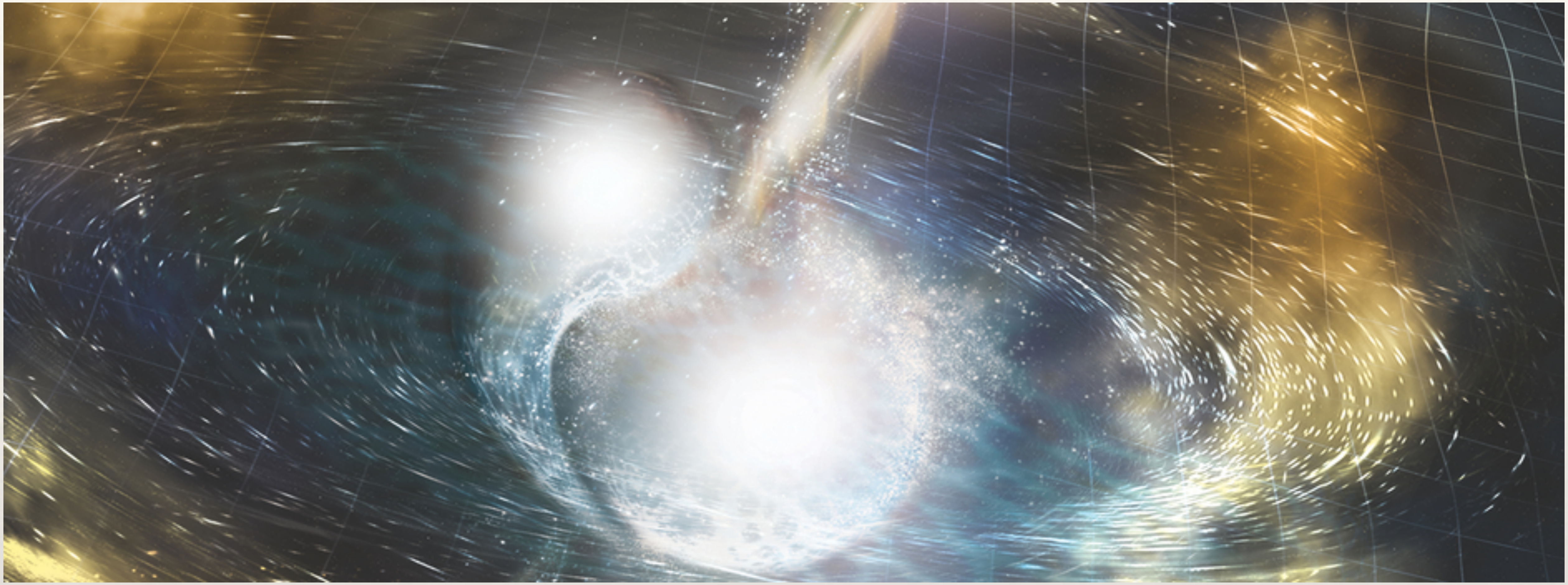
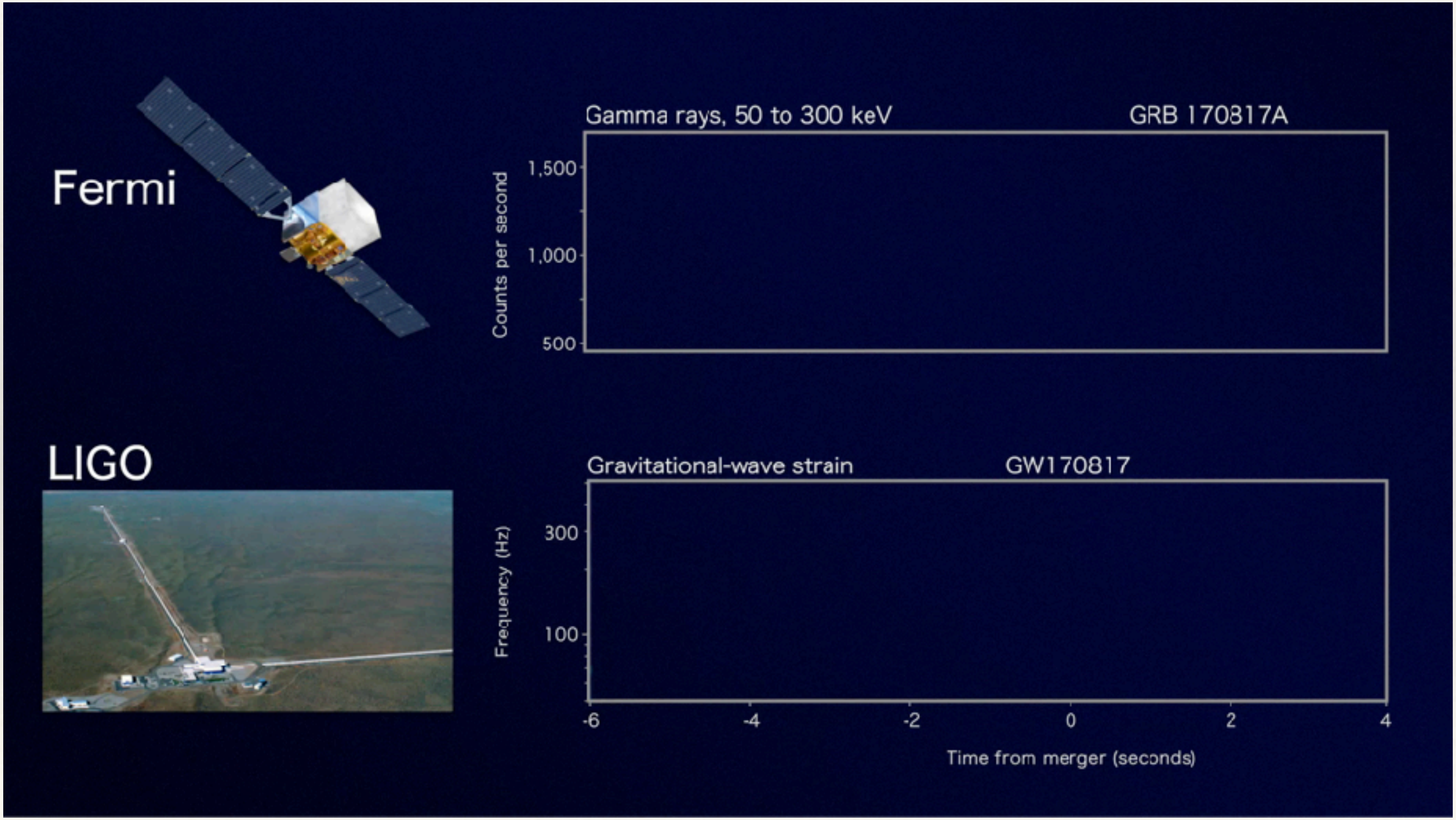


Follow-up of *Fermi* short GRBs with ZTF

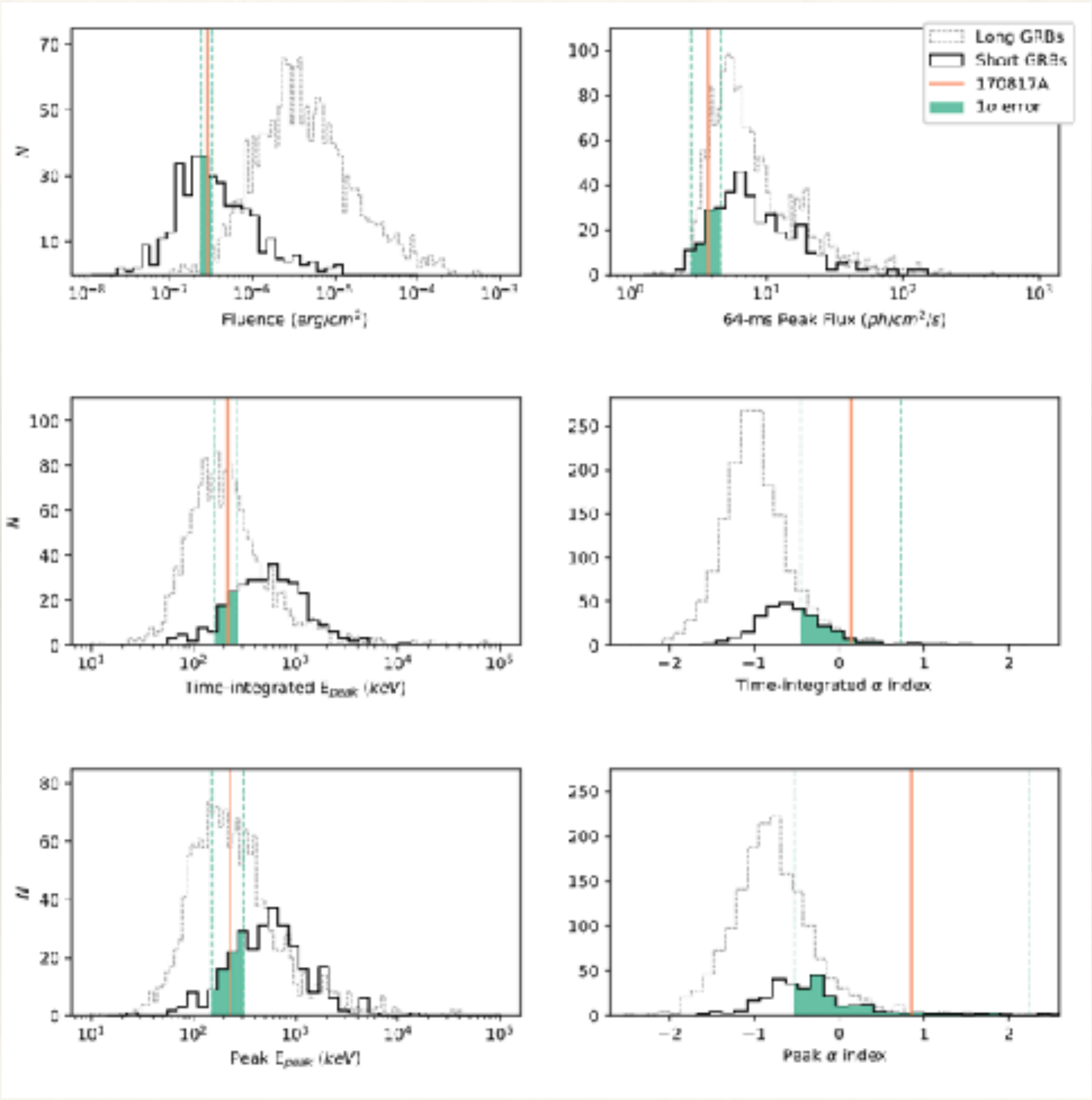
Brad Cenko
NASA GSFC / U. Maryland
March 19, 2019

GW170817 and GRB170817A



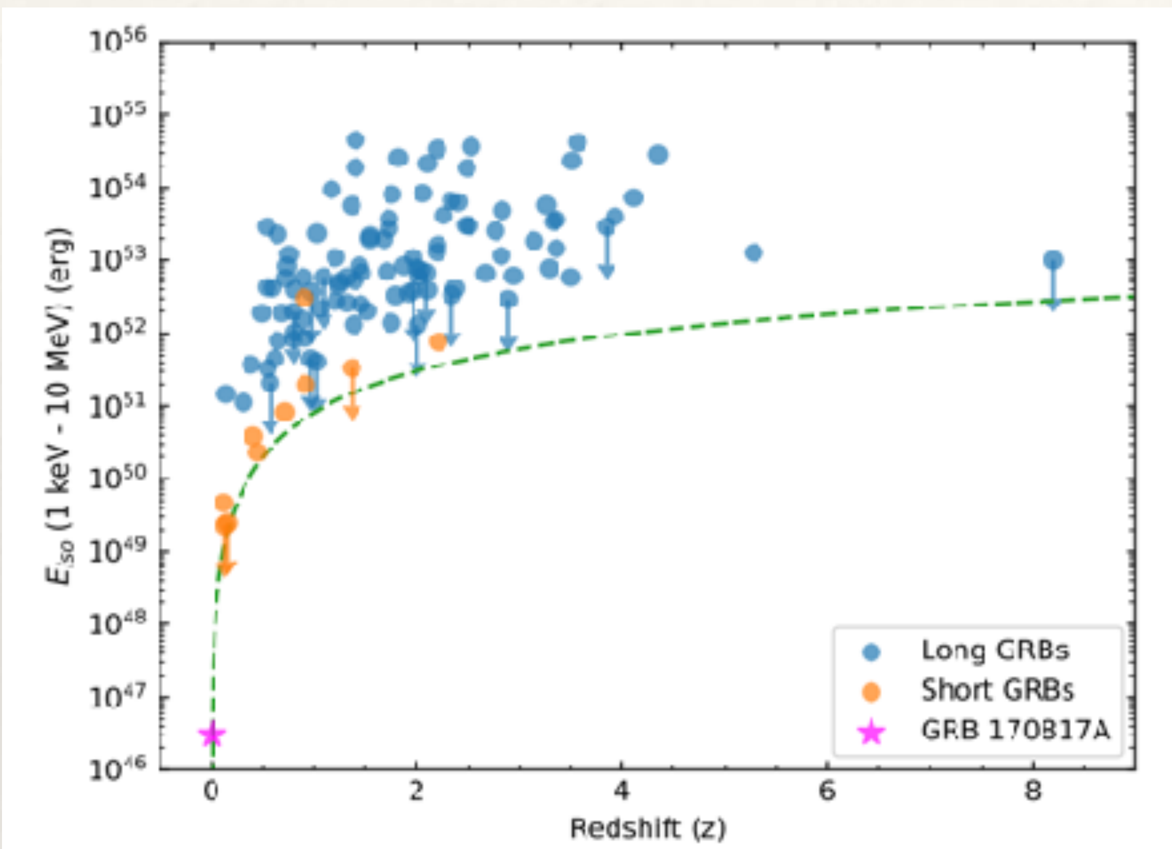
GRB170817A as a Normal GRB

- Based only on observed gamma-ray properties, GRB170817A is fairly typical of short GRB population
- A bit softer than other short GRBs, but in other aspects not unusual

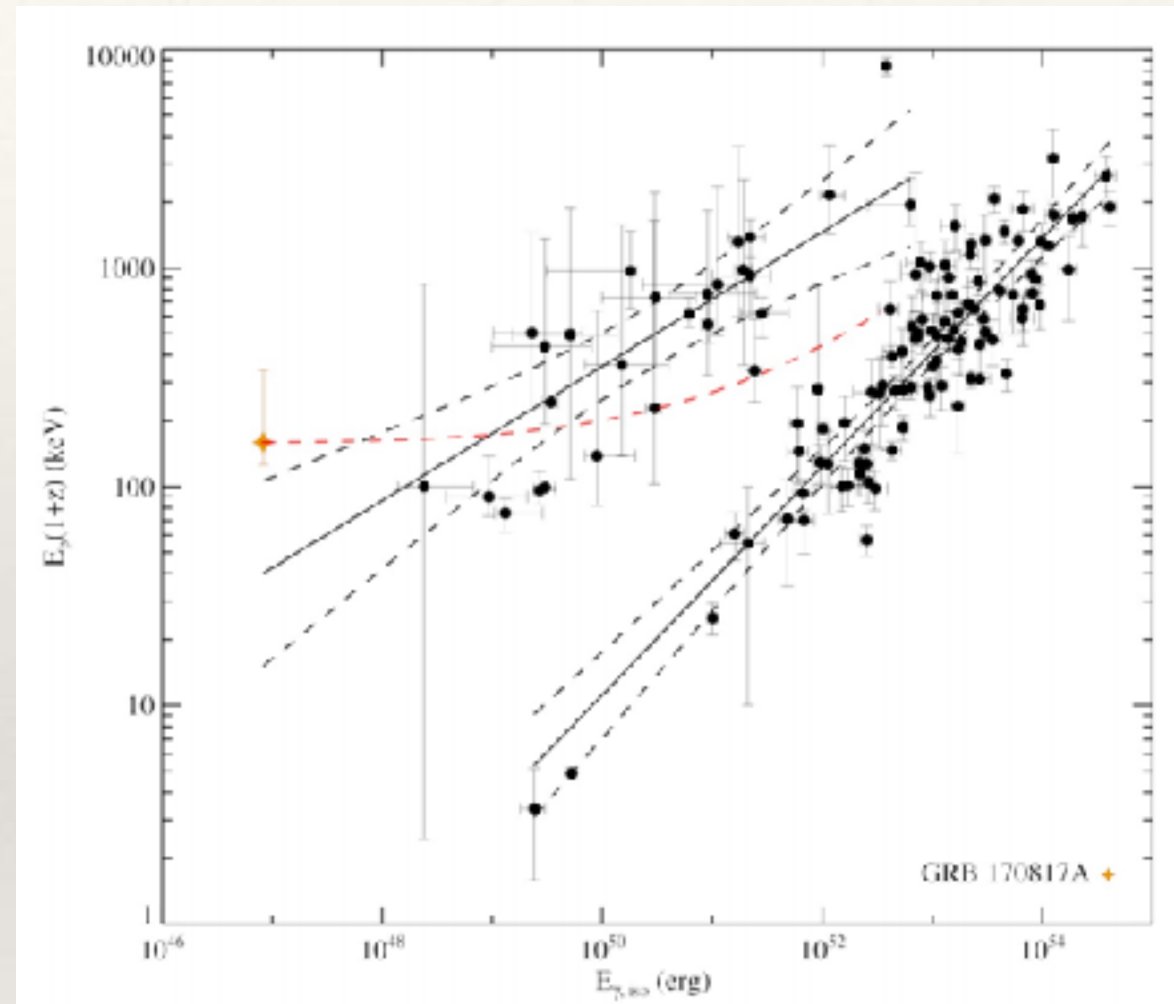


Goldstein+ 2017

GRB170817A as an Unusual GRB



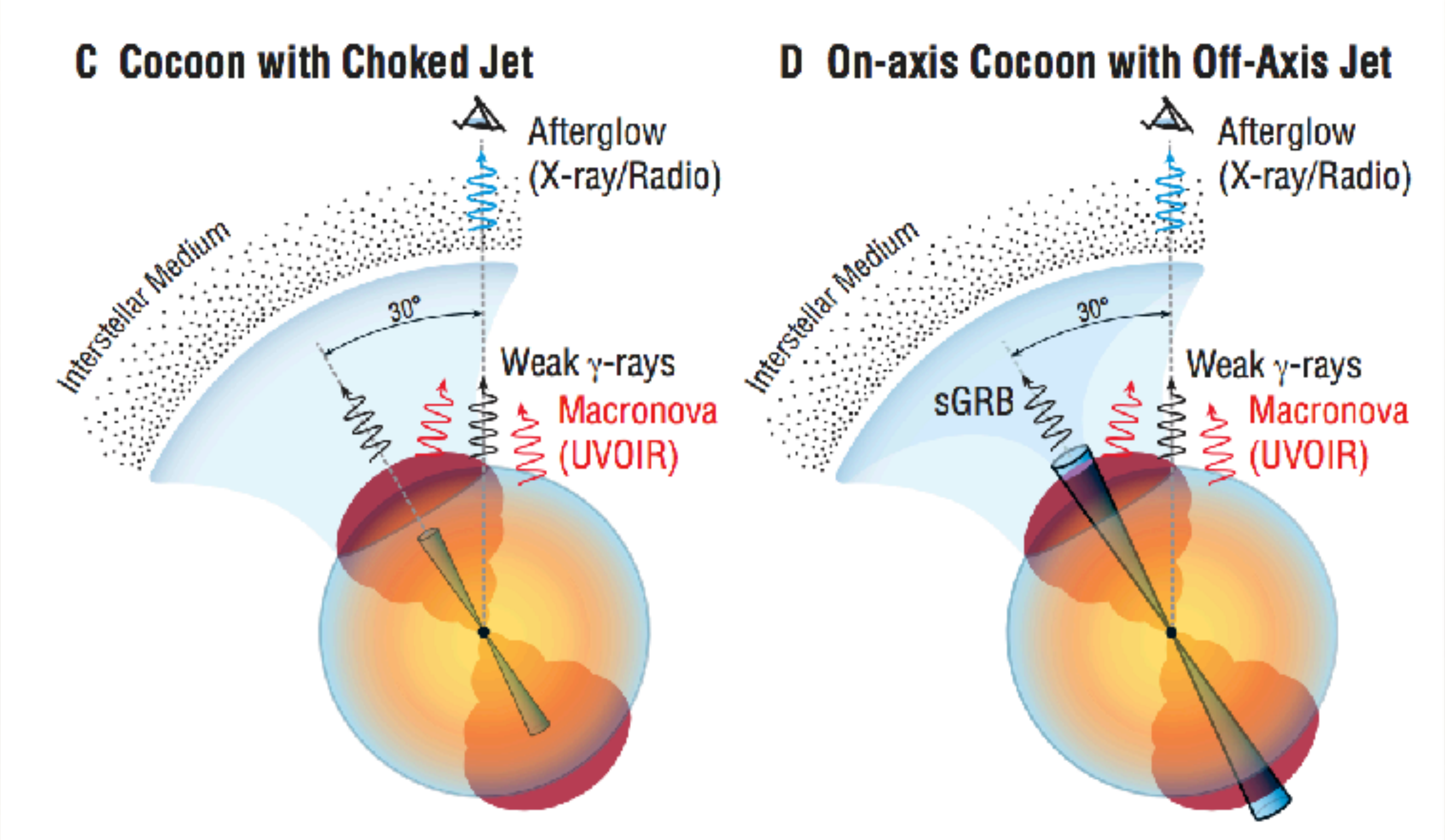
LVC+ 2017



Zhang+ 2017

But given low redshift, much less luminous than any previous short GRB

How do we explain this GW-GRB Connection?

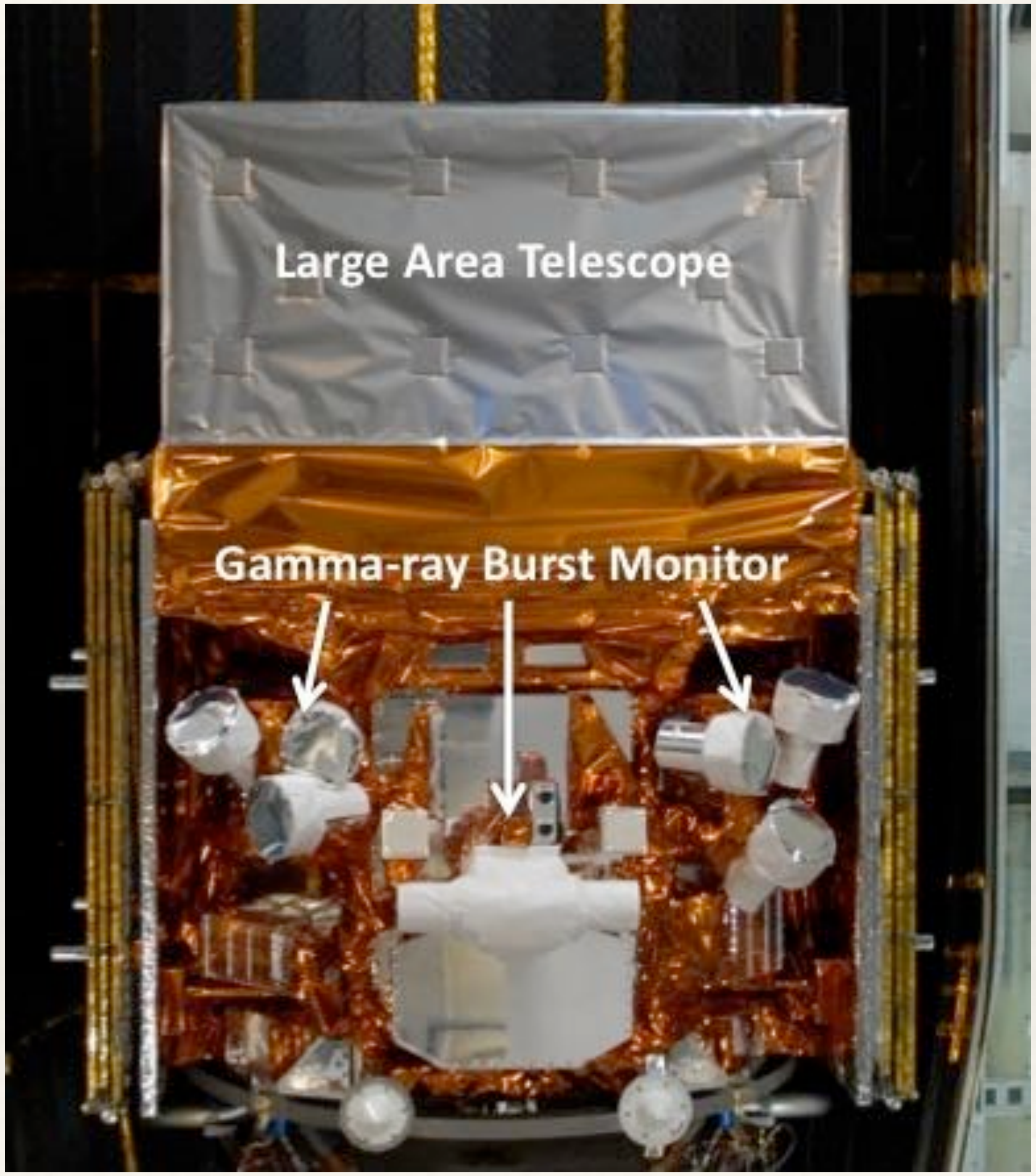


Kasliwal+ 2017

Do all binary NS mergers generate wide-angle, mildly relativistic outflow?

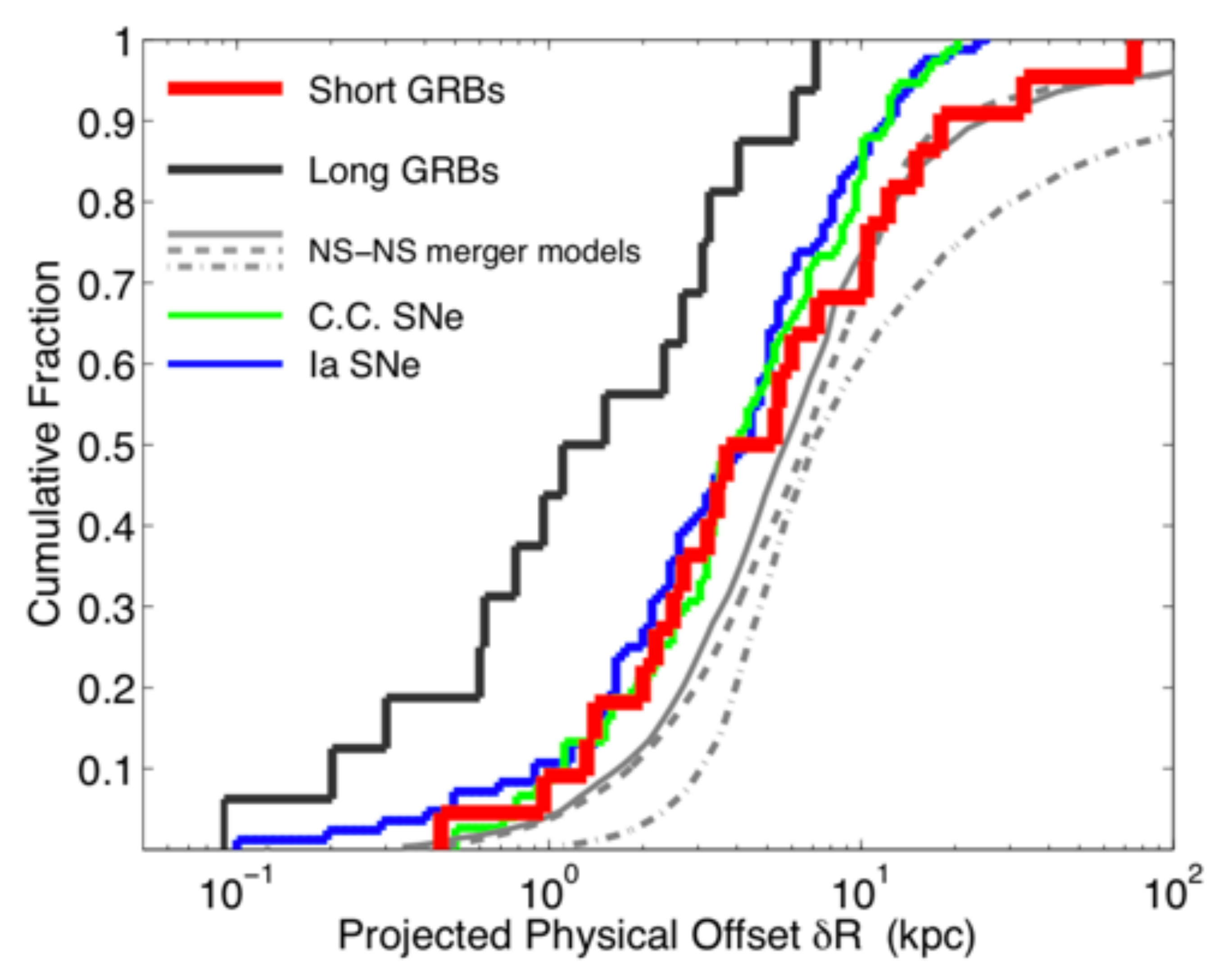
Primary Objective: Kilonova w/o GW

- *Fermi* GBM: On-board trigger sensitive to GW170817 out to ~ 80 Mpc ("offline" trigger out to ~ 100 Mpc)
- For LVC rate of BNS mergers, ~ 6 mergers within this volume per year
- *Fermi*-GBM will detect ~ 4-5 of these (i.e., FOV)
- Rate accessible to any one location on ground ~ few per year
- But typical localizations ~ 500 deg^2



Secondary Objectives

- Most short GRBs will be detected at larger distances (<z> ~ 0.5 from *Swift*)
- Short-lived afterglow signals detectable by ZTF
- Identify host, measure redshifts, host-afterglow offset
- End-to-end test of follow-up for EM-GW follow-up in late 2018 (e.g., Singer thesis)



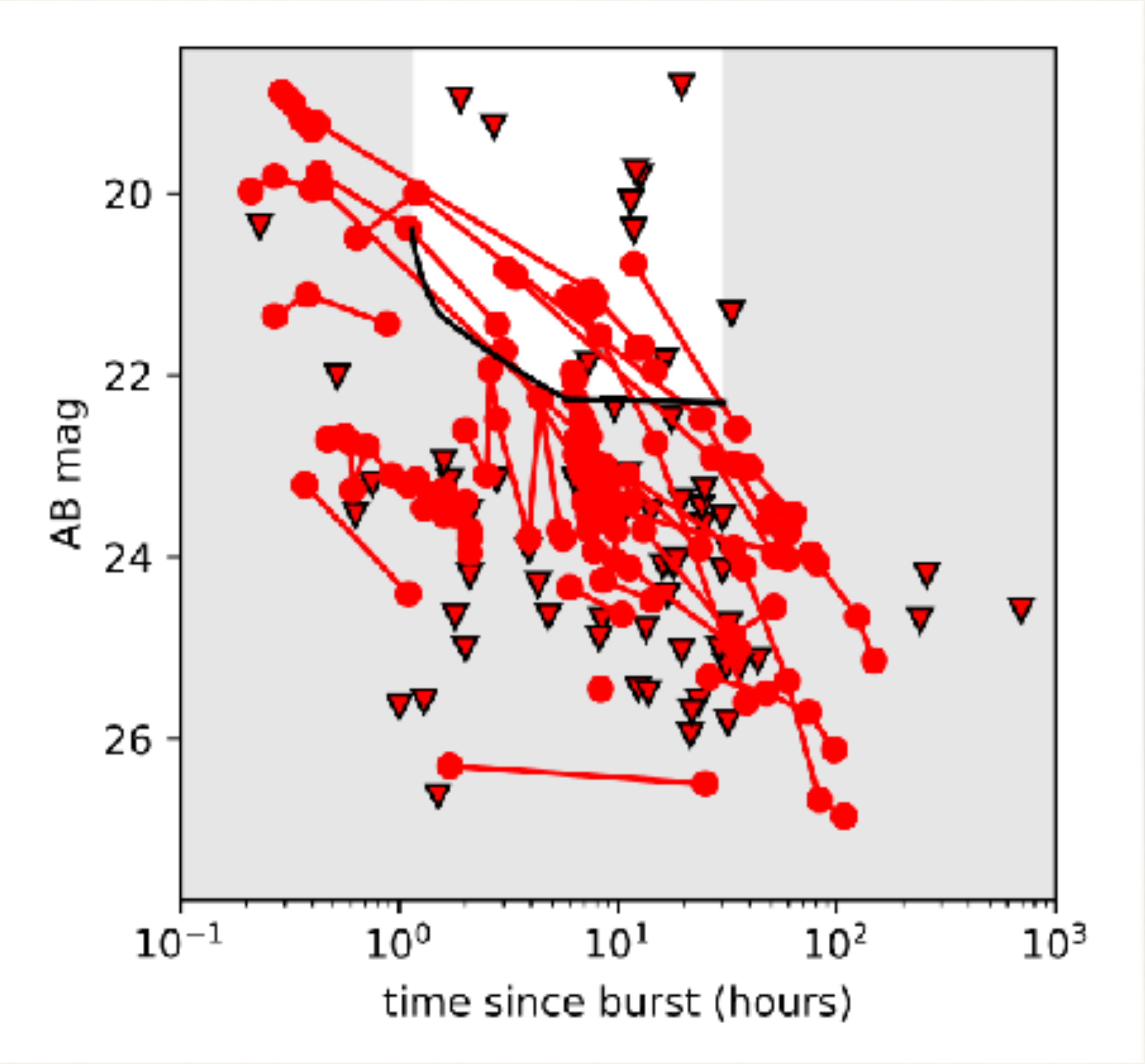
Fong+ 2014

Proposed Program

- Follow-up ~ 2 *Fermi* GRB short GRBs per month
  - Prioritize events that "look like" GW170817 (hard spike and soft thermal tail) and are promptly (~ 12 hours) accessible to Palomar
  - 2-3 epochs, logarithmically spaced, in g on Night 1 (Afterglow phase)
  - 1 g + 1 r/i on Night 2 (kilonova phase), if necessary
  - 1 g + 1 r/i on Night ~ 5 (kilonova phase), if necessary
- Only execute program until LIGO/Virgo O3 starts up (~ November/December 2018)

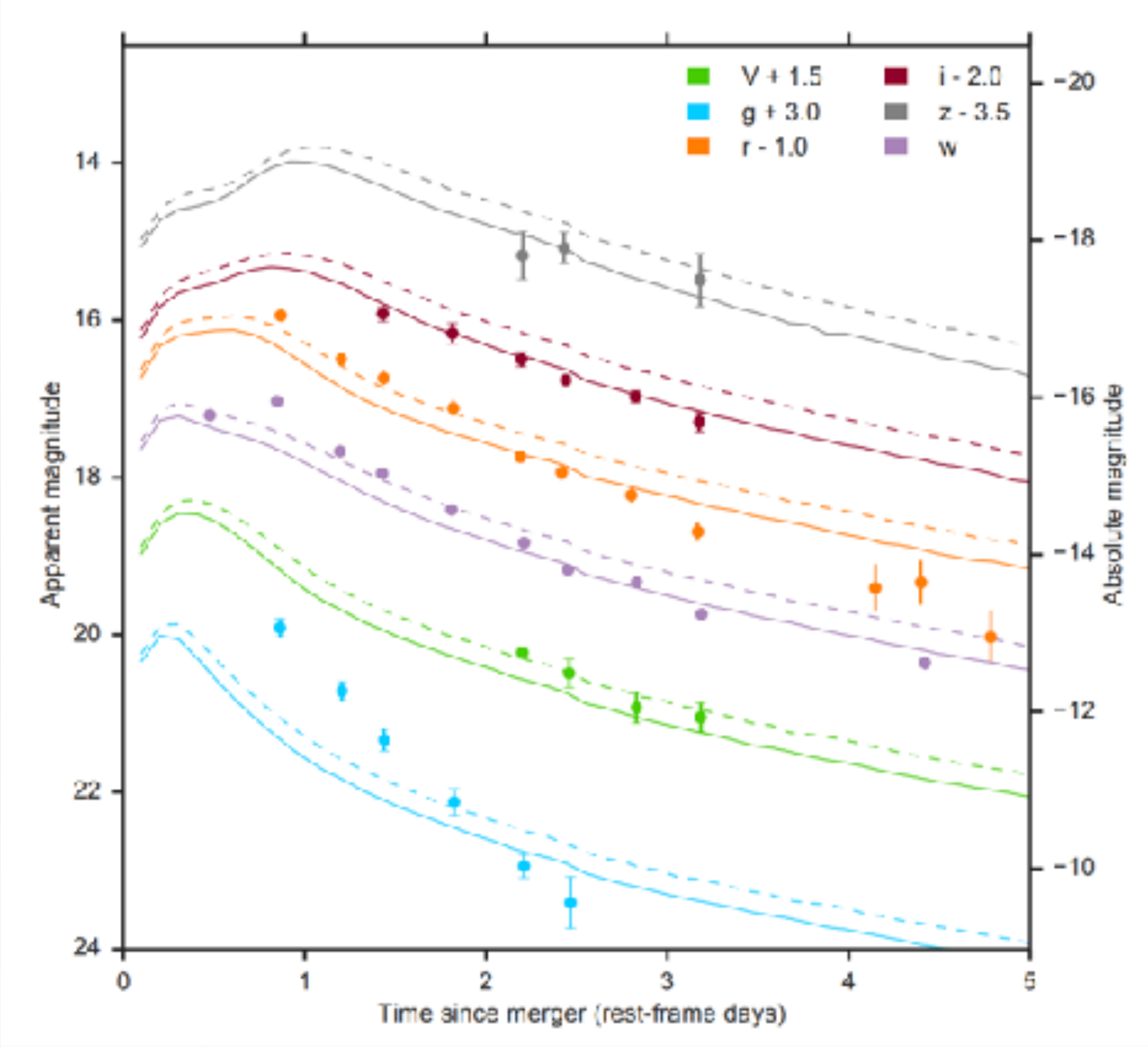
Night 1: Afterglow Phase

- Search for on-axis, distant events by their fast fading "afterglow" emission
- Exposure time ~ 2-3 min, to increase depth (but still shallower than references)
- False positive rate very low (50 events in 4 years of iPTF - Ho et al. 2018)
- ~ 20% of *Swift* short bursts would have detectable afterglows (terminate sequence if successful)



Nights 2+5: Kilonova Phase

- Search for counterpart that is
  - Extremely red (g - r > 1.0)
  - Redder than Night 1
  - Nearby galaxy association
- Longer exposures enables robust color measurement (even for fainter sources)
- Final epoch catches fast faders (in case color evolution of GW170817 unique)



Arcavi+ 2017

Fermi-ZTF Short GRB Summary

- Total request:
  - Per trigger: 1.5 hr N1 + 1 hr N2 + 1 hr N5 = 3.5 hr
  - Per month: 2 triggers = 7.0 hr
  - April-November: 8 months = 56 hr
- Possibility (though not guarantee) of kilonova detection **before** LV O3 starts up again
- Interesting (but not revolutionary) secondary science on the energetics and environments of short GRBs
- Important test case for GW follow-up in O3