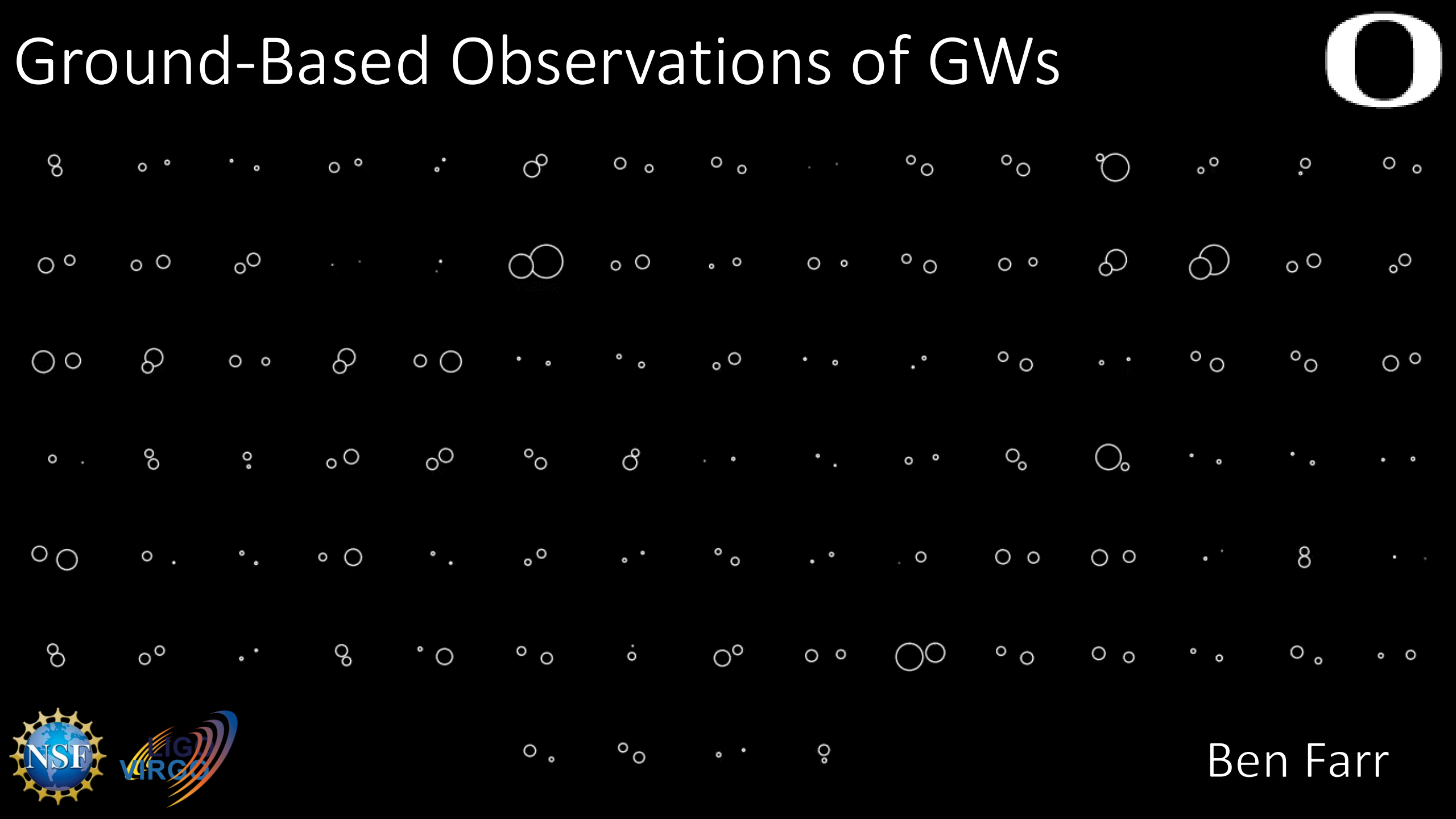
Ground-Based Observations of GWs



Ben Farr

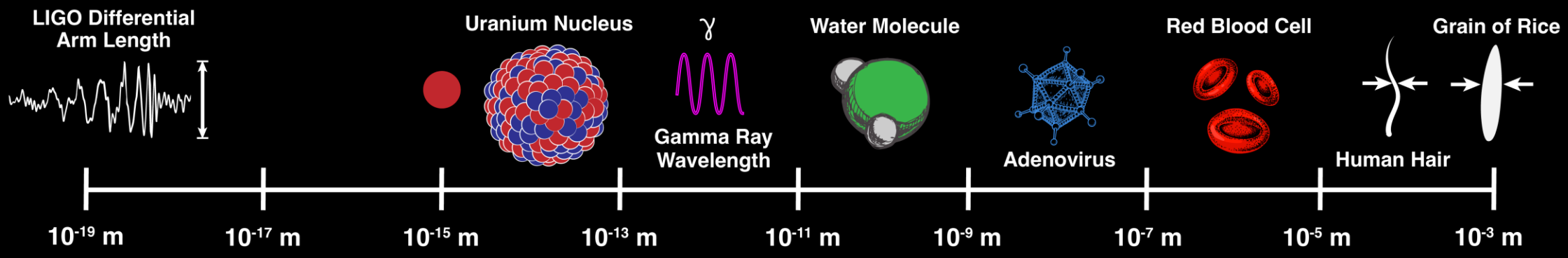
The Problem

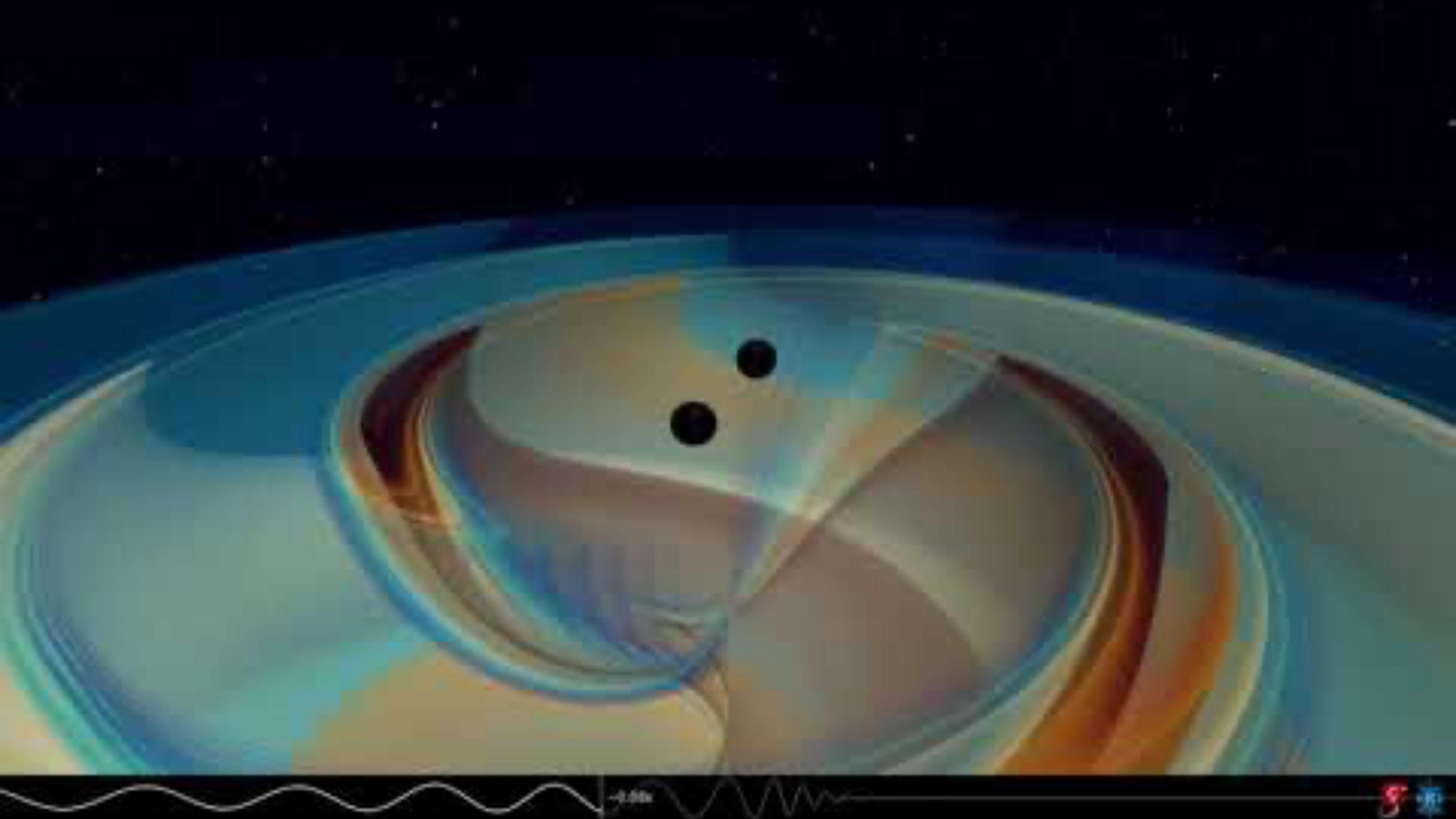
Spacetime is *STIFF*

Young's Modulus of Spacetime

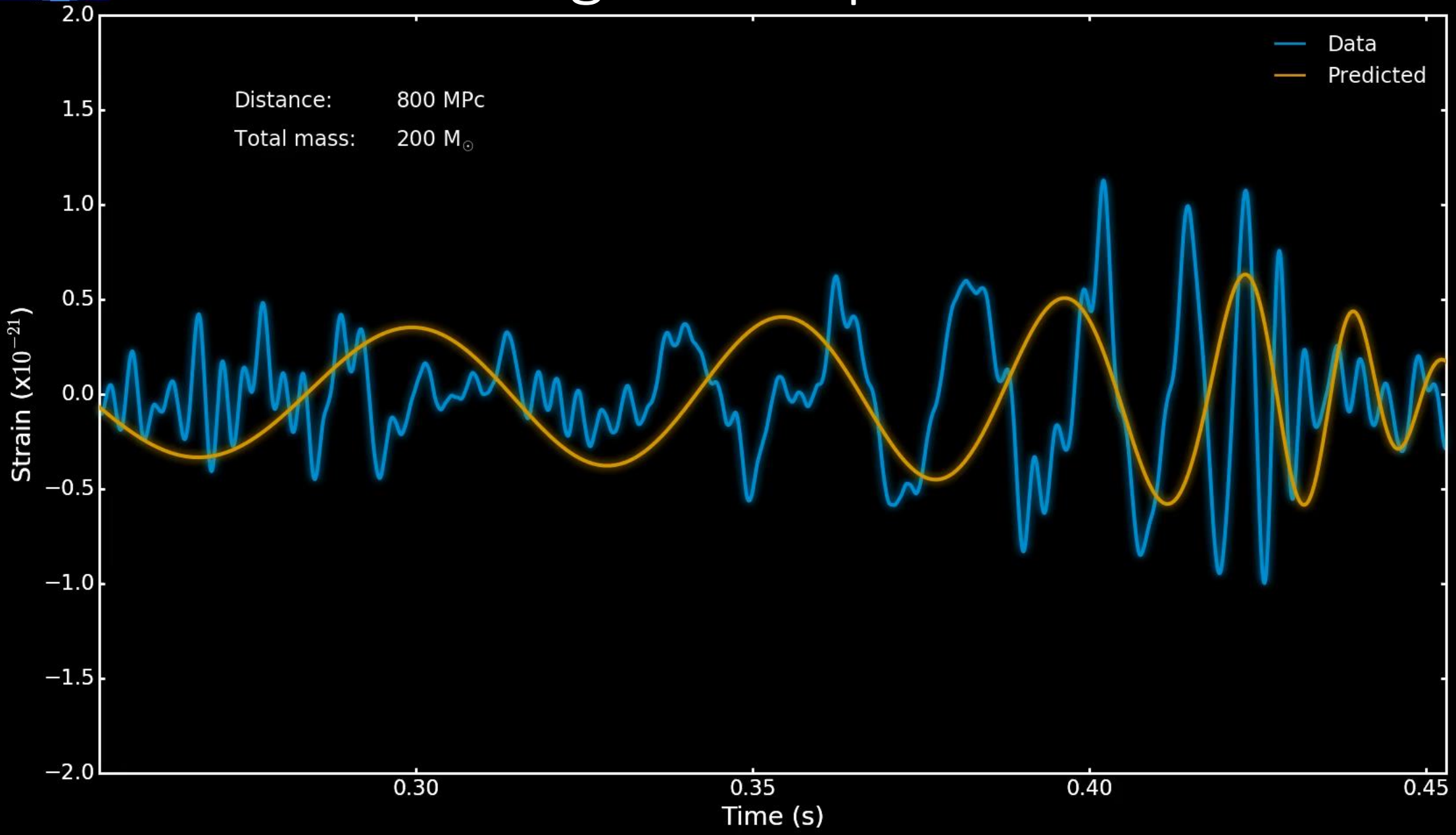
$$\frac{F}{A} = Y_{\text{spacetime}} \frac{\Delta L}{L}$$

$Y_{\text{spacetime}}$





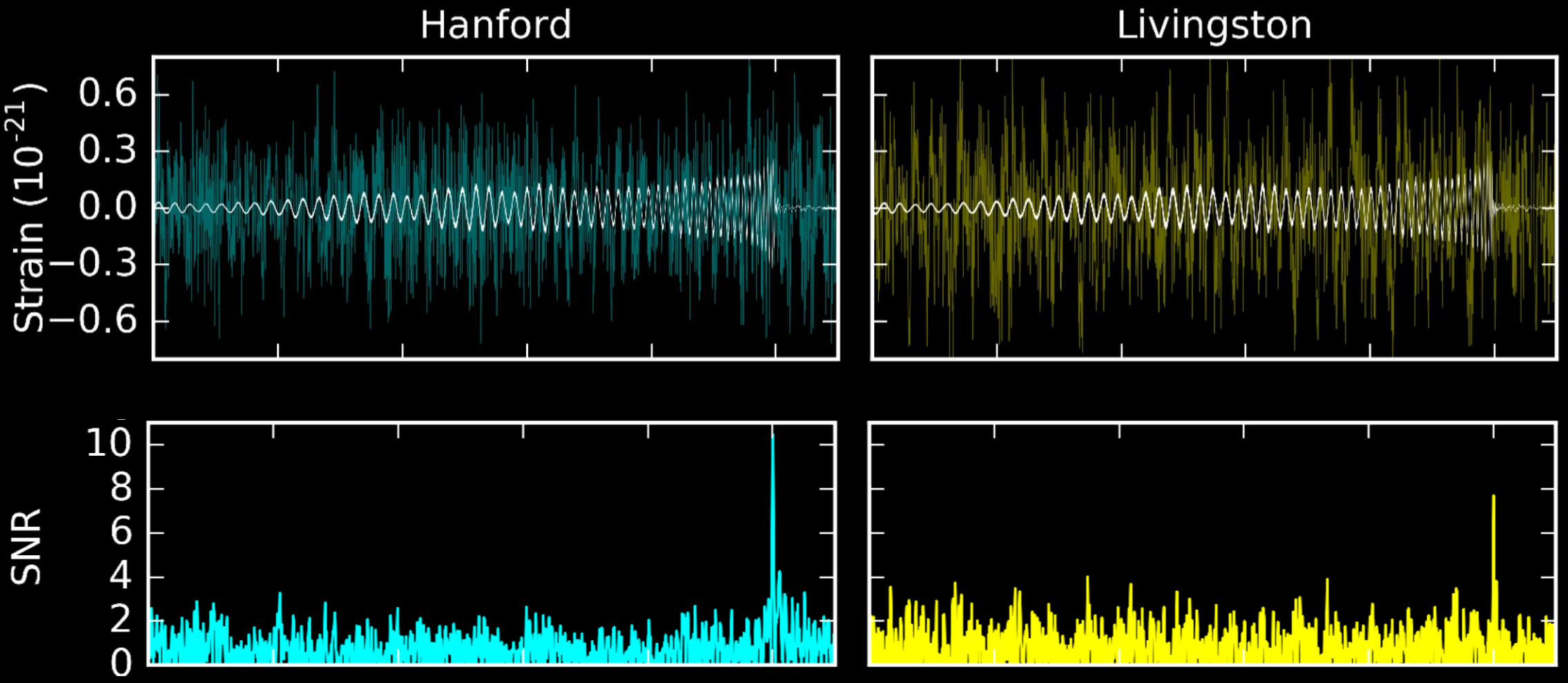
Signal Templates



Data & Best-fit Waveform: LIGO Open Science Center (losc.ligo.org); Prediction & Animation: C.North/M.Hannam (Cardiff University)

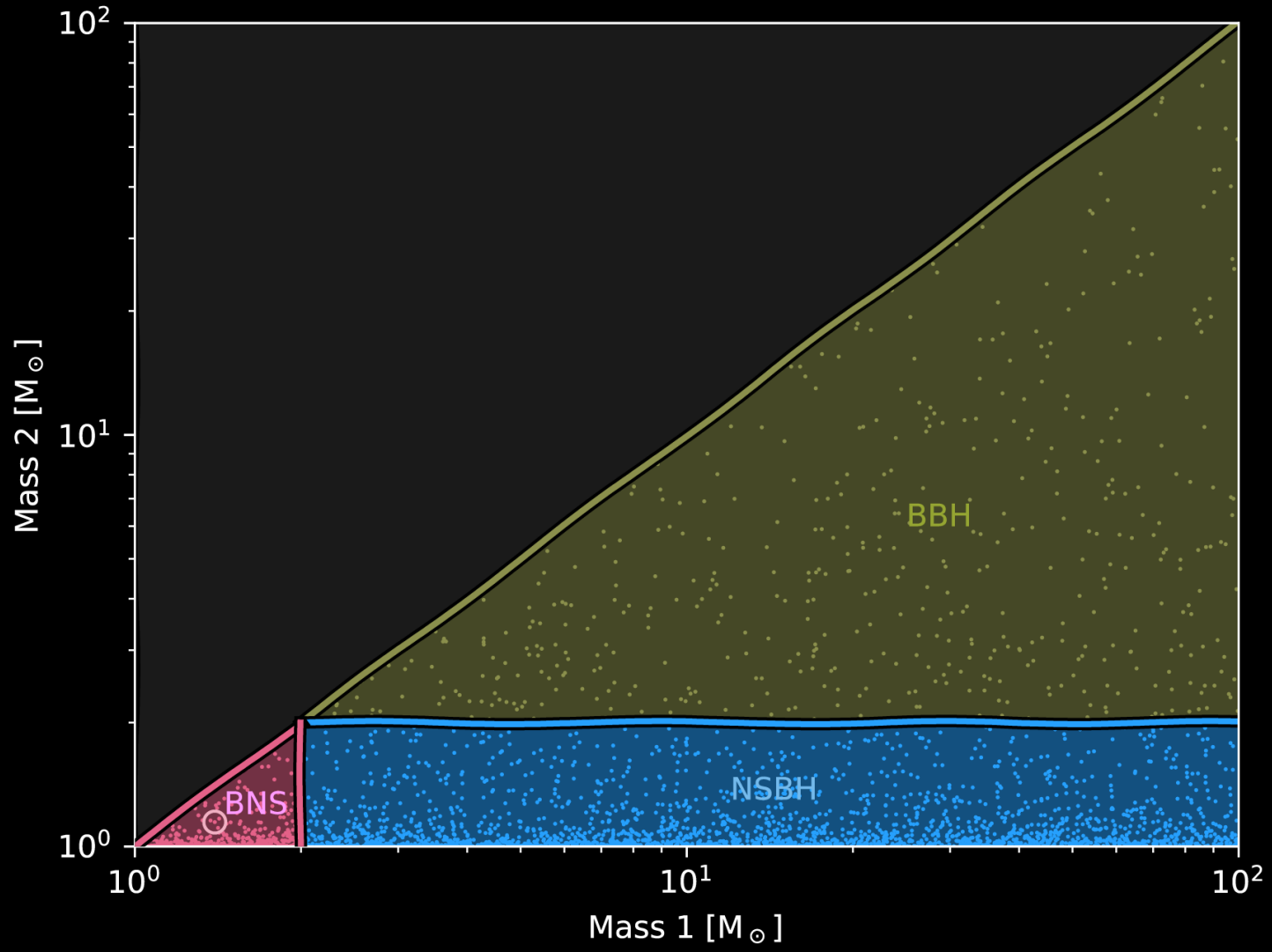
Signal Templates

GW151226



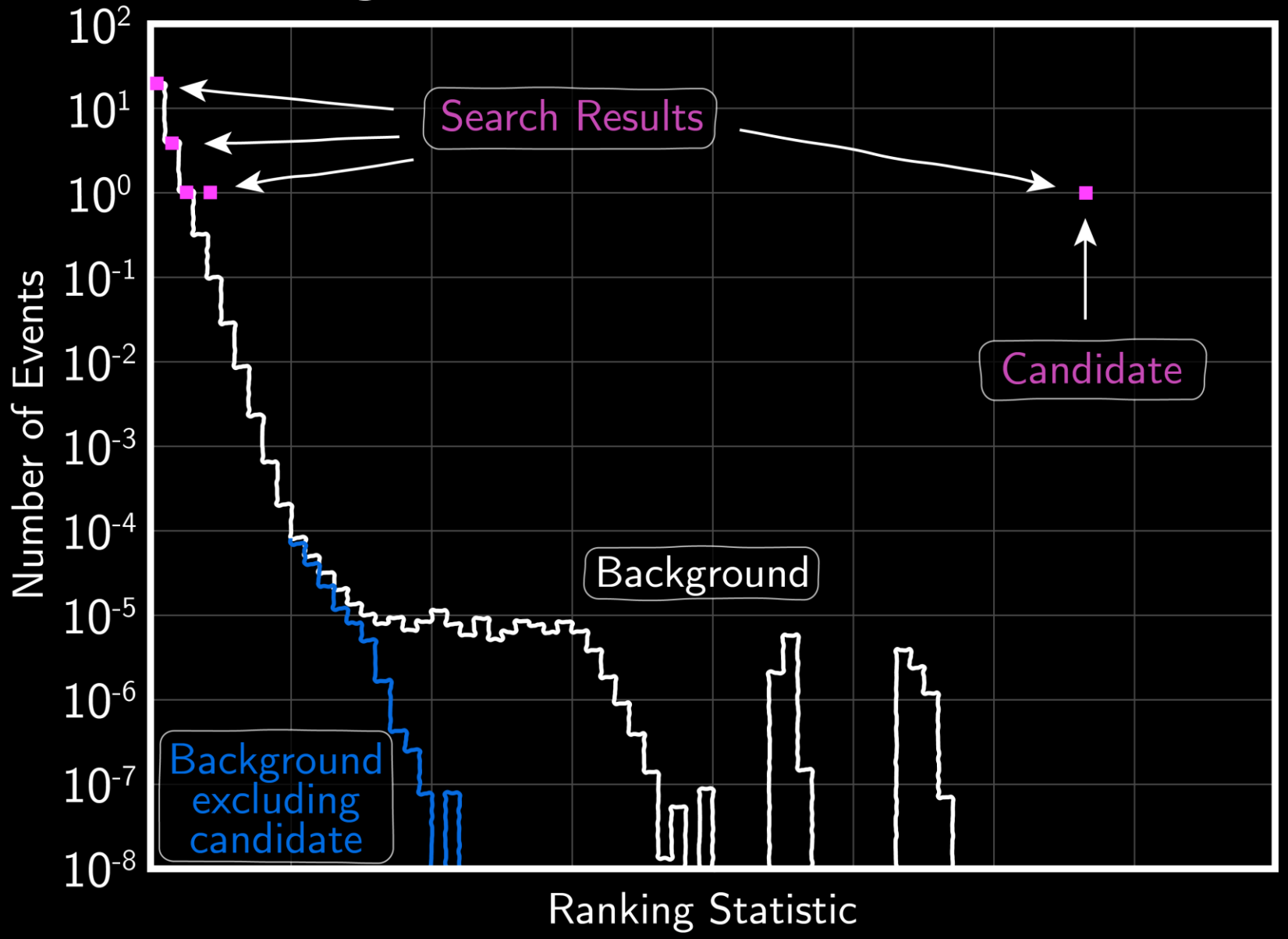
Signal Templates

Template Banks

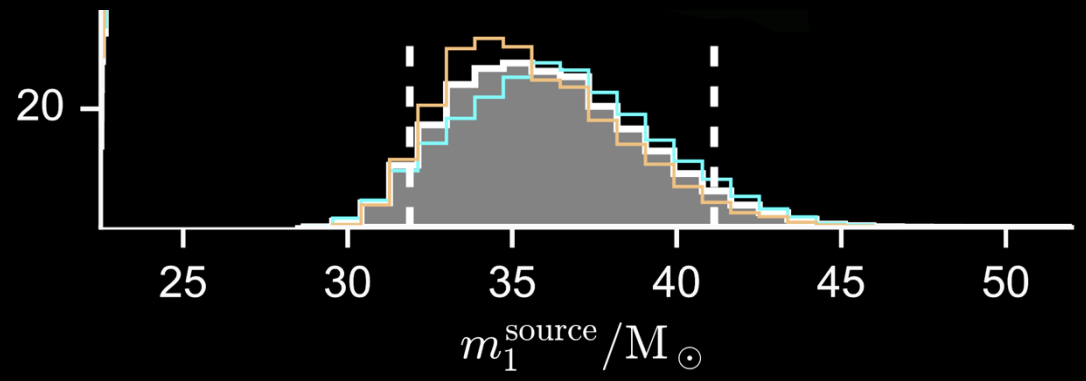


Signal Templates

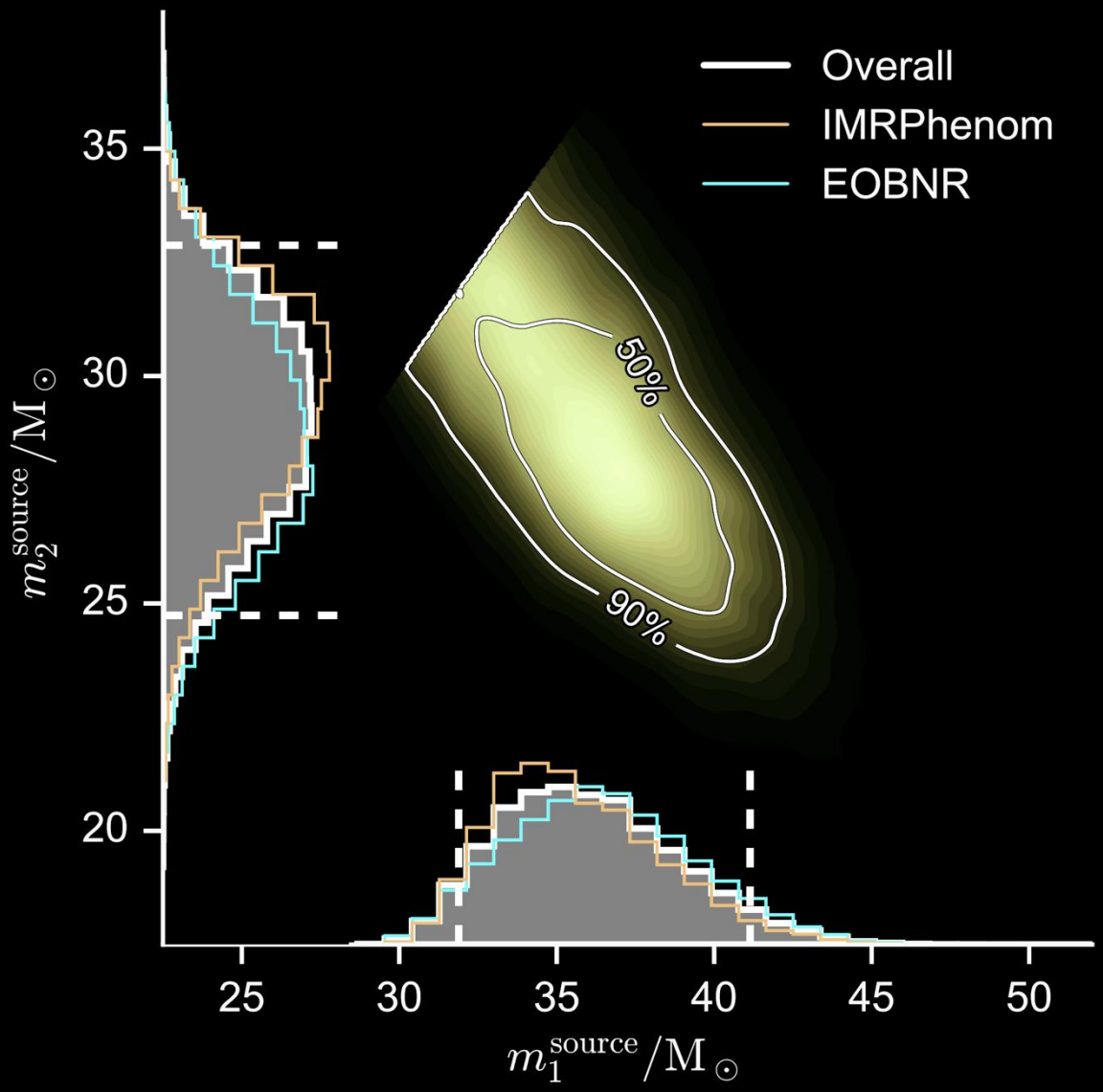
Significance Estimation

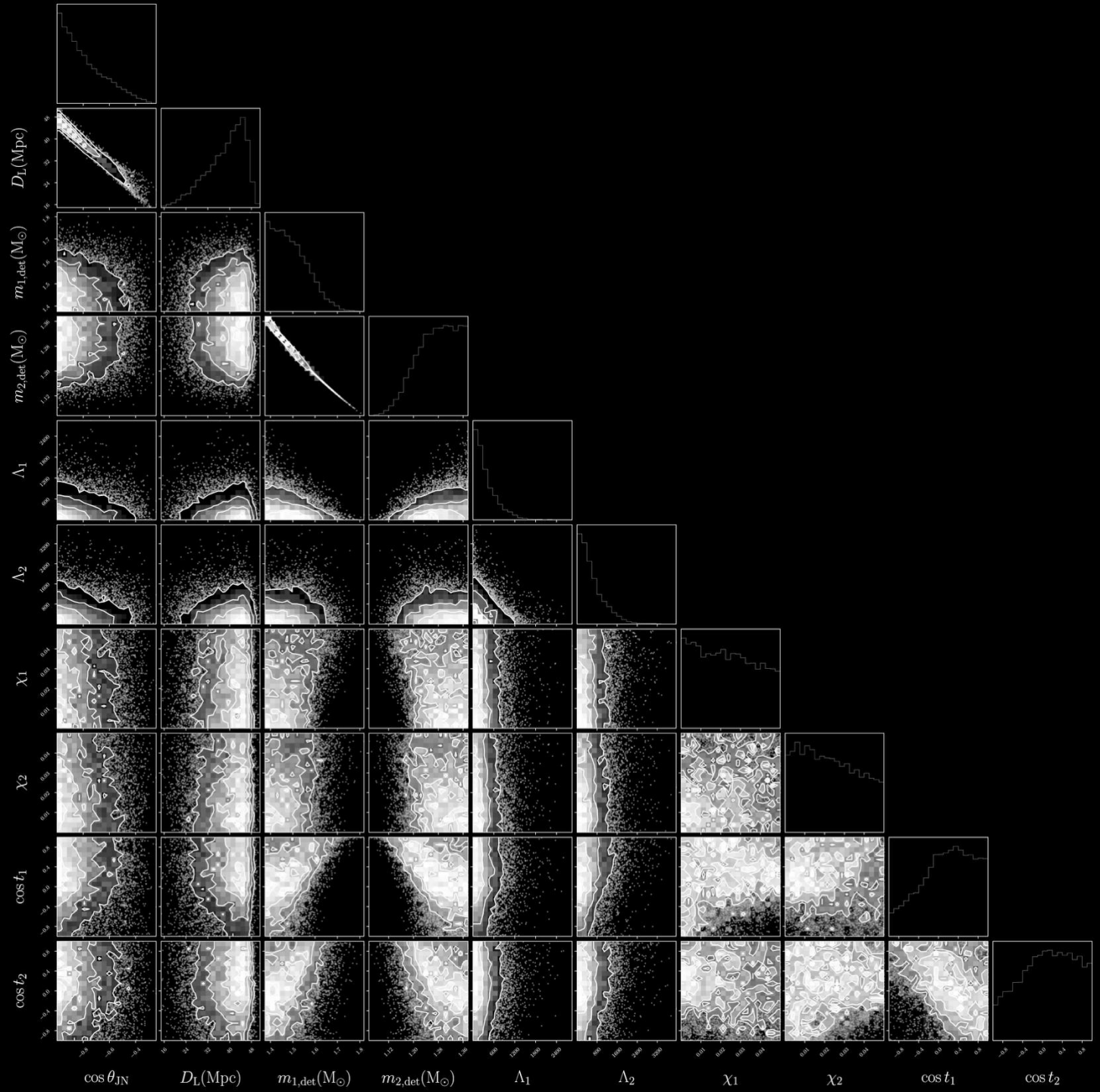


Extracting Astrophysics from a GW Observation



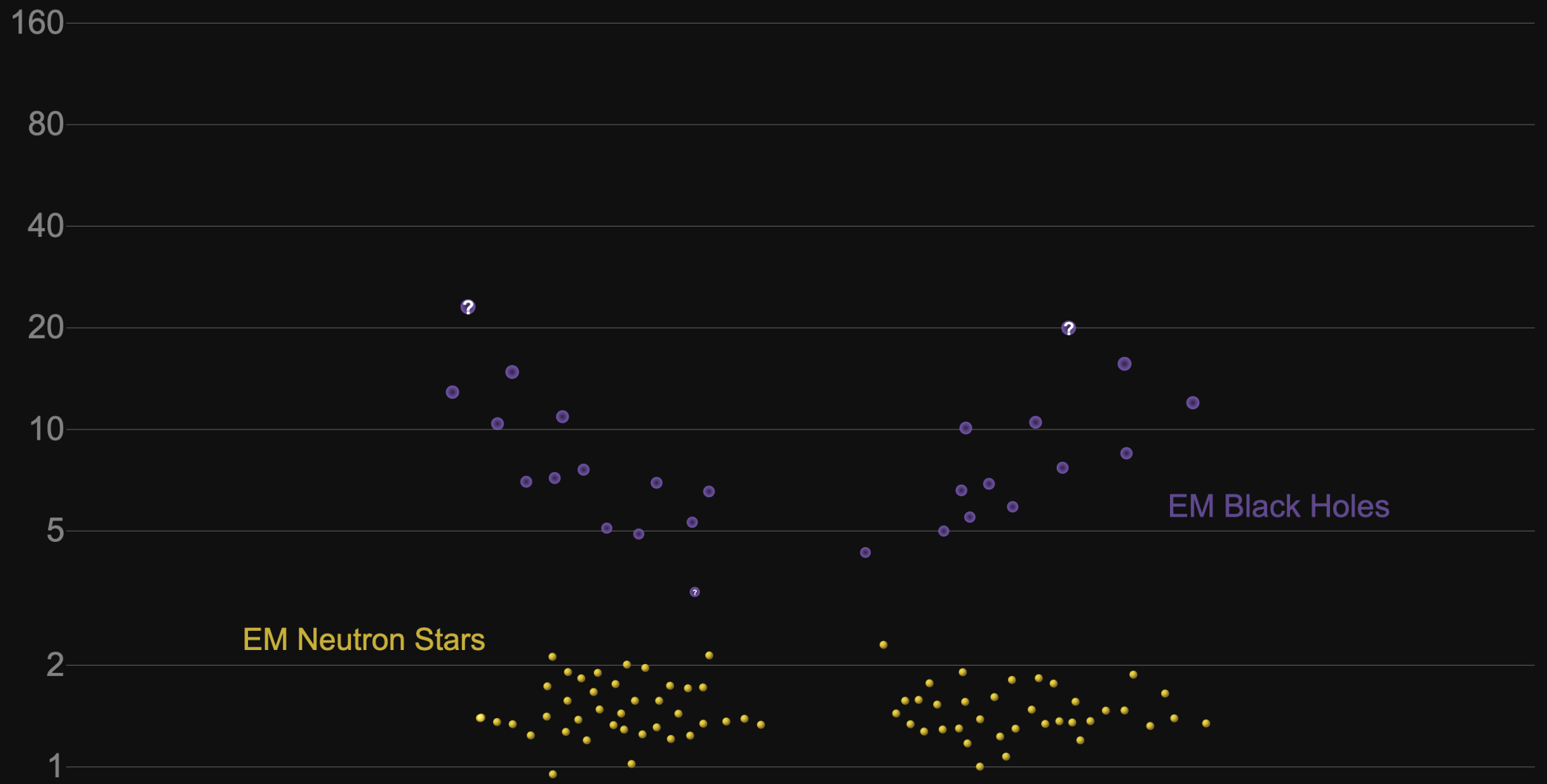
Extracting Astrophysics from a GW Observation




$\cos\theta_{\rm JN}$
$D_{\rm L}(\rm Mpc)$
$m_{1,\rm det}(\rm M_\odot)$
$m_{2,\rm det}(\rm M_\odot)$
Λ_1
Λ_2
χ_1
χ_2
$\cos t_1$
$\cos t_2$

Masses in the Stellar Graveyard

in Solar Masses

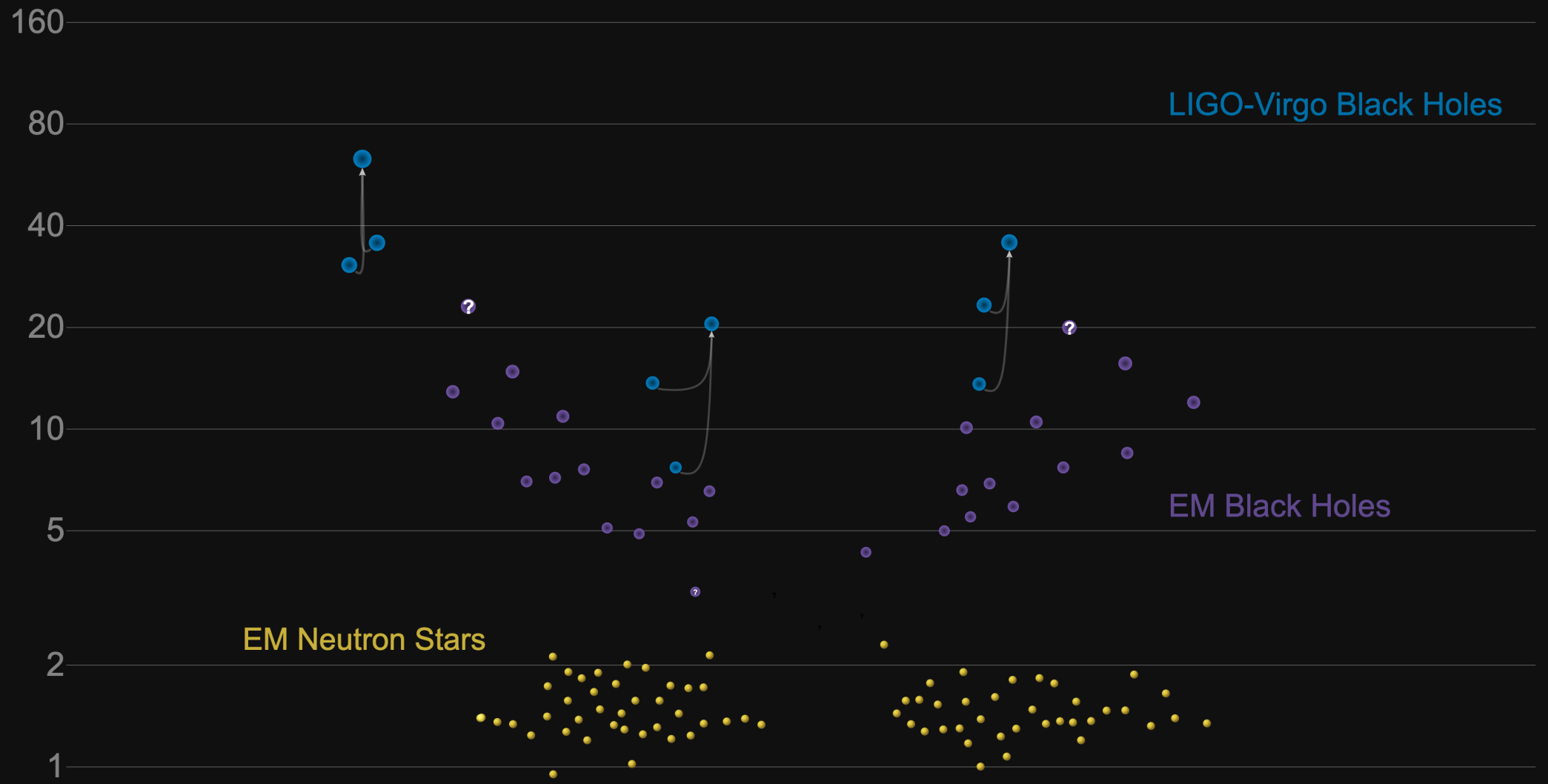


GWTC-2 plot v1.0
LIGO-Virgo | Frank Elavsky, Aaron Geller | Northwestern

01

Masses in the Stellar Graveyard

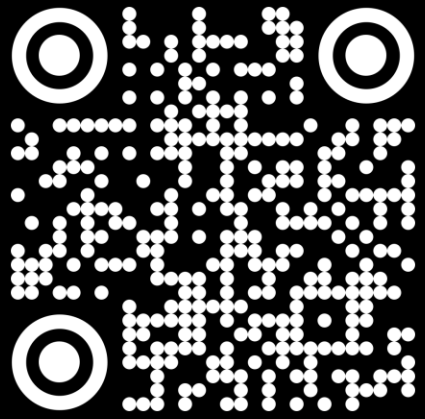
in Solar Masses



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

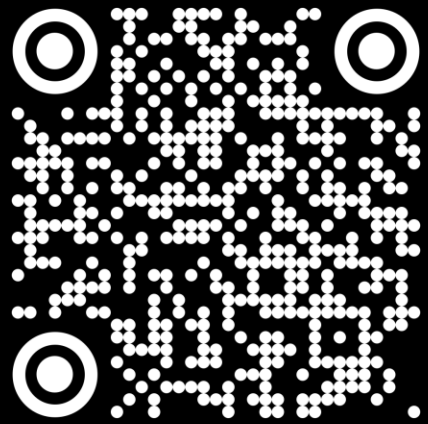
GWTC-1

Paper



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

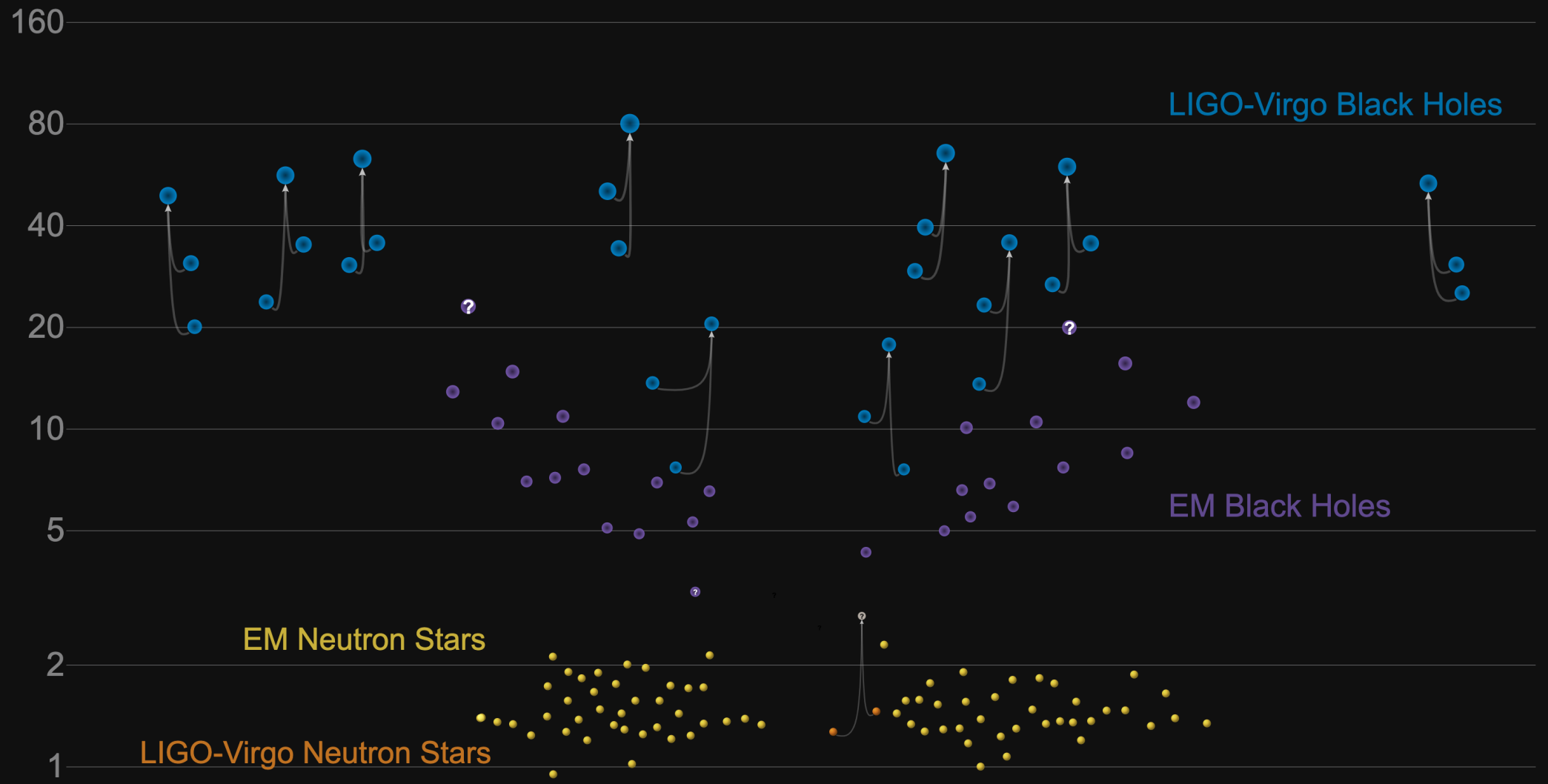
Event Portal



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

Masses in the Stellar Graveyard

in Solar Masses



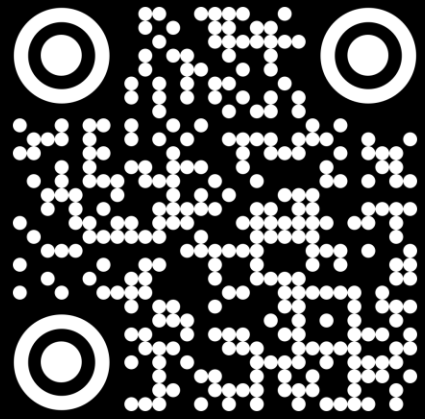
GWTC-2 plot v1.0
LIGO-Virgo | Frank Elavsky, Aaron Geller | Northwestern

GWTC-2

Paper

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

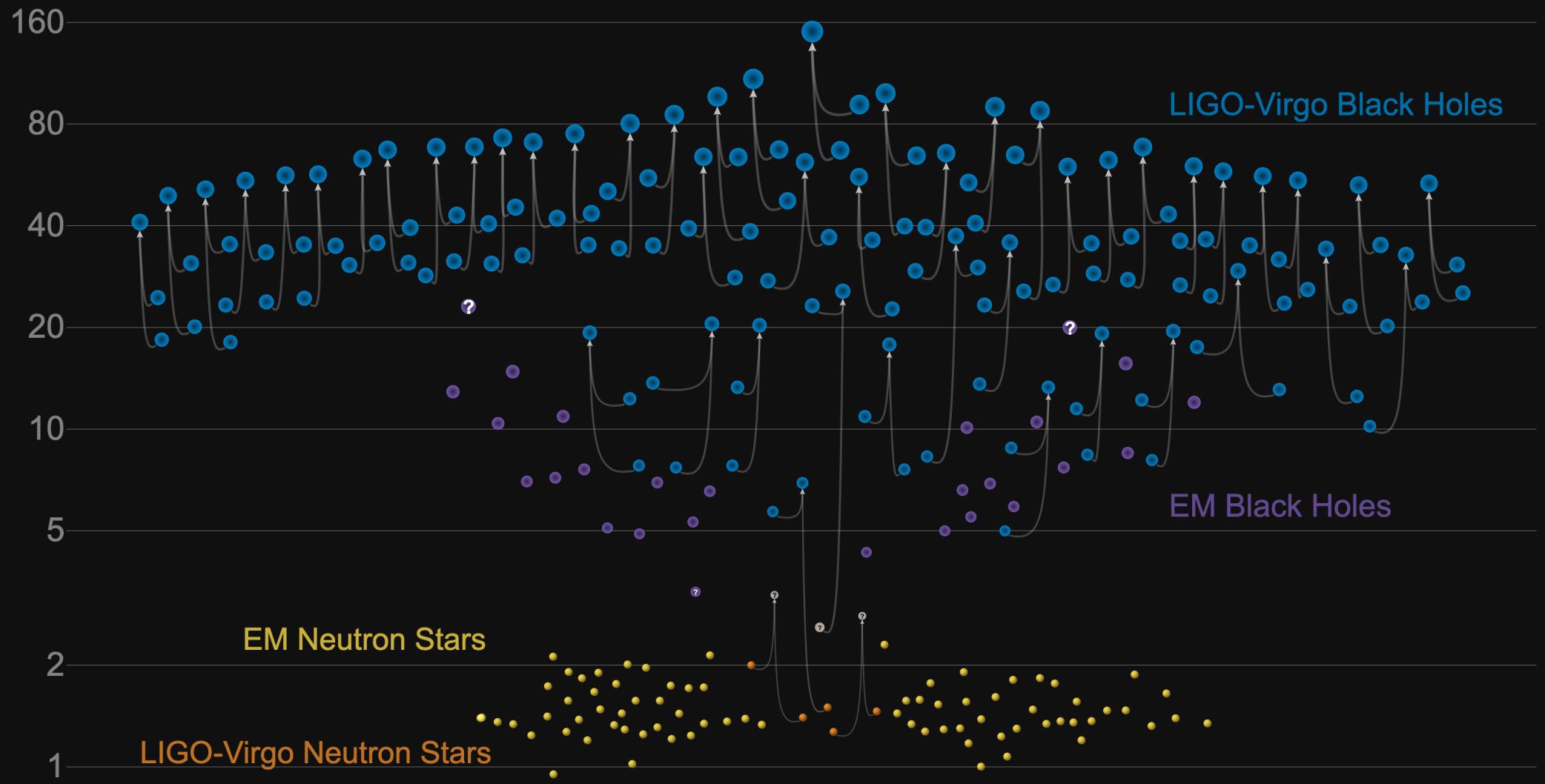
Event Portal



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

Masses in the Stellar Graveyard

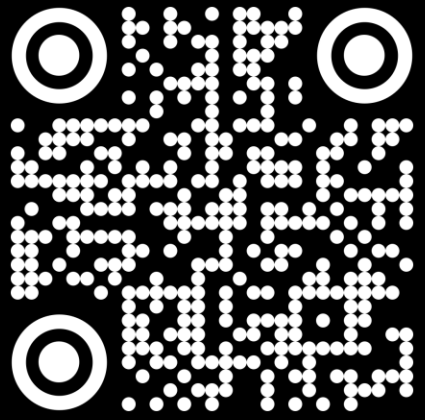
in Solar Masses



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

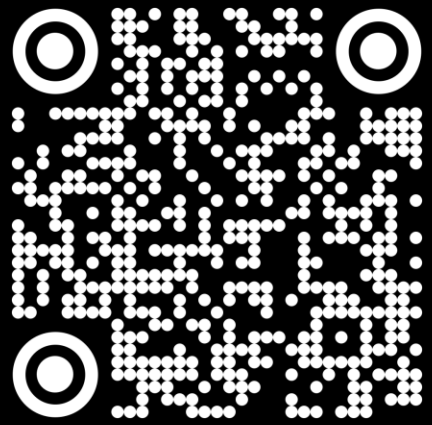
GWTC-3

Paper



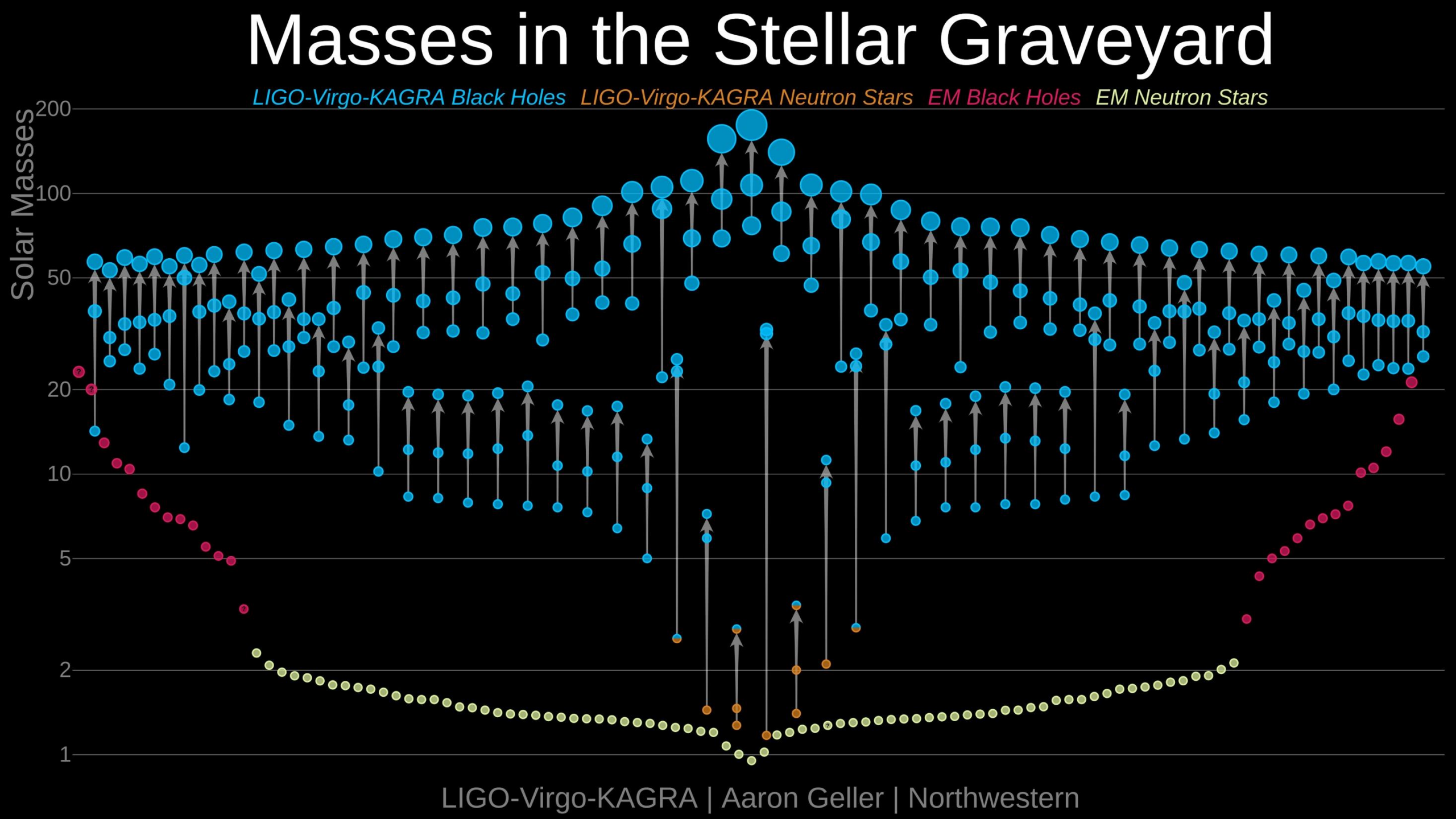
https://dcc.ligo.org/P2000318/public

Event Portal

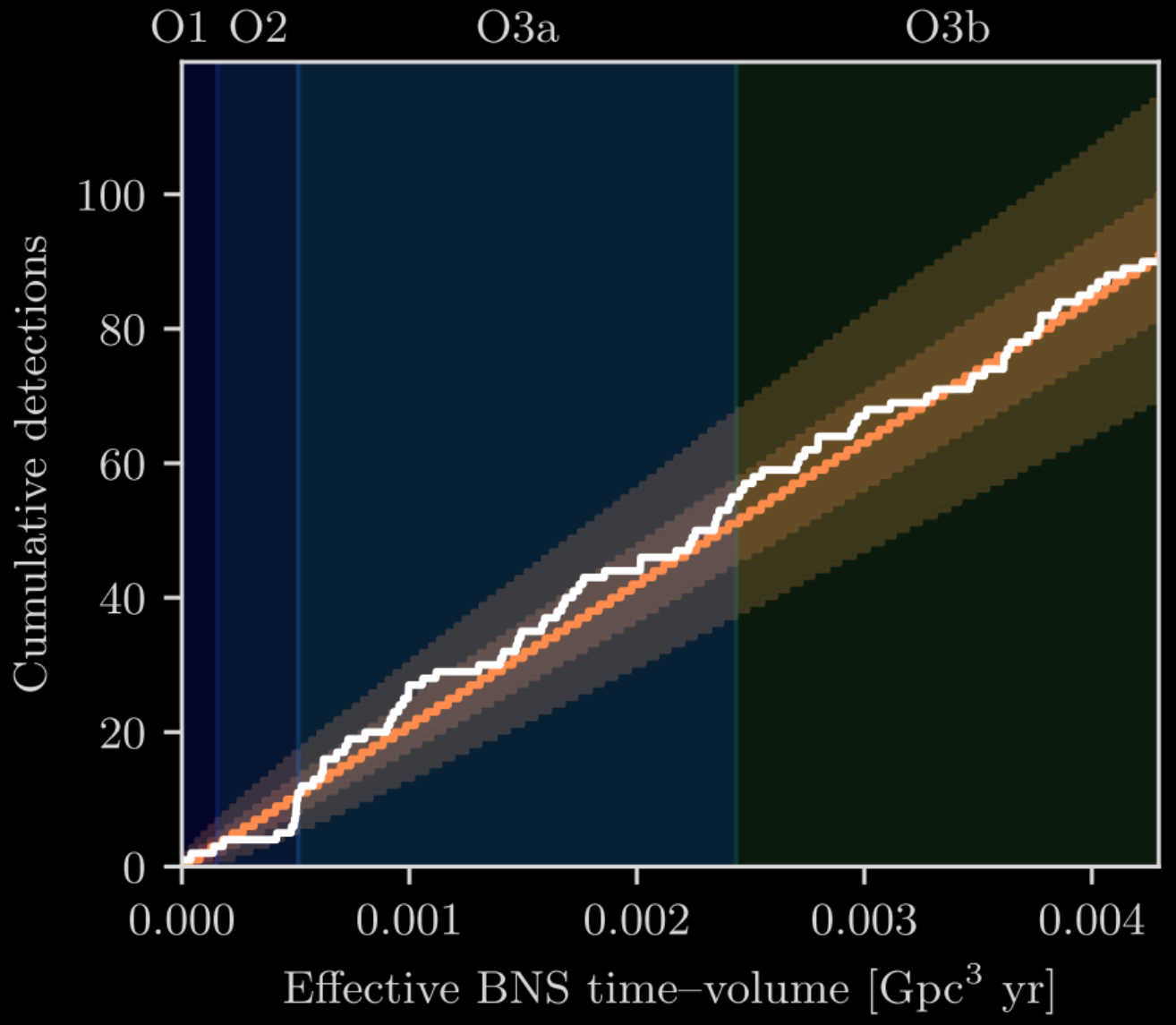


https://gwosc.org/eventapi/html/GWTC-3-confident

Masses in the Stellar Graveyard

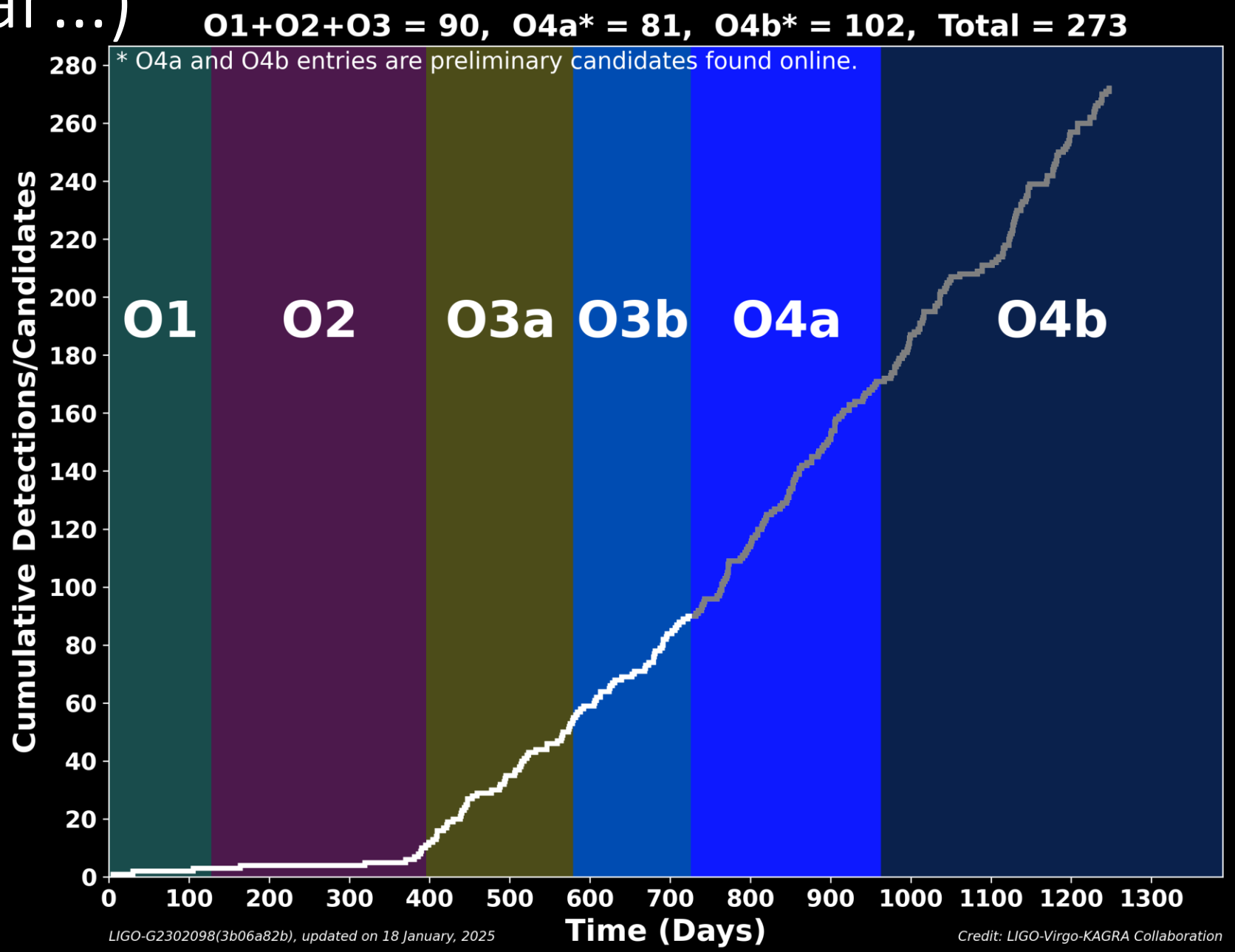


O3 Sensitive Volume

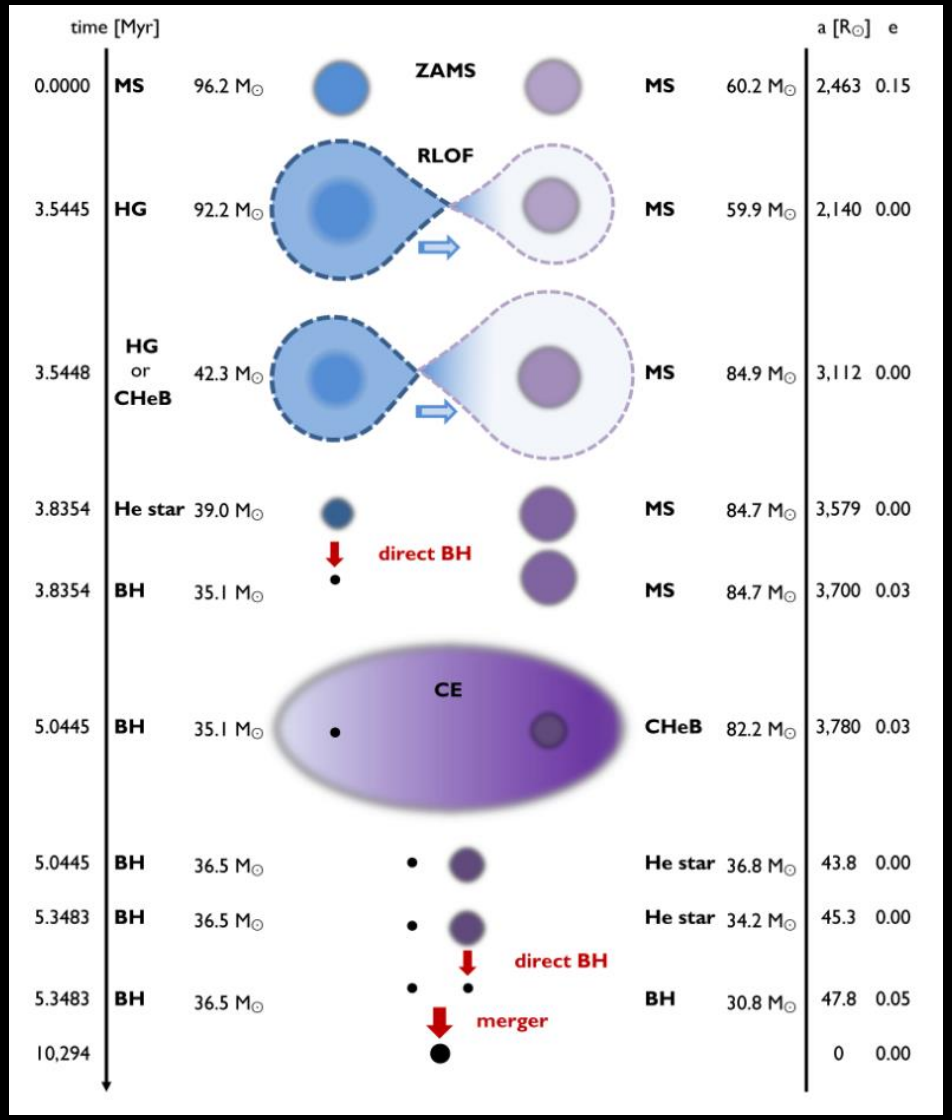


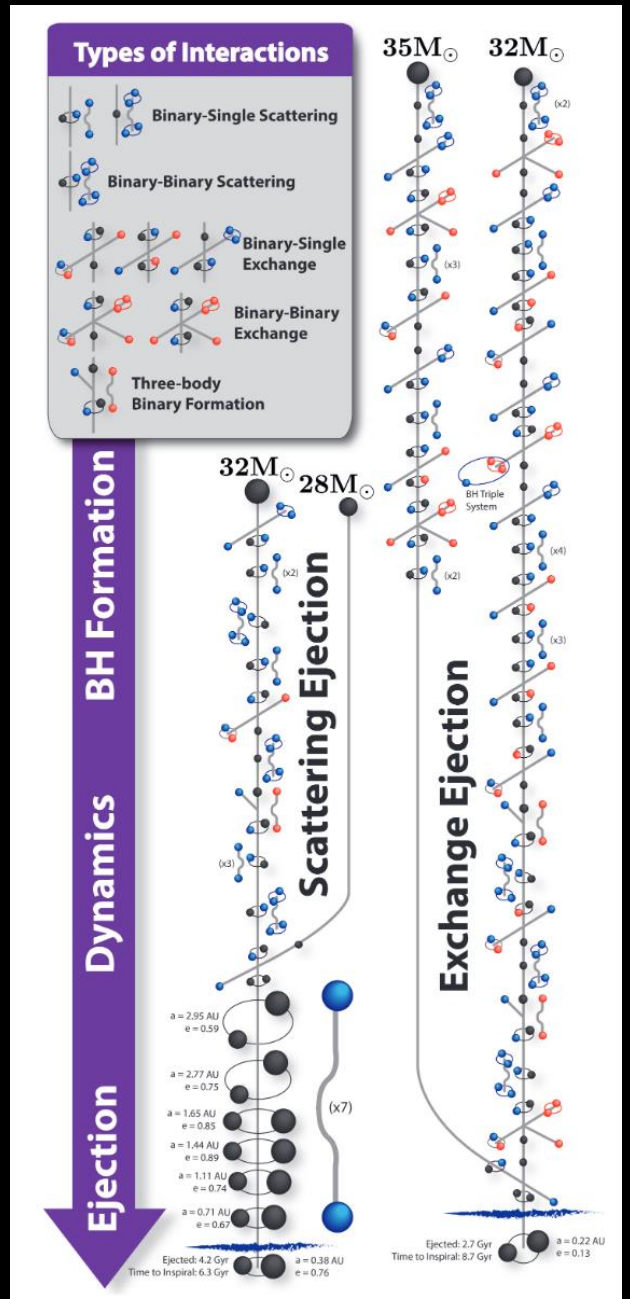
Abbott *et al* 2022 **arXiv:2111.03606 (GWTC-3)**

O4 (so far…)

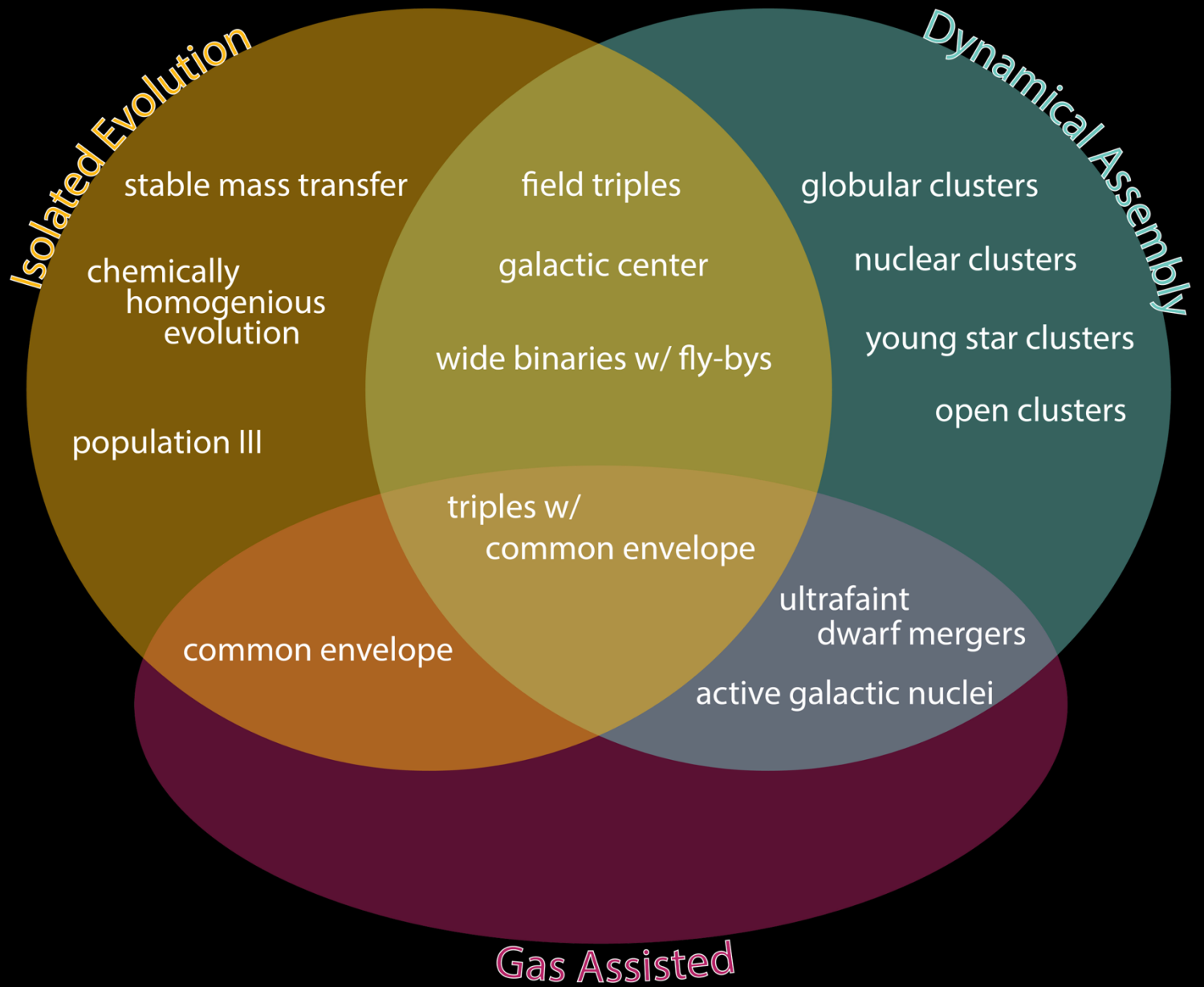

O1+O2+O3 = 90, O4a* = 81, O4b* = 102, Total = 273
* O4a and O4b entries are preliminary candidates found online.
O1
O2
O3a
O3b
O4a
O4b
Cumulative Detections/Candidates
Time (Days)
LIGO-G2302098(3b06a82b), updated on 18 January, 2025
Credit: LIGO-Virgo-KAGRA Collaboration

What can we learn?





What can we learn?



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