

An aerial photograph of a research facility, likely N-PACT, situated in a dense forest. The facility consists of several large, interconnected buildings with blue roofs and walls, surrounded by parking lots and smaller structures. A river or stream flows through the landscape, and a road is visible. The text is overlaid on the image.

**Alex Nielsen**  
**University of Stavanger**

# **Gravitational waves from LIGO-Virgo: Searching for new physics**

**N-PACT, Kristiansand, 5th August 2020**



# Gravitational wave detections so far

- GWTC-1 covered O1+O2 1 BNS (GW170817) and 10 BBH
- O3 April 1, 2019 to 27 March 2020 (suspended due to Covid-19)
- GW190425 high mass BNS ( $3.4M_{\text{solar}}$ )
- GW190814 mass-ratio 9, BBH or NSBH
- KAGRA (Japan) started running Feb 25 2020

# Tests of General relativity

- «Strong» gravity:

$$\sqrt{\frac{GM}{c^2 R}} \sim v/c \sim O(0.5)$$

- Not Planck-scale curvature:

$$R^{abcd} R_{abcd} l_{Pl}^4 \sim \left( \frac{M_{Pl}}{M_{BH}} \right)^4 \ll 1$$

- Gravitational horizon scales:

$$\theta_l = 0 \quad \leftrightarrow \quad \frac{m}{r} \sim 1$$

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## Exclusive: Grave doubts over LIGO's discovery of gravitational waves

The news we had finally found ripples in space-time reverberated around the world in 2015. Now it seems they might have been an illusion



**PHYSICS** 31 October 2018

By [Michael Brooks](#)



Have we really measured gravitational ...



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# Gravitational Waves?



«I do not doubt that the gravitational wave detections are real. But. I spend a lot of time on science communication and I know that many of you doubt that these detections are real. And, to be honest, I cannot blame you for this doubt.»

«We should not hand out Nobel Prizes if we do not know how the predictions were fitted to the data.»

«I have no reason to think that something fishy went on.»

«We still do not know if what LIGO and Virgo see are actually signals from outer space.»

«They do not really know what their detector detects. They just throw away data that don't look like they want it to look. This is not a good scientific procedure.»

«We cannot be sure that these are actually signals coming from outer space and not some unknown terrestrial effect. Let me finish by saying once again that personally I do not actually doubt that these signals are caused by gravitational waves.»

# Journal of Cosmology and Astroparticle Physics

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## On the time lags of the LIGO signals

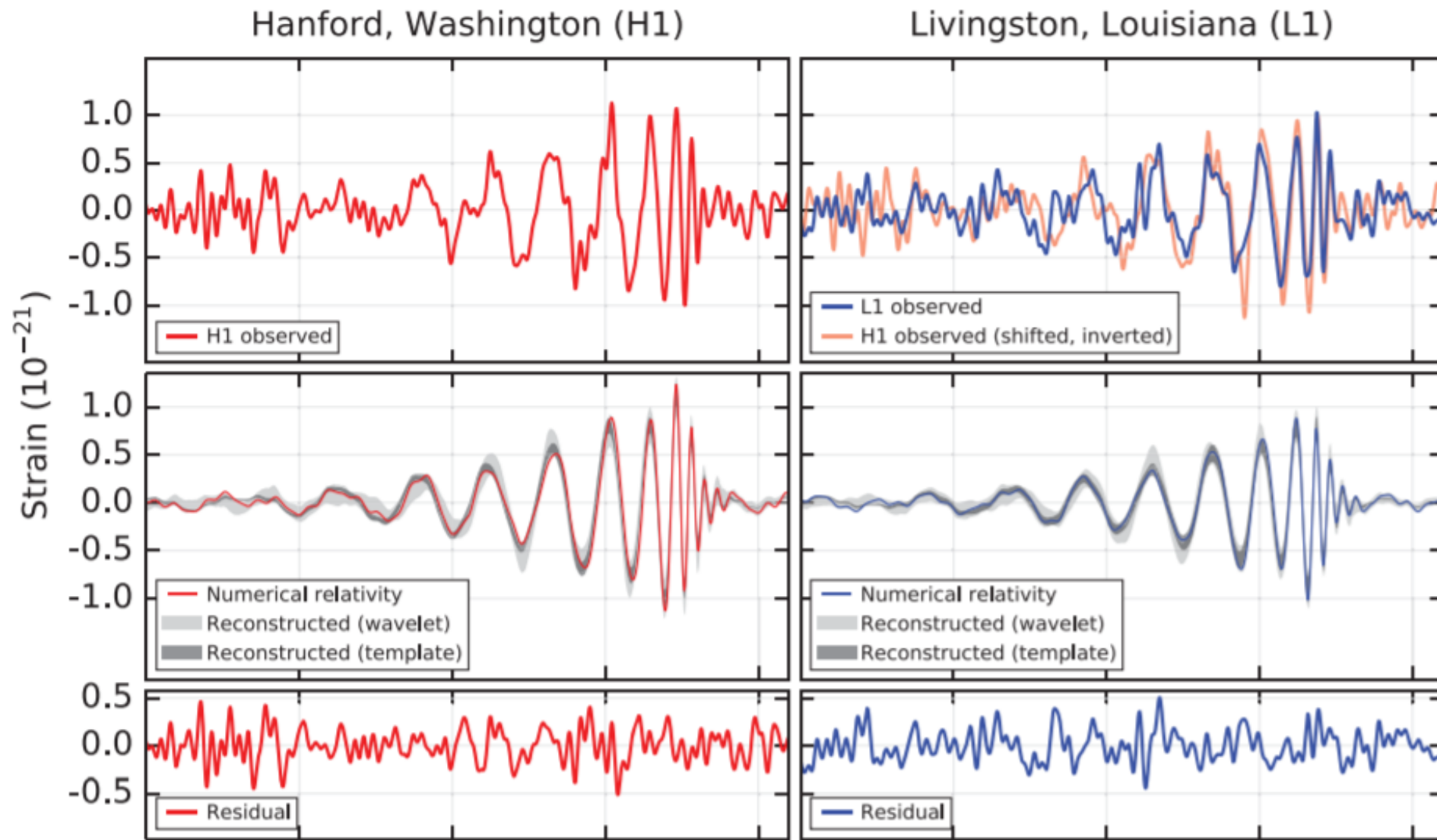
James Creswell<sup>a</sup>, Sebastian von Hausegger<sup>a</sup>, Andrew D. Jackson<sup>b</sup>, Hao Liu<sup>a,c</sup> and Pavel Naselsky<sup>a</sup>

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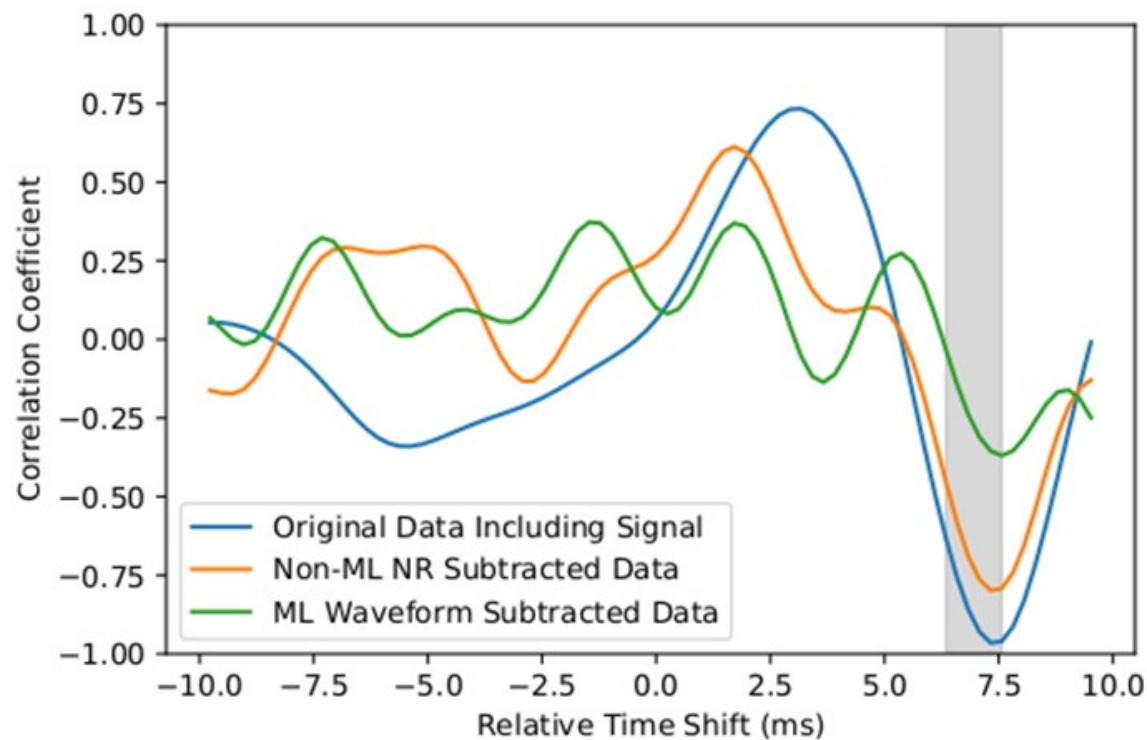
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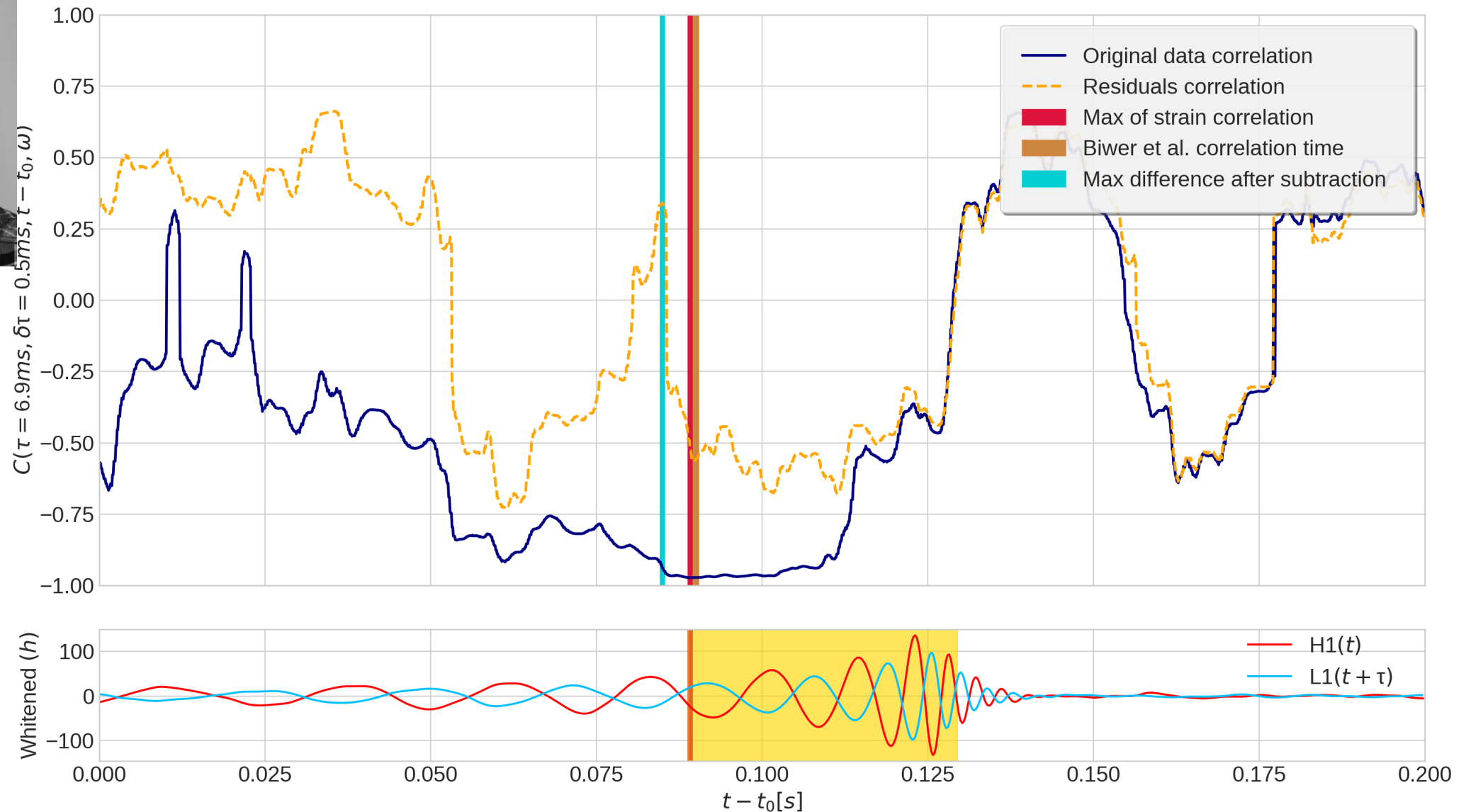


# Pearson correlation coefficient (very agnostic, done by NBI group)

$$C = \int L(t) H(t+a) dt$$

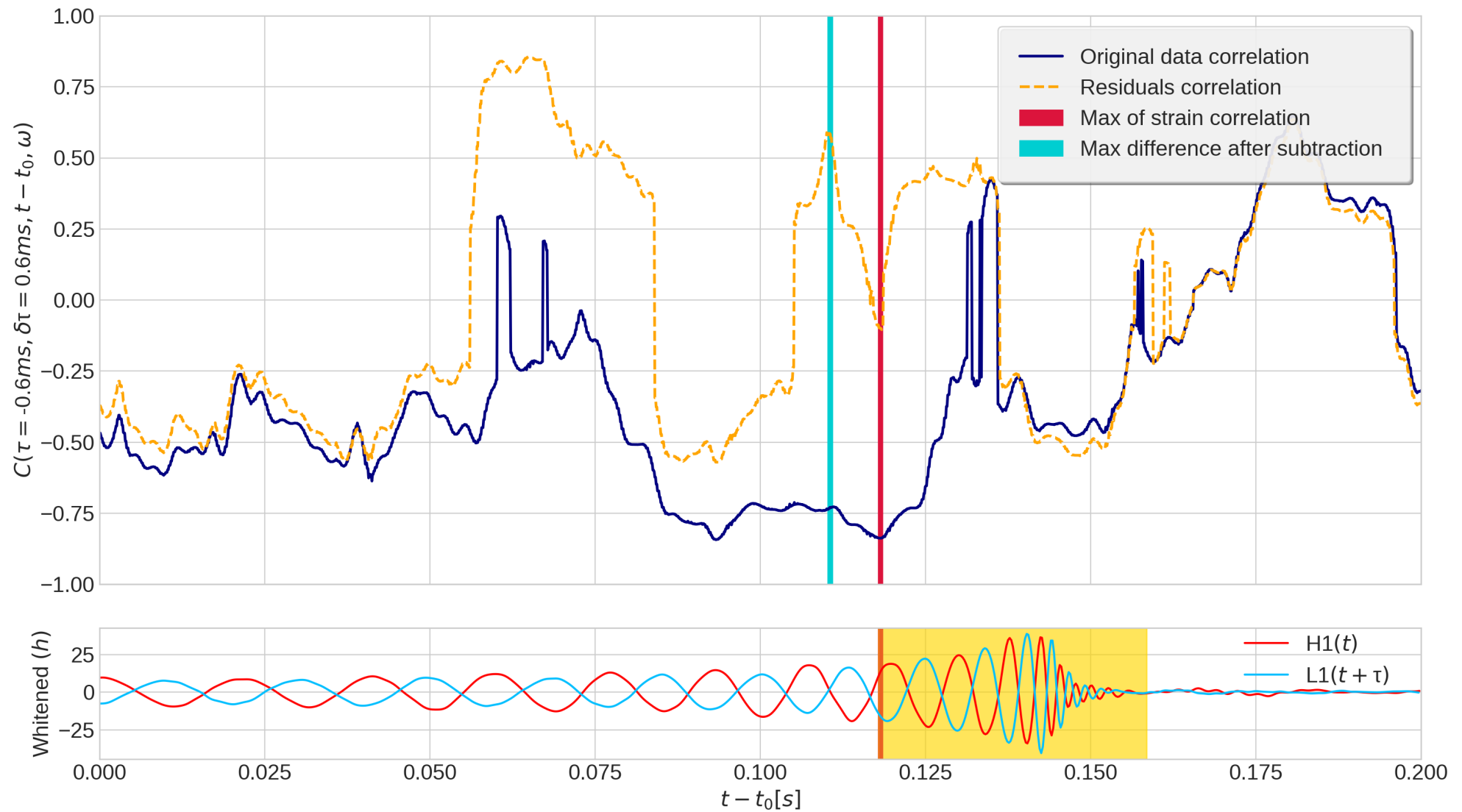


# GW150914 Pearson correlation versus time

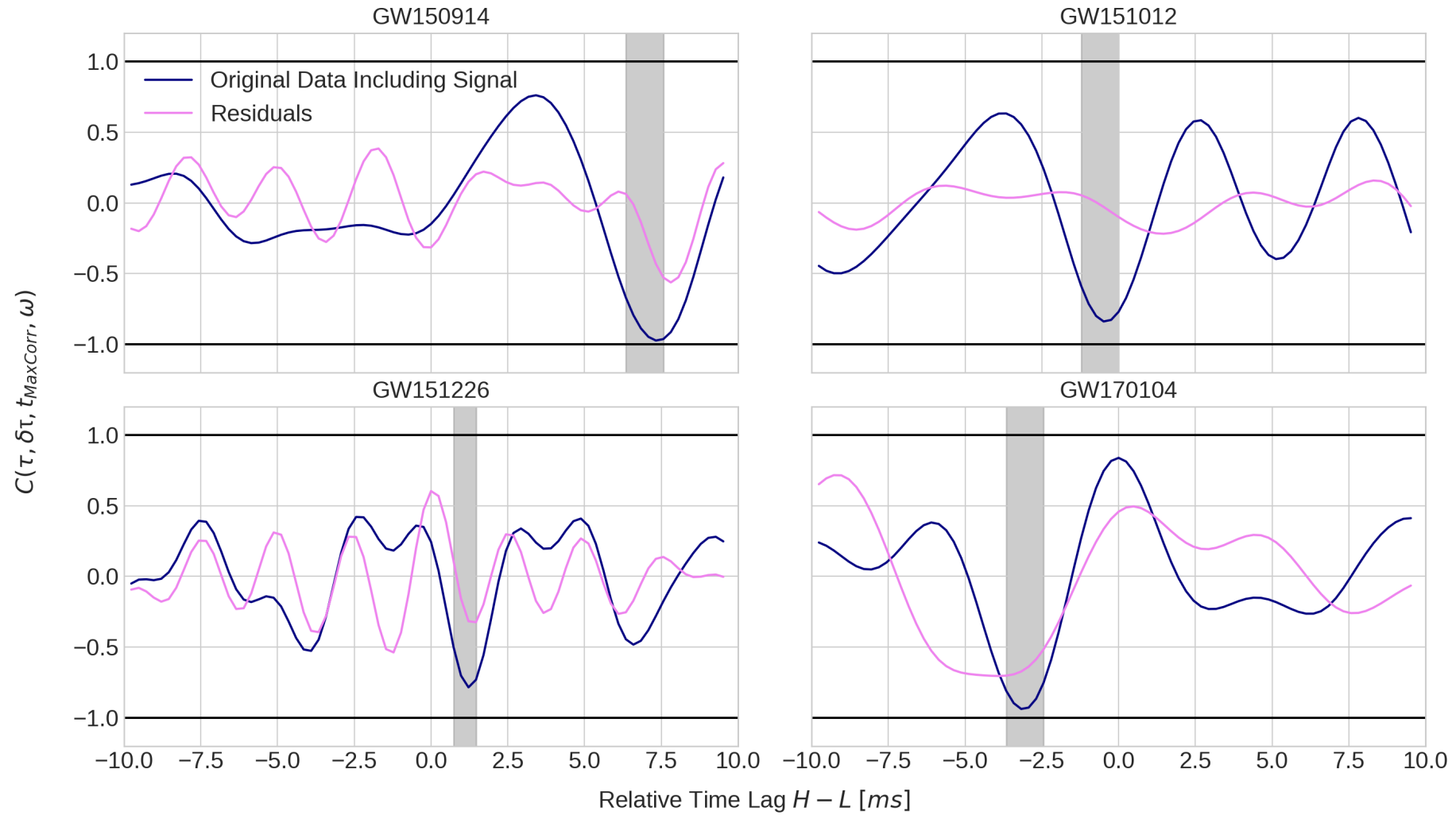


*Marcoccia et al, preliminary*

# GW151012 Pearson correlation versus time

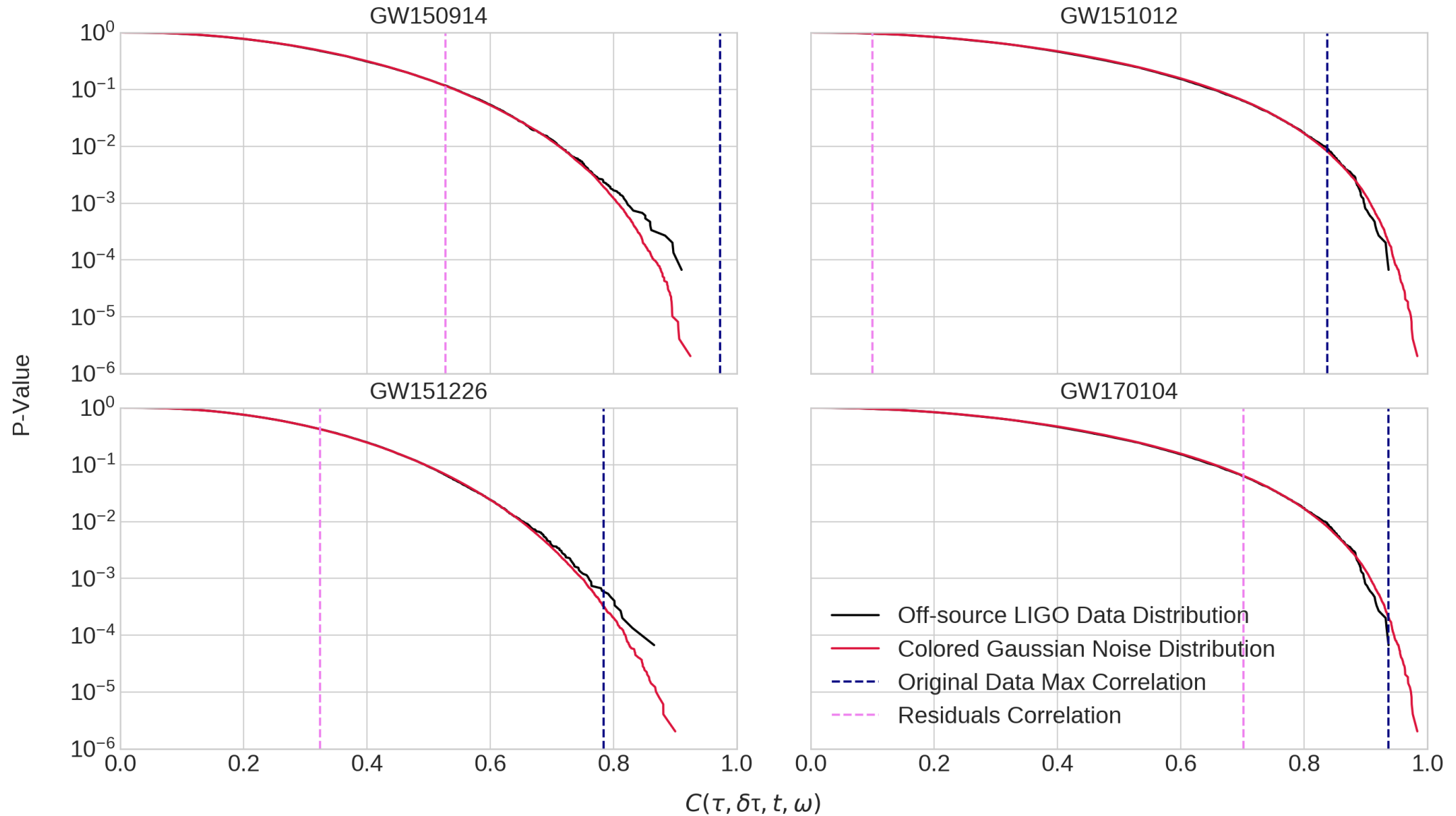


# Pearson correlations, first four events





# Significance of residual correlations



**Thank you**

# Evidence for echoes? Not with GW150914

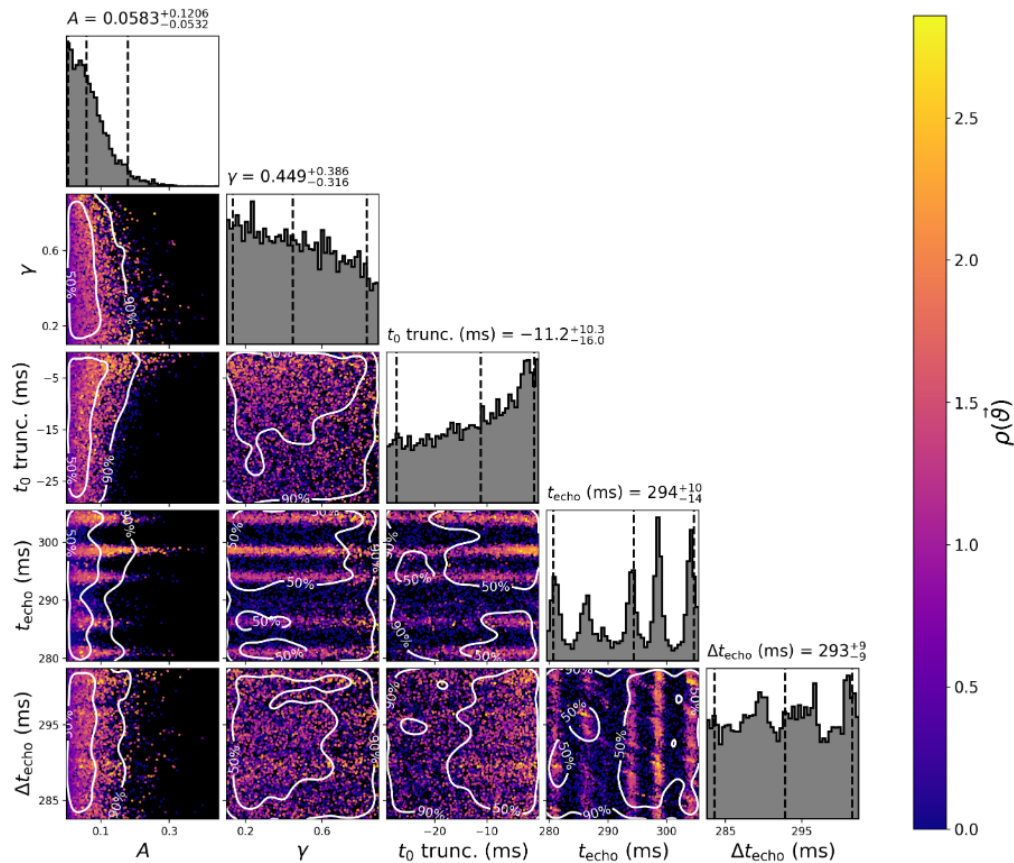


Fig. 5, Nielsen et al. PRD99, 104012

Event	Log Bayes factor	Max SNR
GW150914	-1.8056	2.86
LVT151012	1.2499	5.5741
GW151226	0.4186	4.07

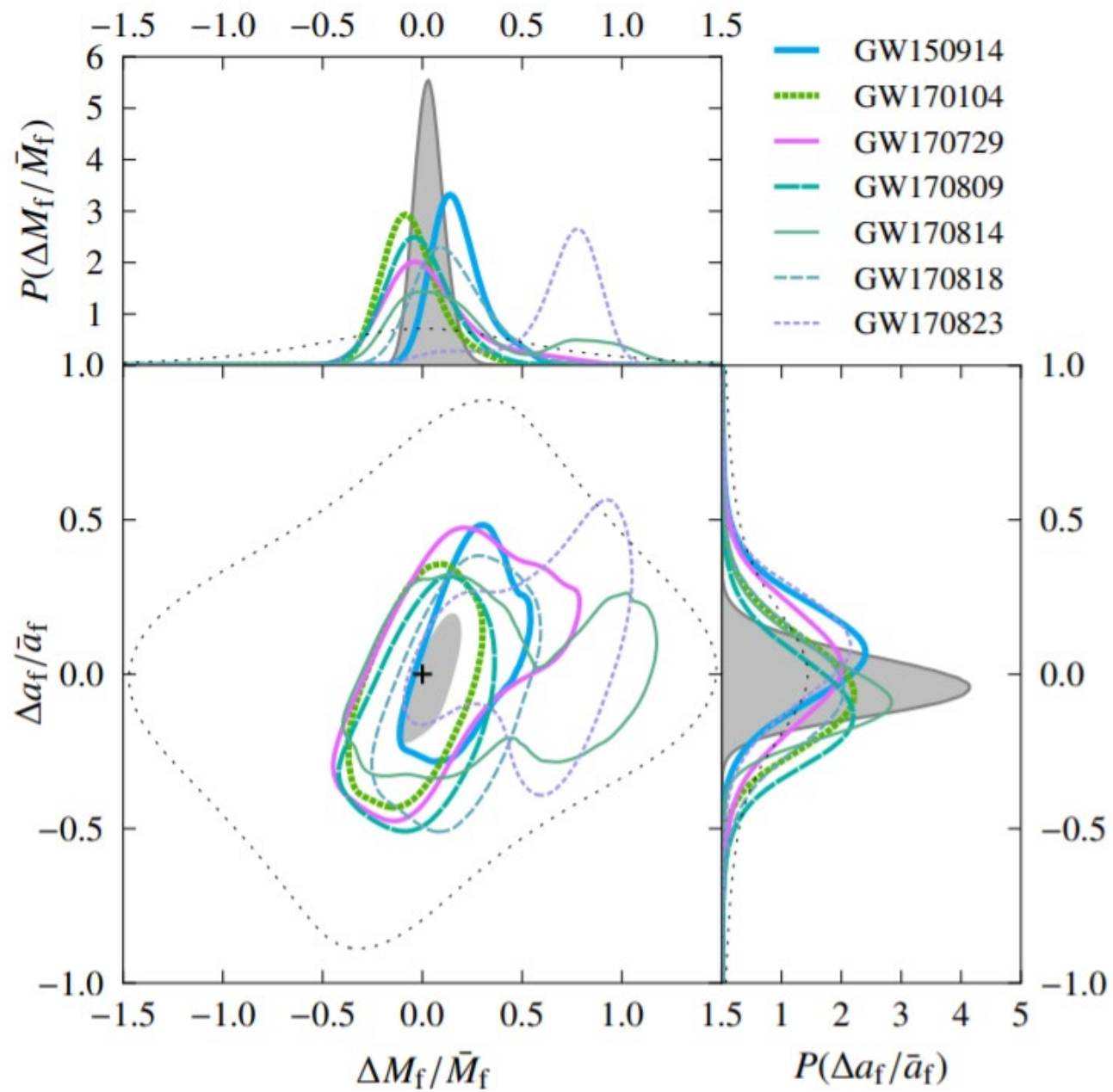


Fig 2. LVC PRD100 (2019) 104036