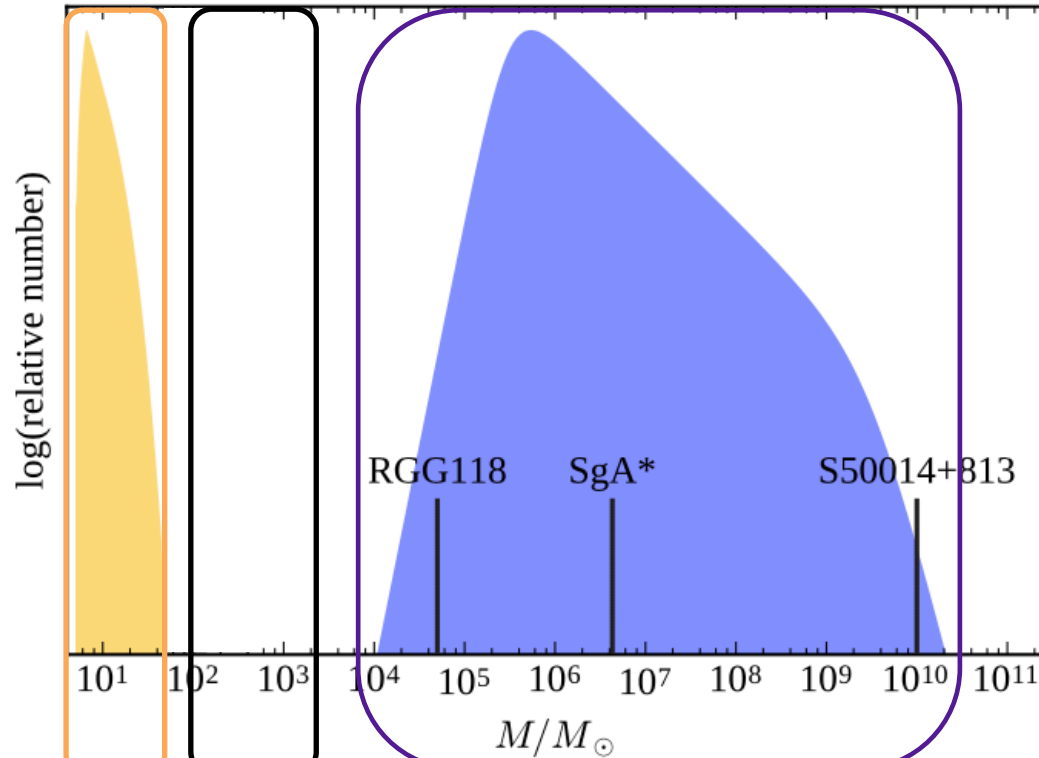


Massive black hole binaries in the cosmos

Marta Volonteri
Institut d'Astrophysique de Paris

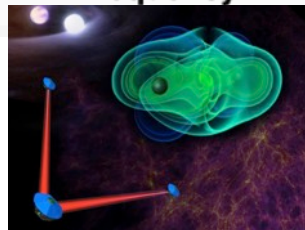
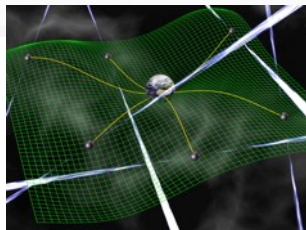
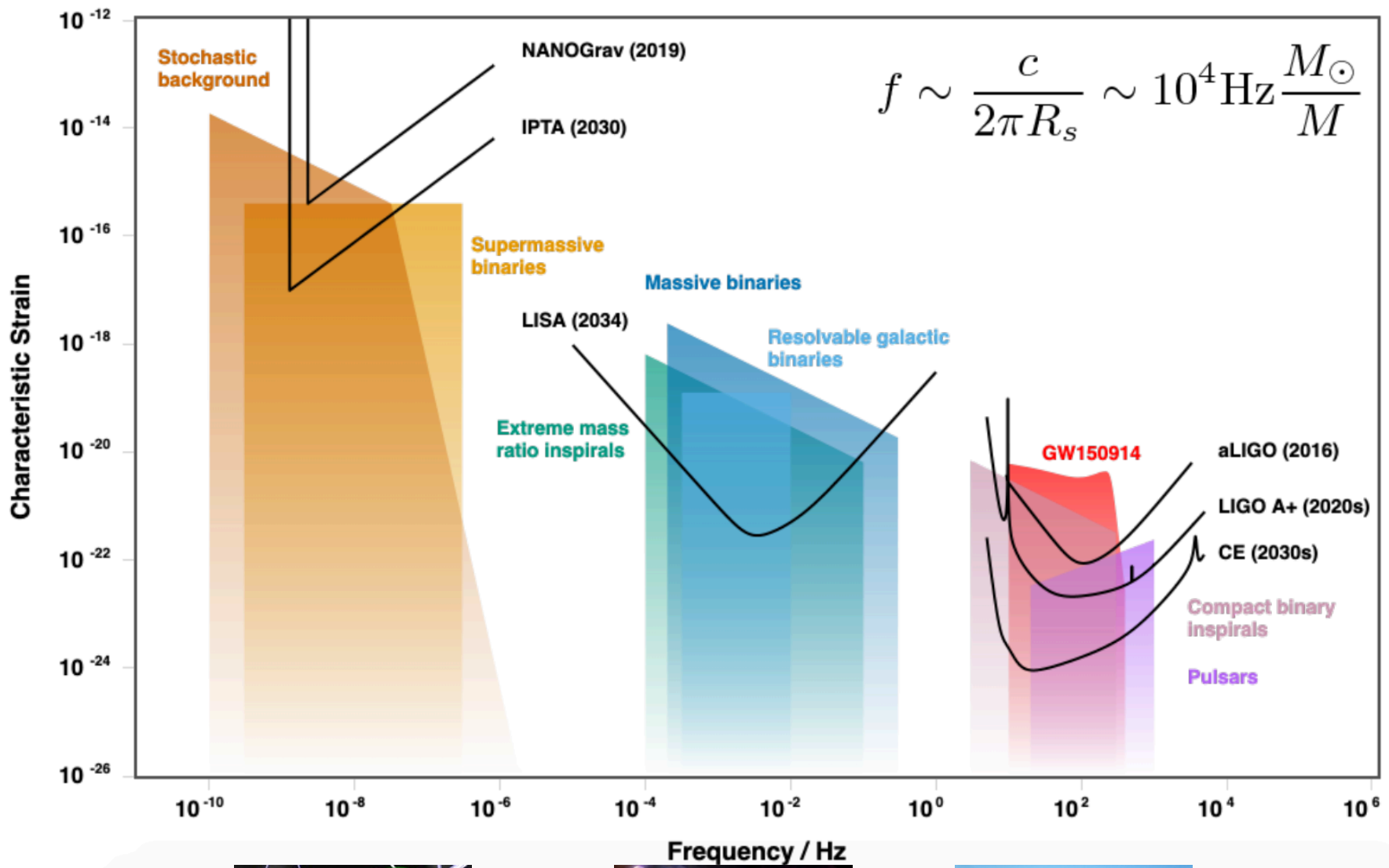
Black Holes in the Universe



Stellar mass black holes

Massive black holes

Something in between?



What can GWs do for MBHs?

What can we infer about the black hole population from the full set of events/background observed by LISA or PTAs?

Use observed distribution of source parameters to compare with models. Which model provides the better explanation of the data?

Arun+2008, Sesana, Gair, Berti, MV 2011;
Sesana 2008, 13; Ravi+2012, 15; Kulier+14;
McWilliams+14



Massive black holes and gravitational waves

How many galaxies host MBHs

→ when, where, how they form

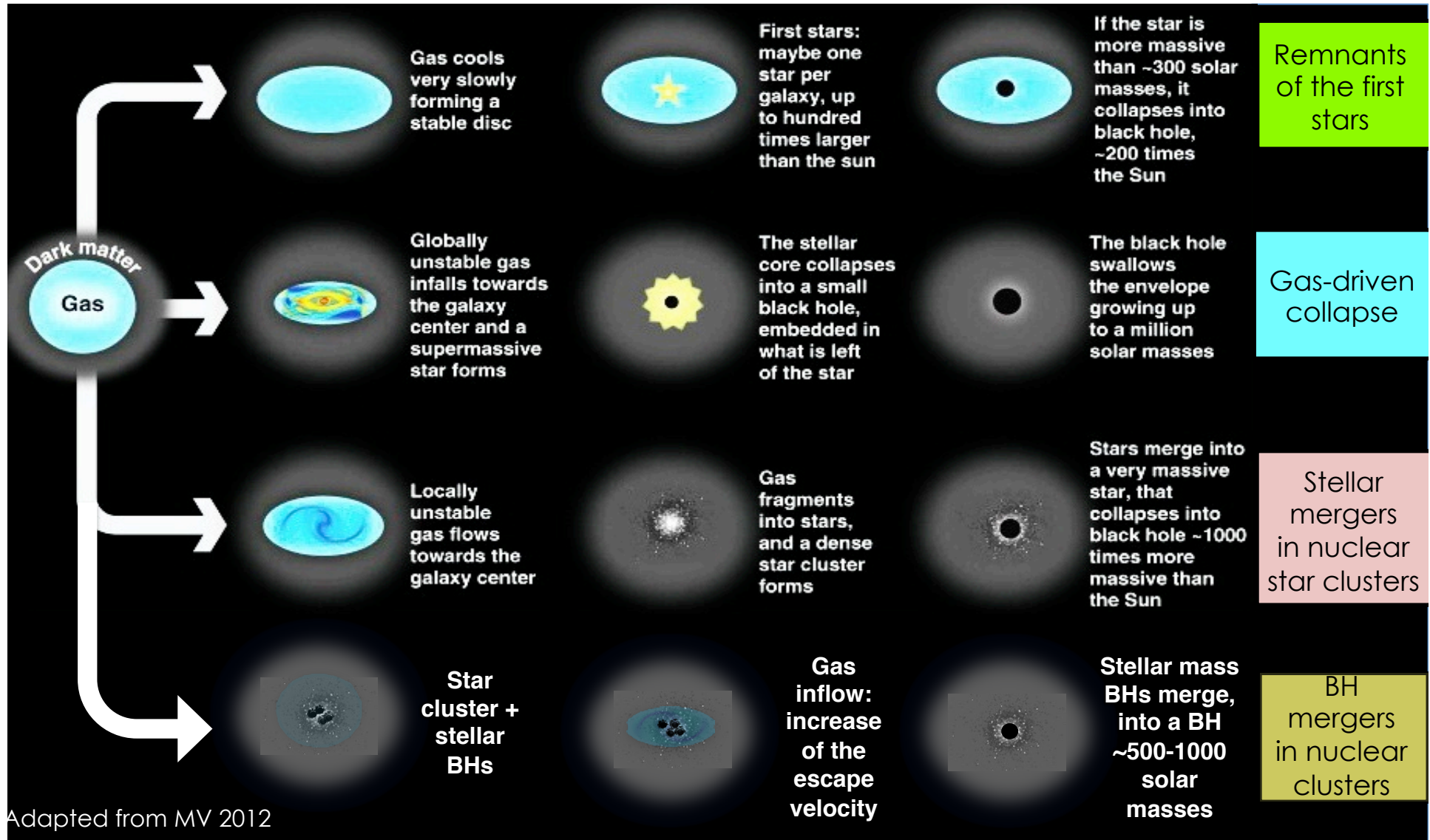
How MBHs grow in mass over time

→ accretion vs MBH-MBH mergers

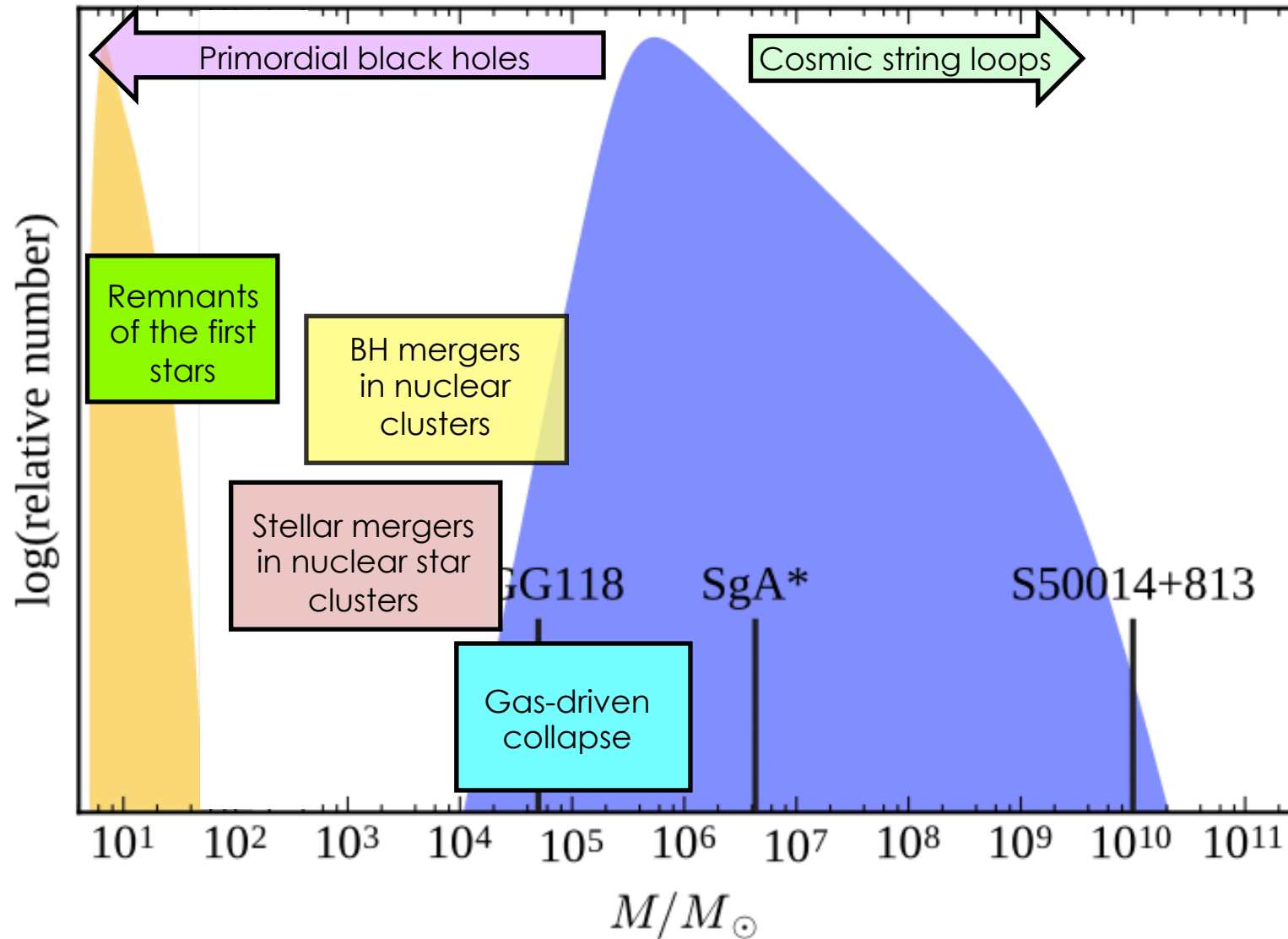
How long it takes for MBHs to merge in halo/
galaxy merger

→ dynamics of MBHs in mergers

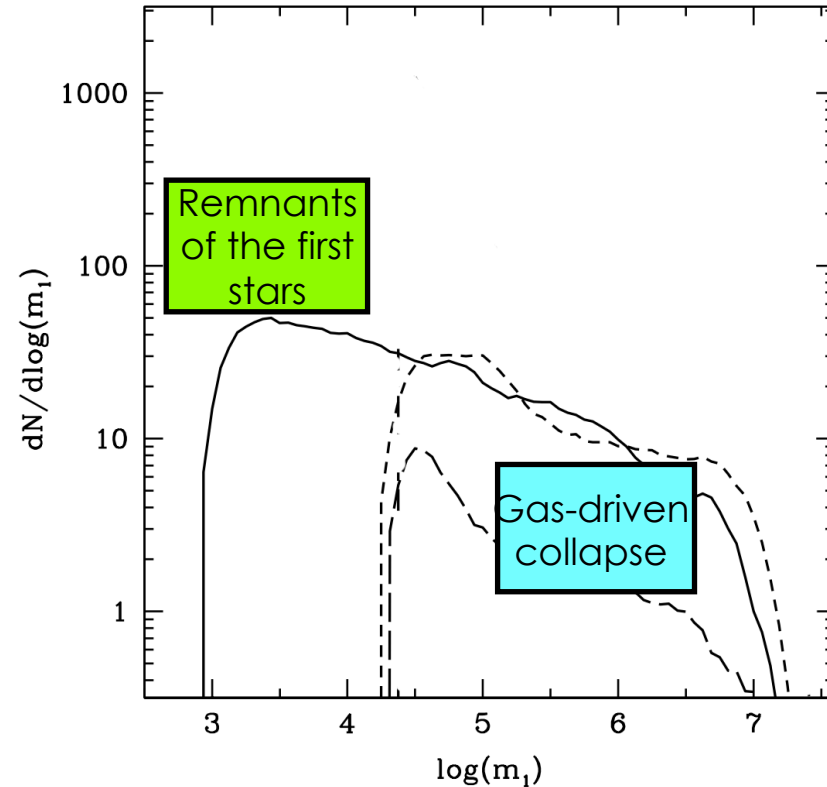
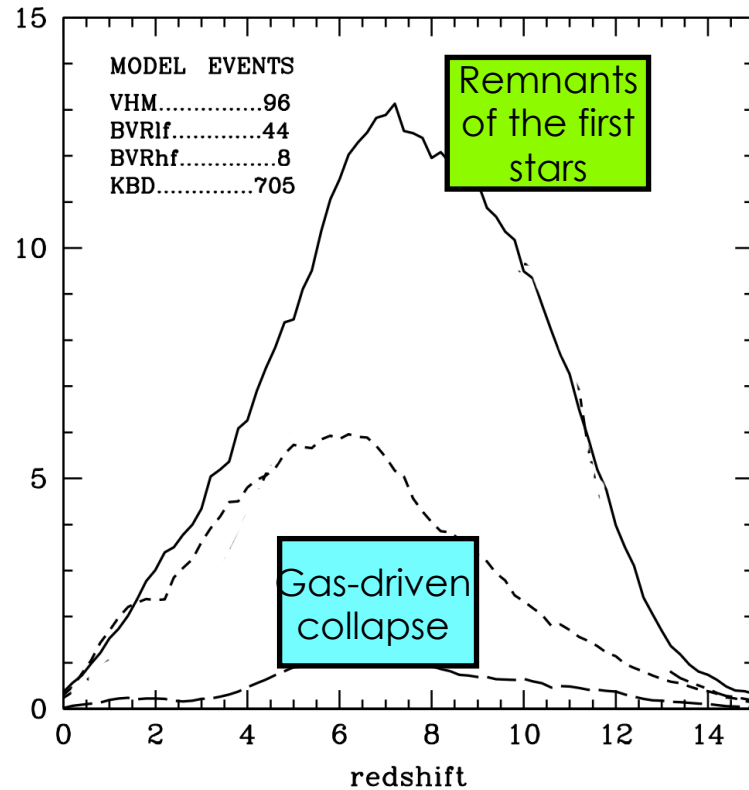
The formation of massive black holes



Massive black hole “seeds”

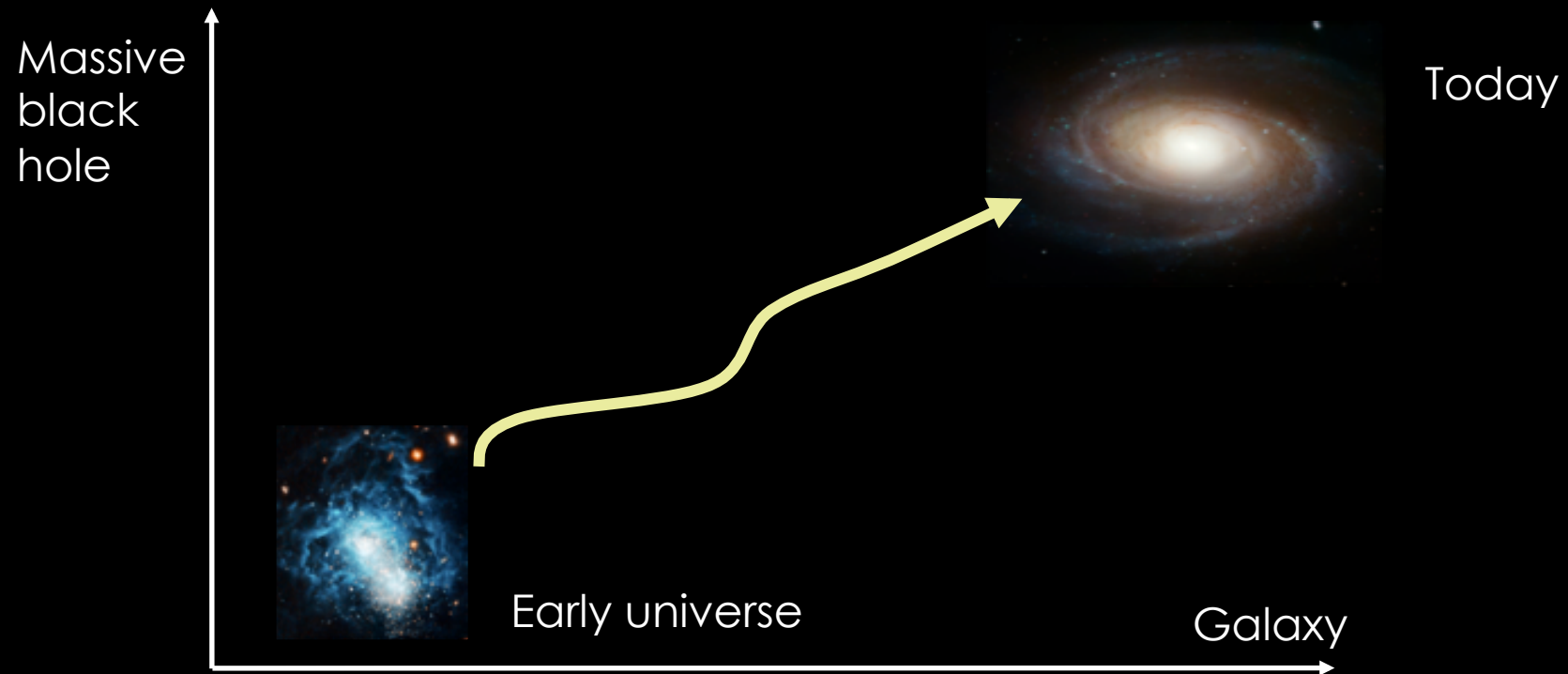


Massive black hole formation and LISA



The mass and frequency in galaxies of MBH seeds is a key ingredient for understanding the shape of the redshift and mass distributions of the merger rate

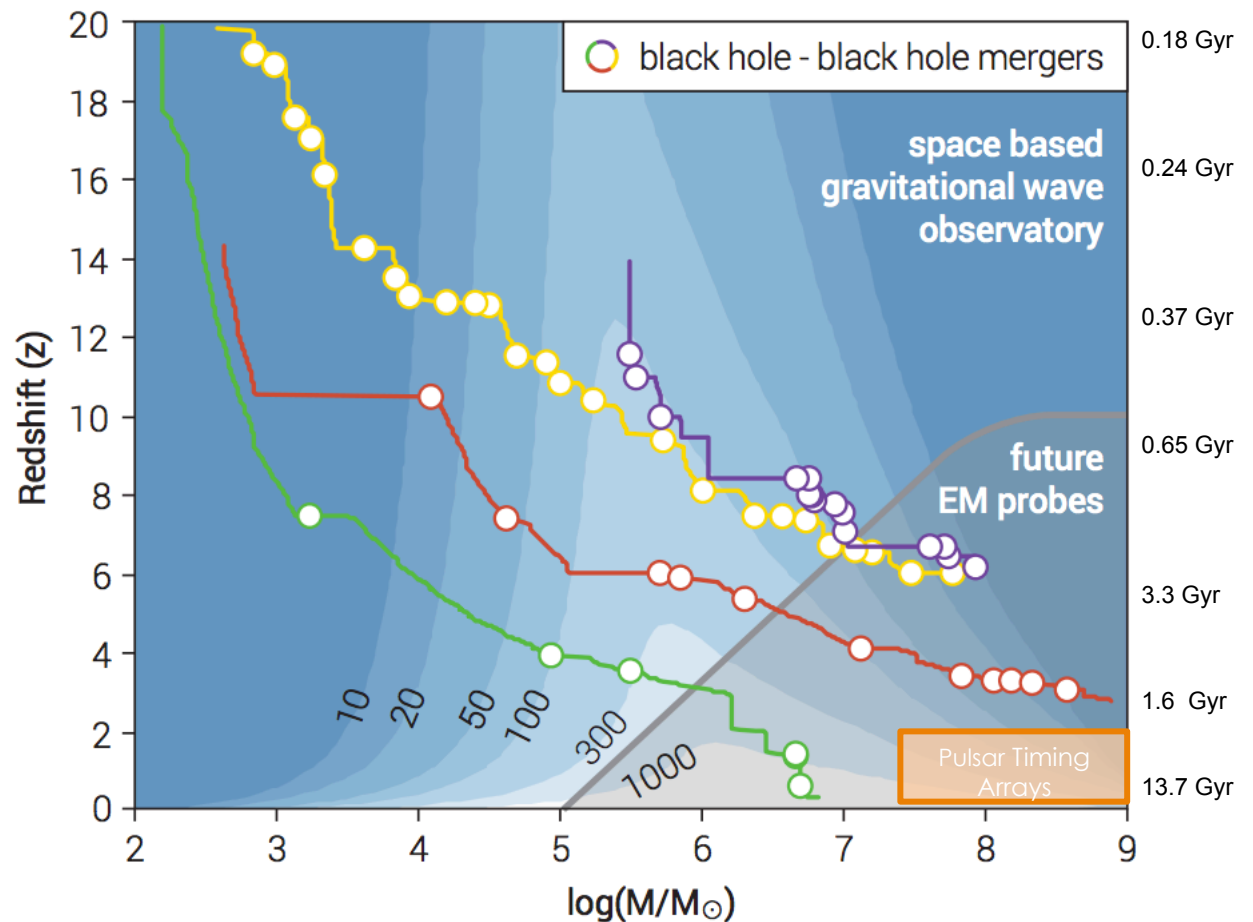
The evolution of black holes in galaxies



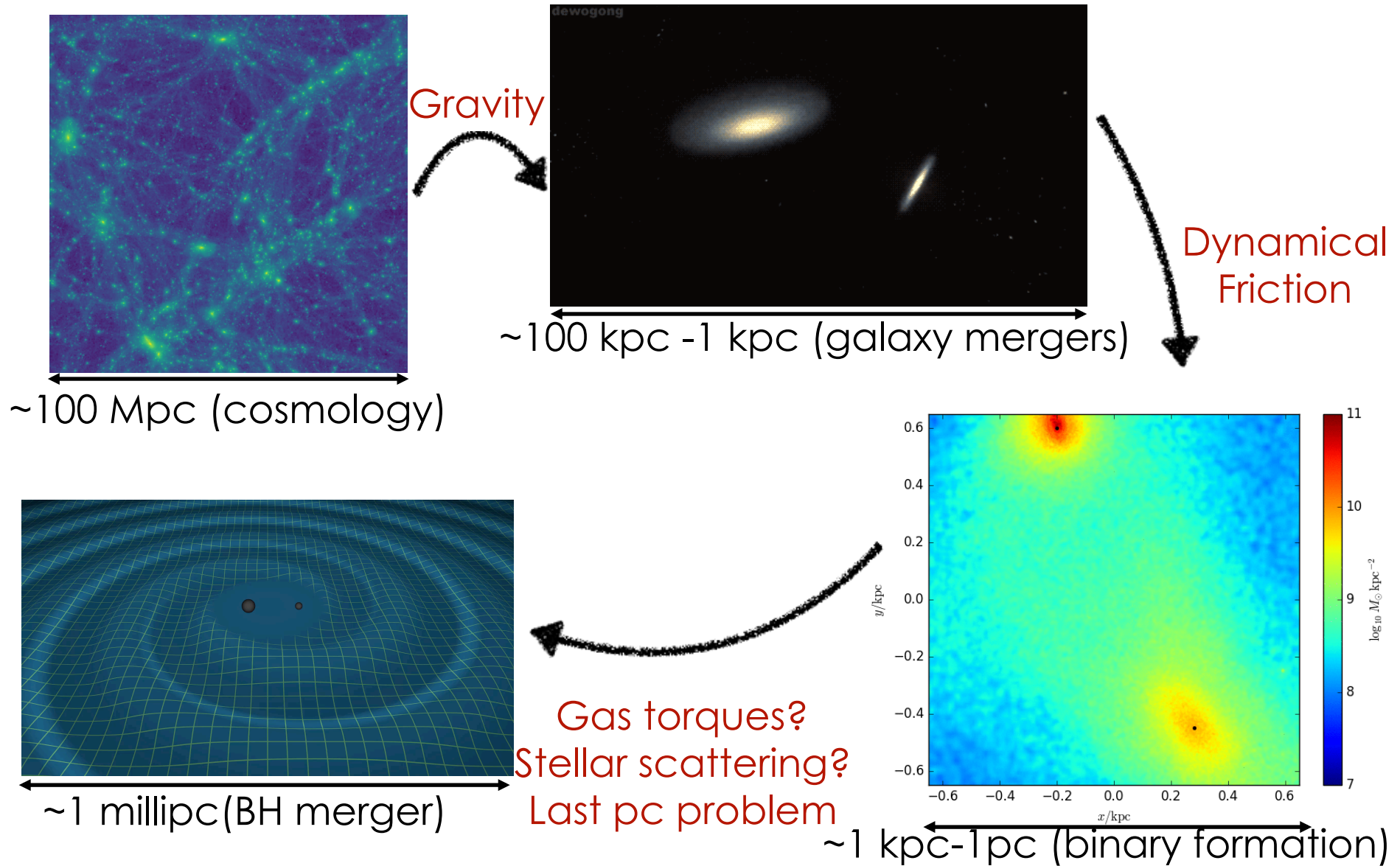
Massive black holes and gravitational waves

MBHs grow along with galaxies through accretion and MBH-MBH mergers

LISA can see black holes at very very early cosmic times: when they form



The journey of two black holes



Courtesy of Hugo Pfister

Summary

A combination of electromagnetic probes and gravitational waves are a unique way of probing massive black hole formation, evolution and dynamics

Full “merger rate” predictions still have large uncertainties – be careful when you pick a merger rate!



GAS



STARS