Glitch noise study of gravitational wave interferometer in KAGRA

Chihiro Kozakai (NAOJ), KAGRA collaboration @ KMI school 2020/11/17

Abstract

KAGRA is a gravitational wave telescope. It is sensitive to external disturbance and therefore the discrimination with gravitational wave signal is important. Visual event investigation tool is developed for that. Also new glitch analysis method using machine learning is proposed.

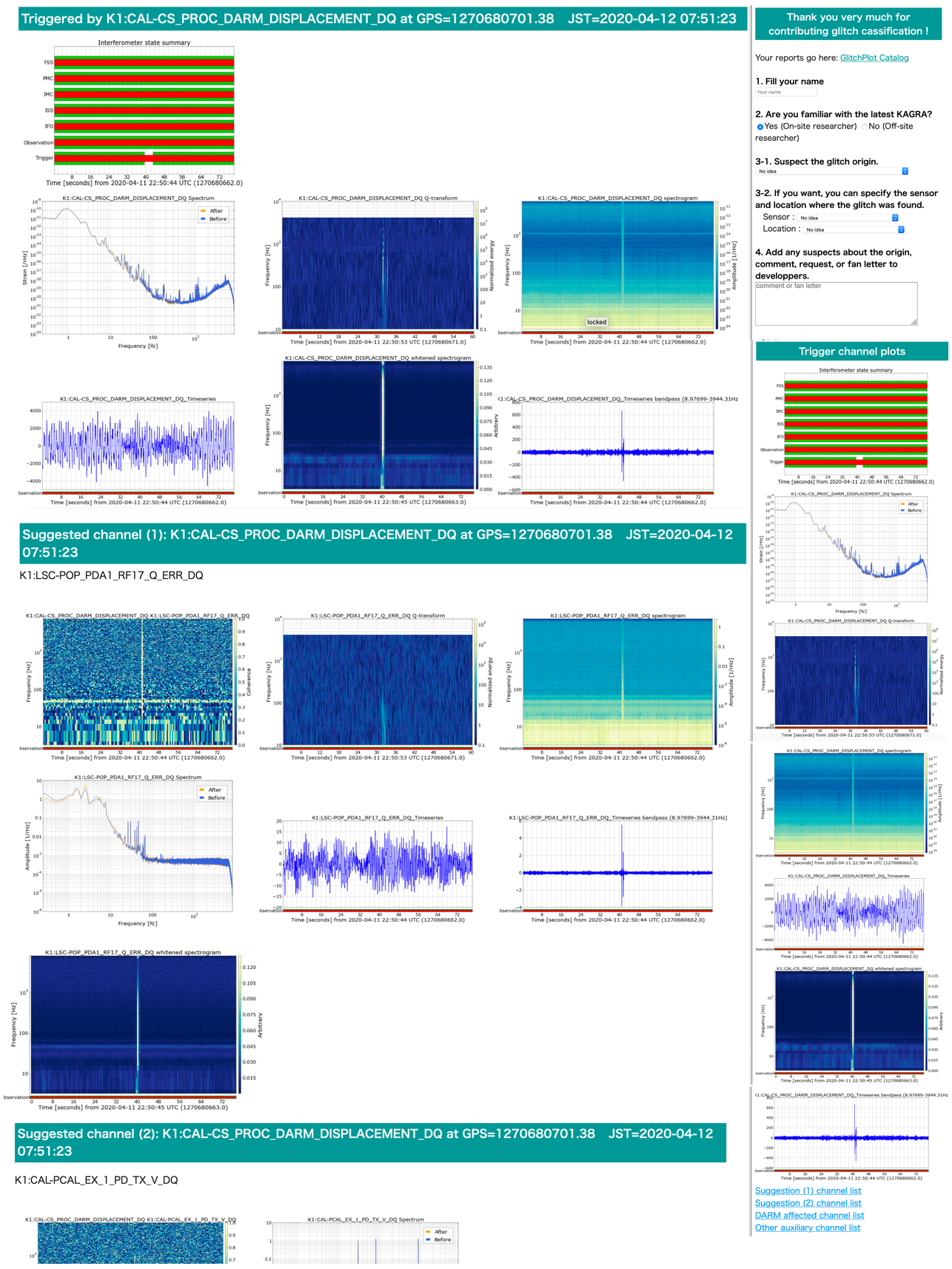
1. Introduction: KAGRA experiment

KAGRA is the Large-scale Cryogenic Gravitational-wave Telescope located in Kamioka, Japan. It is designed as a laser interferometer with configuration of Dual-Recycling Fabry-Perot Michelson interferometer. Gravitational wave is detected by interference of laser which go through 3km Fabry-Perot cavities located perpendicularly. Characteristics of KAGRA are that it is constructed underground and that cryogenic mirrors are used.

2. Glitch noise and auxiliary data

Gravitational wave laser interferometer is very sensitive detector not only to gravitational wave but also to environmental disturbance. The data may have transient excess due to earthquake, lightning, sound and so on. Therefore, Physical Environmental Monitors (PEM) are installed at important places around the interferometer. PEM include sensors like seismometer, accelerometer, magnetometer, microphone and so on. KAGRA also take data of interferometer control related data, cavity power monitors and so on. My study is to identify whether the transient excess in gravitational wave measurement data is any hardware related event or not using these auxiliary data.

3. GlitchPlot: visual event investigation tool



I developed a tool to visualize transient events and summarize them on web page. Depending on properties of each transient event, plot setting is automatically adjusted. What we want to focus is glitch source, so it also has a function to pick up suspicious auxiliary data which show high coherence with gravitational wave data or transient noise. This tool can be used for validation of gravitational wave event candidates.

4. New glitch analysis method proposal based on machine learning

Glitch noise can be characterized by multiple parameters like frequency, duration, SNR, amplitude and so on. The probability distribution estimation of glitch parameters is good application of machine learning. I would propose following procedure.

1. Glitch distribution estimation of auxiliary data using period which do not include any excess in gravitational wave data.
2. Application to event validation: For a gravitational candidate event, search for auxiliary data glitch around the event. If it is significantly rare according to the estimated distribution of 1, the event is judged as detector external disturbance and vetoed.
3. Application to glitch source identification: Estimate the glitch distribution of auxiliary data around glitch of gravitational wave data. If the distribution is significantly different from the result of 1, the auxiliary data should be relevant to glitch source.

Conclusion

Glitch noise identification is one of the important points in the detection of gravitational wave in KAGRA. GlitchPlot, visual event investigation tool is developed for that purpose. A new glitch analysis method using machine learning is proposed.