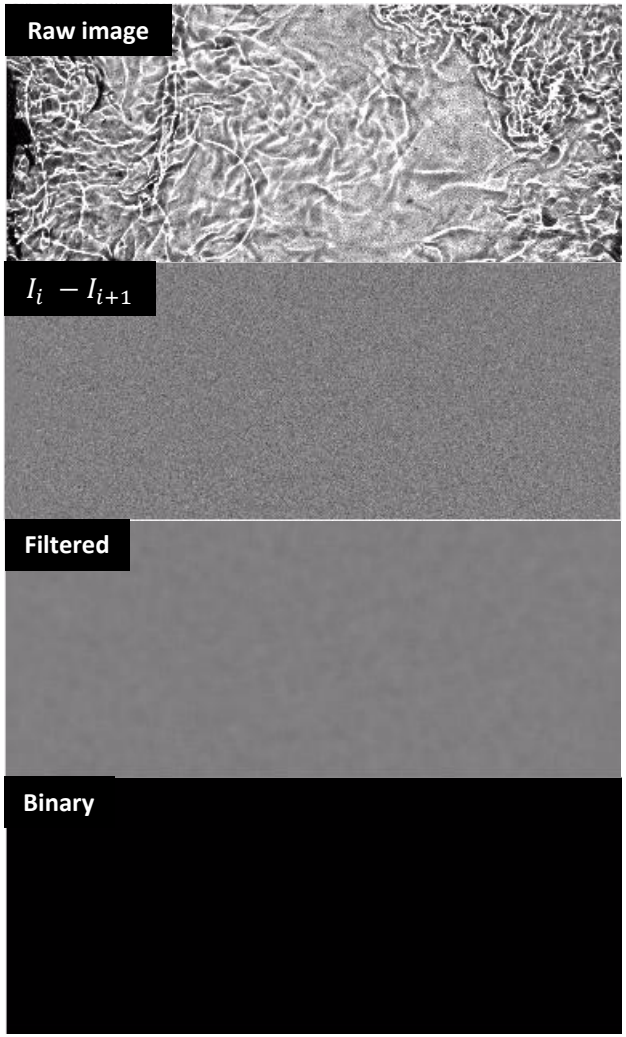
Experimental setup



Schlieren imaging of vapor phase

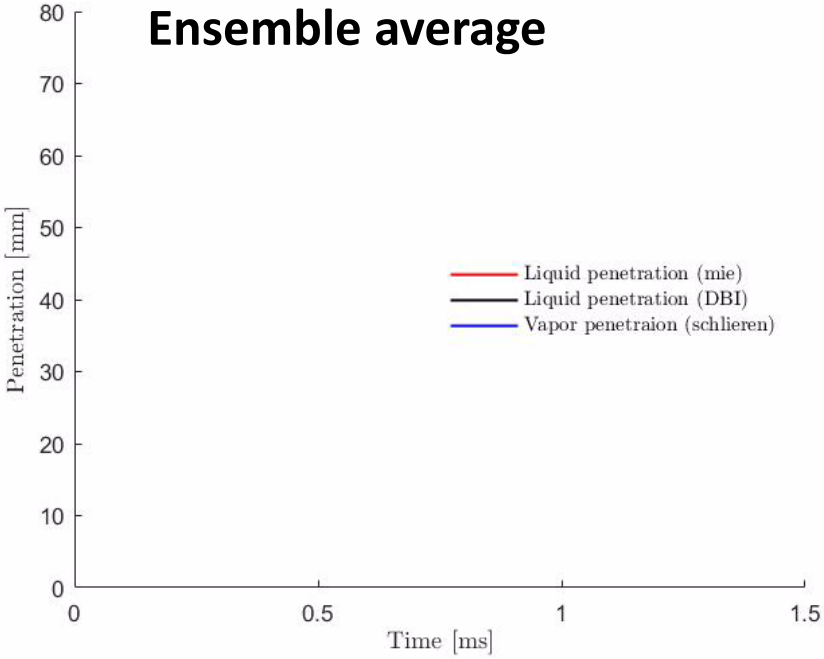
- Imaging gradients in refractive index
- Temporal differencing isolates the rapid processes
- Well defined background noise
- Adaptive filtering
- Thresholding to evaluate vapor boundary





Penetration characteristics

Ensemble average

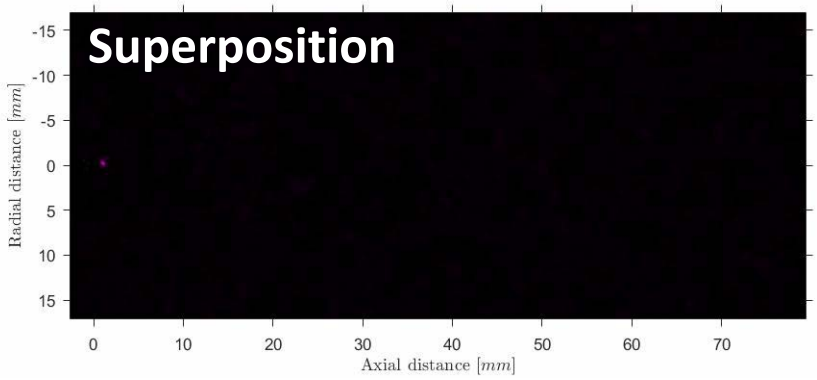


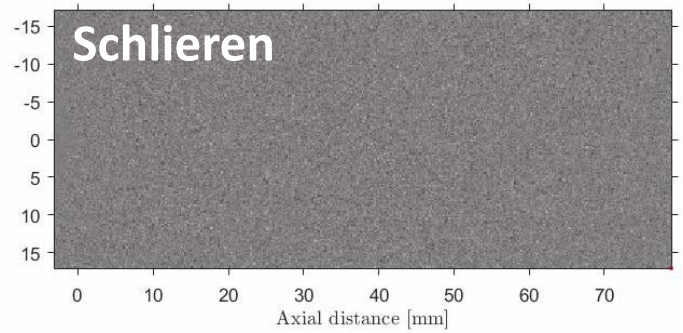
$x_{O_2} = 0$

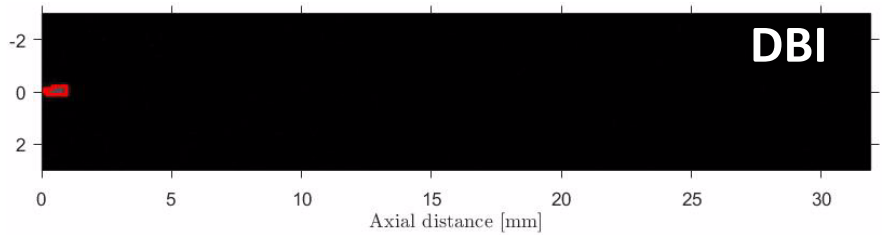
$T_{amb} = 900\ K$

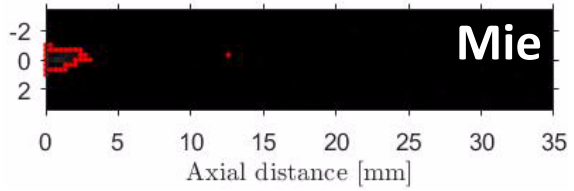
$p_{inj} = 1500\ bar$

$\rho_{amb} = 22.8\ kg/m^3$









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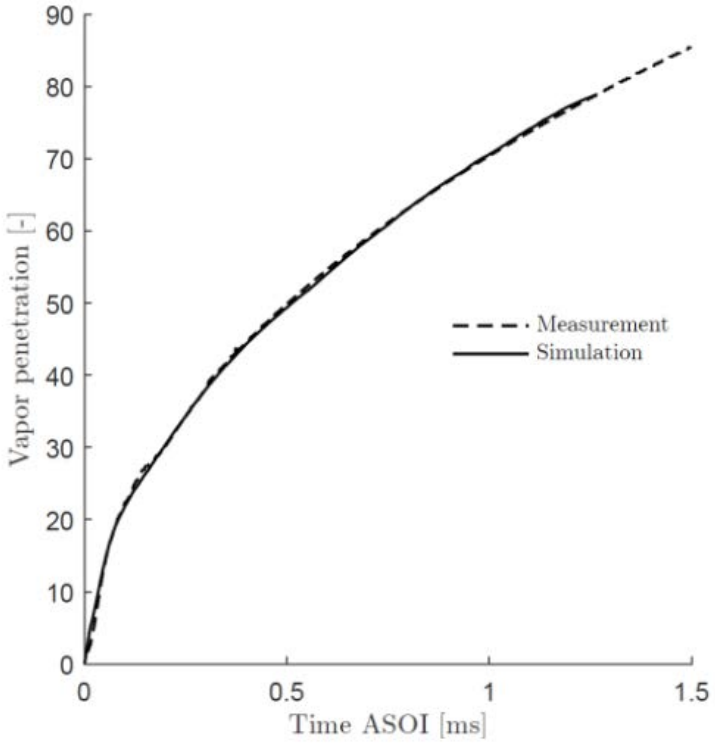
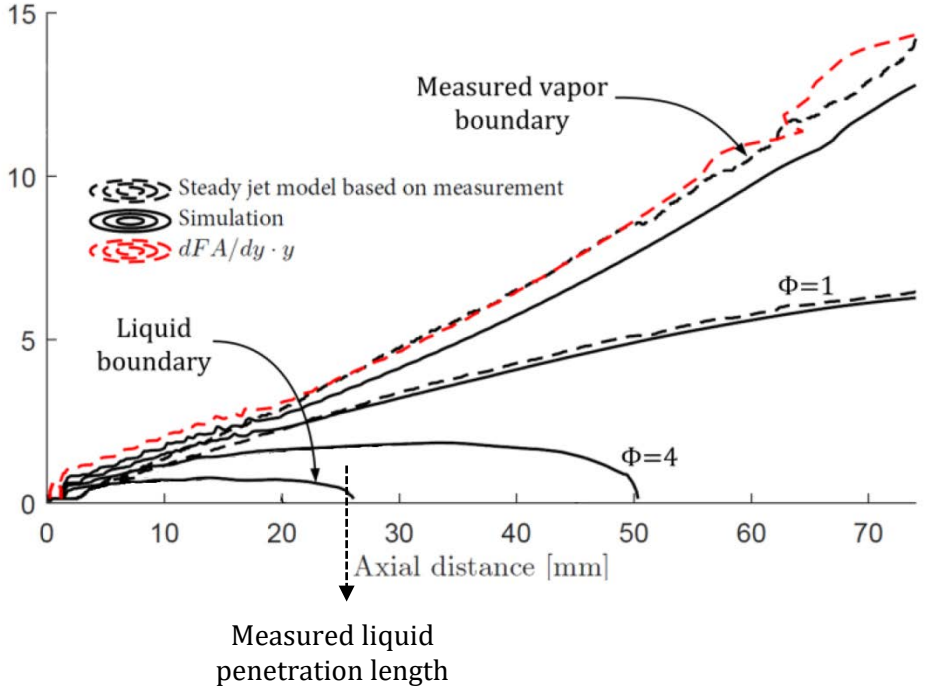
Model validation: Flow field

- Vapor boundary defined by gradient of FA ratio
- Well predicted penetration characteristics



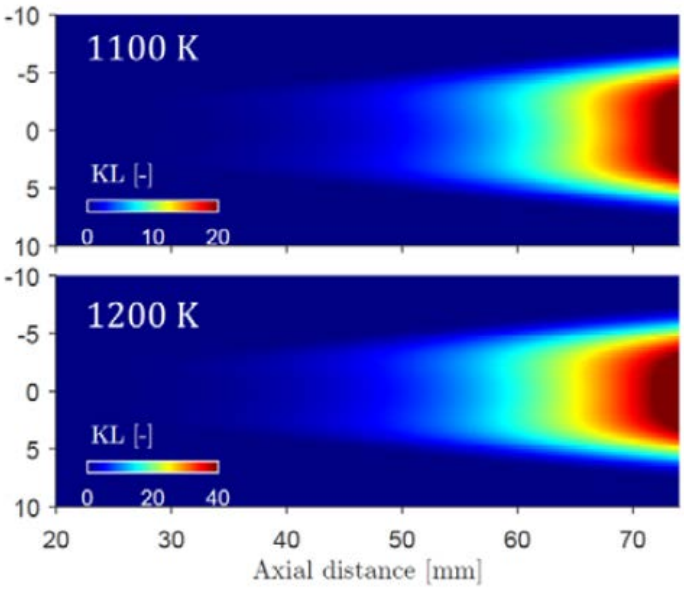


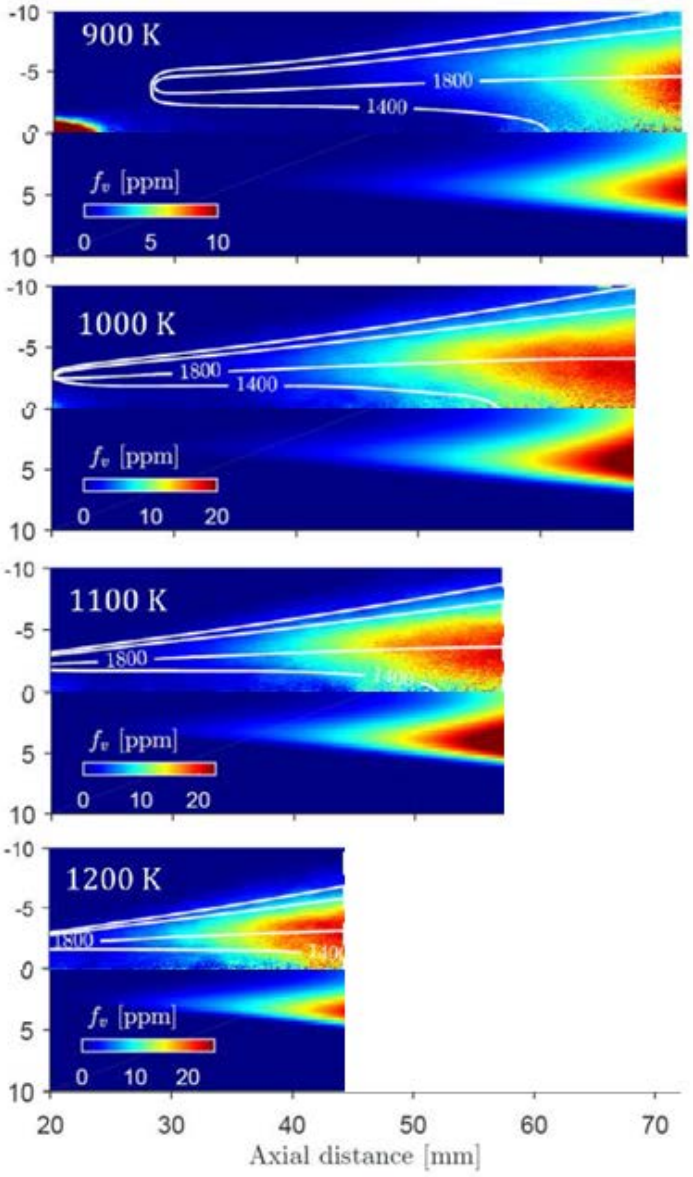
Model validation: Soot volume fraction

Measurement

Simulation

- Opaque flame at higher ambient temperature
- Good agreement spatially and quantitatively
- Flames too optically thick in the visual





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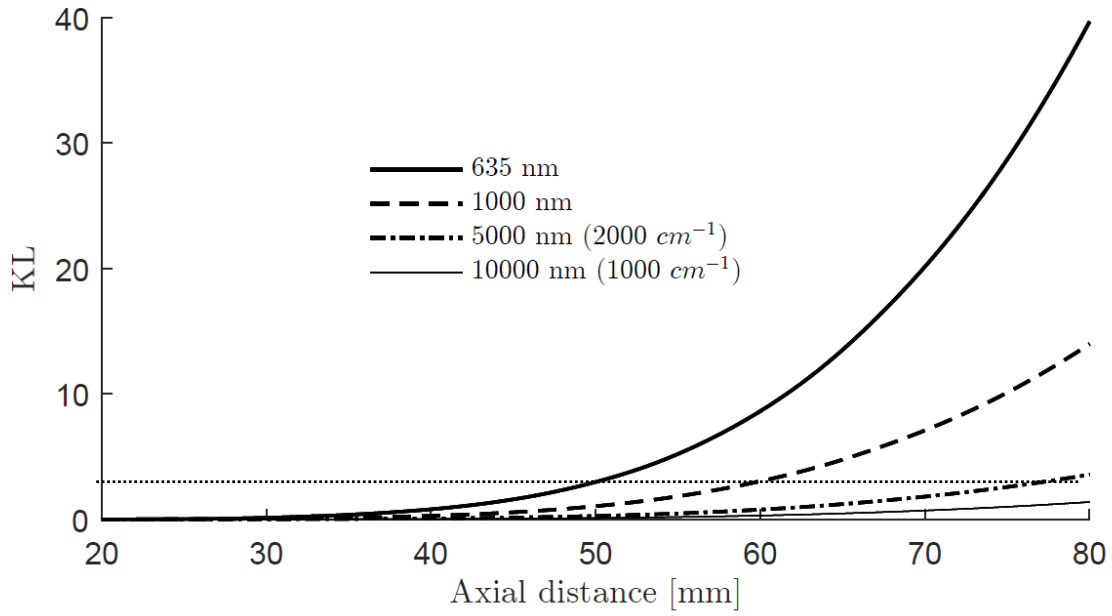
Discussion

- Advances in measurement reliability
- Limitations have been identified
- Infra-red can cope with the high optical thickness
- Gas phase thermometry



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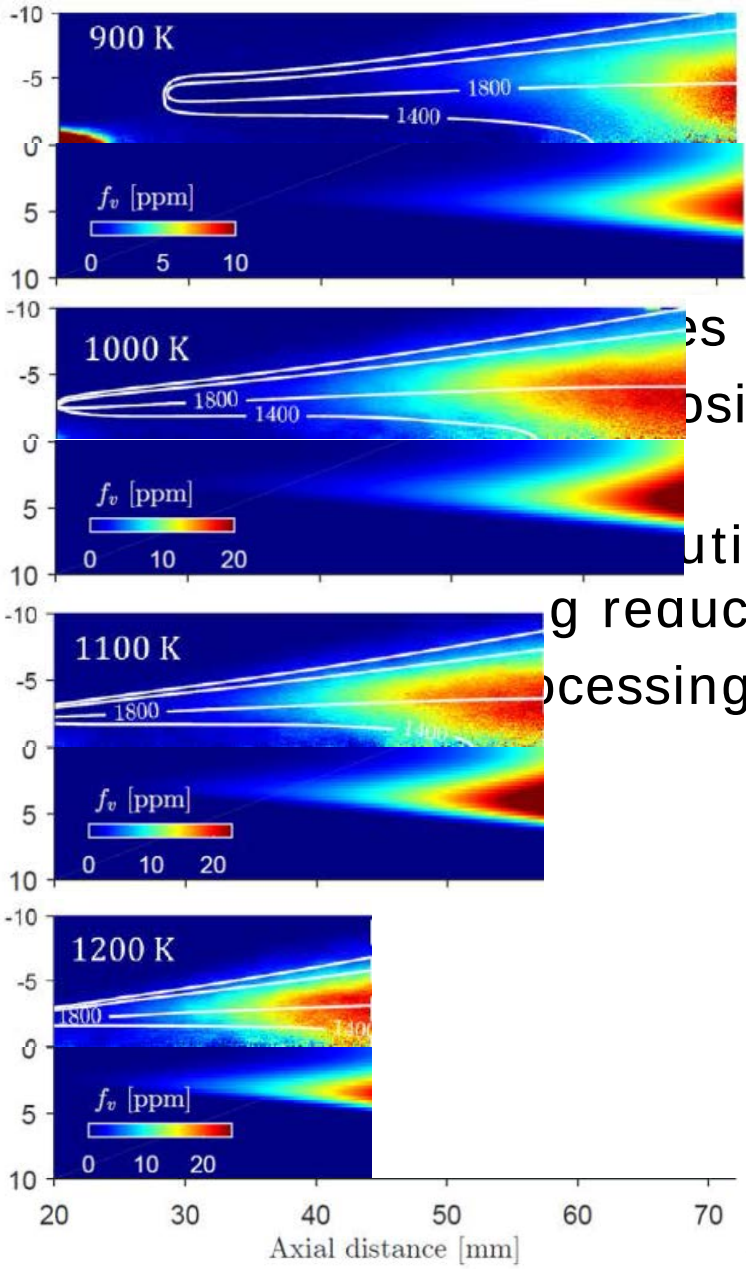

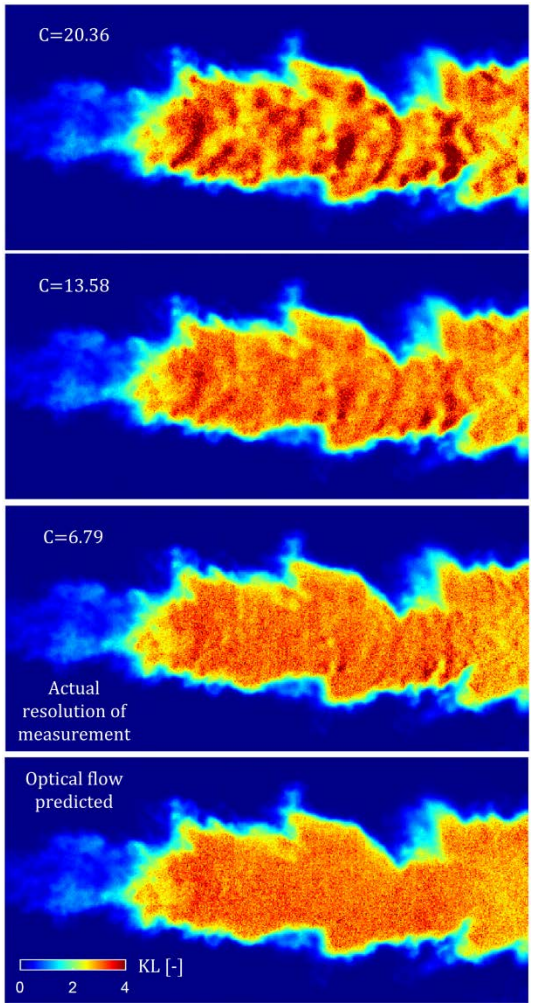

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Flame lift-off length measurement

- Lift-off length is the distance from injector to flame stabilization point
- Measured via OH* chemiluminescence at 309 nm