Gravity Exploration Institute away-day: Gravitational Waves Astrophysical Inference

The Gravitational Waves Astrophysical Inference Group

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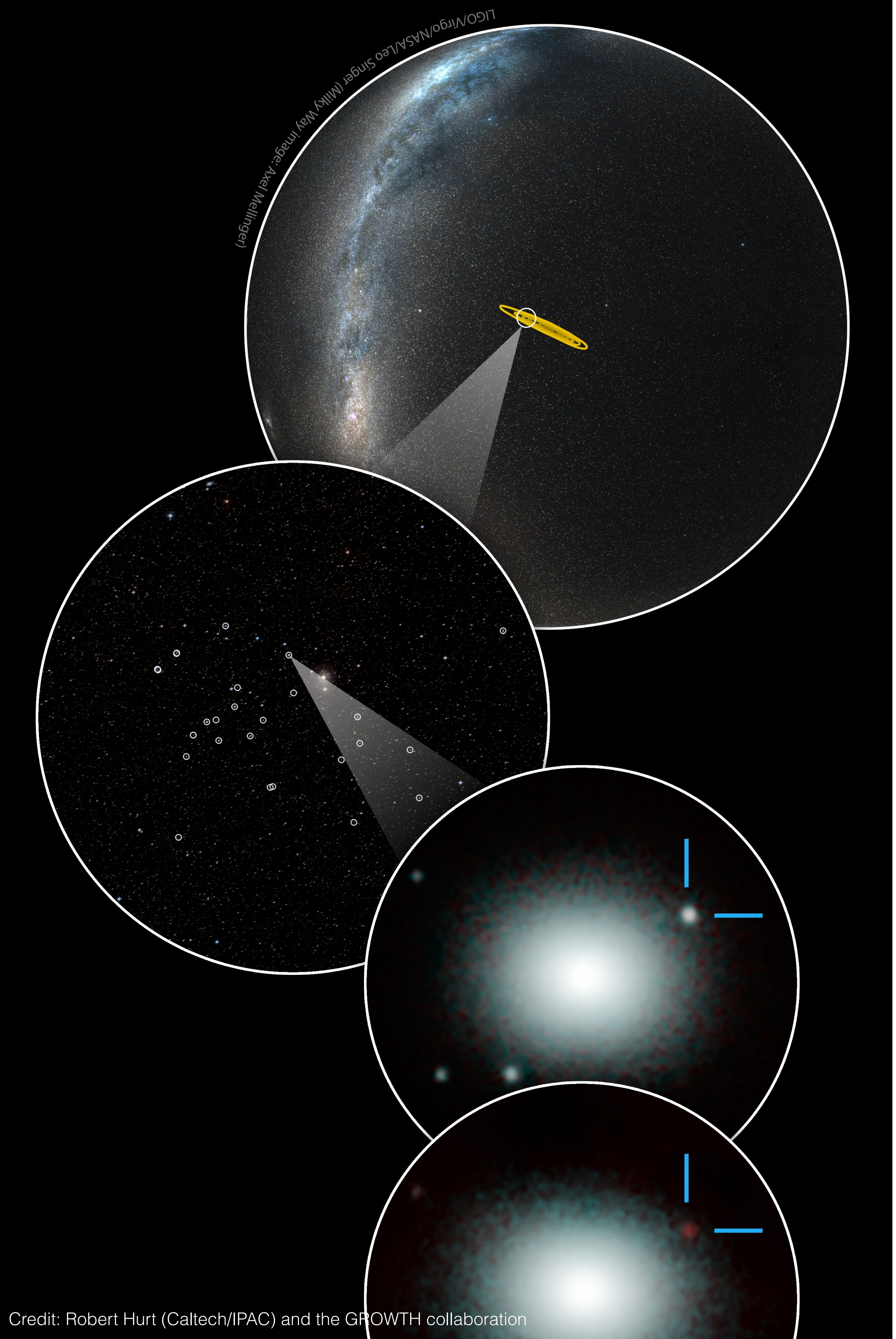


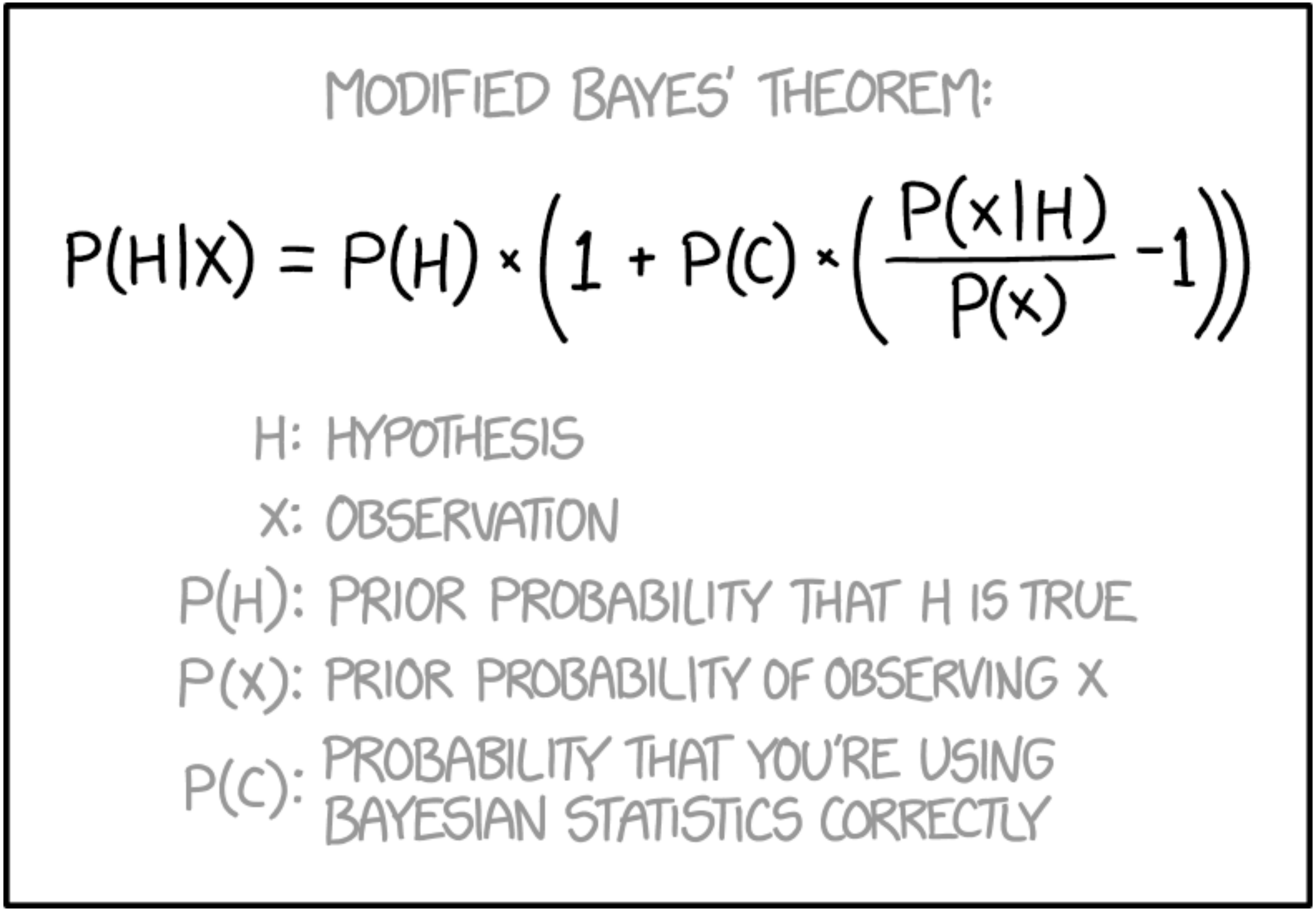
Credit: Robert Hurt (Caltech/IPAC) and the GROWTH collaboration

PE (and Model Selection) in O3

- Trigger generation
- **Online** follow-up:
  - Bayestar
  - **LALInference** online / rapid_pe
- **Offline** follow-up:
  - **ROTA**: "interesting" events
- Providing **PDF**s for **all** events for:
  - LVC publications/working groups
  - **Public releases**

(current) PE in one equation

$$p(\vec{\lambda} \mid \vec{x}, M) = p(\vec{\lambda}) \exp\left(-2 \sum_{i=1}^{N_{det}} \int_{f_{low}}^{f_{high}} df \, \frac{\left| \vec{x}_i(f) - h(f;\, \vec{\lambda}) C_i(f;\, \vec{\lambda}) - g_i(f;\, \vec{\lambda}) \right|^2}{S_i(f;\, \vec{\lambda})} \right)$$



Don't forget to add another term for "probability that the Modified Bayes' Theorem is correct."

Credit: xkcd.com

(current) PE in one equation

$$p(\vec{\lambda} \mid \vec{x}, M) = \boxed{p(\vec{\lambda})} \exp\left(-2 \sum_{i=1}^{N_{det}} \int_{f_{low}}^{f_{high}} df \frac{\left| \vec{x}_i(f) - h(f;\vec{\lambda}) C_i(f;\vec{\lambda}) - g_i(f;\vec{\lambda}) \right|^2}{S_i(f;\vec{\lambda})}\right)$$

- **Marginalisation** over different priors
- **Reweighing** for different priors

(current) PE in one equation

$$p(\vec{\lambda} \mid \vec{x}, M) = p(\vec{\lambda}) \exp\left(-2 \sum_{i=1}^{N_{det}} \int_{f_{low}}^{f_{high}} df \, \frac{\left| \vec{x}_i(f) - h(f; \vec{\lambda}) C_i(f; \vec{\lambda}) - g_i(f; \vec{\lambda}) \right|^2}{S_i(f; \vec{\lambda})} \right)$$

- The **uber-waveform** model
- **Marginalisation** over approximants (GPR, ROM, ...)

(current) PE in one equation

$$p(\vec{\lambda} \mid \vec{x}, M) = p(\vec{\lambda}) \exp\left(-2 \sum_{i=1}^{N_{det}} \int_{f_{low}}^{f_{high}} df \frac{\left| \vec{x}_i(f) - h(f; \vec{\lambda}) C_i(f; \vec{\lambda}) - g_i(f; \vec{\lambda}) \right|^2}{S_i(f; \vec{\lambda})} \right)$$

- **Marginalisation** over detector calibration error

(current) PE in one equation

$$p(\overrightarrow{\lambda} \mid \overrightarrow{x}, M) = p(\overrightarrow{\lambda}) \exp\left(-2 \sum_{i=1}^{N_{det}} \int_{f_{low}}^{f_{high}} df \, \frac{\left| \overrightarrow{x}_i(f) - h(f; \overrightarrow{\lambda}) C_i(f; \overrightarrow{\lambda}) - g_i(f; \overrightarrow{\lambda}) \right|^2}{S_i(f; \overrightarrow{\lambda})} \right)$$

- Multi-dimensional **Glitch** fitting

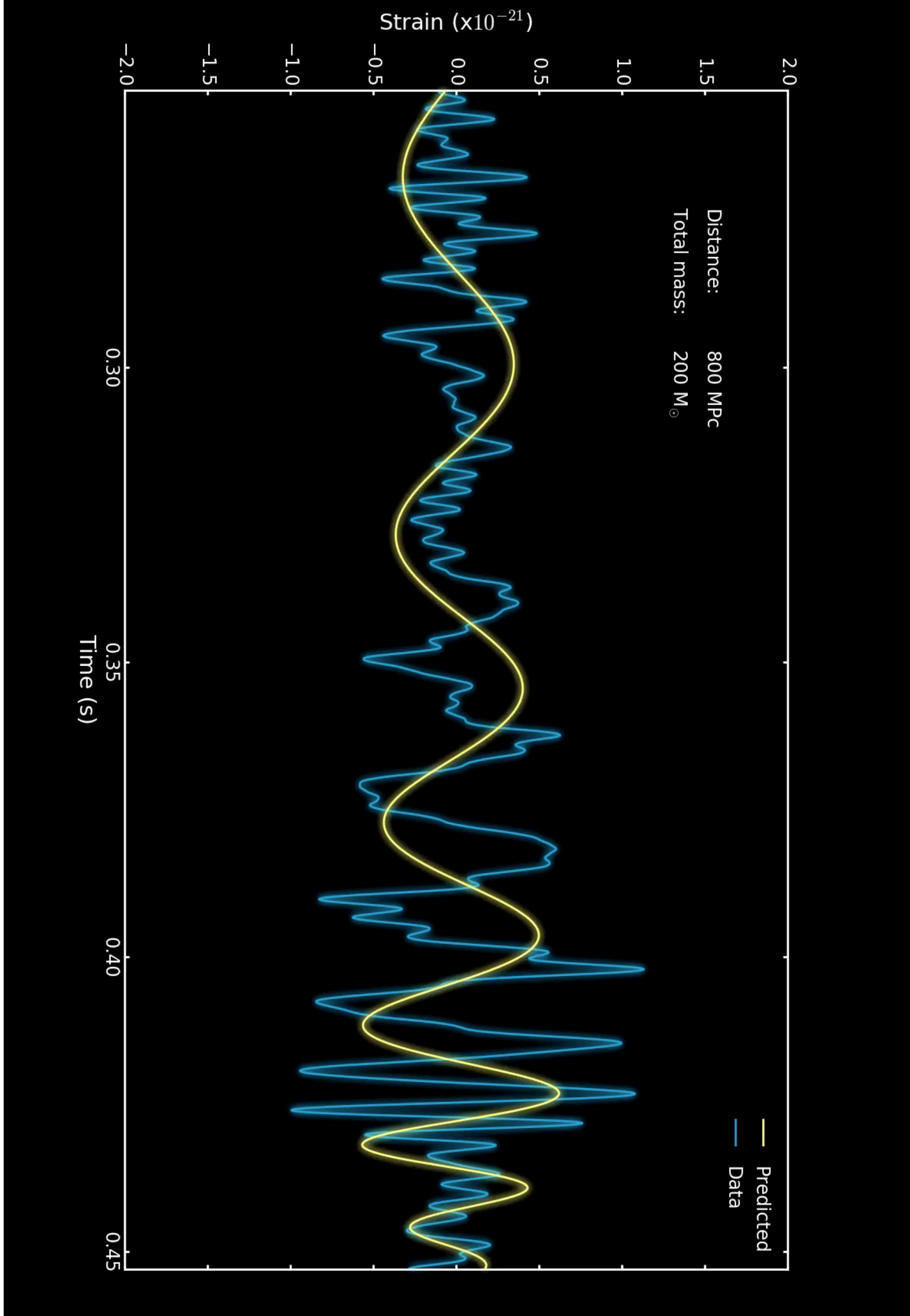
(current) PE in one equation

$$p(\vec{\lambda} \mid \vec{x}, M) = p(\vec{\lambda}) \exp\left(-2 \sum_{i=1}^{N_{det}} \int_{f_{low}}^{f_{high}} df \, \frac{\left| \vec{x}_i(f) - h(f; \vec{\lambda}) C_i(f; \vec{\lambda}) - g_i(f; \vec{\lambda}) \right|^2}{S_i(f; \vec{\lambda})} \right)$$

- **Marginalisation** over PSD error

PE in O3 @ Cardiff ?

- Reduced Order Modelling, **Faster** PE
- **Detection** and PE
- New GW **Likelihood**
  - Signals + Detector
- **Detchar** and PE
- **Understanding** of the parameter space
- **Stacking** (H0, populations, ...)
- **...**



Credit: C. North/M. Hannam, LIGO/Virgo