

Observing Black Holes with GWs



Ben Farr

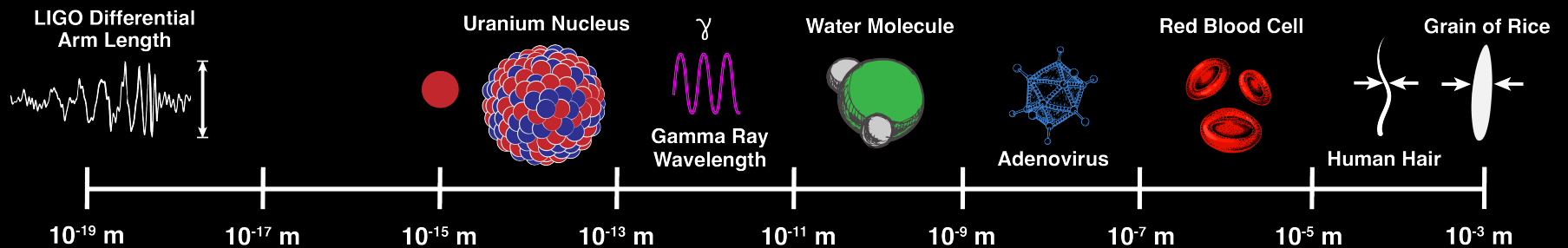
The Problem

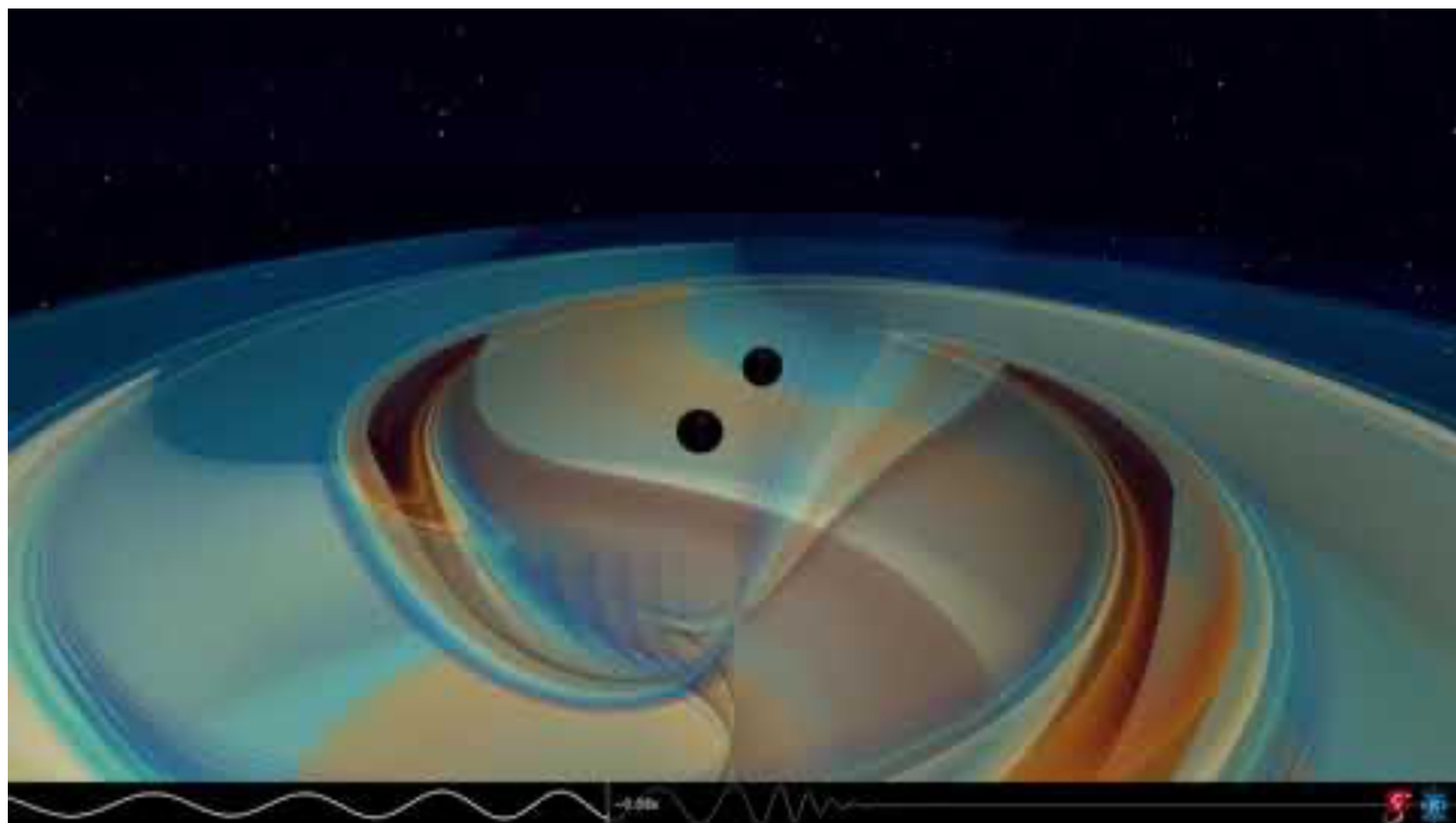
Spacetime is *STIFF*

Young's Modulus of Spacetime

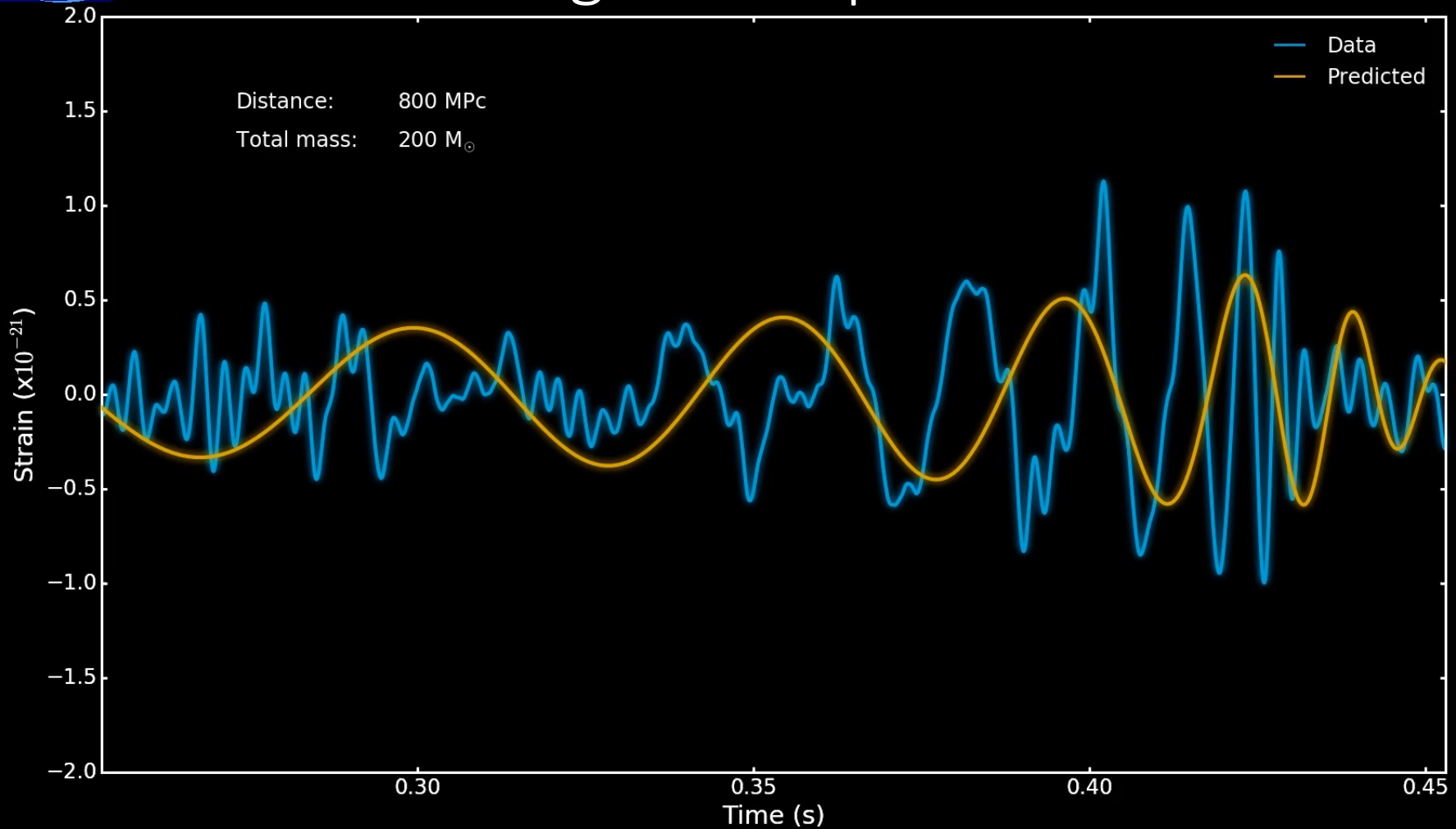
$$\frac{F}{A} = Y_{\text{spacetime}} \frac{\Delta L}{L}$$

$Y_{\text{spacetime}}$





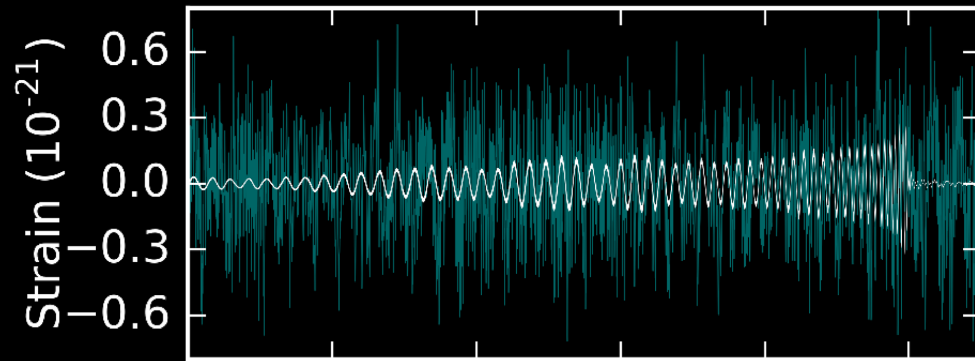
Signal Templates



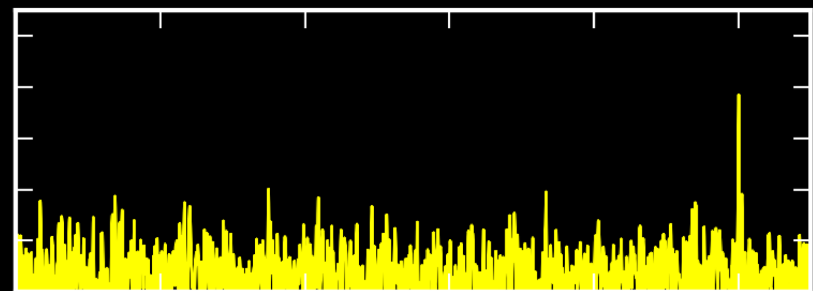
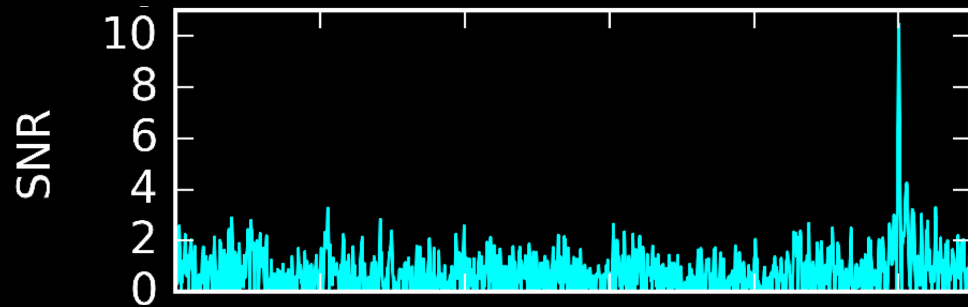
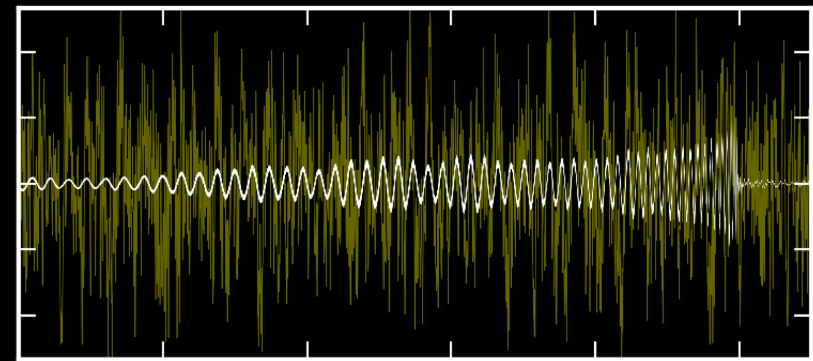
Signal Templates

GW151226

Hanford

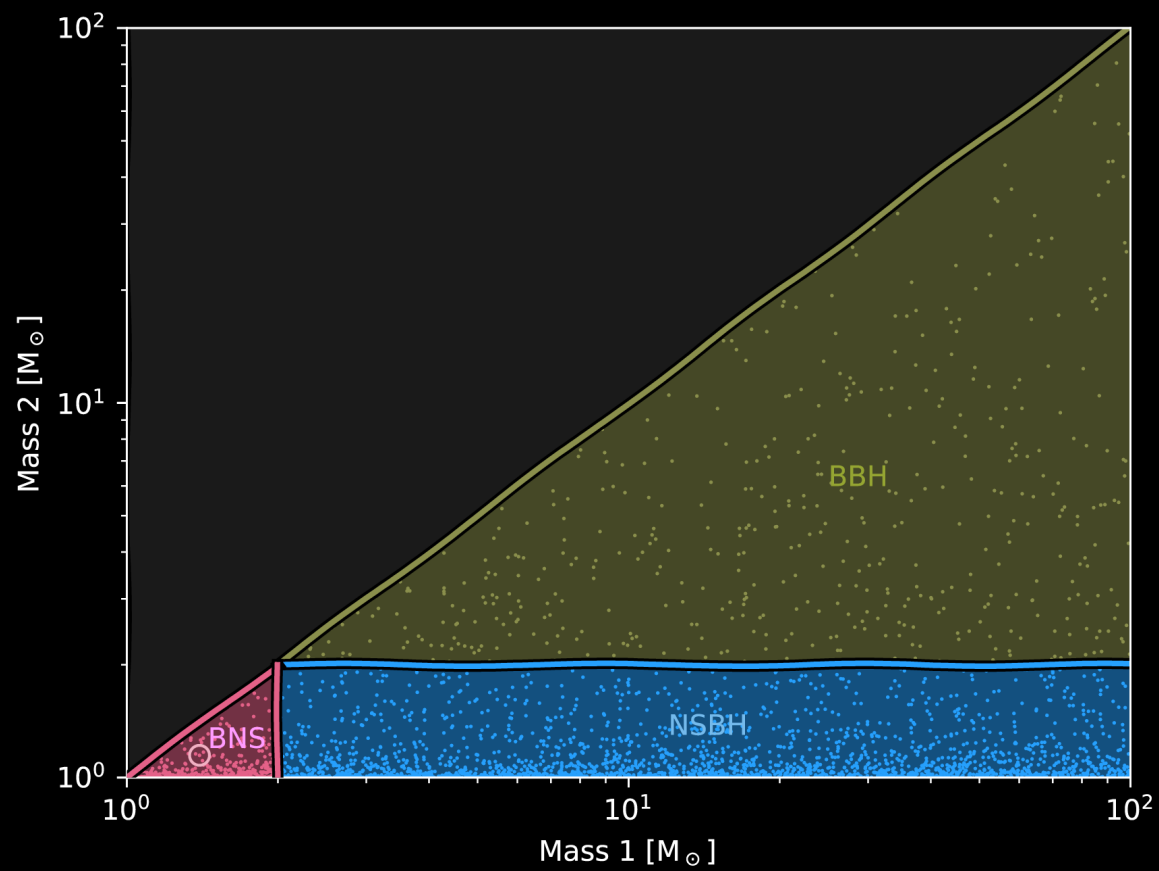


Livingston



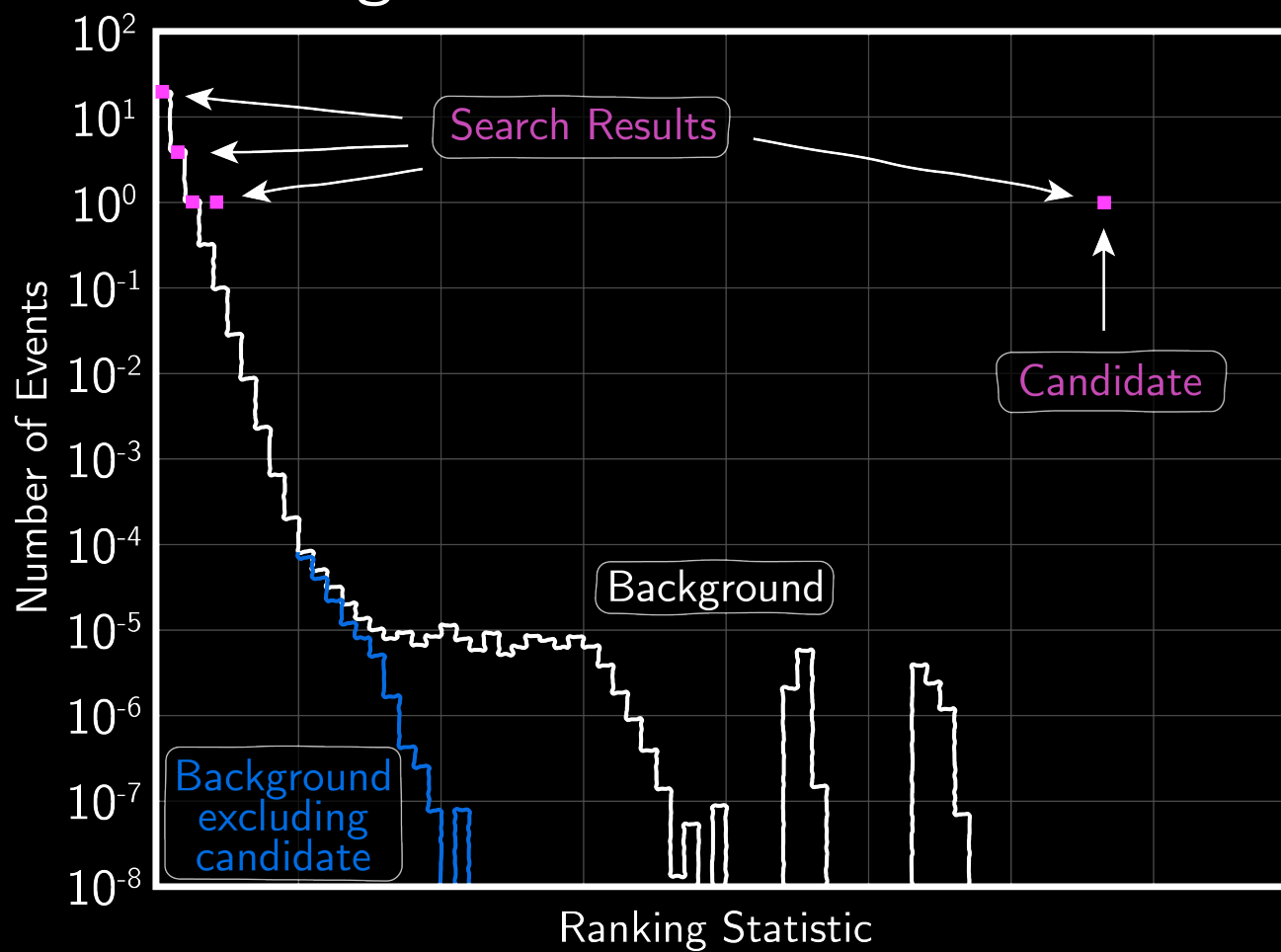
Signal Templates

Template Banks

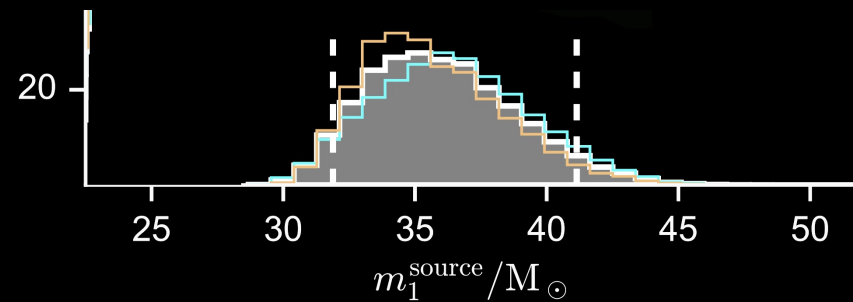


Signal Templates

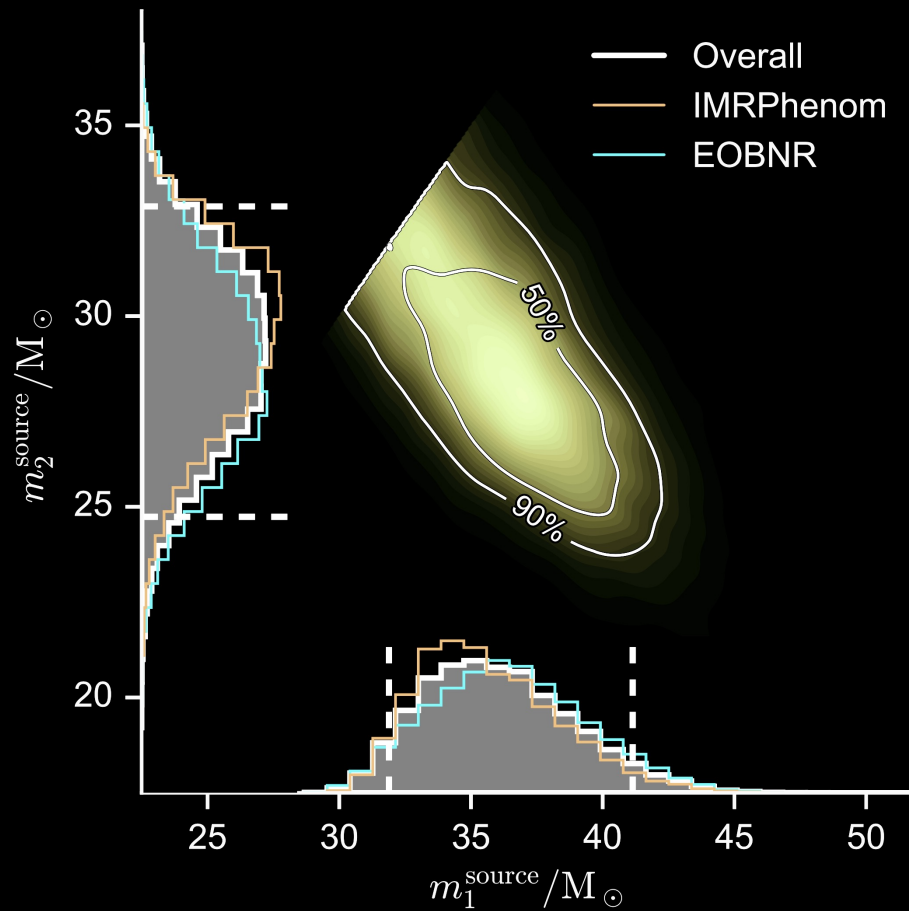
Significance Estimation

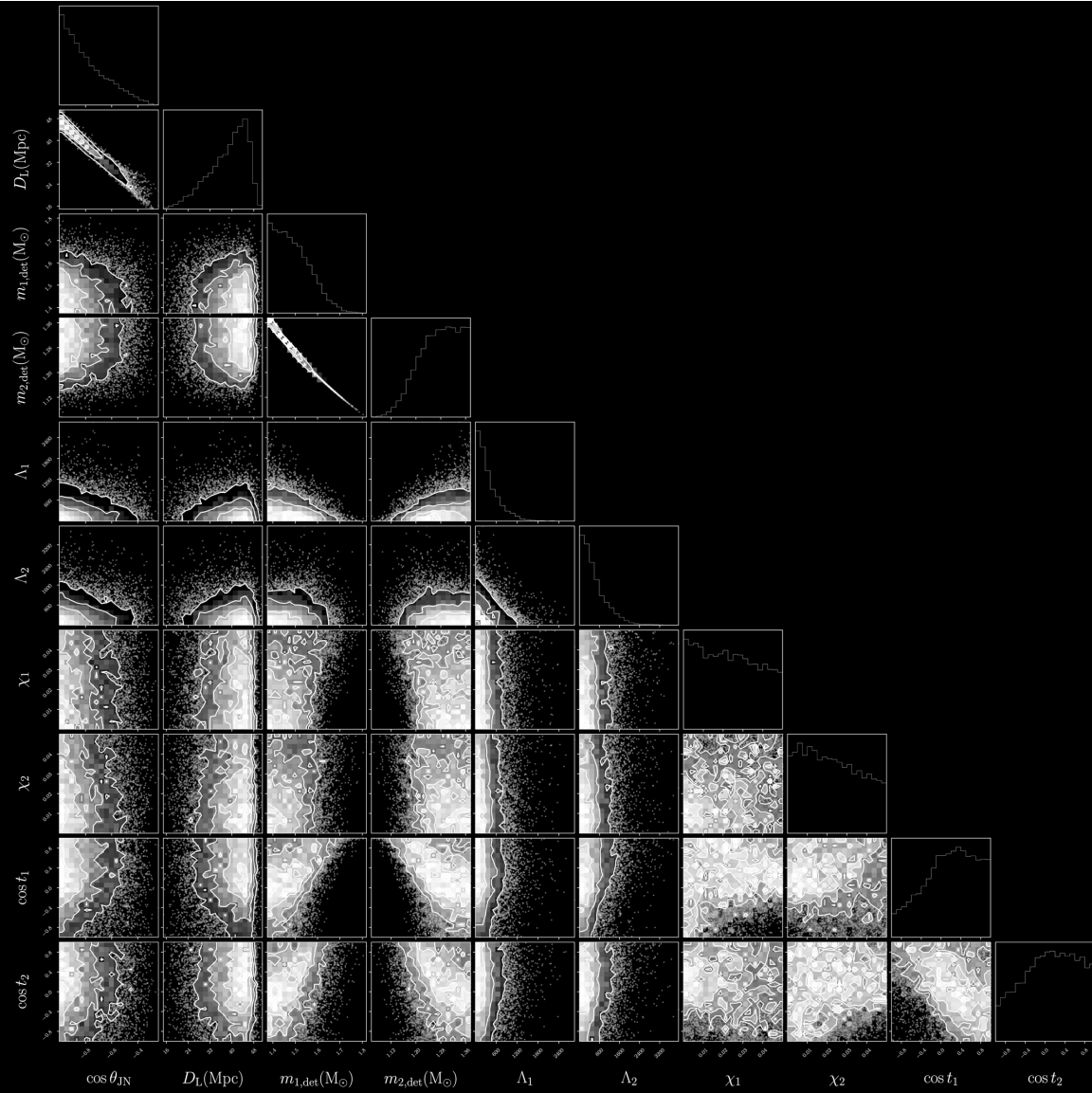


Extracting Astrophysics from a GW Observation



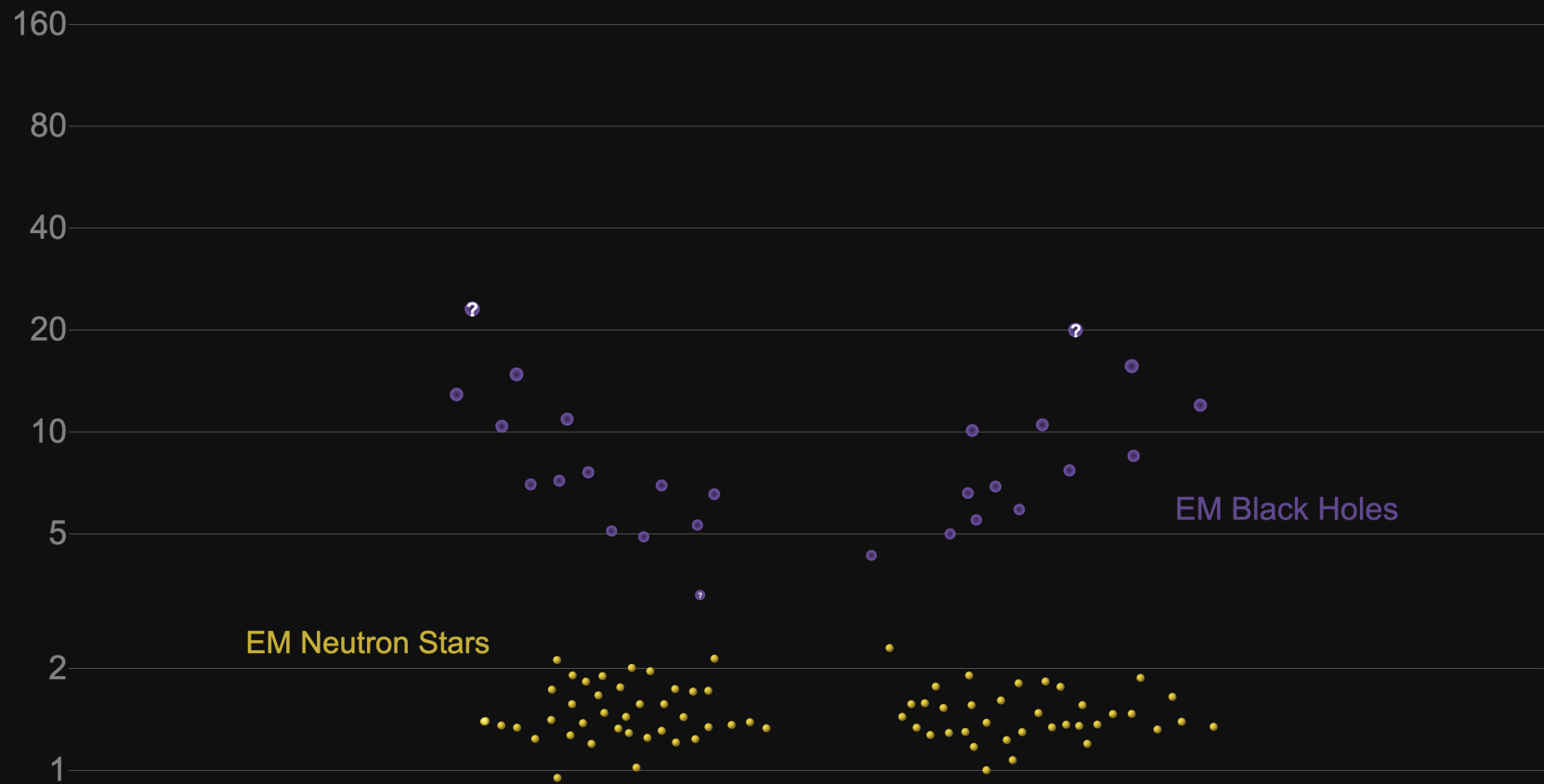
Extracting Astrophysics from a GW Observation





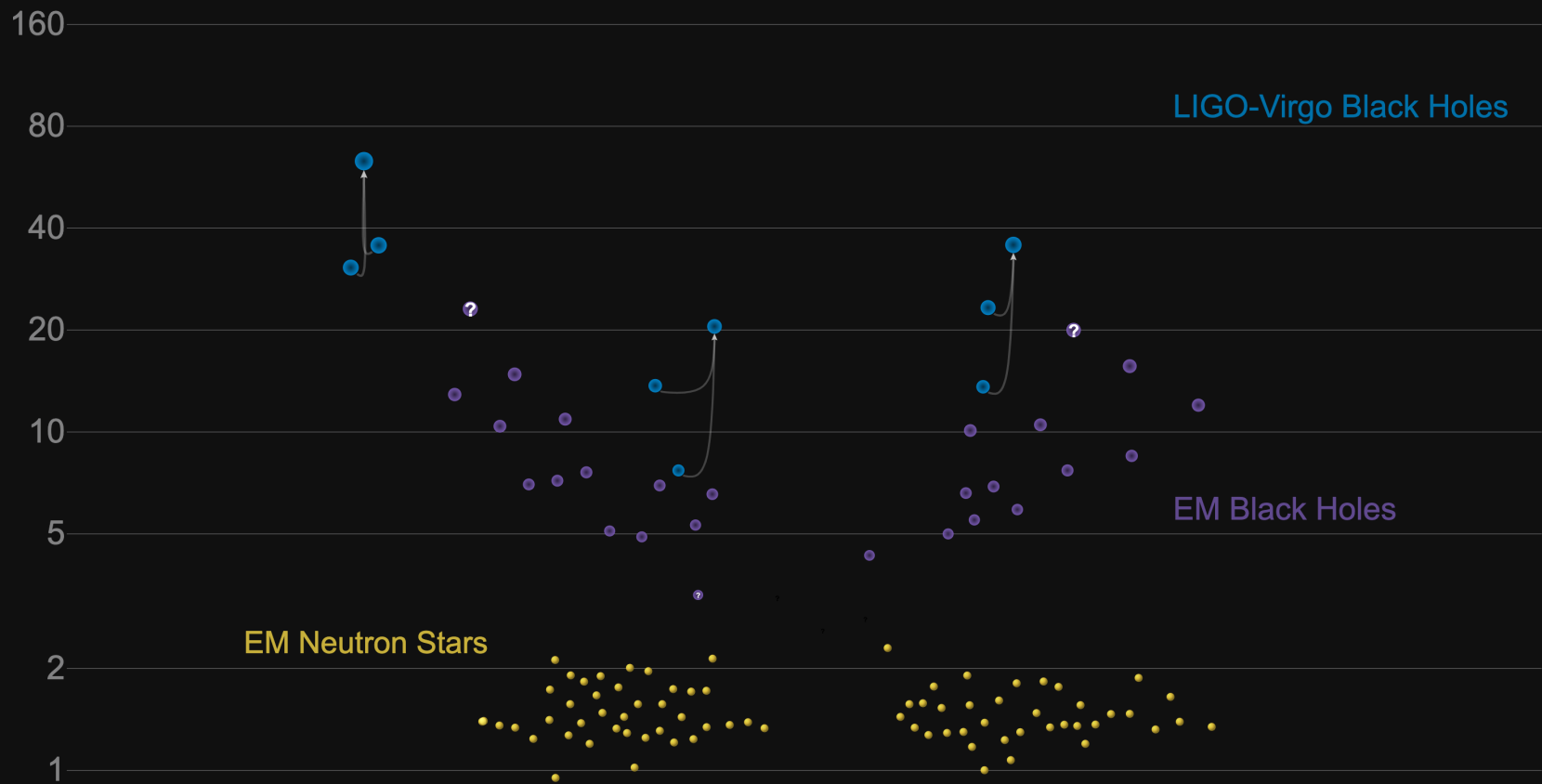
Masses in the Stellar Graveyard

in Solar Masses



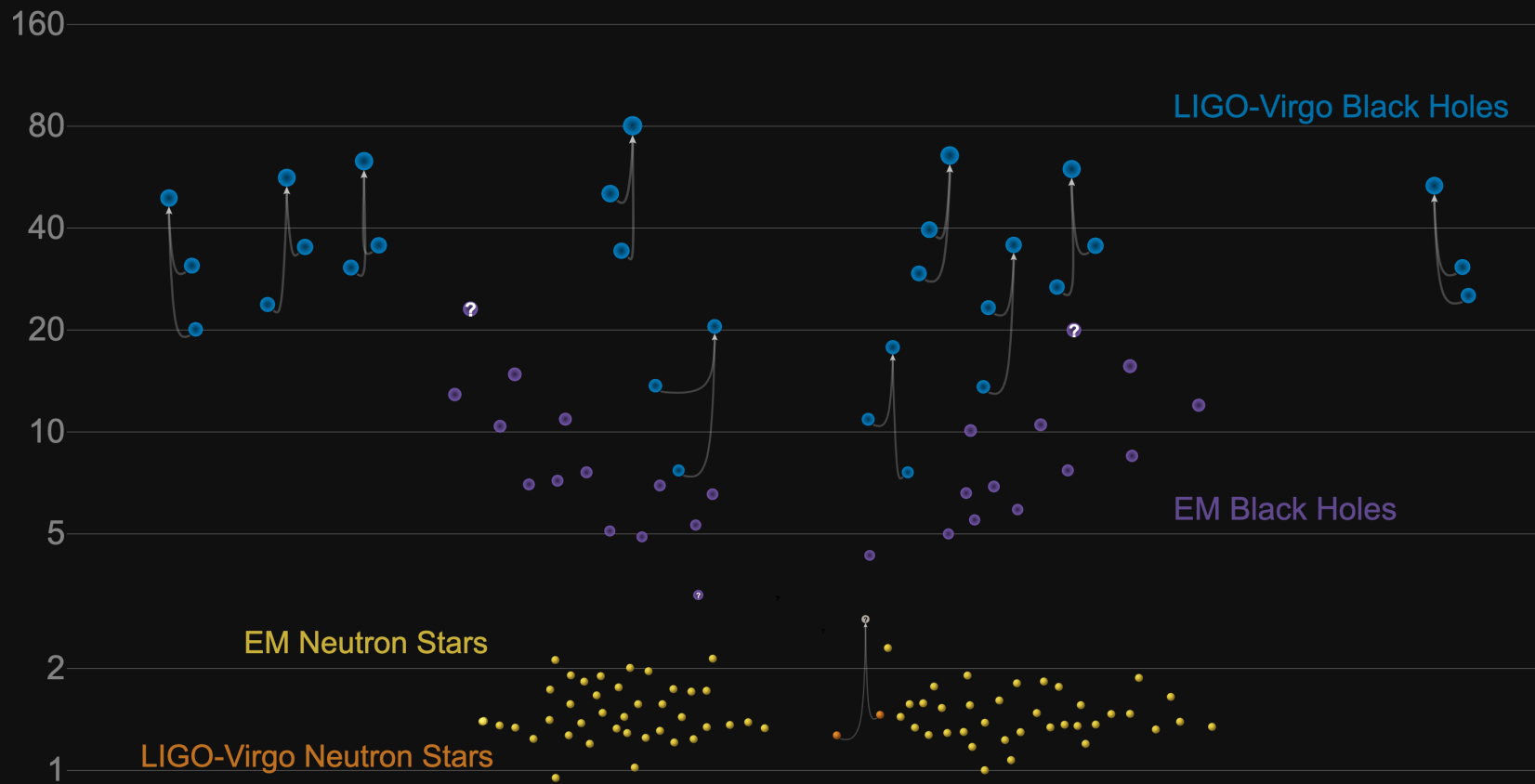
Masses in the Stellar Graveyard

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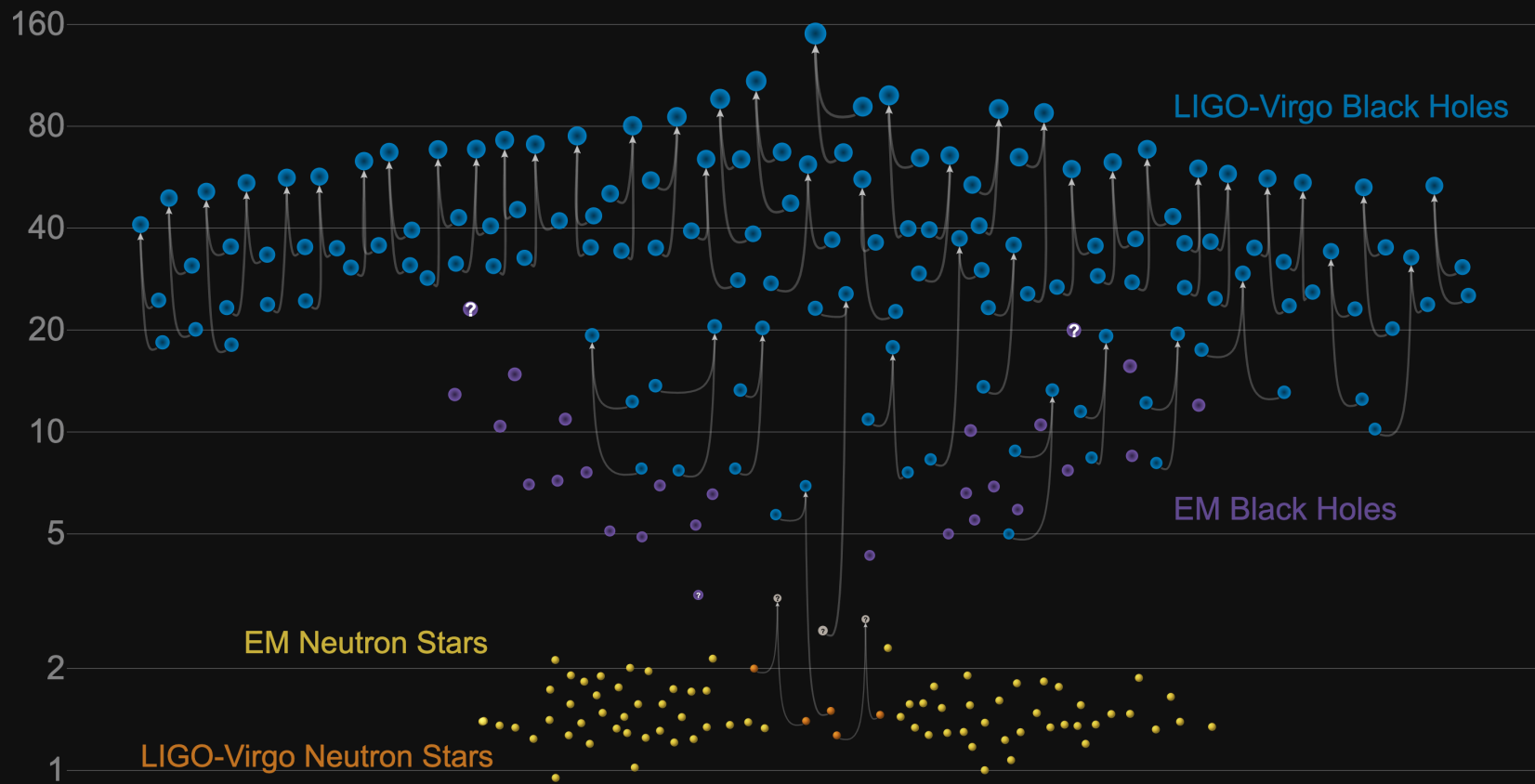
Masses in the Stellar Graveyard

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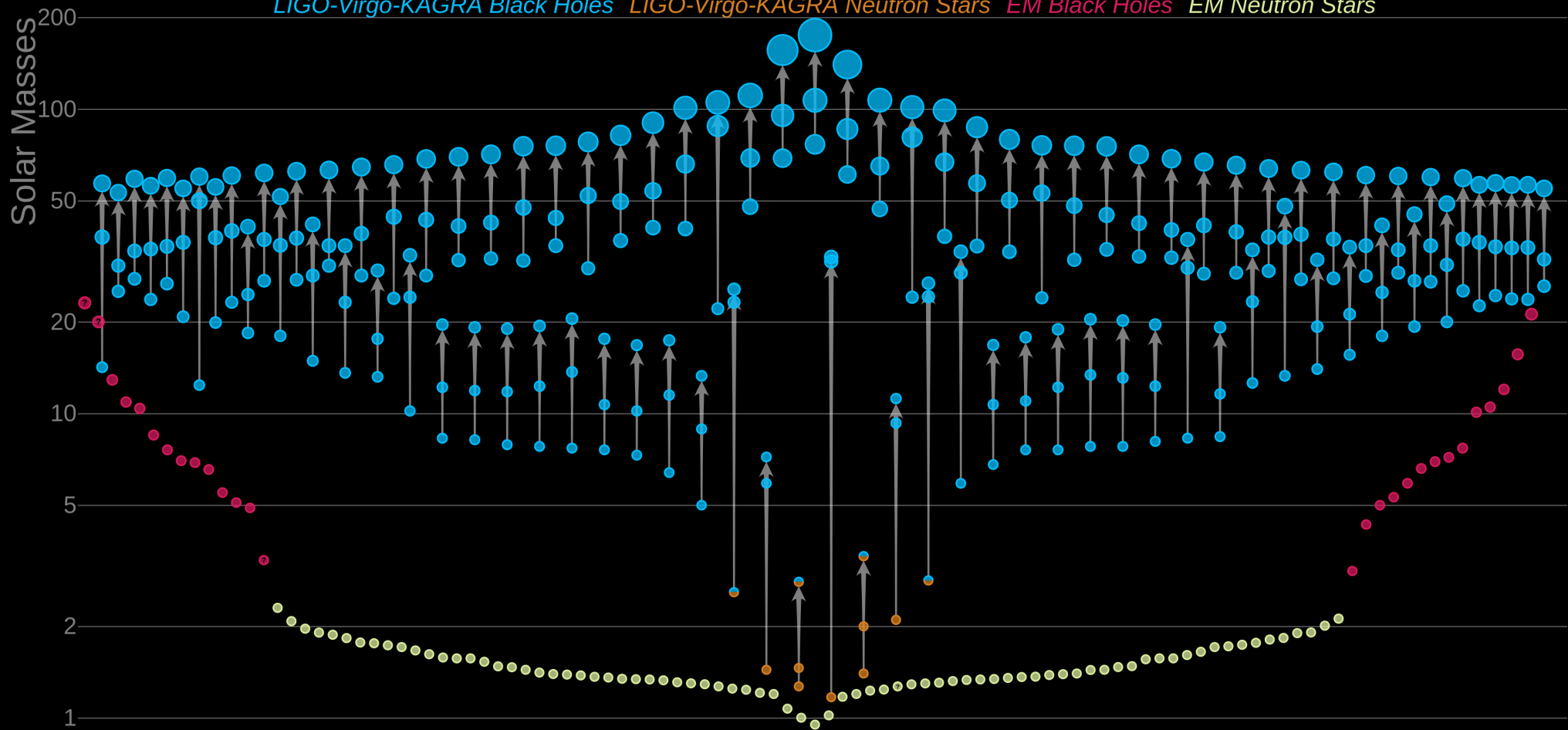
Masses in the Stellar Graveyard

in Solar Masses



Masses in the Stellar Graveyard

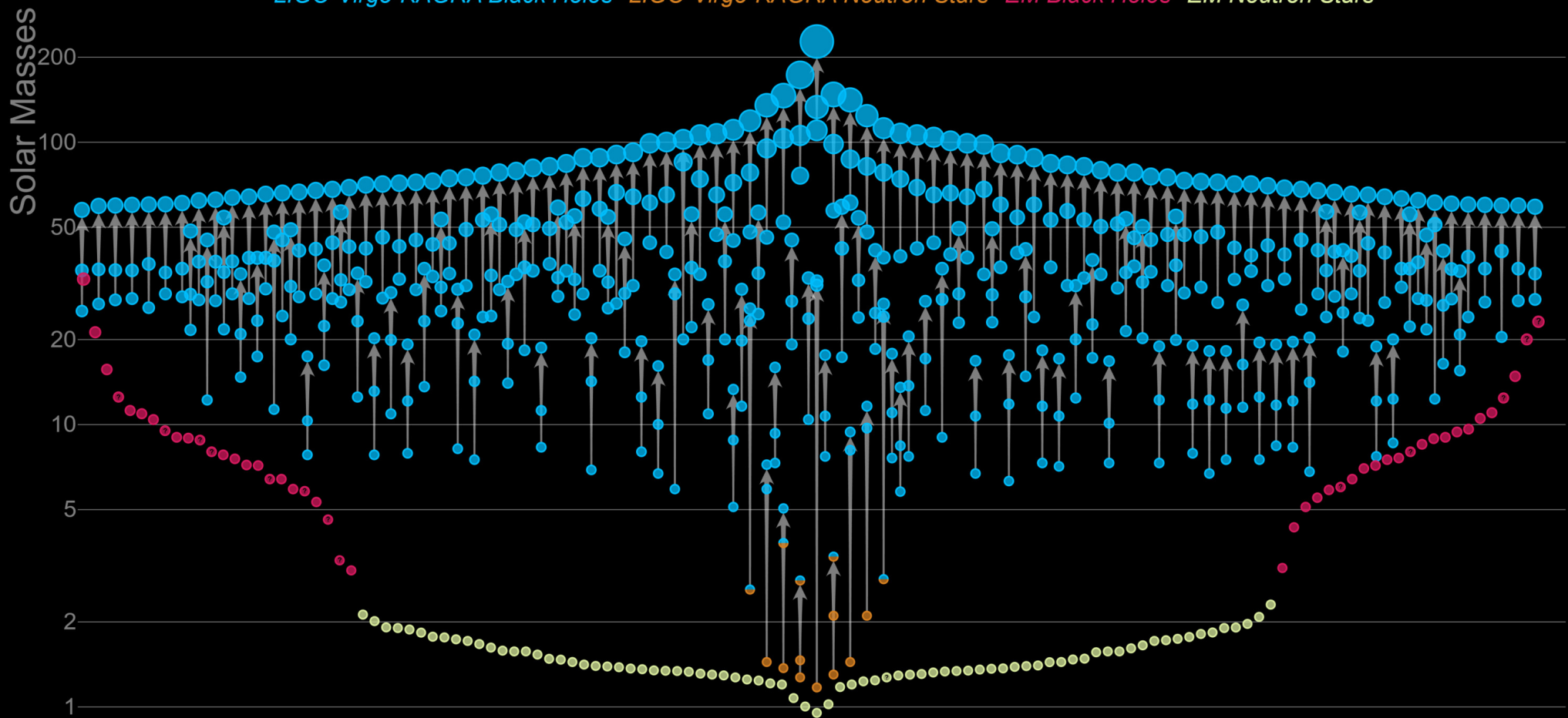
LIGO-Virgo-KAGRA Black Holes *LIGO-Virgo-KAGRA Neutron Stars* *EM Black Holes* *EM Neutron Stars*



LIGO-Virgo-KAGRA | Aaron Geller | Northwestern

Masses in the Stellar Graveyard

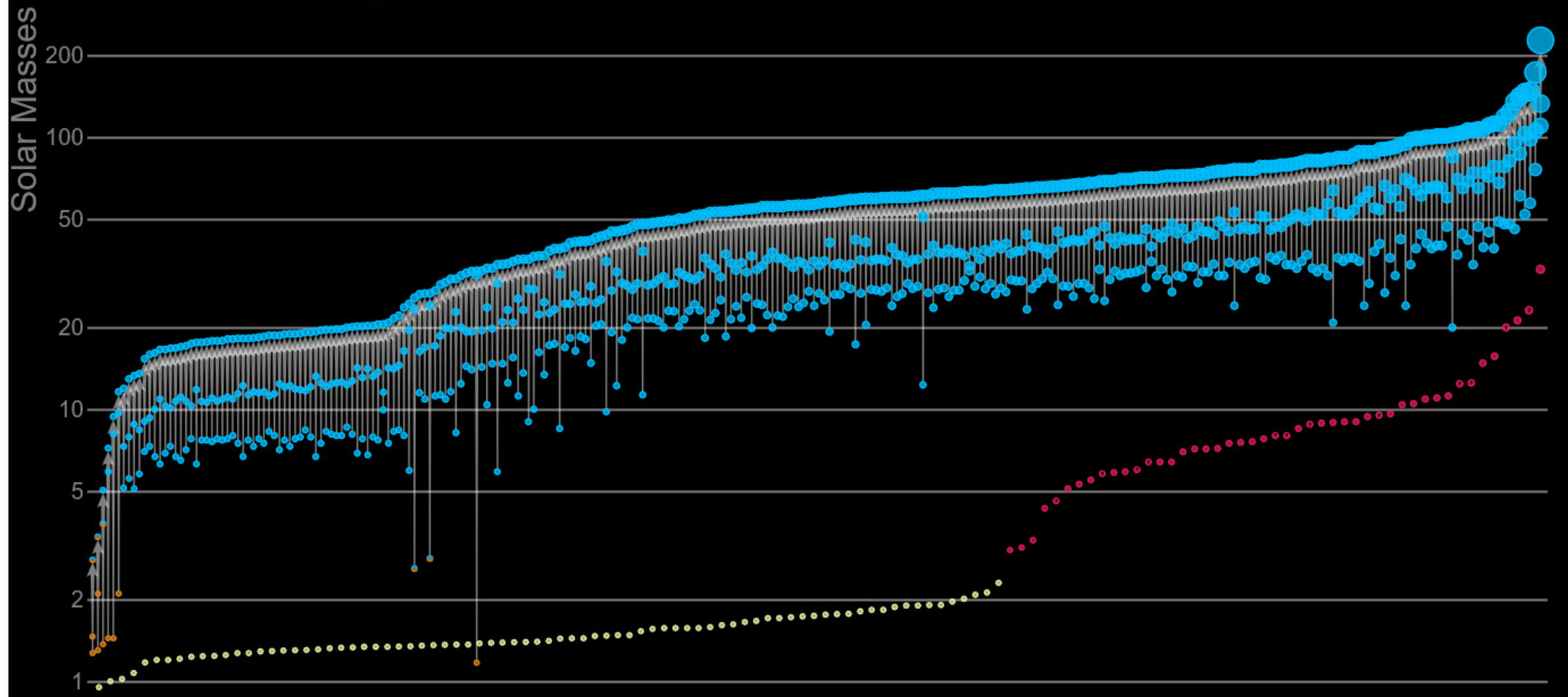
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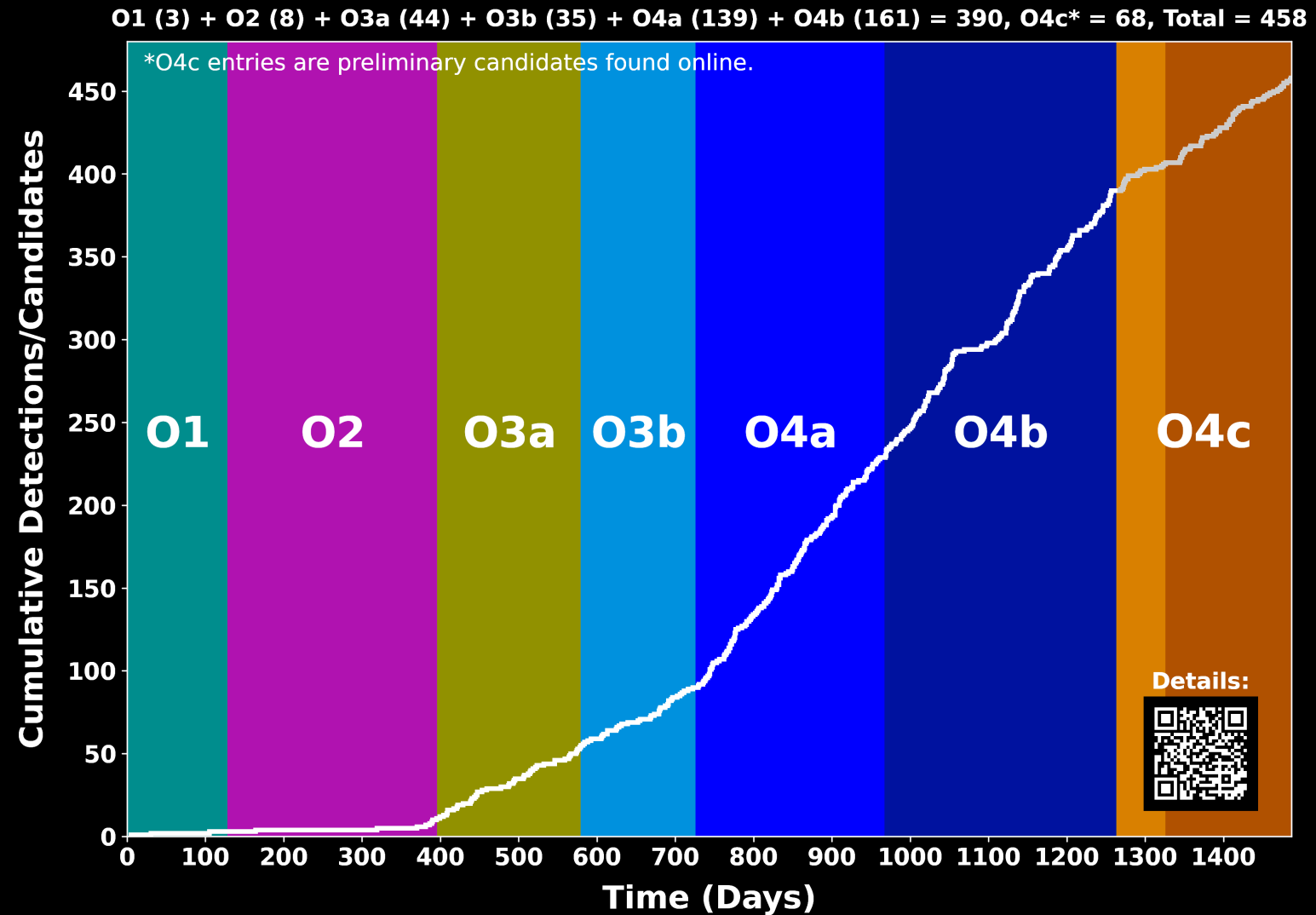
LIGO-Virgo-KAGRA | Aaron Geller | Northwestern

Masses in the Stellar Graveyard

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LIGO-Virgo-KAGRA | Aaron Geller | Northwestern



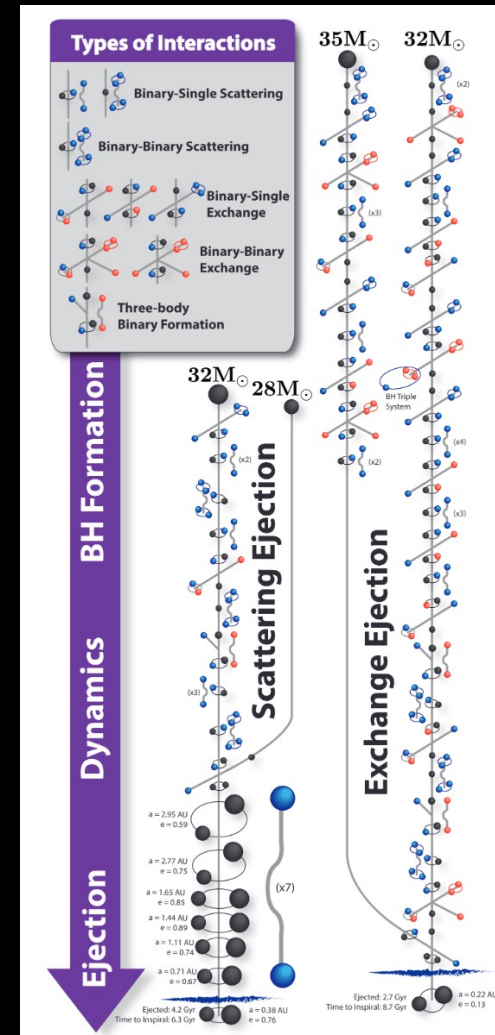
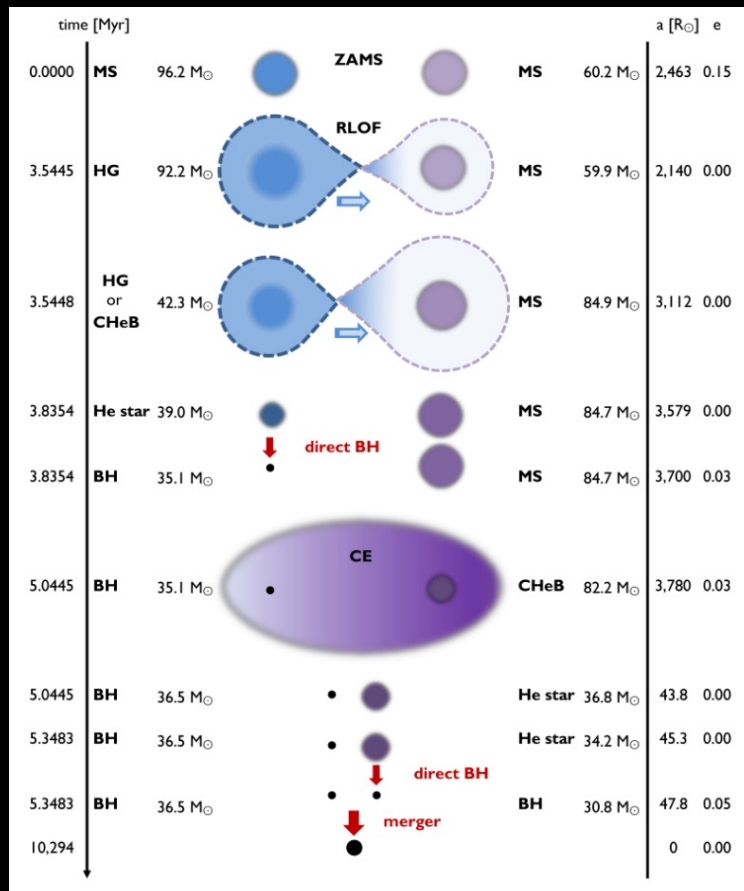
LIGO-G2302098 (f244d4f6), updated on 25 May, 2026

Credit: LIGO-Virgo-KAGRA Collaboration

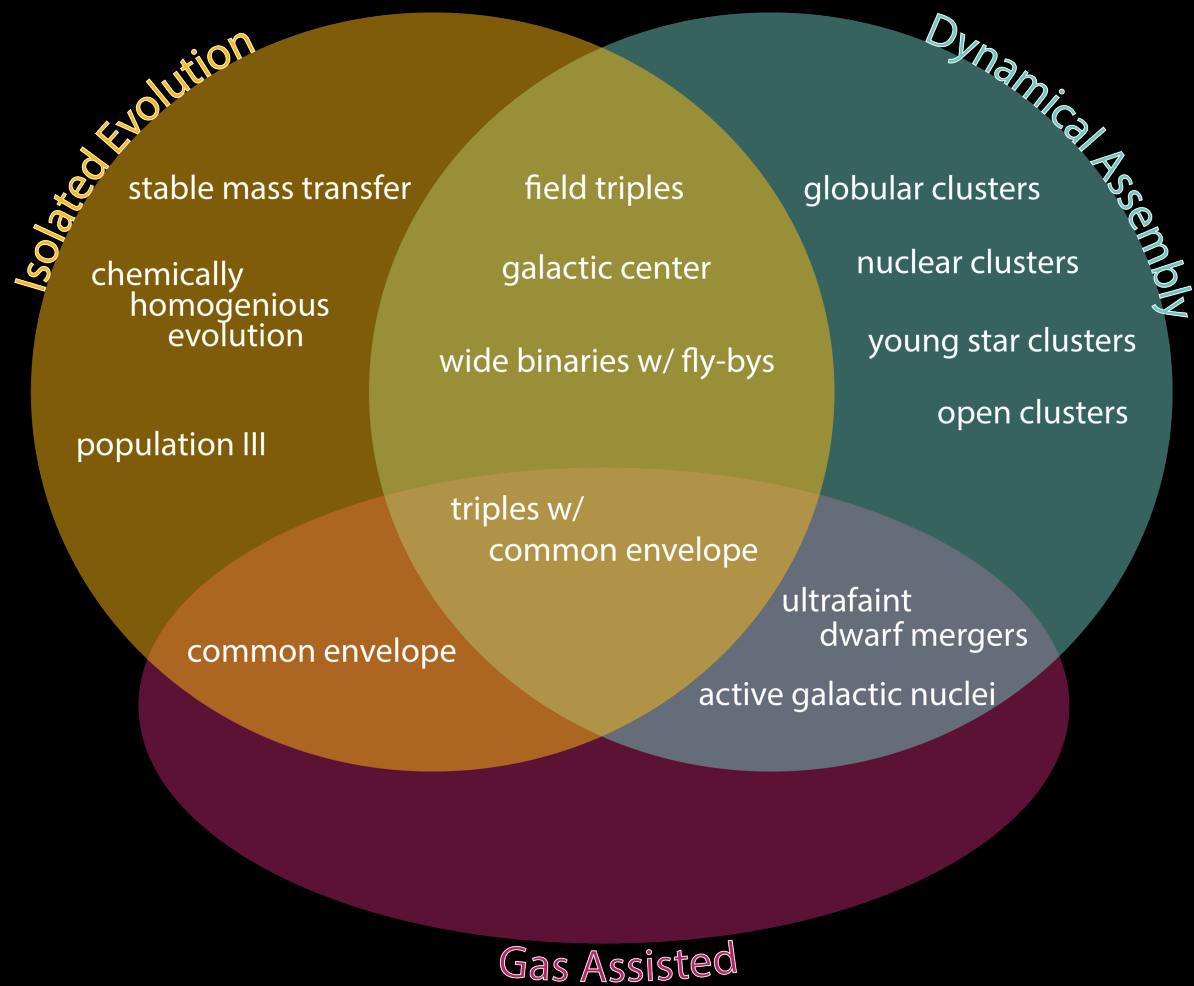
What can we learn?



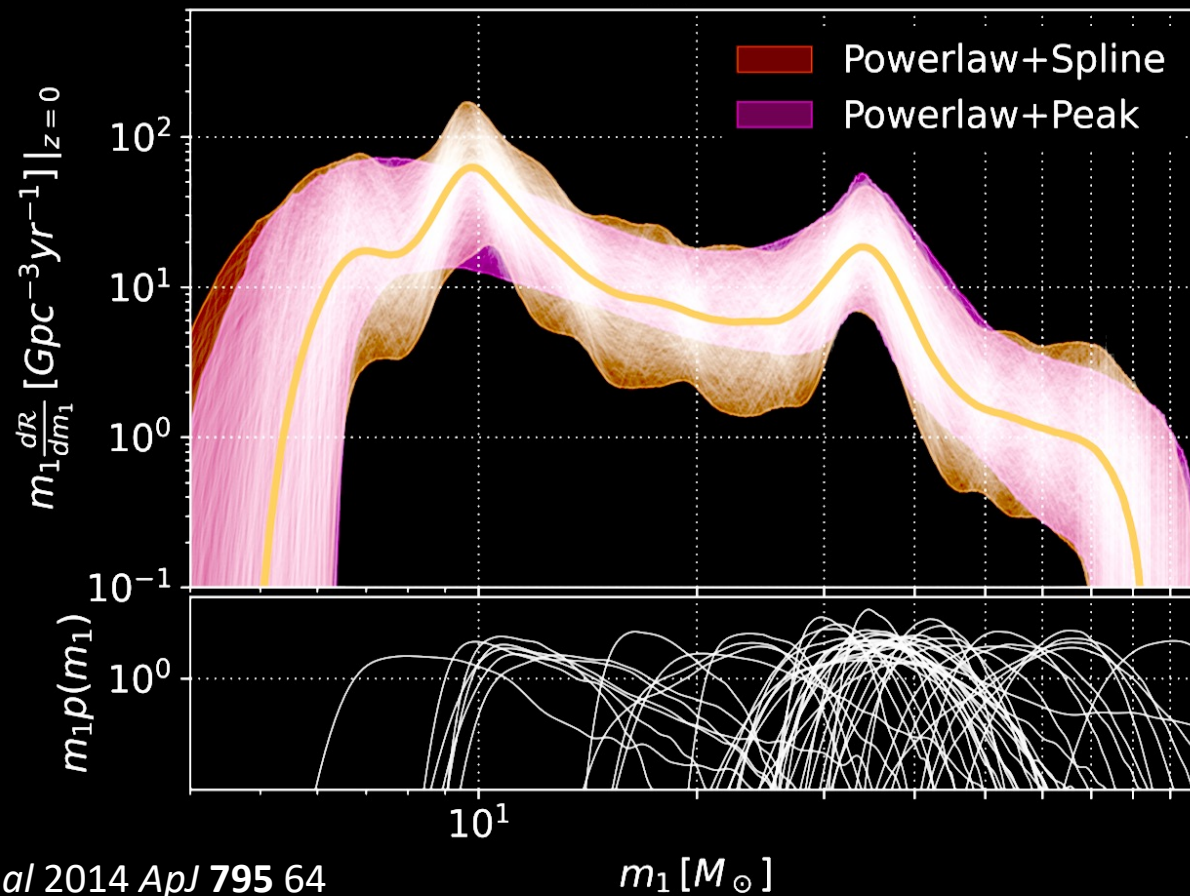
What can we learn?



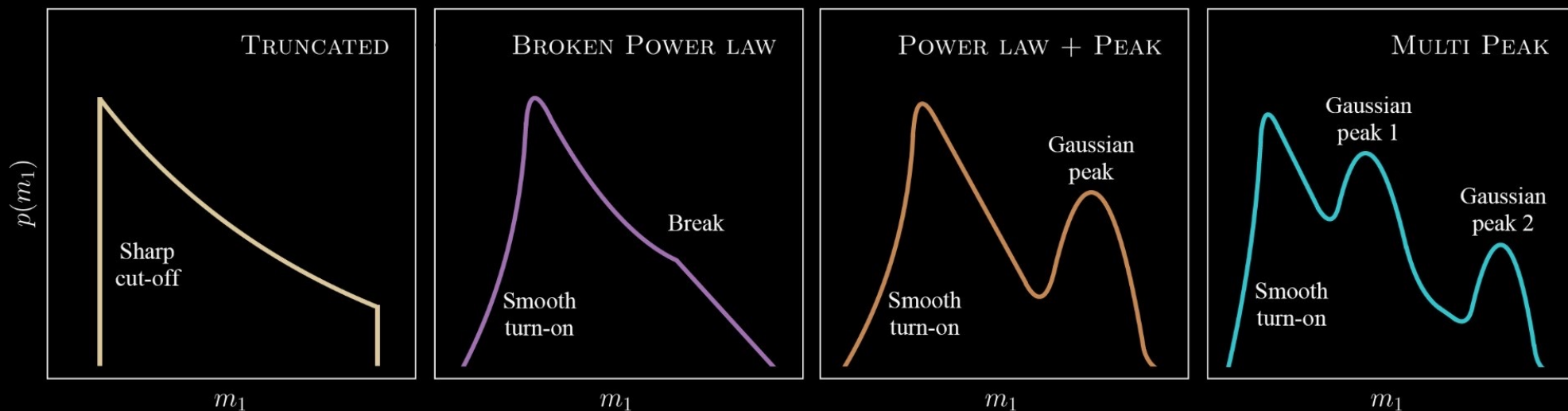
What can we learn?



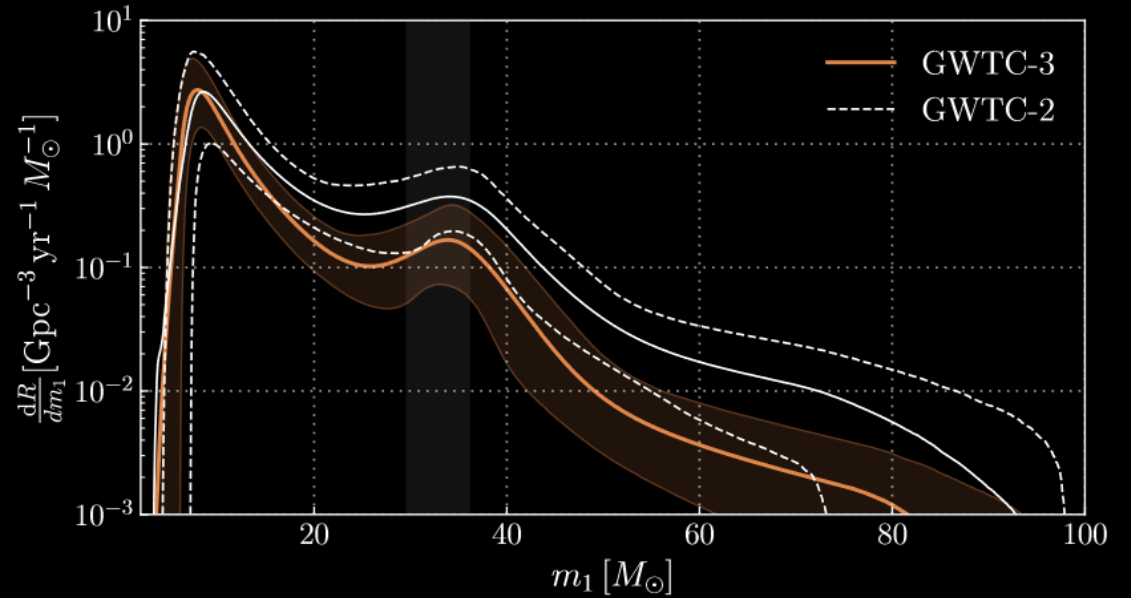
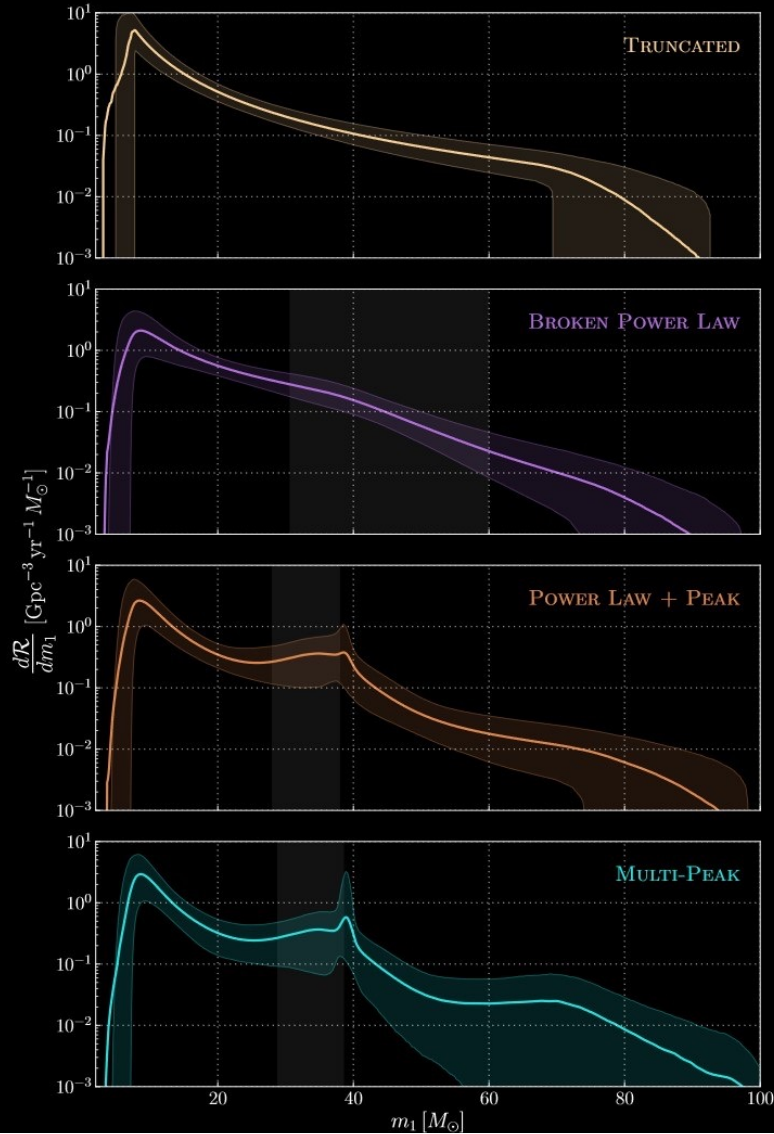
Extracting Astrophysics *many* GW Observations



Population Mass Properties



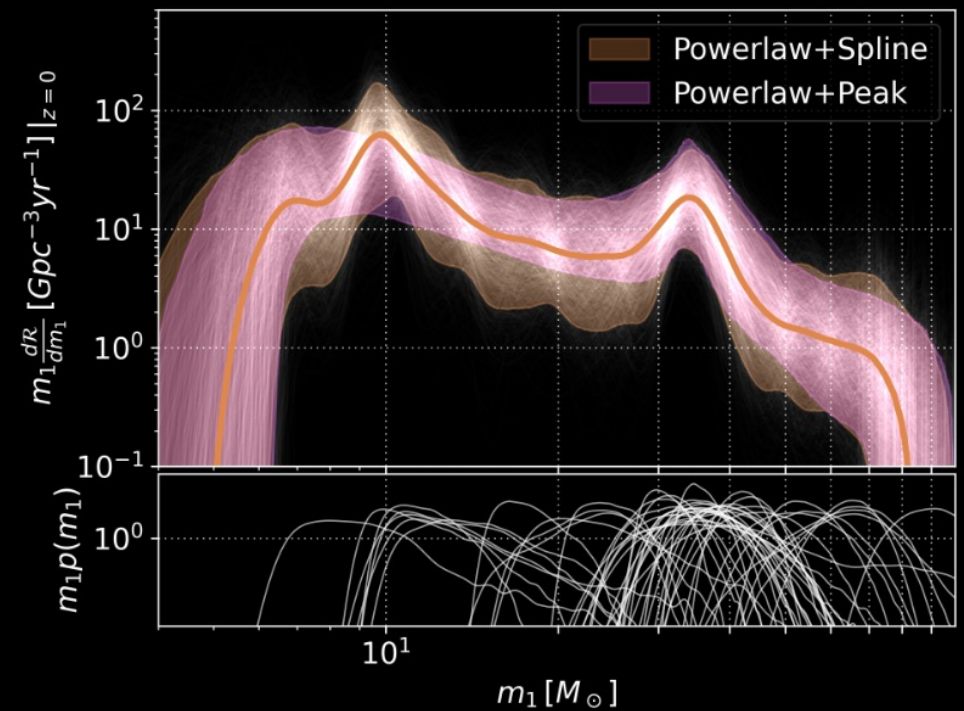
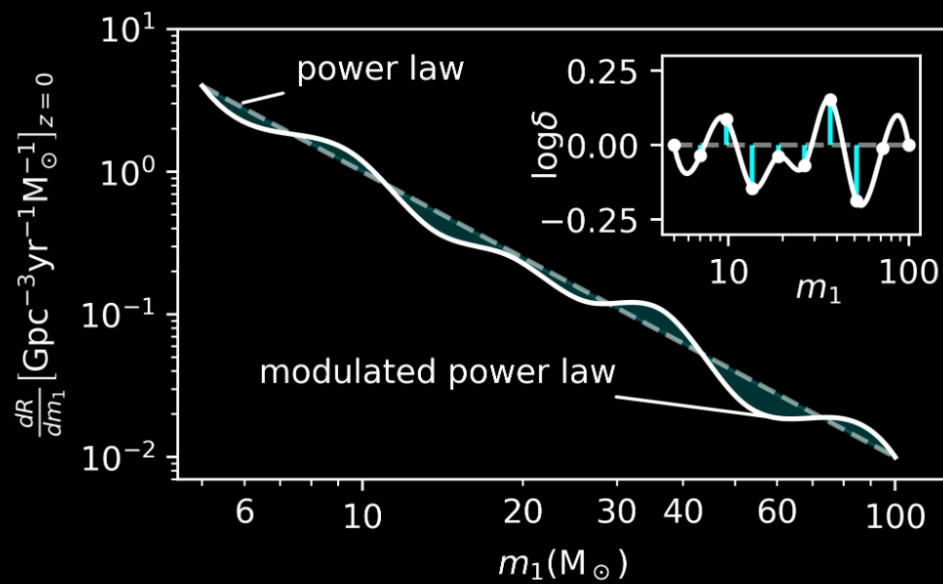
Population Mass Properties



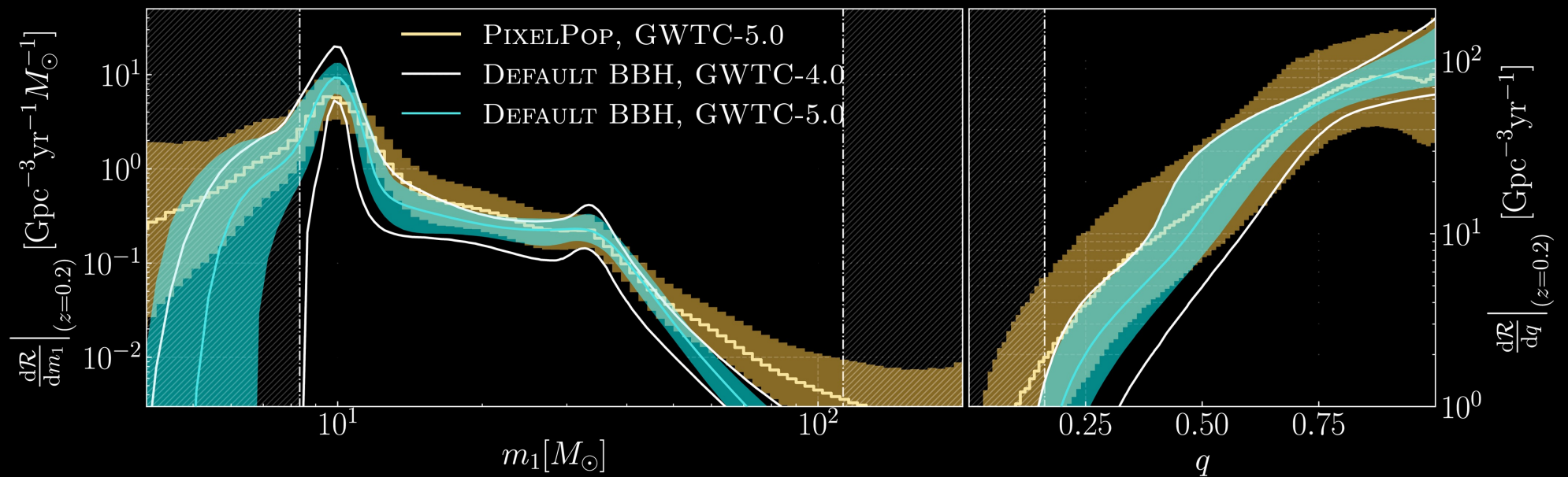
R. Abbott *et al* 2021 *ApJL* **913** L7 (GWTC-2 Pop.)

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

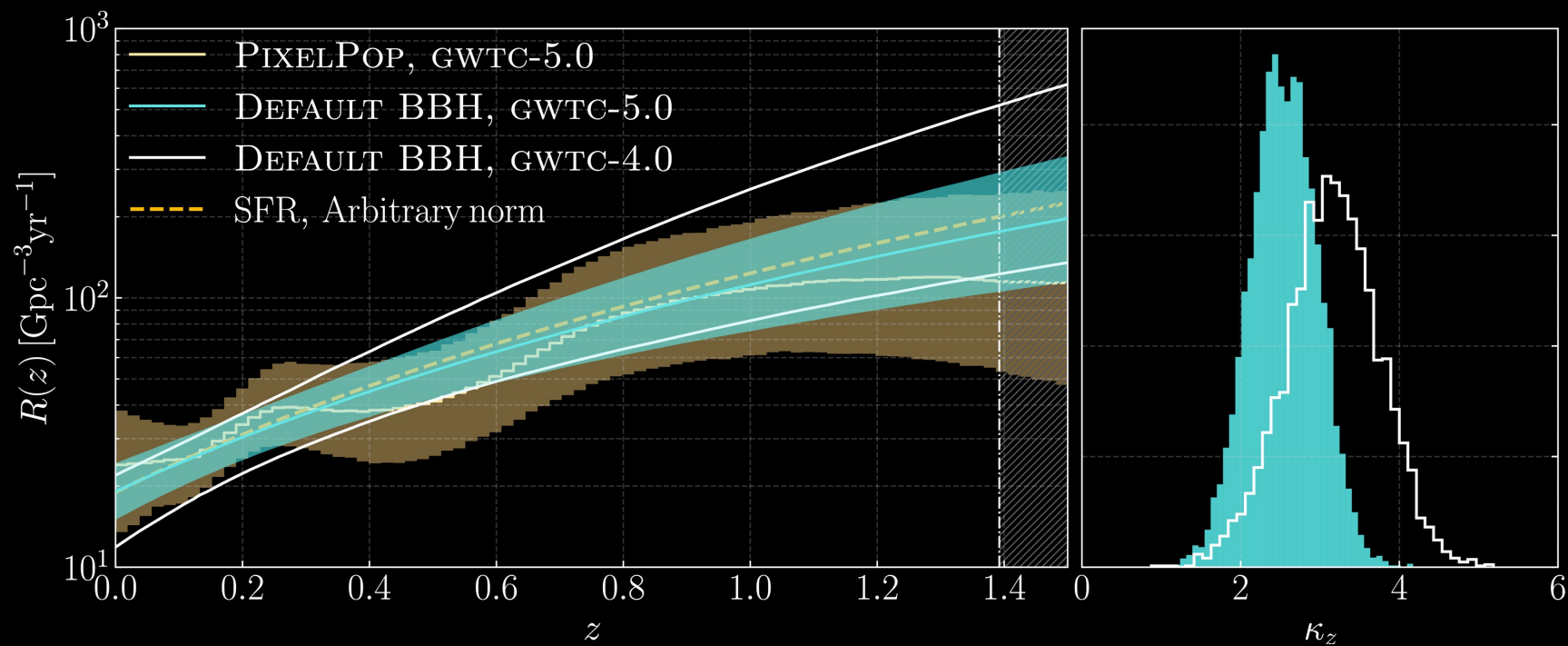
Semi-Parametric Modeling



What can we learn?



What can we learn?



Additional Resources

The Gravitational Wave Open Science Center



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

<https://www.gwosc.org/tutorials>



Open Data

<https://www.gwosc.org/data>



Event portal

<https://www.gwosc.org/eventapi>