

### LIGO/Virgo/KAGRA Public Alerts

- More details about public alerts are provided in the [LIGO/Virgo/KAGRA Alerts User Guide](#).
- Retractions are marked in **red**. Retraction means that the candidate was manually vetted and is no longer considered a candidate of interest.
- Less-significant events are marked in **grey**, and are not manually vetted. Consult the [LIGO Alerts User Guide](#) for more information on significance in D4.
- Less-significant events are not shown by default. Press "**Show All Public Events**" to show significant and less-significant events.

O4 Significant Detection Candidates: **53** (62 Total - 9 Retracted)

O4 Low Significance Detection Candidates: **1065** (Total)

Show All Public Events

Page 1 of 5, next last >

Sort: EVENT ID (A-Z) ▾

Event ID	Possible Source (Probability)	Significant	UTC	GCN	Location	FAR	Comments
S231014r	BBH (99%)	Yes	Oct. 14, 2023 04:05:32 UTC	GCN Circular Query Nations   VOE		1 per 3,0666 years	
S231008ap	BBH (>99%)	Yes	Oct. 8, 2023 14:25:21 UTC	GCN Circular Query Nations   VOE		1 per 20,718 years	

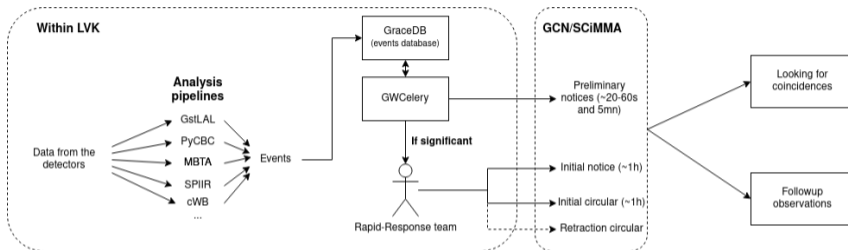
# Status of O4 alerts



Thomas Sainrat



# Overview of the O4 alert process



Two-tier system :

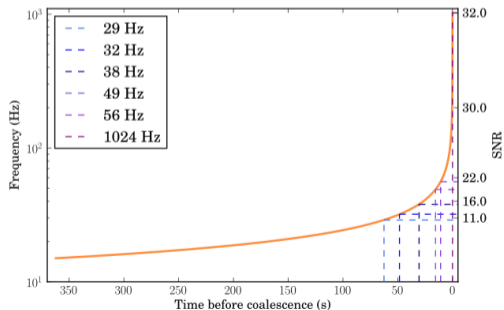
- ▶ **Low-significance events** : False Alarm Rate threshold of 2/day, no human vetting
- ▶ **Significant events** : FAR threshold of 1/5 months for CBC (1/4 years for Burst), systematic human vetting

So far\*, 1000+ low-significance alerts, and 62 significant (including 9 retracted)

\* Oct 15, 18h

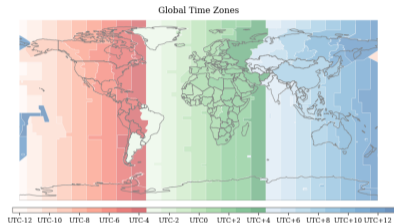
## Special case : Early-Warning alerts

- ▶ Goal : generate alerts before the merger for astronomers to follow
- ▶ Only BNS (= longer templates) are targeted
- ▶ All pipelines produce EW alerts
- ▶ An additional Early-Warning notice is sent → retraction if there is no full-bandwidth event



# Rapid-Response Team (RRT)

- ▶ In charge of vetting the significant events
- ▶ Three timezones : America, Europe, Asia
- ▶ For the Europe timezone:
  - ▶ Half-a-week shifts with two shifters at any time
  - ▶ 168 shift days so far, with 70 individual shifters



## Three levels of shifters :

- ▶ Level-0 : Non-specialist, 24/7 shifters ; in charge of vetting new events
- ▶ Level-1 : Specialist, on-call shifters ; can be called by level-0 shifters for an expert opinion
- ▶ Level-2 : Level-0 + Level-1 + RRT coordinators ; participate in semi-regular calls and called for vetting events with potential multimessenger counterpart

```
////////////////////////////////////  
TITLE:          GCN/LVC NOTICE  
NOTICE_DATE:    Fri 30 Jun 23 12:58:41 UT  
NOTICE_TYPE:    LVC Preliminary  
TRIGGER_NUM:    S230630am  
TRIGGER_DATE:   20125 TJD; 181 DOY; 2023/06/30 (yyyy/mm/dd)  
TRIGGER_TIME:   46686.000000 SOD {12:58:06.000000} UT  
SEQUENCE_NUM:   1  
GROUP_TYPE:     1 = CBC  
SEARCH_TYPE:    1 = AllSky  
PIPELINE_TYPE:  4 = gstlal  
FAR:            2.413e-08 [Hz] (one per 479.6 days) (one per 1.31 years)  
PROB_NS:        0.00 [range is 0.0-1.0]  
PROB_REMNANT:   0.00 [range is 0.0-1.0]  
PROB_BNS:       0.00 [range is 0.0-1.0]  
PROB_NSBH:      0.00 [range is 0.0-1.0]  
PROB_BBH:       0.98 [range is 0.0-1.0]  
PROB_MassGap:   0.04 [range is 0.0-1.0]  
PROB_TERRES:    0.02 [range is 0.0-1.0]  
TRIGGER_ID:     0x10  
MISC:           0x1898403  
SKYMAP_FITS_URL: https://gracedb.ligo.org/api/superevents/S230630am/files/bayestar.multiorder.fits,1  
EVENTPAGE_URL:  https://gracedb.ligo.org/superevents/S230630am/view/  
COMMENTS:       LVC Preliminary Trigger Alert.  
COMMENTS:       This event is an OpenAlert.  
COMMENTS:       LIGO-Hanford Observatory contributed to this candidate event.  
COMMENTS:       LIGO-Livingston Observatory contributed to this candidate event.
```

## GCN Circular 34124

**Subject** LIGO/Virgo/KAGRA S230630am: Identification of a GW compact binary merger candidate  
**Date** 2023-06-30T13:33:07Z 1 month ago  
**From** thomas.sainrat@iphc.cnrs.fr

The LIGO Scientific Collaboration, the Virgo Collaboration, and the KAGRA Collaboration report:

We identified the compact binary merger candidate S230630am during real-time processing of data from LIGO Hanford Observatory (H1) and LIGO Livingston Observatory (L1) at 2023-06-30 12:58:06.902 UTC (GPS time: 1372165104.902). The candidate was found by the CWB [1], MBTA [2], and GstLAL [3] analysis pipelines.

S230630am is an event of interest because its false alarm rate, as estimated by the online analysis, is  $2.4\text{e-}08$  Hz, or about one in 1 year, 3 months. The event's properties can be found at this URL:

<https://gracedb.ligo.org/superevents/S230630am>

The classification of the GW signal, in order of descending probability, is BBH (98%), Terrestrial (2%), NSBH (<1%), or BNS (<1%).

Assuming the candidate is astrophysical in origin, the probability that the lighter compact object is consistent with a neutron star mass (HasNS) is <1%. [4] Using the masses and spins inferred from the signal, the probability of matter outside the final compact object (HasRemnant) is <1%. [4] Both HasNS and HasRemnant consider the support of several neutron star equations of state. The probability that either of the binary components lies between 3 and 5 solar masses (HasMassgap) is 4%.

Two sky maps are available at this time and can be retrieved from the GracedB event page:

\* bayestar.multiorder.fits,1, an initial localization generated by BAYESTAR [5], distributed via GCN notice about 32 seconds after the candidate event time.

\* bayestar.multiorder.fits,2, an initial localization generated by BAYESTAR [5], distributed via GCN notice about 5 minutes after the candidate event time.

The preferred sky map at this time is bayestar.multiorder.fits,2. For the bayestar.multiorder.fits,2 sky map, the 90% credible region is  $3642 \text{ deg}^2$ . Marginalized over the whole sky, the a posteriori luminosity distance estimate is  $8710 \text{ +/- } 2735 \text{ Mpc}$  (a posteriori mean +/- standard deviation).

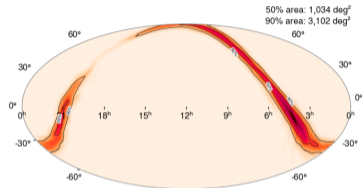
For further information about analysis methodology and the contents of this alert, refer to the LIGO/Virgo/KAGRA Public Alerts User Guide <https://enfollow.docs.ligo.org/userguide/>.

# Content of a public alert

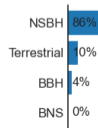
Informations taken from the event with the highest SNR (priority to CBC pipelines)

- ▶ False Alarm Rate
- ▶ GPS time
- ▶ Sky localization
- ▶ Source classification
- ▶ EM-bright properties (conditioned on the event being astrophysical)

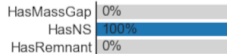
More details in the [EM-follow guide](#)



## Source classification



## EM-bright properties

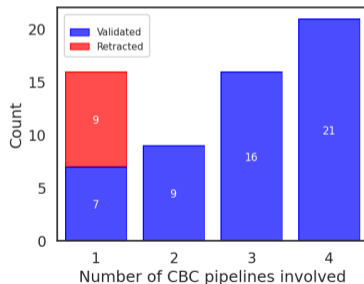
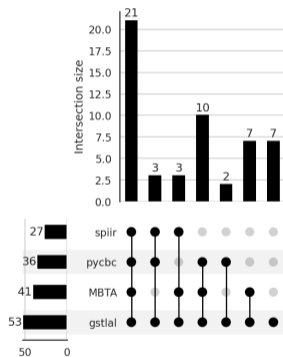


# Significant events from the beginning of O4

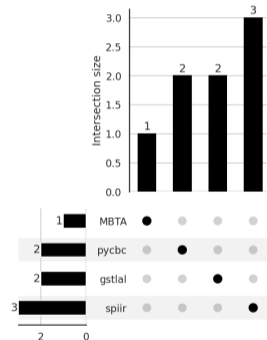
Events with FAR < 2/day:

- ▶ SPIIR: 604
- ▶ PyCBC: 389
- ▶ MBTA: 423
- ▶ GstLAL: 792

## Validated

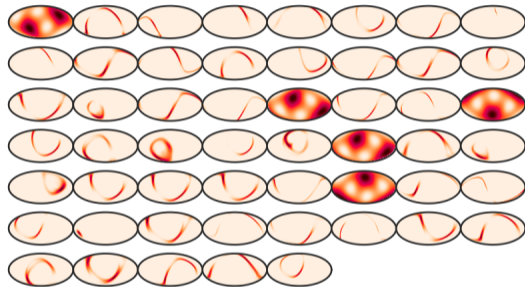
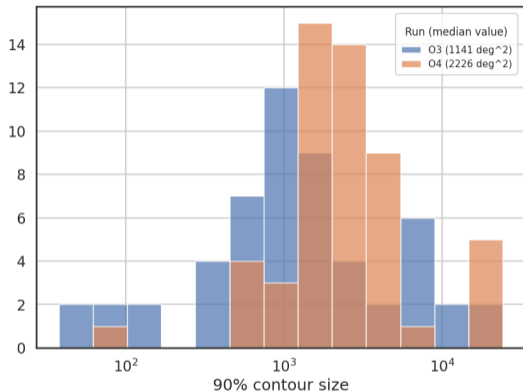


## Retracted



Retracted events were only seen by one pipeline : pay attention to multi-pipeline info

# Comparison with O3 online localization

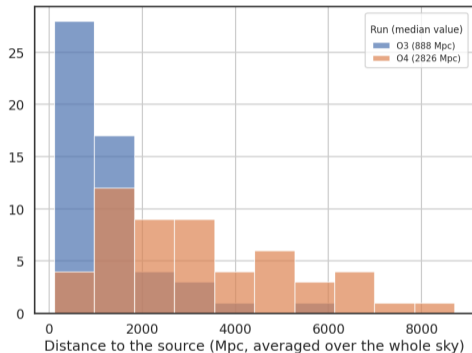


Virgo is not yet part of the run

- ▶ Larger skymaps
- ▶ More single detector events



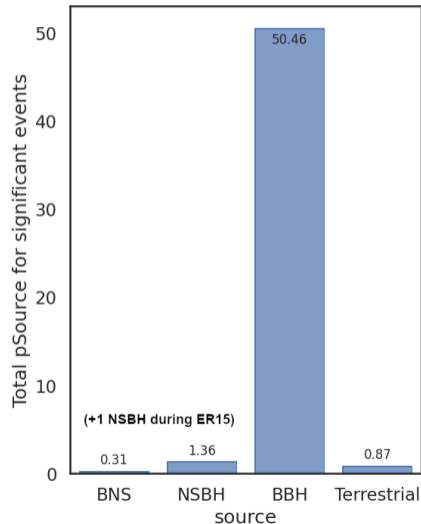
# Comparison with O3 online range



- ▶ The increased range of the detectors allows to probe further
- ▶ Distribution of distances is quite different : improved pipeline efficiency at large distance?

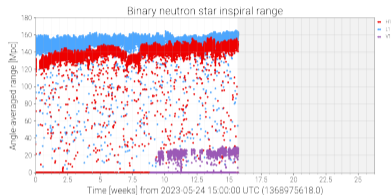
# Source classification

- ▶ Current prediction from the EM-followup guide :
  - ▶ BNS :  $36_{-22}^{+49}$  /year
  - ▶ NSBH :  $6_{-5}^{+11}$  /year
- ▶ This assumed a full HLVK network, with design sensitivity !
  - ▶ 190 Mpc for LIGO  $\rightarrow \sim 160$  Mpc
  - ▶ 100 Mpc for Virgo  $\rightarrow$  aim to join with at least 40 Mpc
  - ▶ 10 Mpc for KAGRA  $\rightarrow$  1-3 Mpc during the first month



O4 is going well

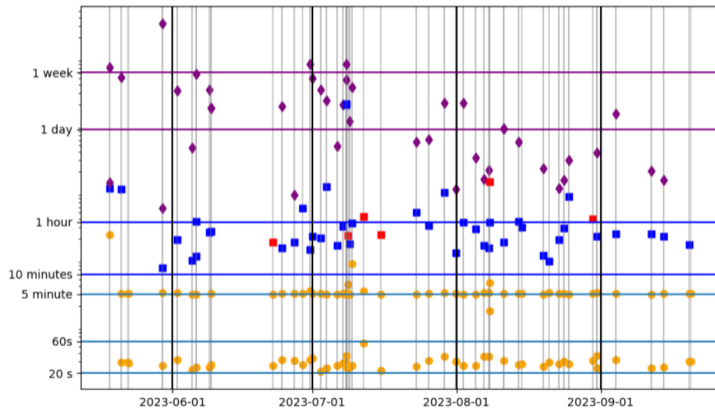
- ▶ O3 event count (56 non-retracted) almost reached in  $\sim 5$  months
- ▶ Looking forward to the rest of the run with an increased sensitivity and Virgo



Personnal feedback on the RRT : very positive experience

- ▶ Good opportunity to interact with the various groups
- ▶ A broader view on the O4 run
- ▶ Feeling the excitement from online alerts

# O4 alert latency



- ▶ Yellow circles : Preliminary notices
- ▶ Blue squares : Initial notice
- ▶ Red squares : Retraction notice
- ▶ Purple diamonds : Update circular