# Power and Cooling in the Data Center:

## Hyper-density Trends and Solutions

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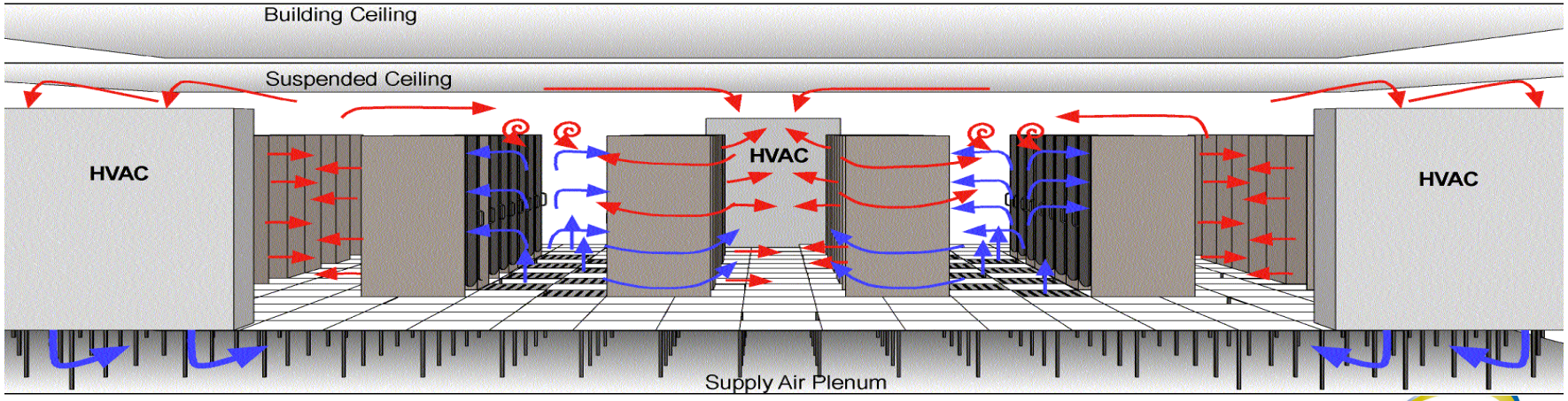
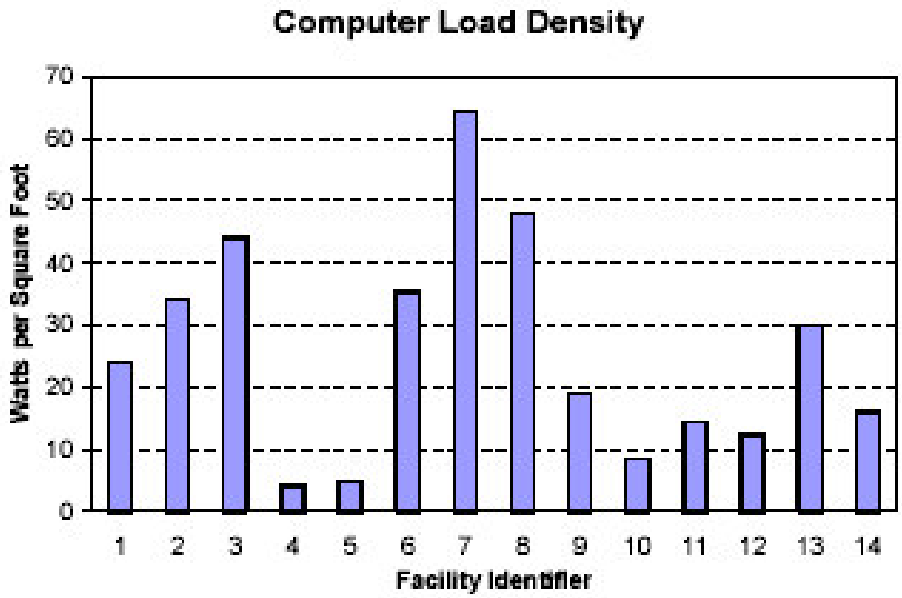
# Modern Datacenter Design

- Raised floor, forced air cooling through perforated panels
- Power and network wiring may be under floor or overheard
- Designed for 5-10 year lifecycles
- Not designed for additional growth in power and cooling capacity
- Cooling efficiencies average between 40-50%



# Average Datacenter Density

- Lawrence Berkley National Labs study found no datacenters in their study that exceeded 1950W/sq meter
- Historical trends have shown loading in the 250-500W/sq meter
- Customers have not seen a need to invest in support for density until now.



# Energy Density of Datacenters

- Datacenter capacity is not rising at the same rate as power density in servers
- Indicates there is a resistance to dense deployments in volume

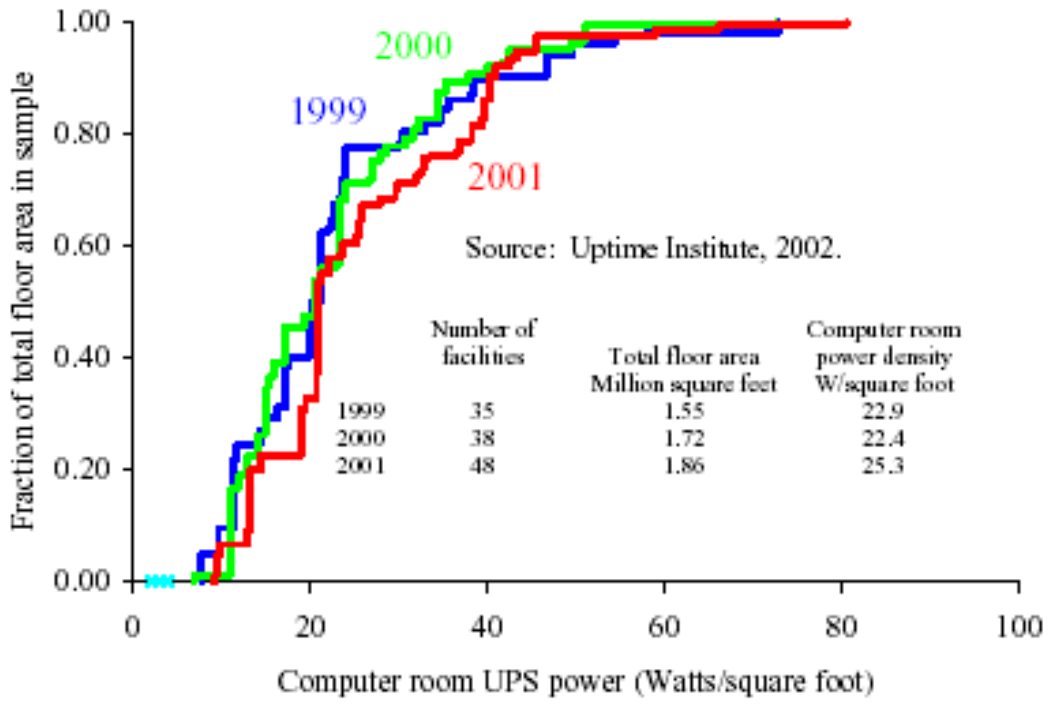
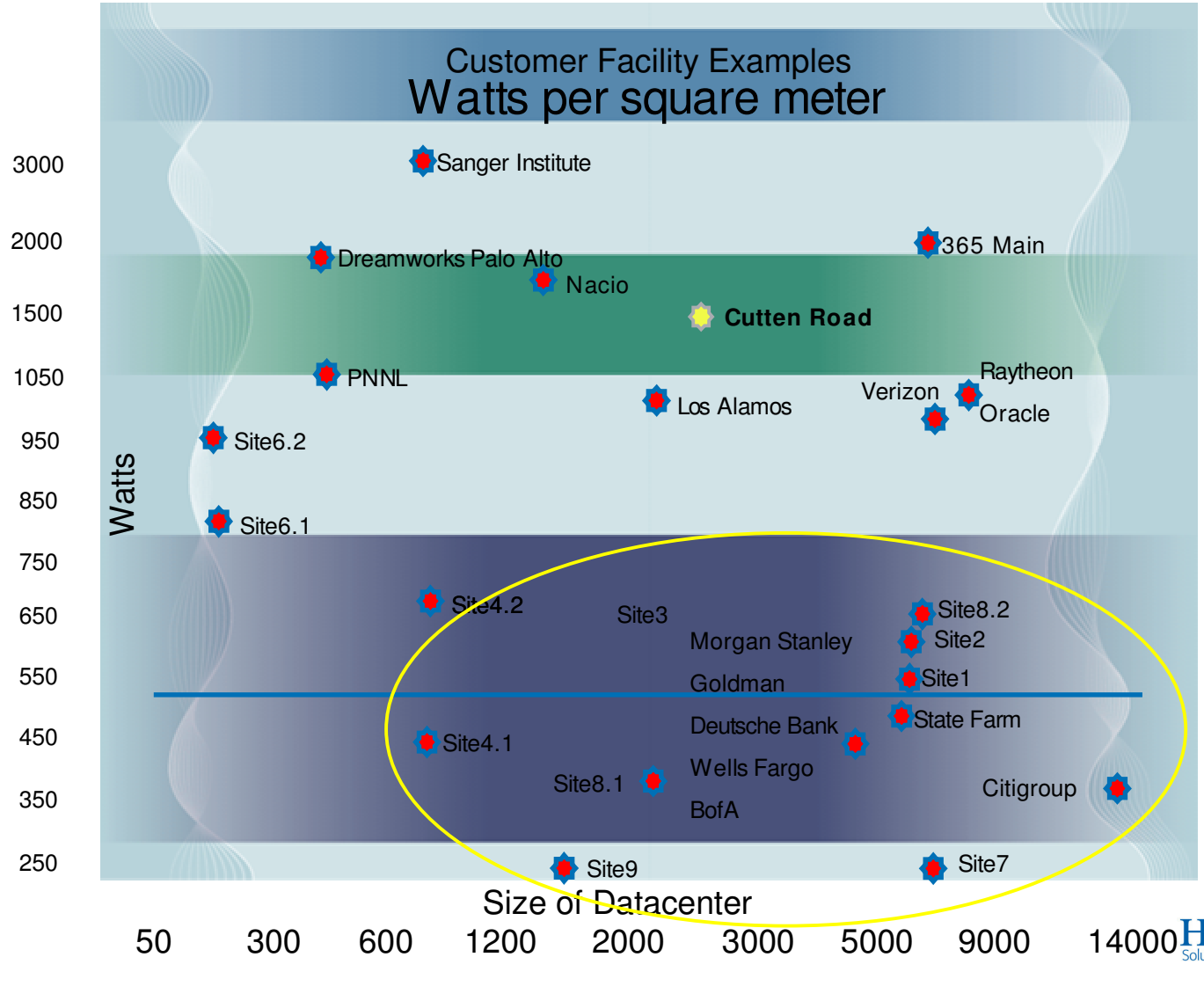



Figure 6. Uptime Institute Energy Density Data

# Customer Landscape



# Datacenter Trends

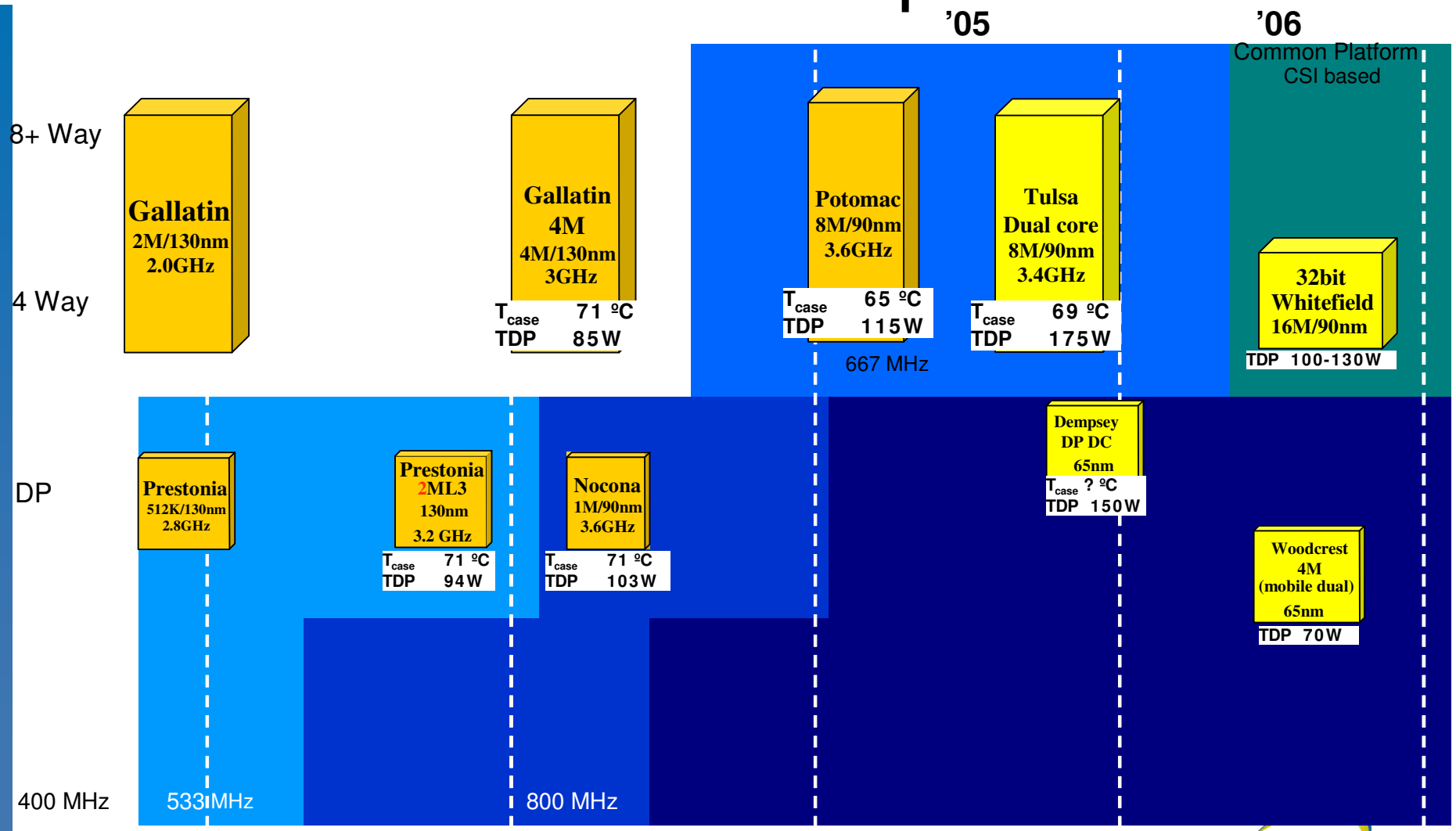
- Four years ago
  - Average servers per rack = 4 – 6
  - Average U size was 5 – 7U
  - Average watts per rack = 1500 – 3000
- Today
  - Average servers per rack = 8-24
  - Average U size is moving down to 2U
  - Average watts per rack = 5000 – 6000
- Future
  - Power densities of 1000+ watts per U are imminent

# Server Trends

## Generation over generation density growth rates

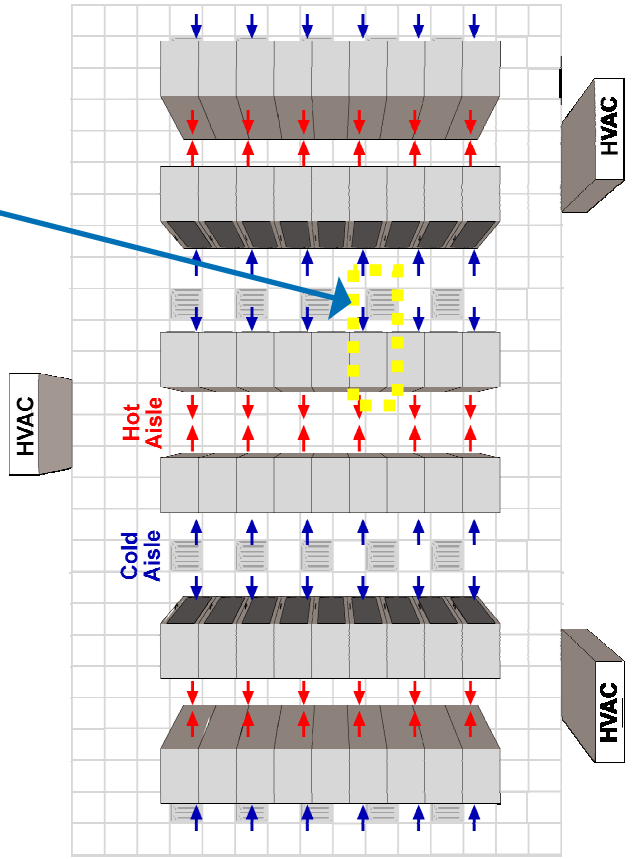
| | | | |
|---|---|---|---|
| DL360 G2<br>246 W | DL360 G3<br>389 W | **58%**<br>2p, 4gb, 2hdd, 1pci | 1U |
| DL380G2<br>362 W | DL380 G3<br>581 W | **60%**<br>2p, 4gb, 6hdd, 2pci | 2U |
| DL580 G1<br>456 W | DL580 G2<br>754 W | **65%**<br>4p, 8gb, 4hdd, 3pci | 4U |

# Intel Processor Roadmap



# Impact of Future Dense Server Designs

- Dense designs drive up the Watts/ square meter requirement
- A typical rack requires 1.3 square meters of space
- At bl30p watt densities of 35000 watts per cabinet (max theoretical), the watt density for a facility of bl30p's could exceed
- >26,000 watts per square meter!



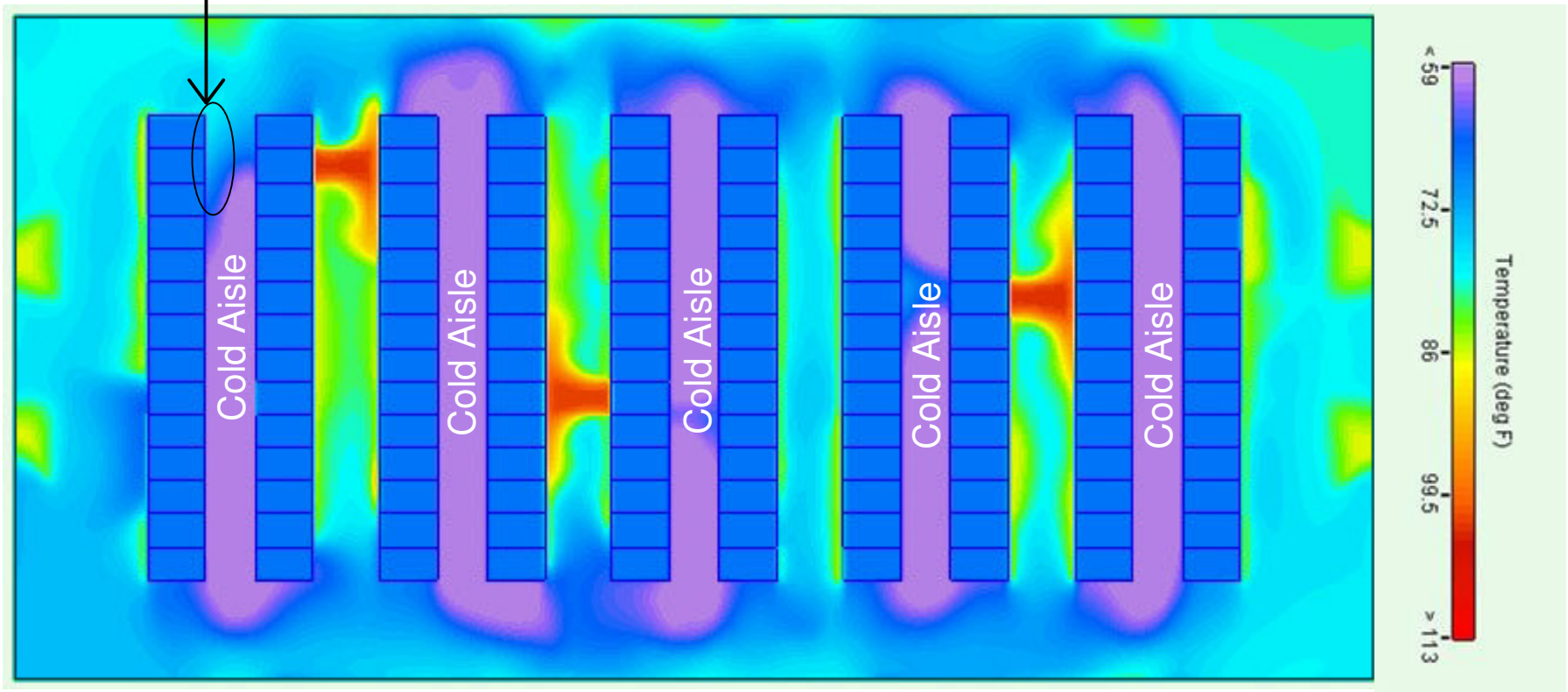
# Understanding the Limits of Data Center Designs

- HP commissioned study
  - Impact of increasing power density
  - What can a facility successfully support?
  - How can we improve the efficiency of a datacenter?
  - Initial data indicates supporting room level power densities above 2000 to 2500 watts per square meter is not practical using classic raised floor designs

# CM750-FL – BC

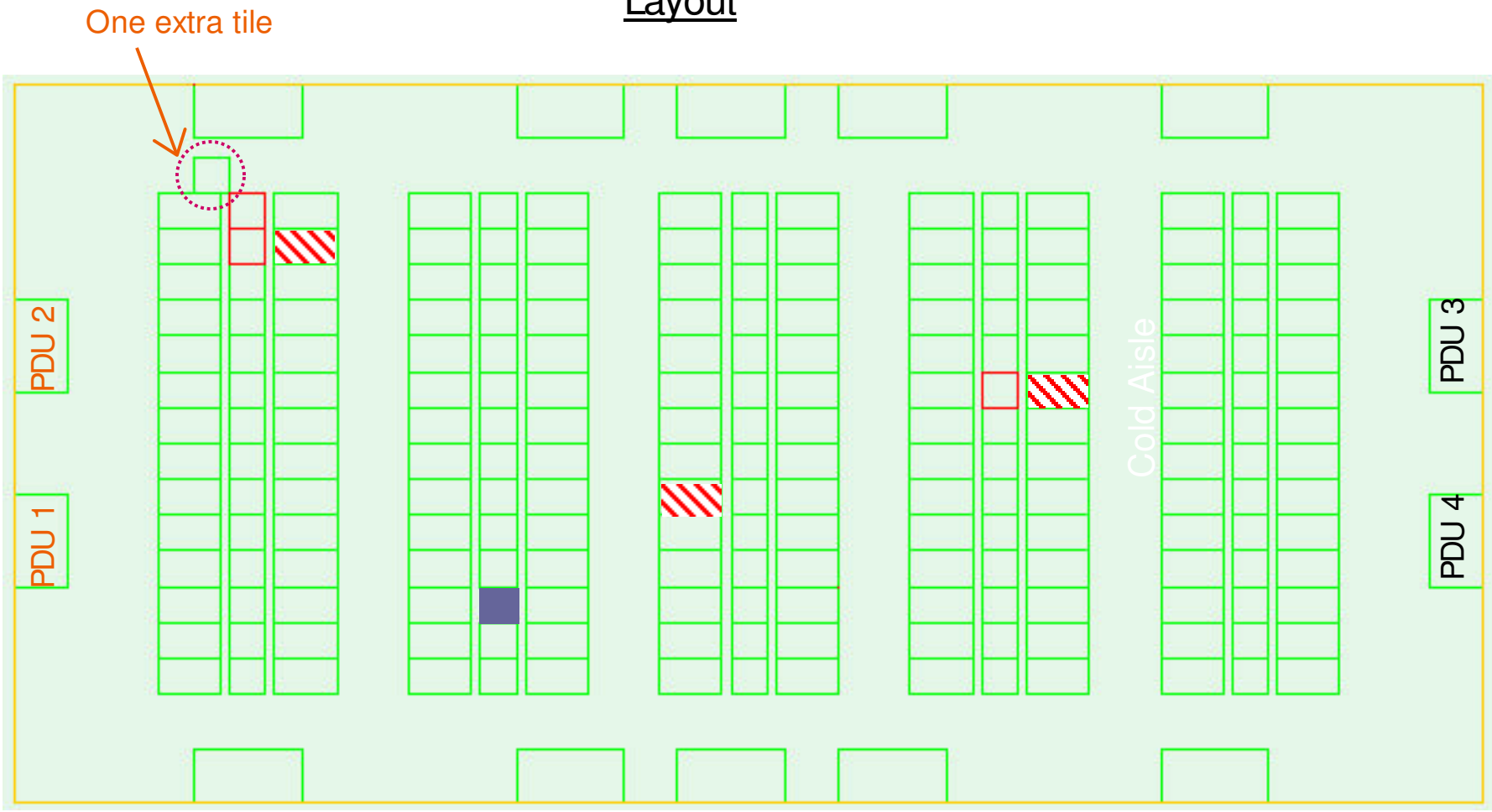
## Y-Plot at 78” from the raised floor

R1C13-C14 max = 78.5ºF



# CM750 - FL – Solved

## Layout



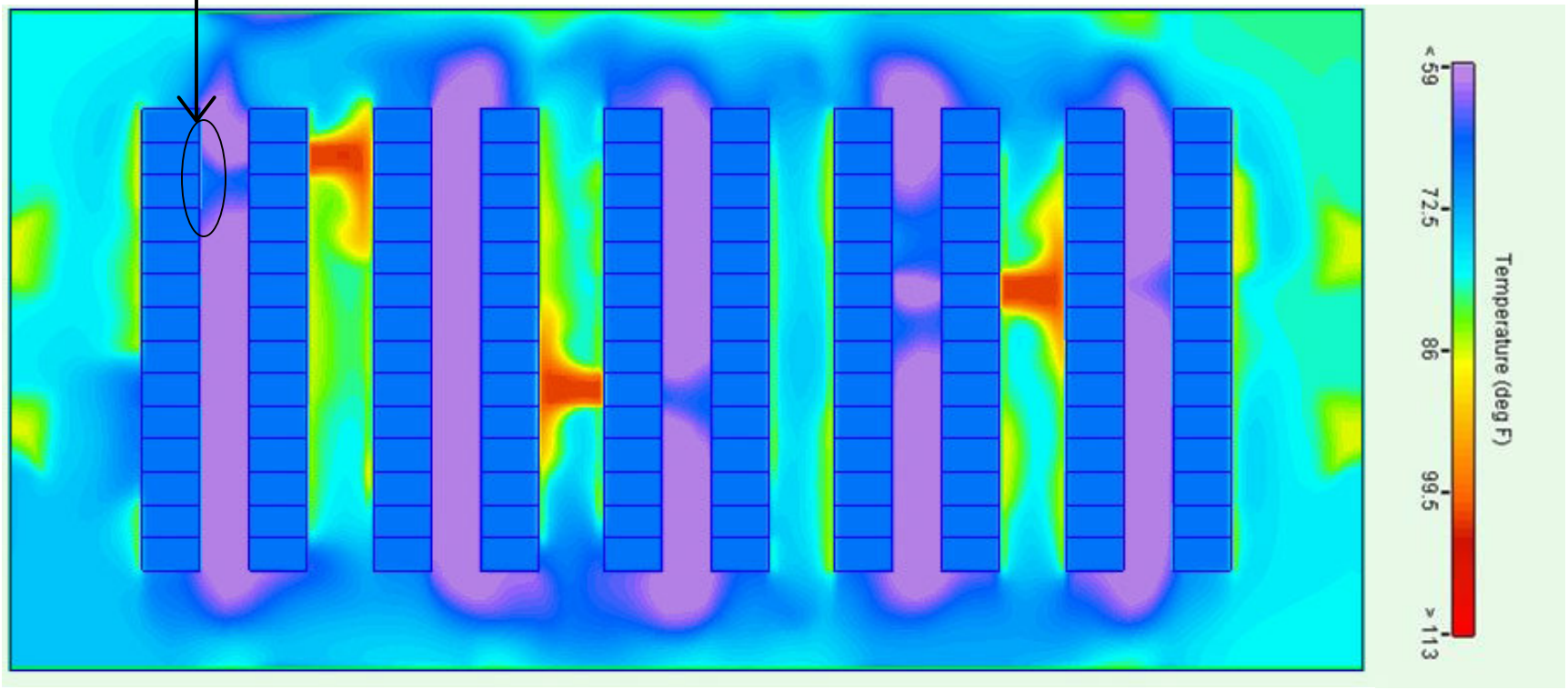

Legend:

= deactivated tiles  = 56% tiles  = 25% tiles  = 30KW cabinets

# CM750-FL – Solved

## Y-Plot at 78” from the raised floor

R1C12 - C13 max = 68.3ºF

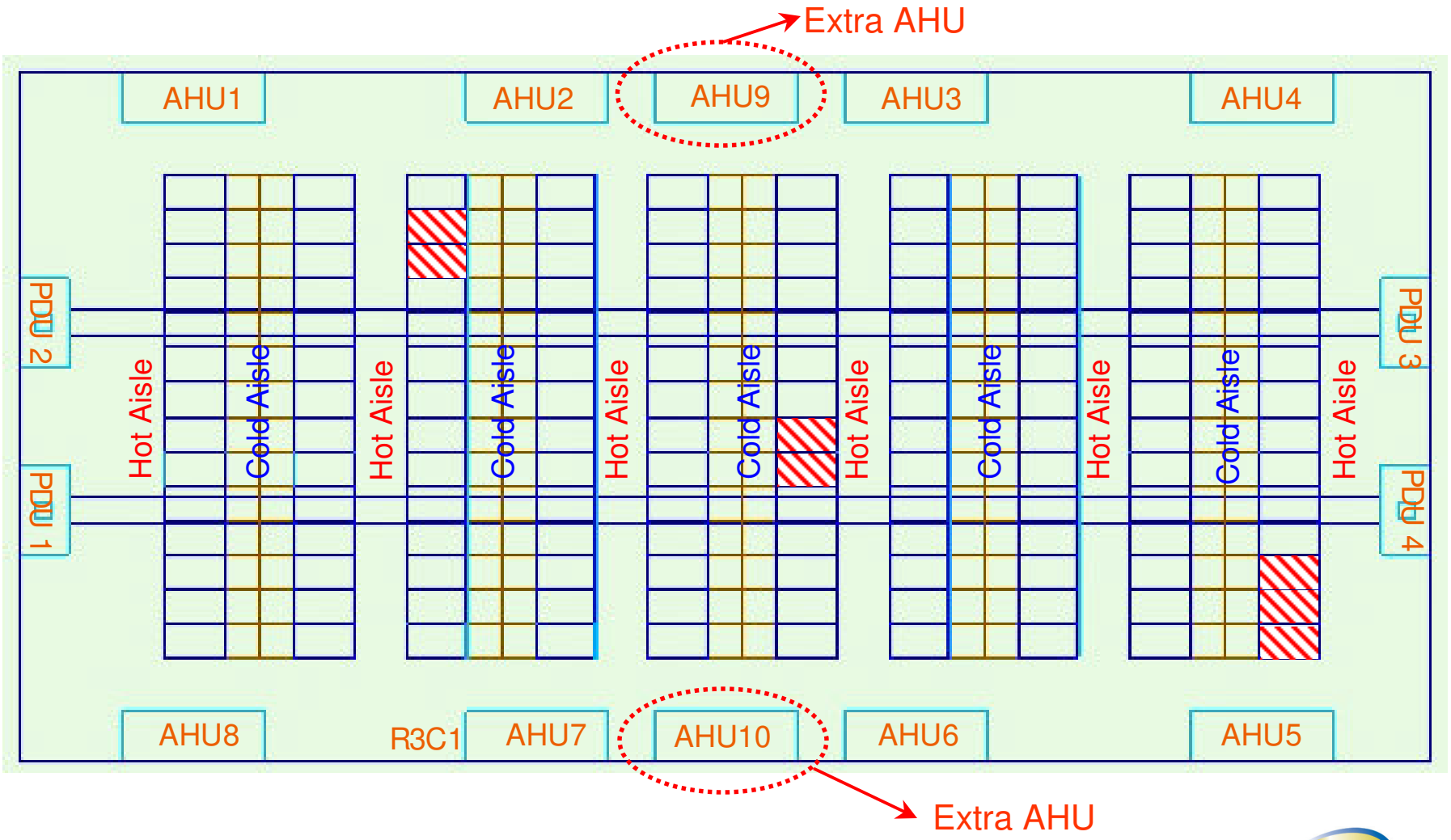



Note: Maximum allowable rack inlet temperature is 77ºF

# CM1500 – FL - BC

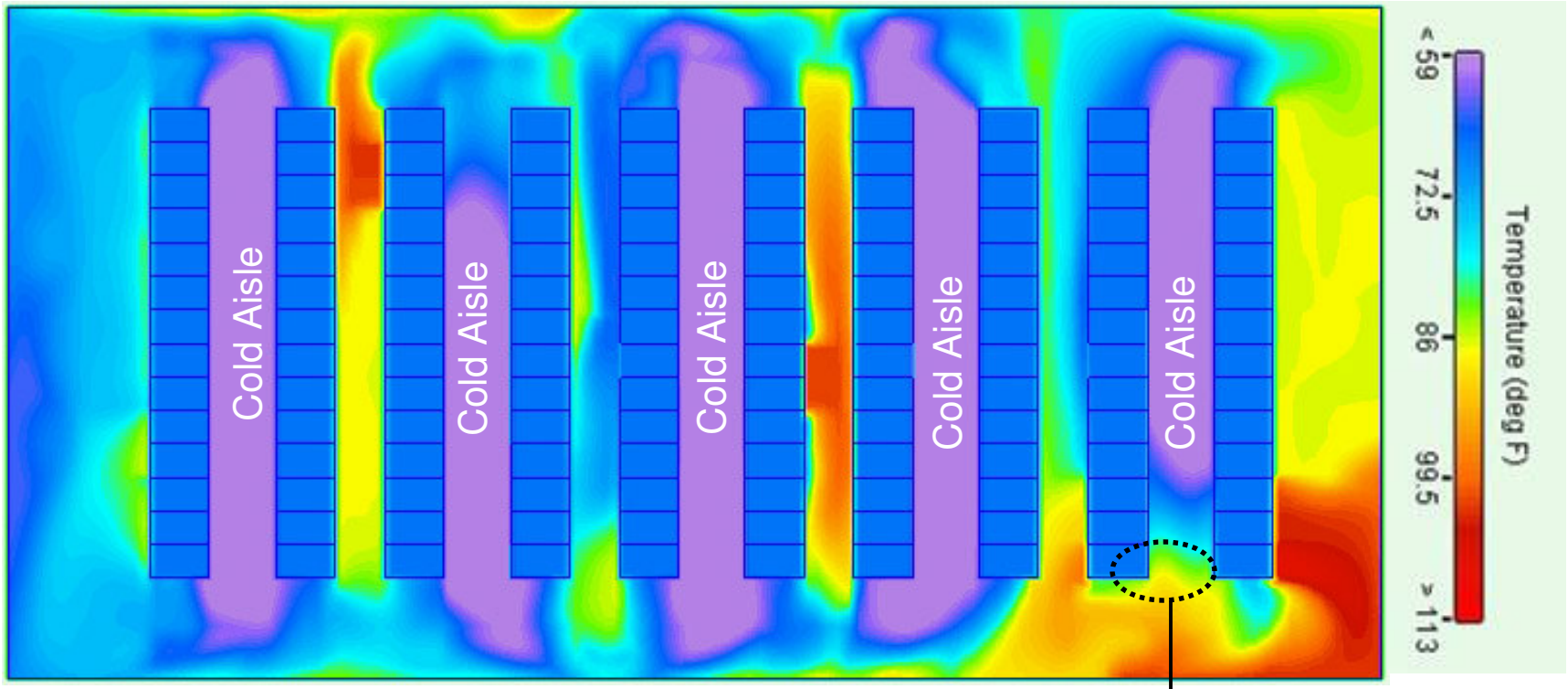
## Layout Top View

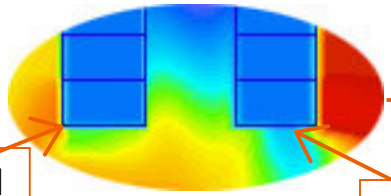
All floor tiles 25% open



# CM1500 – FL - BC

Y-Plot at 78” from the raised floor



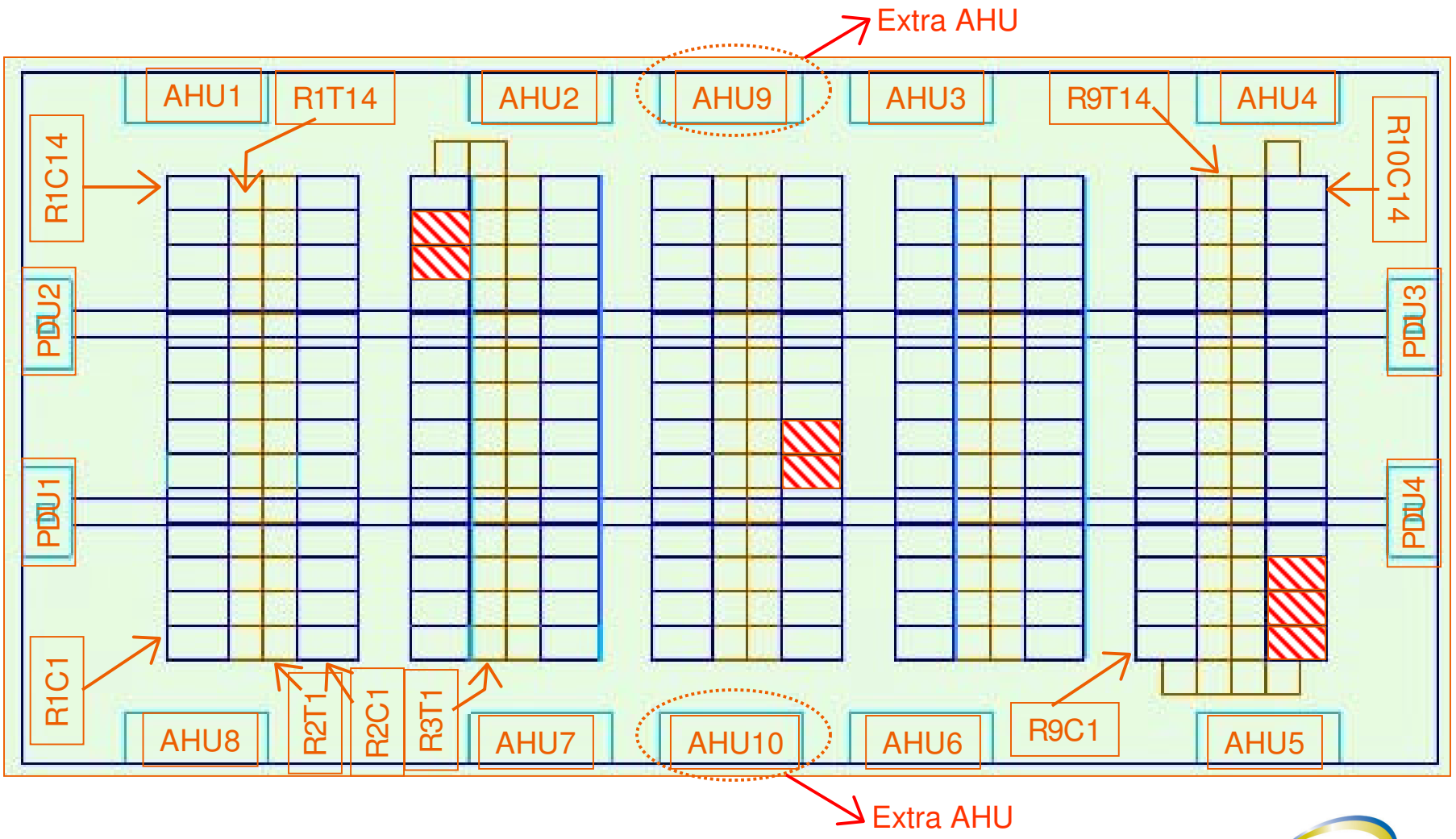
R9C1

R10C1

•Max. inlet temperature occurs at R9C1: 84.1°F

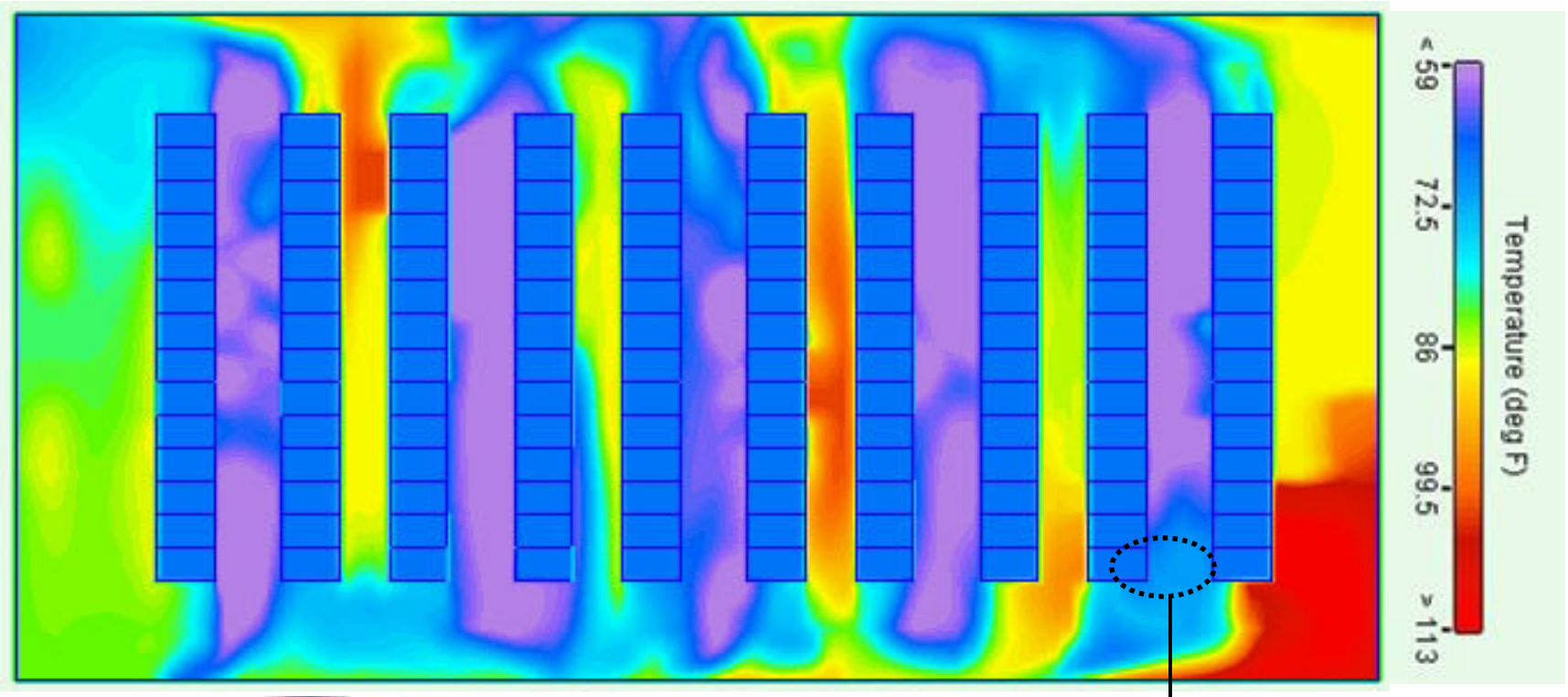
# CM1500 – FL – Solved – HE

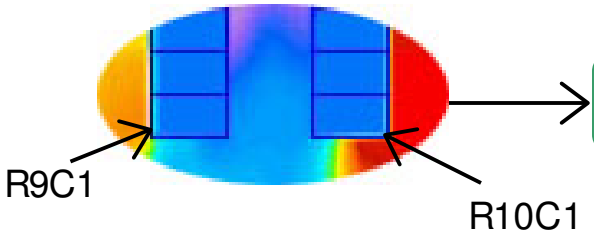
## Layout – Top View



# CM1500 – FL – Solved – HE

Y-Plot at 78” from the raised floor



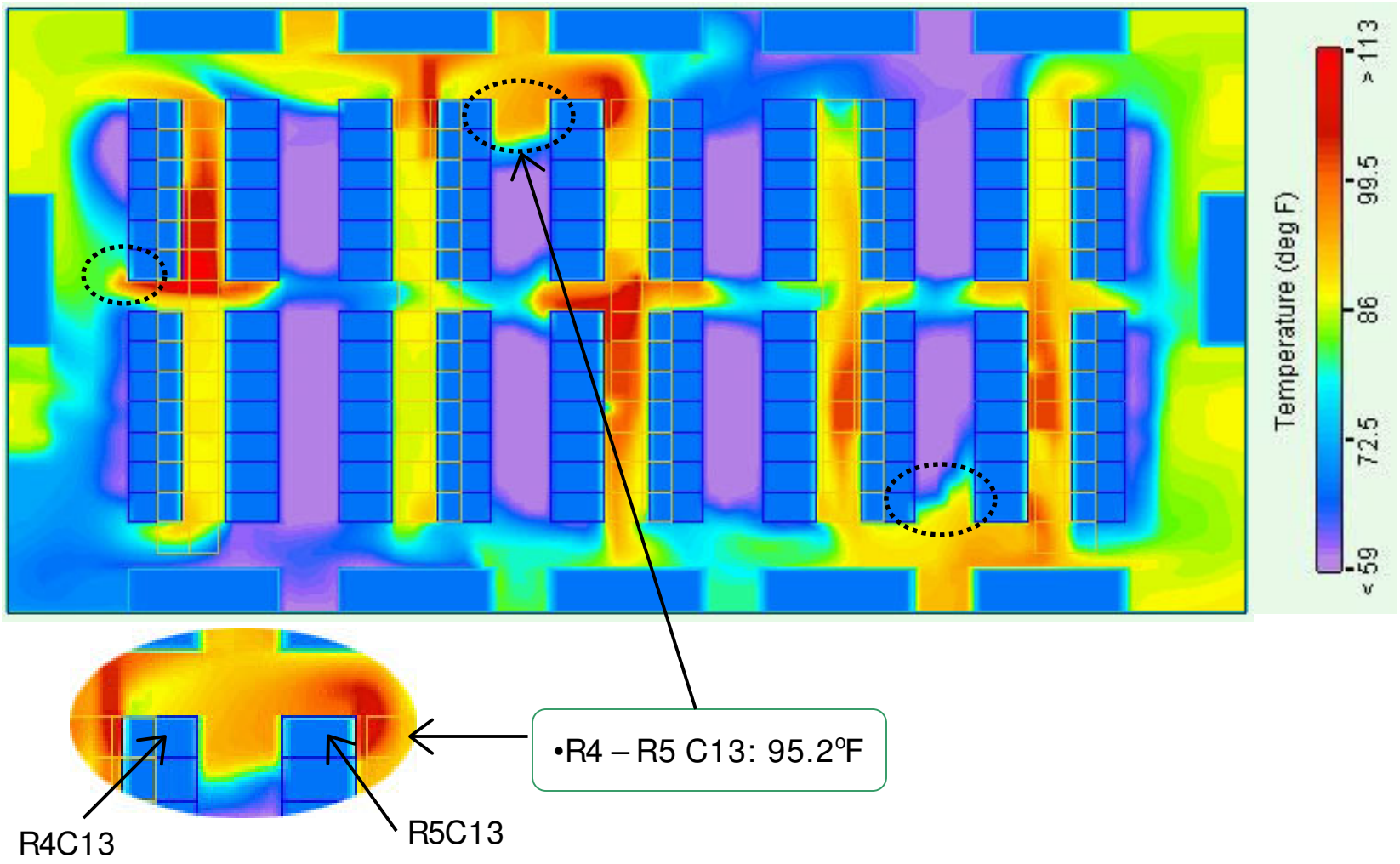




•Max. inlet temperature occurs at R9C1: 71.8ºF

Note: Maximum allowable rack inlet temperature is 77ºF

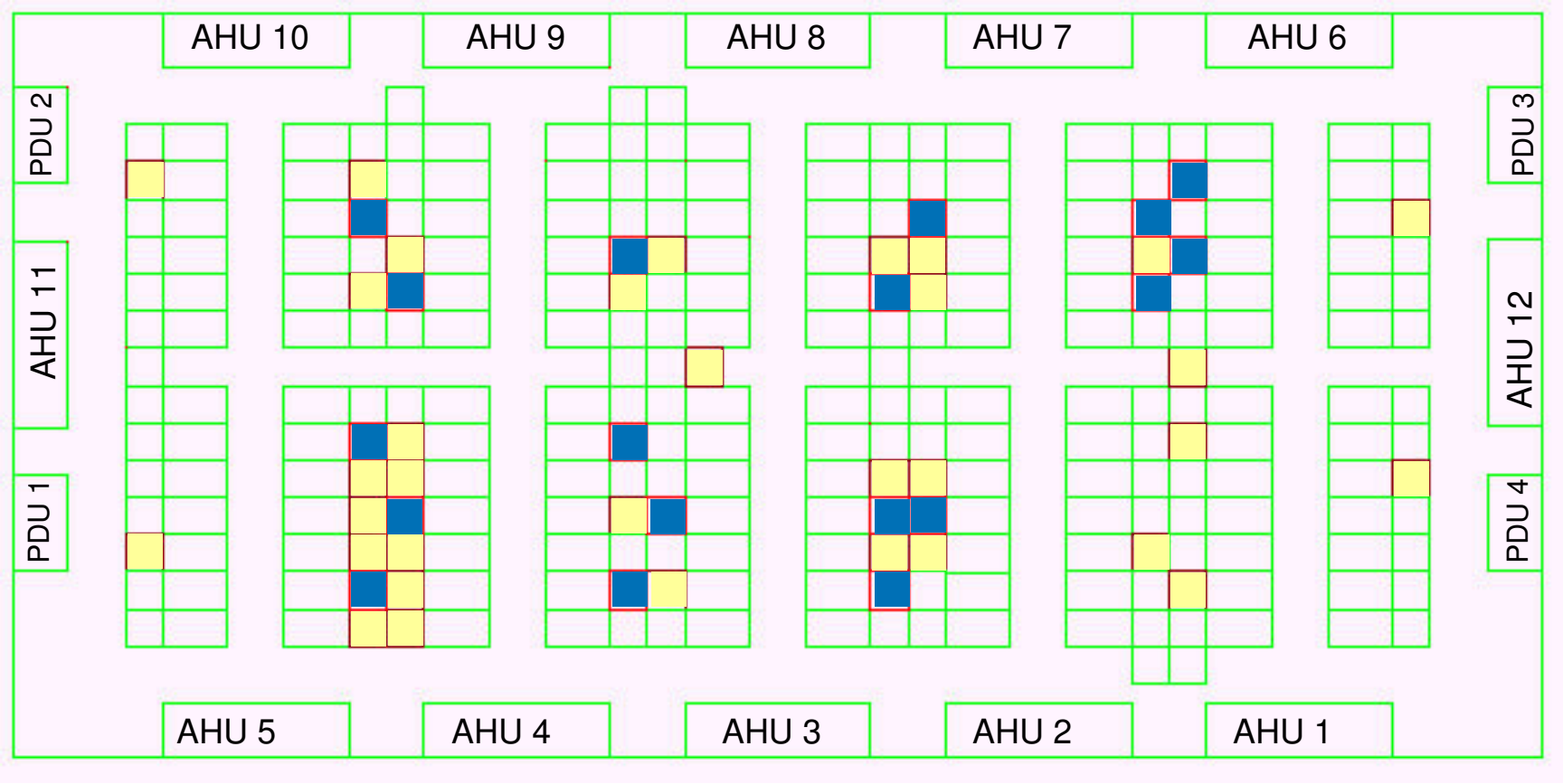
# CM3000-FL – BC

## Y-Plot at 78” from the raised floor



# CM3000-FL - Solved

## Layout – Floor tiles



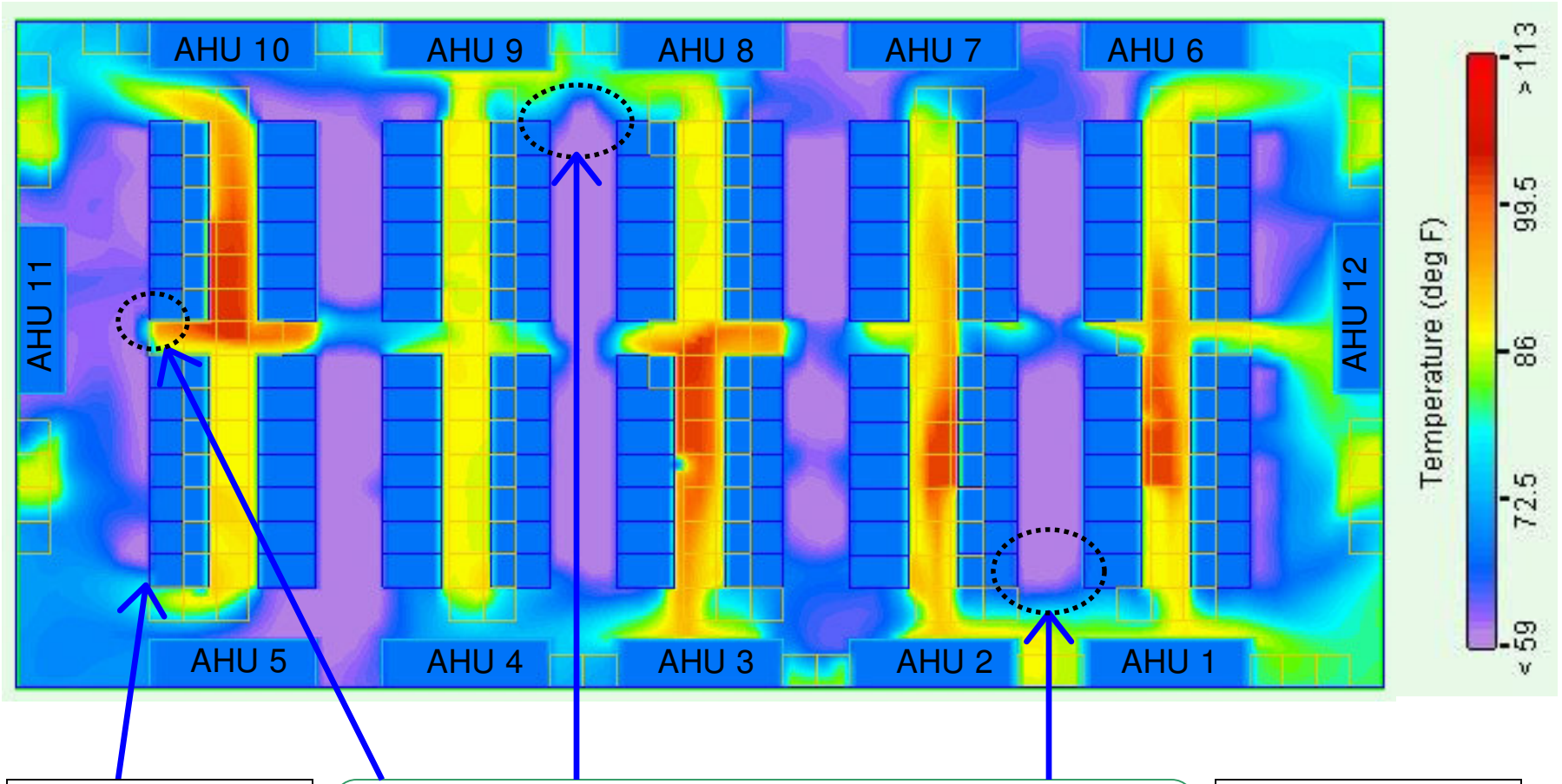

De-activated tiles

25% open tiles

All other tiles are 56% open tiles

# CM3000-FL – Solved

Y-Plot at 78” from the raised floor



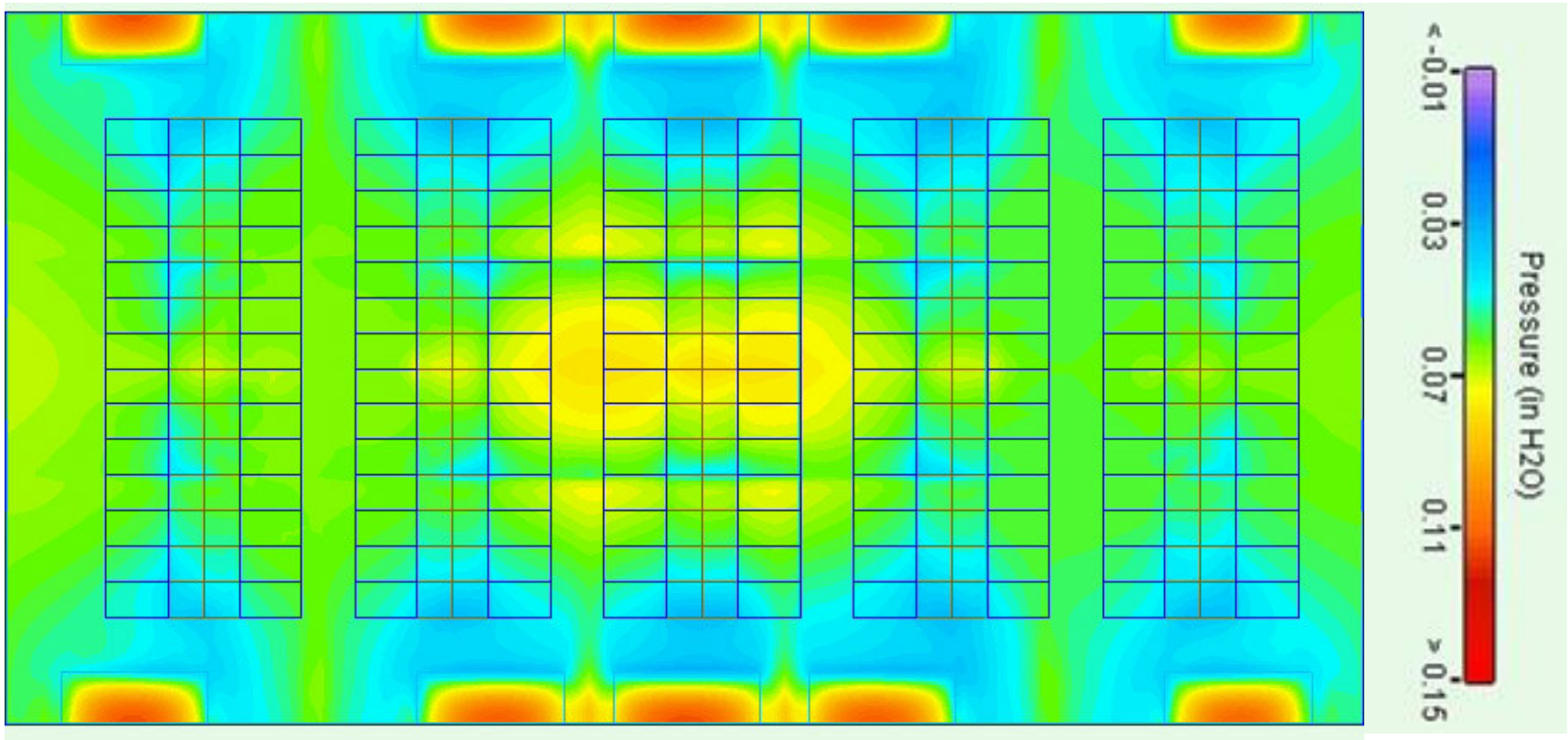

Highly localized region of 77.3 ºF

All hot air temperatures observed in the base case have now come down below 68ºF

Note: Maximum allowable rack inlet temperature is 77ºF

# CM150 – FL - BC

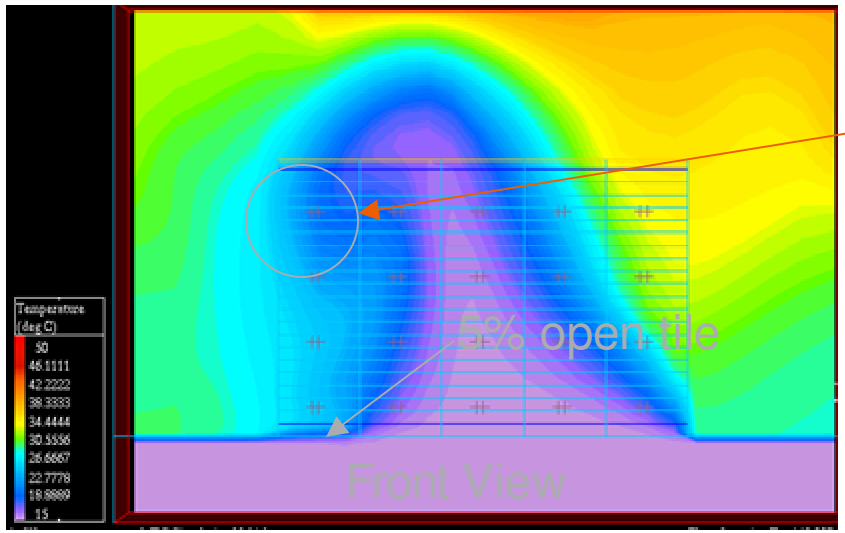
Pressure plot at 2” below the raised floor



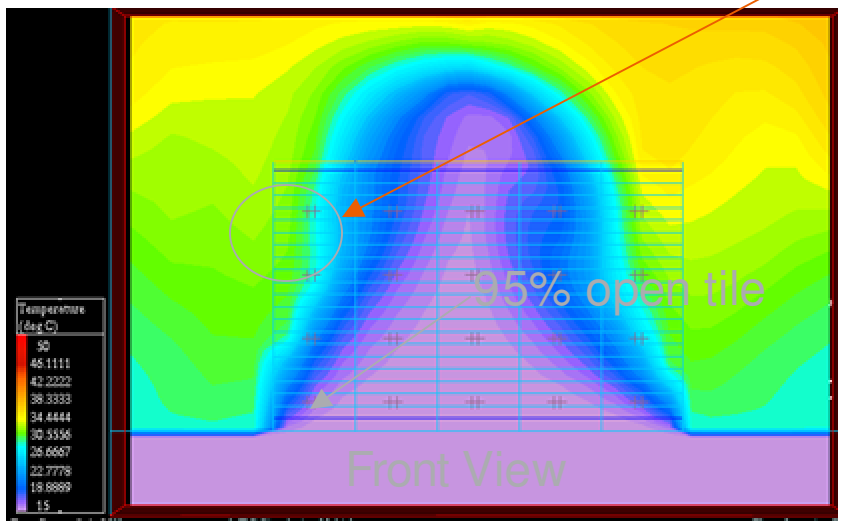

- Max. 0.11” of $H_2O$ observed below the supply of AHU

# Data Center Thermal Modeling

Non-intuitive flow patterns (HPL Palo Alto Smart Data Center Project)



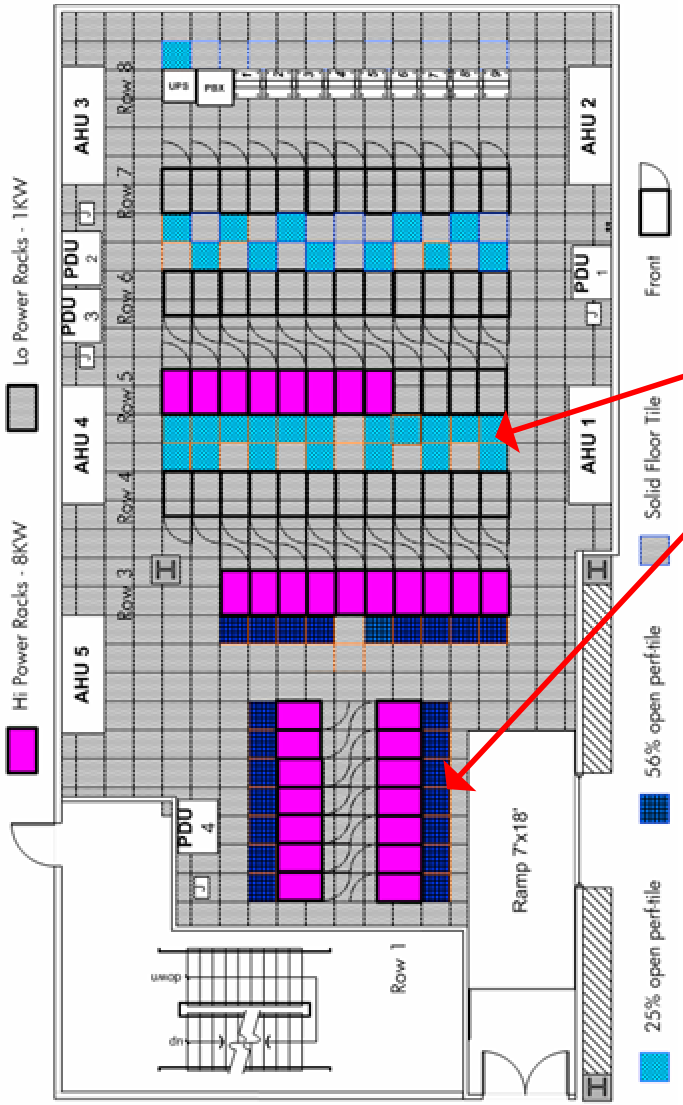

5% open vent tile results in cooler inlet temperature




95% open vent tile results in hotter inlet air temperature

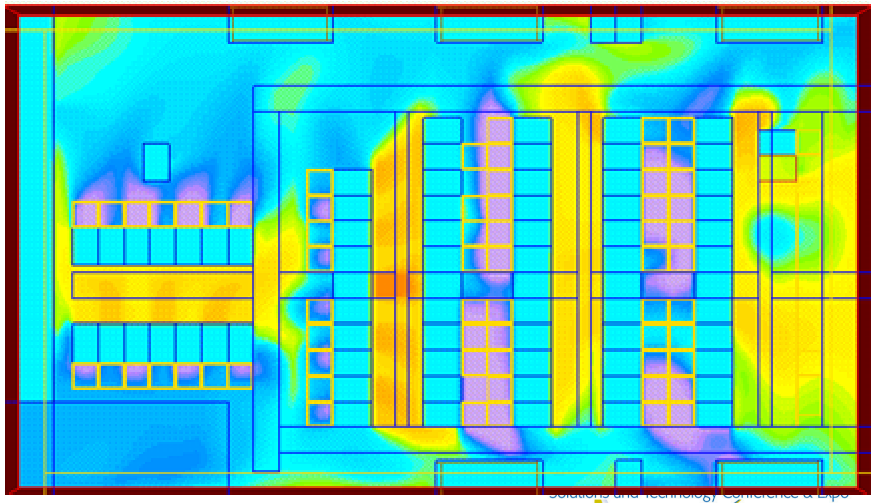
# Data Center Thermal Modeling

## Dreamworks Redwood City (DL360 G3)



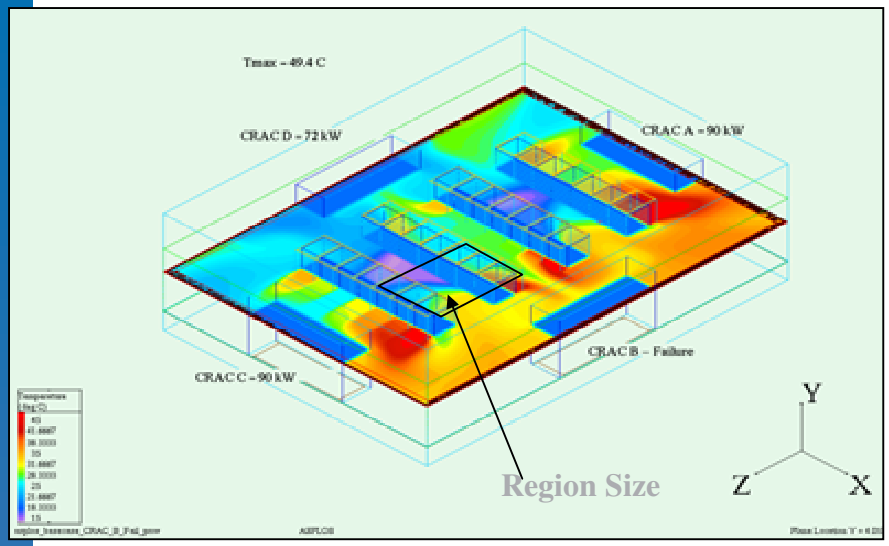

*Solution:*

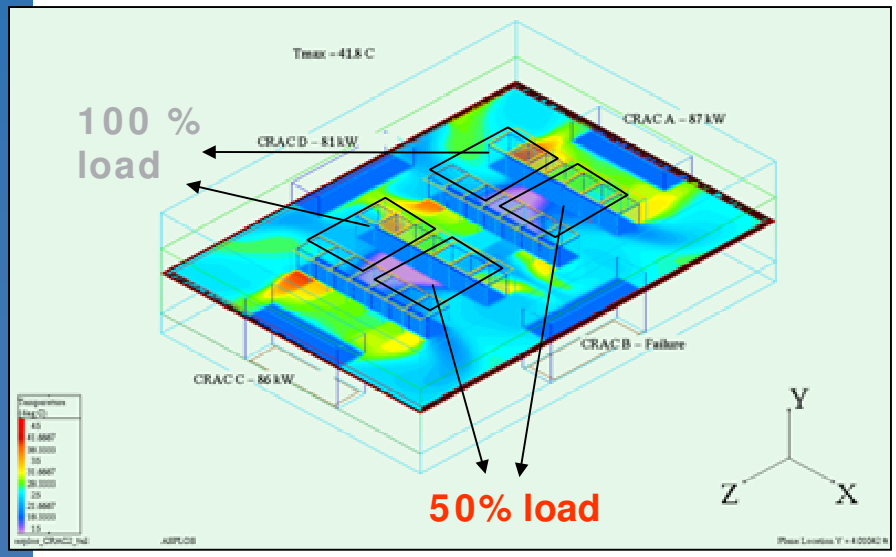
This issue was solved by strategically repositioning inlet air vents (the only degree of freedom allowed by the customer)



# Data Center Thermal Modeling

## Impact of load or cooling changes




Modeling has the capability to show the impact of:

- Turning on new machines
- AC failure
- AC shutdown for scheduled maintenance

Factoid: For a given data center (at 2250 W/sq meter) with an A/C failure, the reaction time to reduce load is less than ~ 35 seconds to prevent redlining & shut-down

# Key Findings

- Use of intuition is counterproductive in managing thermal situations
- Costs to support datacenter designs above 1000 watts/sq meter can become prohibitive
- Harvesting of low hanging fruit lies in improving existing efficiencies
- Thermal modeling can provide significant energy savings and allow for increased densities without spending on new equipment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