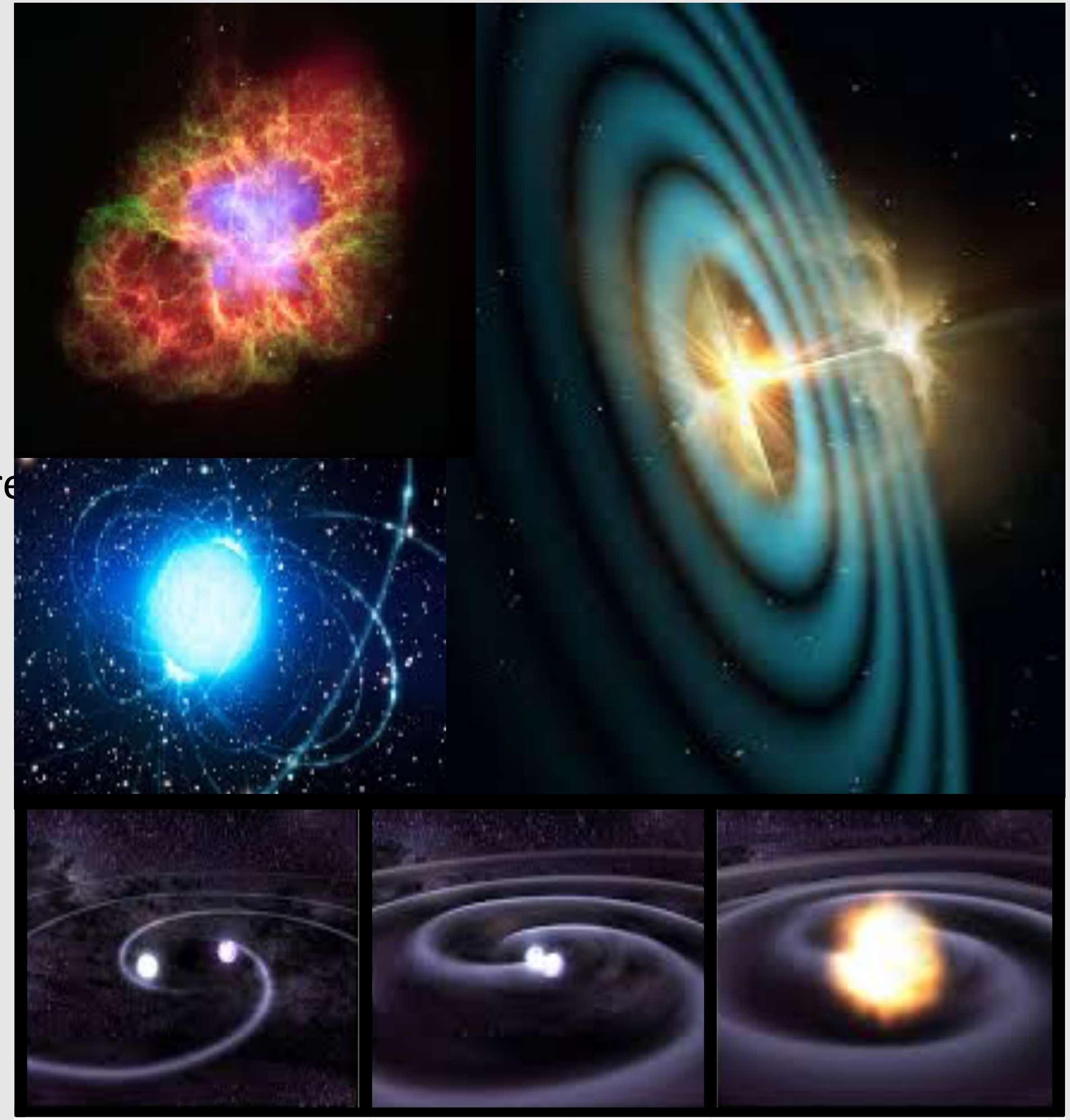
# MOM 2021

G. Modestino LNF-GR2

## Multimessenger Observatory Model

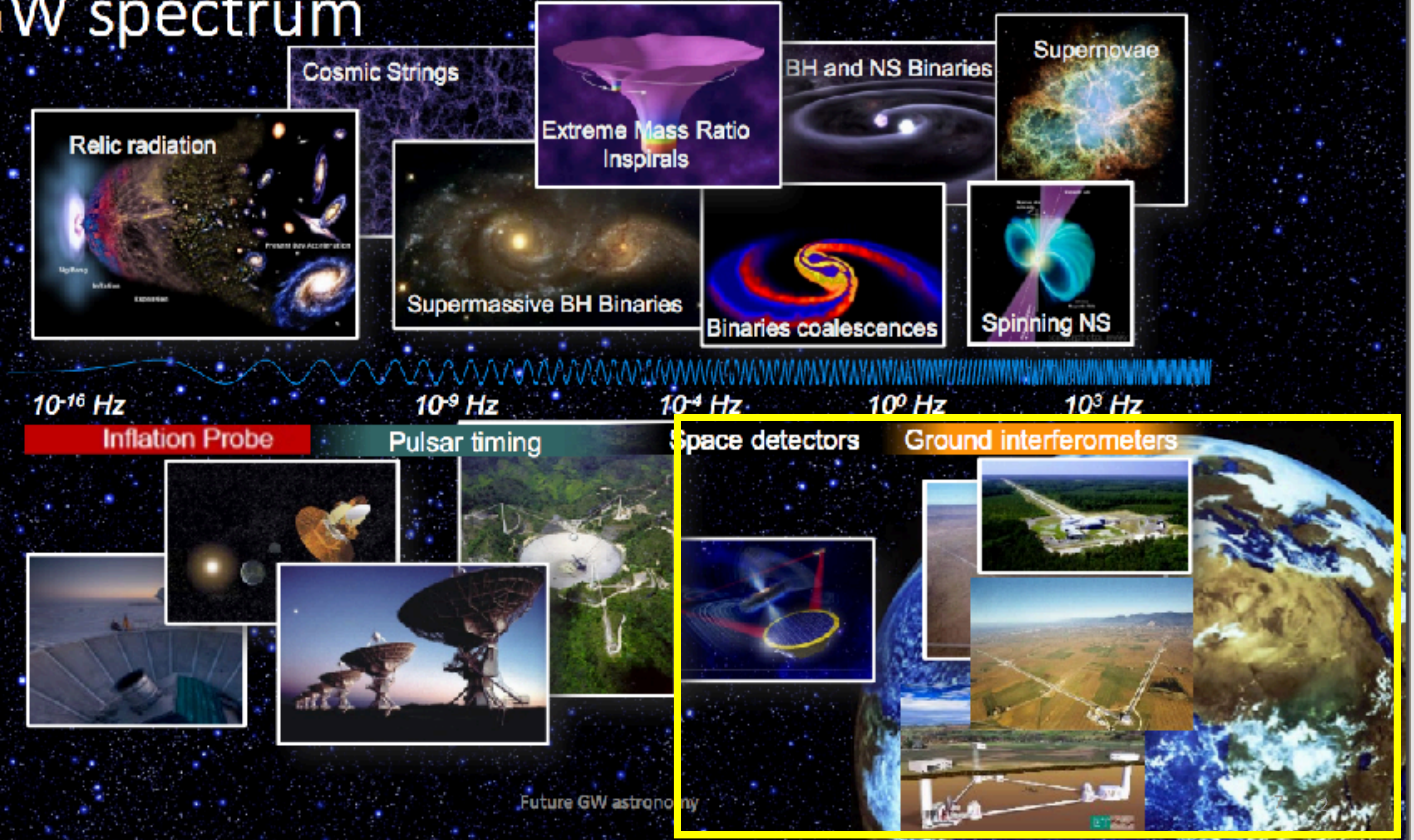


- Study of gravitational wave signals in association with extre astrophysical phenomena

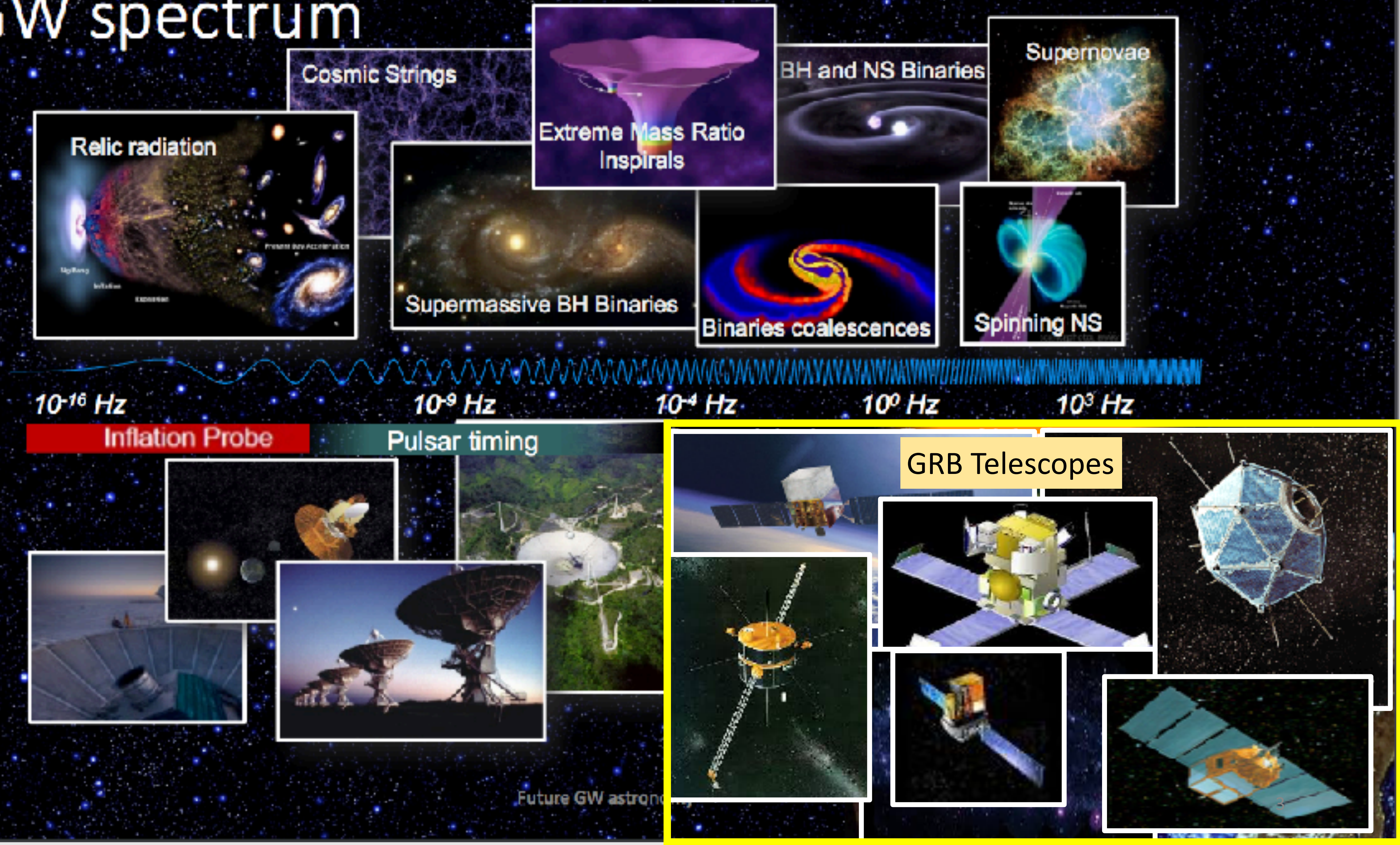
- Review of coincident analysis between GW-GRB events

- GRB data and progenitors
- Astrophysical constraints
- GW170817 vs previous LVC measurements
- Open-ended questions

# The GW spectrum



# The GW spectrum



# GRB Astronomy (since 1968)

10 < EM Satellites

~ 10000 Detected Events

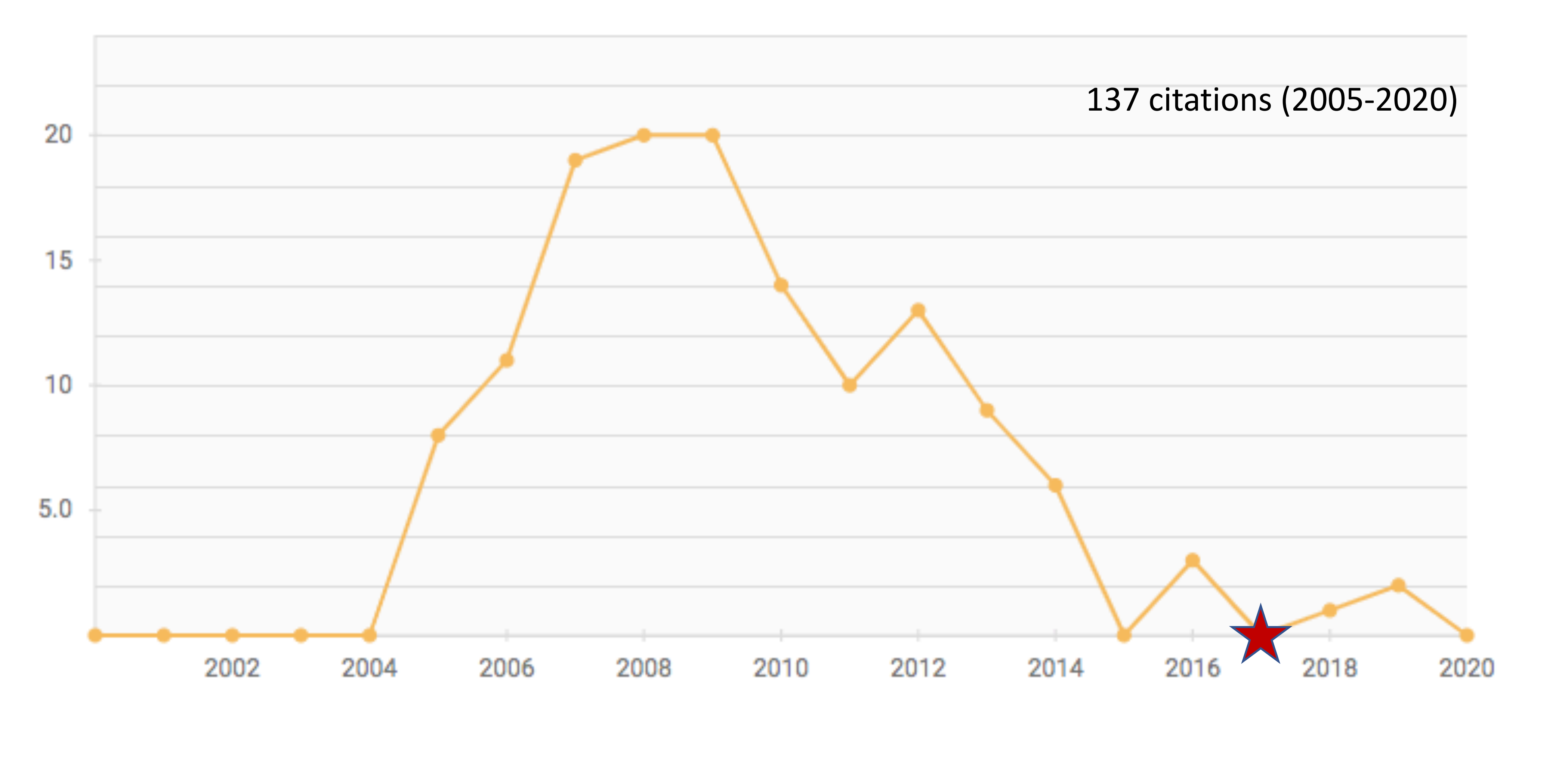
(GRB - GF - SGR – Afterglow)

~ 10000 Candidates for

- Supernovae (SN)
- Magnetars - Soft Gamma Repeaters (SGR)
- Binary system coalescence – merger (NS-NS; BH-NS)

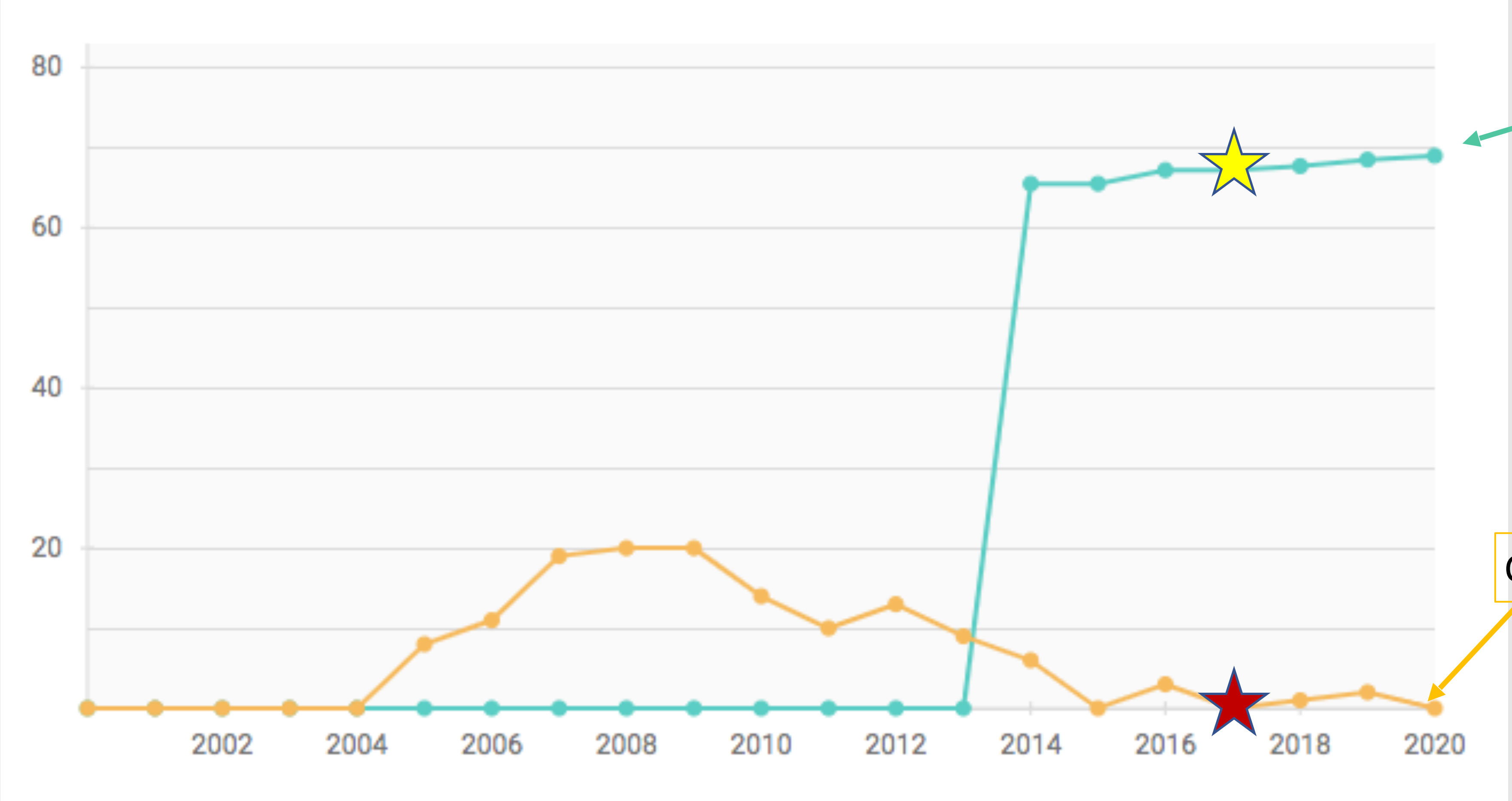
# Search for gravitational waves associated with the gamma ray burst GRB030329 using the LIGO detectors

PHYSICAL REVIEW D **72,** 042002 (2005)



# Search for gravitational waves associated with the gamma ray burst GRB030329 using the LIGO detectors

PHYSICAL REVIEW D **72,** 042002 (2005)

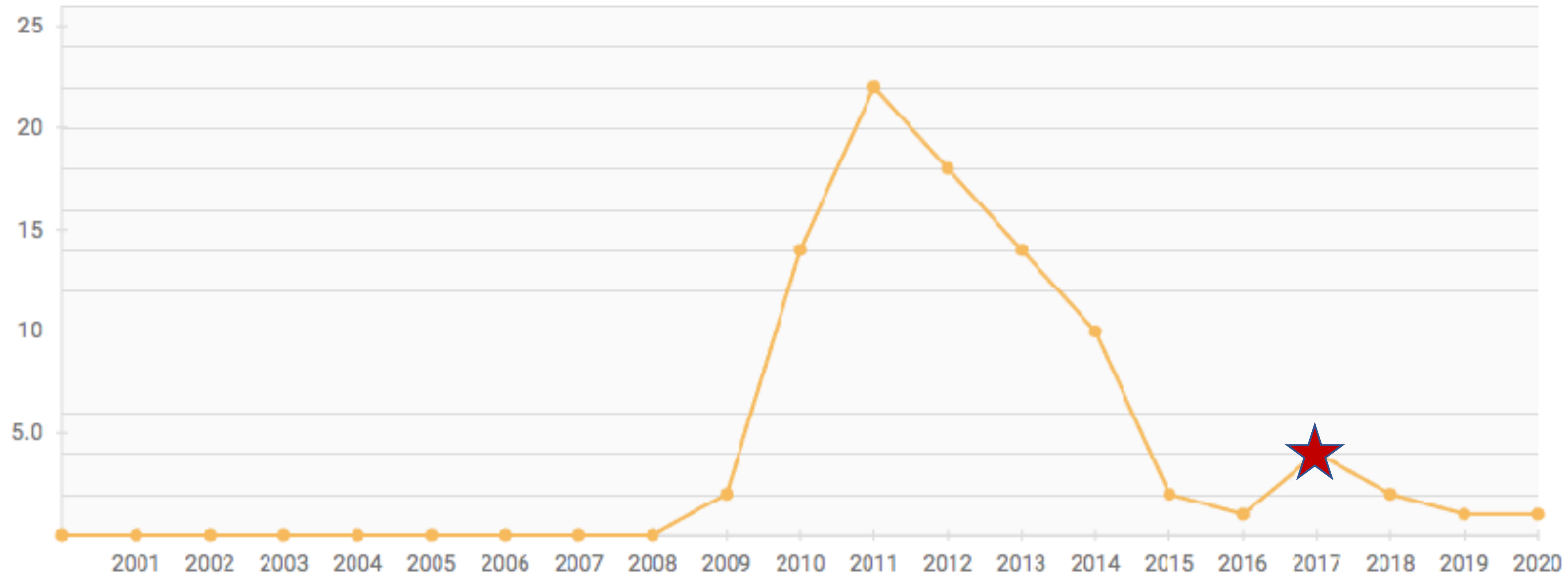



Research interest

Citations per year

cle Search for Gravitational-wave Inspiral Signals Associated with Short Gamma-ray Bursts During LIGO's Fifth and Virgo's First Science Run





Article **Search for Gravitational-wave Inspiral Signals Associated with Short Gamma-ray Bursts During LIGO's Fifth and Virgo's First Science Run**

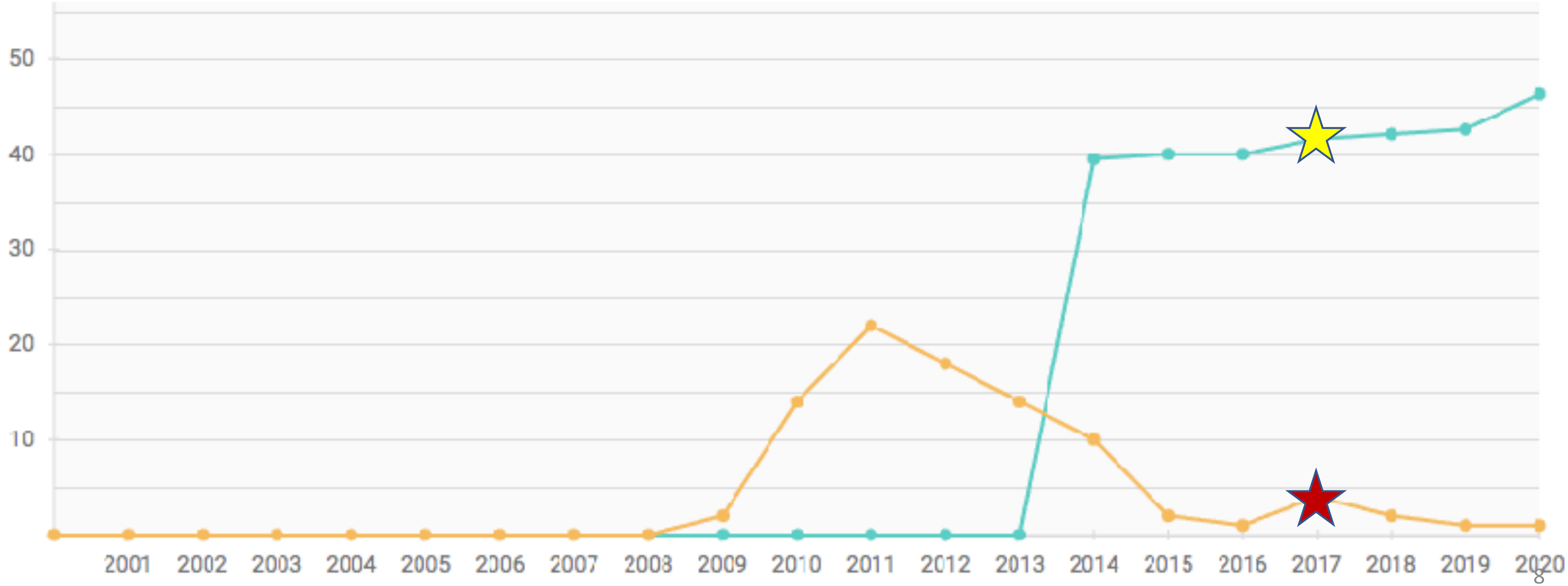
Overview | Stats | Comments | Citations (91) | References (67) | Related research (10+) | Download

Research Interest

Citations · View only

Recommendations

Reads



# Search for gravitational-wave bursts associated with gamma-ray bursts using data from LIGO Science Run 5 and Virgo Science Run 1

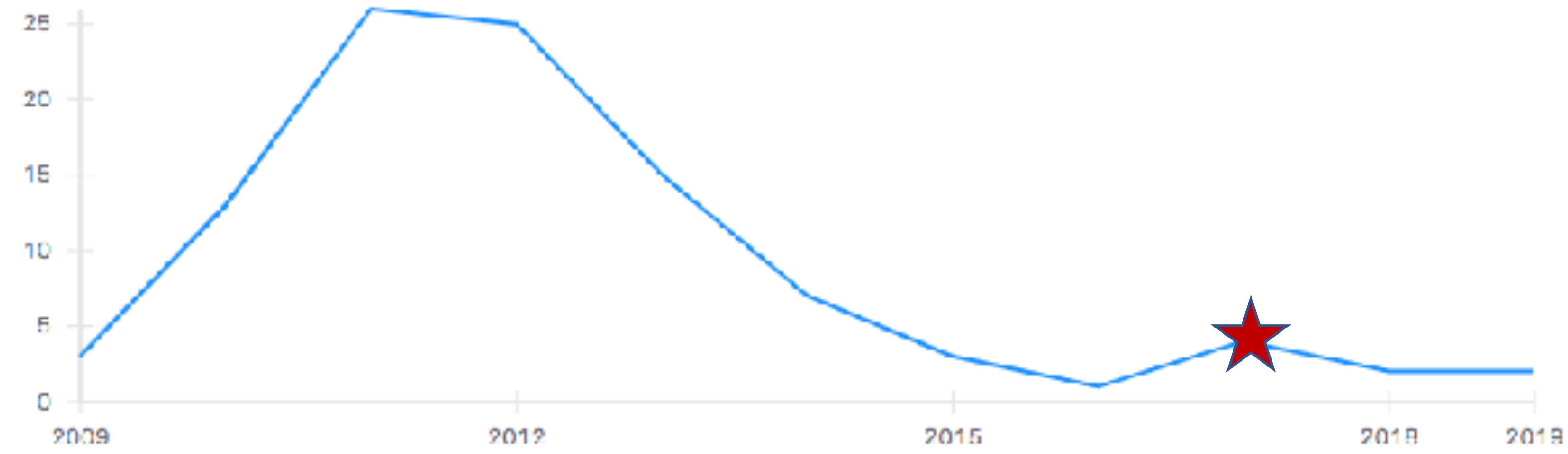
VIRGO Collaboration • B.P. Abbott (LIGO Lab., Caltech) Show All(666)

Aug 26, 2009

15 pages
Published in: *Astrophys.J.* 715 (2010) 1438-1452
e-Print: 0908.3824 [astro-ph.HE]
DOI: 10.1088/0004-637X/715/2/1438
Report number: LIGO-P0900023-V13, LIGO-P0900023-V16
Accelerator experiments: VIRGO
View in: HAL Archives Ouvertes, ADS Abstract Service

pdf cite 

## Citations per year



## Search for gravitational-wave inspiral signals associated with short Gamma-Ray Bursts during LIGO's fifth and Virgo's first science run

LIGO Scientific and VIRGO Collaborations • J. Abadie (LIGO Lab., Caltech) Show All(666)

Jan 4, 2010

8 pages

Published in: *Astrophys.J.* 715 (2010) 1453-1481

e-Print: 1001.0165 [astro-ph.HE]

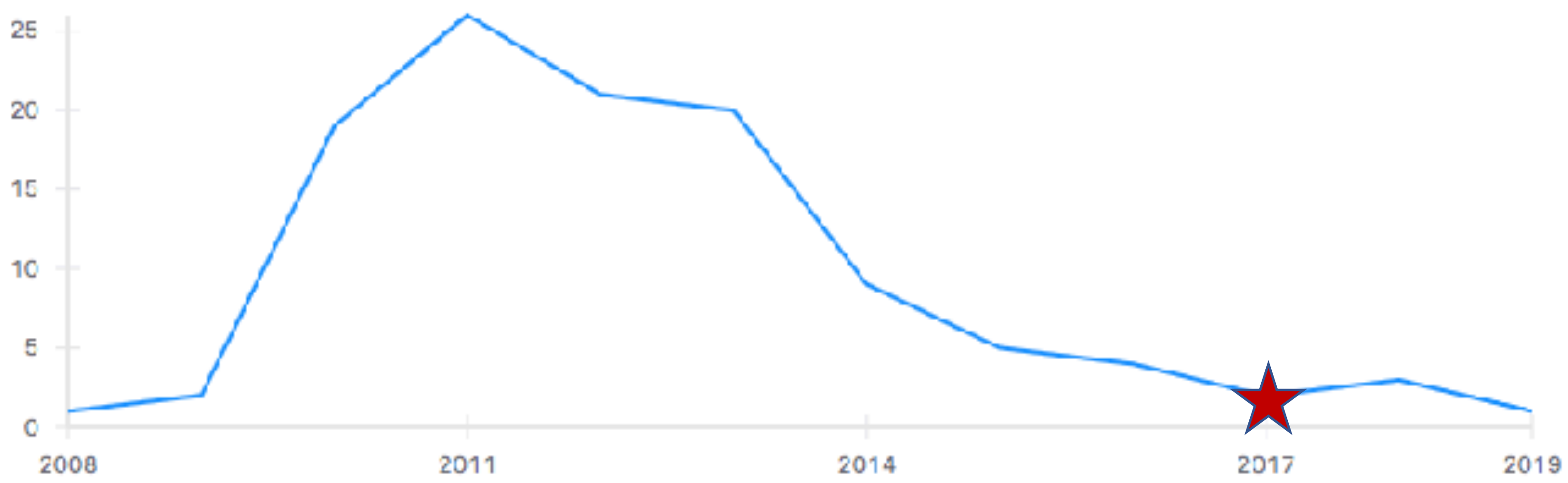
DOI: 10.1088/0004-637X/715/2/1453

Accelerator experiments: LIGO, VIRGO

View in: HAL Archives Ouvertes, ADS Abstract Service

pdf cite 113 citations

### Citations per year



# Search for gravitational waves associated with gamma-ray bursts during LIGO science run 6 and Virgo science runs 2 and 3

LIGO Scientific Collaboration • J. Abadie (LIGO Lab., Caltech) Show All(808)

May 10, 2012

19 pages

Published in: *Astrophys.J.* 760 (2012) 12

e-Print: 1205.2216 [astro-ph.HE]

DOI: 10.1088/0004-637X/760/1/12

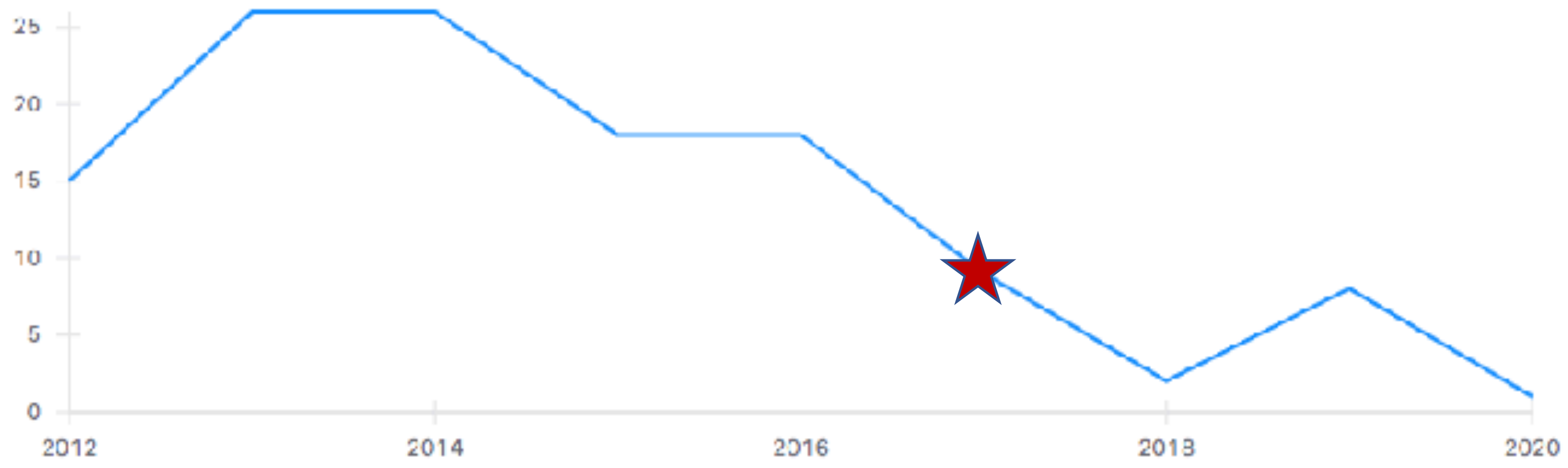
Report number: LIGO-P1000121

Accelerator experiments: LIGO

View in: HAL Archives Ouvertes, ADS Abstract Service

pdf cite 123 citations

## Citations per year



# Search for gravitational wave radiation associated with the pulsating tail of the SGR 1806-20 hyperflare of 27 December 2004 using LIGO

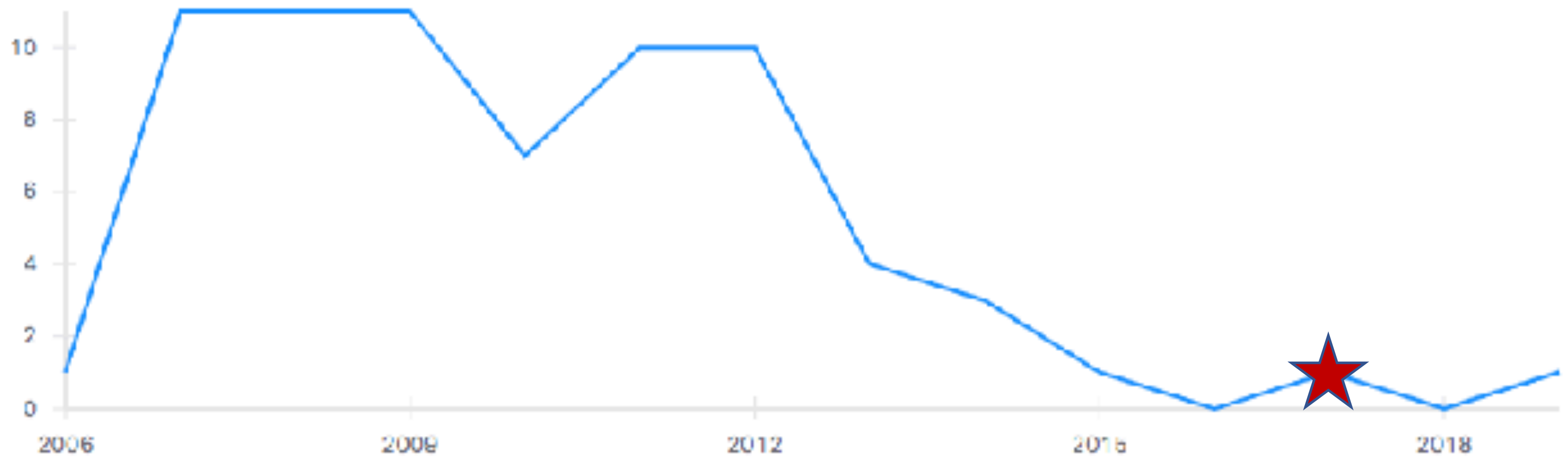
LIGO Scientific Collaboration • B. Abbott (LIGO Lab., Caltech) Show All(447)

Mar 18, 2007

13 pages
Published in: *Phys.Rev.D* 76 (2007) 062003
e-Print: astro-ph/0703419 [astro-ph]
DOI: 10.1103/PhysRevD.76.062003
Report number: LIGO-P040055-01-Z
Accelerator experiments: LIGO
View in: ADS Abstract Service

pdf cite 

## Citations per year



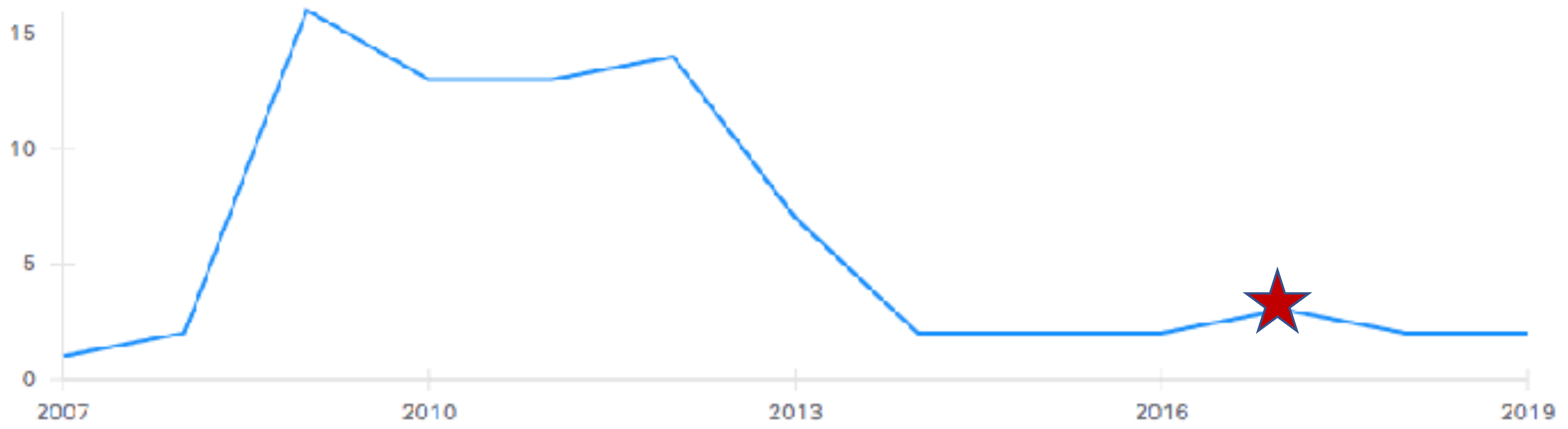
# Search for Gravitational Wave Bursts from Soft Gamma Repeaters

LIGO Scientific Collaboration • B. Abbott (Caltech) Show All(447)
Aug 17, 2008

6 pages
Published in: *Phys.Rev.Lett.* 101 (2008) 211102
e-Print: 0808.2050 [astro-ph]
DOI: 10.1103/PhysRevLett.101.211102
Report number: LIGO-P070105-04-Z
Accelerator experiments: LIGO
View in: ADS Abstract Service

pdf cite 79 citations

## Citations per year



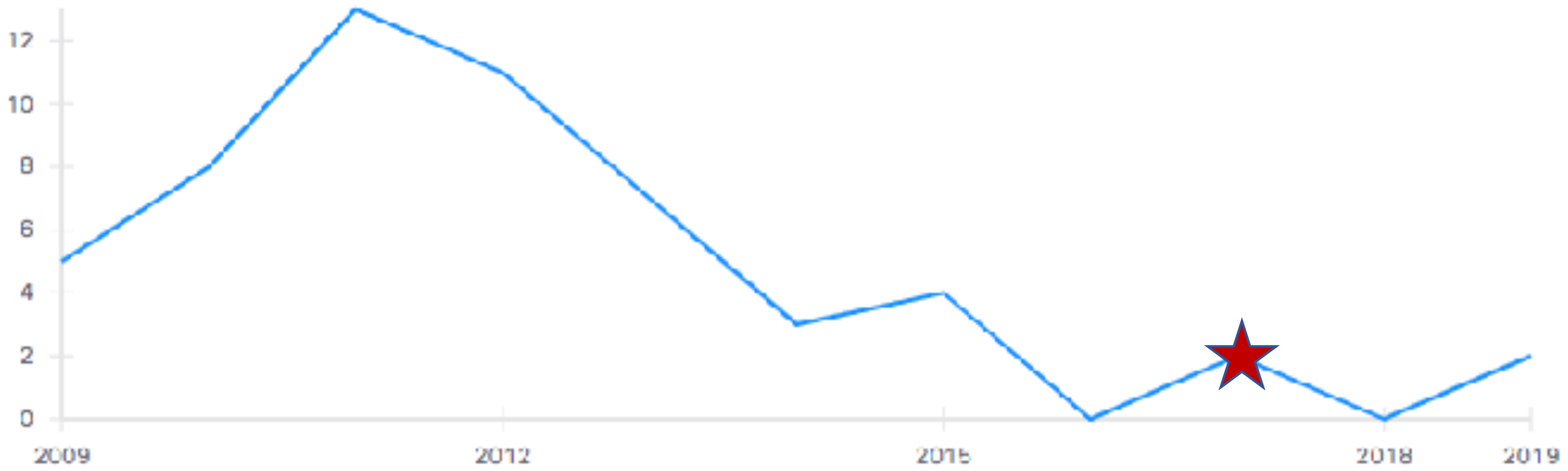
## Stacked Search for Gravitational Waves from the 2006 SGR 1900+14 Storm

LIGO Scientific Collaboration • B.P. Abbott (LIGO Lab., Caltech) Show All(502)
May 3, 2009

7 pages
Published in: *Astrophys.J.Lett.* 701 (2009) L68-L74
e-Print: 0905.0005 [astro-ph.HE]
DOI: 10.1088/0004-637X/701/2/L68
Report number: LIGO-P0900024
Accelerator experiments: LIGO
View in: ADS Abstract Service

pdf cite 66 citations

### Citations per year



## Search for Gravitational Wave Bursts from Six Magnetars

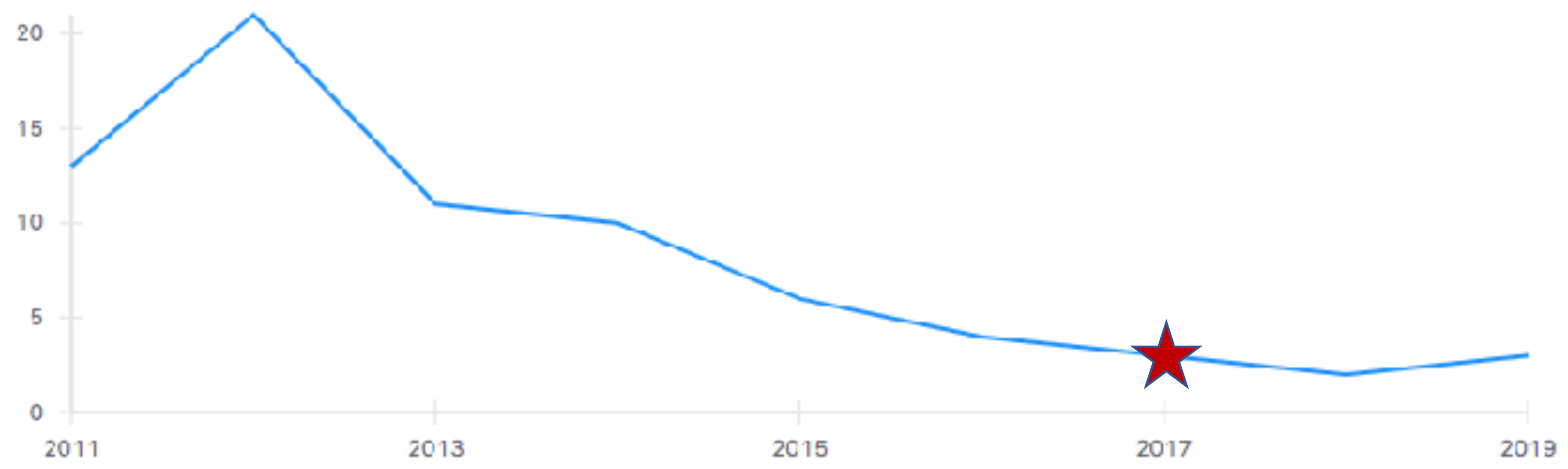
LIGO Scientific and Virgo Collaborations • J. Abadie (Caltech) Show All(768)

Nov 18, 2010

9 pages
Published in: *Astrophys.J.Lett.* 734 (2011) L35
e-Print: 1011.4079 [astro-ph.HE]
DOI: 10.1088/2041-8205/734/2/L35
Accelerator experiments: LIGO, VIRGO
View in: ADS Abstract Service

pdf cite 

### Citations per year



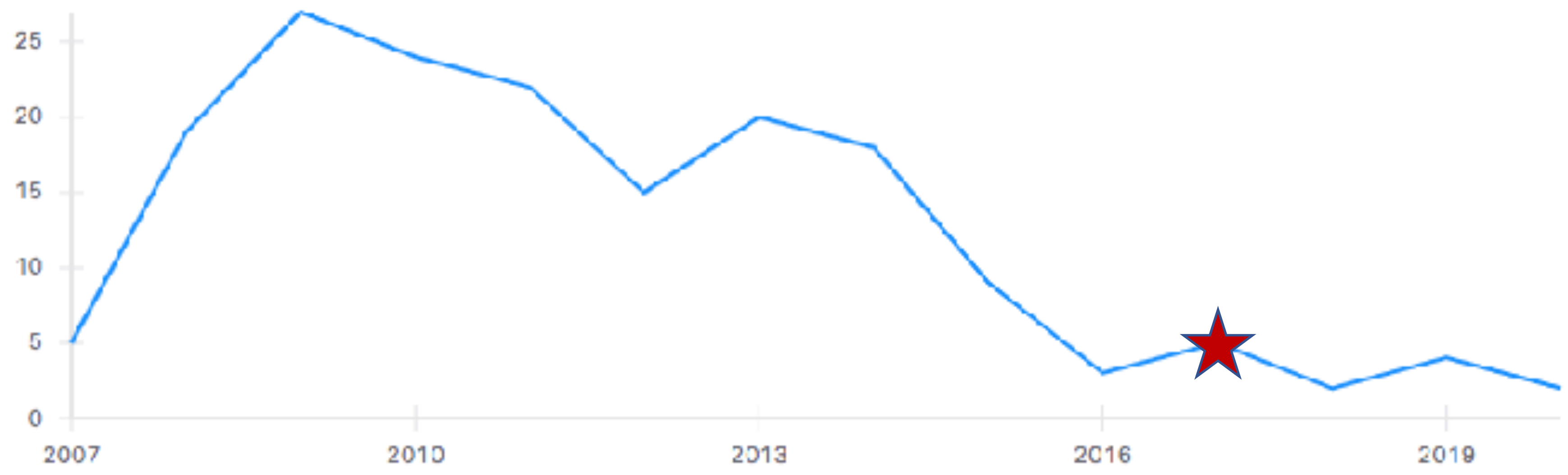
# Implications for the Origin of GRB 070201 from LIGO Observations

LIGO Scientific Collaboration • B. Abbott (LIGO Lab., Caltech) Show All(428)
Nov 8, 2007

10 pages
Published in: *Astrophys.J.* 681 (2008) 1419-1428
e-Print: 0711.1163 [astro-ph]
DOI: 10.1086/587954
Report number: LIGO-P070081-A
Accelerator experiments: LIGO
View in: ADS Abstract Service



## Citations per year



# Implications For The Origin Of GRB 051103 From LIGO Observations

LIGO Scientific Collaboration • J. Abadie (LIGO Lab., Caltech) Show All(570)

Jan 23, 2012

8 pages

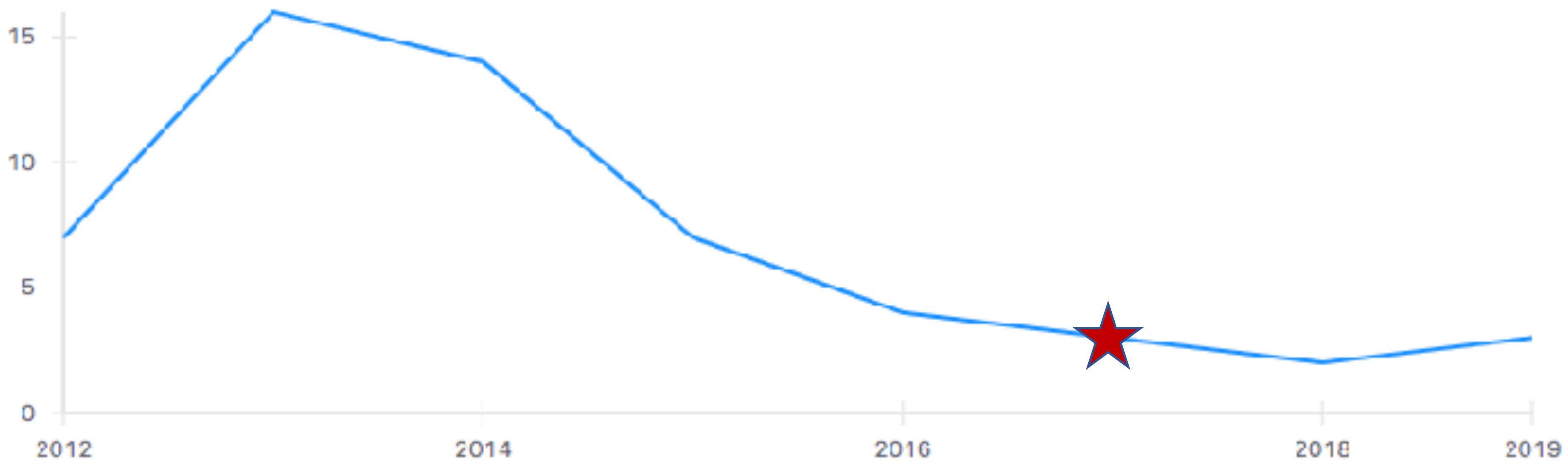
Published in: *Astrophys.J.* 755 (2012) 2
e-Print: 1201.4413 [astro-ph.HE]
DOI: 10.1088/0004-637X/755/1/2

Accelerator experiments: LIGO

View in: HAL Archives Ouvertes, ADS Abstract Service

pdf   cite   56 citations

## Citations per year



# GW170817: Observation of Gravitational Waves from a Binary Neutron Star Inspiral

B. P. Abbott *et al.**

(LIGO Scientific Collaboration and Virgo Collaboration)

(Received 26 September 2017; revised manuscript received 2 October 2017; published 16 October 2017)

On August 17, 2017 at 12:41:04 UTC the Advanced LIGO and Advanced Virgo gravitational-wave detectors made their first observation of a binary neutron star inspiral. The signal, GW170817, was detected with a combined signal-to-noise ratio of 32.4 and a false-alarm-rate estimate of less than one per $8.0 \times 10^4$ years. We infer the component masses of the binary to be between 0.86 and 2.26 $M_\odot$, in agreement with masses of known neutron stars. Restricting the component spins to the range inferred in binary neutron stars, we find the component masses to be in the range 1.17–1.60 $M_\odot$, with the total mass of the system $2.74^{+0.04}_{-0.01} M_\odot$. The source was localized within a sky region of 28 $\mathrm{deg}^2$ (90% probability) and had a luminosity distance of $40^{+8}_{-14}$ Mpc, the closest and most precisely localized gravitational-wave signal yet. The association with the $\gamma$-ray burst GRB 170817A, detected by Fermi-GBM 1.7 s after the coalescence, corroborates the hypothesis of a neutron star merger and provides the first direct evidence of a link between these mergers and short $\gamma$-ray bursts. Subsequent identification of transient counterparts across the electromagnetic spectrum in the same location further supports the interpretation of this event as a neutron star merger. This unprecedented joint gravitational and electromagnetic observation provides insight into astrophysics, dense matter, gravitation, and cosmology.

The Astrophysical Journal Letters, 851:L16 (13pp), 2017 December 10 https://doi.org/10.3847/2041-8213/aa9a35


CrossMark

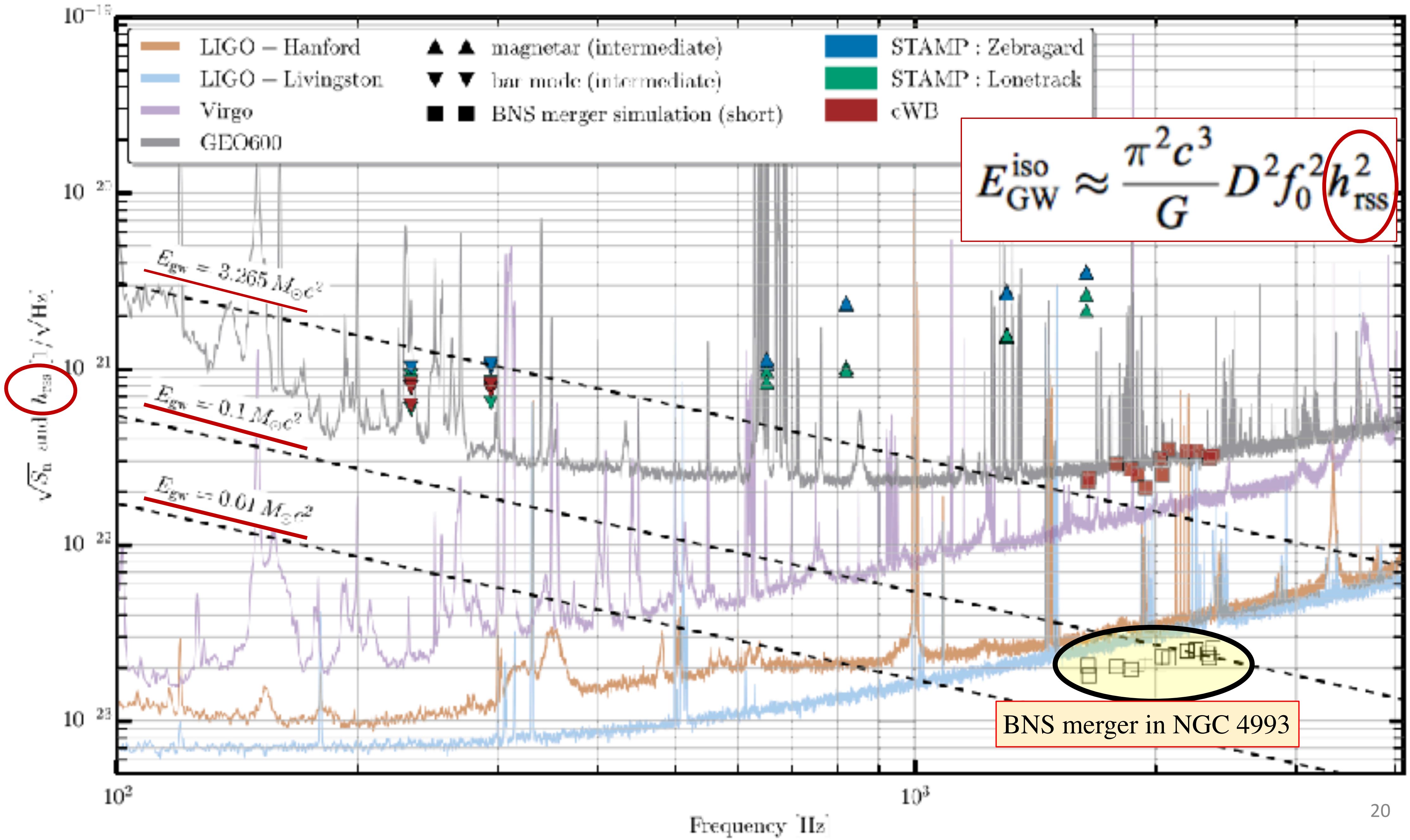
# Search for Post-merger Gravitational Waves from the Remnant of the Binary Neutron Star Merger GW170817

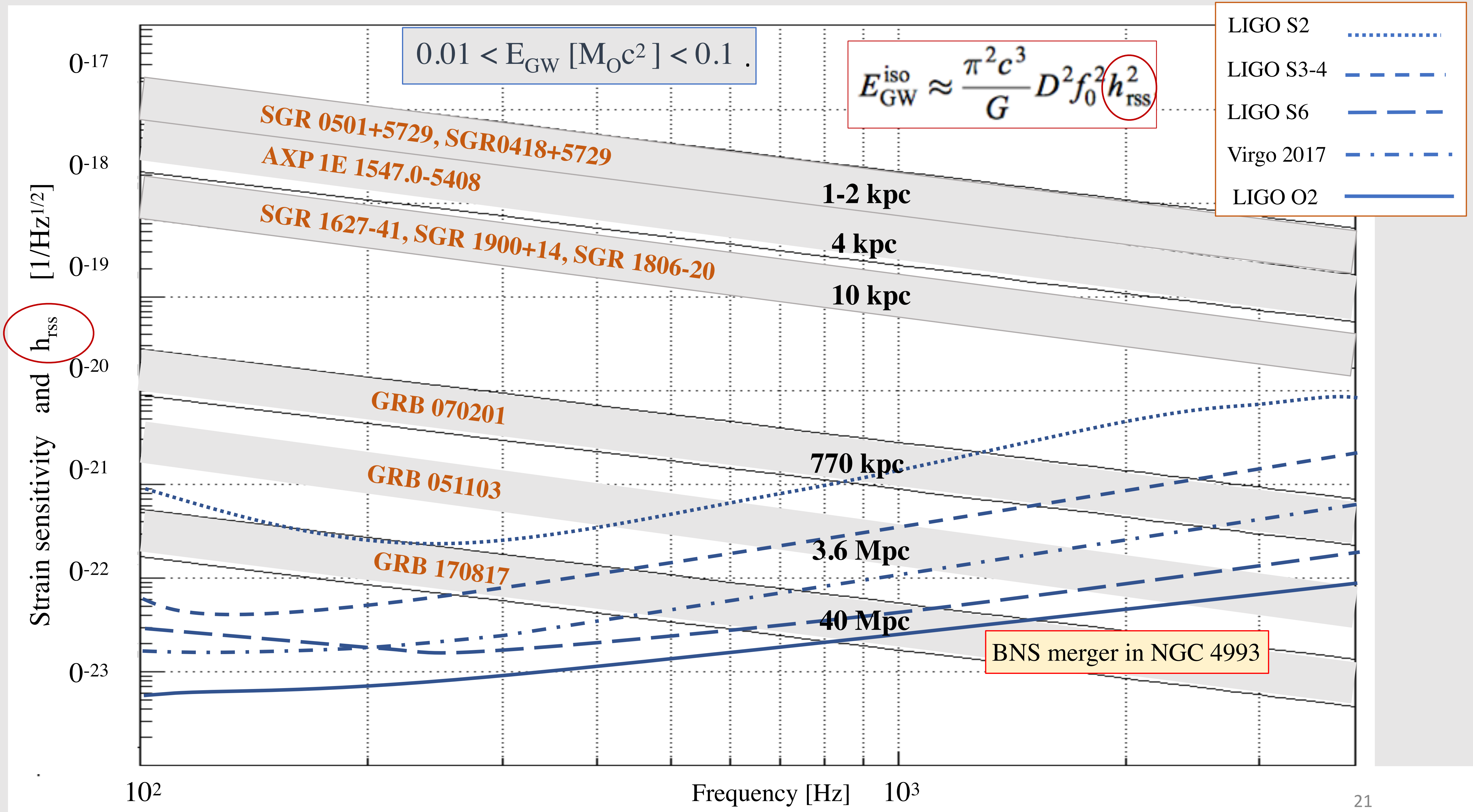
LIGO Scientific Collaboration and Virgo Collaboration
(See the end matter for the full list of authors.)

*Received 2017 October 25; revised 2017 November 10; accepted 2017 November 12; published 2017 December 7*

## Abstract

The first observation of a binary neutron star (NS) coalescence by the Advanced LIGO and Advanced Virgo gravitational-wave (GW) detectors offers an unprecedented opportunity to study matter under the most extreme conditions. After such a merger, a compact remnant is left over whose nature depends primarily on the masses of the inspiraling objects and on the equation of state of nuclear matter. This could be either a black hole (BH) or an NS, with the latter being either long-lived or too massive for stability implying delayed collapse to a BH. Here, we present a search for GWs from the remnant of the binary NS merger GW170817 using data from Advanced LIGO and Advanced Virgo. We search for short- ($\lesssim$1 s) and intermediate-duration ($\lesssim$500 s) signals, which include GW emission from a hypermassive NS or supramassive NS, respectively. We find no signal from the post-merger remnant. Our derived strain upper limits are more than an order of magnitude larger than those predicted by most models. For short signals, our best upper limit on the root sum square of the GW strain emitted from 1–4 kHz is $h_{\rm rss}^{50\%} = 2.1 \times 10^{-22}$ Hz$^{-1/2}$ at 50% detection efficiency. For intermediate-duration signals, our best upper limit at 50% detection efficiency is $h_{\rm rss}^{50\%} = 8.4 \times 10^{-22}$ Hz$^{-1/2}$ for a millisecond magnetar model, and $h_{\rm rss}^{50\%} = 5.9 \times 10^{-22}$ Hz$^{-1/2}$ for a bar-mode model. These results indicate that post-merger emission from a similar event may be detectable when advanced detectors reach design sensitivity or with next-generation detectors.


LIGO – Hanford
LIGO – Livingston
Virgo
GEO600
magnetar (intermediate)
bar mode (intermediate)
BNS merger simulation (short)
STAMP : Zebragard
STAMP : Lonetrack
cWB
$E_{GW}^{iso} \approx \frac{\pi^2 c^3}{G} D^2 f_0^2 h_{rss}^2$
$E_{gw} = 3.265\, M_\odot c^2$
$E_{gw} = 0.1\, M_\odot c^2$
$E_{gw} = 0.01\, M_\odot c^2$
BNS merger in NGC 4993
Frequency [Hz]



0.01 < E_GW [M_O c² ] < 0.1
$E_{GW}^{iso} \approx \frac{\pi^2 c^3}{G} D^2 f_0^2 h_{rss}^2$
LIGO S2
LIGO S3-4
LIGO S6
Virgo 2017
LIGO O2
SGR 0501+5729, SGR0418+5729
AXP 1E 1547.0-5408
SGR 1627-41, SGR 1900+14, SGR 1806-20
1-2 kpc
4 kpc
10 kpc
GRB 070201
770 kpc
GRB 051103
3.6 Mpc
GRB 170817
40 Mpc
BNS merger in NGC 4993
Strain sensitivity and h_rss [1/Hz^1/2]
0-17
0-18
0-19
0-20
0-21
0-22
0-23
10²
Frequency [Hz]
10³

# Multimessenger Astronomy (Searching for)

- Supernovae (SN)
- Magnetars - Soft Gamma Repeaters (SGR)
- Binary system coalescence – merger – (NS-NS; BH-NS)

## MOM Questions

1. Astrophysical data interpretation (only) from EM Telescopes
2. GRB-GW astrophysical correlation (LVC-GRB since 2003)
3. GW170817 vs (previous) LVC measurements