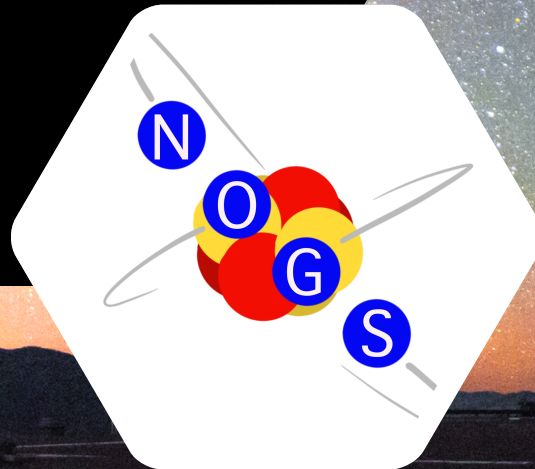


How to Find the Sources of Gravitational Waves and Astrophysical Neutrinos

Rob Morgan



Before we get started...

UW-MadisonPGSC-

PD

Resources for professional development
within the UW-Madison Physics Department



/// Session 10: Fellowship Proposals: A Faculty and Writing Center Panel

When and Where: September 22, 2020; 2:30pm-3:30pm; <https://us02web.zoom.us/j/82686938703>

Overview: Tips and tricks for writing successful fellowship proposals. The Writing Center will give a short presentation on the components of and strategies for grant and proposal writing. Examples of successful graduate research proposals will be analyzed and discussed. Afterward, there will be a physics-specific discussion with professors in the department to tailor the tips to the specific funding agencies you may deal with.

Speakers: Angela Zito (from the UW Writing Center), Justin Vandembroucke, Victor Brar, Uwe Bergmann

On the agenda for today

Space

Data from the (currently) most powerful camera + telescope ever built

Stuff that blows up in space

How astronomical explosions are detected and characterized

Science from stuff that blows up in space

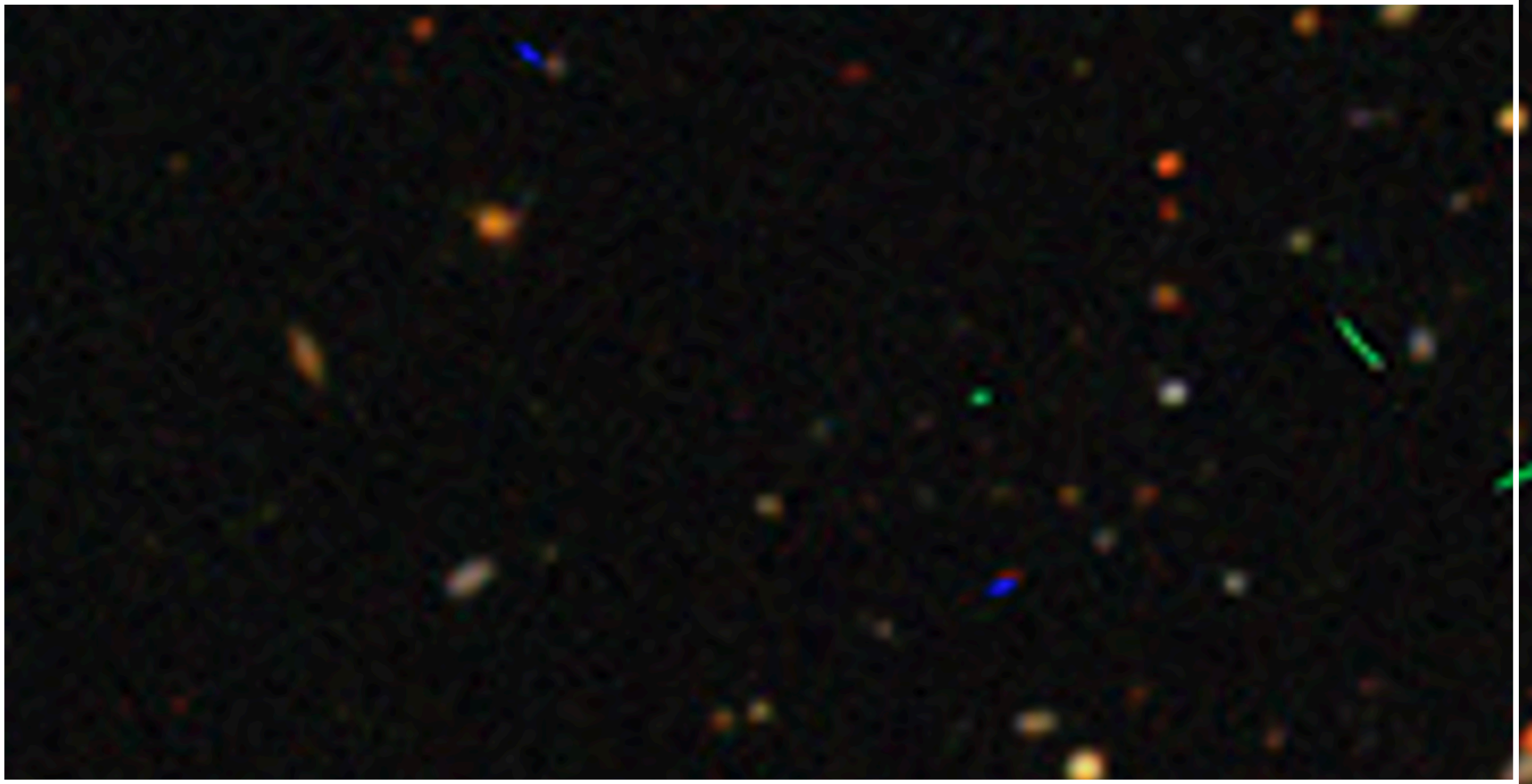
An outline of the science products from multimessenger astronomy

Space

This is space



This is space



This is space



This is a single image of space

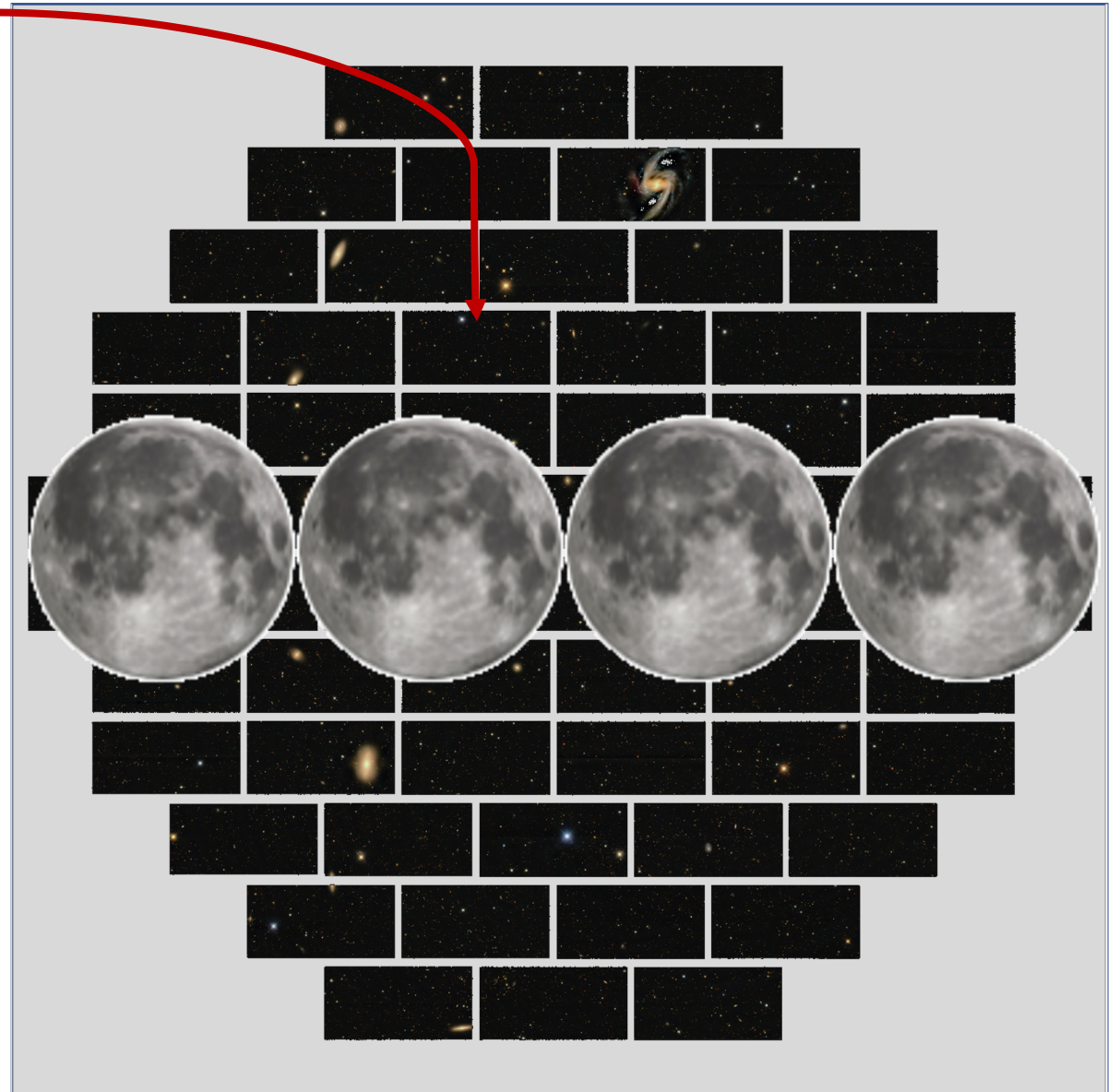


The camera is 570 Megapixels

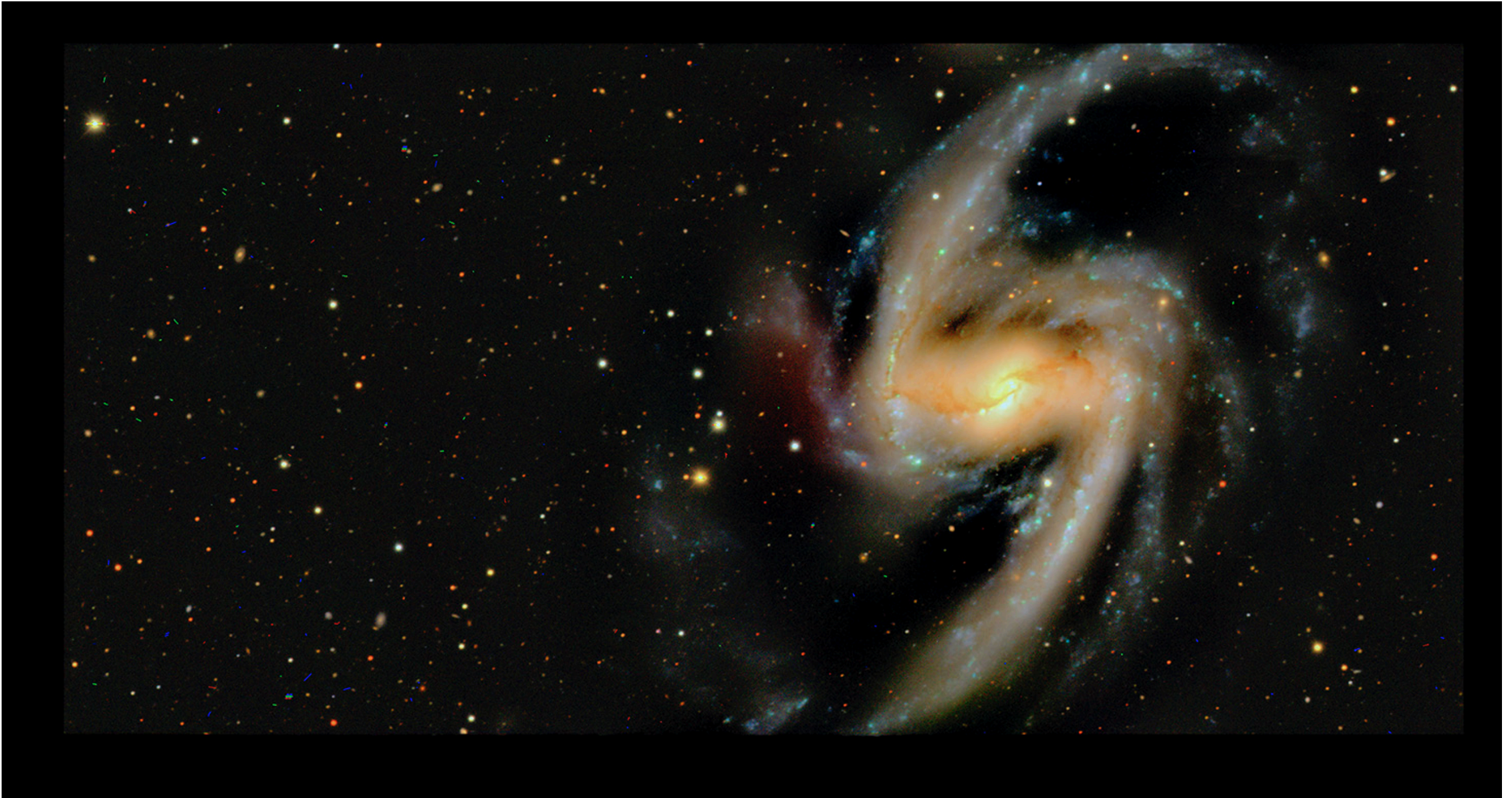
Each image is 5GB

- Each color image is 15GB

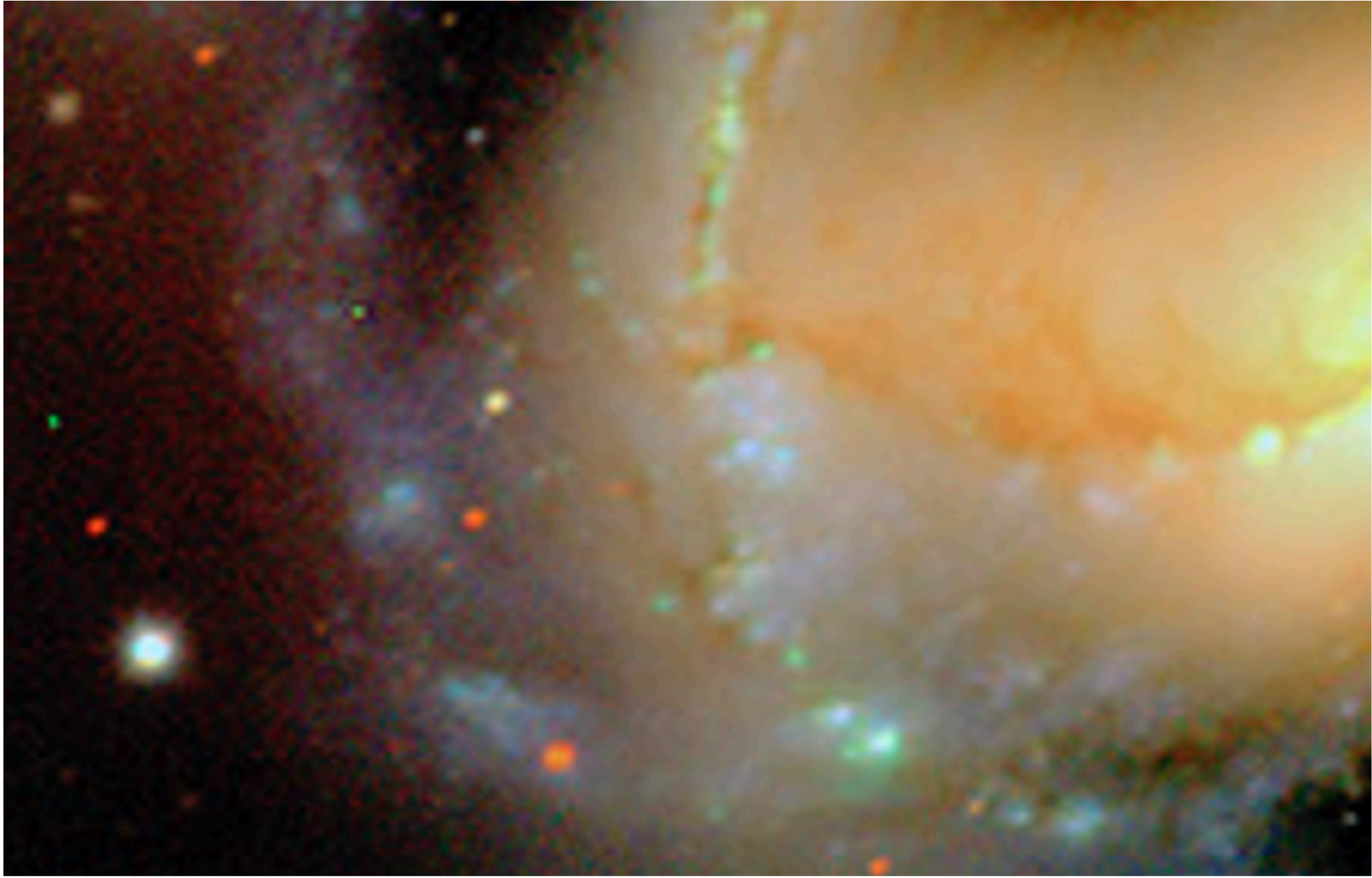
Collected with a 90 second exposure time



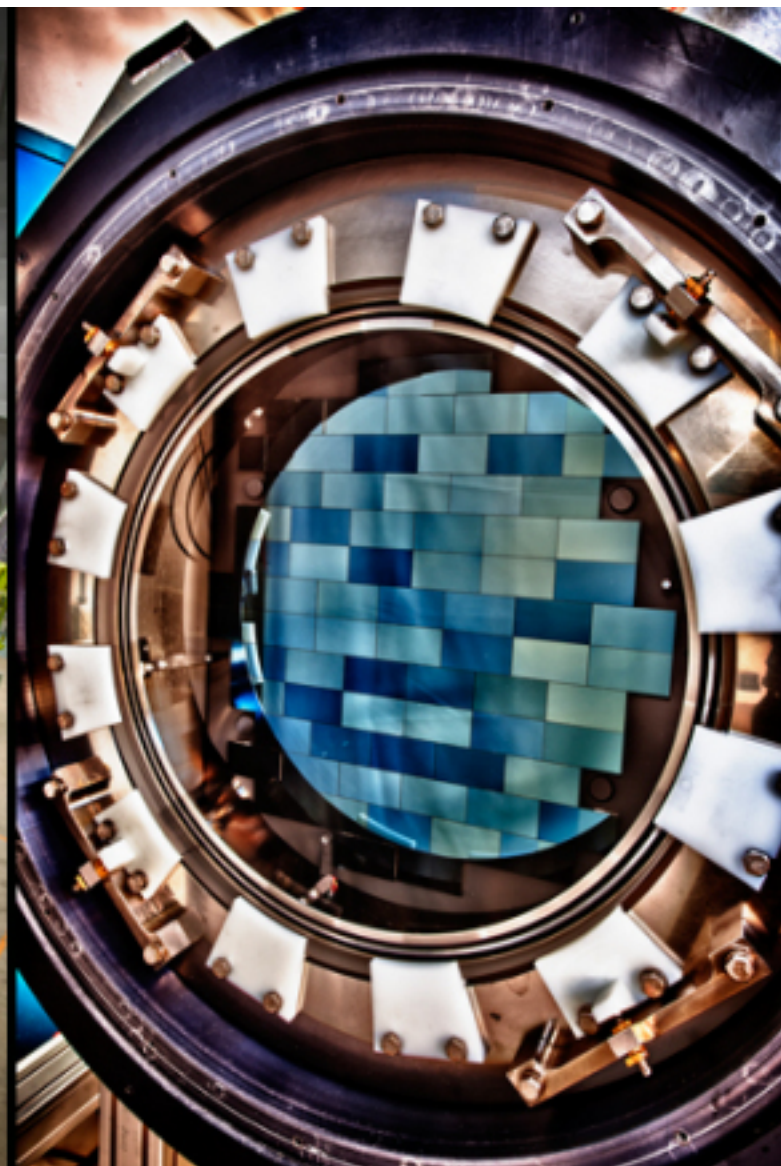
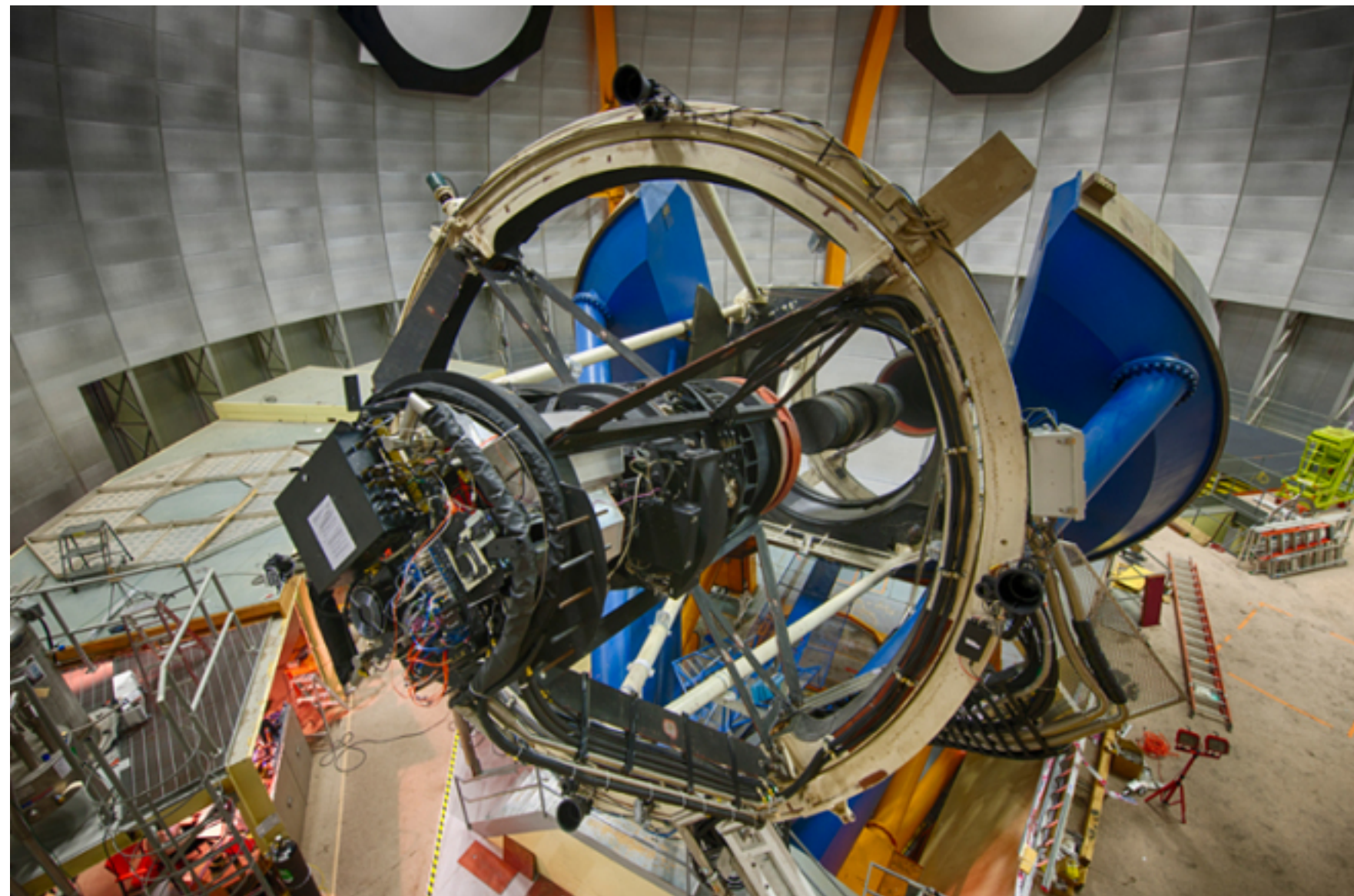
This is 1.6% of a single image of space



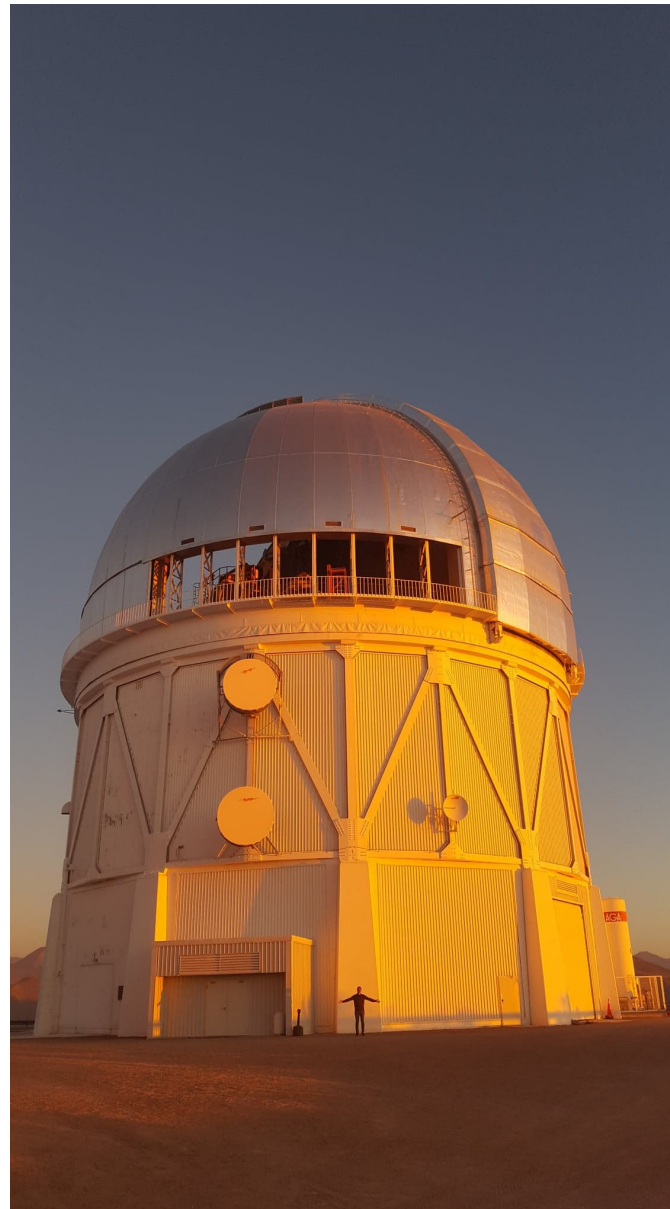
This is 0.02% of a single image of space



The camera and telescope behind that image



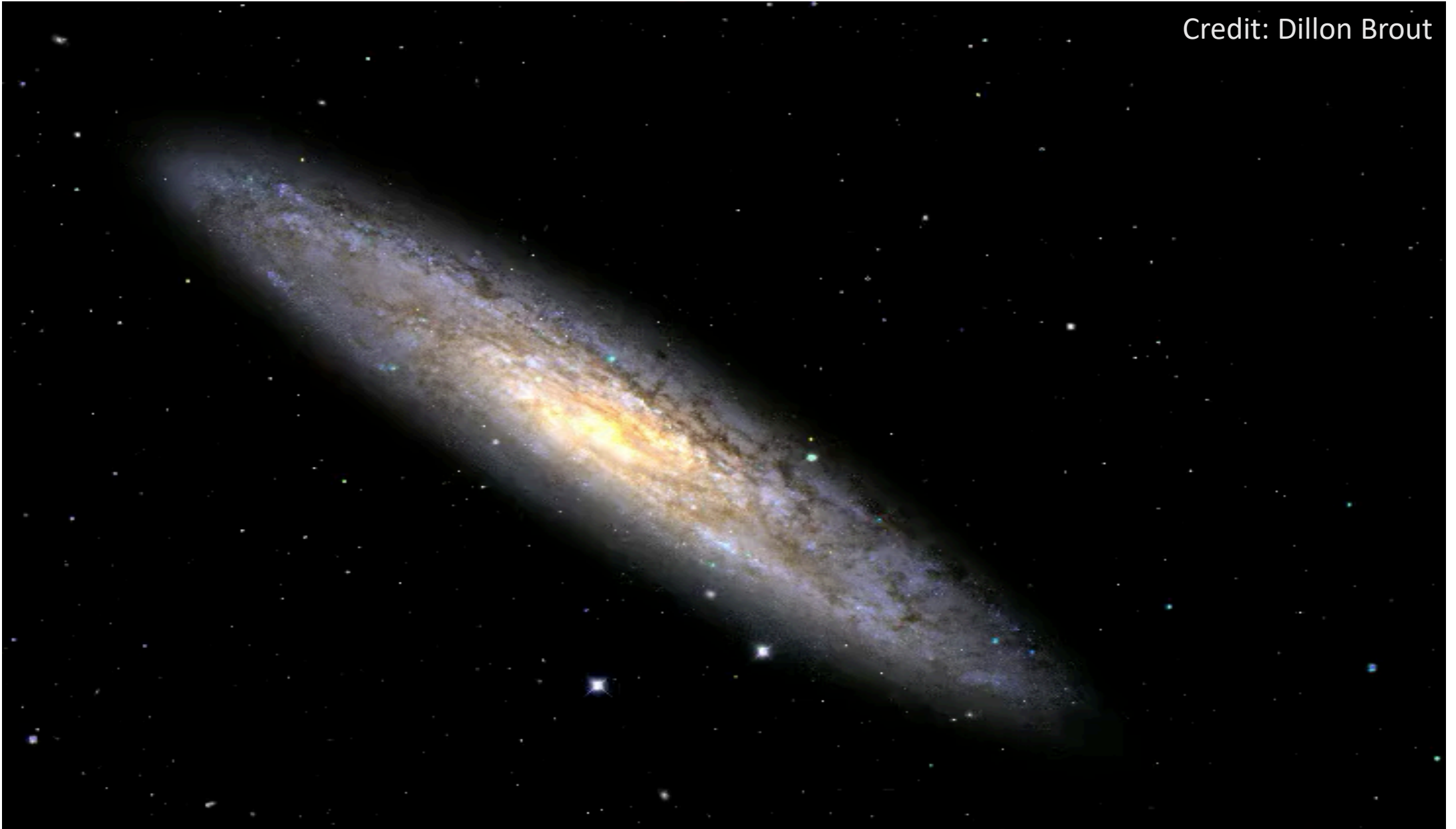
The camera and telescope behind that image



Stuff that blows up in space

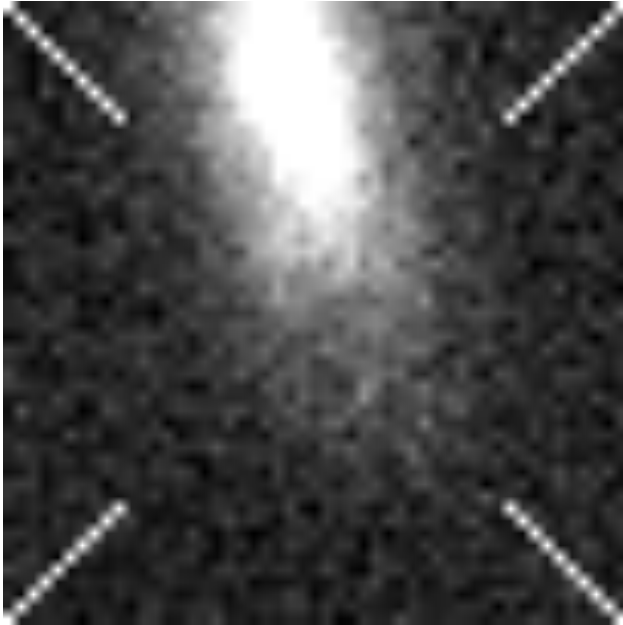
This is what explosions look like in astronomical images

Credit: Dillon Brout

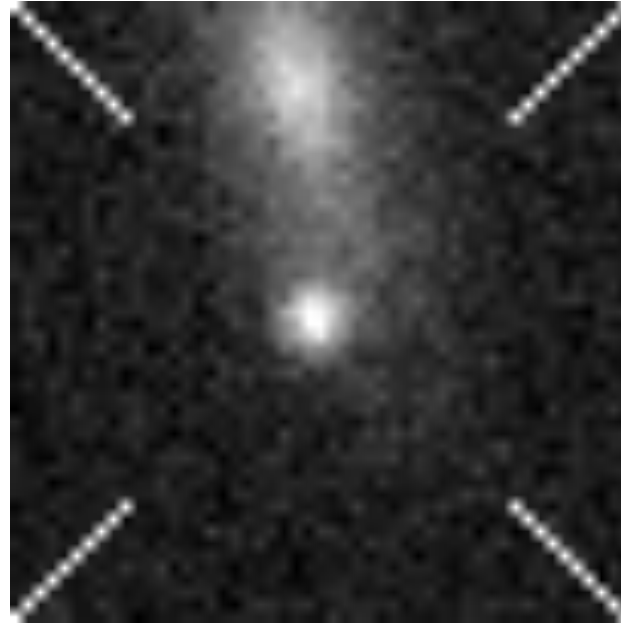


Detecting things that blow up in space

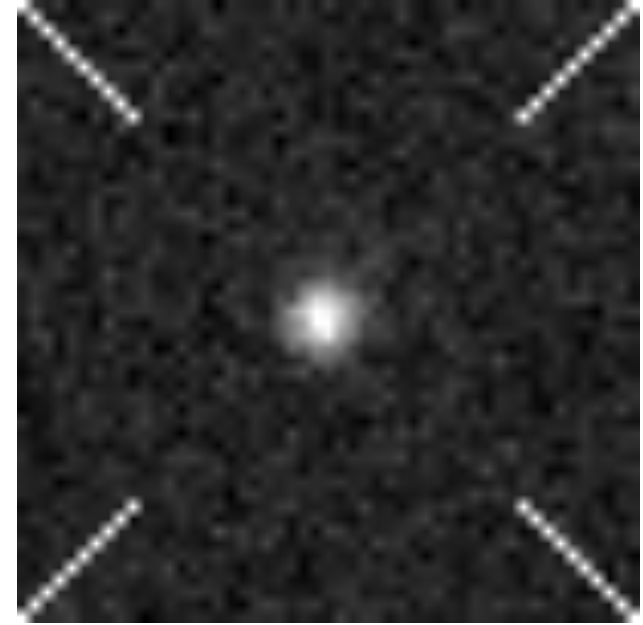
Difference Imaging



Previous Image

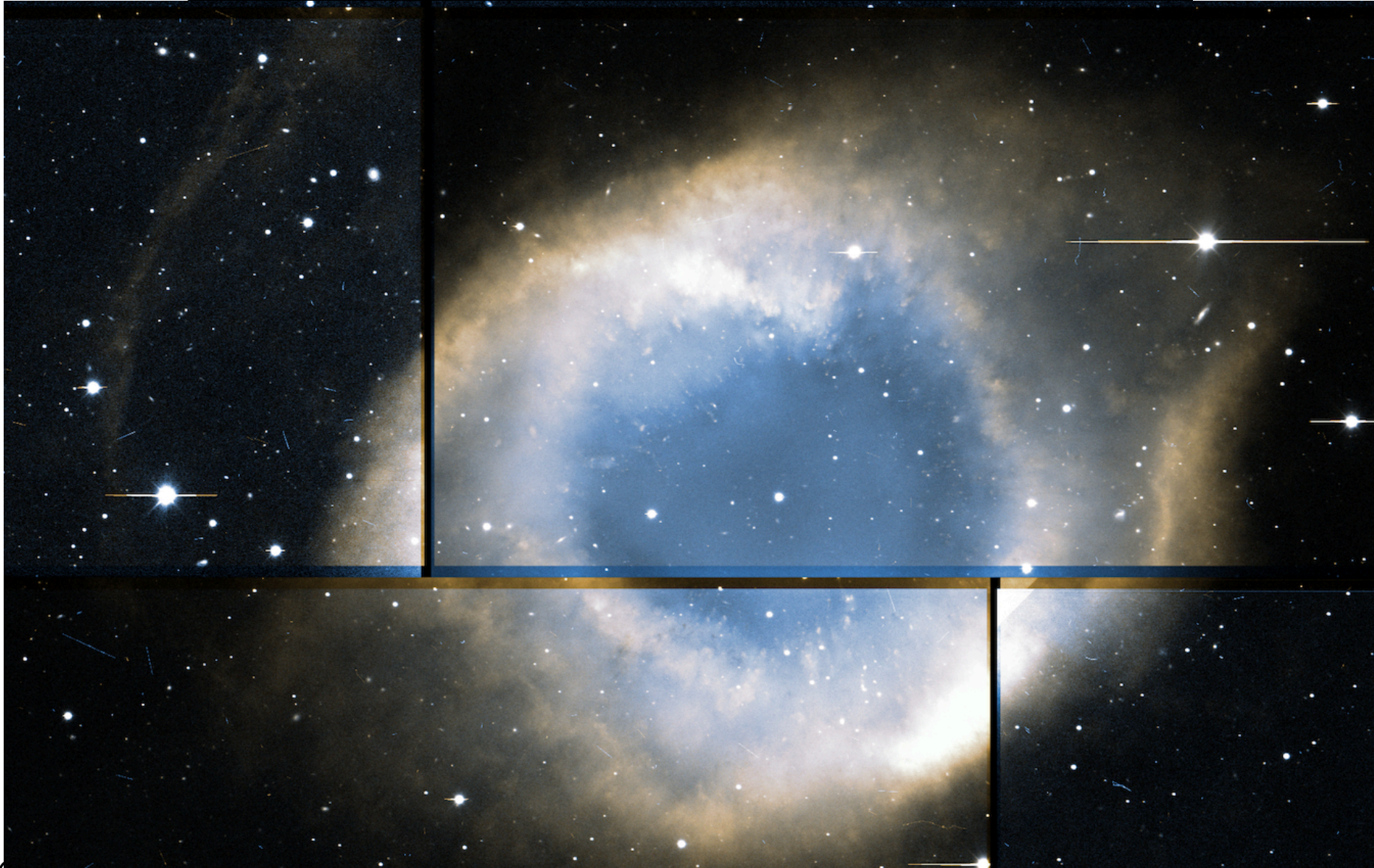


Recent Image



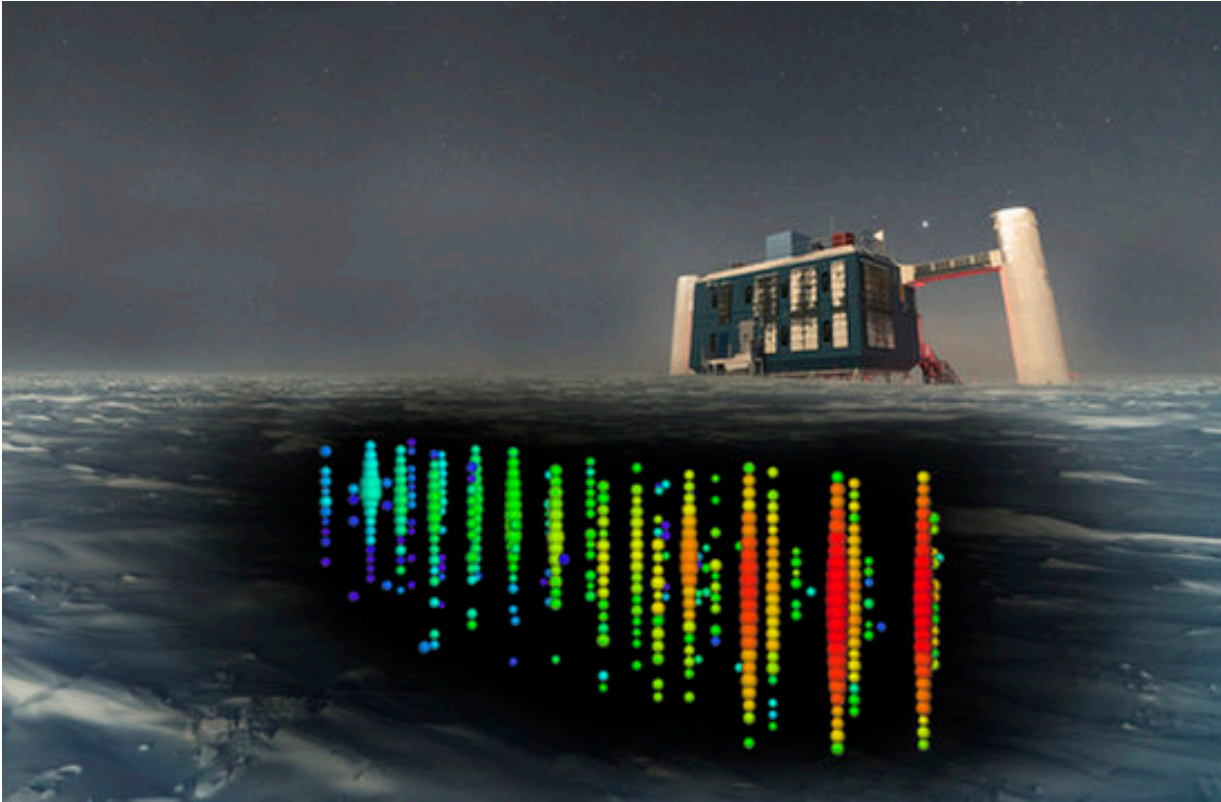
Subtracted Image

Aside: pretty things make my life difficult



Finding stuff that blows up in space

Someone, tell me where to point my telescope!

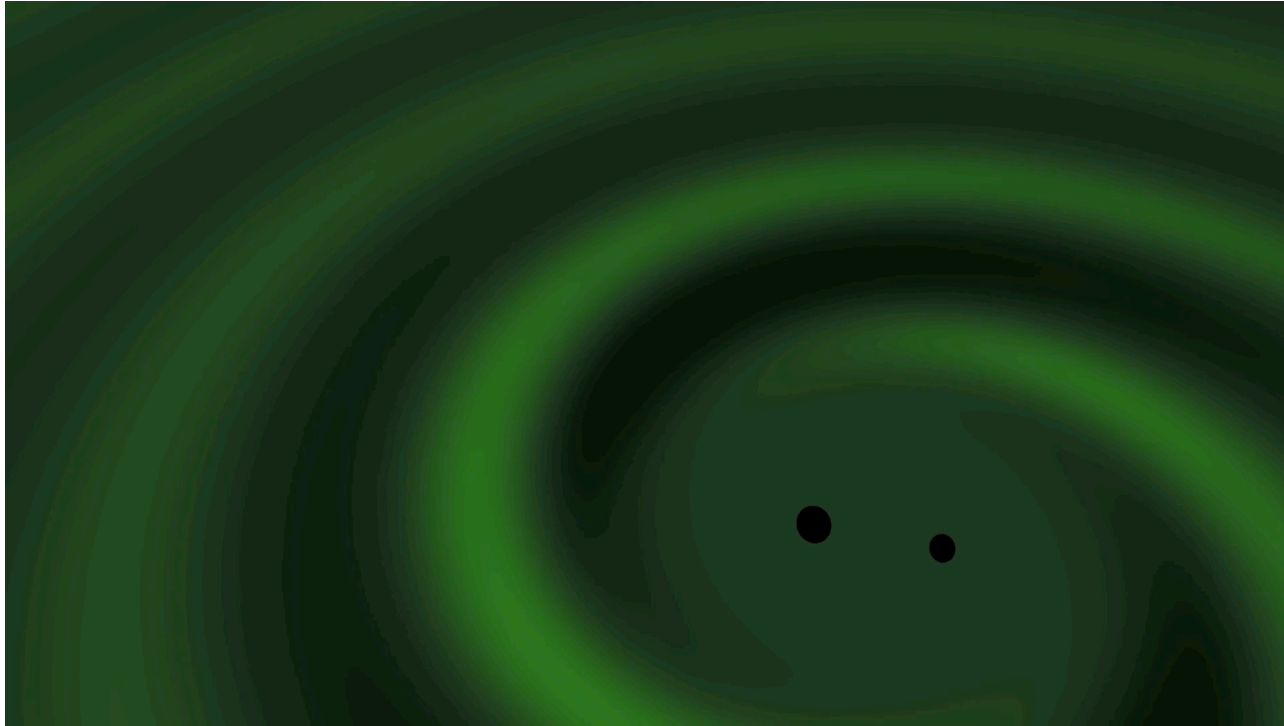


The IceCube Neutrino Observatory
Antarctica

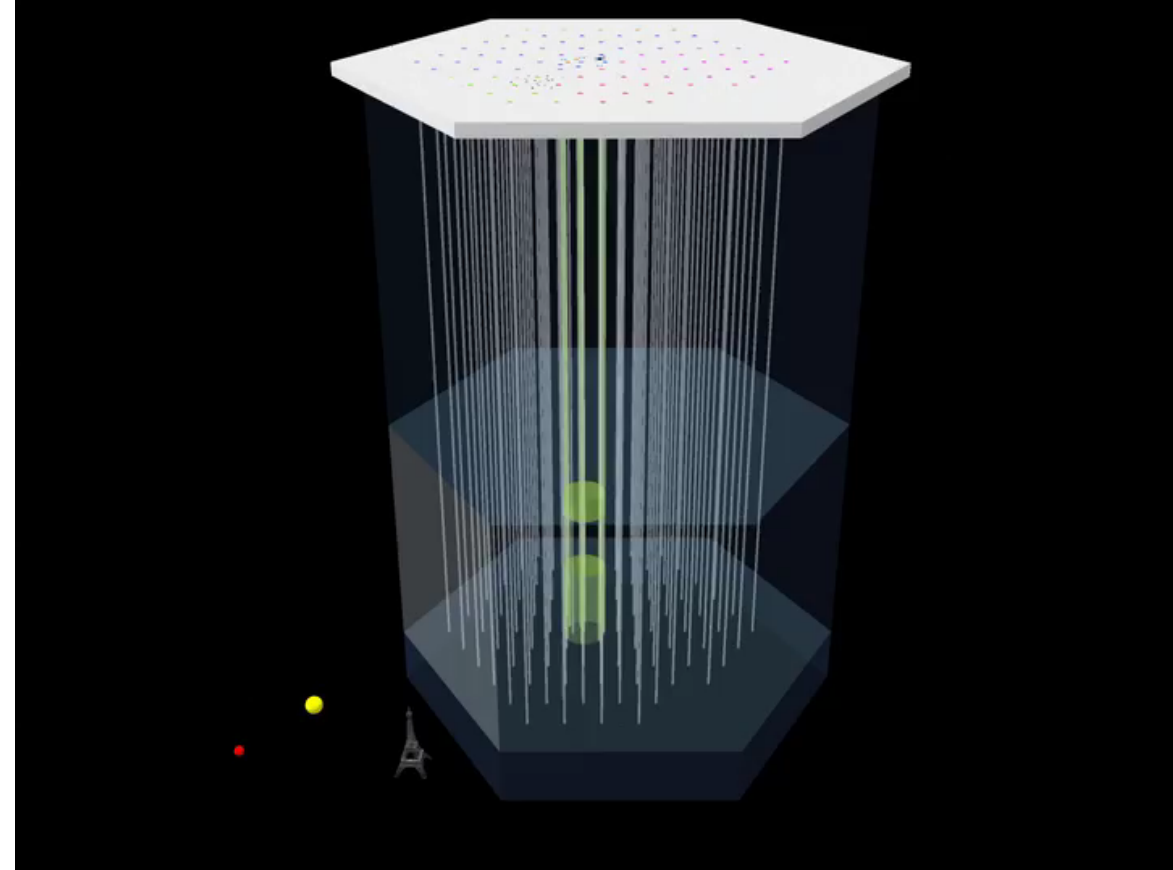


The Laser Interferometer Gravitational-Wave Observatory
Livingston, LA, USA

The detection of multimessenger signals from space



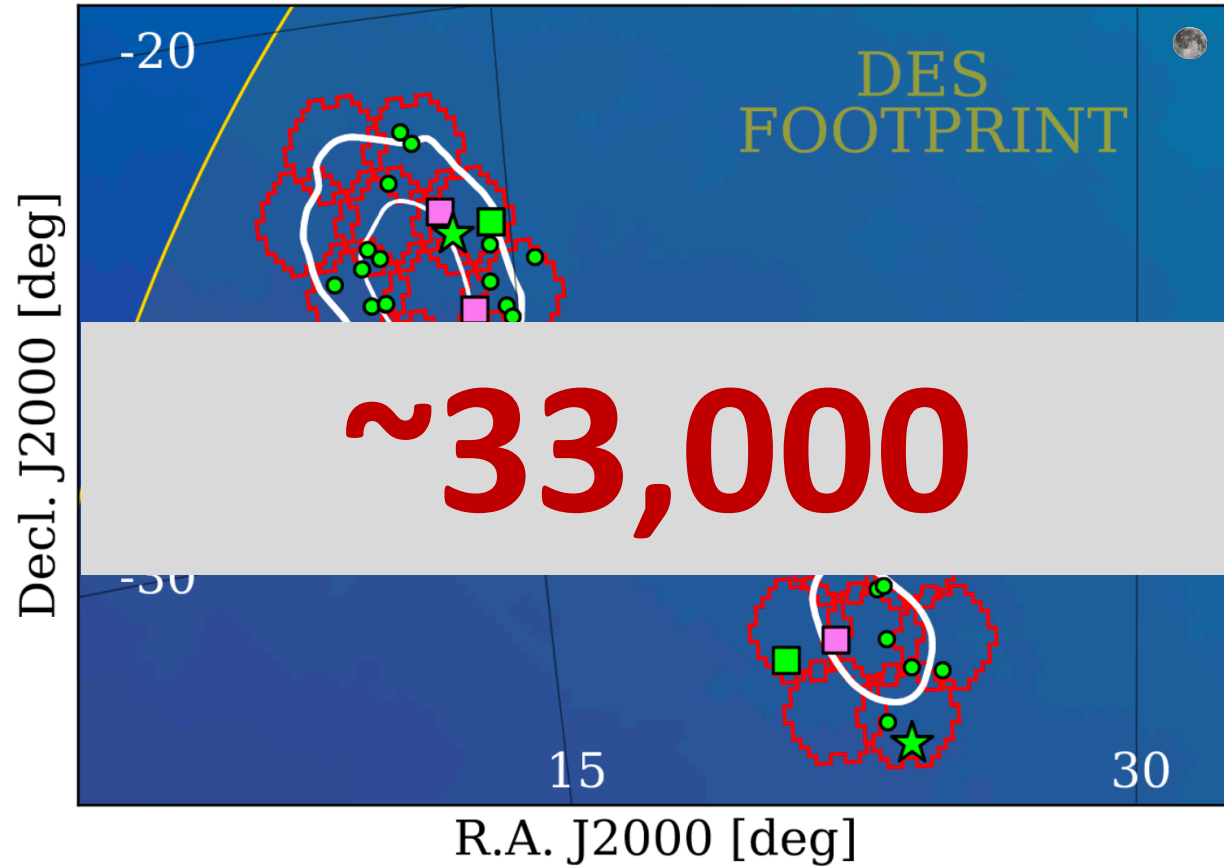
The Detection of a Gravitational Wave by LIGO



The Detection of a Neutrino by IceCube

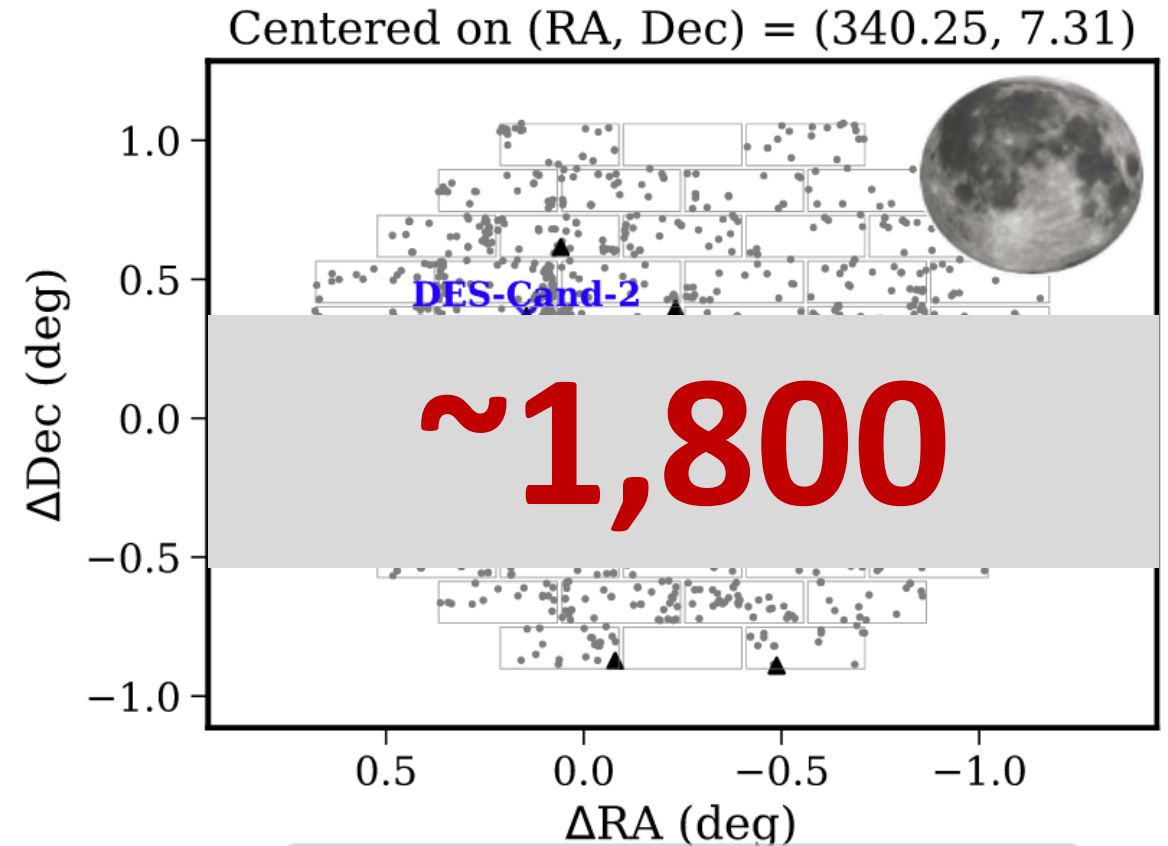
Where did the multimessenger signal come from?

LIGO + Virgo GW190814



[Morgan et al. 2020](#)

IceCube IC171106A



[Morgan et al. 2019](#)

How do you find the one true source?

Machine Learning!

ArtifactSpy

Detecting real explosions in images

- Led by Adam Shandonay, Advised by Rob Morgan

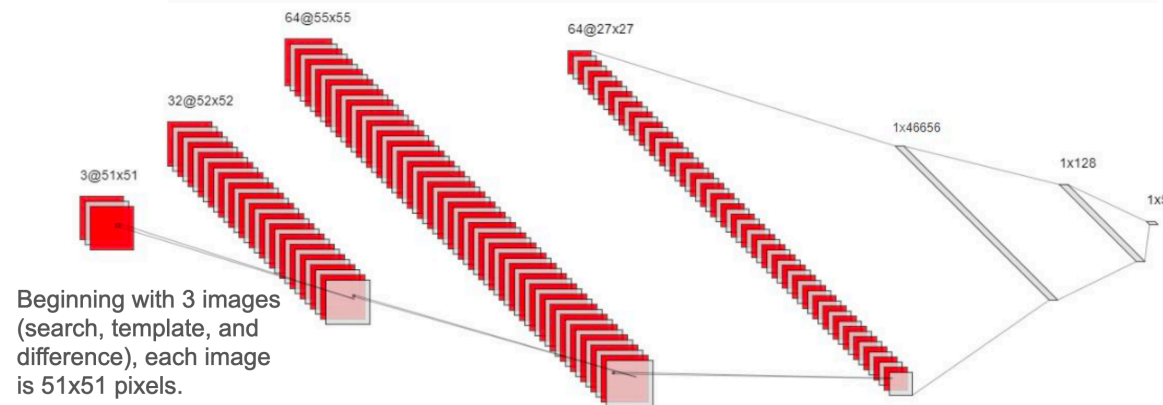
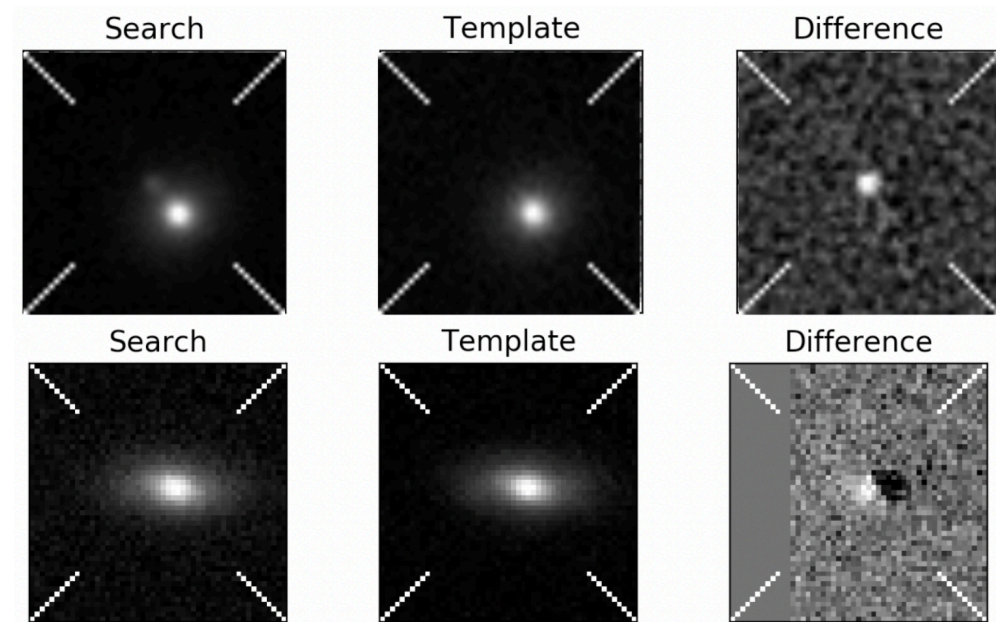
KN-Classify

Differentiating types of explosions

AstRNNomy

Combining temporal and image classification

ArtifactSpy



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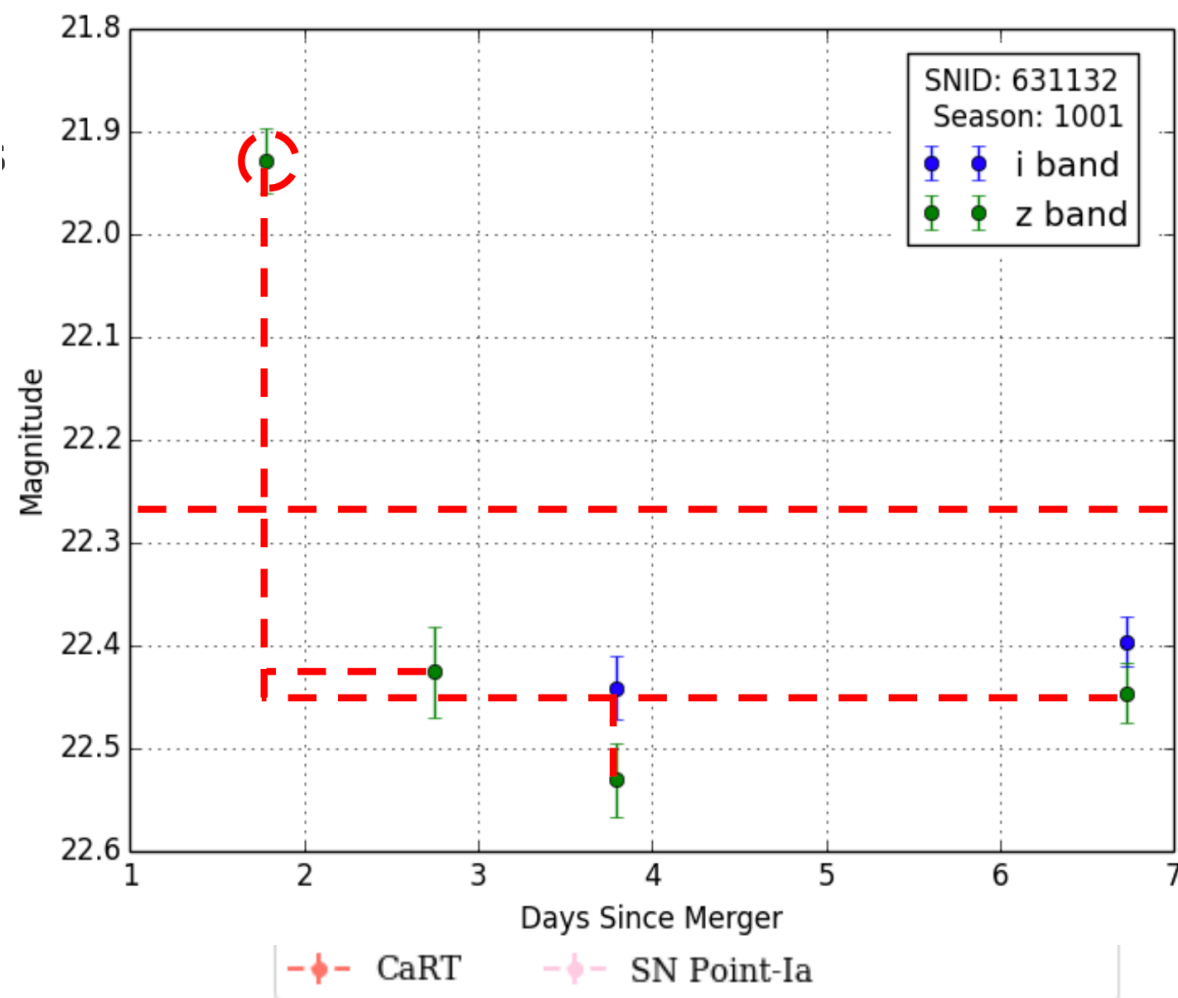
- Led by Adam Shandonay, Advised by Rob Morgan

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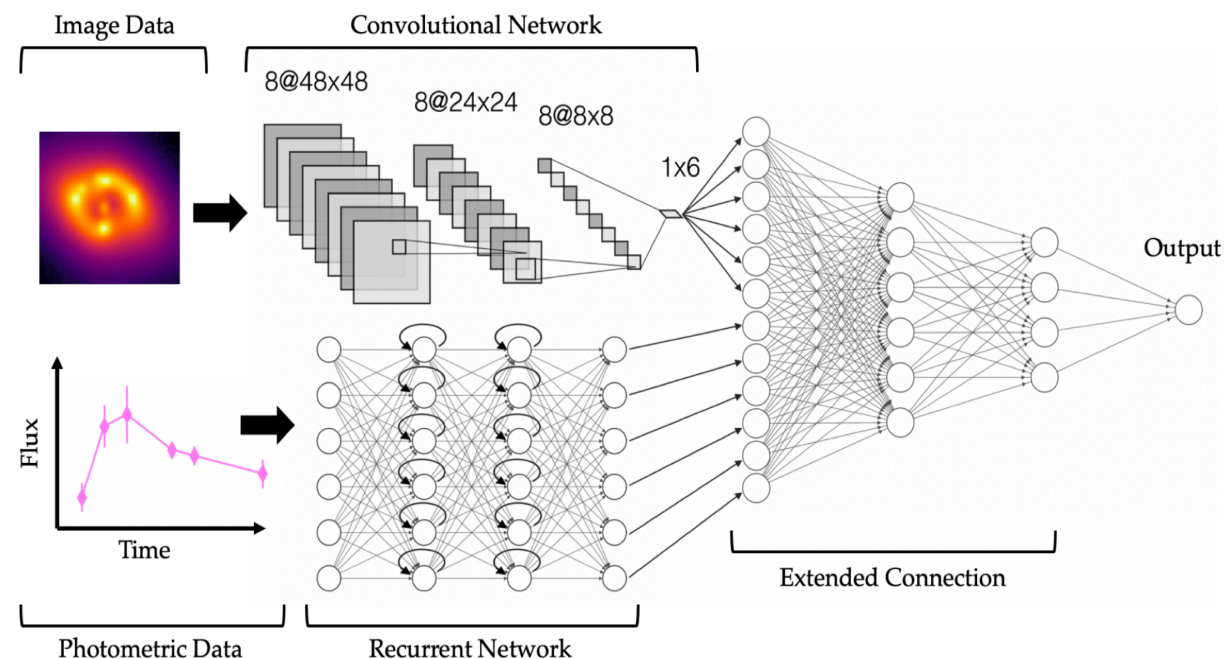
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KN-Classify

Differentiating types of explosions

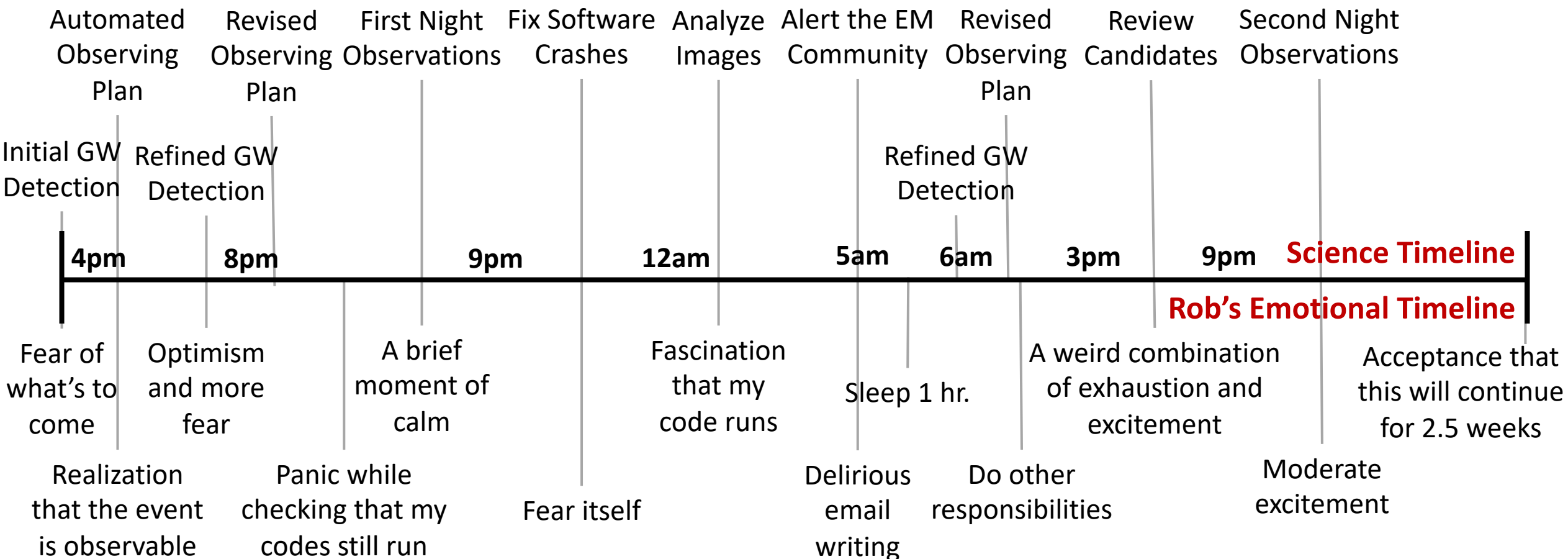
AstRNNomy

Combining temporal and image classification



Working in real-time

Timelines of first 30 hours of GW190814



Science from stuff that blows up in space

Science stemming from multimessenger astronomy

Perhaps the most paper-productive events in scientific history.

With

• N

THE ASTROPHYSICAL JOURNAL LETTERS

Scientific importance [\[edit\]](#)

Scientific interest in the event was enormous, with dozens of preliminary papers (and almost 100 [preprints](#)^[49]) published the day of the announcement, including 8 letters in *Science*,^[15] 6 in *Nature*, and 32 in a special issue of *The Astrophysical Journal Letters* devoted to the subject.^[7] The interest and effort was global: The paper describing the multi-messenger observations^[1] is coauthored by almost 4,000 astronomers (about one-third of the worldwide astronomical community) from more than 900 institutions, using more than 70 observatories on all 7 continents and in space.^{[5][15]}

A. Albert¹, M. André², M. Anghinolfi³, M. Ardid⁴, J.-J. Aubert⁵, J. Aublin⁶, T. Avgitas⁶, B. Baret⁶,
J. Barrios-Martí⁷, S. Basa⁸ [+ Show full author list](#)

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[The Astrophysical Journal Letters](#), [Volume 850](#), [Number 2](#)

[COLUMBIA OBSERVATORY COLLABORATION](#), [THE VIRGO COLLABORATION](#) & [THE LIGO COLLABORATION](#)

More cool stuff from the Bechtol Group

Grad student shoutouts!

Mitch McNanna

Searches for the faintest dwarf galaxies ever detected and constraining dark matter properties

Jimena González

Machine-learning searches for extremely rare cases of gravitational lensing

Megan Tabbutt

Development of new cosmological probes and commissioning the Vera C. Rubin Observatory

Thank you!

How to Find the Sources of Gravitational Waves and Astrophysical Neutrinos

Rob Morgan
robert.morgan@wisc.edu

