INFORMED SHORT GRB KILONOVA SEARCHES WITH ROMAN

Rastinejad et al. 2021, *ApJ*, 916, 2, 82

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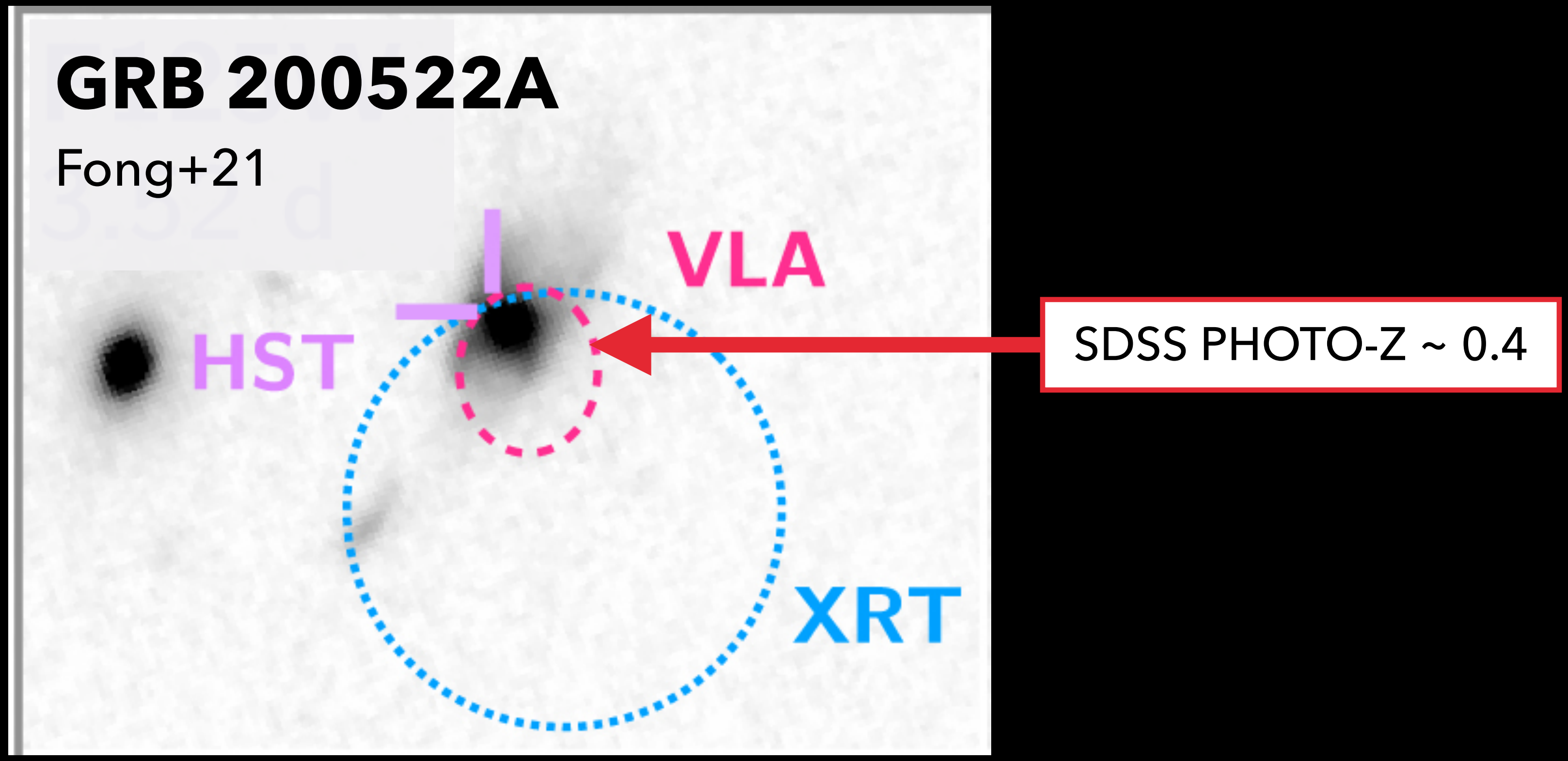
Image Credit: NASA, ESA, and D. Player (STScI)

Advantages to Short GRB Kilonovae Searches

1. *Swift* continues to detect **well-localized** short GRBs



Swift-XRT afterglow detection gives < 5″ prompt localization

Identify likely host(s) + redshift if in footprint of large survey (Legacy Survey, SDSS, LSST in the future)

Advantages to Short GRB Kilonovae Searches

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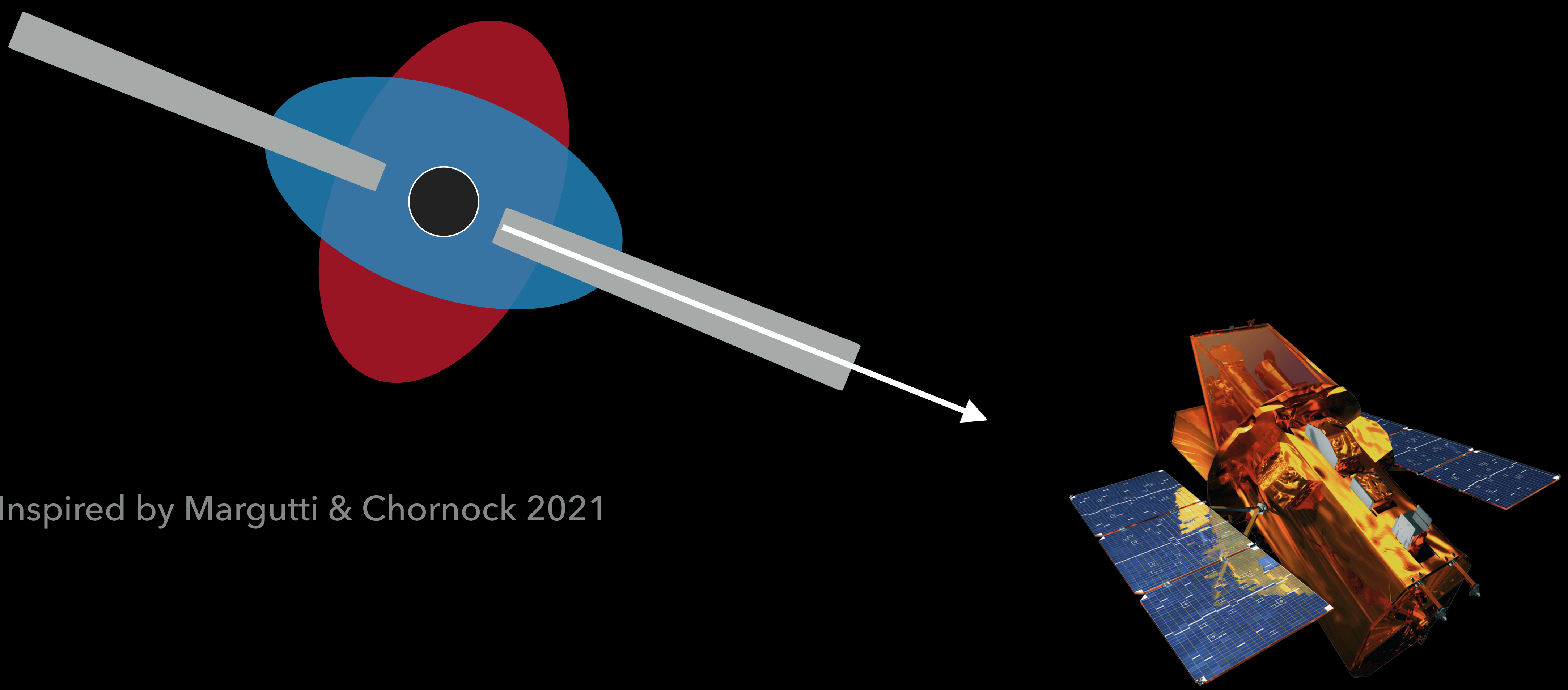
2. Explore kilonovae diversity at approximately **fixed viewing angle**



Inspired by Margutti & Chornock 2021

Advantages to Short GRB Kilonovae Searches

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2. Explore kilonovae diversity at approximately **fixed viewing angle**
3. **Decades of short GRBs discoveries** (>120 Swift SGRBs!)

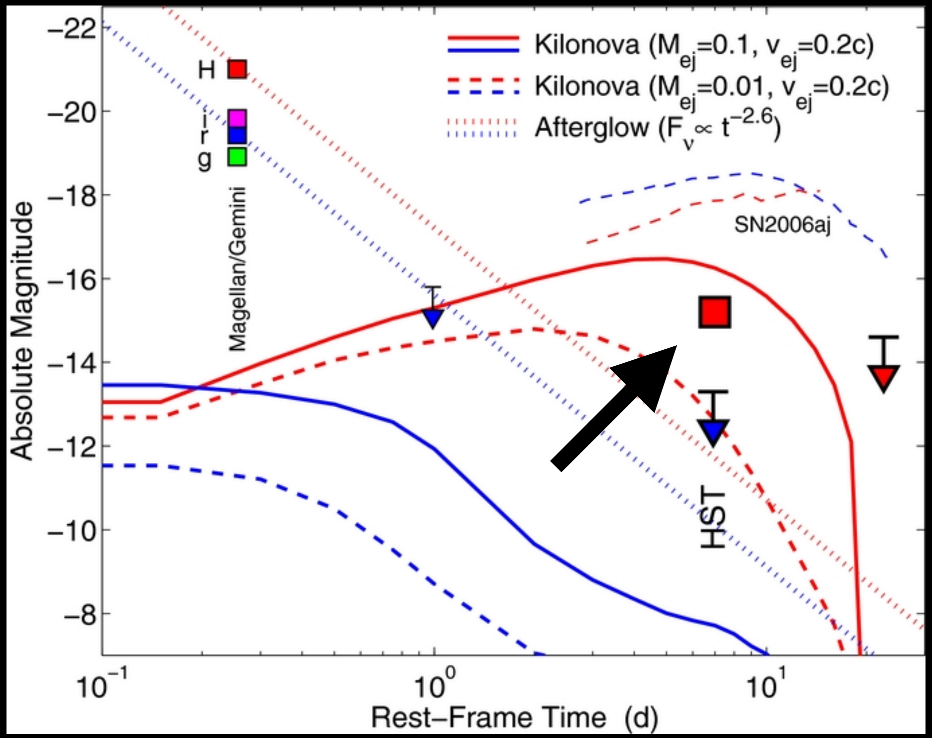
Span the redshift range 0.1 < z < 2:

Need for deep imaging: already ~12 candidate kilonova detections (complicated by afterglow)

See compilations of: Gompertz+18, Ascenzi+19, Rossi+20, Rastinejad+21

GRB 130603B

Tanvir+13, Berger+13



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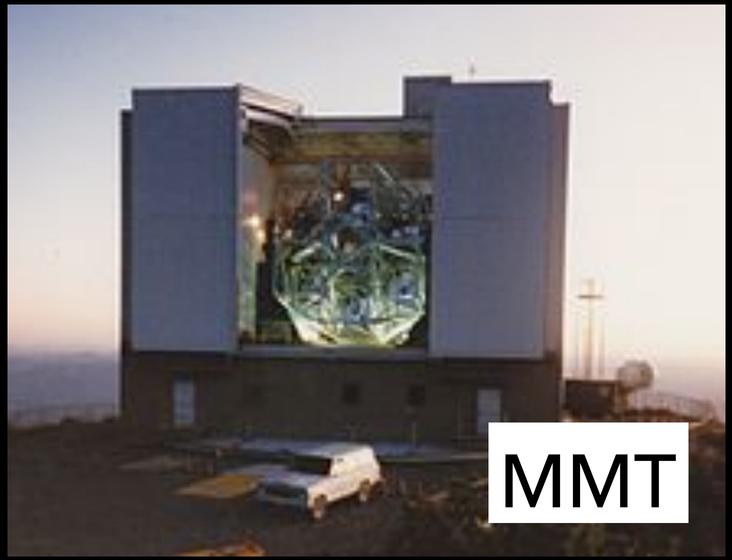
Large sample allows us to look for diversity in observed KNe (colors, luminosities)

↓

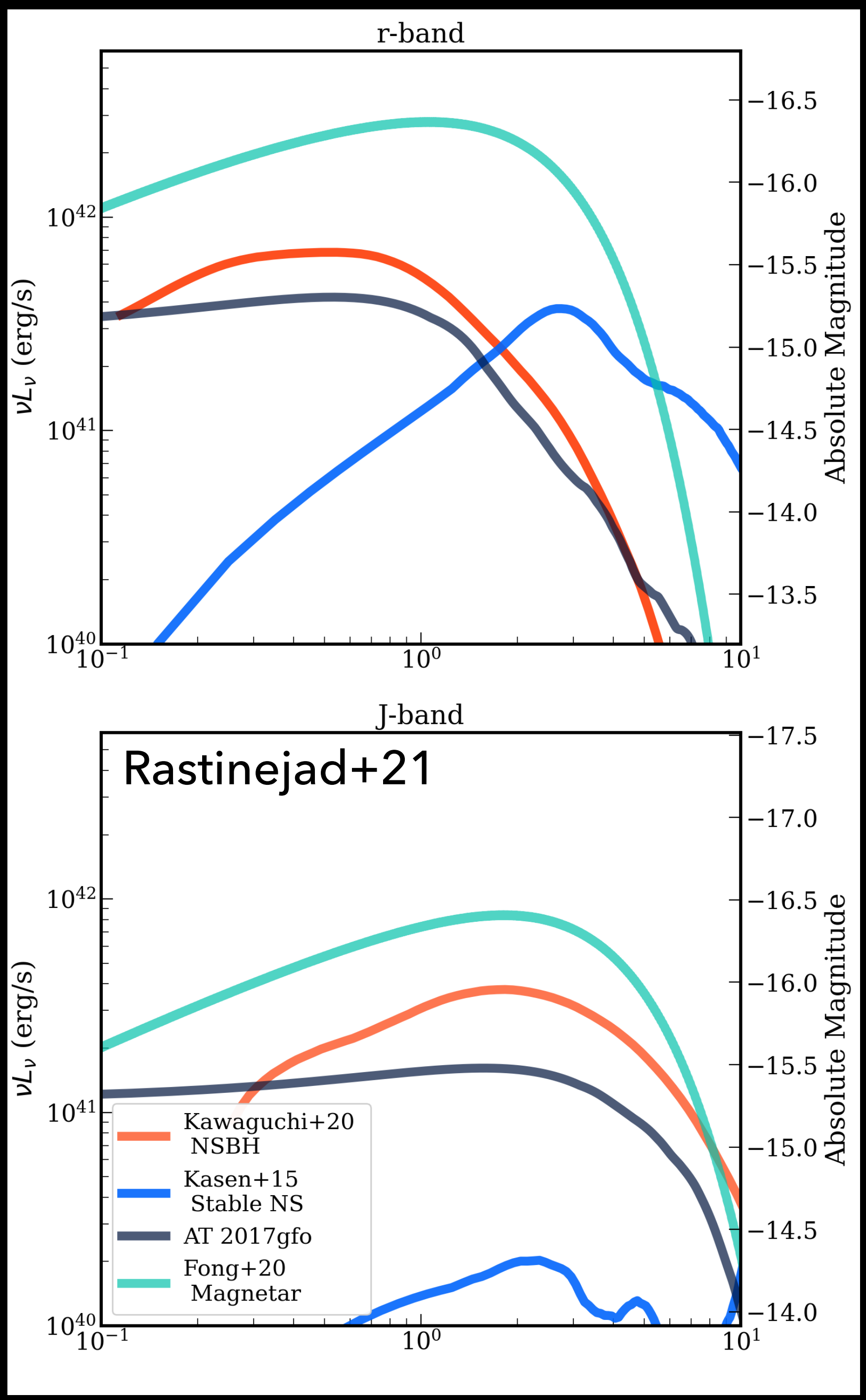
What can we learn from the full sample of Short GRB KNe observations?

Our catalog presents optical/NIR observations of **85 short GRBs** detected 2005-2020



Unpublished Data + **Data Collected from GCNs** + **Literature Data**

Sample Trends Compared to AT2017gfo



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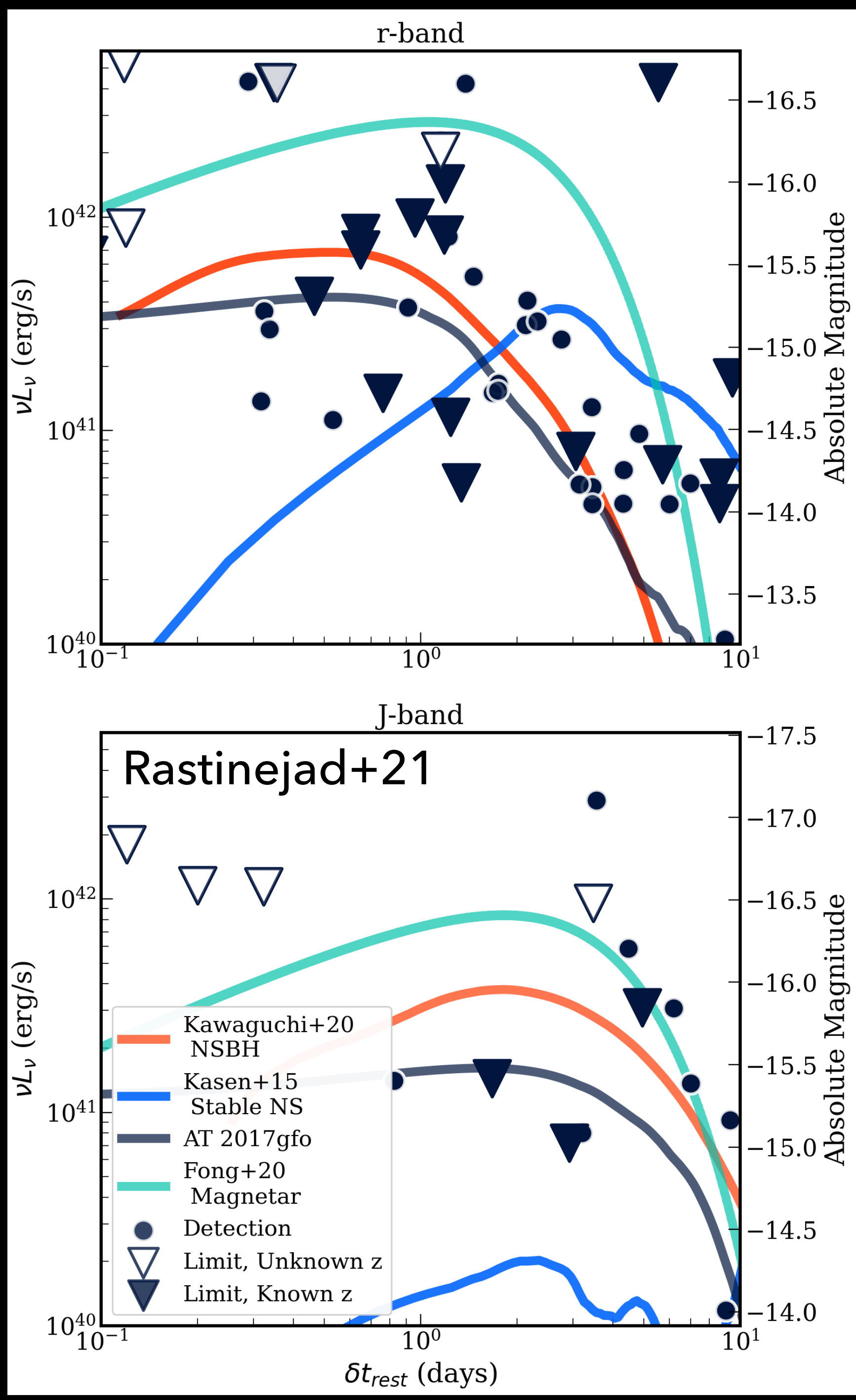
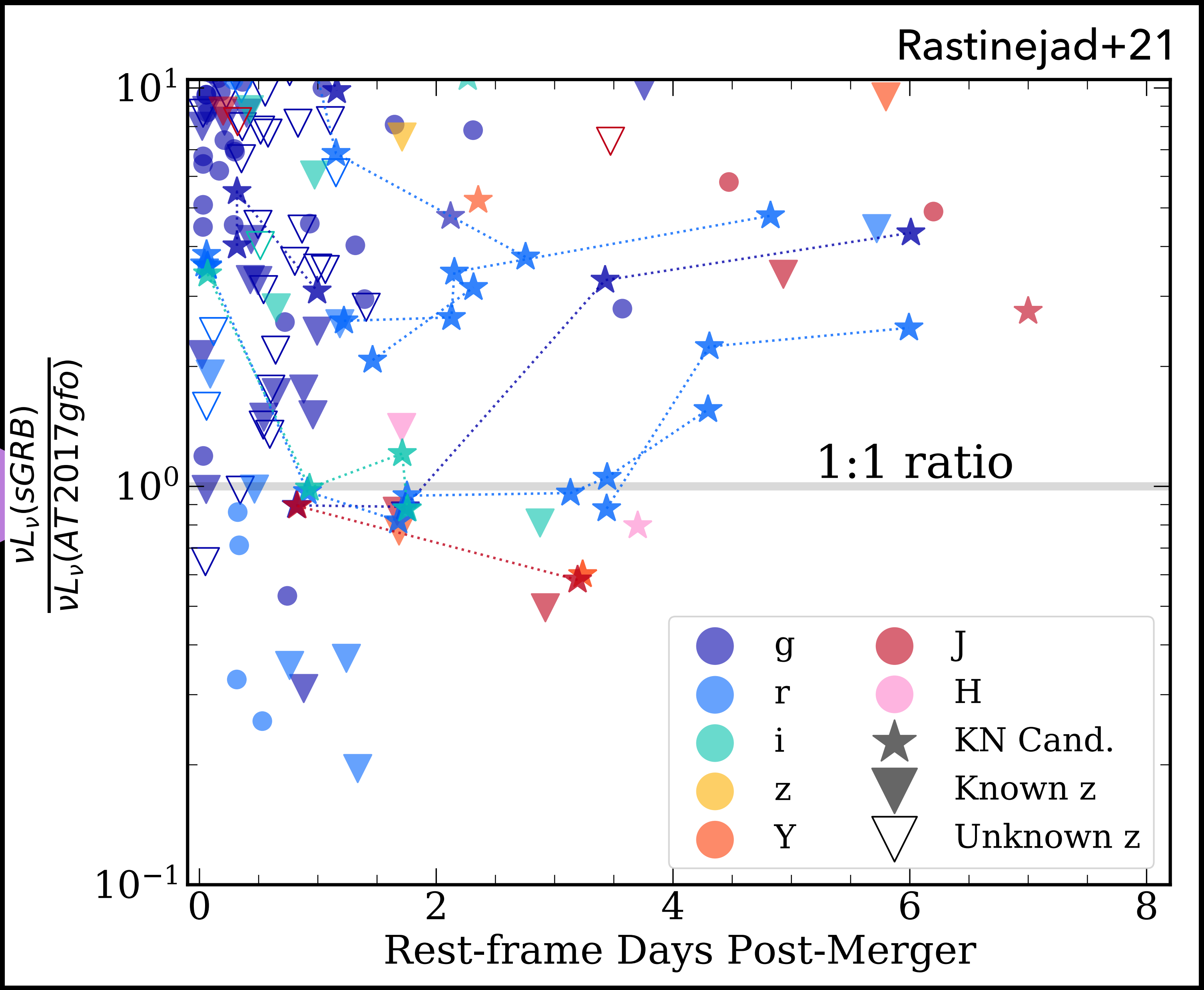
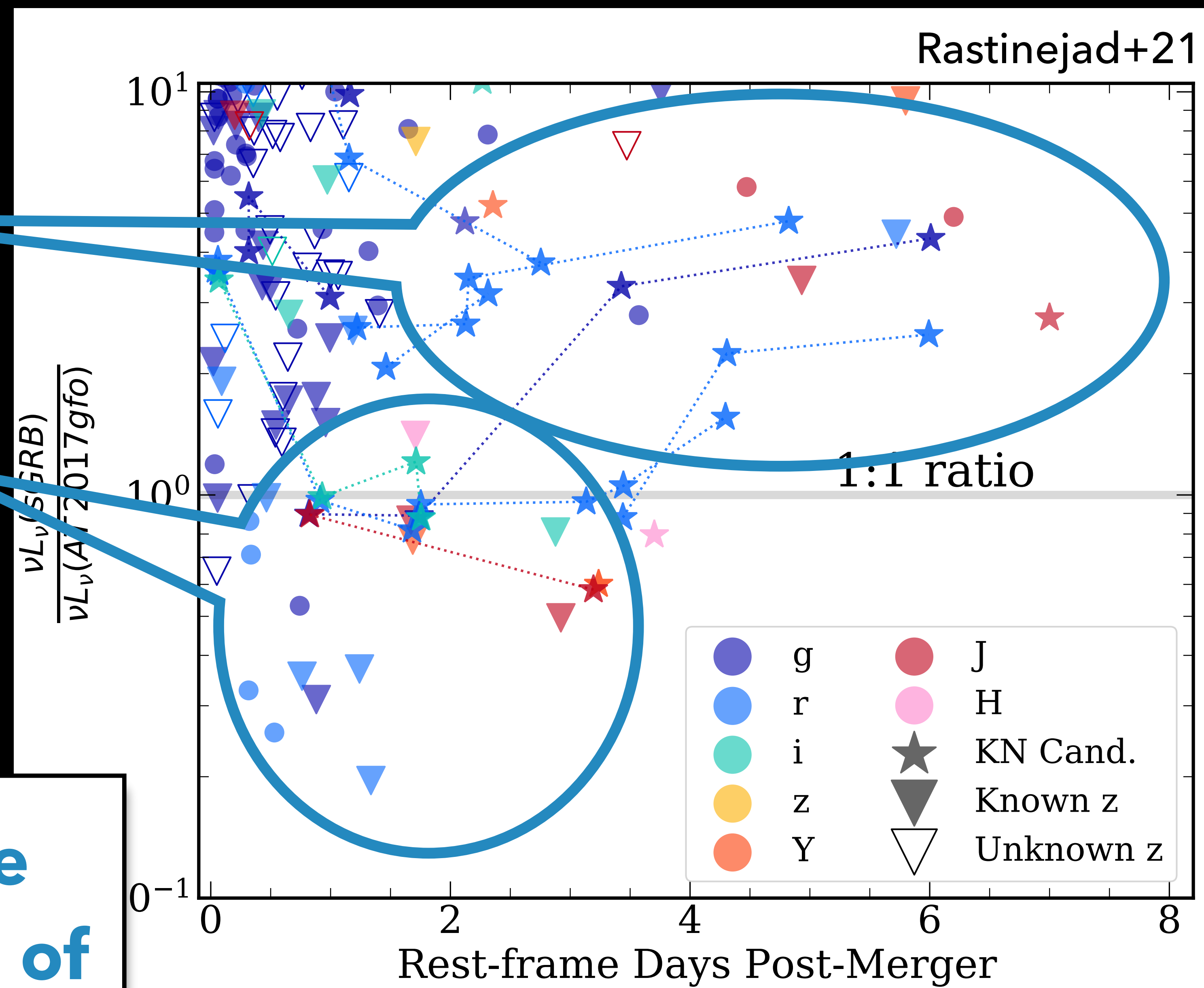




Sample Trends Compared to AT2017gfo

Kilonova candidates are more luminous in bluer bands than AT2017gfo

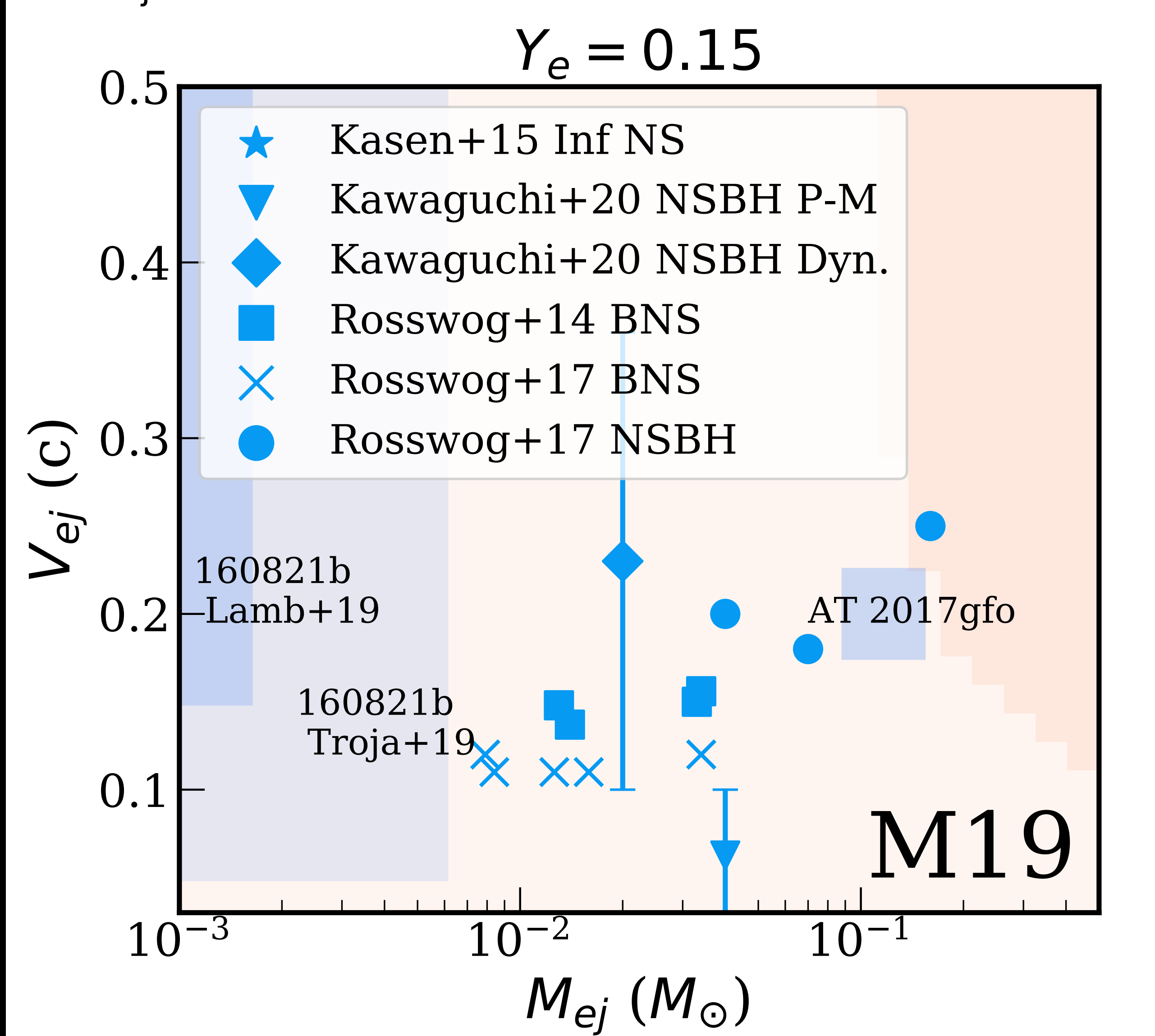
Deep upper limits of 10 bursts fall below 1:1 ratio



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

Ejecta Mass & Velocity Constraints

Rastinejad et al. 2021

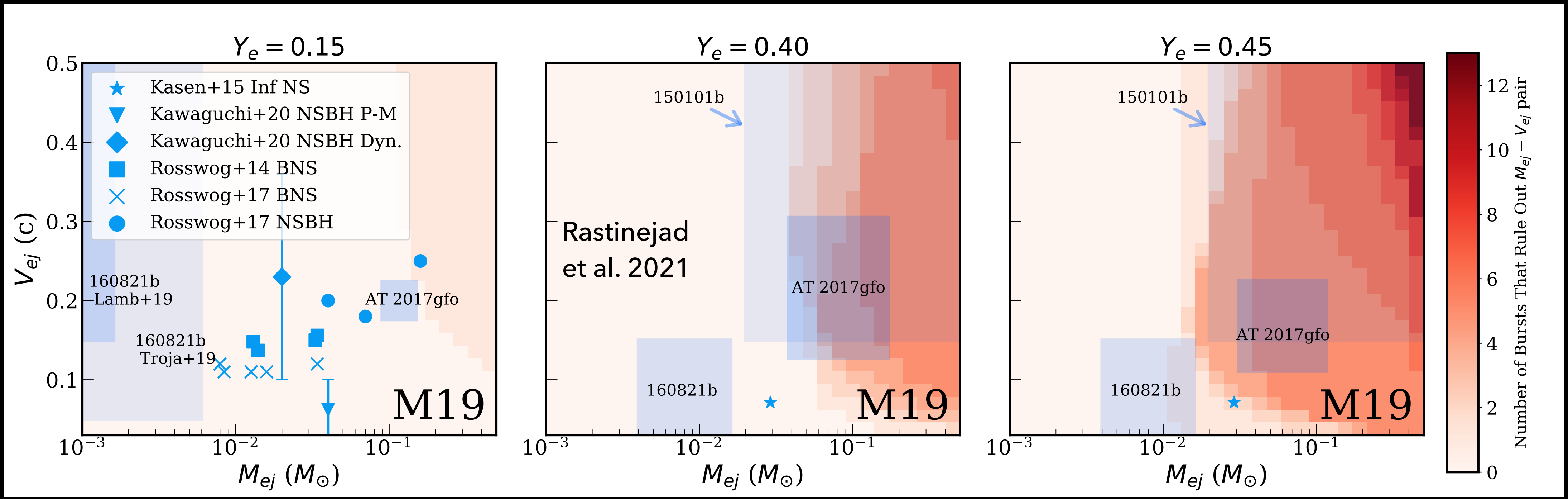


Created grids of analytic models based on Metzger et al. 2019 for each ejecta mass-velocity pair

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

Ejecta Mass & Velocity Constraints

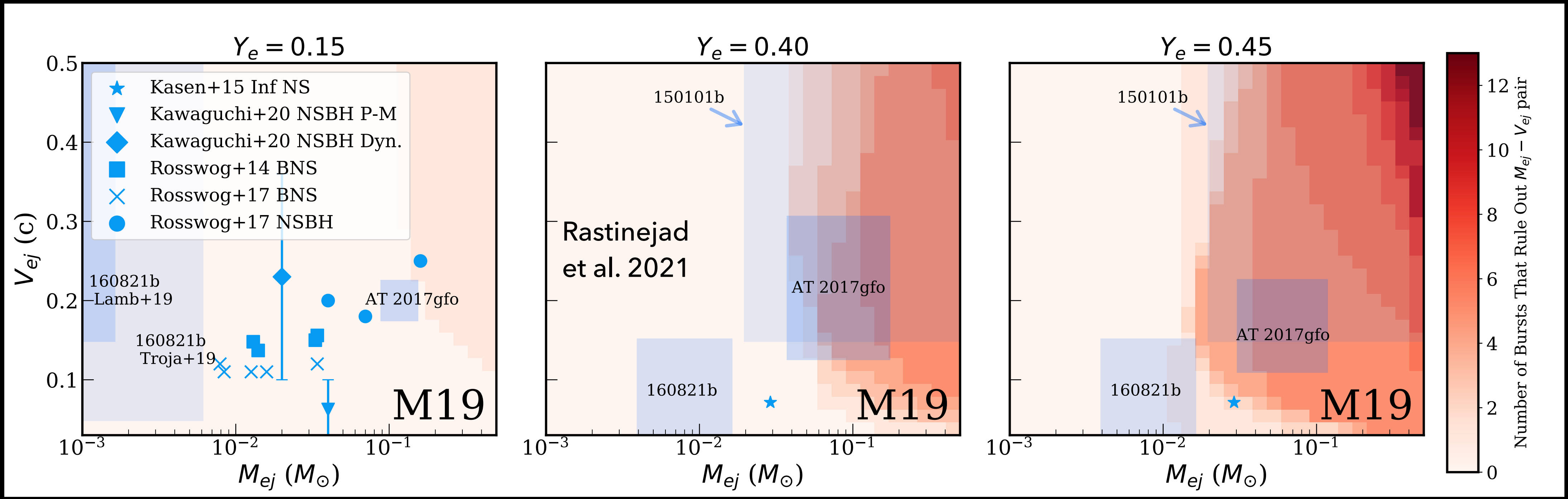
Metzger et al. 2019



Redder KN ⟵ ⟶ Bluer KN

Ejecta Mass & Velocity Constraints

Metzger et al. 2019

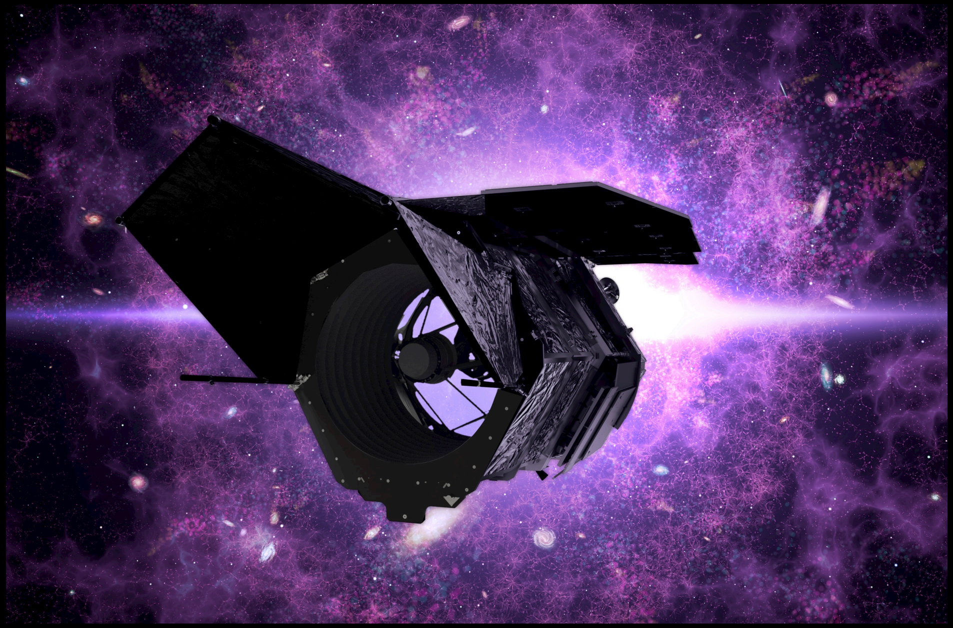


Redder KN ← → Bluer KN

Also compare to Kasen+17 grids: ejecta mass & velocity constraints are **model dependent** and can vary on the order of ~0.1 $M_\odot$ (also see Ascenzi+19)

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

Current observatories effectively probe **nearby** (z < 0.5), **blue**-component SGRB kilonovae



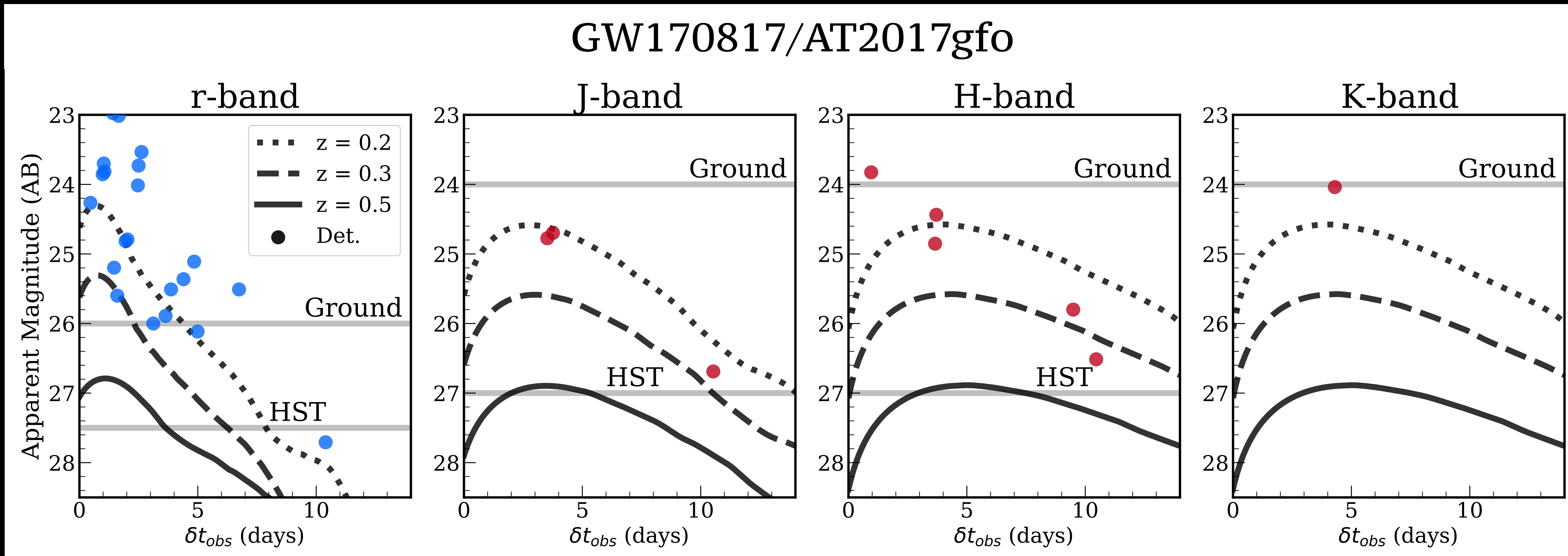
ToO slew times within 2 weeks

Program-Level Requirements for the Nancy Grace Roman Telescope, 8/2020

The Nancy Grace Roman Telescope Wide Field Instrument Is Uniquely Poised to Observe the Diversity of Red KNe Components

Filters	F062	F087	F106	F129	F146	F158	F184	F213
Wavelength (μm)	0.48-0.76	0.76-0.98	0.93-1.19	1.13-1.45	0.93-2.00	1.38-1.77	1.68-2.00	1.95-2.30
Sensitivity (5σ AB mag in 1 hr)	28.5	28.2	28.1	28.0	28.3	28.0	27.5	26.2

https://roman.gsfc.nasa.gov/instruments_and_capabilities.html

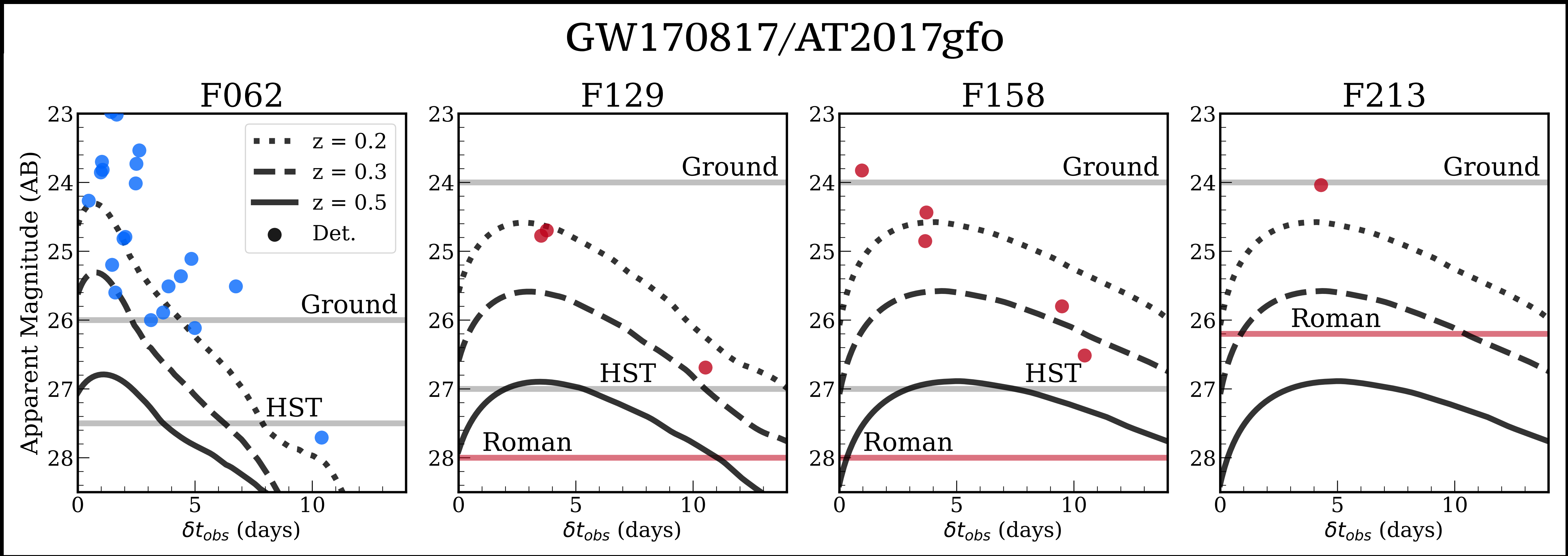


Current state of SGRB KNe observations:

Ground-based facilities can observe only nearby SGRBs **(z < 0.3)** in the optical

Timescales for ground-based facilities to observe AT2017gfo-like KNe point to likely **afterglow contamination**

HST can observe AT2017gfo-like KNe out to z~0.5 but, realistically, can trigger on **only 1 SGRB per year** + **no redder coverage than H-band** (F160W)



Roman will observe SGRB + future GW KNe:

Out to greater redshifts (AT2017gfo out to **z~0.8** in F129)

Synerties with other observatories would allow **multi-epoch observations** to better constrain ejecta masses + velocities

F213 will probe **redder wavelengths** than HST allows for z < 0.3 bursts

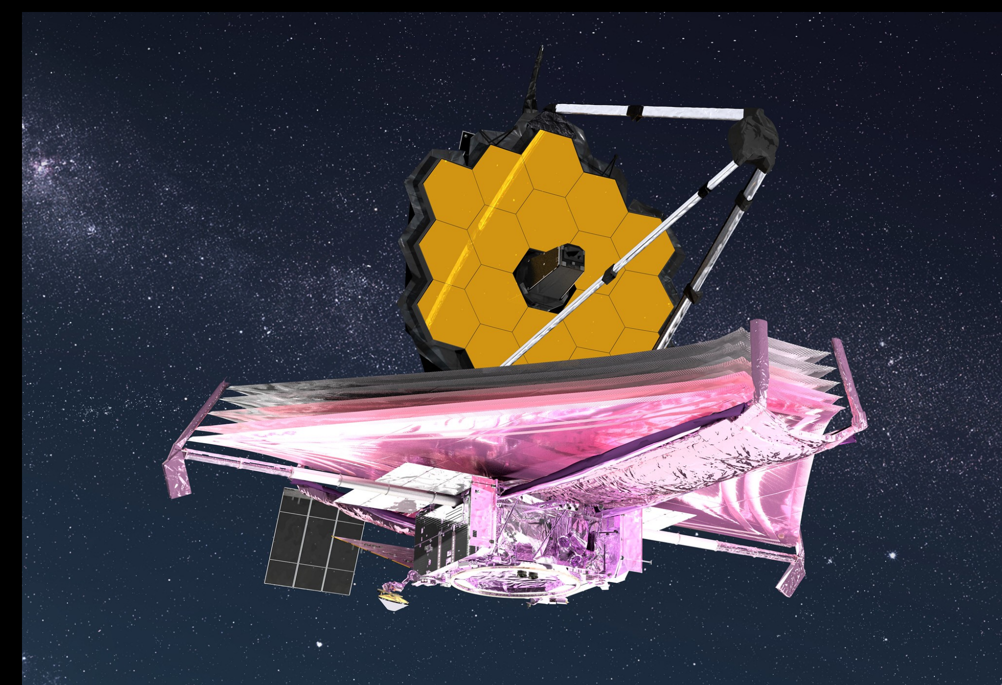
Synergies with other observatories

with the Nancy Grace Roman Telescope

6.5m MMT

8m Gemini

Ground-based, deep, optical observations complement Roman's NIR coverage of nearby SGRB kilonovae



JWST: similar slew times; can probe farther into the IR (later peak) to greater depths

AT2017gfo Spitzer 4.6um detections 43 days post-burst (Kasliwal+18, Villar+18)

Conclusions

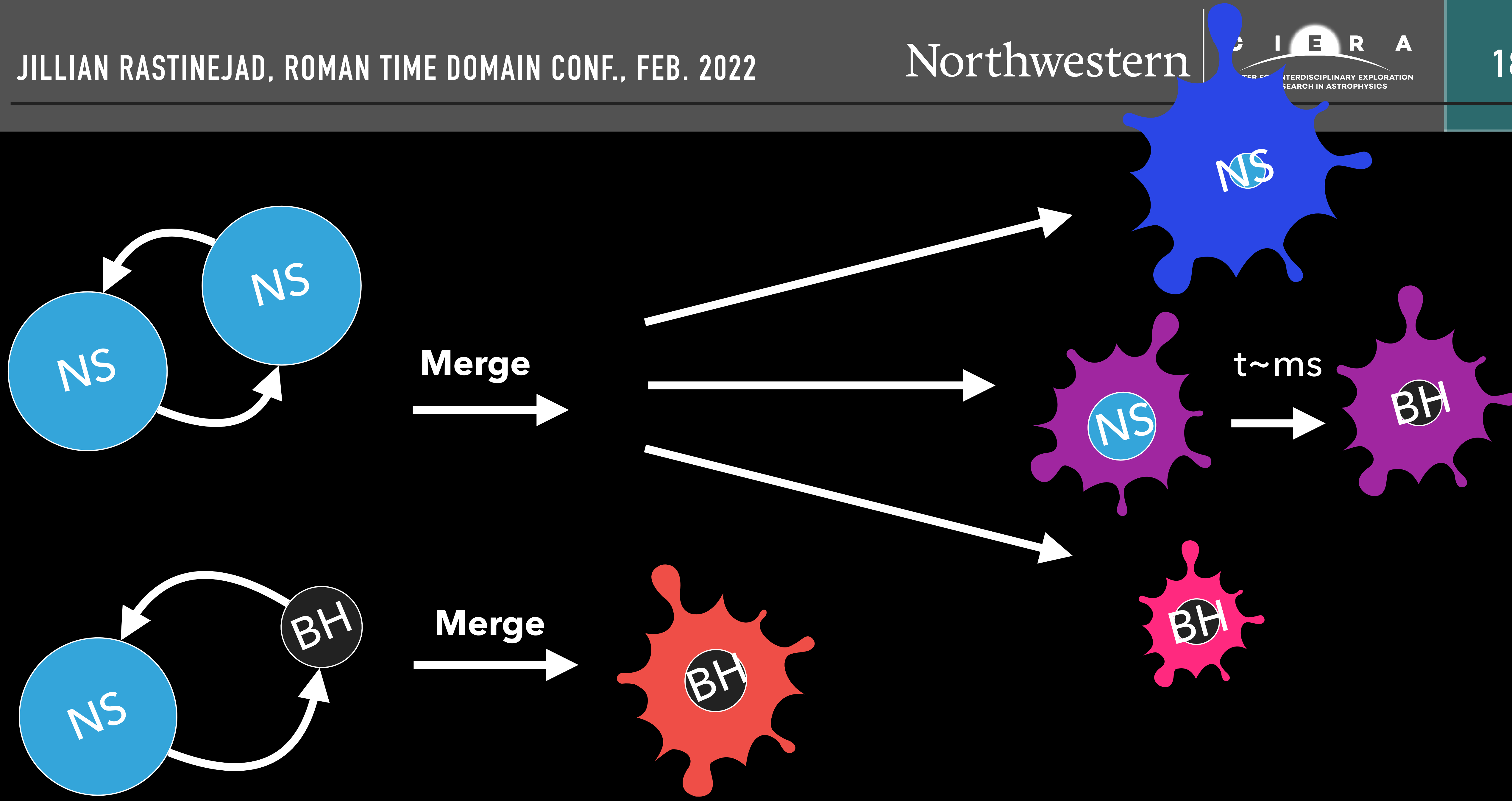
Observations of Short GRB kilonovae are uniquely poised to explore kilonova diversity at a fixed viewing angle out to cosmological redshifts

Current observations demonstrate that rest-frame optical kilonova detections vary by factor of ~100 in luminosity and constrain ejecta masses of 6 bursts to $M_{ej} < 0.05\ M_\odot$

The *Roman Space Telescope* will complement current observing programs, providing unique observations of **red**-component SGRB kilonovae out to **z~0.8**

Full catalog of SGRB kilonovae observations available:
Rastinejad et al. 2021, *ApJ*, 916, 2, 82

Thank you!



Diversity in observed SGRB KNe (colors, luminosities)