Search for GRBs possibly associated with GW using HAWC.

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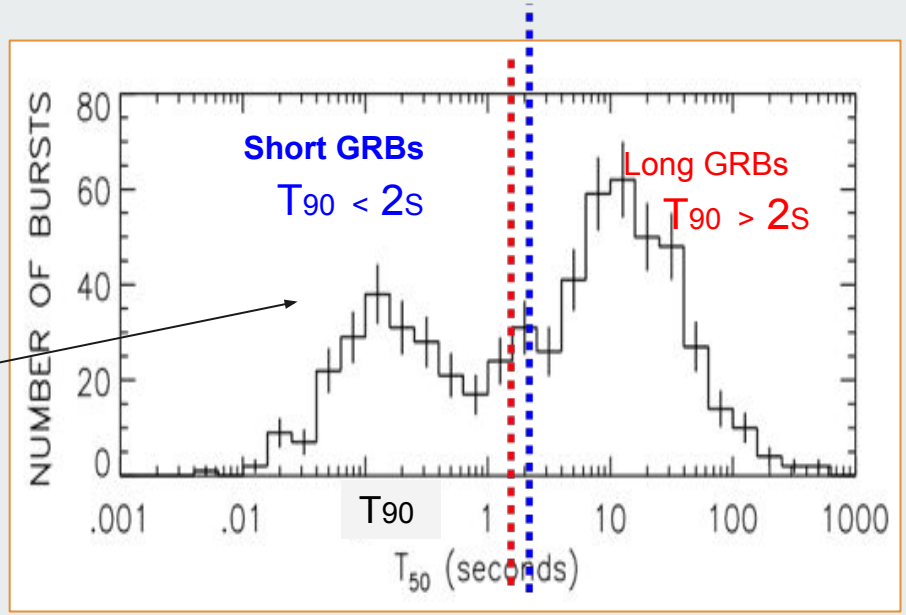
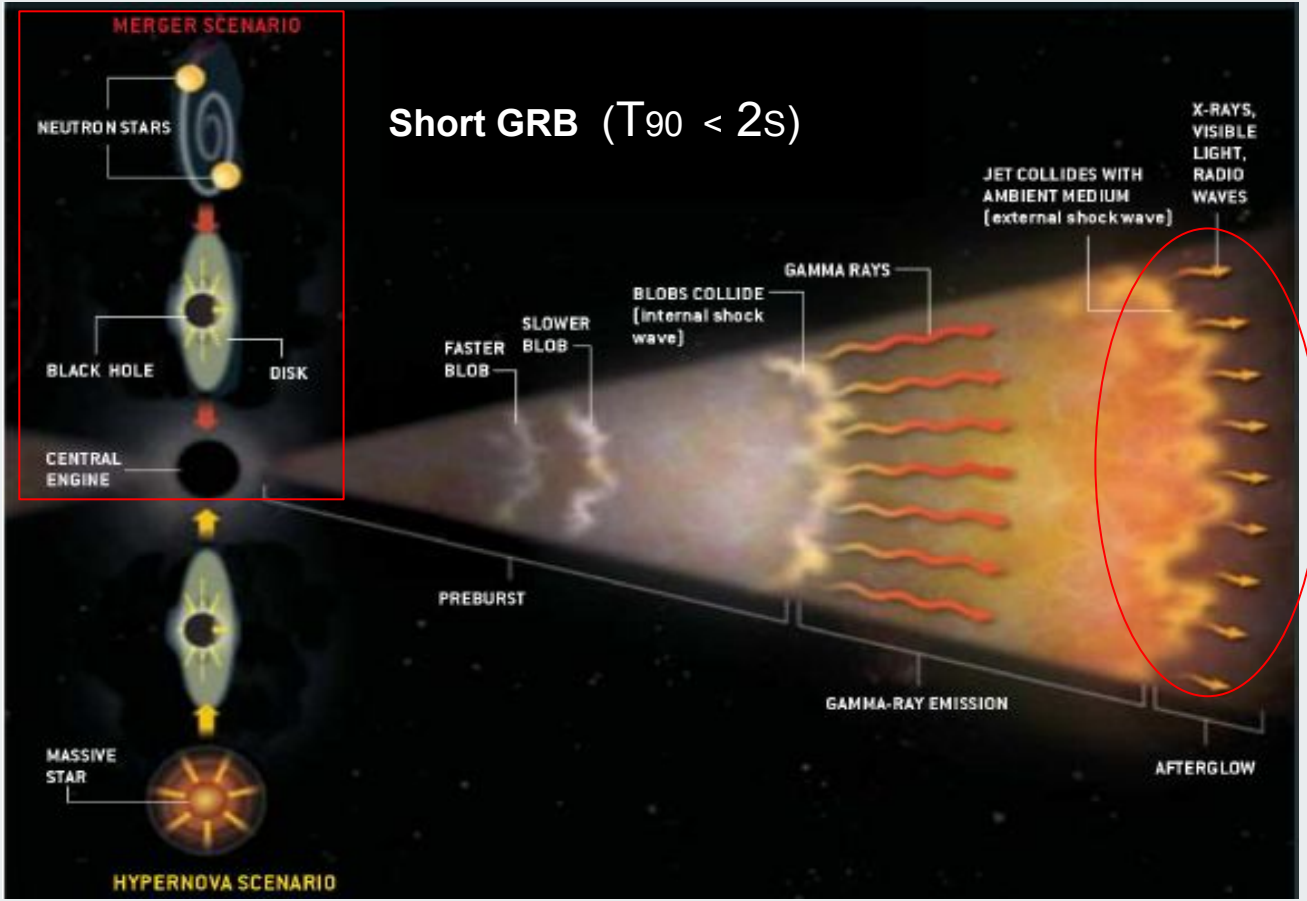
Contents

GRB Phenomenology

- GRBs are bursts of gamma-ray, the most energetic form of radiation.
- Isotropic distribution in the sky.
- Cosmological (GRB 090423 with a redshift of z~8.1 [Salvaterra, R., Valle, M., Campana, S. et al. 2009]).
- No thermal spectrum.
- Two types of GRB: long and short.



Progenitors and Fireball Model



To explain the characteristics of the emissions produced:

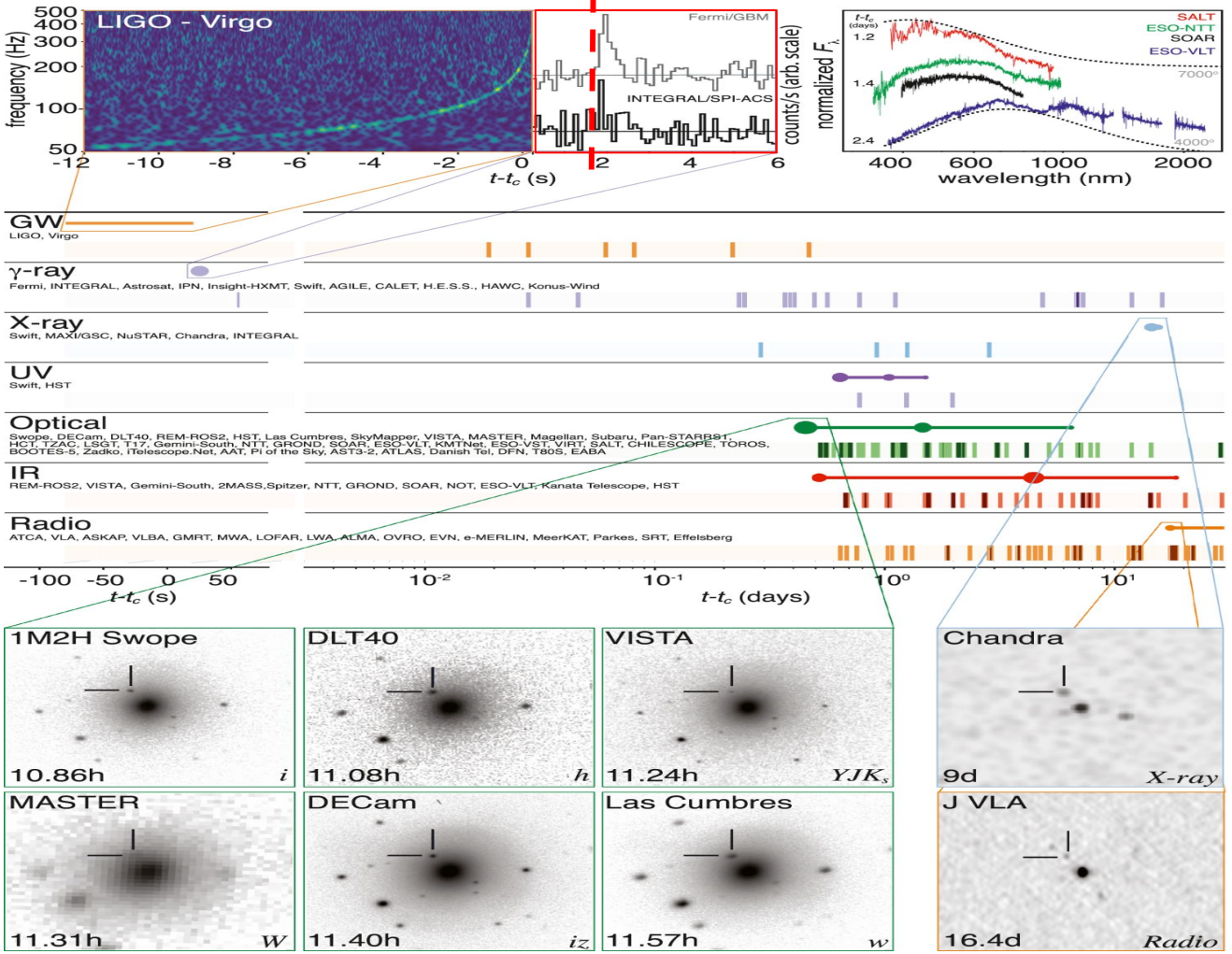
- **Internal Shocks:** Responsible for the prompt emission by dissipation of kinetic energy.
- **External Shocks:** responsible for the afterglow emission due to the shock of the fireball with the interstellar medium.

Models (high and very high energy emission) Synchrotron-Self Compton(SSC) [range of MeV-GeV]

First GRB associated to a GW event.

The observation of the GW170817 transient, which occurred on 17 August 2017 for LIGO-Virgo.

- A gamma-ray burst (GRB 170817A) was detected by the Fermi-GBM, occurring 1.7 seconds after the gravitational wave transient.
- Was associated with a faint electromagnetic gamma-ray counterpart which is most probably the prompt emission of a short GRB.
- The progenitor of this transient
  - The merger of two NSs.
  - Located in the host galaxy NGC 4993.
  - Redshift of z=0.01.



HAWC Observatory

HAWC provides continuous monitoring of the Gamma-ray sky, therefore ideal to search gamma-ray burst counterparts.

Field of view (~2 sr)
Energy range: 300 GeV to 100 TeV.

has also looked for electromagnetic counterparts from Gravitational Wave alerts.

followed up on the GW 170817 event whose position was visible 0.342 days after the GW trigger *(Abbott et al. 2017)*.

No significant detection was observed.

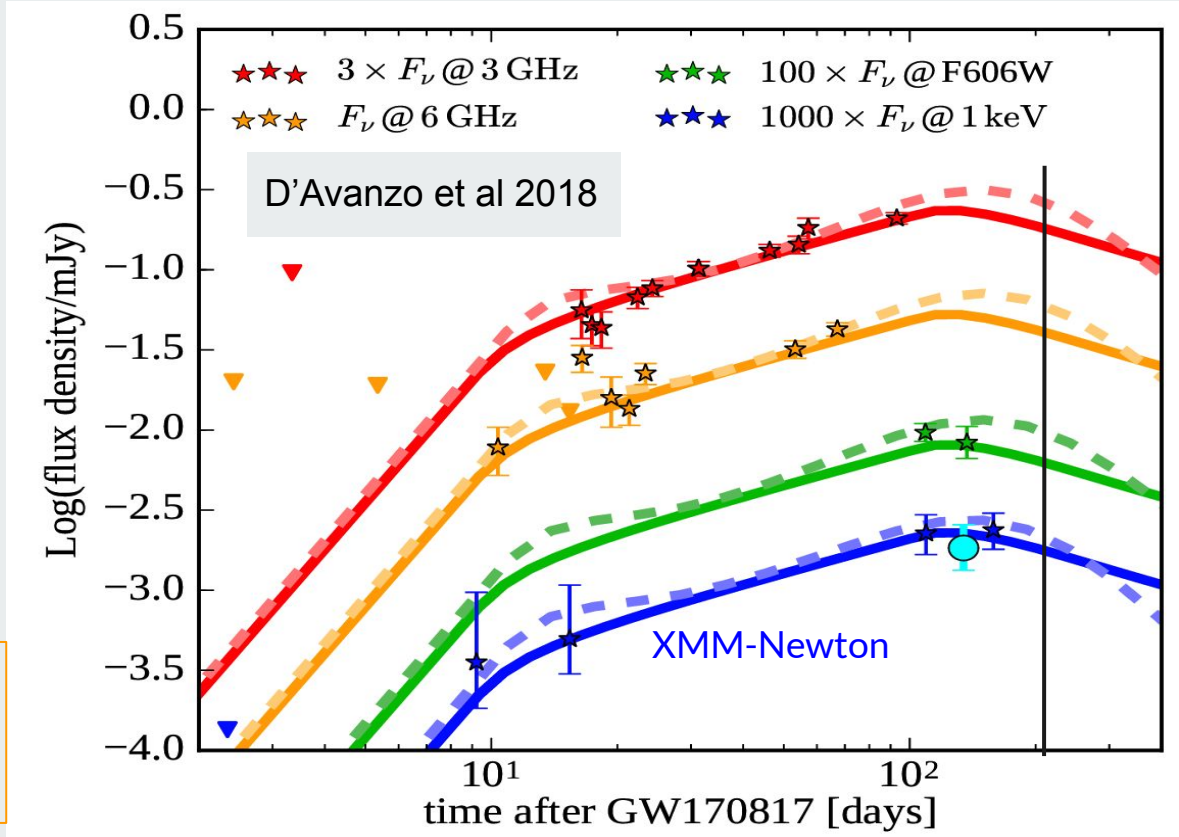
First GRB associated to a GW event.

First detection of the electromagnetic counterpart from a gravitational waves event. (NS-NS merger)

The atypical behavior of the afterglow from GRB 170817A.
From this GRB, the X-ray band appears until 9 days from the merger event and radio until 16 days after merger.

The peak in radio appears approximately 300 days after the merger.

For this reason, we search for late emission in GRBs with similar characteristics in the HAWC field of view



Search for short GRBs in HAWC similar to GRB170817A.

Methodology I

Manual procedure presented in von Kienlin, A., et al. (2019):

Sample selection on Fermi-GBM bursts from December 2014 - July 2022

1. $T_{90} < 2$ s , $T_{90} < 3.5$ s and $T_{90} < 5$ s.
2. Location in Dec range.
3. Cuts:
   - $(t_{50start} - t_{90start}) / (t_{90}) < 0.2$
   - $0.1 < t_{50}/t_{90} < 0.7$
   - Flux Peak (64ms) < 10 ph cm^{-2} s^{-1}

Over the table: Number of bursts passing each criterion

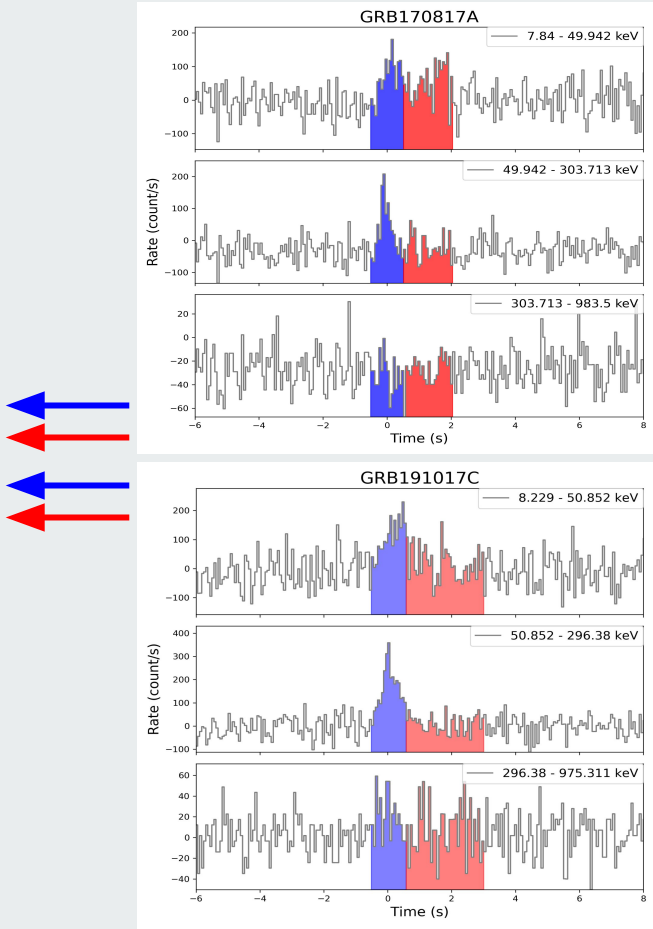
T_{90} < (s)	DEC range (deg)	in FoV	Temporal break
2	[−20 : 60]	193/295	54/295
	[−10 : 50]	150/295	40/295
	[0 : 40]	109/295	29/295
3.5	[−20 : 60]	226/360	67/360
	[−10 : 50]	176/360	49/360
	[0 : 40]	126/360	34/360
5	[−20 : 60]	261/420	81/420
	[−10 : 50]	202/420	54/420
	[0 : 40]	144/420	43/420

Methodology II

Spectral analysis:

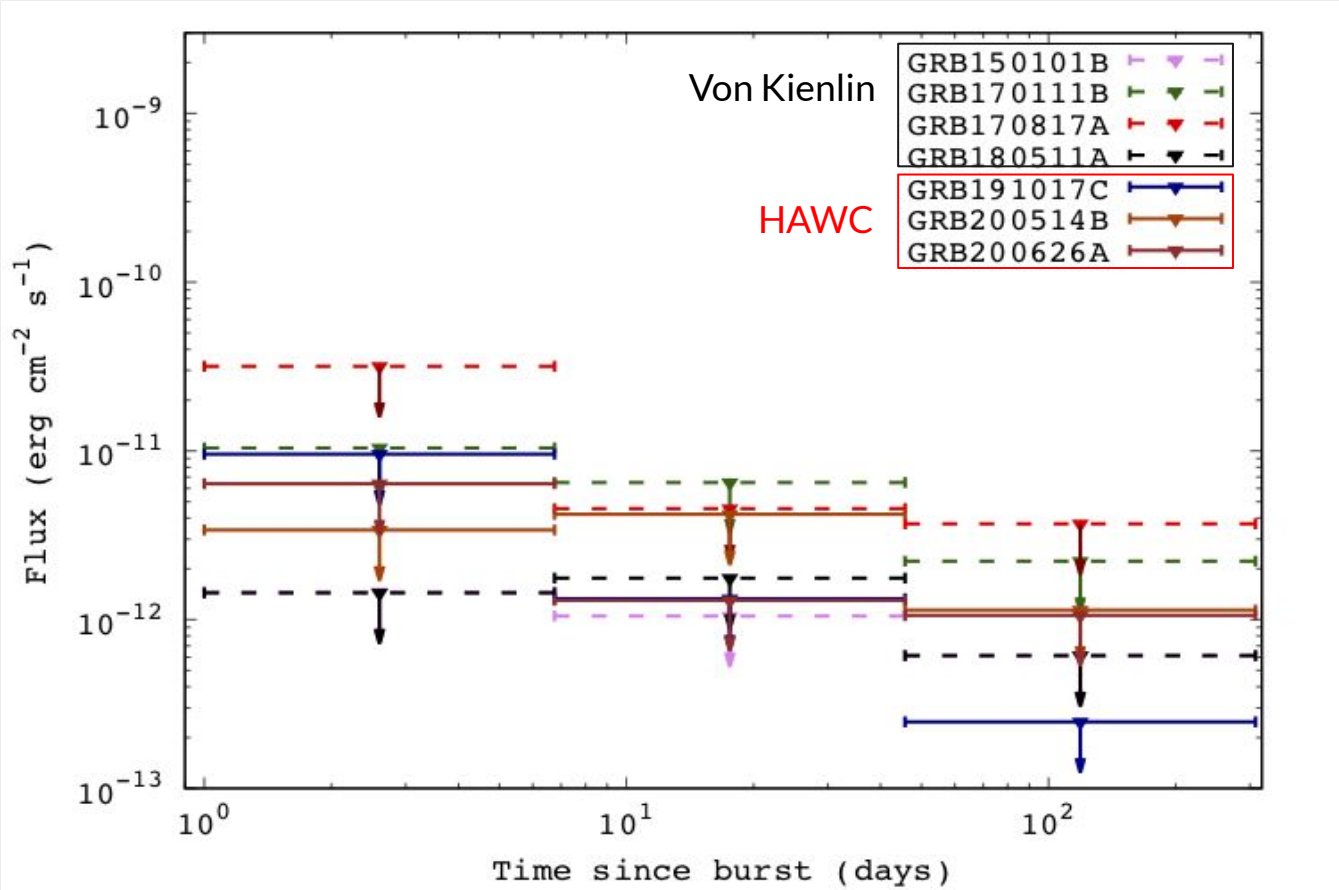
1. Initial peak: Comptonized (Compt)
2. Soft tail: Black Body (BB)

GRB	time (s)	Model	Epeak (keV)	Index	kT	C-stat/DOF
GRB150101B*	-0.016:0.0002	Compt	524 ±176	-0.80 ± 0.20		638.2/885
	0.000:0.064	BB			6.0 ± 0.6	731.3/886
GRB170111B*	-0.128:0.384	Compt	154 ±22	-0.62 ± 0.19		697.0/663
	0.768:0.960	BB			8.1 ± 1.0	731.3/886
GRB170817A*	-0.512:0.512	Compt	181.7 ±85.6	-0.84 ± 0.4		256.76/253
	0.512:2.048	BB			9.69 ± 1.16	320.74/254
GRB180511A*	-0.032:0.032	Compt	639±220	-0.61±0.22		697.9/717
	0.032:0.128	BB			11.1±3.0	667.4/718
GRB191017C	-0.064:0.768	Compt	304 ± 107	-0.81 ± 0.22		248.42/55
	0.768:1.92	BB			12.25 ± 3.18	316.79/256
GRB200514B	-0.256:0.256	Compt	441.7 ± 55	-0.66 ± 0.12		2939.6/249
	0.256:1.408	BB			56.82 ± 1.04	10489/250
GRB200626A	-0.768:0.768	Compt	36.83 ± 0.322	-1.14 ± 0.02		60250/249
	0.768:1.92	BB			20.03 ± 0.02	63729/250



Results: HAWC Upper limits

No significant detection was observed.



Redshift z=0.01 for all

GRB 150101B
GRB 170111B
GRB 170817A
GRB 180511A
GRB 191017C
GRB 200514B
GRB 200626A

Three time bins
bin1 = 7 days
bin2 = 46 days
bin3 = 247 days

Summary

1. Upper limits were calculated for the entire sample of 7 GRBs.

2. We extend the sample showed in von kienlin et al. (2019) with three more bursts that may be consistent with GRB 170817A.
   a. **GRB 191017C**
   b. **GRB 200514B**
   c. **GRB 200626A**

3. Future work: finish analyzing the sample until 2022.