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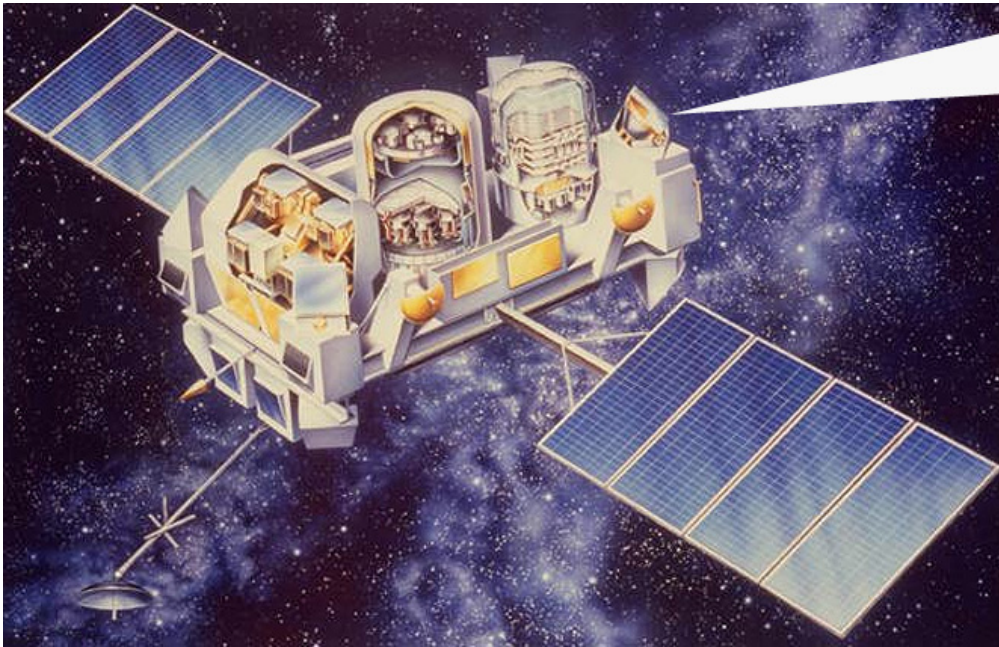
NASA's Next Generation Time-Domain and Multimessenger Alert System

A service of the Astrophysics Science Division at NASA's Goddard Space Flight Center
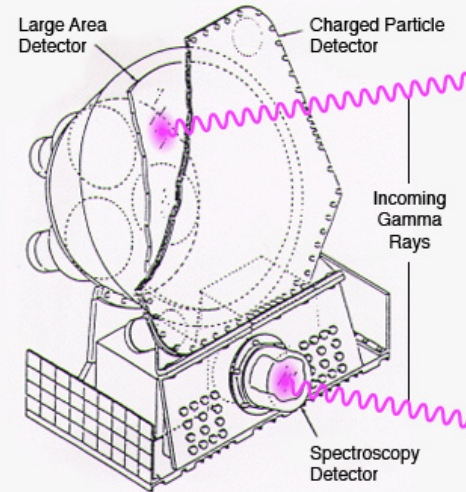
https://gcn.nasa.gov

Gamma-ray Coordinates Network

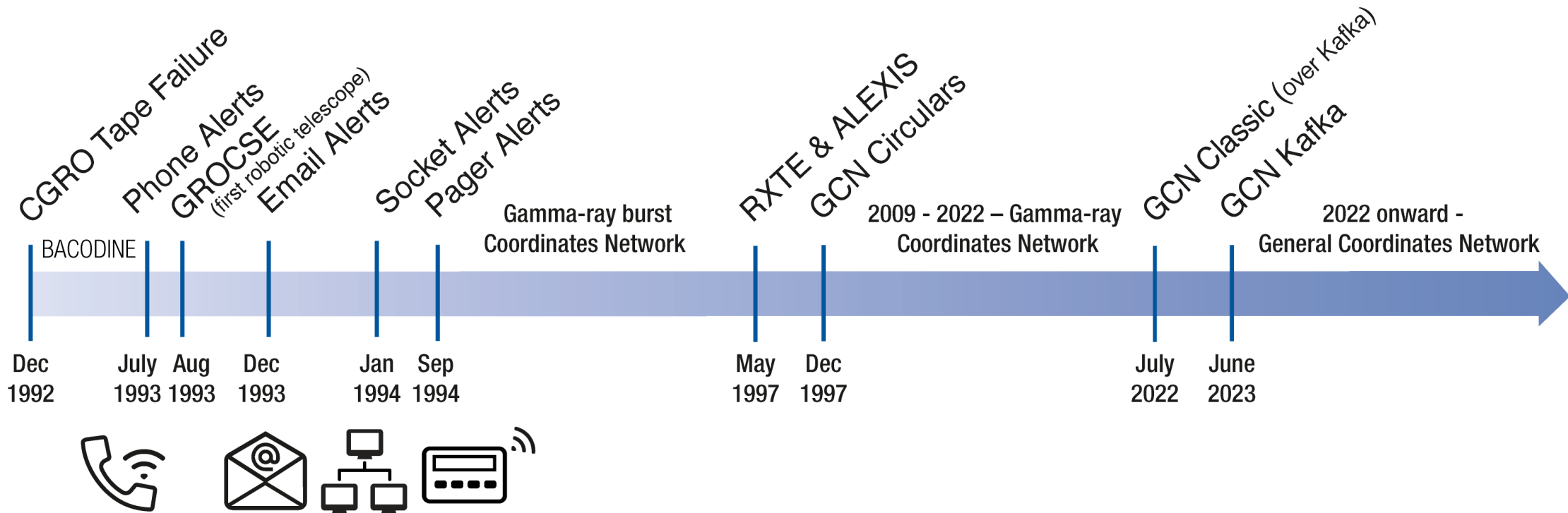# Realtime Alerts Born of Necessity


BATSE Detector Module (1 of 8)

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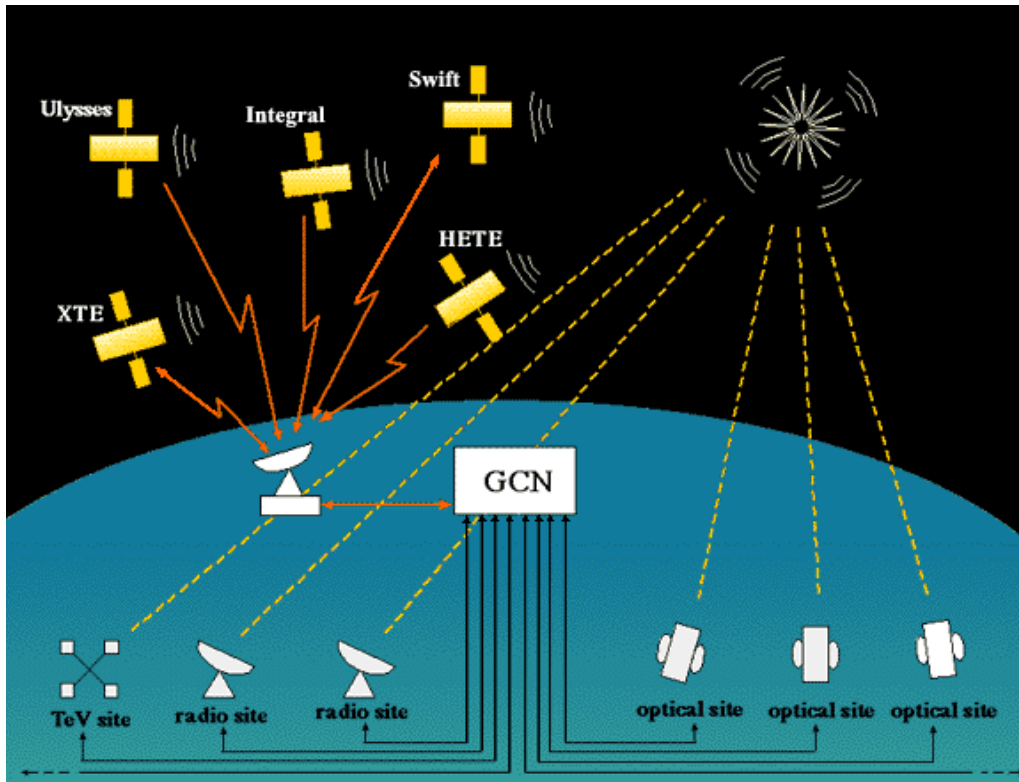
The GCN community enabled worldwide follow-up observations that revealed the nature of gamma-ray bursts:

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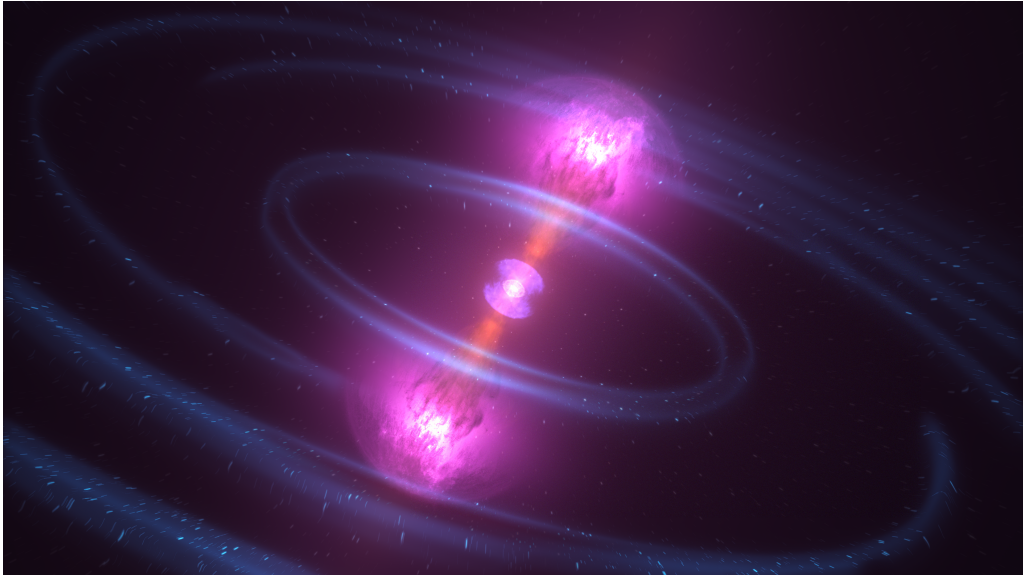
- By and for humans (some automated)
- Freeform text (with established style)
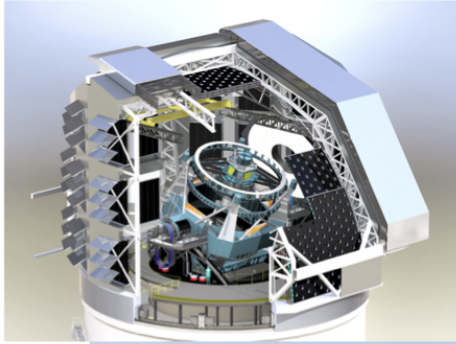- Citable (but not peer-reviewed)

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
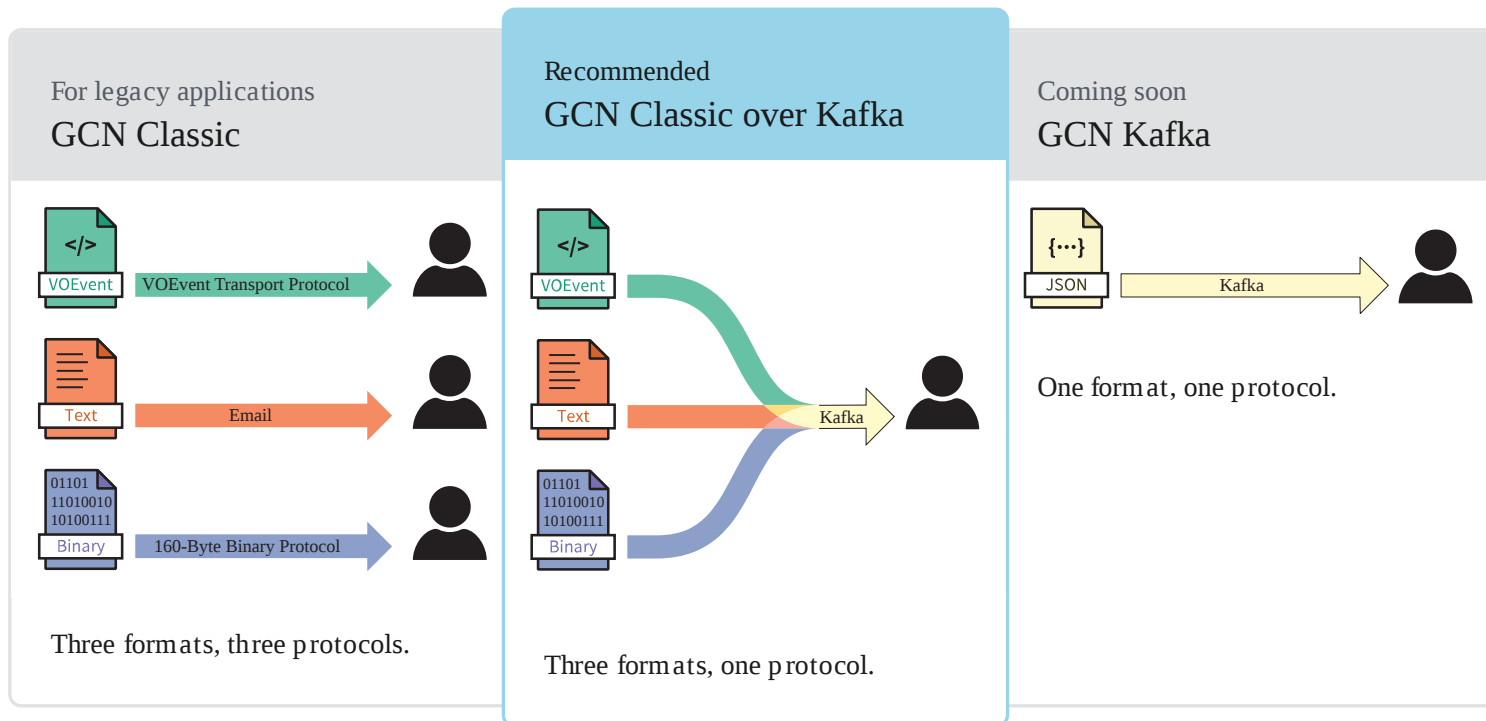
- **GCN Classic** provides three formats over *three custom protocols*
- **GCN Classic over Kafka** provides all three formats over *one standard protocol*: Apache Kafka
- **GCN Kafka** will transition over the next few years to streaming all data in JSON format over Kafka (Notices and Circulars)
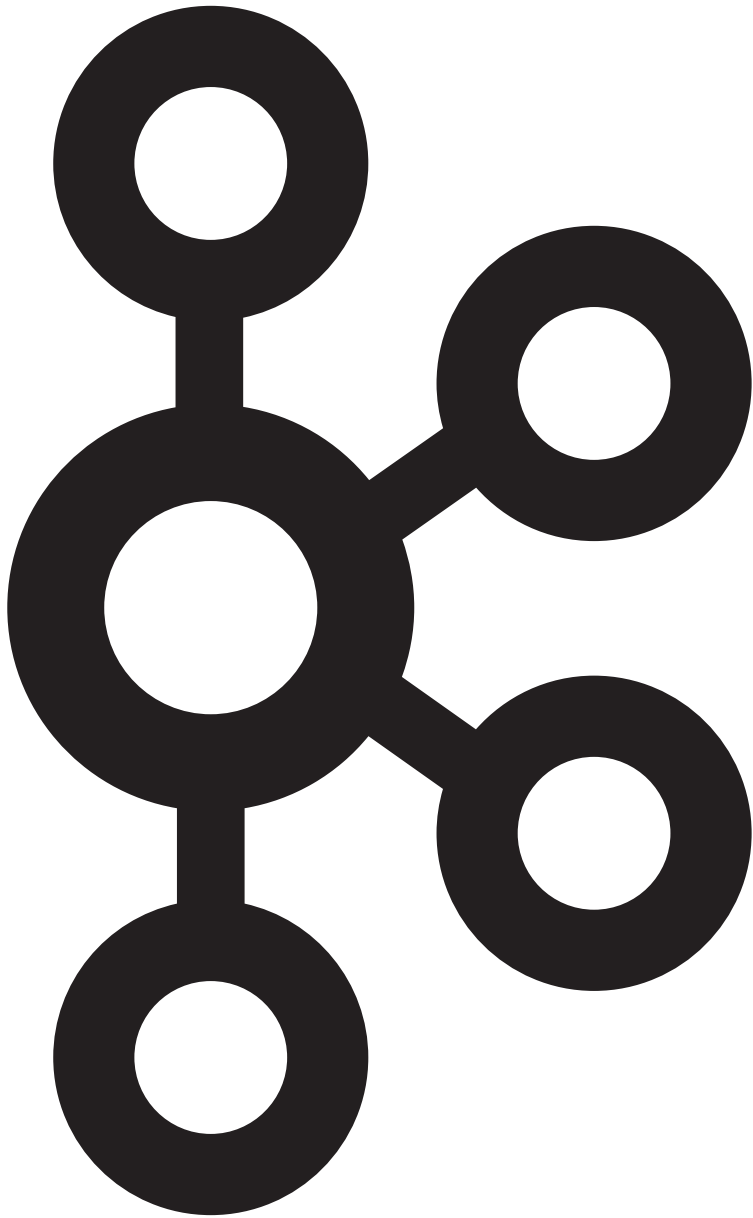
What is Kafka?

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)
- ...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)

Why switch to the new GCN?

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

New GCN web site

at https://gcn.nasa.gov
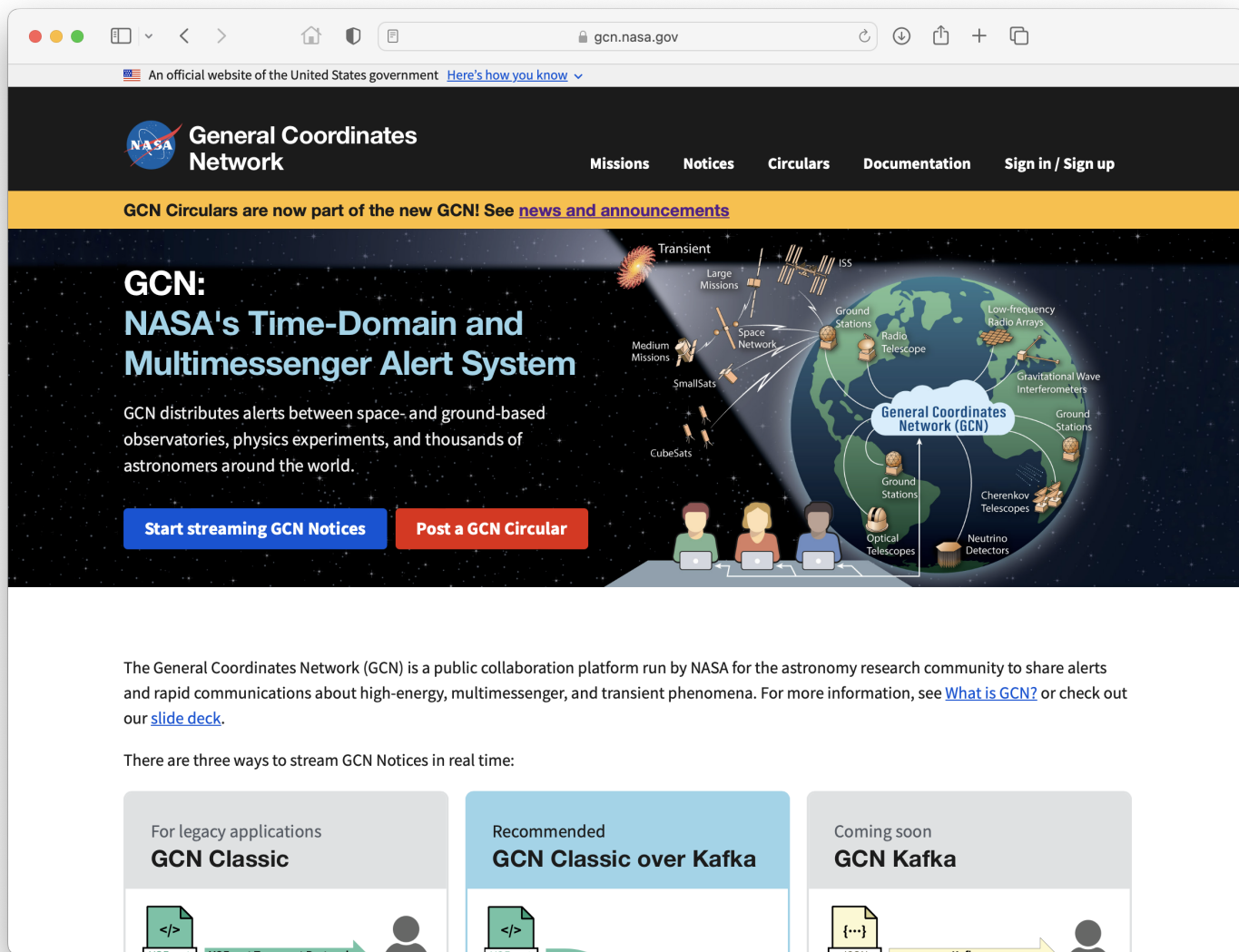
- Updated look and feel
- More accessible, based on US Web Design System
- Single sign on with:
  - email and password
  - Google
  - Facebook
  - LaunchPad (for NASA employees and affiliates)

What is our tech stack?
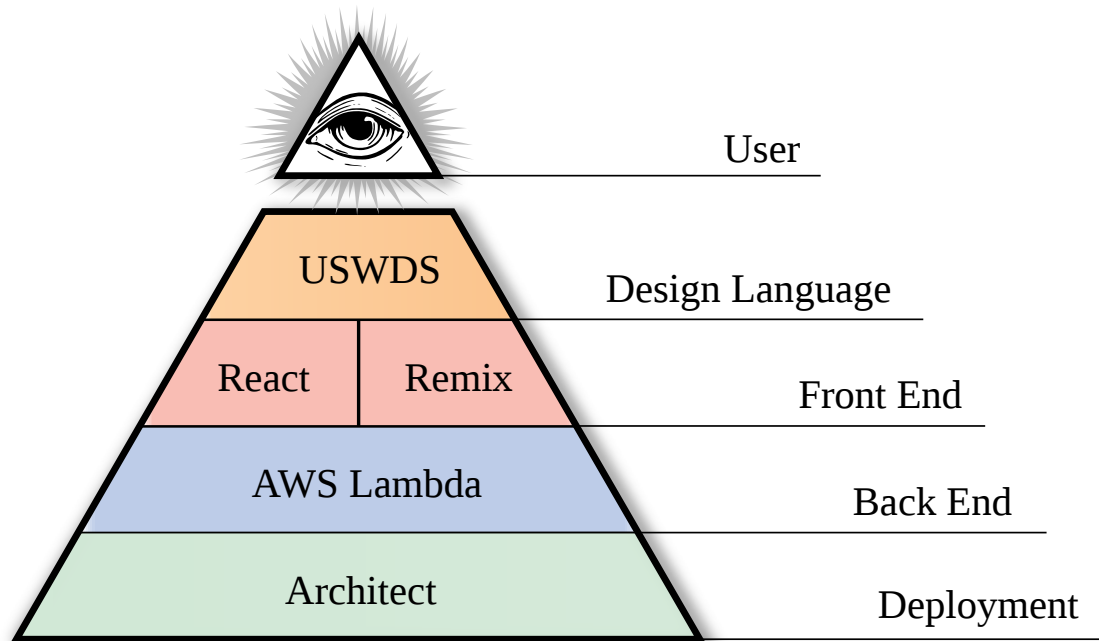
- NASAWDS style framework, based on the US Web Design System
  - Emphasizes accessability
  - Used by most Federal agencies
- 100% TypeScript
  - Asynchronous & scalable
  - Single codebase for server & client
- Early adopters of Remix, a full-stack React framework
- Continuously deployed on AWS Lambda using GitHub Actions and Architect
- 100% open source — contributions welcome! https://github.com/nasa-gcn/gcn.nasa.gov

Self-service email alerts

Email is still the most popular way to receive GCN Notices.

- Previously, users had to contact the GCN Team to create or modify their subscriptions manually.
- Now, you can manage your email subscriptions yourself through our new web site.
- **Note**: to cancel legacy email subscriptions on the old web site, contact us.
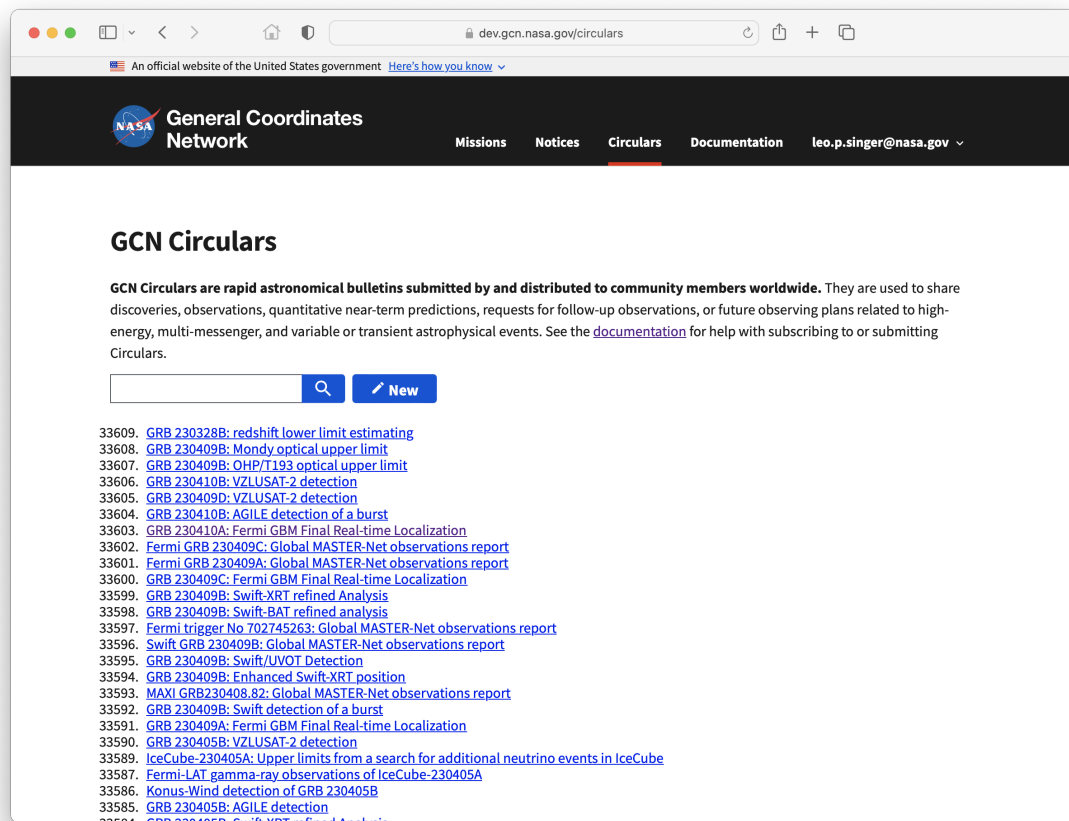
New and improved:

✨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.

(skip ahead for more on GCN Circulars)

What's staying the same?

GCN Classic is not going away any time soon. The following are still fully supported:

- GCN Notices legacy delivery mechanisms (email, socket, VOEvent Transport Protocol) of all current notice types
- GCN Circulars submission and delivery via email
- The old GCN Classic web site, https://gcn.gsfc.nasa.gov
- The live archives of GCN Notices on the old web site

However, new features and notice types are only available on the new web site and GCN Kafka.

Streaming GCN Notices in Python

Launch quick start

Go to https://gcn.nasa.gov and click Start streaming GCN Notices

(skip past demo)
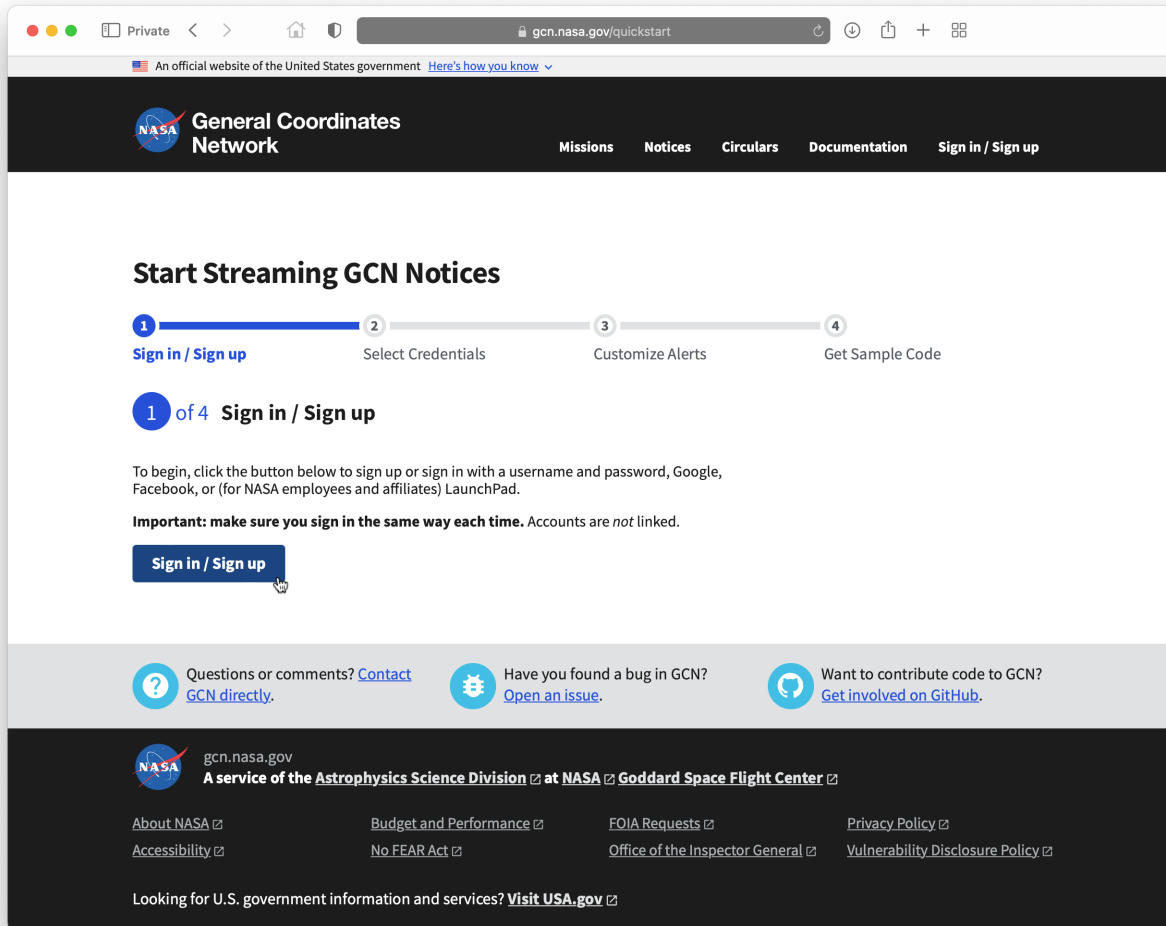
Step 1: Sign in / Sign up

Click "Sign in / Sign up" to create a GCN account.
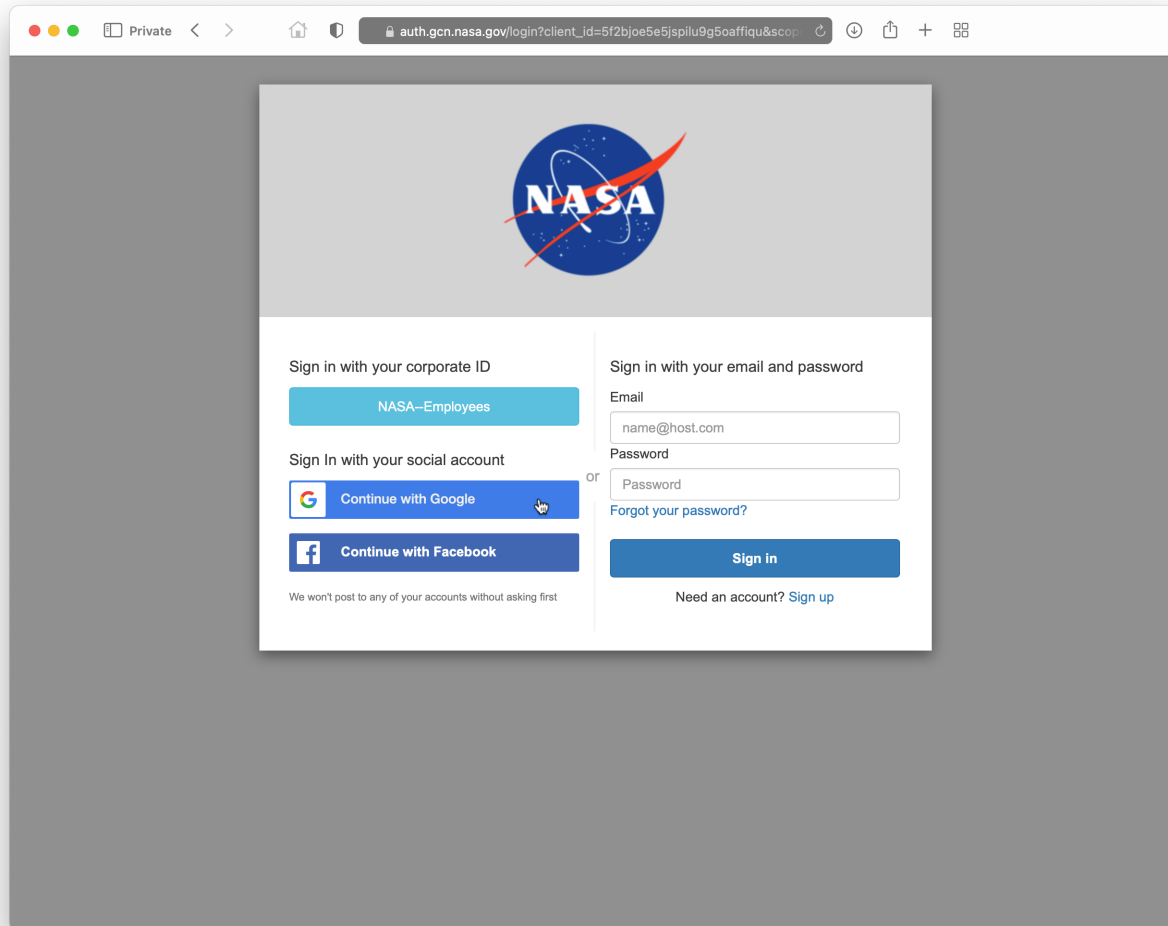
Choose how to sign up

Choose any one of the following methods to sign up:

- Email and password
- Google
- Facebook
- (for NASA employees and affiliates) LaunchPad

Important: make sure you sign in the same way each time. Accounts are *not* linked.
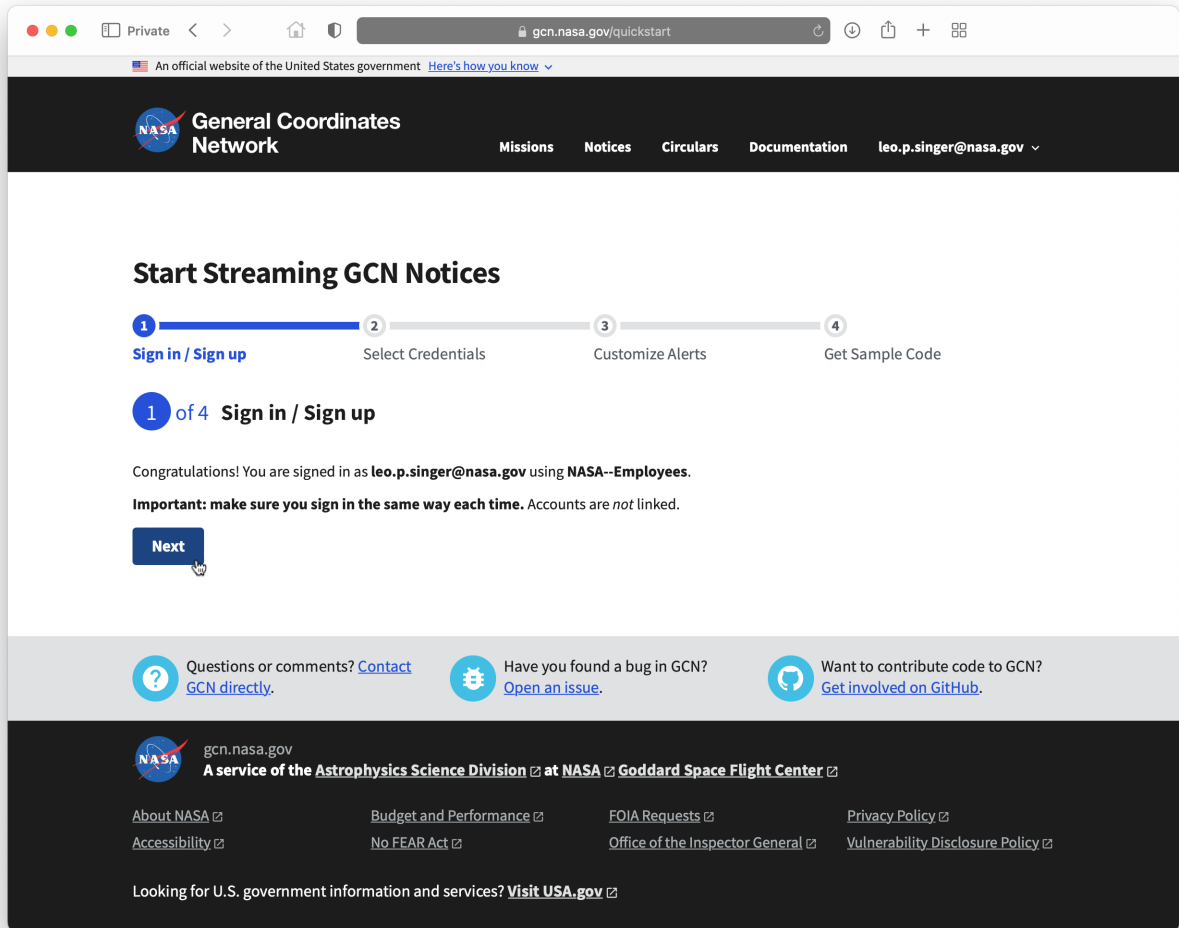
Step 1 is done

Click "Next" to continue

Step 2: Select Credentials

Client credentials allow your scripts to interact with GCN on your behalf.

1. Choose a name for your credential.
2. Complete the CAPTCHA.
3. Click "Create New Credentials" to go to the next step.
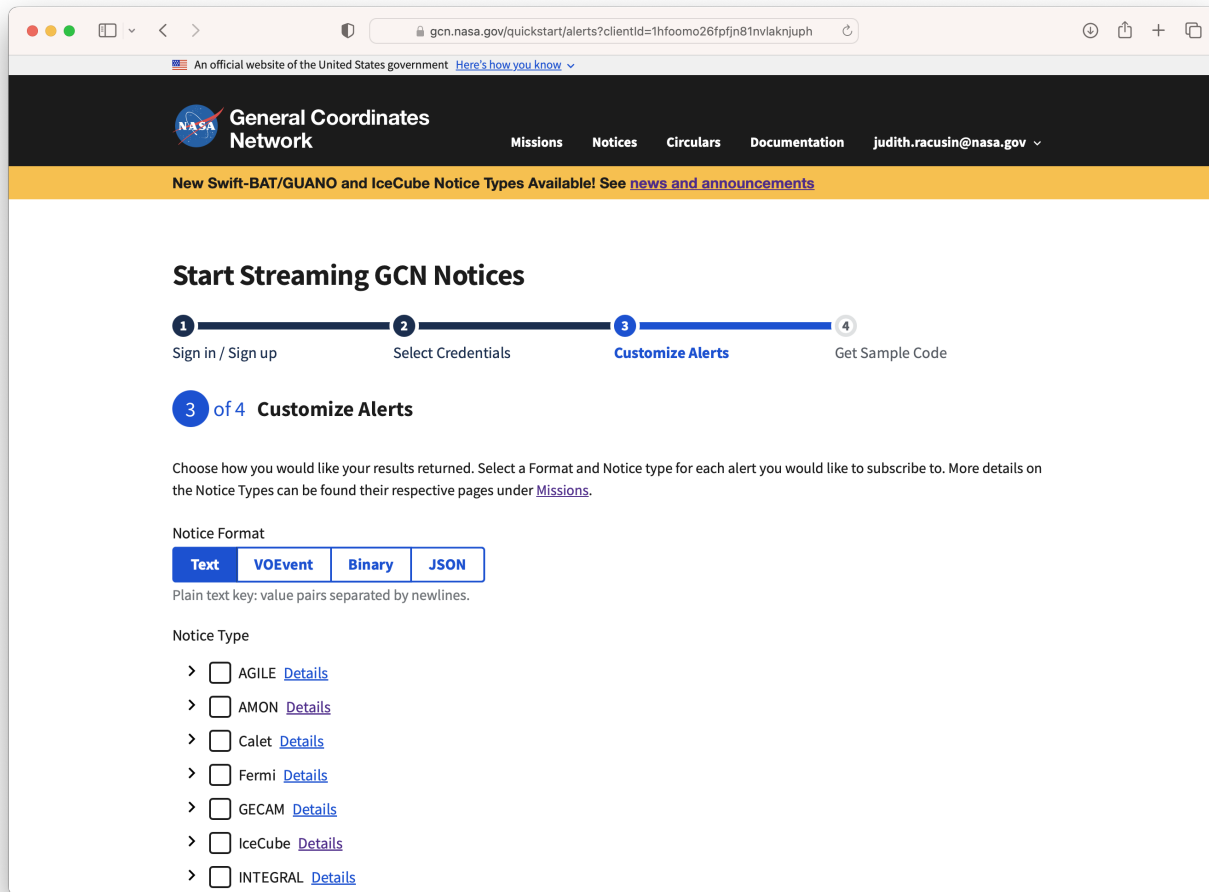
Step 3: Customize Alerts

Select one of these alert formats.

- Text: plain text key-value pairs separated by newlines.
- VOEvent: VOEvent XML.
- Binary: 160-byte binary format. Field packing is specific to each notice type.
- JSON: key-value pairs and arrays, allows embedding attachments.
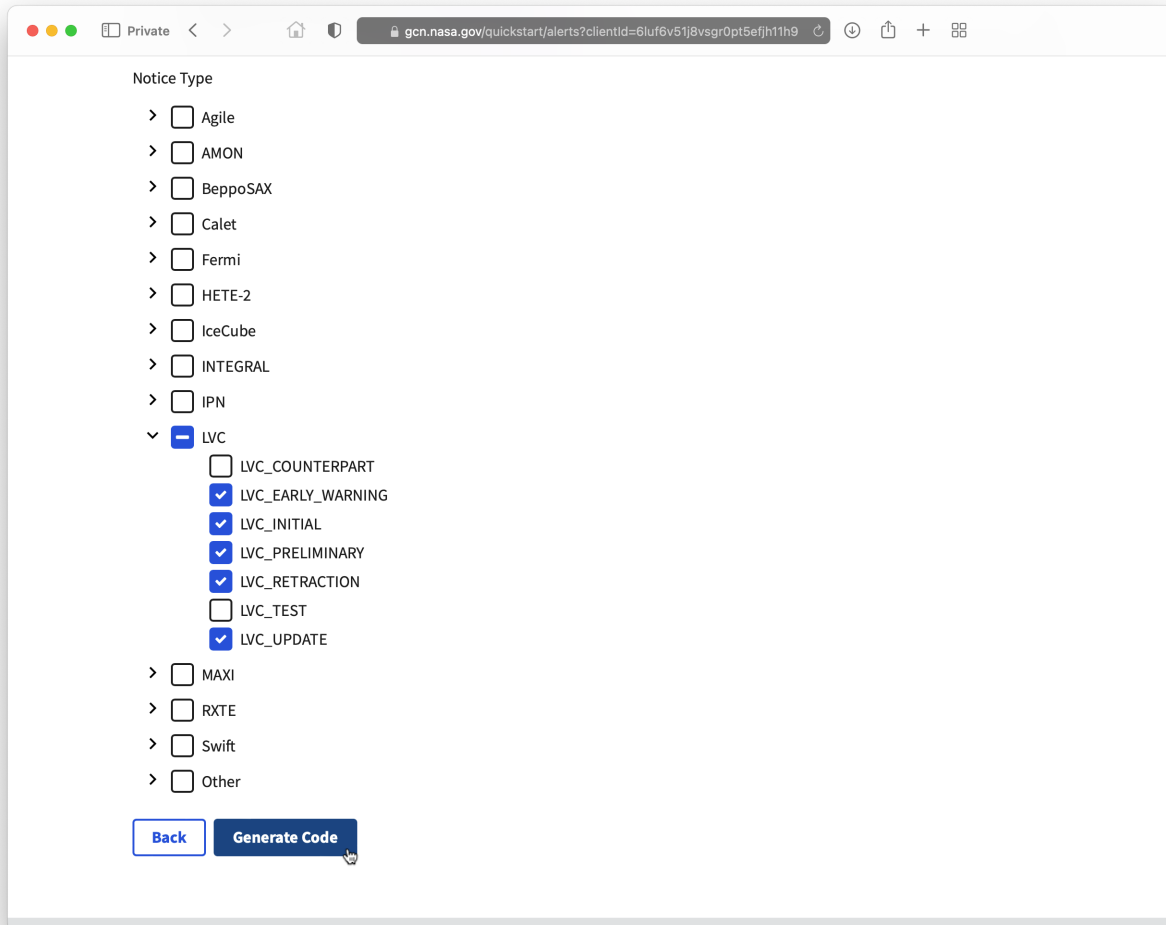
Step 3 Continued: Choose Notice Types

Select the missions that you want to subscribe to. Expand a mission to fine-tune notice types.

Step 4: Get Sample Code

Copy and paste Python client code or download it to your computer to run.

Client sample code is also available in Node.js (ESM or CommonJS), C/C++, C#.

Install Python client

Run this command to install with pip:

```
pip install gcn-kafka
```

or this command to install with with conda:

```
conda install -c conda-forge gcn-kafka
```

Connect to Kafka

```python
from gcn_kafka import Consumer

consumer = Consumer(
    client_id='fill me in',
    client_secret='fill me in'
)
```

Subscribe to topics and receive alerts
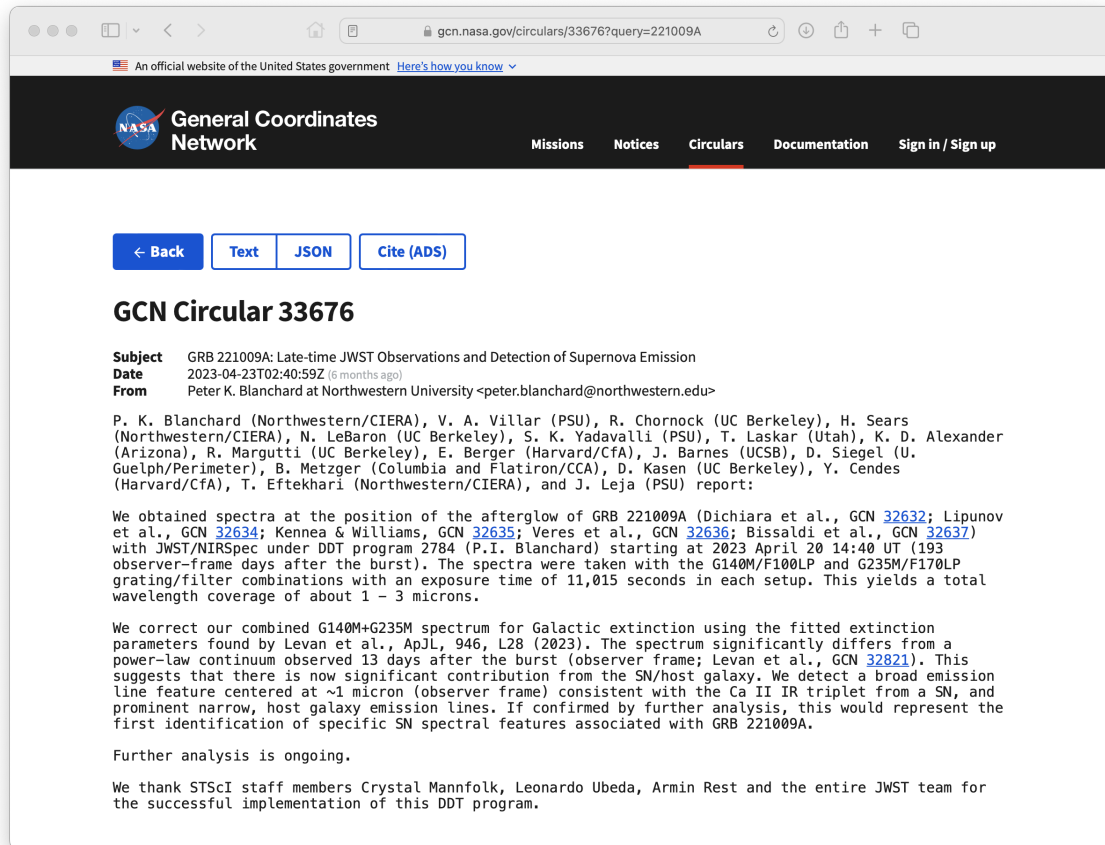
```python
consumer.subscribe([
    'gcn.classic.text.LVC_INITIAL',
    'gcn.classic.text.LVC_PRELIMINARY',
    'gcn.classic.text.LVC_RETRACTION',
    'gcn.classic.text.LVC_UPDATE'
])
while True:
    if message.error():
        print(message.error())
        continue
    for message in consumer.consume(timeout=1):
        print(message.value())
```

The New GCN Circulars

Improvements to Circulars

The new GCN Circulars are:

- **Self service**: Manage your own subscriptions and settings.
- **More inclusive**: It's easy to join the community and submit a GCN Circular.
- **Fast**: Email notifications are distributed in parallel to all users within seconds.
- **Robust**: Circulars run on highly available, distributed cloud services.
- **Sustainable**: GCN Circulars are robustly funded by NASA and are part of the open source GCN project.

Migrating GCN Circulars from GCN Classic

On April 17, 2023, GCN Circulars moved from the old site to the new one. If you had an account on the old system, then you already have an account on the new one!

GCN CIRCULARS MIGRATION CHEAT SHEET

	Old	New
📖 **Web archive**	https://gcn.gsfc.nasa.gov/gcn3_archive.html	https://gcn.nasa.gov/circulars
✉ **Emails come from**	gcncirc@capella2.gsfc.nasa.gov	no-reply@gcn.nasa.gov
➤ **Submit Circulars by email to**	gcncirc@capella2.gsfc.nasa.gov	gcncirc@capella2.gsfc.nasa.gov circulars@gcn.nasa.gov (recommended)
⊕ **Submit Circulars by web form**	(not supported)	https://gcn.nasa.gov/circulars/new

Tutorial: Receiving GCN Circulars

Step 1: Sign in / Sign up

Click "Sign in / Sign up" to sign in to your GCN account or to sign up.

Choose how to sign up

Choose any one of the following methods to sign up:

- Email and password
- Google
- Facebook
- (for NASA employees and affiliates) LaunchPad

Important: make sure you sign in the same way each time. Accounts are *not* linked.

Legacy GCN Classic Circulars users: Select "Sign up" not "Sign in" on first login to migrate your settings.

Step 2: Go to Email Notifications settings

- Select the user menu from the navigation bar.
- Choose **Email Notifications** from the user menu.

Step 3: Toggle Email Notifications

Toggle Circulars **On** or **Off** to enable or disable email notifications.

- Circulars are sent to the email address that is associated with your GCN account.
- **Users migrated from GCN Classic**: If you were subscribed to GCN Circulars in the old system, then you are subscribed in the new system automatically.

Tutorial: Submitting GCN Circulars
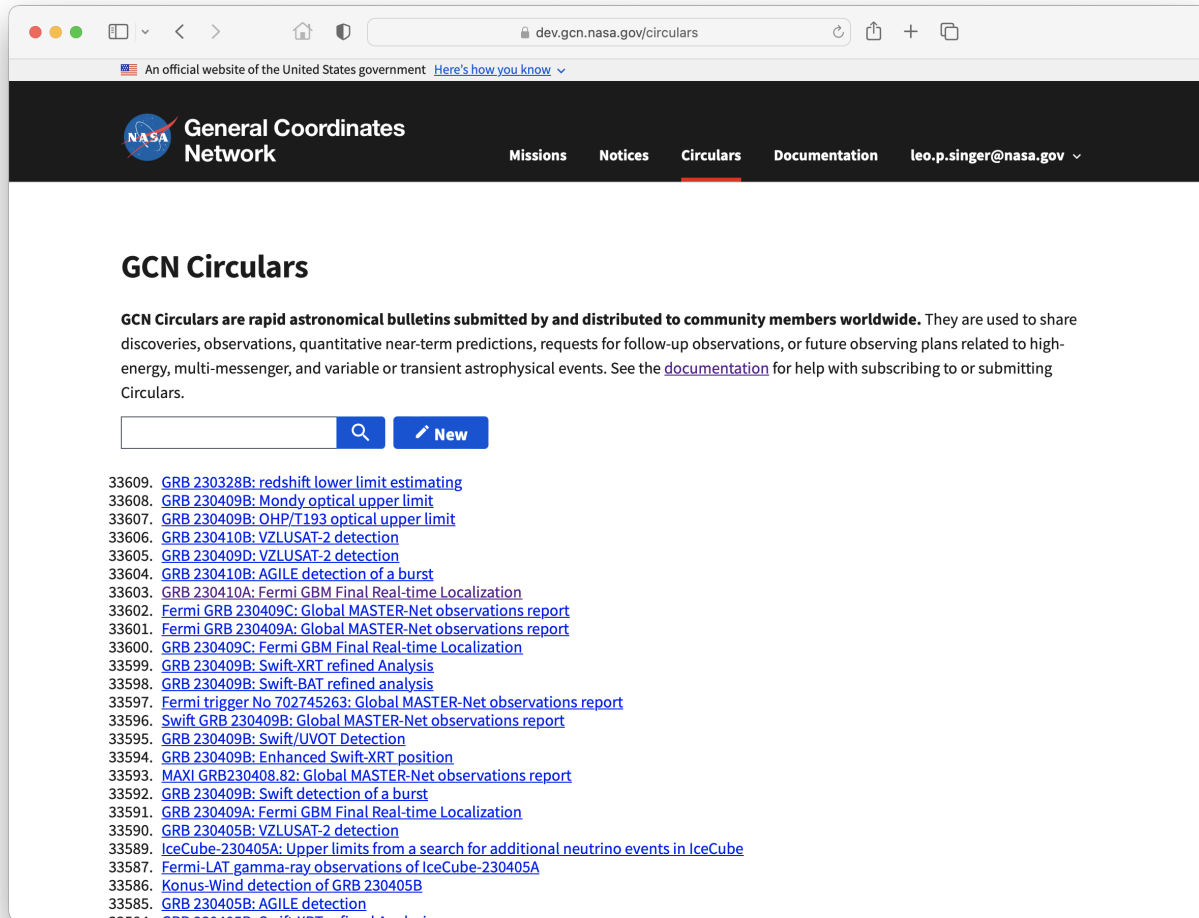
Step 1: Go to New Circular web form

1. Navigate to the GCN Circulars archive by tapping on **Circulars** in the navigation bar.
2. Tap the **New** button.

—*or*—

Go to

https://gcn.nasa.gov/circulars/new
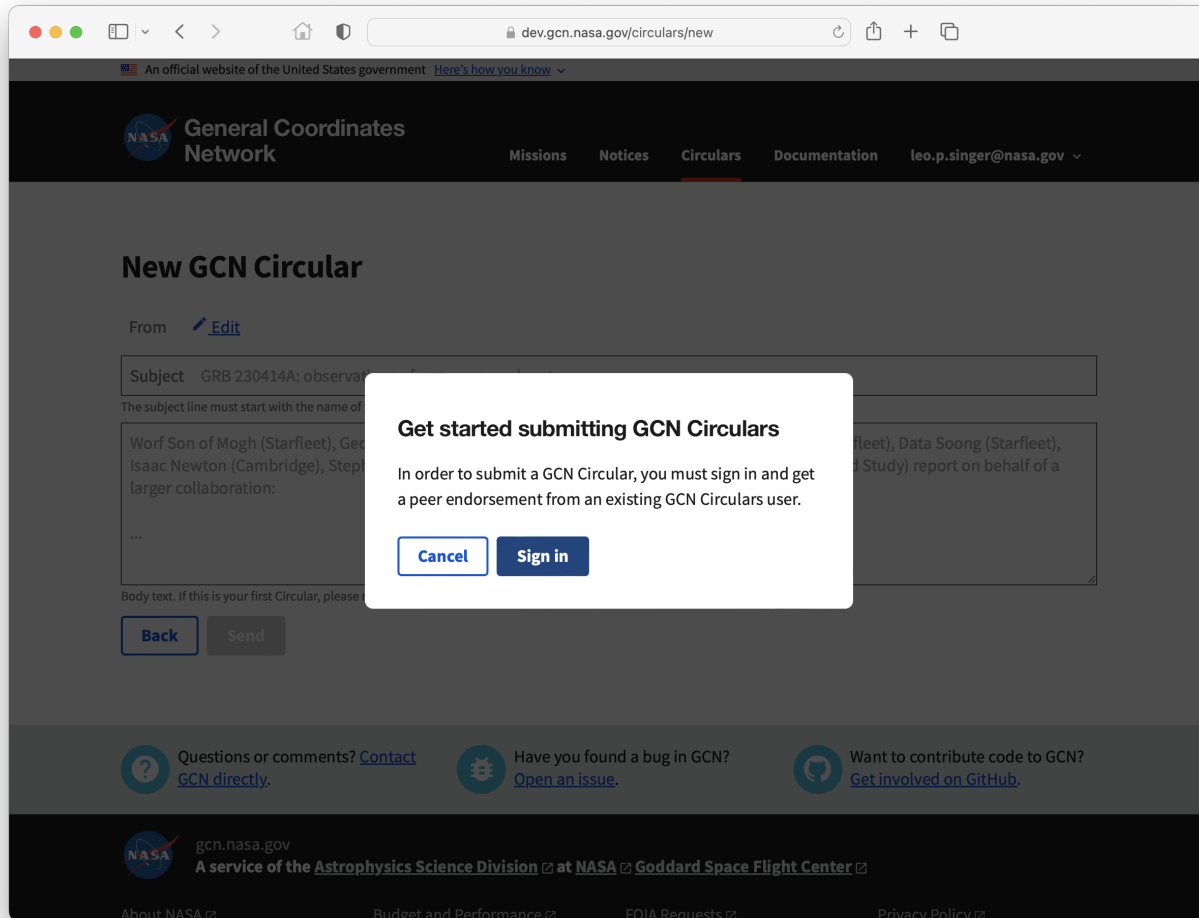
Step 2: Sign in / Sign up

If you are not already signed in, then you will be prompted to sign in.

Tap **Sign in**, then follow the instructions to create a GCN account or sign in with an existing one.

(These are the same accounts used for receiving GCN Circulars, using Kafka, etc.)

Step 3: Get a Peer Endorsement

New users: once you have signed in to GCN, you will be prompted to start the peer endorsement process. Tap **Get a peer endorsement**.

Users migrated from GCN Classic: If you were authorized to submit GCN Circulars in the old system, then you are already authorized to submit Circulars and can endorse others once you have signed in to the new web site.
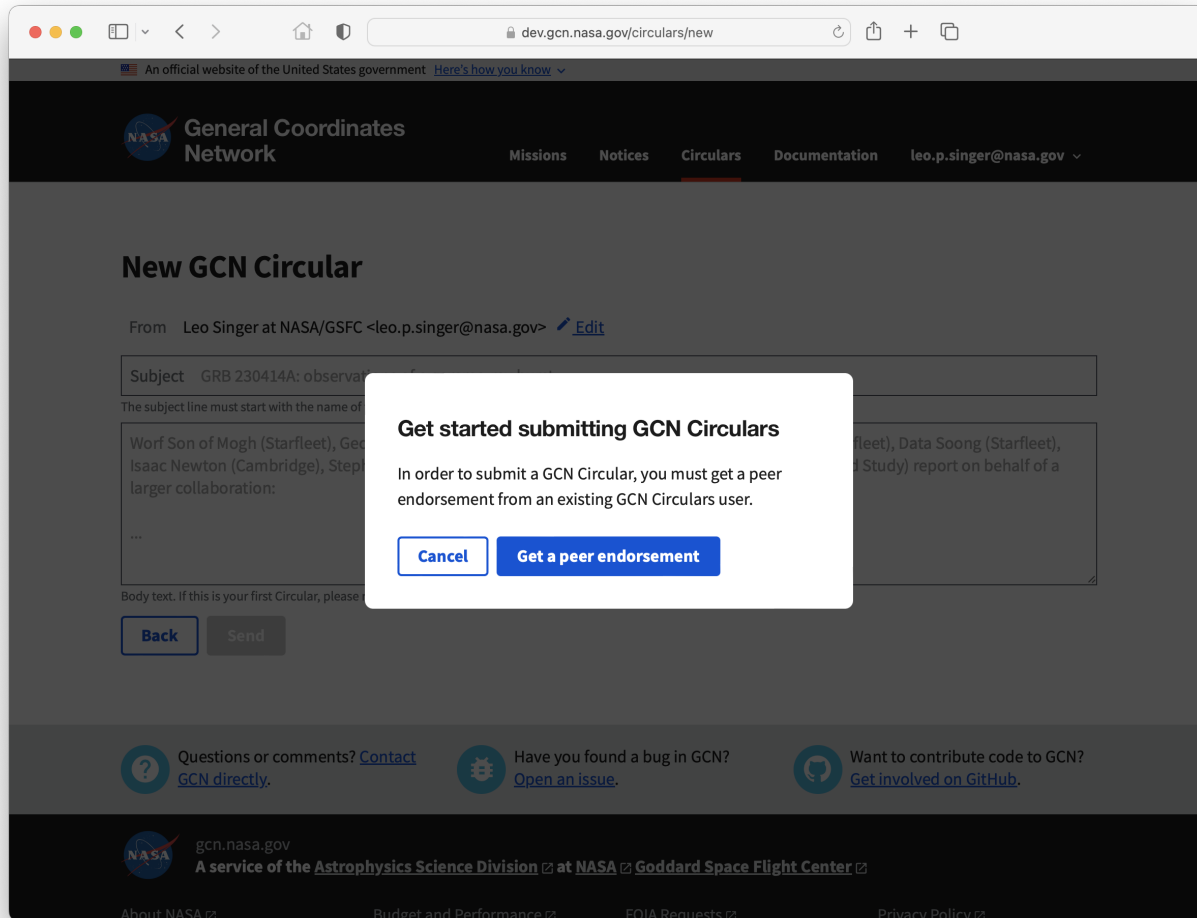
Step 4: Find a Peer Endorser

Find an endorser by name or email.

This should be someone who you know and who knows you: a fellow researcher, an advisor, or instructor.

Note: Endorsers are users who already can submit Circulars *and* have logged in to the new GCN system at least once.

Contact us at https://gcn.nasa.gov/contact if you can't find an endorser.

Step 5: Submit Peer Endorsement Request

Tap **Request**.

Step 5 (continued)

You can find this page again to see the status of your requests by tapping **Peer Endorsements** in the user menu.

- Both you and the person that you selected will receive an email notification for the request.

- When your selected endorser approves your request, you will be notified again.

Step 6: Approve Peer Endorsements Yourself

Congratulations! Now you can post GCN Circulars and you can also approve new users yourself.

When a new user requests an endorsement from you, the request will appear on this same page.
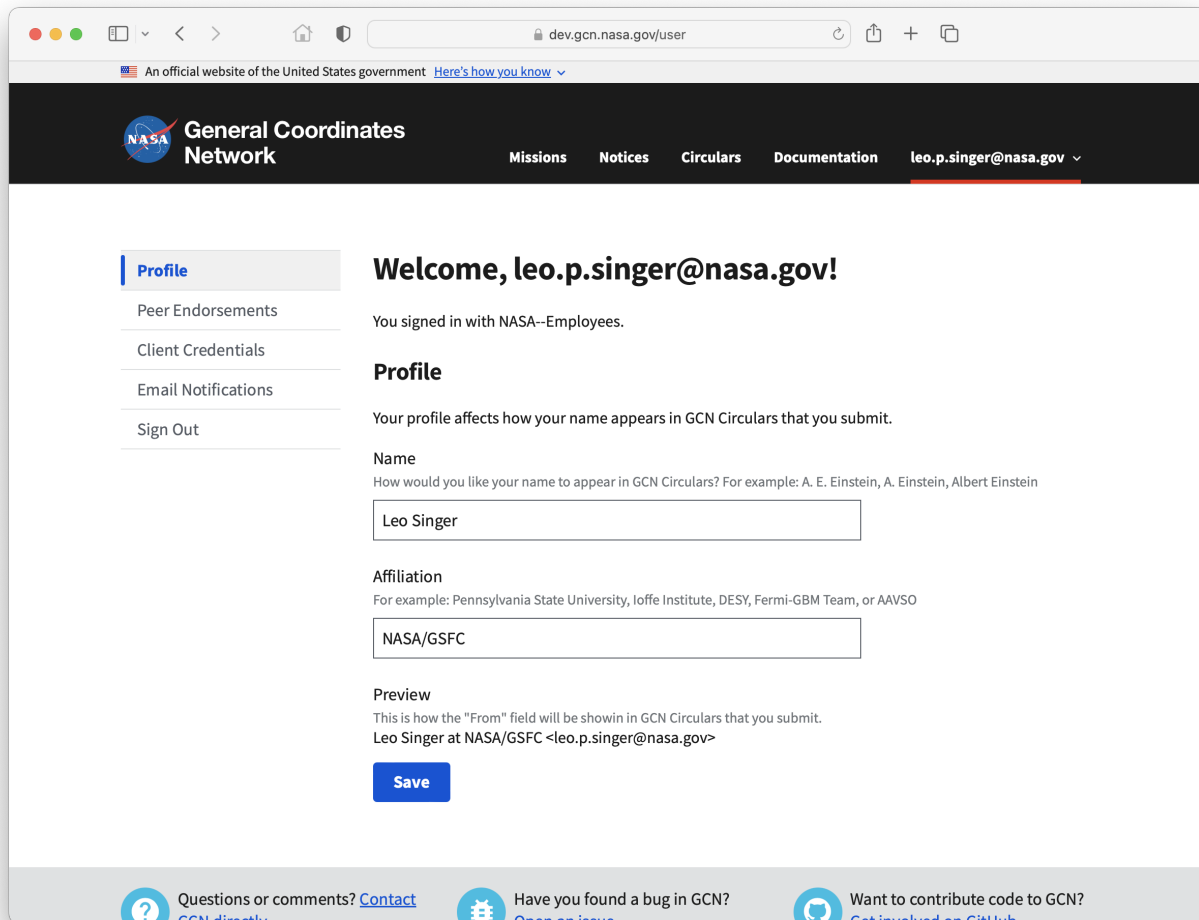
Step 7: Update your Profile and Review the Style Guide

Prepare to submit your first Circular:

- Review the community's Circulars style guide.

- Update your name and optional affiliation as they will appear in Circulars by selecting **Profile** from the user menu.

Step 8: Post a Circular

Submit a Circular in exactly *one* of the following ways:

- By web form: click **New** button on the GCN Circulars archive
- By email: send to circulars@gcn.nasa.gov
- By email (legacy): send to gcncirc@capella2.gsfc.nasa.gov

Important: do *not* Cc: both submission addresses!

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 and source class
- Data extraction via Natural Language Models
- Embed tables, coordinates, images, and styled text in Circulars with "Astro Flavored Markdown"
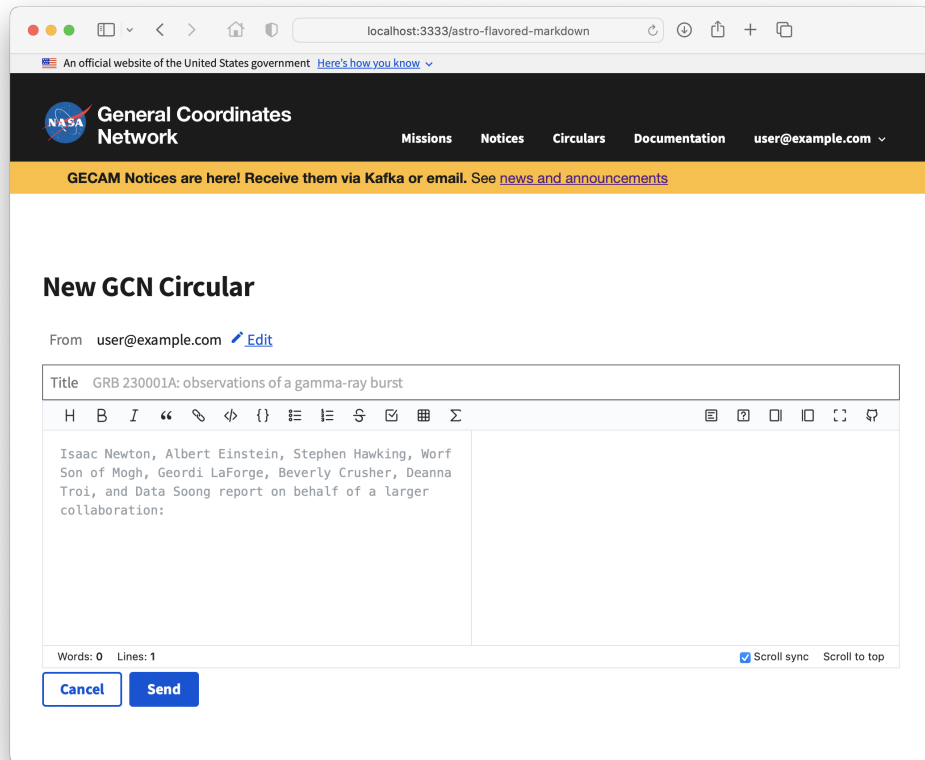
More enhancements are coming to GCN:

- New alert types and alerts from new missions and facilities
  - New Kafka-only notices for Swift-BAT/GUANO and IceCube
  - Many others in development including Glowbug, BurstCube, Super-K, Fermi-GBM, AMON
- 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 provides common core
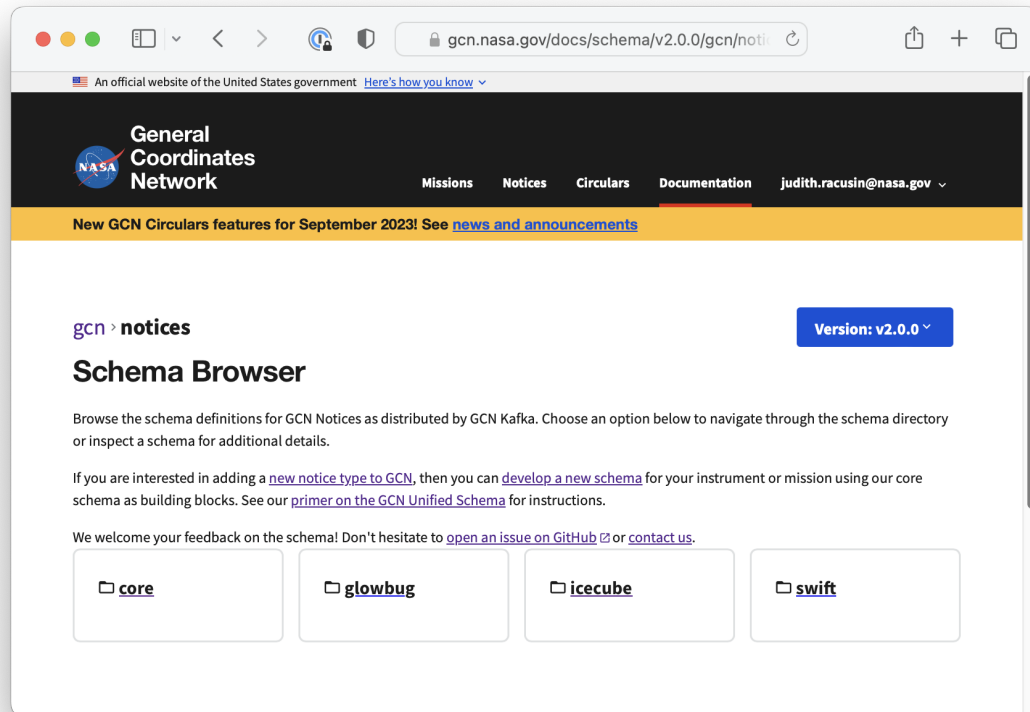
Unified schema and alert format for GCN Kafka

- JSON schema with common core fields
- Instrument/mission/observatory specific fields where needed
- Schema development documentation
- Schema Browser
- GitHub project: nasa-gcn/gcn-schema

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