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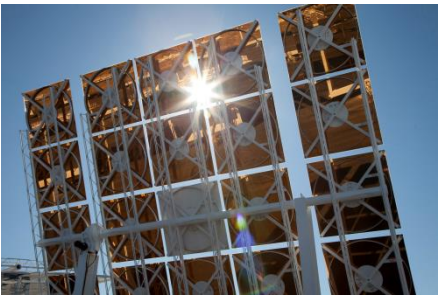

Tower Illuminance Model (TIM): Interactive Real-Time Flyover Simulation Tool to Evaluate Glare and Avian-Flux Hazards

Cianan A. Sims,[1] Clifford K. Ho[2], Luke Horstman,[2] Timothy Wendelin,[3] and Julius E. Yellowhair[2]

[1]Sims Industries
[2]Sandia National Laboratories
[3]National Renewable Energy Laboratorey

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Overview

Sandia National Laboratories

- Background and Objectives
- Tower Illuminance Model
- Glare and Avian Flux Hazard Analyses
- Conclusions

Background

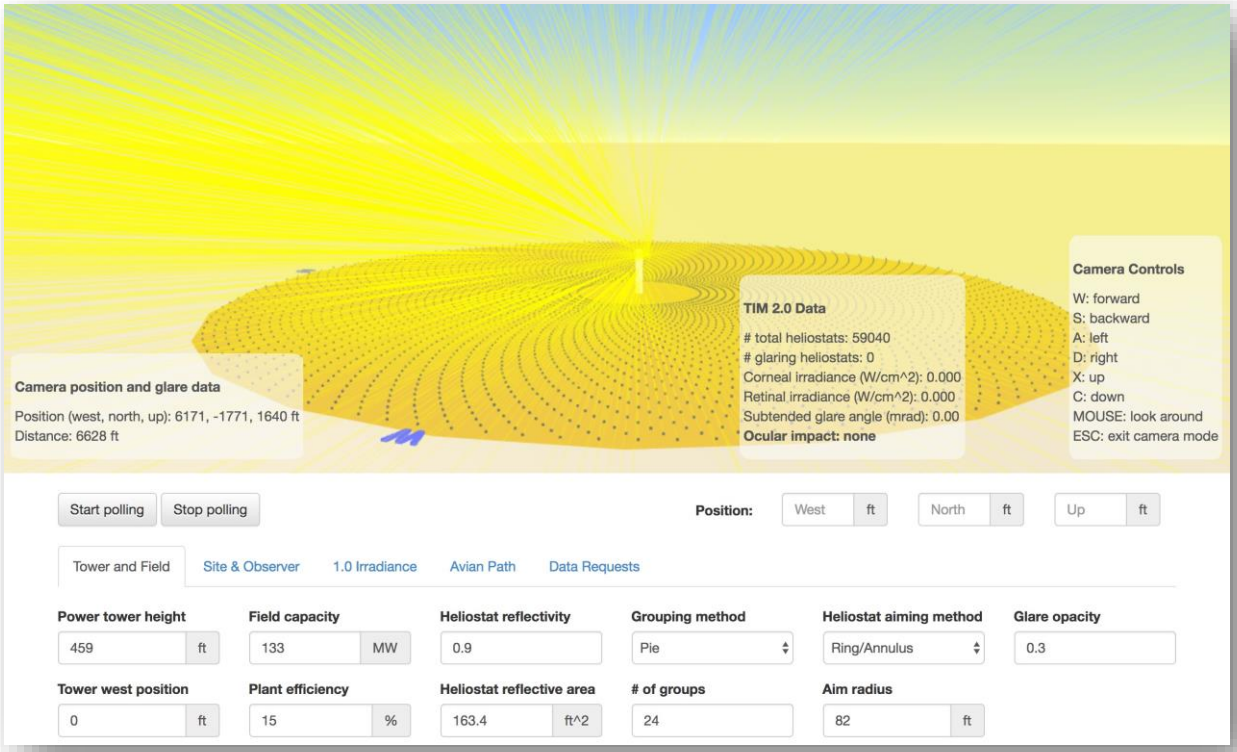
- Heliostats in standby mode can create adverse glare for pilots
- Concentrated flux in standby locations can harm birds

Glare viewed from helicopter over Ivanpah looking NW

MacGillivray Warbler with “Grade 3” solar flux injury found at Ivanpah CSP Plant (Kagan et al., 2014)

Objectives

- Develop an easy-to-use tool that can evaluate glare and avian flux hazards for different heliostat aiming strategies



Tower Illuminance Model (TIM)

Overview

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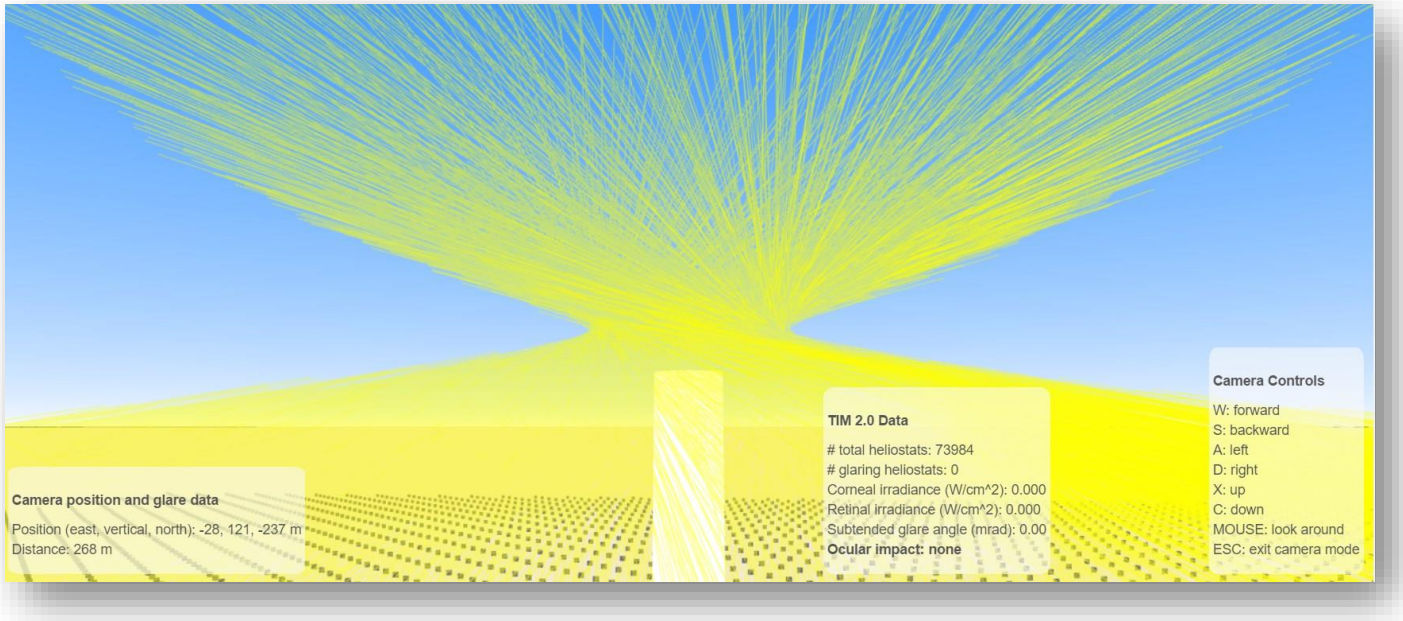
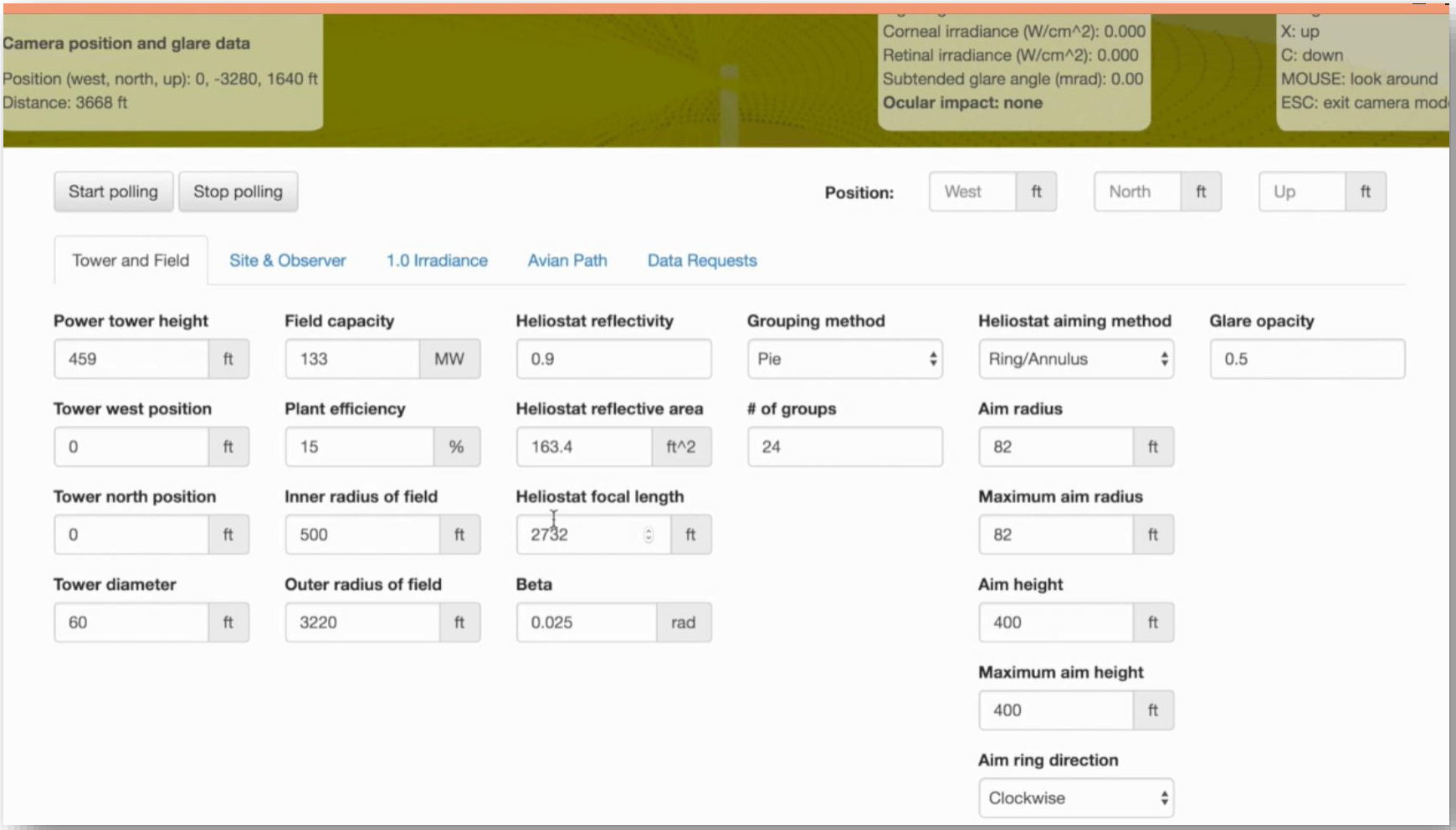
Tower Illuminance Model

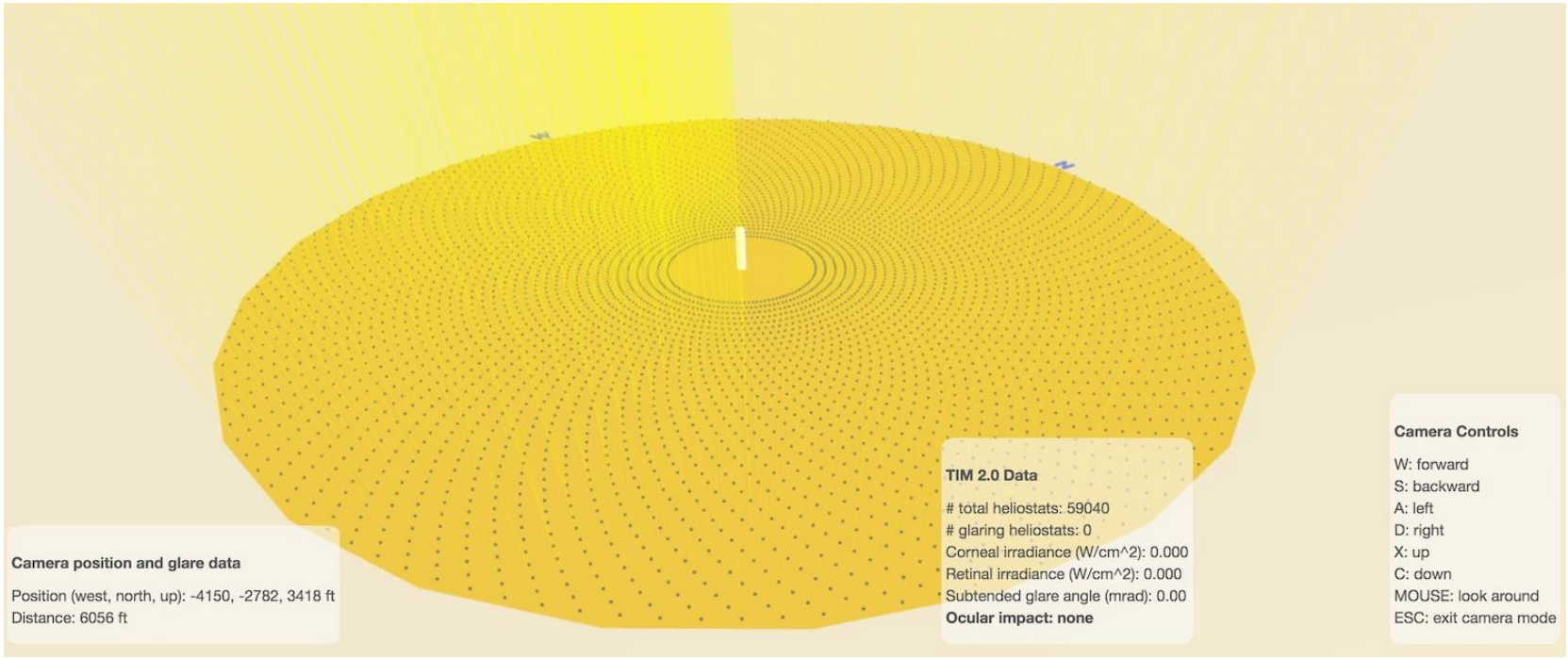
- Interactive 3D simulation of irradiance from alternative heliostat aiming strategies
- Customizable values to specify tower and heliostat field
- Real-time reporting of glare and avian flux hazards as a function of location and time



TIM User Interface

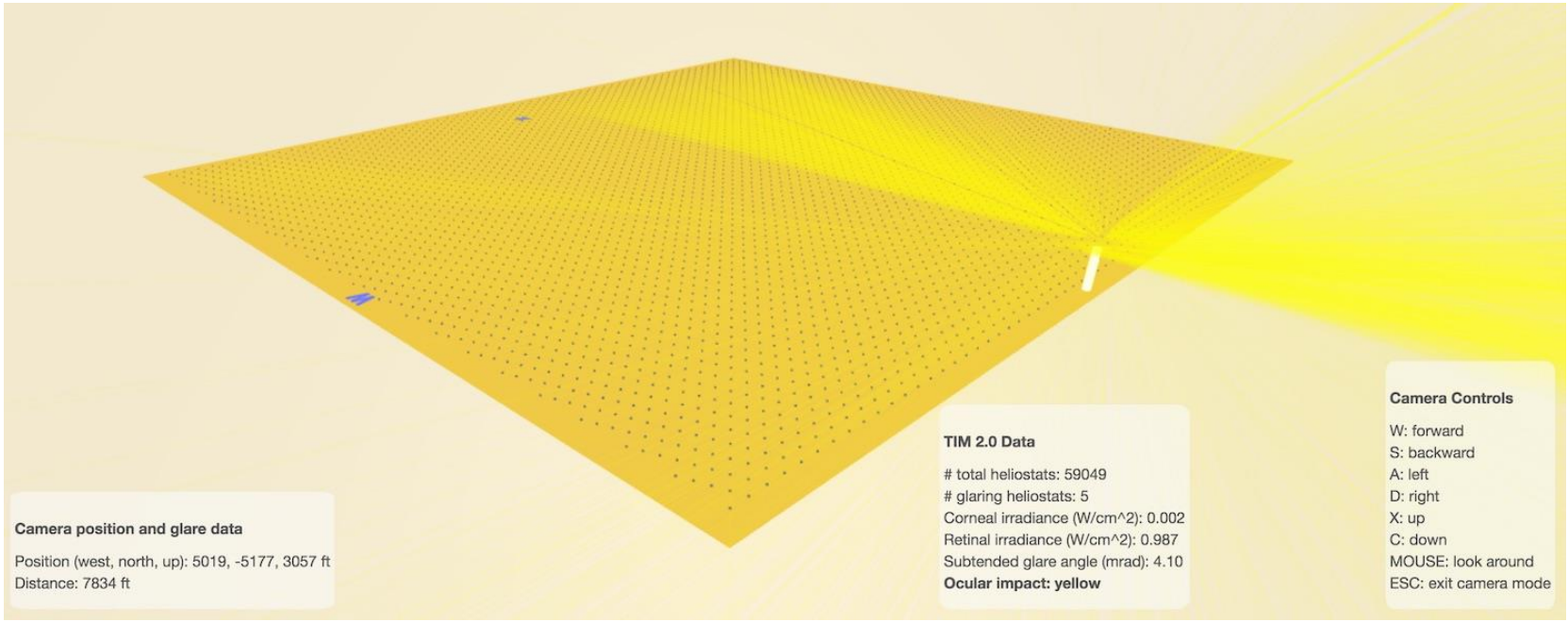


Example: Circular Field Layout



- Tower centrally-located
- ~60,000 heliostats in radial layout

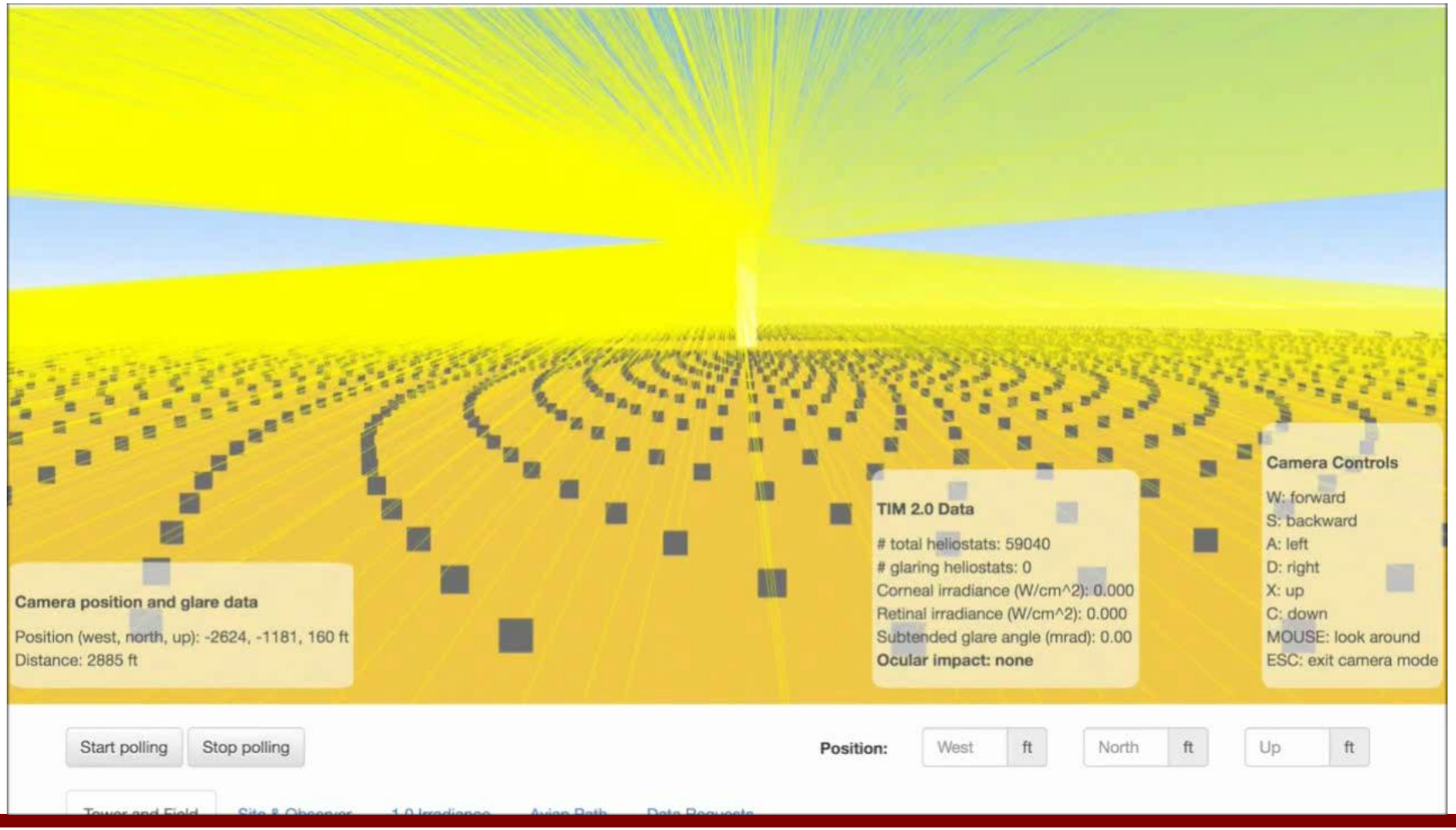
Example: Rectangular Field Layout



- Polar/directional field
- Heliostats in grid layout

TIM – 3D Field Navigator

- Use keyboard buttons to ”fly” through heliostat field
- Glare data updates based on user location



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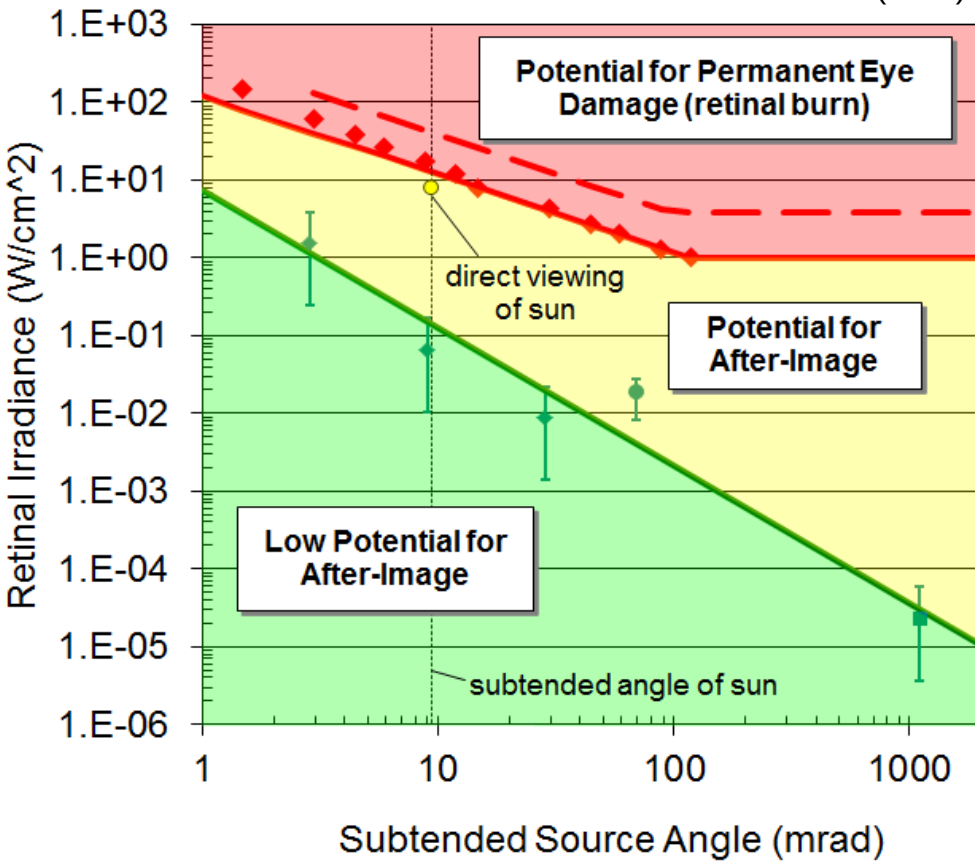
Glare Analyses

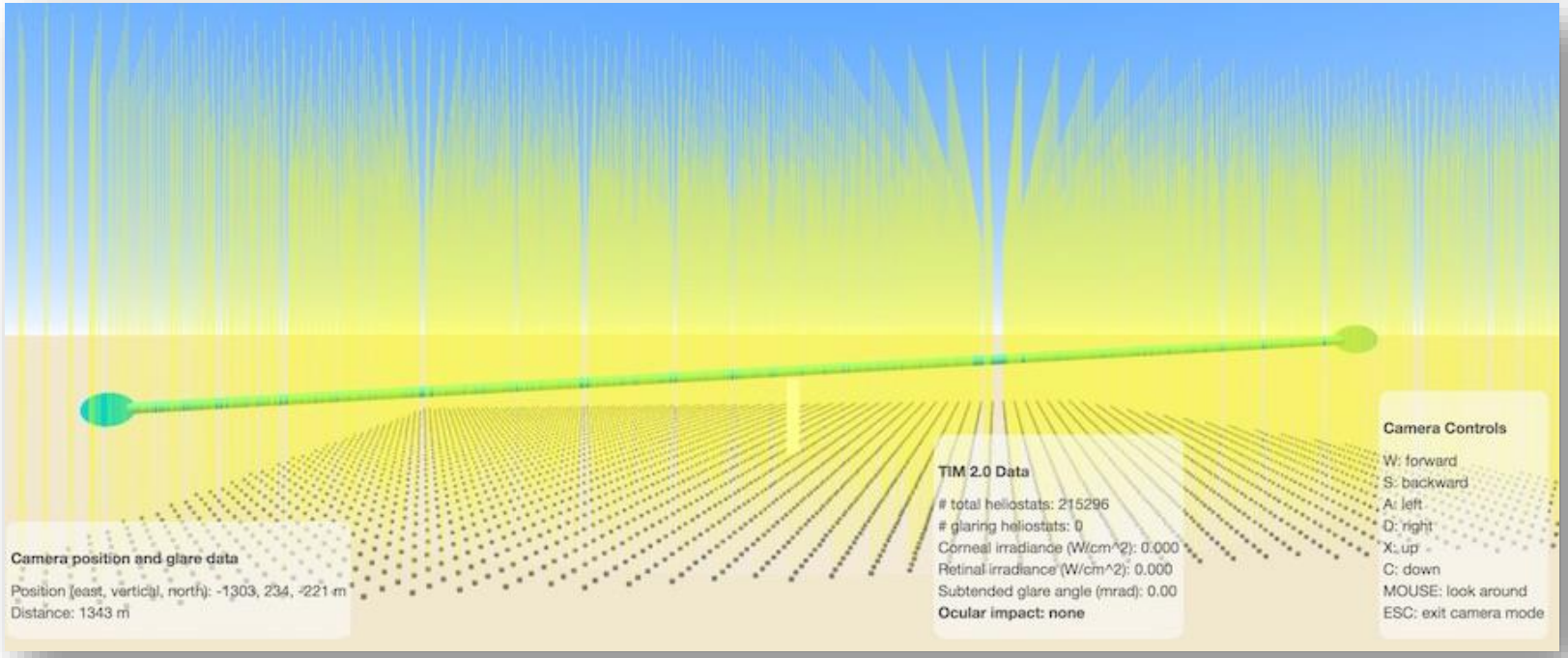
- Determines irradiance and glare impact from heliostats
- Analytical model for speed and qualitative results
- Sub-second results for >50,000 heliostat reflections

Ho et al. (2011)



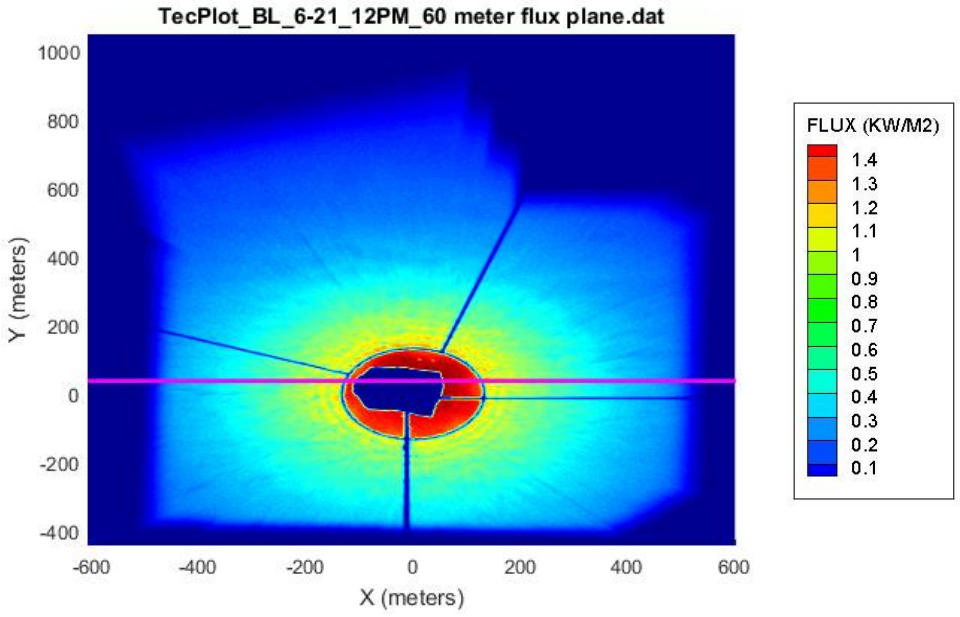
TIM Avian-Flux Hazard Simulation

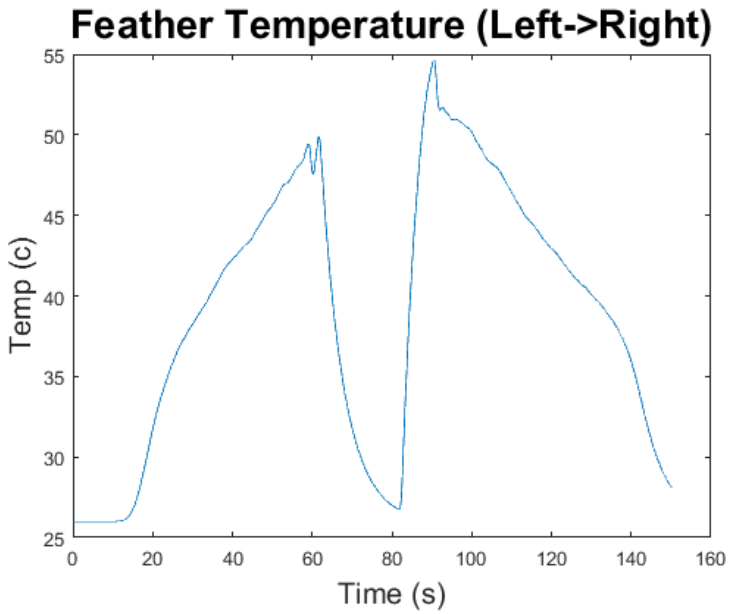
- Simulates bird traveling through airspace above heliostats
- User specifies start and end points



TIM Avian-Flux Simulation

- TIM calculates irradiance and bird feather temperatures along path
  - Solves energy balance





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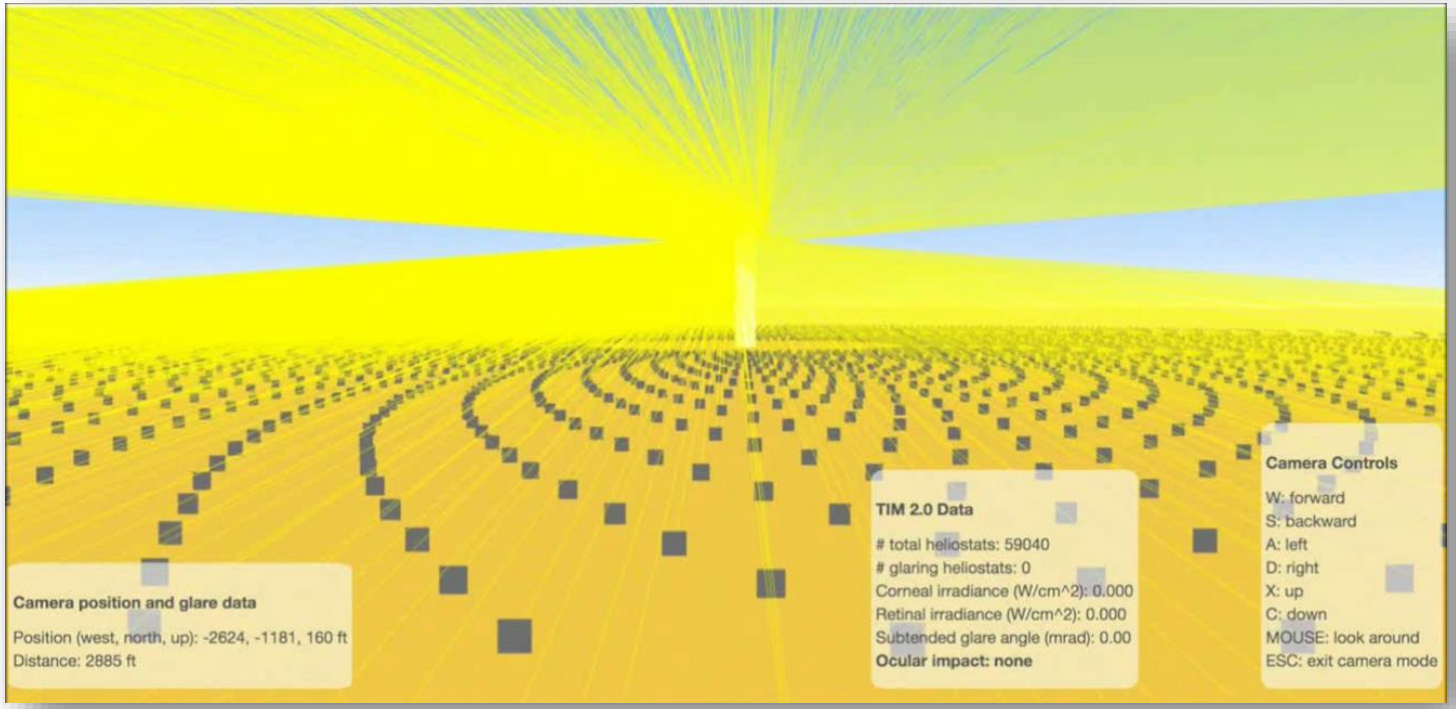
Conclusions

- Tower Illuminance Model (TIM) provides interactive real-time analyses of irradiance, glare, and avian flux hazards for different heliostat aiming strategies
  - Irradiance based on validated analytical models of heliostat beams
  - Glare hazard based on empirical data of ocular impact
  - Avian flux hazards based on bird feather temperature
- TIM can be used to evaluate alternative heliostat standby aiming strategies to minimize glare and avian-flux hazards
- Validation with Soltrace currently being performed

Team / Collaborators

- **Sandia**
  - Cliff Ho (PI), Luke Horstman (avian hazard modeling), Julius Yellowhair (optical modeling)
- **NREL**
  - Tim Wendelin (flux modeling, avian hazards)
- **Sims Industries**
  - Cianan Sims (TIM)
- **CSP Industry**
  - NRG/Ivanpah
    - Doug Davis, George Piantka, Tim Sisk, William Dusenbury
- **DOE**
  - Chris Nichols, Daniel Boff, Michele Boyd

Questions?



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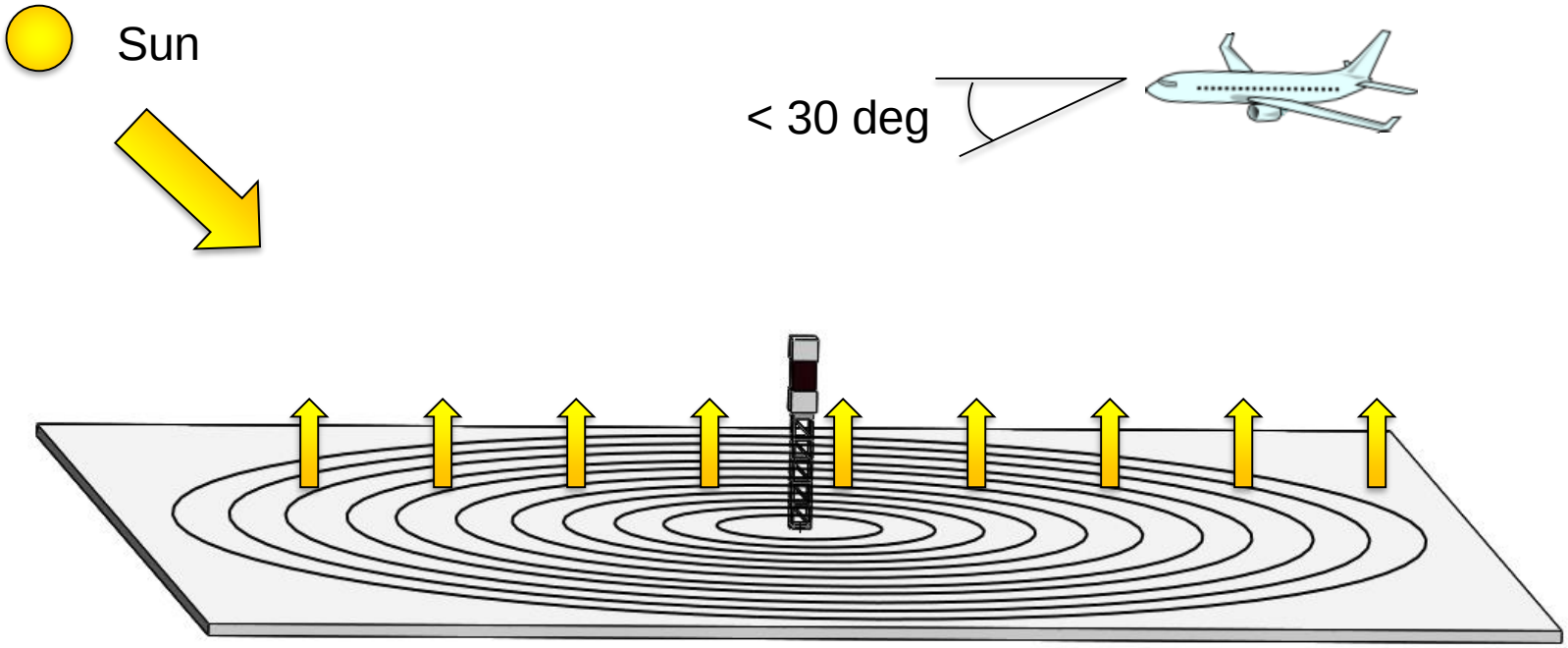
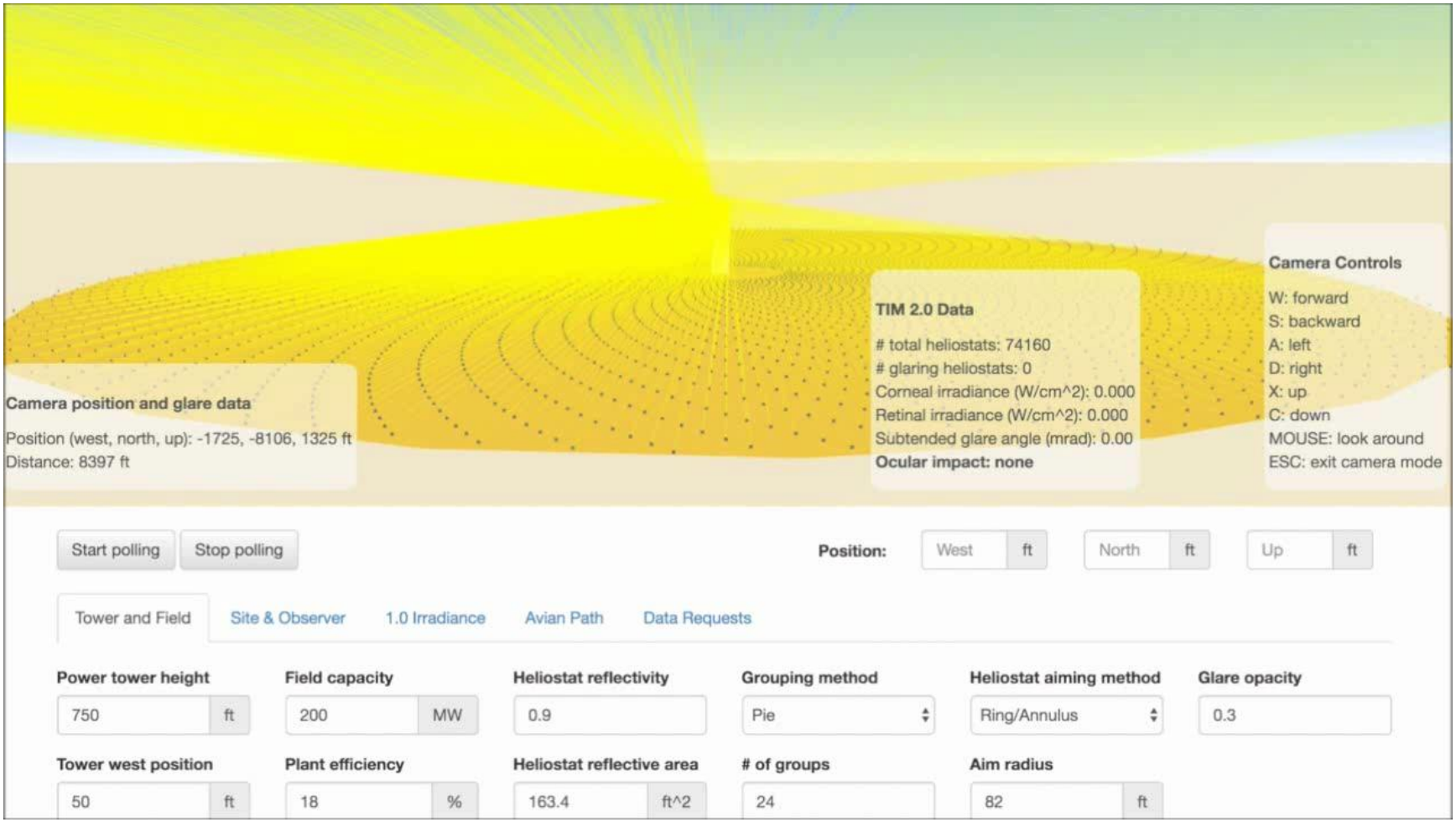
BACKUP SLIDES

Up-Aiming Strategy

- Up-Aiming can eliminate glare and avian flux hazards, but it increases heliostat travel time to receiver

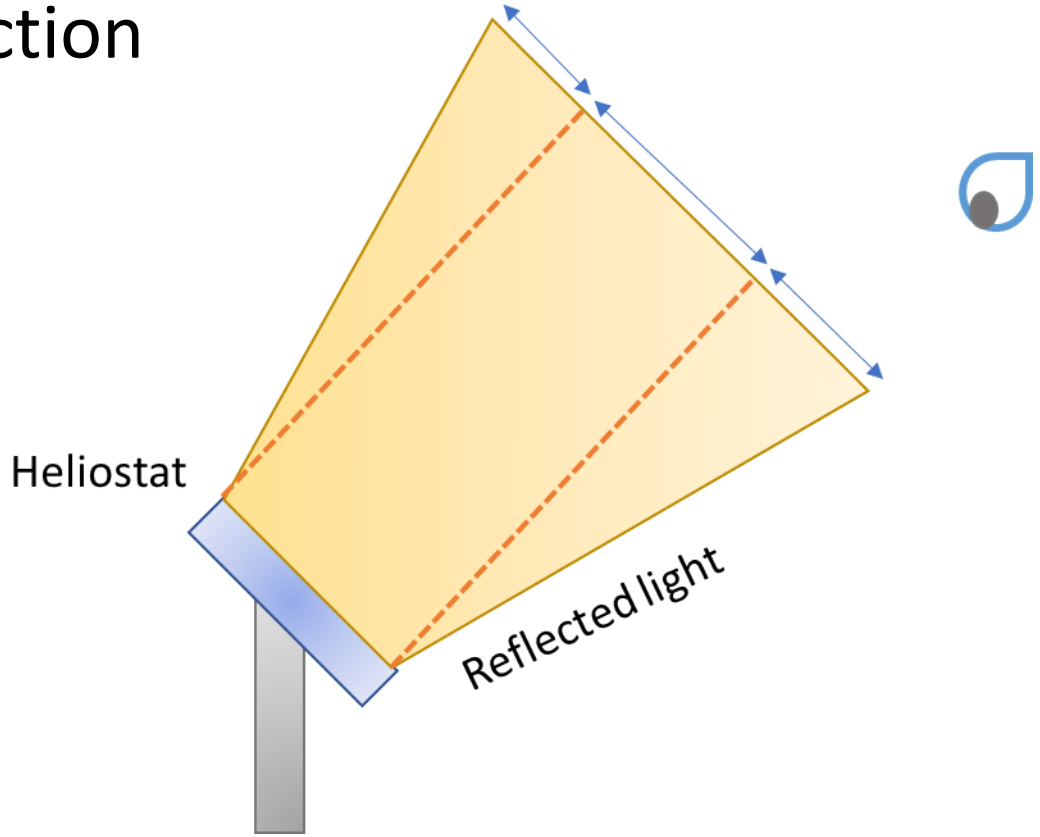


TIM Alternative Aiming



Glare Prediction – Slope Error

- TIM considers beam scatter due to heliostats
- Each heliostat reflection modeled as conical projection



Validation of TIM

- Validation with Soltrace currently being performed