

# SIMULATION OF A WATER MIST CURTAIN USED AS A RADIATION SHIELD

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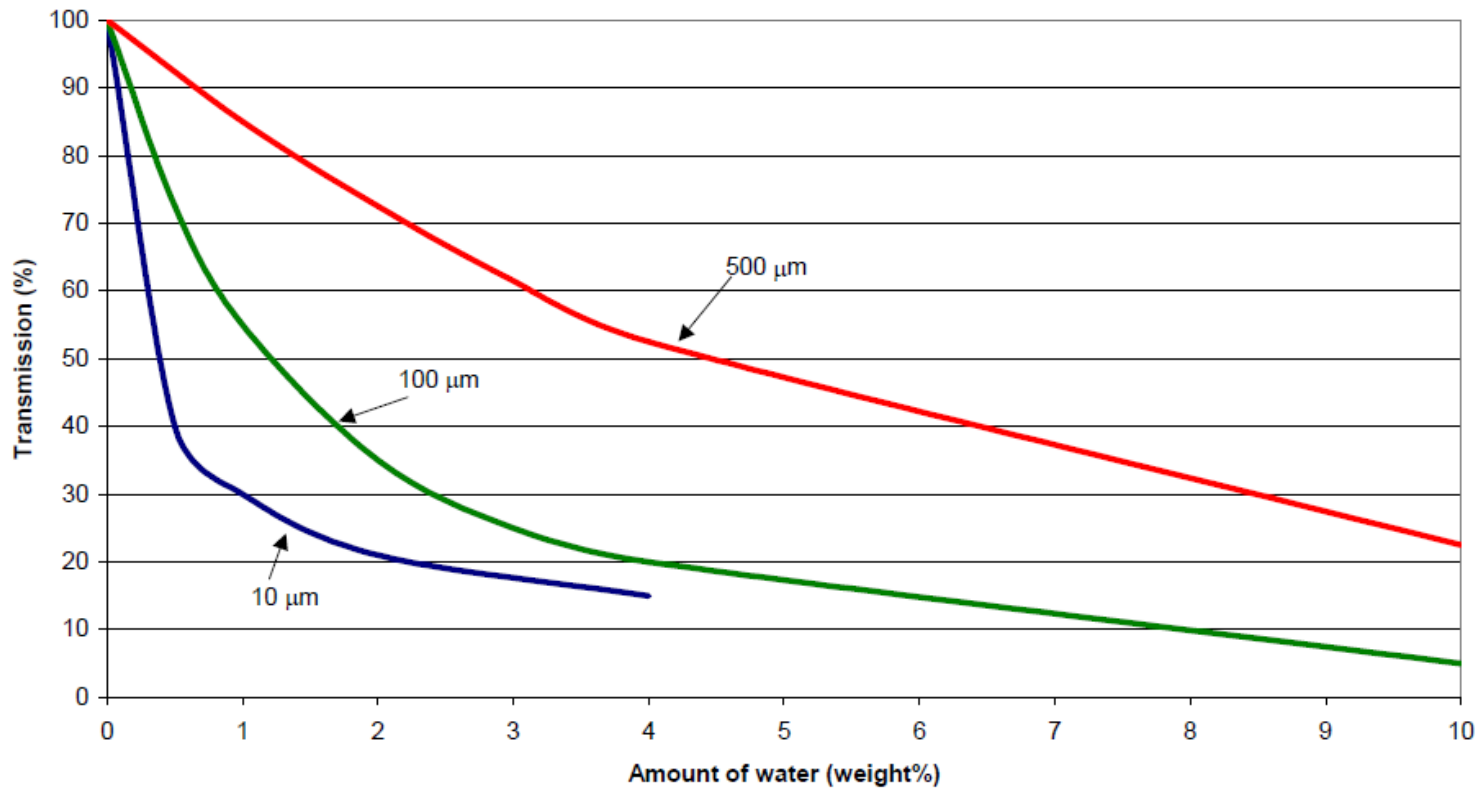


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# Influence of droplet size on shielding effect

Simulated attenuation as a function of droplet size and amount of water



# Motivation

*It is expensive to perform fire tests, and Computational Fluid Dynamics (CFD) of water mist could help to reduce the time and the cost of these tests*

*Further, a good numerical model would be able to scale and vary multiple parameters (geometry, design fire, droplet properties)*



# Research questions

- *How can a high-pressure water mist curtain be modelled in FDS to represent the experiments?*
- *What parameters are important for modelling the water mist curtain?*
- *What are the challenges in modelling water mist?*
- *How can the model be used for scaling (in size and in configuration)?*



# Method

## Experimental Setup:

Data was taken from large scale fire test with 5 nozzle delivering 11.9 L/min at 100 bar  
Performed in the evening with **~1 m/s wind**, providing stable conditions

## Fire Scenario:

A heptane pool with a diameter of 0.8 m, producing ~1200 kW HRR.  
Burn time: 10 min (3 min pre-burn).

## Simulation Approach:

Modelled as a constant 1200 kW fire for 120 s.  
Water mist activation at 60 s

## The steady-state period before and after activation:

To reduce simulation time and find a steady-state period,  
the Generalised Least Squares Modified Dickey-Fuller t-test (GLS-MDF) was used

Pre-activation steady-state period : 30–60 s

Post-activation steady-state period : 90–120 s



# Experiments performed at MSB in Sweden

A three-storey multiple room building (Revinge, Sweden), see Interflam paper from 2019\*

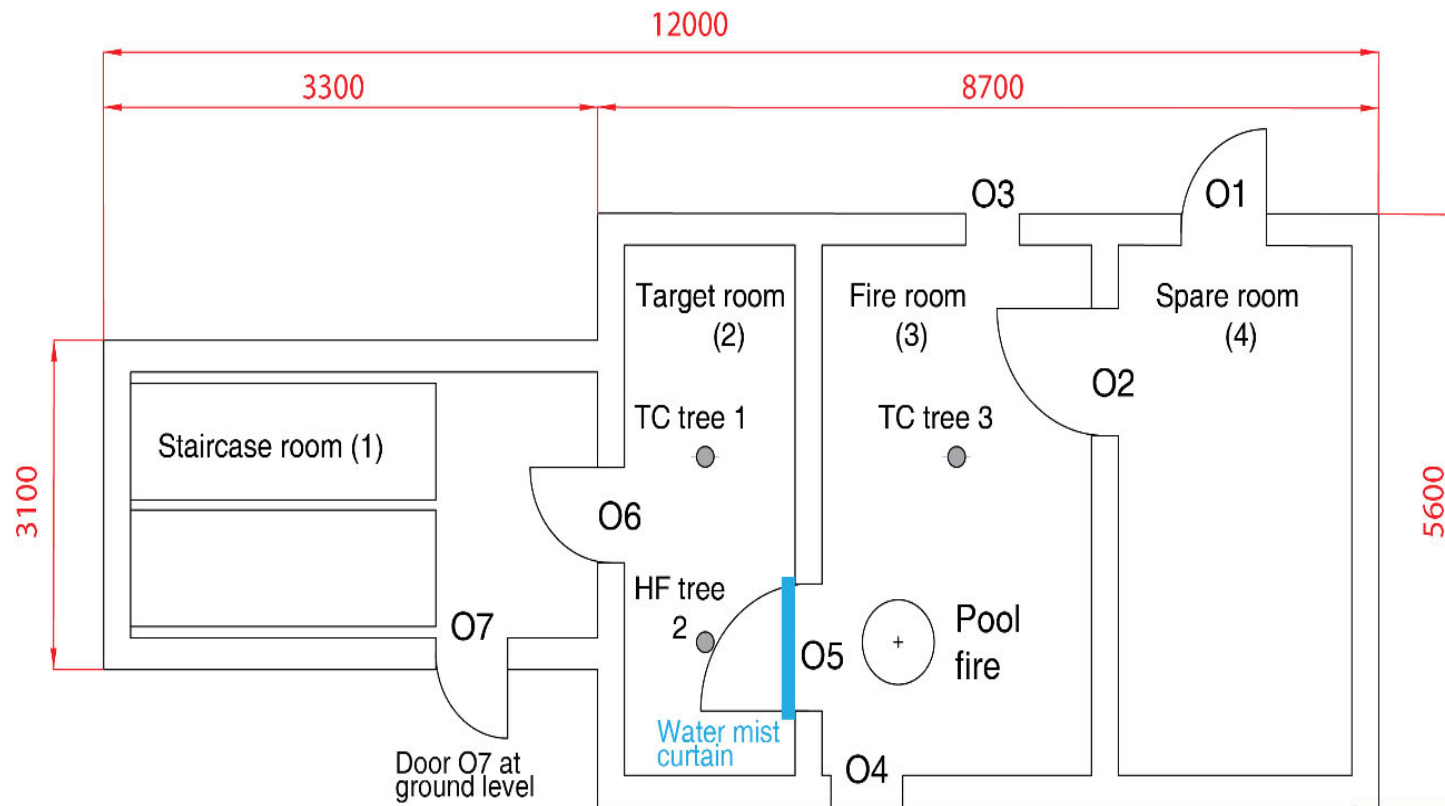


\*Laustsen, L. S., Husted, B. P., and Sørensen, L. S.,  
Full-Scale Fire Tests of High-Pressure Water Mist Used as a Fire Barrier, Interflam 2019.



# Experimental setup

## Test facility



# Measurement and modelling of nozzles

Measurement of spray pattern and droplet size, and velocity (done previously)

Modelling done in FDS version 6.10.1

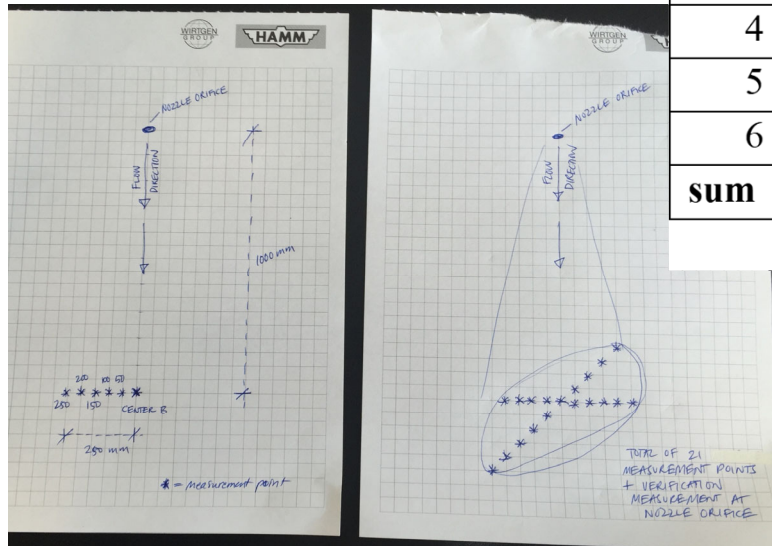
Steps:

1. Model a single nozzle to match the spray (pattern, velocity and size distribution)
2. Insert five single nozzles in the actual position in the door opening

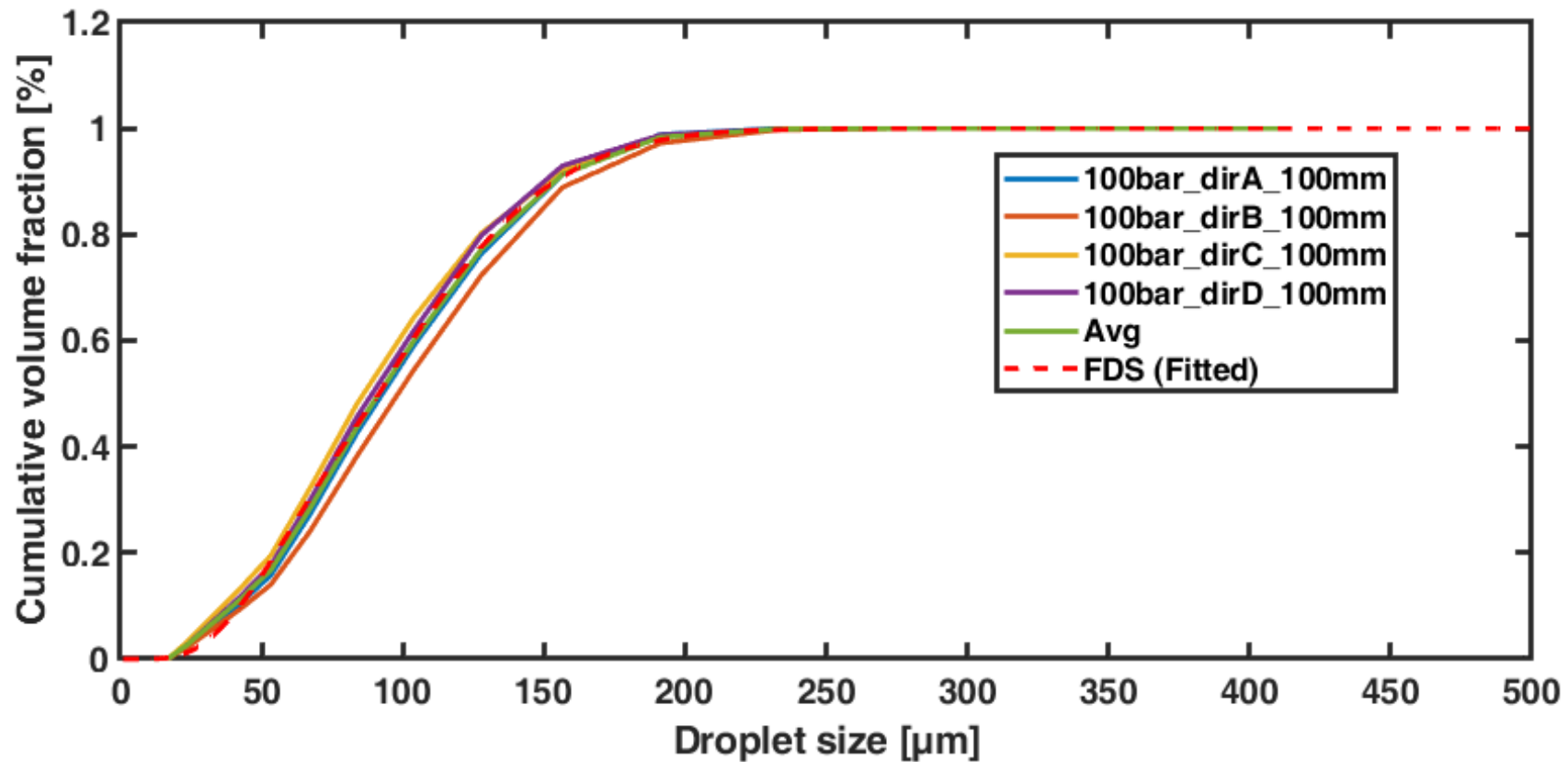


# Spray modelling of a single nozzle

Droplet class	Modelled values		Measured values		
	Angle low° (initial)	Angle high° (initial)	Flow rate [l/min]	Mean Droplet Volume Diameter DV50 [μm]	Mean velocity [m/s]
1	0.5 (0)	1.5 (1.4)	0.0026	73.8	12.21
2	1.5 (1.4)	4.0 (4.3)	0.1670	79.0	10.17
3	2.0 (4.3)	6.0 (7.1)	0.5912	91.6	5.81
4	4.0 (7.1)	12.0 (9.9)	0.6504	109.6	2.75
5	10.0 (9.9)	16.0 (12.7)	0.7649	113.6	1.56
6	14.0 (12.7)	24.0 (14.6)	0.2038	107.0	1.48
<b>sum</b>			2.3800		

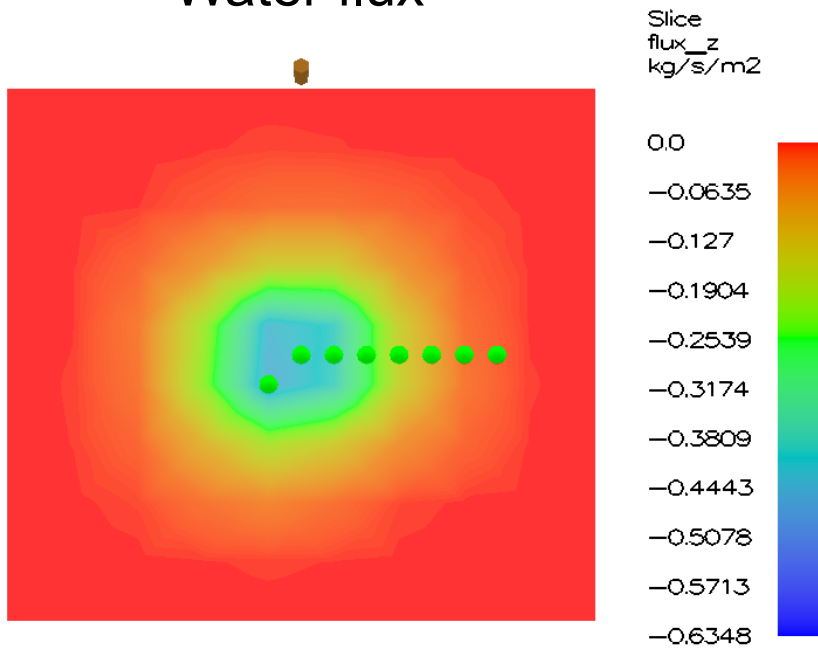


# Examples of droplet distribution at 100 mm from the centre (Droplet class 2)



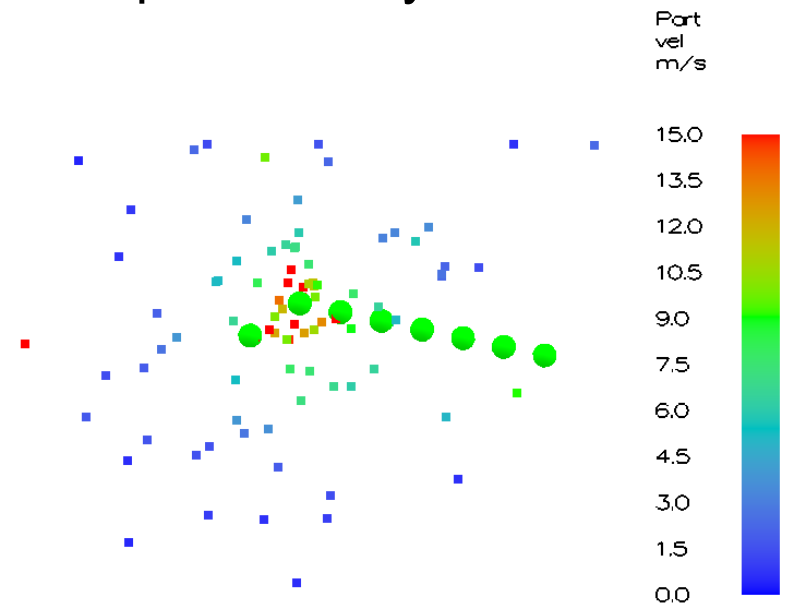
# Modelling single nozzle in FDS

Water flux



1 meter below the nozzle

Droplet velocity

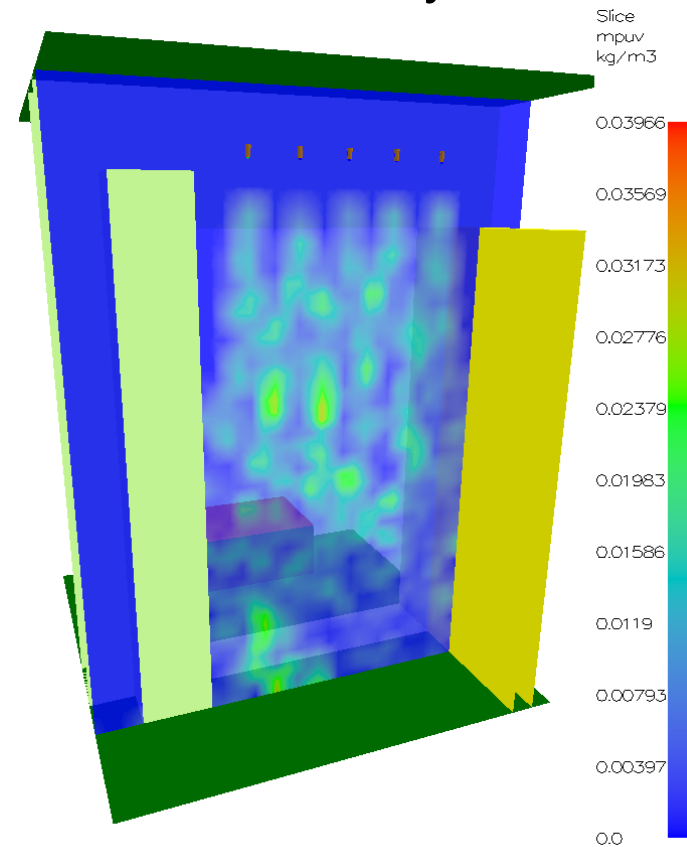


Large green dots are spaced at 50 mm intervals.

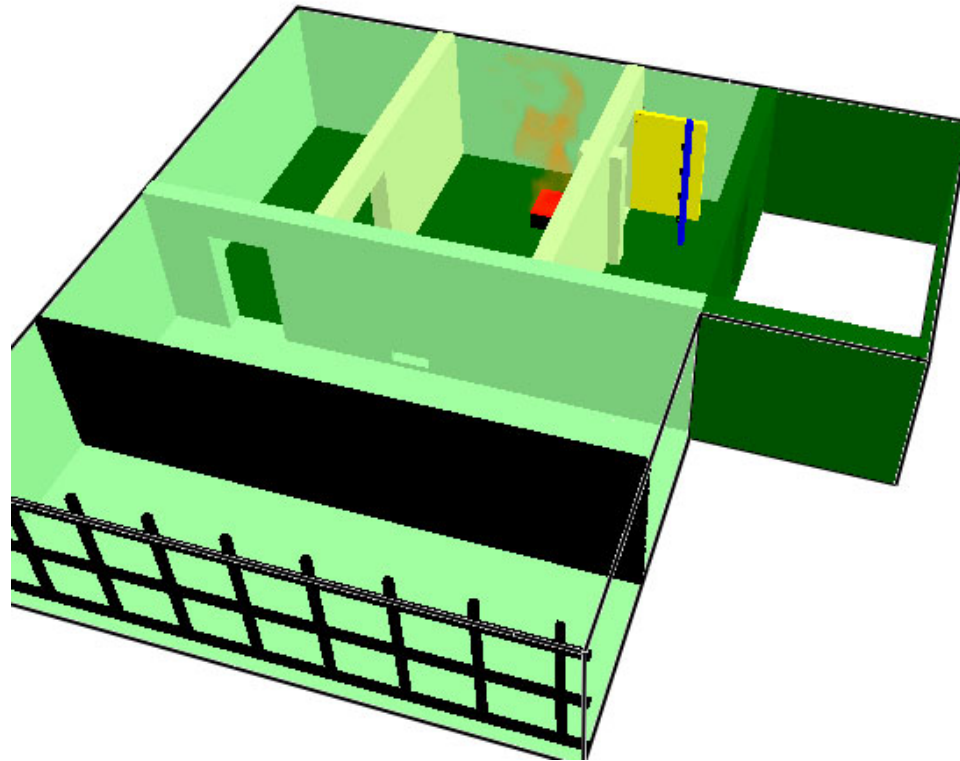


# Spray in door opening

Water density



# Setup of simulation geometry (nyt billede)

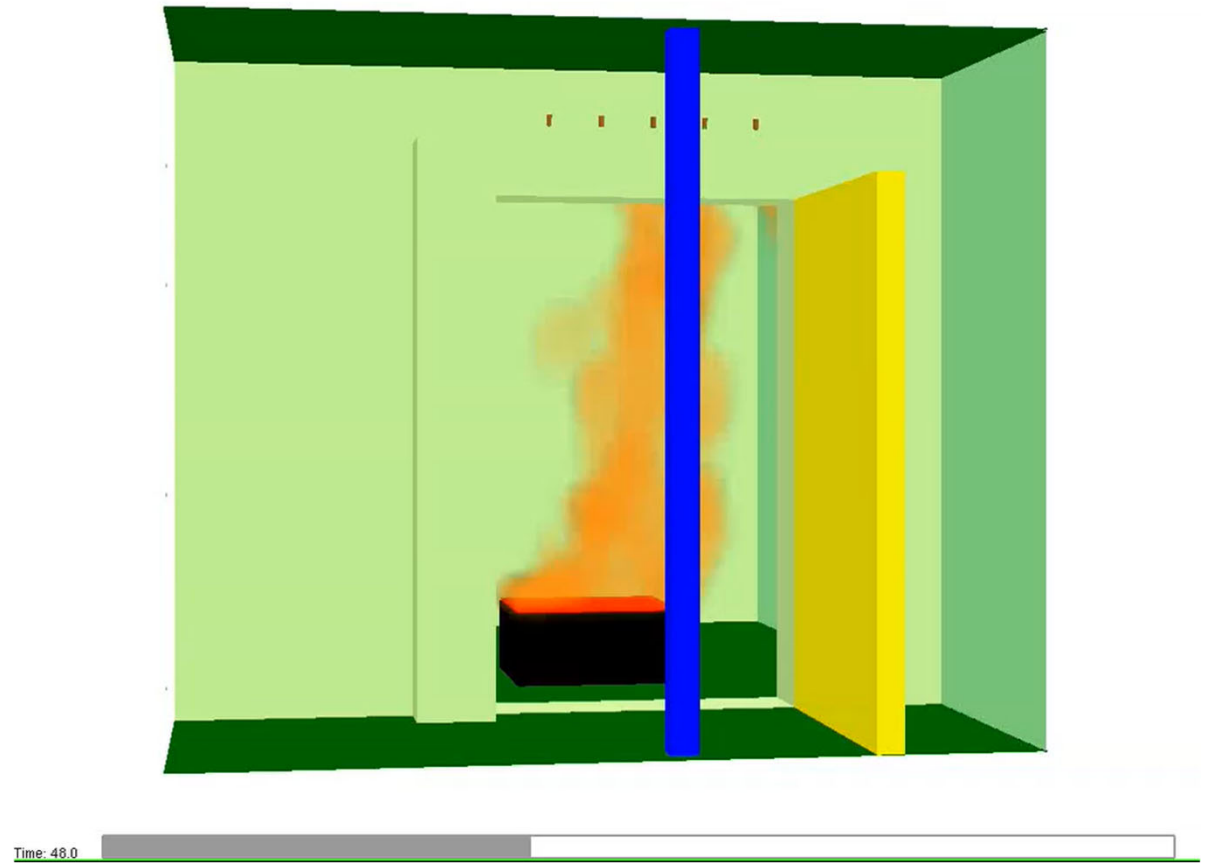


## FDS simulation setup

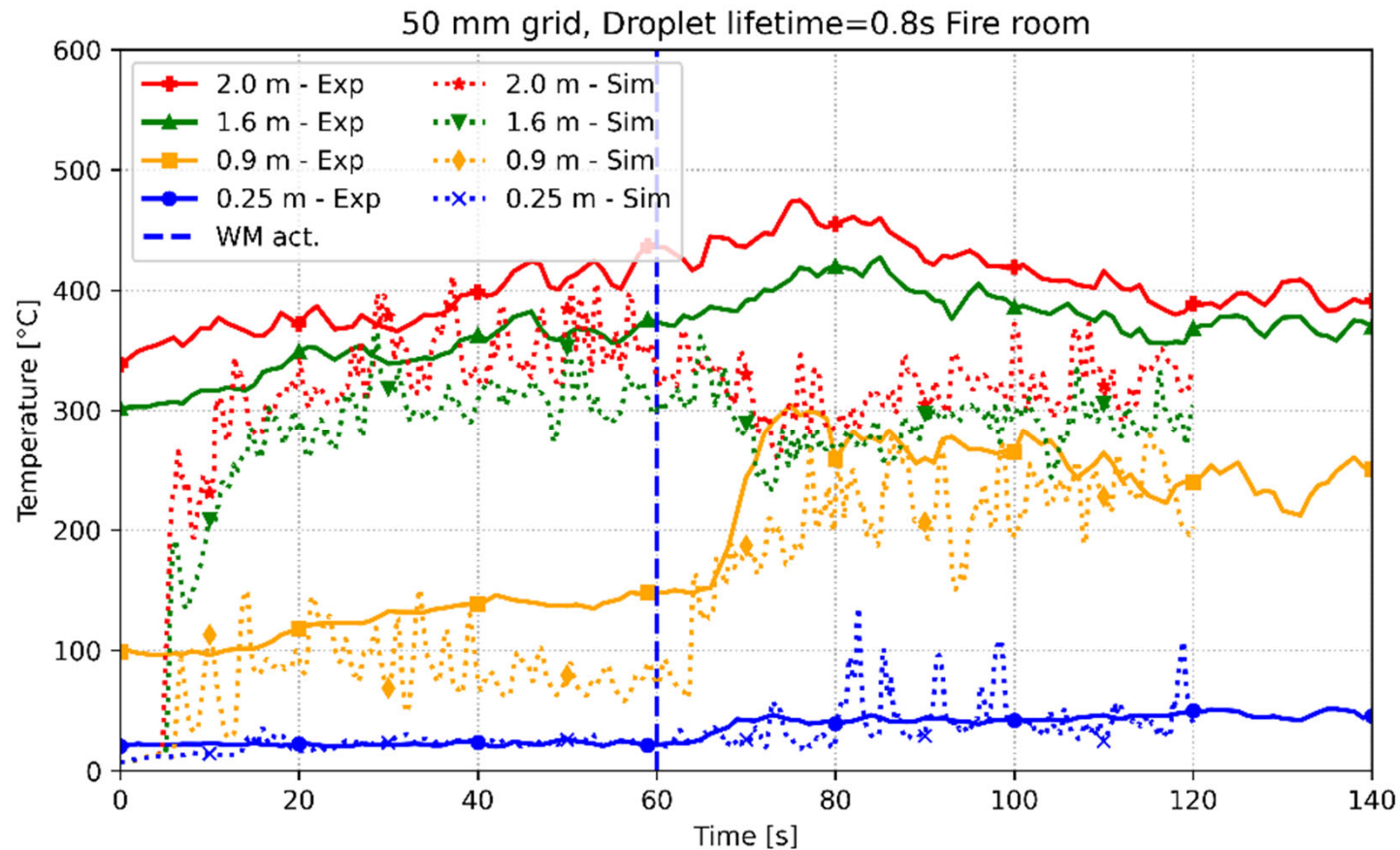
- Uniform simulation grid size: 100 mm, 50 mm or 25 mm
- Radiation angles: 300 (1000 angles for sensitivity study)
- Turbulent dispersion of droplets activated
- The floor was set to be porous
- No accumulation of droplets on surfaces (ADHERE\_TO\_SOLID=-1)
- Droplet lifetime set to 0.8 s to reduce computations and avoid splash up of droplets (to mimic experimental results)



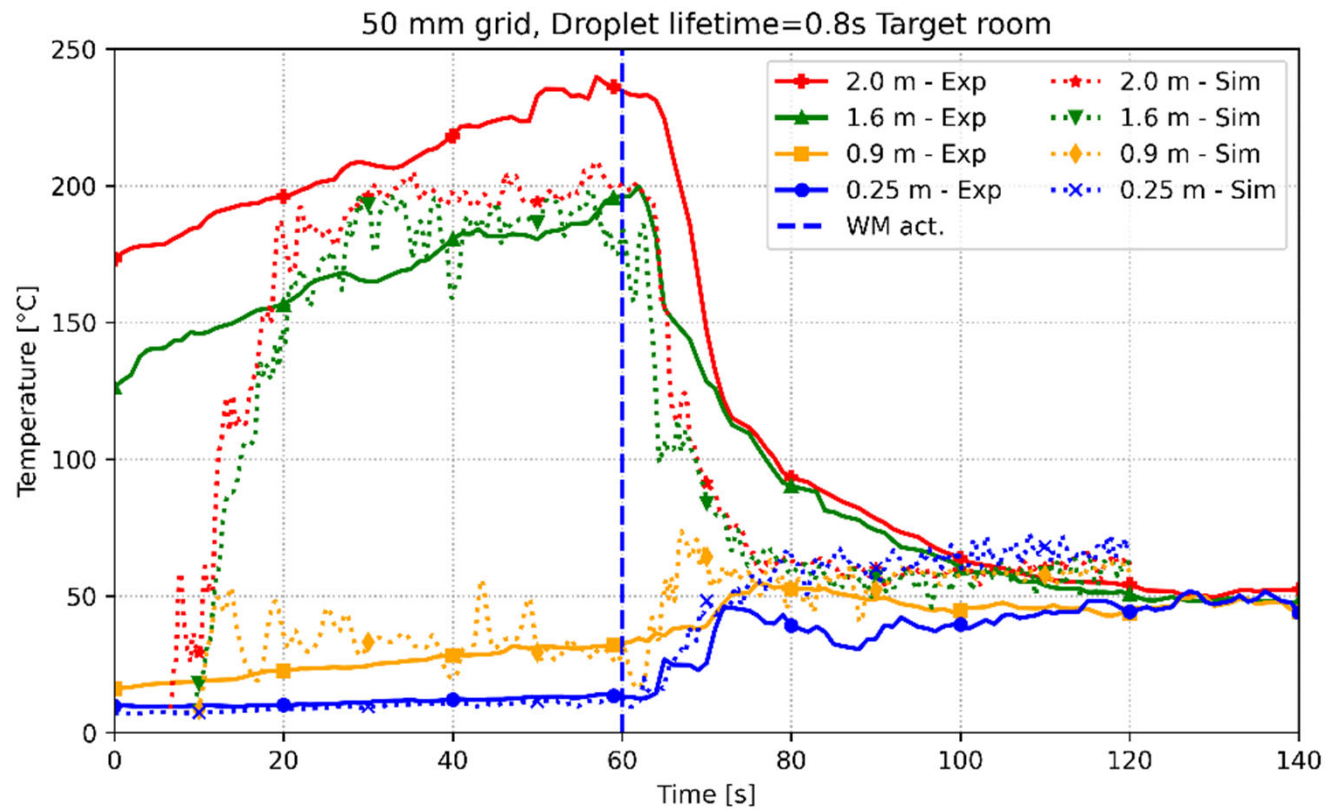
# Movie of experiment and simulation



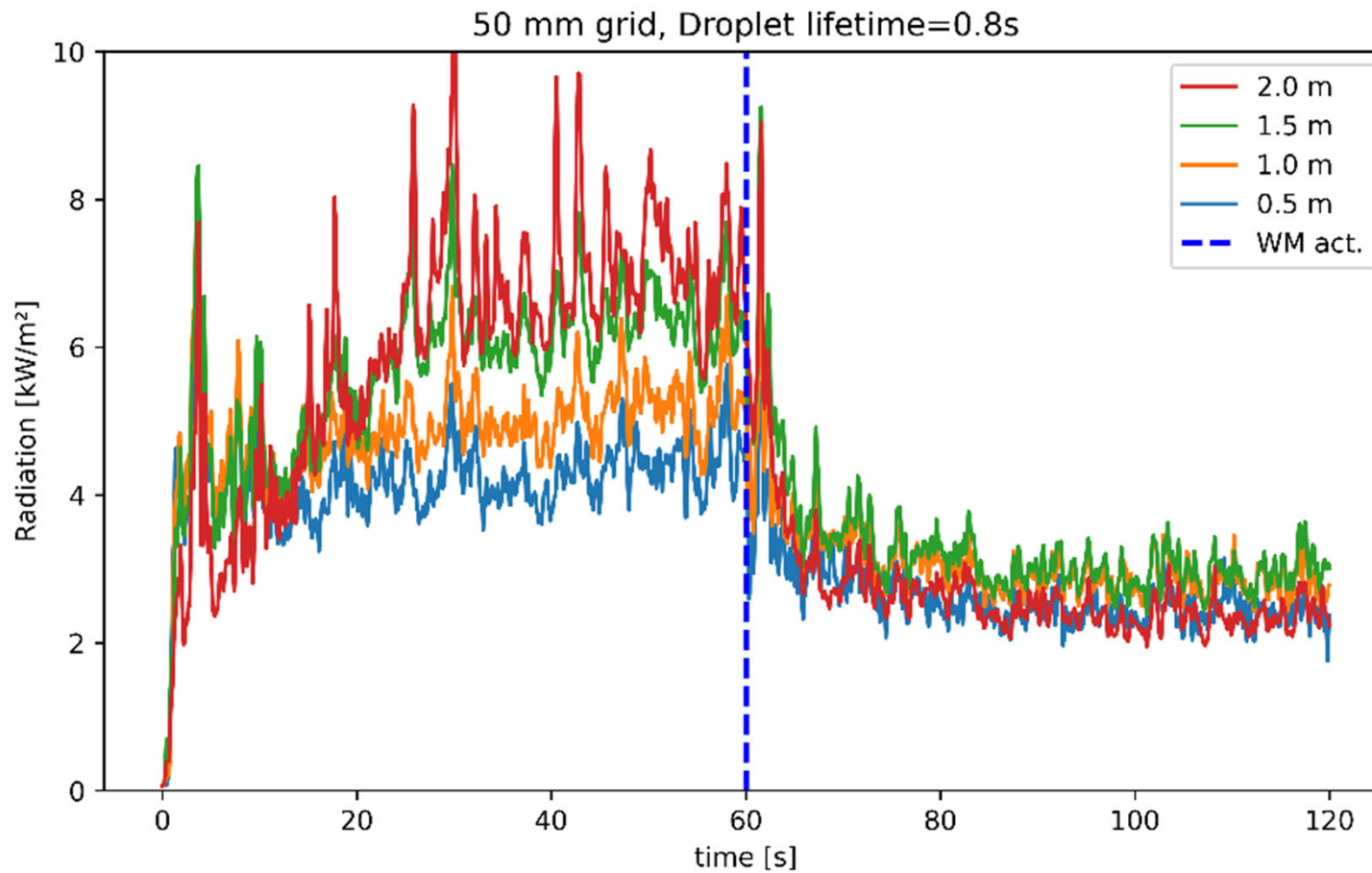
# Temperature in Fire room, 50 mm grid



# Temperature in Target room, 50 mm grid



# Radiation in the Target room at four different heights



# Attenuation of radiation [%]

Simulation time:  
8 days on 64  
cores

Height	Experiments	100 mm grid	50 mm grid	25 mm grid
2.0 m	59	70	66	68
1.5 m	45	60	53	56
1.0 m	39	53	45	47
0.5 m	20	47	44	42



# Conclusion I

- Simulation Accuracy
  - Simulated experiments in Revinge showed good agreement with measurements. Adjusting nozzle spray angle was key to replicating the spray pattern.
- Performance of FDS
  - Accurately predicted room mixing and temperature uniformity. Reasonable radiation attenuation results, but less accurate near the floor.
- Challenges Near Floor
  - Experimental spray followed convective flow due to low momentum. Simulated spray rebounded, increasing water density near the floor. Grid refinement (50 mm) improved accuracy, but some deviation ( $\sim 2x$ ) remained close to the floor



## Conclusion II

- Modelling Recommendations
  - Use a max 50 mm grid size to resolve spray in FDS. Careful spray modelling is essential to replicate the experimental results
- Effective Methodology
  - Simulating individual nozzles before full-scale setup proved efficient and reliable.
- Scaling
  - The comparison of temperature profiles, radiation attenuation, and flame shape with experimental data showed strong agreement, indicating good model fidelity. This suggests that scaling of the geometry and fire in FDS may be feasible



*Thank you!*

See more in Interflam 2025 paper: MC298\_Husted

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