Merging rates of compact binaries in galaxies

Lumen Boco

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Galaxy statistics

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Single galaxy evolution

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Stellar evolution

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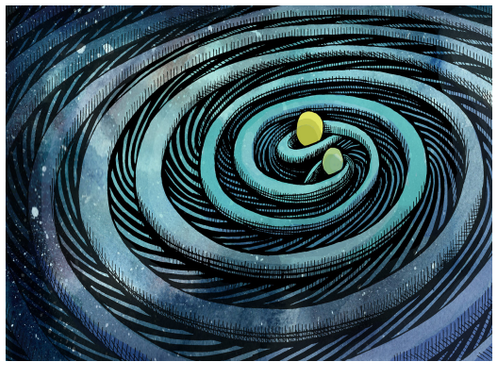
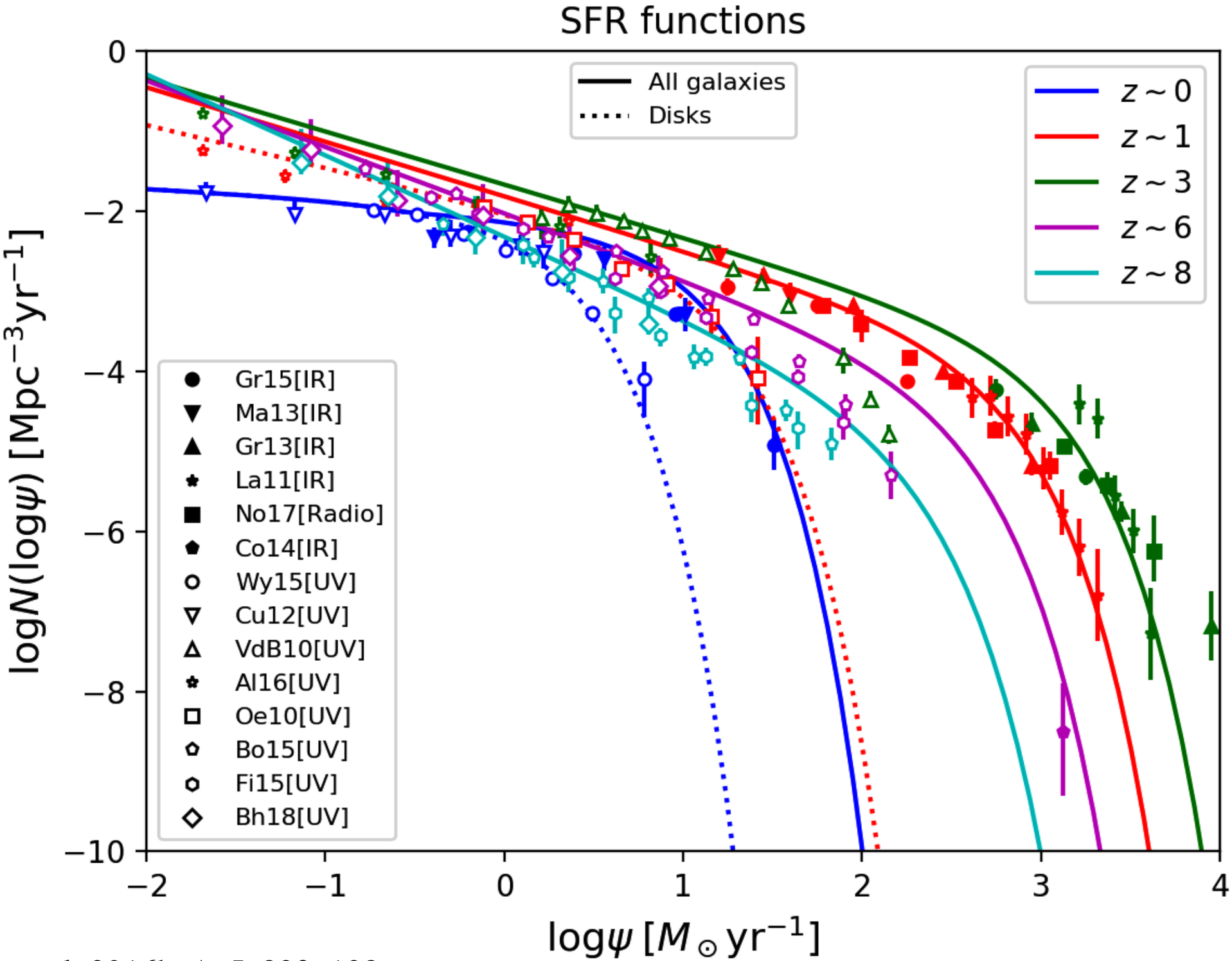
Stellar evolution

GW physics



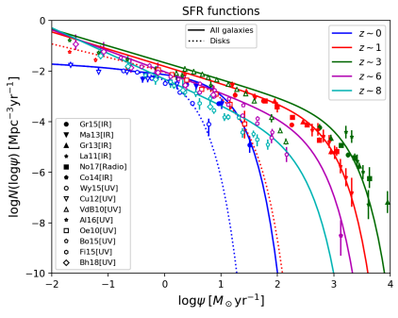
Galaxy statistics



Mancuso et al. 2016b, ApJ, 823, 128

Galaxy statistics

$$\int \mathrm{d}\log\psi\psi$$



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Galaxy statistics

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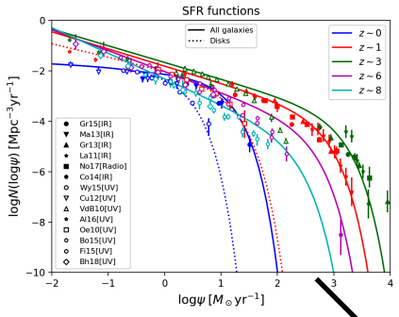
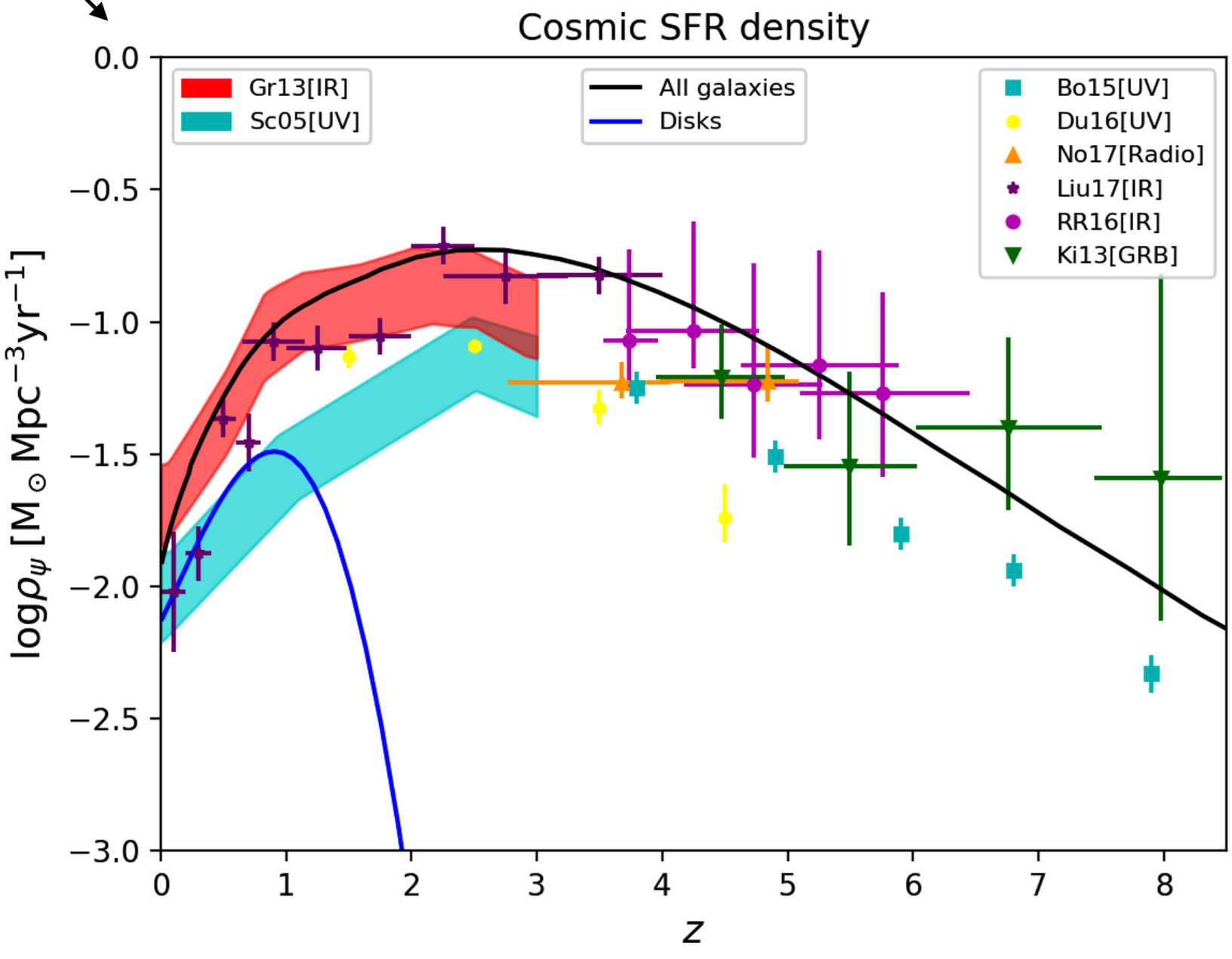




Mancuso et al. 2016b, ApJ, 823, 128

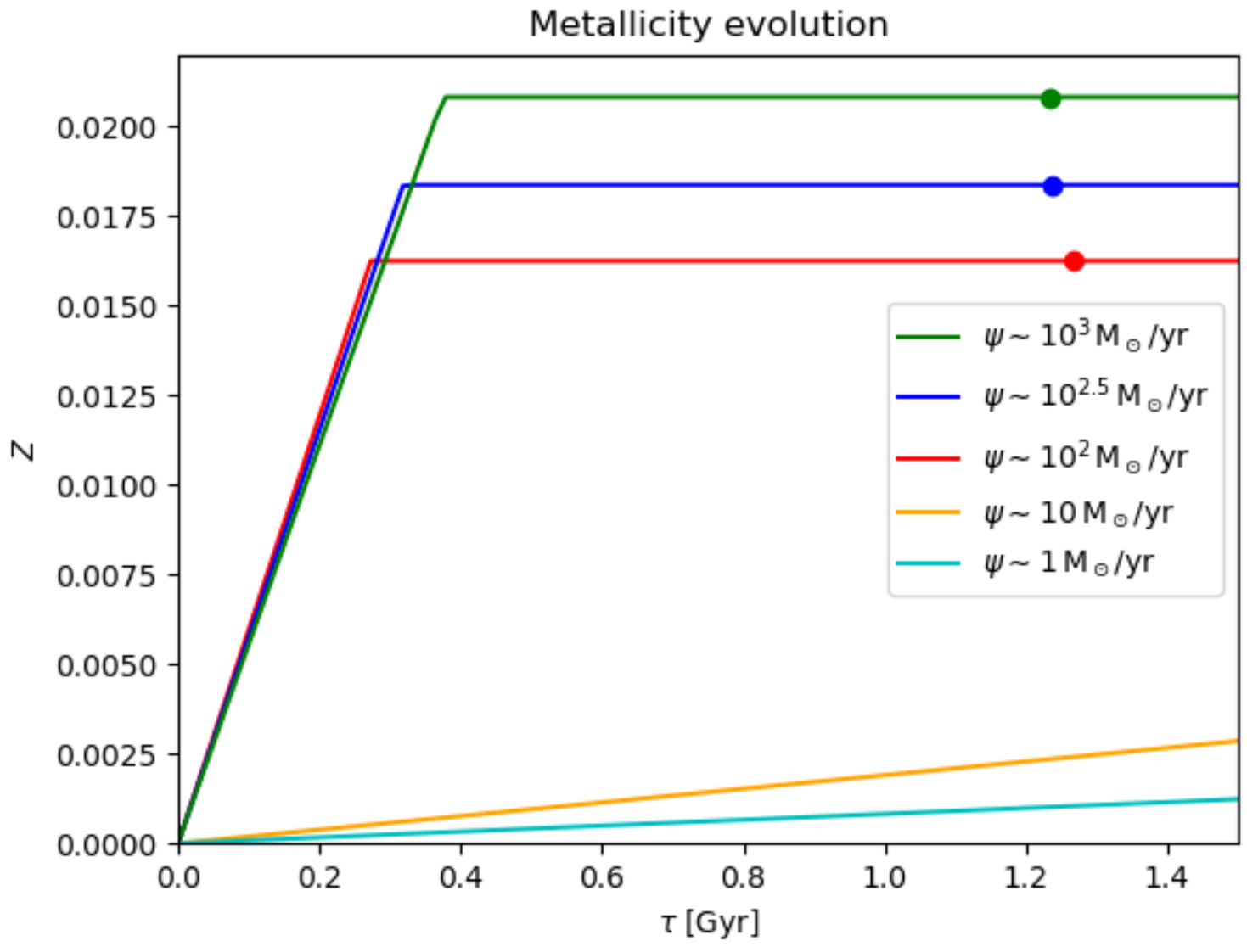
Galaxy evolution

Chemical evolution

Galaxy evolution

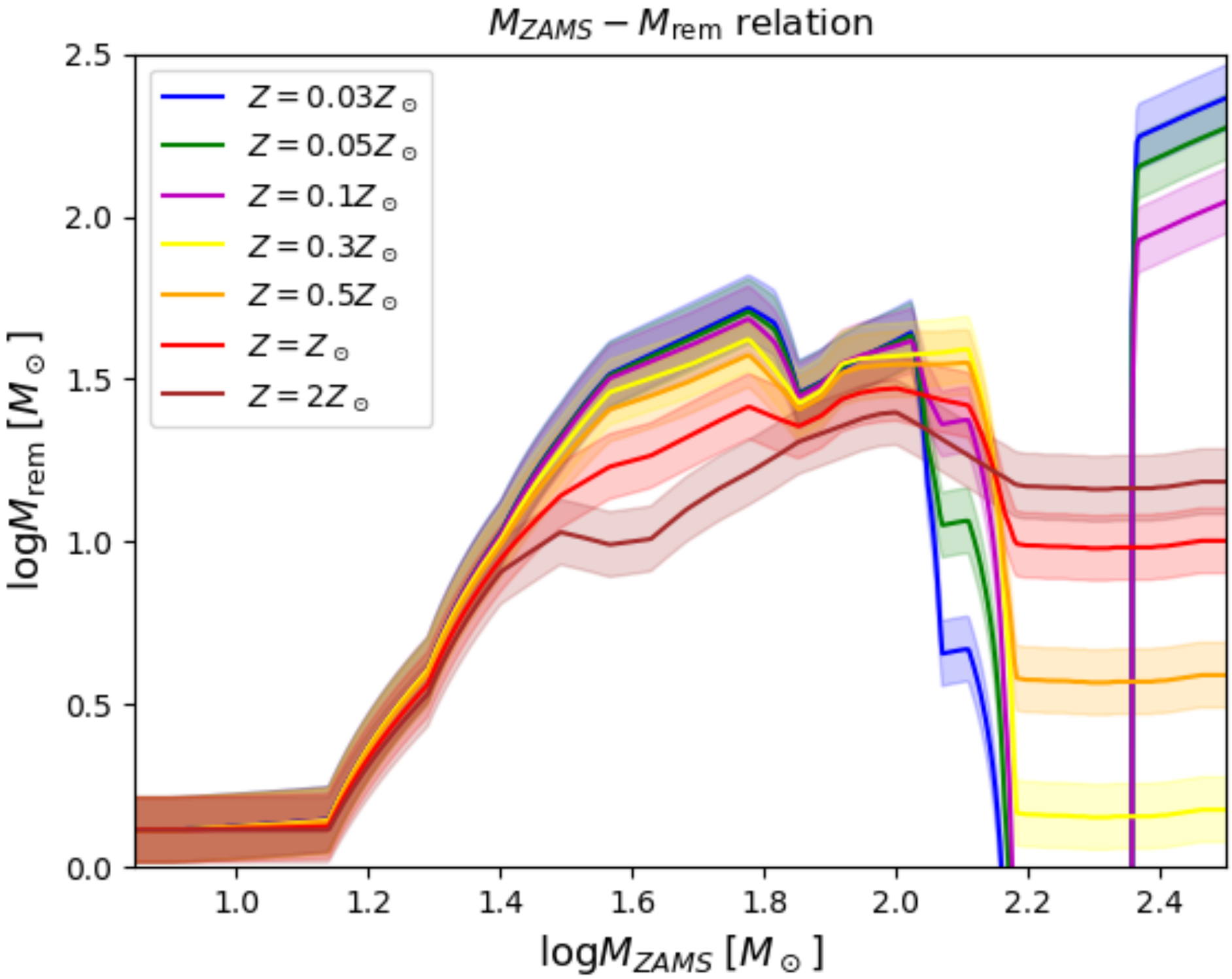
Chemical evolution

$$Z(\tau) = \begin{cases} Z_{\rm sat}\dfrac{\tau}{\Delta\tau_\psi} & \dfrac{\tau}{\tau_\psi} \leq \Delta \\ Z_{\rm sat} & \dfrac{\tau}{\tau_\psi} > \Delta \end{cases}$$



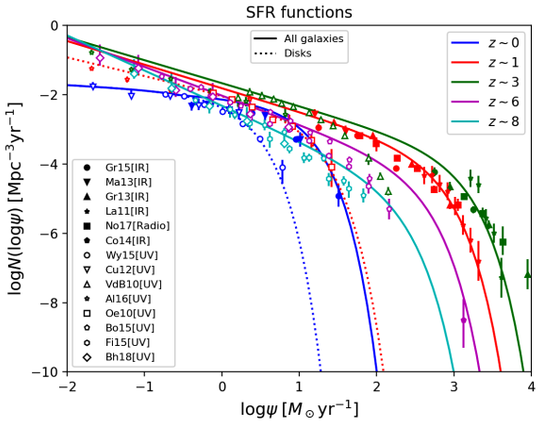
Pantoni et al 2019., arxiv:1906.07458v1

Stellar evolution

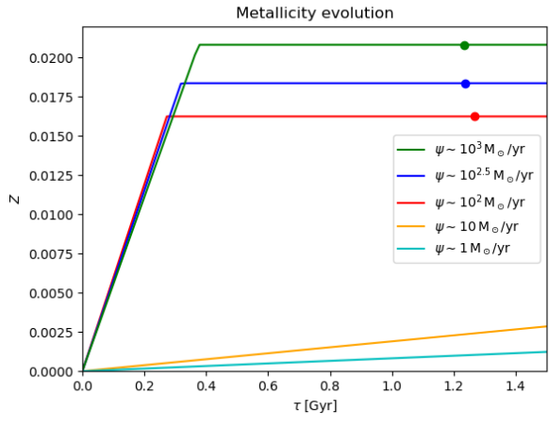


Spera et al. 2017 MNRAS 470, 4739–4749

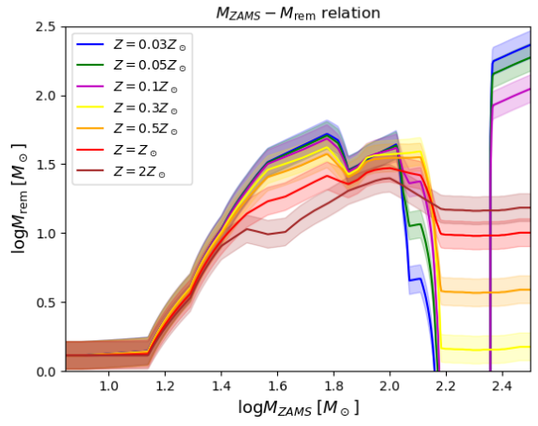
Galaxy statistics



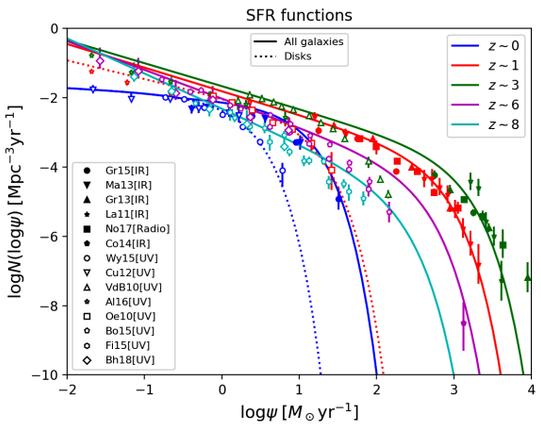
Galaxy evolution



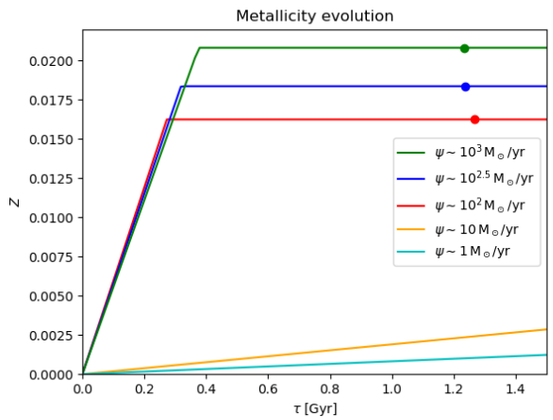
Stellar evolution



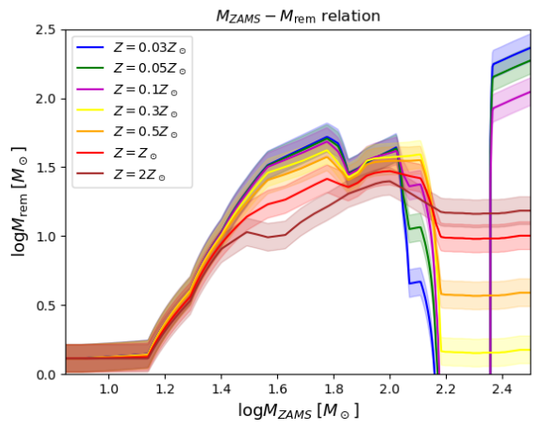
Galaxy statistics



Galaxy evolution



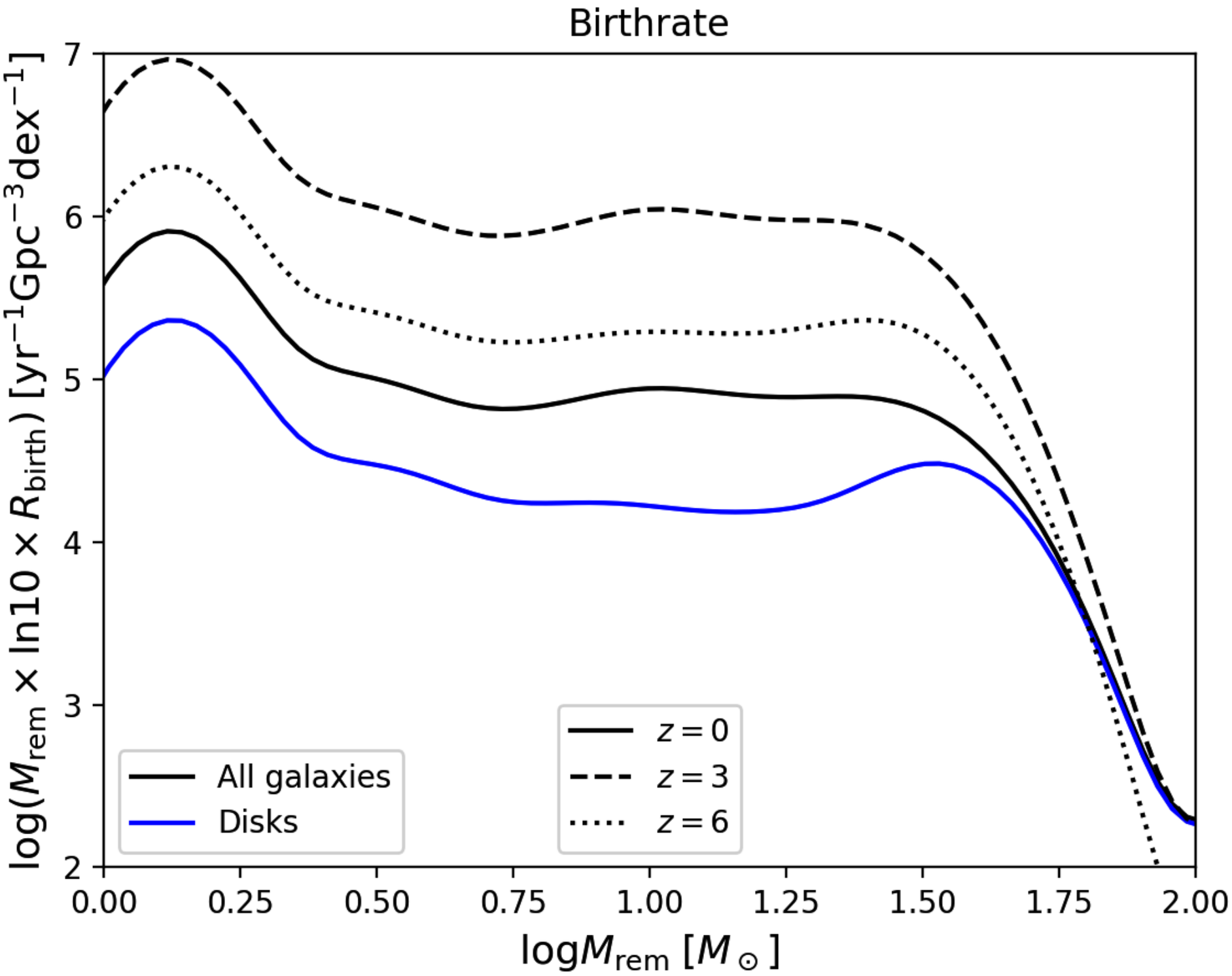
Stellar evolution



Cosmic birthrate of compact remnants

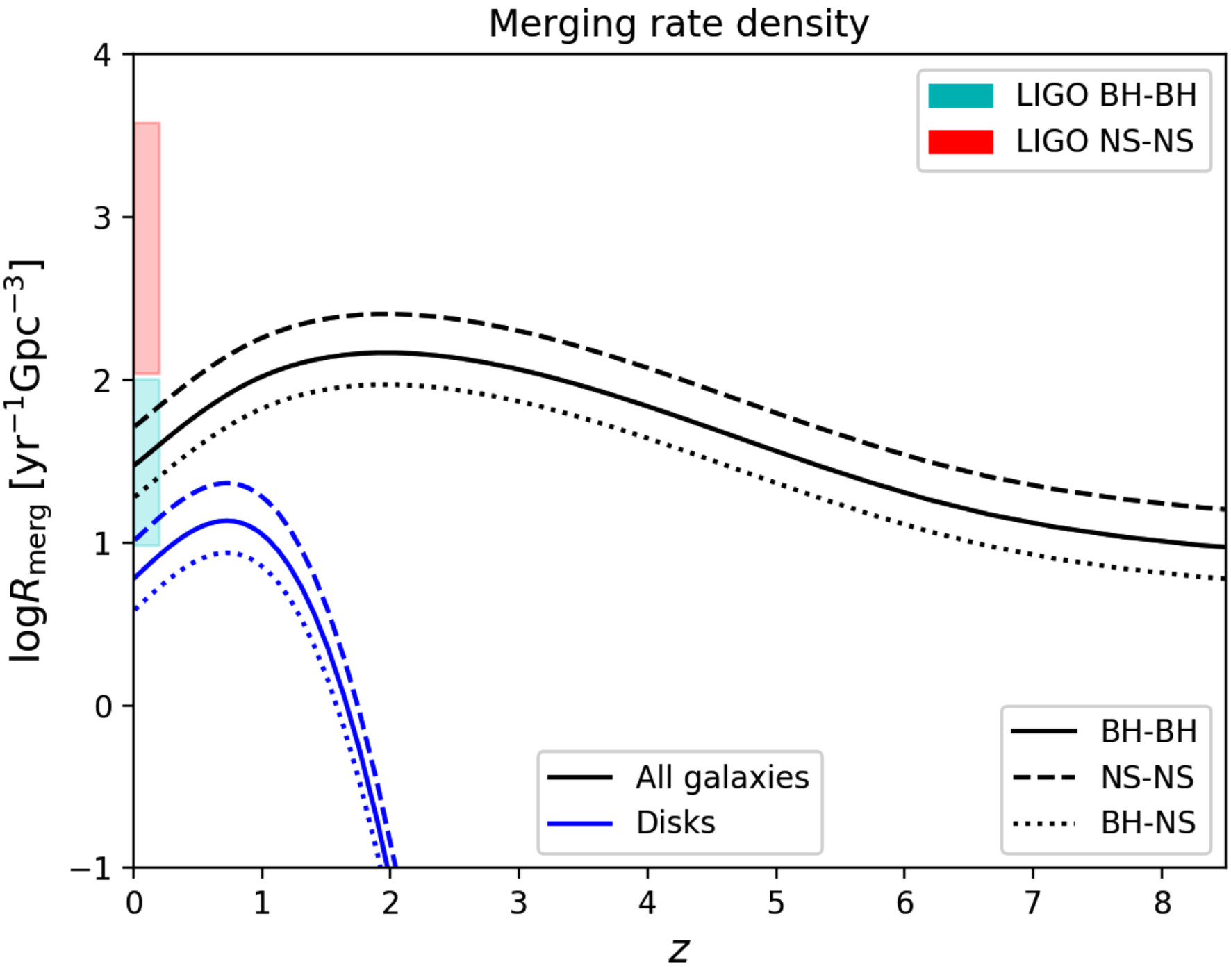
$$R_{\rm birth}(m_\bullet,t)=\int \mathrm{d}\log\psi\,\psi\,\frac{\mathrm{dN}(\psi,\mathrm{t})}{\mathrm{d}\log\psi\mathrm{dV}}\int \mathrm{d}\log\mathrm{Z}\frac{\mathrm{dp}}{\mathrm{d}\log\mathrm{Z}}(\mathrm{Z}\,|\,\psi,\mathrm{t})\int \mathrm{dm}_\star\phi(\mathrm{m}_\star)\frac{\mathrm{dp}}{\mathrm{dm}_\bullet}(\mathrm{m}_\bullet\,|\,\mathrm{m}_\star,\mathrm{Z})$$

Birth rate


Birthrate
$\log(M_{\rm rem} \times \ln 10 \times R_{\rm birth})$ [$\rm yr^{-1} Gpc^{-3} dex^{-1}$]
7
6
5
4
3
2
0.00
0.25
0.50
0.75
1.00
1.25
1.50
1.75
2.00
$\log M_{\rm rem}$ [$M_\odot$]
All galaxies
Disks
$z = 0$
$z = 3$
$z = 6$

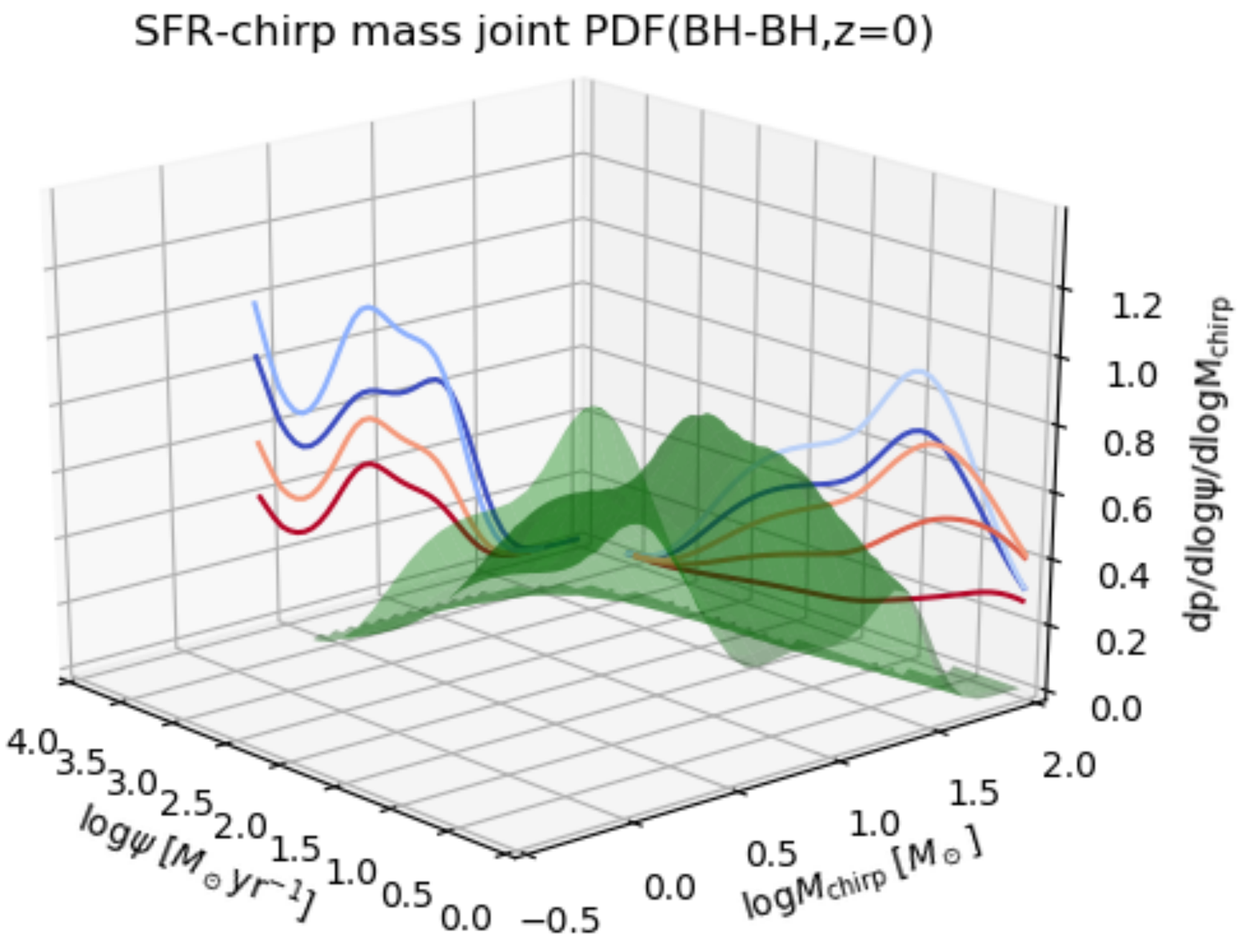
Merging rate

$$R_{\mathrm{merge}}(t) = f_{\mathrm{eff}} \int \mathrm{dm}_{\bullet} \int \mathrm{dt_d} \frac{\mathrm{dp}}{\mathrm{dt_d}} \mathrm{R_{birth}}(\mathrm{m}_{\bullet}, \mathrm{t} - \mathrm{t_d})$$



SFR-Chirp mass joint PDF

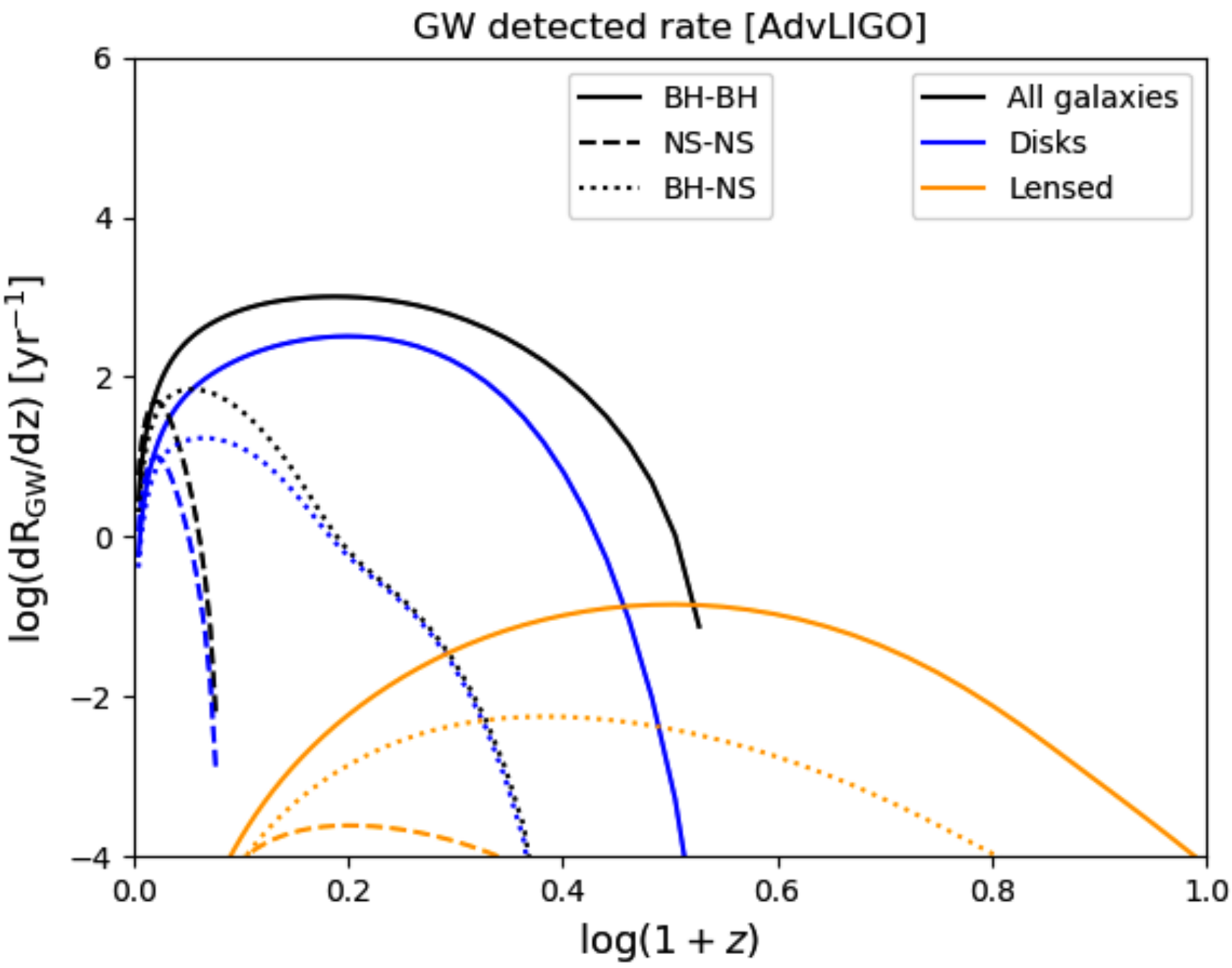
$$M_{\rm chirp} \equiv \frac{(m_1 m_2)^{3/5}}{(m_1 + m_2)^{1/5}}$$



Thank you for your attention!

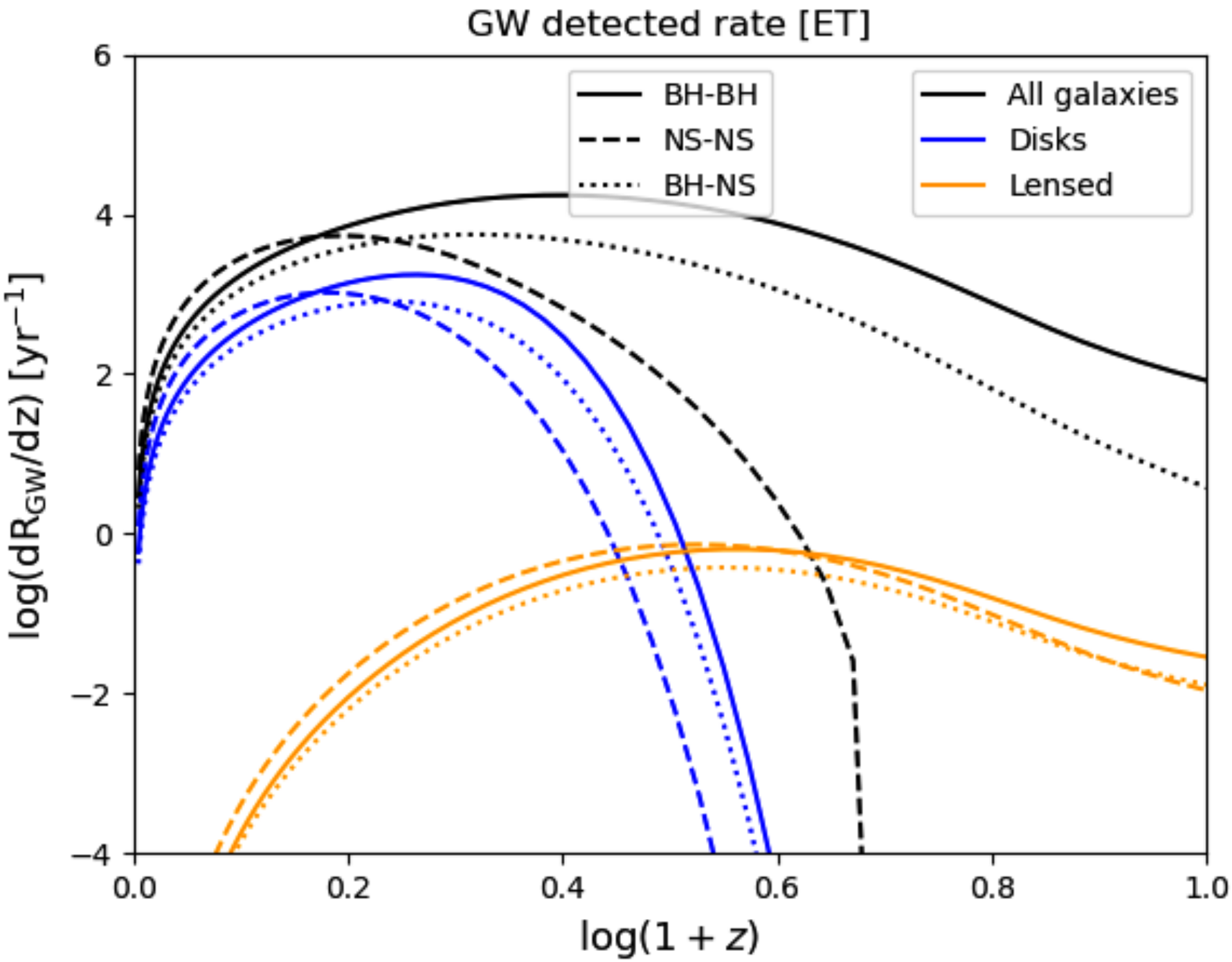
Detection rates

$$\frac{d\dot{N}}{dz}(>\rho_0, z) = \frac{dV}{dz(1+z)} \int d\mathscr{M} R_{merge}(\mathscr{M}, z) \int_{\rho_0}^{\infty} d\rho P_\rho(\rho \,|\, \mathscr{M}, z)$$



Detection rates

$$\frac{\mathrm{d}\dot{\mathrm{N}}}{\mathrm{dz}}(>\rho_0, z) = \frac{\mathrm{dV}}{\mathrm{dz}(1+\mathrm{z})} \int \mathrm{d}\mathscr{M} \mathrm{R}_{\mathrm{merge}}(\mathscr{M}, \mathrm{z}) \int_{\rho_0}^{\infty} \mathrm{d}\rho \mathrm{P}_{\rho}(\rho \,|\, \mathscr{M}, \mathrm{z})$$



Galaxy evolution

Star formation rate

Chemical evolution

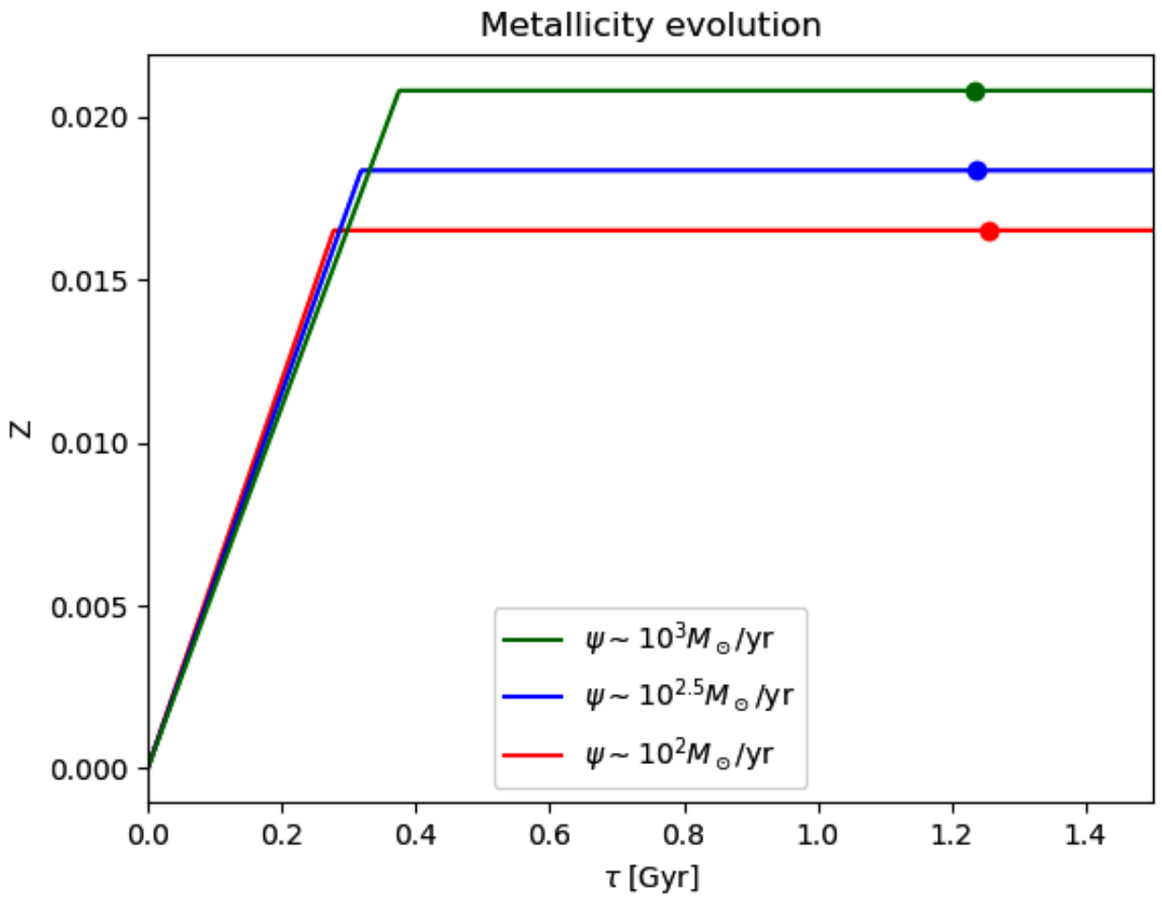
Spheroids

Disks

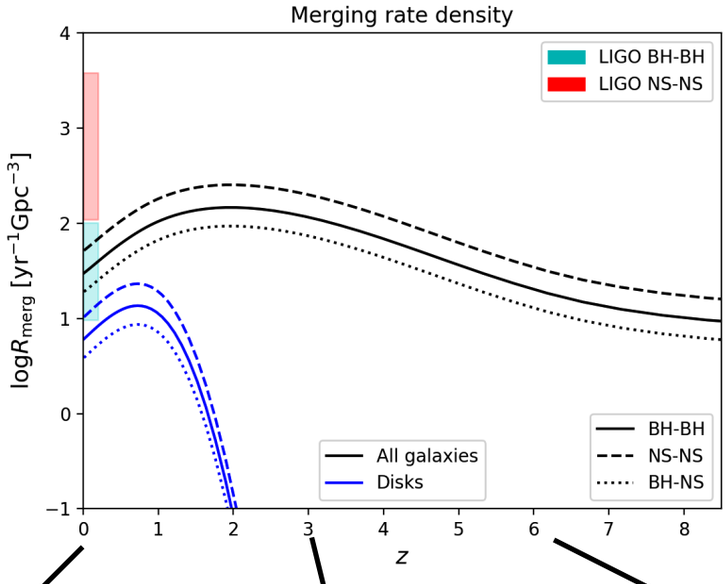
$$\psi(\tau) \propto \tau^k \Theta(\tau - \tau_\psi)$$

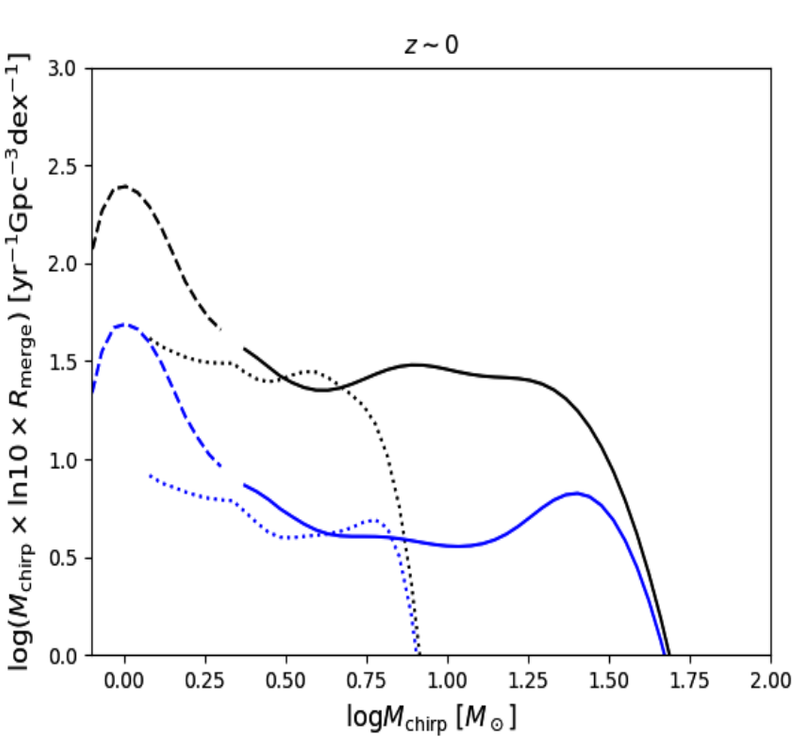
$$\psi(\tau) \propto e^{-\tau/\tau_\psi}$$

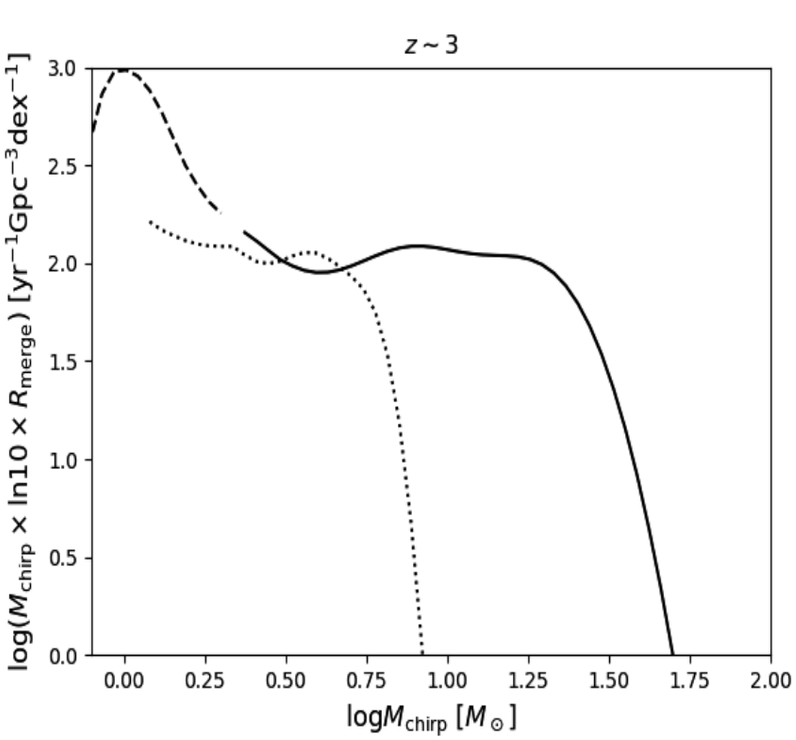
$$Z(\tau) = \begin{cases} Z_{\rm sat} \dfrac{\tau}{\Delta\tau_\psi} & \dfrac{\tau}{\tau_\psi} \leq \Delta \\ Z_{\rm sat} & \dfrac{\tau}{\tau_\psi} > \Delta \end{cases}$$

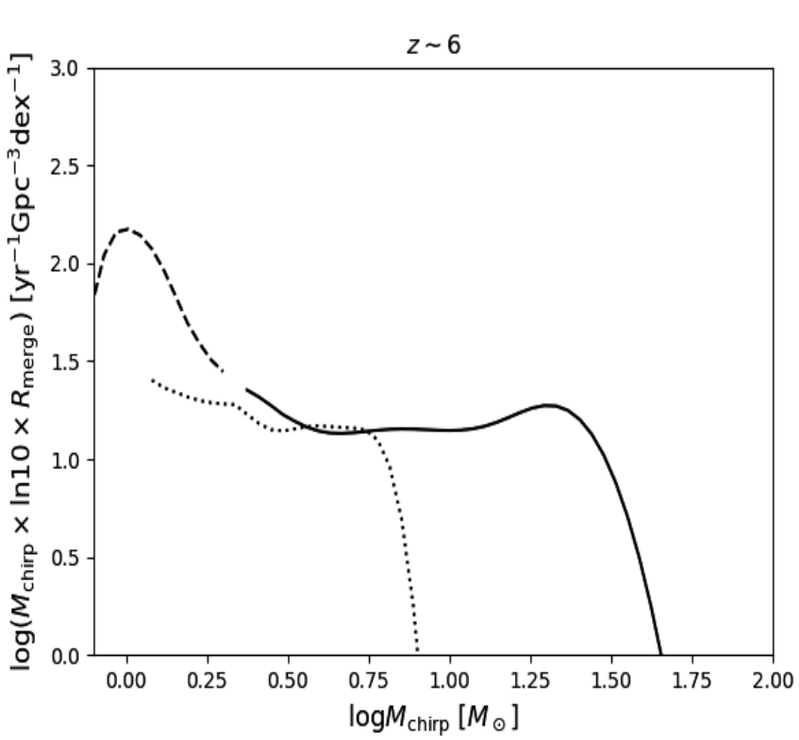


Pantoni et al., arxiv:1906.07458v1

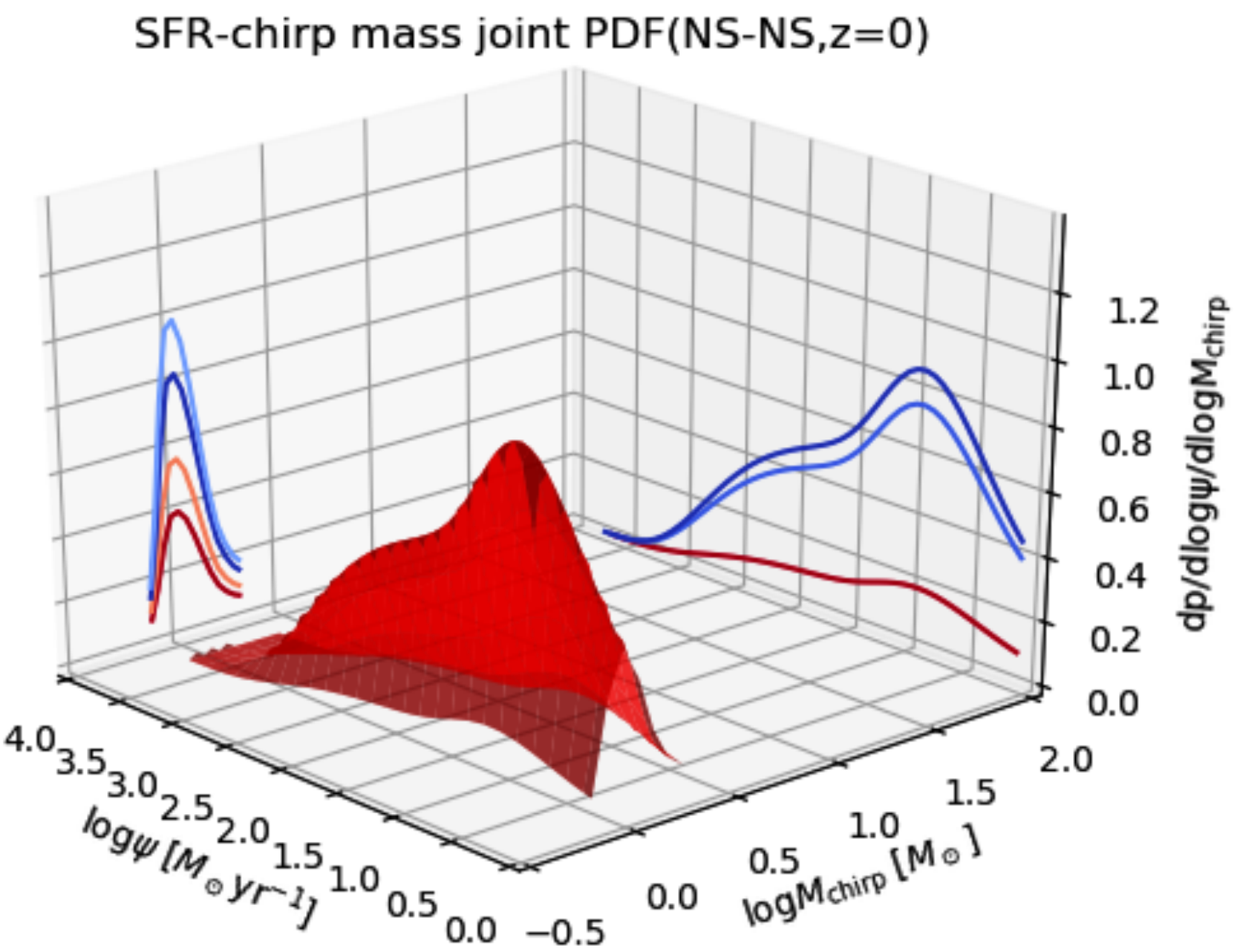

Merging rate density
LIGO BH-BH
LIGO NS-NS
All galaxies
Disks
BH-BH
NS-NS
BH-NS
$\log R_{\rm merg}$ [yr^{-1}Gpc^{-3}]
z


$z\sim0$
$\log(M_{\rm chirp}\times \ln10 \times R_{\rm merge})$ [yr^{-1}Gpc^{-3}dex^{-1}]
$\log M_{\rm chirp}$ [$M_\odot$]

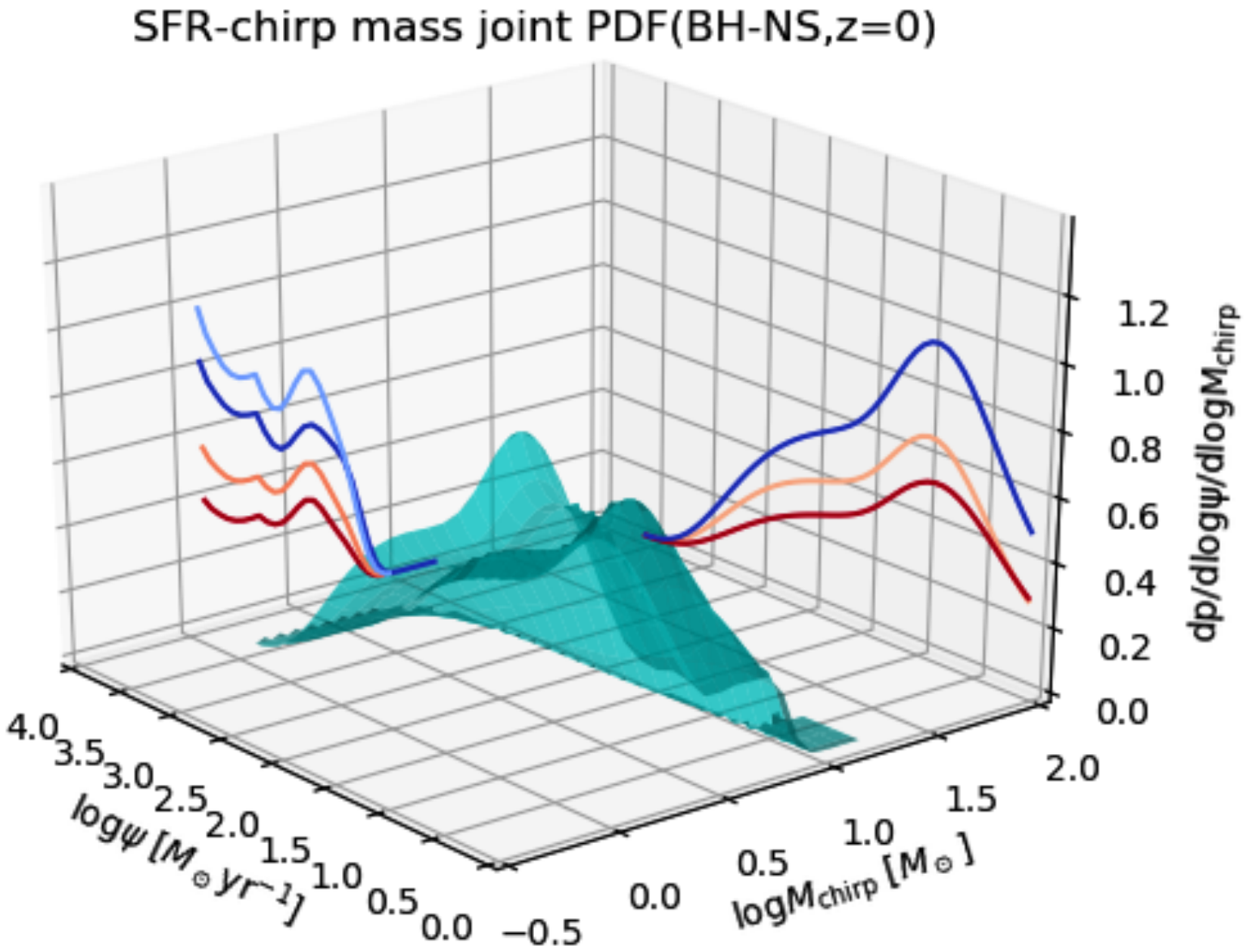

$z\sim3$
$\log(M_{\rm chirp}\times \ln10 \times R_{\rm merge})$ [yr^{-1}Gpc^{-3}dex^{-1}]
$\log M_{\rm chirp}$ [$M_\odot$]


$z\sim6$
$\log(M_{\rm chirp}\times \ln10 \times R_{\rm merge})$ [yr^{-1}Gpc^{-3}dex^{-1}]
$\log M_{\rm chirp}$ [$M_\odot$]

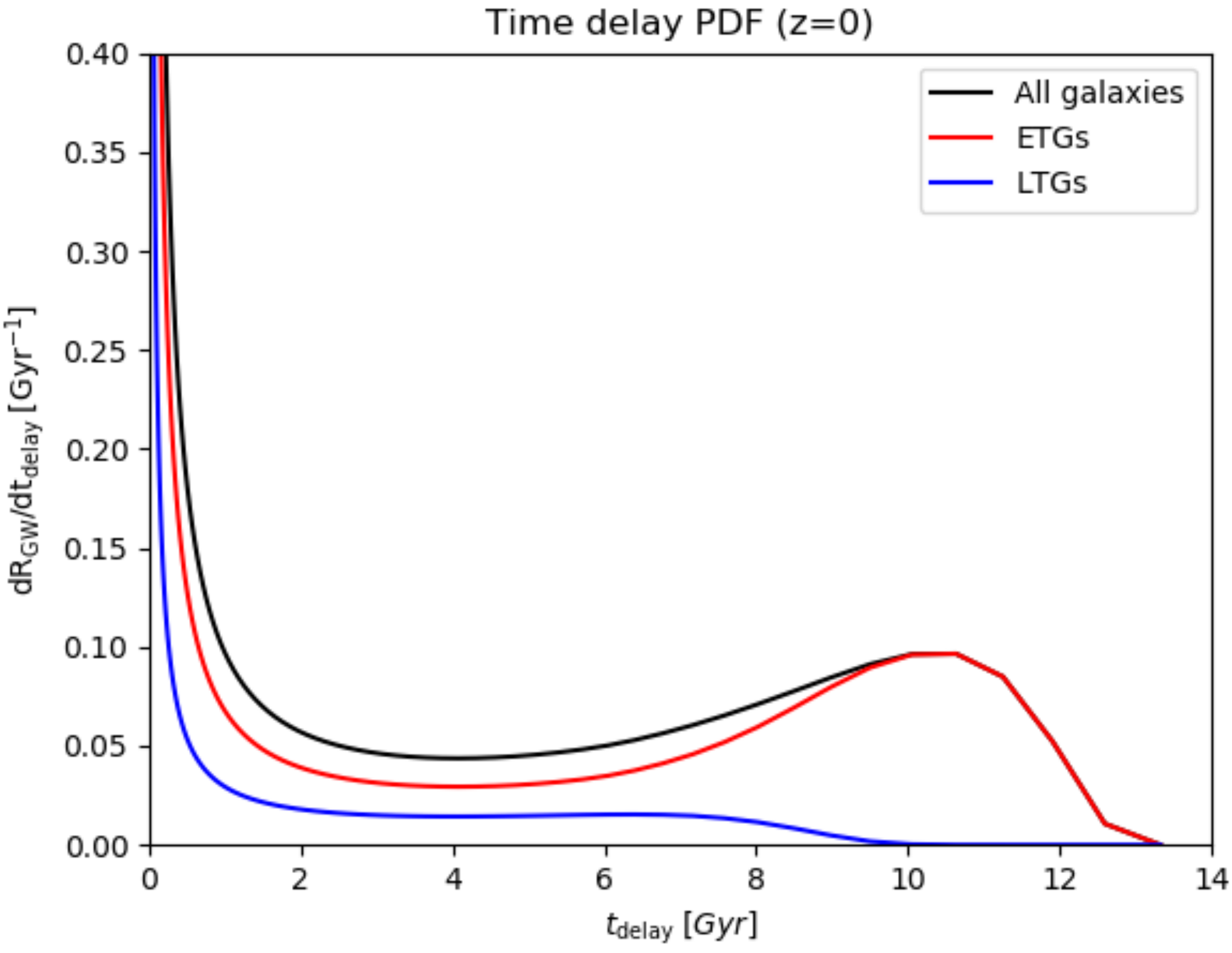
SFR-Chirp mass joint PDF



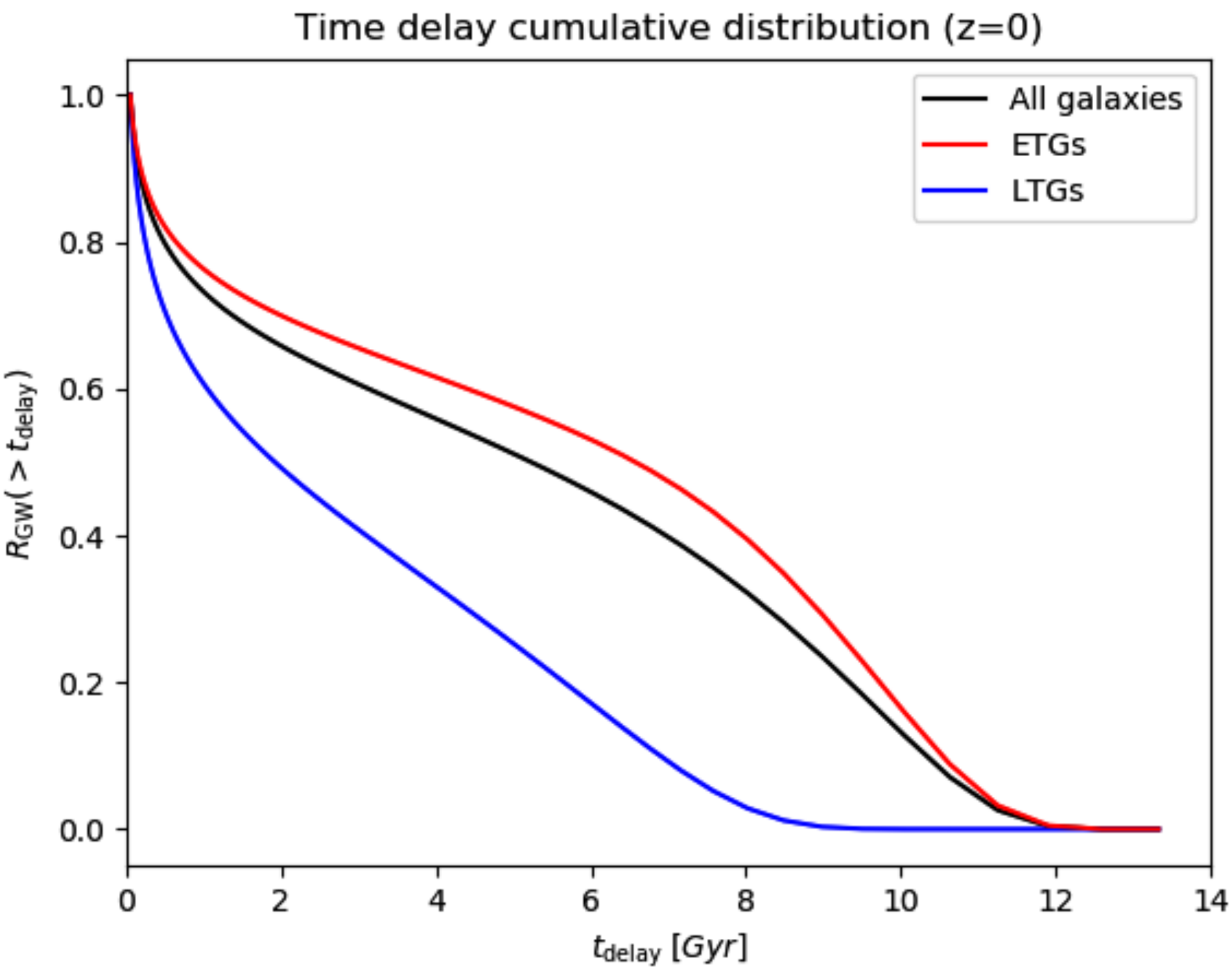
SFR-Chirp mass joint PDF

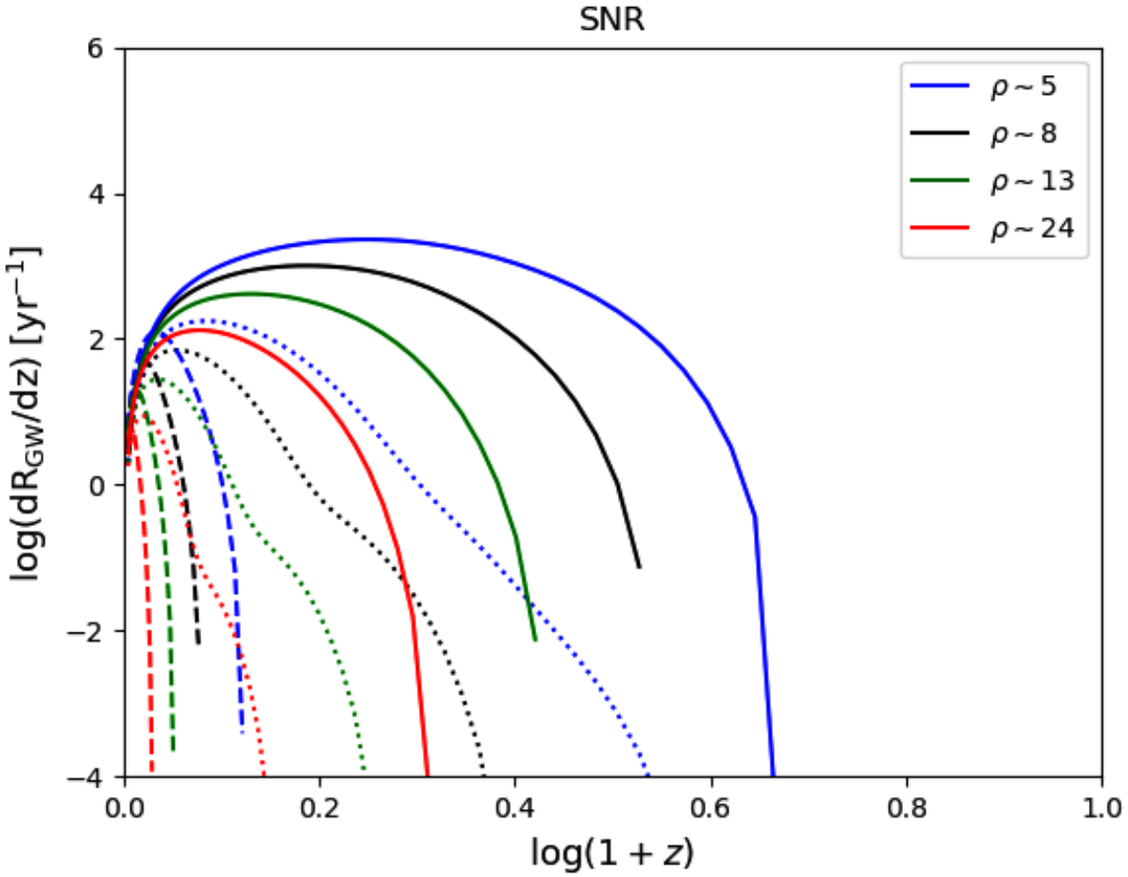


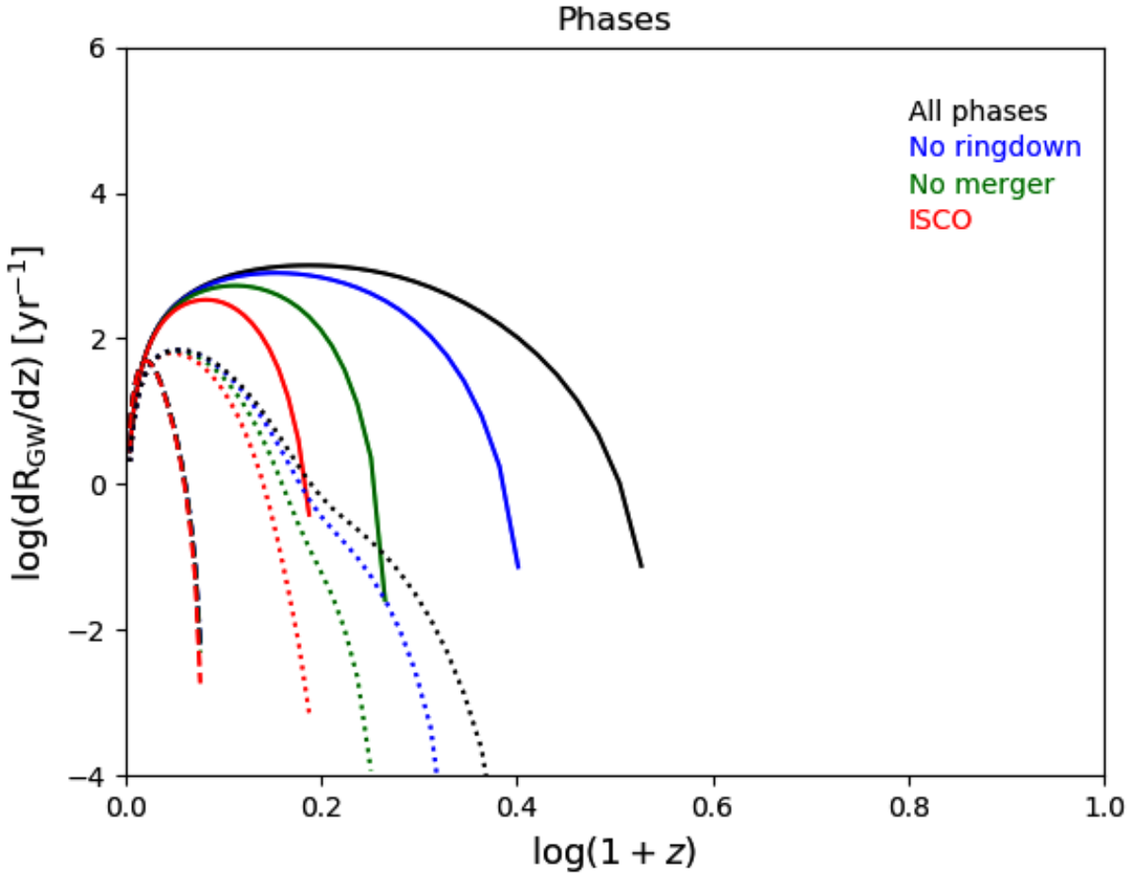
Time delay distribution

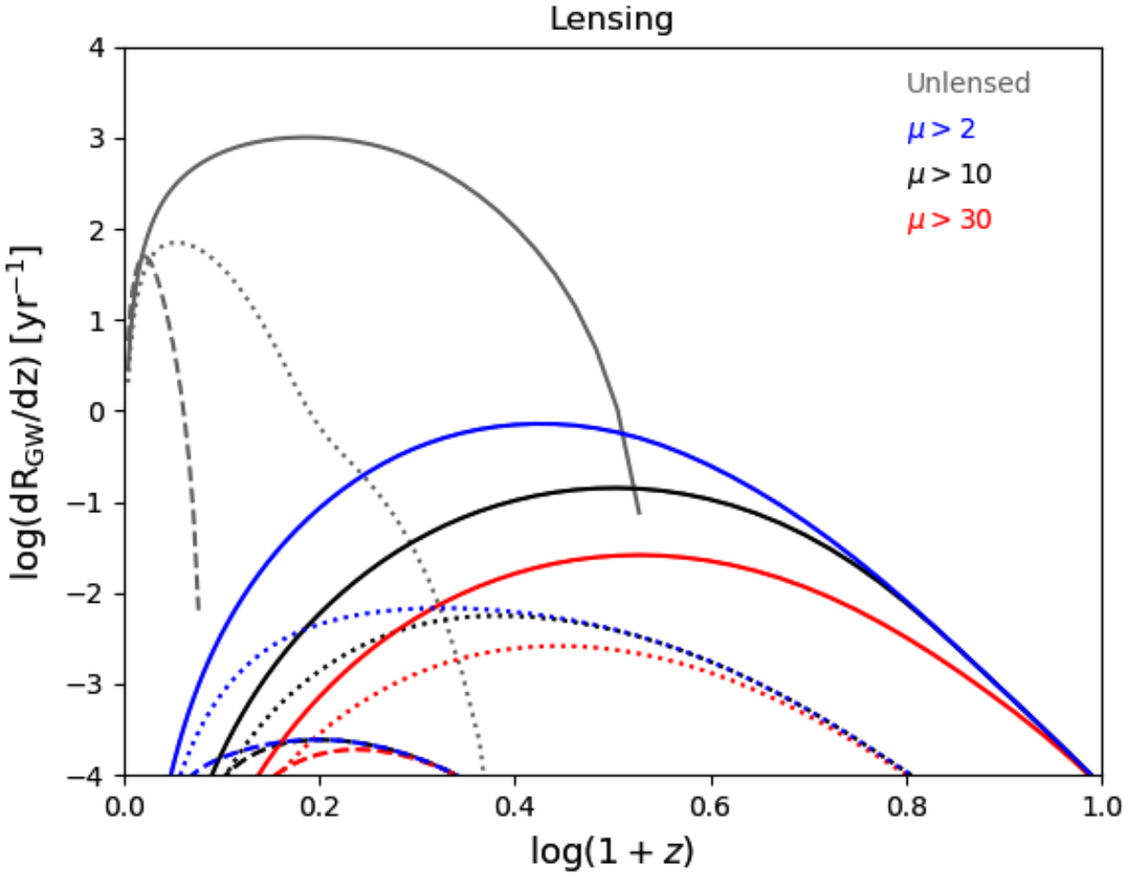


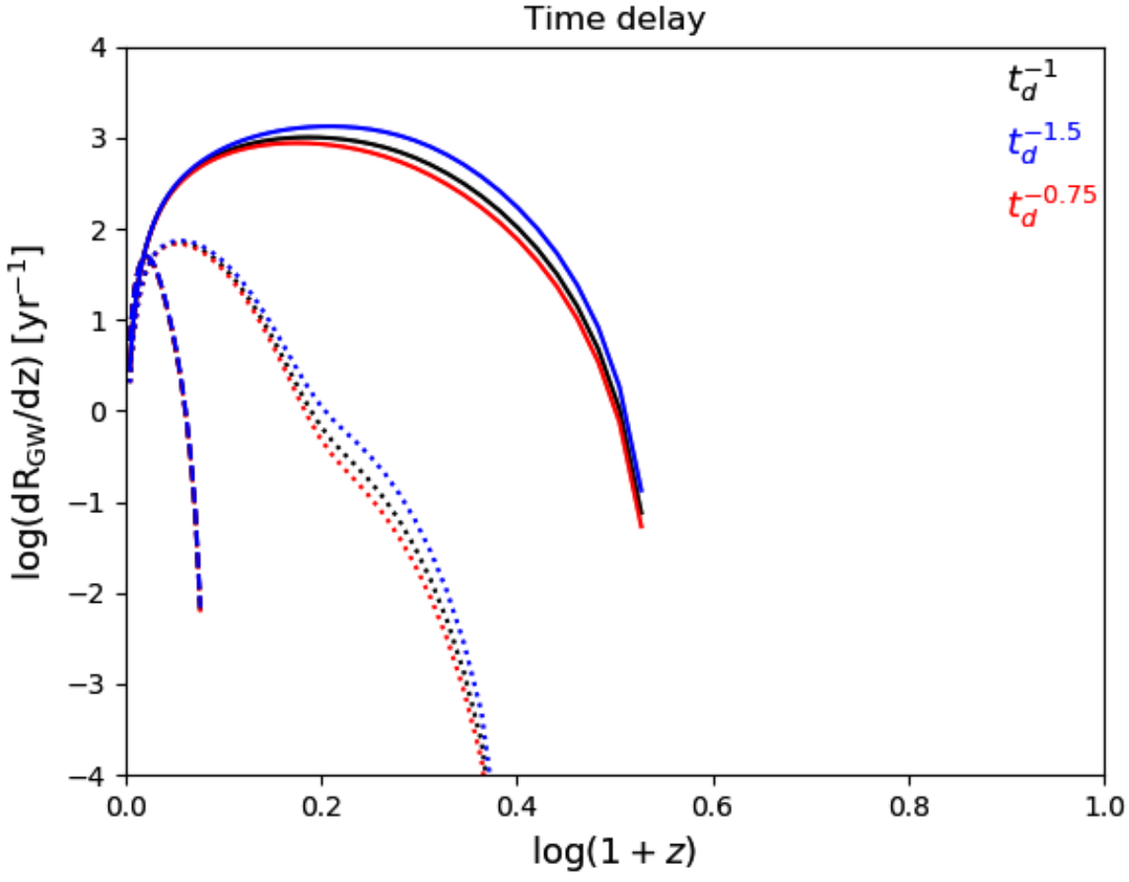
Time delay distribution



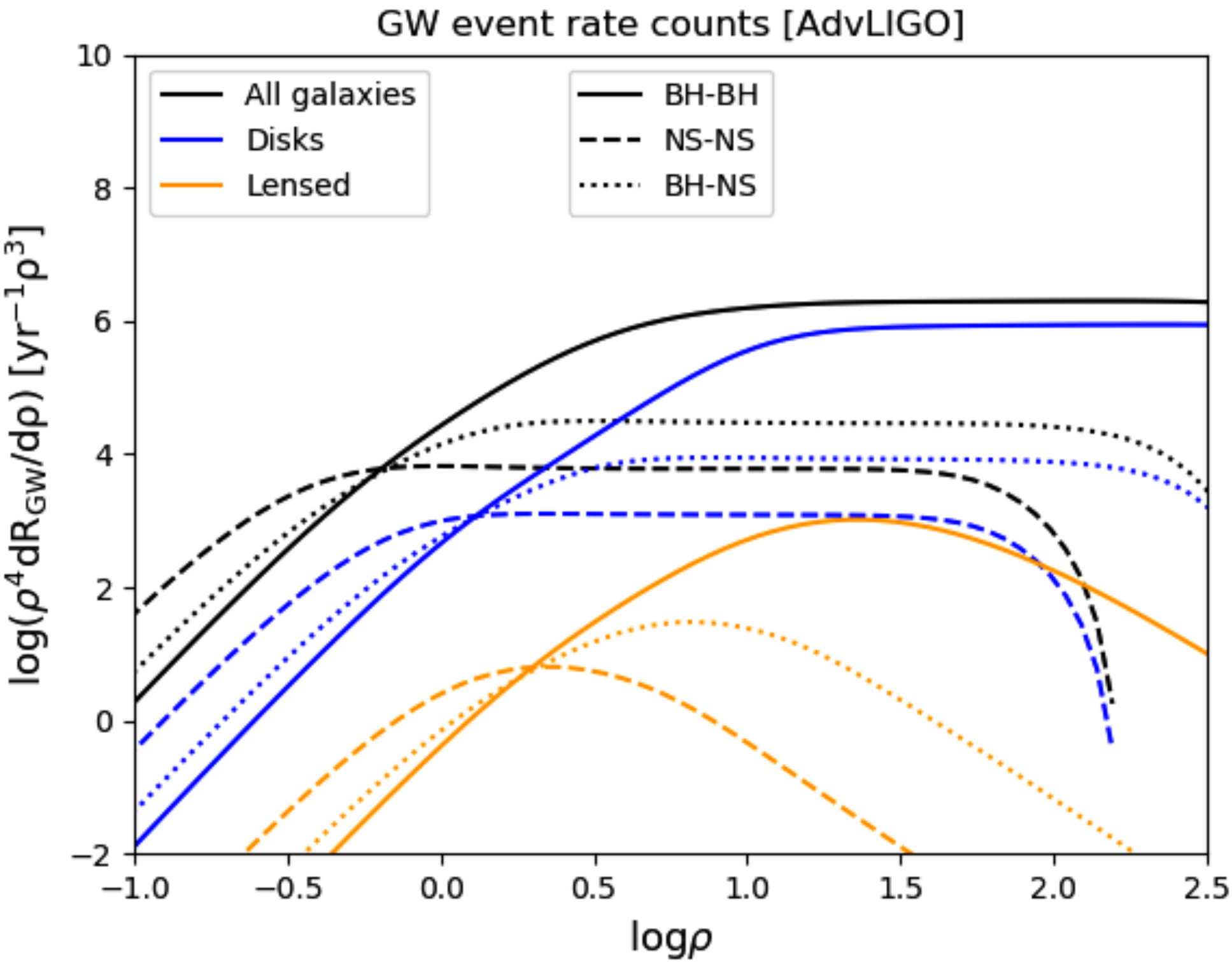

SNR
$\rho \sim 5$
$\rho \sim 8$
$\rho \sim 13$
$\rho \sim 24$
$\log(dR_{GW}/dz)$ [yr^{-1}]
$\log(1+z)$


Phases
All phases
No ringdown
No merger
ISCO
$\log(dR_{GW}/dz)$ [yr^{-1}]
$\log(1+z)$

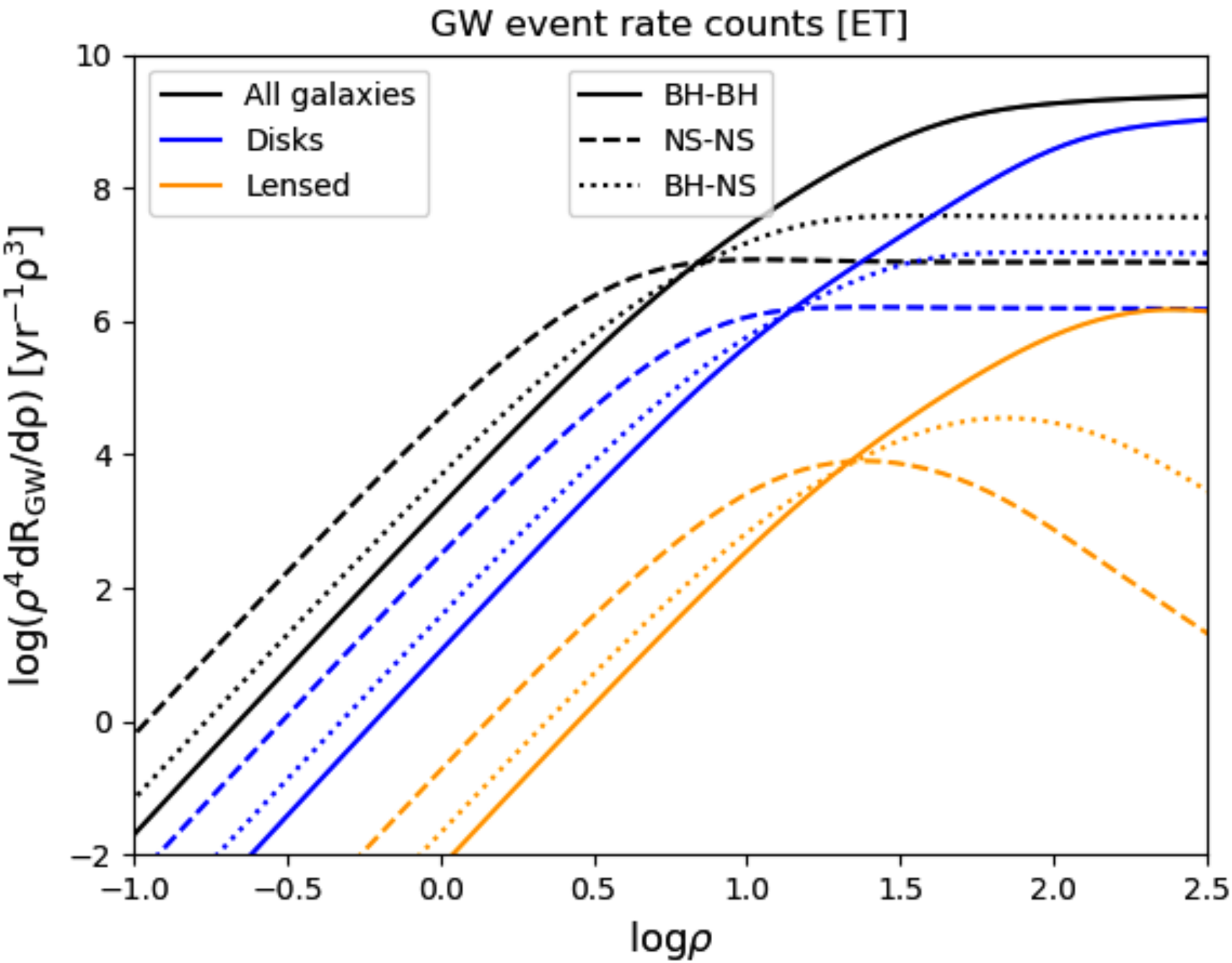

Lensing
Unlensed
$\mu > 2$
$\mu > 10$
$\mu > 30$
$\log(dR_{GW}/dz)$ [yr^{-1}]
$\log(1+z)$


Time delay
t_d^{-1}
$t_d^{-1.5}$
$t_d^{-0.75}$
$\log(dR_{GW}/dz)$ [yr^{-1}]
$\log(1+z)$

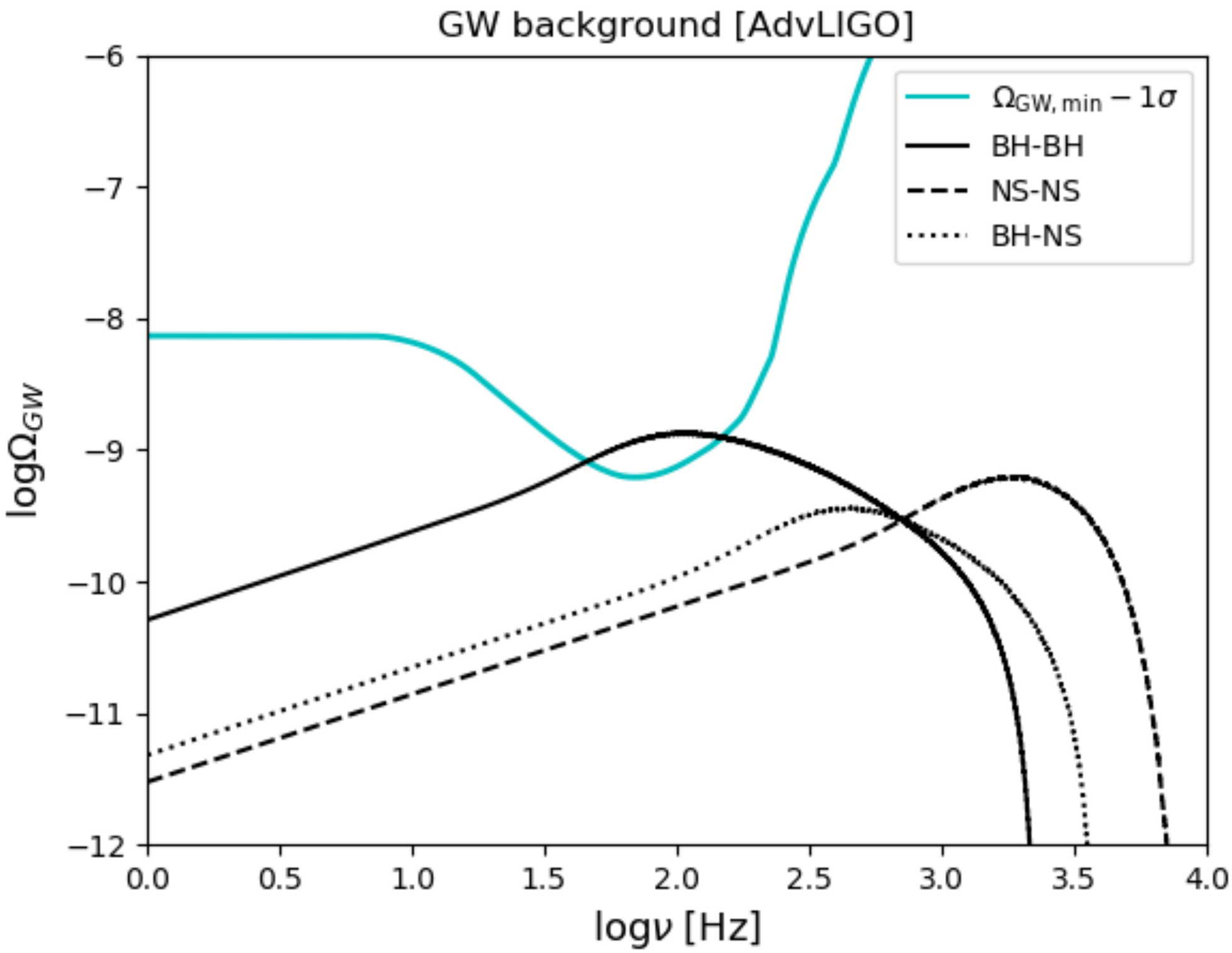
GW number counts



GW number counts



GW background



GW background