

Searches for Compact Binary Coalescences in LIGO and Virgo data

Gabriela González

For the LIGO Scientific Collaboration and the Virgo Collaboration

APS meeting, Feb 13 2010

Session B13: Observational Implications of Gravitational Waves

[LIGO-G1000112](#)



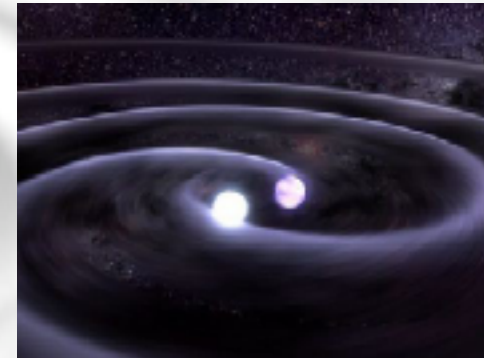
The LIGO-Virgo CBC group searches

LIGO – S5: November 4, 2005 – September 30, 2007

Virgo – VSR1: May 18, 2007 – September 30, 2007

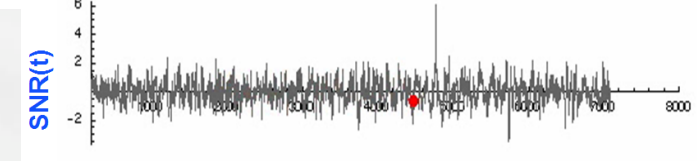
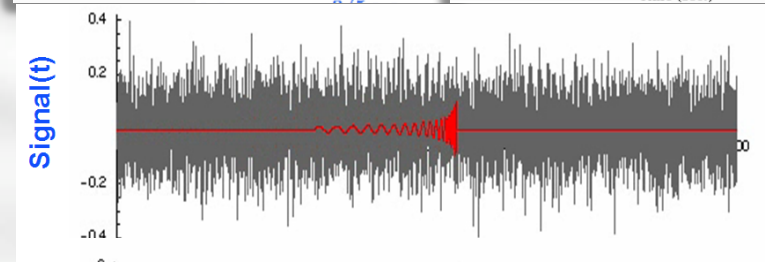
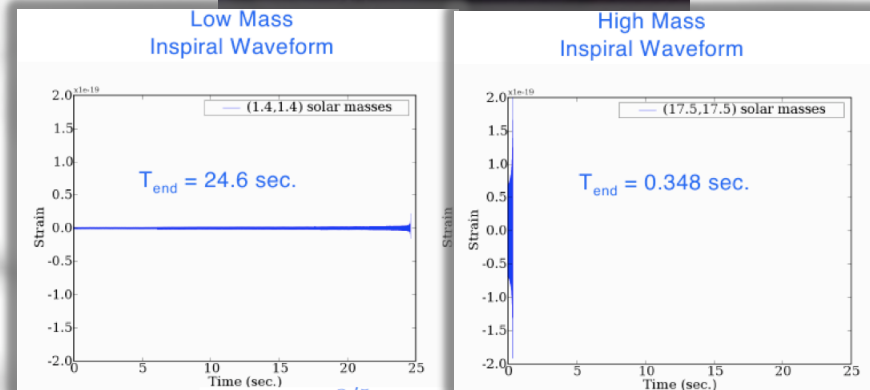
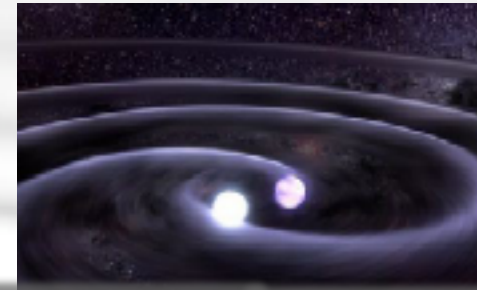
S6 and VSR2 started on July 7 2009 – S6/VSR2a=First 7 weeks

- Low mass search: Total mass from 2-35 M_{\odot}
 - S5 First year search:
PRD 79, 122001 (2009)
 - S5 12-18 month search:
PRD 80, 047101 (2009)
 - S5-VSR1 5 month joint search (nearing completion)
 - S6/VSR2a: Data analyzed
- High mass search: Total mass from 25-100 M_{\odot}
 - (nearing completion)
- S5-VSR1 GRB (triggered) search
 - arXiv:1001.0165v1 (2010)
- S5 Ringdown Search
- Spinning Search



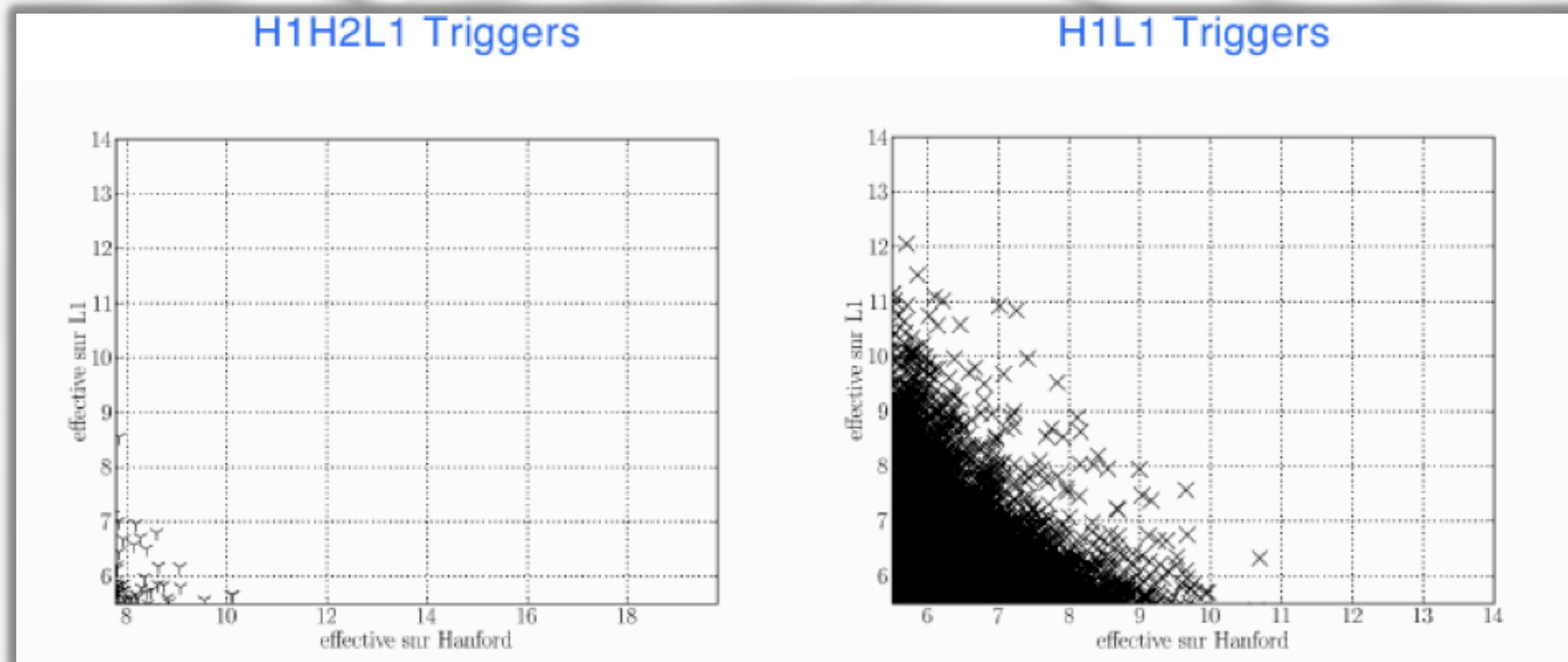
Overview of the Search Pipeline

- Generate a template bank
 - Total mass from 2-35 M_{\odot} (low mass search)
 - Total mass from 25-100 M_{\odot} (high mass search)
 - Minimum component mass 1 M_{\odot}
- Match filter the data
- Search for coincidence in multiple detectors
- Apply data quality
- Signal consistency checks
 - Use χ^2 parameter
- Calculate a false alarm rate
- Interpret the results



False alarm rates (FAR)

- Estimate looking for coincidences with unphysical time delays.
- 2 ifo background coincidences are more likely than 3 or 4 ifo coincidences
- We combine results using FAR, not SNR

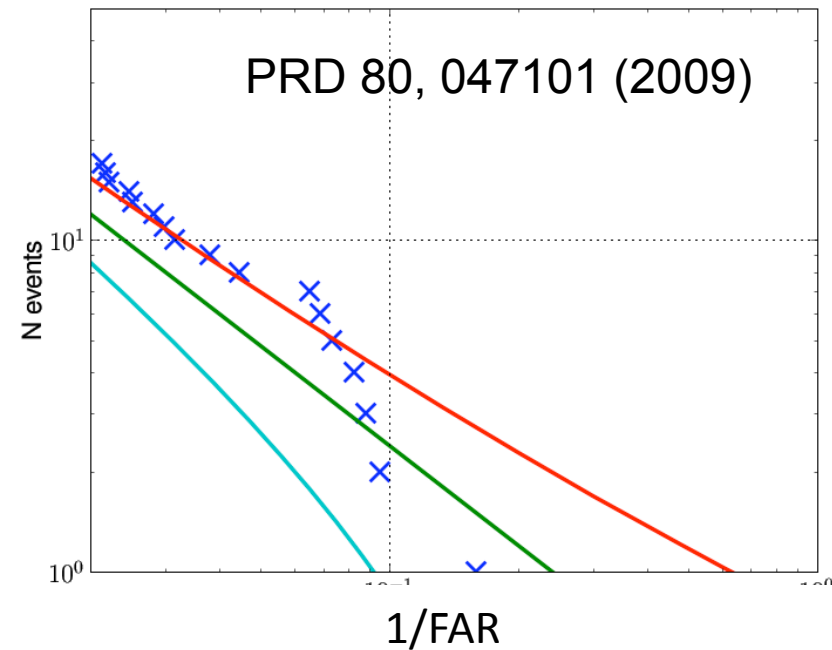
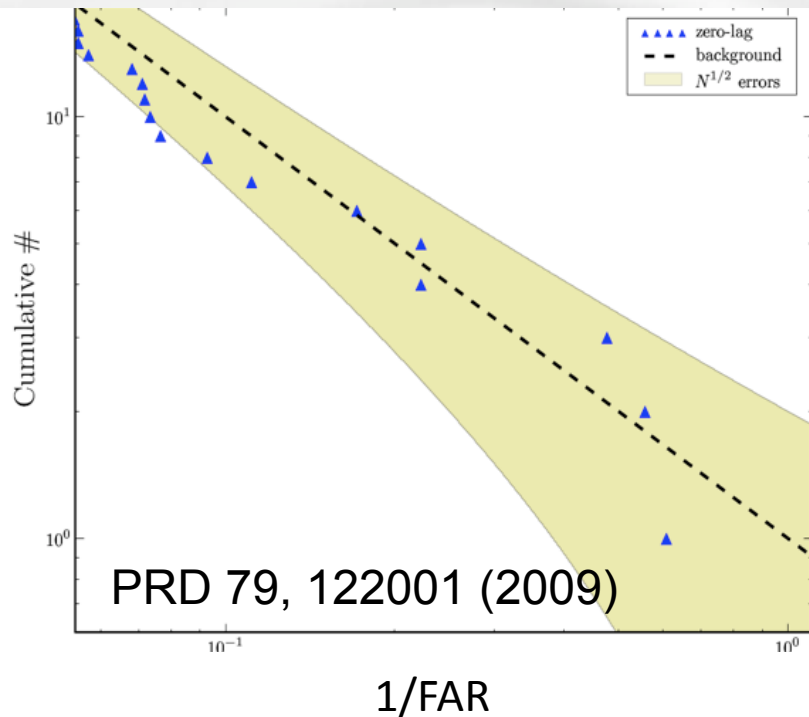


Low Mass Results (pre-VSR1)

Loudest triggers

S5 1st year low mass

S5 12-18 month search



High mass results and remaining S5-VSR1 low mass results will be ready soon!

Low Mass Results (pre-VSR1)

- No triggers were found that were inconsistent with background estimates.
- The loudest triggers were subject to our “follow-up process”
- Our conclusion is that no gravitational wave candidates were found in this search ☹️
- With no potential events, we set upper limits on the rates of binary coalescences.

Upper limits (pre-VSR1)

PRD 80, 047101 (2009)

	Binary neutron stars	Neutron star – black holes	Binary black holes
Current results	$1.4 \times 10^{-2} L_{10}^{-1} \text{yr}^{-1}$	$3.6 \times 10^{-3} L_{10}^{-1} \text{yr}^{-1}$	$7.3 \times 10^{-4} L_{10}^{-1} \text{yr}^{-1}$
Predicted “plausible” astrophysical rates	$6 \times 10^{-4} L_{10}^{-1} \text{yr}^{-1}$	$6 \times 10^{-5} L_{10}^{-1} \text{yr}^{-1}$	$2 \times 10^{-5} L_{10}^{-1} \text{yr}^{-1}$
Predicted “realistic” astrophysical rates	$6 \times 10^{-5} L_{10}^{-1} \text{yr}^{-1}$	$2 \times 10^{-6} L_{10}^{-1} \text{yr}^{-1}$	$2 \times 10^{-7} L_{10}^{-1} \text{yr}^{-1}$
Definition	$m_1 = m_2 = 1.35 M_{\odot}$	$m_1 = 5.0 M_{\odot},$ $m_2 = 1.35 M_{\odot}$	$m_1 = m_2 = 5.0 M_{\odot}$

Astrophysical rates: LIGO-P0900125

Milky Way – $1.7 L_{10}$



Searches for short GRBs

- Analyzed data:
S5/VSR1 Nov 2005-Nov 2007
- 212 GRBs in total
- 33 short GRB
- 22 short GRB with enough data from at least two interferometers

analyzed GRBs

051114	070209
051210	070429B
051211	070512
060121	070707
060313	070714
060427B	070714B
060429	070724
061006	070729
061201	070809
061217	070810B
070201	070923

L1, H1, V1 on!!

Previously published: No GW detected, inspiral merger excluded in M31 at >99% level.

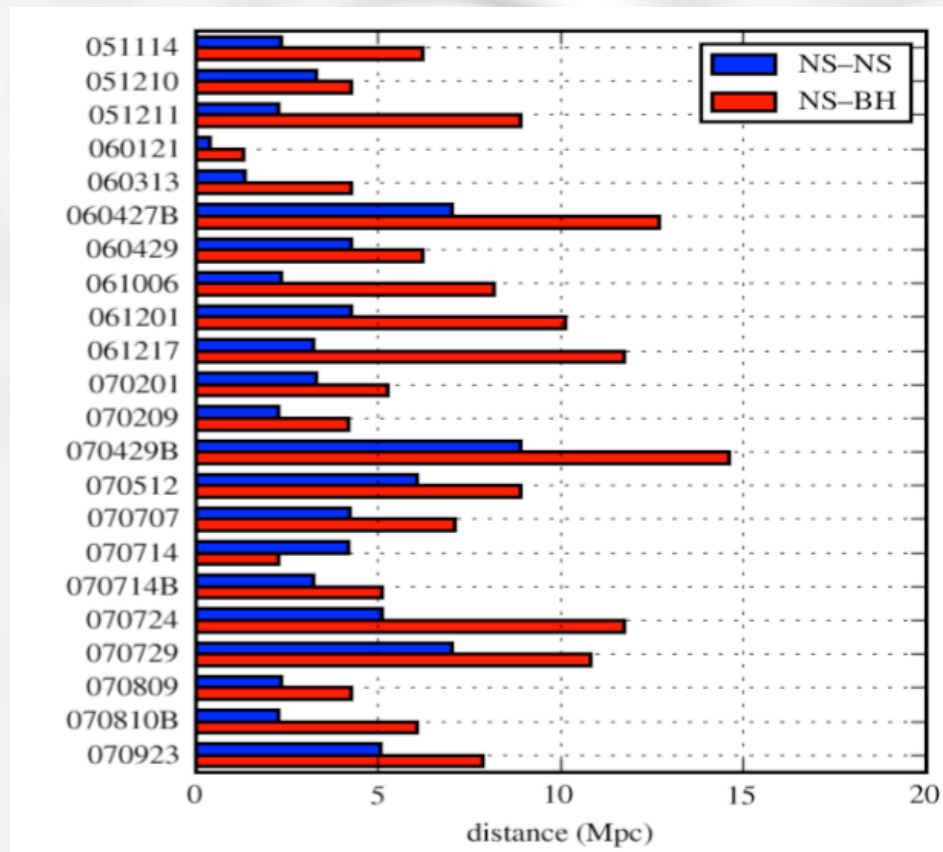
Astrophys. J. **681**, 1419 (2008)

B13, Sat 12:09pm: Seeking optical counterparts to gravitational wave event candidates (Jonah Kanner)

K13, Sun 3:30pm: High Energy Gamma Rays from GRB and Gravitational Wave Detection (many talks!)

GRB search result

No GWs detected ☹️



- ▶ 90% exclusion distances
- ▶ Median NS-NS
(1.4/1.4 M_{\odot})
3.3 Mpc
- ▶ Median NS-BH
(1.4/10 M_{\odot})
6.7 Mpc

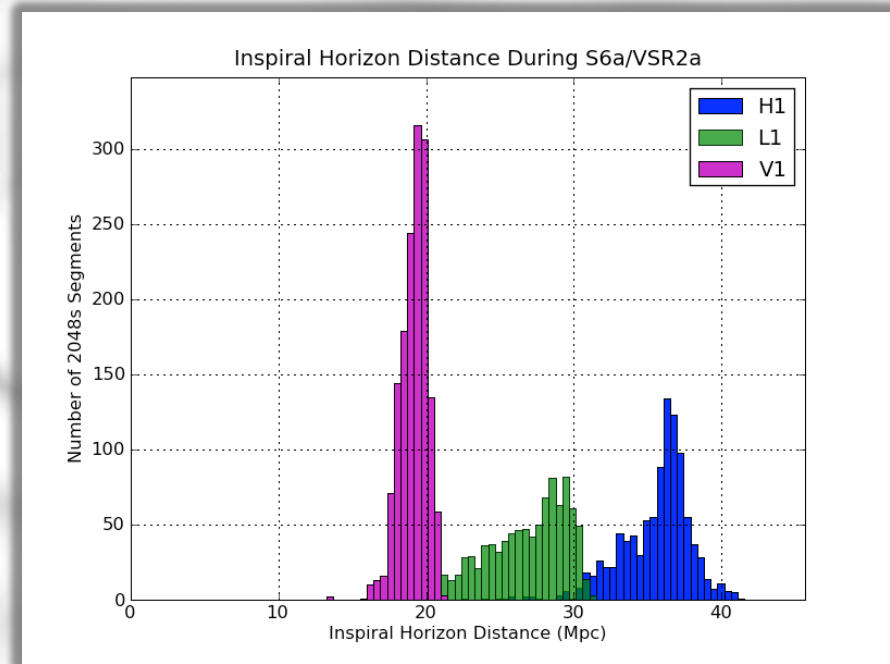
arXiv:1001.0165v1 (2010)

S6-VSR2 Status Update

- S6 and VSR 2 started on July 7 2009
- S6 is LIGO's 6th science run, “Enhanced LIGO”
- VSR2 is Virgo's 2nd science run
- Planned to run for about a year with interspersed commissioning breaks
- S6-VSR2a ran 7 weeks; ended August 24th with first LIGO commissioning break
- Virgo started commissioning break to install new mirrors (better sensitivity!) in January 8, back in ~June

S6-VSR2a Current Status

- All seven weeks analyzed and boxes opened
- Results will undergo internal review and be released soon
- S6a included a Blind Injection Challenge



The Future

- S6 will continue until ~Fall 2010
- Virgo is installing monolithic suspensions and plans to rejoin in three to four months
- Advanced LIGO detectors will begin to be installed in the fall, and will start to come online in 2014 and begin working towards 10x the sensitivity of S5/VSR1
- This will allow us to see 1000 times as many galaxies!

The future

