

Analysis of water distribution efficiency from a sprinkler head

Presented for SUPDET 2014

by

James A Lynch, President Amped I R&D

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Noah L. Ryder, PE, MBA, Principal Custom Spray Solutions,
Inc.

Problem

- Examine use of water to determine nozzle efficiency
- Fixed Pressure (60 psi)
 - Droplet Size
 - Momentum
 - Distribution
- Based on design of nozzle with similar k-factors is one type of nozzle more efficient than another.

Birdcage Transformer Design

- ◆ Small k-factor
- ◆ Short throw
- ◆ Close proximity to the transformer
- ◆ Low pressure
- ◆ Excessive nozzles to protect the transformer (30-40)





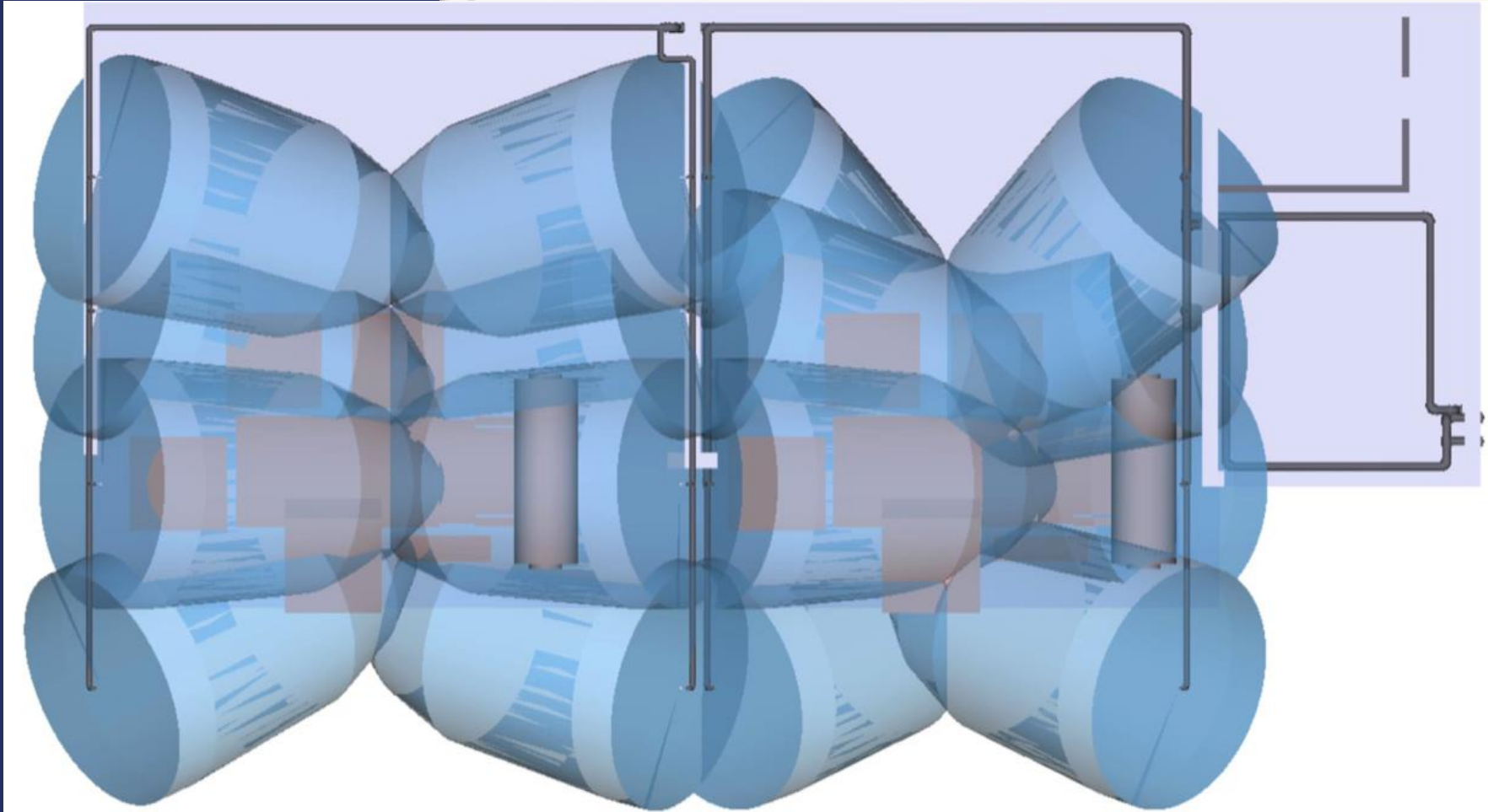
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Consequences



Modified Design Strategies



Typical Design Strategies

Manual Fire Nozzles

Manual Fire Nozzles



Typical Design Strategies

Manual Fire Nozzles

Manual Fire Nozzles



Modified Design Strategies



Nozzles to be examined

- Deflector plate nozzle
 - K-factor 7.2
 - 55.8 GPM (211.2 LPM)



- Rotor / cellar nozzle
 - K-factor 8.9
 - 68.9 GPM (260.8 LPM)



FM testing of nozzle

- FM testing indicated that
 - K-factor – Droplet Size
 - Orientation - Momentum
 - Response time – Fire Size
- Played greater role than design density
- Examine how nozzle design can affect
 - Momentum
 - Droplet size
 - Coverage

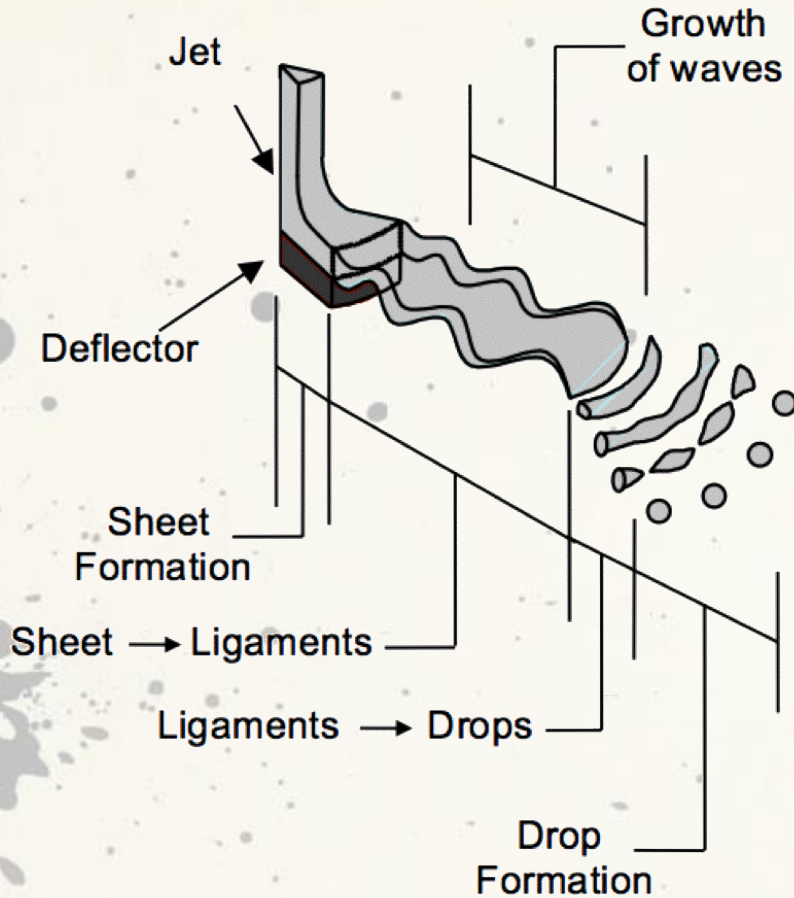
FM Global: Advances in Sprinkler Protection

Movement away from Density and Demand Area

- **What does this test show?**
 - Larger K factor → larger droplets
 - Orientation → water momentum
 - Faster response time → smaller fire to control
 - ~~Density~~

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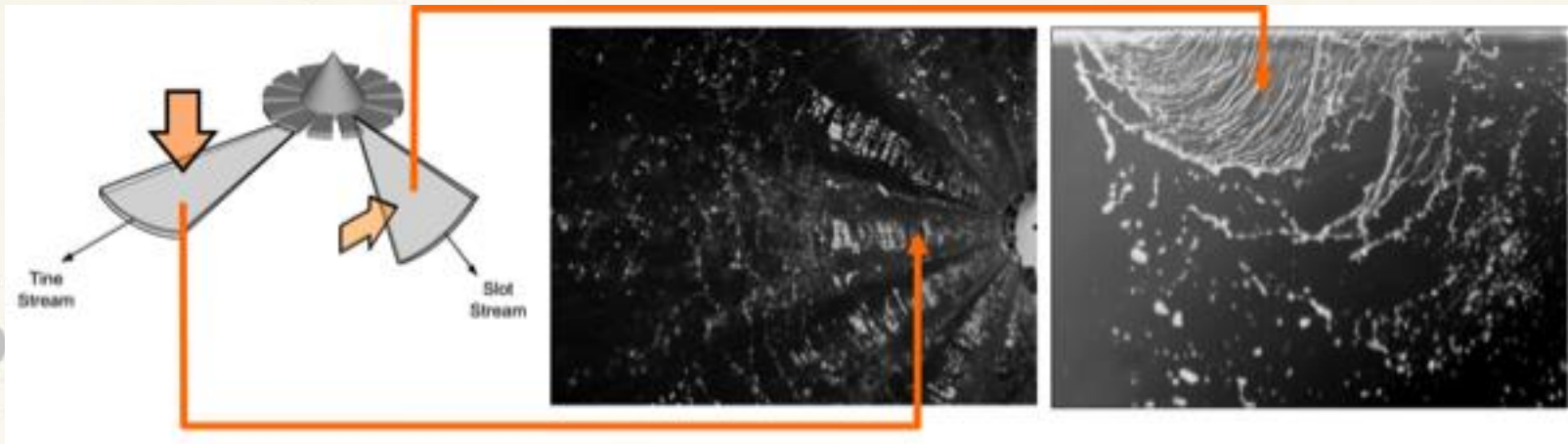
Characterization



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

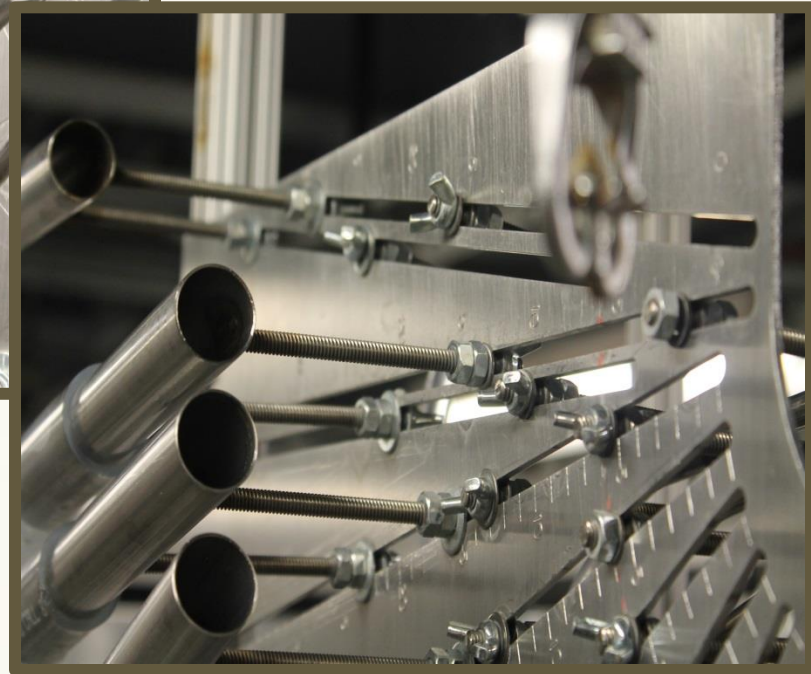
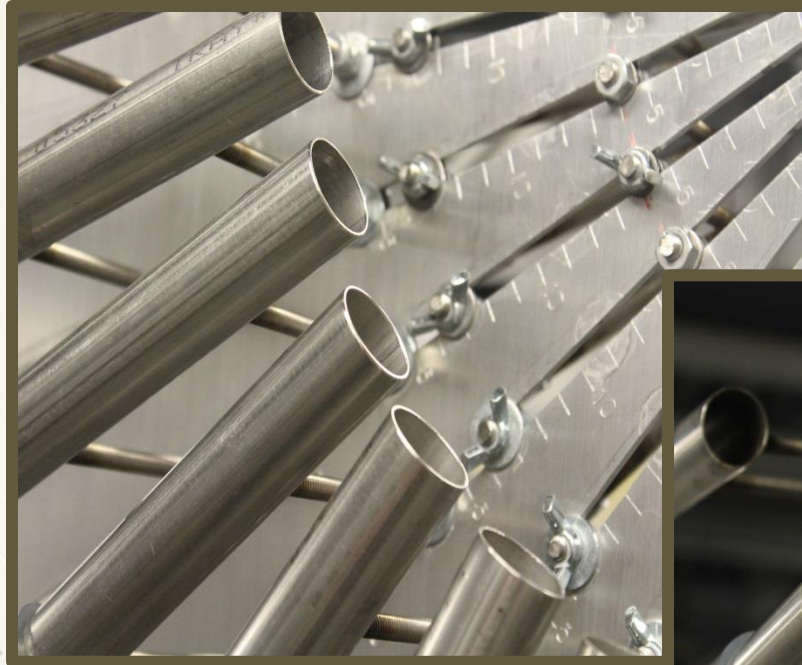


Custom Spray Solutions



- A spray nozzle is placed into the spray scanning system and detailed measurements of the spray are made using shadowgraphy, laser, and other diagnostic techniques. Depending on the nature of the nozzle (tines/slots or not) the characterization may vary in complexity.

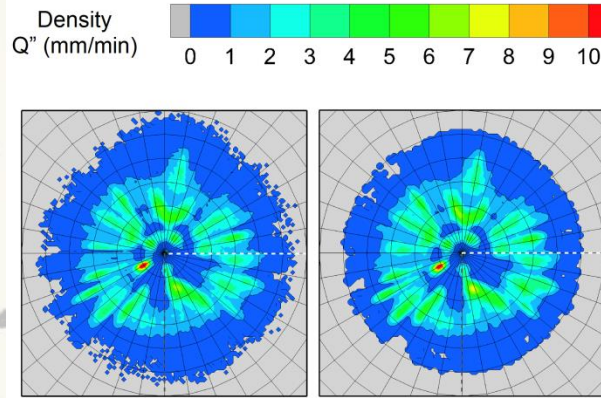
Characterization



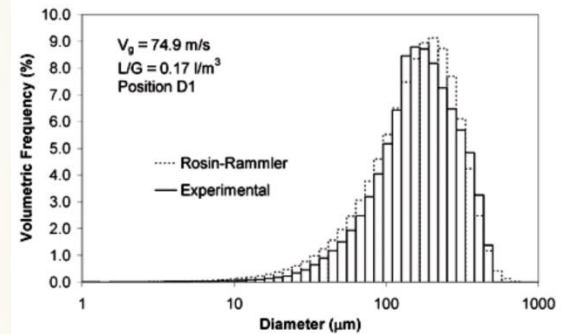
- Versatility of the testing apparatus and methodology allows for measurement optimization.

Custom Spray Solutions

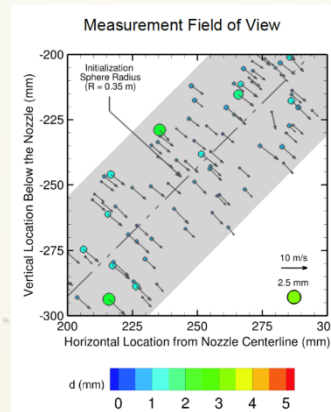
Spray Distribution



Particle Size distribution

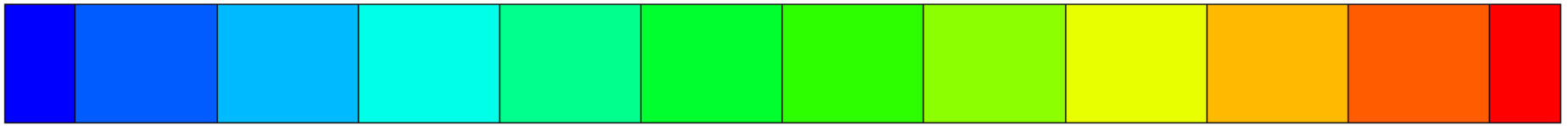


Particle velocity - Momentum

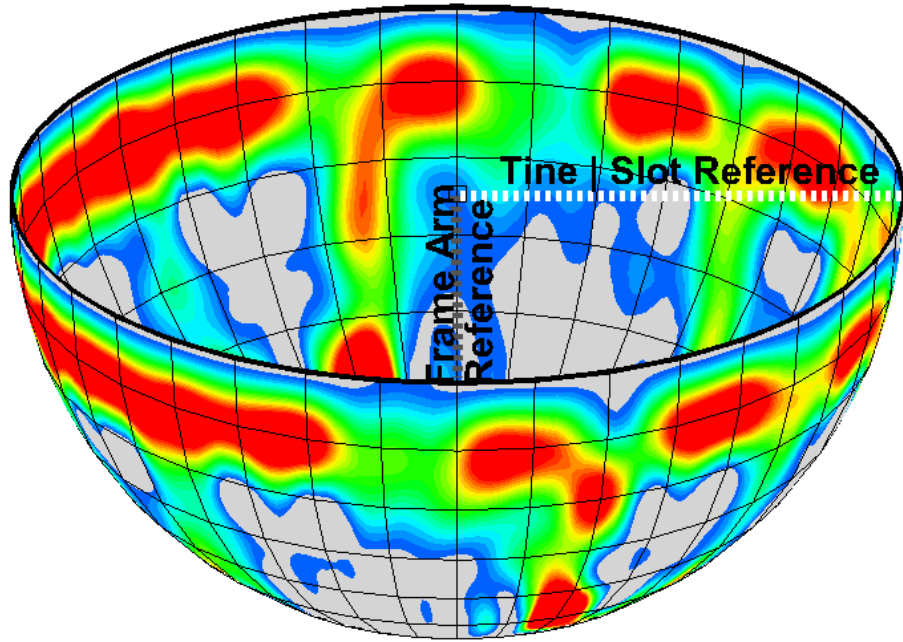


Droplet Size

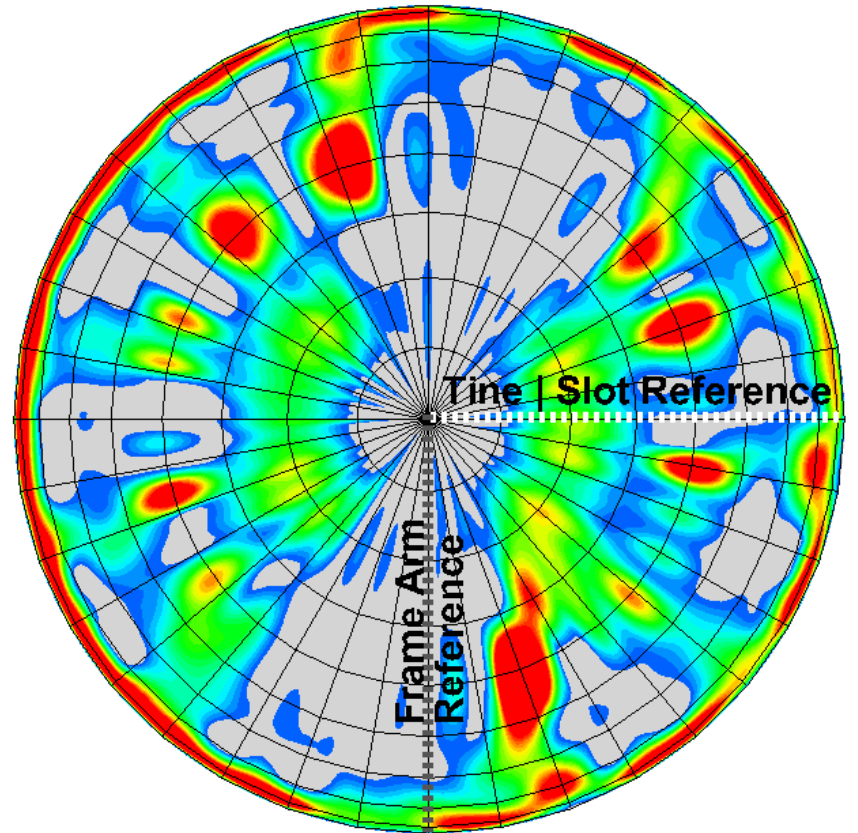
- $D_{v0.5}$ = Volume Median Diameter (VMD)
- Drop size measured in terms of volume (or mass), with 50% of total volume of liquid sprayed drops with diameters larger than median value and 50% with smaller diameter.
- Rotor = 0.57 mm
- Deflector = 1.038 mm

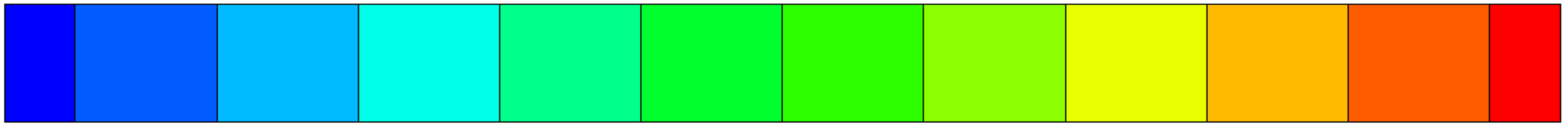


0 1 2 3 4 5 6 7 8 9 10



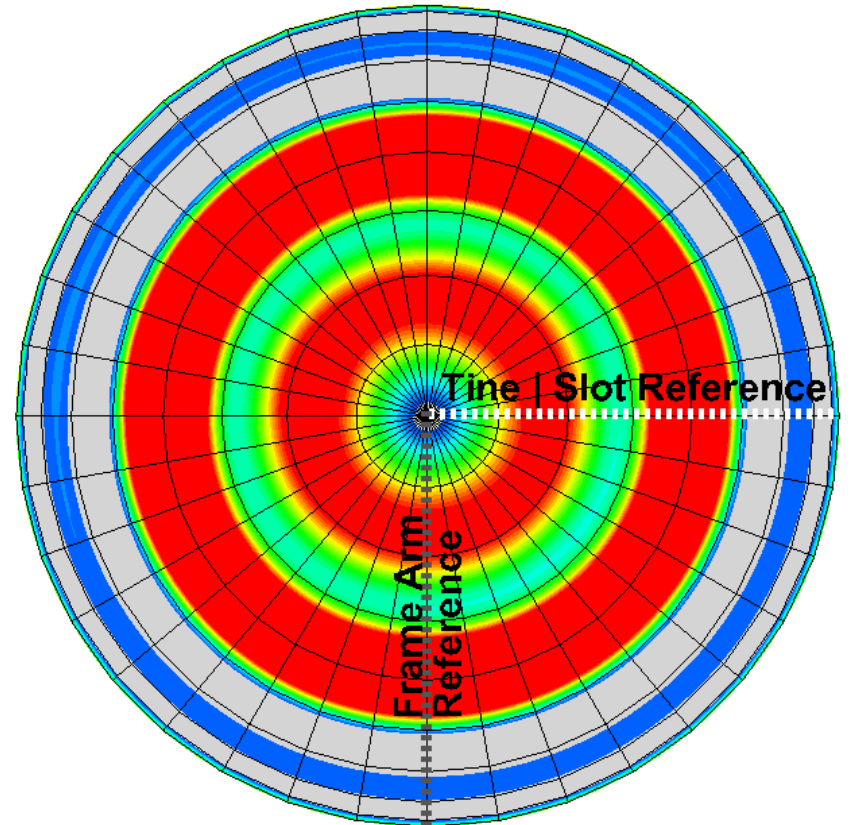
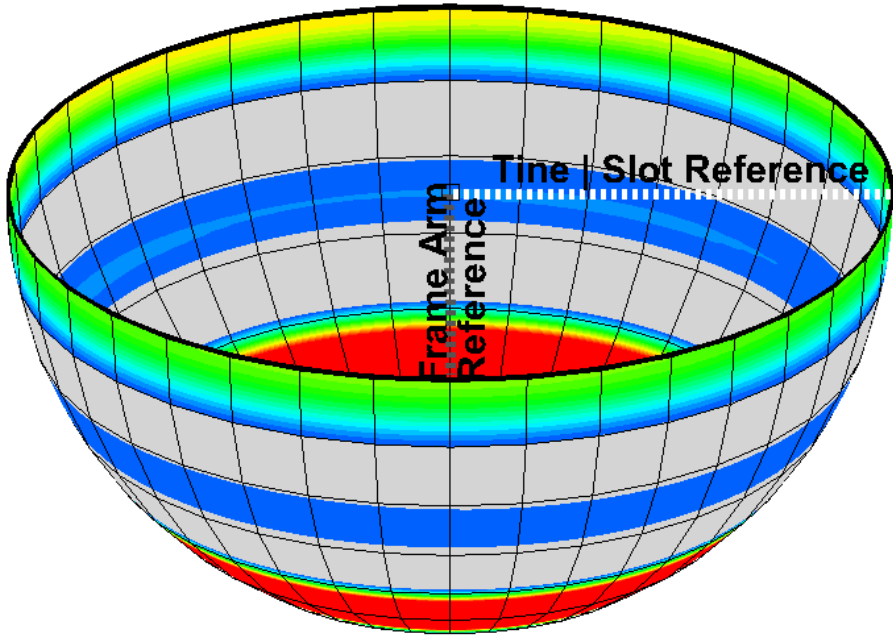
mm/min

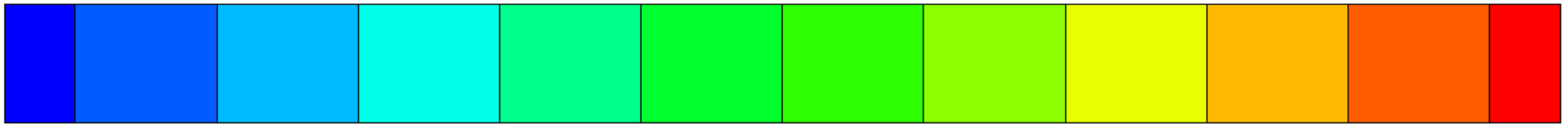




0 1 2 3 4 5 6 7 8 9 10

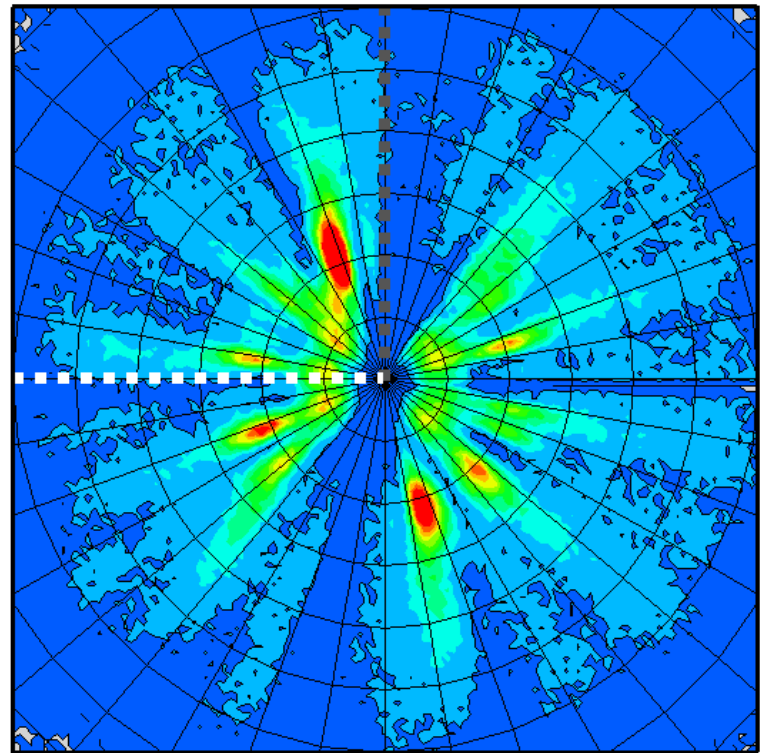
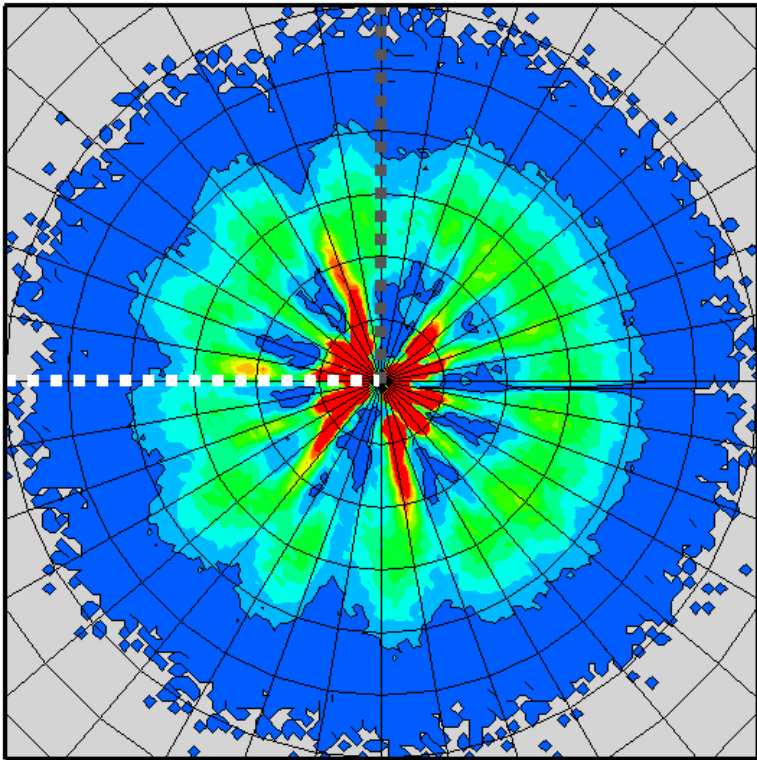
mm/min

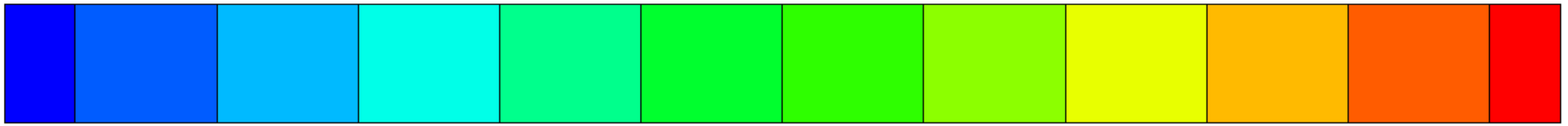




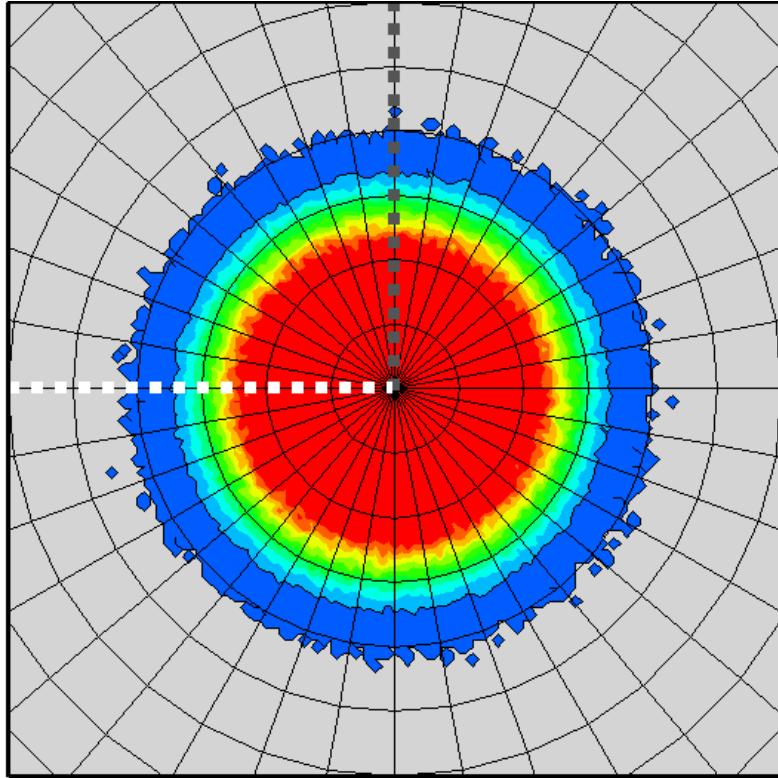
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mm/min

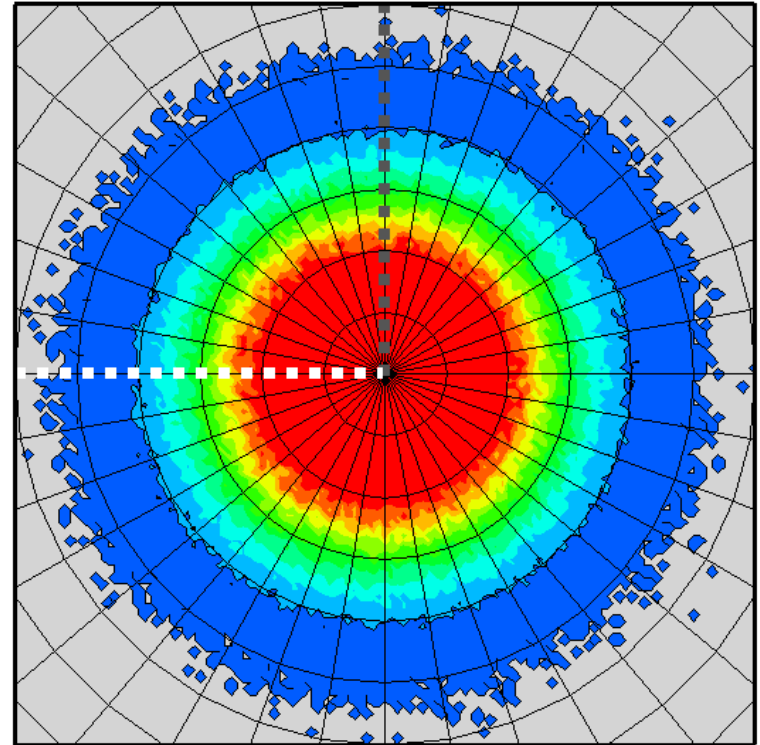




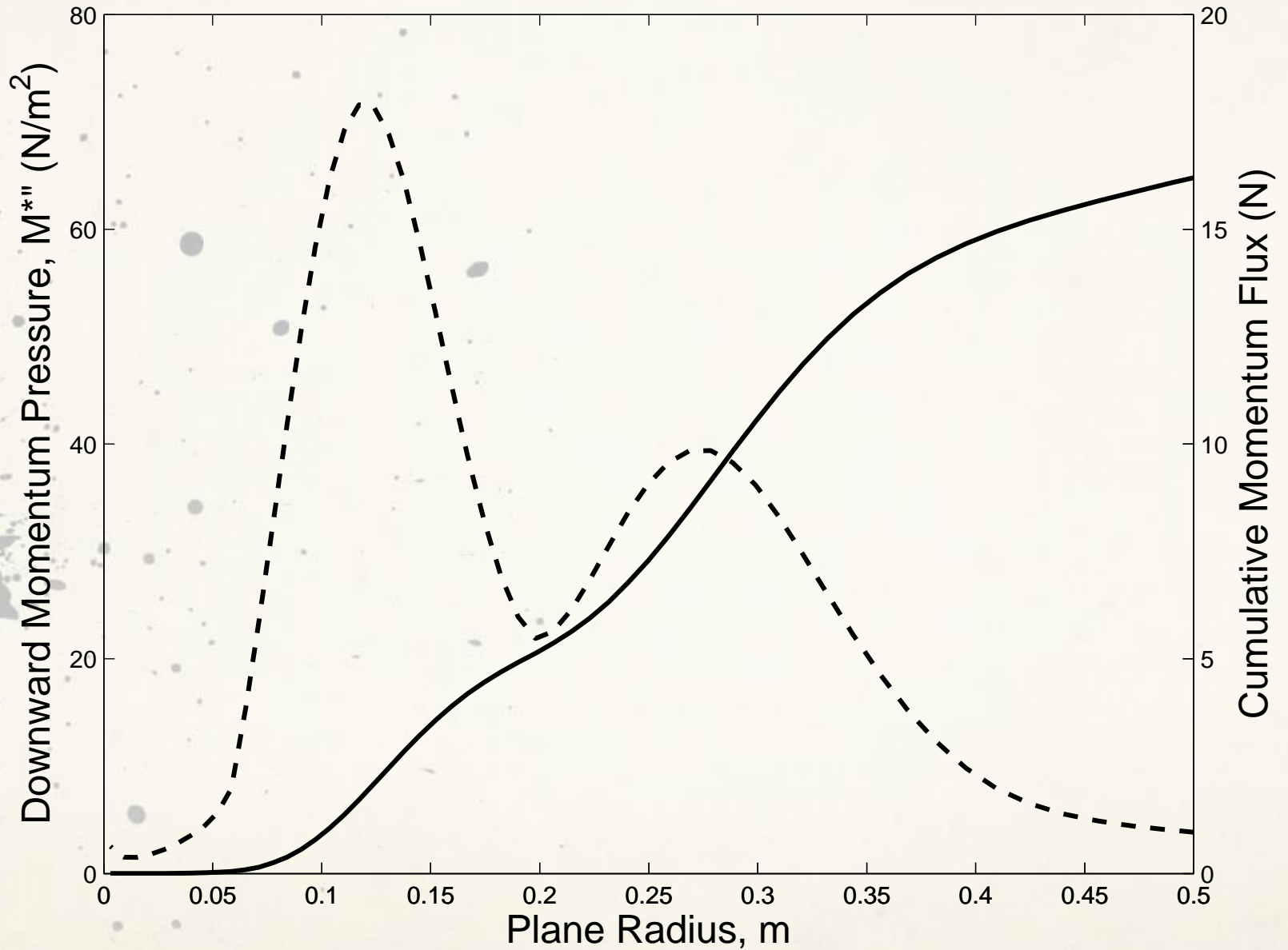
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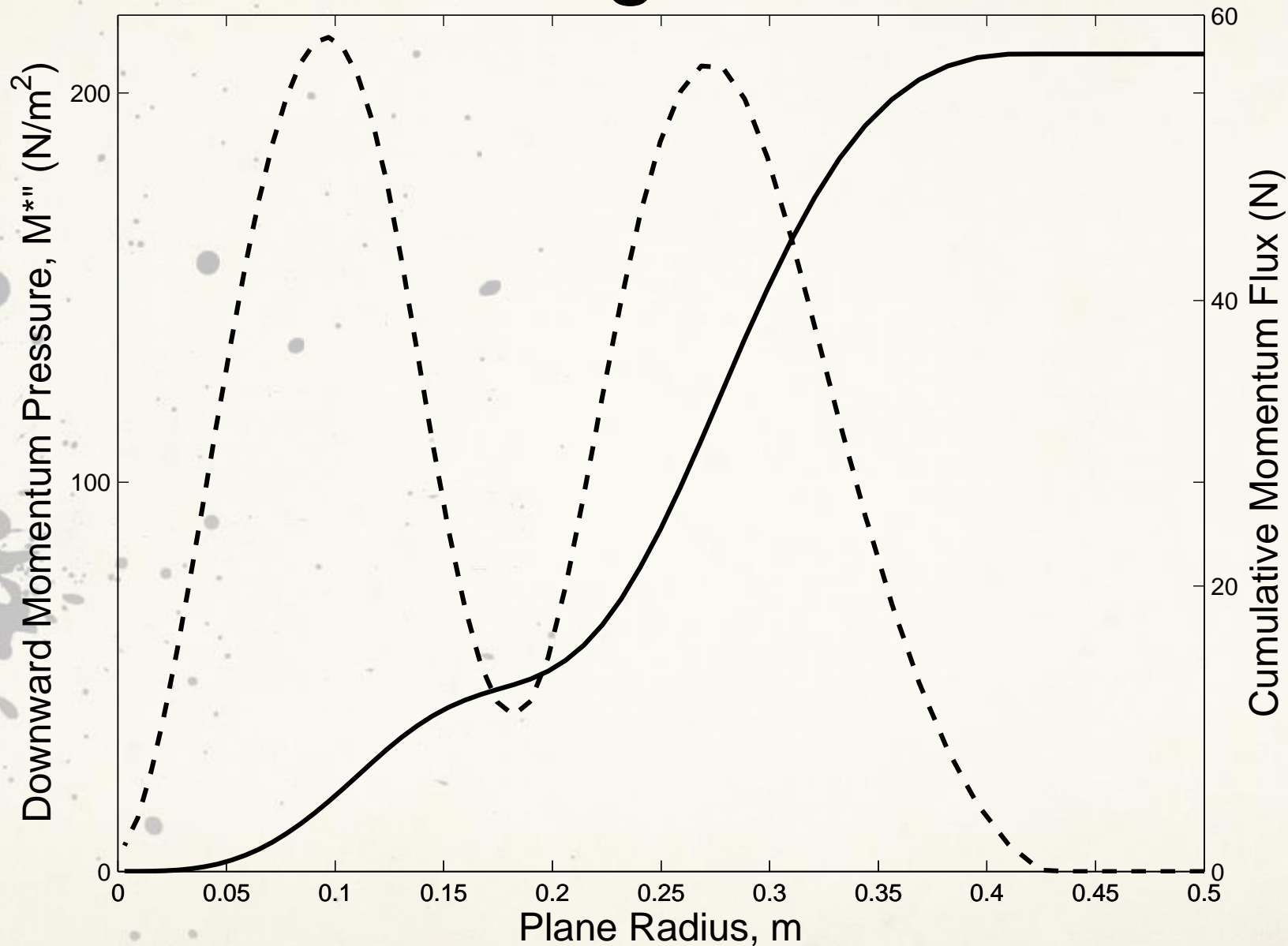
mm/min



Deflector Nozzle



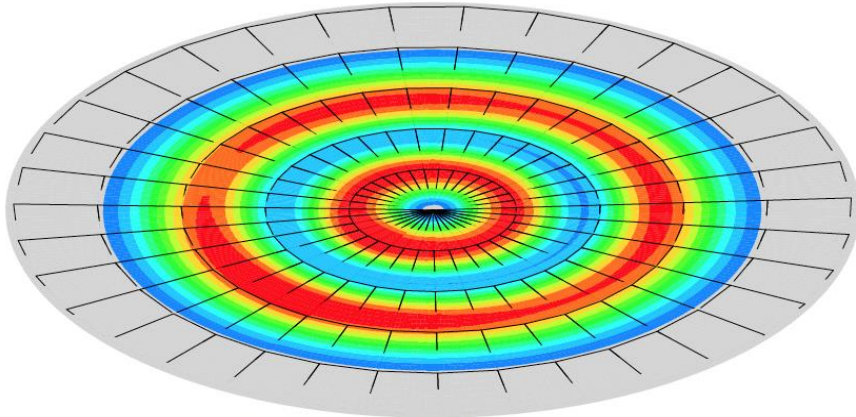
Rotating Nozzle



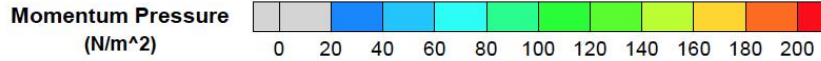
Spray Momentum Analysis

Rotating Nozzle

260.7 LPM @ 4.14 bar // 68.9 GPM @ 60 psi

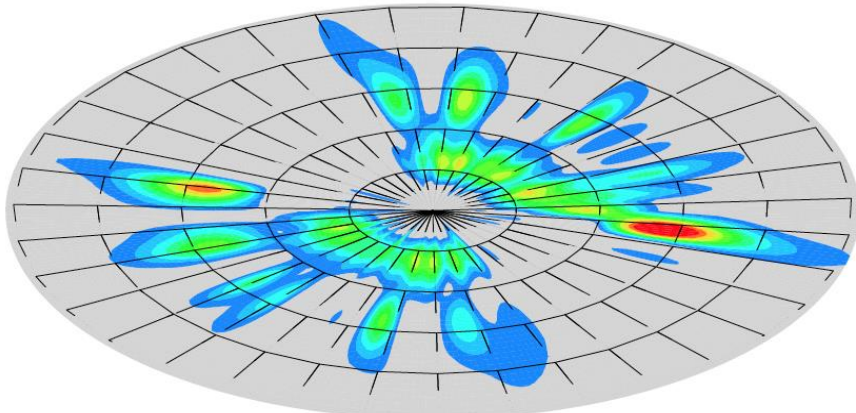


Tangent plane 0.35m below sprinkler.

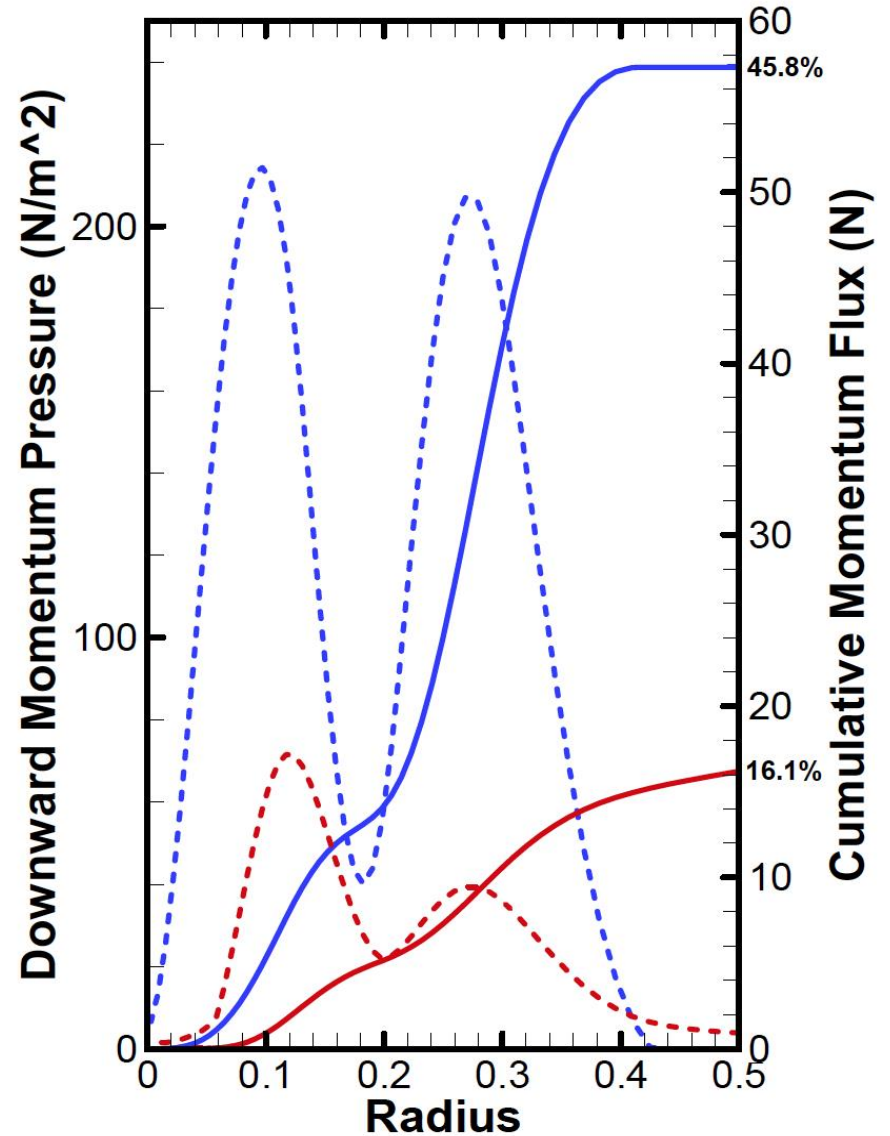


Deflector Nozzle

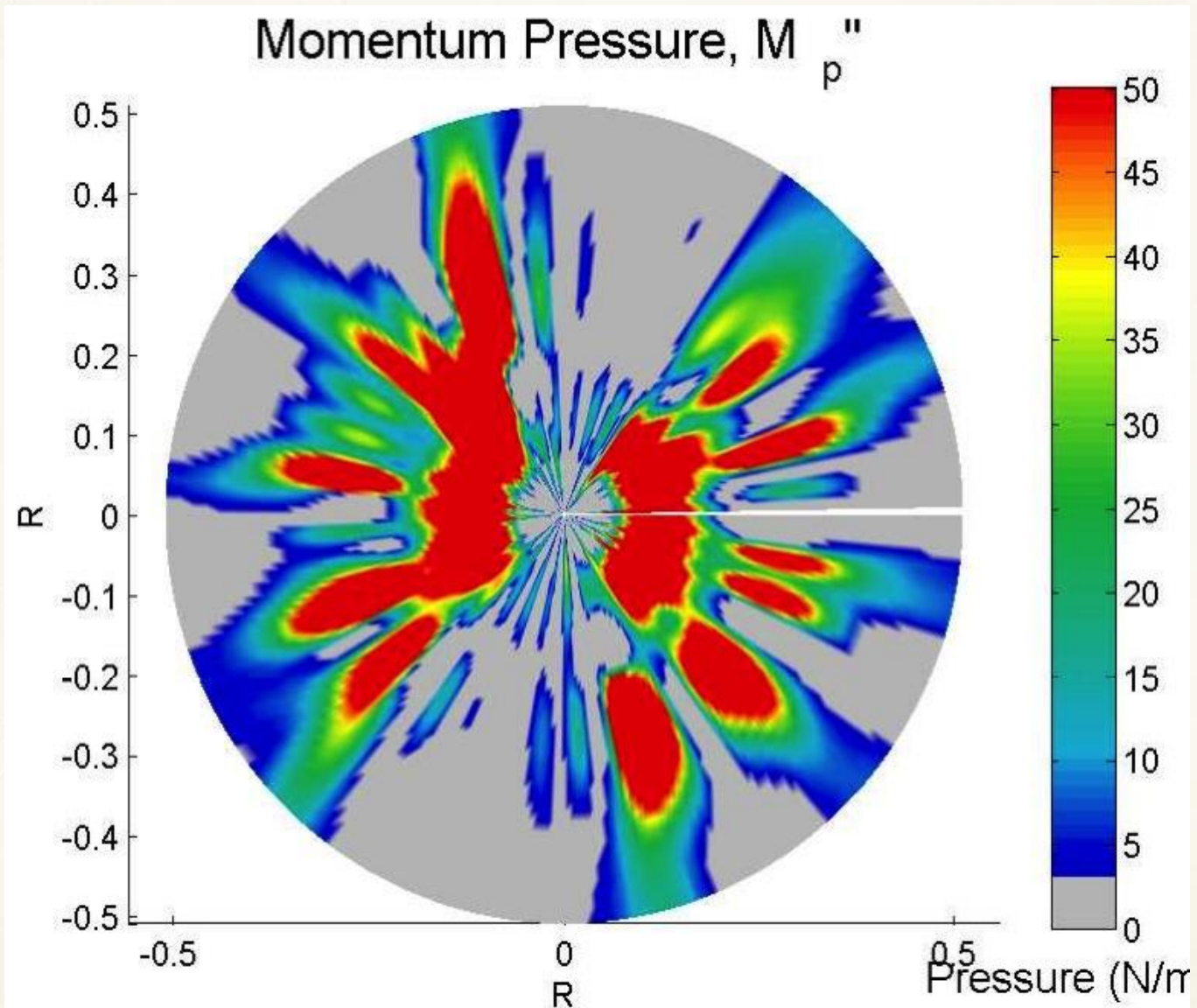
210.9 LPM @ 4.14 bar // 55.8 GPM @ 60 psi



Tangent plane 0.35m below sprinkler.

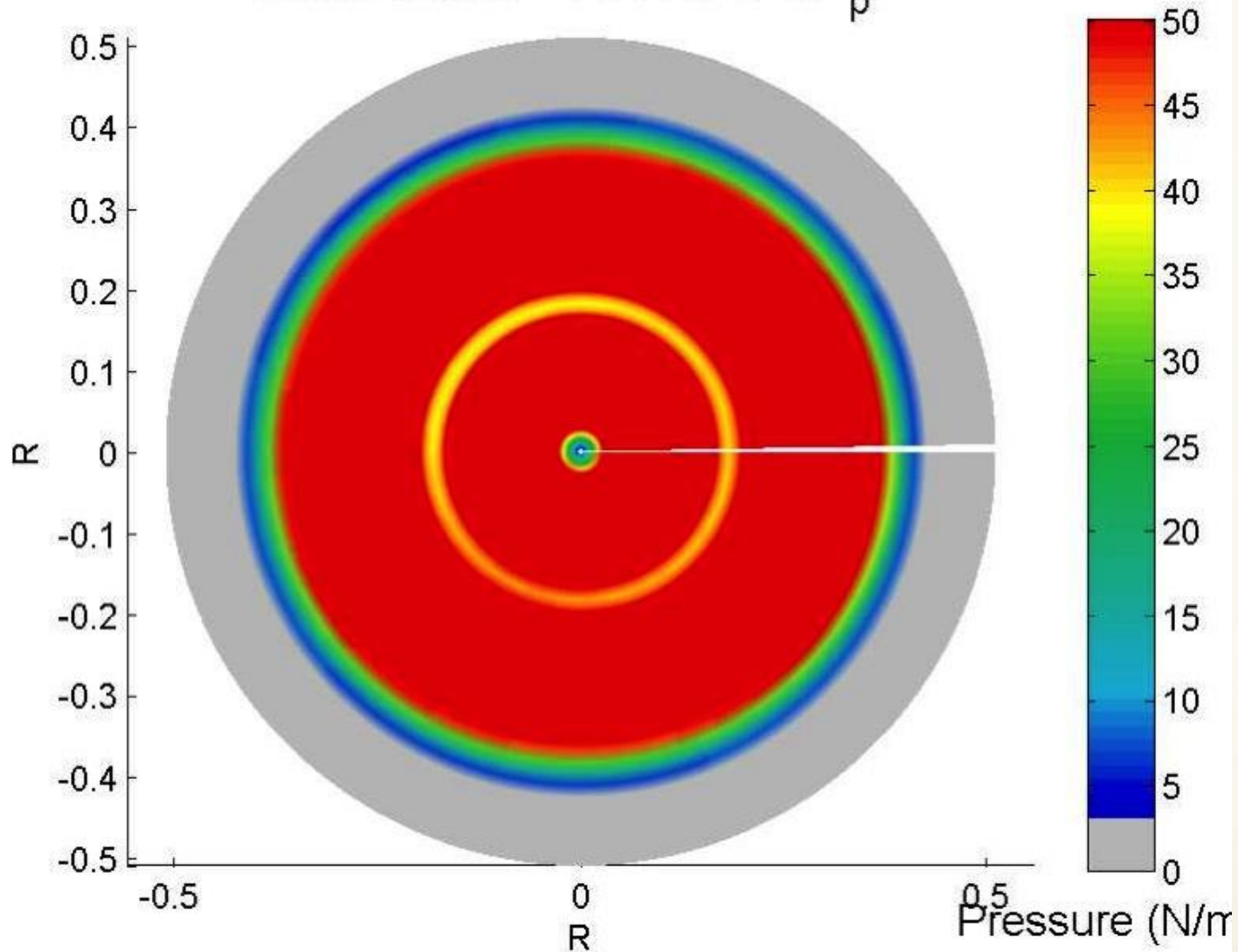


Deflector Nozzle

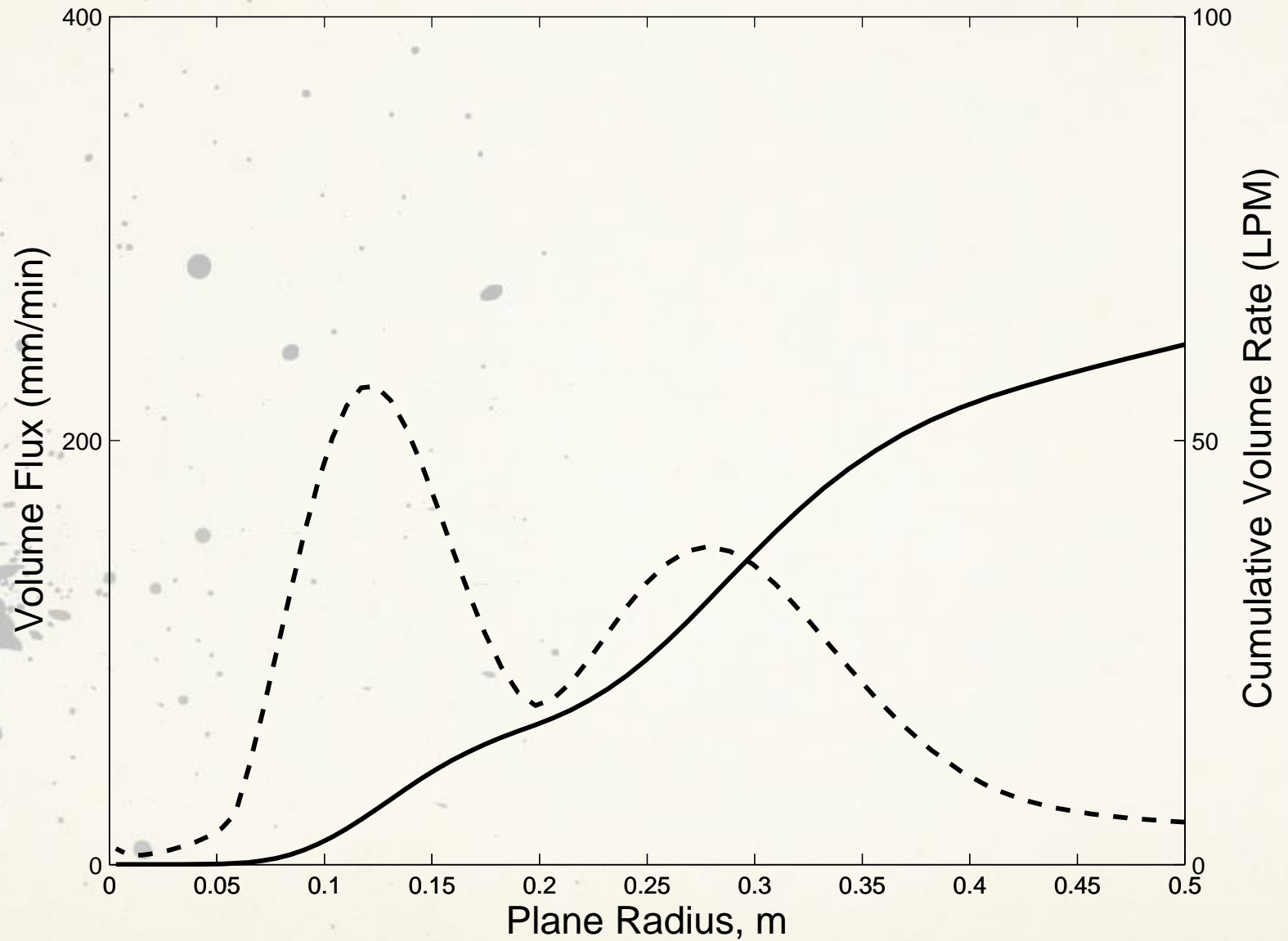


Rotating Nozzle

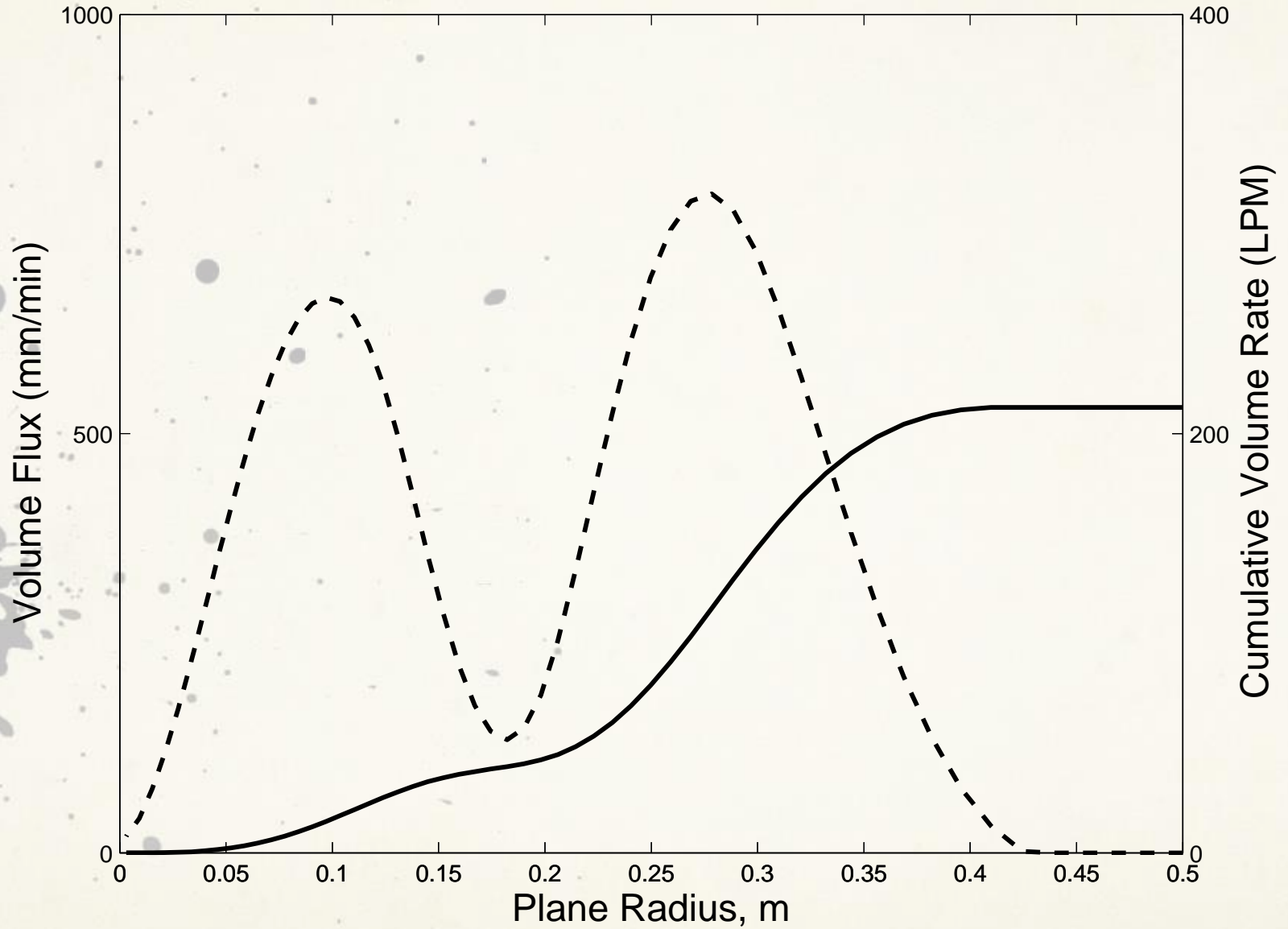
Momentum Pressure, M_p''



Deflector

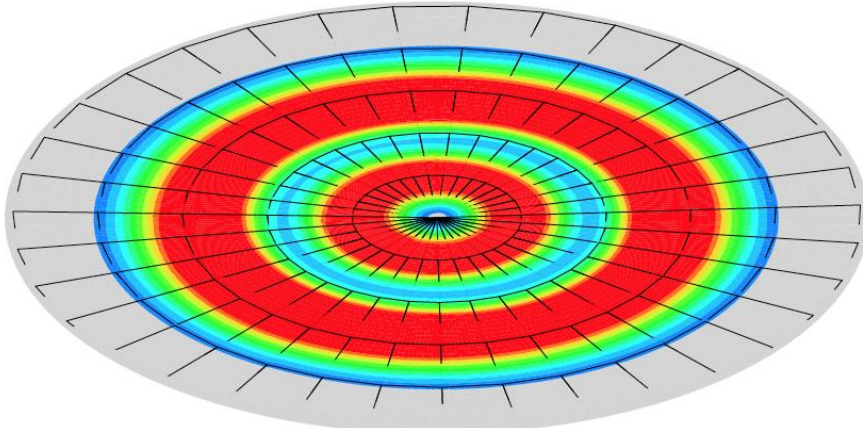


Rotor



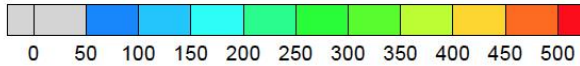
Rotating Nozzle

260.7 LPM @ 4.14 bar // 68.9 GPM @ 60 psi



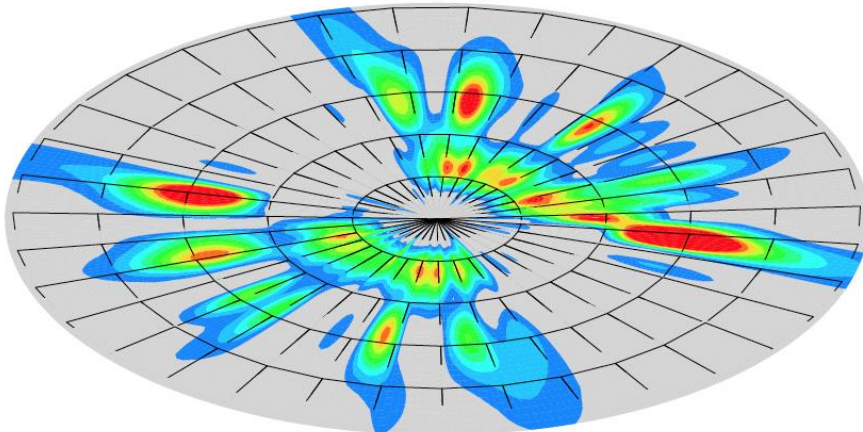
Tangent plane 0.35m below sprinkler.

Volume Flux
(mm/min)

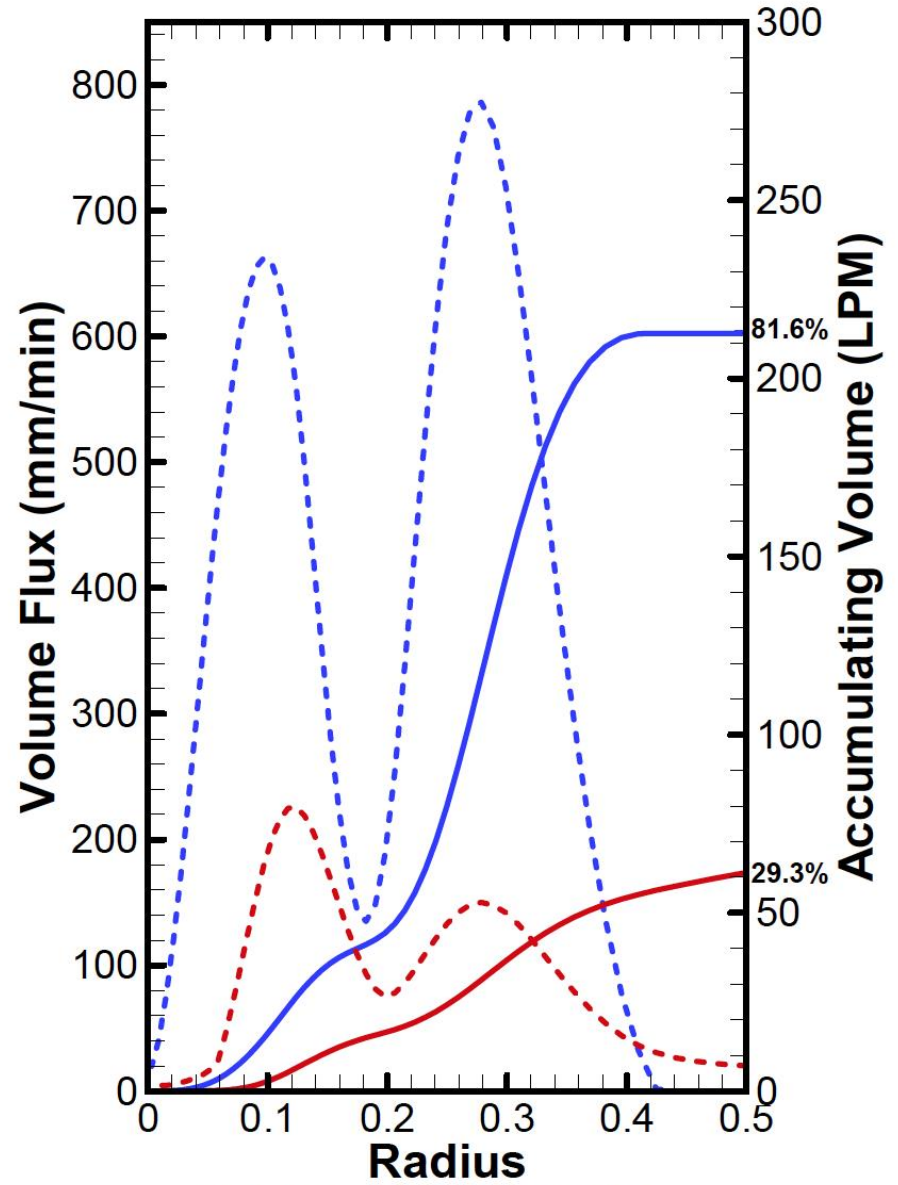


Deflector Nozzle

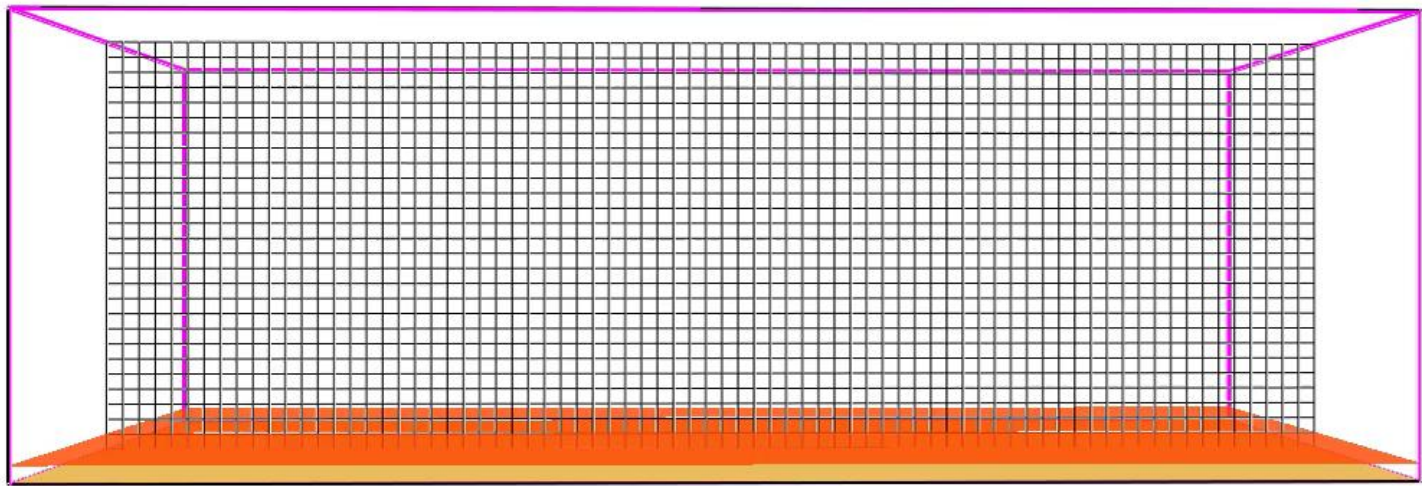
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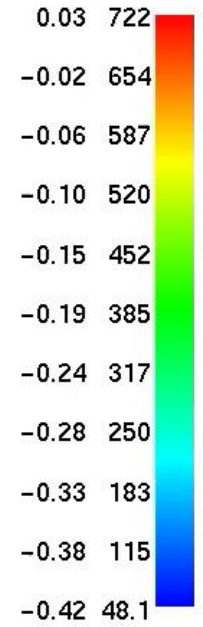
Tangent plane 0.35m below sprinkler.



Percentages based on total sprinkler flow rate.



Slice Part
flux_z diam
kg/s/m²nu-m



Time: 0.0





Part
diam
mu-m

1000

906

812

717

623

529

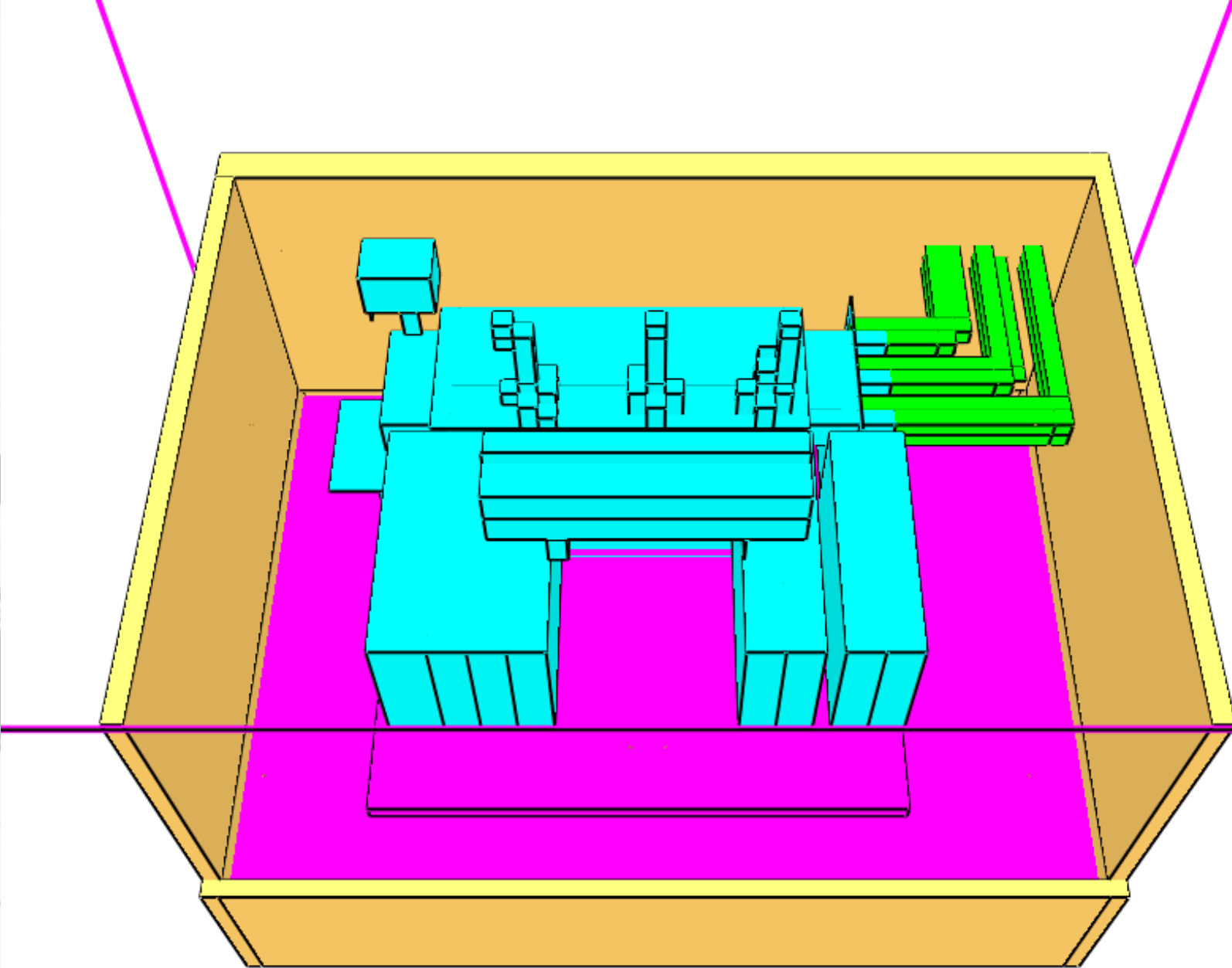
435

340

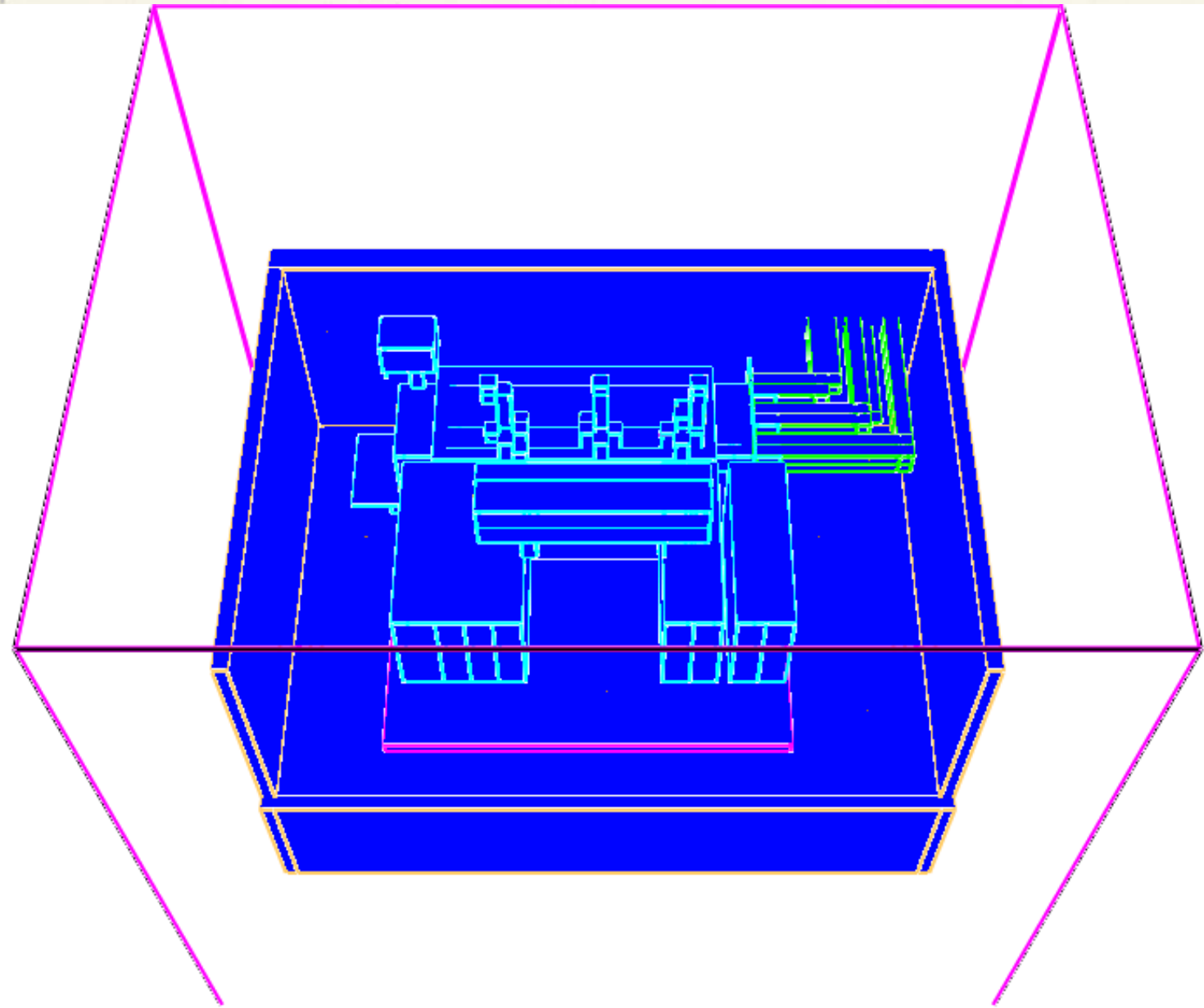
246

152

57.6



Bndry
cpua
kW/m2



Time: 0.0



Additional Information

James A Lynch

jlynch@ampedi.com

1-312-351-5919

Noah Ryder

nryder@dqfire.com

301-775-2967

www.ampedi.com

www.fireriskalliance.com