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Dynamic and Fluid Structural Analysis Modeling of Solar One's Heliostat Field Using High Performance Computing

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Overview

- Introduction
- Dynamic Analysis
- Fluid Structural Interaction
- Why High Performance Computing?
- Questions

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Introduction and Motivation

Central receiver power tower heliostat optical performance

PS10 and PS20 Solar Power Towers in Andalucia, Spain

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Introduction, FEA Model

- The finite element model of the heliostat contains approximately 2.3 million elements.
- It is run on the cluster Glory with 192 processors.
- An Eigen analysis with 20 modes runs in approximately 120 minutes. Gravity deformations take approximately 5 minutes to run.

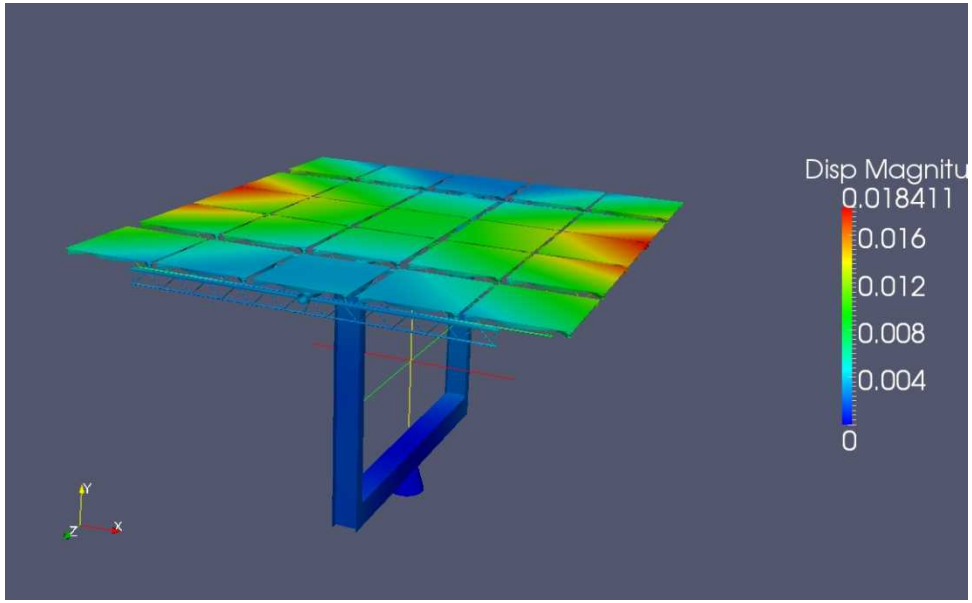

Image of the heliostat under a gravity deformation analysis

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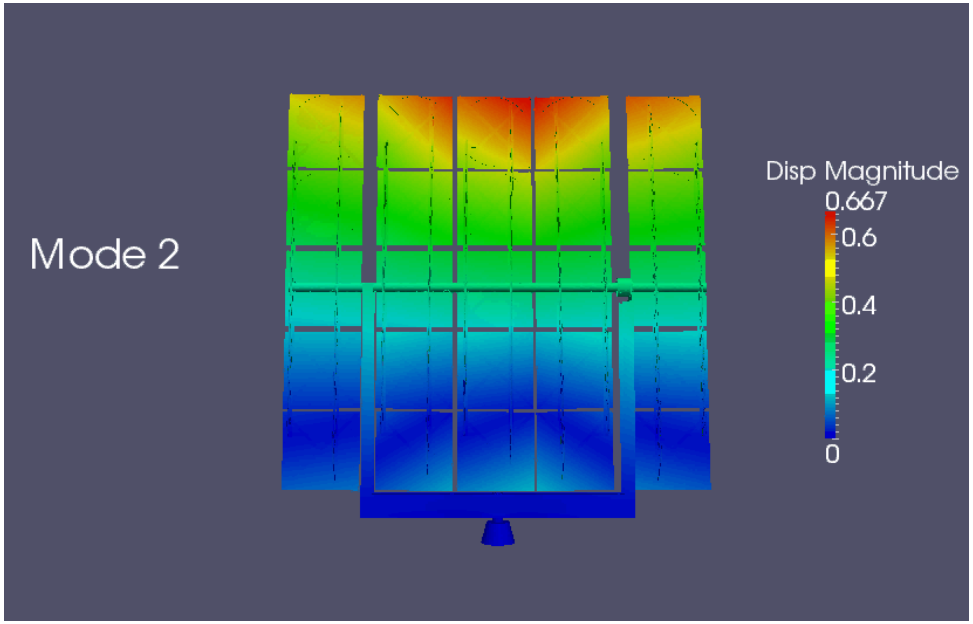
Dynamic Analysis

Heliostat optical performance is coupled with the intrinsic dynamic response of the structure as well as other external loadings.



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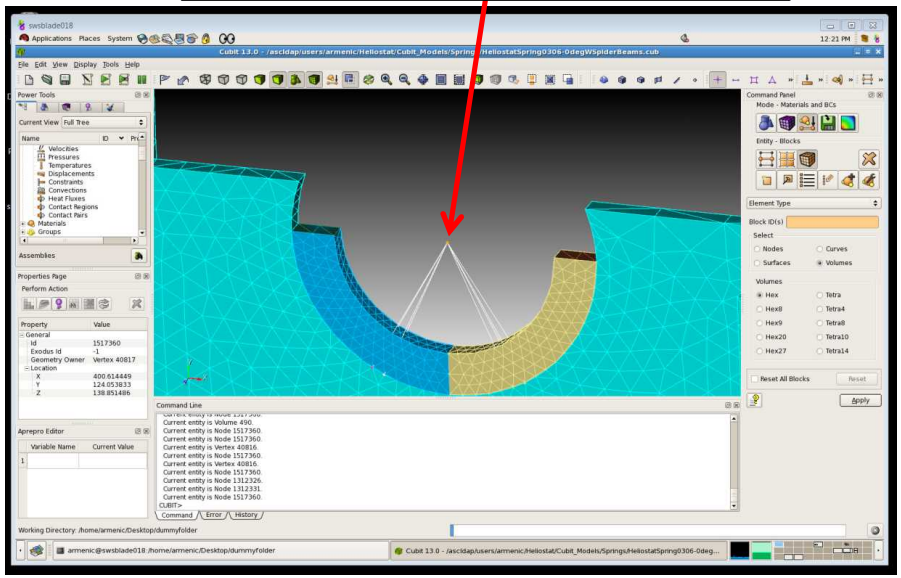
Dynamic Analysis

Improvements have been made to the heliostat model to more accurately account for the dynamic response of the structure.

Spring joints modeling the heliostat rollers



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Dynamic Analysis

- Dynamic results are improving with each iteration of the model. An acceptable target for matching the mode shapes of our Eigen Analysis to measured results is 5 – 10% error.

- Static deformation loadings should also meet this criteria before proceeding to the Fluid Structural (wind) interaction.

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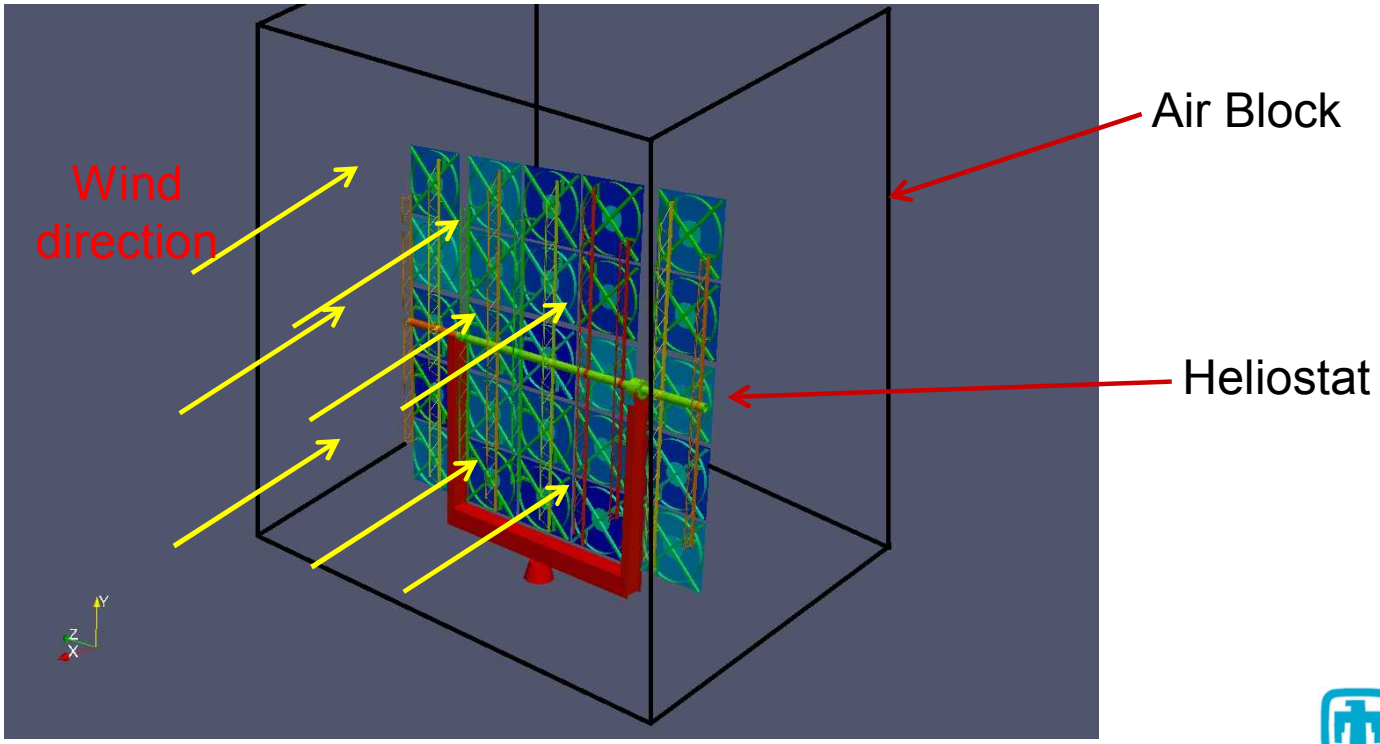
Fluid Structural (Wind) Analysis

The path forward on this project is to mesh the air around the outside of the heliostat and perform a wind loading analysis at various velocities and heliostat orientations.



Fluid Structural (Wind) Analysis

- This wind analysis will be done in Aria and coupled to the structural program Adagio.
- The results of the deformation of the heliostat will be output to a ray tracing program. This will allow for an optical reflectance analysis of the error that the wind imparts on the Power Tower system.

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Why High Performance Computing?

- **Many processors (on the order of hundreds) allow for scaling to extreme fidelity in the modeling process.**

- **Simulation work thus far typically has models that are simplified to under 1,000,000 elements.**

Figure of simplified heliostat taken from “Wind Pressure and Wind-Induced Vibration of Heliostat” by Wang, Li, Gong and Li 2008

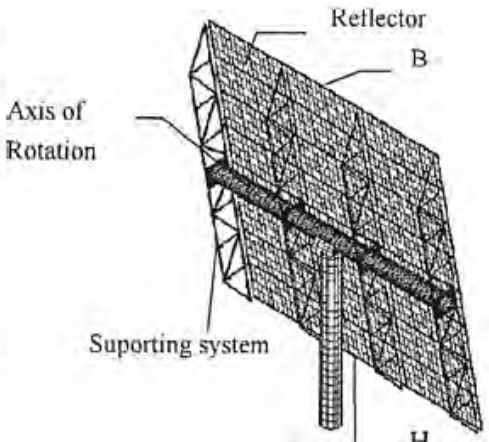

Fig.6 The Finite Element Model of Heliostat

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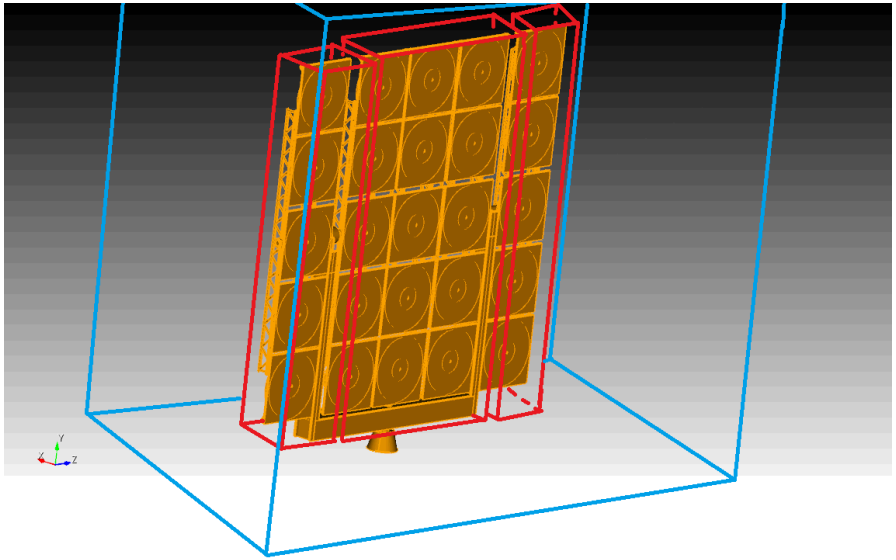
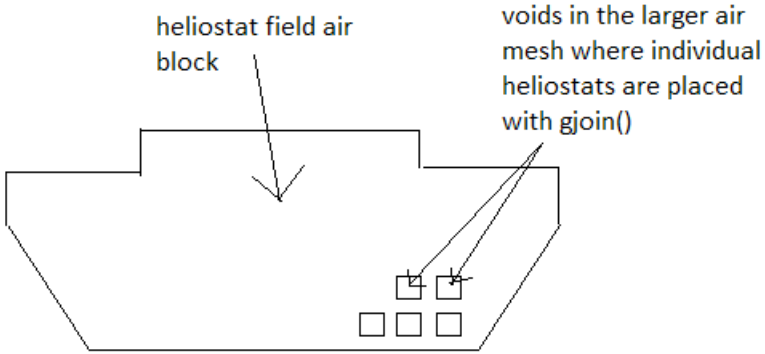
Why High Performance Computing?

Many processors (on the order of hundreds of thousands) allow for scaling to extreme fidelity in the modeling process of the heliostat as well as heliostat field.





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Why High Performance Computing?

How many processors is it going to take?

Assume since one Eigen analysis requires ~200 processors (in 2 hrs) to run, with the air block, I will need ~500 processors/heliostat.

**~ 500 proc/heliostat *
~ 200 heliostat-blocks =
~ 60,000 processors**

cielo
NNSA New Mexico Alliance for Computing at Extreme Scale

Cielo By Numbers

	Phase 1	Phase 2	Cielito
# of Cabinets	72	96	1
# of Service Nodes	208	272	14
# of Compute Nodes	6,704*	8,944*	68
# of Visualization Nodes	(376)	(376)	(4)
# of Compute Cores	107,264	143,104	1,088
Peak Memory BW	572 TB/s	763 TB/s	5.8 TB/s
Memory Capacity per Core	2 GB (4 GB)	2 GB (4 GB)	2 GB (4 GB)
Compute Memory Capacity	226.6 TB	298.2 TB	2.3 TB
Peak Compute FLOPS	1.03 PF	1.37 PF	10.4 TF
Sustained PFS BW	> 160 GB/s		TBD
System Power	< 3.9 MW	< 4.4 MW	
Full System Job MTBI	> 25 hours		
System MTBI	> 200 hours		

* Total compute nodes including Viz nodes and nodes allocated for other services

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