

# ECN4 workshop

## Flame Structure

Kyoto 2015

Bart Somers

Eindhoven University  
of Technology



# Content

## A. Thermodynamics

### 1. Flame Structure

- a) OH\*
- b) OH
- c) Formaldehyde
- d) Formaldehyde/OH combined

### 2. Conclusions

# Content

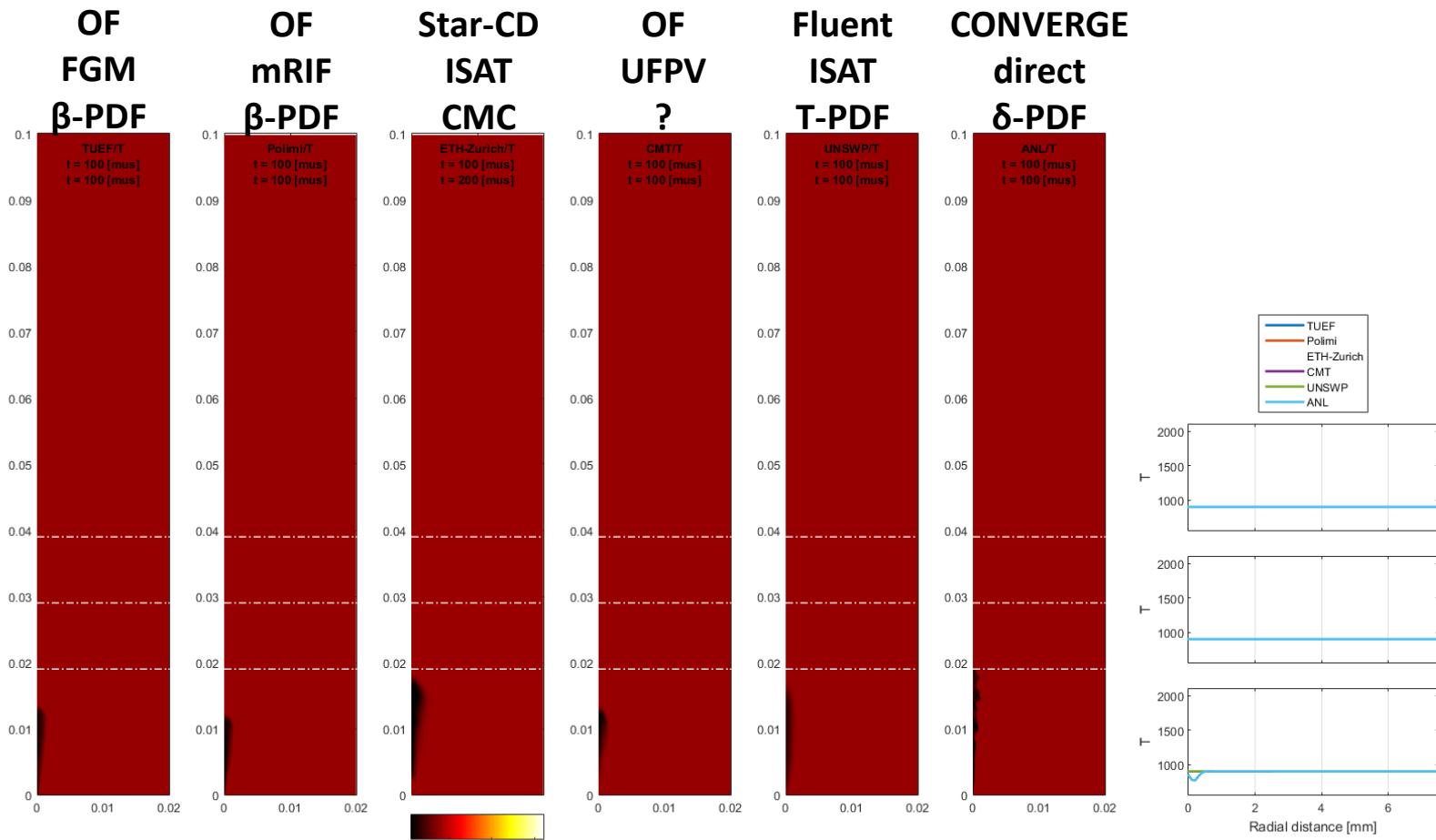
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# A. Thermodynamics



Luo\*

Pei

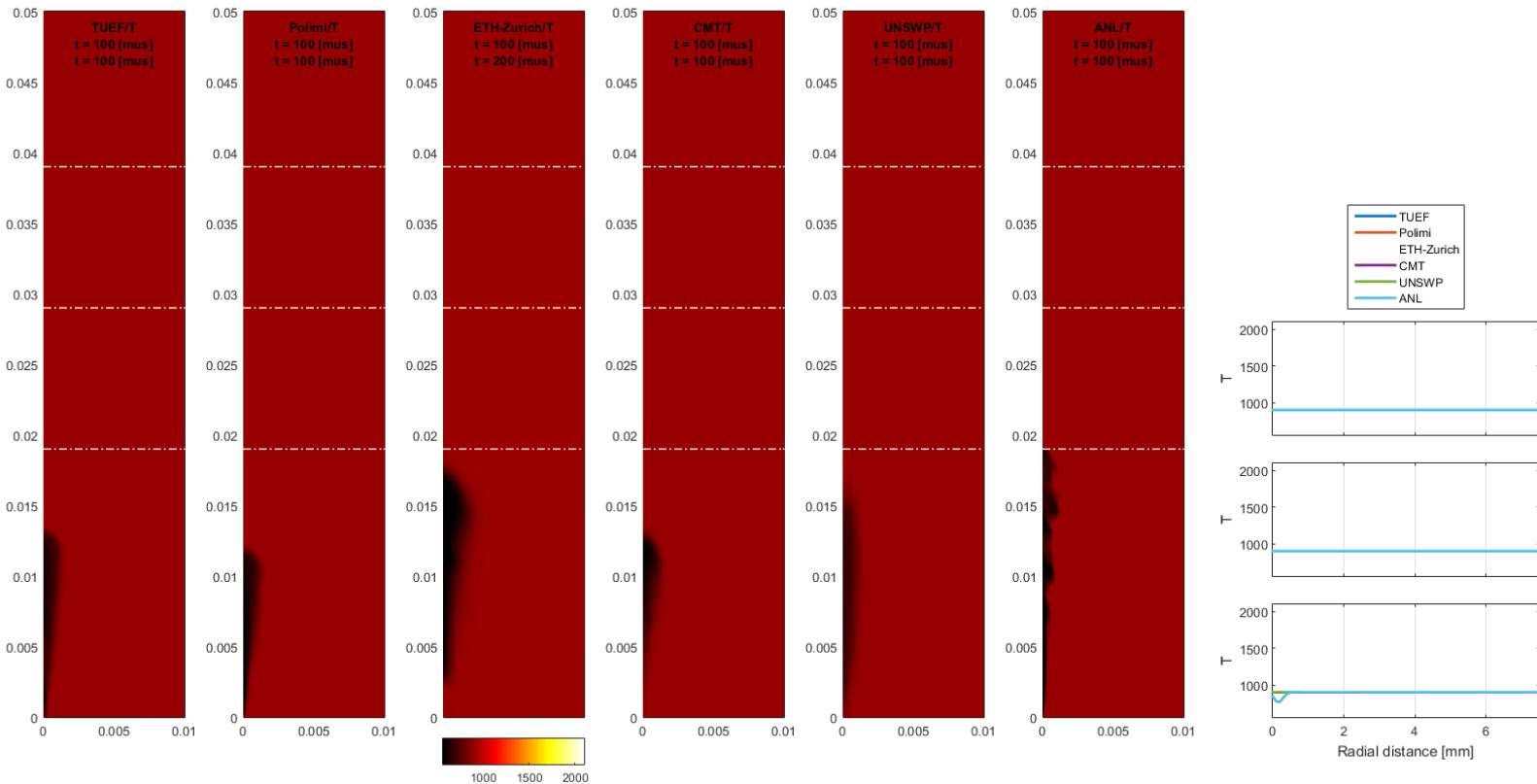
Luo

Luo

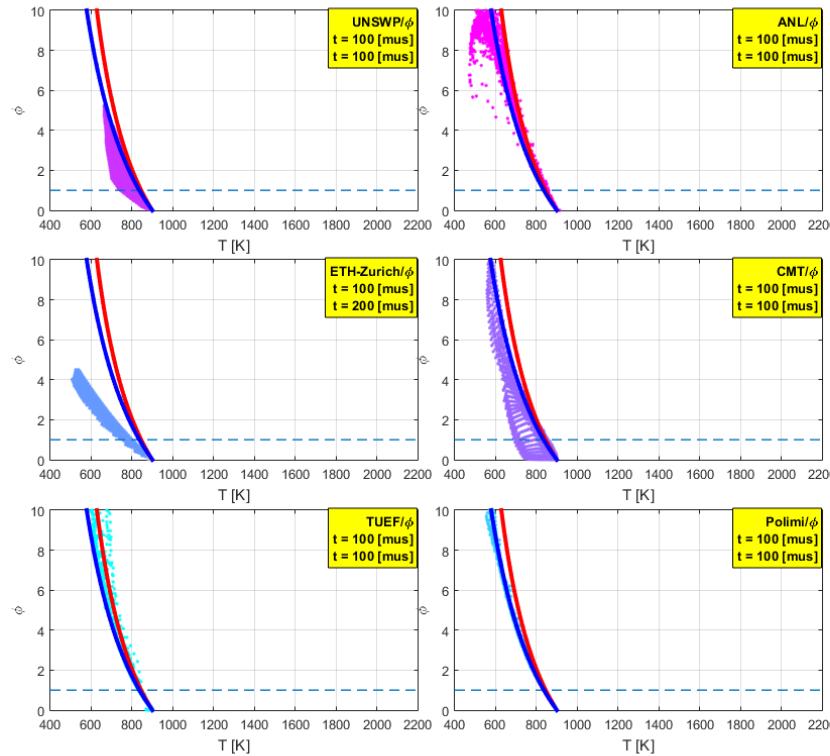
T.Lu 53

Som 2011

# A. Thermodynamics



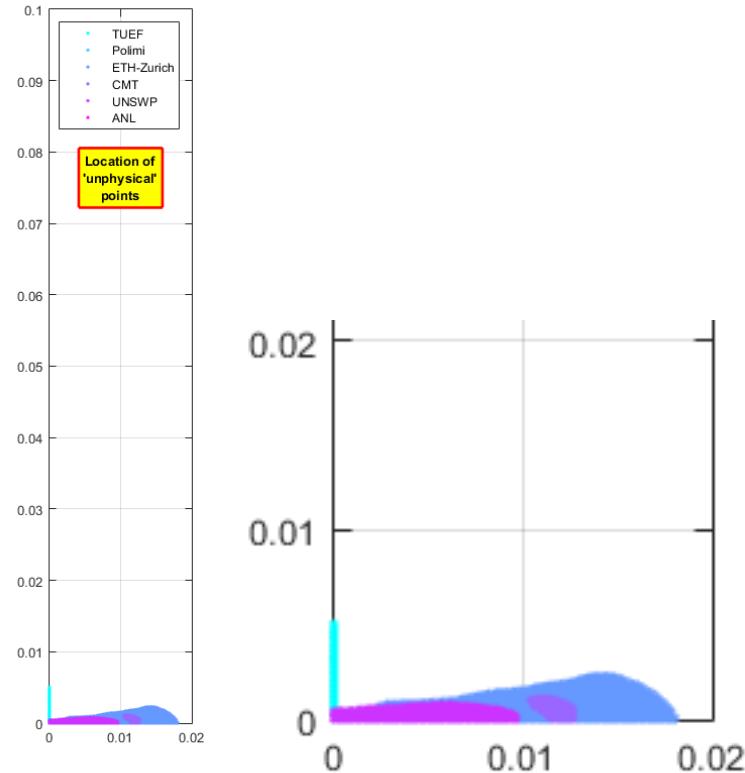
# A. Thermodynamics (phi-T plots)



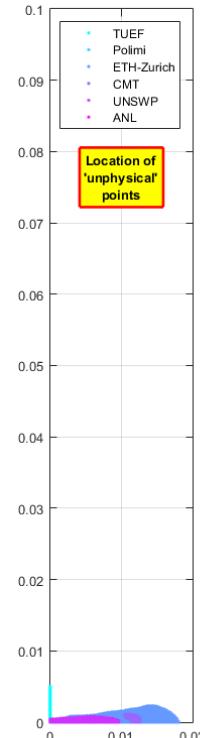
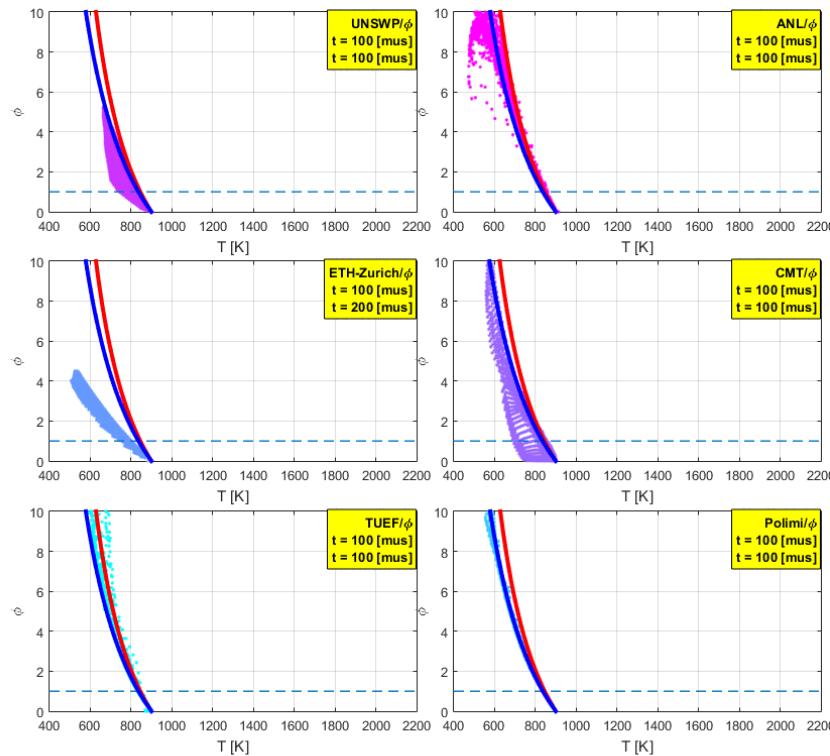
Adiabatic mixing line

— without heat of evap

— with heat of evap



# A. Thermodynamics (phi-T plots)



Adiabatic mixing line

- without heat of evap
- with heat of evap

Reasons

- Interpolation on the rep mesh
- Local violation of CFL criterion

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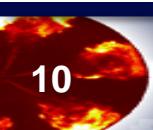
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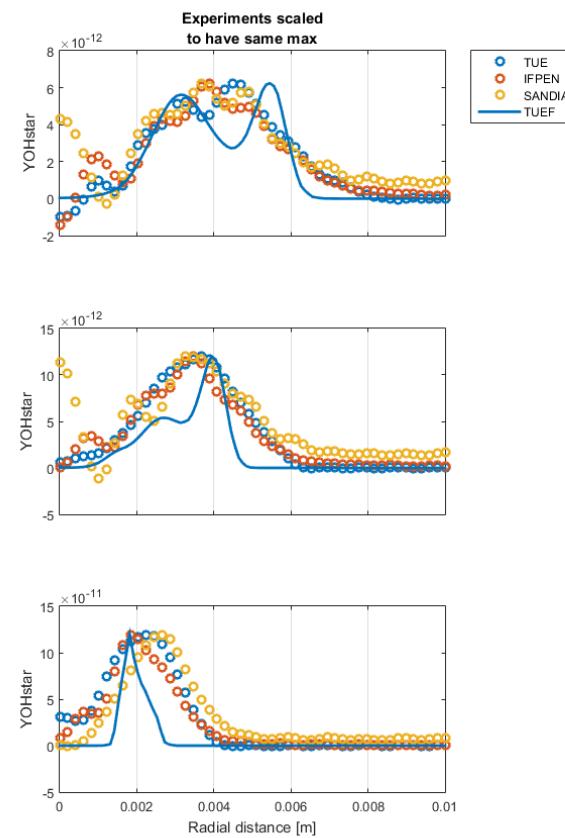
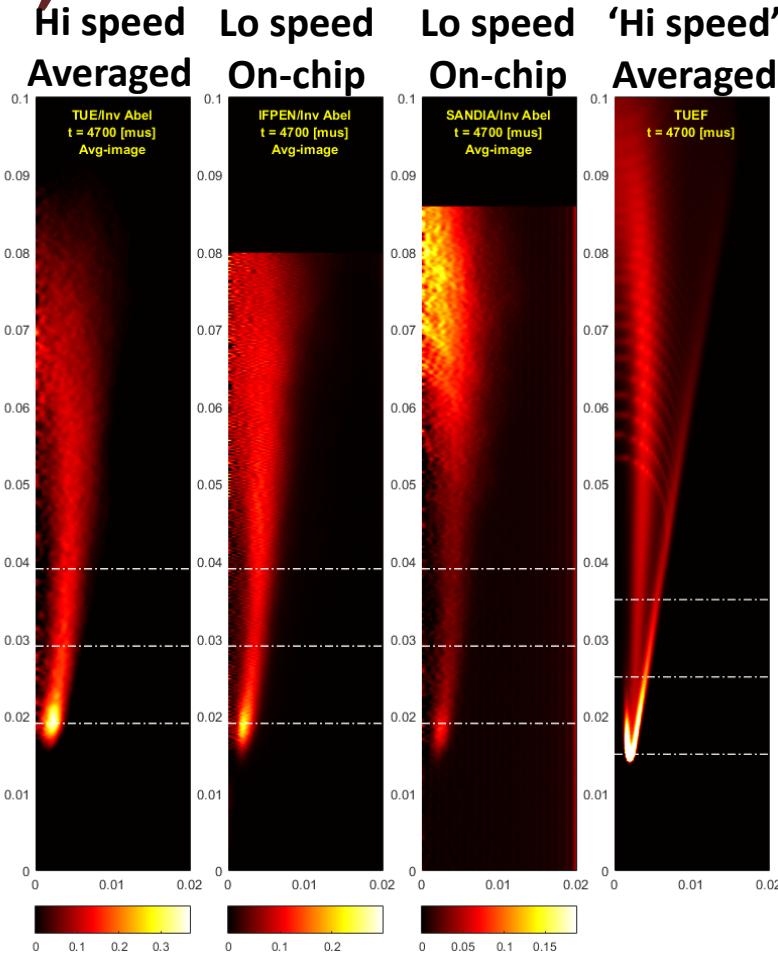
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a) OH\*



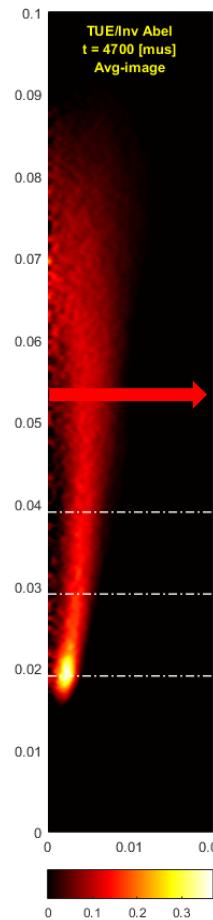
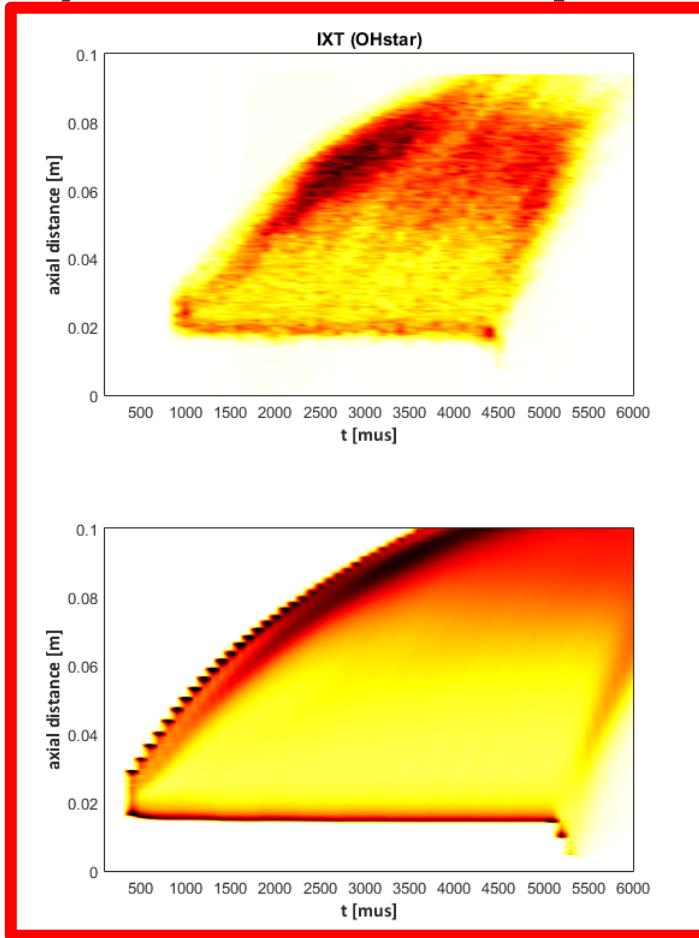
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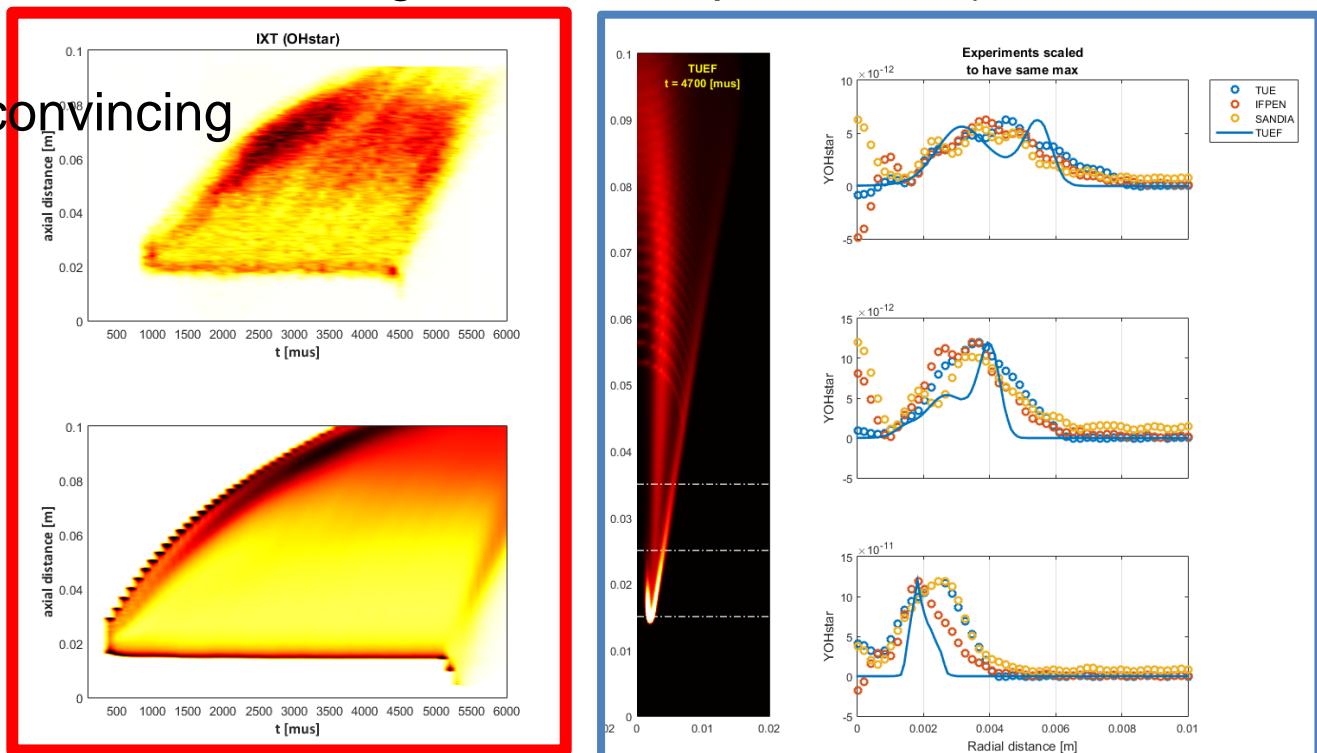
# 1. Flame structure

## a) OH\* time dependent



# Observations

- Results compare surprisingly well (shape and position)
  - Exp amongst each other
  - Num to exp
- ‘Double Structure’ not recognizable in experiments (comb model?)
- IXT plots convincing



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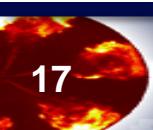
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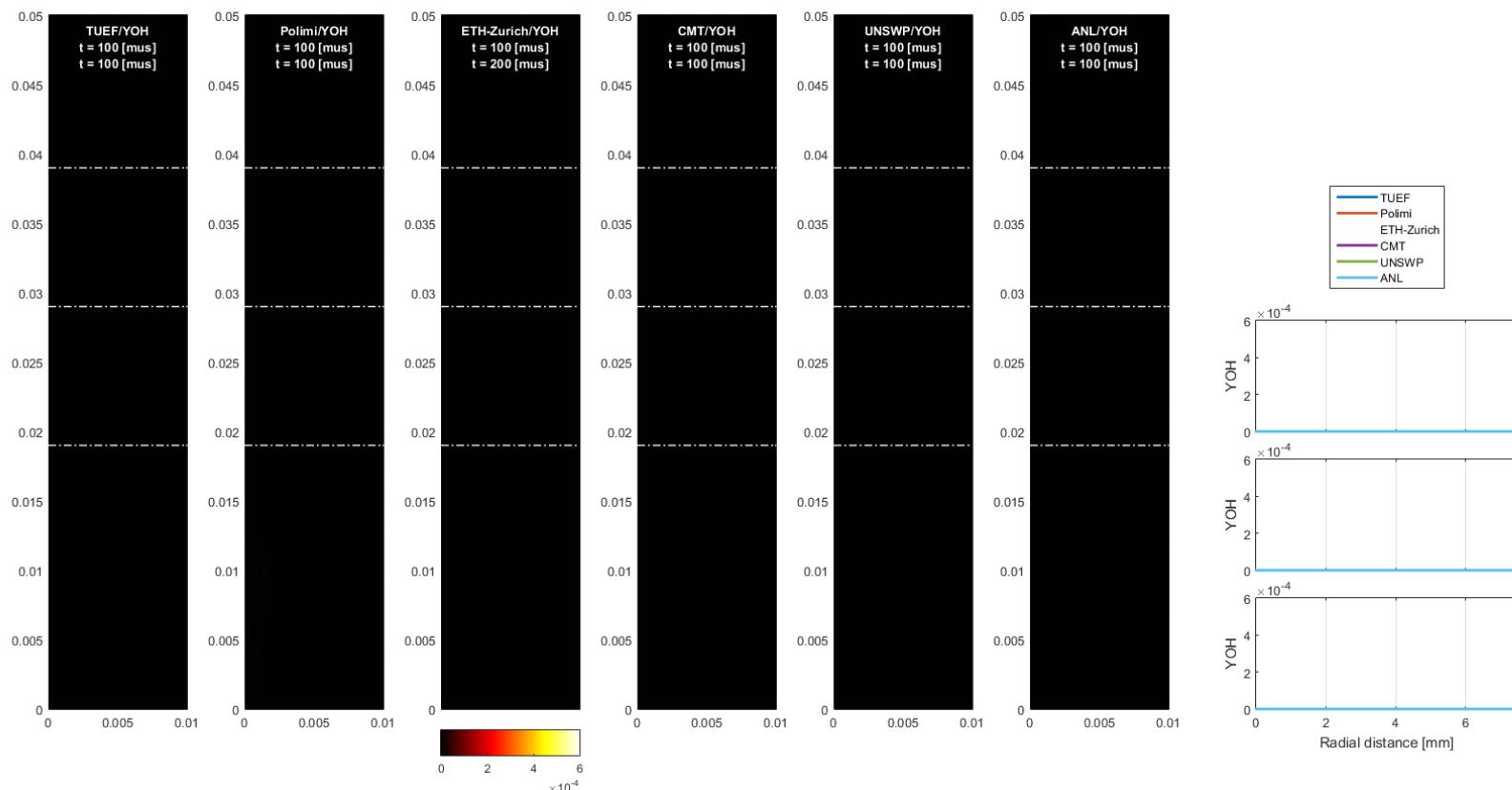
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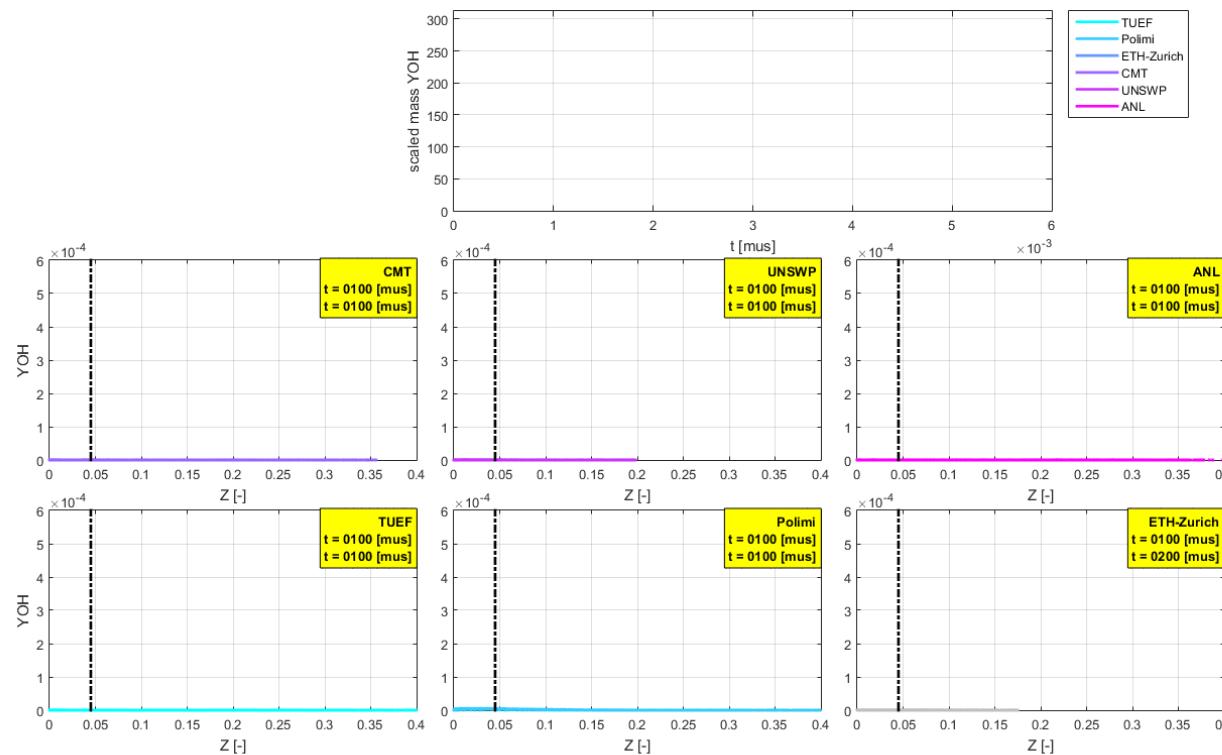
# 1. Flame structure

## b) OH impressum



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## b) OH impressum

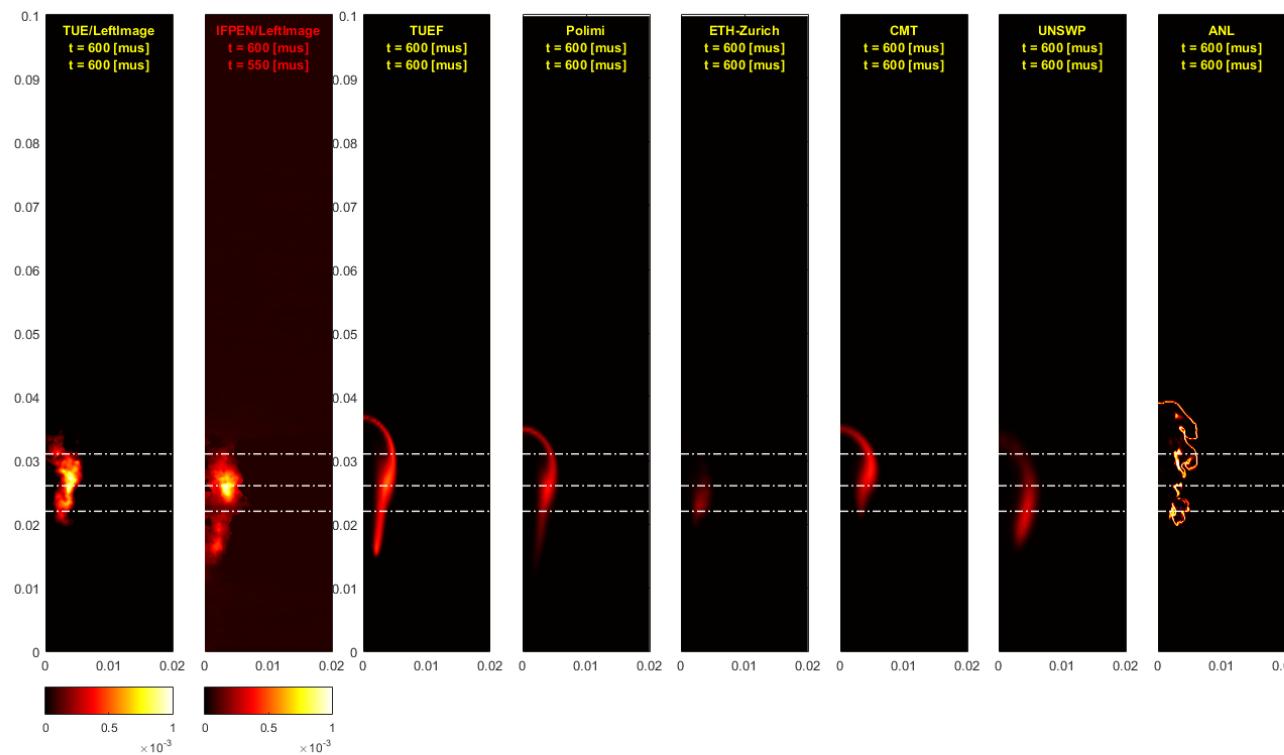


## Observation

- Physical space clearer differences
- Mixture fraction space closer resemblance
  - ETH seems to be wider
  - TUEF/CMT similar peaks concentrations

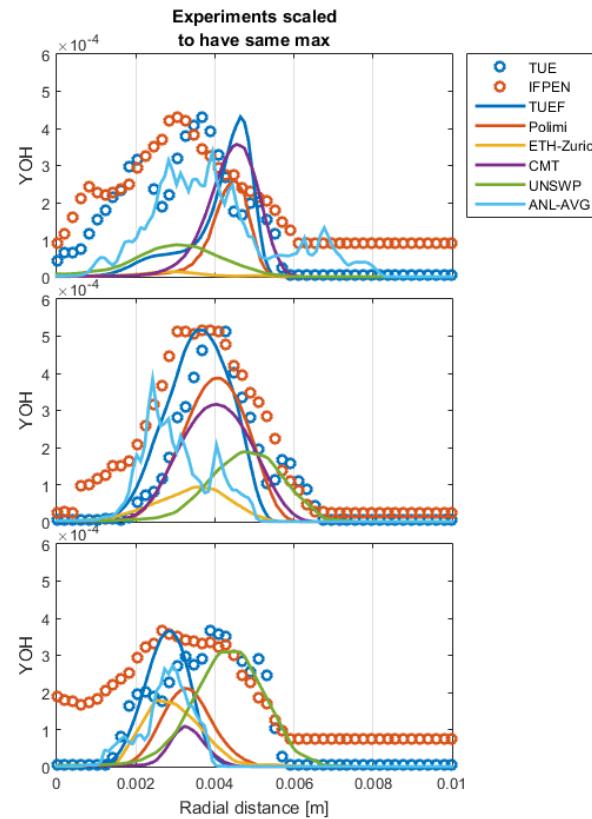
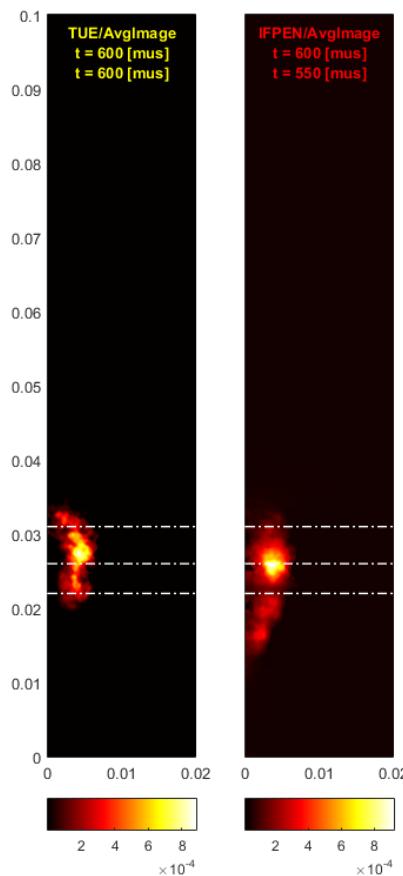
# 1. Flame structure

## b) OH (~600 mus)



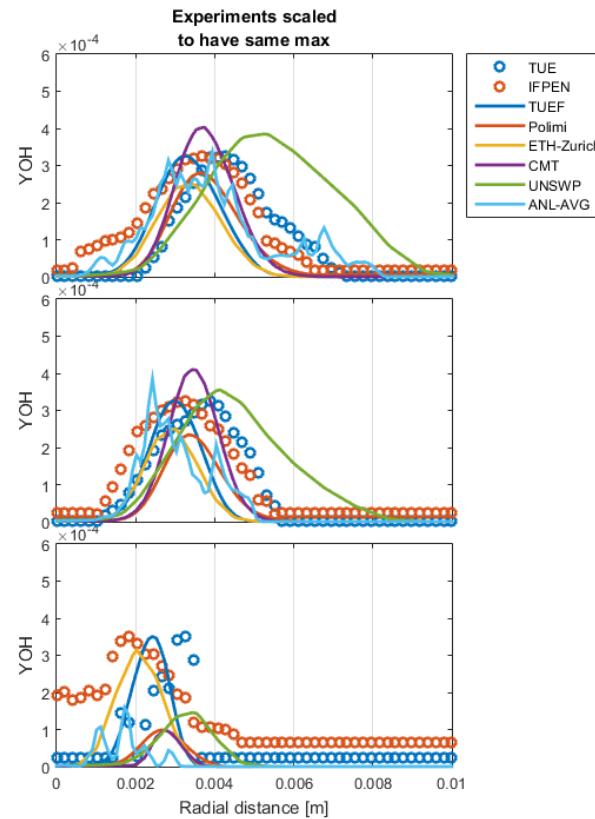
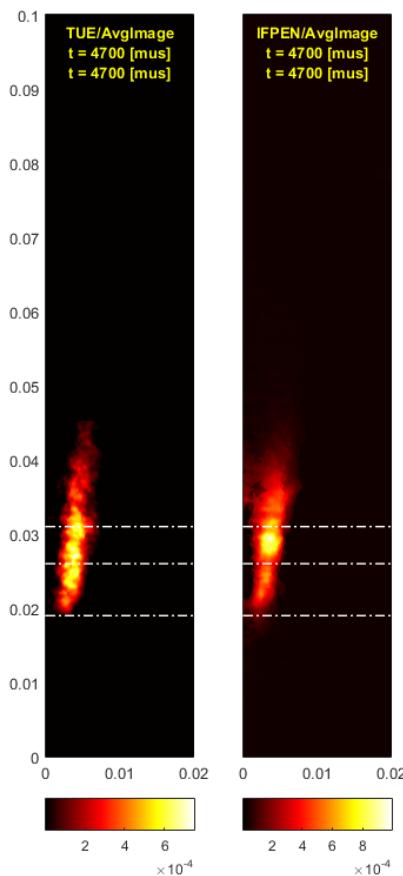
# 1. Flame structure

## b) OH (~600 mus)



# 1. Flame structure

## b) OH ( $\sim 4700$ mus)



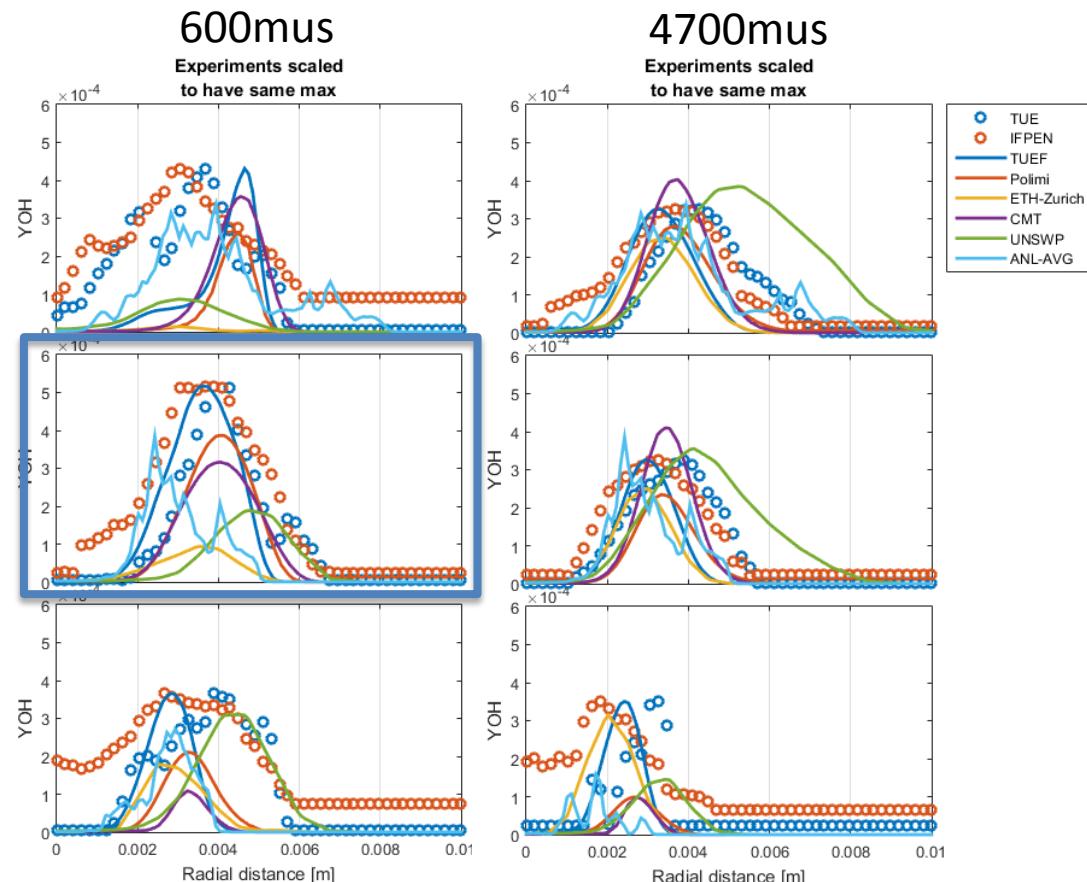
# Observations

600 mus

- Early stage ‘tough cookie’ to compare, phasing makes it difficult. In the ‘established region’ exp compare quite good.

4700 mus is easier.

- Exp compare well, a consistent radial shift max.
- No winner model though UNSW seems to be too wide, TUE too near to axis.
- Experimental profiles wider



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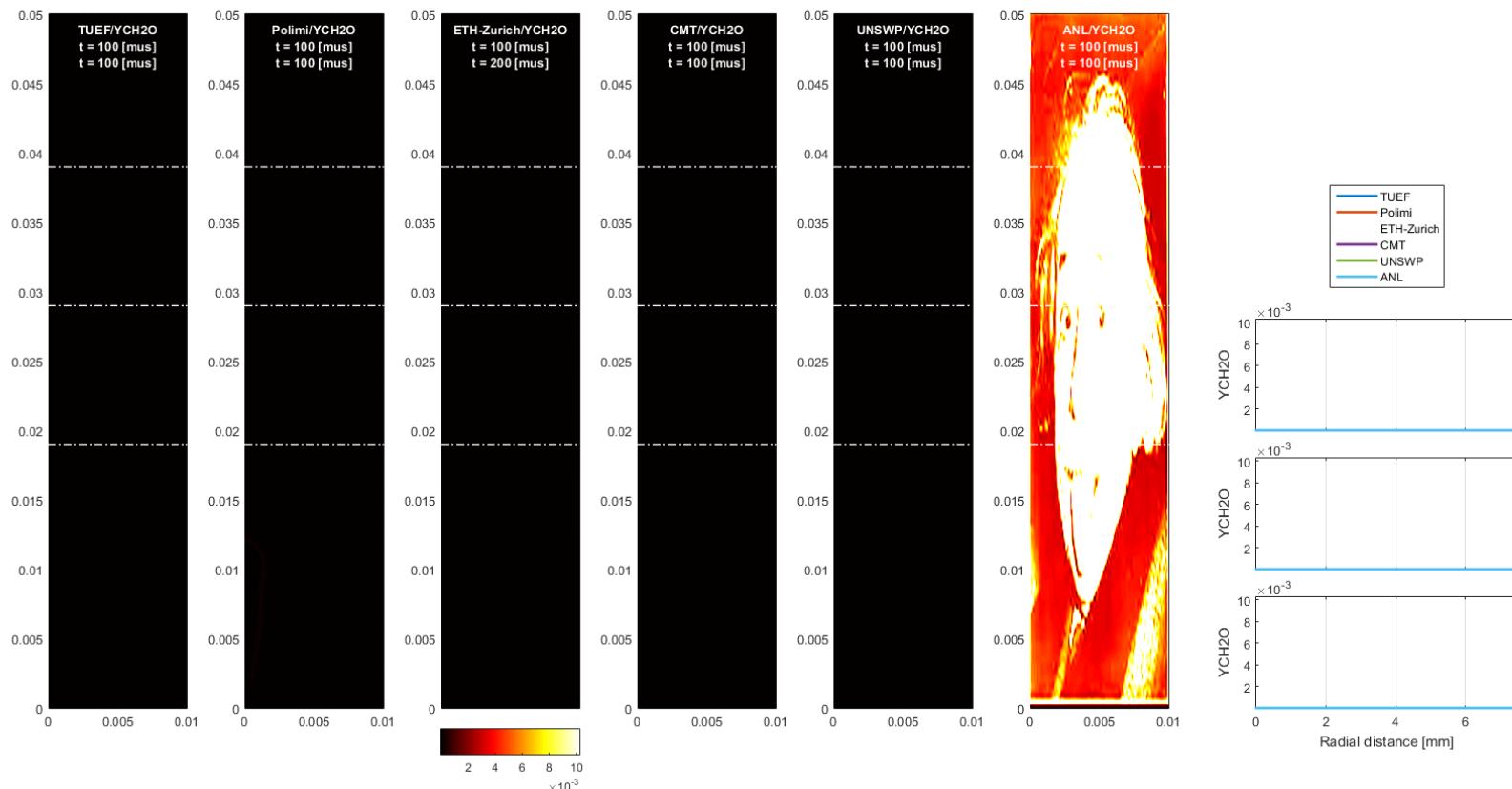
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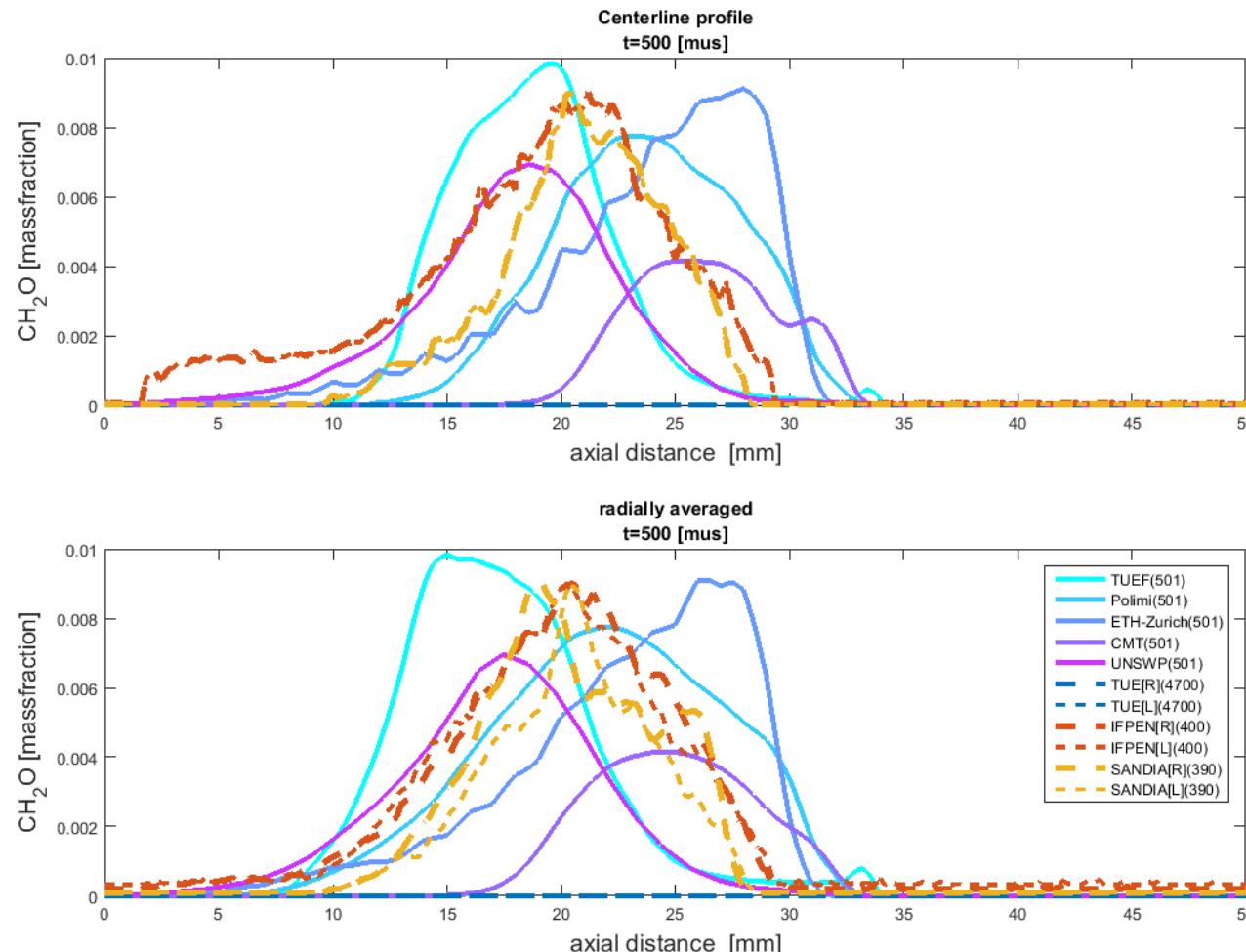
# 1. Flame structure

## c) Formaldehyde Impressum



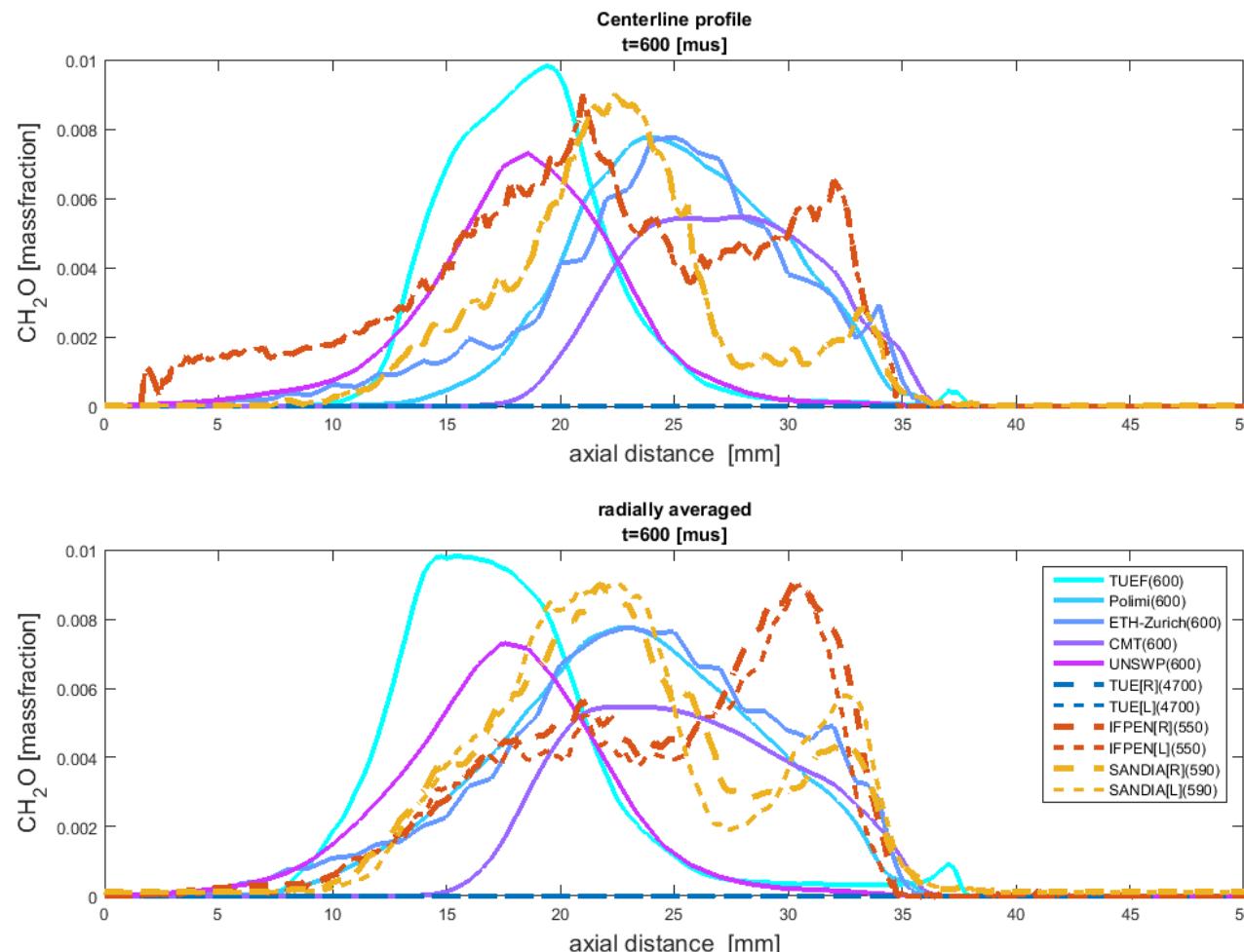
# 1. Flame structure

## c) Formaldehyde Axial profiles (400 mus)



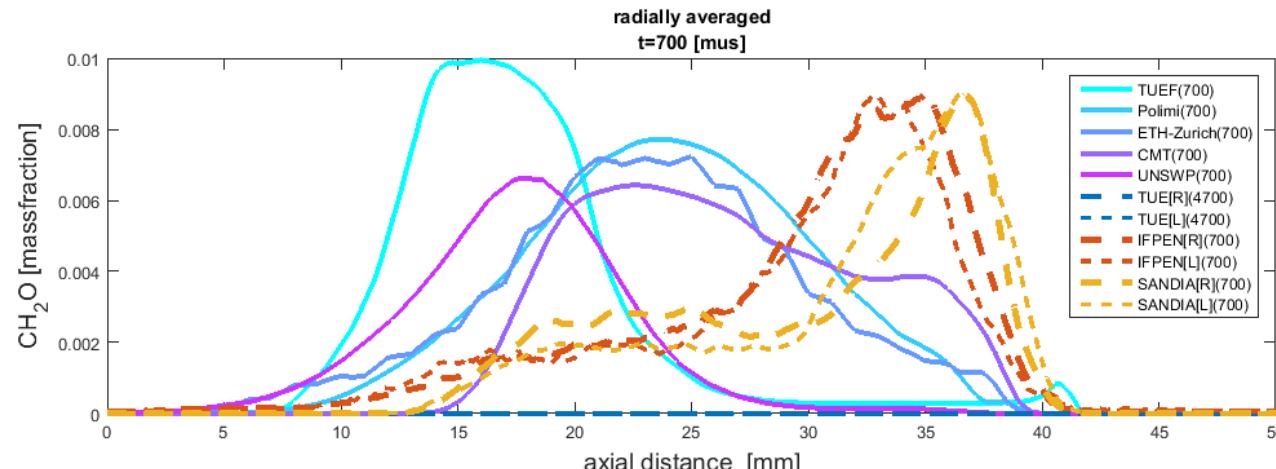
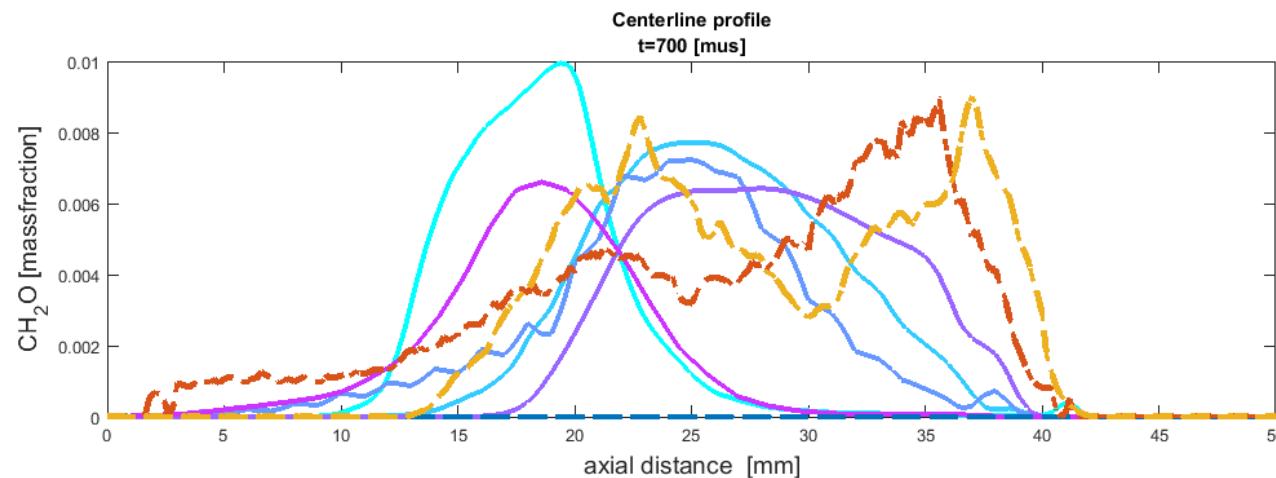
# 1. Flame structure

## c) Formaldehyde Axial profiles (550 mus)



# 1. Flame structure

## c) Formaldehyde Axial profiles (700 mus)



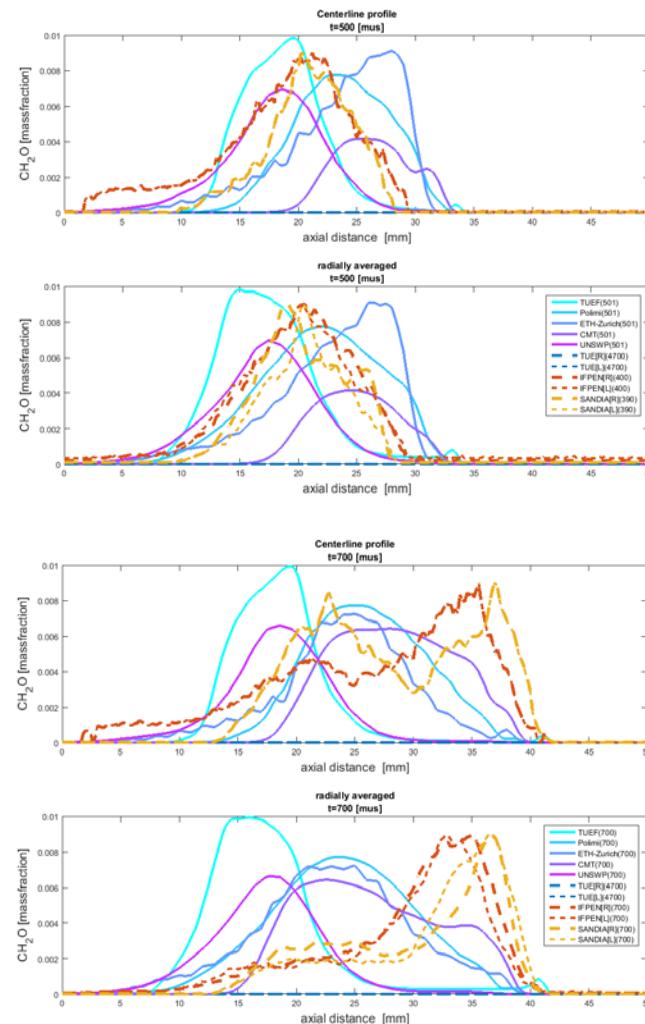
# Observations

400-600 mus

- Some to far upstream (TUE/UNSW)
- Some to far downstream
  - ‘differences in ign delay’
  - But CH<sub>2</sub>O quickly stabilizes
- Exp compare well amongst each other

>700 mus Aromatics/Soot starts to cloud the picture.

- Exp have different relative magnitudes (CH<sub>2</sub>O/A1-A4 intensity)



## 2. Conclusions

- OH\*
  - remarkable, worth investigating more
  - more contributions needed (1 now)
- OH
  - Nice consistent measurement profiles at the ‘established/steady’ regions (early but esp late stages).
  - Numerical models perform equally good or bad?
  - Differences in magnitude cannot be judged at this point.
- Formaldehyde
  - Exp show nice consistent profiles at the early stages
  - Numerical models perform equally well?

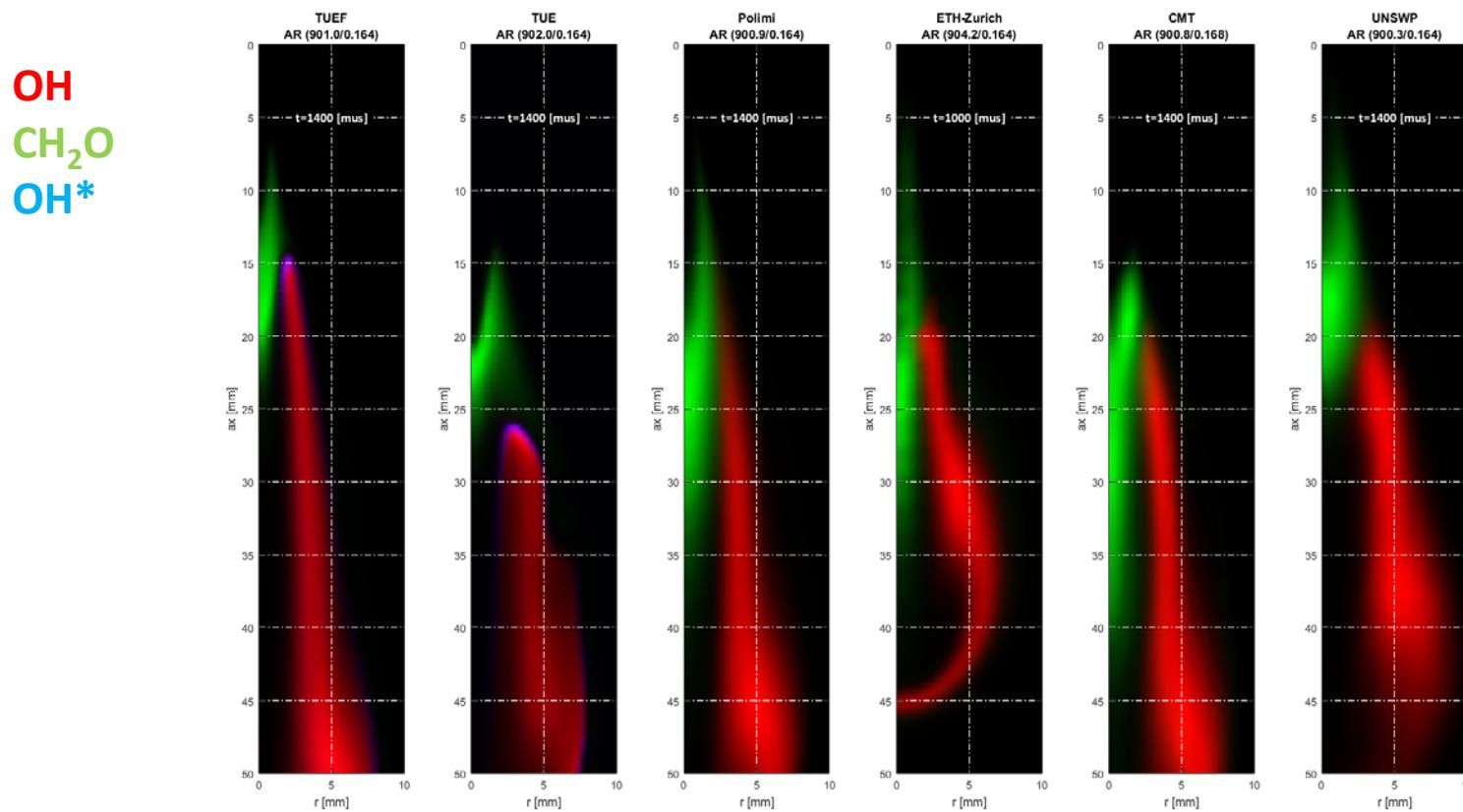


## 2. Conclusions/discussion/wishlist

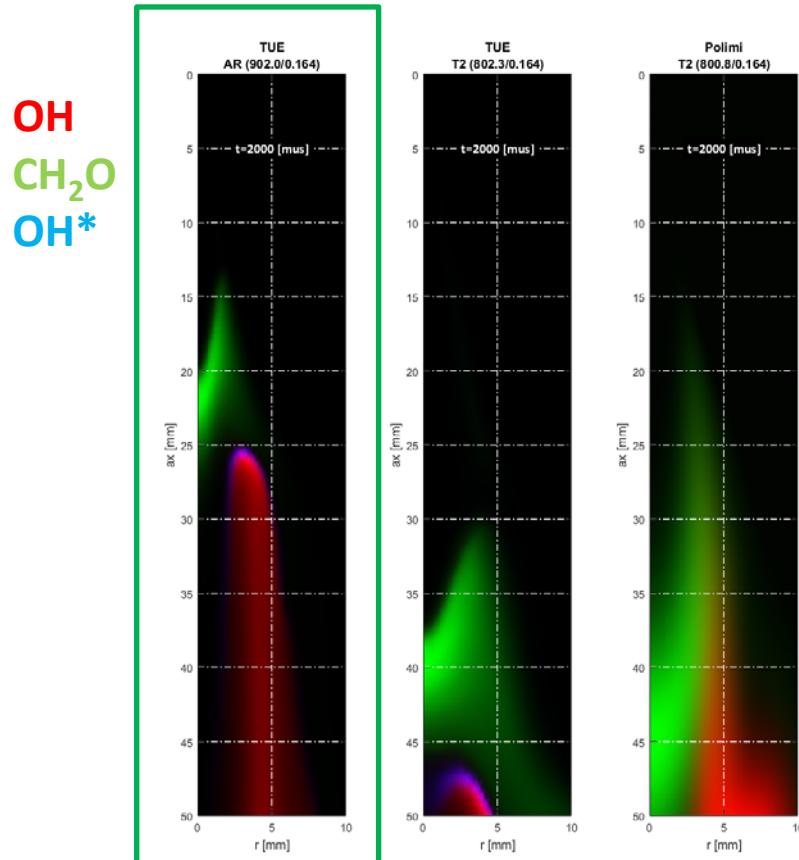
- We should try to determine what is due to mech and what is due to TCI what is due to code
  - Same mech for all
  - More TCI approaches in one code in exactly same setup (OF > FGM/mRIF/CMC)
- Quantitative measurements
- Reconstruct experimental images with ray-tracing
  - Virtual Schlieren/chemiluminescence
  - Virtual LIF
- Cost of simulations (larger mechanisms)
  - Hybrid approaches (UFPV/FGM in a mRIF/CMC/T-PDF model)
- Other important emissions
  - NOx?
  - CO/UHC
- Focus exp on ignition phase
  - Single shot combined CH<sub>2</sub>O and OH
- Burn-out phase could give some interesting insights.



# Combined single shot OH/CH<sub>2</sub>O (AR)

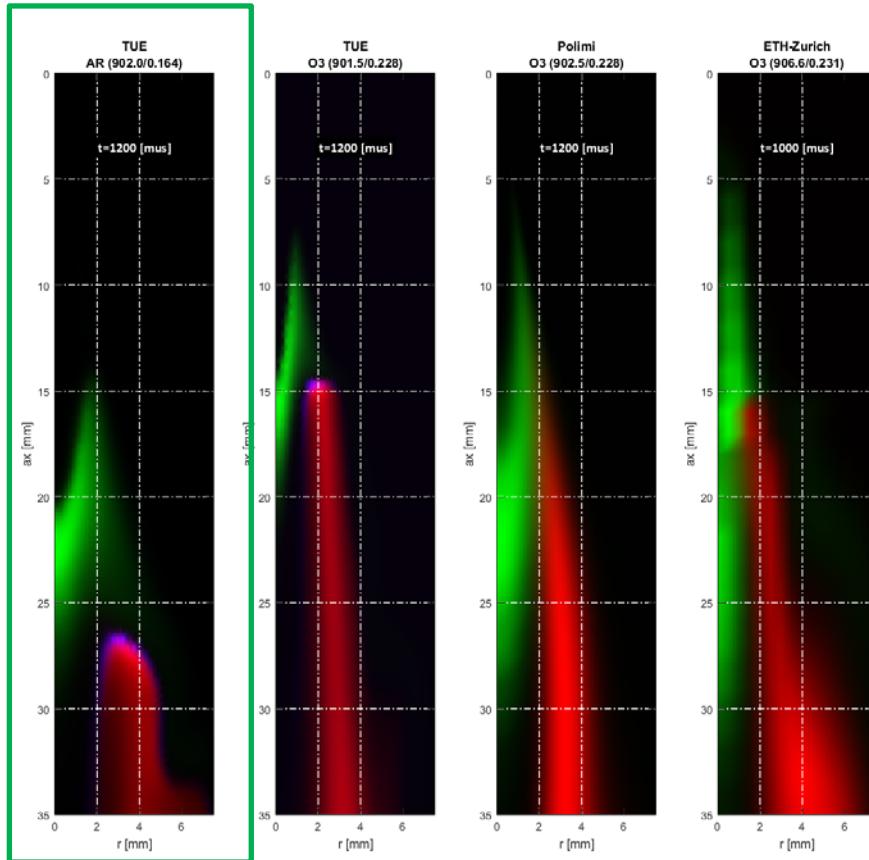


# Combined single shot OH/CH<sub>2</sub>O (T2)



# Combined single shot OH/CH<sub>2</sub>O (O<sub>3</sub>)

OH  
CH<sub>2</sub>O  
OH\*



# Backup slides.



# IGNITION

## c) ROO/CH<sub>2</sub>O/H<sub>2</sub>O<sub>2</sub>

