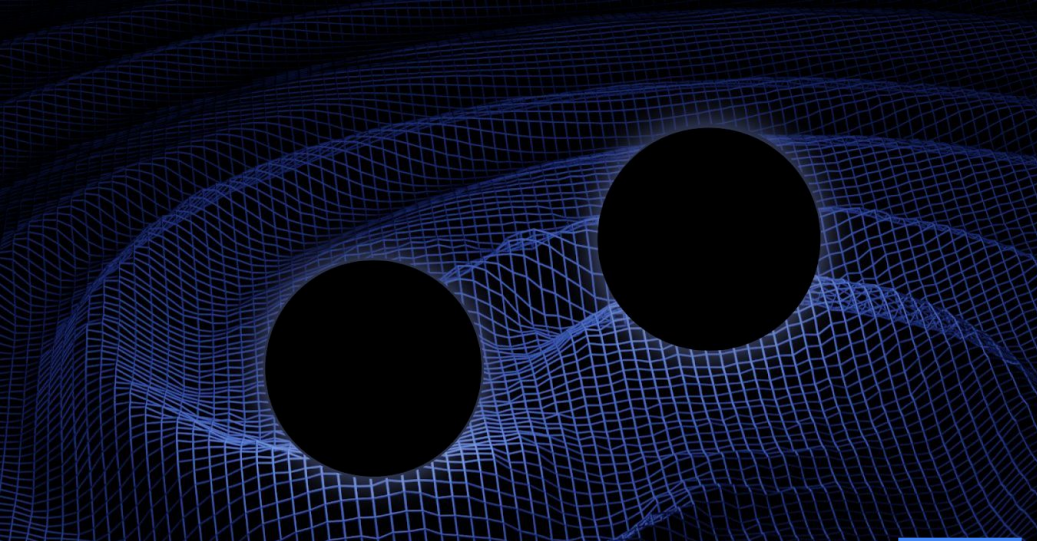


R. Buscicchio
J.Torrado, C.Caprini, G.Nardini,
N.Karnesis, M.Pieroni, A.Sesana

based on:
arXiv:2410.18171 [astro-ph.HE]

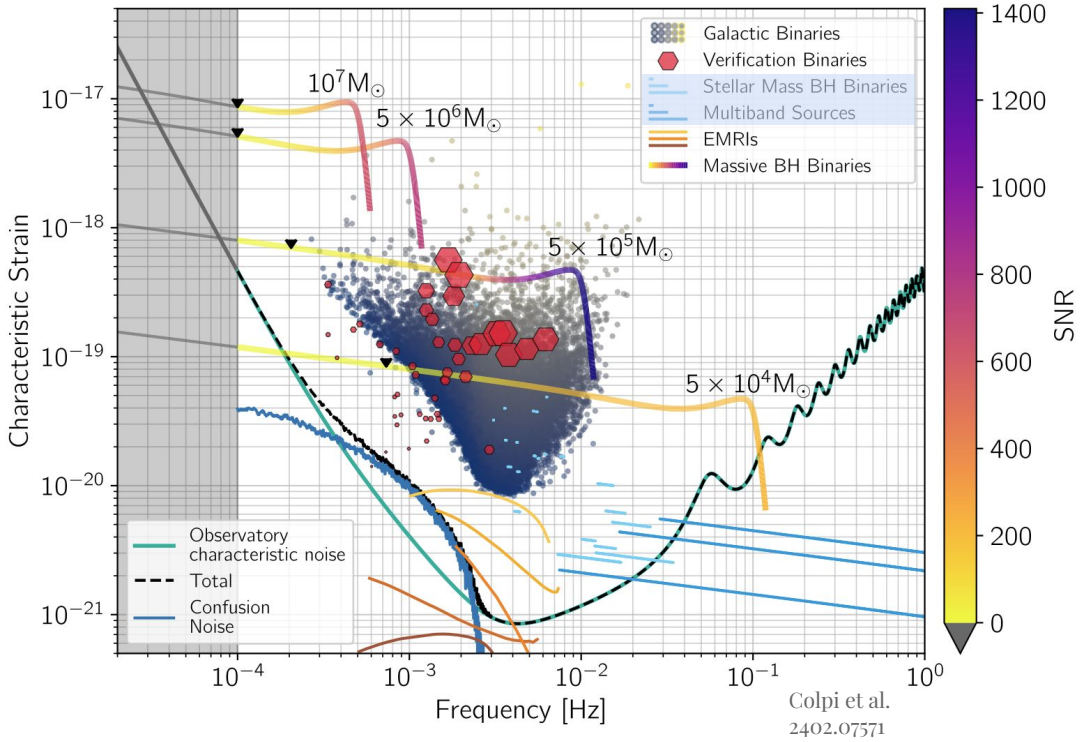
LISA AstroWG meeting
MPA, Garching
Nov 5 – 7, 2024

LISA stellar-mass black holes informed by the GWTC-3 population: event rates and parameters reconstruction

riccardo.buscicchio@unimib.it

The stellar graveyard

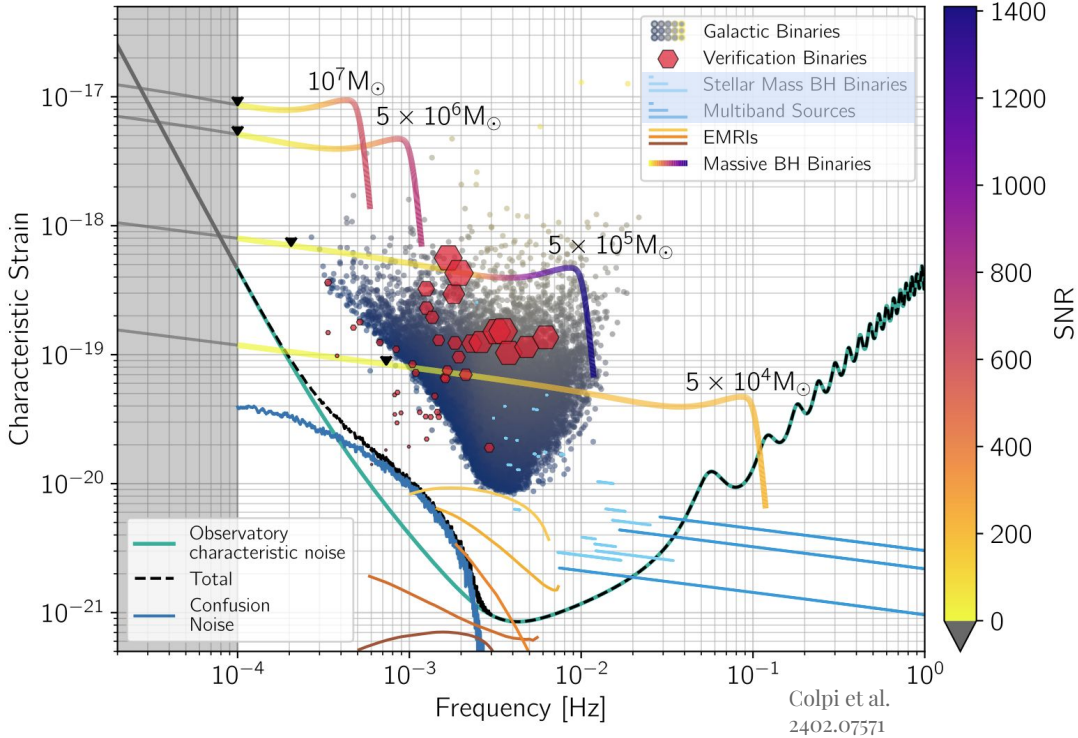
Rewinding a population: This talk



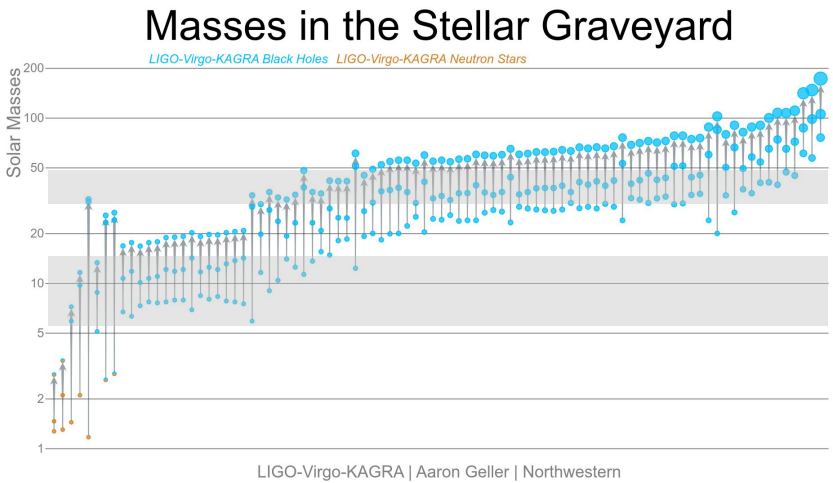
Colpi et al.
2402.07571

The stellar graveyard

Rewinding a population: This talk

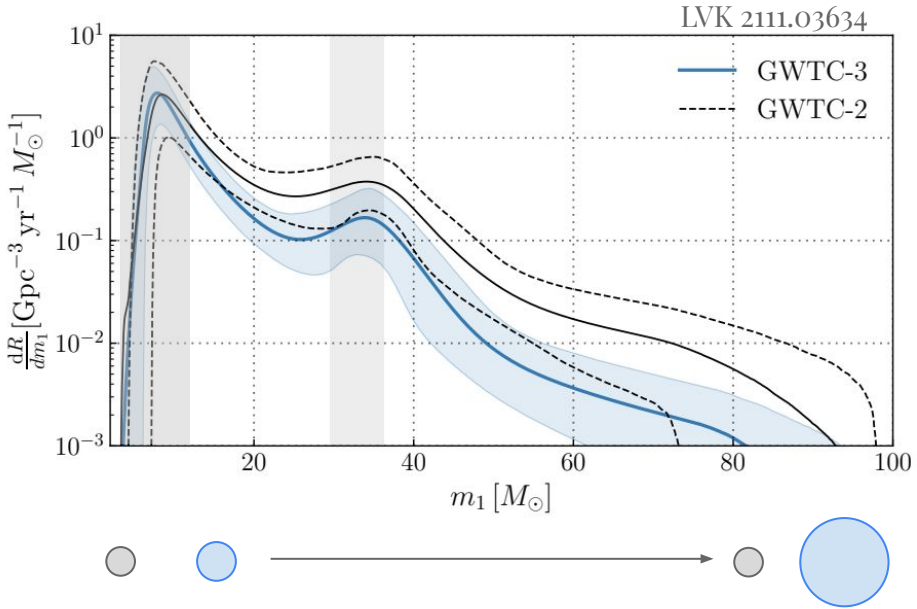


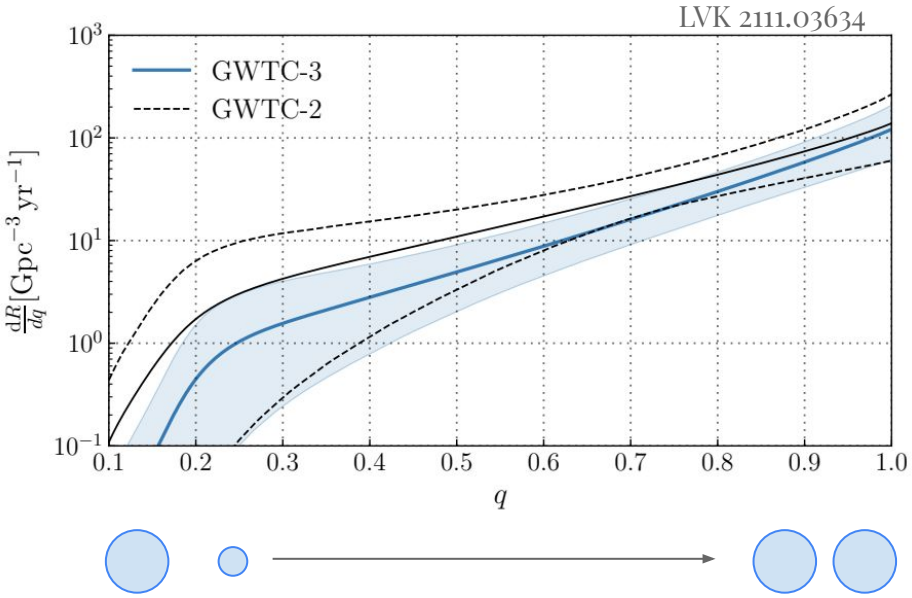
Colpi et al.
2402.07571



The stellar graveyard

Sophisticated histograms

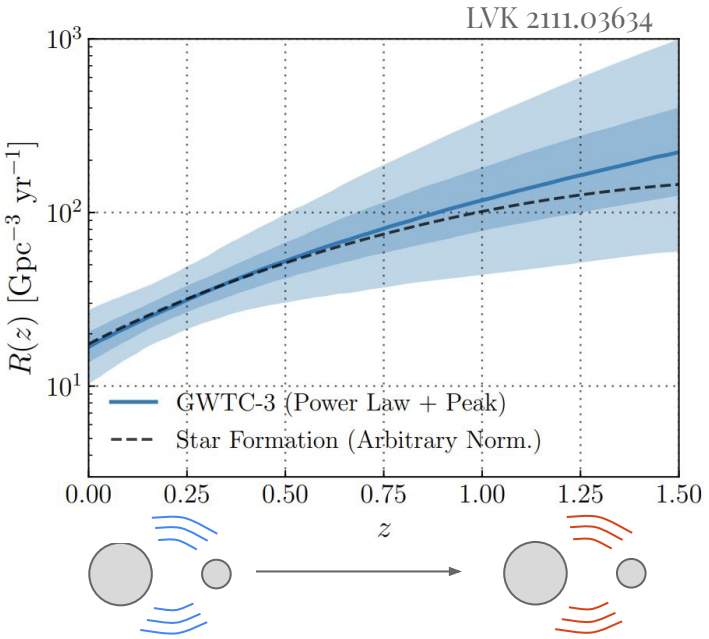


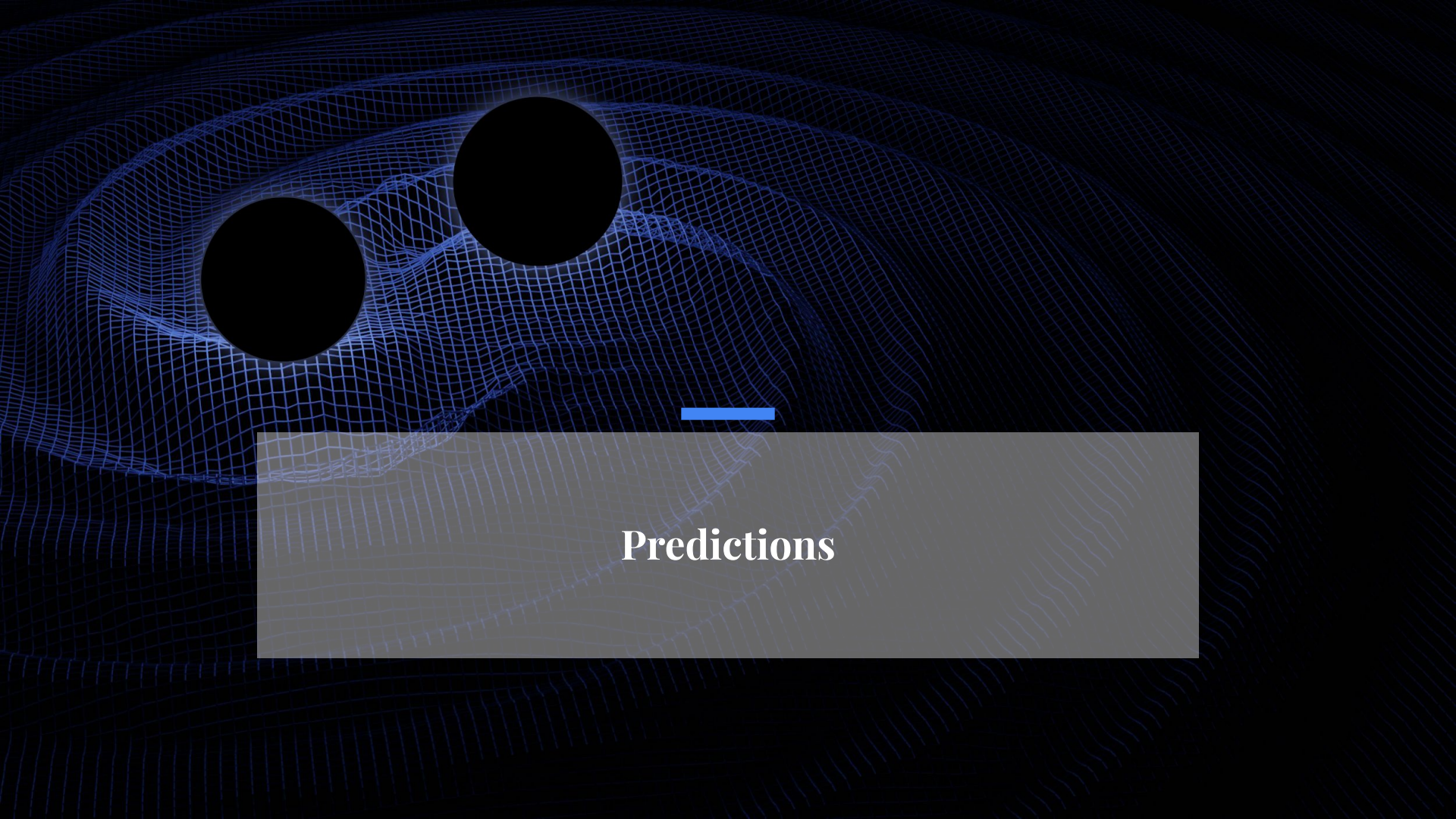


The stellar graveyard

Tracing history

- Evolution
- Environment
- Delays

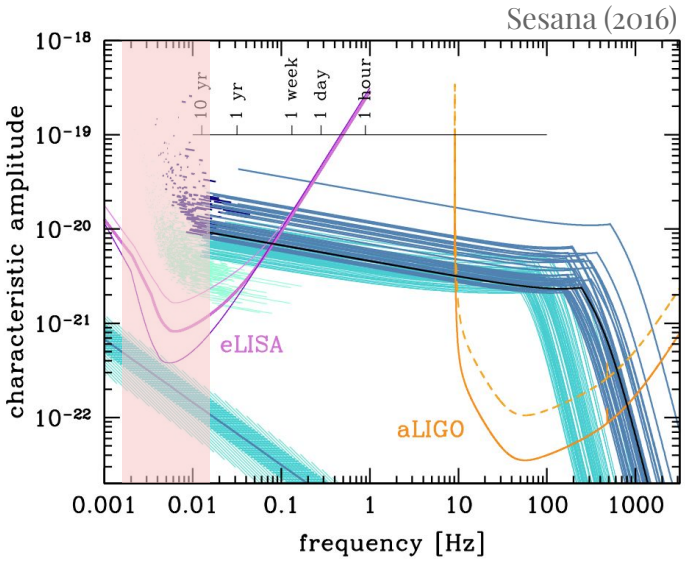


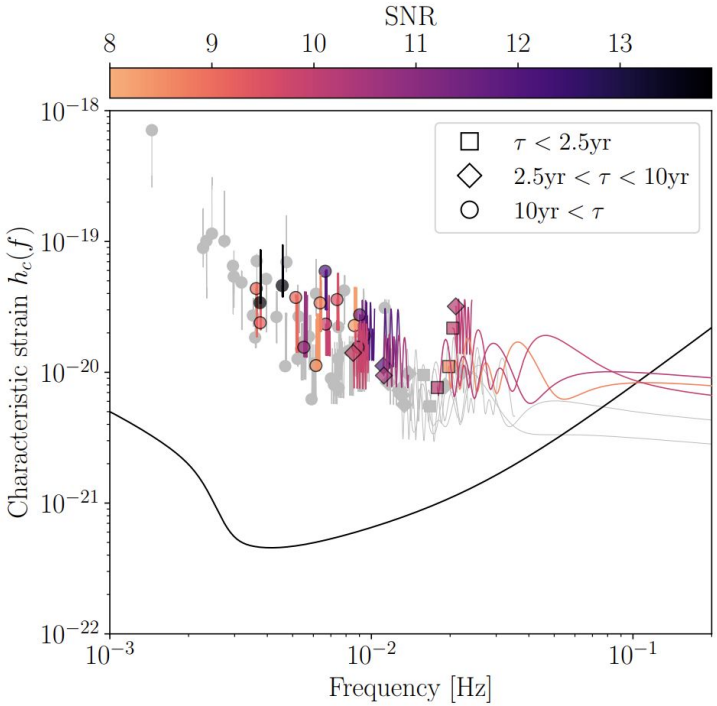


Predictions

A promise

A decade-long one

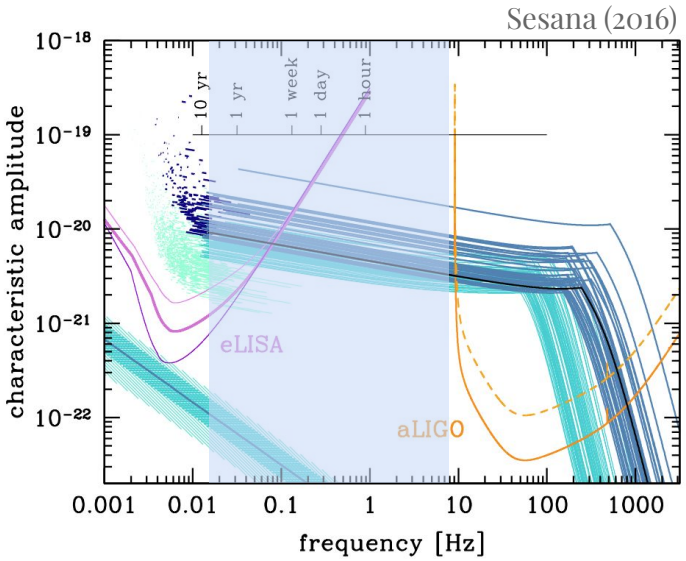


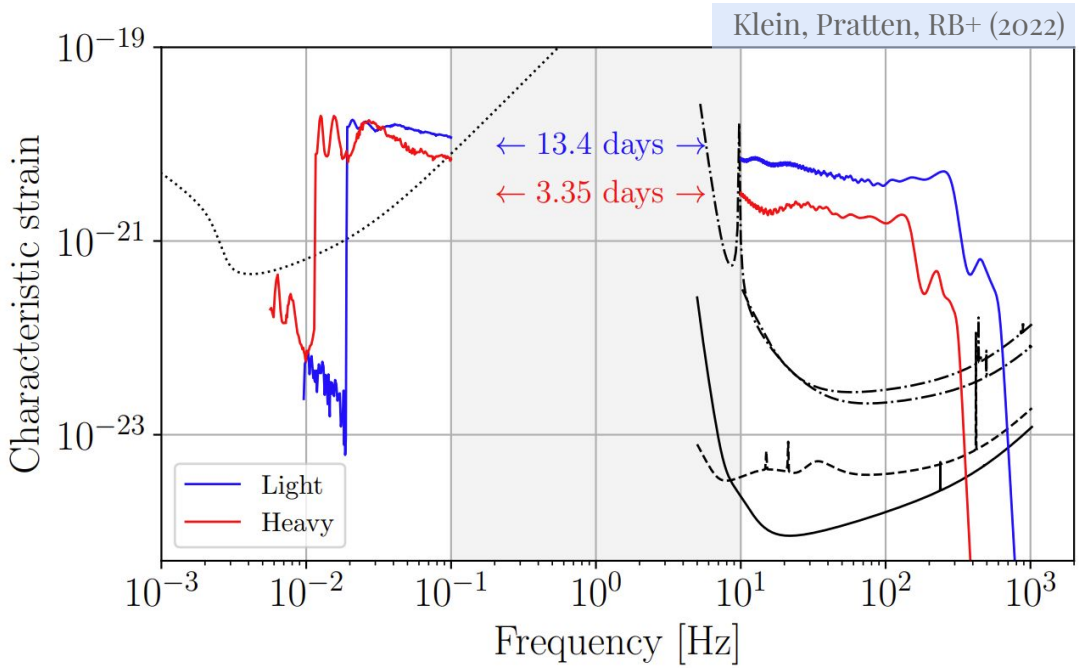


Buscicchio+ (2021)

A promise

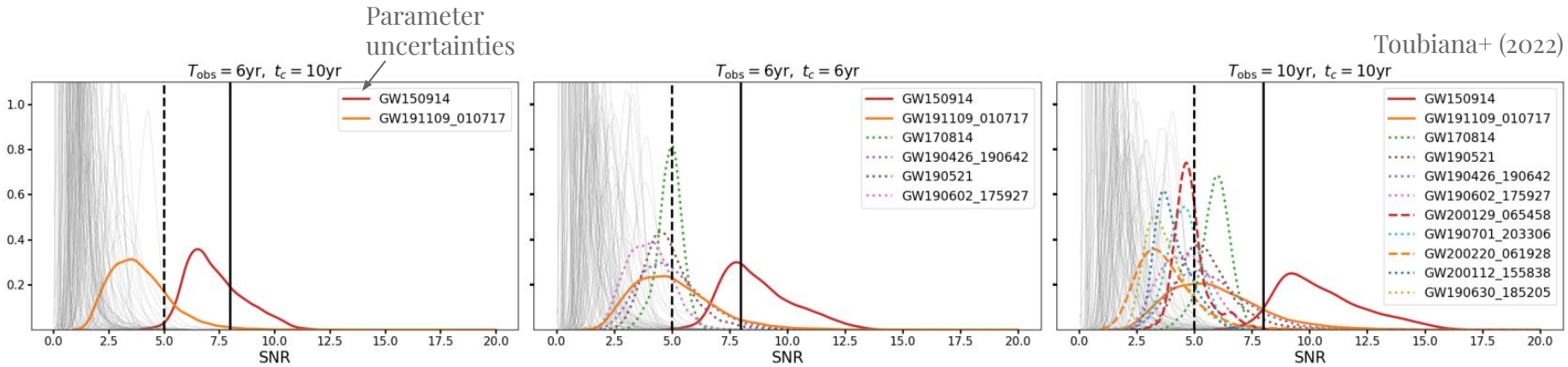
A year-long (eccentric) one





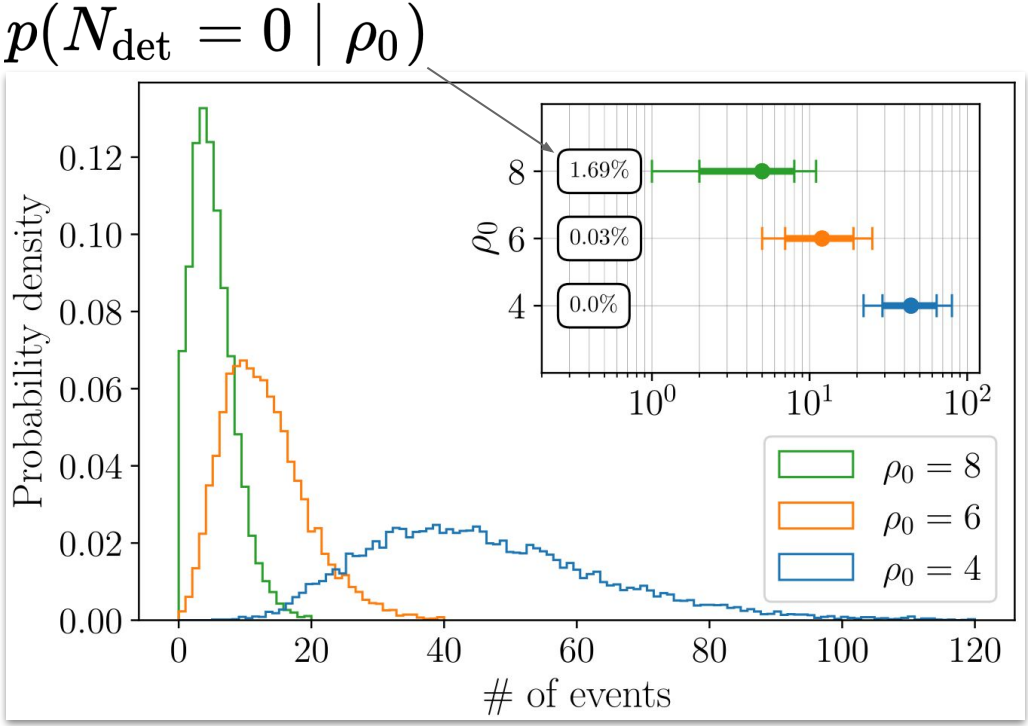
What if?

LISA in the late 10's



Great expectations

LISA in the 30s



GWTC events

GWTC catalogues

SOBBH population → Rapid population

LISA catalogues → Rapid SNR

LISA events → Accurate parameter estimation

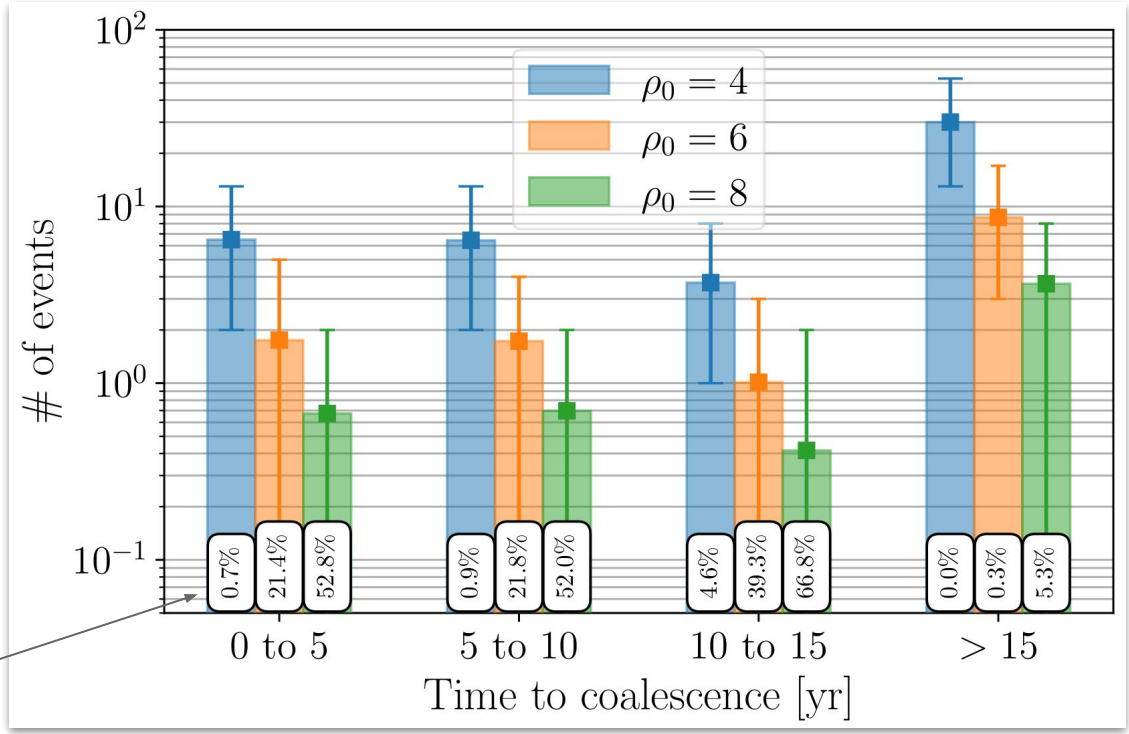
Ballrorgi

Detectability

Aggregated

- By SNR
- By time to coalescence

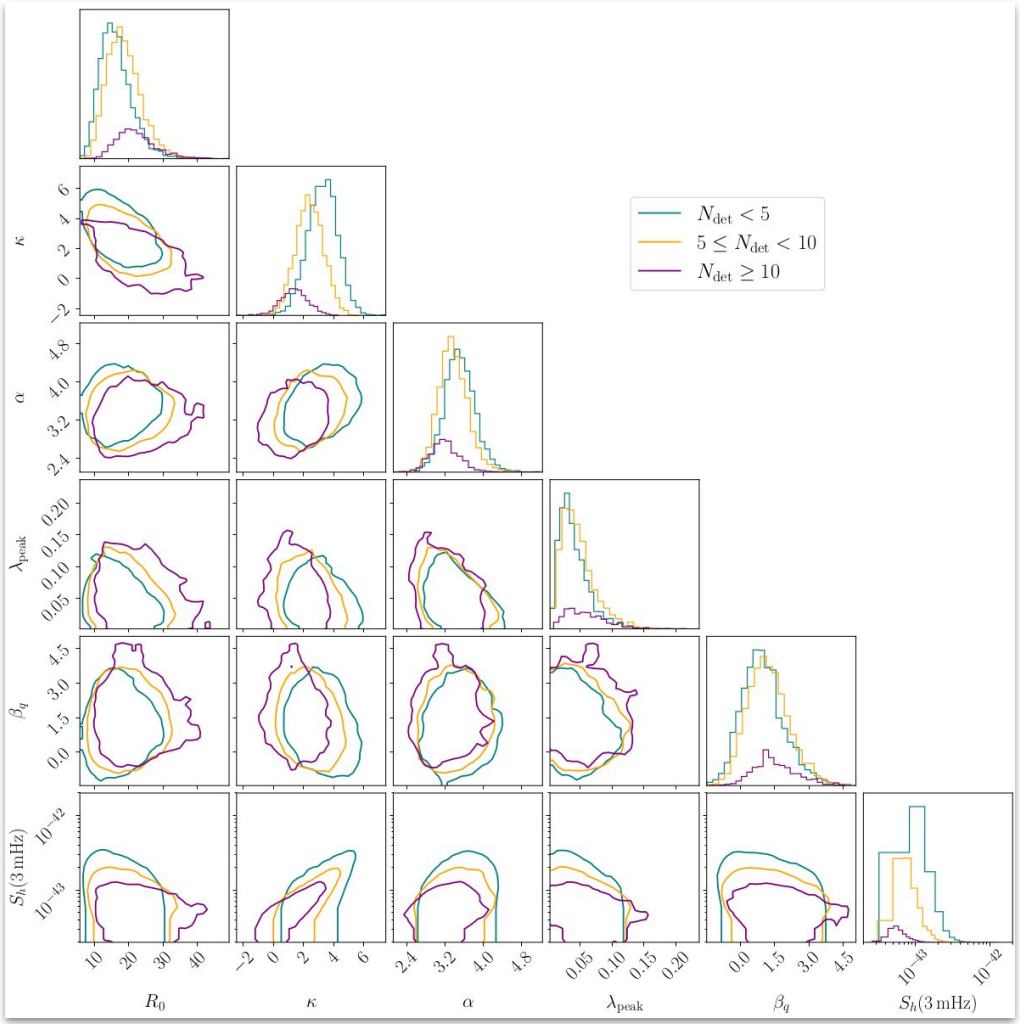
$$p(N_{\mathrm{det}} = 0 \mid \tau_c, \rho_0)$$



Correlations

Pop param vs SGWB level

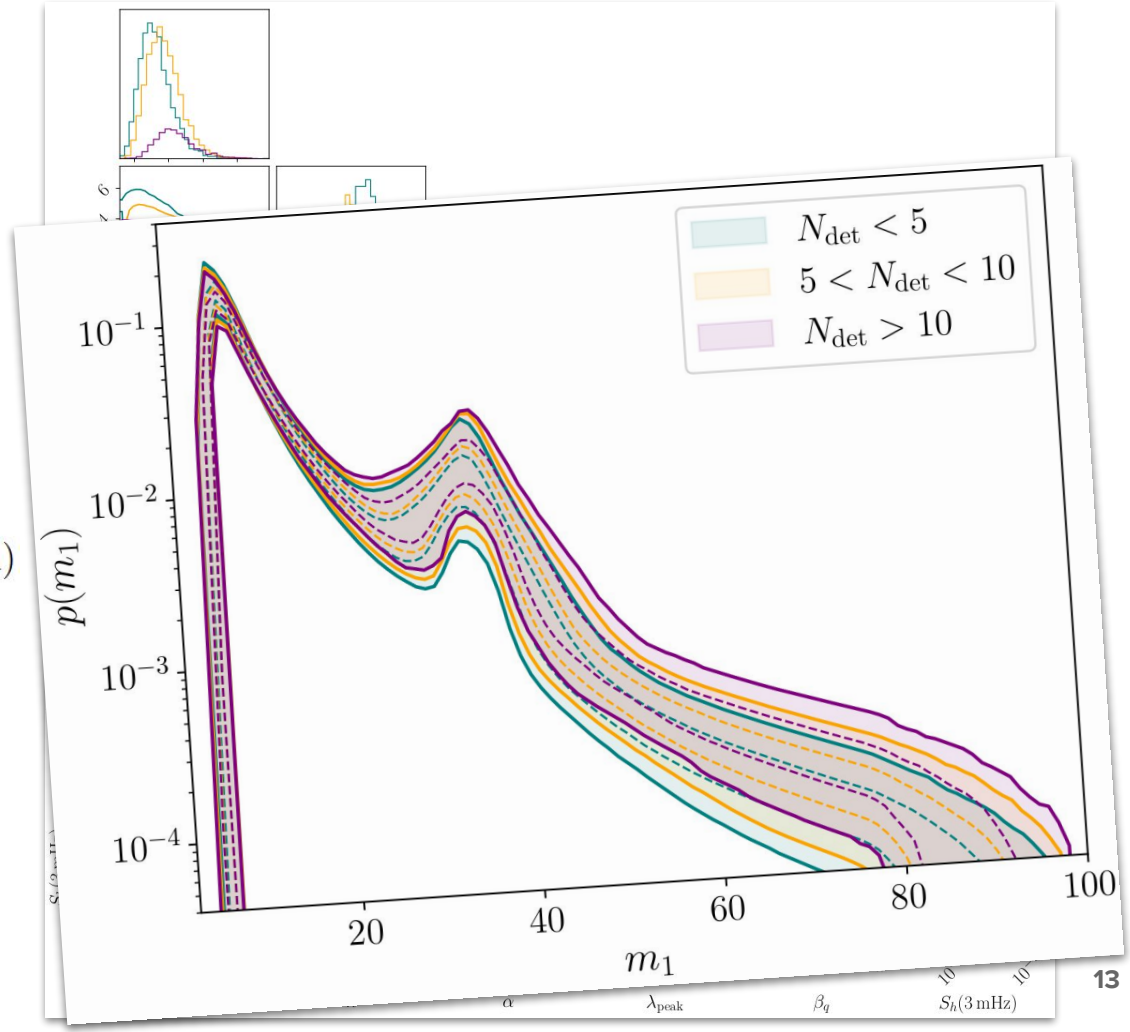
$$\frac{\mathrm{d}^3 N(z, \tau_c, \xi, \Lambda)}{\mathrm{d}\xi \, \mathrm{d}z \, \mathrm{d}\tau_c} = R(z, \tau_c) \left[\frac{\mathrm{d}V_c}{\mathrm{d}z}(z) \right] p(\xi|\Lambda)$$



Correlations

Pop param

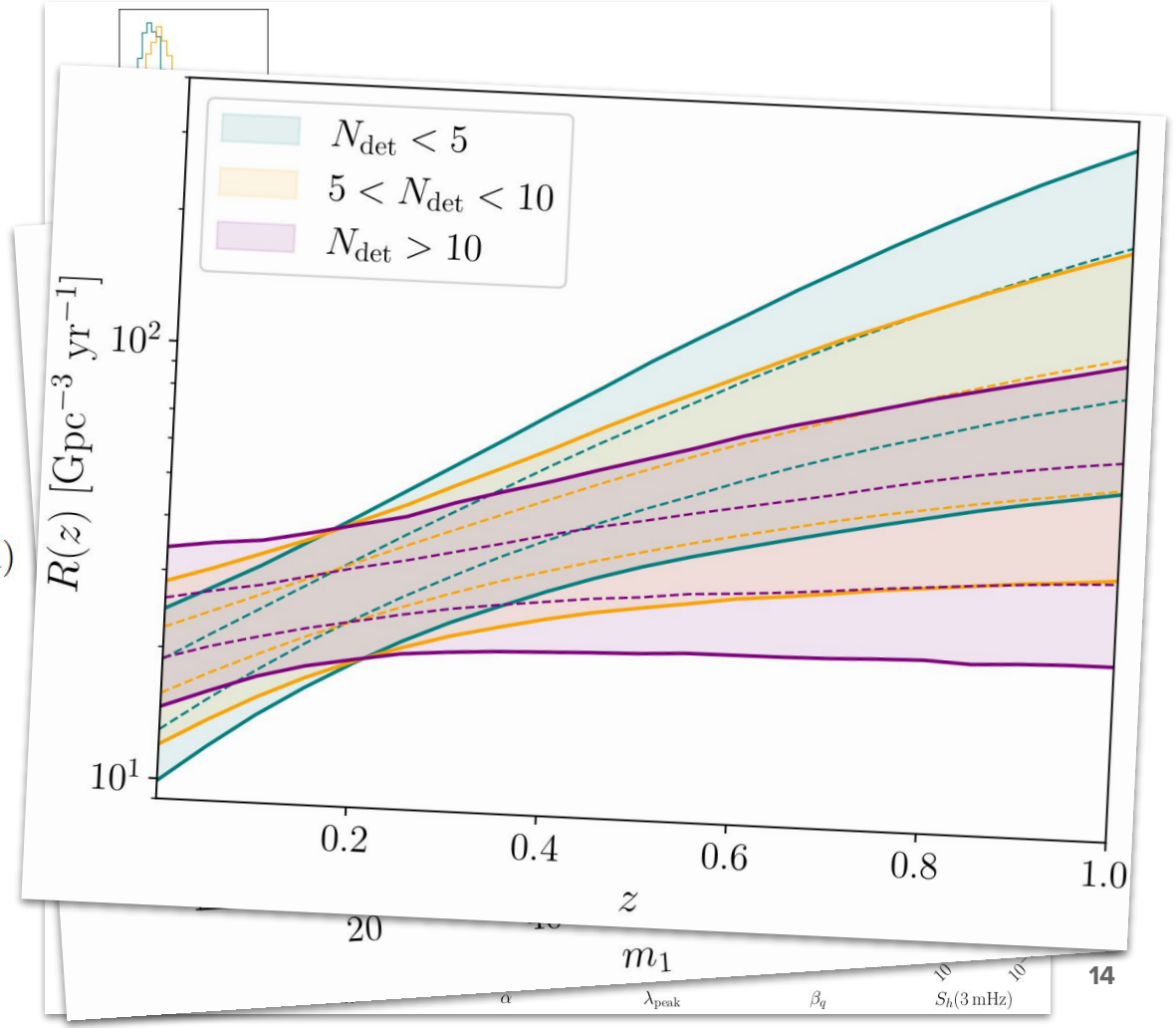
$$\frac{\mathrm{d}^3 N(z, \tau_c, \xi, \Lambda)}{\mathrm{d}\xi \, \mathrm{d}z \, \mathrm{d}\tau_c} = R(z, \tau_c) \left[\frac{\mathrm{d}V_c}{\mathrm{d}z}(z) \right] p(\xi|\Lambda)$$



Correlations

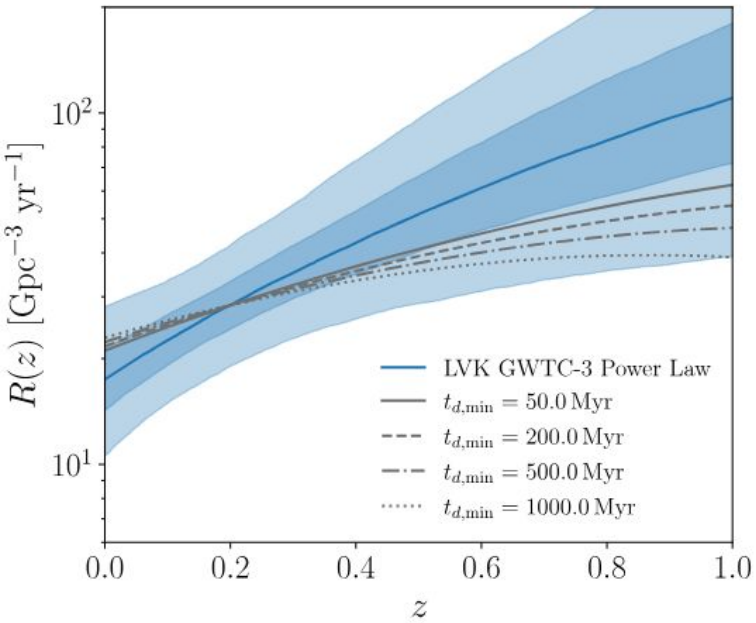
Pop param

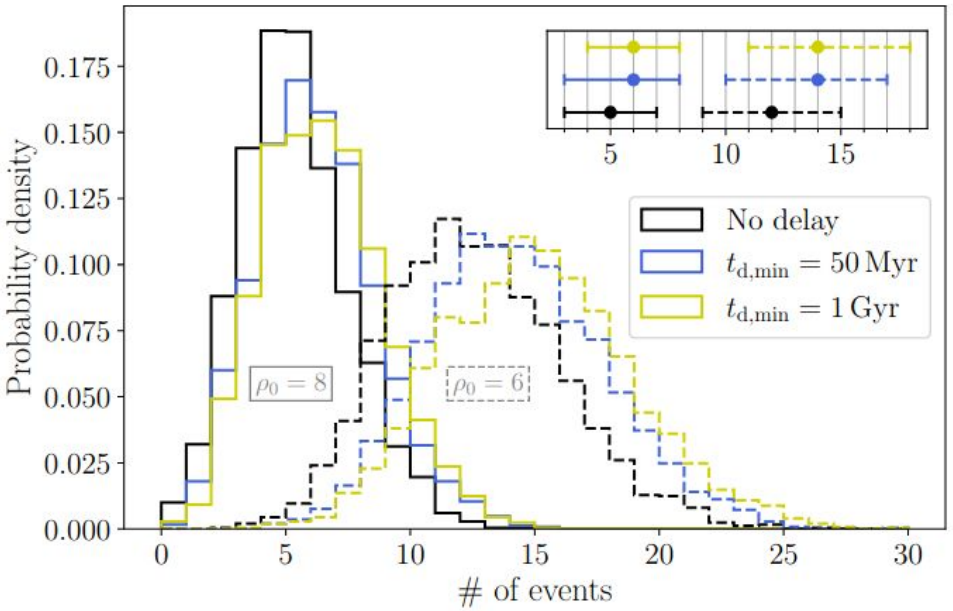
$$\frac{\mathrm{d}^3 N(z, \tau_c, \xi, \Lambda)}{\mathrm{d}\xi\, \mathrm{d}z\, \mathrm{d}\tau_c} = R(z, \tau_c) \left[\frac{\mathrm{d}V_c}{\mathrm{d}z}(z)\right] p(\xi|\Lambda)$$



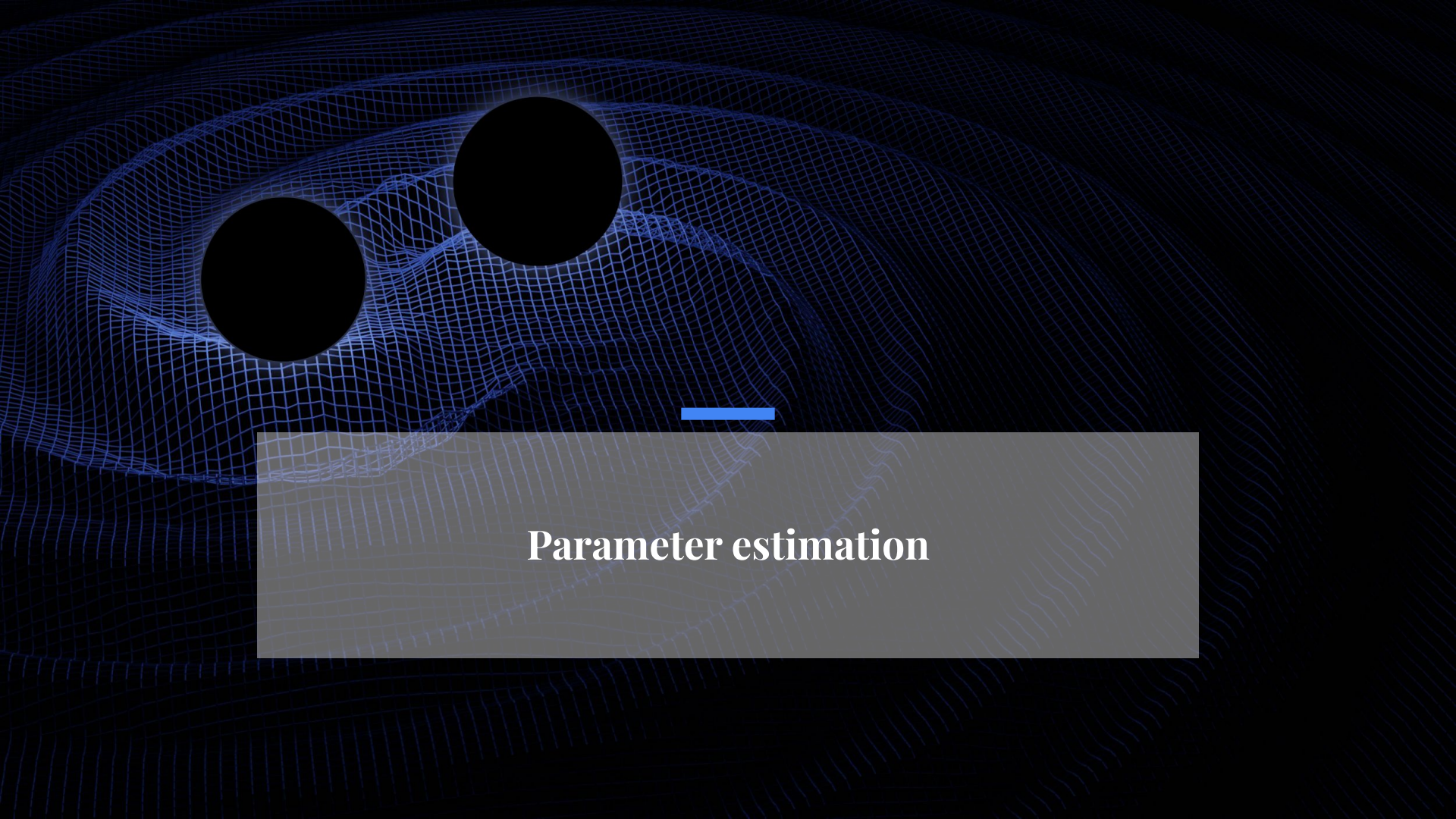
Correlations

Time-delay distribution



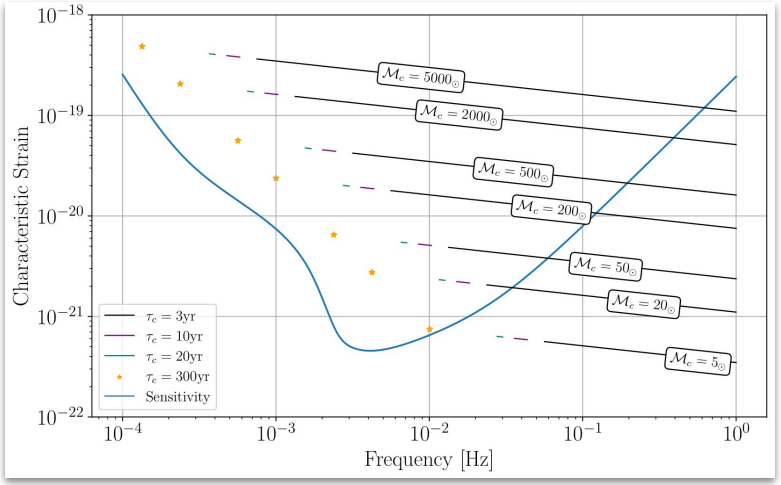


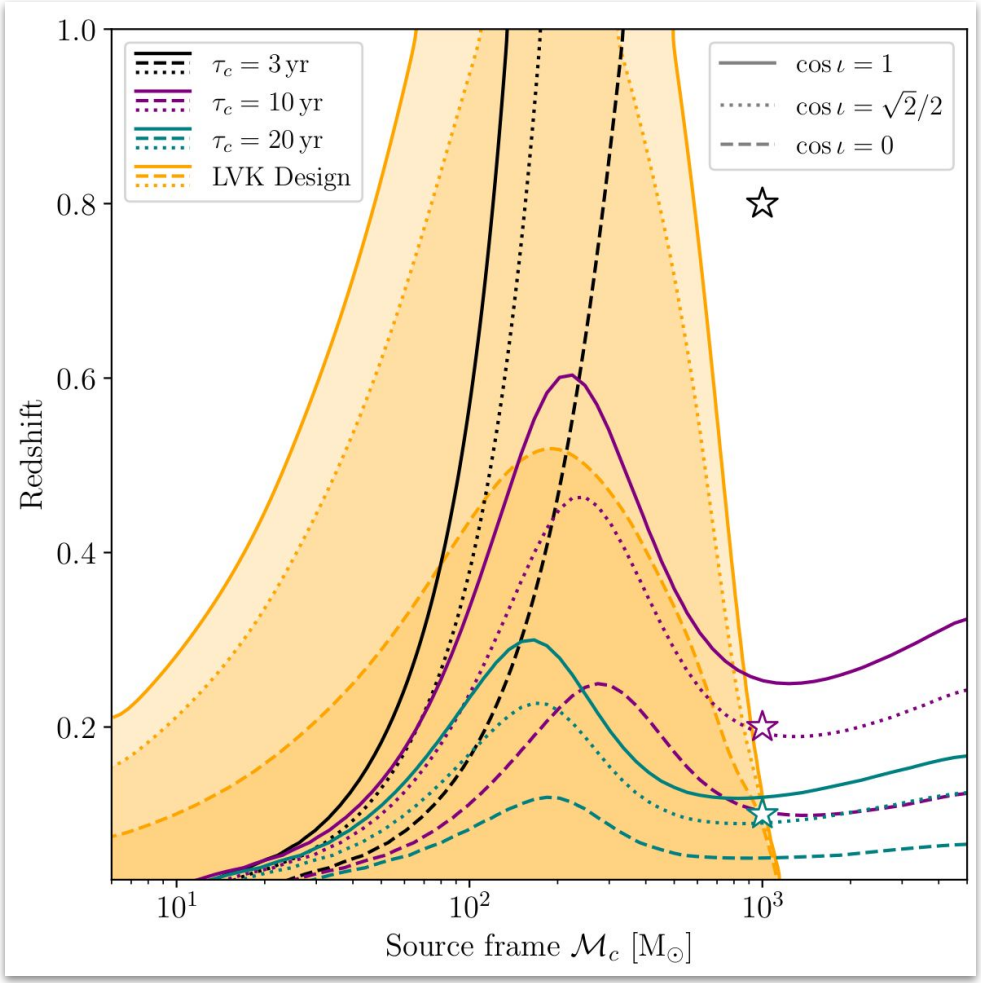
$$R(z) = R_{\rm ref} \int_{t_{d,\min}}^{t_{d,\max}} R_{\rm SFR}(t(z) + t_d) \frac{1}{t_d} \, {\rm d}t_d$$



Parameter estimation

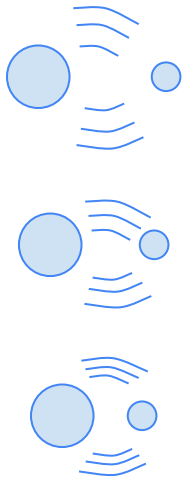
Waterfalls


Characteristic Strain
Frequency [Hz]
$\mathcal{M}_c = 5000_\odot$
$\mathcal{M}_c = 2000_\odot$
$\mathcal{M}_c = 500_\odot$
$\mathcal{M}_c = 200_\odot$
$\mathcal{M}_c = 50_\odot$
$\mathcal{M}_c = 20_\odot$
$\mathcal{M}_c = 5_\odot$
$\tau_c = 3$yr
$\tau_c = 10$yr
$\tau_c = 20$yr
$\tau_c = 300$yr
Sensitivity


$\tau_c = 3\,\mathrm{yr}$
$\tau_c = 10\,\mathrm{yr}$
$\tau_c = 20\,\mathrm{yr}$
LVK Design
$\cos\iota = 1$
$\cos\iota = \sqrt{2}/2$
$\cos\iota = 0$
Redshift
Source frame $\mathcal{M}_c$ [$\mathrm{M}_\odot$]

Bracketing performances

3 times to coalescence ⇾ face-on/off vs edge-on ⇾ low latitude (|sinb|<½)



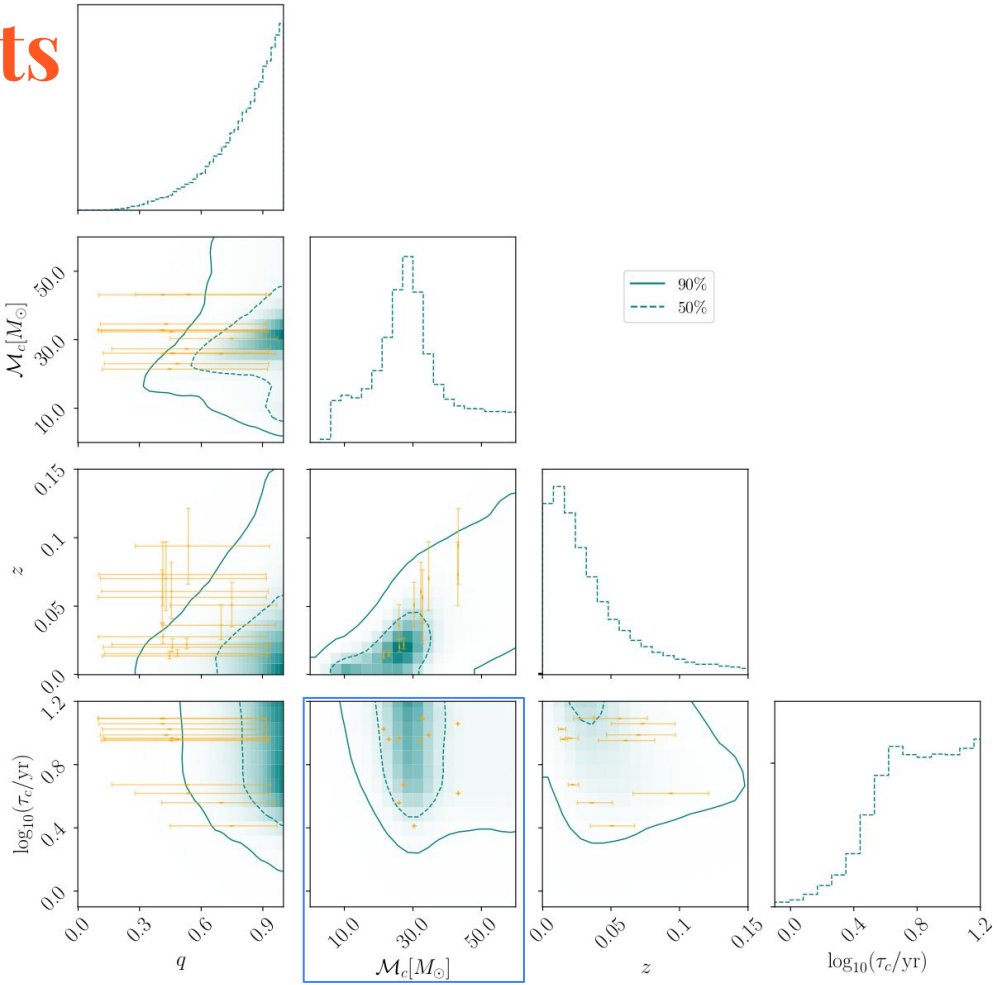
Run	$\mathcal{M}_c[M_\odot]$	$m_1[M_\odot]$	$m_2[M_\odot]$	q	χ_1	χ_2	$f^0_{\rm orb}$[mHz]	τ_c[yr]	z	d_L[Mpc]	$\sin b$	l	$\cos\iota$	ψ	$\phi_{\rm orb}$	SNR
High τ_c	43.10	53.48	45.87	0.9	0.4	0.3	4.4	11.44	0.08	392.599	0.4	4.1	1.0	3.5	0.4	10.01
	32.81	42.14	33.78	0.8	0.4	0.1	5.1	12.38	0.06	294.343	0.2	3.3	−0.9	2.7	0.7	9.18
	32.71	41.52	34.08	0.8	0.5	0.2	5.1	12.37	0.03	113.970	0.01	4.8	0.2	3.7	0.8	10.04
	21.42	31.62	19.37	0.6	0.4	0.3	7.1	10.59	0.01	57.04	0.06	2.9	0.2	0.4	3.6	12.08
Mid τ_c	34.60	42.76	36.97	0.9	0.2	0.5	5.4	9.7	0.07	344.103	0.1	5.3	−0.9	1.1	3.8	8.53
	32.31	49.86	28.08	0.6	0.1	0.4	5.8	9.0	0.06	301.756	0.2	0.4	−0.9	0.6	2.9	9.28
	26.07	33.97	26.48	0.8	0.1	0.5	6.6	9.3	0.02	82.63	−0.04	0.9	0.2	0.006	4.4	10.59
	23.00	26.44	26.40	1.0	0.1	0.1	7.2	9.1	0.01	64.86	−0.09	2.4	−0.03	3.7	4.6	11.17
Low τ_c	43.21	55.23	44.71	0.8	0.6	0.6	6.5	4.2	0.1	510.906	0.4	4.7	−1.0	6.0	4.7	11.12
	30.32	36.05	33.66	0.9	0.02	0.2	9.7	2.6	0.06	254.146	−0.4	4.5	0.9	2.9	3.0	10.55
	25.93	34.89	25.55	0.7	0.3	0.3	9.4	3.6	0.03	122.570	−0.3	1.8	0.3	0.6	5.6	10.59
	27.32	36.36	27.21	0.7	0.4	0.1	8.2	4.7	0.02	92.95	−0.4	4.4	−0.08	3.9	4.5	10.92
☆	1100.0	1263.6946	1263.4418	1.0	0.0	0.0	0.5	17.30	0.10	475.822	0.0	3.1	1	0.0	1	11.03
☆	1200	1378.5759	1378.3002	1.0	0.0	0.0	0.6	5.1	0.2	1012.2935	0.0	3.1	1	0.0	1	12.11
☆	1800.0	2067.8638	2067.4503	1.0	0.0	0.0	0.7	3.0	0.8	5162.1658	0.0	3.1	1	0.0	1	90.12

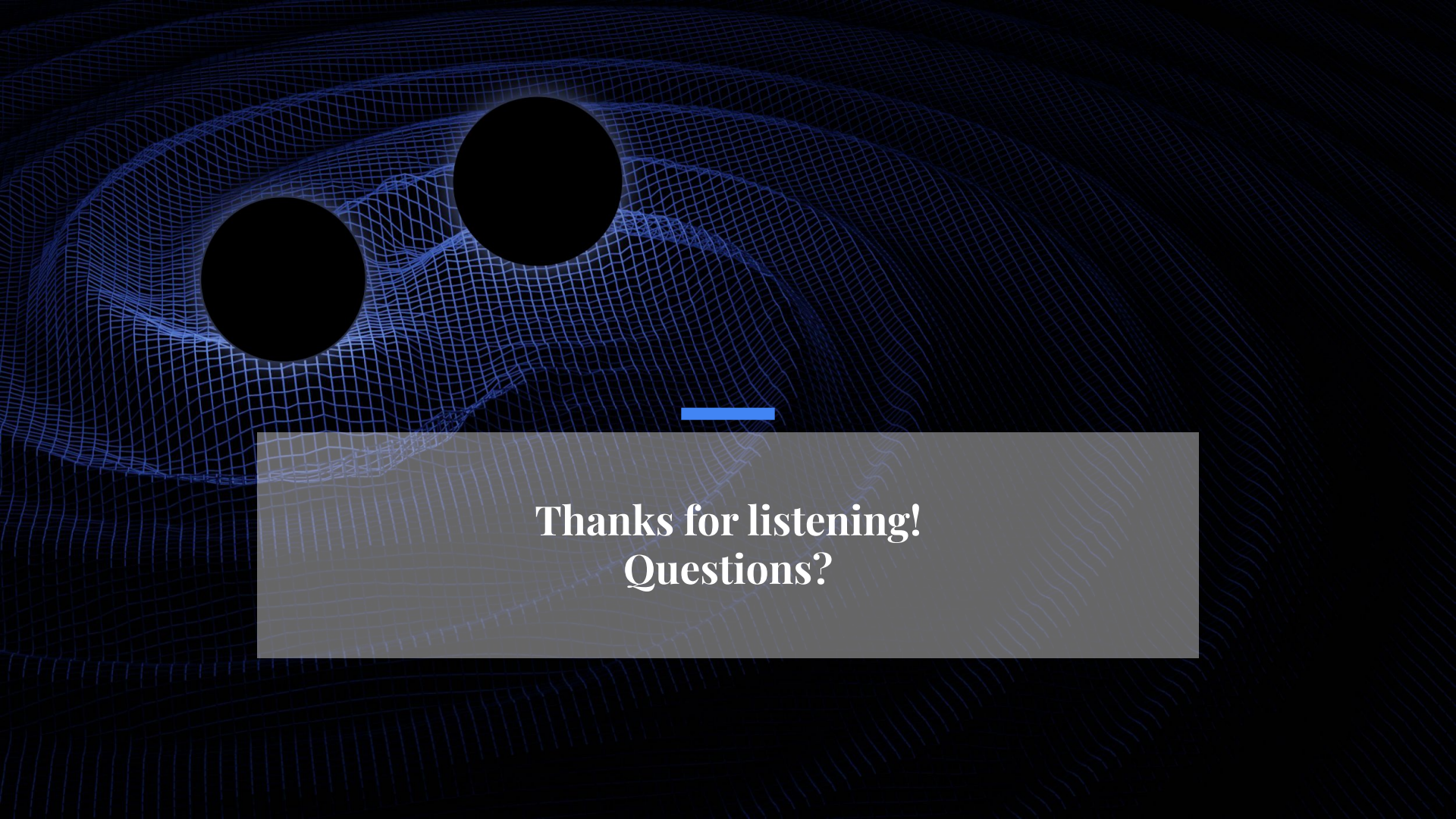
Bracketing performances

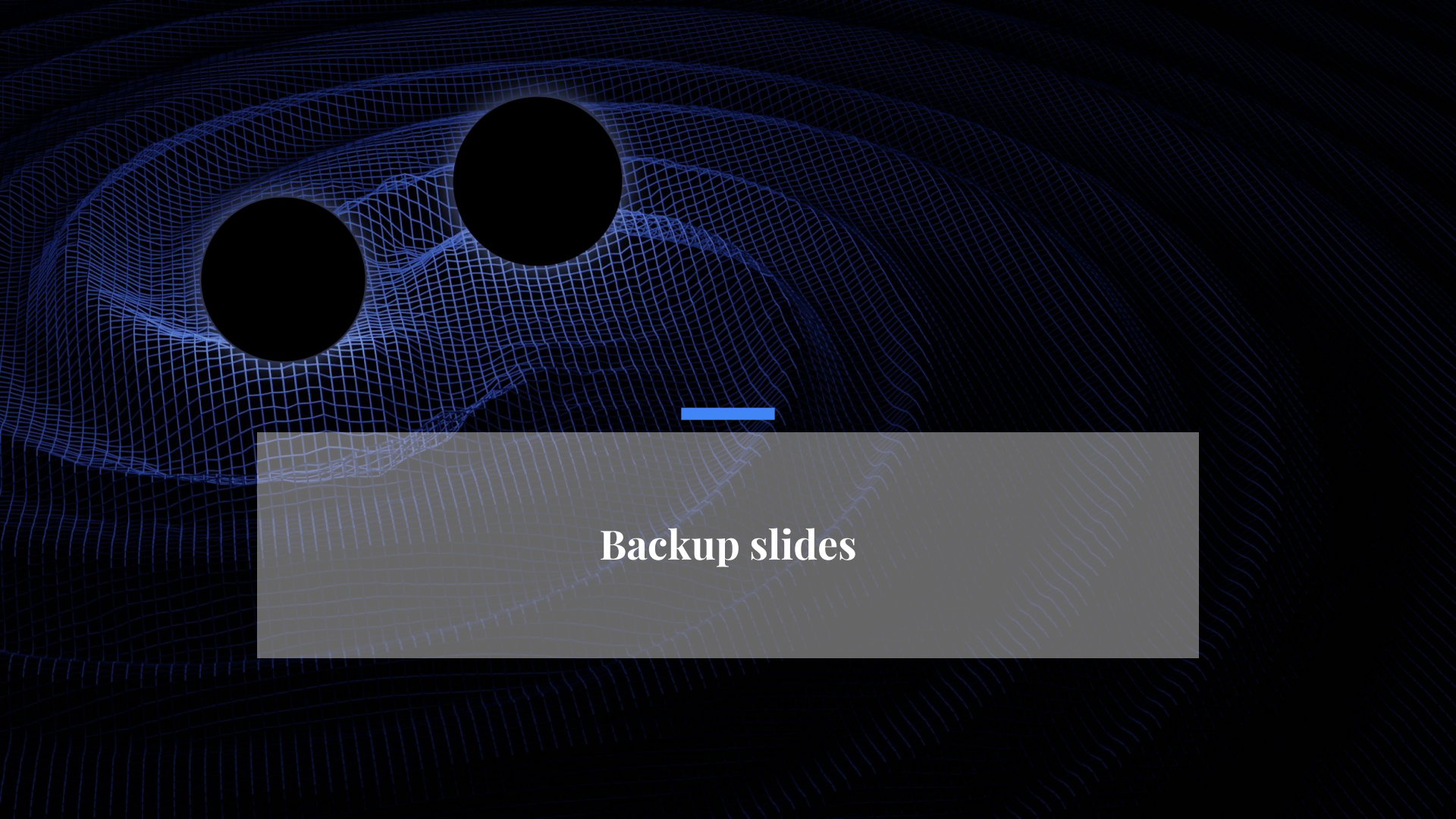
3 times to coalescence ⤑ face-on/off vs edge-on ⤑ low latitude (|sinb|<½)

Run	$\Delta\mathcal{M}_c/\mathcal{M}_c$	$\Delta f^0_{\rm orb}/f^0_{\rm orb}$	$\Delta\tau_c/\tau_c$	z	d_L[Mpc]	$\sin b$	l	$\cos\iota$
High τ_c	2×10^{-4}	7×10^{-7}	4×10^{-4}	$0.07^{+0.02}_{-0.02}$	341^{+116}_{-110}	$0.38^{+0.02}_{-0.02}$	$4.15^{+0.01}_{-0.01}$	$0.8^{+0.2}_{-0.3}$
	2×10^{-4}	7×10^{-7}	4×10^{-4}	$0.06^{+0.02}_{-0.02}$	261^{+97}_{-87}	$0.23^{+0.03}_{-0.03}$	$3.30^{+0.01}_{-0.01}$	$-0.8^{+0.3}_{-0.2}$
	2×10^{-4}	7×10^{-7}	4×10^{-4}	$0.028^{+0.009}_{-0.005}$	125^{+44}_{-22}	$0.004^{+0.089}_{-0.093}$	$4.850^{+0.009}_{-0.009}$	$0.2^{+0.2}_{-0.1}$
	1×10^{-4}	5×10^{-7}	2×10^{-4}	$0.014^{+0.003}_{-0.002}$	61^{+15}_{-9}	$0.04^{+0.06}_{-0.11}$	$2.879^{+0.005}_{-0.005}$	$0.23^{+0.13}_{-0.09}$
Mid τ_c	2×10^{-4}	9×10^{-7}	3×10^{-4}	$0.07^{+0.03}_{-0.02}$	327^{+133}_{-113}	$0.08^{+0.07}_{-0.19}$	$5.260^{+0.010}_{-0.010}$	$-0.8^{+0.3}_{-0.2}$
	2×10^{-4}	8×10^{-7}	3×10^{-4}	$0.06^{+0.02}_{-0.02}$	281^{+104}_{-95}	$0.22^{+0.02}_{-0.03}$	$0.431^{+0.008}_{-0.008}$	$-0.8^{+0.3}_{-0.2}$
	1×10^{-4}	6×10^{-7}	2×10^{-4}	$0.020^{+0.006}_{-0.003}$	90^{+28}_{-16}	$-0.01^{+0.08}_{-0.07}$	$0.897^{+0.007}_{-0.007}$	$0.21^{+0.14}_{-0.10}$
	1×10^{-4}	6×10^{-7}	2×10^{-4}	$0.015^{+0.003}_{-0.002}$	69^{+13}_{-9}	$-0.07^{+0.16}_{-0.05}$	$2.354^{+0.005}_{-0.005}$	$-0.03^{+0.09}_{-0.09}$
Low τ_c	4×10^{-5}	5×10^{-7}	7×10^{-5}	$0.09^{+0.03}_{-0.03}$	444^{+141}_{-138}	$0.371^{+0.009}_{-0.010}$	$4.694^{+0.005}_{-0.005}$	$-0.8^{+0.3}_{-0.2}$
	2×10^{-5}	4×10^{-7}	3×10^{-5}	$0.05^{+0.02}_{-0.02}$	233^{+80}_{-74}	$-0.358^{+0.007}_{-0.007}$	$4.513^{+0.004}_{-0.004}$	$0.8^{+0.2}_{-0.3}$
	2×10^{-5}	3×10^{-7}	3×10^{-5}	$0.04^{+0.02}_{-0.01}$	164^{+71}_{-48}	$-0.280^{+0.010}_{-0.010}$	$1.753^{+0.004}_{-0.004}$	$0.5^{+0.4}_{-0.2}$
	8×10^{-5}	5×10^{-7}	1×10^{-4}	$0.022^{+0.005}_{-0.003}$	99^{+21}_{-14}	$-0.382^{+0.008}_{-0.008}$	$4.426^{+0.005}_{-0.005}$	$-0.09^{+0.09}_{-0.10}$
☆	7×10^{-4}	5×10^{-6}	1×10^{-3}	$0.08^{+0.02}_{-0.02}$	396^{+122}_{-117}	$-0.00003^{+0.15218}_{-0.15409}$	$3.14^{+0.08}_{-0.08}$	$0.8^{+0.2}_{-0.3}$
☆	7×10^{-4}	5×10^{-6}	2×10^{-3}	$0.17^{+0.04}_{-0.05}$	842^{+246}_{-246}	$-0.001^{+0.138}_{-0.142}$	$3.14^{+0.06}_{-0.06}$	$0.8^{+0.2}_{-0.3}$
☆	5×10^{-6}	9×10^{-7}	6×10^{-6}	$0.74^{+0.05}_{-0.08}$	4684^{+428}_{-584}	$-0.0009^{+0.0248}_{-0.0254}$	$3.139^{+0.006}_{-0.006}$	$0.90^{+0.08}_{-0.12}$

Highlights


90%
50%
$\mathcal{M}_c[M_\odot]$
z
$\log_{10}(\tau_c/\mathrm{yr})$
q
$\mathcal{M}_c[M_\odot]$
z
$\log_{10}(\tau_c/\mathrm{yr})$


Thanks for listening!
Questions?



Backup slides

Nothing special

in each catalog