# On Axis Guiding
# and
# Continuous Real Time Autofocus

## Astro Imaging Channel

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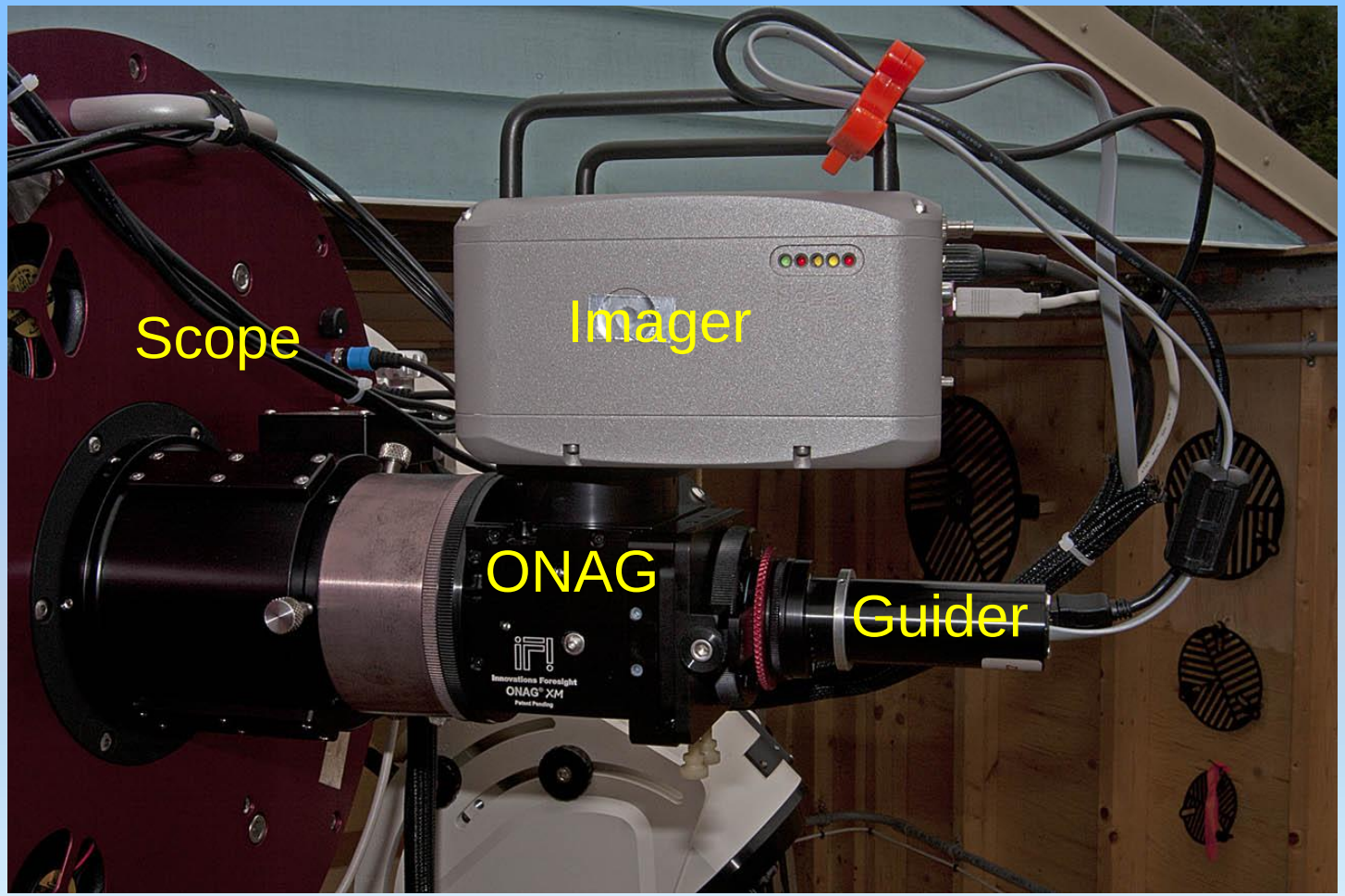
**Innovations Foresight, LLC**

# On Axis Guider - ONAG®



# ONAG® Dichroic beam splitter

Imager

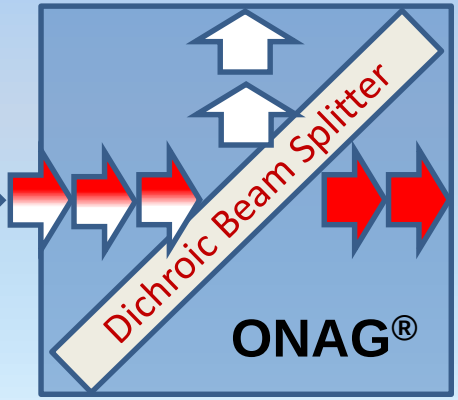
Visible < 750nm

Imaging camera side

Starlight

Visible + NIR

Scope side




NIR > 750nm

Guiding camera side

Guider

# ONAG®

Innovations Foresight

SharpLock

HOT PRODUCT 2012 SKY & TELESCOPE

Astronomy magazine 2012 Star Products

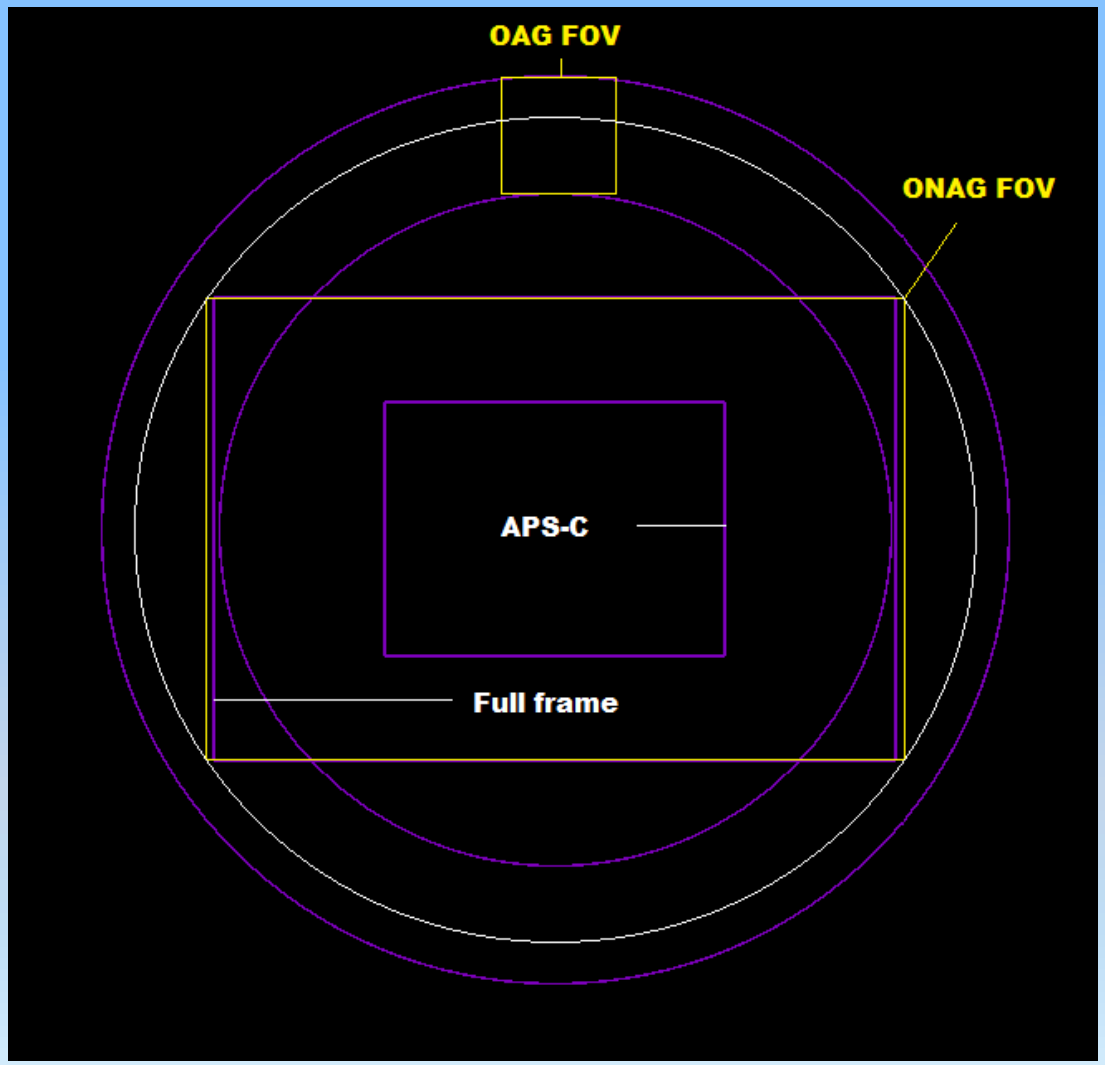
- Same scope, no-flexure.
- Large field of view (on and off-axis).
- No rotation (same flat frames, stay in focus).
- Multi-star guiding (support APS-C size guider for robotic setups).
- Continuous auto-focus capability (*SharpLock* technology).
- Seeing effects significantly reduced by guiding in NIR.



# ONAG® specification

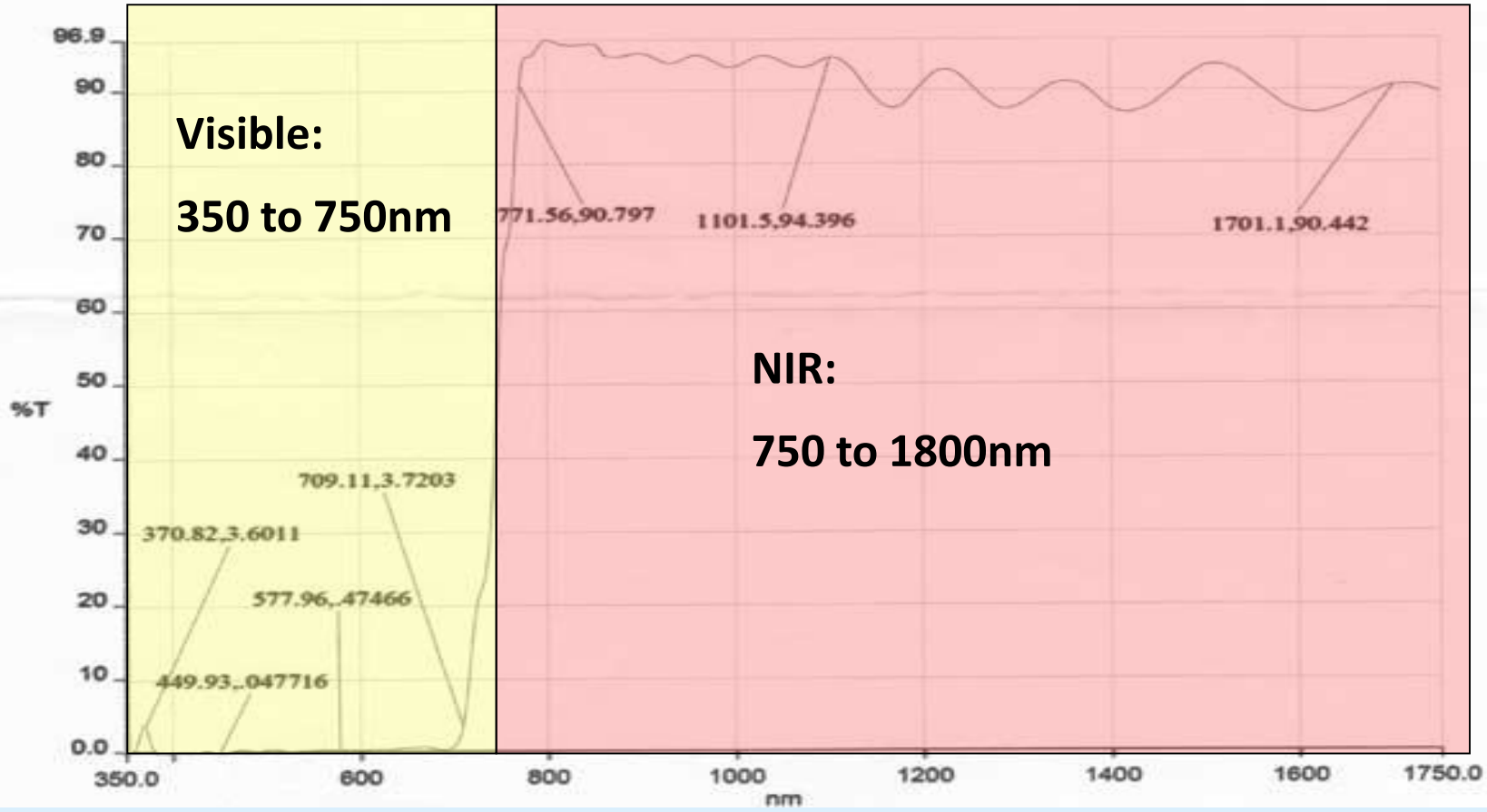
| | |
|---|---|
| • Multi-coated dichroic mirror : | Laser aligned at factory |
| • Weight : | <850g (1.87 lbs) |
| • Reflection (visible 350nm-750nm): | >98% (typical) |
| • Transmission (NIR 750nm-1200nm): | >90% (typical) |
| • ONAG SC back-focus (imager): | 66mm (2.59″) |
| • ONAG XM back-focus (imager): | 68mm (2.67″) |
| • X/Y stage vertical travel (guider): | 37mm (1.46″) |
| • X/Y stage horizontal travel (guider): | 24mm (0.95″) |
| • Helical guider focuser travel: | 9mm (minimum) |

# ONAG® FOV

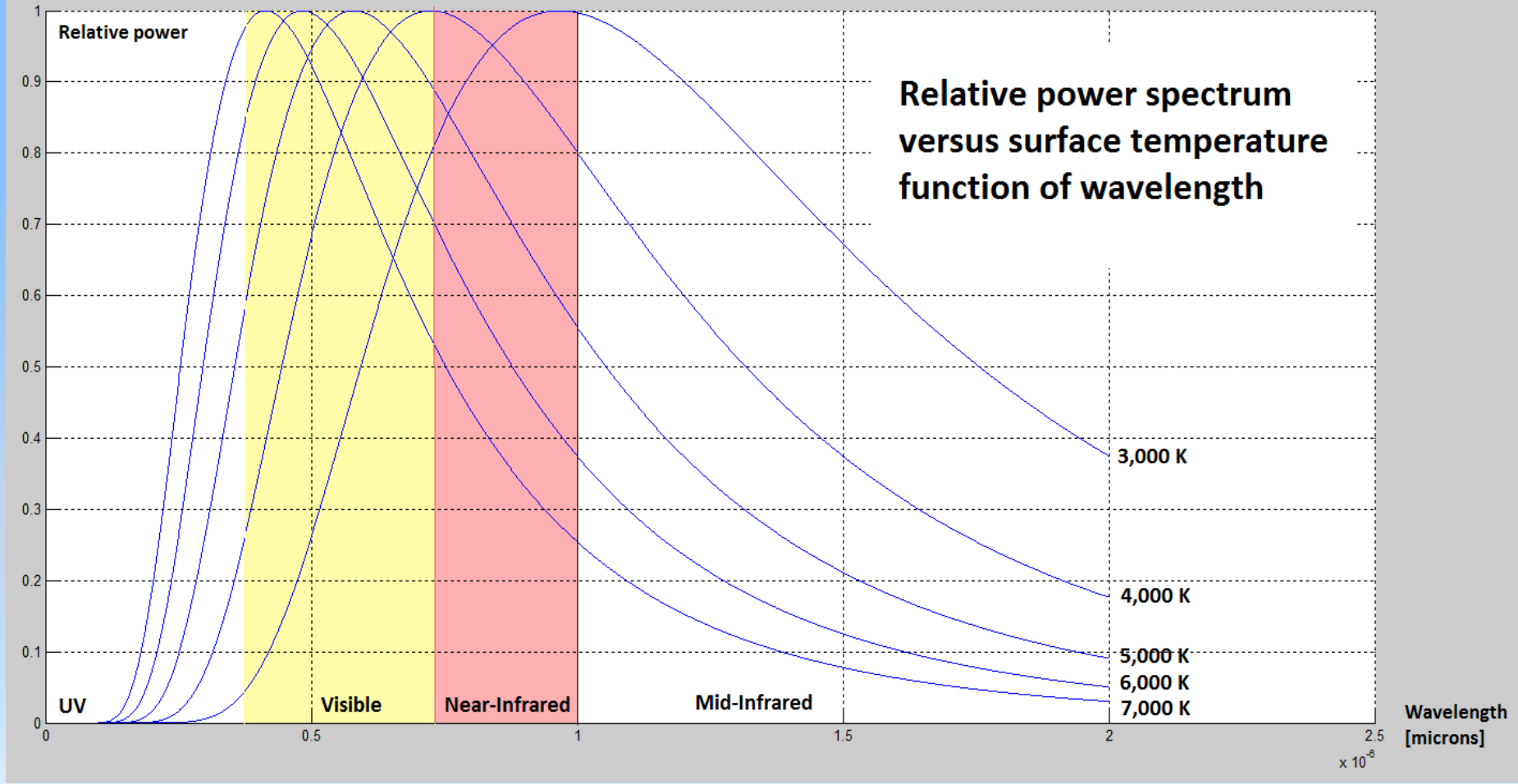


# ONAG® transmission spectrum

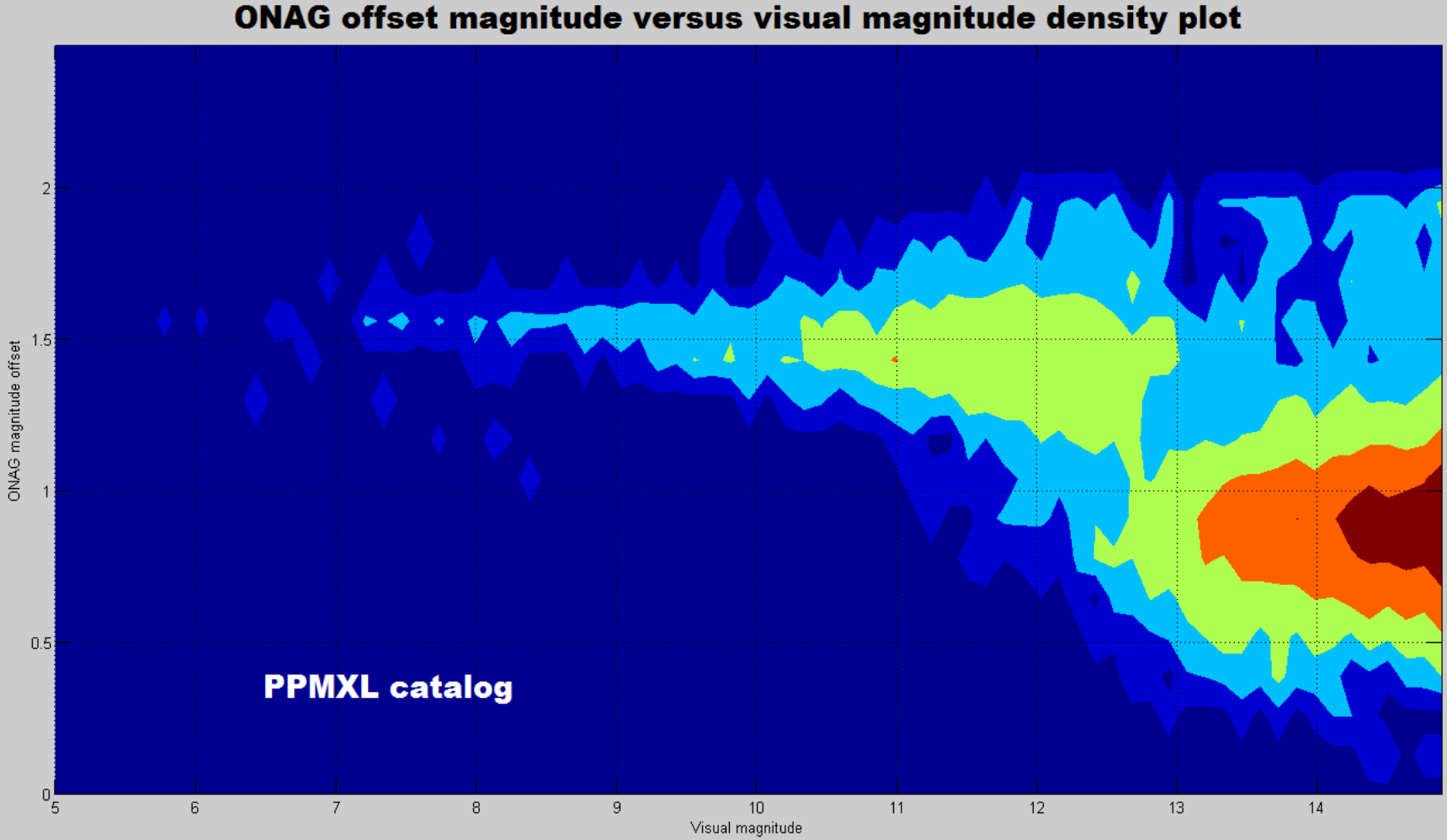
## ONAG® coating test report



# Near infrared guiding

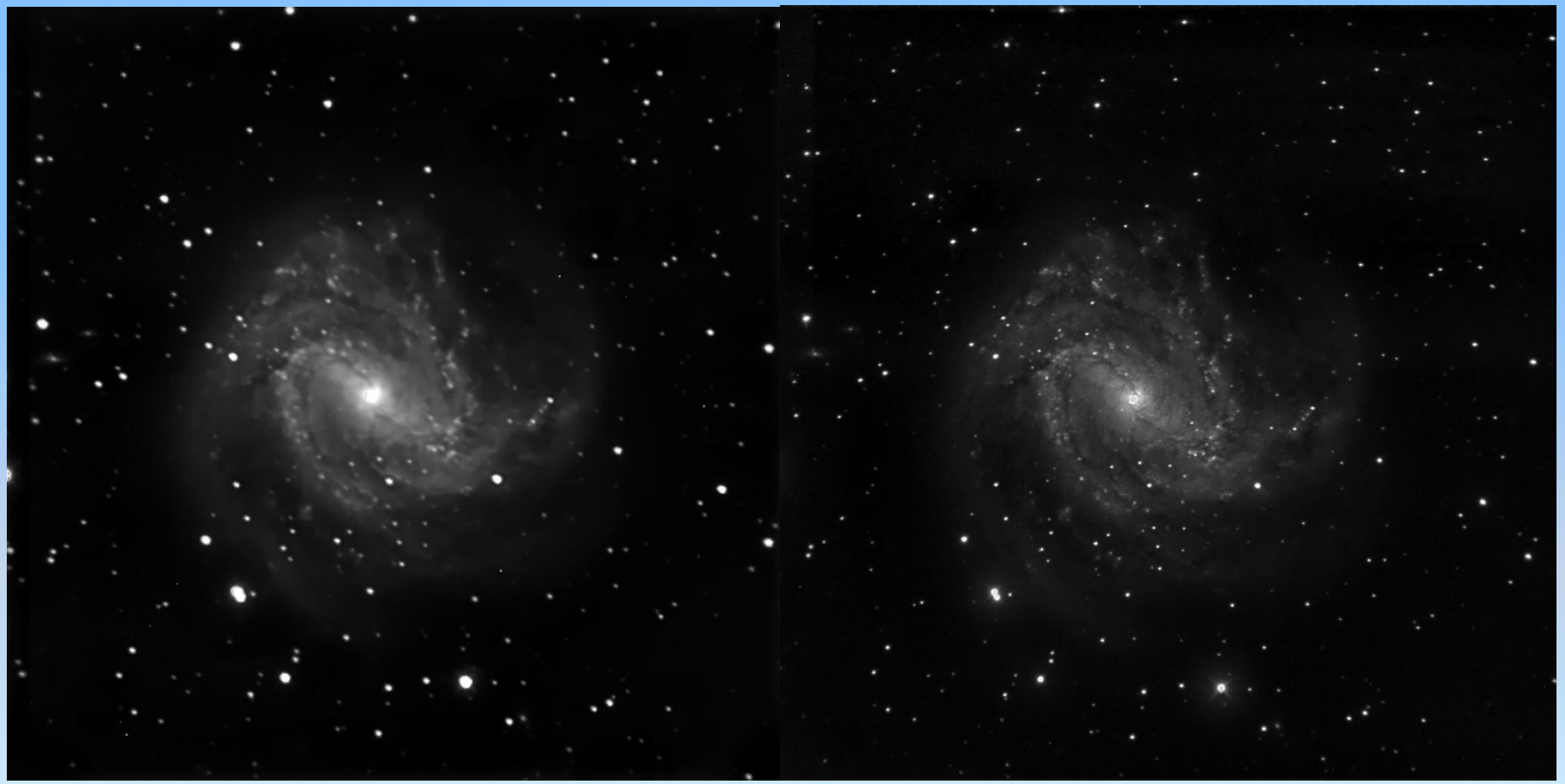


# ONAG magnitude offset density (PPMXL)



# NIR guiding and seeing

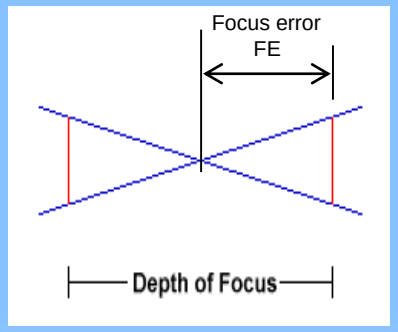
**Mario Motta's relay telescope 32" @ f/6 + STL11000 + AO-L  M86 @ ~14 degrees**

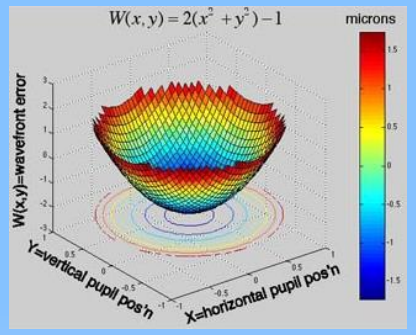


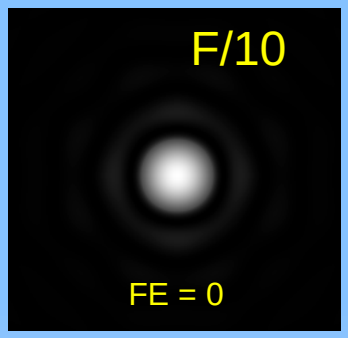
**M83 with full spectrum guiding (OAG)**

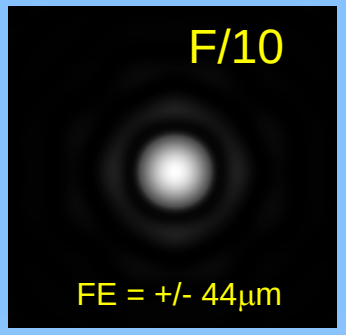
**M83 with NIR guiding (ONAG)**

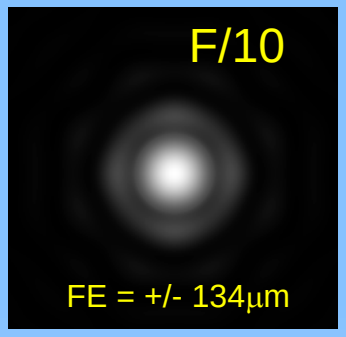
# How much focus error is too much?




Wave front error: 0 λ λ/10 λ/3

Focus error for λ/3: +/- 2.44 x $F^2$ x λ = CFZ (Rayleigh's limit)

Focus error for λ/10: +/- 0.8 x $F^2$ x λ = ~1/3 CFZ

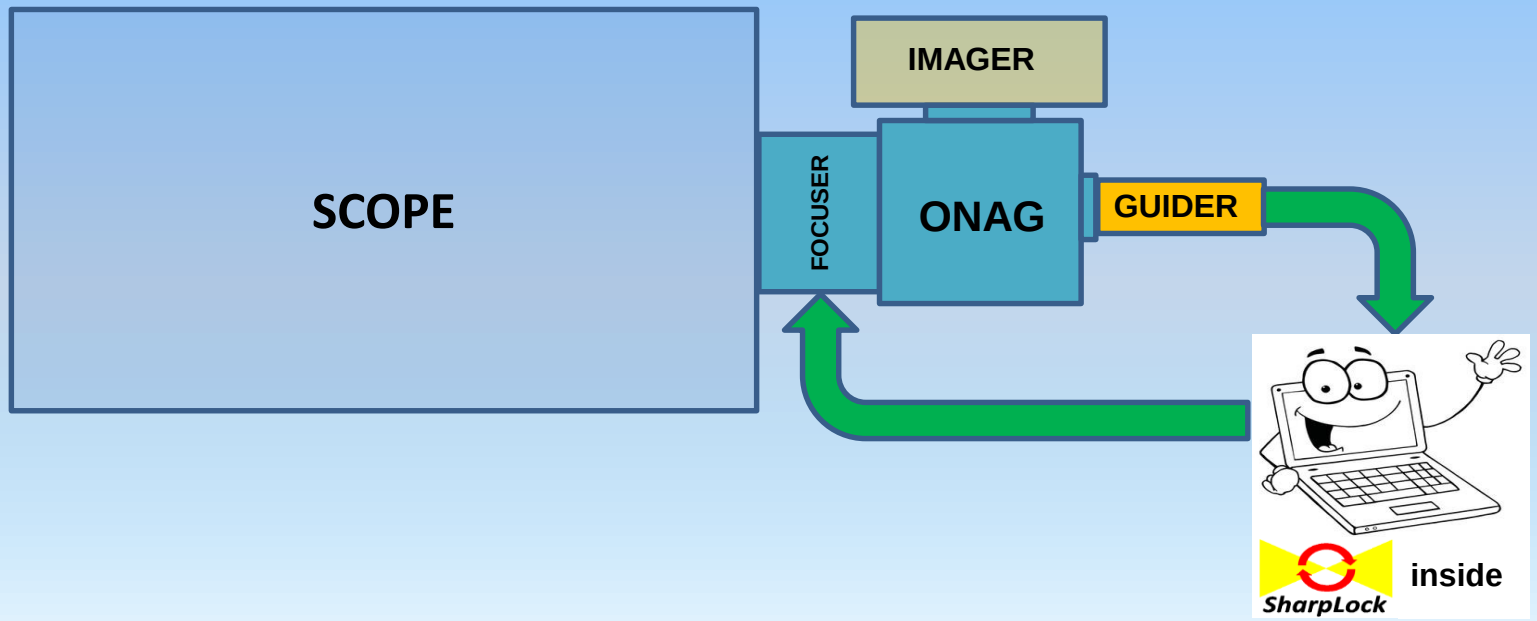
Rule of thumb: **Focus error effect < λ/10**

| F/# λ = 550 nm | F/3 | F/6 | F/8 | F/10 |
|---|---|---|---|---|
| Focus error λ/10 | +/- 4 *μm* | +/- 16 *μm* | +/- 28 *μm* | +/- 44 *μm* |
| CFZ error λ/3 | +/- 12 *μm* | +/- 48 *μm* | +/- 86 *μm* | +/- 134 *μm* |

# FocusLock Overview

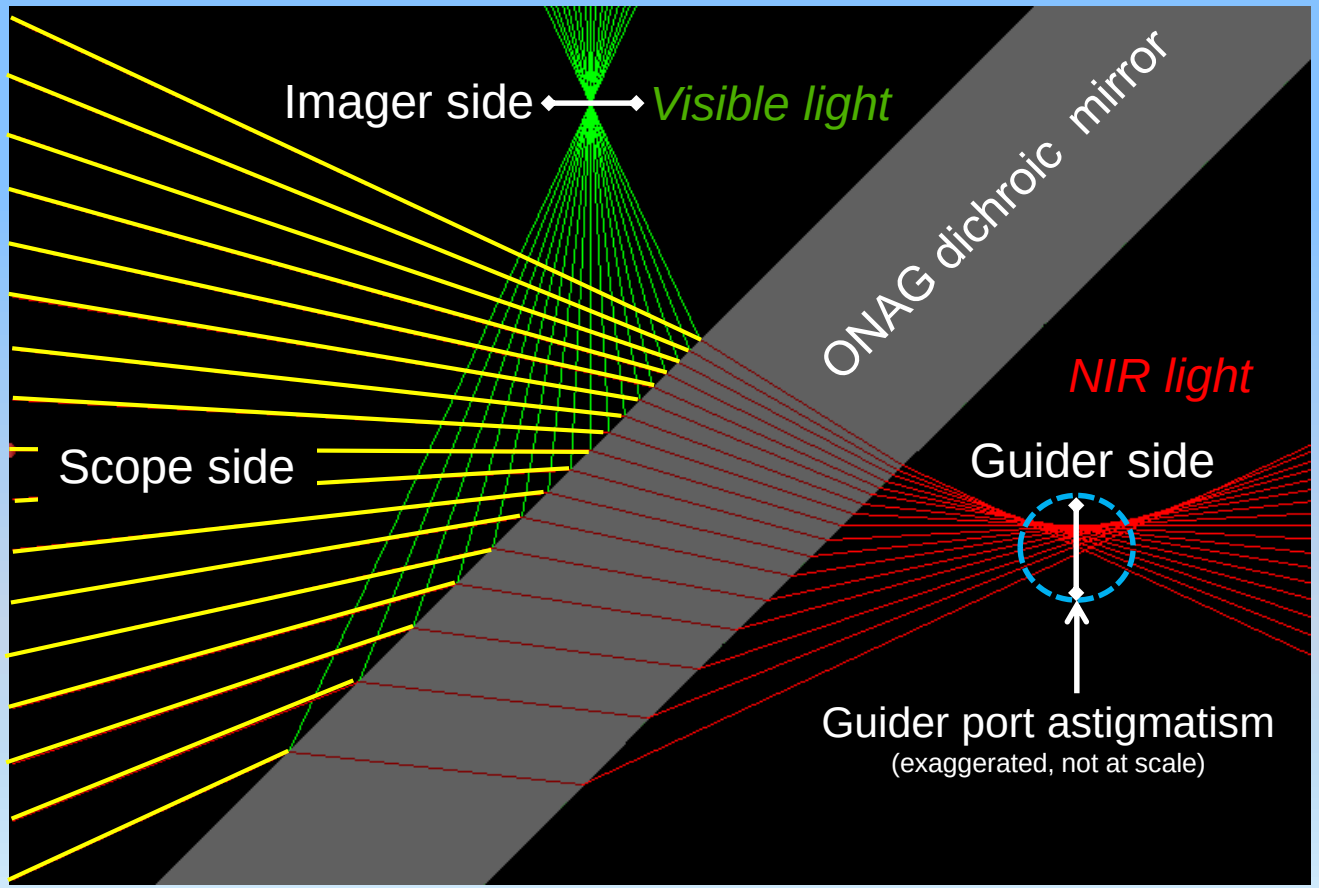
- Continually maintains critical focus without any interruptions in imaging operations. Scope remains on target.

- Uses the guide star images for focus directionality & quality assessments while auto-guiding.



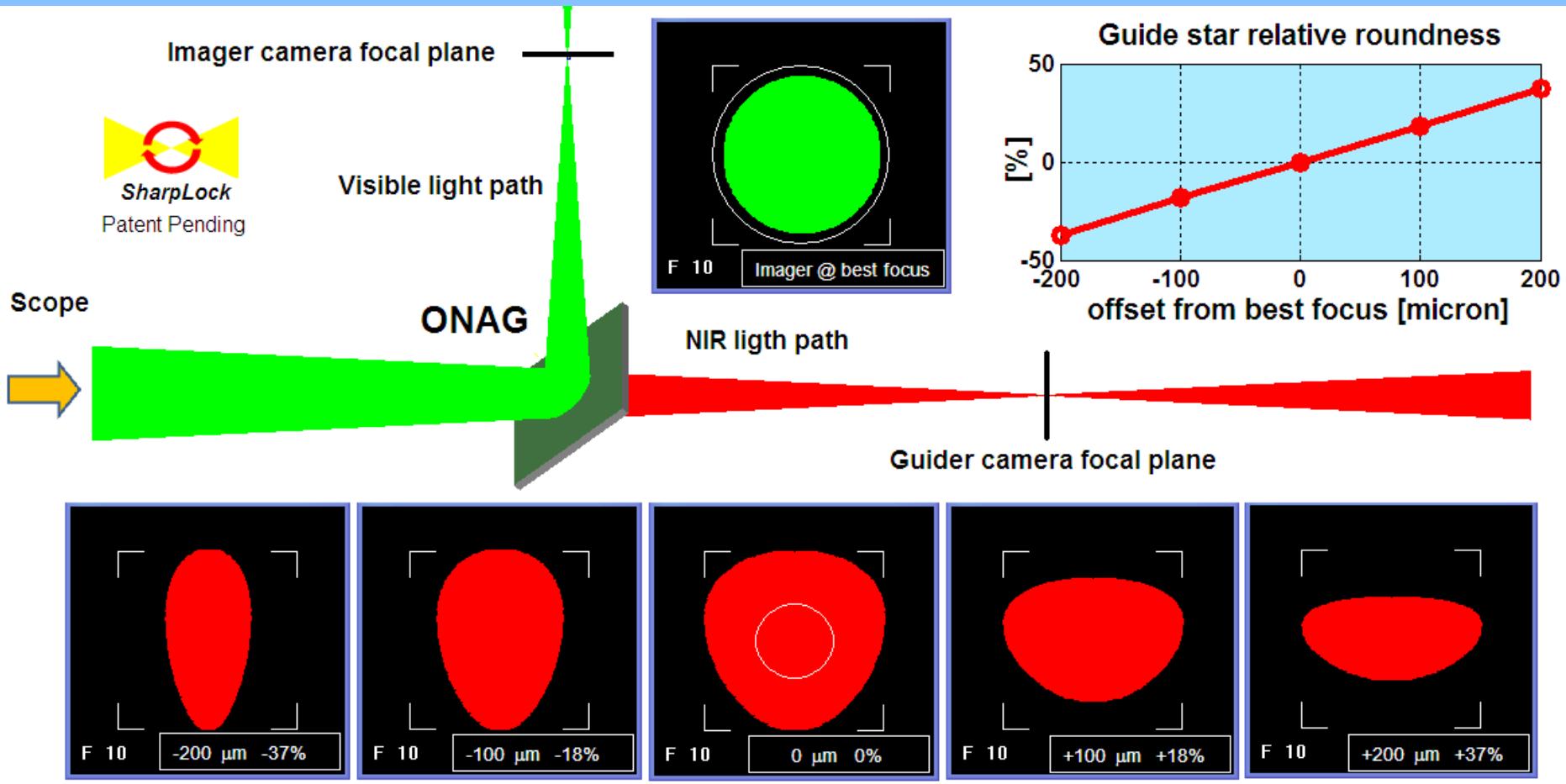
# Guide star profile

Guide star a best focus:





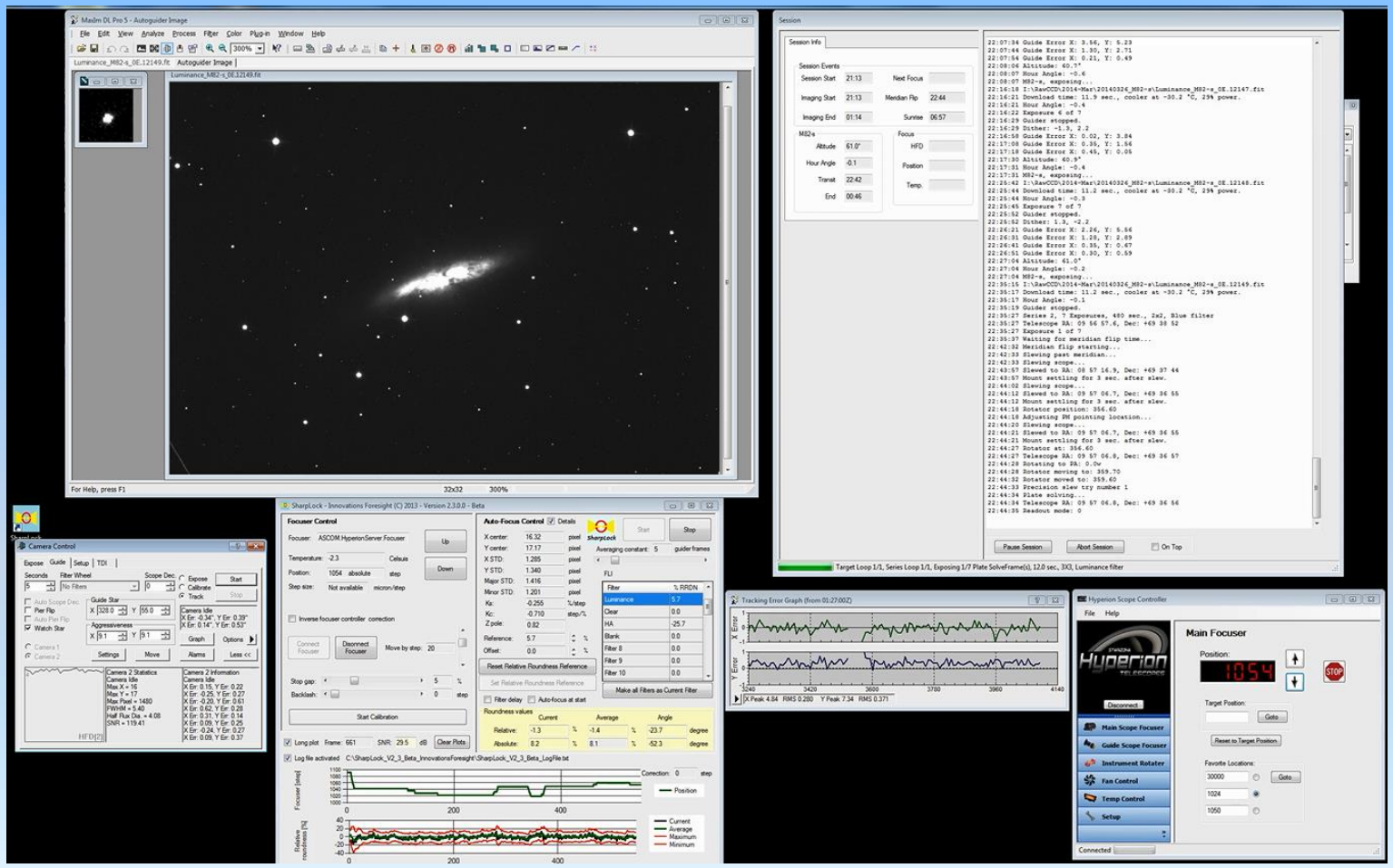
# *SharpLock* Optical concept




Guide star shapes versus best focus offsets

# Periodic refocusing versus *SharpLock* side by side

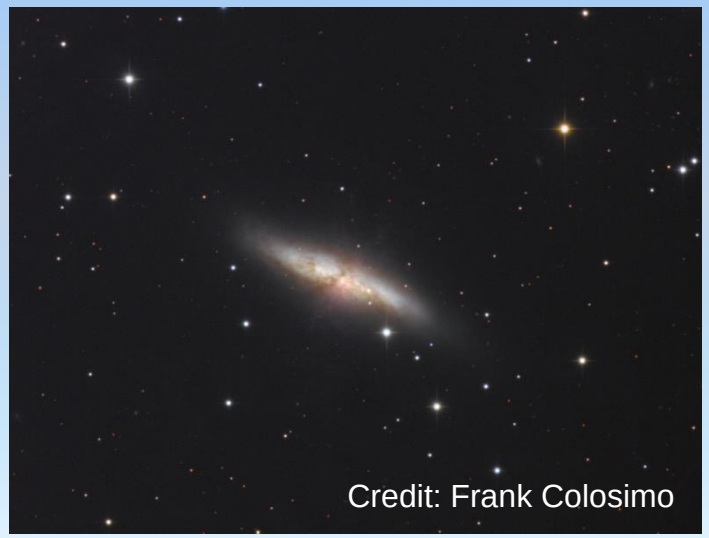
CCDAP, same scopes, mounts, time & location. Credit Frank Colosimo



# Periodic refocusing v.s. *SharpLock*
# M82 - 27 March 2014

Location: Blue Mountain Vista Observatory, New Ringgold PA (USA)
Scopes/Mounts: Hyperion 12.5" F/8 (same model) / PME
Imager #1: SBIG STL-11000, 9x9μm, periodic focus (every filter or 30')
24 frames (LRGB): 4h46' ~ 12' per frame (include periodic focus)
Imager #2: Apogee U8300, 11x11μm, ONAG +*SharpLock*
28 frames (LRGB): 4h22" ~ 9' per frame (no interruption)

**Saving: 2.6' per frame, total for 28 frames = 1h13' or 27%**




**Periodic focus**

**Stacked FWHM in arc"**

L: 2.3
R: 2.5
G: 2.5
B: 2.6


**ONAG + *SharpLock***

**Stacked FWHM in arc"**

L: 2.4
R: 2.2
G: 2.2
B: 2.4

# Thank you!


*Clear skies!*