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Parameter estimation for the binary black hole merger GW150914

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On behalf of the
LIGO Scientific & Virgo Collaboration

DCC G1600269

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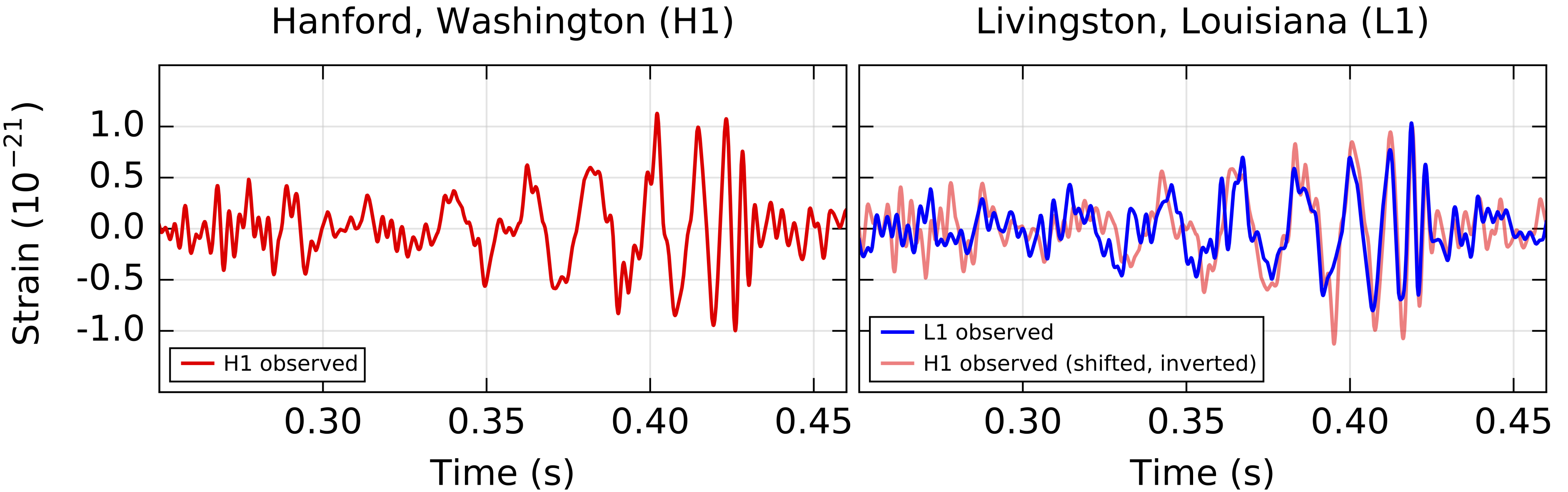
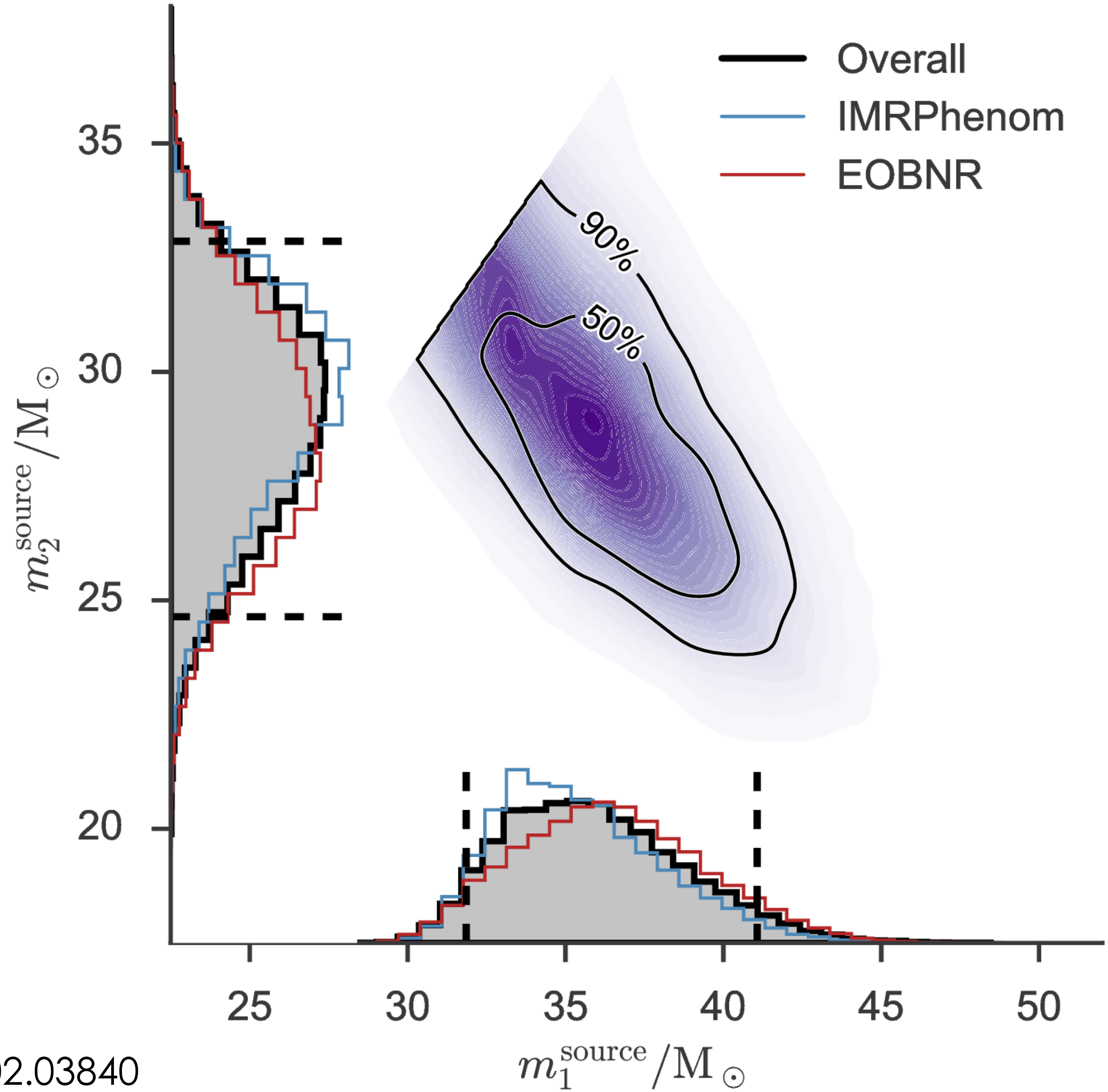


arXiv:1602.03837



arXiv:1602.03840

Bayes' theorem

$$p(\theta|d) = \frac{p(d|\theta)\, p(\theta)}{p(d)}$$

Bayes' theorem

$$p(\theta|d) = \frac{p(d|\theta)\,p(\theta)}{p(d)}$$

Likelihood

Prior

Posterior

Evidence

Likelihood

$$p(d|\theta) \propto \exp\left[-\frac{1}{2}\sum_k \langle h_k(\theta) - d_k | h_k(\theta) - d_k \rangle\right]$$

Likelihood

$$p(d|\theta) \propto \exp\left[-\frac{1}{2}\sum_k \langle h_k(\theta) - d_k | h_k(\theta) - d_k \rangle\right]$$

$$h_k(\theta) \rightarrow h_k(\theta)\left[1 + \delta A_k\right] \exp\left[i \delta \phi_k\right]$$

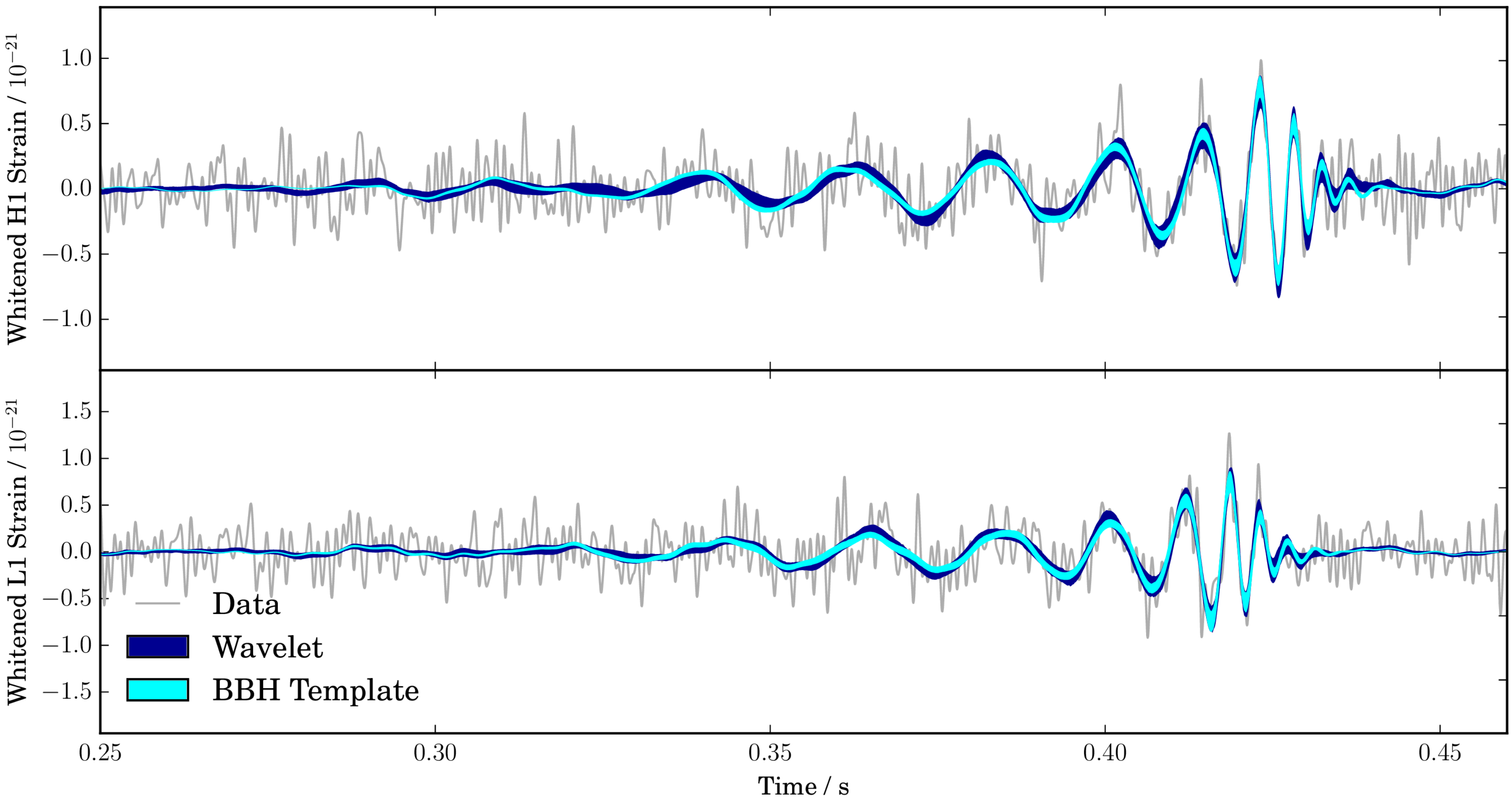
Likelihood

$$p(d|\theta) \propto \exp\left[-\frac{1}{2}\sum_k \langle h_k(\theta) - d_k | h_k(\theta) - d_k \rangle\right]$$

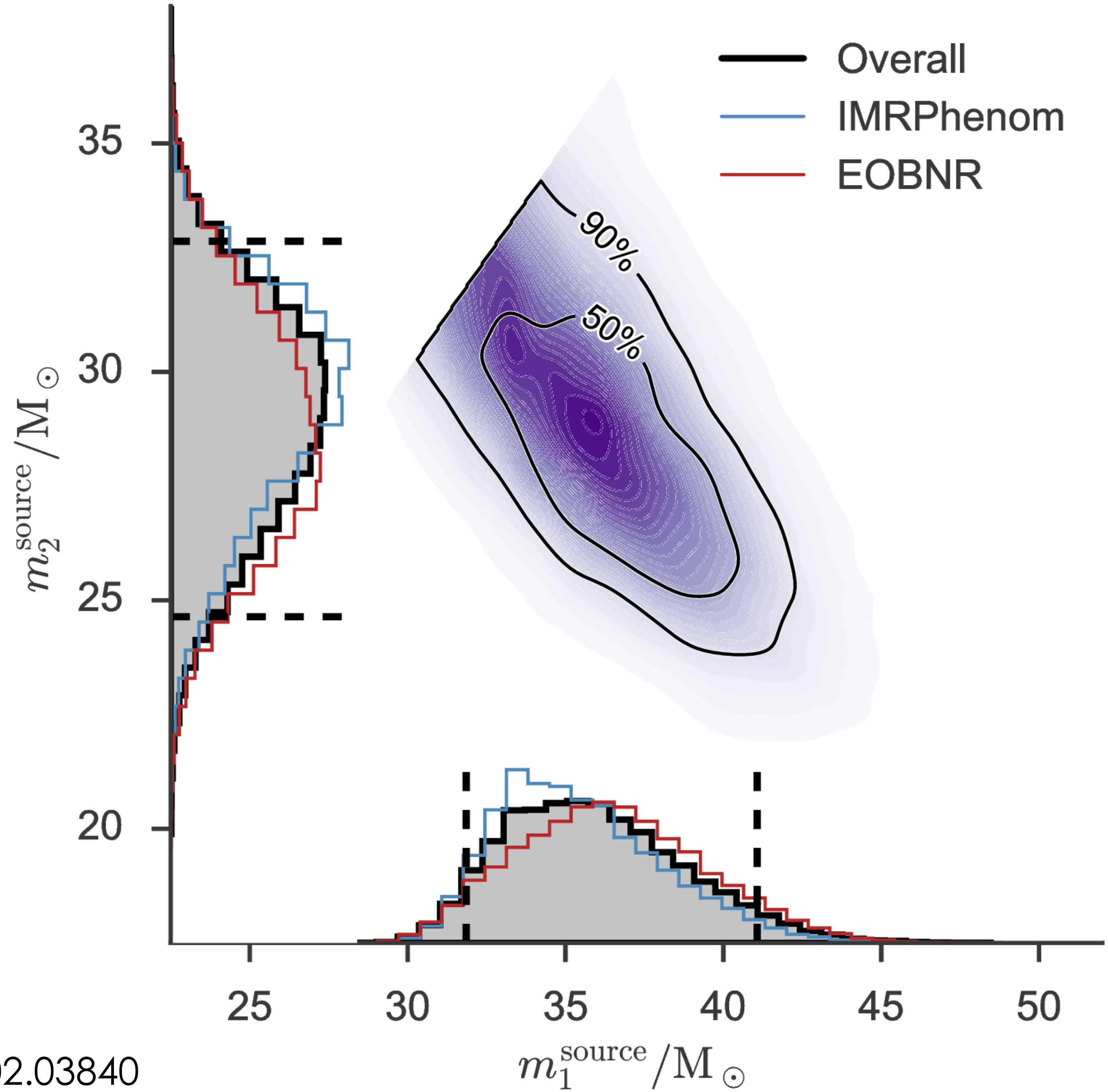
$$h_k(\theta) \rightarrow \boxed{h_k(\theta)}\,[1 + \delta A_k] \exp\left[i\delta\phi_k\right]$$

Waveform

Waveform



arXiv:1602.03840



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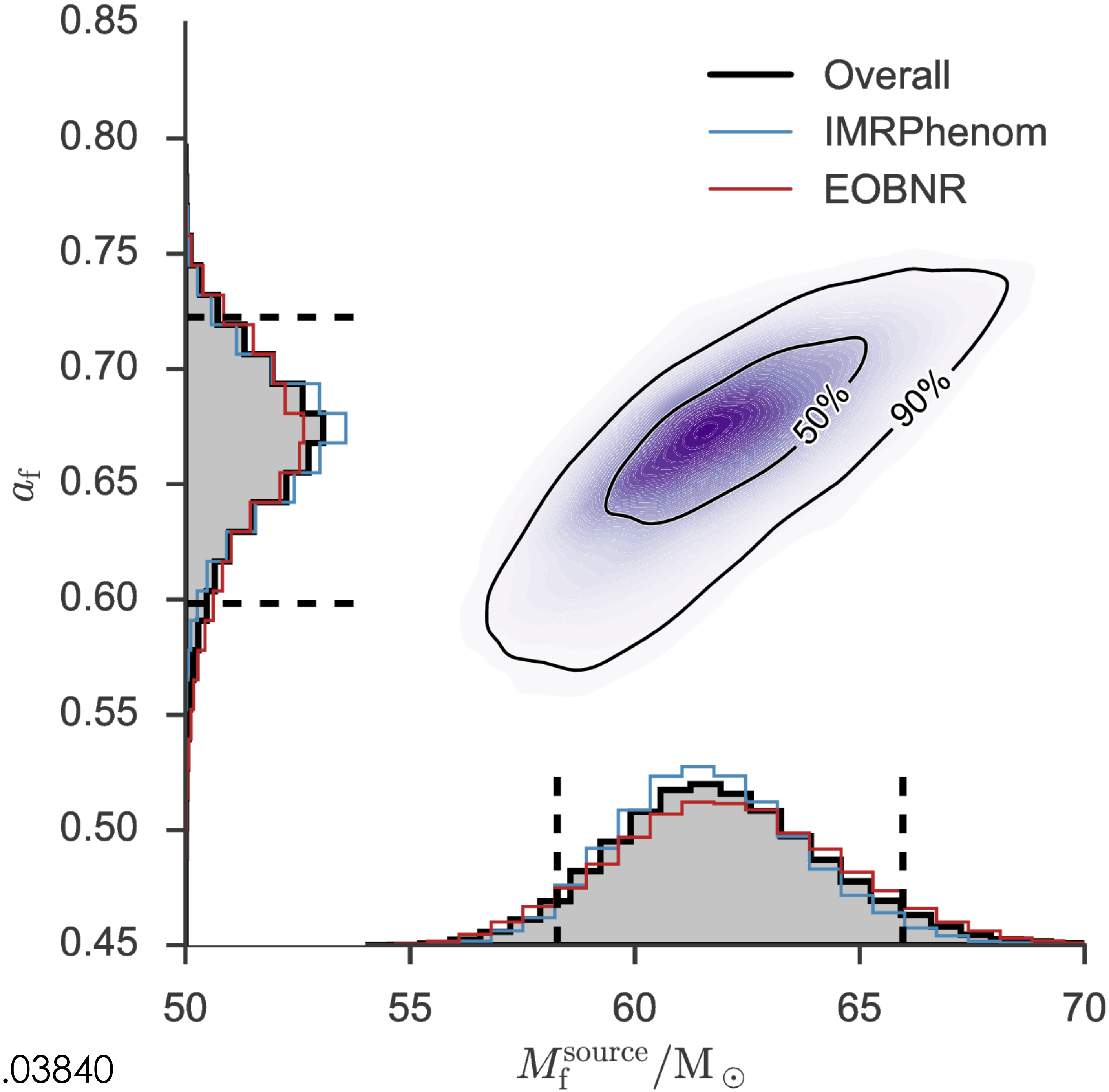

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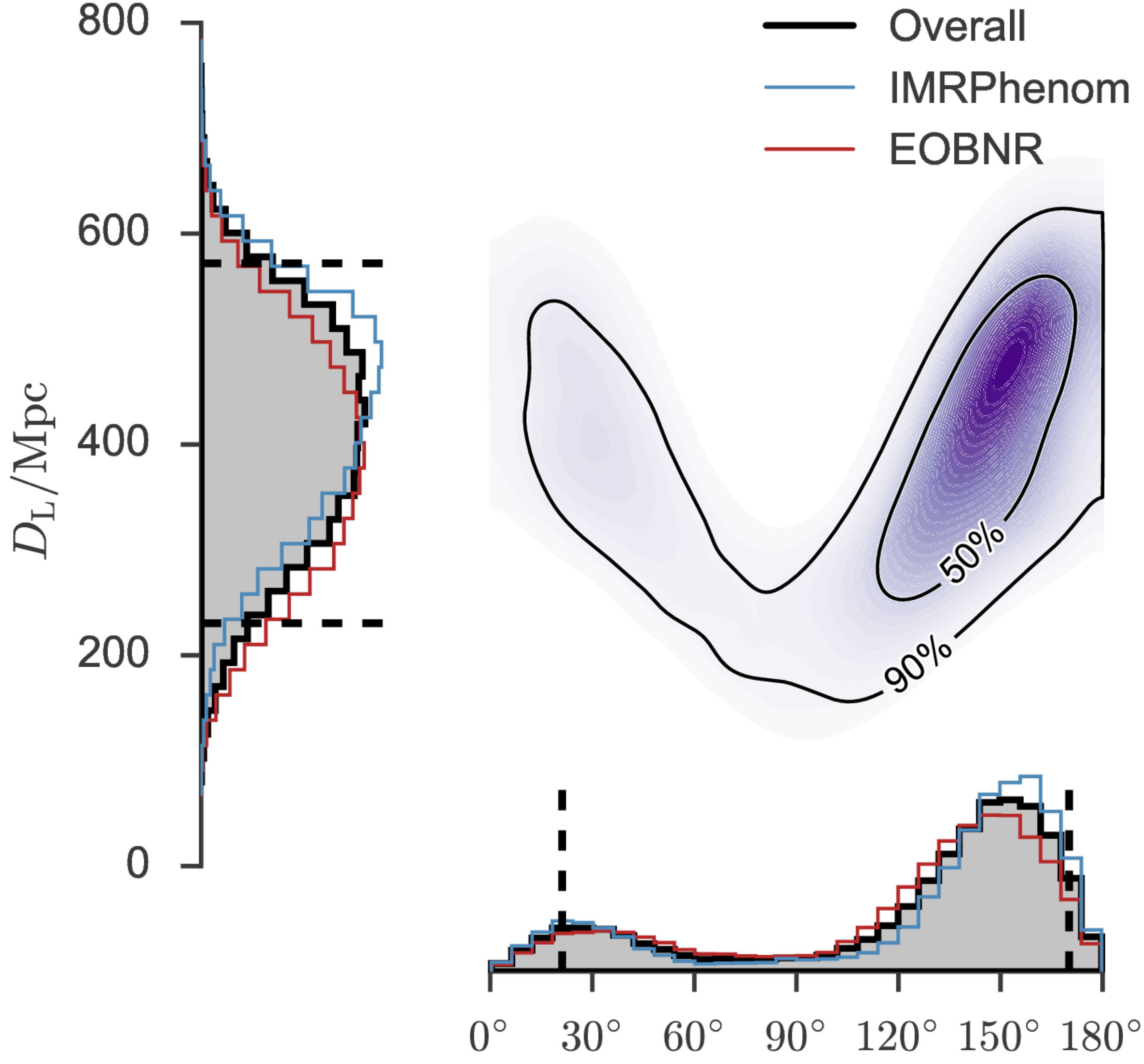
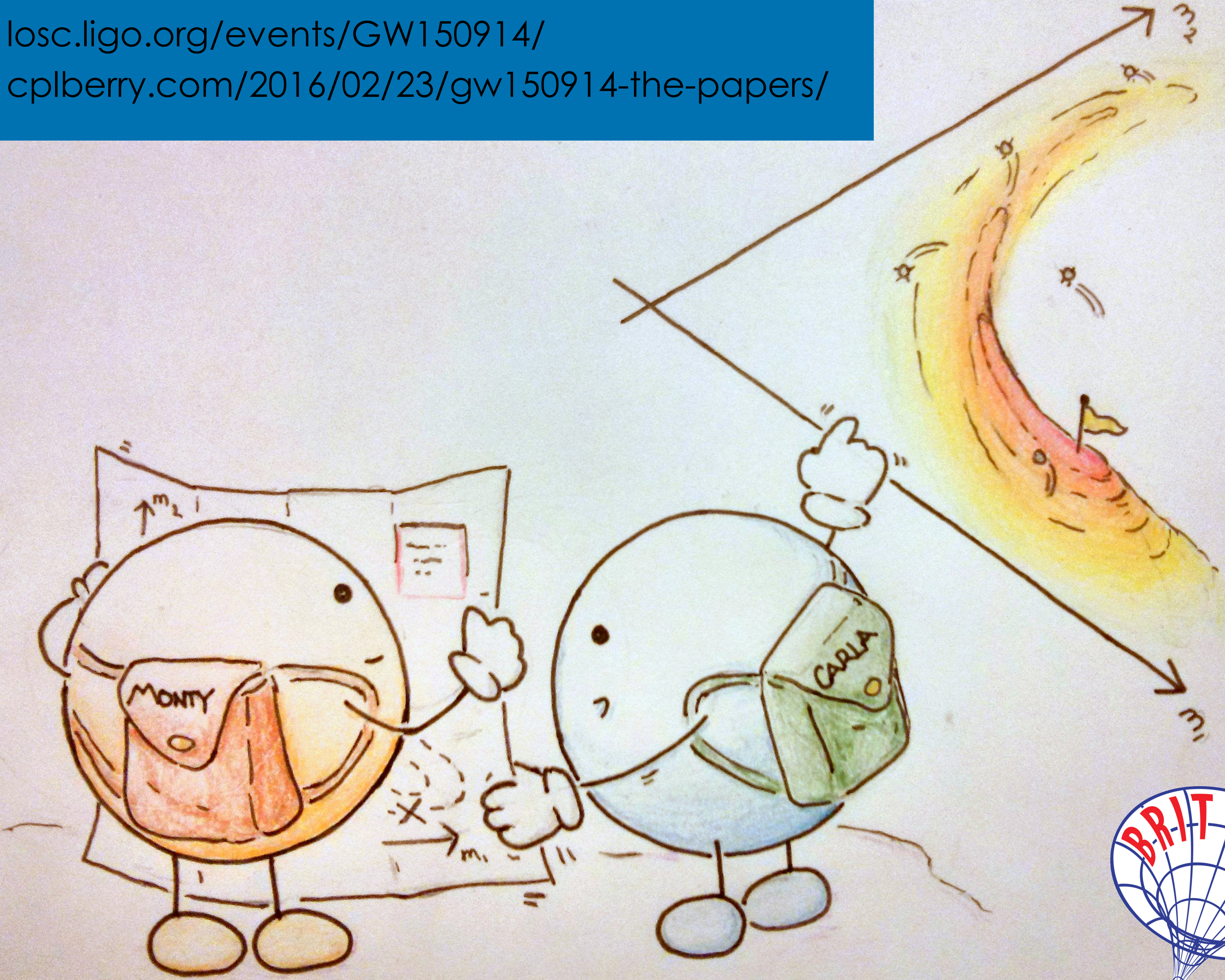


arXiv:1602.03840

- Gravitational waves encode information about their source
- Some parameters are better measured than others
- Better waveforms and calibration can improve estimates
- Accuracy currently limited by signal-to-noise ratio

losc.ligo.org/events/GW150914/

cplberry.com/2016/02/23/gw150914-the-papers/

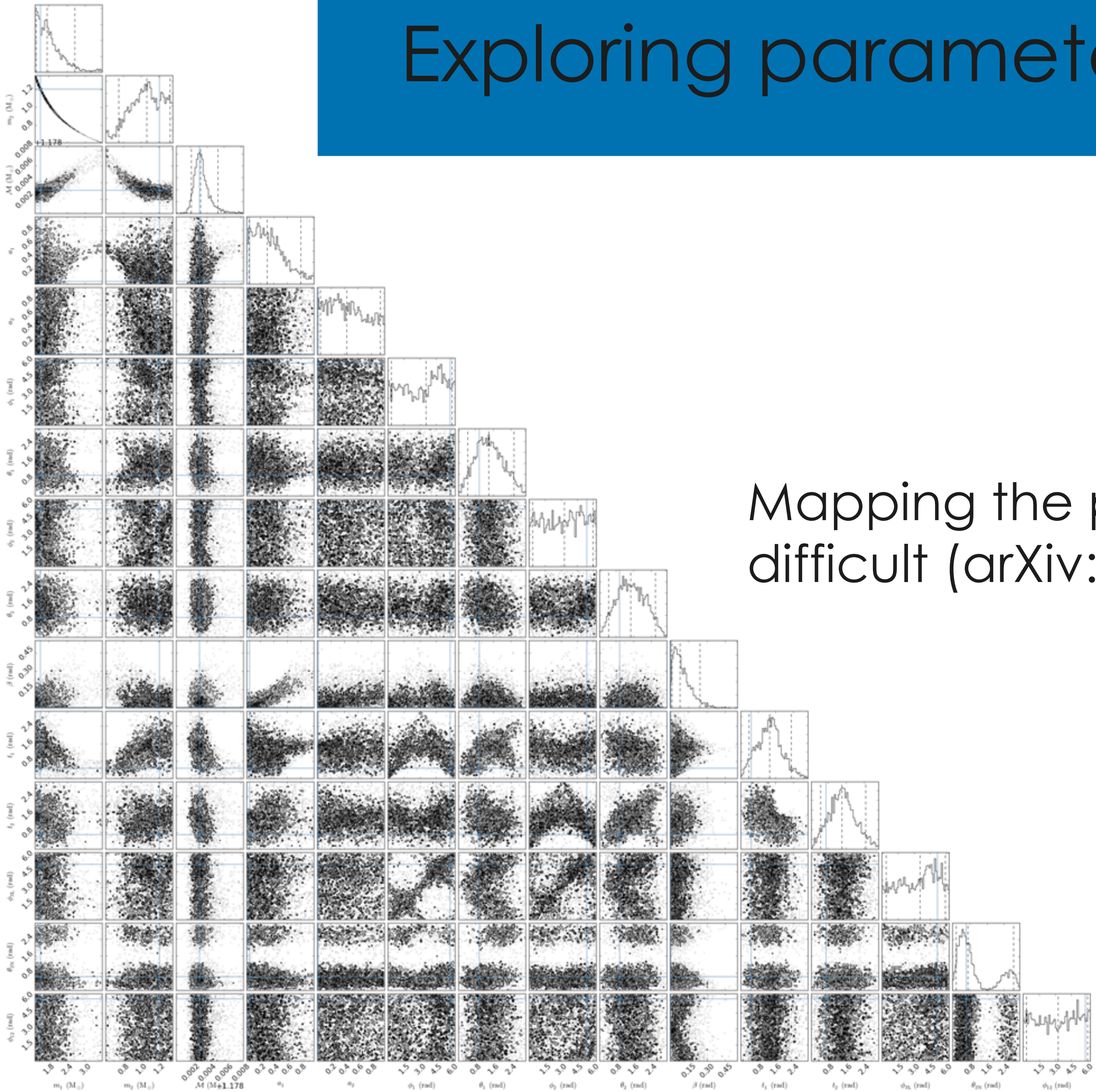


Chirp mass

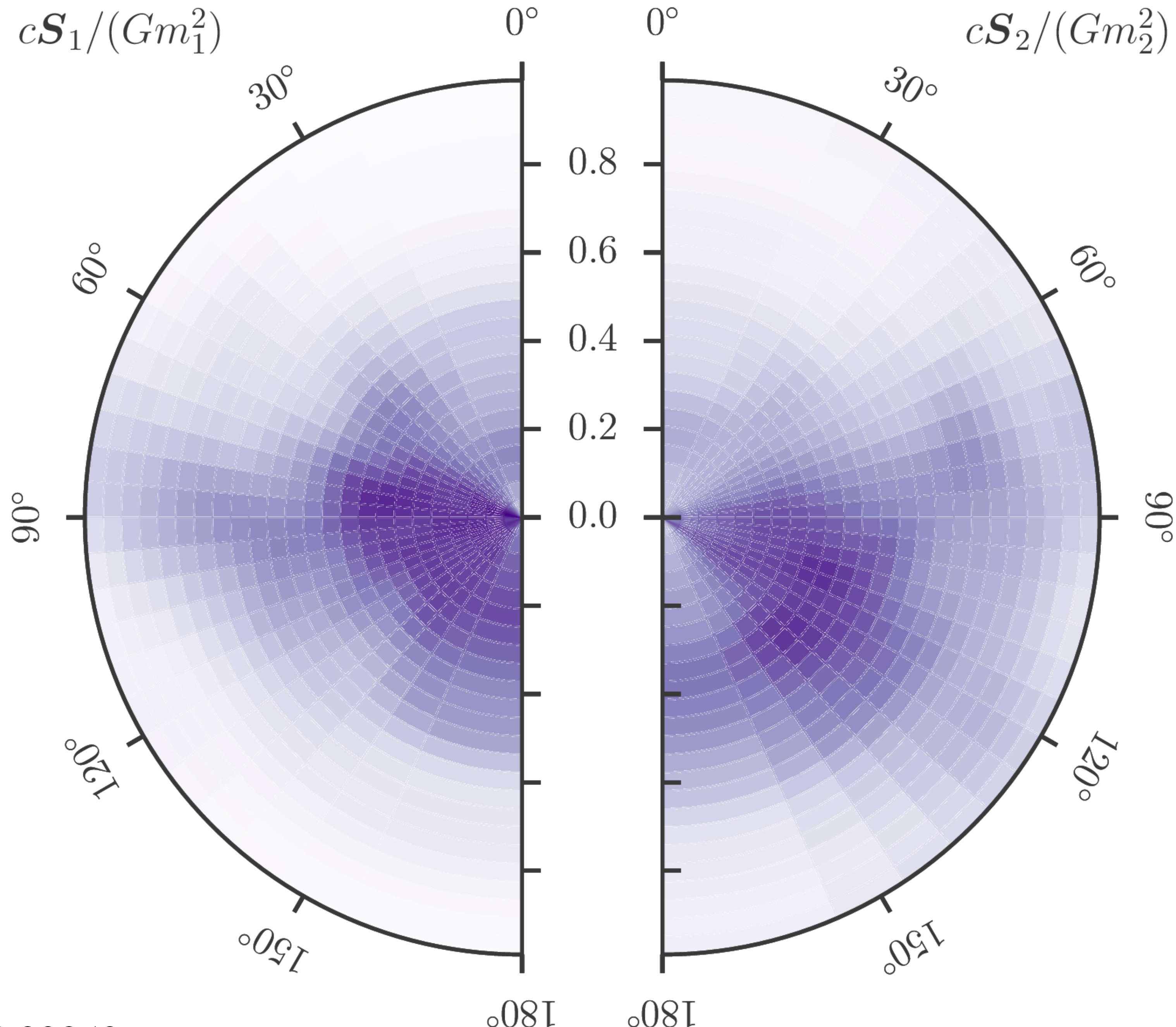
$$\mathcal{M}_{\rm c} = \frac{(m_1 m_2)^{3/5}}{(m_1 + m_2)^{1/5}}$$

Chirp mass gives leading-order amplitude and phase evolution (arXiv:0903.0338)

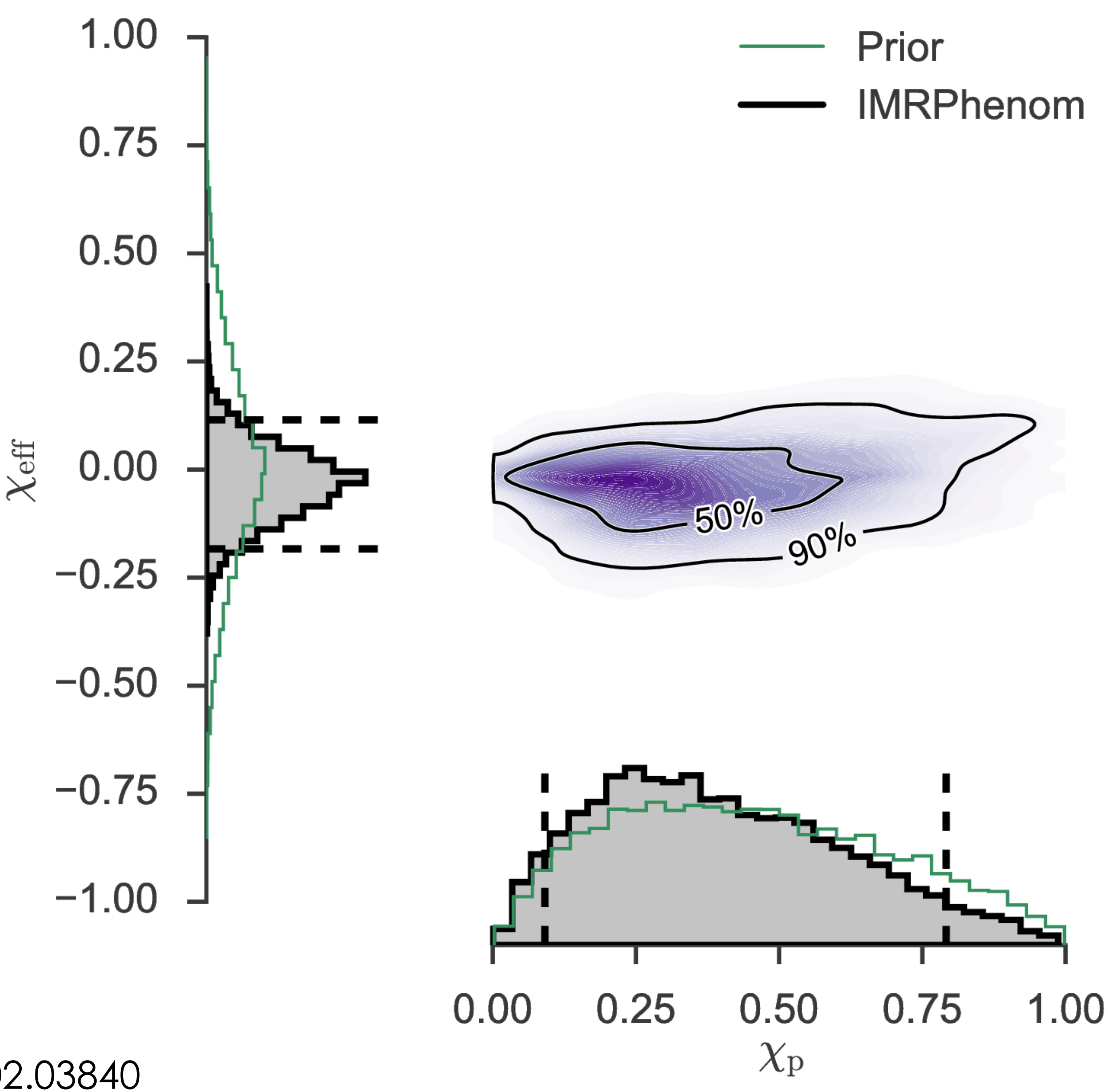
Exploring parameter space



Mapping the posterior is difficult (arXiv:1409.7215)



$cS_1/(Gm_1^2)$
$cS_2/(Gm_2^2)$
0°
30°
60°
90°
120°
150°
180°
0.8
0.6
0.4
0.2
0.0



arXiv:1602.03840

Data release | 2015, HL | 2016, HLV | new 2015, recoloured | Show/hide columns

The First Two Years of Electromagnetic Follow-Up with Advanced LIGO and Virgo

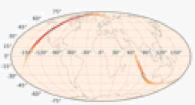
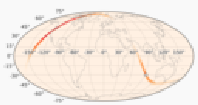
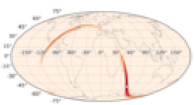
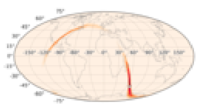
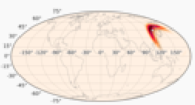
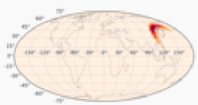
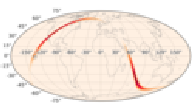
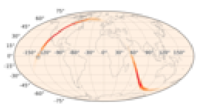
Singer et al. 2014 arXiv:1404.5623 | Berry et al. 2015 arXiv:1411.6934

www.ligo.org/scientists/first2years/

This web page
additional onli
related to the
Two Years of
Follow-Up with
and Virgo" and
paper "Param
for Binary Neu
Coalescences

Data release | 2015, HL | 2016, HLV | new 2015, recoloured | Show/hide columns

Catalog of simulated events and sky maps for two-detector, HL, 2015 configuration. This is the same configuration as the 2015 tab, except that the simulated detector noise is data from initial LIGO's sixth science run, recoloured (filtered) to have the same PSD as the early Advanced LIGO configuration. See also ASCII tables of simulated signals, detections, and parameter-estimation accuracies in Machine Readable Table format.

event ID	sim ID	network	SNR			BAYESTAR			LALINFERENCE_NEST			sky maps	
			net	H	L	50%	90%	searched	50%	90%	searched	BAYESTAR	LALINFERENCE_NEST
4532	899	HL	13.9	10.1	9.5	180	750	190	170	790	150		
4572	1243	HL	13.2	10.0	8.7	230	830	45	200	920	33		
4618	1768	HL	10.8	8.0	7.3	160	540	220	130	440	280		
4647	1964	HL	12.4	8.6	9.0	260	890	1200	190	780	780		
4711	2704	HL	10.7	8.0	7.1	370	1200	300	450	1600	520