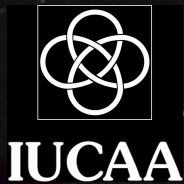# The Robo-AO Interface to USSTRATCOM:
How to Do On-Demand All-Sky
LGS AO Observations

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Center for Adaptive Optics 2014 Retreat
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IUCAA

Robo-AO is a collaboration between the Inter-University Centre for Astronomy and Astrophysics and the California Institute of Technology
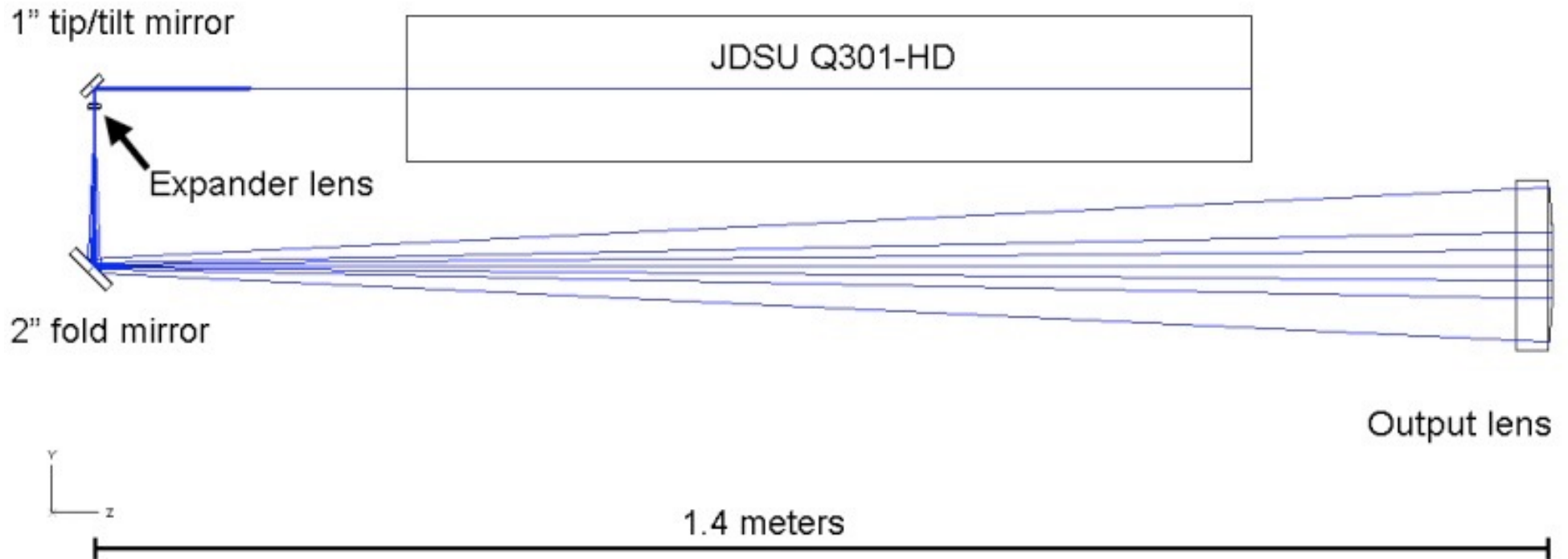
Laser beam projector

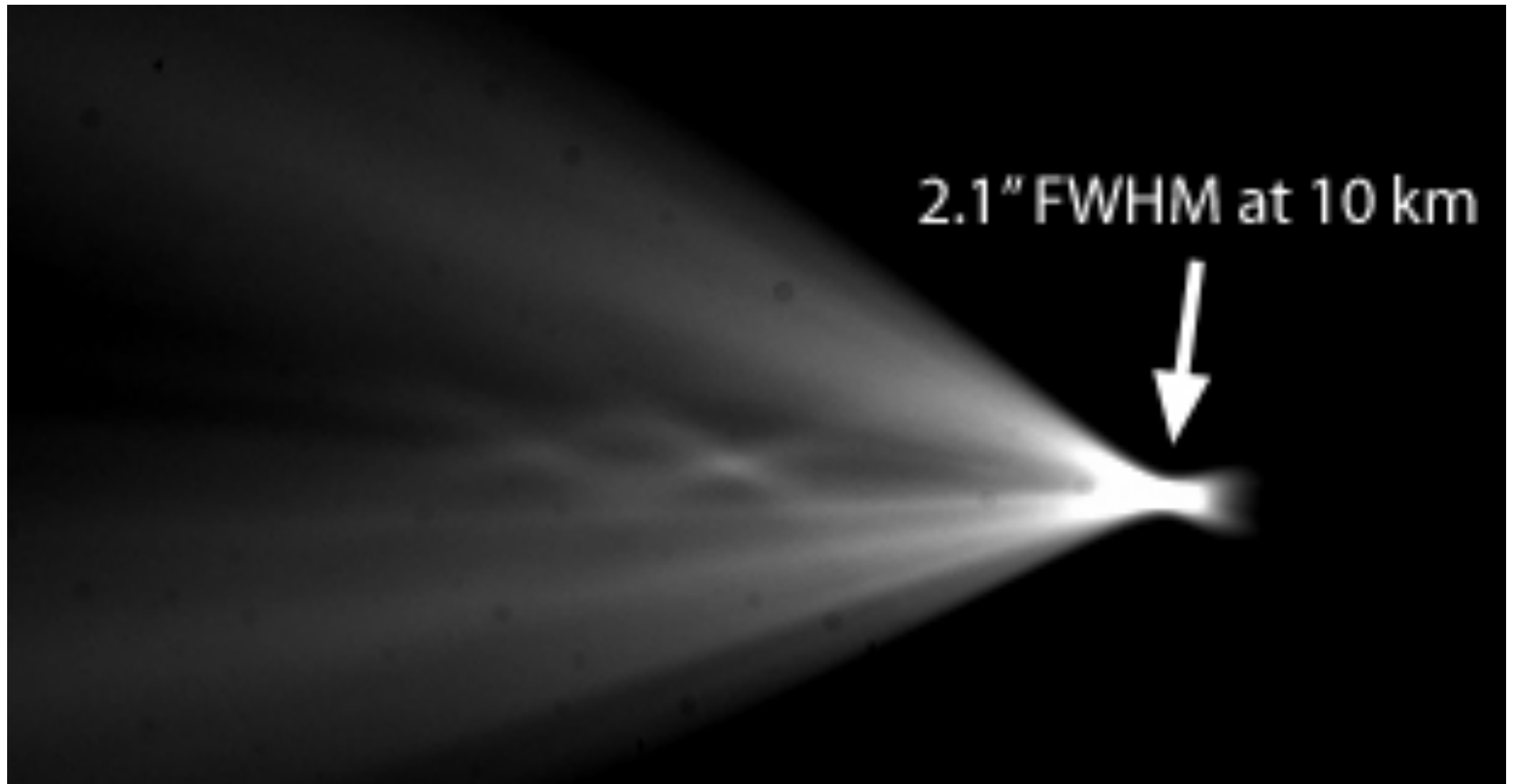UV Class 1 w.r.t. aircraft; no human spotters
~ 20x more intense than Solar UV

Laser Beam Projector

1" tip/tilt mirror

JDSU Q301-HD

Expander lens

2" fold mirror

Output lens

1.4 meters

- JDSU commercial laser
  - 12 W @ 10 kHz, λ=355nm
  - Robust and reliable
- Uplink jitter correction with AO loop

Robo-AO UV Laser at the P60

- $m_U \sim 8$;   2.1" FWHM in 1.5" U seeing

2.1" FWHM at 10 km

Robo-AO Laser Operations

- First day setup
  - Purge air from cooling system, clean filter
  - Coolant is water (with a touch of propylene glycol in winter)
  - Focus laser system on sky
    - Temperature sensitive projector
  - Recenter laser pointing
    - Very rare

- Beginning of night
  - Ready to lase when turned on
  - ~15 minutes to stabilize (~18C laser head, ~10C cooling)

Robo-AO Laser Operations

- At each pointing
  - Propagate laser after telescope pointing
  - Automated spiral search to center laser in WFS
  - Switch range gate off/on twice for backgrounding
  - Run through exposure, shutter before slew

- Laser does this ~250 times per night
  - Very robust, have had essentially no problems

- Safety system ensures laser cannot propagate unless telescope is in position, closure window is opened

Queue Scheduler

- Intelligent system, decides based on priority
  - Priority calculated "on the fly"

- Large set of science programs
  - 30+ science programs
  - 10,000+ science targets

- Robotic systems benefit from all sky observing
 - Need capability to observe anywhere at any time
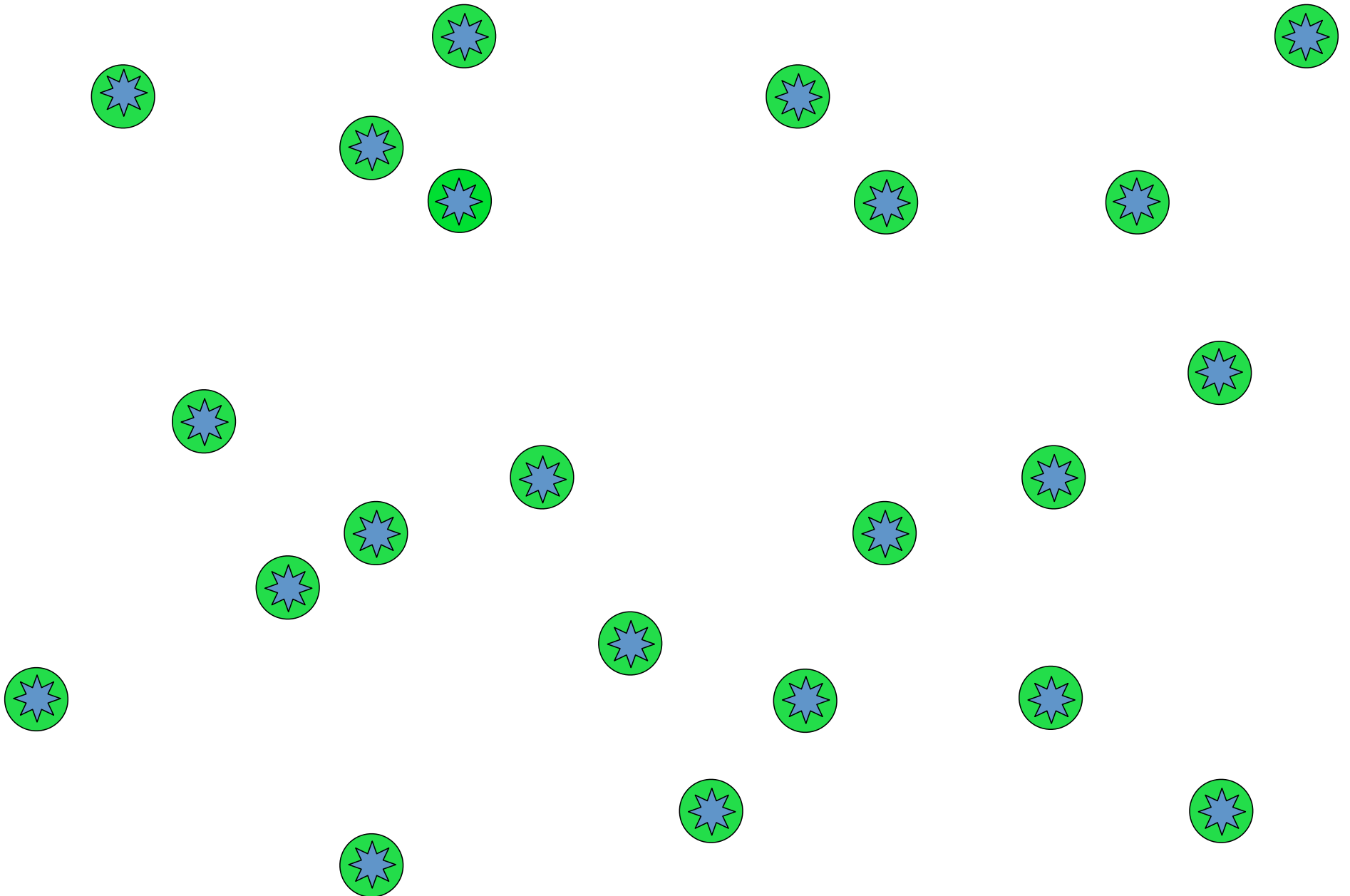
Laser Closure Windows

- US based LGS operators interface with USSTRATCOM
  - Provide satellite avoidance information
  - Observatories usually use RA, Dec based targets
    - Less than 100 targets per night

- **Robo-AO** is unusual
  - We requested ~1500 targets!

- We developed a new azimuth-elevation based strategy
  - Based on USSTRATCOM azimuth-elevation windows
  - Allows all-sky observations at almost any time

Laser Closure Windows
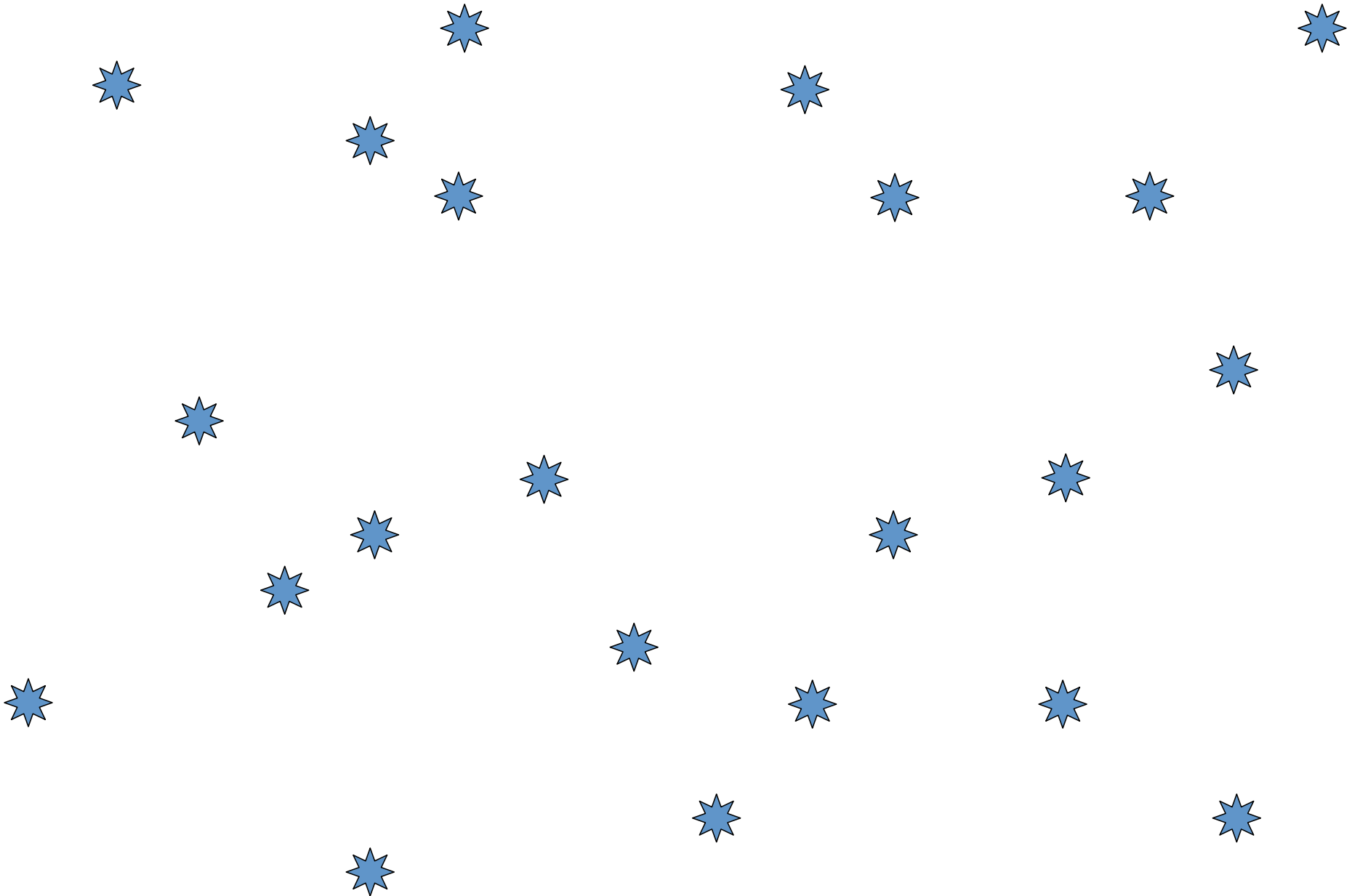
Laser Closure Windows
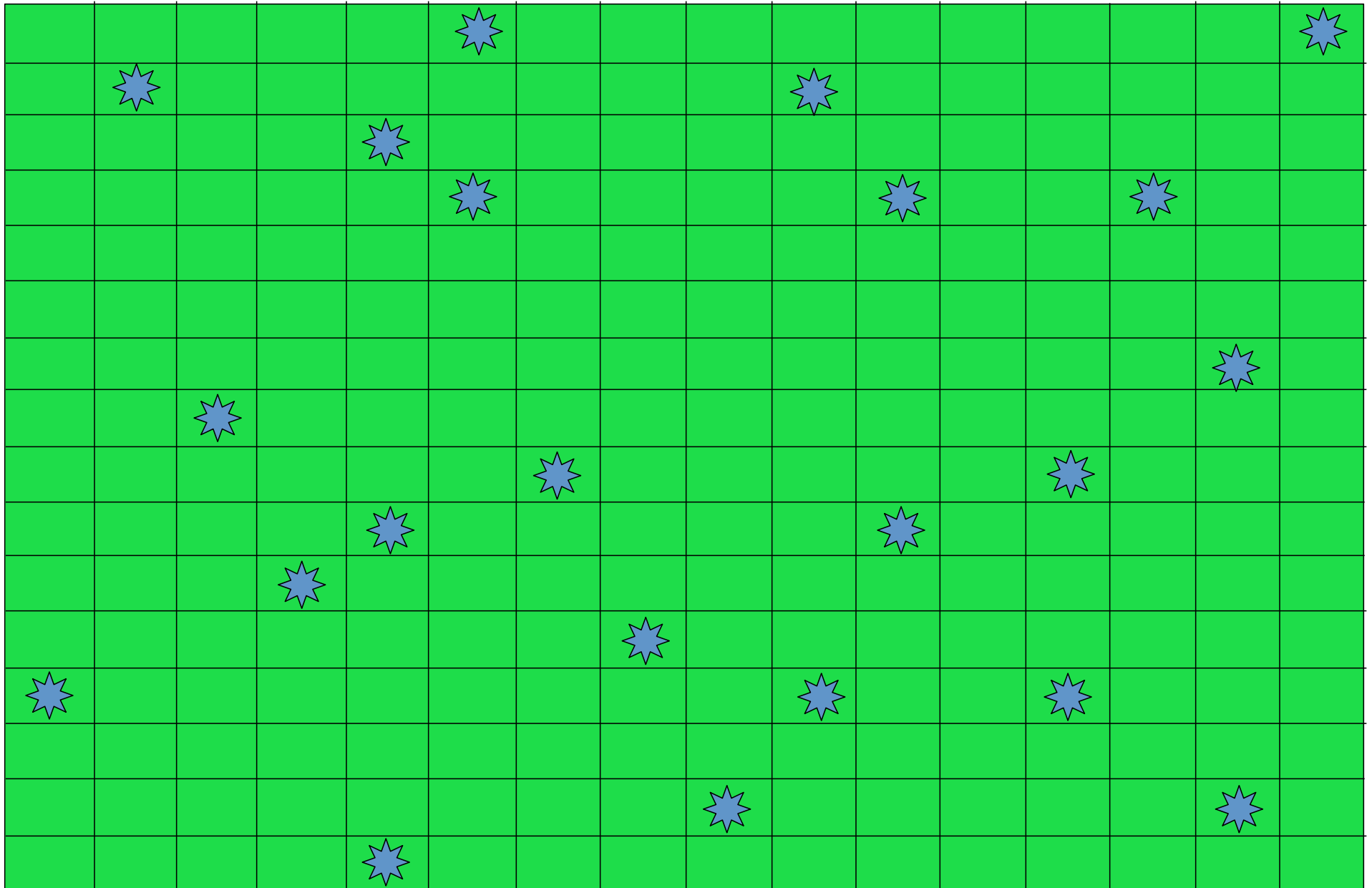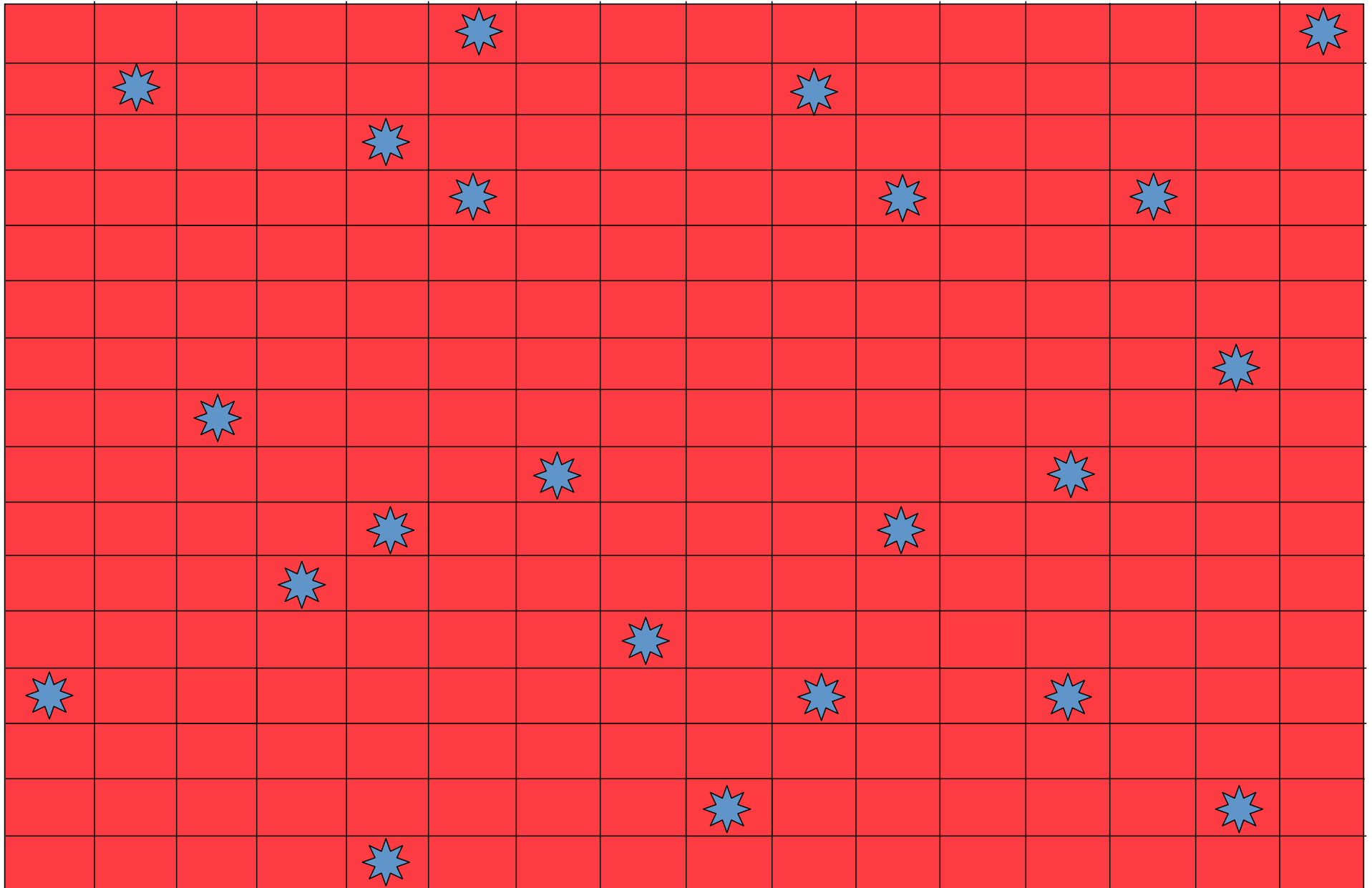
Laser Closure Windows

Laser Closure Windows

Laser Closure Windows

Laser Closure Windows

Laser Closure Windows

Laser Closure Windows

- Successful operation for ~1.5 years
  - Closure windows are "essentially invisible"

- Automated interaction with new space-track.org website
  - Under development

- Upgrading Keck USSTRATCOM interaction with **Robo-AO** system
  - Target of opportunity observations only

- Plan to provide code to LGS community

Thank you!

http://robo-ao.org

See videos on Youtube
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