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High Temperature Falling Particle Receiver

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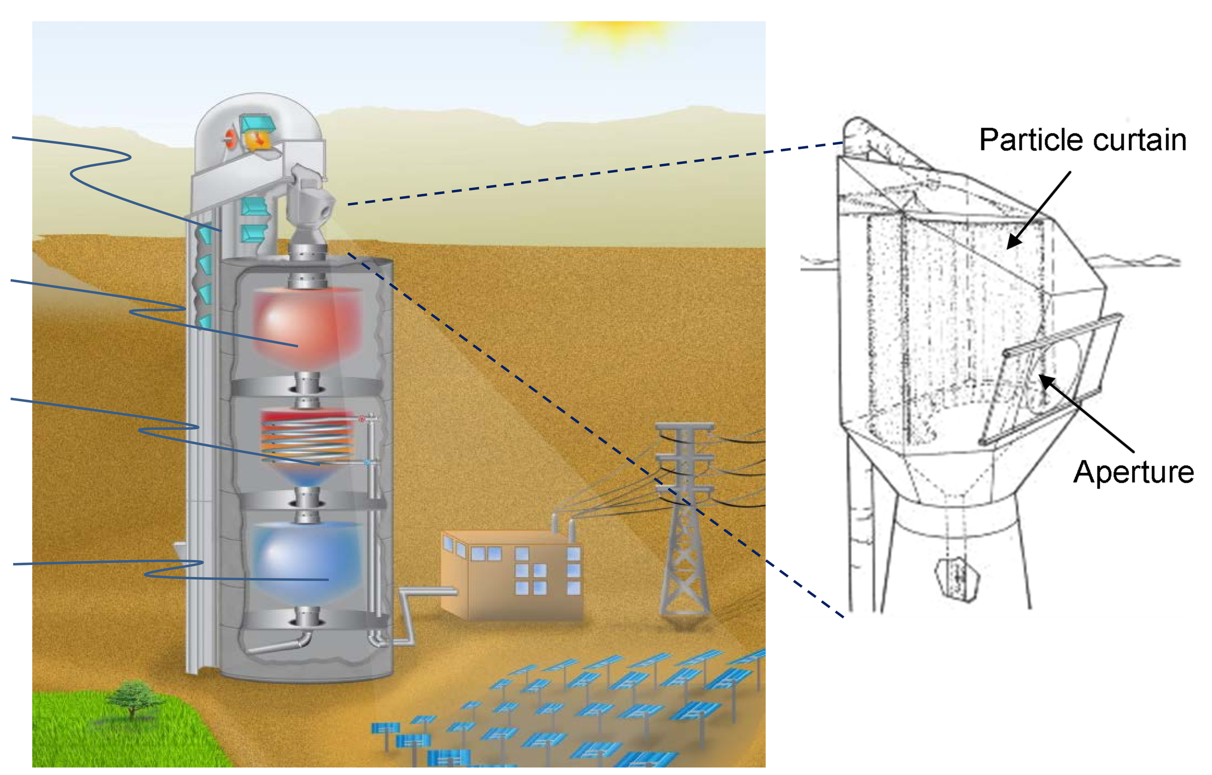
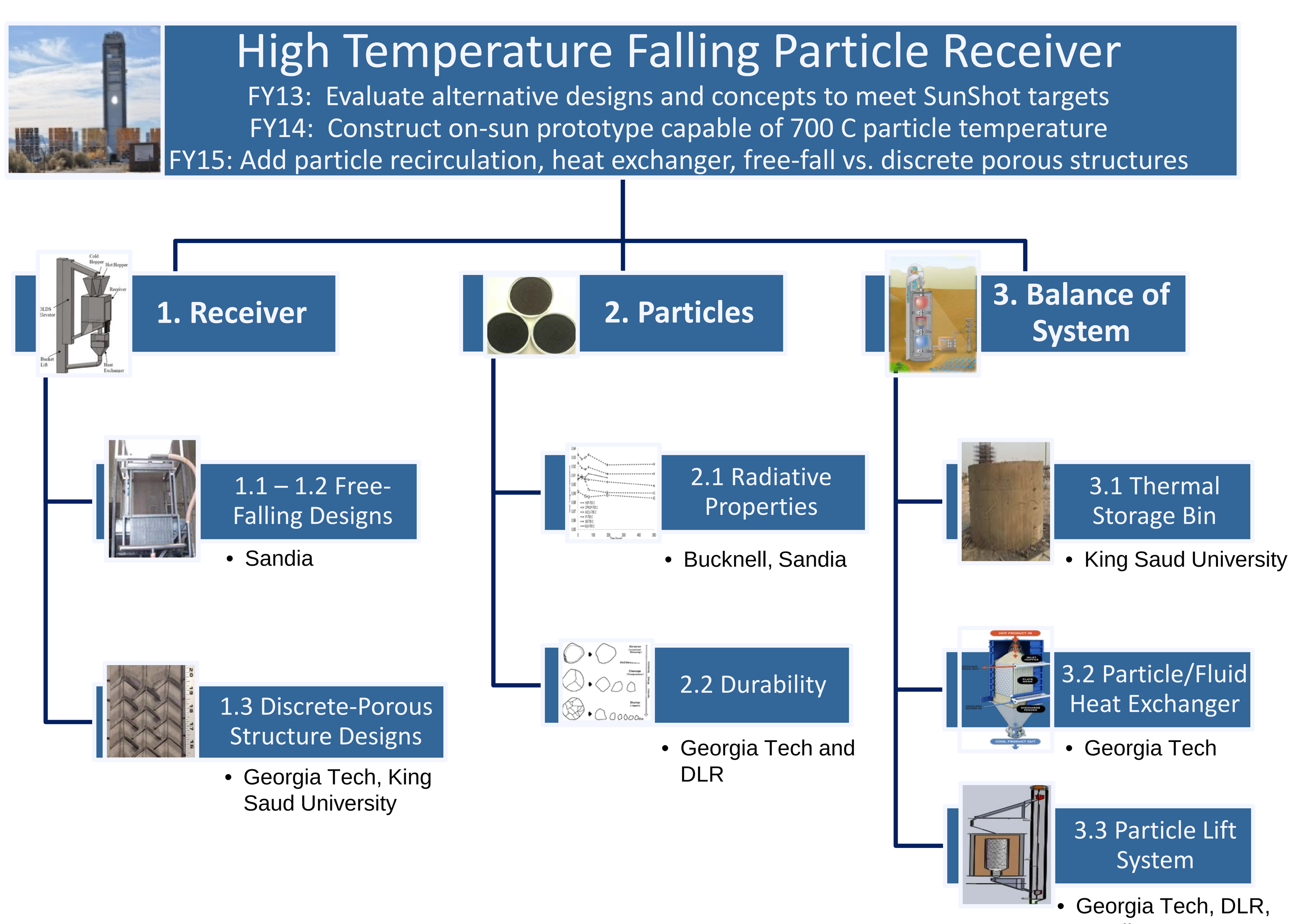
PROBLEM STATEMENT & VALUE PROPOSITION

- Conventional nitrate-salt receivers limited to ~600°C
- Tubular receivers have flux limitations / thermal stresses
- Need higher temperatures to enable more efficient power cycles and cheaper storage
- Direct absorption using solid particles can achieve temperatures above 1000°C
- System is scalable and can achieve SunShot targets



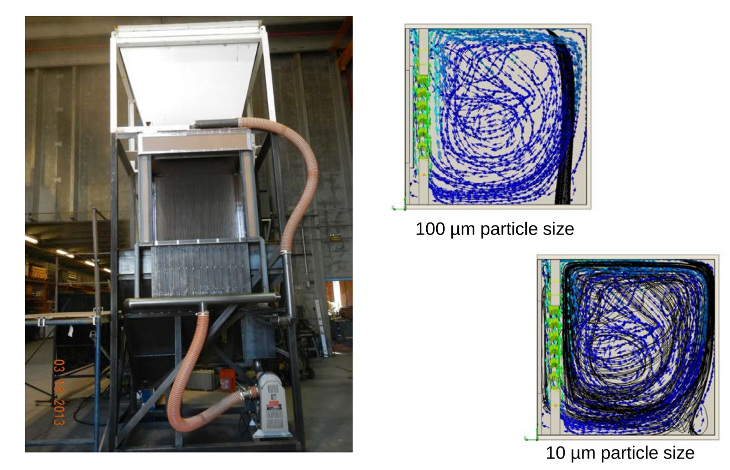
OBJECTIVES & APPROACH



RESULTS

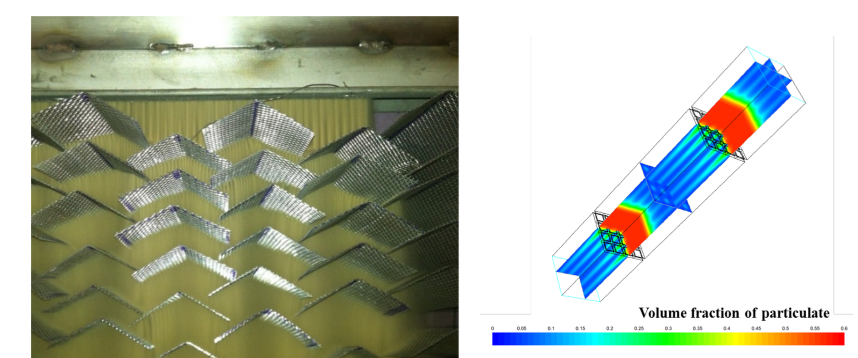
1. Receiver Designs

Free-Falling



- Modeled and tested free-falling particle designs with air curtains
- Modeled thermal performance with CFD
- Identified optimal particle size, flow rates, and recirculation schemes to achieve 700°C

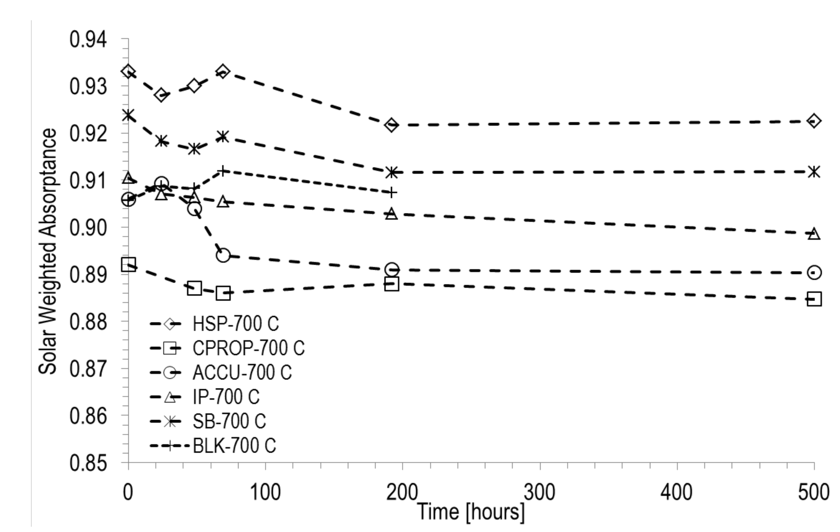
Discrete Porous Structures



patent pending

- Modeled and tested discrete porous structures to increase residence time of particles in beam
- Demonstrated required flow rates with no clogging
- Tested durability of wire mesh over thousands of cycles at 800°C

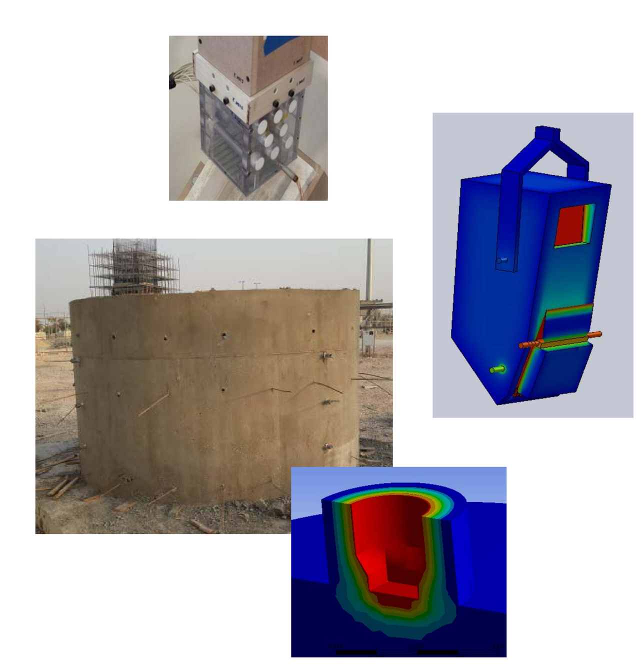
2. Particles



- Identified 5 commercial particles with solar absorptance > 85% after 500 hours at 700°C in air
- Evaluated chemical reduction and different particle compositions to improve solar absorptance at high temperatures
- Demonstrated particle durability up to 1000°C

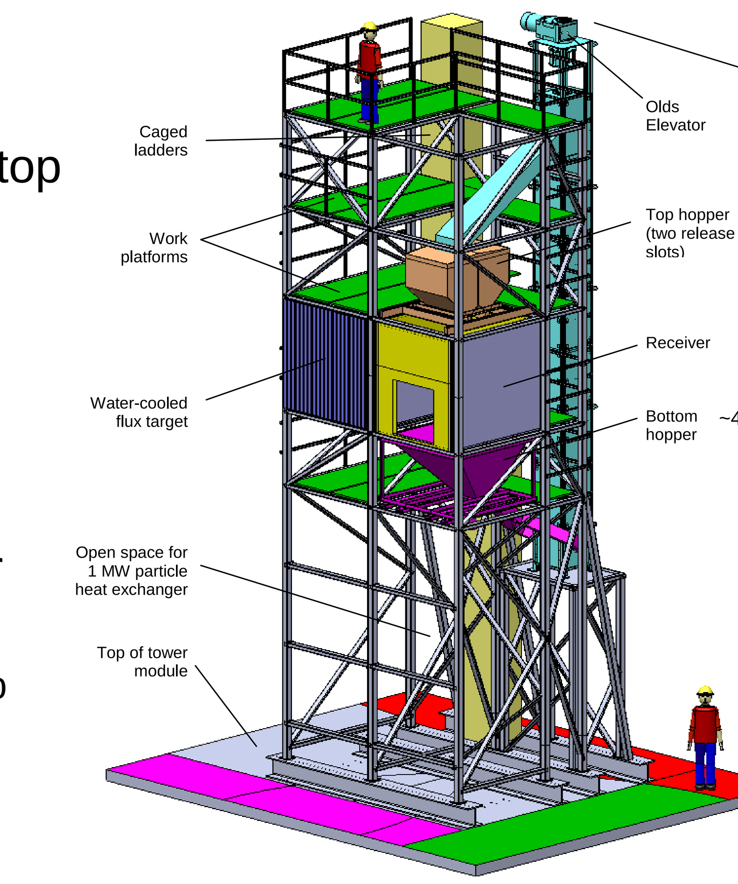
3. Balance of System

- Designed, modeled, and tested hot storage bin designs up to 700°C
- Evaluated particle-to-fluid heat exchangers and demonstrated ~100 W/m^2-K
- Modeled several commercial-scale particle-lift designs to carry particles from bottom of tower to top of receiver



On-Sun Testing

- Designed on-sun prototype system with top hopper, receiver, bottom hopper, Olds Elevator, flux target, work platforms, instrumentation, and data acquisition
- Achieved peak particle temperatures >900 °C and bulk particle temperatures >700 °C for mass flow of 1 – 7 kg/s/m
- Achieved particle heating of ~200 °C per meter of illuminated drop distance
- Achieved thermal efficiencies ~70 – 80%
- Obstructed flow design reduced terminal velocity to 0.5 m/s and provided higher heating rates, but deterioration occurred



PATH TO MARKET

- Collaborated with Abengoa Solar on design of 1 MW falling particle receiver system in Spain
- Received DOE APOLLO award with Abengoa Solar on high-temperature falling particle receiver for combined air-Brayton cycle
- Working with DOE ELEMENTS program to develop reactive particle receivers with thermochemical storage
- Developing concepts and designs for solarized supercritical CO_2 Brayton cycles

FUNDING & KEY INSTITUTIONS

- FY13 – FY16: $4.5M (DOE)
- Sandia National Laboratories
- Georgia Institute of Technology
- Bucknell University
- King Saud University
- German Aerospace Center (DLR)

SunShot U.S. Department of Energy

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