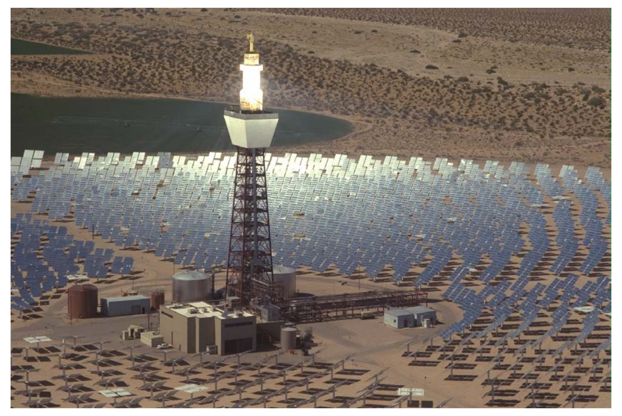
High-Temperature Receivers and Selective Absorber Coatings

Sandia National Laboratories

Clifford K. Ho, (505) 844-2384, ckho@sandia.gov

Problem Statement

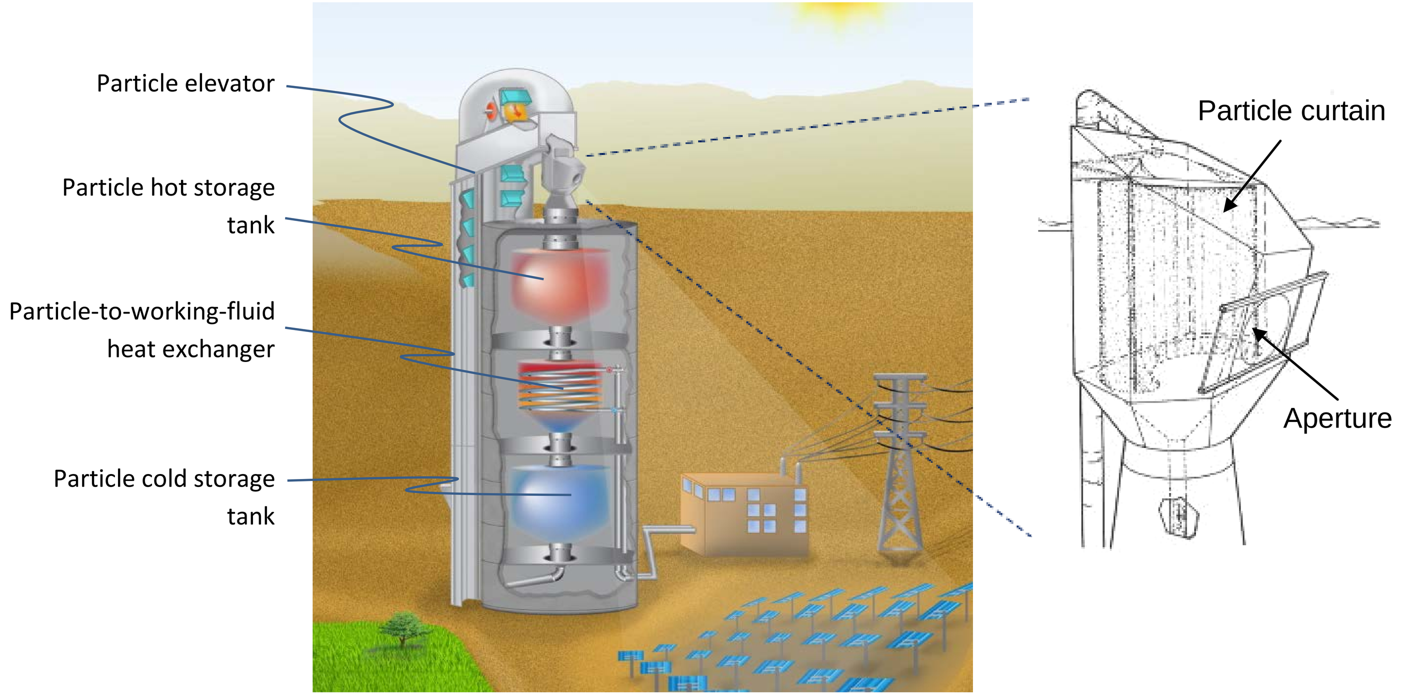
- To achieve the SunShot goal of \$0.06/kWh, high-efficiency, high-temperature receivers and power cycles are being sought for central receiver systems (T > 650 °C)
- Radiative and convective losses can significantly reduce receiver thermal efficiency at these higher temperatures
- Need to minimize heat losses from central receivers while maximizing solar absorptance



Solar Two molten-salt central receiver, Daggett, CA

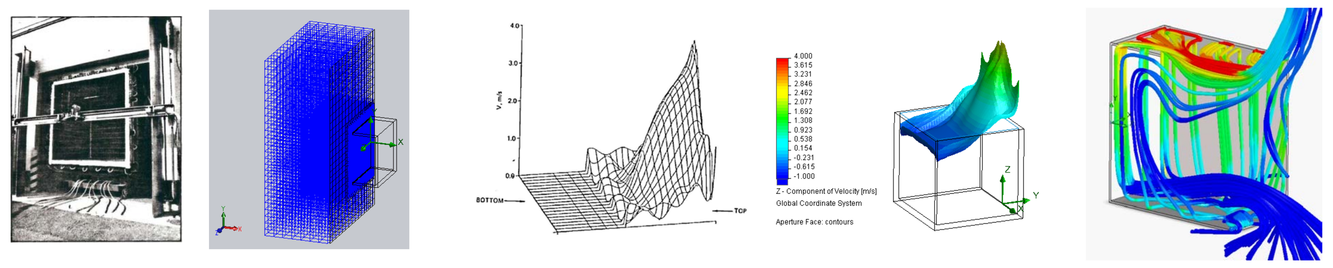
Objectives and Approach

- Develop stable and durable selective absorber coatings that maximize solar absorptance while minimizing thermal emittance at high temperatures in air
- Develop and validate computational fluid dynamics models of irradiance and heat loss in central receivers
- Use validated models to design and develop high-temperature, high-efficiency central receivers that meet SunShot goals

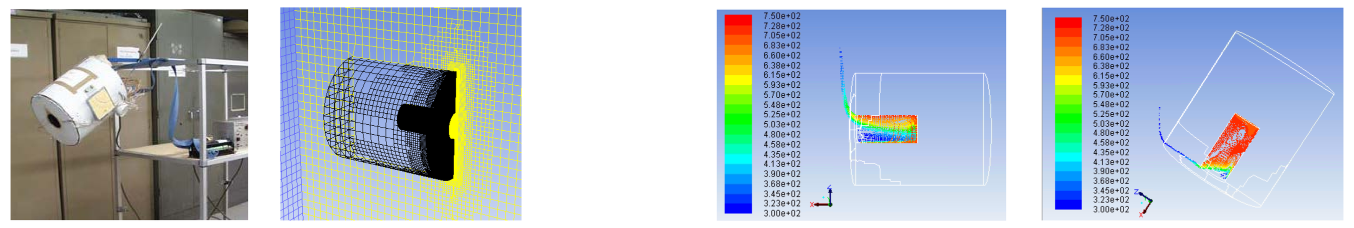


Concept for high-temperature central receiver system using solid particles as the heat-transfer and storage media

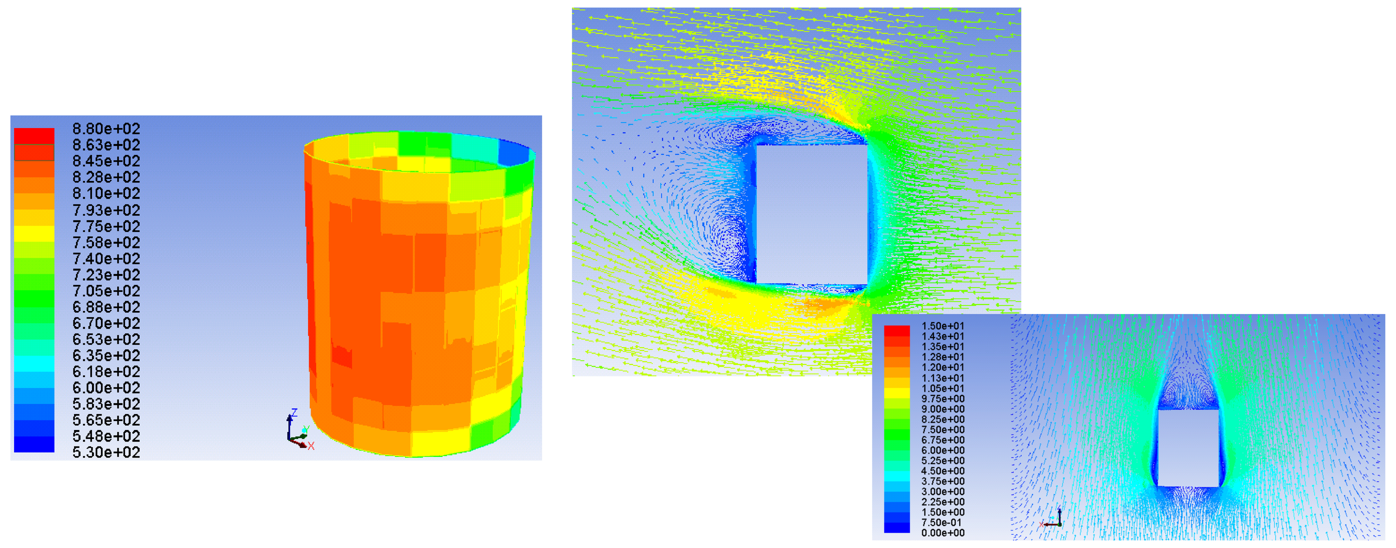
Model Development and Validation



Computational fluid dynamics modeling of cubical cavity tests conducted at Sandia (Yuan et al., 2012)

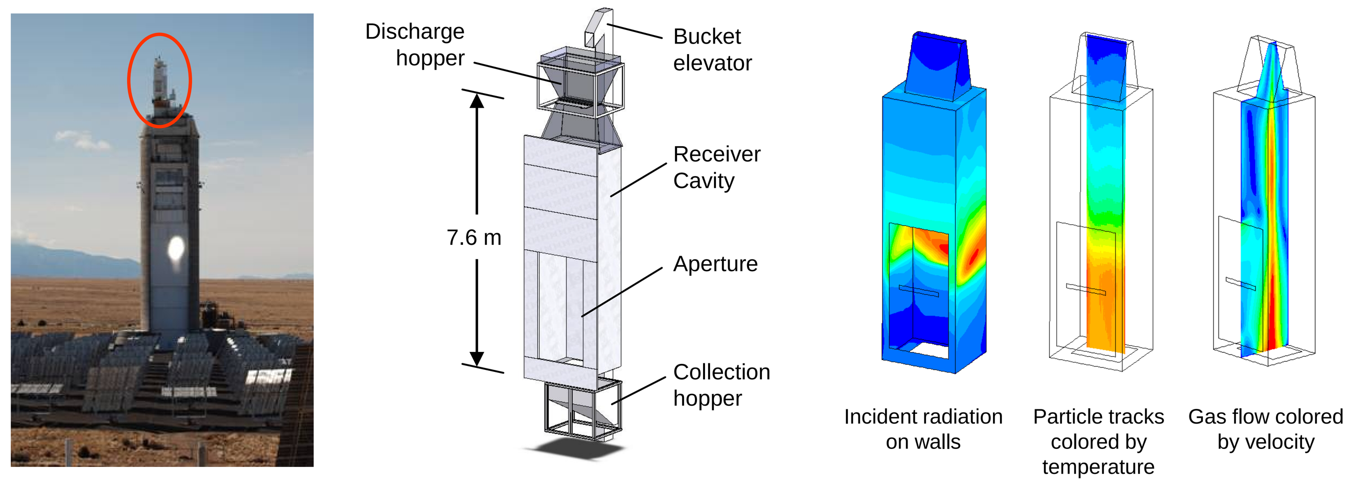


Computational fluid dynamics modeling of cylindrical cavity tests (Taumoefolau and Lovegrove, 2004) with investigation of different orientations, turbulence models, and correlations (Yuan et al., 2012)



Computational fluid dynamics modeling of the Solar Two receiver with consideration of different wind velocities and heat flux distributions on surface temperatures and heat loss (Christian and Ho, 2012)

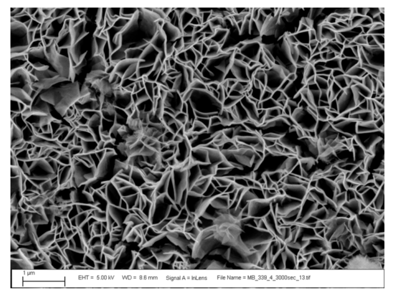
Novel Receiver Design and Testing



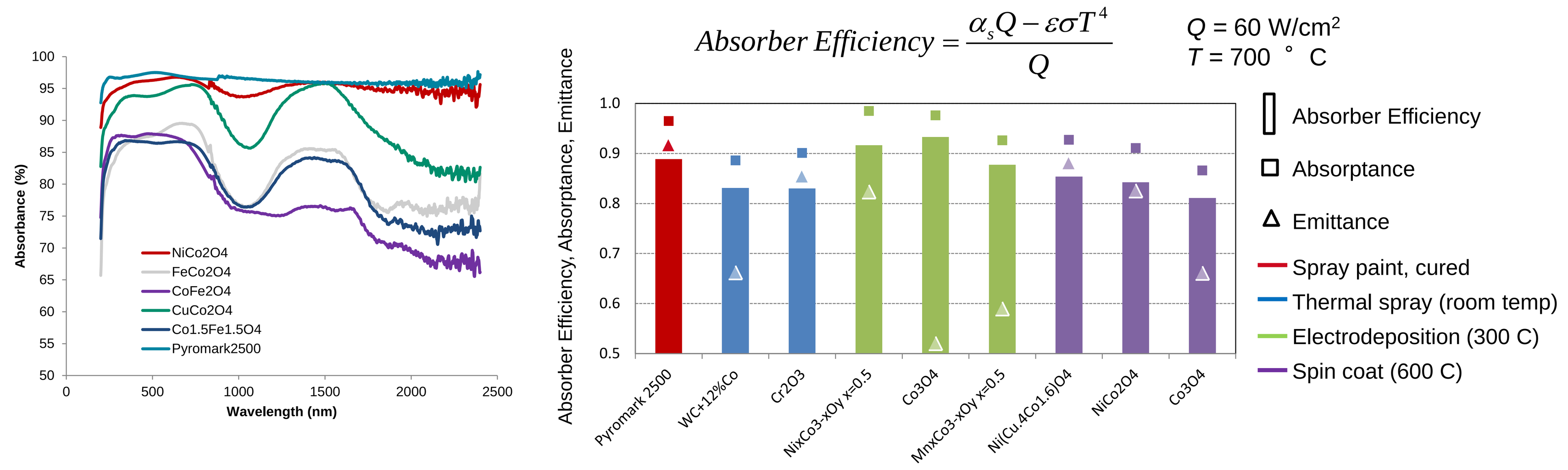
Testing and modeling of a prototype solid particle receiver at the National Solar Thermal Test Facility at Sandia National Laboratories, Albuquerque, NM. The modeling (right) considered irradiation from the heliostat field, reradiation, discrete (particle) flow, and convection with turbulent particle interaction.

Selective Absorber Coatings

- Evaluating spinel oxide materials that are stable in air at high temperatures and amenable to doping and substitution to tailor optical properties
- Developing methods for large-scale in-situ application



Scanning electron micrograph of the surface of Co_3O_4 on SS304L substrate (electrodeposition/thermal annealing)



Spectral absorptance (left) and selective absorber efficiency (right) of several candidate materials

Participants

Clifford Ho (Lead), Andrea Ambrosini, Aaron Hall, Tim Lambert, Jim Pacheco, James Yuan, Joshua Christian, Cianan Sims, Rod Mahoney, Marlene Bencomo, Brian Iverson, Greg Kolb, Nathan Siegel, Daniel Ray, J.J. Kelton, Cheryl Ghanbari, Tim Moss, Kye Chisman

References

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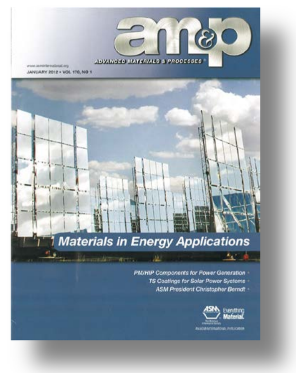

SunShot U.S. Department of Energy

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