GRB-triggered searches for gravitational waves from compact binary inspirals in LIGO and Virgo data during S5/VSR1

Nickolas Fotopoulos (UWM) for the LIGO Scientific Collaboration and the Virgo Collaboration

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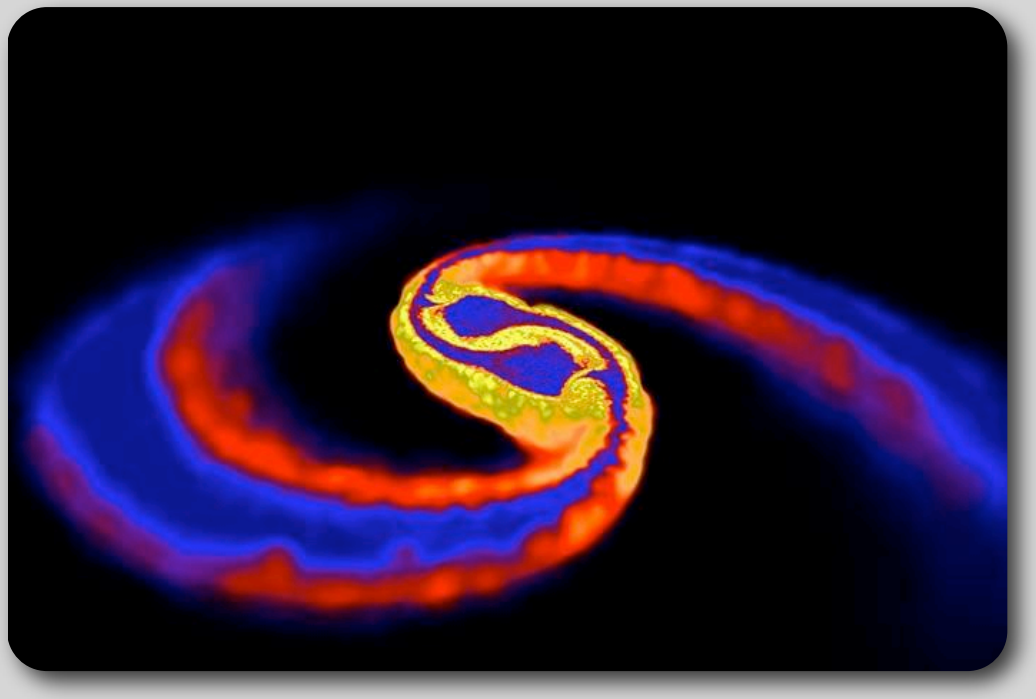
UNIVERSITY of WISCONSIN UWMILWAUKEE LSC VIRGO GEO 600

LIGO-G0900504-v8

Short GRBs: ideal targets for GW astronomy (I)

- Most short GRBs are probably NSs disrupted by compact companions in the final stages of inspiral.
- A detection will constrain component masses and spins.*
- A high-SNR detection will constrain NS equations of state.†
- Simultaneous EM/GW observations can measure absolute luminosity distance.‡

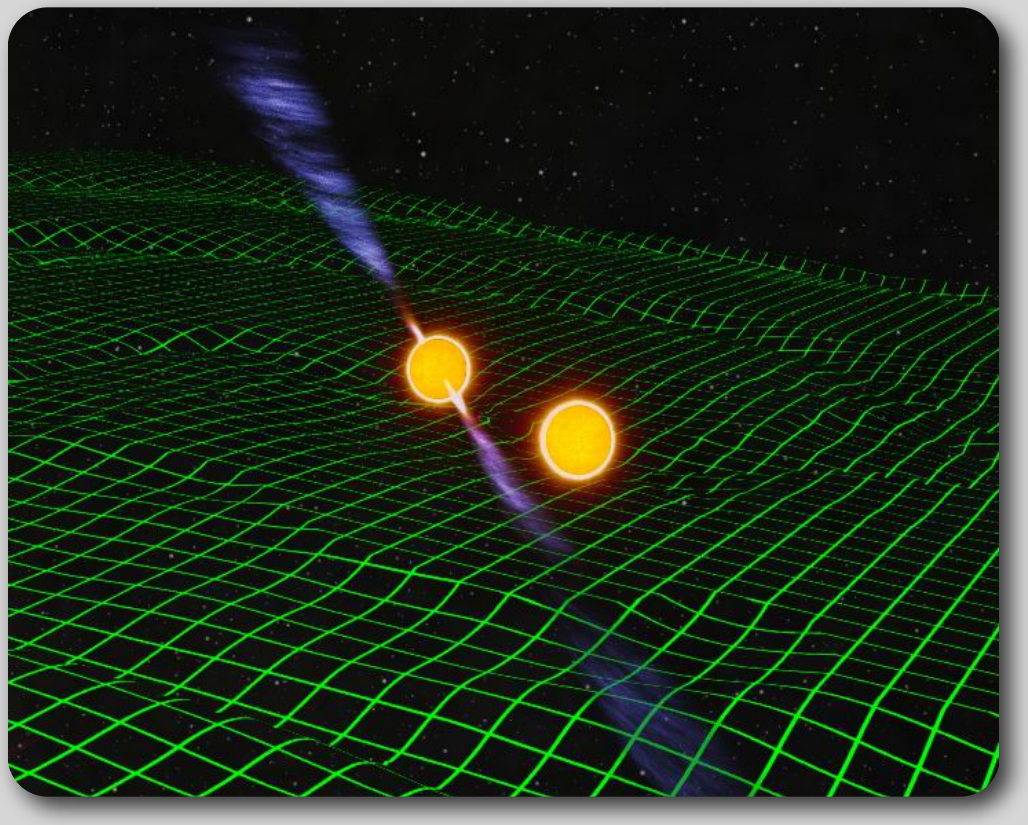


NS-NS merger simulation
Price and Rosswog

* Cutler and Flanagan, PRD 49, 2658 (1994); Finn and Chernoff, PRD 47, 2198 (1993); Poisson and Will, PRD 52, 848 (1995)
† Flanagan and Hinderer, PRD 77, 021502 (2008); Read et al, arXiv:0901.3258
‡ Nissanke et al, arXiv:0904.1017

Short GRBs: ideal targets for GW astronomy (II)

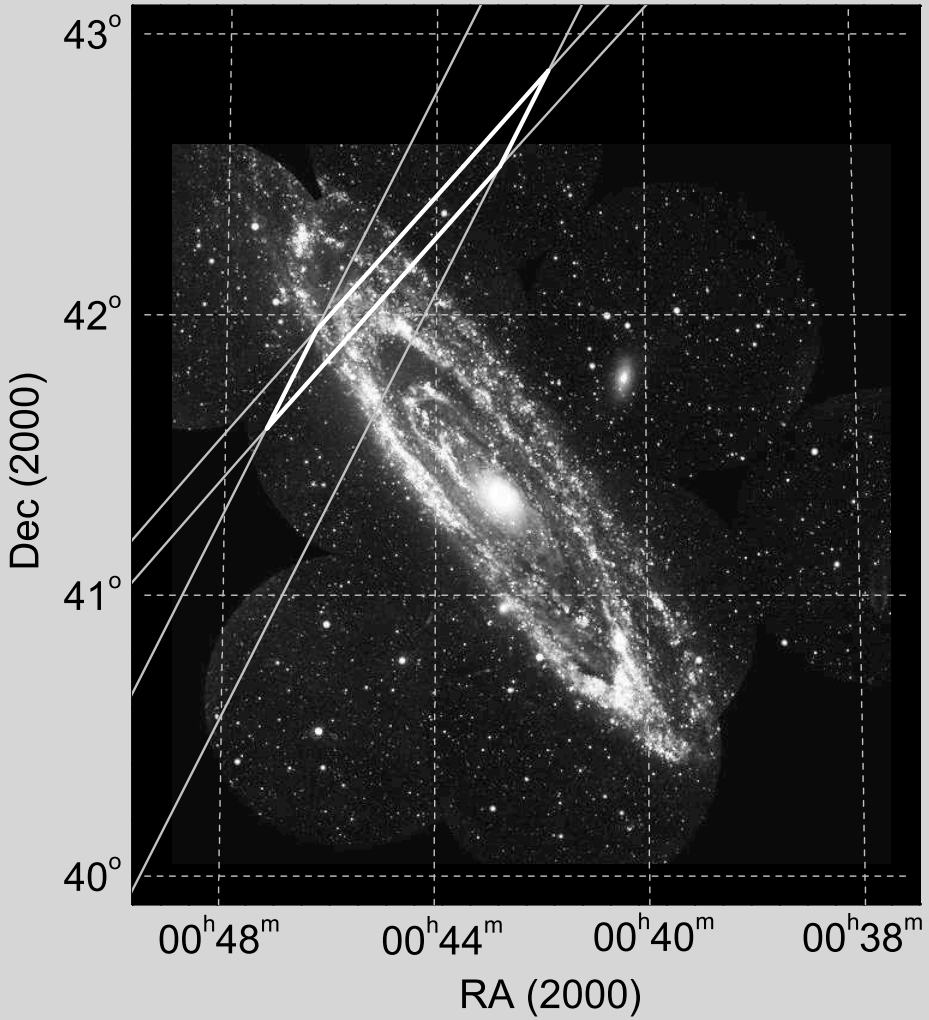
- A significant GW candidate with an EM counterpart is a far more compelling detection.
- A known time and sky location can be searched with significantly lowered thresholds.
- The GW emission during inspiral is well modeled. This enables matched filtering, which digs more deeply into the detector noise than unmodeled searches.



NS-NS inspiral depiction
John Rowe Animation

GRB 070201: not an inspiral in M31

- GRB 070201 occurred in the direction of M31, the Andromeda galaxy.
- M31 is ~770 kpc away, well within LIGO's range.
- LIGO observations ruled out an inspiral progenitor in M31 at >99% confidence.* They allow a soft gamma repeater (SGR) progenitor.†
- The present search has lower thresholds and algorithmic improvements.



IPN 3σ Sky Localization
Mazets et al, ApJ 680, 545 (2008)

* Abbott et al, ApJ 681, 1419 (2008)
† Ofek et al, ApJ 681, 1464 (2008); Mazets et al, ApJ 680, 545 (2008)

S5: Nov 2005 – Nov 2007 | VSR1: May 2007 – Oct 2007

- 212 GRBs
- 33 short GRBs
- 22 short* GRBs while two+ GW detectors were taking good data (duty cycle, data quality)

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Already published: no inspiral in M31

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Long duration but other suggestive features

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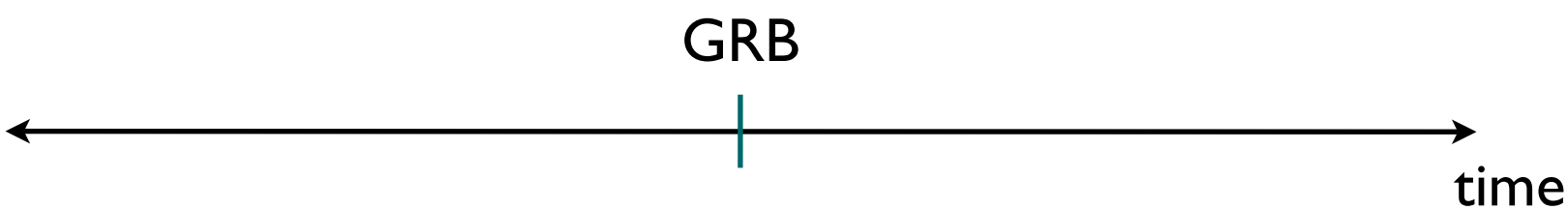
Analysis done differently;
Three-detector analysis

070923

Experiment overview



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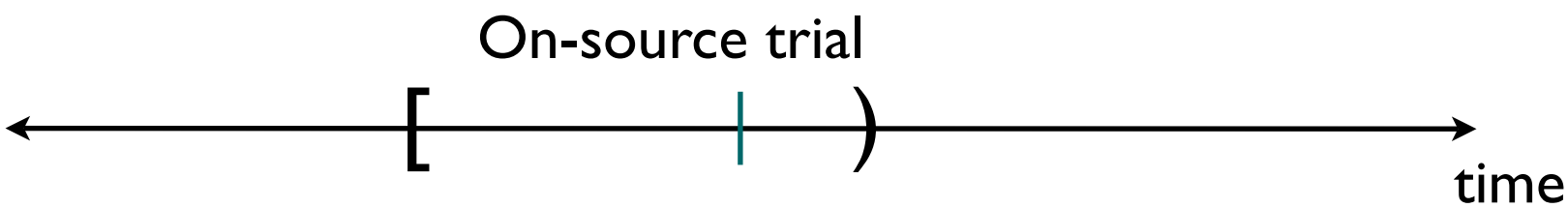

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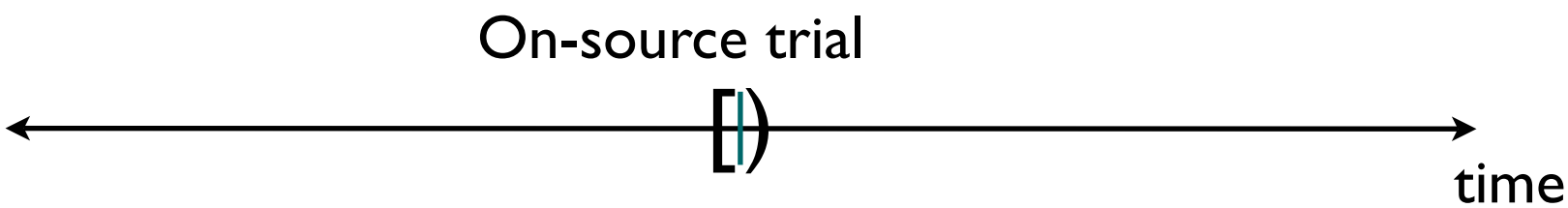

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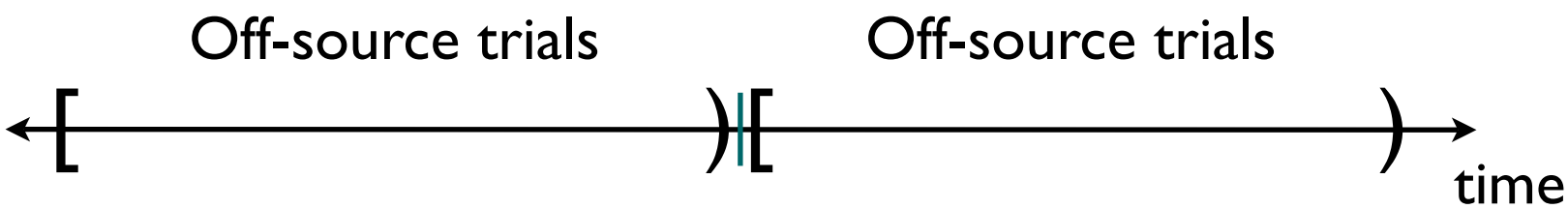

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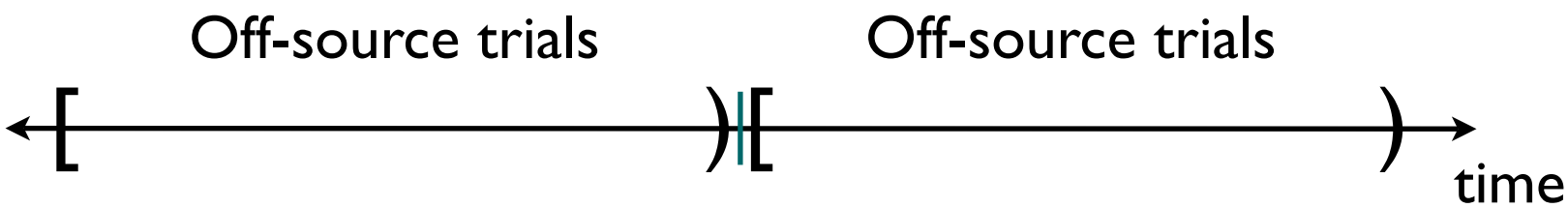

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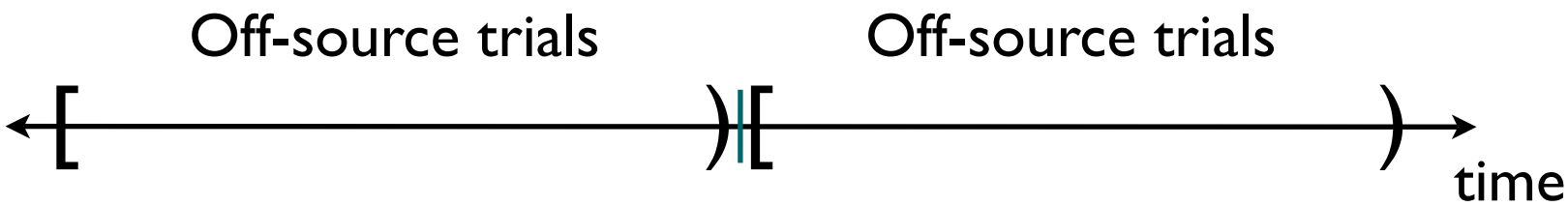

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* Abbott et al, PRD 73 (2006) 062001

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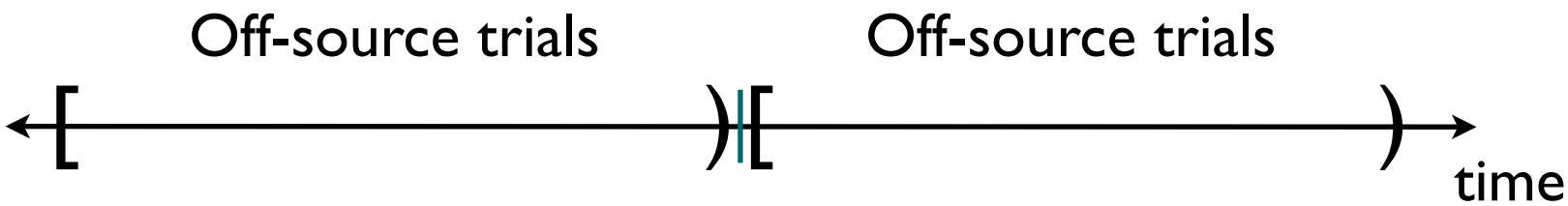

- We reuse the hierarchical inspiral search pipeline used in previous LIGO analyses.*
- We combine injection and off-source trials to form a likelihood statistic.

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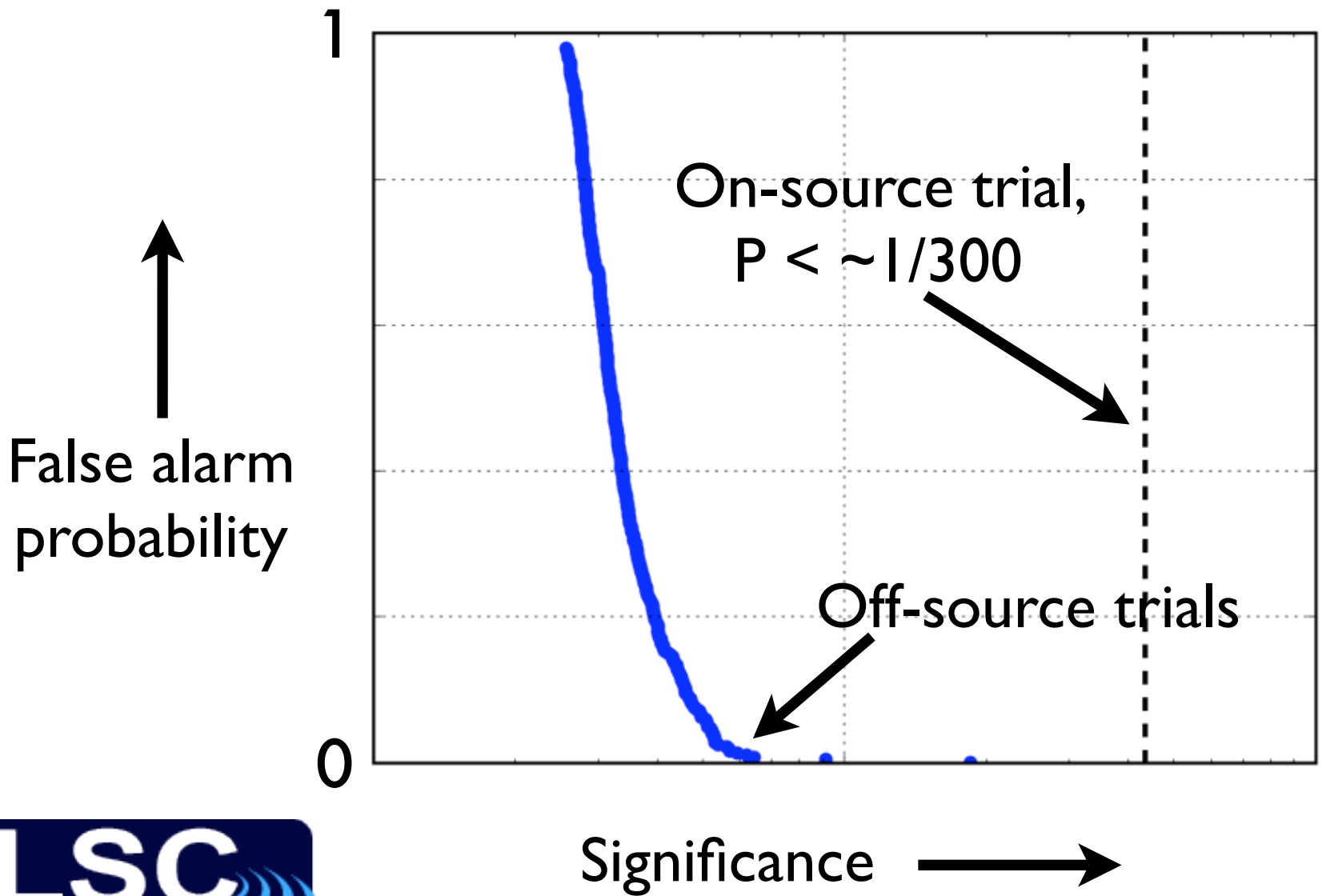
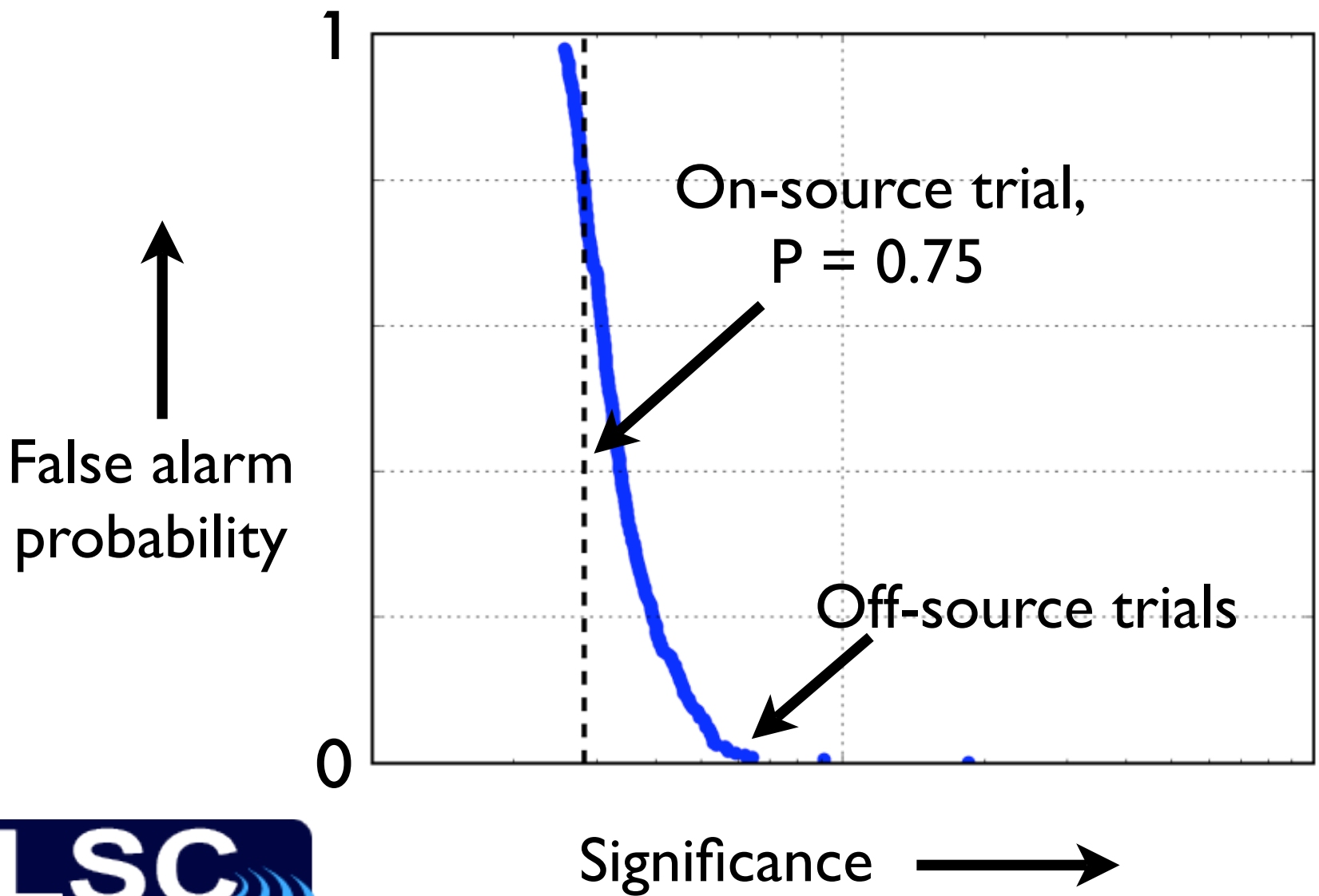
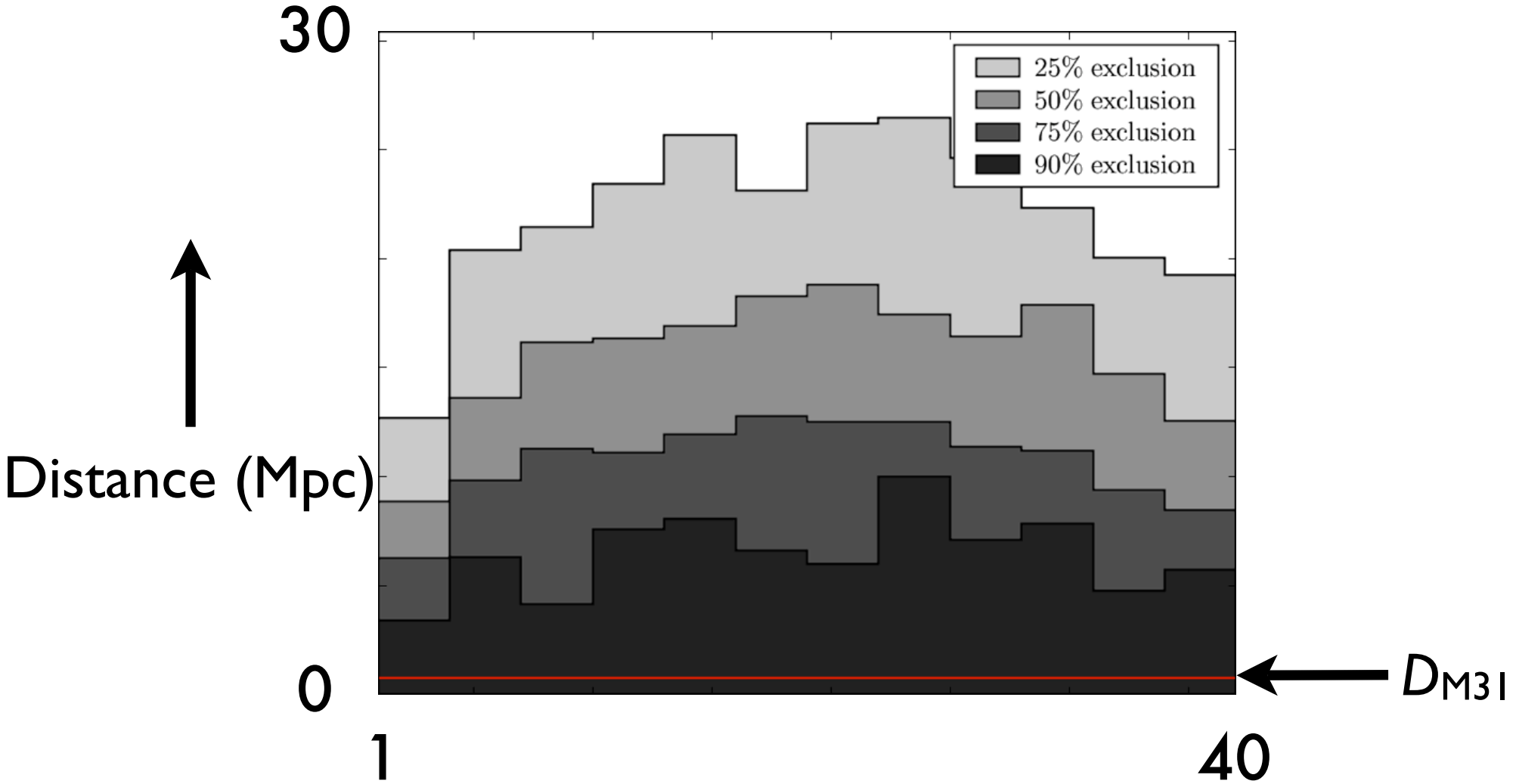
What a detection might look like



What a null result might look like



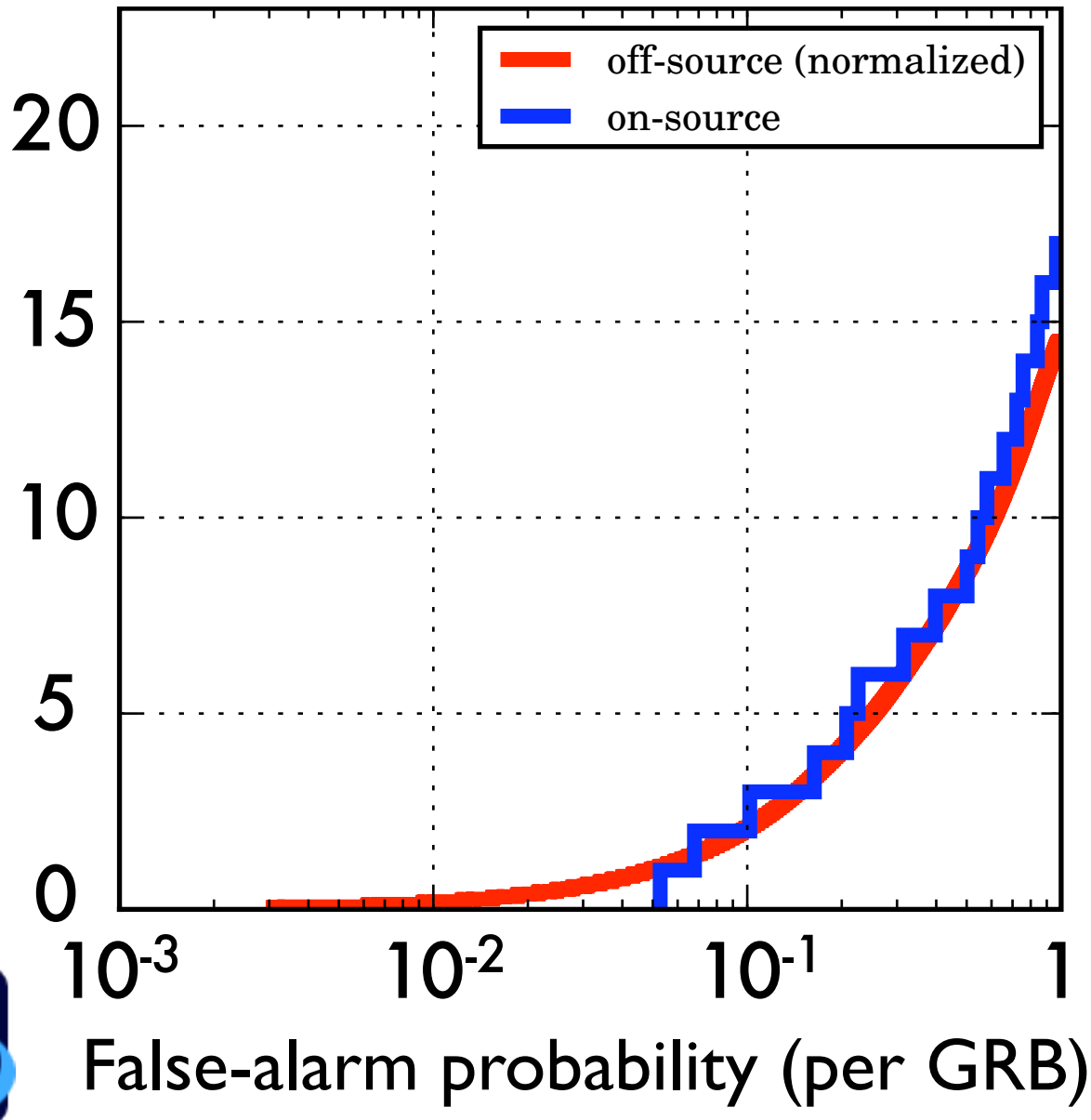
Astrophysical exclusions from null results



(example recycled from previous GRB 070201 analysis)

Preliminary results for 21 GRBs: no gravitational waves

Cumulative histogram



GRB 070923 analyzed differently; result TBA

Four GRBs yielded no candidates

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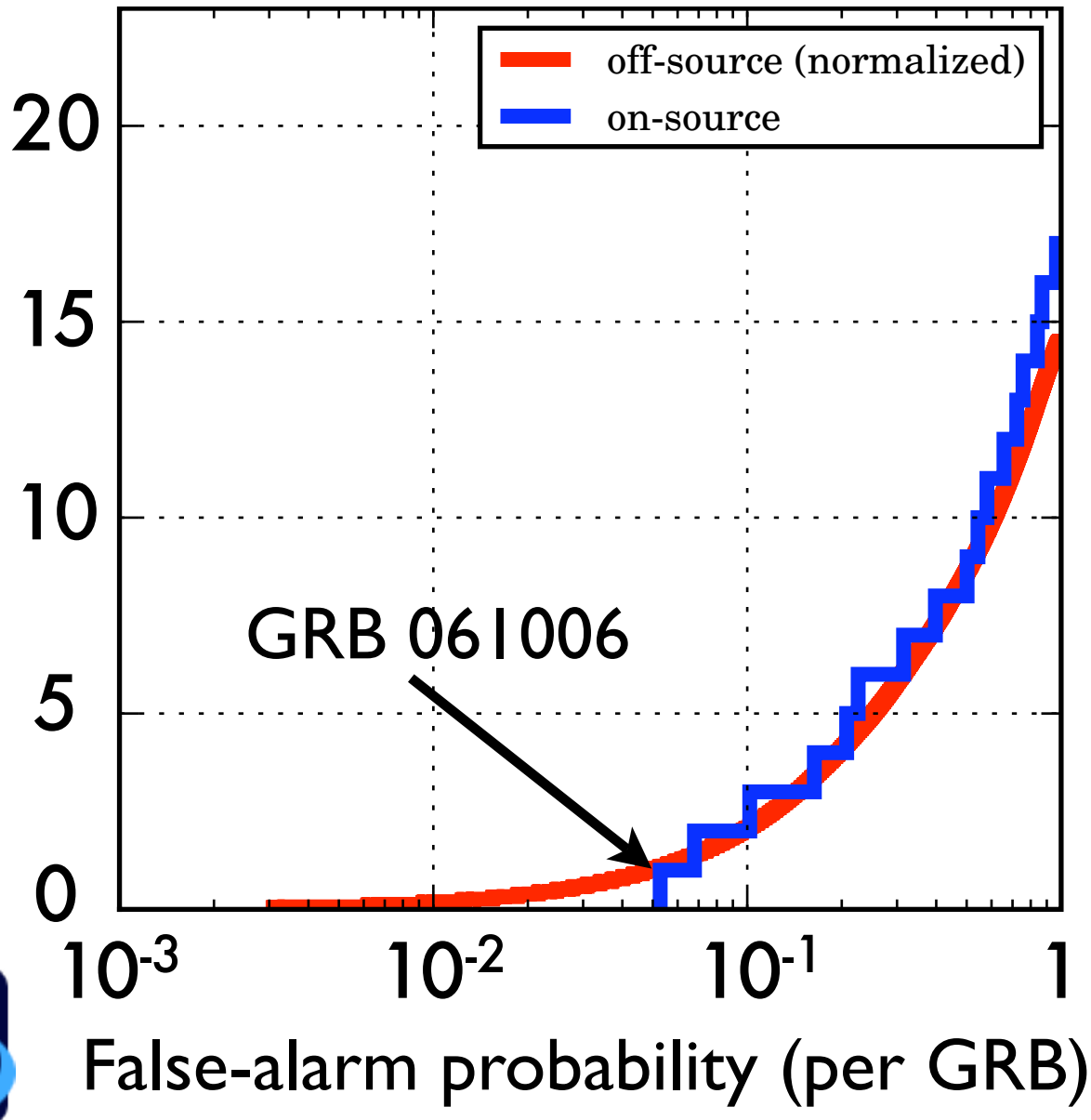

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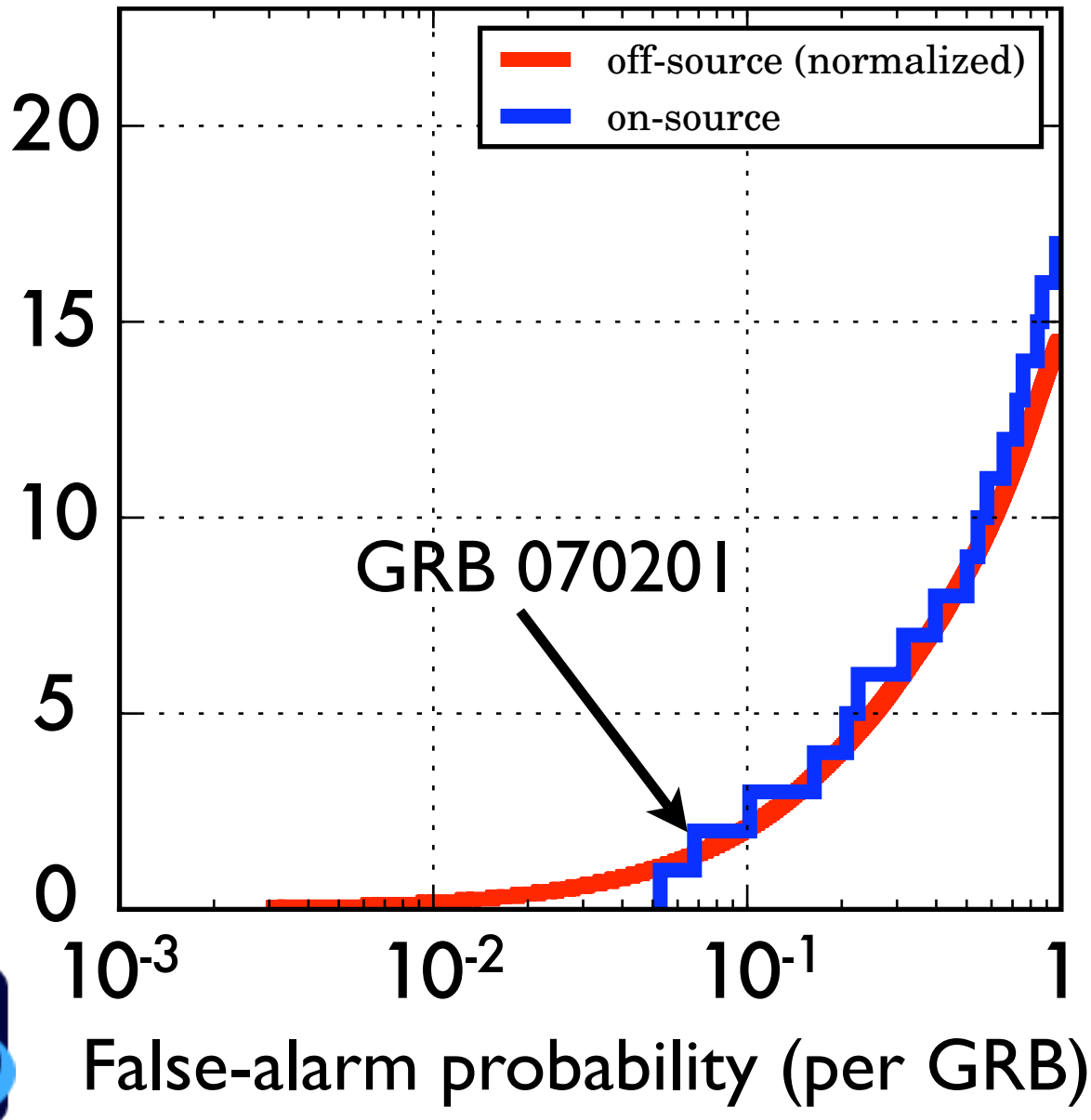

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Where we are, where we will be

- We discovered no GWs from compact binary inspirals in coincidence with 21 short GRBs in S5/VSR1. GRB 070923, distance exclusions, and a population search are forthcoming.
- S6/VSR2 begins in a few weeks with enhanced detectors.
- Advanced detectors are due to come online around 2014.
- LIGO and Virgo are committed to multi-messenger astronomy. A coincident detection would provide enormous science.