



Results of transient GW searches with Advanced LIGO

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INTRODUCTION



- Binary black holes
- Binary neutron stars
- Neutron star - black hole binaries
- Intermediate mass black hole binaries



BINARY BLACK HOLES



O 1 SCIENCE RUN

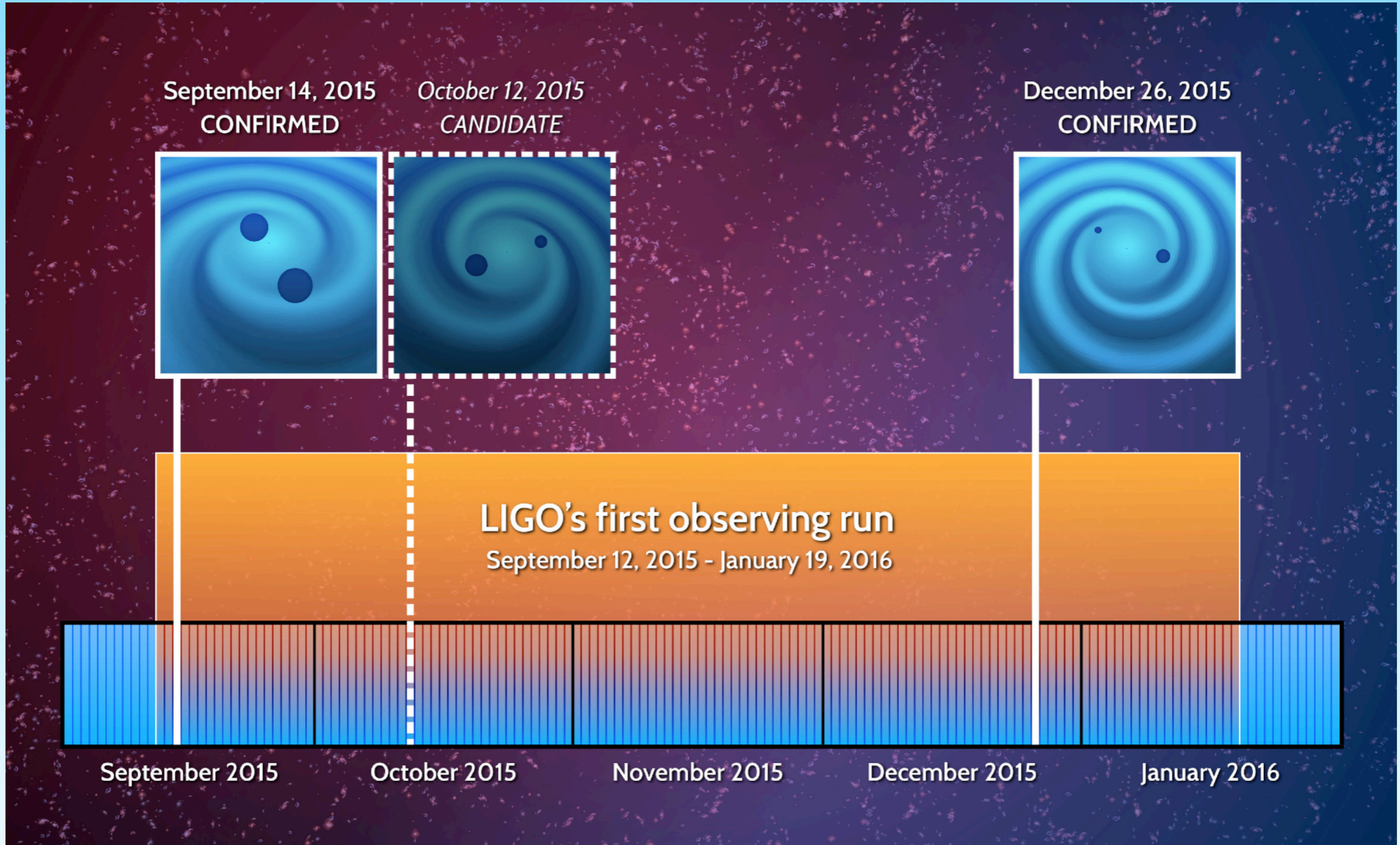
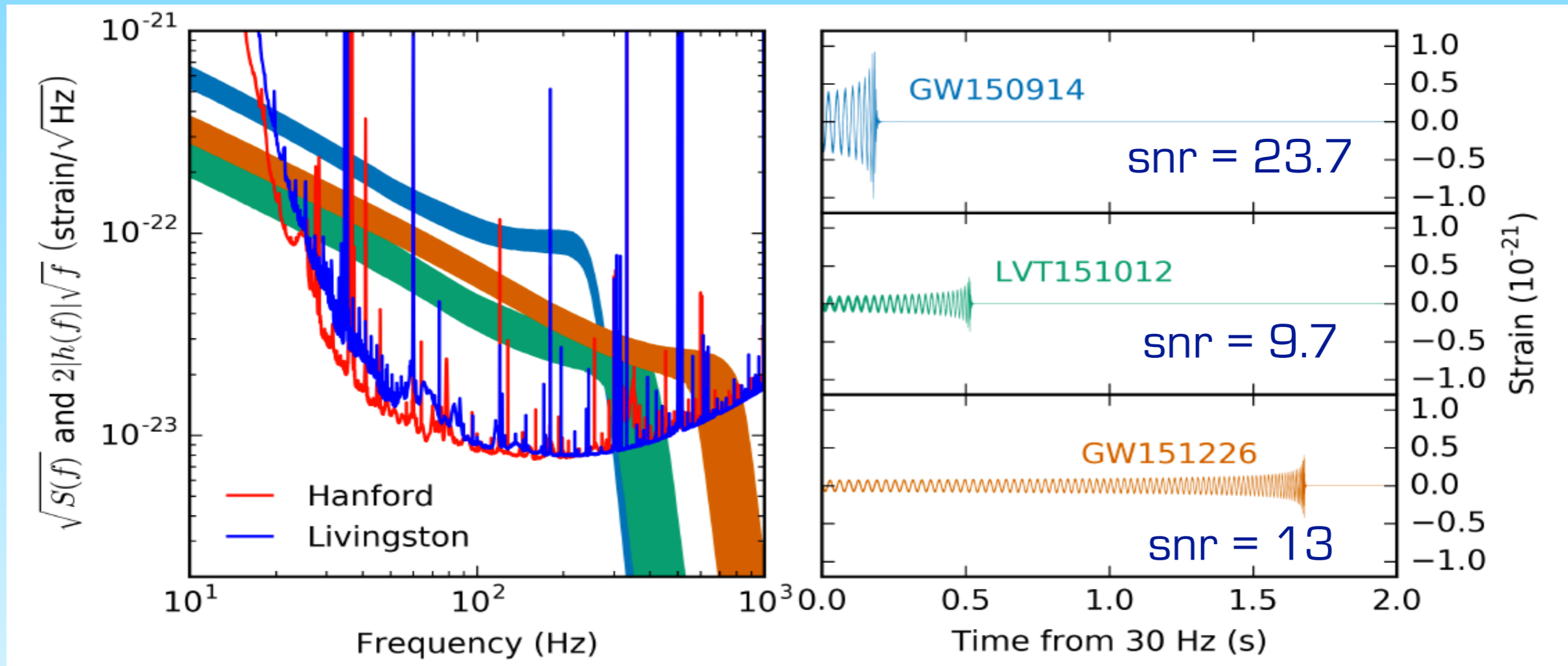


Image : LIGO/Virgo



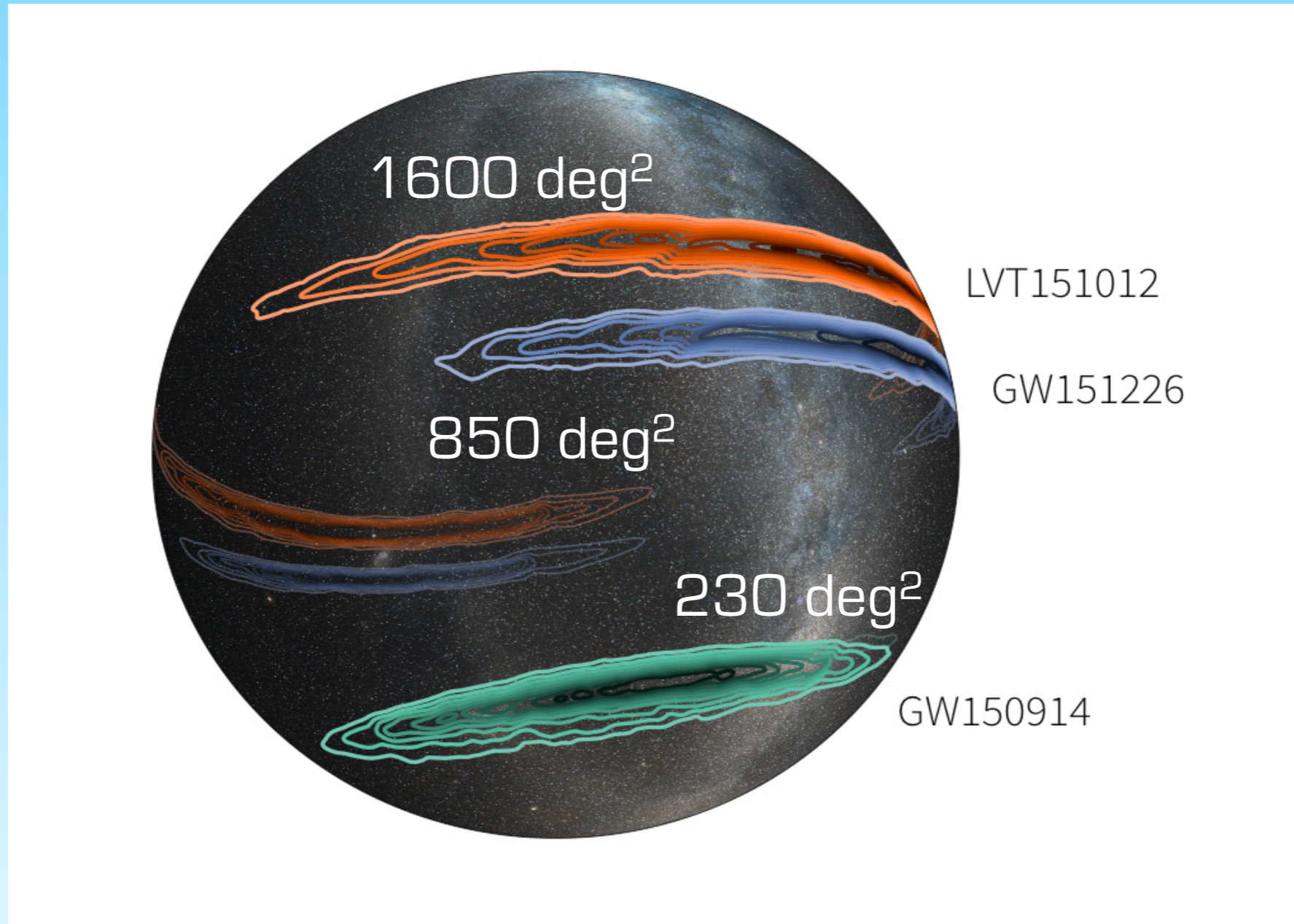
O1 SCIENCE RUN



- Detections display a range of system types
 - surprisingly large masses for GW150914
 - GW151226 & LVT151012 more “x-ray binary” like
- low mass : dominated by inspiral - constrains chirp mass
- high mass : dominated by merger-ringdown - constrains total mass



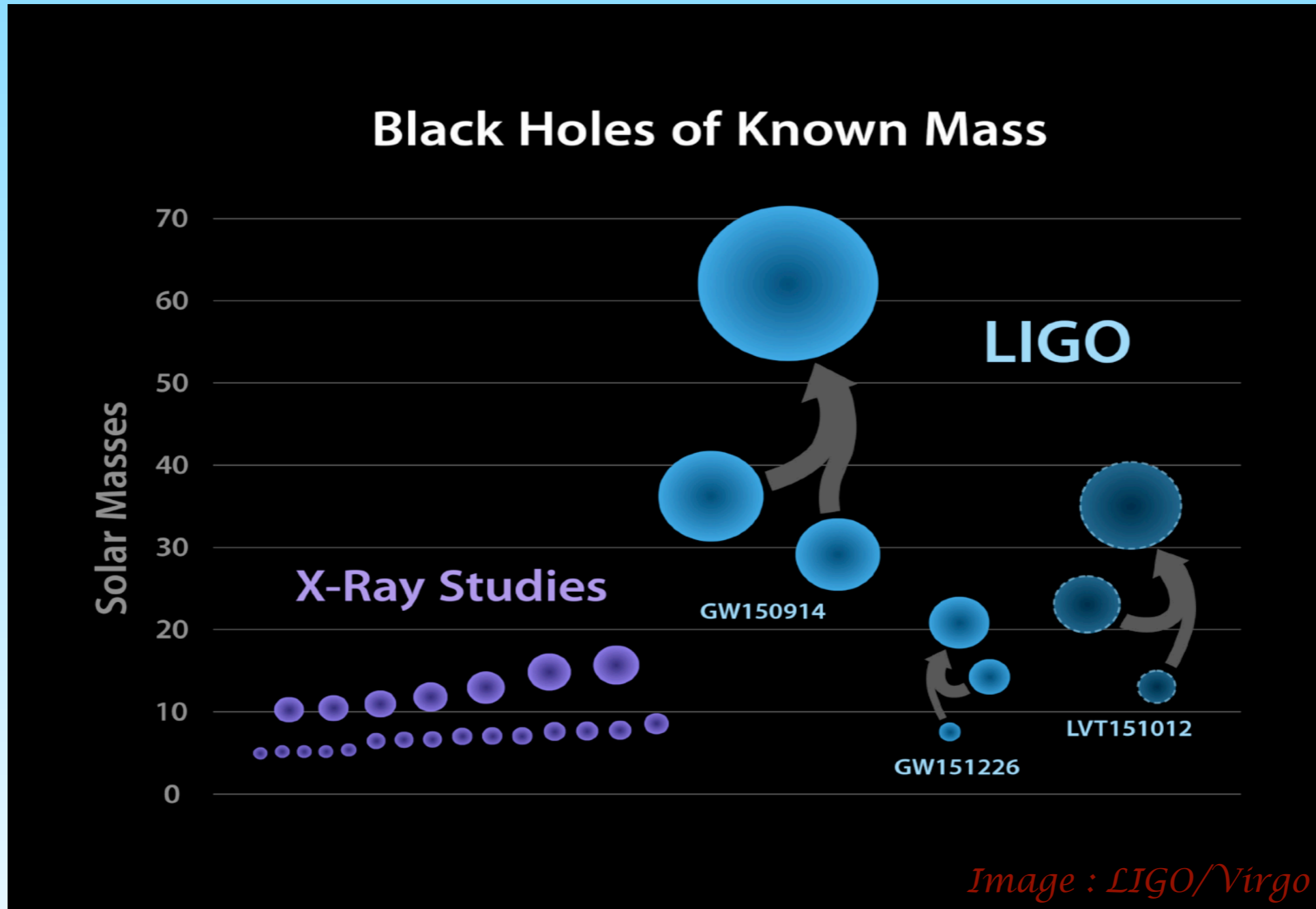
SKY LOCATION



- 2 detector network gives large sky position errors
- Errors should improve with addition of Advanced Virgo



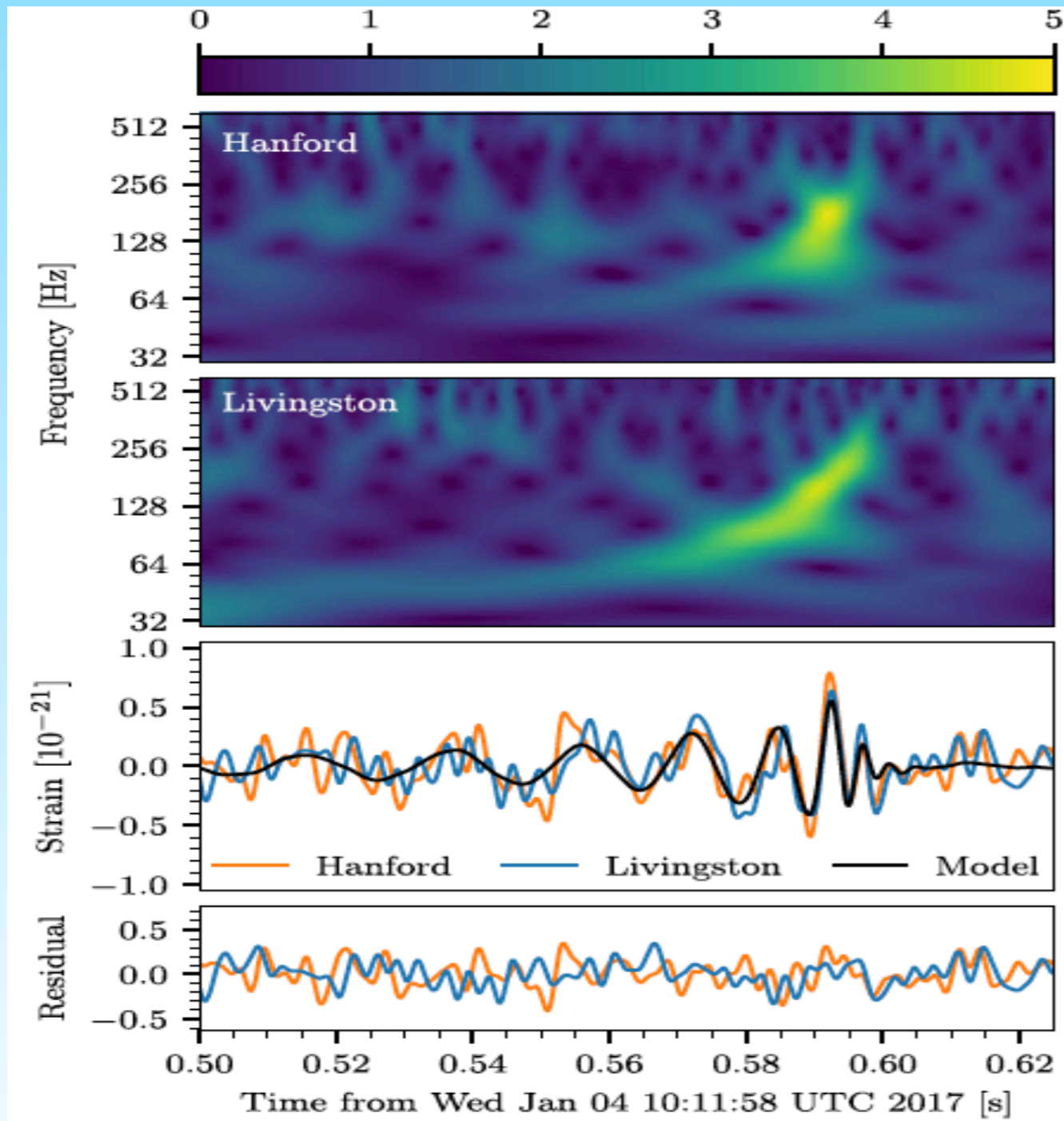
01 BBH DETECTIONS



🌐 01 provided parameters for 9 BHs



02 - GW170104



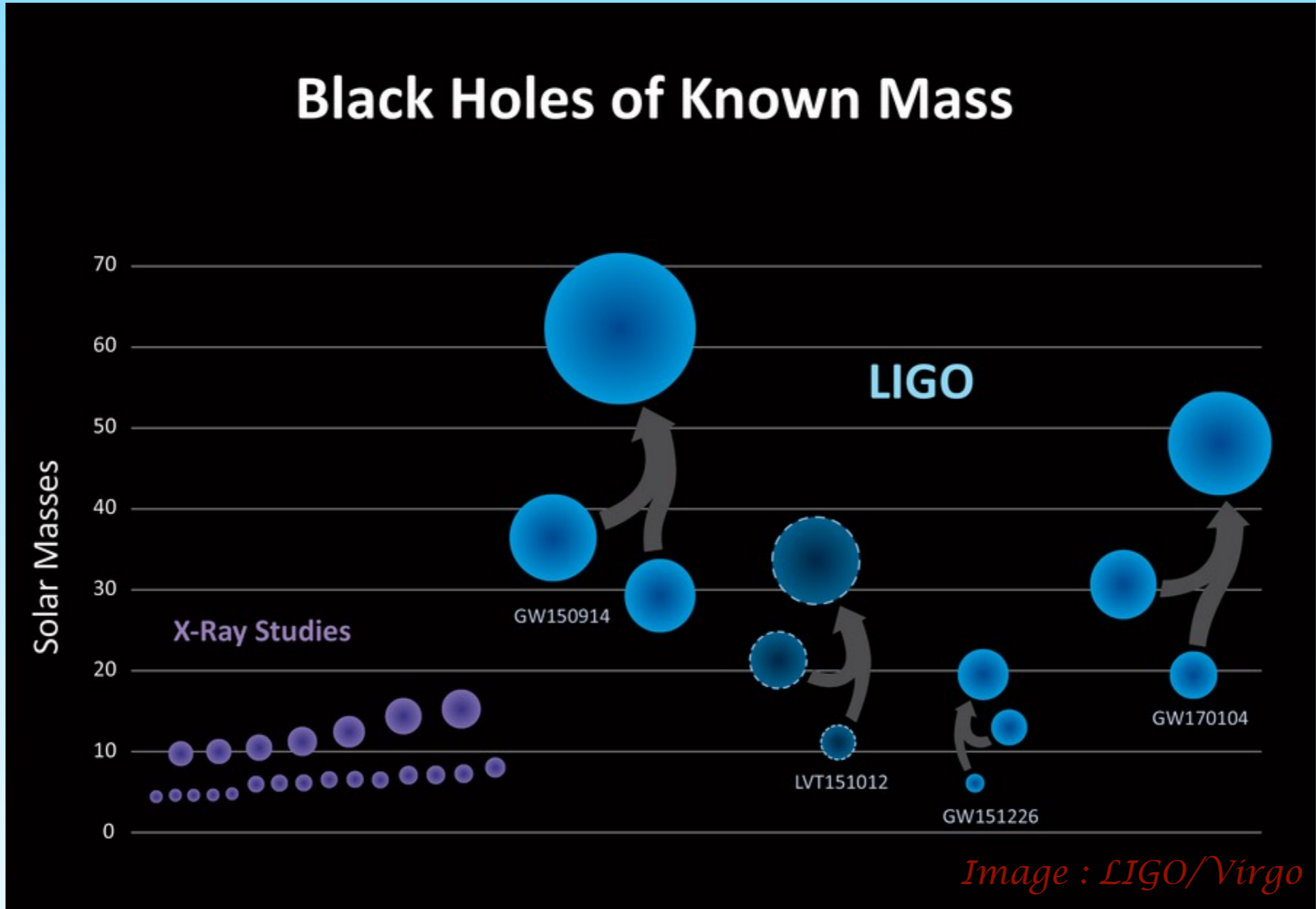
New BBH detection on the 17th of January 2017

1st detection of the second science run

Masses again quite large

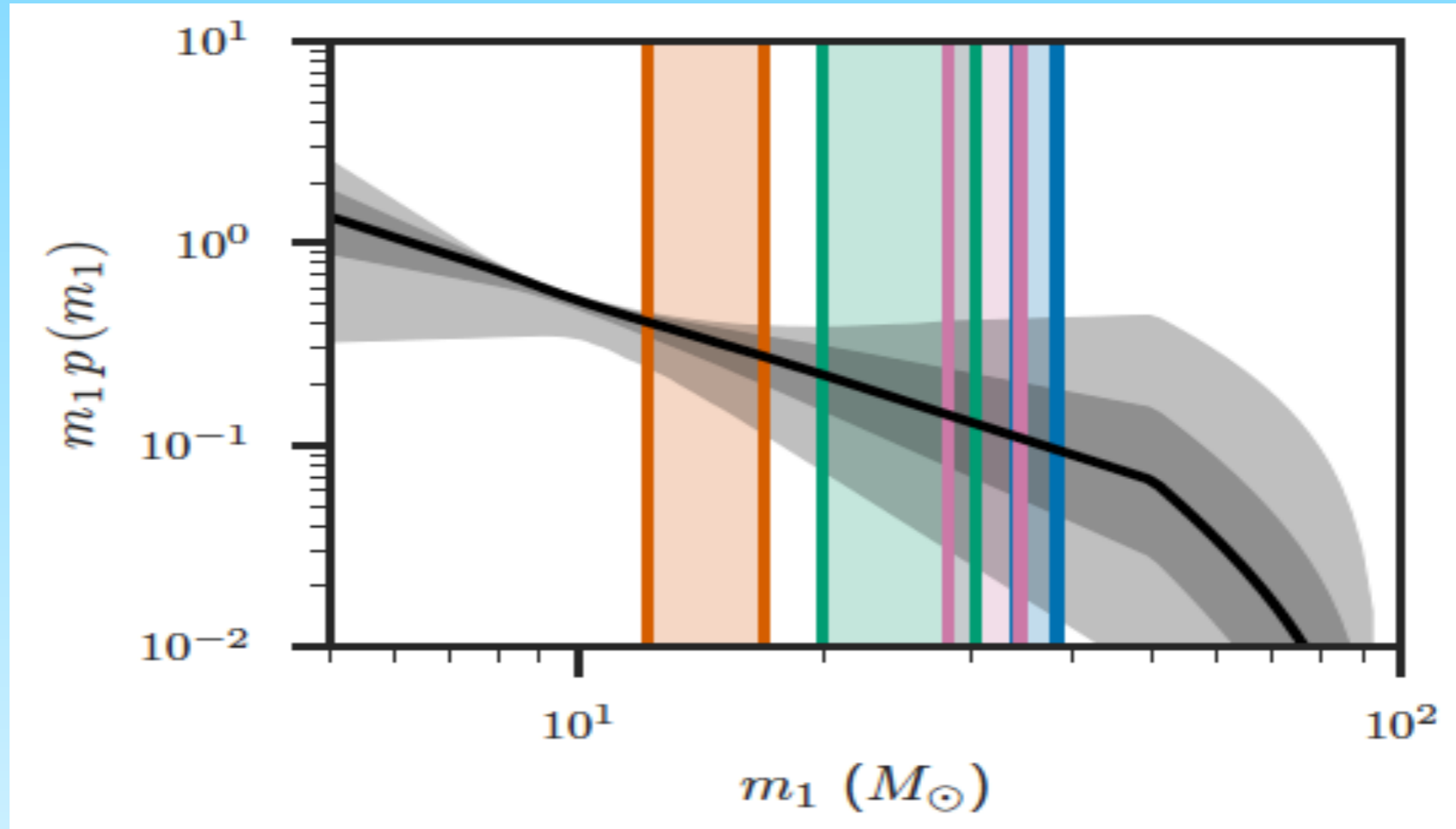


GW170104





BBH RATES



- Flat distribution in the log of the individual masses
- Power law distribution in the primary mass, uniform in the secondary
- Combined rate estimate from O1 : 9-240 $\text{Gpc}^{-3} \text{yr}^{-1}$ (90% CI)
- Combined rate O1+GW170104 : 12-213 $\text{Gpc}^{-3} \text{yr}^{-1}$ (90% CI)

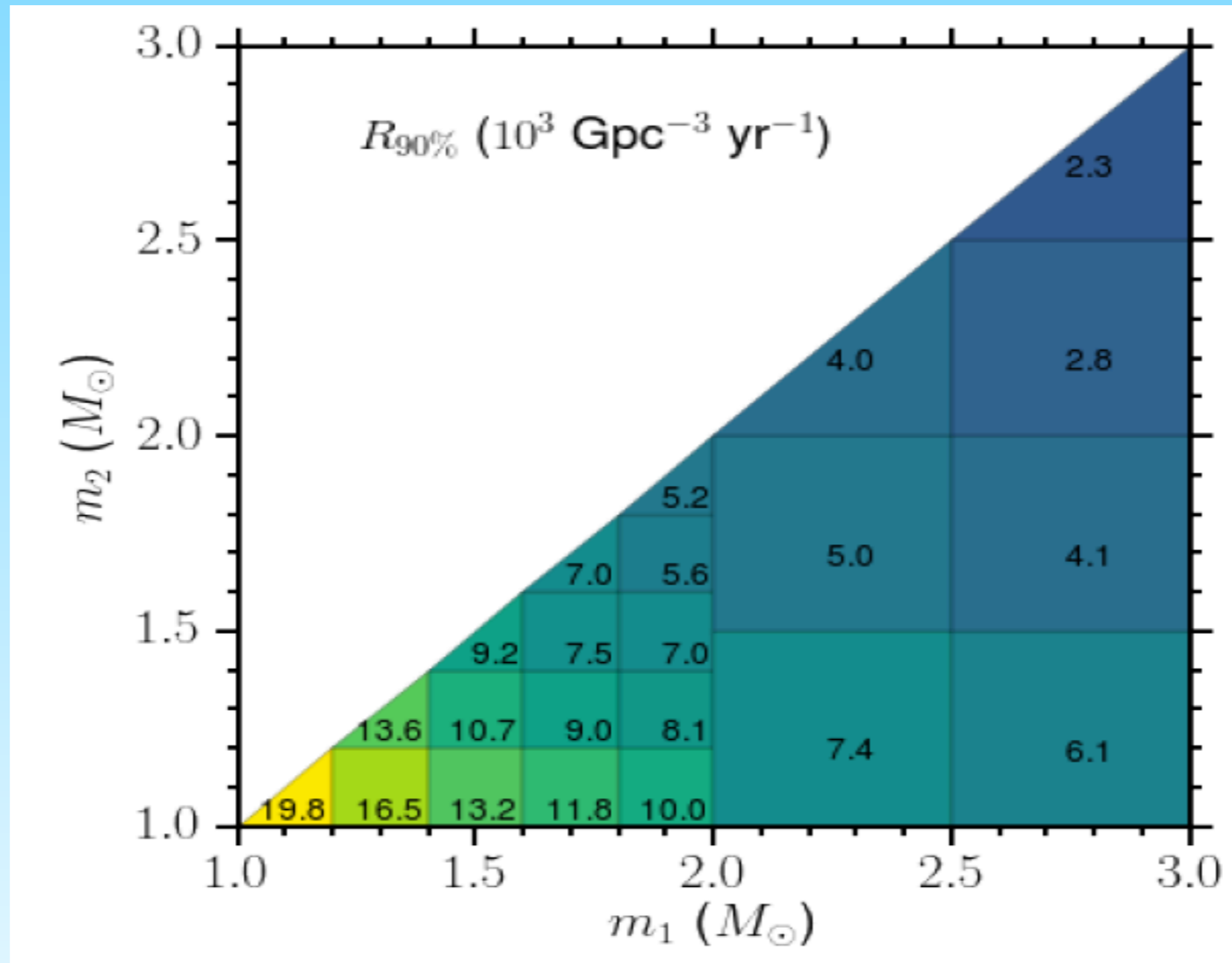
Abbott et al, Phys.Rev. X6 (2016) no.4, 041015
Abbott et al, Phys.Rev.Lett. 118 (2017) 221101



BINARY NEUTRON STARS



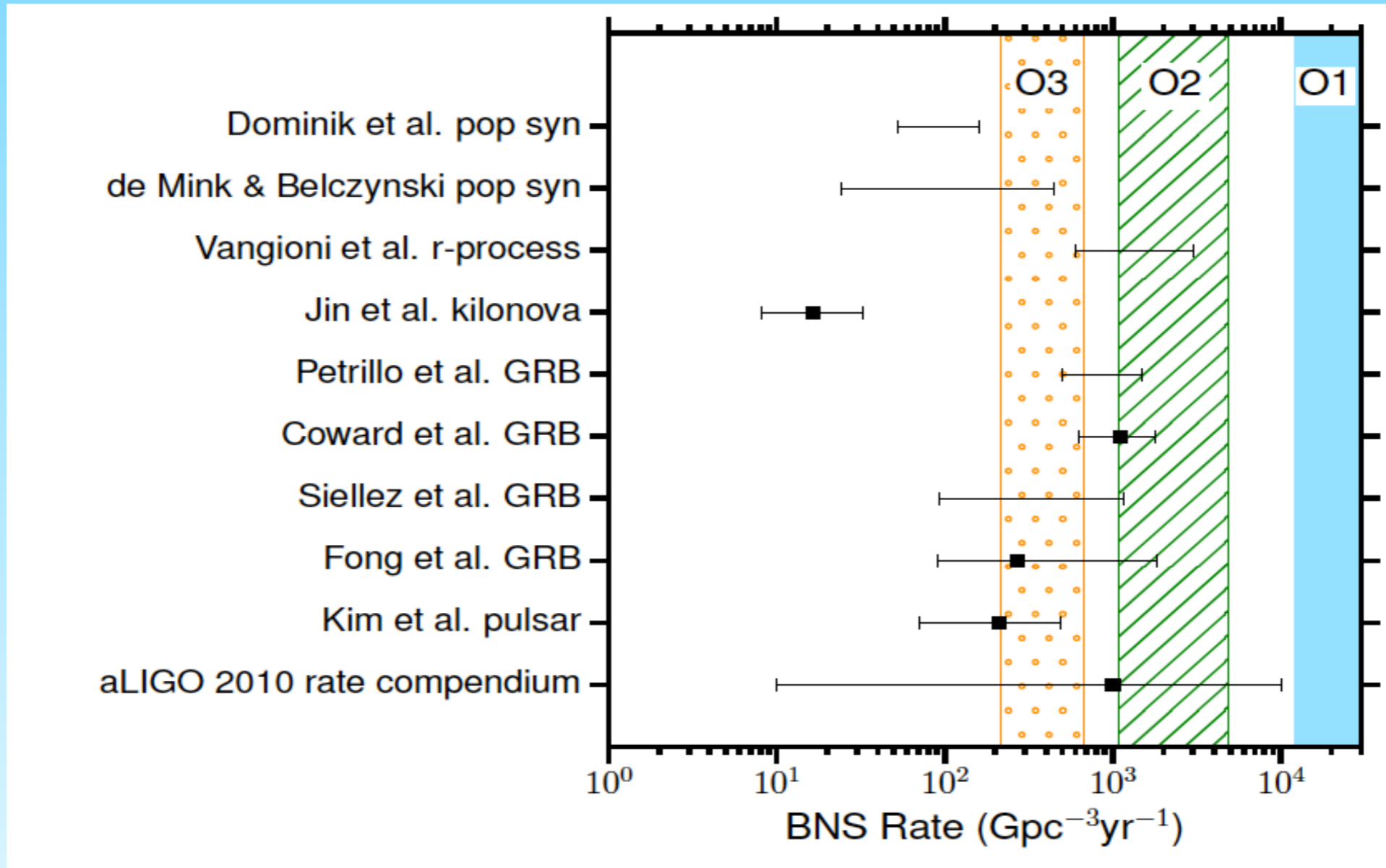
BNS RATES



- No BNS seen in O1
- 90% CI rate estimate : $12,000 \text{ Gpc}^{-3} \text{ yr}^{-1}$
- Order of magnitude improvement over initial LIGO rates



BNS RATES



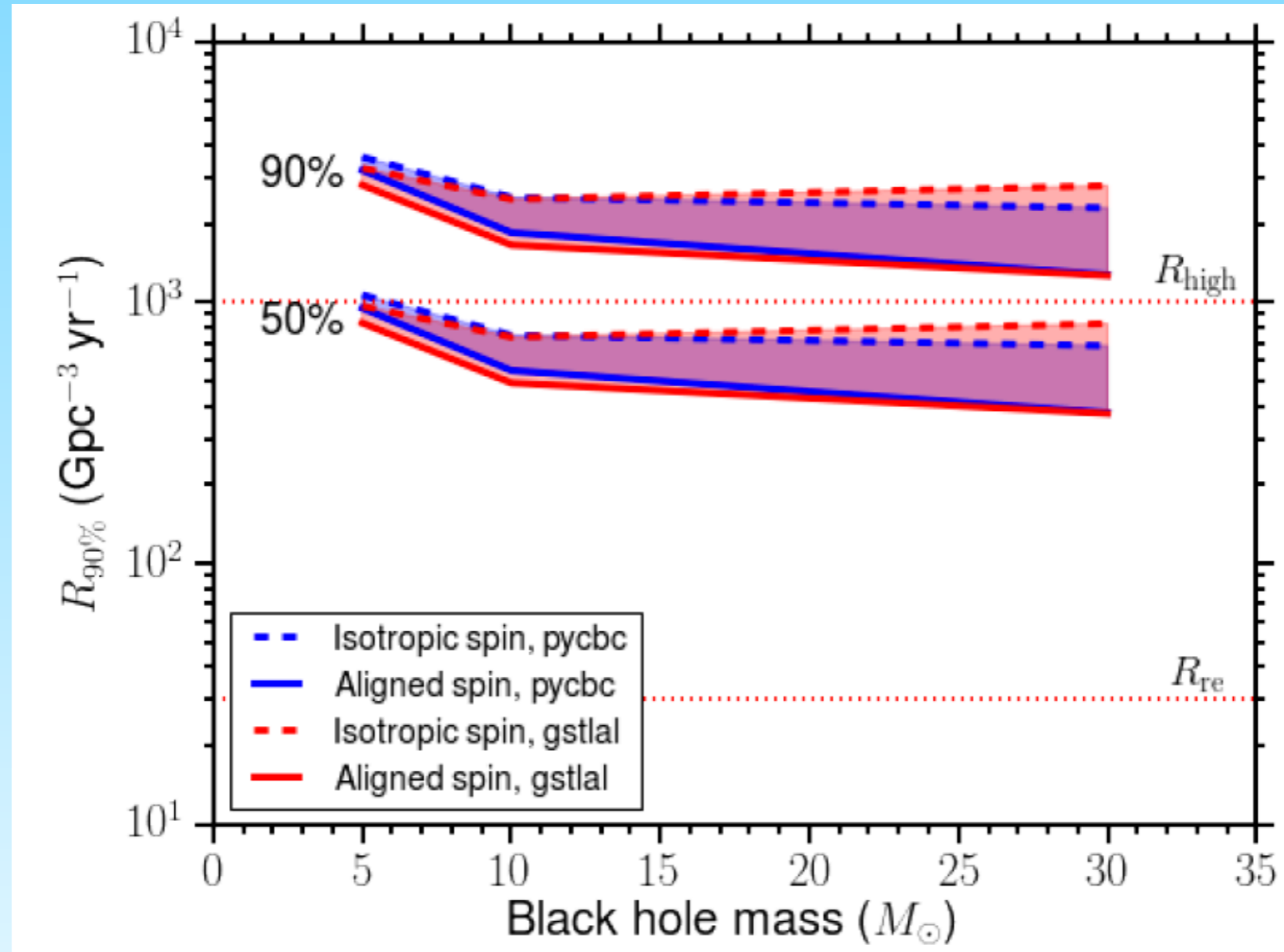
Not enough information in O1 to rule out BNS formation models



NEUTRON STAR-BLACK HOLE BINARIES



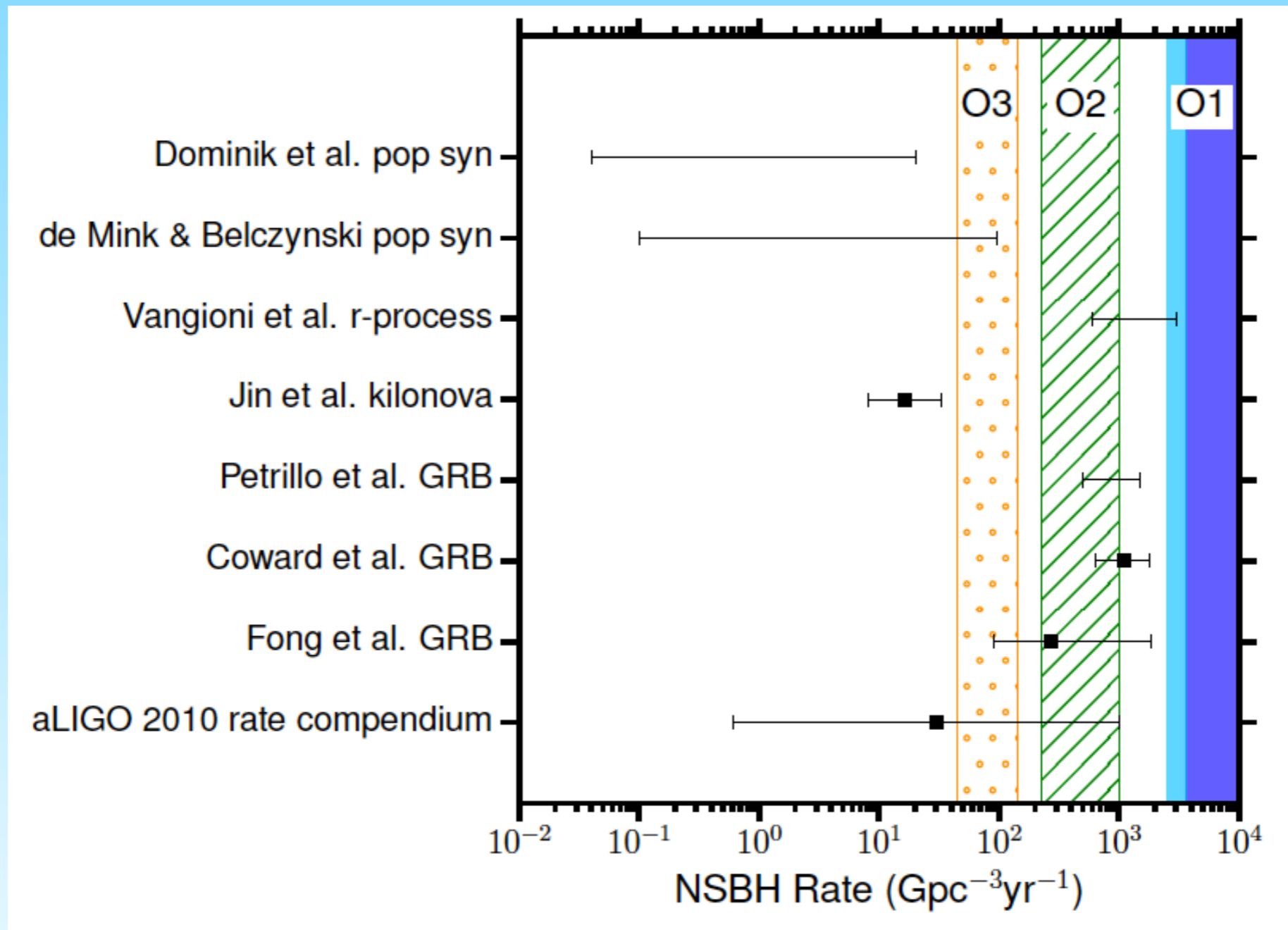
BHNS RATES



- No BHNS seen in O1
- 90% CI rate estimate : $<3600 \text{ Gpc}^{-3} \text{yr}^{-1}$
- Order of magnitude improvement over initial LIGO rates



BHNS RATES



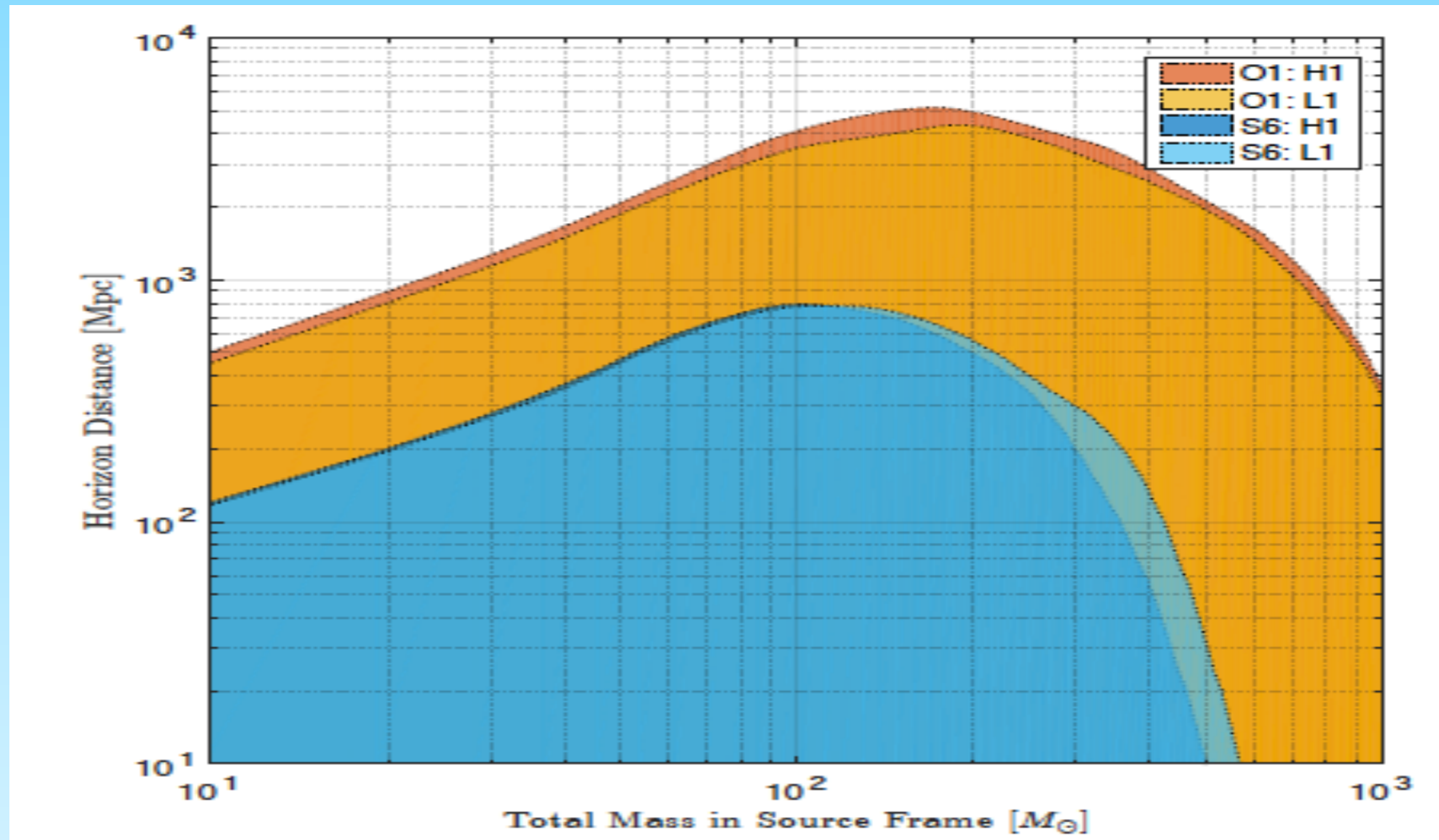
 Only the most optimistic upper limit is ruled out using O1 data



INTERMEDIATE MASS BLACK HOLE BINARIES



IMBHB RATES



- Detection horizon increased from 800 Mpc to 5 Gpc
- No IMBHB ($M > 100 M_{\odot}$) seen in O1
- 90% CI rate estimate : $< 0.93 \text{ Gpc}^{-3} \text{ yr}^{-1} \sim 0.3 \text{ GC}^{-1} \text{ yr}^{-1}$
- 2 orders of magnitude improvement over initial LIGO rates



CONCLUSION

- **The era of GW astronomy is finally here**
- **3+1 direct measurements of BBH mergers**
- **BBHs come in a range of flavours, and merge within the Hubble time**
- **Total mass heavier than anything seen in x-ray binaries**
- **BBH astrophysical event rate is $12-213 \text{ Gpc}^{-3} \text{ yr}^{-1}$**
- **No BNS, NSBH or IMBHBs observed so far**
- **Upper event rate estimates constitute improvements of 1-2 orders of magnitude over previous LVC results**