

# Agile Deflectometry

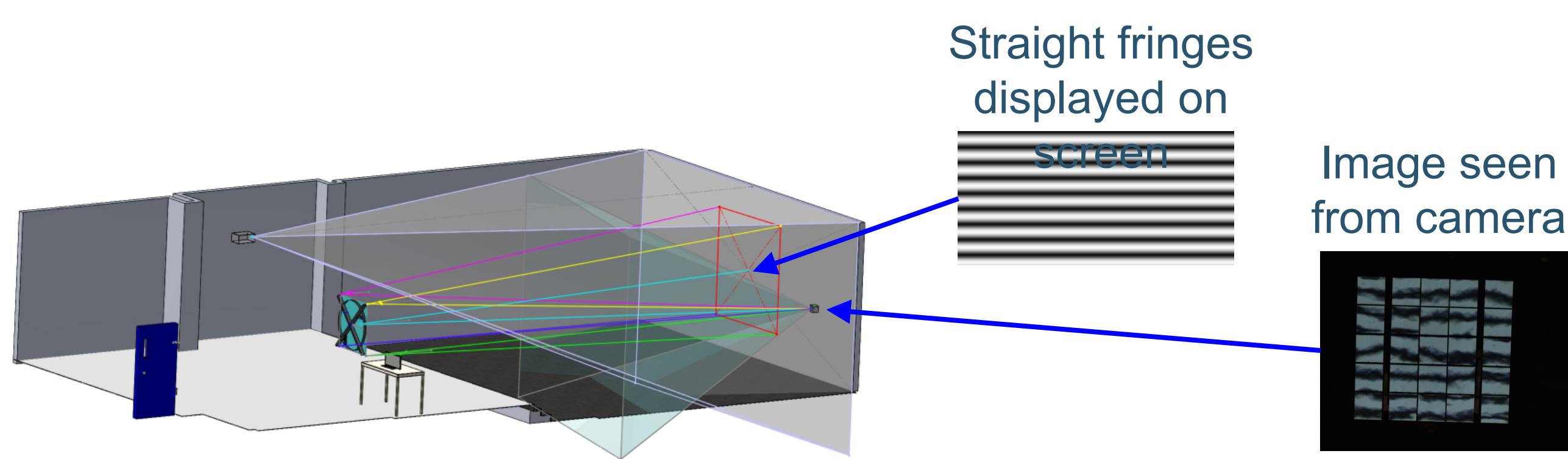
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## Introduction

Deflectometry is an optical metrology method to measure surface slope maps of mirrors. Deflectometry can be used in Concentrating Solar Power (CSP) to support: mirror design, high-volume manufacturing, solar field assessment, and education. With flexible code, deflectometry systems can adapt to a wide range of problems. Sandia's deflectometry system, called SOFAST, recently underwent significant improvements to make it more flexible, easy to use, and versatile.

## Deflectometry Principle of Operation

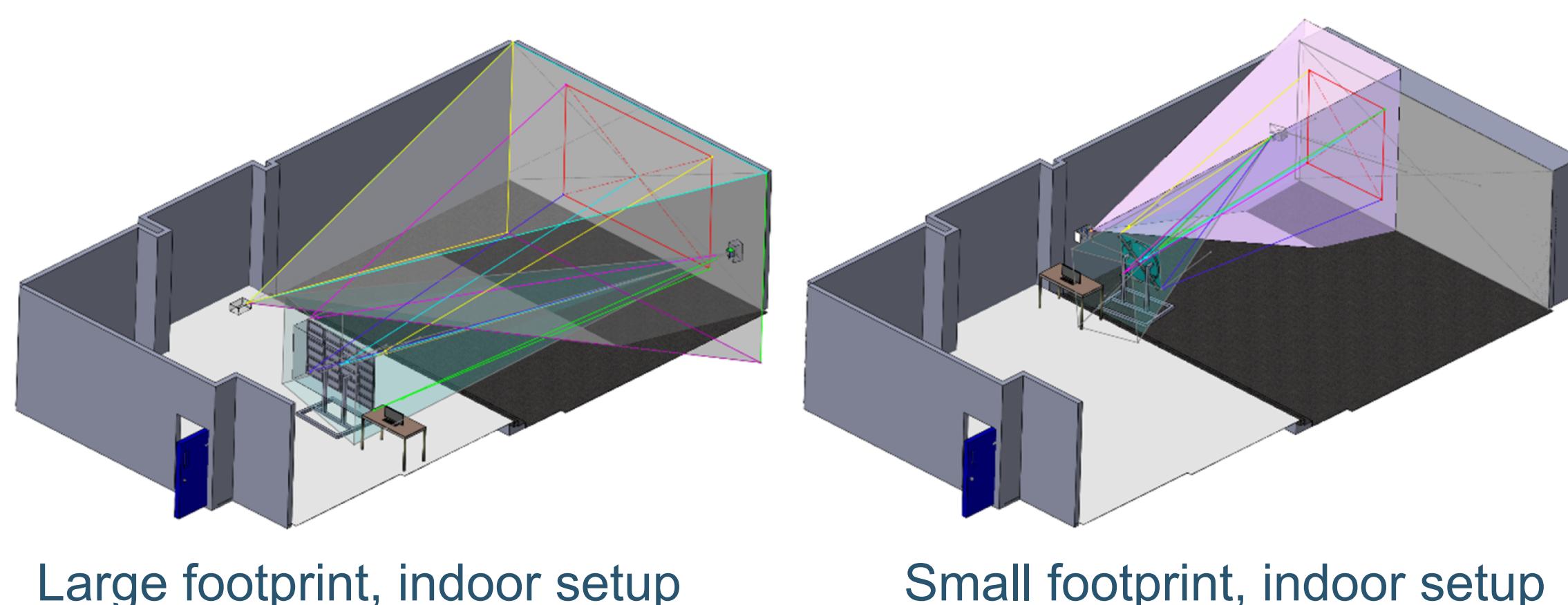
A camera captures displayed fringes in reflection of the CSP mirror. Curvature in the mirror is seen as distortion of the straight fringes.



## Improvements Made to Sandia's Deflectometry Tool

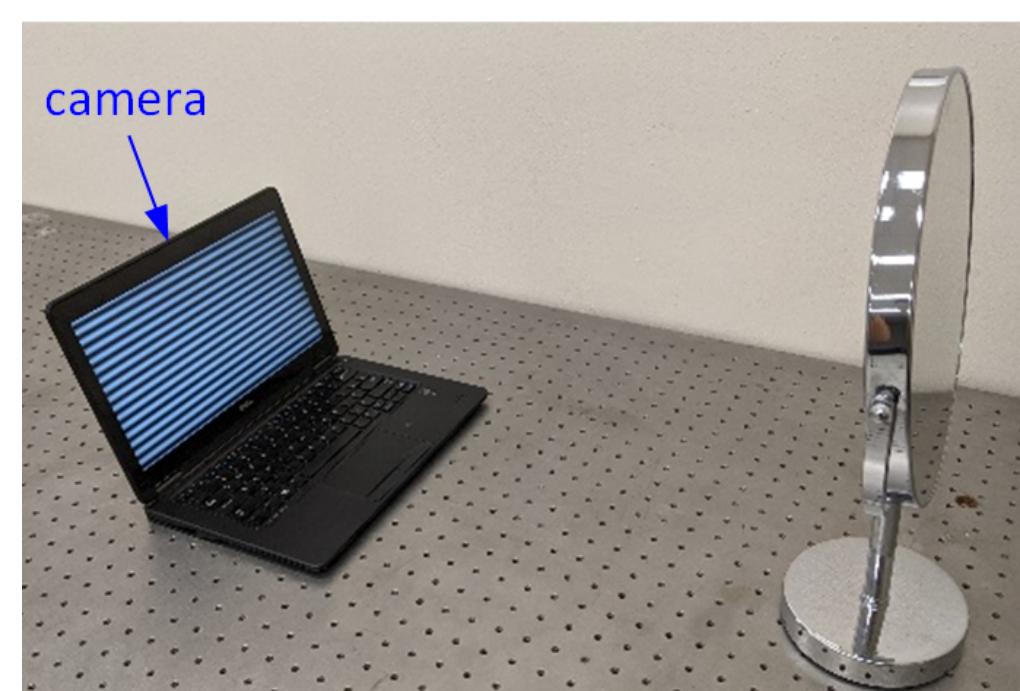
### CAD Layout Tool

SOFAST setups have strict geometrical constraints. We developed an accompanying SolidWorks layout tool to allow users to easily design new SOFAST setups.

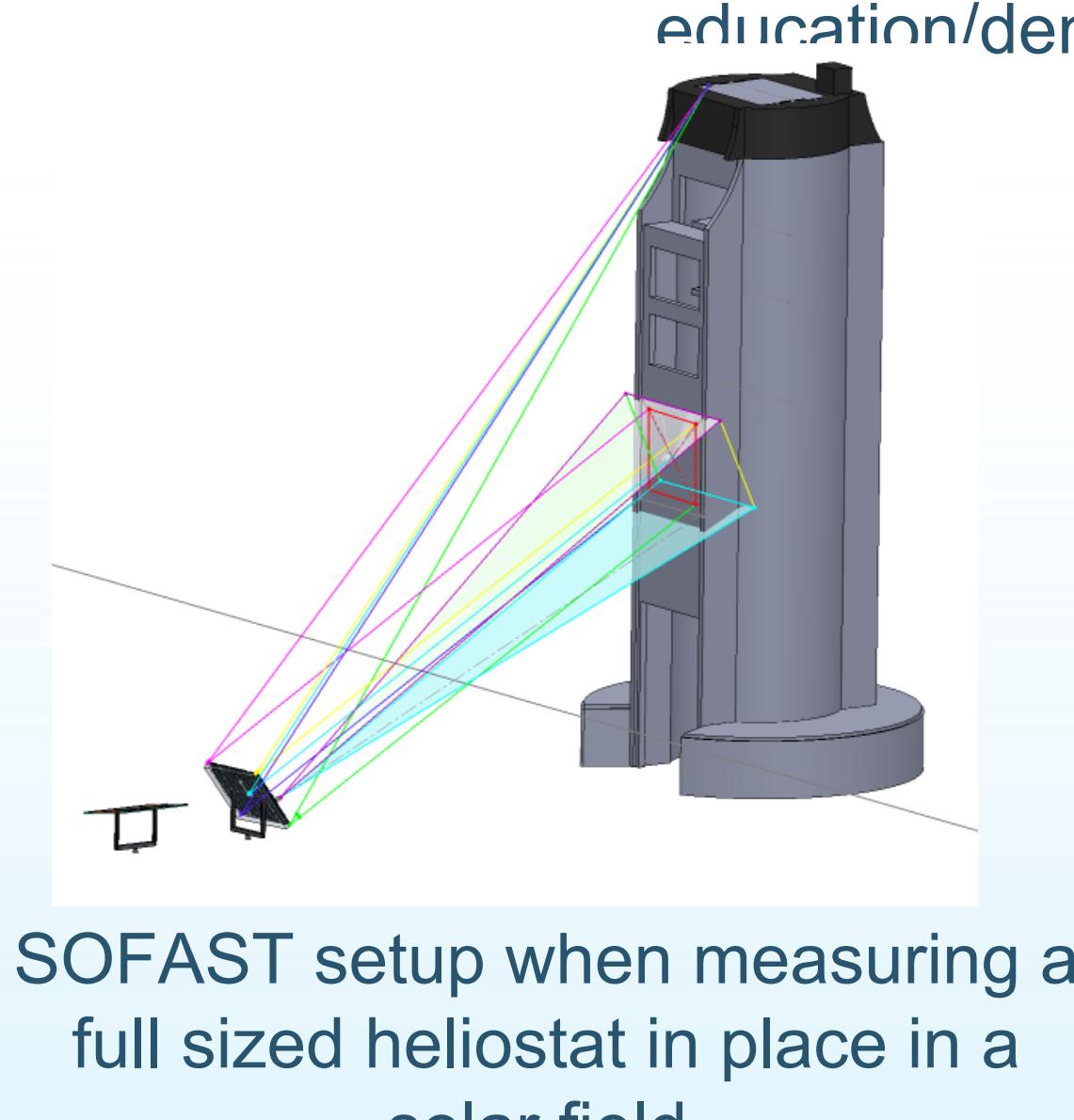
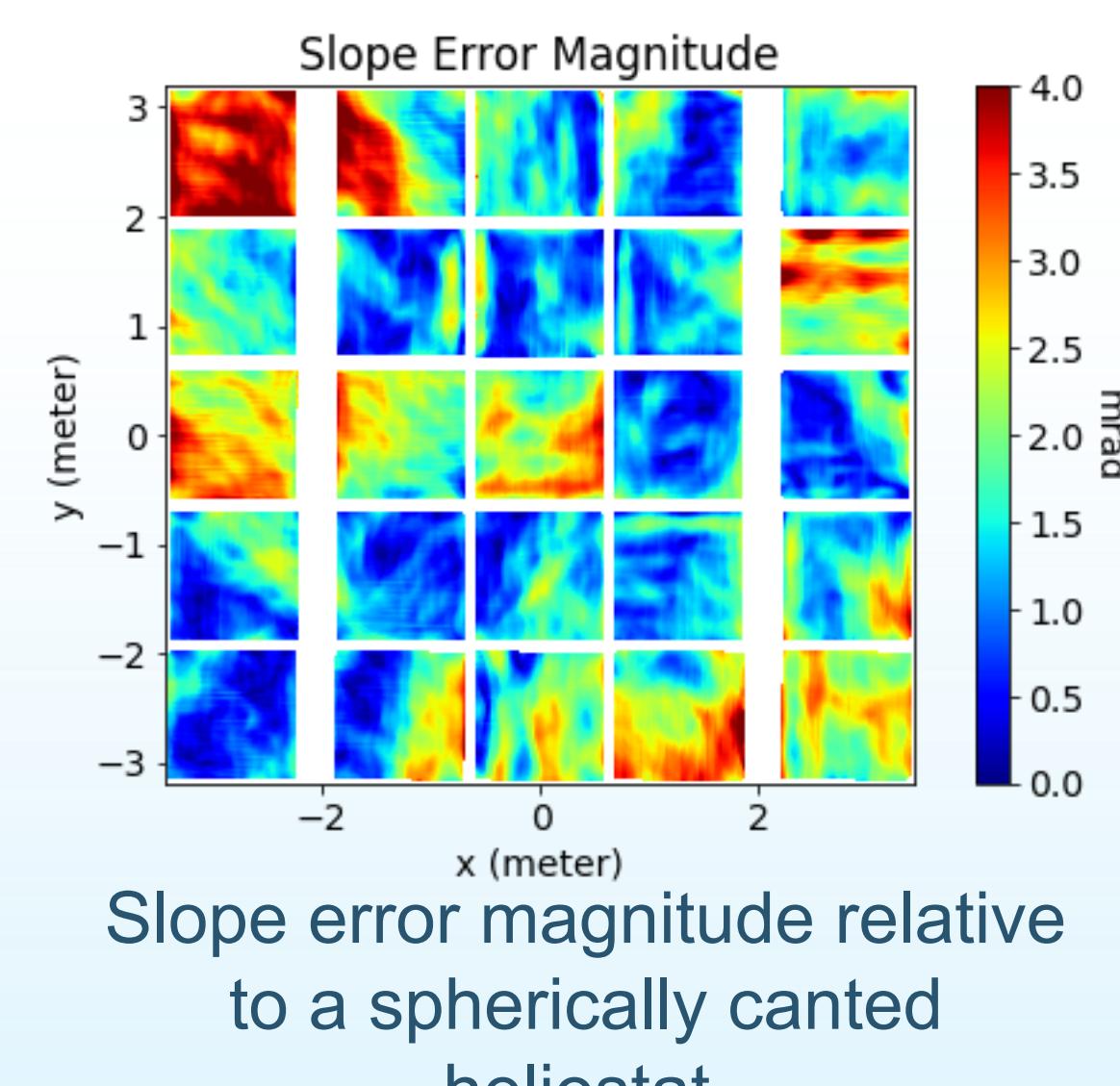
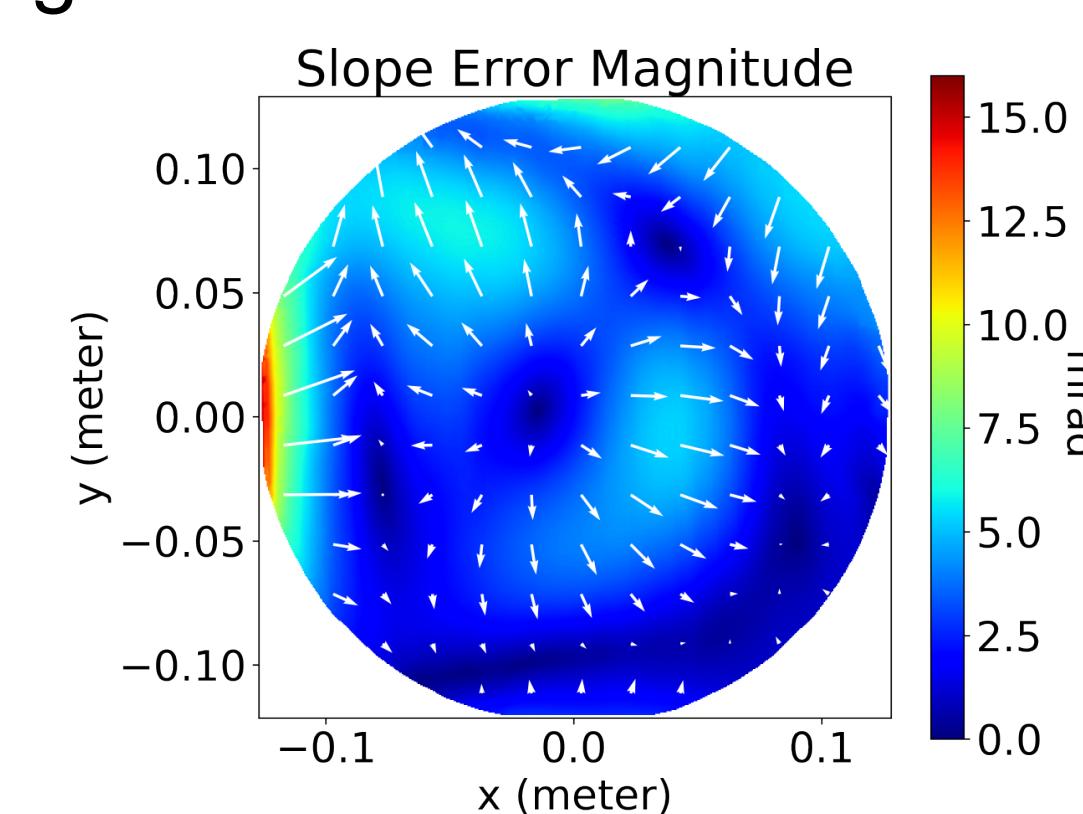


### Scalability

SOFAST systems have been demonstrated across a wide range of scales. We have measured mirrors 0.13m wide with a small laptop setup and full heliostats 9.3m wide using the side of a solar tower as a screen.



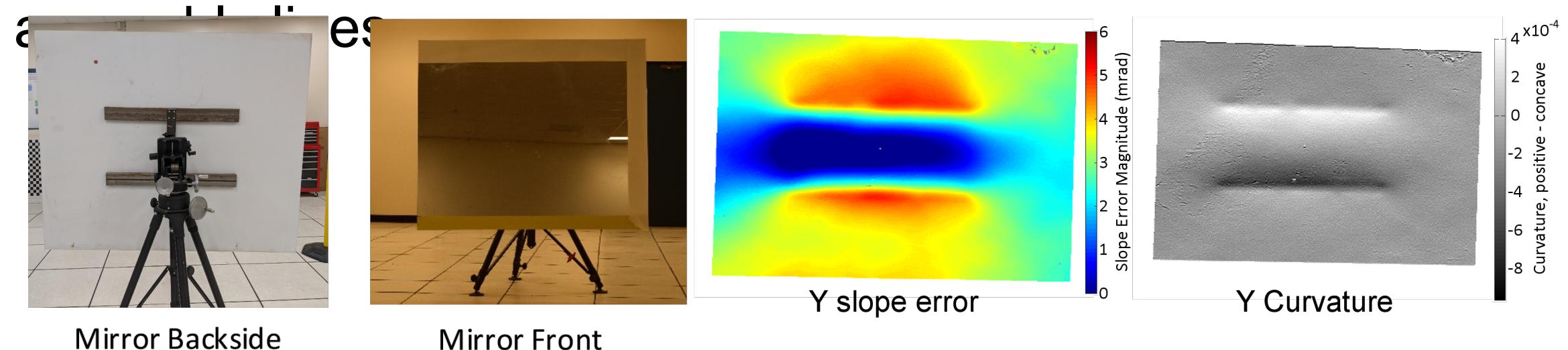
Benchtop SOFAST setups are easy to set up and ideal for education/demonstrations.



Add Sand Number to the funding statement

## Prototype Diagnosis

Deflectometry's quick feedback is especially useful when prototyping new mirror designs or for quality control in factory applications.

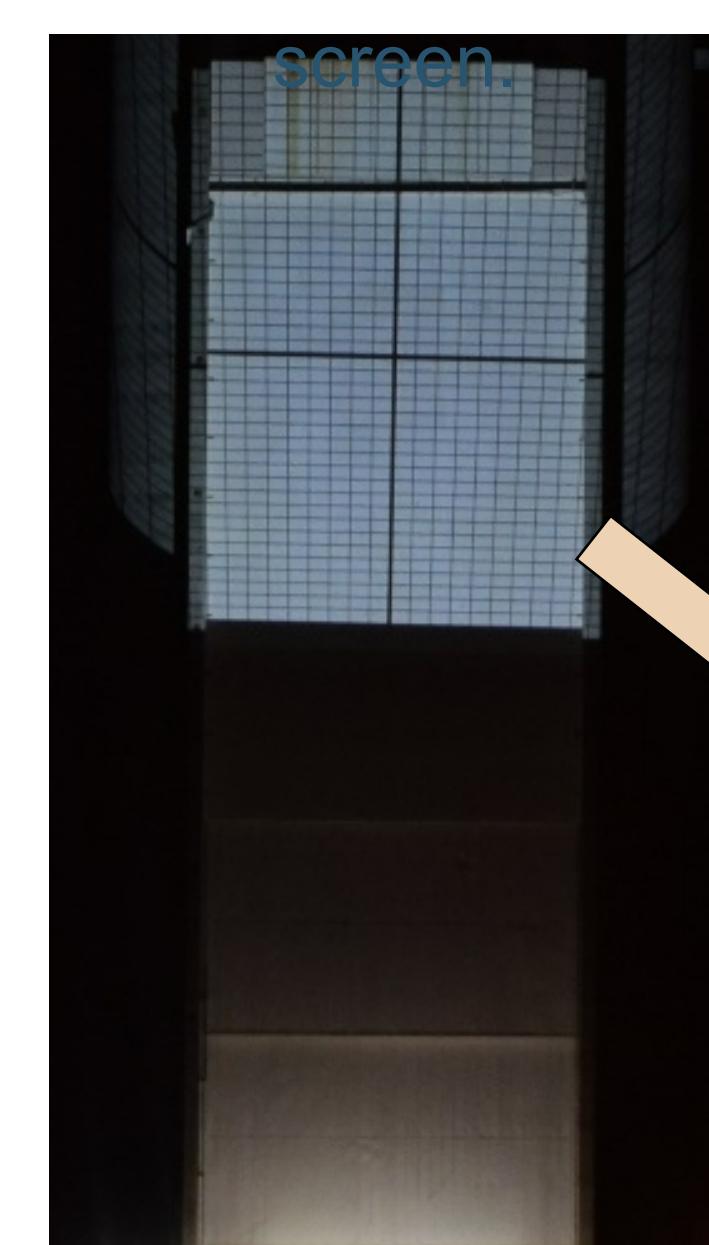


A "print-through" artifact of a mirror's support structure shows up in a SOFAST measurement.

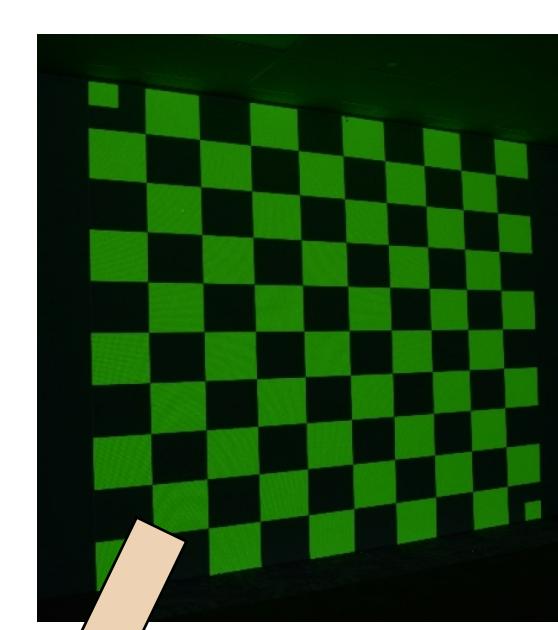
## Calibration

We developed a photogrammetric screen calibration tool. This tool can calibrate SOFAST displays quickly and can perform calibrations on displays in inaccessible locations.

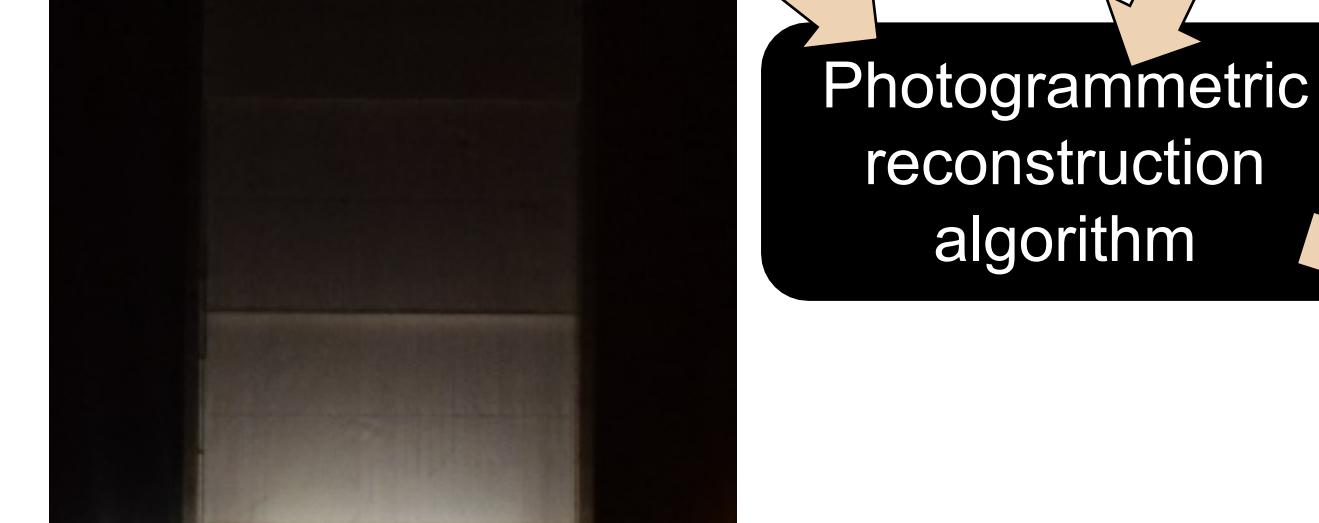
Calibrating the side of a solar tower used as a screen



Quickly calibrating a screen inside a laboratory



Photogrammetric reconstruction algorithm

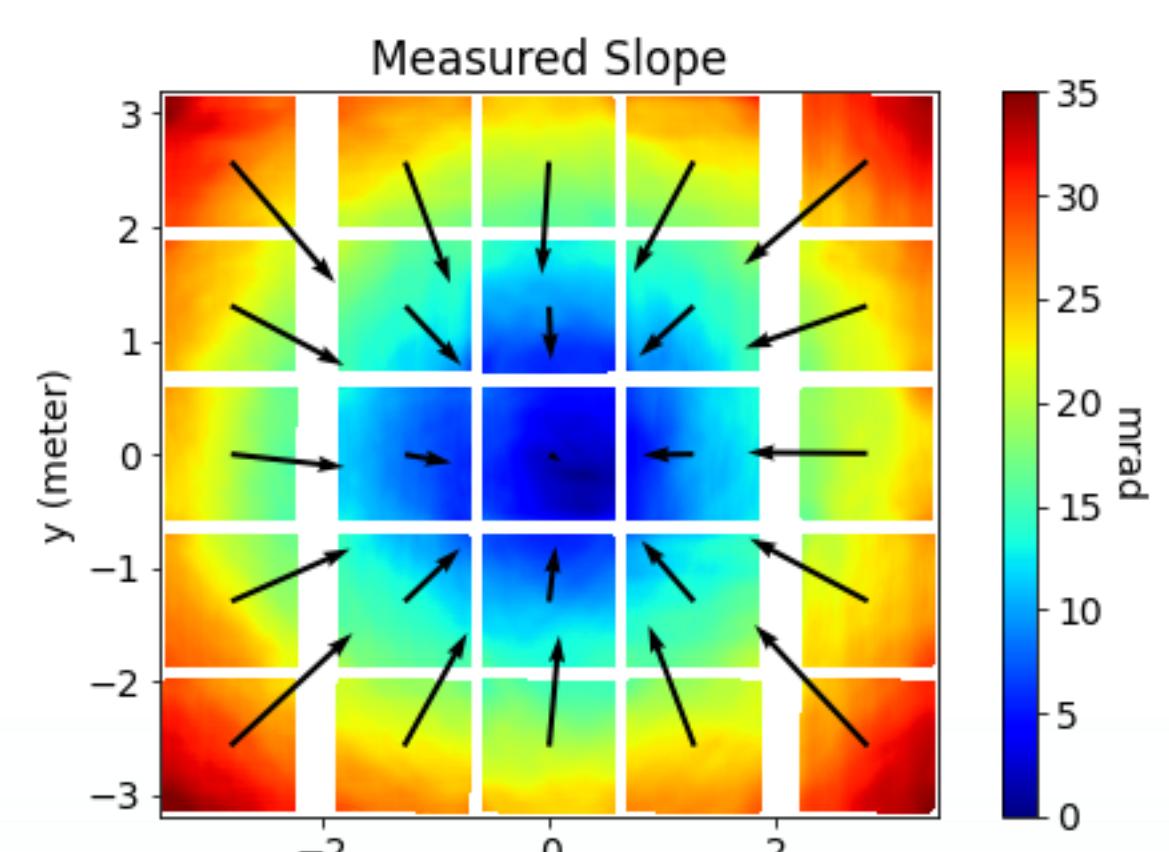


## Multi-Facet Measurements

SOFAST can measure single mirror facets, and also multi-faceted heliostats. Below is an orthorectified image of measured slope and canting angles of a 25 facet heliostat.



Multifacet heliostat measured by SOFAST



Measured slope magnitude with arrows showing facet canting.

## Discussion

Deflectometry tools for CSP need to be versatile and easy to set up and configure. Recent developments to the Sandia deflectometry tool, SOFAST, have significantly increased the extensibility of the tool, both in ease of setup and scale of measurement systems.