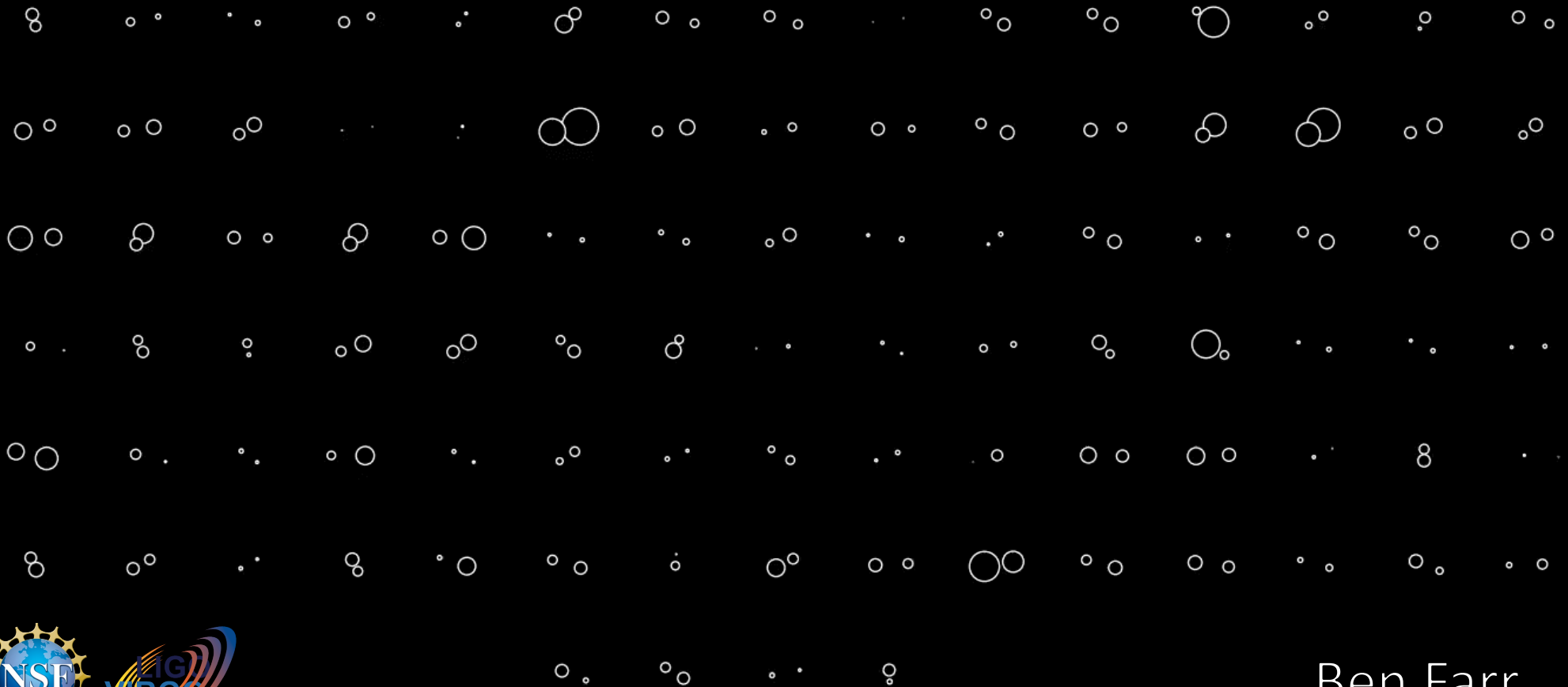


Putting the **O** in LIGO



Ben Farr

Additional Resources

The Gravitational Wave Open Science Center



Tutorials (jupyter/collab notebooks, videos, etc.)

<https://www.gw-openscience.org/tutorials>



Open Data

<https://www.gw-openscience.org/data>

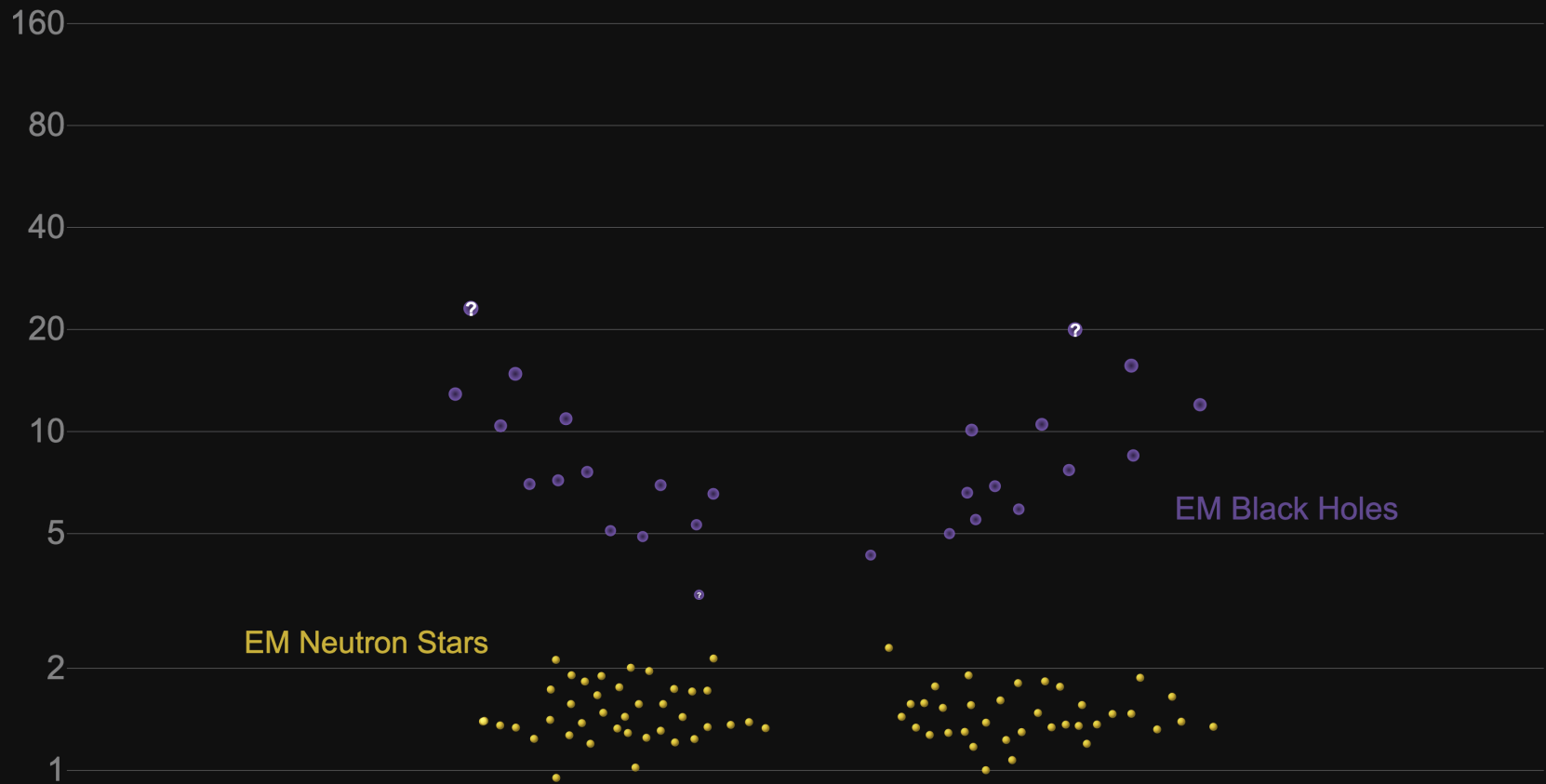


Event portal

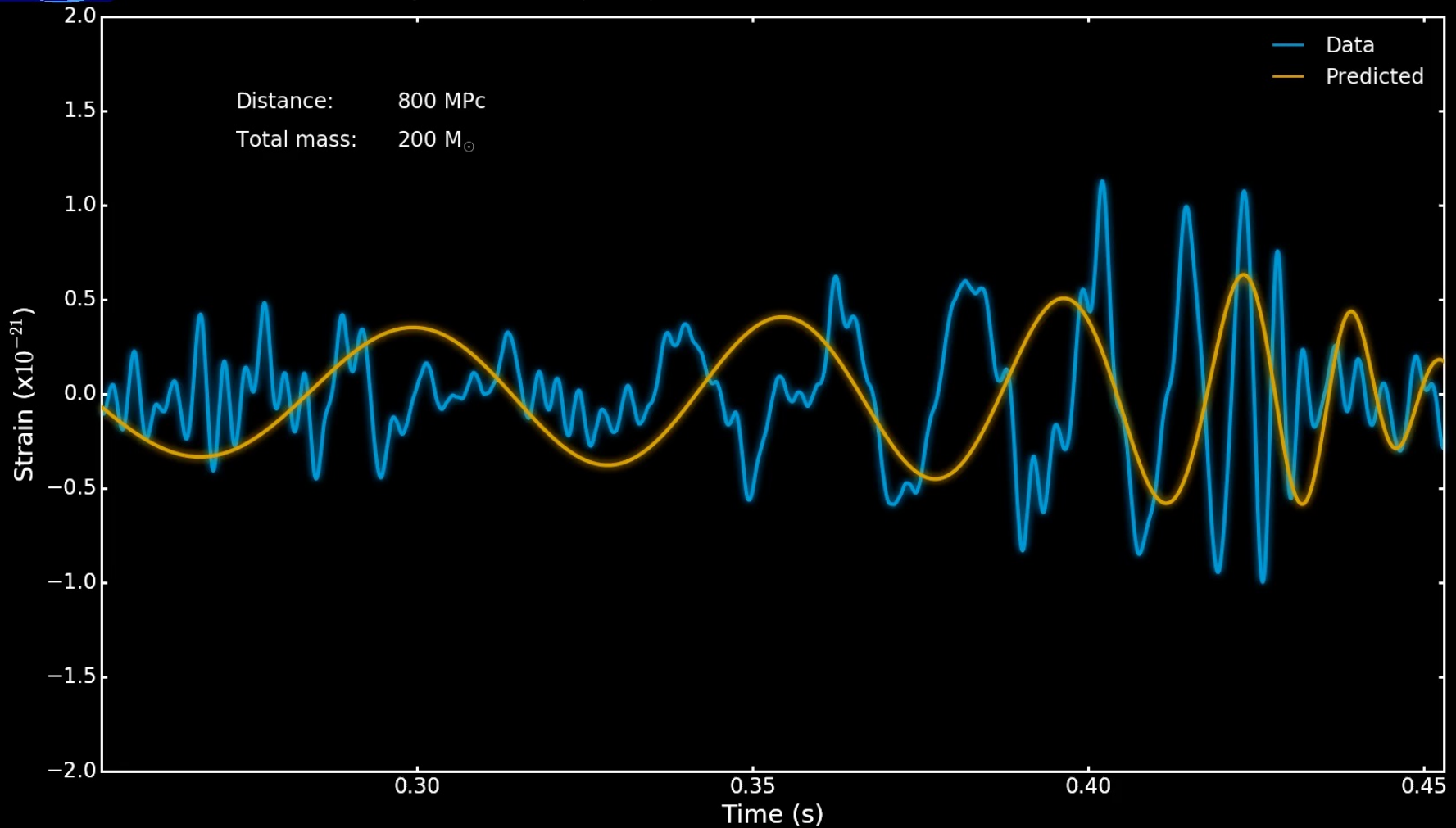
<https://www.gw-openscience.org/eventapi>

Masses in the Stellar Graveyard

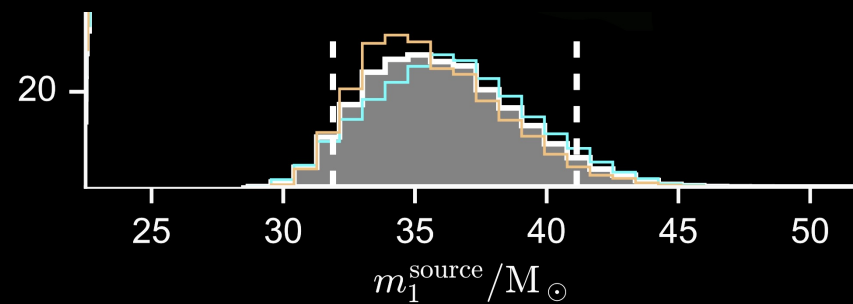
in Solar Masses



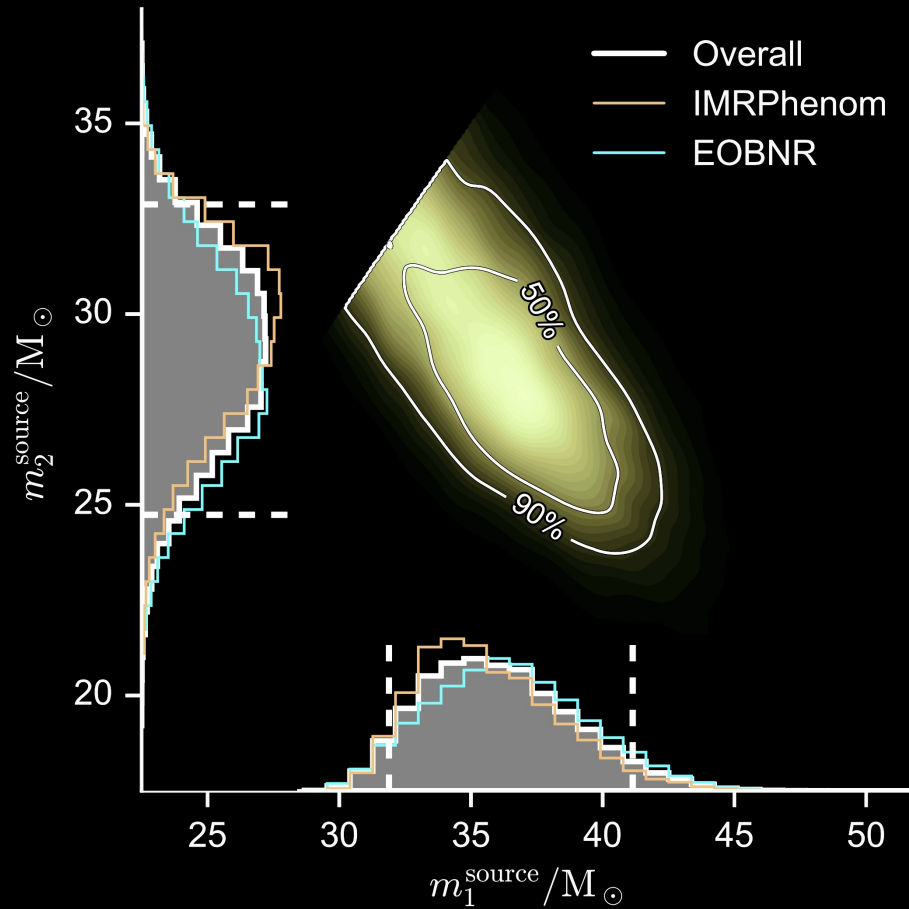
Extracting Astrophysics from a GW Observation



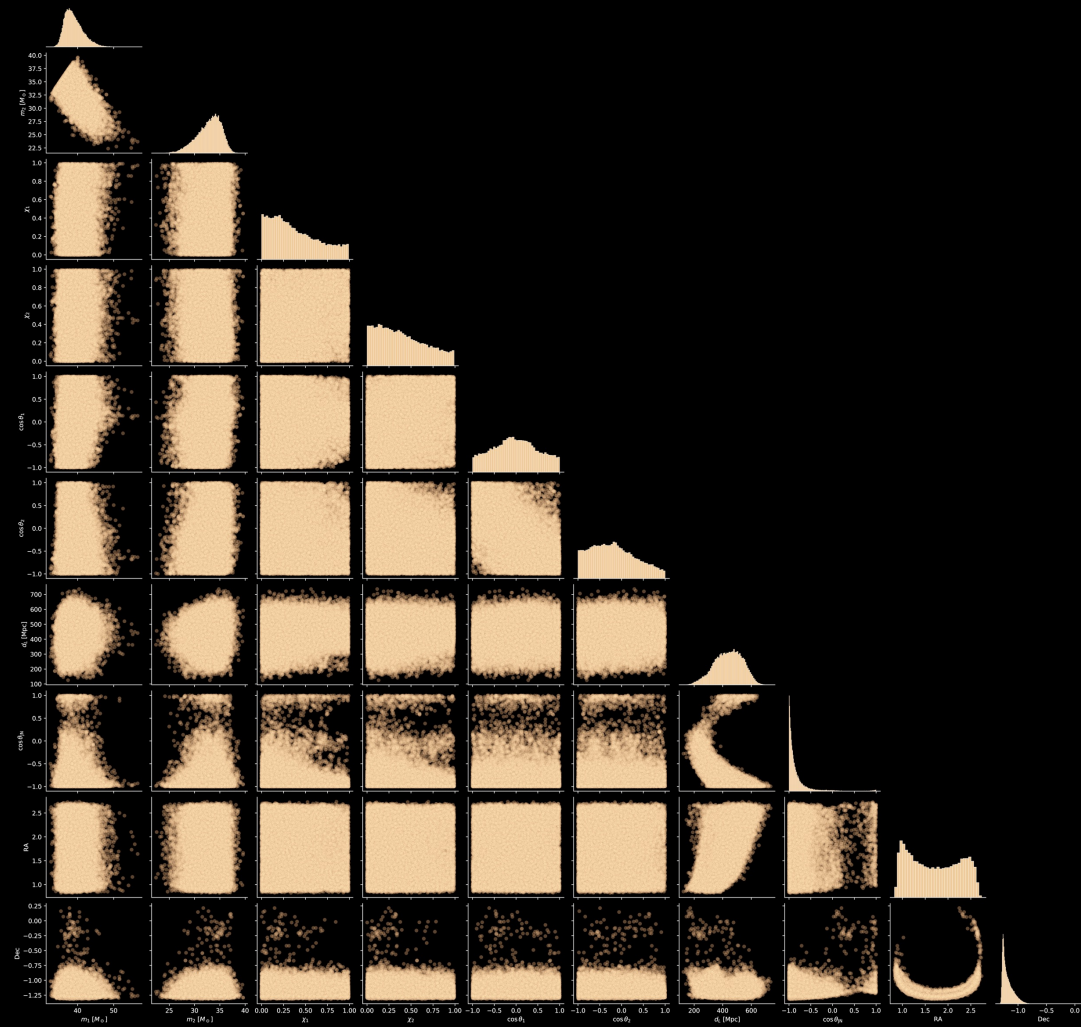
Extracting Astrophysics from a GW Observation



Extracting Astrophysics from a GW Observation



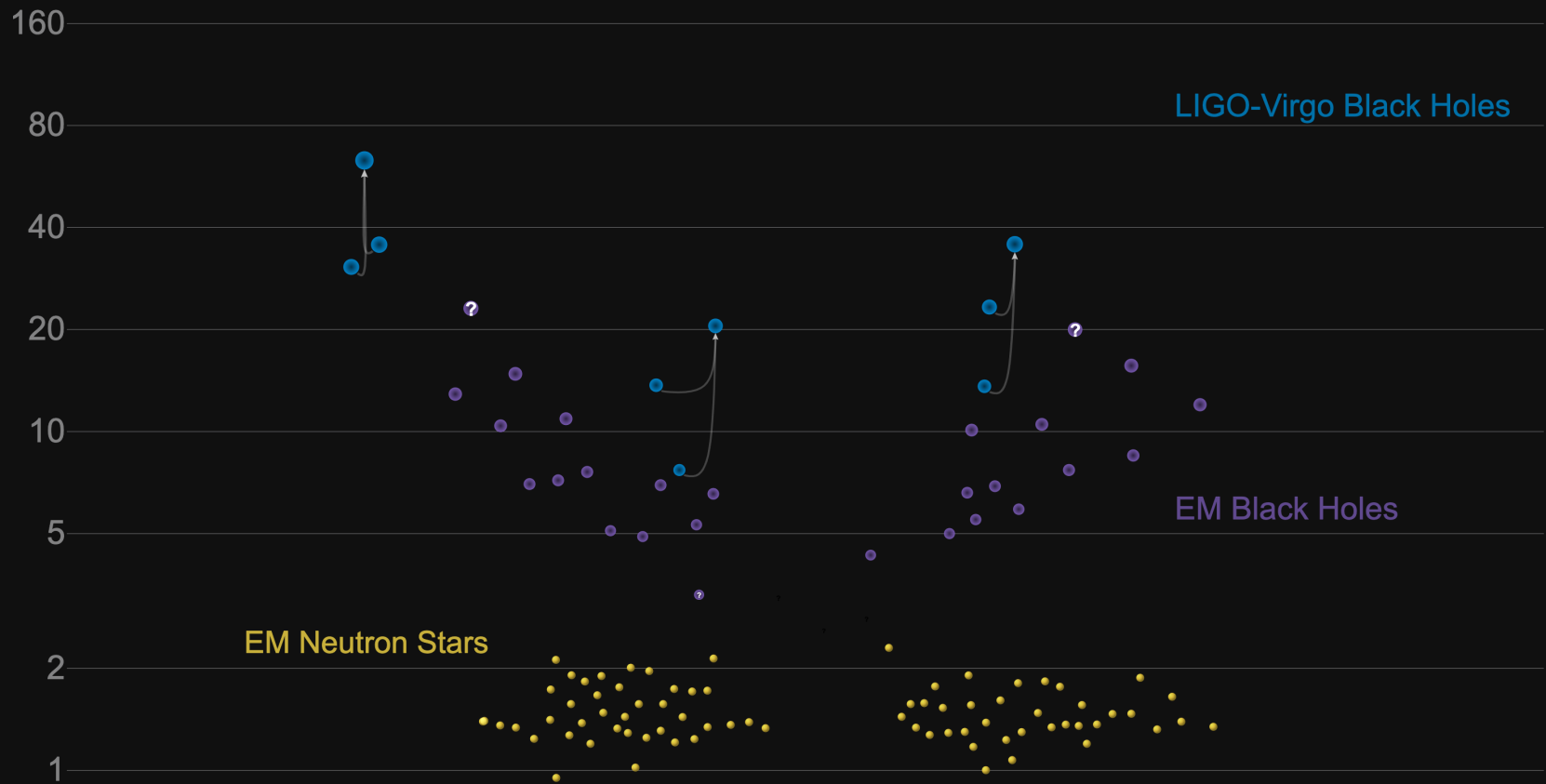
Extracting Astrophysics from a GW Observation



01

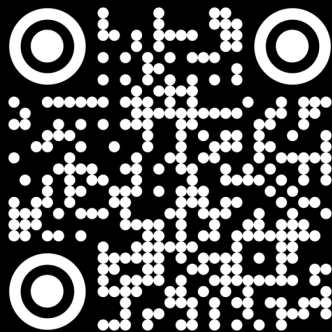
Masses in the Stellar Graveyard

in Solar Masses



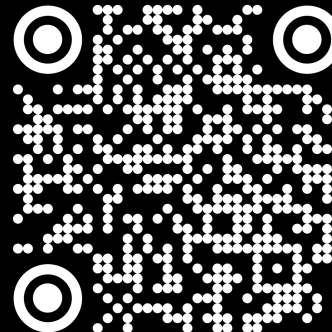
GWTC-1

Paper



<https://dcc.ligo.org/LIGO-P1800307/public>

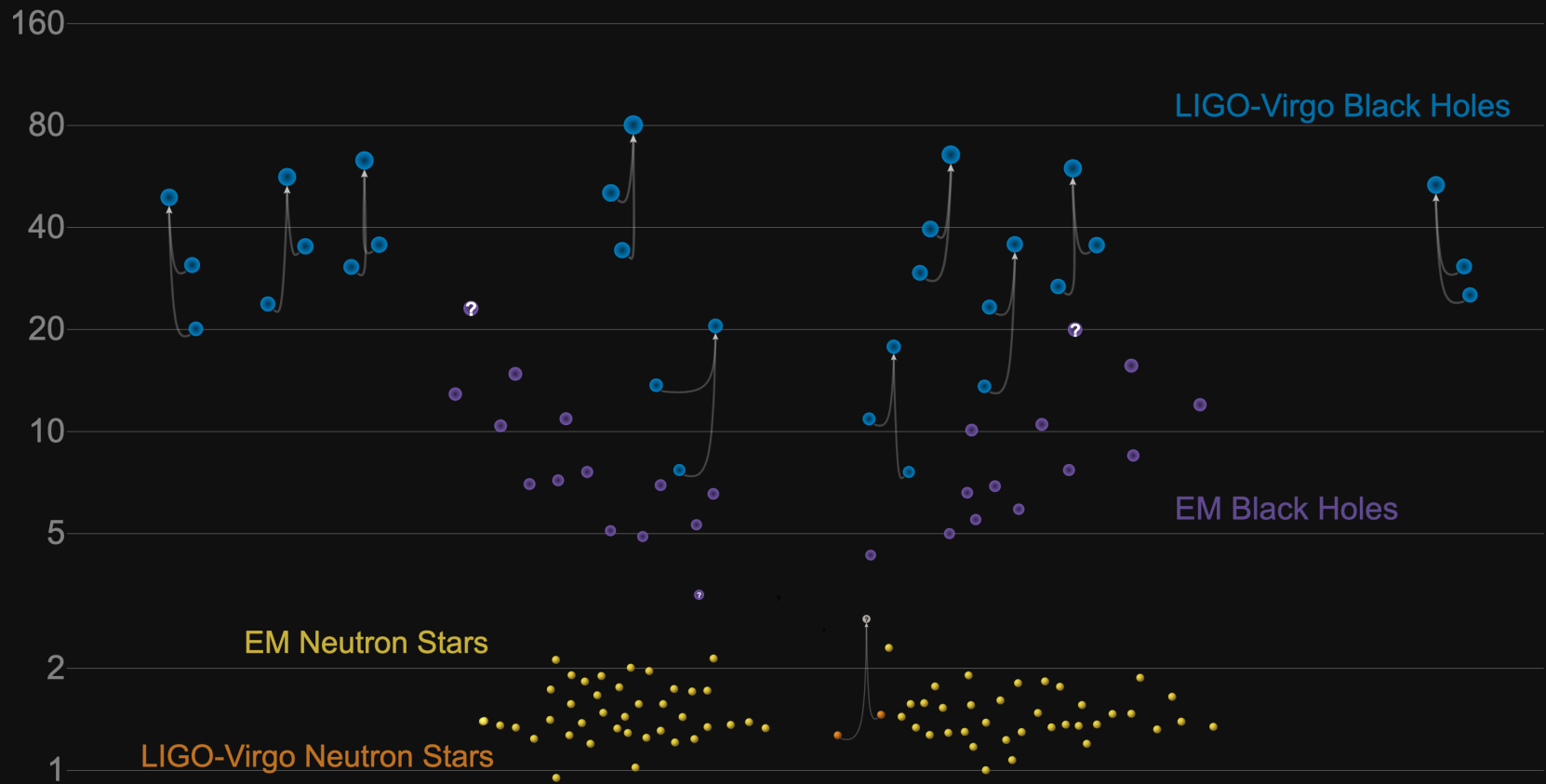
Event Portal



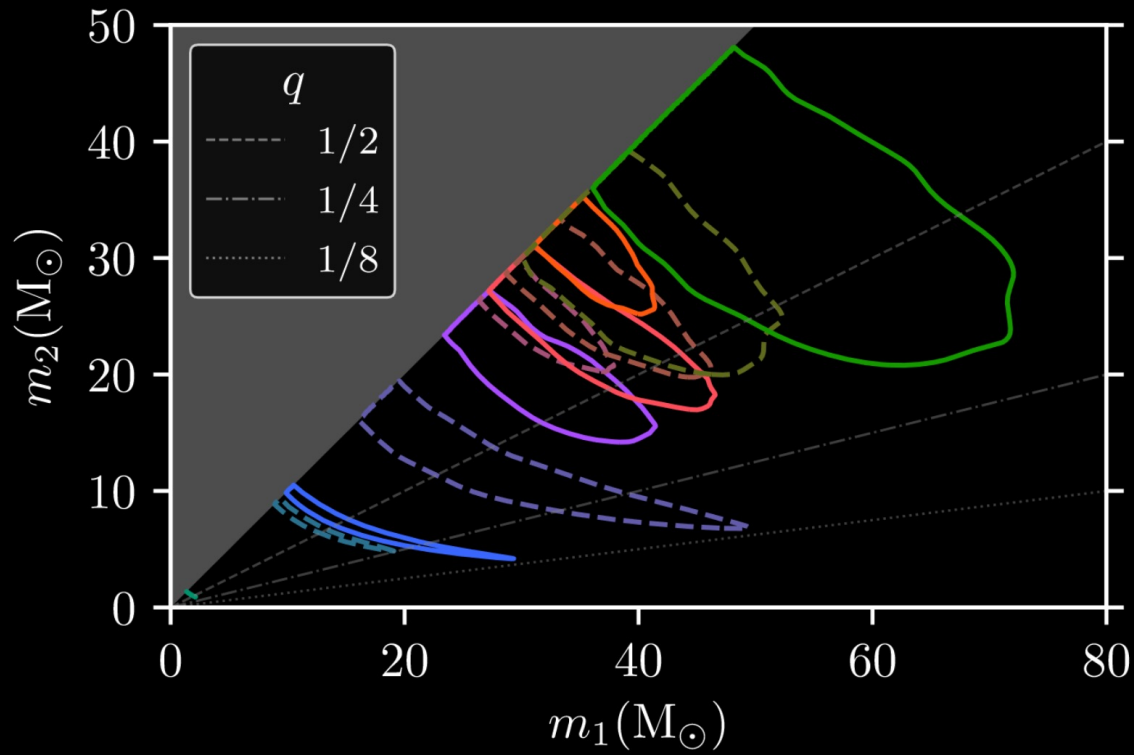
<https://gwosc.org/eventapi/html/GWTC-1-confident>

Masses in the Stellar Graveyard

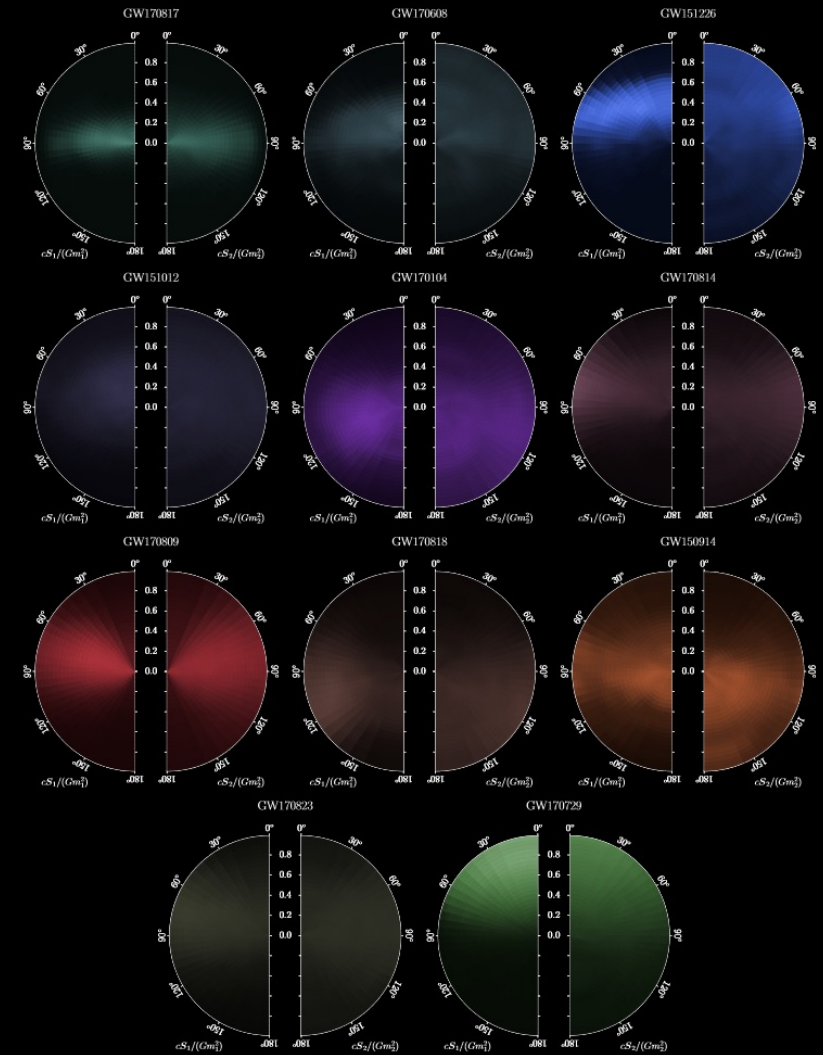
in Solar Masses



What we learned

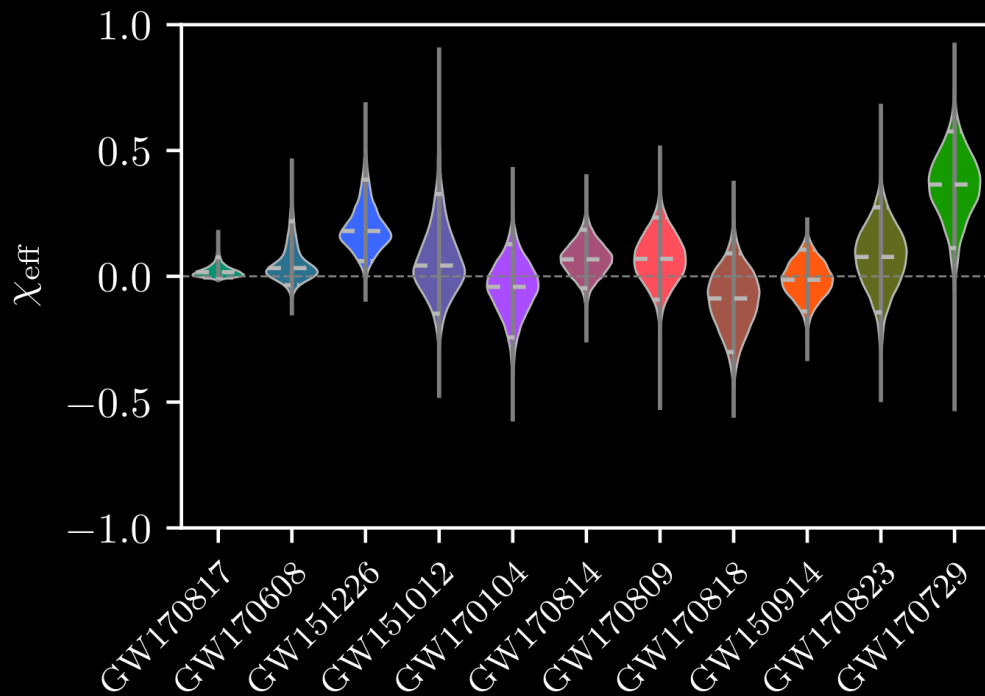


Abbott *et al* 2019 Phys. Rev. X 9, 031040 (GWTC-1)

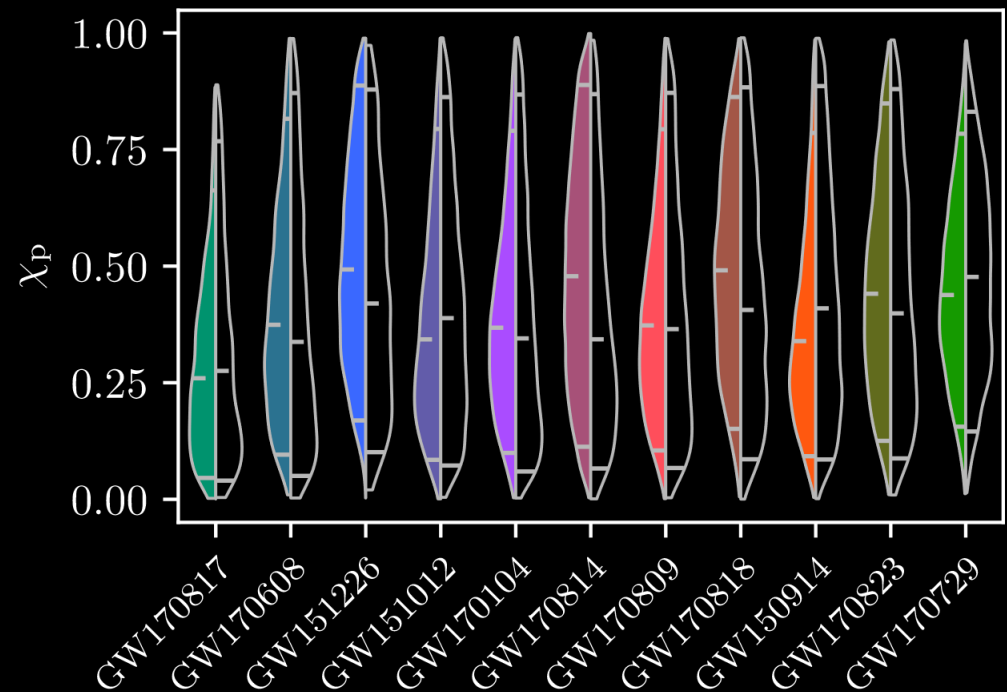


What we learned

$$\chi_{\text{eff}} = \frac{(m_1 \vec{s}_1 + m_2 \vec{s}_2) \cdot \hat{L}_N}{m_1 + m_2}$$

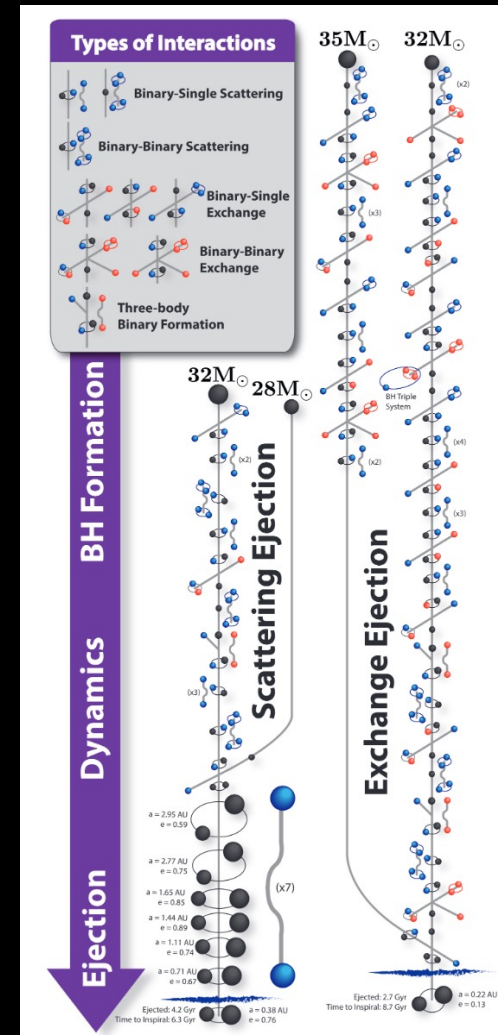
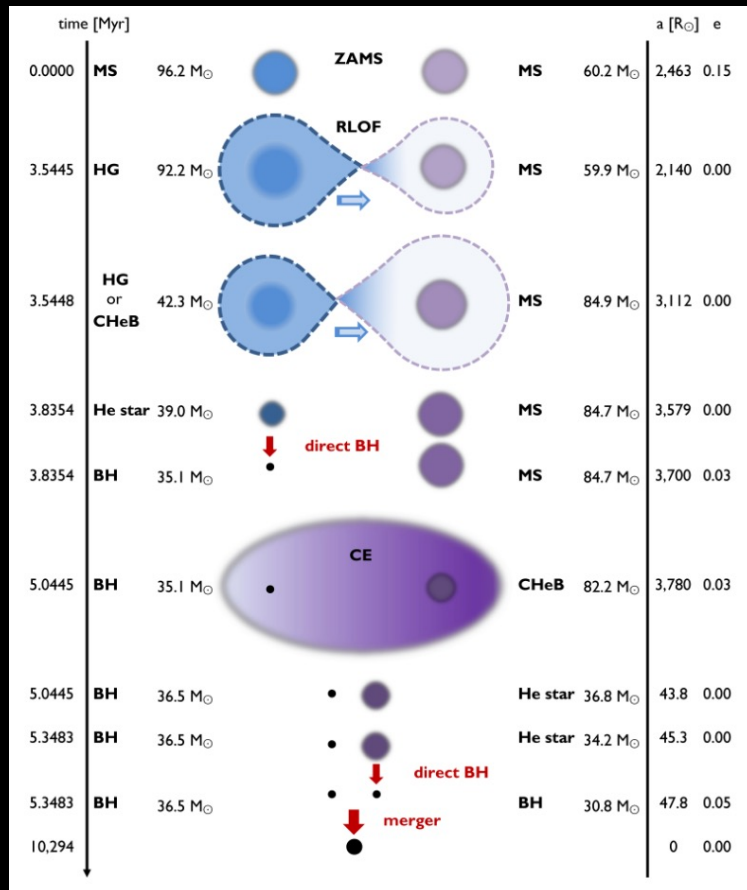


$$\chi_p = \frac{1}{B_1 m_1^2} \max(B_1 s_{1\perp}, B_2 s_{2\perp})$$

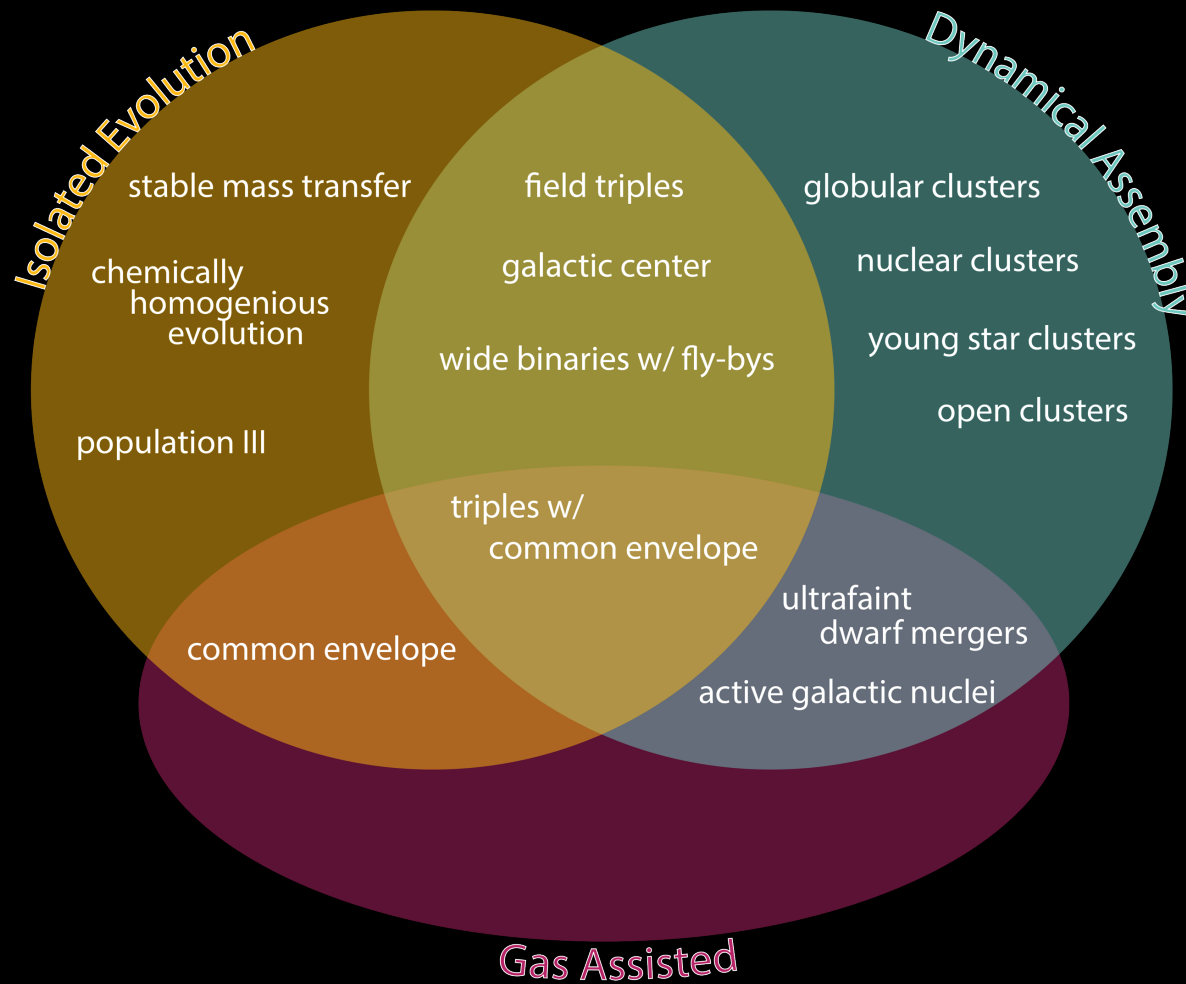


Abbott *et al* 2019 Phys. Rev. X **9**, 031040 (GWTC-1)

Why is this important?



Why is this important?



LIGO-Virgo's 3rd Observation Run

O3 began on April 1, 2019.

Mid-run commissioning break started Oct 1 2019 at 15:00:00 UTC.

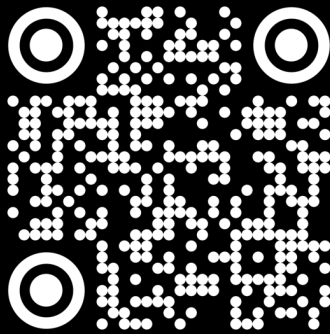
- Scattered light mitigation.
- Hanford squeezing improvements.
- Virgo power increased from 18W to 26W.

LIGO/Virgo/KAGRA Memorandum of Agreement signed Oct 4.

O3b began Nov 1 at 15:00:00 UTC, and ended March 27, 2020.

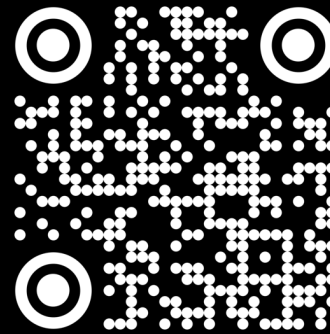
GWTC-2

Paper



<https://dcc.ligo.org/P2000061/public>

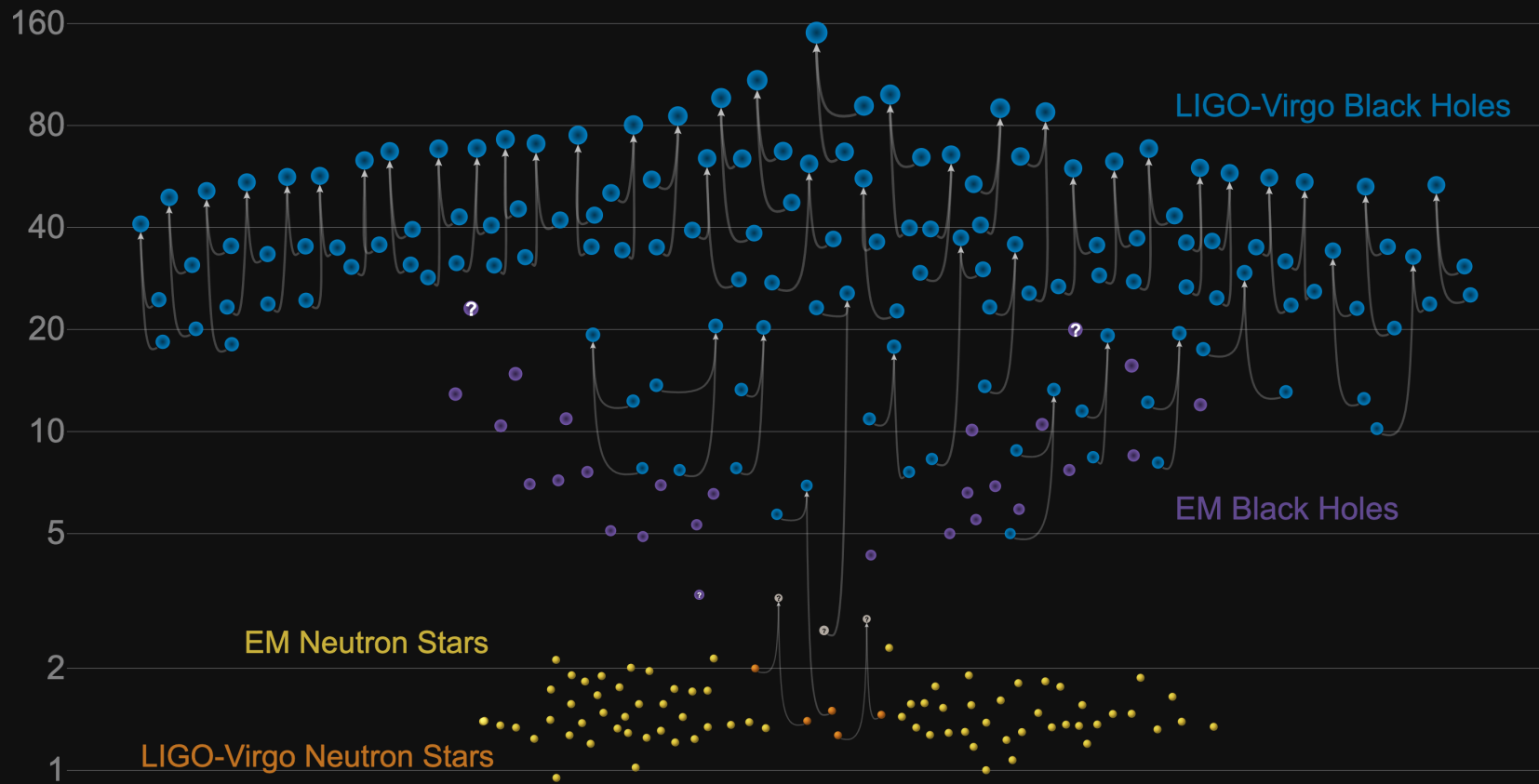
Event Portal



<https://gwosc.org/eventapi/html/GWTC-2>

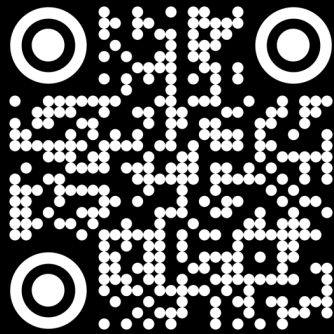
Masses in the Stellar Graveyard

in Solar Masses



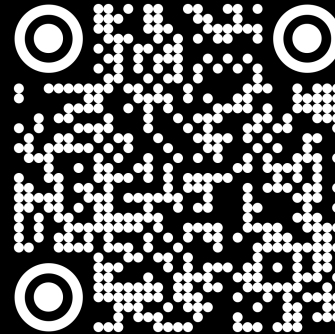
GWTC-3

Paper



<https://dcc.ligo.org/P2000318/public>

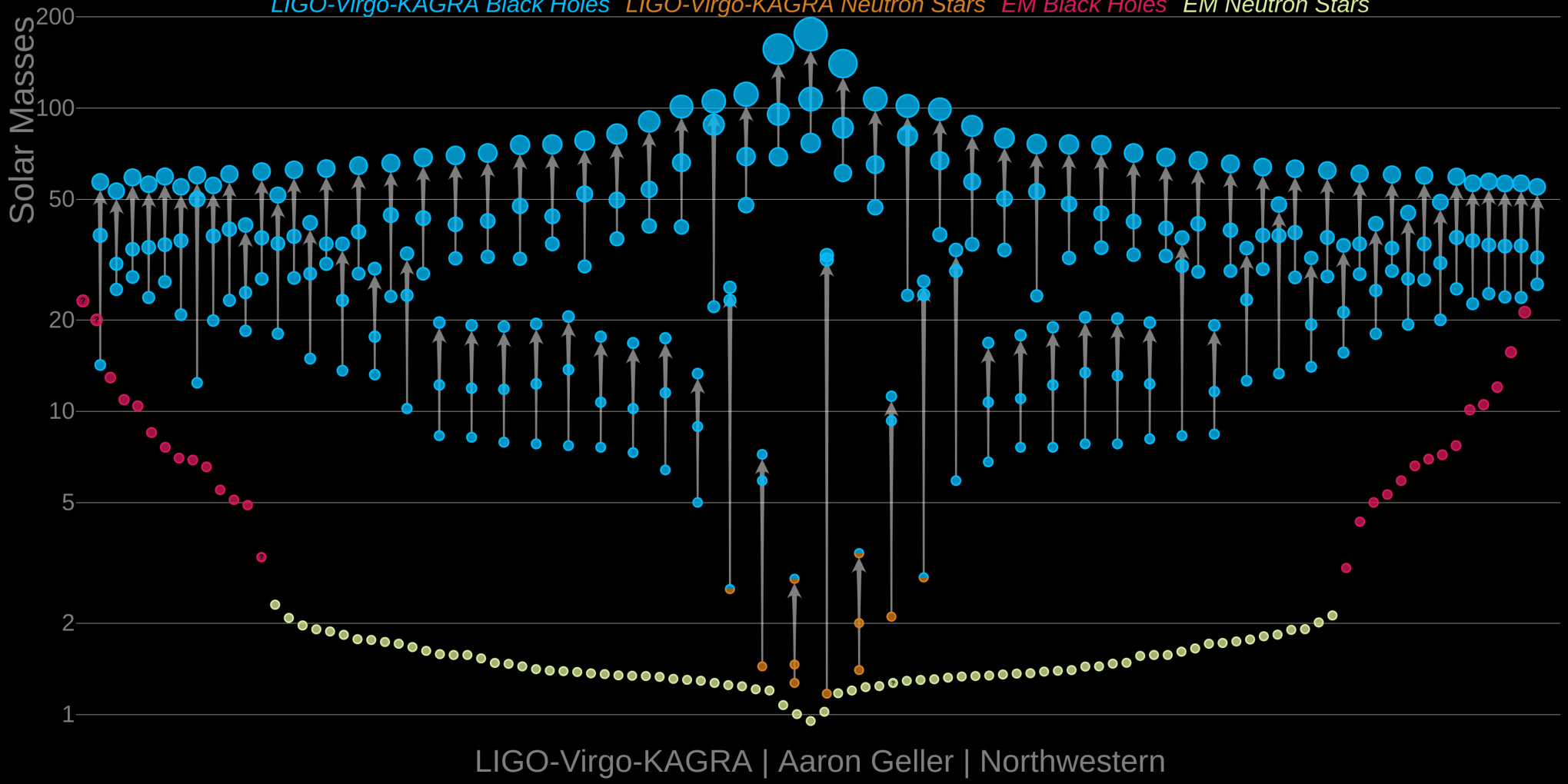
Event Portal



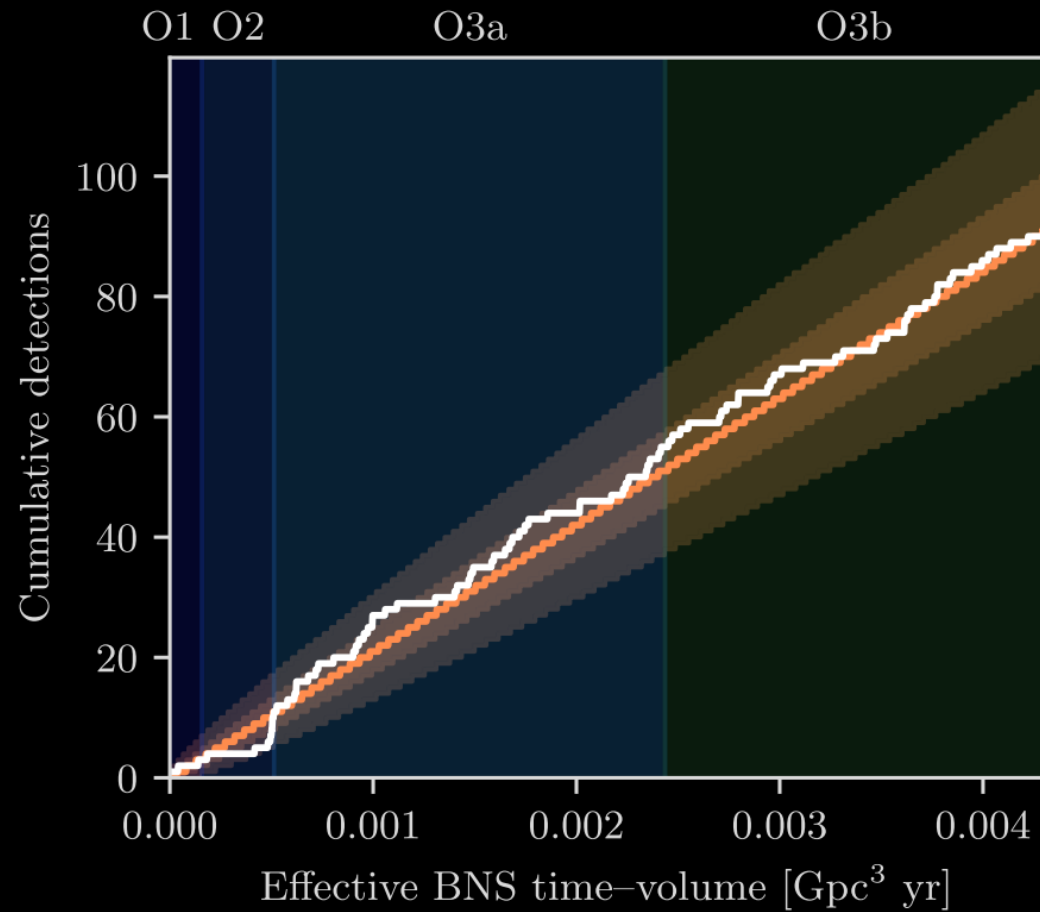
<https://gwosc.org/eventapi/html/GWTC-3-confident>

Masses in the Stellar Graveyard

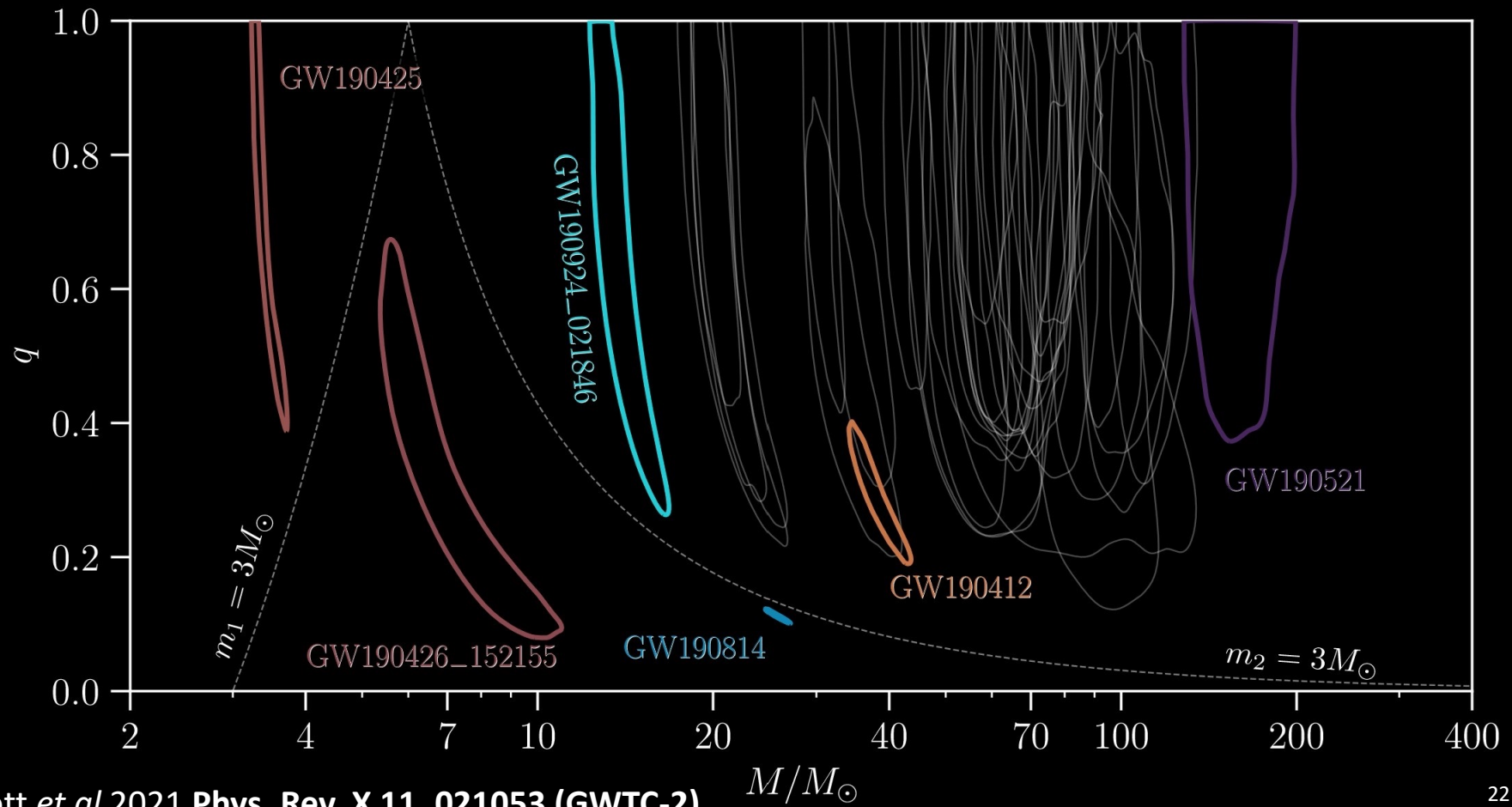
LIGO-Virgo-KAGRA Black Holes *LIGO-Virgo-KAGRA Neutron Stars* *EM Black Holes* *EM Neutron Stars*



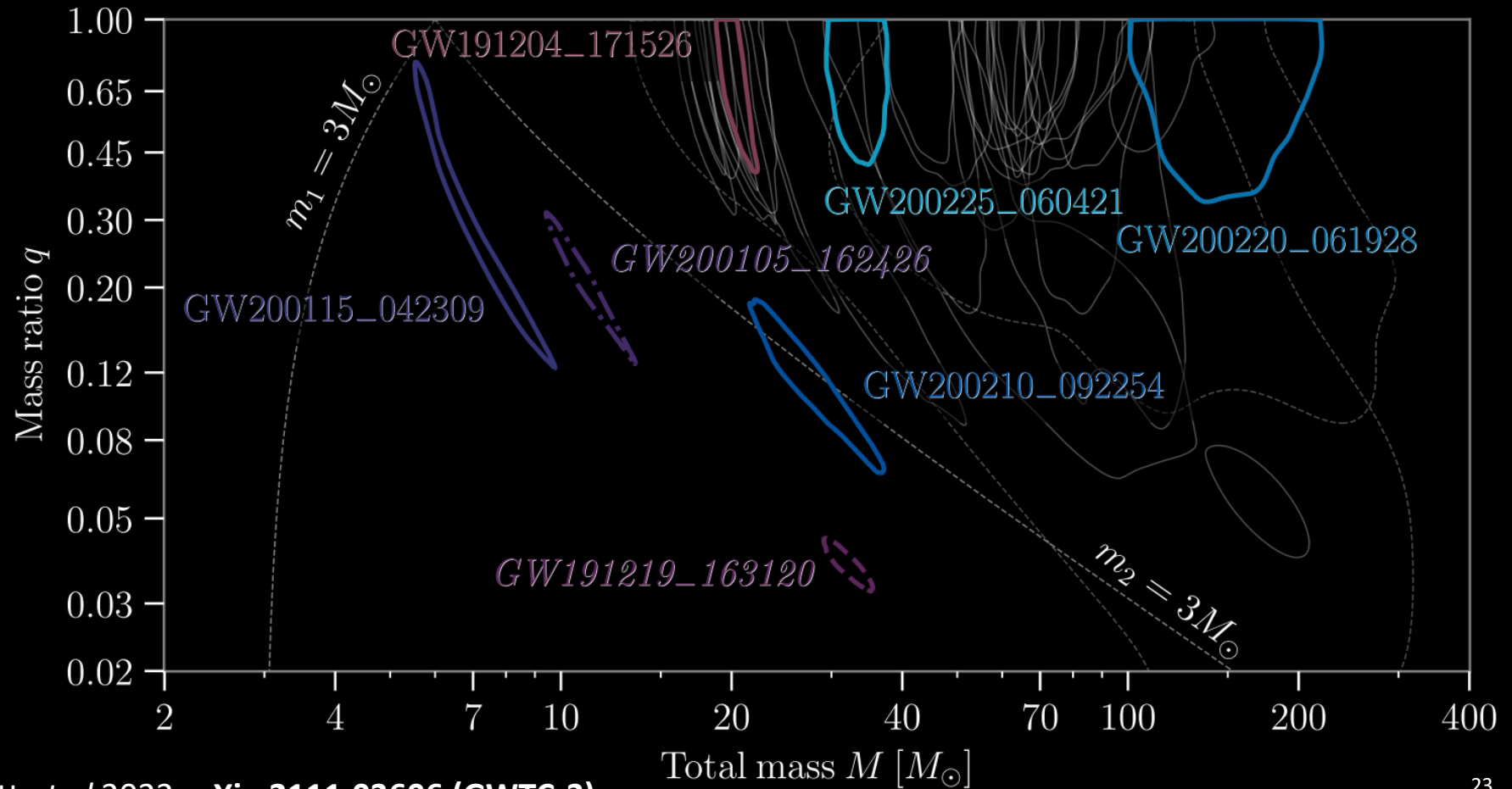
O3 Sensitive Volume



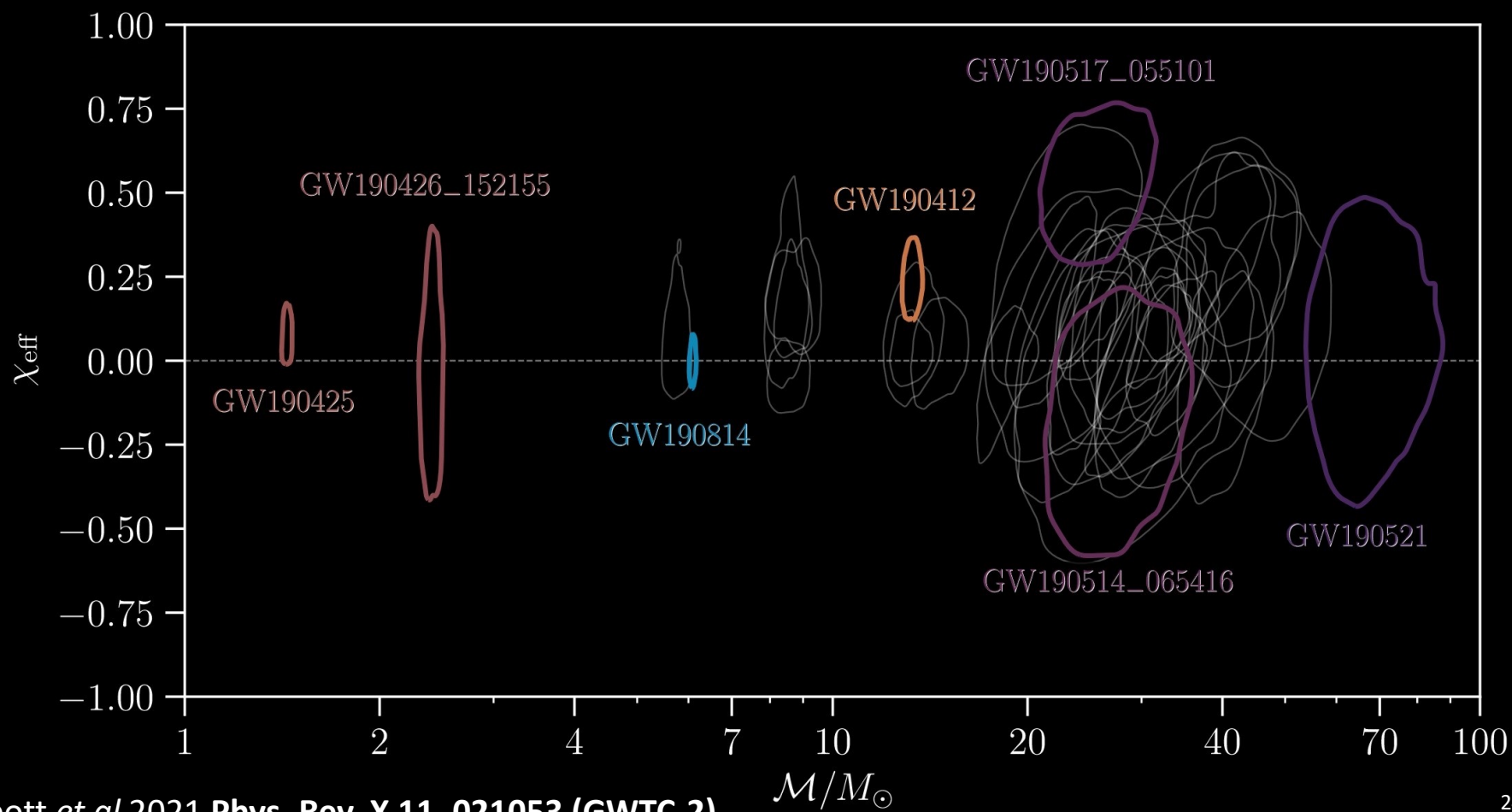
Source Masses – GWTC-2



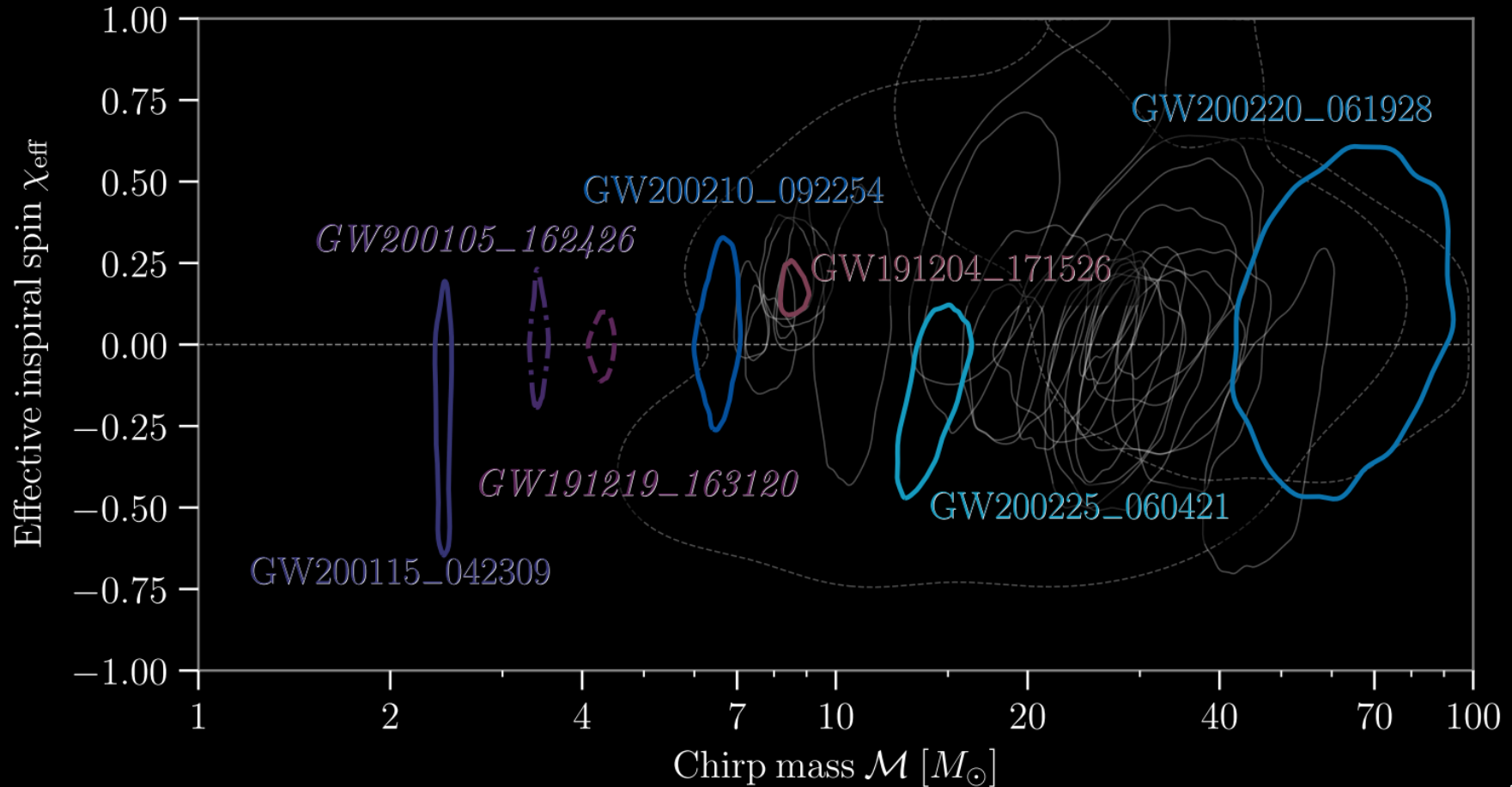
Source Masses – GWTC-3



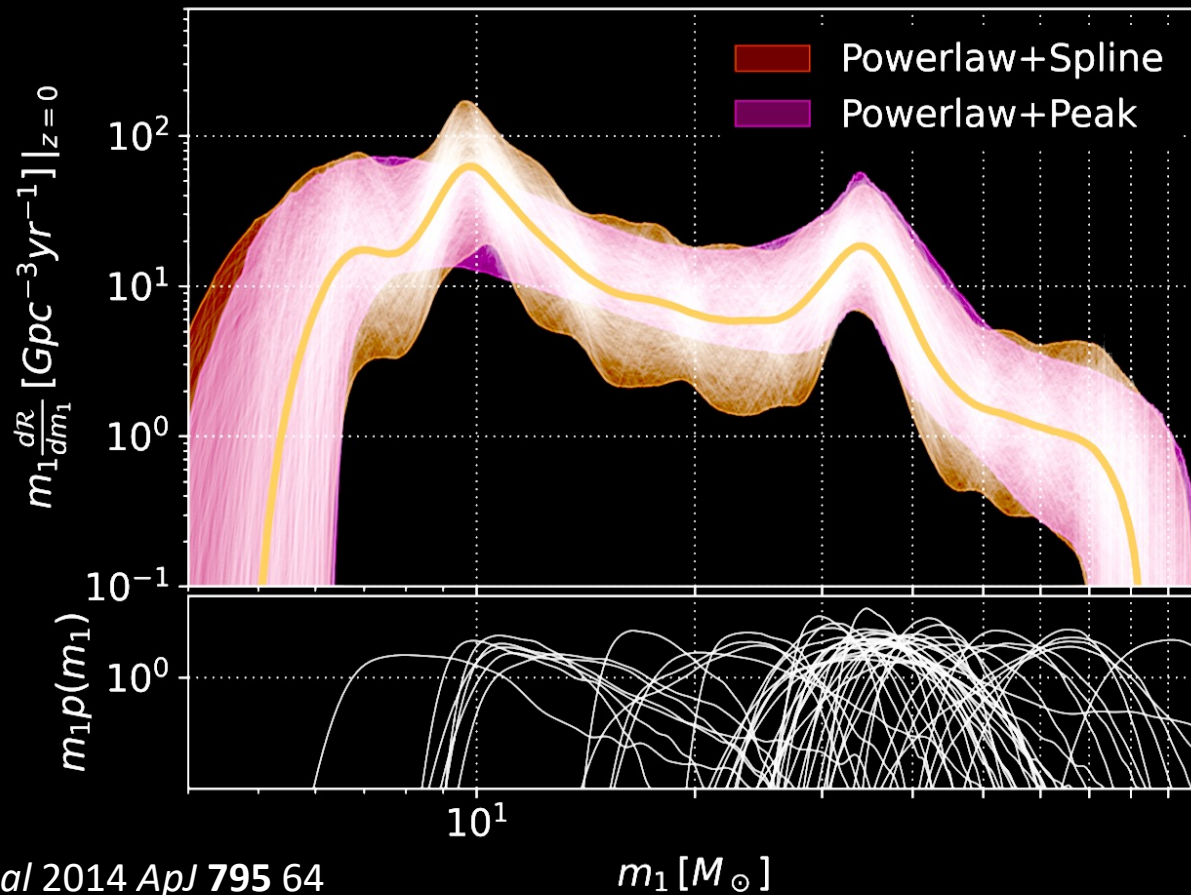
Source Spins – GWTC-2



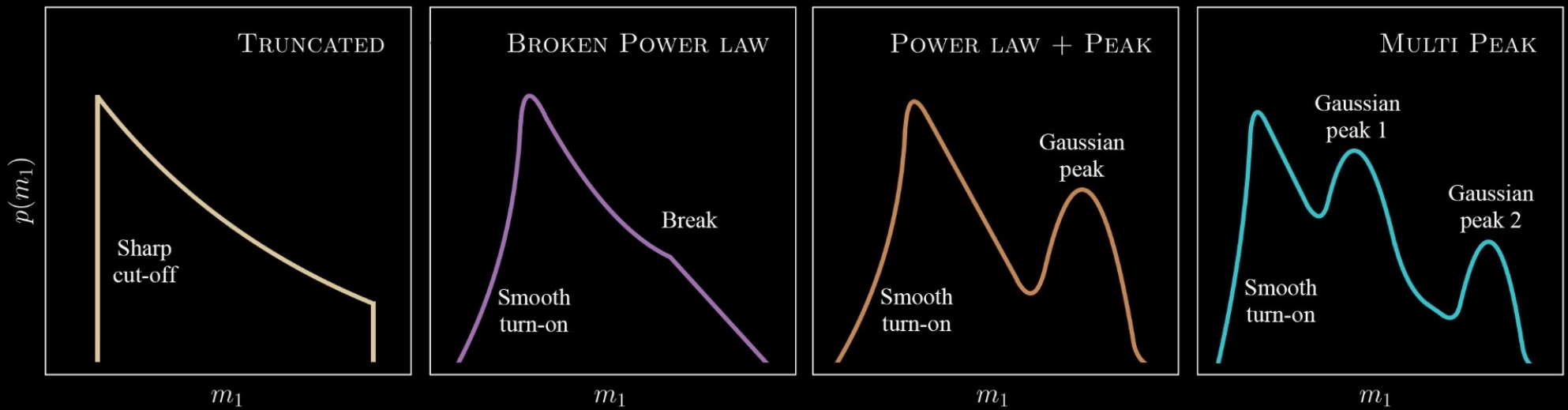
Source Spins – GWTC-3



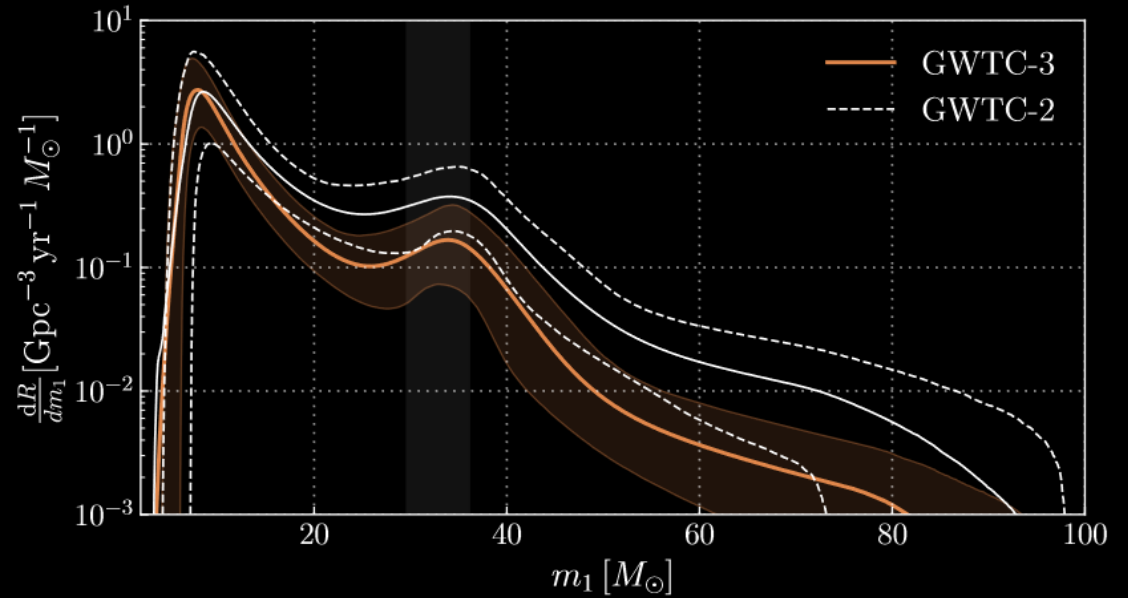
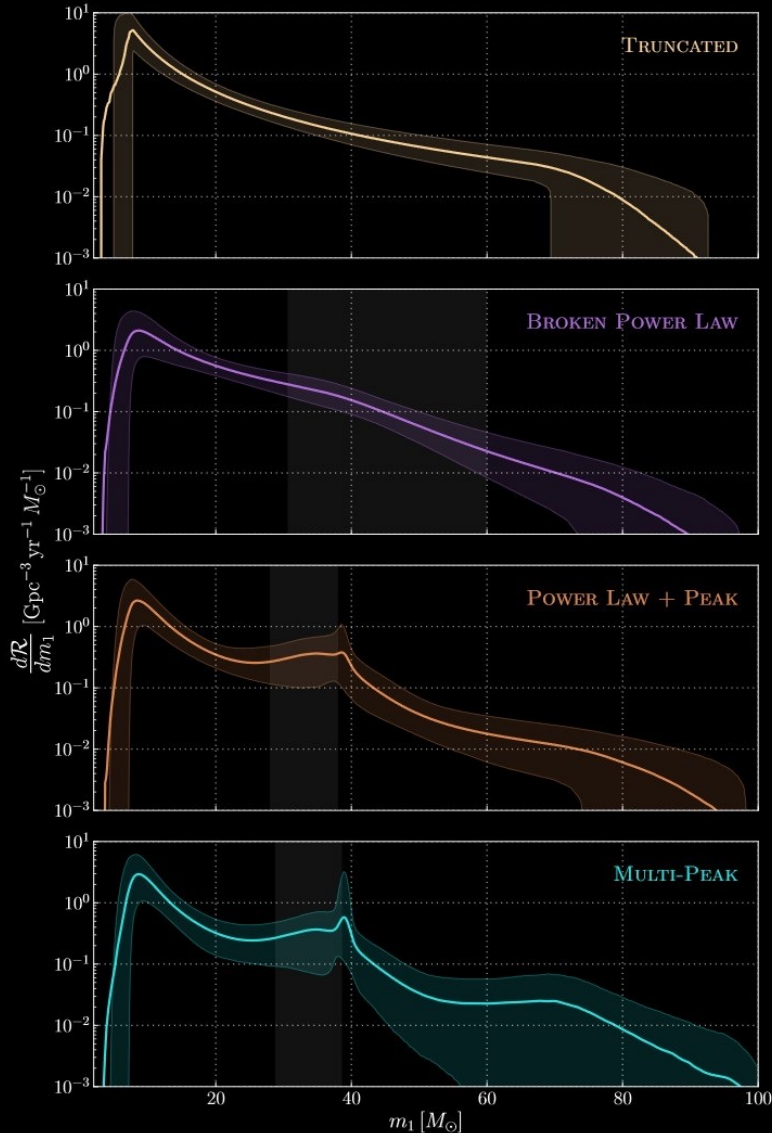
Extracting Astrophysics *many* GW Observations



Population Mass Properties



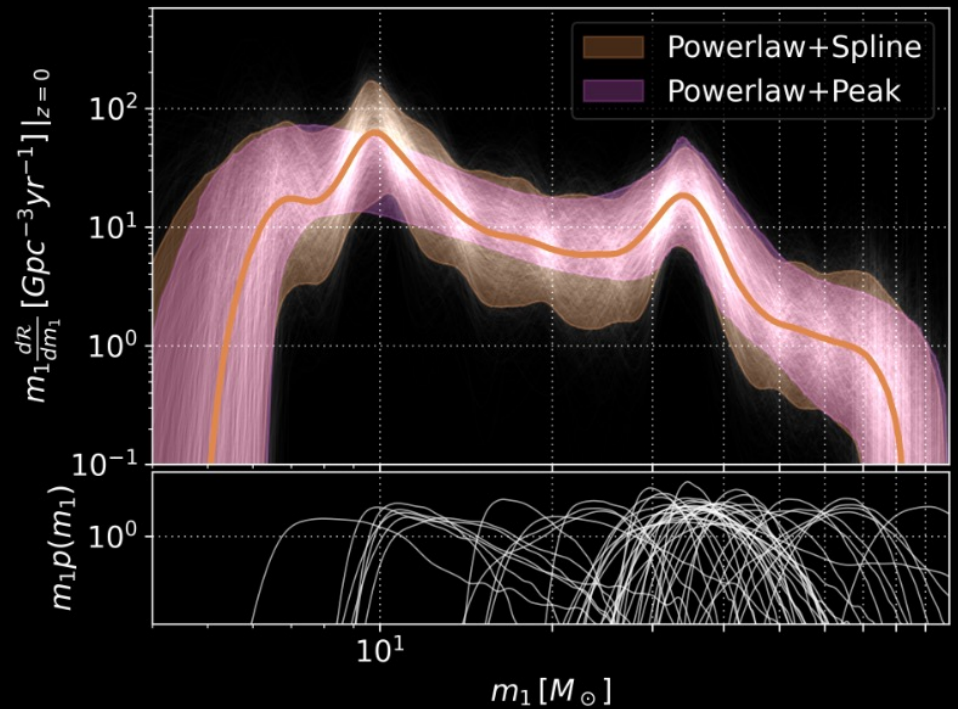
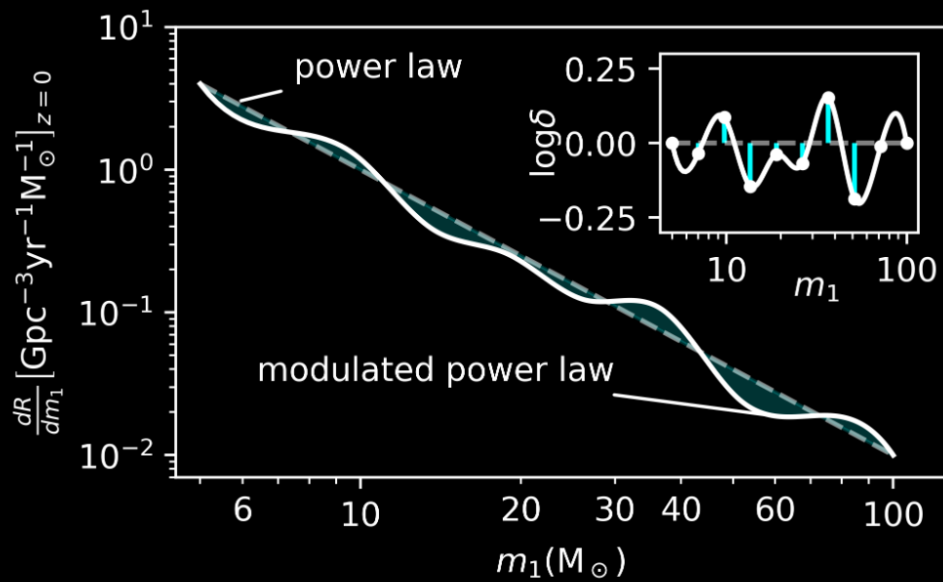
Population Mass Properties



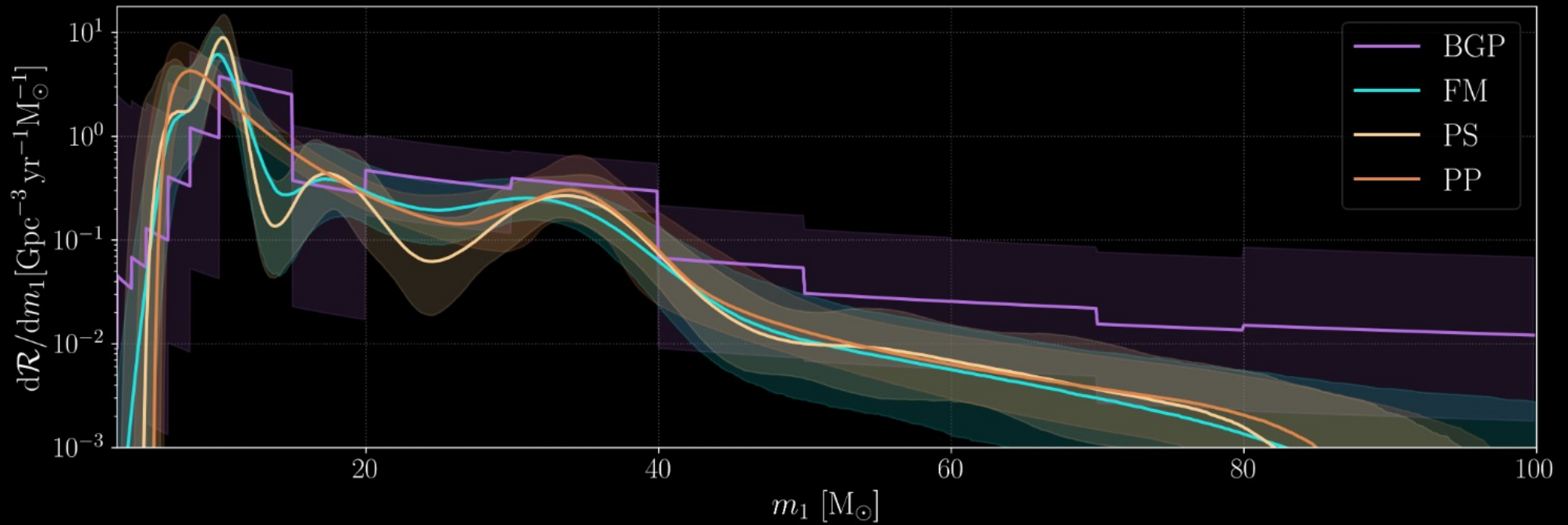
R. Abbott *et al* 2021 *ApJL* 913 L7 (GWTC-2 Pop.)

R. Abbott *et al* 2022 arXiv:2111.03634 (GWTC-3 Pop.)

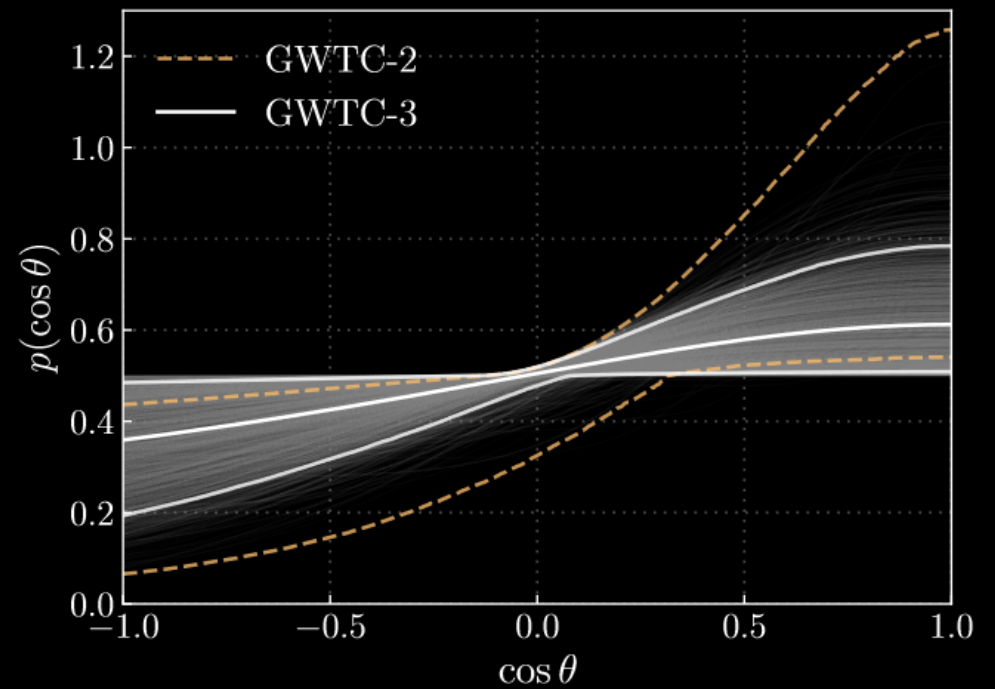
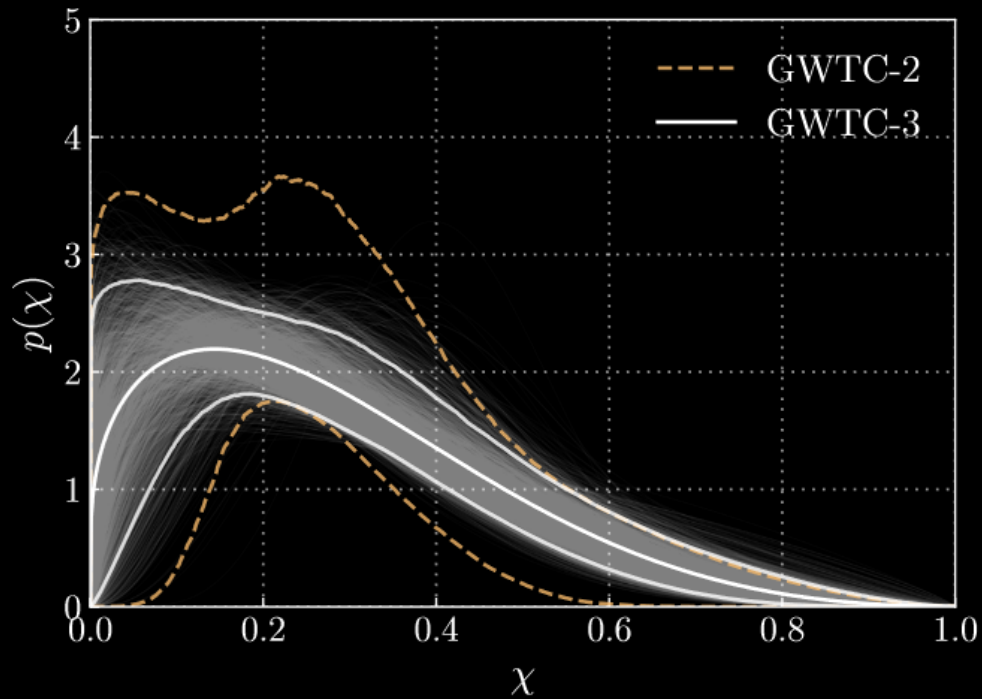
Semi-Parametric Modeling



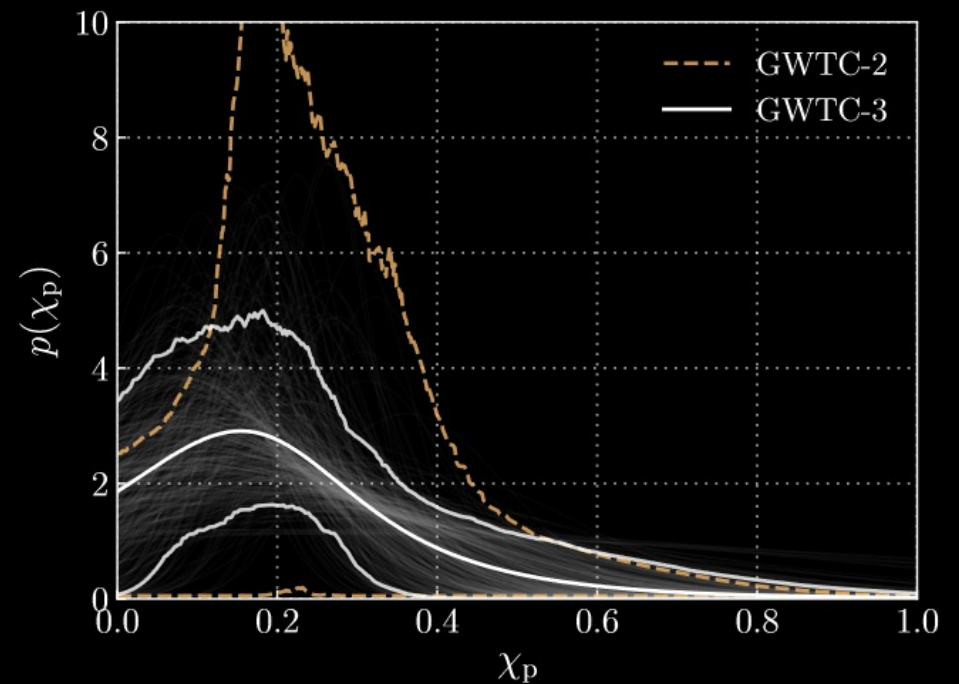
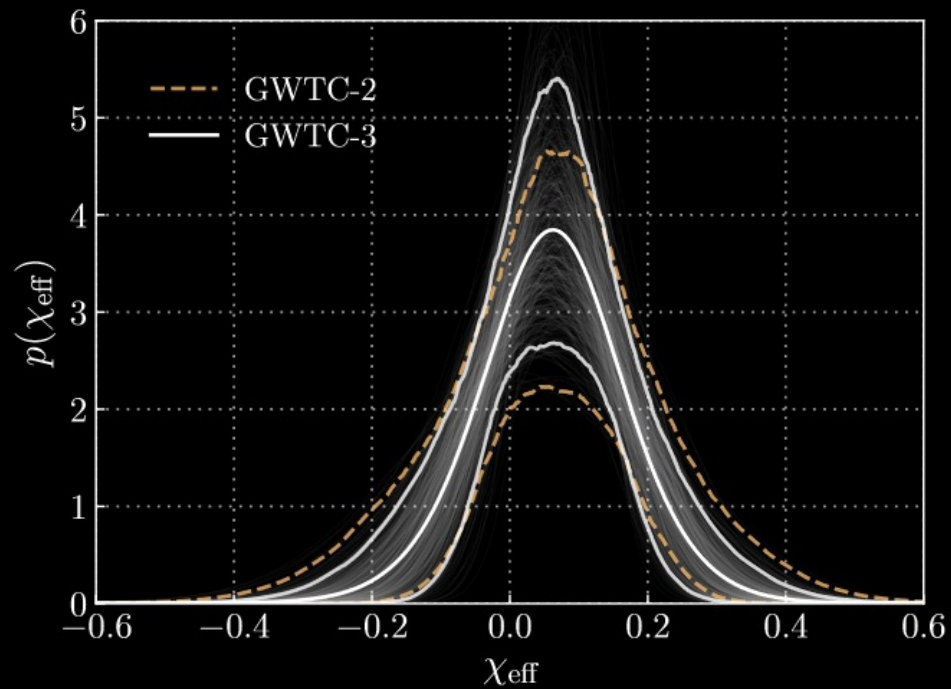
Population Mass Properties



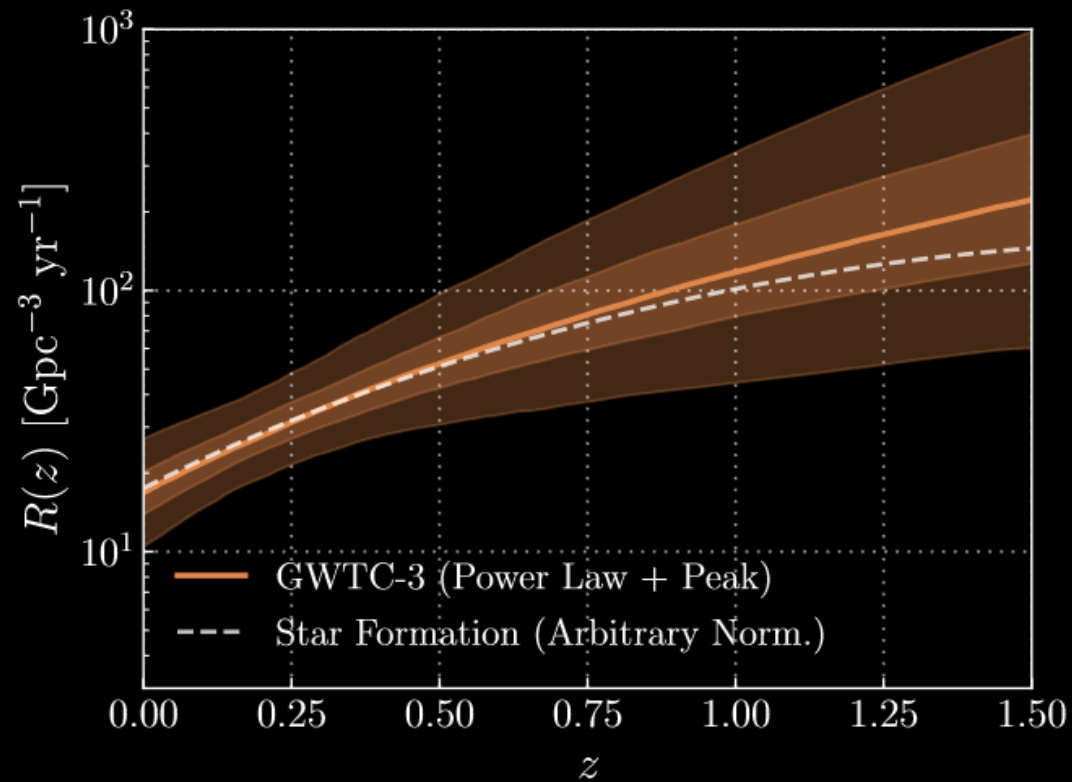
Population Spin Properties



Population Spin Properties



Redshift Dependence



Thank You