Introducing the Engine Combustion Network

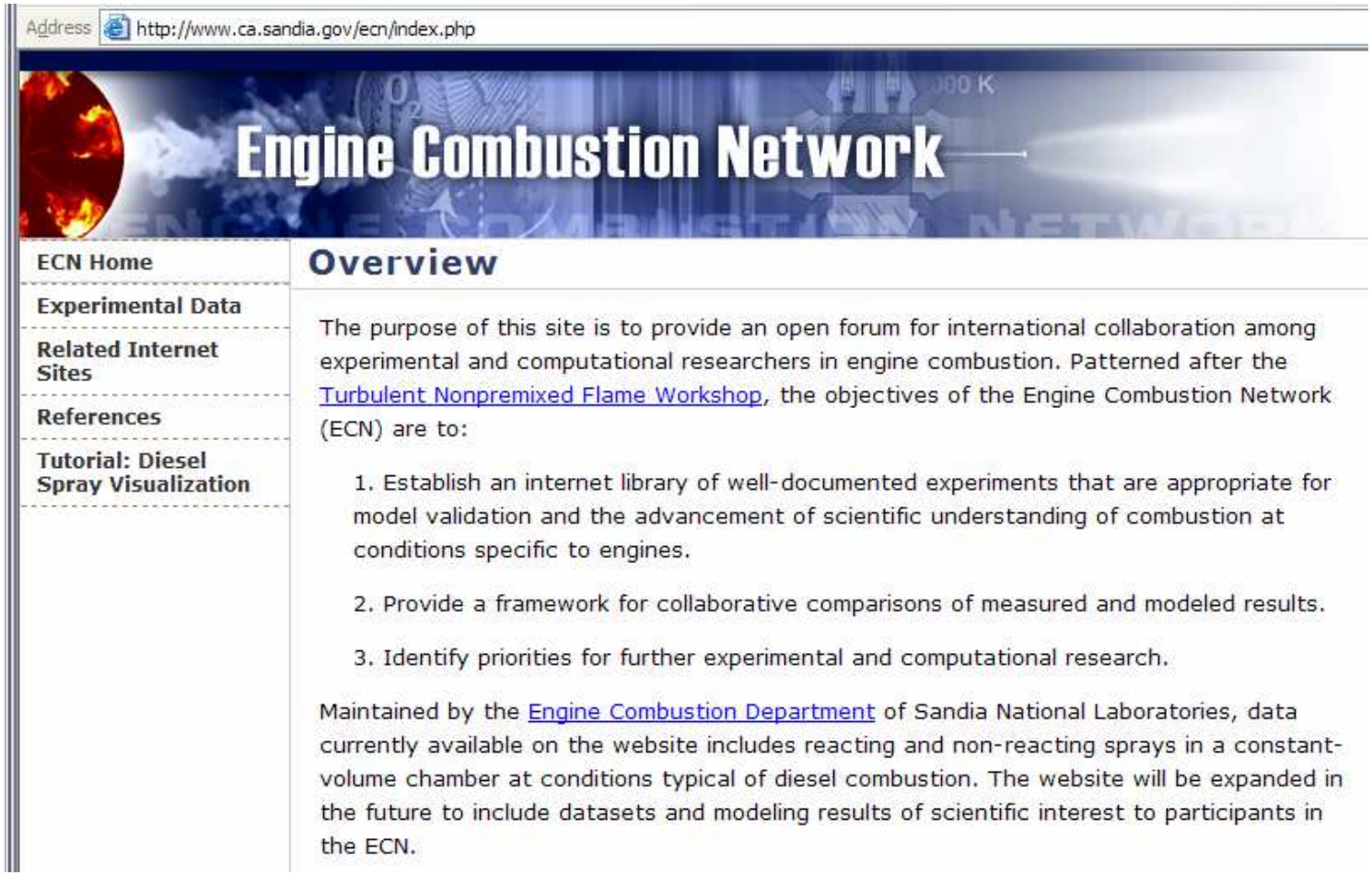
Lyle M. Pickett

Sandia National Laboratories

Sponsor: ***DOE Office of Vehicle Technologies***
Program Manager: Gurpreet Singh

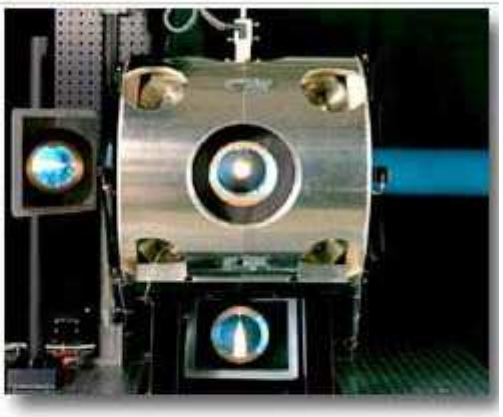
Engine Combustion Network

- **Collaborative modeling/experimental website started.**
- **http://www.ca.sandia.gov/ECN**



Engine Combustion Network

Constant-Volume Diesel Combustion



A wide range of ambient (charge-gas) environments can be simulated at the time of fuel injection in this facility, allowing the effect of each variable to be assessed. With full optical access, the following ambient conditions can be generated:

- Ambient gas temperatures from 450 K to 1300 K
- Ambient gas densities from 3 to 60 kg/m^3
- Ambient gas oxygen concentrations from 0% to 21%

These conditions span or exceed those typically experienced in a diesel engine.

Fuel is injected using common-rail fuel injectors with the following parameter range:

- Injection pressures above ambient from 40 to 200 MPa
- Nozzle sizes from 0.05 to 0.5 mm
- #2 diesel, single-component reference (n-heptane, cetane), and oxygenated fuels

The data obtained in this facility is useful for model development and validation because of the well-defined boundary conditions and the wide range of conditions employed. (Go to experimental data search).

Links at the left describe the methods for generating these conditions, the diagnostics applied, and the archival data acquired in the facility.

Accurate models require accurate boundary conditions.

- **Vessel and ambient gases**
  - **Temperature spatial distribution and fluctuation**
  - **Pressure/density**
  - **Ambient gas composition (N_2, O_2, CO_2, H_2O, minor species)**
  - **Velocity/turbulence**
  - **Geometry**

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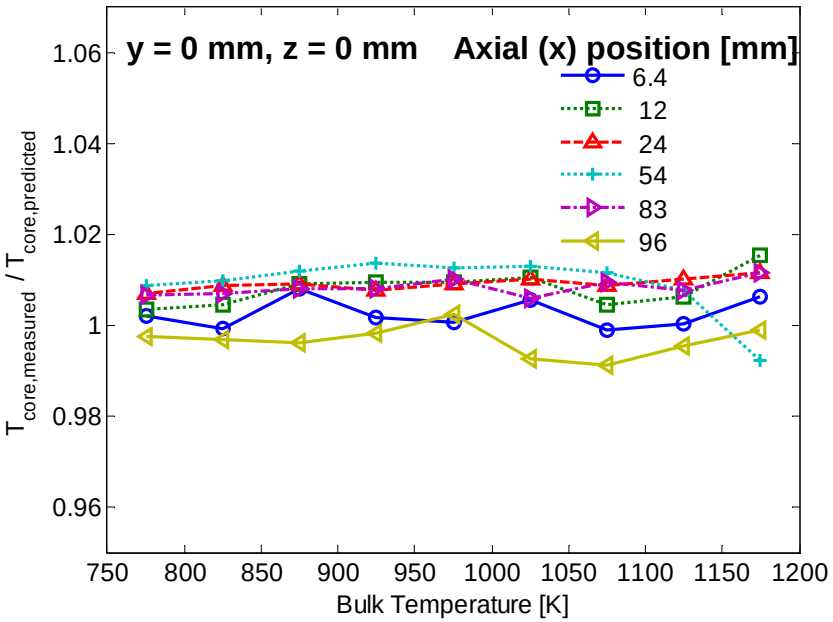
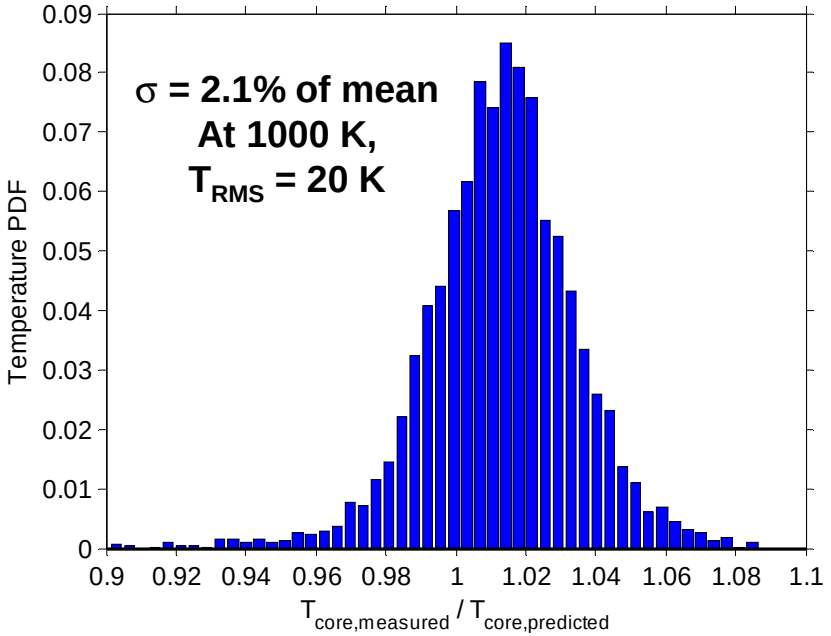
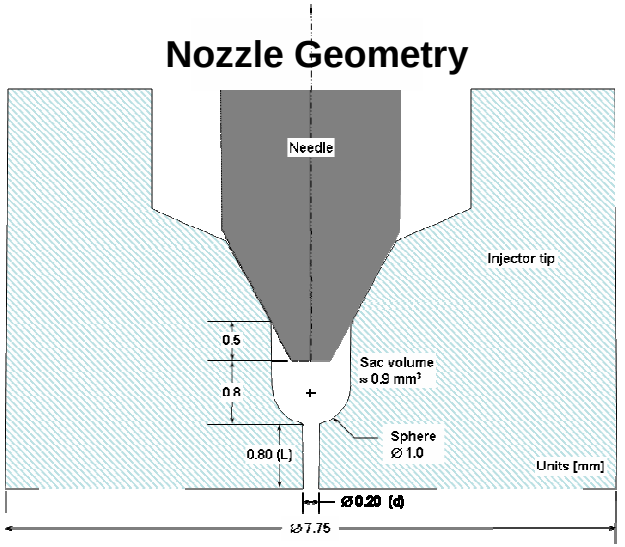
Average Temperature Distribution During Vessel Cool Down

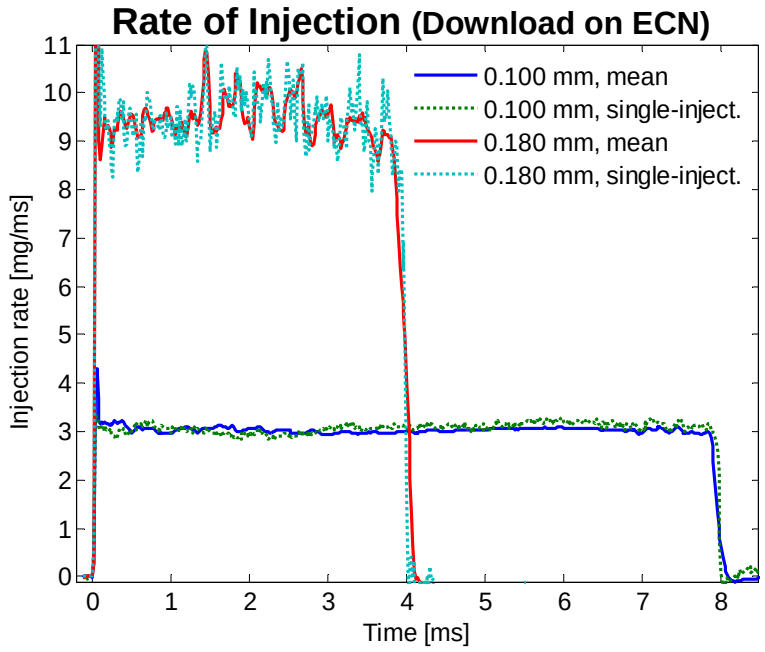


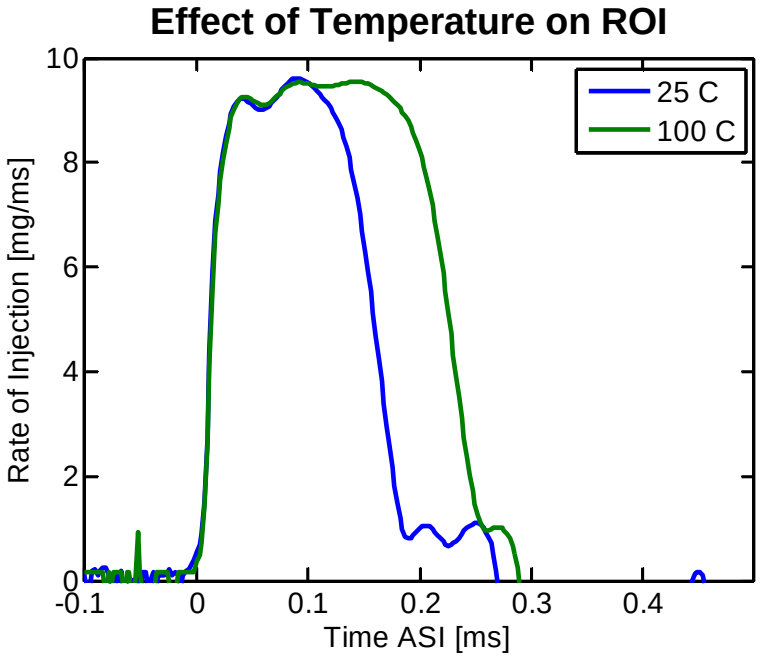
Local Temperature Variation During Vessel Cool Down



- **Injector and Nozzle BCs**
  - **Injection pressure**
  - **Geometry and flow coefficients**
    - **Discharge and area contraction**
    - **K factor, hydro-erosion**
    - **Molds/x-ray tomography of internal geometry**
  - **Rate of injection**
  - **Temperature**
    - **Affects fuel density, viscosity, and ROI, $\Delta\tau_{inj}$.**
  - **Fuel**
    - **Preference to defined surrogate fuels.**

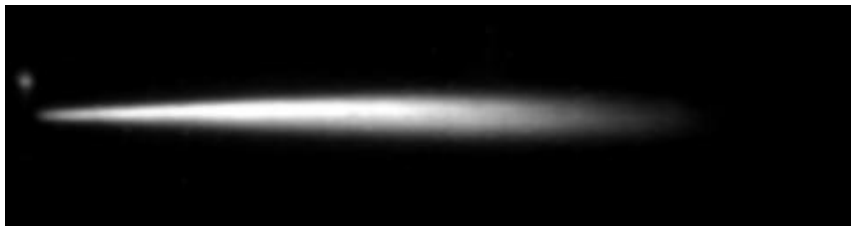




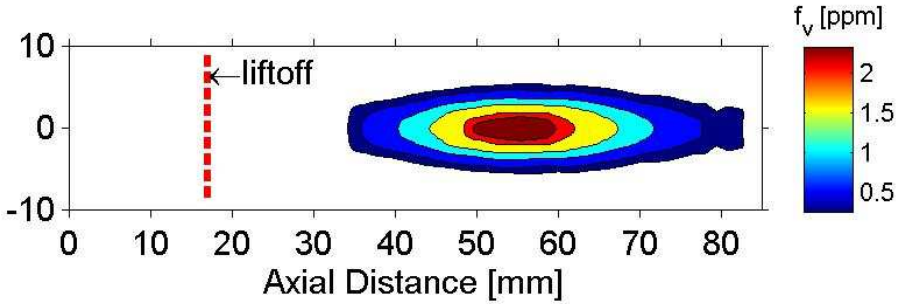


Data available on the website

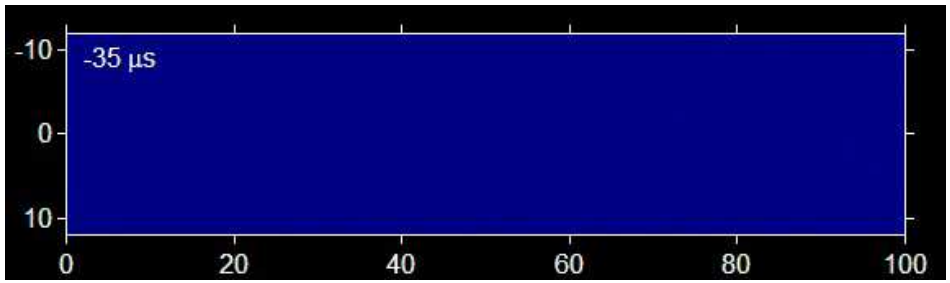
- **Liquid Penetration Length**



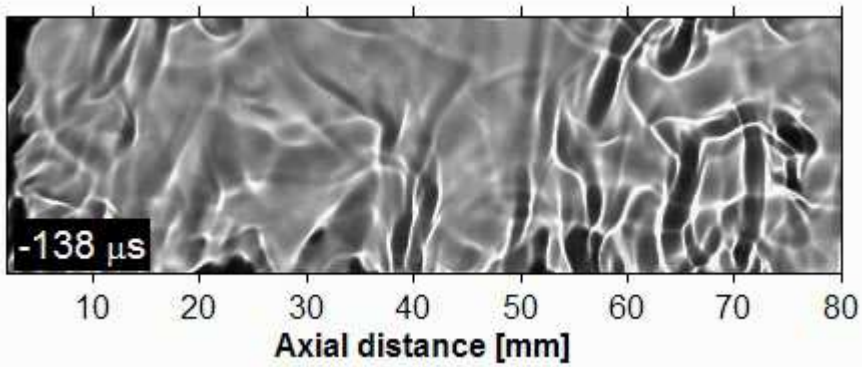
- **In-situ soot volume fraction**



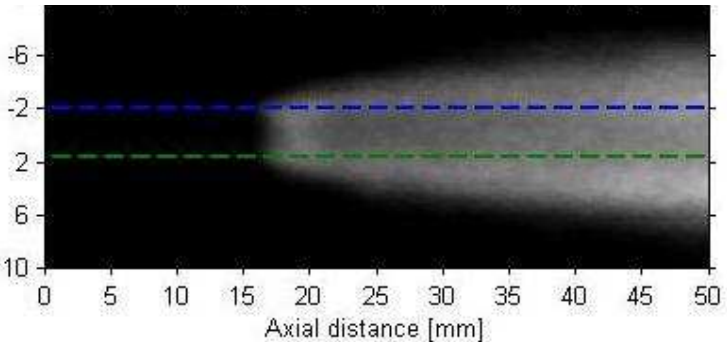
- **High-speed Movies (reacting)**



- **Jet Penetration (non-reacting)**



- **Lift-off Length**
- **Ignition Delay**



- **Data obtained over the past 10 years at well-characterized ambient and injector conditions.**

Easy to find data with search utility

- **Temperature Variation**

DATA SEARCHING UTILITY
Simply click on values to narrow selection or choose select conditions below.
Results will be displayed after query yields less than 200 records.
* Baseline Condition Diesel * Baseline Condition n-heptane * Soot vs Inj Press * Soot vs Ambient O
reset search * Soot vs Orifice Diameter * All Soot Measurements

Experimental Type	Ambient O_2 [%]	Ambient T [K]	Amb Dens [kg/m3]	Inj Press [MPa]
ALL	ALL	ALL	ALL	ALL
Soot	21	800	14.8	138
Lift-Off Length		850		
Ignition Delay		900		
Jet Penetration		950		
Liquid Length		1000		
High Speed Movie		1100		
		1200		
		1300		

Expand results table to show more data columns
Click here for the Column header definitions
Tabular data may be copied and pasted into delimited text or Excel file.

O_2 [%]	T_a [K]	ρ_a [kg/m^3]	d [mm]	Inj P [MPa]	Fuel Type	Fuel T_{fl} [K]	Liquid Length [mm]	Lift-Off Length [mm]	Ign Dly [ms]	Pres Rise [MPa]
21	800	14.8	0.180	138	D2	436	0	65.2	2.12	none
21	850	14.8	0.180	138	D2	436	0	41	1.24	none
21	900	14.8	0.180	138	D2	436	0	31.2	0.88	none
21	950	14.8	0.180	138	D2	436	0	24.7	0.69	none
21	1000	14.8	0.180	138	D2	436	0	21.8	0.56	none
21	1100	14.8	0.180	138	D2	436	0	15.9	0.38	none
21	1200	14.8	0.180	138	D2	436	0	12.5	0.29	none
21	1300	14.8	0.180	138	D2	436	0	9.2	0.23	none

- **EGR Variation (Baseline n-heptane)**

DATA SEARCHING UTILITY
Simply click on values to narrow selection or choose select conditions below.
Results will be displayed after query yields less than 200 records.
* Baseline Condition Diesel * Baseline Condition n-heptane * Soot vs Inj Press * Soot vs Ambient O2
reset search * Soot vs Orifice Diameter * All Soot Measurements

Experimental Type	Ambient O_2 [%]	Ambient T [K]	Amb Dens [kg/m3]	Inj Press [MPa]	Noz Diam [mm]	Fuel Type	T_{Fuel} [K]
ALL	ALL	ALL	ALL	ALL	ALL	ALL	ALL
Soot	0	1000	14.8	150	0.100	NHPT	373
Lift-Off Length	21						
Ignition Delay	15						
Jet Penetration	12						
Liquid Length	10						
High Speed Movie	8						

Expand results table to show more data columns
Click here for the Column header definitions
Tabular data may be copied and pasted into delimited text or Excel file.

O_2 [%]	T_a [K]	ρ_a [kg/m^3]	d [mm]	Inj P [MPa]	Fuel Type	Fuel T_{fl} [K]	Liquid Length [mm]	Lift-Off Length [mm]	Ign Dly [ms]	Press Rise [MPa]	Soot f_V [ppm] [mm] [mm]	Movies	Jet Penetrate
0	1000	14.8	0.100	150	NHPT	373	9.2	0	0	none	none	Shadow	PenvsTime
21	1000	14.8	0.100	150	NHPT	373	0	17	0.53	PvsT	img f_v x y	Soot; Chemi.	none
15	1000	14.8	0.100	150	NHPT	373	0	23.4	0.73	PvsT	img f_v x y	Soot; Chemi.	none
12	1000	14.8	0.100	150	NHPT	373	0	29.2	0.95	PvsT	img f_v x y	Soot; Chemi.	none
10	1000	14.8	0.100	150	NHPT	373	0	35.1	1.13	PvsT	img f_v x y	Soot; Chemi.	none
8	1000	14.8	0.100	150	NHPT	373	0	42.3	1.52	PvsT	img f_v x y	Chemi.	none

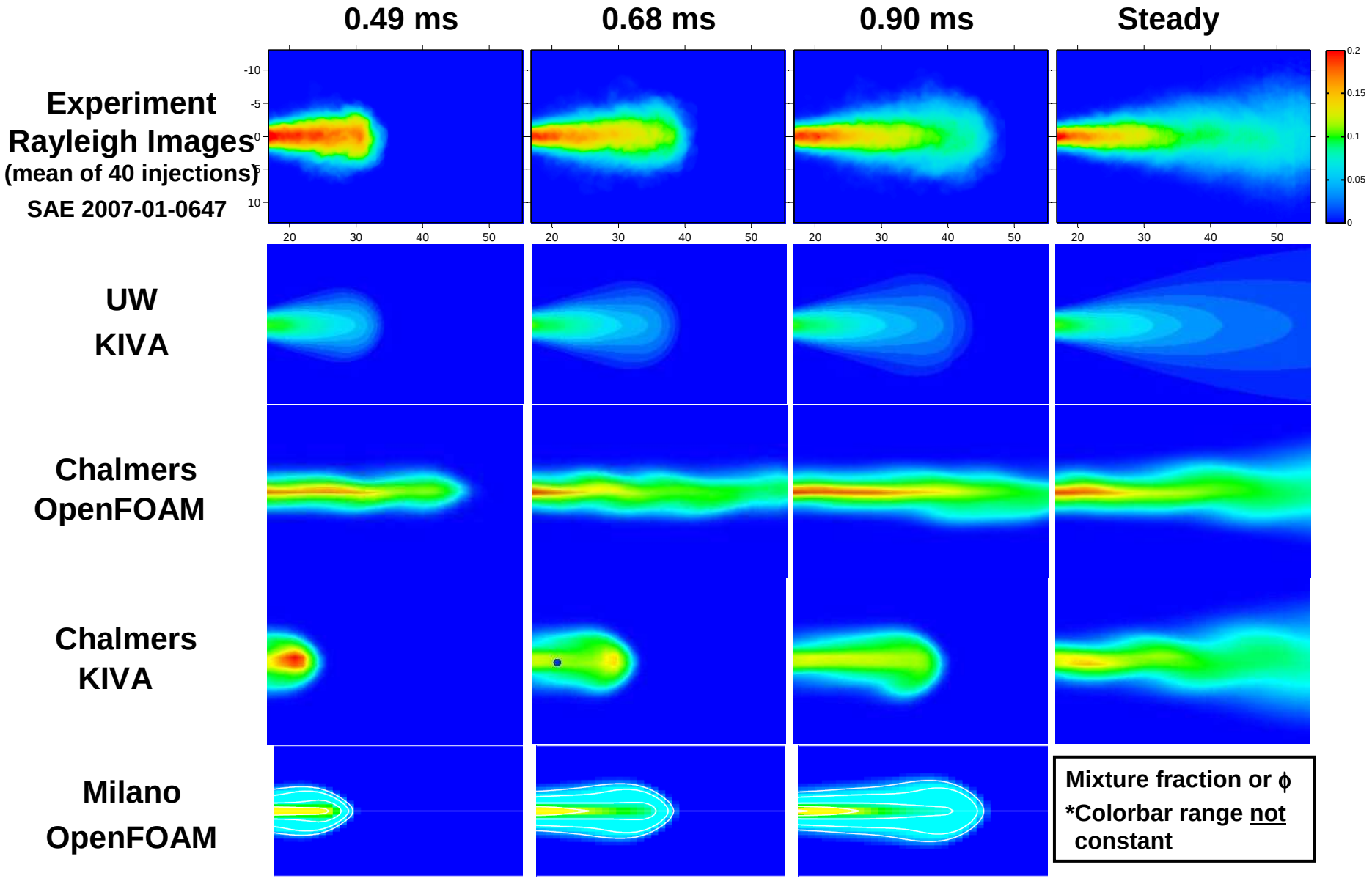
Modeling of "baseline n-heptane condition" by multiple groups.

- **Four papers at this year's SAE Congress**

Paper	Authors	Code/Emphasis
SAE 2008-01-1331 Thurs. 9:00 AM	Vishwanathan, Reitz *University of Wisconsin*	KIVA-CHEMKIN Lift-off and Soot
SAE 2008-01-0968 Mon. 1:30 PM	Campbell, Hardy, Gosman *Imperial College*	STAR-CD ECFM3Z
SAE 2008-01-0961 Mon. 11:00 AM	Karrholm, Tao, Nordin *Chalmers University*	OpenFOAM+KIVA Lift-off and Ignition
SAE 2008-01-0954 Mon. 10:00 AM	D'Errico, Ettorre, Lucchini *Politecnico di Milano*	OpenFOAM Eddy Dis. + PSR

- **Above authors have been kind enough to share detailed modeling results for comparison to ECN data.**
  - **Compiled in this presentation.**

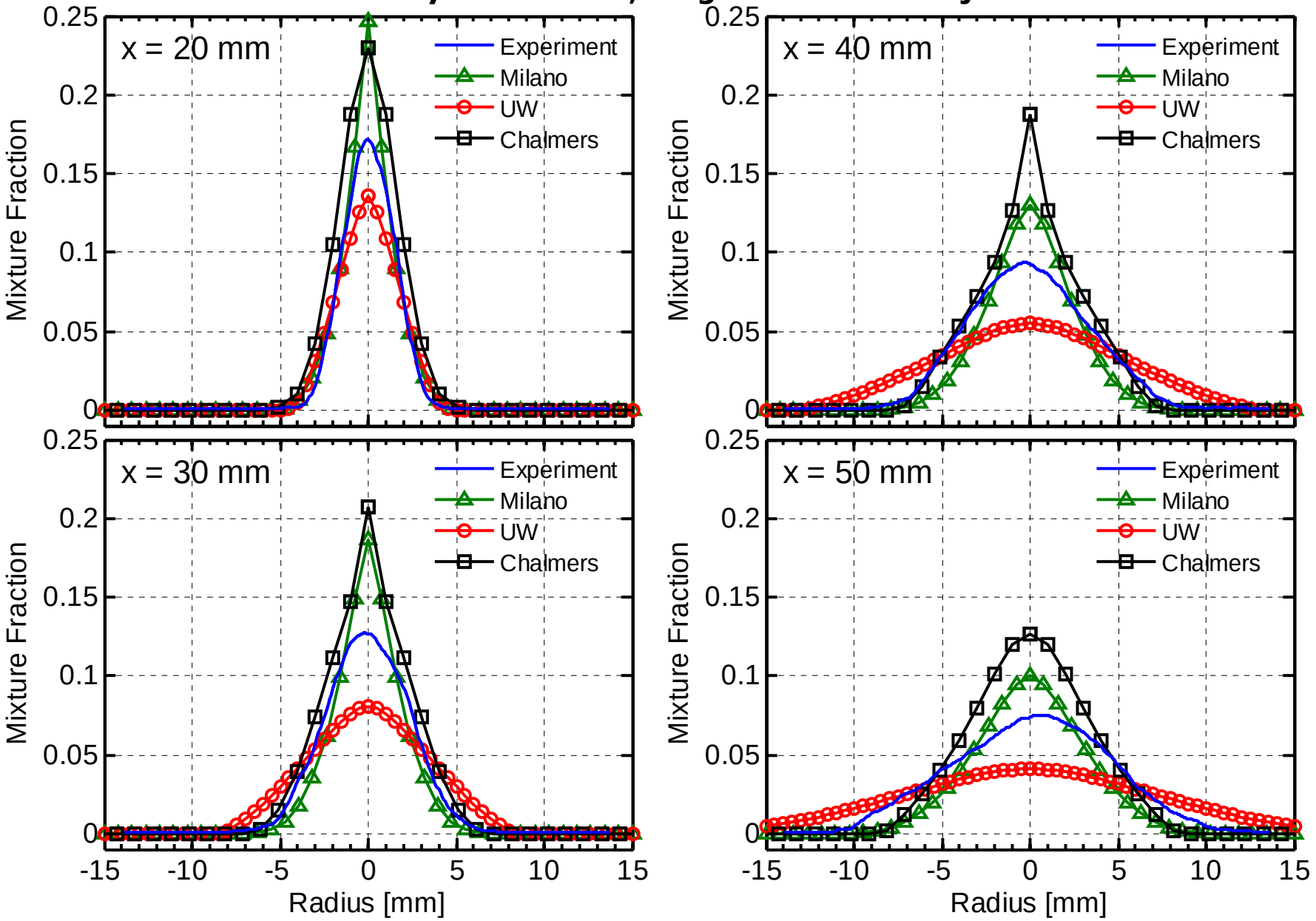
Baseline n-heptane conditions--Non-reacting
Ambient: 0% O_2, 1000 K, 14.8 kg/m^3, 42 bar
Injector: n-heptane, 1542 bar, 373 K, 0.100 mm nozzle



Detailed comparison

Non-reacting (0% O_2) Baseline n-heptane conditions

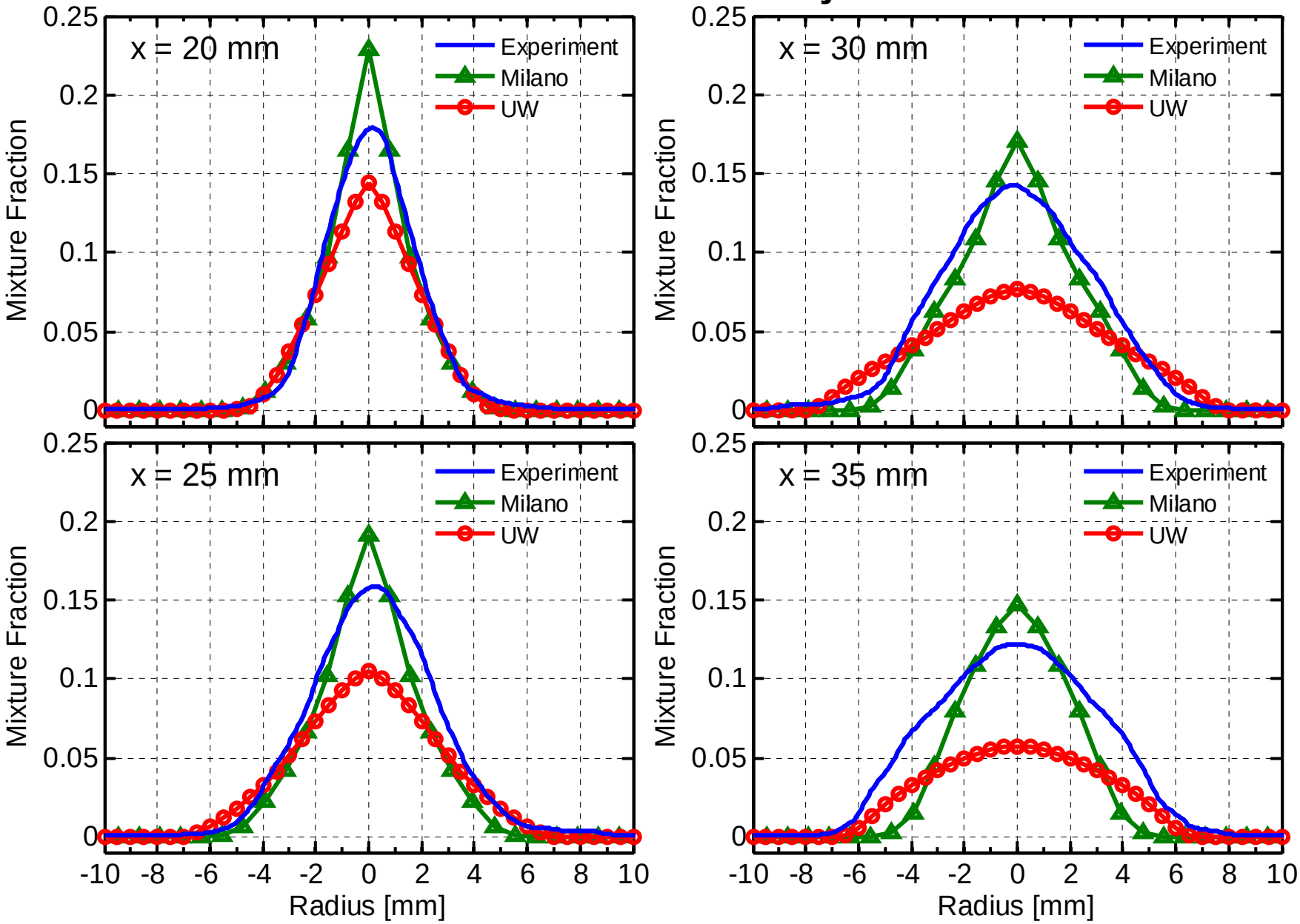
"Steady" conditions, long after start of injection



Detailed comparison

Non-reacting (0% O_2) Baseline n-heptane conditions

0.68 ms after start of injection



Future of the ECN

- **Other experimental results added to the website.**
  - **Will include data from various facilities, including engines.**
  - **All facilities must adequately define boundary conditions.**
  - **Please approach us if you would like to participate.**
- **Improving accuracy of experimental techniques and quantifying uncertainties.**
  - **Detailed velocity (turbulence) distribution**
    - **In chambers**
    - **In non-reacting, vaporizing fuel jets**
    - **In reacting jets**
  - **Rate of injection compared using several techniques.**
  - **Experimental datasets repeated in other facilities.**
- **Forum for model comparison**
  - **Model results also posted to the website.**

Future of the ECN

- **Identification of a few key working conditions recommended for future experimental and modeling efforts.**
- **Suggested ambient conditions (LTC)**
  - **Ambient temperature 900 K**
  - **Ambient pressure 60 bar (ambient density 22.8 kg/m^3)**
  - **Ambient oxygen concentration 15% O_2 (High EGR)**
- **Injector conditions to be defined.**
  - **Participants will work with the same injector nozzle, nozzle shape, injection duration, fuel, fuel temperature and so forth.**
  - **Injectors to be shared amongst ECN participants.**