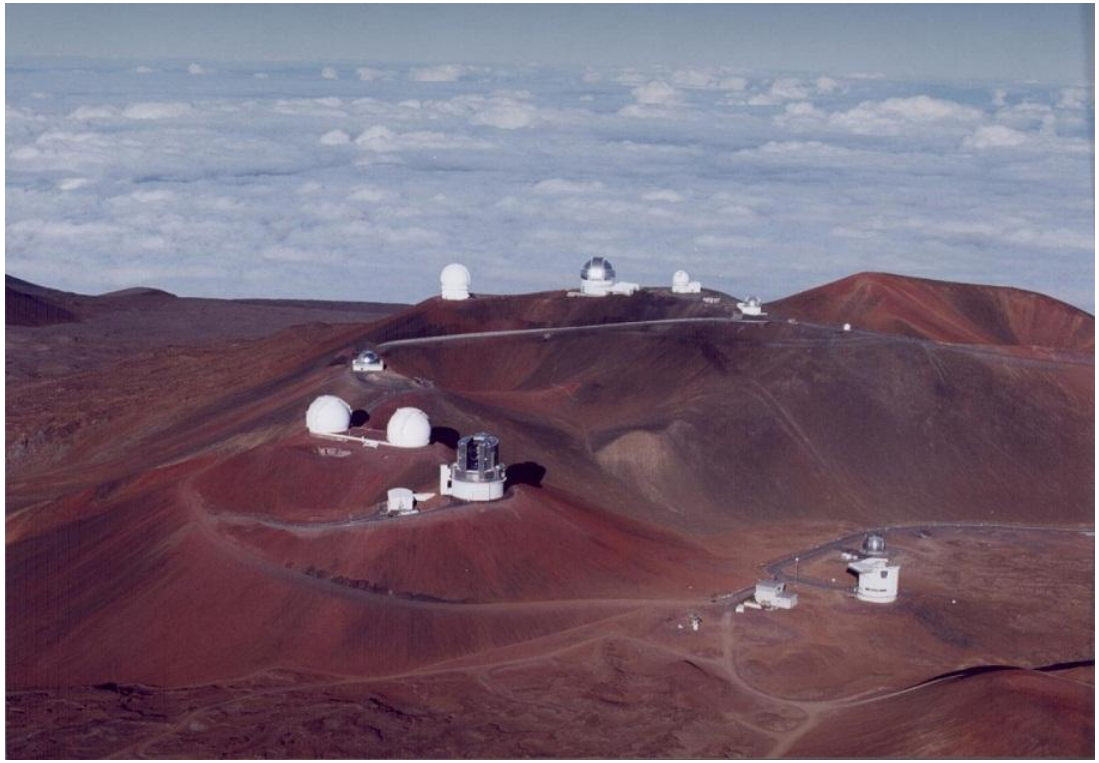
Subaru Ground-Layer AO Simulation



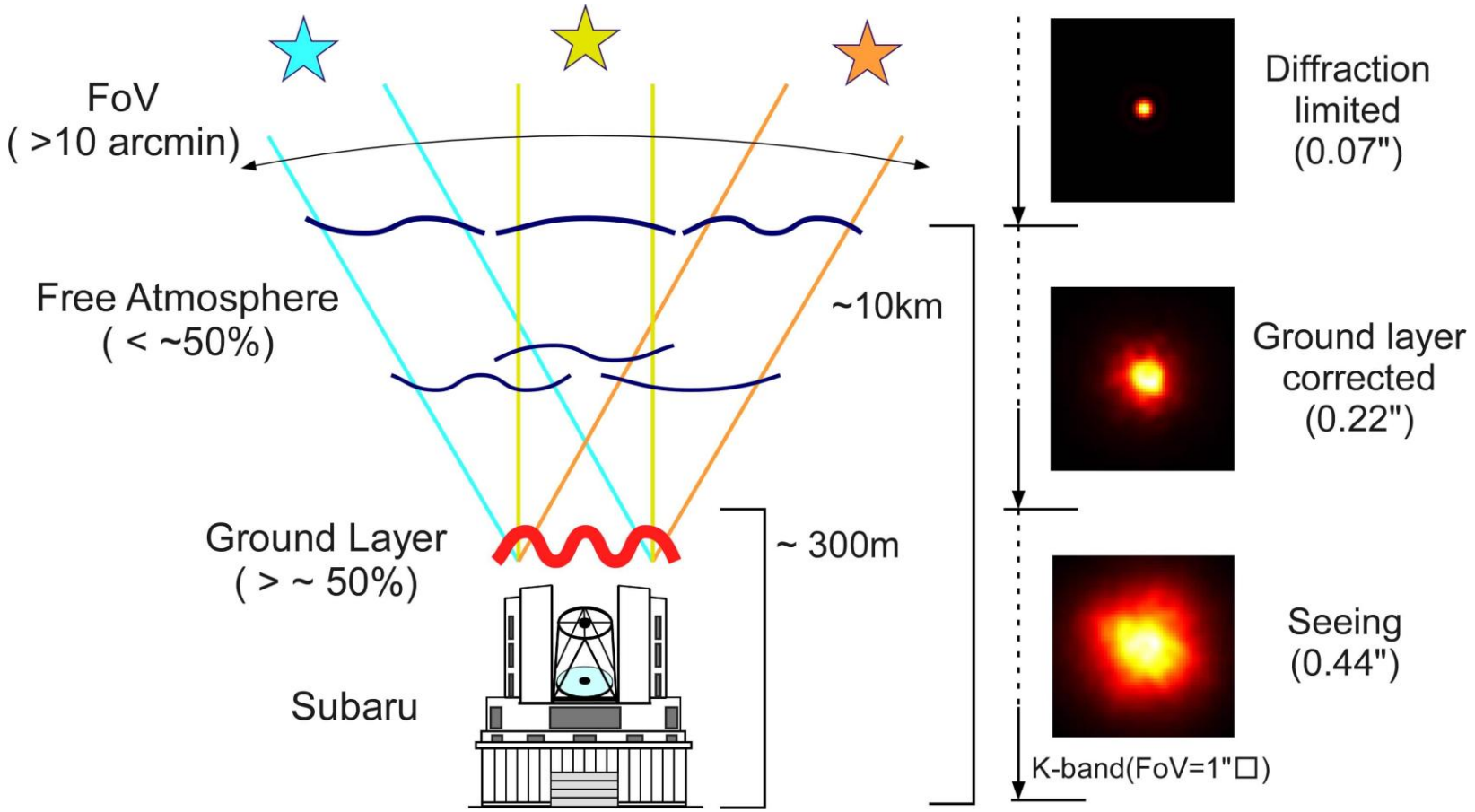
Shin Oya (Subaru Telescope)
Subaru Next Generation AO Working Group

2013/6/13 @ Sapporo

Basic idea of GLAO

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

GLAO correction (simulation)

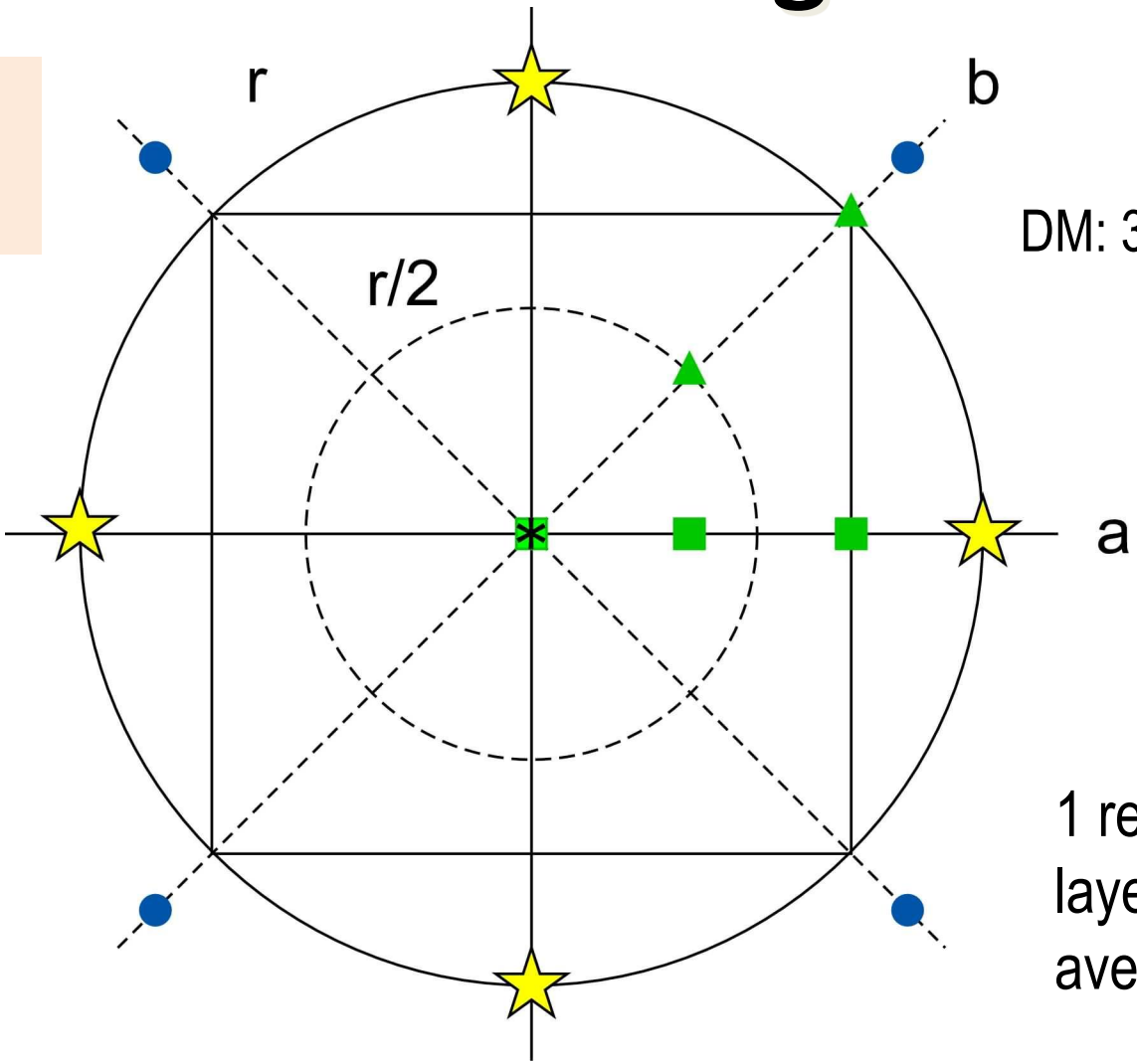


Effective for wide field of view

Subaru GLAO configuration

ϕ = 15 arcmin
r = ϕ/2

LGS: 10 mag
TTFGS: 18mag



DM: 32 act. Across
@ -80m

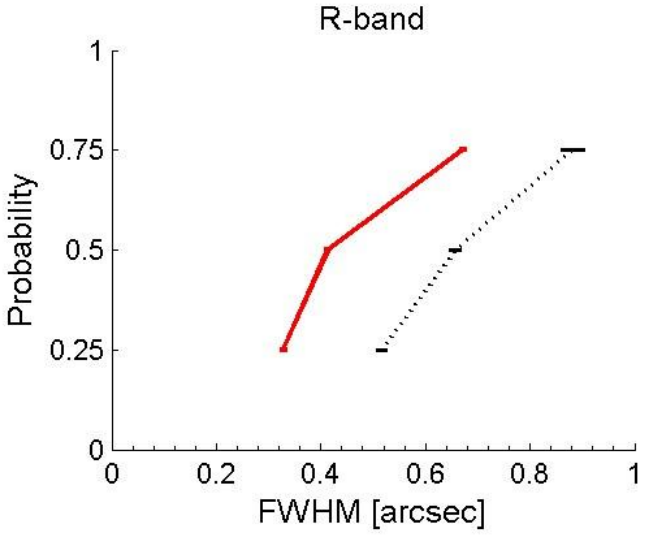
Subaru seeing:
- good: 0.56”
- moderate: 0.73”
- bad: 0.97” (at 0.5 μm)

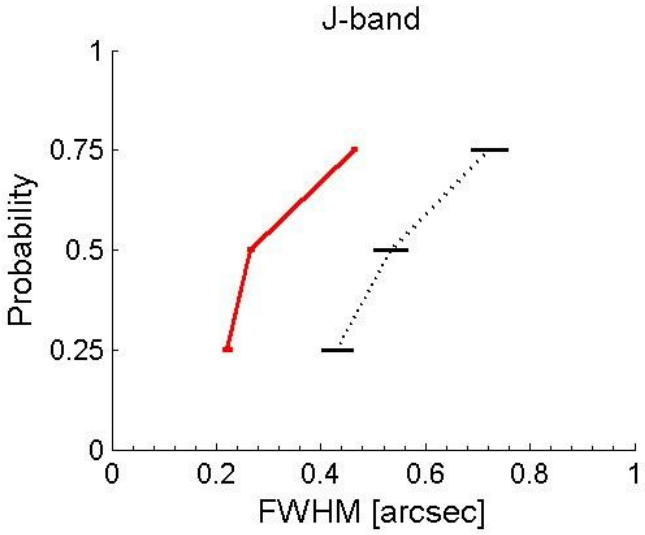
1 reconstruction layer (0m) by averaging GL

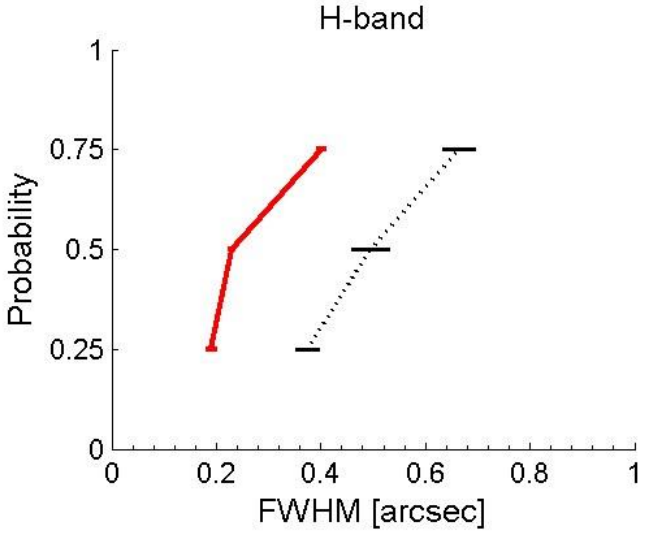
★: HoGS ＋: TTF-GS (between LGS)
■: PSF eval.(toward GS) ▲: (between GS)
∗ : DM fitting

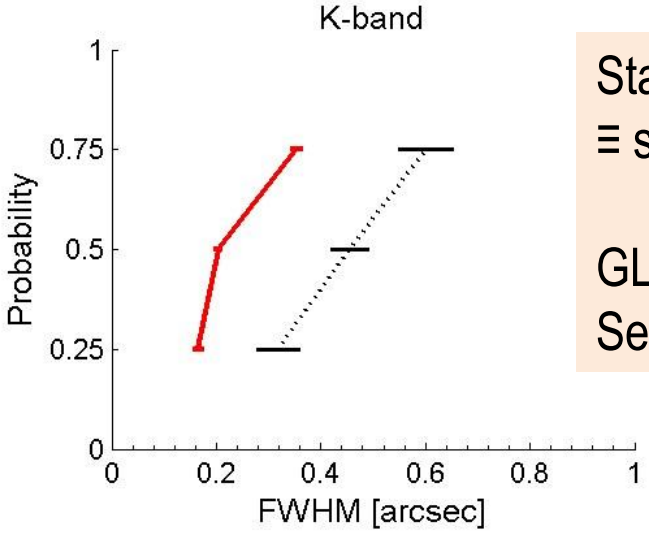
Seeing dependence of FWHM

@zenith







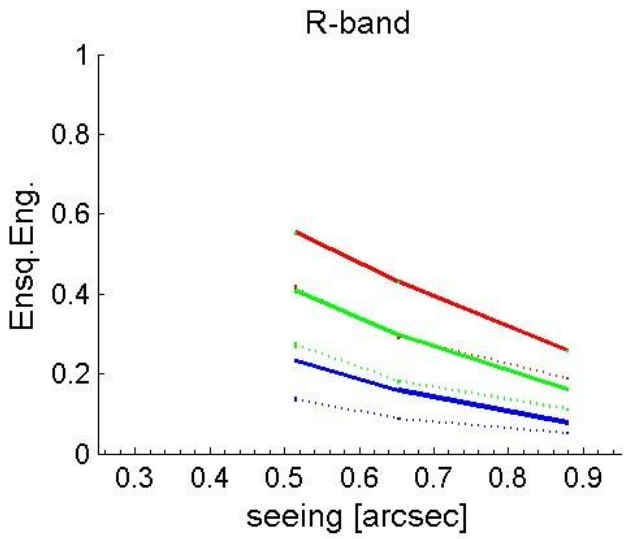


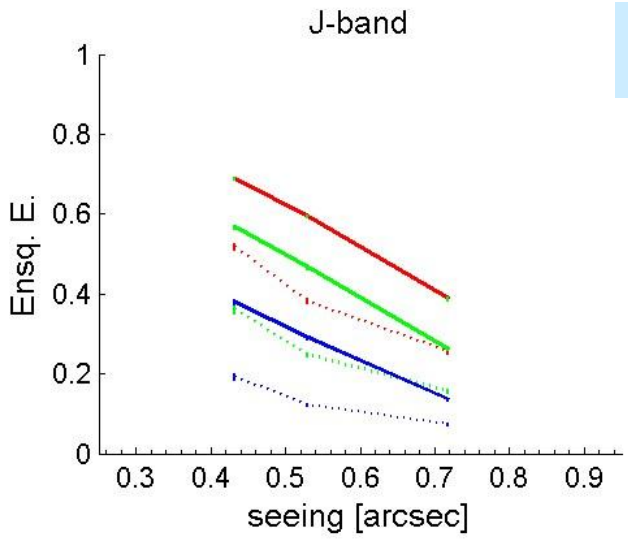
Stalibiy
≡ std / ave

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

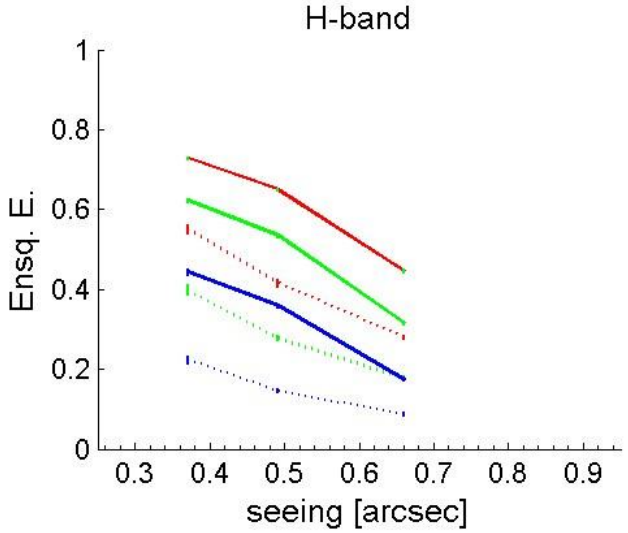
GLAO: solid , Seeing: dotted; error bars shows standard deviation along time axis

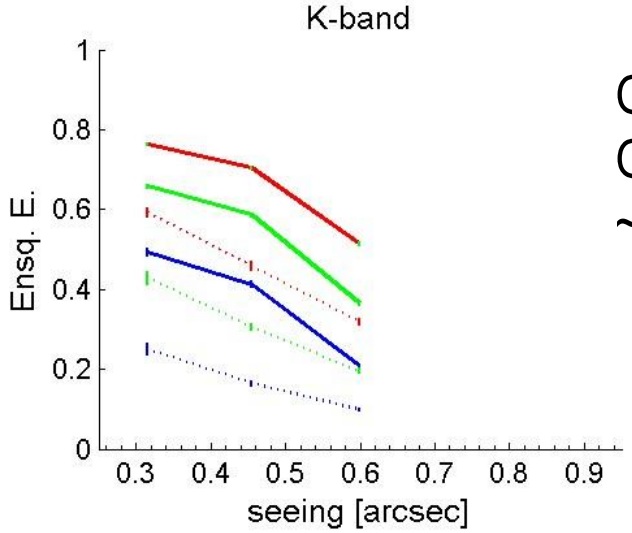
Seeing dependence of Ensquared Energy





@zenith





Gain ≡
GLAO / Seeing
~ 1.5 to 2

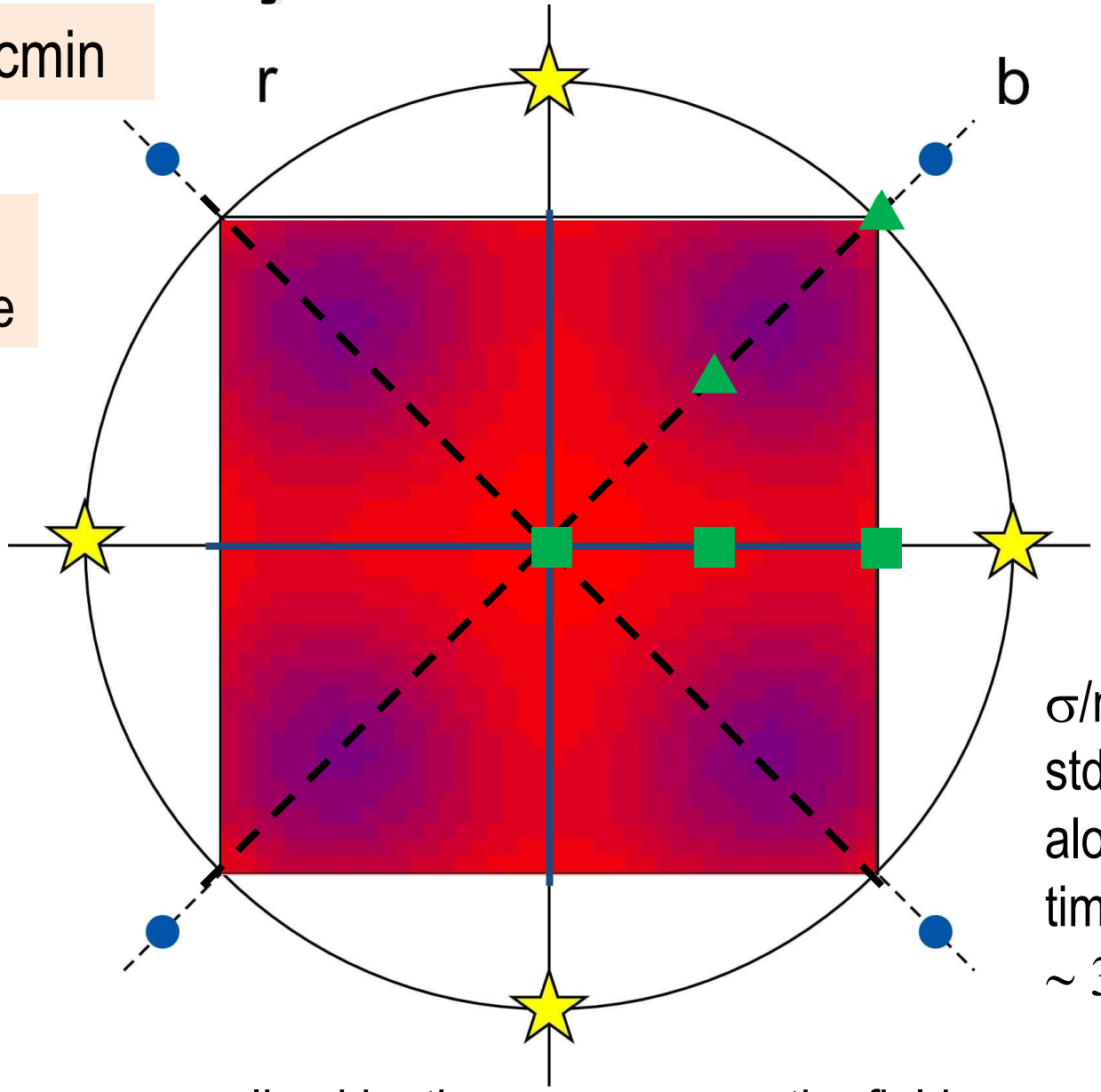
width: blue: 0.24"、green: 0.36"、red: 0.48“
GLAO: solid lines, Seeing: dotted line

Uniformity of FWHM over FoV

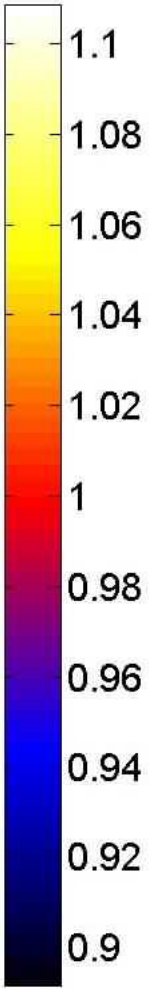
@zenith

r = 7.5 arcmin

K-band
moderate



+3 σ/m



-3 σ/m

σ/m =
std/ave
along
time
~ 3%

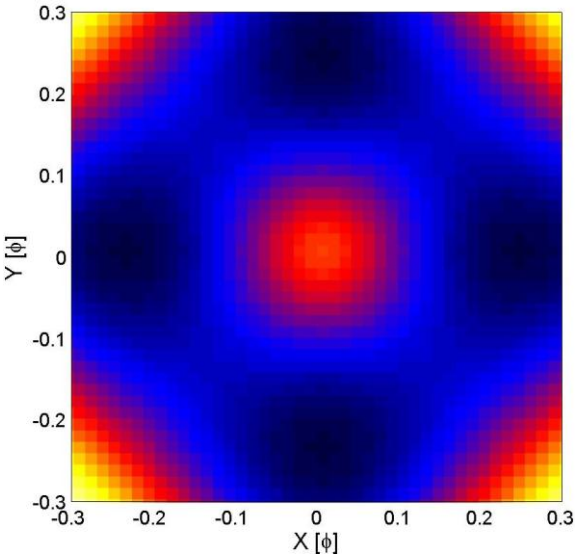
normalized by the average over the field

FWHM Uniformity for other bands

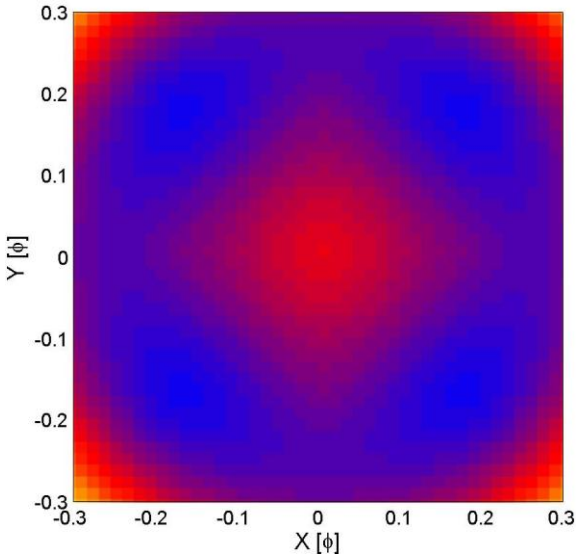
+10%

-10%

R (σ/m=1.2%)

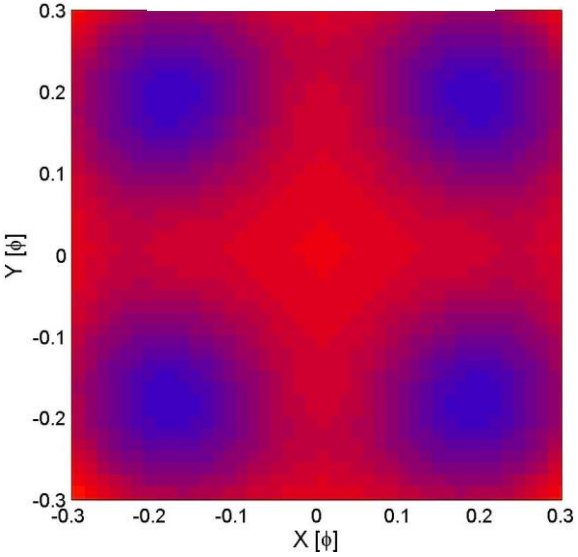


J (σ/m=2.4%)

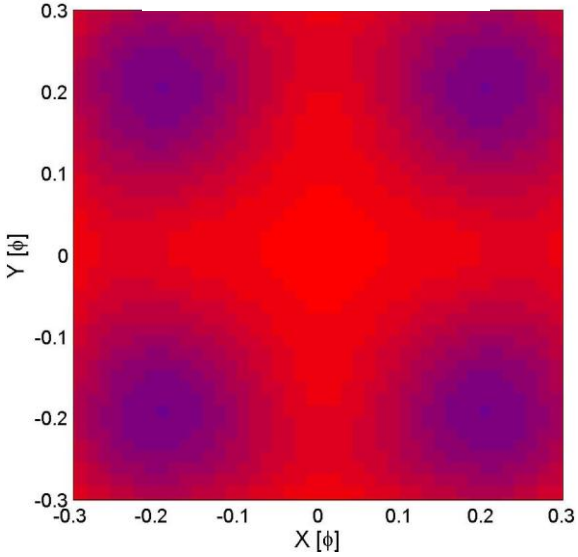


@zenith

H (σ/m=2.8%)



K (σ/m=3.6%)



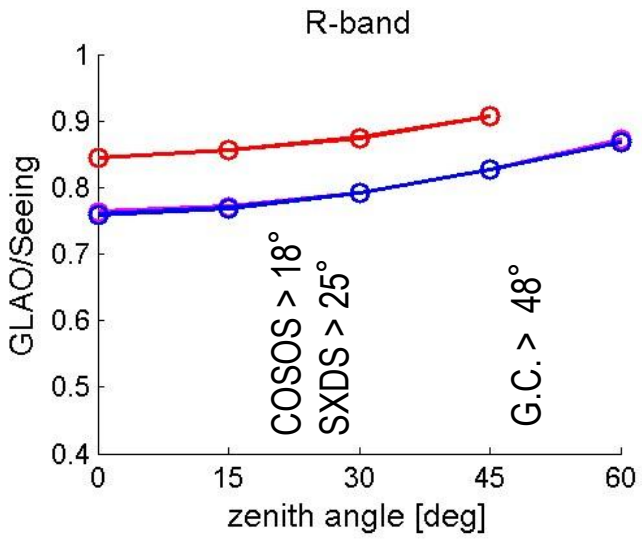
NIR
+/-5%

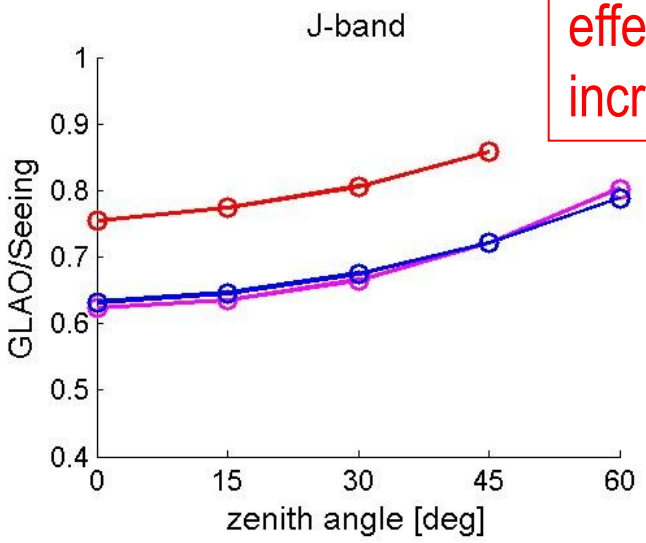
difference by seeing condition < 6%

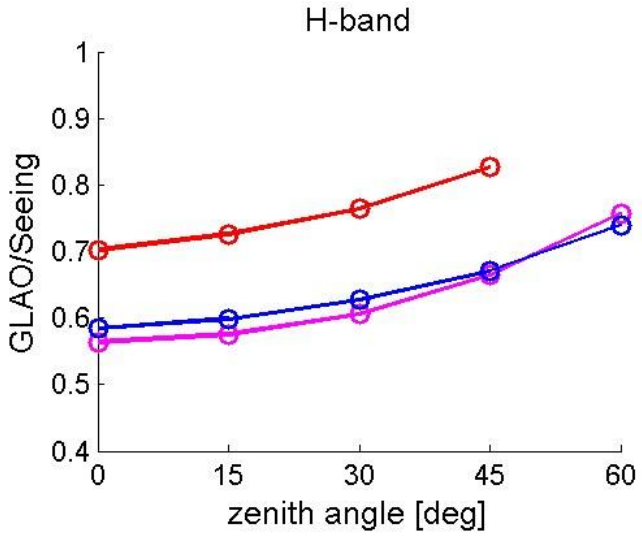
Zenith angle dependency: GLAO / Seeing

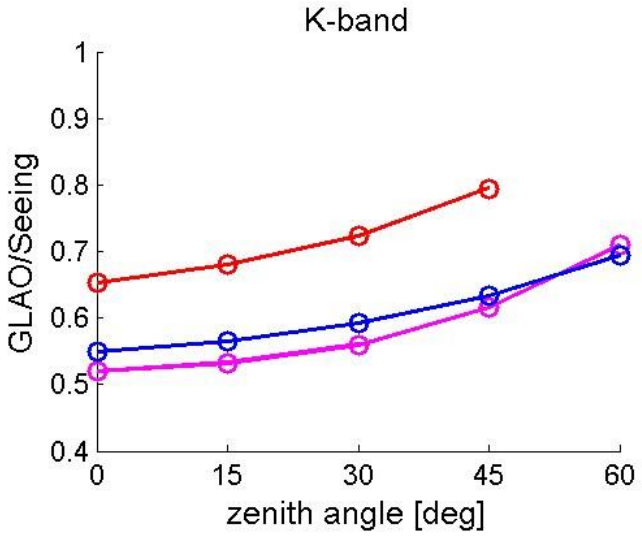
effective height increases

FWHM









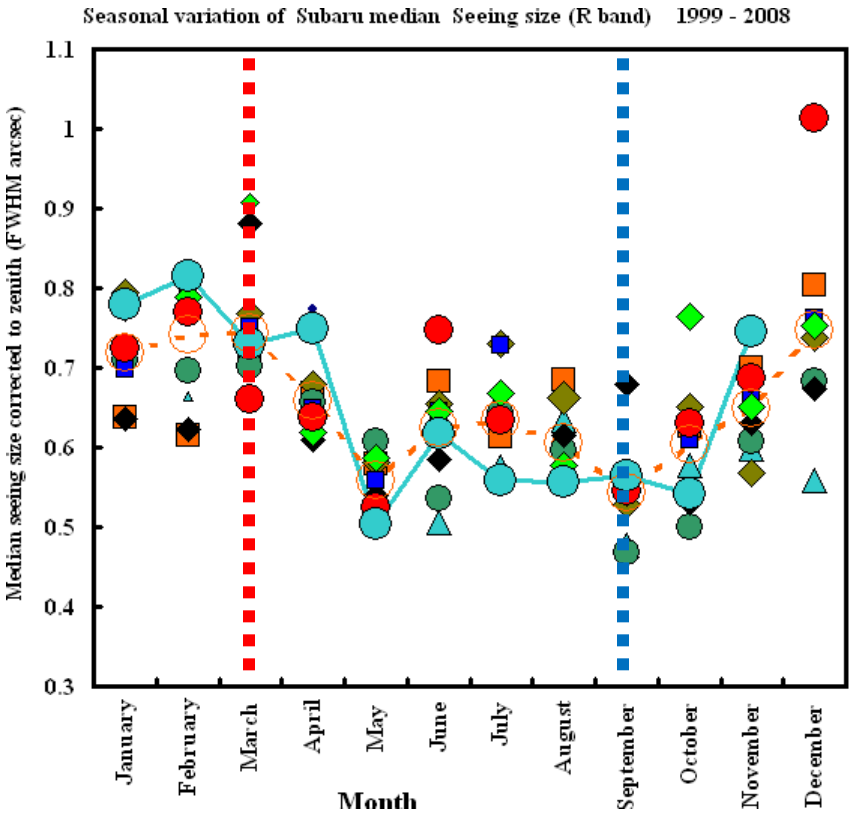
seeing:
-good
-moderate
-bad

loss by 10% at 45° and by 20% at 60°

Seasonal Variation of Seeing

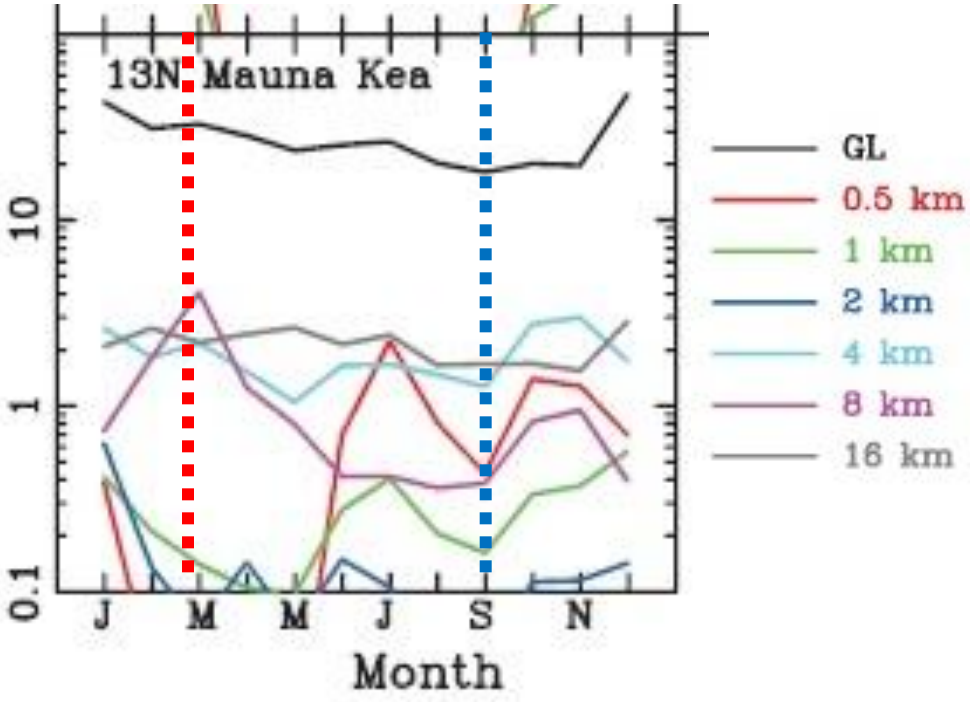
Subaru IQ

http://www.subaru.nao.ac.jp/Observing/Telescope/ImageQuality/Seeing/



13N site, profile

Els+09,PASP,121,527(Fig.5)



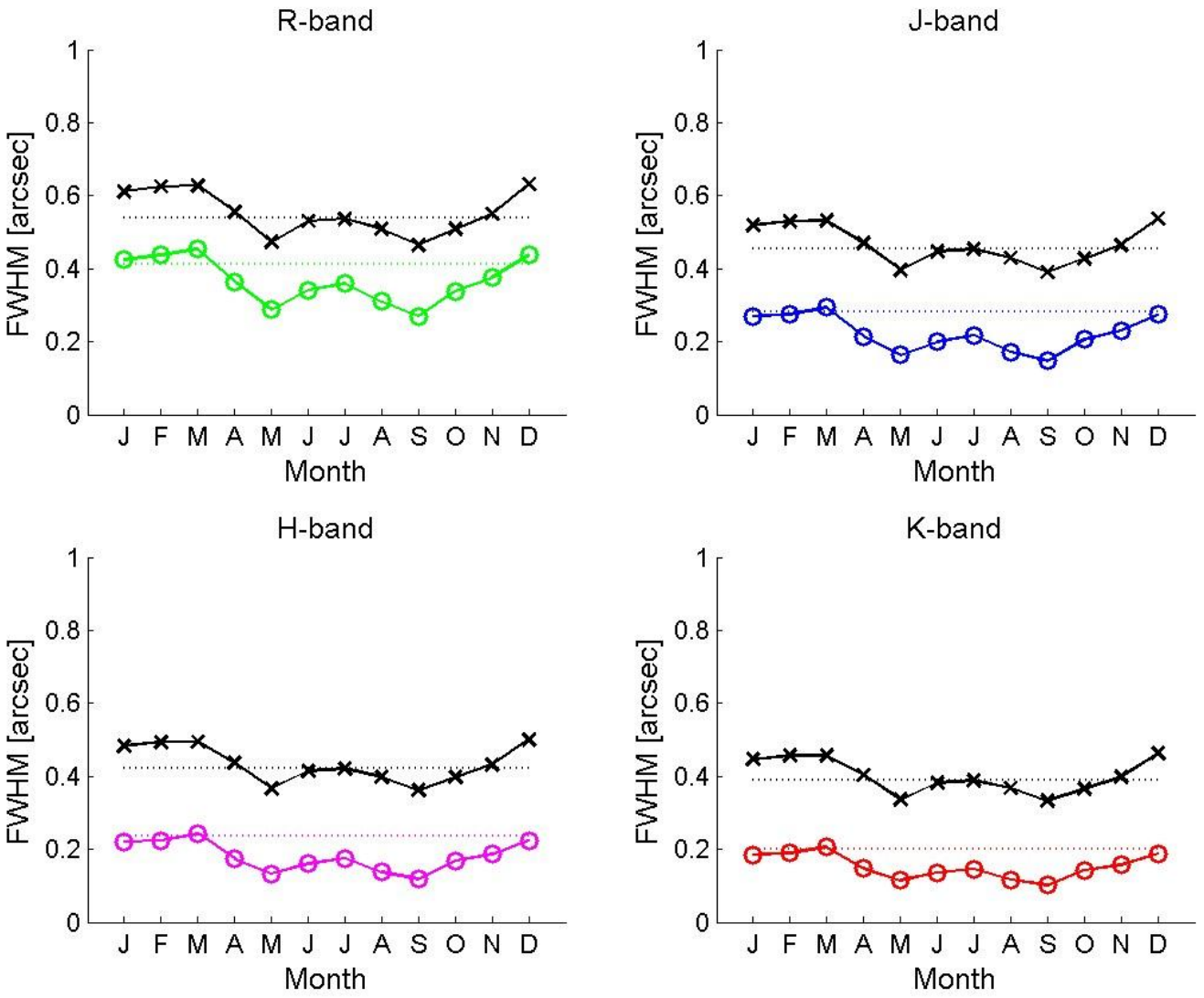
Characteristic months

Sep (good) & Mar (bad).

Subaru AG

25%-ile	Sep (50%-ile)	50%-ile	Mar (50%-ile)	75%-ile
0.49"	0.54"	0.64"	0.74"	0.84"

Seasonal Variation of FWHM

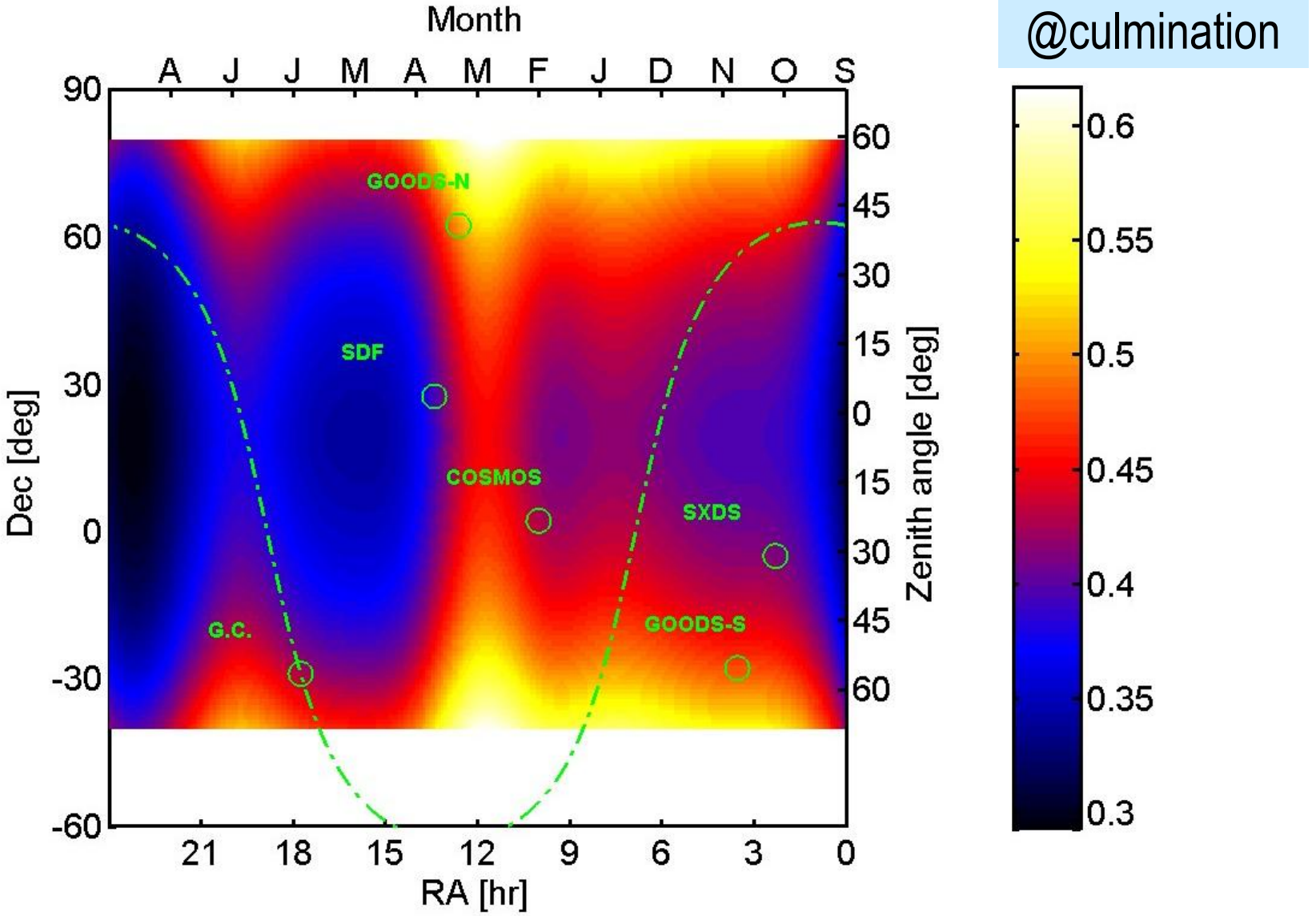


@zenith

Variation
+/-30%

GLAO: R: green、J: blue、H: magenta、K: red; Seeing: black
moderate: dotted line

FWHM ratio (GLAO/Seeing) Map



culmination at

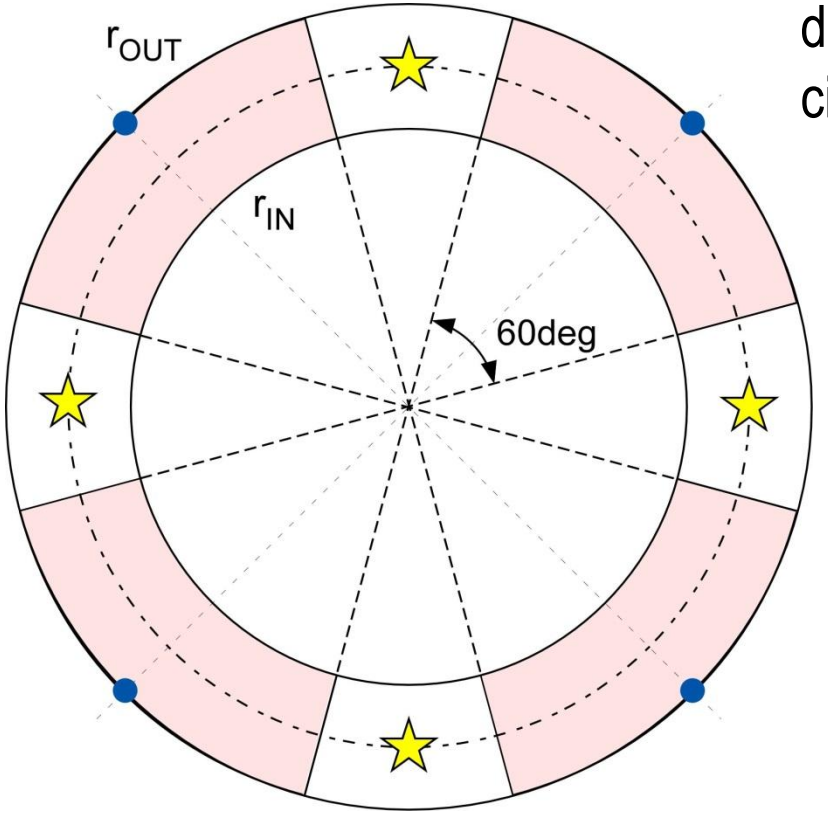
shift the map: late ← midnight → early

Sky coverage

B-configration

★:LGS

●: TTFGS



diameter of the dotted circle is 7.5'

Number of TTFGS in each of 4 pink region

preliminary

D. Simons, Gemini technical notes TN-PS-G0030, (1995).

r(in, out) = r_circ	TTFGS(R-band)	b: 10~20 deg	30~50 deg	60~90 deg	
(7' ,8') = 1.6'	< 18 mag	> 6.7	> 3.0	> 1.8	standard
	< 19 mag	> 10.7	> 4.8	> 2.8	1mag dim
(7', 8.5') = 2.0'	< 18mag	> 34.7	> 7.4	> 4.3	1' larger dia

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.