A Method for Determining AO Off-Axis PSFs

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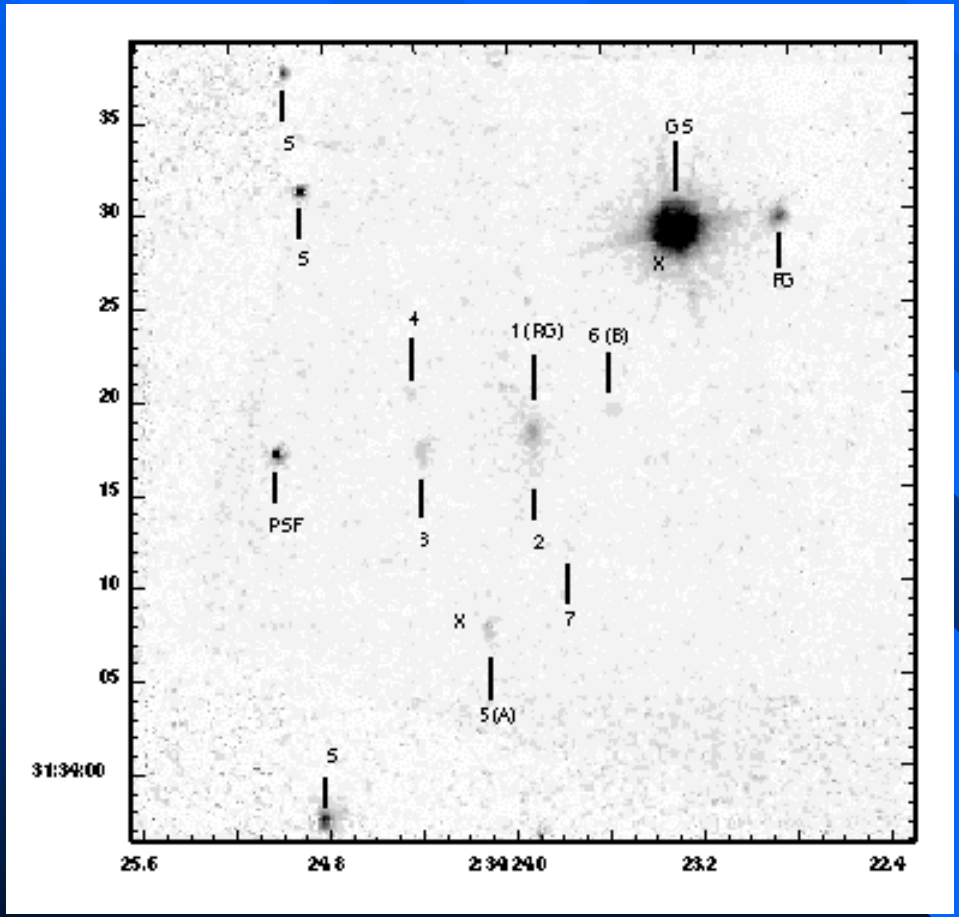
Scientific Observations



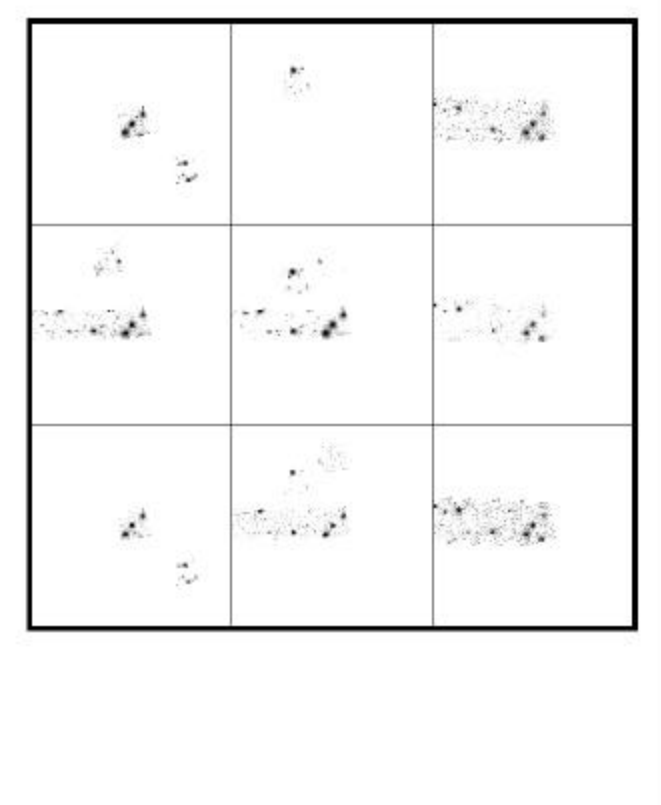
CFHT Pueo/KIR image of 3C68.2 field (~ 1 square-arcminute FOV)

Guide-star is at the faint limits for full correction

Scientific target is 20 arcseconds away

Suitable PSF stars are rare

Calibration Observations

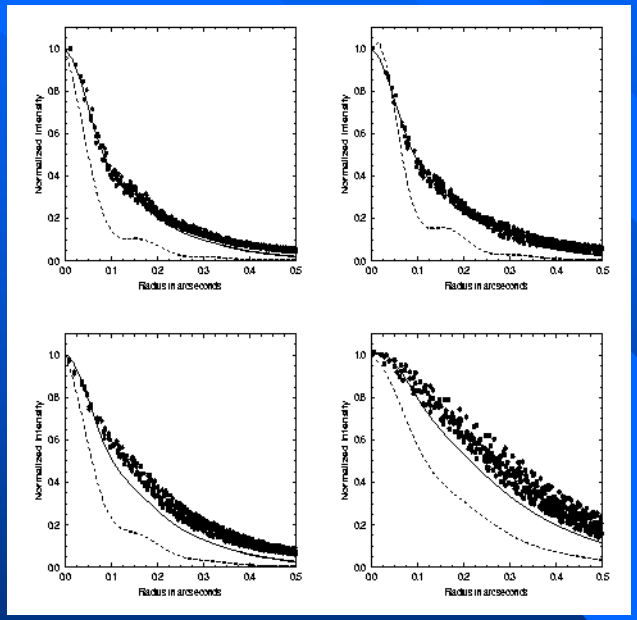


- CFHT Pueo MONICA/KIR observations of M5 (~ 1 square-arcminute FOV)
- Unsaturated image of guide-star in center of field
- Many PSF stars in field
- One set of J, H, K images per night

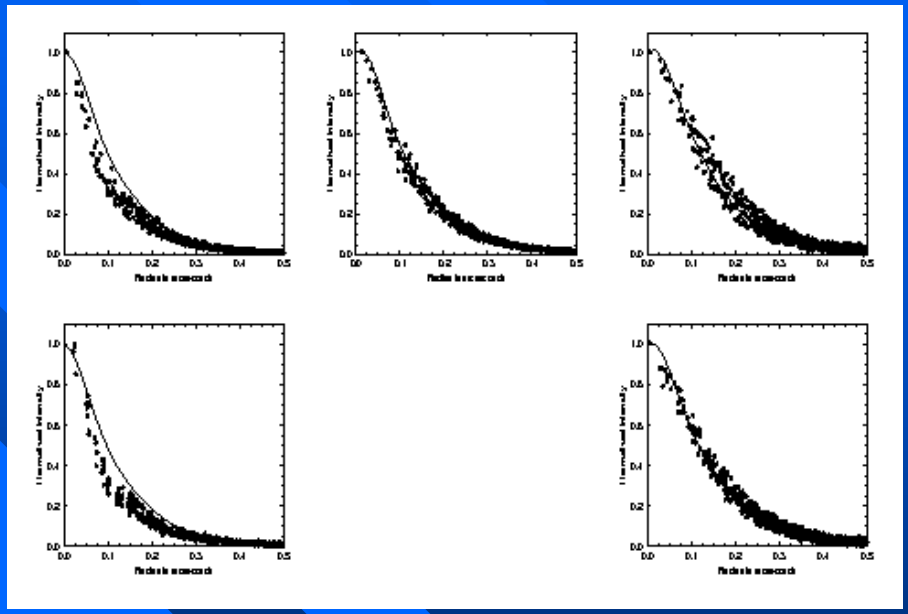
Generating Off-Axis PSFs

- Obtain on-axis PSF for each scientific observation
- Obtain crowded star-field calibration image
- Deconvolve calibration image with its on-axis PSF
- Convolve the residual calibration image with the on-axis PSF for the scientific observation

Off-Axis PSFs

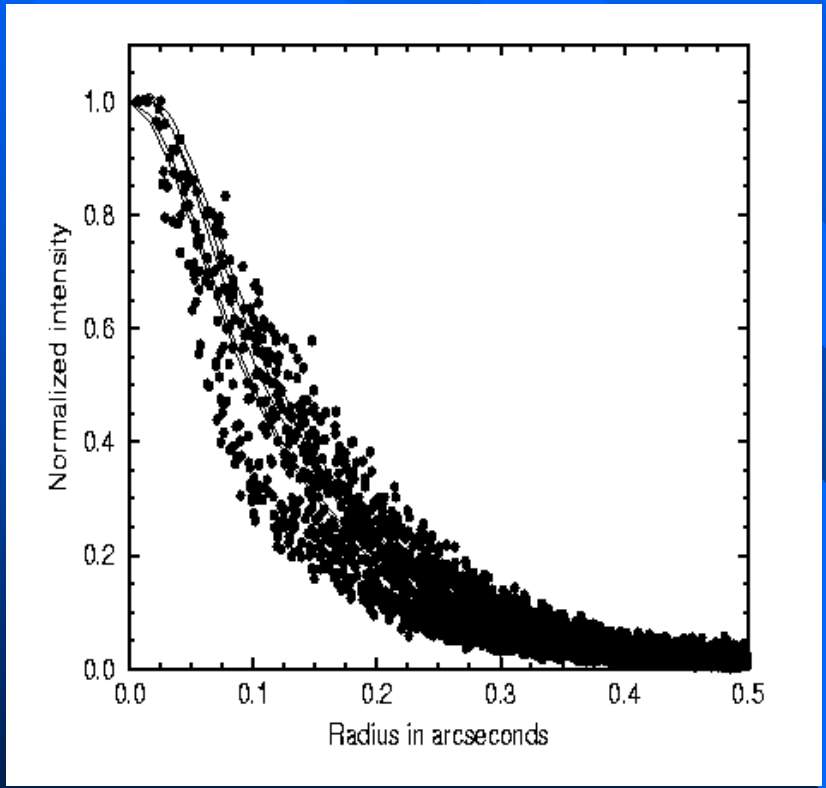


PSFs at 5, 10, 20, 30 arcseconds off-axis



PSFs at 20 arcseconds off-axis at different azimuthal angles

Average Off-Axis PSF



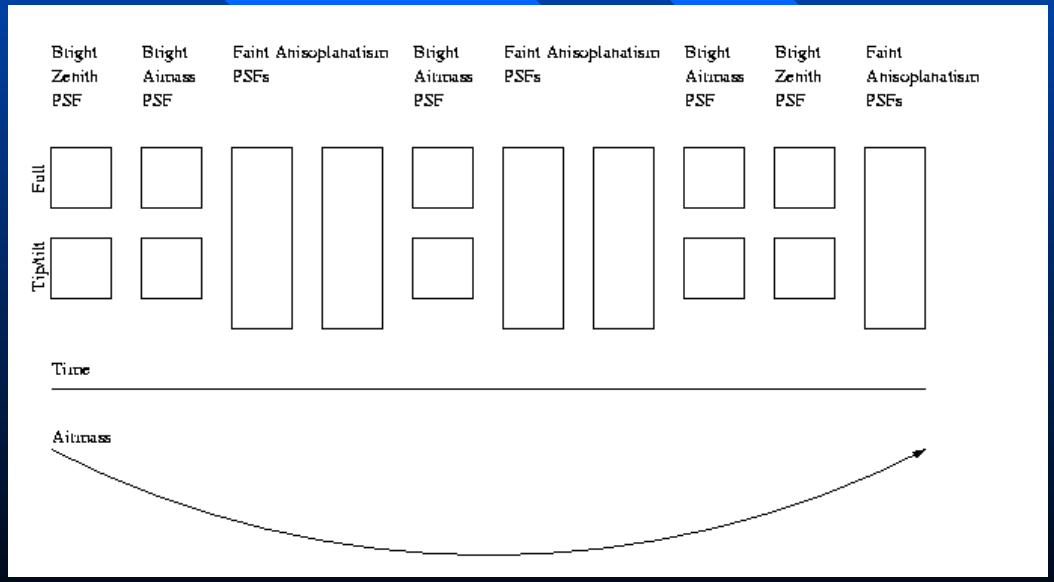
The average PSF at 20 arcseconds off-axis

Correct mean Strehl and FWHM for scientific observation

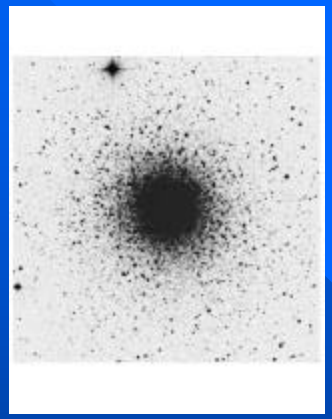
Does not account for azimuthal anisoplanatism

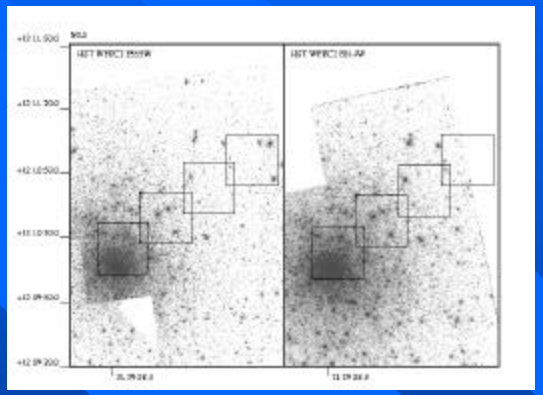
Improved Test of the Method

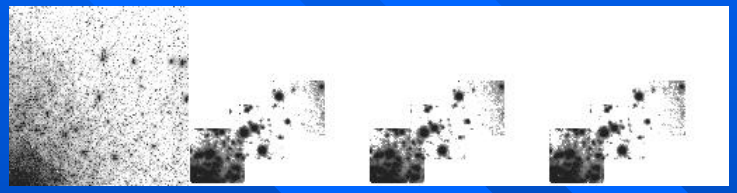
- Obtain several star-field calibration images with a faint guide-star
- Obtain calibration PSFs for bright guide-stars at zenith and star-field airmass



Lick AO/IRCAL Observations of M15





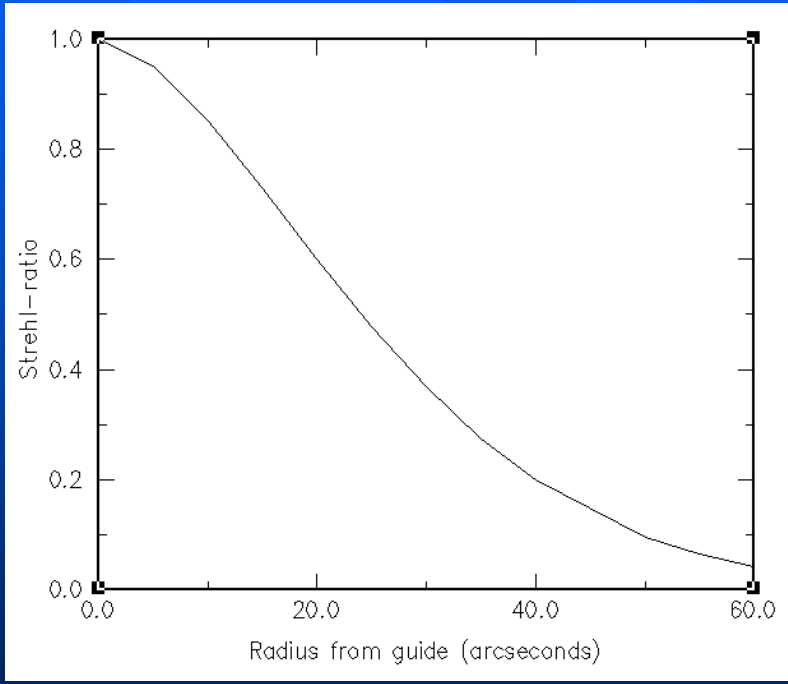


Faint guide-star calibration images in J, H, and K over 2 nights (30 ~ 1 arcminute long)

Bright guide-star PSFs at zenith and cluster airmass

Estimates of r0 from WFS information (Don Gavel, LLNL)

Isoplanatic Angle



Single layer turbulence with D/r0>>1

Obtain on-axis Strehl (J: 4%, H: 6%, K: 10%) and isoplanatic angle (J: 150 arcsec, H: 80 arcsec, K: 60 arcsec) as a function of airmass

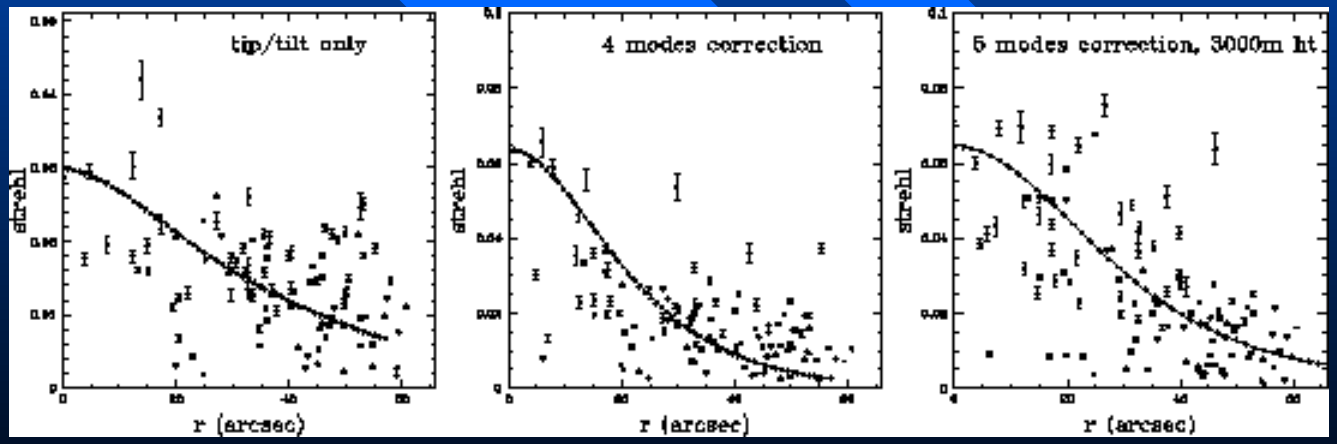
Obtain estimate of mean altitude of layer (1000 – 3000 m)

Modeling / Simulations

Single layer turbulence modeled with a synthetic phase-screen

Inputs are r0 and mean altitude of layer

Model number of corrected modes, subapertures of WFS and number of degrees of freedom in DM (Sasha Hinkley, UCSC/CfAO)



Summary

- A single observation of a crowded star-field can determine off-axis PSF for entire night given on-axis PSF information
- A single low-altitude layer is sufficient to explain isoplanatic angle for Lick AO

Future Work

- Better determination of Strehl in crowded star-fields
- Work repeated with laser guide-stars
- More sophisticated simulations (Miska Lelouarn, UCSC/CfAO)
- Method would benefit greatly from an independent measurement of mean altitude of turbulence (SCIDAR / DIMM for Lick or Mauna Kea?)