

Department of Physics “G. Occhialini”
Ph.D. in Physics and Astronomy
ET Symposium



Multi-messenger prospects for black hole - neutron star mergers in the Einstein Telescope era

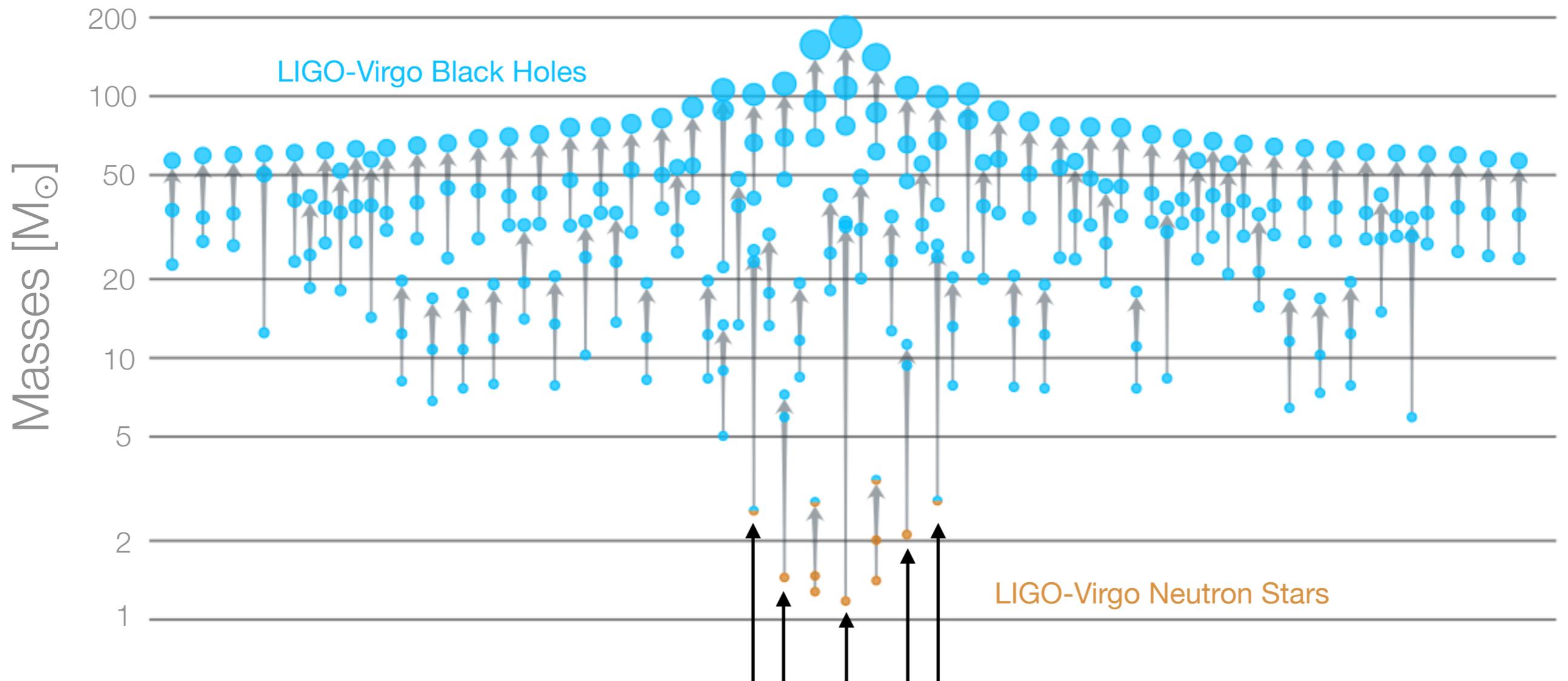
Alberto Colombo

Om Sharan Salafia, Francesco Iacovelli, Michele Mancarella, Giancarlo Ghirlanda, Bruno Giacomazzo, Monica Colpi, Raphael Duque, Igor Andreoni, Floor Broekgaarden, Tassos Fragos, Fabio Ragosta, Matteo Barsuglia, Silvia Piranomonte, Andrea Melandri, Adrew Levan, Anand Shreya

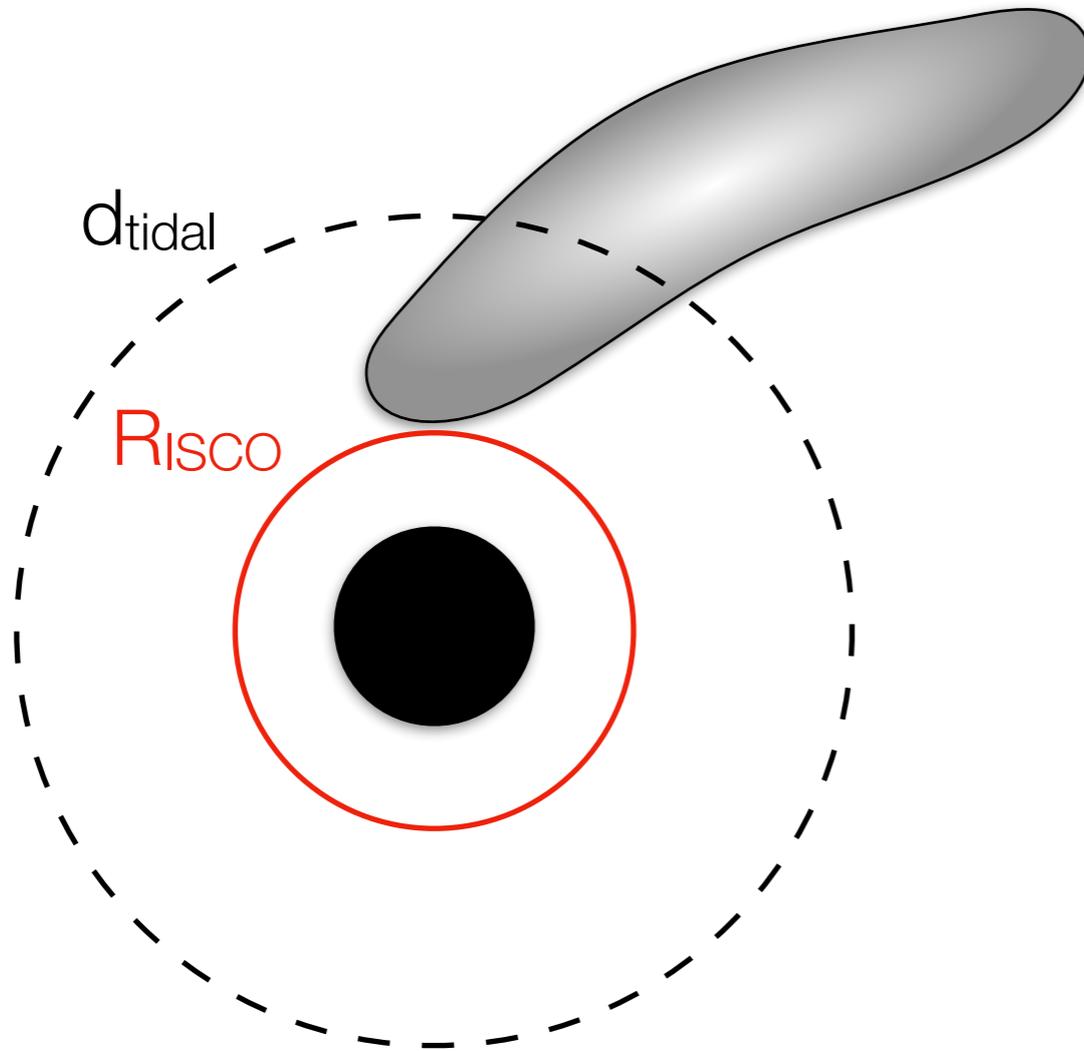
May 10th, 2023

BHNS Candidates

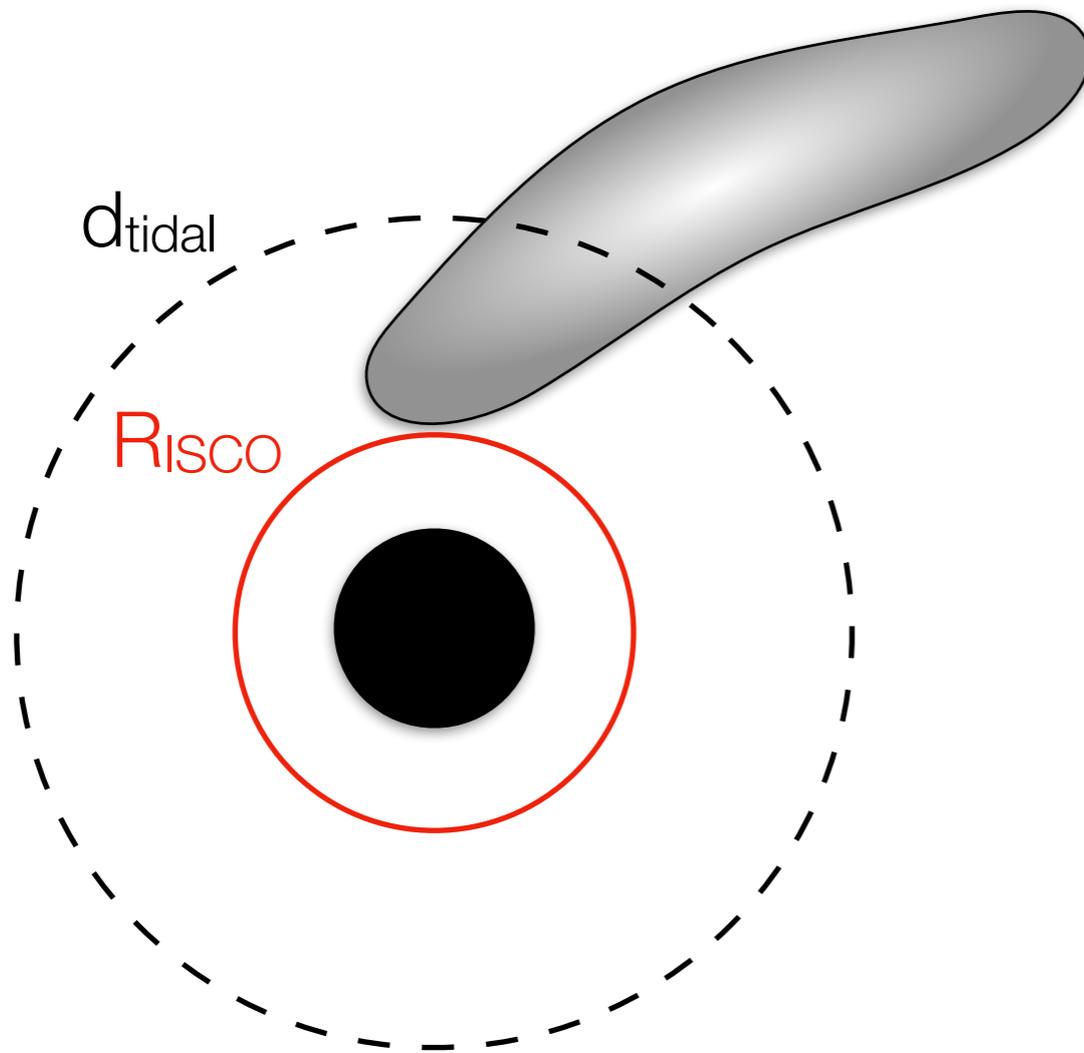
LIGO-Virgo, Northwestern, Frank Elavsky, Aaron Geller



BHNS Mergers

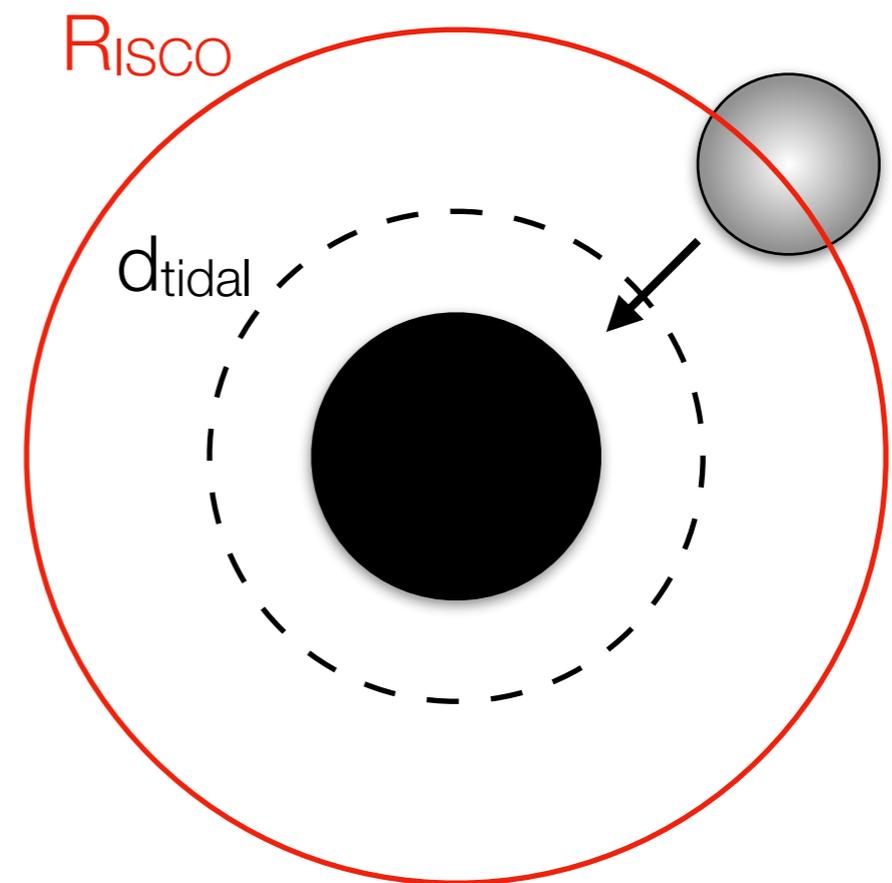
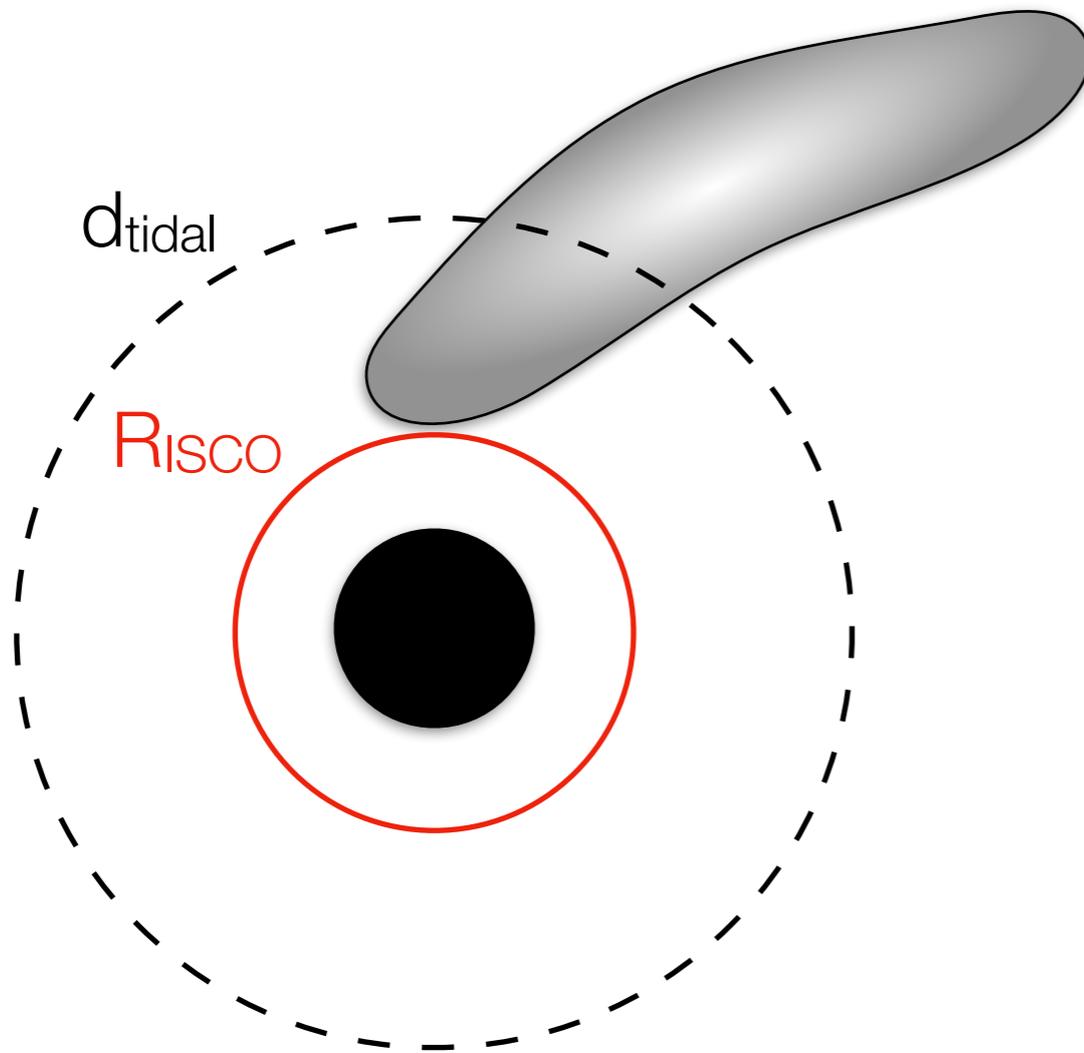


BHNS Mergers



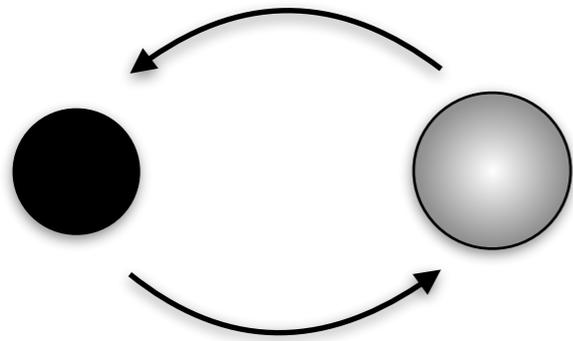
Low massive and/or rapidly spinning BH

BHNS Mergers

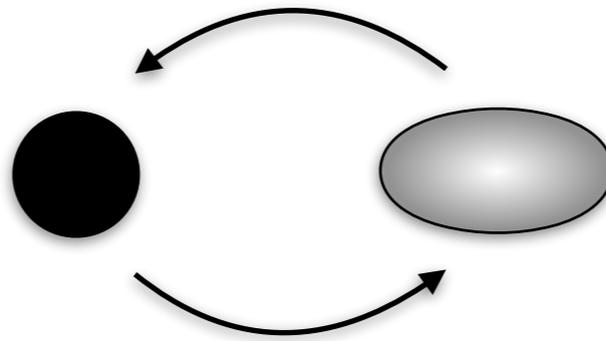
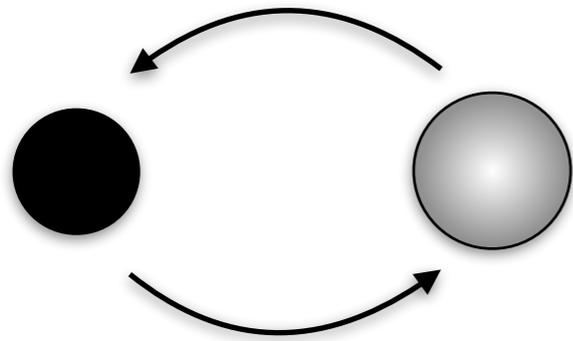


Low massive and/or rapidly spinning BH

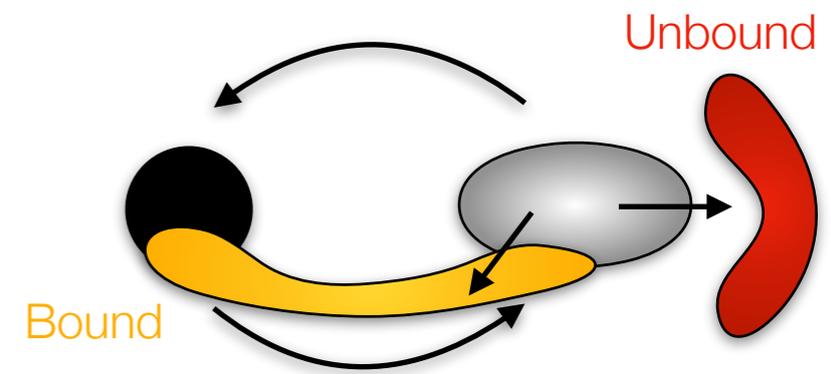
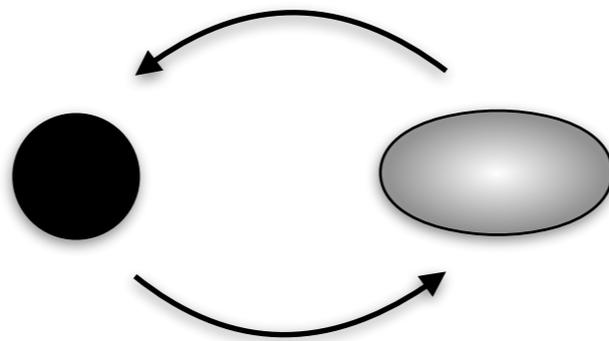
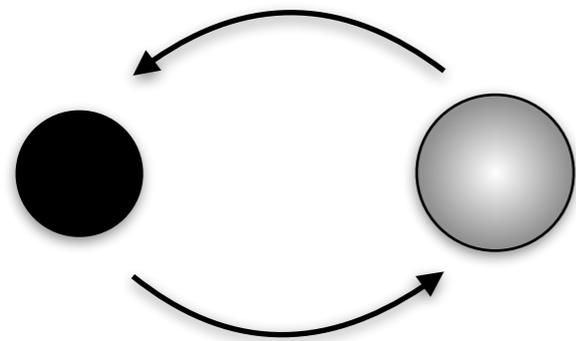
BHNS Merger and Kilonova Emission



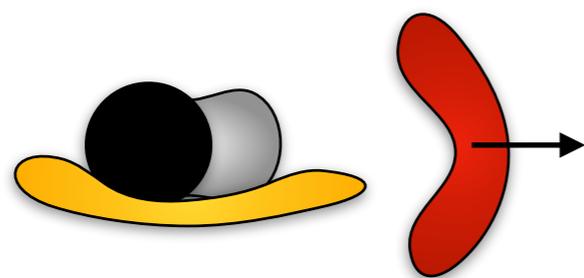
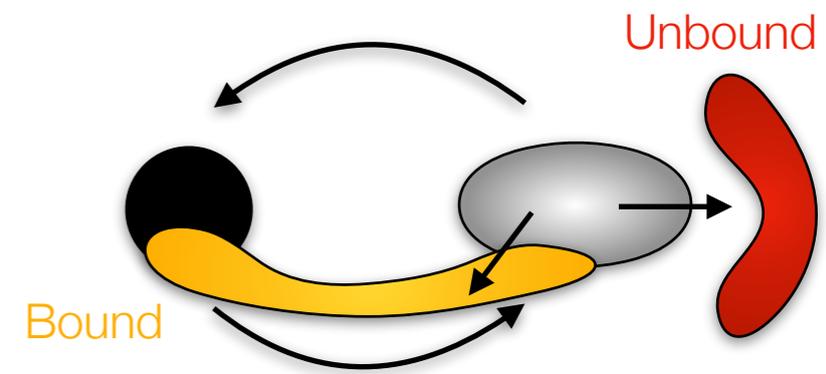
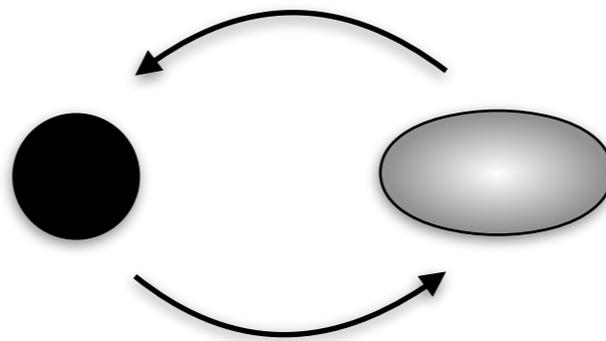
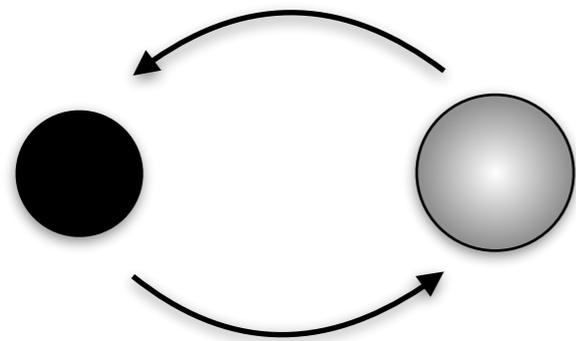
BHNS Merger and Kilonova Emission



BHNS Merger and Kilonova Emission

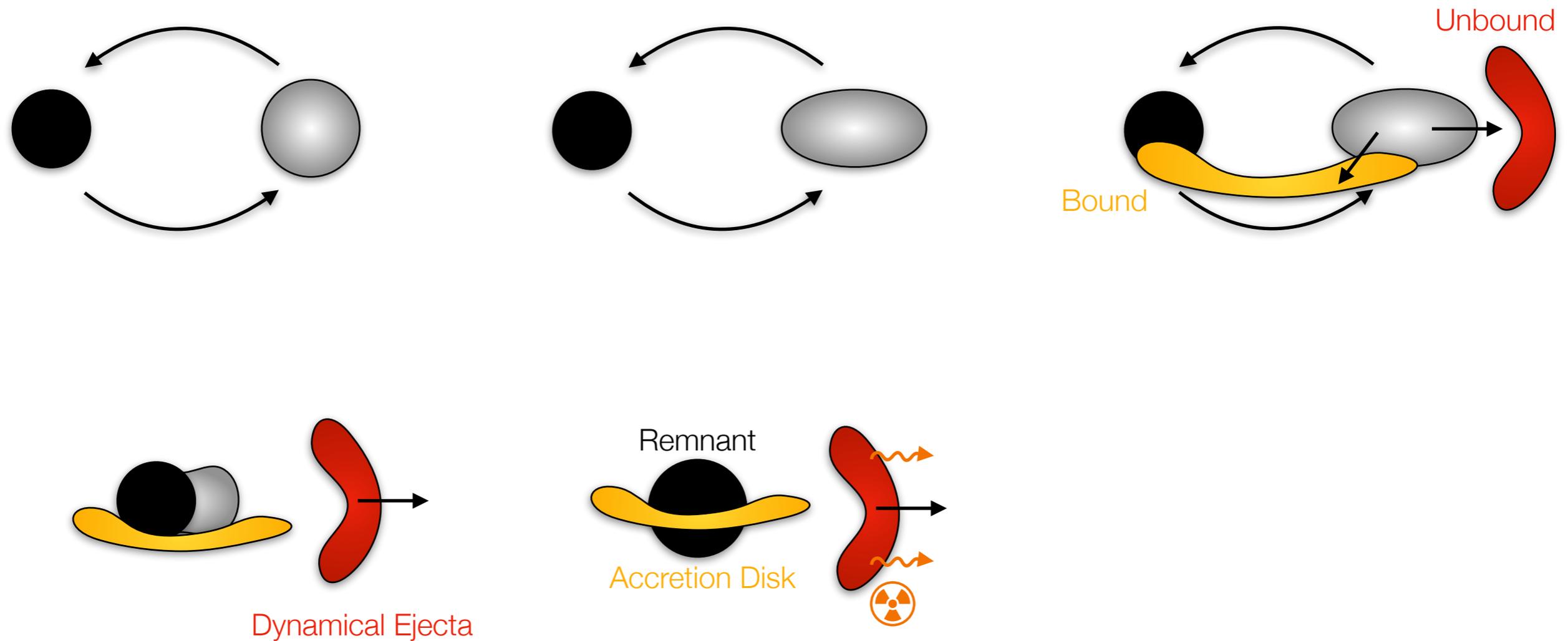


BHNS Merger and Kilonova Emission

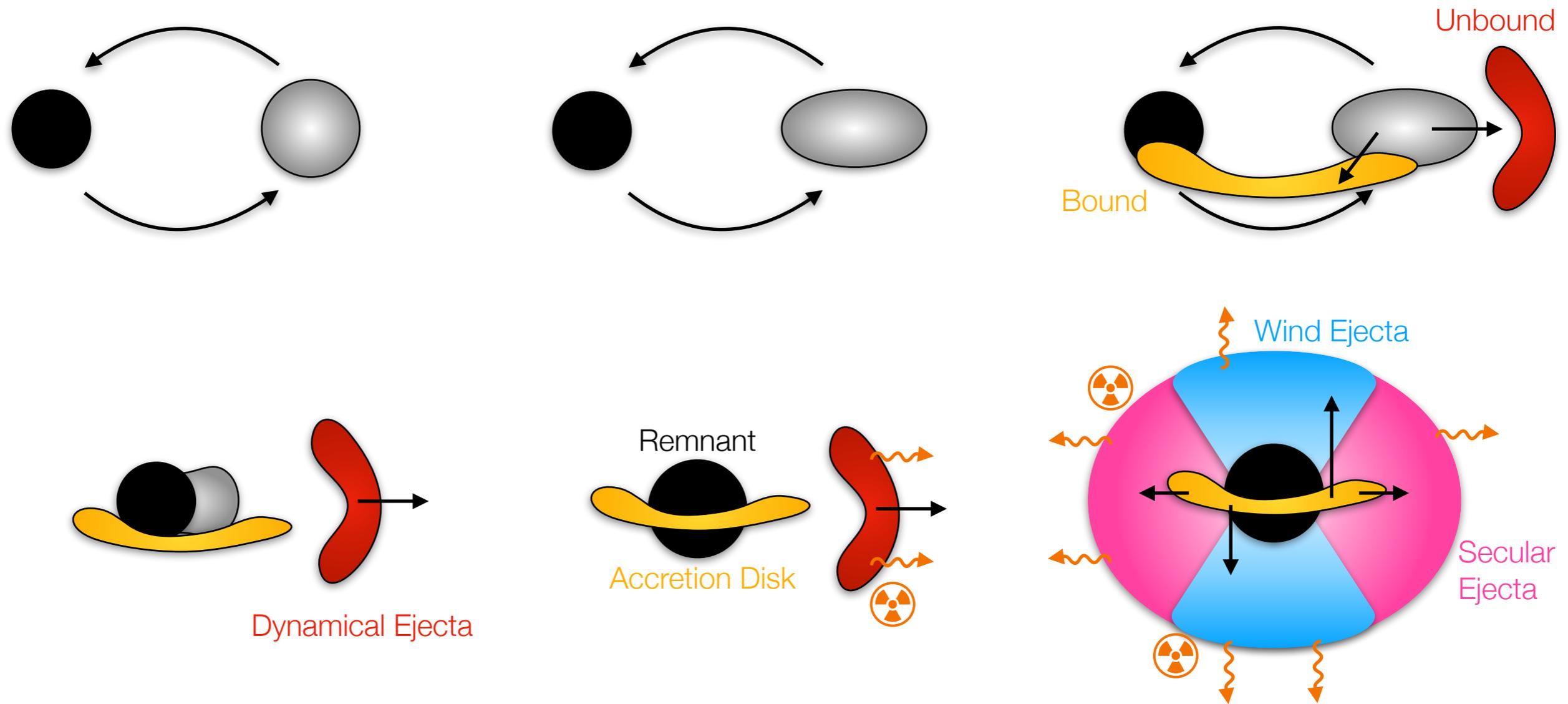


Dynamical Ejecta

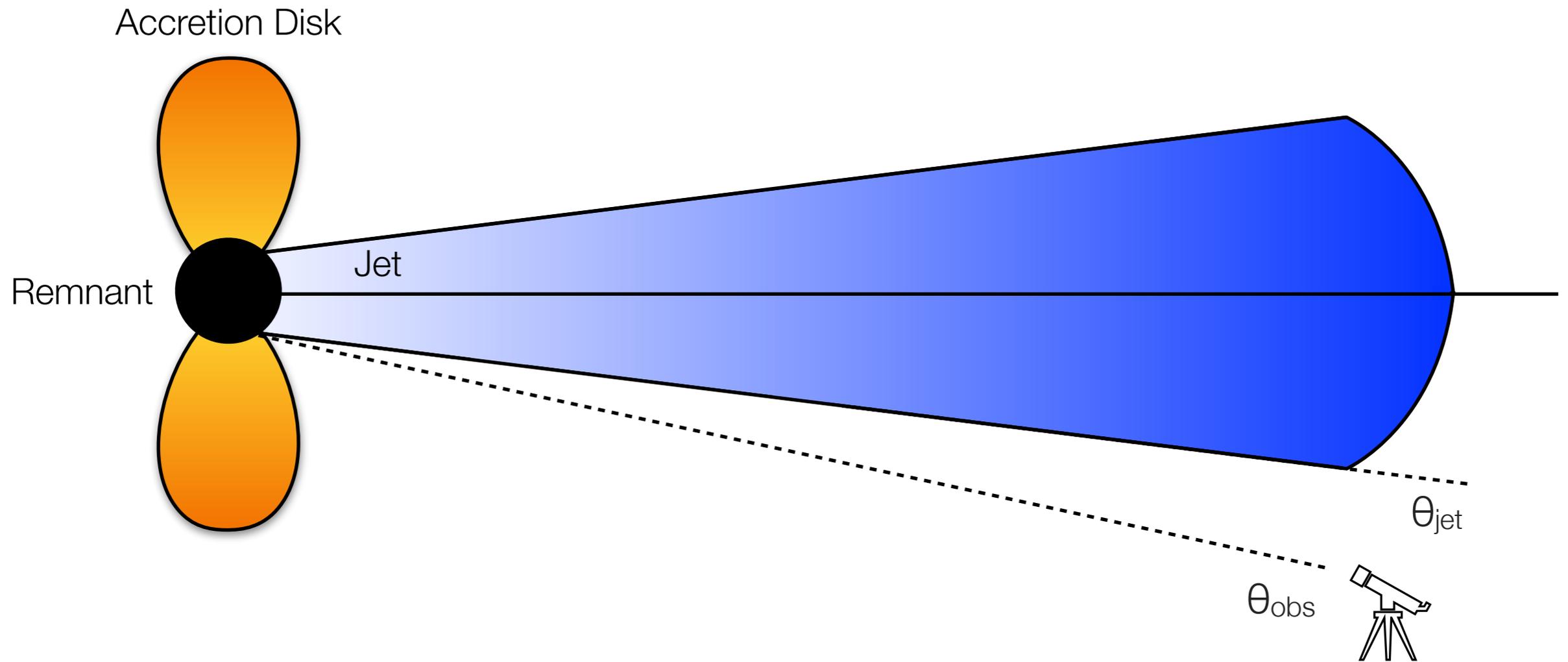
BHNS Merger and Kilonova Emission



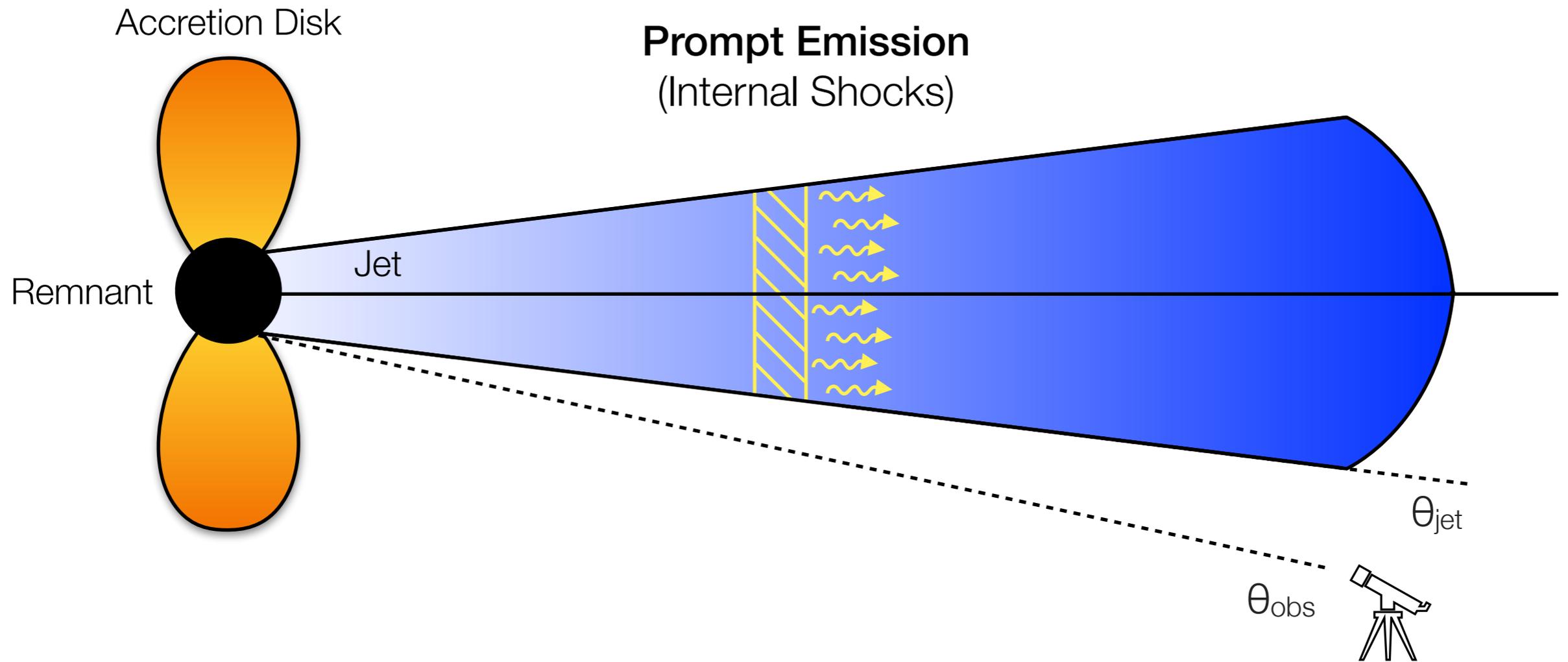
BHNS Merger and Kilonova Emission



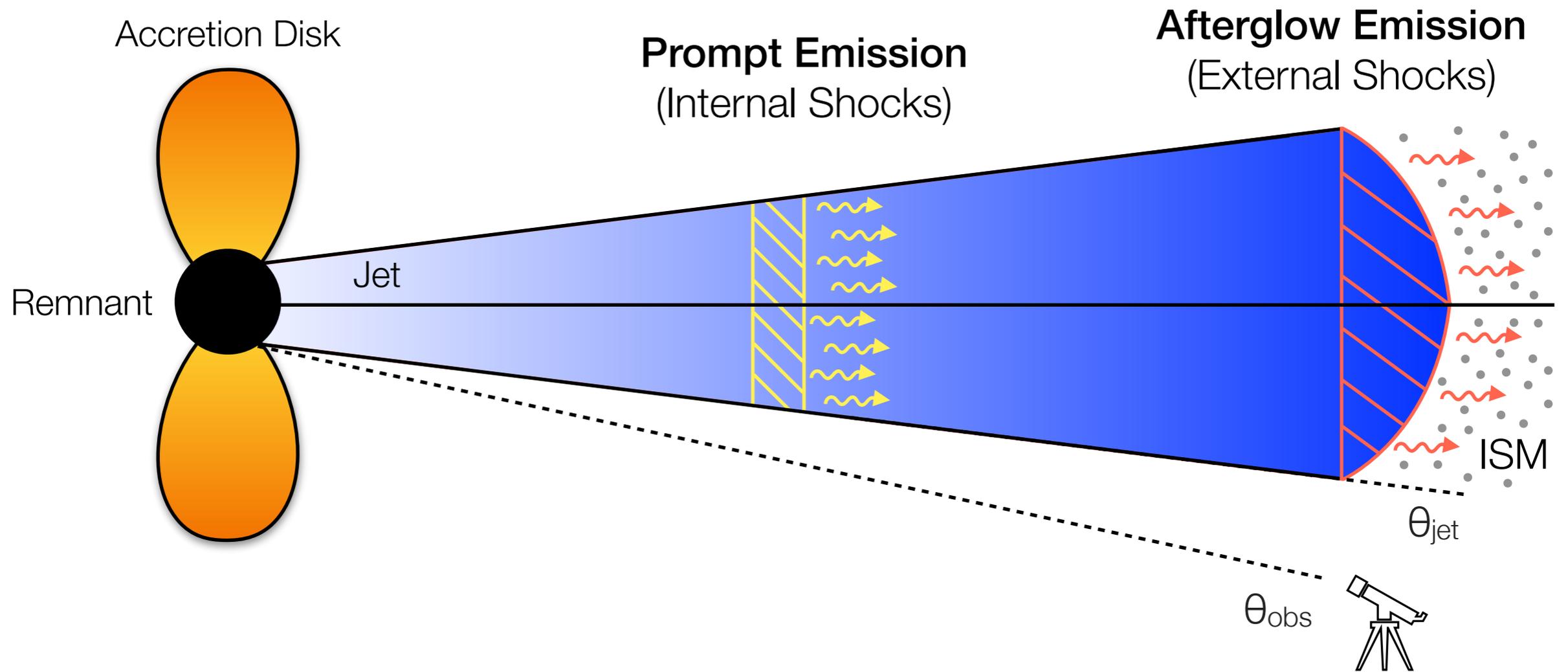
Prompt and GRB Afterglow Emission



Prompt and GRB Afterglow Emission



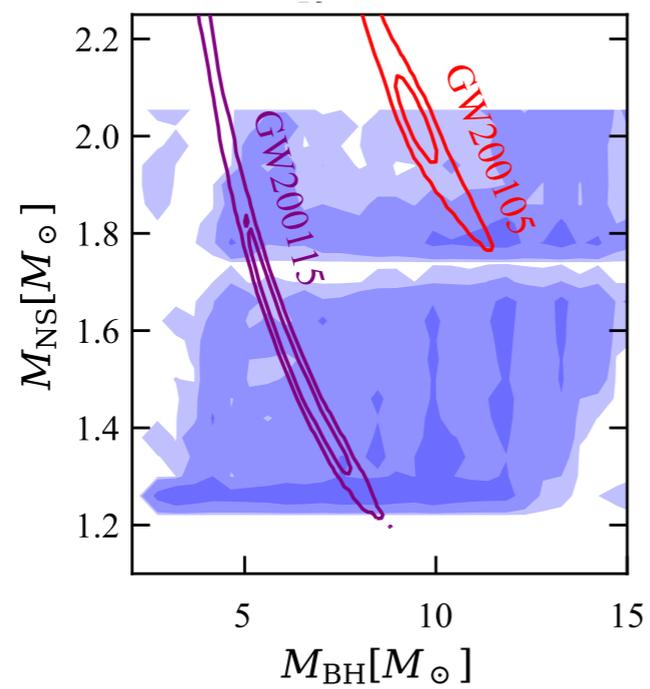
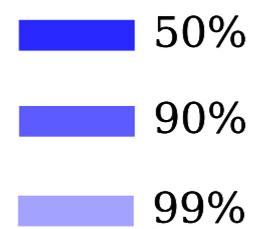
Prompt and GRB Afterglow Emission



What are the prospects for future multi-messenger observations of black hole - neutron star mergers?

The Model

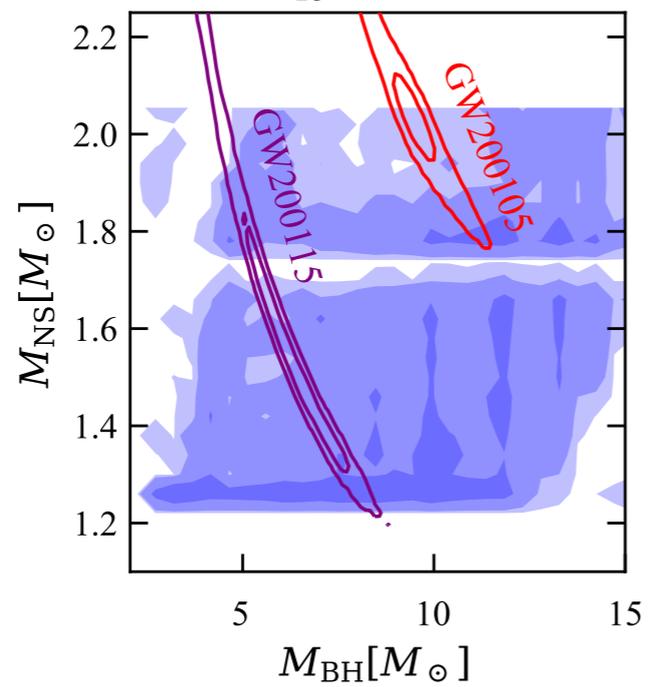
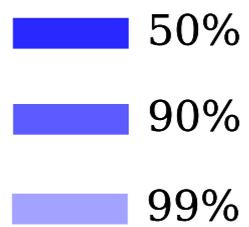
BHNS population
mass distribution
redshift distribution
BH spin distribution



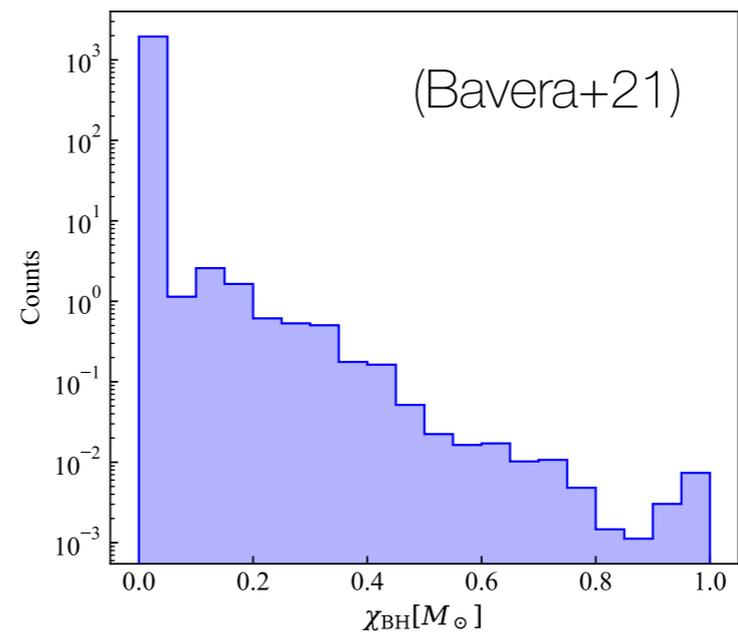
(Broekgaarden+21)

The Model

BHNS population
mass distribution
redshift distribution
BH spin distribution



(Broekgaarden+21)



The Model

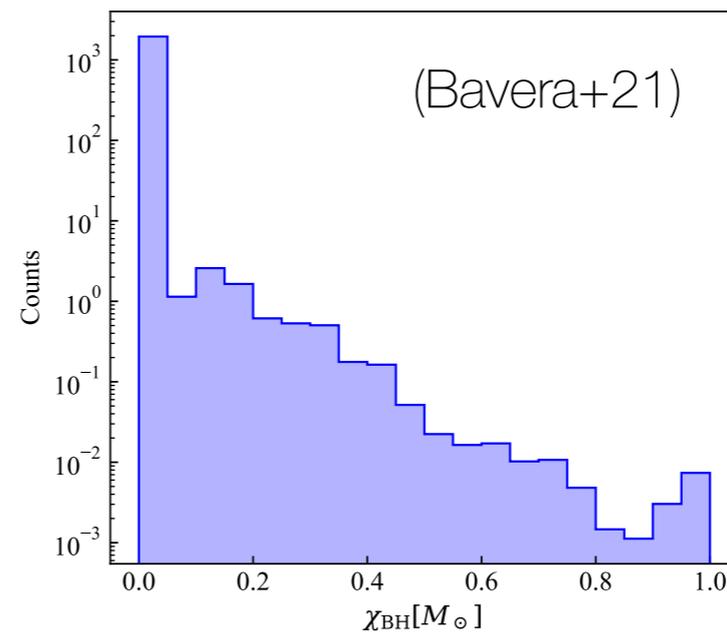
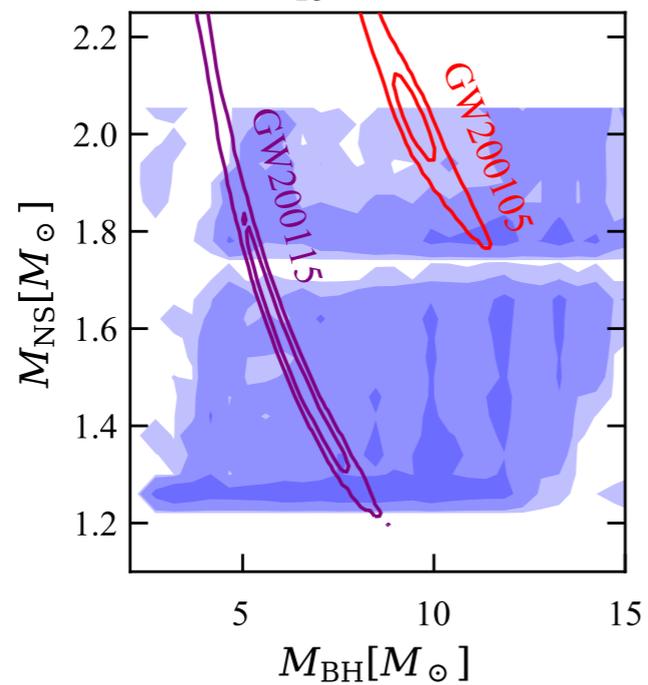
GWFAST (NS EoS, θ_v , RA, DEC, t_{coal} , Φ)
(Iacovelli+22)

GW SNR
 Δd_L
 $\Delta \Omega$

BHNS population
mass distribution
redshift distribution
BH spin distribution

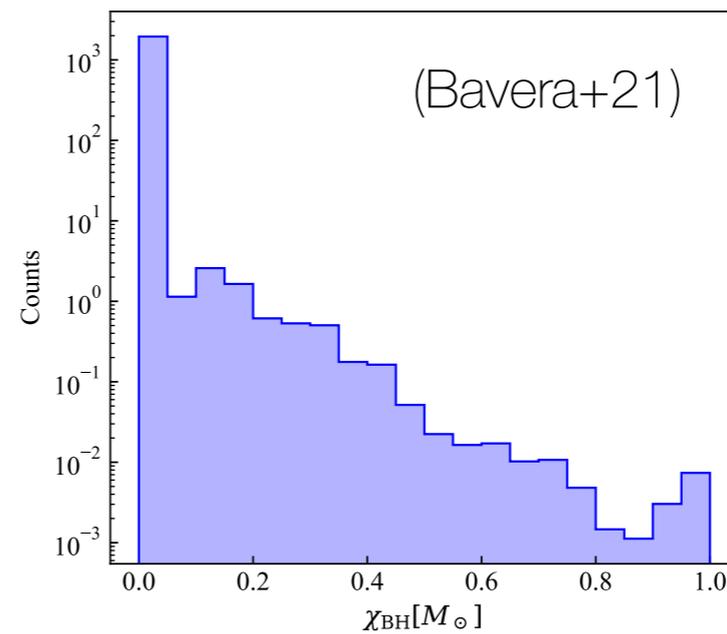
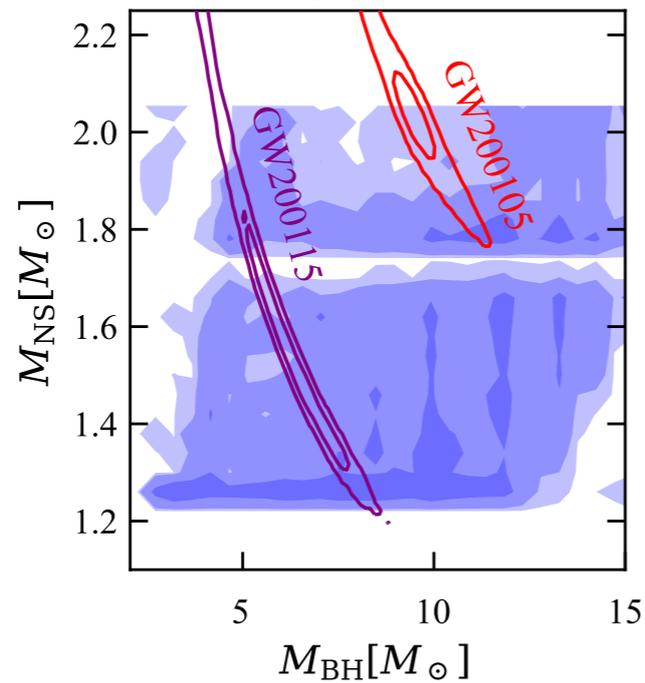
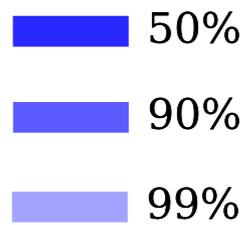
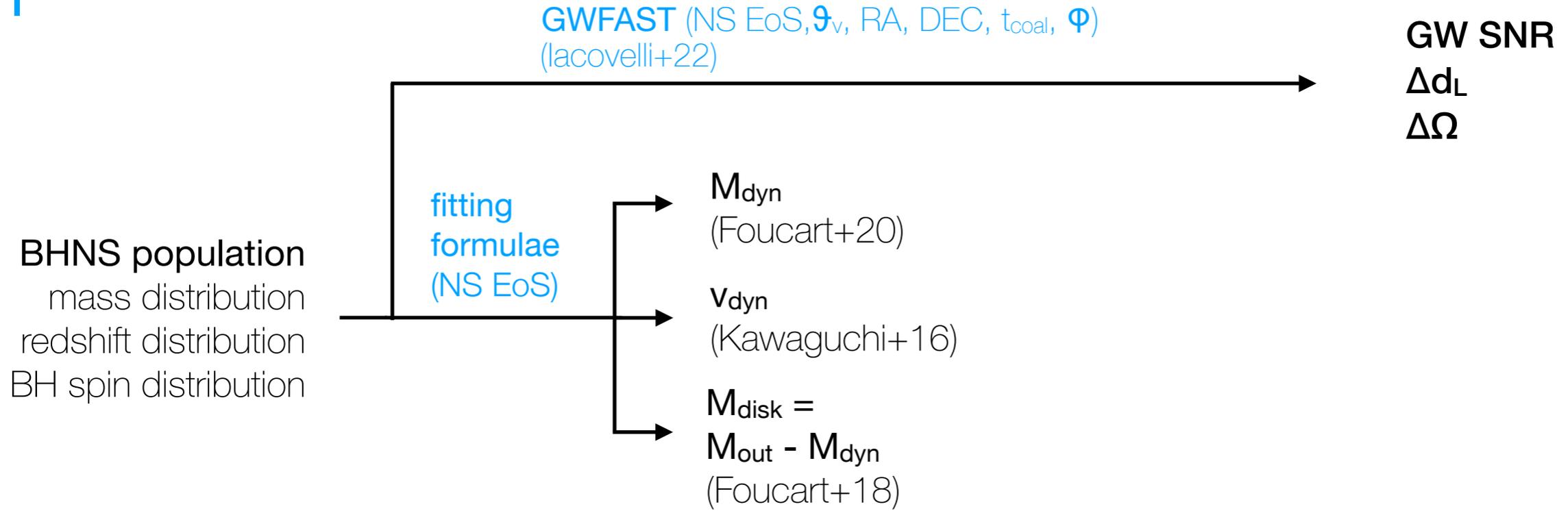


50%
90%
99%



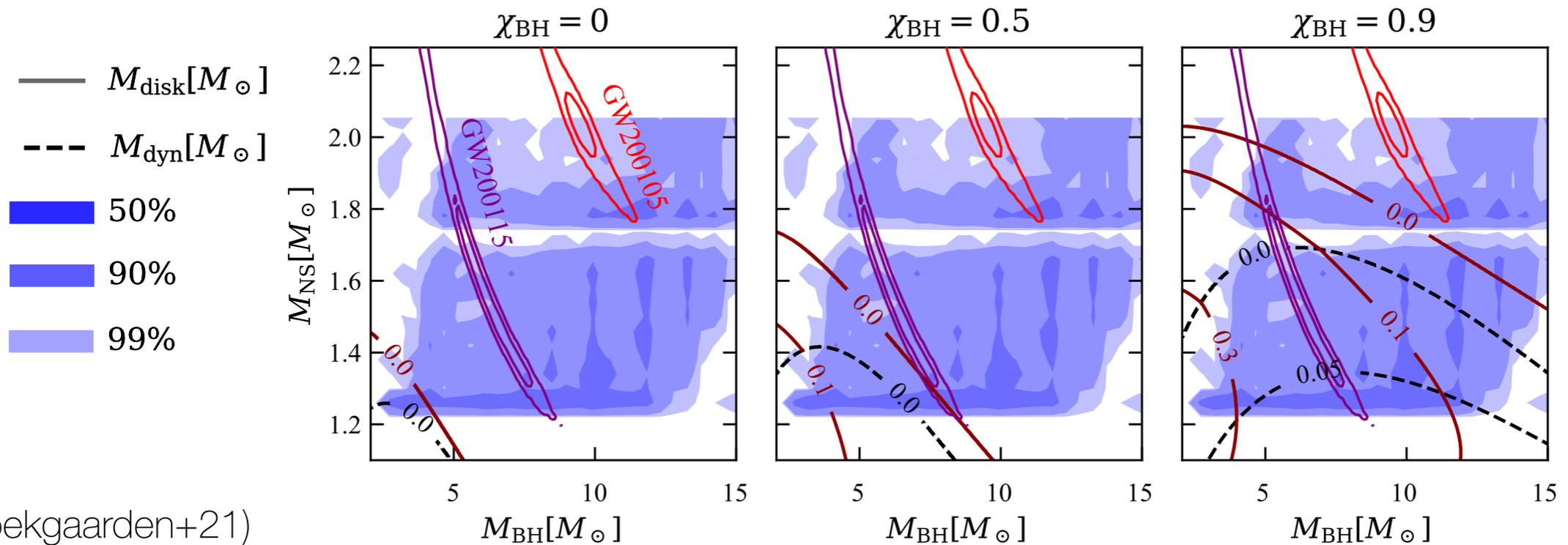
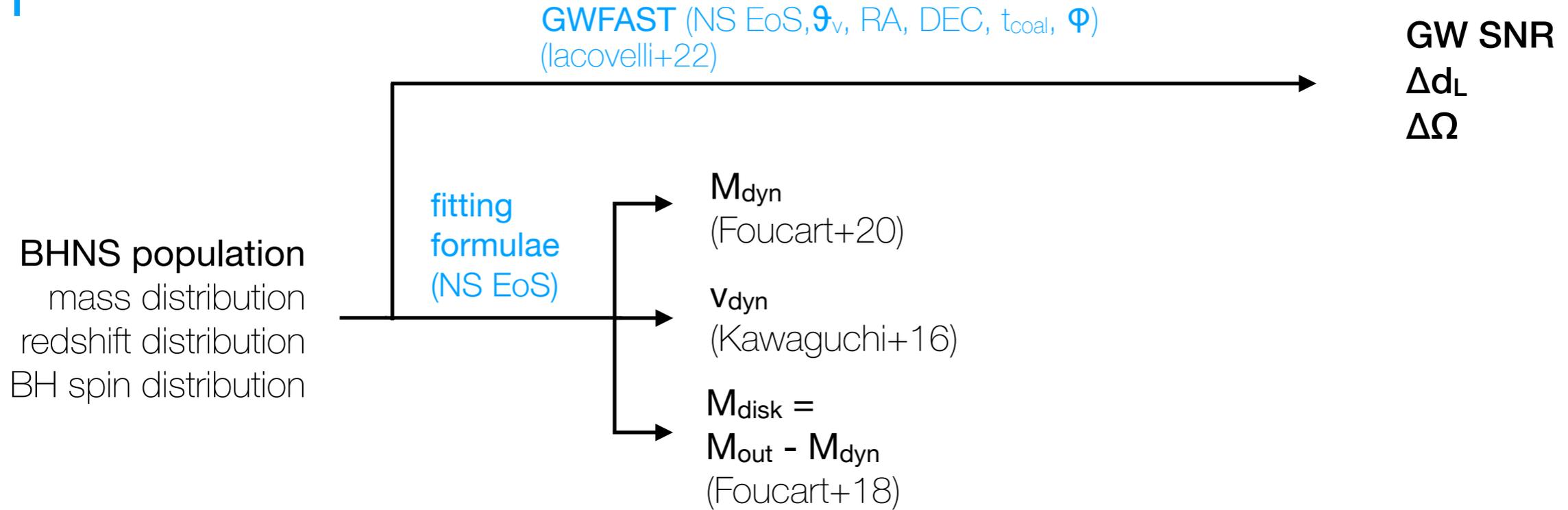
(Broekgaarden+21)

The Model



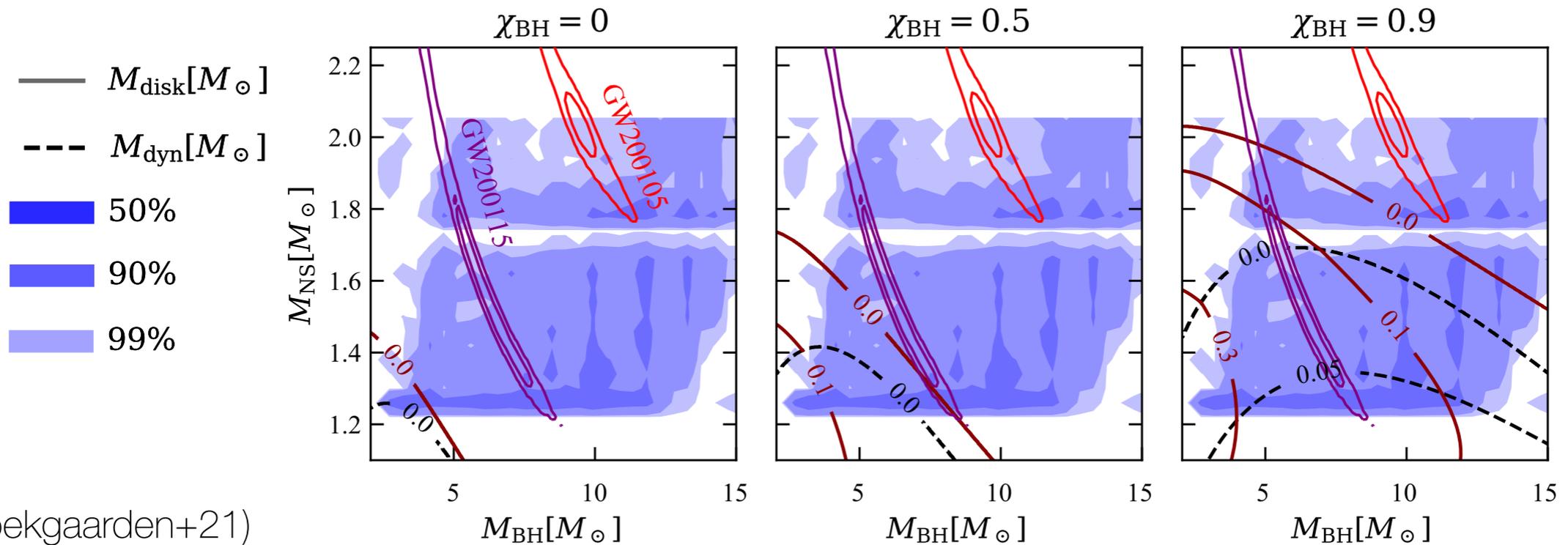
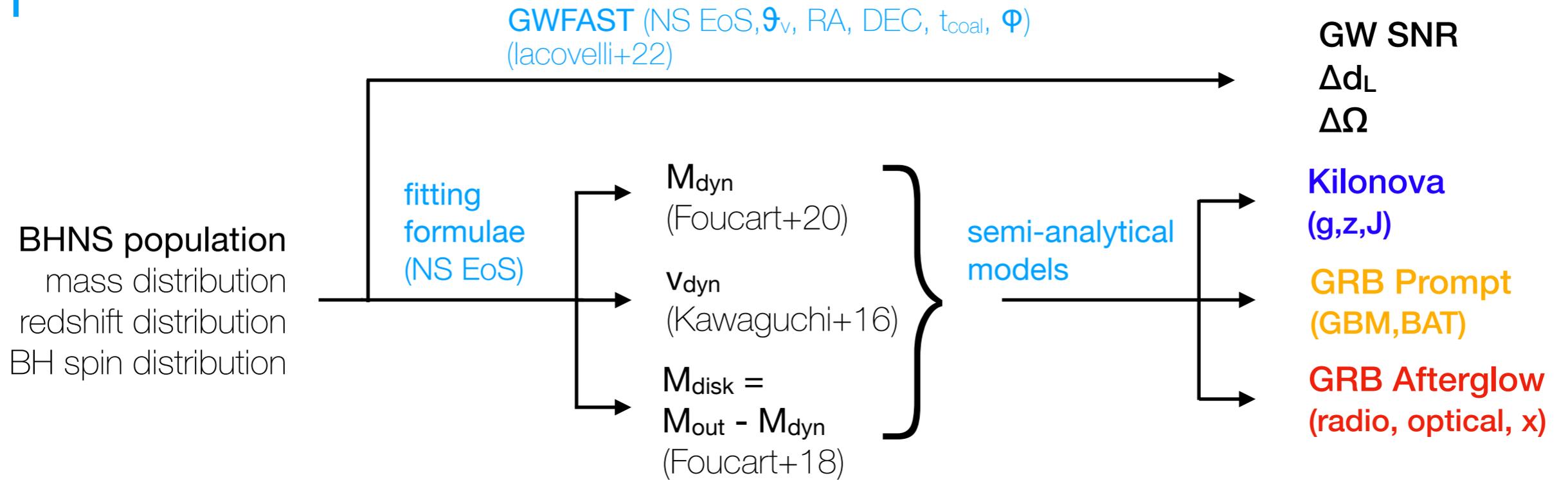
(Broekgaarden+21)

The Model



(Broekgaarden+21)

The Model



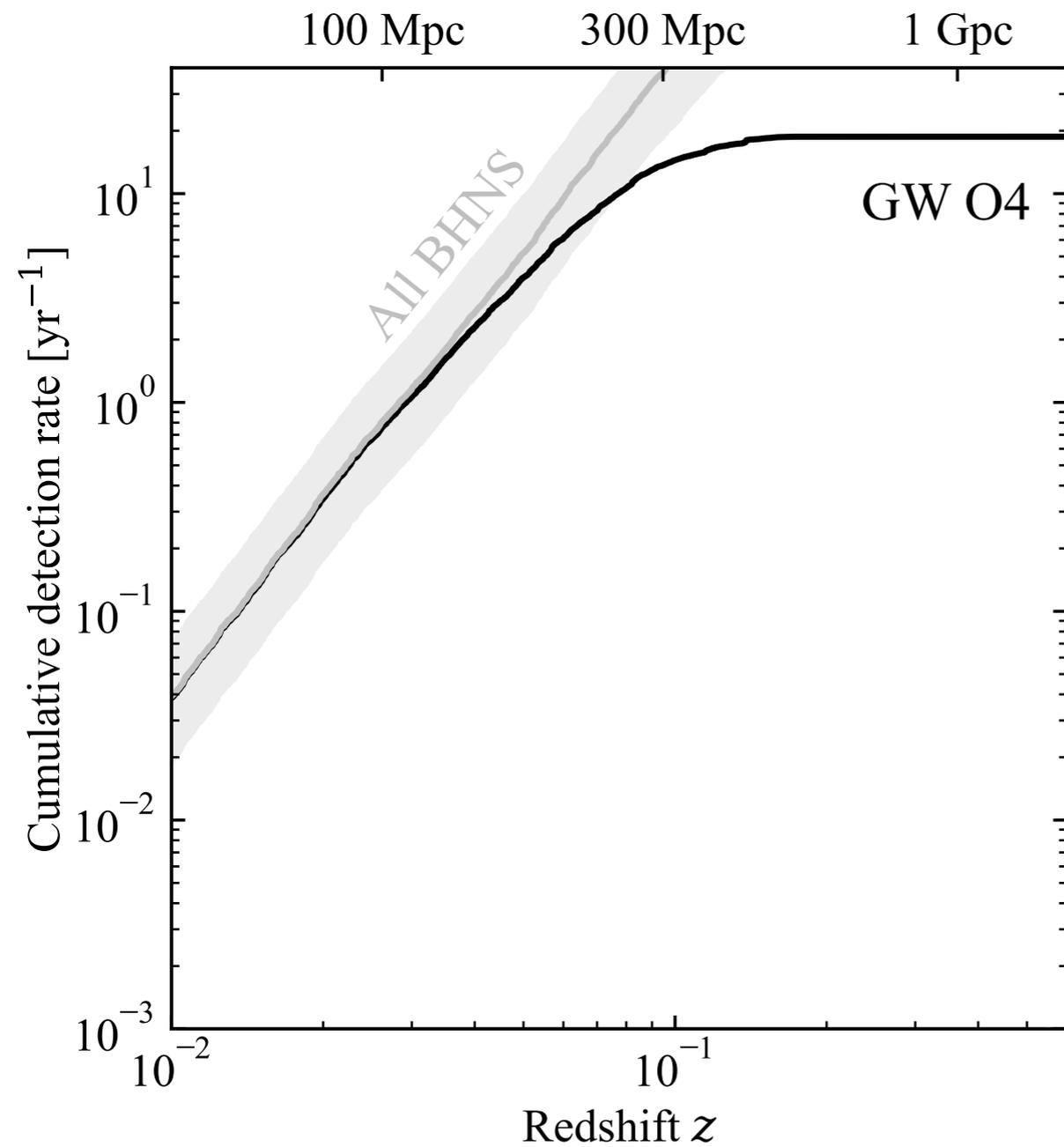
(Broekgaarden+21)

Will we have a multi-messenger observation of a black hole - neutron star merger during O4?

Will we have a multi-messenger observation of a black hole - neutron star merger during O4?

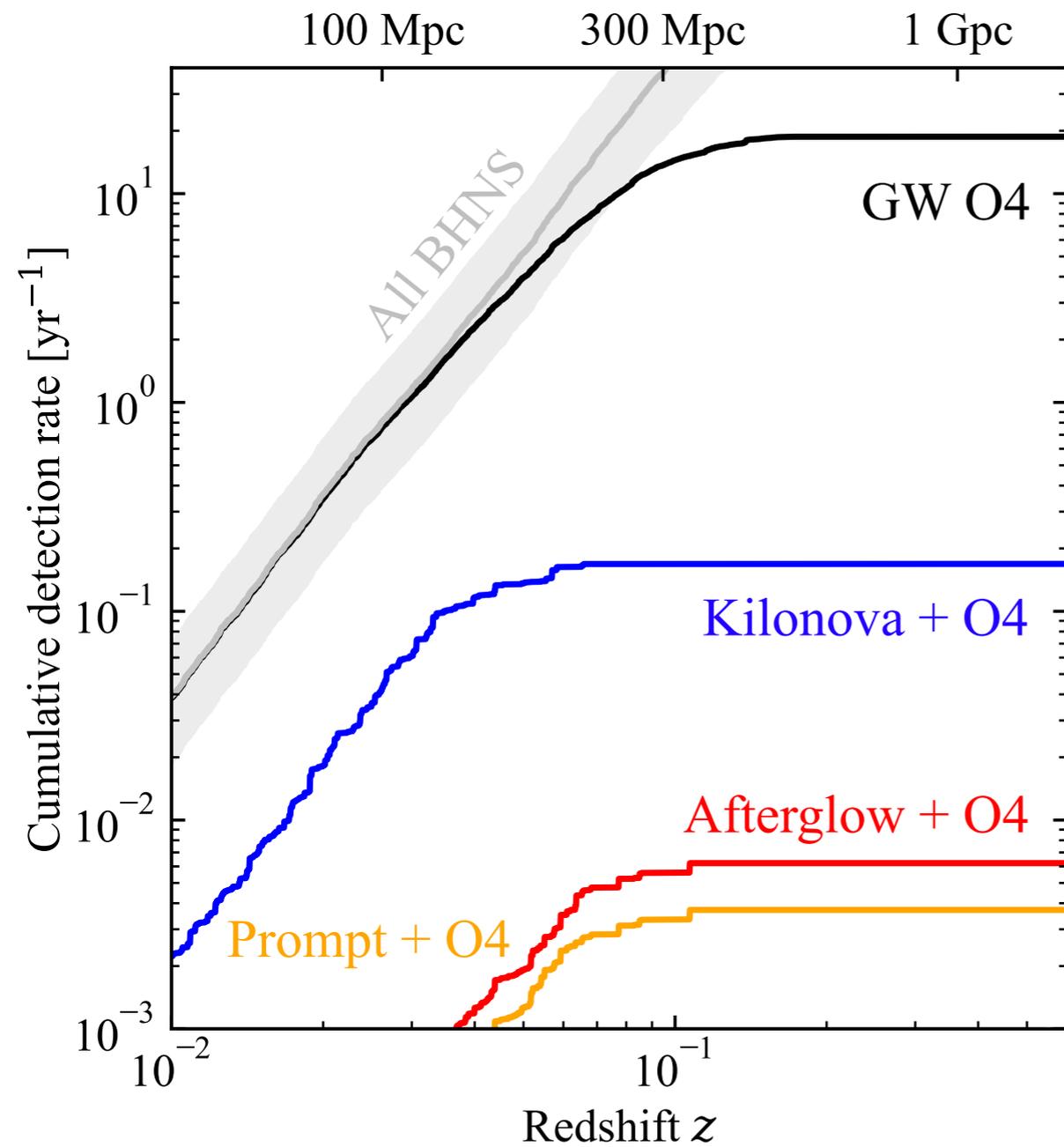
(most likely) No.

BHNS O4 Predictions



(Colombo+23, in prep)

BHNS O4 Predictions



(Colombo+23, in prep)

BHNS O4 Predictions

See also:

GW+KN

Frostig et al. (2022)

Zhu et al. (2021)

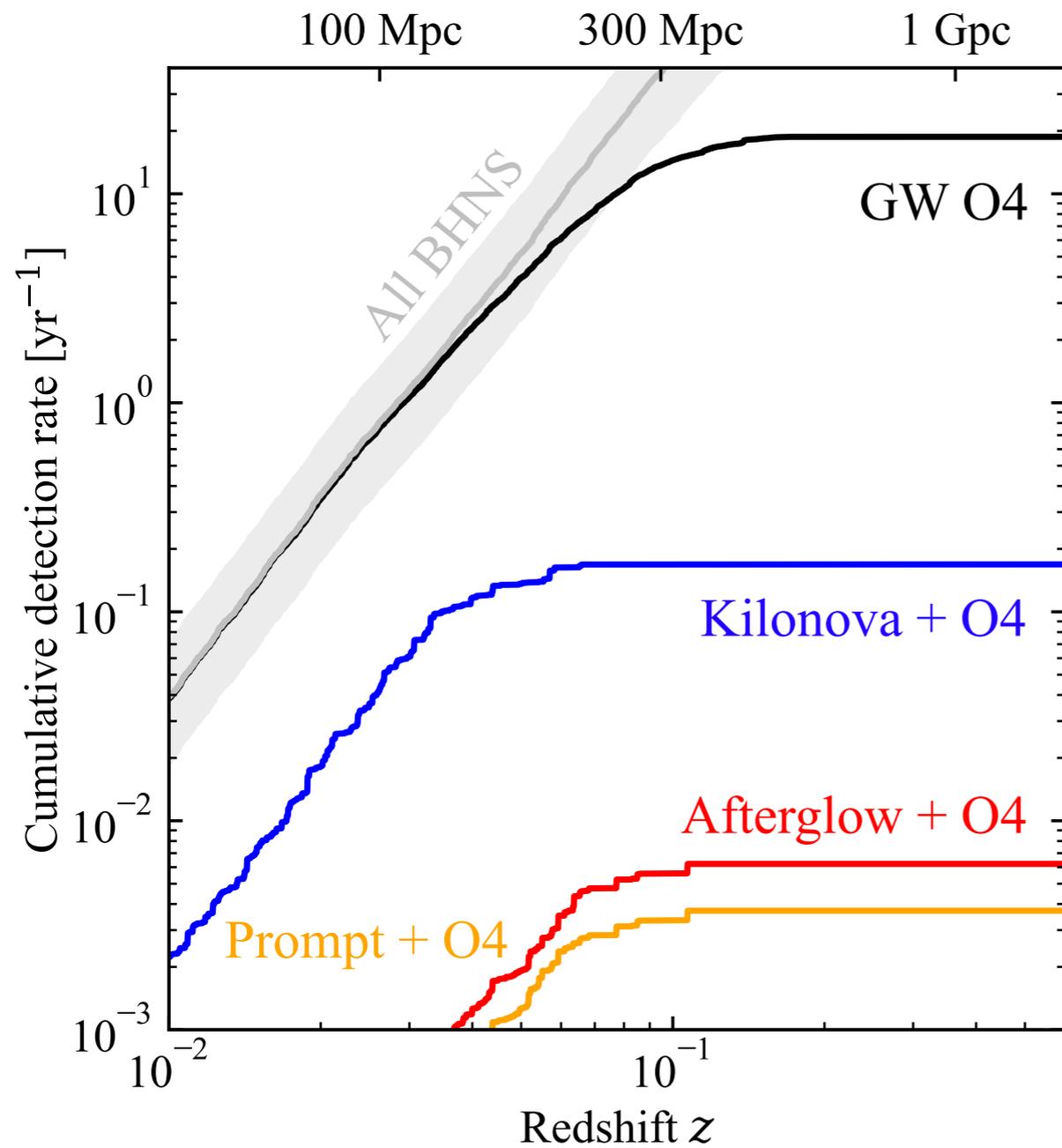
Mochkovitch et al. (2021)

GW+GRB

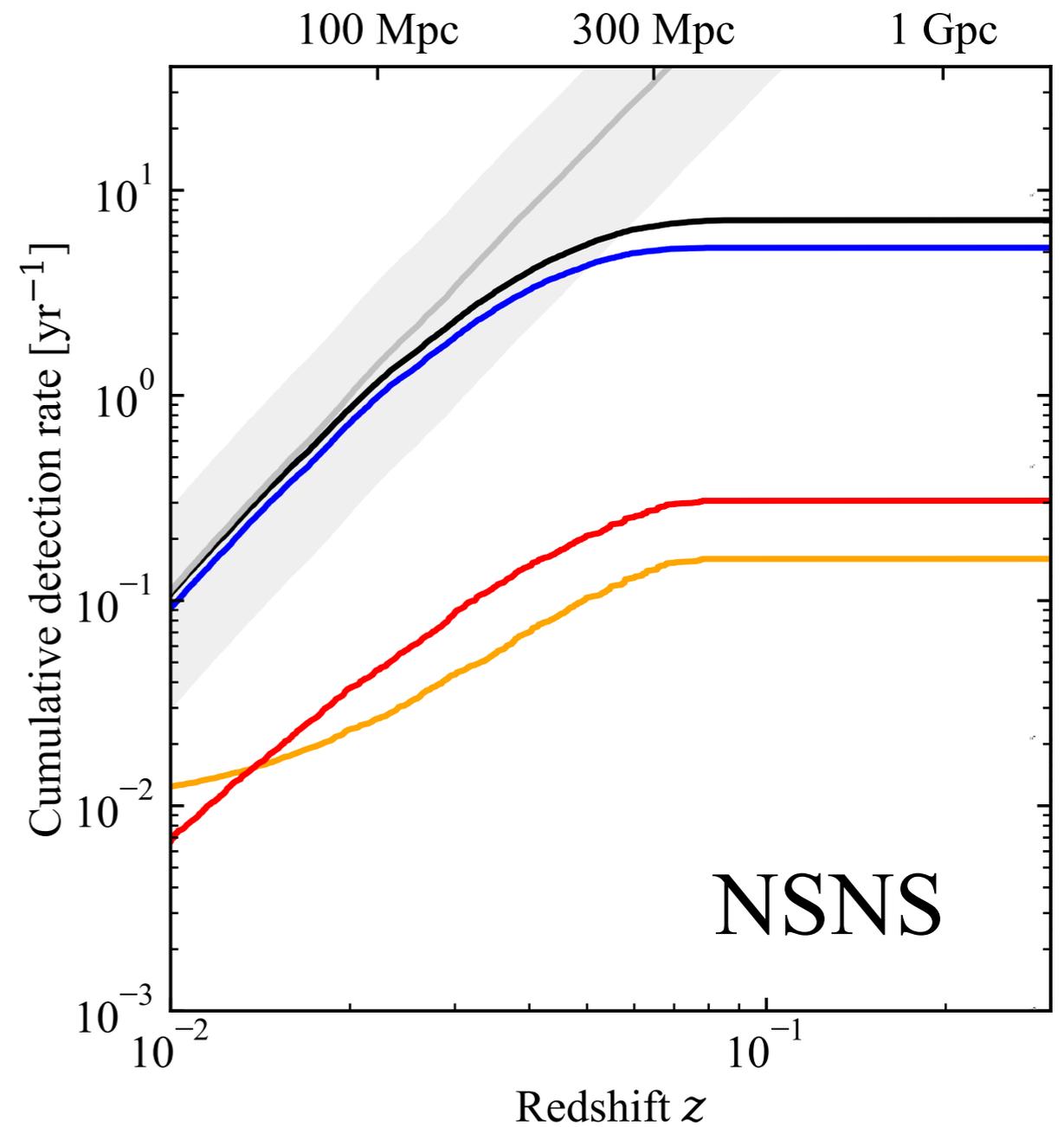
Patricelli et al. (2022)

Duque et al. (2019)

Saleem et al. (2018)



(Colombo+23, in prep)



(Colombo+22)

BHNS O4 Predictions

See also:

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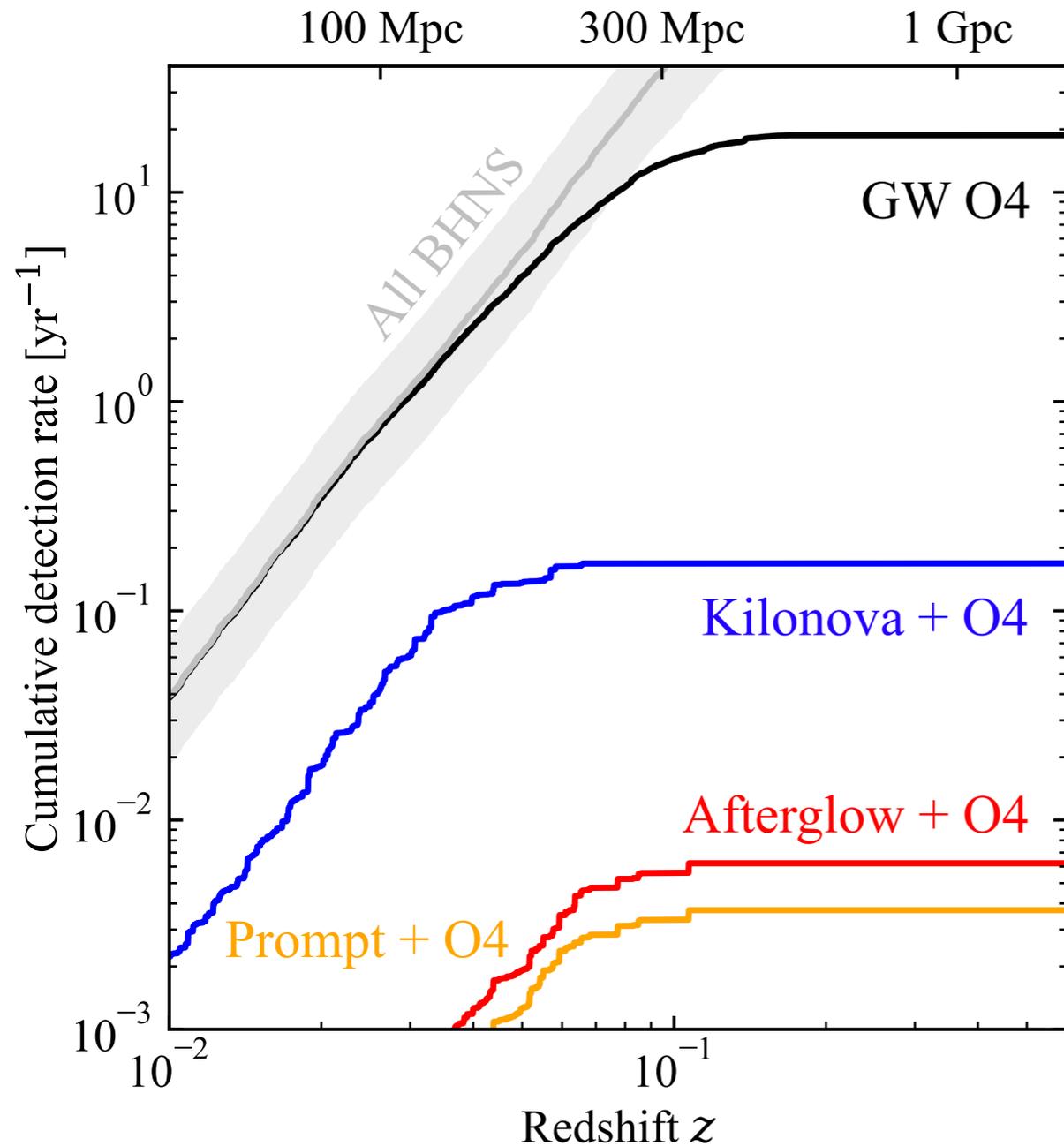
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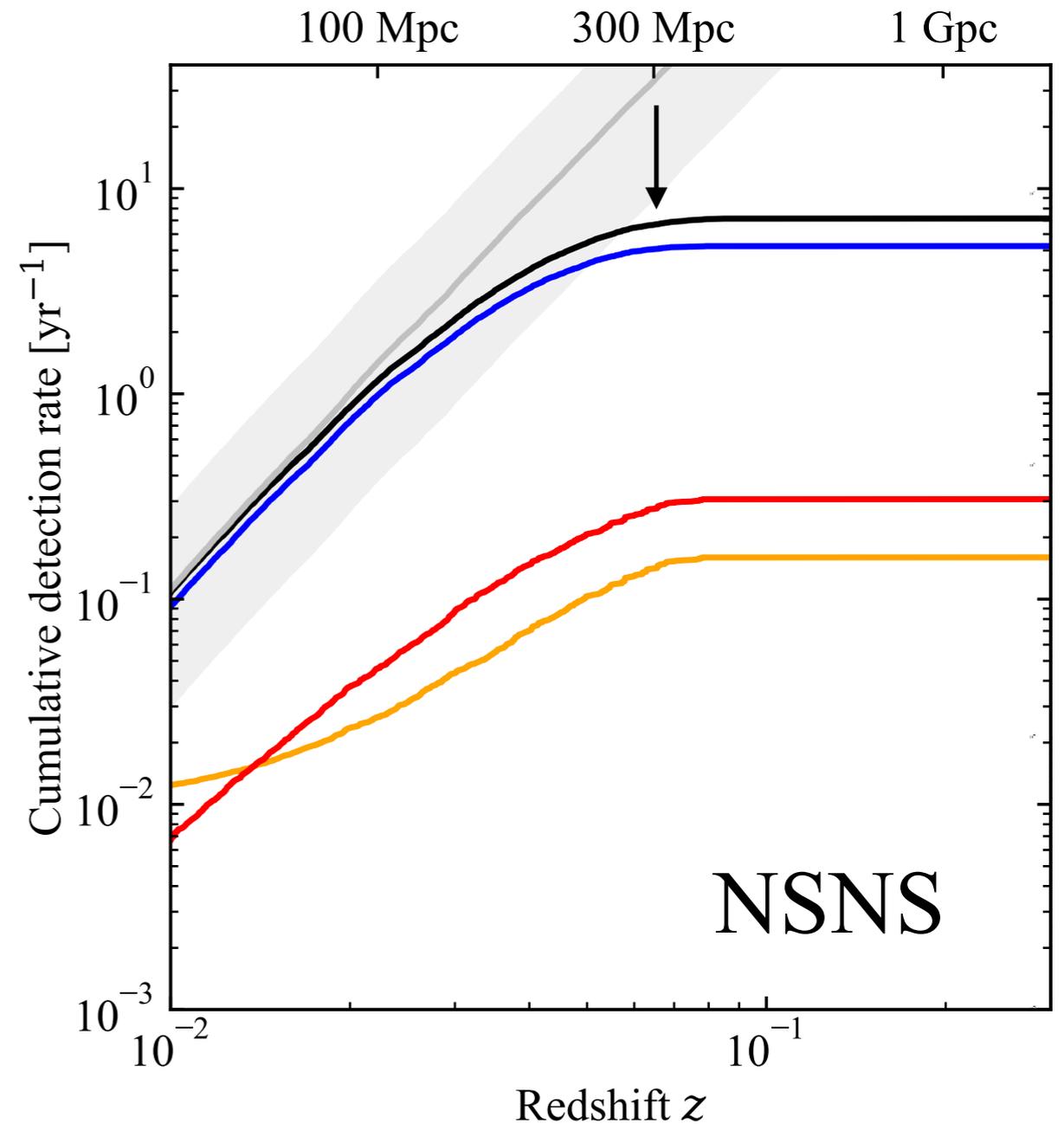
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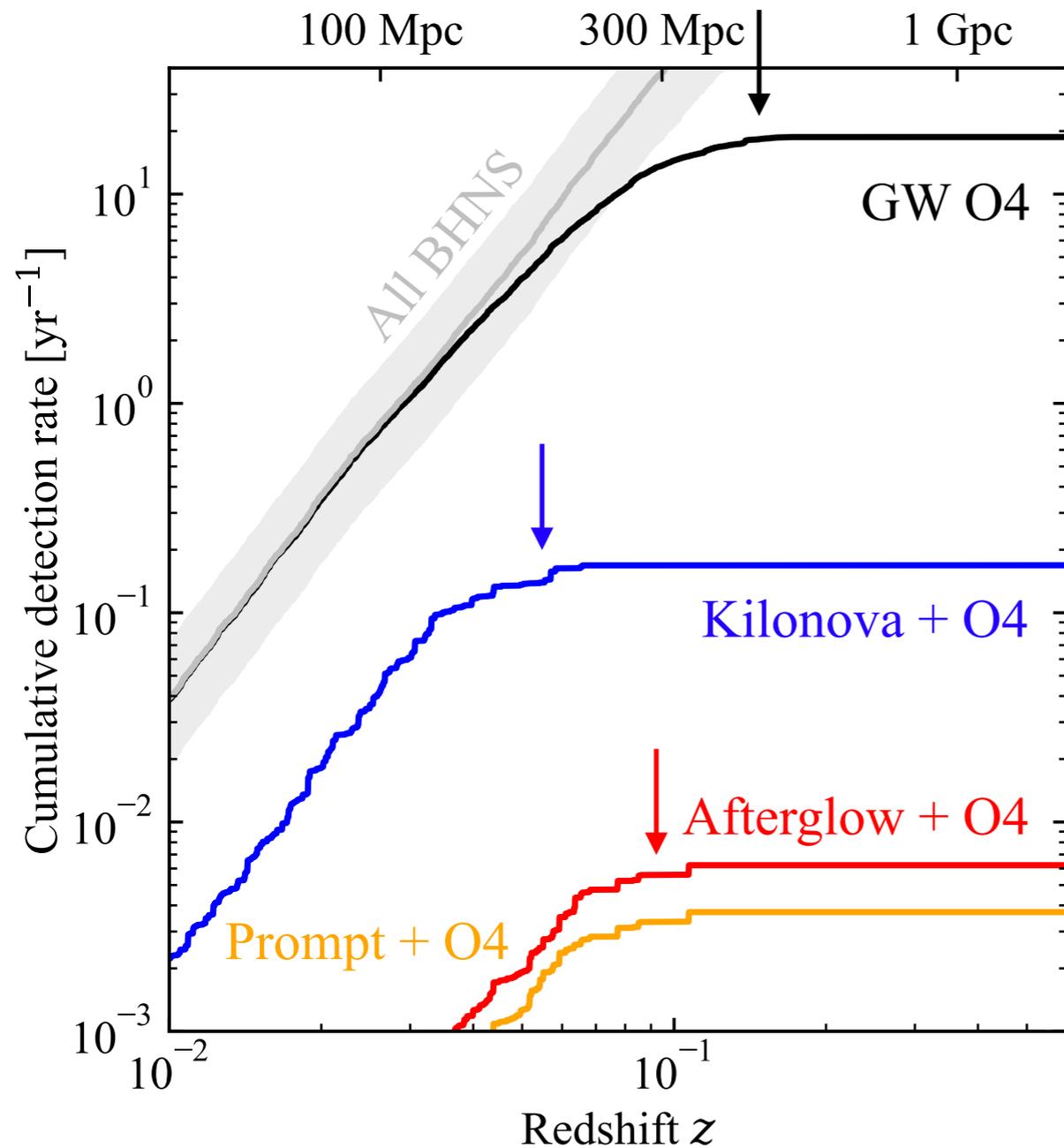
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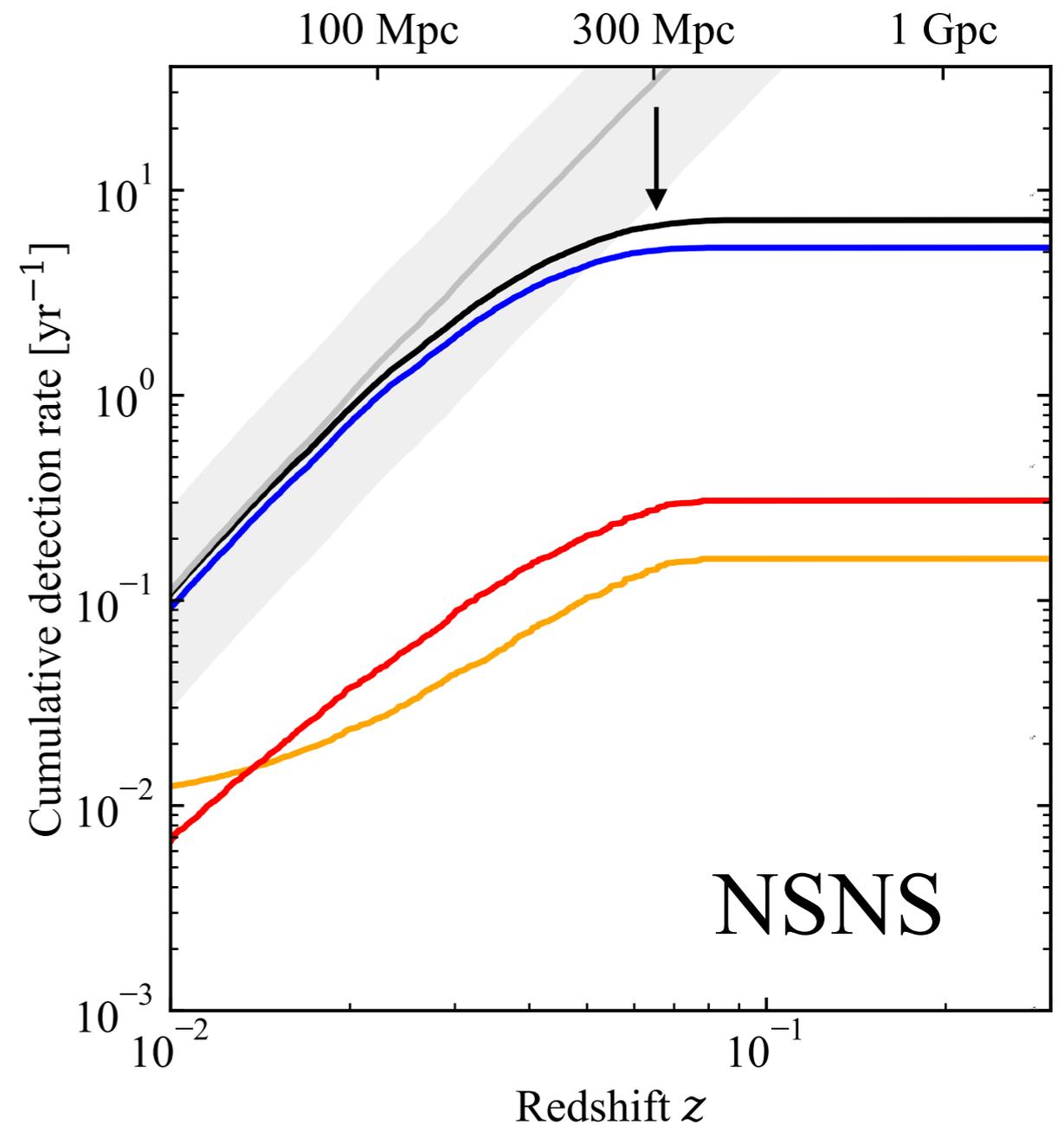
Patricelli et al. (2022)

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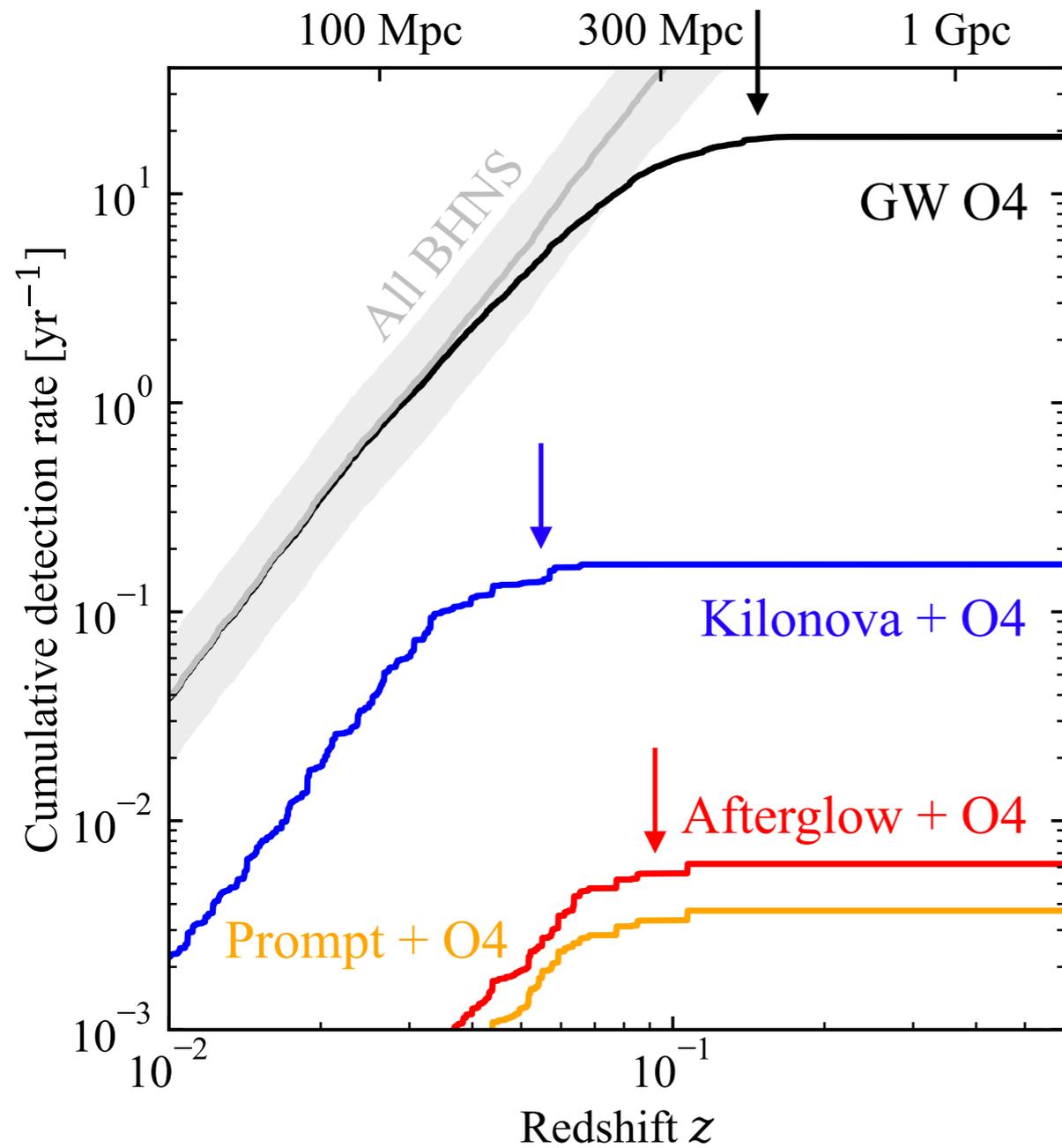


(Colombo+23, in prep)

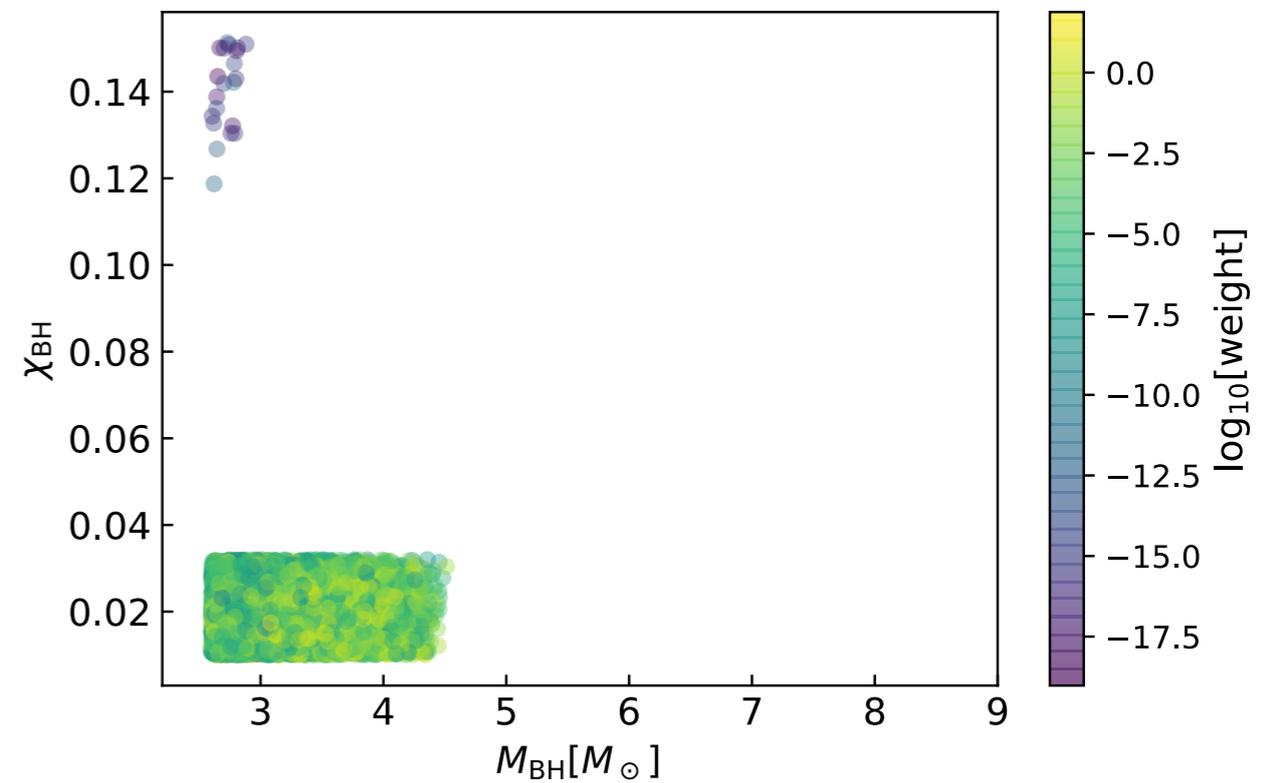
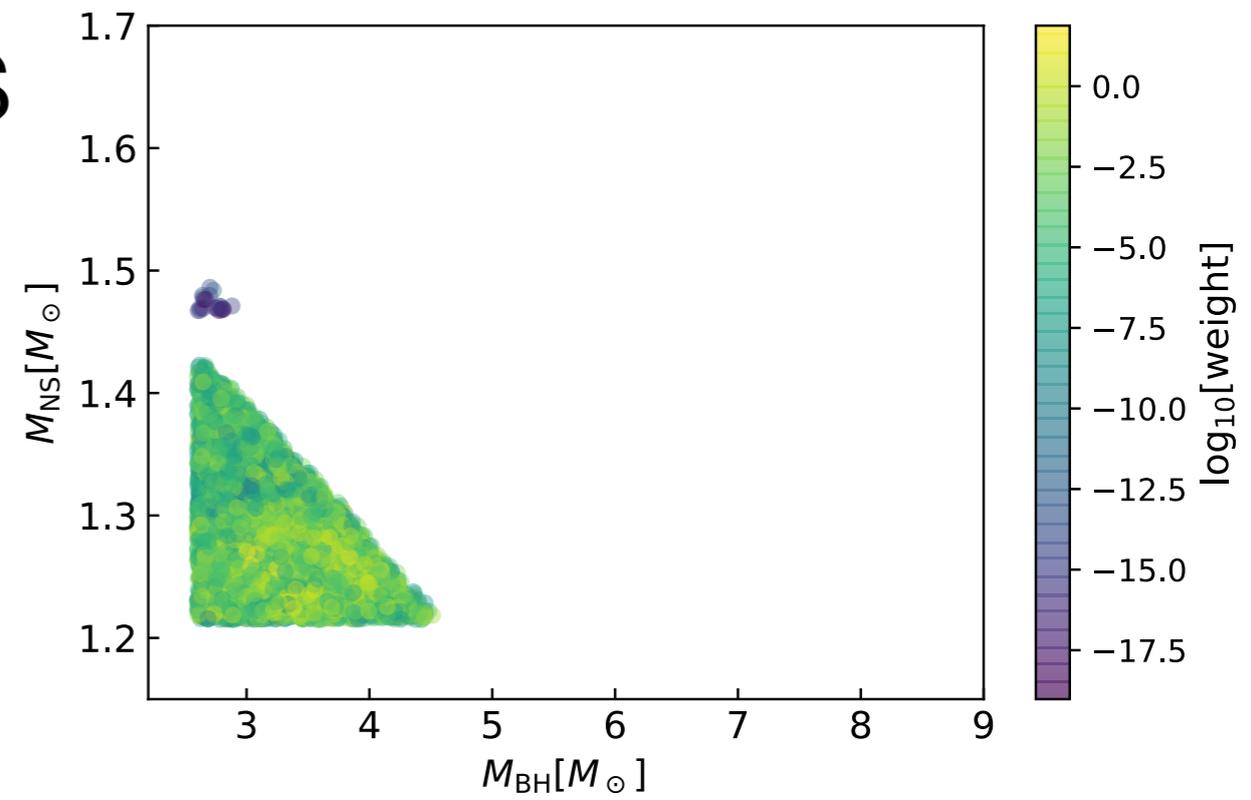


(Colombo+22)

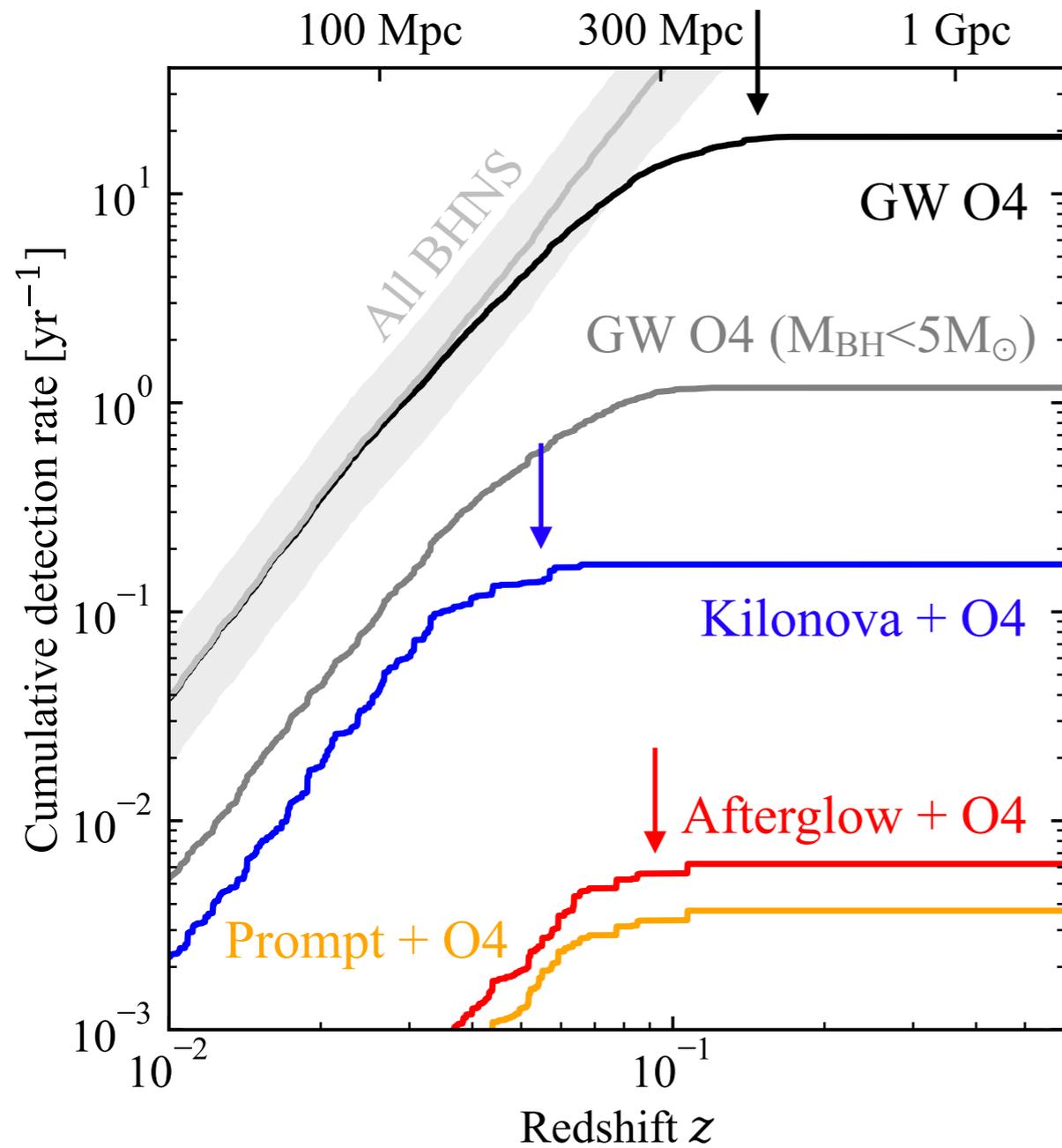
BHNS O4 Predictions



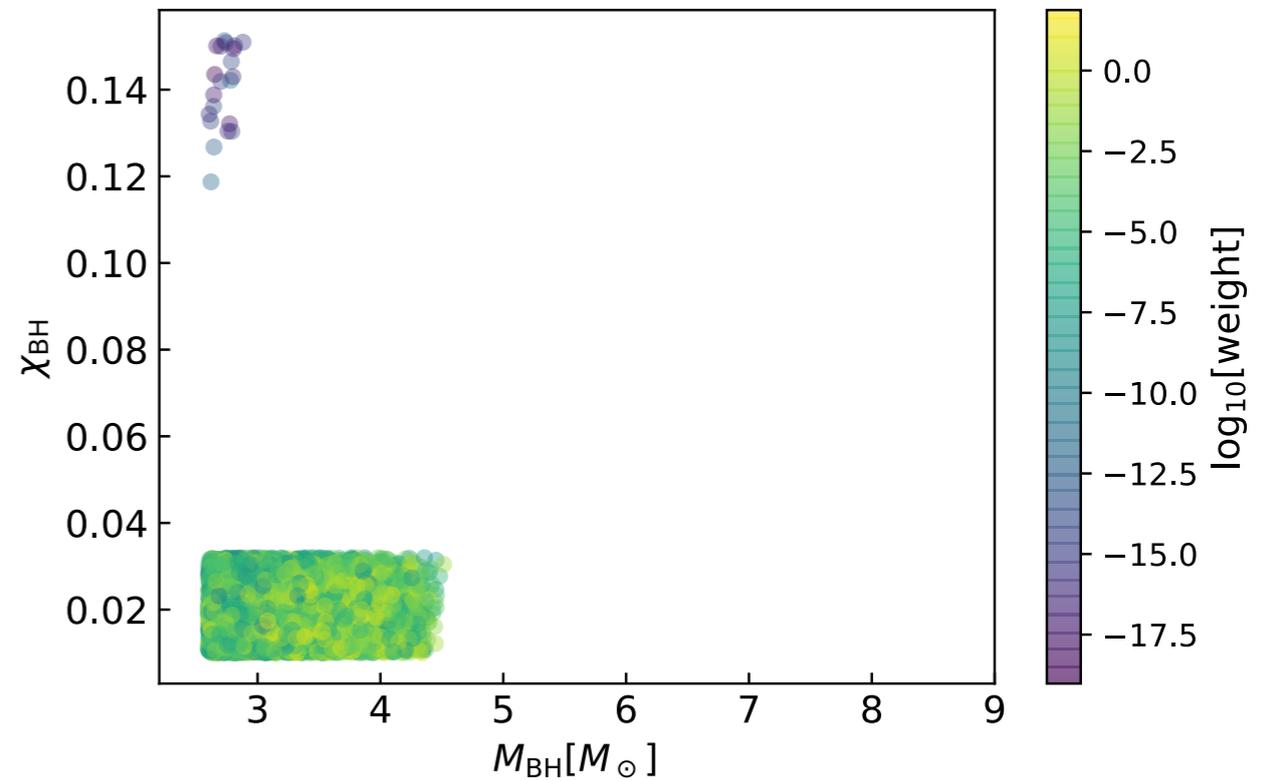
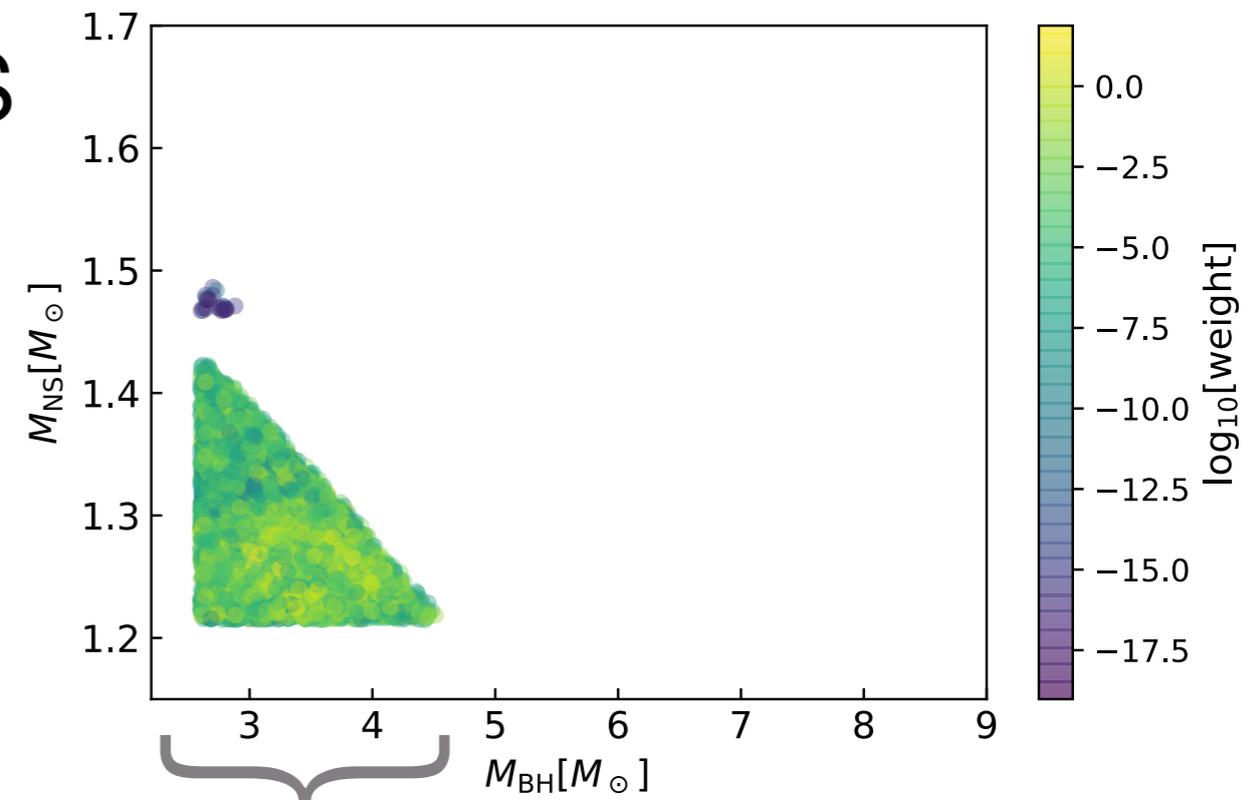
(Colombo+23, in prep)



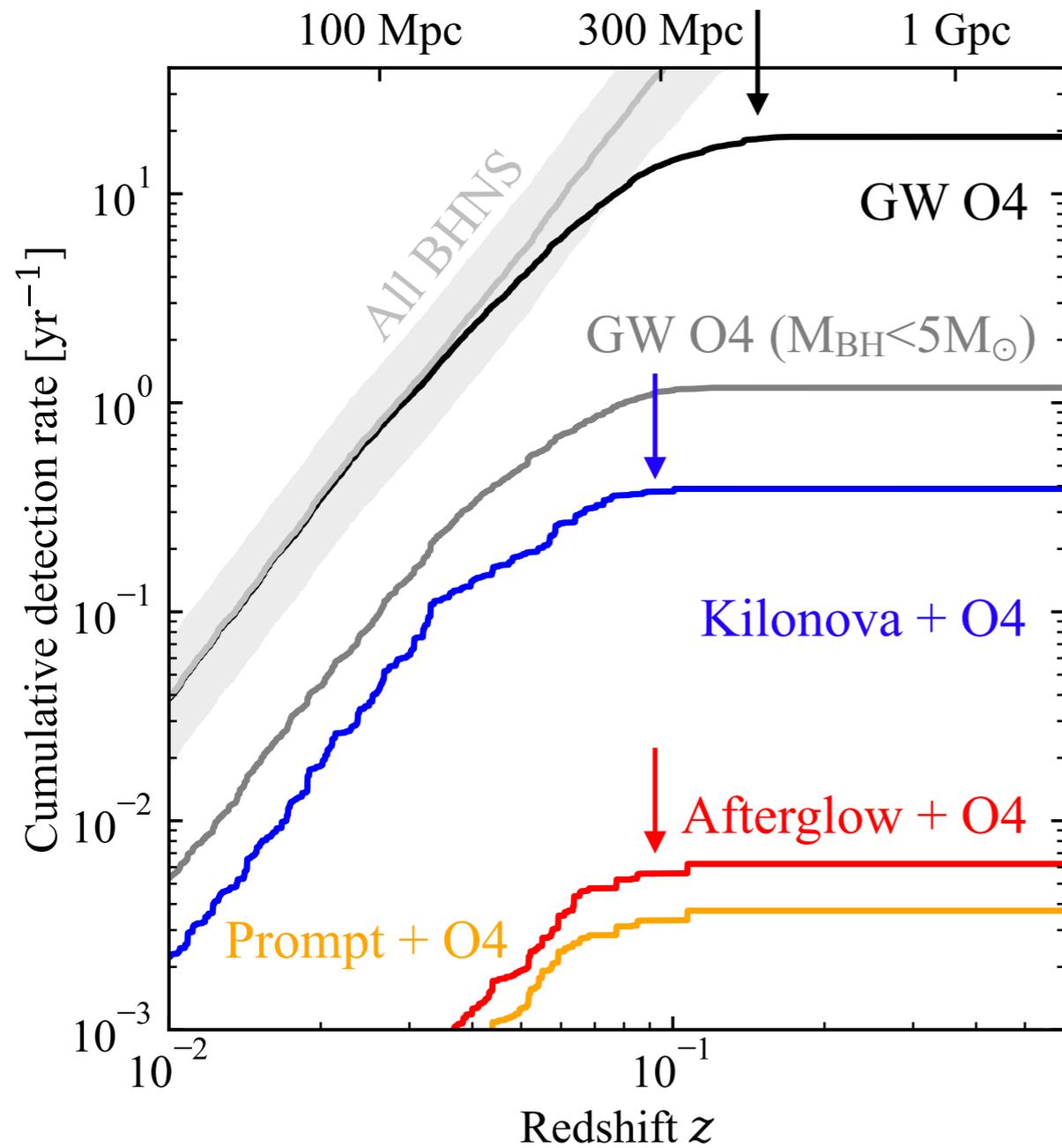
BHNS O4 Predictions



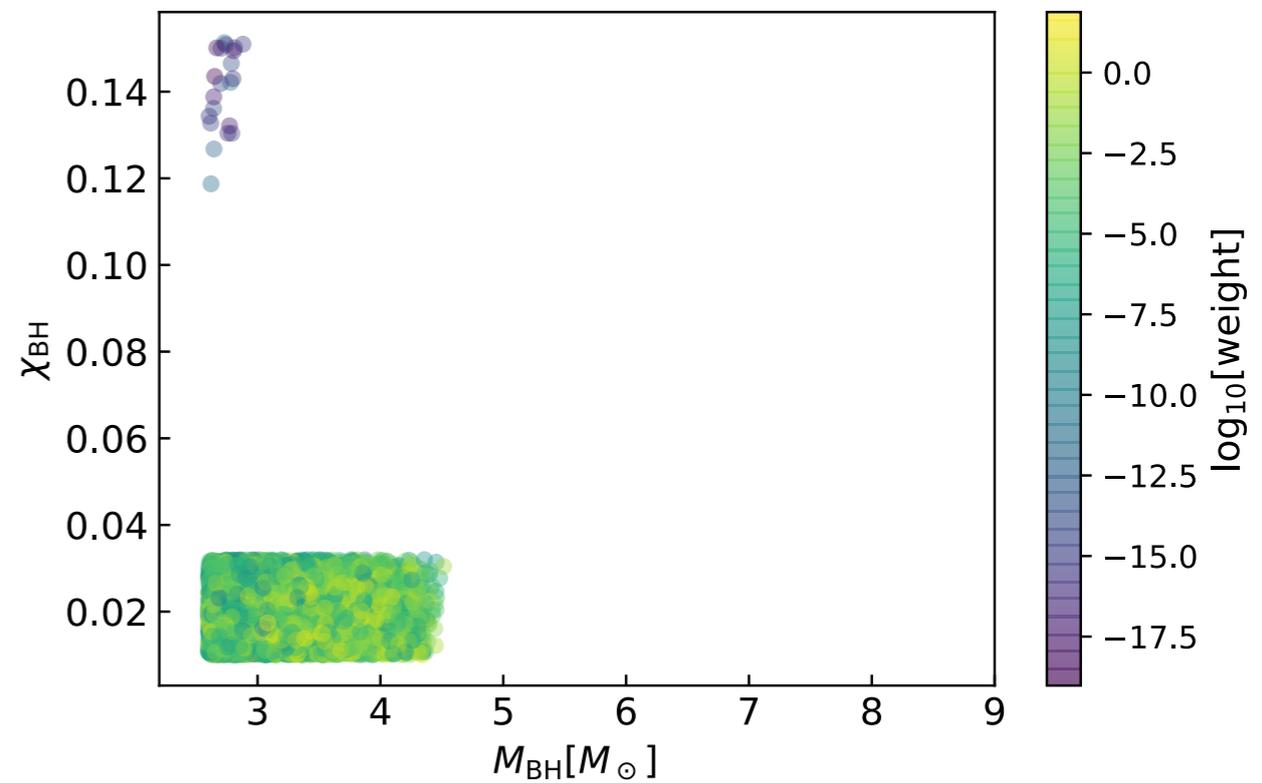
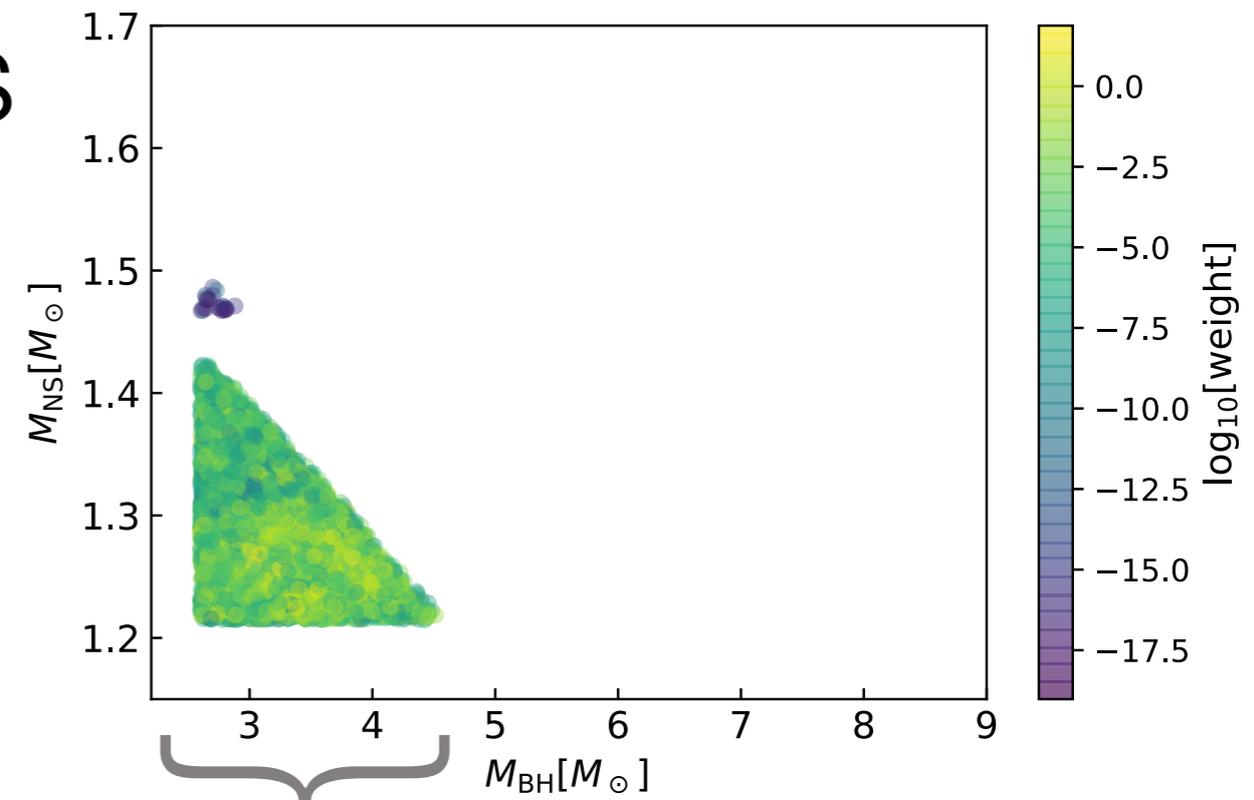
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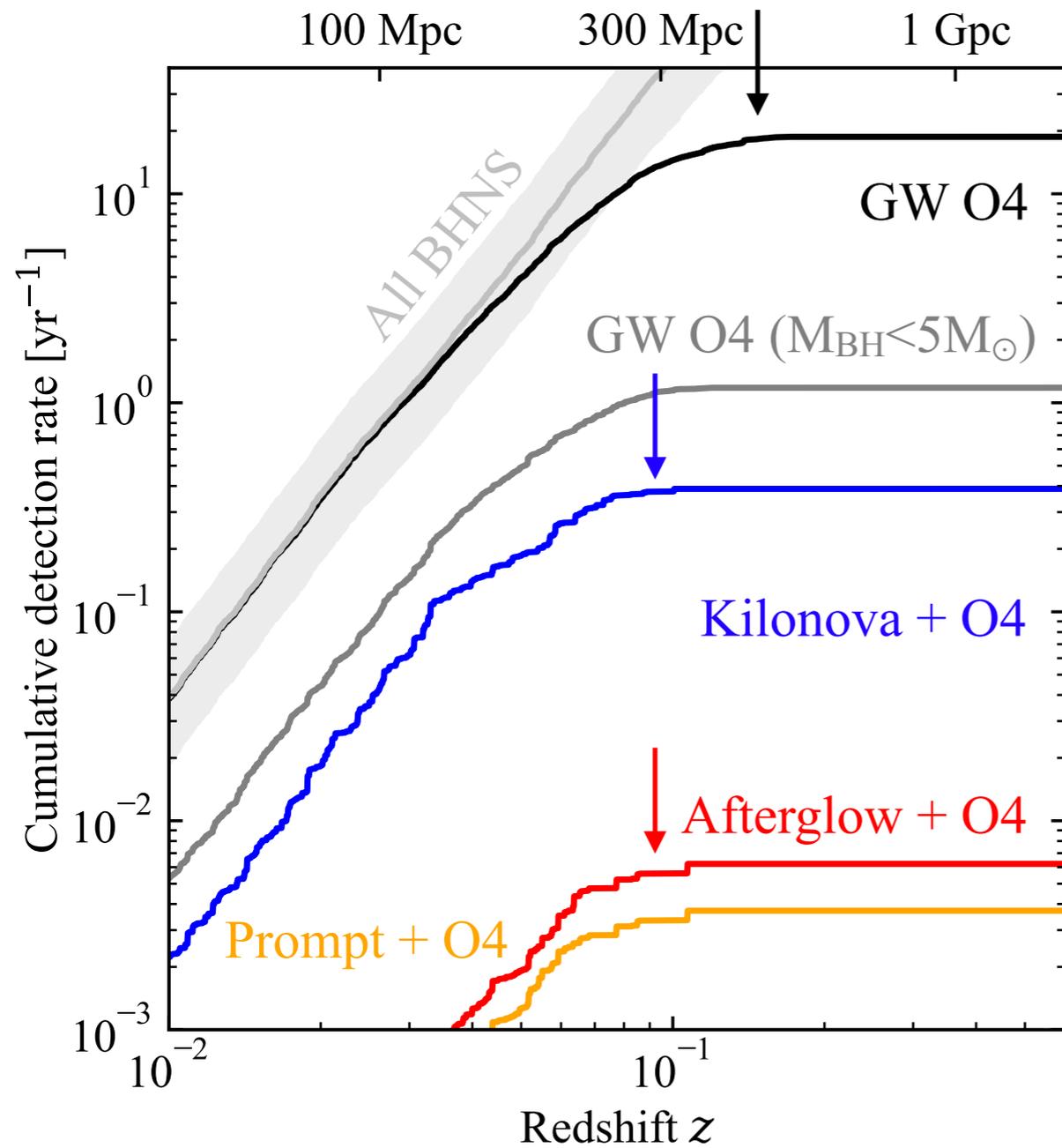
BHNS O4 Predictions



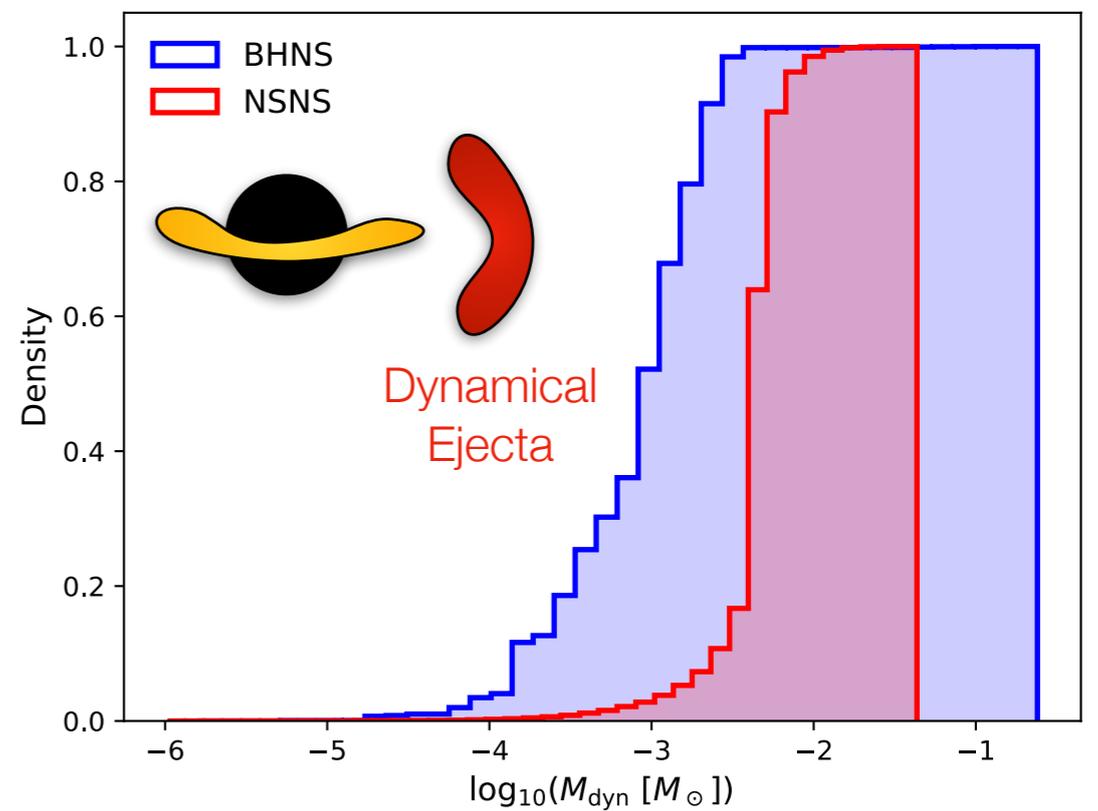
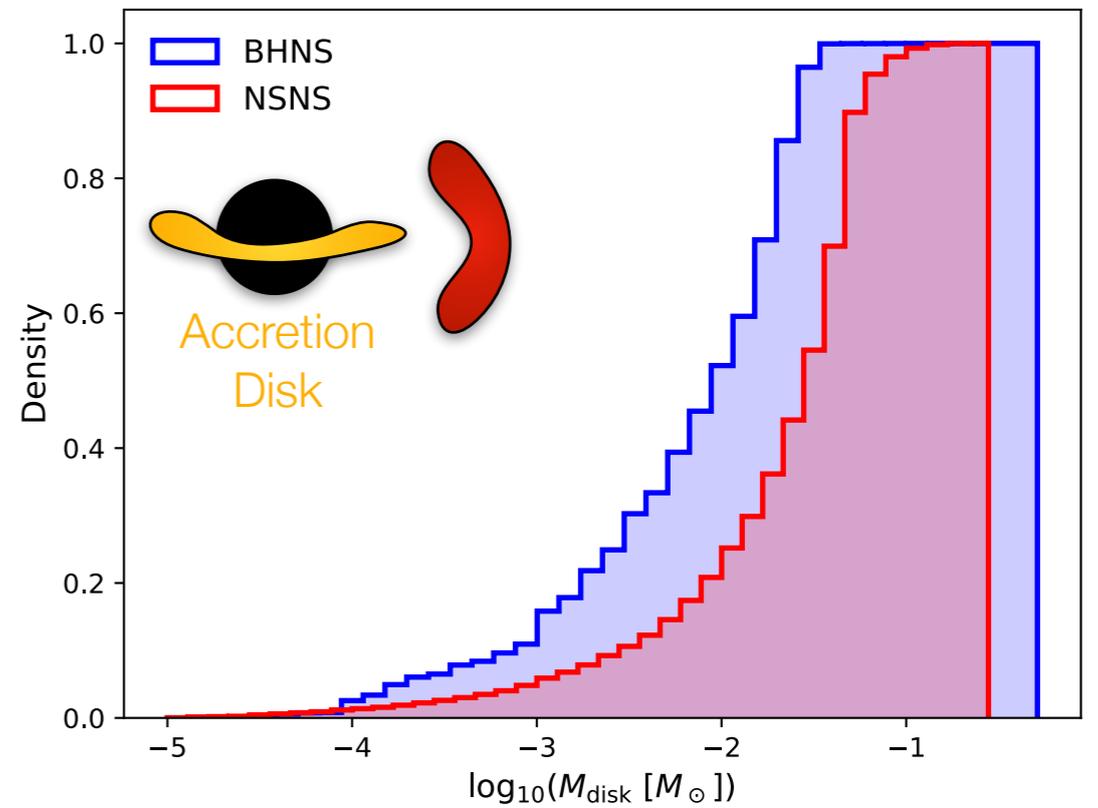
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BHNS O4 Predictions

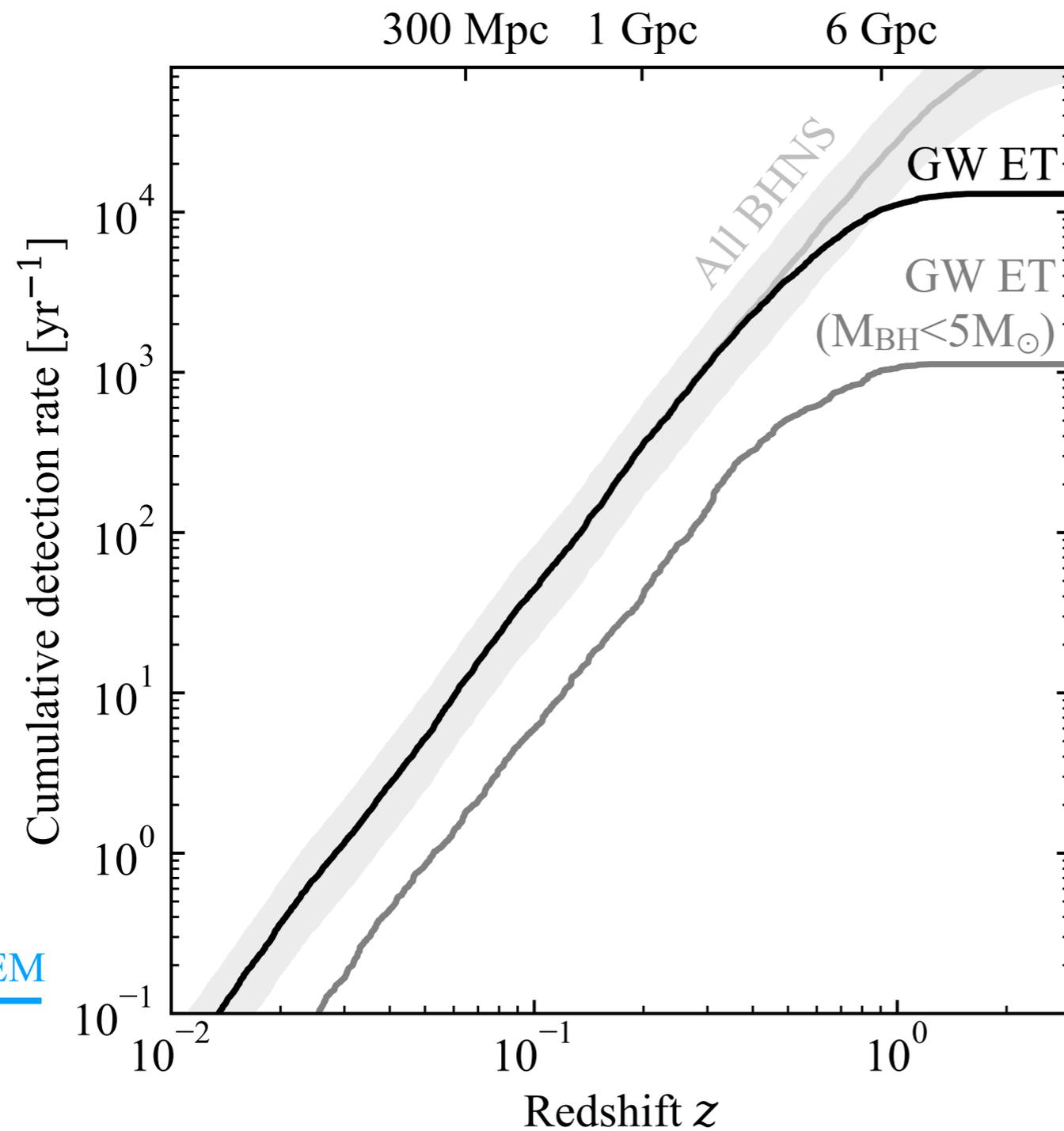


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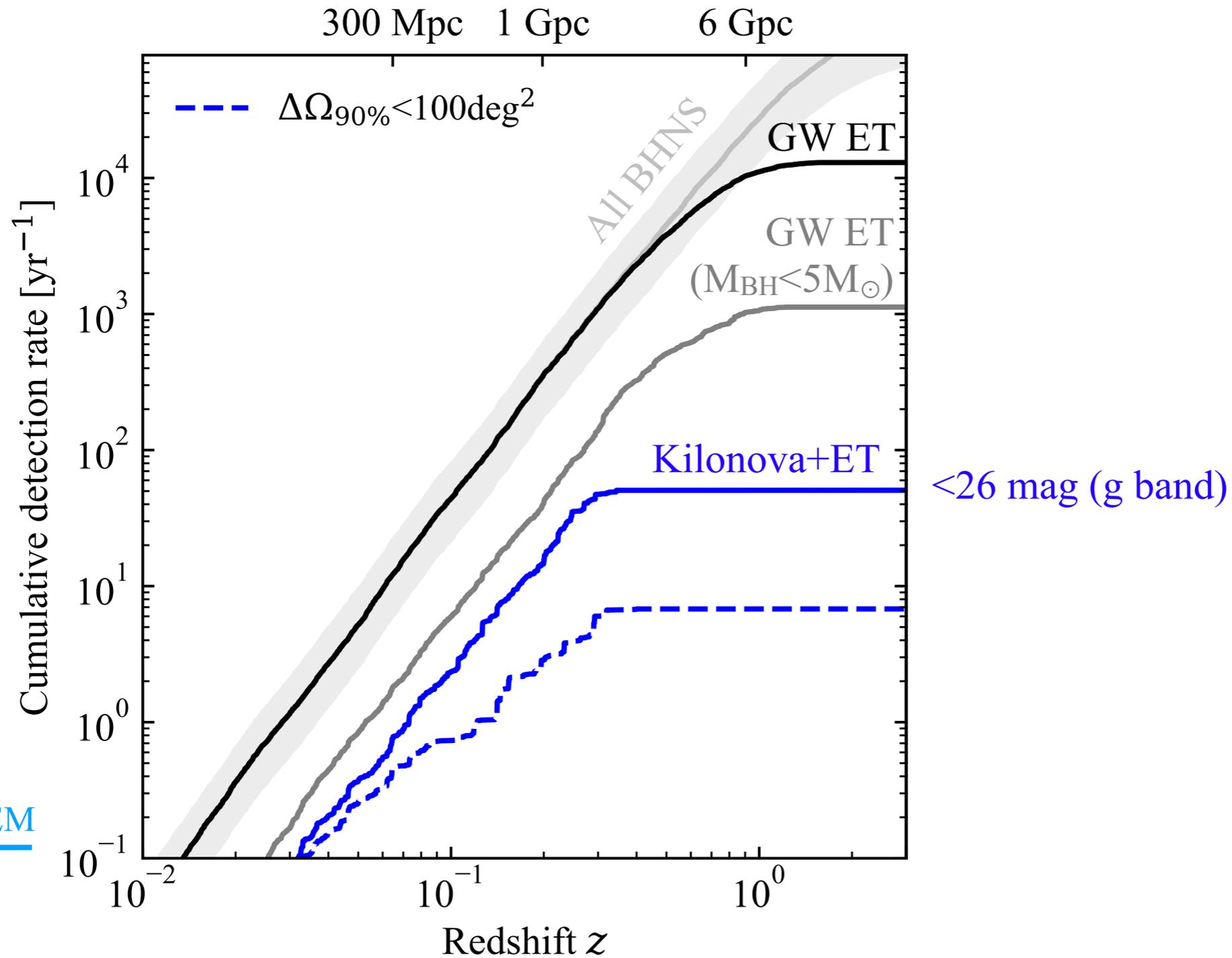
A (preliminary) look on the Einstein Telescope era

BHNS ET $\Delta 10\text{km}$ Predictions

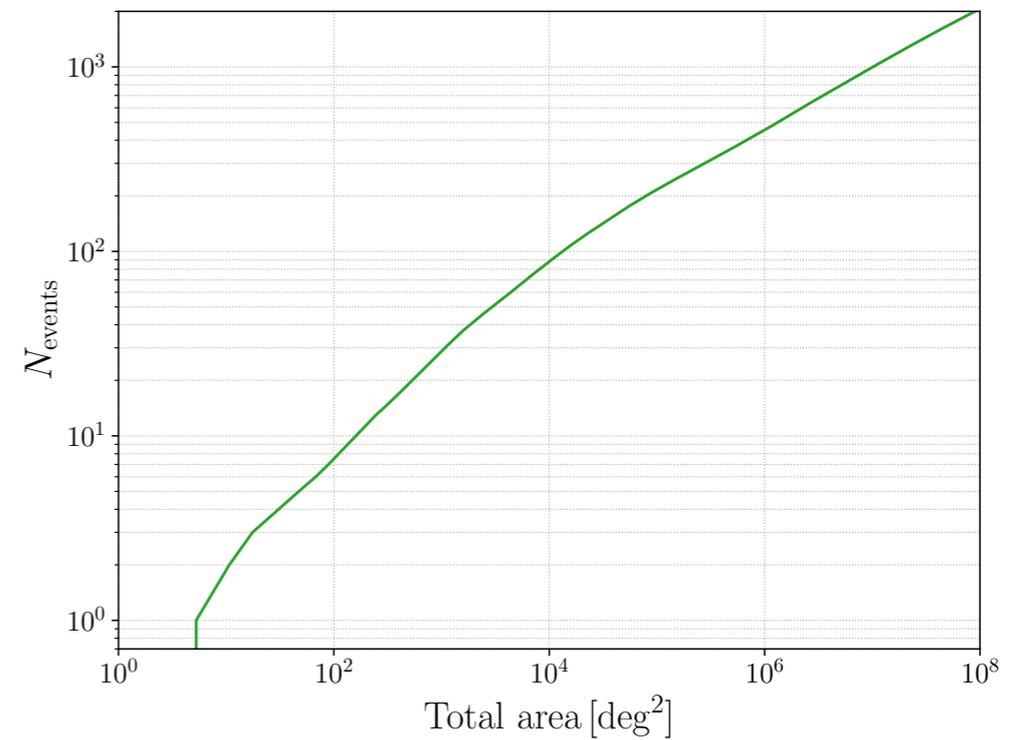
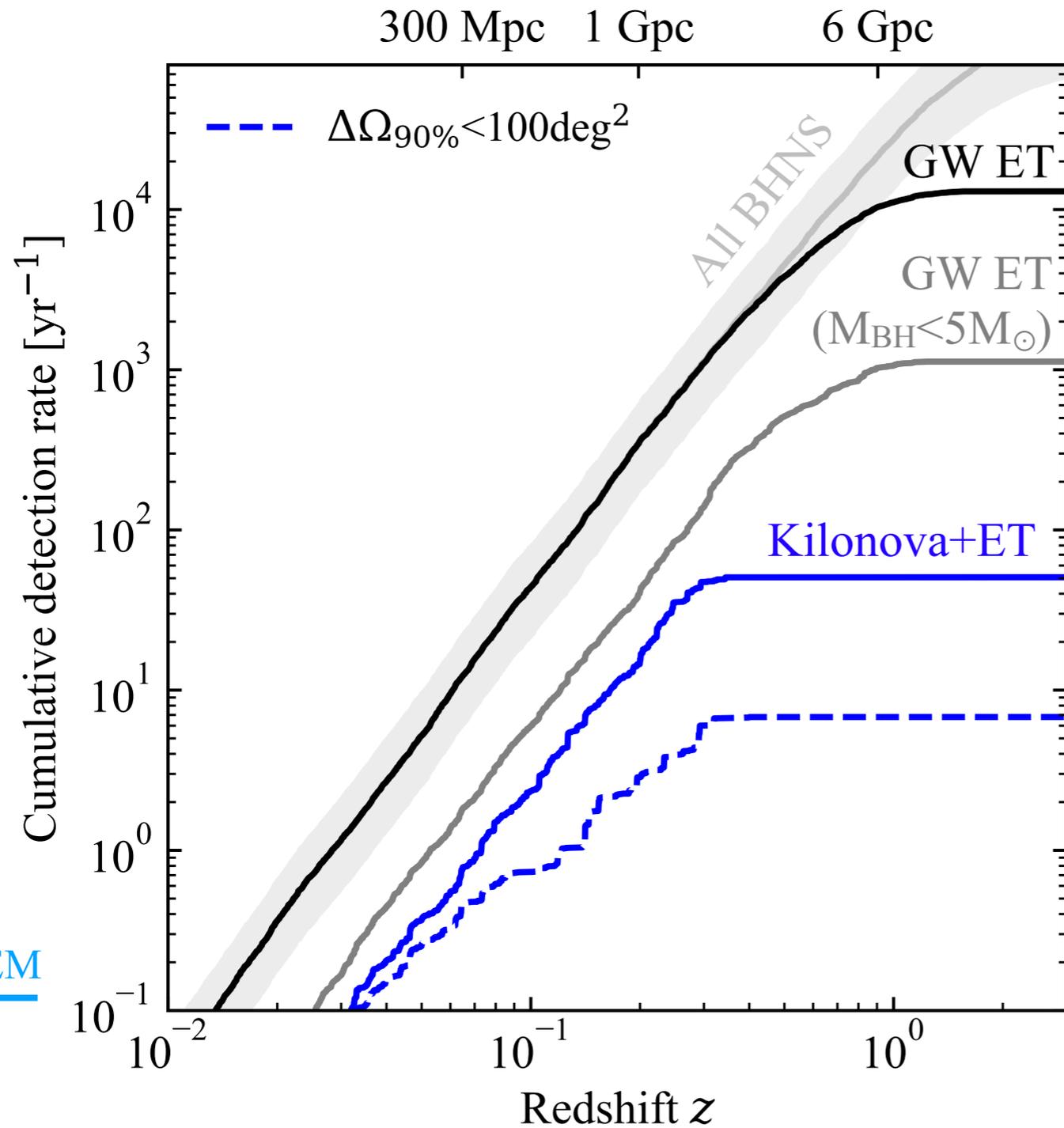


O4 GW+EM
↓

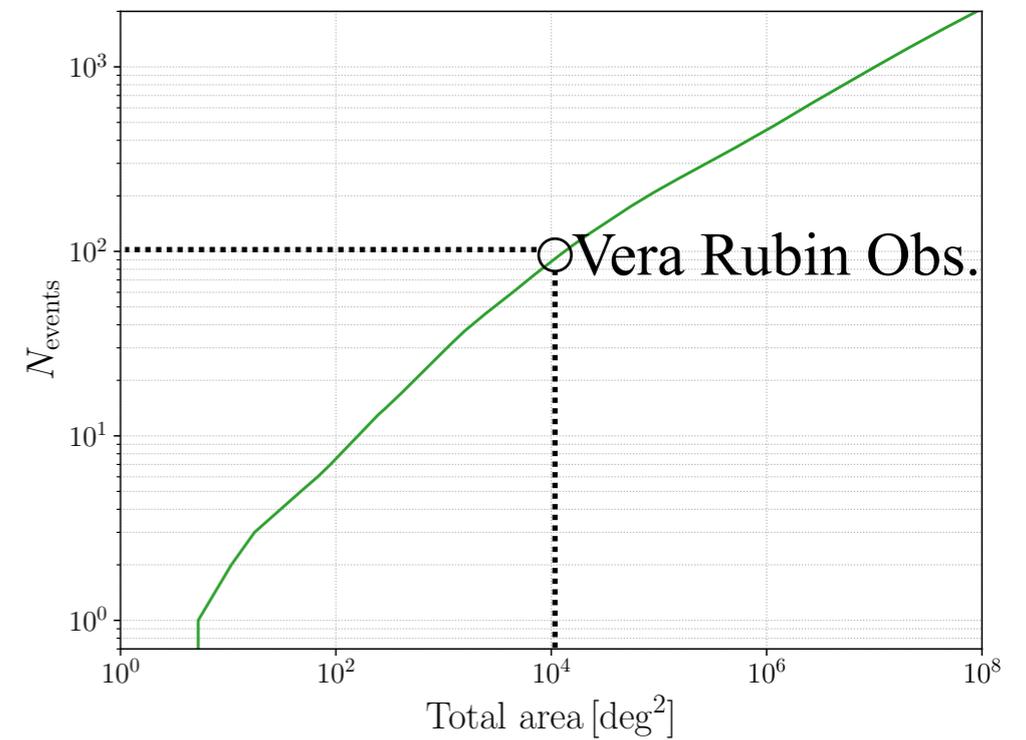
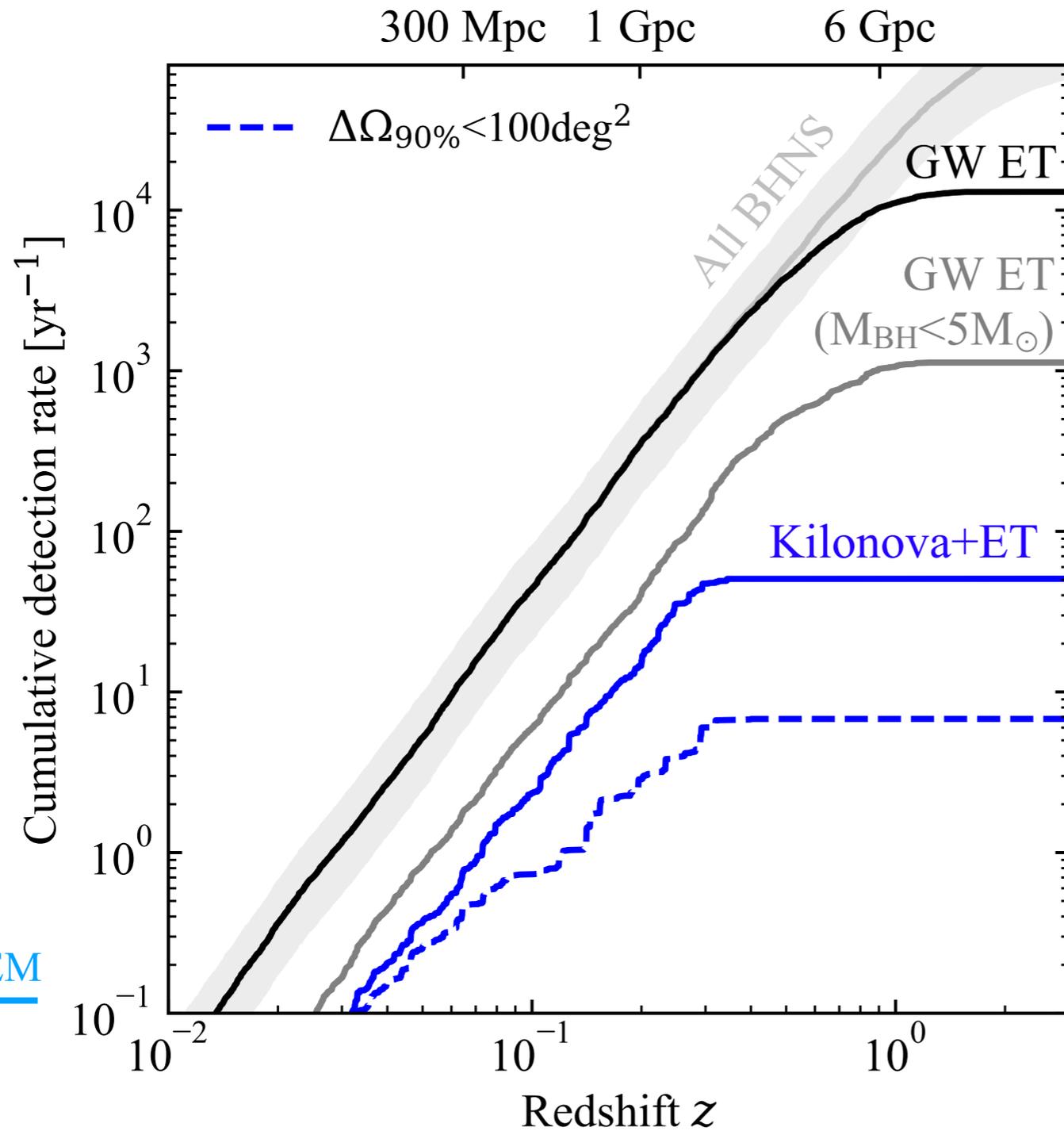
BHNS ET $\Delta 10\text{km}$ Predictions



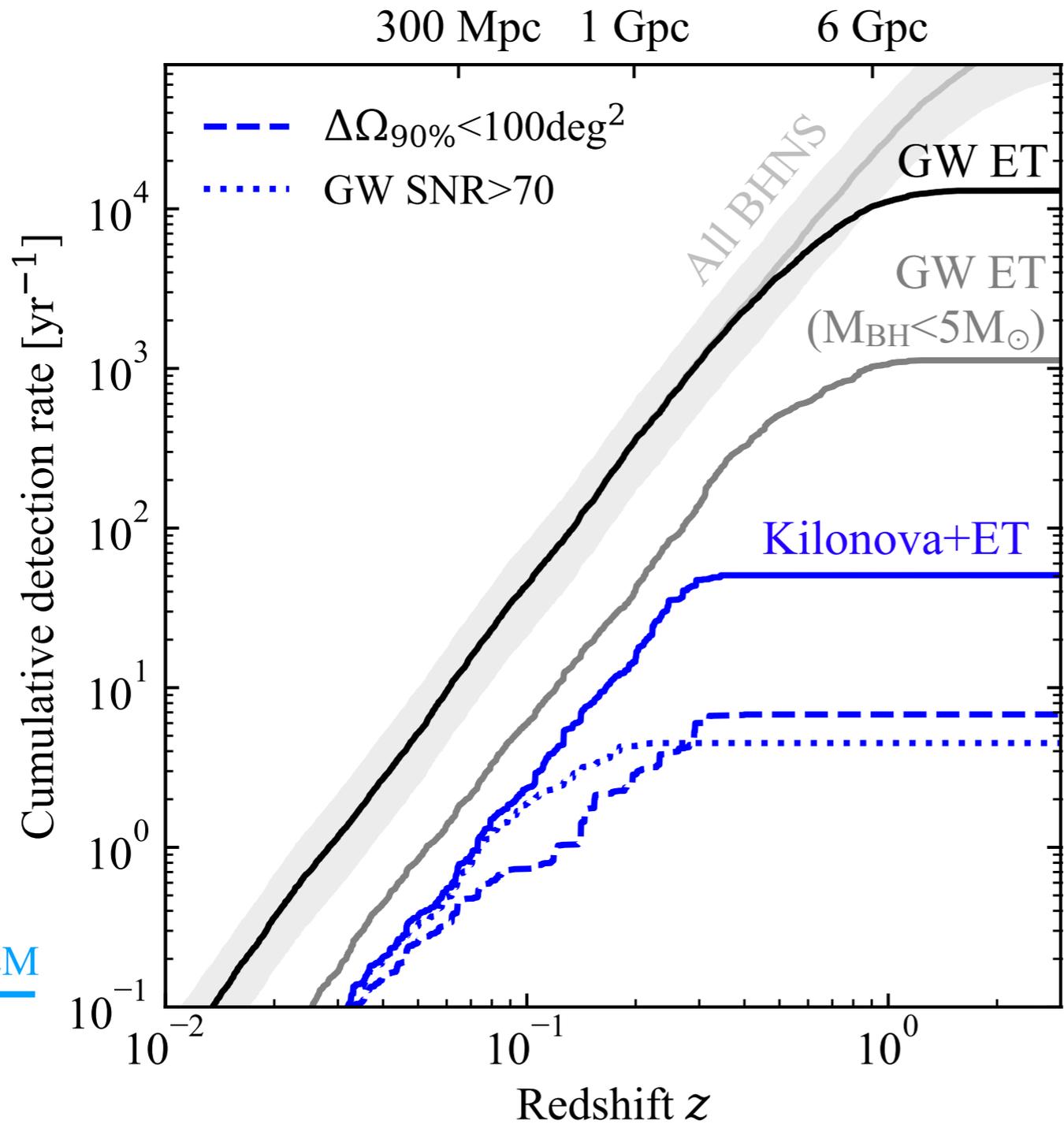
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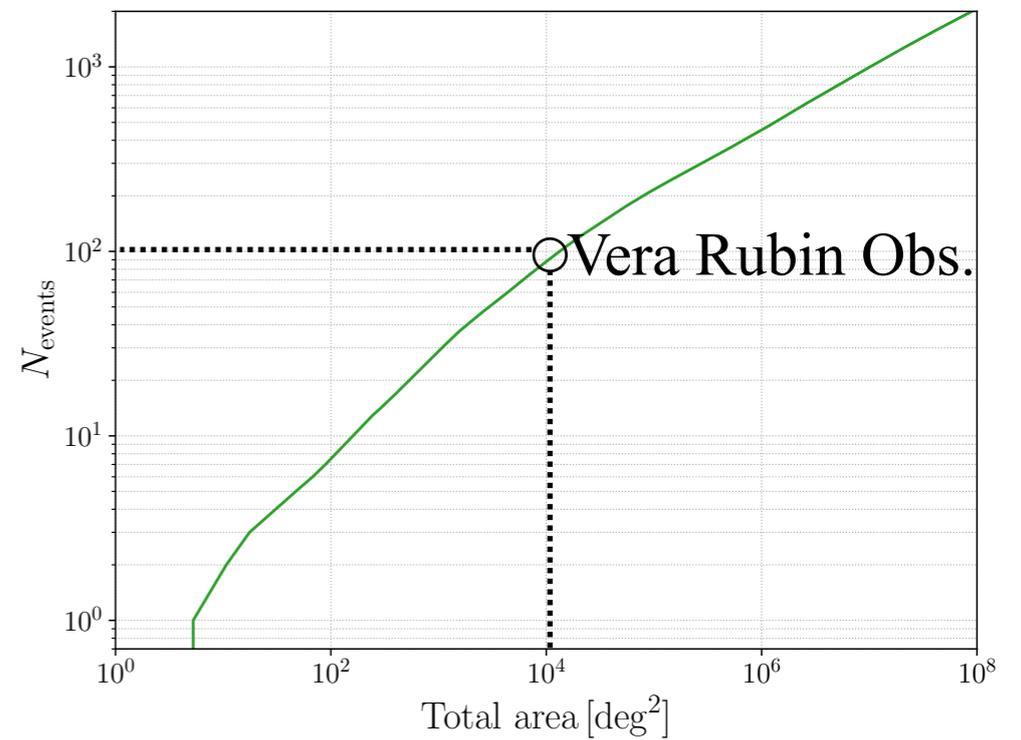
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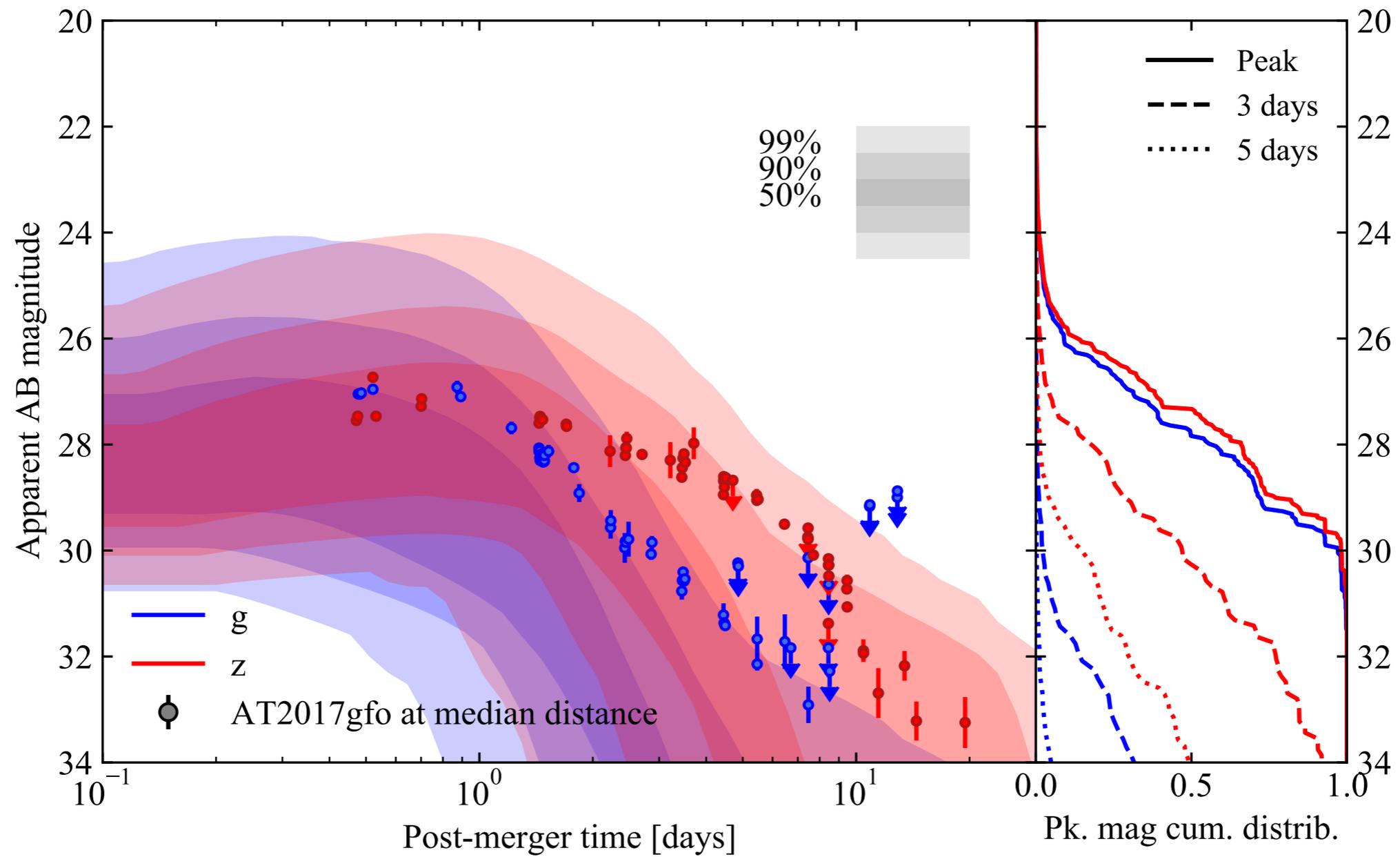
BHNS ET $\Delta 10\text{km}$ Predictions



O4 GW+EM

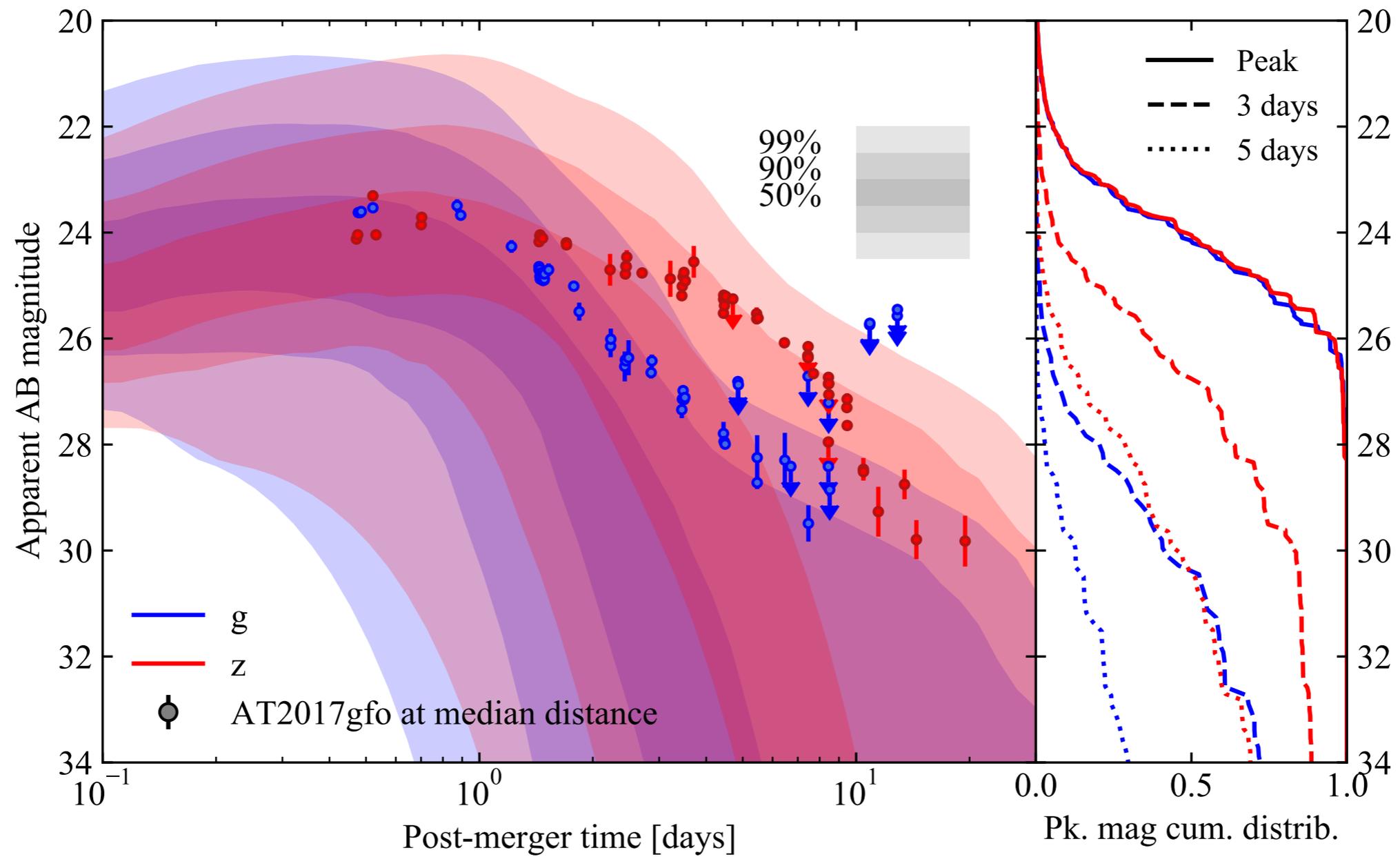


BHNS ET Kilonovae



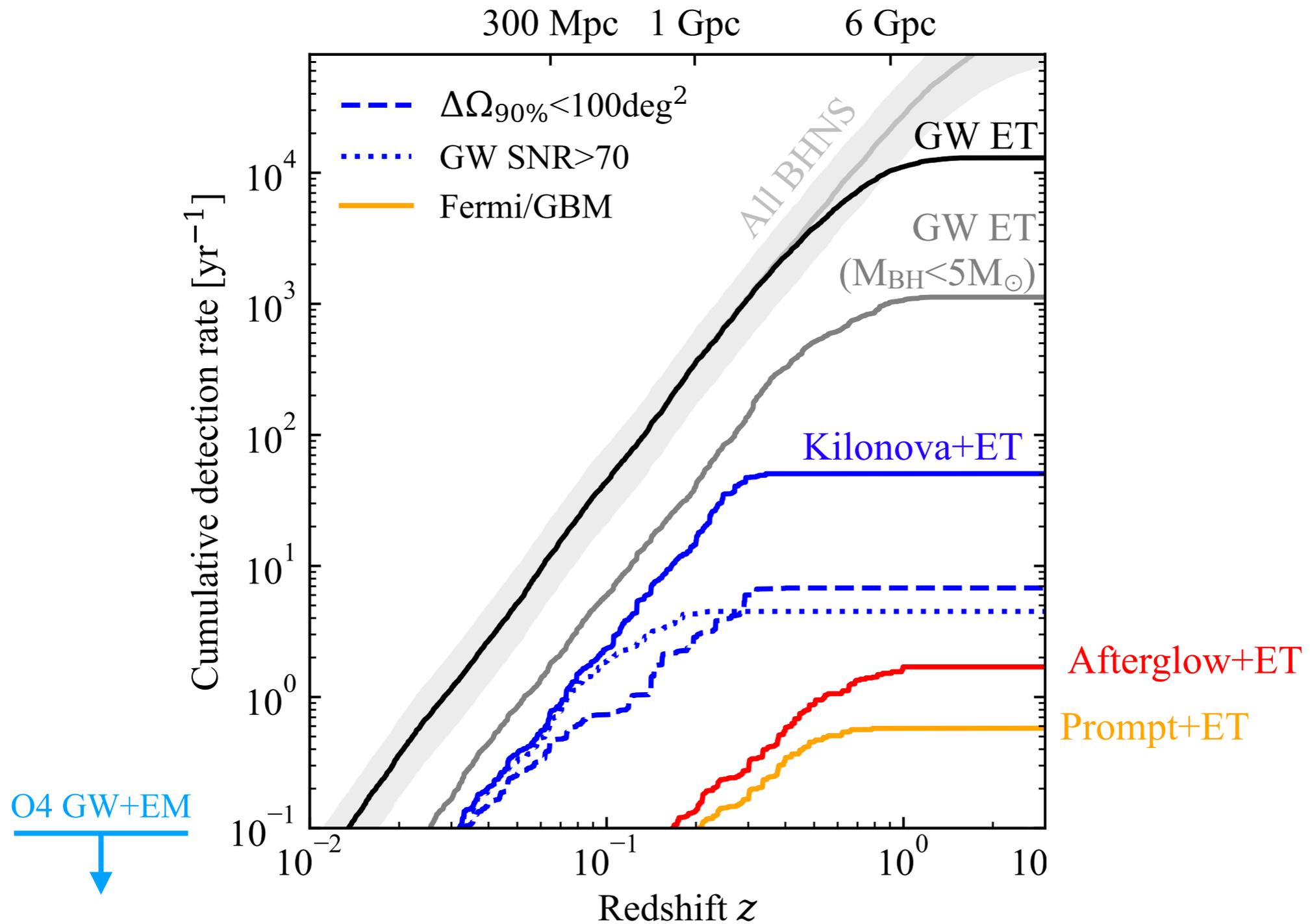
GW SNR > 12

BHNS ET Kilonovae

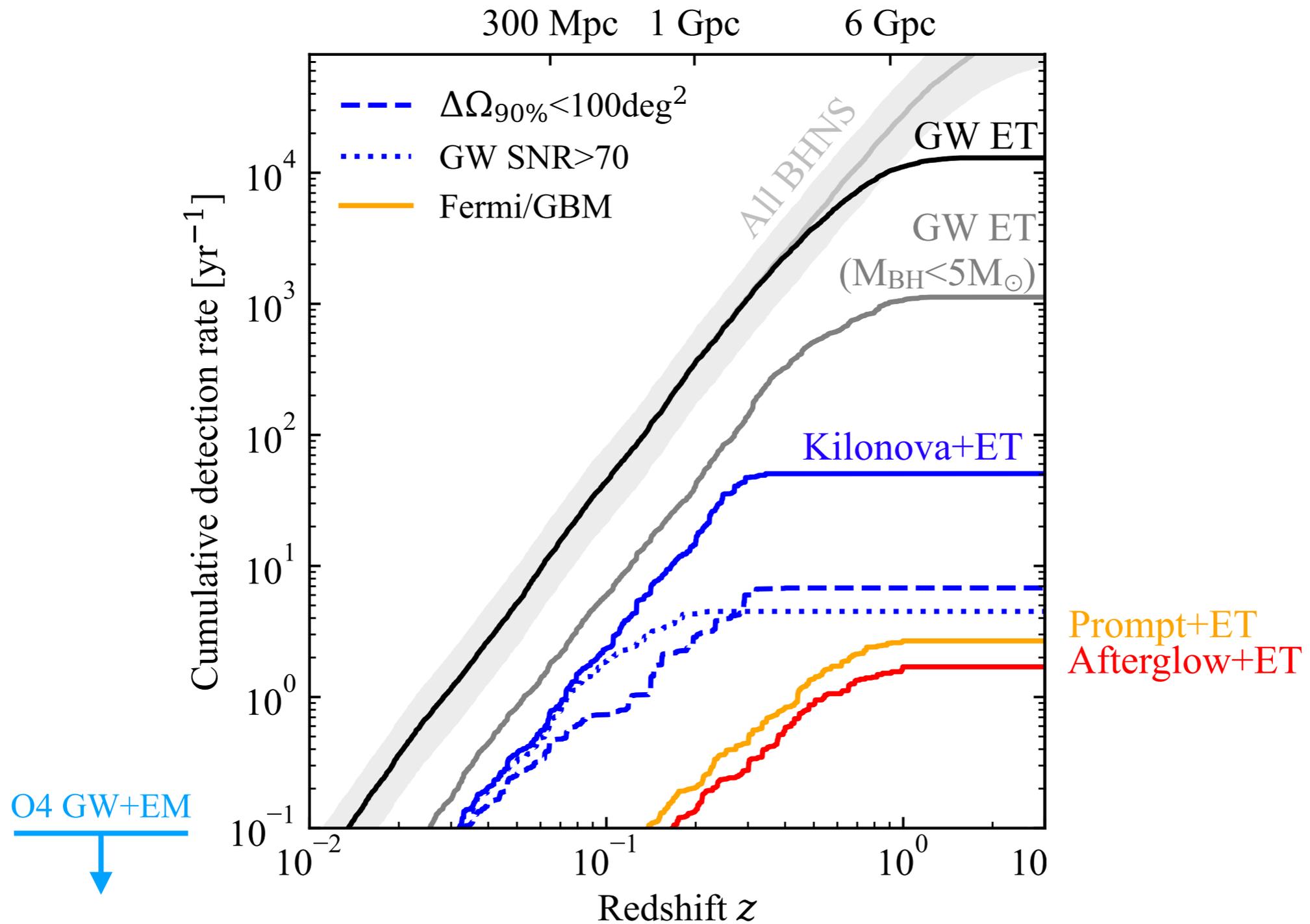


GW SNR > 70

BHNS ET Jet Emissions



BHNS ET Jet Emissions



Summary

- BHNSs with **low massive** and **non-sipping** BHs are the most favor candidates to have an EM emission
- BHNS GW+EM detection rates in **O4/O5** are low ($<1 \text{ y}^{-1}$)
- **ET** will allow us to detect EM counterparts from BHNSs ($>1 \text{ y}^{-1}$)
- Strategies to **select GW events** are fundamental to increase the detections of EM counterparts from BHNSs
- Future high-energy instruments are fundamental to increase detections of **jet related emissions**

See also:

Boersma et al. (2022)

Zhu et al. (2022)

Thank you for your attention!