Observational estimate of the binary black hole coalescence rate

Tomasz Bulik[1]
Chris Belczynski[1,2]
Andrea Prestwich[3]

[1]Univerity of Warsaw
[2]University of Texas, Brownsville
[3]Harvard Smithsonian CfA

The two binaries

IC10 X-1

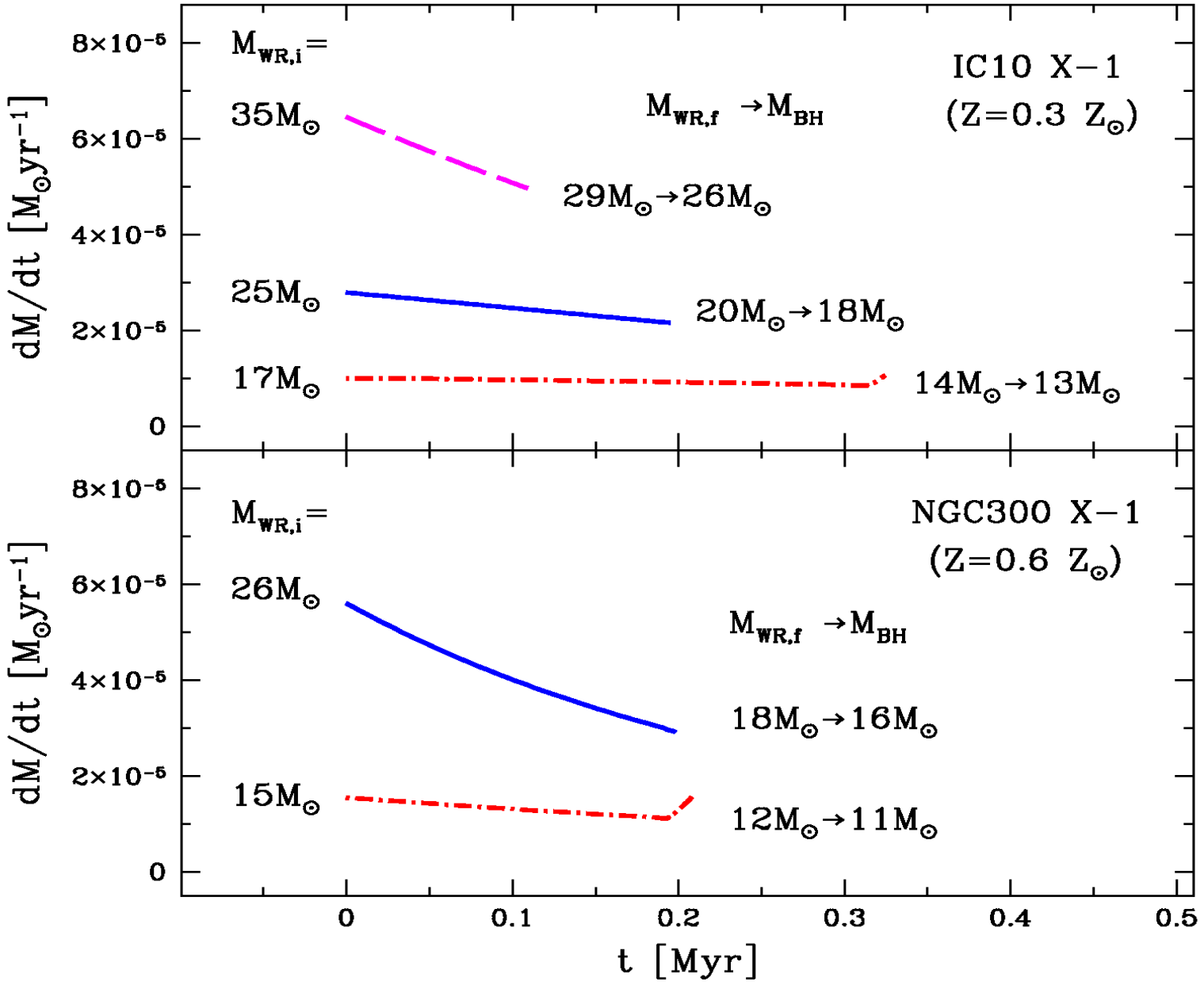
- M_{BH}=23-33 Msun
- M_{WR}=17-35 Msun
- P= 35h
- Host metallicity=0.3

NGC300 X-1

- M_{BH}=14.5-20 Msun
- M_{WR}=15-26 Msun
- P=32h
- Host metallicity=0.6

Both are tight binaries with BH accreting from WR stars

Further evolution



SN and BH formation

- SN – probably direct collapse to BH
- Small or little kick
- Systems not disrupted
- Small ellipticity induced e~0.04
- Chirp masses:
  - IC10 X-1: 15-26 Msun
  - NGC300 X-1: 11-15 Msun

Estimate of the rate density

- Volume surveyed: determined by the possibility of spectroscopy of the WR star
- Detectability time – X-ray active phase – lifetime of the WR star

$$R = 0.36 \pm^{0.50}_{0.26} Mpc^{-3}\, Myr^{-1}$$

Estimate of the detection rate

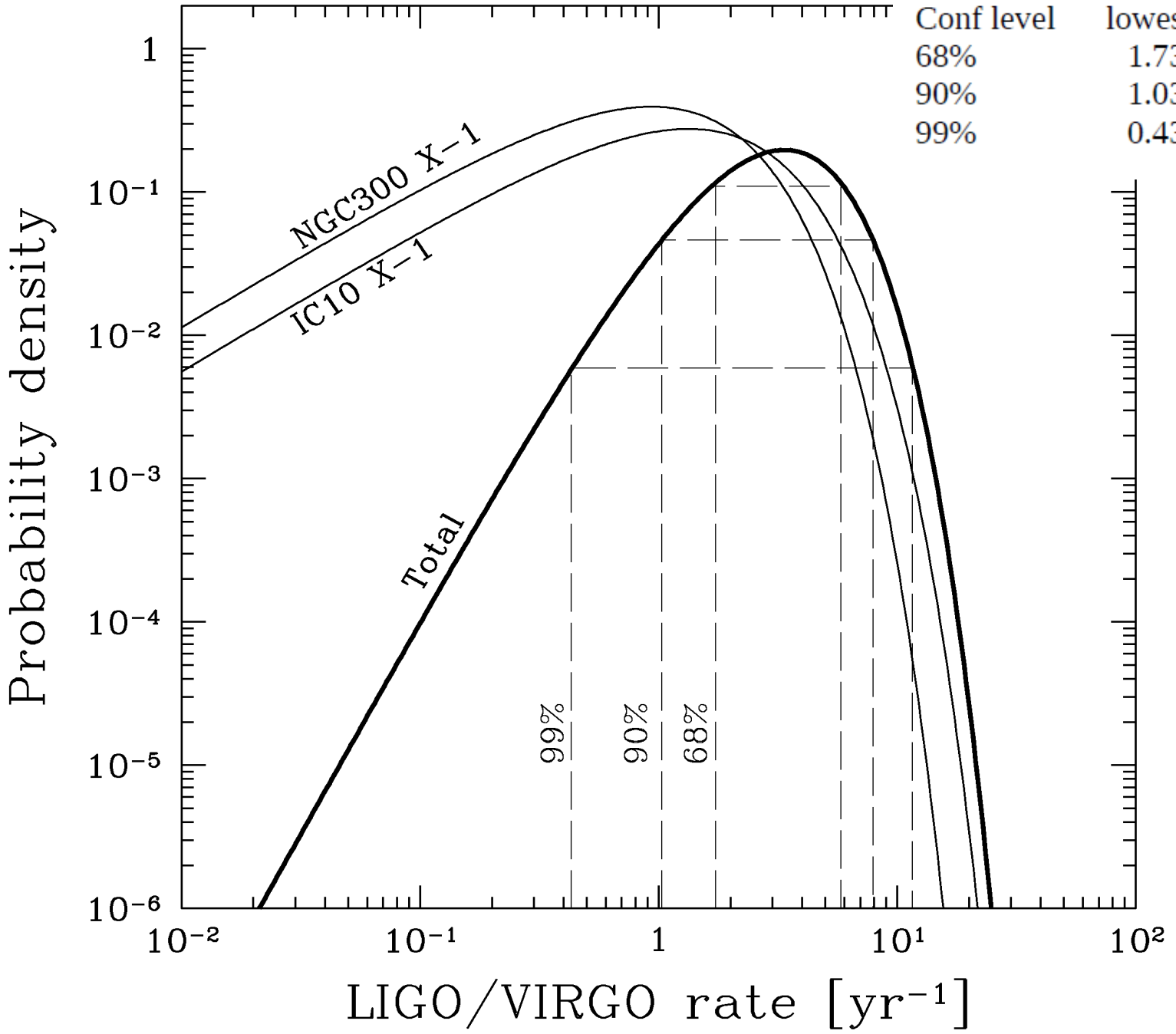
- Assume lowest chirp masses
- Assume that SNR is

$$SNR \propto \frac{M_{chirp}^{5/6}}{D}$$

- Assume sensitivity to DNS of 18Mpc
- Find the probability density of each rate

Detection rates

Conf level	lowest rate	highest rate per year
68%	1.73	5.80
90%	1.03	7.91
99%	0.43	11.6



Discussion of assumptions

- BH masses – lowest possible
- Chirp masses – taken from the low end
- No kicks – adding kicks does not alter results

- No metallicity evolution
- Star formation rate: assumed constant

Conclusions

- Observational estimate of merger rate possible
- The LIGO/VIRGO rate estimate is

$$R_{LIGO/VIRGO} = 3.36 \pm^{4.55}_{2.32} \, yr^{-1}$$

- It is a conservative estimate, so...

  the detection should be around the corner !
- Low metallicity is the key factor!