Systematic exploration of the dynamic infrared sky with Palomar Gattini-IR

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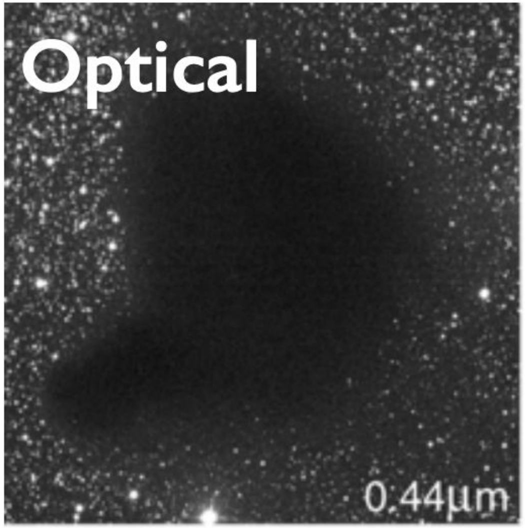
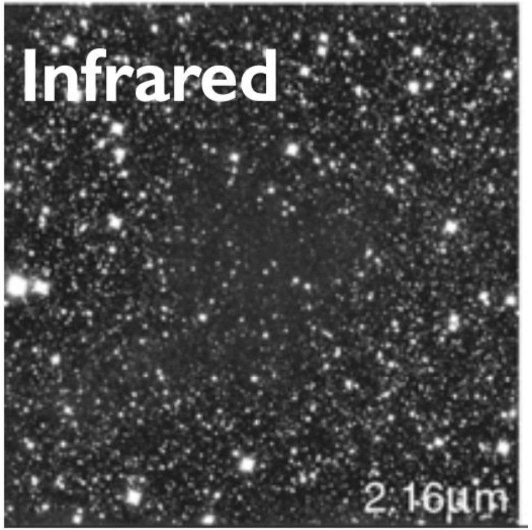
On behalf of the Palomar Gattini-IR team

Why search for transients in infrared?

- Explore phase space of transients invisible to optical transient surveys due to dust obscuration
  - Dusty classical novae in the galaxy
  - Obscured supernovae in nearby galaxies



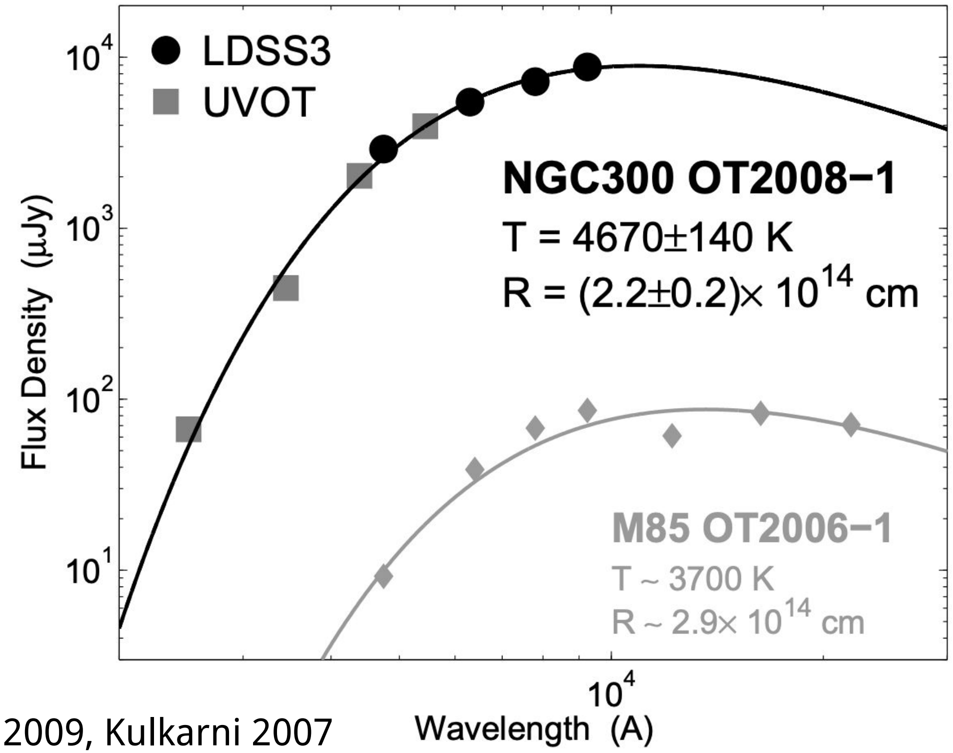


Credit: ESO

Why search for transients in infrared?

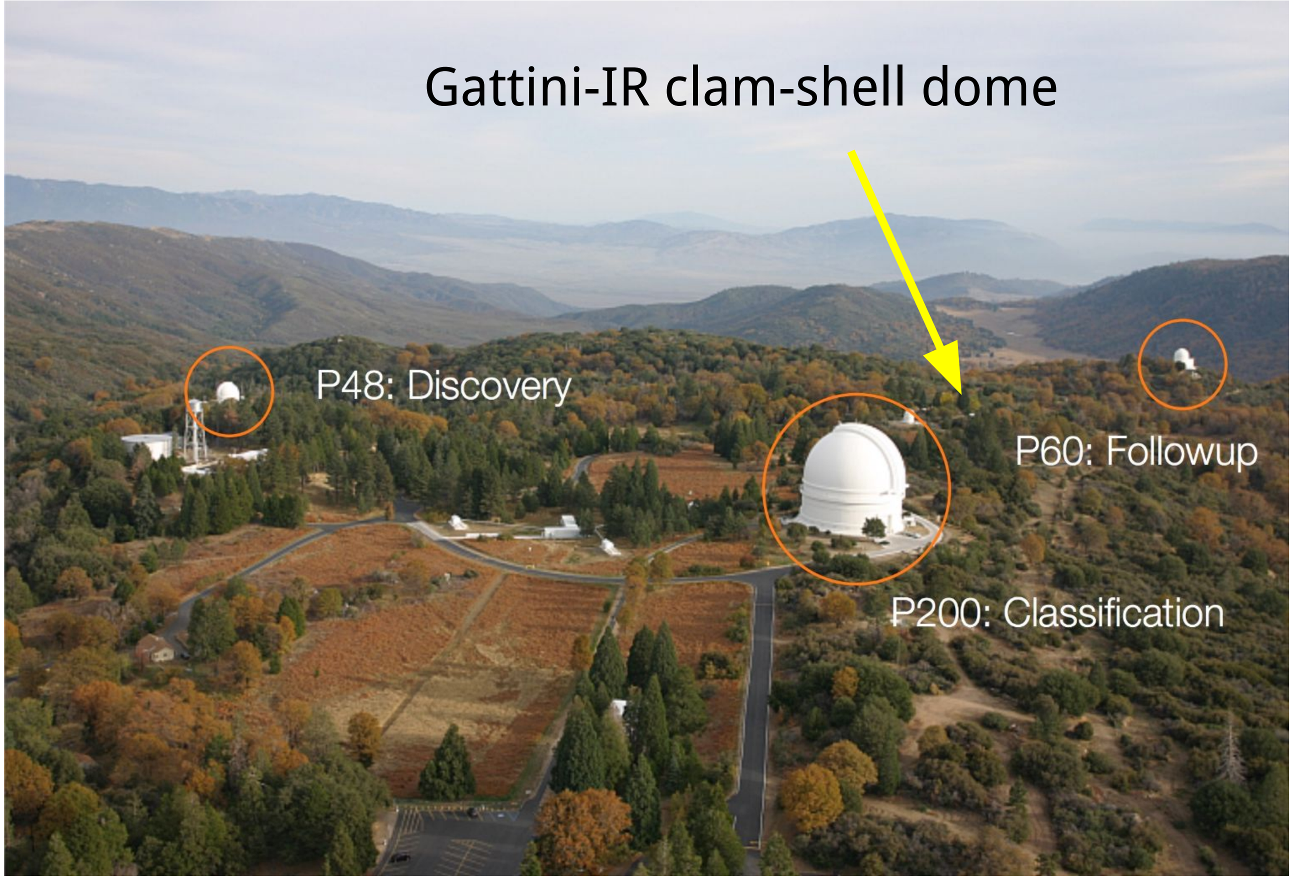
Emission peaks in the infrared

- Intrinsically red transients
  - Luminous red novae (stellar mergers)
  - Intermediate luminosity red transients
  - Kilonova counterparts of GW events

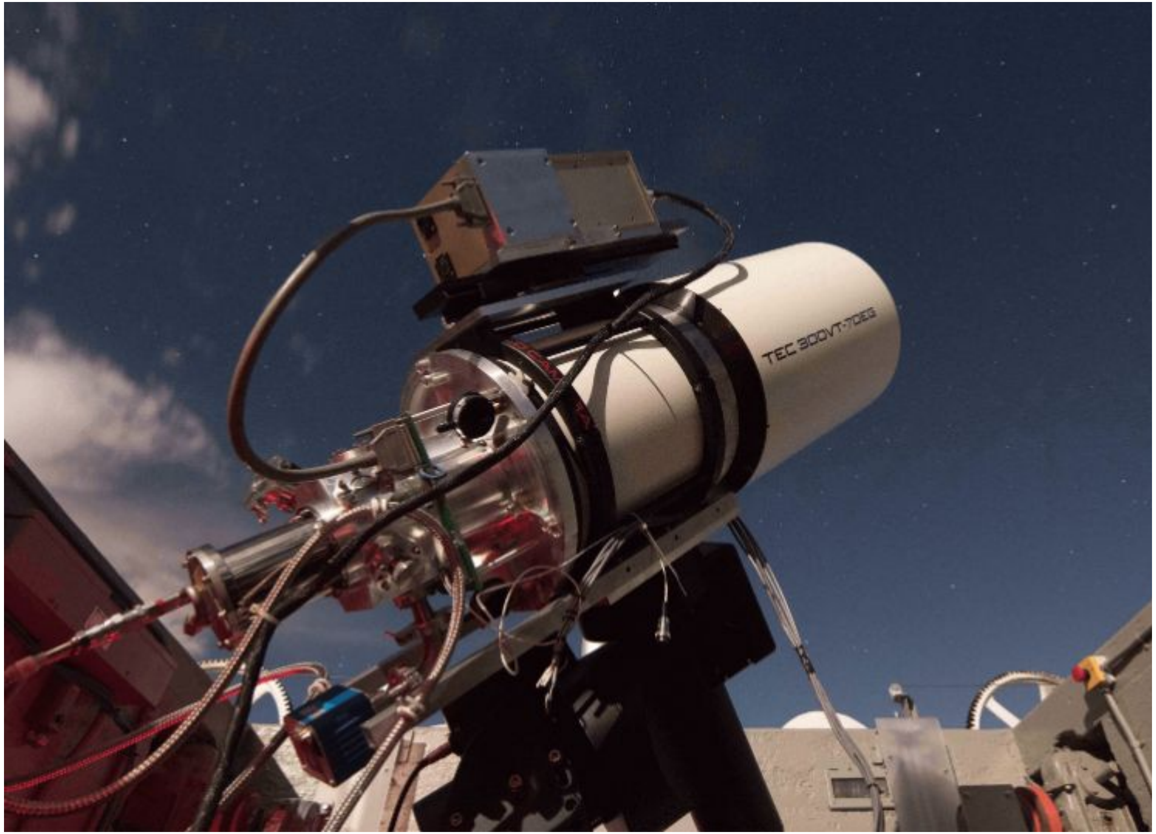


Berger+ 2009, Kulkarni 2007

Gattini-IR at Palomar observatory



Telescope and Detector



- 30 cm aperture
- f/1.4 optics
- 2K x 2K H2RG detector, cooled to 80 K
- 18 μm pixels
- 8.7 arcsec/pixel
- 25 sq. deg. FOV
- J-band filter

Field of View: Comparison (in cyan)

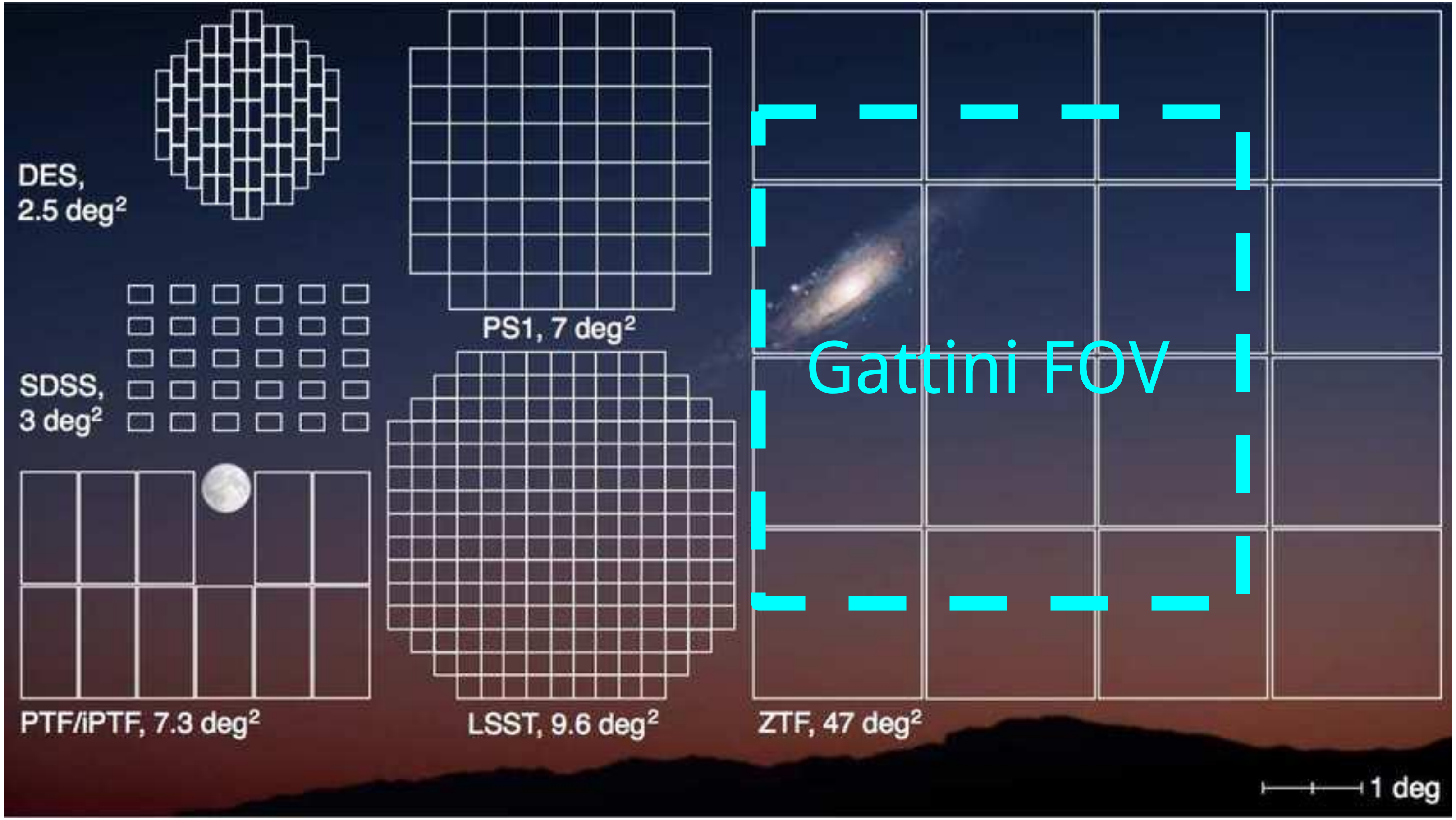
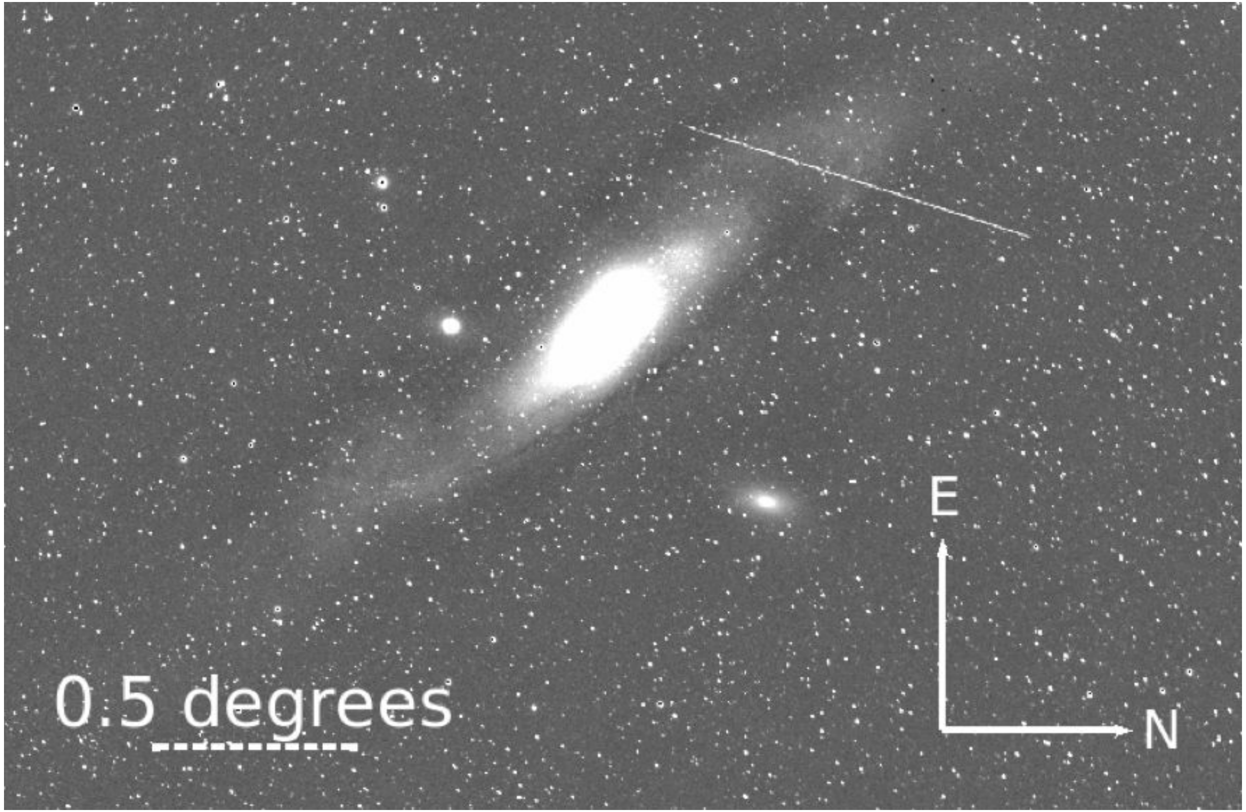


Figure adapted from Laher 2017

First light



First light image of M31 from September 2018 (total exposure time of 36 s)

Nominal survey design

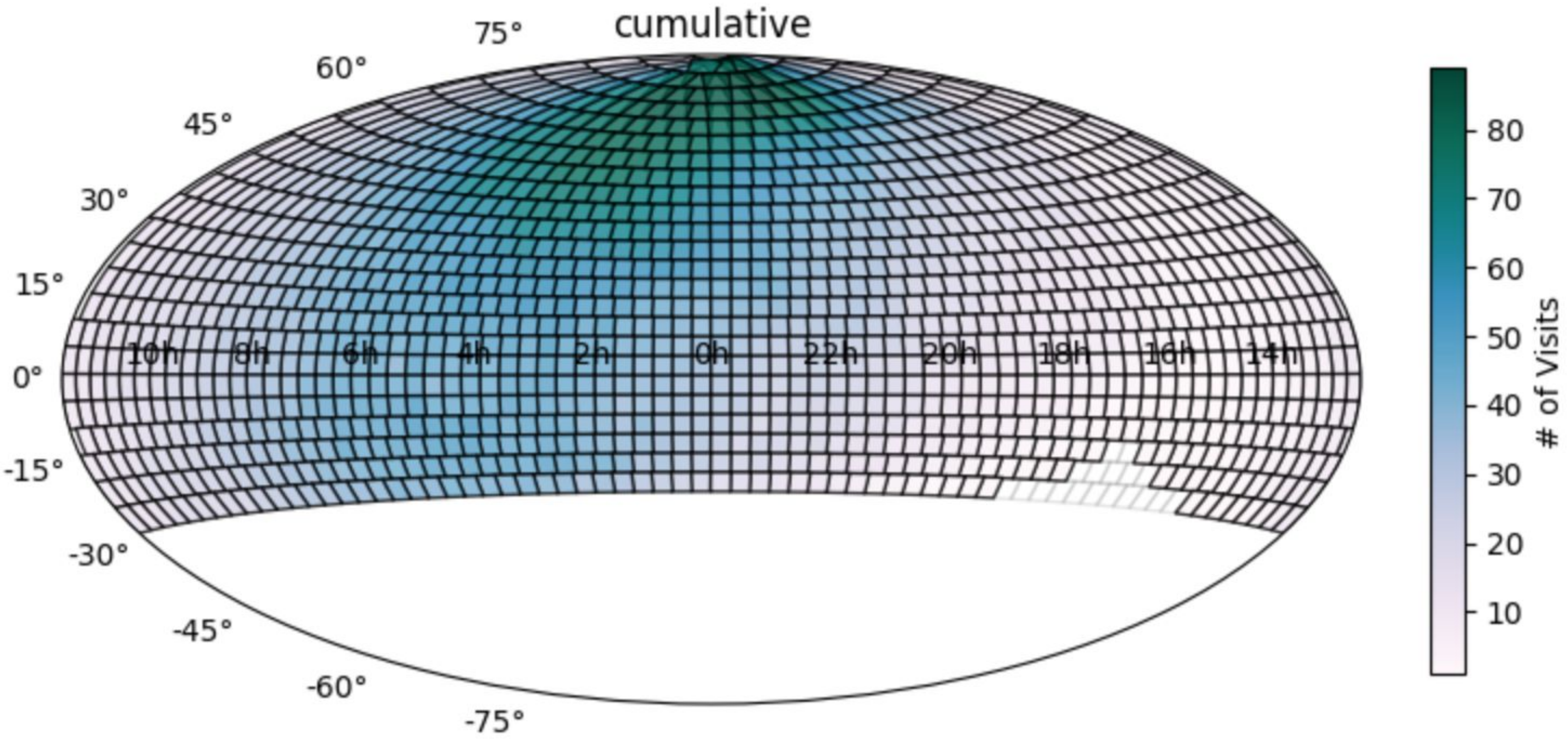
- Entire Palomar sky divided into fixed grid of ~ 1330 fields

- Each field visit = 8 dithered exposures with a total exposure time of 65 s. Dither amplitude ~ 3 arcmin.
- Aimed sensitivity of 16.4 AB (15.5 Vega) mag every night.

- Sky coverage ~ 20,000 sq. deg. every night. Typical cadence ~ 1 - 2 days over entire sky.

- ToO interrupts for deeper coverage of exceptional events (GW triggers, neutrinos, etc.)

Sky coverage so far



Data reduction pipeline

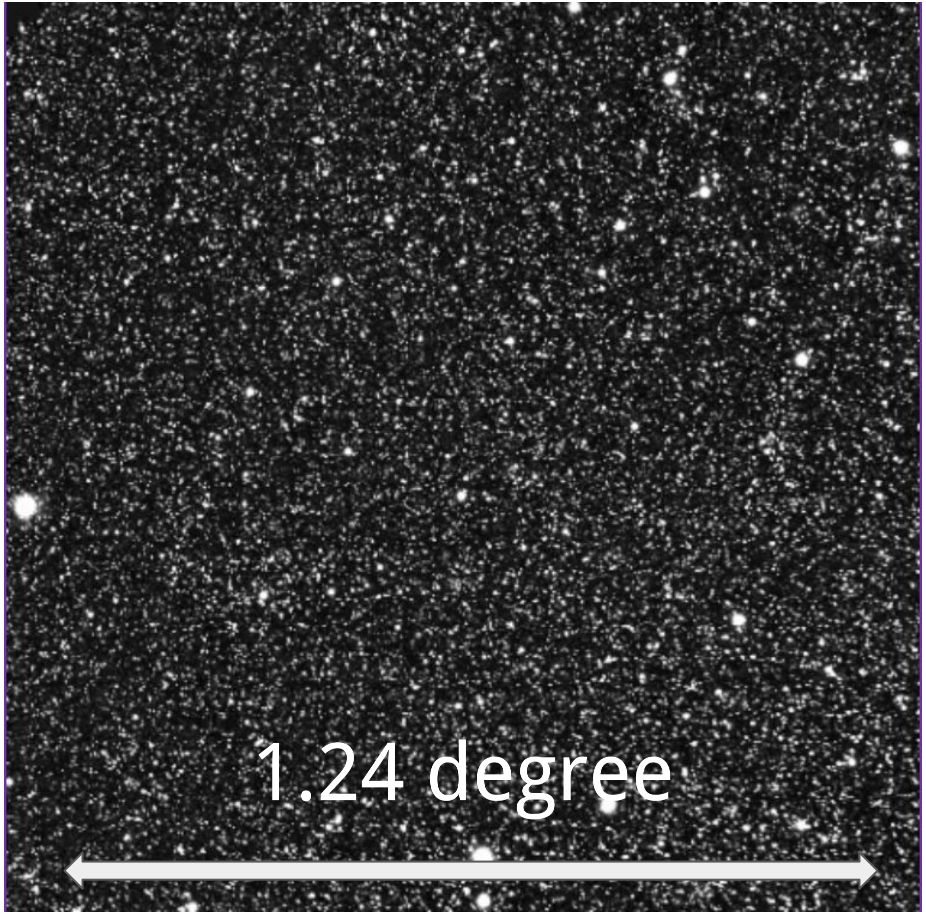
- Raw images divided into four quadrants (1K x 1K).

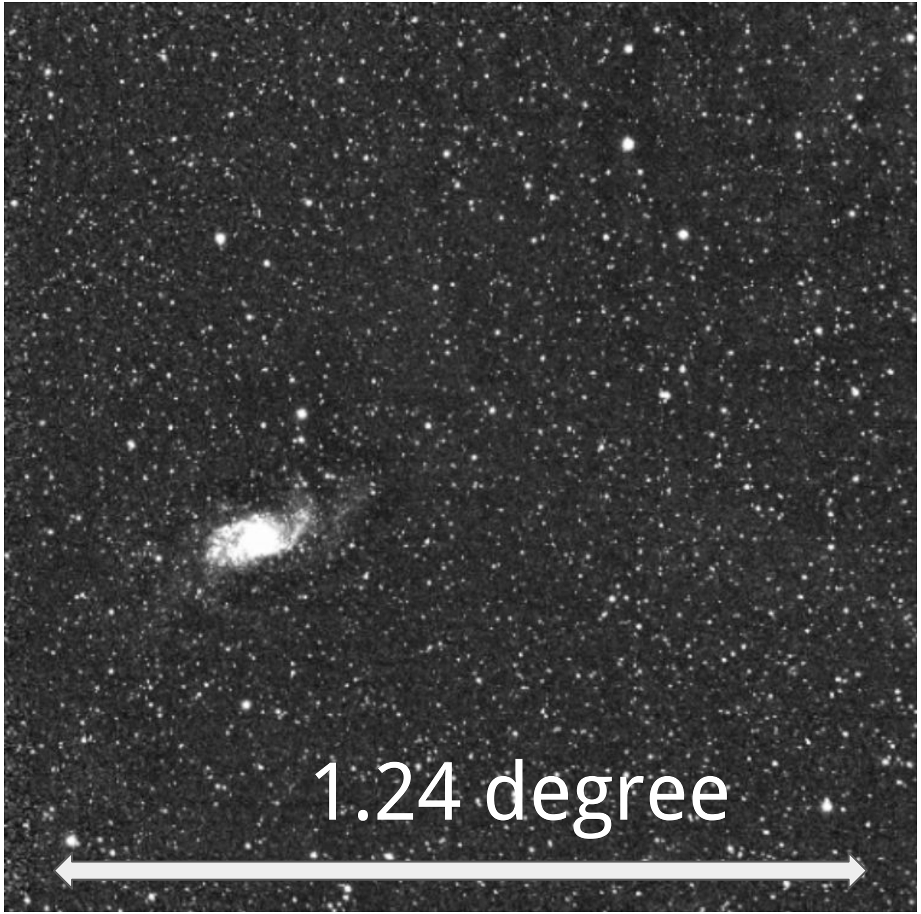
- Followed by flat-fielding and Gaia-based astrometric solutions for each image. Dithered frames are stacked by `drizzling’ on to a 2x finer pixel grid (4.3 arcsec / pixel).

- Photometric solutions by cross-match to 2MASS stars.

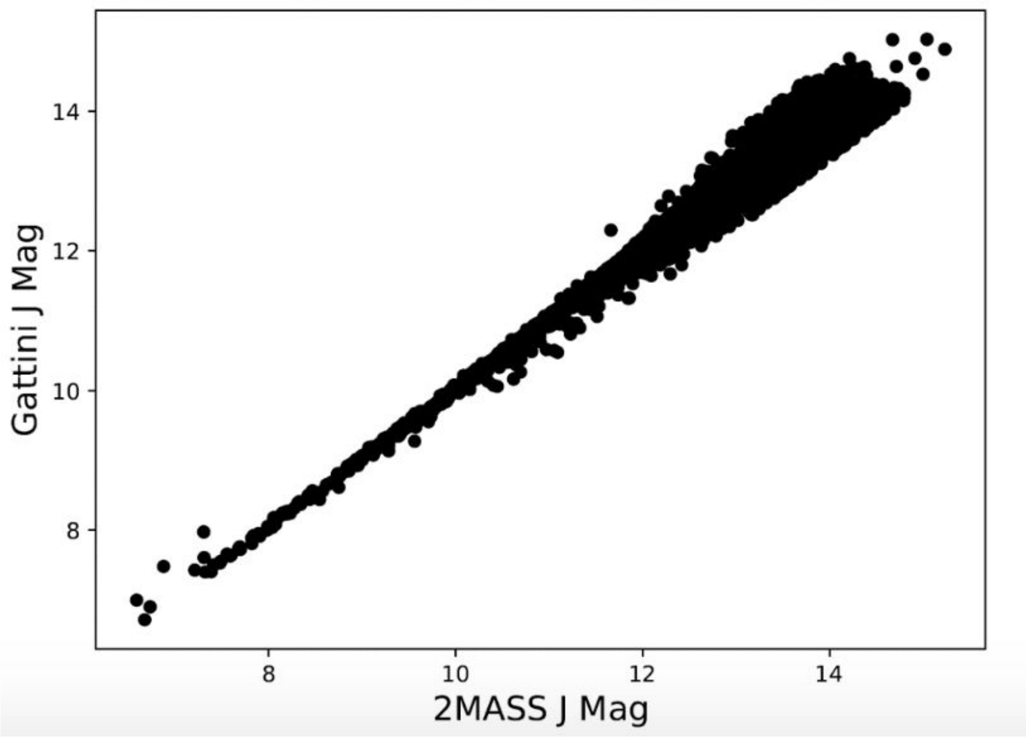
- Image subtraction for transient discovery based on ZOGY algorithm (Zackay+ 2016).

Examples: Drizzled nightly products





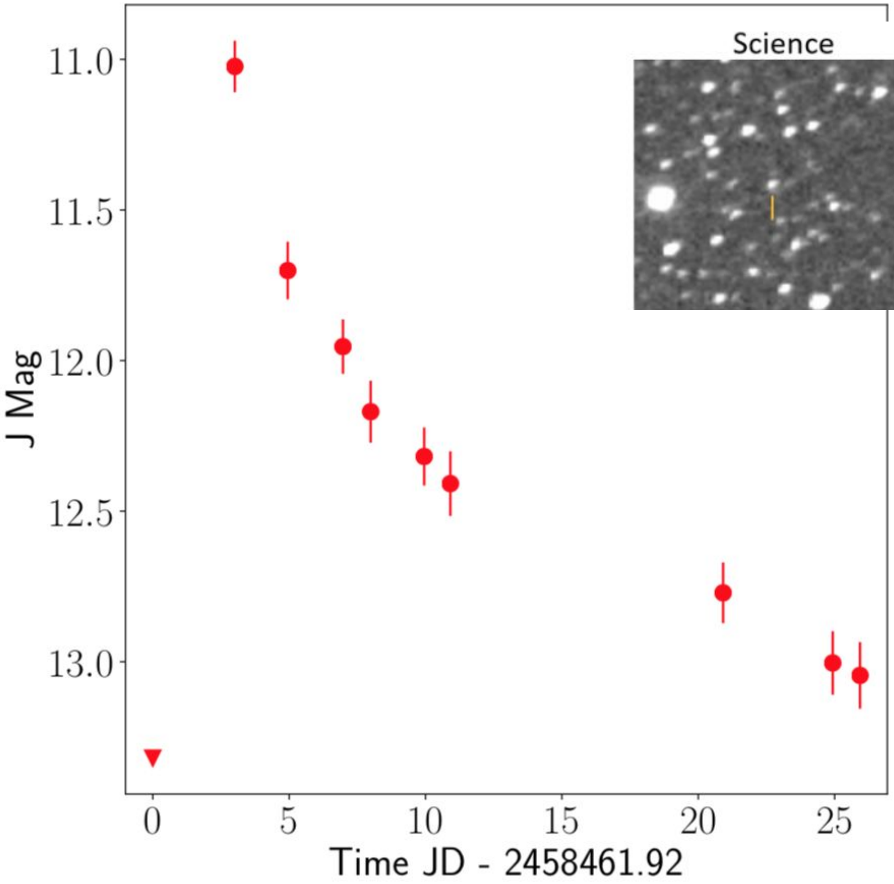
Gattini photometry against 2MASS

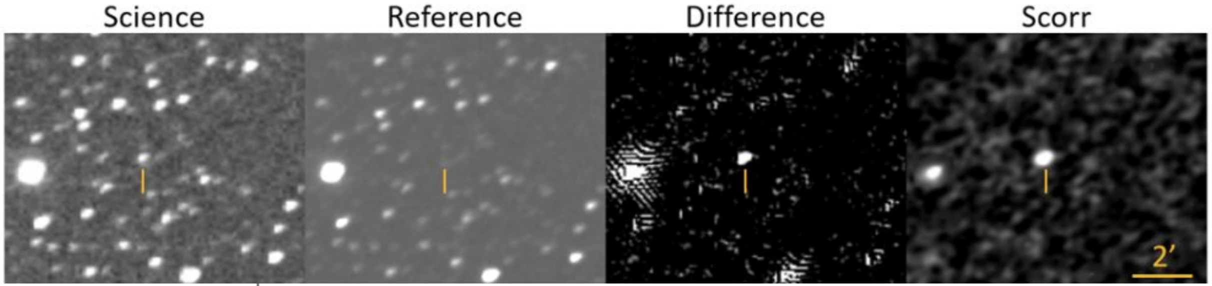


- Currently achieving median depth of ~ 15 Vega mag (15.9 AB).
- Sensitivity limited by variations in optical focus quality.
- **Tools available to get J-band light curves of any detected object**

Early science from commissioning data

Light curve of dwarf nova AT 2018jro



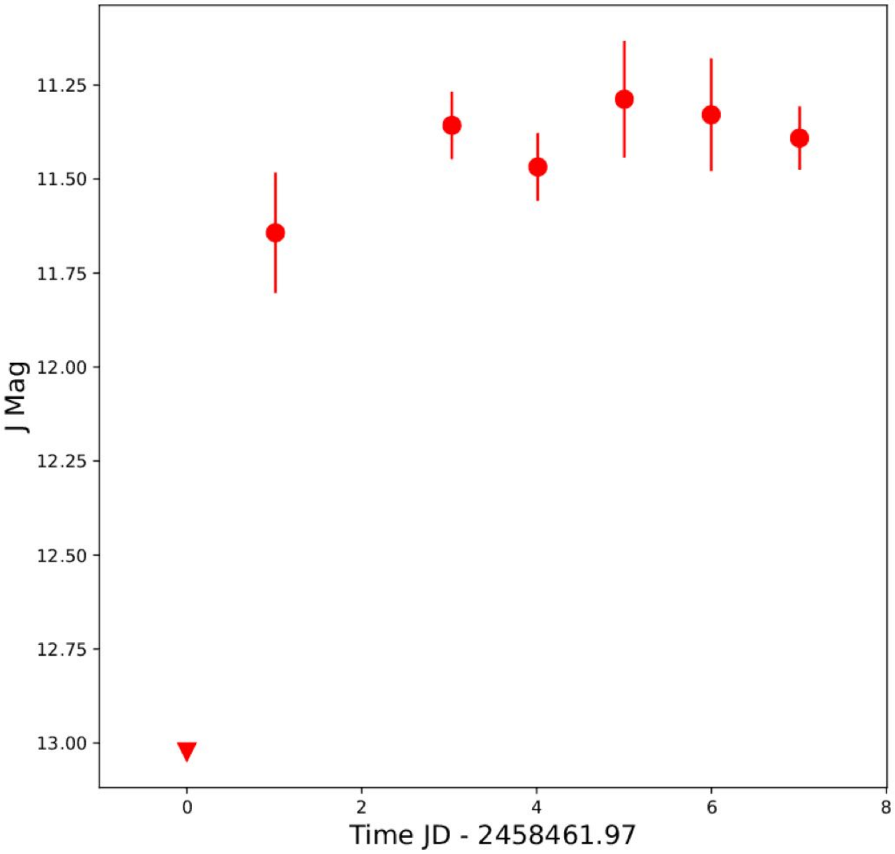


Palomar Gattini-IR J band detections of AT 2018jro

ATel #12305; ***K. De (Caltech), M. Hankins (Caltech), M. M. Kasliwal (Caltech), A. Moore (ANU), S. M. Adams (Caltech), M. Ashley (UNSW), J. Burnham (SRL/Caltech), A. Delacroix (COO/Caltech), T. Greffe (COO/Caltech), D. Hale (COO/Caltech), R. Lau (JAXA), D. McKenna (COO/Caltech), E. O. Ofek (Weizmann), R. Smith (COO/Caltech), J. Sokoloski (Columbia), J. Soon (ANU), T. Travouillon (ANU)***
*on **18 Dec 2018; 03:33 UT***
Credential Certification: Kishalay De (kde@astro.caltech.edu)

Subjects: Infra-Red, Optical, Nova

NIR brightening of blazars



- J band light curve of blazar S50716+714
- R band brightening reported in Atel #12298
- Coincident J band brightening of ~ 1.5 mags recovered in Gattini data

Timeline

- Telescope commissioned at Palomar in September 2018.
- Robotic telescope operations began in October 2018.
- Real-time data reduction pipeline running since November 2018 (De et al. in prep).

- Real-time image subtraction pipeline implemented in January 2019. Effort going into automating search for `real' transients from subtractions.

- **Gattini-IR serves as a test-bed for future IR transient surveys (WINTER at Palomar, DREAMS in Australia).**