ECN 5 topic 4/5
Ignition and flame structure - model results & analysis (in spray A)

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Questions and discussion

Talk outline

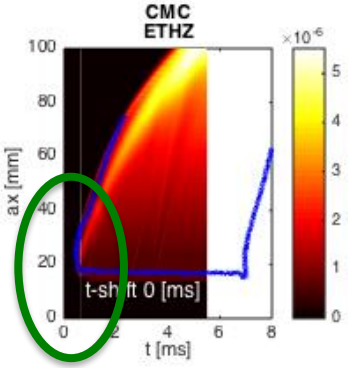
- *Spatial comparison at early times*
- *Spatial comparison at late times*
- Conclusions & recommendations

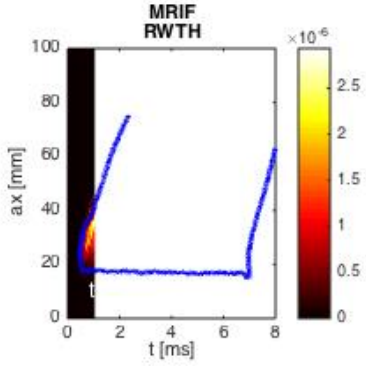
Spatial structure @ignition

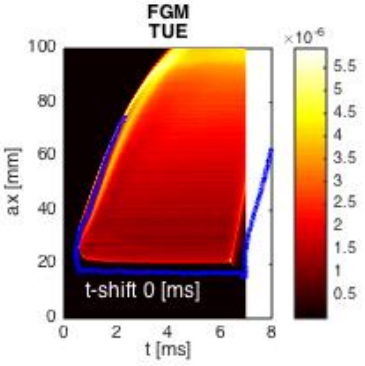
Base(900K, 15%)

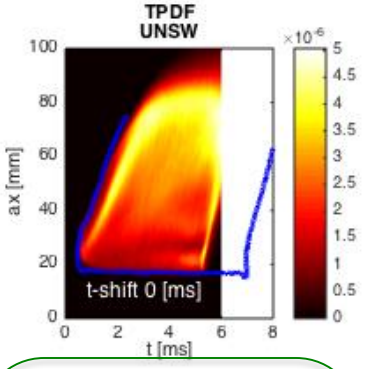
IXT plots (radially integrated OH as fie of time), blue line is 0.1 contour of experiments

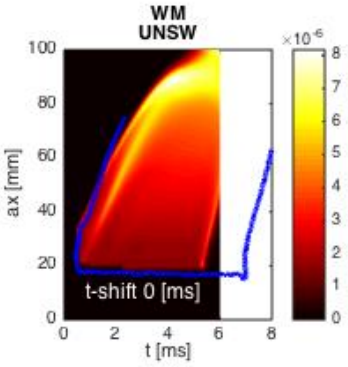
- 6 contributors
- **CAI** mechanism

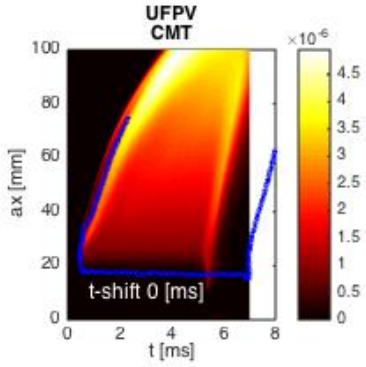


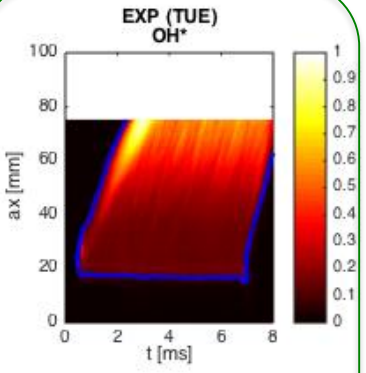












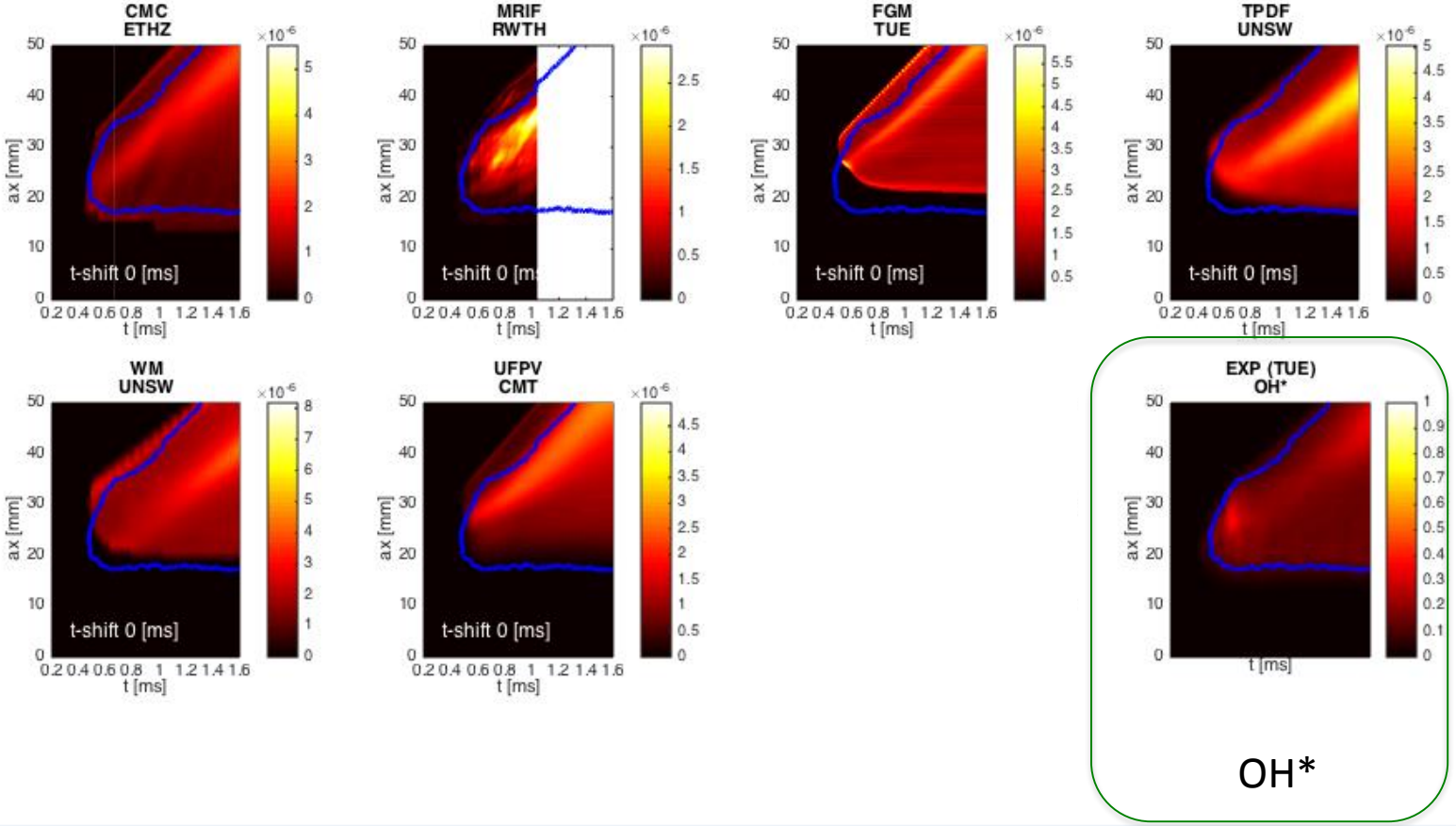
OH*

Spatial structure @ignition

Base(900K, 15%)

Around ignition

- 6 contributors
- **CAI** mechanism

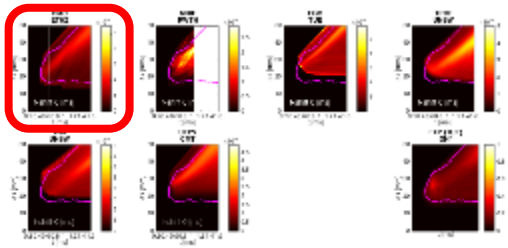


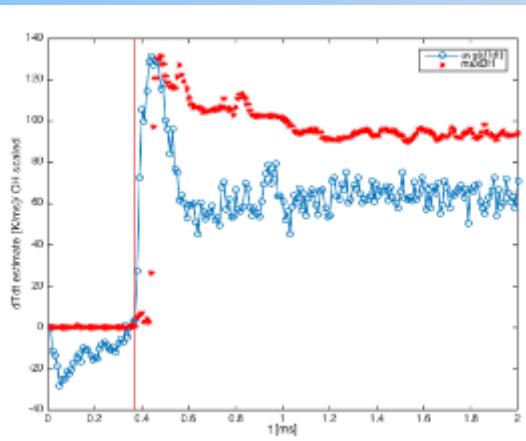
Spatial structure @

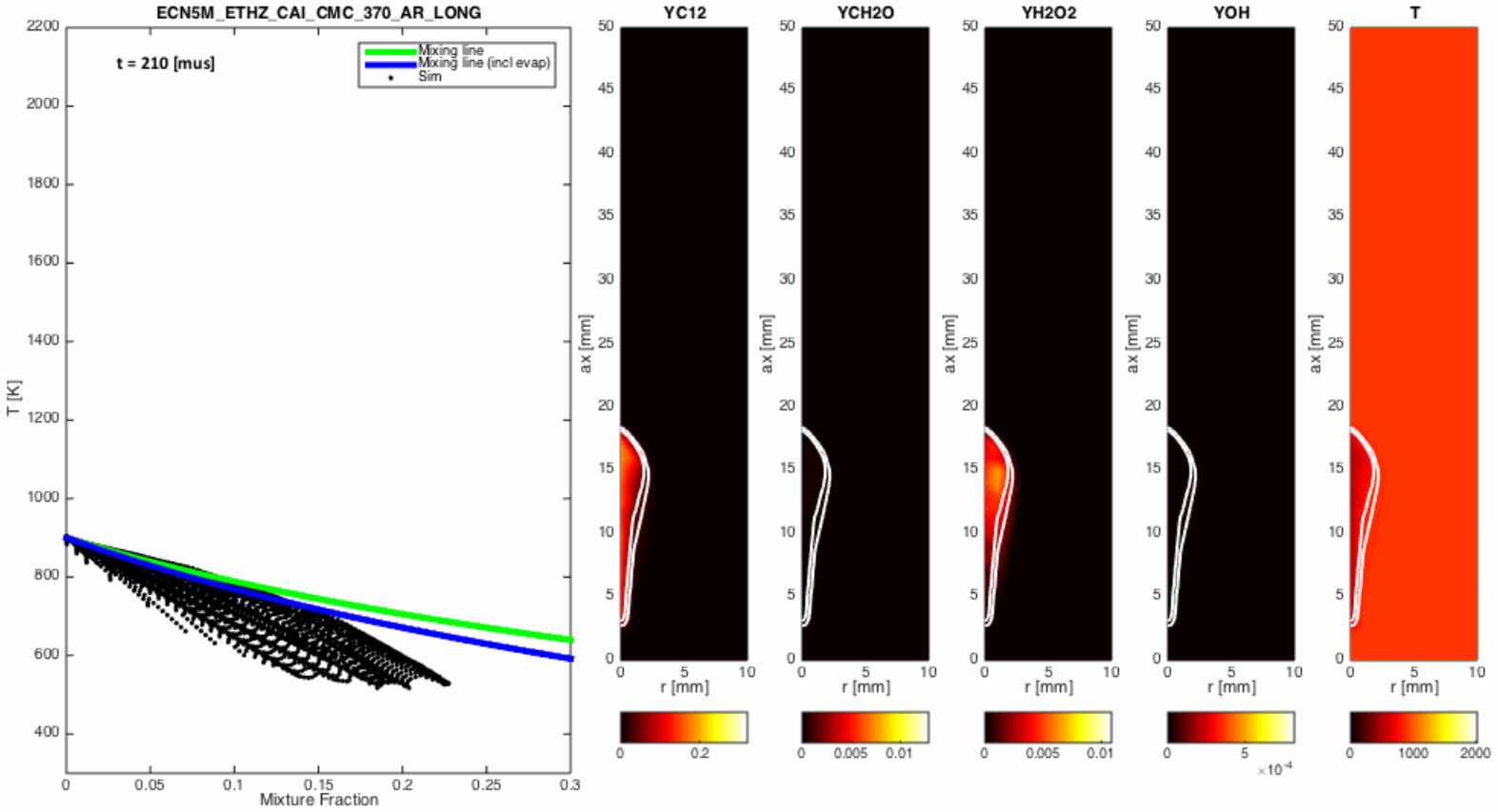
Base(900K, 15%)

Movies (because we ca

ETHZ, CMC, ?,RANS





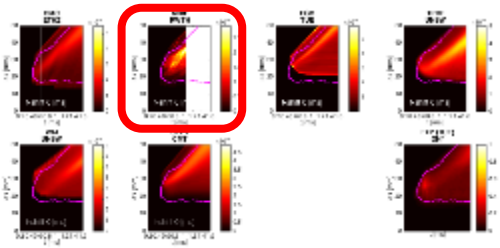


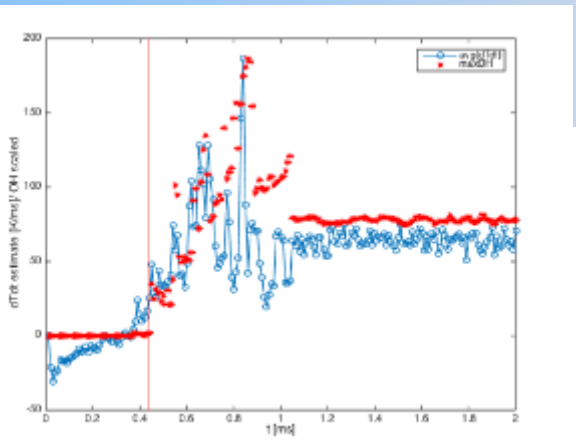
Spatial structure @

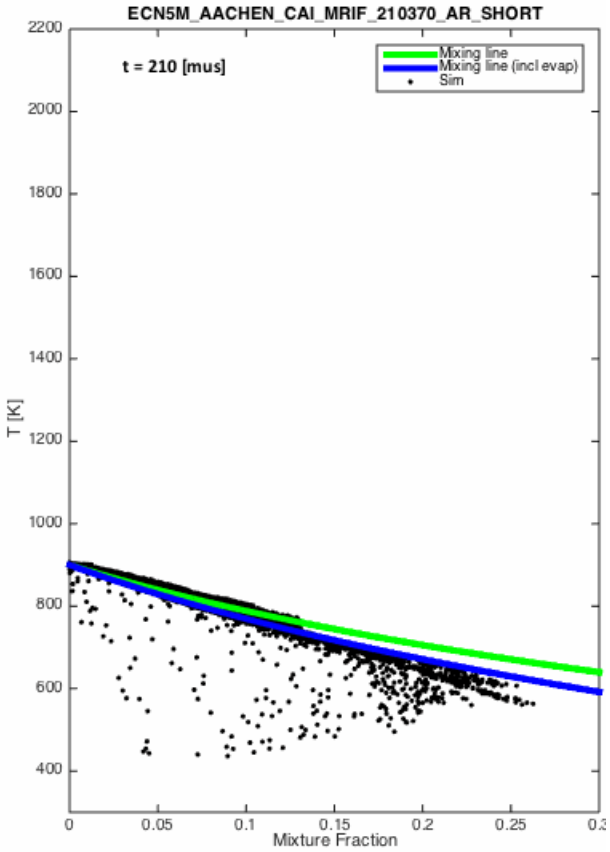
Base(900K, 15%)

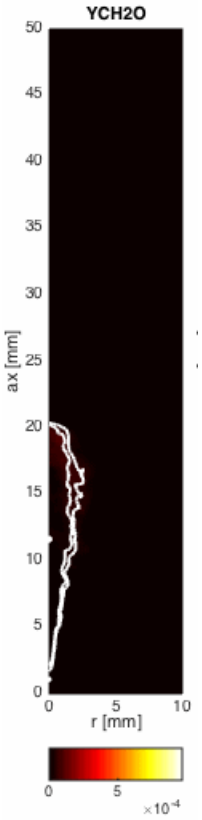
Movies (because we ca

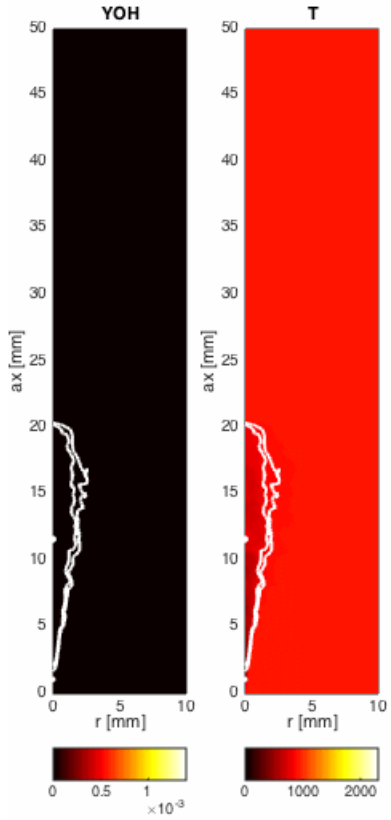
RWTH, MRIF,?, betaPDI









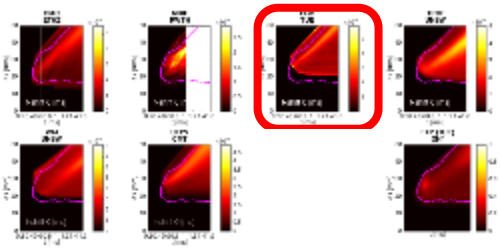


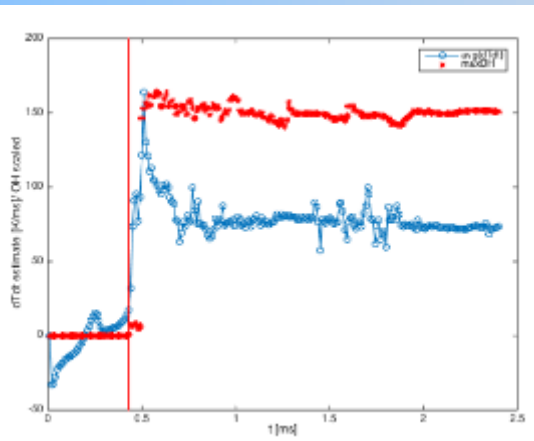
Spatial structure @

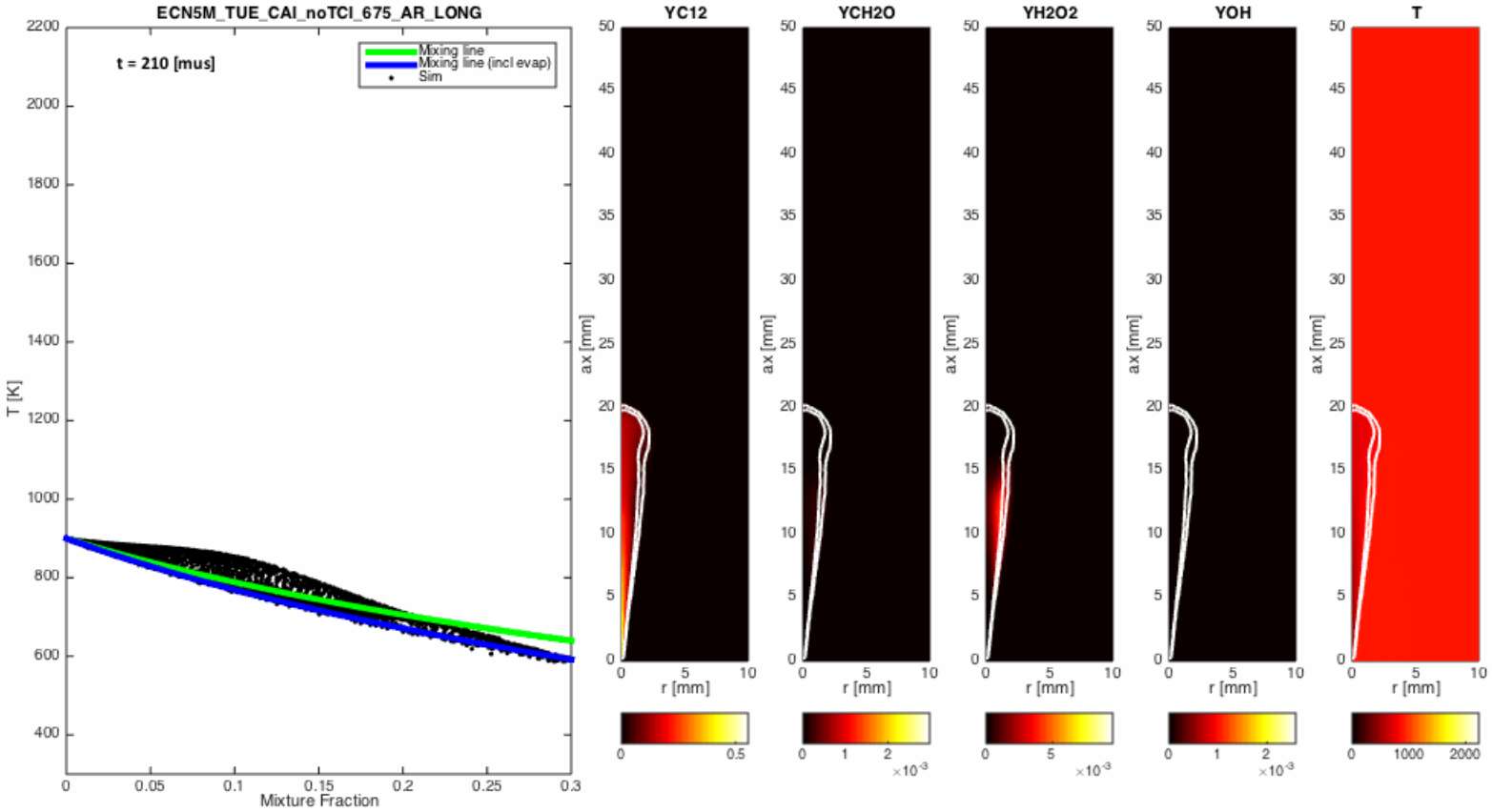
Base(900K, 15%)

Movies (because we ca

TUE, FGM, OpenFOAM







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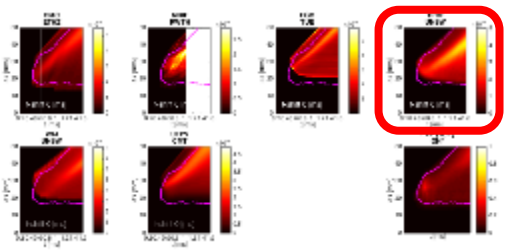
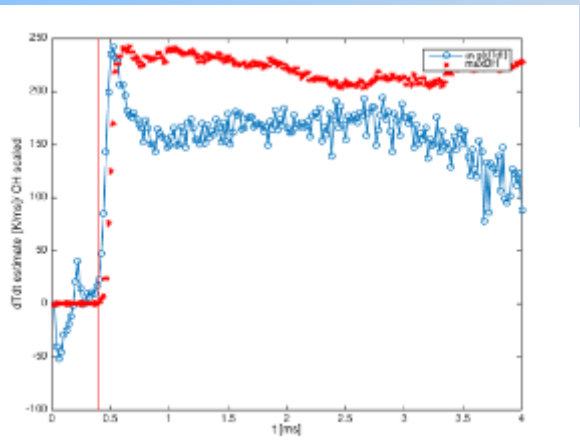
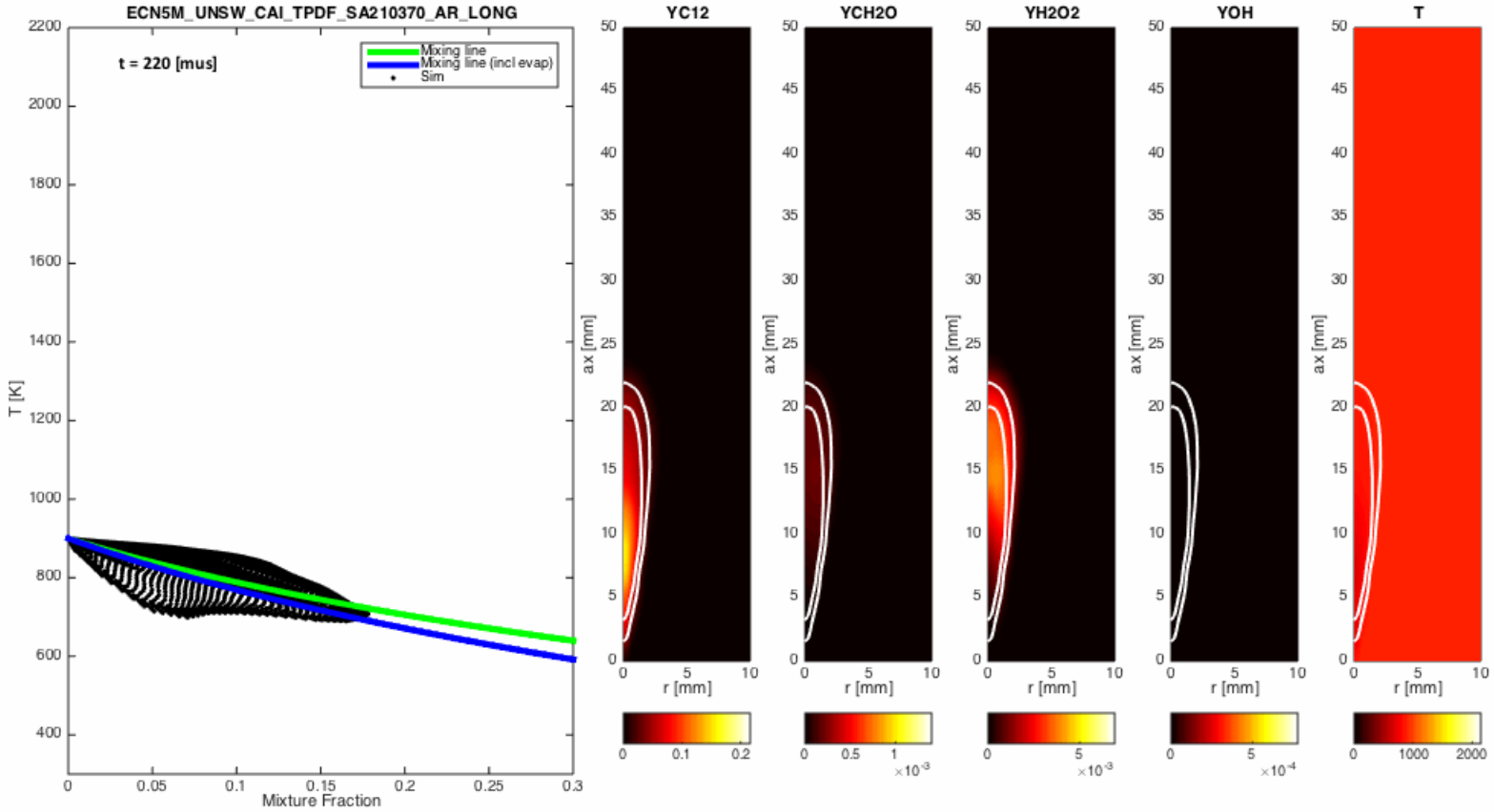
Movies (because we ca

UNSW, TPDF, ?, RANS







Spatial structure @

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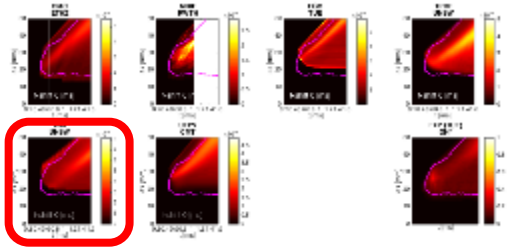
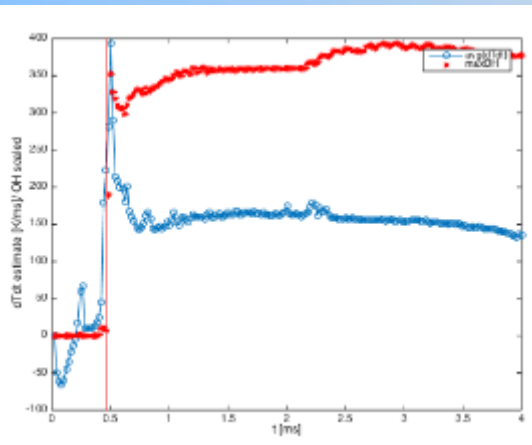
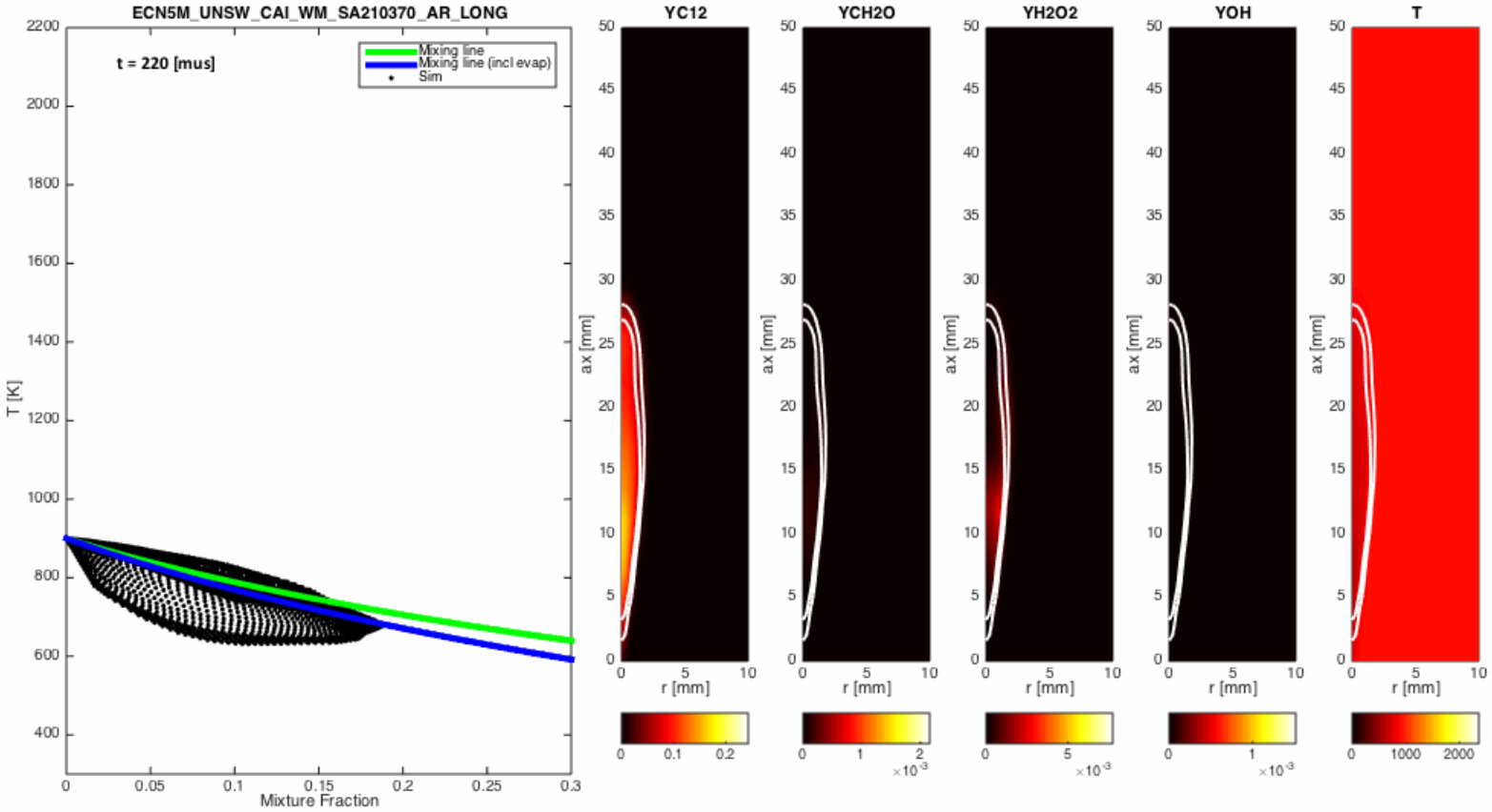
Movies (because we ca

UNSW, WM, ?, RANS







Spatial structure @

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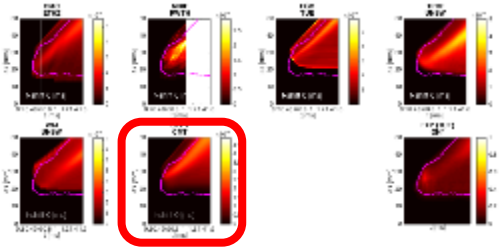
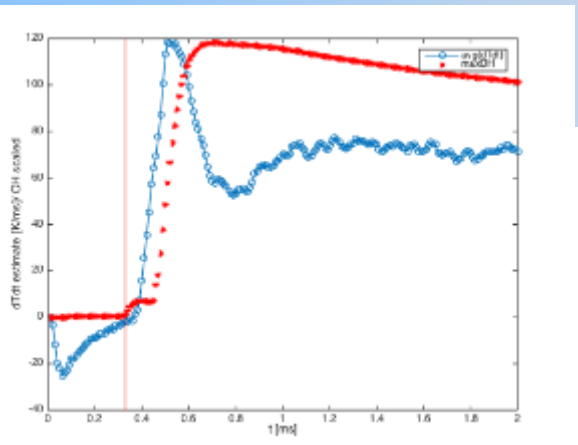
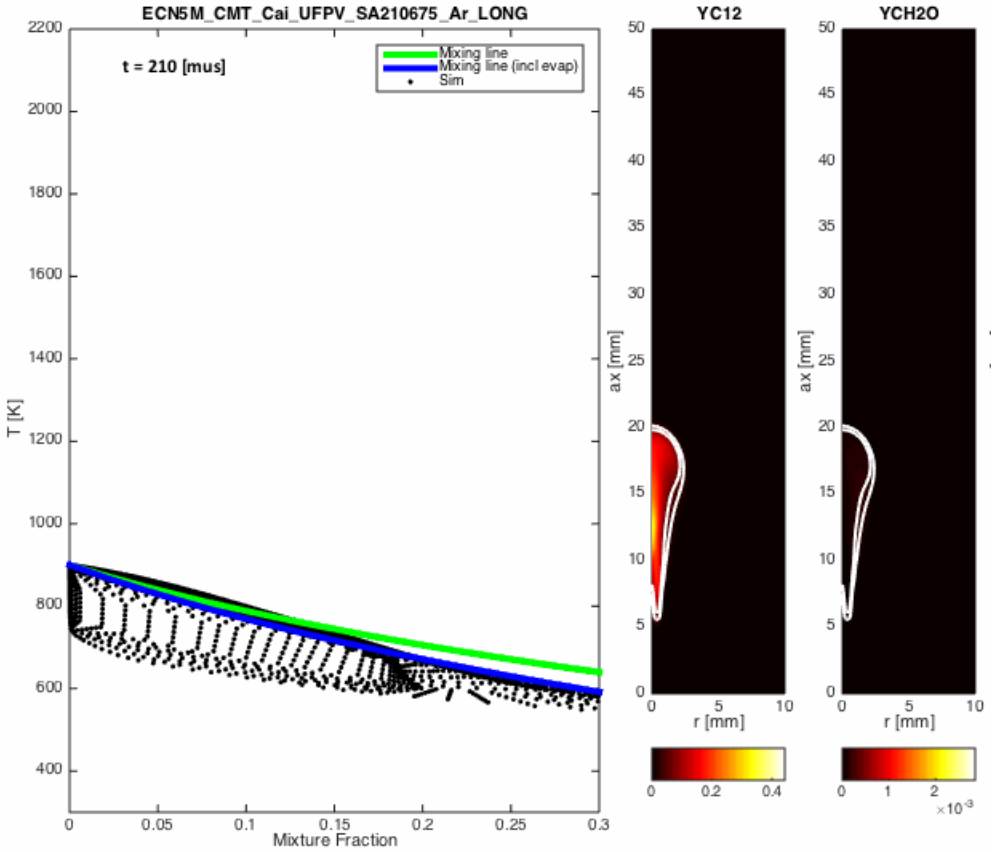
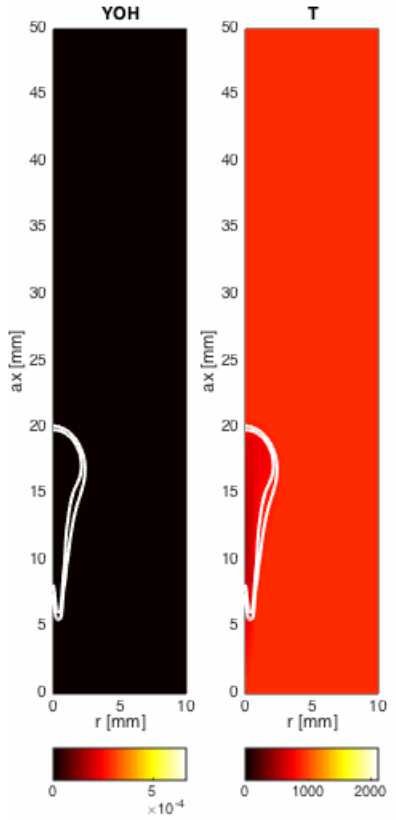
CMT, UFPV, OpenFOAM









Conclusions

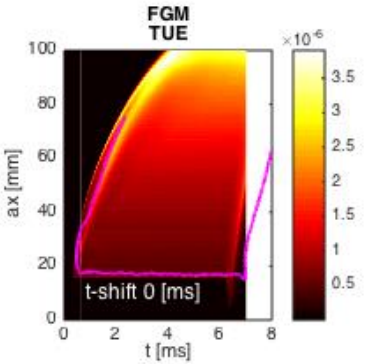
- Some ‘unphysical’ points still remain mostly this is time-step issue. Near nozzle.
- Ignition on the rich side. Although the actual value depends on combustion model (see dif TUE and Others)
- OHstar ignition correlates with second stage ignition (see scatter plots).
- Second stage ignition mostly confined by $Z < 0.1$. (Only ETHZ not)
- Well mixed models reach higher T (200 K). Which is logical. Can have its effect on emission models

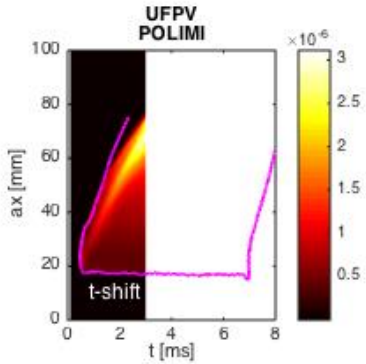
Spatial structure @ignition

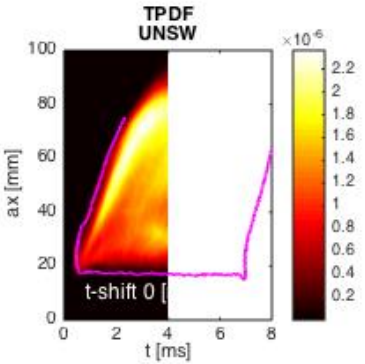
Base(**900K**, 15%)

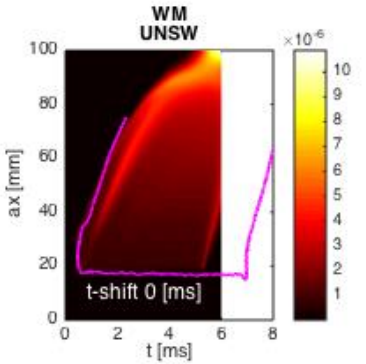
IXT plots (radially integrated OH as fie of time), magenta line is 0.1 contour of experiments

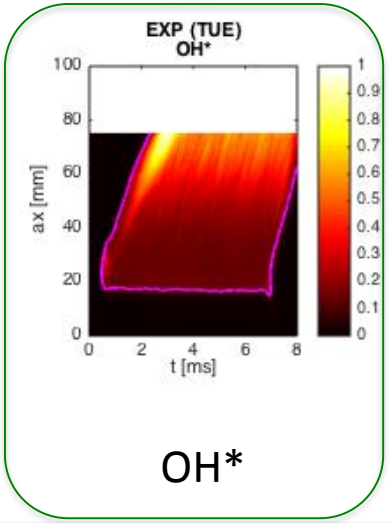
- 4 contributors
- **YAO** mechanism











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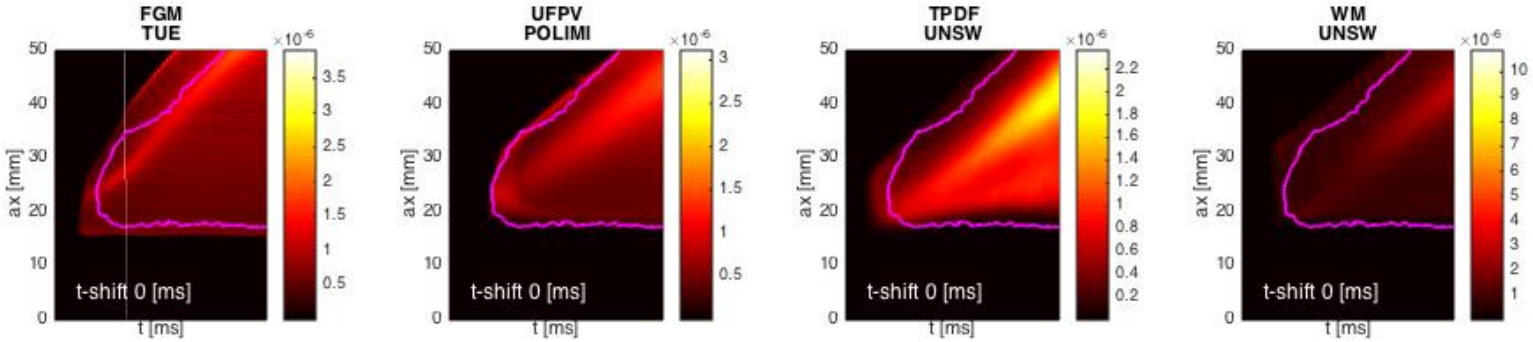
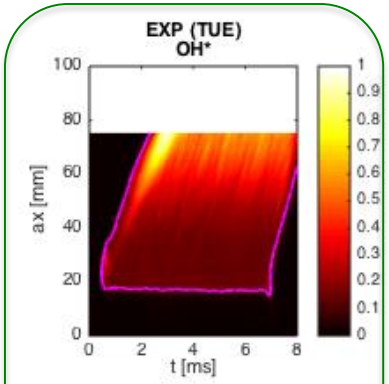




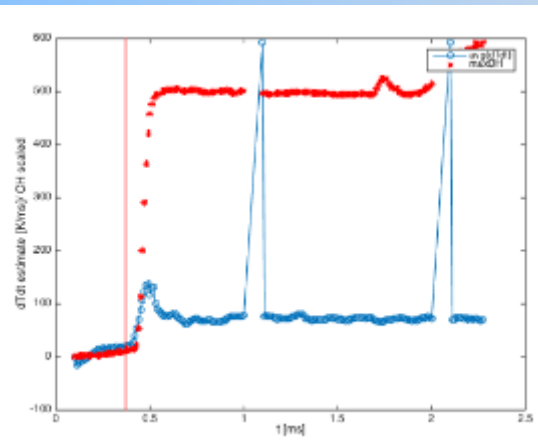
OH*

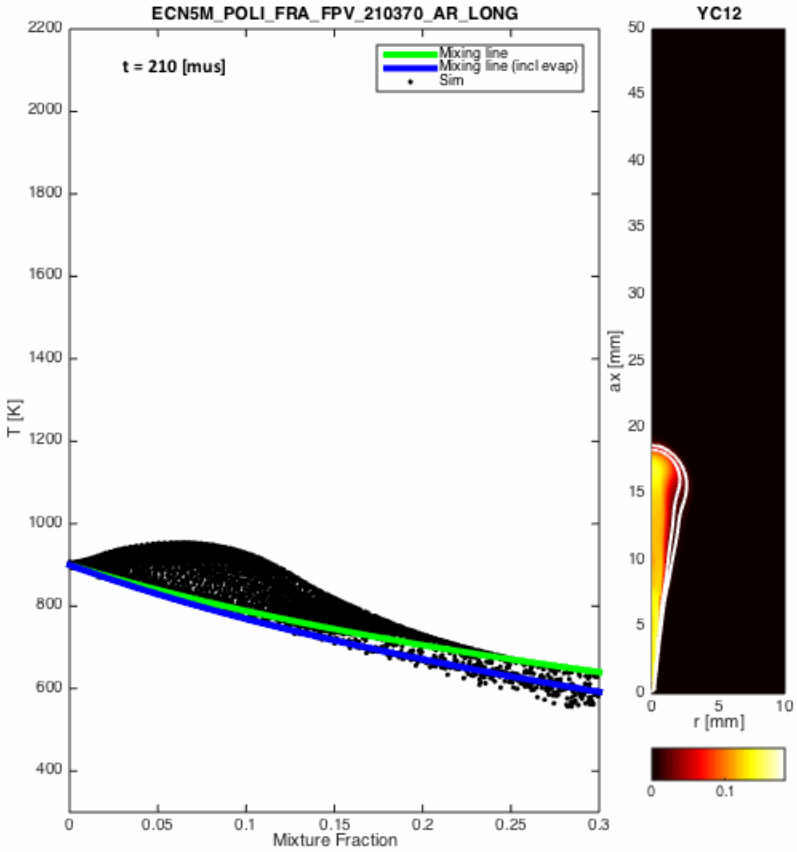
Spatial structure @

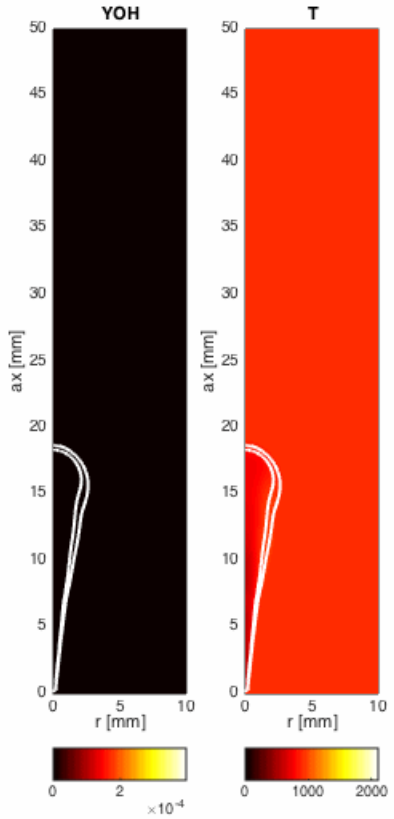
Base(**900K**, 15%)

Movies (because we can)

POL, UFPV, OpenFOAM, betPDF, RANS



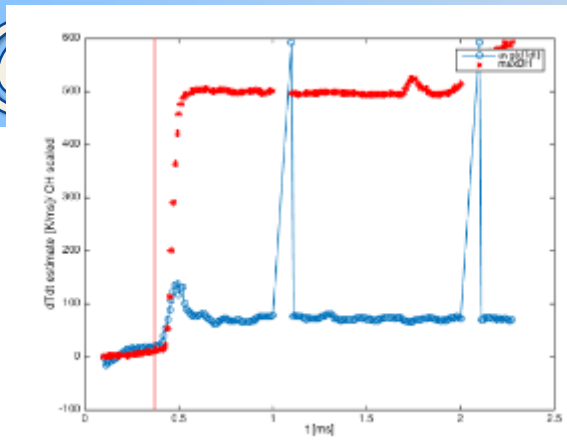


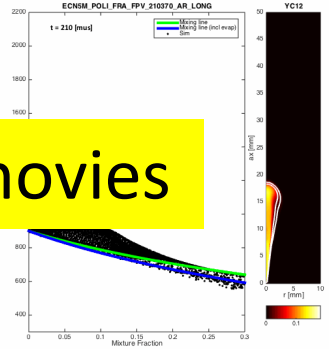


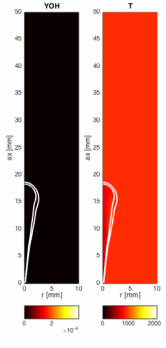
Spatial structure @

Base(900K, 15%)

Compare to ignition probability plots





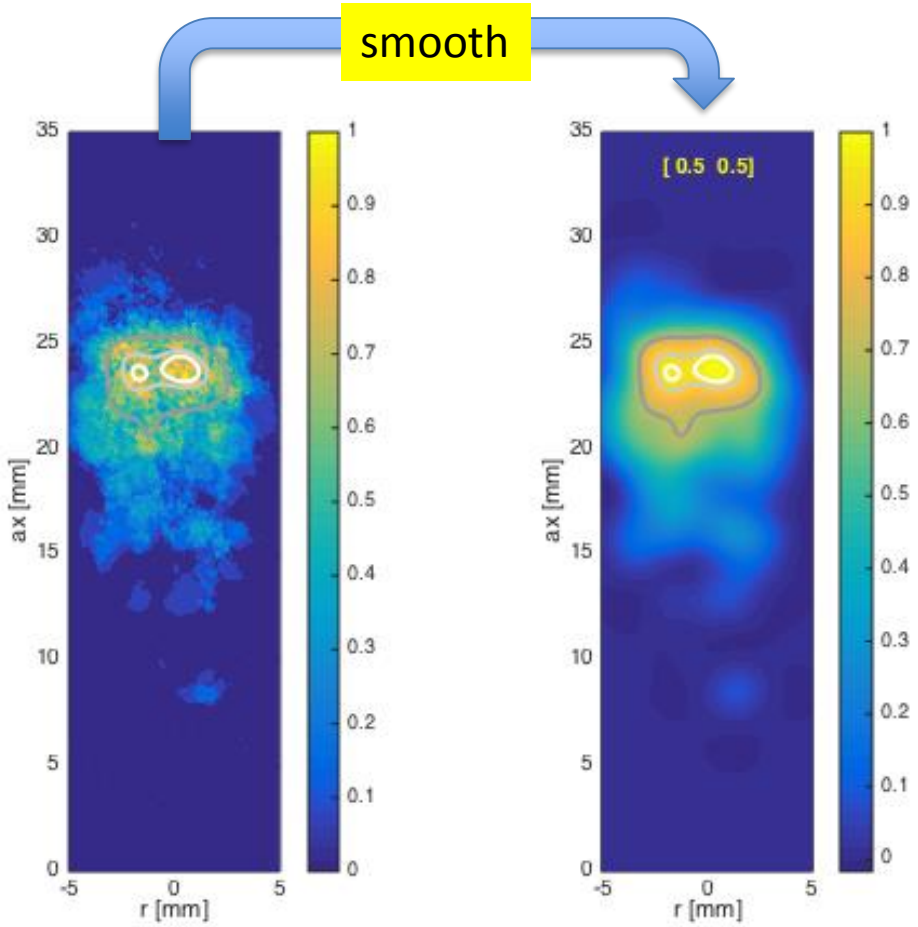


Change the scene from these movies

Spatial structure @ignition

Base(900K, 15%)

Ignition Kernel analysis, Ignition probability (IFPen)



Extract

0.7 0.9 0.95 contours

Spatial structure @ignition

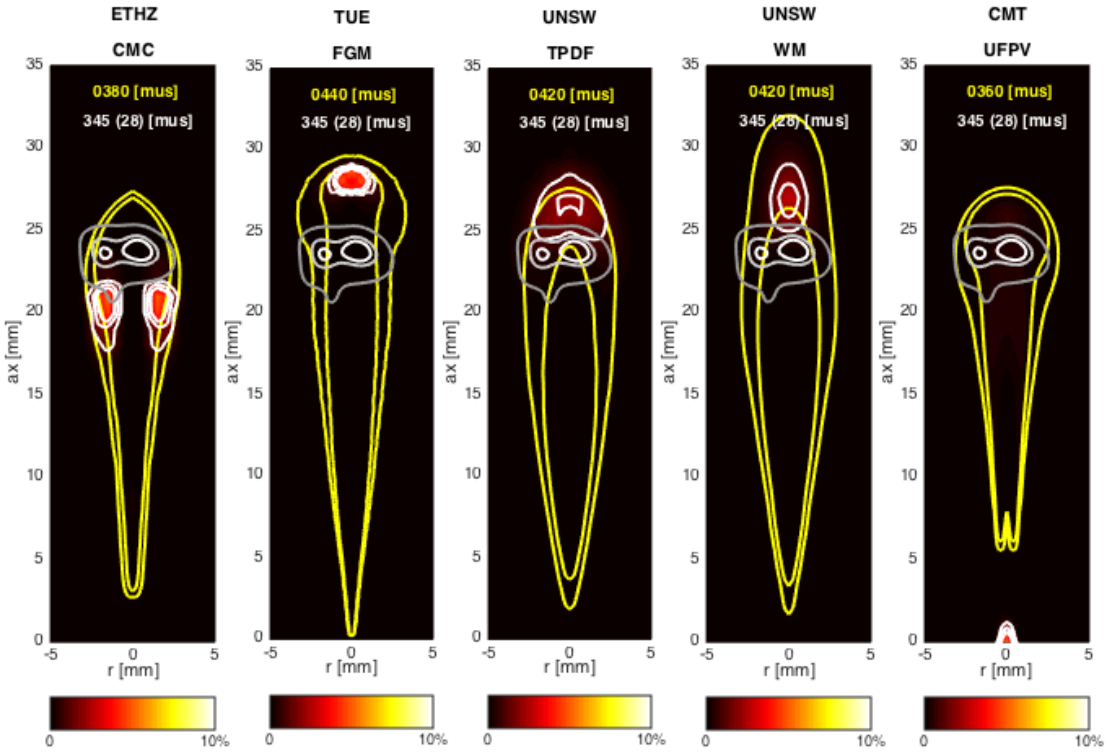
Base(**900K**, 15%), mirrored fields

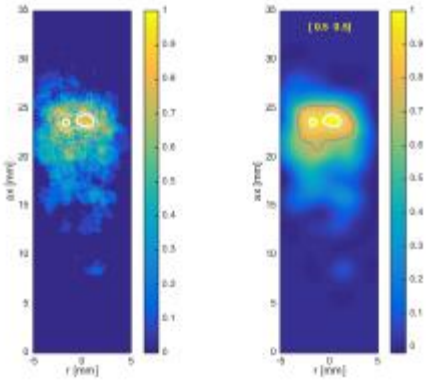
Yellow - Zmr and Zst,

White - 0.02*OHmax

Greys = 0.7 0.9 0.95 prob contour

First instance OH reaches 0.02 of max (of all times)





CAI

ETHZ ignites at sides

Others at top

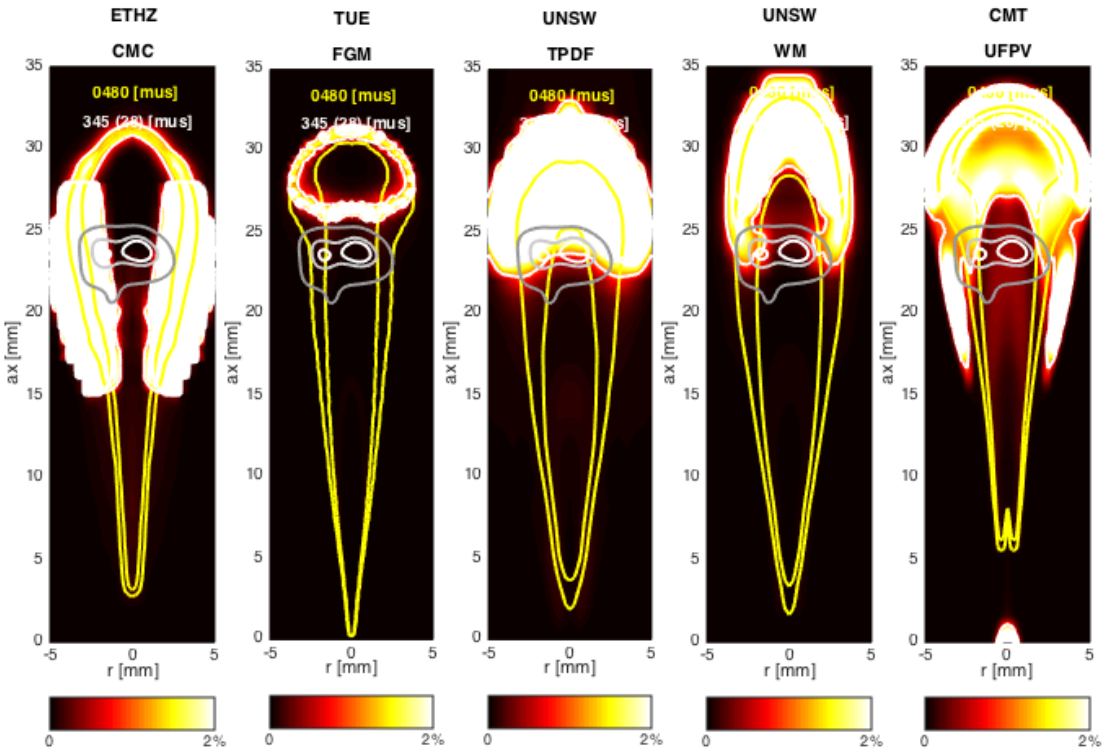
CMT issue at nozzle

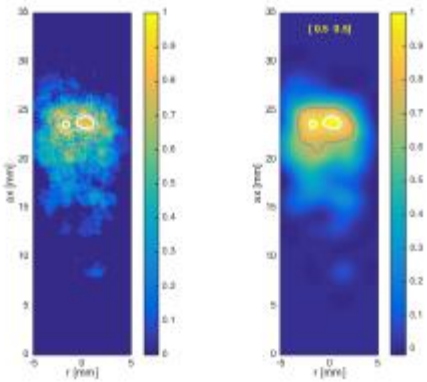
All at markedly different times

Spatial structure @ignition

Base(**900K**, 15%)

Same time instances





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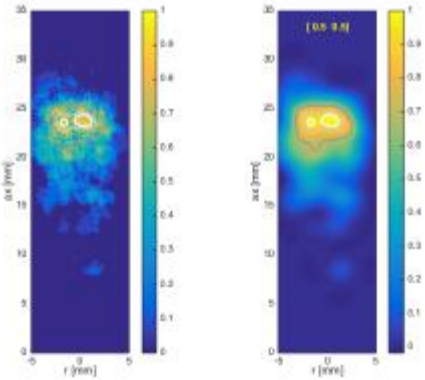
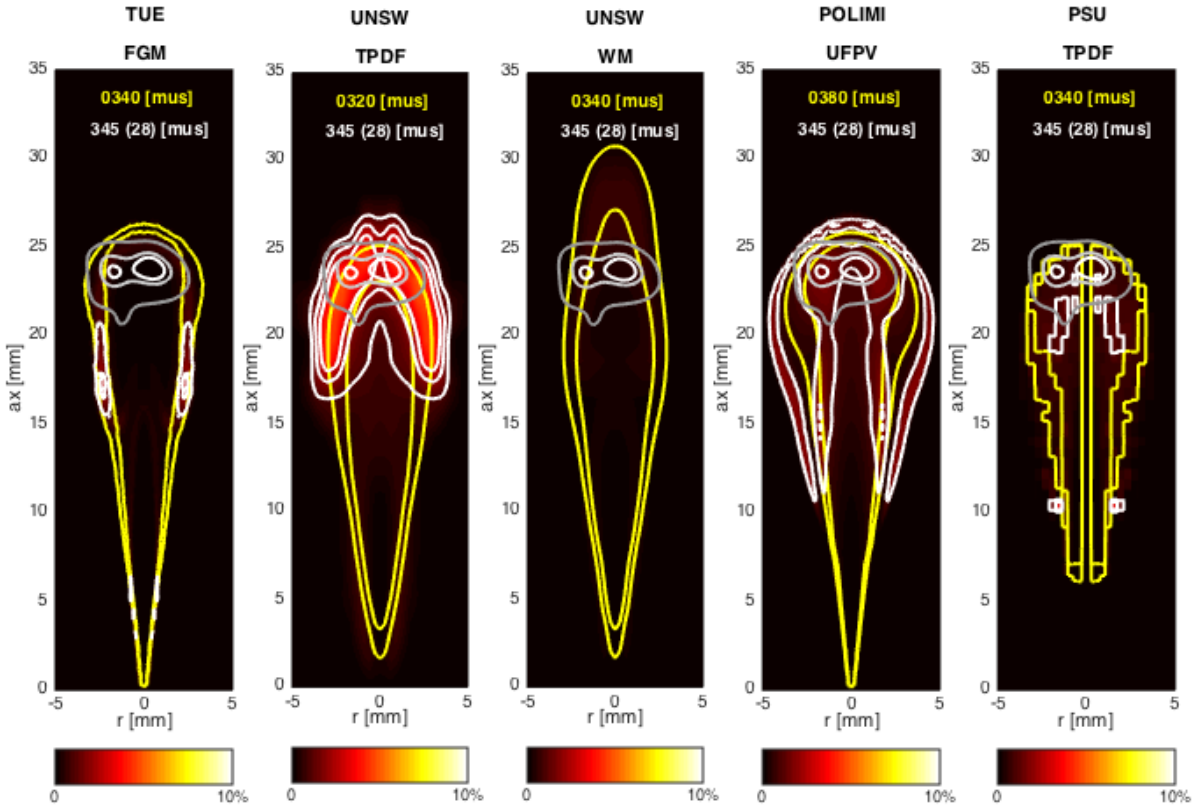




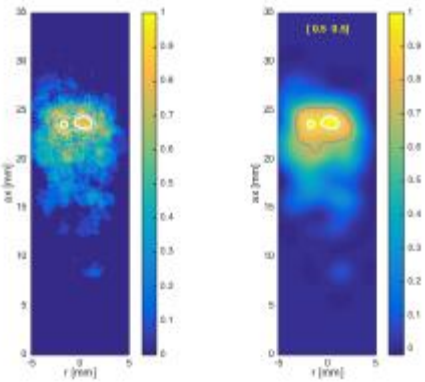
YAO

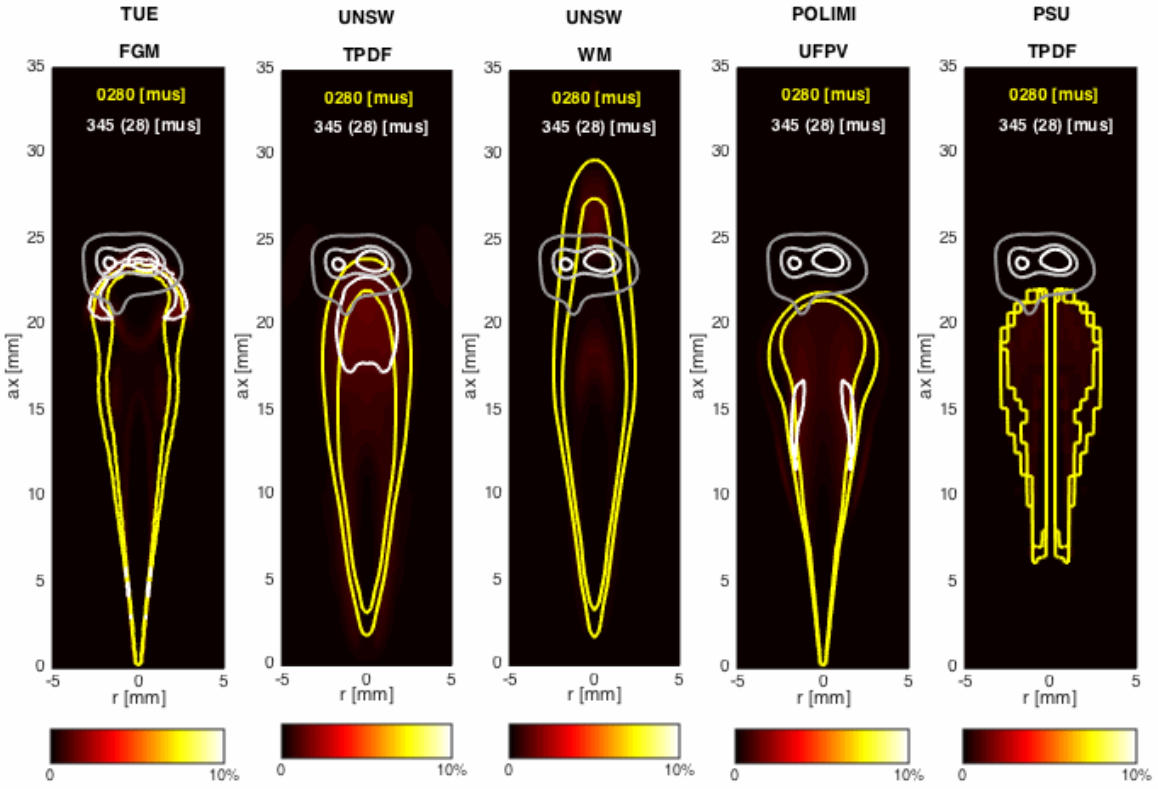
Tough to see.

Far less variation between institutes

Spatial structure @ignition

Base(**900K**, 15%), mirrored fields
Same time instances





YAO

TUE/POL/PSU show also ignition at the flanks

POL-complicated double lobe

USNW ignition at top
PSU also TPDF but first at the top then at foot (sim to TUE)

All at slightly different times (less then for CAI)

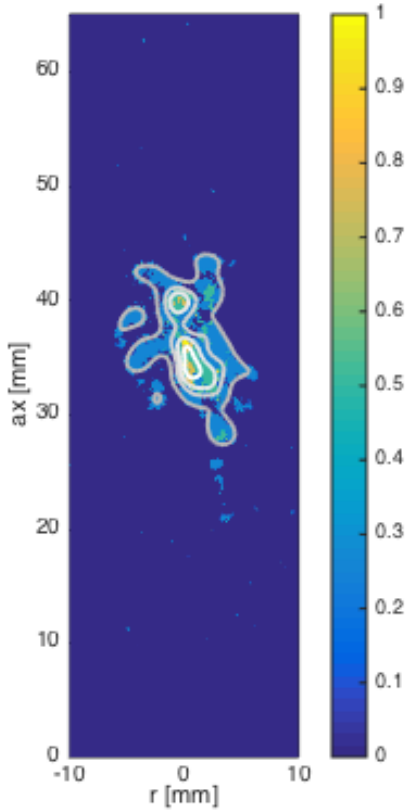
Conclusions

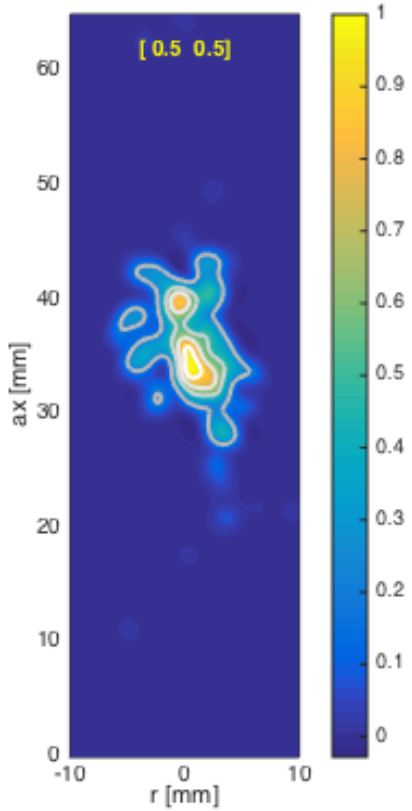
- Most show ignition at the flanks, only UNSW (TPDF and WM) not.
- YAO show more consistent behavior wr to moment of ignition between models, less variation.
- The actual code used might factor in… (TPDF results with different codes and different ‘mixing models’)

Spatial structure @ignition

Base(**800K**, 15%)

Ignition Kernel analysis, Ignition probability





Extract probability plots

Spatial structure @ignition

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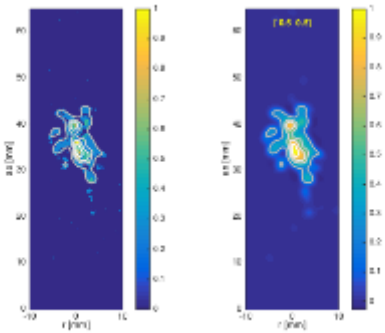
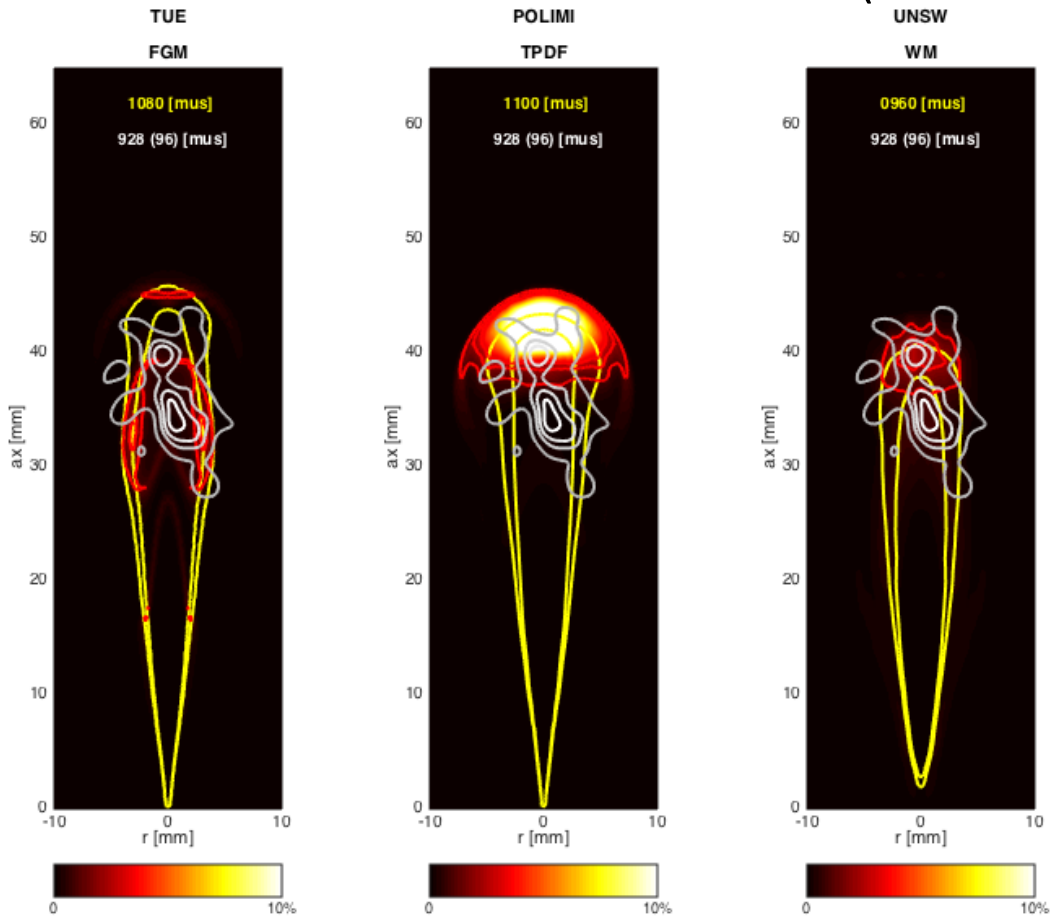
White - 0.02*Ohmax

Greys = 0.7 0.9 0.95 prob contour

First instance OH reaches 0.02 of max (of all times)





YAO

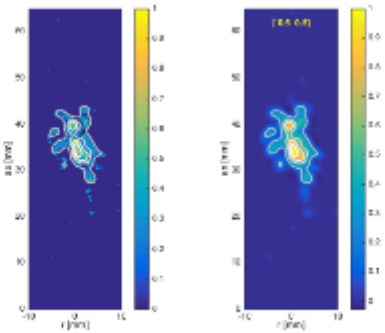
All at slightly different times

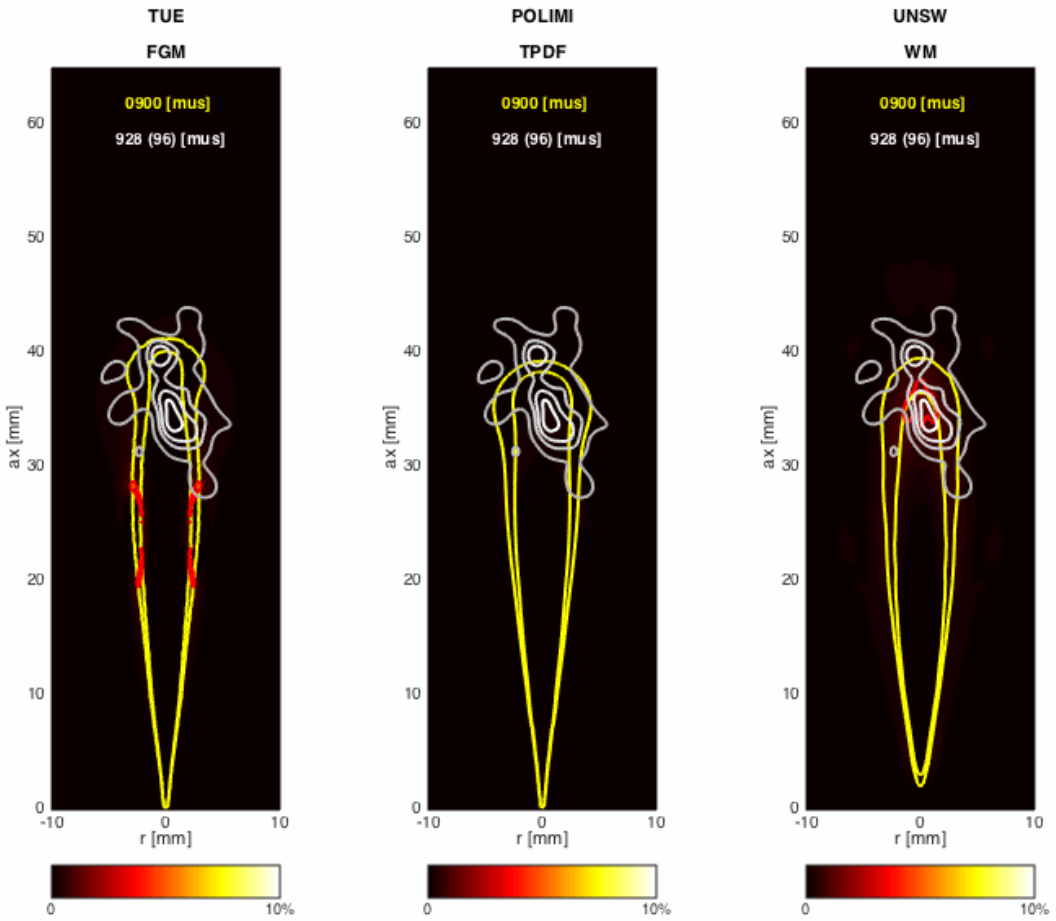
TUE/POL: BOTH progress var methods late (1080 mus)
But behavior different
TUE: at Zmr

Spatial structure @ignition

Base(**800K**, 15%), mirrored fields

Time sequence





YAO

All at slightly different times

TUE/POL: BOTH progress var methods late (1080 mus)

But behavior different

- TUE deltaPDF
- POL betaPDF

Warning, timestep 100mus for POL at 1000mus.

Conclusions

- TUE ignition at the flanks, only UNSW at top.
- POL at the top although time resolution is maybe reason
- POL/TUE both OpenFOAM and LibIce, both progress variable method (FGM vs ADF)
- Again YAO show more consistent behavior wr to moment of ignition between models, less variation.

Talk outline

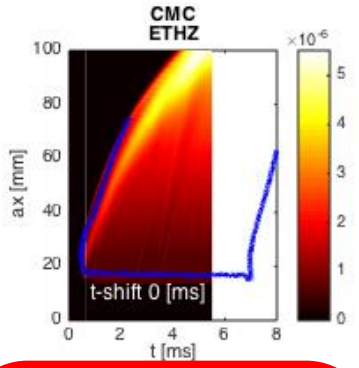
- *Spatial comparison at late times (recession)*
- Conclusions & recommendations

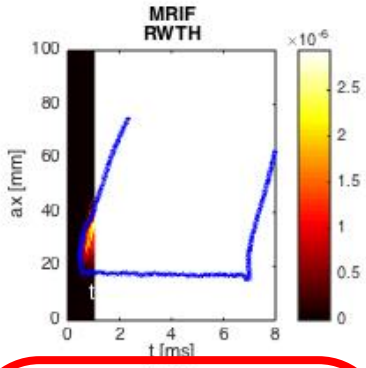
Spatial structure @ignition

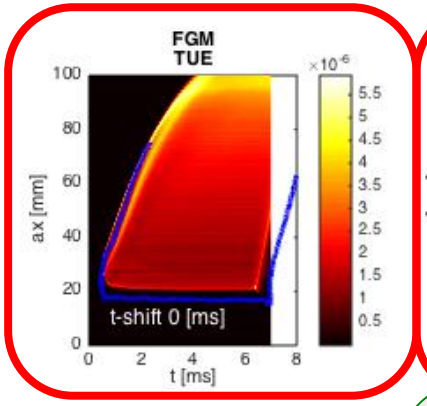
Base(900K, 15%)

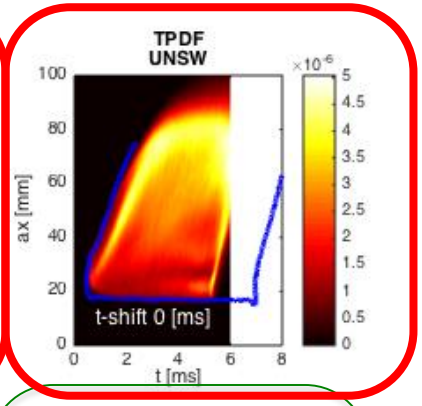
IXT plots (radially integrated OH as fie of time), blue line is 0.1 contour of experiments

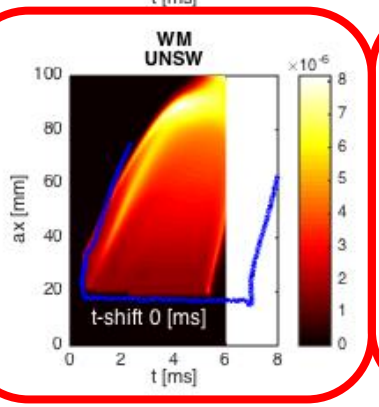
- 6 contributors
- **CAI** mechanism

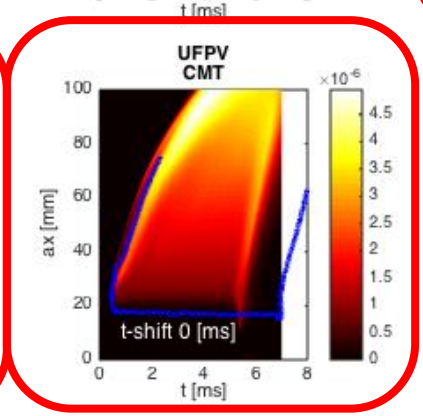


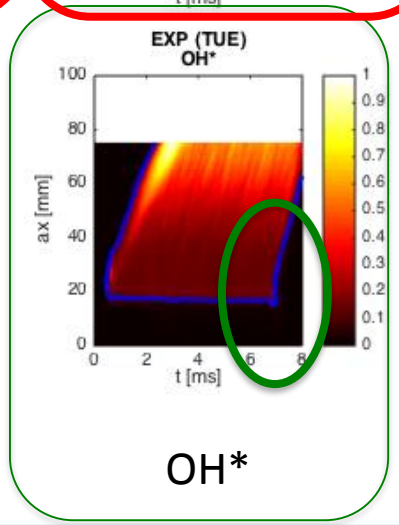










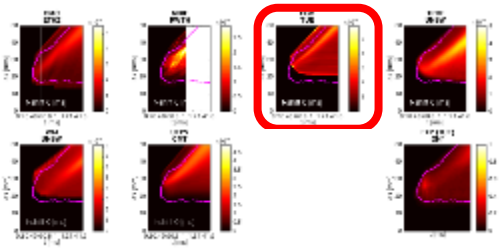


Spatial structure @ignition

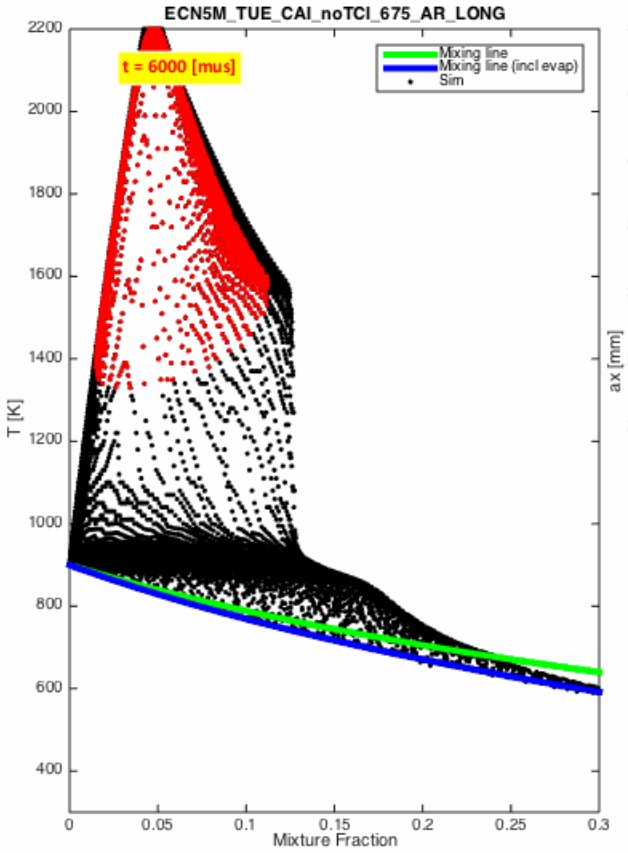
Base(**900K**, 15%)

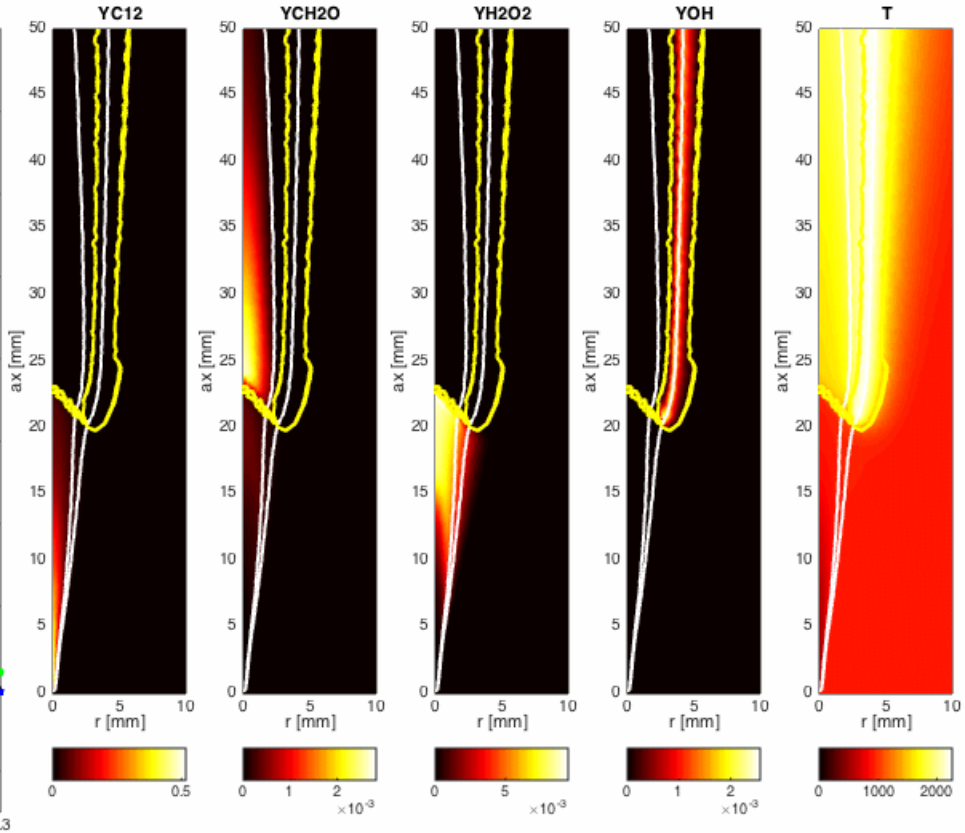
Movies (because we ca

TUE, FGM, OpenFOAM



CAI



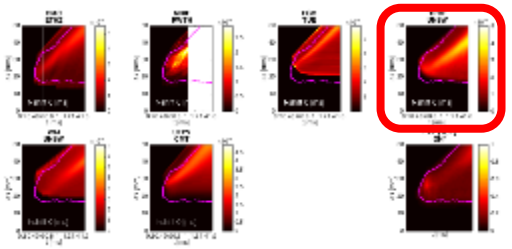


Spatial structure @ignition

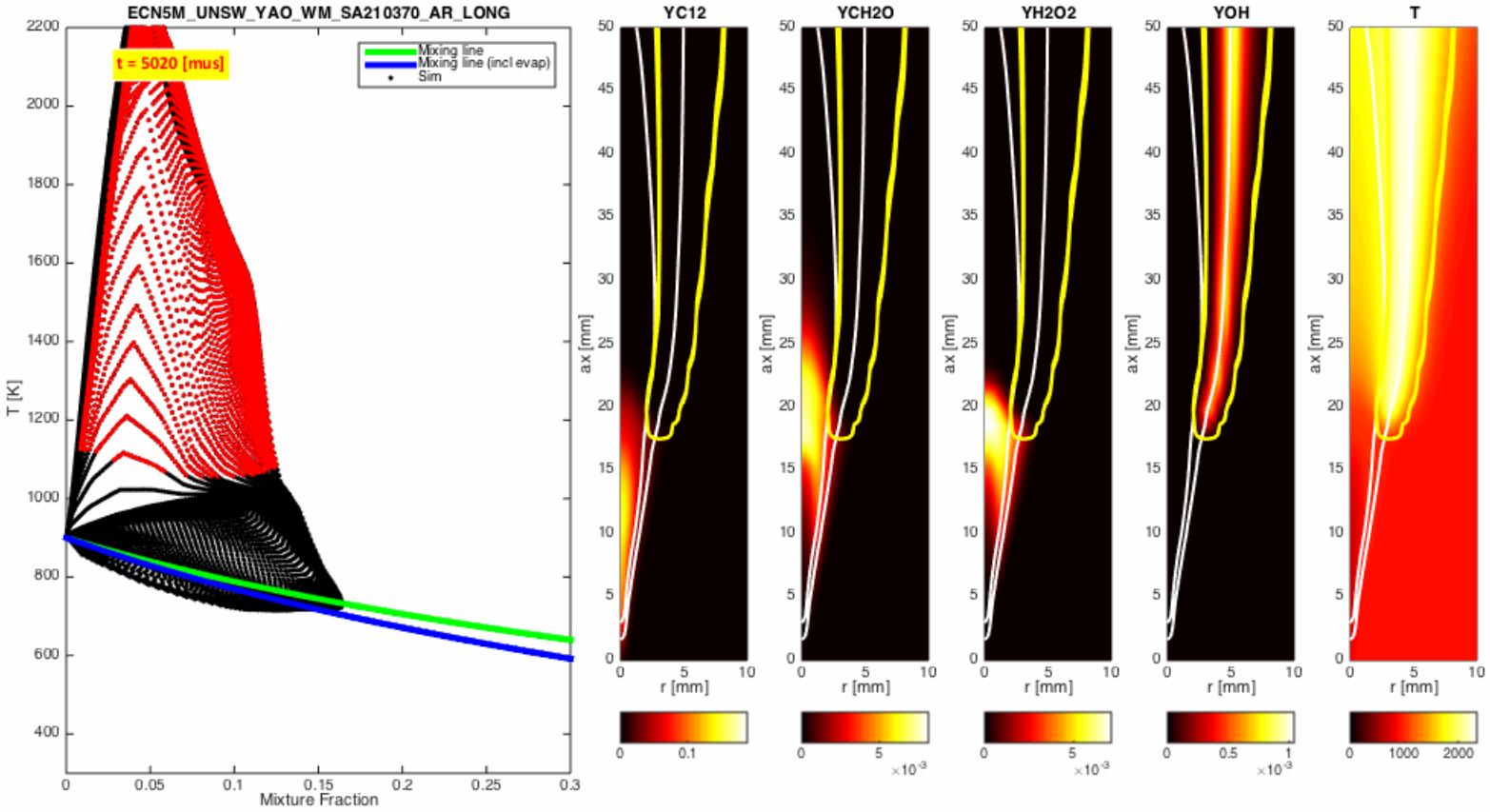
Base(900K, 15%)

Movies (because we ca

UNSW, TPDF, ?, RANS



YAO

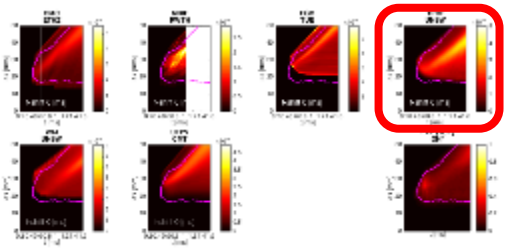


Spatial structure @ignition

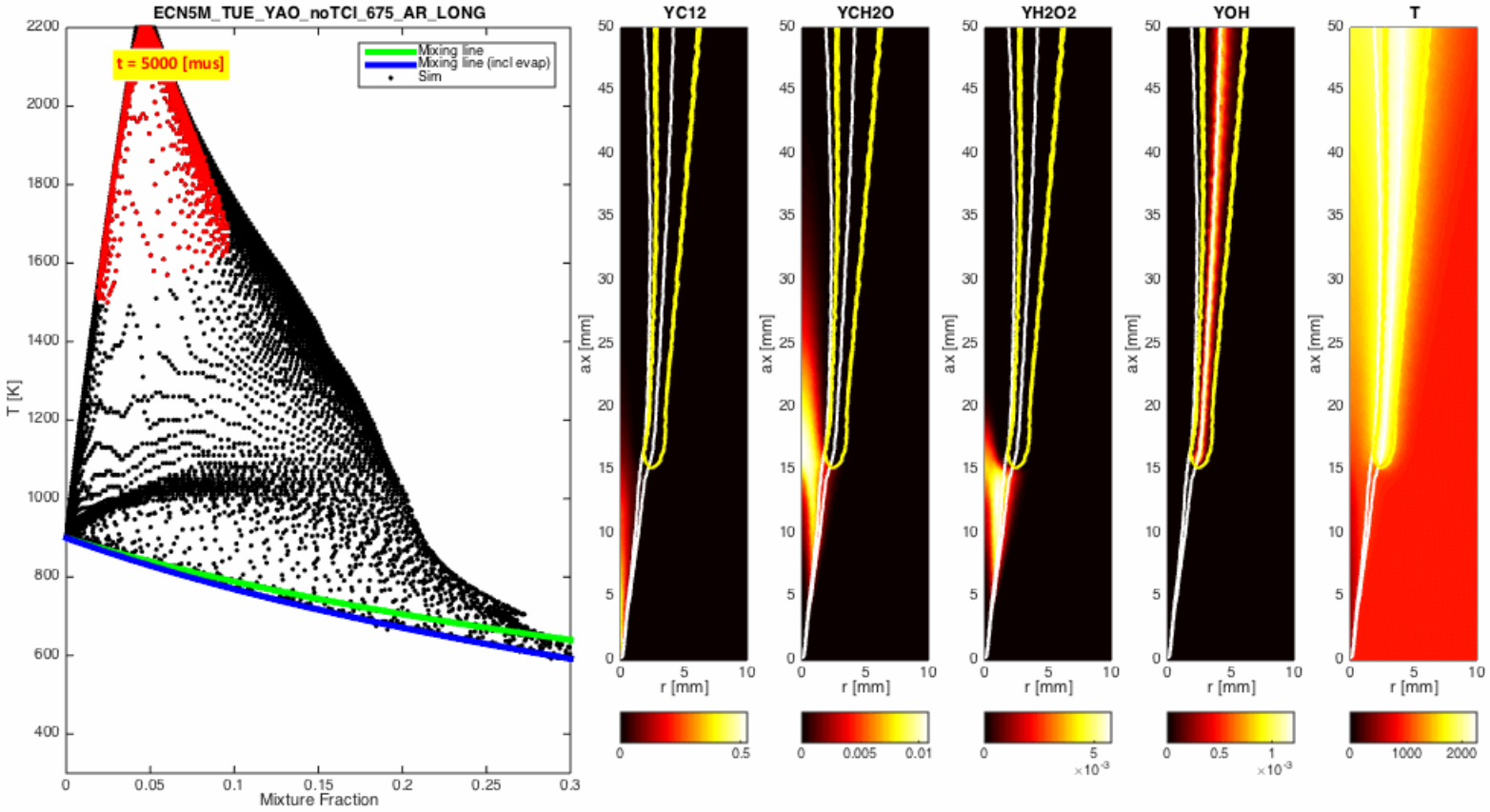
Base(900K, 15%)

Movies (because we ca

TUE, FGM, OpenFOAM



YAO

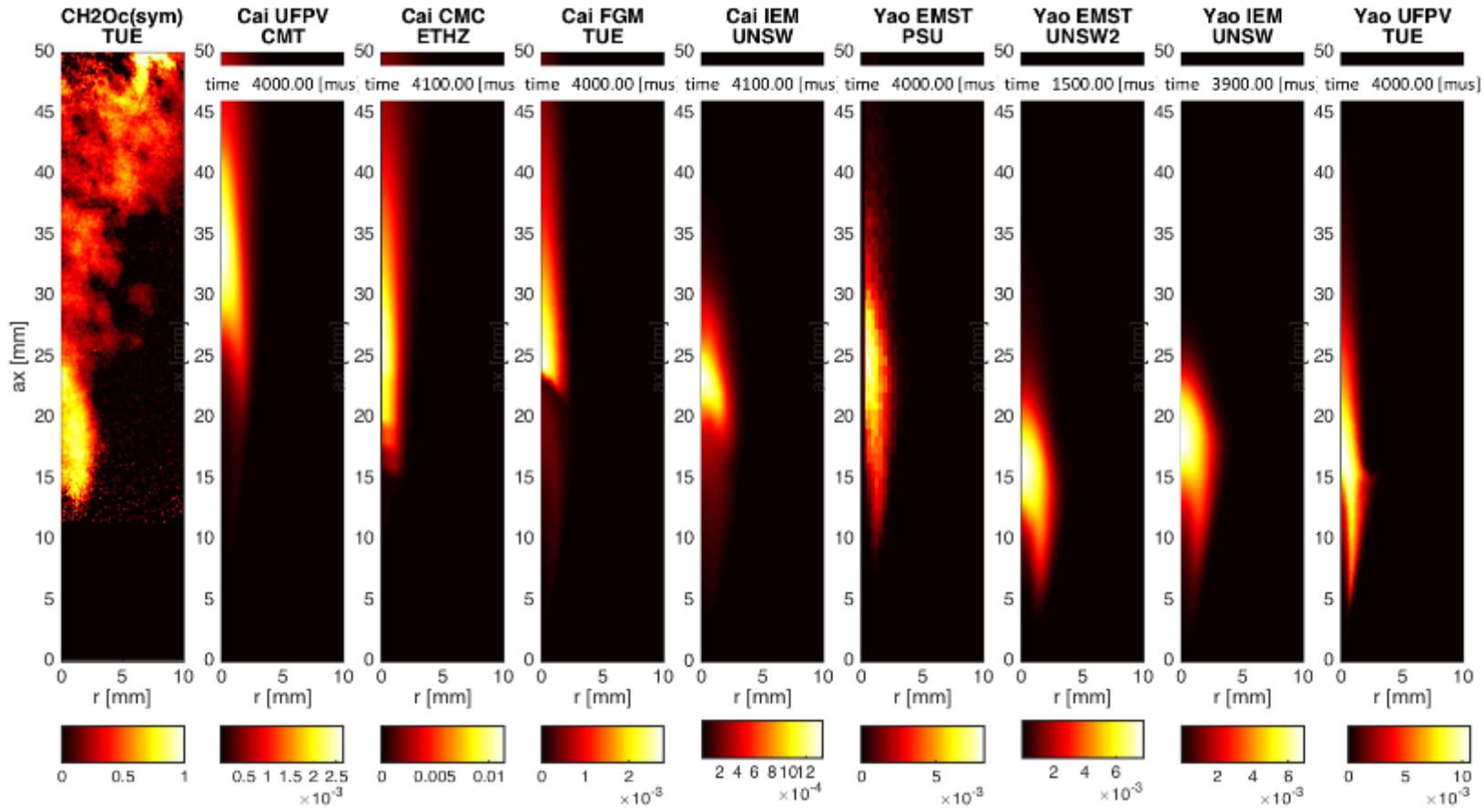


Conclusions

- CAI result TUE shows hardly any recession
- YAO does…

On/OFF resonant CH2O

Encore Formaldehyde



TUE EXP: PC Bakker/Noud Maes