

Gemini North Laser Adaptive Optics Performance: First Science Data

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and the Gemini LGS Team



Gemini Laser Guide Star (LGS) Concept:

- Project V ~ 9 artificial star onto sky for adaptive optics (AO) correction using a ~10 Watt laser tuned to 589 nm (sodium layer).
- High-order aberrations are corrected using the Laser Guide Star.
- Only focus and tip/tilt require a Natural Guide Star.
- Visible light used for AO correction, near-IR light used for science.
- Allows correction similar to non-laser AO systems but over much larger sky area (40% vs. 4%), fainter depth ($R \sim 18$ vs. $R \sim 15$), and with less anisoplanatism.
- Allows better than 0.1" angular resolution with a S/N increase of a factor of 2 to 3 over non-AO.
- LGS was commissioned at Gemini in February 2007.

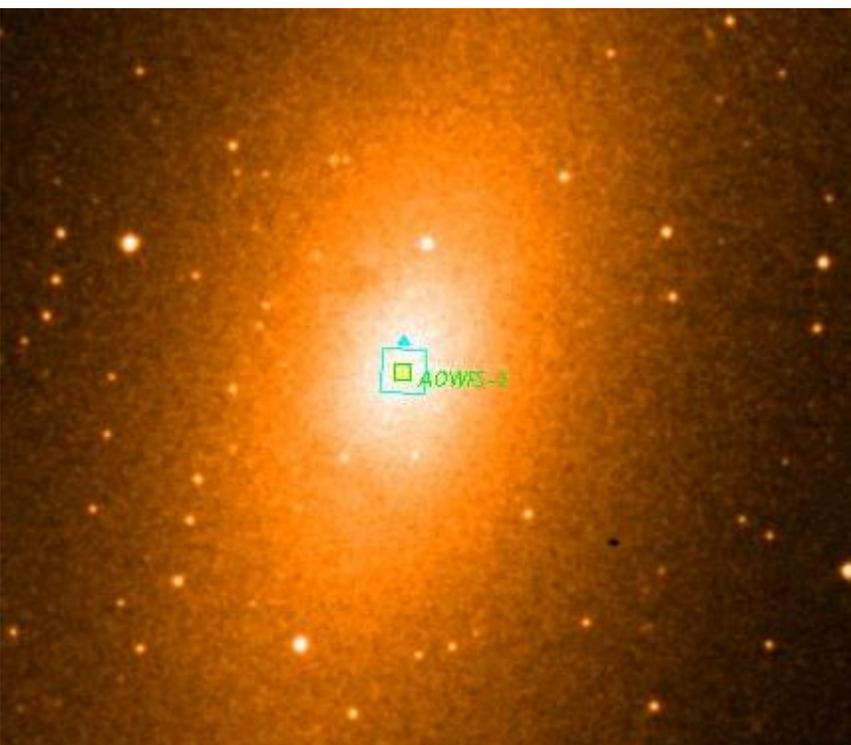
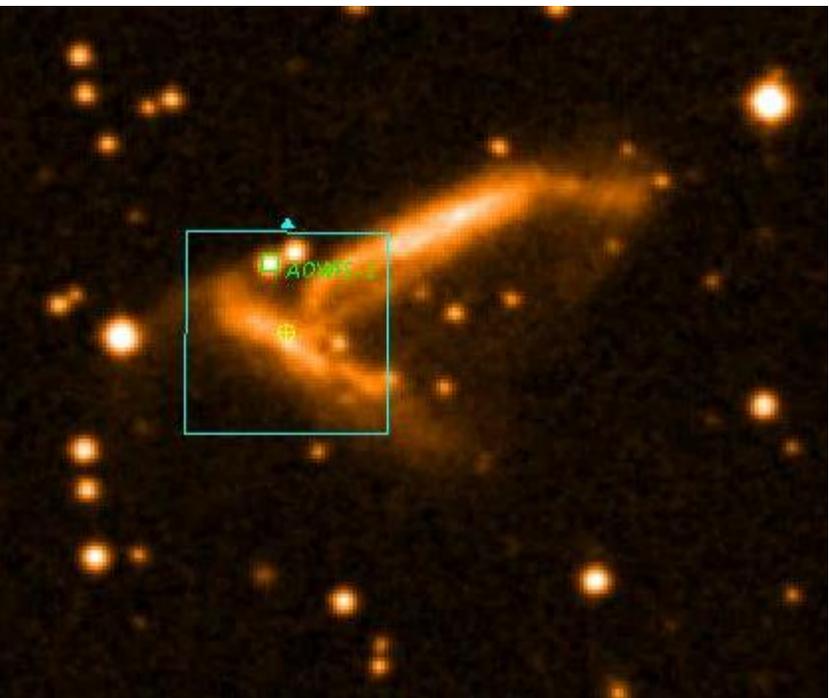
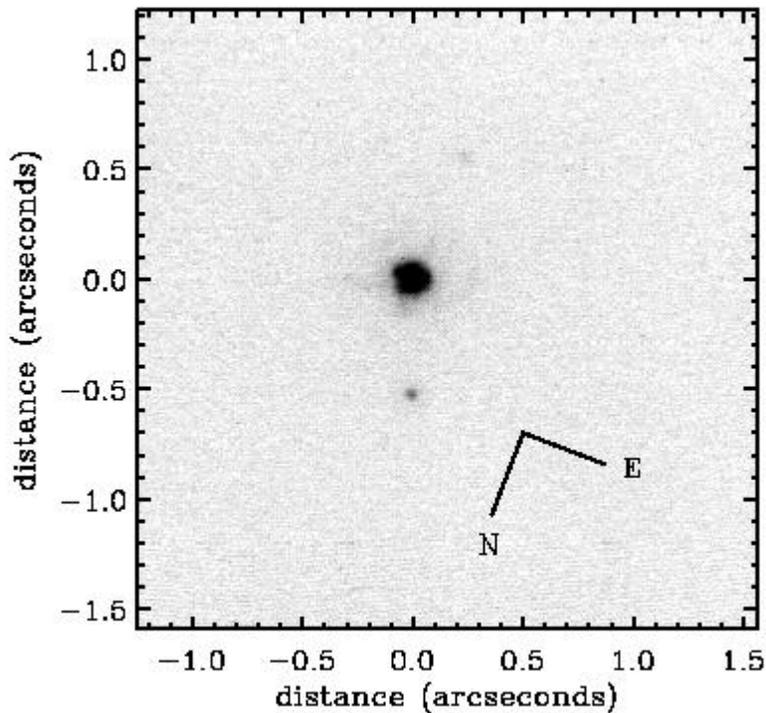
Gemini Laser Guide Star (LGS) Uses:

Imaging (near-infrared):

- Globular Clusters
- Binaries: stars, brown dwarfs and solar system objects
- Extended emission regions

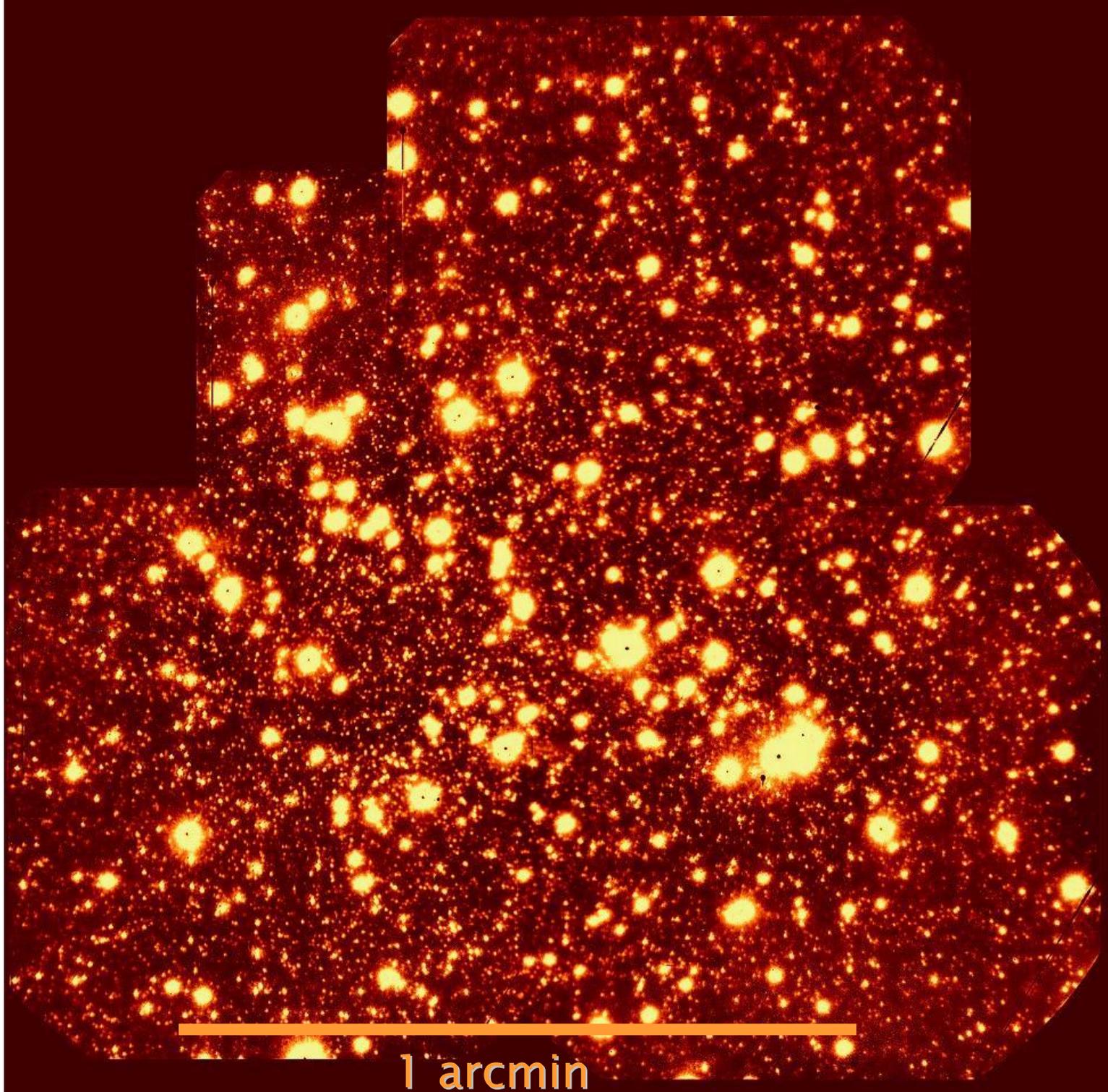
IFU Spectroscopy (near-infrared):

- Embedded Star Forming Regions
- Galaxy Cores



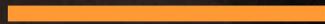
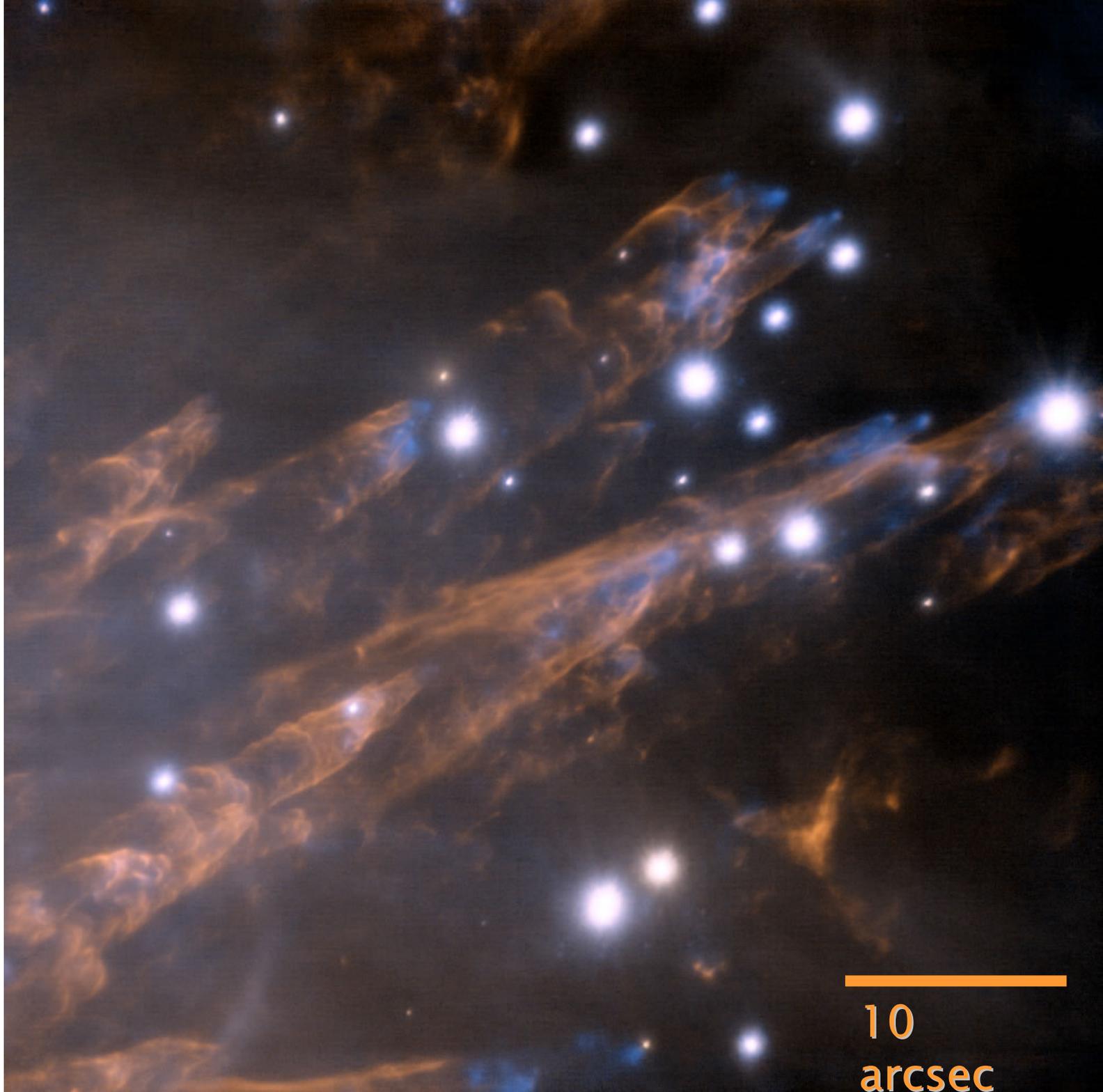
M13

Altair/LGS in
“mosaic”
mode, 4 guide
stars in 4
separate
pointings.



Orion Bullets

Images of Orion taken with LGS at f/14 through the Fe II, H₂ (1-0) and K-band filters and then combined into one color composite image.

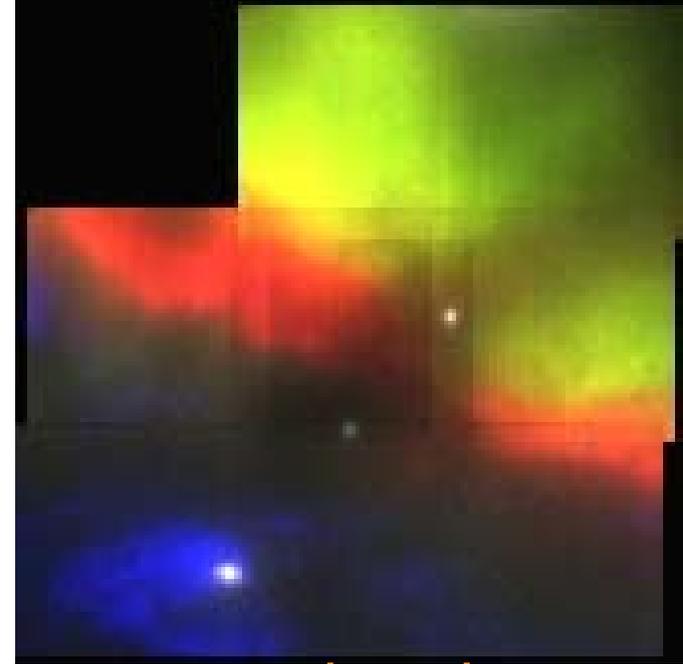


10
arcsec

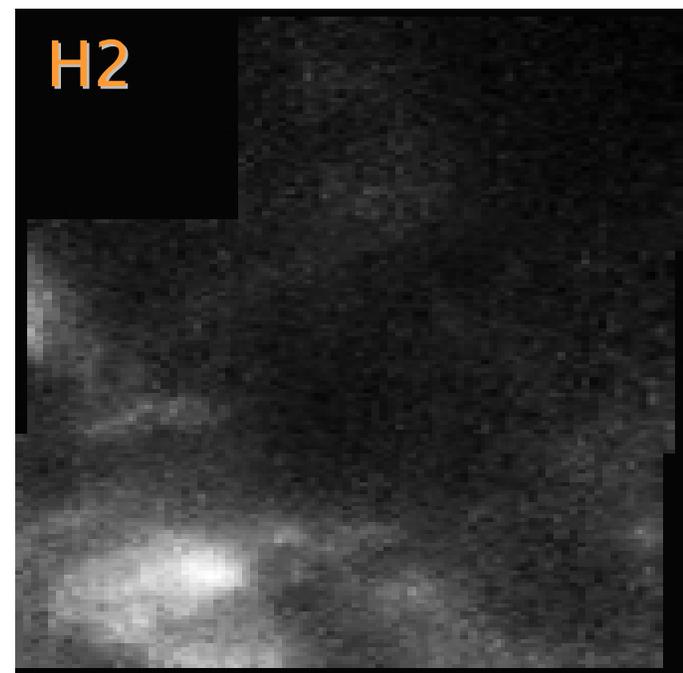
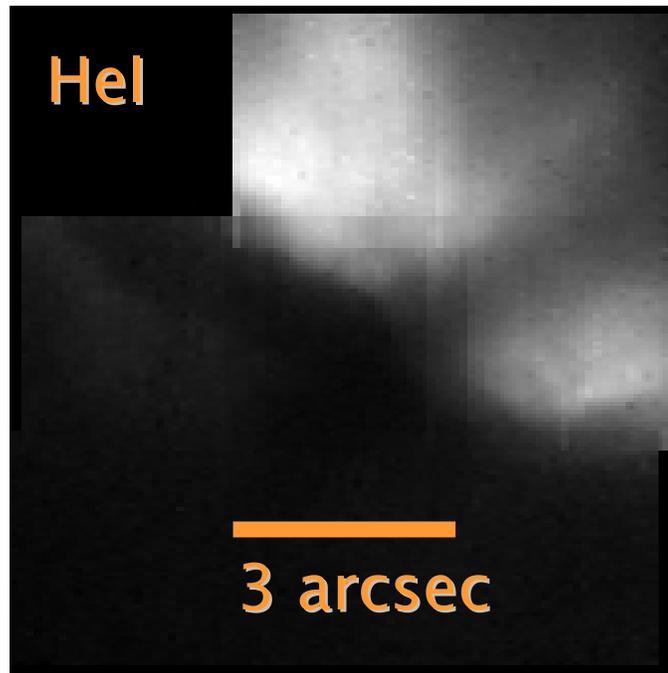
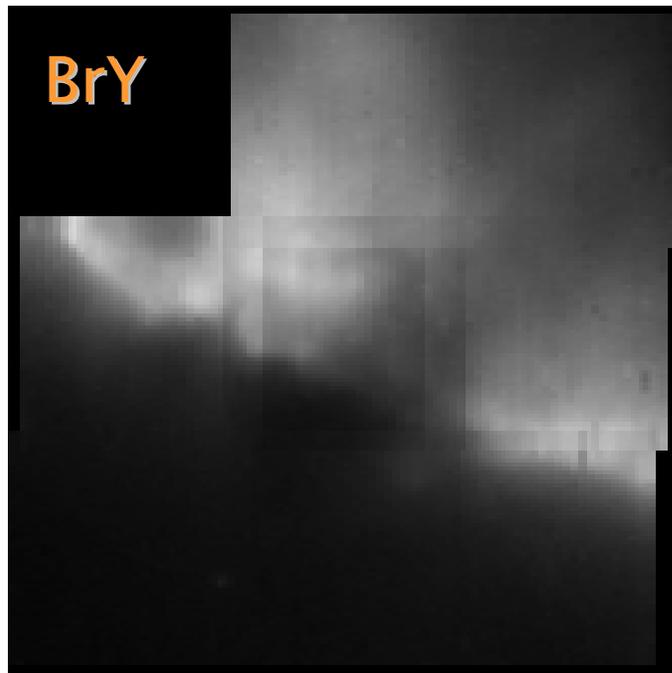
Monoceros R2

NIFS LGS observations of a small section of Monoceros R2 star forming region. This is an 8 arcsec x 8 arcsec R~5000 K-band spectral cube composed of 8 separate pointings.

(K. Labrie)



Narrow band +
continuum
falsecolor

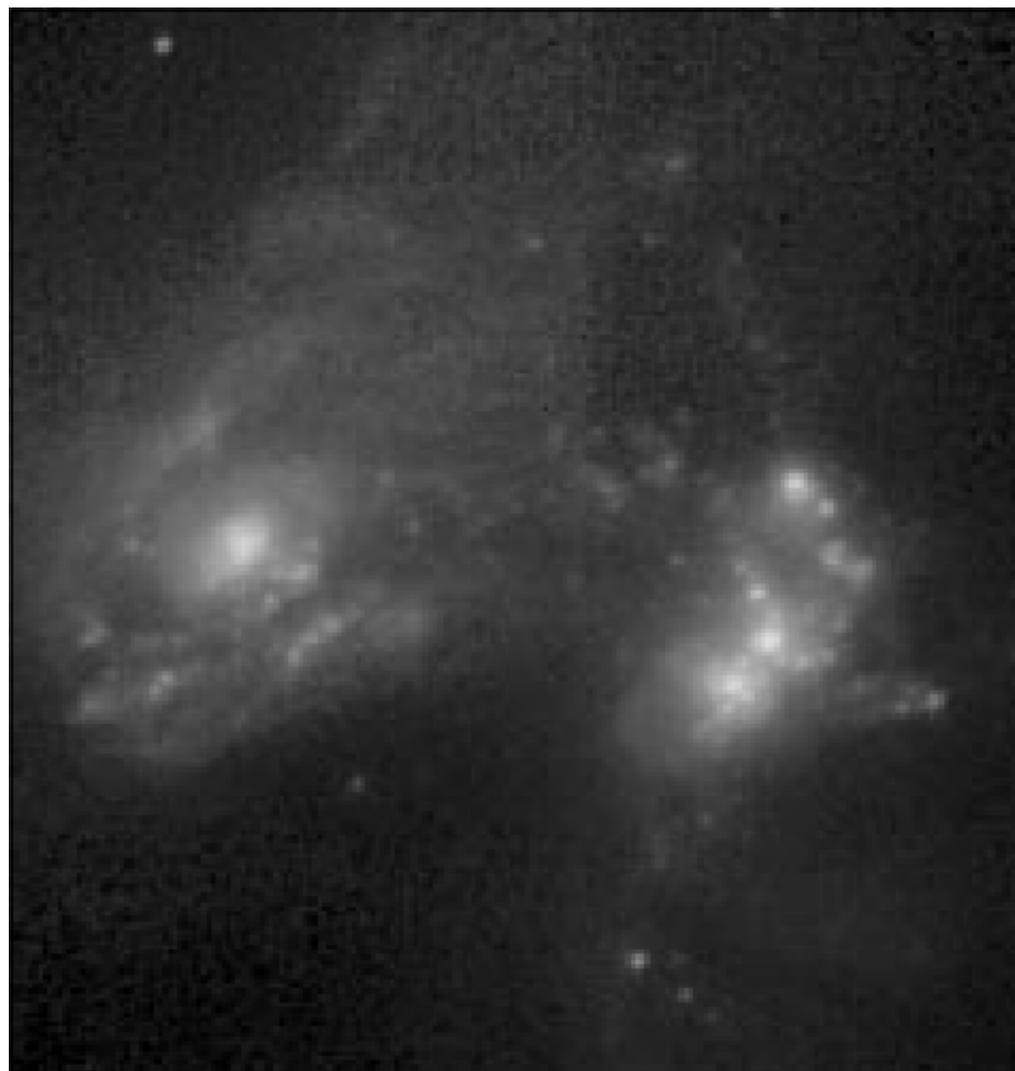
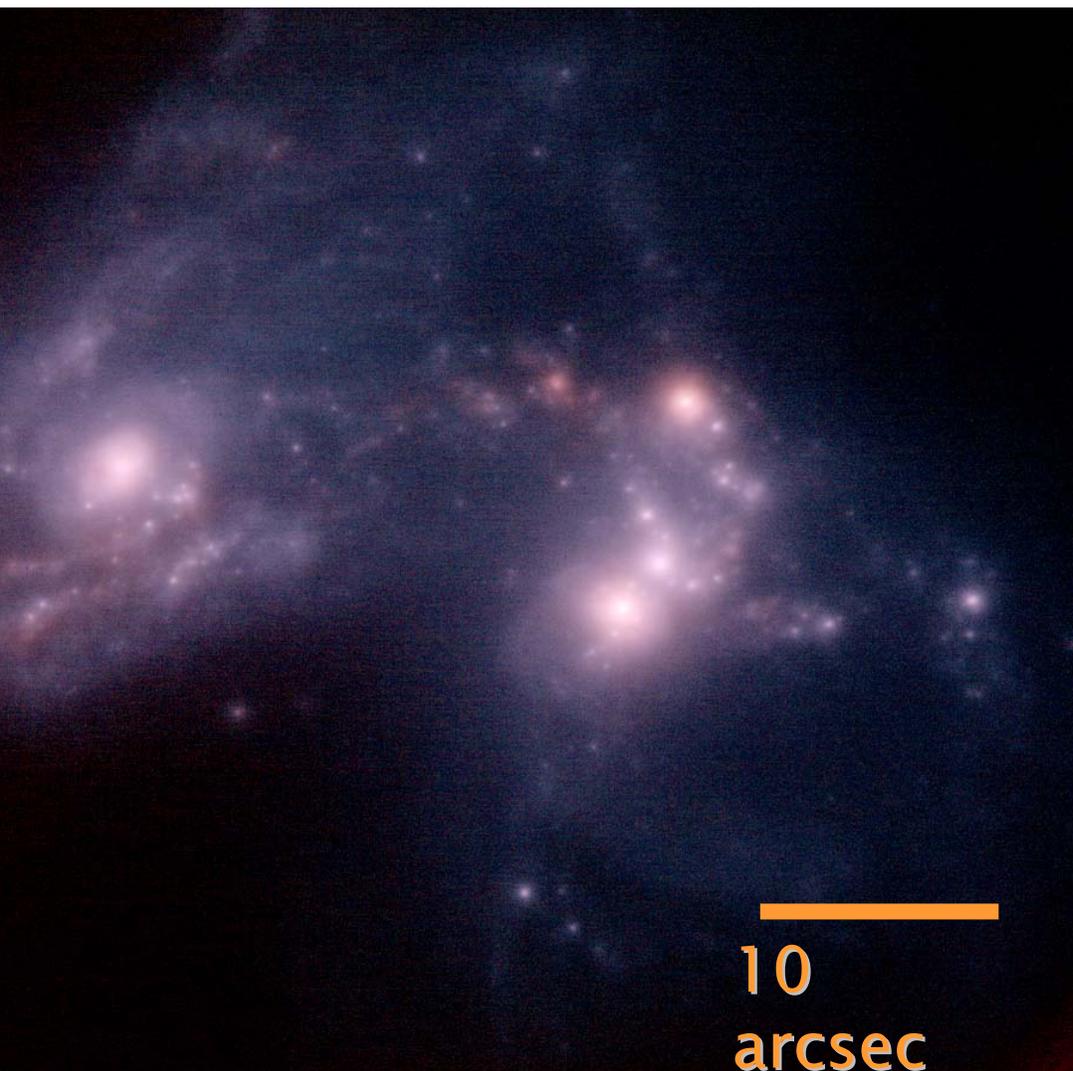


Arp 299

False color H-band (blue) K-band (red) f/14 NIRI LGS (left)
(D. Gratadour)

Guiding on extended nucleus ($R \sim 14$)

Resolution exceeds HST
(H-band, right)



Gemini Laser Guide Star (LGS) Logistics

- Targets are submitted to Air Force Space Command at least 3 working days prior to observation. In practice, this means that rapid response is not available for LGS.
- More personnel are needed during LGS use (mainly laser spotters and laser technicians). Scheduling is typically in one week blocks in grey/bright time each month, integrated into the Gemini queue.

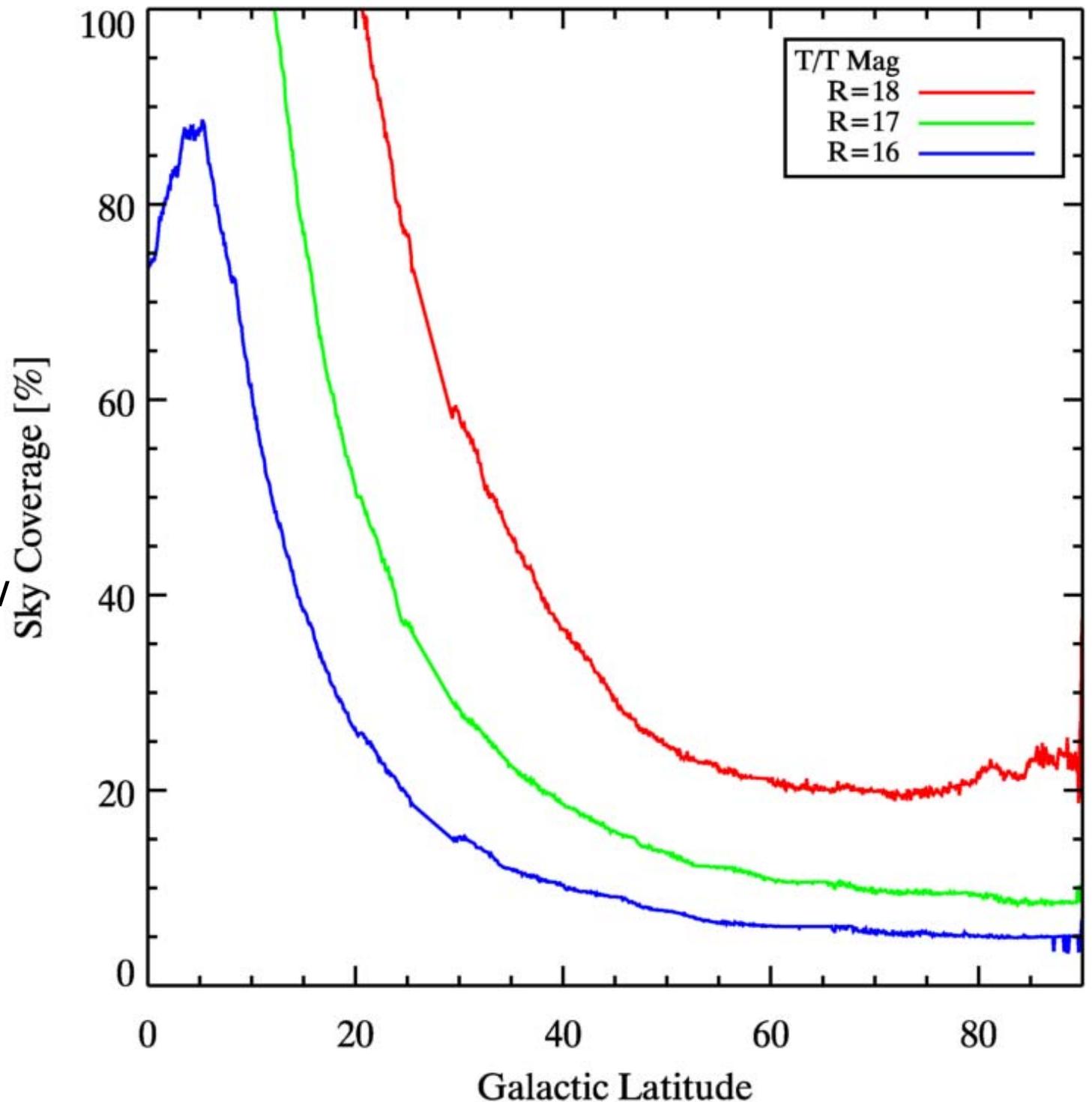
TT Star requirements:

- $R < 18.5$ for point sources within 23–27 arcseconds of science target for spectroscopy and f/32 imaging ($p = +/ - 25$, $q = +27, -23$). 50 arcsec separation for NIRI f/14 imaging only.
- $R < 16.5$ for extended sources (low overhead), $16.5 < R < 18.5$ (increased overhead)
- TT “Star” should have a FWHM of $< 1''$.
- Only Band 1 and Band 2 LGS programs will be observed.
- Photometric conditions or nearly so are required, with reasonable seeing (CC=50%, IQ=70%).
- Elevation limit is 40 degrees (hardware limit).

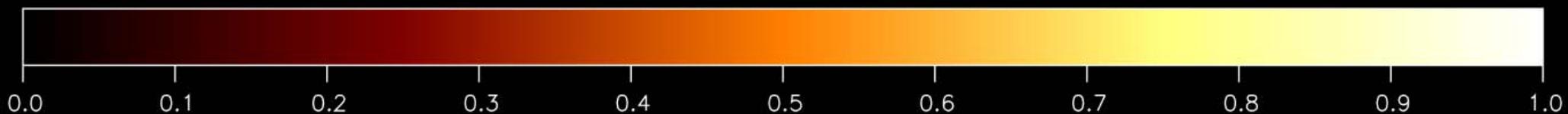
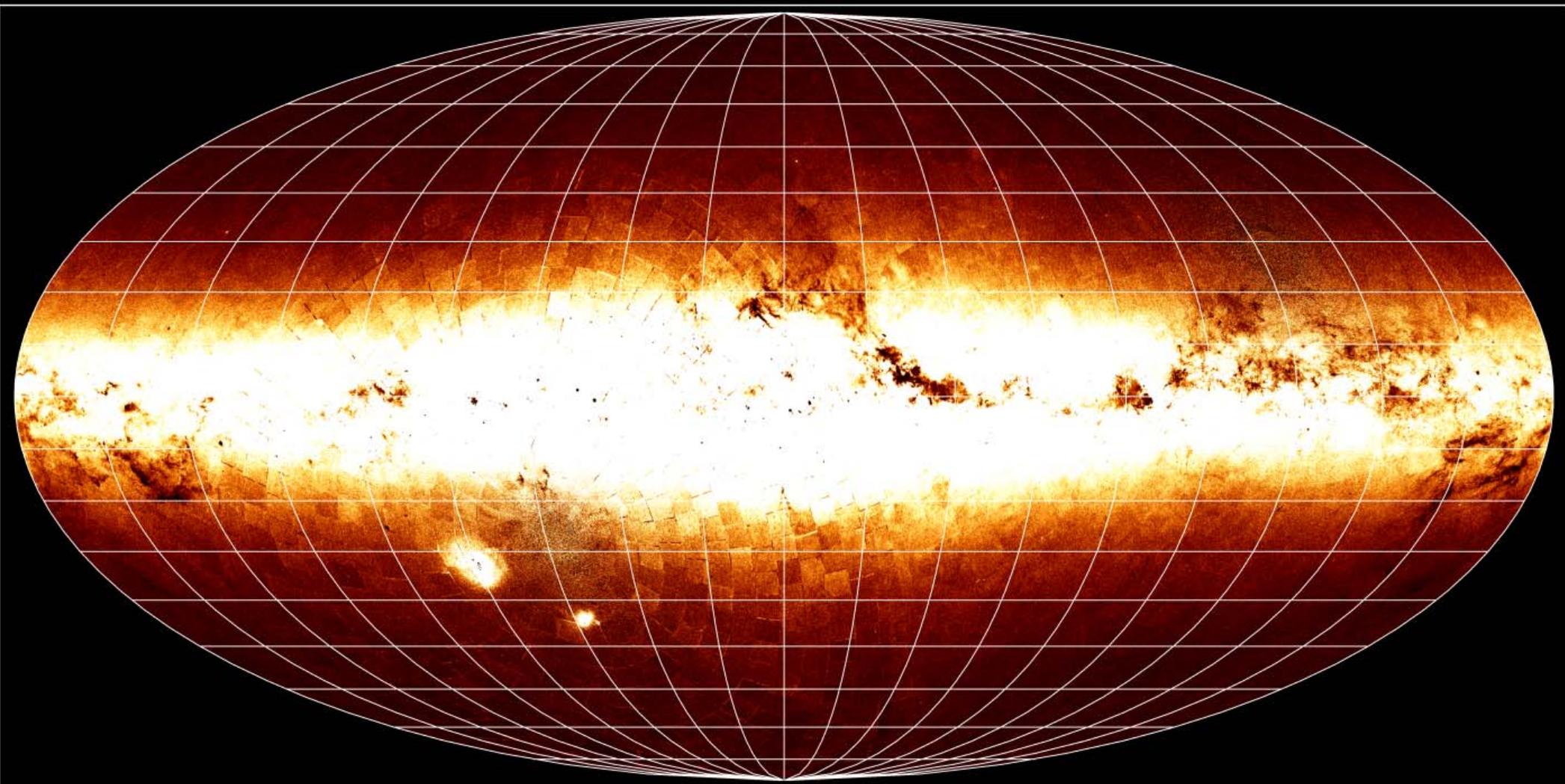
LGS Sky Coverage

Is a strong function of galactic latitude

R=18.5 with new moon and R=18 with full moon.



LGS Sky Coverage



Sky fraction (R=17)

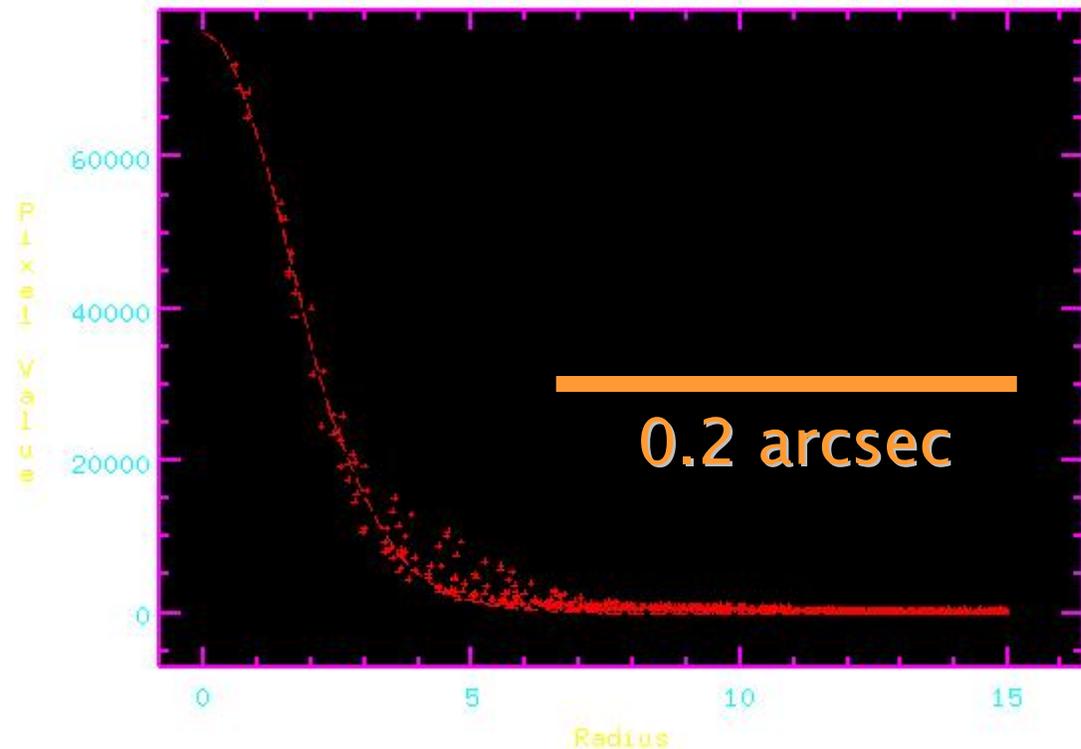
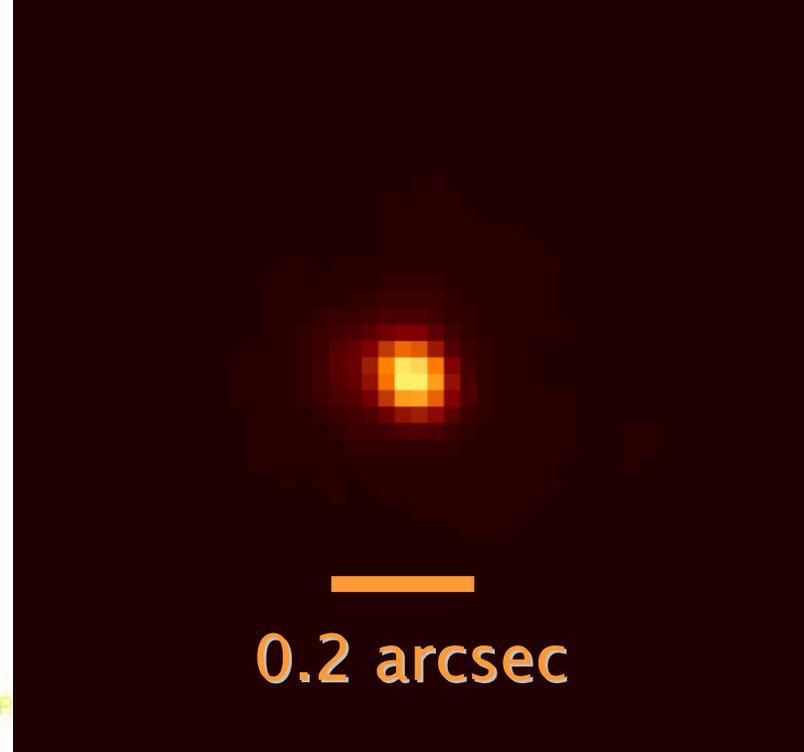
LGS PSF

Work on PSF optimization is ongoing.

2007 Apr 30 PSF has FWHM=0.083 arcsec
Strehl = 30% (K').

Native seeing was $V \sim 0.4$ arcsec, star was $R \sim 12$.

The PSF is stable on timescales of weeks to months.



The Good News:

- LGS + NIFS are an excellent combination.
- LGS + NIRI spectroscopy is also a good pairing.
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Short-Term Improvements (6 months to 1 year):

- Documentation (www, OT libraries, sample PSFs)
- LGS + NIRI f/14 imaging PSF (core OK, wings show some asymmetry)
- Acquisition time reduction (training)
- LGS + NIRI f/32 imaging PSF (Strehl improvements)
- Depth improvement for extended sources (slow-focus sensor)
- Faint TTGS stars (Strehl improvements, depth: dichroic, iris, software)
- Increase of TTGS separation from 23–27" to 30+" (HIA, minor optics work)
- Integration of the Neutral Density filter into the OT

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Long-Term Improvements (1 year to 2 years):

- Increase of TTGS separation from 30" to 60"? (HIA, major optics work)
- Elevations below 40 degrees? (difficult at this point)
- Vibration reduction?
- Other upgrades?

Summary of Gemini North Laser AO

- LGS AO can feed either NIRI (imaging spectrograph) or NIFS (IFU spectrograph)
- LGS AO was commissioned in Feb 2007.
- System Verification (SV) observations are now finished.
- It is now being integrated into the Gemini North queue operations. It is being used in the queue one week per month in grey/bright time.
- Non-sidereal targets are supported.
- Delivery of Strehls up to 30% with ongoing performance work.
- 2007A LGS queue is on schedule.
- We want to hear from PIs about LGS data quality (good and bad).