Rise of the machines: first year operations of the Robo-AO
visible-light laser-adaptive-optics instrument

Christoph Baranec, PI
now at U. Hawai‘i - Inst. for Astronomy

on behalf of the Robo-AO collaboration
Robo-AO on the Palomar 60” telescope

Robotic Software

Adaptive Optics System + Vis/NIR Science Instruments

Laser guide star

Robotic Telescope (P60)
Haro 637 (r, i, z to RGB)

<table>
<thead>
<tr>
<th>λ (nm)</th>
<th>FWHM</th>
<th>Strehl</th>
<th>RMS WFE (nm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>625</td>
<td>0.11&quot;</td>
<td>7.1%</td>
<td>161</td>
</tr>
<tr>
<td>765</td>
<td>0.12&quot;</td>
<td>14.7%</td>
<td>168</td>
</tr>
<tr>
<td>890</td>
<td>0.14&quot;</td>
<td>20.4%</td>
<td>178</td>
</tr>
</tbody>
</table>

~1/2 resolving power of HST at < 1/10,000th the cost
Robotic software and automations

- Linux/C++: ~120,000 lines of code
- ~86 s target-to-target overheads
- Intelligent queue scheduling
  - including non-sideral targets
  - takes into account USSTRATCOM open windows
- 20x 90s observations per hour (>9,000 so far)
- Auto data reduction and registration pipeline

Reed Riddle (Caltech)
AO Science... by the thousands!
Ultimate AO Binarity Survey

Survey of ~3,000+ members in local solar neighborhood
(Based on RECONS sample, T. Henry et al.)

All spectral types,
companions down to
brown dwarfs for most

Robo-AO: 0.1” to 1.0”
1 to 100 AU range

Nicholas Law
(Project Scientist,
UNC Chapel Hill)
Displayed: 414 3”x3” images, ~2.5 nights
Running total: 3,081 for the survey
Predictive laser deconfliction above 40° El.

6 predictive requests per night
(150 targets per list)

5 lists cover fixed Az-El boxes of ~6 square degrees each

1 list of high-priority or low-elevation targets

Cleared to use the laser for rapid target-of-opportunity events, e.g., supernovae, near-earth object discoveries!
IR camera/TT upgrade at Palomar
Visitor instrument port: eyepiece
Robo-AO Mk II ➔ UH88

• Much better native seeing
• More available time!
• Approaching HST resolution
• On-sky in <2 years
• Testbed for testing new instrumentation
  – ELT IR wavefront sensors
  – Multiple ROI Tip-Tilt
  – Single-mode fiber feed
Astronomical Foundation, by a gift from Samuel Oschin, and by Robo-AO partner institutions, the California Institute of Technology and the Inter-University Centre for Astronomy and Astrophysics.