DESIGN AND EVALUATION OF AN ON-SUN PROTOTYPE FALLING-PARTICLE CAVITY RECEIVER

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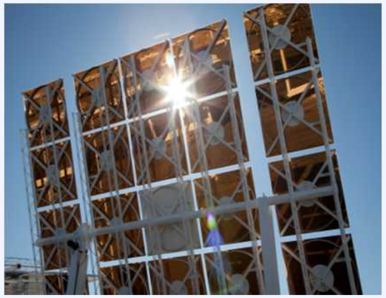


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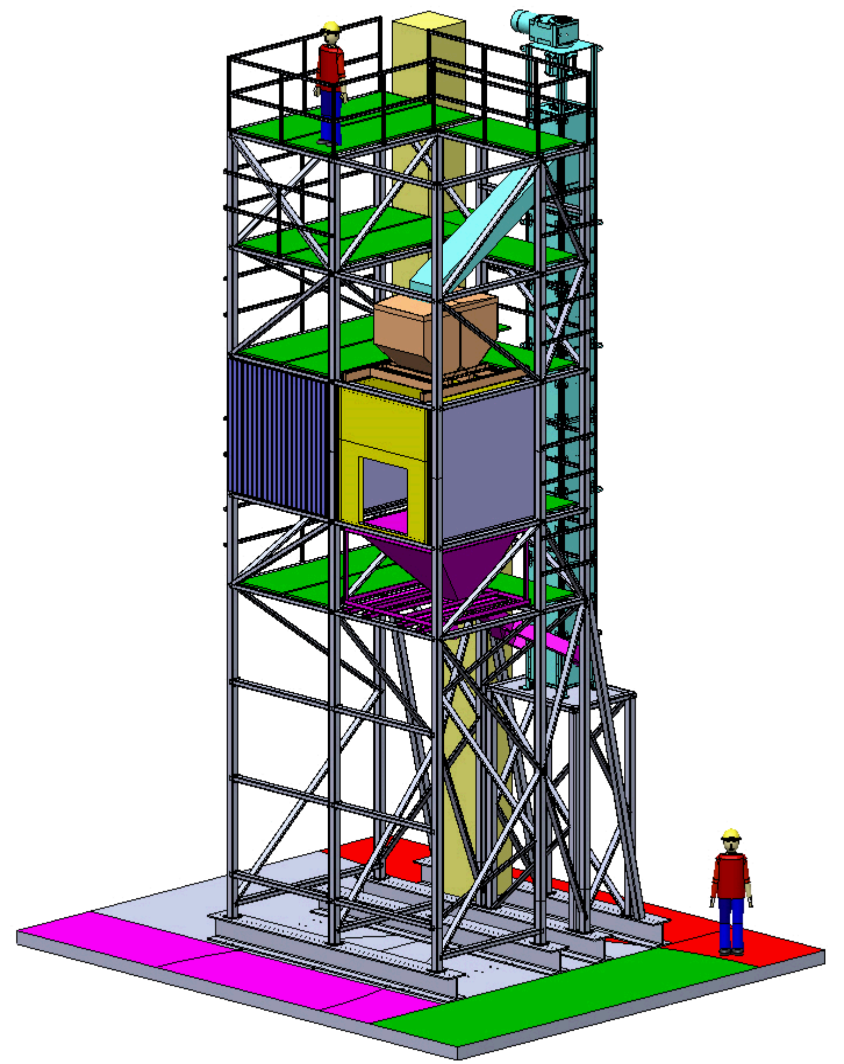
Introduction

- Solid Particle Receiver
  - Uses 280 μm ceramic particles as heat transfer fluid (HTF)

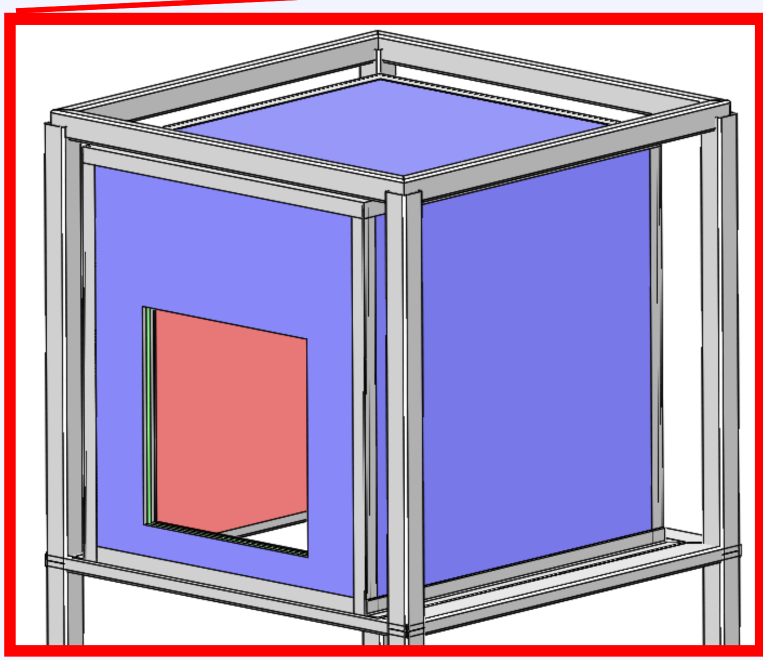
- Main Components
  - Particle elevator
  - Top Hopper
  - Receiver
  - Bottom Hopper

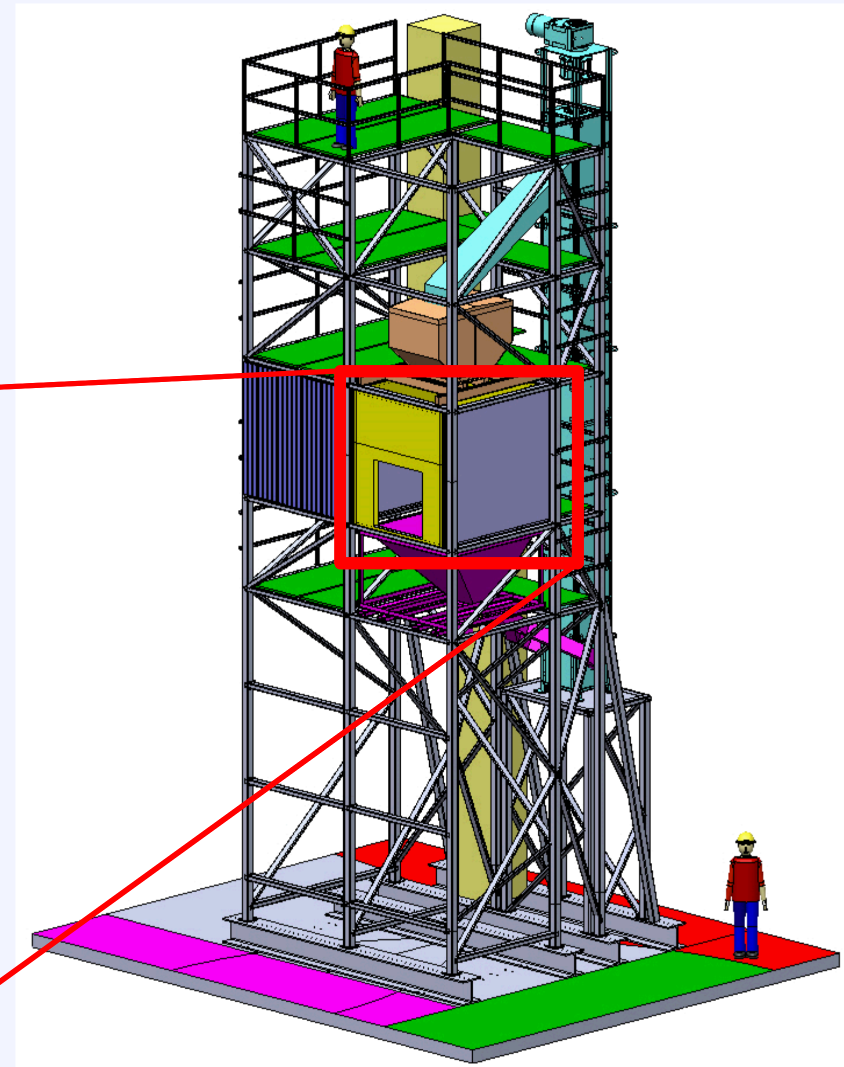
- Additional Features
  - Beam characterization panel (BCS)
  - Work platforms
  - Spillage protection boards



Introduction

- Receiver
    - Needs to withstand high fluxes
    - Needs to withstand high temperatures
    - Needs to be thermally efficient
    - Needs to withstand particle wear





Presentation Overview

- Objectives
- Approach
- Results
- Conclusion

Objectives

- Design a solid particle receiver
  - 1 MW incident power
  - 1200°C wall temperatures
  - Particle wear

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Approach

- Perform CFD
- Analyze analytical heat transfer across insulation materials
- Design a suitable experimental cavity

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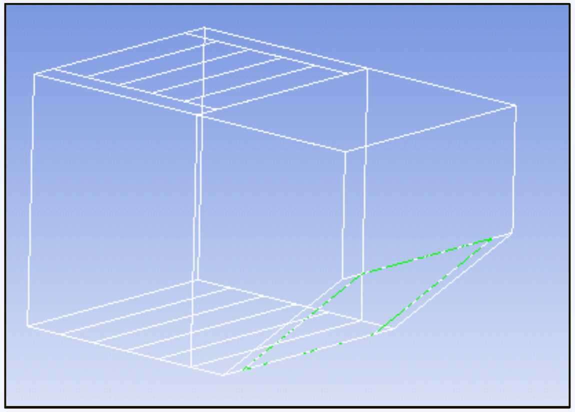
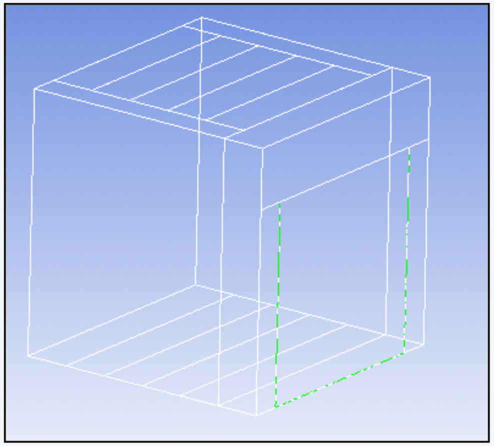
CFD Simulations

- FLUENT
- Relevant Models
  - Flow and Turbulence
  - Discrete Ordinates radiation modeling
    - 8x8 division and 3x3 pixel discretization
    - Two-Band model (Solar and Thermal)
    - Beam width representative of NSTTF heliostats
  - Discrete Phase Model
    - Particles interact directly with radiation

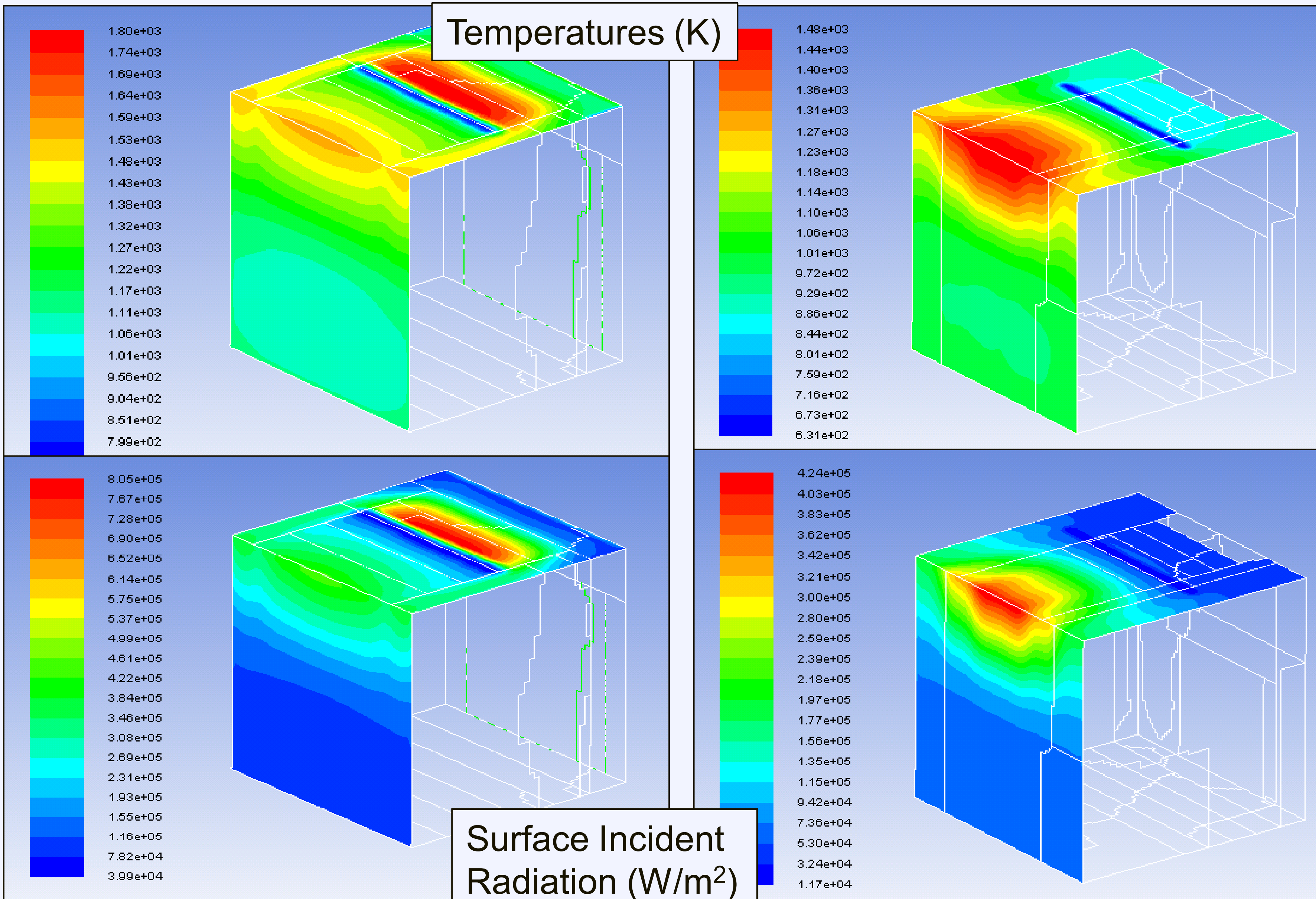




CFD Simulations – Nod Angle Analysis

Study	Thermal Efficiency	Radiative heat loss as percentage of total incident power	Convective heat loss as percentage of total incident power	Particle Outlet temperature (°C)	Peak Wall Temperature (°C)
0°	80.2%	12.1%	7.7%	624	1396
38°	76.6%	16.9%	6.5%	612	1376
50°	79.2%	17.0%	3.7%	621	1369

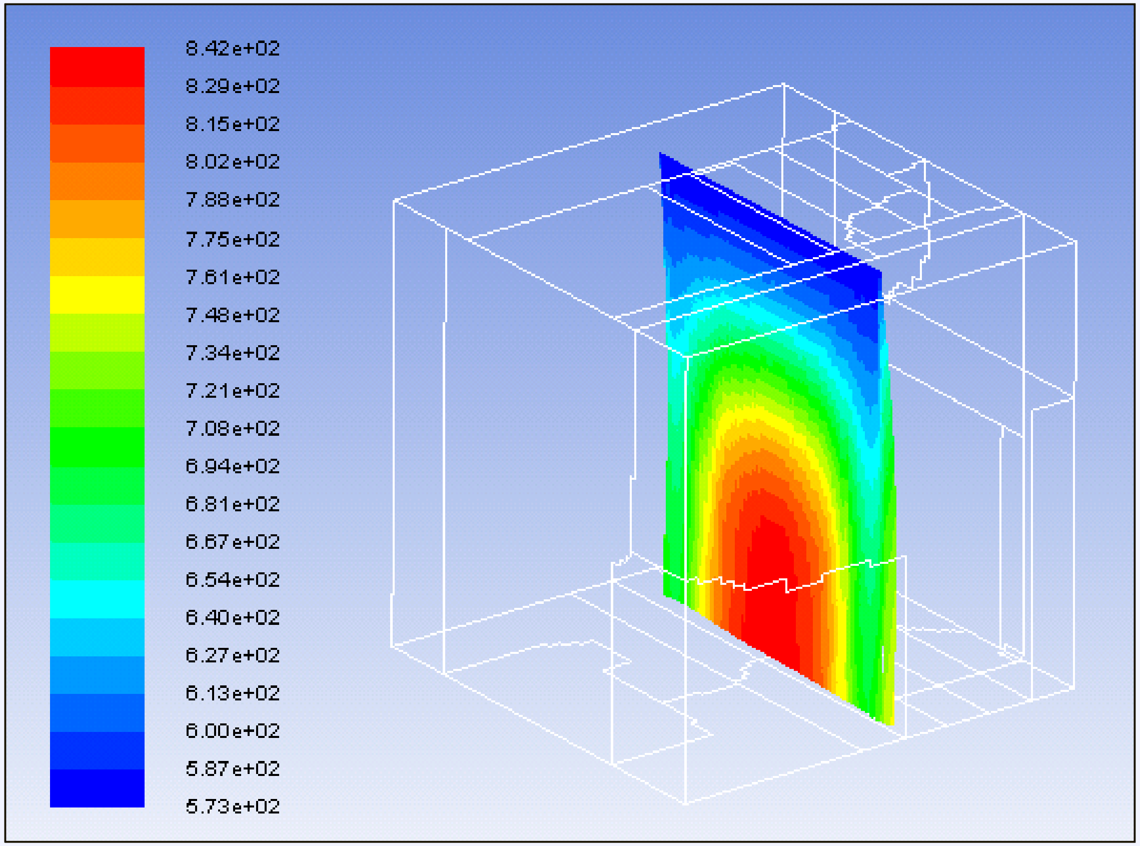
CFD Simulations – Cavity Size



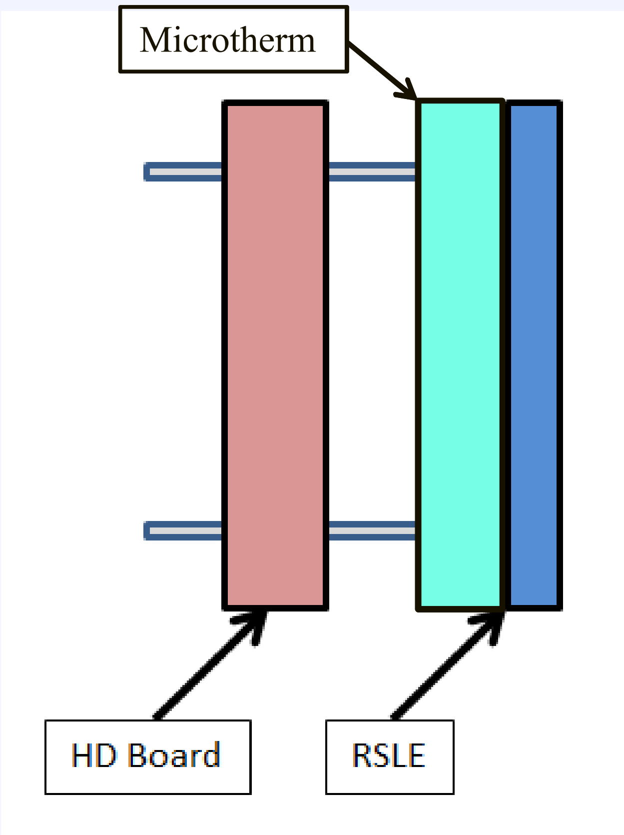
CFD Simulations – Nod Angle Analysis

Study	Thermal Efficiency	Radiative heat loss as percentage of total incident power	Convective heat loss as percentage of total incident power	Particle temperature rise (°C)	Peak Wall Temperature (°C)
1.3 m cavity, 2.5 kg/s/m, front drop	80.2%	12.1%	7.7%	324	1396
2 m cavity, 1.7 kg/s/m, front drop	87.2%	9.67%	3.11%	250	1433
2 m cavity, 2.7 kg/s/m. front drop	93.6%	4.75%	1.69%	161	1185
2 m cavity, 1.7 kg/s/m, back drop	88.3%	4.84%	6.85%	252	1340
2 m cavity, 2.7 kg/s/m, back drop	93.3%	3.26%	3.45%	158	1197

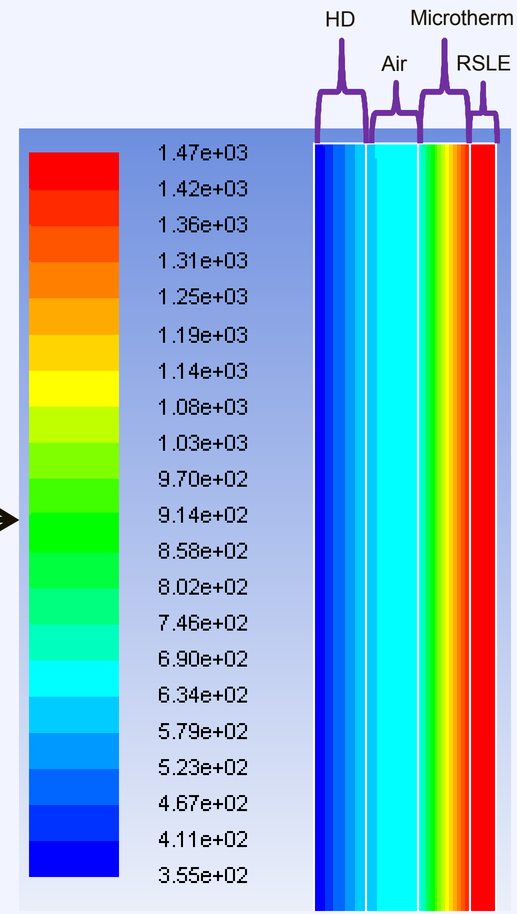
CFD Simulations – Particle Curtain



Experimental Design



Fluent
Analysis



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Conclusions

- No nod angle
- Wall temperatures will be limited to 1200°C
- A larger cavity size of 2 m x 2 m x 2 m will be used
- Receiver walls composed of sandwiched insulation design: RSLE > Microtherm > Air > HD