

GRB-triggered searches for gravitational-wave inspiral signals in LIGO data

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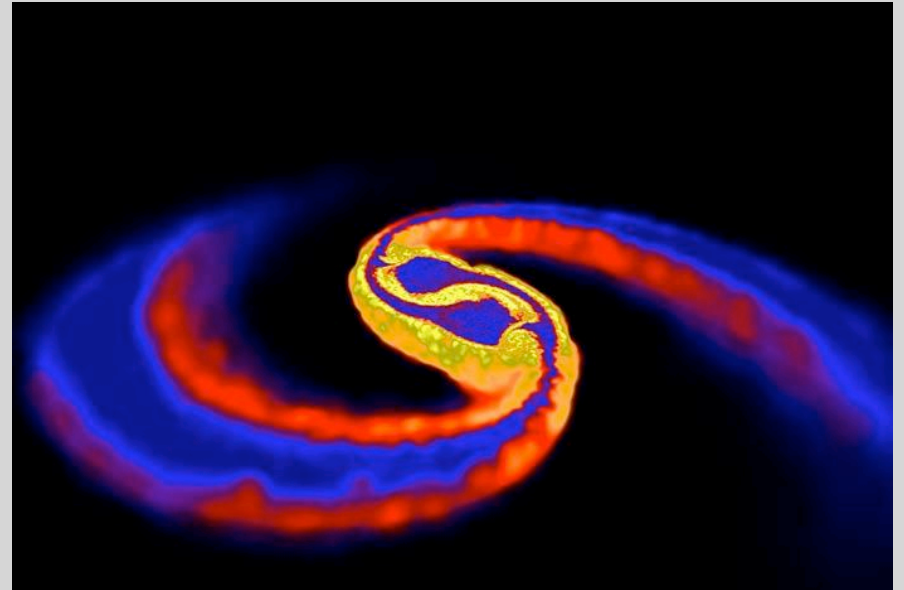
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2007-12-13

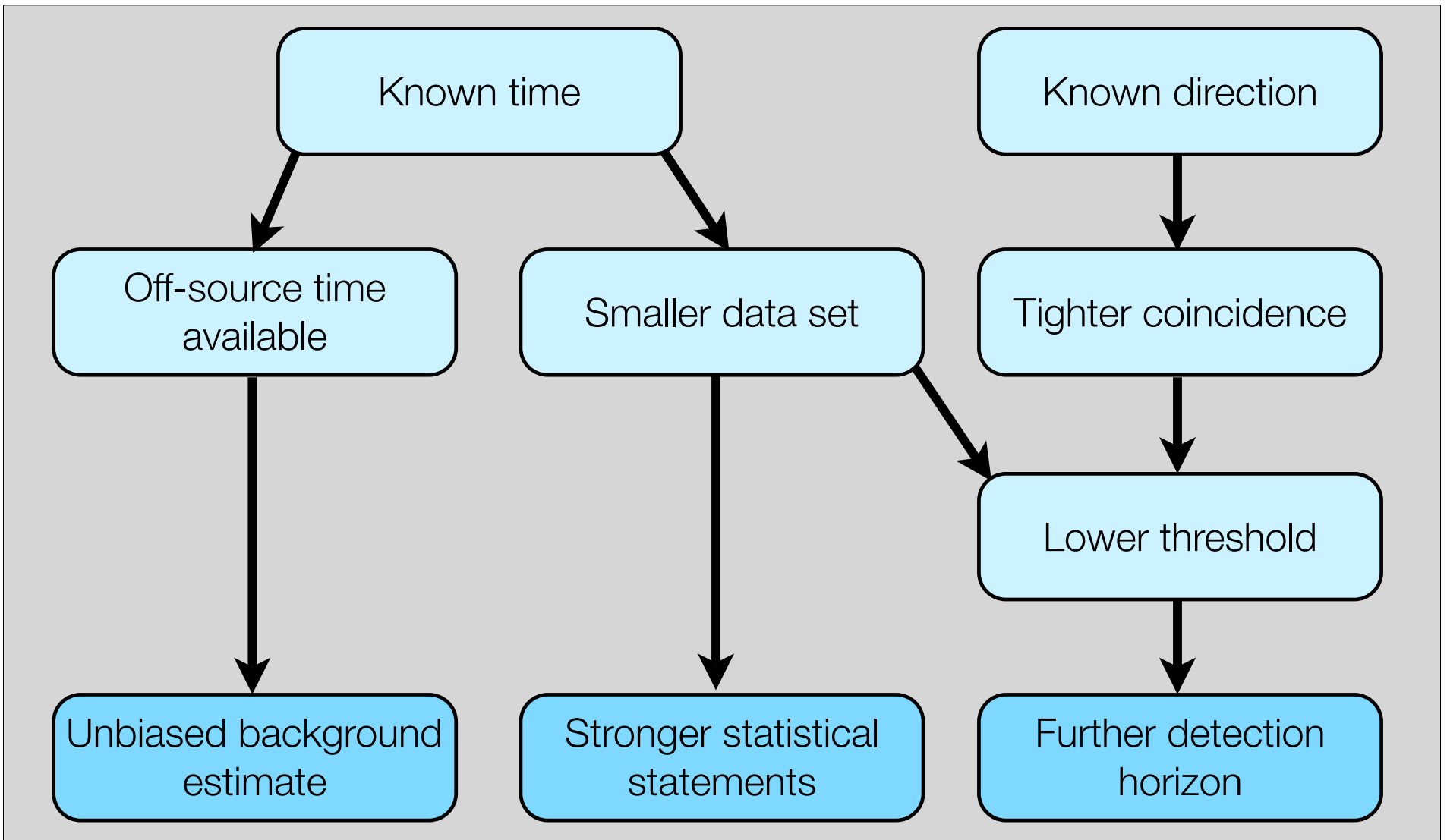


Short GRBs: a primer

- GRBs are categorized by the duration of their observed emission. Short GRBs emit for $\lesssim 2$ seconds; long GRBs emit for $\gtrsim 2$ seconds.
- The tidal disruption of a NS near the final stages of inspiral with a companion NS or low-mass BH may produce a short GRB.
- Some short GRBs are believed to originate from Soft Gamma Repeaters (SGRs).



NS-NS merger simulation
Credit: Daniel Price and Stephan Rosswog
@ New Scientist



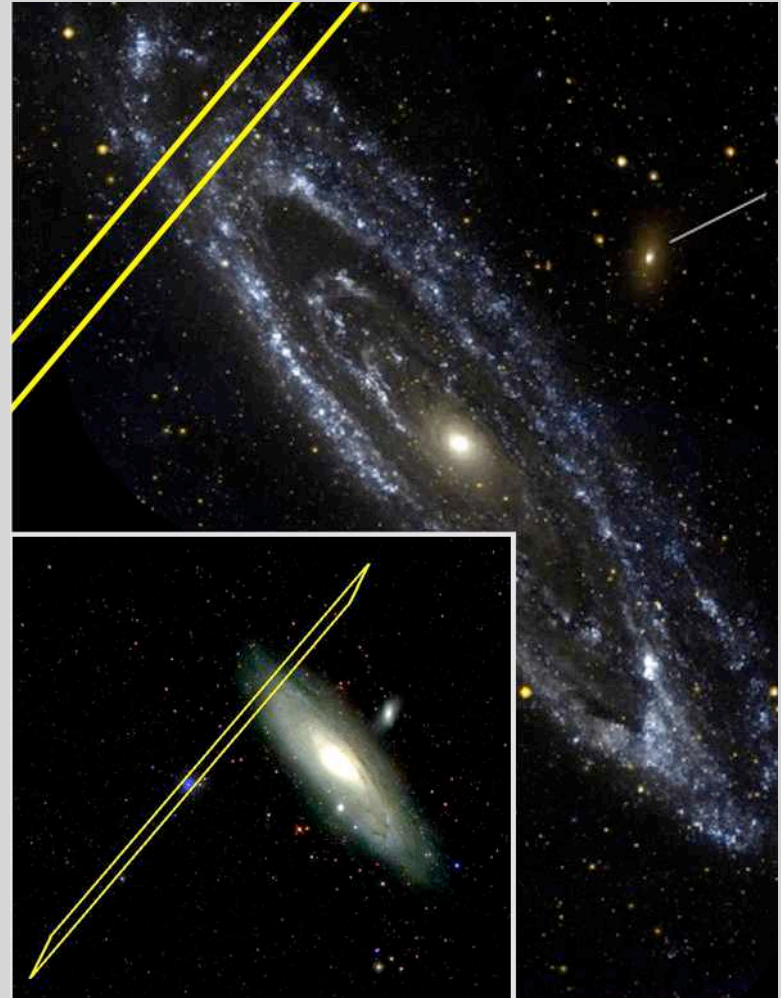
Benefits of externally triggered searches

An external trigger will help the plausibility of first detection.

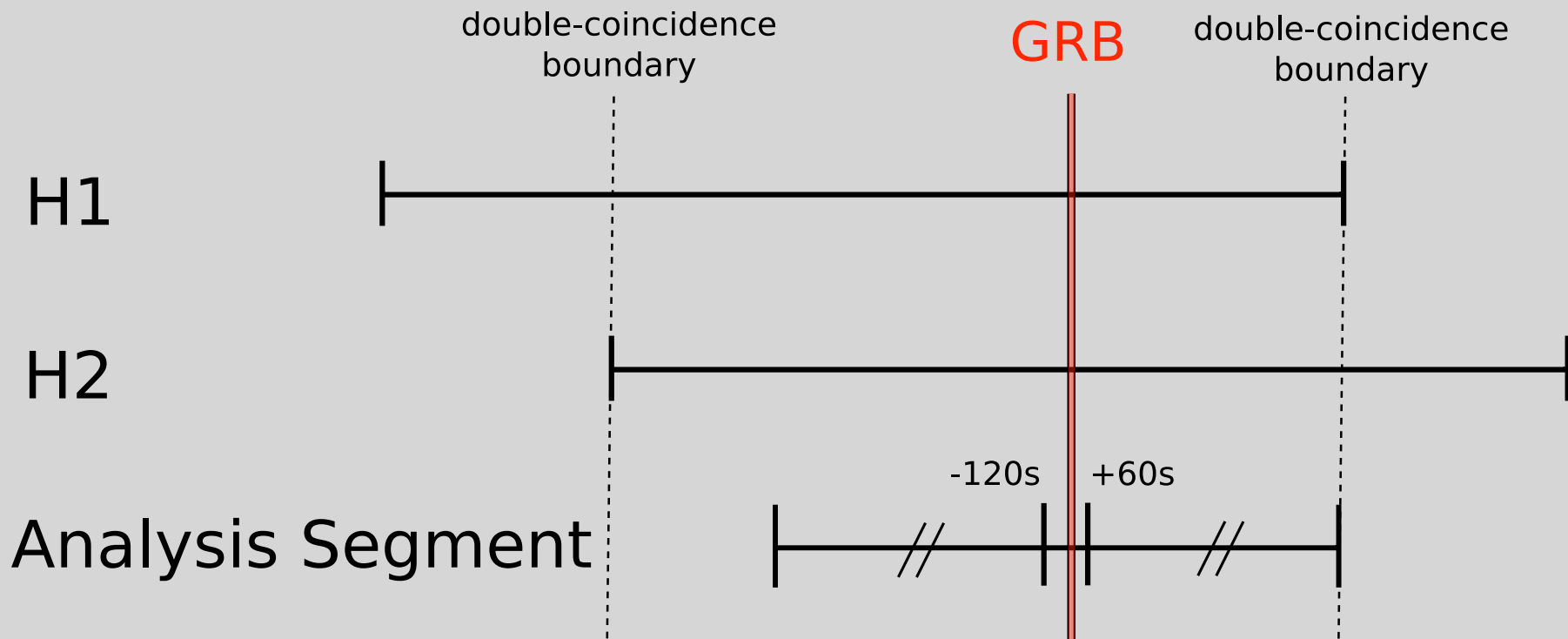
Coincident EM/GW observation will tell us more about the source.

GRB 070201

- Short GRB detected by several space-based instruments
 - Directional uncertainty covers part of M31. $D_{M31} \approx 770$ kpc !
 - Energetics suggested that if the source is in M31, it is probably not a canonical short GRB. An SGR is more likely.
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- LIGO detectors **H1** and **H2** online
 - See also Isabel Leonor's talk on the unmodeled GW burst analysis

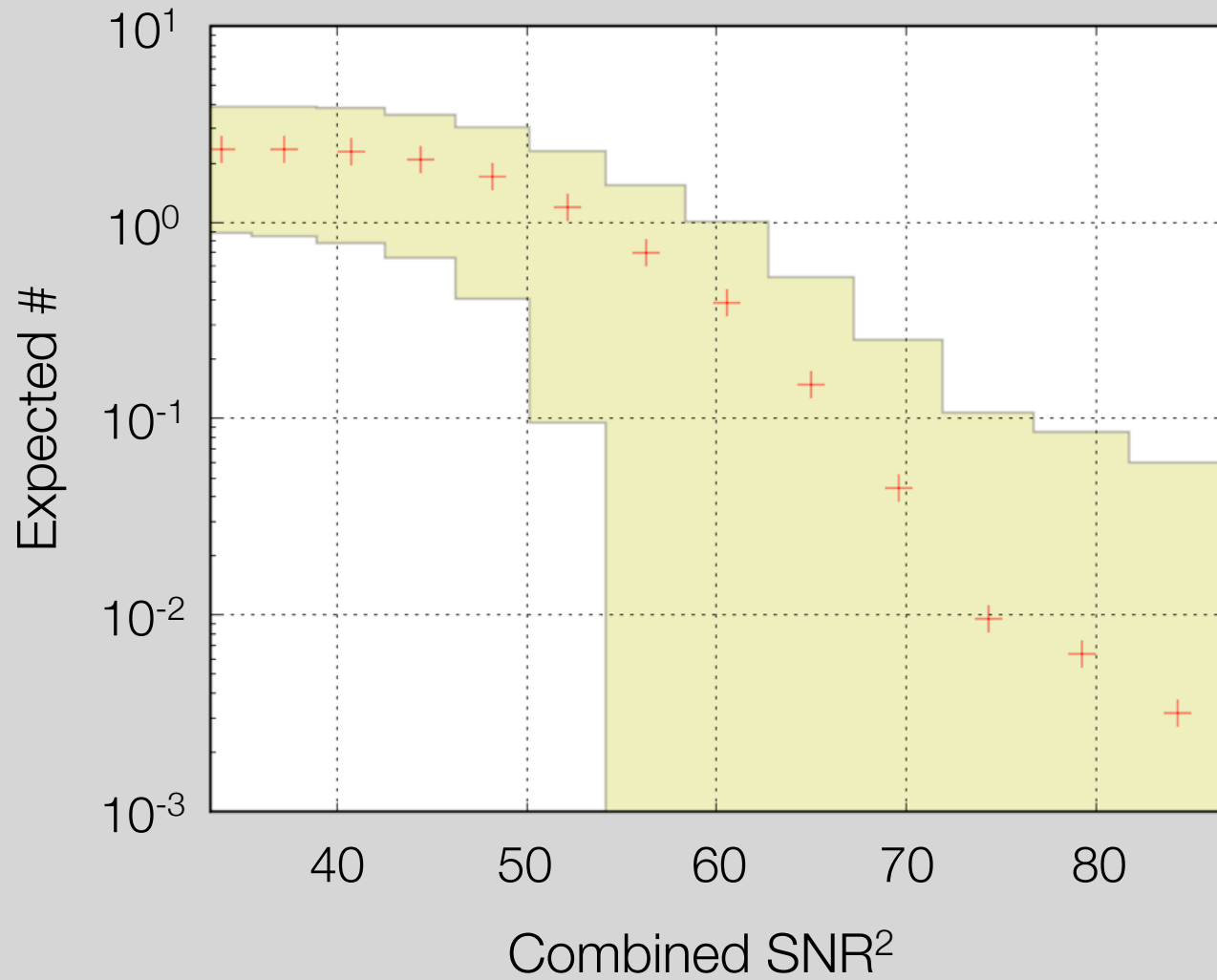


Larger: M31 in UV from GALEX
Inset: M31 in optical from SDSS



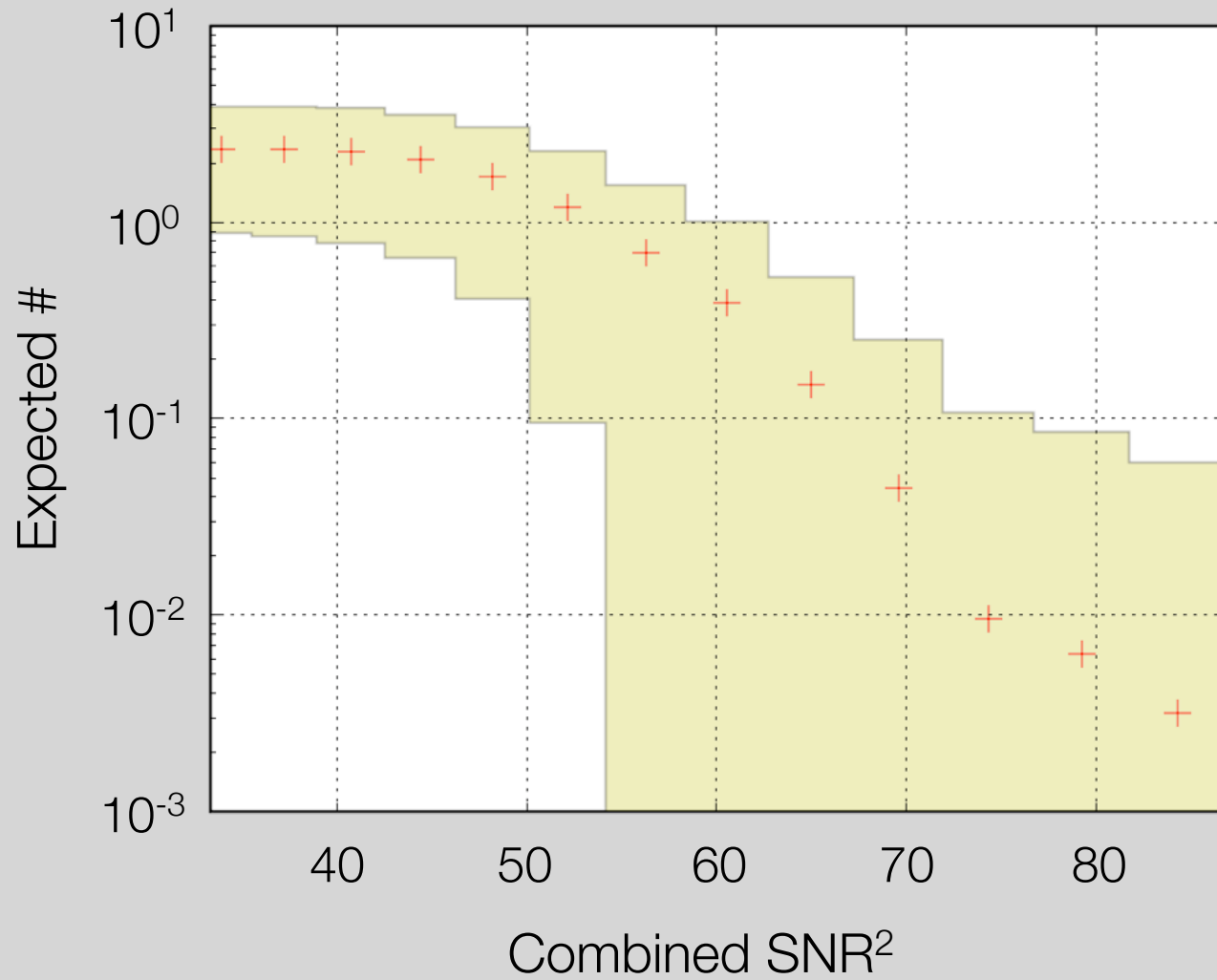
GRB 070201
segment selection

Highly conservative choices
Used large off-source region for
background estimation
GRB 070201 used ~60000s



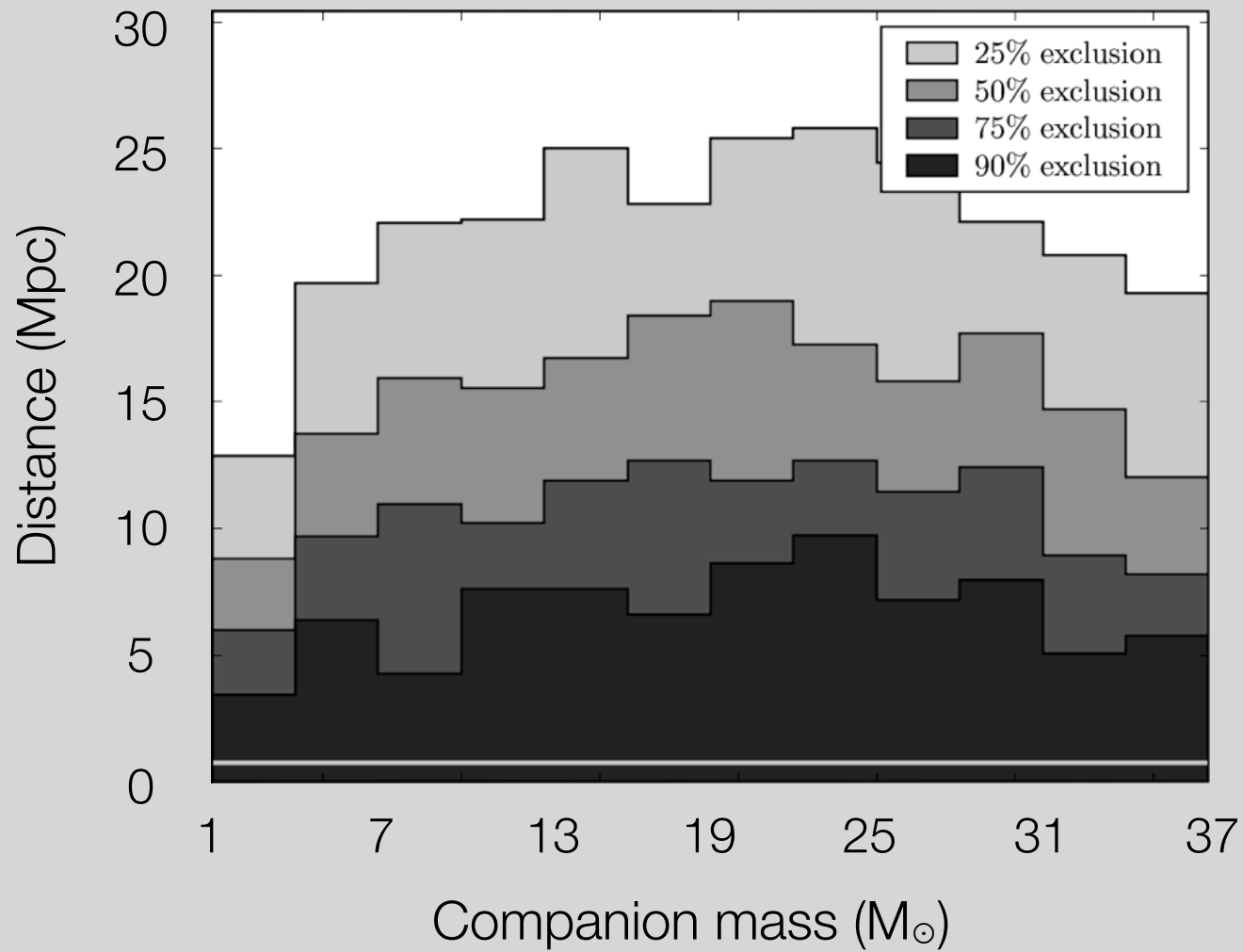
Background estimate

Estimated from 323 trials
2.7 candidates expected



Results

2.7 candidates expected
0 candidates observed



Inspiral Upper limits

Inspiral in M31 ruled out with >99% confidence

The rest of S5: overview

- 213 GRBs (212 with sky localization)
- 32 short GRBs.
- 26 short GRBs while two or more GW detectors were online.
- 21 short GRBs with >14000 seconds of available data in at least two LIGO instruments (probably fewer after data quality cuts).

Plan: Analyze these 21 short GRBs, then the rest

New requirements: Generalization and automation



http://www.uoregon.edu/~ileonor/ligo/s5/grb/online/S5grbs_list_valid.html

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List of GRBs Detected by Satellite Experiments During LIGO's S5 Run (validated)

External Triggers Group

GRB-GWB search results, 25-ms

GRB-GWB search results, 100-ms

Total number of valid GRB triggers: 213

[Ascii version](#) Last update: Wed Nov 15 12:32:00 2007 Pacific

GCN number	GRB Date	redshift	UT time	GPS seconds	RA (deg)	Dec (deg)	GRB duration (sec)	GRB fluence (E-7 ergs/cm ²)	Fave LHO	Fave LLO	Fave GEO	Fave VRG	LHO-LLO time delay (sec)	LHO-GEO time delay (sec)	LLO-GEO time delay (sec)	LHO-VRG time delay (sec)	LLO-VRG time delay (sec)
06823	070925	--	15:52:35	874770769.000	253.217	22.036	30	>20	0.503	0.285	0.313	0.368	0.0070706	0.0203509	0.0132803	0.0233552	0.0162846
06818	070923	--	19:15:23	874610137.000	184.623	38.294	0.05	0.102	0.225	0.281	0.522	0.488	0.0054819	0.0166068	0.0220886	0.0162362	0.0217181
06808	070920B	--	21:04:32	874357486.000	0.127	34.844	20.2	6.6	0.678	0.563	0.345	0.073	0.0034903	0.0195424	0.0160521	0.0224510	0.0189608



All-S5 Changes

GRB 070201

- two detectors only
- simple frequentist
- detection efficiency took CPU-decades to evaluate
- copious off-source data available
- -120/+60 second on-source segment

All S5

- arbitrary number of detectors
- additional population statement
- Bayesian?
- importance sampling of mass-distance space?
- background estimate from counting time-shifted coincidences?
- new values



Summary

- LIGO observations have ruled out GRB 070201 being a compact binary inspiral in M31 with >99% confidence. We cannot exclude the event having been an SGR in M31.

<http://arxiv.org/abs/0711.1163>

- We are now finalizing a search procedure for all short GRBs in S5 data. Generalizations and automation for analysis work are almost complete.
- Our interpretation framework has a lot of room for improvement. In addition to improving individual detection/upper limit evaluations, we would like to make a statement about the GRB population as a whole.

