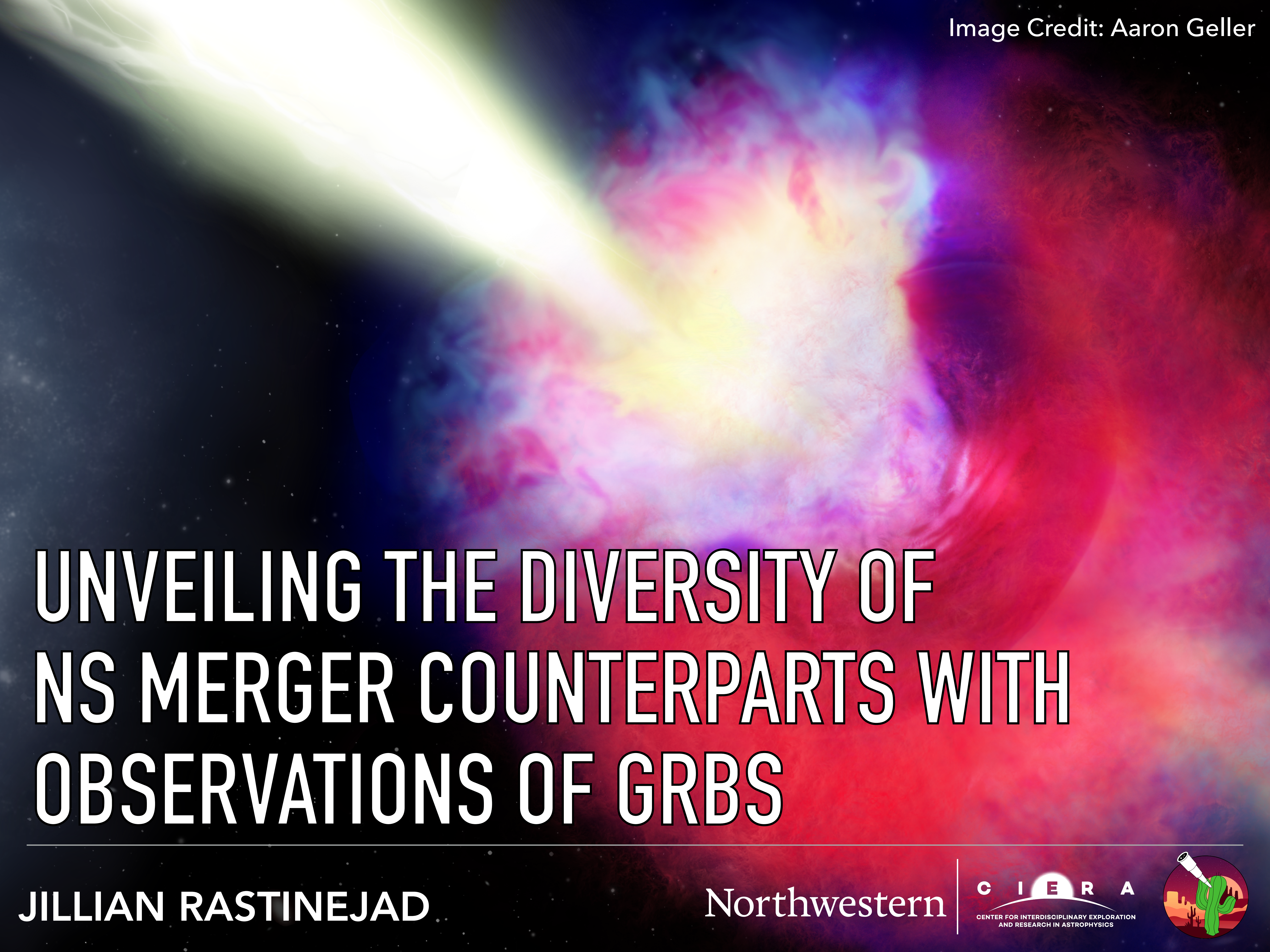


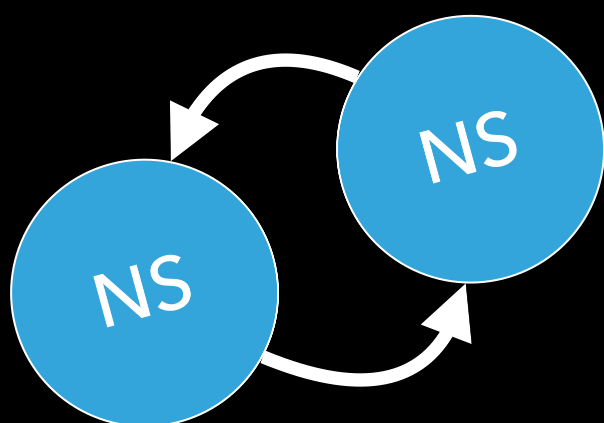
UNVEILING THE DIVERSITY OF NS MERGER COUNTERPARTS WITH OBSERVATIONS OF GRBS

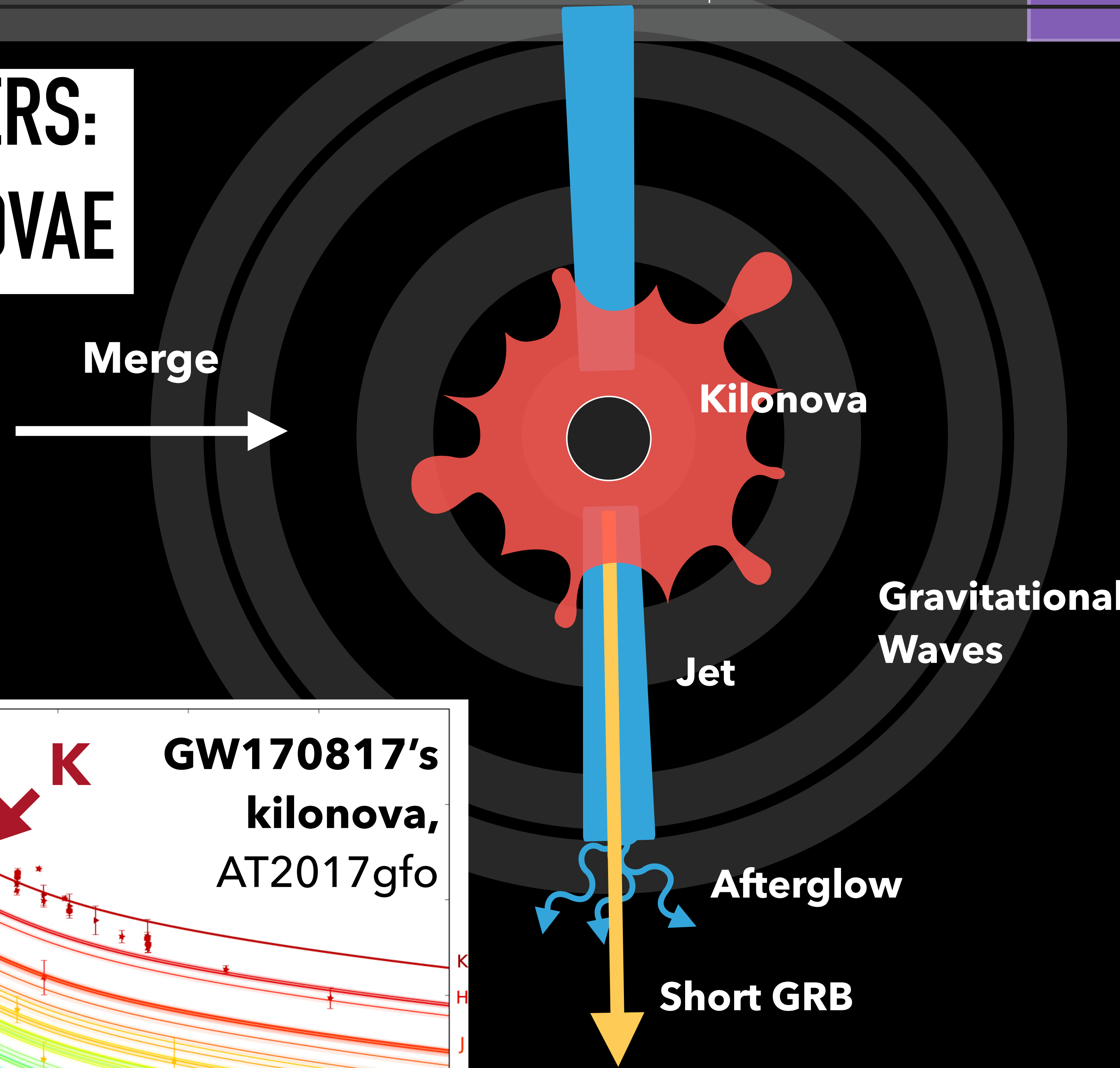
JILLIAN RASTINEJAD

Northwestern

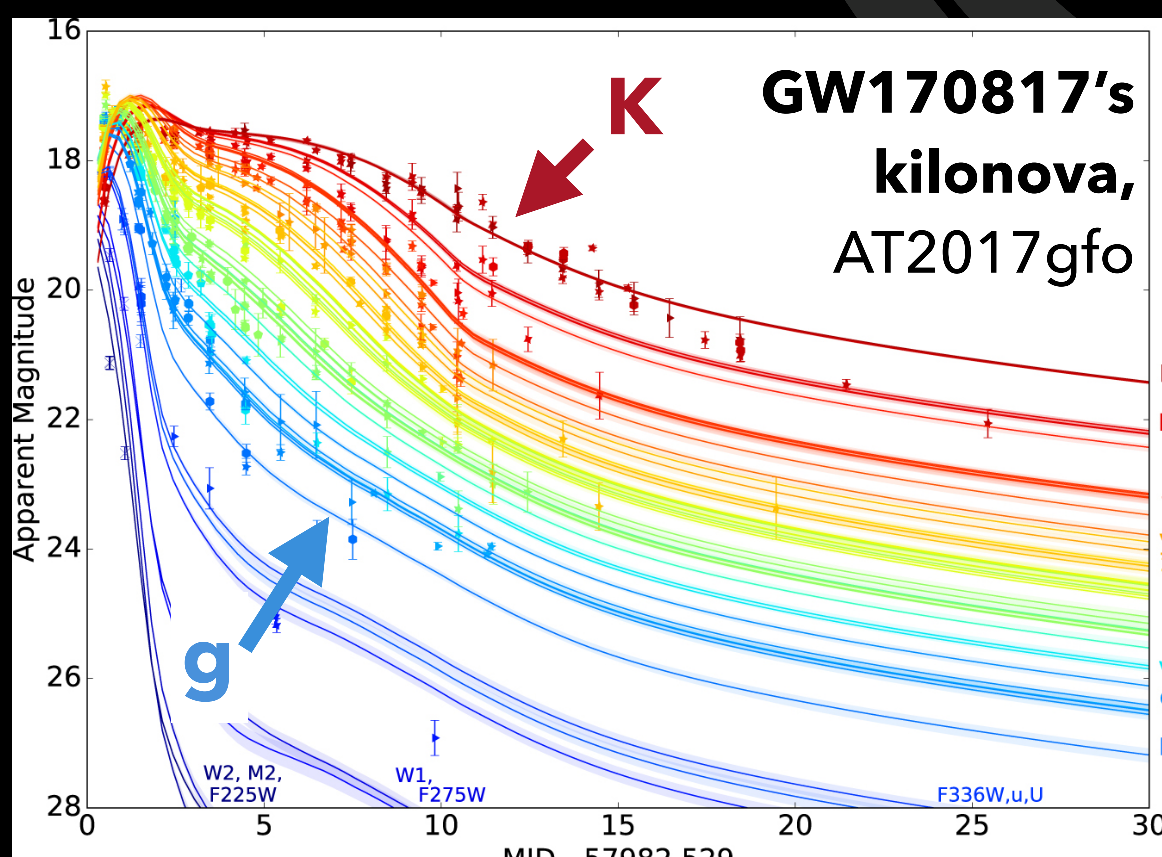
CIERA
CENTER FOR INTERDISCIPLINARY EXPLORATION AND RESEARCH IN ASTROPHYSICS

NEUTRON STAR MERGERS: SHORT GRBS + KILONOVAE

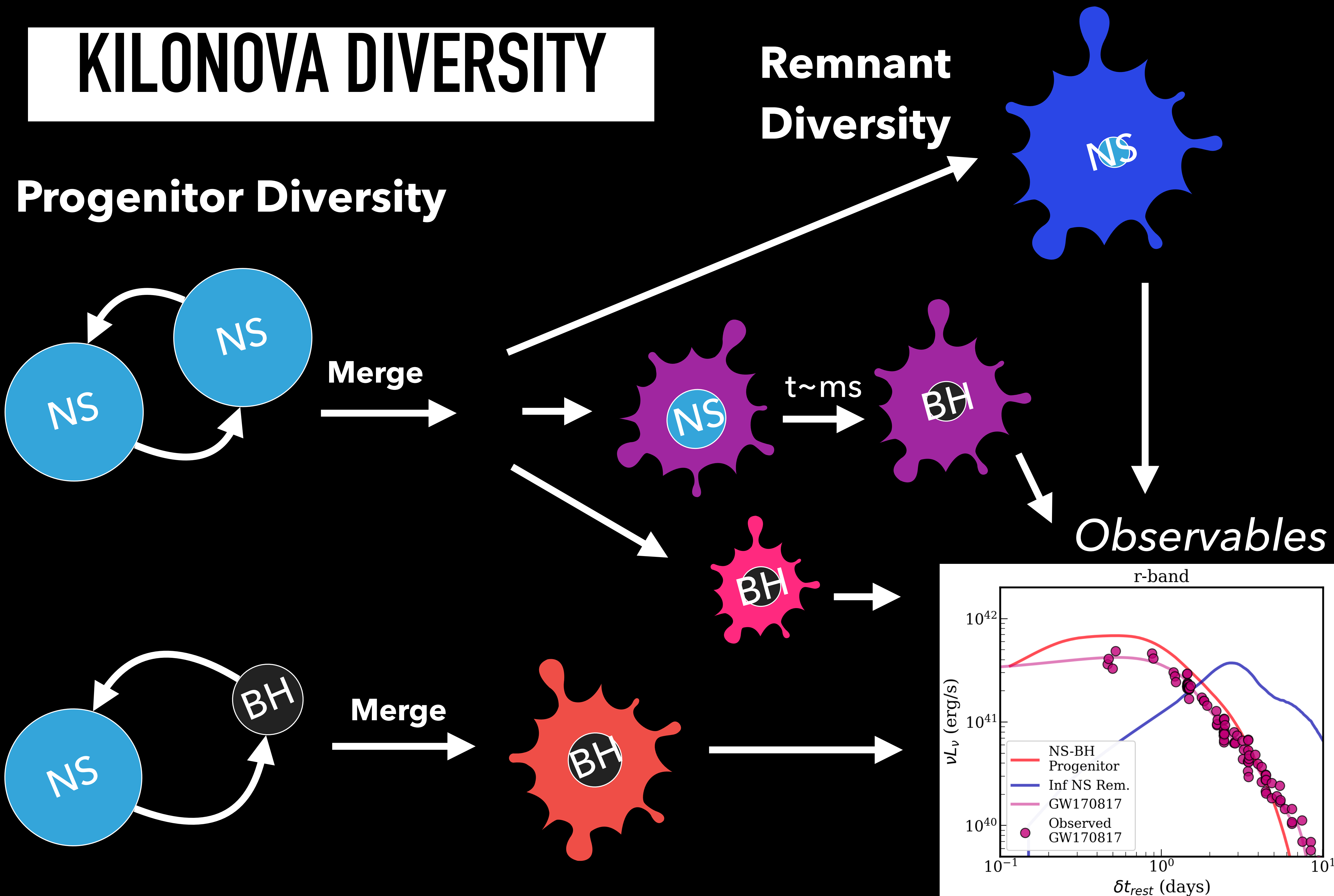




Villar+17 with data compiled from Andreoni+17; Arcavi+17; Coulter+17; Cowperthwaite+17; Diaz+17; Drout+17; Evans+17; Hu+17; Kasliwal+17; Lipunov+17; Pian+17; Pozanenko+17; Shappee+17; Smartt+17; Tanvir+17; Troja+17; Utsumi+17; Valenti+17



KILONOVA DIVERSITY



Searches for Kilonovae

e.g., Smartt+17, Yang+18, Andreoni+21

Blind Searches in Large Surveys

Team SAGUARO

(Searches After Gravitational waves Using ARizona Observatories)

THE UNIVERSITY OF ARIZONA

David Sand | Michael Lundquist (now at Keck) | Griffin Hosseinzadeh | Manisha Shrestha | Azalee Bostreom

Northwestern University

Wen-fai Fong | Kerry Paterson (now at MPIA) | Jillian Rastinejad | Saarah Hall

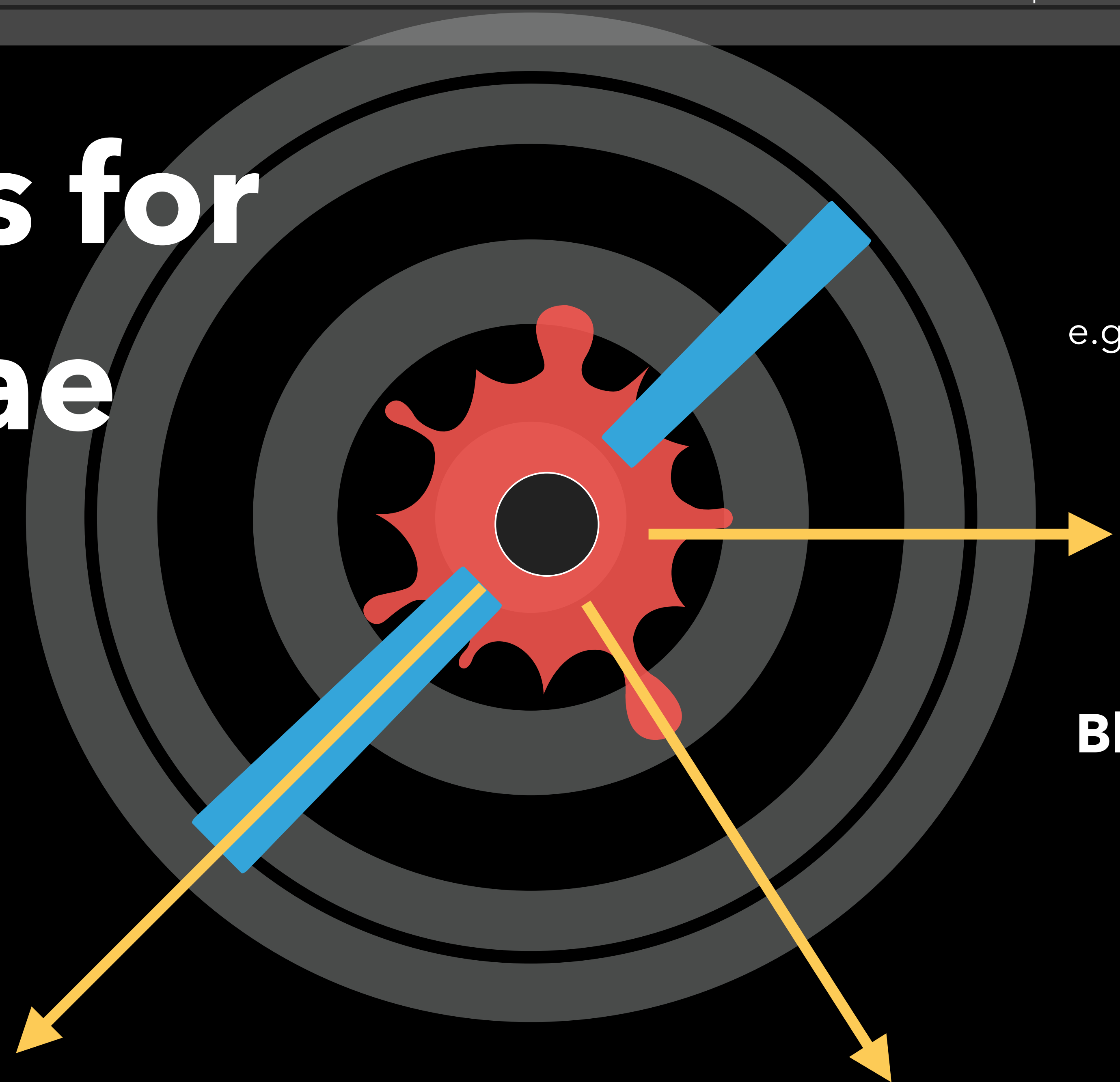
Lundquist+19, Paterson+21, Rastinejad+22a

LIGO

Virgo

Gravitational Waves

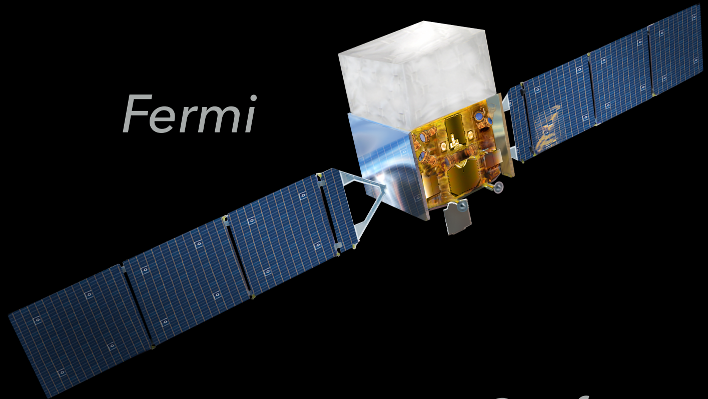
Searches for Kilonovae



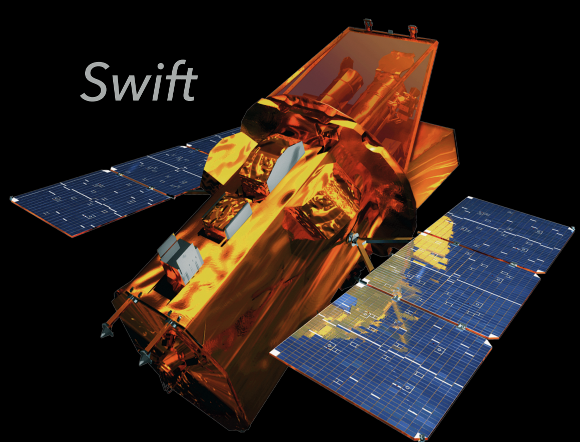
e.g., Smartt+17, Yang+18, Andreoni+21

Blind Searches in Large Surveys

Fermi



Swift



Short GRBs

LIGO

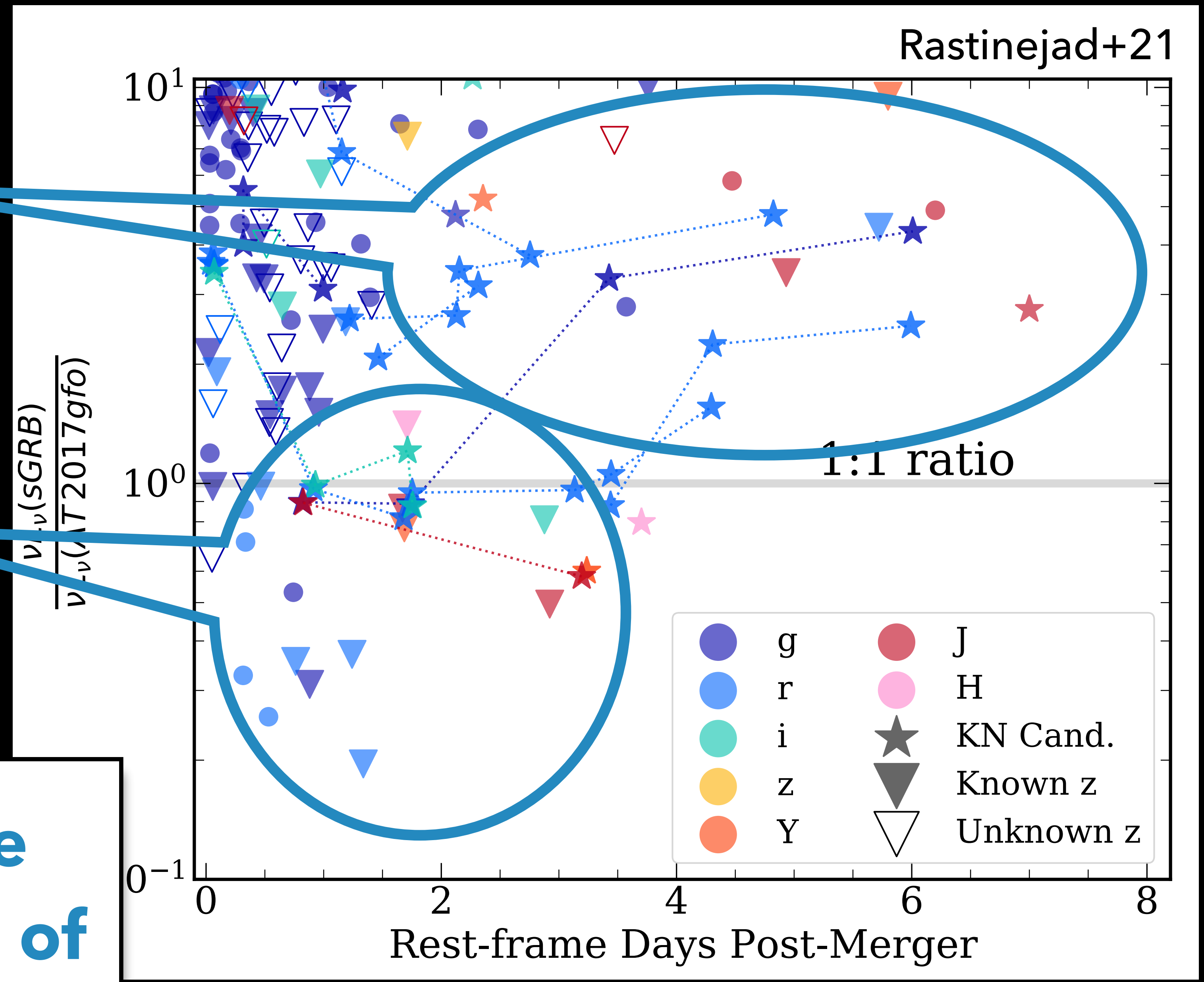
Virgo

Gravitational Waves

Comparing all SGRB KN observations to AT2017gfo

Kilonova candidates are more luminous in bluer bands than AT2017gfo

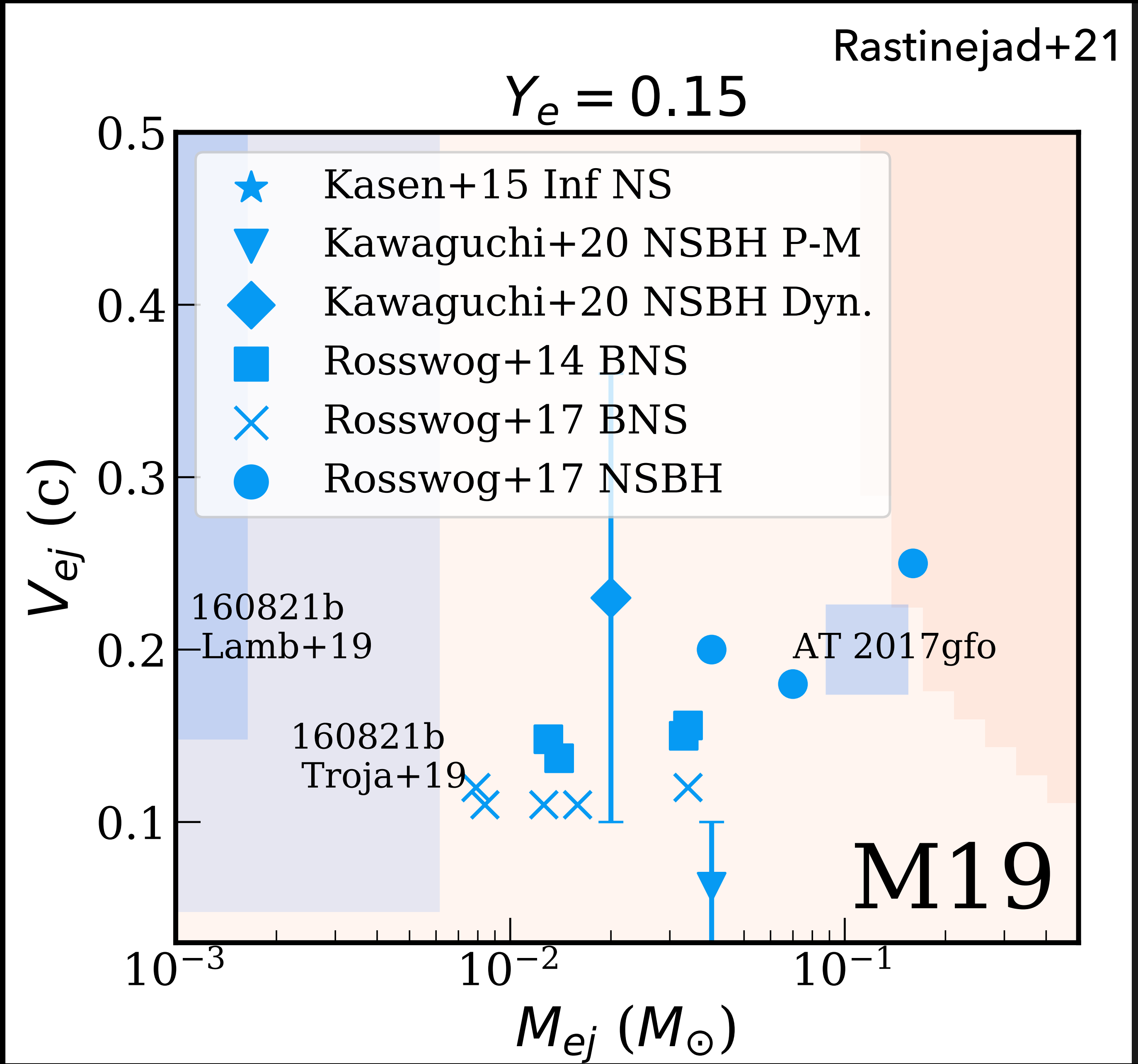
Deep upper limits of 10 bursts fall below 1:1 ratio



Rest-frame optical KNe observations show span of ~100 in luminosity

See also Gompertz+18, Ascenzi+19, Rossi+20

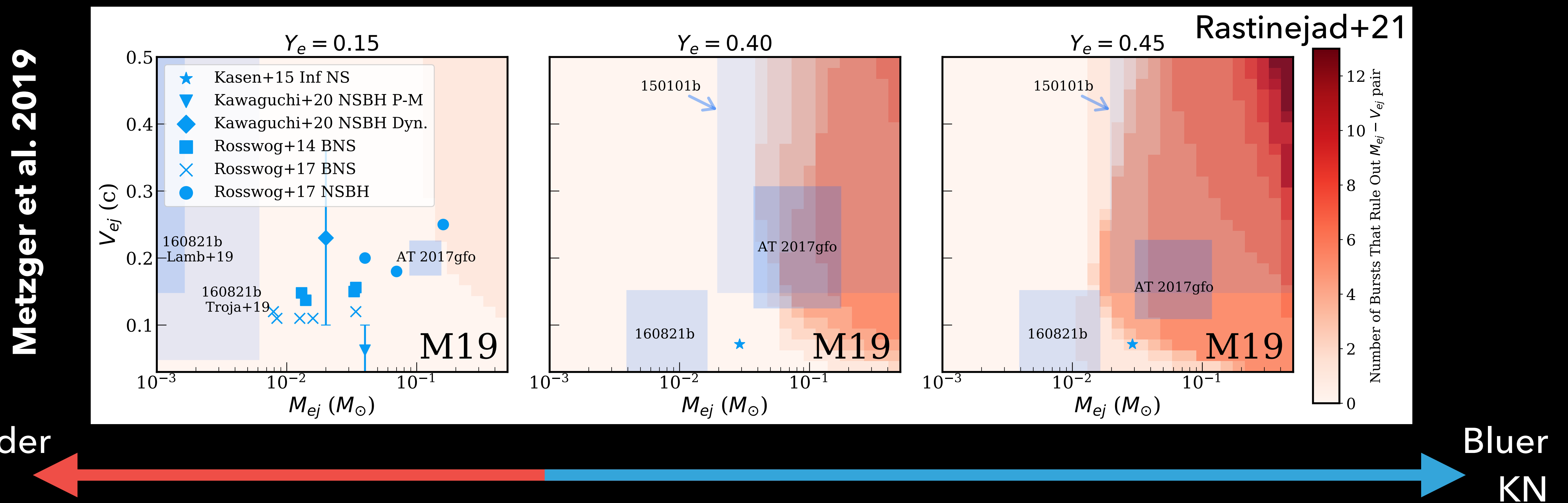
SGRB Kilonova Ejecta Masses



Created grids of analytic models based on Metzger et al. 2019 for each ejecta mass-velocity pair

Used deep limits to rule out models and eliminate region of parameter space

SGRB Kilonova Ejecta Masses



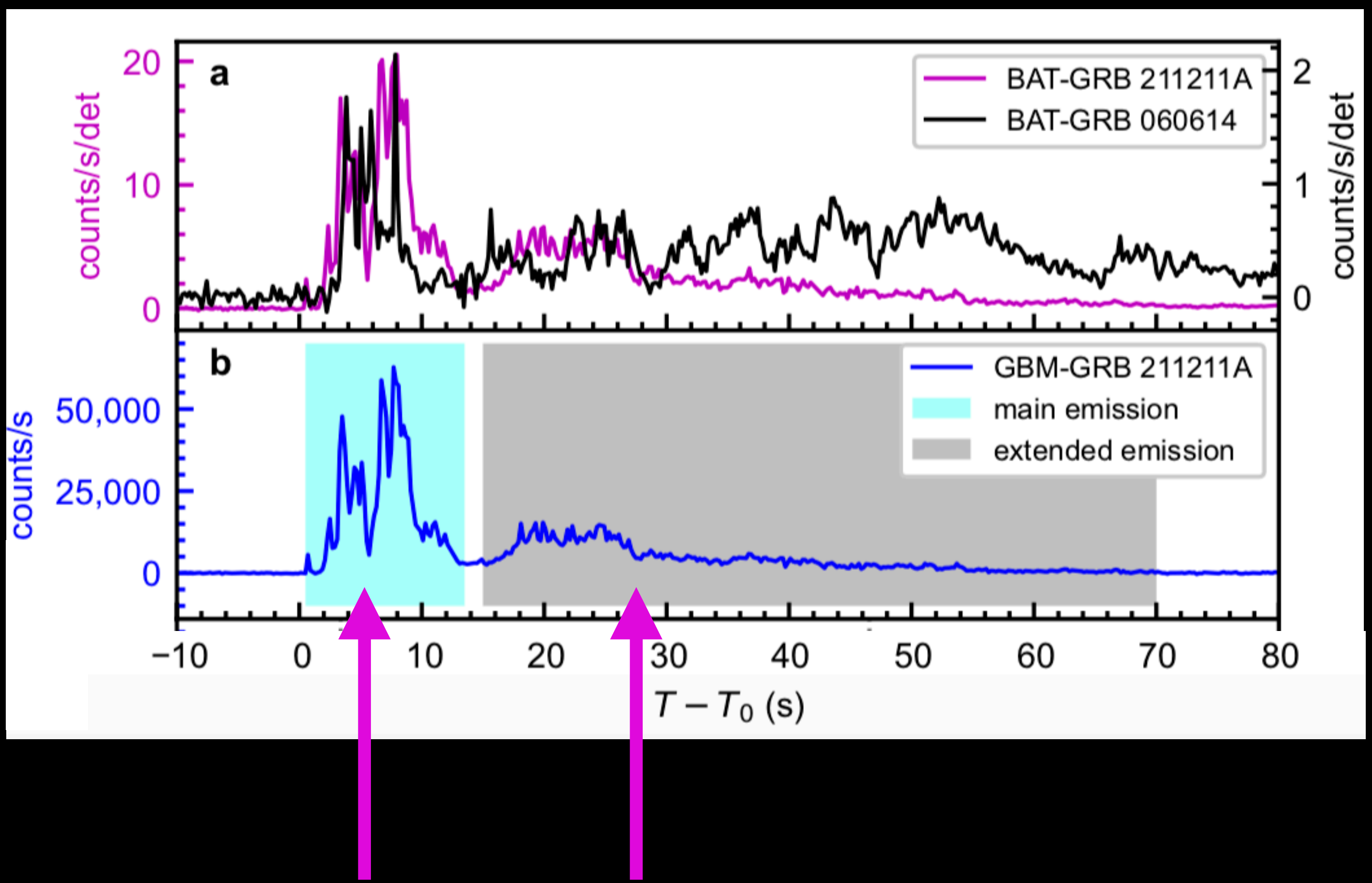
Current short GRB observations constrain blue ejecta diversity **better than red ejecta**

Constraints are **model dependent** and can vary on the order of ~0.1 $M_\odot$ (also see Ascenzi+19)

GRB 211211A: Exciting Ingredients

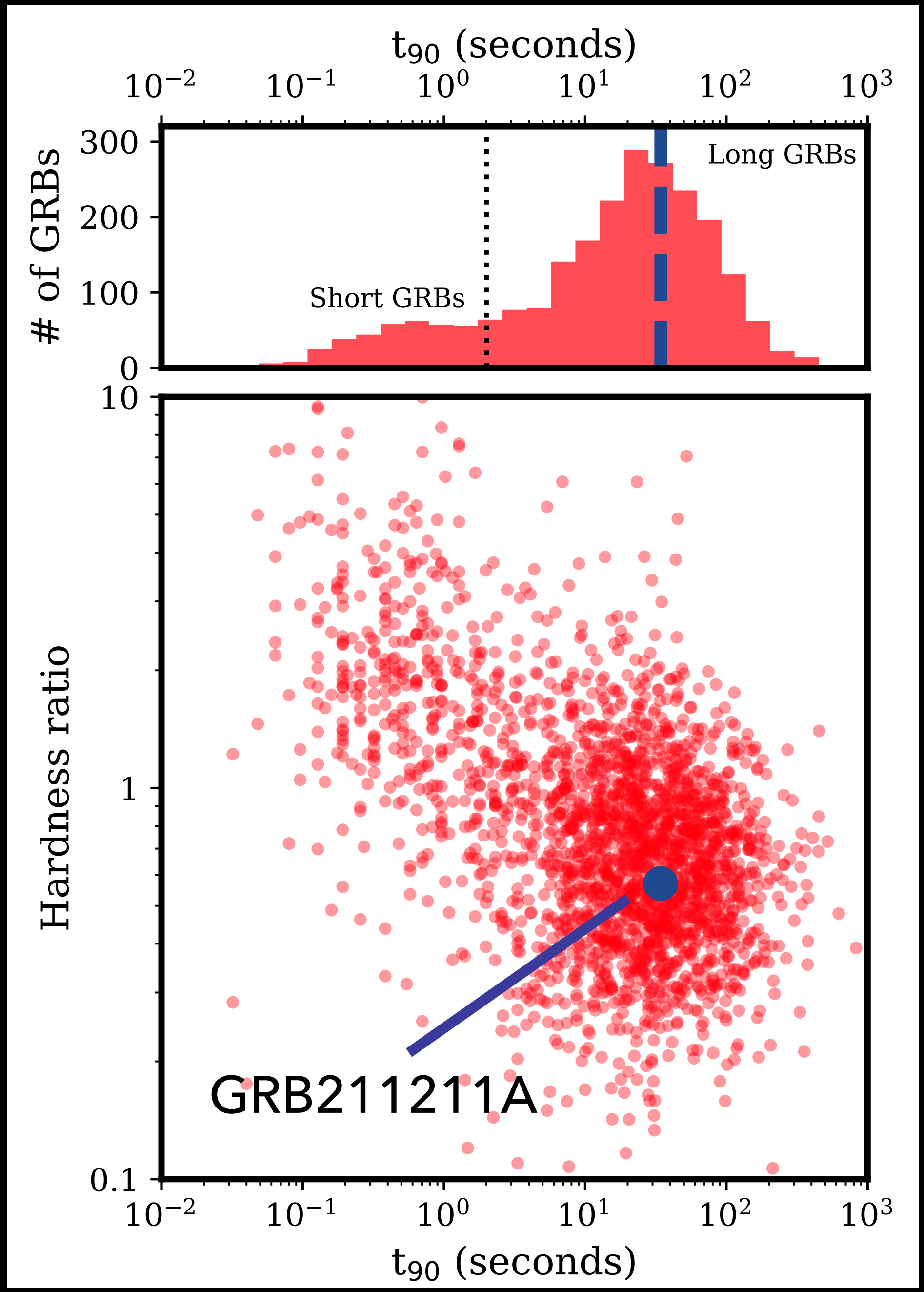
An ambiguous gamma-ray light curve

Yang+22



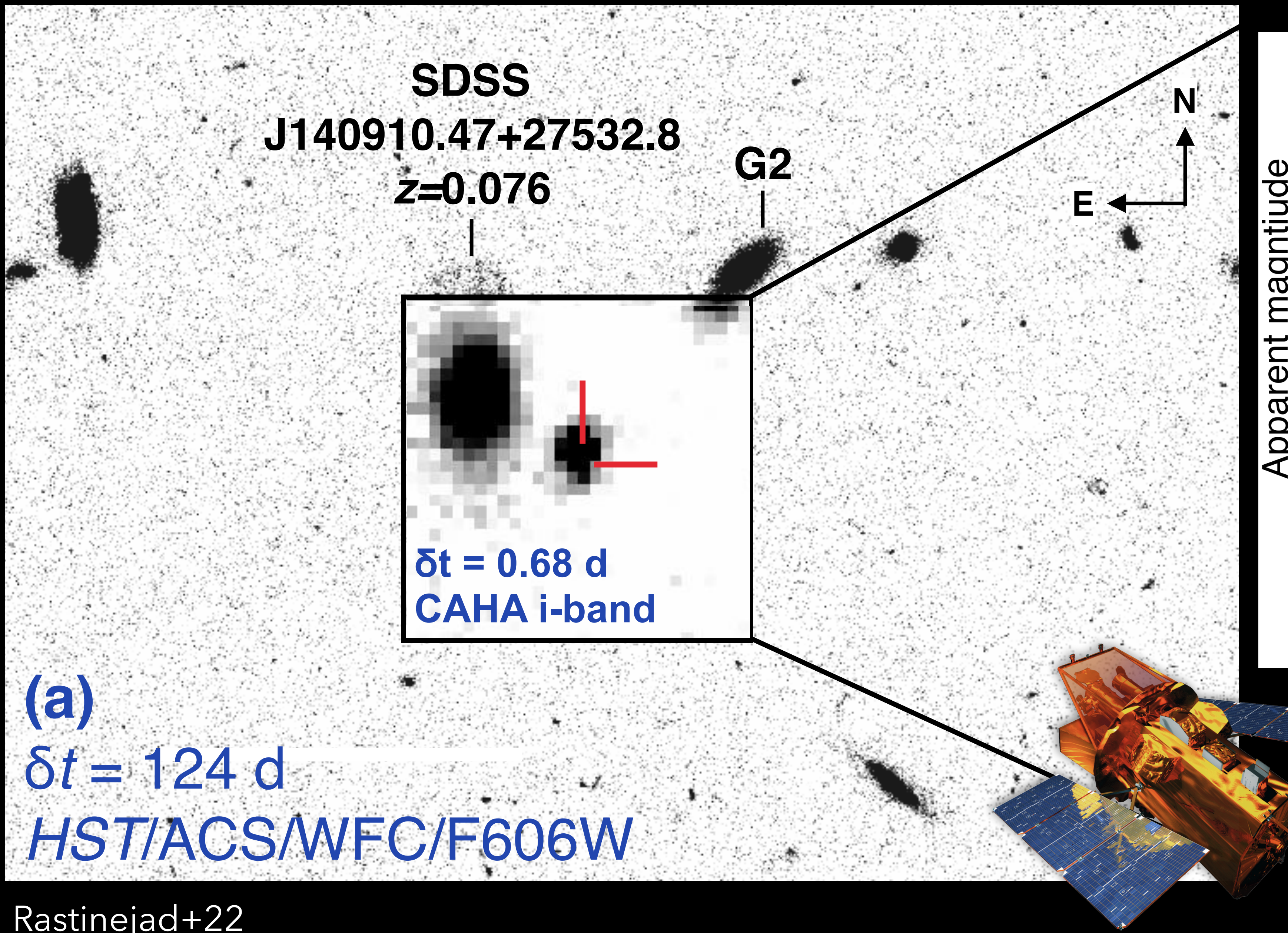
Spectrally-hard pulse complex lasting ~12s

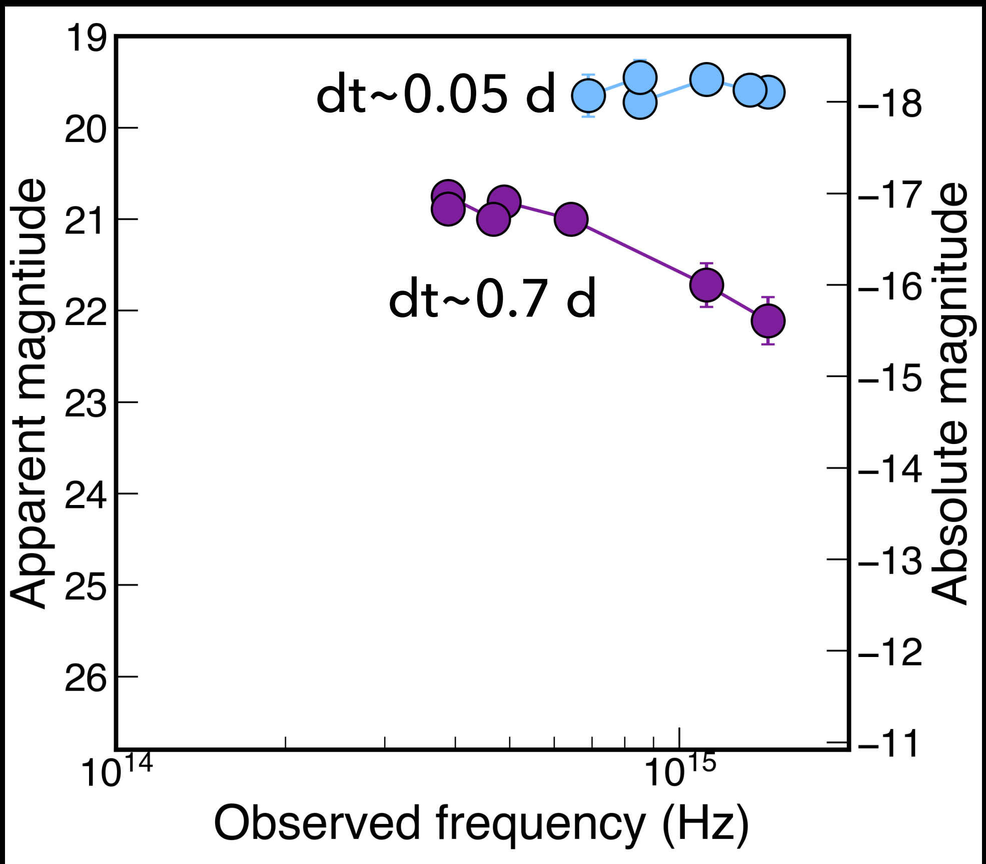
Tail of softer extended emission (seen for ~25% of SGRBs)



Rastinejad+22

Observing a red excess following the **50-s duration GRB 211211A at 350 Mpc**





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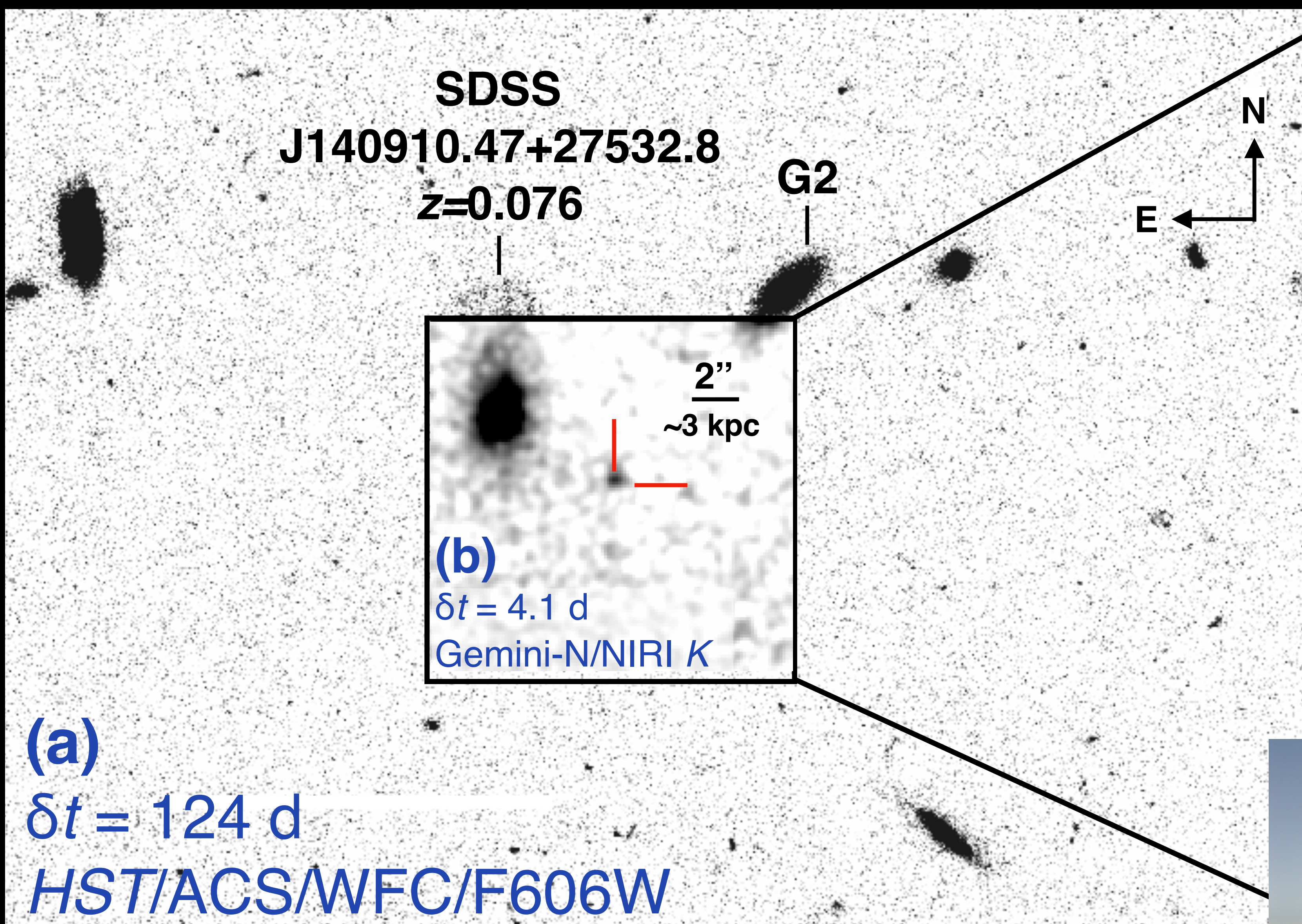
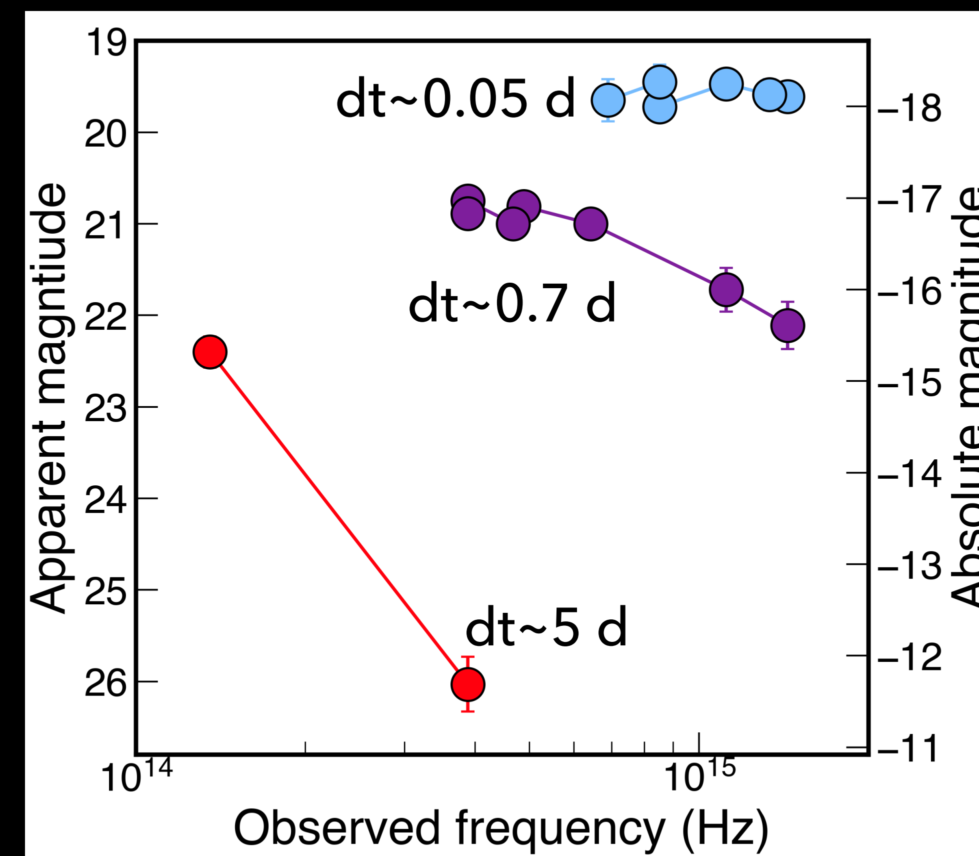
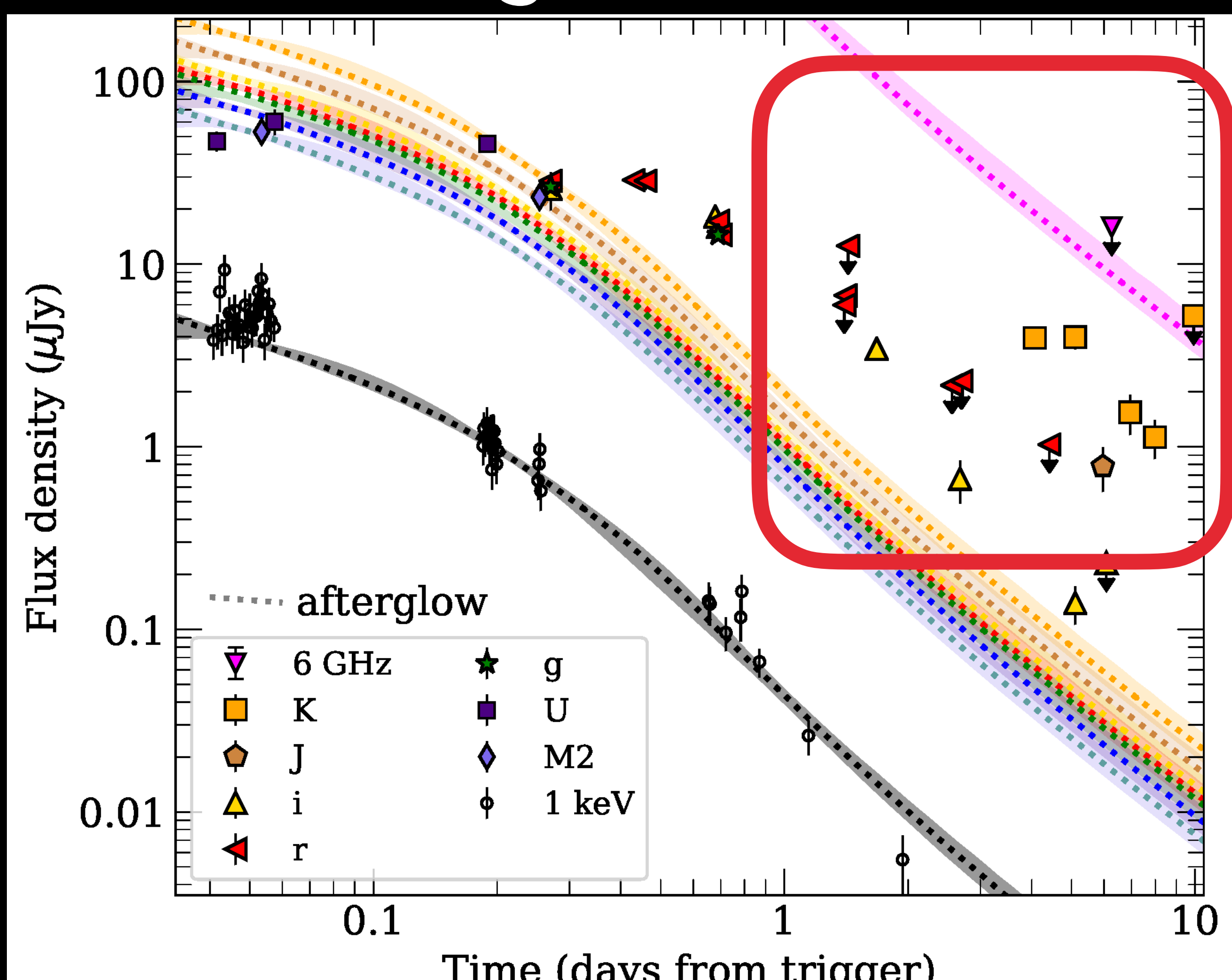




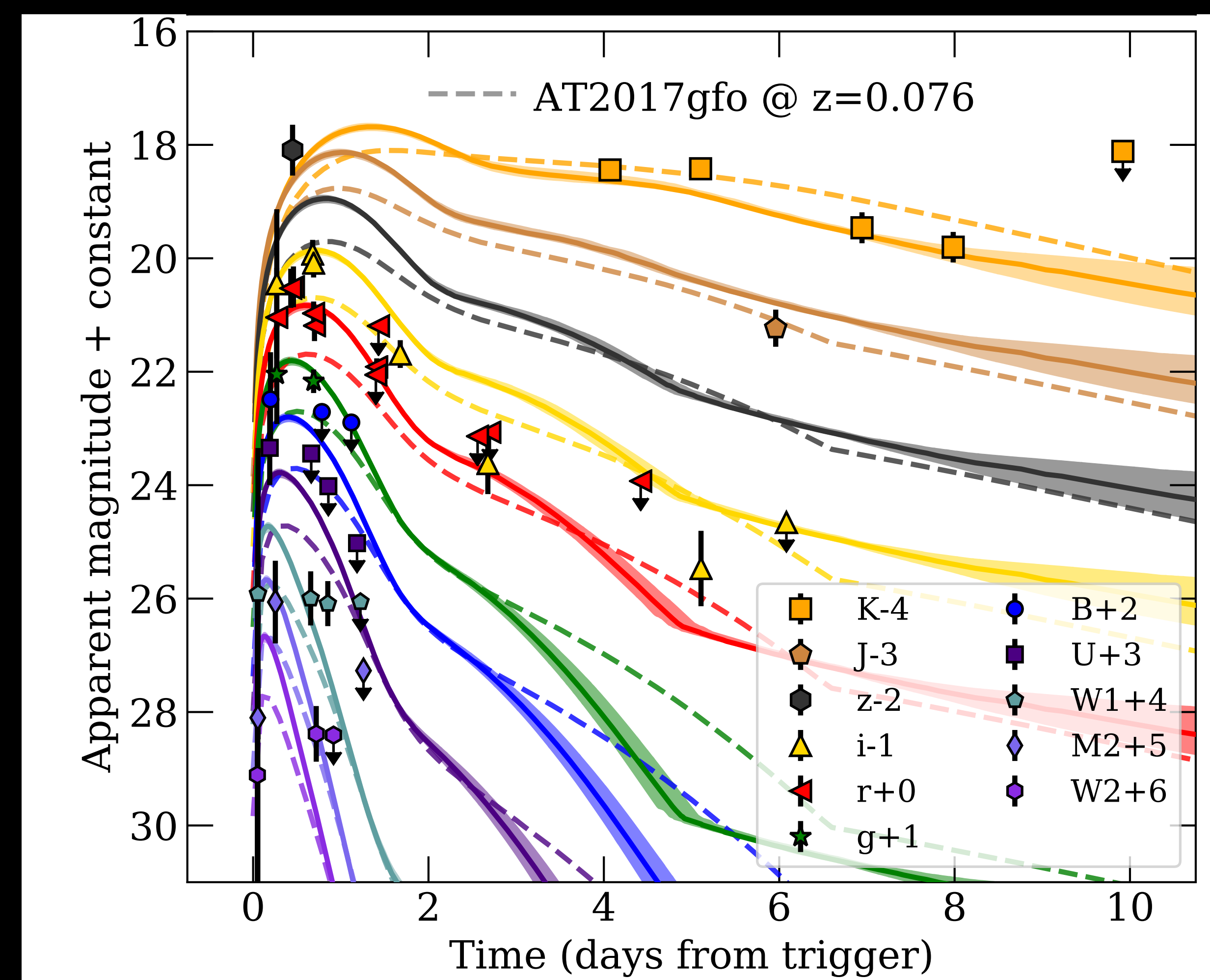
Rastinejad+22

The 2nd-closest kilonova to date comes from a surprising source: the **50-s duration GRB 211211A**

Broadband Observations + Afterglow Model

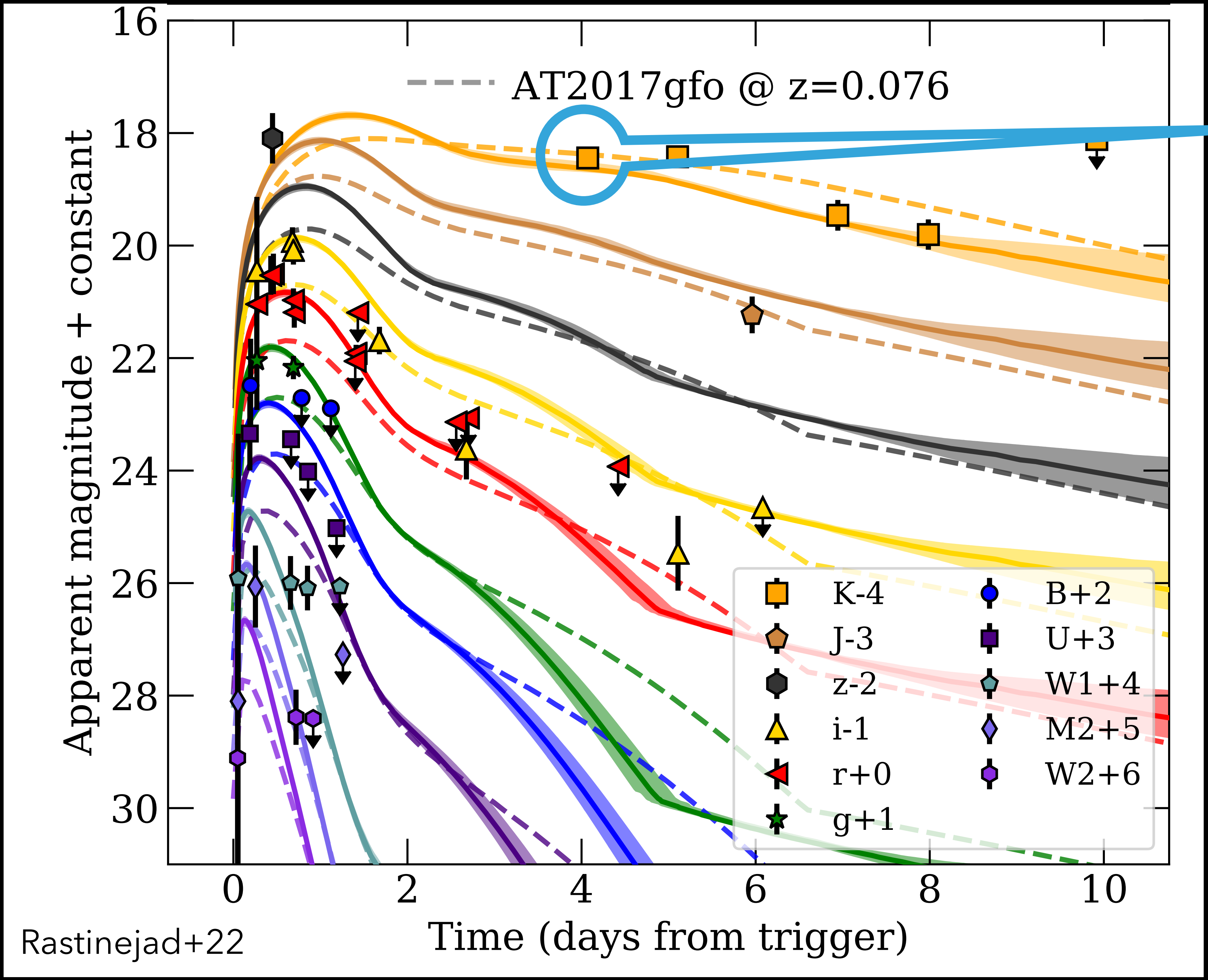


Afterglow-subtracted Optical/ NIR Observations + KN Model



Rastinejad+22b

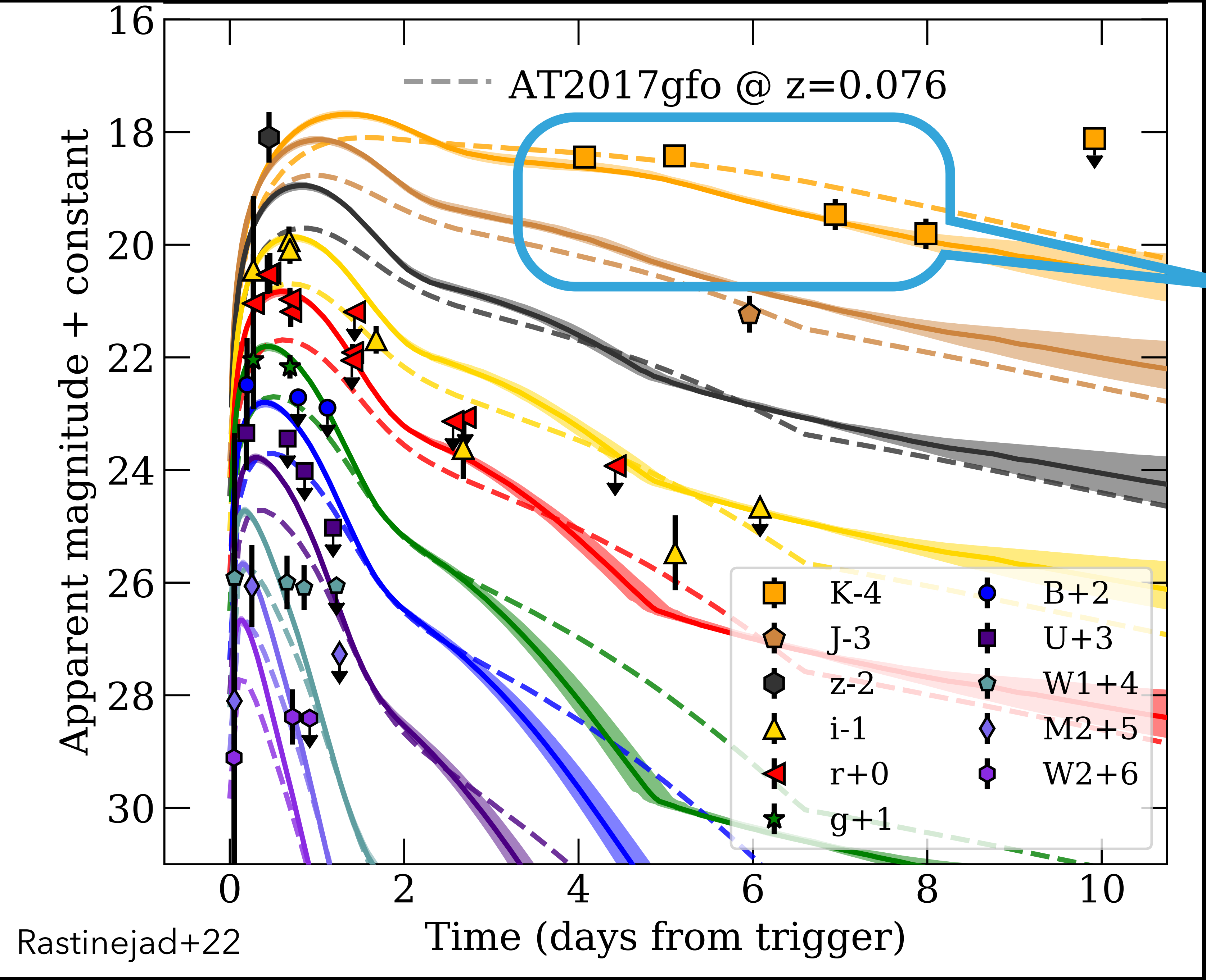
The 2nd-closest kilonova to date comes from a surprising source: the **50-s duration GRB 211211A**



Rastinejad+22

Nearly the same K-band luminosity as AT2017gfo

The 2nd-closest kilonova to date comes from a surprising source: the **50-s duration GRB 211211A**



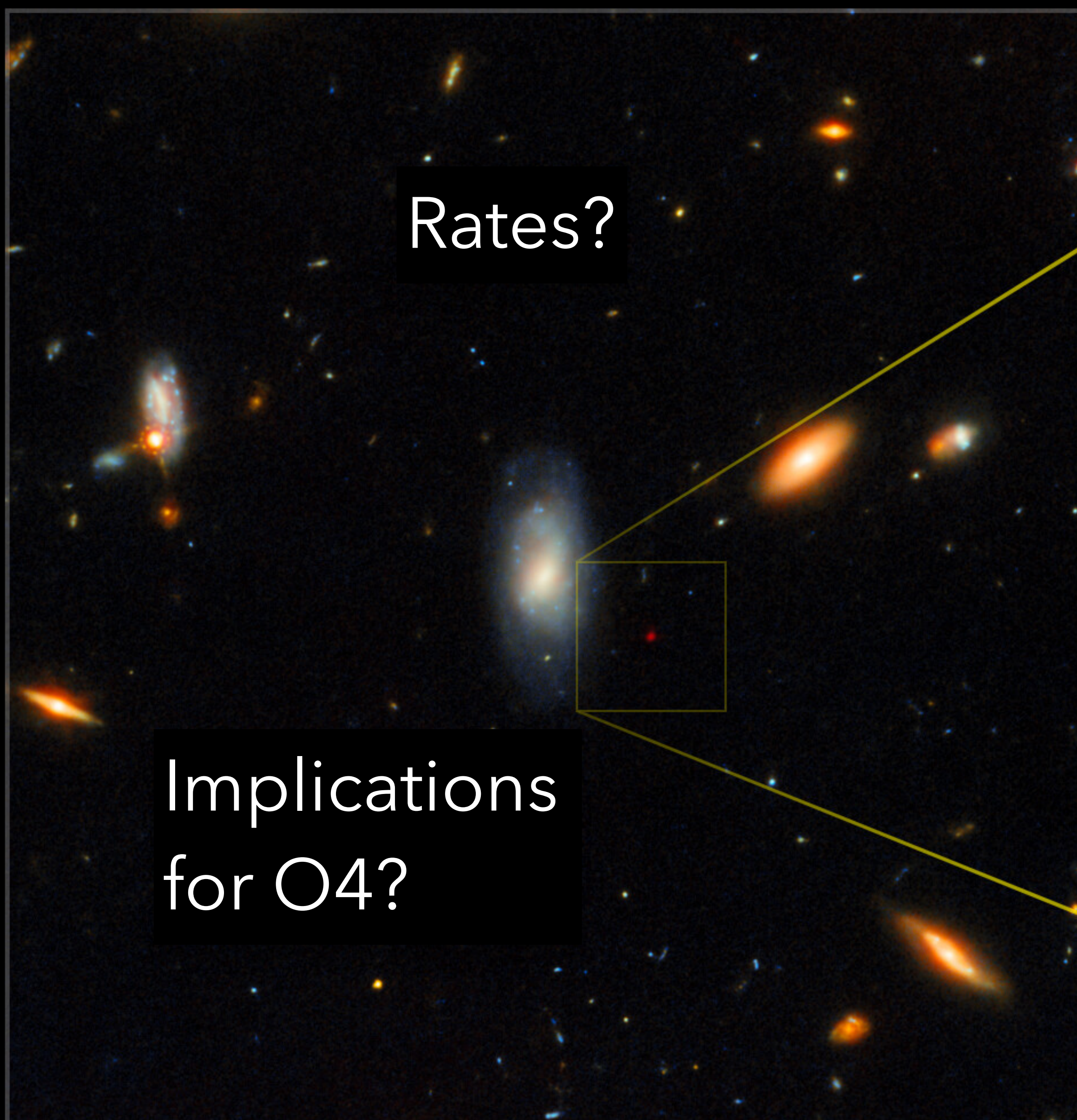
Nearly the same K-band luminosity as AT2017gfo

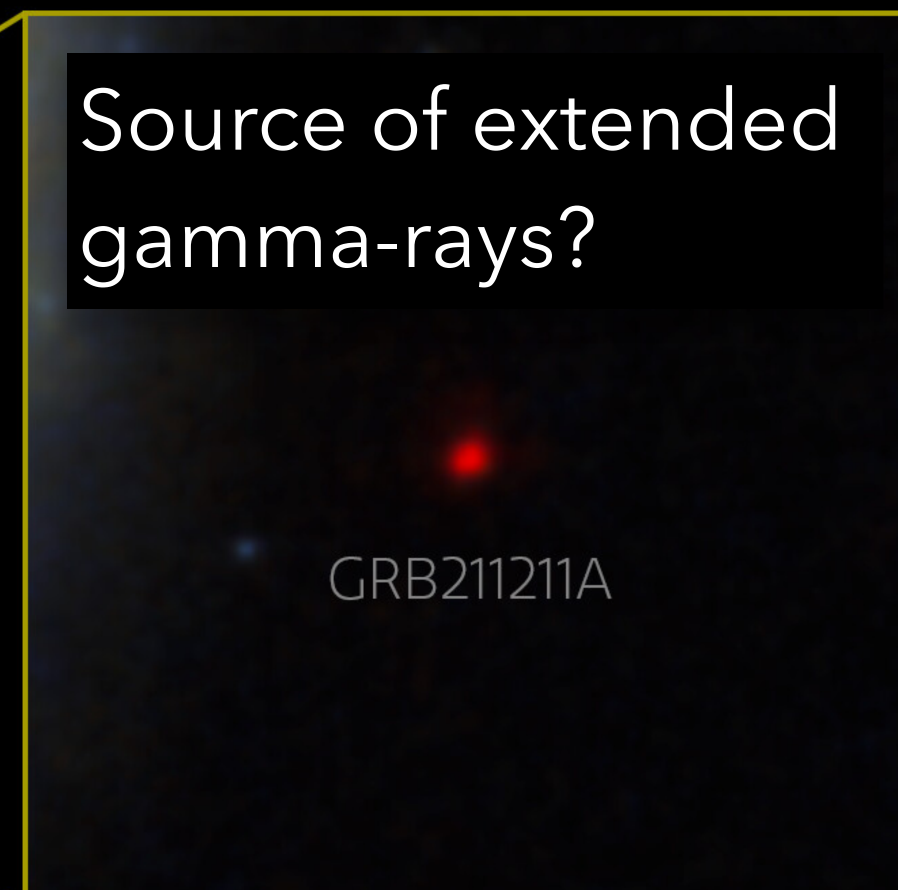
K-band fades on similar timescales to AT 2017gfo

Deep limit on a SN counterpart at ~17 days

Higher-z scenarios are limited by Swift/UVOT afterglow detection

The 2nd-closest kilonova to date comes from a surprising source: the **50-s duration GRB 211211A**





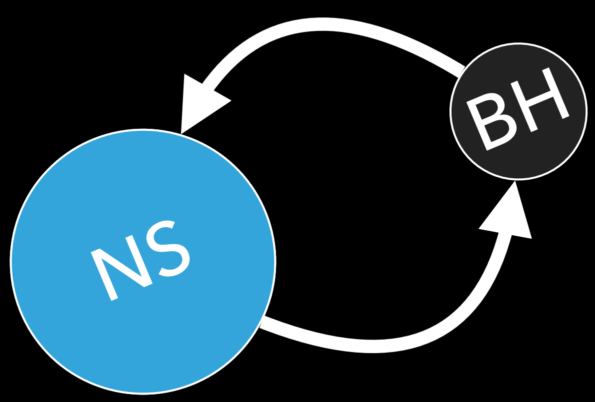
Average ejecta mass per KNe?

International Gemini Observatory/NOIRLab/NSF/AURA/M. Zamani; NASA/ESA

GRB 211211A: Implications

What causes the extended gamma-ray emission? Favored explanations:

NSBH Merger: late-time fall-back accretion from tidally-disrupted material; e.g. Rosswog+07, Desai+19



*Tentatively disfavored due to larger blue component

Magnetar Remnant: rotational energy imparted into relativistic wind; e.g. Metzger+08, Gompertz+14, Gompertz+22

*Tentatively favored due to ability to explain consistent EE timescales (~100s when system becomes optically-thin neutrinos)

GRB 211211A: Implications

What causes the extended gamma-ray emission? Favored explanations:

NSBH Merger: late-time fall-back accretion from tidally-disrupted material; e.g. Rosswog+07, Desai+19

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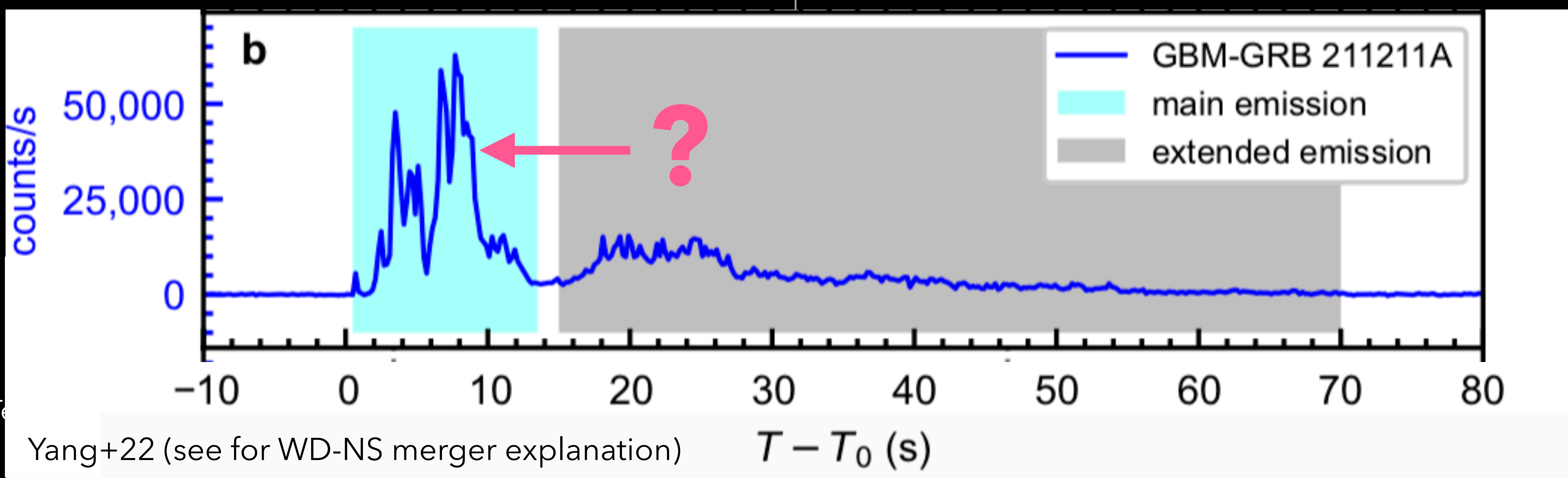

Yang+22 (see for WD-NS merger explanation)

Future coincident GWs + LGRBs may decide!*

*see Sarin, Lasky & Nathan 2022

Conclusions

I. Rest-frame optical SGRB kilonovae span a factor of ~100 in luminosity. Deep upper limits constrain ejecta masses of 6 bursts to $M_{ej} < 0.05\ M_\odot$.

II. The long GRB 211211A was accompanied by a fast-fading NIR transient that strongly resembles the kilonova AT2017gfo, demonstrating the long complex gamma-ray light curves may spawn from a NS merger origin.

Thanks to a large team, including Wen-fai Fong + the Fong research group, Kerry Paterson, Charlie Kilpatrick, Andrew Levan, Ben Gompertz, Matt Nicholl, Gavin Lamb, Nial Tanvir, Daniele Malesani