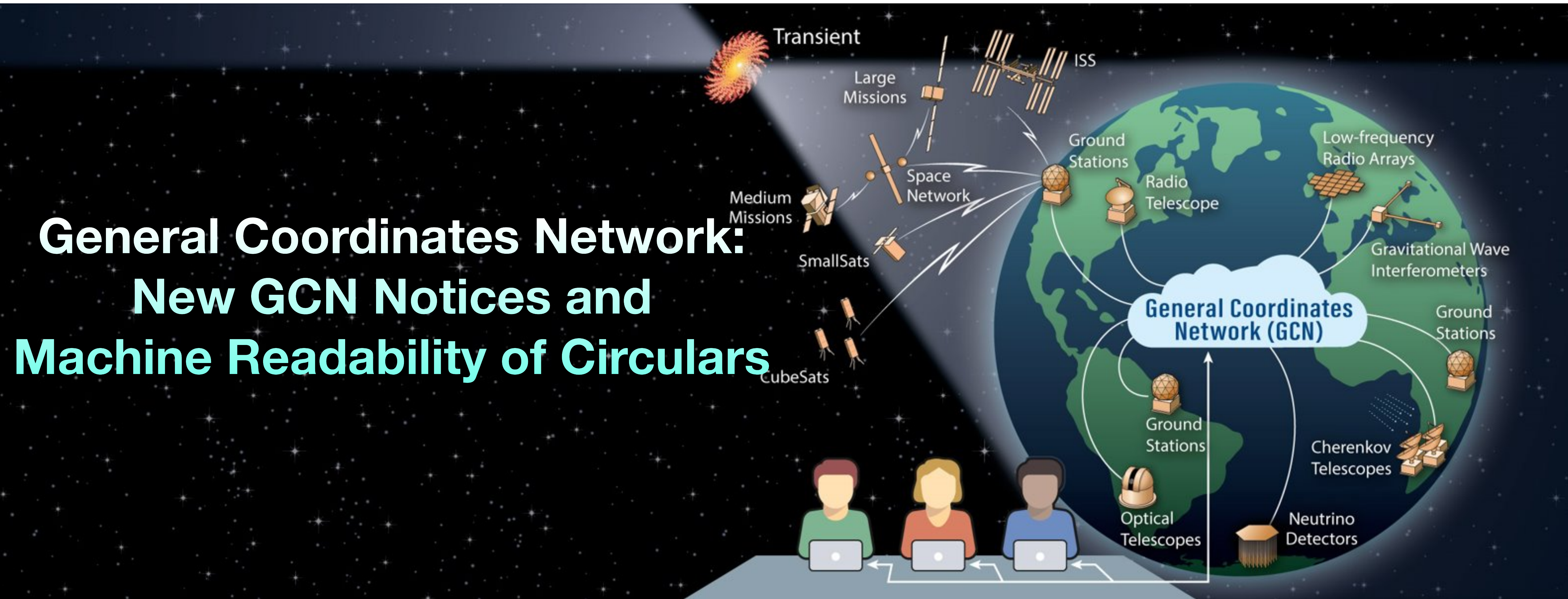
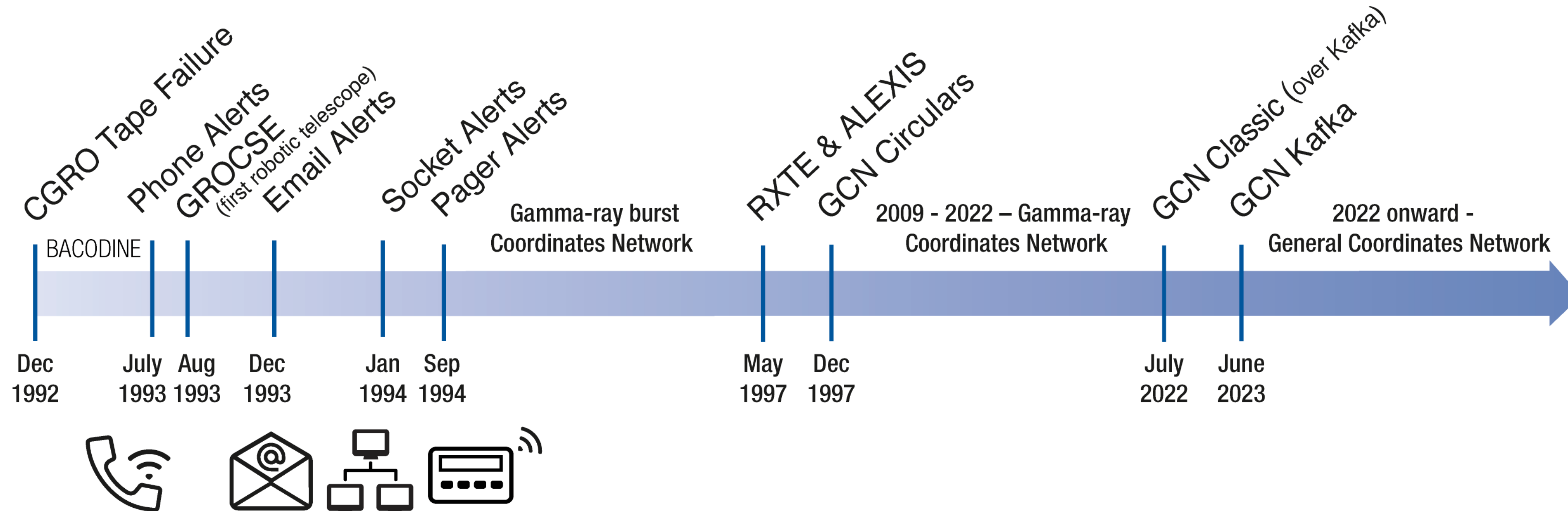


11th International Fermi Symposium, 2024  
College Park, MD



**General Coordinates Network:  
New GCN Notices and  
Machine Readability of Circulars**

# Early History of General Coordinates Network (GCN)



- Compton Gamma-Ray Observatory's (CGRO) onboard recorder failed in 1992
- Need to downlink events as they occurred created an opportunity for realtime follow-up
- BATse COordinates DIstribution NETwork (BACODINE) was built to receive and distribute those alerts worldwide
- BACODINE provided new alert formats (phone, email, socket, and pager)
- New instruments and transient types led to the Gamma-ray Coordinates Network

# There are two kinds of GCN data products:

## GCN NOTICES

```
TITLE:          GCN/FERMI NOTICE
NOTICE_DATE:   Wed 26 Aug 20 22:10:07 UT
NOTICE_TYPE:   Fermi-GBM Flight Position
RECORD_NUM:    45
TRIGGER_NUM:   620172587
GRB_RA:        296.300d {+19h 45m 12s} (J2000),
                296.250d {+19h 45m 00s} (current),
                296.416d {+19h 45m 40s} (1950)
GRB_DEC:       +71.817d {+71d 49' 00"} (J2000),
                +71.868d {+71d 52' 03"} (current),
                +71.693d {+71d 41' 35"} (1950)

GRB_ERROR:     5.50 [deg radius, statistical plus systematic]
GRB_INTEN:     1078 [cnts/sec]
DATA_SIGNIF:   22.80 [sigma]
INTEG_TIME:    1.024 [sec]
GRB_DATE:      19087 TJD; 239 DOY; 20/08/26
GRB_TIME:      79782.72 SOD {22:09:42.72} UT
GRB_PHI:       20.00 [deg]
GRB_THETA:     150.00 [deg]
DATA_TIME_SCALE: 1.0240 [sec]
HARD_RATIO:    0.54
LOC_ALGORITHM: 3 (version number of)
MOST_LIKELY:   93% GRB
2nd MOST_LIKELY: 4% Generic Transient
DETECTORS:    0,0,0, 0,1,1, 0,0,0, 0,0,0, 0,0,
SUN_POSTN:    156.00d {+10h 24m 01s} +10.00d {+09d 59' 51"}
SUN_DIST:     94.05 [deg] Sun_angle= -9.3 [hr] (East of Sun)
MOON_POSTN:   258.31d {+17h 13m 14s} -22.27d {-22d 15' 56"}
MOON_DIST:    97.64 [deg]
MOON_ILUM:    63 [%]
GAL_COORDS:   103.87, 21.63 [deg] galactic lon,lat of the burst (or transient)
ECL_COORDS:   41.25, 79.40 [deg] ecliptic lon,lat of the burst (or transient)
LC_URL:       http://heasarc.gsfc.nasa.gov/FTP/fermi/data/gbm/triggers/2020/bn200826923/
COMMENTS:     Fermi-GBM Flight-calculated Coordinates.
COMMENTS:     This trigger occurred at longitude,latitude = 209.65,1.28 [deg].
COMMENTS:     The LC_URL file will not be created until -15 min after the trigger.
```

- By and for machines
- Fixed, predefined format
- Schema specific to each notice type

## GCN CIRCULARS

```
TITLE:  GCN CIRCULAR
NUMBER: 28298
SUBJECT: GRB 200826B: Fermi GBM detection
DATE:   20/08/27 21:10:30 GMT
FROM:   Christian Malacaria at NASA-MSFC/USRA <cmalacaria@usra.edu>
```

C. Malacaria (NASA-MSFC/USRA) and C.Meegan (UAH)  
report on behalf of the Fermi GBM Team:

"At 22:09:42.72 UT on 26 August 2020, the Fermi Gamma-Ray Burst Monitor (GBM) triggered and located GRB 200826B (trigger 620172587 / 200826923).

The on-ground calculated location, using the GBM trigger data, was reported in GCN 28292.

The GBM light curve shows an exceptionally bright long GRB with a duration (T90) of about 7.4 s (50-300 keV). The time-averaged spectrum from T0-0.003 s to T0+ 12.544 s is best fit by a Band function with Epeak = 410.3 +/- 5.6 keV, alpha = -0.64 +/- 0.01, and beta = -2.52 +/- 0.04. The event fluence (10-1000 keV) in this time interval is (1.414 +/- 0.006)E-04 erg/cm^2. The 1.024-sec peak photon flux measured starting from T0+5.1 s in the 10-1000 keV band is 110.1 +/- 0.7 ph/s/cm^2.

The spectral analysis results presented above are preliminary; final results will be published in the GBM GRB Catalog:  
<https://heasarc.gsfc.nasa.gov/W3Browse/fermi/fermigbrst.html>

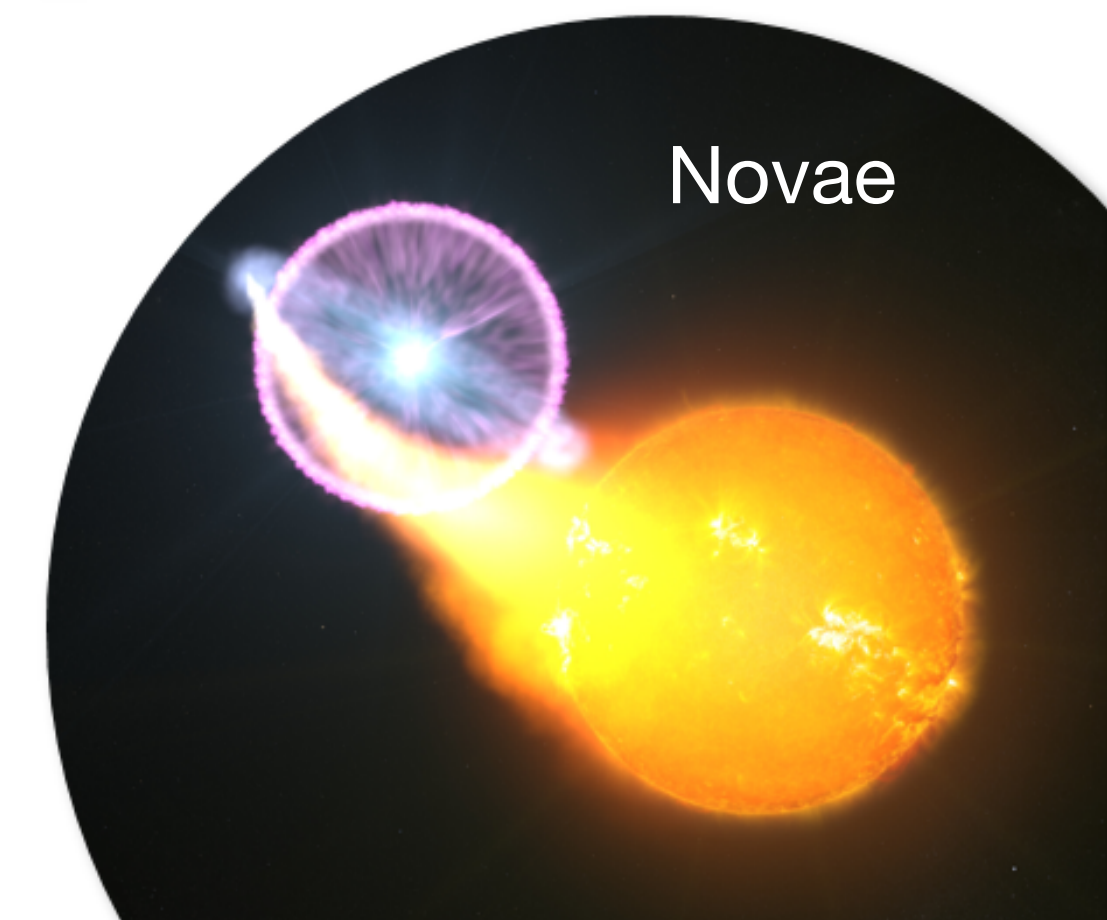
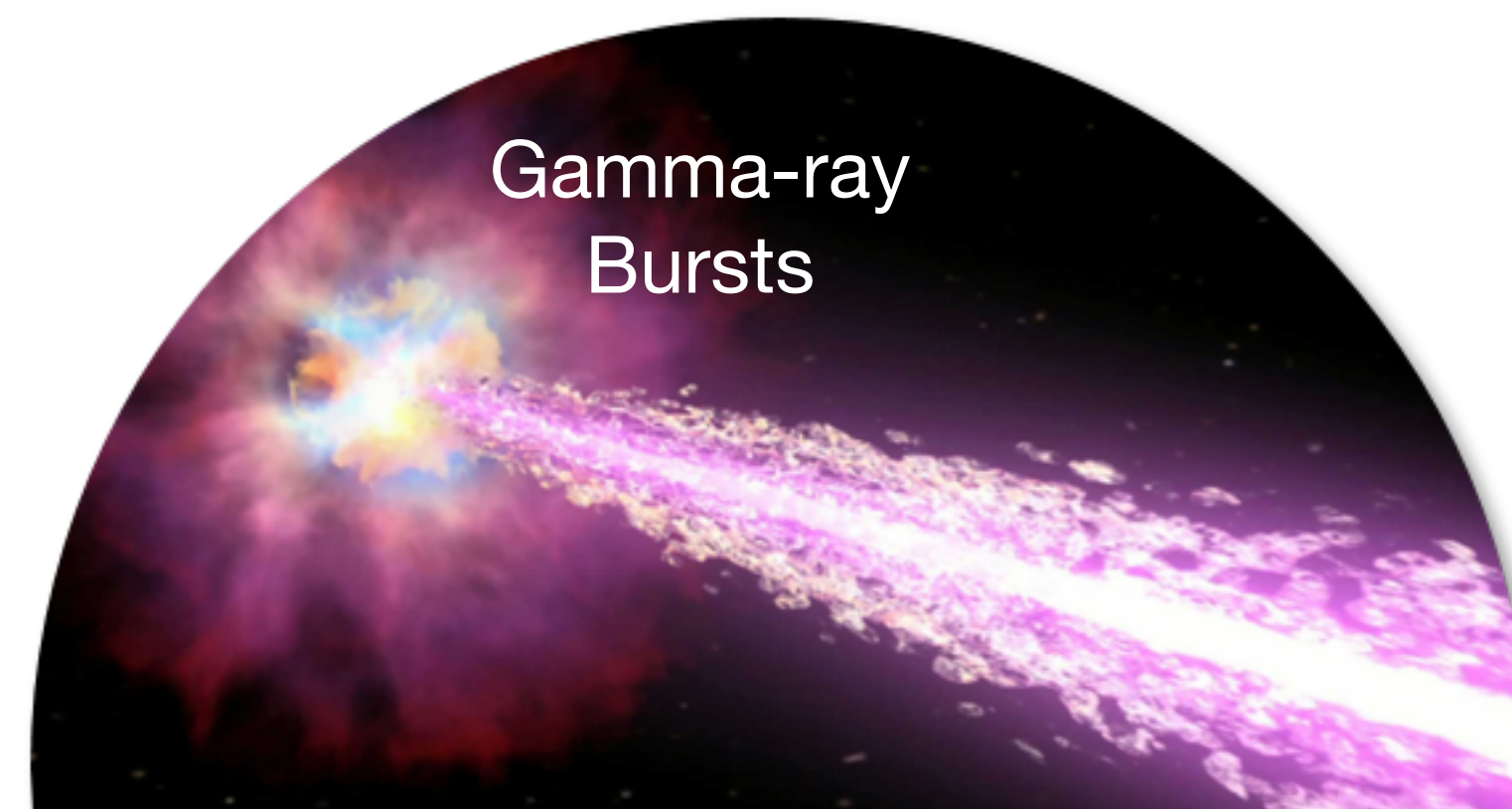
For Fermi GBM data and info, please visit the official Fermi GBM Support Page:  
<https://fermi.gsfc.nasa.gov/ssc/data/access/gbm/>

- By and for humans (some automated)
- Freeform text (with established style)
- Citable (but not peer-reviewed)

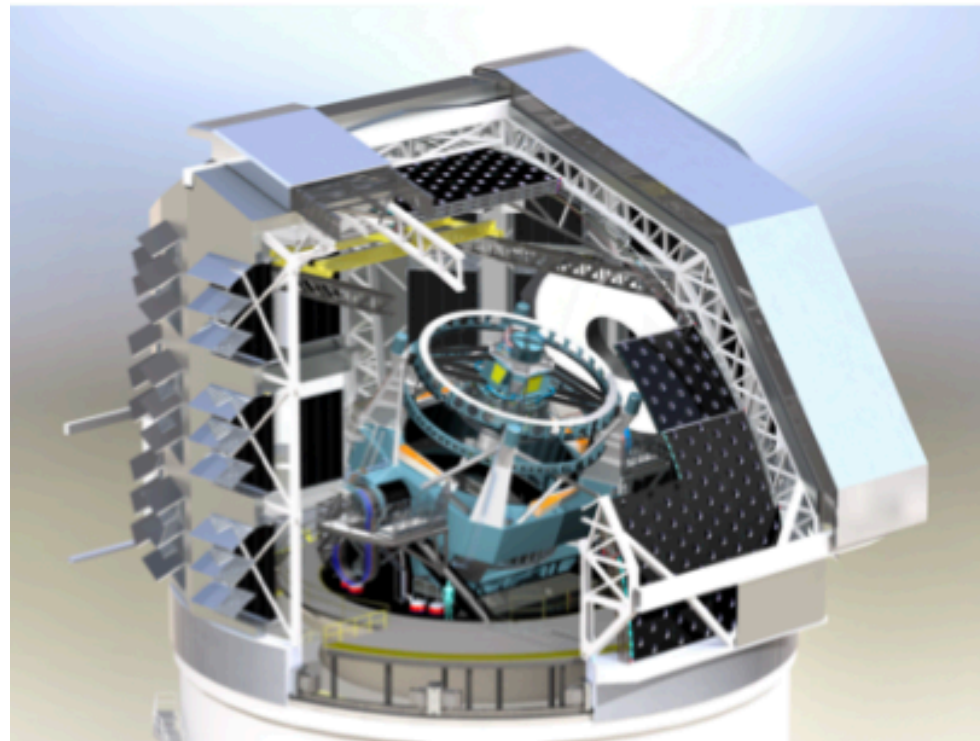
# Changing Scientific Landscape: Fast Astronomical Transients

GCN is constantly evolving to serve new transients, messengers, and observatories:

- Gravitational wave events (GW150914, GW170817)
- High-energy neutrinos (IC170922A)
- Tidal disruption events (Swift J1644+57)
- Magnetar giant flares (200415A)



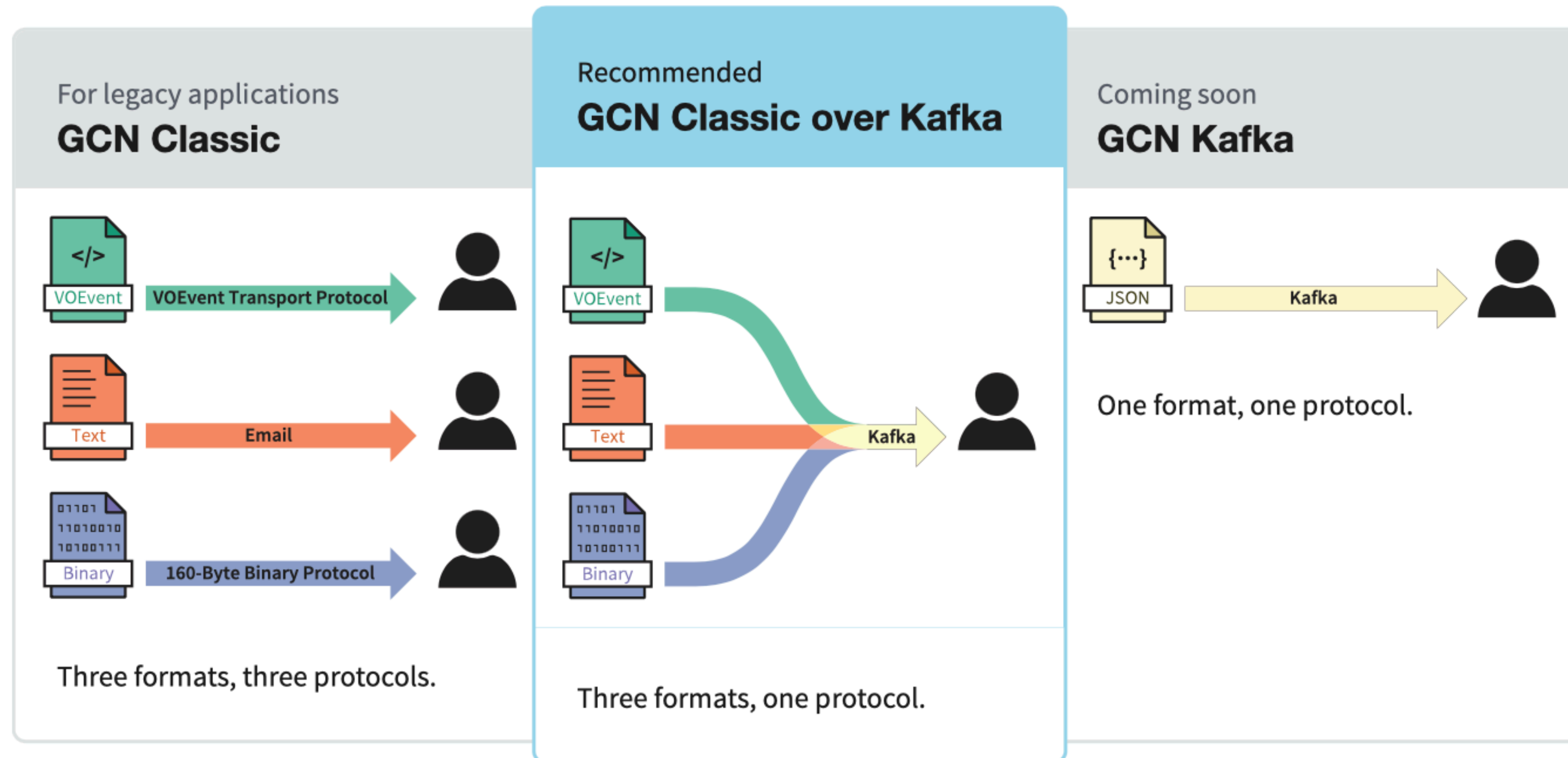
# Changing Technological Landscape



Rubin Observatory/NSF/AURA

- Internet standards have led to new, better ways to serialize astronomy data ([VOEvent](#), JSON, [Avro](#), etc.)
- Encryption is necessary on the modern Internet (e.g. https)
- Industry has developed general time-series databases and streaming frameworks
- The [Vera C. Rubin Observatory](#) will use Apache Kafka to distribute [transient alerts as its primary data product](#)
- Many other experiments are following suit: [Zwicky Transient Facility](#), [LIGO/Virgo/KAGRA](#)






# Introducing the New GCN: Built on Kafka



- GCN Classic provides three formats over *three custom protocols*
- GCN Classic over Kafka provides all three formats over *one standard protocol: Apache Kafka*

New GCN is built on standard protocol for streaming alerts: **Apache Kafka**

# Why to Switch to New GCN?

	GCN Classic	GCN Classic over Kafka
 <b>Self-service</b>	<b>NO.</b> Users need to contact administrator in order to make account and subscription changes	<b>YES.</b> Manage your own account and subscription settings through the web site
 <b>Open standards</b>	<b>NO.</b> Notices are sent using three custom protocols	<b>YES.</b> Notices are sent using one standard protocol, <a href="#">Apache Kafka</a>
 <b>Open source</b>	<b>NO.</b> Custom software needed to receive notices	<b>YES.</b> Receive notices using open-source software
 <b>Highly available</b>	<b>NO.</b> Notices are broadcast by a single server	<b>YES.</b> Notices are broadcast by a cluster of highly-available Kafka brokers in the cloud
 <b>Secure</b>	<b>NO.</b> Notices are sent as plaintext	<b>YES.</b> Notices are protected with SSL/TLS

gcn.nasa.gov

An official website of the United States government [Here's how you know](#)

**NASA General Coordinates Network**

Missions Notices Circulars Documentation Sign in / Sign up

GCN Circulars are now part of the new GCN! See [news and announcements](#)

## GCN: NASA's Time-Domain and Multimessenger Alert System

GCN distributes alerts between space- and ground-based observatories, physics experiments, and thousands of astronomers around the world.

[Start streaming GCN Notices](#) [Post a GCN Circular](#)

# New GCN Website

at <https://gcn.nasa.gov>

- Updated look and feel
- More accessible, based on [US Web Design System](#)
- Single sign on with:
  - Email and password
  - Google
  - Facebook
  - LaunchPad (for NASA employees and affiliates)



GCN Circulars are now part of the new GCN! See [news and announcements](#)

## GCN Circulars

GCN Circulars are rapid astronomical bulletins submitted by and distributed to community members worldwide. They are used to share discoveries, observations, quantitative near-term predictions, requests for follow-up observations, or future observing plans related to high-energy, multi-messenger, and variable or transient astrophysical events. See the [documentation](#) for help with subscribing to or submitting Circulars.

Search

Search for Circulars by submitter, subject, or body text (e.g. 'Fermi GRB').  
To navigate to a specific circular, enter the associated Circular ID (e.g. 'gcn123', 'Circular 123', or '123').

- 33937. [Fermi GRB 230603A: Global MASTER-Net observations report](#)
- 33936. [Fermi trigger No 707039690: Global MASTER-Net observations report](#)
- 33935. [GRB 230506B: Chandra localization of the X-ray afterglow](#)
- 33934. [ZTF and GIT Observations of the Candidate Optical Afterglow AT2023jxk](#)
- 33933. [GRB 230606A: Swift-BAT refined analysis](#)
- 33932. [GRB 230606A: Gaoyazi/GOT optical upper limit](#)
- 33931. [GRB 230606A: Fermi GBM Observation](#)
- 33930. [GRB 230606A: BOOTES-5/JGT optical upper limit](#)
- 33929. [LIGO/Virgo/KAGRA S230602ap: Zwicky Transient Facility observations](#)
- 33928. [GRB 230606A: Swift-XRT refined Analysis](#)
- 33927. [GRB 230604A: GRBAlpha detection](#)
- 33926. [GRB 230606A: Swift/UVOT Upper Limits](#)
- 33925. [LIGO/Virgo S230606z: Global MASTER-Net observations report](#)

New GCN features for October 2023! See [news and announcements](#)

## GCN Circular 34760

**Subject** LIGO/Virgo/KAGRA S230924an: Identification of a GW compact binary merger candidate  
**Date** 2023-09-24T13:34:06Z (a month ago)  
**From** Biswajit Banerjee at Gran Sasso Science Institute (GSSI) <biswajit.banerjee@gssi.it>  
**Via** Web form

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

New and improved:



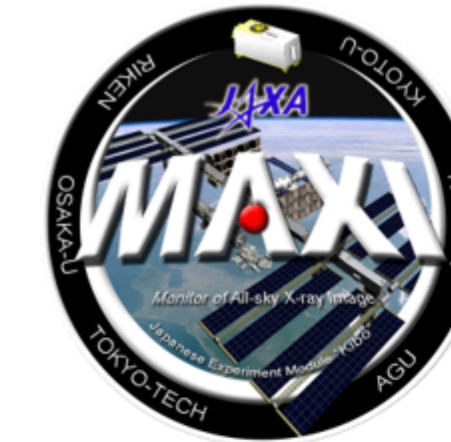
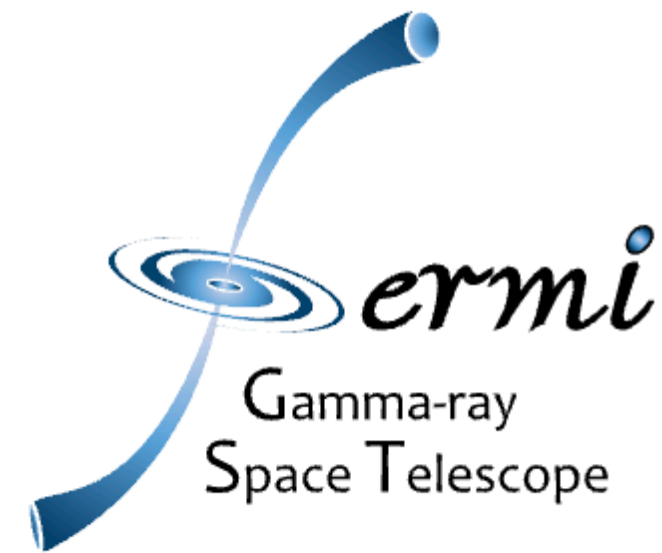
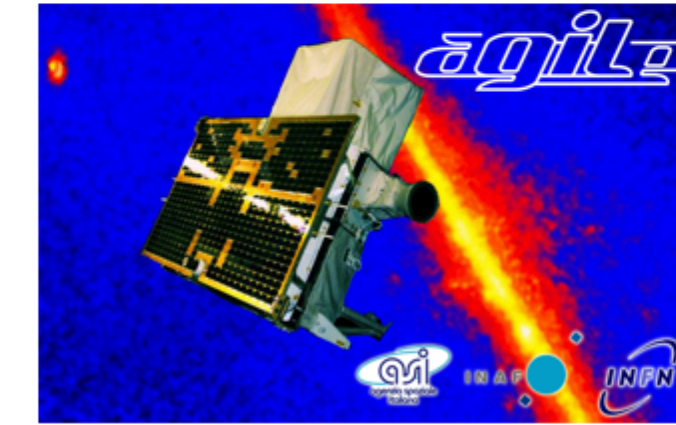
at <https://gcn.nasa.gov/circulars>

- Browse and search our new [archive](#).
- Manage your own email subscriptions.
- Enroll yourself and your colleagues to submit Circulars with arXiv-style peer endorsements.
- Submit Circulars with our [new Web form](#), or continue to submit by email.
- Real-time integration with [SAO/NASA Astrophysics Data Service \(ADS\)](#)

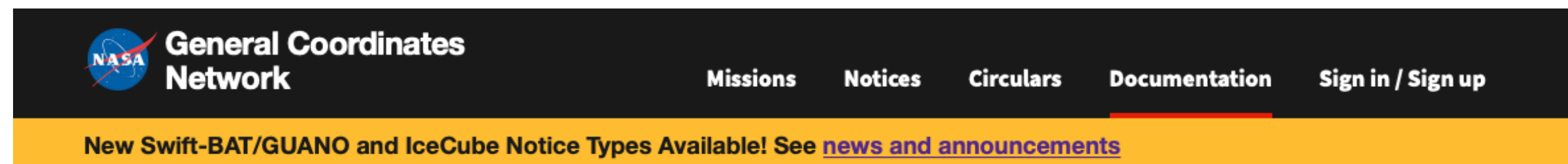
# GCN Classic Notices

GCN Notice Producer

Missions/Observatories/Experiments



# Create New GCN Notices



- About GCN
- Circulars
- Code of Conduct
- Contributing
- Frequently Asked Questions
- History
- Kafka Client Setup
- Notices**
- About
- Consuming
- Producing
- Unified Schema
- Archive
- Road Map
- Schema Browser

## New Notice Producers

The following steps guide new instrument, mission, or observatory producers into setting up new notices streams that are distributed to the user community via [Kafka](#). This process requires interaction with the [GCN Team](#) to enable accounts and Kafka topics creation on the GCN Kafka broker. The GCN Team is also happy to work with the mission teams to help construct your alerts.

### Start Producing Alerts

- 1 Sign in / Sign up**

Decide which of your team members will have programmatic access to produce your alerts. Make sure that they have all signed in at least once to the [GCN website](#) and the [GCN test website](#).
- 2 Name Your Kafka Topics**

The naming convention for Kafka topics follow the format `gcn.notices.mission.notices_type`. The mission name should be in lowercase, and the Kafka topics should be in snake\_case format, with the words in lowercase separated by underscores. Example for a single observatory, such as IceCube is `gcn.notices.icecube.lvk_nu_track_search`. For missions with multiple instruments, you can include the instrument name as `gcn.notices.mission.instrument.notices_type`, for example, Swift-BAT Kafka topic should be `gcn.notices.swift.bat.alert`. Pick a prefix for your Kafka topic names, `mission.*`.
- 3 Contact the GCN Team**

Send the [GCN Team](#) your list of team members from Step 1 and your chosen Kafka topic prefix from Step 2. The GCN Team will reply after they have configured producer permissions for your team.

- New Notices topics streamed by only GCN Kafka
- **For step by step instructions: Notices > Producing**
- New Notices produced by only Unified Schema: IceCube, Swift-BAT Guano are our first new Notices producers
- **Notices format: JSON**
- Create your Kafka Topic
- **Draft your Schema**



**New GCN Notices**



# New Notice Types: Unified schema and alert format

- JSON Core Schema with common core fields and consistent units
- Instrument/mission/observatory specific fields where needed
- <https://github.com/nasa-gcn/gcn-schema>
- New Producers: IceCube, Swift/BAT-GUANO, Einstein Probe
- BurstCube, SVOM, SGR and gamma-ray transients New Notices by IPN (soon)

JSON example of IceCube GW Follow-up Schema:

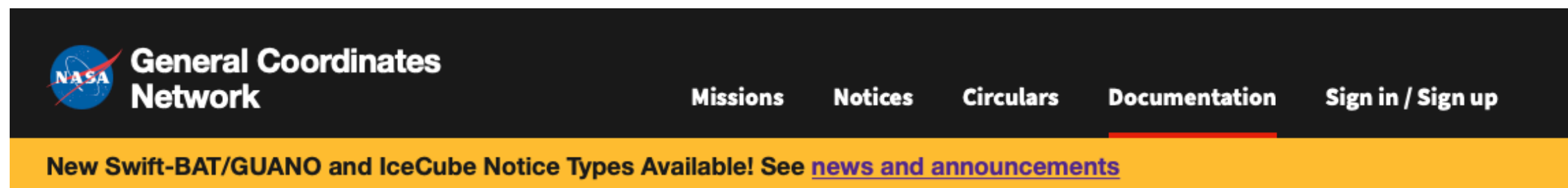
```
{
  "$id": "https://gcn.nasa.gov/schema/gcn/notices/icecube/LvkNuTrackSearch.schema.json",
  "$schema": "https://json-schema.org/draft/2020-12/schema",
  "type": "object",
  "title": "IceCube LVK Alert Nu Track Search",
  "description": "IceCube LVK Coincident Neutrino Track Search",
  "allOf": [
    {
      "$ref": "/schema/gcn/notices/core/Alert.schema.json",
      "description": "Alert information (alert_datetime and alert_type) from LVK alert notices"
    },
    {
      "$ref": "/schema/gcn/notices/core/FollowUp.schema.json",
      "description": "ID (ref_ID) of LVK alert notice"
    },
    {
      "$ref": "/schema/gcn/notices/core/AdditionalInfo.schema.json"
    }
  ]
}
```

Schema

```
{
  "$schema": "https://gcn.nasa.gov/schema/gcn/notices/icecube/LvkNuTrackSearch.schema.json",
  "type": "IceCube LVK Alert Nu Track Search",
  "reference": { "gcn.notices.LVK.alert": 4642 },
  "ref_ID": "MS230427r",
  "alert_datetime": "2023-04-16T05:32:29.55Z",
  "trigger_time": "2023-04-16T05:22:26.0Z",
  "observation_start": "2023-04-16T05:14:06.0Z",
  "observation_stop": "2023-04-16T05:30:46.0Z",
  "observation_livetime": 1000,
  "pval_generic": 0.5,
  "pval_bayesian": 0.45,
  "n_events_coincident": 2,
  "coincident_events": [
    {
      "event_dt": -123.4,
      "ra": 345.82,
```

Notice

# Create Mission Schema



- About GCN
- Circulars
- Code of Conduct
- Contributing
- Frequently Asked Questions
- History
- Kafka Client Setup
- Notices**
  - About
  - Consuming
  - Producing
  - Unified Schema**
  - Archive
  - Road Map
  - Schema Browser

## Unified Schema

The GCN Unified Schema is a framework for defining GCN Notices types using a common format, standardized field names, uniform data types, and consistent physical units across multiple missions. If you are joining GCN as a [new notice producer](#), then you can contribute your own notice types to the Unified Schema present at [GitHub](#).

The over-the-wire format for GCN Notices in the Unified Schema is [JavaScript Object Notation \(JSON\)](#), an Internet standard for encoding arbitrary data as human-readable text. Despite having "JavaScript" in its name, JSON is ubiquitous, and many programming languages have standard library support for JSON.

The definition of the GCN Unified Schema is itself expressed in JSON format using the [JSON Schema](#) standard. JSON Schema makes it possible for us to provide automatic, interactive documentation of the schema in our [Schema Browser](#).

Crafting a schema for a new notice type involves selecting one or more of the predefined [core schema](#) and adding your own optional mission-specific fields. This approach allows the flexibility of inclusion of mission-specific parameters while ensuring consistency where possible. We encourage producers to utilize the core schema as much as possible.

As you are developing your schema, don't hesitate to [contact us](#) with any questions!

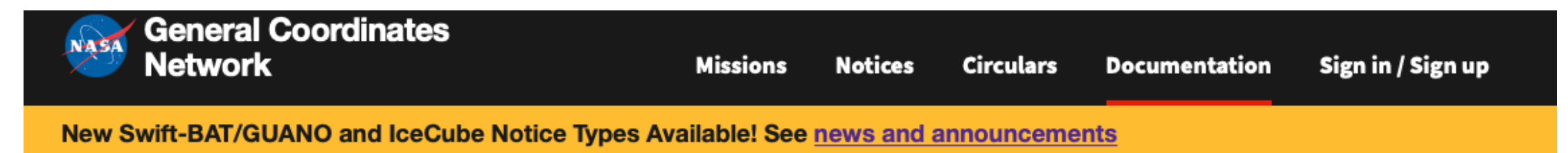
## Fork the GitHub Repository

To get started, fork the [nasa-gcn/gcn-schema](#) repository on GitHub and check it out on your computer. If you are new to GitHub, refer to our [GitHub primer](#).

## File Naming Conventions

Create a folder in the repository for your mission following the naming convention `gcn/notices/mission`. Add one or more files for schema definitions named `gcn/notices/mission/schema_name.schema.json`. The mission name should be lowercase and the schema name should be [snake\\_case](#). Each file corresponds to a [Kafka topic](#) named `gcn.notices.mission.schema_name`.

- Fork & Set-up GitHub Repository:
  - [GCN Schema v3.0.0](#)
- Design Your Schema
  - See Sample code/Existing Examples
  - Use Core Schema & Specific fields
  - Validate & Submit Schema for Feedback
- Explore Schema-Browser for Schema definitions and examples



gcn > notices

Version: v3.0.0

## Schema Browser

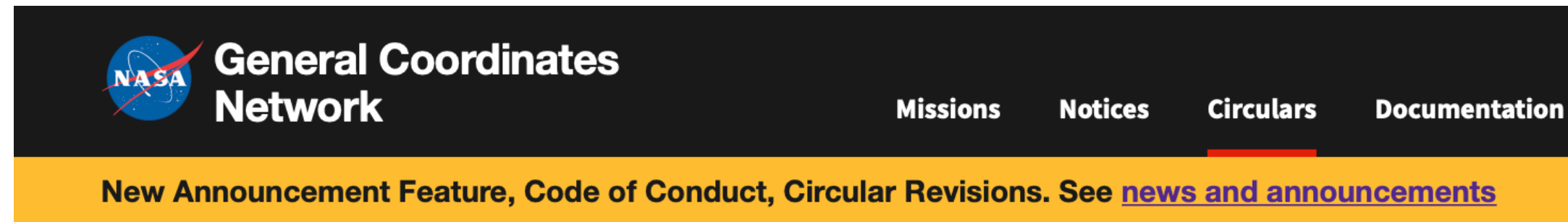
Browse the schema definitions for GCN Notices as distributed by GCN Kafka. Choose an option below to navigate through the schema directory or inspect a schema for additional details.

If you are interested in adding a [new notice type to GCN](#), then you can [develop a new schema](#) for your instrument or mission using our core schema as building blocks. See our [primer on the GCN Unified Schema](#) for instructions.

We welcome your feedback on the schema! Don't hesitate to [open an issue on GitHub](#) or [contact us](#).

- [core](#)
- [glowbug](#)
- [icecube](#)
- [swift](#)

# GCN Circulars: Large Language Model application



NASA General Coordinates Network

Missions Notices Circulars Documentation

New Announcement Feature, Code of Conduct, Circular Revisions. See [news and announcements](#)

[← Back](#) [Text](#) [JSON](#) [Cite](#)

## GCN Circular 21520

**Subject** GRB 170817A: Fermi GBM detection  
**Date** 2017-08-17T20:00:07Z (7 years ago)  
**From** Andreas von Kienlin at MPE <azk@mpe.mpg.de>

A. von Kienlin (MPE), C. Meegan (UAH) and A. Goldstein (USRA)  
report on behalf of the Fermi GBM Team:

"At 12:41:06.47 UT on 17 August 2017, the Fermi Gamma-Ray Burst Monitor triggered and located GRB 170817A (trigger 524666471 / 170817529).

The on-ground calculated location, using the GBM trigger data, is RA = 176.8, DEC = -39.8 (J2000 degrees, equivalent to 12 h 47 m, -39 d 48'), with an uncertainty of 11.6 degrees (radius, 1-sigma containment, statistical only; there is additionally a systematic error which we have characterized as a core-plus-tail model, with 90% of GRBs having a 3.7 deg error and a small tail suffering a larger than 10 deg systematic error. [Connaughton et al. 2015, ApJS, 216, 32] ).

The angle from the Fermi LAT boresight at the GBM trigger time is 91 degrees.

The GRB light curve shows a weak short pulse with a duration (T90) of about 2 s (50-300 keV). The time-averaged spectrum from T0-0.512 s to 2.048 s is well fit by a power law function with an exponential high-energy cutoff. The power law index is -0.89 +/- 0.5 and the cutoff energy, parameterized as Epeak, is 82 +/- 21 keV

The event fluence (10-1000 keV) in this time interval is (2.3 +/- 0.4)E-07 erg/cm^2. The 1.024-sec peak photon flux measured starting from T0-0.32 s in the 8-1000 keV band is 1.9 +/- 0.2 ph/s/cm^2.

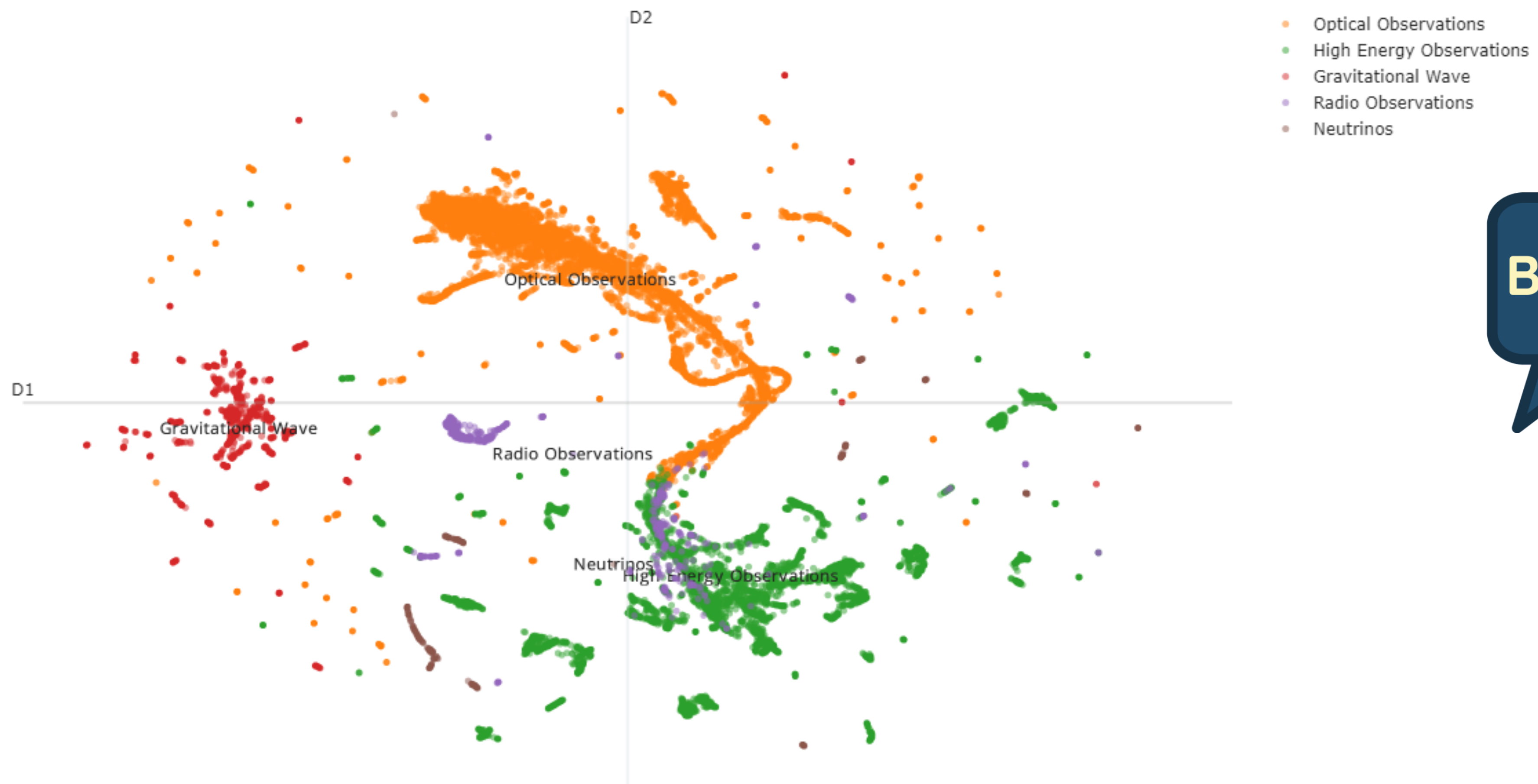
The spectral analysis results presented above are preliminary; final results will be published in the GBM GRB Catalog."

- ◆ Human-written, Flexible and Unstructured alerts
  - ◆ Difficult to parse with conventional methods
- LLM trained for human-written text:
- Topic modeling, such as observation-based cluster
  - Information Extraction, such as Redshift

# GCN Circulares: Topic Modeling for observation-type clustering

- BERT (Bidirectional Encoder Representations from Transformers) - Google AI
- BERT architecture based model “all-MiniLM-L6-v2” - fine-tuned for observational based clustering
- 5 Different type of observational cluster are extracted with BERTopic library

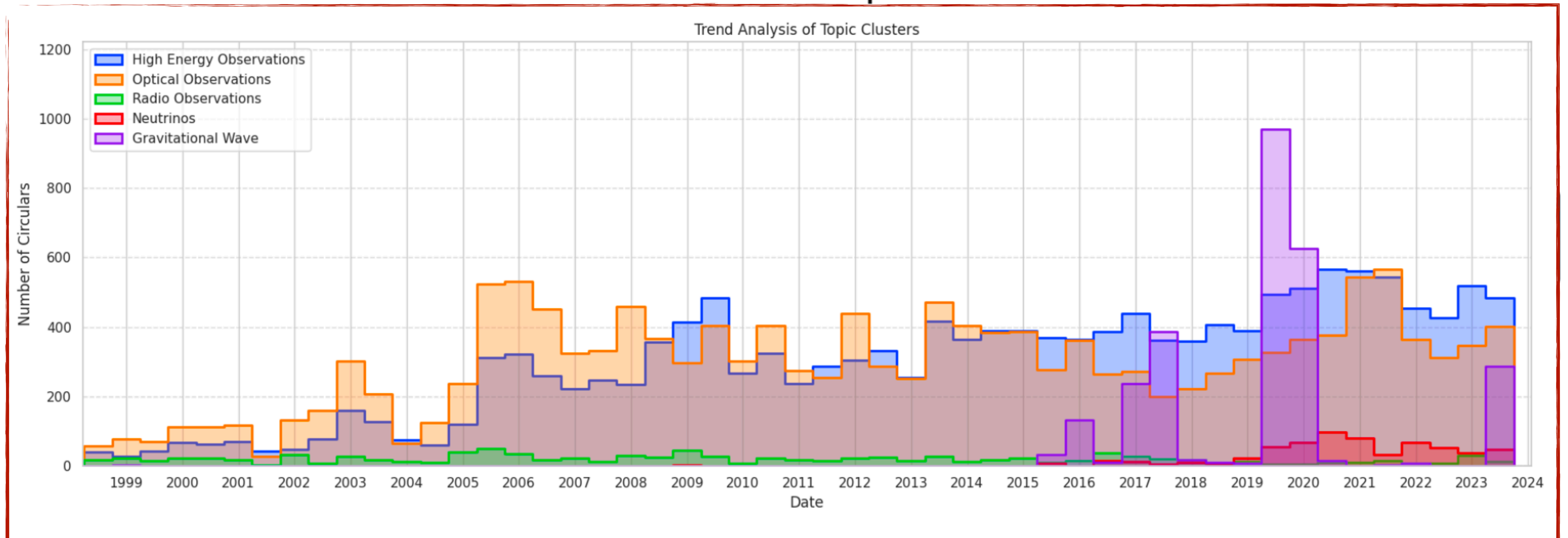
Documents and Topics



# GCN Circulares: Topic Modeling for observation-type clustering

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## Documents and Topics

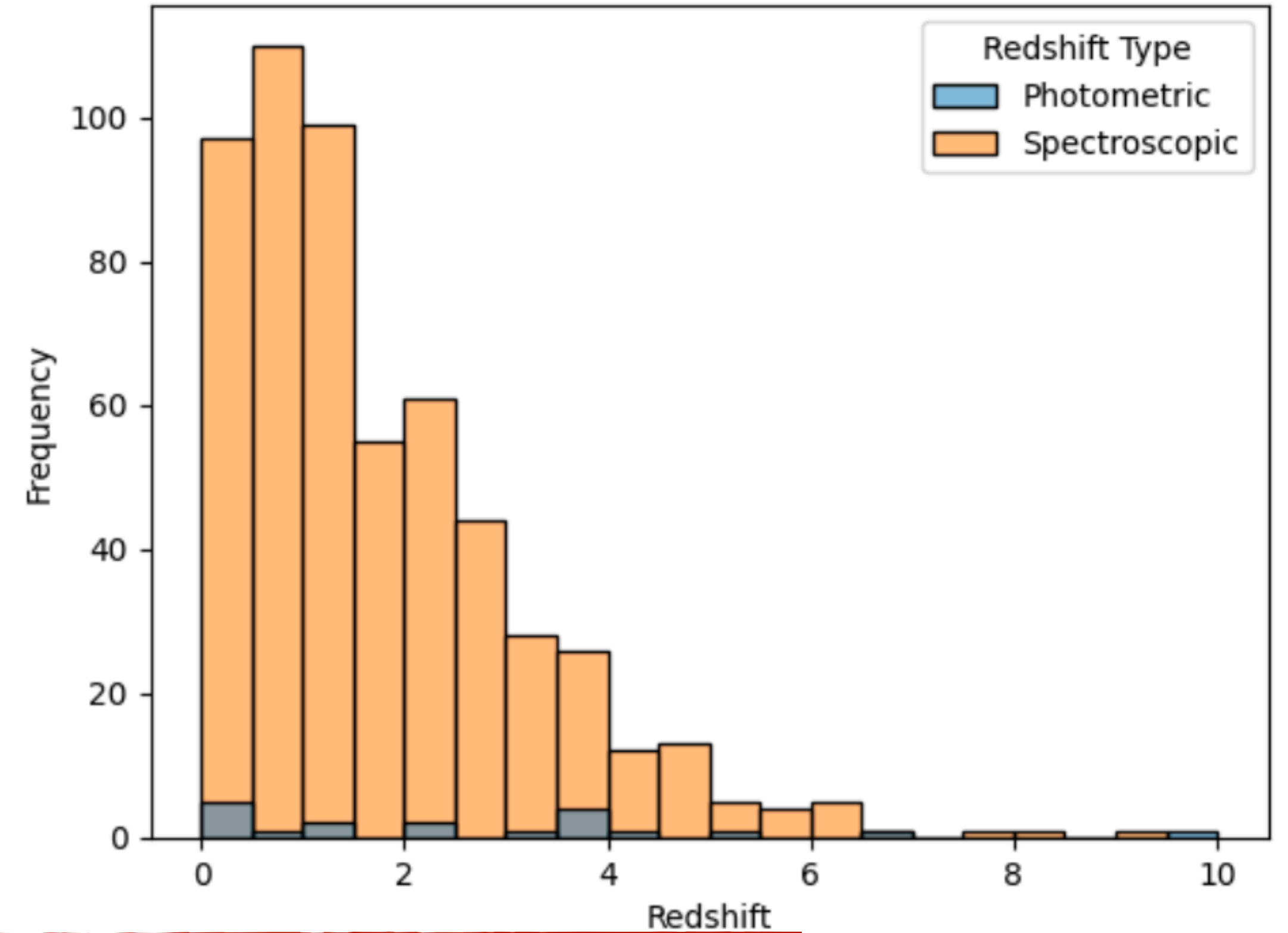




# GCN Circulares: Information Extraction

Mistral-7B-Instruct-v0.2

- Fine-tuned generative text-model
- Trained on publicly available conversational data-search
- Prompt Tuning output parsing and RAG done with LangChain library
- Info: Redshift values, event names, instrument, redshift-type
- Accuracy measured on Swift GRB table is 98%



GCN	Actual z	Predicted z	Actual GRB	Predicted GRB	Actual Telescope	Predicted Telescope
9457	2.625	z = 2.63	090529	GRB090529	VLT	ESO Very Large Telescope
9518	0.54	z = 0.54	090618	GRB090618	Lick	Lick Observatory
9542	0.54	0.54	090618	GRB090618	SAO RAS	SAO RAS
9673	3.00	3.00	090715B	GRB090715B	WHT	William Herschel Telescope
9712	2.71	z = 2.71	090726	GRB090726	SAO RAS	SAO RAS 6-m telescope
9761	2.737	2.737 +/- 0.002	090809	GRB090809	VLT	Kueyen telescope of ESO's VLT
9771	2.452	2.452	090812	GRB090812	VLT	VLT (Paranal observatory)


# Thanks for listening!


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Web site: <https://gcn.nasa.gov>

This presentation: <https://nasa-gcn.github.io/gcn-presentation/>

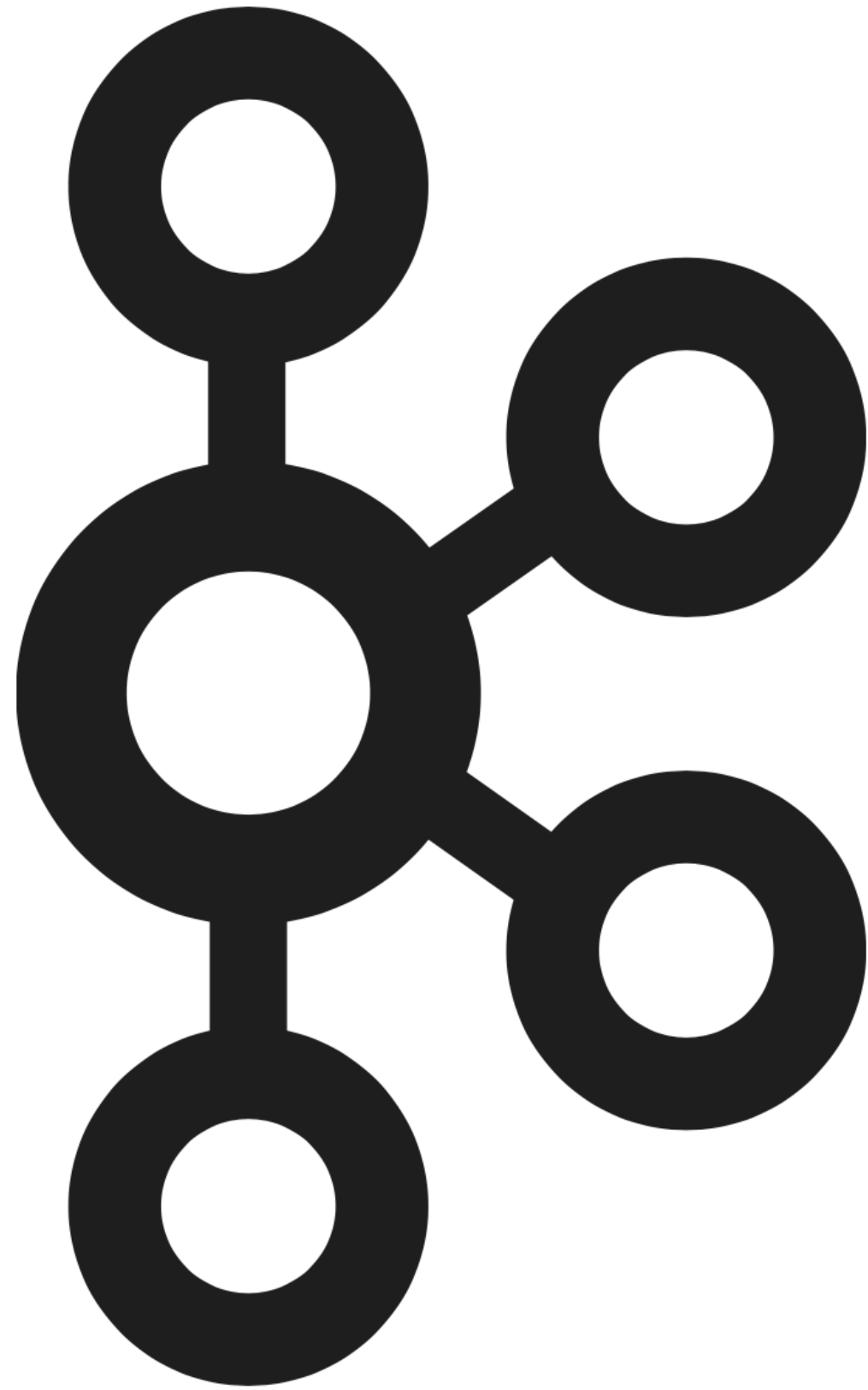


 **Questions or comments?** [Contact GCN directly](#)

 **Have you found a bug in GCN?** [Open an issue](#)

 **Want to contribute code to GCN?** [Get involved on GitHub](#)

# What is Kafka?



*Apache Kafka is an open-source distributed event streaming platform used by thousands of companies for high-performance data pipelines, streaming analytics, data integration, and mission-critical applications.*

— from <https://kafka.apache.org/>

## **Kafka is widely used at NASA**

- Existing Kafka applications at NASA include:
  - GCN (Goddard Space Flight Center)
  - Complex Event Processor - Deep Space Network (Jet Propulsion Laboratory)
  - Enterprise Business Information Services (Jet Propulsion Laboratory)
  - Federated Airspace Management Framework (Ames Research Center)
- All Federal agencies are using self-managed Kafka brokers, either Apache Kafka or Confluent Platform
- GCN is sponsoring [FedRAMP](#) authorization for [Confluent Cloud](#) to make it easy for NASA and other federal agencies to deploy Kafka software-as-a-service