A WAY TO CHARACTERIZE THE RANGE OF VALIDITY OF A FIRE MODEL

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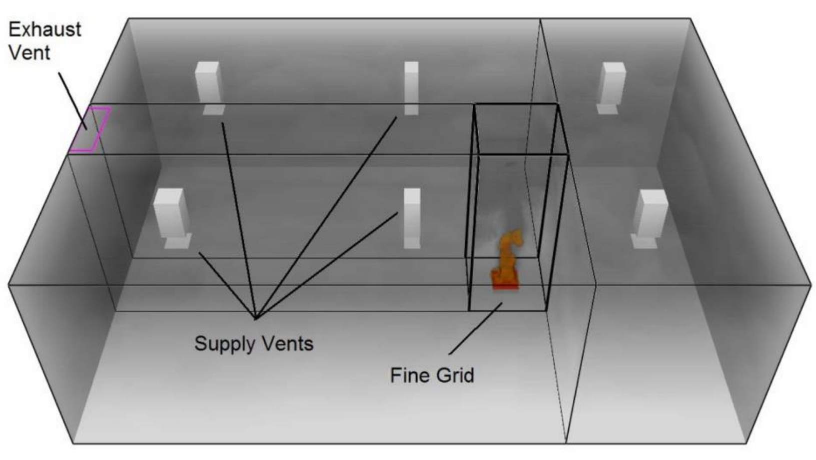
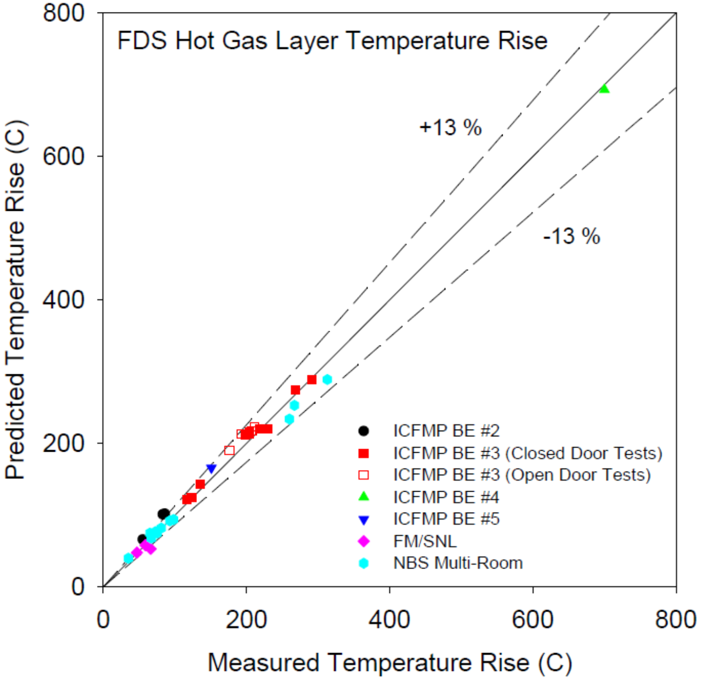
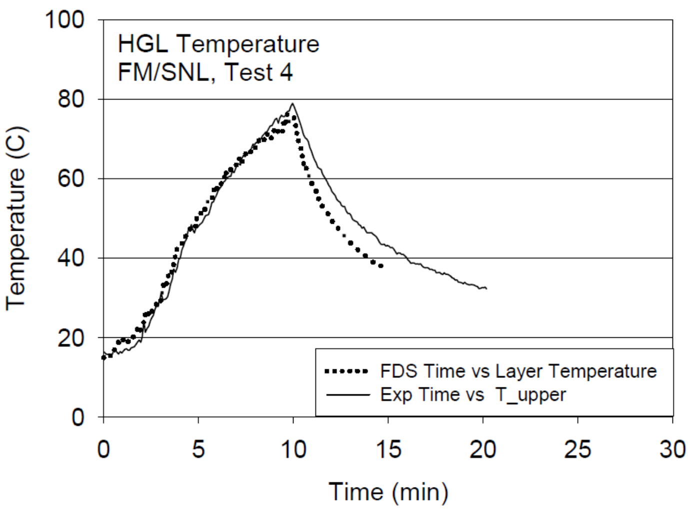
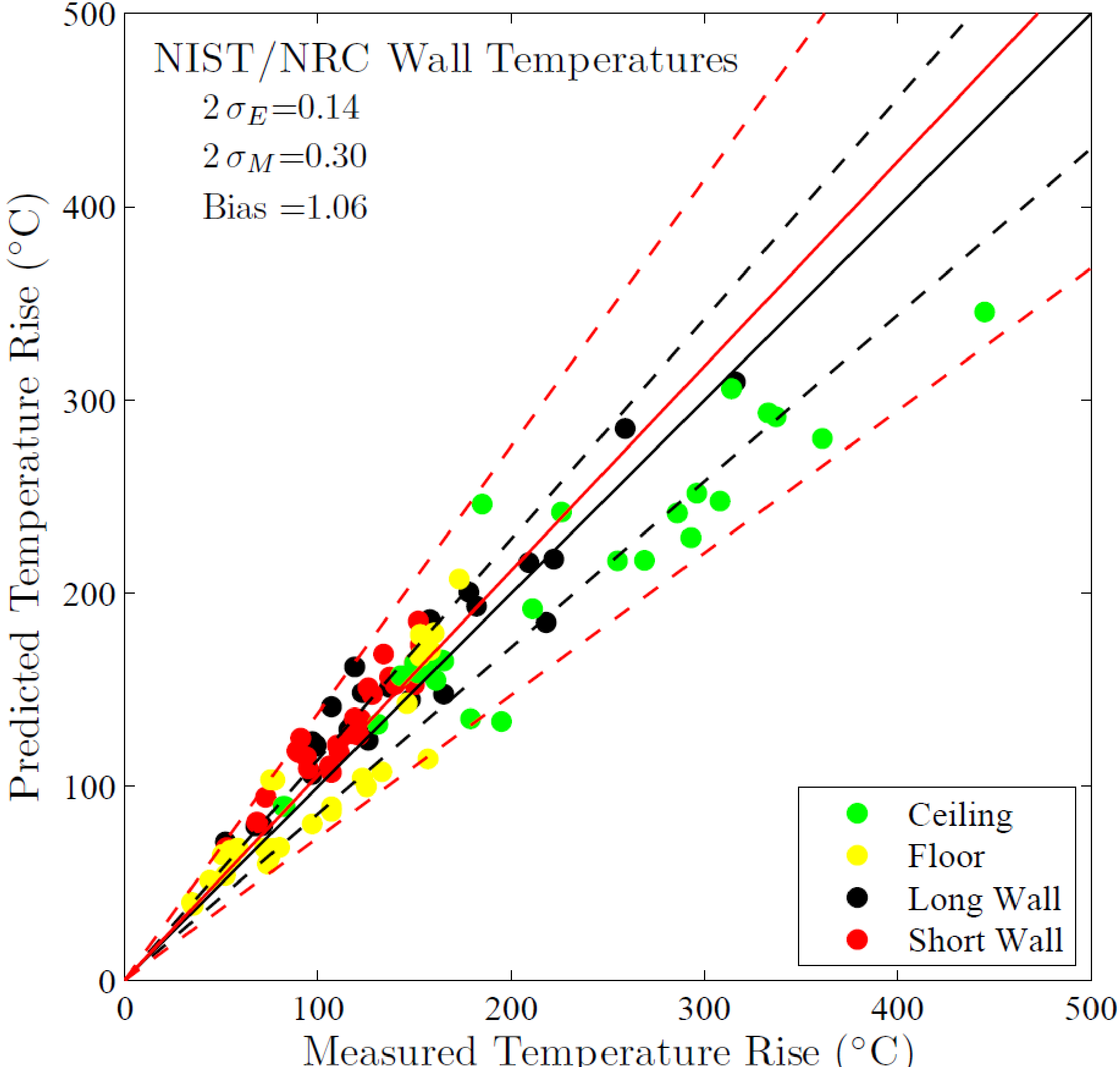
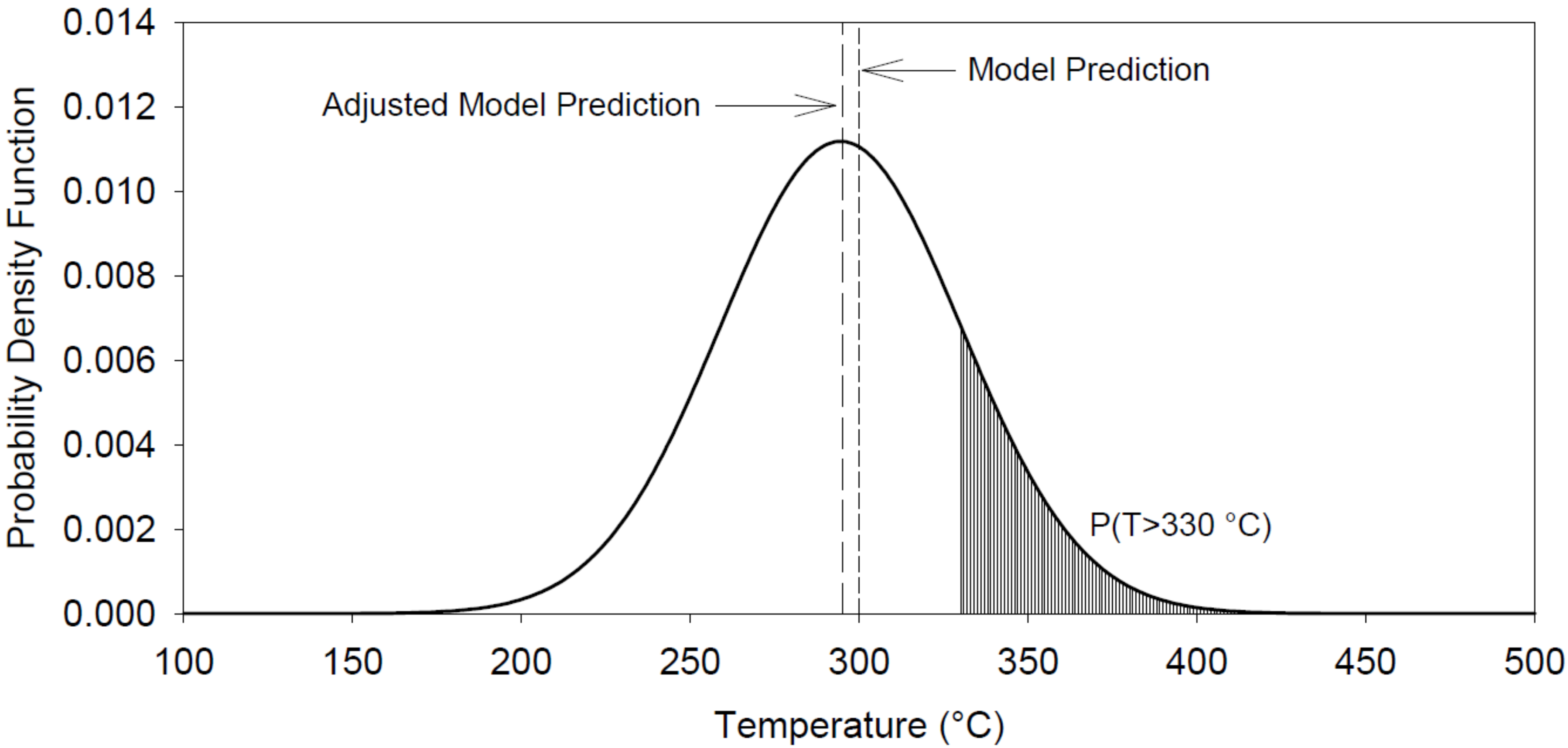
US NRC/EPRI Fire Model Validation Study
NUREG-1824








NIST/NRC Wall Temperatures
$2\,\sigma_E$=0.14
$2\,\sigma_M$=0.30
Bias =1.06
Ceiling
Floor
Long Wall
Short Wall
Predicted Temperature Rise (°C)
Measured Temperature Rise (°C)
0
100
200
300
400
500

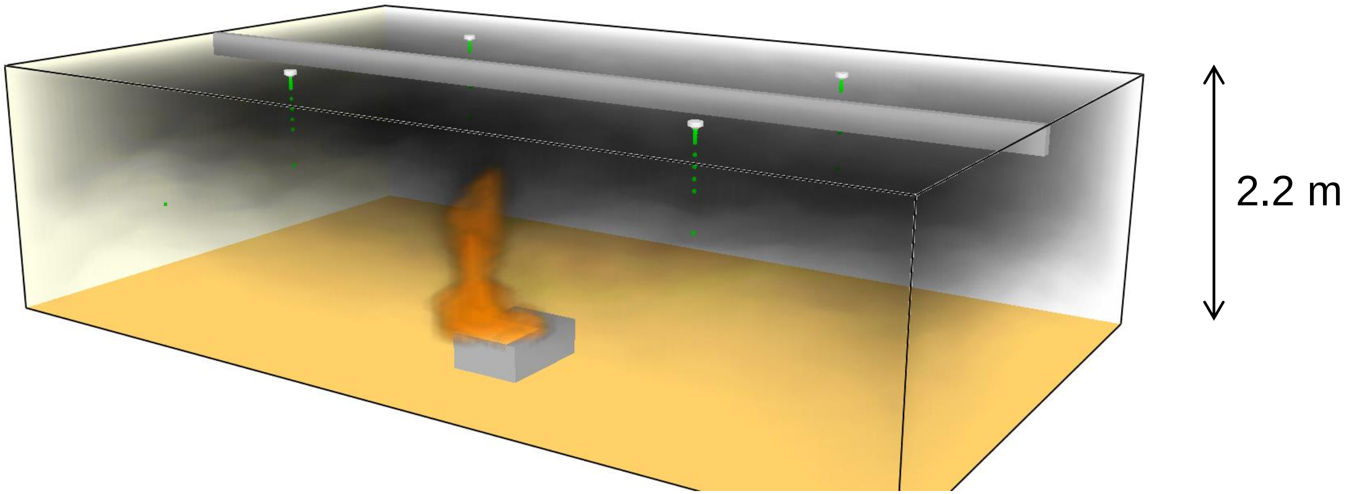


0.014
0.012
0.010
0.008
0.006
0.004
0.002
0.000
Probability Density Function
100
150
200
250
300
350
400
450
500
Temperature (°C)
Adjusted Model Prediction
Model Prediction
P(T>330 °C)

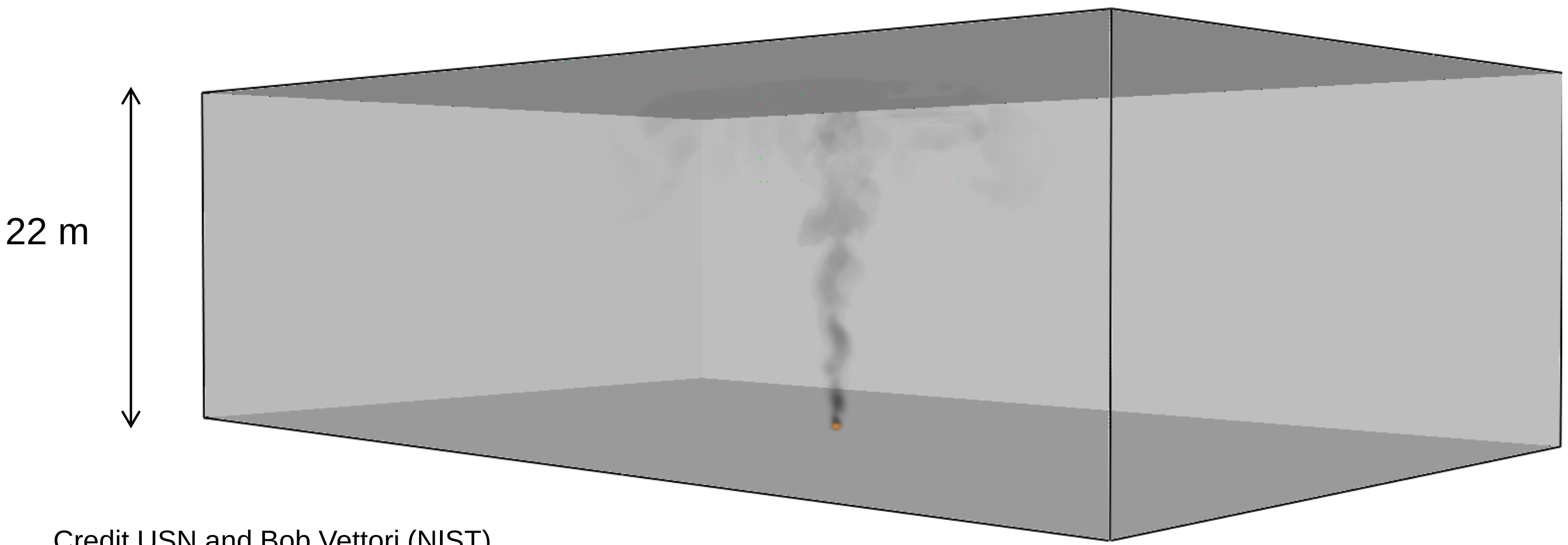
Output Quantity	FDTs		FIVE		CFAST		MAGIC		FDS		Exp
	δ	$\tilde{\sigma}_M$	δ	$\tilde{\sigma}_M$	δ	$\tilde{\sigma}_M$	δ	$\tilde{\sigma}_M$	δ	$\tilde{\sigma}_M$	$\tilde{\sigma}_E$
HGL Temperature Rise	1.44	0.25	1.56	0.32	1.06	0.12	1.01	0.07	1.03	0.07	0.07
HGL Depth	N/A		N/A		1.04	0.14	1.12	0.21	0.99	0.07	0.07
Ceiling Jet Temp. Rise	N/A		1.84	I.D.	1.15	I.D.	1.01	0.08	1.04	0.08	0.08
Plume Temperature Rise	0.73	I.D.	0.94	I.D.	1.25	0.28	1.01	0.07	1.15	I.D.	0.07
Flame Height*	I.D.	I.D.	I.D.	I.D.	I.D.	I.D.	I.D.	I.D.	I.D.	I.D.	I.D.
Oxygen Concentration	N/A		N/A		0.91	I.D.	0.90	0.18	1.08	0.14	0.05
Smoke Concentration	N/A		N/A		2.65	I.D.	2.06	I.D.	2.70	I.D.	0.17
Room Pressure Rise	N/A		N/A		1.13	0.37	0.94	0.39	0.95	0.51	0.20
Target Temperature Rise	N/A		N/A		1.00	0.27	1.19	0.27	1.02	0.13	0.07
Radiant Heat Flux	2.02	I.D.	1.42	0.55	1.32	0.54	1.07	0.36	1.10	0.17	0.10
Total Heat Flux	N/A		N/A		0.81	0.47	1.18	0.35	0.85	0.22	0.10
Wall Temperature Rise	N/A		N/A		1.25	0.48	1.38	0.45	1.13	0.20	0.07
Wall Heat Flux	N/A		N/A		1.05	0.43	1.09	0.34	1.04	0.21	0.10

I.D. indicates insufficient data for the statistical analysis.
N/A indicates that the model does not have an algorithm to compute the given Output Quantity

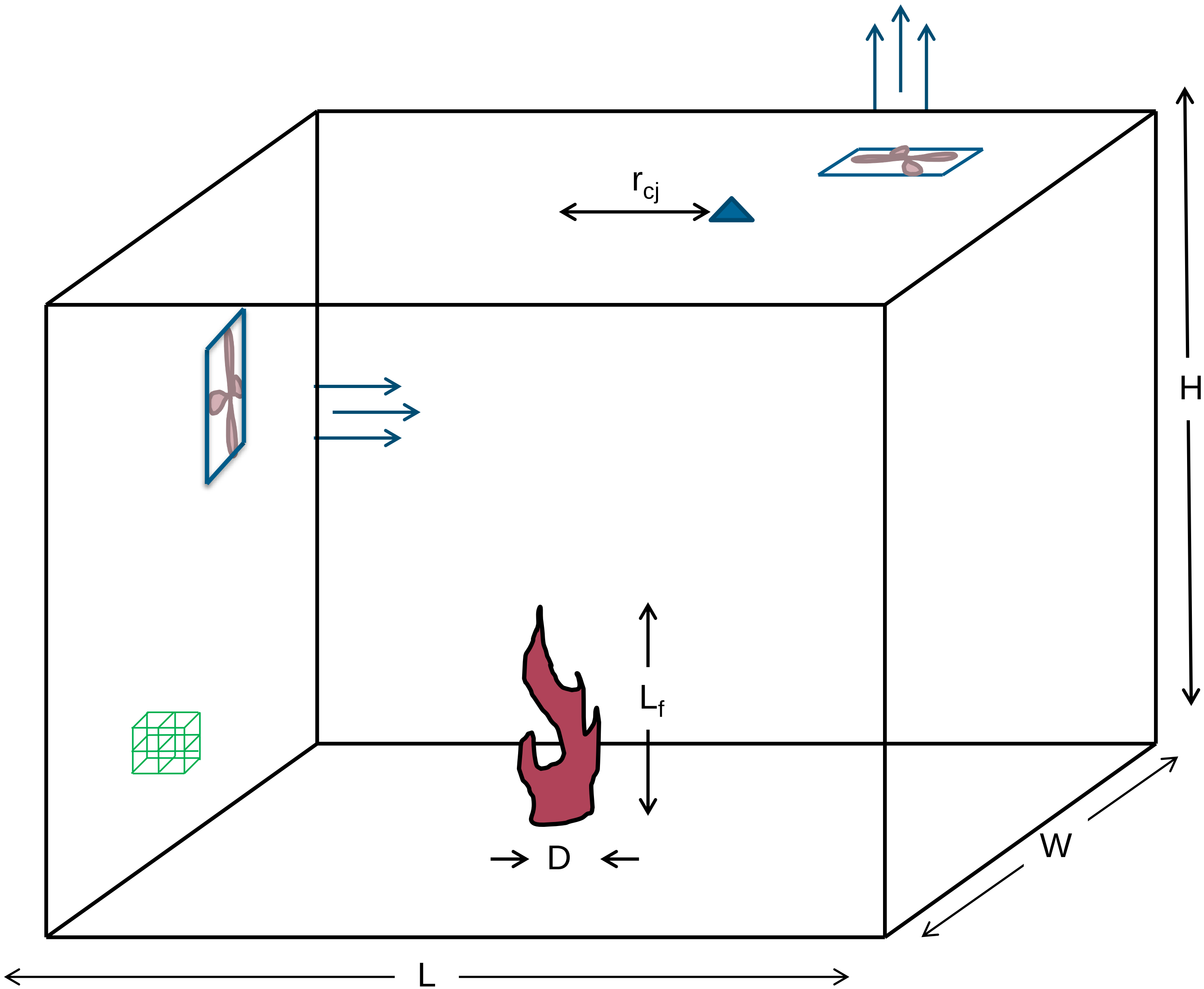
Big fires in a small space…



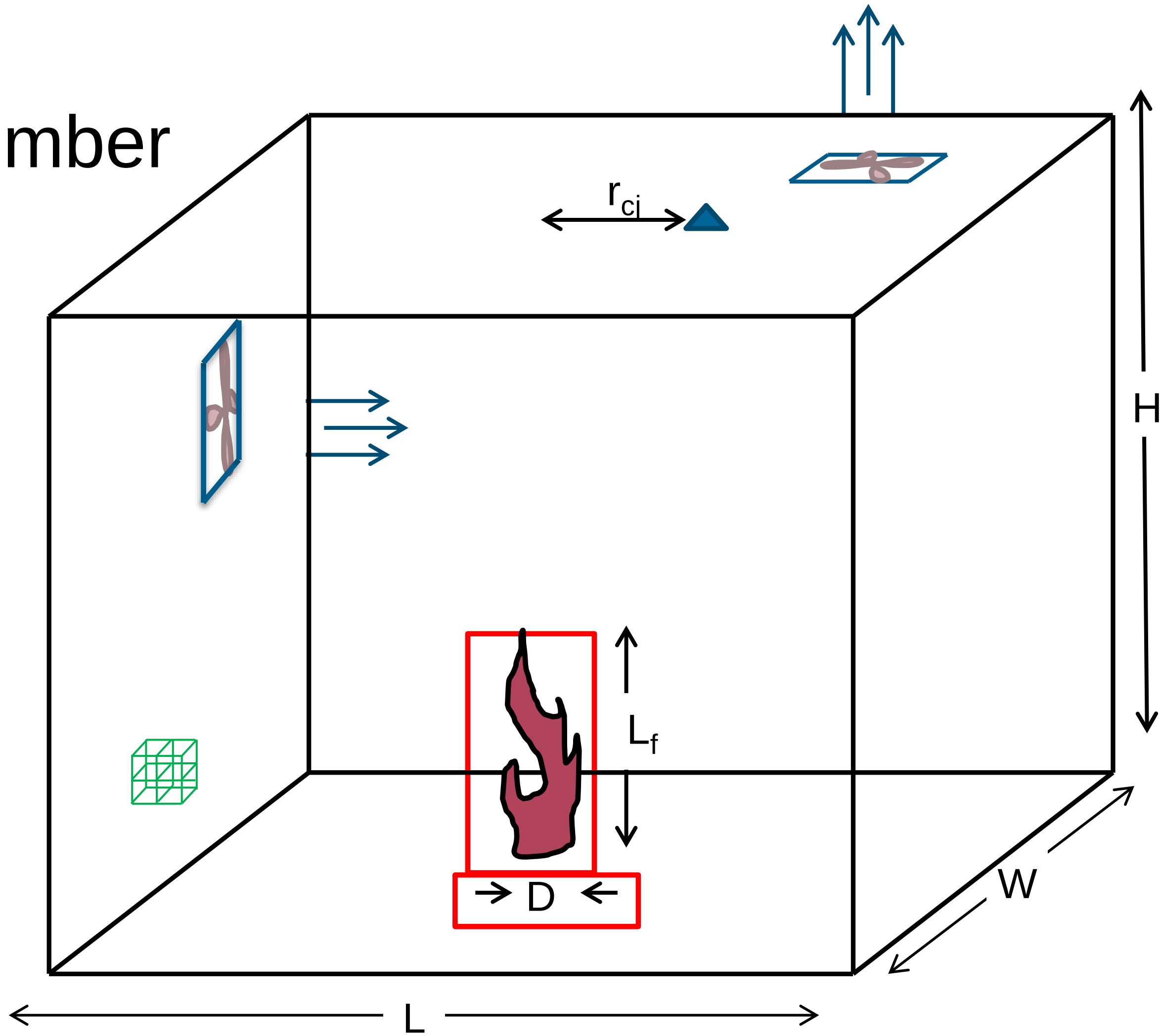
Small fires in a big space…



Credit USN and Bob Vettori (NIST)

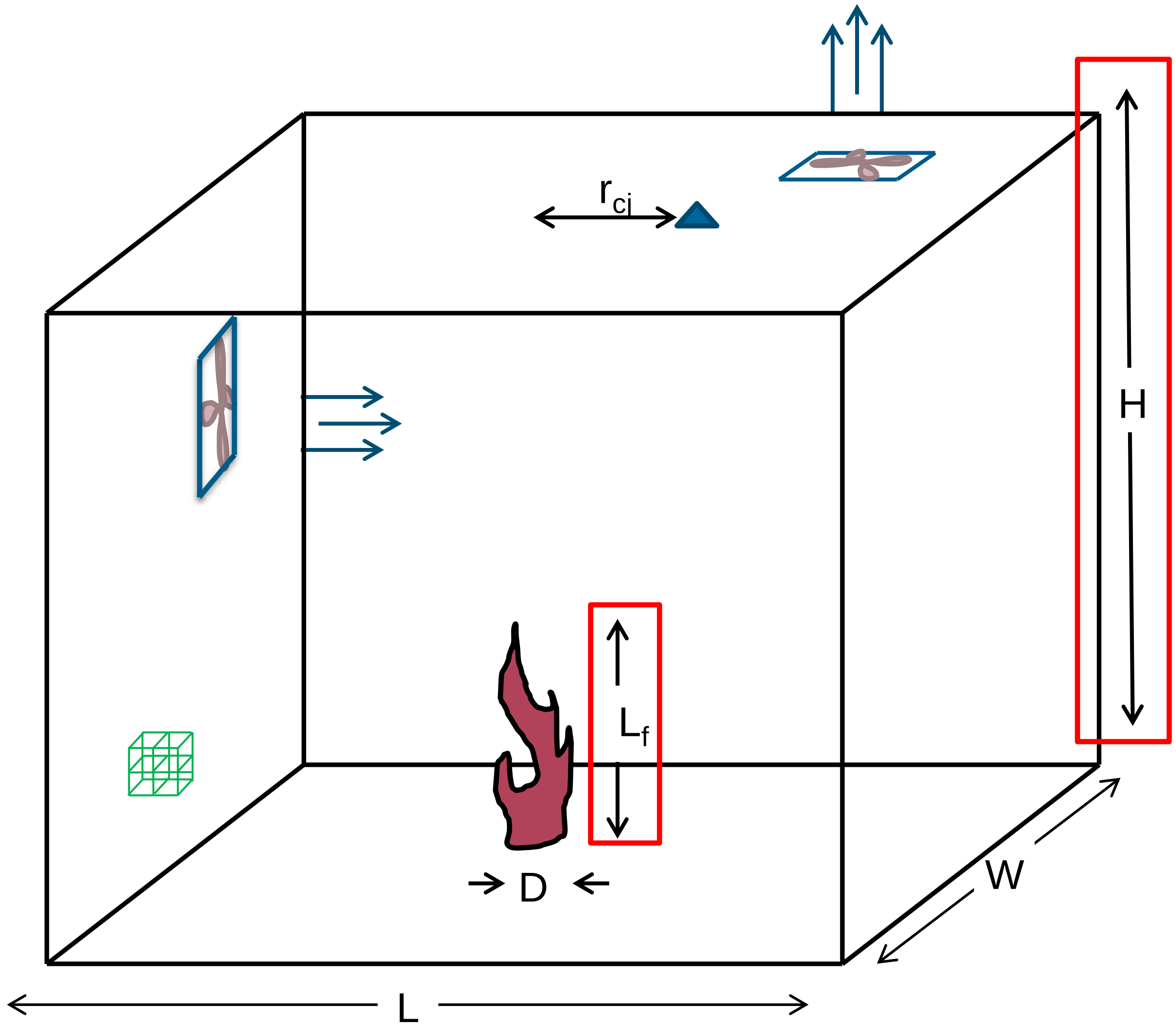

r_cj
H
L_f
D
W
L

Fire Froude Number

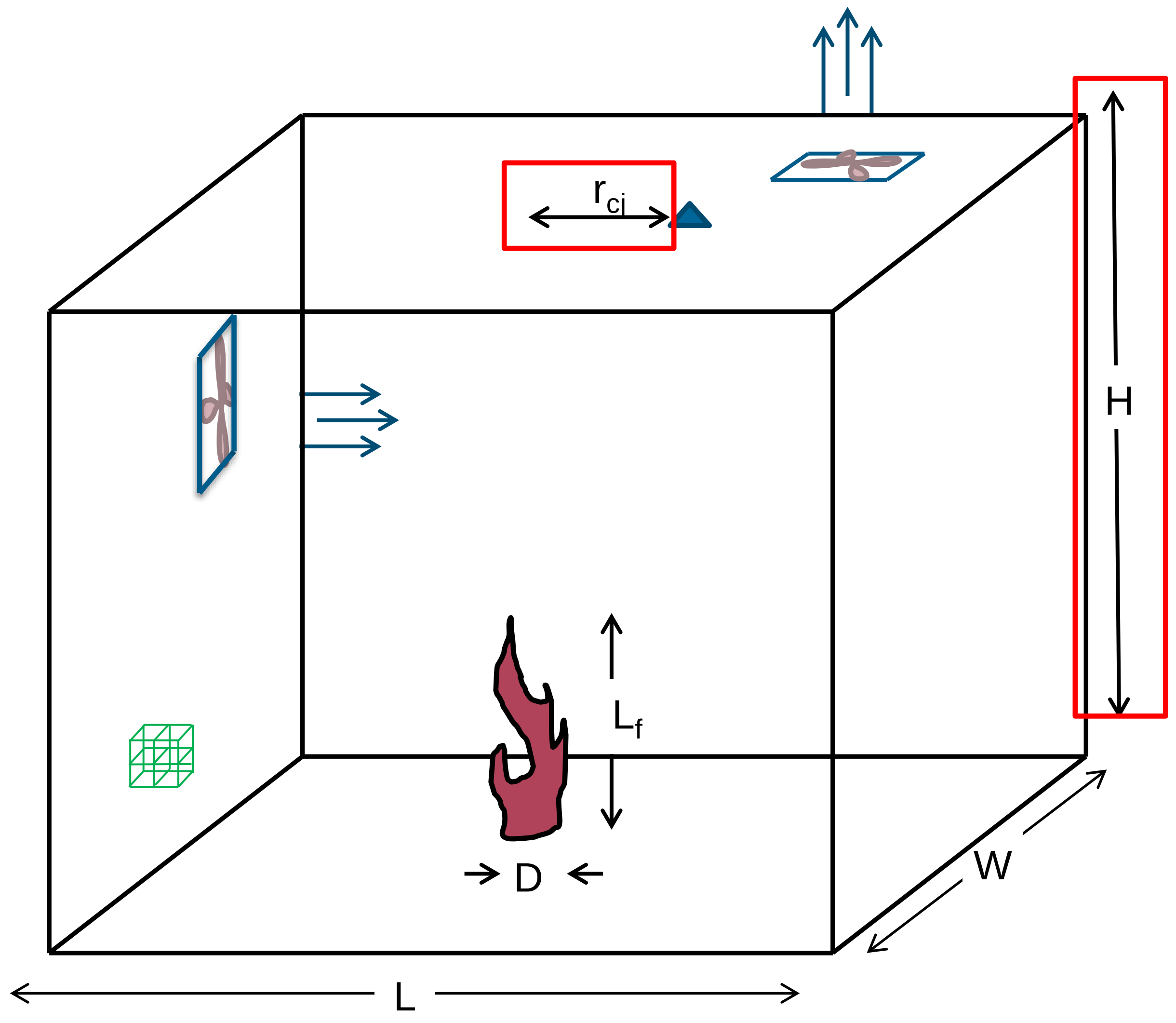


$$Q^* = \frac{\dot{Q}}{\rho_\infty c_p T_\infty \sqrt{gD} D^2}$$

Flame Height relative to Ceiling Height L_f / H

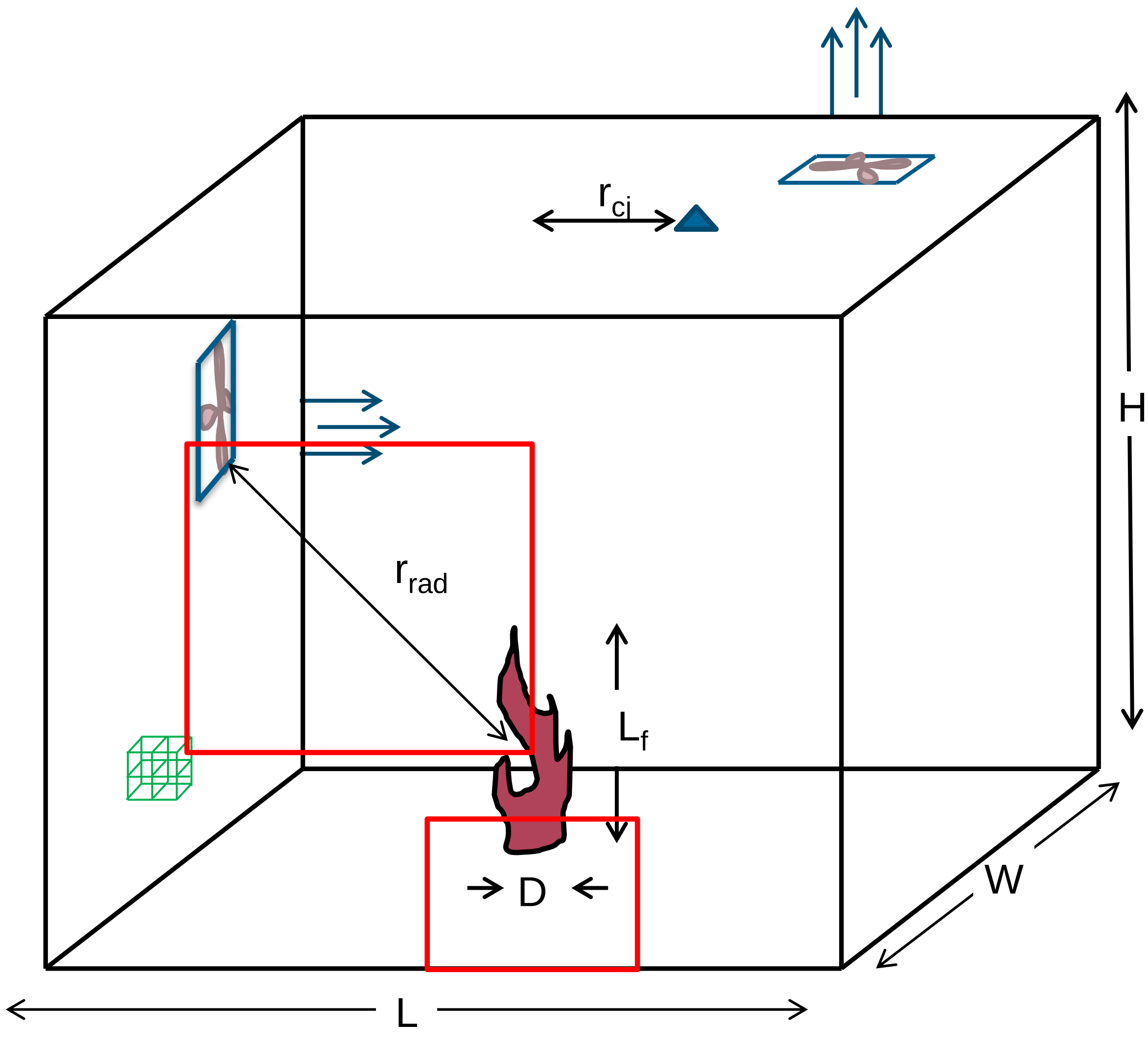


Relative Distance along the Ceiling, r_{cj}/H



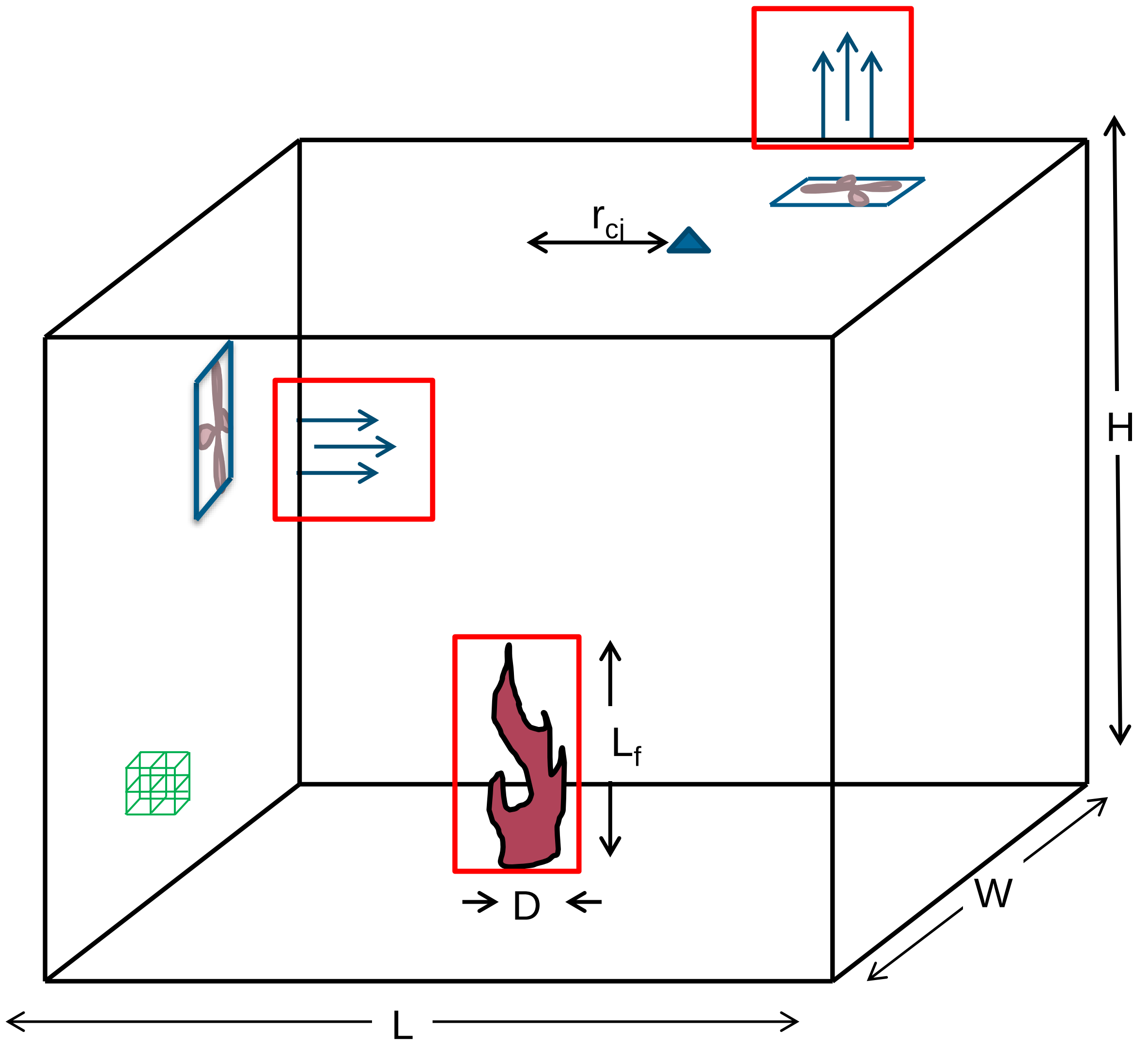
Target distance relative to Fire Diameter

r_{rad}/D



Global Equivalence Ratio

$$\phi = \frac{\dot{m}_f}{r\,\dot{m}_{O_2}} \equiv \frac{\dot{Q}\,(\mathrm{kW})}{13,100\,(\mathrm{kJ/kg})\,\dot{m}_{O_2}}$$



Characteristic Fire Diameter Relative to Cell Size

D*/d*x*

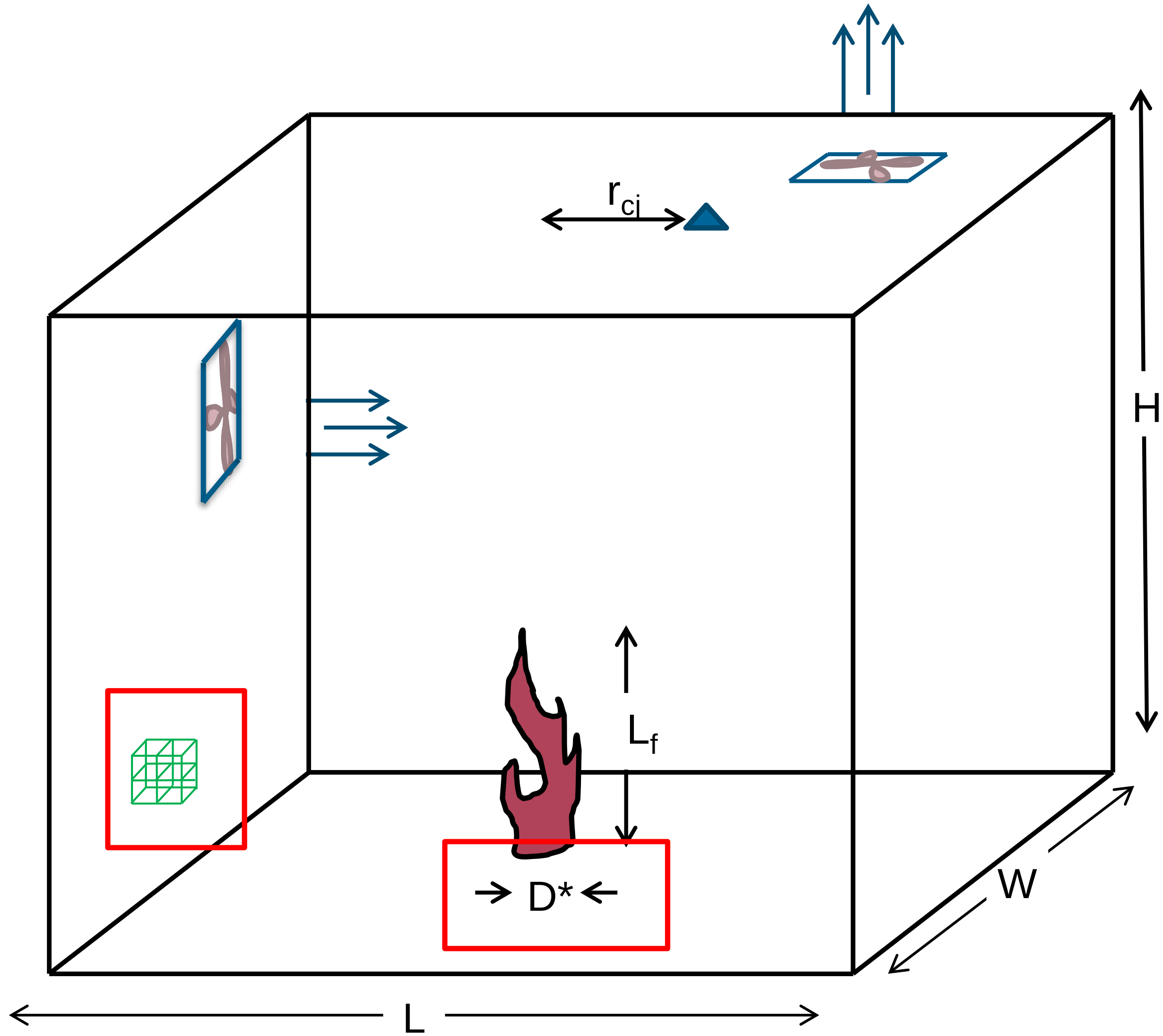


Table 1: Summary of the major experimental parameters.

Test Series	$\dot{Q}$ (kW)	D (m)	H (m)	Q^*	D^* (m)	L_f/H	ϕ	H/D^*	$W/H - L/H$	r_{cj}/H	r_{rad}/D
Arup Tunnel	5344	1.6	7	1.4	1.8	0.8	0.03	3.8	1.1 – 42.9	0 – 1.1	N/A
ATF Corridors	50 – 500	0.5	2.4	0.3 – 3.1	0.3 – 0.7	0.3 – 1	0.01 – 0.07	8.5 – 3.4	0.8 – 7.1	0.8 – 6	N/A
Bryant Doorway	34 – 511	0.3	2.4	0.4 – 6.4	0.2 – 0.7	0.3 – 1	0.01 – 0.16	9.9 – 3.4	1 – 2.1	0.6 – 0.8	N/A
CSTB Tunnel	1965 – 2484	0.8	1.9	2.9 – 3.7	1.2 – 1.3	2.1 – 2.4	0.04 – 0.05	1.5 – 1.4	1.3 – 28.4	1.6 – 12.6	N/A
FM/SNL	470 – 516	0.9	6.1	0.5 – 0.6	0.7	0.3	0.2	8.8 – 8.5	2 – 3	0.2 – 0.3	N/A
Hamins Burner	0.4 – 162	0.1 – 1	Open	0.1	0 – 0.5	Open	Open	Open	Open	N/A	0.1 – 12
Heskestad	$10^2 - 10^7$	1.1	Open	$10^{-1} - 10^4$	0.4 – 44	Open	Open	Open	Open	N/A	N/A
LLNL Enclosure	50 – 400	0.6	4.5	0.2 – 1.4	0.3 – 0.6	0.1 – 0.4	0.03 – 0.22	15.9 – 6.9	0.9 – 1.3	0.3 – 1	N/A
McCaffrey Plume	14 – 57	0.3	Open	0.2 – 0.7	0.2 – 0.3	Open	Open	Open	Open	N/A	N/A
NBS Multi-Room	110	0.3	2.4	1.4	0.4	0.4 – 5.2	0.12	6.2	1	0.5 – 0.7	0.9 – 2.4
NIST RSE	50 – 600	0.15	1	4.9 – 58.4	0.3 – 0.8	1 – 2.9	0.1 – 1.15	3.5 – 1.3	1 – 1.5	N/A	N/A
NIST/NRC	350 – 2200	1	4	0.3 – 1.9	0.6 – 1.3	0.4 – 1	0.04 – 0.7	6.5 – 3.1	1.8 – 5.4	0.3 – 2	2 – 4
NRCC Facade	5000 – 10300	4.3	2.8	0.1 – 0.2	1.8 – 2.4	1 – 1.8	2.5 – 5.2	1.5 – 1.2	1.6 – 2.2	N/A	0
NRL/HAI	50 – 520	0.3 – 0.7	Open	1 – 1.1	0.3 – 0.7	Open	Open	Open	Open	N/A	0.3 – 8
Sandia Plume	2025 – 5450	1	Open	1.7 – 4.6	1.2 – 1.8	Open	Open	Open	Open	N/A	N/A
SP AST	450	0.3	2.4	5.7	0.7	1	0.13	3.5	1 – 1.5	N/A	N/A
Steckler	31.6 – 158	0.3	2.1	0.7 – 3.5	0.2 – 0.4	0.3 – 0.7	0.01 – 0.6	9.1 – 4.8	1.3	N/A	N/A
UL/NFPRF	4400	1	7.6	3.7	1.7	0.8	0	4.5	4.9	0.1	N/A
Ulster SBI	30 – 60	0.2	Open	1.4 – 2.8	0.2 – 0.3	Open	Open	Open	Open	N/A	1 – 7.5
USCG/HAI	250 – 1000	0.3	3	5.6 – 22.4	0.5 – 0.9	0.6 – 1.1	0.26 – 1.02	5.6 – 3.2	1.7 – 2.3	0 – 0.8	6 – 15
USN Hawaii	100 – 7700	0.3 – 2.5	15	1.3 – 0.7	0.4 – 2.1	0.1 – 0.4	0	40.3 – 7.1	4.9 – 6.5	0 – 1.2	N/A
USN Iceland	100 – 15700	0.3 – 3.4	22	1.3 – 0.6	0.4 – 2.8	0.1 – 0.4	0	59 – 7.8	2.1 – 3.4	0 – 1	N/A
Vettori Flat	1055	0.7	2.6	2.3	1	1.2	Closed	2.8	2.1 – 3.5	0.8 – 2.9	N/A
Vettori Sloped	1055	0.7	2.5	2.3	1	1.2	0.23	2.6	2.2 – 2.9	N/A	N/A
VTT Large Hall	1860 – 3640	1.4 – 1.8	19	0.7	1.2 – 1.6	0.2	0	15.8 – 12.1	1 – 1.4	0 – 0.6	N/A
WTC	965 – 1460	1	3.8	0.8 – 1.2	0.9 – 1.1	0.7 – 0.9	0.5 – 0.7	4.1 – 3.5	0.9 – 1.8	0.1	0.5 – 2

Acknowledgments:

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References

NUREG-1824, V&V of Selected Fire Models for Nuclear Power Plant Applications

NUREG-1934, Nuclear Power Plant Fire Modeling Application Guide