GRB Beaming and Gravitational-Wave Observations

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LIGO S6/Virgo VSR2

Beaming angles limit from event rates limit...

- Compact binary coalescences rates upper limit:
  - Non-detection from LIGO S6/VSR2 established upper limits on the event rates in local Universe (Abadie et al. 2011).
- Short GRB beaming angles lower limit:
  - Fraction of sky covered by beamed gamma rays: $f_b = 1 - \cos\theta_j$.
  - Apply observed rate density of GRB: $\mathcal{R} = \mathcal{R}_{\mathrm{GRB}}/f_b = \mathcal{R}_{\mathrm{GRB}}/(1-\cos\theta_j)$.

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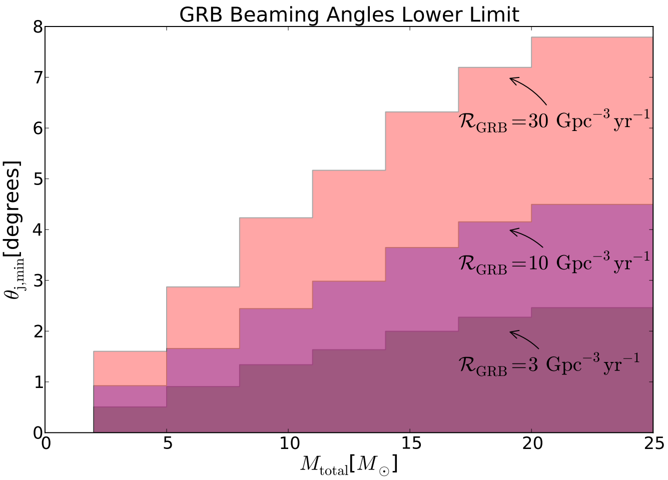
Short GRB Beaming Angles Limit



Assumed $\mathcal{R}_{\mathrm{GRB}} = 10\,\mathrm{Gpc}^{-3}\mathrm{yr}^{-1}$,
$\theta_j \geq 1^\circ$ for NS-NS, and $\theta_j \geq 4^\circ$ for NS-BH($\sim 20M_\odot$).

Advanced LIGO/Virgo

- Improve expected detection rates:
  - Higher sensitivity: high laser power, seismic isolation.
  - Detector network: LIGO-India, KAGRA ($\sim$2020).
  - Beamed GRB: expected rates is improved by 7 times if $\theta_j \sim 30^\circ$, 60 times if $\theta_j \sim 10^\circ$.

	Network	$\theta_j = 10^\circ$	$\theta_j = 30^\circ$	$\theta_j = 90^\circ$
[conservative]	HL(no SRM)	15/yr	1.7/yr	0.23/yr
	HLV	50/yr	5.6/yr	0.75/yr
[optimistic]	HLVJI	104/yr	12/yr	1.6/yr

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- Pros and cons of triggered detections
  - Pros
    -lower SNR threshold due to known time and sky location.
    -higher SNR due to almost on-axis detection.
  - Con
    -Only on-axis GRBs/binaries are observed.

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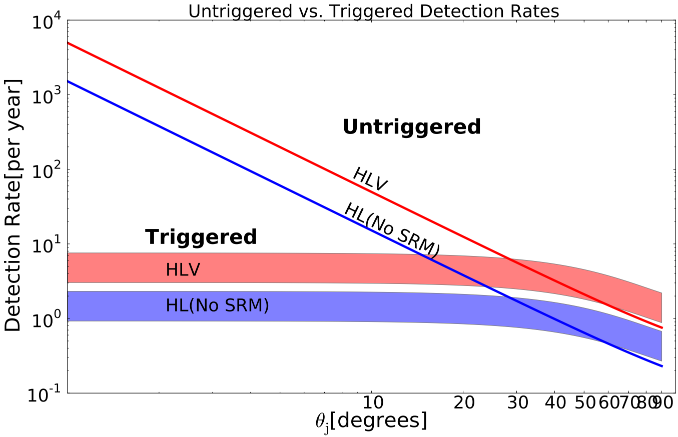

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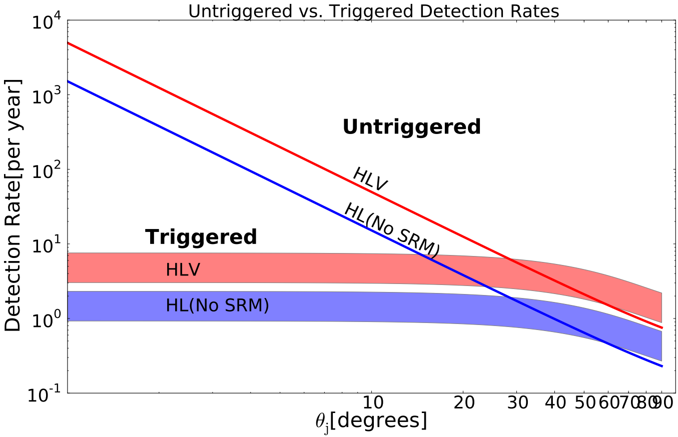

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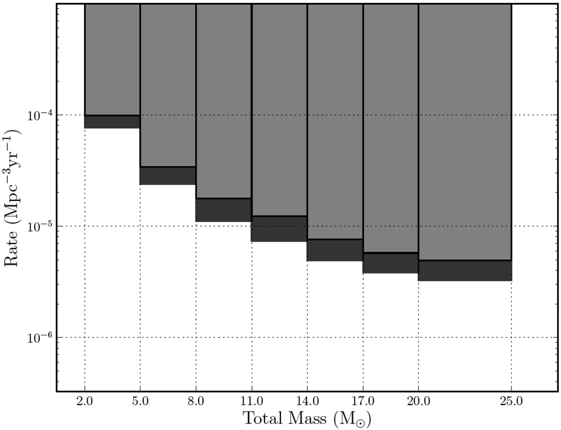
Binary Mergers Event Rates Limit



(Abadie et al. 2011, Phys Rev D85.082002)

$\mathcal{R} \lessapprox 8 \times 10^{-5}\,\mathrm{Mpc}^{-3}\mathrm{yr}^{-1}$ for NS-NS.

$\mathcal{R} \lessapprox 7 \times 10^{-6}\,\mathrm{Mpc}^{-3}\mathrm{yr}^{-1}$ for NS-BH($\sim 10 M_\odot$).

Advanced LIGO/Virgo

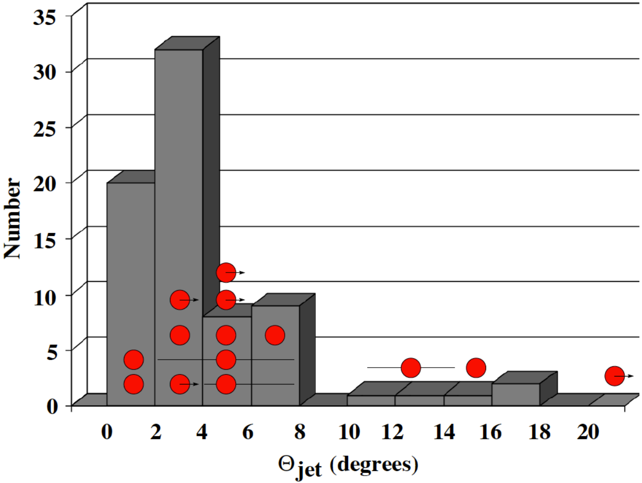
- Coincident to Coherent Search
  - Find effective SNR threshold if applied coherent search (Schutz 2011):$\rho_{\rm network} \sim$ 10.7–12.2.
  - NS-BH: $4.5 \times 10^{-4}\,{\rm Mpc}^{-3}{\rm yr}^{-1}$ for $M_{total} \sim 3\,M_{\odot}$, and $6.5 \times 10^{-5}\,{\rm Mpc}^{-3}{\rm yr}^{-1}$ for $M_{total} \sim 22\,M_{\odot}$.

Advanced LIGO/Virgo

Network	$V_0(\mathrm{Gpc}^3)$	$\theta_j = 10^\circ$	$\theta_j = 30^\circ$	$\theta_j = 90^\circ$
HL(no SRM)	0.027	15/yr	1.7/yr	0.23/yr
HLV(no SRM)	0.046	26/yr	2.9/yr	0.39/yr
HLV	0.092	50/yr	5.6/yr	0.75/yr
HLVJ	0.14	74/yr	8.4/yr	1.1/yr
HLVI	0.14	77/yr	8.7/yr	1.2/yr
HLVJI	0.19	104/yr	12/yr	1.6/yr

Table: Mean detectable volume and expected detection rates (per year) for 1.4 $M_\odot$–1.4 $M_\odot$ binaries.

Observed GRB Beaming Angles



(Nicuesa Guelbenzu et al. arXiv:1206.1806)