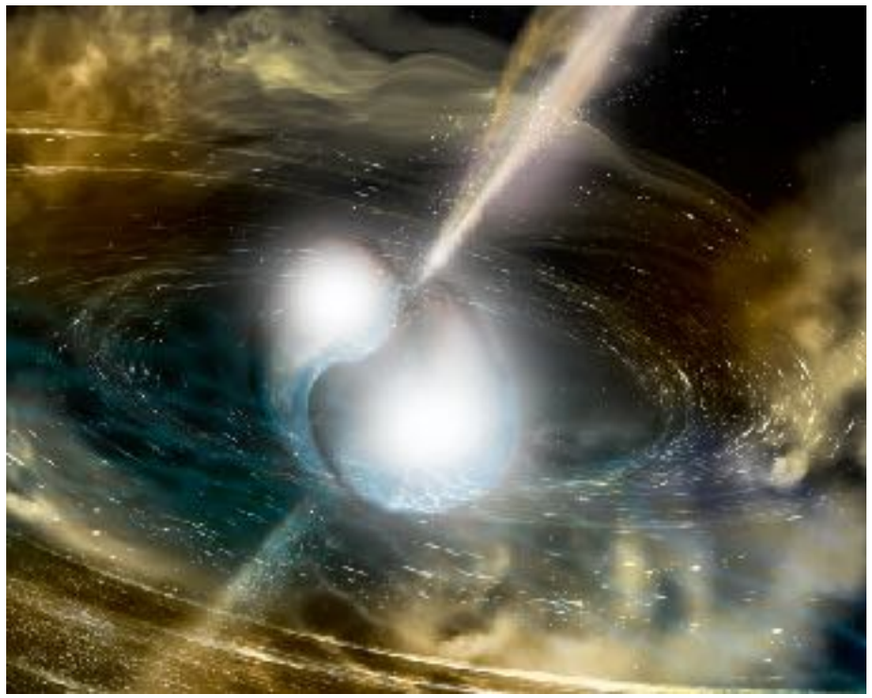
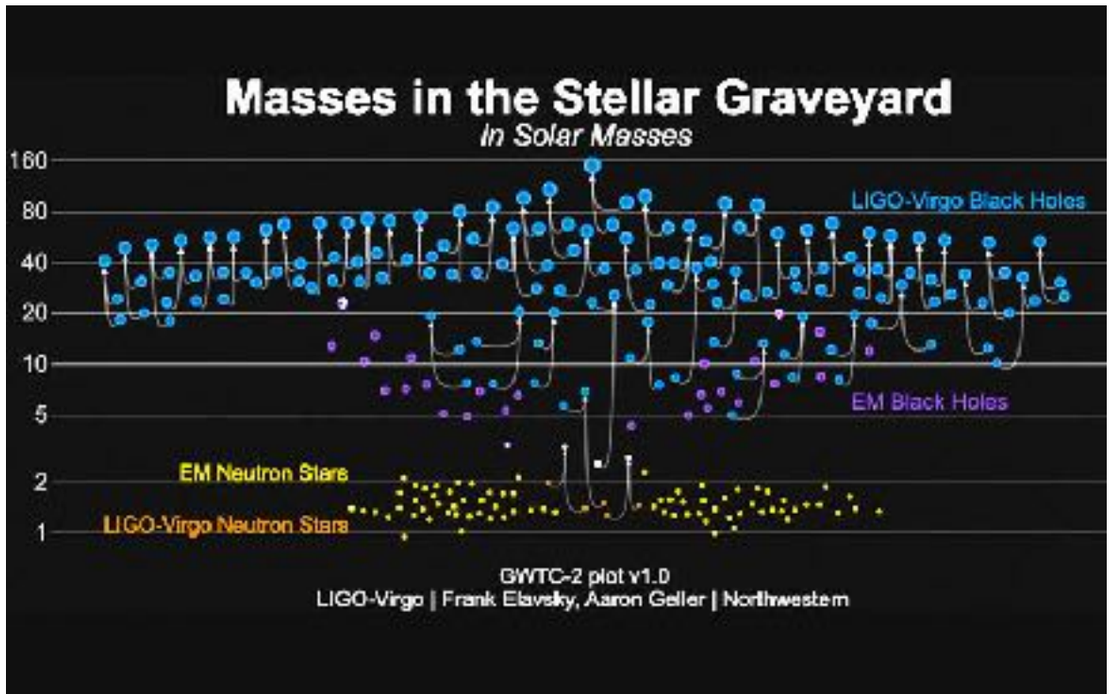
ASTROPHYSICAL POPULATIONS WITH EINSTEIN TELESCOPE



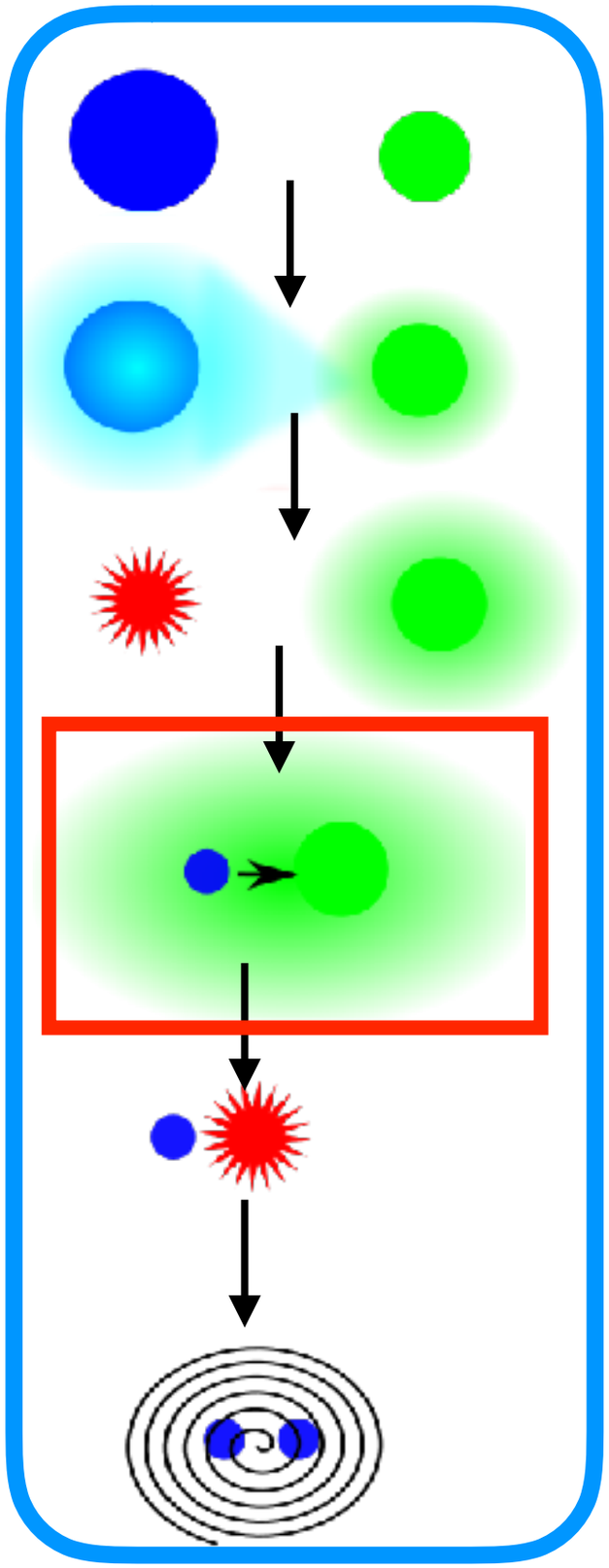


Astrid Lamberts
Observatoire de la Côte d'Azur

(with lots of input from Michela Mapelli,Padova University & INFN)

ET France workshop - Feb. 4 2021

WHERE WE STAND: FORMATION CHANNELS

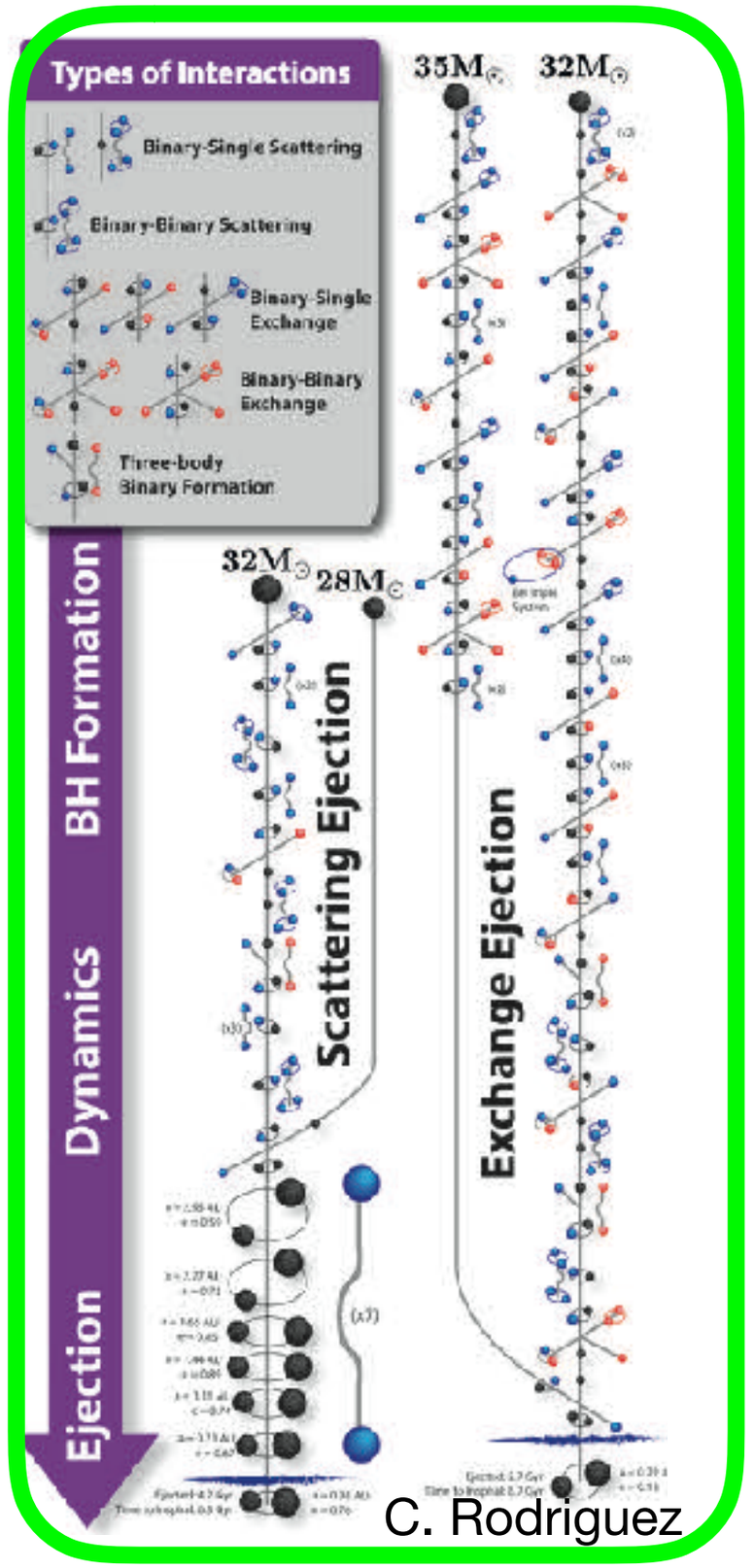


Isolated binary evolution (including chemically homogeneous evolution)

Young star clusters

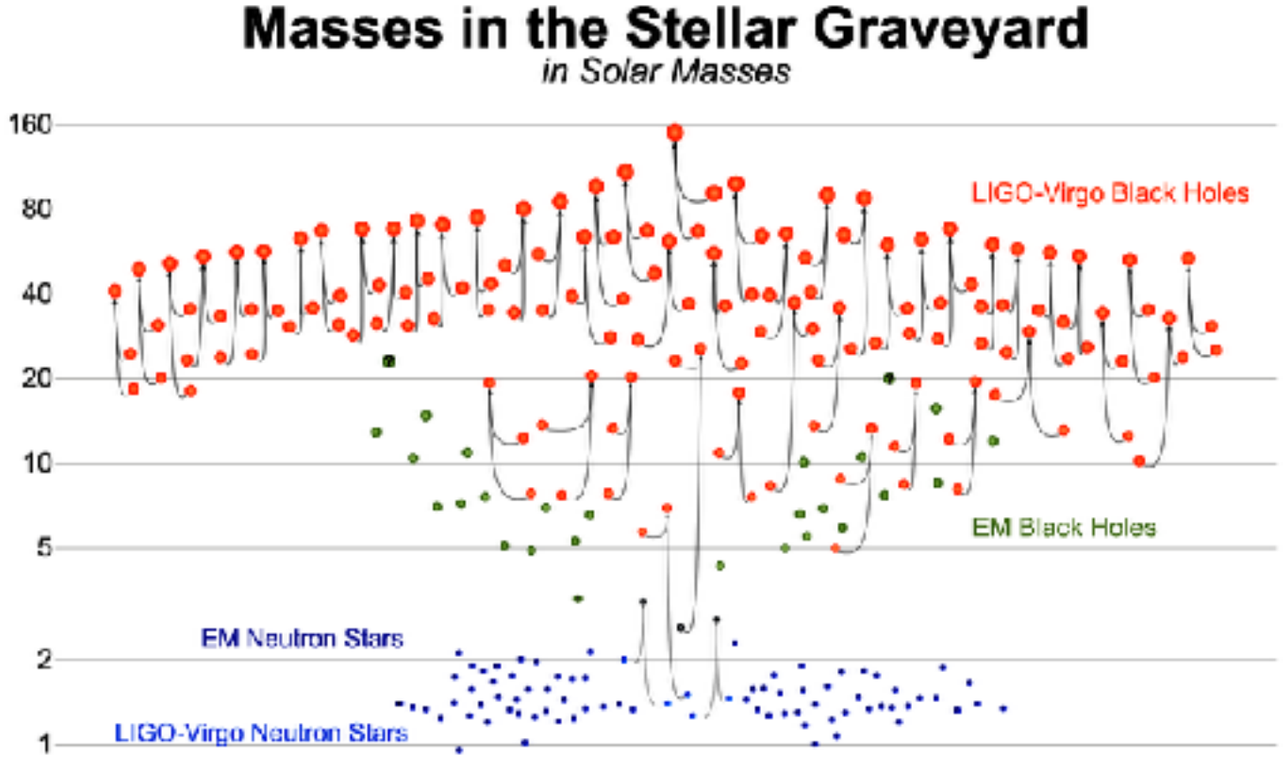
Globular clusters

Others: AGN disks, triples, nuclear star clusters



C. Rodriguez

WHERE WE STAND: MASS SPECTRUM

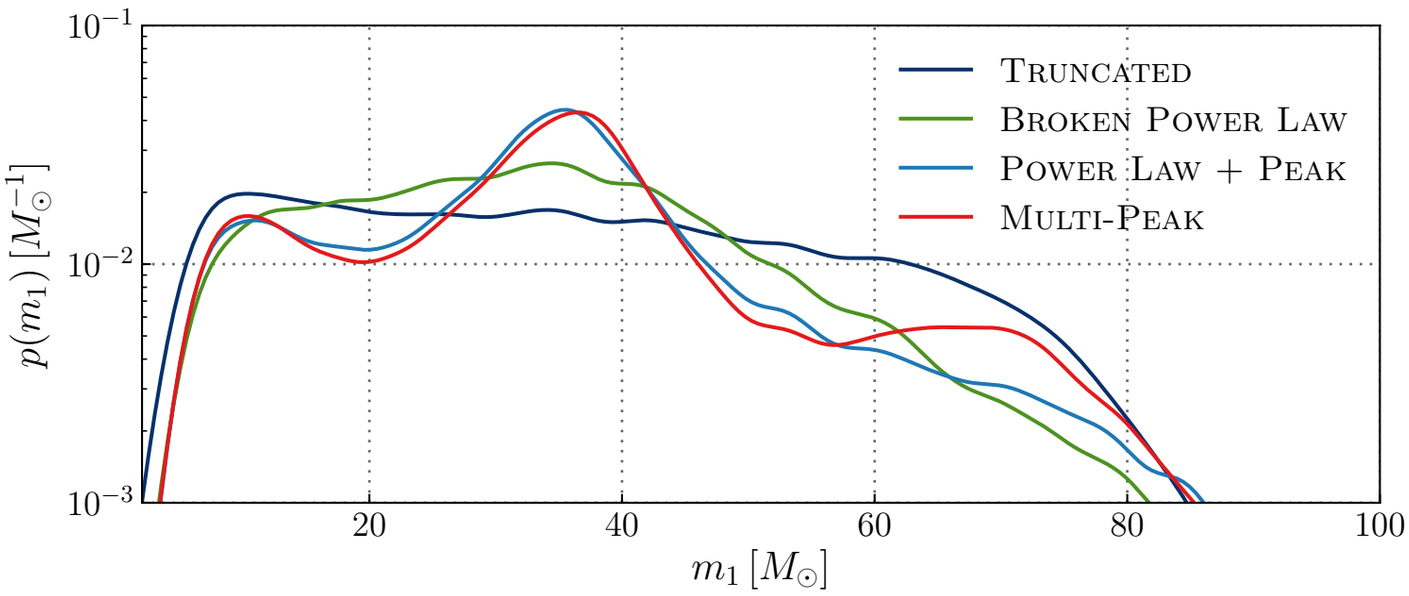


- first unequal masses
- Massive BHs
- Lower mass gap object
- BNS masses differ from MW

GWTC-2 plot v1.0
LIGO-Virgo | Frank Elavsky, Aaron Geller | Northwestern

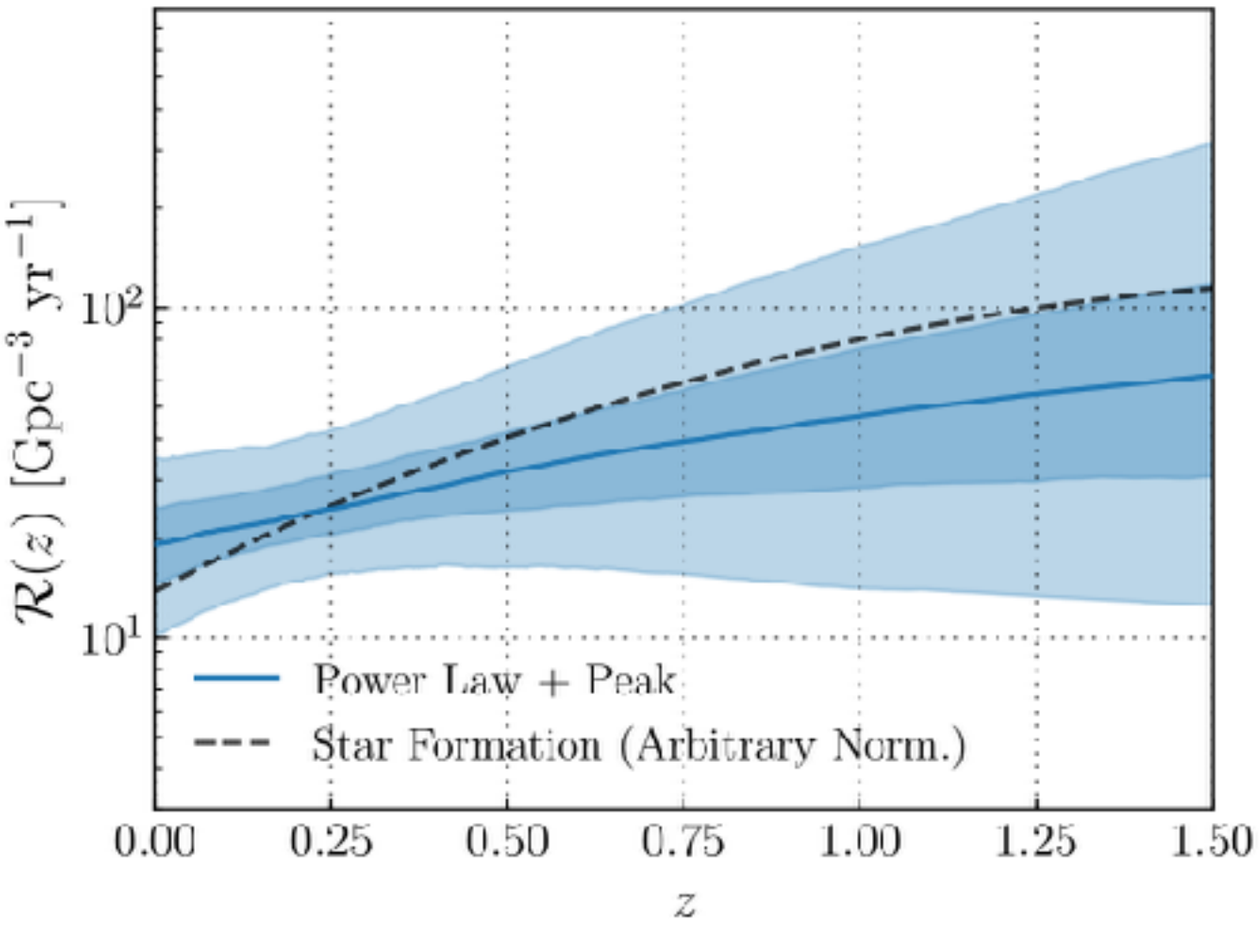
O3a
Observed mass spectrum
- Peak 35-40 Msun
- Decrease >60 Msun
- Cutoff <8 Msun

LVC: GWTC-2 populations paper



WHERE WE STAND: REDSHIFT EVOLUTION

Merger rate density of BBHs from GWTC2
(Abbott et al. 2020, arXiv:2010.14533)

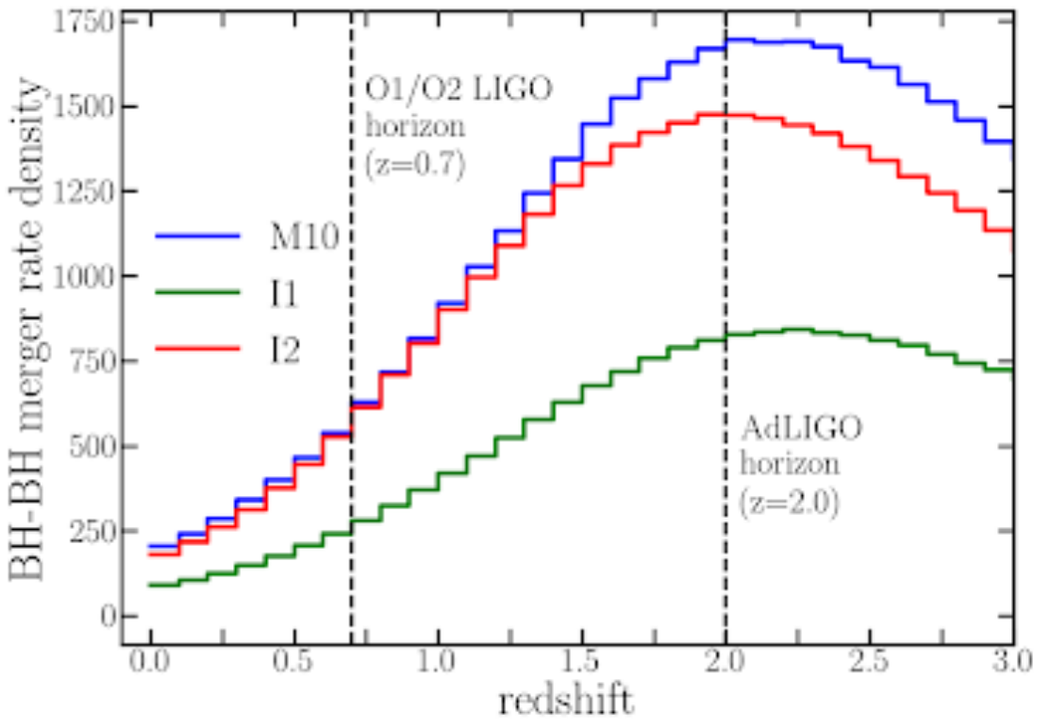


First measurement for BBHs:
z-evolution consistent with evolution of star formation rate

Not sensitive enough for BNS z-evolution

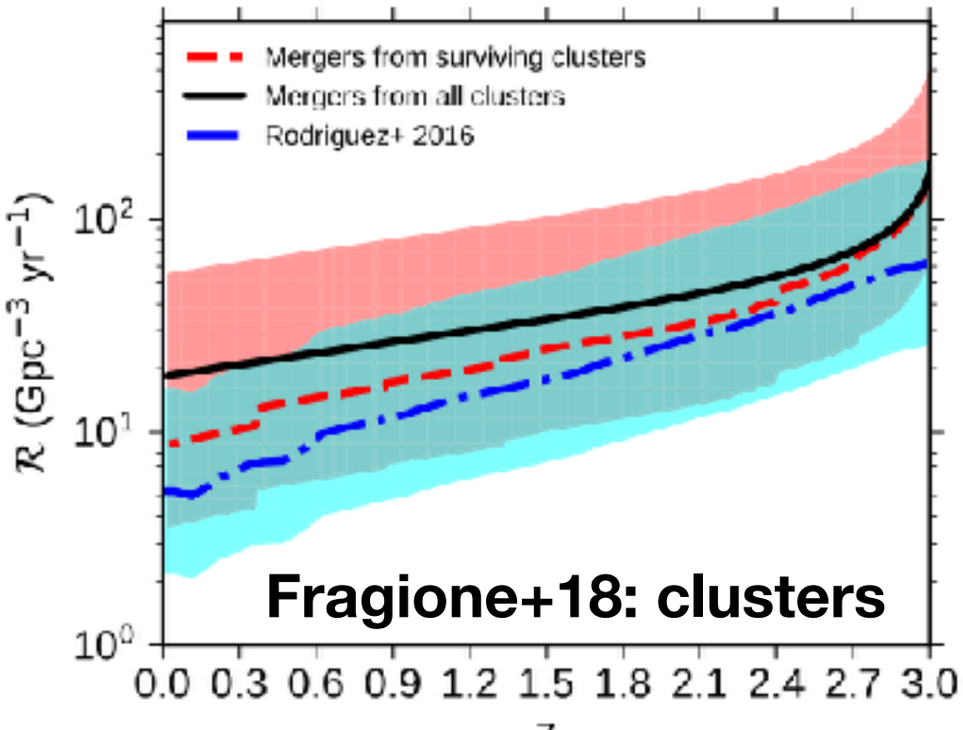
WHERE WE STAND: REDSHIFT EVOLUTION

Klencki+18: different binary models



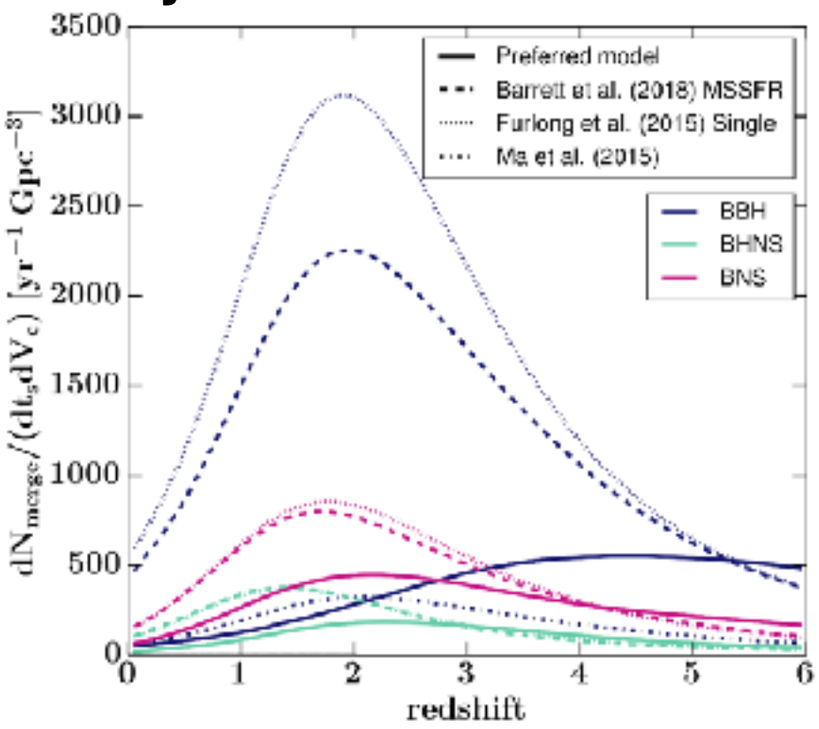
Models: Major uncertainties, owing to formation channels and star formation/metallicty model

2G detectors will partially solve the question



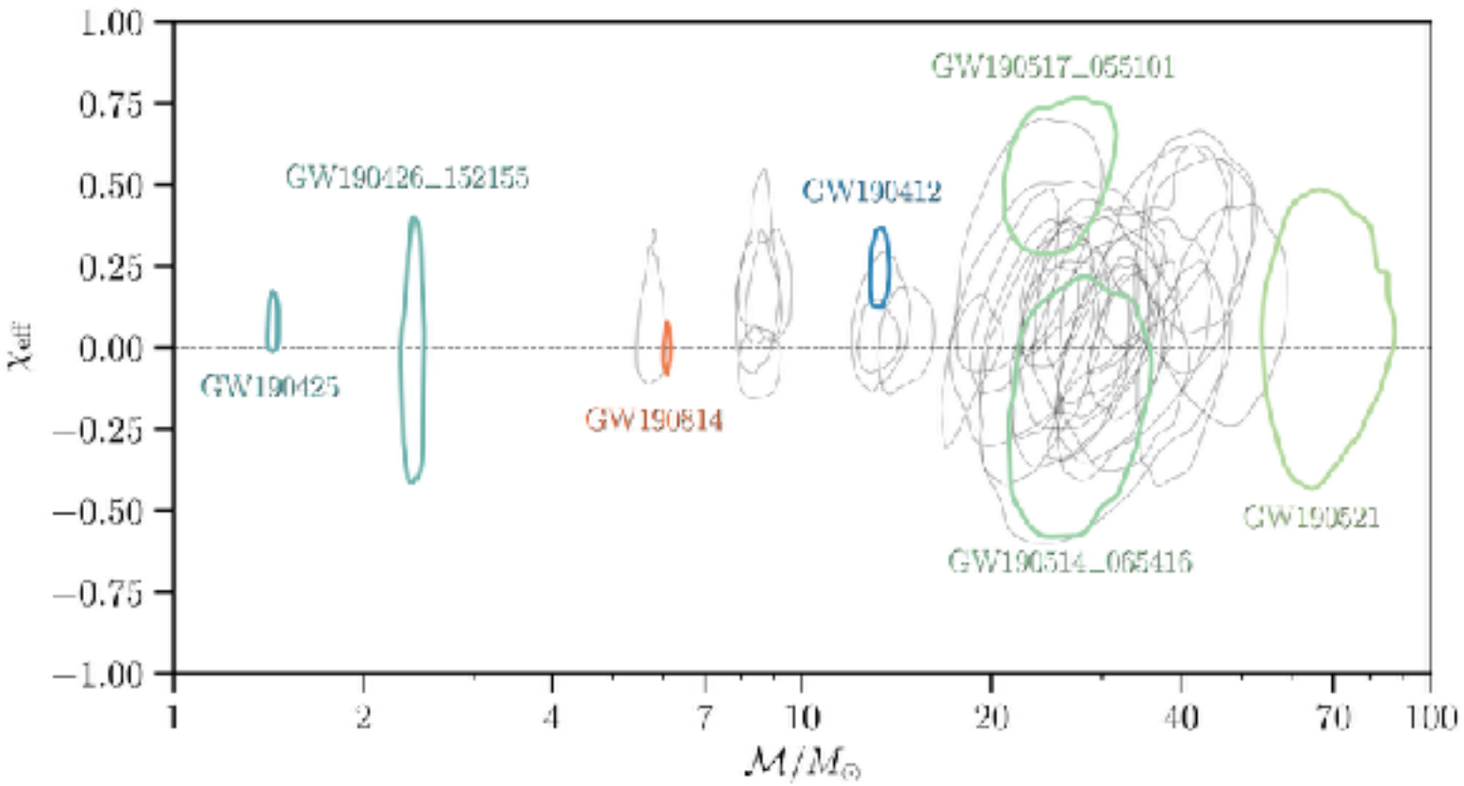
Fragione+18: clusters

Neijssel+19: different SFR



WHERE WE STAND: SPINS

Spin aligned with orbit versus Mchirp in GWTC2



- Some systems have mis(anti)-aligned: challenge for isolated binary channel

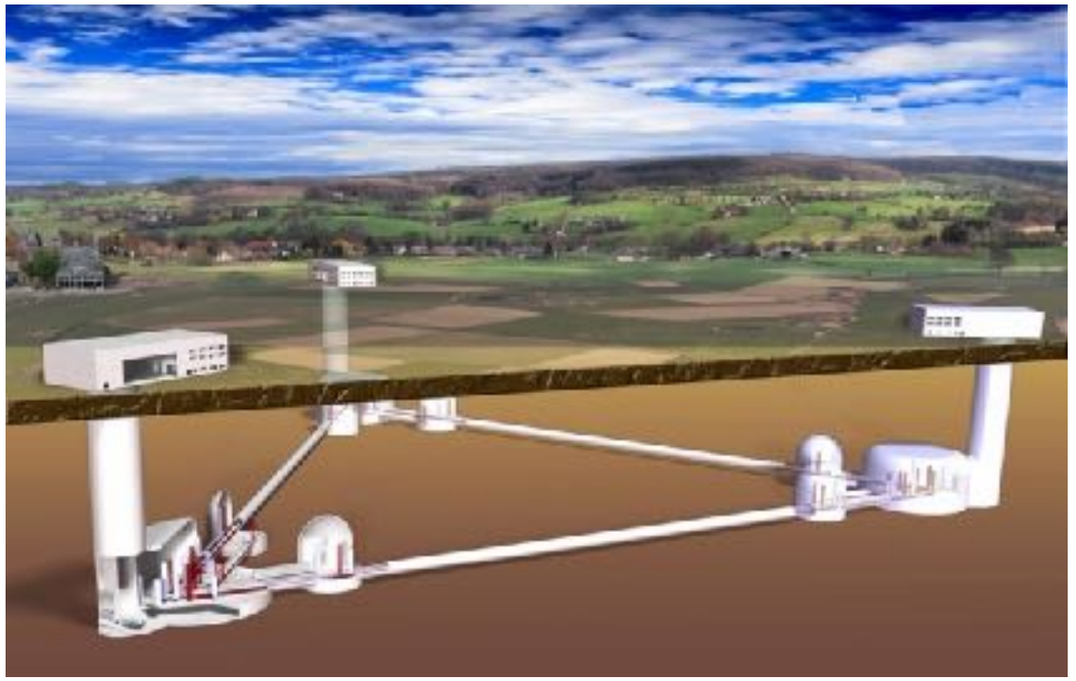
- Some systems have precession

- Some systems have non-zero aligned spin : isolated binary formation channel

=> (at least) two formation channels?

Hard to model properly (angular momentum transfer, Belczynski+20)

THE EINSTEIN TELESCOPE REVOLUTION



A world of new possibilities, much beyond what Virgo/LIGO/KAGRA will do

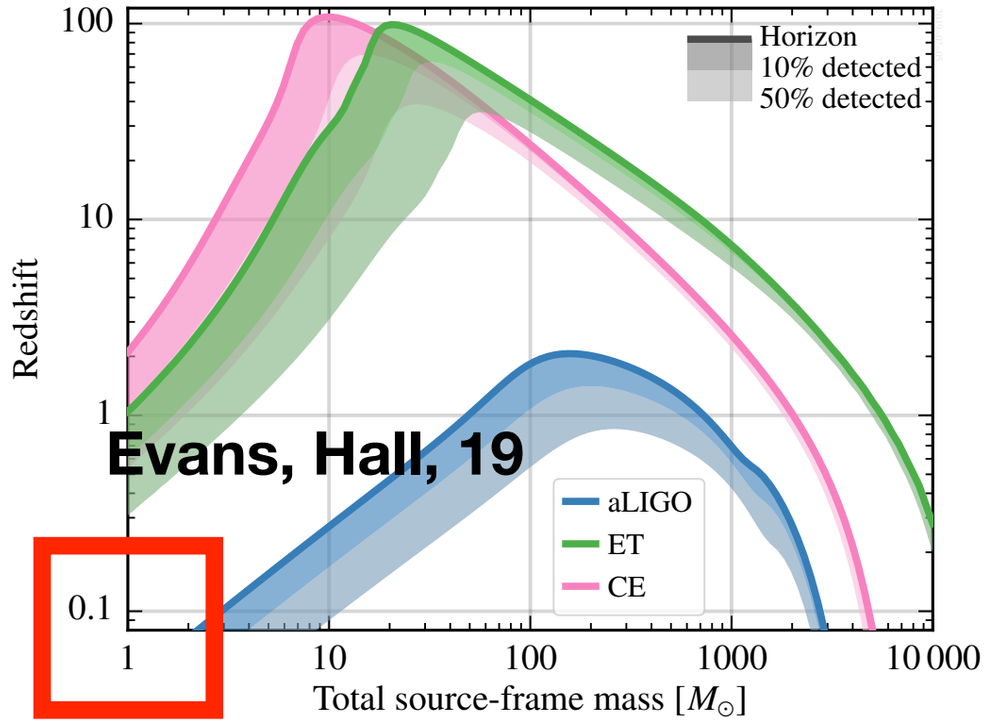
Discovery/understanding based on

Intrinsic properties (mass, spin)

Environmental properties (redshift, localisation)

INTRINSIC: BBH MASS SPECTRUM

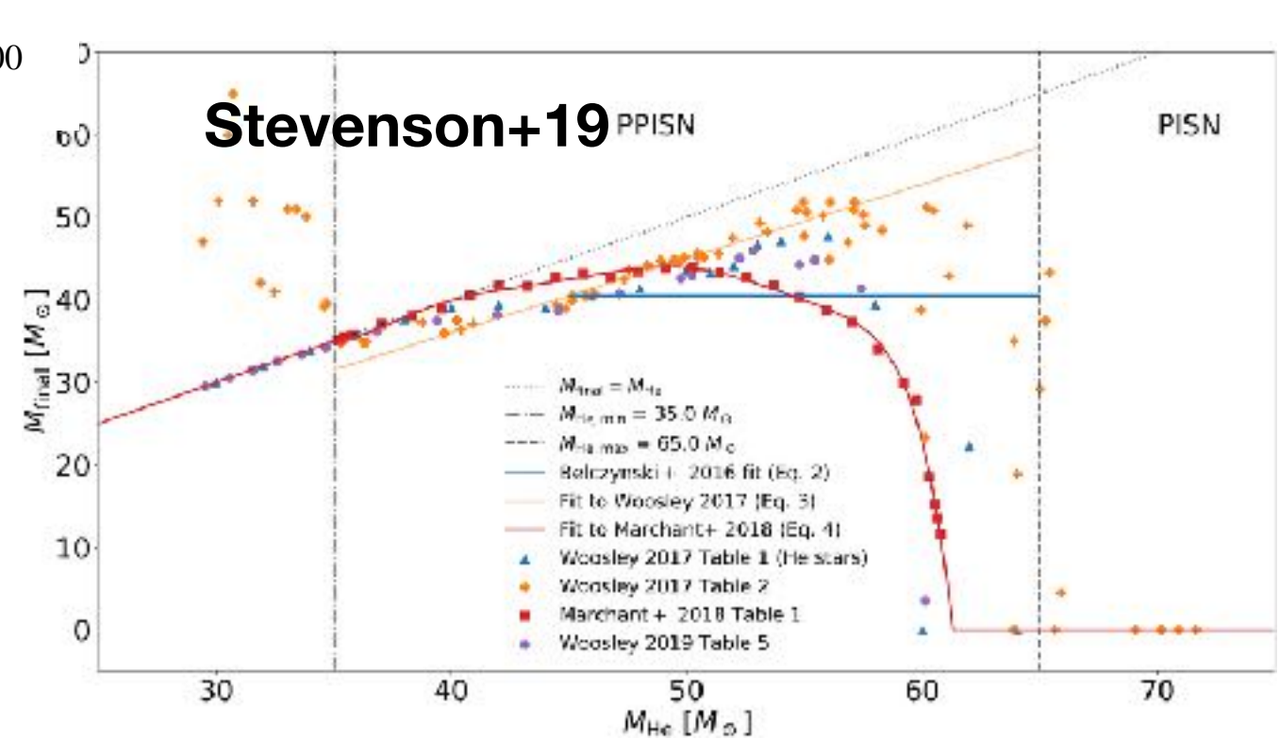
1 BBH merger every 15 minutes (10^6/yr)



Confirmation/contours of lower mass gap? (may be found by 2G)

PISN mass gap (and z-evolution?):

(Woosley 2017, 2019; Belczynski et al. 2016; Spera & MM 2017; Giacobbo et al. 2018; Marchant et al. 2018, 2019, 2020; Stevenson et al. 2019; MM et al. 2020; Farmer et al. 2019, 2020; Farrell et al. 2020; Costa et al. 2020; Tanikawa et al. 2020)



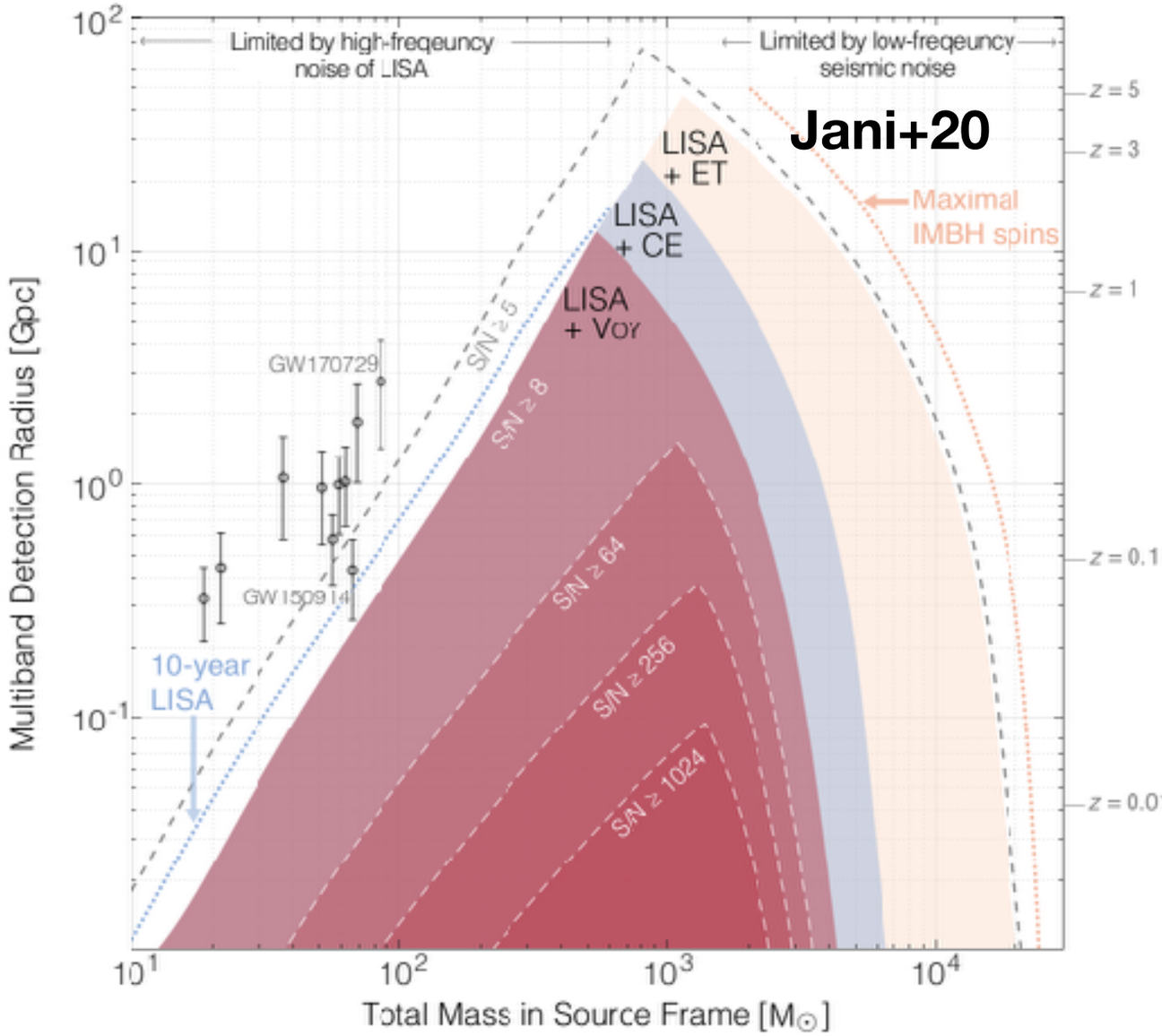
INTRINSIC: BBH MASS SPECTRUM

Sub-solar mass black-hole: smoking gun for primordial BH

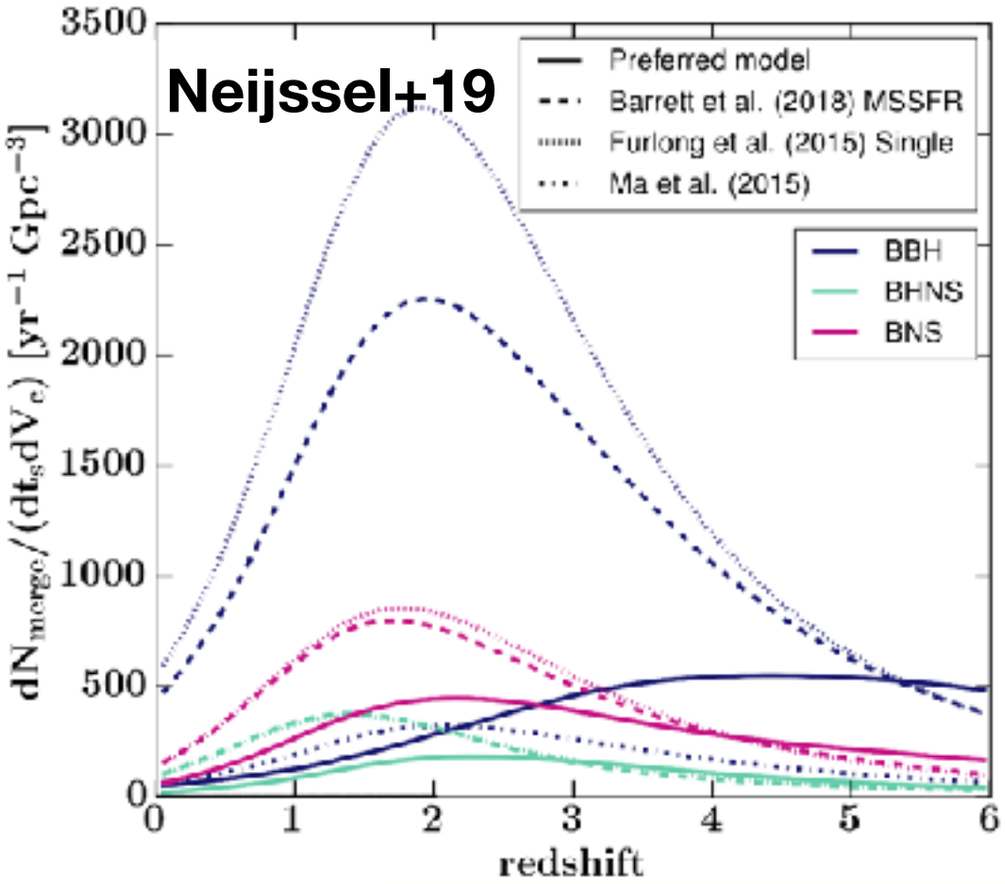
Intermediate mass black holes:

Mass spectrum, z evolution

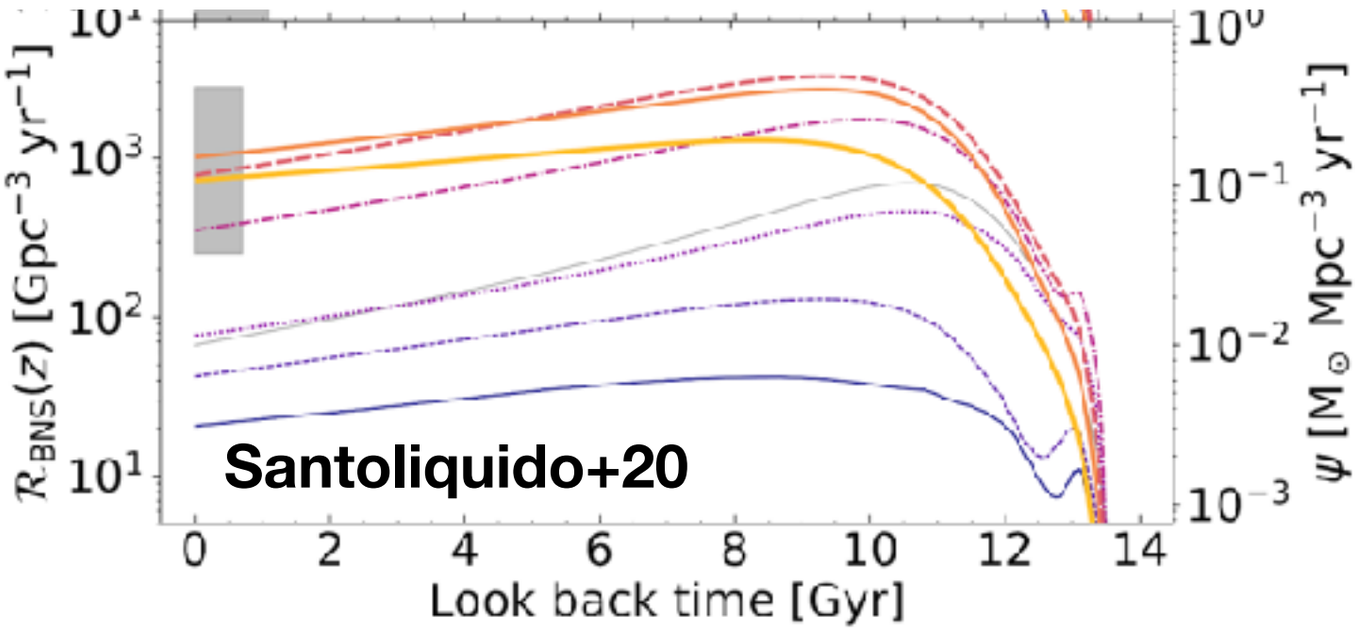
-> formation channels



INTRINSIC: BNS UP TO Z~2



Varying common envelope



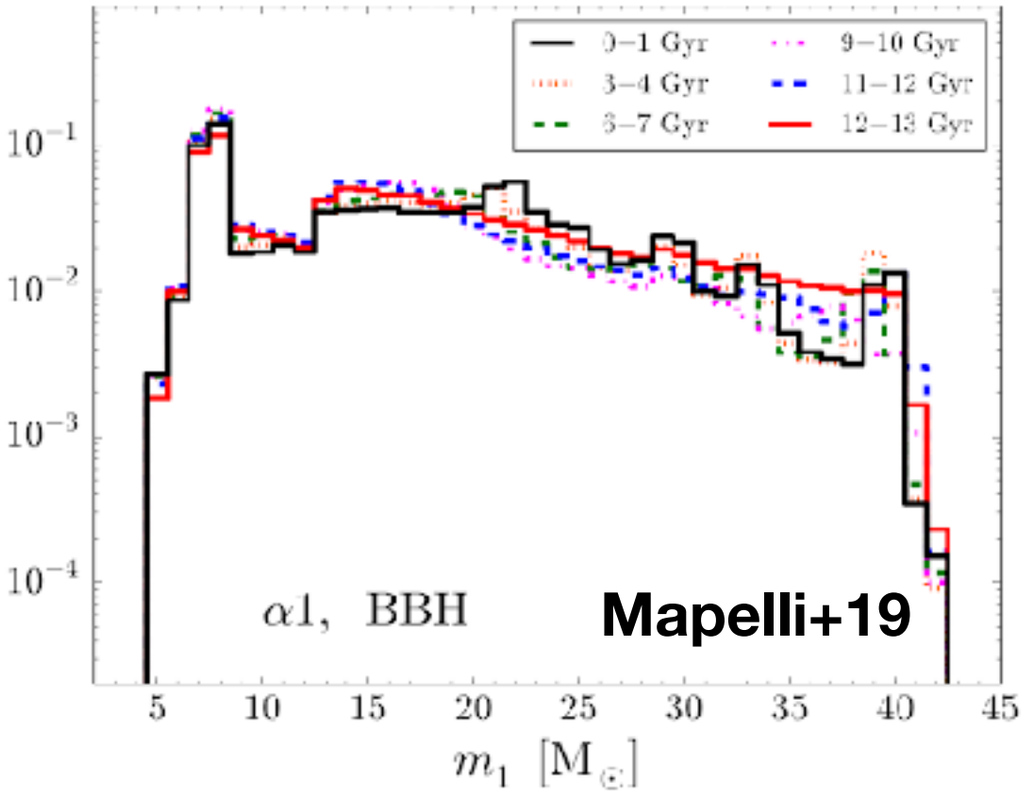
BNS: Limited impact of metallicity on BNS merger rate

Delay time <> star formation rate (well known by ~2035)

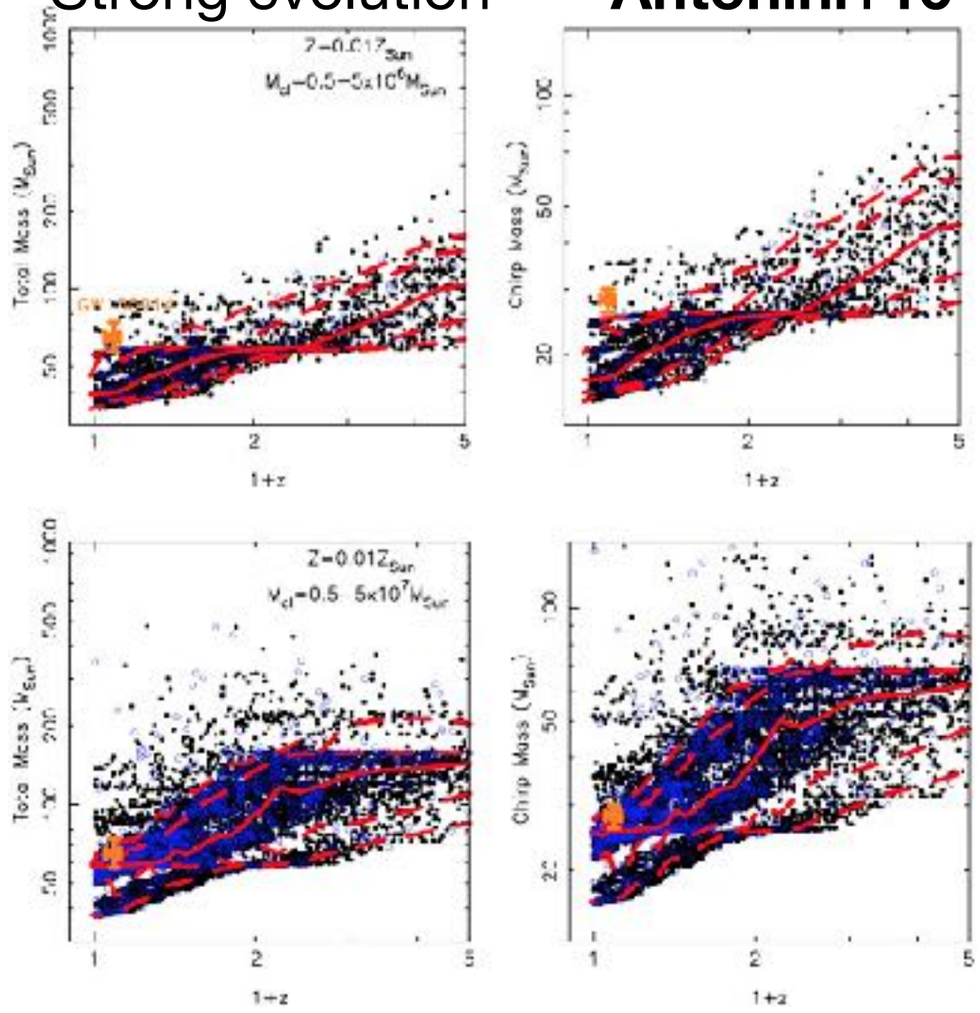
-> constraints on common envelope

ENVIRONMENT: MASS(Z), SPIN(Z)

Very limited evolution



Strong evolution **Antonini+16**



BBH: Very different predictions from different models: combination of evolution channels and star formation/metallicity evolution

-> strong constraining power or degeneracies?

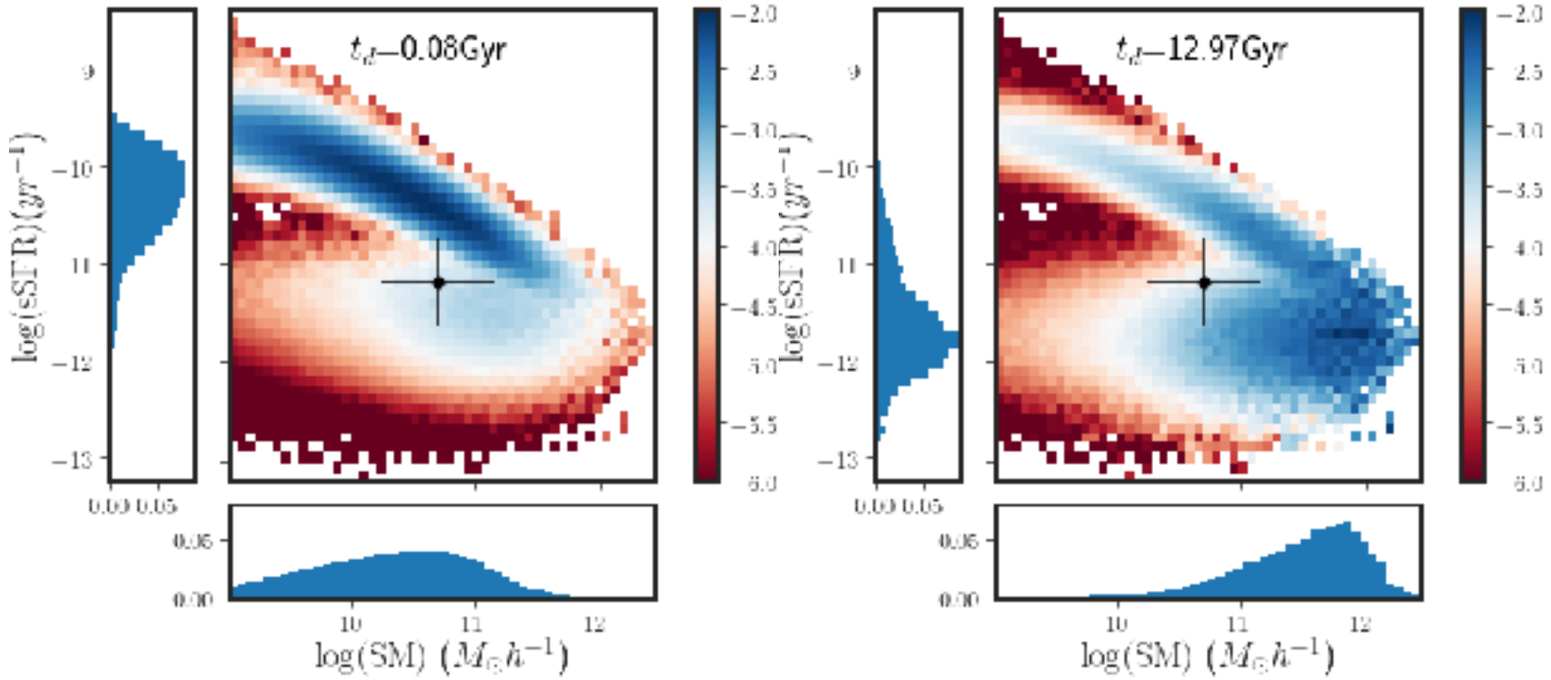
ENVIRONMENT: BNS HOST GALAXIES

BNS mergers to z~2: peak of star formation

If EM counterpart is found (needs good sky localisation)

-Much larger sample than LIGO/Virgo: “preferred” environments? (galaxy type vs merger properties, localisation of the merger…)

-Connection to GRB/kilonova physics (impact of ET less clear)



Adhikari+20

Small delay time”: star forming galaxies
Long delay time: massive galaxies

ENVIRONMENT: BBH HOSTS

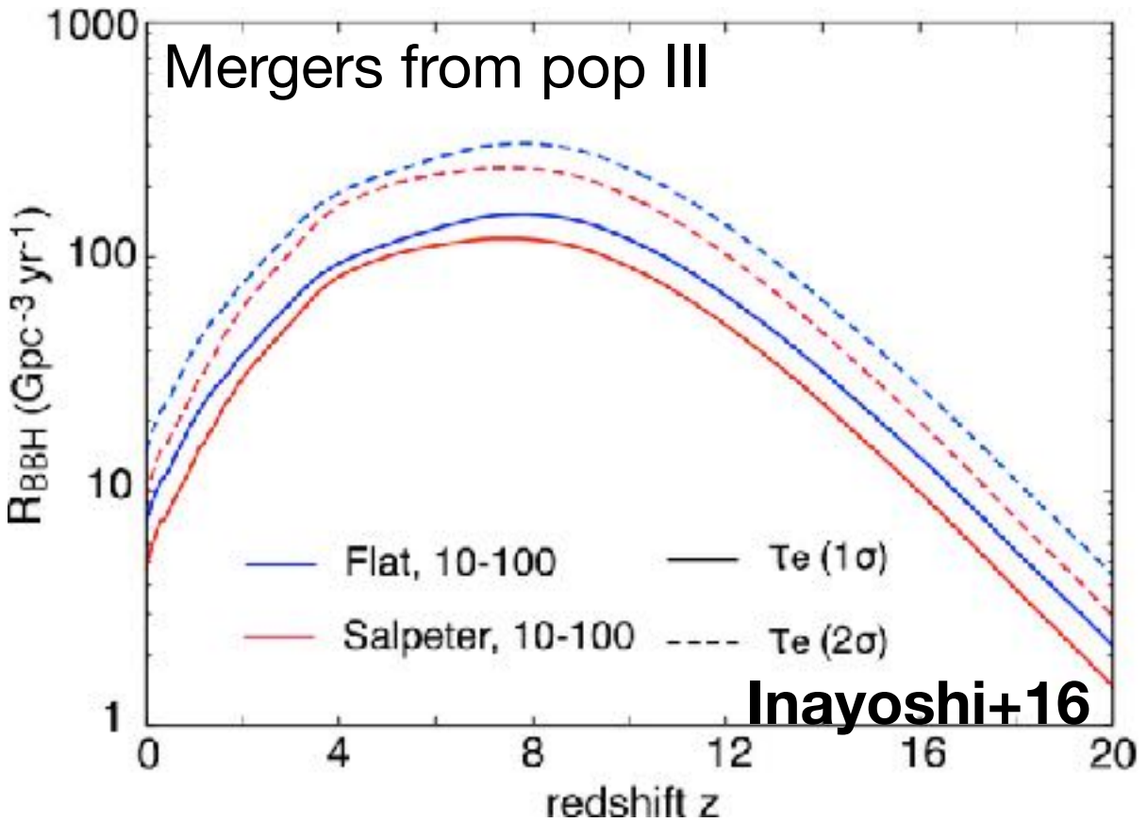
Do (some) BBH mergers have EM counterparts? (needs good localisation: with 3G network, or multi band GW)

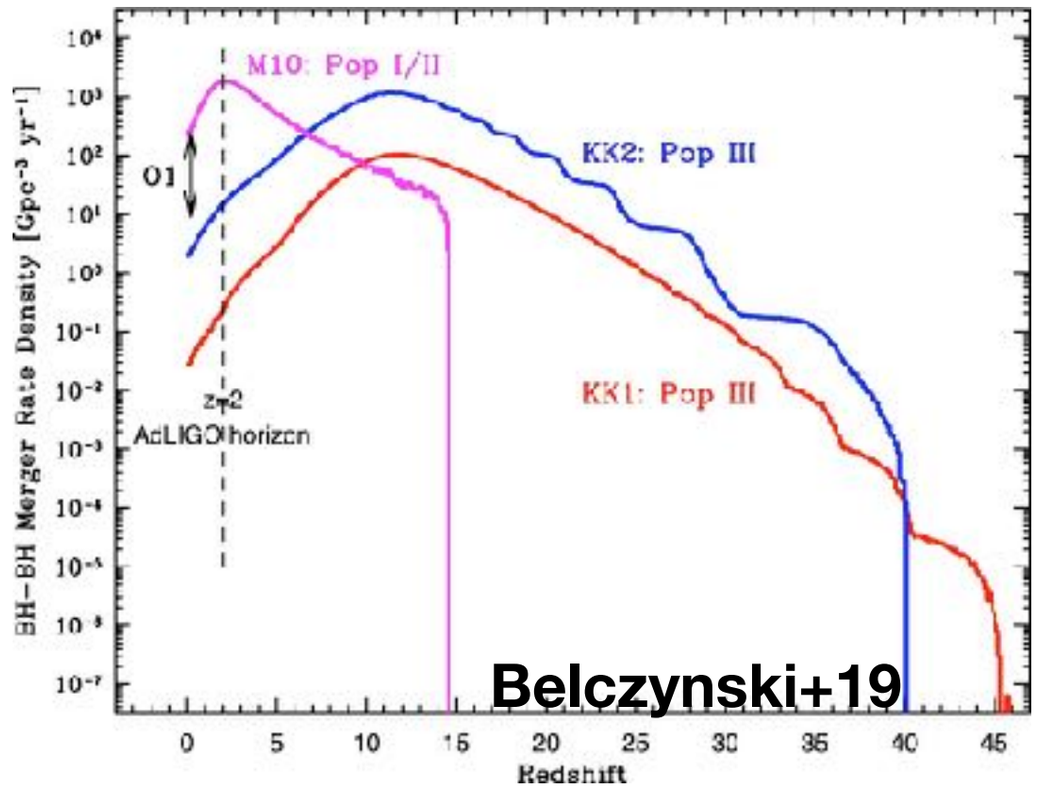
Statistical association with galaxy catalogs: types of host galaxies? AGN? (needs good sky localisation)

BBH mergers as a tracer of large scale structure: cosmological parameters, bias factor at higher z than most EM surveys

BBH mergers as standard candles? BHs with M>45Msun seem rare (PISN gap?)-> use BBH “maximal GW luminosity” as a standard candle?

EARLY UNIVERSE WITH BBH





BBH mergers well into the “dark ages”: probes of individual “first stars” (EM telescopes give probe of population)

Reionisation: start? end?

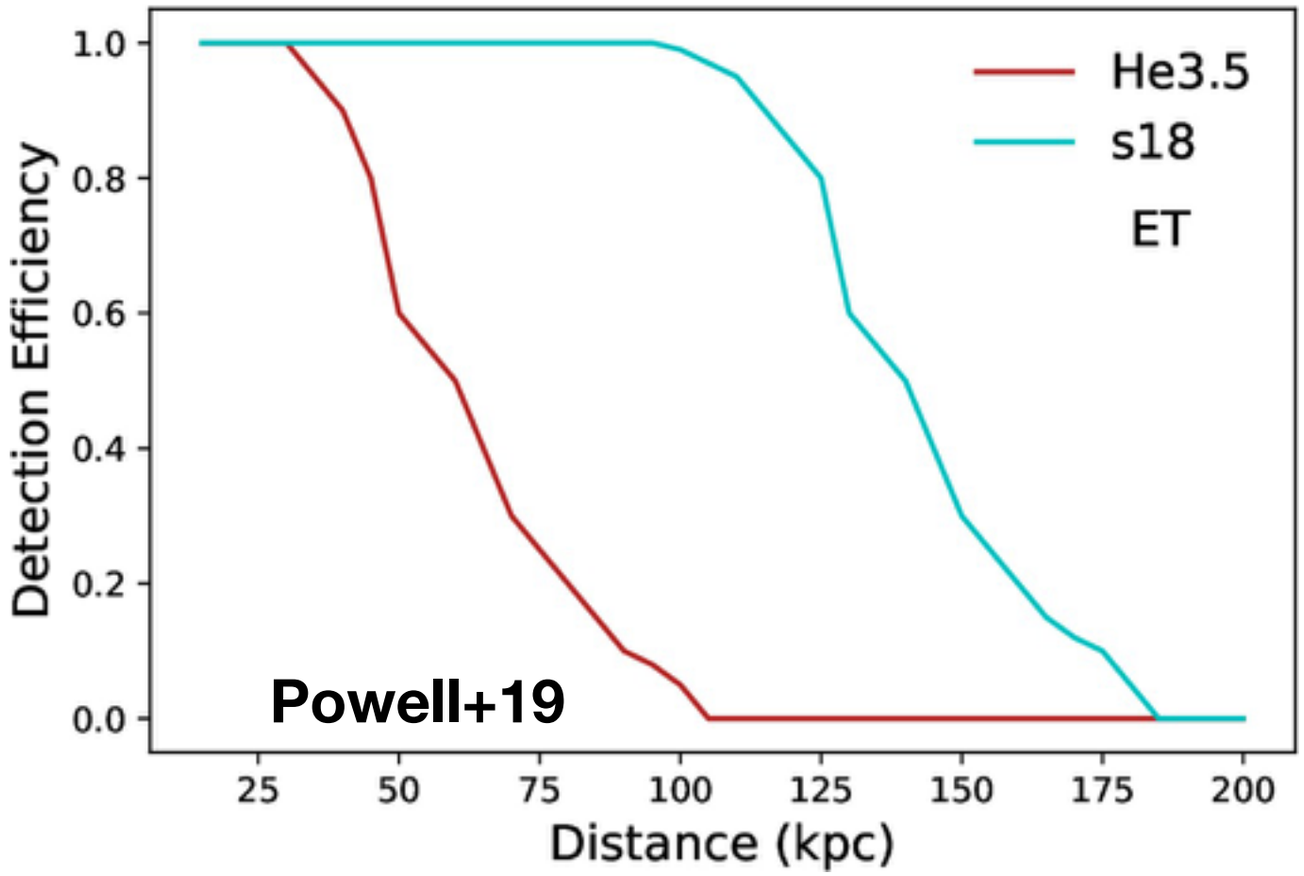
Very low metallicity environments

LOCAL GROUP: CORE-COLLAPSE SUPERNOVAE

New class of sources

Major uncertainties on GWs from CCSN models

Most energetic model: <20 kpc by 2G, 200 kpc by ET



THE ET REVOLUTION

A million BBH mergers/year, BNS mergers up to z~2

Very large sample of intrinsic source parameters (spins, masses):

Formation channels?

IMBHs?

Mass gaps ?

Primordial black holes?

Environmental parameters: redshift, (statistical) determination of host galaxy:

First stars & cosmic reionisation?

Do BBHs have EM counterparts?

Host galaxies vs time vs merger properties?

Large scale structure beyond EM methods?