NSF's National Optical-Infrared Astronomy Research Laboratory

GEMINI OBSERVATORY
Exploring the Universe, Sharing its Wonders

Probing the Time Domain with the Gemini North Adaptive Optics System

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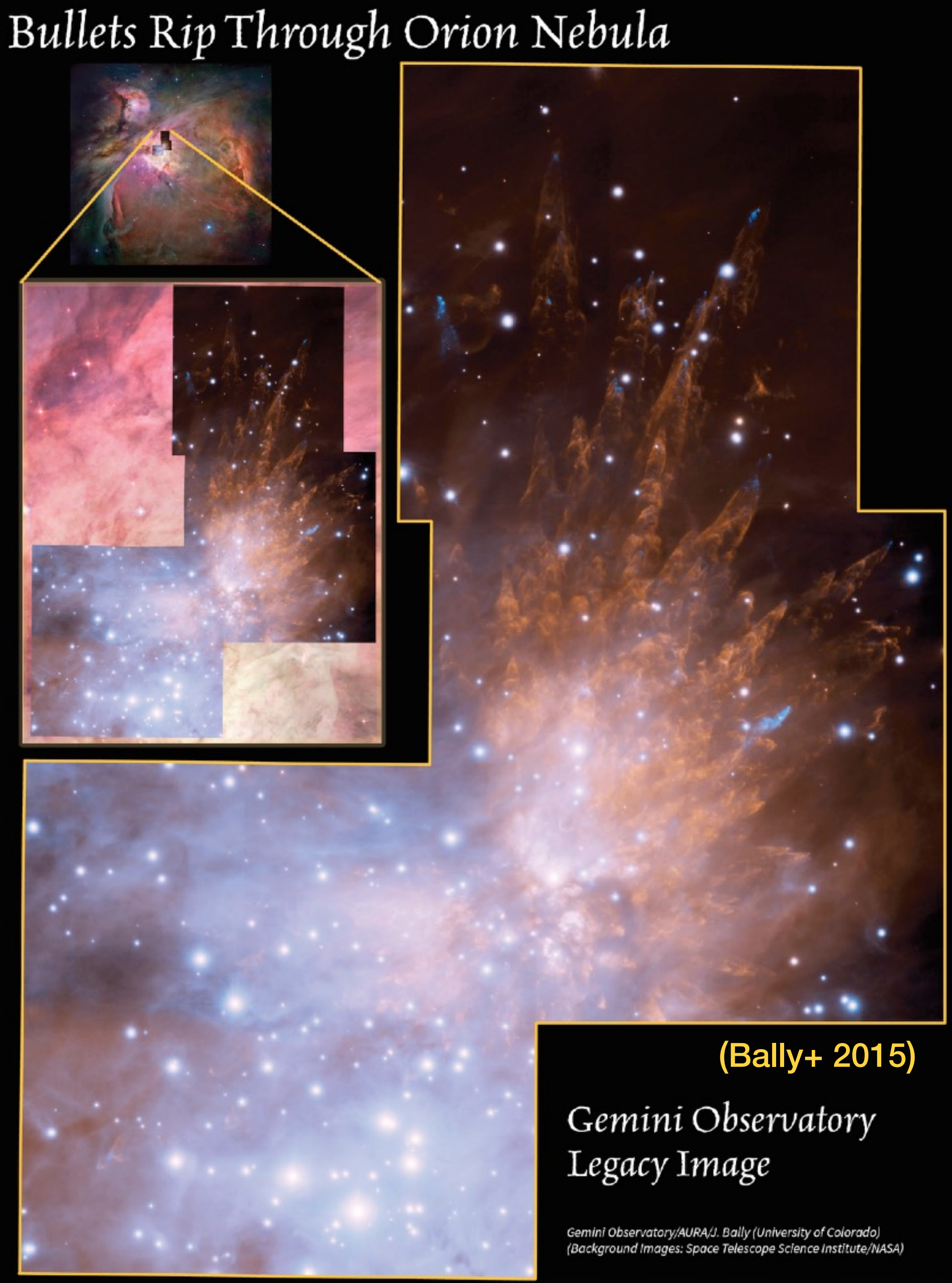
GeMS/GSAOI

Gemini Multi-Conjugate AO System (GeMS) delivers images with FWHM < 0.09″ in K over the 1.4′ field of the Gemini South AO Imager.



(Bally+ 2015)


Sep 2019

Probing the Time Domain with High Spatial Resolution

Science White Paper for the Astro2020 Decadal Survey

Astro2020 Decadal Survey White Paper

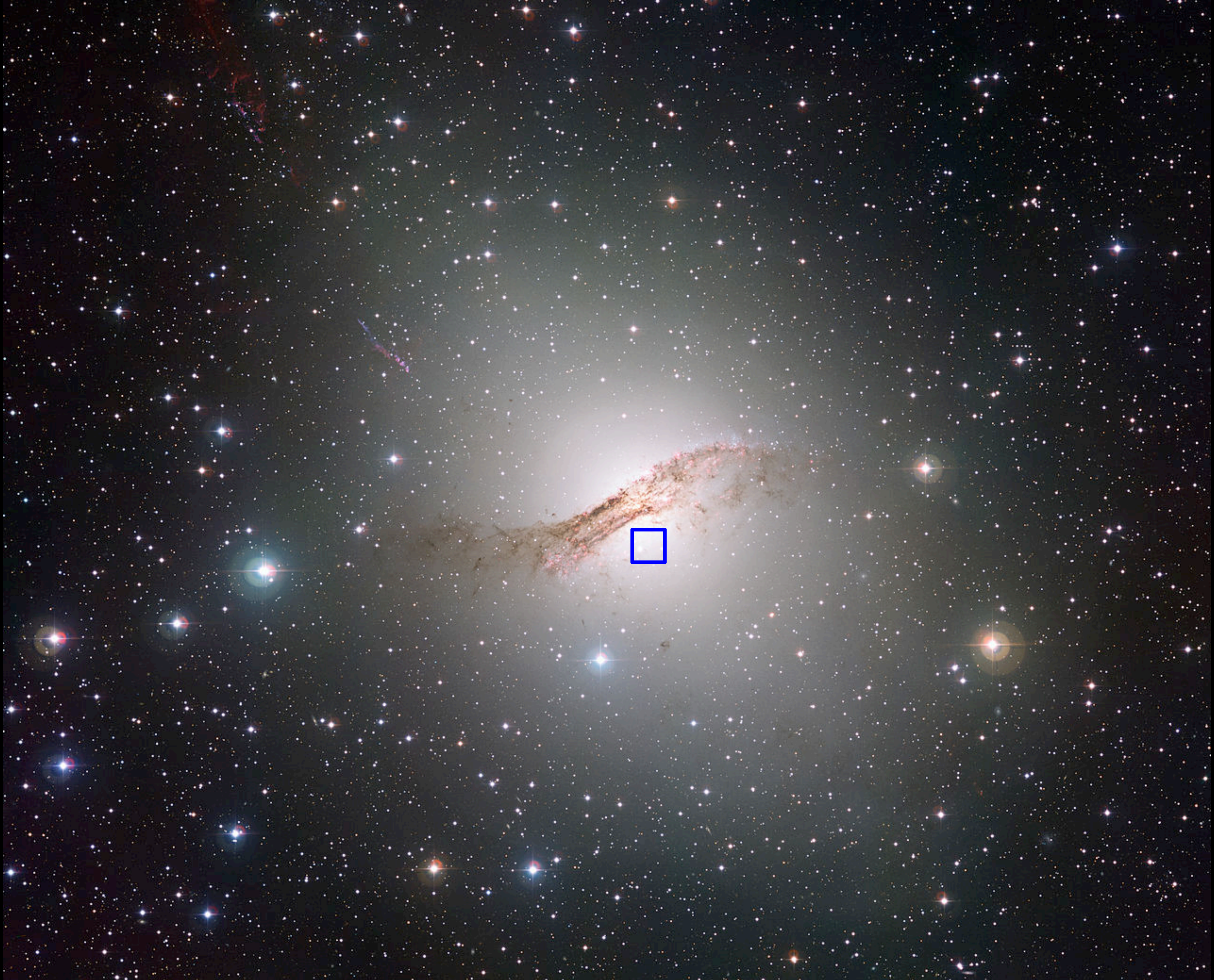
Thematic Areas:

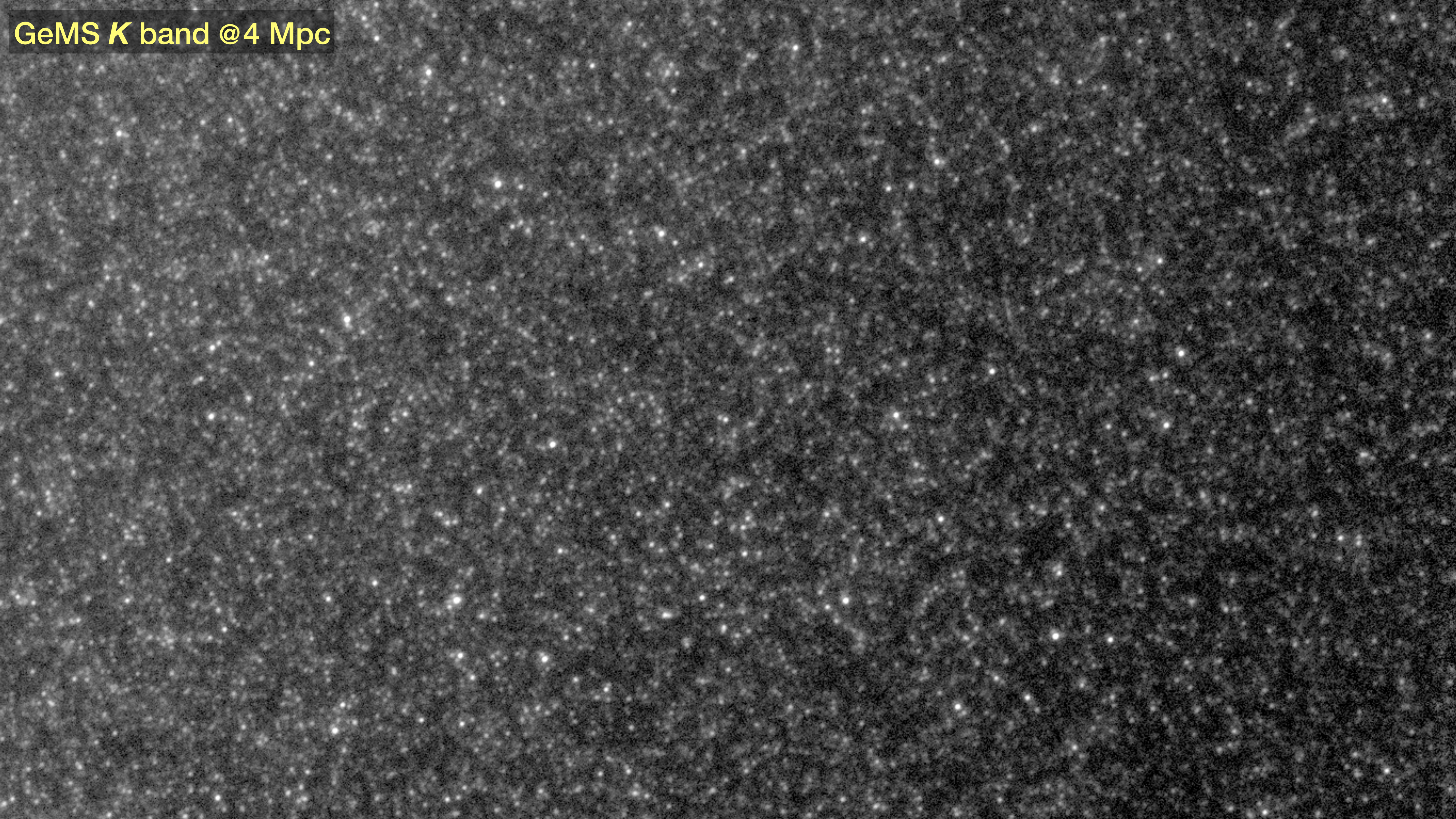
- ✔ Resolved Stellar Populations and their Environments
- ✔ Cosmology and Fundamental Physics
- ✔ Multi-Messenger Astronomy and Astrophysics

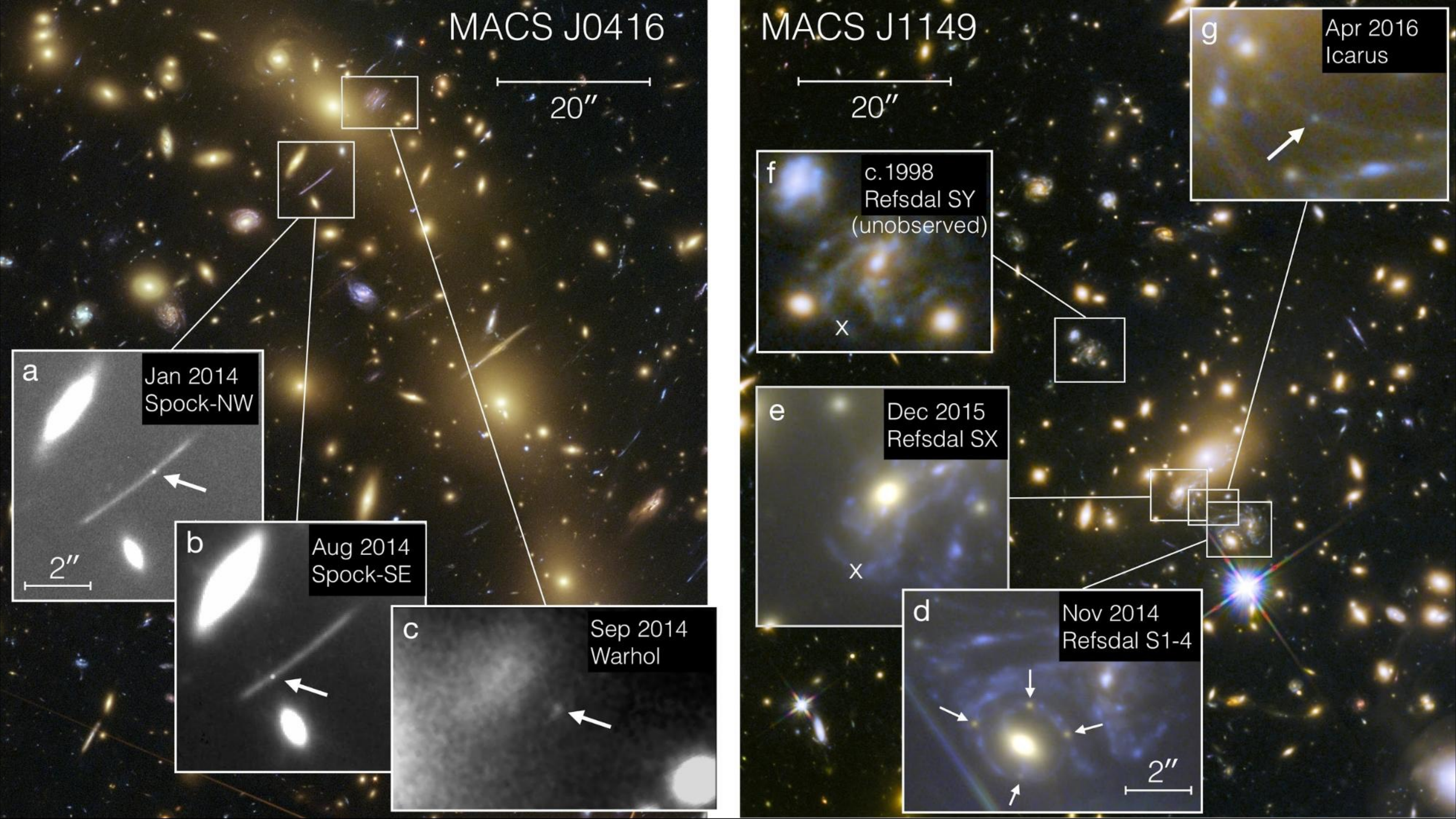
"This white paper highlights the scientific opportunities lying between these two landmark missions, i.e., science enabled by… observations with both high cadence in the time domain and high angular resolution in the spatial domain."

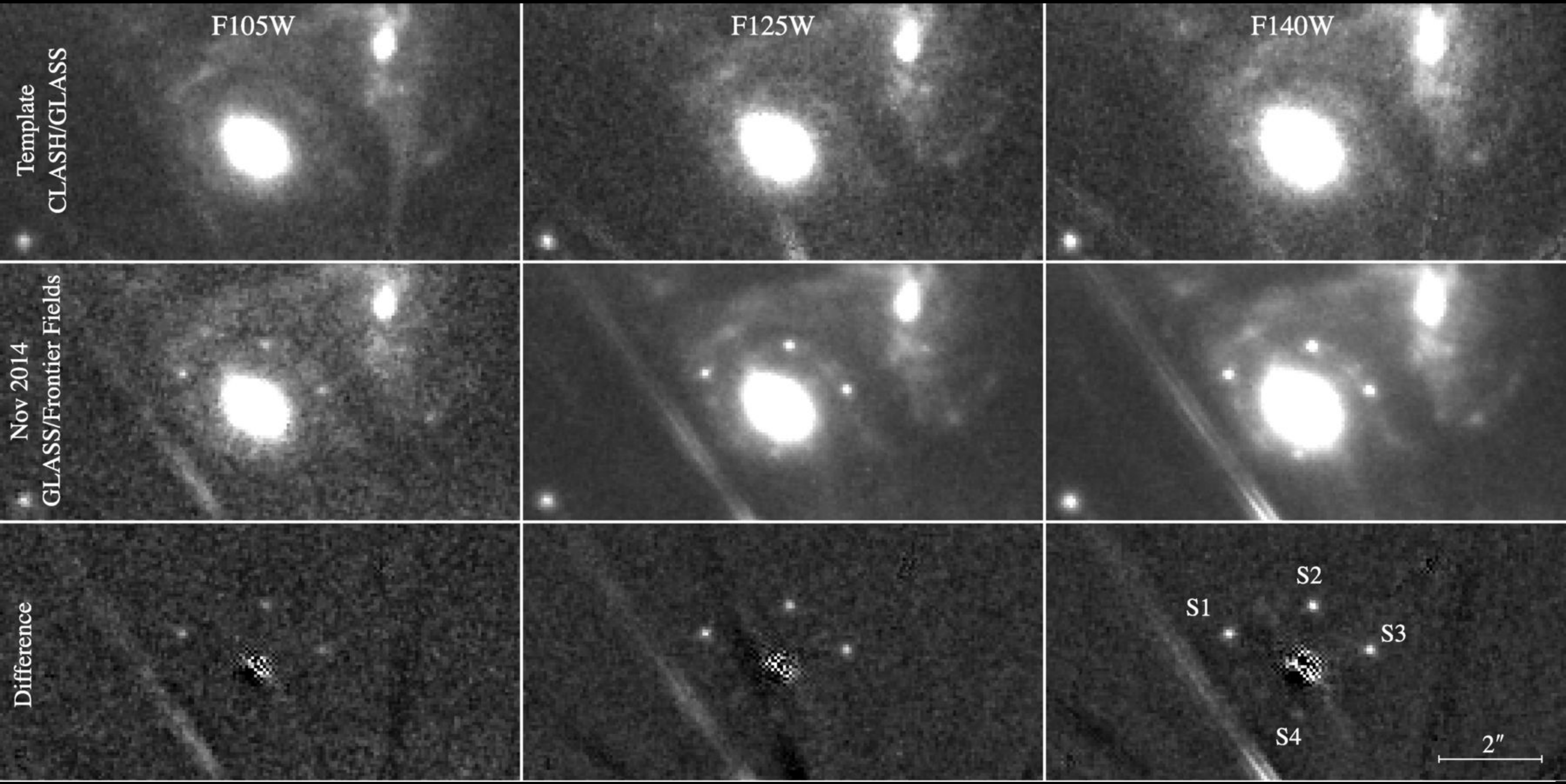
Abstract:

Two groundbreaking new facilities will commence operations early in the 2020s and thereafter define much of the broad landscape of US optical-infrared astronomy in the remaining decade. The Large Synoptic Survey Telescope (LSST), perched atop Cerro Pachón in the Chilean Andes, will revolutionize the young field of Time Domain Astronomy through its wide-field, multi-band optical imaging survey. At the same time, the James Webb Space Telescope (JWST), orbiting at the Sun-Earth L2 Lagrange point, will provide stunningly high-resolution views of selected



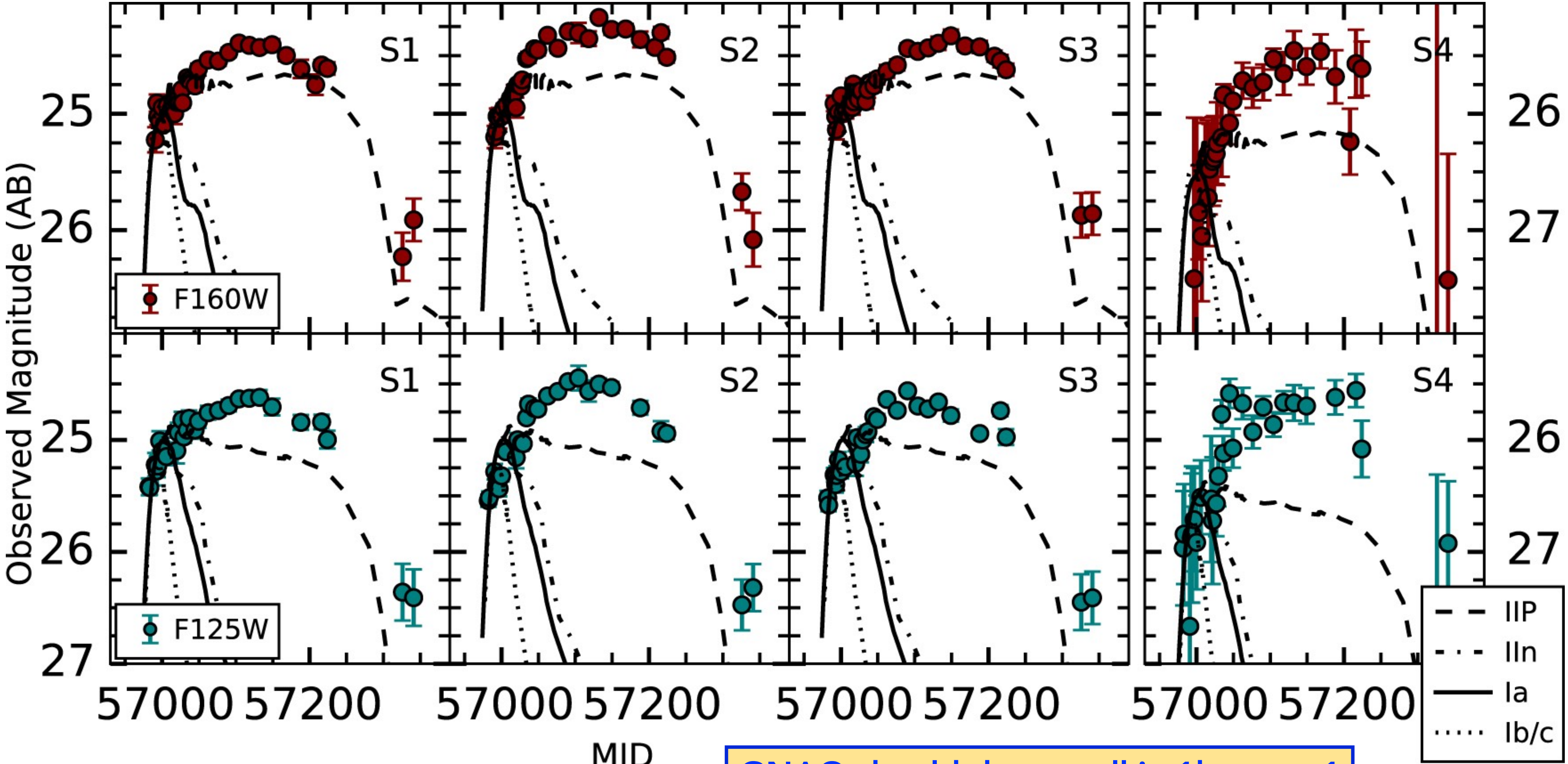

GeMS K band @4 Mpc


MACS J0416
20″
a
Jan 2014
Spock-NW
2″
b
Aug 2014
Spock-SE
c
Sep 2014
Warhol
MACS J1149
20″
f
c.1998
Refsdal SY
(unobserved)
x
e
Dec 2015
Refsdal SX
x
d
Nov 2014
Refsdal S1-4
2″
g
Apr 2016
Icarus



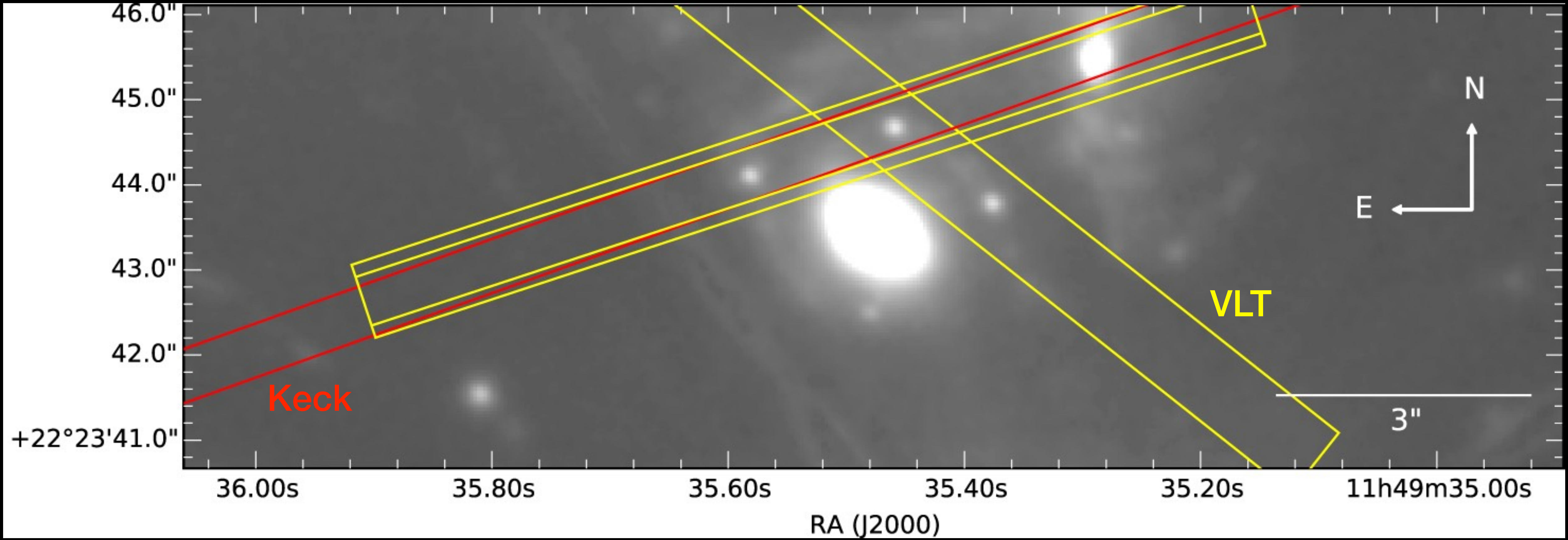
Lensed SN Refsdal: Brightest at longest wavelength; High-resolution essential.

WFC3/IR Light Curves of SN Refsdal Images at z=1.49



GNAO should do as well in 1hr at z≈1

Spectroscopic Follow-up of Supernova Refsdal

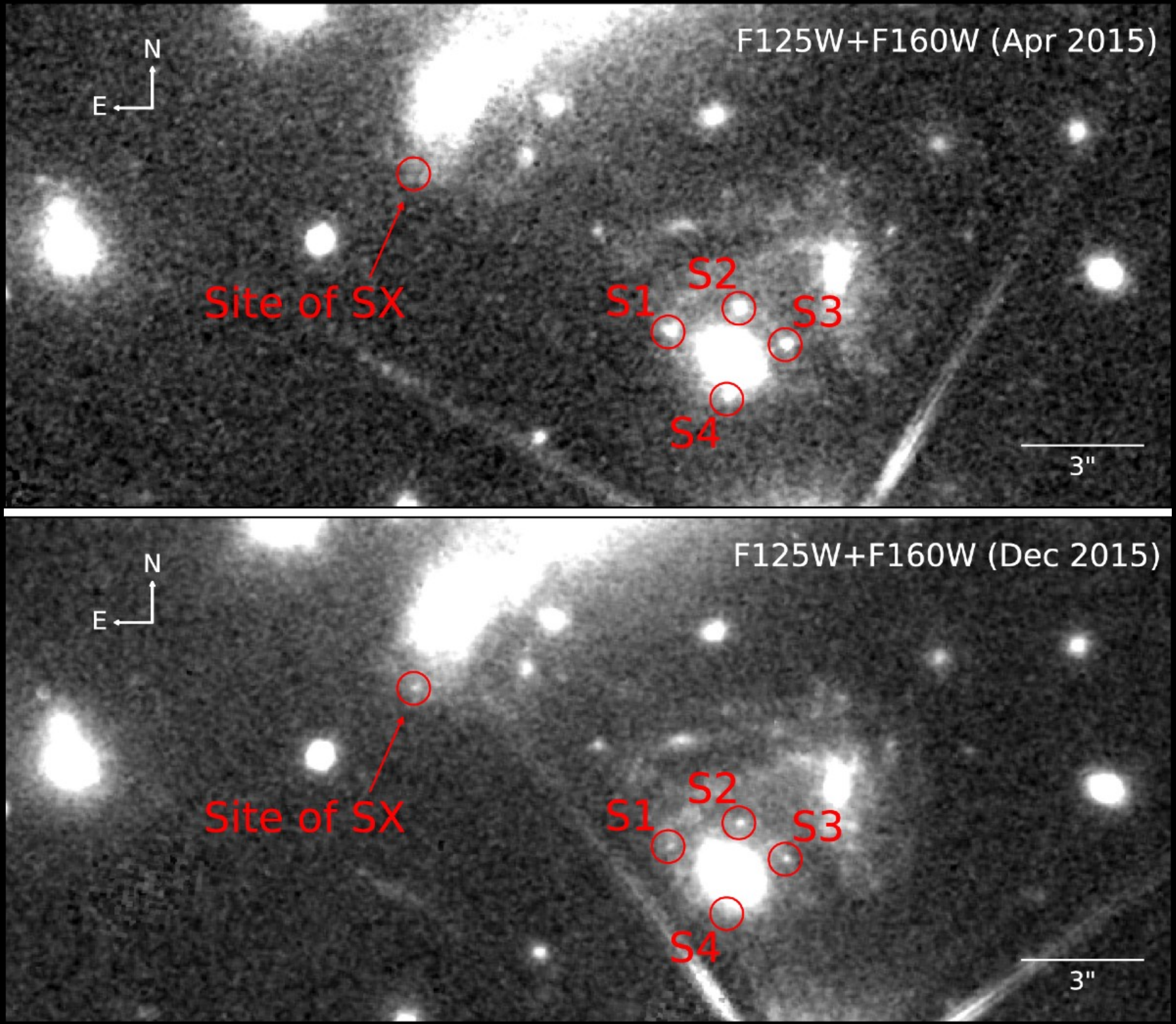


AO-assisted near-IR IFS such as GIRMOS could efficiently obtain spectra of all lensed images at the same time.

Kelly et al. 2016, ApJ

GNAO can monitor to test predictions for time & location of additional images of lensed transients.

In this way, GNAO can be a powerful complement to JWST observations.



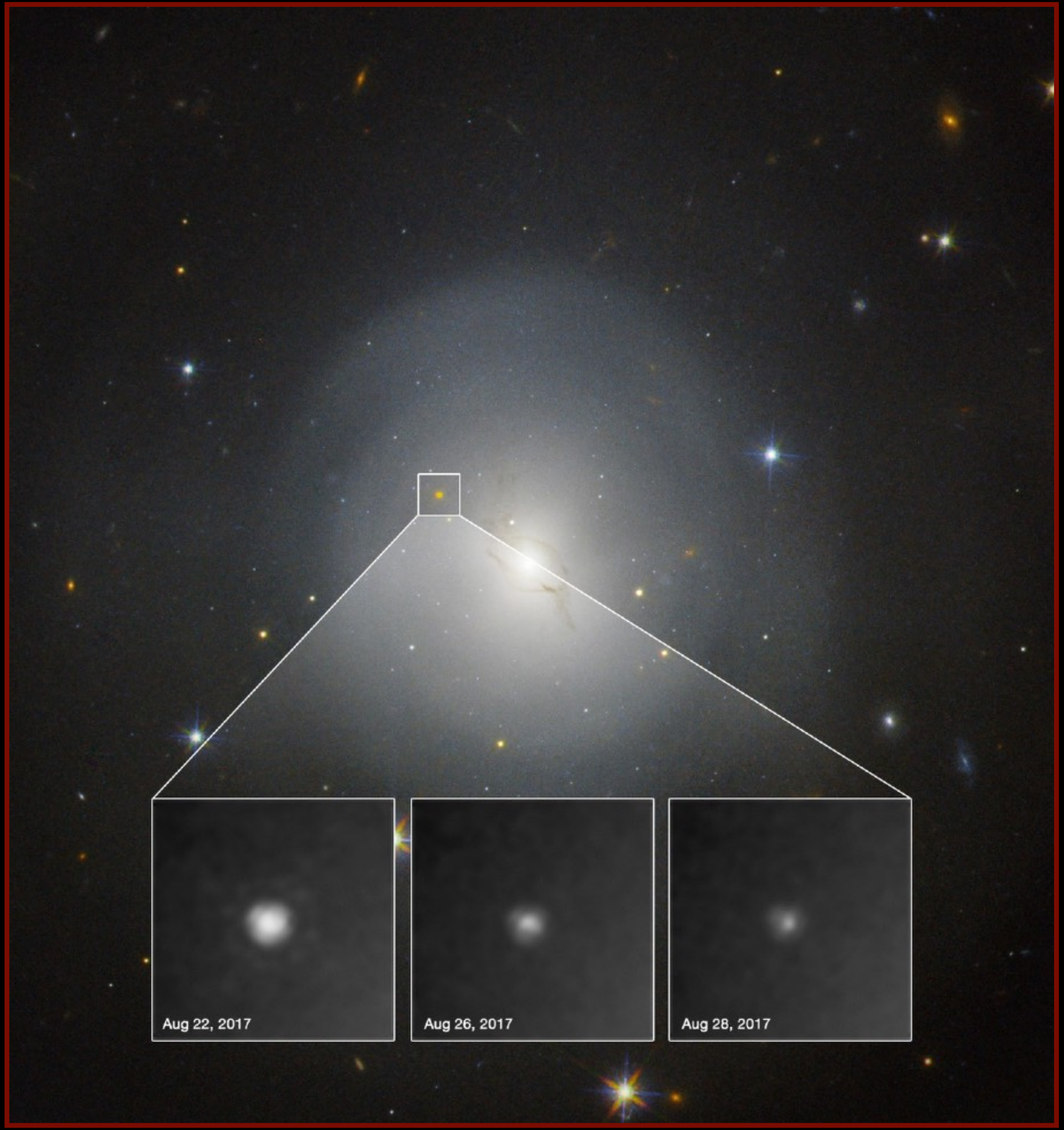
Kelly et al. 2016, ApJL

Multi-Messenger Follow-up

MMA is a key driver for GEMMA, including kilonovae produced by binary neutron star (**BNS**) mergers. **GW170817** and its associated **GRB, 1.7 sec** after LIGO signal, prove at least ***some*** short-duration GRBs result from BNS mergers.

This remains the only MMA source detected in GWs and electromagnetic radiation.

But, rapid follow-up of short duration GRBs can provide information on the onset and evolution of kilonovae even when the GW signal goes undetected.



HST observation of GW170817 kilonova in NGC4993

A&A 623, A92 (2019)
https://doi.org/10.1051/0004-6361/201832835

Astronomy & Astrophysics

The X-shooter GRB afterglow legacy sample (XS-GRB)★

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(Affiliations can be found after the references)

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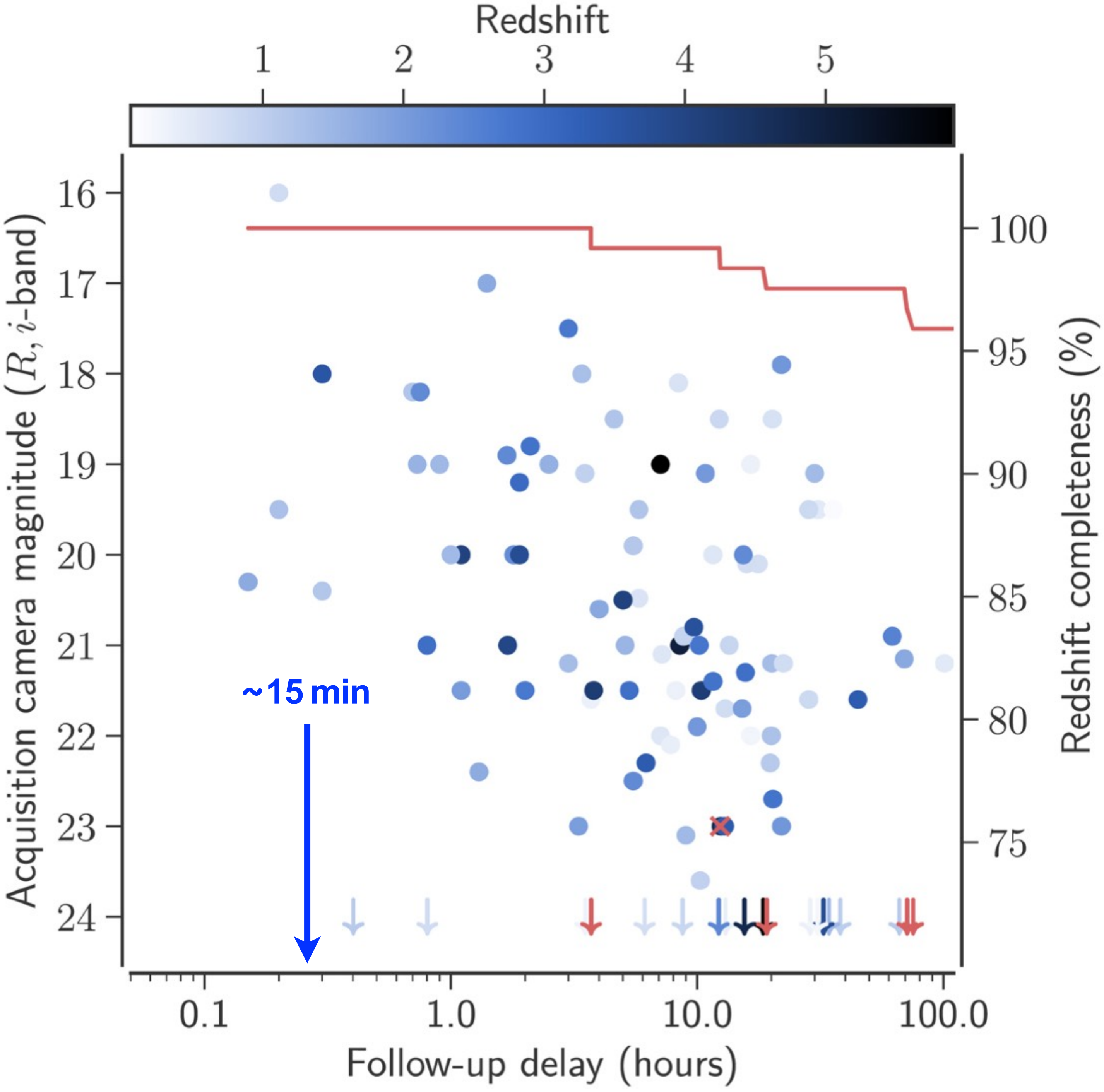
ABSTRACT

In this work we present spectra of all γ-ray burst (GRB) afterglows that have been promptly observed with the X-shooter spectrograph until 31/03/2017. In total, we have obtained spectroscopic observations of 103 individual GRBs observed within 48 hours of the GRB trigger. Redshifts have been measured for 97 per cent of these, covering a redshift range from 0.059 to 7.84. Based on a set of observational selection criteria that minimise biases with regards to intrinsic properties of the GRBs, the follow-up effort has been focused on producing a homogeneously selected sample of 93 afterglow spectra for GRBs discovered by the *Swift* satellite. We here provide a public release of all the reduced spectra, including continuum estimates and telluric absorption corrections. For completeness, we also provide reductions for the 18 late-time observations of the underlying host galaxies. We provide an assessment of the degree of completeness with respect to the parent GRB population, in terms of the X-ray properties of the bursts in the sample and find that the sample presented here is representative of the full *Swift* sample. We have constrained the fraction of dark bursts to be <28 per cent and confirm previous results that higher optical darkness is correlated with increased X-ray absorption. For the 42 bursts for which it is possible, we have provided a measurement of the neutral hydrogen column density, increasing the total number of published HI column density measurements by ~33 per cent. This dataset provides a unique resource to study the ISM across cosmic time, from the local progenitor surroundings to the intervening Universe.

Key words. gamma-ray burst: general – galaxies: high-redshift – ISM: general – techniques: spectroscopic – catalogs – galaxies: star formation

ESO's VLT/X-shooter GRB Afterglow Legacy Survey targets a mix of long and short duration GRBs.

About 10 observed in "Rapid Response Mode" with delays < 1 hour.



BNS merger optical/IR emission has at least 2 distinct components…

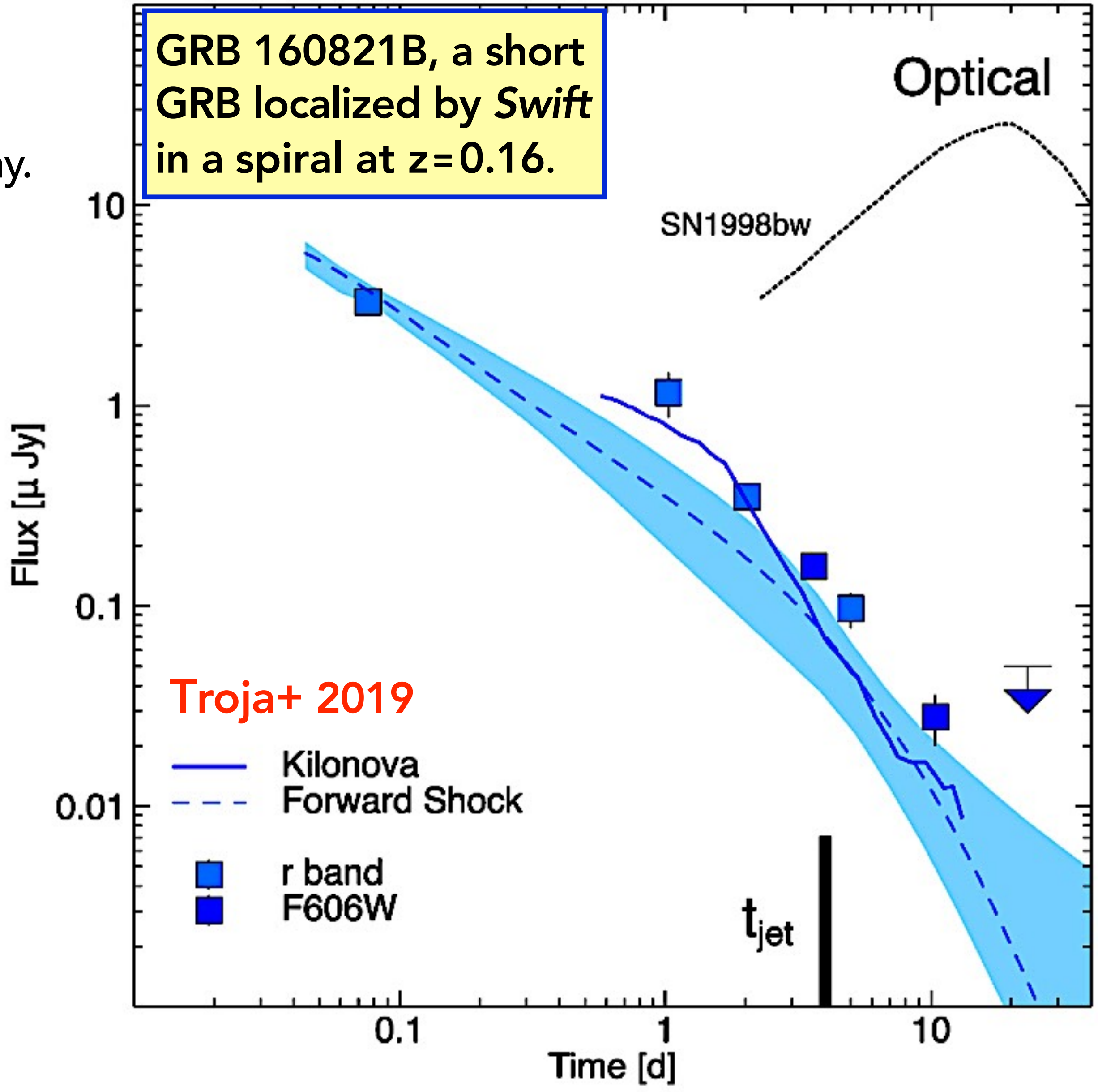
Standard afterglow, from the interaction of the relativistic jet with surrounding medium, and a ***kilonova component***, powered by radioactive decay.

GRB **afterglow** probes the jet structure, geometry, and properties of the surrounding environment.

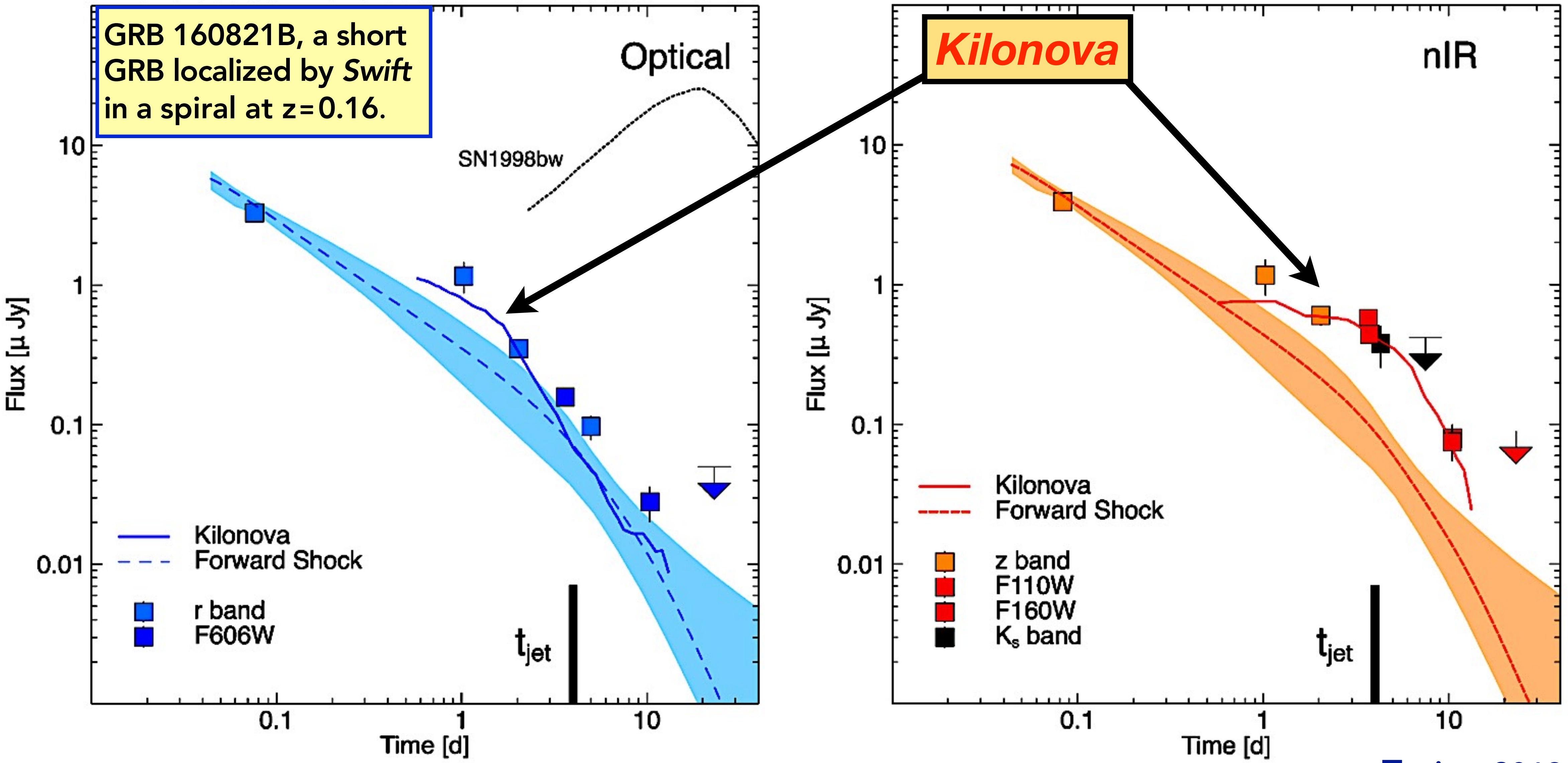
Kilonova reveals the yield of heavy elements, *but* can be difficult to disentangle from the afterglow.

The **kilonova** peaks in the near-IR within days. **Afterglow** is generally blue and peaks minutes after the explosion, but can take days to fade…

Multi-wavelength datasets, probing the emission at early times, are critical for quantitative modeling of the kilonova evolution and detailed understanding of the heavy element production.



Near-IR improves ability to disentangle components



GNAO can minimize contamination from galaxy light in IR

Troja+ 2019

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Take aways…

- GNAO will deliver data quality at least as good as GeMS, *and* will operate nightly in the regular Gemini Queue
- This opens a world of opportunities for time-domain science at high angular resolution, including:
  - photometric monitoring of variable sources;
  - rapid follow-up of explosive events.
- Start thinking of cool TDA science you can do with GNAO, maybe via ***AEON***!

And be sure to come to Gemini's 20th Anniversary Science Meeting in June!