

Low-Latency Alerts Update

Open LVEM call, December 15th, 2022

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Main Developers

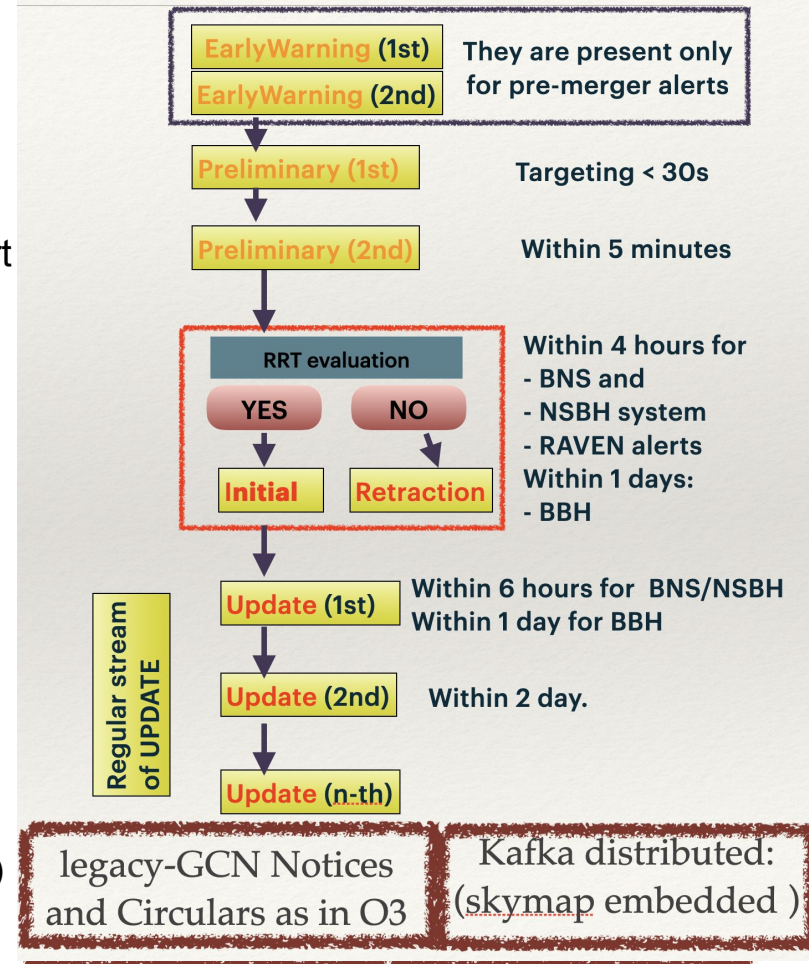
1. Leo Singer
2. Deep Chatterjee
3. Cody Messick
4. Brandon Piotrkowski
5. Geoffrey Mo

Confirmation from last OpenLVEMs

- **Confirmed timeline of alerts**
- **Mass-gap** moved from `p_astro` to source-properties section of GCN
- EM-Bright probabilities (**HasNS** and **HasRemnant**) will be quantities marginalized over large number of equation of neutron star models (instead of single 2H Equation of State from O3)
- Skymap information will be provided using “**multiorder**” **MOC** based fits format. Flattened skymap will be available in GraceDB for legacy usage.
- **EarlyWarning** (negative time) alert will be provided
- Coincident alerts (RAVEN+LLAMA) will be publicly distributed
- MULTIPLE DISTRIBUTION CHANNEL for alerts:
 - GCN Notices and Circulars as in O3.
 - Kafka based one with embedded skymap via SCiMMA and GCN

Alert system: Public alert

- (1st) **EarlyWarning** (fully automatic)
- (2nd) **EarlyWarning** (fully automatic) possible second alert as new localization are available.
- (1st) **Preliminary** (fully automatic) alert (targeting < 30s).
- (2nd) **Preliminary** alert (fully automatic) after search is completed by all the pipelines with updated localization (targeting < 3 minutes).
- A (3rd...n-th) Preliminary will be published in case of improved localization before Rapid Response Team (RRT) validation.



The Public Userguide

- Updated observational capabilities
- Alert content update - Mass-gap moved to source properties
- Receiving of GCN alerts - Three avenues to getting alerts
- Early warning capabilities

The screenshot shows the top navigation bar of the 'IGWN | Public Alerts User Guide' website. It includes a search bar and a 'userguide' link. Below the navigation bar is a blue header with the text 'Primer on public alerts for astronomers from the LIGO, Virgo, and KAGRA gravitational-wave observatories.'

The main content area features a table of contents on the left and a central section titled 'LIGO/Virgo/KAGRA Public Alerts User Guide'. The table of contents includes: 'Getting Started Checklist', 'Observing Capabilities', 'Data Analysis', 'Alert Contents', 'Sample Code', 'Additional Resources' (with 'Early-Warning Alerts' highlighted), 'Change Log', and 'Glossary'. Below the table of contents is a 'Question? Issues? Feedback?' section with an email address: 'emfollow-userguide@support.ligo.org'.

The central section contains a welcome message: 'Welcome to the LIGO/Virgo/KAGRA Public Alerts User Guide! This document is intended for both professional astronomers and science enthusiasts who are interested in receiving alerts and real-time data products related to gravitational-wave (GW) events.' It also states: 'Four sites (LHO, LLO, Virgo, KAGRA) together form a global network of ground-based GW detectors. The LIGO Scientific Collaboration, the Virgo Collaboration, and the KAGRA Collaboration jointly analyze the data in real time to detect and localize transients from compact binary mergers and other sources. When a signal candidate is found, an alert is sent to astronomers in order to search for counterparts (electromagnetic waves or neutrinos).' Finally, it explains: 'LIGO/Virgo/KAGRA alerts are public. Alerts are distributed through NASA's Gamma-ray Coordinates Network (GCN, https://gcn.nasa.gov) and Scalable Cyberinfrastructure to support Multi-Messenger Astrophysics (SCIMMA, https://scimma.org). There are two types of alerts: human-readable GCN Circulars and machine-readable Notices. This document provides a brief overview of the procedures for vetting and sending GW alerts, describes their contents and format, and includes instructions and sample code for receiving Notices and decoding GW sky maps.'

The central section also features a figure with three panels: 'Lightcurve from Fermi/GBM (50 - 300 keV)', 'Sky map showing the localization region for a GW event, with the LIGO/Virgo/KAGRA detector network overlaid on a globe, and two inset images showing the localization regions for 'Binary BH 151226' and 'Binary NS 151226'.

Observation capability updated

- The event rate (a bit optimistic) are based on the best possible sensitivity curve, and the change in SNR threshold from 12 to 8.
- Final and more realistic numbers will be updated once engineering run is performed and representative sensitivity curve are available

Annual number of public alerts

(log-normal merger rate uncertainty \times Poisson counting uncertainty)

04	HKLV	36^{+49}_{-22}	6^{+11}_{-5}	260^{+330}_{-150}
05	HKLV	180^{+220}_{-100}	31^{+42}_{-20}	870^{+1100}_{-480}
		BNS	NSBH	BBH

Receiving of GCN alerts

Instructions on receiving of alerts are now available on the Userguide:

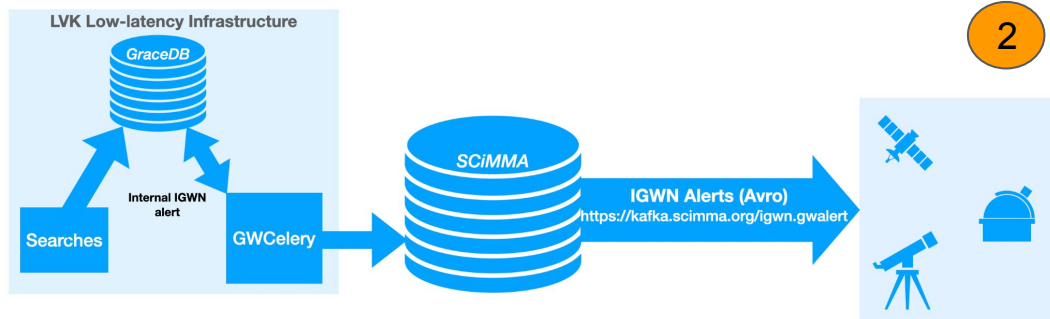
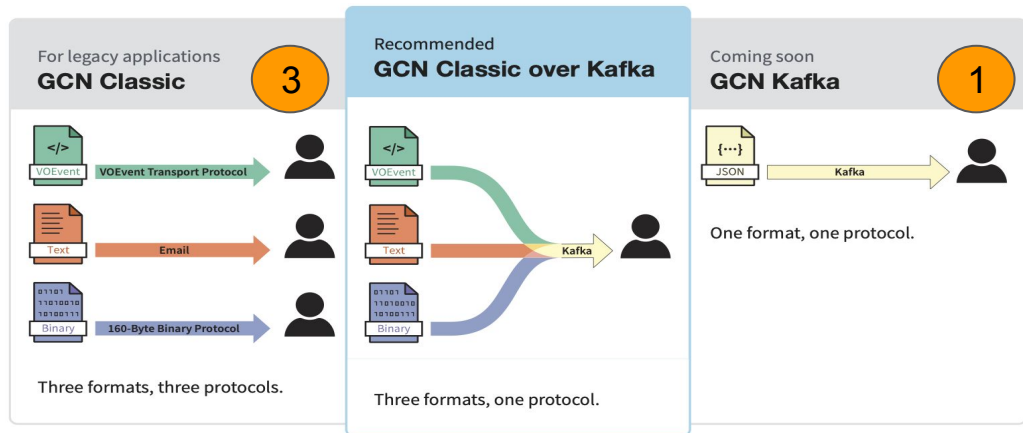
Users need to use one of the following:

1. [GCN-kafka for connecting to GCN](#) to receive JSON-serialized notices over Kafka
2. hop-client to receive Avro-serialized notices over [Kafka from SCiMMA](#).
3. Classic GCN format (like in O3)

Kafka Notices via GCN with embedded sky-map using JSON

Kafka Notices via SCiMMA with embedded sky-map using Avro

[A quick walkthrough](#)



Parameter Estimation Updates

Shifting from LALInference to Bilby

RapidPE-RIFT starts to run on MDC triggers, documentation currently under progress

Details on automation of PE results are under discussion

Updates on a future call

Summary

- kafka (avro/json) packets finalized.
- User Guide has been published
- **December 15th 2002.**
- Now operational the distribution of public alerts using kafka transport (using SCiMMA and the upcoming GCN Kafka infrastructure):

- SCiMMA:

`kafka://kafka.scimma.org/igwn.gwalert`

- GCN Kafka:

subscribing to `igwn.gwalert`

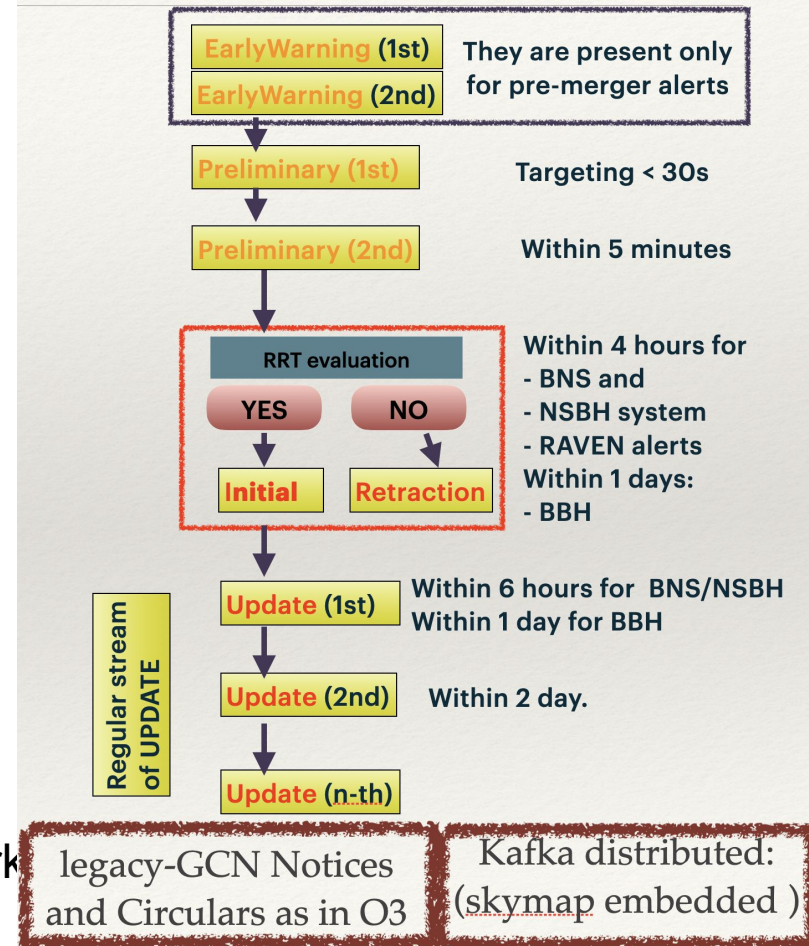
No.	Log Entry Created ▾	Submitter	Comment
204	2022-12-13 15:42:37 UTC	LIGO/Virgo EM Follow-Up	Kafka alert notice sent to <code>kafka://kafka.gcn.nasa.gov/igwn.gwalert (MS221213p-initial.json)</code> em_follow lvem public
203	2022-12-13 15:42:37 UTC	LIGO/Virgo EM Follow-Up	Kafka alert notice sent to <code>kafka://kafka.scimma.org/igwn.gwalert (MS221213p-initial.avro)</code> em_follow lvem public
199	2022-12-13 15:42:35 UTC	LIGO/Virgo EM Follow-Up	New VOEvent (MS221213p-3-Initial.xml) em_follow lvem public gcn_received gcn_email_notok
187	2022-12-13 15:37:48 UTC	LIGO/Virgo EM Follow-Up	Volume rendering of <code>bayestar.muliorder.fits,1 (bayestar.volume.png)</code> sky_loc lvem public
174	2022-12-13 15:37:43 UTC	LIGO/Virgo EM Follow-Up	Source classification copied from M399362 (<code>subthreshold.p_astro.json</code>) lvem public p_astro
173	2022-12-13 15:37:43 UTC	LIGO/Virgo EM Follow-Up	Source properties copied from M399362 (<code>subthreshold.em_bright.json</code>) lvem public em_bright
151	2022-12-13 15:37:24 UTC	LIGO/Virgo EM Follow-Up	Kafka alert notice sent to <code>kafka://kafka.gcn.nasa.gov/igwn.gwalert (MS221213p-preliminary.json)</code> em_follow lvem public
150	2022-12-13 15:37:24 UTC	LIGO/Virgo EM Follow-Up	Kafka alert notice sent to <code>kafka://kafka.scimma.org/igwn.gwalert (MS221213p-preliminary.avro)</code> em_follow lvem public
143	2022-12-13 15:37:22 UTC	LIGO/Virgo EM Follow-Up	Mollweide projection of <code>bayestar.muliorder.fits,1 (bayestar.png)</code> sky_loc lvem public
142	2022-12-13 15:37:22 UTC	LIGO/Virgo EM Follow-Up	New VOEvent (MS221213p-2-Preliminary.xml) em_follow lvem public gcn_received gcn_email_notok

We encourage users to use the hourly MDC events on GraceDB to test their listeners. Search `MDC` in the search bar of `gracedb`.

Extra slides

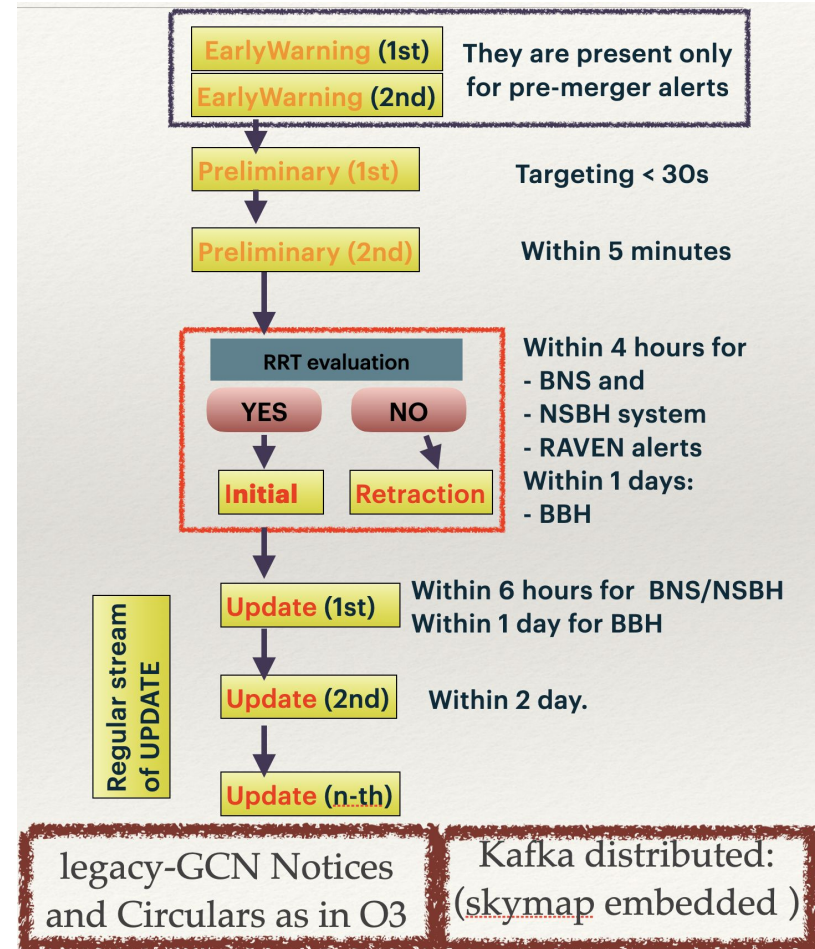
Alert system: Public alert

- FAR threshold (**Trial factor will be applied**)
 - 1/(2 months) (CBC)
 - To be discussed if lower FAR may be considered for CBC Early Warning.
 - 1/(1 year) (Burst)
- Multiple distribution channels for alerts
 - **GCN** (classic)-notices and circulars (as in O3)
 - **Kafka-based** alerts with embedded skymap via SCiMMA and GCN network



Alert system: Public alert

- RRT meeting and a human/rapid-PE evaluation typically within 4 hours for BNS or 1 day for vanilla BBH.
- An **Initial/Update** or **Retraction** alert will be sent. An Initial/Update alert can contain improved localization and source classification.
- Update alerts will be sent when improved PE results are available.



Avro schema for public alerts (Final !)

```
{ "name": "Alert",
  "namespace": "igwn.alerts.v1_0",
  "type": "record",
  "doc": "Alert schema v1.0.",
  "fields": [
    {"name": "author", "type": "string"},
    {"name": "alert_type", "type": "igwn.alerts.v1_0.AlertType",
      "doc": "The type of alert; the possible values are EARLY_WARNING, PRELIMINARY, INITIAL, UPDATE,
RETRACTION."},
    {"name": "time_created", "type": "string", "doc": "The time the superevent was created in ISO 8601 format."},
    {"name": "superevent_id", "type": "string", "doc": "The GraceDB superevent ID."},
    {"name": "is_public", "type": "boolean", "doc": "Whether or not the event is public."},
    {"name": "is_injection", "type": "boolean", "doc": "Whether or not the event corresponds to an injected signal."},
    {"name": "event", "type": ["null", "igwn.alerts.v1_0.EventInfo"],
      "doc": "Information about the event, if any."},
    {"name": "external_coinc", "type": ["null", "igwn.alerts.v1_0.ExternalCoincInfo"],
      "doc": "Information about the coincidence with a non-GW event, if any."},
    {"name": "urls", "type": {"type": "map", "values": "string", "default": {}}, "doc": "URLs relevant to the event, if any."}
  ]
}
```

```
{ "name": "AlertType",
  "namespace": "igwn.alerts.v1_0",
  "type": "enum",
  "doc": "The type of alert.",
  "symbols": ["EARLY_WARNING", "PRELIMINARY", "INITIAL", "UPDATE", "RETRACTION"]
}
```

To be published in the O4 User Guide (Early November).
First draft will be published at the next openLVEM.