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LSC LIGO Scientific Collaboration

Binary neutron-star parameter estimation with Advanced LIGO

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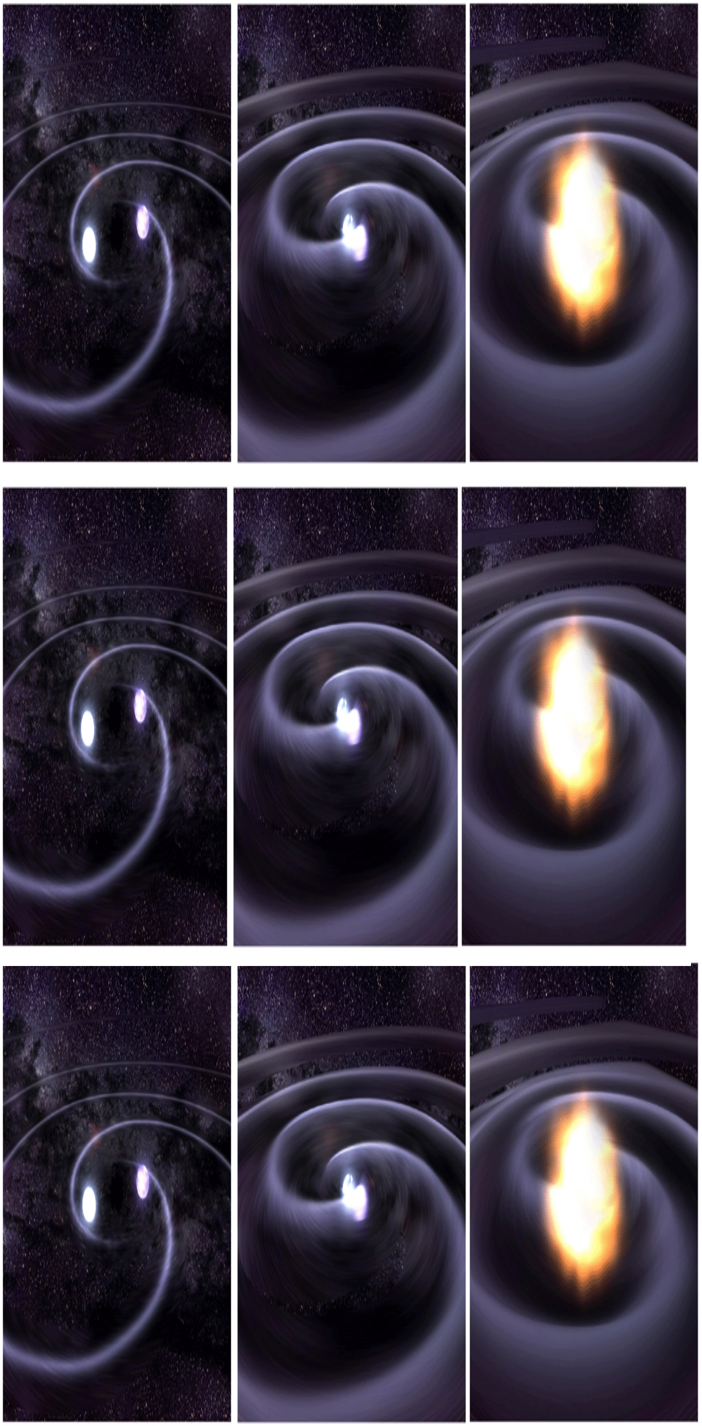
17 June 2015

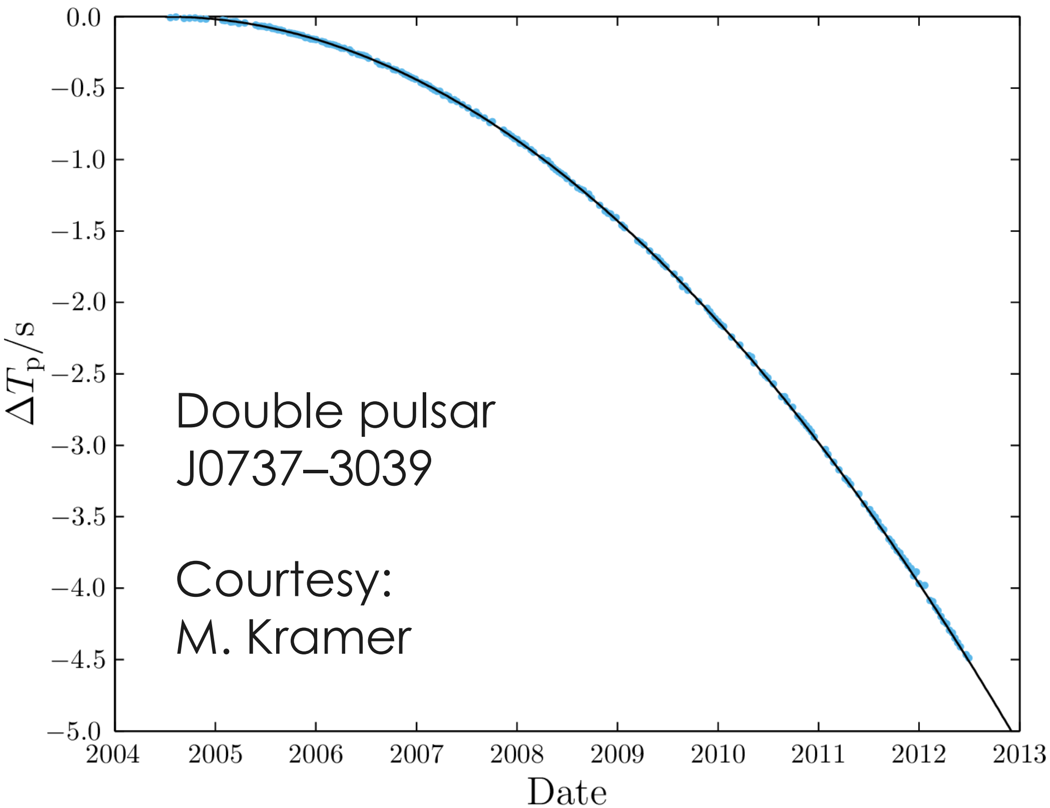
GWPAW, Osaka

LIGO Document Number DCC-G1500553



Binary neutron stars

0.4–400 events per year at design sensitivity (arXiv:1003.2480)

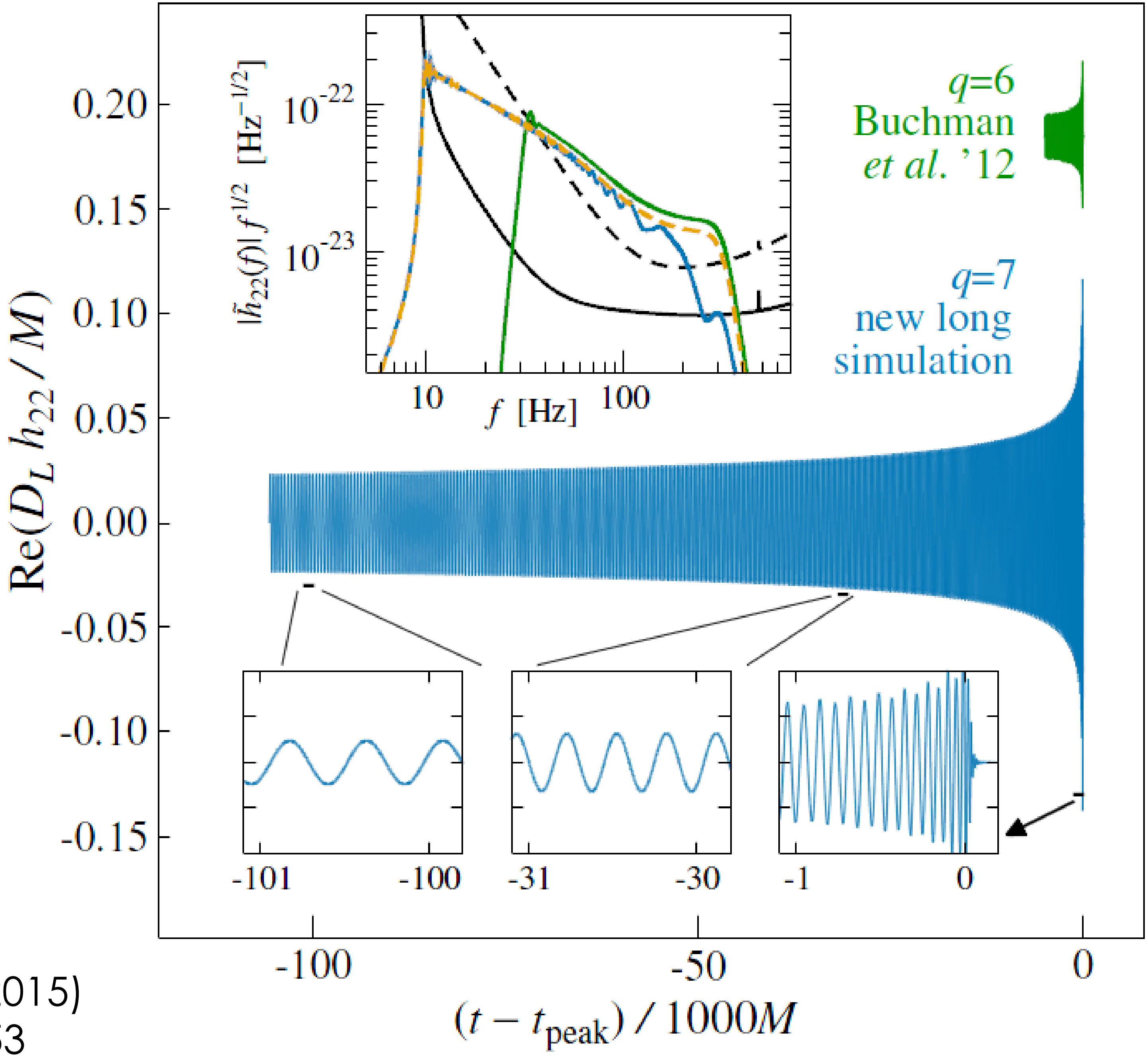


Credit: NASA

How we do parameter estimation

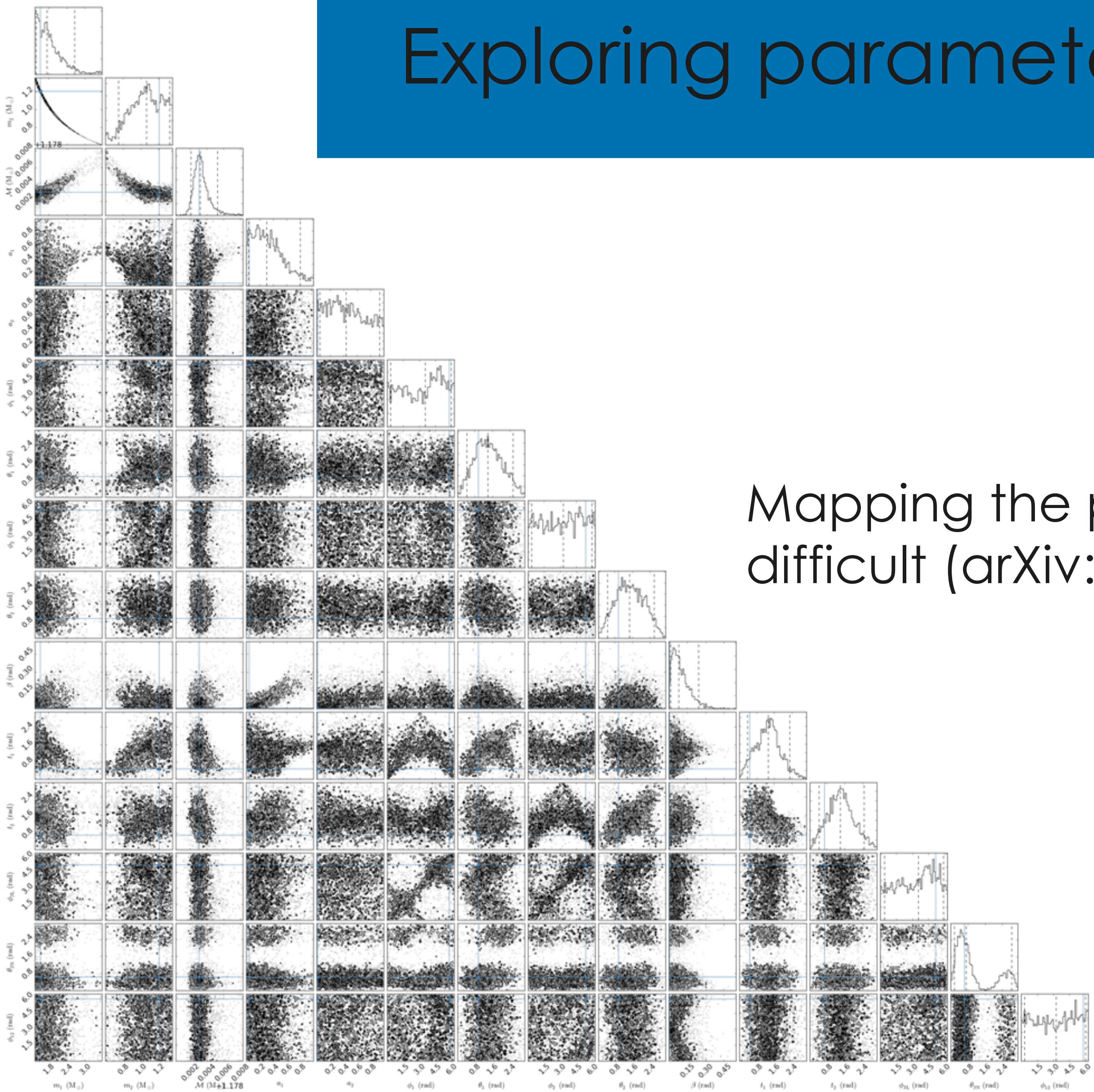
What we can learn about binary neutron stars

Inspirals are well under-stood



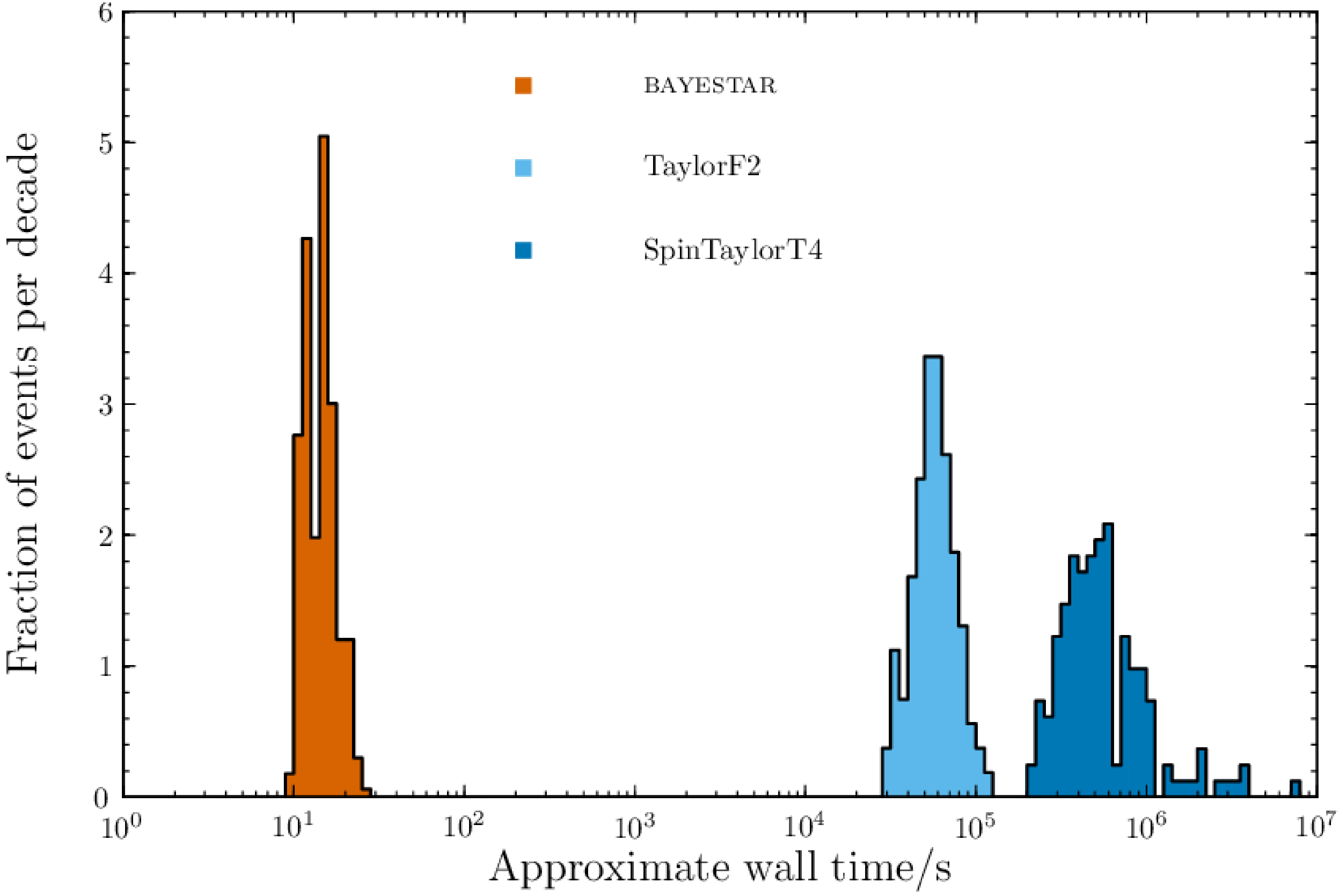
Szilagyi *et al.* (2015)
arXiv:1502.04953

Exploring parameter space



Mapping the posterior is difficult (arXiv:1409.7215)

Time taken


BAYESTAR
TaylorF2
SpinTaylorT4
Fraction of events per decade
Approximate wall time/s
0
1
2
3
4
5
6
10^0
10^1
10^2
10^3
10^4
10^5
10^6
10^7

How we do parameter estimation

What we can learn about binary neutron stars

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

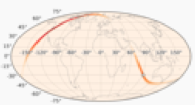
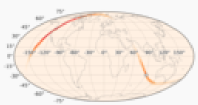
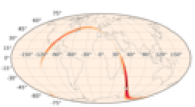
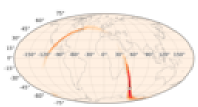
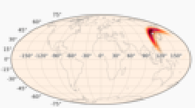
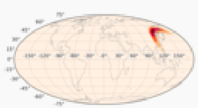
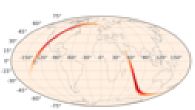
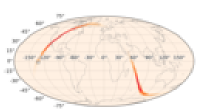
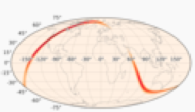
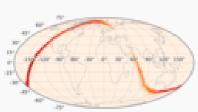
Singer et al. 2014 arXiv:1404.5623 | Berry et al. 2015 arXiv:1411.6934

www.ligo.org/scientists/first2years/

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

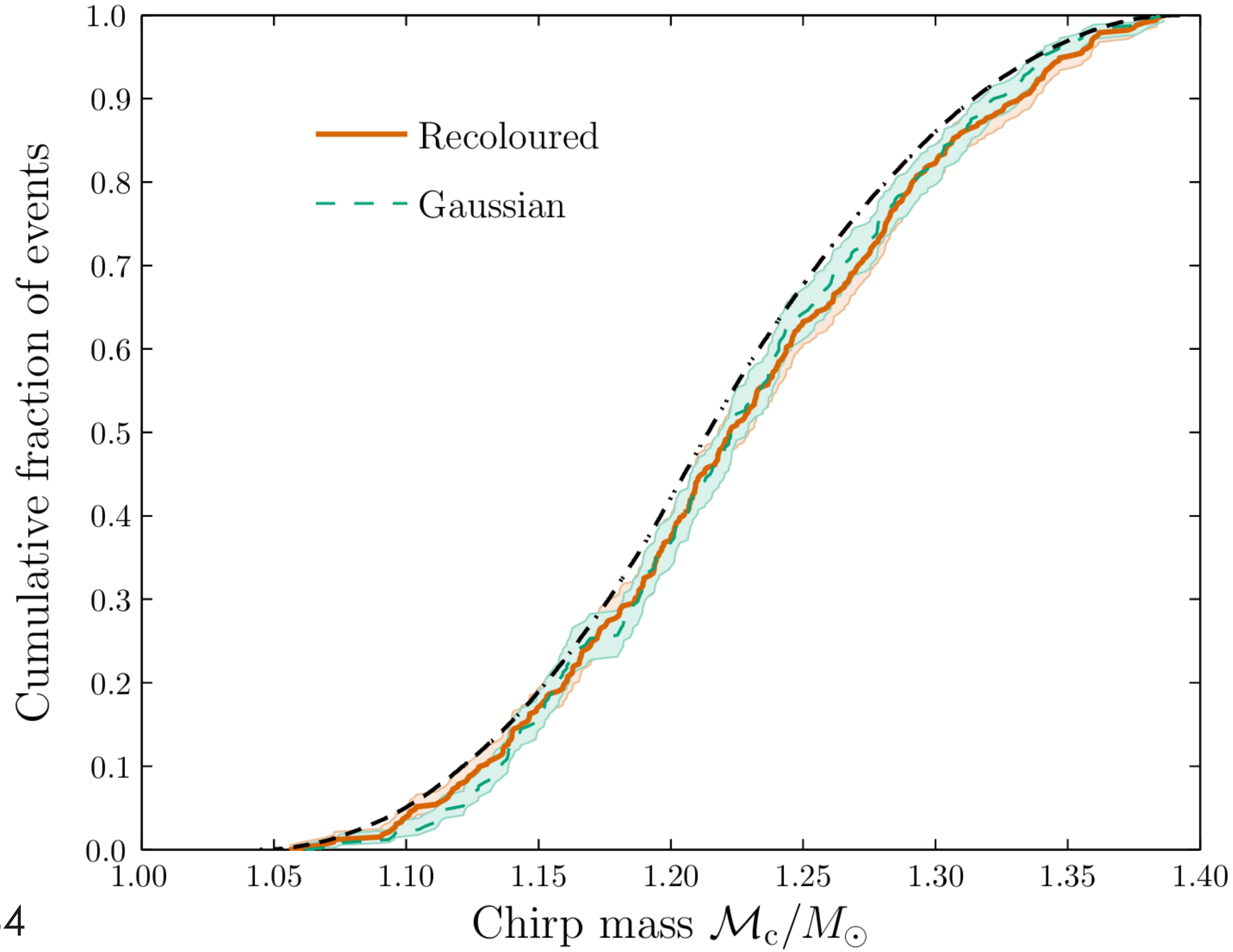
Data release | 2015, HL | 2016, HLV | new 2015, recoloured | Show/hide columns

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		
								00	190	780	780		
								00	450	1600	520		

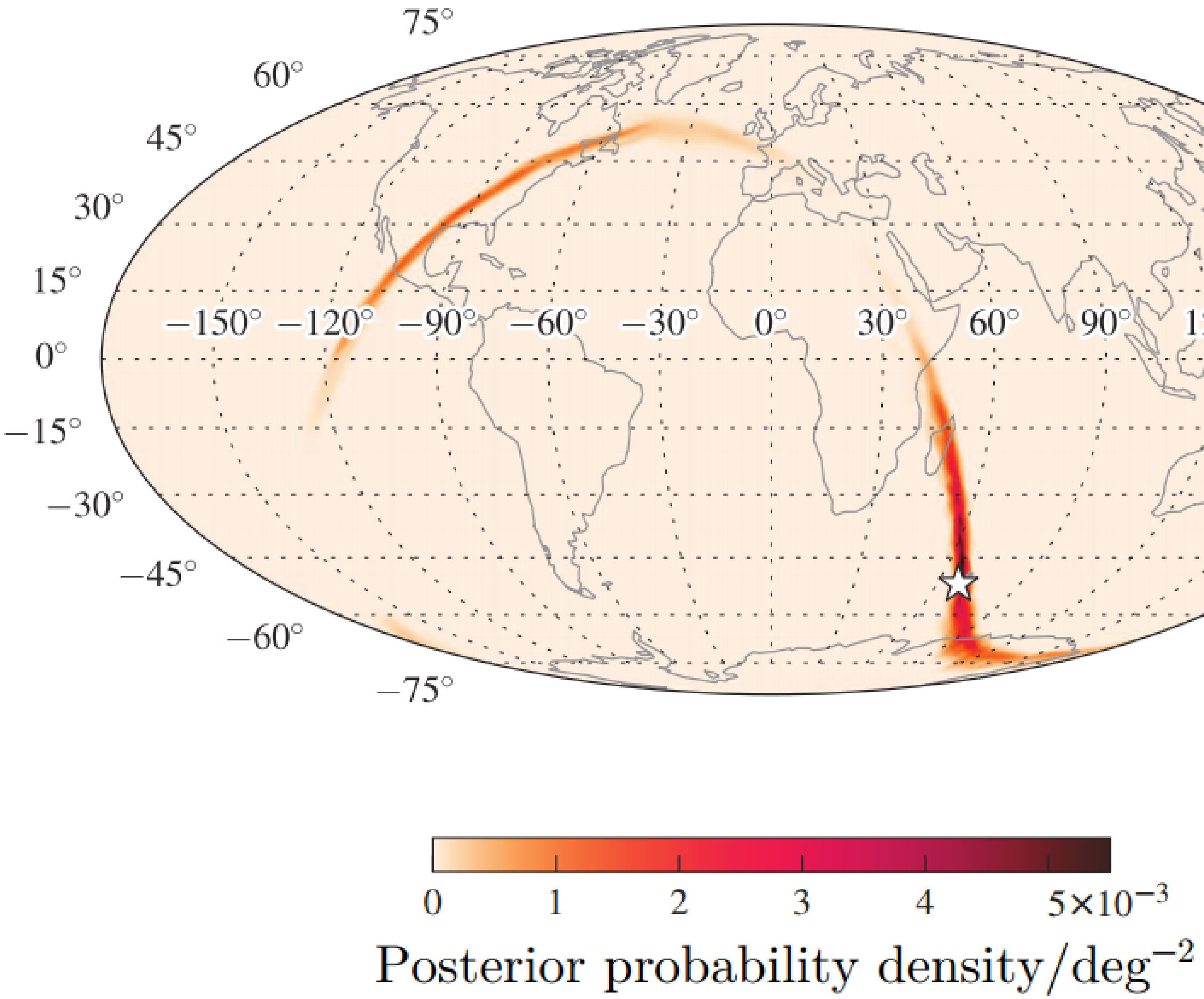
Amaldi 11, 11 am, 22 June 2015
Leo Singer: The needle in the 100 deg^2 haystack

Detection



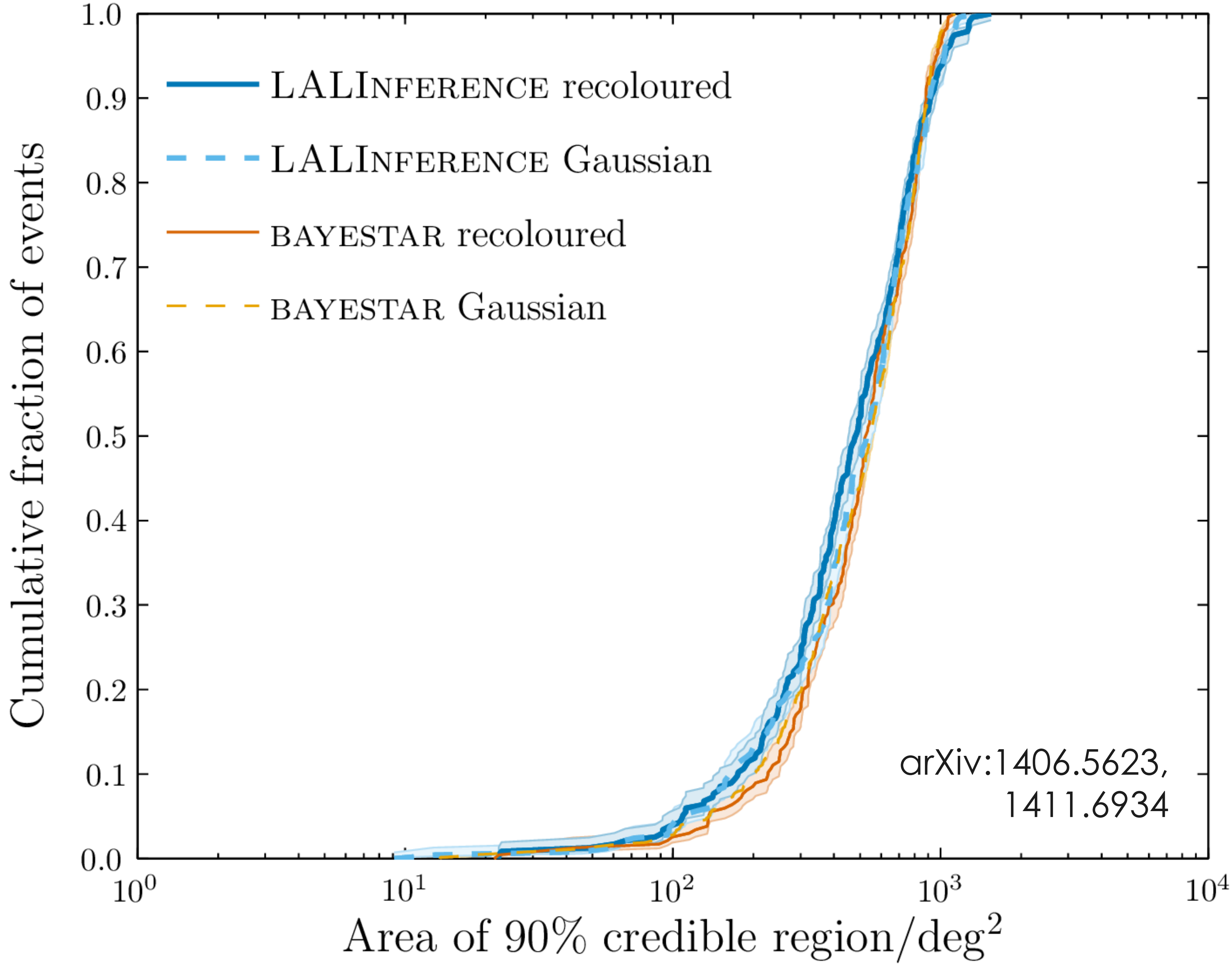
arXiv: 1411.6934

Sky localization



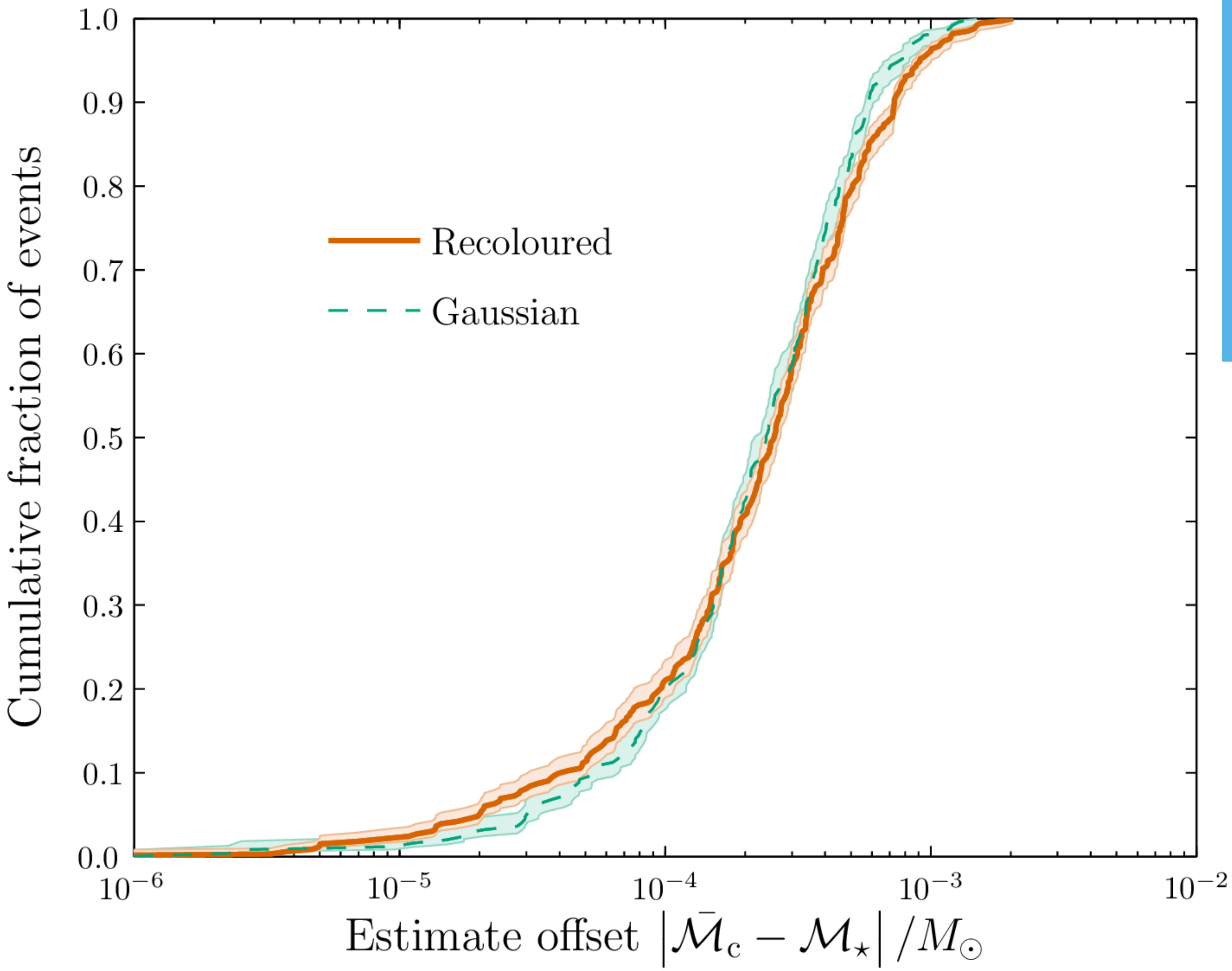
www.ligo.org/scientists/first2years/

arXiv:1411.6934



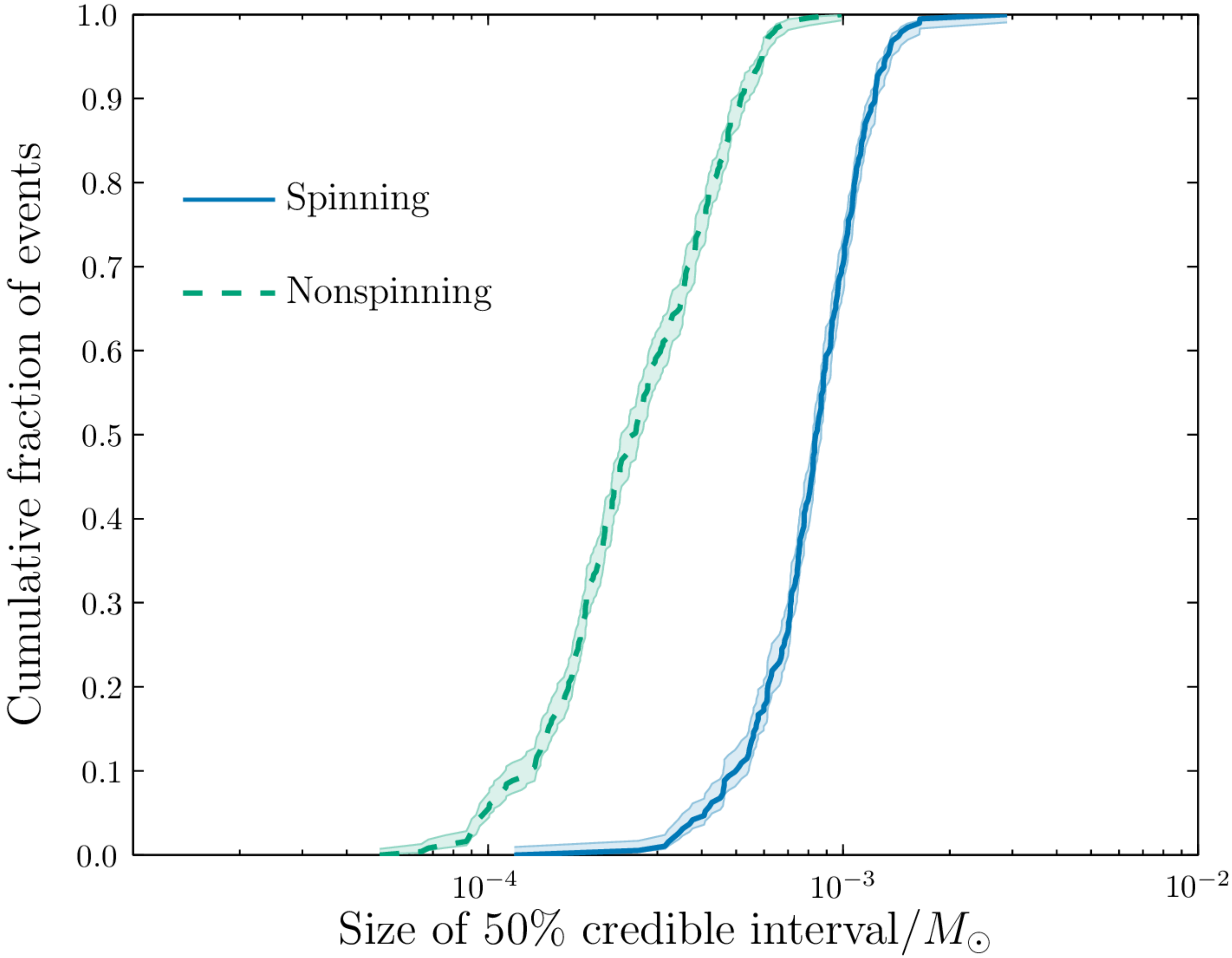
LALInference recoloured
LALInference Gaussian
BAYESTAR recoloured
BAYESTAR Gaussian
Cumulative fraction of events
Area of 90% credible region/deg^2
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1.0
10^0
10^1
10^2
10^3
10^4
arXiv:1406.5623,
1411.6934

arXiv:1411.6934



Chirp mass without spin

Preliminary



Chirp mass with spin

Farr *et al*. (2015) in prep.

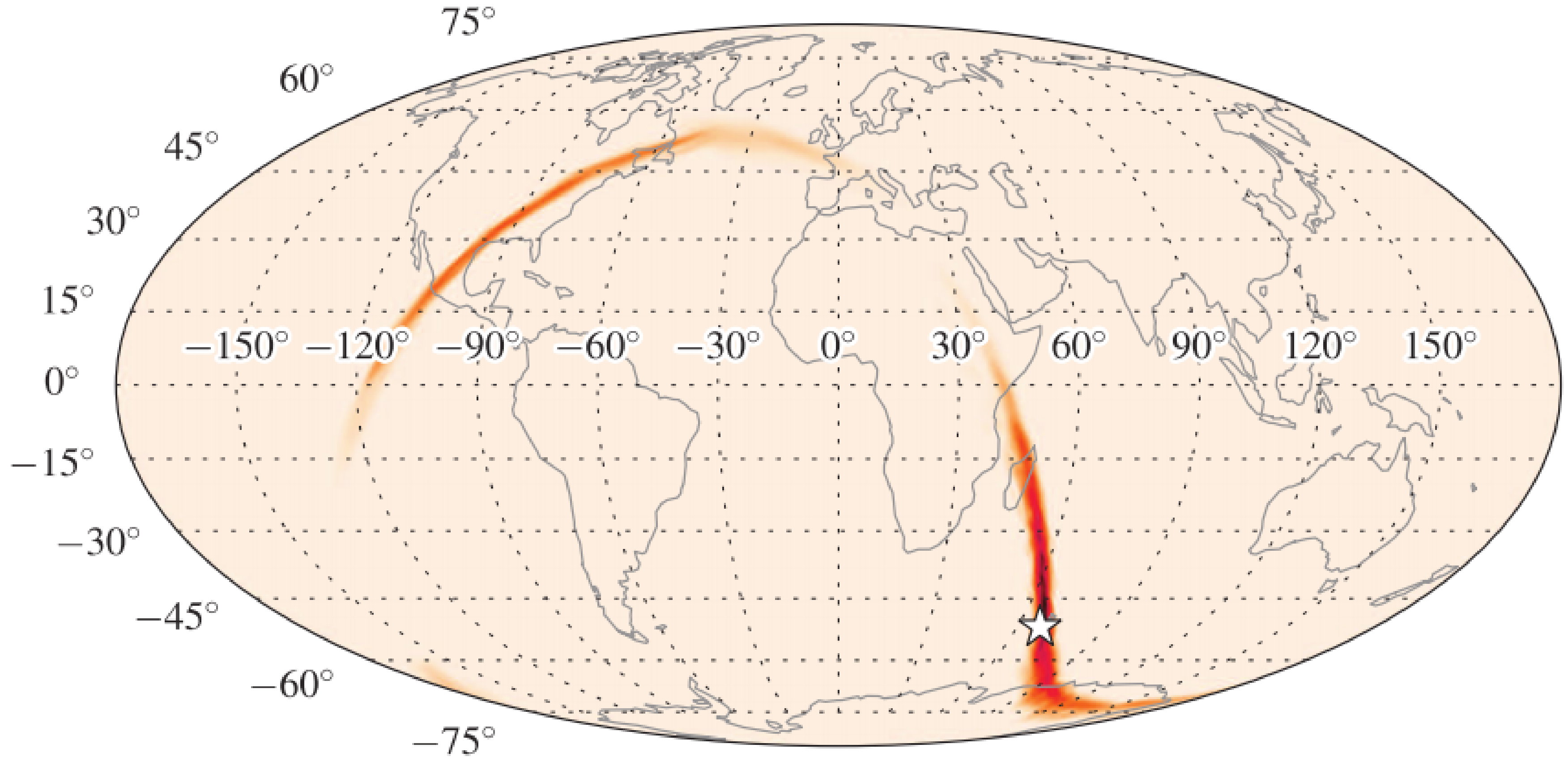
Summary

Binary neutron stars may be main source for Advanced LIGO & Virgo.

Parameter estimation can be expensive.
Adopt different approaches for different problems

Measure sky position at low latency & chirp mass at medium latency.
Individual masses (and spins) may not be well measured.

Thank you



arXiv:1411.6934

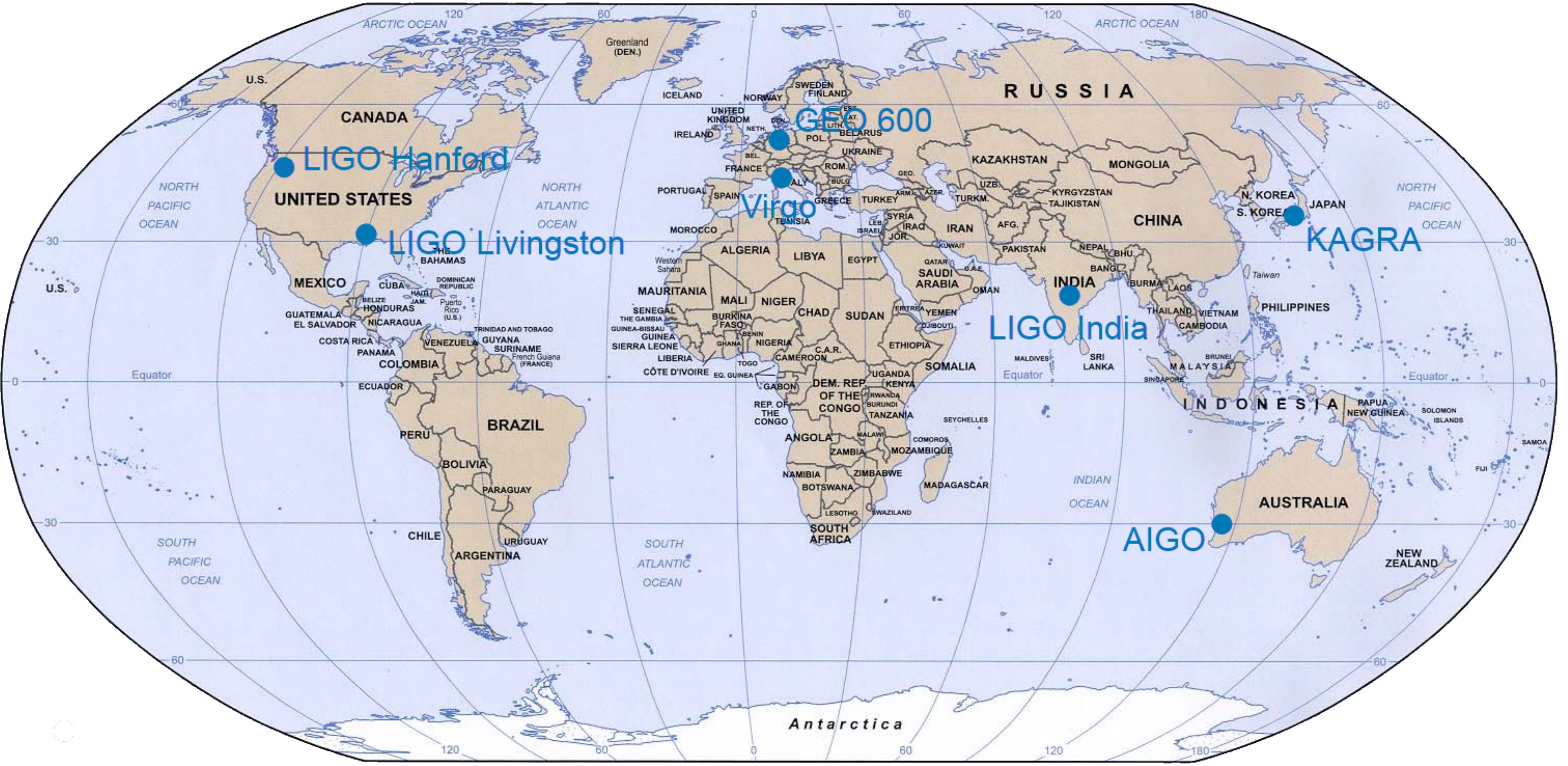
www.ligo.org/scientists/first2years/

Advanced-detector era

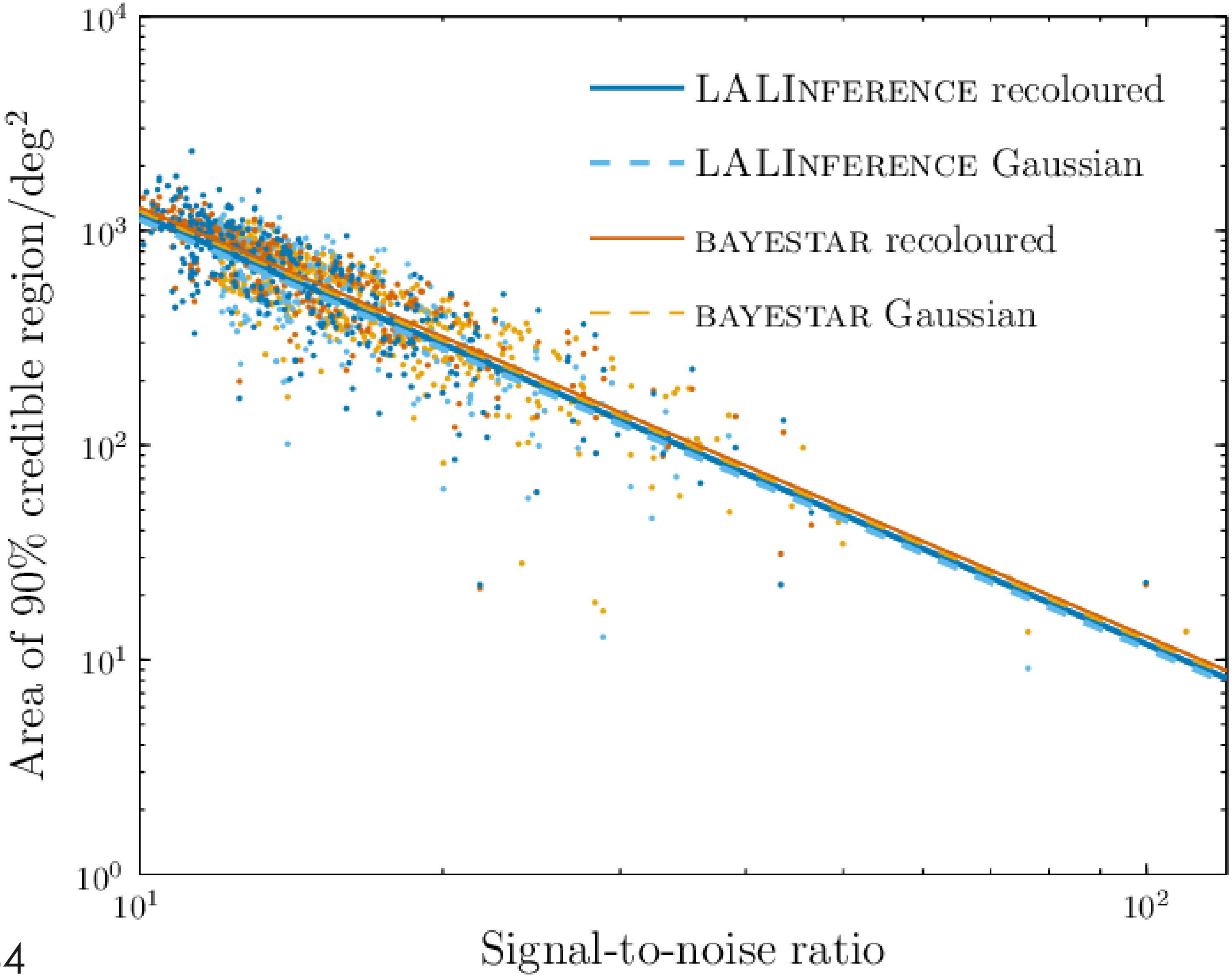
Epoch			2015	2016 – 2017	2017 – 2018	2019+	2022+ (India)
Estimated run duration			3 months	6 months	9 months	(per year)	(per year)
Burst range/Mpc		LIGO	40 – 60	60 – 75	75 – 90	105	105
		Virgo	—	20 – 40	40 – 50	40 – 80	80
BNS range/Mpc		LIGO	40 – 80	80 – 120	120 – 170	200	200
		Virgo	—	20 – 60	60 – 85	65 – 130	130
BNS detections			0.0004 – 3	0.006 – 20	0.04 – 100	0.2 – 200	0.4 – 400
90% CR	% within	5 deg^2	< 1	2	*1 – 2*	*3 – 8*	*17*
		20 deg^2	< 1	14	*10 – 12*	*8 – 28*	*48*
		median/deg^2	481	235	—	—	—
searched area	% within	5 deg^2	6	20	—	—	—
		20 deg^2	16	44	—	—	—
		median/deg^2	88	29	—	—	—

See arXiv:1304.0670

Detector network



Sky localization



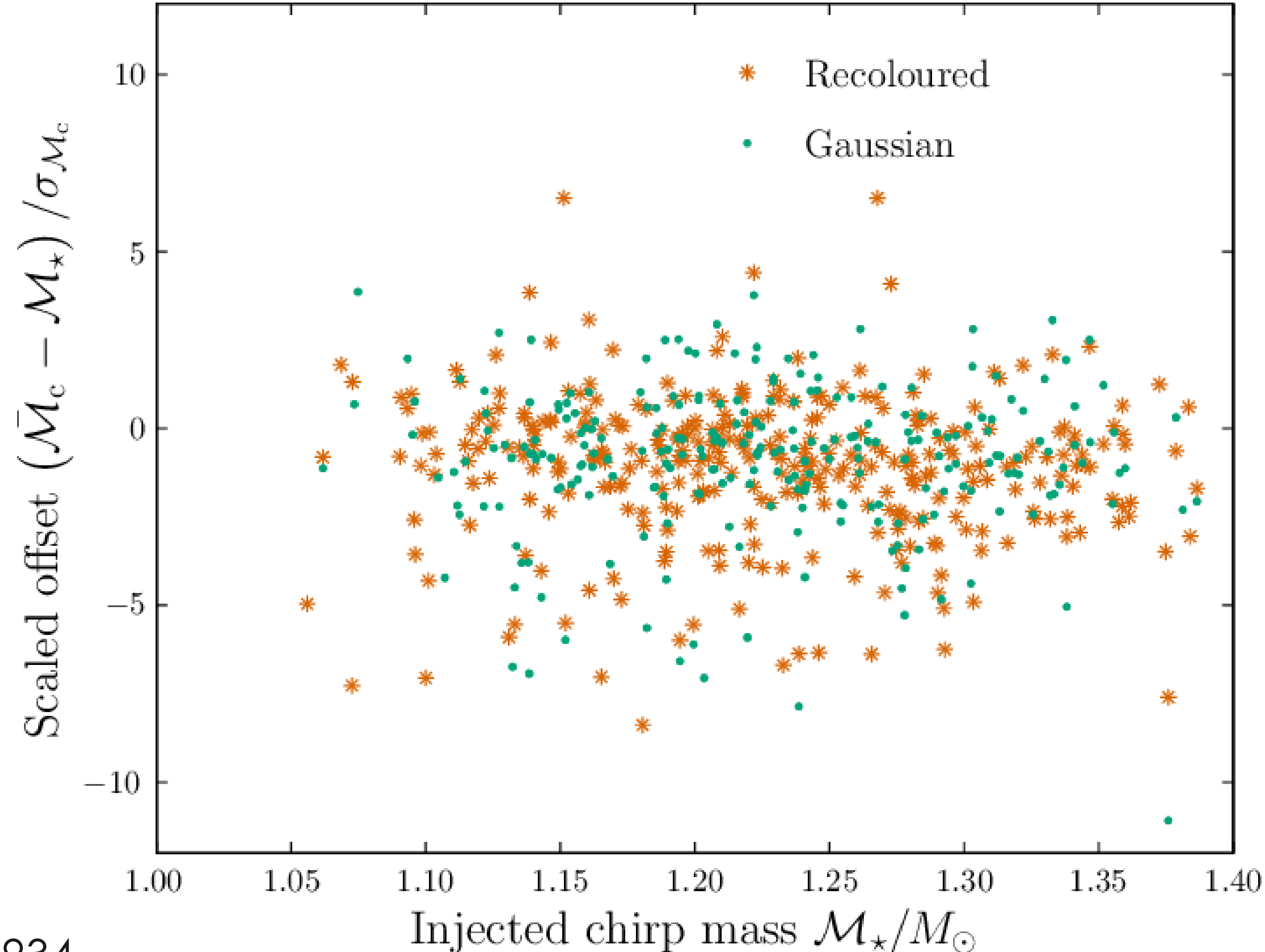
arXiv:1411.6934

Chirp mass

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

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

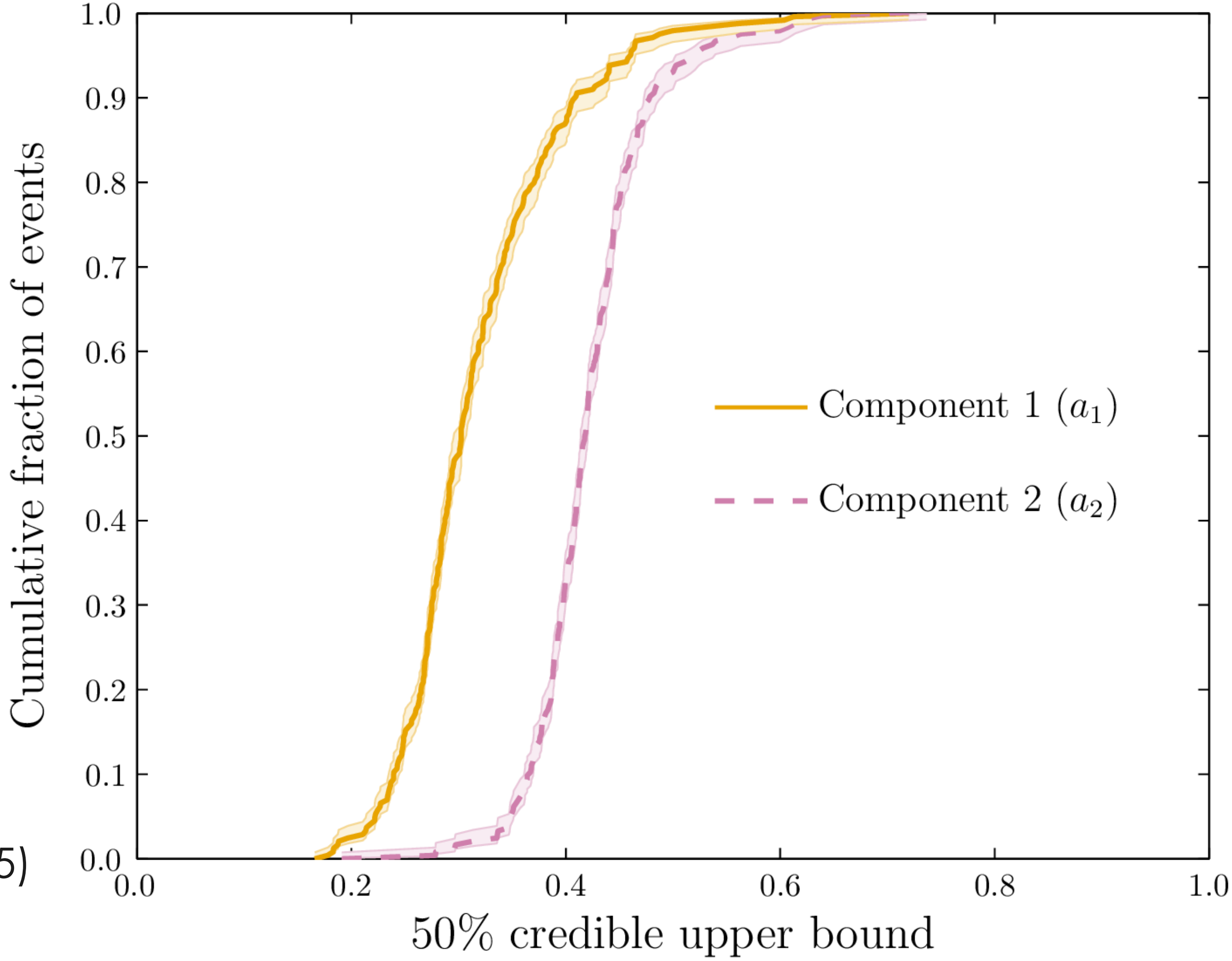
Chirp mass



arXiv:1411.6934

Spin

Preliminary



Farr *et al*. (2015) in prep.