poster 23

Can we distinguish formation models of a super-massive black-hole?

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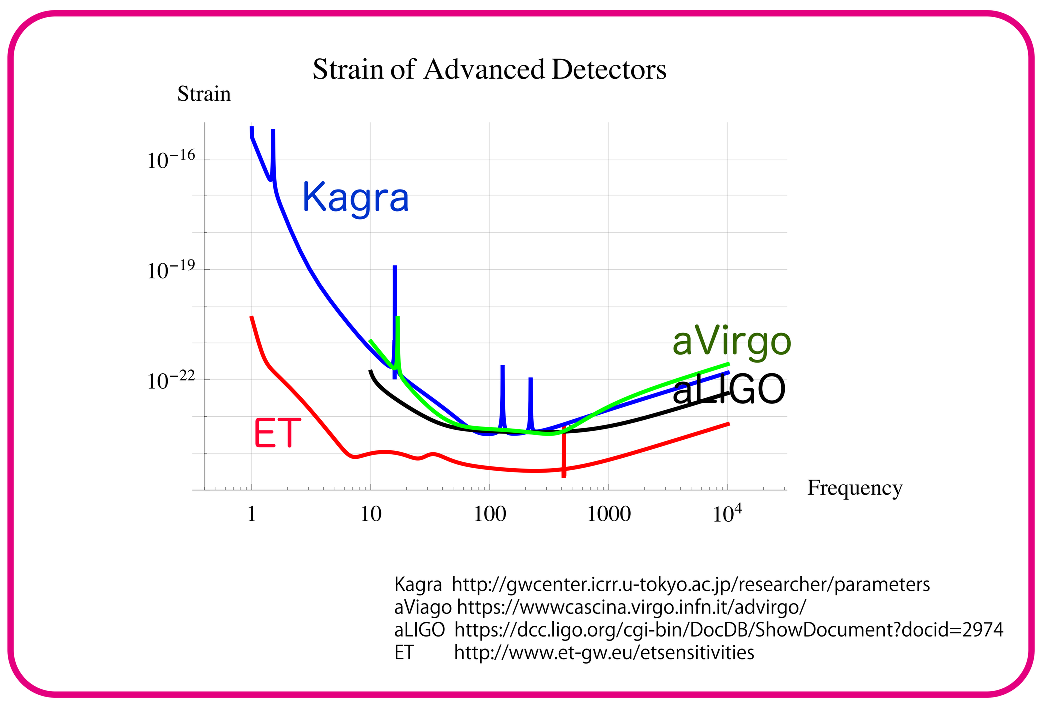
Outline & Summary

The second generation of detectors, such as KAGRA, advanced LIGO, advanced VIRGO, and future planned Einstein Telescope have enough sensitivity over 10 Hz, which enable us to detect the **ring-down gravitational wave** from a BH of the mass less than 2000 M_solar. We discuss how can we distinguish models for forming a super-massive black-hole (**SMBH**) via mergers of intermediate-mass black-holes (**IMBHs**) by accumulating event data. We assume two different merging histories; **hierarchical growth** and **monopolistic growth**, and compare their event rates.

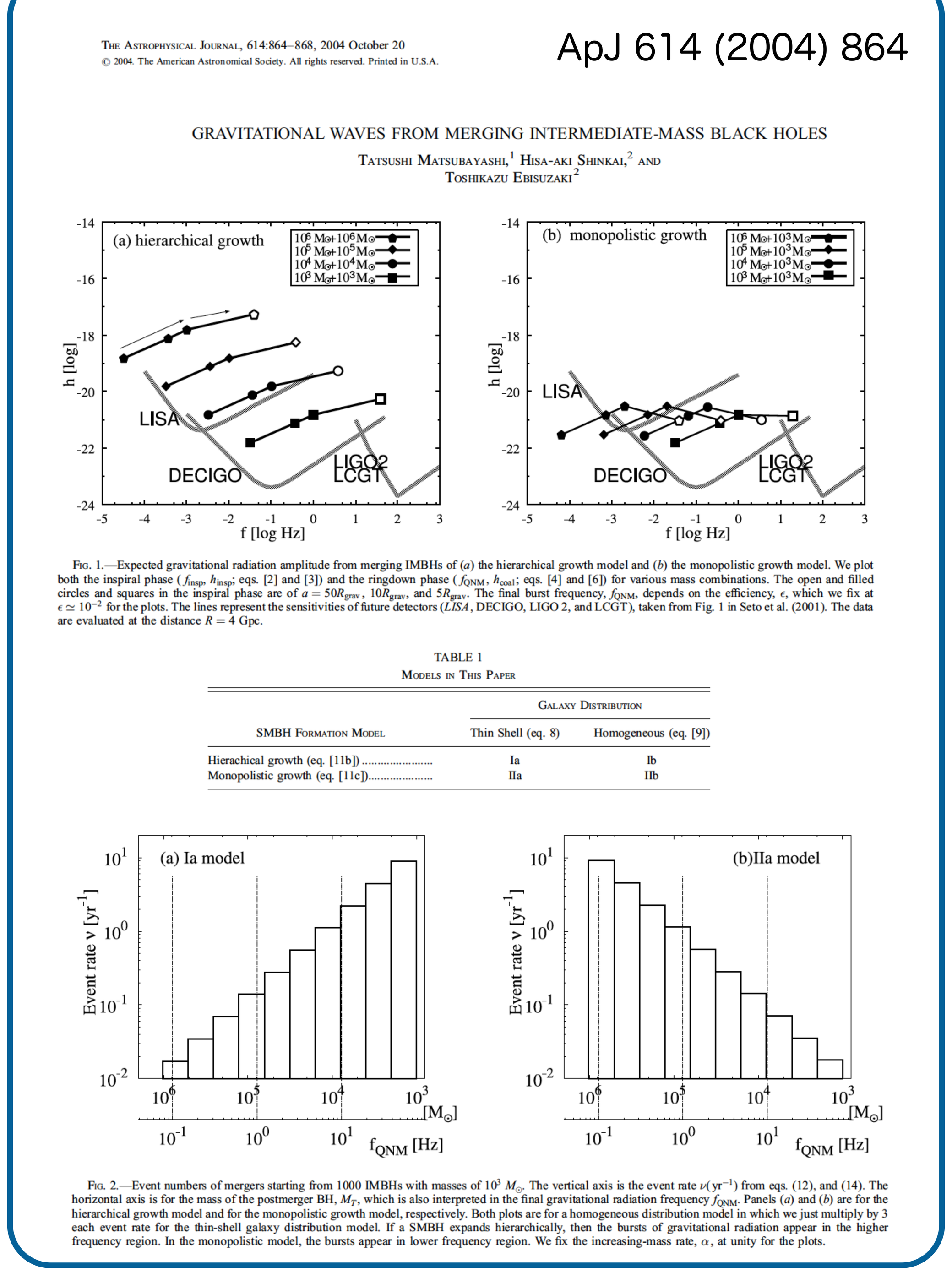
The former model assumes accumulations of coalesces of equal-mass binaries, while the latter assumes only one BH grows by sweeping others.

The observable distances highly depend on the unknown BH spin parameter, but we show event rates will differ by models as a function of frequency, corresponding to mass distribution function of each model.

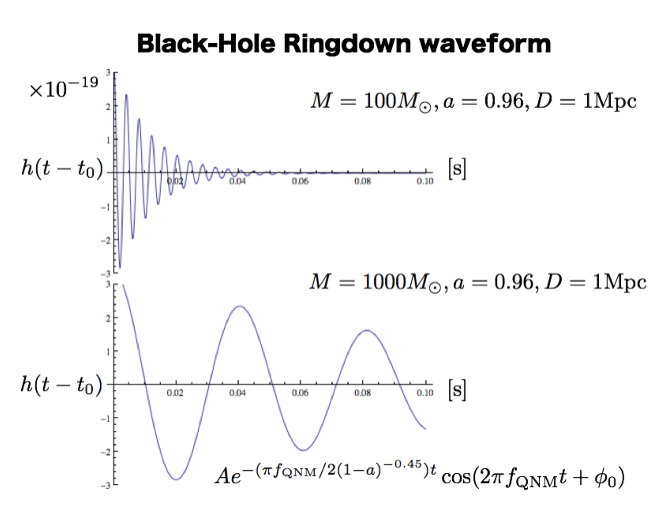


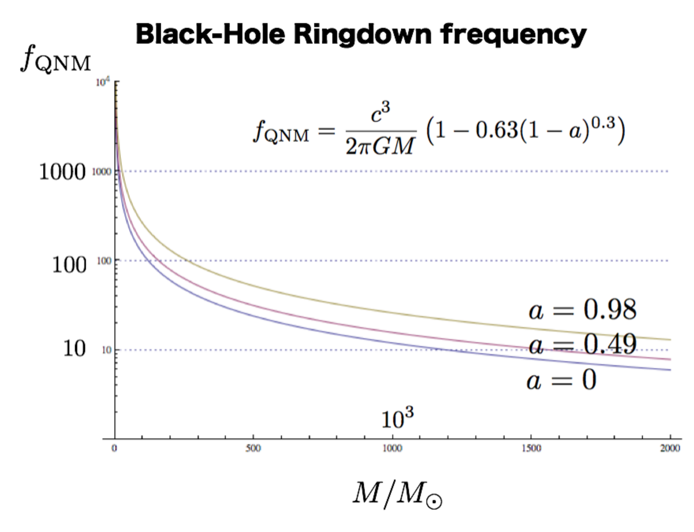
IMBH-IMBH inspiral at Space Interferometers

ApJ 614 (2004) 864

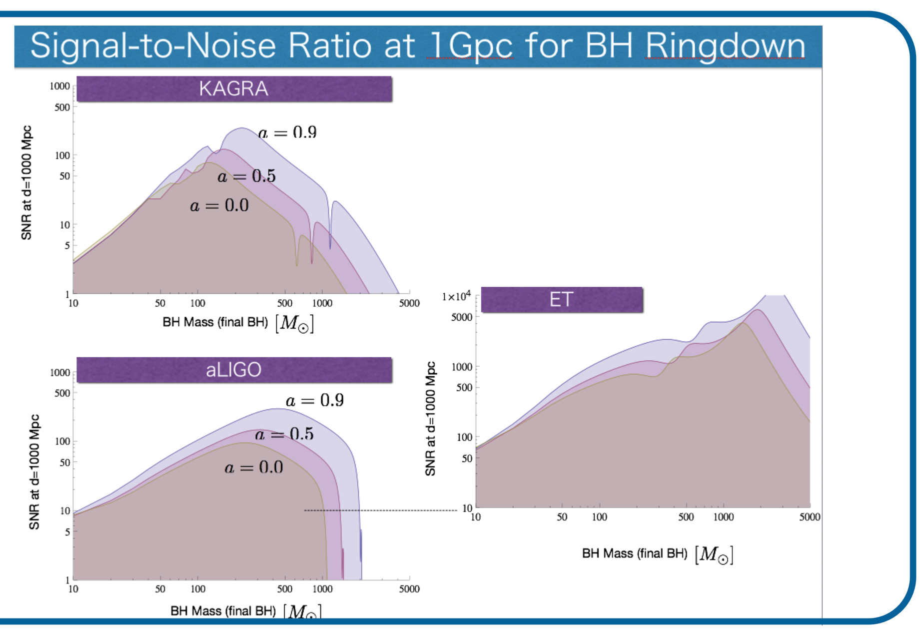


IMBH ringdown at Ground Interferometers

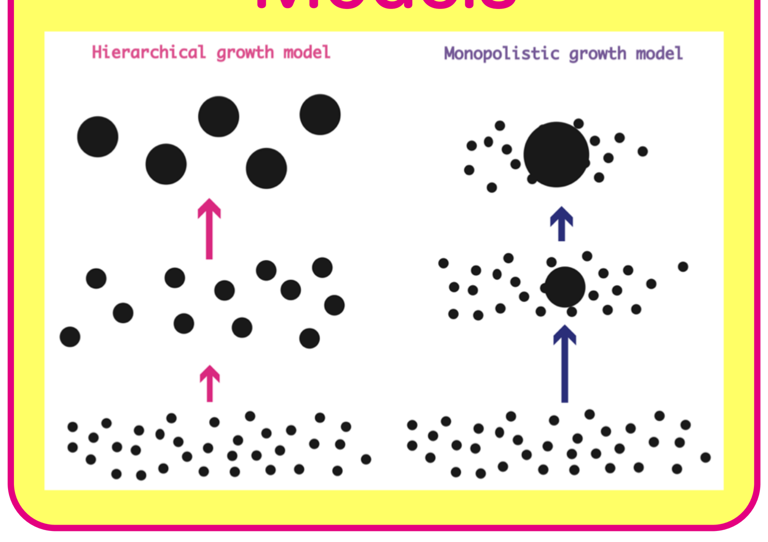




Signal-to-Noise Ratio at 1Gpc for BH Ringdown



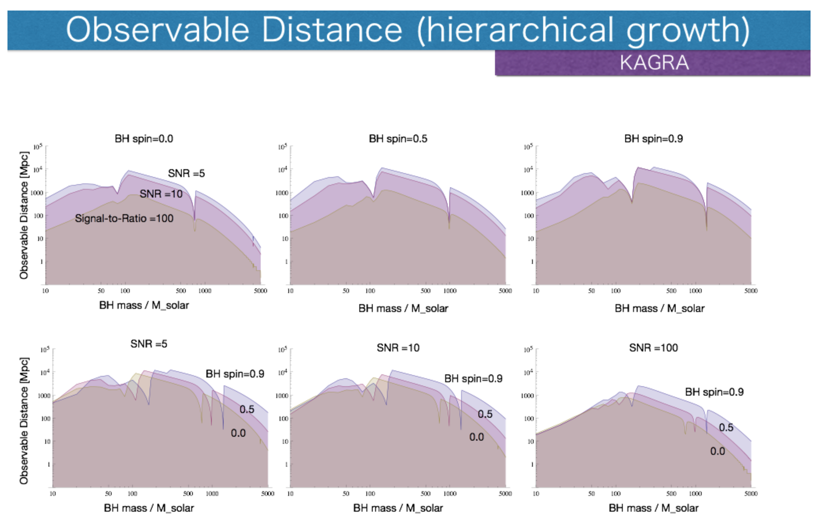
Models



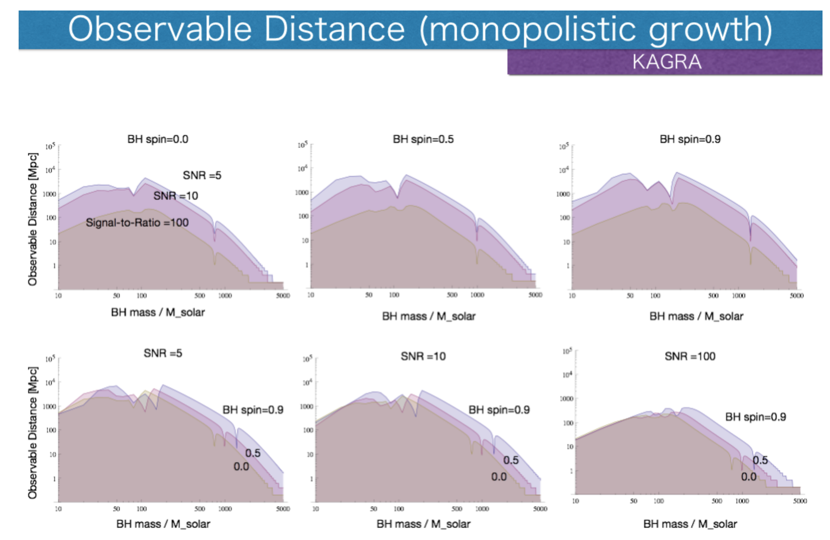
Signal-to-Noise Ratio

$$\langle\rho^2\rangle = \left(\frac{S}{N}\right)^2 = \frac{1}{20\pi^2}\frac{(1+z)Q\mathcal{A}^2}{f_{\rm qnr}S_h[f_{\rm qnr}/(1+z)]}\left[\frac{(1+z)M}{D(z)}\right]^2\left[\frac{4\mu}{M}\right]^2$$
$$= \frac{8}{5}\frac{1}{[1-0.63(1-a)^{0.3}]^2}\epsilon_r\frac{(1+z)M}{S_h[f_{\rm qnr}/(1+z)]}\left[\frac{(1+z)M}{D(z)}\right]^2\left[\frac{4\mu}{M}\right]^2$$

Observable Distance (hierarchical growth) — KAGRA



Observable Distance (monopolistic growth) — KAGRA



Event Rate

Miller (2002) ApJ 581, 438
Will (2004) ApJ 611, 1080
Fregeau + (2006) ApJ 646, L135

cosmological model

- H_0=72 km/s/Mpc
- $\Omega_{m0} = 0.27$, $\Omega_{k0} = 0$, and $\Omega_{d0} = 0.73$.

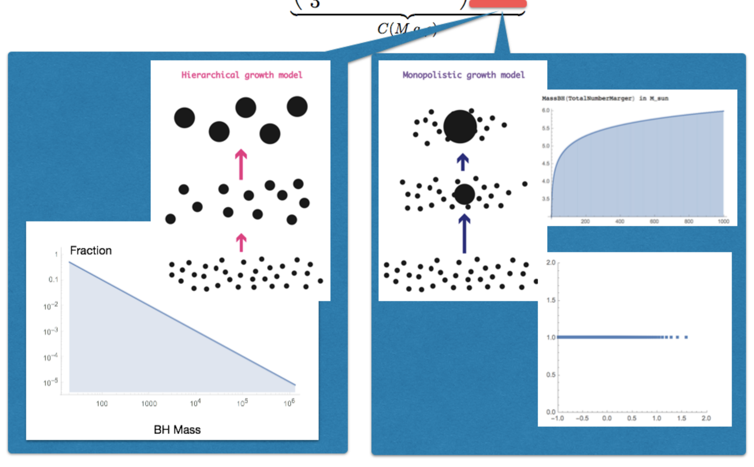
$$R(M,a,\rho) = \underbrace{\left(\frac{4\pi}{3}n_{gc}d_L(M,a,\rho)^3\right)f(M)}_{C(M,a,\rho)}\nu(M,\mu) \quad (1)$$

where

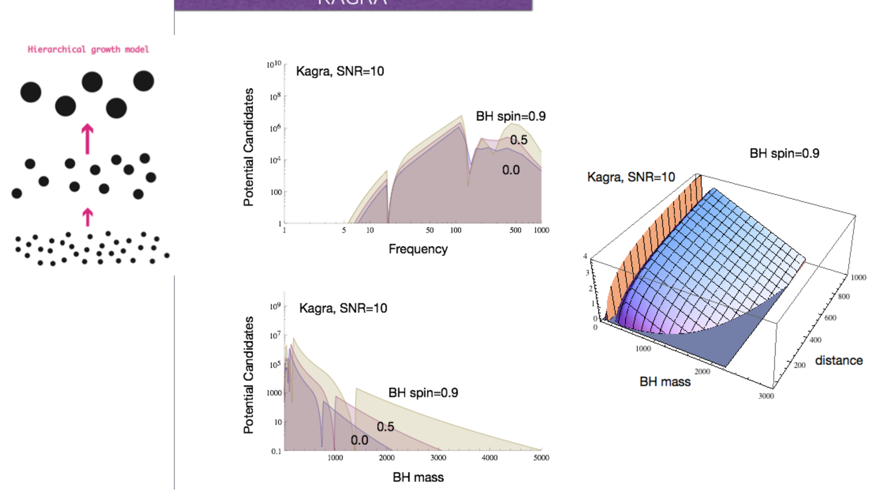
- $d_L(M,a,\rho)$ is the distance reached for a given SNR ρ as a function of total mass M, and spin of BH a. (model factor)
- $n_{gc} = 8h^3$ Mpc^{-3} is the number density of globular cluster.
- $f(M)$ is the fraction of globular clusters. (model factor)
- $\nu(M) = 10^{-10}M/\mu$ [/yr] is the rate of small mass BH merge with BH of mass M. (unknown factor)

Fraction Rate

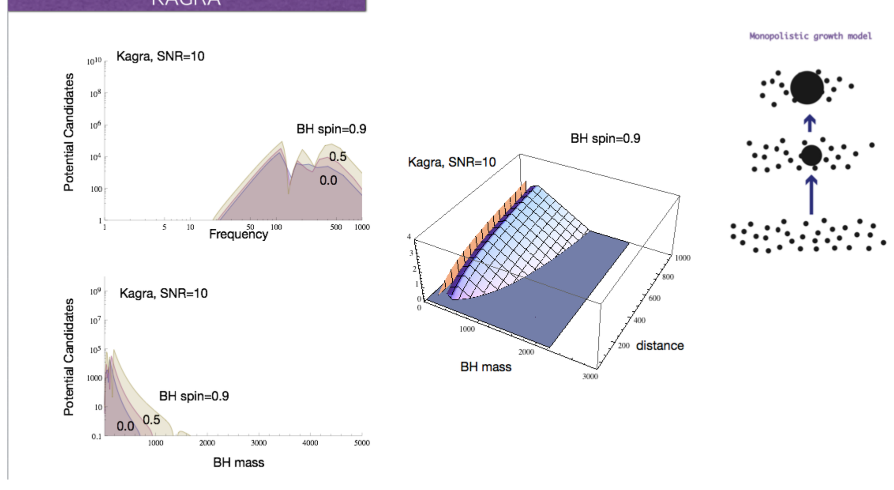
$$R(M,a,\rho) = \underbrace{\left(\frac{4\pi}{3}n_{gc}d_L(M,a,\rho)^3\right)f(M)}_{C(M,a,\rho)}\nu(M,\mu)$$



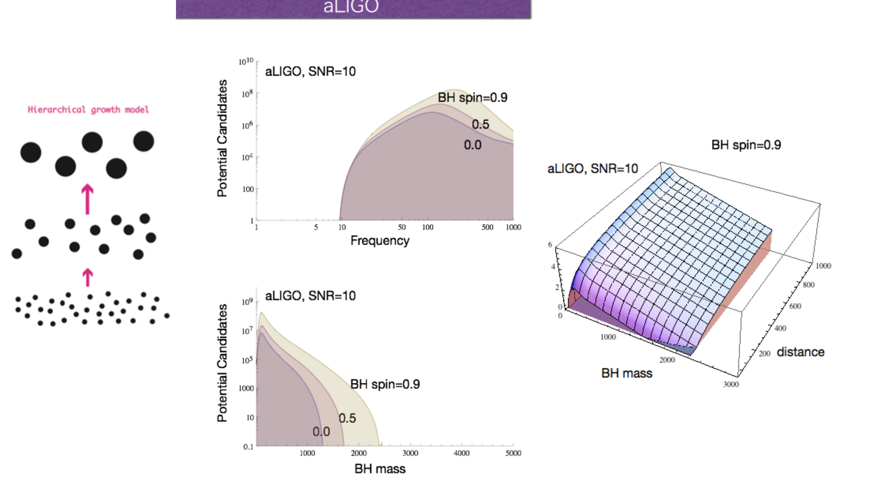
Potential Candidates (hierarchical growth) — KAGRA



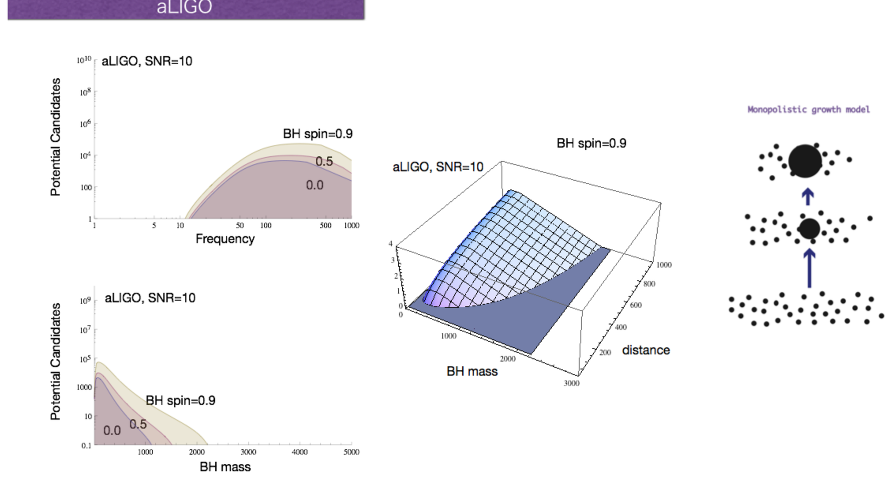
Potential Candidates (monopolistic growth) — KAGRA



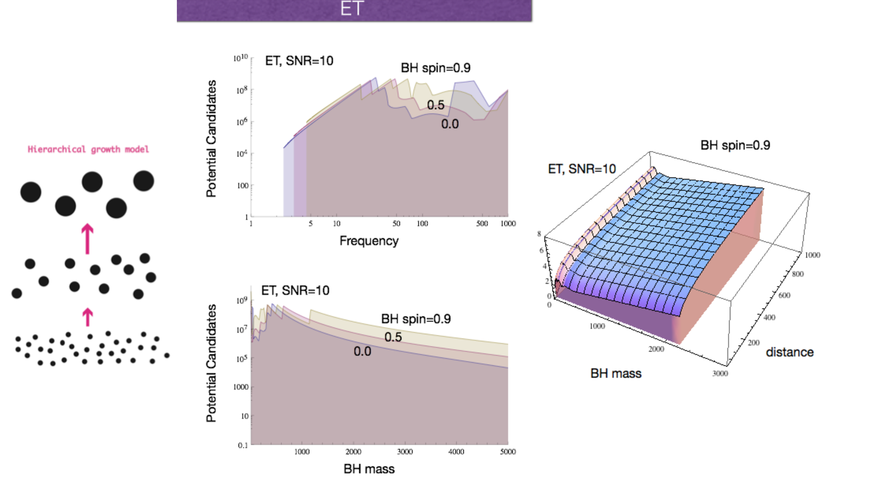
Potential Candidates (hierarchical growth) — aLIGO



Potential Candidates (monopolistic growth) — aLIGO



Potential Candidates (hierarchical growth) — ET



Potential Candidates (monopolistic growth) — ET