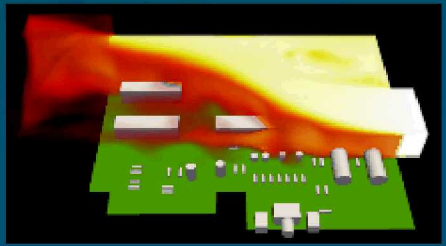
SAND2019-13855PE

RTD Calibration Results



PRESENTED BY

Tyler Voskuilen

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RTD Calibration

Multiple calibration runs on different boards

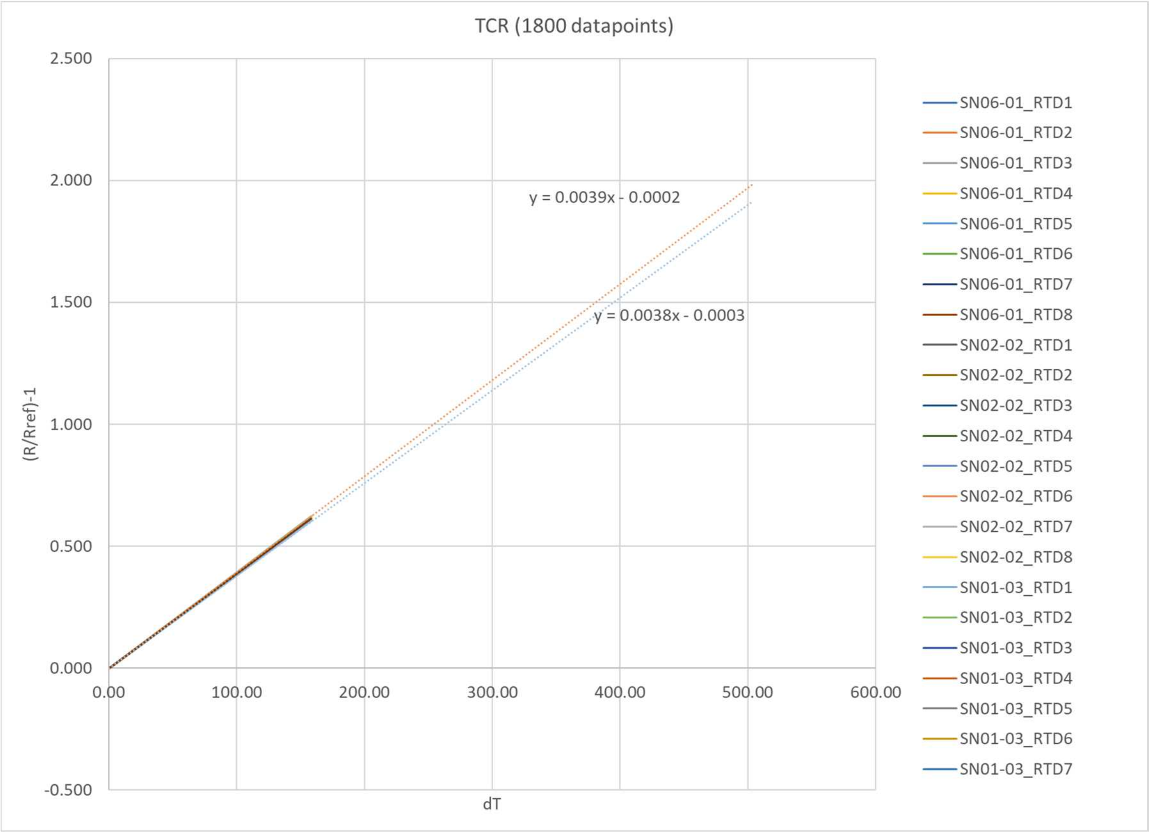
Coefficient of thermal resistance is very consistent between boards and sensors

- Also very close to expected literature value

Still need to quantify expected uncertainty in measured temperature

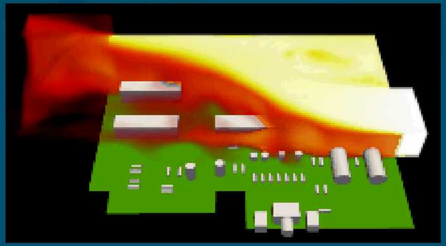
- In earlier calibration it was almost entirely due to uncertainty in CTR
- High-Low difference is 3.6%

Test components (wire insulation) started melting at upper temperature range



Voltage differences in 0-500 °C range are about 80 mV

Model Development Status Update



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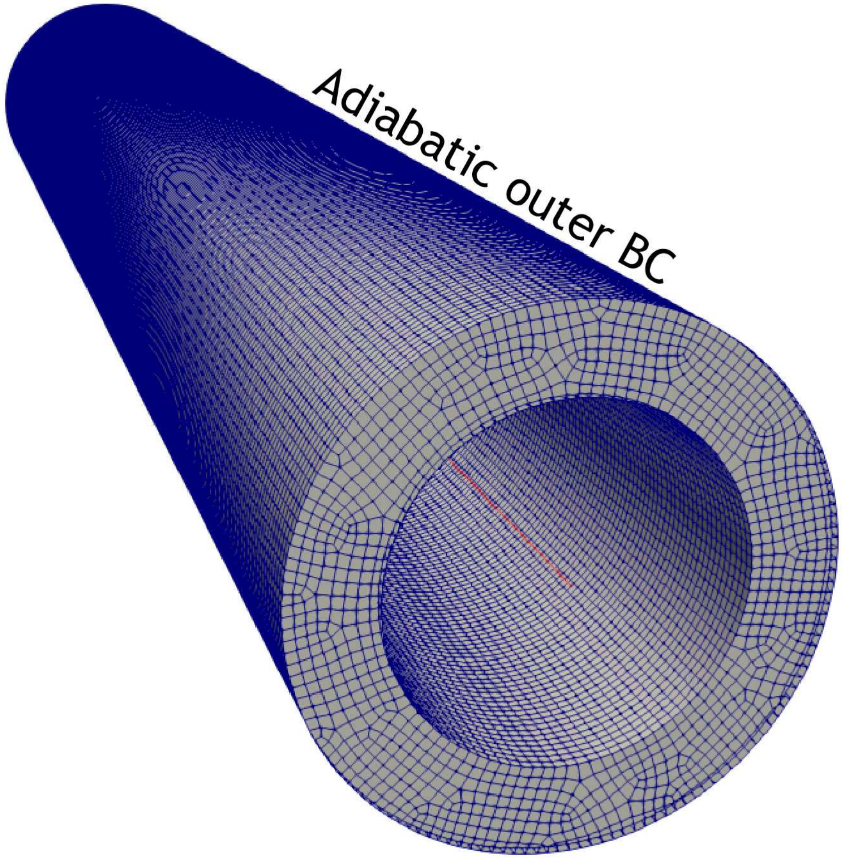
Overview

- Model geometries
- Tier descriptions
- Open questions
- Mini-tube comparisons

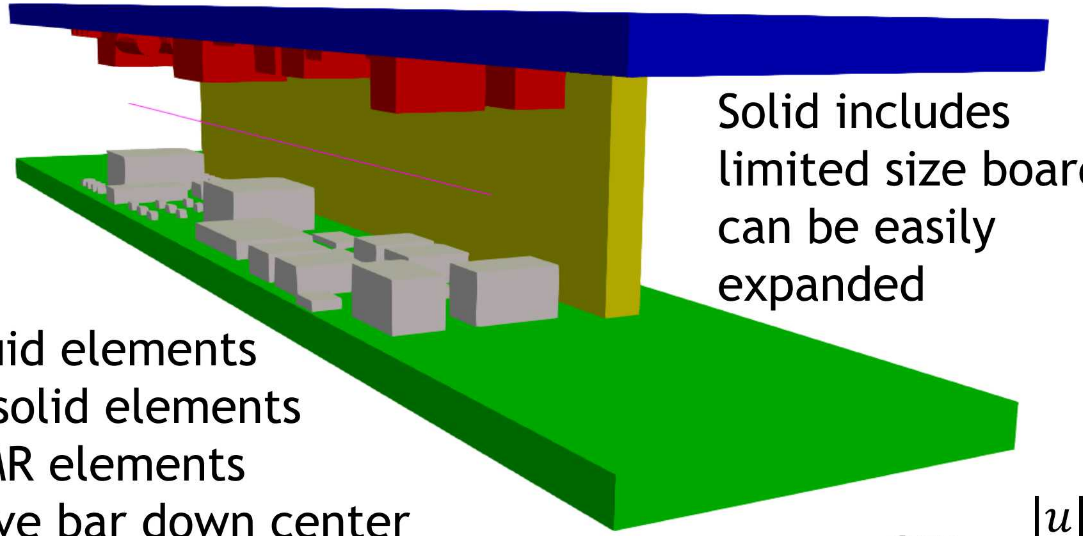
Model Geometries

Mini-Tube

310k elements
Advective bar down center



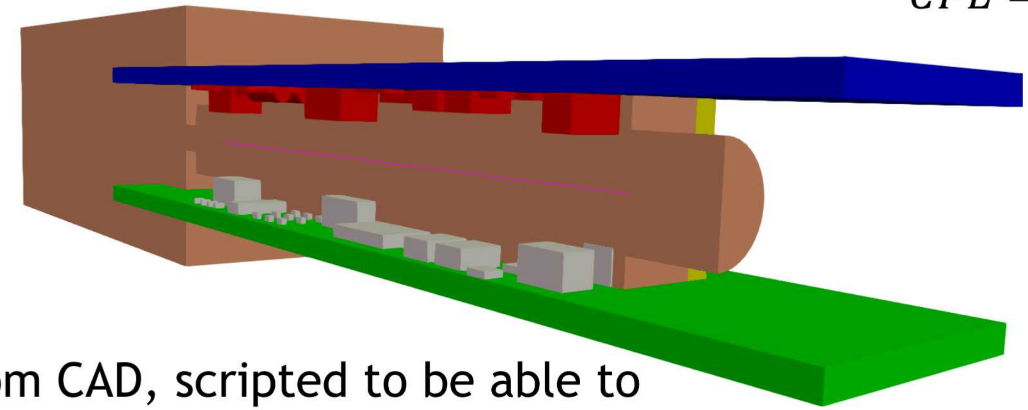
Sub-Box Small



Solid includes limited size boards – can be easily expanded

1-8M fluid elements
0.5-1M solid elements
500k PMR elements
Advective bar down center

$$CFL = \frac{|u|\Delta t}{\Delta x}$$



Built from CAD, scripted to be able to remove components and remesh easily

Advective Bar

The "Advective bar" (or just "bar") is a simplified conjugate heat transfer model in Sierra/Aria

The "bar" is a 1D block on which a basic mass and energy balance is solved

The "bar" is coupled to the thermal solve through a user-selected heat transfer correlation that accounts for local property changes (Re, Pr, etc…)

Correlations typically have large uncertainty – especially when applied to reacting depositing flows

Question 1: How well can we match the mini-tube results using an advective bar?

Question 2: How well does an advective bar that matches the mini-tube predict behavior in sub-box small?

Model Tiers (SBS)

Tier 1 (Complete)

PMR

DES Turbulence

3D CHT (Fuego/Aria)

Option for advective bar (Aria/Aria)

Tier 2 (In Progress)

Thermal decomposition and charring of board materials
- Changes thermal properties
- Produces CH_4

Gas-phase combustion (EDC)
- Complete (O_2 + CH_4)
- Torch output relatively low in O_2 (Tiger)

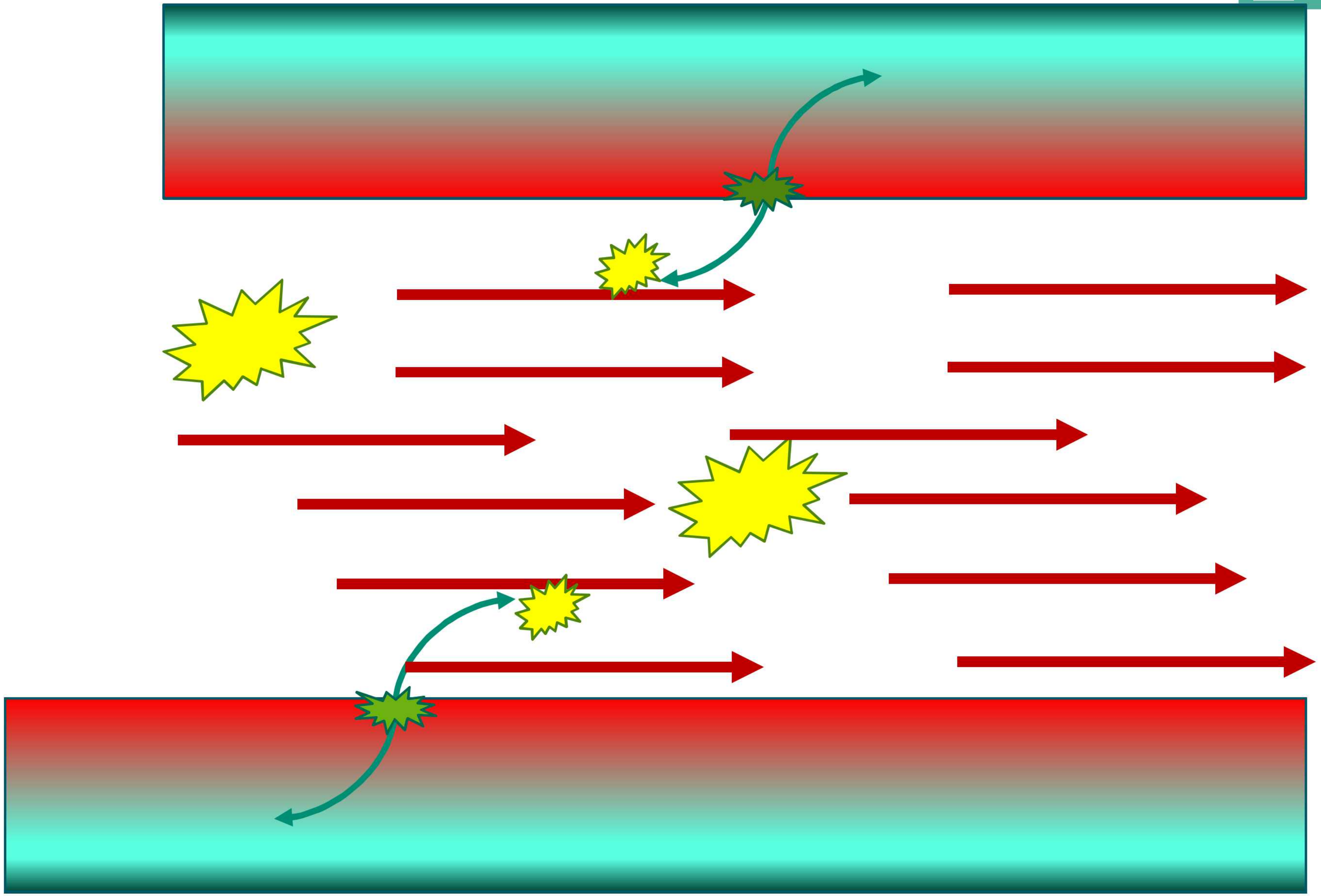
Tier 3 (Planned)

Deposition of KCl on surfaces
- Deposits latent heat of vaporization
- Adds insulating layer

Tier 2: Overview

Physics added

- Reacting gas
- Reacting boards
- Outgassing boards



Tier 2: Details

Fluid Domain

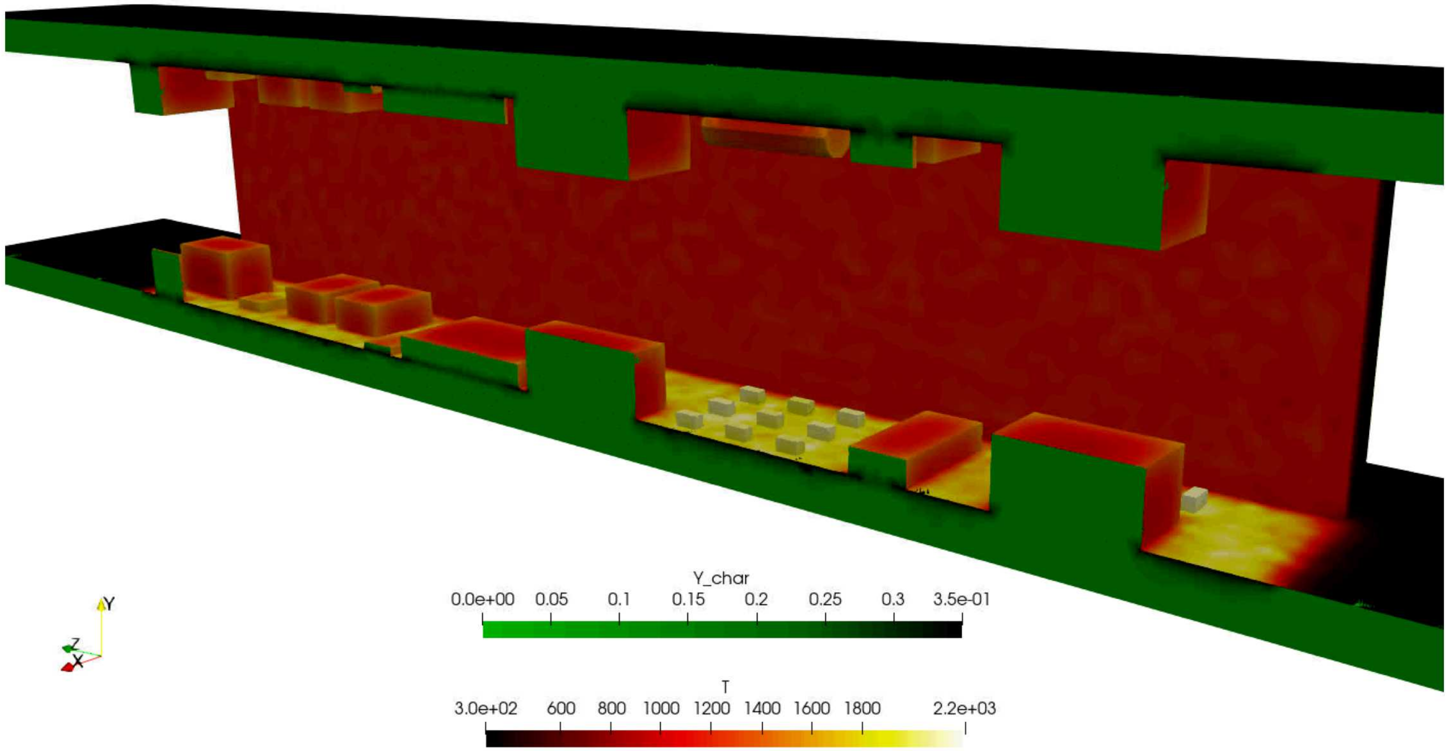
- Magnussen's Eddy Dissipation Concept (EDC)
  - Hydrocarbon + oxygen combustion
  - Turbulent, well mixed gas
  - Integral representation of combustion effects

Solid Domain

- Irreversible chemical reactions
  - Epoxy → $0.5CH_4$+0.5Char
- Model gas transport through domain
  - diffusion, porous flow

Interface

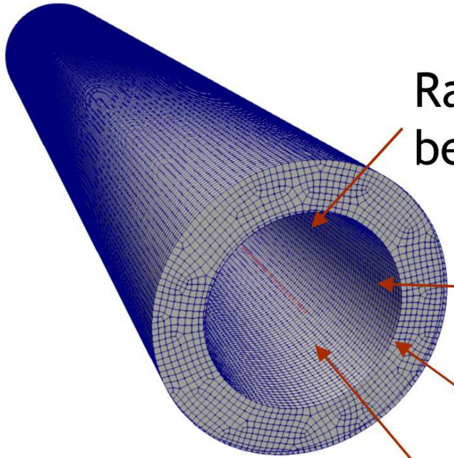
- 1 or 2 way coupling



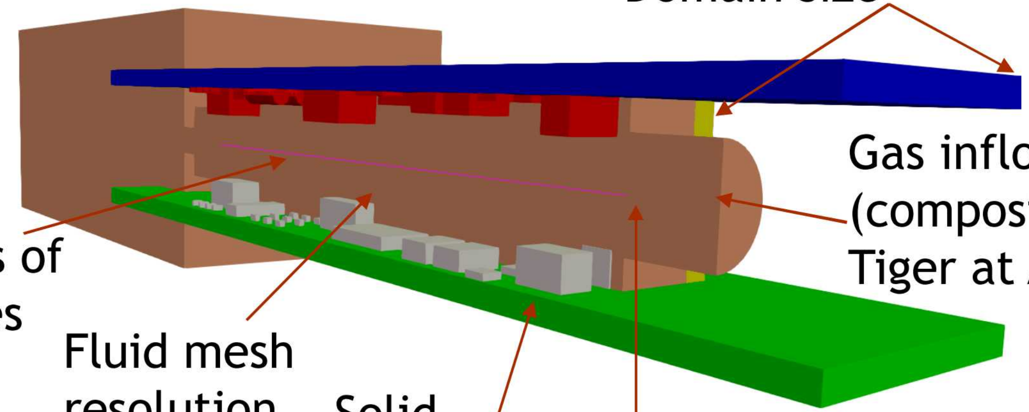
Key Model Inputs & Outputs

Inputs

Mini-Tube



Sub-Box Small



Outputs

- Gas exit temperature
- Tube surface temperatures at TC locations
- Energy added to the tube

- Gas exit temperature
- Pressure drop
- Board temperatures at RTD locations
- Full temperature statistics (avg, min, max)
- Bio burden reduction (% of the volume)

Key Questions

What is the inflow condition (exiting the combustion chamber)?

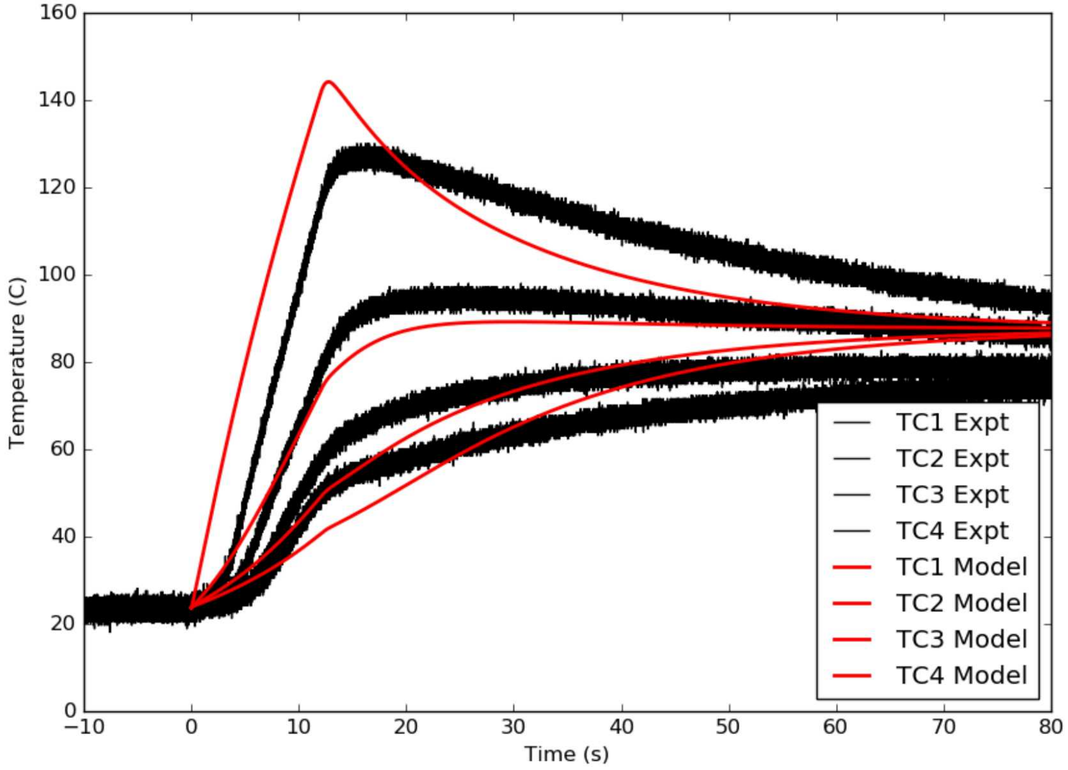
- Tiger predicts adiabatic flame temperature of 2708 K for this mixture
- Initial tube test showed < 200 ^{o}C measured combustion chamber temperature

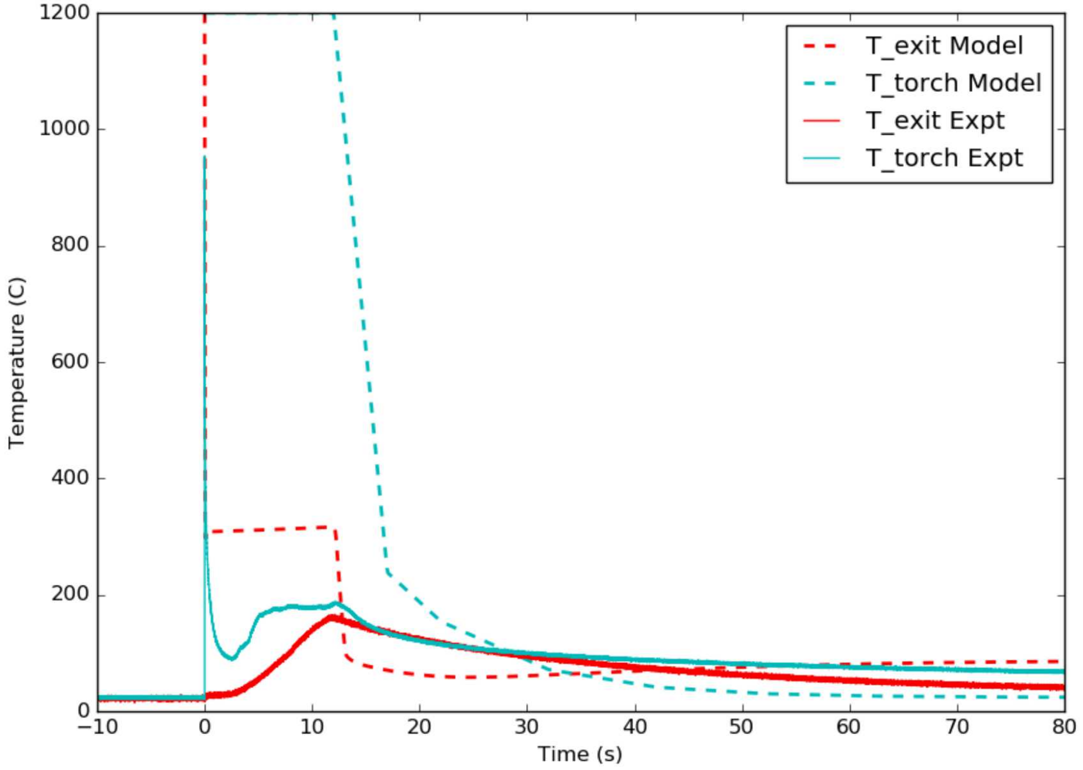
- Plan is to use the tube data as much as possible to better understand the input conditions

How does the mass flow rate change during the burn?

- Could be qualitative from pressure traces and test videos of exhaust and transparent combustion chamber

Preliminary Data (Shot 73)





Adjusted combustion temperature to 1200 ^{o}C (using 2708 K over-predicted T by a lot)

Due to deposition on surfaces?

Low temperatures in both combustion chamber and exhaust

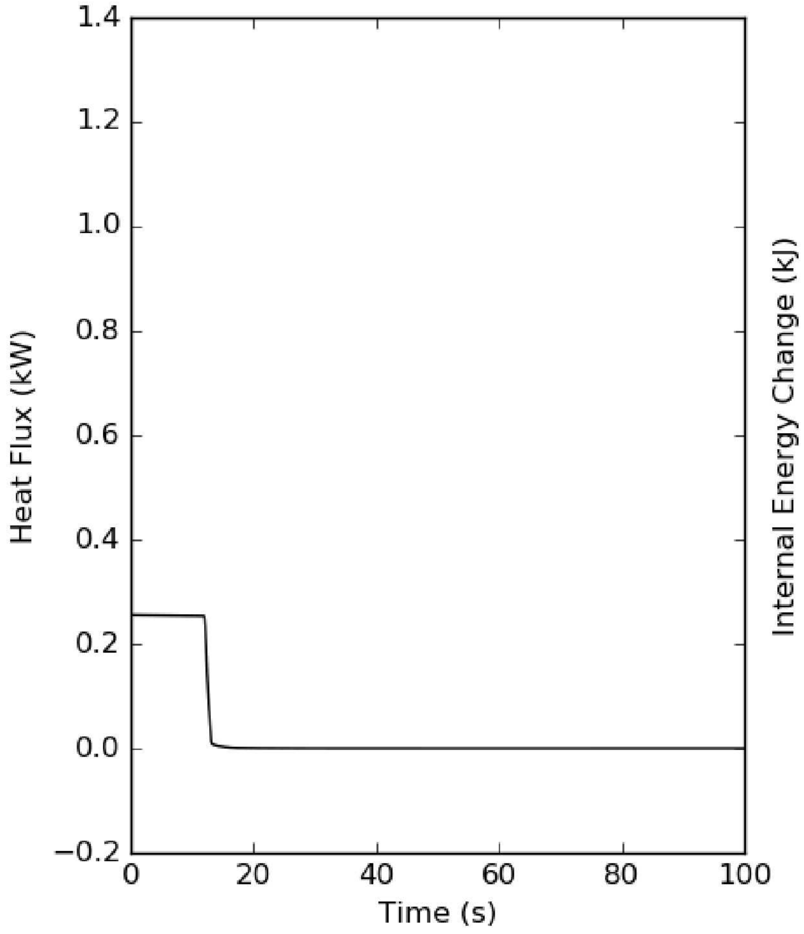
Long cooldown time?
What size is the exit TC?
When did the burn really start? After a 2-3 s lag?

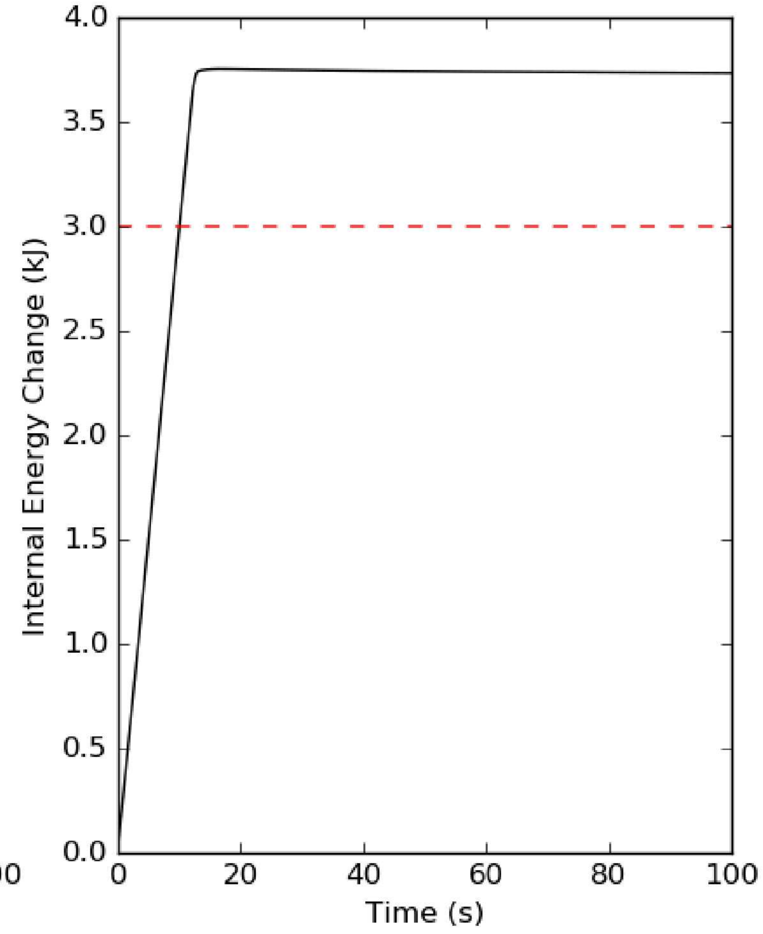
Energy Balances

Goal was simply to match approximate final temperatures to calculate energy deposited

Target of 3 kJ was based on 1.5 MJ/kg

Achieved close to 1.9 MJ/kg





Current & Planned Activities

1. Finish Tier 2 development (Phil)
2. Explore parameter space with mini-tube model/test data to better understand the inflow conditions (should we wait for test data with the modified combustion chamber?) (Kevin)
3. Begin Tier 3 development (Tyler)
4. Run SBS Tier 1 with chip configuration planned for first tests (Depends on #2)
5. Run SBS Tier 2 and assess impact of additional physics (Depends on #1 & 2)
6. Run SBS Tier 3 and assess impact of additional physics (Depends on #1, 2, & 3)