Subaru Ground-Layer AO Simulation

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Subaru Next Generation AO Working Group
2014/7/28 @ Mitaka
Basic idea of GLAO

- Corrects only turbulence close to the ground
- Improves seeing over wide-field of view

GLAO correction (simulation)

Effective for wide field of view
Subaru GLAO configuration

\[ \phi = 15 \text{ arcmin} \]
\[ r = \phi/2 \]

LGS: 10 mag
TTFGS: 18 mag

Subaru seeing:
- good: 0.56"
- moderate: 0.73"
- bad: 0.97"
(at 0.5 \( \mu \text{m} \))

DM: 32 act. Across @ -80m

1 reconstruction layer (0m) by averaging GL

\[ \star : \text{HoGS} \quad \oplus : \text{TTF-GS (between LGS)} \]
\[ \square : \text{PSF eval. (toward GS)} \quad \blacktriangle : \text{(between GS)} \]
\[ \ast : \text{DM fitting} \]
Seeing dependence of FWHM

GLAO: solid, Seeing: dotted; error bars shows standard deviation along time axis

GLAO: 1~7%
Seeing: 2~10%

Stalibiy ≡ std / ave
Seeing dependence of Ensquared Energy

Gain \equiv \frac{\text{GLAO}}{\text{Seeing}} \sim 1.5 \text{ to } 2

width: blue: 0.24'', green: 0.36'', red: 0.48''

GLAO: solid lines, Seeing: dotted line
Zenith angle dependency: GLAO / Seeing

- FWHM
- COSOS > 18°
- SXDS > 25°
- G.C. > 48°

effective height increases

seeing:
- good
- moderate
- bad

loss by 20% at 45° and 30% at 60°
Seasonal Variation of Seeing

Subaru IQ

13N site, profile
http://sitedata.tmt.org

Characteristic months Sep (good) & Jan (bad).

<table>
<thead>
<tr>
<th></th>
<th>25%-ile</th>
<th>Sep (50%-ile)</th>
<th>50%-ile</th>
<th>Jan (50%-ile)</th>
<th>75%-ile</th>
</tr>
</thead>
<tbody>
<tr>
<td>Subaru AG</td>
<td>0.49&quot;</td>
<td>0.54&quot;</td>
<td>0.64&quot;</td>
<td>0.72&quot;</td>
<td>0.84&quot;</td>
</tr>
</tbody>
</table>

Subaru AG
Seasonal Variation of FWHM

GLAO: R: green, J: blue, H: magenta, K: red; Seeing: black
moderate: dotted line
FWHM ratio (GLAO/Seeing) Map

K-band

shift the map: late ← midnight → early

@culmination
Sky coverage

B-configuration

★: LGS
●: TTFGS

Diameter of the dotted circle is 7.5'

Number of TTFGS in each of 4 pink region

<table>
<thead>
<tr>
<th>r(in, out) = r_circ</th>
<th>TTFGS(R-band)</th>
<th>b: 10~20 deg</th>
<th>30~50 deg</th>
<th>60~90 deg</th>
</tr>
</thead>
<tbody>
<tr>
<td>(7',8') = 1.6'</td>
<td>&lt; 18 mag</td>
<td>&gt; 6.7</td>
<td>&gt; 3.0</td>
<td>&gt; 1.8</td>
</tr>
<tr>
<td></td>
<td>&lt; 19 mag</td>
<td>&gt; 10.7</td>
<td>&gt; 4.8</td>
<td>&gt; 2.8</td>
</tr>
<tr>
<td>(7', 8.5') = 2.0'</td>
<td>&lt; 18mag</td>
<td>&gt; 34.7</td>
<td>&gt; 7.4</td>
<td>&gt; 4.3</td>
</tr>
</tbody>
</table>

Ground layer measurement at Subaru

Local ground-layer at Subaru?
- 70m below and leeward of the ridge (laminar flow?)
- fine resolution data for more detailed simulation

Luna Shabar (PTP) by Univ.BC
optical: 1 ~ 1000m

SNODAR by Univ. NSW
acoustic: 10 ~ 100m

On-going!!
RAVEN at Subaru

RAVEN is a Multi-Object AO (MOAO) demonstrator, yet has GLAO mode.

Succeeded in the 1st light in May!!
RAVEN first light result

Seeing

FWHM = 0.32"

Correction

H-band

GLAO

FWHM = 0.13"

Best FWHM < 0.2" is REAL, not only in the simulation!!
Summary

- Expected FWHM is 0.2" in the K-band under moderate seeing condition. Stability (std/ave) along time axis is same or better than seeing.
- Gain of ensquared energy is ~ 1.5 to 2
- Gain of FWHM deceased with zenith angle by 20% at 45deg and by 30% at 60deg
- Seasonal variation of FWHM is ~30% (except Jan)
- Even at galactic pole, expected number of an 18mag star in each of 4 TTFGS of φ15' case is > 1.
- Ground-layer evaluation at Subaru is on-going.
- FWHM < 0.2" in the H-band was actually achieved by RAVEN GLAO mode.