Low-Latency Update

OpenLVEM, September 23, 2022

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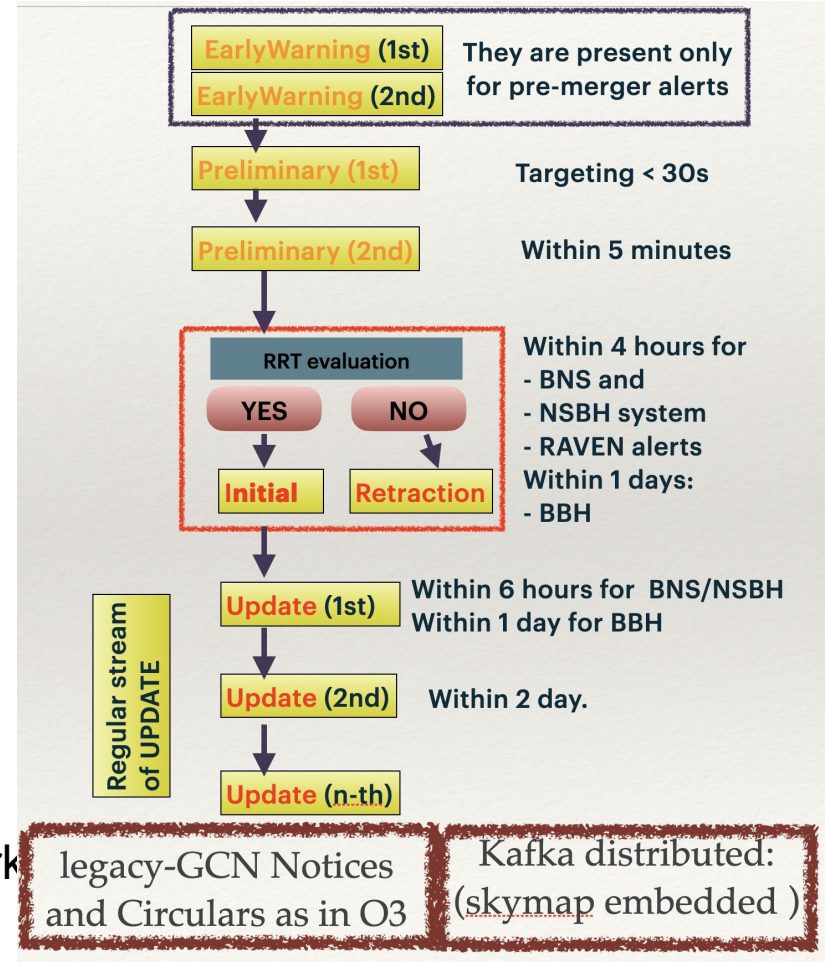
Summary

- What's new from last LIGO-Virgo-KAGRA July Town Hall Telecon
  - Revised expectation:
    - MDC alert streaming should start **early November**.
    - Latency budget available end of October
- Draft of kafka/avro packets finalized. Asking for feedback from you.
- User Guide will be published **early November** after the finalisation of the latency budget and the content of the "kafka" streaming alert.
- Now operational in our internal testing environment: public alerts distributed over kafka (using SCiMMA infrastructure). In production it will be on the `kafka://kafka.scimma.org/igwn.gwalert` and `kafka://kafka.gcn.nasa.gov/igwn.gwalert` topics.

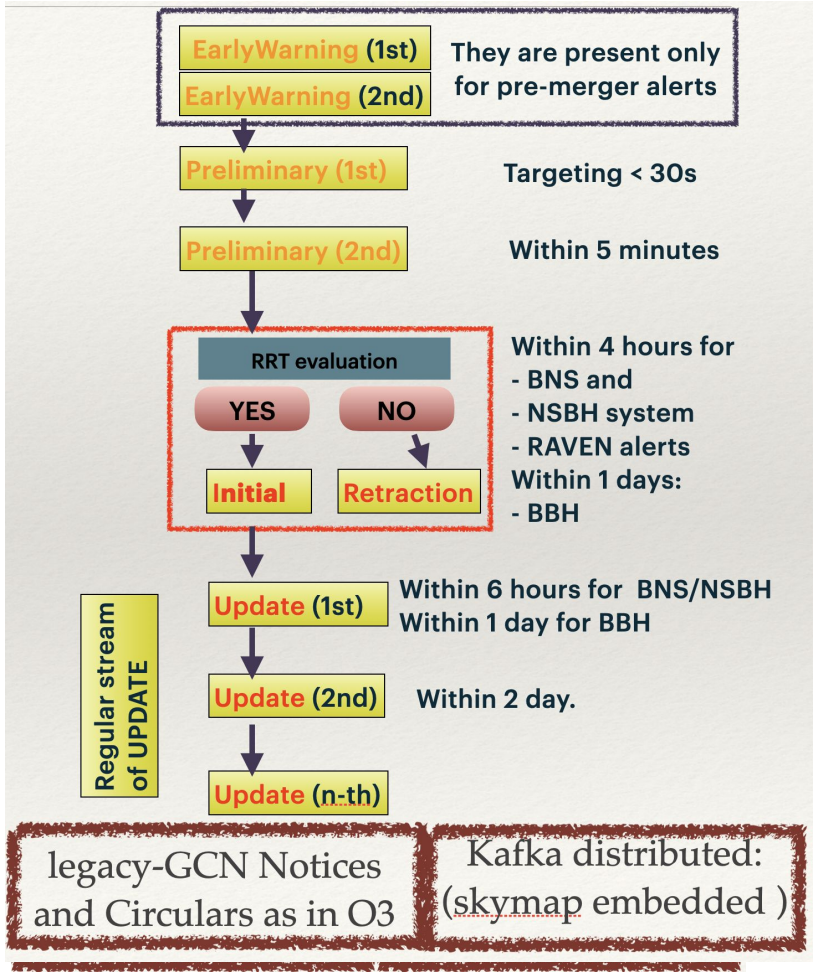
Alert system: Public alert

- 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** (legacy)-notices and circulars (as in O3)
  - **Kafka-based** alerts with embedded skymap via SCiMMA and GCN network



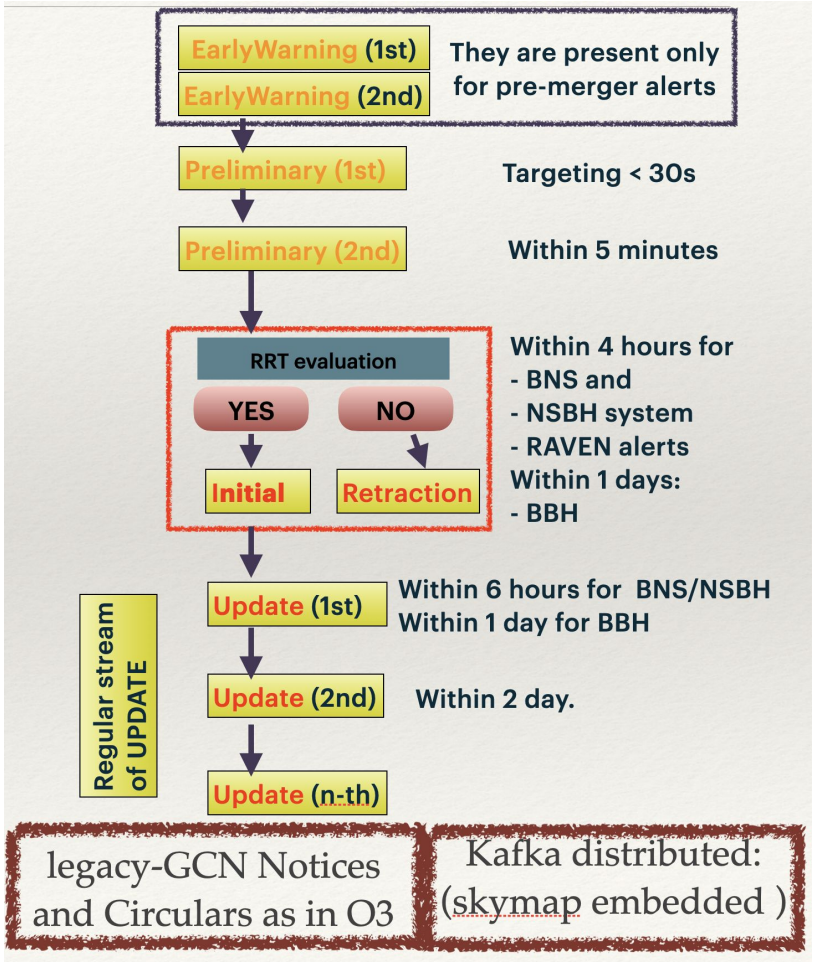
Alert system: Public alert

- (1st) **EarlyWarning** (fully automatic)
  [It is under consideration to send the first one without localization information. Need your feedback if this is useful if the MDC study show that this may reduce latency of > 2s]
- (2nd….3rd….) **EarlyWarning** (fully automatic) 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 Rapide Response Team (RRT) validation.



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.



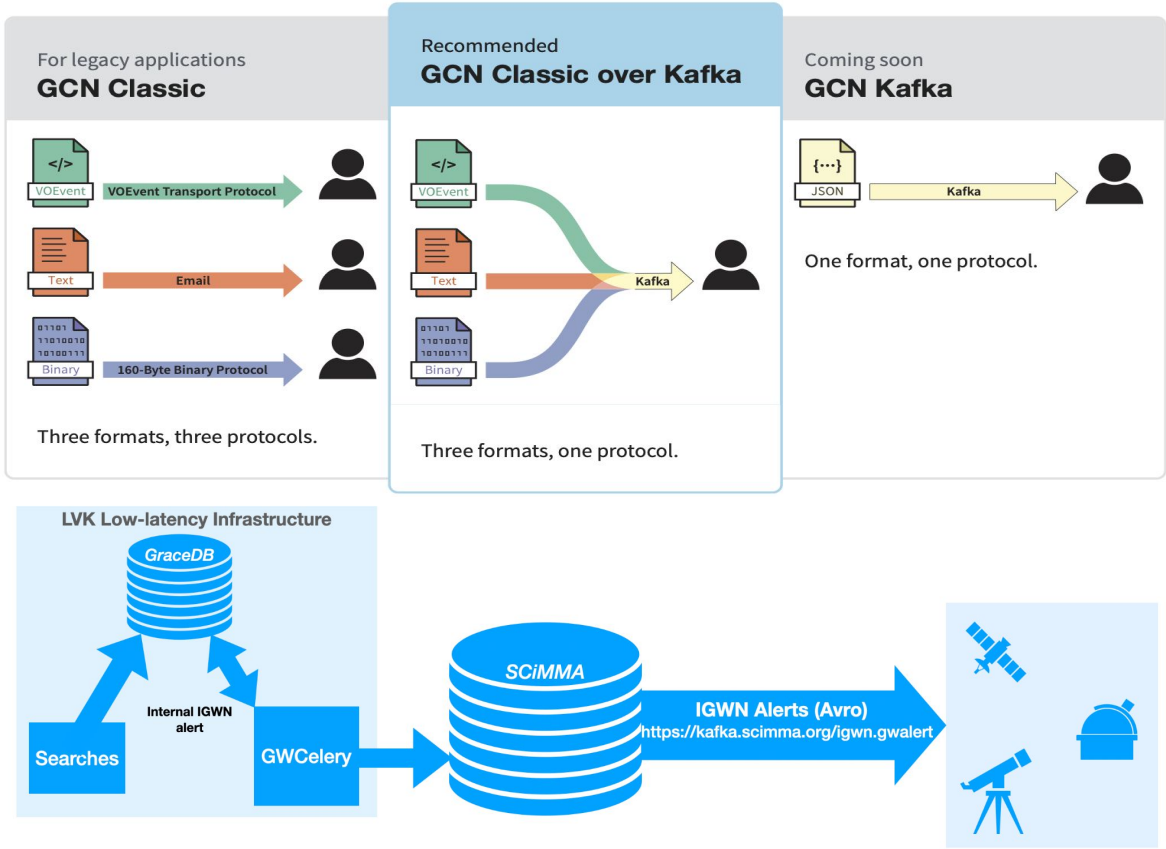
GCN system support in O4

We will continue feeding the GCN classic stream of VO using the standard “legacy” channel

We will feed alerts in json format to GCN kafka brocker.

We will distribute OPA alert using SCiMMA kafka broker.

We are considering to provide streaming alert to other distribution system (on request).



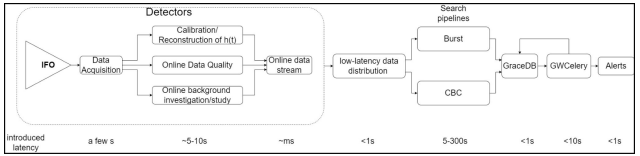
Avro schema for public alerts (DRAFT)

```
{  "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 an 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.

On-going LVK Mock Data Challenge (MDC)



- CBC injection **training set** modeled based on previous LVK observing runs[1]. Presently assumed distribution is not an assertion of real astrophysical on behalf of LVK collaboration.

Binary type	Max m_1	Min m_1	Max m_2	Min m_2	m_1 distribution	m_2 distribution	Max a_1	Max a_2	a_1 distribution	a_2 distribution
BNS	2.053556	1.0	2.053556	1.0	uniform	uniform	0.4	0.4	uniform & isotropic	uniform & isotropic
NSBH	60.0	1.0	2.053556	1.0	m^{-1}	uniform	0.998	0.4	uniform & isotropic	uniform & isotropic
BBH	100.0	2.053556	100.0	2.053556	$m^{-2.35}$	m	0.998	0.998	uniform & isotropic	uniform & isotropic

- Total of 50K CBC events were injected - 20465 BNS, 17946 NSBH, and 11589 BBH

[1] Definition of neutron used in determining the population is based on a high evidence neutron EoS model based on GW170817 data.

MDC dates

MDC #	Start date	End data
00	Dec 03 18:39:42 UTC 2021	Jan 12 18:39:42 UTC 2022
01	Jan 12 18:39:42 UTC 2022	Feb 21 18:39:42 UTC 2022
02	Feb 21 18:39:42 UTC 2022	Apr 02 18:39:42 UTC 2022
03	Apr 02 18:39:42 UTC 2022	Jun 21 18:39:42 UTC 2022
04	Jun 21 18:39:42 UTC 2022	Jul 31 18:39:42 UTC 2022
05	Jul 31 18:39:42 UTC 2022	Sep 09 18:39:42 UTC 2022
06	**Sep 09 18:39:42 UTC 2022**	**Oct 19 18:39:42 UTC 2022**
07	**Oct 19 18:39:42 UTC 2022**	**Nov 28 18:39:42 UTC 2022**
08	**Nov 28 18:39:42 UTC 2022**	**Jan 07 18:39:42 UTC 2023**
09	**Jan 07 18:39:42 UTC 2023**	**Feb 16 18:39:42 UTC 2023**

- Currently 4 CBC and 3 burst pipelines are participating.
- Early Warning triggers are being produced and tested.
- Low-latency system is producing skymaps, p-astro, and EM-Bright
- Review has been conducted
- Discussion on making MDC generated OPA alerts public is still pending. **We need your feedback about that in order to arrive to a LVK collaboration decision**.
- Studies underway to make first parameter estimation results in 15 mins latency.

Confirmation from last openLEVM

- **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

Revised time-table

Preliminary result and testing on the live MDC leaded as to revise to expected time-table:

- Latency budget available end of **October**
- Final format kafka/avro packets will be finalized in **October**
- MDC alert streaming should start **early November**.
- User Guide will be published **early November** after the finalisation of the latency budget and the content of the “kafka” streaming alert.

We plan to complete this work before next openLEVM conference scheduled for **October 20th** and to discuss the improvement on the **November** 17th call.

Conclusions

Need feedback from you about:

1. Which FAR the OpenLVEM community consider appropriate for early-warning alerts?

2. Are you interested in receiving an MDC stream of OPA alerts generated by the ongoing MDC before the start of O4 ?

3. If yes, would you consider receiving them under a MoU ?

4. If it is possible to receive Early Warning alerts with a reduced latency of more than two second without skymap (Localization Information), would that be considered useful ?