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

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LSC

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).
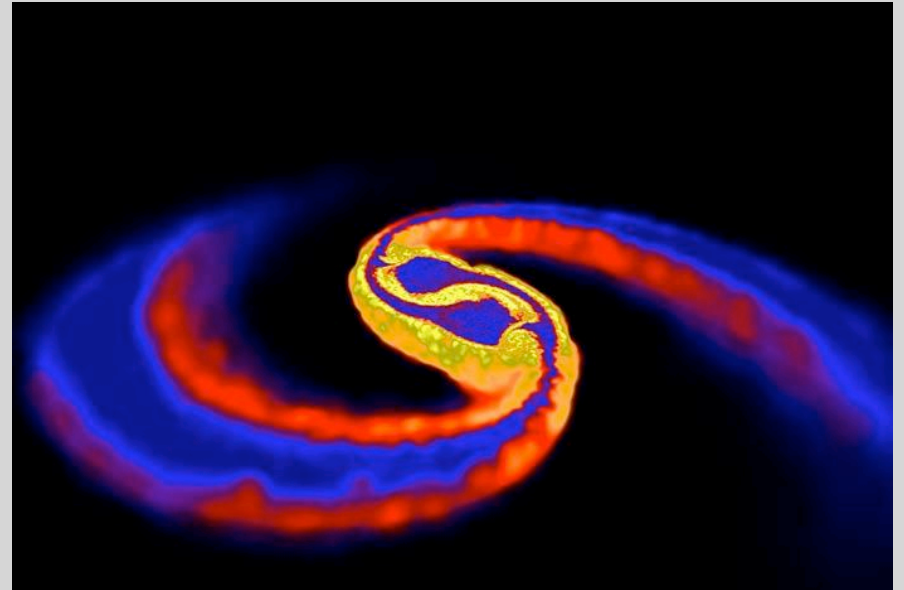
NS-NS merger simulation
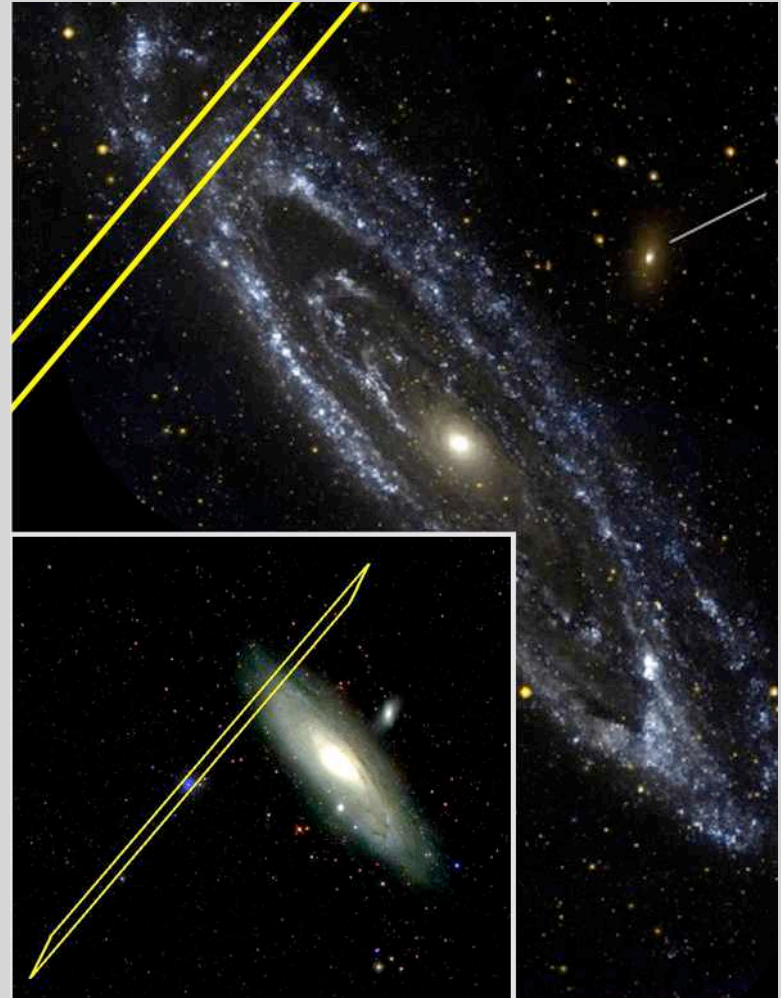Credit: Daniel Price and Stephan Rosswog
@ New Scientist
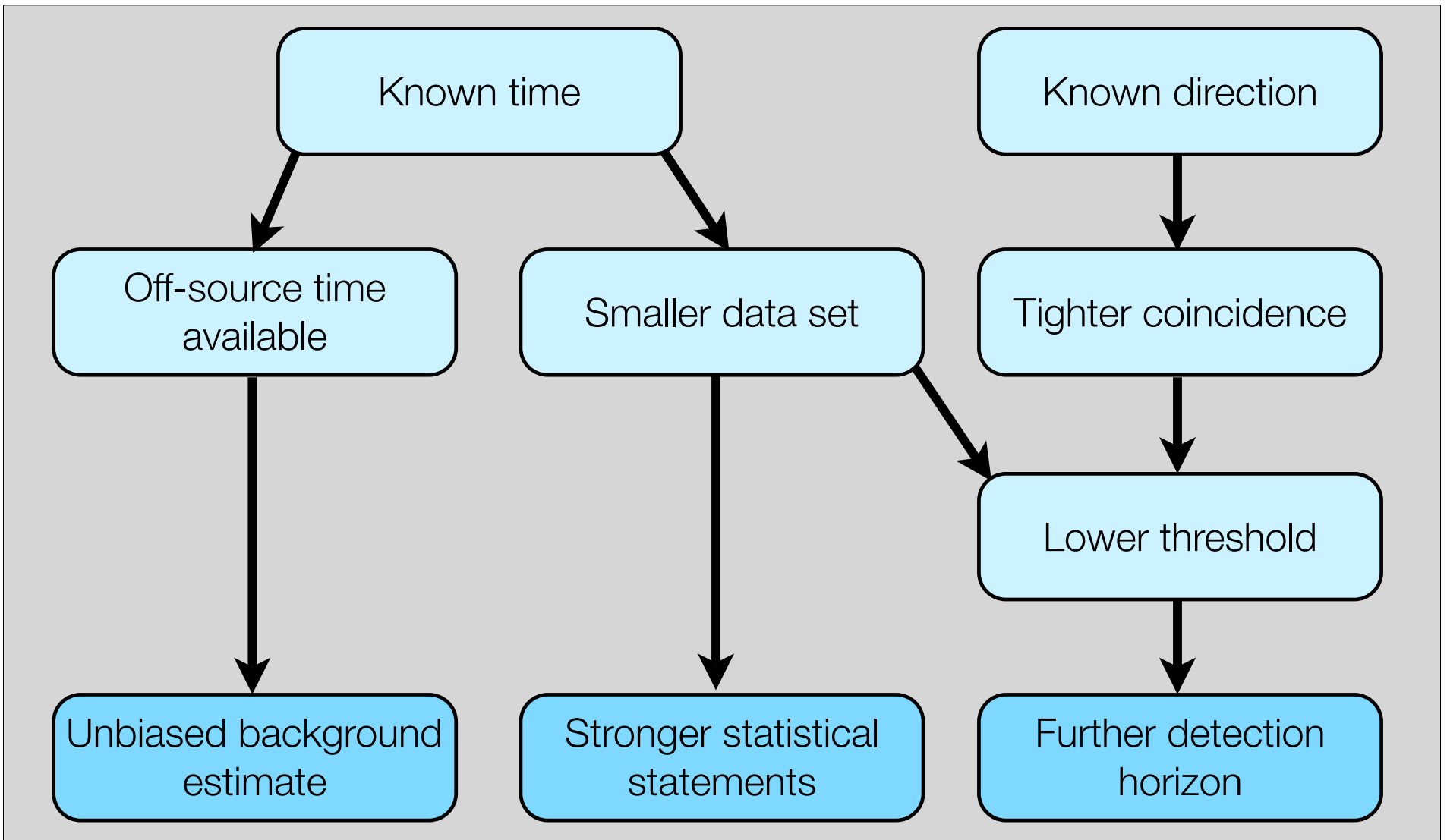
Benefits of externally triggered searches

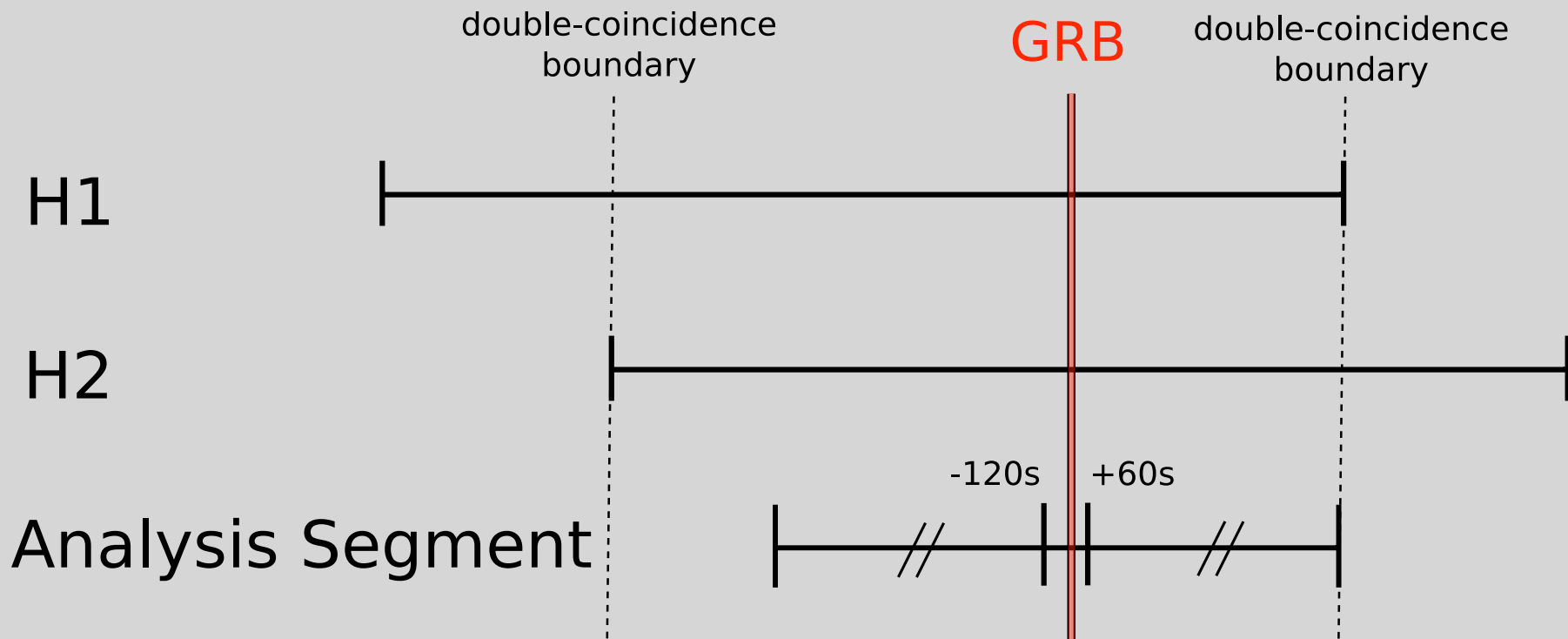An external trigger will help the plausibility of first detection.

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.

- LIGO detectors H1 and H2 online

- See also Isabel Leonor's talk on the unmodeled GW burst analysis

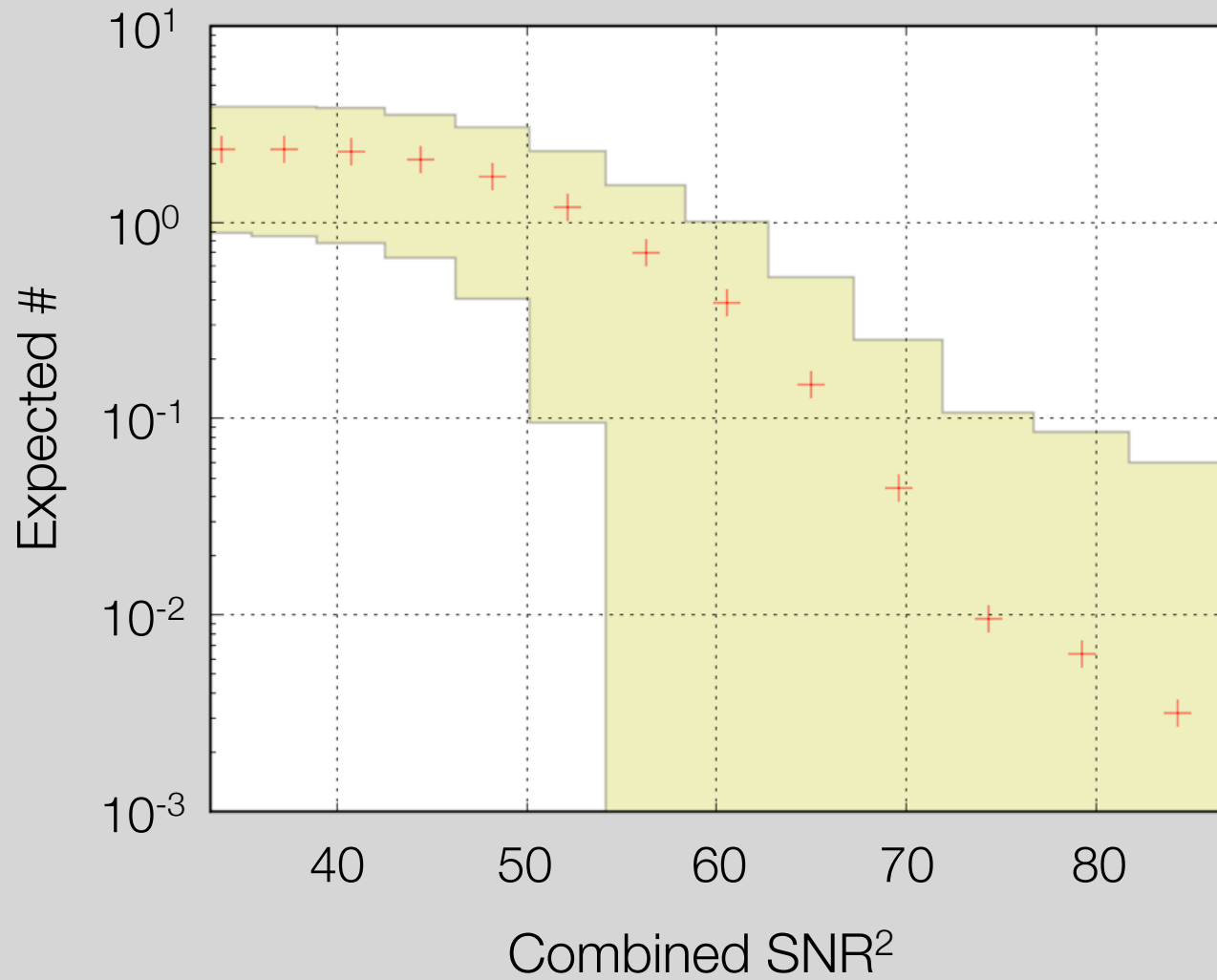Larger: M31 in UV from GALEX
Inset: M31 in optical from SDSS

double-coincidence boundary   GRB   double-coincidence boundary

H1

H2

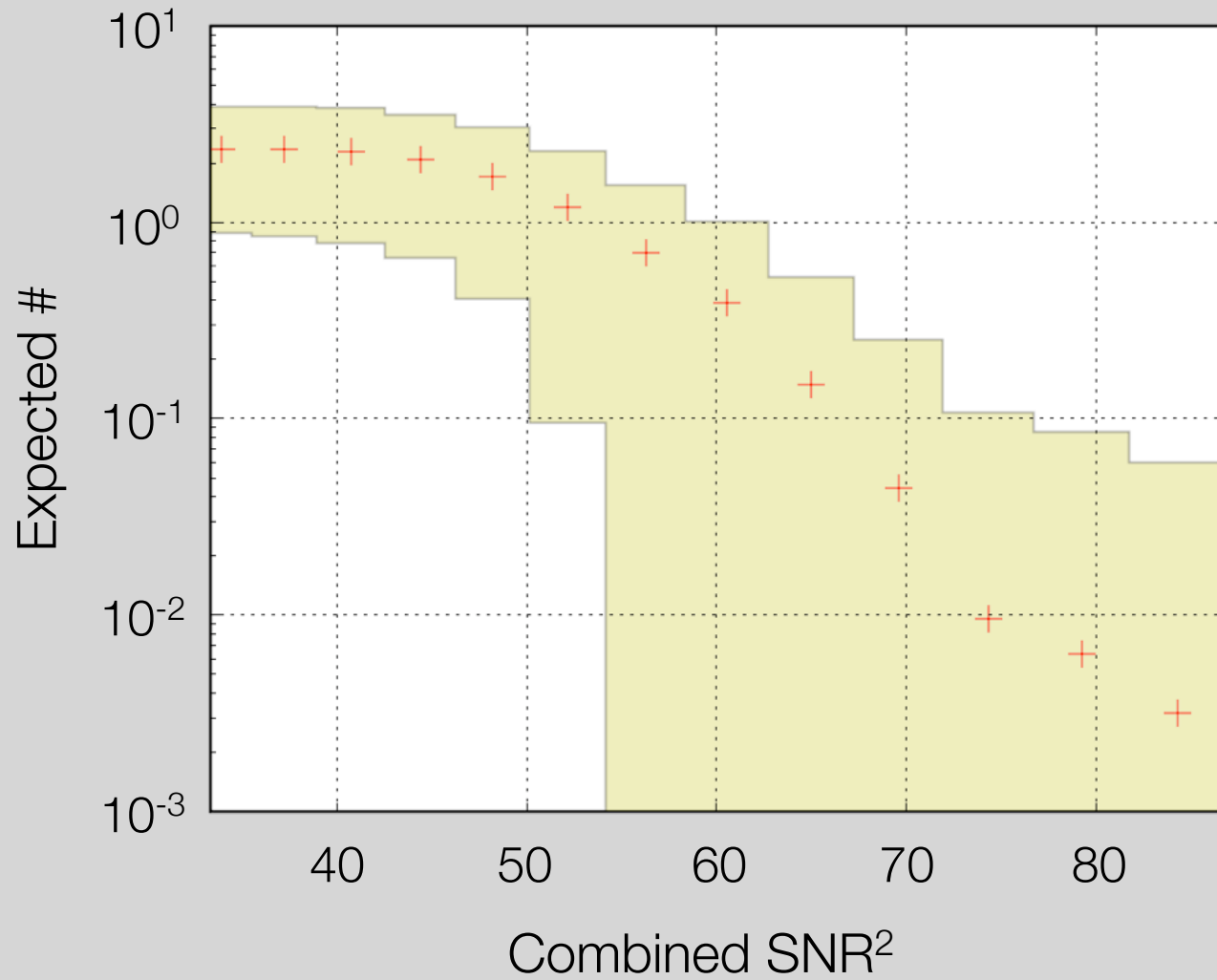-120s   +60s

Analysis Segment

GRB 070201
segment selection

Highly conservative choices

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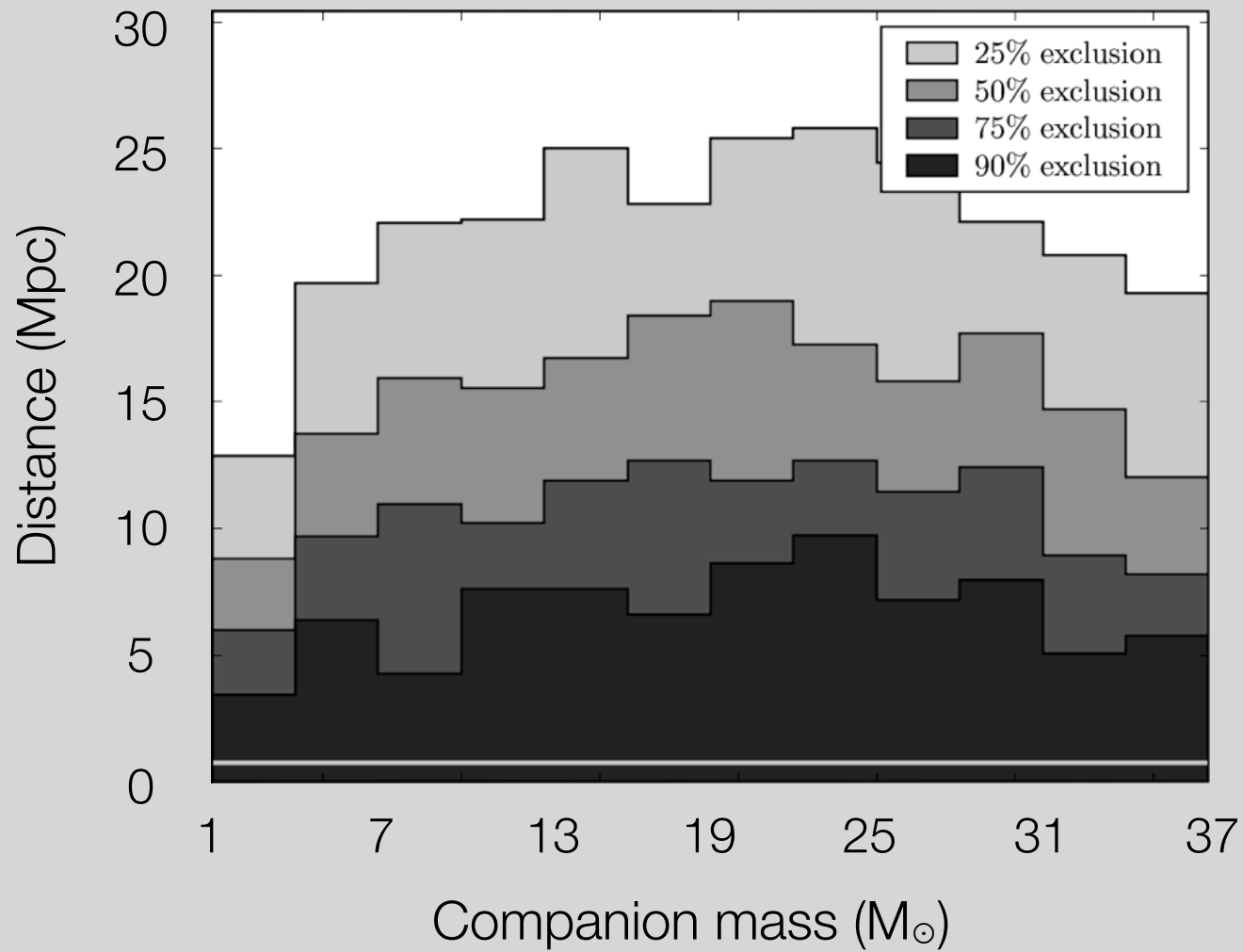
GRB 070201 used ~60000s

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

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.