Basic idea of GLAO

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

GLAO correction (simulation)

- FoV (>10 arcmin)
- Free Atmosphere (< ~50%)
- Ground Layer (> ~ 50%)

Subaru

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 \( \mu m \))

DM: 32 act. Across @ -80m

1 reconstruction layer (0m) by averaging GL

\( f = 15 \text{ arcmin} \)
\( r = f/2 \)

\( \star \) : HoGS
\( + \) : TTF-GS (between LGS)
\( - \) : PSF eval. (toward GS)
\( \uparrow \) : (between GS)
\( \ast \) : DM fitting
Seeing dependence of FWHM

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

Stalibiy $\equiv$ std / ave

GLAO: 1~7%
Seeing: 2~10%
Seeing dependence of Enquared Energy

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

GLAO: solid lines, Seeing: dotted line

Gain \equiv \frac{\text{GLAO}}{\text{Seeing}} \sim 1.5 \text{ to } 2
Uniformity of FWHM over FoV

$r = 7.5$ arcmin

$\sigma/m = \text{std/ave along time} \sim 3\%$

normalized by the average over the field

K-band moderate
FWHM Uniformity for other bands

@zenith

NIR +/-5%

difference by seeing condition < 6%

+10%

-10%

R (σ/m=1.2%) J (σ/m=2.4%)

H (σ/m=2.8%) K (σ/m=3.6%)
**Zenith angle dependency: GLAO / Seeing**

- **FWHM**
- **R-band**
- **J-band**
- **H-band**
- **K-band**

*effective height increases*

seeing:
- good
- moderate
- bad

loss by 10% at 45° and by 20% at 60°
Seasonal Variation of Seeing

Subaru IQ

13N site, profile
Els+09, PASP, 121,527 (Fig.5)

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

<table>
<thead>
<tr>
<th></th>
<th>25%-ile</th>
<th>Sep (50%-ile)</th>
<th>50%-ile</th>
<th>Mar (50%-ile)</th>
<th>75%-ile</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>0.49&quot;</td>
<td>0.54&quot;</td>
<td>0.64&quot;</td>
<td>0.74&quot;</td>
<td>0.84&quot;</td>
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</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

Month

@culmination

culmination at late ← midnight → early

shift the map:

Dec [deg]

Zenith angle [deg]

RA [hr]

GOODS-N

SDF

COSMOS

SXDS

GOODS-S

G.C.
Sky coverage

B-configuration
★: LGS
●: TTFGS

Diameter of the dotted circle is 7.5'

Number of TTFGS in each of 4 pink regions


<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; 18 mag</td>
<td>&gt; 34.7</td>
<td>&gt; 7.4</td>
<td>&gt; 4.3</td>
</tr>
</tbody>
</table>
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
- Uniformity of FWHM over FoV is ~ <5 % in NIR
- Gain of FWHM deceased with zenith angle by 10% at 45deg and by 20% at 60deg
- Seasonal variation of FWHM is ~30%
- Even at galactic pole, expected number of an 18mag star in each of 4 TTFGS of Φ15' case is > 1.