UNIVERSITY OF BIRMINGHAM

Discoveries from Advanced LIGO

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On behalf of the
LIGO Scientific & Virgo Collaborations
DCC G1601624
30 August 2016, GRAMPA

We can detect gravitational waves

Binary black holes exist

Binary black holes merge

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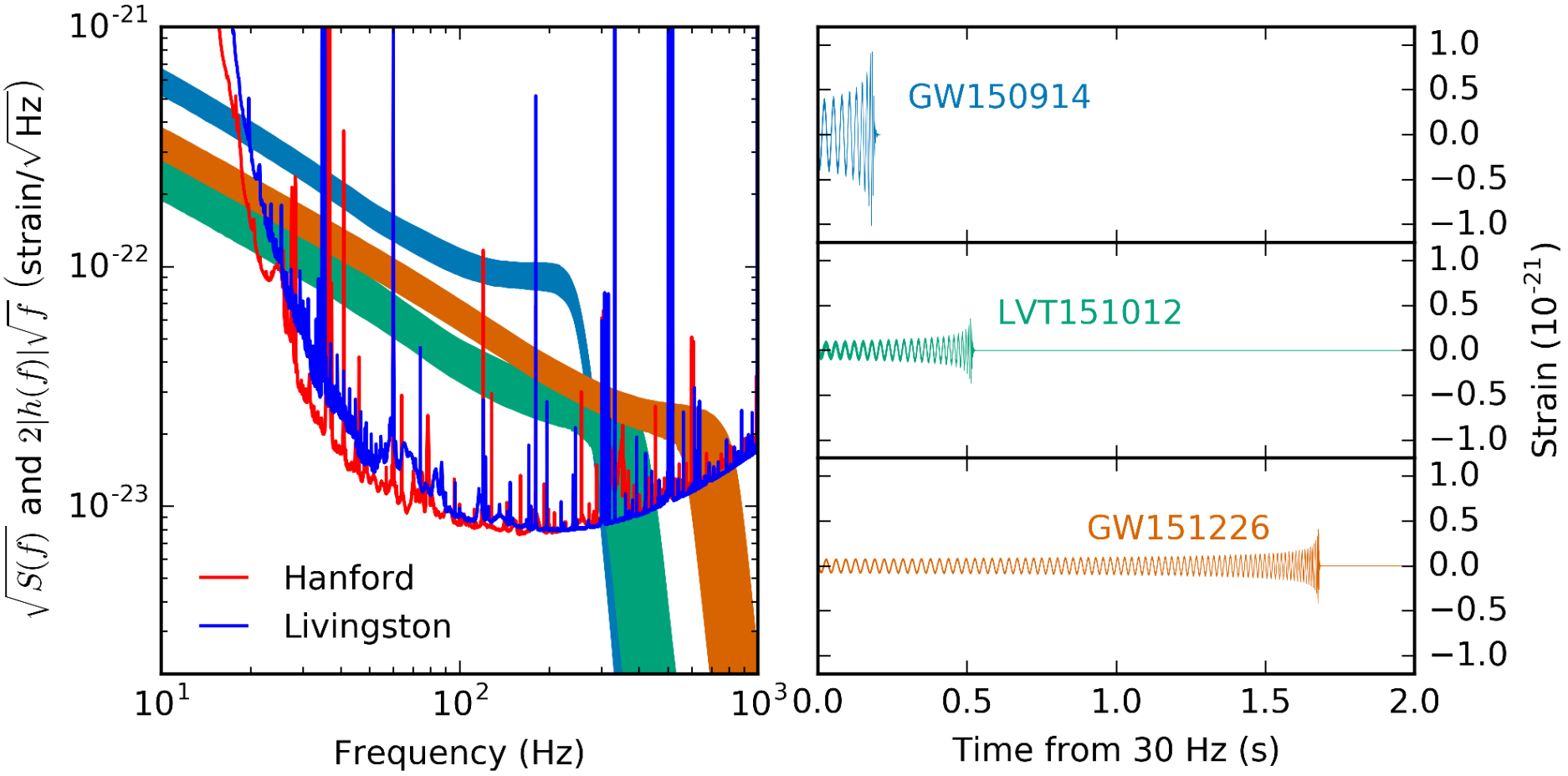
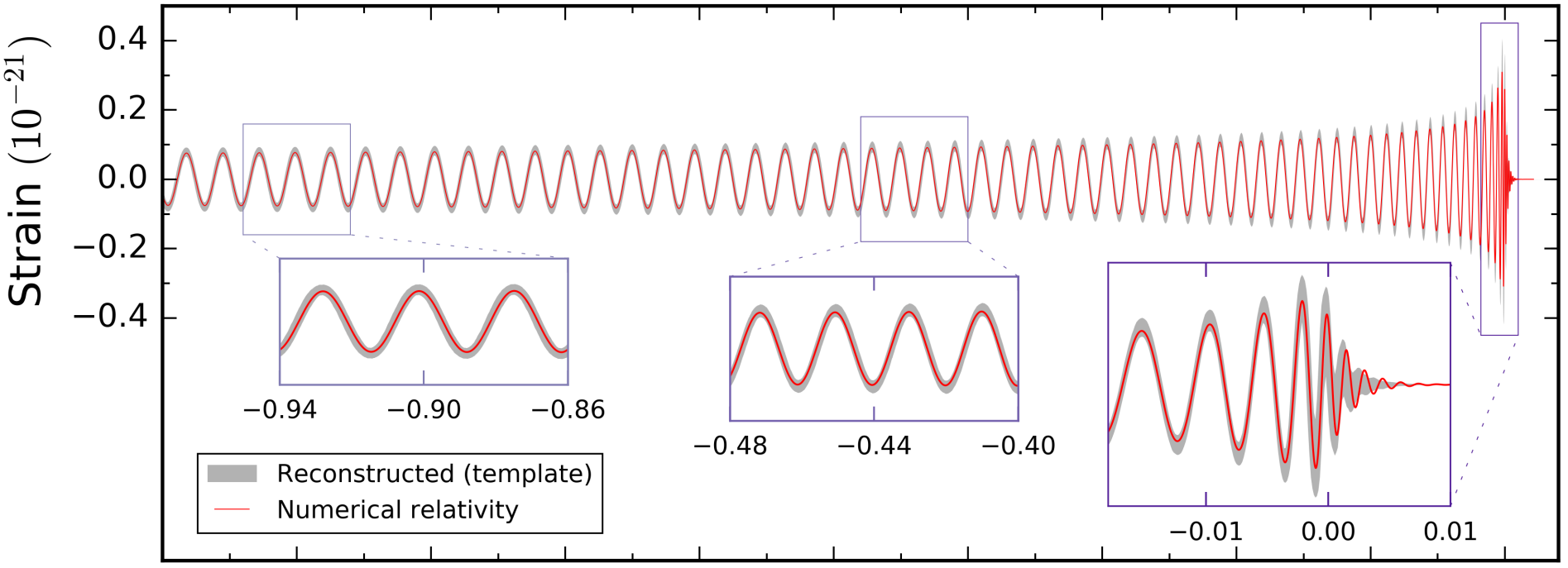
Detection



LVC arXiv:1606.04856

Waveforms



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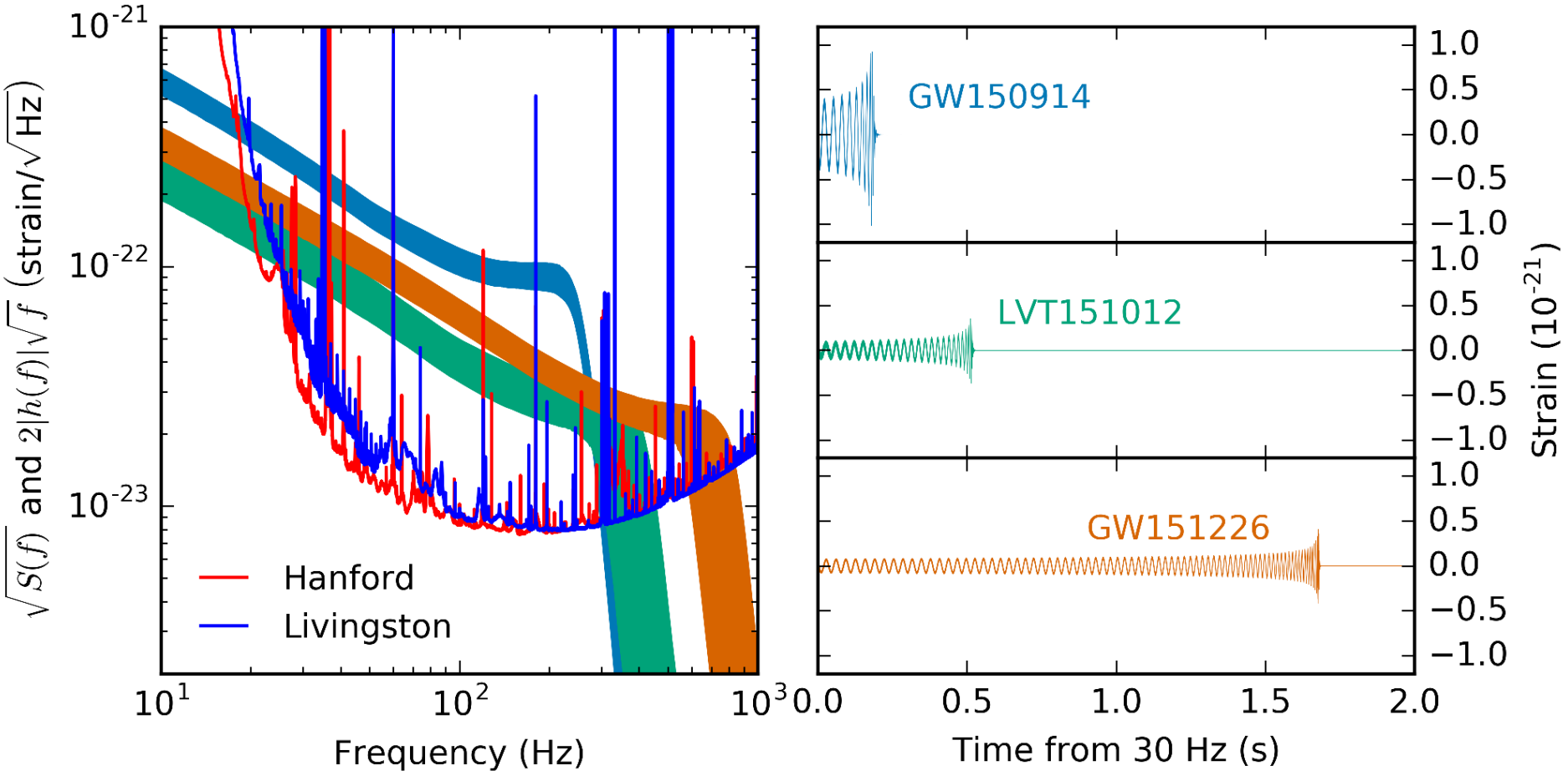

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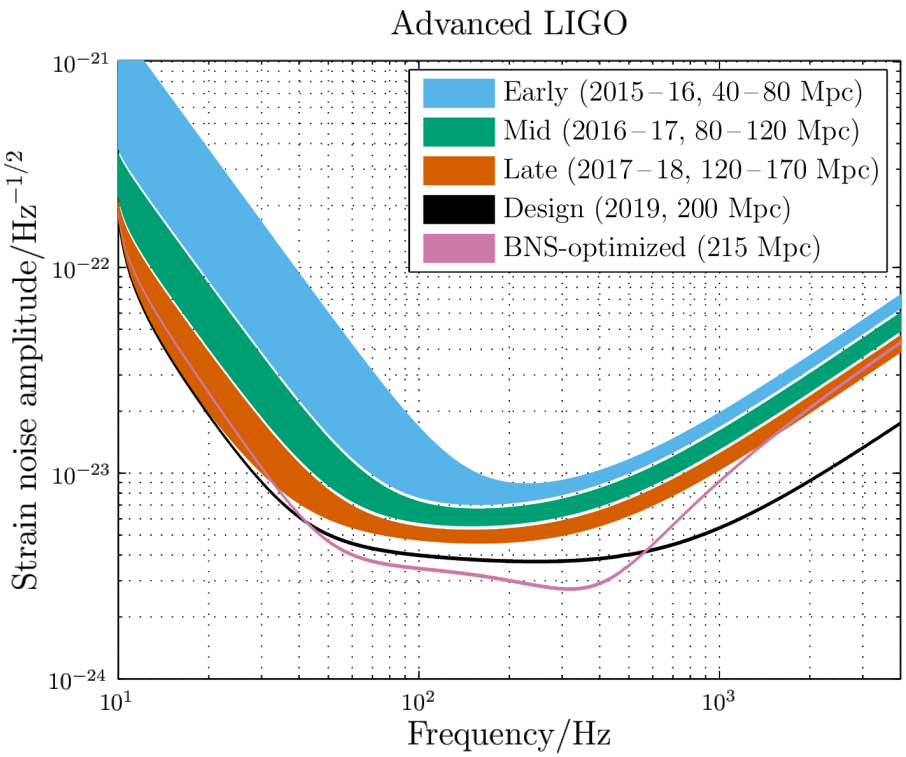
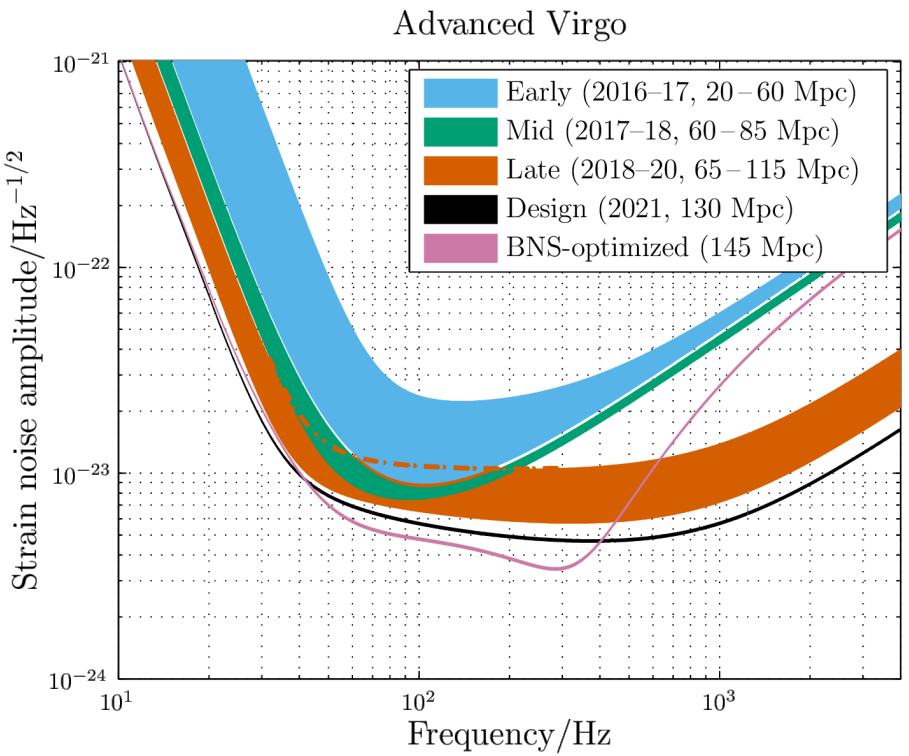
Future observing runs





LVC arXiv:1303.0670

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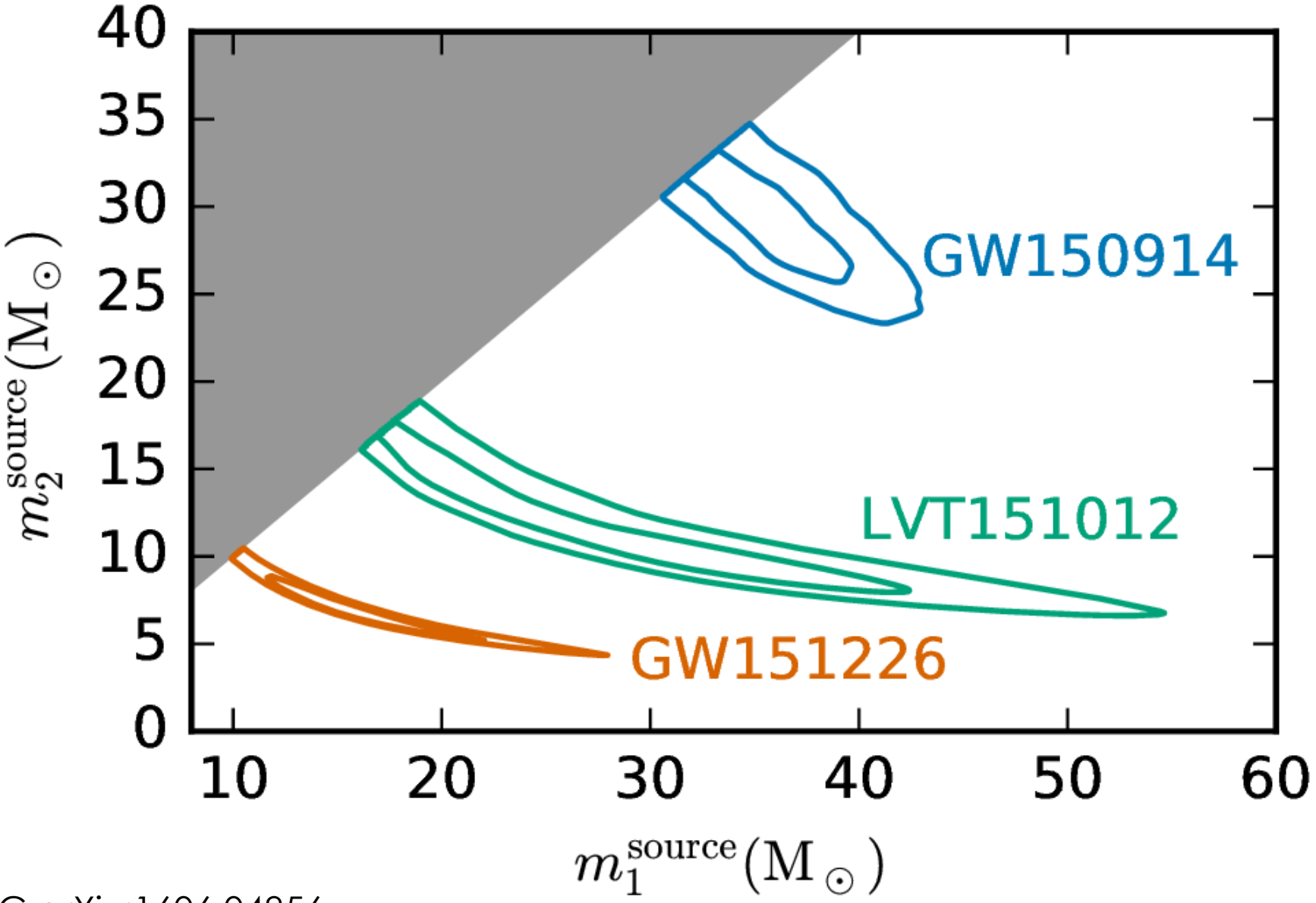


LVC arXiv:1606.04856

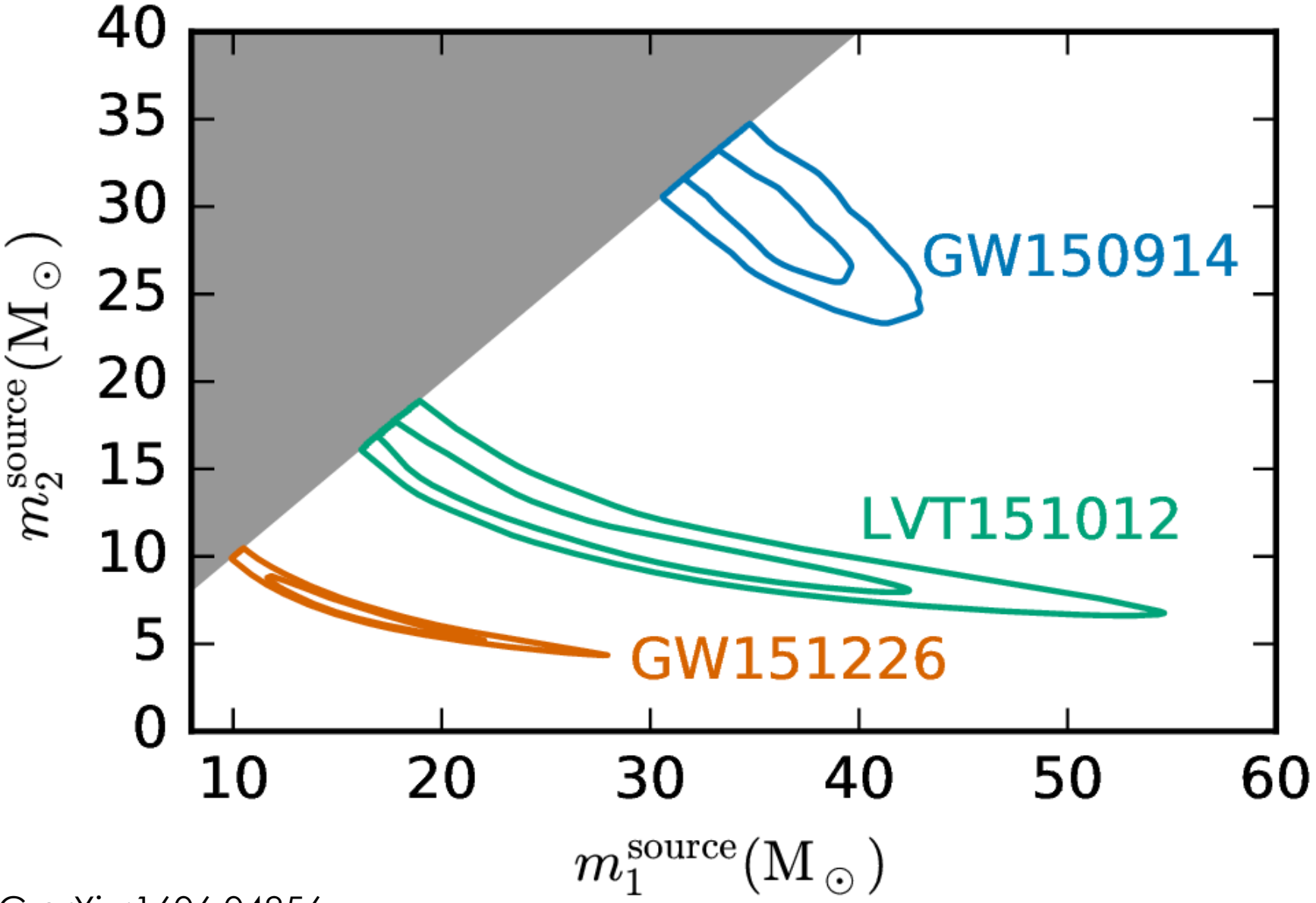
Credit: ButterflyLove1

Upper limits on the rates of binary neutron star and neutron-star--black-hole mergers from Advanced LIGO's first observing run

The LIGO Scientific Collaboration, the Virgo Collaboration: B. P. Abbott, R. Abbott, T. D. Abbott, M. R. Abernathy, F. Acernese, K. Ackley, C. Adams, T. Adams, P. Addesso, R. X. Adhikari, V. B. Adya, C. Affeldt, M. Agathos, K. Agatsuma, N. Aggarwal, O. D. Aguiar, L. Aiello, A. Ain, P. Ajith, B. Allen, A. Allocca, P. A. Altin, S. B. Anderson, W. G. Anderson, K. Arai, M. C. Araya, C. C. Arceneaux, J. S. Areeda, N. Arnaud, K. G. Arun, S. Ascenzi, G. Ashton, M. Ast, S. M. Aston, P. Astone, P. Aufmuth, C. Aulbert, S. Babak, P. Bacon, M. K. M. Bader, P. T. Baker, F. Baldaccini, G. Ballardin, S. W. Ballmer, J. C. Barayoga, S. E. Barclay, B. C. Barish, D. Barker, F. Barone, B. Barr, L. Barsotti, M. Barsuglia, D. Barta, J. Bartlett, I. Bartos, R. Bassiri, A. Basti, J. C. Batch, C. Baune, V. Bavigadda, et al. (899 additional authors not shown)

(Submitted on 25 Jul 2016)

We report here the non-detection of gravitational waves from the merger of binary neutron star systems and neutron-star--black-hole systems during the first observing run of Advanced LIGO. In particular we searched for gravitational wave signals from binary neutron star systems with component masses $\in [1,3]M_{\odot}$ and component dimensionless spins < 0.05. We also searched for neutron-star--black-hole systems with the same neutron star parameters, black hole mass $\in [2,99]M_{\odot}$ and no restriction on the black hole spin magnitude. We assess the sensitivity of the two LIGO detectors to these systems, and find that they could have detected the merger of binary neutron star systems with component mass distributions of $1.35 \pm 0.13M_{\odot}$ at a volume-weighted average distance of $\sim$ 70Mpc, and for neutron-star--black-hole systems with neutron star masses of $1.4M_{\odot}$ and black hole masses of at least $5M_{\odot}$, a volume-weighted average distance of at least $\sim$ 110Mpc. From this we constrain with 90% confidence the merger rate to be less than 12,600 $\mathrm{Gpc}^{-3}\,\mathrm{yr}^{-1}$ for binary-neutron star systems and less than 3,600 $\mathrm{Gpc}^{-3}\,\mathrm{yr}^{-1}$ for neutron-star--black-hole systems. We find that if no detection of neutron-star binary mergers is made in the next two Advanced LIGO and Advanced Virgo observing runs we would place significant constraints on the merger rates. Finally, assuming a rate of $10^{+20}_{-7}\,\mathrm{Gpc}^{-3}\,\mathrm{yr}^{-1}$ short gamma ray bursts beamed towards the Earth and assuming that all short gamma-ray bursts have binary-neutron-star (neutron-star--black-hole) progenitors we can use our 90% confidence rate upper limits to constrain the beaming angle of the gamma-ray burst to be greater than $2.3^{+1.7^{\circ}}_{-1.1}$ ($4.3^{+3.1^{\circ}}_{-1.9}$).



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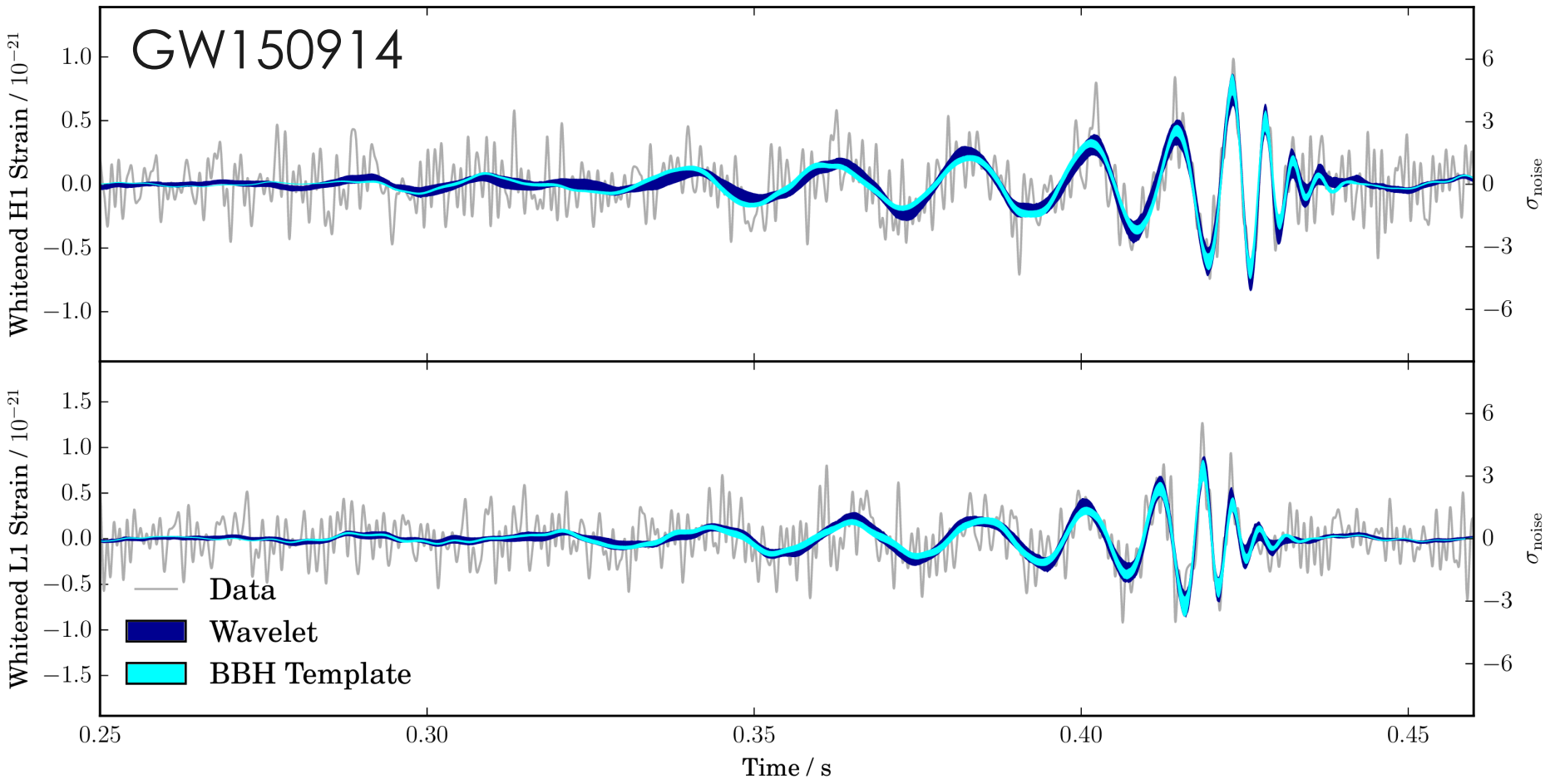
Waveform



LVC arXiv:1602.03840

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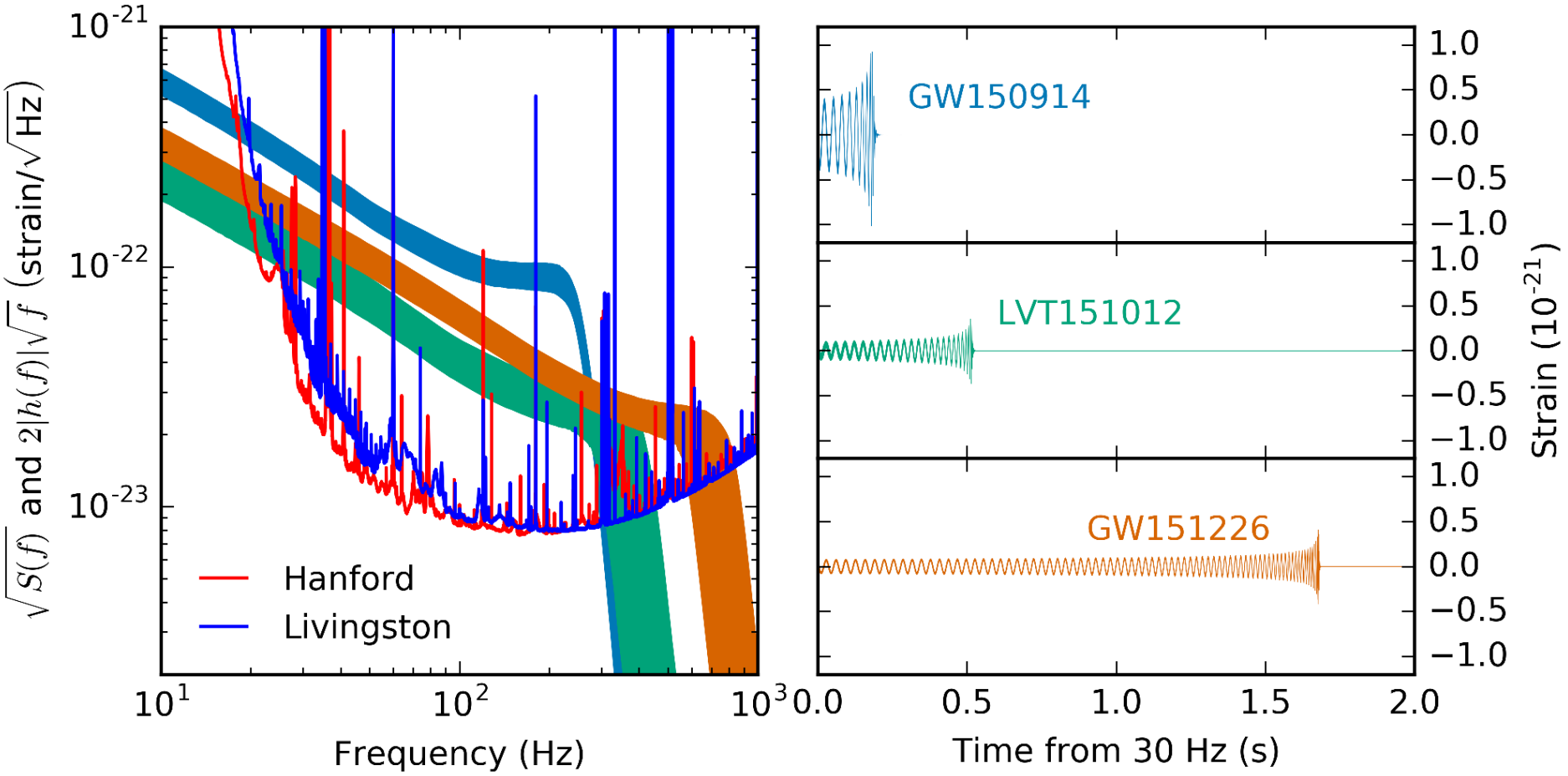

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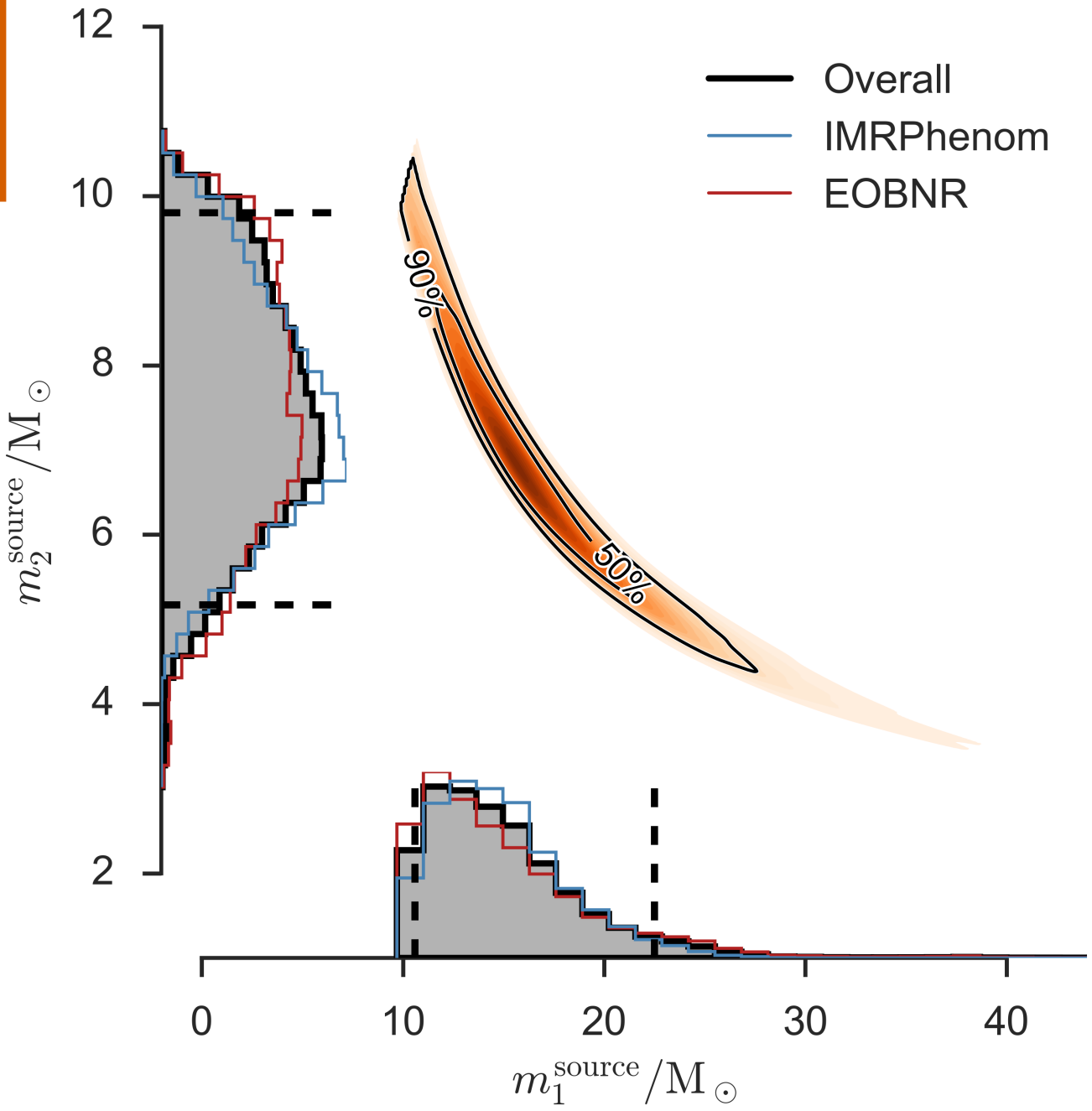
Masses



LVC
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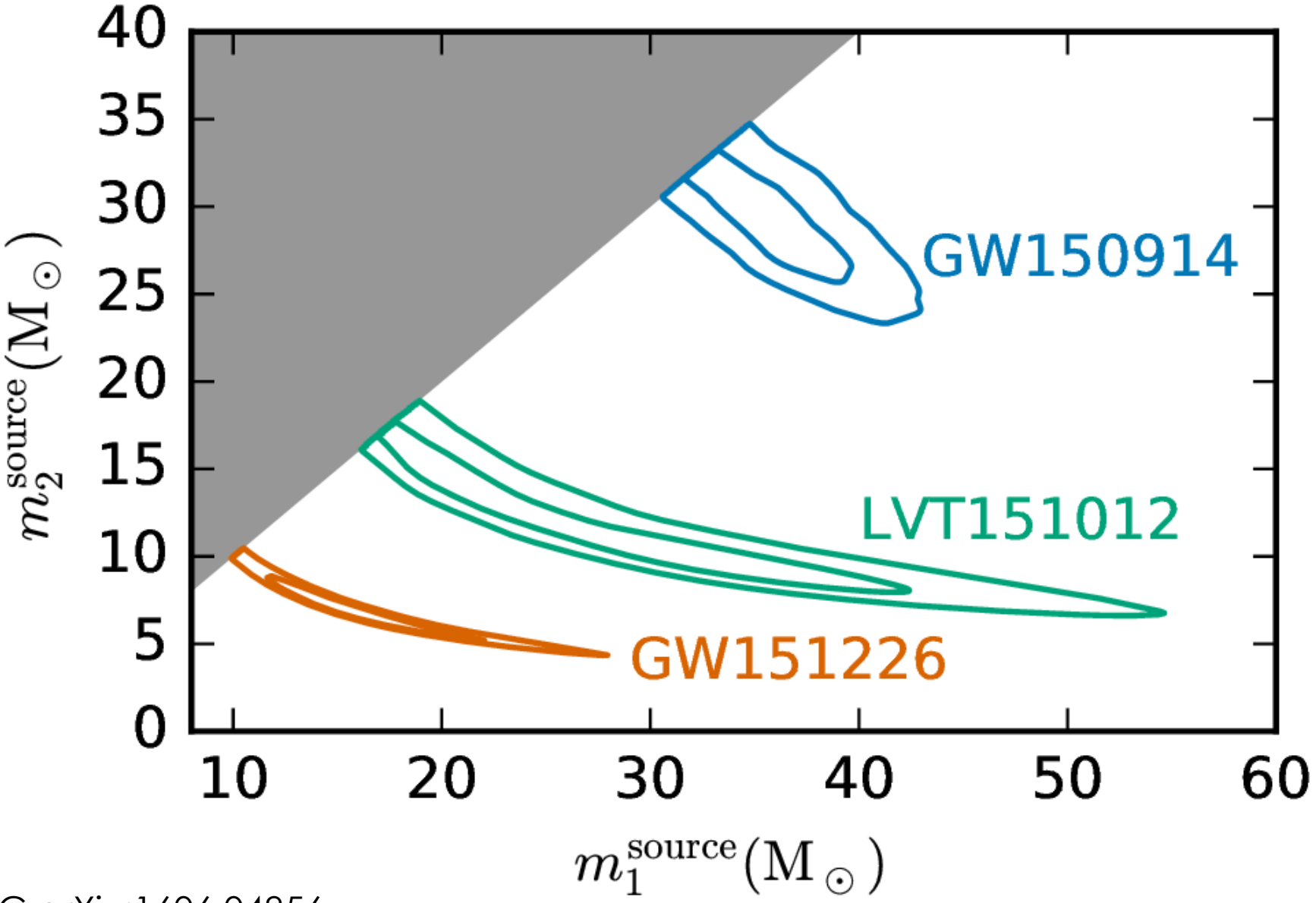
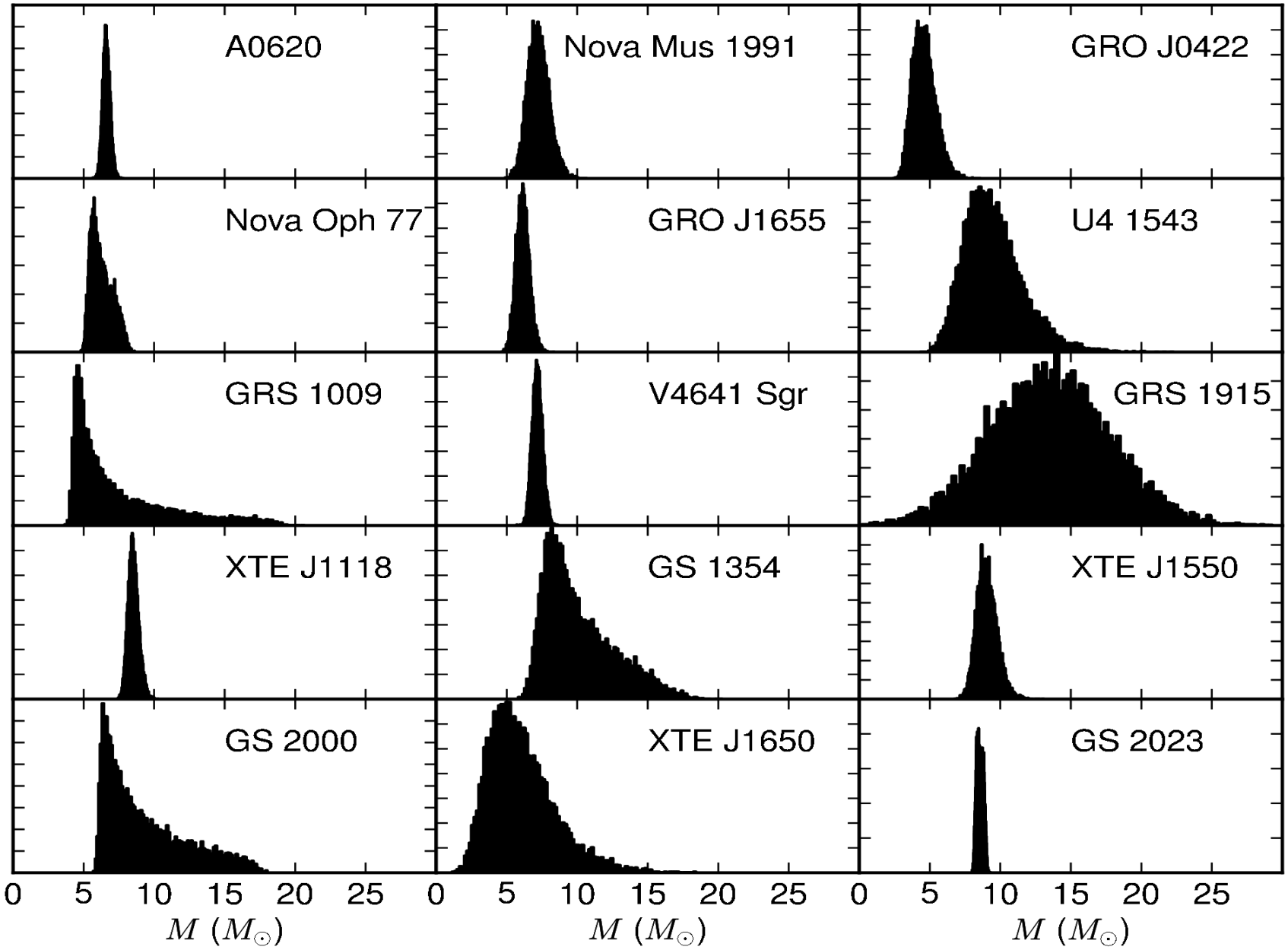
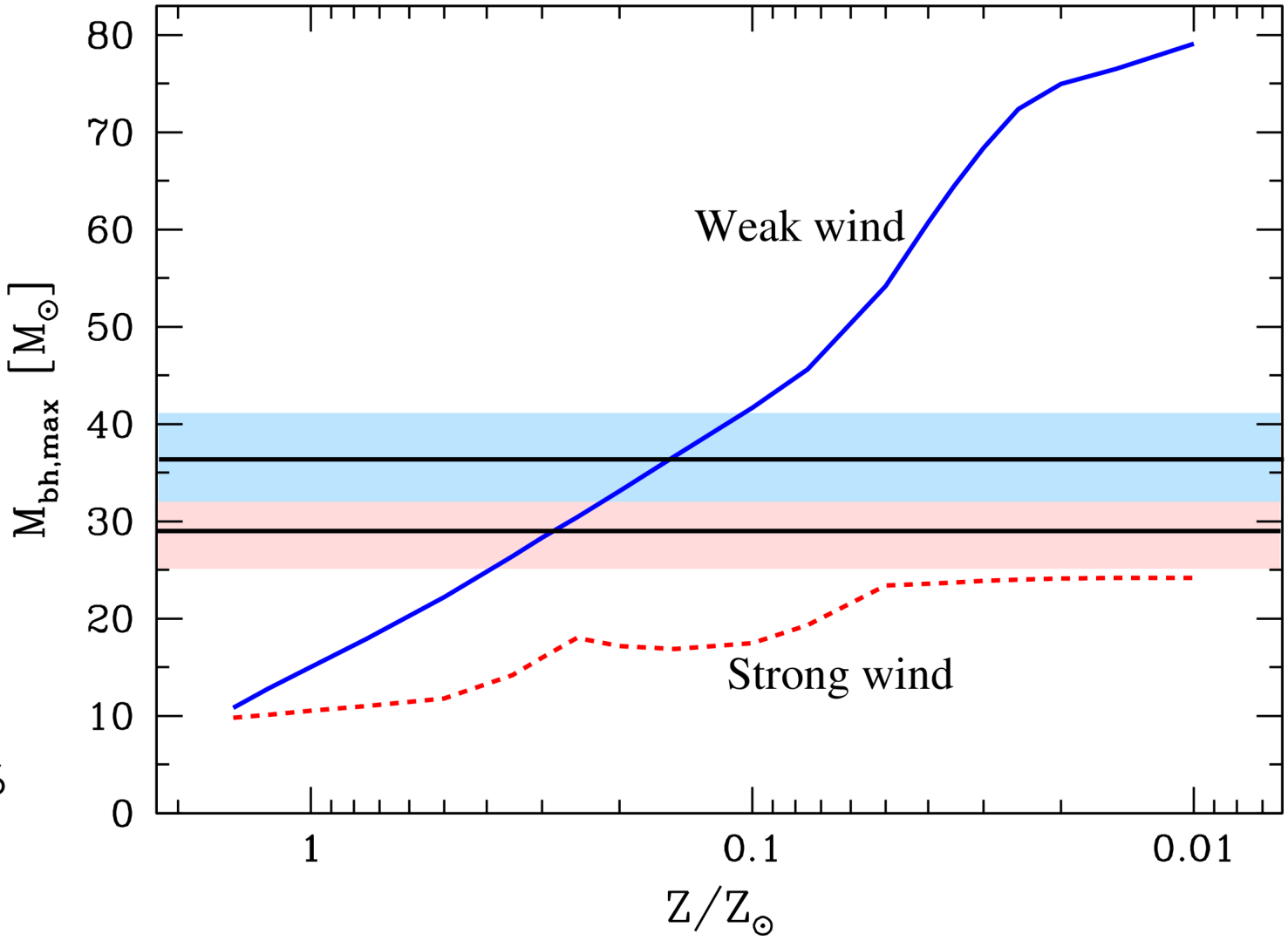


LVC arXiv:1606.04856

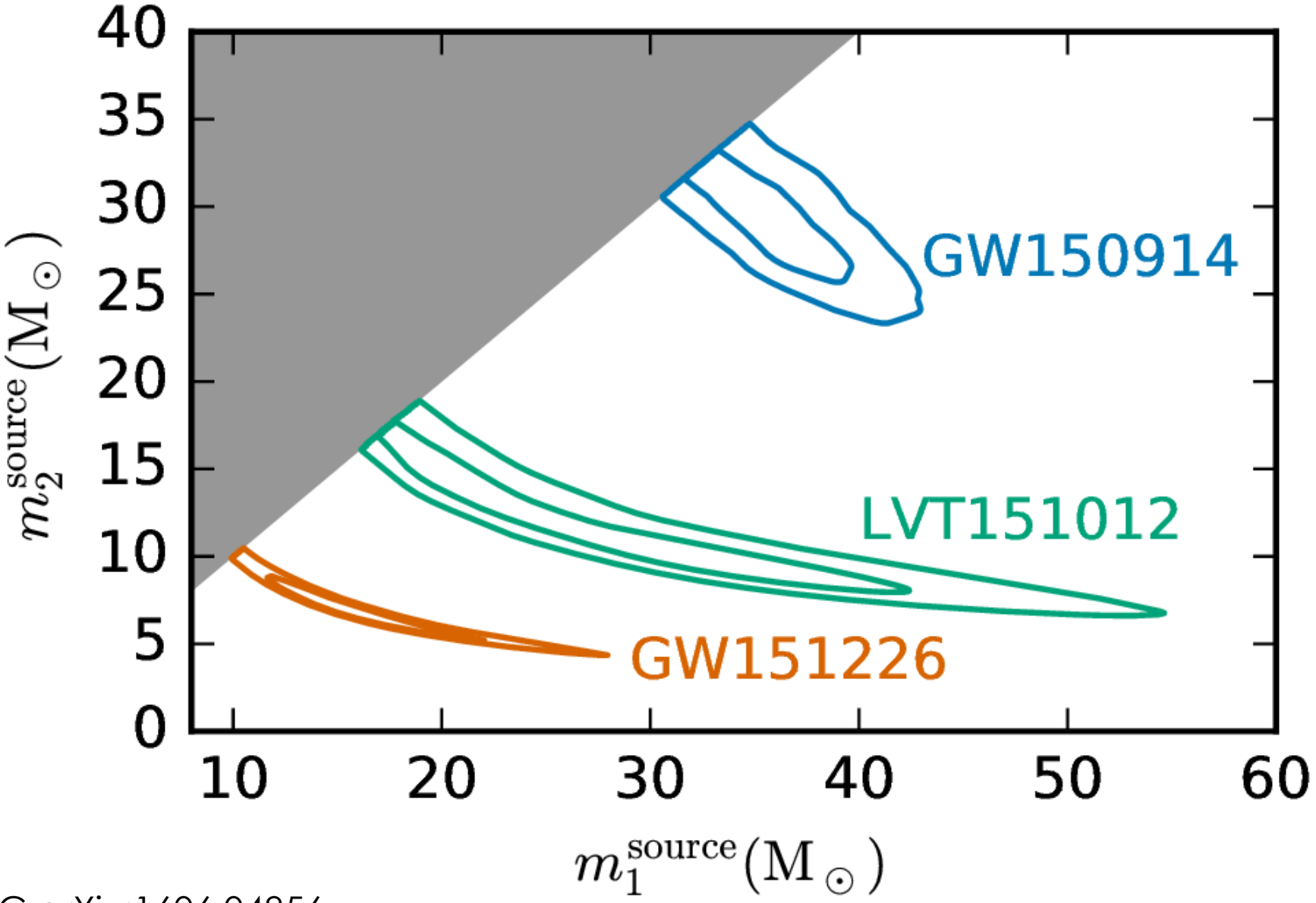
Farr *et al*. arXiv:1011.1459



Metallicity



LVC
arXiv:1602.03846
Belczynski *et al.*
arXiv:0904.2784



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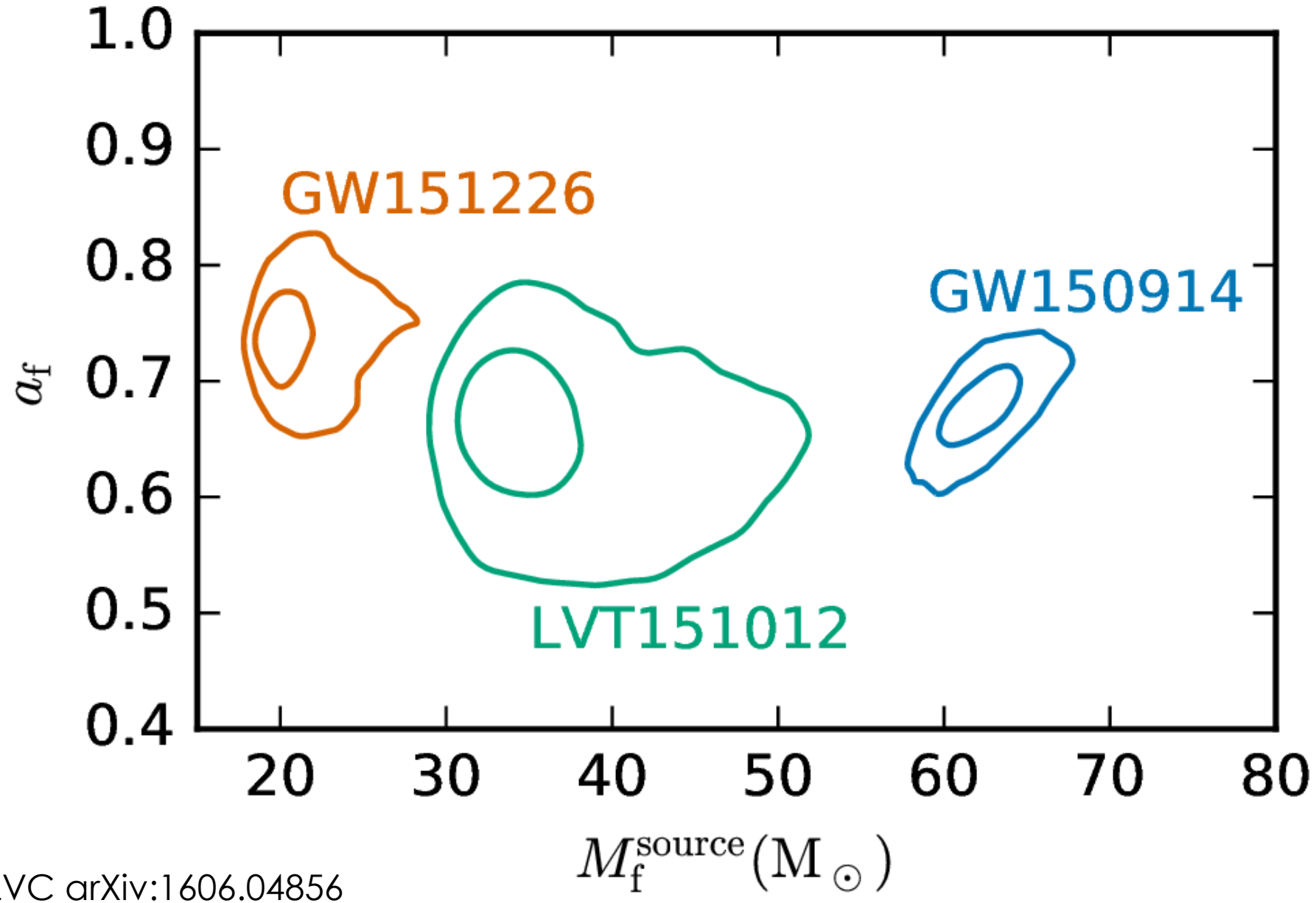
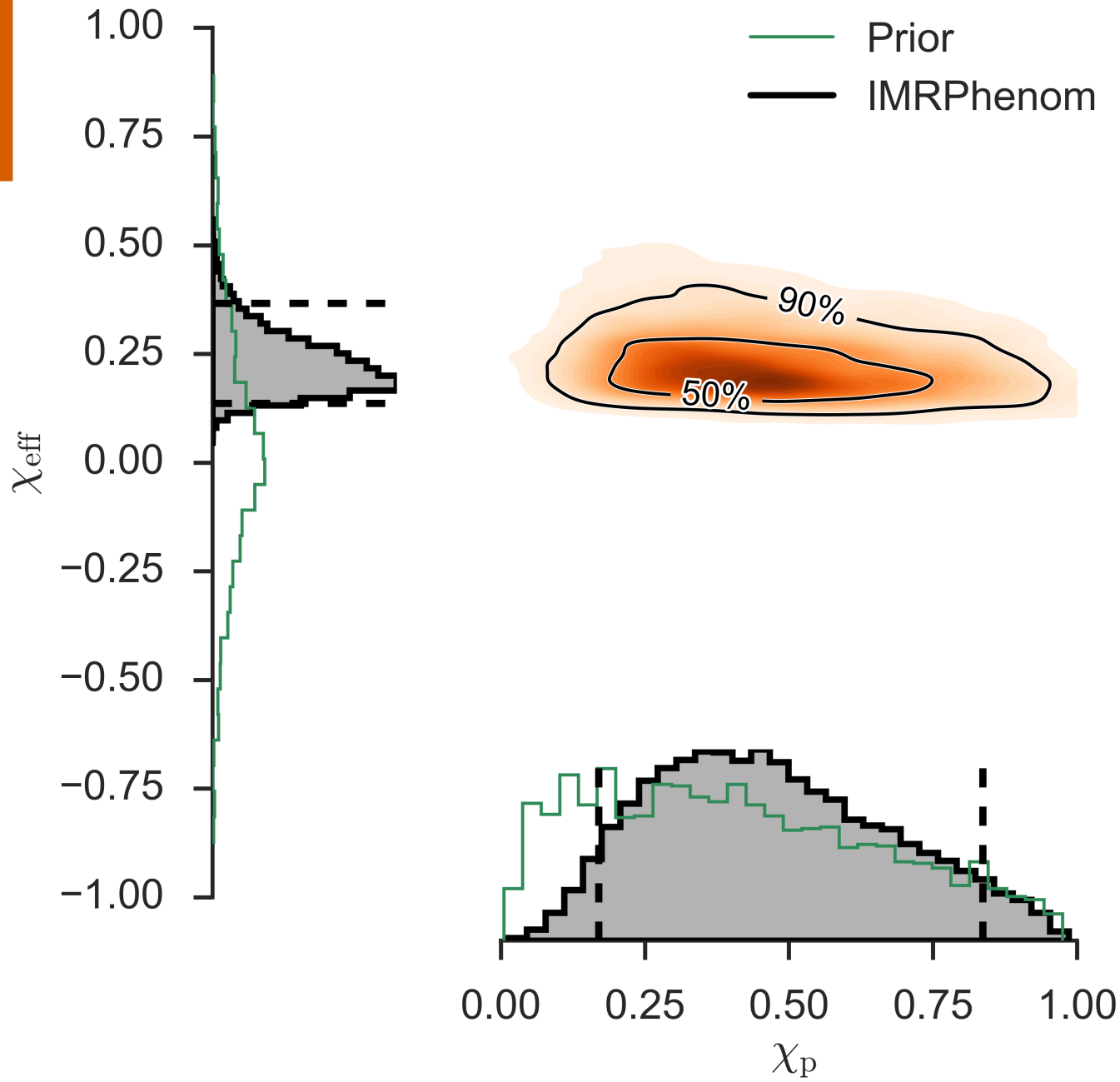


LVC arXiv:1606.04856

Spin



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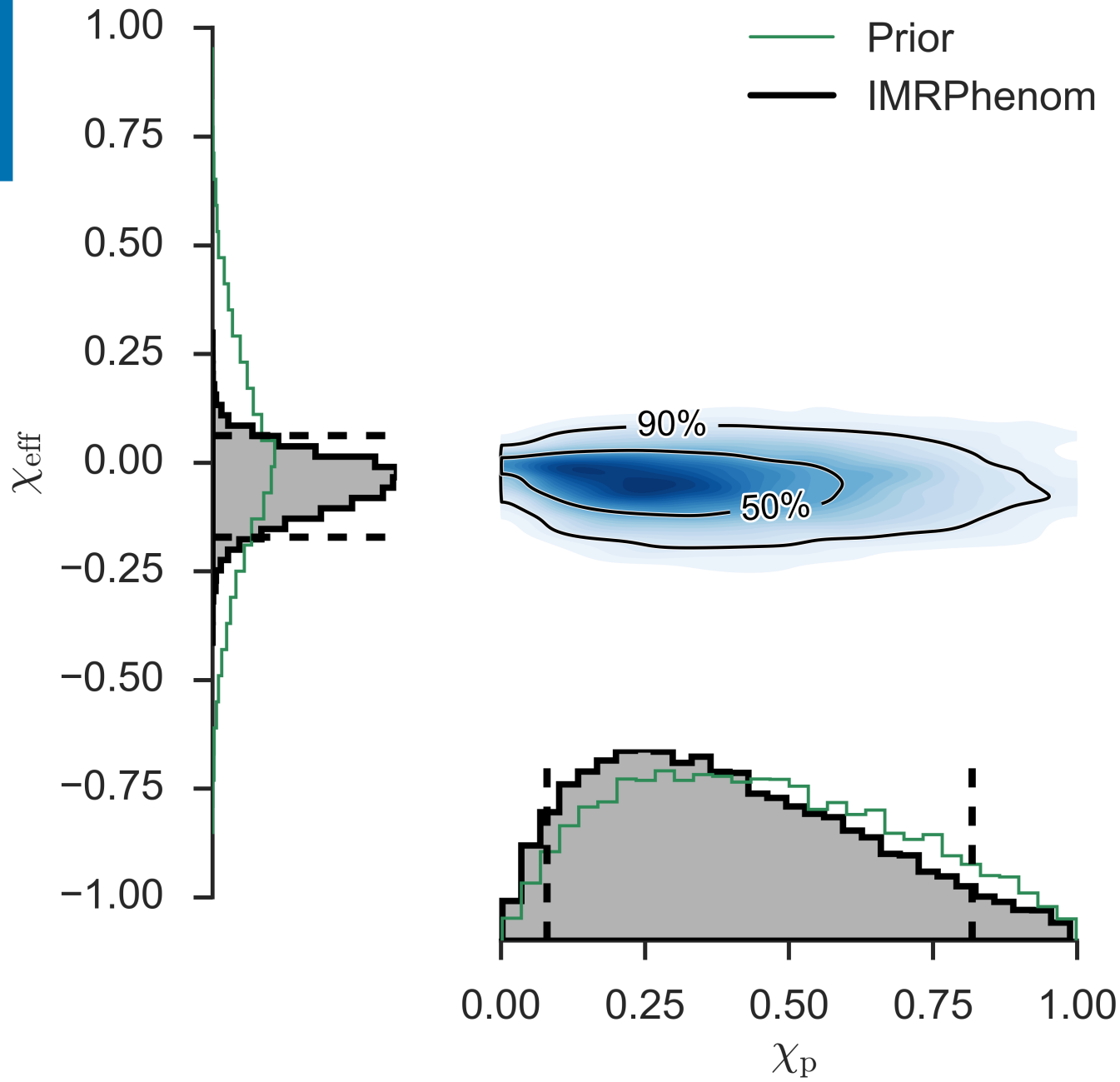
Spin



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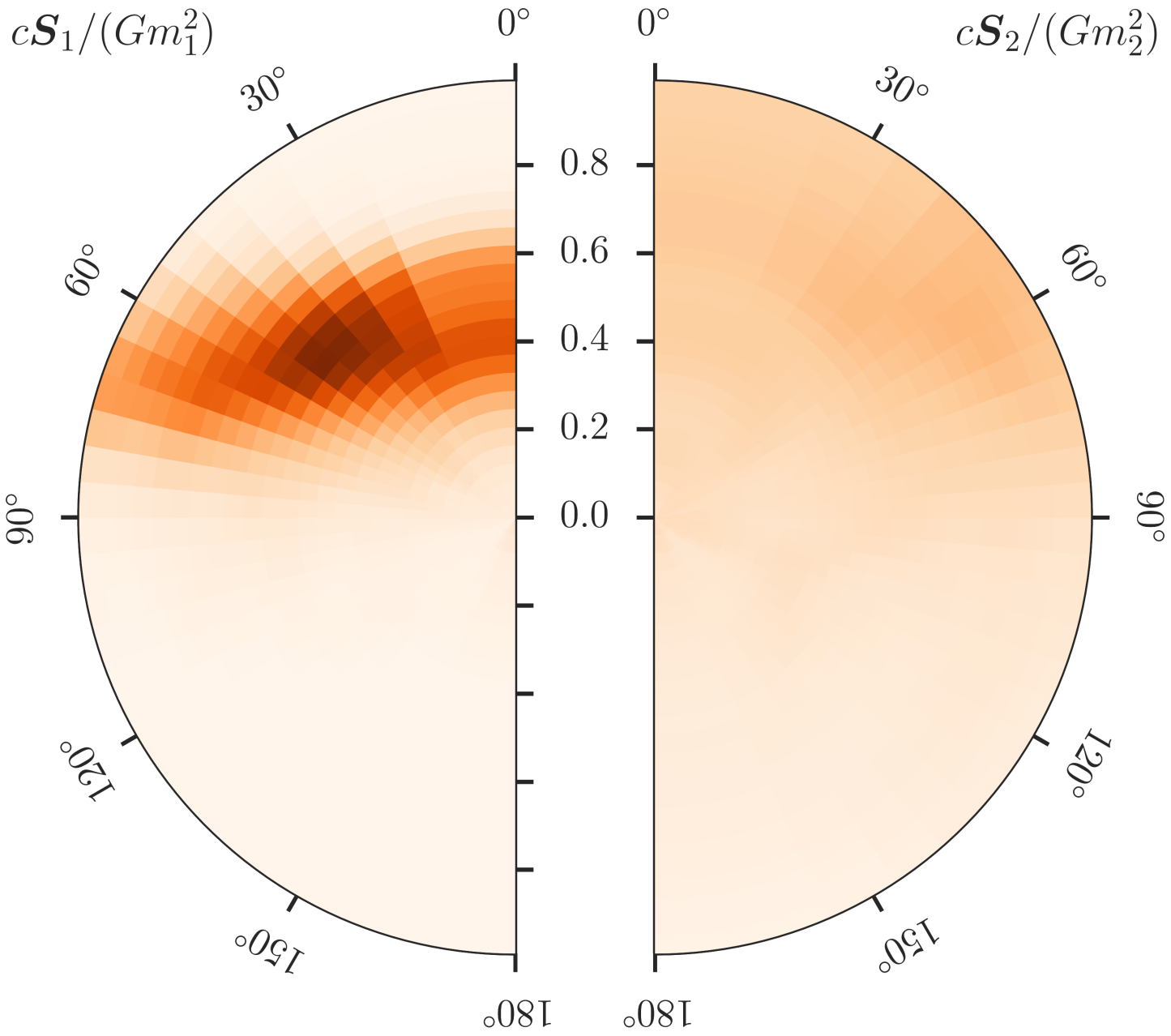
arXiv:1606.04856
arXiv:1602.03840

Spin



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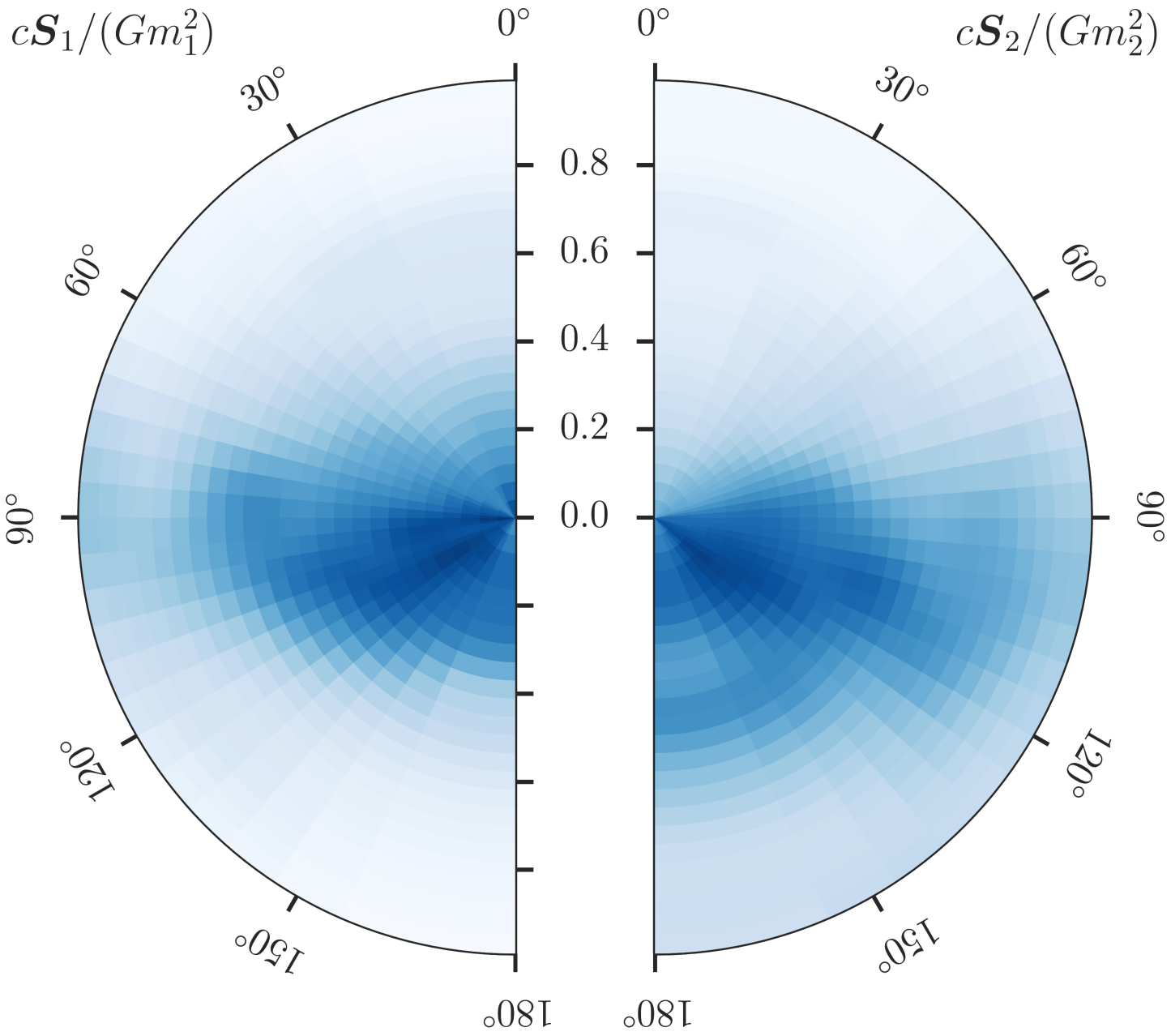
Spin



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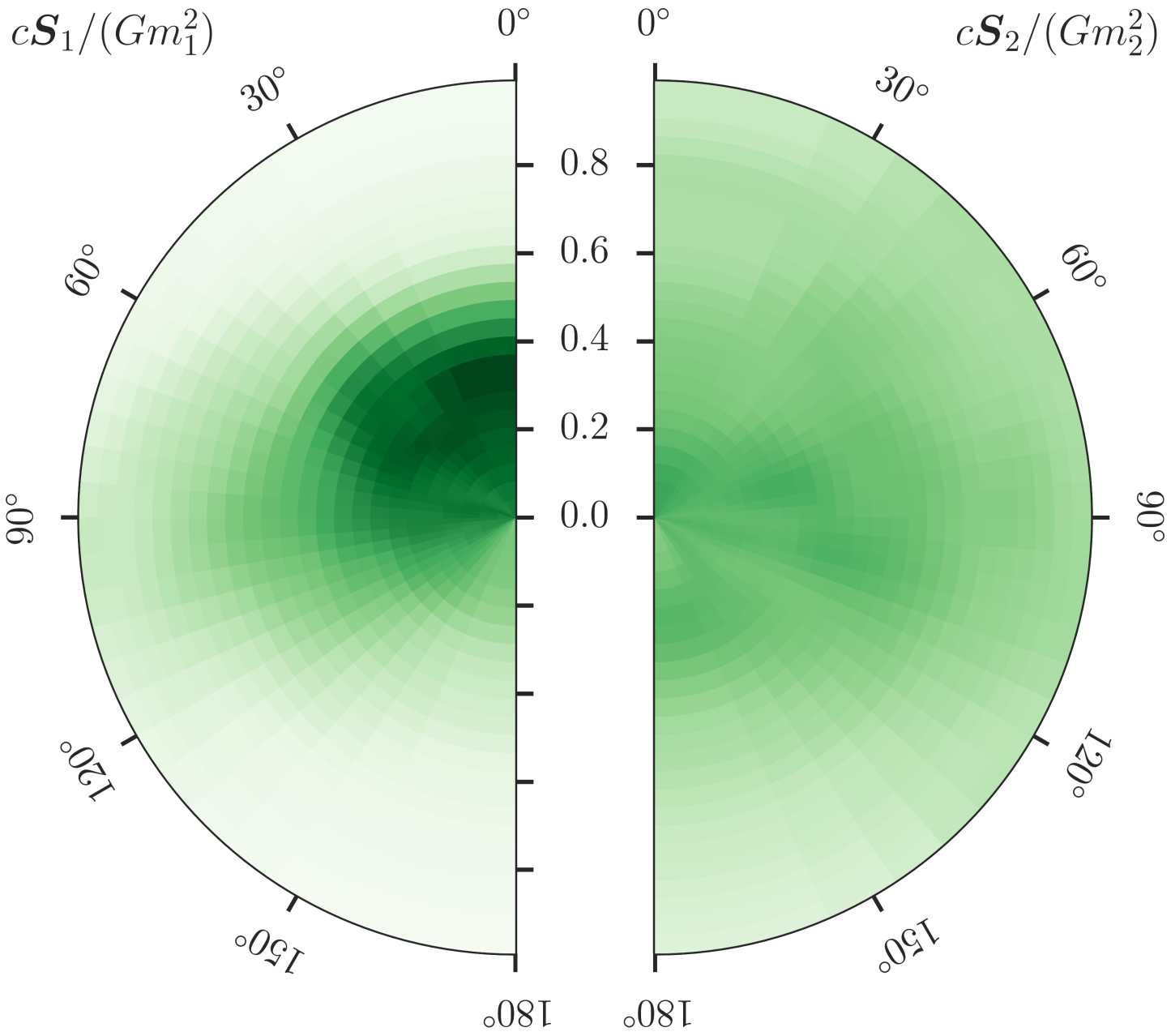
Spin



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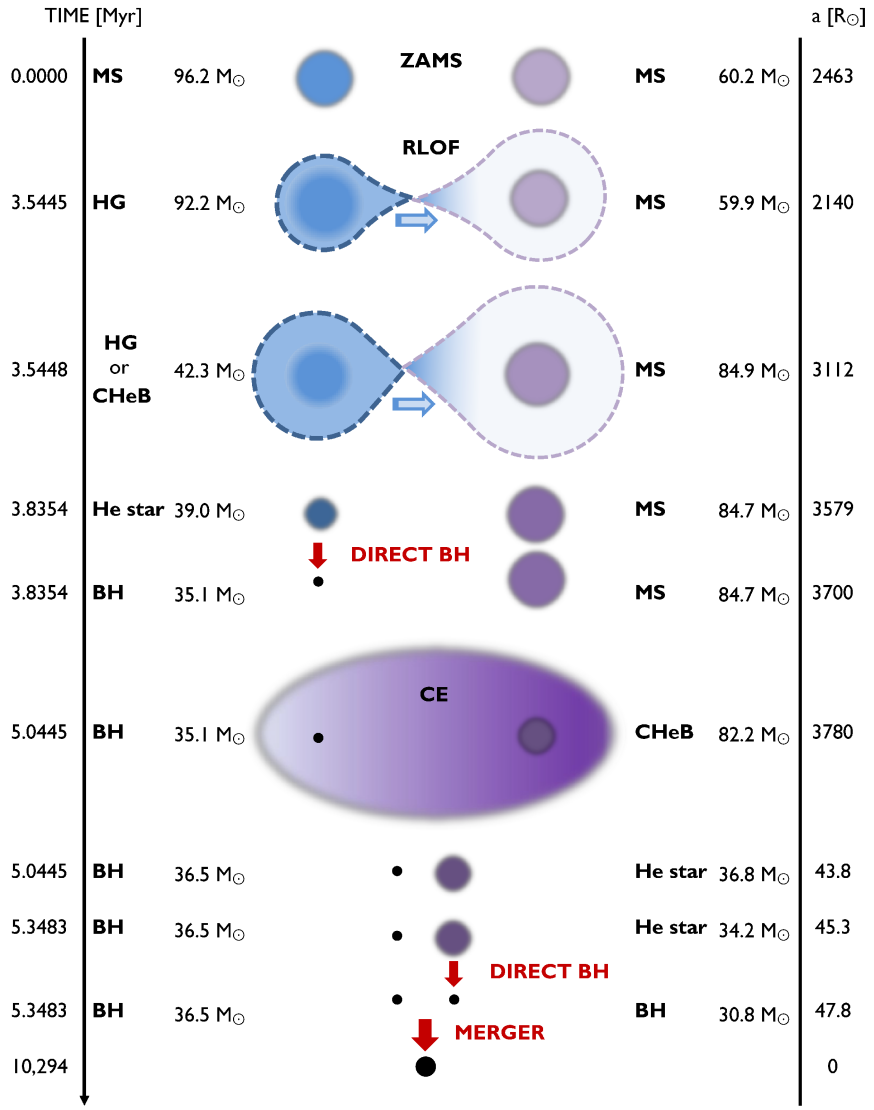
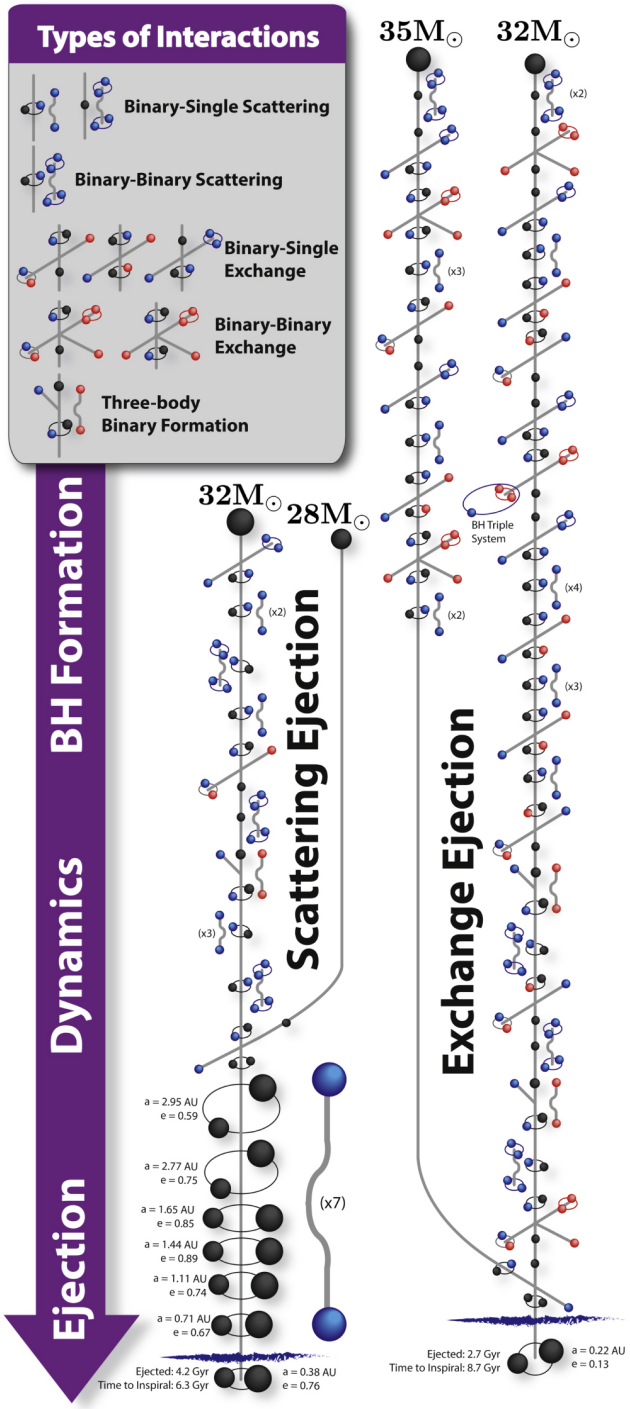
Binary formation



Rodriguez *et al.*
arXiv:1604.04254



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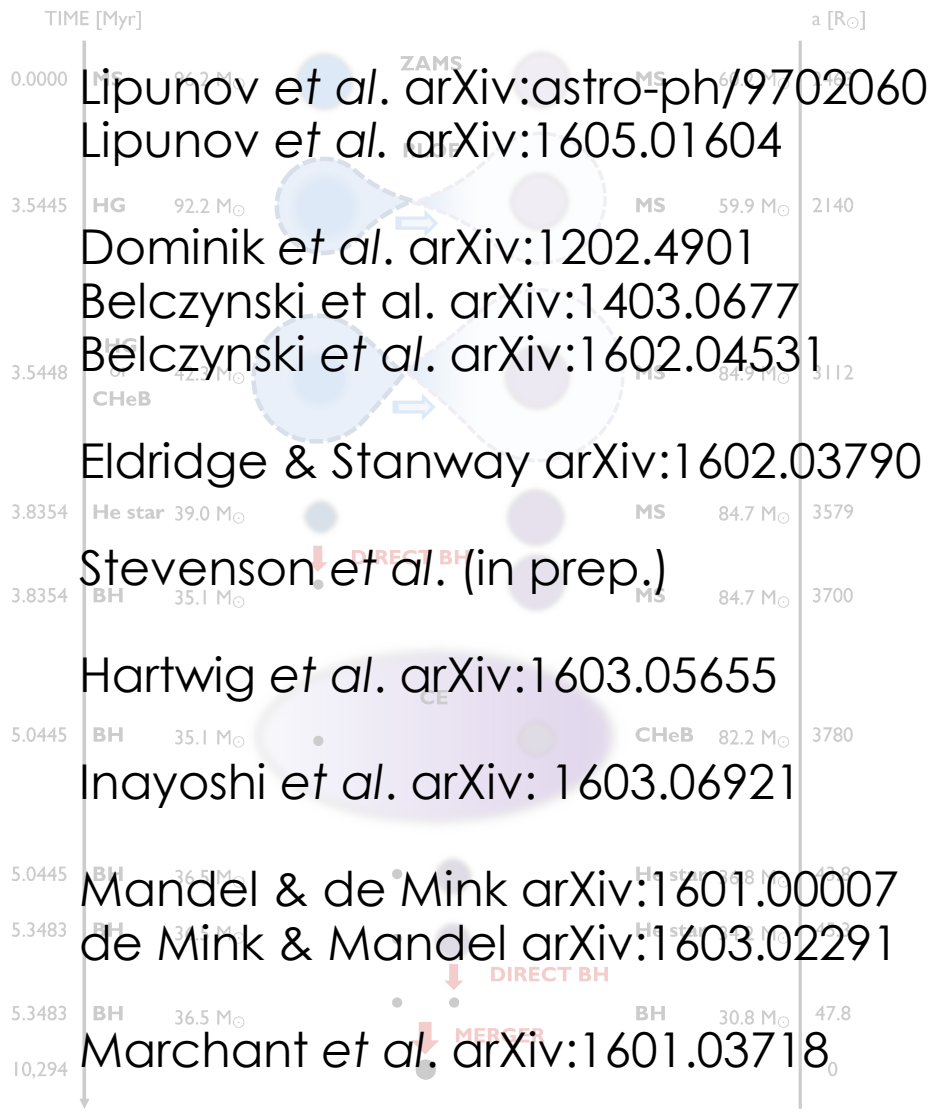
Binary formation



Lipunov *et al*. arXiv:astro-ph/9702060
Lipunov *et al*. arXiv:1605.01604

Dominik *et al*. arXiv:1202.4901
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Eldridge & Stanway arXiv:1602.03790

Stevenson *et al*. (in prep.)

Hartwig *et al*. arXiv:1603.05655

Inayoshi *et al*. arXiv: 1603.06921

Mandel & de Mink arXiv:1601.00007
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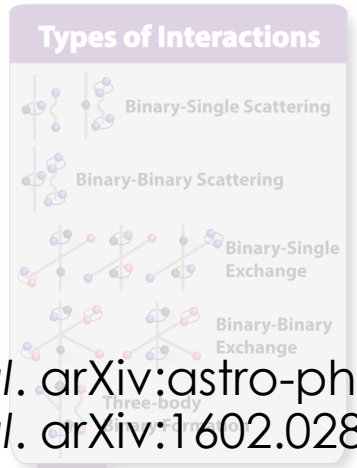
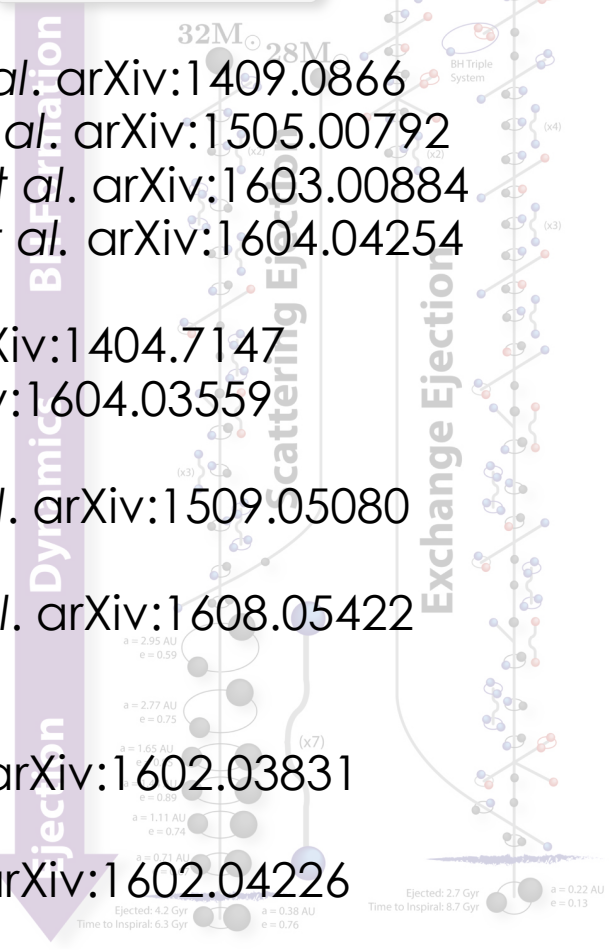
Marchant *et al*. arXiv:1601.03718





O'Leary *et al*. arXiv:astro-ph/0508224
O'Leary *et al*. arXiv:1602.02809

Morscher *et al*. arXiv:1409.0866
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Mapelli arXiv:1604.03559

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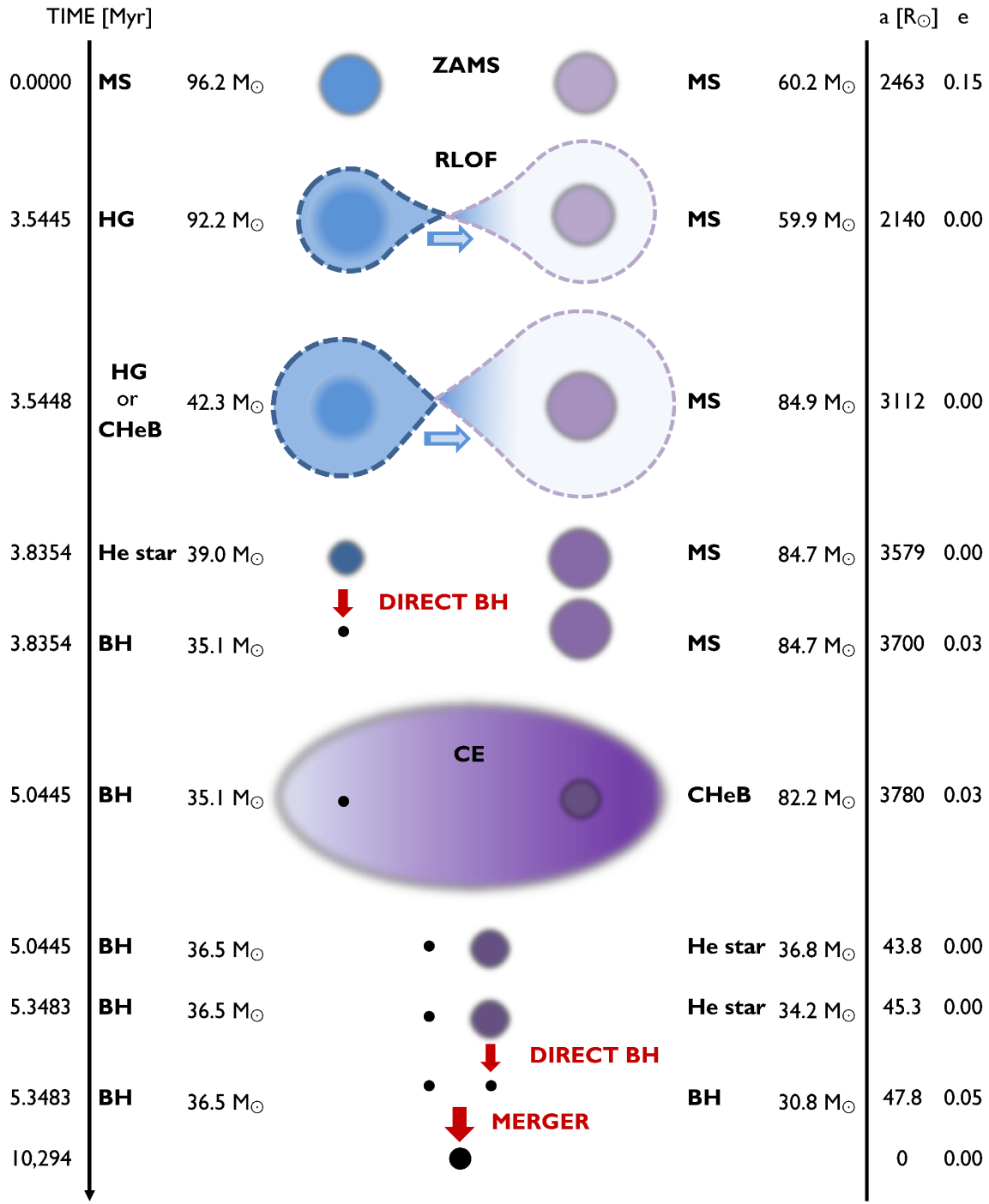
Stone *et al*. arXiv:1602.04226



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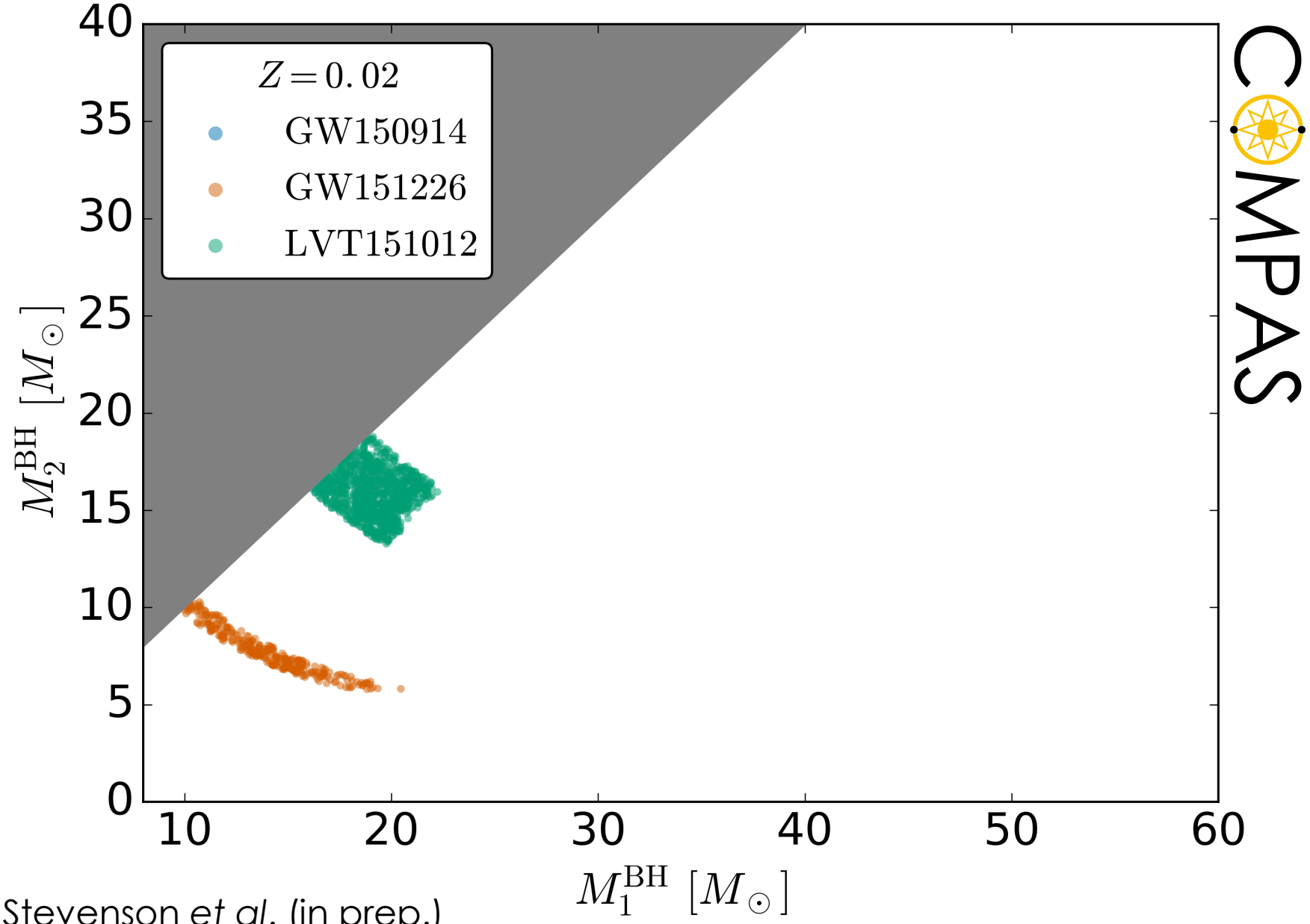
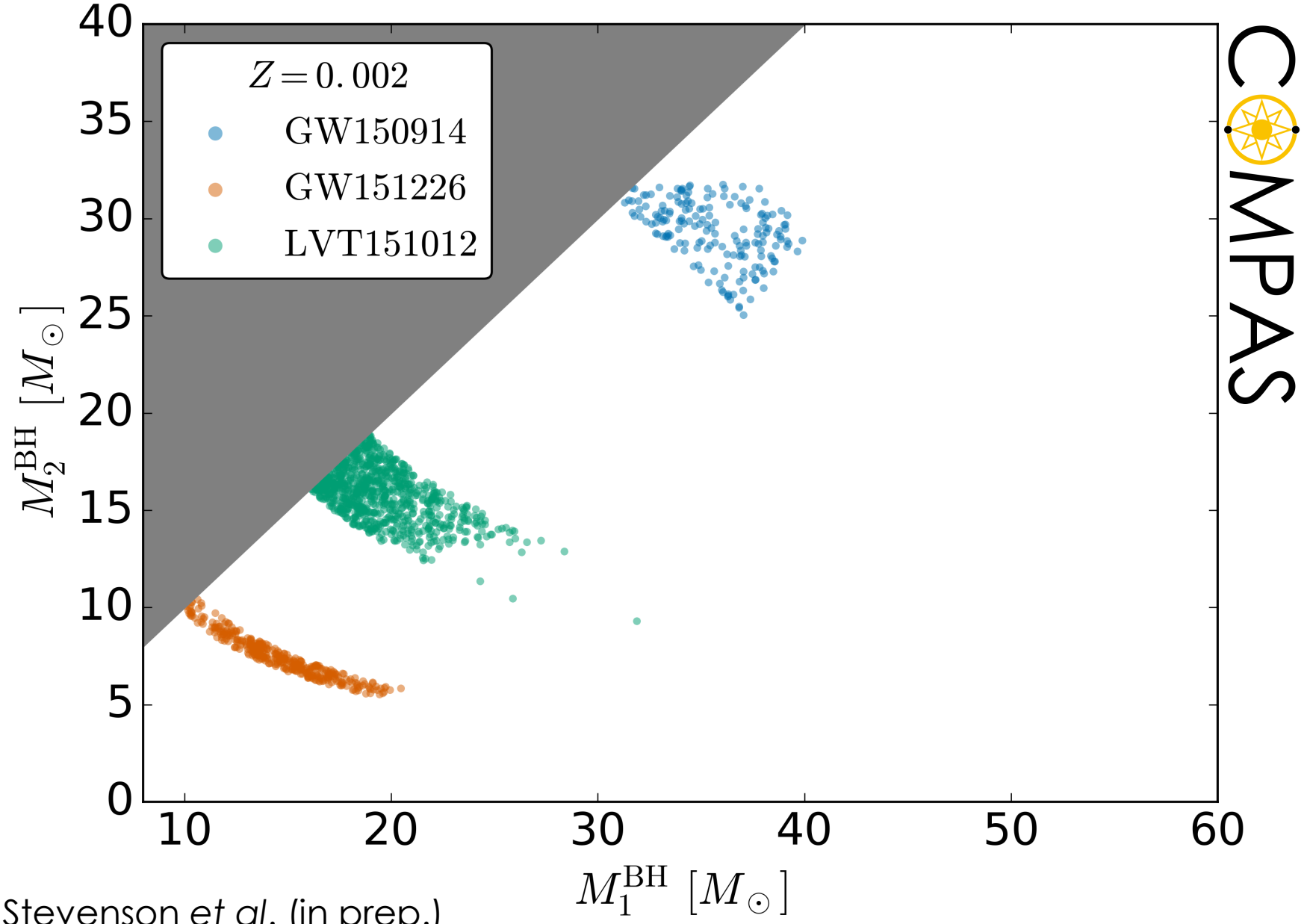


COMPAS

Stevenson *et al.* (in prep.)



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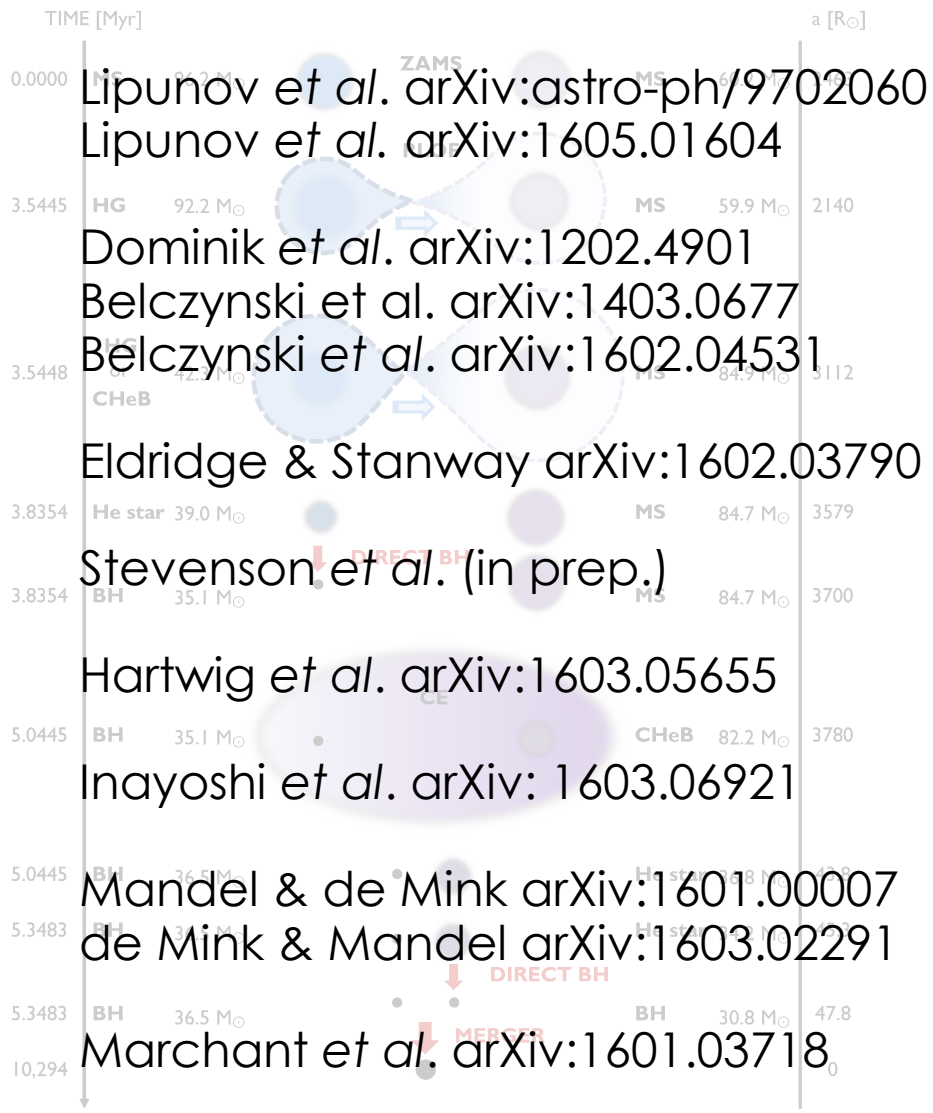

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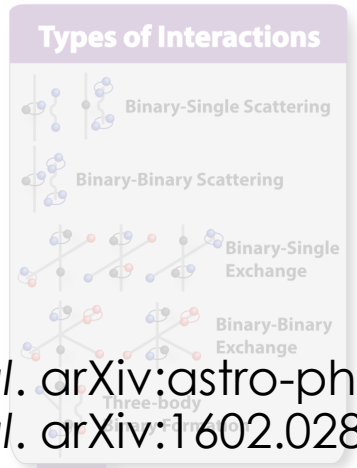

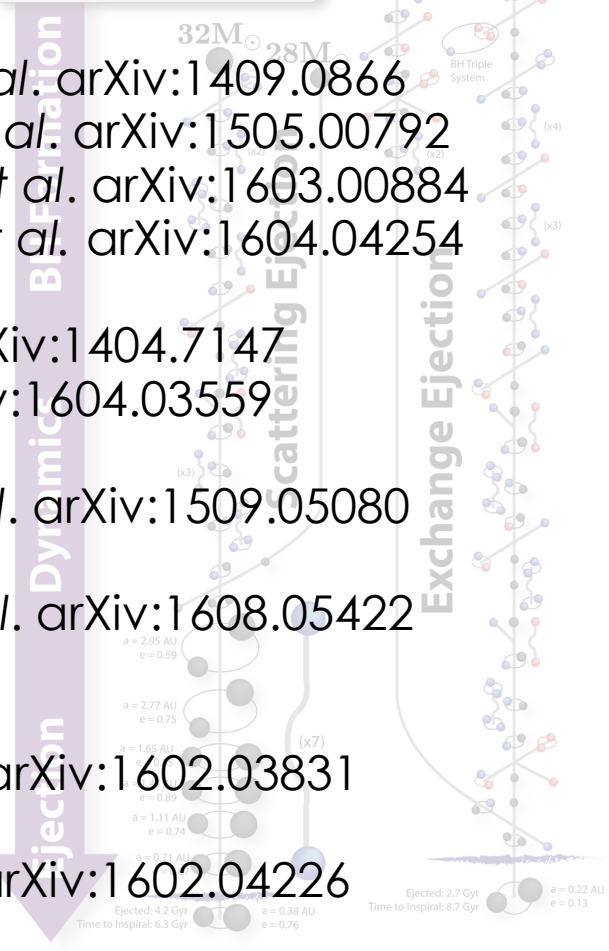

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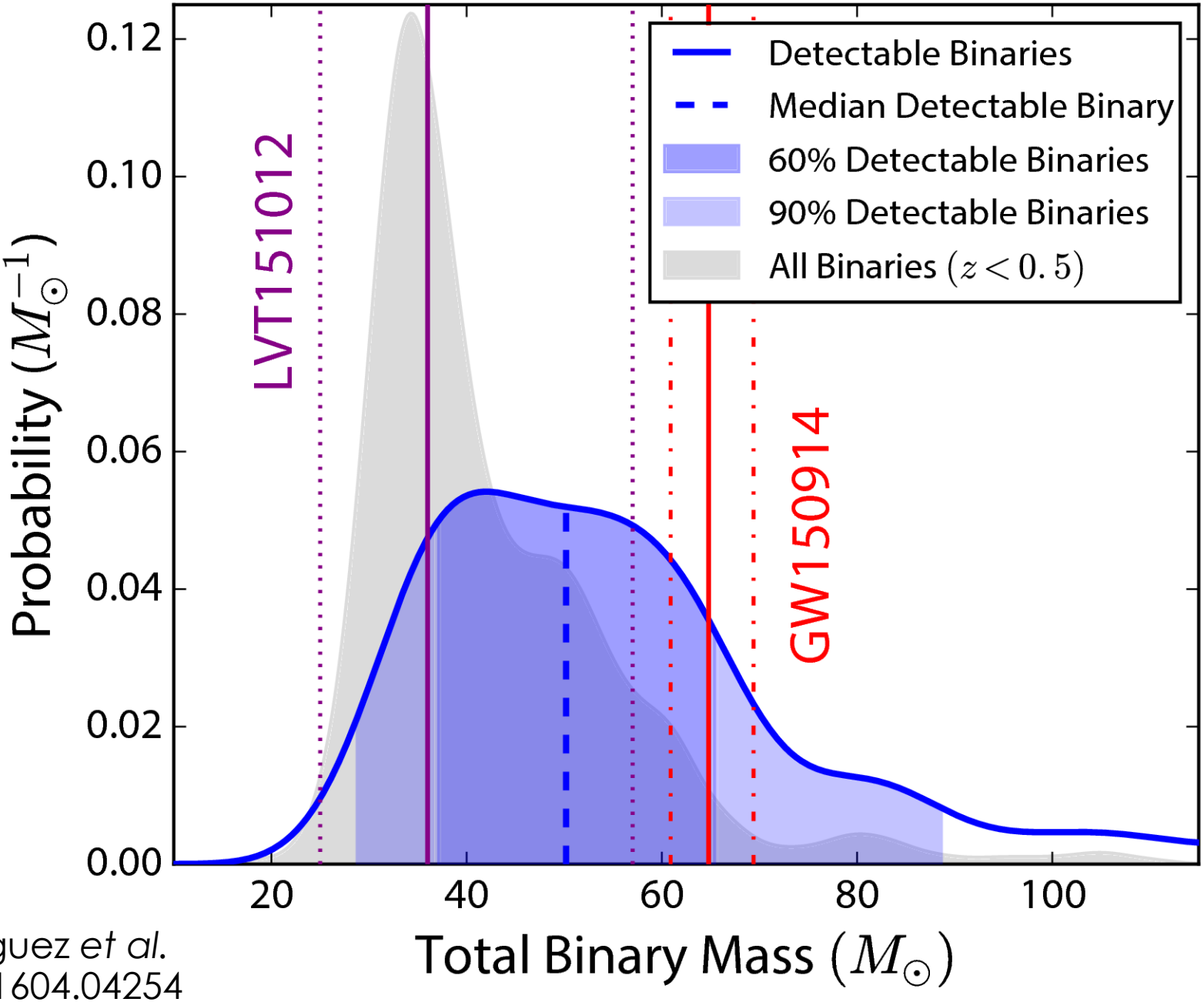

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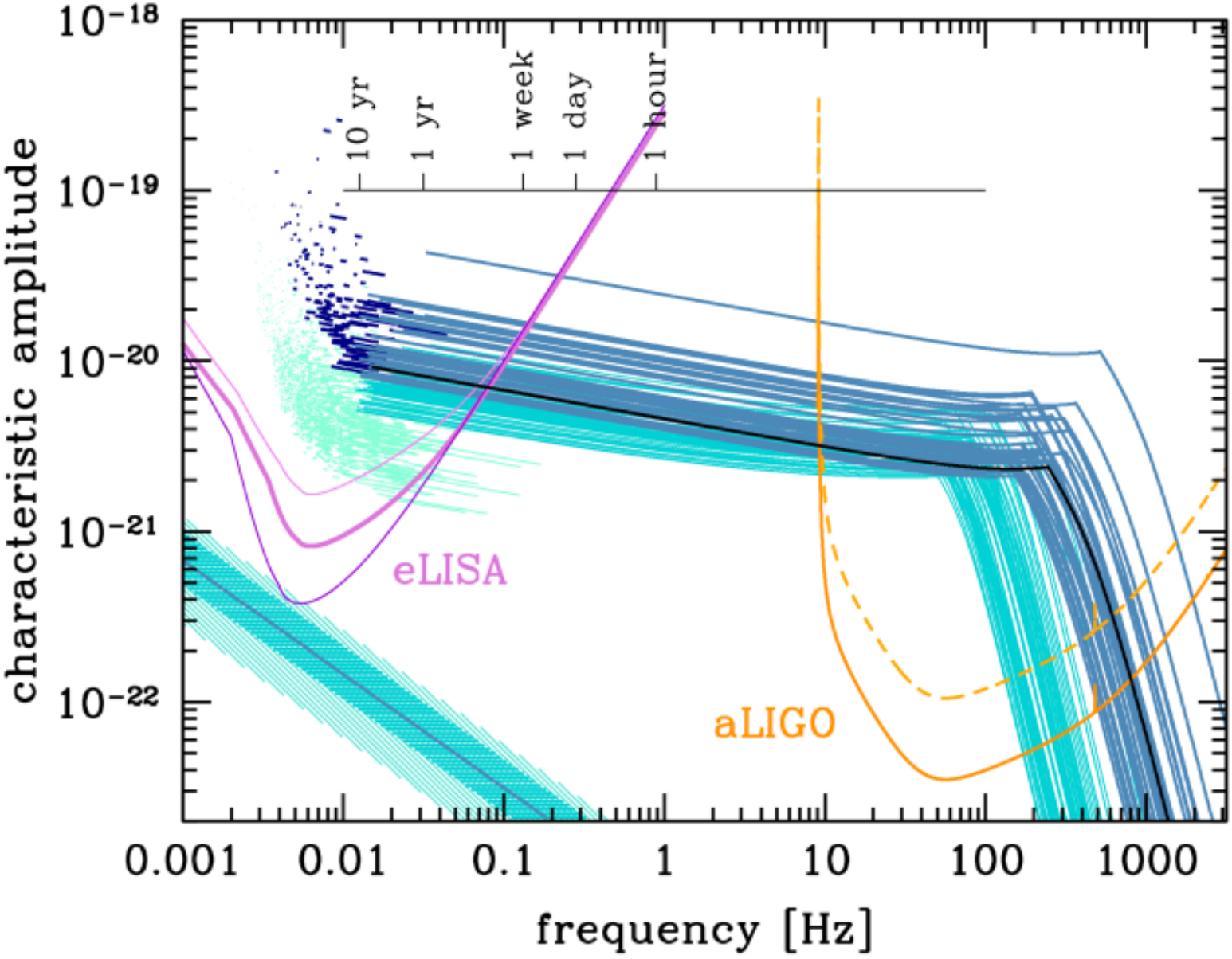
arXiv:1604.04254

Sesana arXiv:1602.06951



Nishizawa *et al*. arXiv:1606.09295

Breivik *et al*. arXiv:1606.09558

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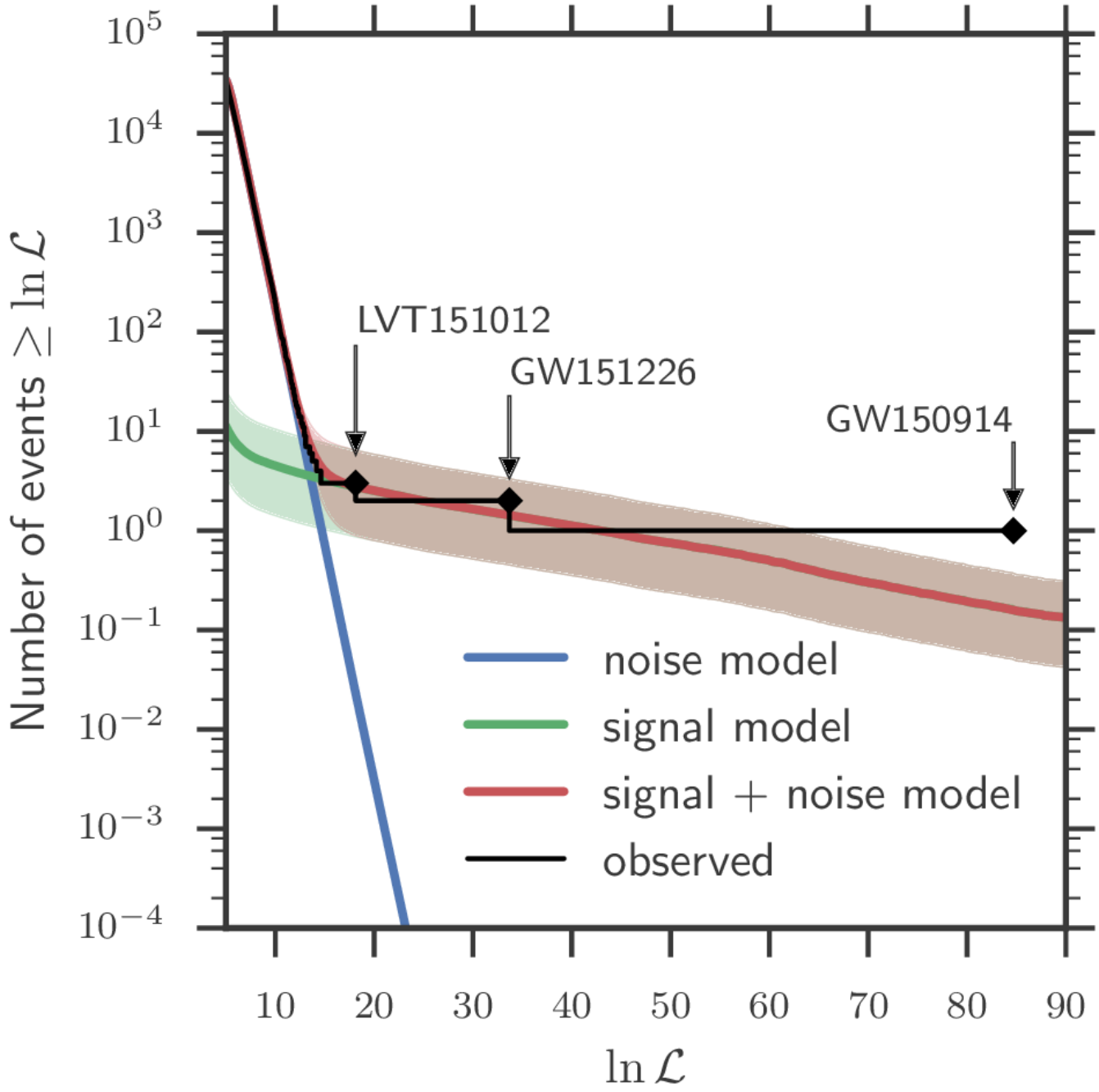
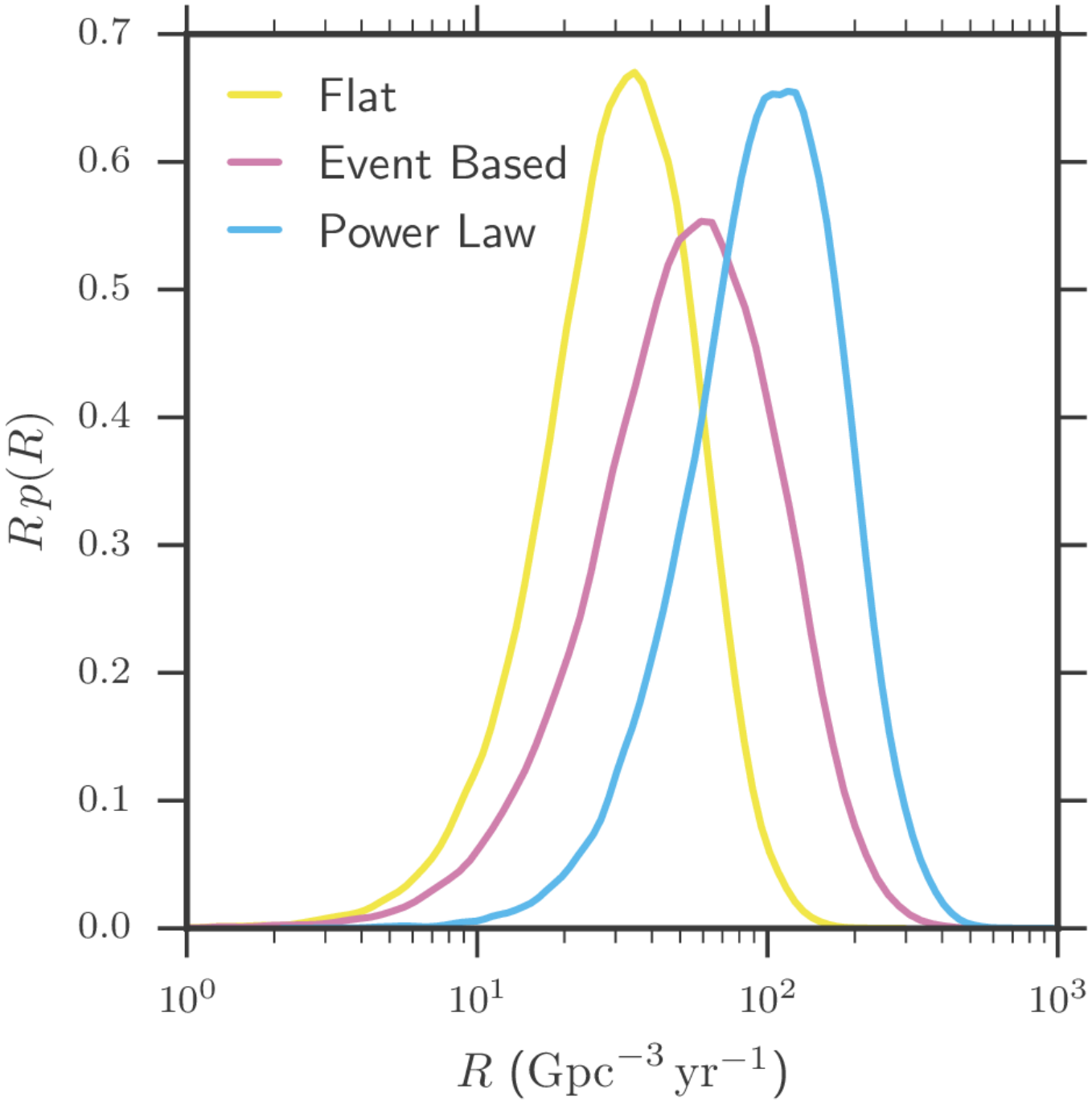
Counts



LVC
arXiv:1606.04856
arXiv:1602.03842

Rates



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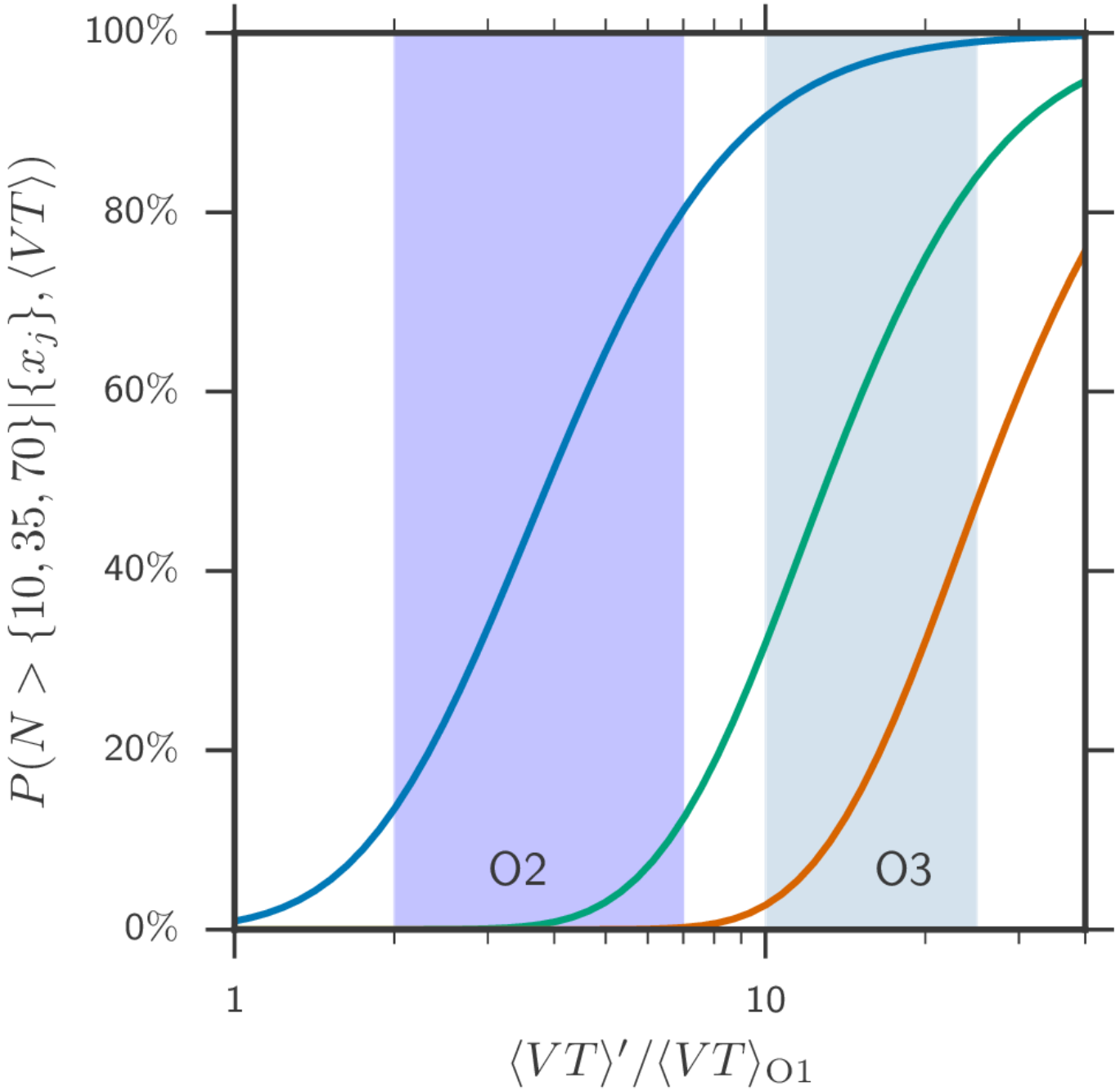
Events



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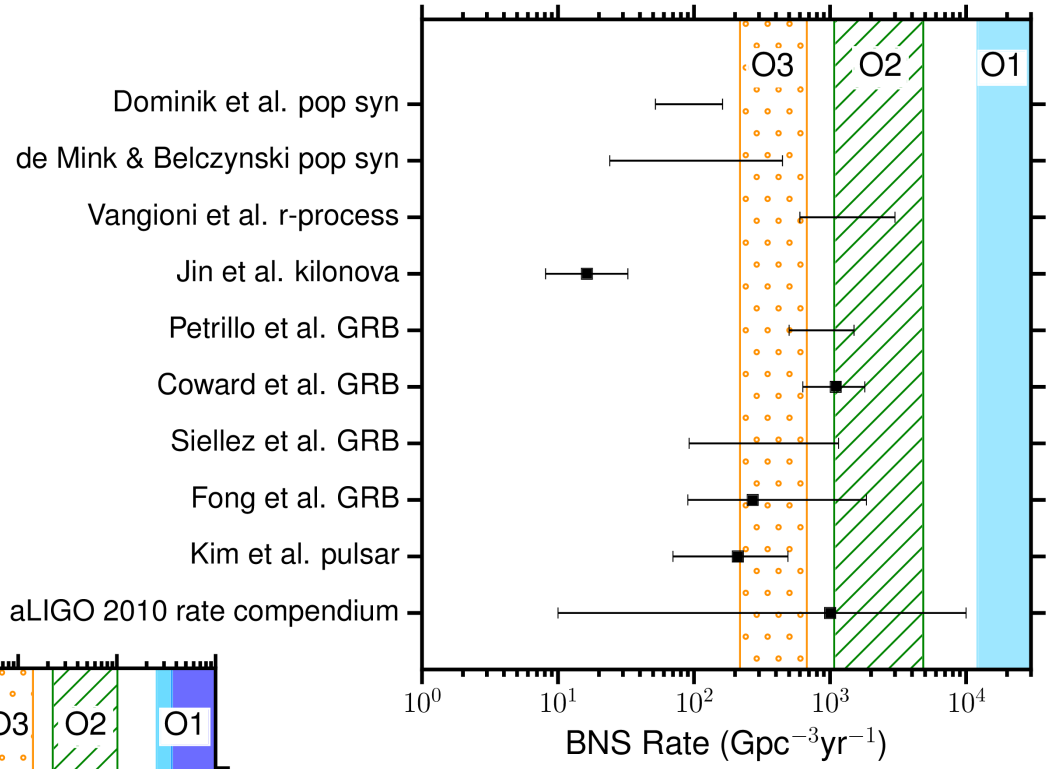
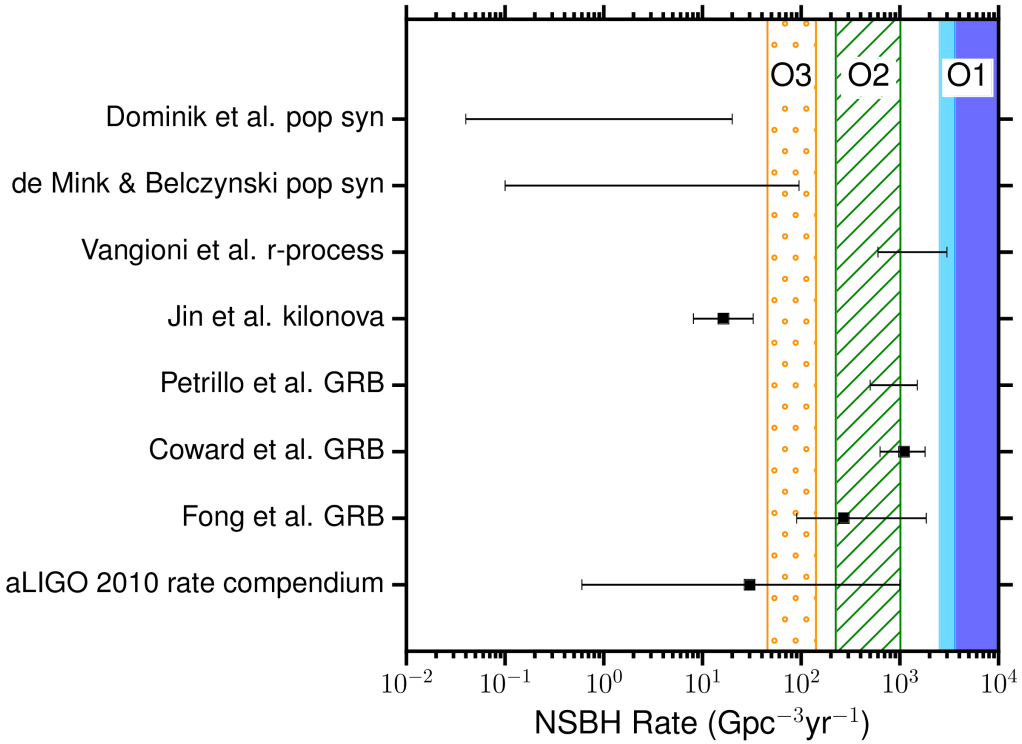
Limits





LVC
arXiv:1607.07456

- Gravitational-wave detection is possible
- There is a family of heavy binary black holes
- Spin uncertain but moderate values preferred
- Formation channel is currently uncertain
- There will be more detections

LVC arXiv:1602.03840 arXiv:1602.03846 arXiv:1606.04856

Thank you

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