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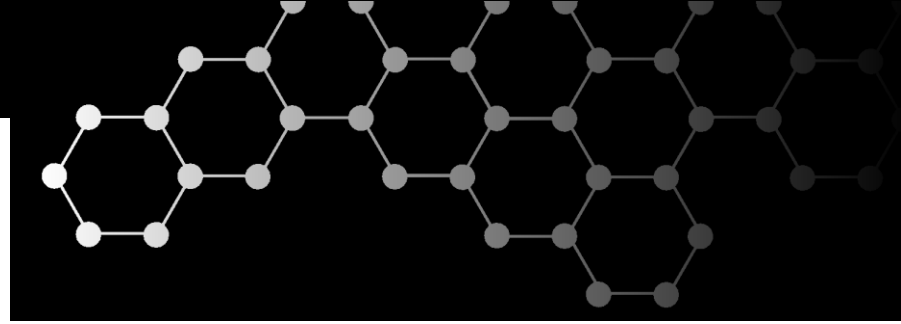
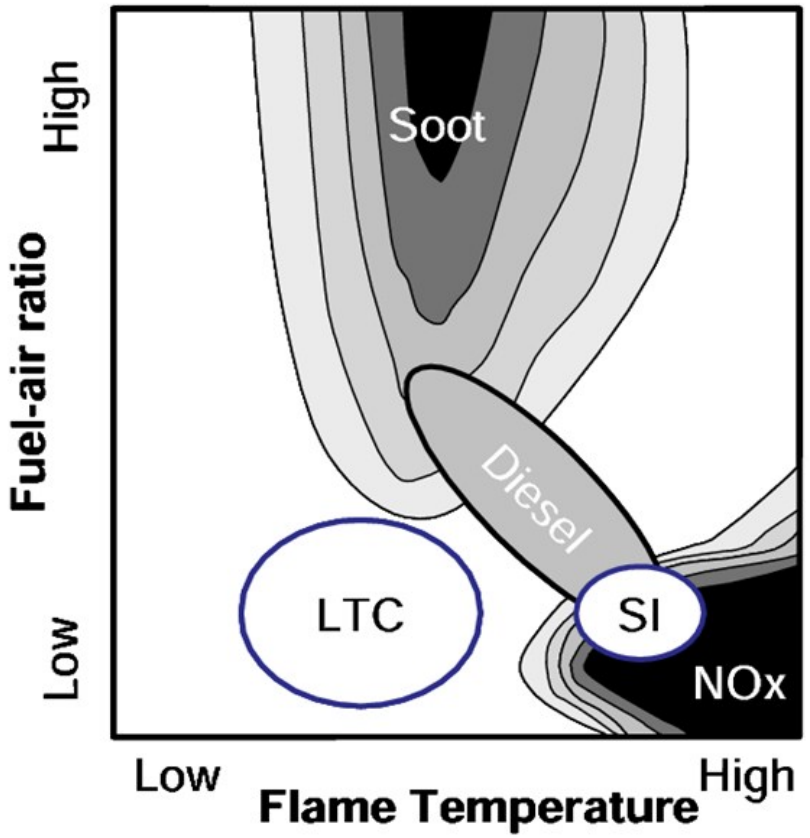


A Representative Interactive Linear Eddy Model

CERC
Combustion Engine Research Center

Background

- New engine concepts with high efficiency and low emissions might operate in non-standard combustion mode
- Assumptions of many combustion models might be violated

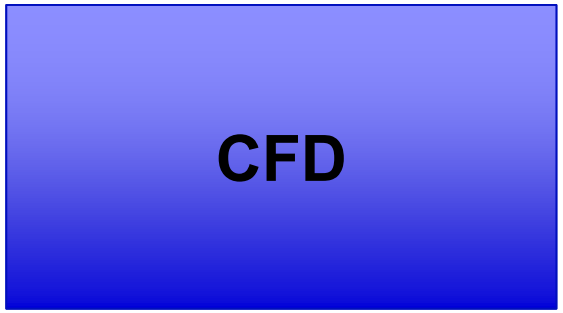


Background

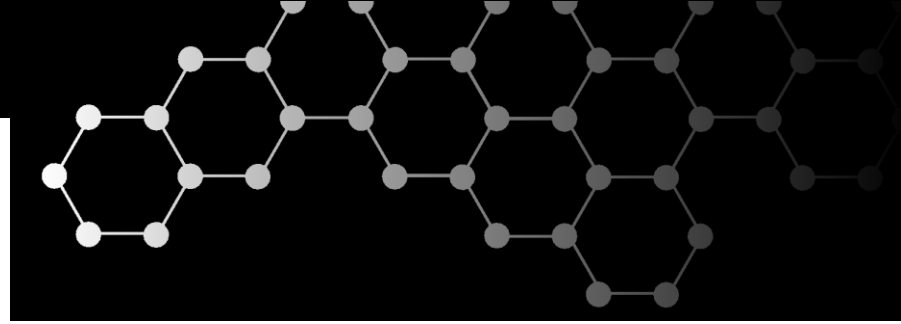
Development of an economical turbulent combustion model with the following features:

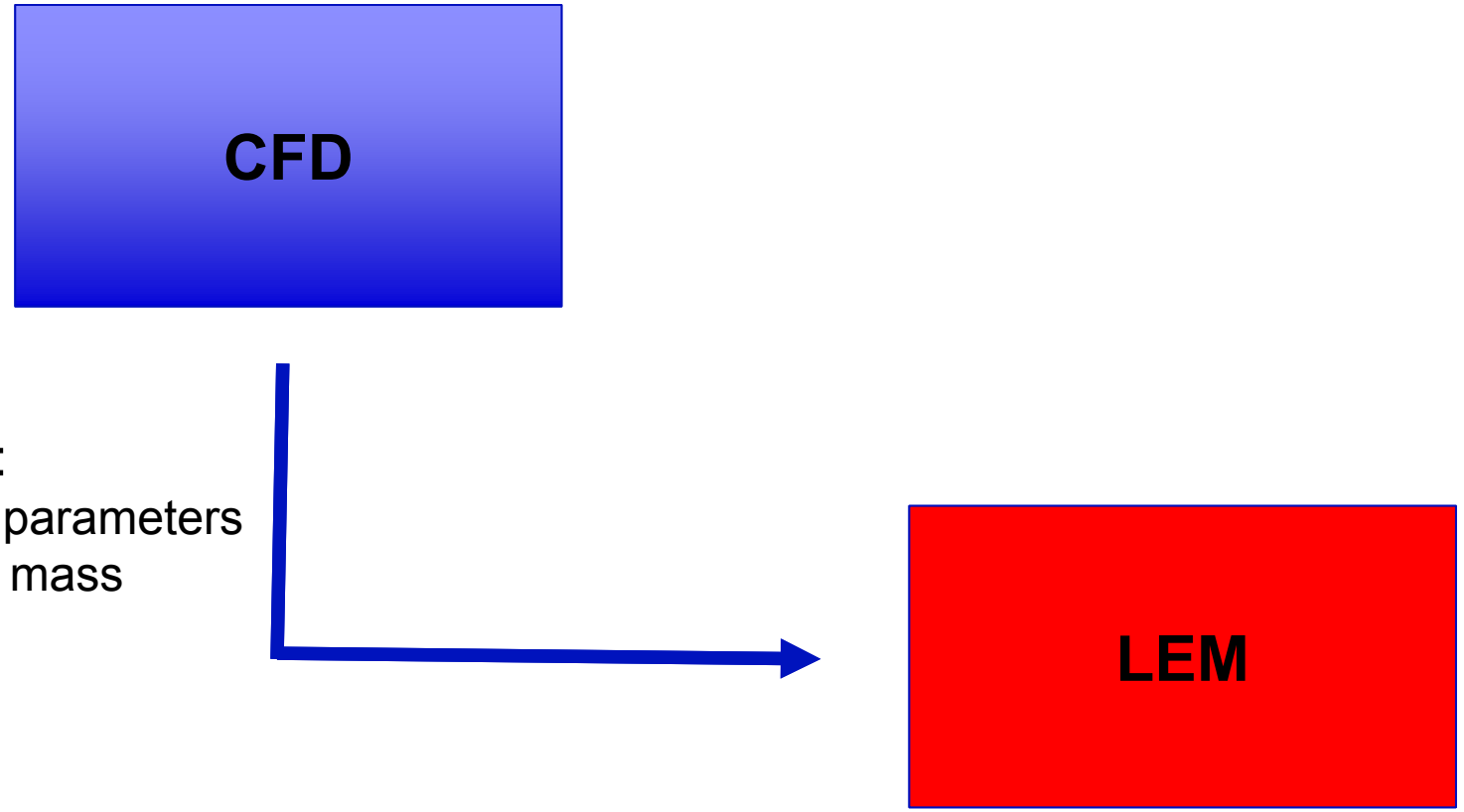
	Present	Future
Multi-regime; Low temperature combustion; Slow chemistry	X	
Physically realistic turbulence structure		X

Method



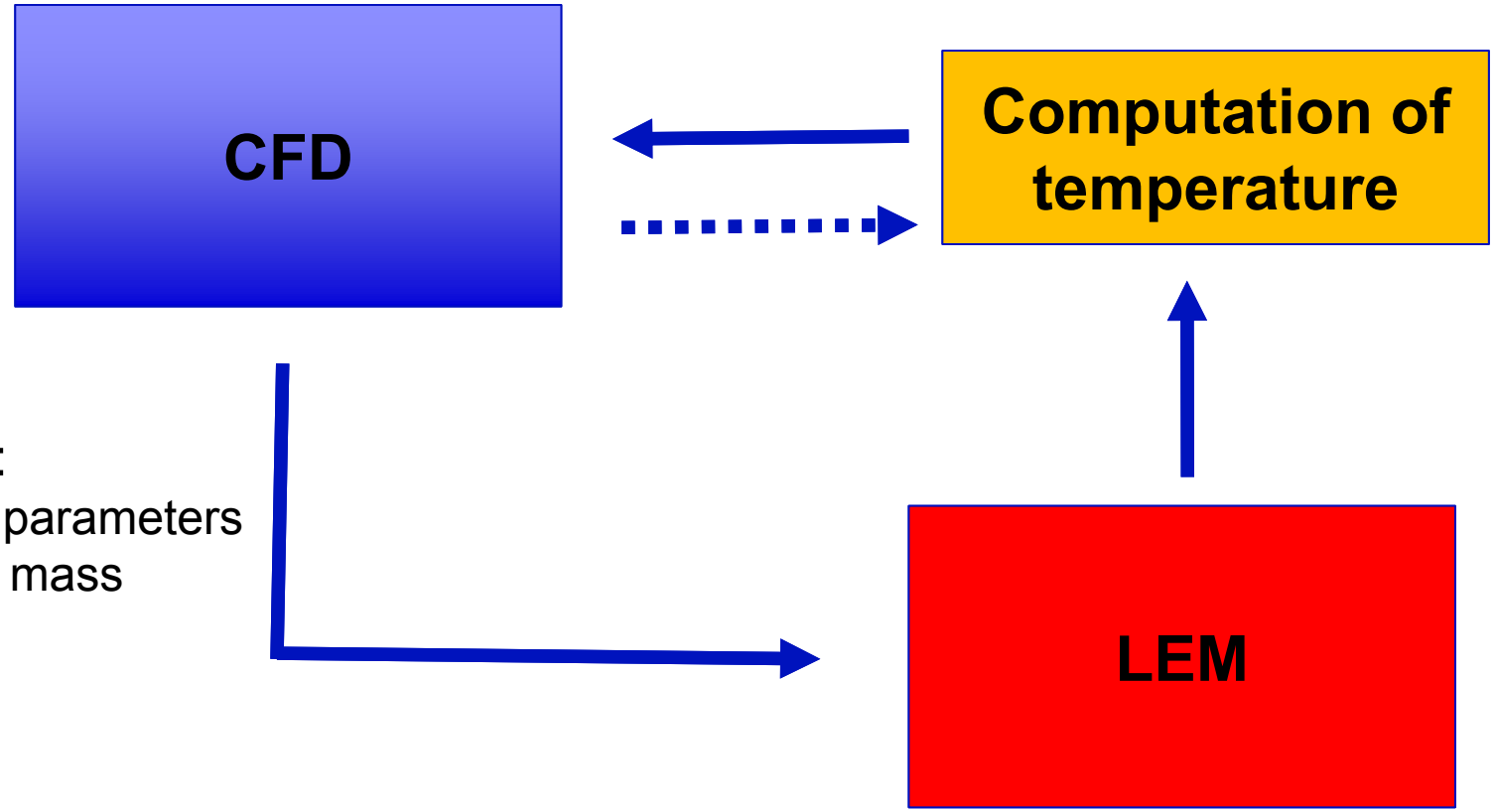
Method





Input of LEM:
- Turbulence parameters
- Evaporated mass
- pressure

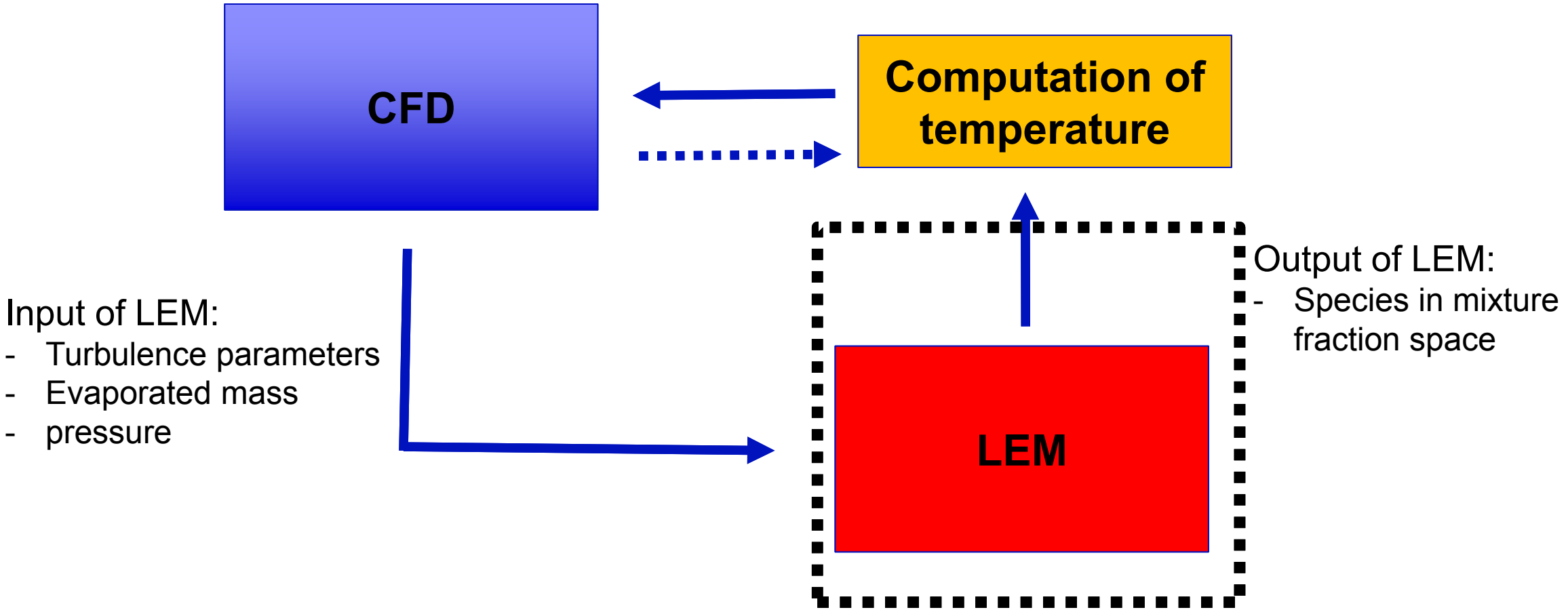
Method



Input of LEM:
- Turbulence parameters
- Evaporated mass
- pressure

Output of LEM:
- Species in mixture fraction space

Method

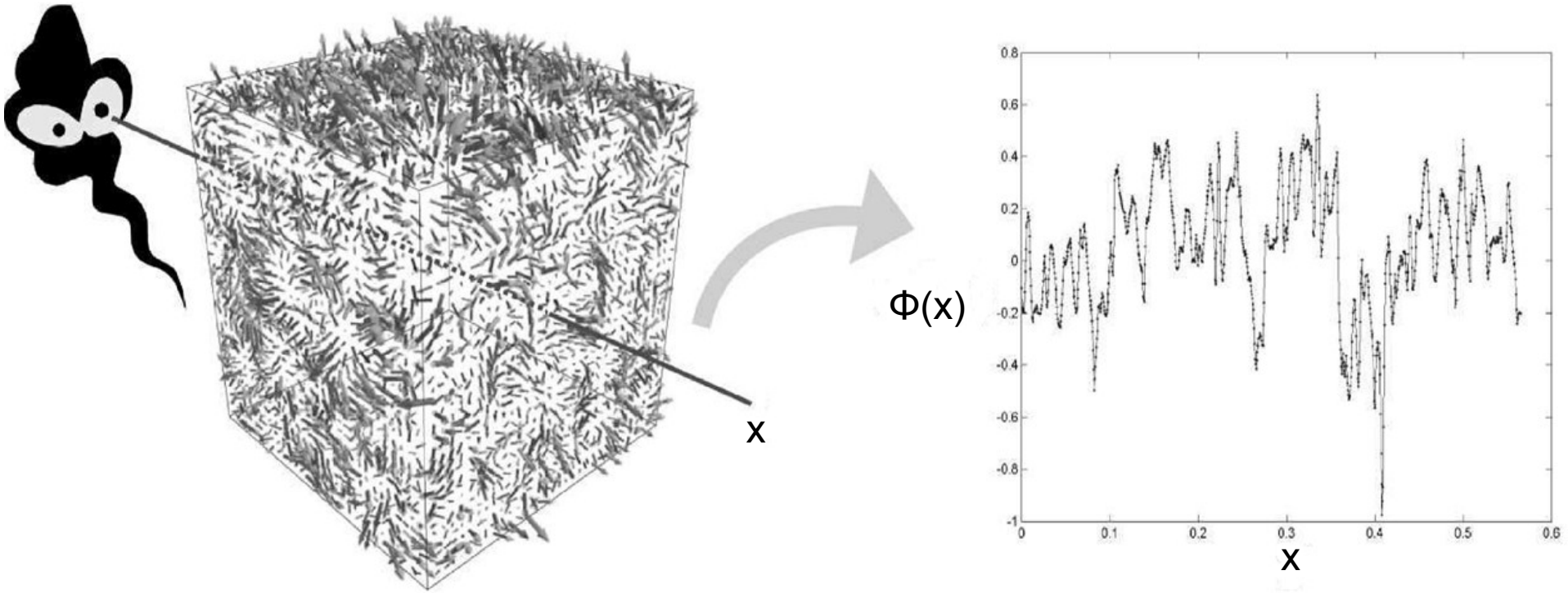


Input of LEM:
- Turbulence parameters
- Evaporated mass
- pressure

Output of LEM:
- Species in mixture fraction space

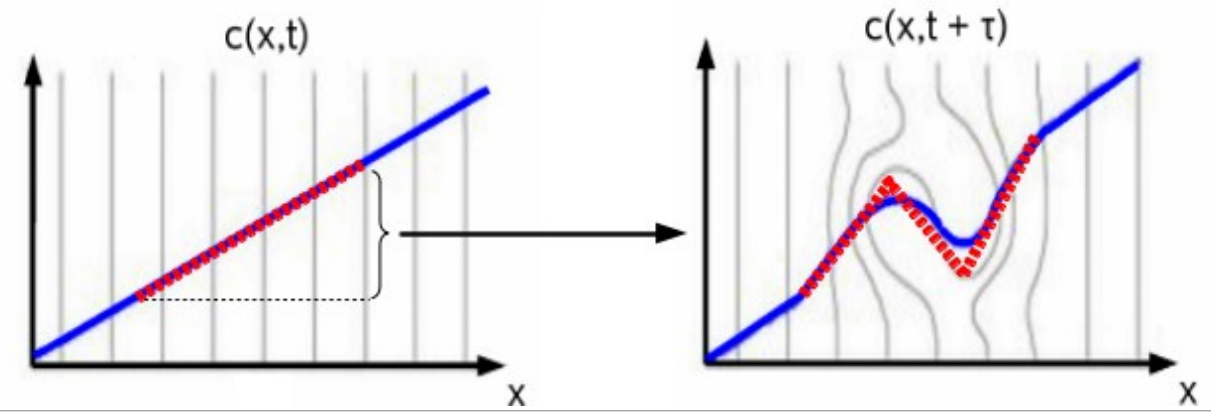
Methods

LEM turbulence looks at 3D turbulence along a 1D line



Methods

- LEM is a stochastic, unsteady turbulent mixing/reaction simulation on a 1D spatial domain
- Resolves all length and time scales
- Conventional time marching of molecular diffusion and chemistry
- Turbulent mixing (eddies) modeled by triplet maps
  - size, location and time are stochastically sampled in accordance with turbulence phenomenology

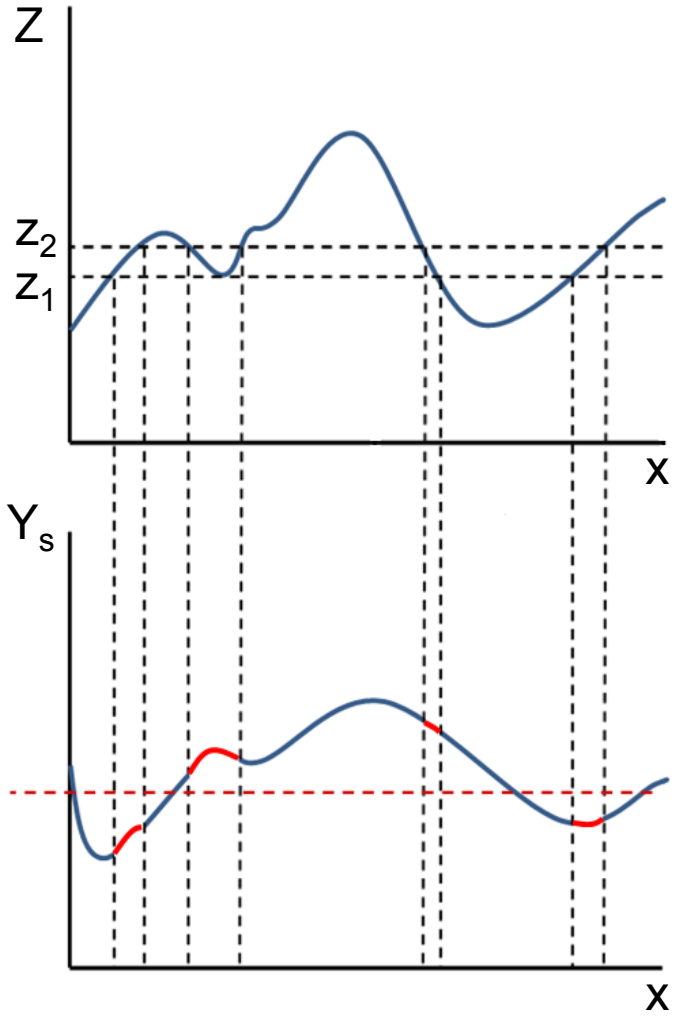


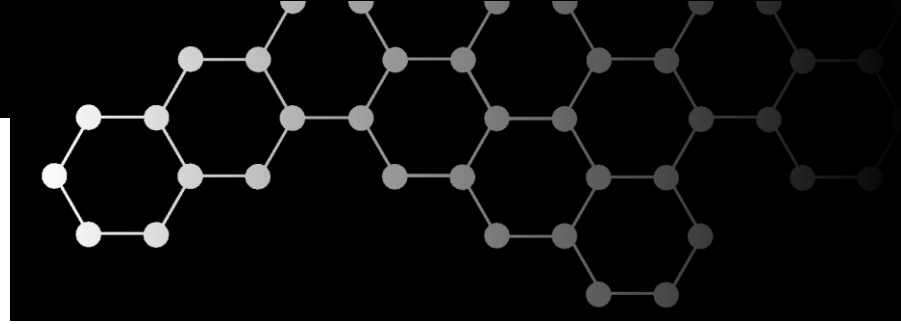
Methods

Output of LEM:

Mass fraction of any species s conditioned on mixture fraction space

$< Y_s \mid z_1 < z < z_2 >$





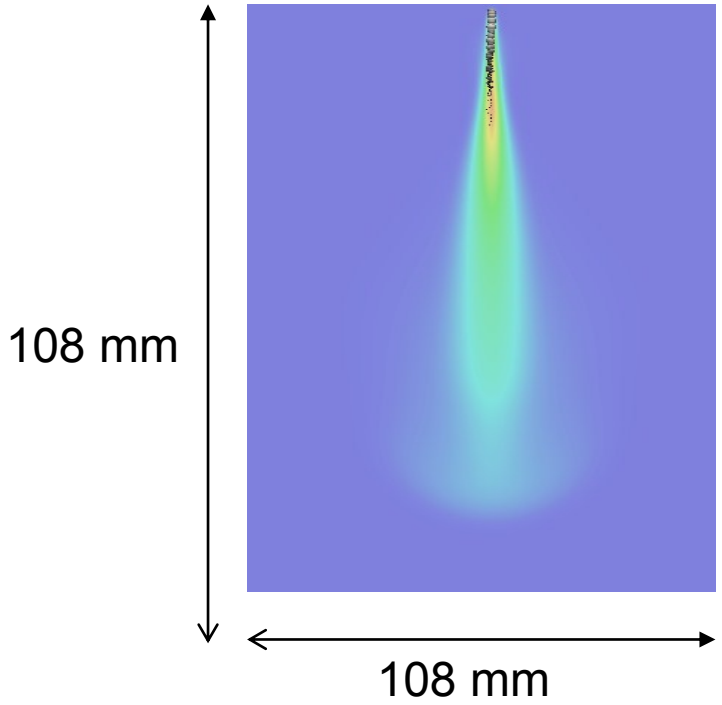
Test Case

Comparison between RILEM and RIF

Test Case

Comparison between RILEM and RIF

- ECN Spray-H[1] case:
  - Fuel: n-heptane
  - Ambient: 21% mole air fraction
  - Pressure: 42 bar
  - Temperature: 1000 K



[1]Engine combustion network, www.sandia.gov/ecn

Test Case

- RILEM numerical set-up:
  - CFD grid: 2D wedge mesh with 23328 gridpoints
  - LEM grid: 2000-3000 gridpoints (depending on turbulent input parameters)
  - Spray break-up: Huh-Gosman, Kelvin Helmholtz

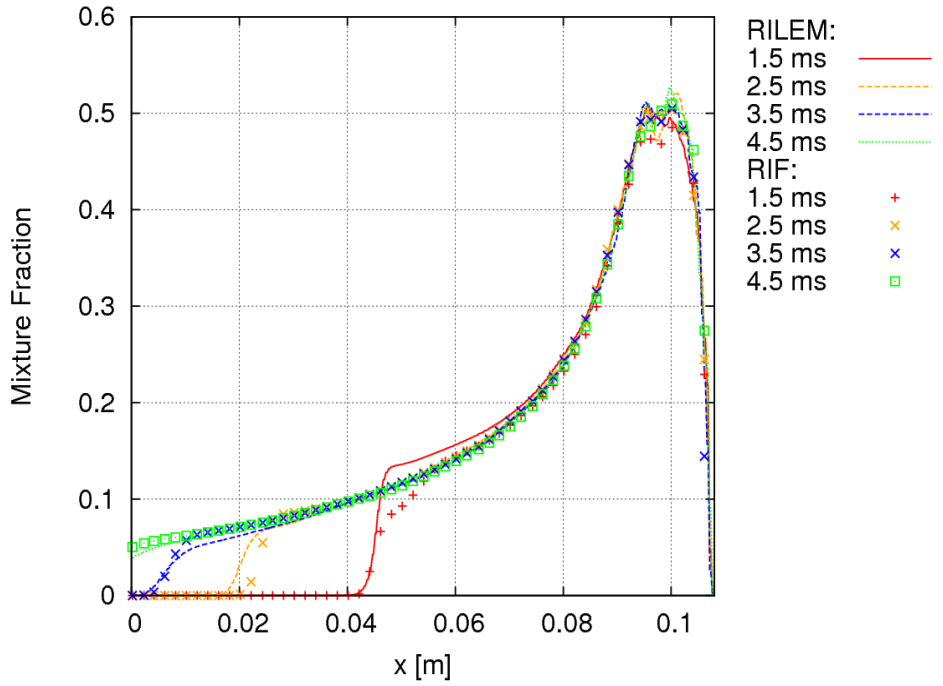
- Chemical mechanism
  - [1]Reduced n-heptane mechanism: 35 species and 80 reactions

[1]Rente, Golovitchev, Denbratt, SAE paper 2001

Results

- Comparison between the results for RIF and RILEM for the spray H case:

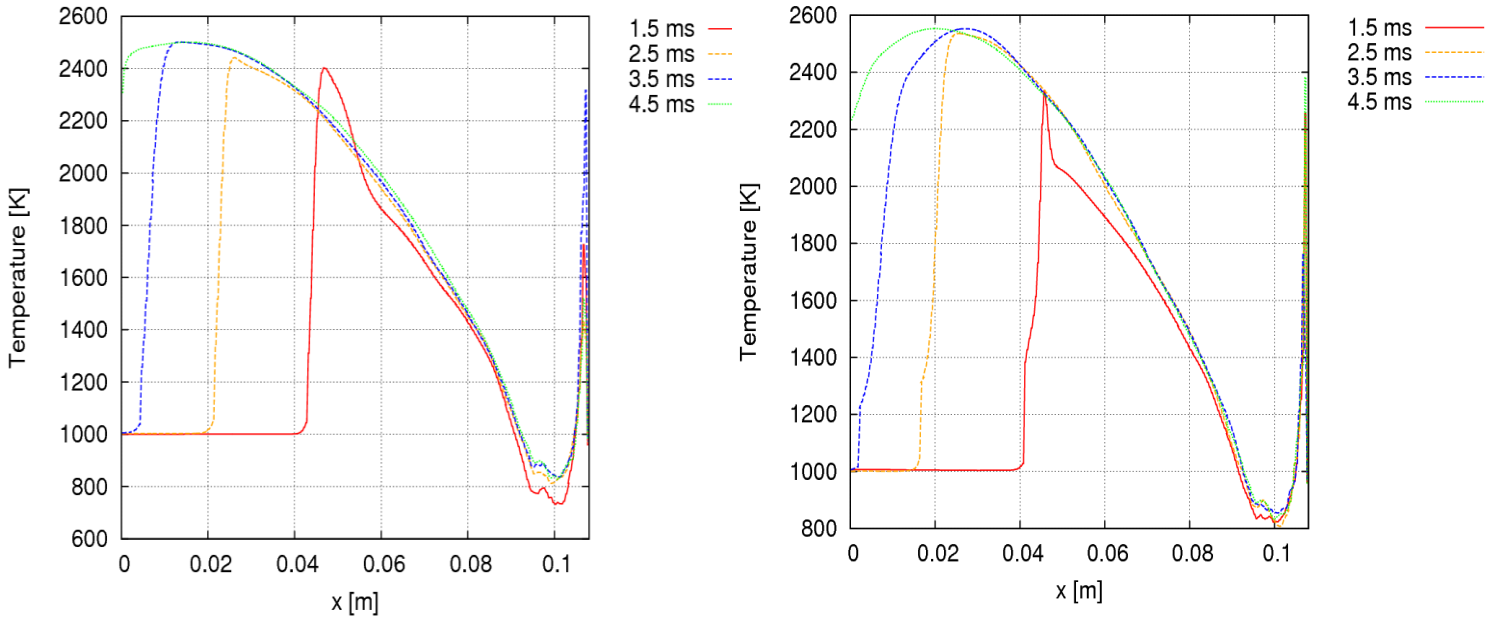
Interpolated mixture fractions along a line through the nozzle in the simulated combustion chamber at t = 1.5, 2.5, 3.5 and 4.5 ms. On the horizontal axis 0.108 m corresponds to the position directly below the nozzle.



Results

- Comparison between the results for RIF and RILEM for the spray H case:

Interpolated temperatures along a line through the nozzle in the simulated combustion chamber at t = 1.5, 2.5, 3.5 and 4.5 ms. On the horizontal axis 0.108 m corresponds to the position directly below the nozzle.



Conclusion

Summary of RILEM features relative to RIF

	RIF	RILEM
Cost	Low	High
Scal Diss. Rate	Input	Captured within LEM
Mean values conditioned on Z	Yes	Yes
Fluctuation statistics	No	Yes
Regimes	Flamelet	Multiple