NGAO Photometric Accuracy Budget Strategy

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Outline

- Photometry Science
- ELT Simulations
- Photometric Variance Sources
- Performance Budget Strategy
 - Analytic Expressions
 - Numerical Investigations
 - Simulations
 - Data Analysis
- Outstanding Issues
- Discussion

Photometric Error Sources

Noise Processes

- Photon Noise
 - Source photon noise
 - Imperfect background subtraction
- Detector Issues
 - Noise
 - Read Noise
 - Fixed-Pattern Noise
 - Dark Current
 - Popcorn Noise (rapid level shifts)
 - Residual flat-fielding errors (linear, but wrong constant)
 - Detector non-linear response
 - □ Few/Single pixel errors
 - Cosmic rays / hot pixels
 / dead pixels
 - Quantum efficiency variations

PSF Uncertainties

- On-axis
 - Time-Variability of AO Performance
 - Telescope Vibrations
 - Saturation
 - Off-axis

- Residual angular anisoplanatism
 - Passive PSF estimation
 - **DIMM** θ_0 errors
 - Wind-induced anisoplanatism
 - Telemetry noise
 - Active PSF shaping
 MCAO residuals
- **Optics**
 - Residual field dependent aberrations (esp. field curvature)
 - Variable transmission (coating degradation)
 - Field dependent transmission (beamwalk)

Source Uncertainties

- Stellar
 - Star variability
 - Time-variable chromatic emmissions (variable color)
 - Maculation (sunspots)
- Extrastellar
 - Crowding
 - Differential interstellar extinction

Environmental

- Atmospheric scintillation
- Variable extinction
 - Scatter
 - Transparency waves
 - Airmass variation across FoV
 - Heterochromatic extinction

Calibration

- Filter
 - Bandpass uncertainties

Proposed Performance Budget Strategy



NGAO Error Budget KBO imaging scenario

> Based on Lick, Palomar & Keck experience

	Total Equivalent WFE									
131 nm										
High-Order Errors							Tip-Tilt Errors			
121 nm							3.88 mas (51 nm)			
							1			
Atmosphere		Calibration					Systematics		Atmosphere	
93 nm		76 nm 0			0	.71 mas (9 nm)		3.81 mas (50 nm)		
Atmospheric Fitting59 nmBandwidth33 nmHigh-order Measurement41 nmLGS Tomography29 nmAsterism Deformation22 nmMultispectral25 nmScience Scintillation15 nmWFS Scintillation10 nm							Tilt Measuremer Tilt Bandwidth Tilt Anisoplanati Res. Centroid A Res. Atmospher Res. Telescope	nt sm nisoplanatism ic Dispersion Pointing Jitter	2.39 mas 1.68 mas 0.00 mas 1.99 mas 0.95 mas 1.05 mas	
	29 nm 22 nm 25 nm 15 nm 10 nm	50 nm	45 nm	28 nm	20 nm	0 nm	S	Science Inst. Mechanical Long-Exposure Field Rota	Drift tion	0.50 mas 0.50 mas
	17				Go-to	Contro	ol	0 nm		
Angular Aniospianalism	17 1111			Res. Na Layer Focus High-Order Aliasing		IS I	3 nm 20 nm			
			DM I Hyst Drive	Finite S eresis e Digitiz	e Stroke is jitization			25 nm 13 nm 3 nm		
		Static WFS Zero-point Calibration Dynamic WFS Zero-point Calibrati Unc. AO Sys. Aberrations Unc. Instrument Aberrations DM-to-Lenslet Misregistration				libratior Calibra ns tion	n tion	25 nm 15 nm 20 nm 25 nm 13 nm		
Unc. Dynamic Telescope Aberrations						23 nm				

NGAO Photometry Budget

M31 Bulge Scenario



Input Assumption - Site Data

- Mauna Kea median seeing conditions at $\lambda = 0.5 \ \mu m$:
- $r_0 = 18$ cm. $\sigma = 3$ cm. $L_0 = 75$ m.
- $\theta_0 = 2.5$ arcsec
- $f_G = 39 \text{ Hz}$
- $L_0 = 75 \text{ m}$
- C_n^2 profile from data

Altitude (km)	Fractional C_{r}^{2}	Wind Speed (m/s)
0.0	0.471	6.7
2.1	0.184	13.9
4.1	0.107	20.8
6.5	0.085	29.0
9.0	0.038	29.0
12.0	0.093	29.0
14.8	0.023	29.0



Median sodium density = $4 \times 10^9 \text{ atoms/cm}^2$