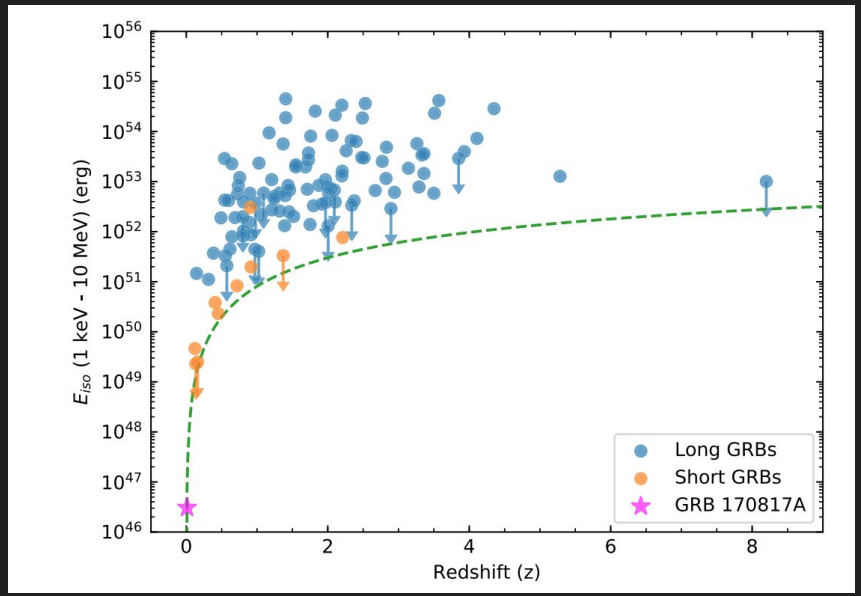
Follow-up of Binary NS Mergers with ZTF

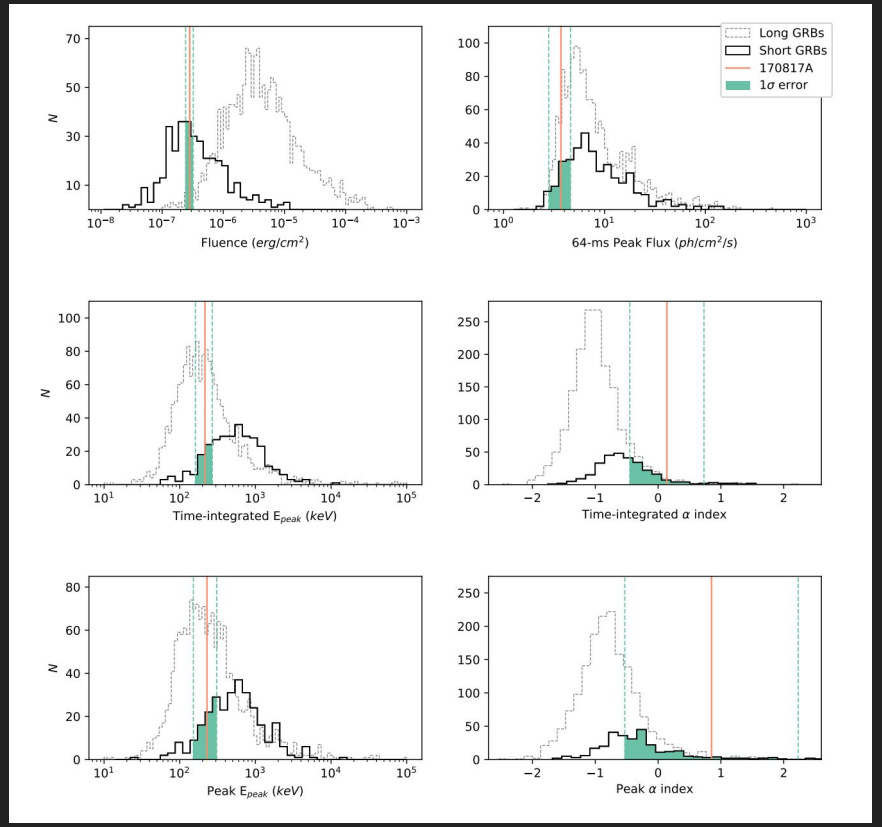
Ginny Cunningham on behalf of MMA SWG
March 13, 2019

GRB170817

Low-luminosity short GRB that was observed off-axis



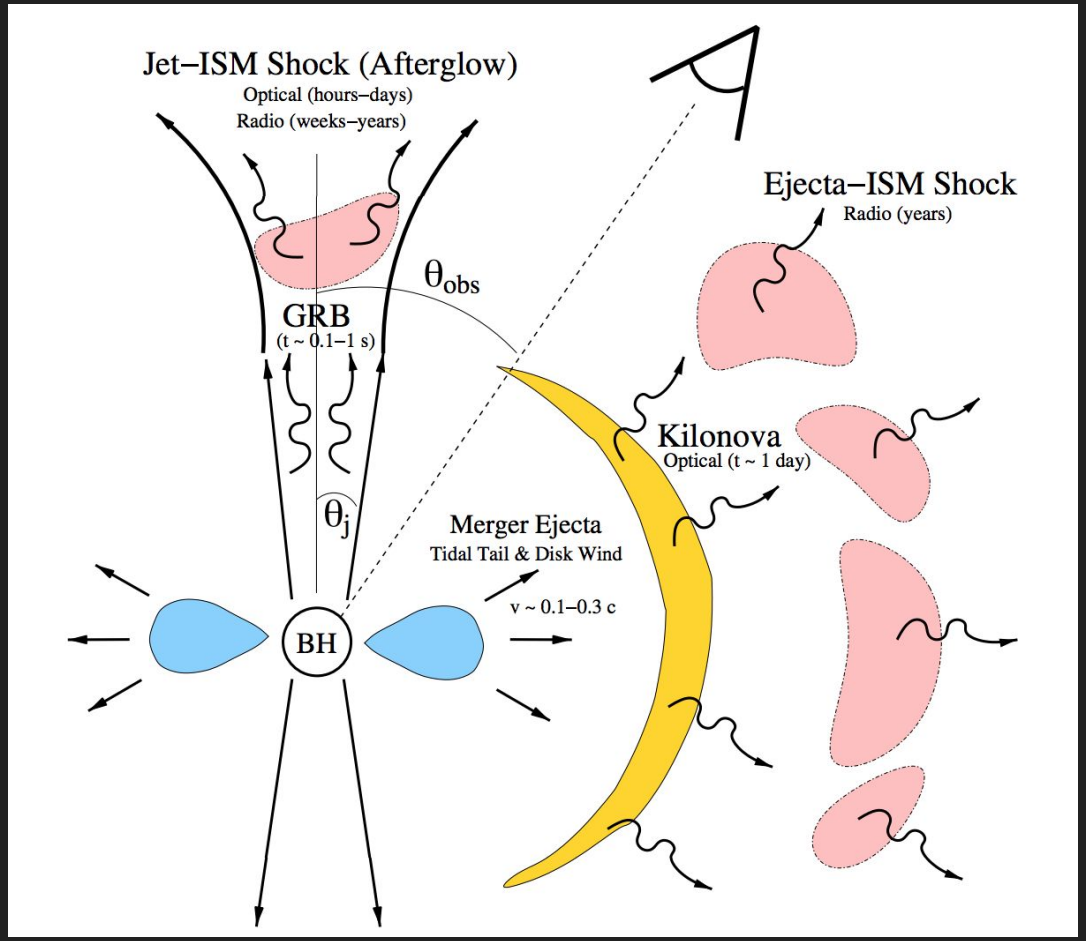
LVC+ 2017



Goldstein+ 2017

The Kilonova:

Do all short GRBs emit this isotropic optical emission?



Metzger & Berger (2012)

Previous work following up *Fermi* short GRBs with ZTF was published Jan 2019:

2900 square degree search for the optical counterpart of short gamma-ray burst GRB 180523B with the Zwicky Transient Facility

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Summary of previous triggers:

- 6 triggers in ~ 6 months
- 2 hrs on average each night
- ~10 final candidates on average per trigger
- Total time used: 9.97 hours
  - 0.65% of the total ZTF time
  - 1.6% of partnership time

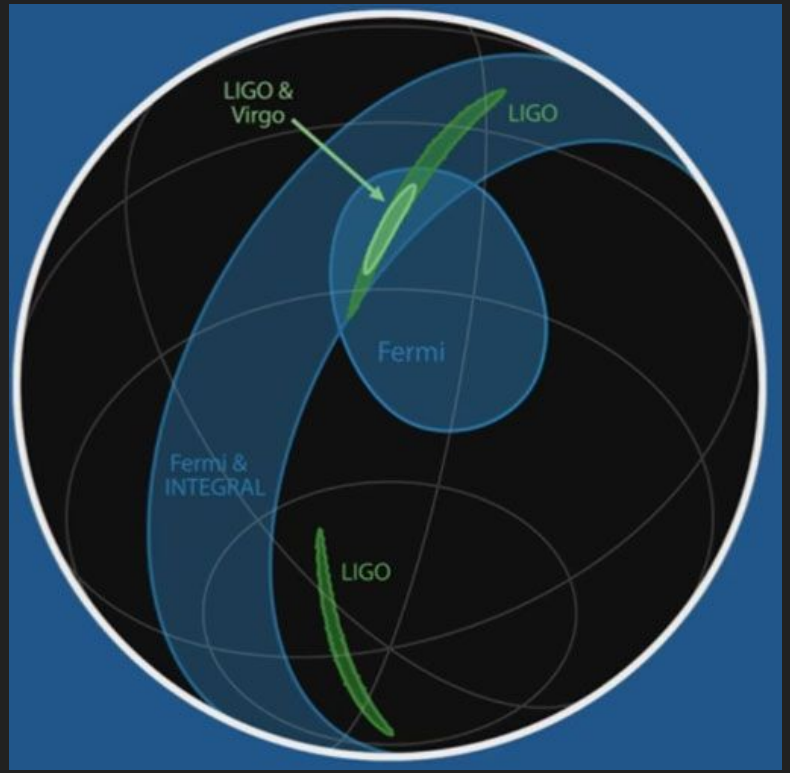
1. GRB180523B (2900 deg2, 60% coverage, 14 new candidates)
2. GRB180626C (300 deg2, 87% coverage, 0* new candidates)
3. GRB180715B (250 deg2, 37% coverage, 14 new candidates)
4. GRB180728B (350 deg2, 90% coverage, 0* new candidates)
5. GRB180913A (550 deg2, 72% coverage, 12 new candidates)
6. GRB181126B (1400 deg2, 77% coverage, 11 new candidates)

* = Revised localization from IPN at dt ~ 24 hours

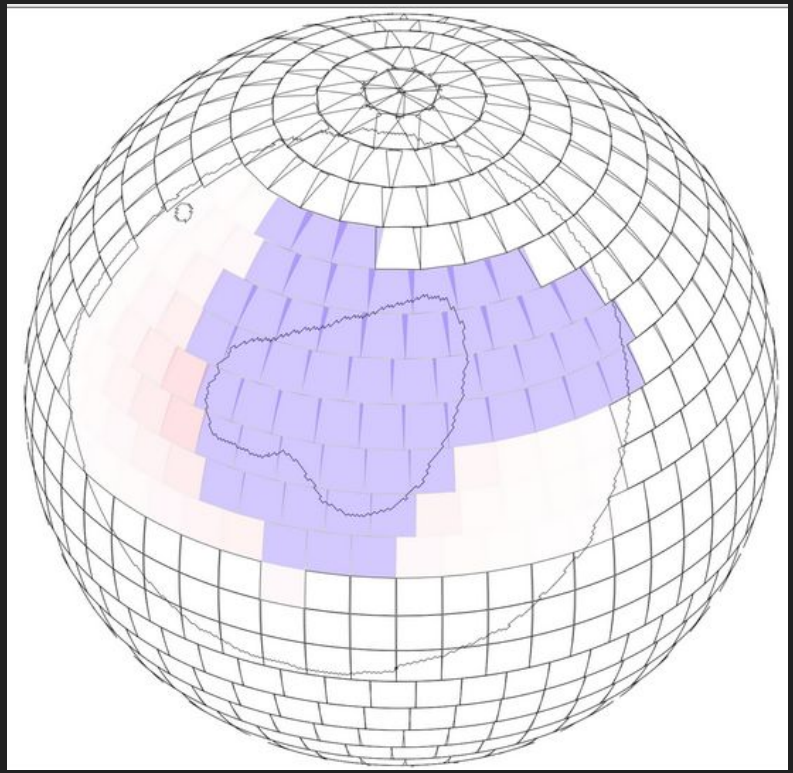
LIGO's O3 Run

- Engineering run begins March 4
- O3 begins April 1
- Operates for 12 months
- Virgo online for duration of O3
- Improved sensitivity
- Alerts sent via GCN
- Binary NS merger rate of 100-3000 $Gpc^{-3}\ yr^{-1} \rightarrow$ 7 yr^{-1} detected by LIGO

ZTF can cover LIGO localization in <1 hour



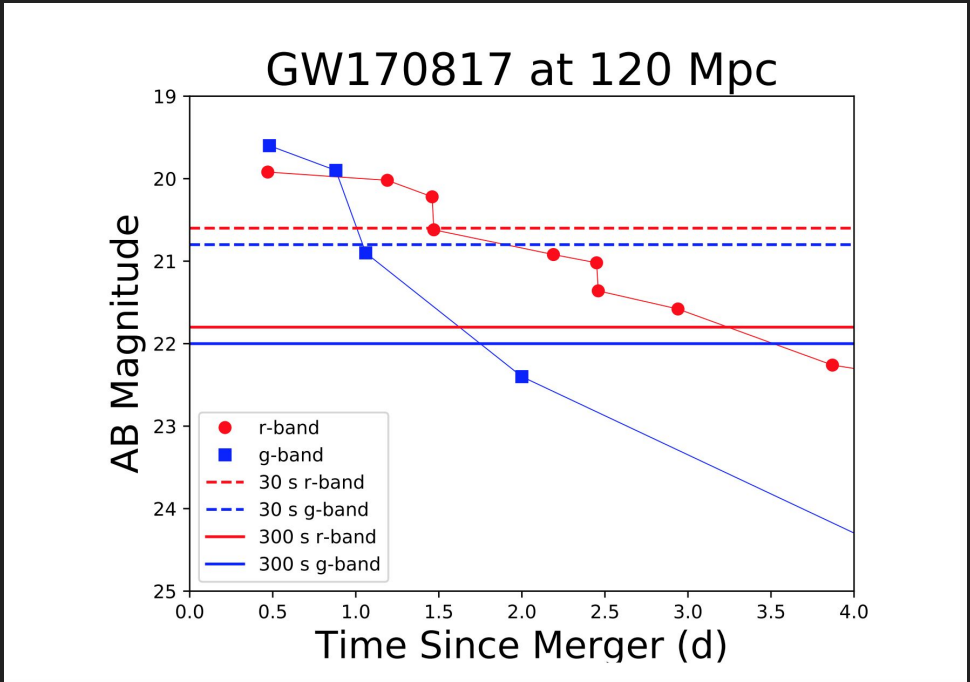
LIGO/Virgo Collaboration



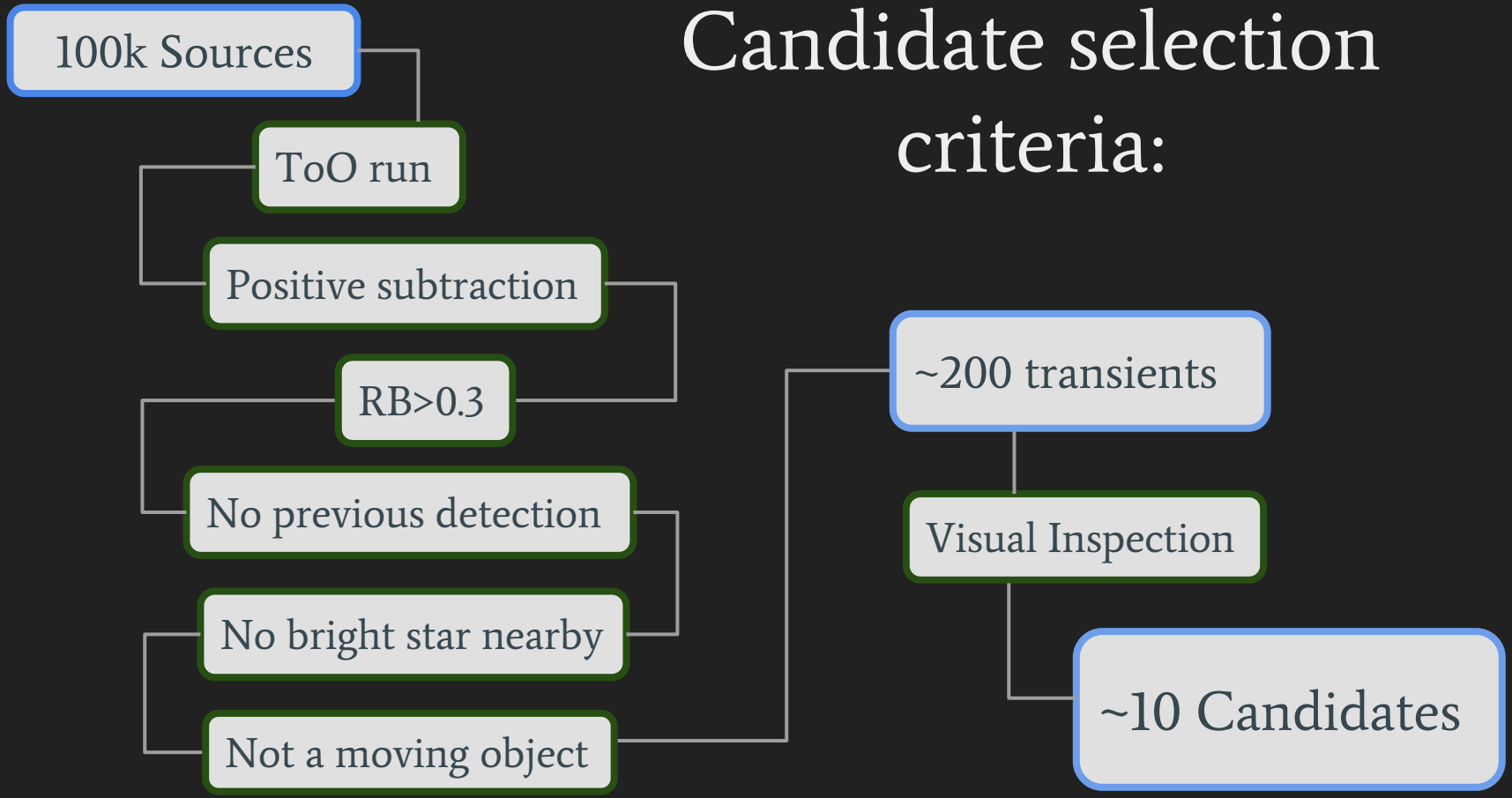
Coughlin+ 2019

Proposed plans for O3 run

- 6 requested ToO triggers
- Prioritize NS merger events
- Observations on night 1, 2, 3, and maybe 7
  - ~14 hours total per trigger
- 300 s exposures
- Search for fast-fading, extremely red transients that are getting redder over a few days timespan

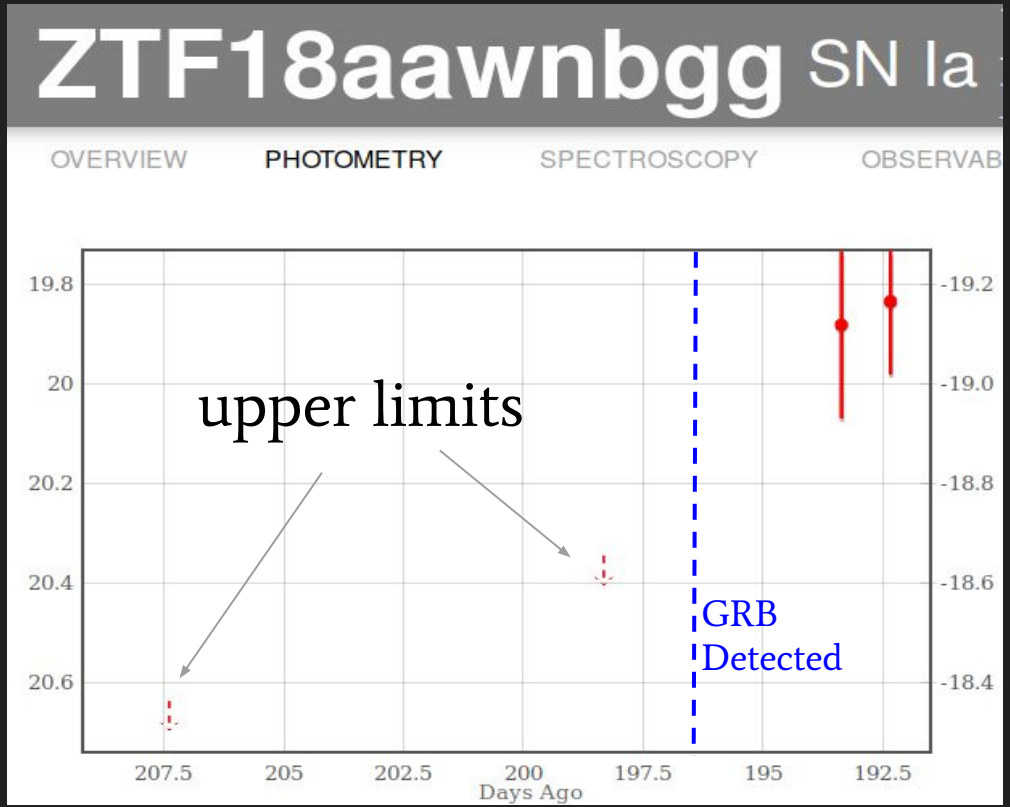


Candidate selection criteria:



Example candidate:

No previous detections!



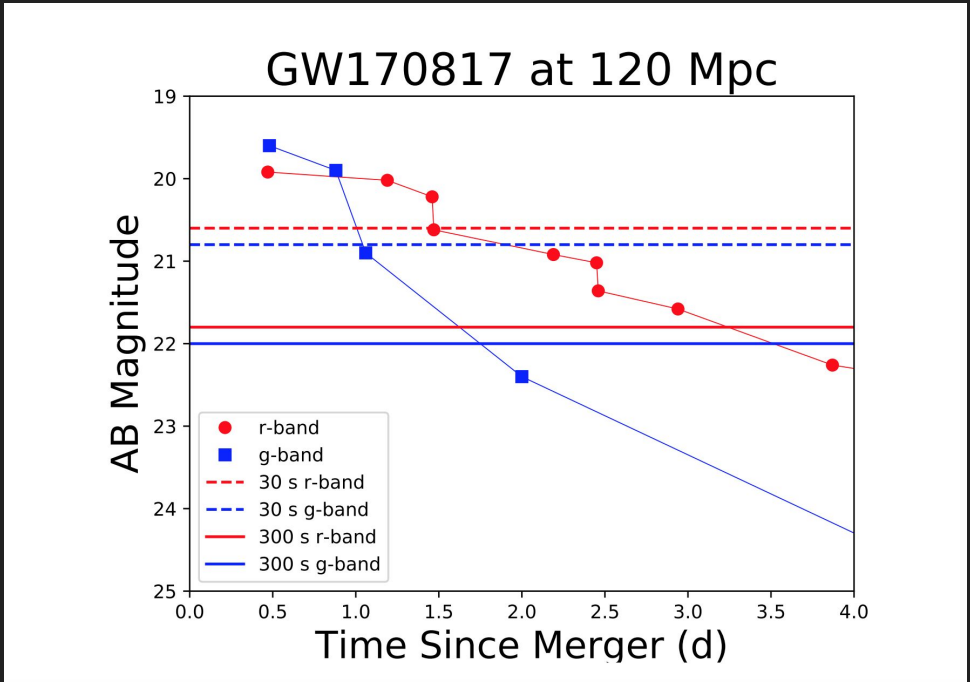
Send to GROWTH, VLA, *Swift*...

New and Improved

- Previous triggers proved to be great test run to prepare for O3
- Completely automated process for ToO marshall
- Automatic GCN notices
- Expect smaller localization regions → fewer candidates for scanning and follow up

Proposed plans for O3 run

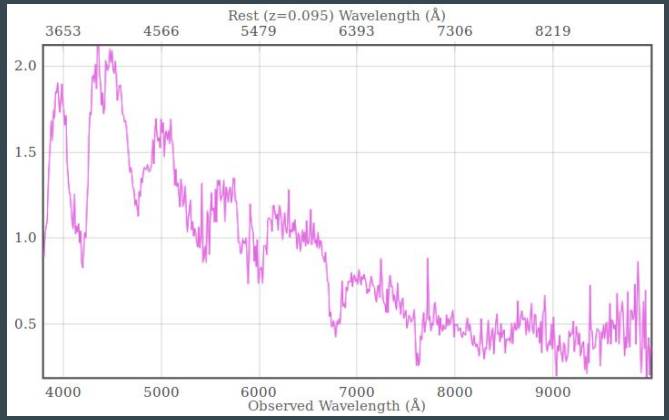
- 2-6 ToO triggers
- Prioritize NS merger events
- Observations on night 1, 2, 3, and maybe 7
  - ~14 hours total per trigger
- 300 s exposures
- Search for fast-fading, extremely red transients that are getting redder over a few days timespan



Backup Slides

Further Follow-up

- 14 candidates to follow up
  - KPED, LCO
  - SEDM, DCT, P200



Candidate	Coordinates	magnitude at discovery	Date of last observation	Data available
ZTF18aawozzj	12:31:09.02 +57:35:01.8	g=20.2	June 9	P200+DBSP Spectrum
ZTF18aawnbgg	10:40:54.05 +23:44:43.3	r=19.88	June 9	P200+DBSP Spectrum
ZTF18aawmvbj	10:12:41.17 +21:24:55.5	r=19.75	June 9	P200+DBSP Spectrum
ZTF18aawcwsx	10:40:33.46 +47:02:24.4	r=19.84	June 5	P60+SEDM Spectrum
ZTF18aawnbkw	10:38:47.66 +26:18:51.8	r=19.91	June 12	KPED r=20.01
ZTF18aawmqwo	09:52:06.90 +47:18:34.8	r=19.98	June 21	KPED r=19.9
ZTF18aawmkik	08:51:11.45 +13:13:16.7	r=19.04	June 12	KPED r=20.6
ZTF18aawnmlm	11:03:11.38 +42:07:29.9	r=20.12	June 19	KPED r=20.2
ZTF18aauhzav	10:59:29.32 +44:10:02.7	r=19.97	June 19	KPED r=16.5
ZTF18aavrhqs	11:58:09.57 +63:45:34.6	r=19.99	June 21	KPED r=21.4
ZTF18aawmwwk	10:35:26.51 +65:22:34.3	r=19.9	June 21	KPED r=19.8
ZTF18aawwbwm	08:16:44.98 +35:34:13.1	r=19.79	Not observable	
ZTF18aawmjru	08:39:11.39 +44:01:53.6	r=18.43	Not observable	
ZTF18aawmigr	08:48:01.76 +29:13:51.9	r=19.63	Not observable	