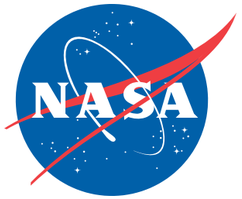
National Aeronautics and
Space Administration



General Coordinates Network

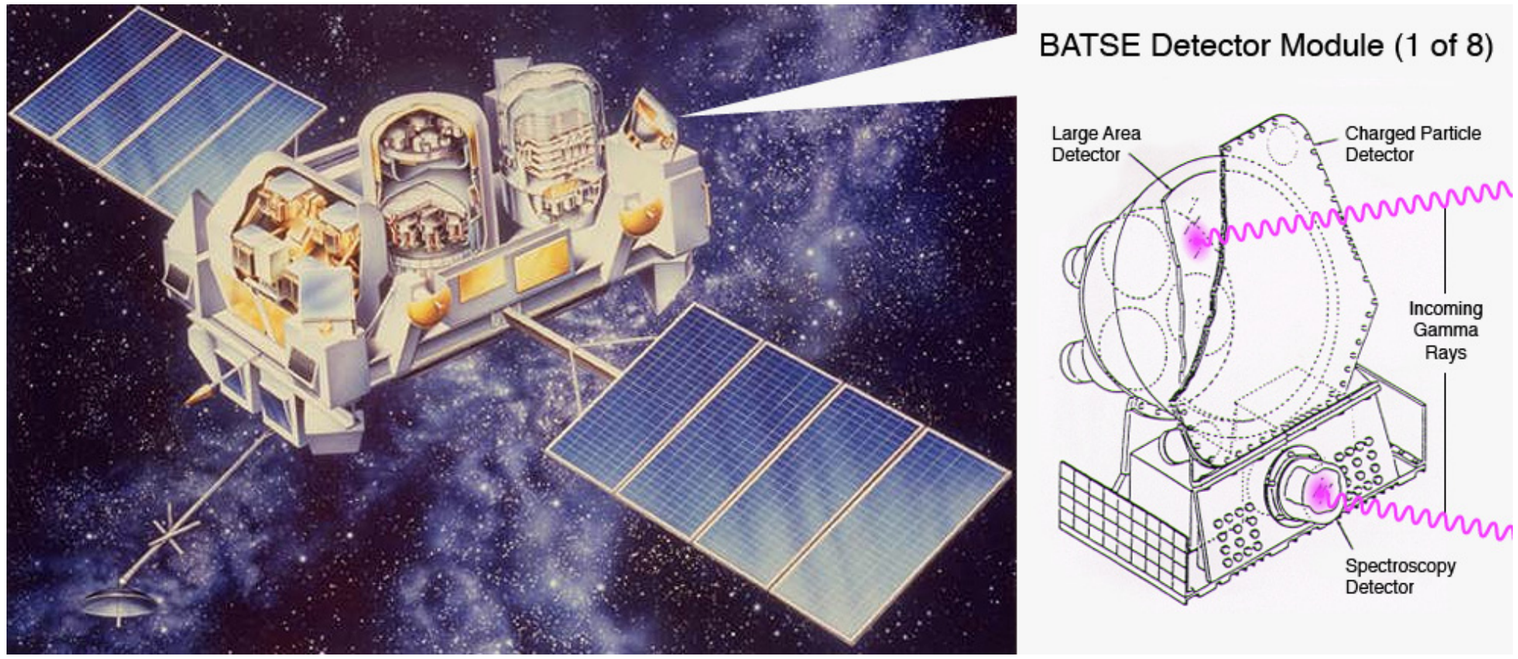
NASA's Next Generation Time-Domain and Multimessenger Alert System

A service of the Astrophysics Science Division at NASA's Goddard Space Flight Center

https://gcn.nasa.gov

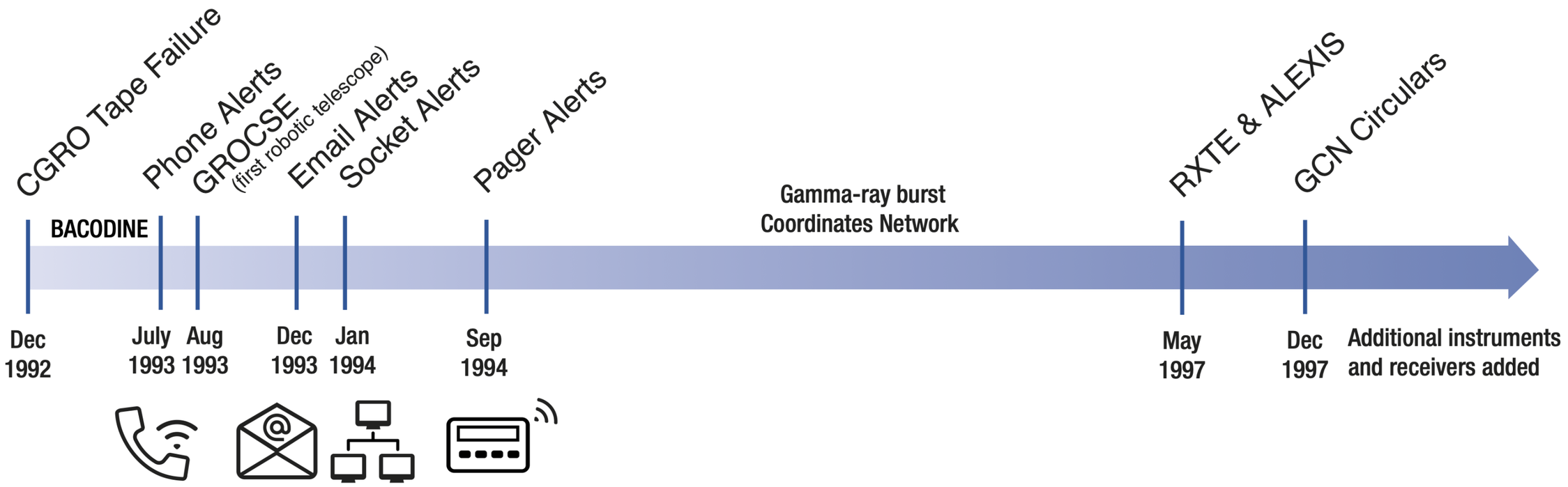
Gamma-ray Coordinates Network

Realtime Alerts Born of Necessity



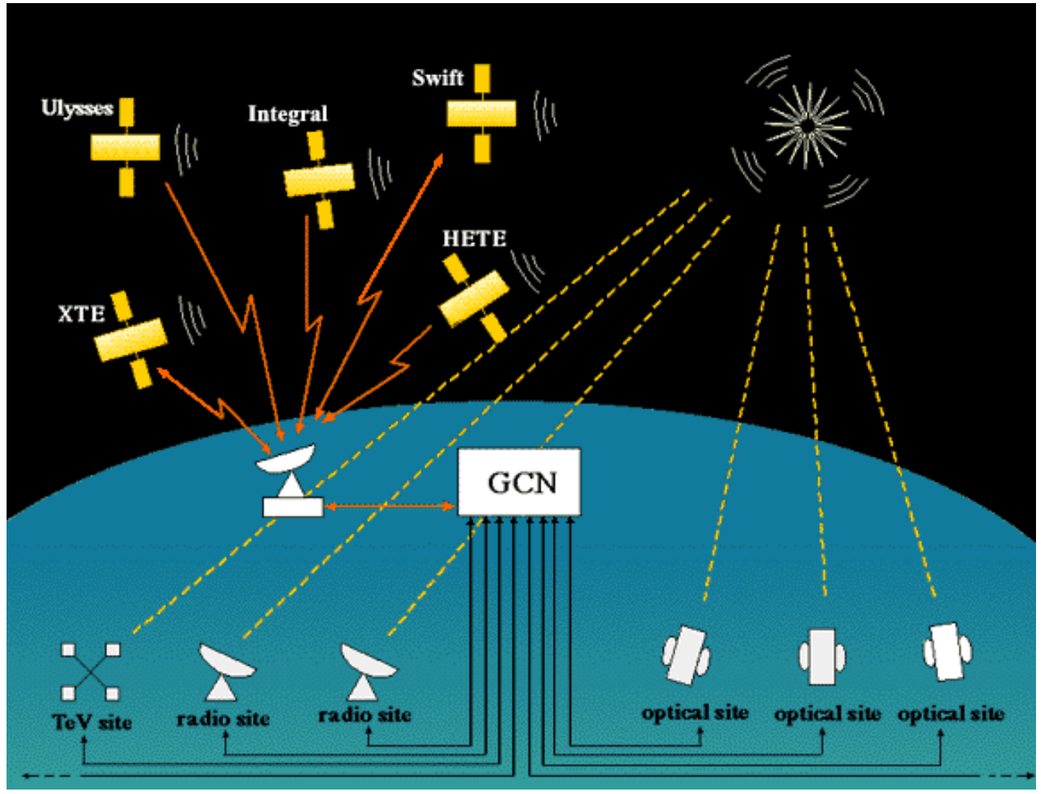
- The Compton Gamma-Ray Observatory's onboard recorder failed in 1992
- The need to downlink events as they occurred created an opportunity for realtime follow-up
- BAtse COordinates DIstribution NEtwork (BACODINE) was built to receive and distribute those alerts worldwide

Early History of GCN



- BACODINE provided new alert formats (phone, email, socket, and pager)
- New instruments and transient types led to the Gamma-ray Coordinates Network

GCN Enabled Seminal Breakthroughs in Astrophysics



The GCN community enabled worldwide follow-up observations that revealed the nature of gamma-ray bursts:

- Afterglows and redshifts confirmed their distant, extragalactic origin
- Supernova-GRBs established massive stellar deaths as the cause of long GRBs
- Afterglow and host studies established neutron star mergers as the cause of short GRBs

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_ILLUM:       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.
```

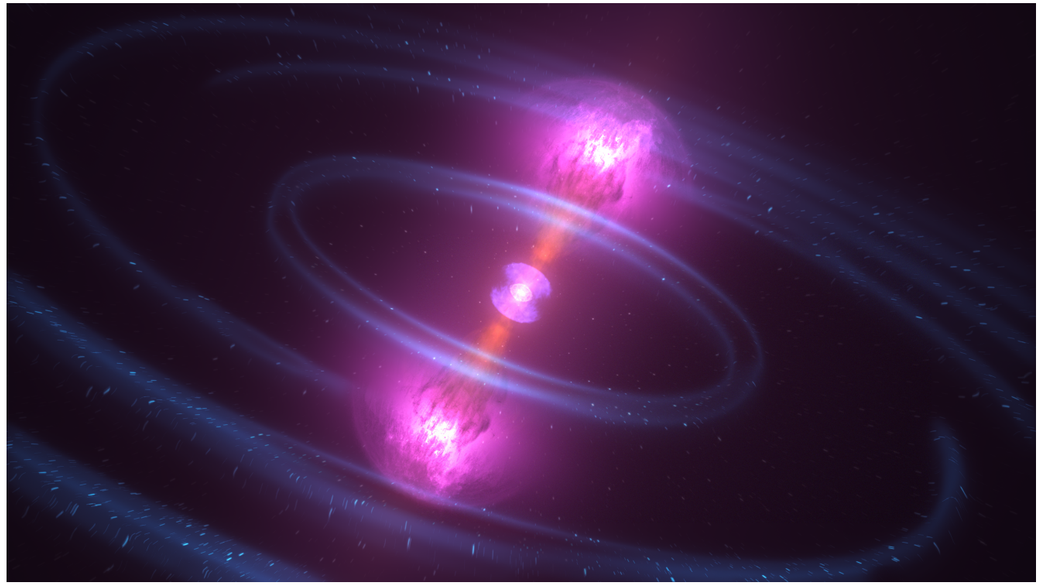
- By and for machines
- Fixed, predefined format
- Schema specific to each notice type

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)

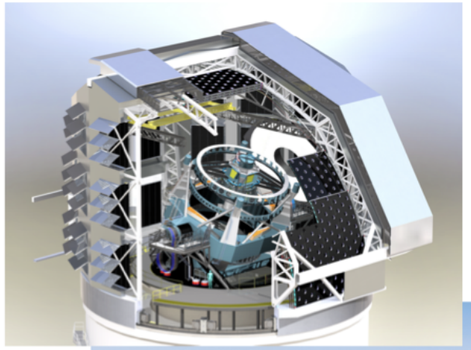
The Changing Scientific Landscape



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)

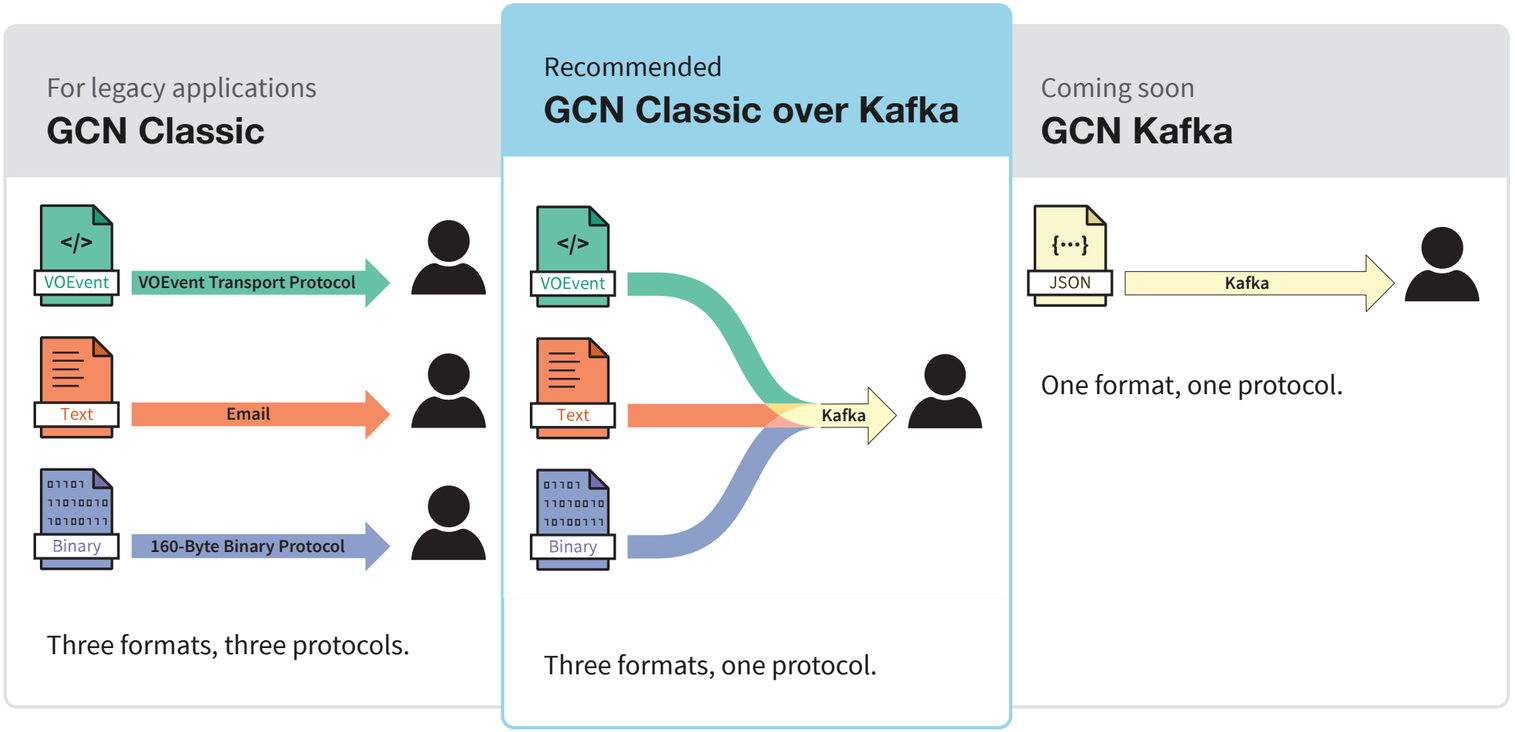
The Changing Technological Landscape



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



The New GCN is 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

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)
- ...plus many other applications in other Federal agencies
- 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

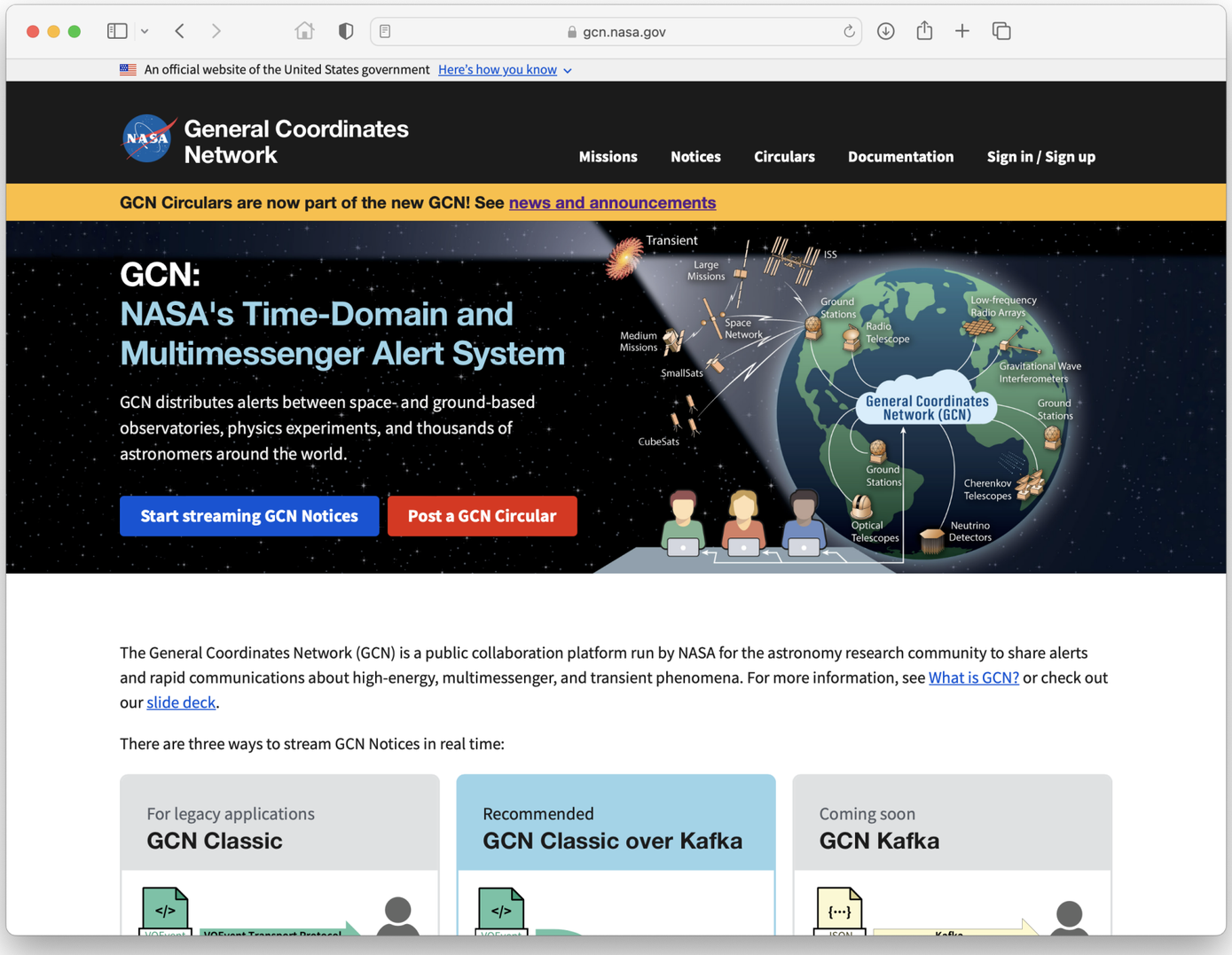
What is special about GCN's Kafka cluster?

It's special because it's so ordinary! It's a plain 3-broker Kafka cluster

- No custom auth extensions to side-load into the server
- No vendor lock-in: we use Confluent Platform, but we could use open-source Apache Kafka or fully managed solutions like Confluent Cloud or Amazon MSK

We use standard OpenID Connect (OIDC) for single sign-on

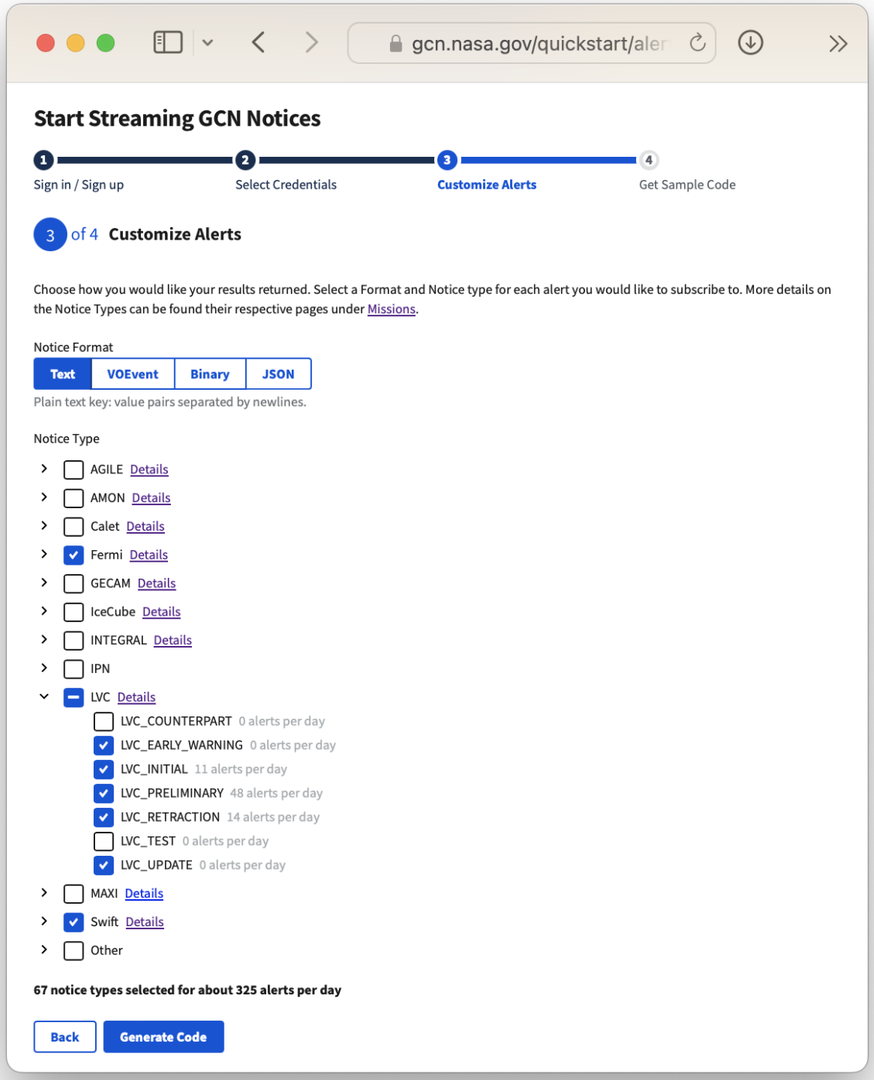
- We use Amazon Cognito, one of many off-the-shelf OIDC auth solutions
- We use the same auth system across our web site and our Kafka broker
- We have a straightforward path to adopting SciTokens (an HPC single sign-on infrastructure based on OpenID Connect, adopted by LIGO)



New GCN web site

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)

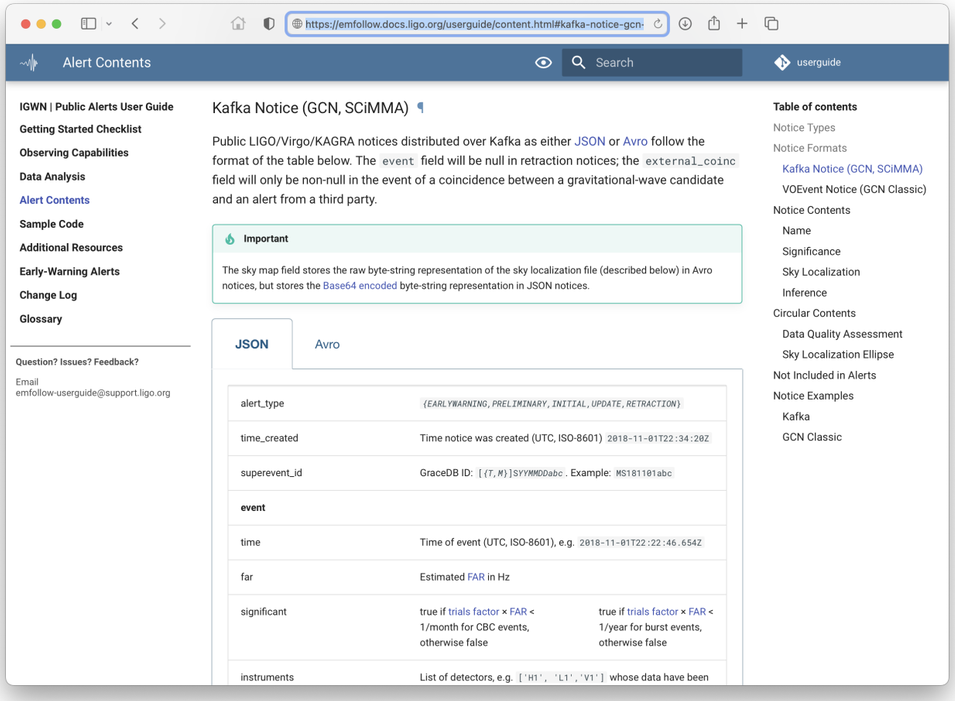


Start streaming GCN Notices

at https://gcn.nasa.gov/quickstart

- Start streaming GCN noticices in seconds!
- Receive alerts from Fermi, Swift, LIGO/Virgo/KAGRA*, IceCube, +many more
- Use our "quick start" interface to:
  - Sign in / sign up
  - Create API credentials
  - Customize your alerts
  - Generate Kafka client code for your favorite language (Python, JS, C++, C#, ...)

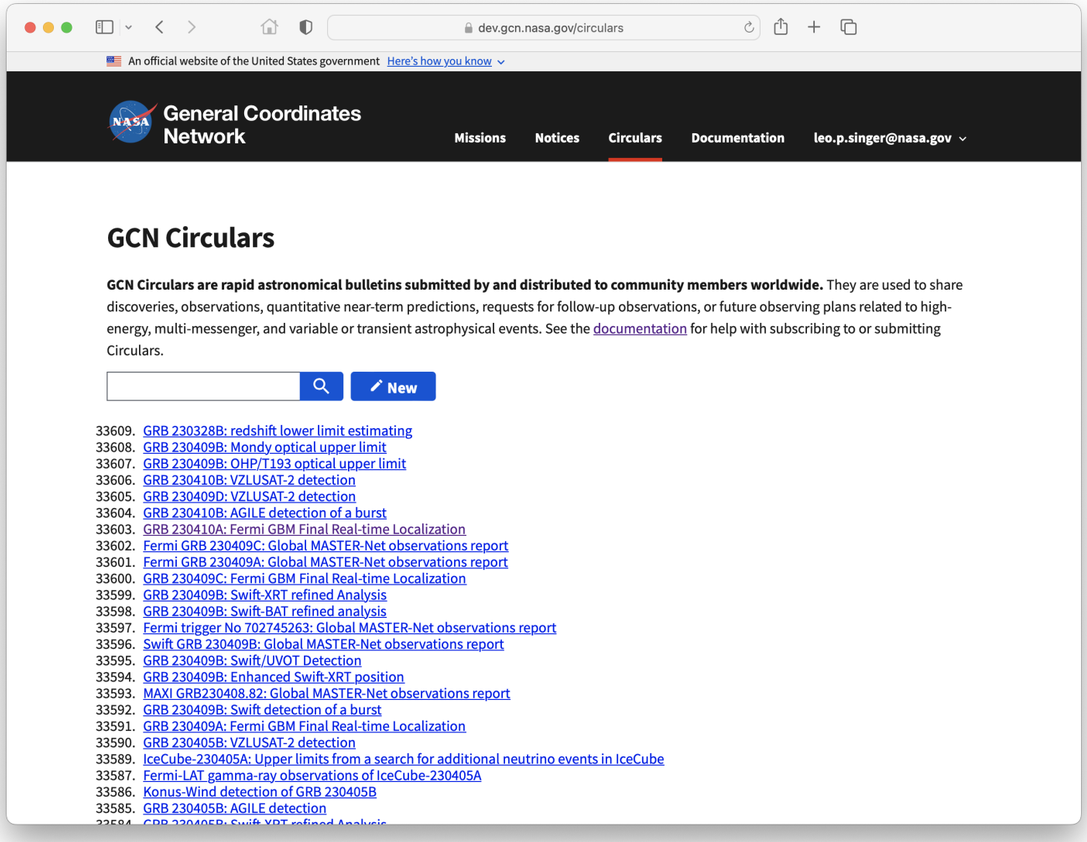
* see also https://emfollow.docs.ligo.org/userguide/tutorial/receiving/gcn.html



New JSON alerts over Kafka

Several missions and experiments are starting to send us alerts in JSON.

- LIGO, Virgo and KAGRA are publishing JSON records to GCN a Kafka topic called `igwn.gwalert`.
  - Classic notice types (VOEvent, text, binary) still supported
  - See LIGO/Virgo/KAGRA Public Alerts User Guide for details



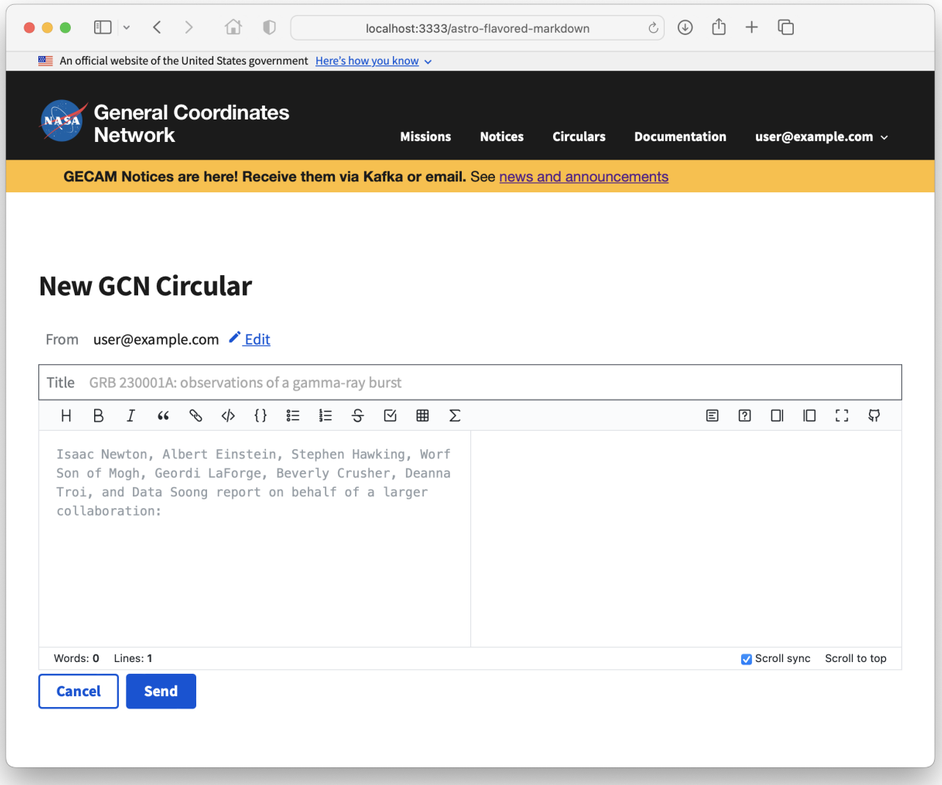
New and improved:

GCN Circulars

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.

What’s next for GCN?



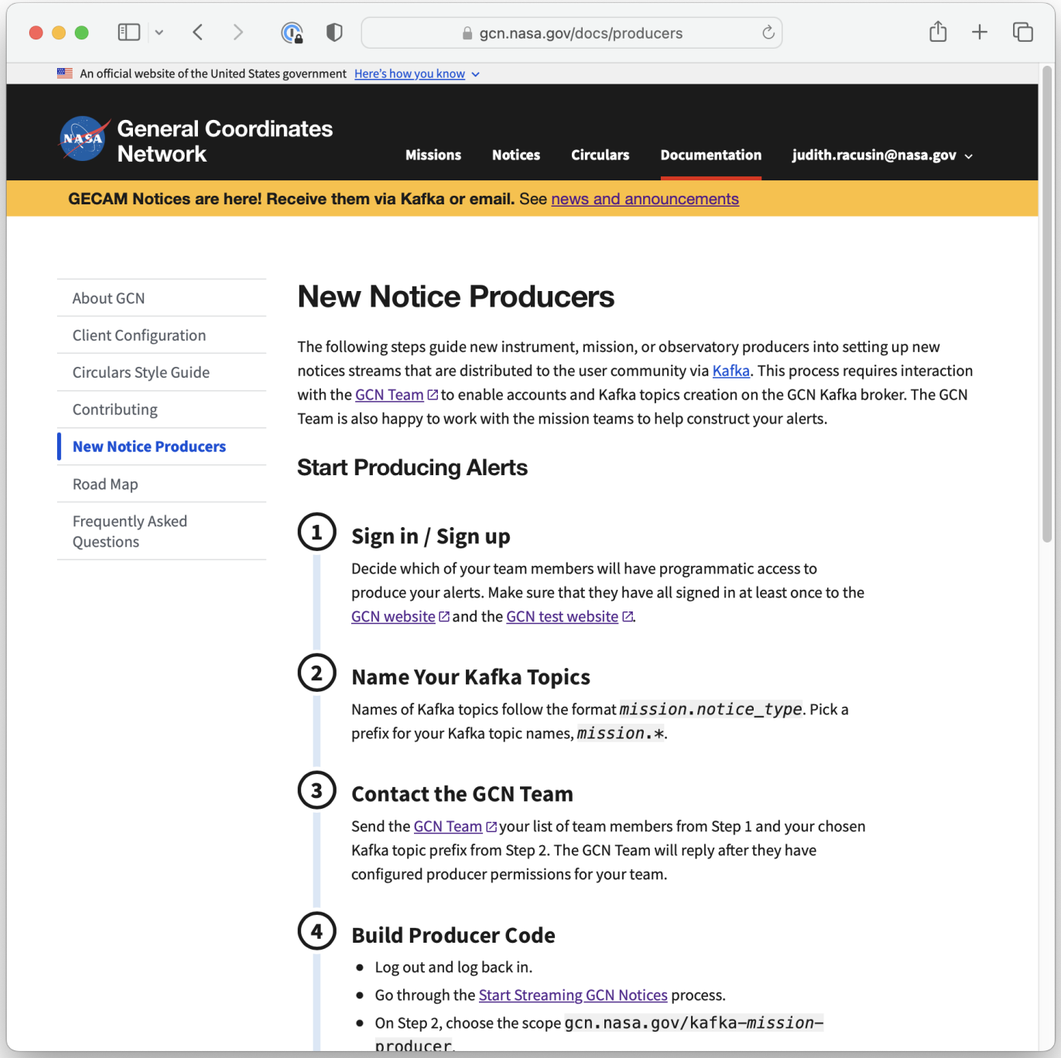
Coming soon to GCN Circulars

We're planning lots of enhancements soon to make GCN Circulars even better:

- Receive Circulars over Kafka
- Real-time integration with SAO/NASA Astrophysics Data Service (ADS)
- Link multiple emails with your account
- Link your ORCID to your account
- DOIs and BiBTeX entries for all Circulars
- Browse Circulars by event
- Embed tables, coordinates, images, and styled text in Circulars with “Astro Flavored Markdown”

More enhancements are coming to GCN:

- New alert types and alerts from new missions and facilities
- Unified schema and alert format for GCN Kafka
- Integrated, searchable database of Notices and Circulars (GCN Viewer)
- Interoperability with other transient Kafka brokers (e.g. SCiMMA)



Create new Notice types

- All new notice topics will only be distributed by GCN Kafka
- See step-by-step instructions
- Preferred notice format is JSON
- Unified JSON schema in development

Unified schema and alert format for GCN Kafka

- JSON schema with common core fields
- Instrument/mission/observatory specific fields where needed
- https://github.com/nasa-gcn/gcn-schema

JSON example (in development):

```
{
  "$id": "https://github.com/nasa-gcn/gcn-schema/blob/main/gcn/notices/fermi/gbm/Trigger.schema.json",
  "$schema": "https://json-schema.org/draft/2020-12/schema",
  "title": "Trigger",
  "description": "fermi gbm Trigger",
  "type": "object",
  "properties": {
    "alert_info": {
      "$ref": "https://github.com/nasa-gcn/gcn-schema/blob/main/gcn/notices/core/AlertInfo.schema.json"
    },
    "identifiers": {
      "$ref": "https://github.com/nasa-gcn/gcn-schema/blob/main/gcn/notices/core/Identifiers.schema.jso
    },
    "event_info": {
      "$ref": "https://github.com/nasa-gcn/gcn-schema/blob/main/gcn/notices/core/EventInfo.schema.json"
```

NASA's Time Domain and Multimessenger Vision

Adapted from V. Connaughton's slides

NASA's Physics of the Cosmos (PhysCOS) program is studying the organizational, programmatic, and technical aspects of a future Time-Domain and MultiMessenger (TDAMM) General Observing Facility (GOF). **GCN is to play a vital role.** The GOF would facilitate:

- On a timescale of **seconds to hours**: alert systems (e.g. **GCN**); information flows between science, mission, and operations; observing schedules and science timelines
- On a timescale of **hours to months**: coordinated targets of opportunity, coordinated observation planning
- On a timescale of **years**: Strategic coordination of planning, missions, interfaces, and tools.

For more information, contact the study leads, Brian Humensky and Chris Roberts.

Thanks for listening!

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