

Test Run Analysis of KAGRA O4 data for Stochastic Gravitational- Wave Background Search

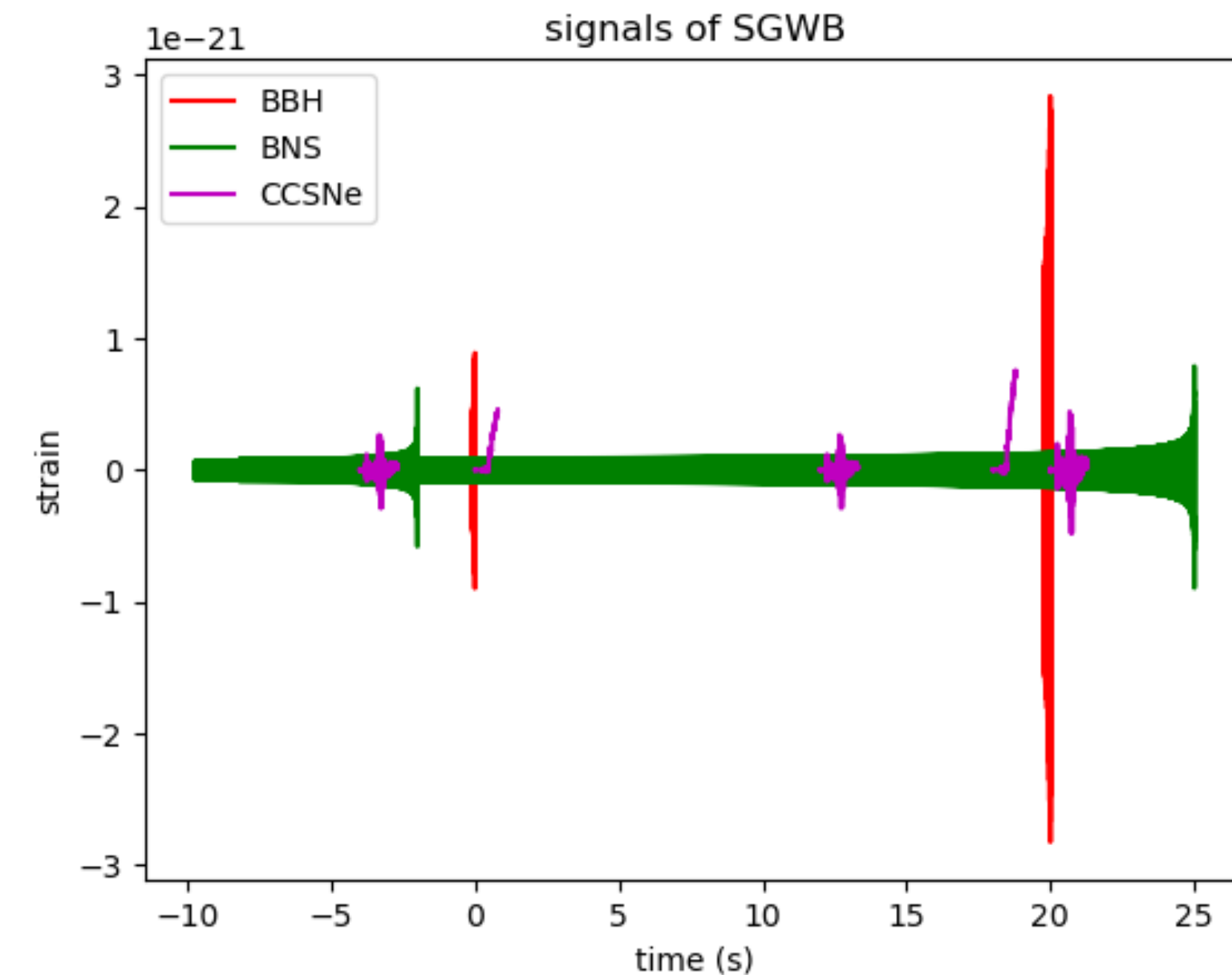
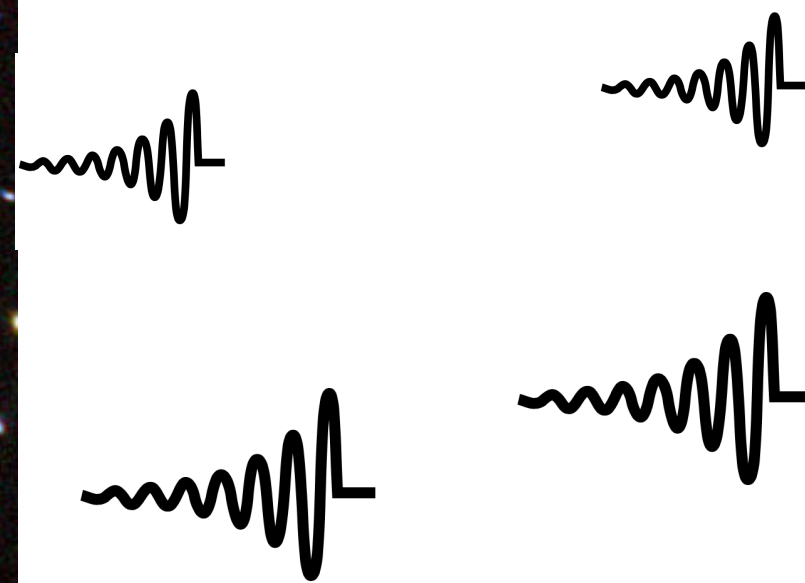
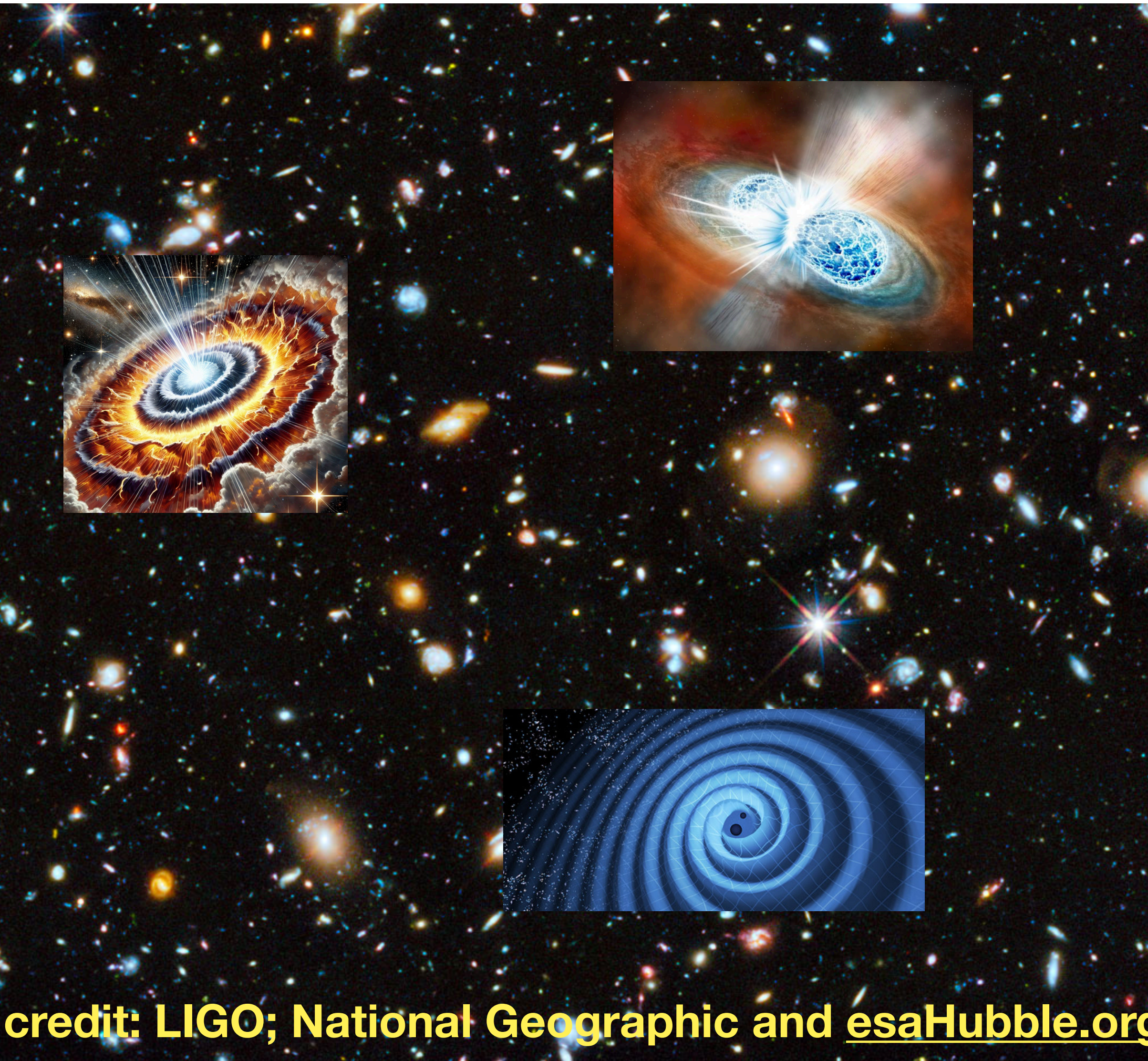
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Project members: Chia-Hsuan Hsiung, Yong-Xiang Yang

Research Results Presentation Meeting of the ICRR inter-University Research Program FY2024

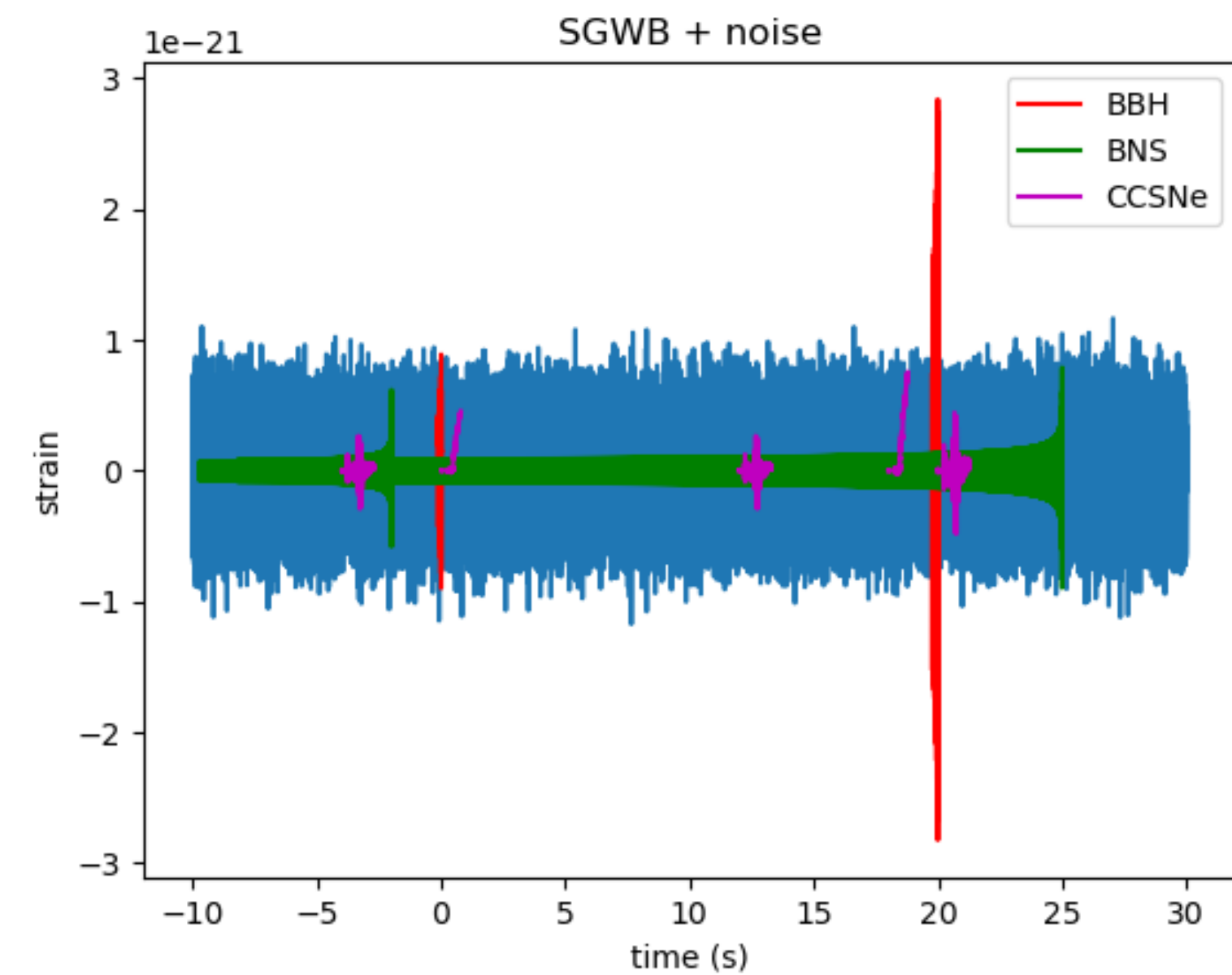
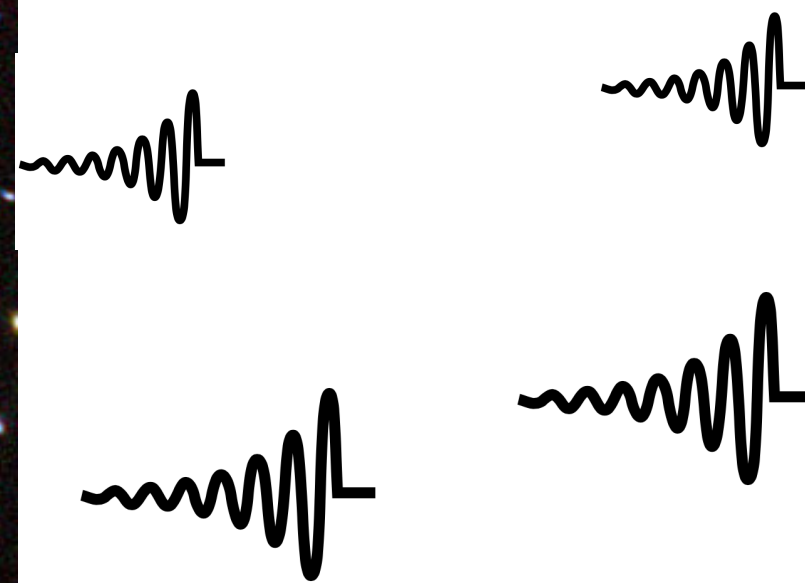
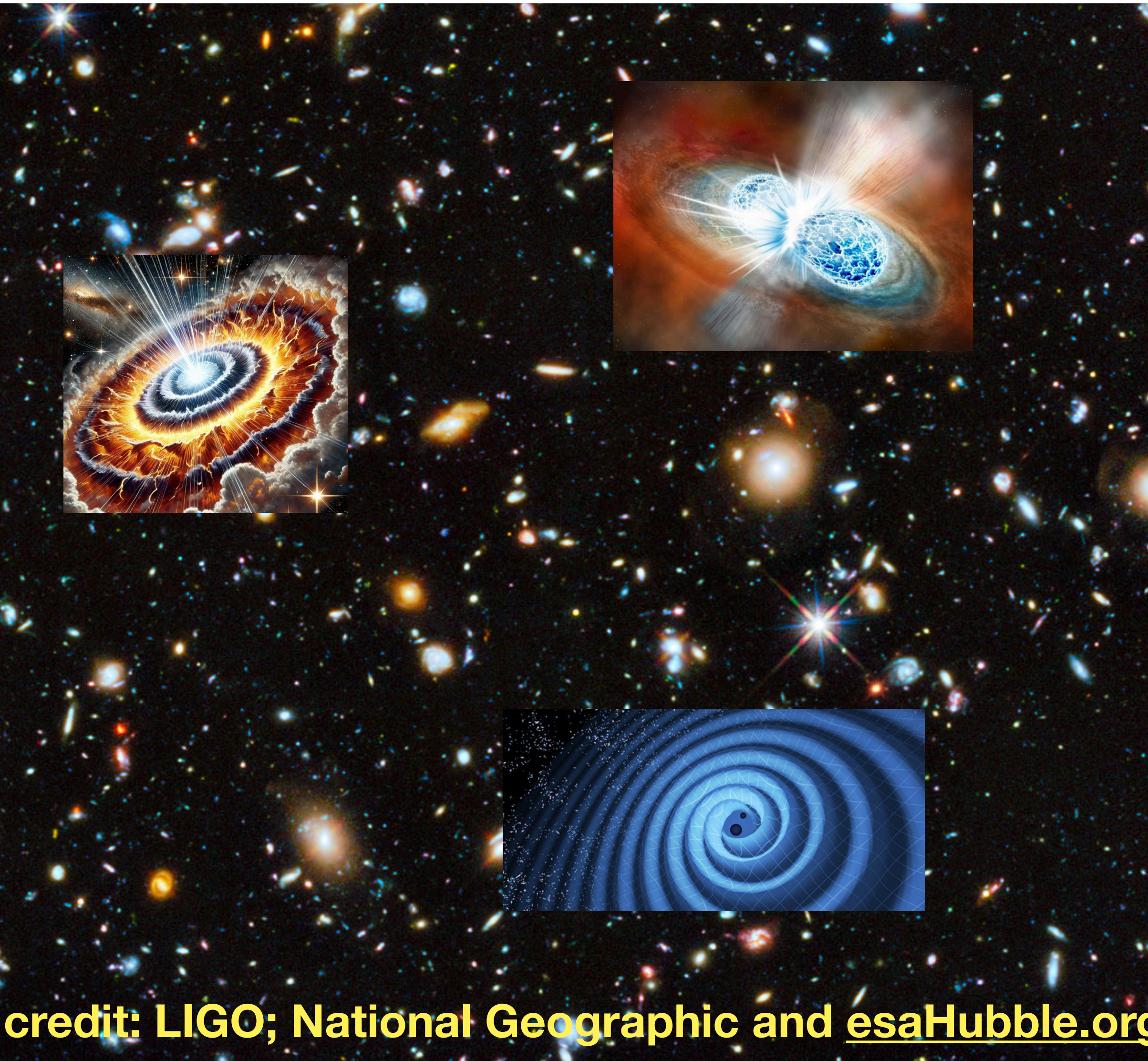
Stochastic Gravitational-Wave Background



CCSNe waveform credit: Murphy et al. 2009

credit: LIGO; National Geographic and esaHubble.org

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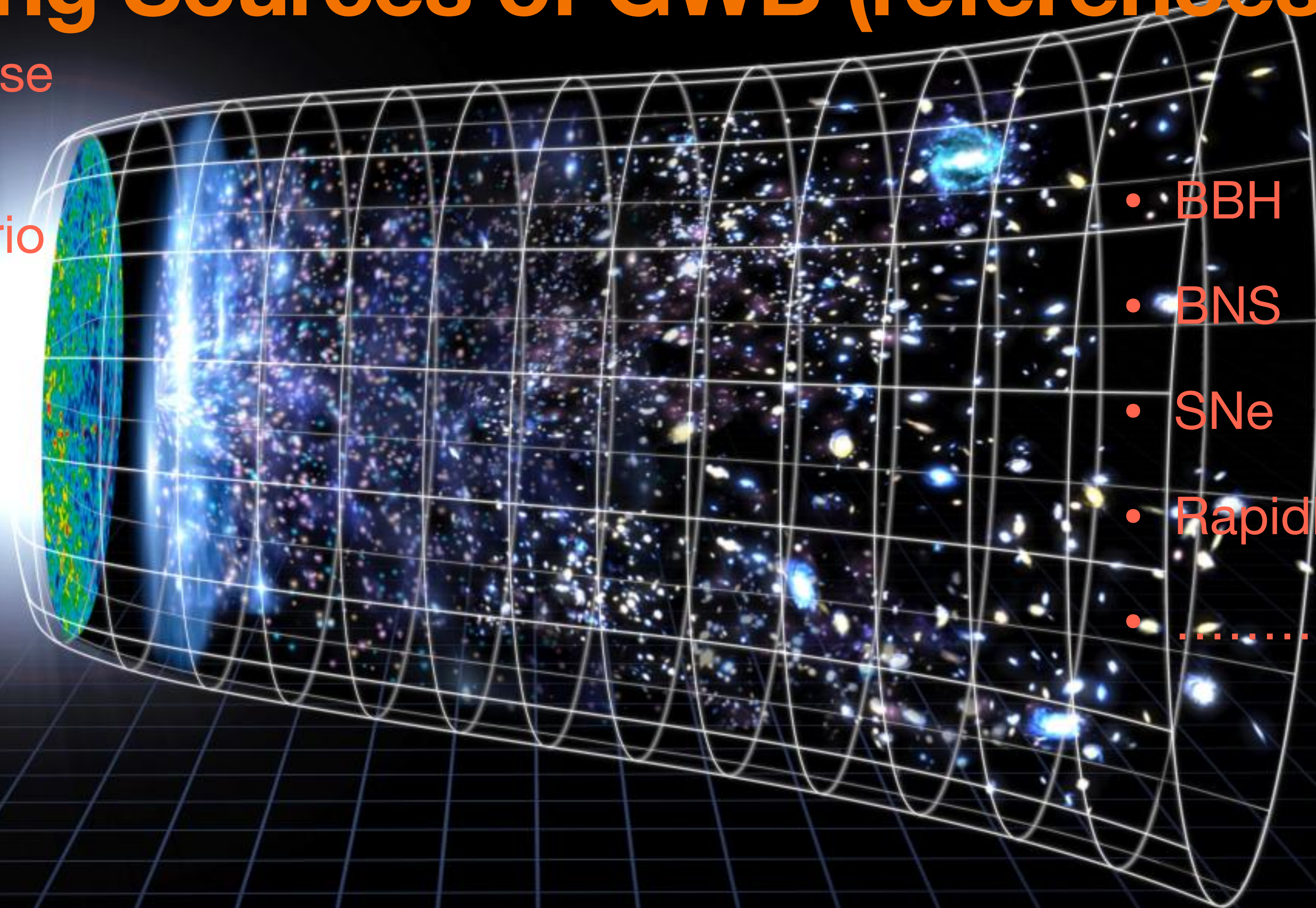


CCSNe waveform credit: Murphy et al. 2009

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Promising Sources of GWB (references)

- First Order phase transition
- Inflation scenario
- Primordial BH
- Cosmic string
-



- BBH
- BNS
- SNe
- Rapidly rotating NS
-

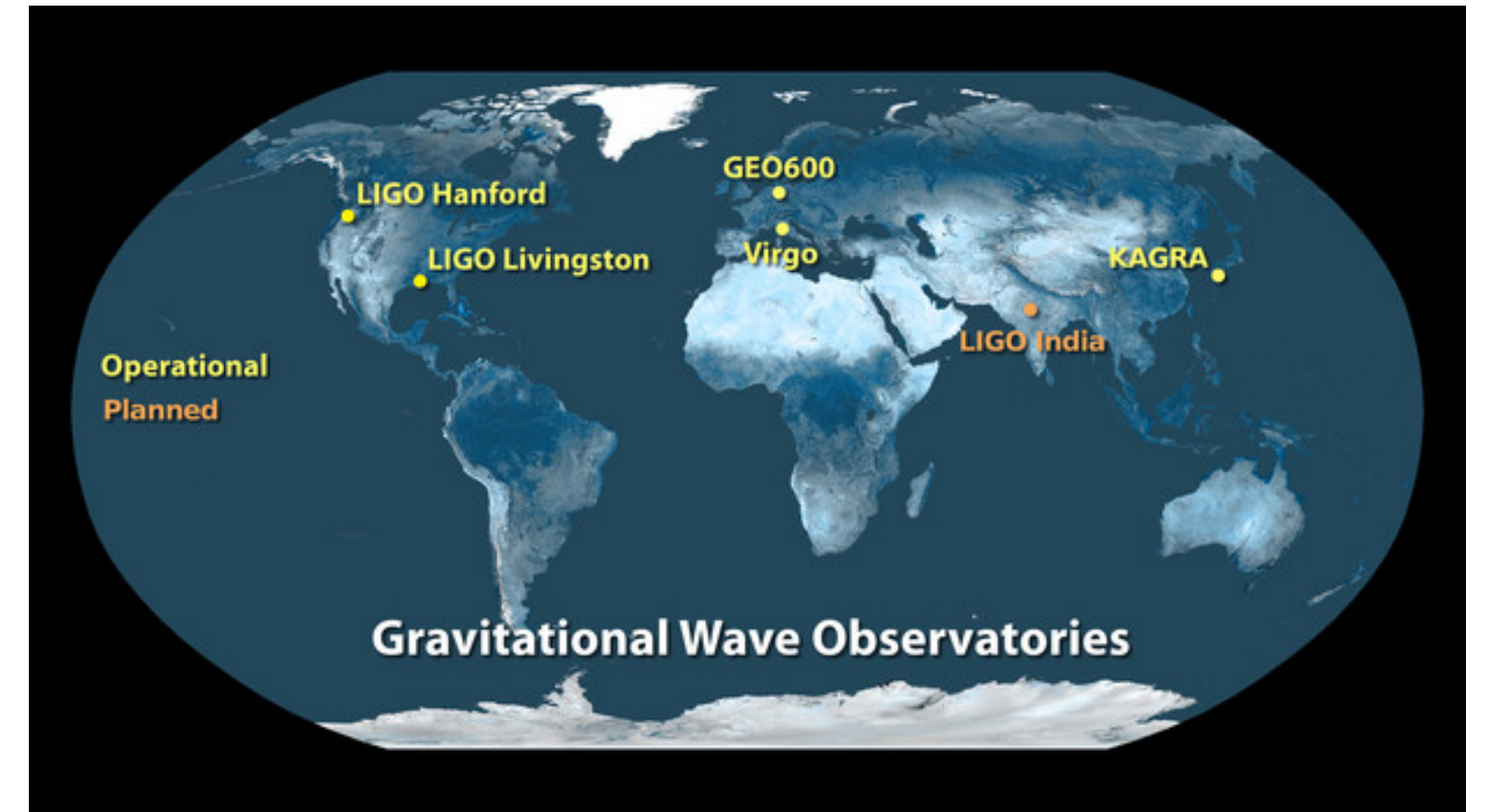
Primary Goal of SGWB Search and Methodology

- Goal: to estimate the energy density of SGWB

$$\Omega_{GW}(f) = \frac{1}{\rho_c} \frac{d\rho_{GW}}{d \ln f},$$

ρ_{GW} : energy density of GW,

ρ_c : critical energy density of universe



<https://www.ligo.caltech.edu/image/ligo20160211c>

- Method: measure the exceed power in cross-correlation of data in pairs of detectors

$$- \left\langle h_I^*(f) h_J(f) \right\rangle \propto \gamma(f) S_h(f) \propto \Omega_{GW}(f)$$

- Only data LIGO (H1, L1) and Virgo (V1) have been used for the search

- Status: upper limit of $\Omega_{GW}(f = 25Hz)$ for various sources (3.4×10^{-10} for CBC, 5.8×10^{-9} for cosmological sources)

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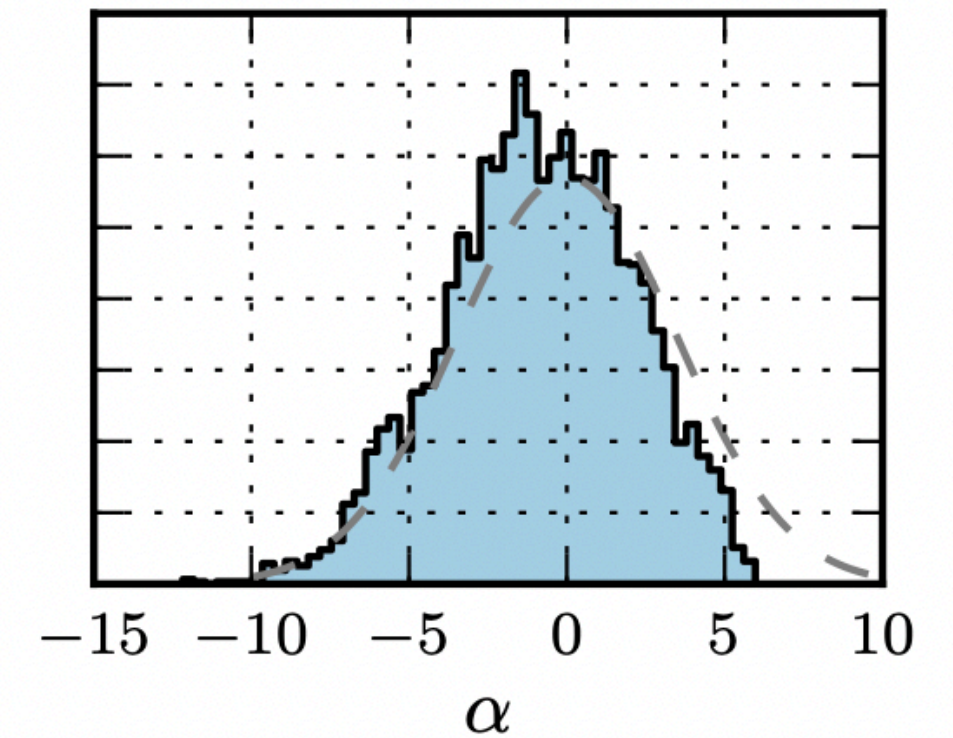
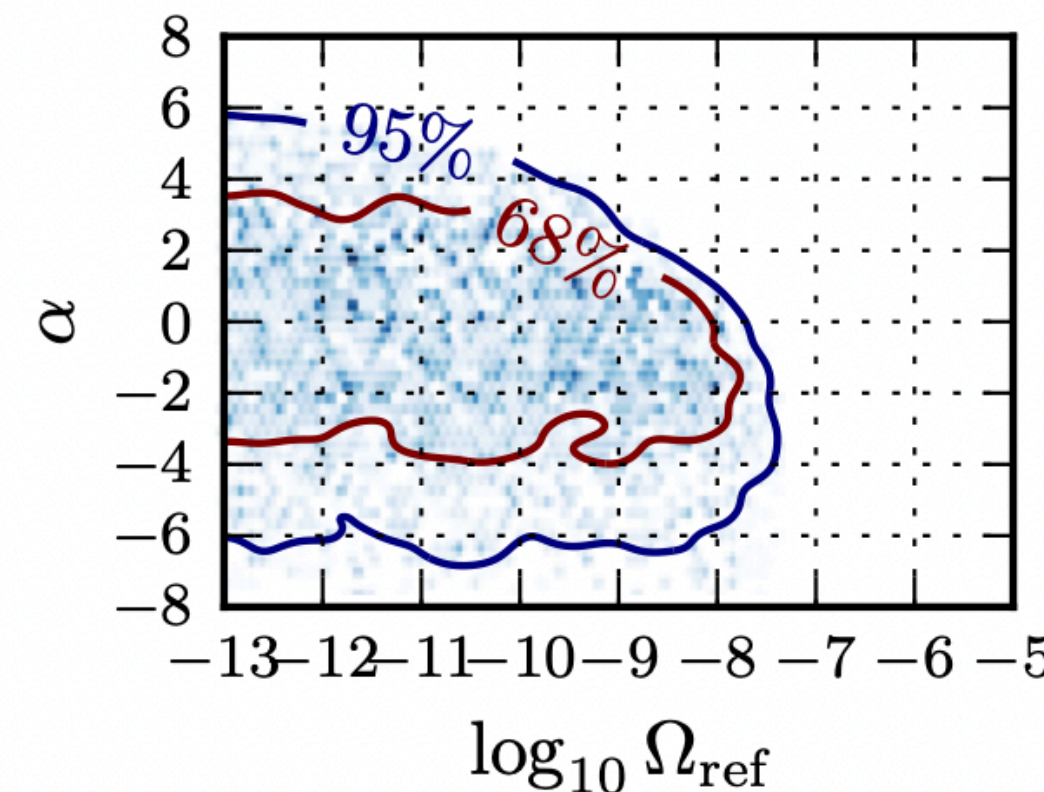
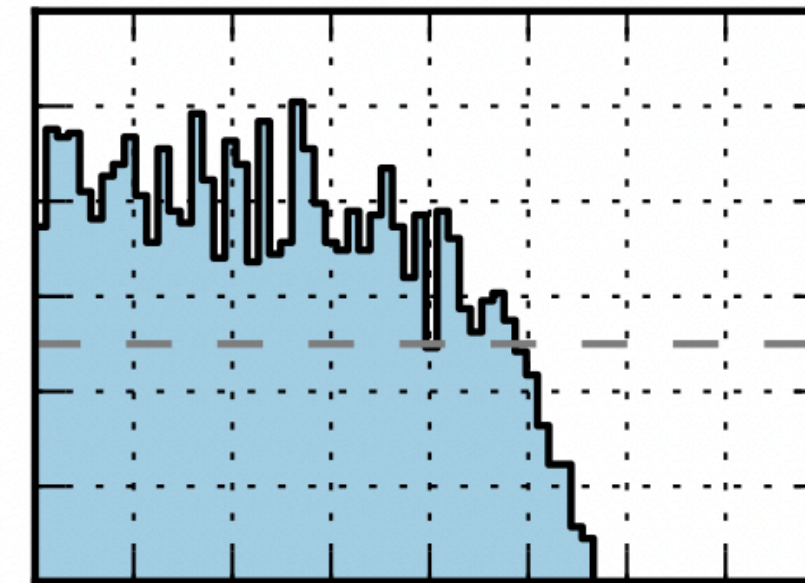
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Motivation of Analyzing KAGRA's data

- With the current analysis method, KAGRA O4 data may not be significantly aid the search of SGWB, but the analysis remains valuable
 - Understanding KAGRA data quality
 - Preparation for future observation run
- Non-gaussianity analysis of SGWB with cross-correlation of four detectors.
 - Provide additional insights into the source origins
 - Promotes broader utilization of KAGRA data
 - With design sensitivities of LIGO, Virgo and KAGRA 80 Mpc sensitivity, we can have 2-sigma detection of non-gaussianity within one year
 - Working on the pipeline

Test Analysis with KAGRA O4a data

- Duration: May 24th, 2023 (15:00 UTC) to June 23th, 2023 (0:00 UTC)
- Analysis Baselines: HK and LK
- Science_segment:
 - LIGO: DMT-ANALYSIS_READY
 - KAGRA: GRD_SCIENCE_MODE
- Channel:
 - LIGO: GDS-CALIB_STRAIN_CLEAN_AR
 - KAGRA:CAL-CS_PROC_DARM_STRAIN_DQ
- Pipeline: Pygwb

Good News

KAGRA O4a data quality is stable

- No long gate data
 - All gates are shorted than 5 sec
- Small percentage of gated data ($< 0.06\%$)
- Small percentage of delta sigma cuts ($\sim 4\%$)

Areas Requiring Further Investigation

- Suspicious lines in coherence
 - 100 Hz line and 32.6875Hz line are found in LK and HK baseline, not listed in notch list. Further analysis planned in O4c.
- Veto-definer-file preparation
 - Improve analysis by excluding long gate data.
 - Have learned how to create the veto-define-file for KAGRA data

Final Remarks and Preparation of O4c

- Thanks for the ICRR Inter-University Research Program, we can travel to Kamioka sites with my students (Jan 20-24, 2025)
 - Know more about the data problems from on-site people
 - Investigation of the possible reasons for lock loss problems. Important for increase duty cycle of data.
- Readiness for O4c KAGRA Analysis.