UNIVERSITY OF BIRMINGHAM

LSC LIGO Scientific Collaboration

Early Advanced LIGO binary neutron-star sky localization and parameter estimation

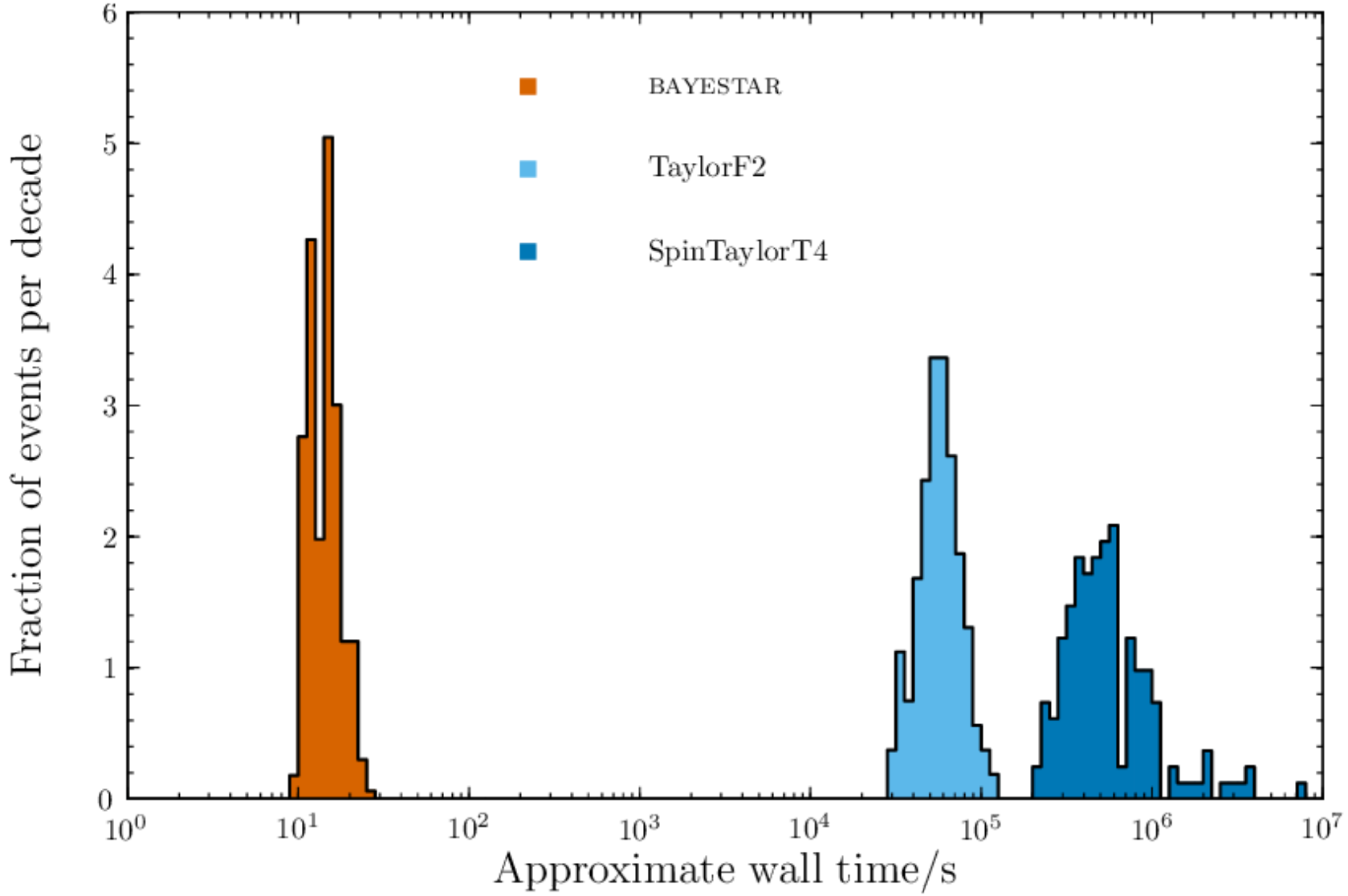
Christopher Berry
University of Birmingham
cplb@star.sr.bham.ac.uk
@cplberry

Ilya Mandel, Hannah Middleton, Leo Singer, Alex Urban, Alberto Vecchio, Salvatore Vitale, Kipp Cannon, Ben Farr, Will Farr, Philip Graff, Chad Hanna, Carl-Johan Haster, Satya Mohapatra, Chris Pankow, Larry Price, Trevor Sidery & John Veitch

23 June 2015

Amaldi 11, Gwangju

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 well can we measure sky location?

How well can we measure intrinsic parameters?

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

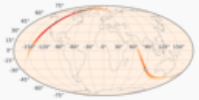
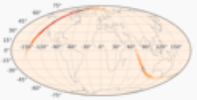
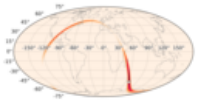
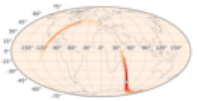
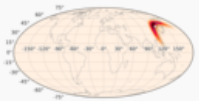
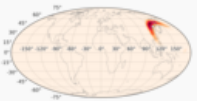
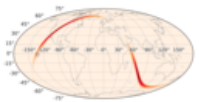
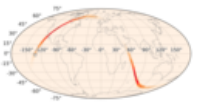
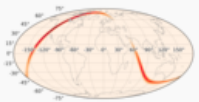
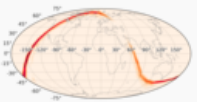
Berry et al. 2015 arXiv:1411.6934

www.ligo.org/scientists/first2years/

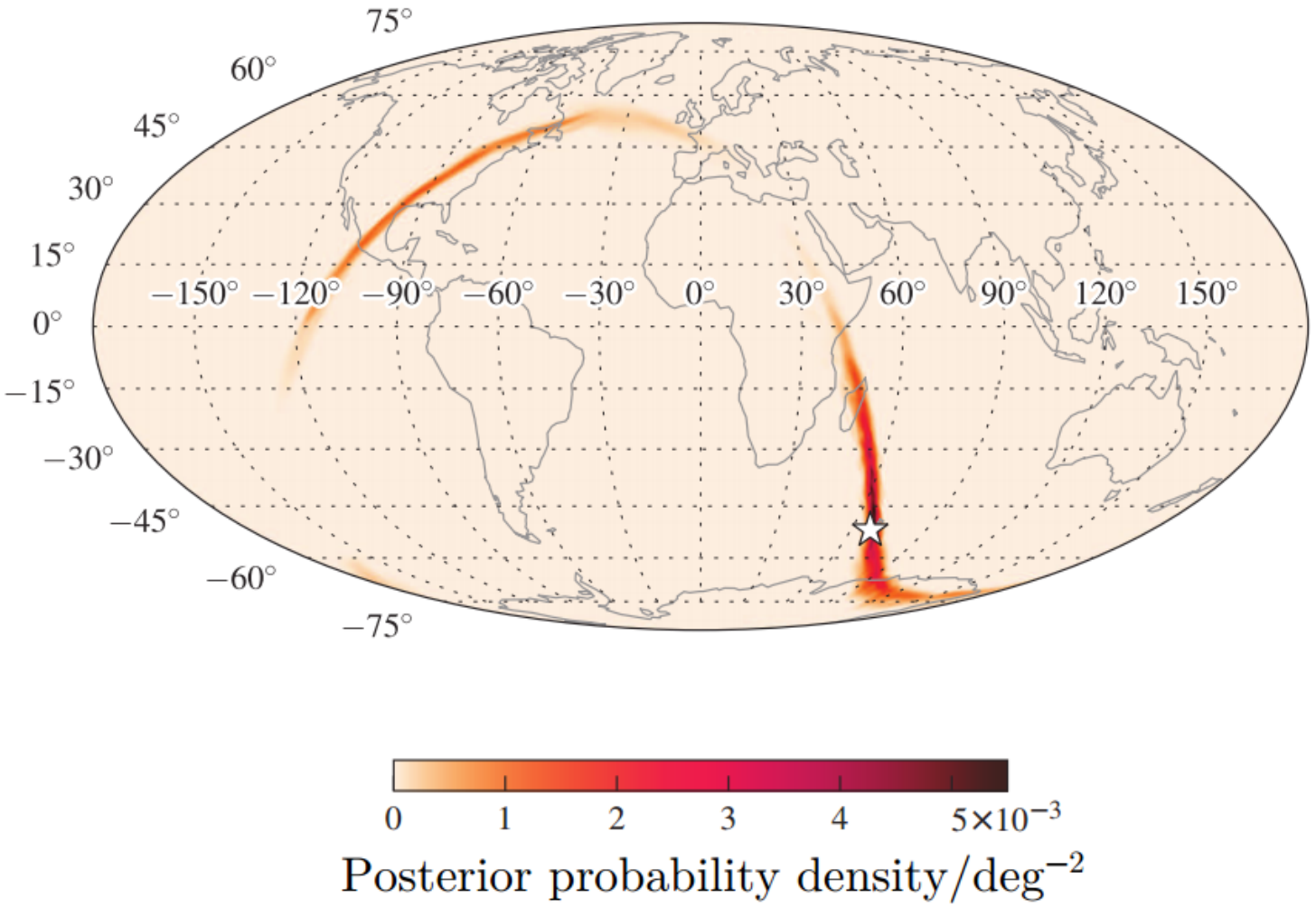
Data release 2015, HL 2016, HLV new 2015, recoloured Show/hide columns

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

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		

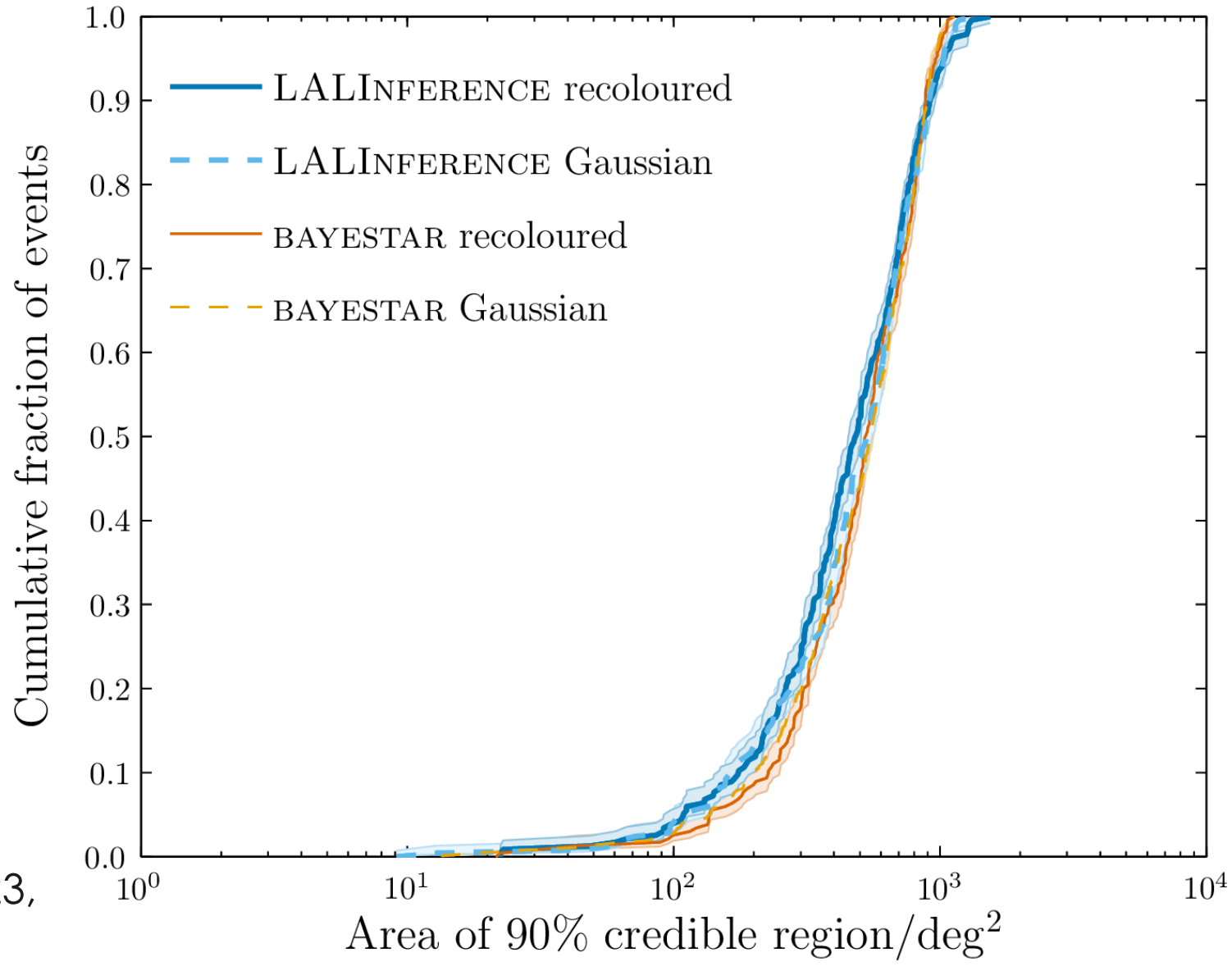
Sky map



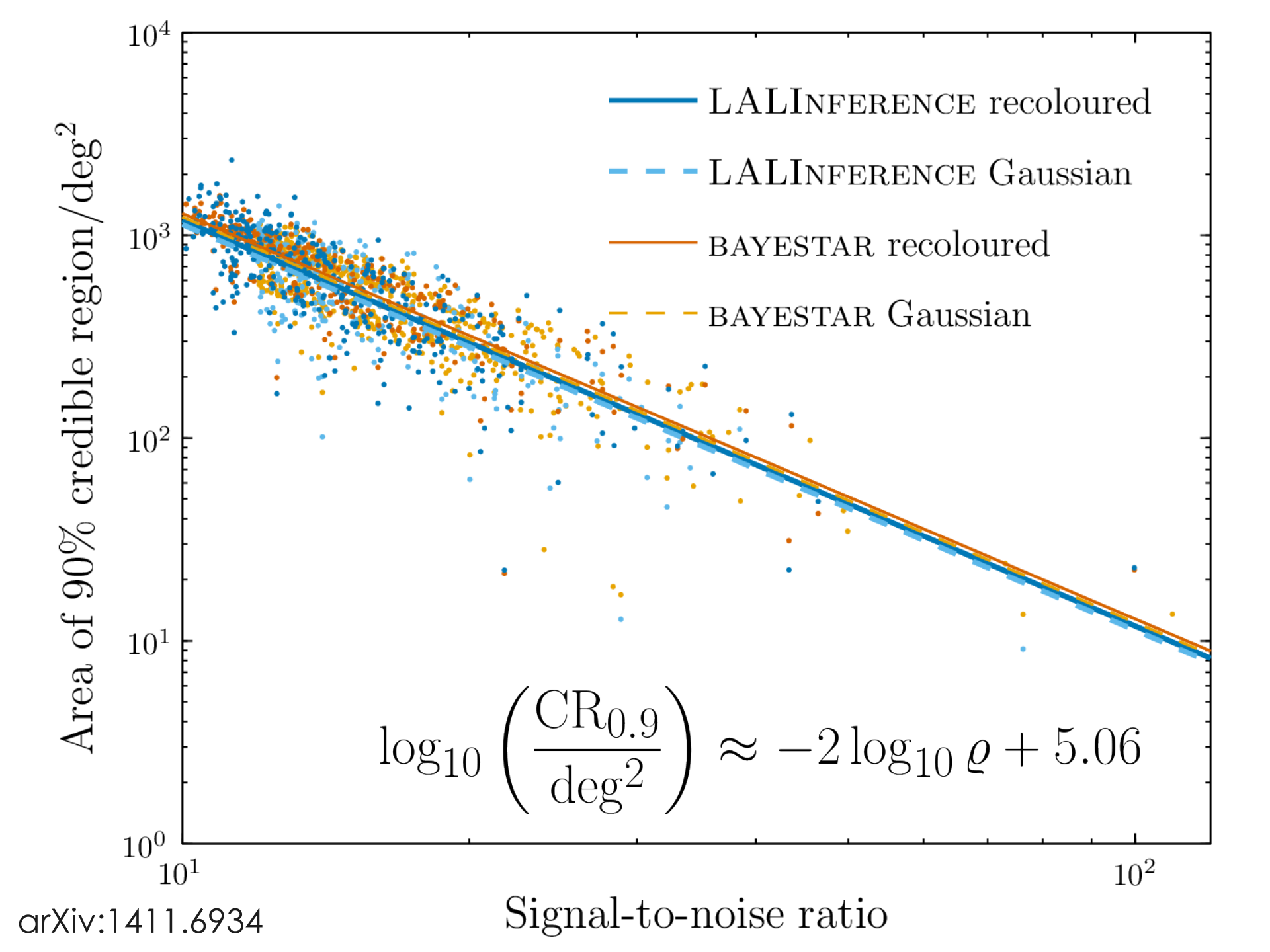
www.ligo.org/scientists/first2years/

arXiv:1411.6934

Sky localization



arXiv:1406.5623,
1411.6934

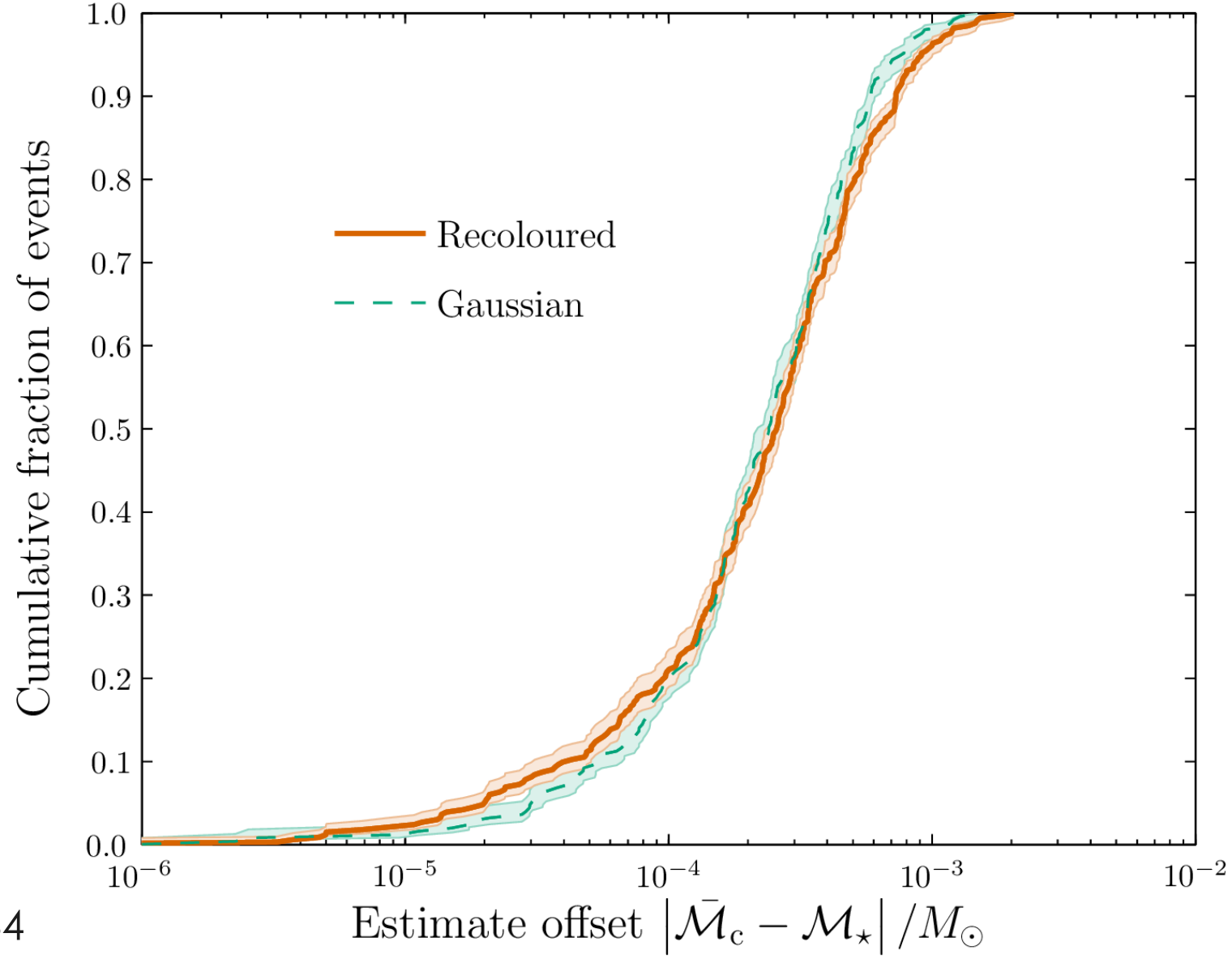


arXiv:1411.6934

How well can we measure sky location?

How well can we measure intrinsic parameters?

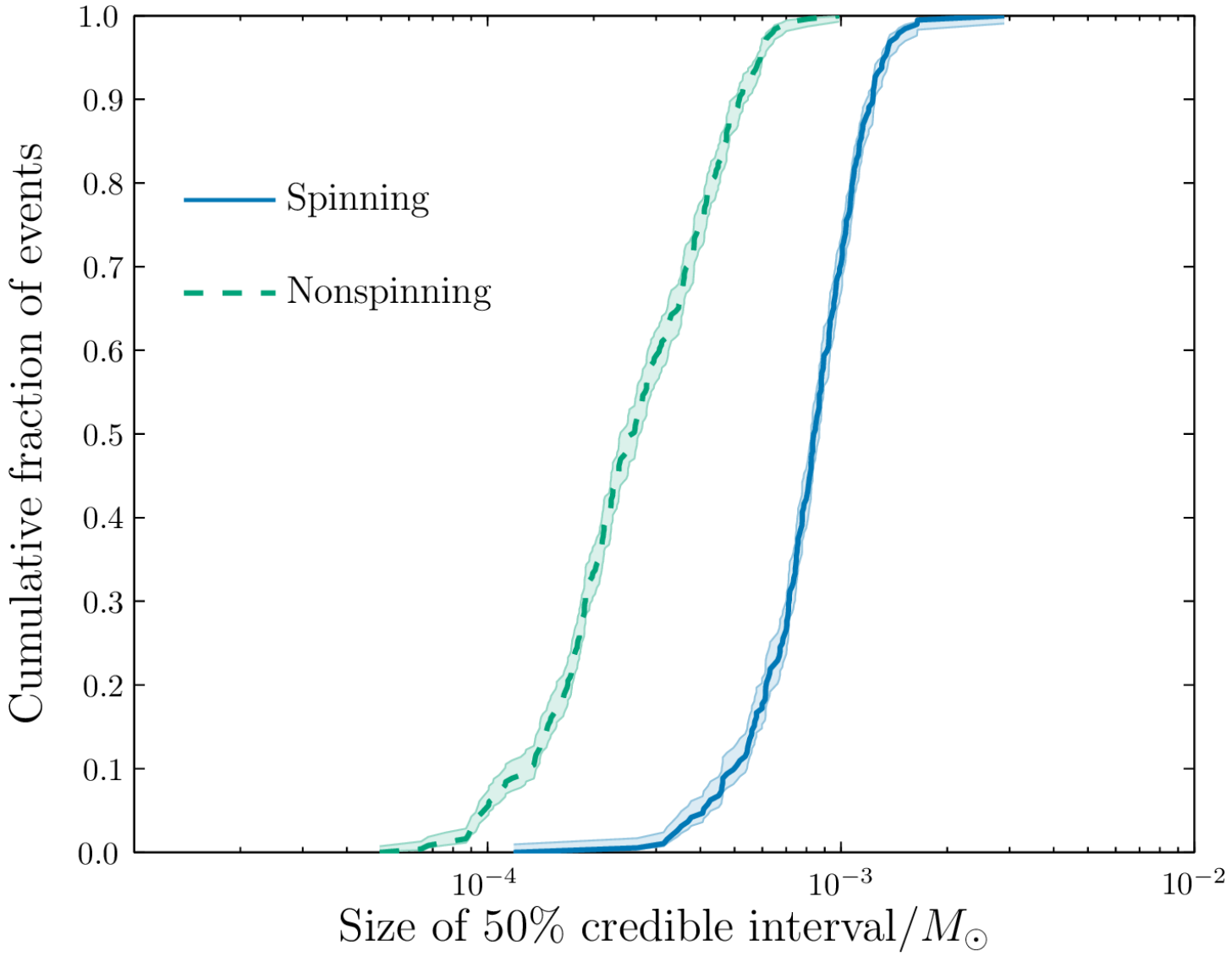
Chirp mass



arXiv:1411.6934

Chirp mass with spin

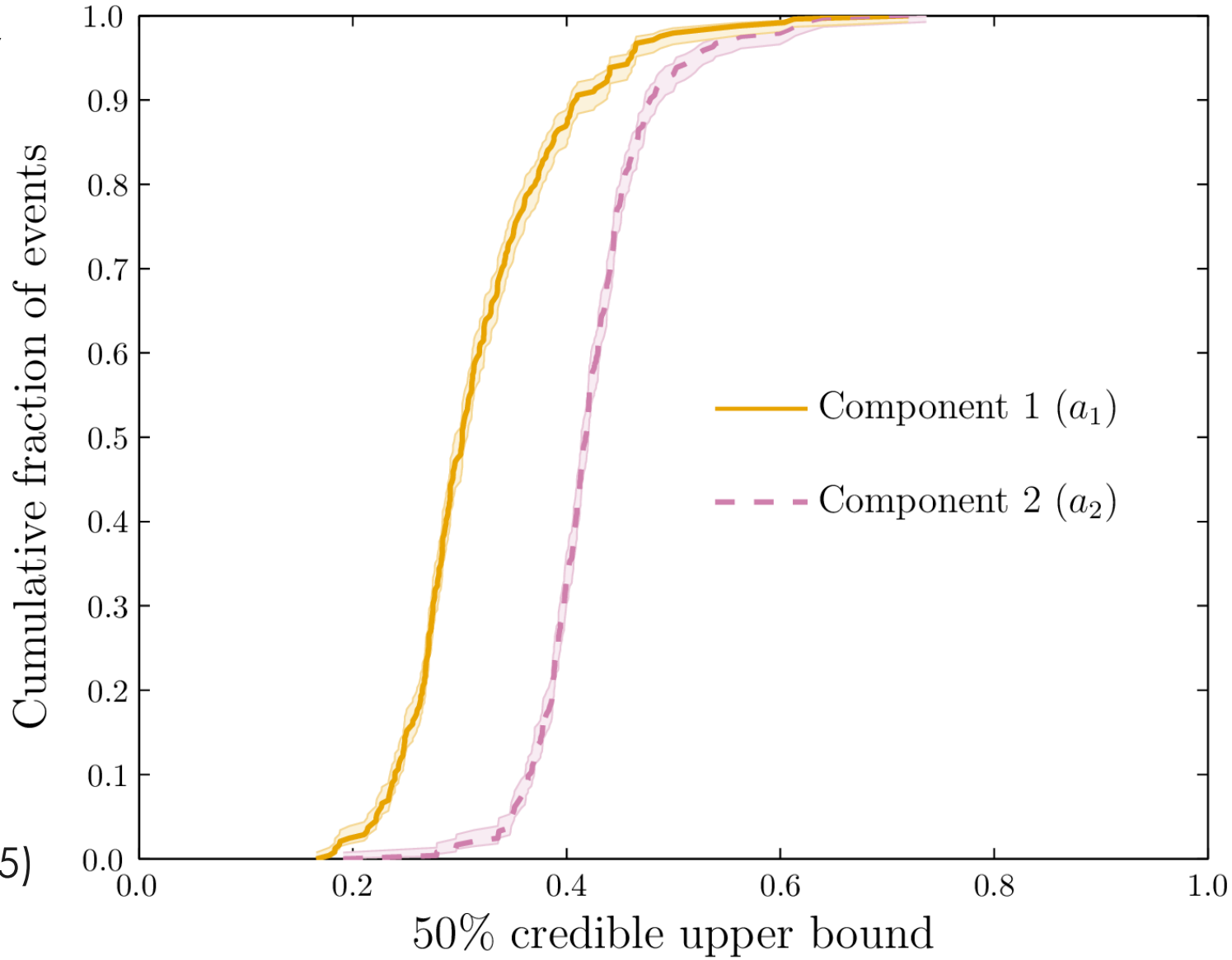
Preliminary



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

Spin magnitude

Preliminary



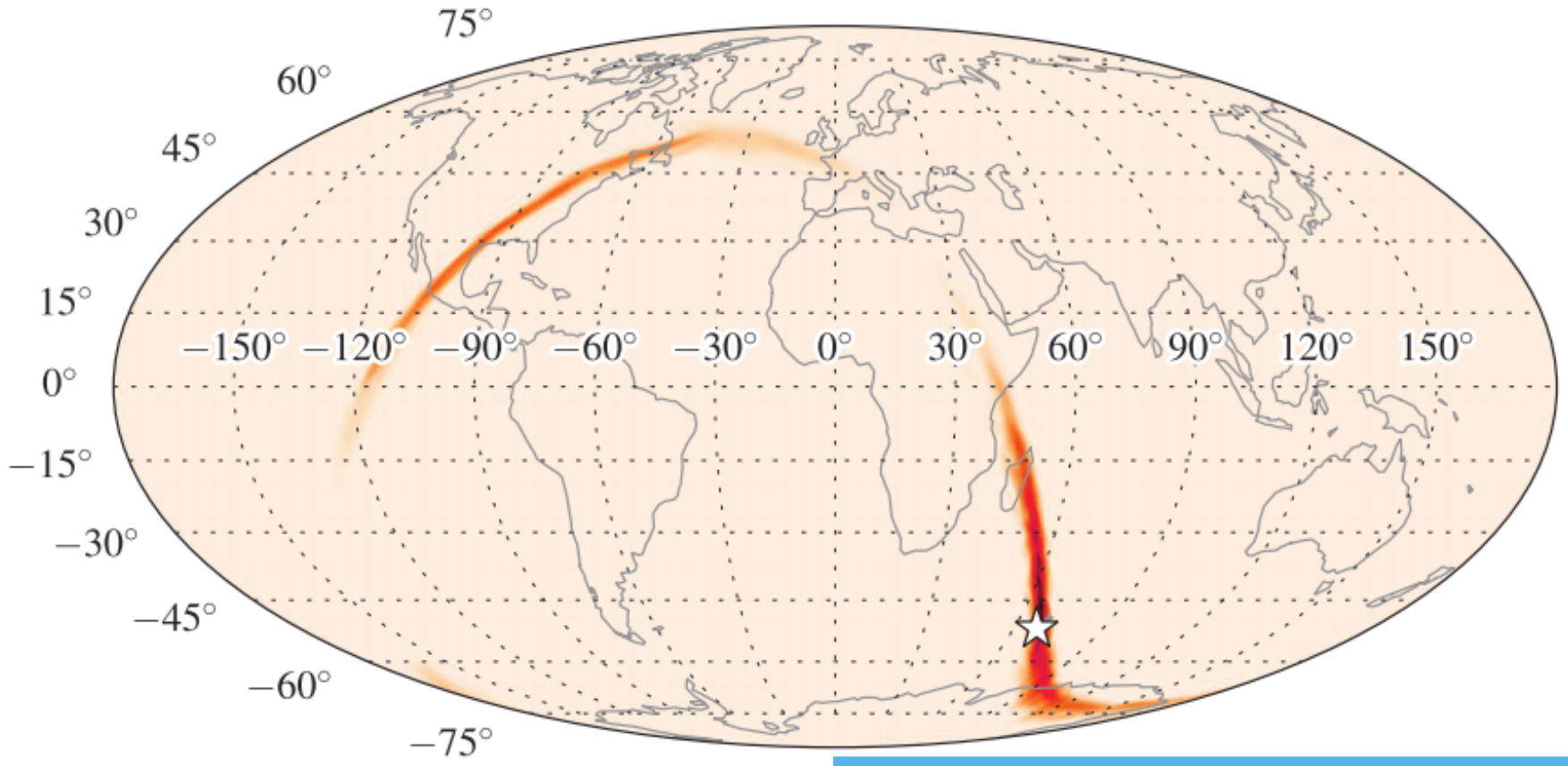
Farr *et al*. (2015) in prep.

Summary

Sky position determined at low latency (< 30 s).
Sky areas are large:
- 50% CR ~ 150 deg^2,
- 90% CR ~ 630 deg^2,
- Searched area ~ 130 deg^2.

Chirp mass measured to ~ 3 $\times 10^{-4}$ solar masses at mid latency.
Mass–spin degeneracy means individual masses and spins not well determined.

Thank you

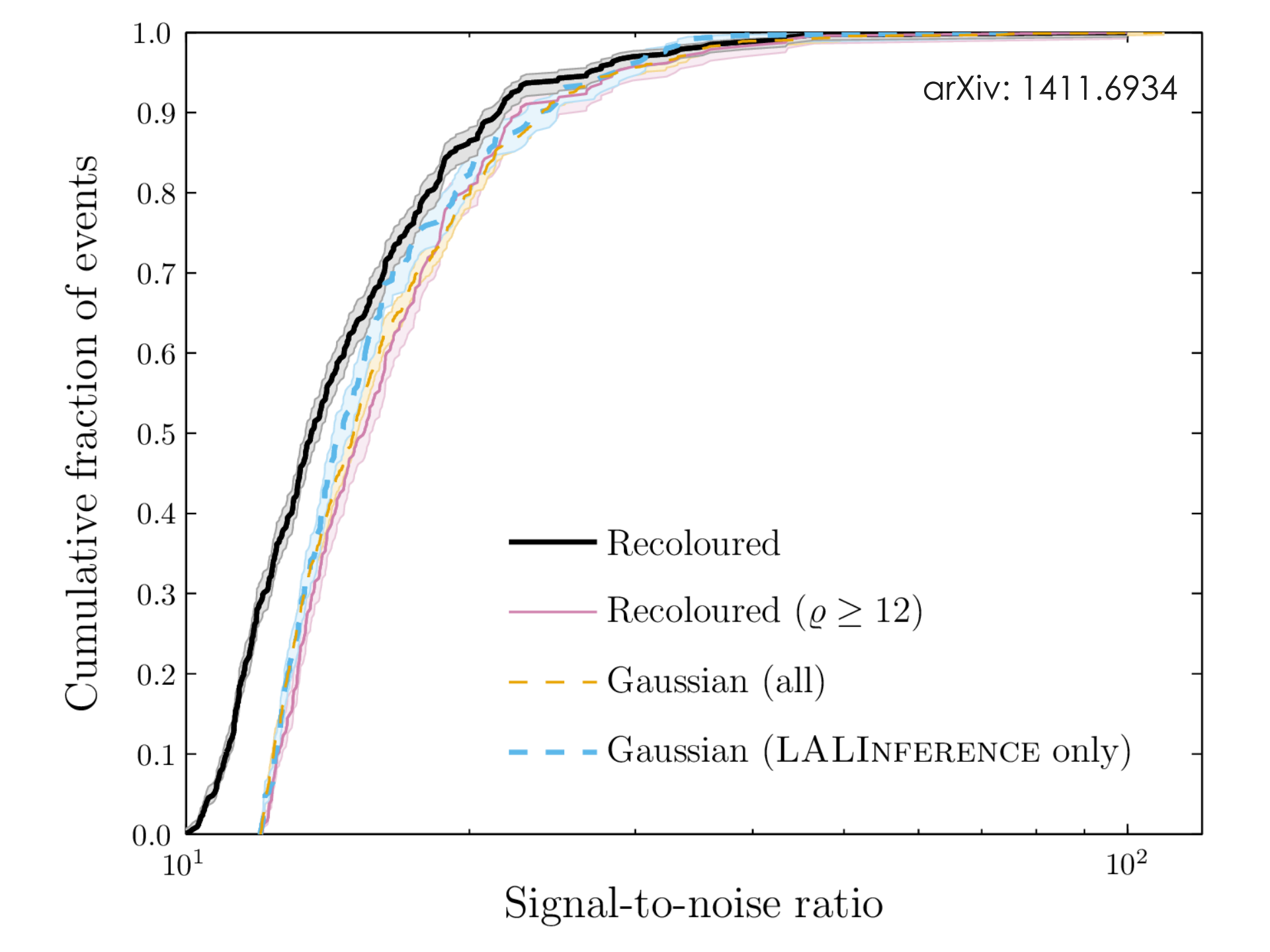


arXiv:1411.6934
ApJ; 804:114; 2015
www.ligo.org/scientists/first2years/

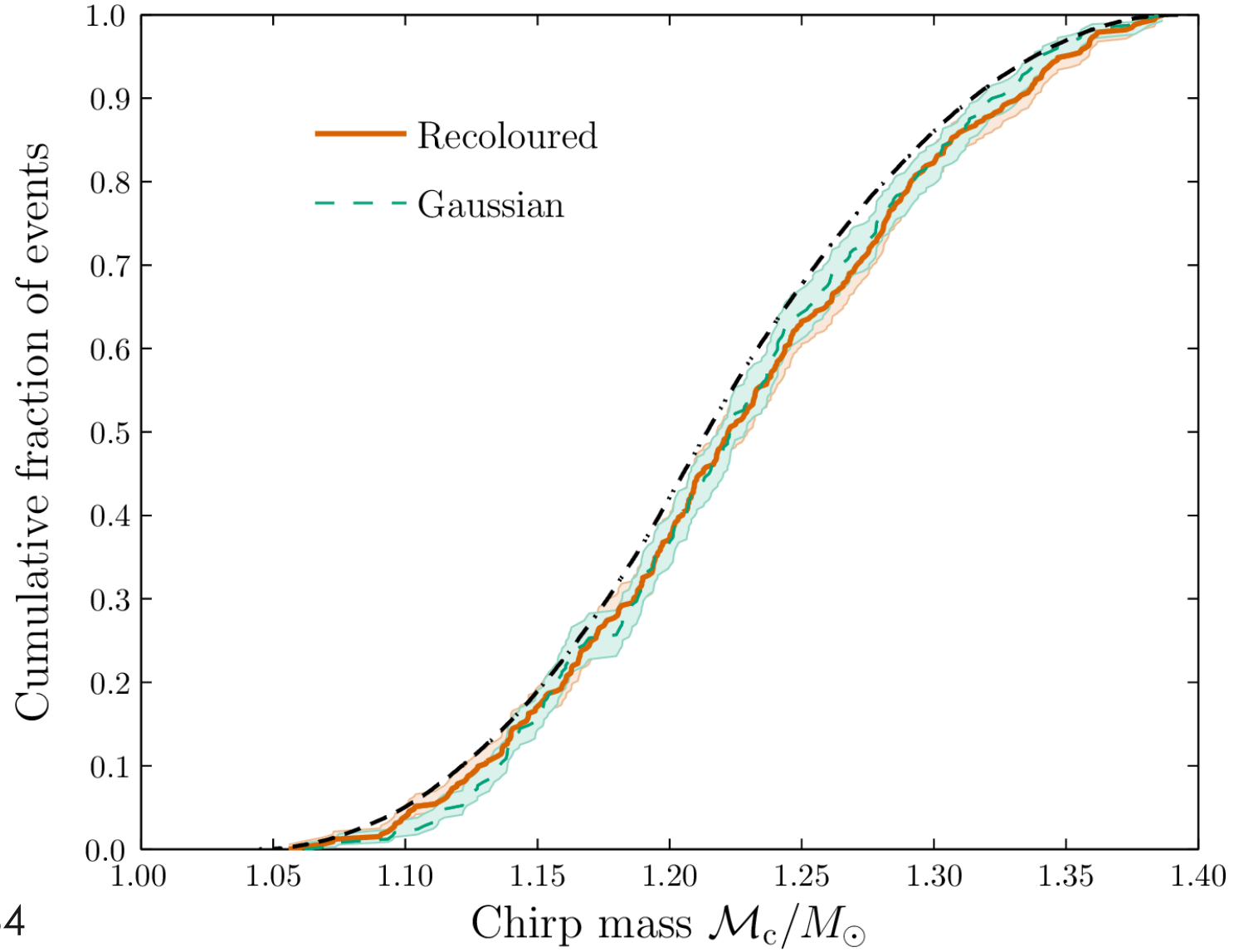
Advanced-detector era

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


arXiv: 1411.6934
Cumulative fraction of events
Signal-to-noise ratio
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
10^1
10^2
Recoloured
Recoloured ($\varrho \geq 12$)
Gaussian (all)
Gaussian (LALInference only)

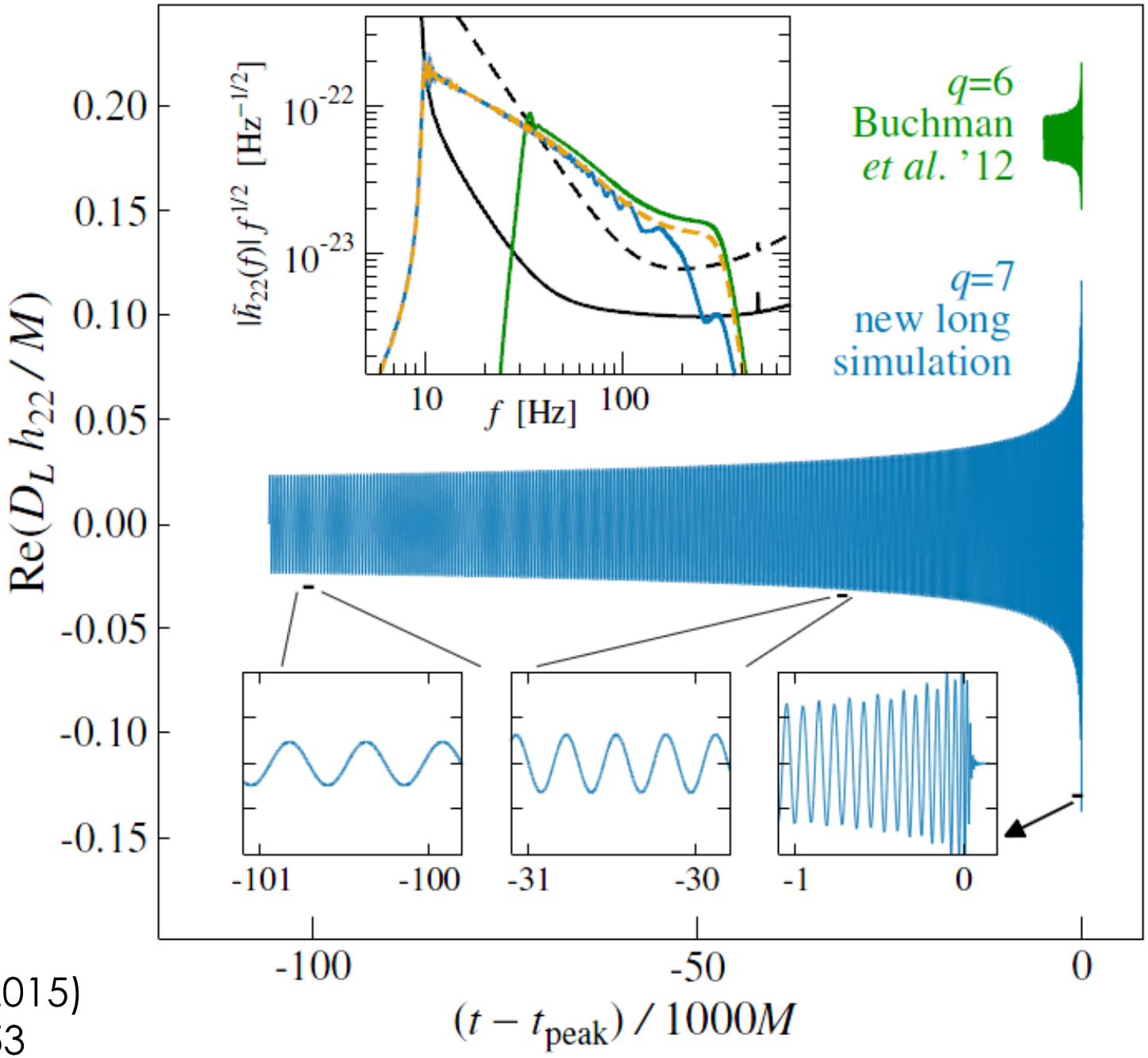
Detection



arXiv: 1411.6934

Detector network

Inspirals are well under-stood



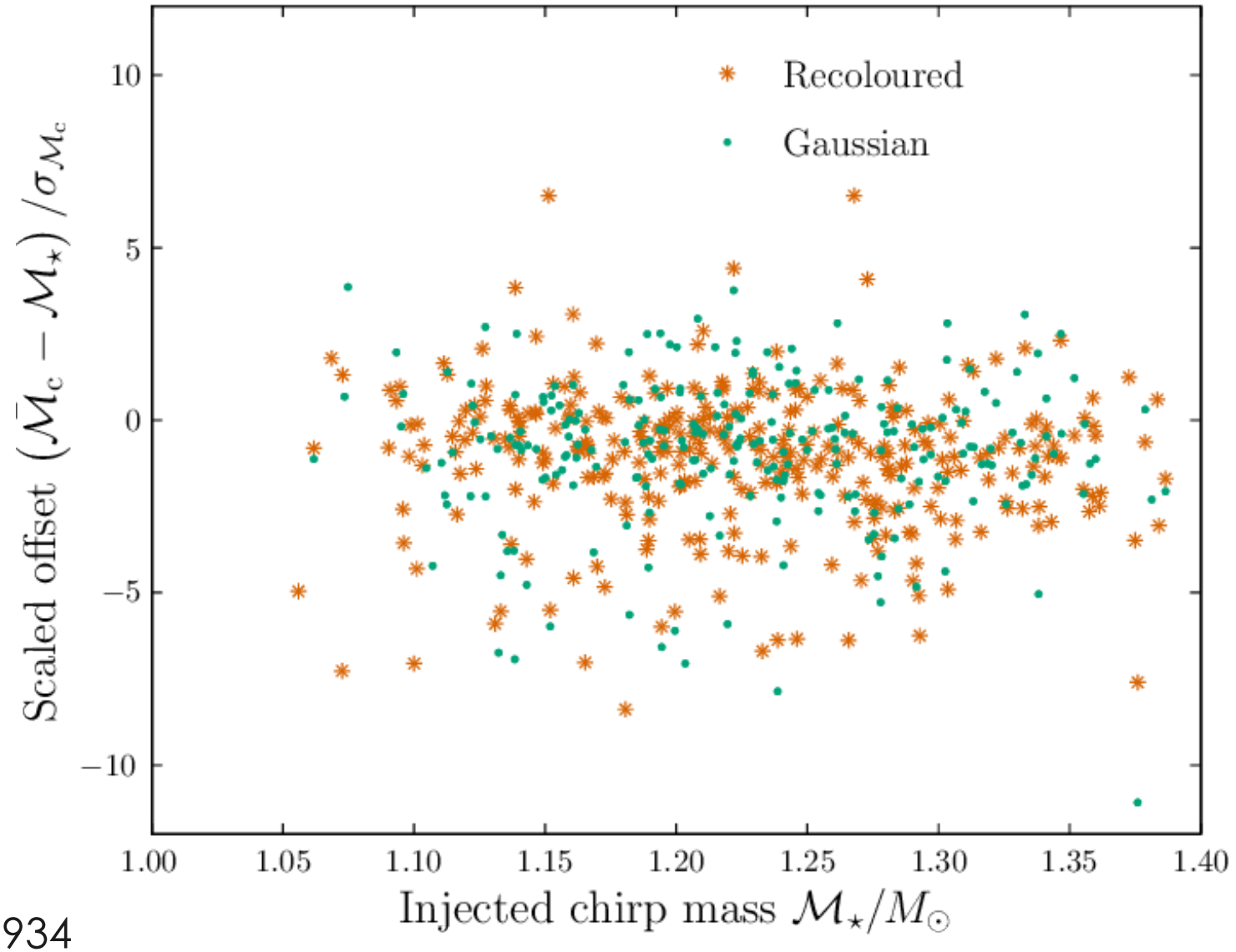
Szilagyi *et al*. (2015)
arXiv:1502.04953

Chirp mass

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

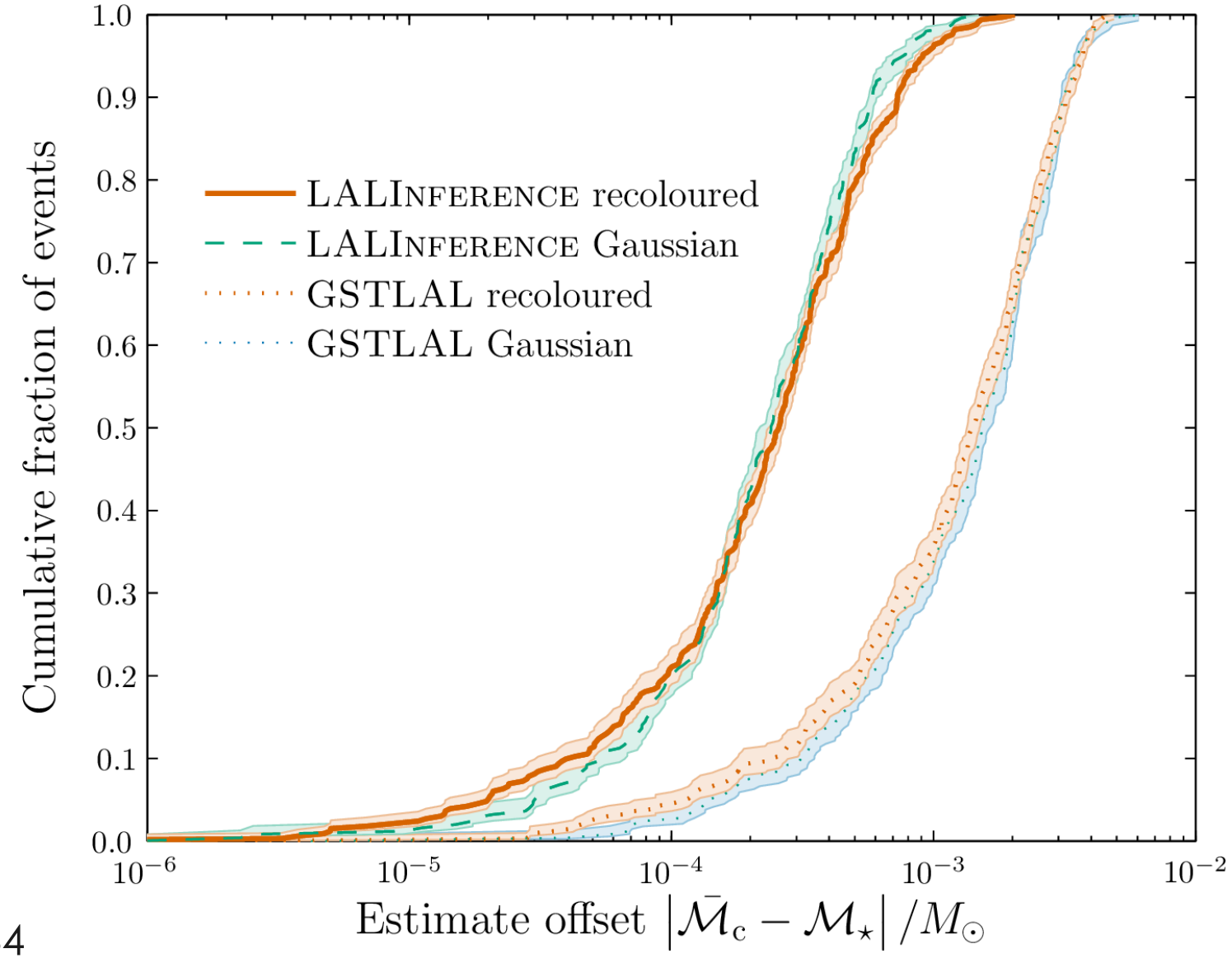
Chirp mass gives leading-order amplitude and phase evolution (arXiv:0903.0338)

Chirp mass



arXiv:1411.6934

Chirp mass



arXiv:1411.6934