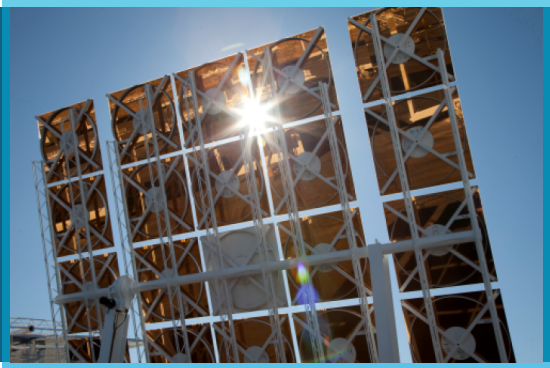
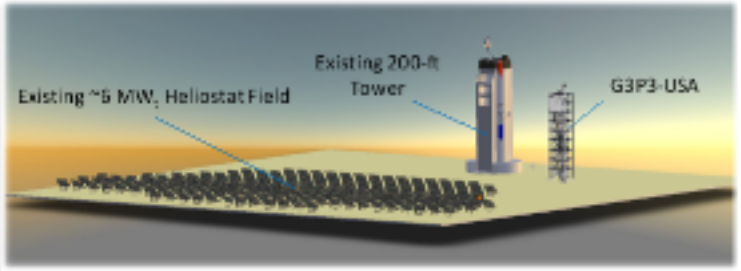
SAND2021-15541PE

Sandia National Laboratories

Overview of the Gen3 Particle Pilot Plant (G3P3)





PRESENTED BY

Clifford K. Ho

Sandia National Laboratories, Albuquerque, NM, ckho@sandia.gov

Contributors:

Brantley Mills, Kevin J. Albrecht, Jeremy Sment, Francisco Alvarez, Nathan Schroeder, Henk Laubscher, Luis Garcia Maldonado, Org. 08923

SAND2021-10301 PE

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Gen 3 CSP Program (FY19 – FY24)

Achieve higher temperatures, higher power-cycle efficiencies, and lower LCOE

Brayton Energy	NREL	Sandia
Gas Phase Pathway	Liquid Phase Pathway	Solid Phase Pathway

18 months
FY19 – FY20

6 months
FY20

DOE Downselection (March 2021)

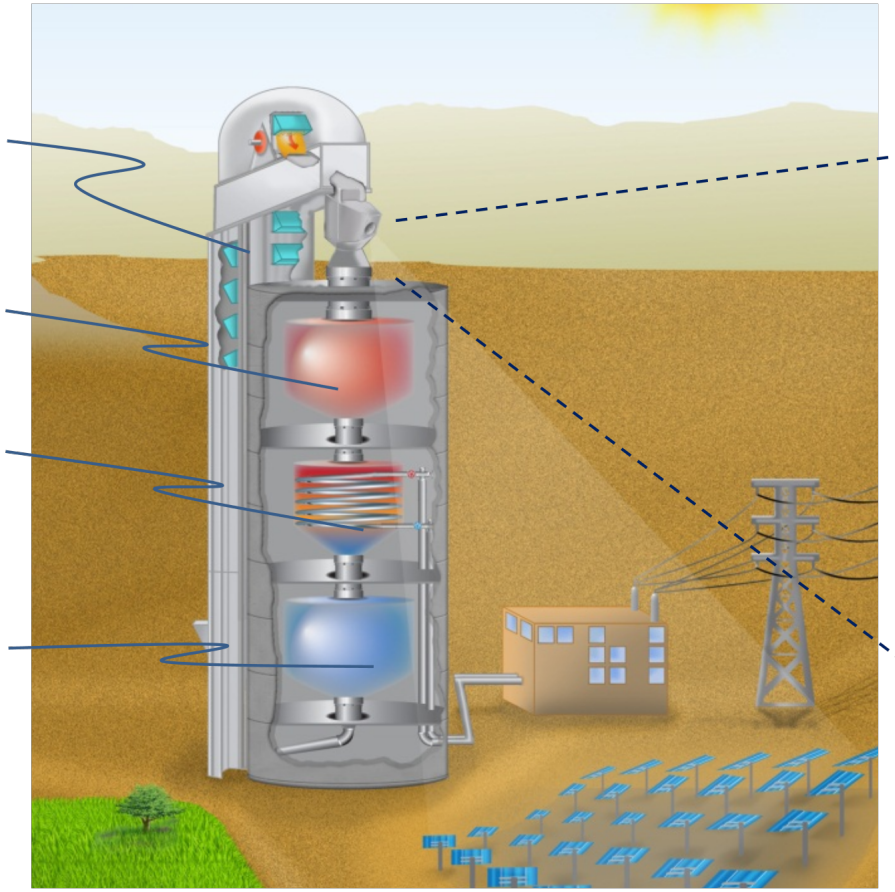
3 years
FY21 – FY23

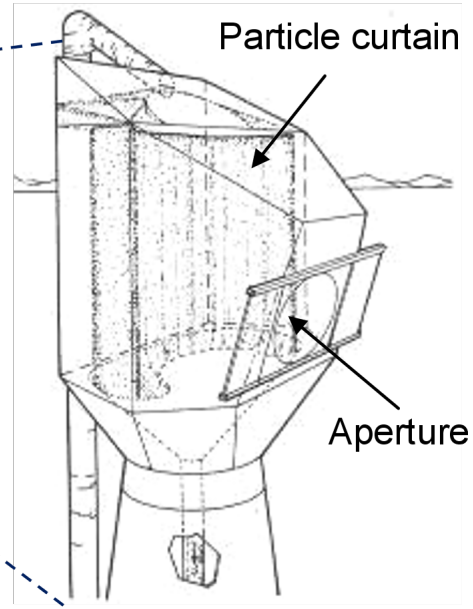
Introduction to the Team

Role	Team Members	
PI / Management	• Sandia National Labs (PI, PMP, financial, facilities)	
R&D / Engineering	• Sandia National Laboratories • Georgia Institute of Technology • King Saud University • German Aerospace Center	• CSIRO • U. Adelaide • Australian National University • CNRS-PROMES
Integrators / EPC	• EPRI • Bridgers & Paxton / Bohannan Huston	
CSP Developers	• SolarDynamics	
Component Developers / Industry	• Carbo Ceramics • Solex Thermal Science • Vacuum Process Engineering • FLSmidth	• Materials Handling Equipment • Allied Mineral Products • Matrix PDM
Utility	• Saudi Electric Company	

Background and Value Proposition

High-Temperature Particle-Based CSP

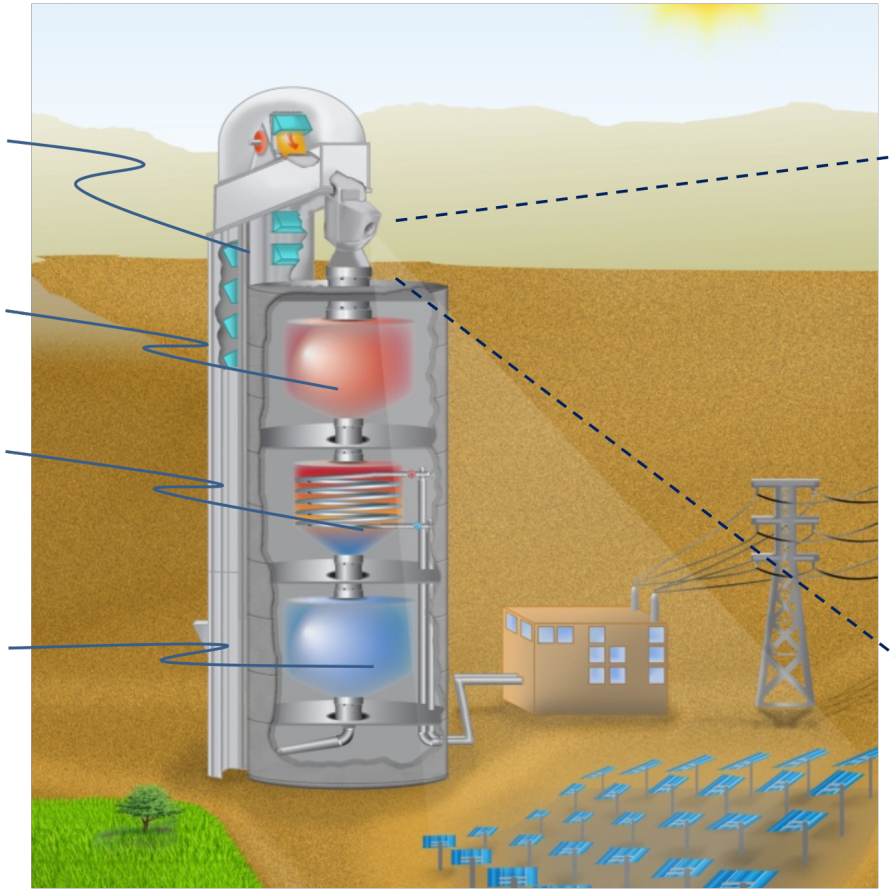


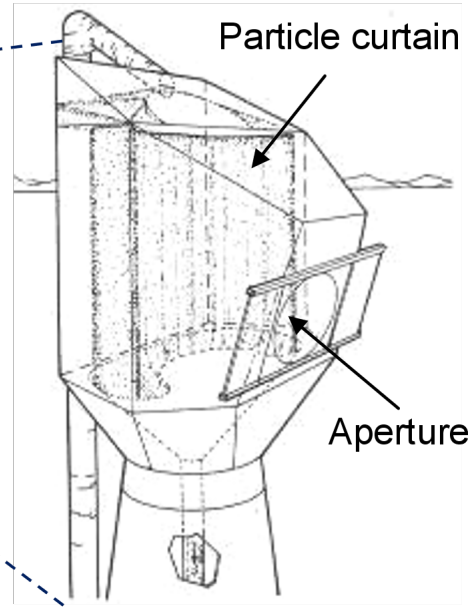


Falling particle receiver

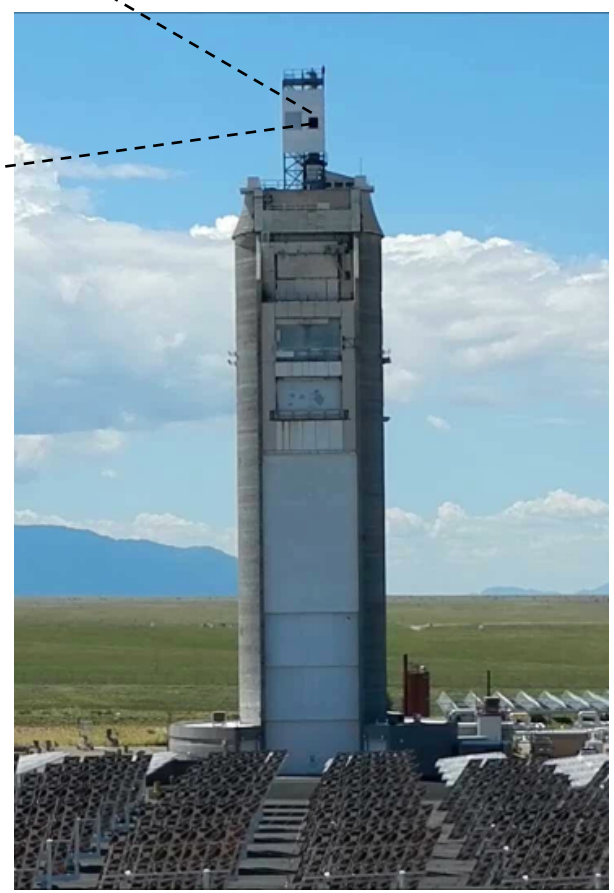
Background and Value Proposition

High-Temperature Particle-Based CSP





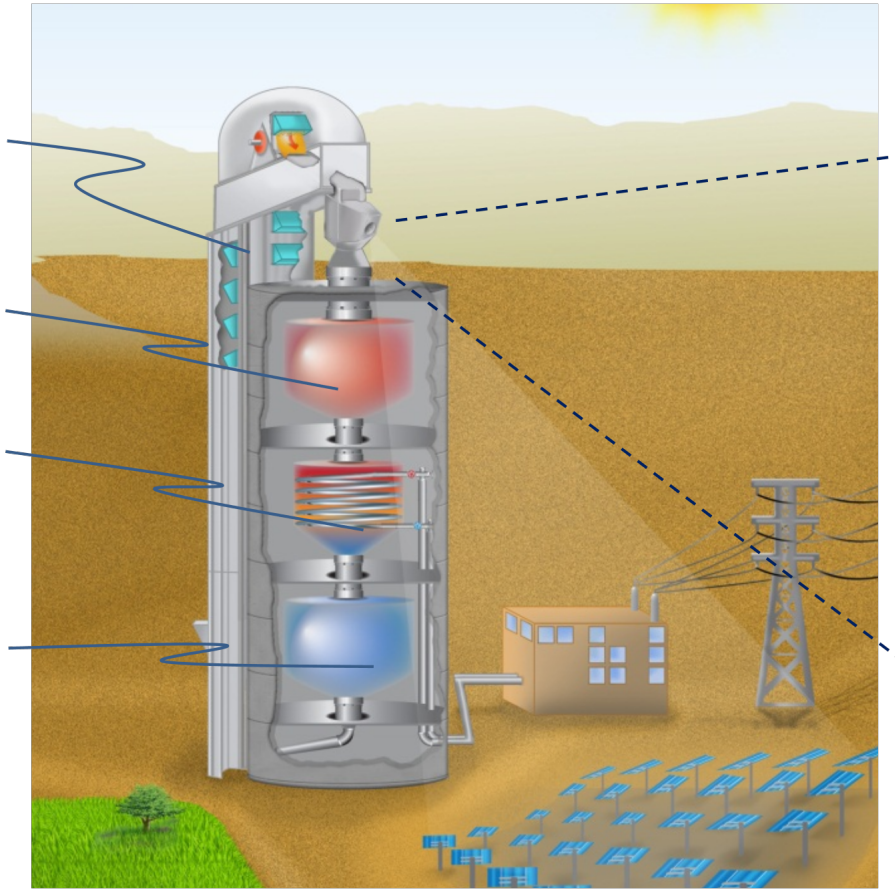
Falling particle receiver

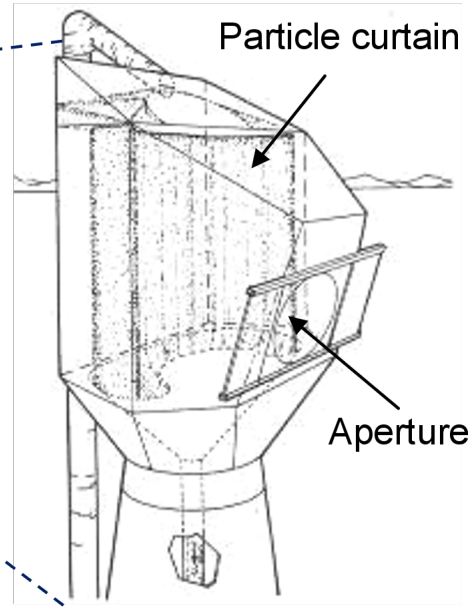


National Solar Thermal Test Facility
Sandia National Laboratories

Background and Value Proposition

High-Temperature Particle-Based CSP

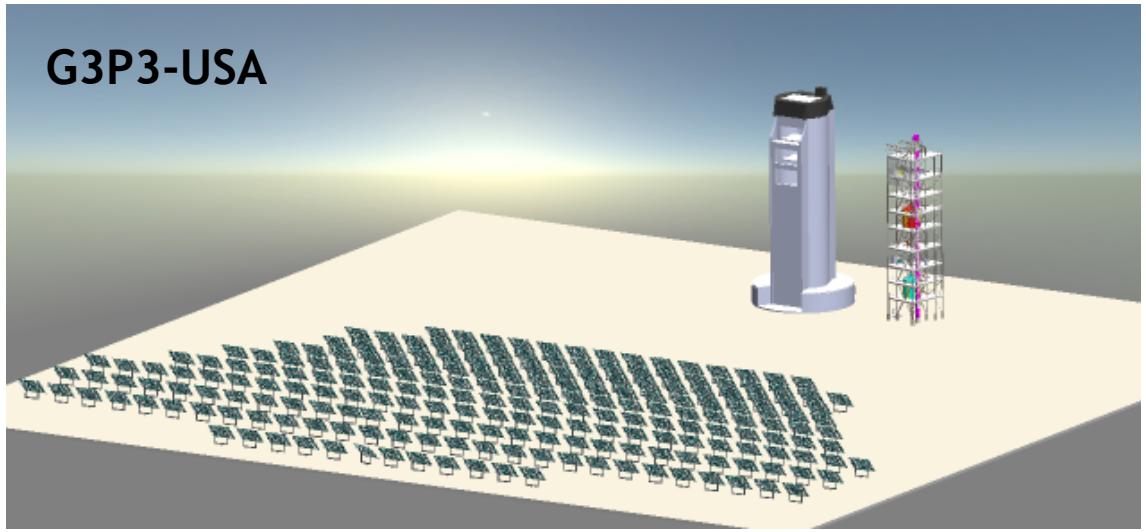


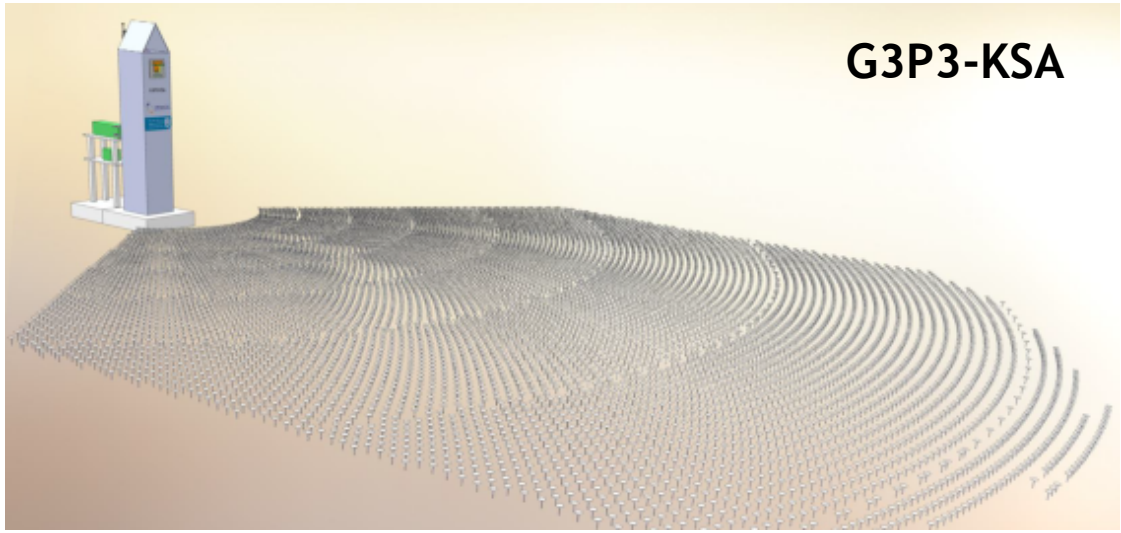


Falling particle receiver

- Higher temperatures (>1000 ˚C) than molten nitrate salts
- Direct heating of particles vs. indirect heating of tubes
- No freezing or decomposition
  - Avoids costly heat tracing
- Direct storage of hot particles

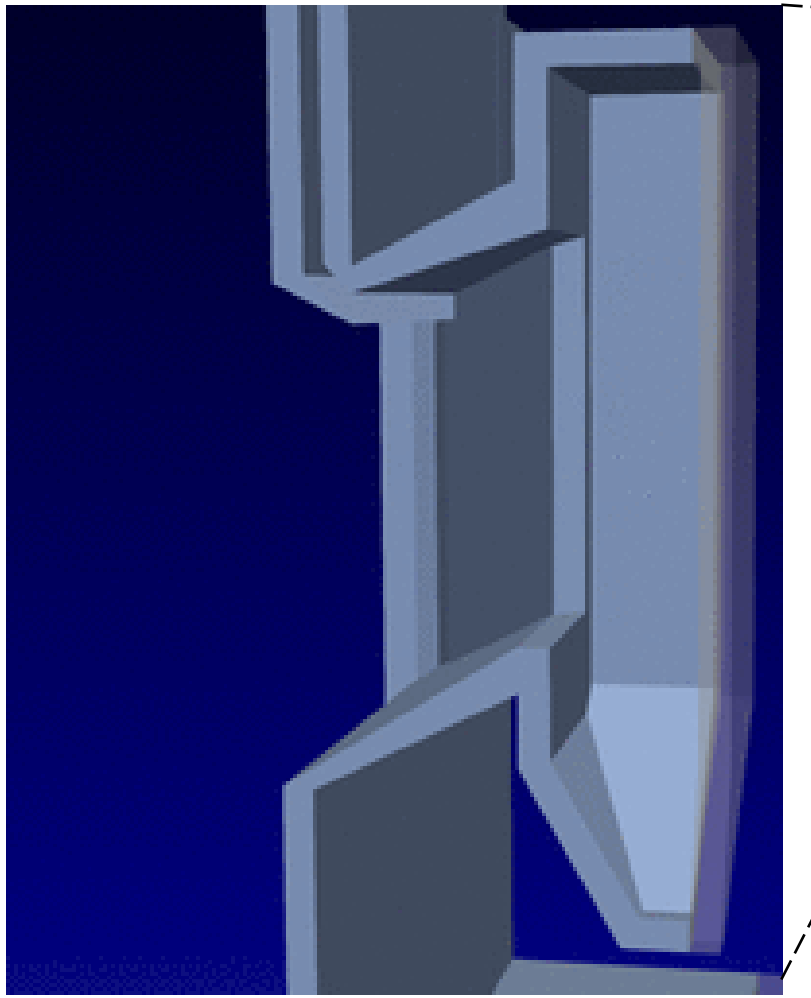
G3P3-USA and G3P3-KSA

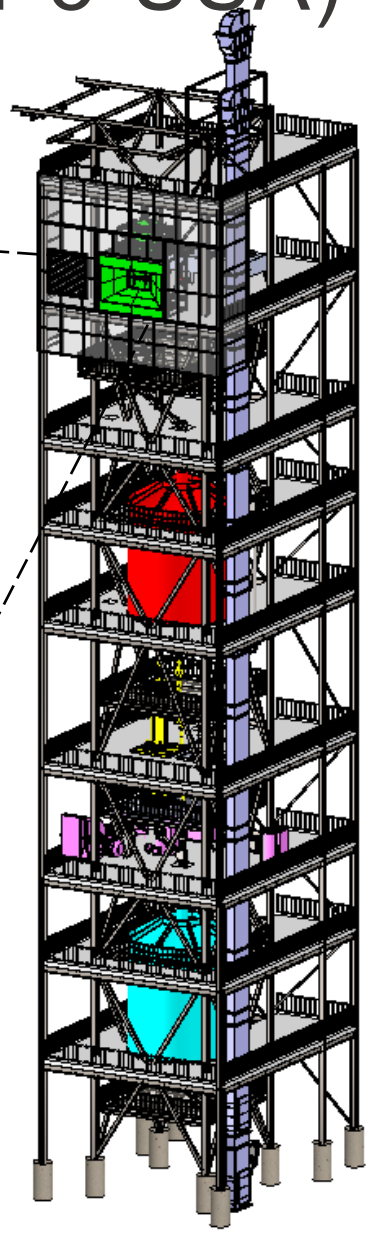




Gen3 Particle Pilot Plant (G3P3-USA)

Next-Generation High-Temperature Falling Particle Receiver





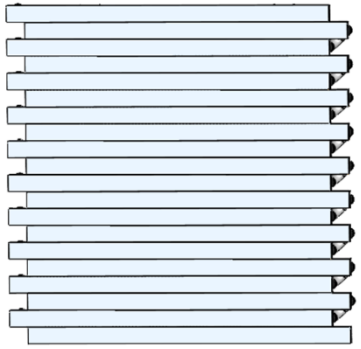
Gen 3 Particle Pilot Plant

- ~1 – 2 MW_t receiver
- 6 MWh_t storage
- 1 MW_t particle-to-sCO_2 heat exchanger
- ~300 – 400 micron ceramic particles (CARBO HSP 40/70)

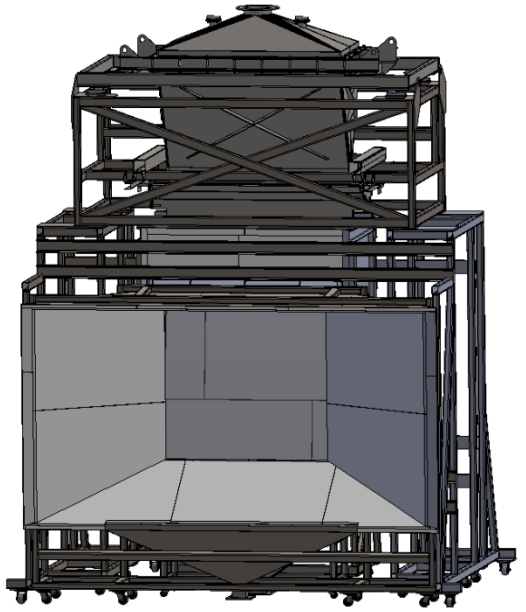
K. Albrecht, SNL

Falling Particle Receiver Overview (B. Mills)

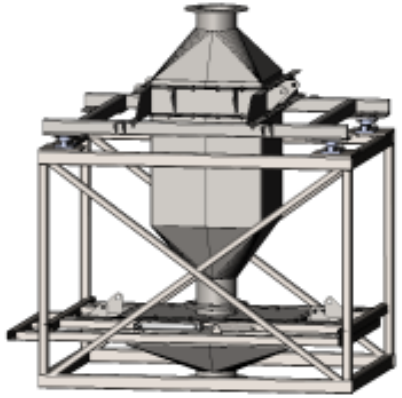
- Construction of G3P3-USA falling particle receiver consists of **6 major components**:
  - Receiver feed hopper
  - Receiver cavity
  - SNOUT
  - Receiver bottom hopper
  - Weigh hopper
  - Calibration panel



Calibration panel



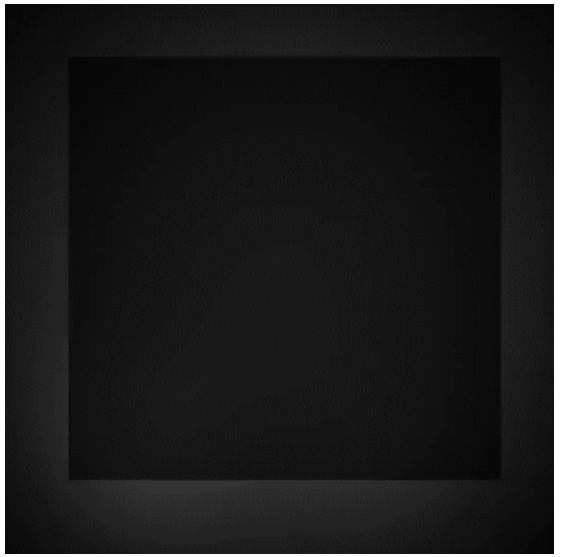
Receiver



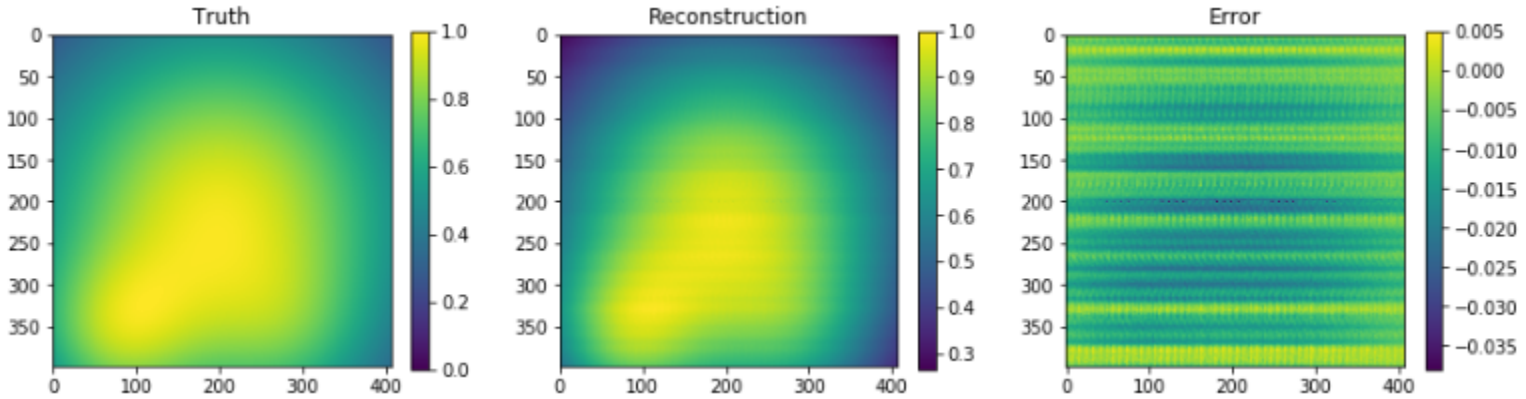
Weigh hopper

Radiative Flux Wand (B. Mills)

- A translating flux wand is planned for integration into the receiver SNOUT at the cavity aperture
  - Enables *in-situ* radiative flux measurements
  - Minimizes disruption in operation
- A post-processing strategy has been developed to reconstruct radiative flux profiles and quantify error

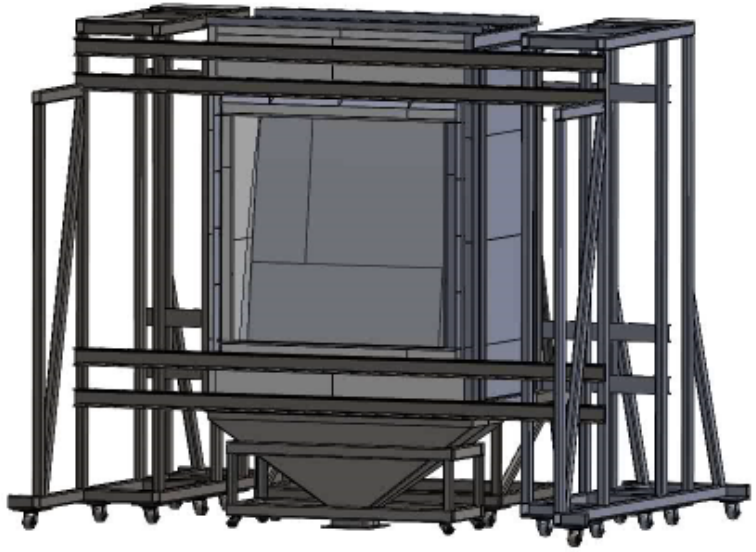


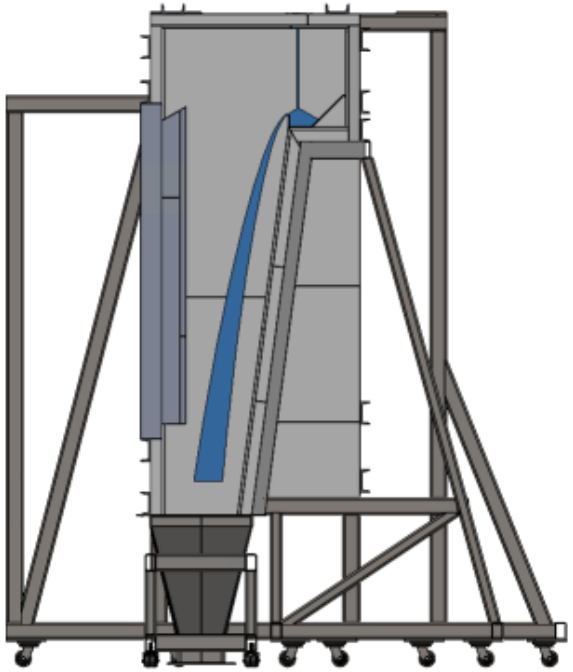
Variable Reflectivity



Receiver Cavity and SNOUT (B. Mills)

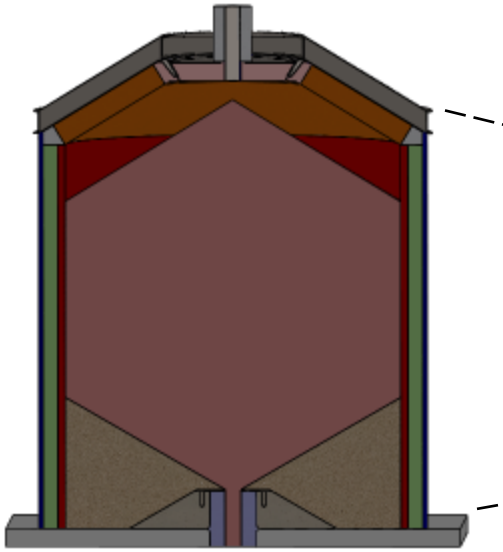
- Catch-and-release trough in the cavity near peak flux
- Receiver assembly is modular for easy access and repairs

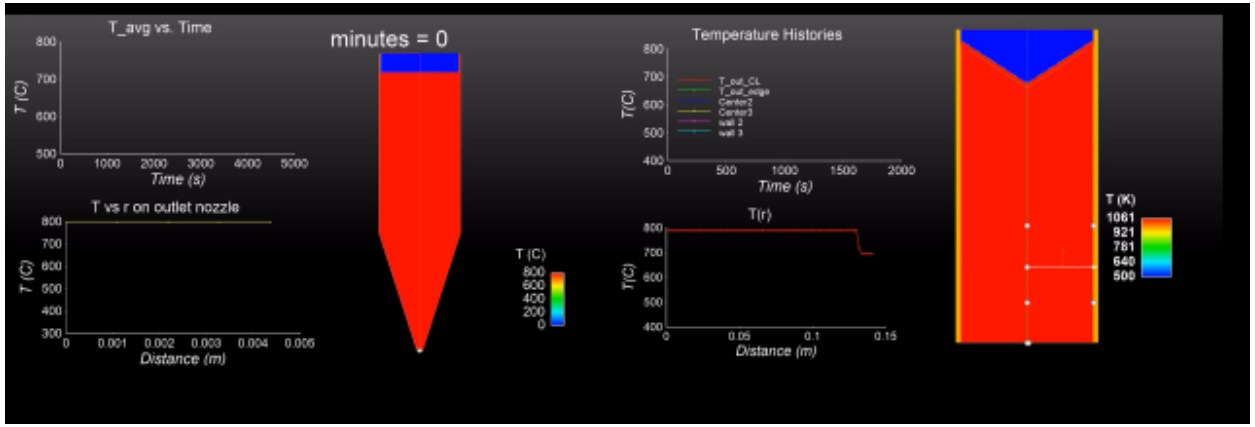


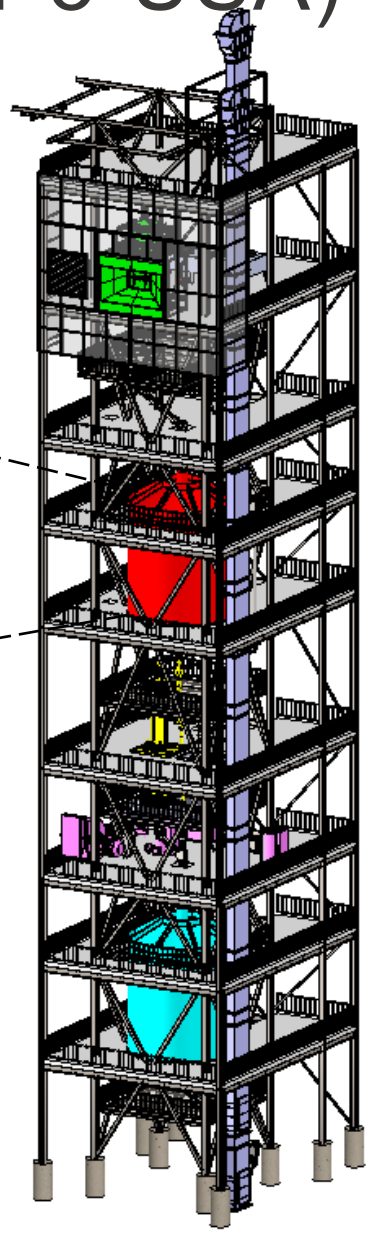


Gen3 Particle Pilot Plant (G3P3-USA)

High-Temperature Particle Storage Bin
(Allied Mineral Products, Matrix PDM, Sandia – J. Sment)







Gen 3 Particle Pilot Plant

- ~1 – 2 MW_t receiver
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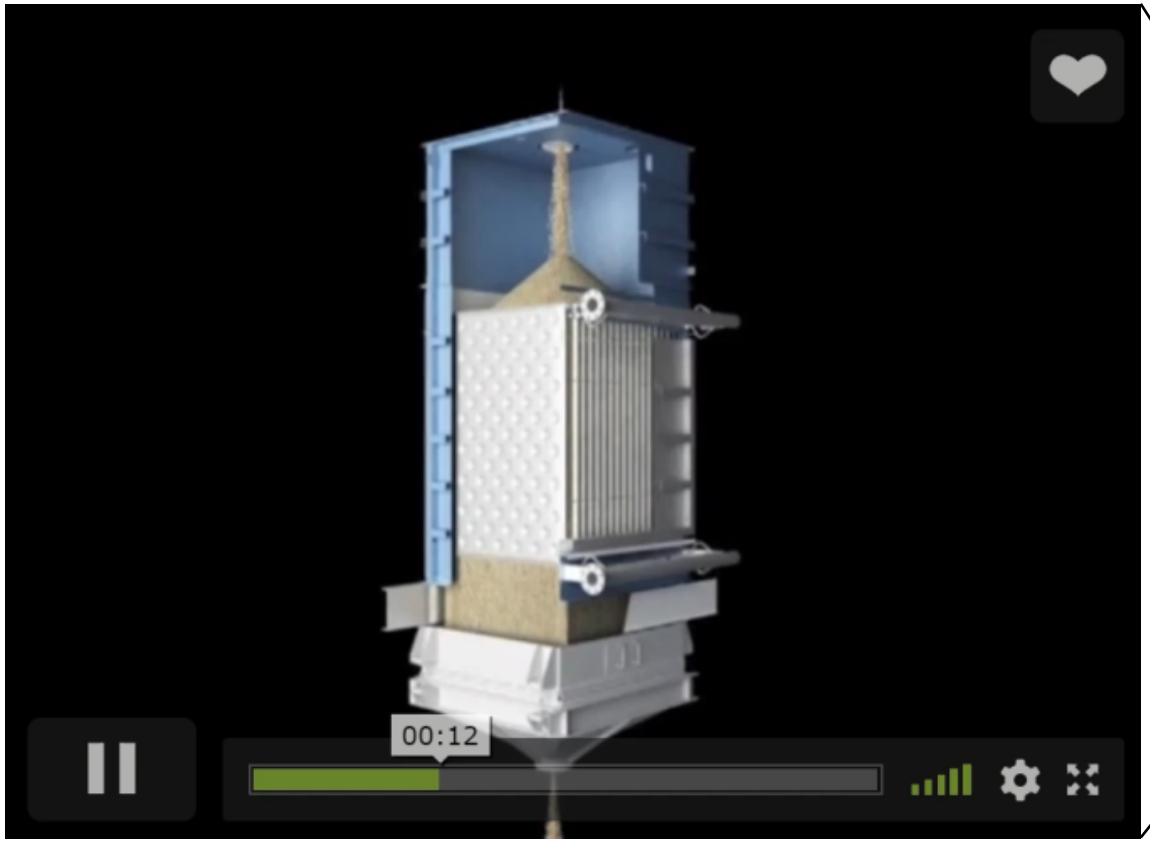
- ~300 – 400 micron ceramic particles (CARBO HSP 40/70)

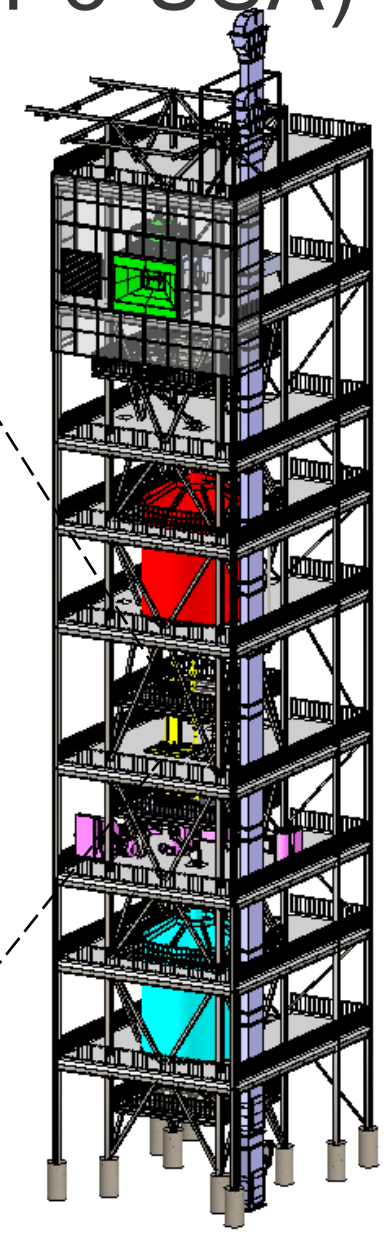
K. Albrecht, SNL

Gen3 Particle Pilot Plant (G3P3-USA)

High-Temperature Particle-to-sCO_2 Heat Exchanger
(VPE, Solex, Sandia – K. Albrecht)



https://www.solexthermal.com/our-technology/cooling/



K. Albrecht, SNL

Gen 3 Particle Pilot Plant

- ~1 – 2 MW_t receiver
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- 1 MW_t particle-to-sCO_2 heat exchanger
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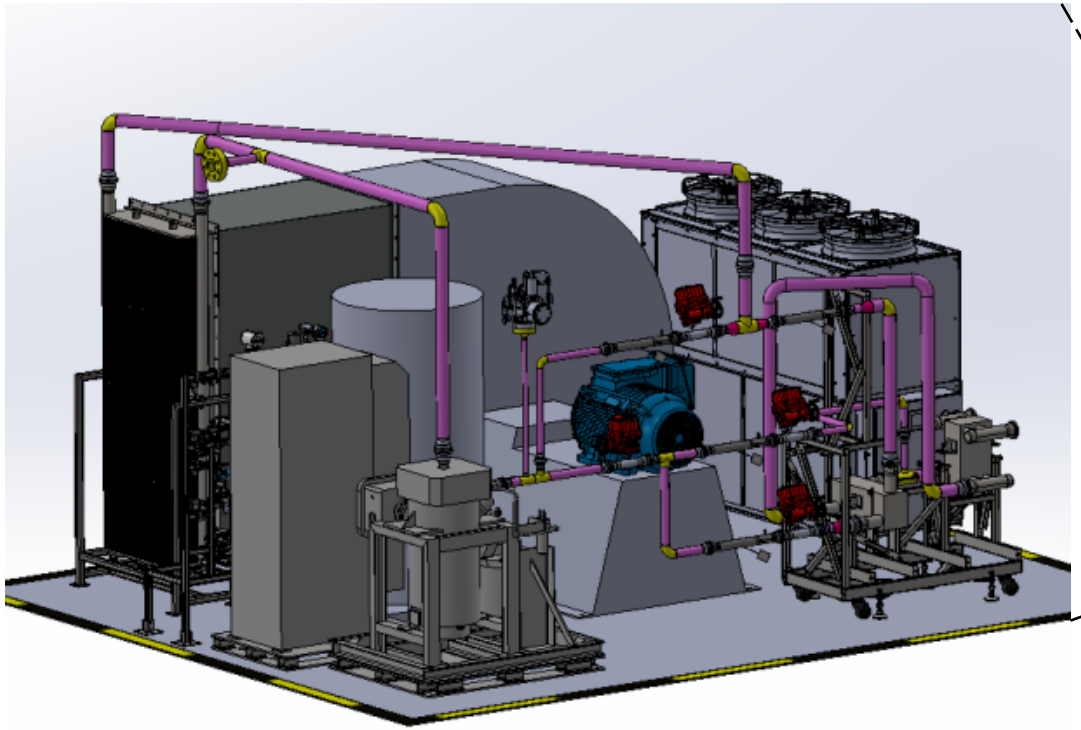
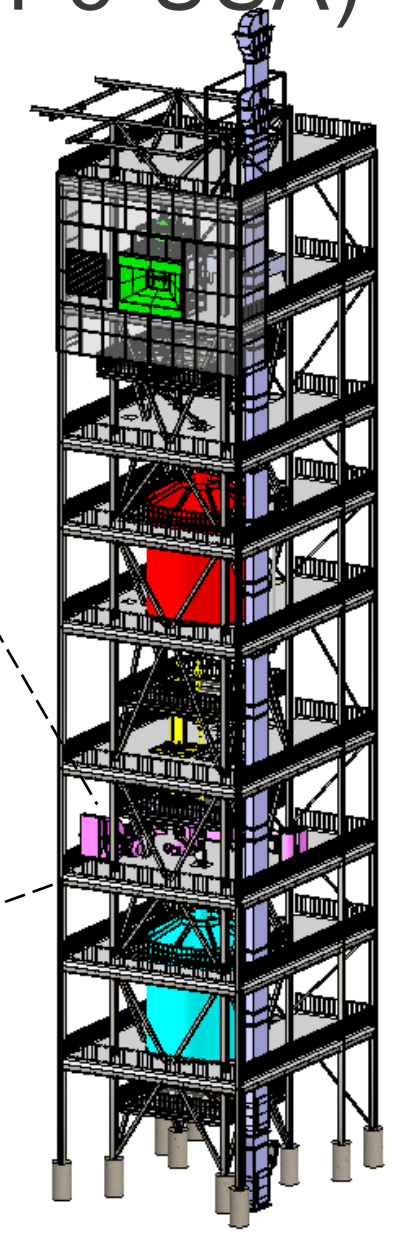
Gen3 Particle Pilot Plant (G3P3-USA)

sCO2 loop and recuperator skid (F. Alvarez)





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K. Albrecht, SNL

Gen3 Particle Pilot Plant (G3P3-USA)

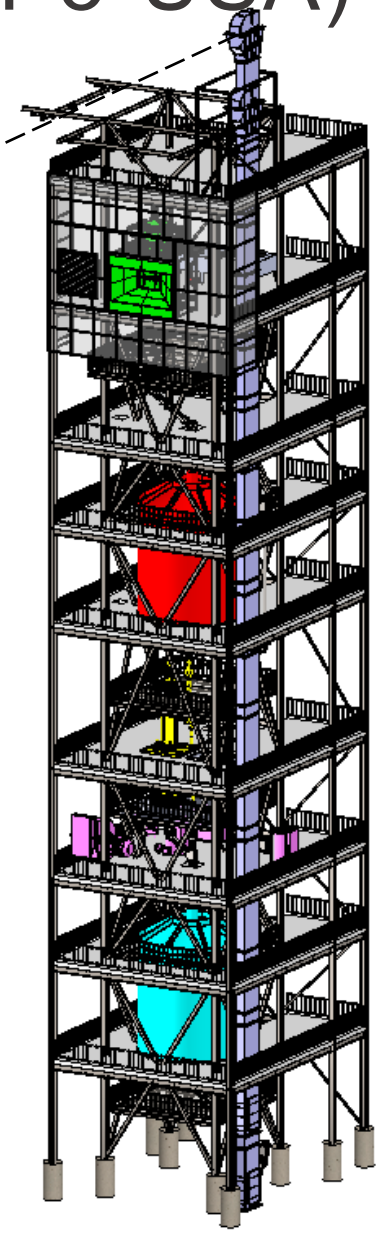
SS304 Bucket Elevator
(Materials Handling Equipment)

CONVEYING

Bucket Elevator

CIMBRIA

https://www.youtube.com/watch?v=R1WVS-ySQ8M&t=37s

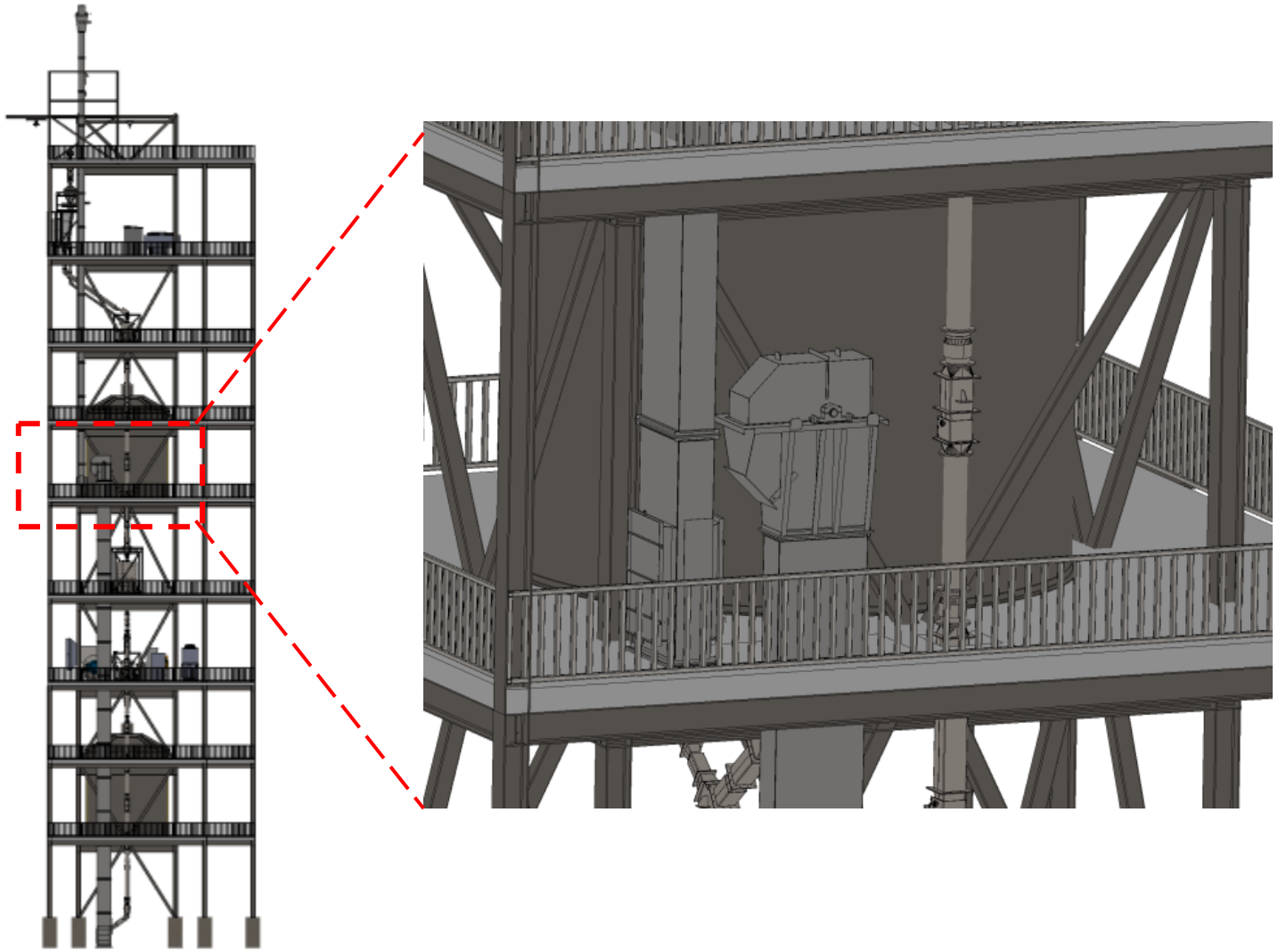


K. Albrecht, SNL

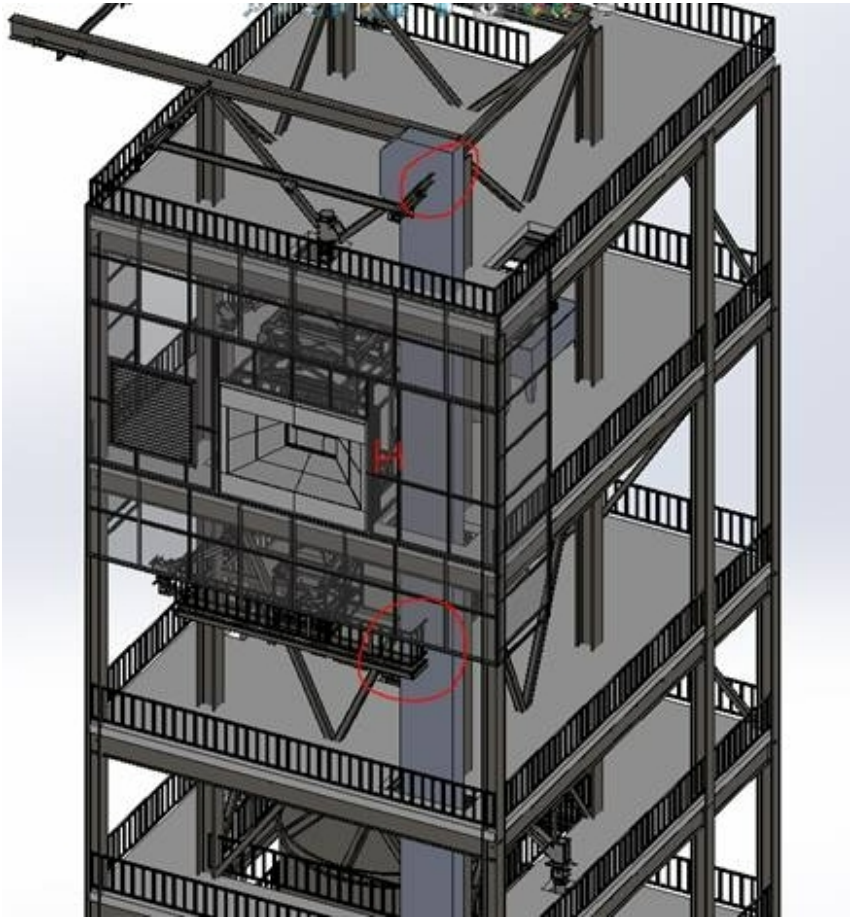
Gen 3 Particle Pilot Plant

- ~1 – 2 MW_t receiver
- 6 MWh_t storage
- 1 MW_t particle-to-sCO_2 heat exchanger
- ~300 – 400 micron ceramic particles (CARBO HSP 40/70)

Re-Design for Two Shorter Elevators in Series



Looking east

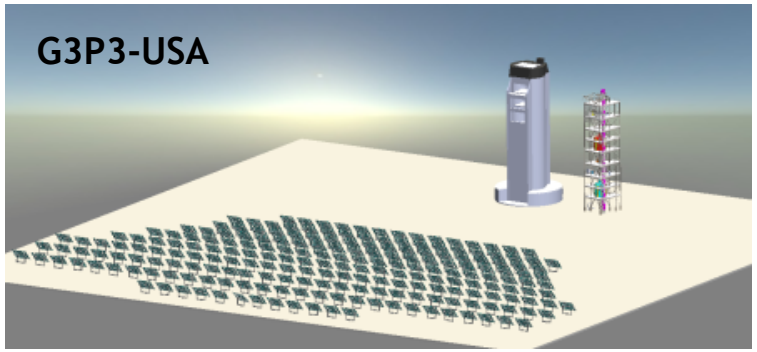


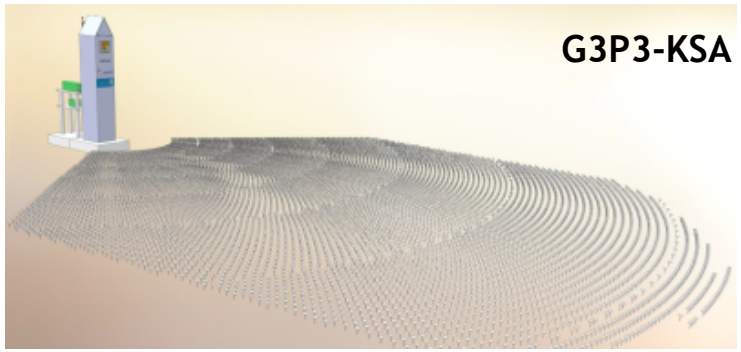
Potential interference with existing structures

Summary

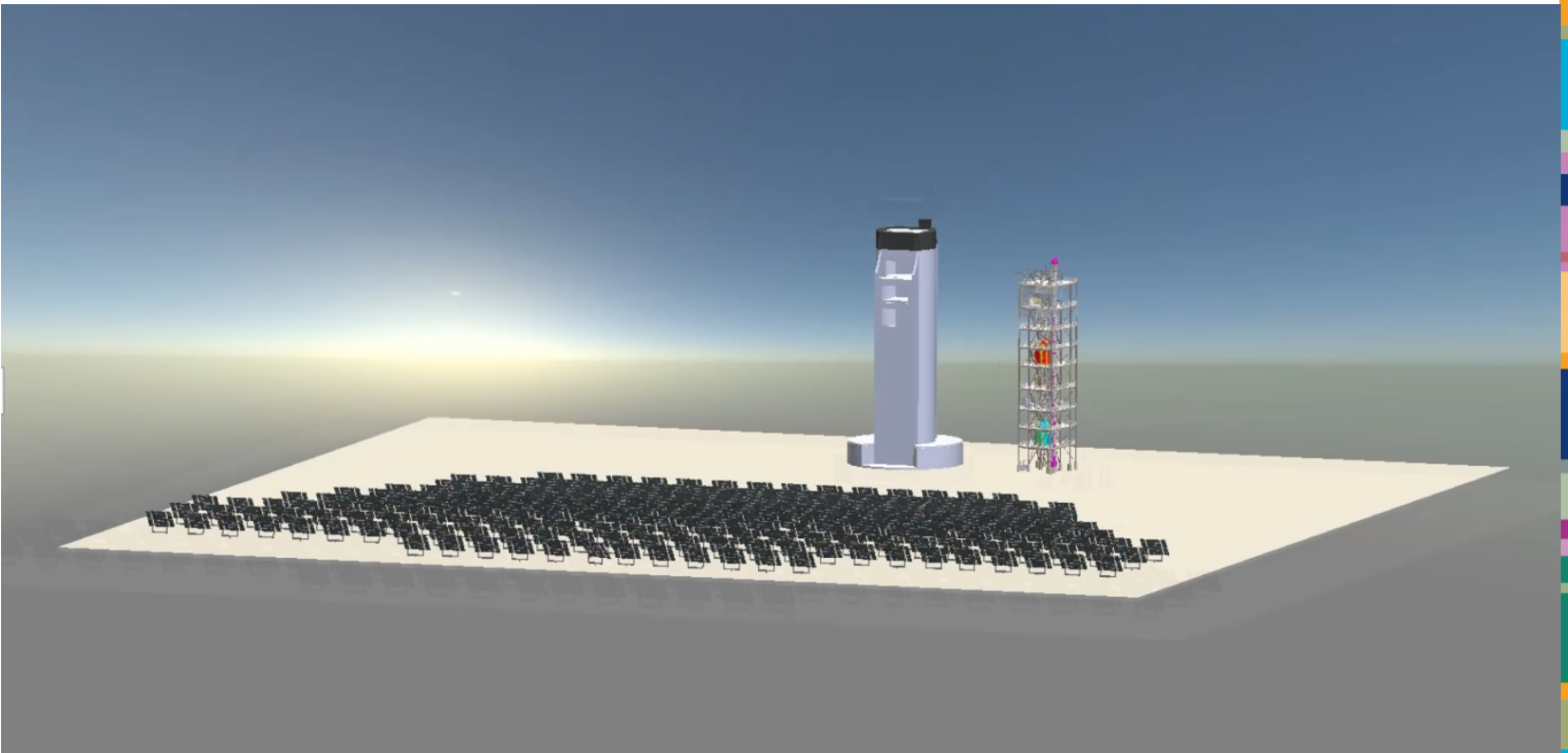
Summary

- G3P3-USA and G3P3-KSA being developed
- Final design and procurement of key components for G3P3-USA
  - Receiver
  - Storage
  - Particle-to-sCO2 heat exchanger and sCO2 loop
  - Lift
- Risks and challenges
  - Delays from permitting and approvals
  - Increased costs due to supply chain and labor shortages
  - Heat loss from storage and bucket elevator
  - Installation of bucket elevator and storage bins by general contractor
  - Start-up and time to achieve steady-state





G3P3-USA
National Solar Thermal Test Facility (NSTTF), Albuquerque, NM



Acknowledgments

- This work is funded in part or whole by the U.S. Department of Energy Solar Energy Technologies Office under Award Number 34211
  - DOE Project Managers: Matthew Bauer, Shane Powers, Vijay Rajgopal, Levi Irwin, Andru Prescod, Mark Lausten, Avi Shultz

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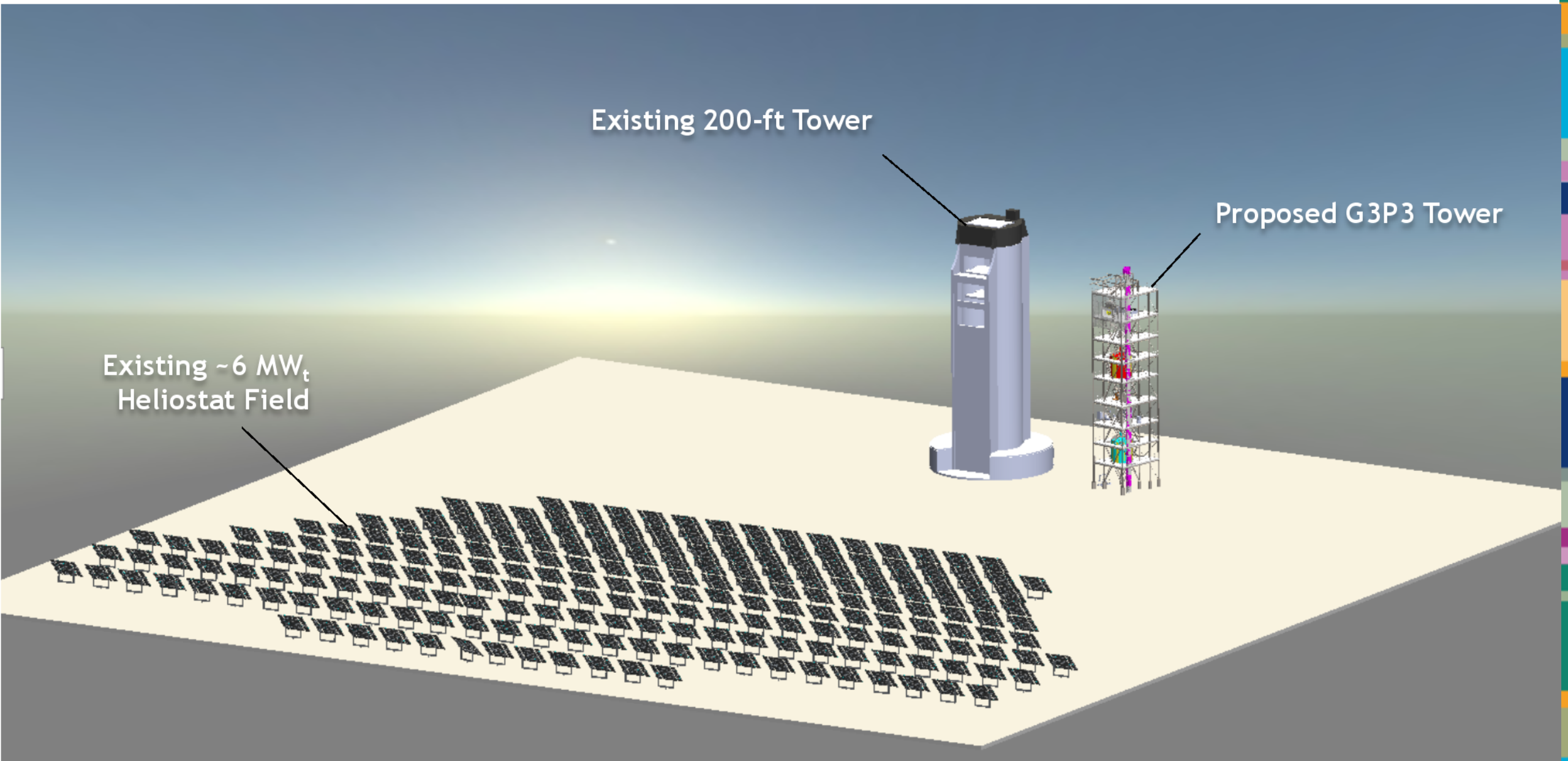
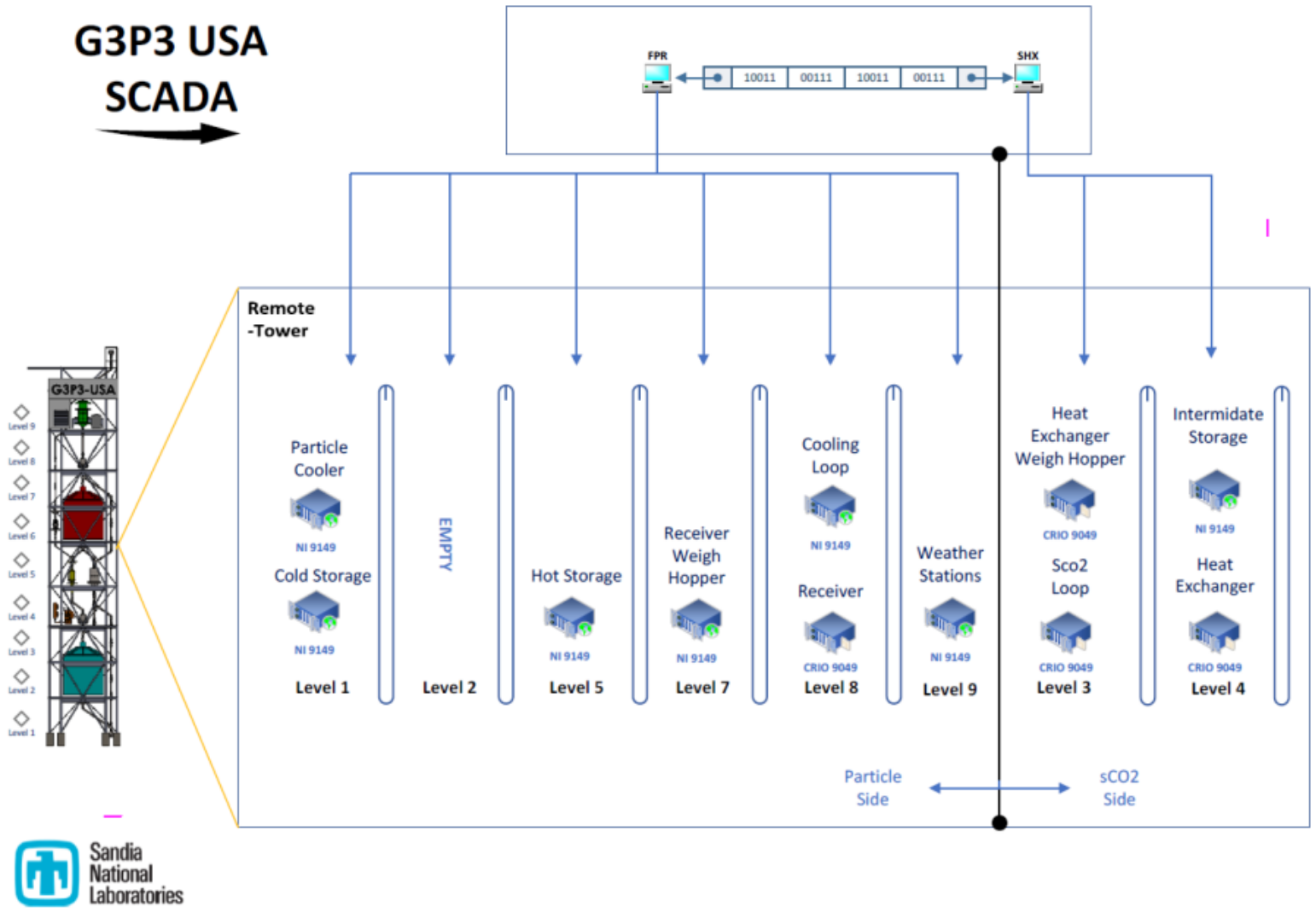
National Solar Thermal Test Facility (NSTTF), Albuquerque, NM



Backup Slides

G3P3 Tower Data Architecture and Acquisition

- G3P3 SCADA framework has been completed
  - Two independent but linked control systems, the particle loop (FPR) and sCO_2 loop (SHX)
  - Subsystems were assigned to a node at which the data is gathered and control signals are provided
- The lead for each node will provide instrumentation needs



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G3P3 Tower Data Architecture and Acquisition

- National Instruments (NI) cRIO 9049 and NI 9149 devices were procured ahead of schedule
  - Both devices gather data and provide control signals
  - cRIO chassis can provide real time control locally
  - NI 9149 chassis provide remote control

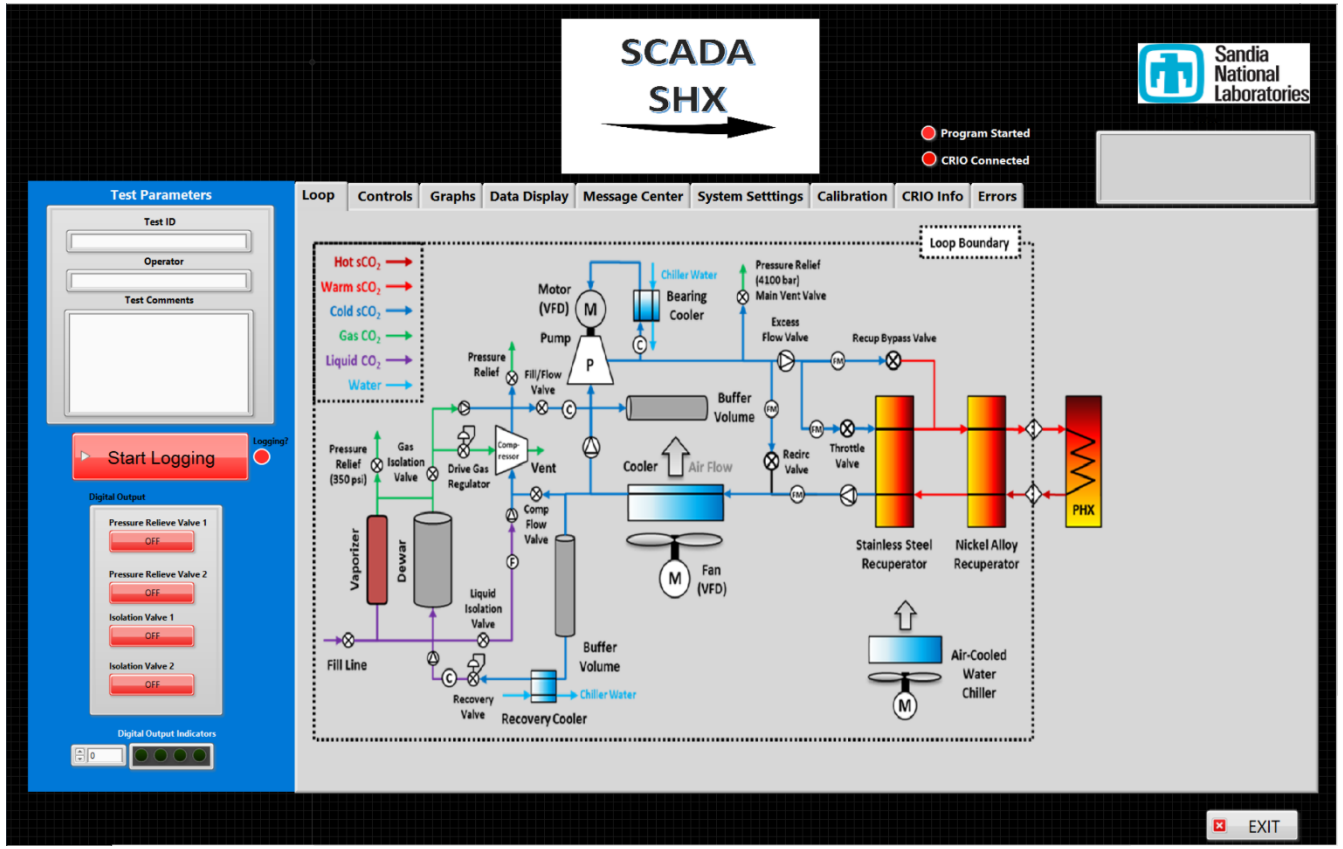
NI cRIO 9049[1]

NI 9149[1]

- The cRIO 9049 and NI 9149 chassis will arrive in Q2

[1] https://www.ni.com/en-us/shop/hardware/products

G3P3 Tower Data Architecture and Acquisition



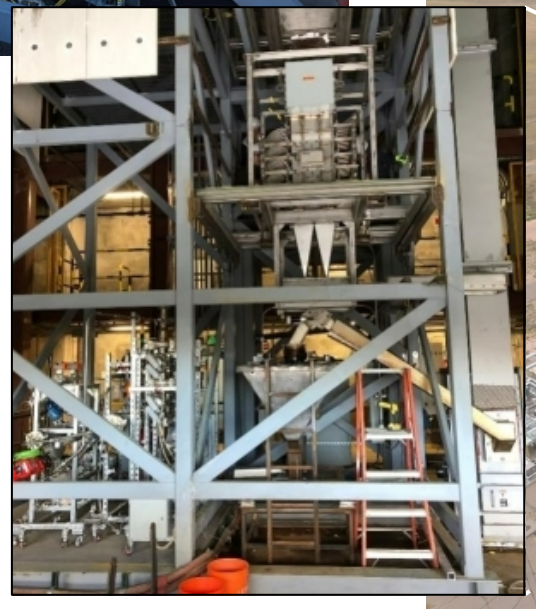
- sCO_2 loop cRIO code was written and is currently being tested
  - cRIO devices require internal logic to acquire data and autonomously enact controls
  - sCO_2 loop code architecture will be deployed on the remaining cRIOs

- Subcomponent instrumentation will be finalized and procured in Q2
  - G3P3 FPR software will begin development upon component arrival

High-T, High-P Particle-to-sCO2 Heat Exchanger

100 kW particle-to-sCO2 heat exchanger

~100 kW sCO2 flow loop



Integration of heat exchanger and sCO2 flow loop in tower

On-sun testing of integrated system with falling particle receiver