Poster Sparkler

Tuesday, 22nd of July 2025

Characterizing the Prompt Convection Region of Core Collapse Supernovae Gravitational Waves using Coherent WaveBurst

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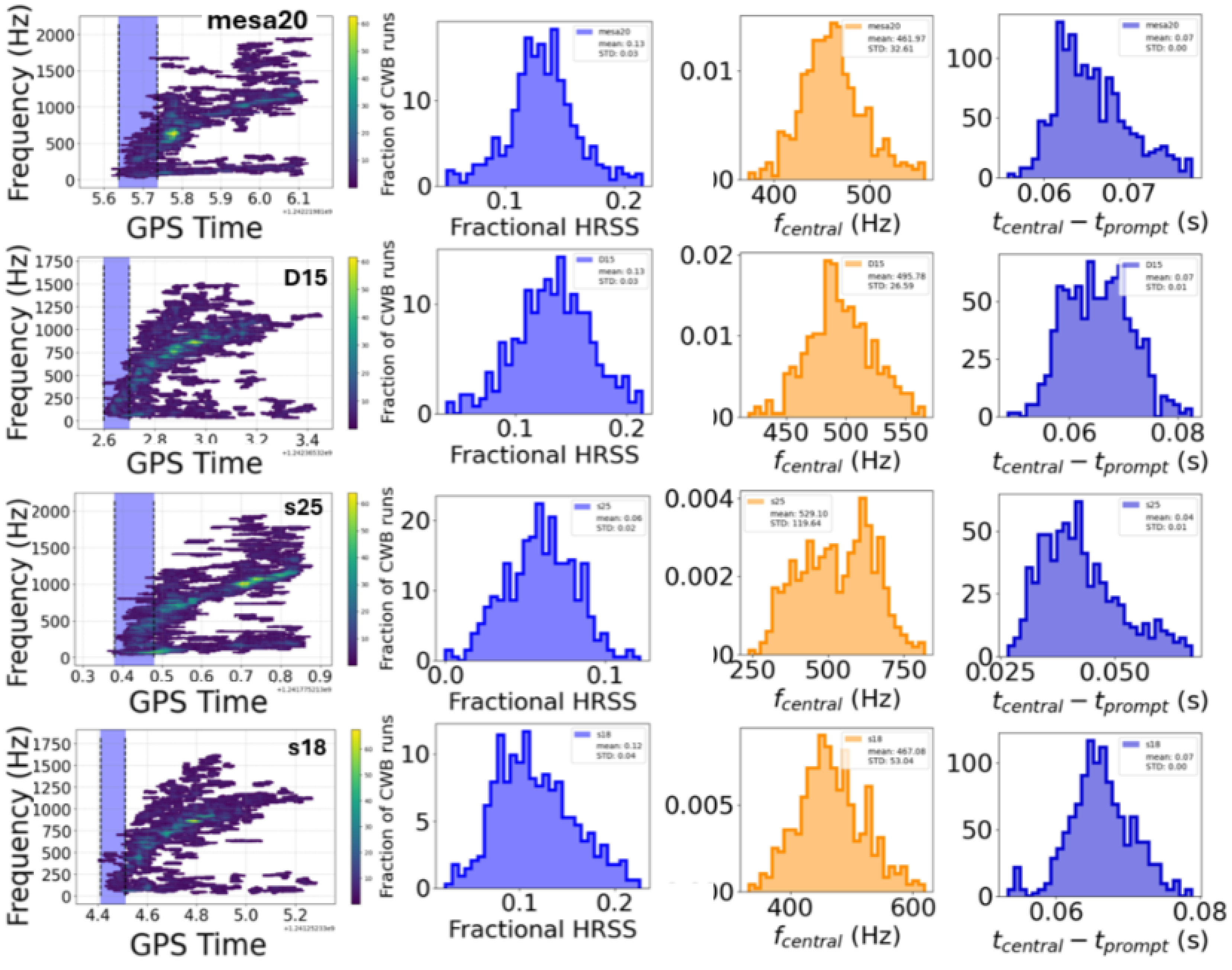
Prompt convection:

- First stochastic feature of GW signal
- Reverses negative entropy and lepton gradients formed at shock wave
- Up to ~100 ms after bounce

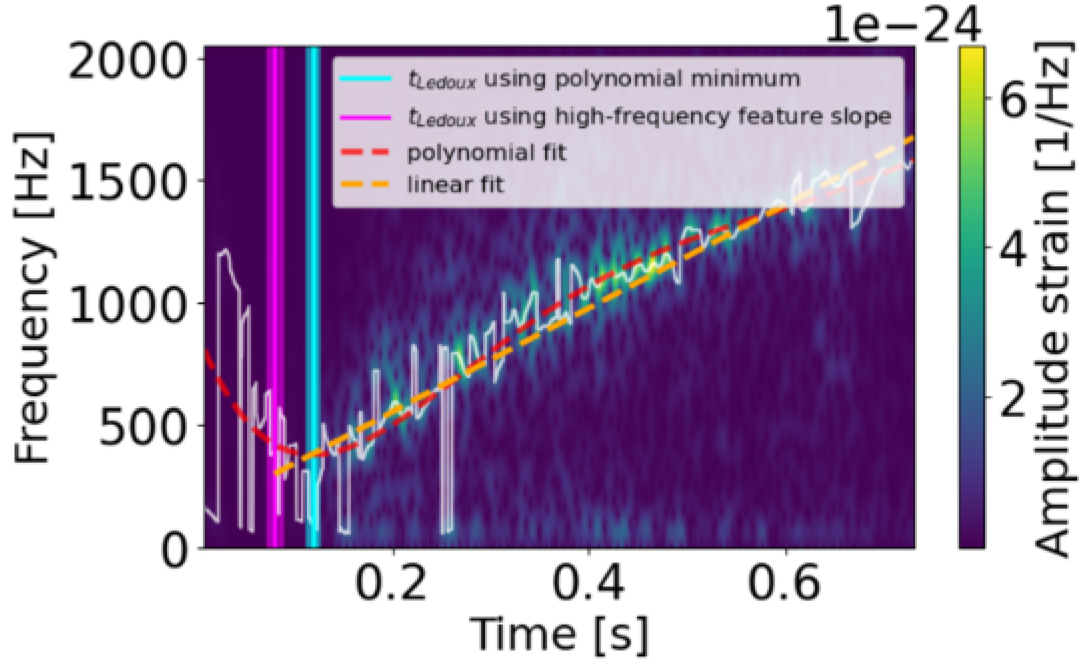
Goal:

- Determine the characteristics of the prompt convection signal in CCSNe gravitational waves



Model	EoS	Neutrino Transport	GR Treatment
mesa20	SFHo	Multi-dimensional moment	Effective potential
D15	LS220	Ray-by-ray	Monopole correction
s25	SFHo	Multi-dimensional moment	Monopole with GR potential
s18	LS220	Multigroup transport method	GR finite-volume based solver

Determining the end of prompt convection:



Remaining questions:

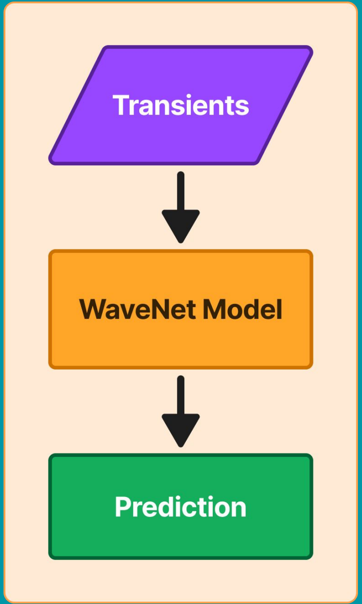
- Can we relate the frequency, timing, or strength of the prompt signal to physical parameters of the proto-neutron star?

Single detector search for Core Collapse Supernova using Machine Learning

Andy Chen[1], Chia-Jui Chou[1], **Kuo-Chuan Pan**[2], Yi Yang[1], Shih-Chieh Hsu[3], Albert Kong[2]

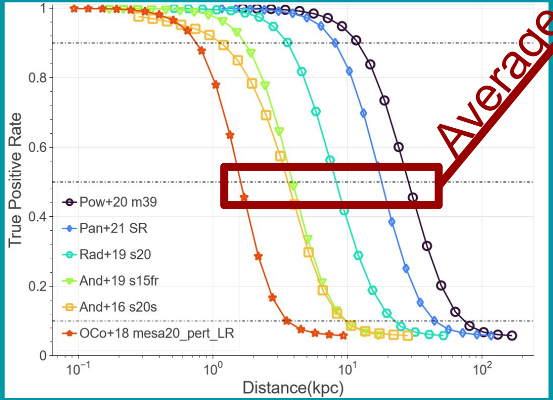
1. National Yang Ming Chiao Tung University, Taiwan 2. National Tsing Hua University, Taiwan 3.University of Washington, USA

CCSNet workflow:



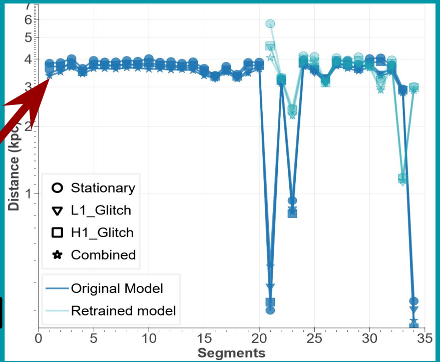
We built a ML classifier that can search for CCSN events in scenarios where coherence-based approaches are not applicable, namely single detector search. We compare the performance between dual and single detector setup, and performance a range of robustness test including longevity, glitch resilience, and waveform generalizability.

Probing sensitivity from the test result

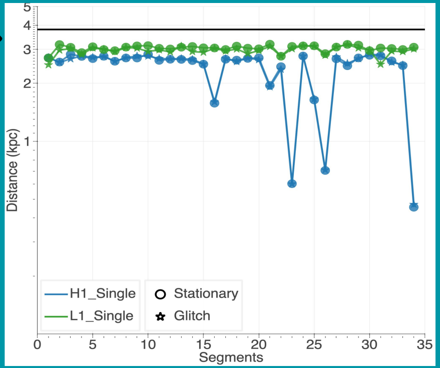


Average this

Dual Detector



Single Detector



Core-collapse supernova gravitational-wave physical inference - estimating the time of the Ledoux convection

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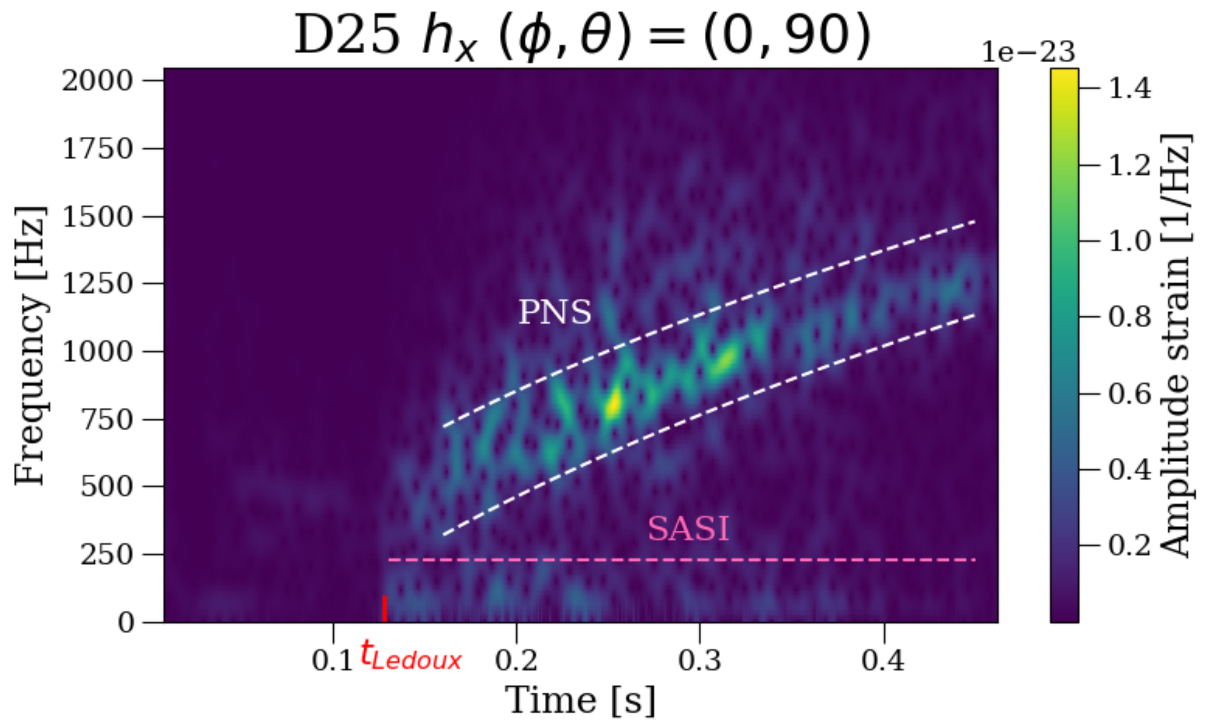
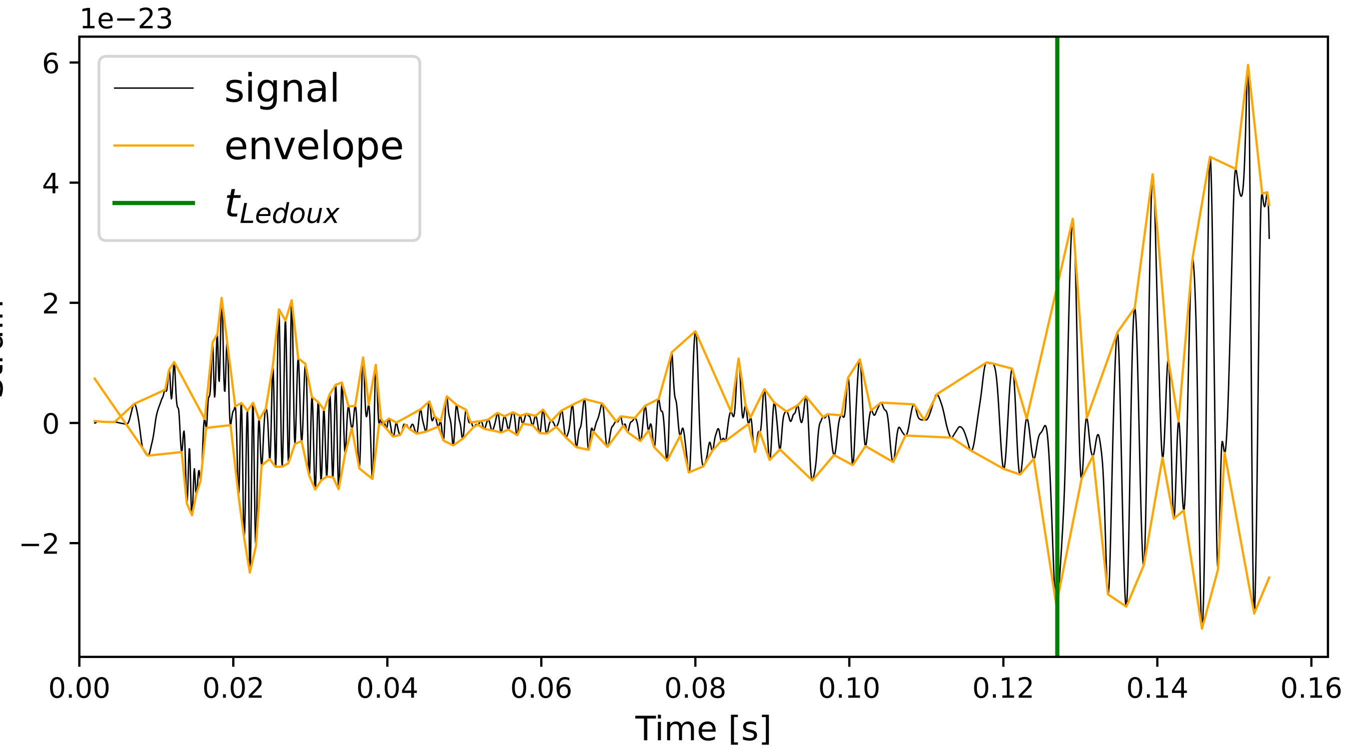
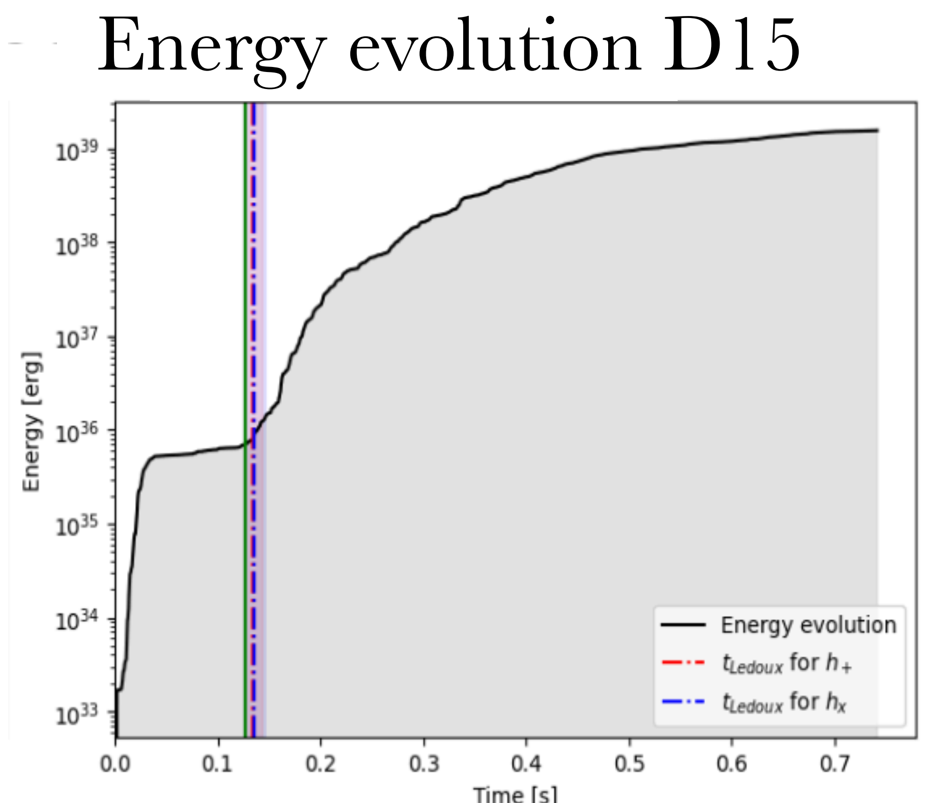
Our goal was to develop a method to find the time when strong gravitational waves are emitted. We developed two different approaches of finding this time.



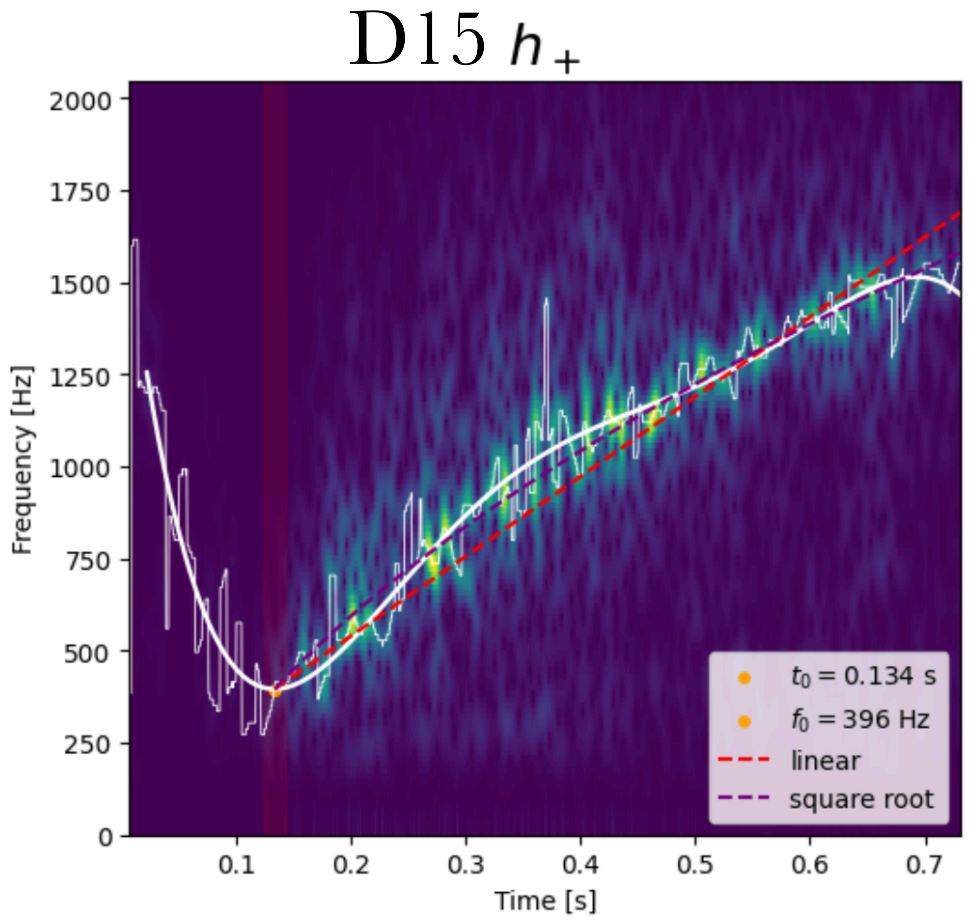


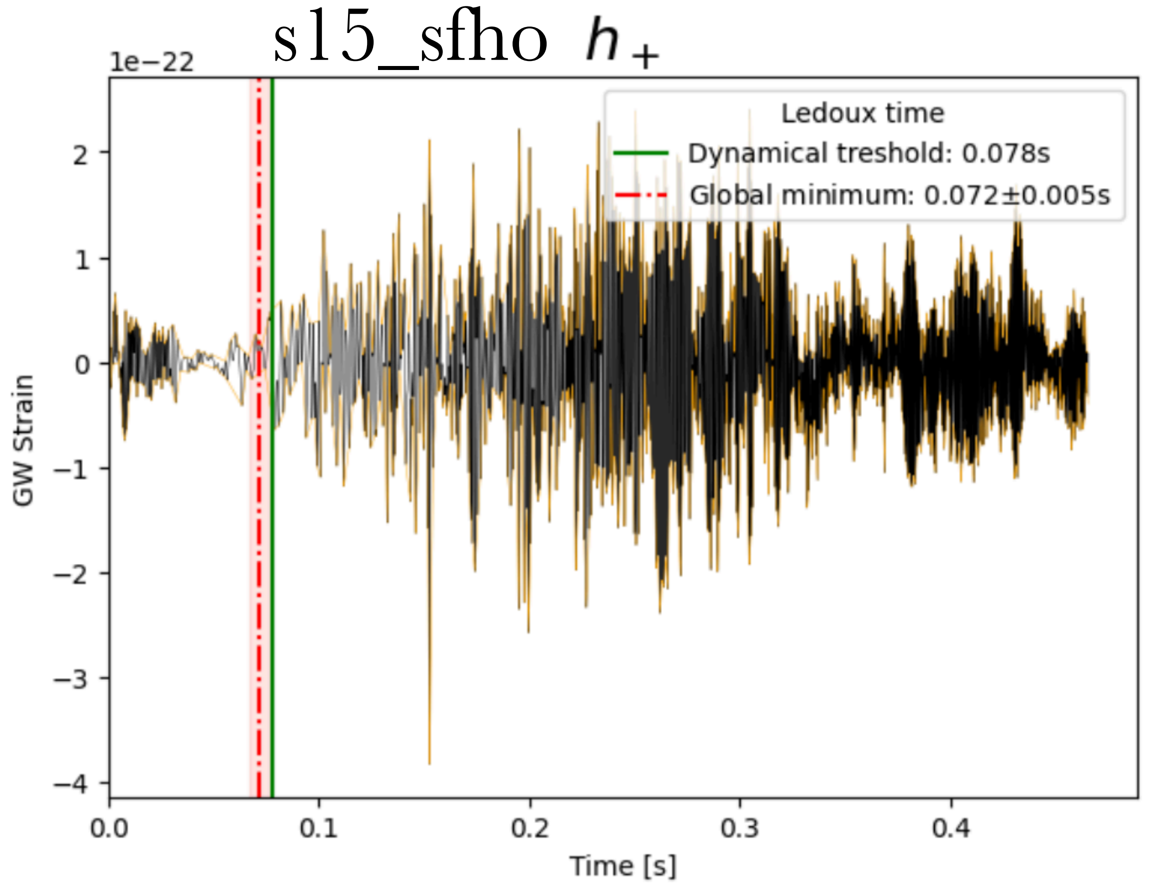
First one is called dynamic threshold method which searches for steep rise in strains, by calculating the envelopes of the signal and searching for a value that exceeds 3σ.



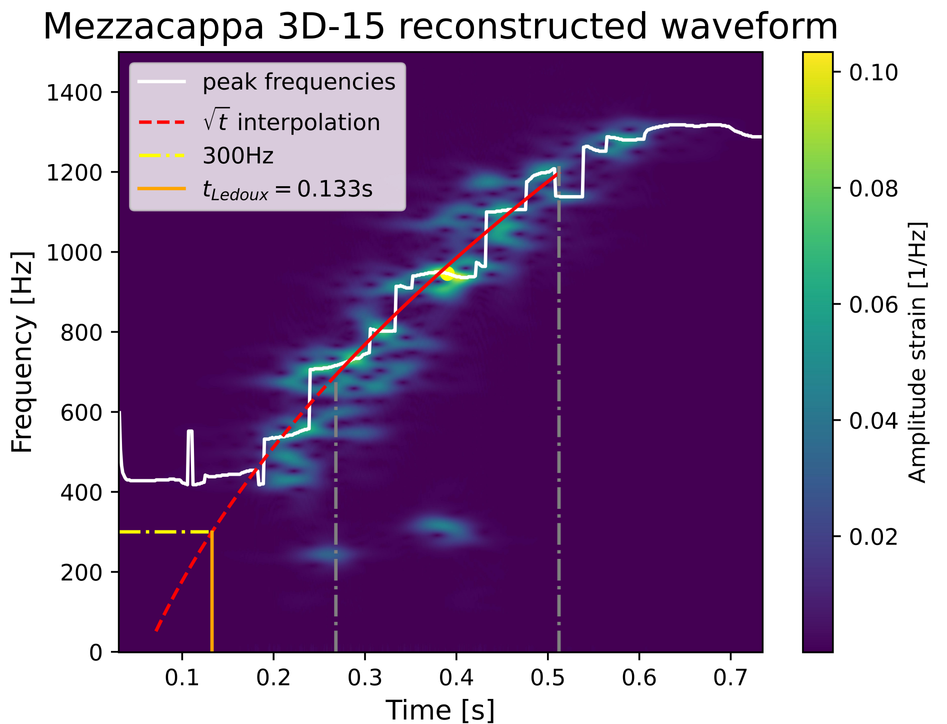
This method coincides with significant energy release and marks the beginning of high frequency feature of PNS oscillations and SASI.

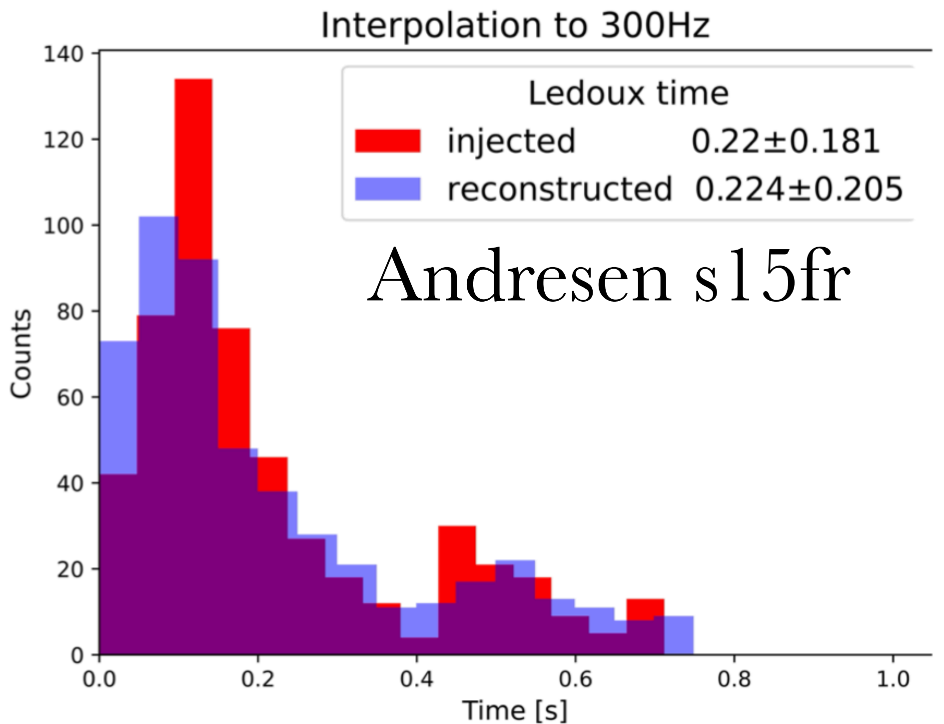
The second one tracks the time evolution of peak frequencies in time-frequency domain and searches for the global minimum of the fitted polynomial.





But for reconstructed signals we do not see the prompt convection feature and this method fails. We fit square root and linear function to the HFF and interpolate to 300Hz.





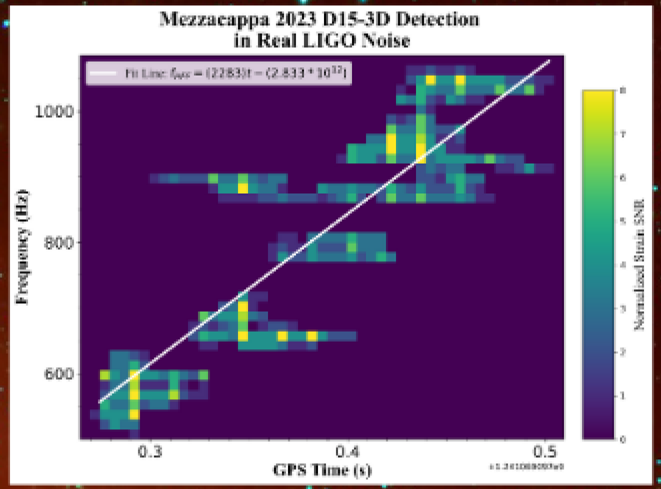
Extracting PNS Parameters from the High Frequency Feature

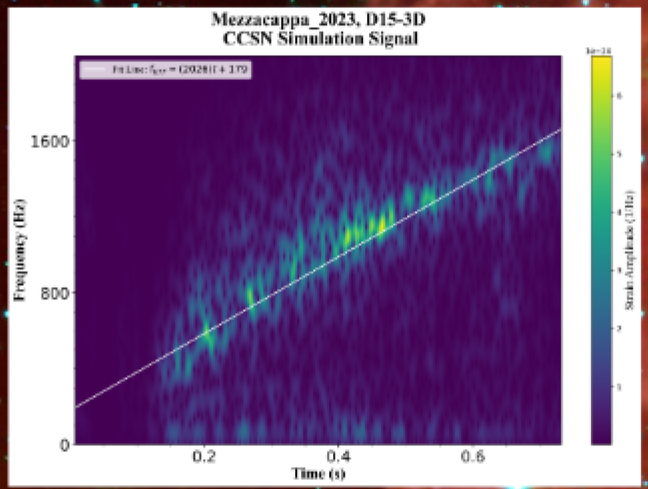
Olivia Korensky[1], Marek Szczepańczyk[2], Alejandro Casallas-Lagos[2]

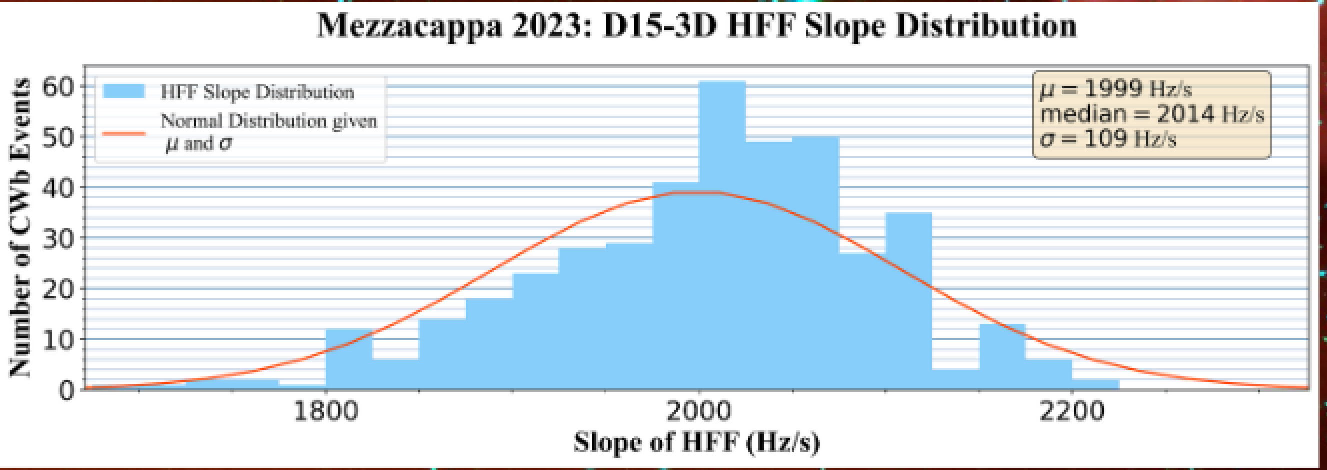
In this project, we investigate two questions:

1. **How is our ability to accurately measure the HFF slope affected by LIGO noise?**

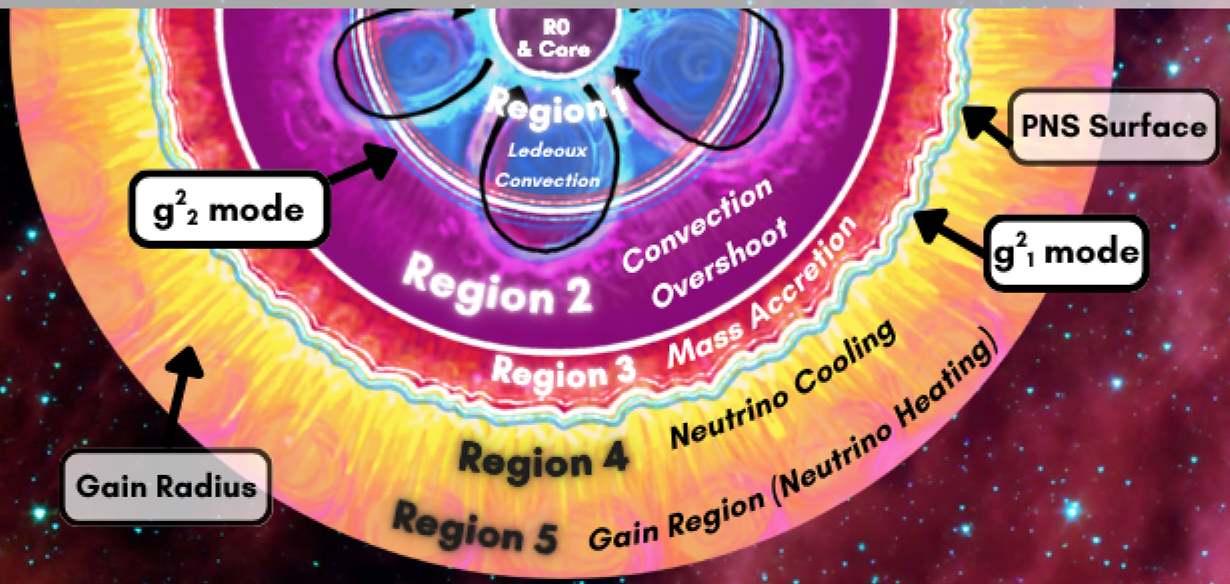
- We inject 5 CCSN simulations into hundreds of samples of LIGO noise and extract detectable pixels using CWb.
- We use modified χ^2 linear regression to calculate the HFF slopes per sample per model.







Overlapping error bounds and low Δ/Δσ values for 4/5 models for the HFF slopes with and without LIGO noise imply that LIGO noise does not significantly inhibit the accuracy of HFF slope calculation.

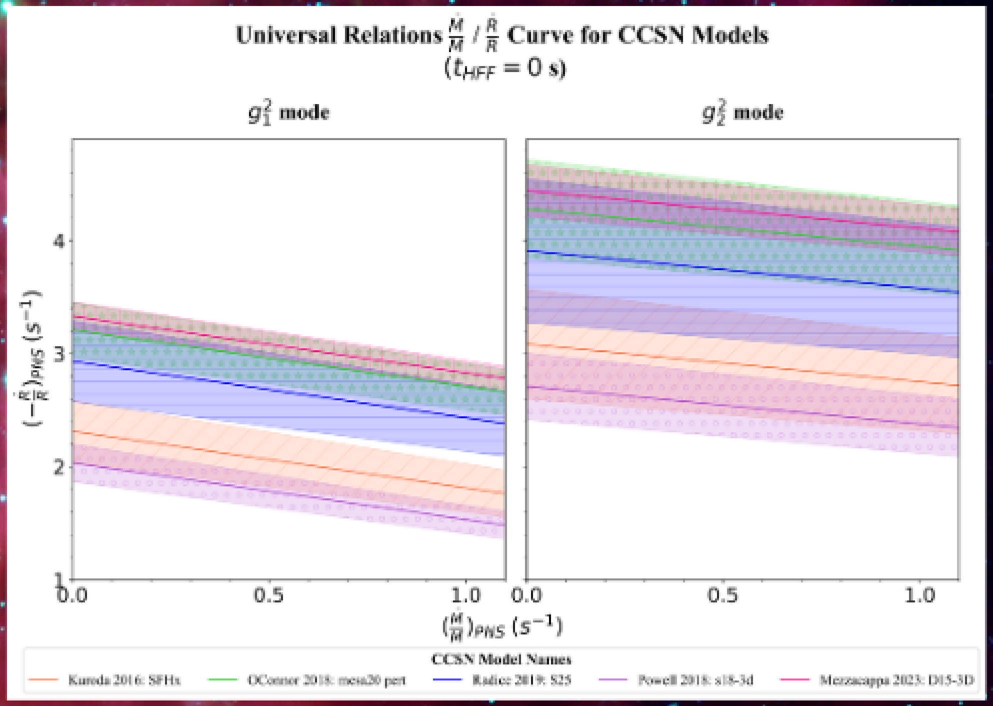


2. **Can we use the g-mode contributions to the HFF slope in LIGO noise to test the validity of Universal Relations?**

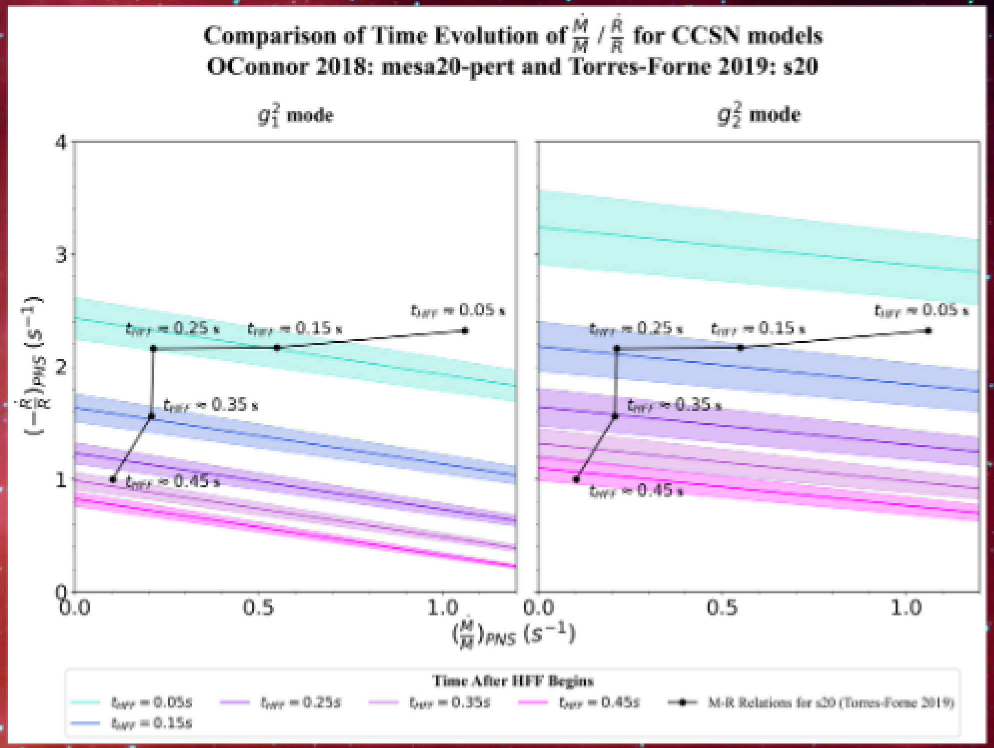
- Using linear perturbation derivations by Alejandro Casalla-Lagos, we assume the locations of the g^2_1 and g^2_2 modes to be in the PNS surface and center respectively.
- We derived $\dot M/M$ - $\dot R/R$ relations for a given $\dot f/f$ using the Universal Relations proportionalities.
- We plot these relations assuming the HFF is dominated by either mode for various models (above right)/times elapsed from HFF beginning (below right).

$$f_{g_1^2} \propto \frac{M_{PNS}}{R_{PNS}^2} \rightarrow \frac{\dot f_{g_1^2}}{f_{g_1^2}} = \frac{\dot M_{PNS}}{M_{PNS}} + 2\left(\frac{-\dot R_{PNS}}{R_{PNS}}\right)$$

$$f_{g_2^2} \propto \sqrt{\frac{M_{PNS}}{R_{PNS}^3}} \rightarrow \frac{\dot f_{g_2^2}}{f_{g_2^2}} = \frac{1}{2}\left(\frac{\dot M_{PNS}}{M_{PNS}}\right) + \frac{3}{2}\left(\frac{-\dot R_{PNS}}{R_{PNS}}\right)$$



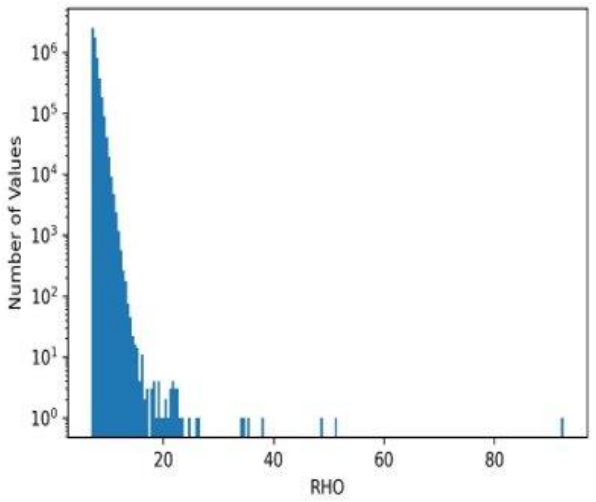
With data on M - R evolution provided by CCSN modelers, these derived $\dot M/M$ - $\dot R/R$ relations offer a promising way to test Universal Relations and track g-mode evolution.



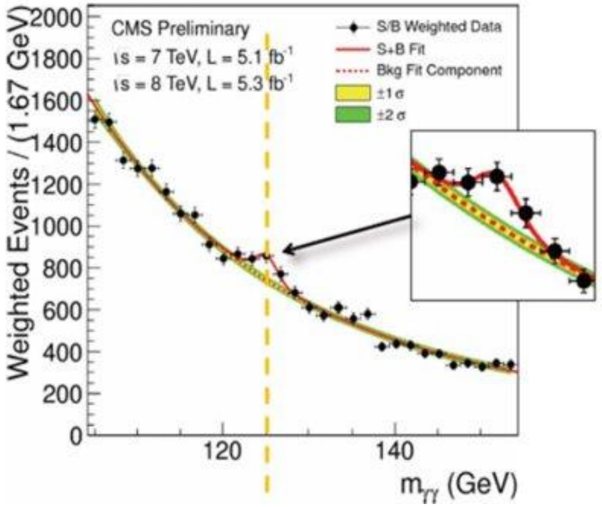
Distributional Methods for Detecting Gravitational Waves from Core-Collapse Supernovae

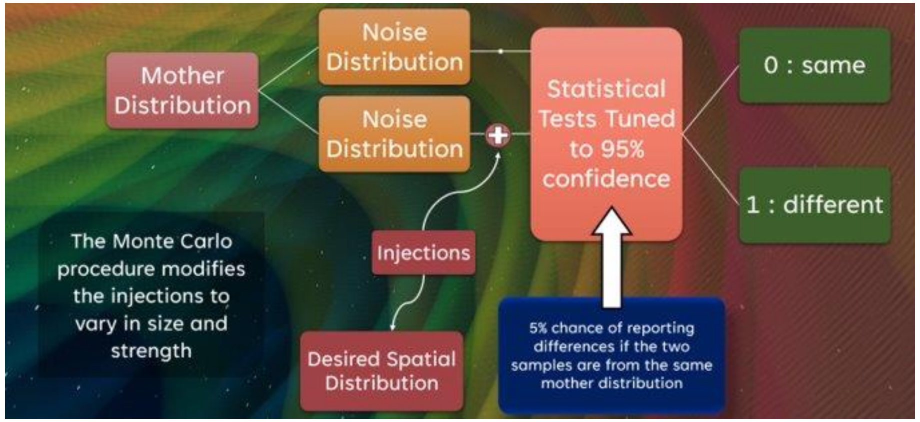
Kya Schluterman, Alani Miyoko, Michele Zanolin

In use already:



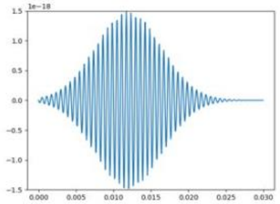
What we want to implement:





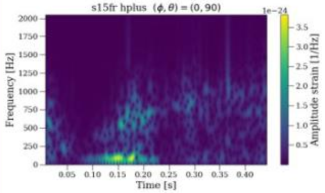
Extreme emission

Sine-gaussian waveforms over:
Tau = 1-1000ms
Freq = 55-2000Hz



Rapidly rotating

S15fr -15 Mo Rapidly rotating model from Andresen_2019.



Slowly rotating

D15 - 15 Mo ZAMS mass exploding model from Oak-Ridge D-series run.