KAGRA burst activities

Kazuhiro Hayama (U. Fukuoka)
on behalf of the KAGRA burst working group

Current activities

- Joining O3 and contributing to main burst searches, i.e. all-sky searches and triggered searches.
- Prepare for LIGO-Virgo-KAGRA collaboration on the burst data analysis. Discussing with LV burst chairs.
- Toward O4 (and even O3), development of various methods for getting new GW science by various units see appendix to know current progress of the units.

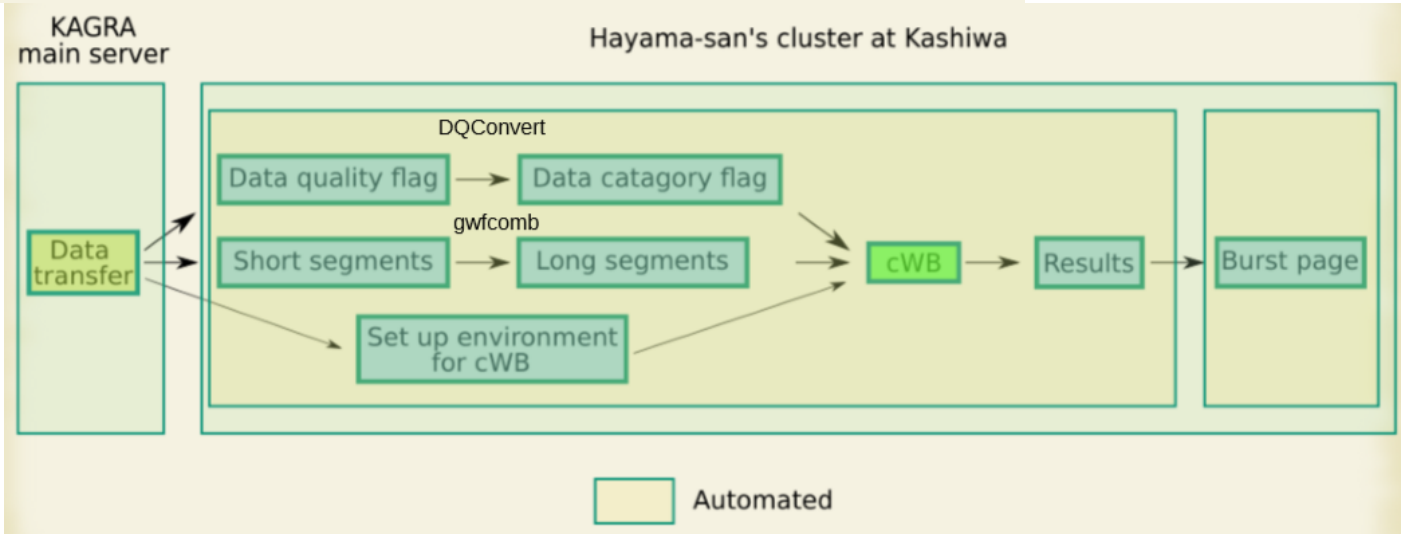
Contributing to O3 burst searches

Development of a burst search pipeline in collaboration with people in LIGO-Virgo (Sergey Klimenko, Marek Szczepanczyk, Marco Drago)

- cWB based pipeline with new feature, Stokes parameter to understand the evolution of rotation of GW sources.
- The pipeline has been tested in ER2.
- Discussion with LV burst group on how to make process for O3 is being done.

Testing the pipeline in ER2

- cWB has been installed on a cluster for burst search.
  - Able to carry out offline search
  - or triggered search.



- We have also tested the pipeline using the data from the second engineering run of KAGRA.
  - In total, 1093 triggers were identified with cWB in a ~ 6 hrs run.
  - no significance can be computed because there was one detector and shifting data in time was impossible.

Mervyn Chan (U. Fukuoka)

Prepare for L-V-K burst data analysis

- We shared the status of both L-V and KAGRA burst activities at the L-V burst call.
- From KAGRA site, I showed all burst proposals, and we will discuss more concrete way of L-V-K collaboration very soon.
- For O3, we agreed that the important procedure is to have MoA between L-V and KAGRA for collaborating on searches and observation papers. We also confirmed that pipelines using O3 for publication should be reviewed at first.
- During LVC meeting in Sep (2-5), the L-V-K burst chairs will discuss on the collaboration for O3 more concretely.

One concern

- There is not yet an MOU between LIGO and KAGRA with regards to sharing data and collaborating on papers. It's still far away from having people collaborate on papers and contribute to searches. It is still mostly in playground. We will probably have more information within the coming months.

(One of the burst chairs)

MOA will be soon issued!

Burst Power of KAGRA:
The proposals in the burst research units

- Searches
  - All sky
    - Cosmic strings : Cannon, Kuroyanagi
    - Supernovae : Zong-Hong, Putten, Hayama, Miyoki,
    - All kind: Tjonnie LI
    - Polarization : Tjonnie Li
  - Triggered searches
    - Pulsar glitches : Hui
    - Supernovae : Hayama, Oohara, Takahashi
    - Others
- Post-processing (very similar to characterization of burst signals)
  - Denoising, event rejection : Yokoyama, Tjonnie Li, Takahashi
  - Time-frequency analysis : Itoh, Kanda, Kong, Oohara, Pinto
  - Parameter estimation : Feng-Li Lin, Tjonnie Li, Hayama
- Characterization of burst signals
  - Classification : Pinto
  - Non-Gaussian : Yokoyama, Pinto
  - Using PEM : Miyoki
  - Machine learning : Kong, Liu, Takahashi

LV burst activities for O3

O3 Project Updates (List of O3 Deliverables)

- **Short duration search**, latest call (Aug 06)
- **Long duration search**, latest call (Aug 06)
- **IMBH search**, Latest call (Aug 02)
- **eBBH search**,
- **O3a CBC catalog paper burst contribution**, Latest call (Aug 01)
- **O3a GRB paper**, Latest call (Aug 01)
- **Cosmic string search**
- **FRB search**, Latest call (Aug 01)
- **Magnetars search**, Latest call (Aug 01)
- **Supernova search**
- **HEN search**

R&D groups

- **Low latency**, Latest call (Aug 02)
- **Signal Characterization**, Latest call (Aug 01)
- **Supernova**, Latest call (Aug 06)
- **BBH**
- **GRB**, Latest call (Aug 01)
- **Detchar**, latest Detchar call (Aug 05)

Appendix:
Proposals in the KAGRA burst groups.

Burst Group O3 Activities
in
Beijing Normal University

2019.6.27

Current Status

(1) Gravitational Wave Non-template Search Based on BayesWave and Its Improvement

We need non-template gravitational wave search methods, which are complementary to the matched filtering pipelines. The pipelines that have been tested in practice (O1 and O2) are coherent WaveBurst (cWB) and BayesWave. BayesWave uses a wavelet decomposition and Bayesian inference methods to reconstruct GW signals, and distinguish between real astrophysical signals and instrumental noise. The KAGRA Burst group is already preparing to use cWB for O3 observation, and currently no KAGRA internals use BayesWave. We will use BayesWave for O3 observation as a complement to the matched filtering pipelines and cWB, and make improvements based on the original BayesWave, such as improve the measurement of the polarization of gravitational waves and increase the calculation speed.

(2) Gravitational Wave Denoising Technology Based on Empirical Mode Decomposition and Independent Component Analysis

Combining the two technologies, we can develop an adaptive noise reduction technology to improve the signal-to-noise ratio of the gravitational wave signals, which is helpful to detect weaker gravitational wave signals such as gravitational waves from core-collapse supernovae, currently the numerical simulation results of several research teams all indicate that the gravitational wave signals intensity of the supernovae are much lower than that of CBC, which limits their detection range.

(3) Gravitational Wave Trigger Based on Deep Learning

Event Trigger Generator (ETG) based on deep learning for CBC.

Because the neural network has certain generalization capabilities, the algorithm we developed is also helpful for searching burst signals.

BayesWave (Project 1) can be the ETG's follow-up, which can reconstruct waveforms and other parameters.

Future Plan

- We are studying the source code and principle of BayesWave. After the start of O3 this year, on the one hand, we will process the O3 data with the BayesWave version that has been verified by O2 observation. This is to ensure the reliability of the results. On the other hand, we will make improvements on original BayesWave, especially in detecting the polarization of gravitational wave signals and pipeline’ s computational efficiency . The improved BayesWave will also validate its effectiveness through O3 data, compare its results to the original BayesWave (O2 version) and other pipelines used in O3. The results of the study will be helpful to both the CBC and Burst group of KAGRA.
- We will first use the simulated gravitational wave data to verify the validity of the EMD-ICA denoising algorithm, and then use it for O3 data for further verification. We will use this algorithm in conjunction with BayesWave and other pipelines to see if it will improve the weak gravitational wave signals’detection.
- Event Trigger Generator (ETG) based on deep learning for both CBC and burst signals.

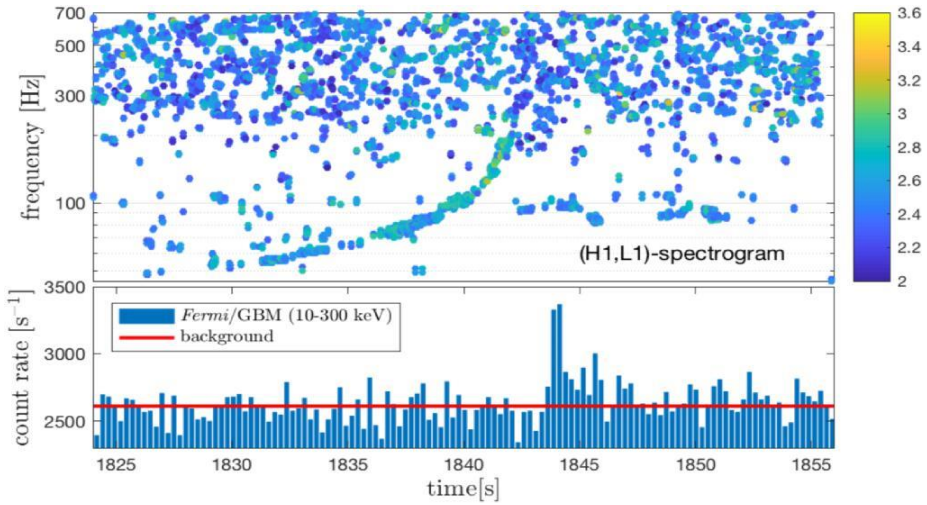
•Broadband Extended Gravitational-wave Emission: status

M.-V. Putten

•A new window for small un-modeled signals from extreme transient events on modern gaming hardware

Discovery:

Observational evidence for Extended Emission to GW170817, 2019, van Putten, M.H.P.M., & Della Valle, M., MNRAS, 482, L46



•Interpretation:

•Multi-messenger Extended Emission from the compact remnant in GW170817, 2019, van

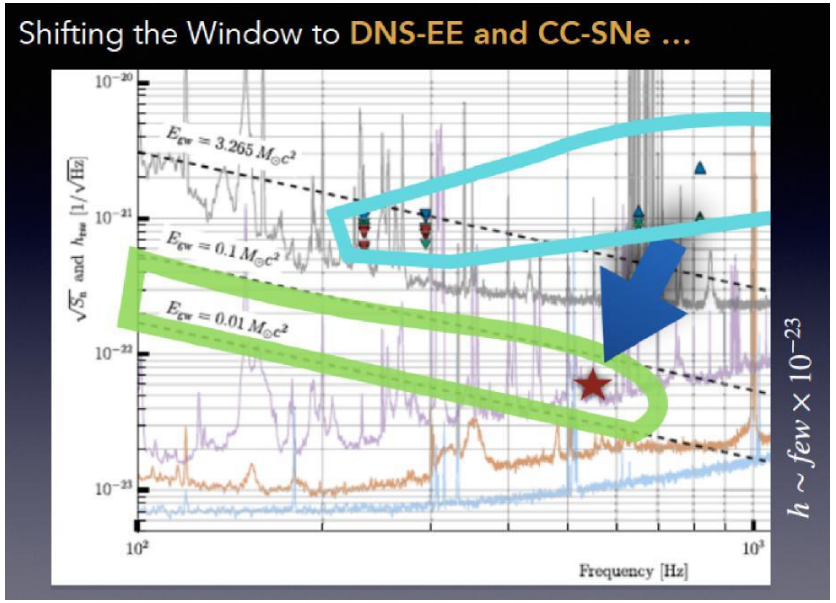
•Putten, M.H.P.M., & Della Valle, M., & Levinson, A., ApJ Letters, to appear

•Broadband Extended Gravitational-wave Emission: plans

New Window for un-modeled signals:

User Guide 1.0 and GPU-platform description:

JGW-T1909860-v1



•LIGO O1: Post-processing of (H1,L1)-spectrograms...

Ongoing and Planned analysis:

•LIGO O2: Analysis of 3113 frames of H1&L1 data (4096s each)...

•KAGRA: Estimate sensitivity distance to GW170817EE-like events by signal injections...

•LIGO O3: Data access??

Unit leader : N.Kanda @Osaka City U.

Project: Transient signal analysis

members : Nobuyuki Kanda, Satoshi Tsuchida, Takahiro Sawada

purpose : to develop/study short transient GW signals, i.e. CBC at merger phase, CBC from BBH, and Burst from supernovae.

current status of 'burst' data analysis

- Update our Linux cluster
  - CPUs -> 920 cores
  - SL6 -> SL7
  - Latest LAL suite (will be installed soon)
- *Developing new signal filter*
  - *For transient signal in complex-frequency domain*

short-term plans using O3 data

- Evaluate our new filter
- Perform new signal filter on observation data
  - of KAGRA's waveform injection test
  - around real events from LV(+K)

Research Unit Status: Y. Itoh-OCU (2019April)

[Project]: independent component analysis

[Working group]: Burst,

[Members]: Yousuke Itoh

[Collaborators]: Toyokazu Sekiguchi, Junya Kume, Jun'ichi Yokoyama (U. Tokyo), Soichiro Morisaki

[Description]: Using the RESCEU cluster, we apply ICA on GW and PEM data to (1) clean the strain channel data and (2) find out transfer functions among channels.

[Status]: Study on iKAGRA data is on-going, found a moderate increase of SNR using the strain and seismic channel. The results are reported by J. Kume at the 22nd f2f.

[Short term plan]: Apply ICA on O3 data, hopefully using more and multi-PEM channels using the RESCEU cluster. Tune and find out performance of ICA.

Niigata Univeristy

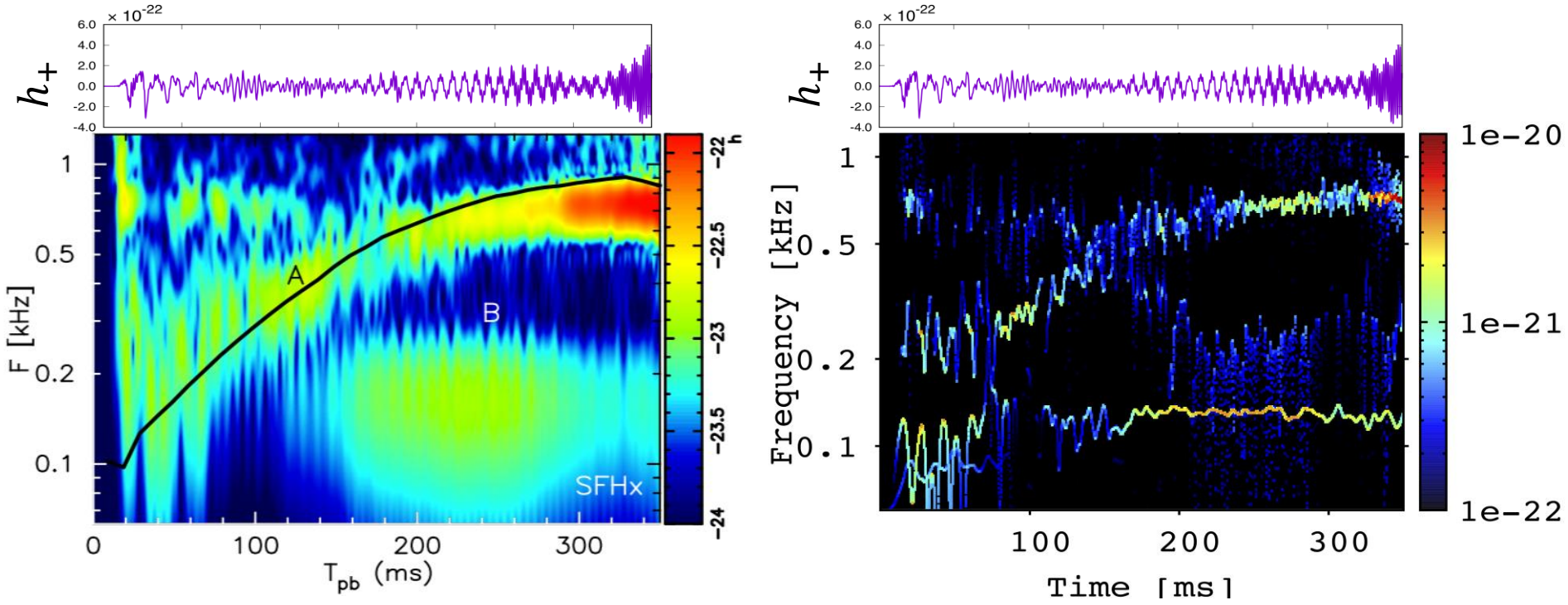
- Leader: Ken-ichi Oohara
- members: Mei Takeda (M2), Ryo Negishi (M2)
  collaborated with Nagaoka UT
- Analysis of gravitational waves from SNe with HHT
  - in progress
    - Extraction of SASI modes in core collapse SNe
    - Search of optimum parameters of HHT
  - planning
    - software injection of SN-GW in real noise data
- Burst search with HHT
  - planning
    - Improvement of EMD (empirical mode decomposition) is necessary.

Current activity of Nagaoka U. Tech group

with Niigata Univ., Nagaoka-CT, OCU, Fukuoka Univ.

Project: parameter estimation

- We perform analysis of gravitational waves from standing accretion shock instability (SASI) [1] of a core collapse supernova by using Hilbert-Huang transform (HHT).



[1] T. Kuroda, K. Kotake, and T. Takiwaki, ApJ, 829, L14 (2016)

Future plan

- HHT analysis:
  - We will consider how to quantitatively evaluate the time-frequency maps of HHT.
  - We should confirm our proposed analysis method to more realistic case i.e. simulation or real noise plus signal.
- Noise reduction:
  - Denoising Autoencoder (Neural network etc.)
  - Sparse modeling

•Feng-Li Lin@NTNU

ω We currently work on the pipeline construction for testing the equation of state (EoS) for the binary neutron stars (BNS) and exotic stars. We have built up the EOB template bank for BNS, and now are trying to adopt PyCBC or gstlal Inference to do data analysis. We are also trying to adopt new method such as GPU or stochastic templates to accelerate the procedure.

ω In the future we like to study the hyper collisions of black holes, and apply for the corresponding gravitational wave (GW) emission, and wish to study the near-horizon physics of black holes. The nature of GW should be burst-like.

•Data Analysis Activity

•Kipp Cannon

•東京大学, April 19, 2019

•Data Analysis Activity

•Kipp Cannon

•東京大学, April 19, 2019

•Group (Bursts)

- Kipp CANNON (faculty)
- TSUNA Daichi (D1)
- NISHIZAWA Atsushi (faculty)

- Activities

  - Cosmic string burst search: modern pipeline for better performance, easier use, and with new ranking statistic for higher sensitivity. (Tsuna)

2019 Progress Report of USannio Working Group

KAGRA Data Analysis Working Group Meeting, July 24 2019

Pinto, I. (U. Sannio)

Topics :

- Use of triangular norms for the estimation of arrival-time delays;
- Use of Radon transform for robust chirp-mass estimation from time-frequency data (as described in 2018 USannio Data Analysis Workplan for KAGRA)

Work Done/Results :

Application of the above techniques to the eleven GW events from O1 & O2, using public-domain (LOSC) data;

References :

E. Mejuto-Villa, Innocenzo Pinto, Luigi Troiano, "Triangular Norms for GW Data Fusion," IEEE Trans. Fuzzy Systems, 10.1109/TFUZZ.2019.2910453 (2018)

E. Mejuto-Villa, Innocenzo Pinto, Luigi Troiano, "On the Application of T-Norms to Gravitational Wave Data Fusion: A Confirmatory Study," LIGO-P1900189 (2019)

E. Mejuto-Villa, PhD Thesis, University of Sannio (2019)
https://drive.google.com/file/d/154XtY3N7UNtY96uBWDCxztQhUcUSqhwr/view