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The Development of the Heliostat Focusing and Canting Enhancement Technique

An Optical Heliostat Alignment Tool for the National Solar Thermal Test Facility

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Sandia National Laboratories

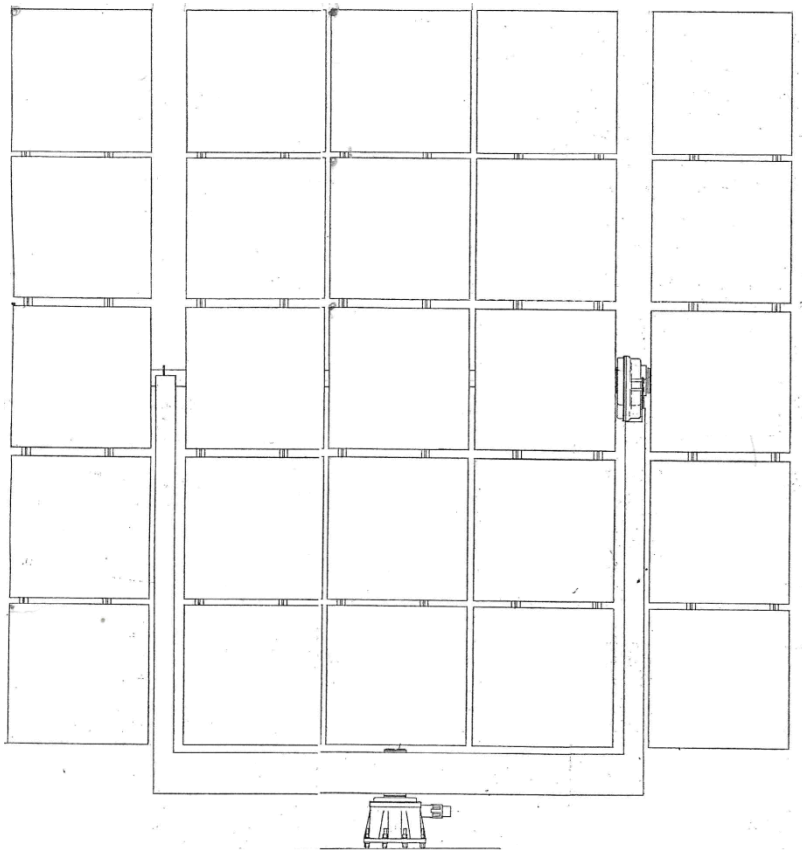
Outline

- Project Background
- Heliostat Alignment Motivation
- 3 Stages of H-FACET
  - Video Acquisition
  - Processing
  - Alignment
- Results
- Ongoing Work

Research Power Tower at Test Facility

- 222 heliostats
- Can generate about 5 MWt of power
- 200’ central tower receiver

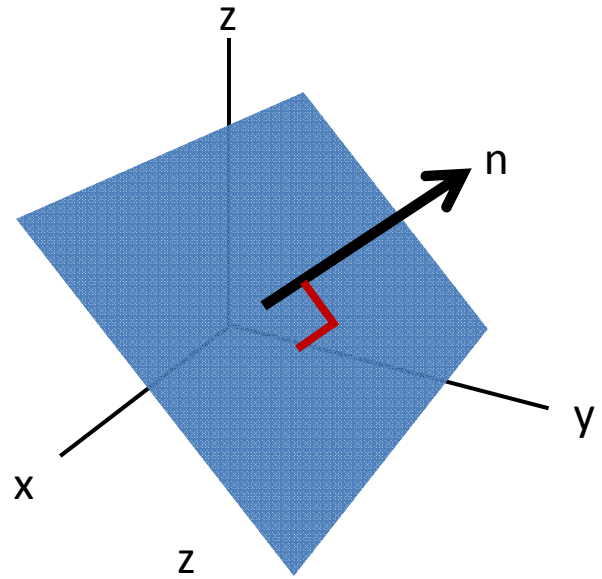
Test Facility Heliostats



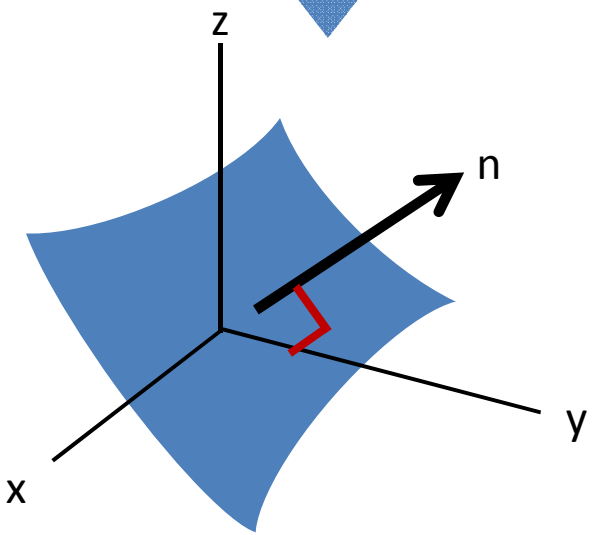
- Each heliostat contains 25 mirror facets
- Facets can be flat or curved
- Each facet must be individually aligned
- Alignment carried out by adjusting bolts on the back of each facet

Facet Alignment

- Canting
  - 3-D orientation of the facet



- Focusing
  - Paraboloidal curvature of the mirror



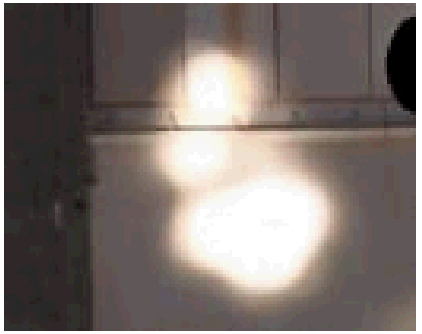
Previous Alignment Methods

- On-sun manual alignment
- Mechanical measurement
  - Gauge blocks, inclinometers
- Optical methods
  - Fringe reflection, photogrammetry, camera look-back, collimated laser beam
- Most methods are labor intensive and/or not useful for in-field alignment

Motivation

- The test facility's heliostats vary in alignment quality

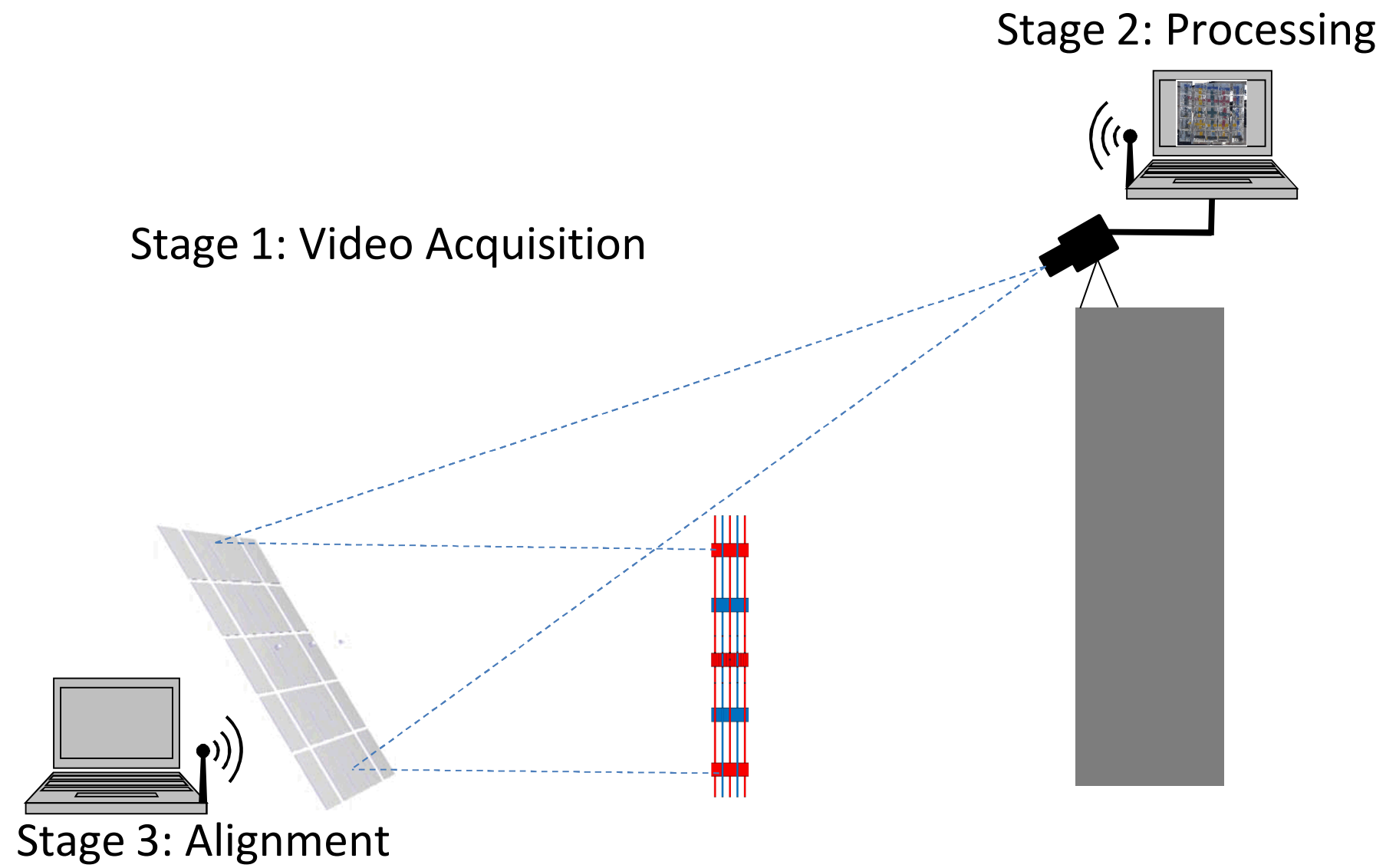
- There is a need for an optical alignment tool that is:
  - Capable of producing desired beam shapes
  - Suitable for in-field alignments
  - Fast



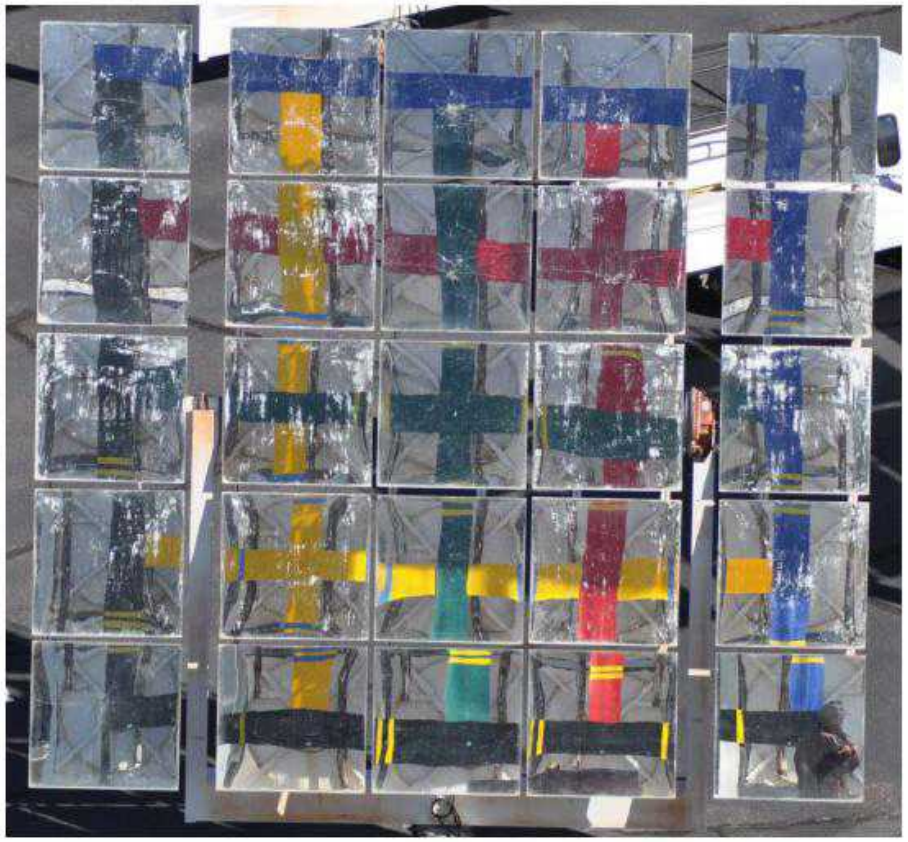
Poorly aligned beam at NSTTF

Desired beam

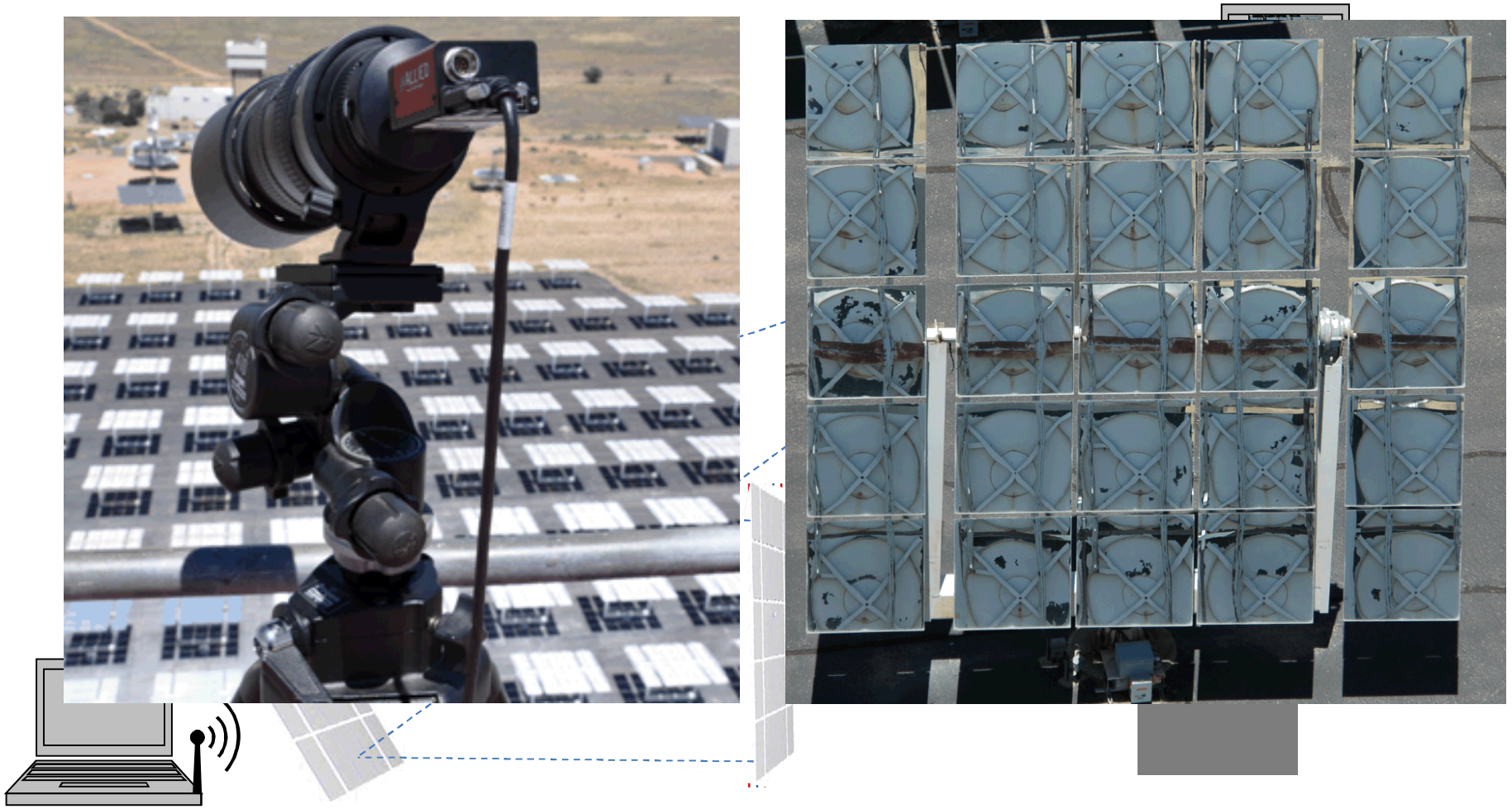
Heliostat Focusing and Canting Enhancement Technique



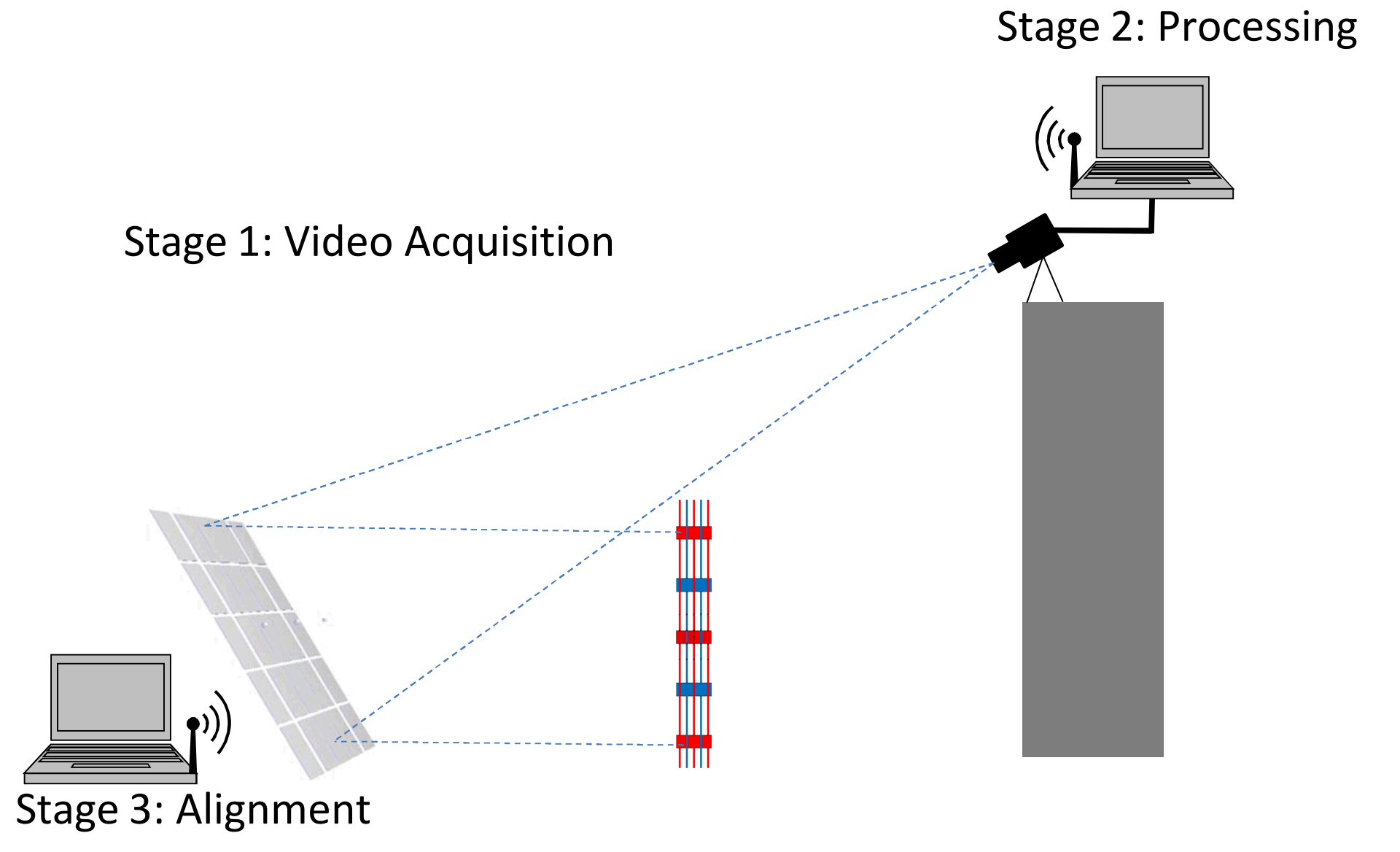
Stage 1: Video Acquisition



Stage 1: Video Acquisition

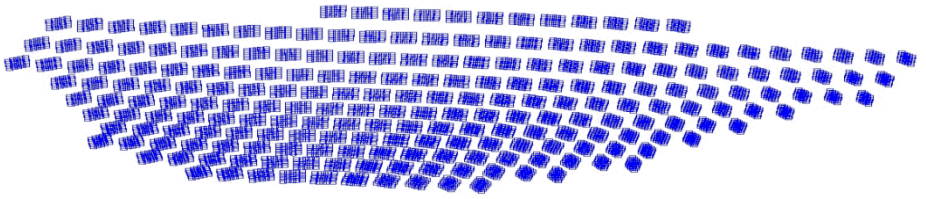


Heliostat Focusing and Canting Enhancement Technique



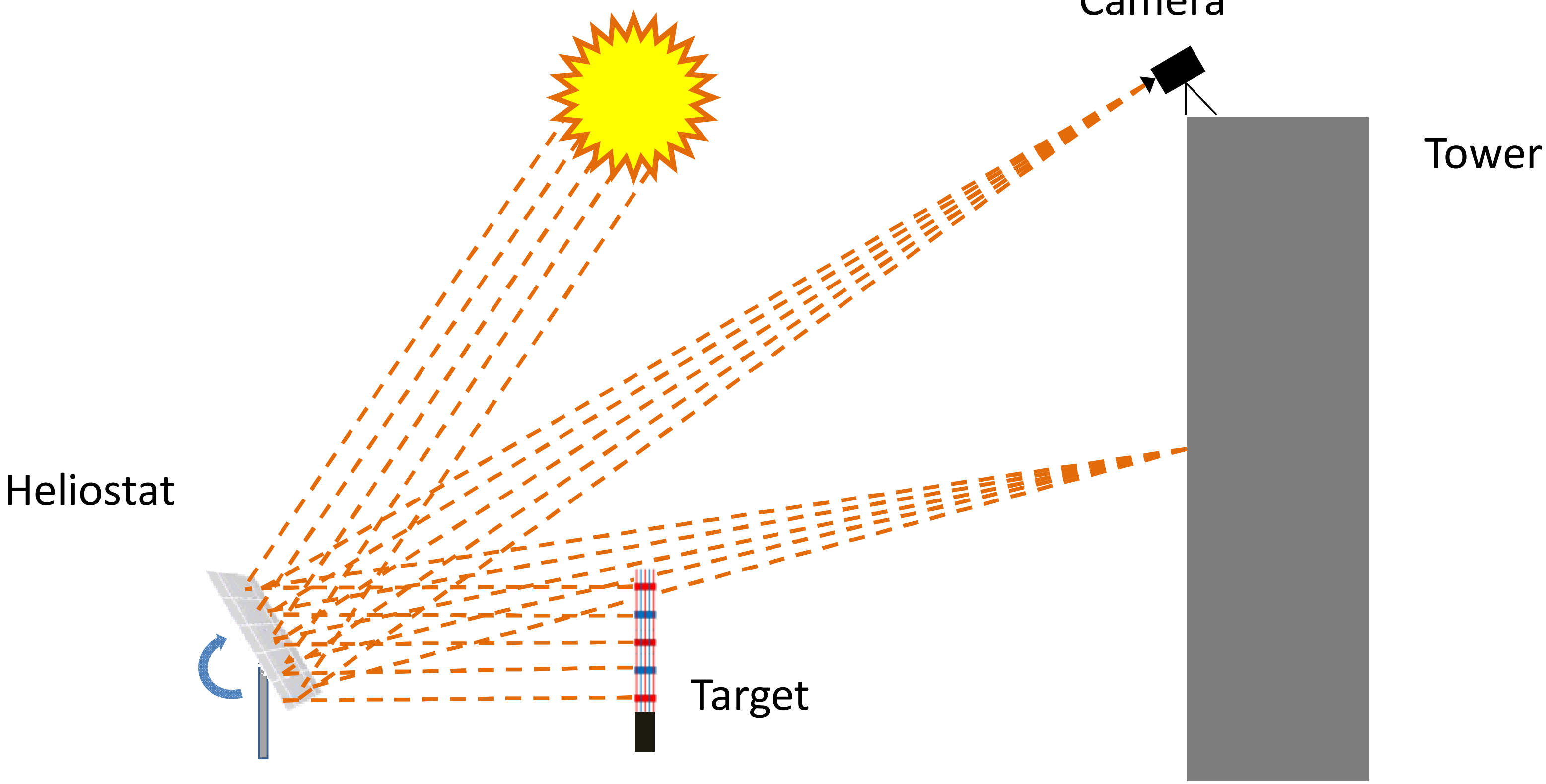
Stage 2: Processing

- MATLAB software calculates and displays how the reflected target should appear on an ideally shaped heliostat
- Software uses a virtual heliostat field for calculations
  - Key positions of heliostats, sun, aimpoint implemented in code



Stage 2: Processing

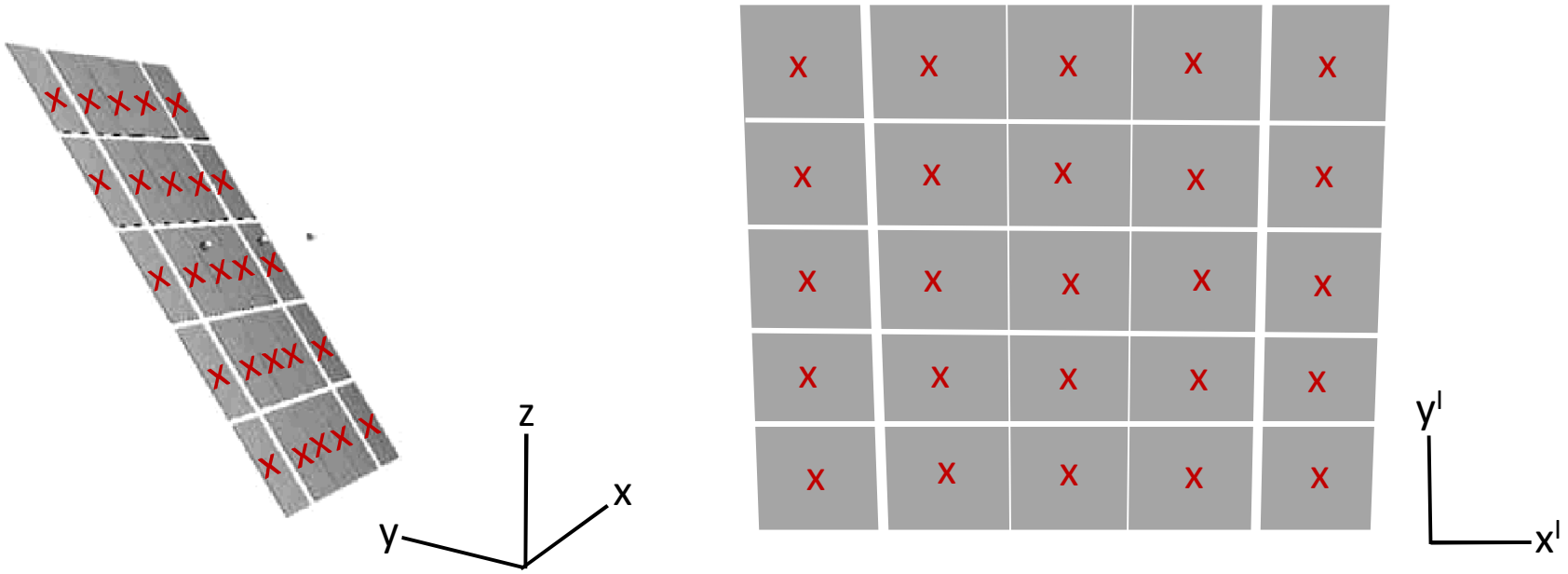
- Ideal heliostat alignment determines ideal reflection shape for reflection points are calculated
- On-board off-axis orientation into target reflection compared theoretical to tower



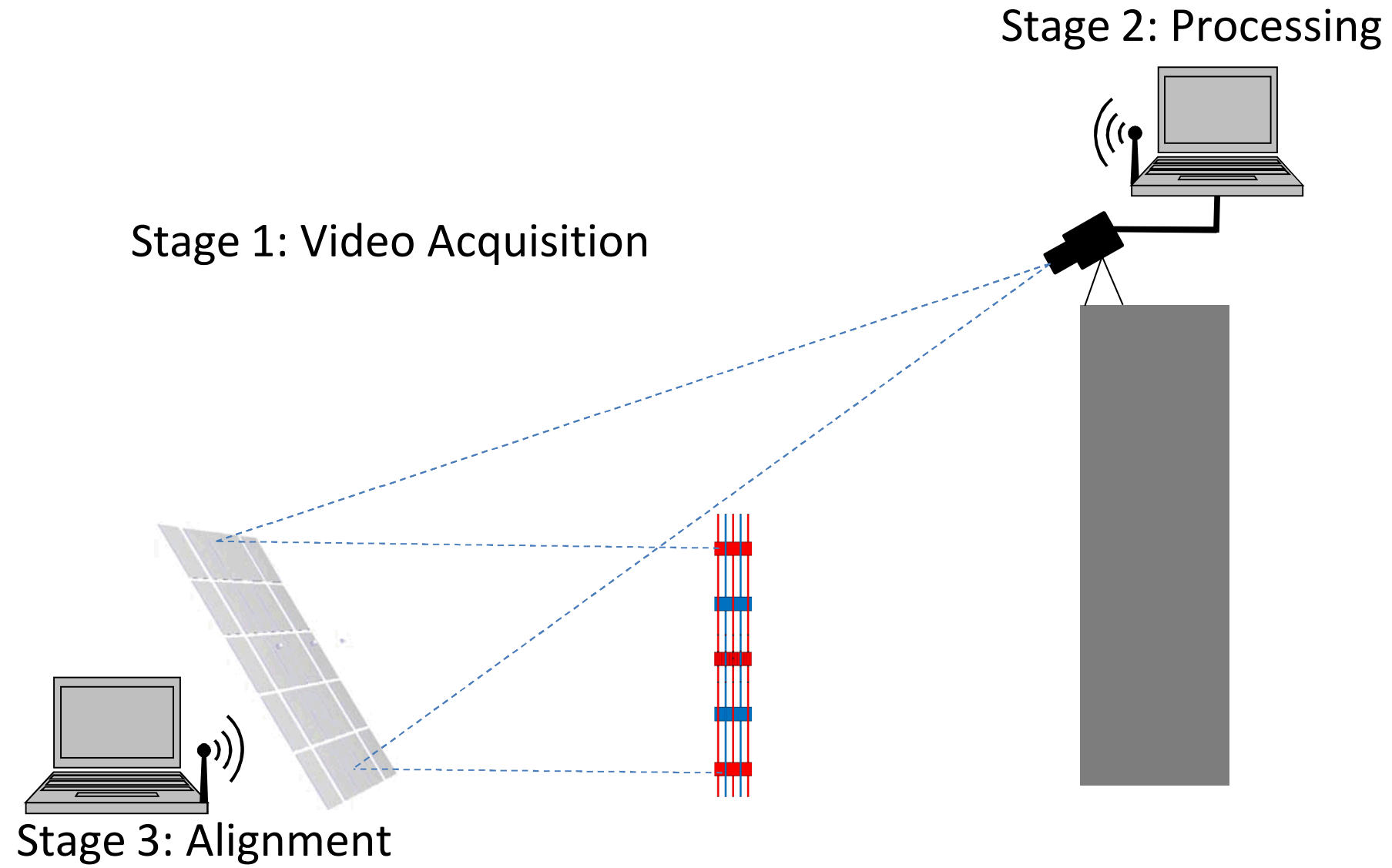
Heliostat in target alignment
On-board off-axis reflected to

Stage 2: Processing

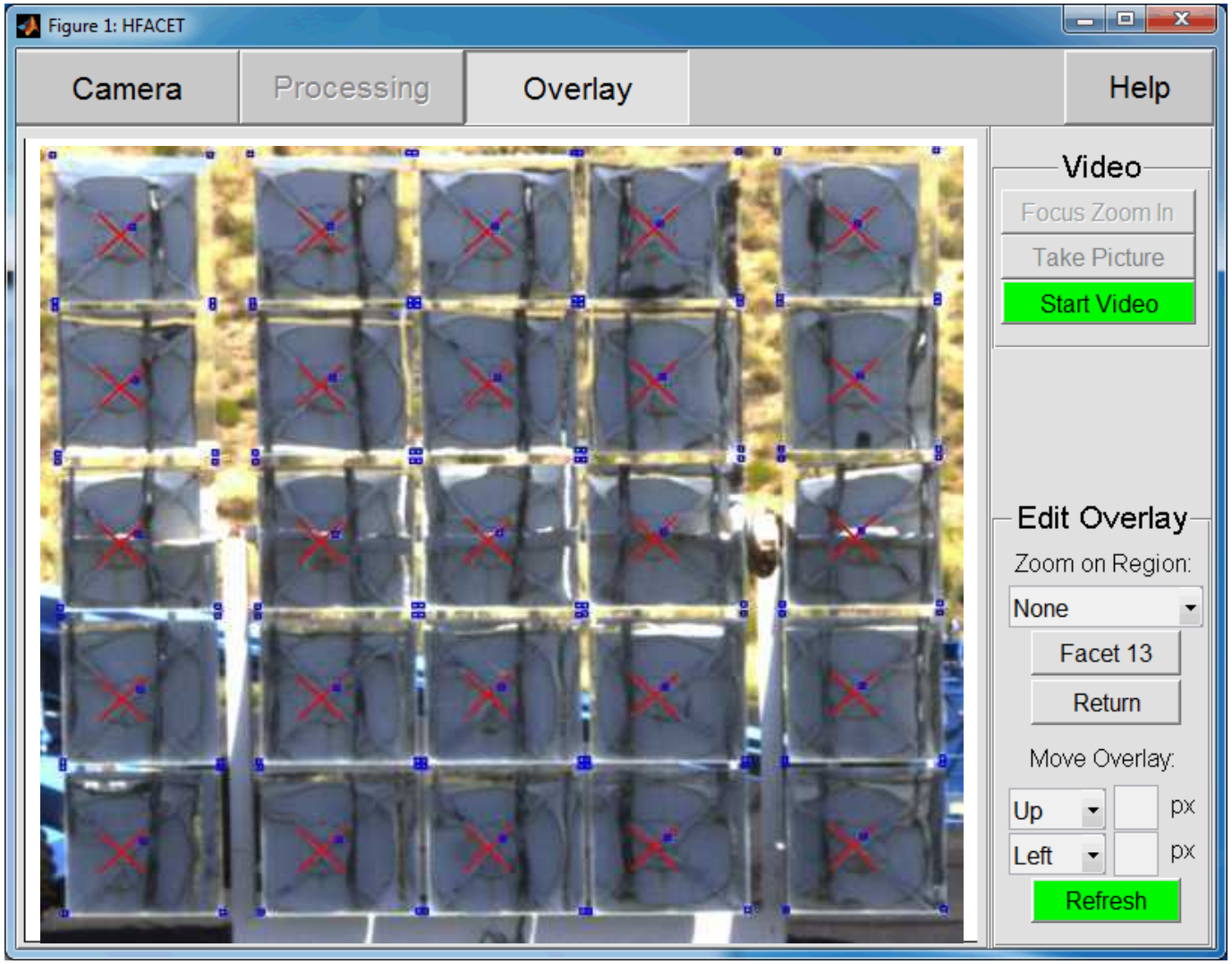
- Locations of ideal reflection found in 3D
- Locations must be appropriately transformed and overlaid onto acquired 2D camera video



Heliostat Focusing and Canting Enhancement Technique



Stage 3: Alignment



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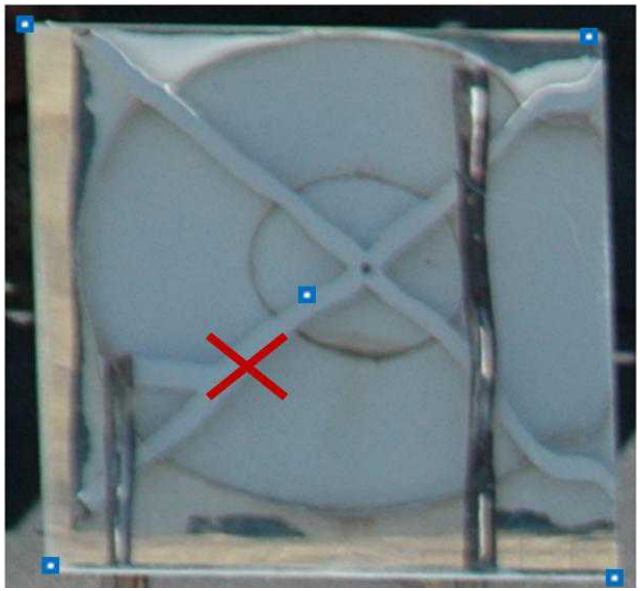
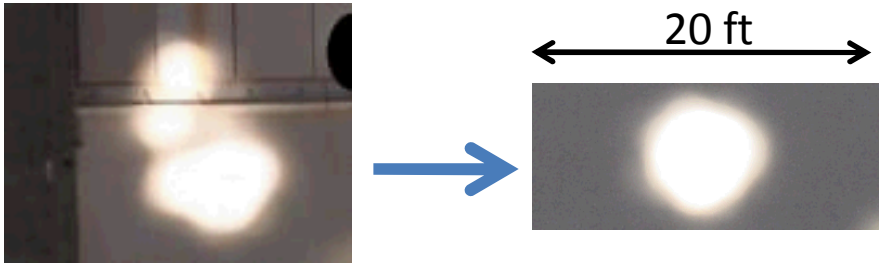


Poorly canted facet

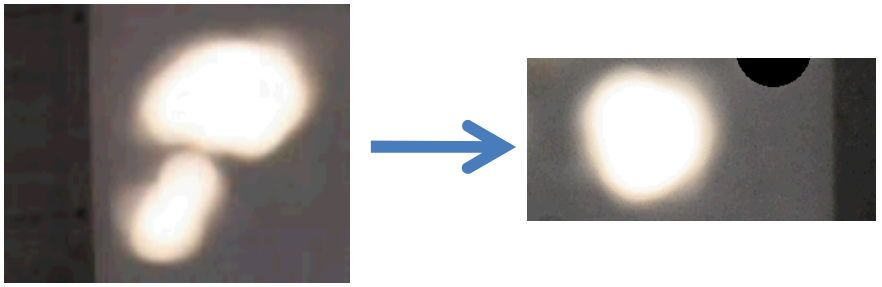
Properly canted facet

Results – Beam Quality

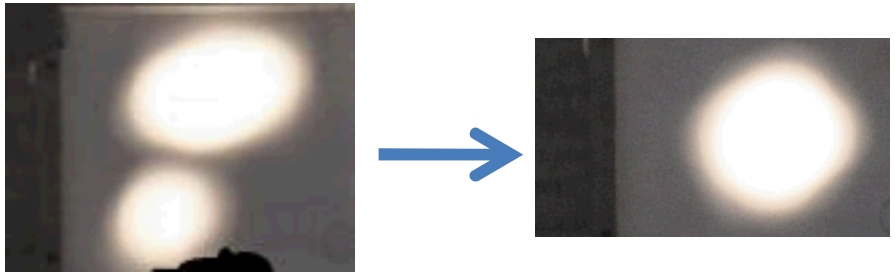
- Method has been demonstrated for canting corrections
  - Reduction in beam area
  - Improvement in overall beam shape



Heliostat 8E3



Heliostat 8E5



Heliostat 11E5

Results - Benefits

- Non-contact measurement
- Useful visual feedback
- Low-cost / minimal labor
- Efficient / accurate canting alignment
- Can use existing heliostats as targets
- Easily adaptable to other existing heliostat fields

Ongoing Work

- Focusing
  - Developed and being implemented into field
- Verification
  - Quantifying canting and focusing results with Sandia's Beam Characterization System
  - Simulating multiple alignment scenarios with Helios

Summary

- Past heliostat alignment methods have been inefficient
- H-FACET has been developed to replace past alignment methods
- H-FACET has been implemented at the test facility for canting purposes
- Results show that H-FACET is simple and accurate
- Work to improve H-FACET will continue

Alignment of Heliostats Using the Heliostat Focusing and Canting Enhancement Technique

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Concentrating Solar Technologies

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