

# Searching for Short Unmodelled Gravitational Wave Transients

Early insights and ongoing research

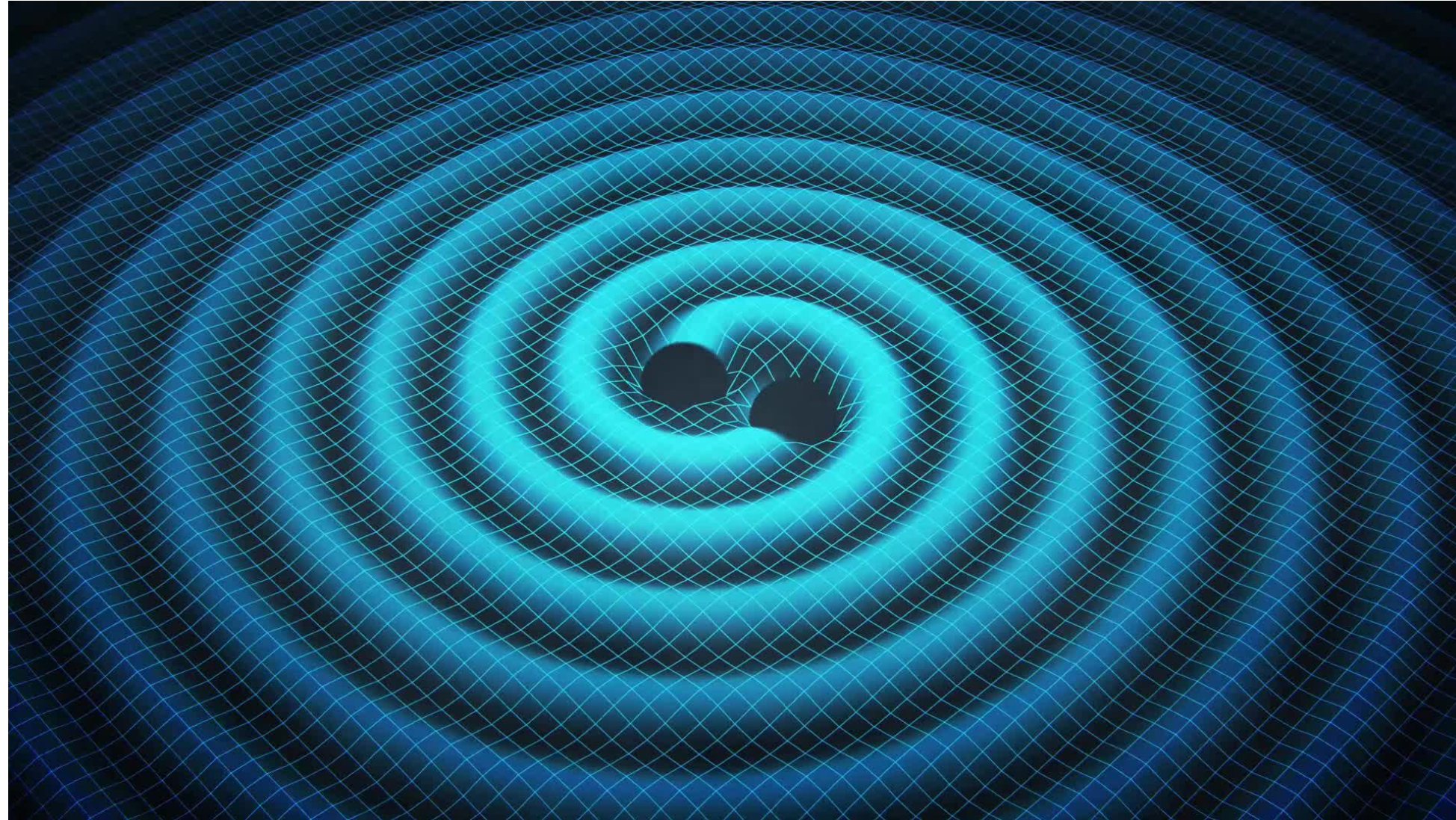


**UNIVERSITÉ  
DE GENÈVE**

Sarah Baimukhametova

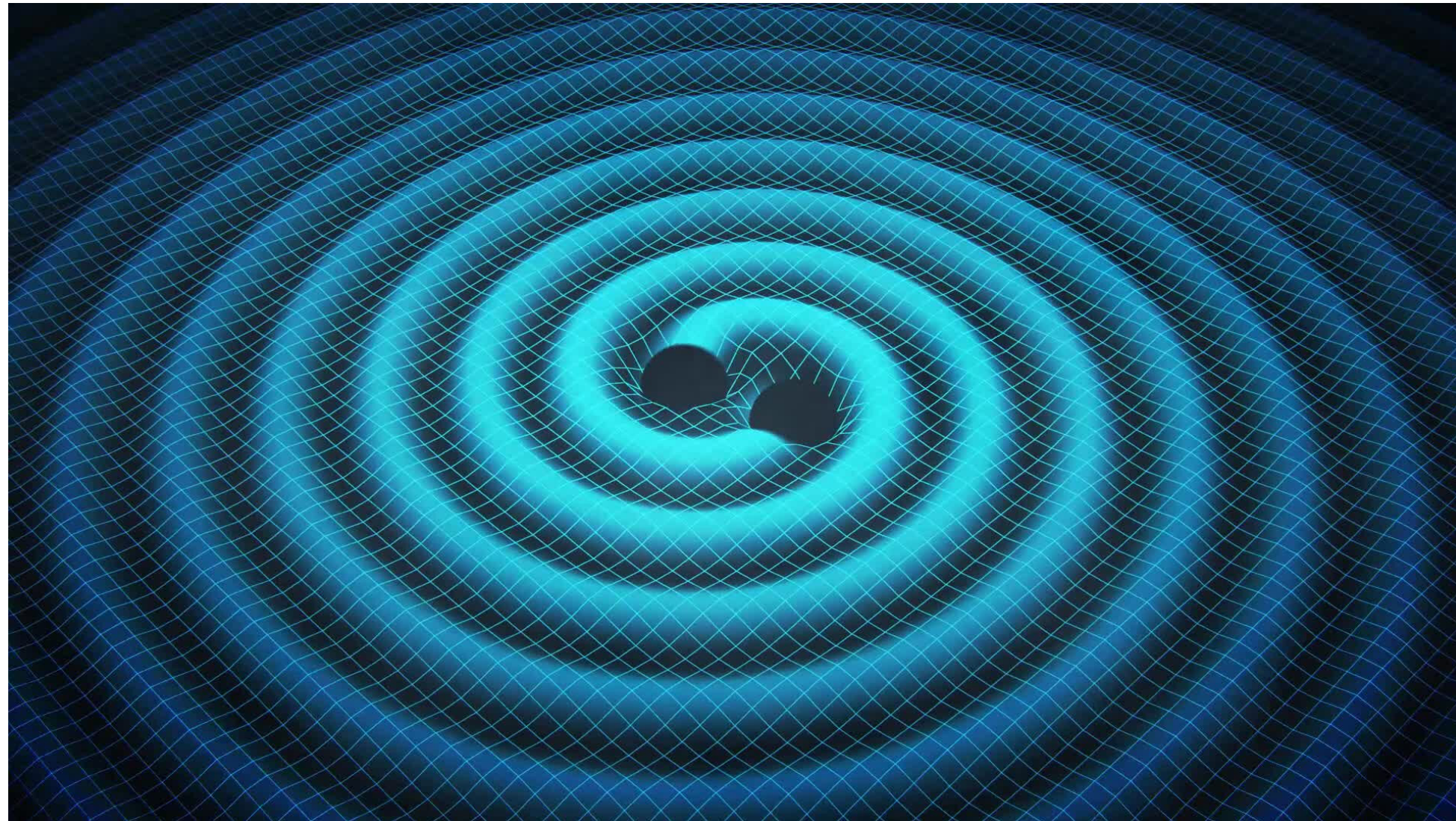
# Gravitational waves

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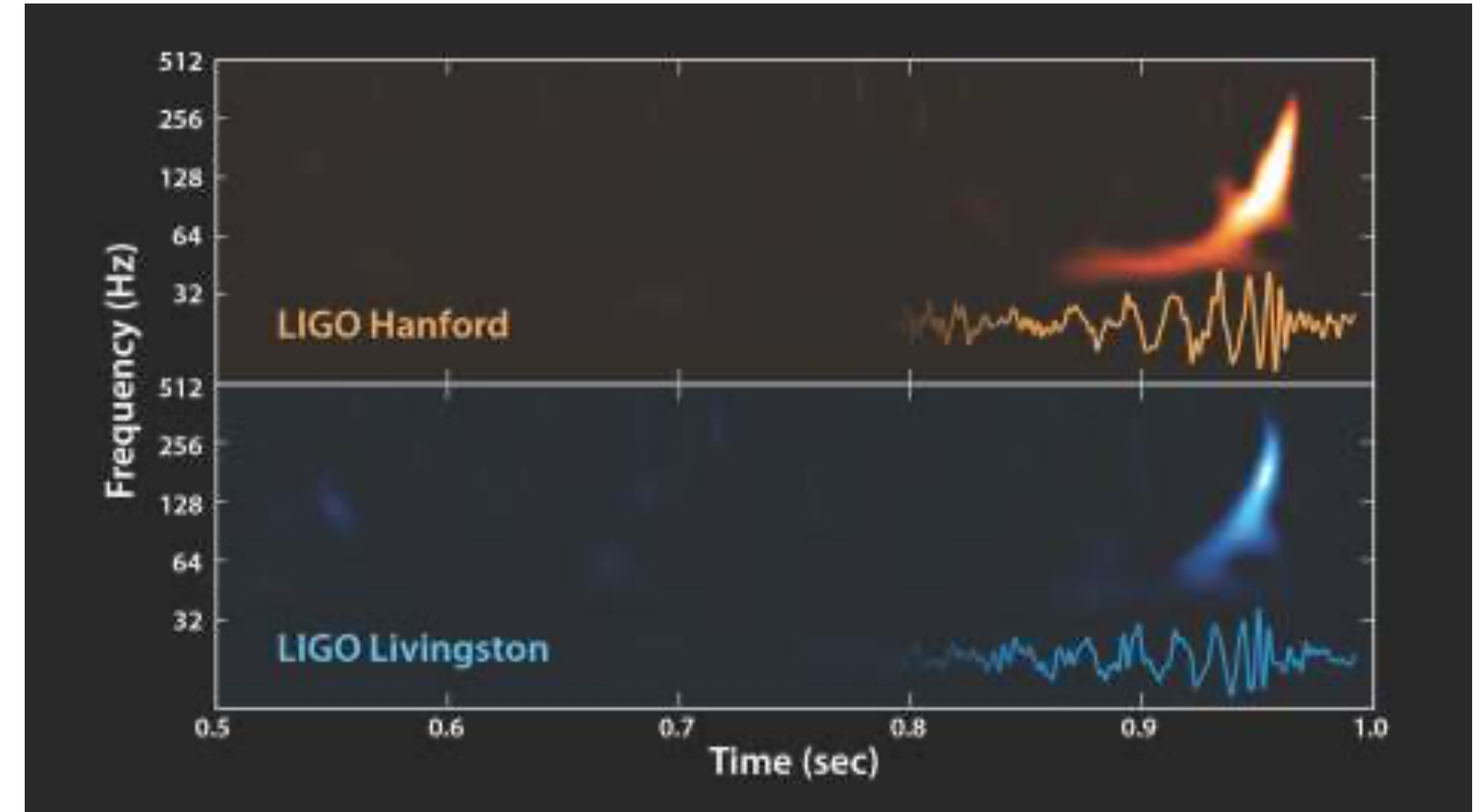


- Ripples through spacetime predicted by Einstein in 1916
- Generated by mergers of massive objects (but not exclusively)

# Gravitational waves



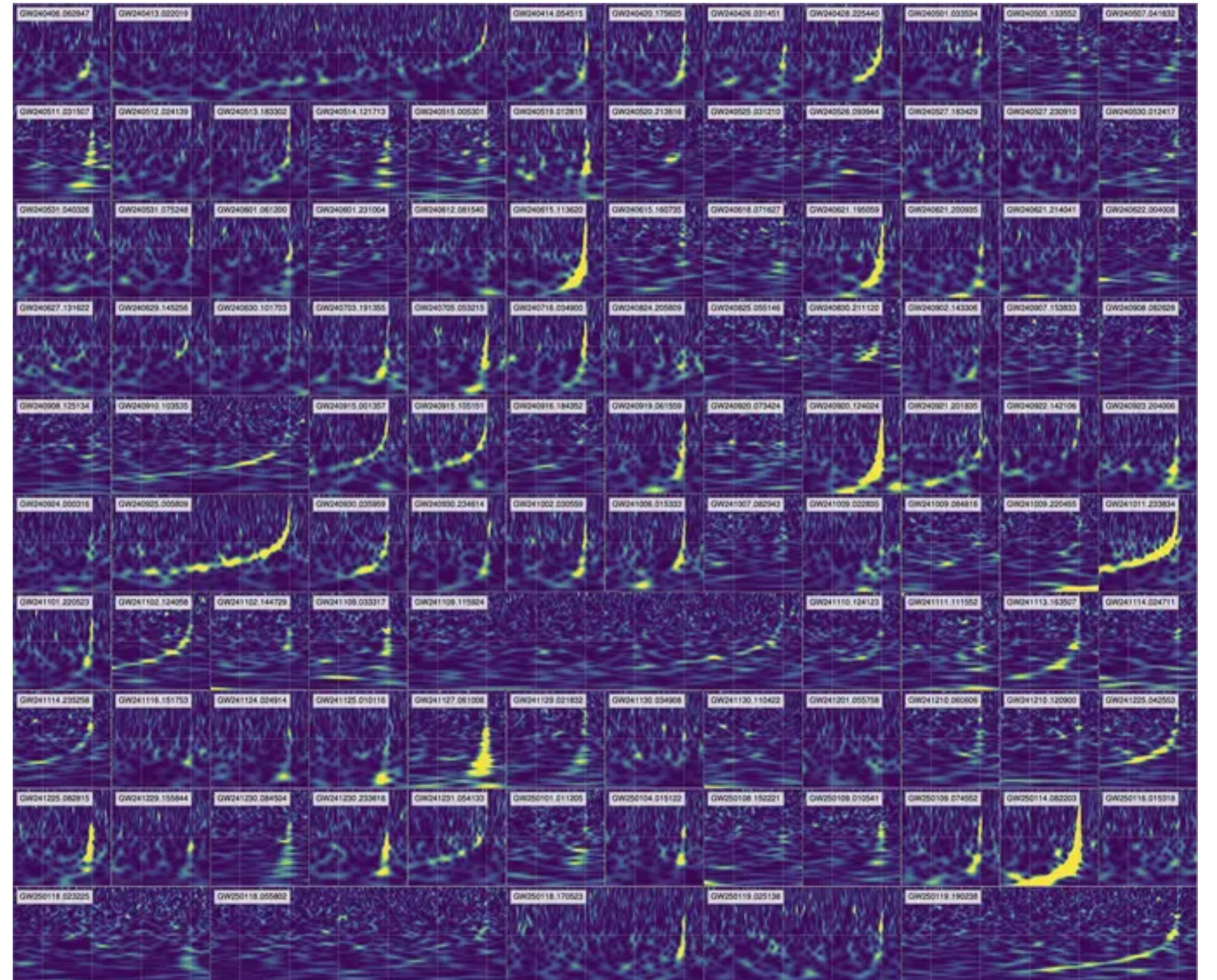
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First detection in 2015  
GW150914 from a binary black  
hole merger

# GWTC-5.0

Updated catalog of all gravitational wave events up to date announced on May 26th 2026

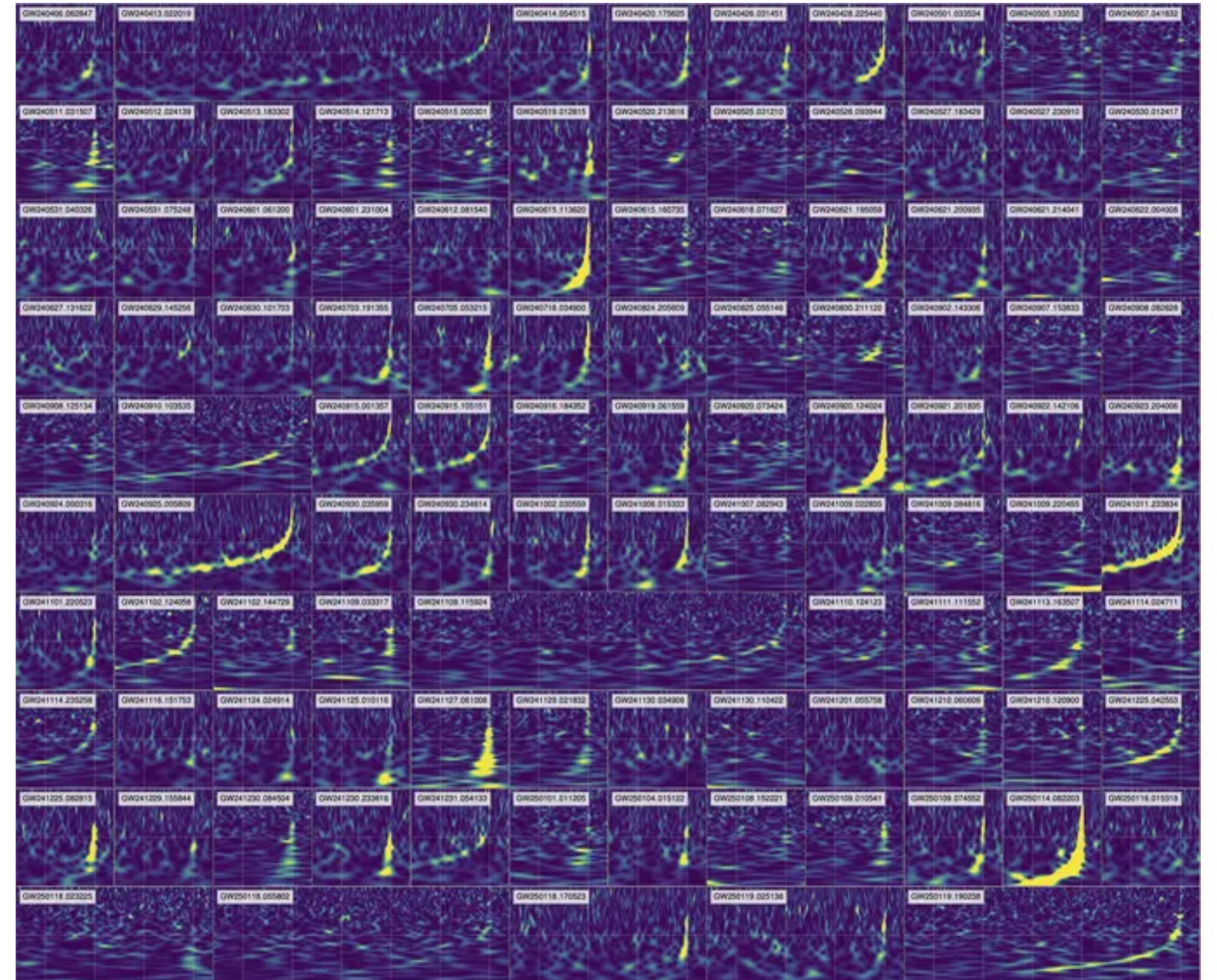


Spectrograms of all gravitational wave events in GWTC-5.0 found in O4b @ Derek Davis, University of Rhode Island, LIGO-Virgo-Kagra

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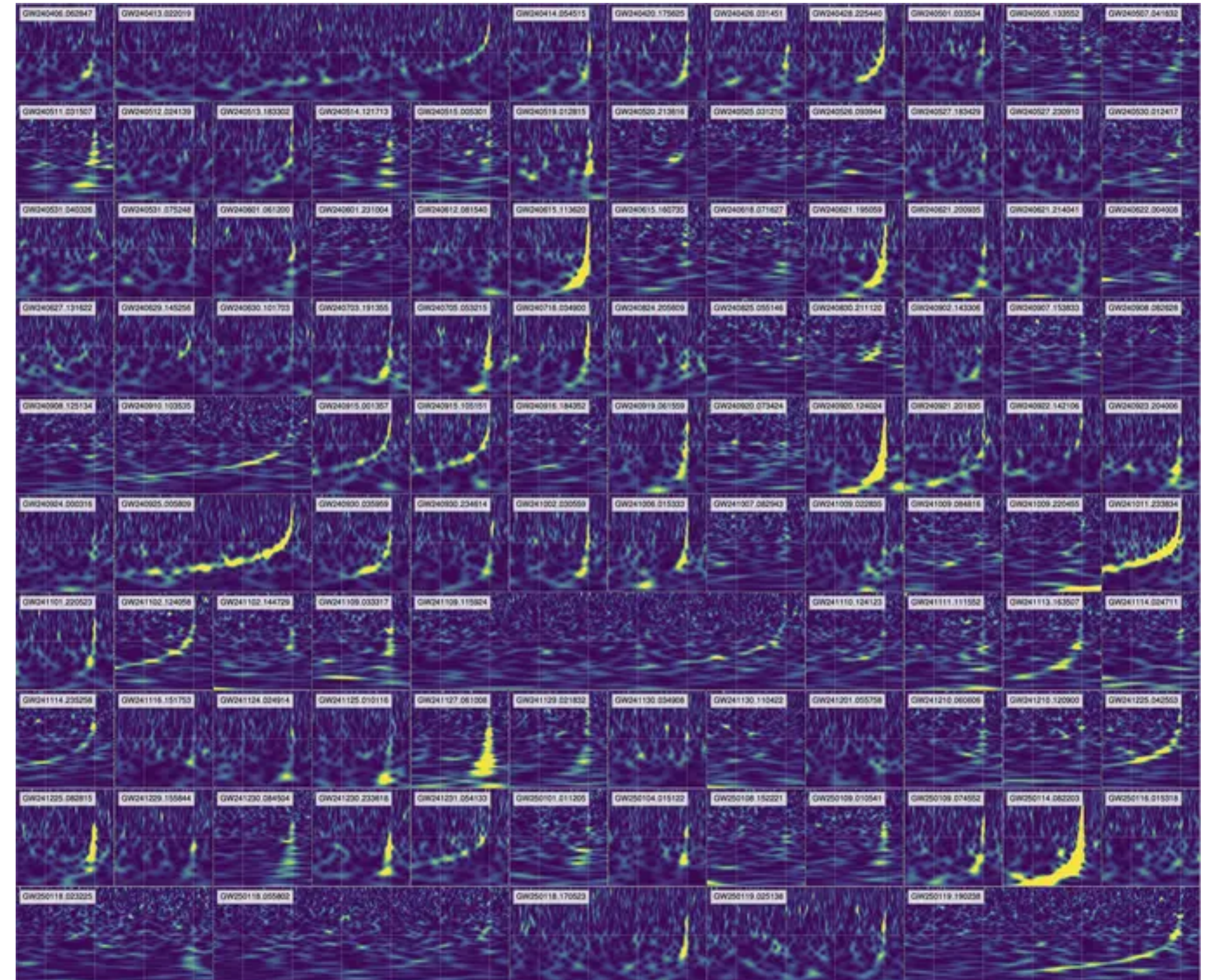


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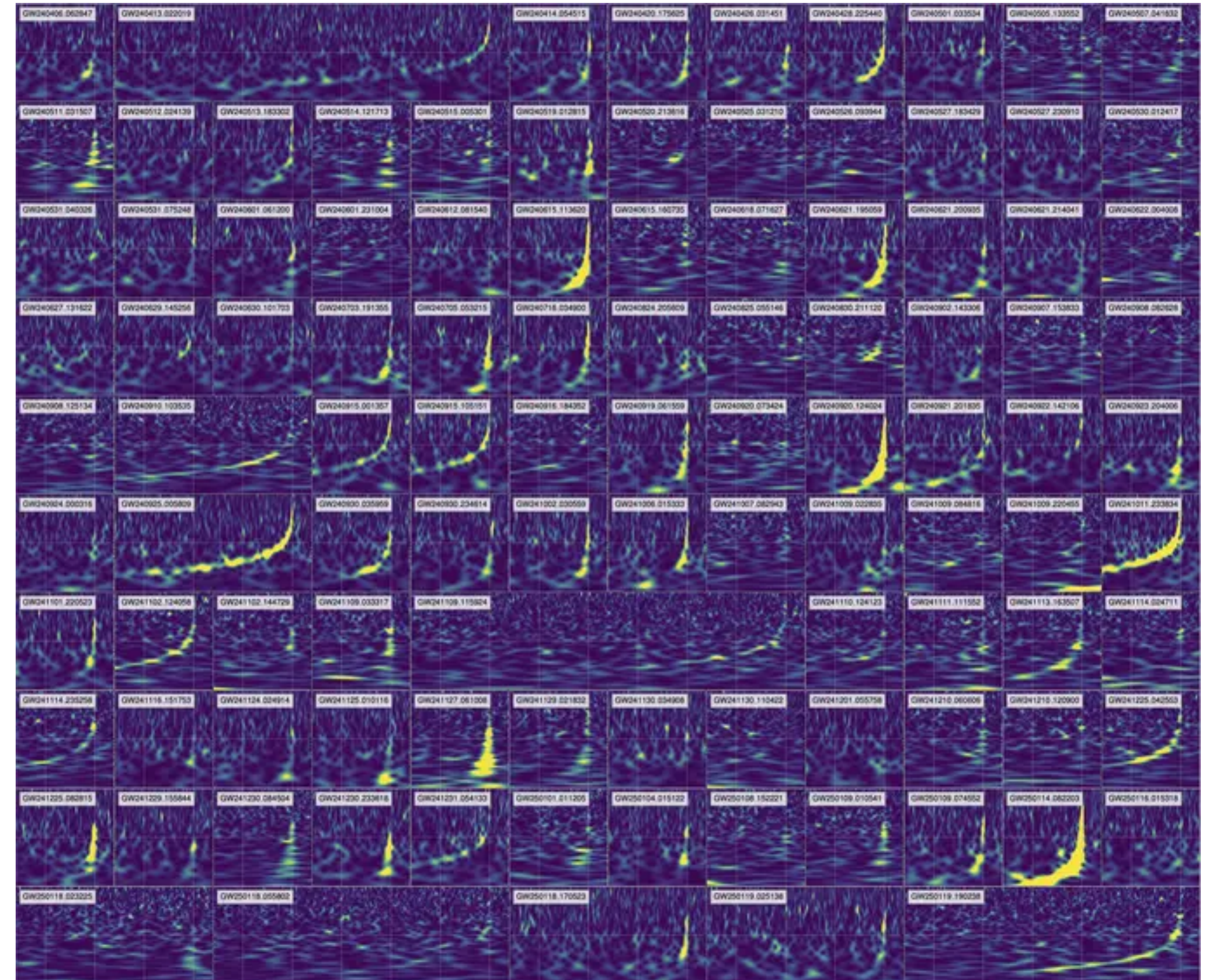


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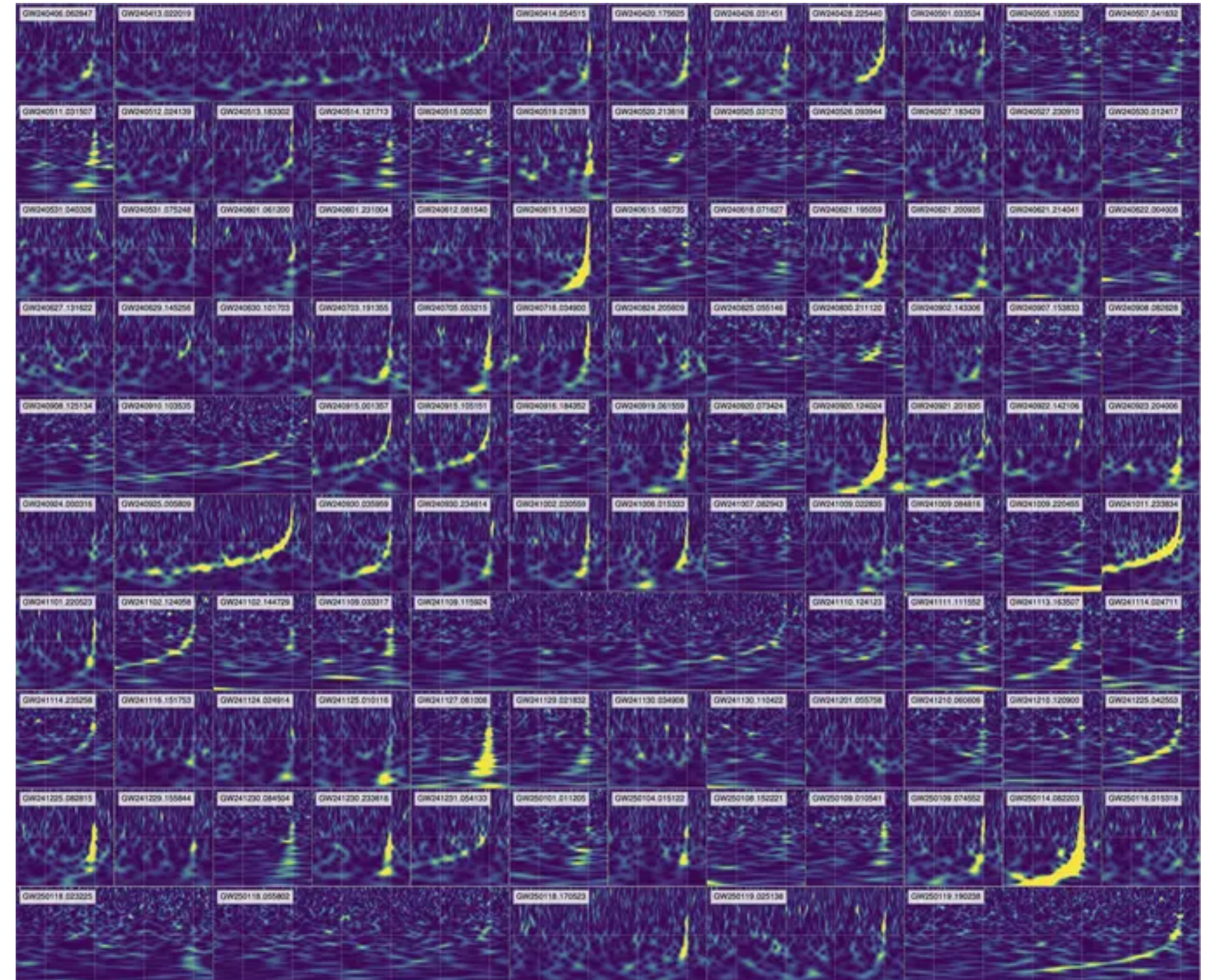


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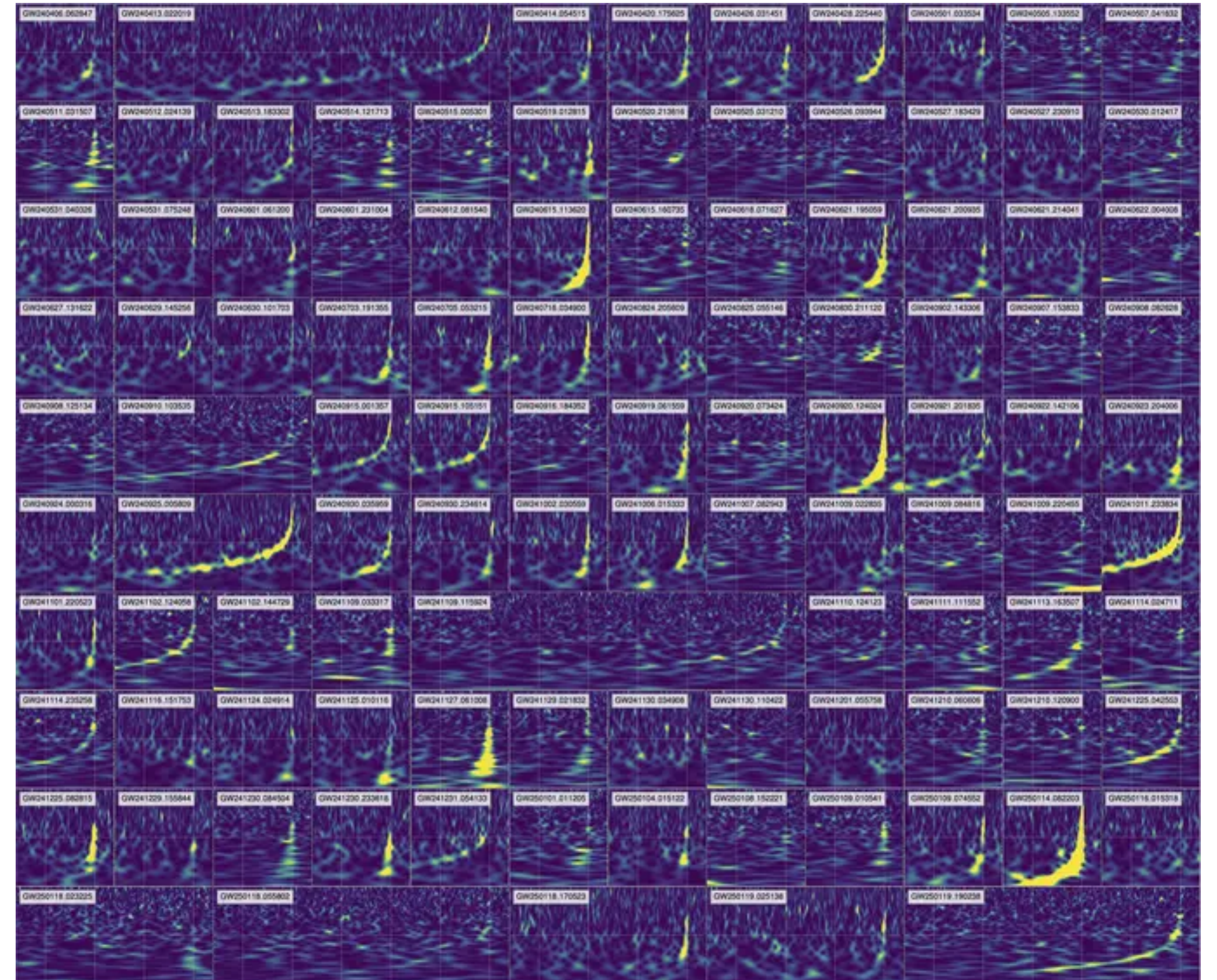


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- Most precise sky localisation (GW240615, 6 deg<sup>2</sup>)



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# **In the meantime the search continues**

**Short unmodelled / burst**

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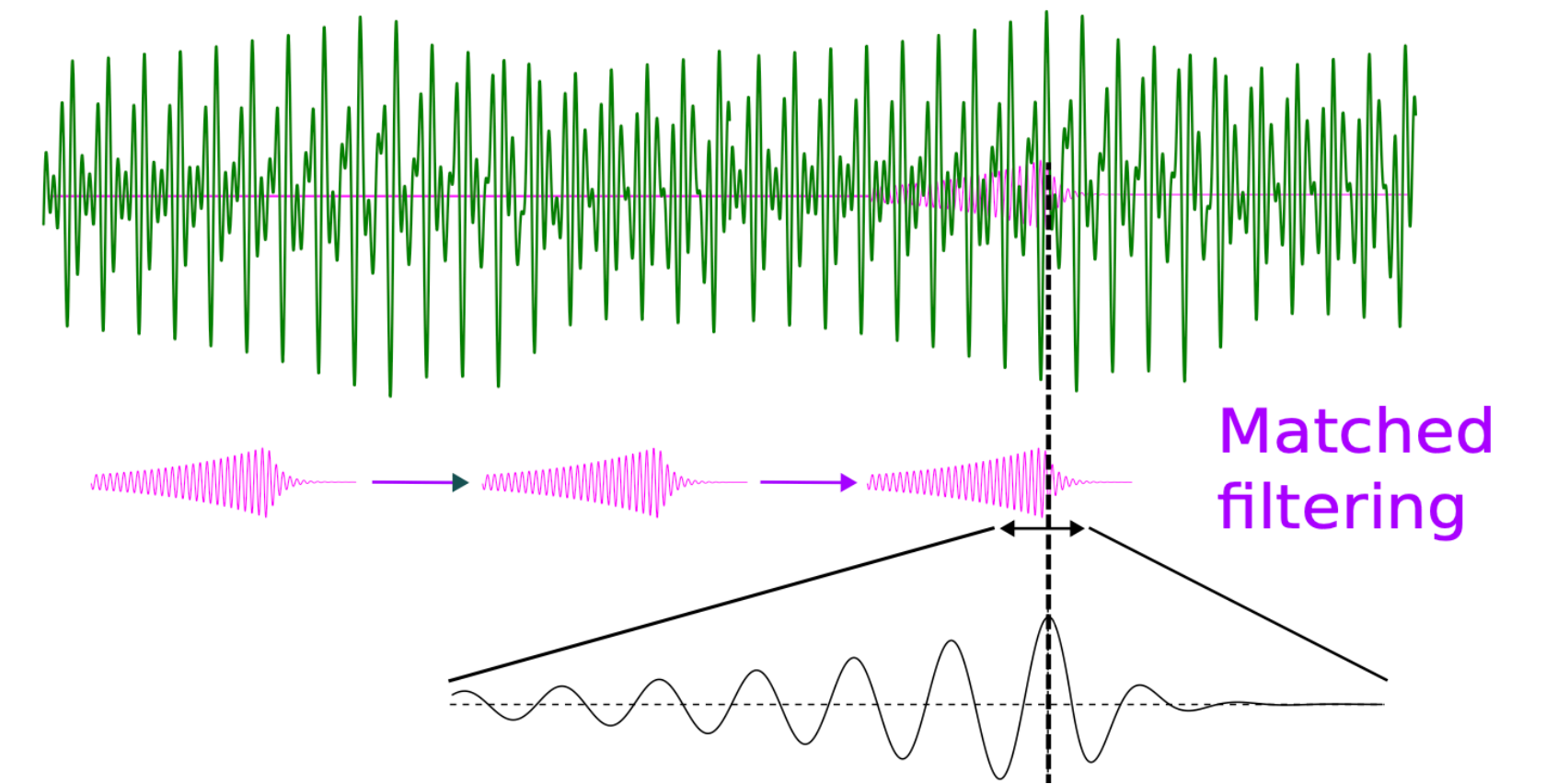
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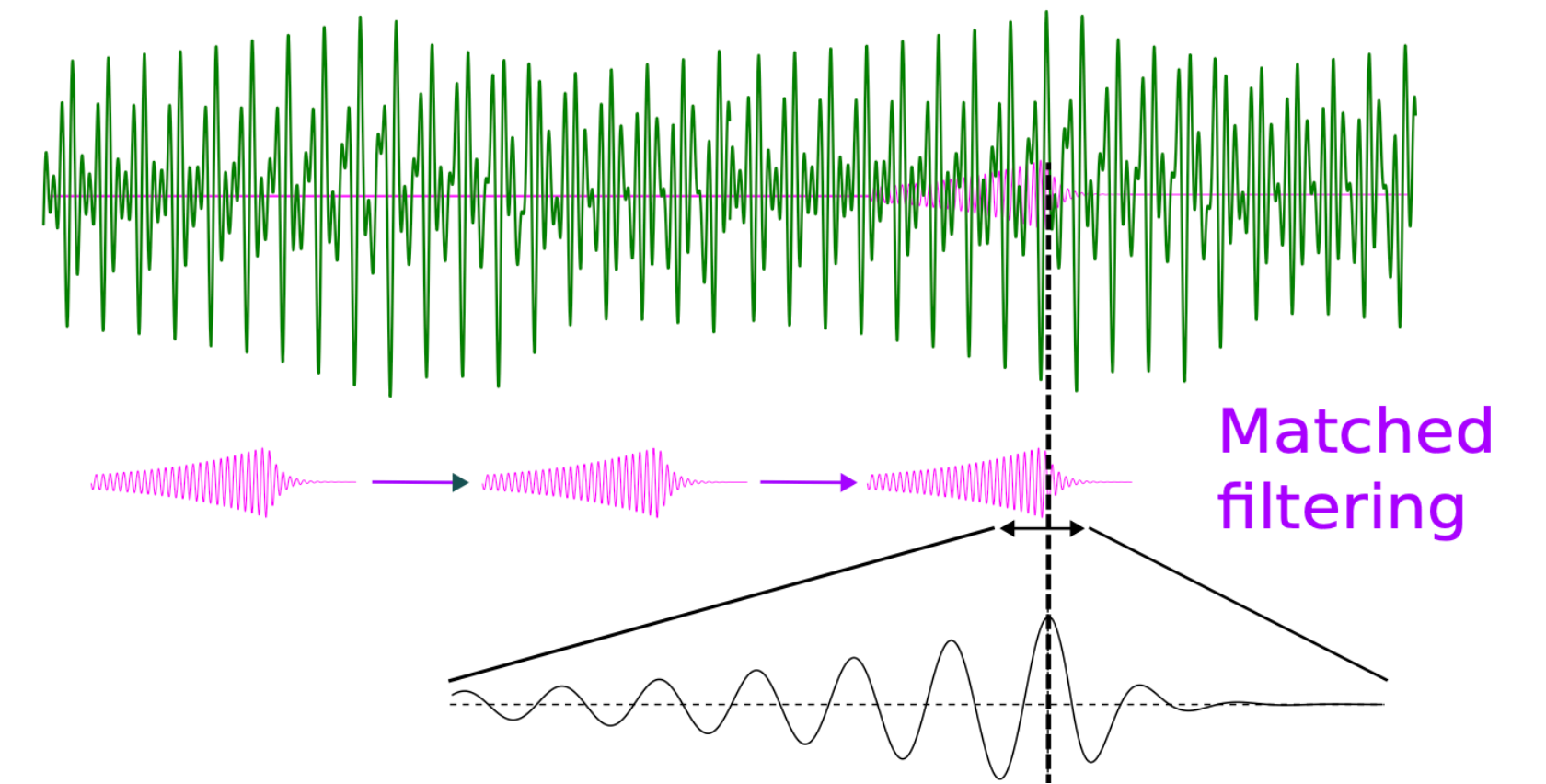
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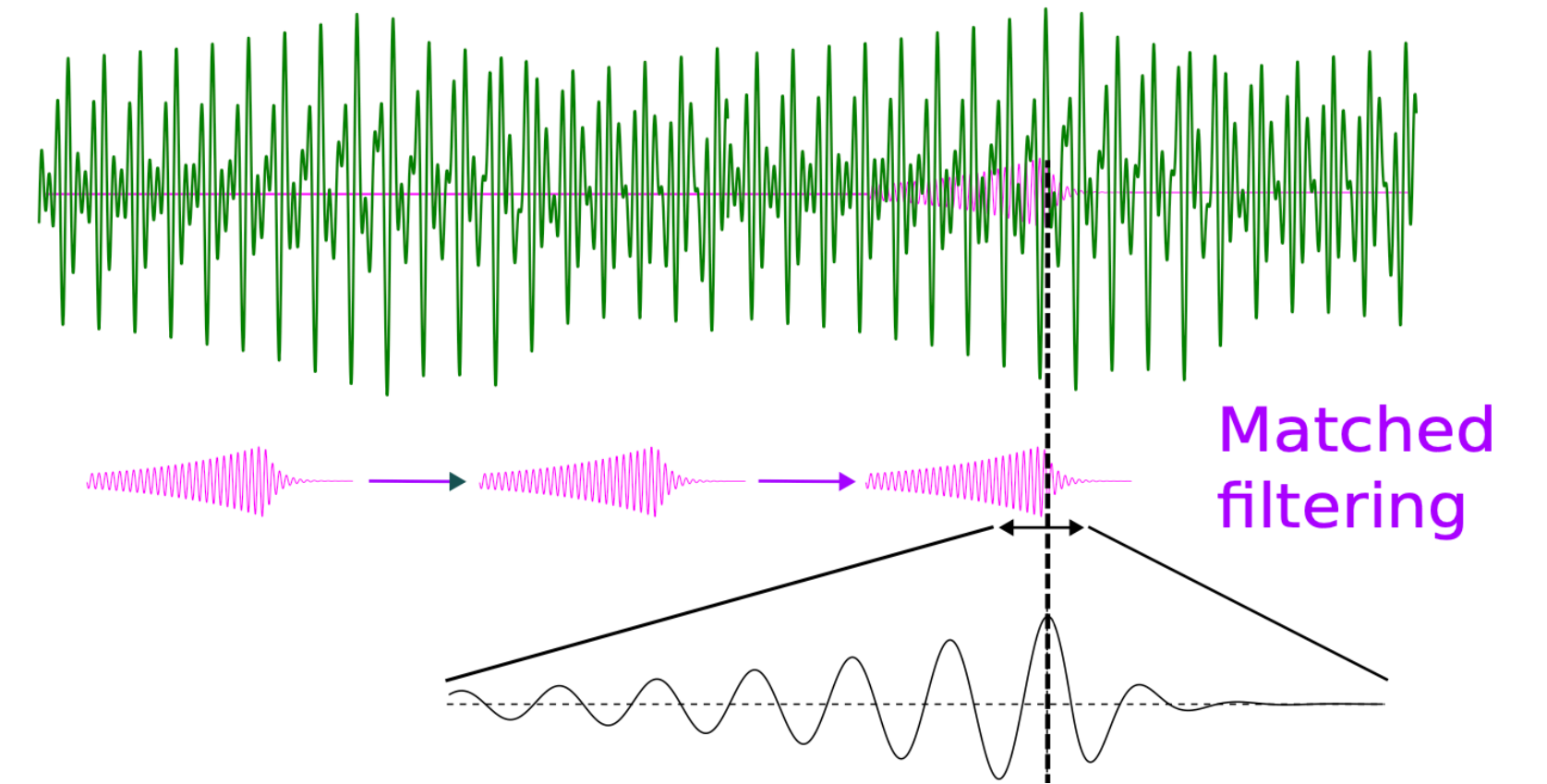
## Short unmodelled / burst

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### Matched filtering

- Cross-correlation between modelled signal template and strain
- Mathematically optimal way to detect gravitational waves



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CBCs are modelled well with relativity and Newtonian dynamics.

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What happens if:

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- Exotic or extreme black holes?
- Cosmic catastrophes?

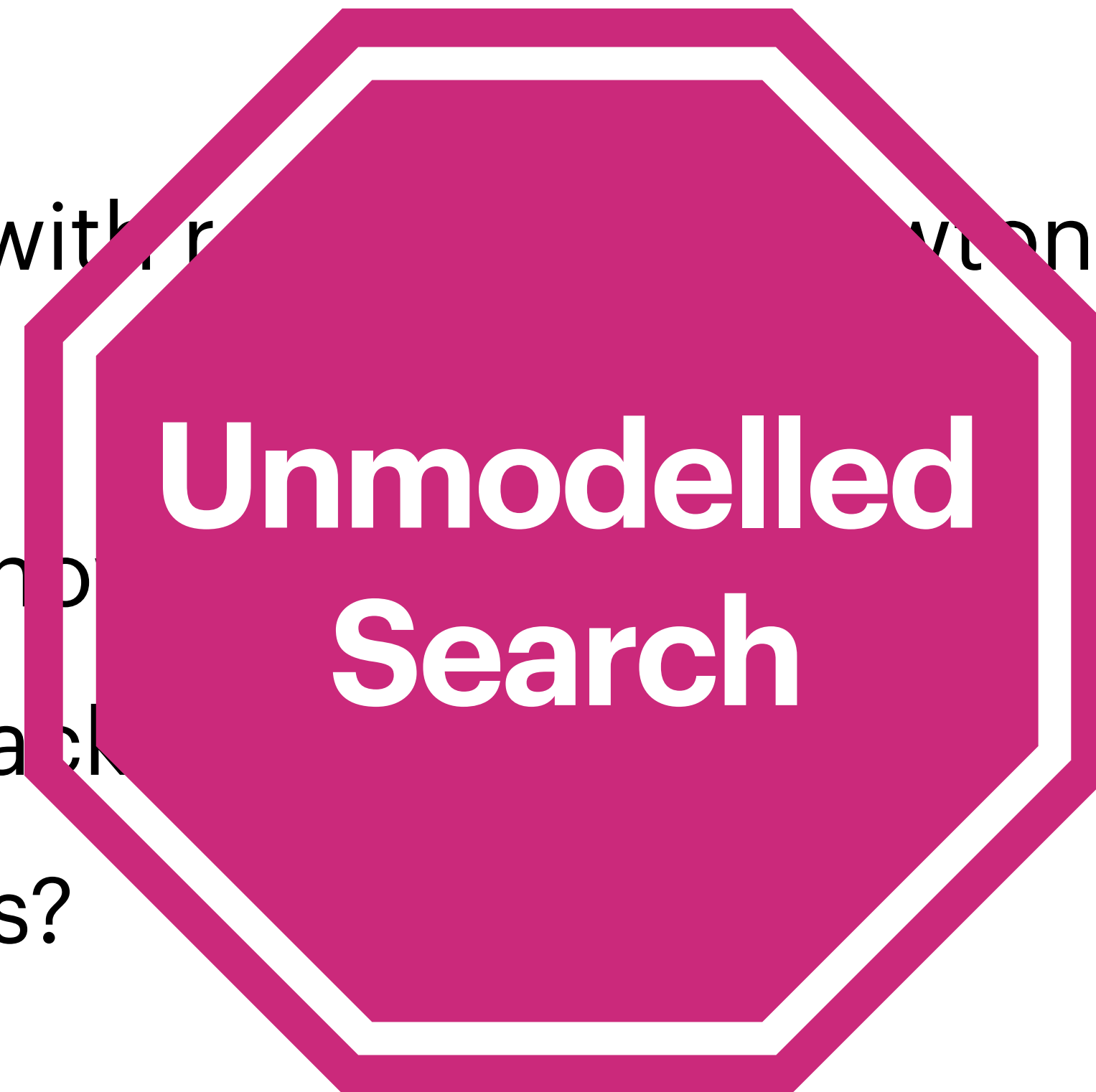
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Short unmodelled / burst

CBCs are modelled well with relativistic hydrodynamic dynamics.

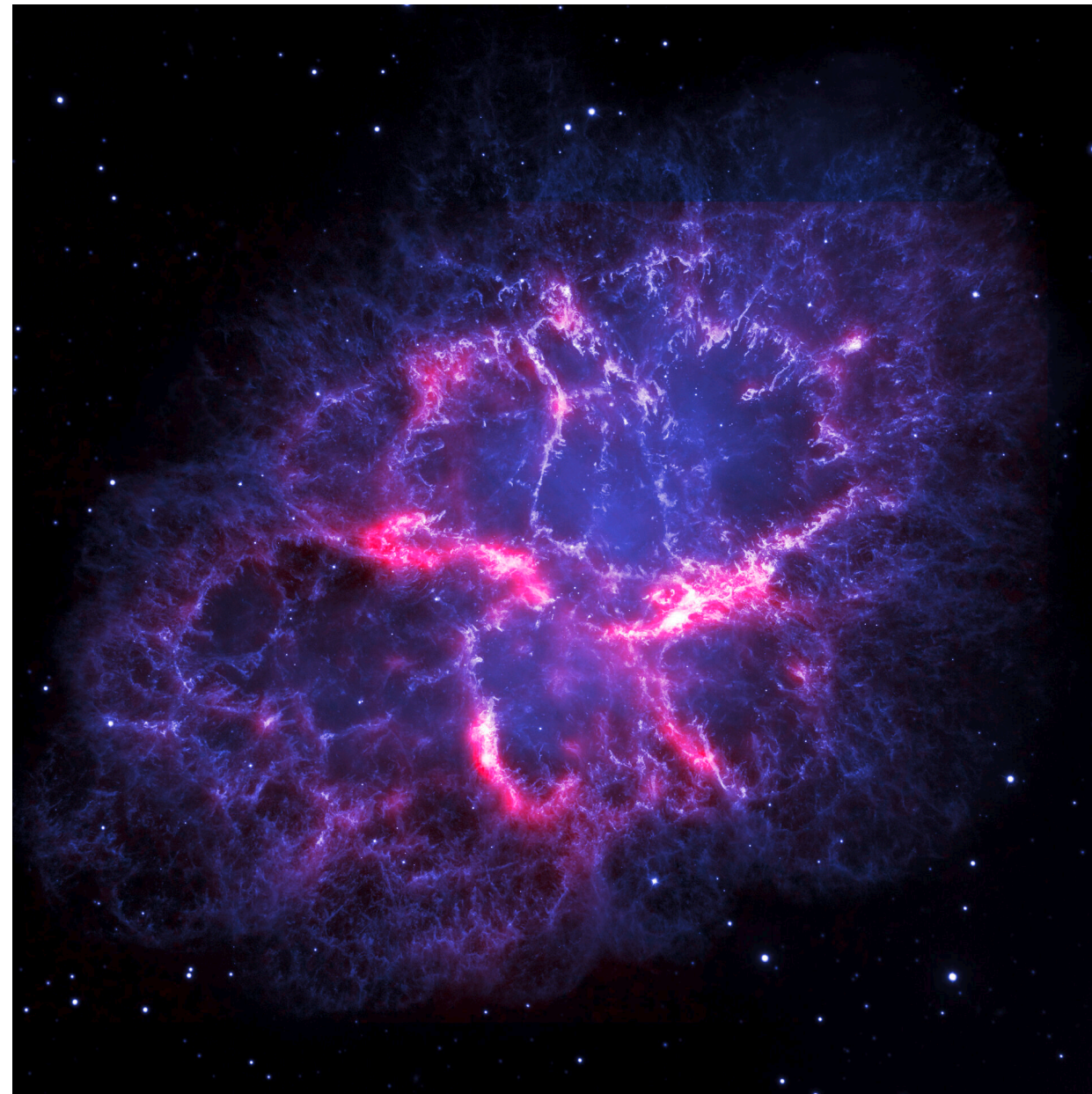
What happens if:

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- Cosmic catastrophes?



**What kind of signals are we looking for?**

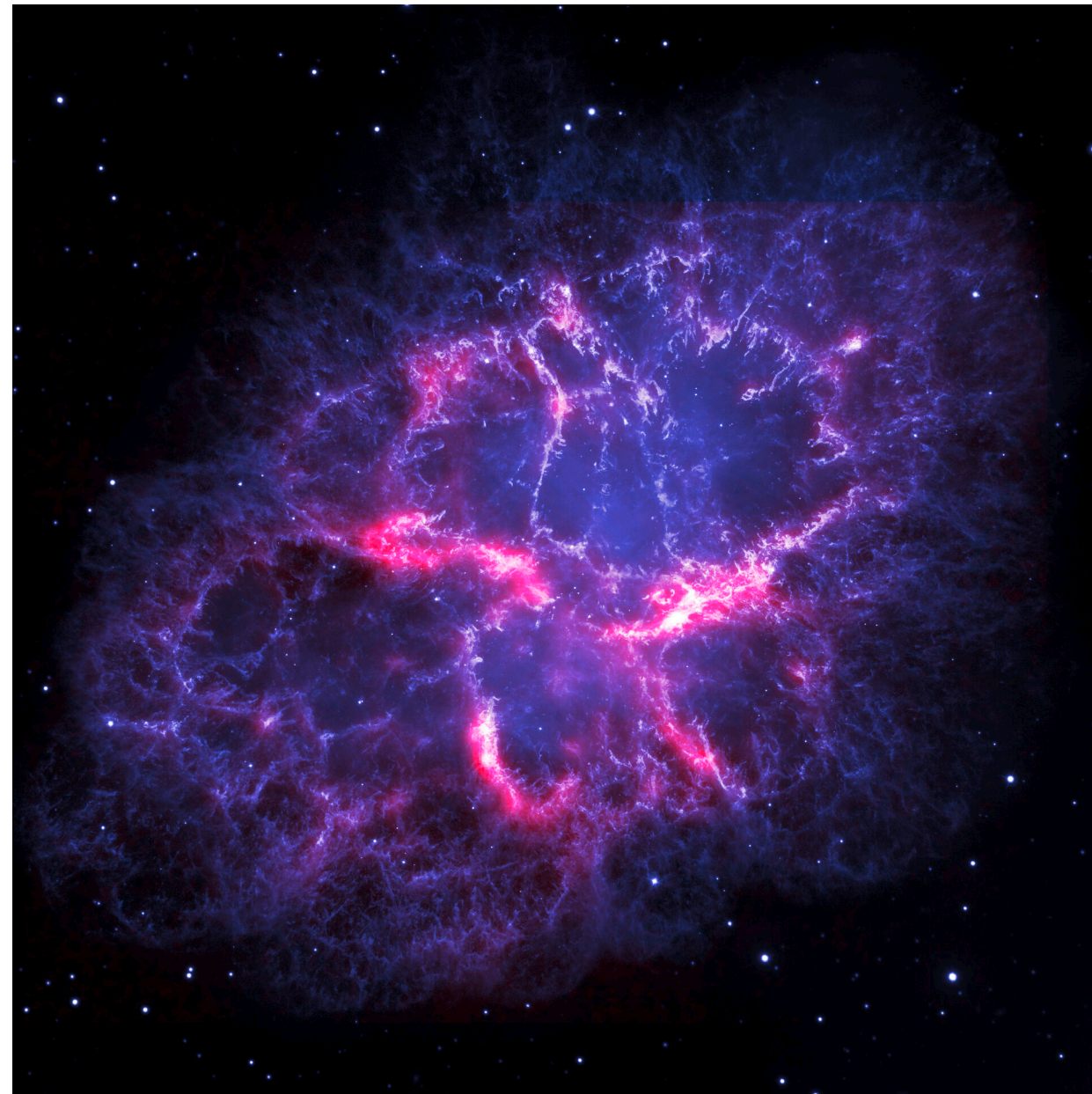
# What kind of signals are we looking for?



Core-collapse supernova remnant

Credit: ESA/Herschel/PACS/MESS Key Programme Supernova Remnant Team; NASA, ESA and Allison Loll/Jeff Hester (Arizona State University)[3]

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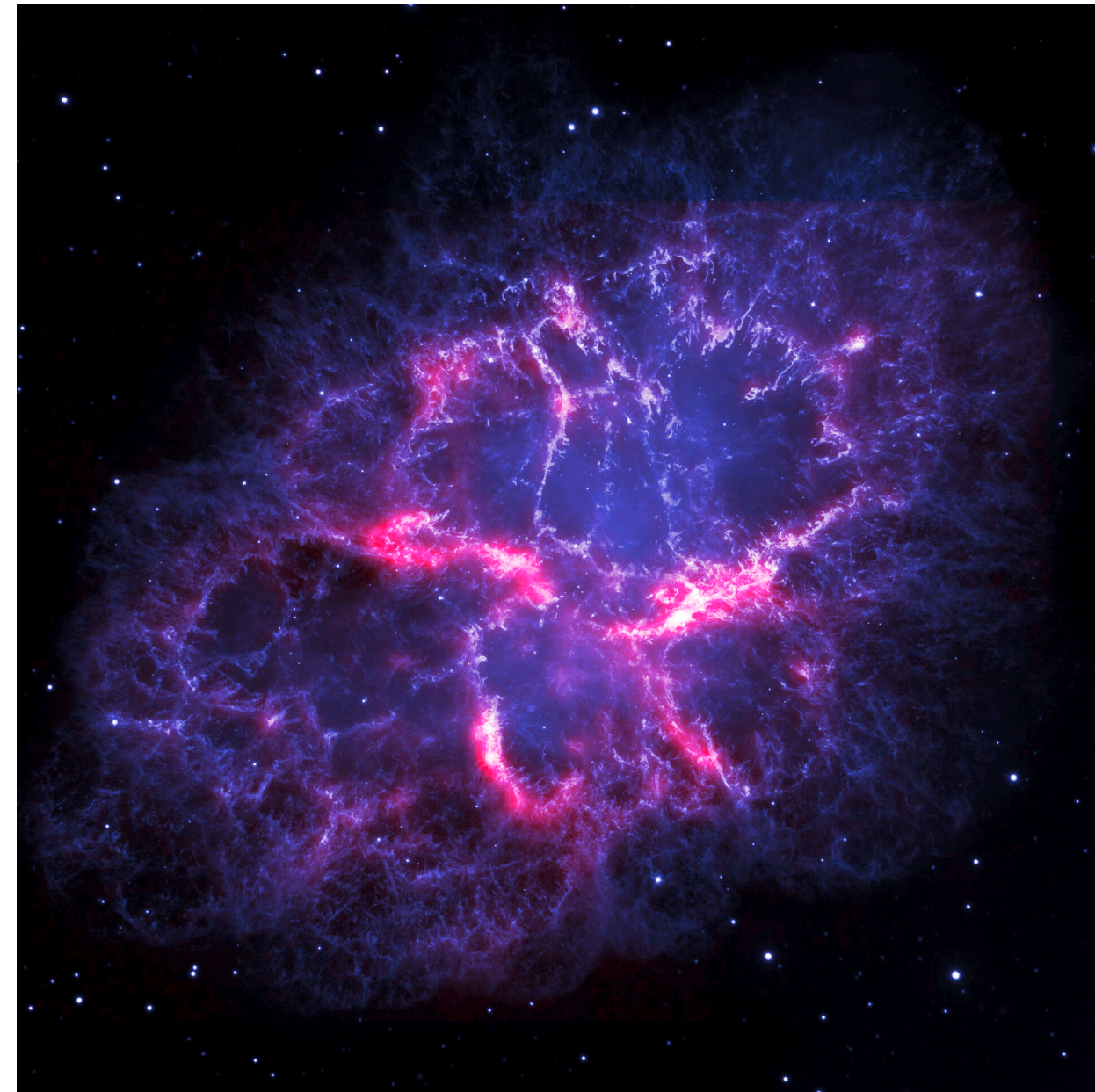


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Artistic conception of a magnetar  
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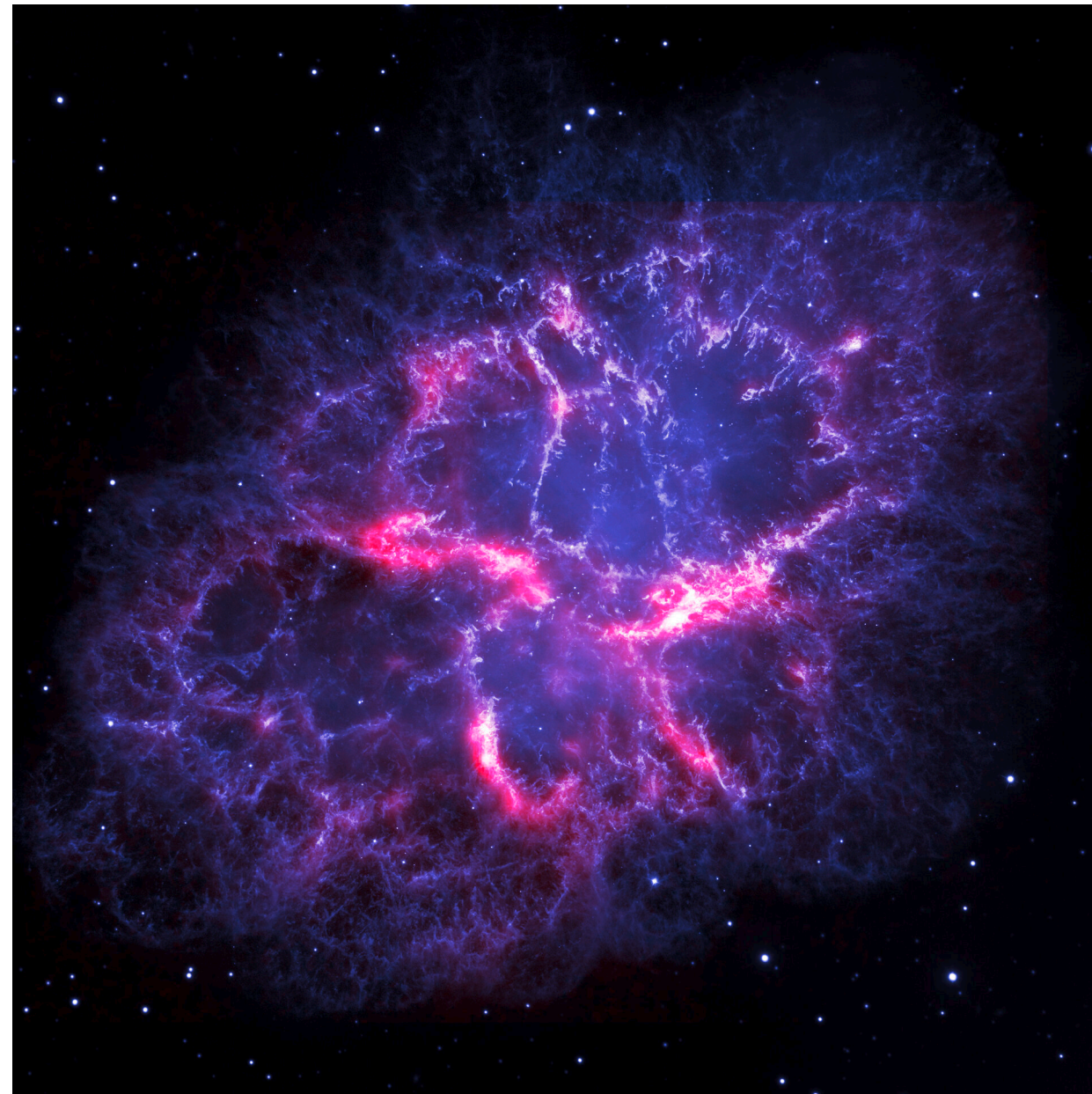


Artistic conception of a magnetar  
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Artistic conception of a starquake  
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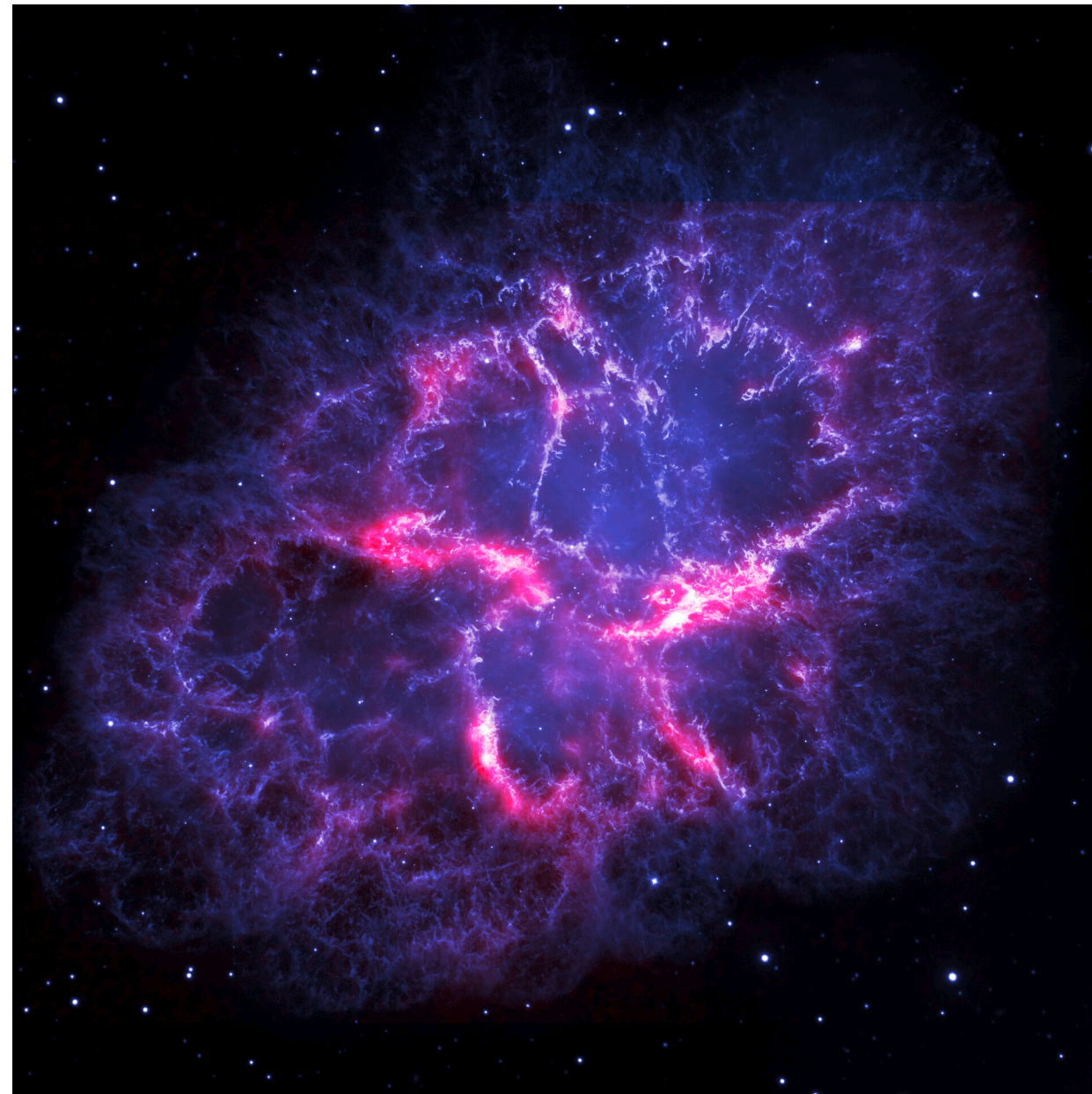


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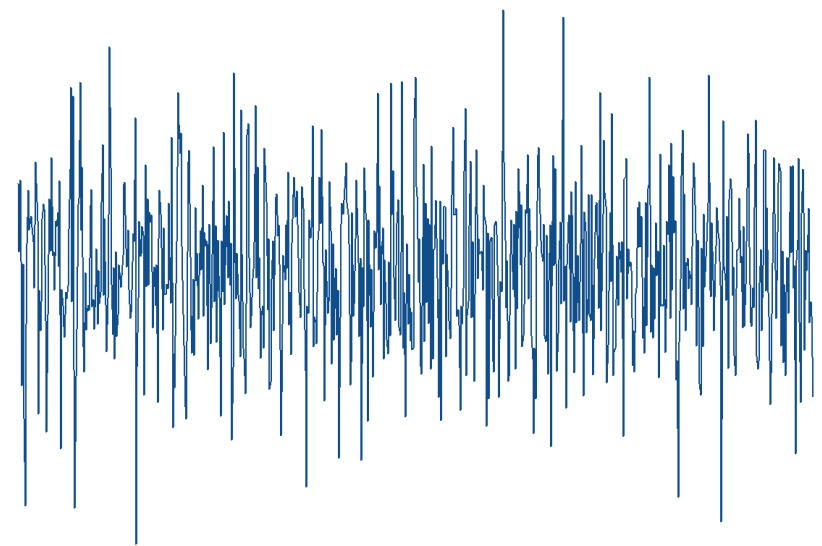
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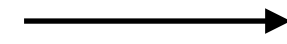
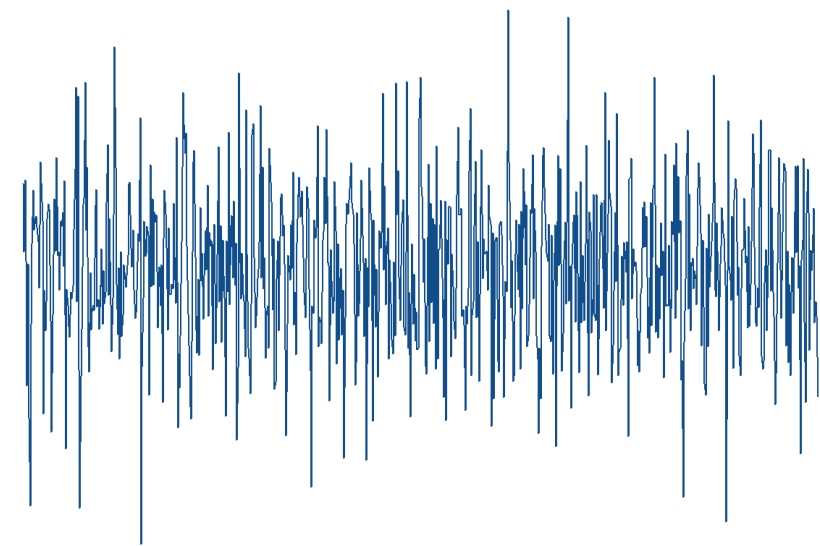
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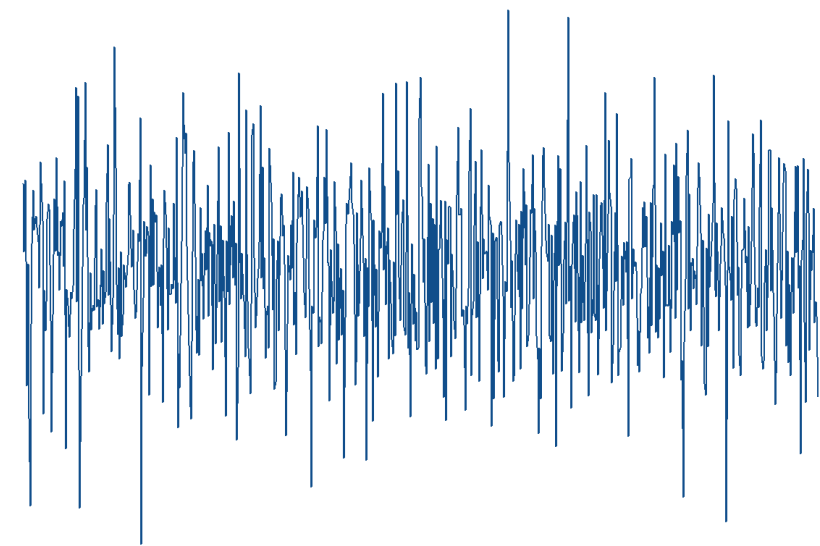


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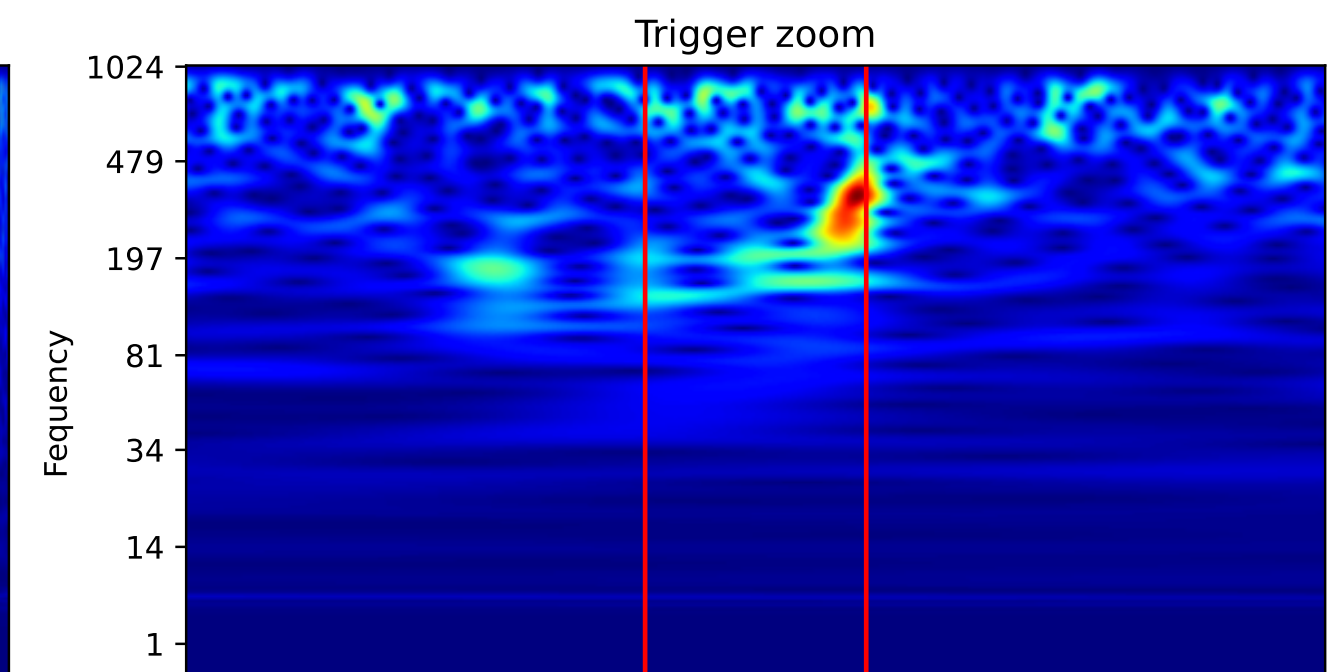
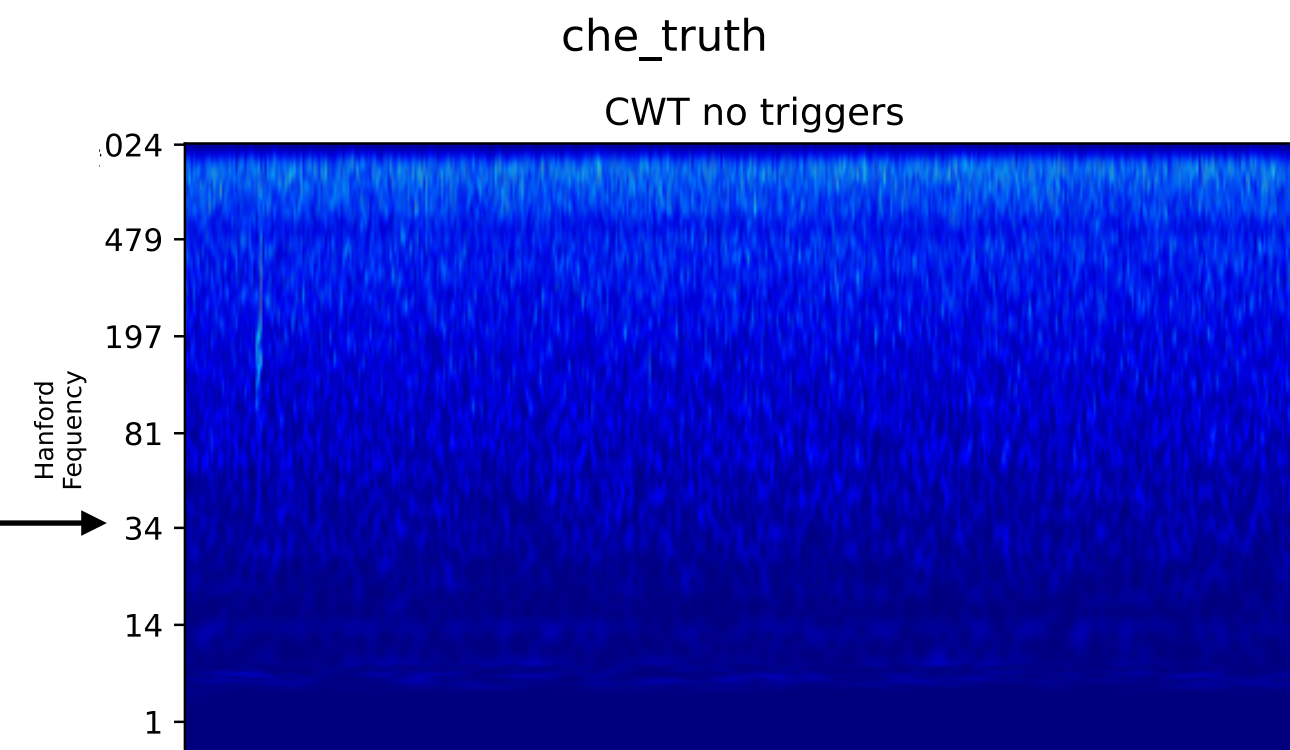


**Lightweight  
analysis:  
"There is  
something  
interesting  
happening at  
this moment in  
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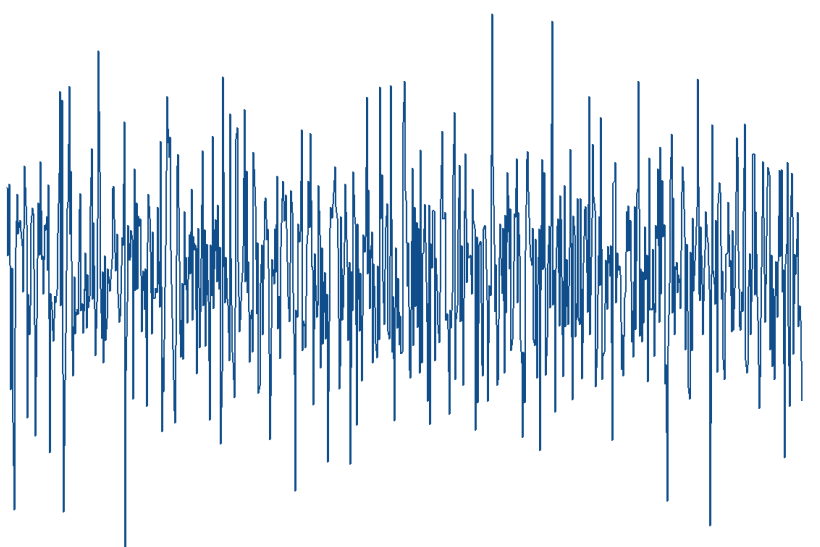
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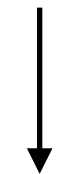
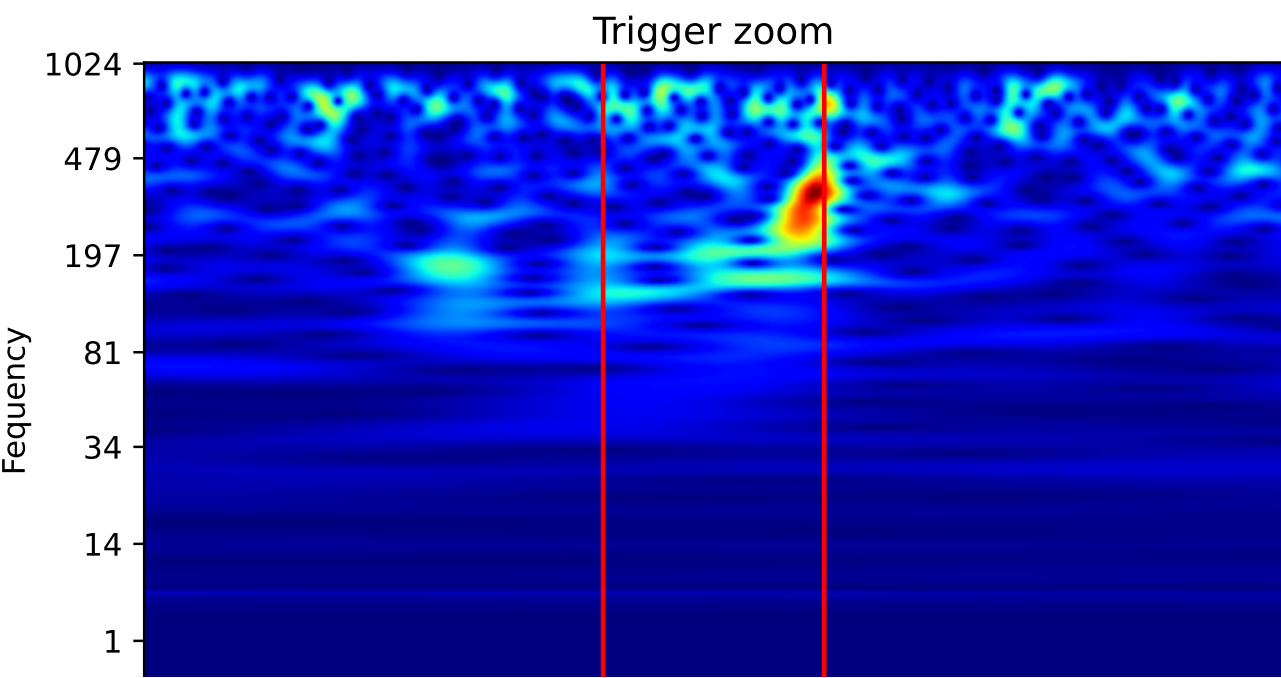
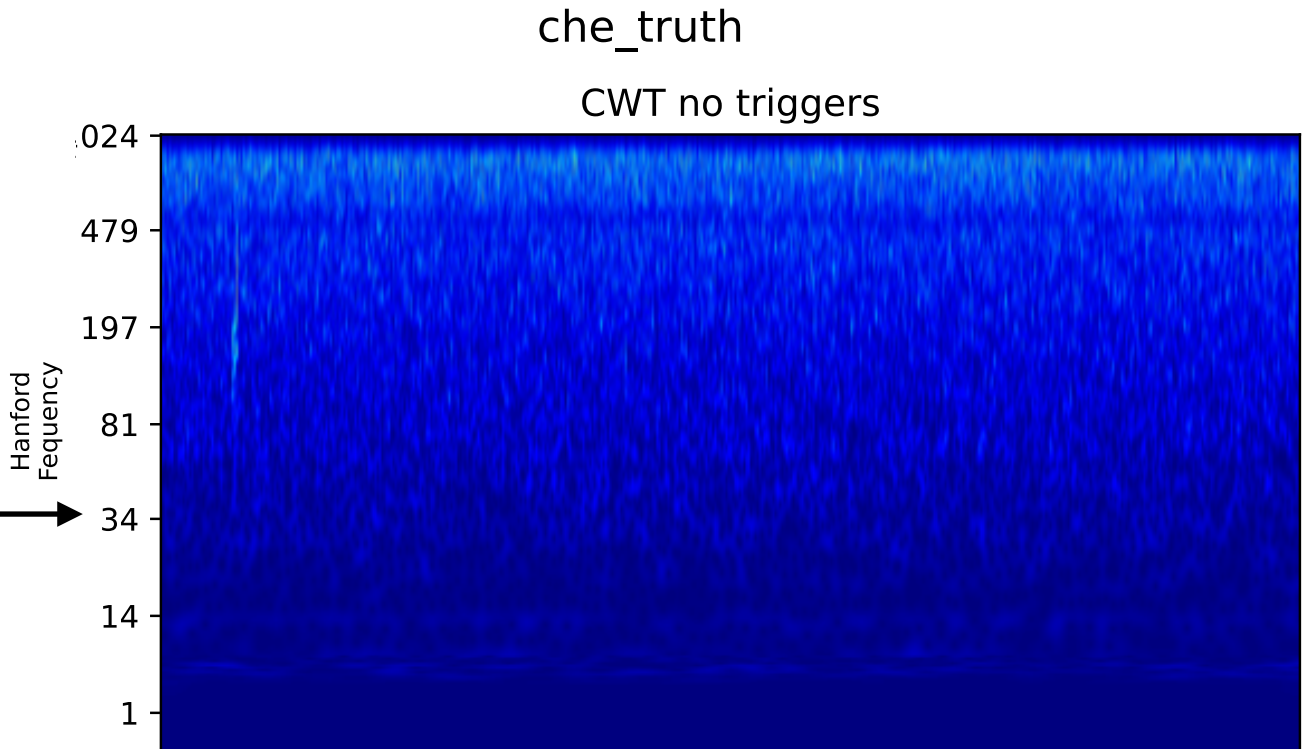
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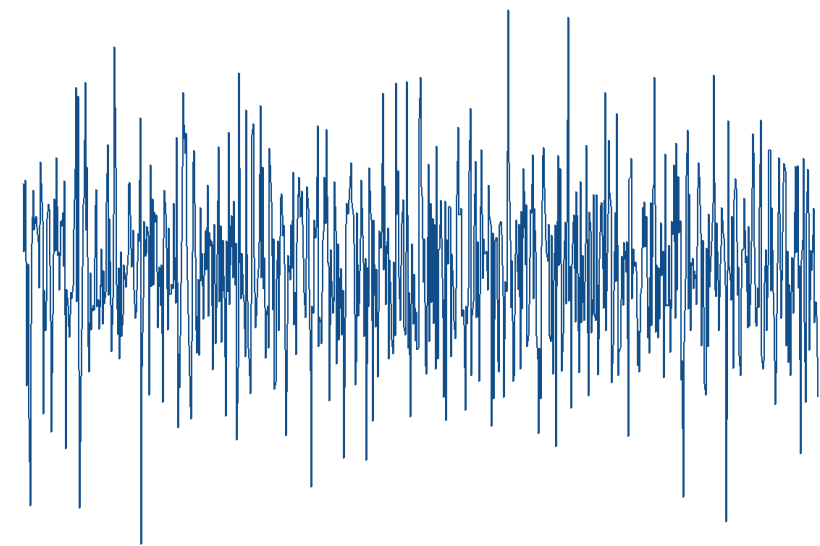


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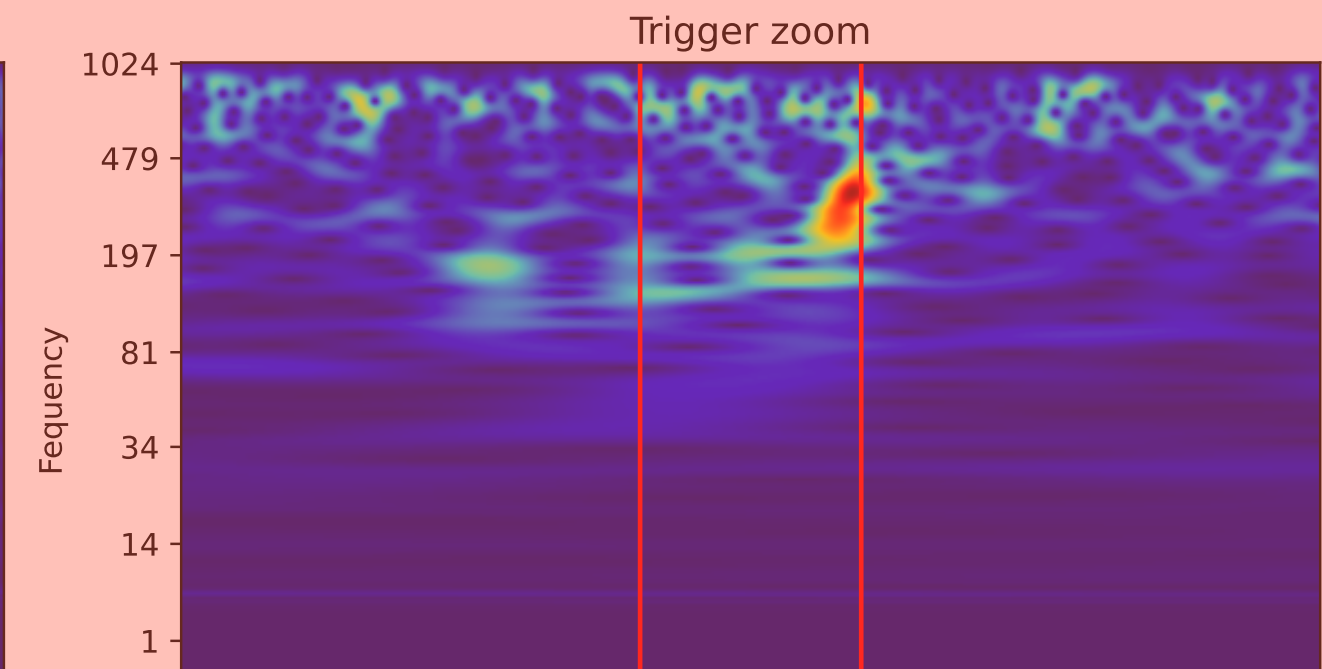
**Heavy analysis**

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**Block one**



**Heavy analysis**

# **Block one**

**Lightweight analysis and spectrograms**

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- Needs to be fast, cheap and reproducible

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Transformation function

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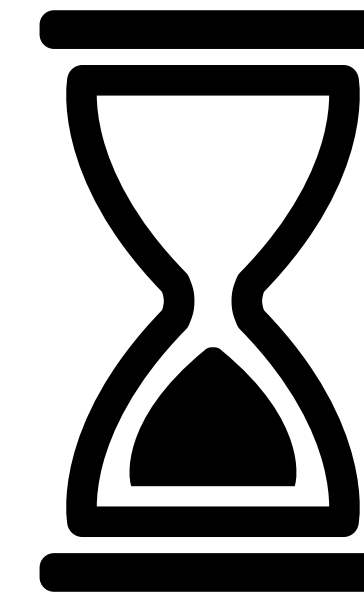
# Block one

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Transformation function



TFD: time - frequency domaine  
TD - time domaine

- Wilson-Daubechies-Meyer wavelets in TFD
- Q-transform excess of energy in TFD
- Wavelet transformation in TD

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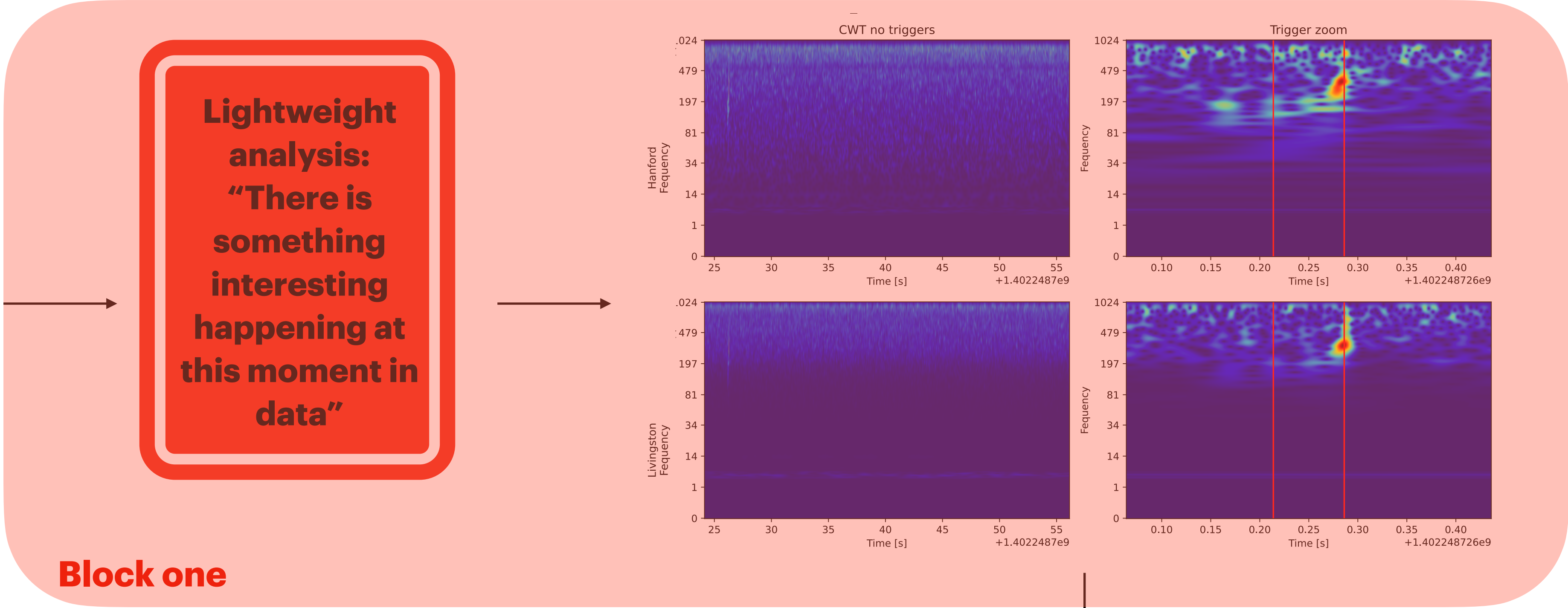
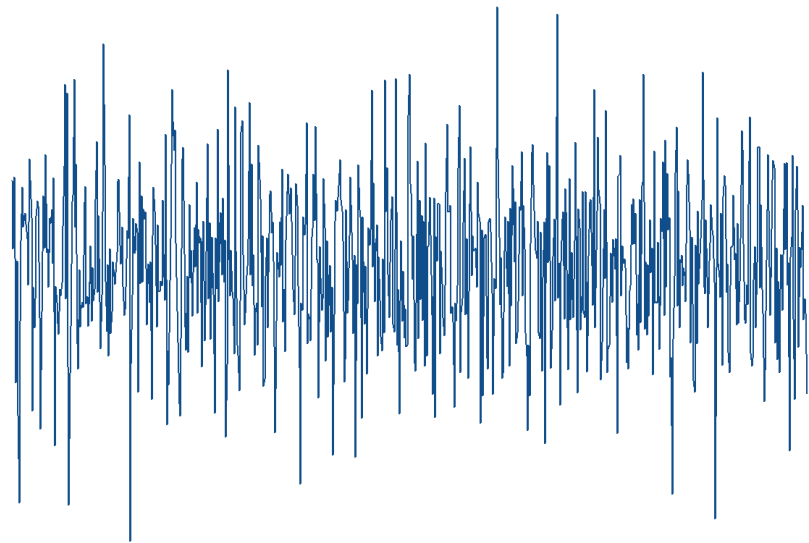
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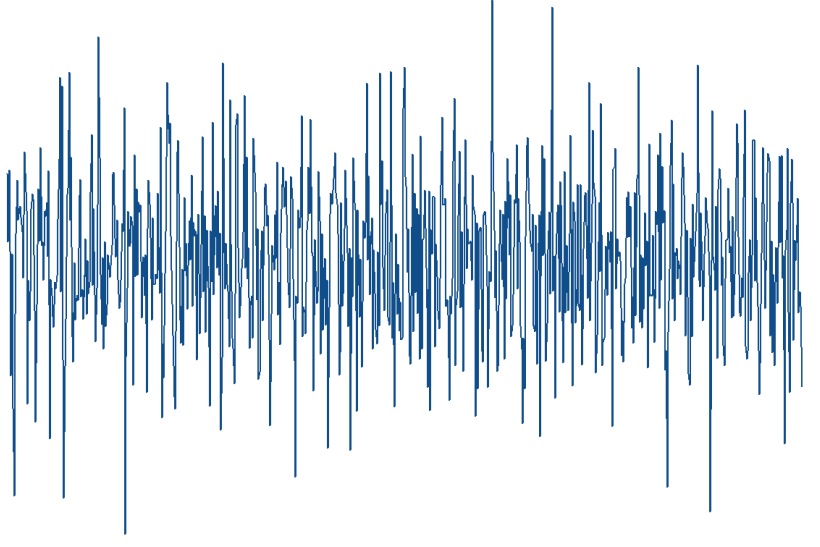
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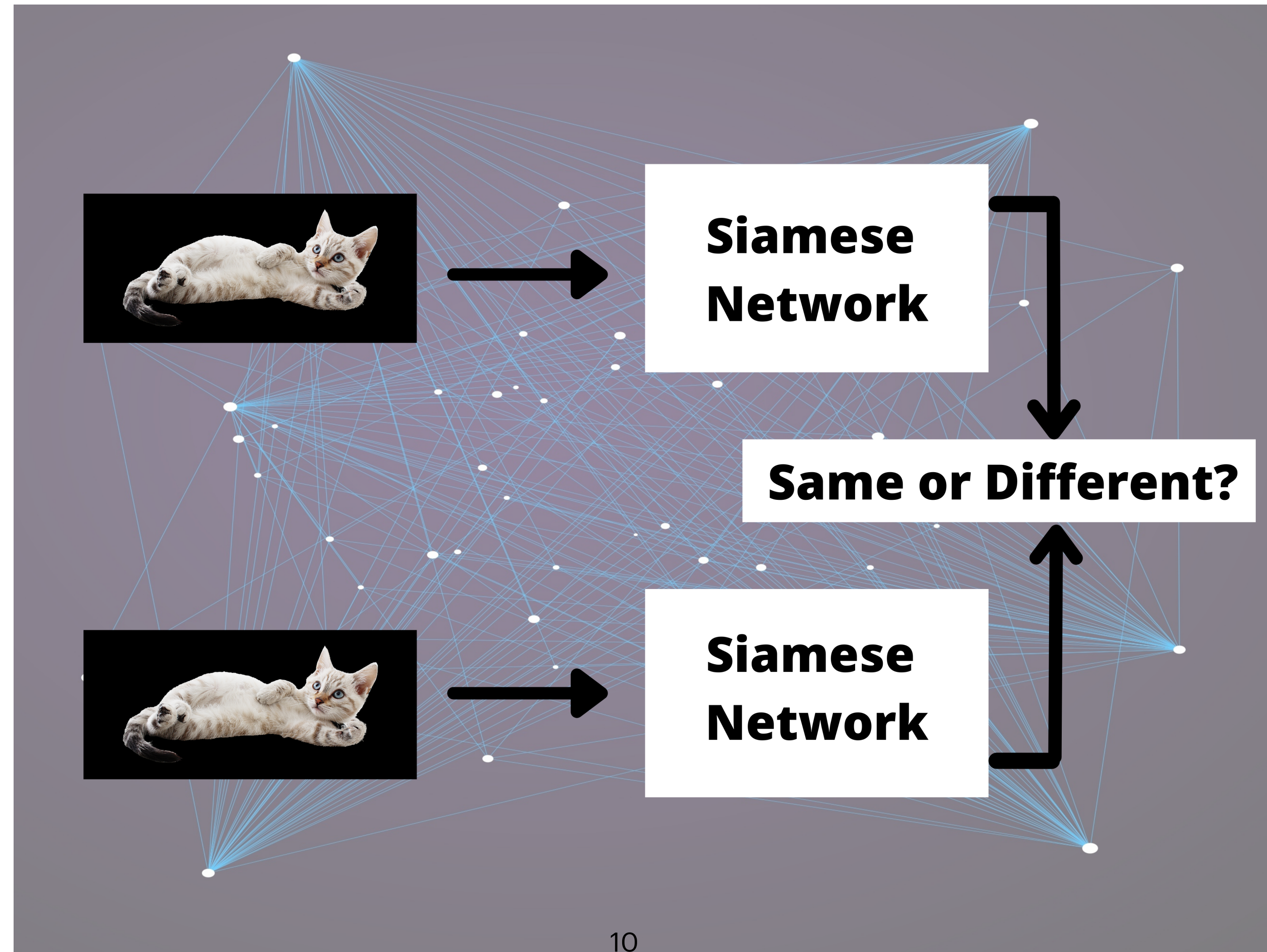
**Block one**

**Heavy analysis**

**Block two**

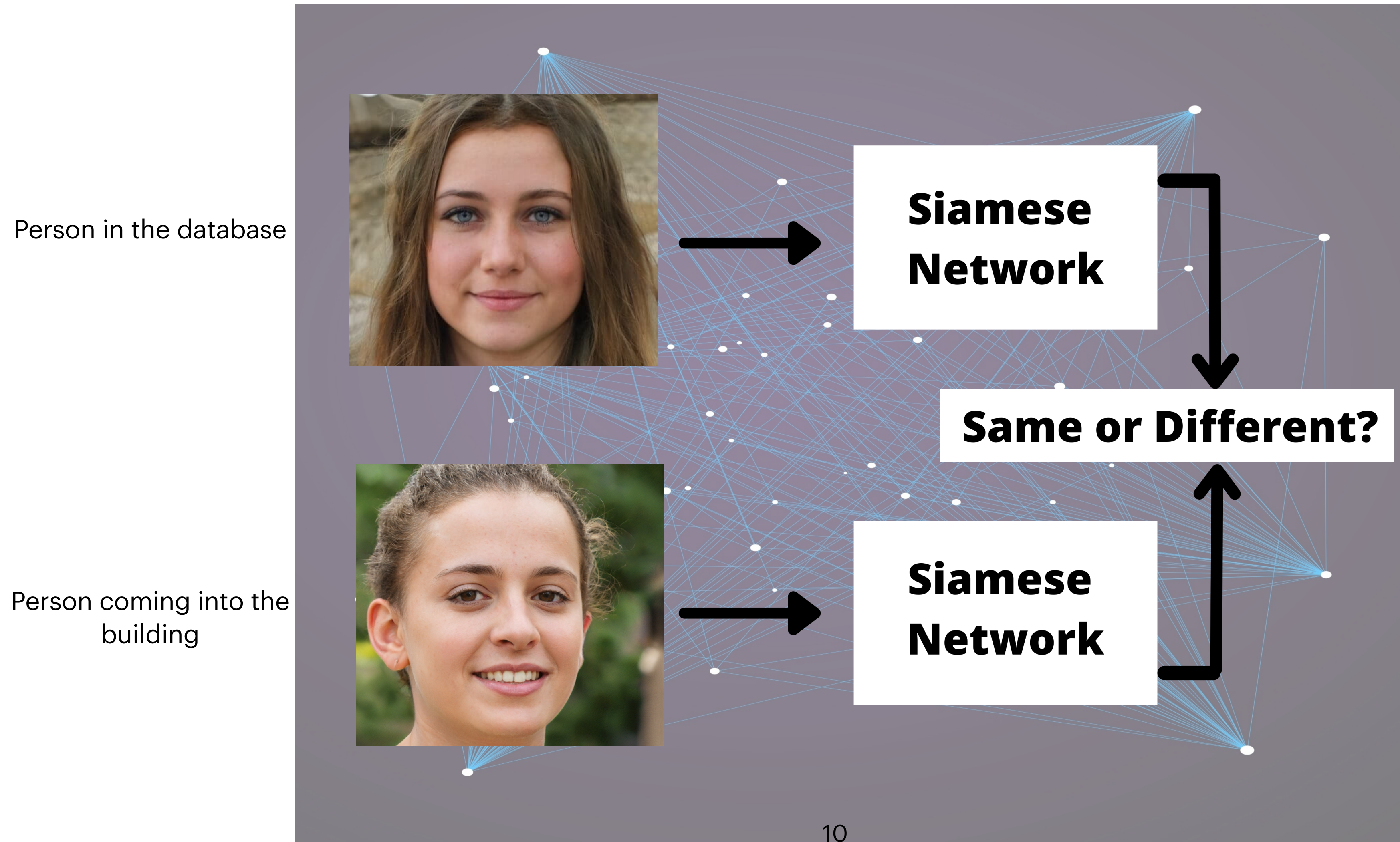
# Block two

## Siamese convolutional neural network



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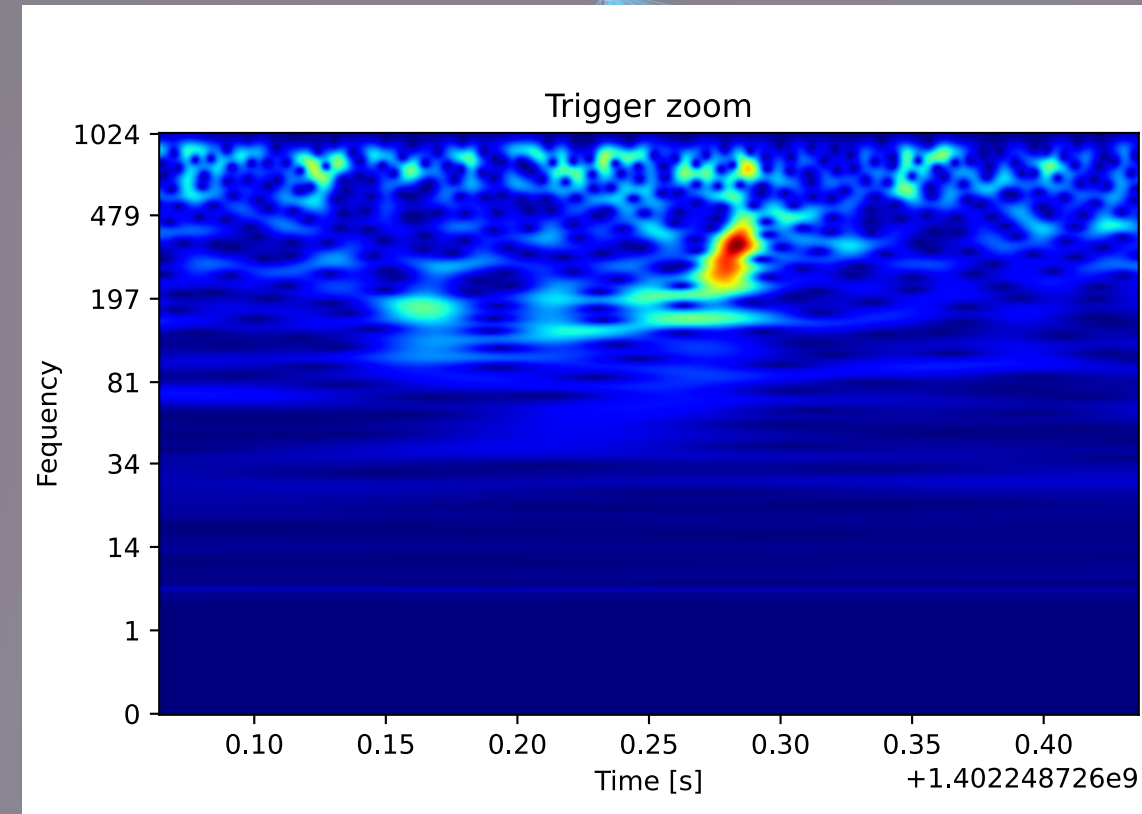
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# Block two

## Siamese convolutional neural network

Hanford

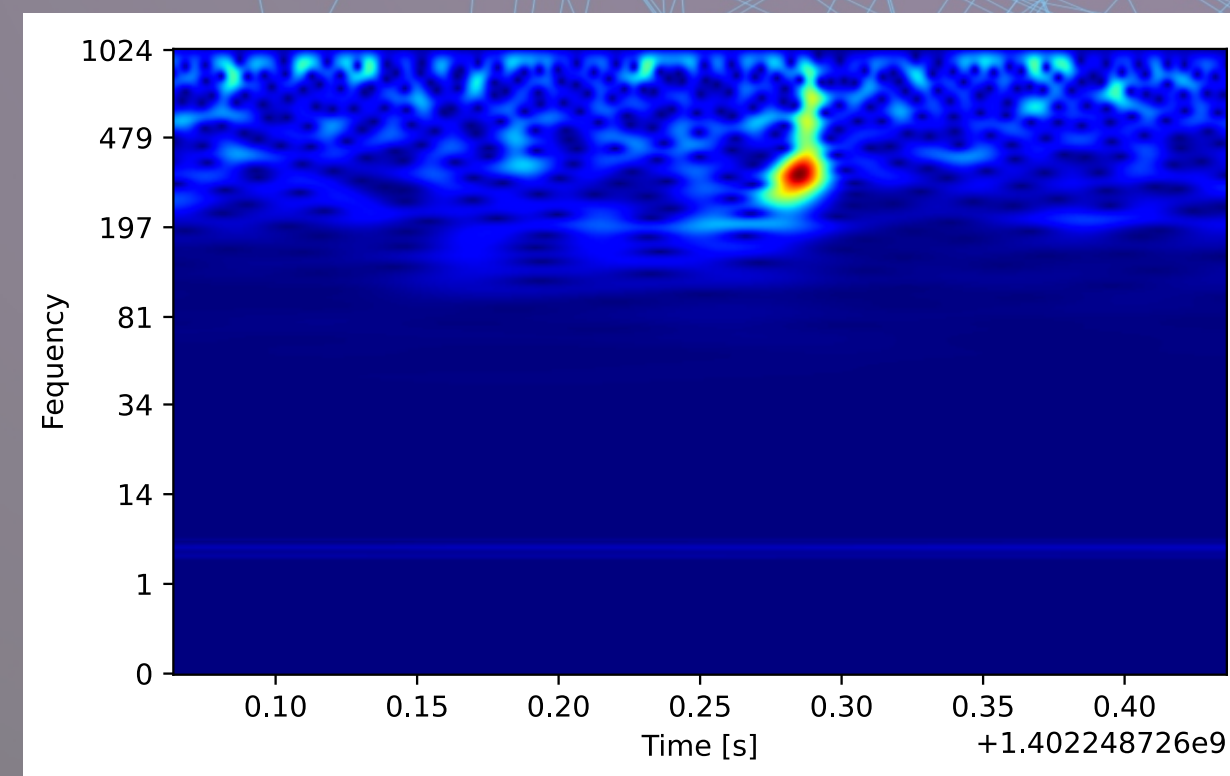


**Siamese  
Network**

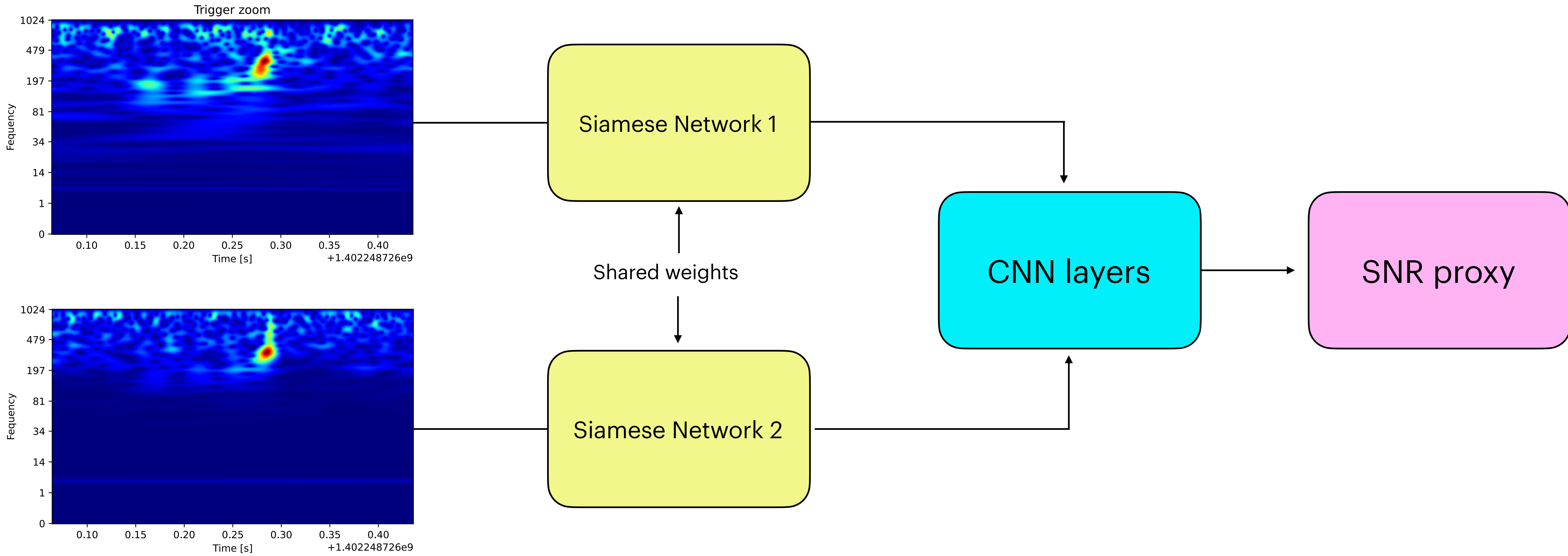
**Same or Different?**

**Siamese  
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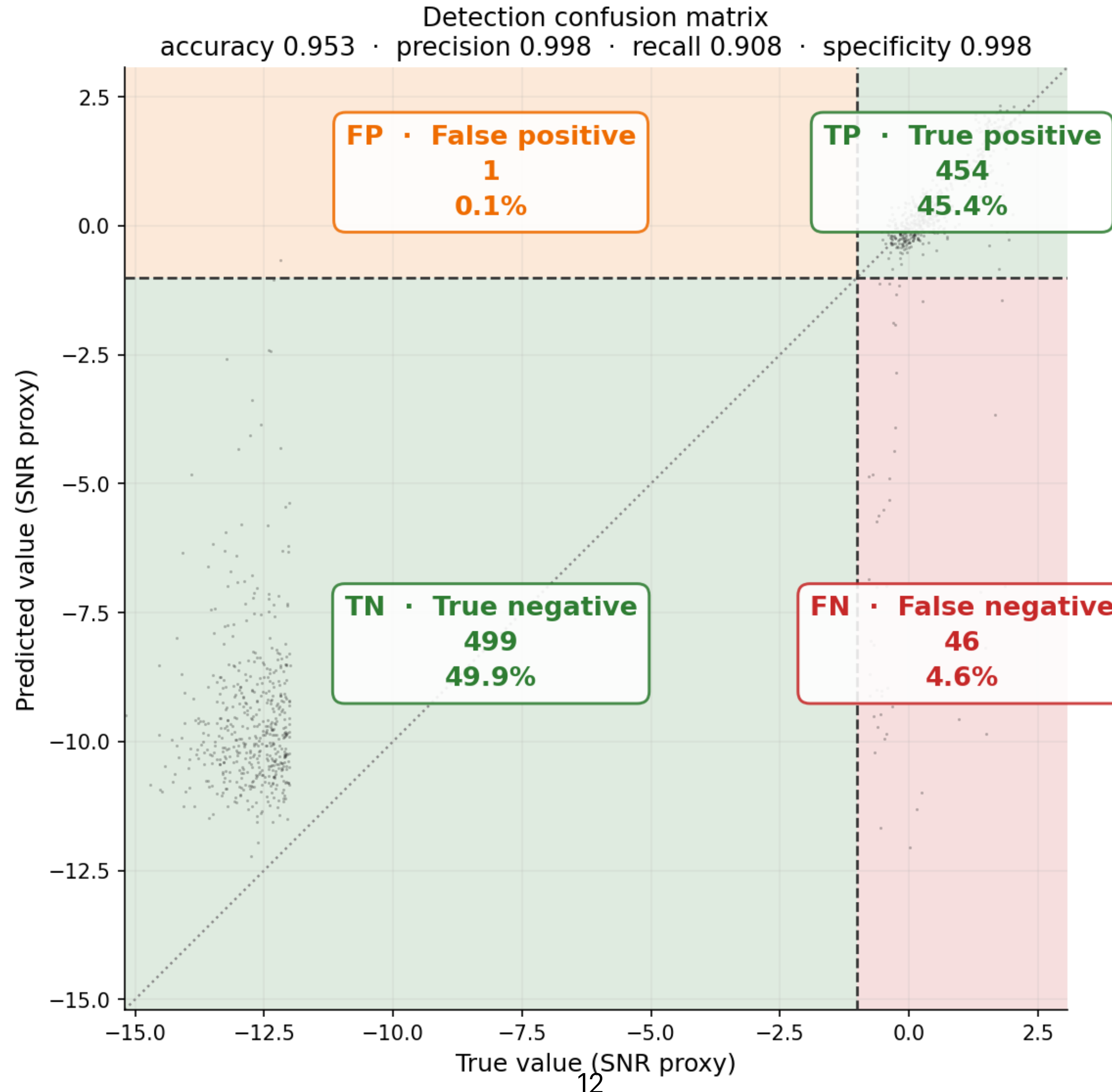
Livingston



# Network



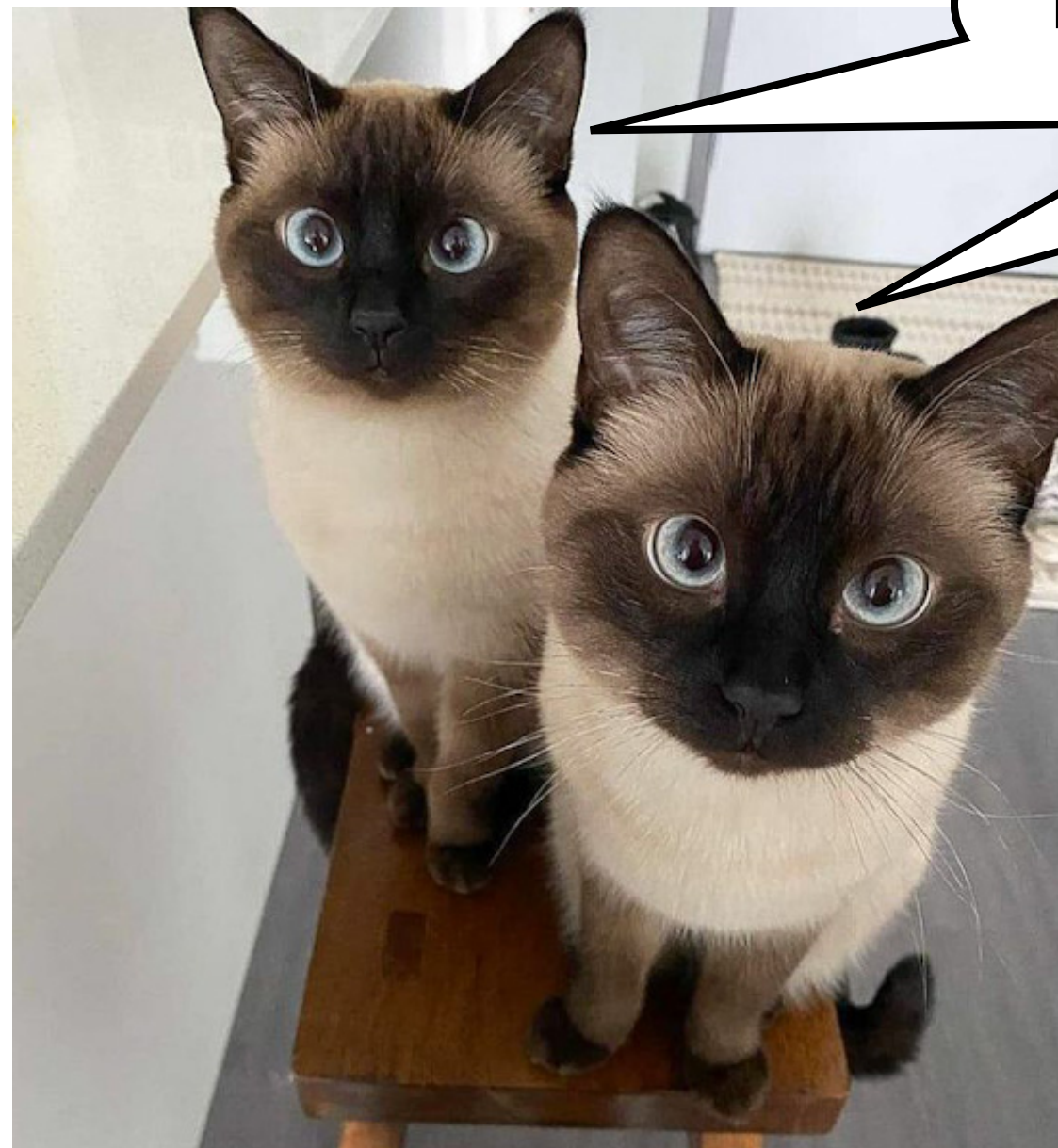
# Preliminary detection capability



# Summary

- Many CBC signals were detected with GWTC-5.0
- All 161 are binary black hole mergers
- Burst signals are an illusive phenomenon with great potential
- We are working on their detection

Thank you for your attention!



# References

## Astrophysical Sources & Gravitational Waves

- **Binary Black Hole (BBH) Mergers**

- *Article:* ExtremeTech. (2016). *What are gravitational waves and where does physics go from here now that we've found them.* [Link](#)
- *Data Portfolio:* LIGO Scientific Collaboration, Virgo Collaboration, & KAGRA Collaboration. (2026). *GWTC-5 observational results.* LIGO Document Control Center. [PDF](#) | *Pre-print available via arXiv:* [arXiv:2605.27223](#)

- **Core-Collapse Supernovae (CCSN)**

- *Image:* European Space Agency. (2013). *The Crab Nebula [Image].* [Link](#)
- *Research Paper:* Gossan, S. E., Sutton, P. J., Ando, S., Heng, I. S., McIver, J., Moore, C. D., ... & Ott, C. D. (2016). Observing gravitational waves from core-collapse supernovae with a multidetector network. *Physical Review D*, 93(4), 042002. <https://doi.org/10.1103/PhysRevD.93.042002>

- **Magnetars**

- *Article:* The Brighter Side of News. (2024). *Newborn magnetar offers rare evidence of Einstein's relativity in a stellar explosion.* [Link](#)
- *Research Paper:* Kouvaris, C. (2024). *Gravitational waves from magnetars.* arXiv pre-print. [arXiv:2406.03513](#)

- **Starquakes**

- *Article:* Scienceline. (2016). *Starquake.* [Link](#)
- *Research Paper:* Giliberti, E., & Cambiotti, G. (2021). *Starquakes in millisecond pulsars and gravitational waves emission.* arXiv pre-print. [arXiv:2102.02540](#) (*Published version in MNRAS*, 491, 1064).

- **Cosmic Strings**

- *Research Paper:* Damour, T., & Vilenkin, A. (2001). Gravitational wave bursts from cusps and kinks on cosmic strings. *Physical Review D*, 64(6), 064008. <https://doi.org/10.1103/PhysRevD.64.064008>

## Signal Pipelines & Machine Learning

- **Data Analysis Pipelines**

- *Q-Pipeline:* Chatterji, S. (2005). *The search for transient gravitational-wave bursts in LIGO data* [Doctoral dissertation, Massachusetts Institute of Technology]. GWIC Thesis Portfolio. [PDF](#)
- *cWB Pipeline:* Klimenko, S., Vedovato, G., Drago, M., Salemi, F., Tiwari, V., Prodi, G. A., ... & Mitselmakher, G. (2021). Coherent WaveBurst framework for analysis of gravitational wave bursts. *SoftwareX*, 15, 100723. [suspicious link removed]
- *WDF Pipeline:* Flanagan, É. É., & Hughes, S. A. (2000). *Wilson-Daubechies-Flanagan time-frequency analysis for gravitational wave bursts.* arXiv pre-print. [arXiv:gr-qc/0011041](#)

- **Deep Learning & Computer Vision**

- *Siamese Neural Networks:* Towards Data Science. (2020). *What are Siamese Neural Networks in deep learning?* Available at: <https://towardsdatascience.com/what-are-siamese-neural-networks-in-deep-learning-bb092f749dcb/>