# Challenges and Advances in Suppression

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Fire & Risk Alliance, LLC.


SFPE
Foundation®

# Mission & Vision*

- Established by the Society of Fire Protection Engineers as the SFPE Educational and Scientific Foundation in 1979

Mission:

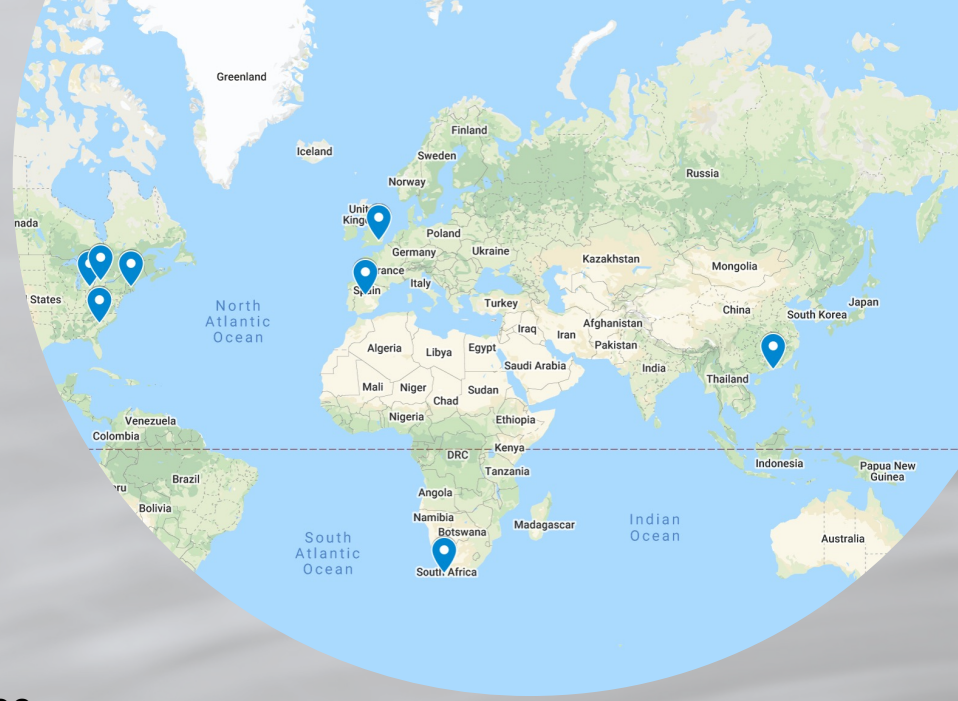
- *Enhance the scientific understanding of fire and its interaction with the natural and built environments.*

Vision:

- Facilitate scientific and engineering ***research*** focused on fire risk, safety, mitigation, control, and human response.
- Facilitate the development of ***engineering methods*** to mitigate the adverse consequences of unwanted fires.
- Provide ***education*** and research opportunities for the next generation of fire protection engineers.

**Currently developing 2022-2025 Strategic Plan.*

# Student Research Grants




Any student researching fire protection or fire safety engineering topics may apply

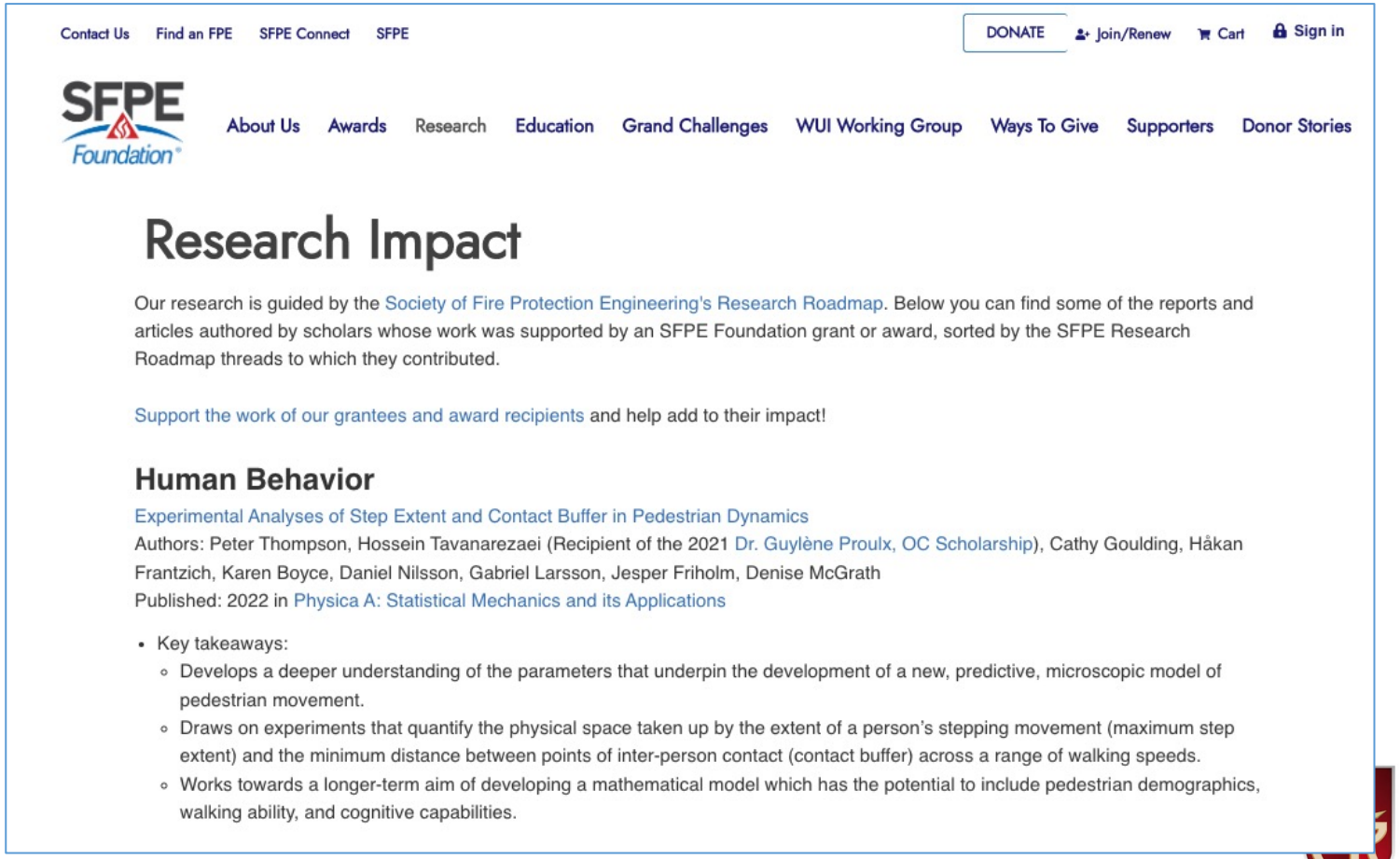
5-8 awards per year, $5,000 per awardee

Evaluated on technical merit, usefulness, qualifications, achievability

Applications due in May and November annually

# New "Research Impact" Page on Website

- Visit: https://www.sfpe.org/foundation/foundationresearch/impact
- All Foundation-funded research projects since 2020 mapped to SFPE Research Roadmap topics; includes links to published journal articles, reports, webinars, and more
- Continuing updates to add visualizations and enhance user interface
- Example of Impact:
  - One 2020 Student Research Grant ($5k) winner's project turned into 4 peer-reviewed journal article publications and contributed to gaps in 4 Research Roadmap areas!

# Get involved

- Sign up for the Foundation's **monthly e-news brief**; send us content suggestions
- Follow us on **LinkedIn** and **Twitter**
- **Share** our award, scholarship, and grant opportunities with your networks
- Watch one of our **free recorded webinars** through the *Research in Fire Engineering Webinar Series* (up to 6 PDH for FREE)
- Join the Foundation's **Academic Leadership Council**, **Grand Challenges Initiative**, or **WUI Working Group Initiative**

- **Donate** to support our work:
  - Annual Campaign
  - Fitzgerald Matching Fund Challenge
  - Student Travel Fund
  - Leave a gift to the Foundation in your will; join the Legacy Society

- Let us know: How can we work together?

# Abstract

Environments are becoming more challenging to provide protection for as storage heights and densities increase, new construction materials are introduced, and unique and out of the box architectural designs are envisioned. Developing protection schemes for these can be complex right from the start, with something as “simple” as choosing the right sprinkler all the way through to requiring testing and modeling. This presentation will highlight some of today’s most challenging problems, identify what makes them so difficult, and cover some advances in equipment, analysis, and tools that can help solve these challenges.

# Suppression Challenges

- Challenging Applications
  - Storage Challenges (Tall rack storage, ASRS)
  - Lithium-ion batteries (BESS, EV's)
  - New Materials
  - Architectural Advances & Unique Structures
- "Universal" Challenges
  - Sloped/Domed Ceilings
  - Obstructions
  - Water Availability (increasingly water is scarce)
  - Contamination
- Advances & Solutions
  - FPRF studies and guidance
  - Technology
  - Software (Sprinklerdatabase, spray data inclusion in Pyrosim, Revit Plugin)

# Sloped Ceiling Design

sloped, obstructed

# Sloped Ceiling Concerns

Ceiling slope will cause biased activation patterns

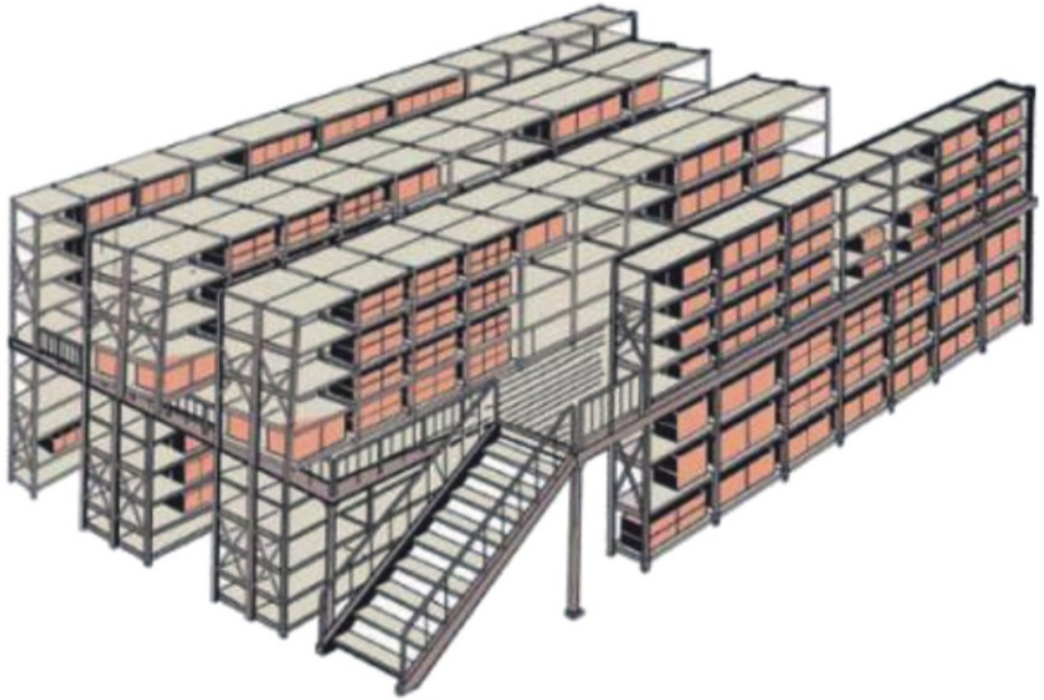
Activation of sprinklers affected by presence of obstructed construction (purlins and girders)

Orientation of sprinklers and resulting ceiling impingement of spray (parallel to floor or ceiling)

Sprinkler sprays impinging on obstructed construction (not considered in this study though addressed in others)

Variations in sprinkler characteristics and operating pressures (consistency of results)

# Walkways, Mezzanines, & Obstructions



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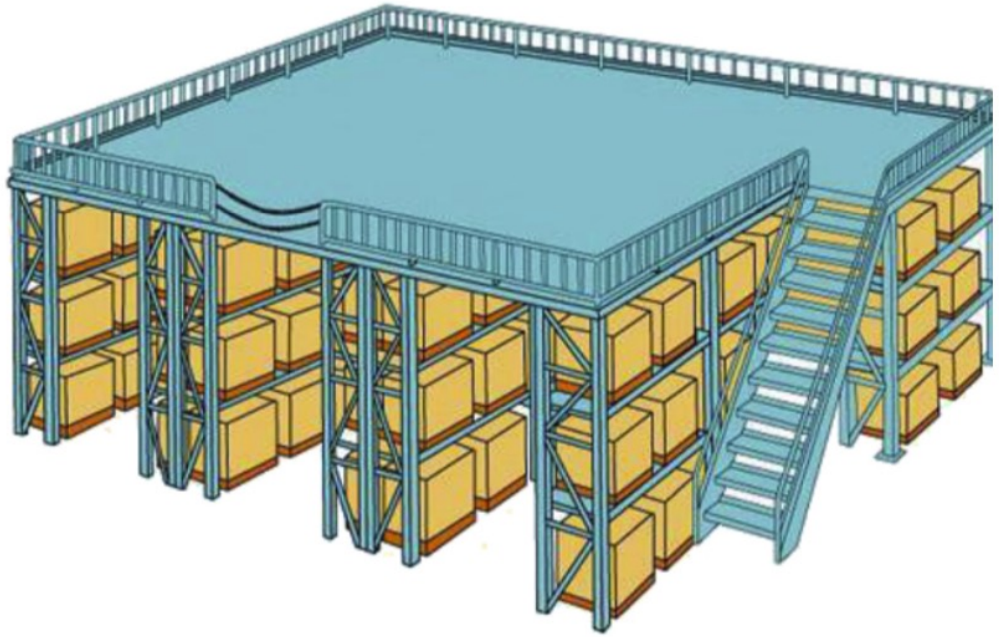
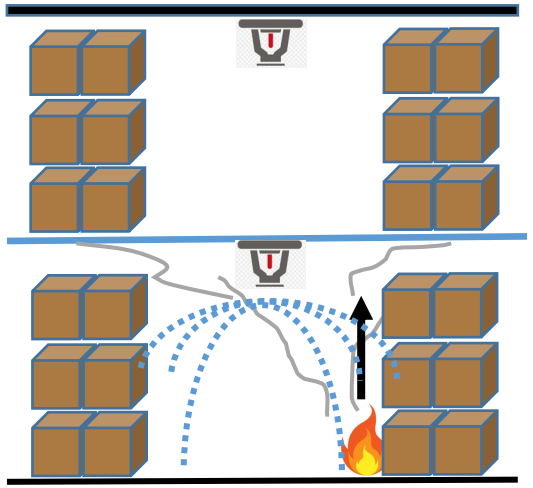
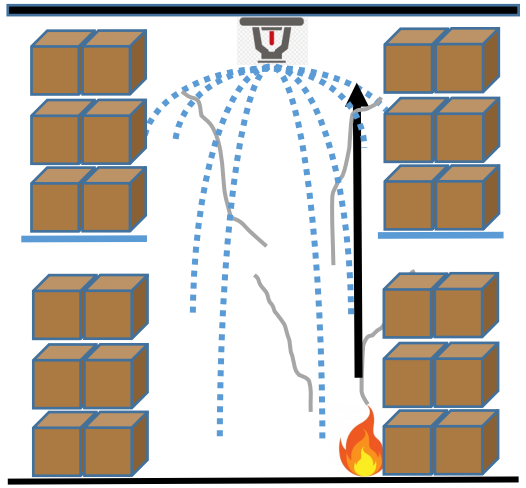


(b)

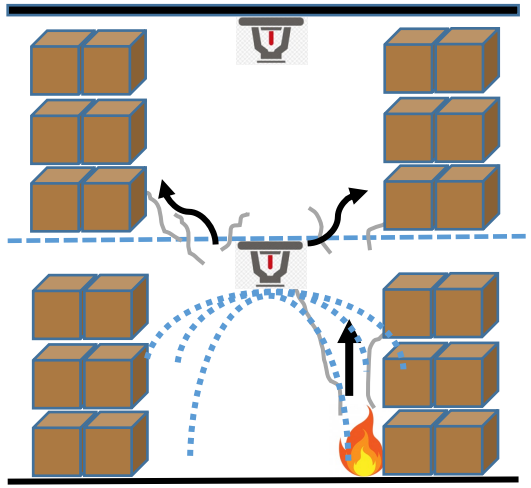
# Walkways & Mezzanines



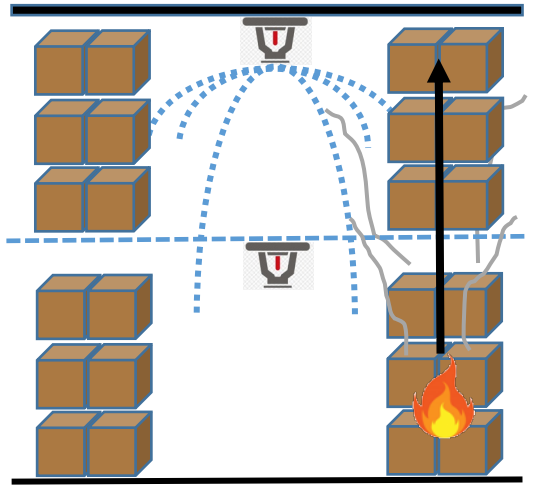
Solid Shelf/Walkway



Solid Shelving



Perforated Shelf/Walkway



Perforated Shelf/Walkway

# Obstruction & Walkway Concerns

Sprinkler sprays impinging on walkways altering ADD and pre-wetting of surfaces

Activation of sprinklers affected by presence of obstructions

Variations in sprinkler characteristics and operating pressures (consistency of results)

# Automated Storage & Retrieval Systems

# ASRS Concerns

Sprinkler sprays not able to penetrate the storage array

Activation of sprinklers affected by presence of obstructions

First responders ability to access the hazard and remove the combustibles

# EV’s

# EV Concerns

Sprinklers can’t deliver water to the source (if available)

Fire may be more “dynamic” with batteries involved

Sprinkler’s ability to prevent spread to adjacent vehicles

# BESS: 83kWh

https://www.youtube.com/c/fmglobal

# BESS Concerns

Sprinklers can’t deliver water to the BESS

Fire may be more “dynamic” with batteries involved, water make things worse?

Sprinkler’s ability to prevent spread to adjacent units/racks

Access for FD

# Now Some Details

# Sloped Ceiling Project Overview

1

## Phase I

- Storage protection survey
- Sprinkler activation simulations
- Sprinkler spray simulations

2

## Phase II

- Sprinkler activation simulations
- Sprinkler spray simulations
- Test matrix development

3

## Phase III

- Cold flow spray testing
- Additional simulations
- Full-scale testing and guidance document

https://www.nfpa.org/News-and-Research/Data-research-and-tools/Suppression/Protection-of-Storage-Under-Sloped-Ceilings

# Project Strategy

## Sprinkler activations

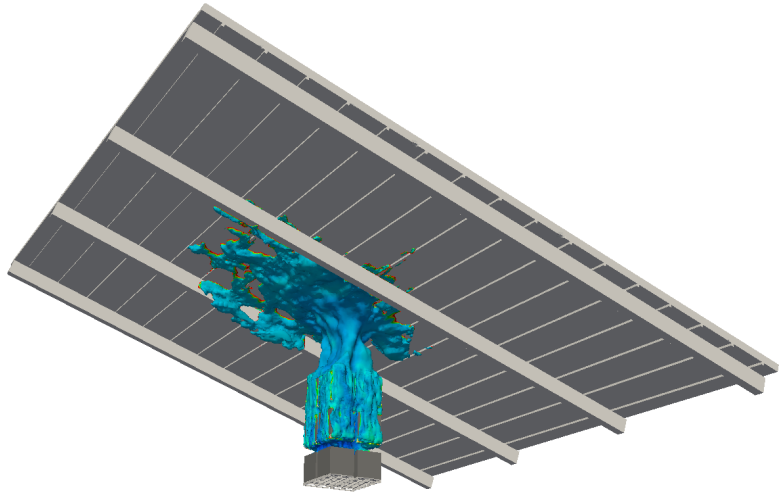
- effect of slope
- effect of obstructed construction
- effect of ridge

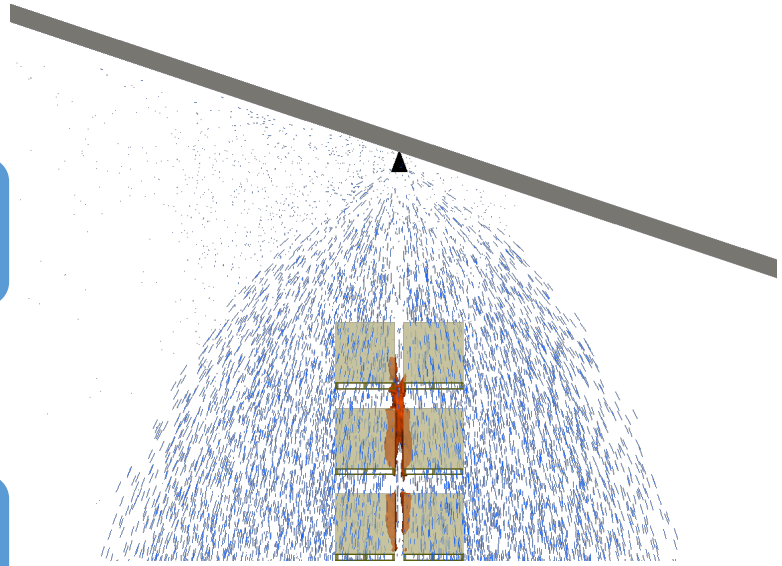
## Spray dynamics

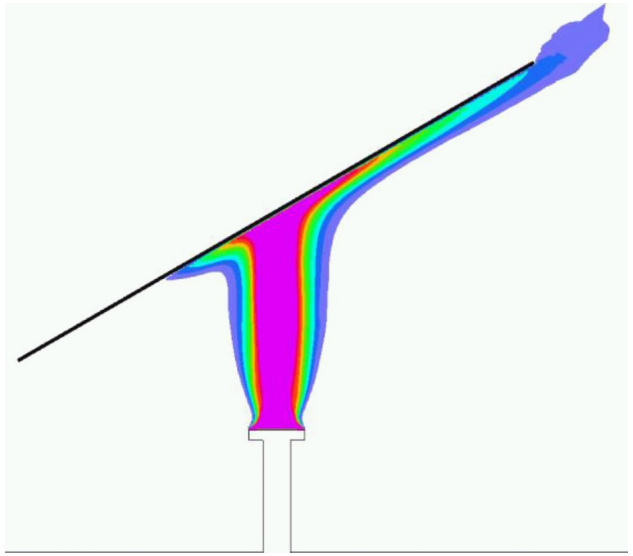
- water distribution
- deflector orientation

## FireFOAM solver

- validated for sloped ceiling flows



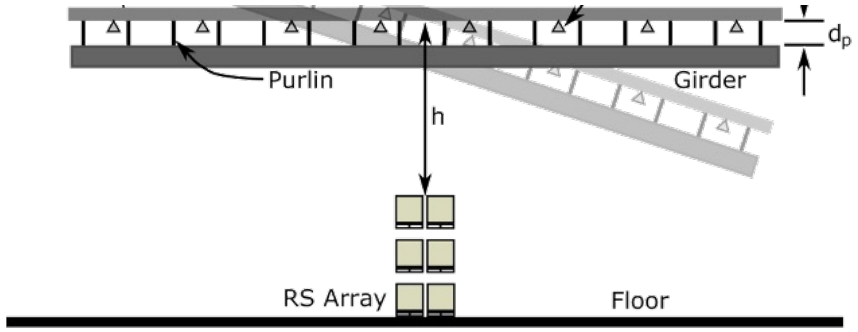


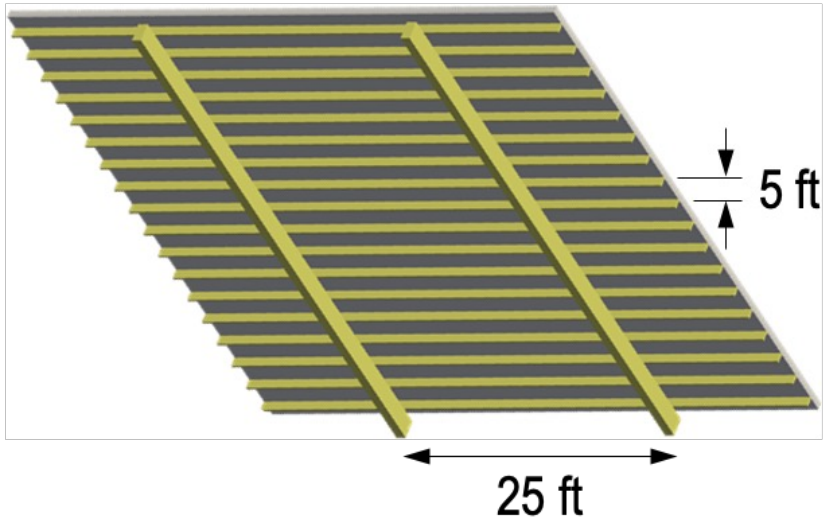


Chatterjee & Meredith (2015), Chatterjee et al. (2017)

# Activation Simulation Parameters

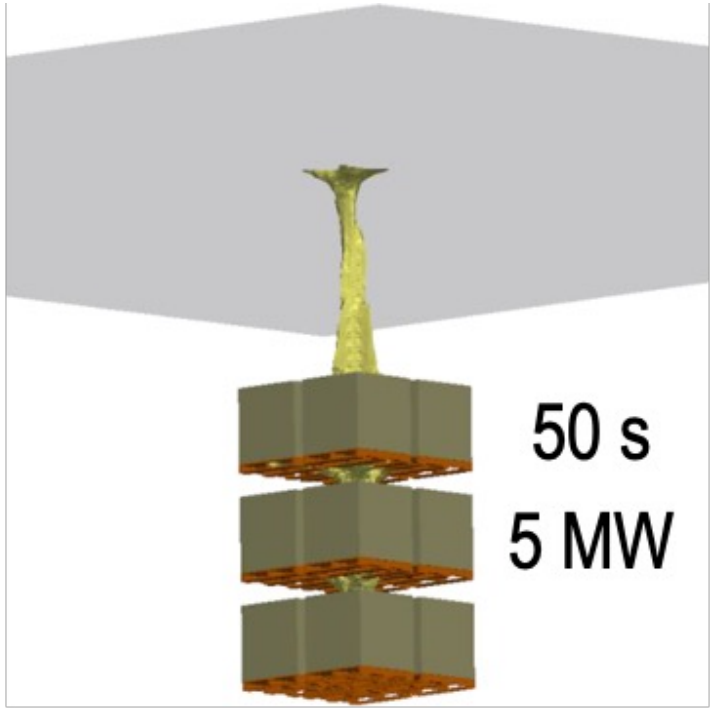
- Industrial-scale setup
  - 80 ft x 80 ft ceiling
  - 10 – 20 ft clearance
- 2:12 – 8:12 ceiling slopes (0°– 34° inclinations)
- Quick- and standard-response sprinklers
- Unobstructed and obstructed ceiling construction
  - 4 – 24 in. deep purlins, 5 ft spacing
  - 24 in. deep girders, 25 ft spacing
- Ceiling Ridge – 20 ft and 40 ft away

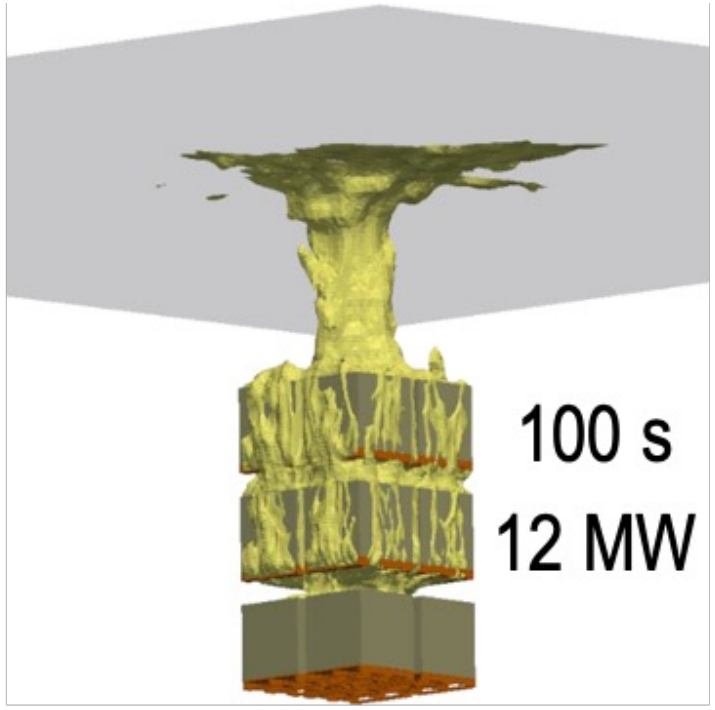


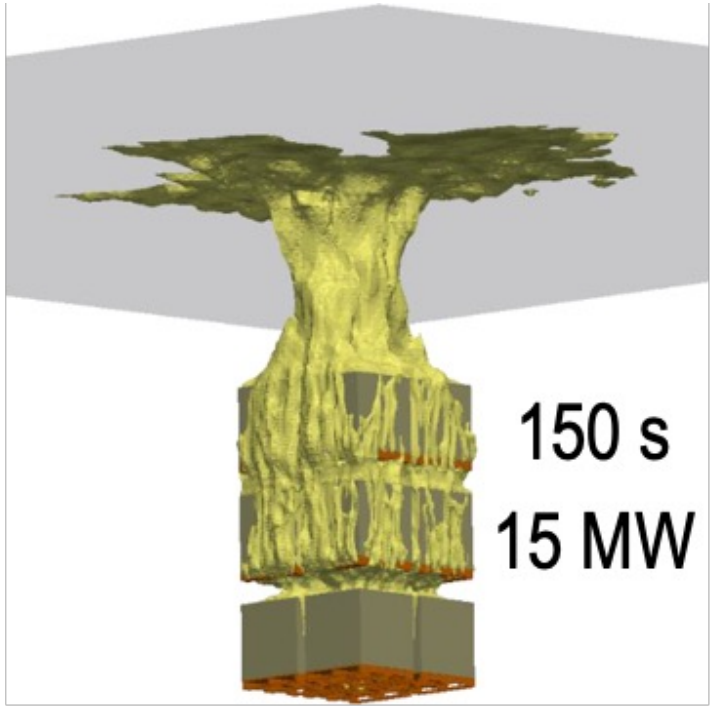



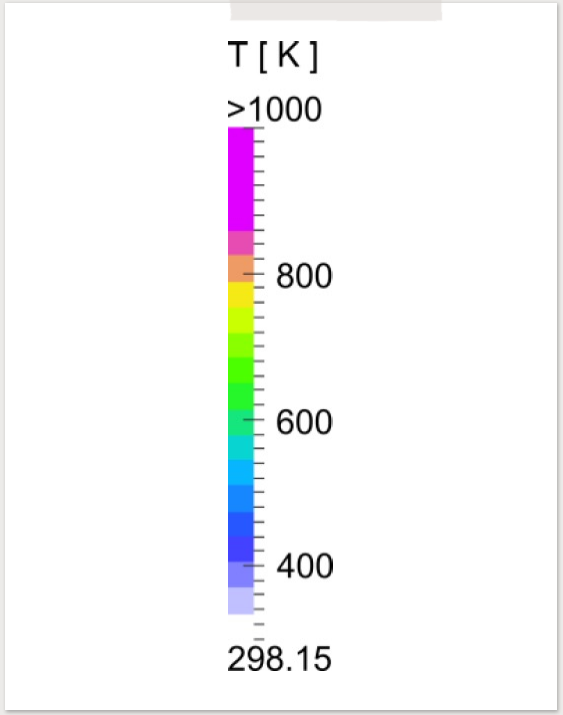
# Numerical Model

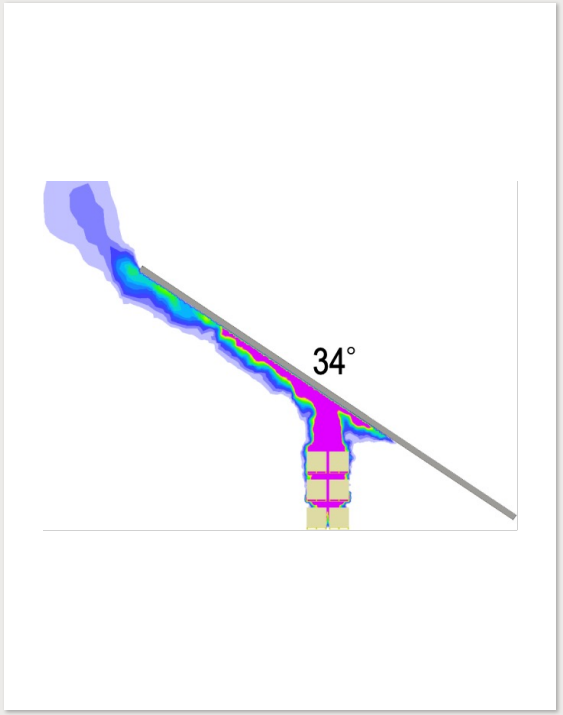
- Industrial-scale setup
  - 3-tier high rack-storage of FM Global CUP commodity

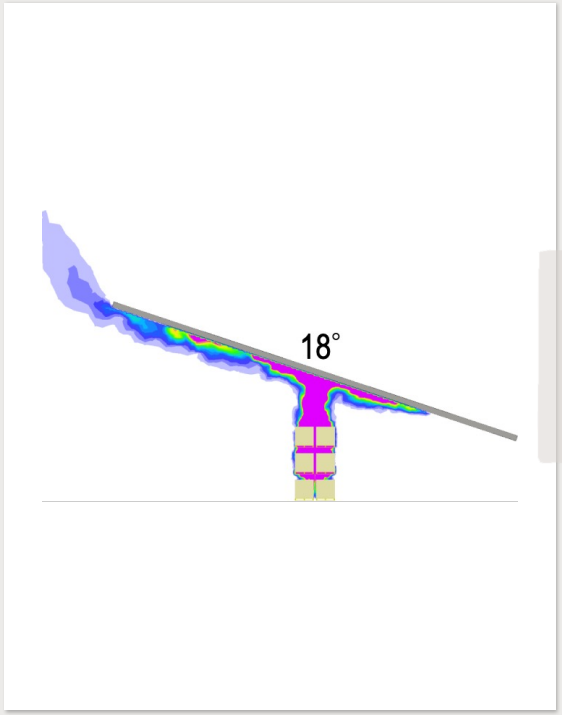


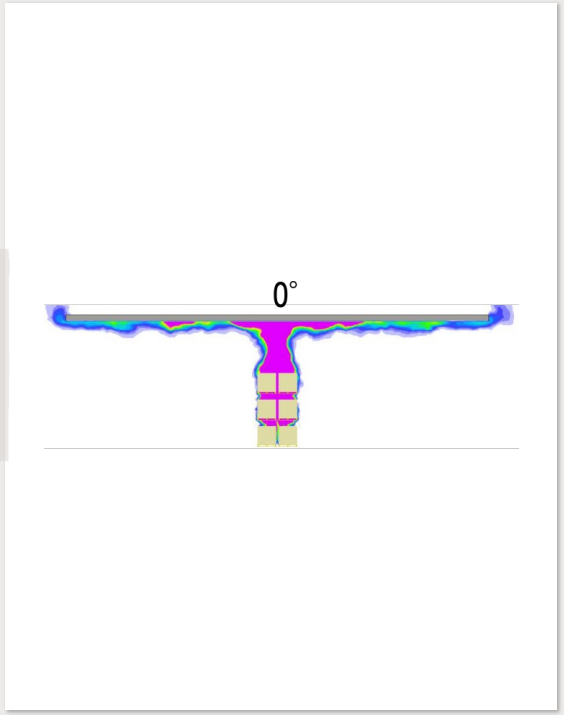





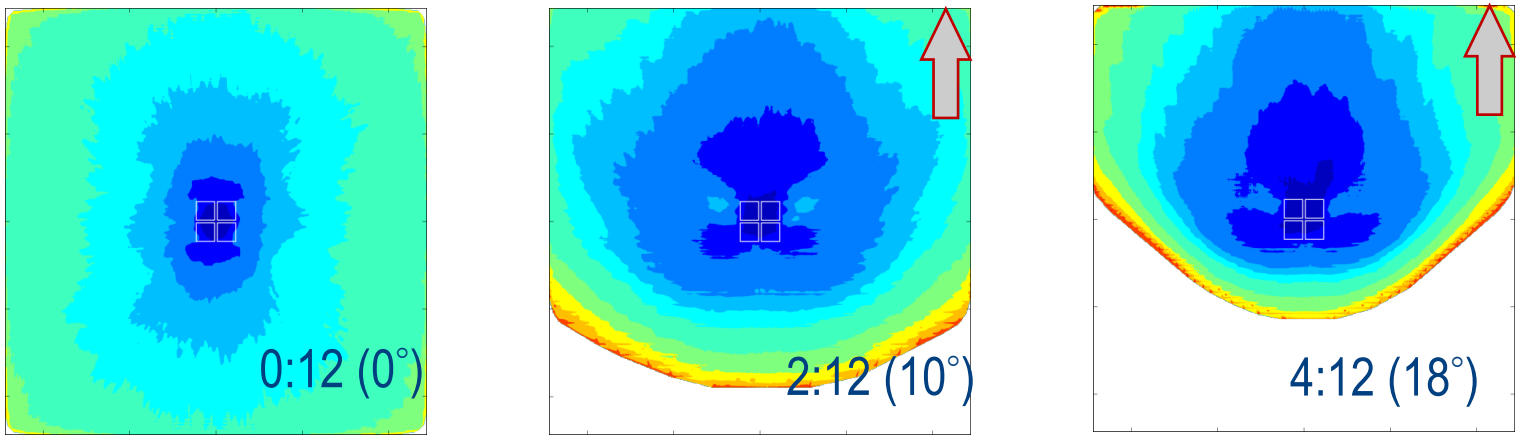



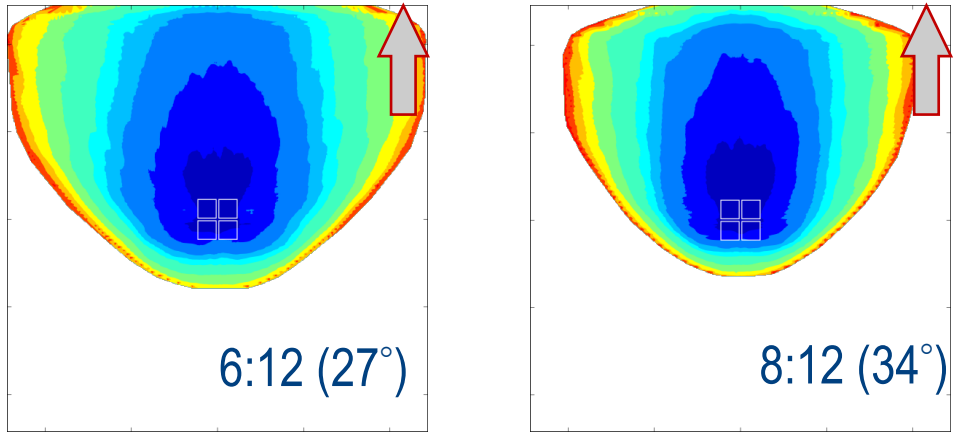



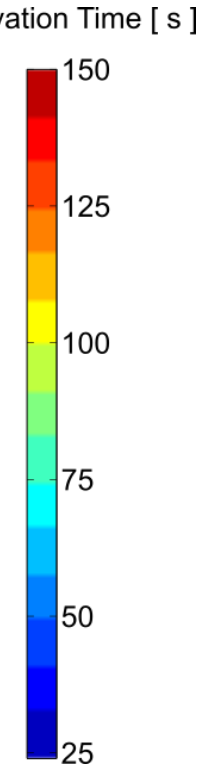

# Effect of Ceiling Slope

# Sprinkler Activation – Unobstructed Ceiling

- Quick-response, ordinary temperature (QR/OT) sprinkler activations
  - Ceilings ≤18° (4 in 12) similar to horizontal ceiling
  - Significant delays and skew for ceilings ≥ 27° (6 in 12)



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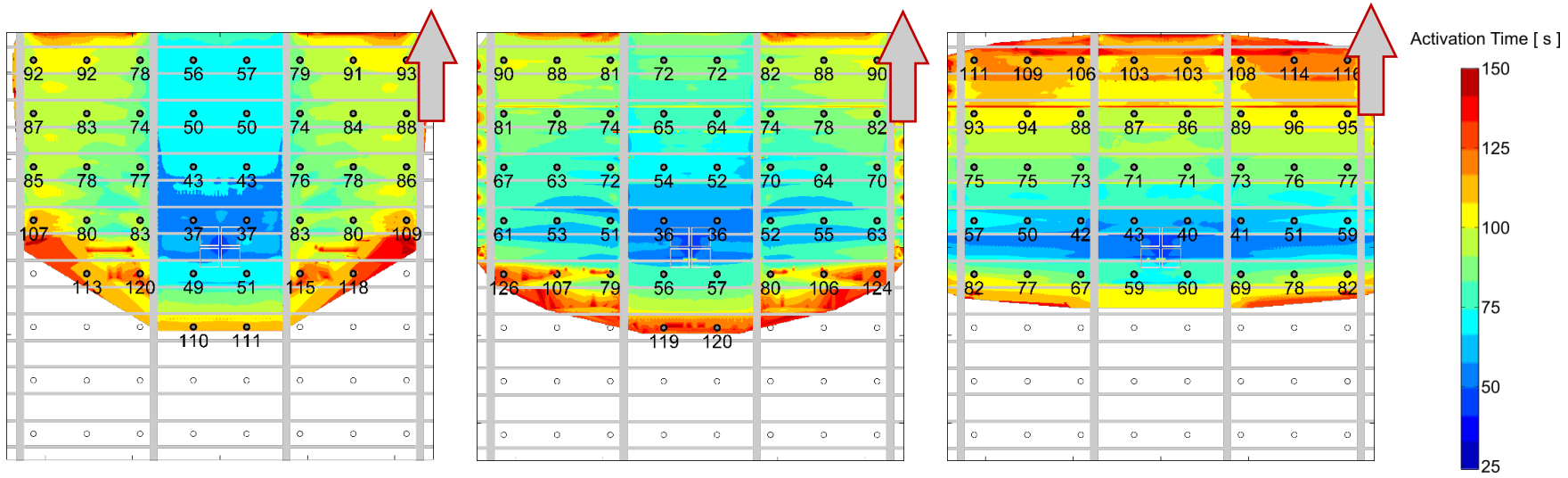
# Sprinkler Activation – Obstructed Construction

QR/OT sprinkler activations:

| Inclination | Purlin Depth | | | |
|---|---|---|---|---|
| | 4 in. | 8 in. | 12 in. | 24 in. |
| 0° | ● | ● | ● | ● |
| 10° | ● | ● | ● | ● |
| 18° | ● | ● | ● | ● |




4 in. 12 in. 24 in.

18° ceiling inclination



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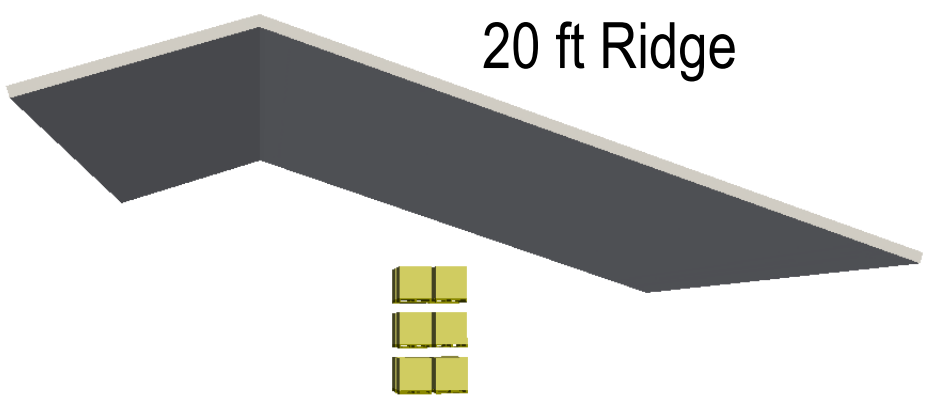
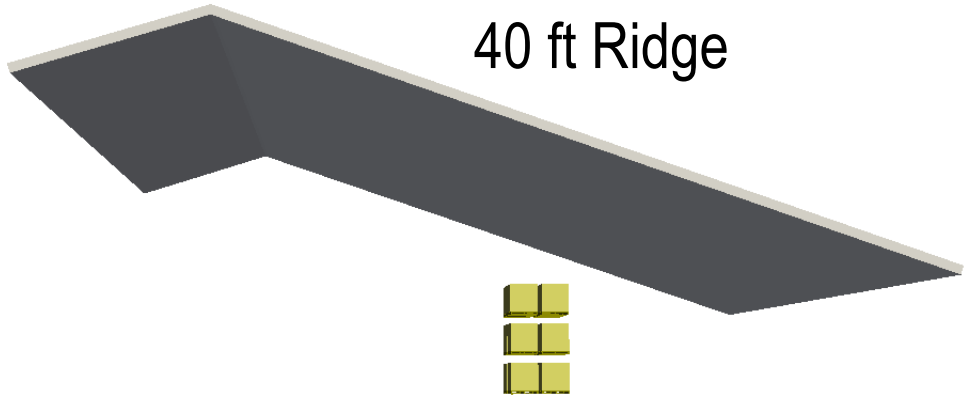
# Ridge Simulations

20 ft Ridge

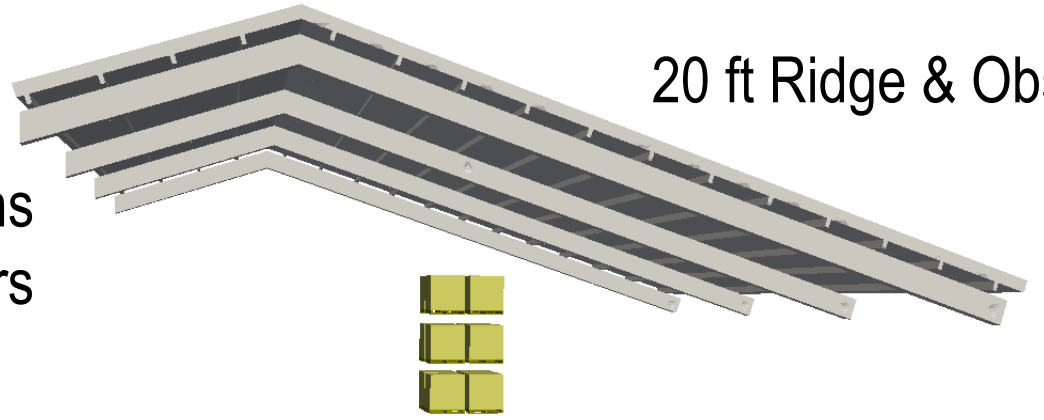


40 ft Ridge



20 ft Ridge & Obstructions

8 in. Purlins
24 in. girders





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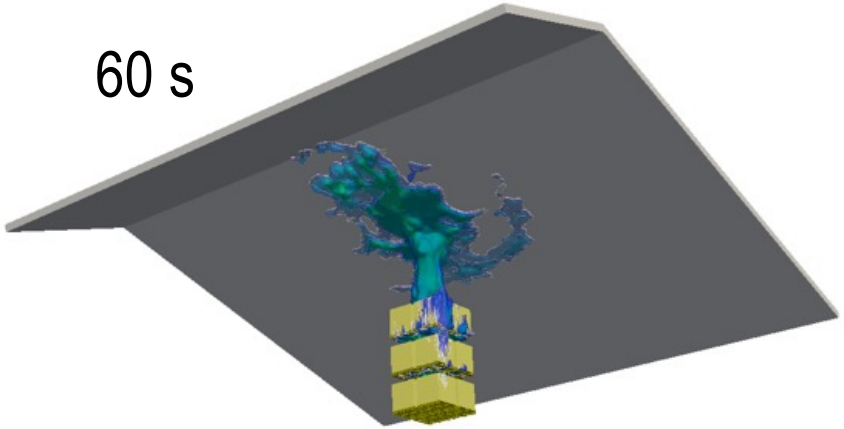
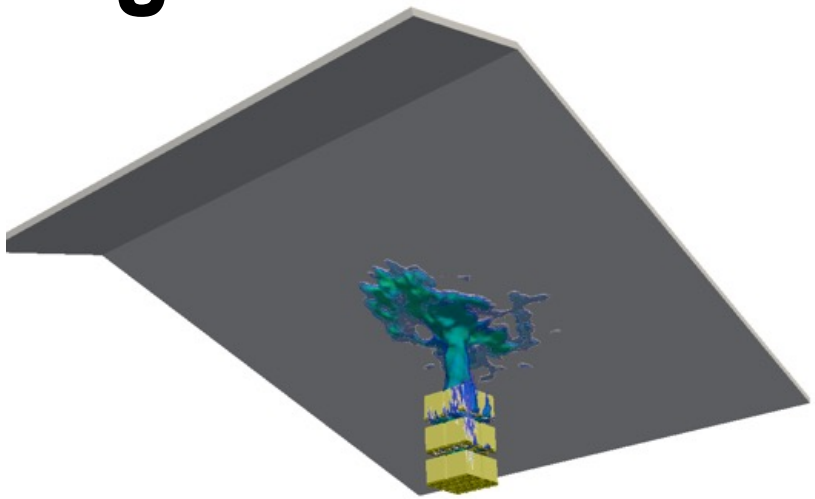
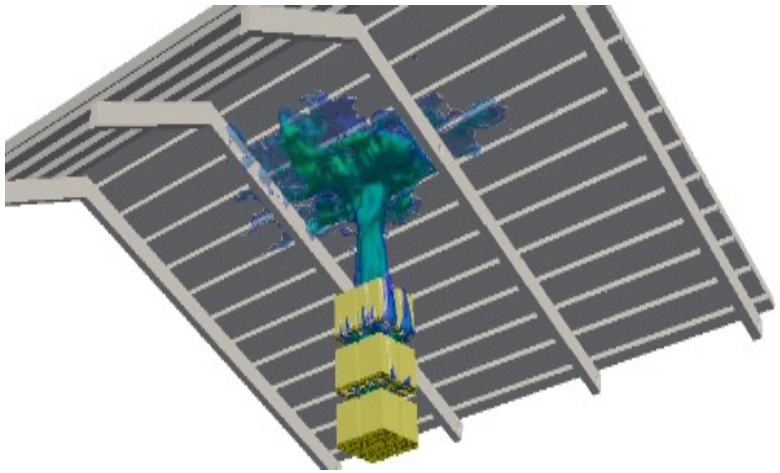
# Ceiling Jet with Ridge

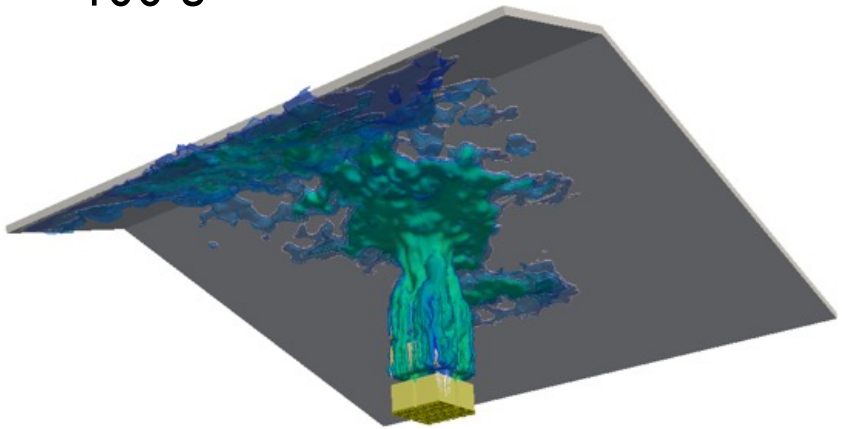
60 s

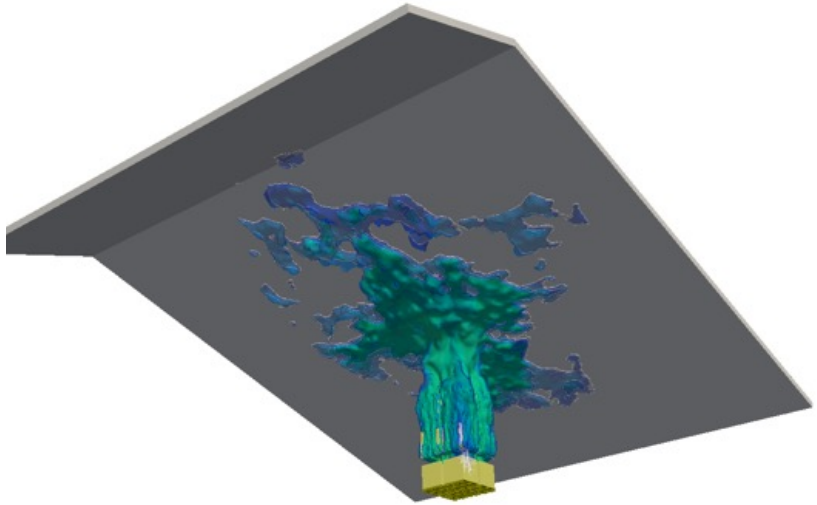


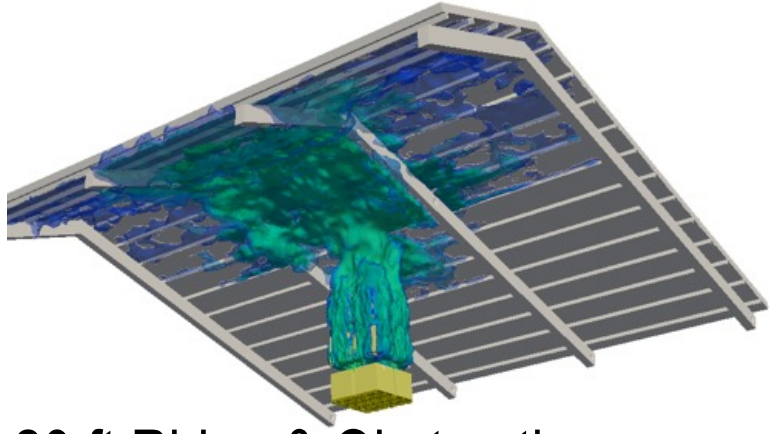




100 s







20 ft Ridge & Obstructions



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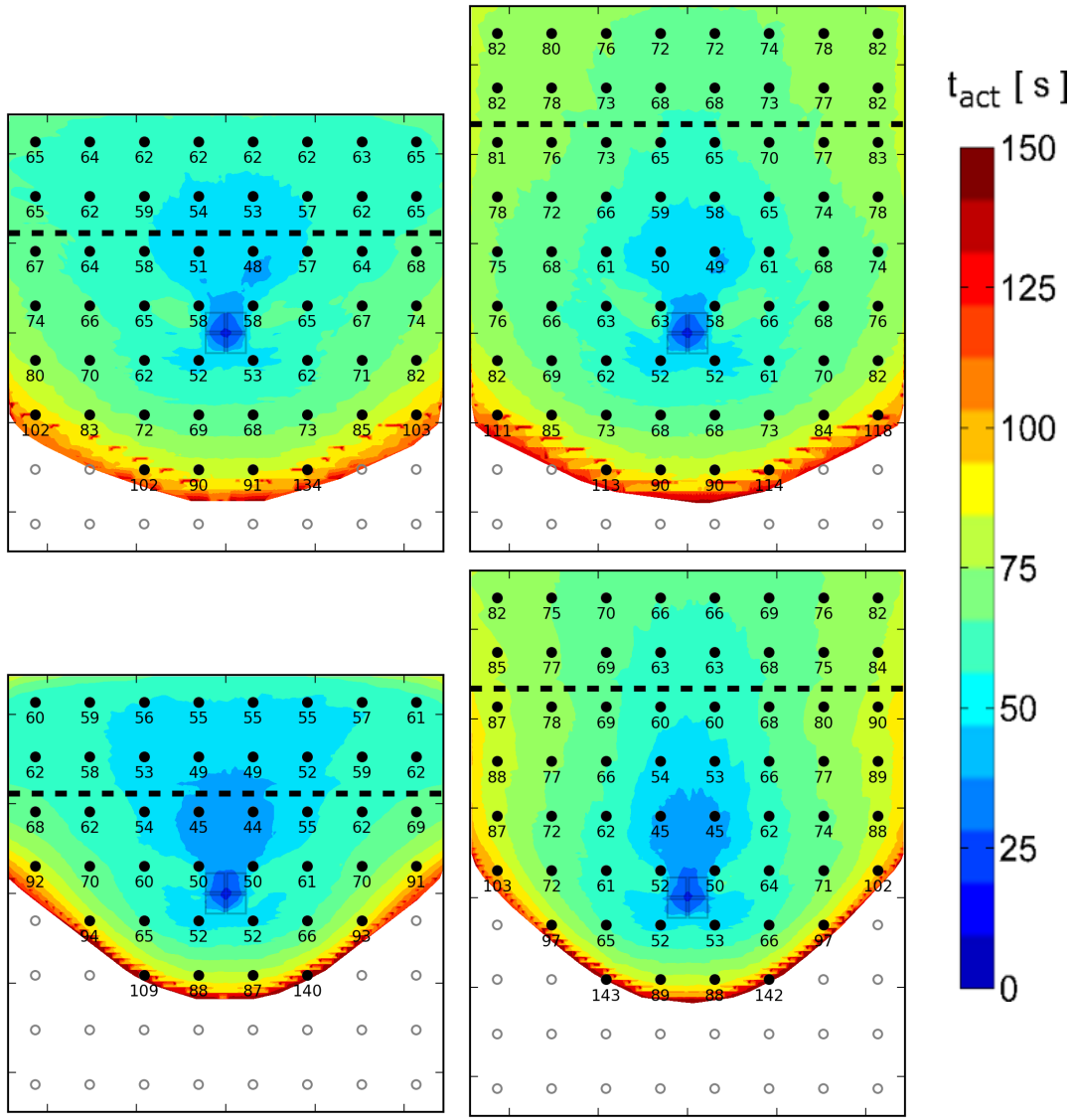
# Sprinkler Activation Comparisons

10º ceiling

18º ceiling




20 ft ridge

40 ft ridge



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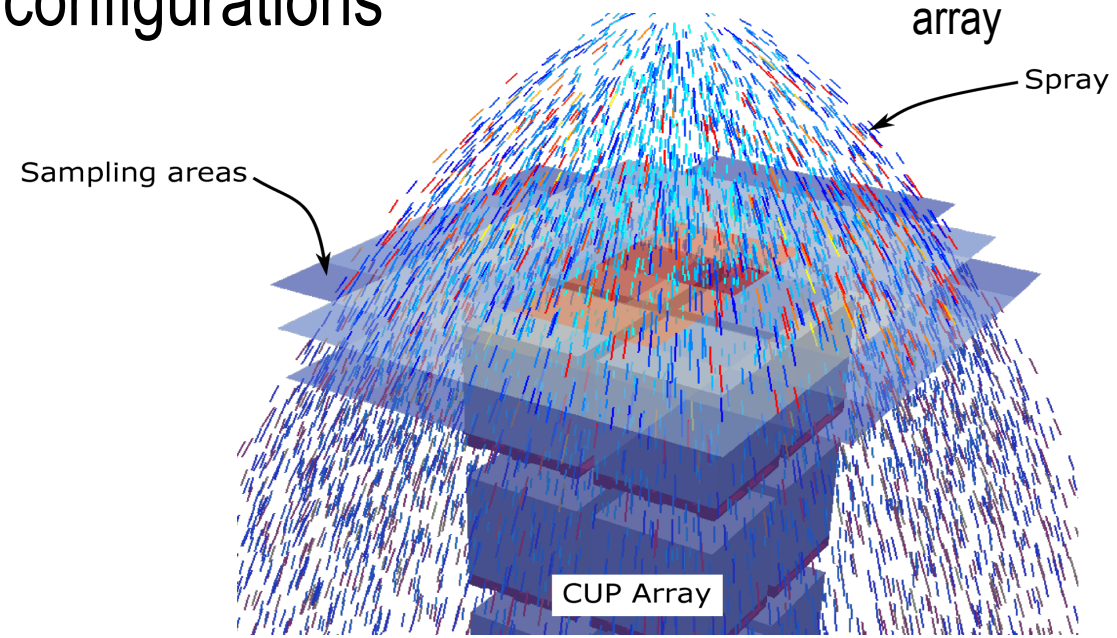
# Sprinkler Sprays

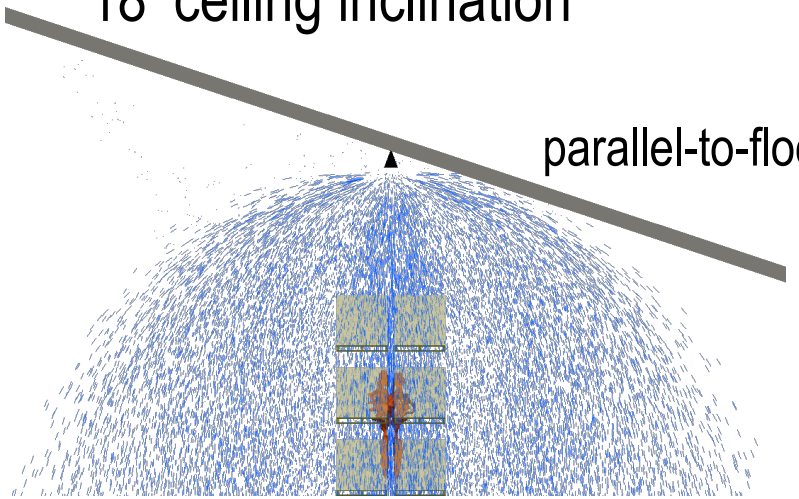
- Sprinklers with Flow Rate ~100 gpm
  - K-14 pendent sprinkler
  - K-17 pendent sprinkler
  - K-11.2 upright sprinkler
- Single and four sprinkler configurations

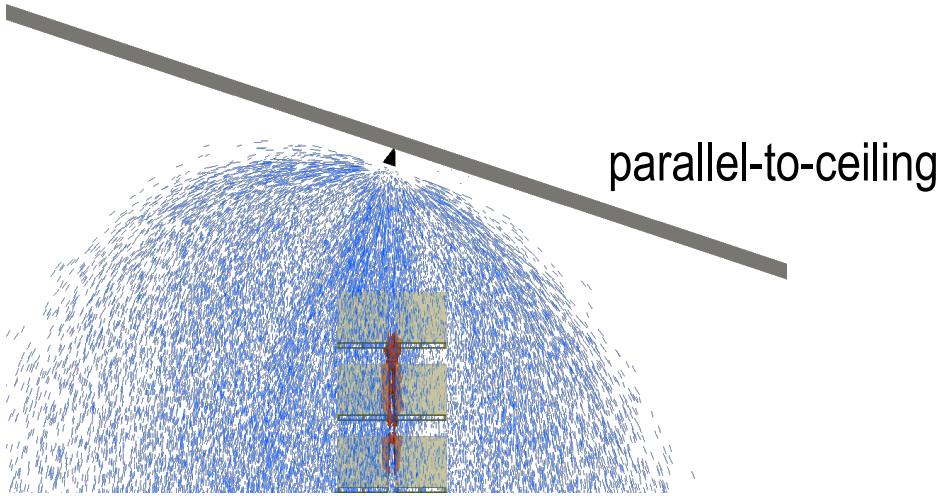
2 ft x 2 ft virtual collection buckets located 1 ft above the rack-storage array

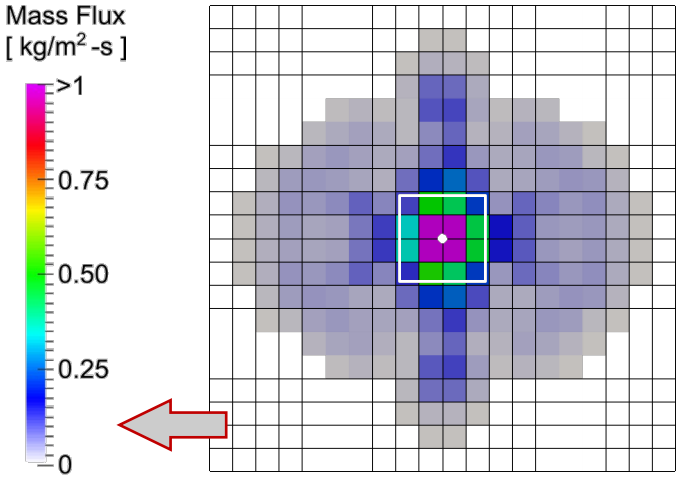


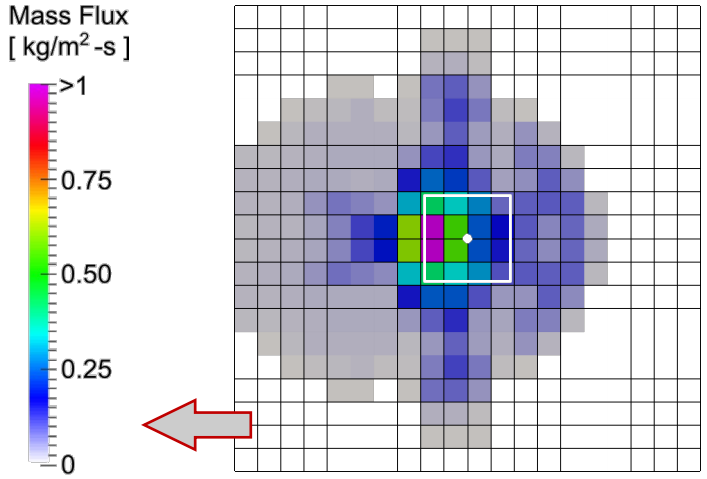
# Water Flux – Single Pendent K-17 Sprinkler

18° ceiling inclination

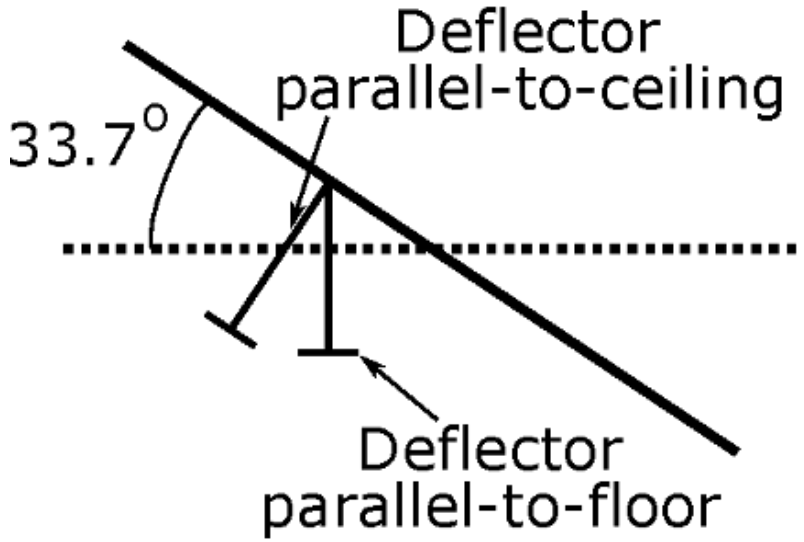


# Sprinkler Sprays

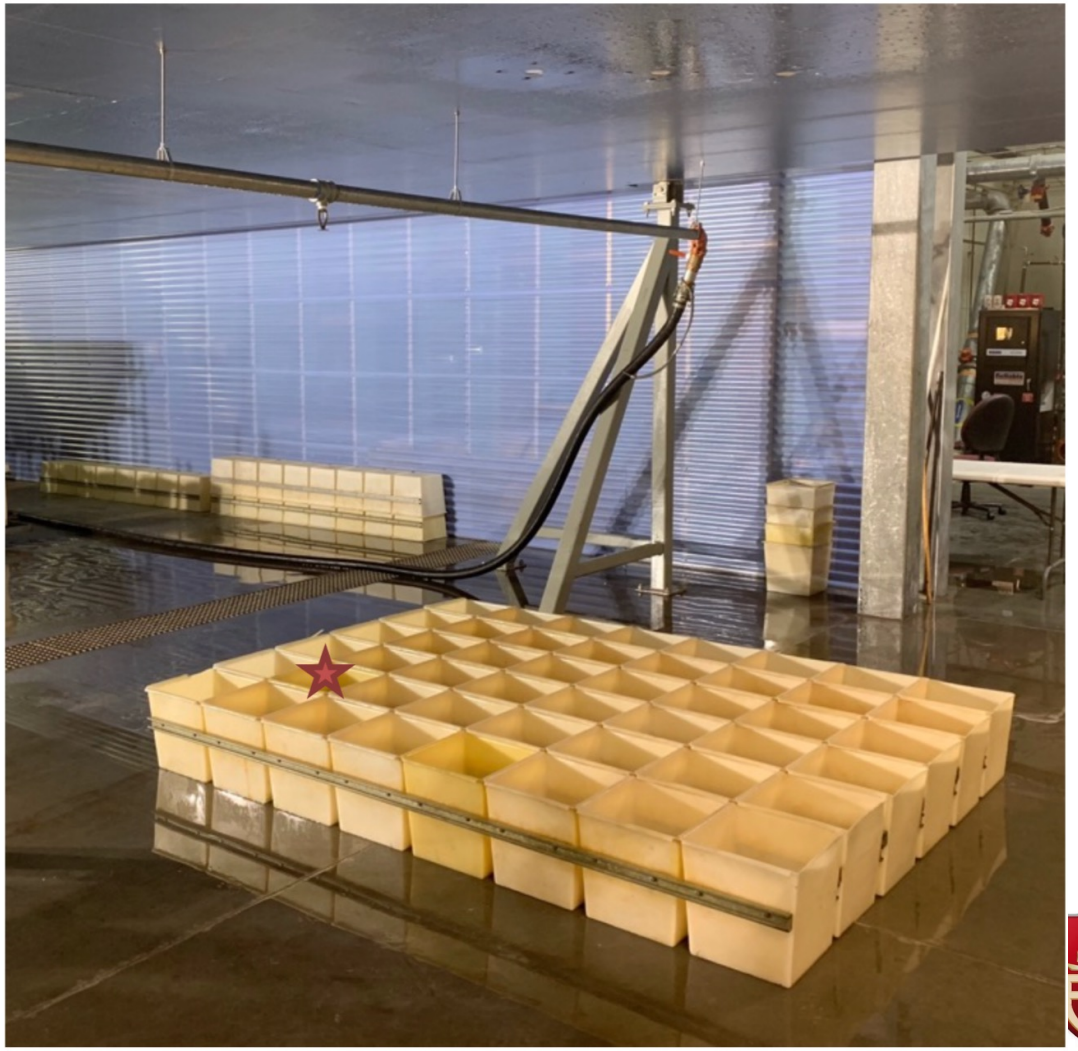



Deflector

- Evaluate ceiling slope effect on water distribution above rack-storage commodity
- Determine optimal sprinkler installation orientation
  - parallel-to-floor
  - parallel-to-ceiling

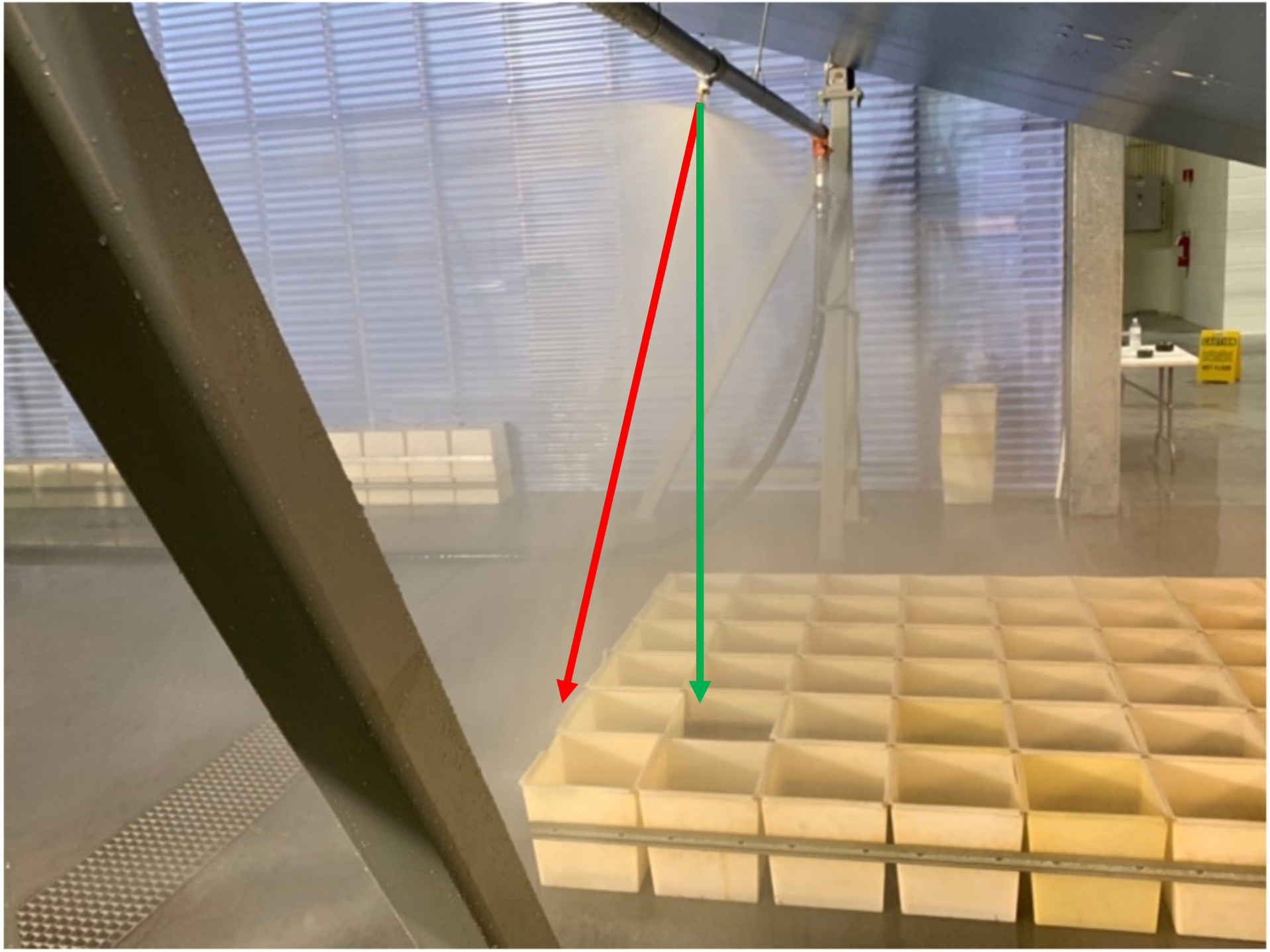
# Sloped Ceiling Tests @ Reliable

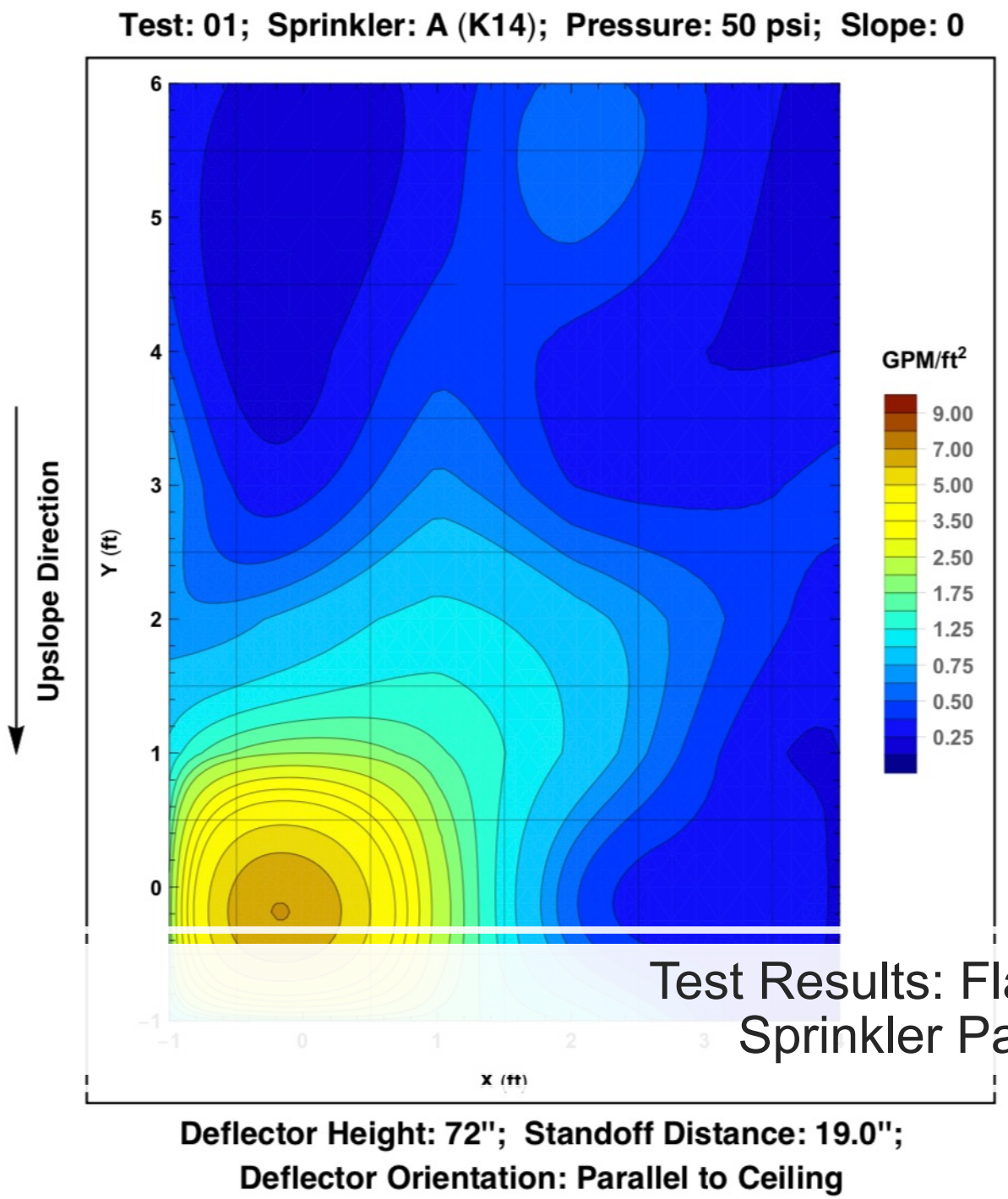
| Sprinkler Manufacturer | 1 | | 2 |
|---|---|---|---|
| K-factor | 14 | | 16.8 |
| Pressure (psi) | 35 | 50 | 75 |
| Ceiling Slope | 0:12 | | 4:12 |
| Nominal Standoff Distance | 8" | | 18" |
| Deflector Parallel Orientation | Ceiling | | Floor |

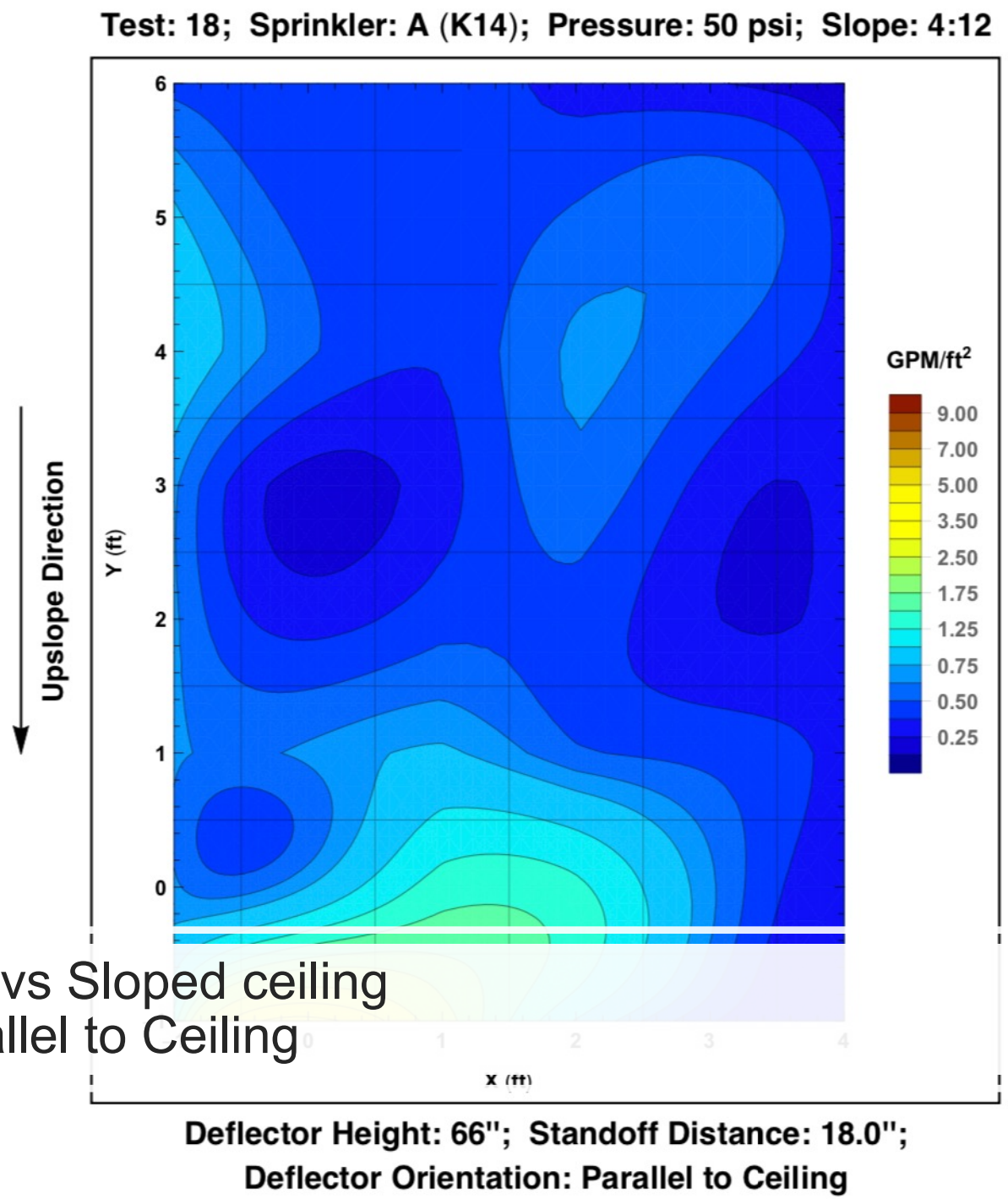


# Test Matrix

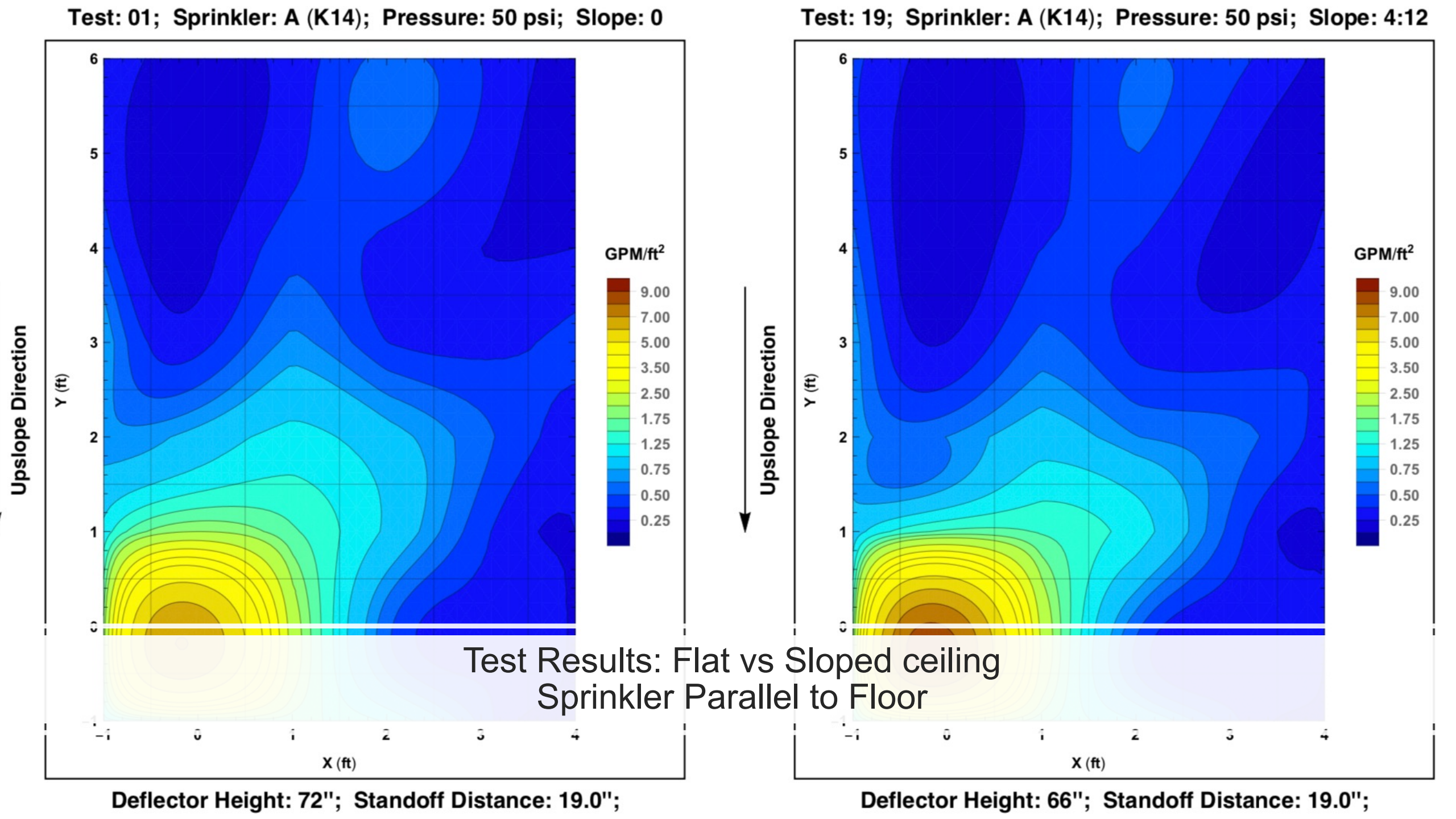
| | | K-Factor | 14 | | 16.8 | |
|---|---|---|---|---|---|---|
| | | **Sprinkler** | **A** | **B** | **C** | **D** |
| Ceiling Slope: 0:12 (0°) | **Pressure (psi)** | **35** | Test 02 | Test 06 | Test 10 | Test 07 |
| Deflector Parallel to the Floor | | **50** | Test 01 | Test 05 | Test 09 | Test 08 |
| Nominal Standoff Distance: 18" | | **75** | Test 03 | Test 04 | - | - |
| Ceiling Slope: 4:12 (18.4°) | | **35** | - | - | Test 11 | Test 14 |
| Deflector Parallel to the Ceiling | | **50** | Test 18 | Test 15 | Test 12 | Test 13 |
| Nominal Standoff Distance: 18" | | **75** | Test 17 | Test 16 | - | - |
| Ceiling Slope: 4:12 (18.4°) | | **35** | - | - | - | - |
| Deflector Parallel to the Floor | | **50** | Test 19 | - | - | - |
| Nominal Standoff Distance: 18" | | **75** | Test 20 | - | - | - |
| Ceiling Slope: 4:12 (18.4°) | | **35** | - | - | Test 21 | Test 24 |
| Deflector Parallel to the Floor | | **50** | Test 28 | Test 25 | Test 22 | Test 23 |
| Nominal Standoff Distance: 8" | | **75** | Test 27 | Test 26 | - | - |
| Ceiling Slope: 4:12 (18.4°) | | **35** | - | - | Test 33 | Test 36 |
| Deflector Parallel to the Ceiling | | **50** | Test 29 | Test 32 | Test 34 | Test 35 |
| Nominal Standoff Distance: 8" | | **75** | Test 30 | Test 31 | - | - |





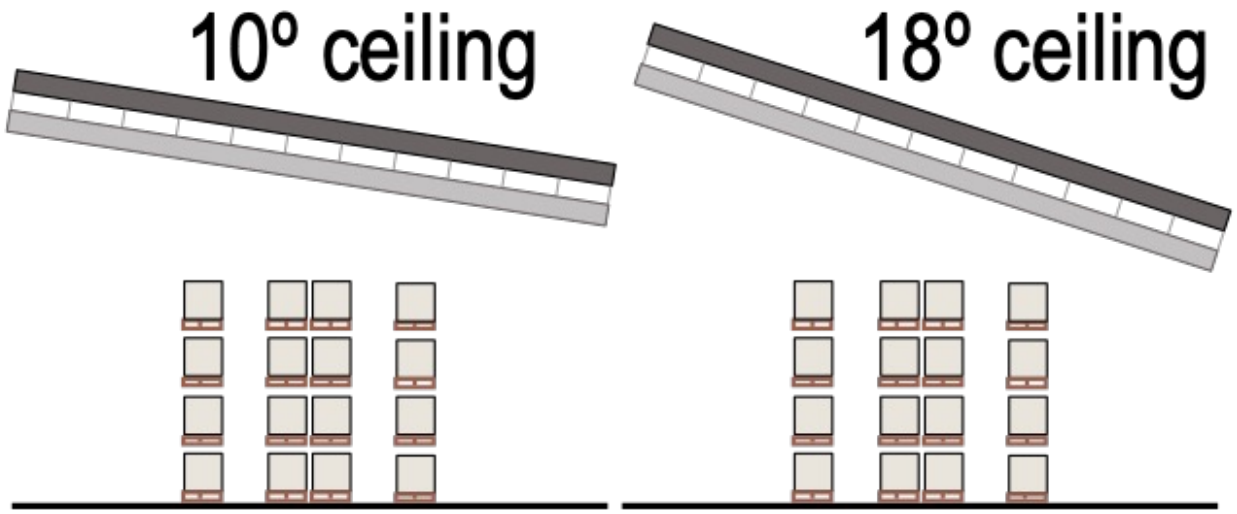



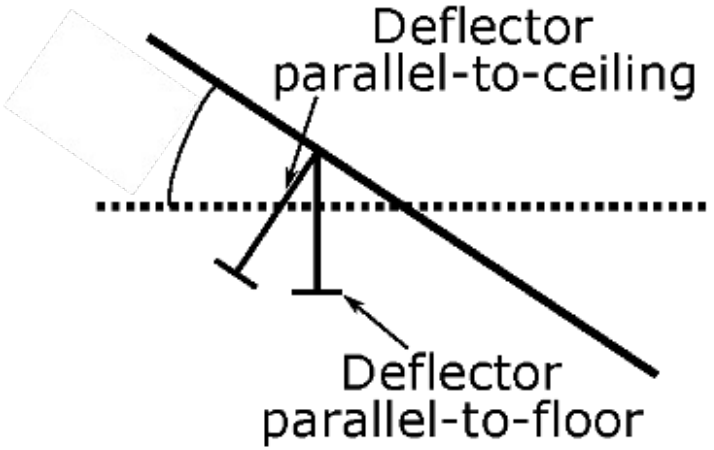

Test Results: Flat vs Sloped ceiling
Sprinkler Parallel to Ceiling


Test: 01; Sprinkler: A (K14); Pressure: 50 psi; Slope: 0
Test: 19; Sprinkler: A (K14); Pressure: 50 psi; Slope: 4:12
Upslope Direction
Upslope Direction
Y (ft)
X (ft)
GPM/ft²
9.00
7.00
5.00
3.50
2.50
1.75
1.25
0.75
0.50
0.25
Test Results: Flat vs Sloped ceiling
Sprinkler Parallel to Floor
Deflector Height: 72"; Standoff Distance: 19.0";
Deflector Height: 66"; Standoff Distance: 19.0";

# Sloped Ceiling Tests – Primary Variables

- Ceiling inclination
  - 10° (2 in 12)
  - 18° (4 in 12)
- Purlin depth
- Deflector orientation
  - Parallel-to-Floor
  - Parallel-to-Ceiling

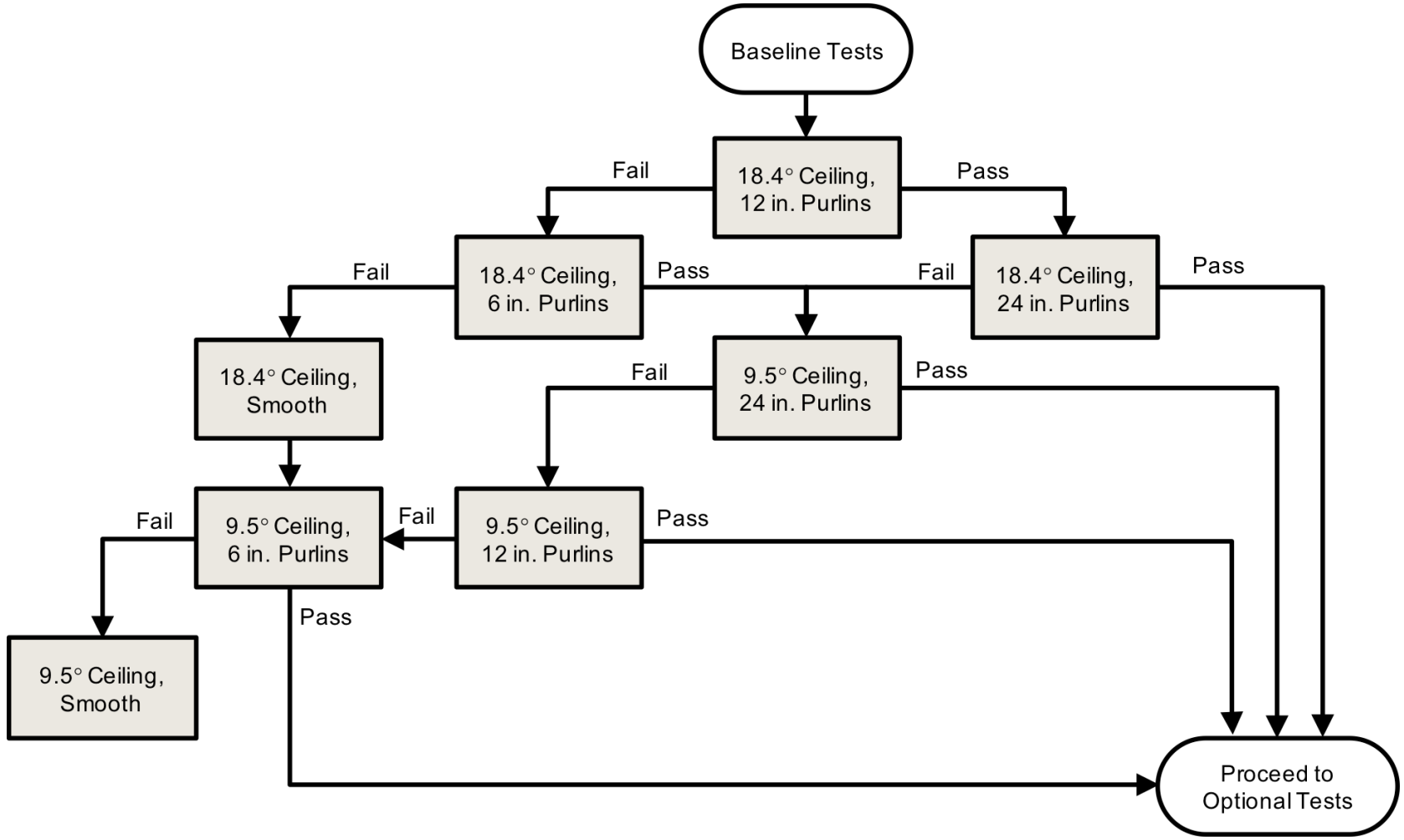



Deflector

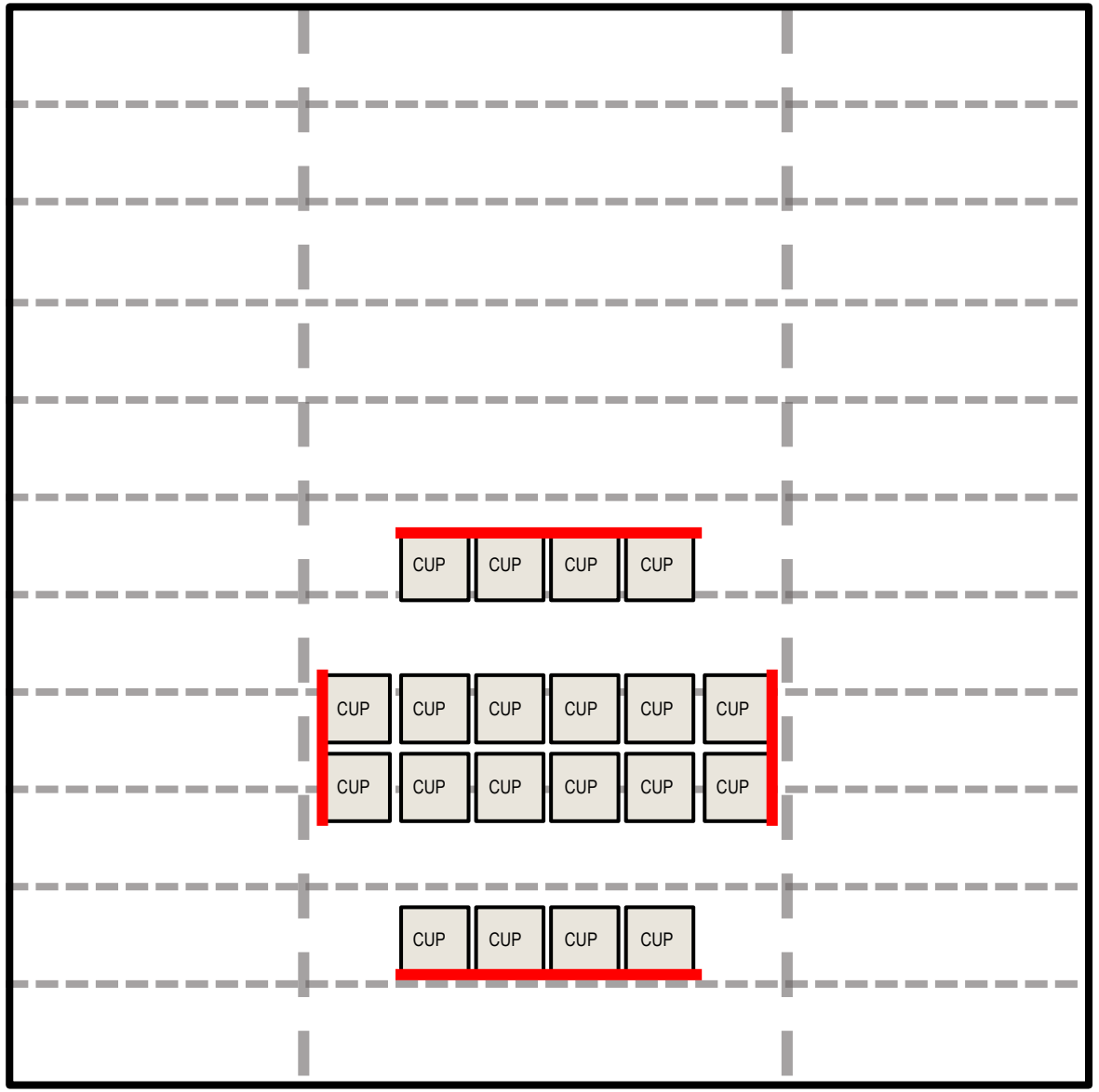
# Sloped Ceiling Tests – Test Progression

- Start with 18° ceiling and sprinklers deflectors oriented parallel-to-floor
  - Success – increase purlin depth
  - Failure – decrease purlin depth
- Once conditions for 18° ceiling established, examine 10° ceiling (if needed)



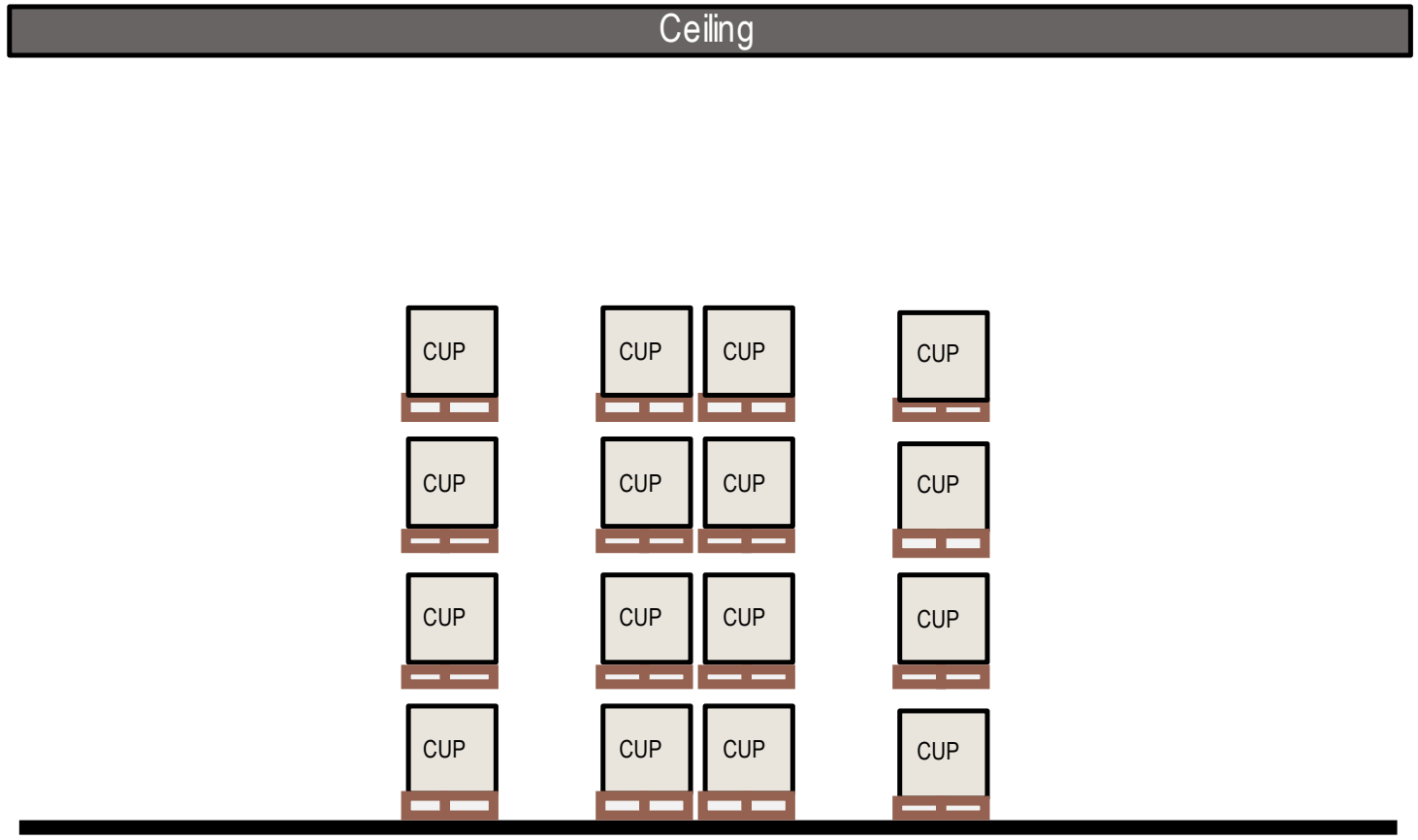
# Evaluation Criteria

- Extent of fire spread
- Number of sprinkler activations
- Ceiling steel temperatures >1000°F



# Baseline Test

- Horizontal ceiling, no obstructions
- Benchmark suppression performance
- Start with K-16.8 at 35 psi (100 gpm)




CAUTION/CUIDADO
CAUTION/CUIDADO
CAUTION/CUIDADO
CAUTION/CUIDADO
CAUTION/CUIDADO
CAUTION/CUIDADO
CAUTION/CUIDADO

# Large-Scale Testing Results

| | Baseline | Test 1 | Test 2 | Test 3 | Test 4 | Test 5 | Test 6 | Test 7 |
|---|---|---|---|---|---|---|---|---|
| Slope (degrees) | 0 | 18 | 18 | 10 | 10 | 10 | 10 | 18 |
| Deflector Orientation | Floor | Floor | Floor | Floor | Ceiling | Floor | Floor | Floor |
| Deflector Distance from Ceiling mm (in) | 330 (13) | 330 (13) | 460 (18) | 460 (18) | 460 (18) | 610 (24) | 610 (24) | 460 (18) |
| Purlin Depth mm (in) | - | - | 300 (12) | 300 (12) | 300 (12) | 450 (18) | 450 (18) | 300 (12) |
| Purlin Channels Open/Closed | - | - | Open | Open | Open | Closed | Closed | Closed |
| Girder Depth mm (in) | - | - | 600 (24) | 600 (24) | 600 (24) | 600 (24) | 600 (24) | 600 (24) |
| First Sprinkler Operation (s) | 82 | 78 | 74 | 82 | 76 | 97 | 83 | 73 |
| Last Sprinkler Operation (s) | 85 | 210 | 186 | 101 | 152 | 647 | 94 | 233 |
| Total # Sprinkler Operations | 3 | 10 | 13 | 6 | 4 | 9 | 7 | 7 |
| Perimeter Sprinkler Operations | No | Yes | Yes | No | No | No | No | No |
| Fire to Ends of main Array | No | No | No | No | No | Yes | No | No |
| Aisle Jump | No | Yes | Yes | Yes | No | Yes | No | No |


THIS SIDE UP

# Guidance

Protection guidelines are available

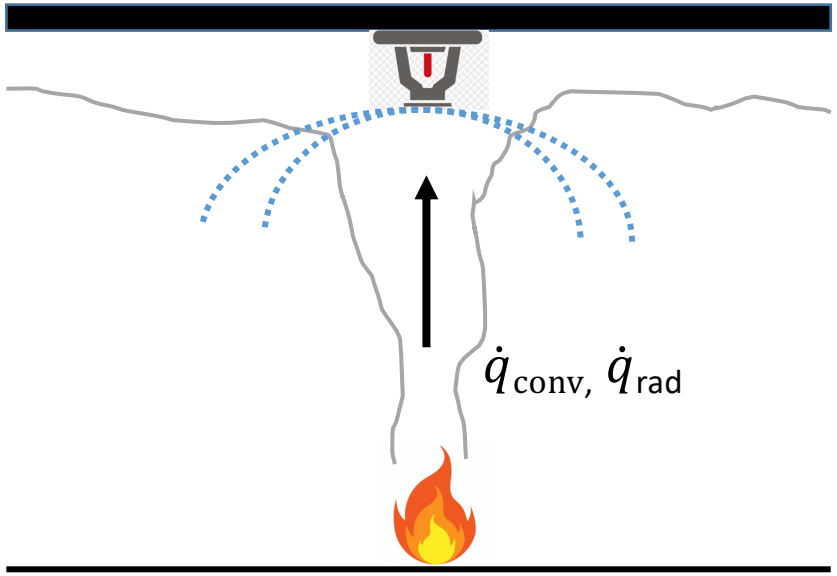
- NFPA 13: *Standard for Installation of Sprinkler Systems*
- FM Global Data Sheet 2-0: *Installation Guidelines for Automatic Sprinklers*

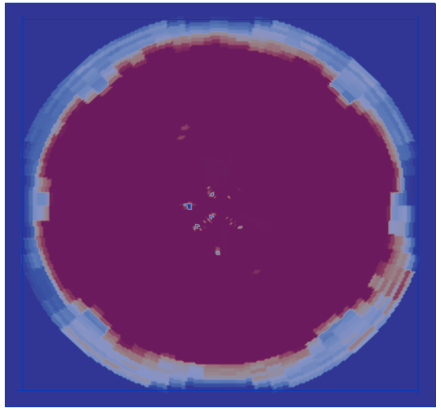
Max ceiling slope/inclination specified (now 4:12)

Require installation of drop ceiling or in-rack sprinklers for higher slopes

https://www.nfpa.org/News-and-Research/Data-research-and-tools/Suppression/Impact-of-Elevated-Walkways-in-Storage-on-Sprinkler-Protection-Phase-1

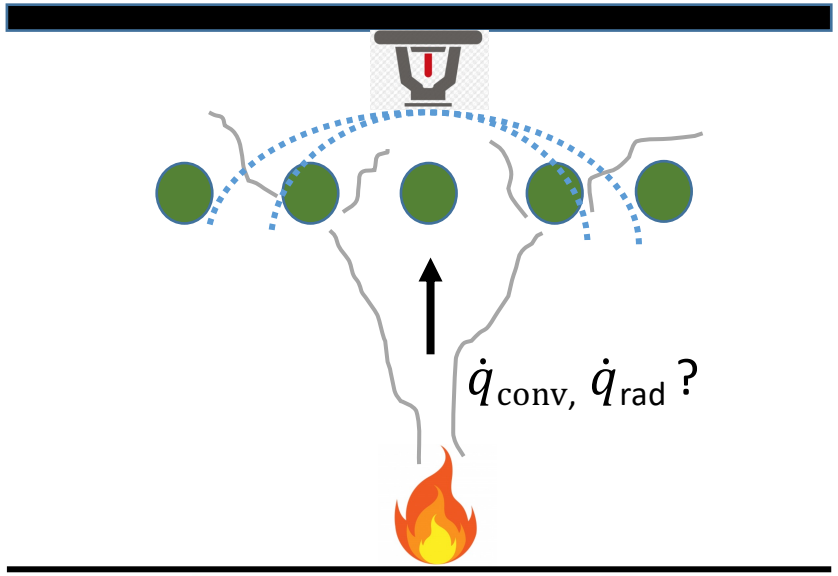
# Challenge: Obstructions

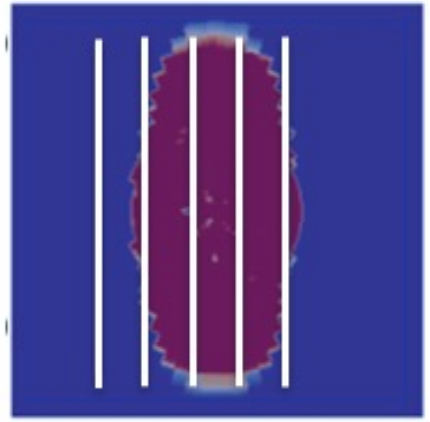


Actual Delivered Density to Floor

No Obstructions

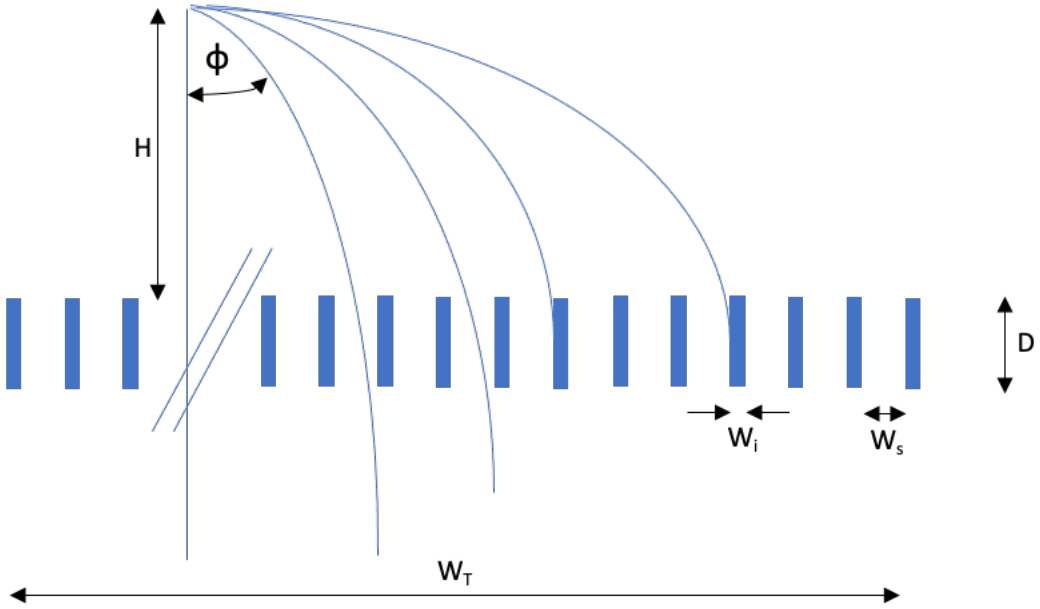


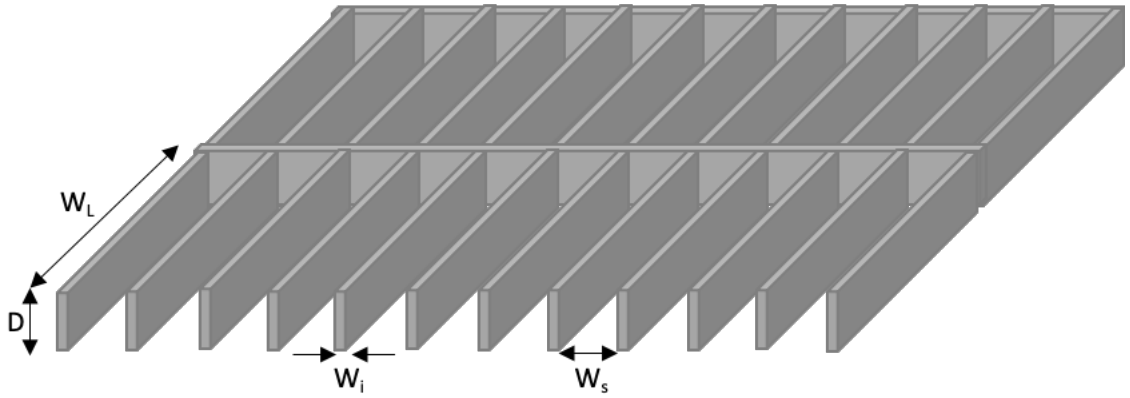



Actual Delivered Density to Floor

With Obstructions

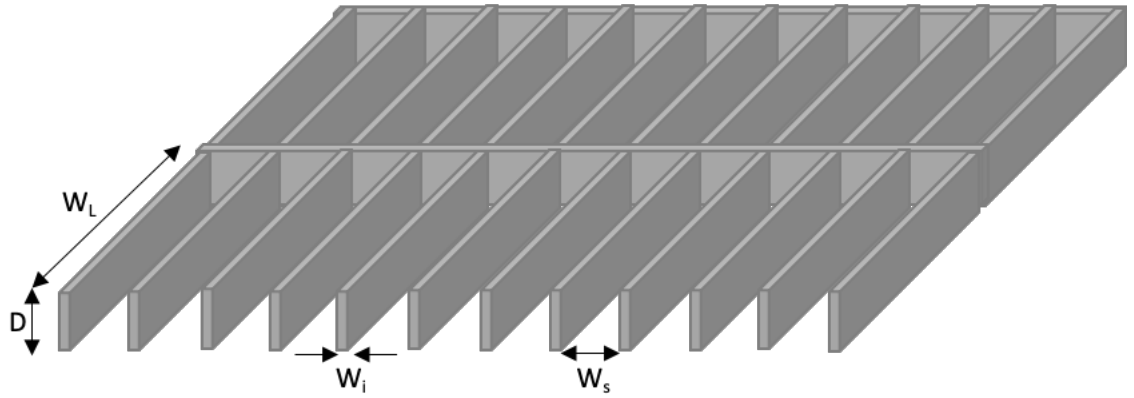
# Walkways, Ceiling Grates, Mezzanine, & Others



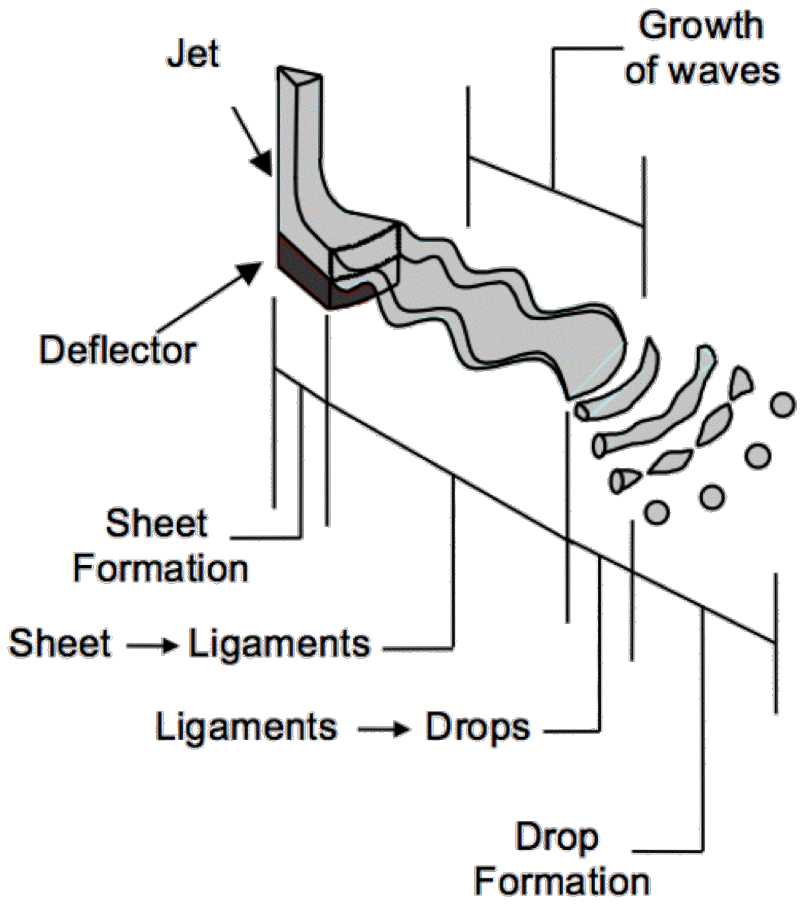



# Research Plan: Modeling & Cold Flow Experiments

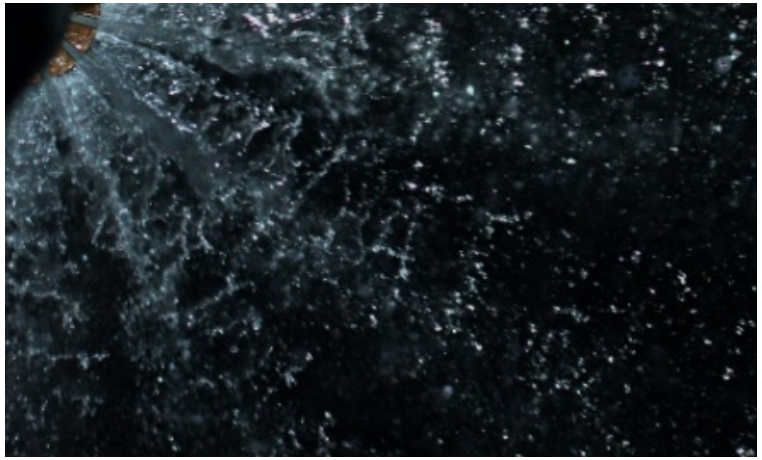
| | | | | | |
|---|---|---|---|---|---|
| | | K-Factor | 11.2 | 17 | 22 |
| **Modeling Parameters** | | **Sprinkler** | 1 | 2 | 3 |
| Baseline No Mezzanine | **Pressure (psi)** | 7, 20, 50 | NA | | |
| D (in) = 1/4, 3/8, 1/2, 3/4, 1.0<br>L (in) = 1, 1.5, 2, 3, 4, 5, 6<br>$W_i$ (in) = 1/8, 1/4, 3/8<br>$W_S$ (in) = 1/2, 3/4, 1, 1.25, 1.5 | | 7, 20, 50 | $W_T$ = 36, 44, 52, 60 | | |



# Background: Spray characteristics




- Droplet formation differs for each sprinkler arrangement (k-factor, pressure, type).

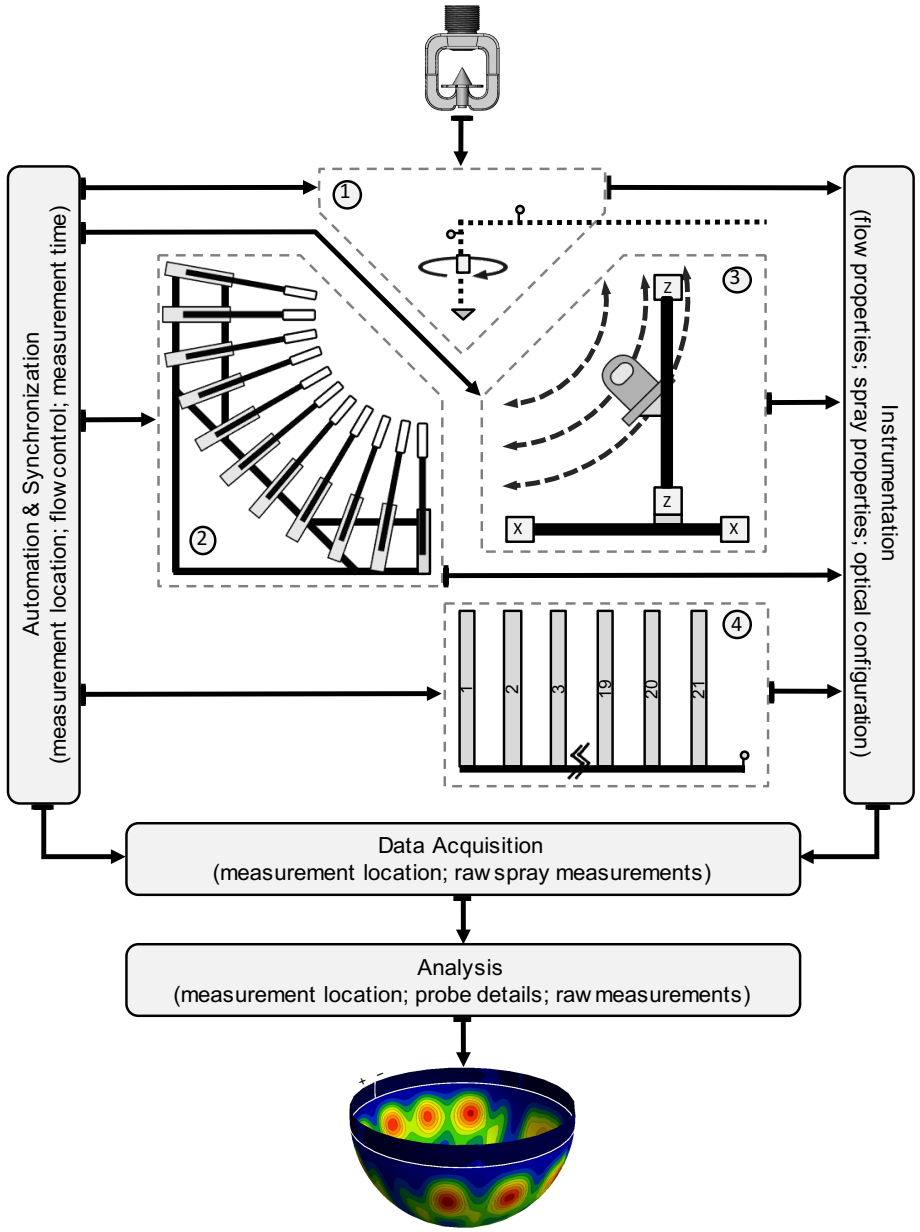


# Technology: 4S Spray Measurements

- Primary Subsystems:

(1) Flow Control & Sprinkler Rotation
(2) Mechanical Sphere Patternation
(3) Optical Sphere Patternation
(4) Integral Line Patternation

- Supported by:
  - Automation & Synchronization
  - Instrumentation
- Complete characterization of the discharged spray characteristics.
  - 1250 GB of data per characterization
  - After data reduction approaches: < 1 MB

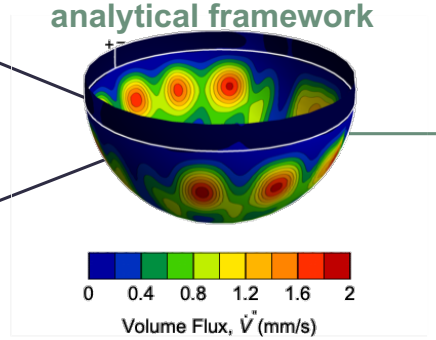


# Spray Characterization

Suppression evaluation Method

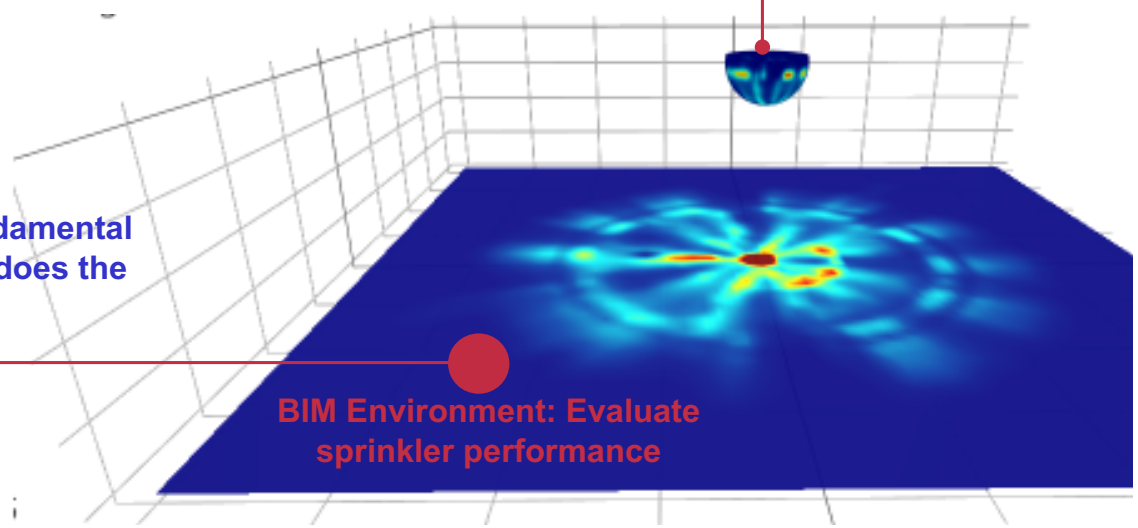
Spatially-resolved Spray Scanning System (4S)

4S measurements + analytical framework

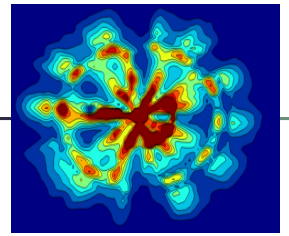



Answer to the fundamental question : What is the Spray

BIM Environment: Initialize the sprinkler spray



Method of Direct Evaluation of Nozzle Spraying Performance



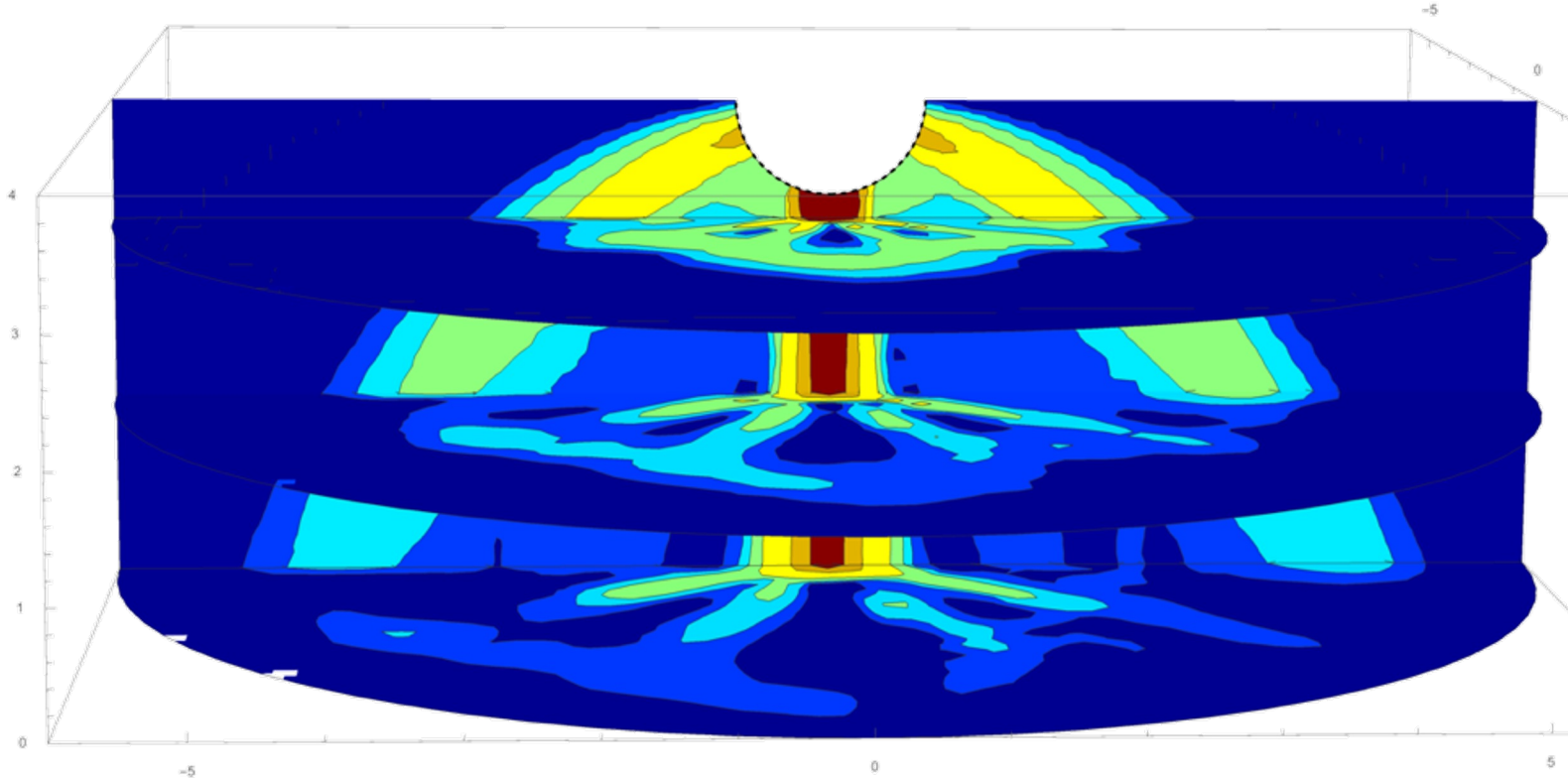
Unprecedented fast sprinkler spray evaluation

Answer to the fundamental question : Where does the water go?

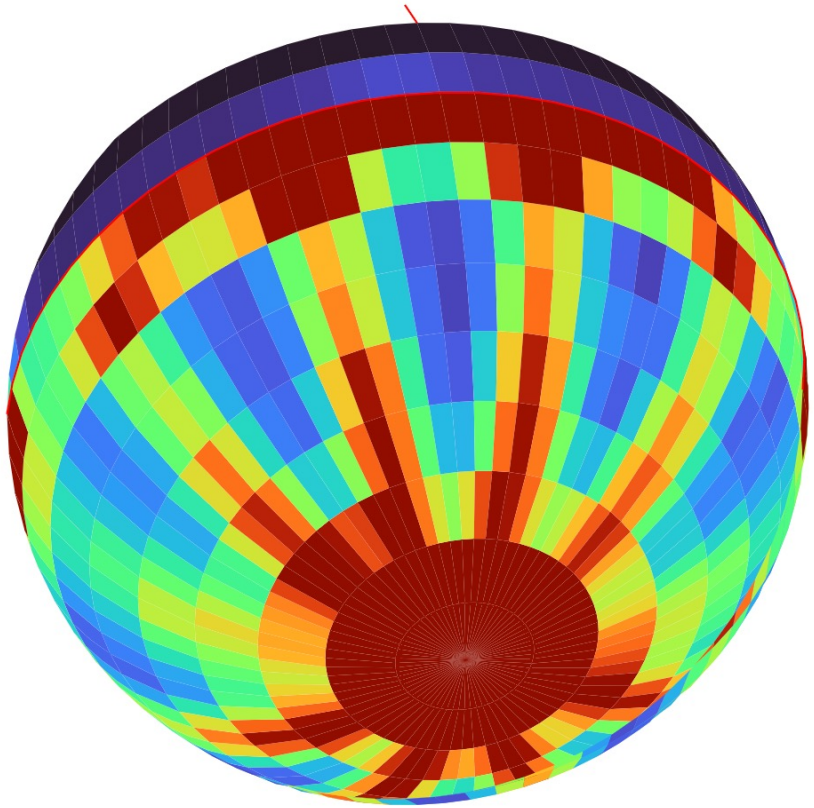
BIM Environment: Evaluate sprinkler performance

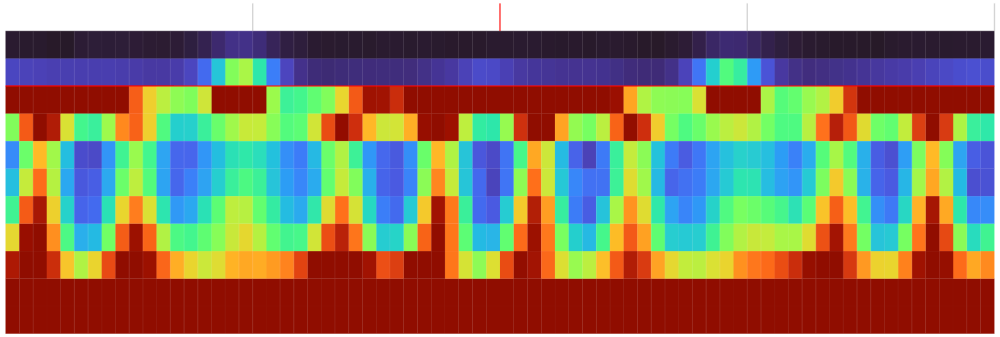
# What is Generated

- 4S output produces “slice” files
- These results are for “cold flow” environments
- How does introduction of a fire/buoyant plume impact results?



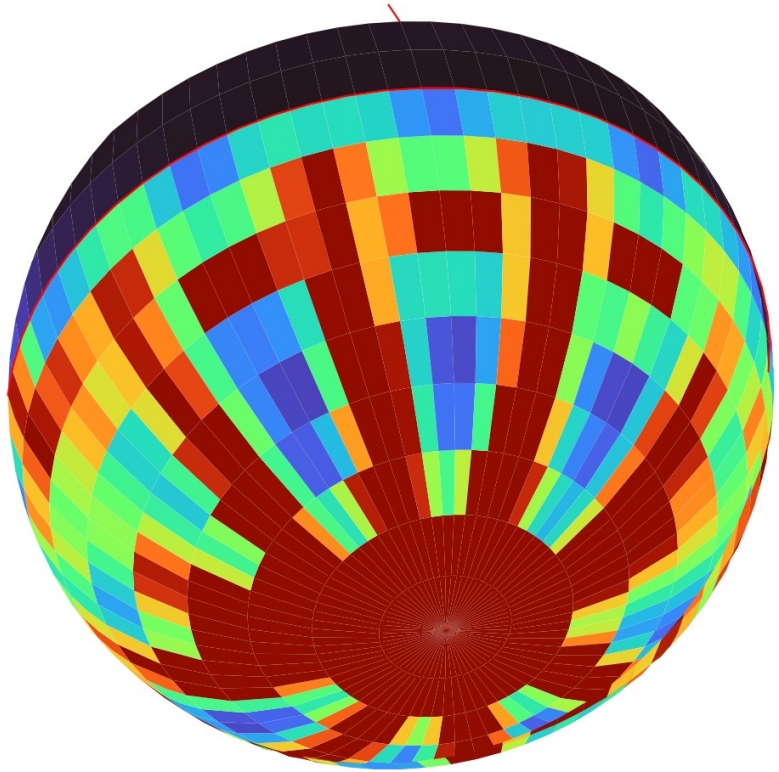
# Spray Characterizations: K14 ESFR (35 psi)

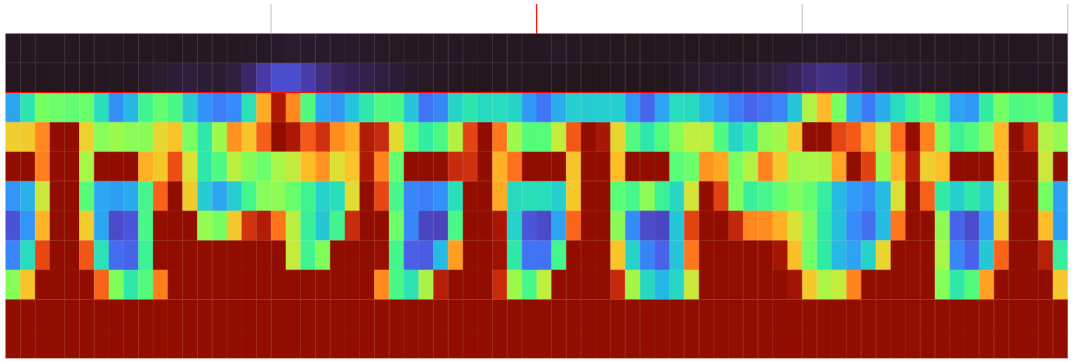


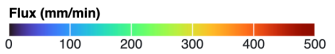



Maximum Display Value: 500 mm/min

# Spray Characterizations: K16.8 ESFR (35 psi)

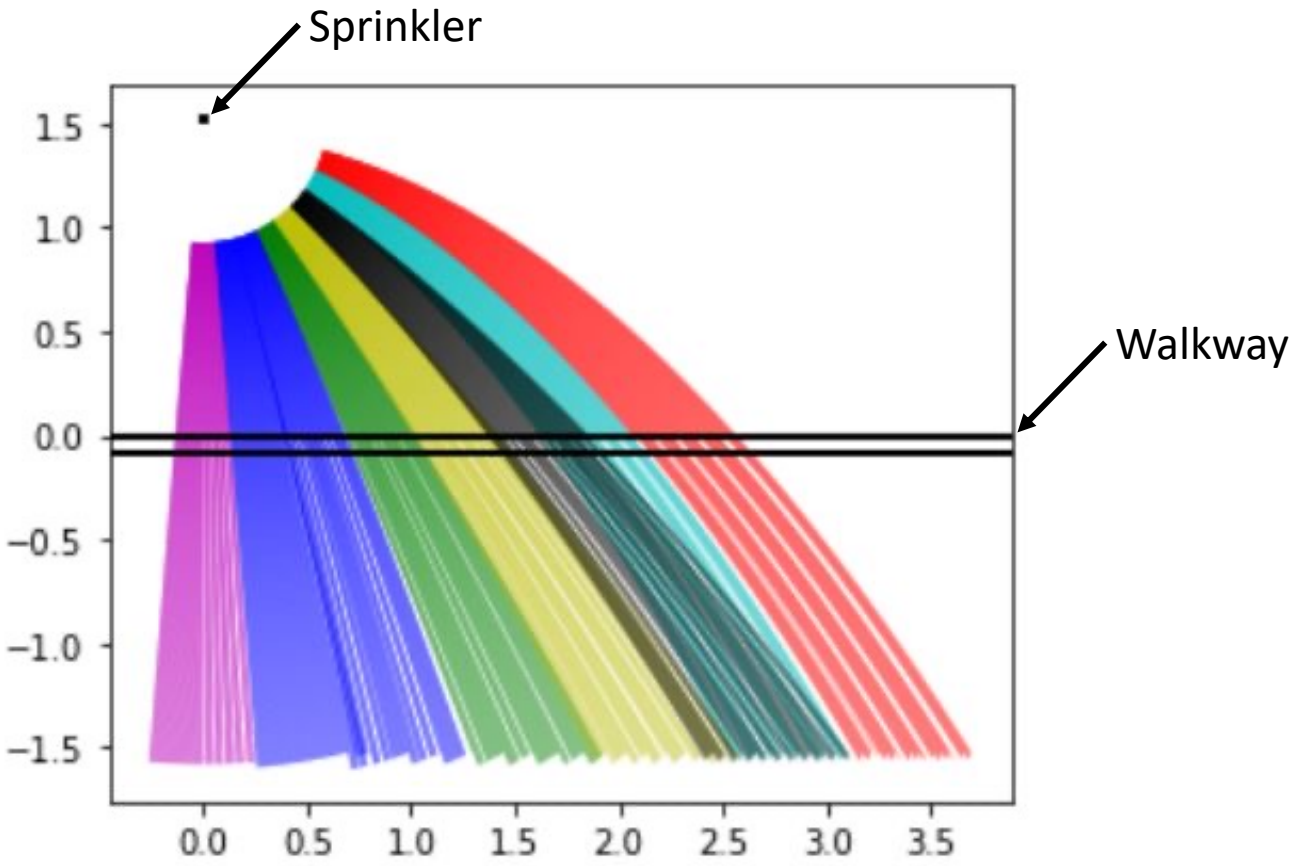




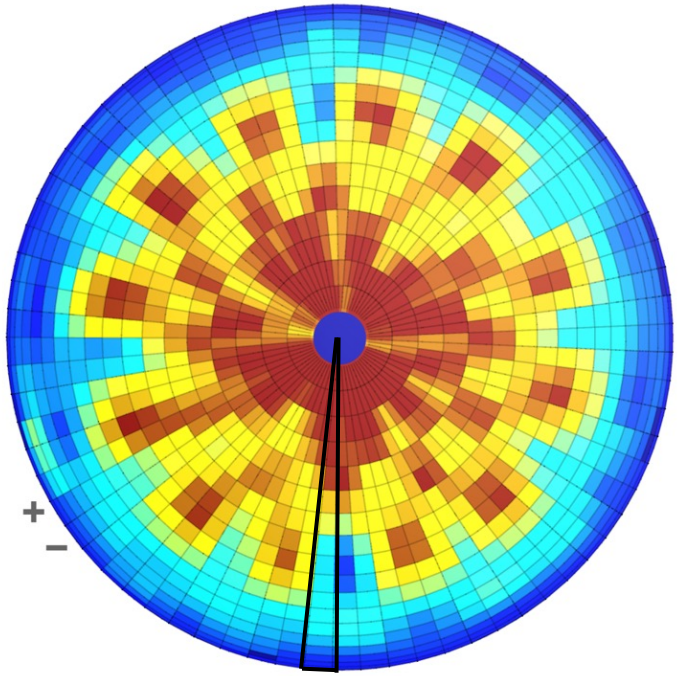



Maximum Display Value: 500 mm/min

# Simulation Visualization



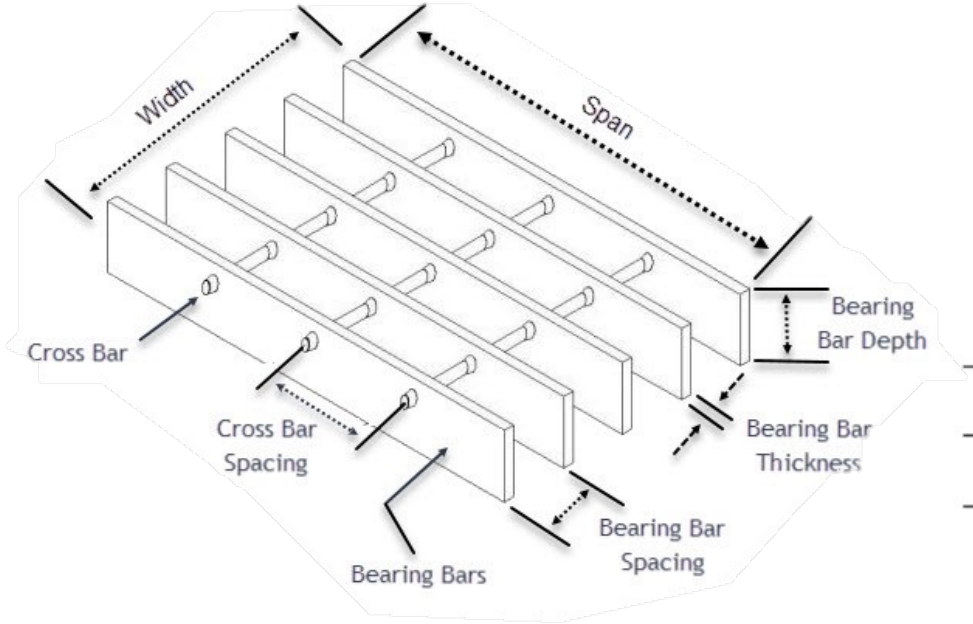

Spray visualization represents a $5^{o}$ wedge of full $360^{o}$ sprinkler characterization.



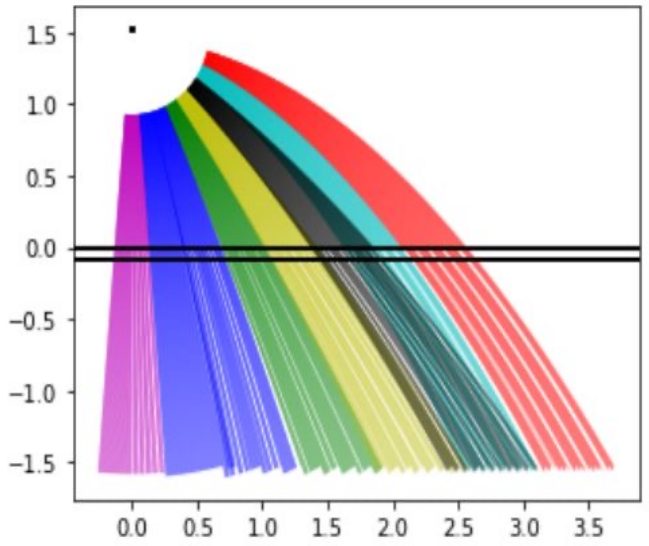

Input parameters are supplied by the characterization conducted with the 4S.

# Simulation Visualization

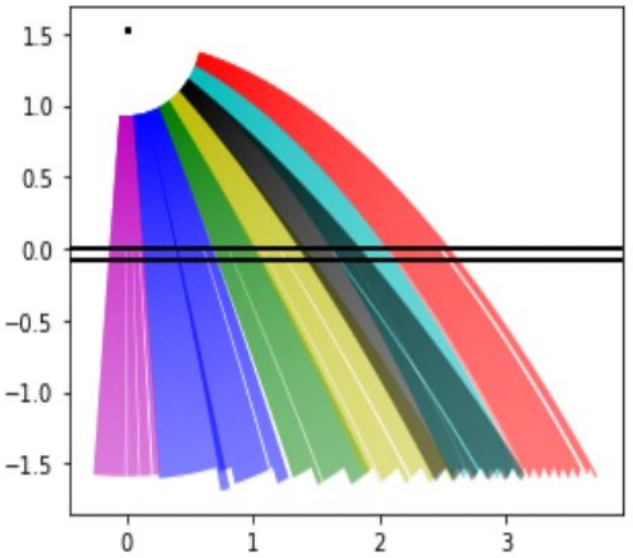
| Grate Specifications | | | | |
|---|---|---|---|---|
| | Height (ft) | Bar Depth (in) | Bar Thickness (in) | Bar Spacing (in) |
| **a** | 5 | 1 | .25 | 1 |
| **b** | 5 | 1 | .25 | 2 |
| **c** | 5 | 4 | .25 | 1 |
| **d** | 10 | 4 | .25 | 1 |



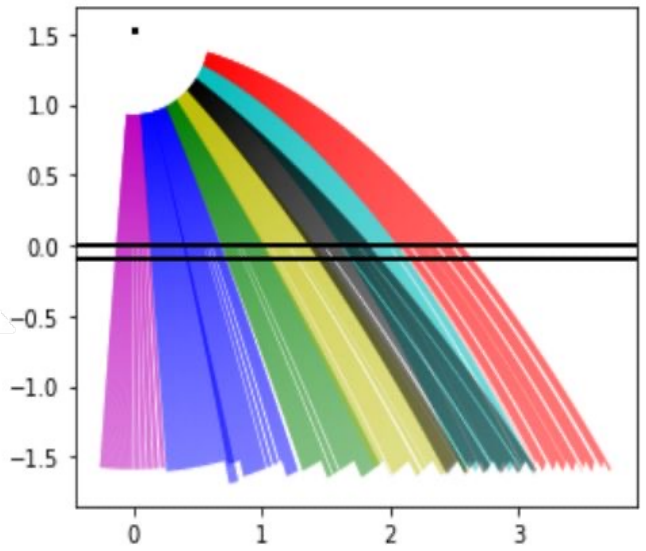

a



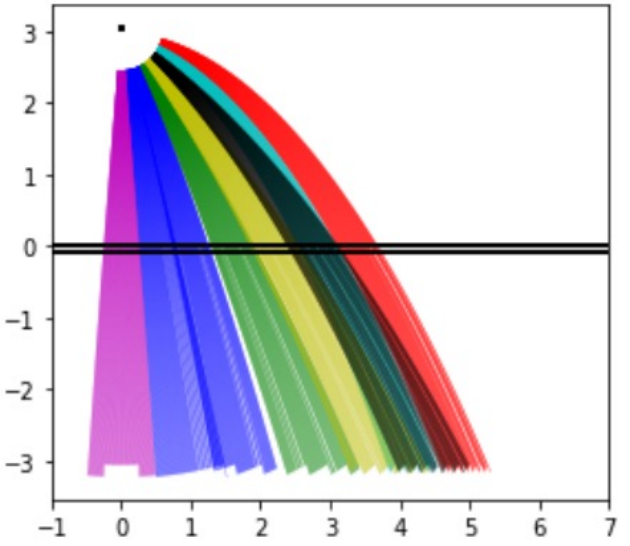
b



c

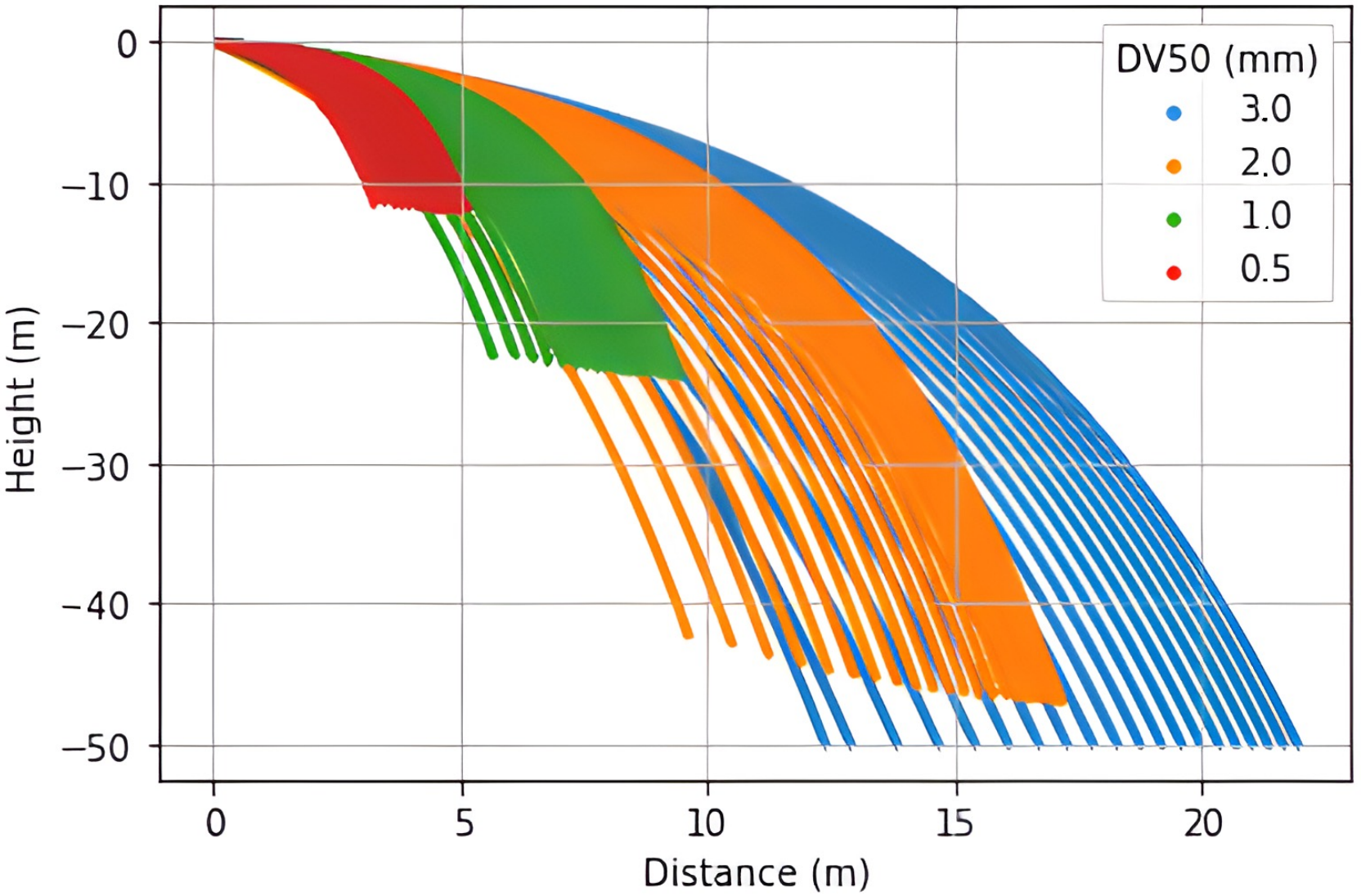


d



# $V_x \rightarrow$Zero Impact of Drop Size and Velocity

- Velocity from 5-25 m/s
- Drop sizes from 0.5-3mm



# Simulation Output

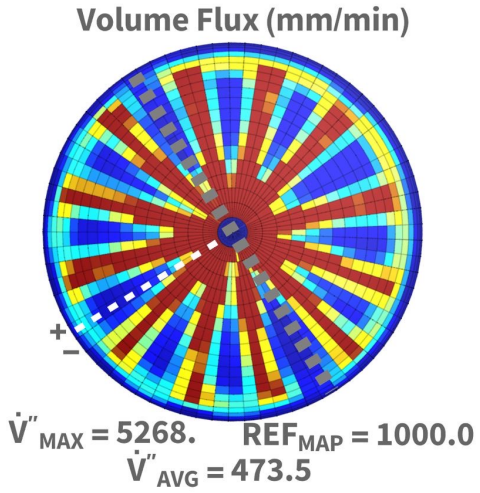
- Each simulation represents a single row of the output. By running the simulation for each azimuthal angle section, a percentage of drops that pass through on their original trajectory is calculated for the entire characterization.

- Using the fraction of water that makes it through the elevated walkway we can scale the volume flux from the original sprinkler characterization.

| Azimuthal Angle \ Elevation Angle | 180 | 170 | 160 | 150 | 140 | 130 | 120 | 110 | 100 |
|---|---|---|---|---|---|---|---|---|---|
| 0 | 0.87 | 0.98 | 0.87 | 0.92 | 0.88 | 0.78 | 0.79 | 0.81 | |
| 5 | 0.87 | 0.98 | 0.85 | 0.92 | 0.86 | 0.79 | 0.8 | 0.75 | |
| 10 | 0.87 | 0.98 | 0.83 | 0.92 | 0.81 | 0.87 | 0.76 | 0.81 | |
| 15 | 0.87 | 0.98 | 0.85 | 0.86 | 0.84 | 0.83 | 0.77 | 0.85 | |
| 20 | 0.87 | 0.96 | 0.87 | 0.85 | 0.81 | 0.79 | 0.75 | 0.8 | |
| 25 | 0.87 | 0.96 | 0.91 | 0.85 | 0.87 | 0.76 | 0.77 | 0.8 | |
| 30 | 0.87 | 0.96 | 0.91 | 0.87 | 0.86 | 0.79 | 0.7 | 0.75 | |
| 35 | 0.87 | 0.96 | 0.91 | 0.92 | 0.85 | 0.85 | 0.77 | 0.8 | |
| 40 | 0.87 | 0.96 | 0.91 | 0.92 | 0.81 | 0.87 | 0.75 | 0.8 | |
| 45 | 0.87 | 0.94 | 0.91 | 0.86 | 0.84 | 0.82 | 0.78 | 0.8 | |
| 50 | 0.87 | 0.94 | 0.86 | 0.86 | 0.85 | 0.87 | 0.74 | 0.8 | |
| 55 | 0.87 | 0.94 | 0.91 | 0.86 | 0.81 | 0.79 | 0.8 | 0.81 | |
| 60 | 0.87 | 0.96 | 0.91 | 0.85 | 0.86 | 0.73 | 0.71 | 0.8 | |
| 65 | 0.87 | 0.96 | 0.87 | 0.92 | 0.86 | 0.78 | 0.8 | 0.85 | |
| 70 | 0.87 | 0.96 | 0.87 | 0.92 | 0.8 | 0.86 | 0.75 | 0.85 | |
| 75 | 0.87 | 0.96 | 0.91 | 0.91 | 0.81 | 0.86 | 0.79 | 0.75 | |
| 80 | 0.87 | 0.96 | 0.86 | 0.86 | 0.87 | 0.86 | 0.8 | 0.81 | |
| 85 | 0.87 | 0.96 | 0.86 | 0.85 | 0.87 | 0.78 | 0.74 | 0.84 | |
| 90 | 0.87 | 0.96 | 0.91 | 0.84 | 0.86 | 0.79 | 0.79 | 0.87 | 0.68 |

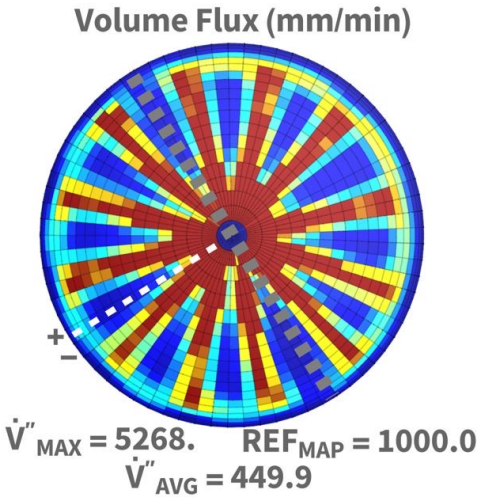
# Effect on Volume Flux: K16.8 (35 psi)

**Original Pattern**

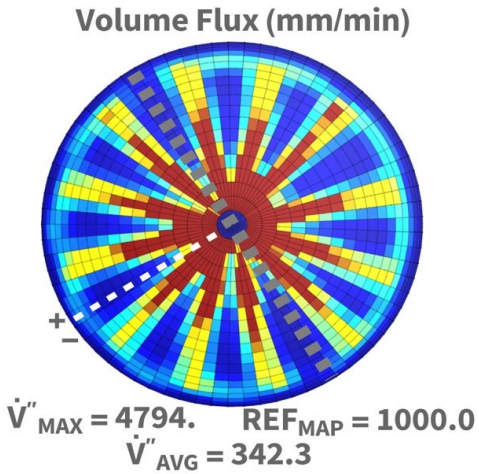



| | Height (ft) | Bar Depth (in) | Bar Thickness (in) | Bar Spacing (in) | Volume Passed |
|---|---|---|---|---|---|
| **a** | 8 | 1 | 0.1875 | 1 | 94.8% |
| **b** | 8 | 6 | 0.1875 | 1 | 72.0% |
| **c** | 20 | 1 | 0.1875 | 1 | 96.3% |
| **d** | 20 | 6 | 0.1875 | 1 | 79.4% |

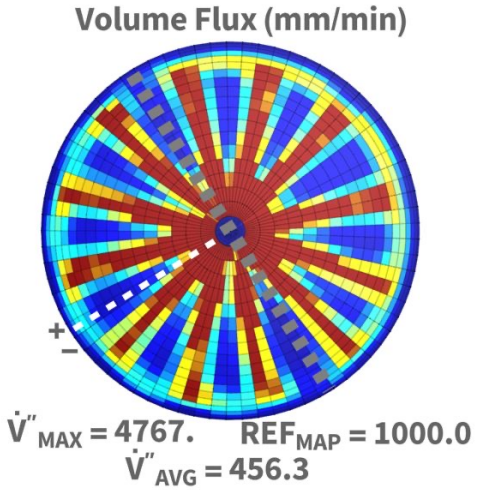
**a**



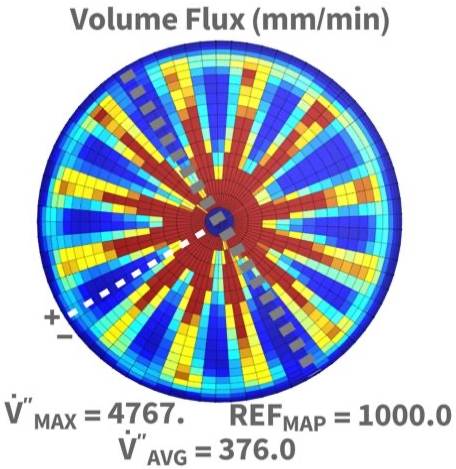

**b**

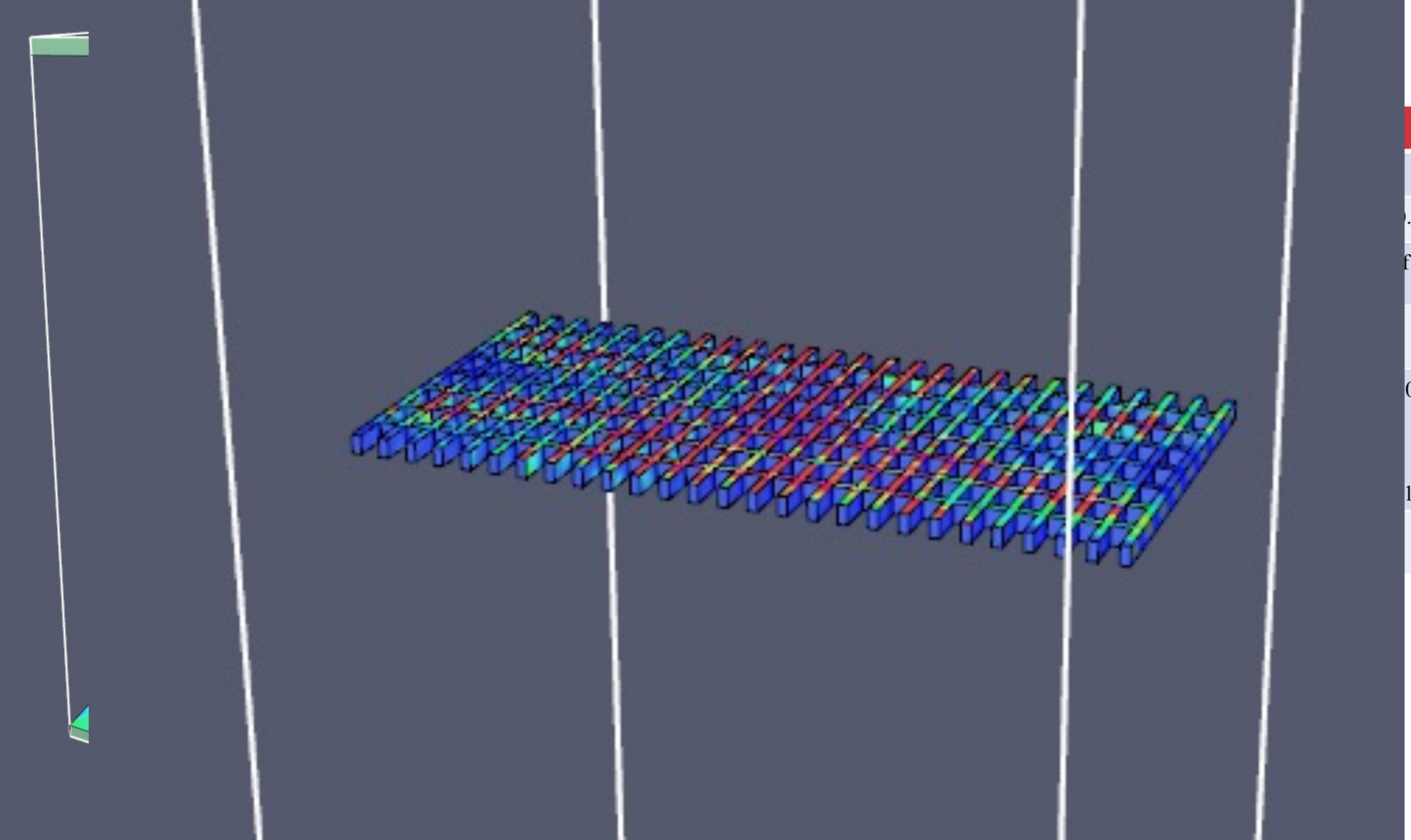



**c**




**d**



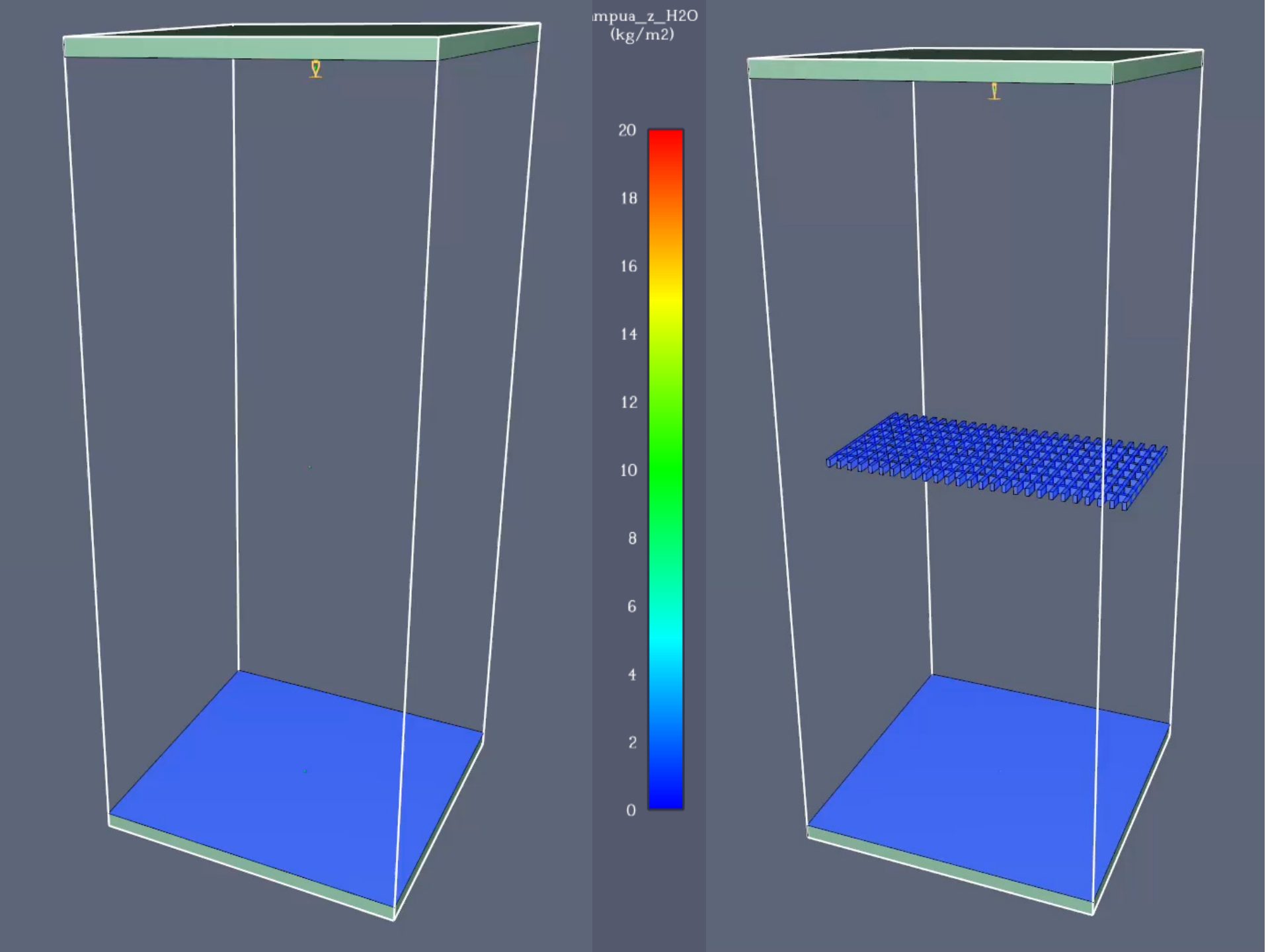


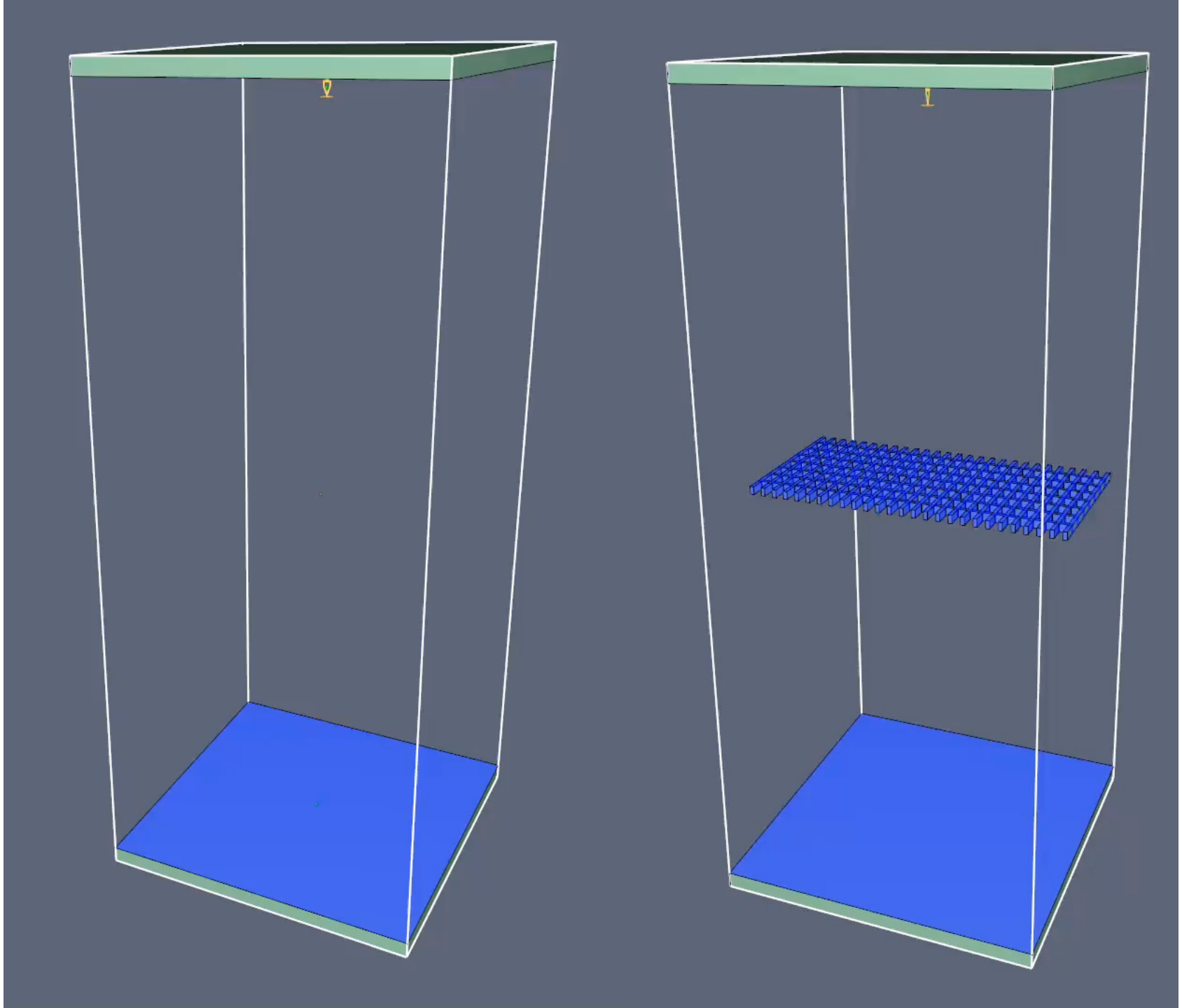
.025 m

f water

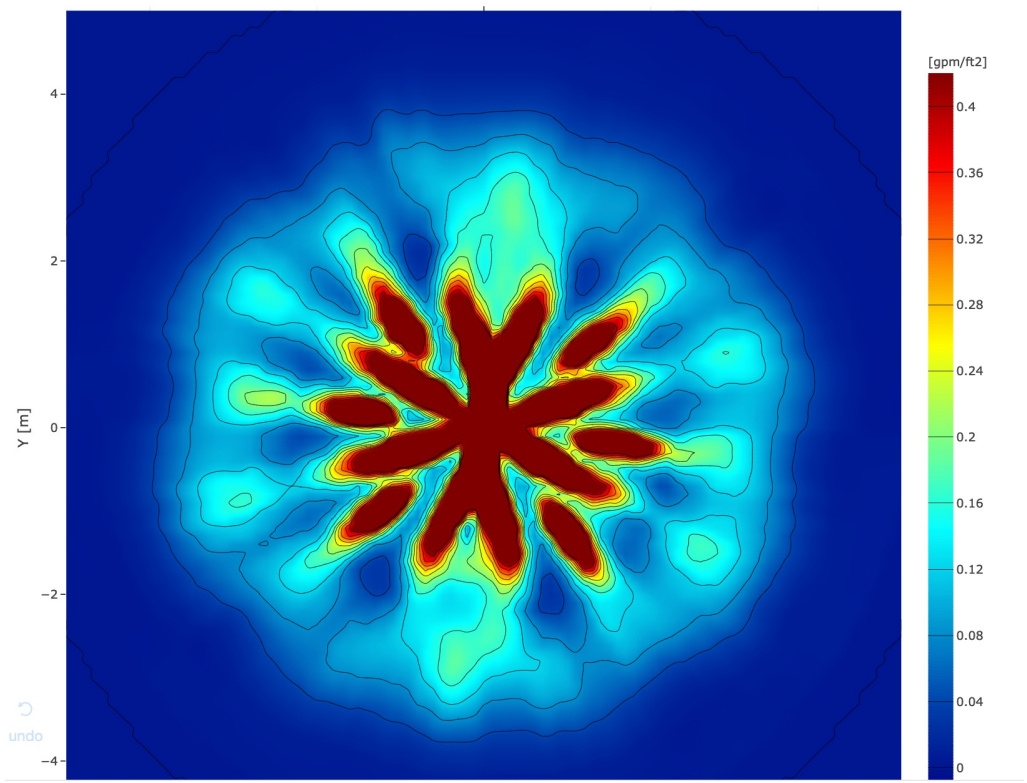
0.05 m

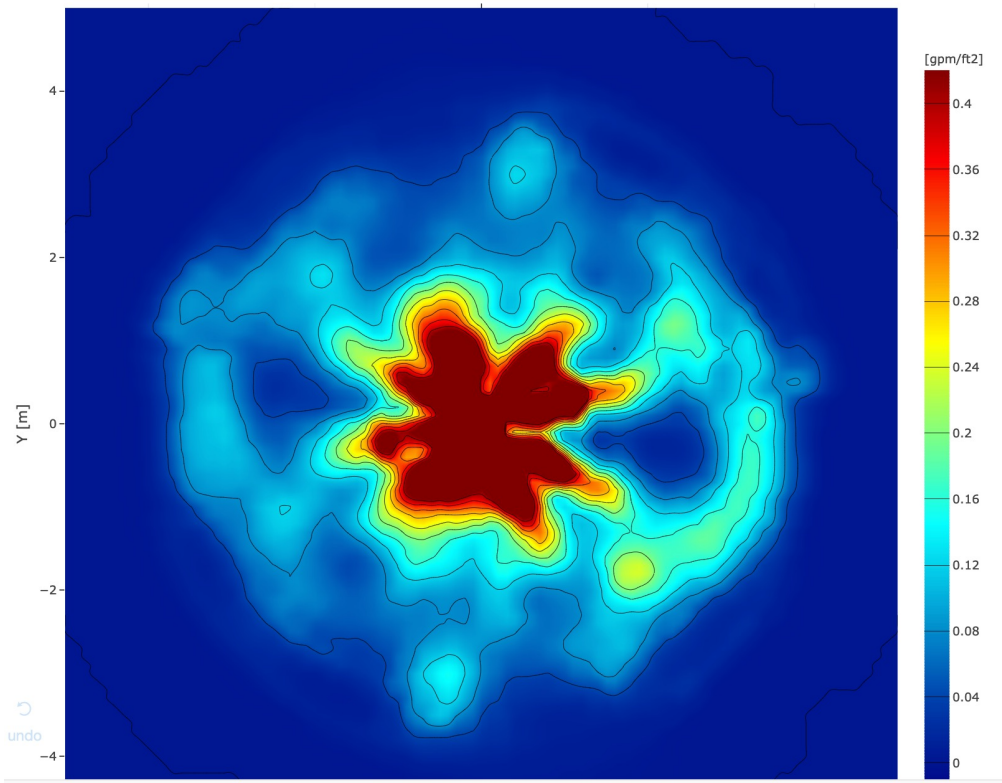
l m


mpua_z_H2O
(kg/m2)
20
18
16
14
12
10
8
6
4
2
0



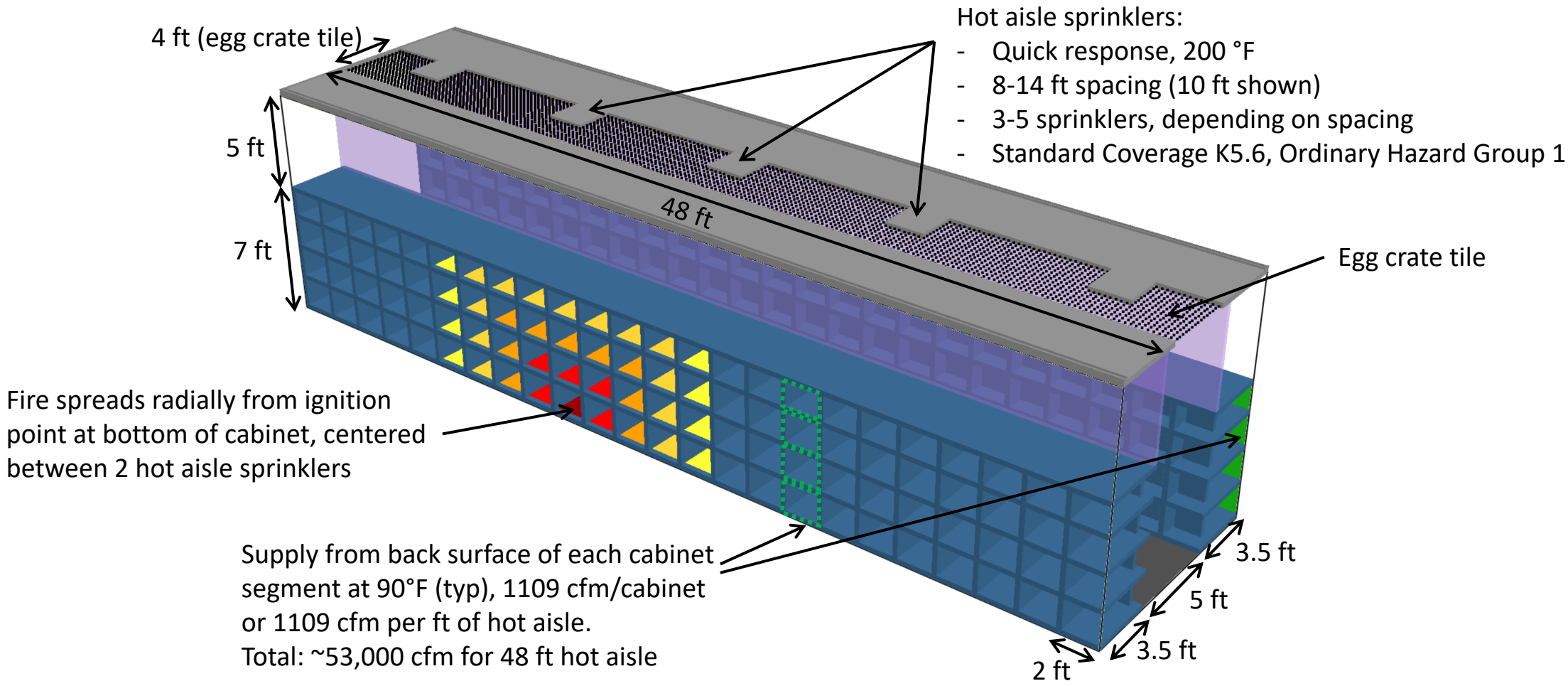
# Before & After



# Model Overview

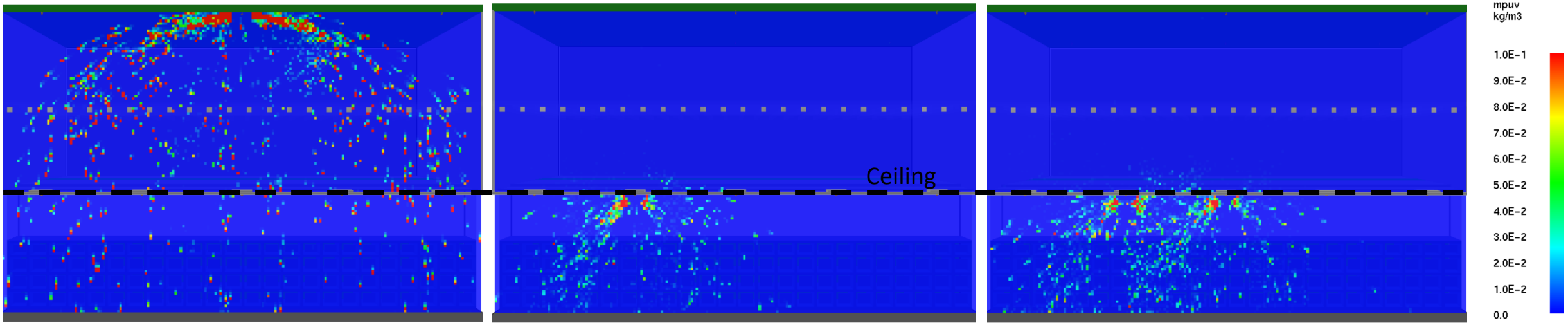
- Hot aisle extended to 48 ft length to match plenum



# Sprinkler Spray: Baseline Configuration

- When viewing sprinkler (liquid) water density by source (roof versus hot aisle sprinklers):
  - Compared to the water spray provided by the hot aisles, roof water spray within the hot aisle is limited and distributed across the hot aisle rather than concentrated near the fire

Sprinkler (Liquid) Water Density (5 Second Average)




Roof Sprinkler Only
(Before Hot Aisle Sprinkler Operation)

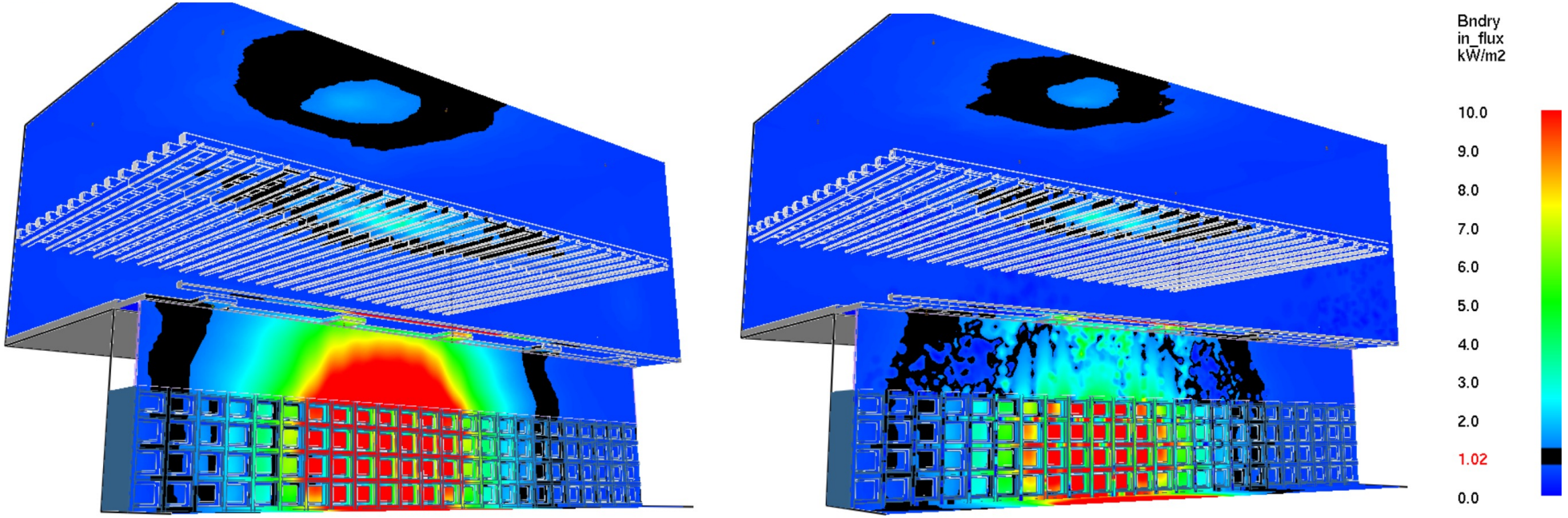
Hot Aisle Sprinkler Only
(1 Sprinkler Operating)

Hot Aisle Sprinklers Only
(2 Sprinklers Operating)

# Model Results

- Sprinklers provide considerable cooling to surfaces in hot aisle
- Impact of ceiling tiles on heat flux clearly observable

Incident Heat Flux at 5 Minutes:



# Initial Takeaways

- What % of spray altered is acceptable needs to be determined
- Sprinklers with strong downward central cores (170-190°) less impact to spray
- Smaller droplets (less momentum) transition to primarily vertical velocity component earlier, larger drops later
- Percent open is not only driver of blockage, horizontal component of droplet velocity also what drives obstruction with grating

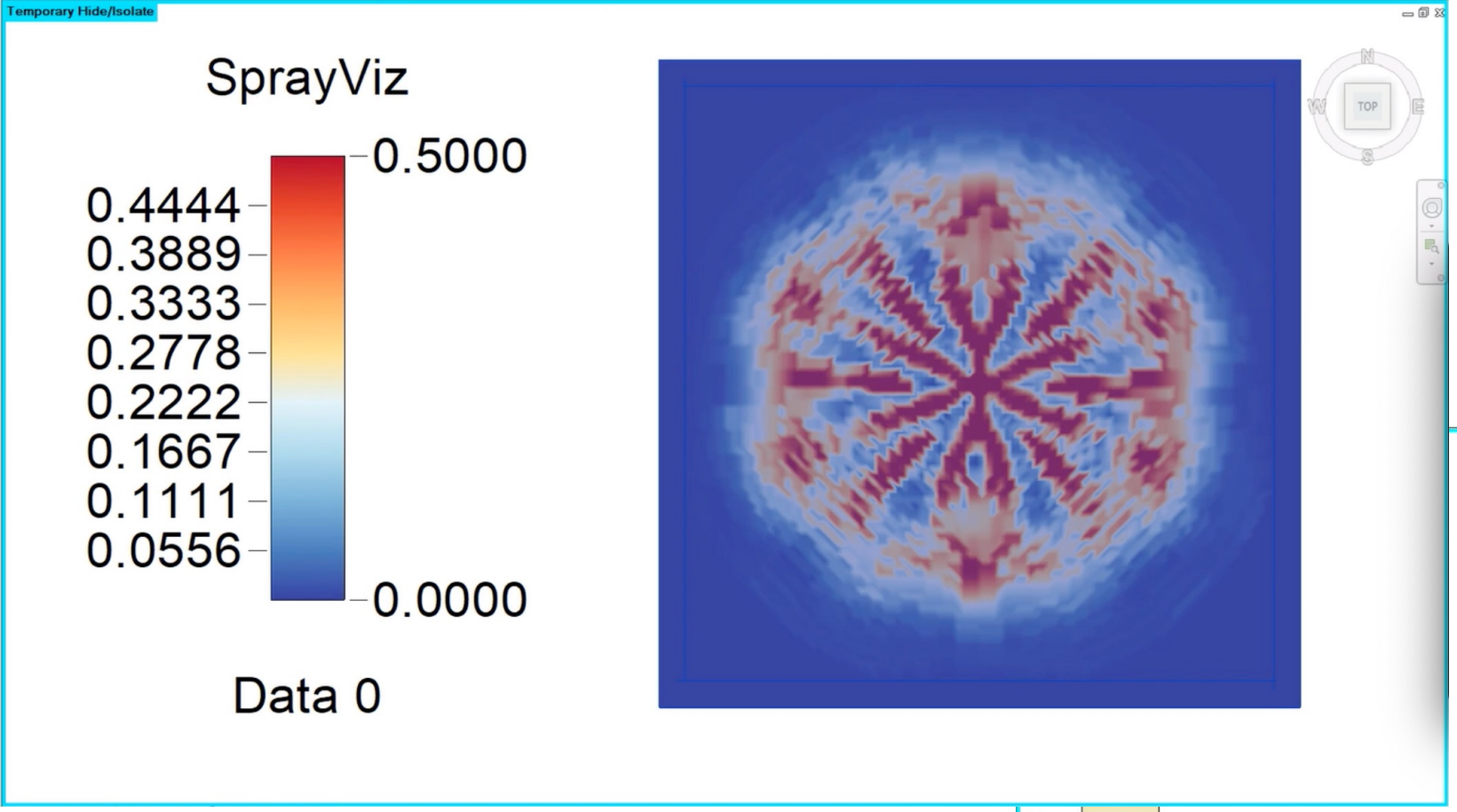
# Tools, Aides, & Advances in Technology

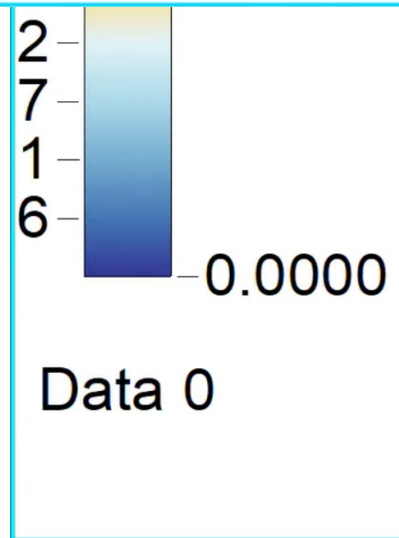
- Sprinkler characterization details required for analysis
  - Drop size, number concentration, pressure, velocity all matter
- Modeling of suppression sprays, REVIT BIM plugin evaluating sprinkler orientation and effect of obstructions
- FireFOAM and FDS CFD allows for more detailed analysis

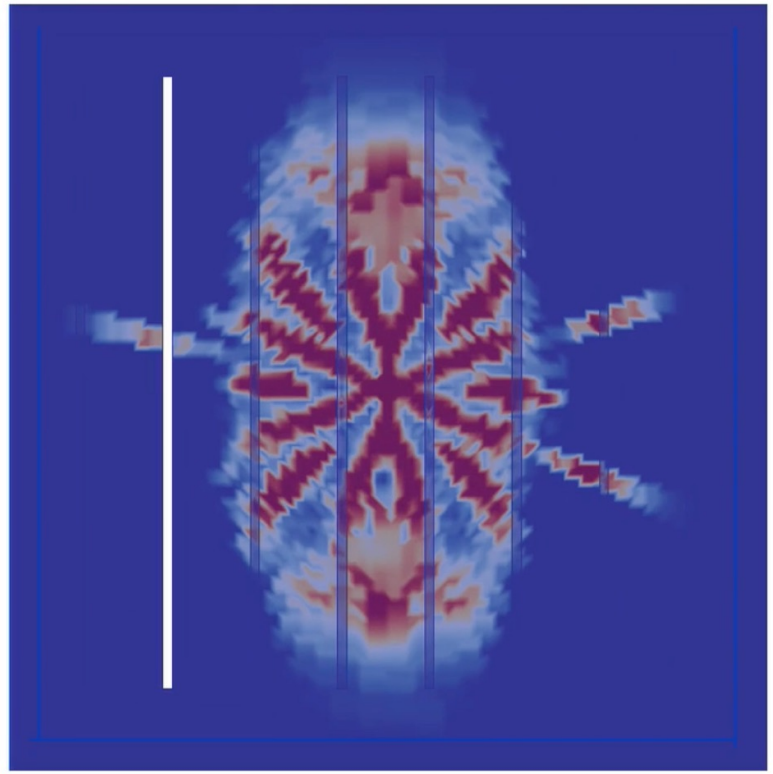
- SMART and Specialty Sprinklers and Suppression Devices
- Targeted Sprays
- Robots and Drones
- “Common Sense Solutions”

**NONE OF THE FOLLOWING ARE ENDORSEMENTS FOR ANY SPECIFIC PRODUCT OR TECHNOLOGY**

# Tools, Aides, & Technology


Temporary Hide/Isolate
SprayViz
0.5000
0.4444
0.3889
0.3333
0.2778
0.2222
0.1667
0.1111
0.0556
0.0000
Data 0
TOP


2
7
1
6
0.0000
Data 0



Sprinkler Database | Search by Manufacturer, Model No., SIN | Spray Tools | Learn | Sign In

# Advanced Sprinkler Spray Data

Using a revolutionary spray characterization device, the Spatially-resolved Spray Scanning System (4S), a complete description of a sprinkler spray, including spray angle, droplet size, and detailed spatial data is captured. This data allows us to make detailed comparisons between sprinklers and allows us to predict the sprinkler spray pattern.

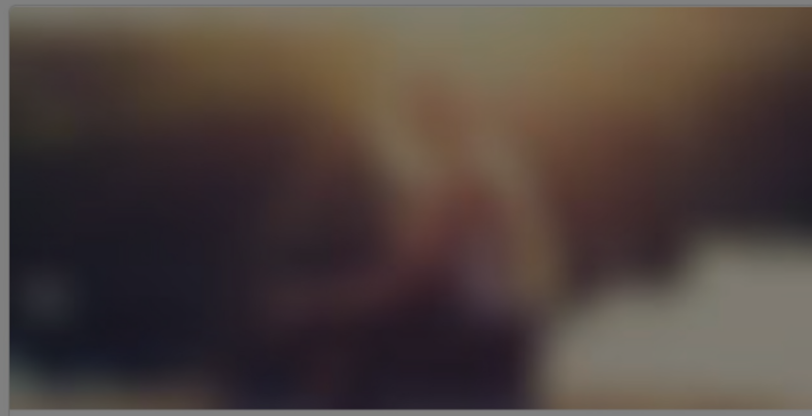
Learn More

# Sprinkler Database

## Explore Spray Data

Advanced spray data requires advanced tools. Explore the sprinkler spray patterns and initial spray metrics from the 4S using the the tools below.

Spray Pattern | Spray Metrics

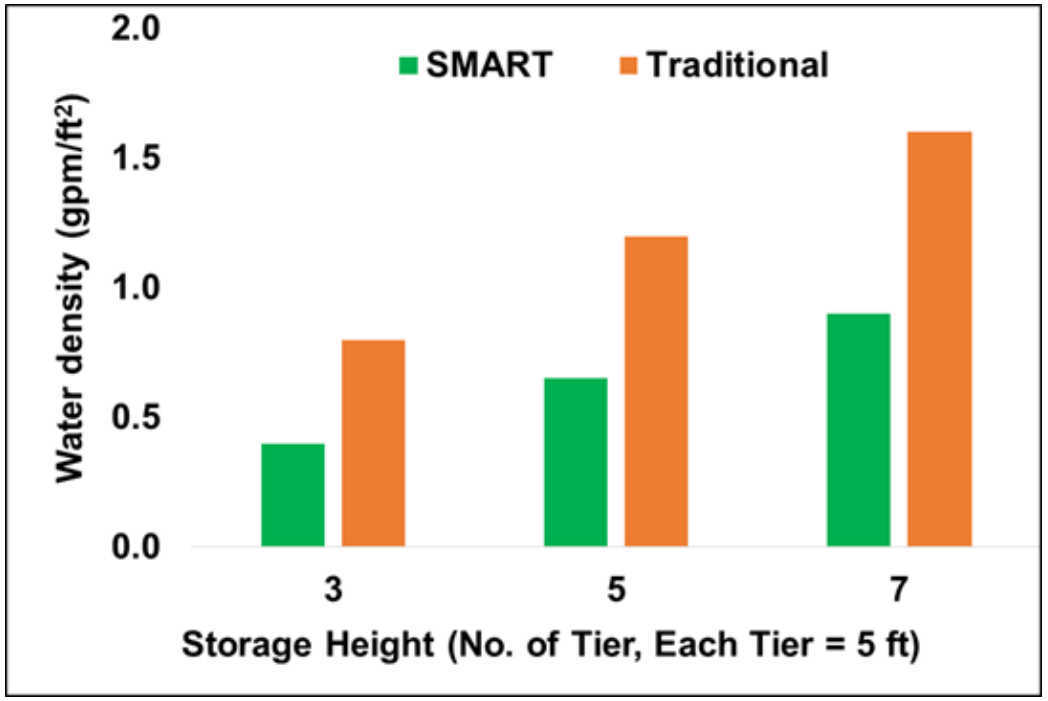


# Specialty Sprinklers

# SMART Sprinklers

- Solenoid valves or similar per sprinkler
- Activate based on detection (ASD, heat, smoke, etc.)
- Can be opened/closed “as needed”
- Monitored for P, flow, etc. often have TC for temperature as well

# SMART Sprinklers



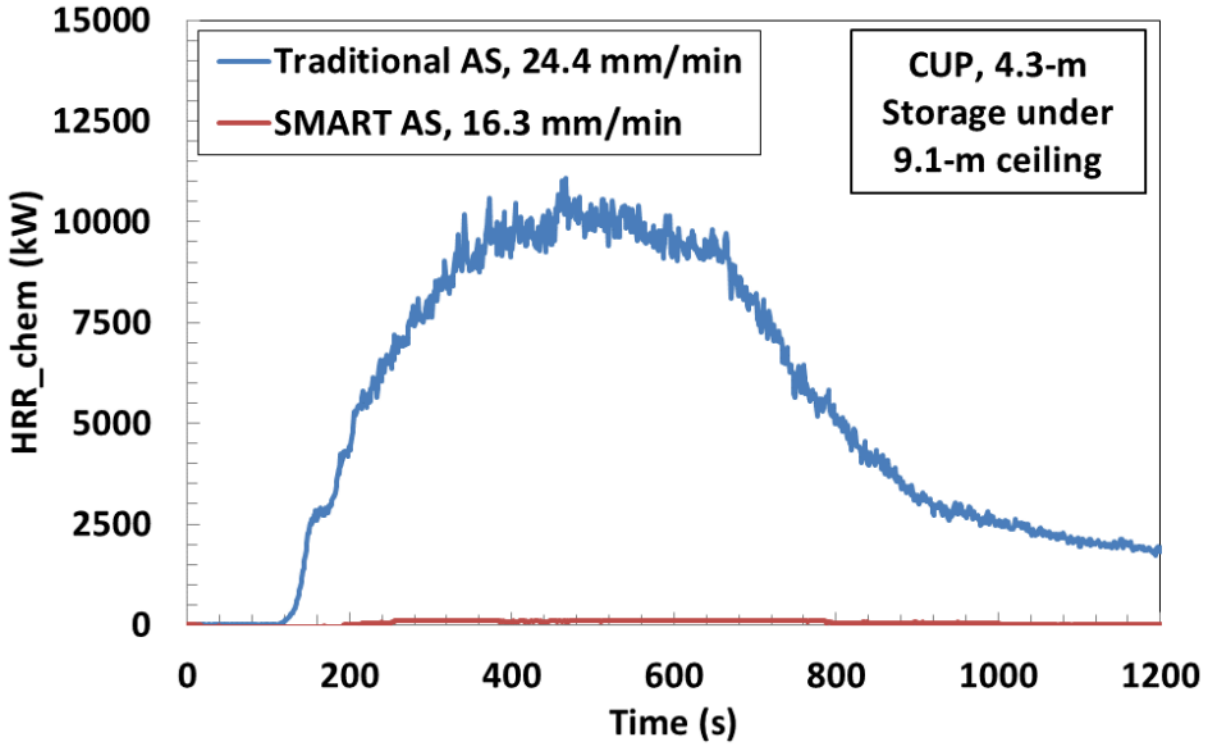




Figure 3-5: HRRs in 3-tier CUP rack storage tests using traditional and SMART sprinklers.

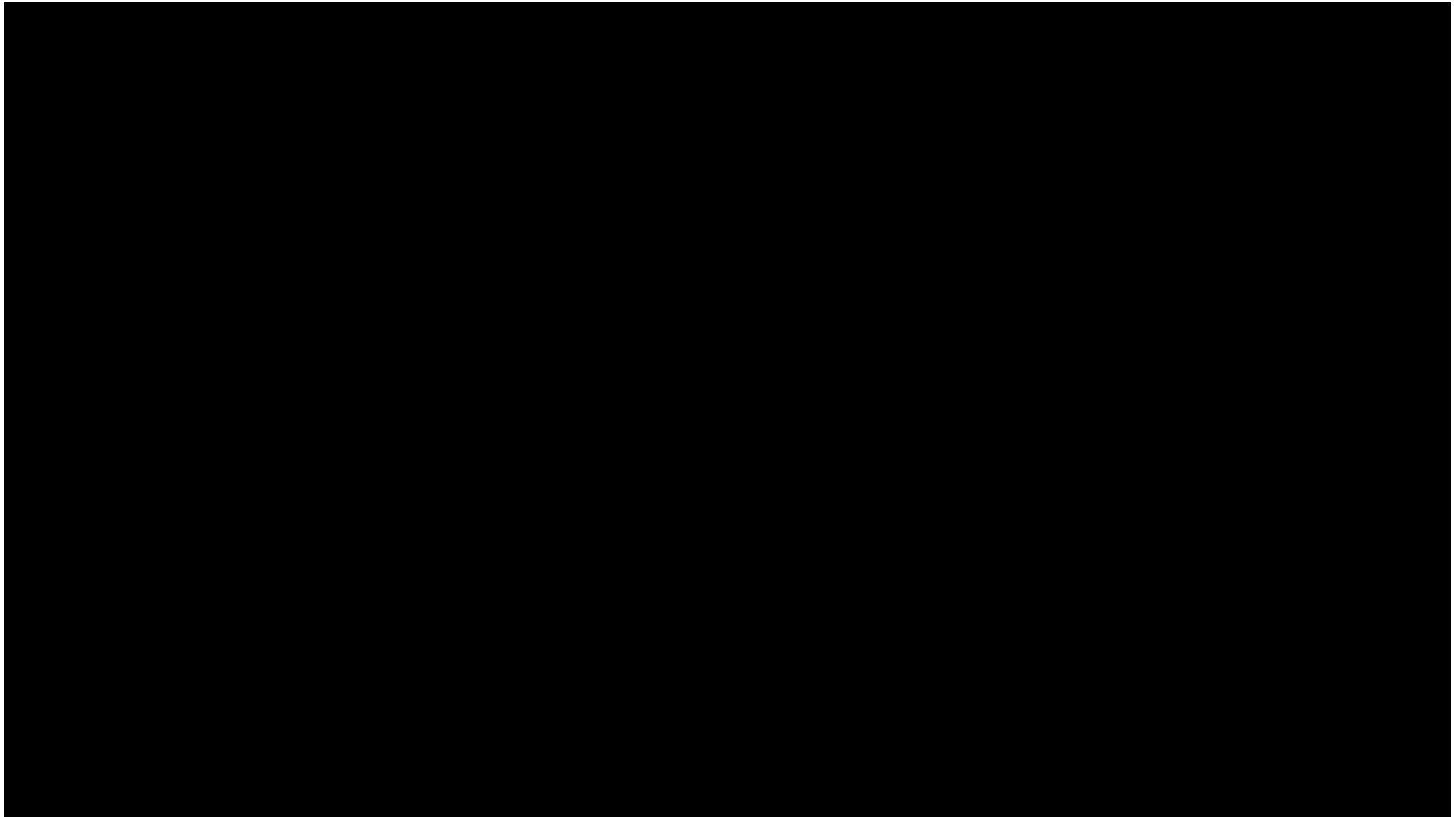
https://www.sfpe.org/publications/periodicals/sfpeeuropedigital/sfpeeurope20/europeissue20feature1

# EV Fire Suppression

https://www.beros.dk/

# Detection & Targeted Suppression

# Drones



# Thank You!

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nryder@fireriskalliance.com
301.775.2967