Searching for Neutron Star–Black Hole binaries with gravitational waves

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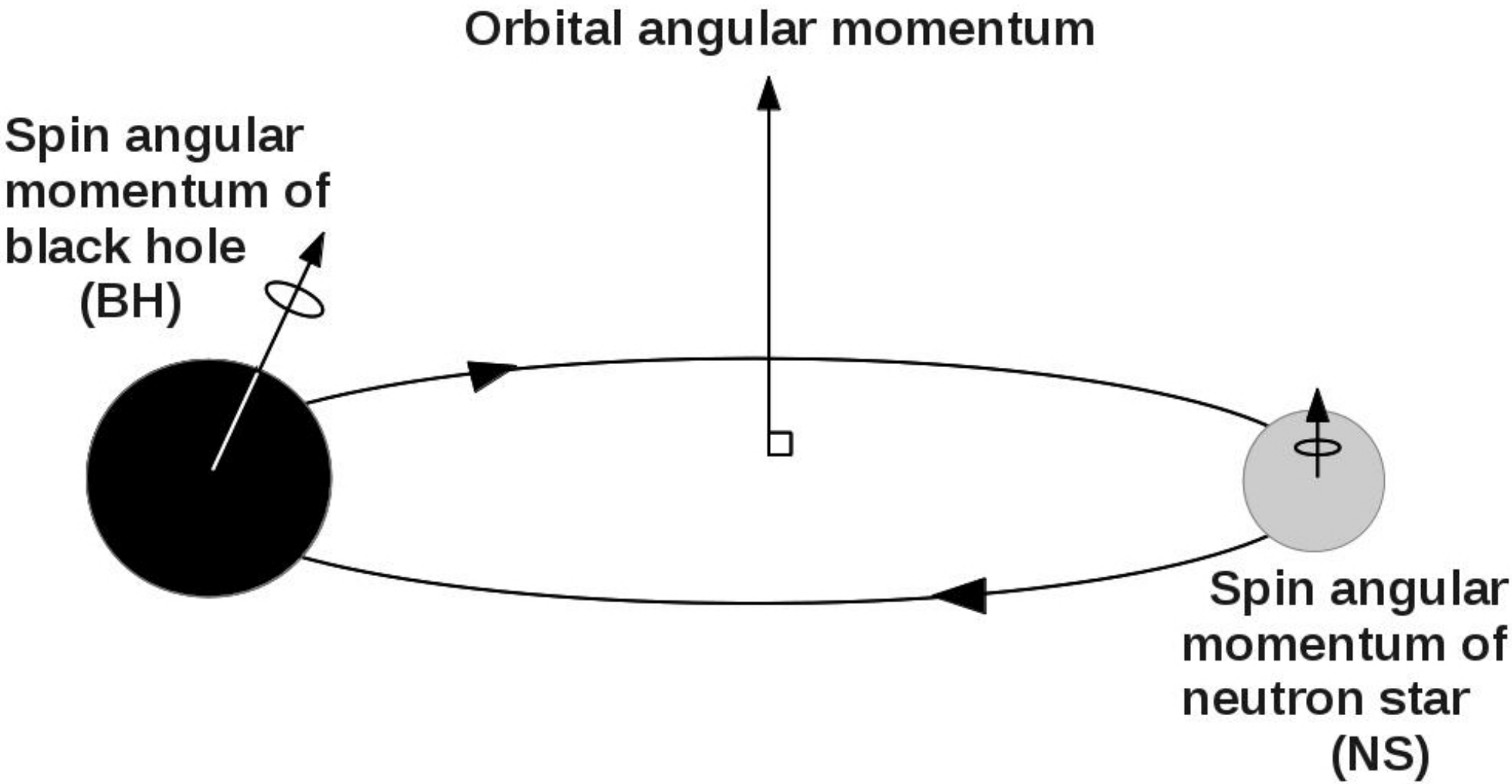
LIGO-G1500507

Neutron Star-Black Hole

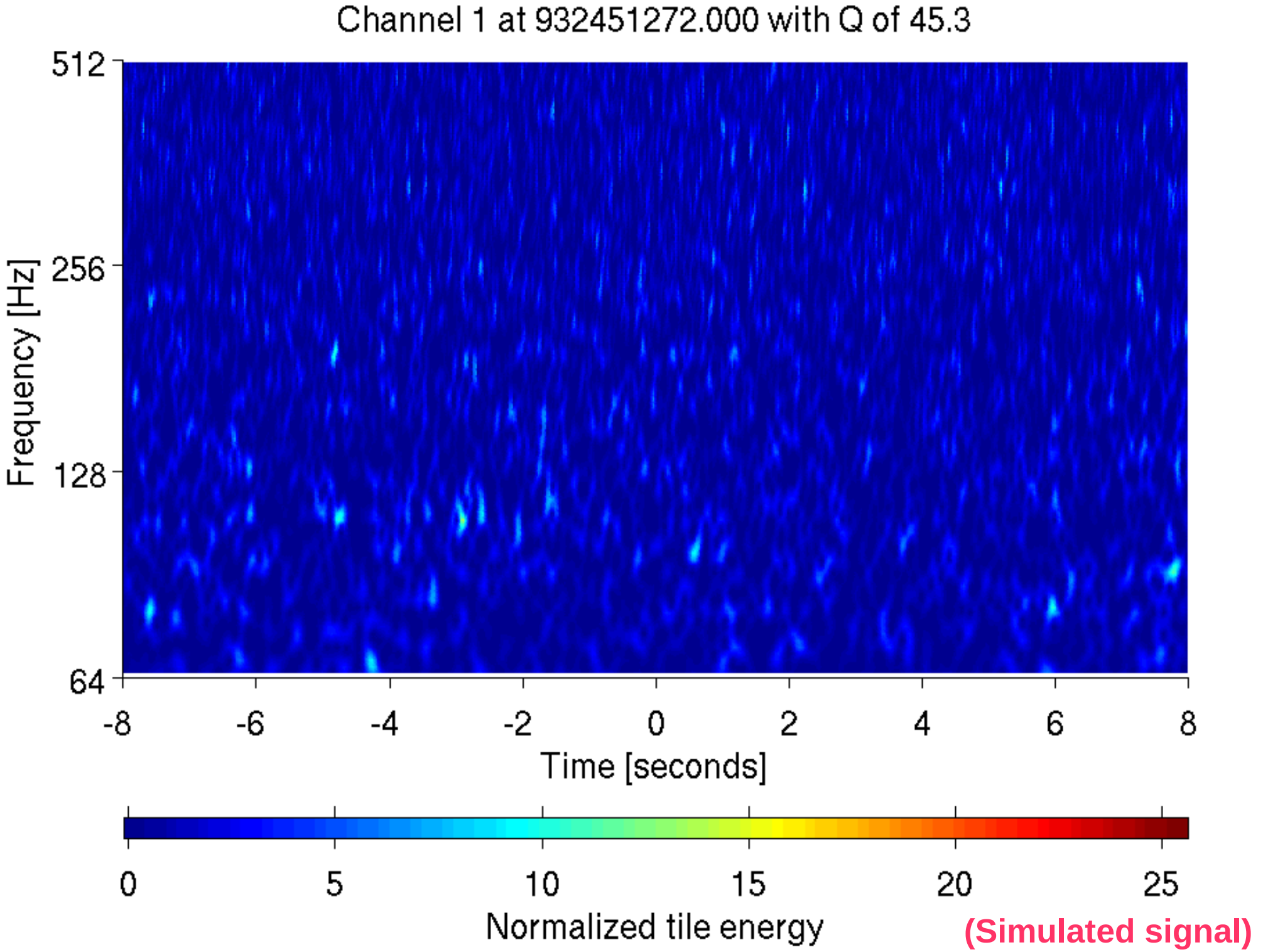


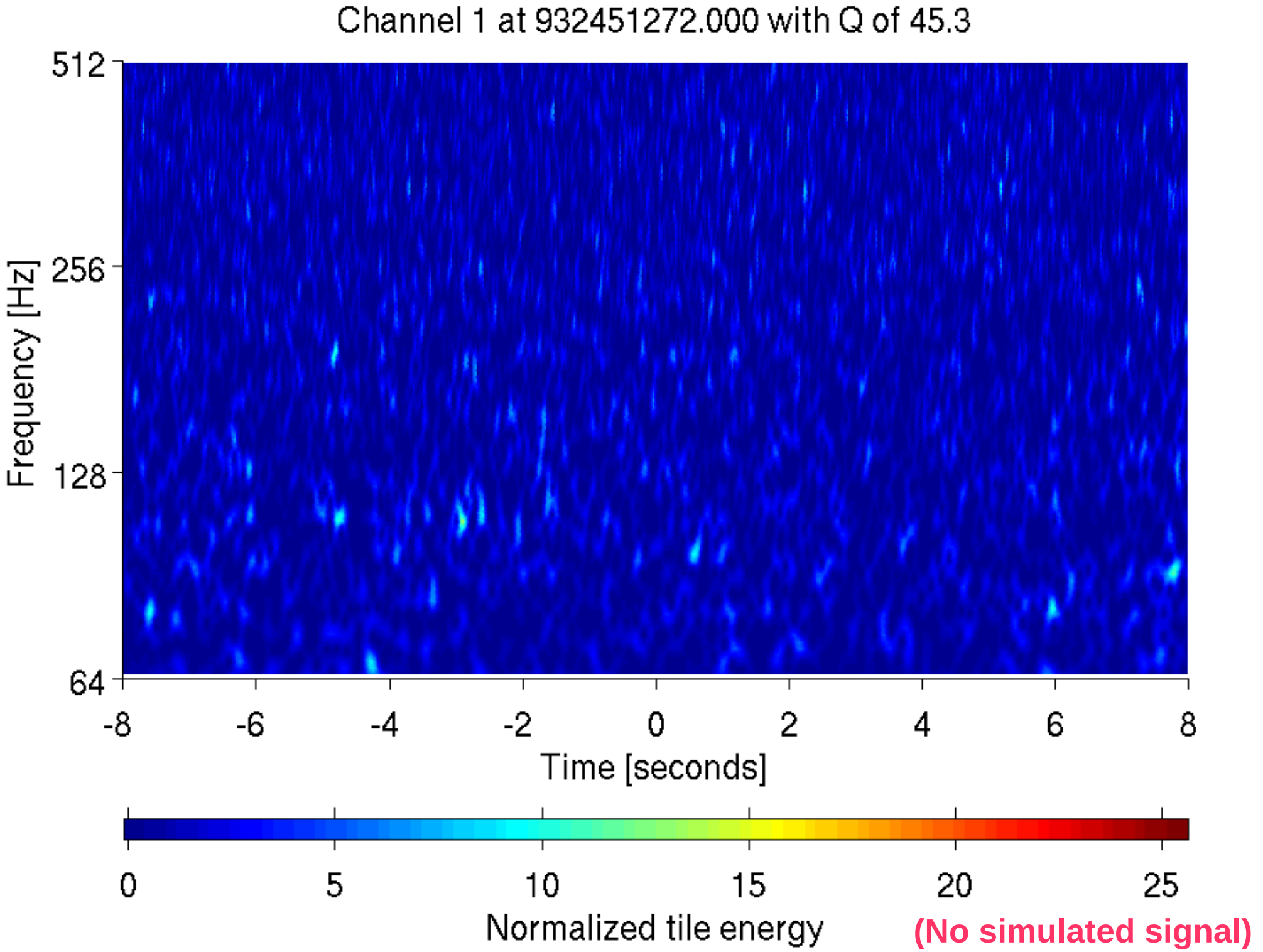
Binary differences

- **Neutron Star-Neutron Star:**
  very near equal mass, low spins, potential tidal disruption, potential EM counterparts, longer signals

- **Neutron Star-Black Hole:**
  high mass ratio, high BH spins, potential tidal disruption, potential EM counterparts, longer signals

- **Black Hole-Black Hole:**
  near equal mass, high spins, no disruption, no EM counterparts, ringdown signals, shorter signals


Channel 1 at 932451272.000 with Q of 45.3
512
256
128
64
Frequency [Hz]
-8
-6
-4
-2
0
2
4
6
8
Time [seconds]
0
5
10
15
20
25
Normalized tile energy
(Simulated signal)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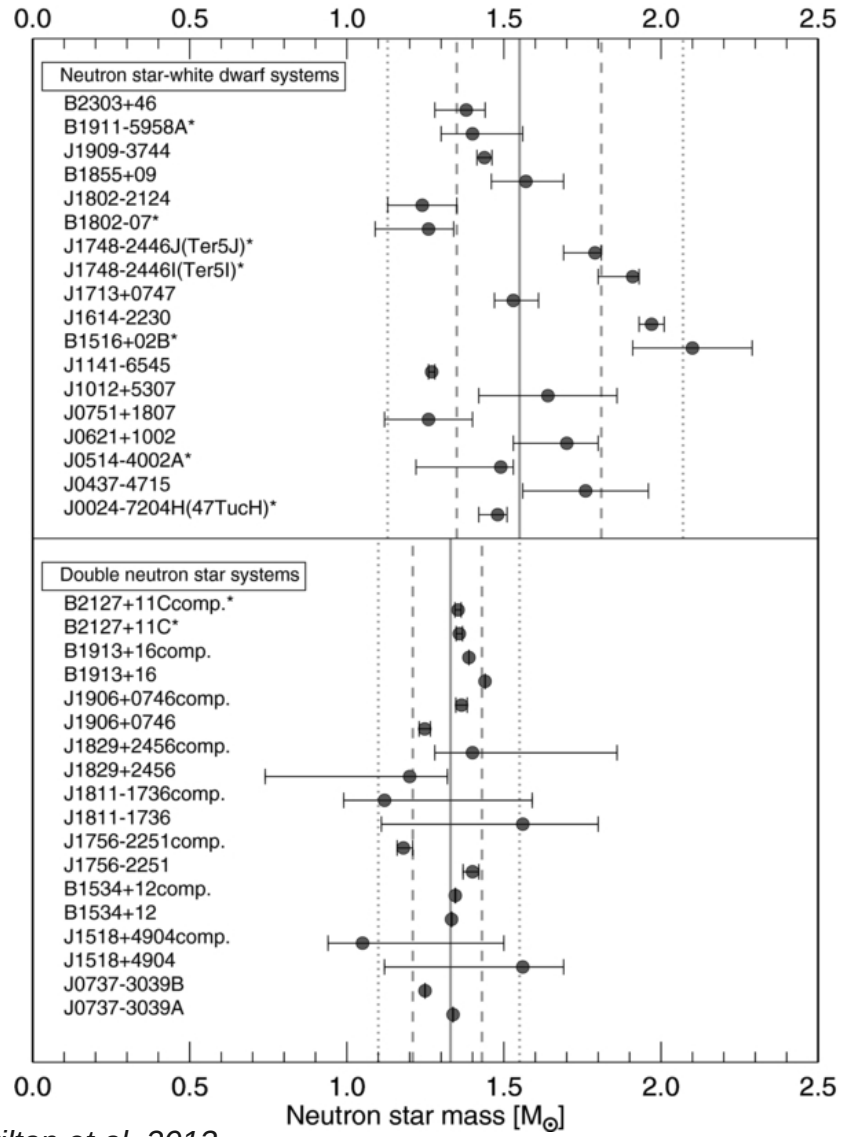
Stellar mass black hole parameters

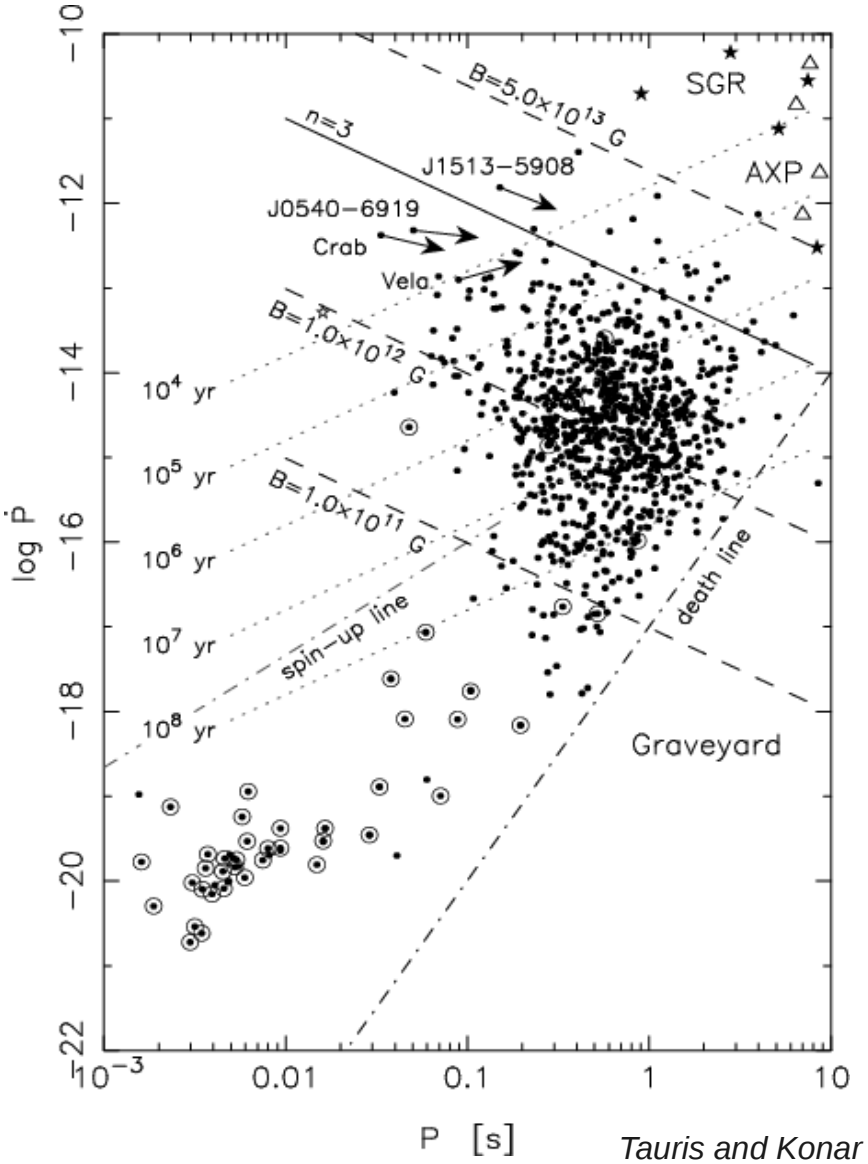
system	binary type	M_solar	D (kpc)	method	a_*
A0620-00	LMXBT K 0.5	6.61±0.12	1.06±0.12	CF	0.12±0.18[4]
XTE J1550-564	LMXBT G or K 1.5 1.54 days	9.10±0.61	4.38±0.50	CF QPO Fe	0.34±0.28[8] 0.7±0.01[2] 0.55±0.22[8]
GRO J1655-40	LMXBT F5 2.6 days	6.30±0.27	3.2±0.5	CF QPO	0.7±0.05[4] 0.75±0.01[2]
GRS 1915+105	LMXBT KIII 30.8 days	14.0±4.4	11.0±1.0	CF QPO	>0.98[4] 0.68±0.08[2]
4U 1543-47	LMXBT Roche	9.4±1.0	7.5±1.0	CF	0.80±0.05[4]
H 1743-322	LMXBT Roche	11.3	10	QPO QPO	>0.68[1] 0.74[2]
LMC X-3	LMXB transit	10	50	CF	<0.3[4]
M33 X-7	HMXB wind	15.65±1.45	840±20	CF	0.84±0.05[4]
LMC X-1	HMXB wind	10.9	50	CF	0.92±0.07[4]
Cyg X-1	HMXB wind OB 19.2±1.9 5.6days	14.8±1.0	1.86±0.12	QPO Fe CF	0.49±0.01[5] 0.97±0.02[6] >0.983(3σ)[3,7]

Sources: *1. Mondal, ApJ 708 (2010),*
2. Mukhopadhyay, ApJ 694 (2009)
3. Gou et al., ApJ 742 (2011)
4. McClintock et al.,, CQG 28 (2011)
5. Axelsson et al., AA 438 (2005),
6. Fabian et al., 1204.5854
7. Gou et al. 1308.4760
8. Steiner et al. MNRAS 416 (2011)

Neutron stars



Kiziltan et al. 2013



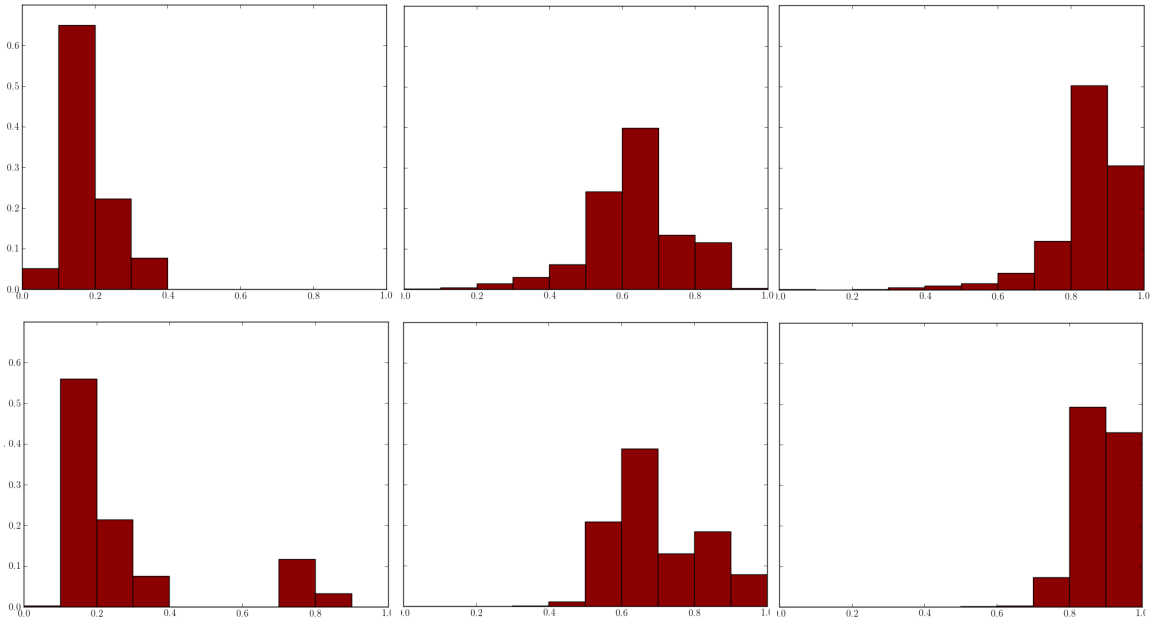
Tauris and Konar 2001

Hypercritical Common Envelope

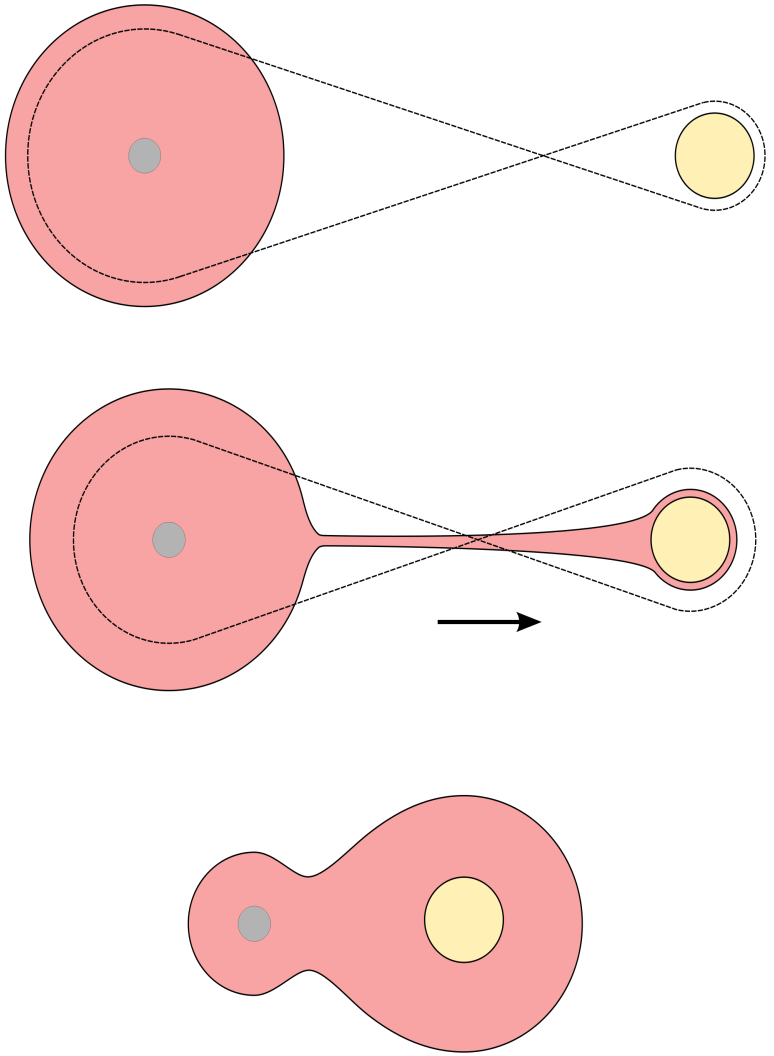
Some neutron star binaries are observed at separations less than one solar radius.

Mechanism to tighten orbits, from hypercritical common envelope.

During this process the acceptor object can accrete large amounts of mass and angular momentum

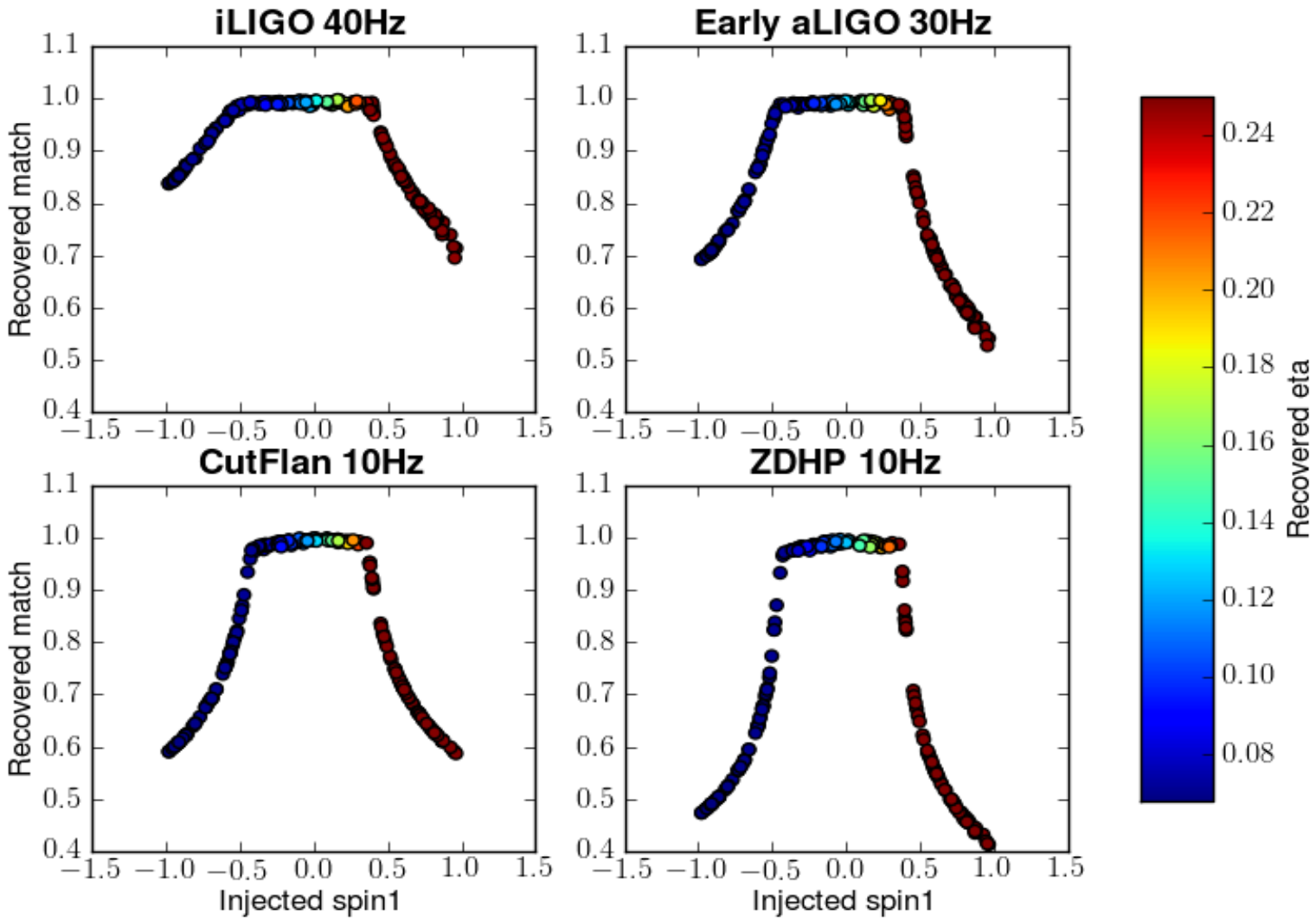


(AN, O'Shaughnessy in preparation)

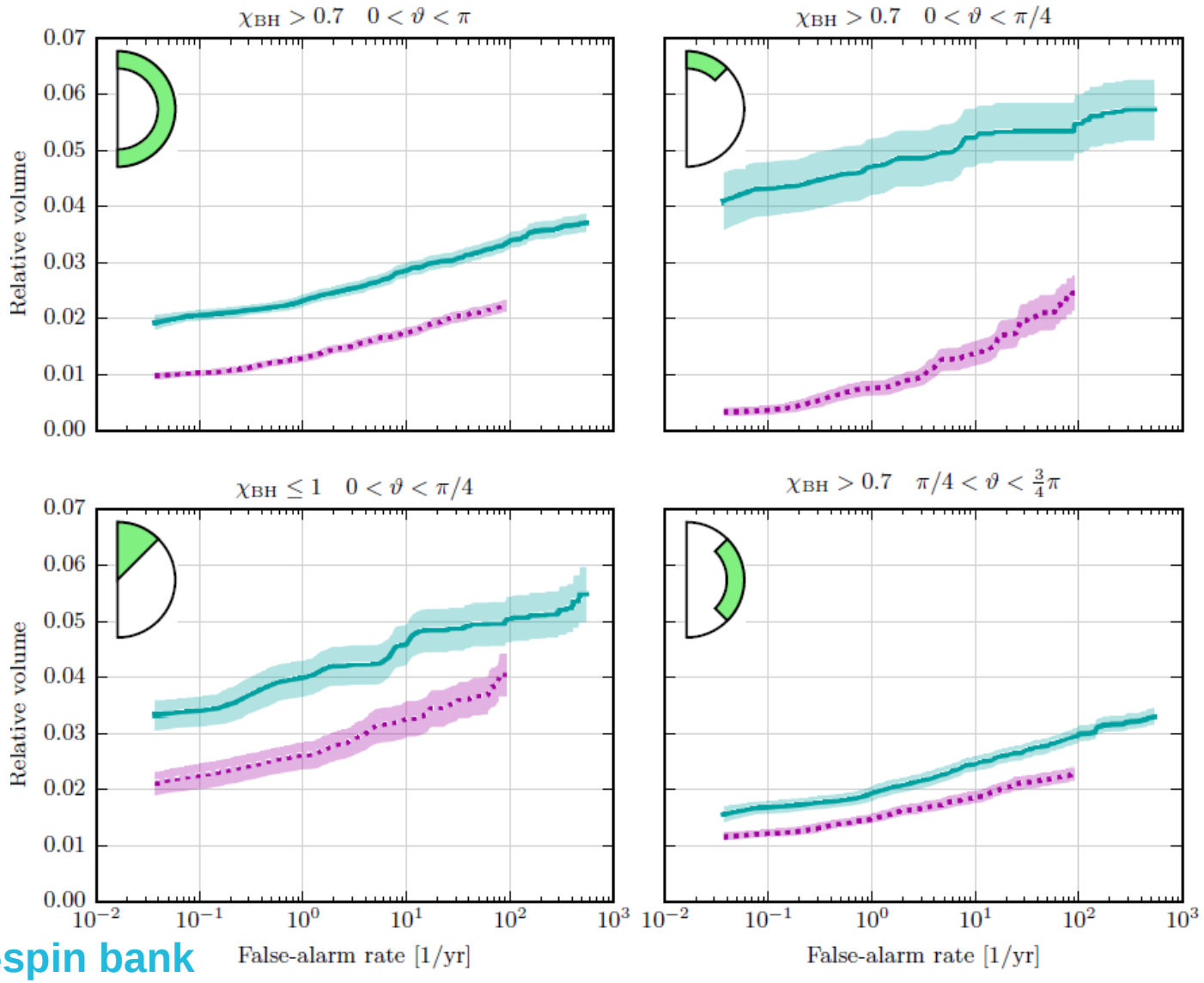


Source: Cryptic C62, Trex2001

Maximised matches for different sensitivities



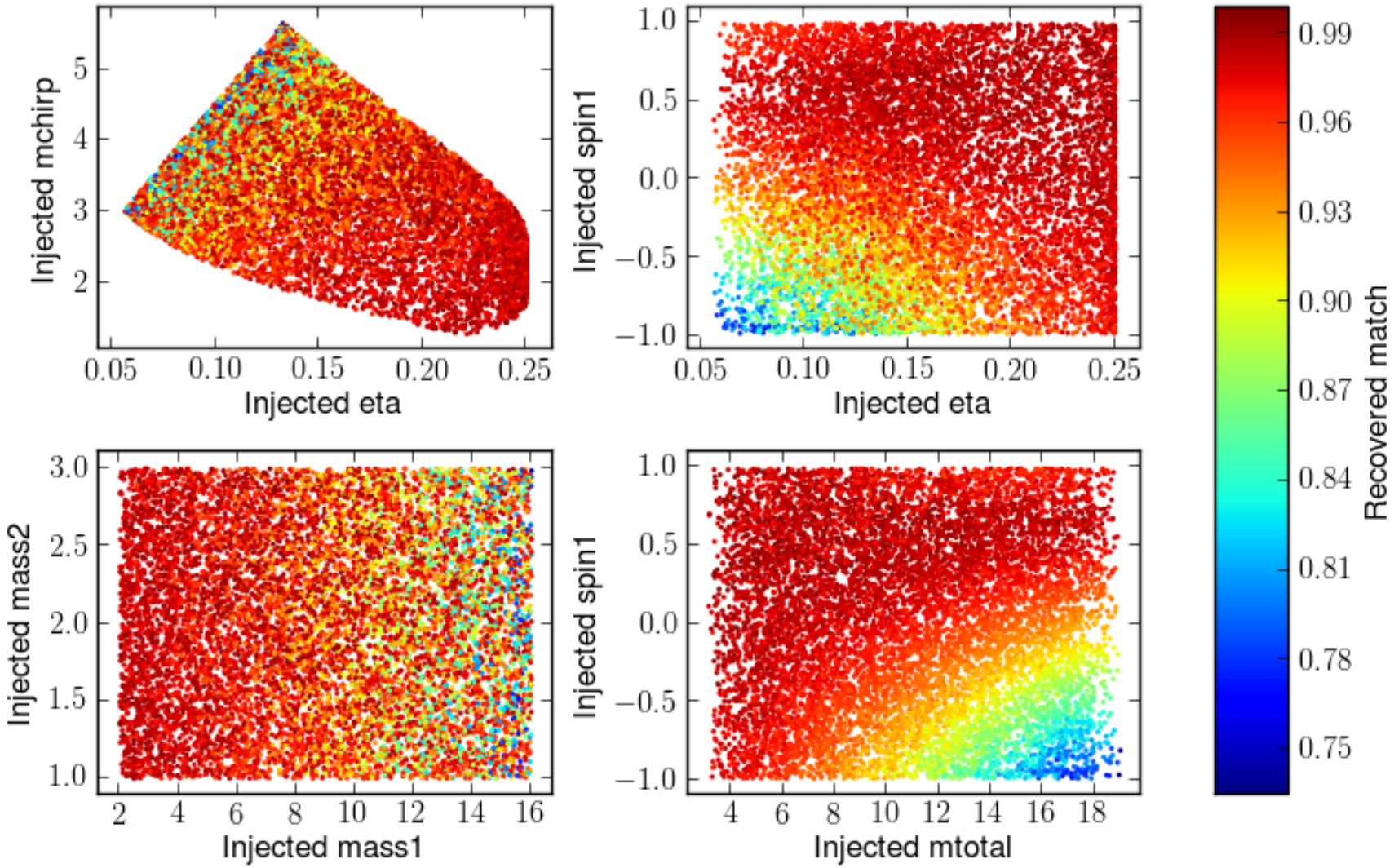
ROCs, precessing signals 2



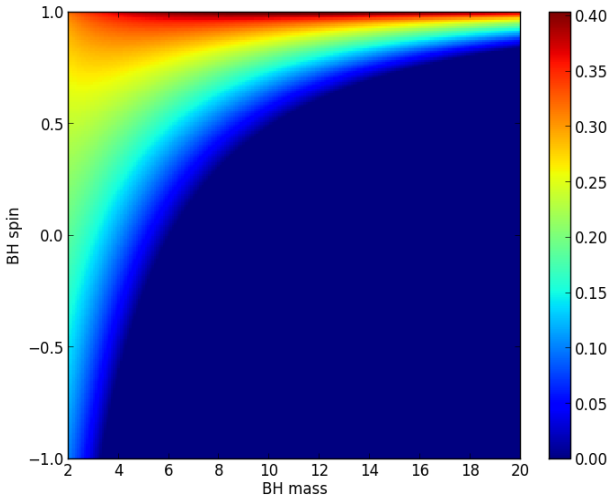
Cyan: Aligned-spin bank

Magenta: Non-spinning bank

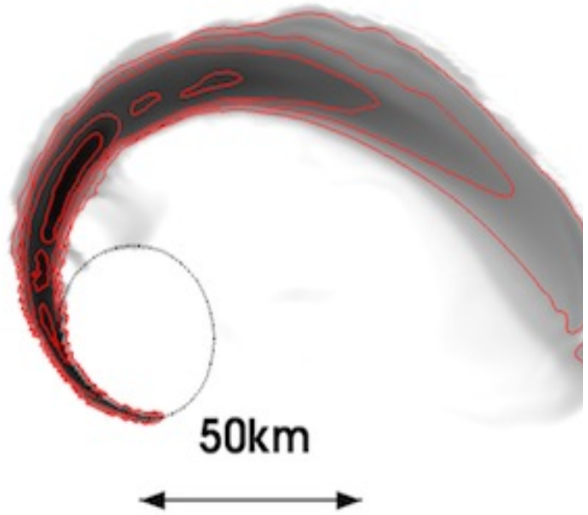
Merger and ringdown effects



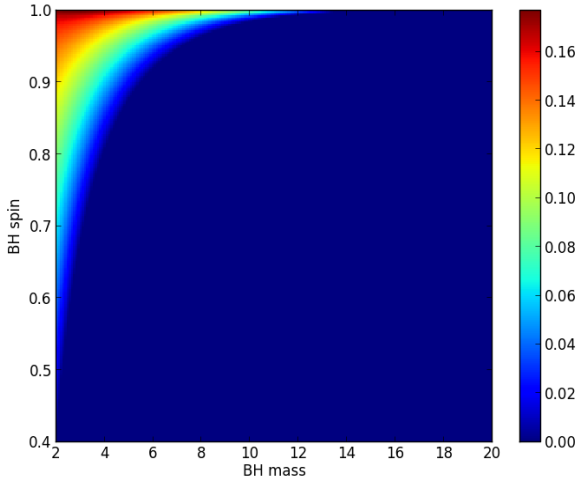
Tidal disruption and r-process



NS radius = 15.5km

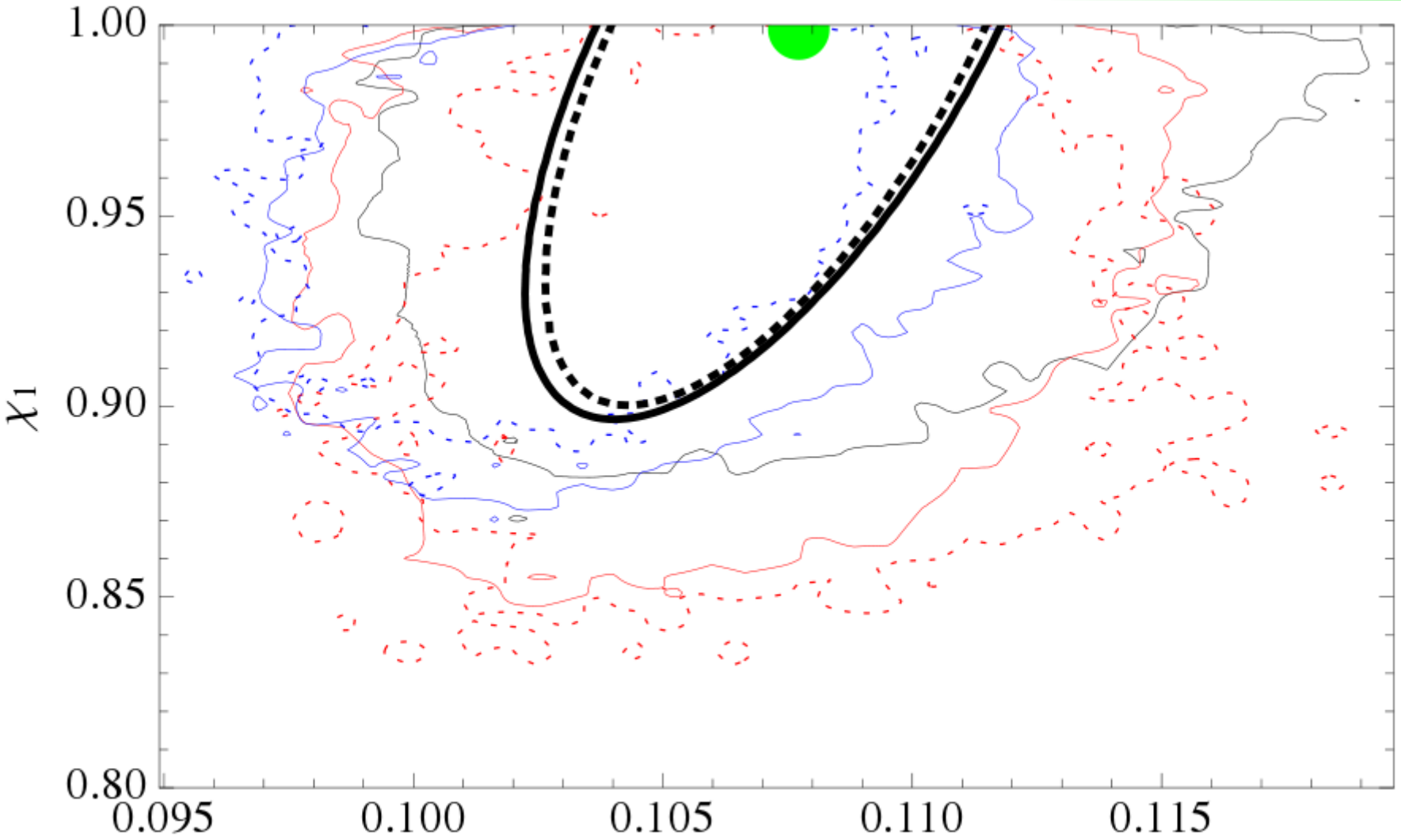


(Q7S7 Foucart et al. 2012)



NS radius = 9km

Parameter Estimation



O'Shaughnessy et al. 2014

Summary

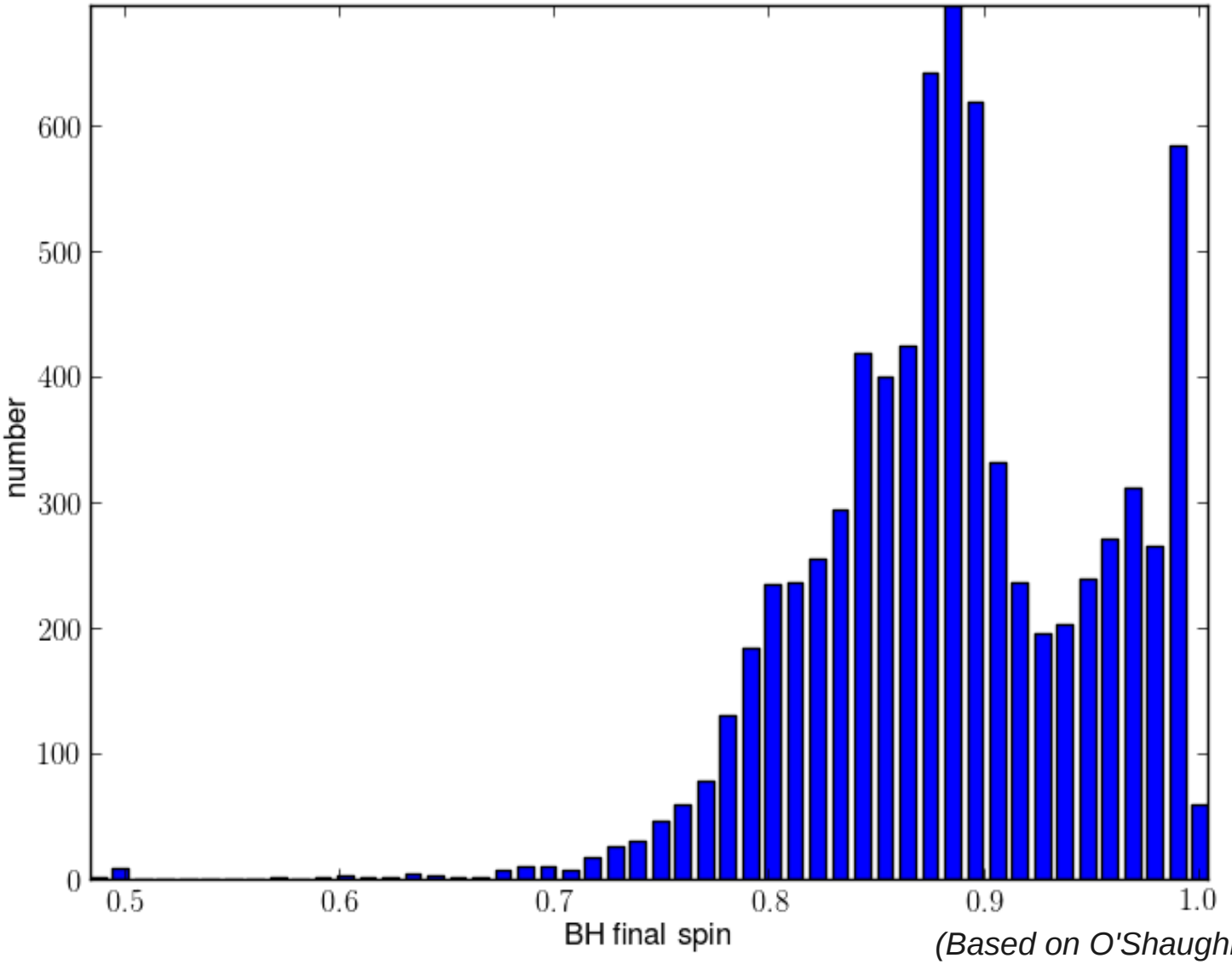
- Searching over aligned spin improves detection rate.
- We cannot yet do a precessing search.
- Fast inspiral-merger-ringdown waveforms may allow us to extend the parameter range further.
- We are only just beginning to explore the effect of mass loss on NSBH searches.

Further Reading

Thank You

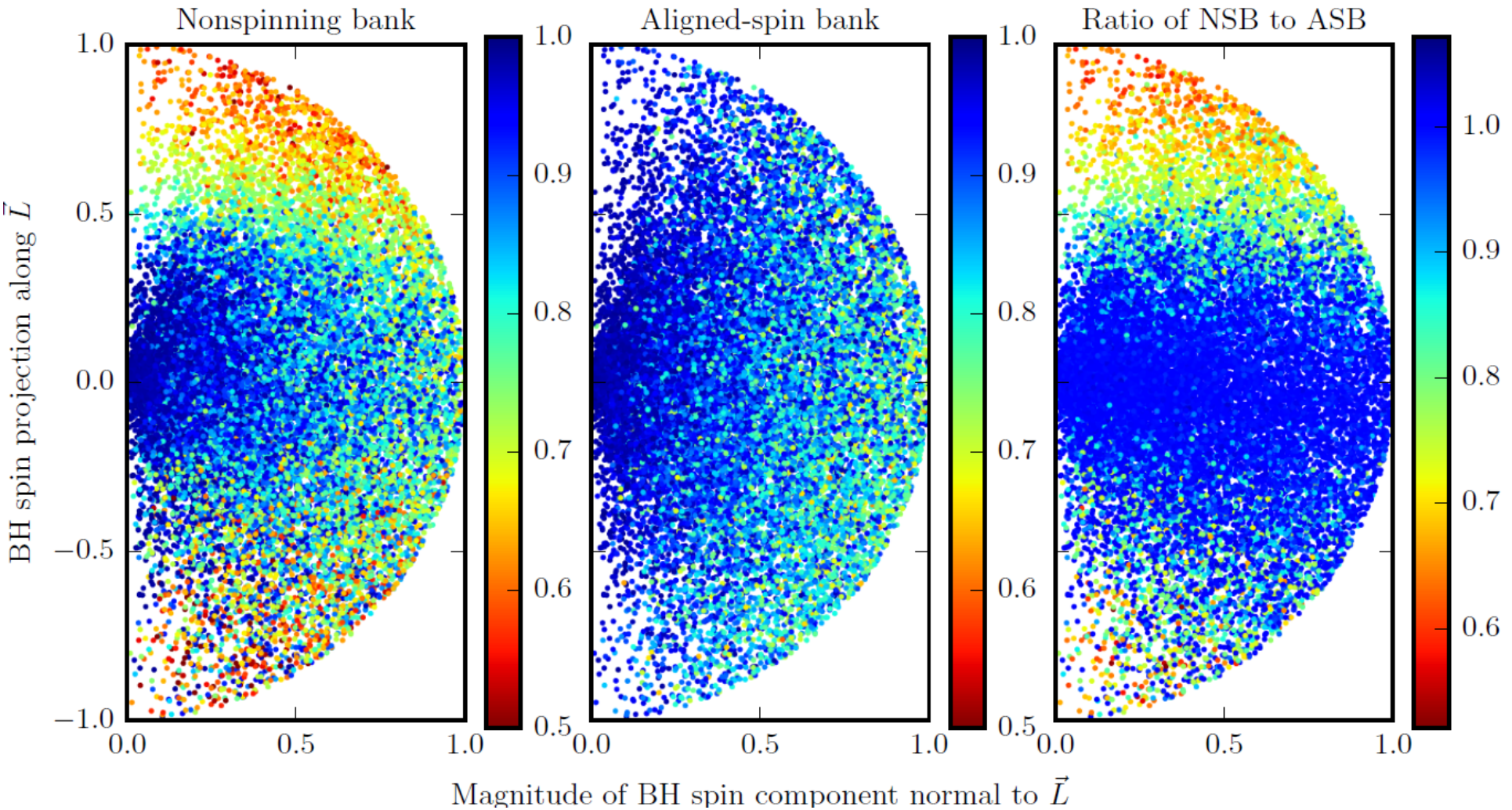
- arXiv: 1304.3332
- arXiv: 1403.0544
- arXiv: 1405.6731
- arXiv: 1411.6815

BH spin-up due to common envelope

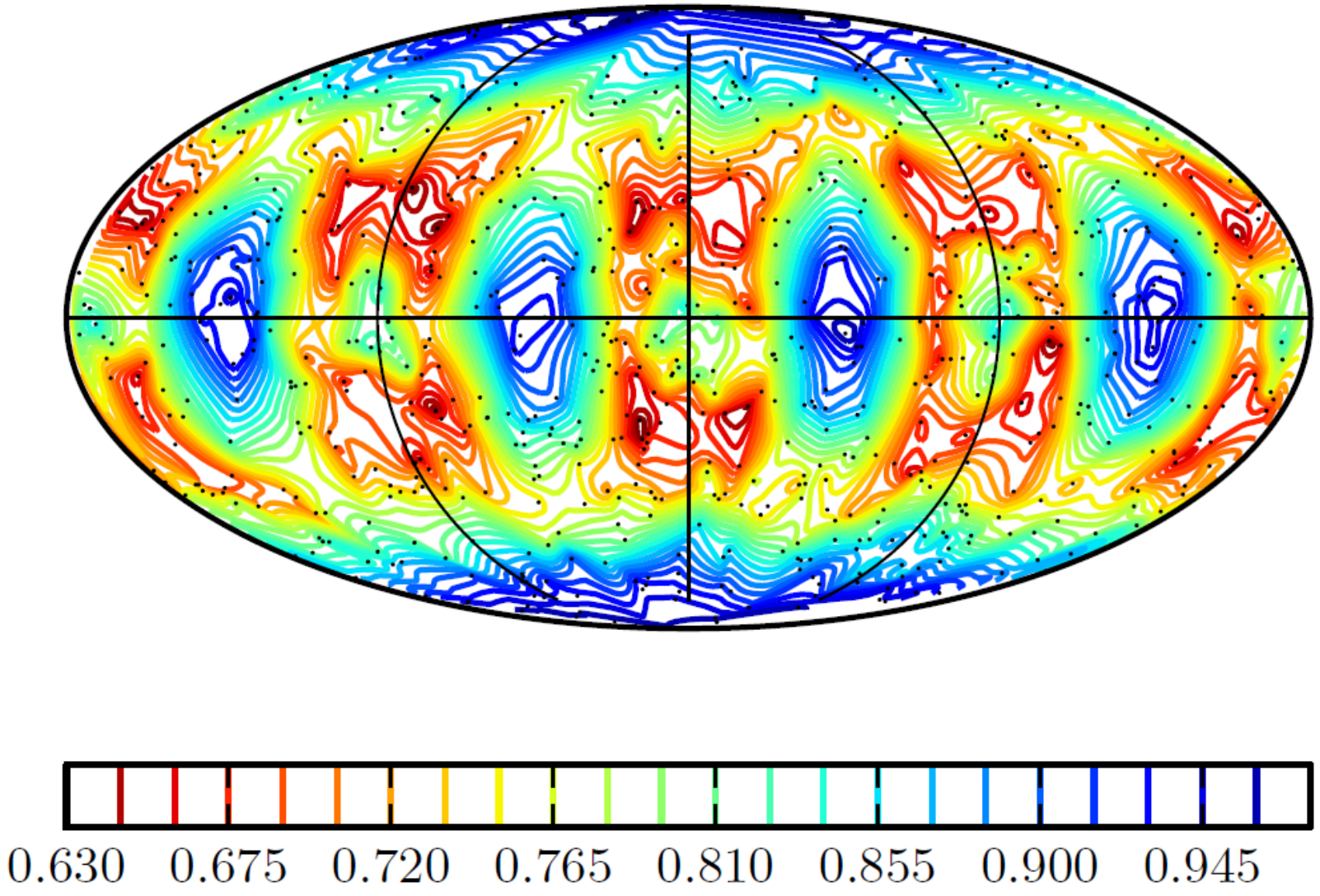


(Based on O'Shaughnessy et al, 2005)

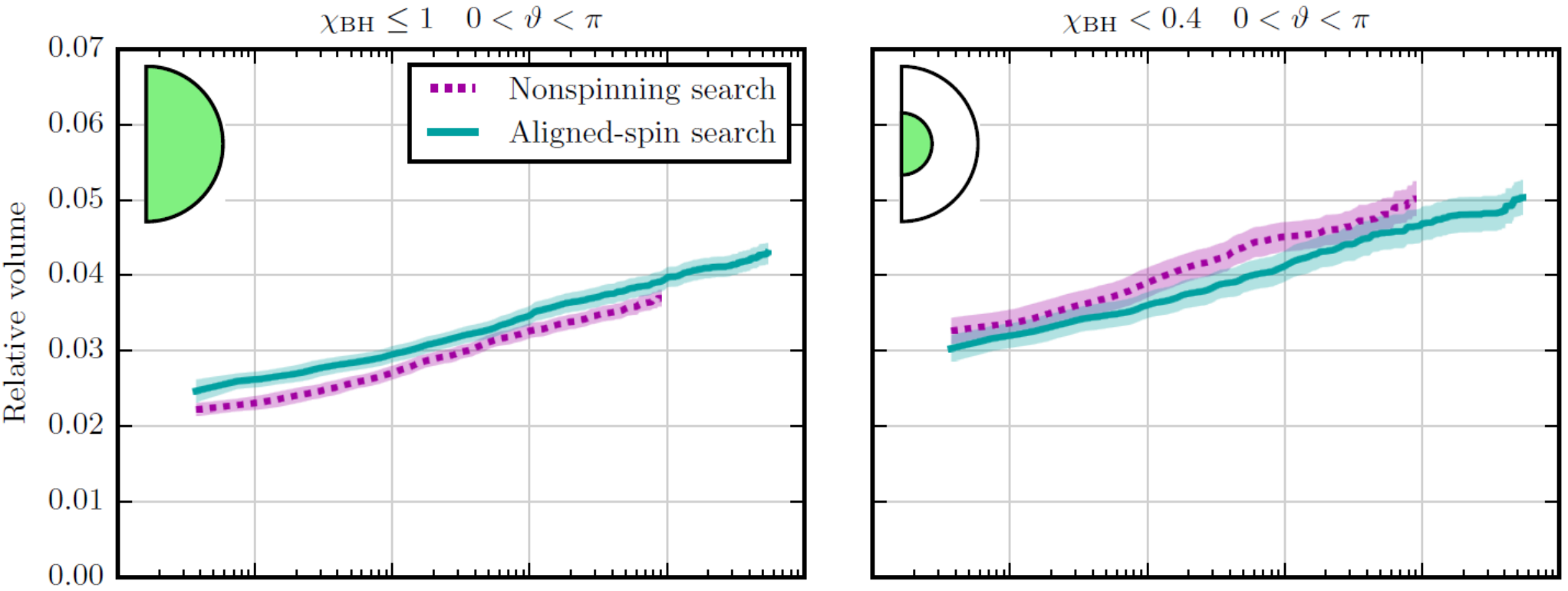
Projected precessing BH spin



Highly precessing signals – importance of orientation



ROCs, precessing signals 1



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