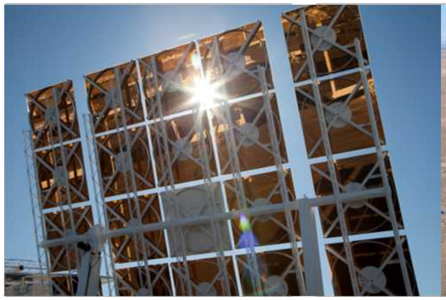
SAND2016-2950PE

Exceptional service
in the national interest

Sandia National Laboratories

Overview of Concentrating Solar Power Research at Sandia



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SAND2016-XXXX

U.S. DEPARTMENT OF ENERGY

NNSA National Nuclear Security Administration

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Outline

- **Sandia CSP Research**
- **Integration of FOCUS and CSP**
- **Doing work with Sandia**

Timeline of CSP Development

Sandia National Laboratories

Solar One and Solar Two
10 MW_e
Daggett, CA
1980's – 1990's

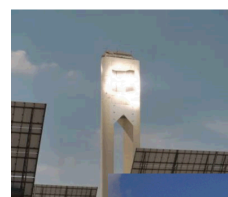
Stirling Energy Systems
1.5 MW_e, AZ, 2010

Ivanpah, steam, 377 MW_e, CA, 2014

1970's → 1980's – 1990's → 2000's → SunShot 2011 -

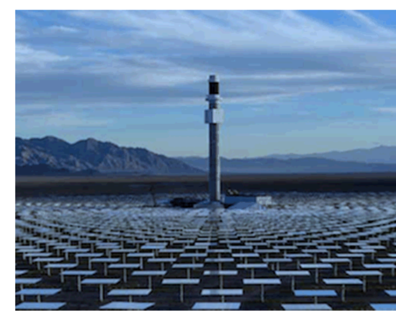
National Solar Thermal Test Facility
6 MW_t, Albuquerque, NM, Est. 1976

SEGS, 1980's
9 trough plants
354 Mw_e, CA



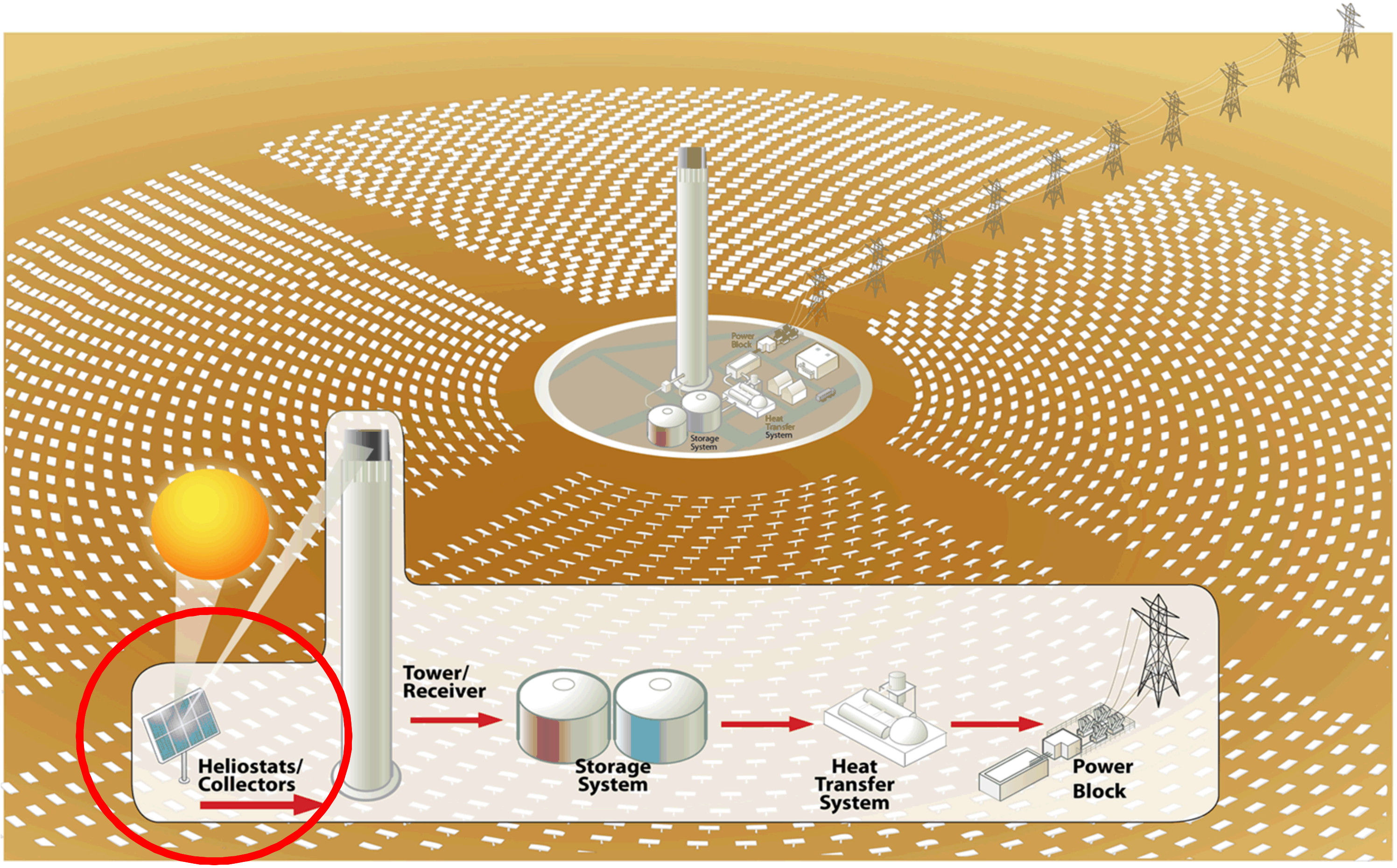
PS10/20, steam, Spain, 2007-2009

Gemasolar, molten salt, 19 MW_e, Spain, 2011

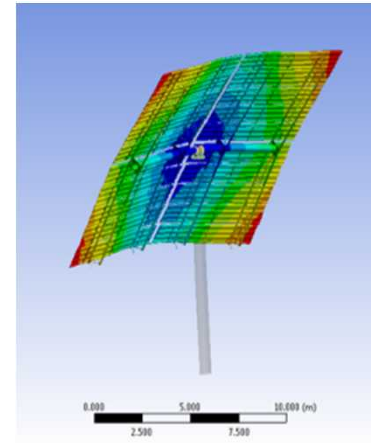


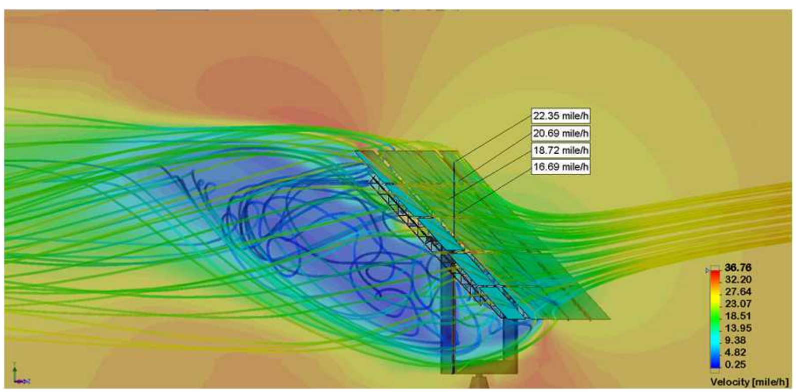
Crescent Dunes, molten salt, 110 MW_e, NV, 2016

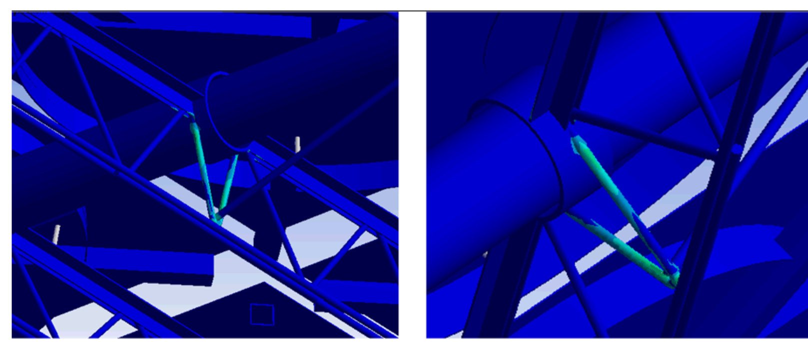
Sandia CSP Research



Optical Accuracy



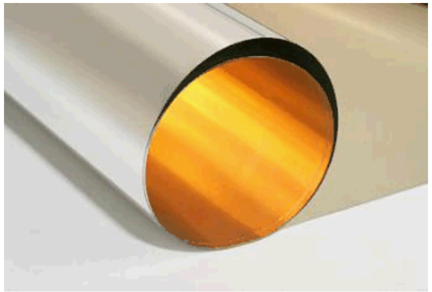




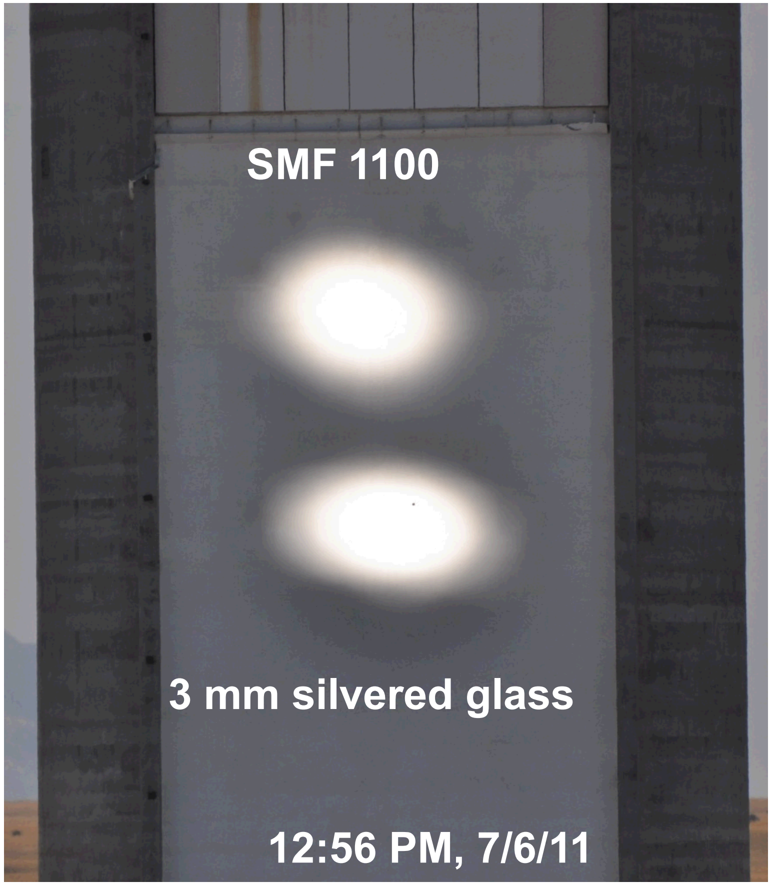
Truss Cross Members at Torque Tube

Mirror canting, tracking, gravity sag, and dynamic wind loads can affect optics and fatigue

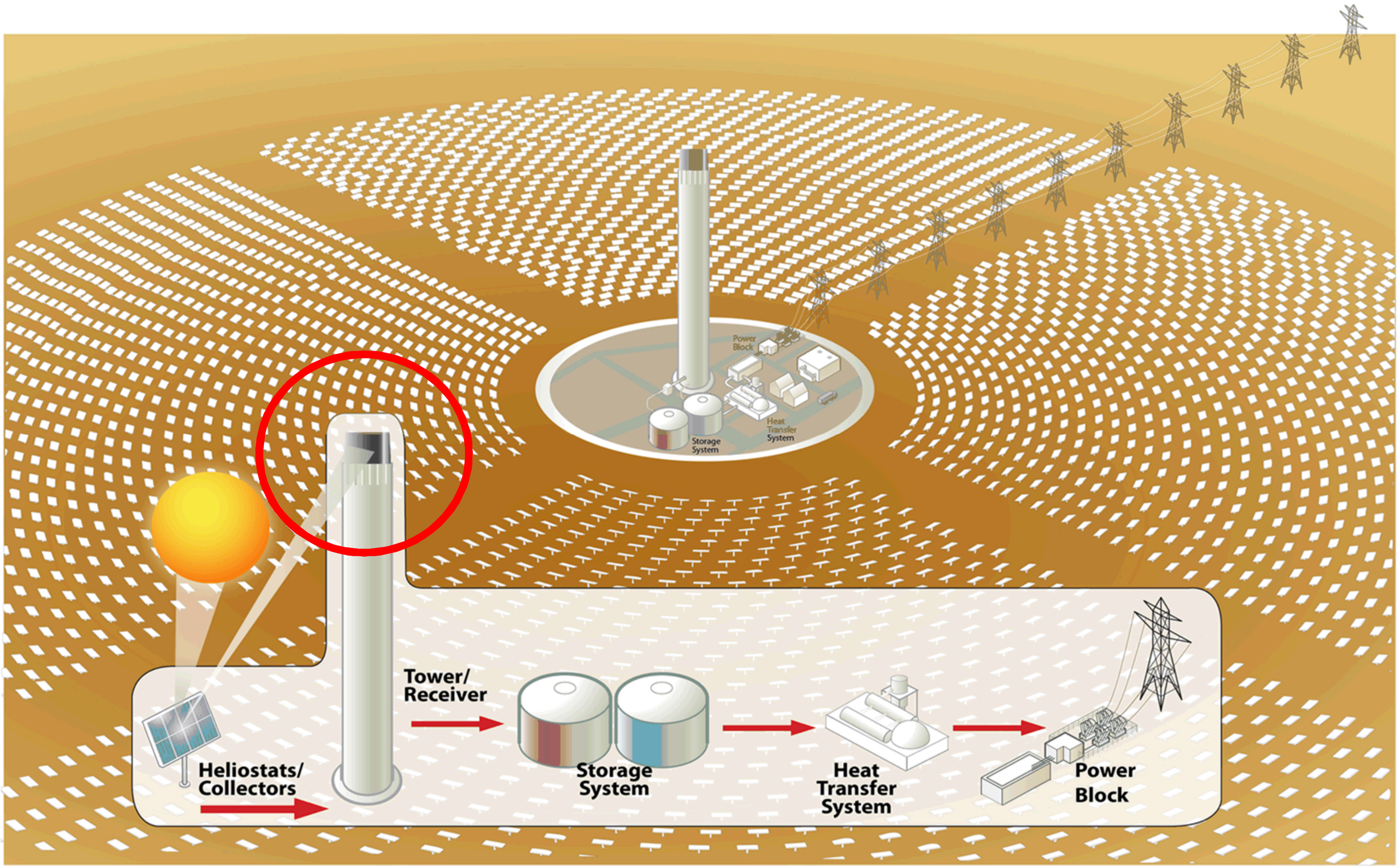
Advanced Reflective Materials



Heliostat with 3M™ Solar Mirror Film 1100

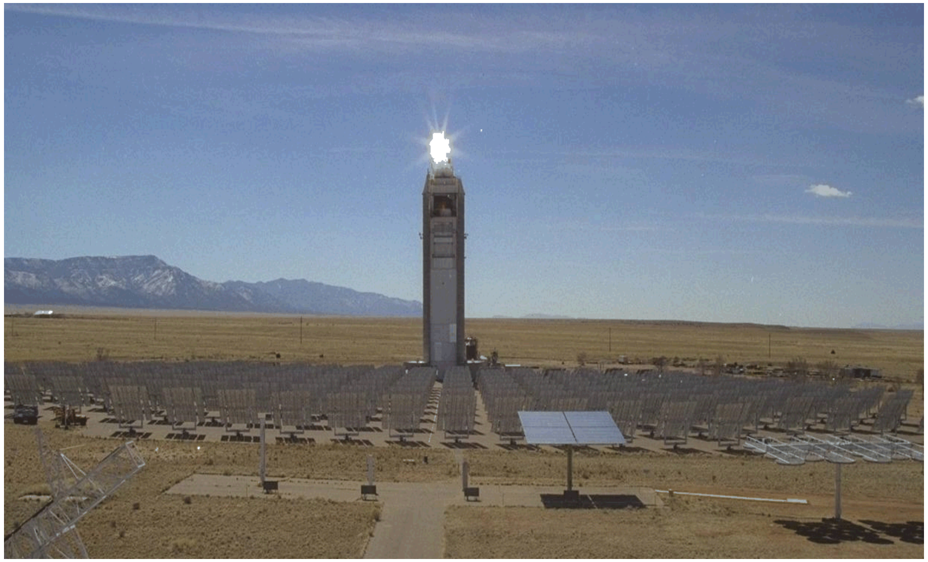


Receivers



Tower/
Receiver
Heliostats/
Collectors
Storage
System
Heat
Transfer
System
Power
Block

High-Temperature Receivers



National Solar Thermal Test Facility, Sandia National Laboratories, Albuquerque, NM

Cavity receiver

External tubular receiver

- Maximize solar absorptance and minimize heat loss (selective absorber coatings, geometry, concentration ratio)
- Need materials that operate at high temperature (>650 °C) and are durable in air

Fractal-Like Receiver Designs

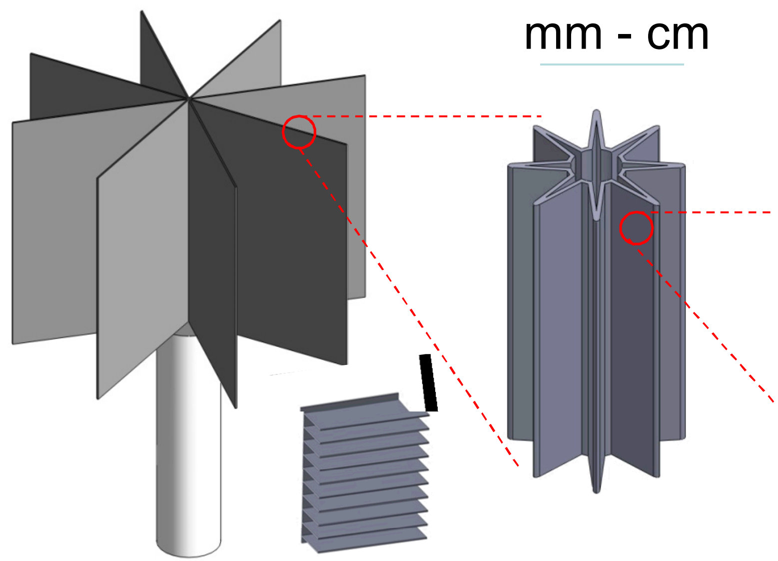
- Develop fractal-like designs and structures across multiple scales to increase solar absorptance while minimizing heat loss

~10 m

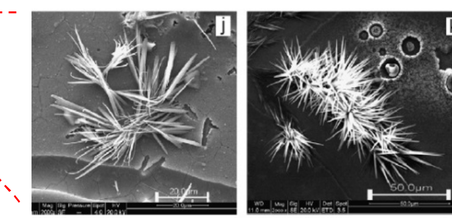
Conventional cylindrical solar receiver

meters

mm - cm



microns

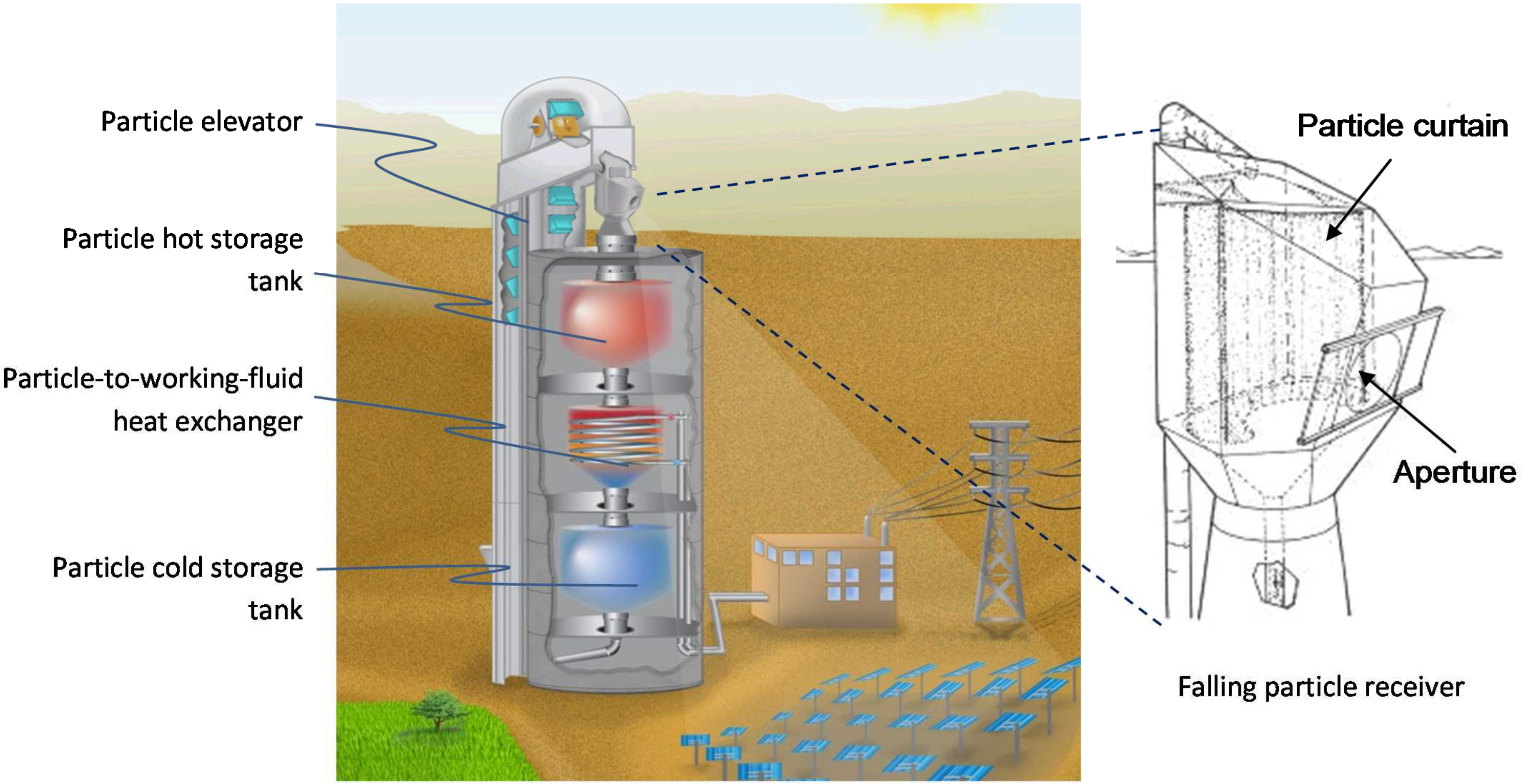


Sharma et al. (2009)

New fractal-like designs with light-trapping and low-emittance properties at multiple scales

Patents Pending

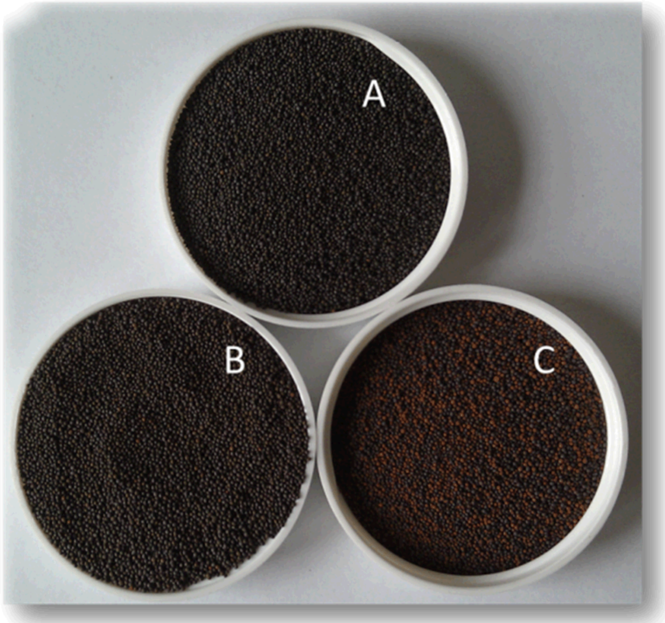
High Temperature Falling Particle Receiver (DOE SunShot Award FY13 – FY16)



Participants: Sandia, Georgia Tech, Bucknell U., King Saud Univ., DLR

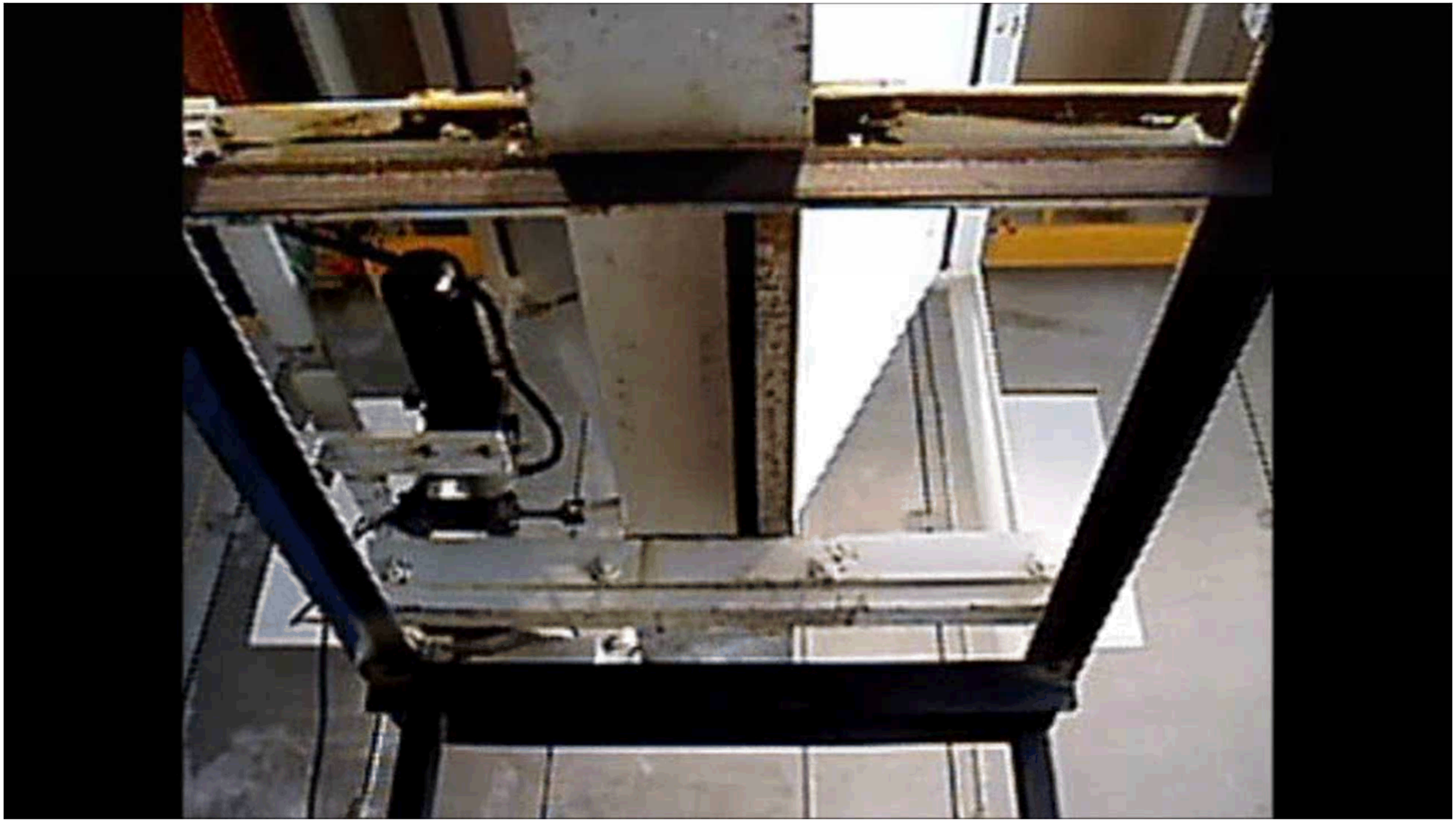
Advantages of Particle Receivers

- Direct heating of particles
  - Higher temperatures than conventional molten salts
    - Enable more efficient power cycles (e.g., sCO2 at ~700 C)
  - Higher solar fluxes for increased receiver efficiency
- Direct storage of hot particles
  - Reduced costs

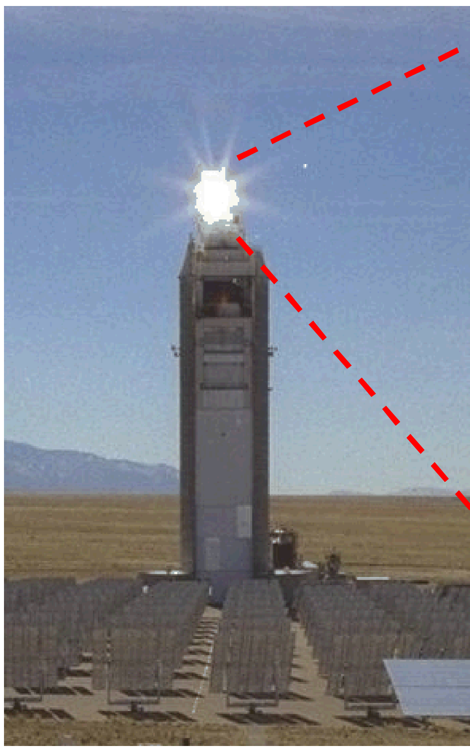


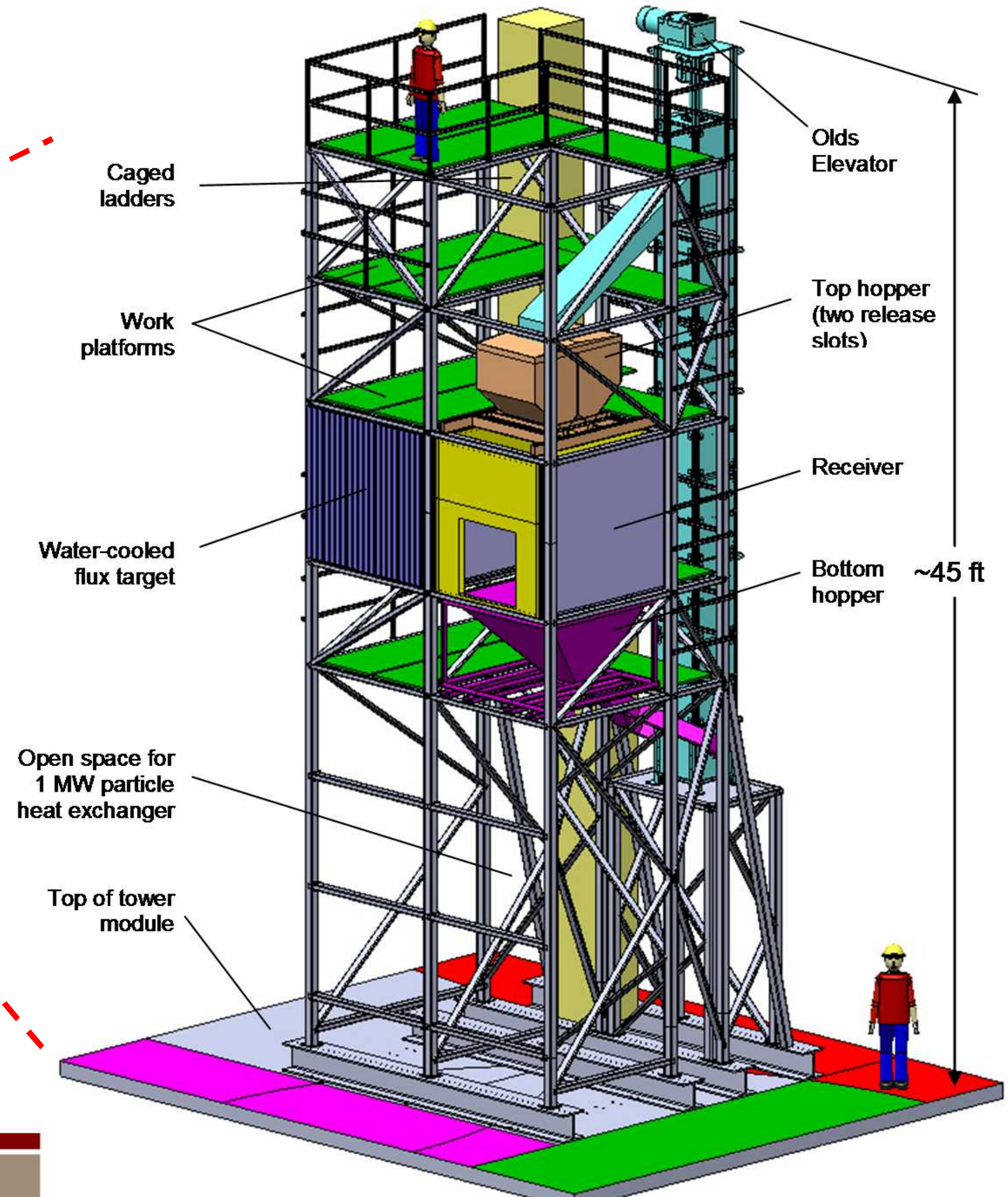
CARBO ceramic particles (“proppants”)

Particle Receiver Designs – Free Falling



Prototype System Design

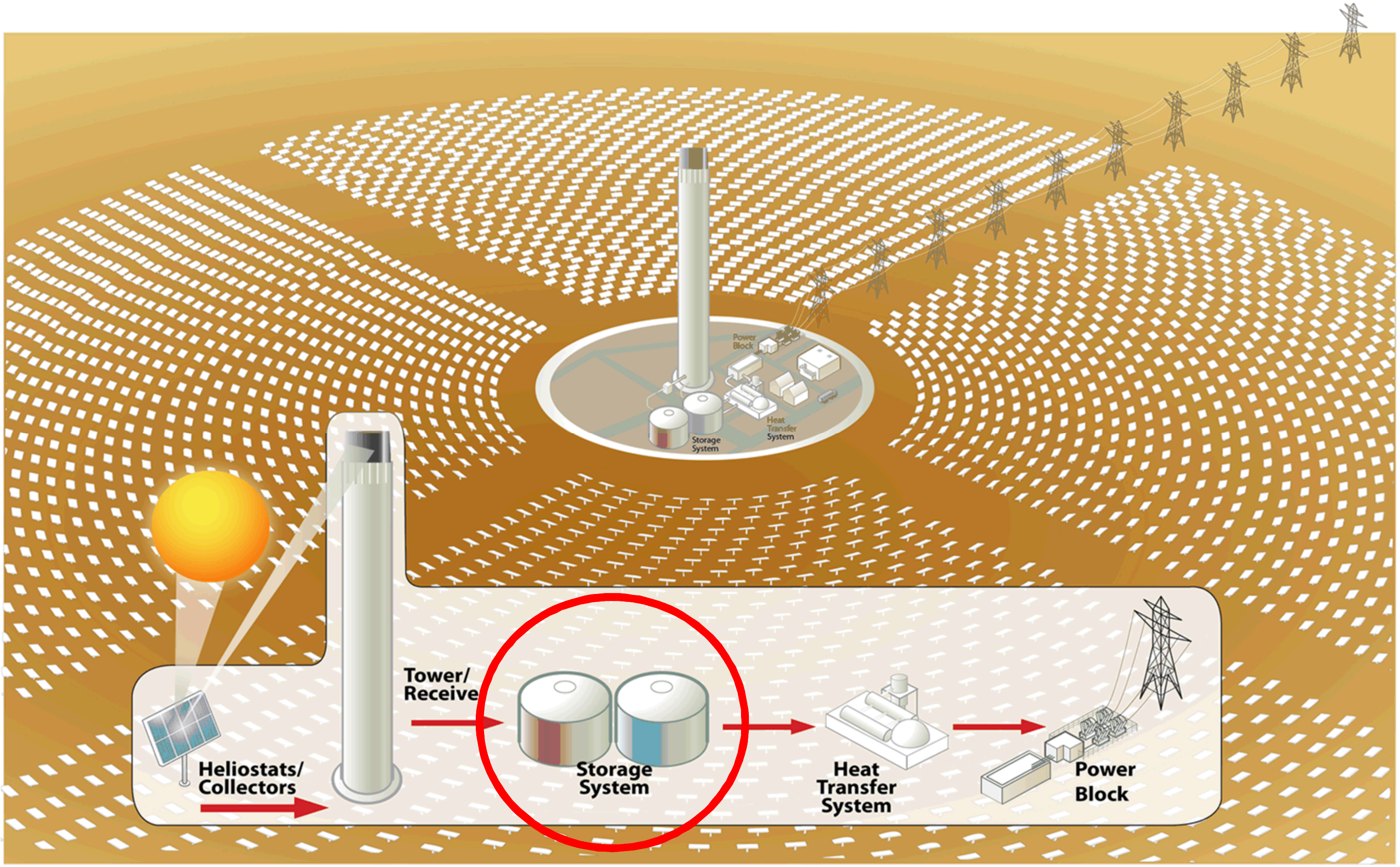




On-Sun Tower Testing

Over 600 suns peak flux on receiver
(July 20, 2015)

Thermal Storage



Molten-Salt Test Loop

- 3 parallel test loops
- Salt Temperature: 300 – 585 C (572 - 1085 F)
- Maximum pressure: 40 bar (580 psi)
- Maximum flow: 44-70 kg/s (600 gpm)

AREVA Molten-Salt Linear Fresnel System

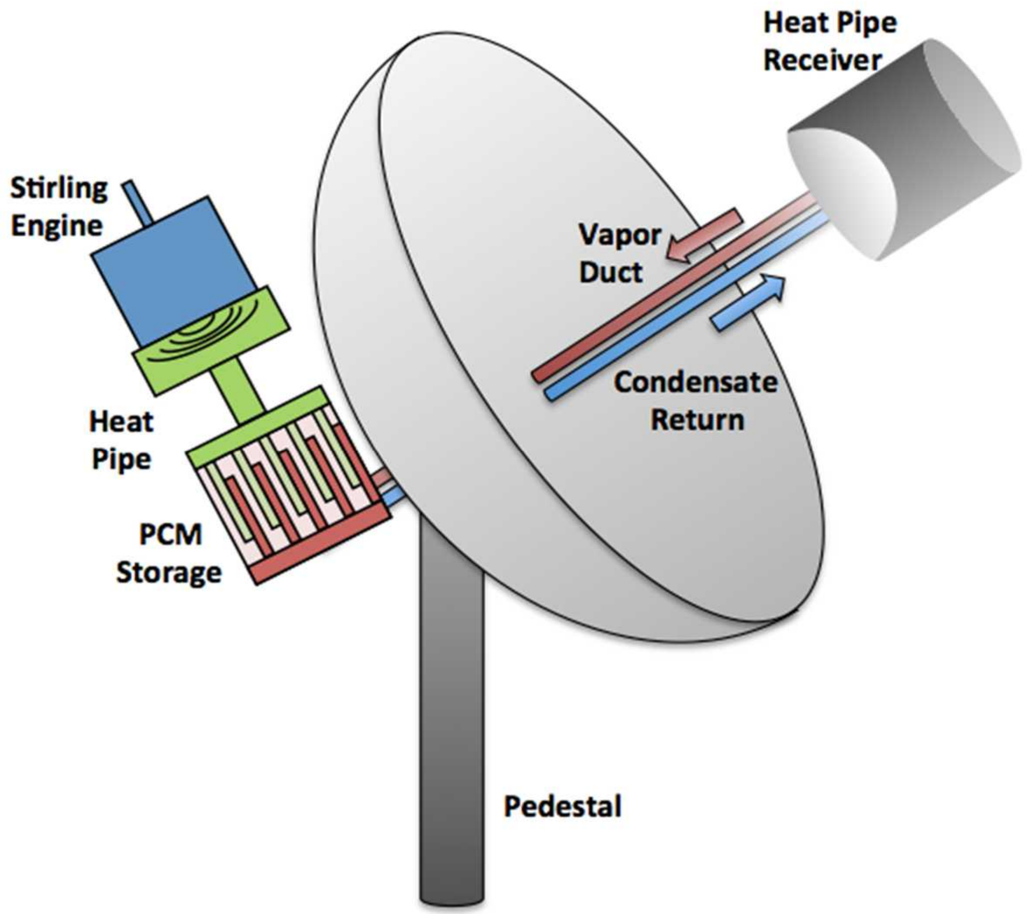
Dish Stirling Thermal Storage

Goal:

- Thermal storage for dish Stirling systems (6 hours)

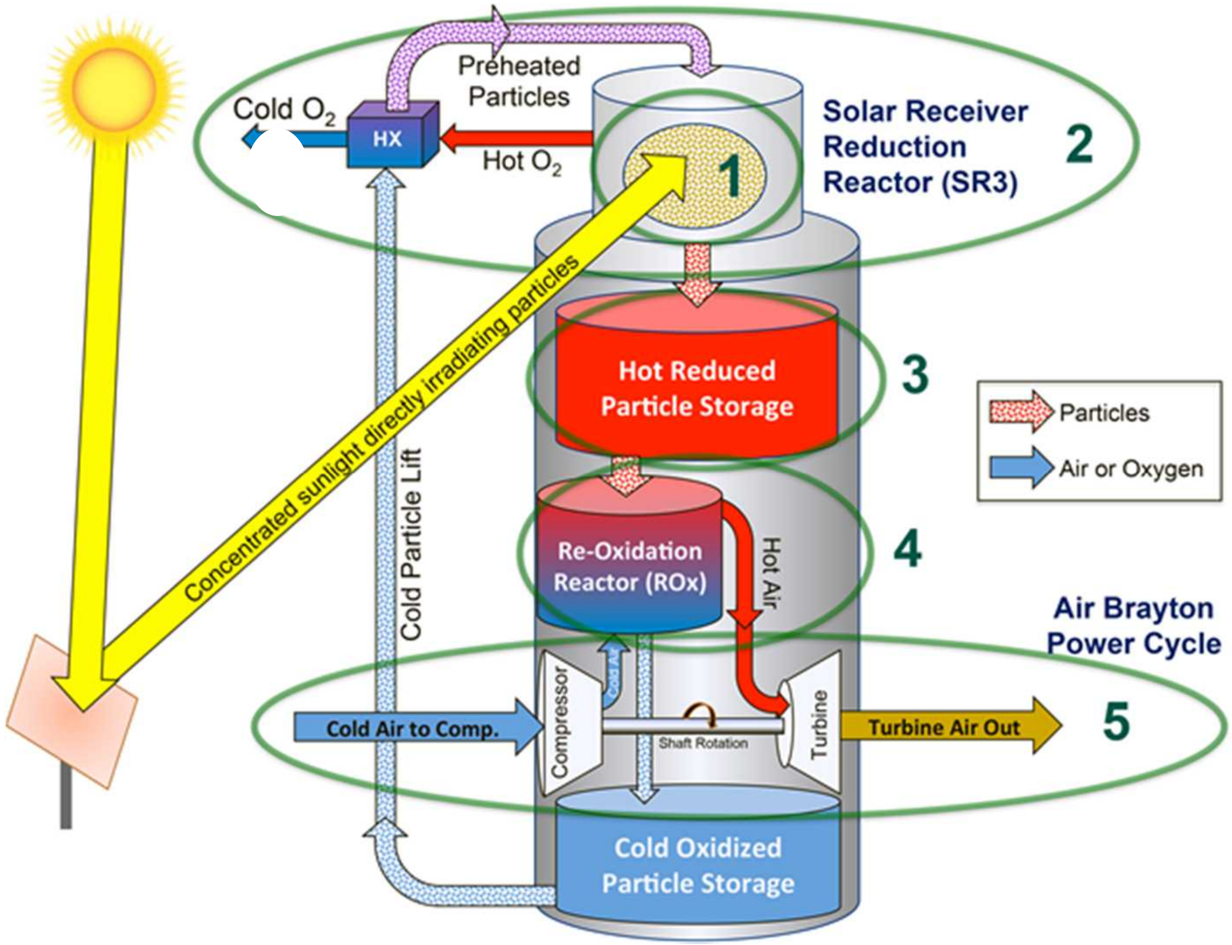
Innovation:

- Heat pipe transport to storage and engine
- Condensate return via pump
- Latent storage and transport matches Stirling cycle isothermal input



Thermo-Chemical Energy Storage

Particles Provide Reaction Enthalpy + Sensible Heat Storage for Increased Capacity, Higher Temperature Delivery



High Performance Reduction/Oxidation Metal Oxides for Thermochemical Energy Storage (PROMOTES)

Outline

- **Sandia CSP Research**
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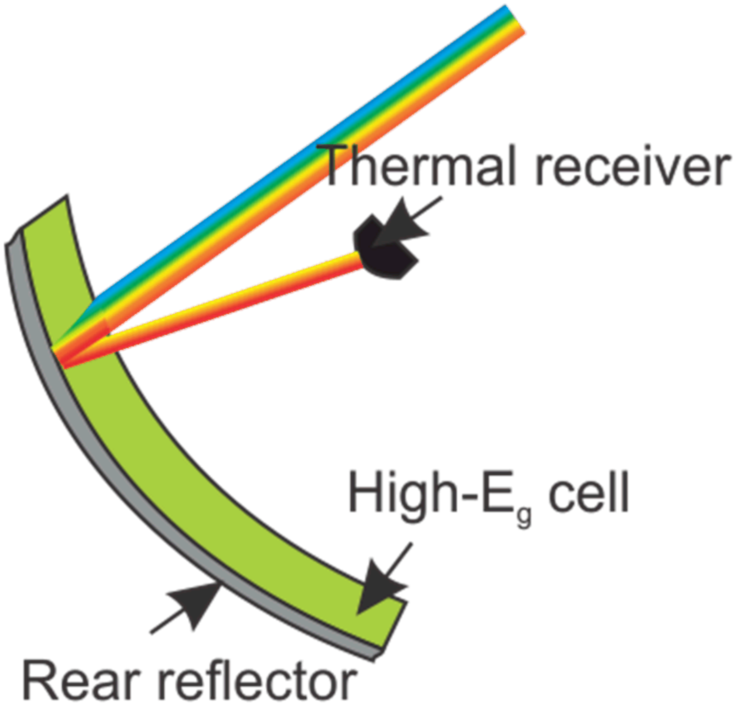
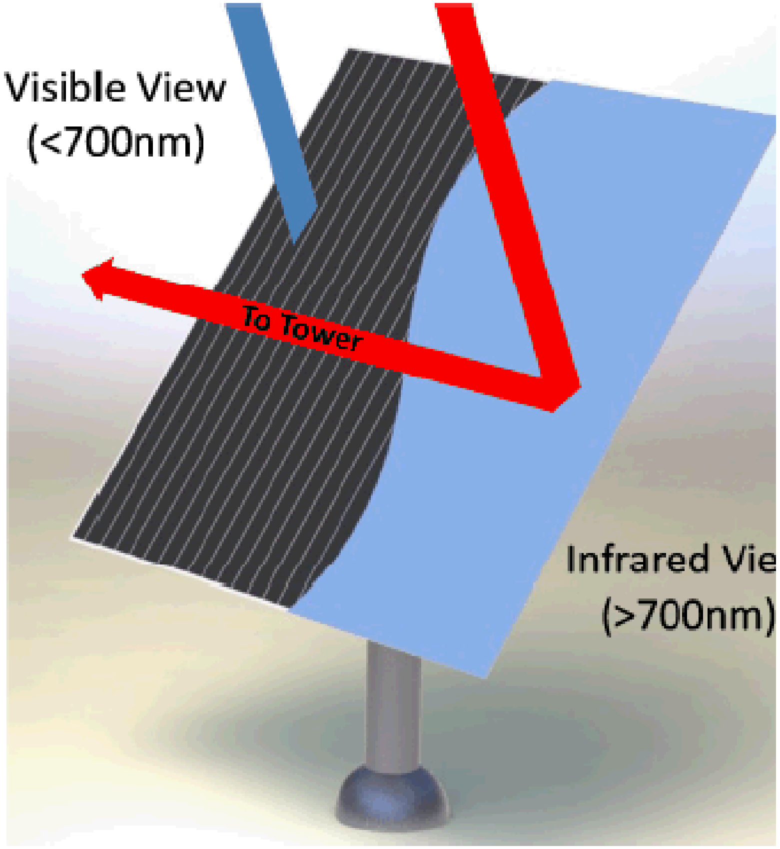
ARPA-E FOCUS

- Full-Spectrum Optimized Conversion and Utilization of Sunlight
  - Develop hybrid solar energy converters and storage systems (PV and CSP)

Light-Filtering/Spectrum-Splitting Mirrors

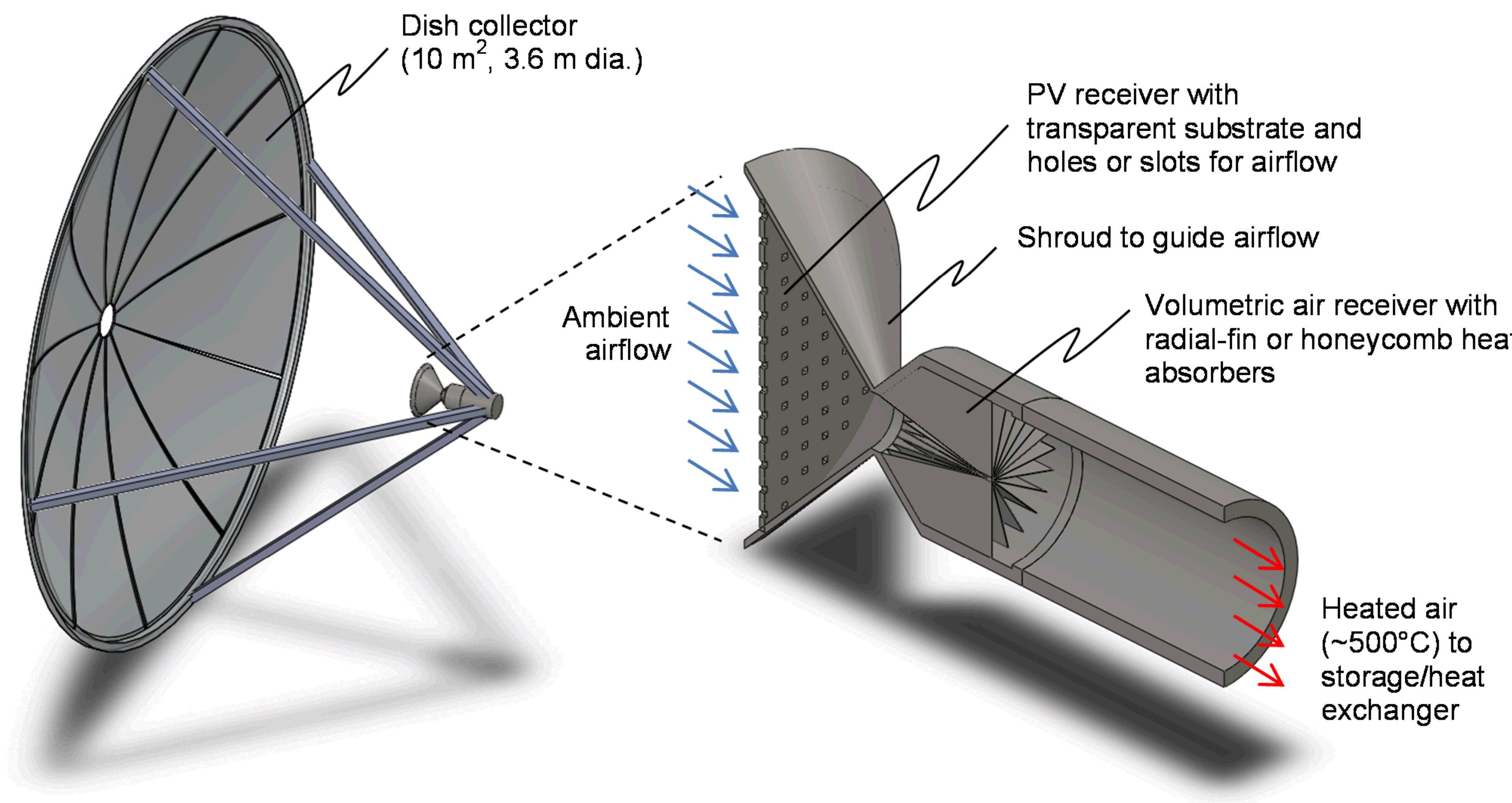




Arizona State University – Professor Zachary Holman

Patent Pending

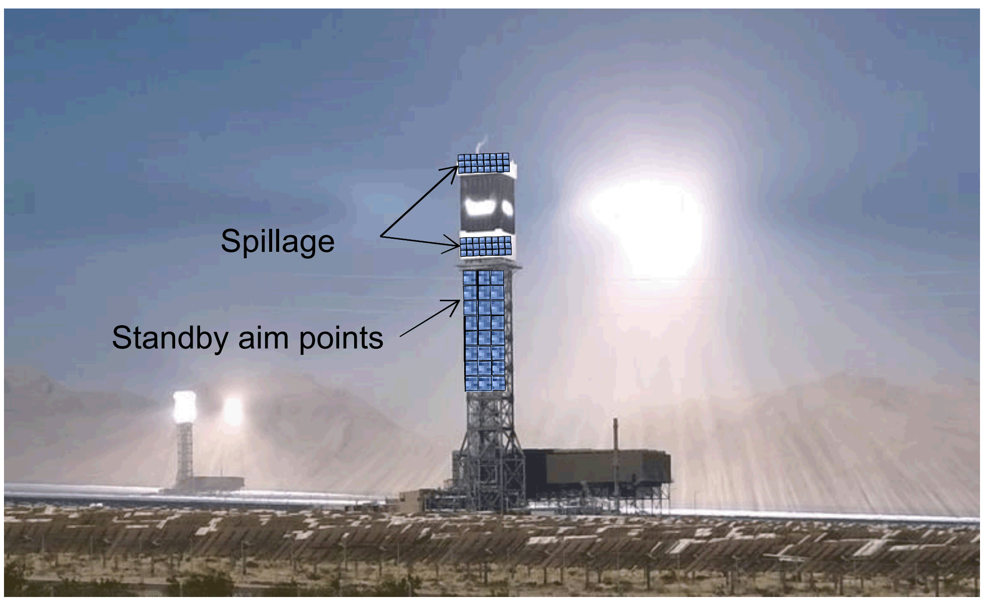
High-Temperature PV Topping Cells

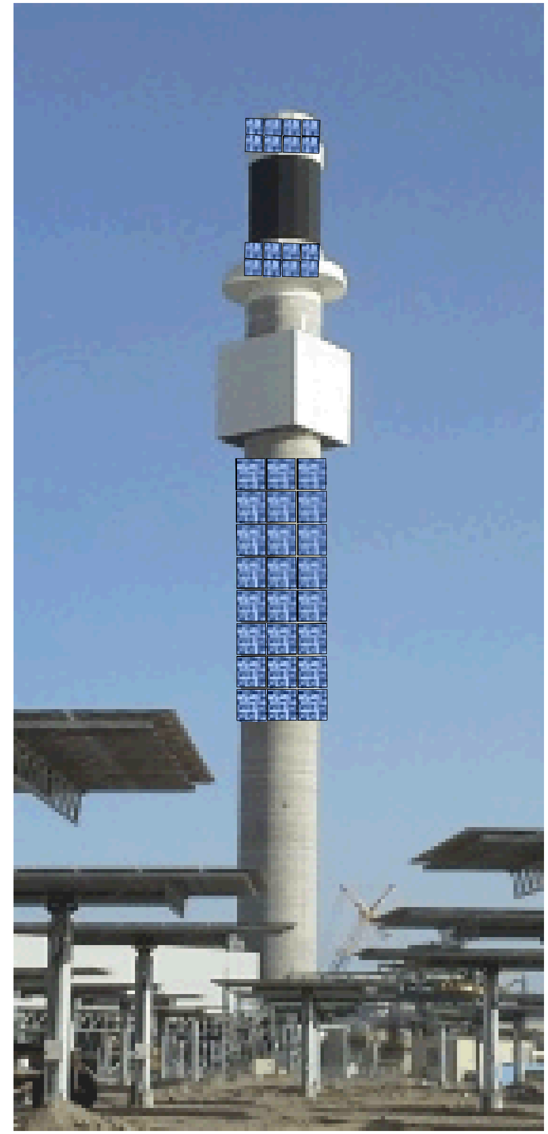


Patent Pending

High-Temperature PV as Heat Shields

Sandia National Laboratories





Patent Pending

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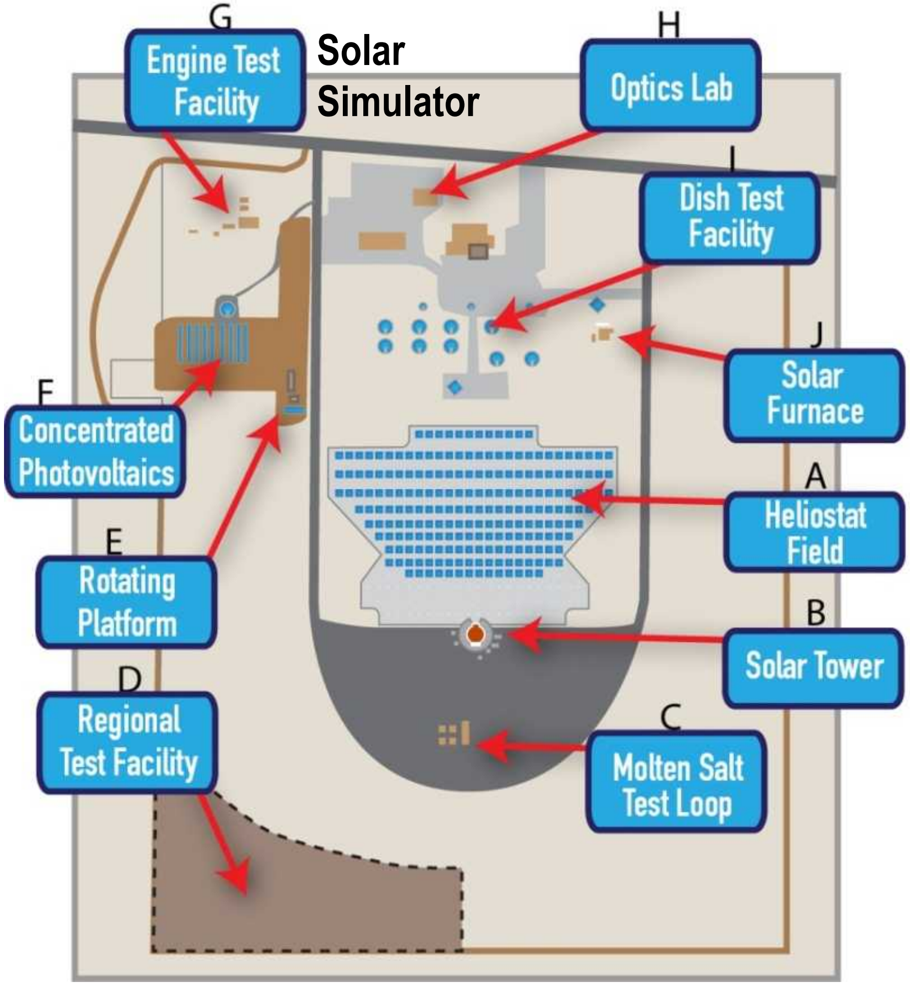
The National Solar Thermal Test Facility



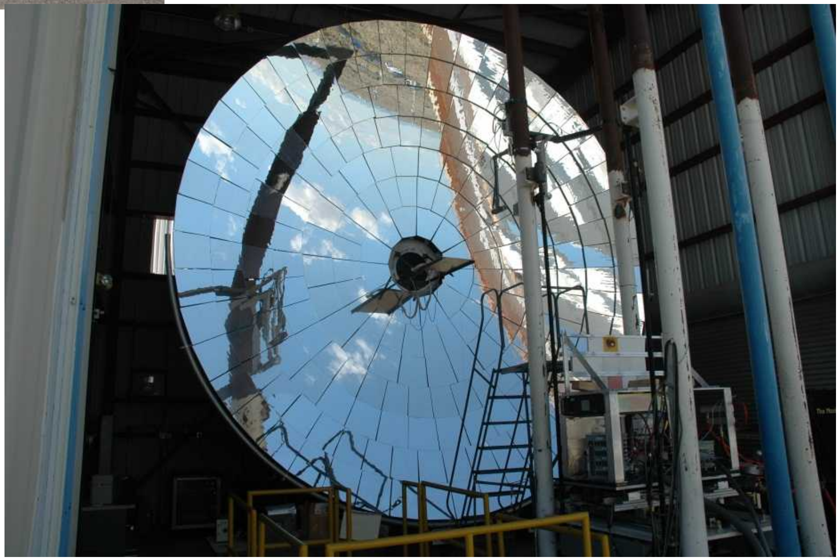
NSTTF is a DOE Designated User Facility

- Strategic Partnerships Projects (SPP)
- Cooperative Research And Development Agreement (CRADA)

Solar Furnace

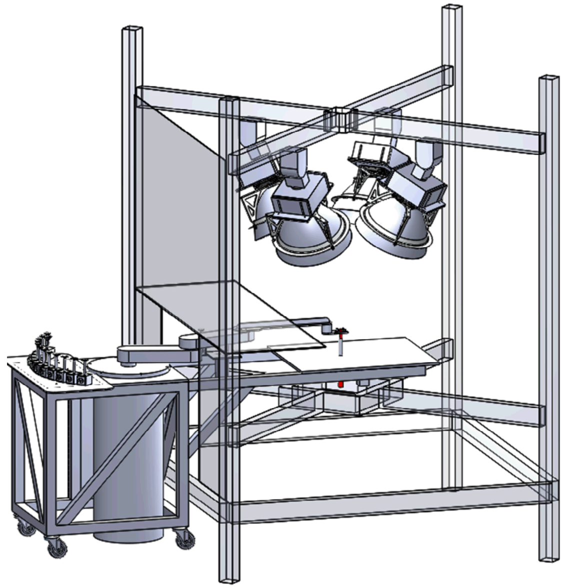
Sandia National Laboratories

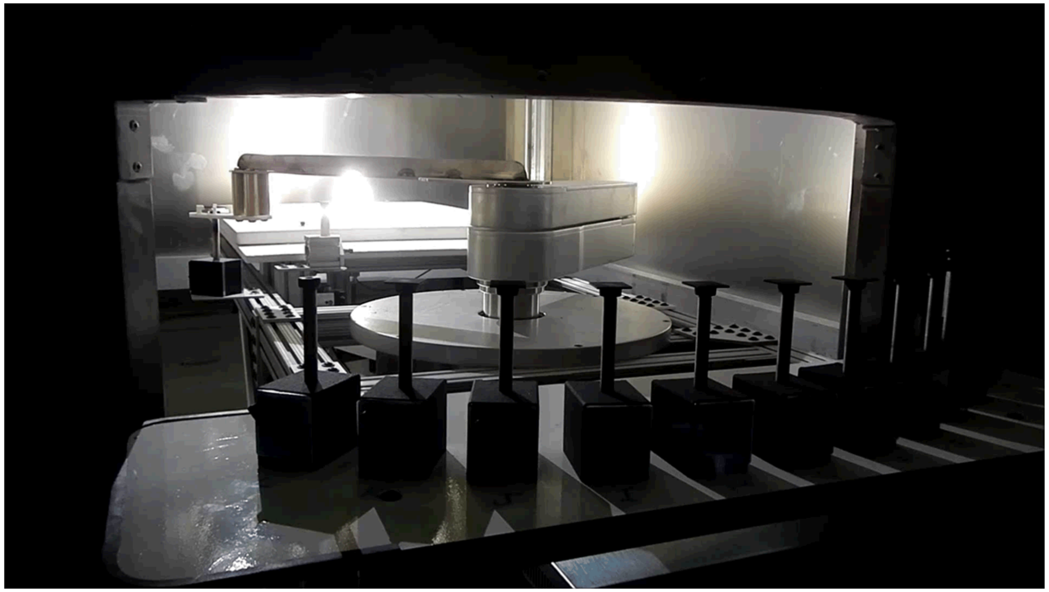
- 16 kW Solar Furnace
- Peak flux ~600 W/cm^2 (6000 suns)
- 5 cm spot size



Solar Simulator

- High-Flux Solar Simulator with Automated Sample Handling and Exposure System (ASHES)
  - Four 1.8 kW lamps
    - 7.2 $kW_{electric}$, 6.2 $kW_{radiative}$
  - 1100 kW/m^2 peak flux over 1 inch spot size





Questions?

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