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High-Temperature Particle Heat Exchanger for sCO2 Power Cycles

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SuNLaMP 1507

FUNDING PROGRAM: SuNLaMP

PROJECT OVERVIEW

- PI: Cliff Ho, Sandia National Laboratories
- Partners: Solex Thermal Science, Vacuum Process Engineering, Babcock & Wilcox, Georgia Institute of Technology, National Renewable Energy Laboratory
- DOE Funding: $4.6M (3 years)

SUMMARY STATEMENT

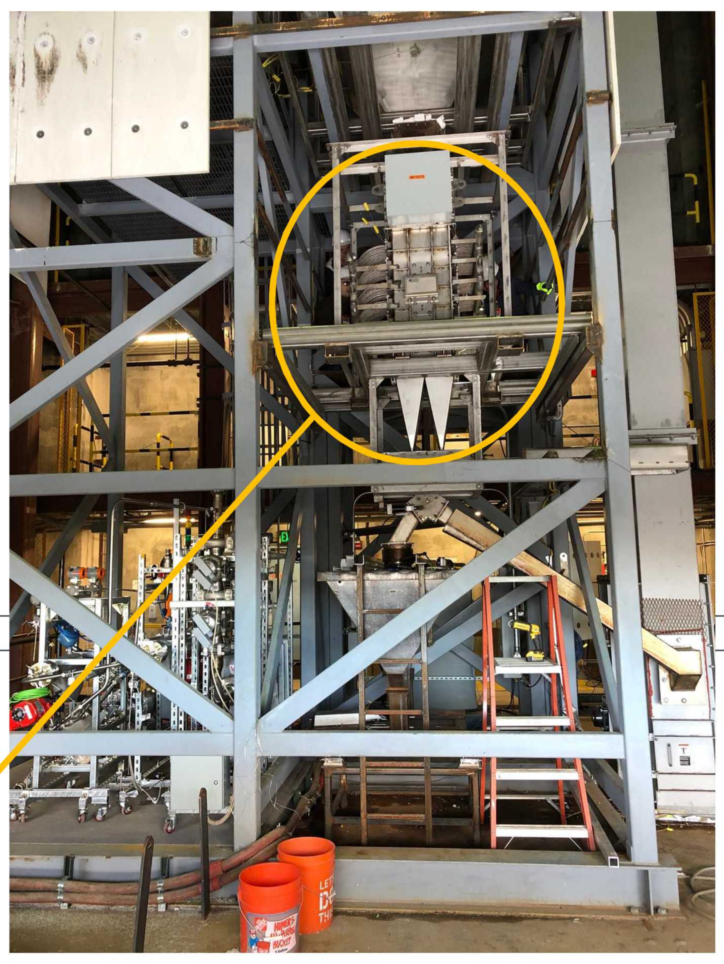
- **Problem statement:** Particle receiver technologies are being developed to achieve higher temperatures, but a particle-to-sCO_2 heat exchanger does not exist
- **Resulting solution:** Design, develop, and test a particle/sCO2 heat exchanger operating at sCO_2 temperatures of ≥700 °C and pressures ≥20 MPa that will enable high-efficiency sCO_2 power cycles
- **Critical capability:** Sandia has the nation's only solar tower test facility, falling-particle receiver test loop, and $sCO2_2$ loop design capability that can be used to test the particle-to-sCO_2 heat exchanger

KEY ACTIVITIES

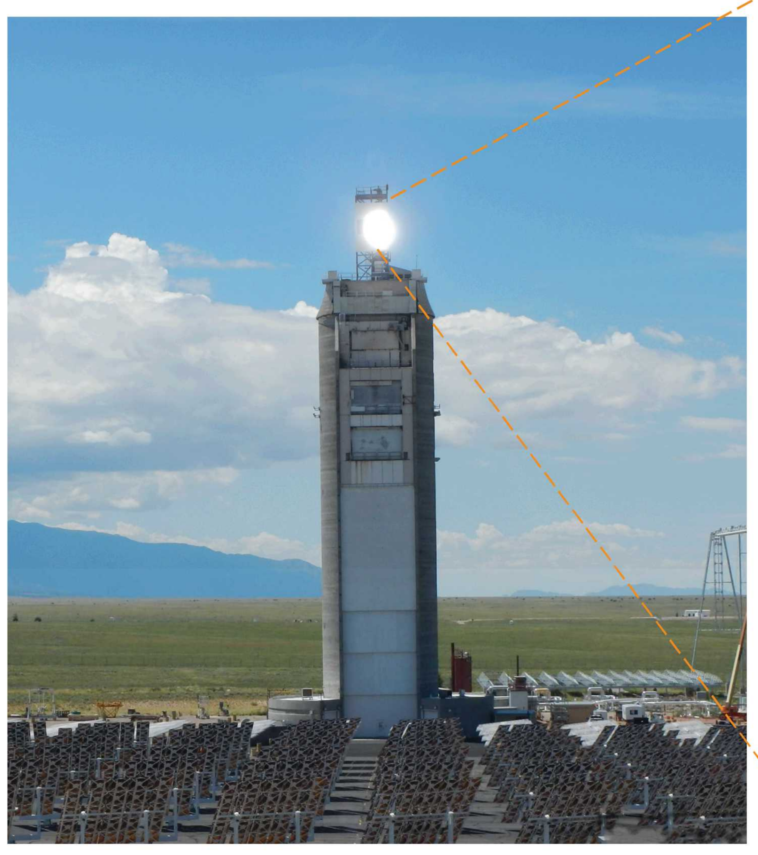
- ❑ Phase 1
  - Work with industry to design fluidized-bed and moving packed-bed particle/sCO2 heat exchanger designs
  - Use analytical hierarchy process to downselect design
- ❑ Phase 2
  - Procure heat exchanger and sCO2 flow system and commission subsystem components
  - Develop models and tests to examine heat transfer and flowability
- ❑ Phase 3
  - Integrate heat exchanger and sCO2 flow system with particle receiver and perform on-sun tests

KEY OUTCOMES AND IMPACT

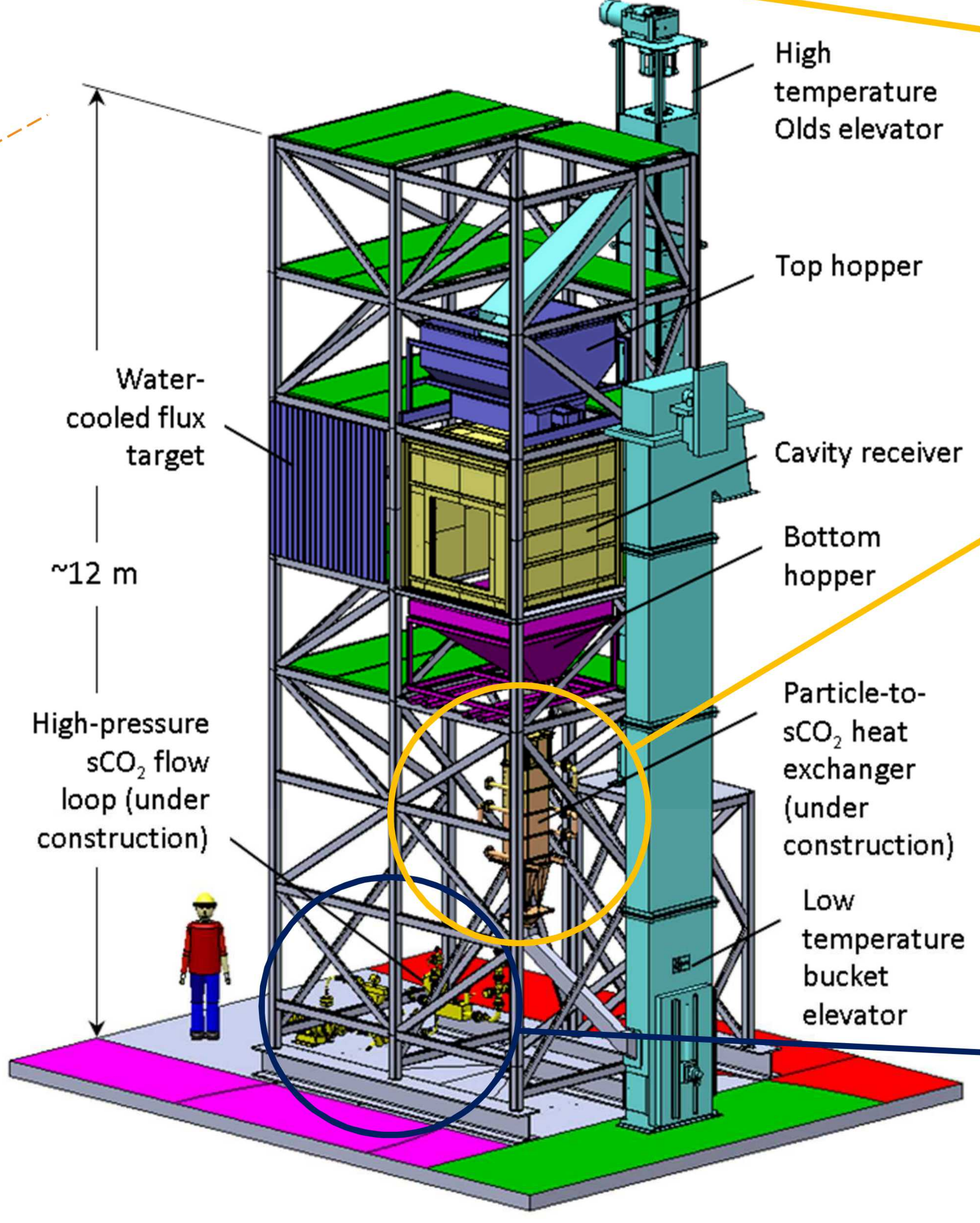
- ➢ Teamed with industry to design fluidized and moving-packed-bed particle/sCO2 heat exchangers
- ➢ Measured particle/wall heat transfer coefficient at ~200 W/m^2-K for shell-and-plate design
- ➢ Performed particle flowability tests at 600 °C
- ➢ Designed 100 kW$_t$ sCO2 flow system for integration with heat exchanger
- ➢ **Impact**: Demonstration of first solarized heating of sCO_2 using particles in 2019



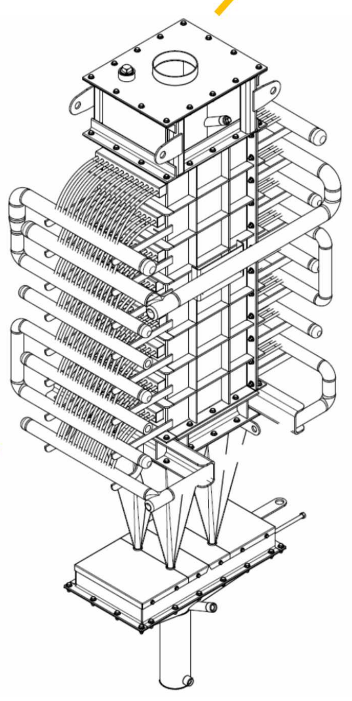
Integrated Falling Particle Receiver/Heat Exchanger/sCO2 loop



Particle receiver testing at the National Solar Thermal Test Facility at Sandia National Laboratories, Albuquerque, NM

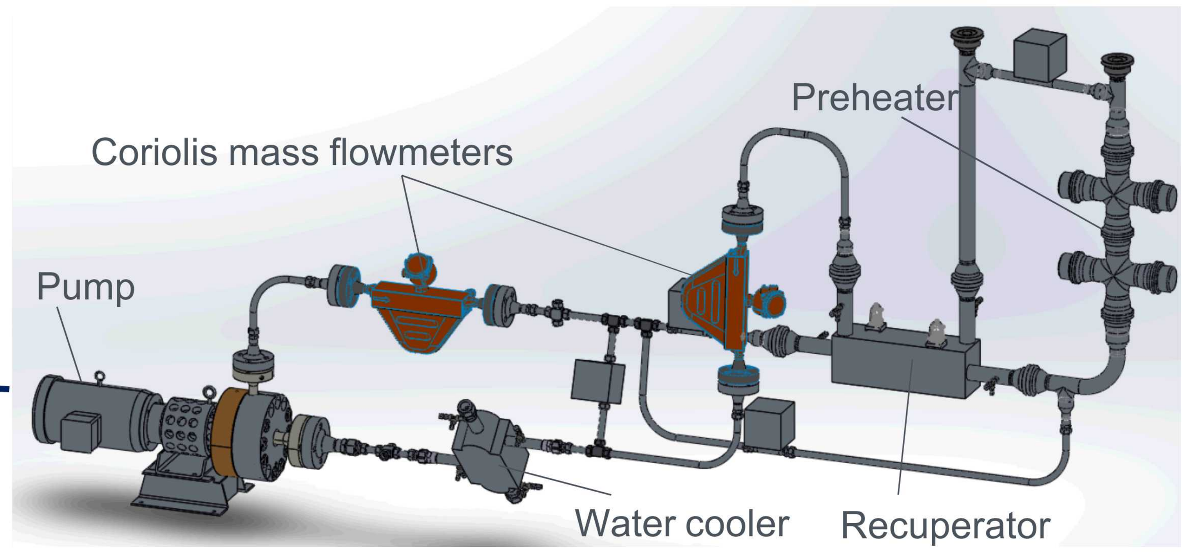


High-Temperature Particle Receiver



Solex/VPE/Sandia particle/sCO2 shell-and-plate heat exchanger

- Heat duty = 100 kW
- $T_{particle,in}$ = 775 °C
- $T_{particle,out}$ = 570 °C
- $T_{sCO2,in}$ = 550 °C
- $T_{sCO2,out}$ = 700 °C
- $\dot{m}$ = 0.5 kg/s



sCO_2 flow system provides pressurized sCO_2 at 550 °C to heat exchanger for test and evaluation

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