

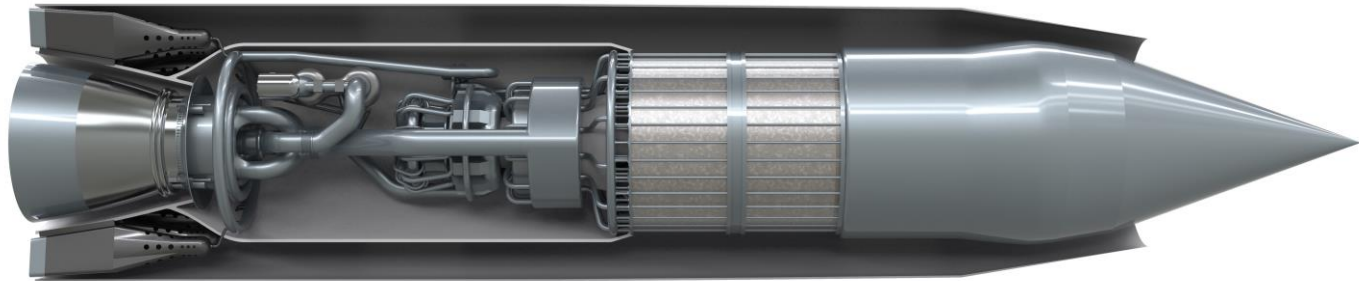
# Large Eddy Simulation of a Lean Hydrogen Combustor

Tin-Hang (Enson) Un, Salvador Navarro-Martinez

---

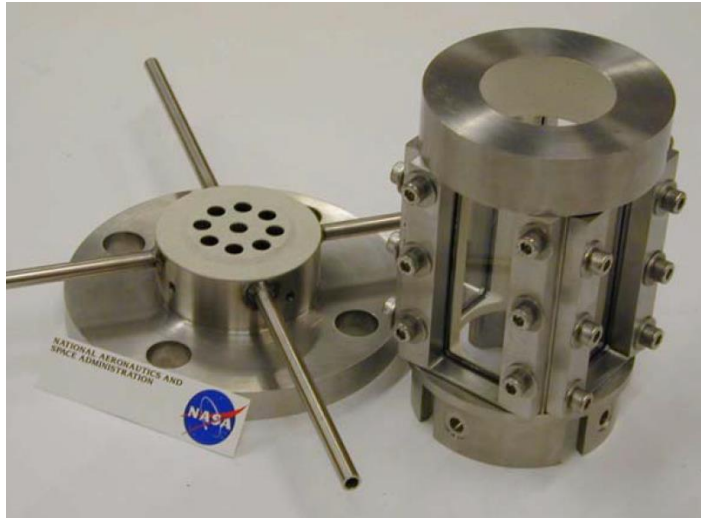
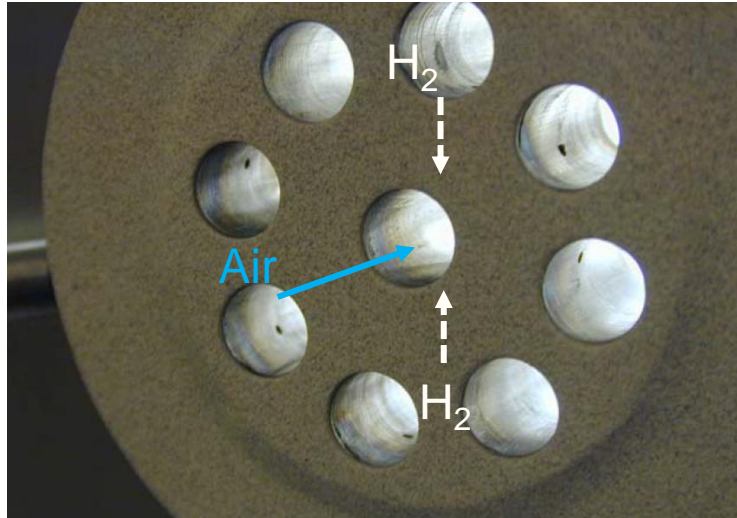
## Motivations

- Lean hydrogen combustion
- Multi-mode aeroengine
- Experimental data available



# Experimental configurations

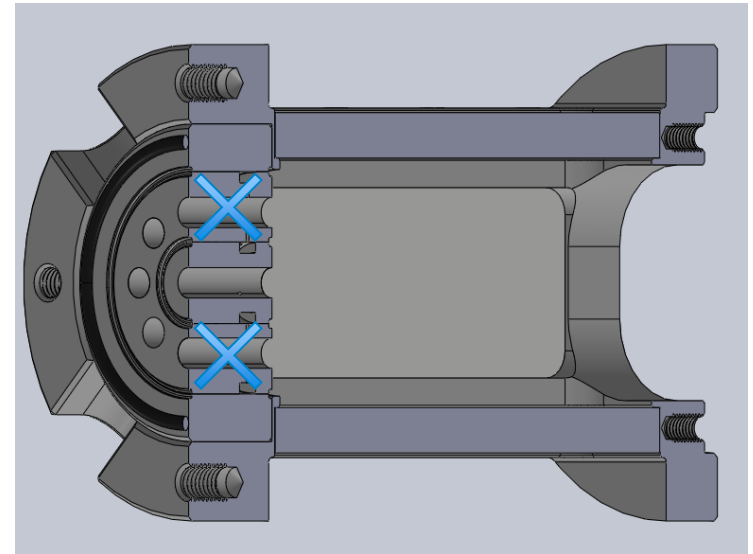
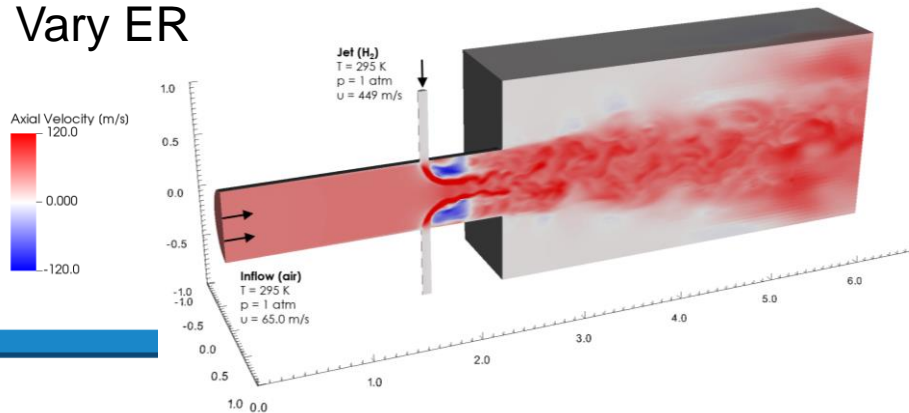
NASA



# Experimental configurations

## UCL

- $M \sim 0.4-0.5$  (at jet)
- $Re \sim 25,000$
- Jet-to-crossflow momentum ratio  $\sim 3.4$
- Vary ER



# Challenges

- Multiple scales in geometry  
Combustor ~ 5 cm, premixer ~ 0.6 cm, injector ~ 0.09 cm
- Unstable flame due to lean mixture  
Problem with “numerical” ignition  
Problem with sustaining flame

## Approach – AMReX + PeleC + PelePhysics

### AMReX

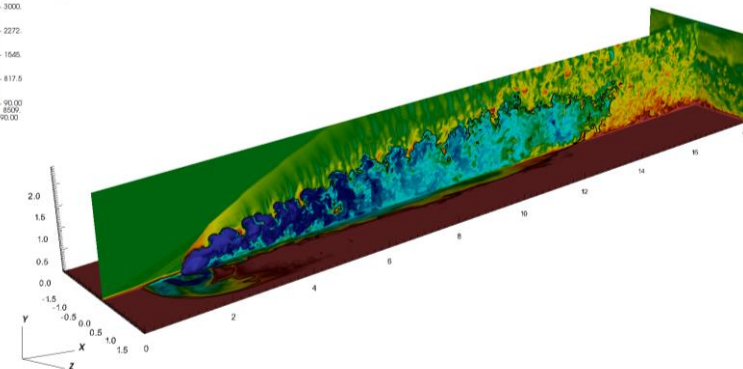
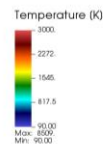
- Adaptive Mesh Refinement
- Parallelisation on CPU & GPU
- Embedded boundaries

### PeleC

- Fully compressible Navier-Stokes
- FV, PPM
- TVD Runge-Kutta 2
- Smagorinsky LES

### PelePhysics

- Detailed transport and chemistry properties
- ARK ODE solver



## Turbulence modelling

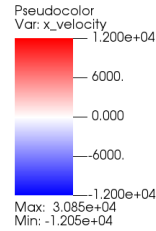
- Smagorinsky model for momentum and energy equations ( $C_S=0.1$ ,  $Pr_T=0.7$ )
- Implicit turbulent dissipation for species

## Combustion modelling

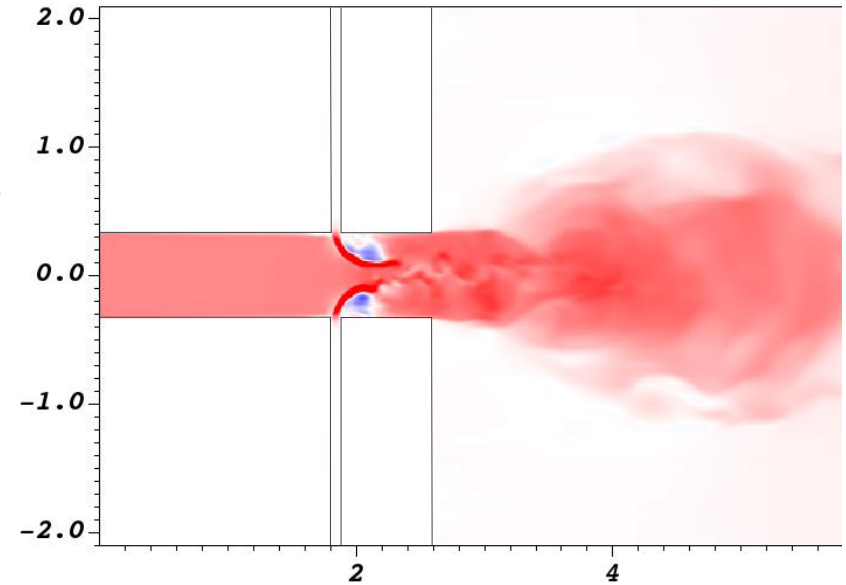
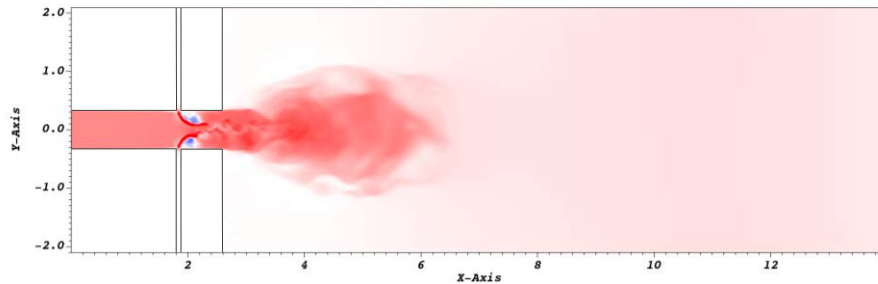
- Quasi-laminar,  $\overline{\omega(\psi)} \approx \omega(\bar{\psi})$
- Smallest mesh size = 0.1 mm ~ hydrogen flame thickness
- 9 species 19 equation Li-Dryer chemical mechanism

# Results

## Overall flow field



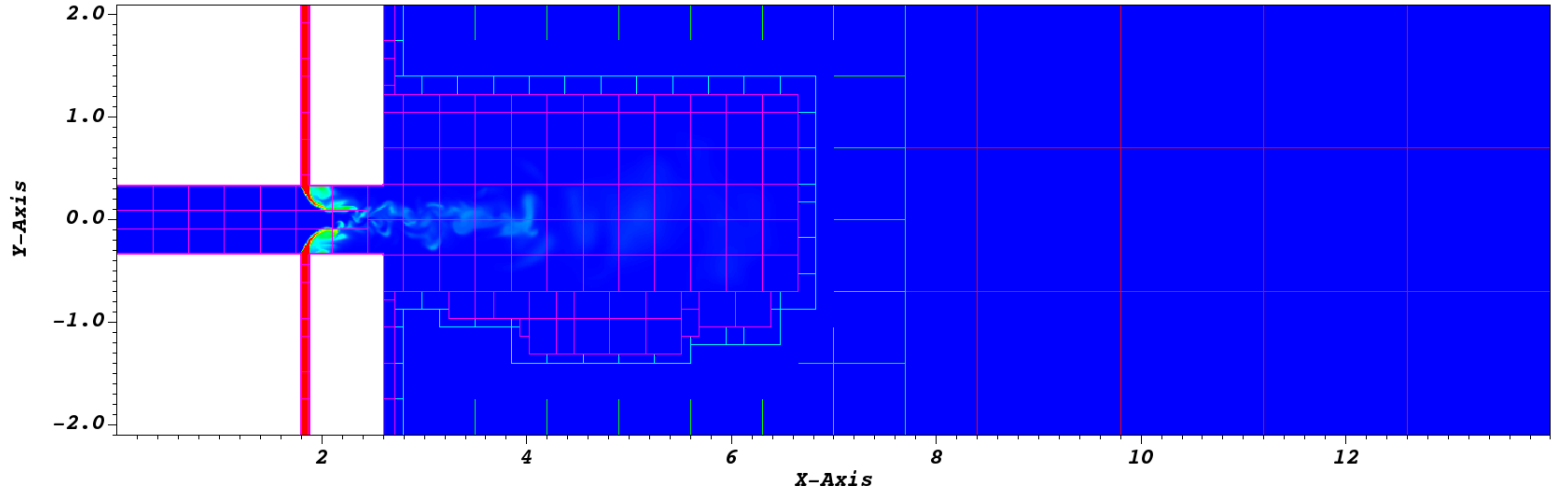
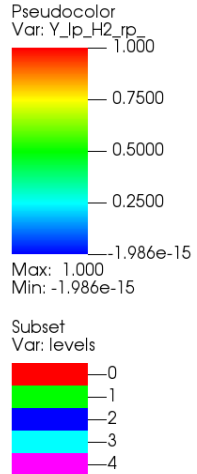
Cycle: 3500 Time:0.000929335





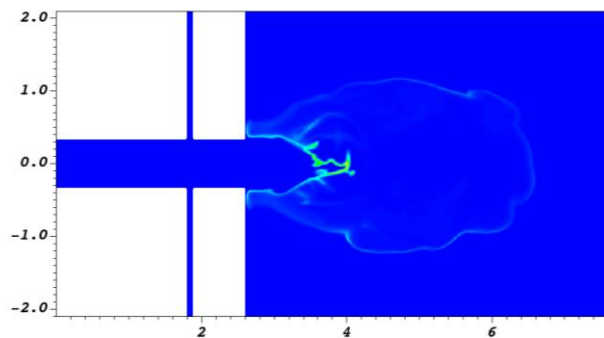
# Results

## AMR

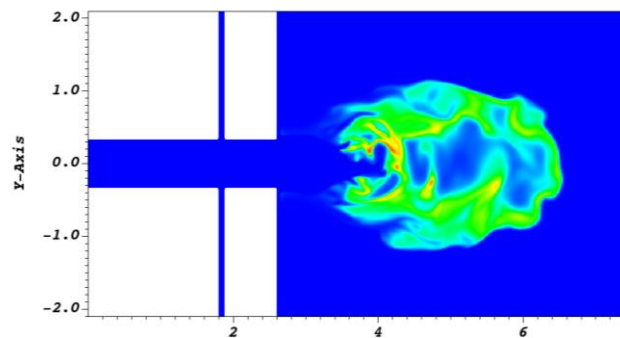


# Results

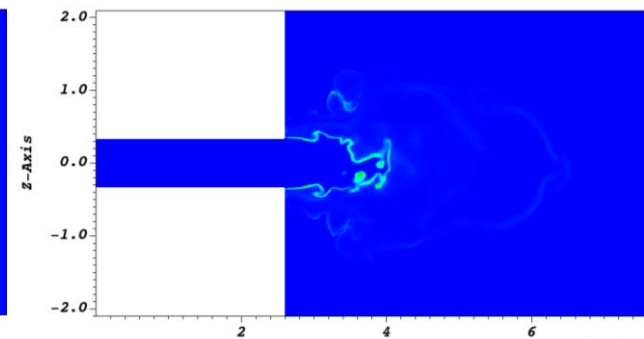
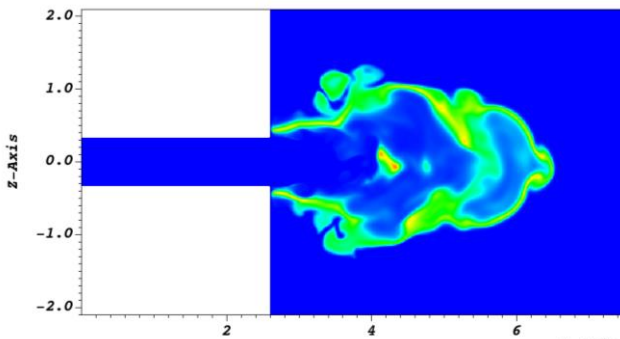
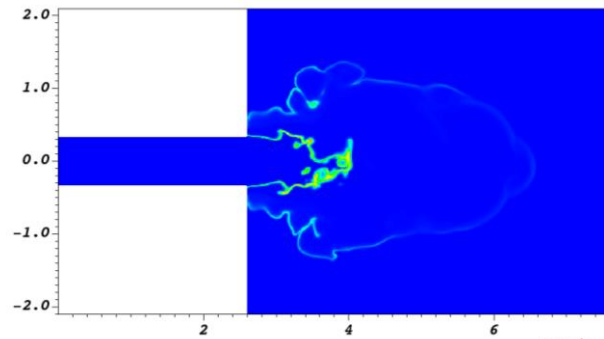
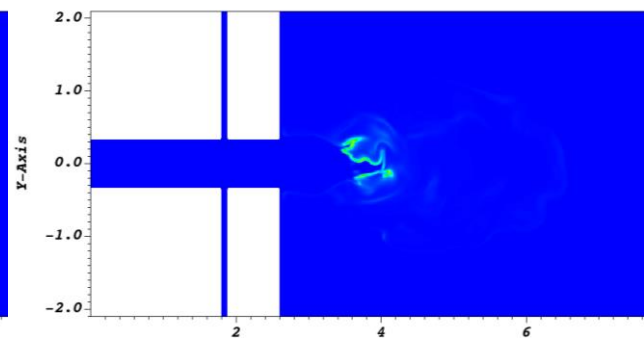
HO<sub>2</sub>



OH

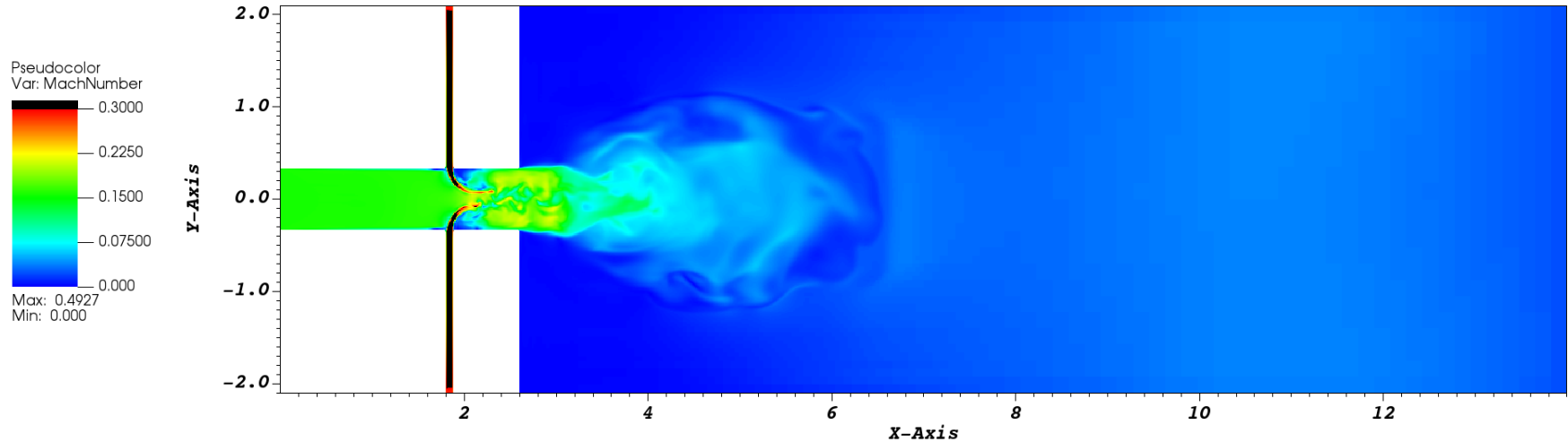


Heat release rate



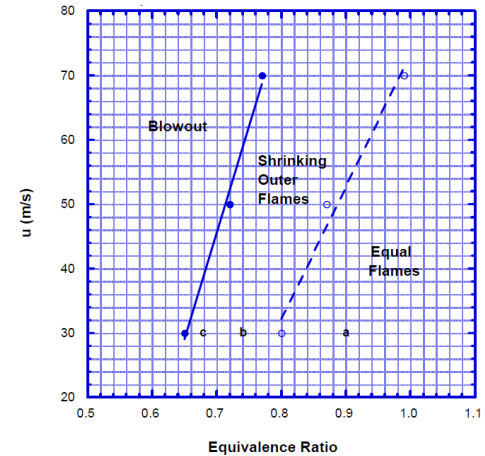
# Results

## Compressibility



## Summary & Future works

- LES of a lean hydrogen aeroengine combustor
- AMR + EB strategy for complex geometries
- Ignition difficulties
  
- Compare with experimental data
- Analyse the effect of equivalence ratio on flame stability
- Produce a stability map and explore the region between stable and unstable



**Thank you**

*Questions?*

---