

Credit: SXS Lensing

Astrophysical results from compact binary coalescences

EPS-HEP 2017 held on 05 Jul 2017 in Venice

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for the LSC and Vigo

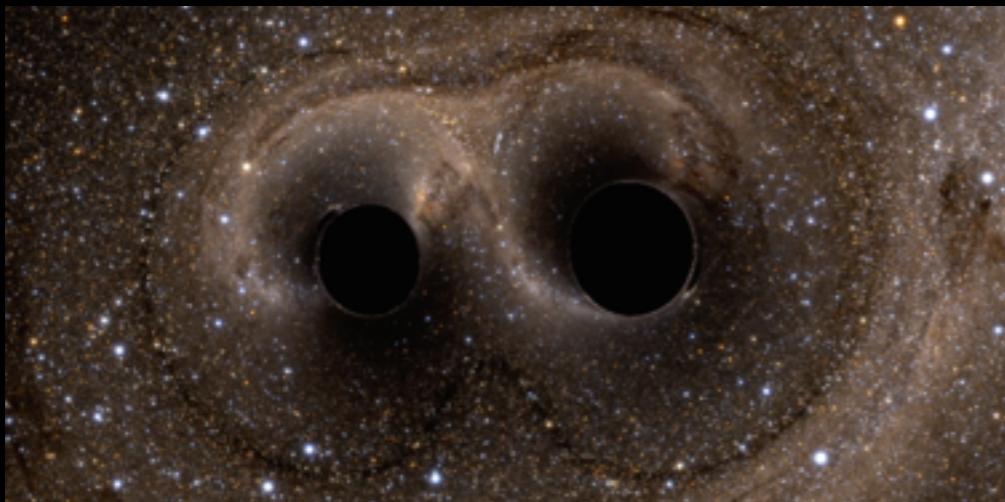


Gravitational-wave sources

Modelled

Unmodelled

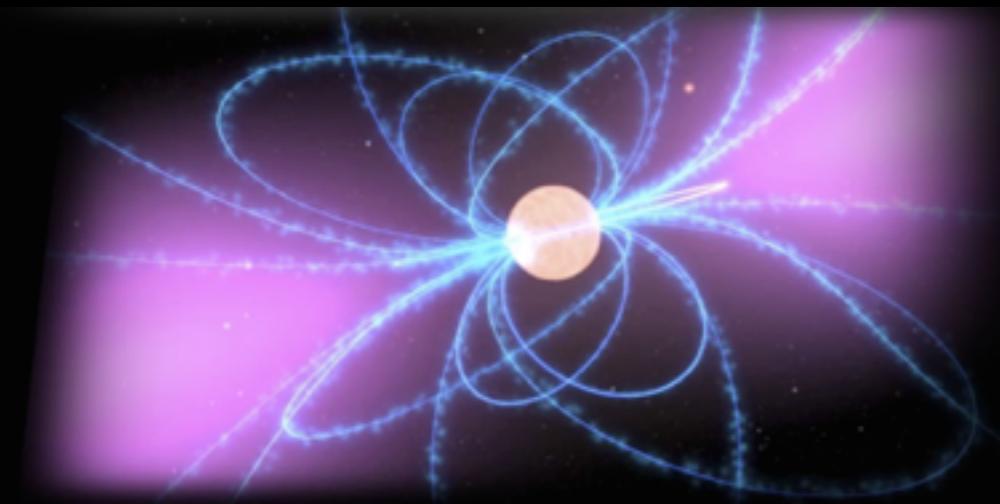
Compact Binary Coalescence



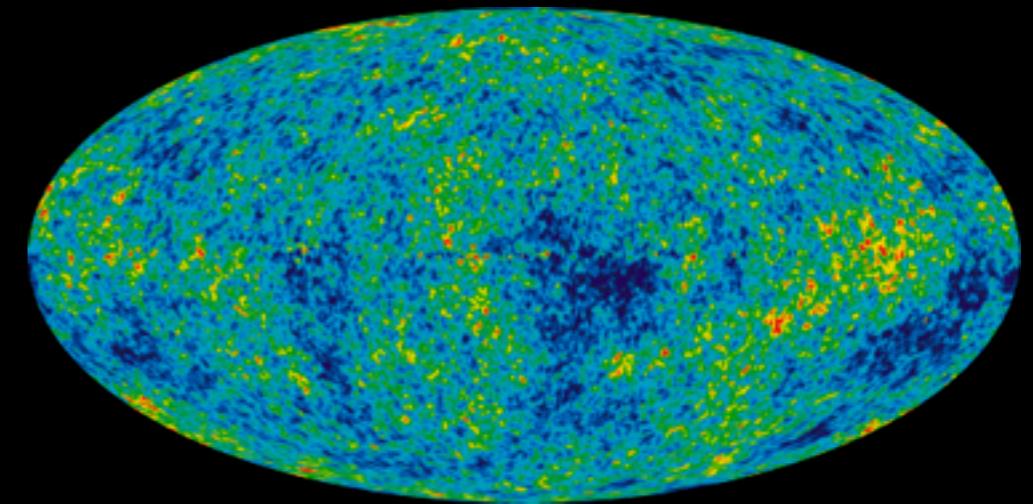
Burst



Continuous waves



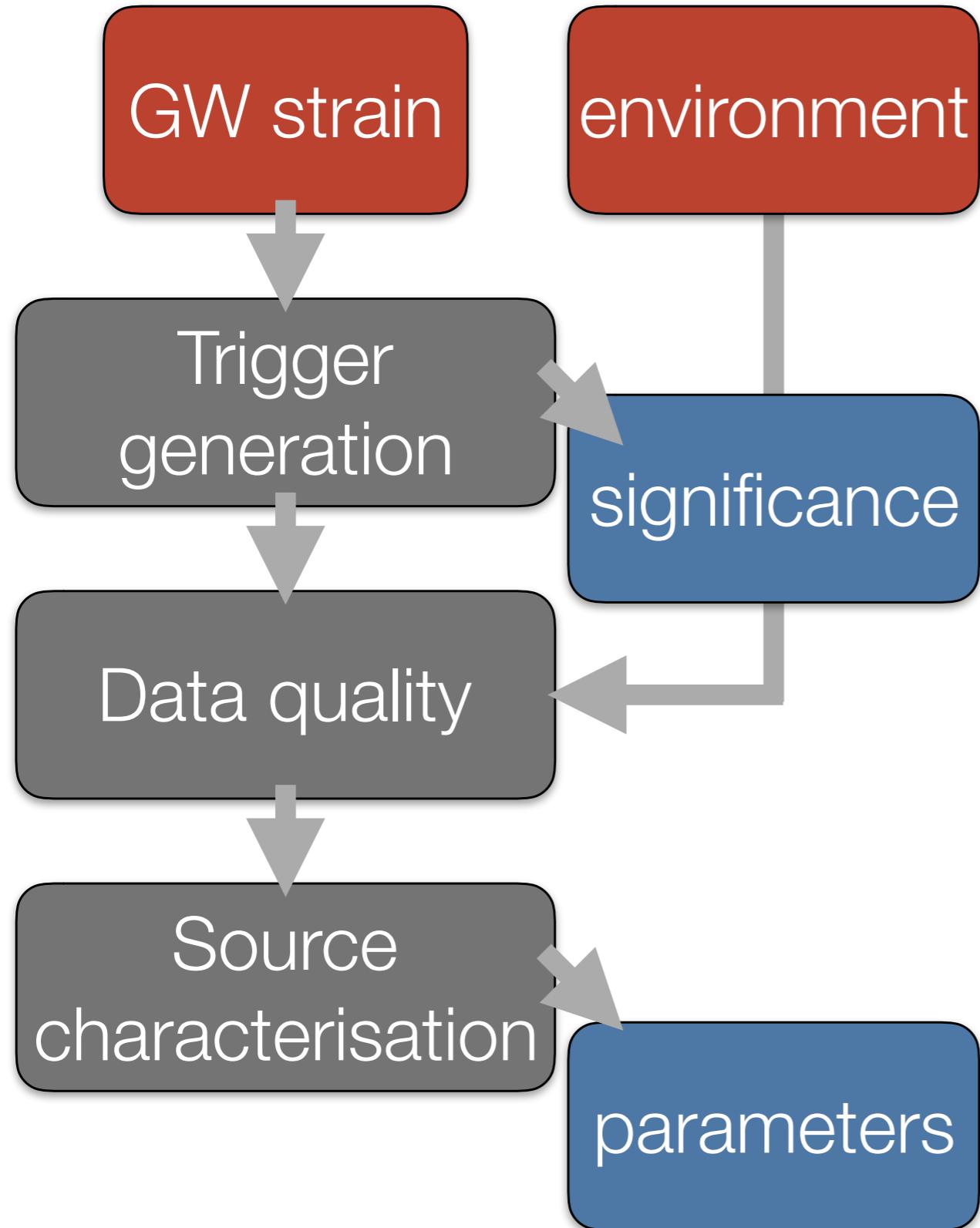
Stochastic



Transient

Continuous

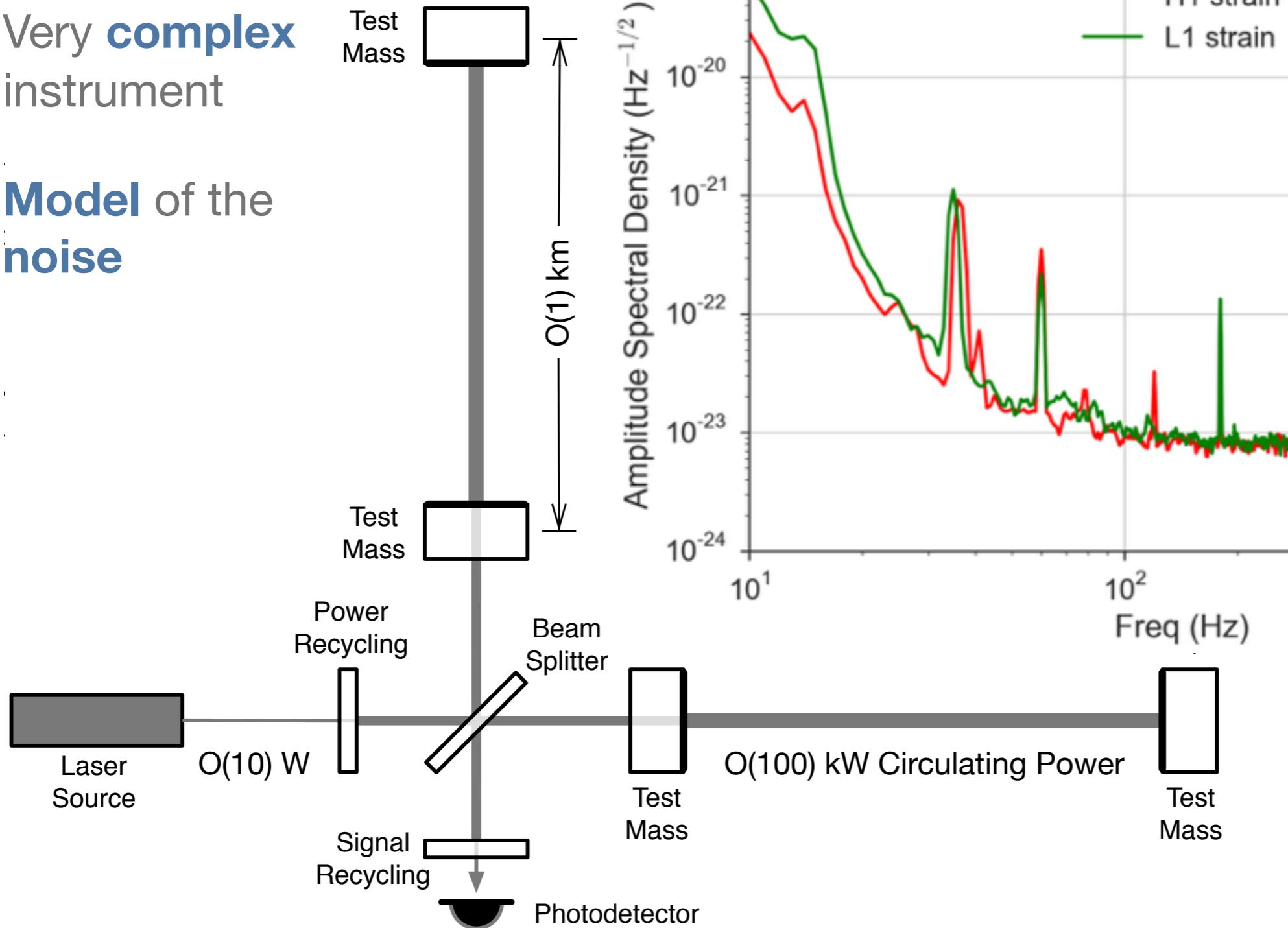
GW pipeline



Virgo observatory. Credit: Virgo

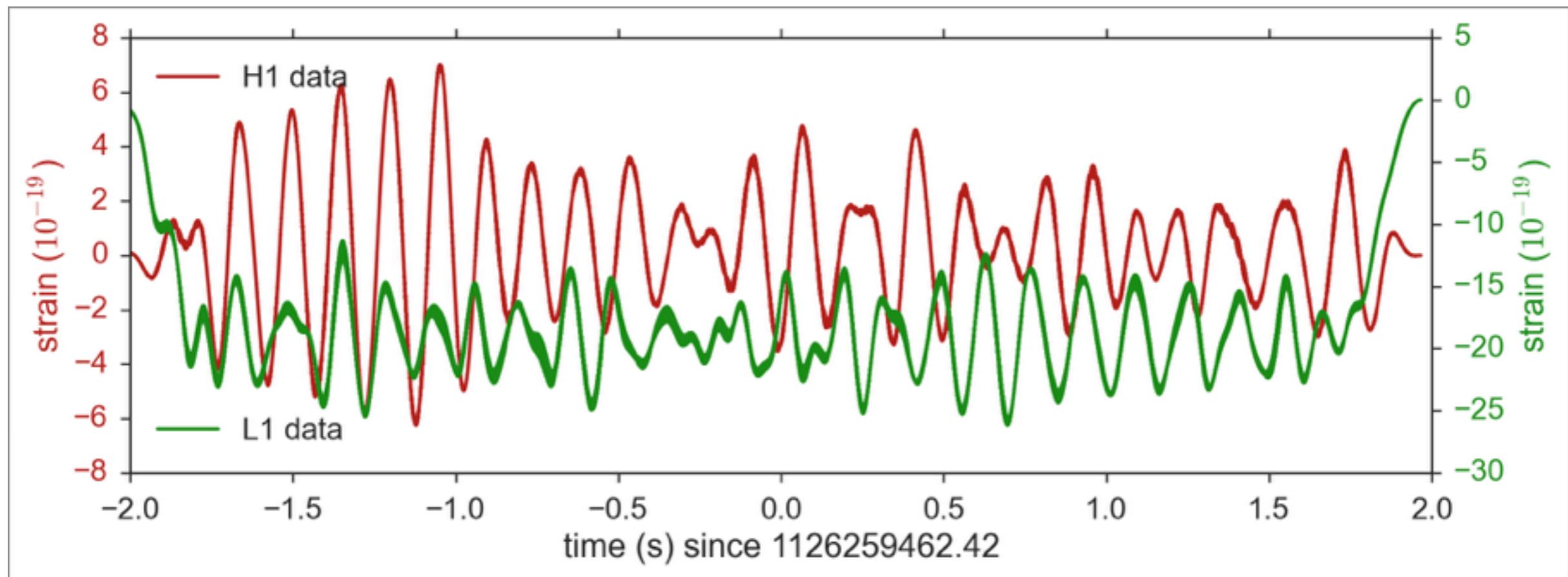
Observatories

- Very **complex** instrument
- **Model** of the noise



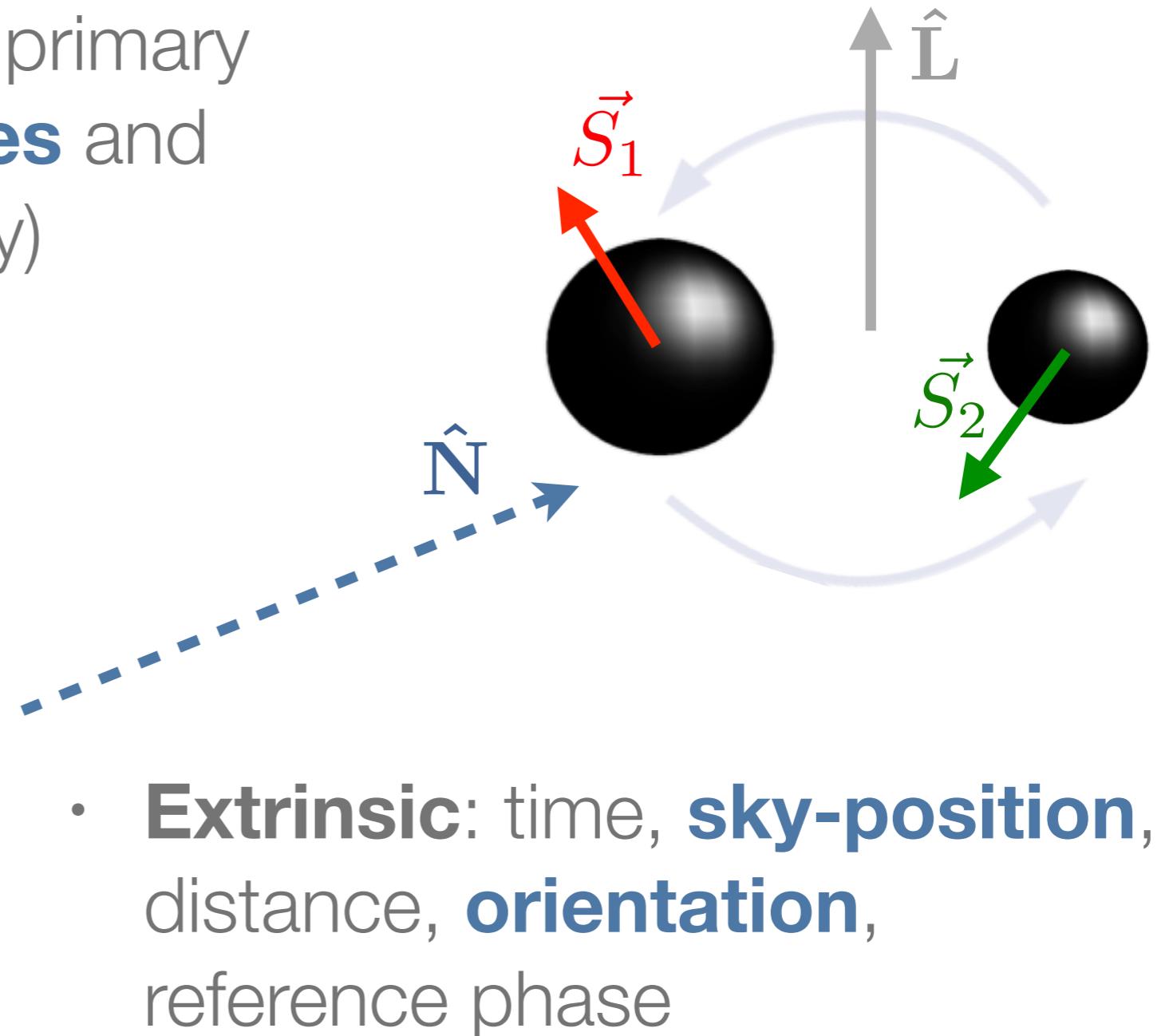
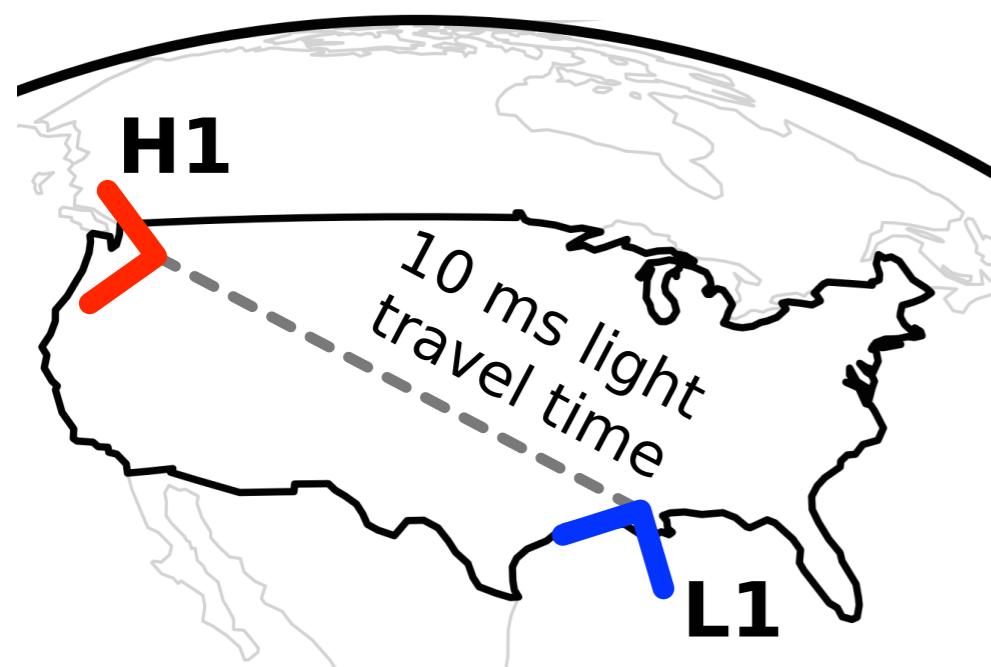
GW150914 strain data

- September 14, 2015 at 09:50:45 UTC:



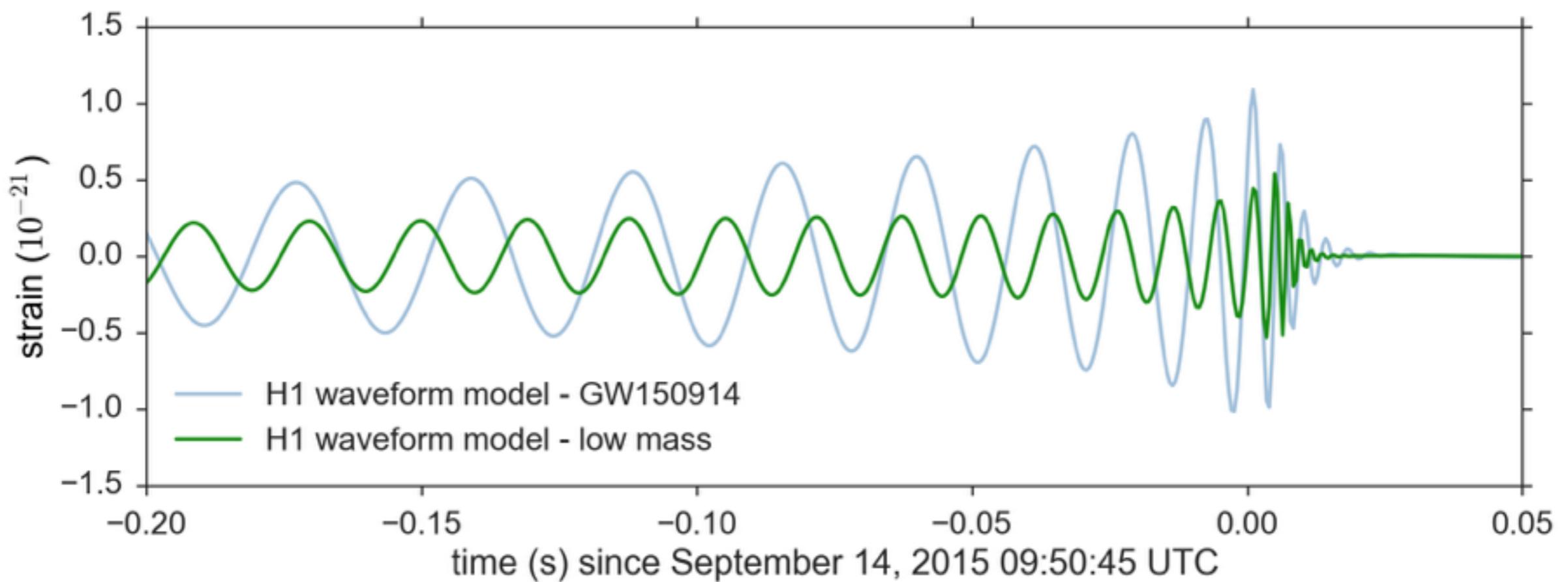
Compact Binary Coalescence

- **Intrinsic** parameters: primary and secondary **masses** and **spins** (and eccentricity)



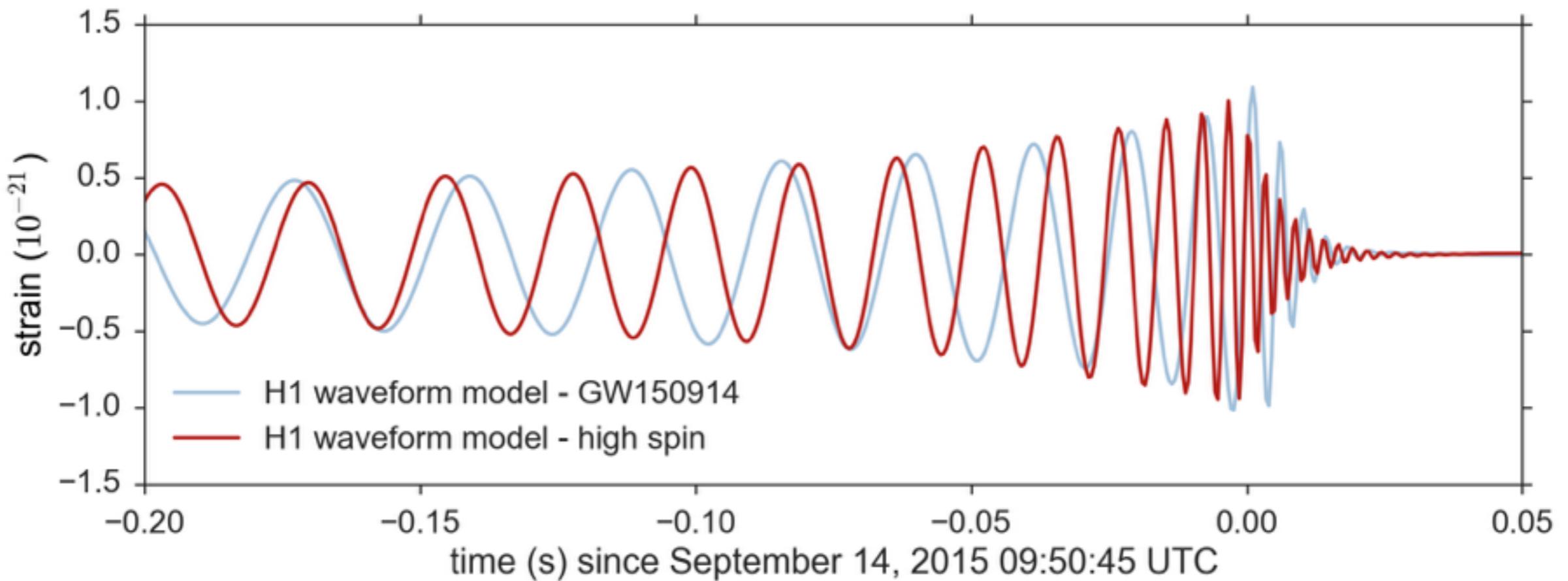
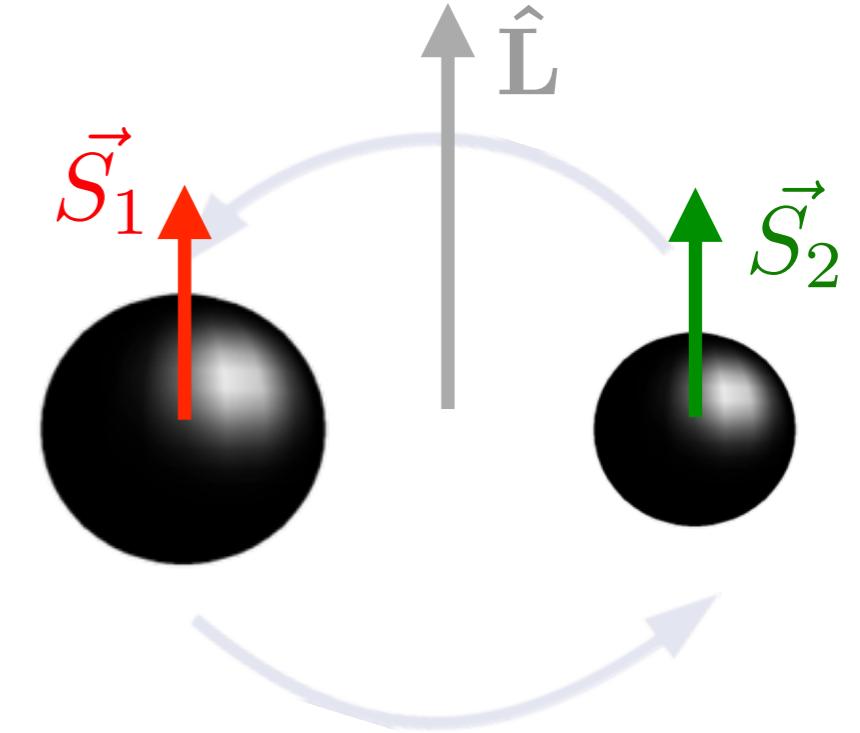
Masses from the inspiral and ringdown

- Chirp mass: $\mathcal{M} = \frac{(m_1 m_2)^{3/5}}{(m_1 + m_2)^{1/5}}$
- Mass ratio: $q = \frac{m_1}{m_2}$
- Total mass:
ringdown



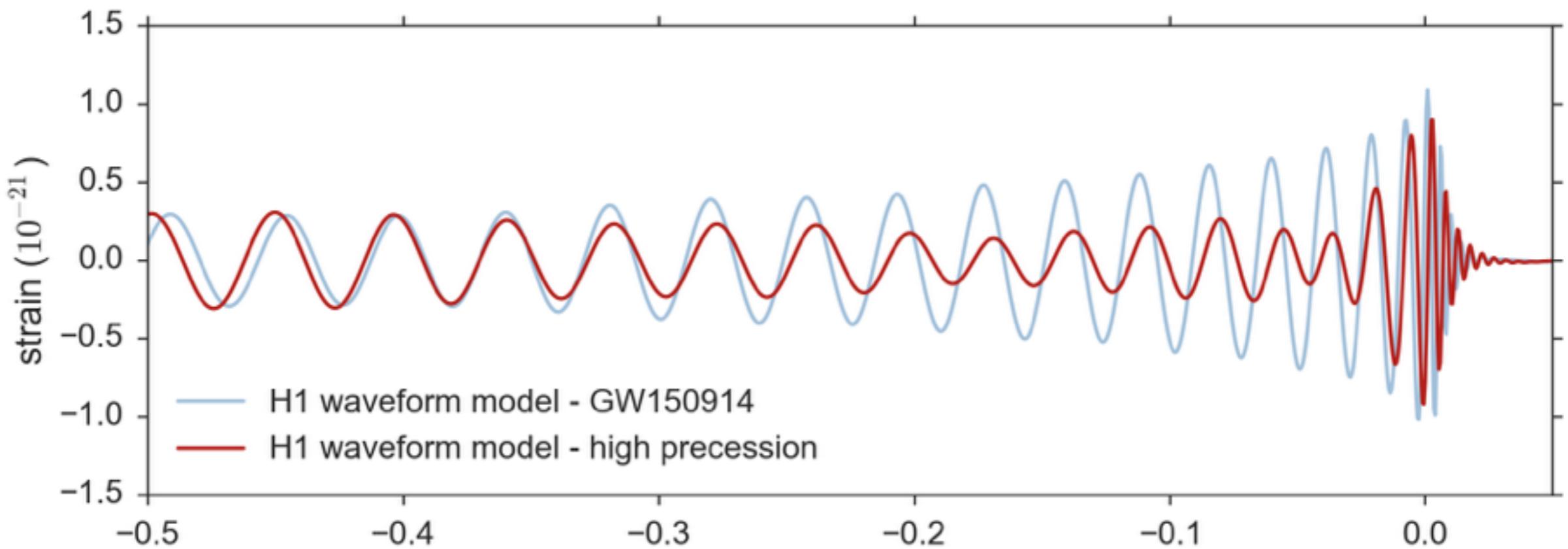
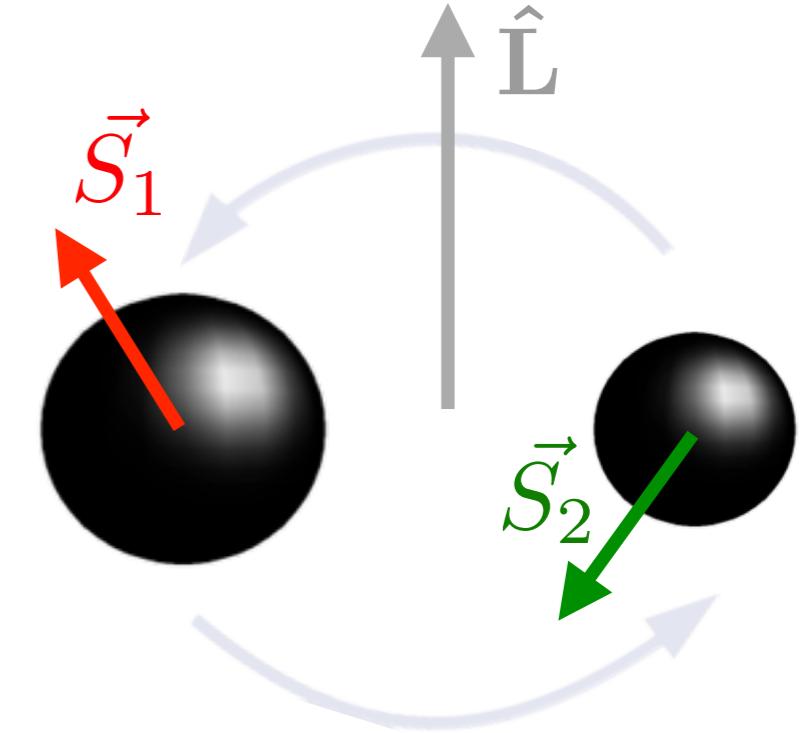
Effects of spins

- 2 spin vectors
 - **Magnitude: orbital hang-up**
 - Mis-alignment: precession and modulations

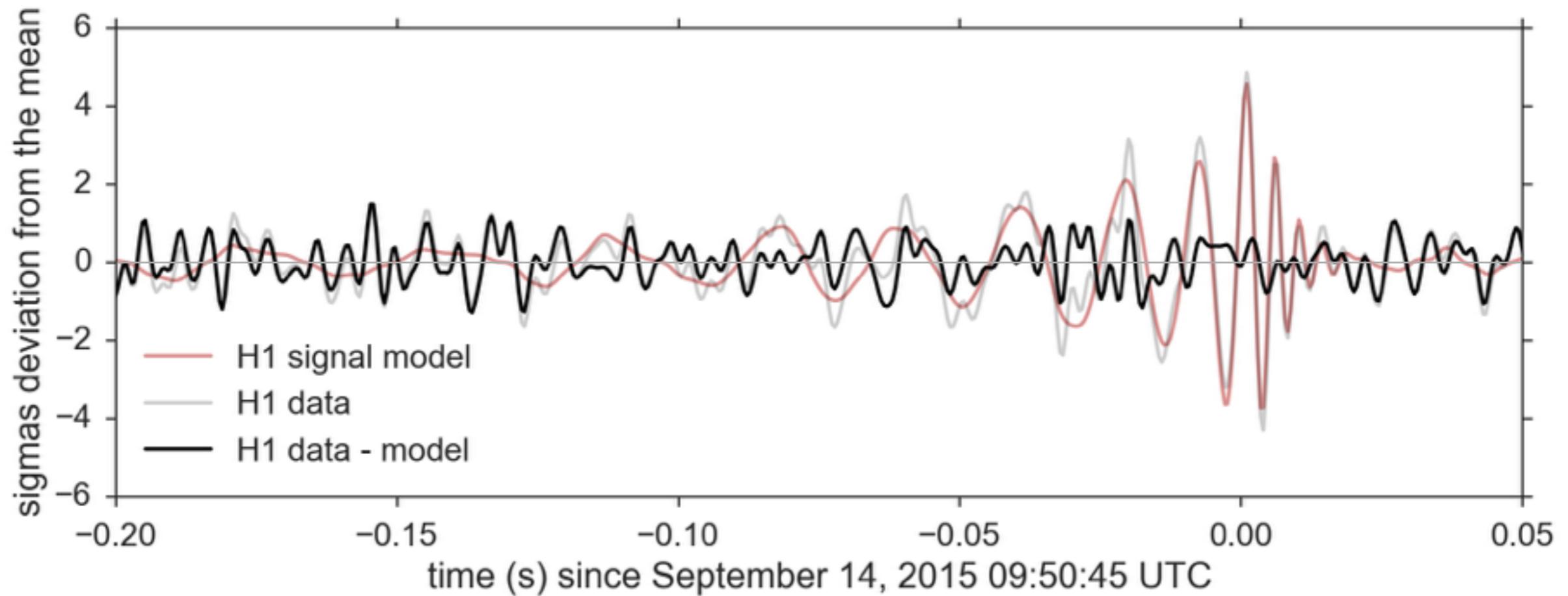


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To find the signal: Likelihood



- How close is the **remainder** to the **mean**?
 - Assumptions: **gaussianity** and **stationarity**

Parameter Estimation

- We want the **posterior** probability of parameters $\vec{\lambda}$, given the data \vec{x} . With **Bayes'** theorem:

$$p(\vec{\lambda}|\vec{x}, M) = \frac{p(\vec{\lambda}|M) p(\vec{x}|\vec{\lambda}, M)}{p(\vec{x}|M)}$$

- Fit a **model** to the data (**noise** and **signal** models)
- Build a **likelihood** function
- Specify **prior** knowledge
- **Numerically** estimate the resulting **distribution** (**sampling** algorithms)

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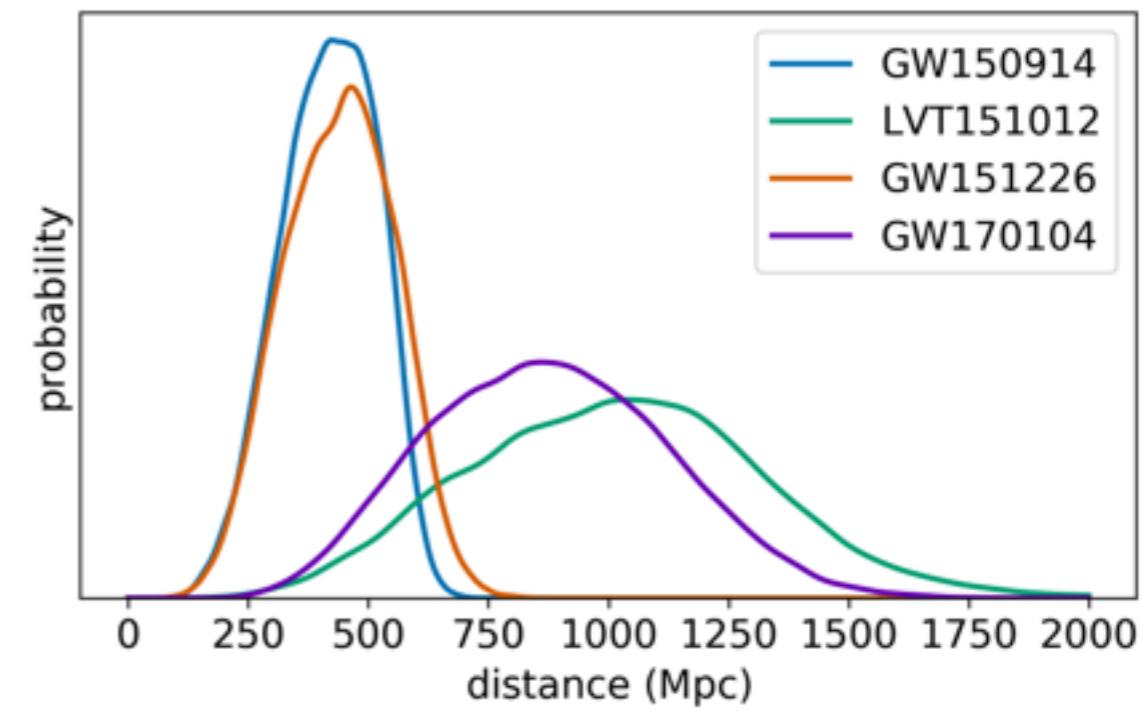
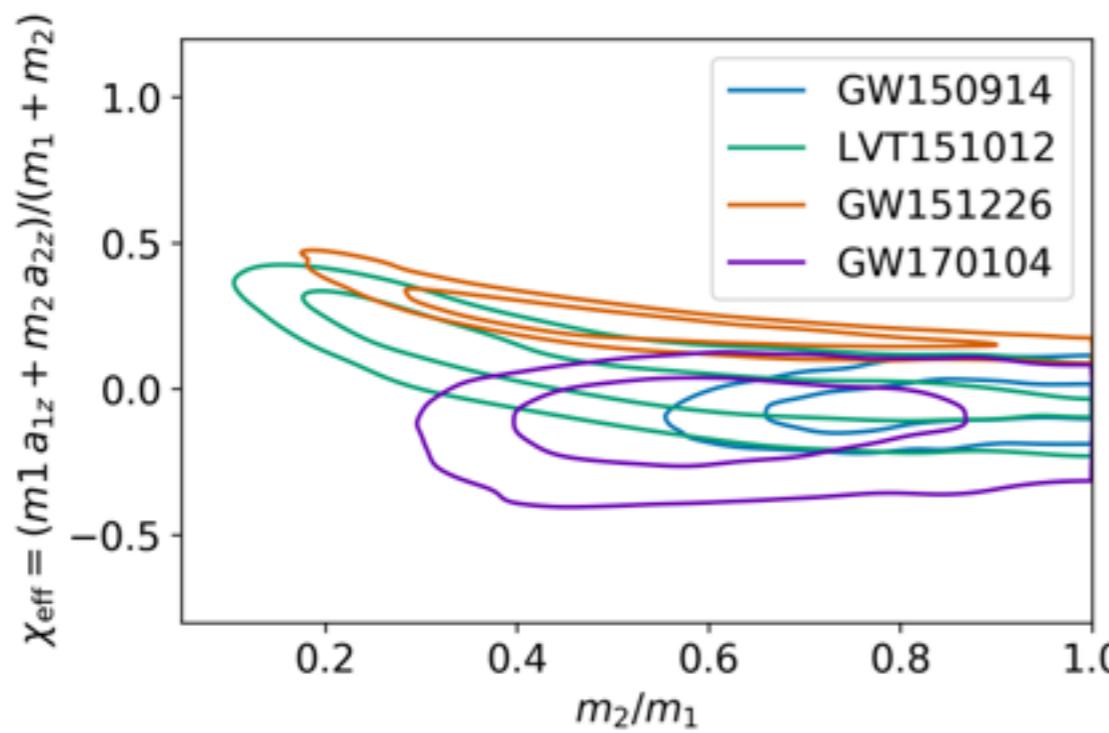
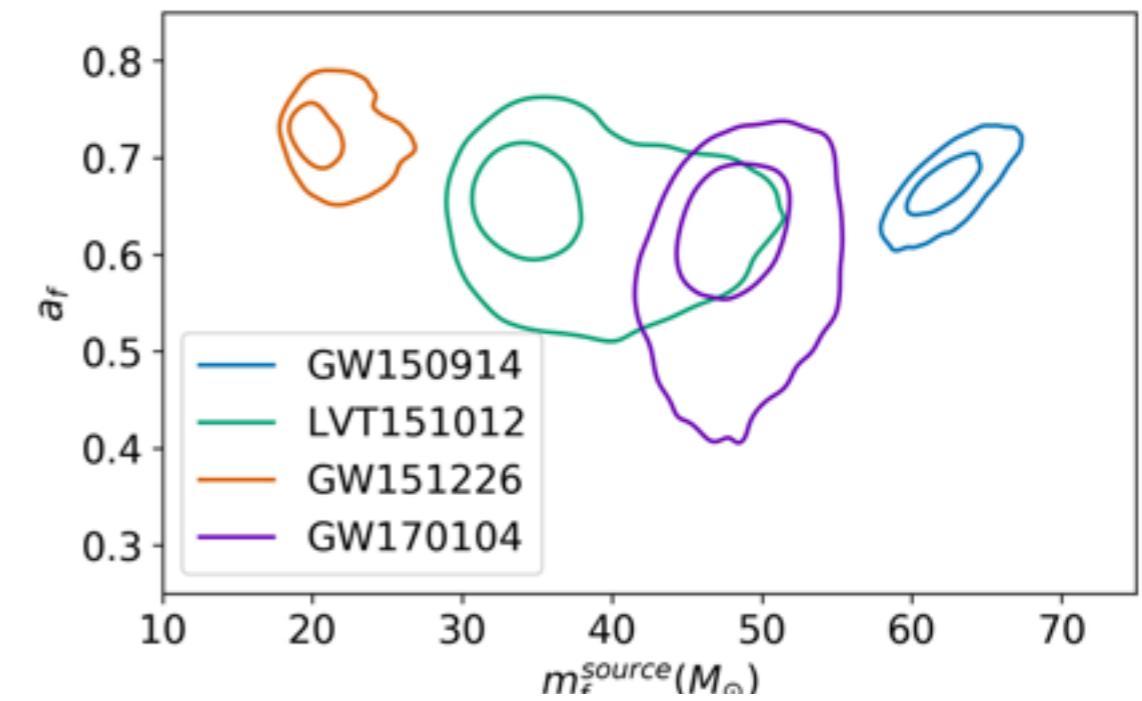
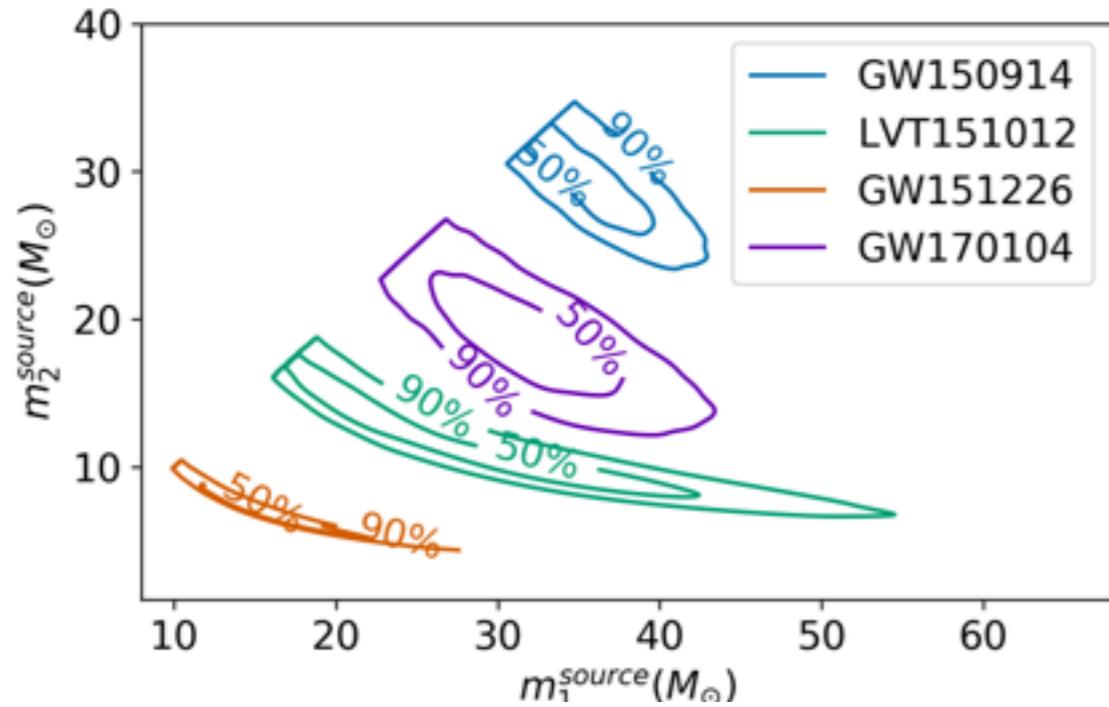
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Gravitational-wave observations

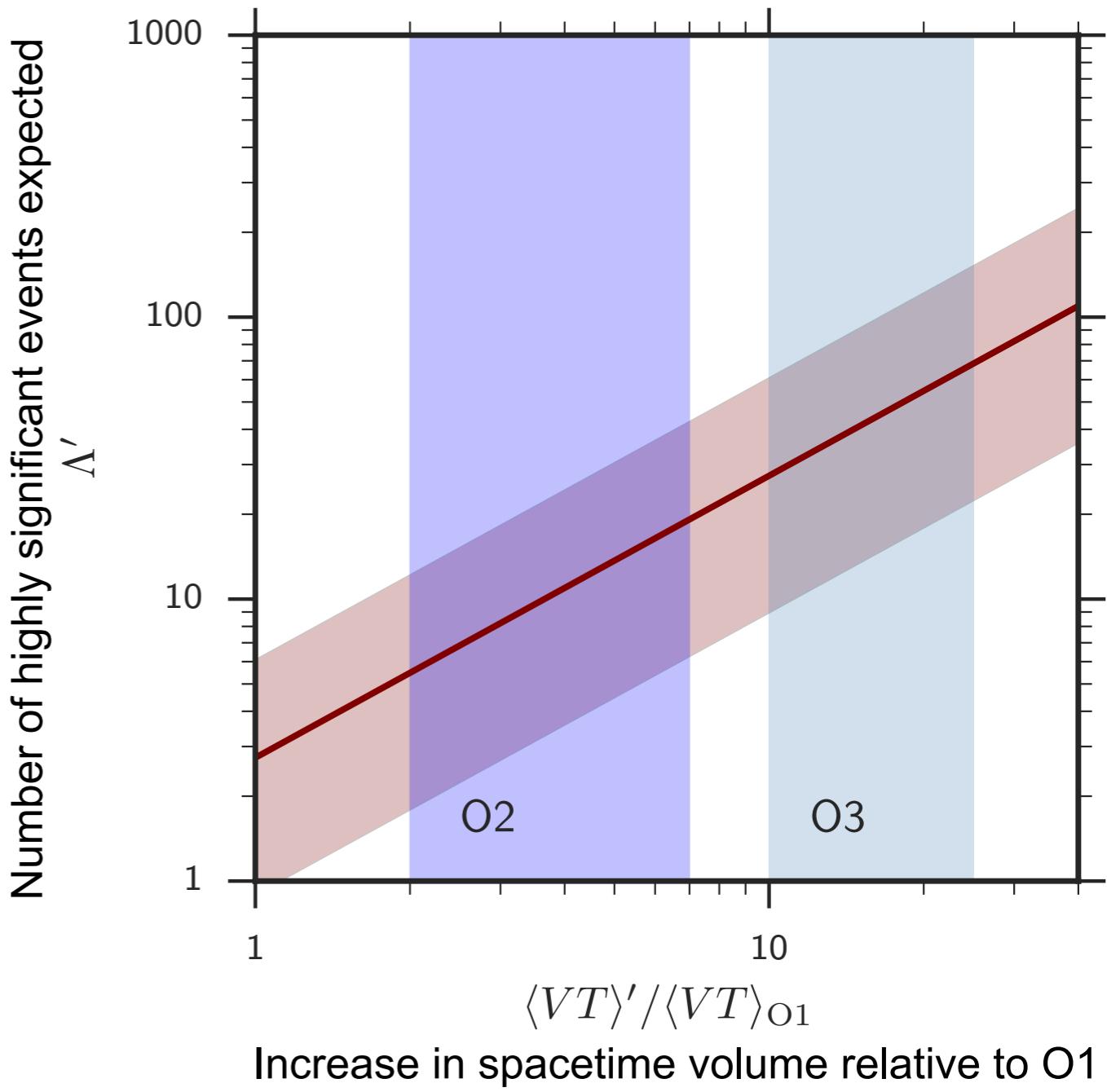


Physical and astrophysical implications

- **New** observational medium delivers **heavy** stellar mass black-holes
 - **General Relativity** describes well gravitational-wave observations
 - Merging binary black-holes exist in a **broad mass range**
- New access to **black holes spins** (GW151226: **at least one black-hole spinning**)
- Measured **masses** and **spins** consistent with both:
 - **Isolated binary evolution** (more aligned spins)
 - **Dynamical formation** (more misaligned spins)

Future observations

- **More** Binary Black Holes
 - Better **spin** constraints (magnitude **and** orientation)
- **Neutron stars** in binaries
- New **tests** of **General Relativity**
- Neutron stars **equation of state**
- Population of **compact objects**



[LIGO-Virgo Collaboration, Phys. Rev. X 6, 041015, 2016]

