# Astro COLIBRI

## Real-time alerts of the transient sky with Astro-COLIBRI

***Patrick Reichherzer*** and ***Fabian Schussler***

*on behalf of the Astro-COLIBRI team*

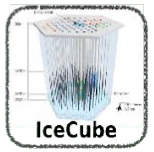
20.11.2023

# Idea of workshop

events

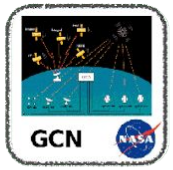
photons, GWs, ν

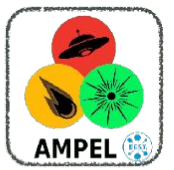
monitoring observatories



follow-up-observ.

alert
- creator
- streams
- broker



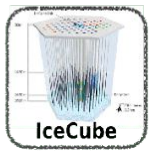


# Idea of workshop

events

photons, GWs, ν

monitoring observatories



Multi-messenger transients
***Marica Branchesi***

MWL+MM emission of GRBs
***Giancarlo Ghirlanda***

Powering Source of Gamma Ray Burst Associated Supernovae
***Amit Kumar***

MWL/MM emissions of AGN
***Foteini Oikonomou***

IceCube realtime alerts: science and infrastructure
***Massimiliano Lincetto***

Online Analysis Framework with KM3NeT
***Vincent Cecchini***

ZTF/LSST brokers (e.g. European Broker Initiative)
***Jakob Nordin***

Sub-TeV neutrino counterparts to sub-threshold gravitational wave events
***Tista Mukherjee***

GCN
***Judith Racusin***

alert
- creator
- streams
- broker

TNS TAU | GCN | four π sky | PennState AMON | AMPEL | FINK

follow-up-observ.

Observing Strategy for Electromagnetic Follow-up of Gravitational-Wave Events
***Elahe Khalouei***

Detectability of GRB Optical Prompt and Afterglow with Iranian National Telescope
***Soroush Shakeri***

tilepy
***Monica Seglar Arroyo***

Virtual Observatory
***Ada Nebot***

ASAS-SN SkyPatrol
***Kyle Hart***

SkyPortal
***Theophile Jegou du Laz***

BHTom
***Lukasz Wyrzykowski***

RAPAS
***Thierry Midavaine***

## *Citizen Science*

The United Nations Open Universe Initiative
***Ulisses Barres de Almeida***

AAVSO
***Heinz-Bernd Eggenstein***

Kilonova-Catcher
***Sarah Antier***

Unistellar + SETI
***Tom Esposito***

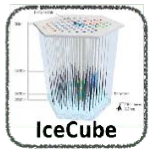
# Idea of Astro-COLIBRI

**Schüssler+** (2021, *ICRC*)
**PR+** (2021, *ADASS*)
**PR+** (2021, *ApJS*)
**PR+** (2023, *Galaxies*)
**Schüssler+** (2023, *ICRC*)

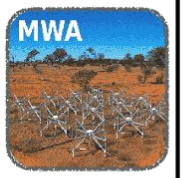
events

photons, GWs, ν

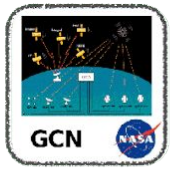
monitoring observatories

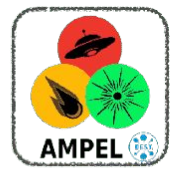


follow-up-observ.



alert
- creator
- streams
- broker





```
////////////////////////////////////////////////////////////////////////
TITLE:   GCN CIRCULAR
NUMBER:  32562
SUBJECT: IceCube-220918A - IceCube observ
DATE:    22/09/18 14:54:14 GMT
FROM:    Erik Blaufuss at U. Maryland/Ice

The IceCube Collaboration (http://icecube

On 2022-09-18 at 12:46:05.32 UT IceCube
event was selected by the ICECUBE_Astrot
This alert has an estimated false alarm
operating state at the time of detection.

After the initial au
algorithms have been

Date: 2022-09-18
Time: 12:46:05.32 UT
RA: 75.15 (+3.79 /
Dec: +3.58 (+3.70 /

We encourage follow-

Given the geometry o
several Fermi 4FGL o
Dec: 4.27 deg (1.42
region.

The IceCube Neutrino
realtime alert point
```

```
////////////////////////////////////////////////////////////////////////
TITLE:           GCN/AMON NOTICE
NOTICE_DATE:     Sun 18 Sep 22 12:46:52 UT
NOTICE_TYPE:     ICECUBE Astrotrack Bronze
STREAM:          25
RUN_NUM:         137065
EVENT_NUM:       22012496
SRC_RA:           75.5684d {+05h 02m 16s} (J2000),
                  75.8669d {+05h 03m 28s} (current),
                                          9s} (1950)
                                          0"} (J2000),
                                          2"} (current),
                                          4"} (1950)
                                           stat-only, 90% containment]
                                           stat-only, 50% containment]
                                             22/09/18 (yy/mm/dd)
                                          2} UT
                                          }   +1.75d {+01d 45' 07"}
                                          gle= 6.7 [hr] (West of Sun)
                                          }  +27.24d {+27d 14' 10"}
                                          alactic lon,lat of the event
                                          cliptic lon,lat of the event
```

This XML file does not appear to have any style information associated with it. The document tree is shown below.


```
<voe:VOEvent xmlns:voe="http://www.ivoa.net/xml/VOEvent/v2.0" xmlns:xsi="http://www.w3.org/2001/XMLSch
 18T12:46:05.32_25_137065_022012496_1" role="observation" version="2.0" xsi:schemaLocation="http://www
  <Who>
    <AuthorIVORN>ivo://nasa.gsfc.tan/gcn</AuthorIVORN>
    <Author>
      <contactName>Icecube Realtime Committee</contactName>
      <contactEmail>roc@icecube.wisc.edu</contactEmail>
    </Author>
    <Date>2022-09-18T14:54:31</Date>
    <Description>This VOEvent message was created with TAN VOE version: 15.08 17jun22</Description>
  </Who>
  <What>
    <Param name="Packet_Type" value="174"/>
    <Param name="Pkt_Ser_Num" value="2"/>
    <Param name="AMON_ID" value="13706522012496" ucd="meta.id">
      <Description>Alert identification number.</Description>
    </Param>
    <Param name="run_id" value="137065" ucd="meta.id">
      <Description>Run id.</Description>
    </Param>
    <Param name="event_id" value="22012496" ucd="meta.id">
      <Description>Event id within a given run.</Description>
    </Param>
    <Param name="Event_TJD" value="19840" unit="days" ucd="time"/>
    <Param name="Event_SOD" value="45965.32" unit="sec" ucd="time"/>
    <Param name="Stream" value="25" unit="dn" ucd="meta.id">
      <Description>IceCube coincidence stream identification</Description>
    </Param>
    <Param name="Rev" value="1" unit="dn" ucd="meta.id">
      <Description>Alert revision</Description>
    </Param>
    <Param name="signalness" value="0.4180" unit="dn" ucd="stat.probability">
      <Description>Probability of a neutrino event being astrophysic
    </Param>
    <Param name="FAR" value="1.7147" unit="yr^-1" ucd="stat.probabil
      <Description>False Alarm Rate. Number per year.</Description>
    </Param>
    <Param name="energy" value="168.3449" unit="TeV" ucd="phys.energ
      <Description>Likely neutrino energy (in TeV).</Description>
    </Param>
    <Param name="src_error_90" value="3.5699" unit="deg" ucd="stat.e
      <Description>Angular error of the source, statistical only, (9
    </Param>
    <Param name="src_error_50" value="2.0800" unit="deg" ucd="stat.e
      <Description>Angular error of the source, statistical only, (5
    </Param>
    <Param name="Trigger_ID" value="0x0"/>
    <Param name="Misc_flags" value="0x19000000"/>
    <Group name="Trigger_ID">
      <Param name="SubType" value="indi"/>
      <Param name="Test" value="false"/>
      <Param name="RADec_valid" value="false"/>
      <Param name="Retraction" value="false"/>
      <Param name="InternalTest" value="false"/>
    </Group>
```


**Fermi-LAT gamma-ray observations of IceCube-220918A and detection of a new gamma-ray source, Fermi J0502.5+0037**

ATel #15620; *S. Garrappa (DESY-Zeuthen), S. Buson (Univ. of Wuerzburg) and J. Sinapius (DESY-Zeuthen) on behalf of the Fermi-LAT collaboration:*
*on* ***19 Sep 2022; 20:50 UT***
*Credential Certification: Simone Garrappa (simone.garrappa@gmail.com)*

Subjects: Gamma Ray, Neutrinos, Request for Observations, AGN, Blazar

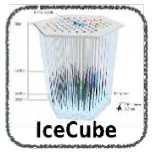
# Idea of Astro-COLIBRI

**Schüssler+** (2021, *ICRC*)
**PR+** (2021, *ADASS*)
**PR+** (2021, *ApJS*)
**PR+** (2023, *Galaxies*)
**Schüssler+** (2023, *ICRC*)

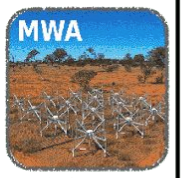
events

photons, GWs, ν

monitoring observatories



follow-up-observ.



alert
- creator
- streams
- broker

TNS TAU

GCN

four π sky

PennState AMON

AMON

AMPEL

FINK

(real-time) DBs

COLIBRI API

detailed event/src. info

CDS ALADIN SIMBAD

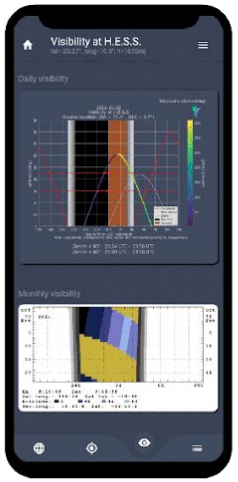
FAVA

TOBY

push alerts

cone search

visibility



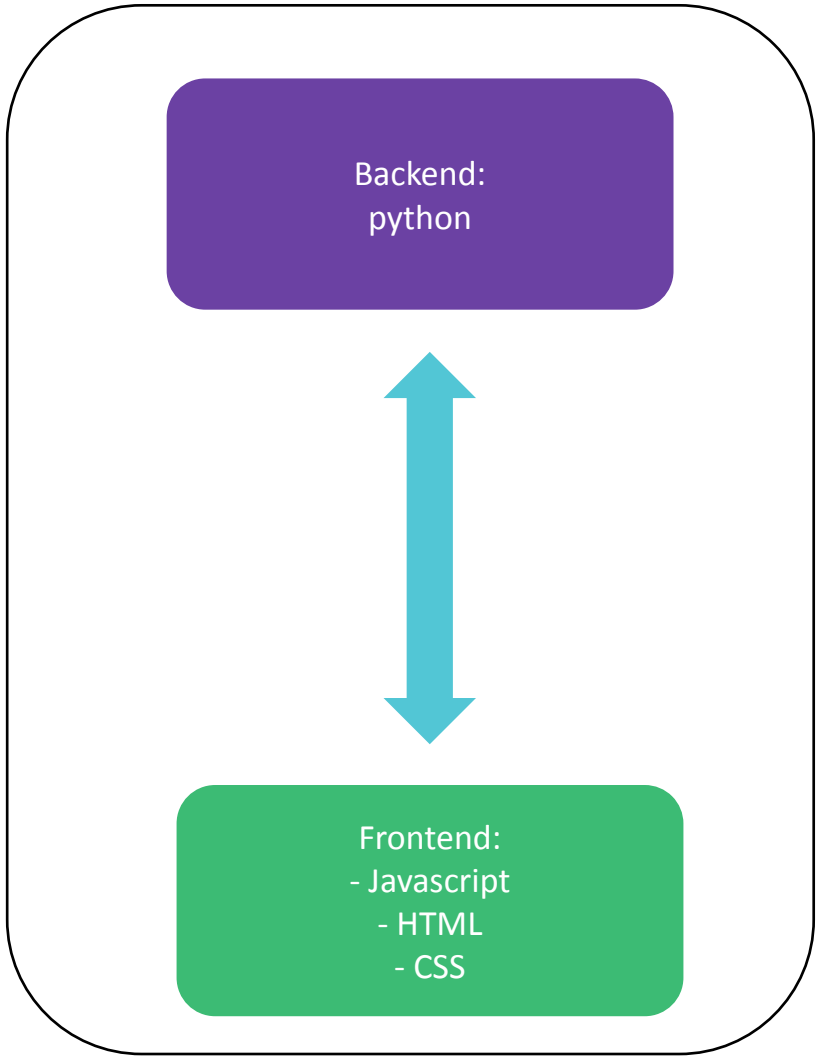

event info

Astro-COLIBRI App / Website

# History of Astro-COLIBRI (pre-release)

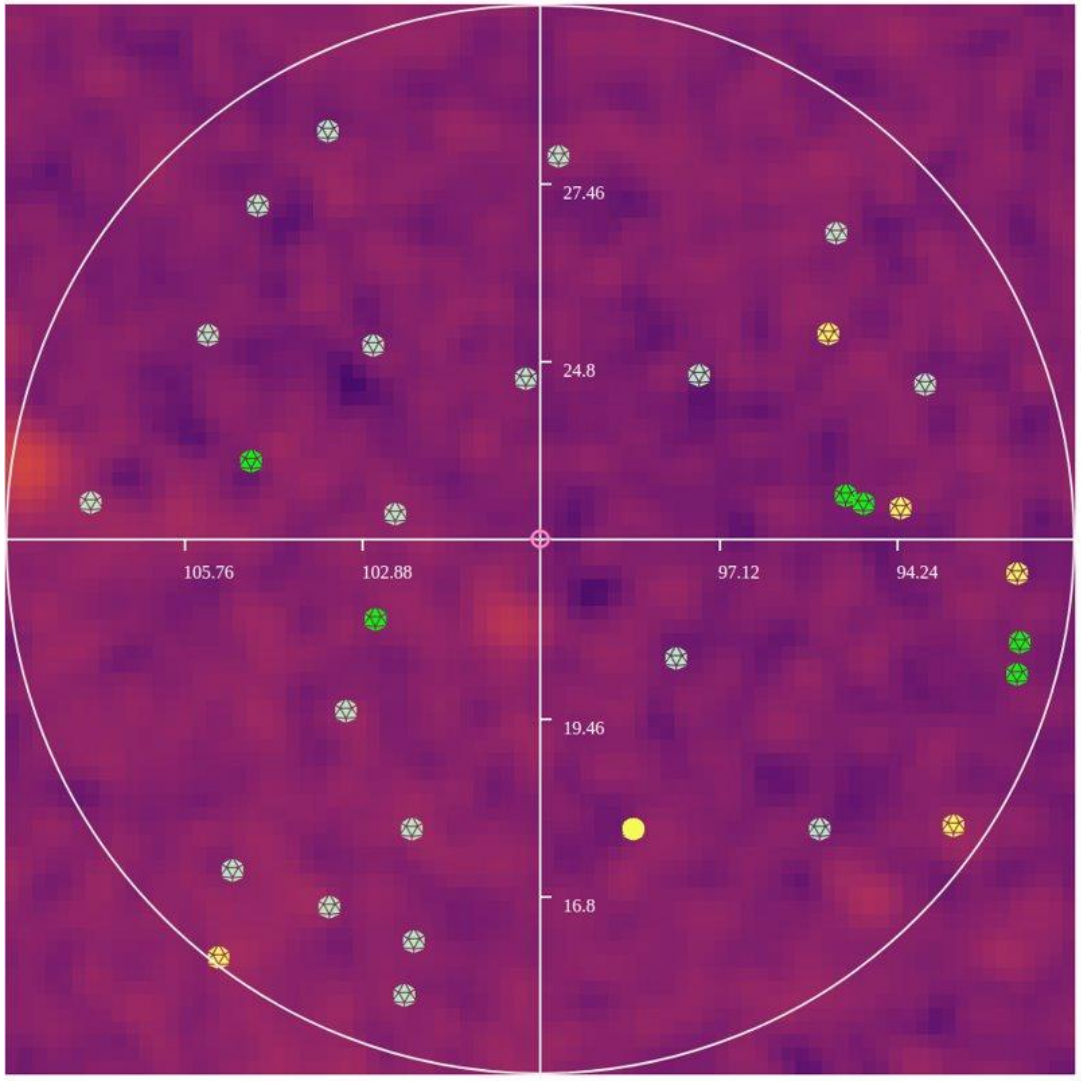
After 4 merges and ≈200 commits:

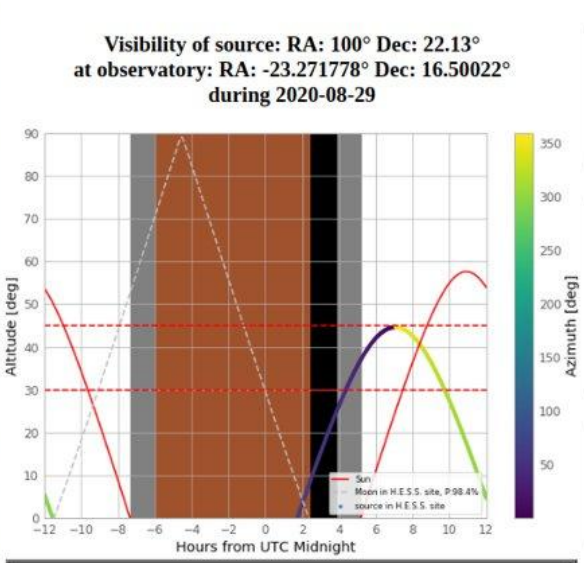
H.E.S.S. collaboration meeting (**November 2019**)

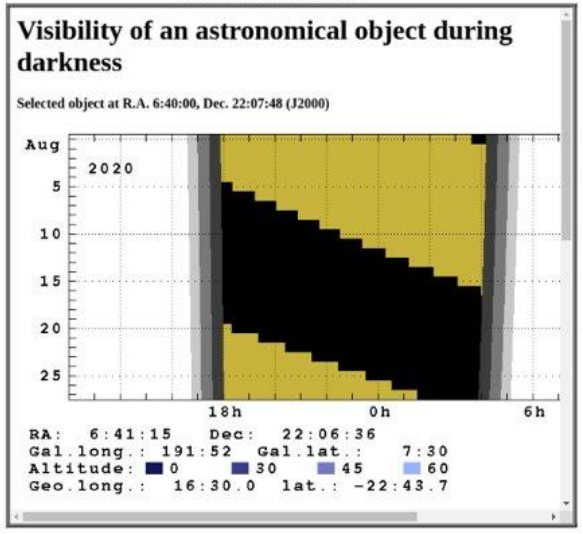


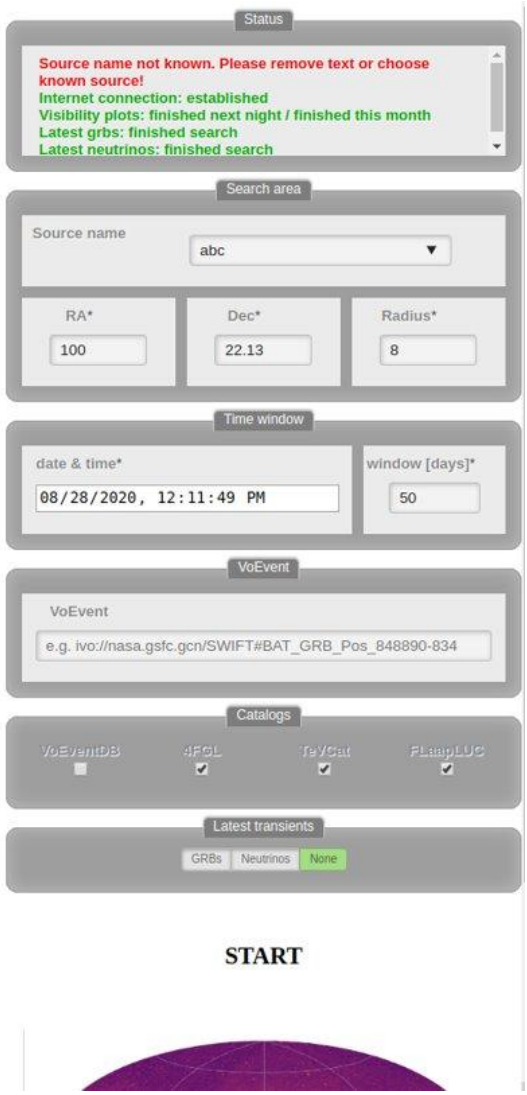
## August 2020

After further 10 merges and ≈230 commits:



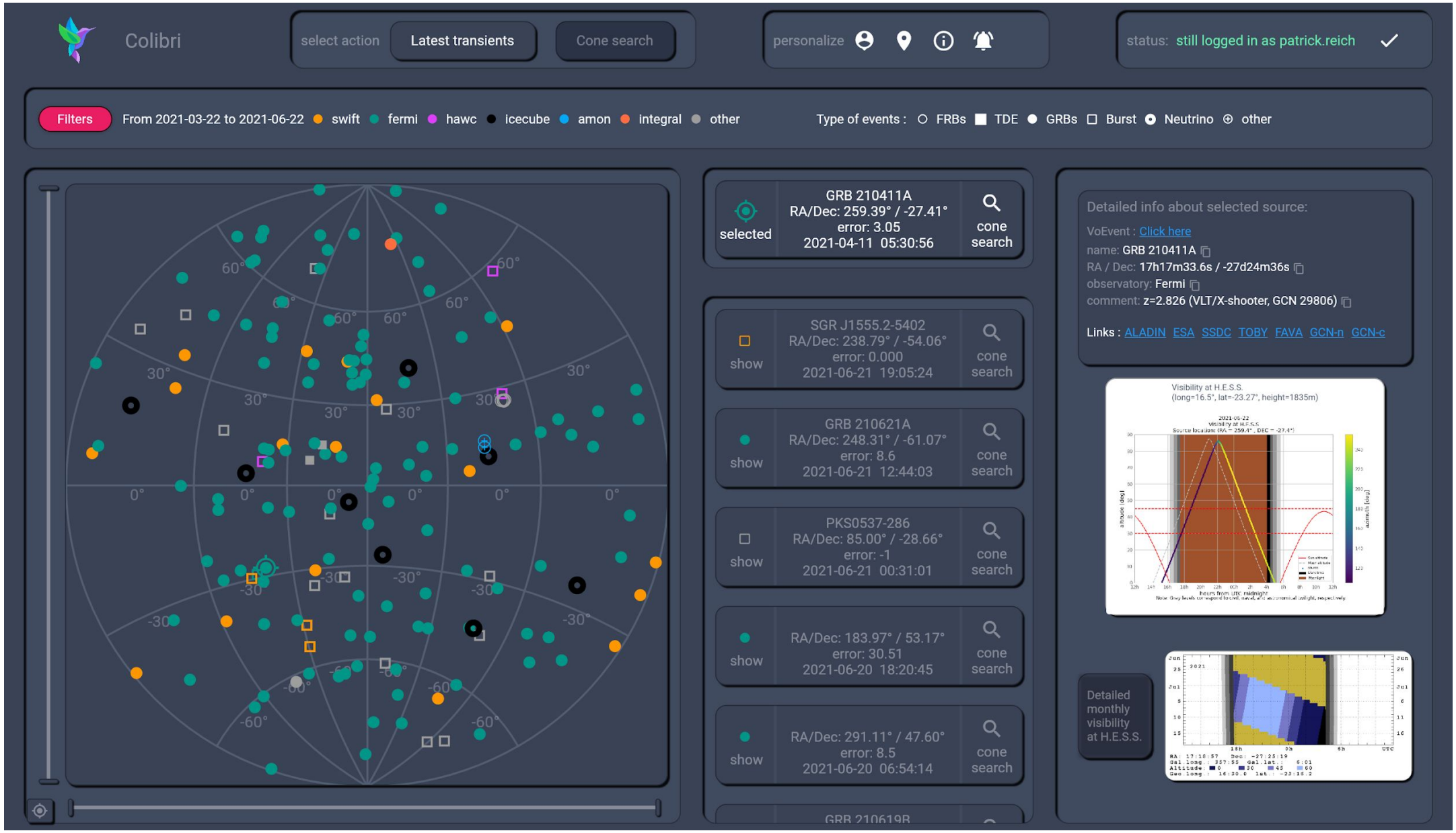



# History of Astro-COLIBRI

Release of **v1.0.0** in **August 2021**: P. Reichherzer *et al.* 2021 ApJS **256** 5




Backend: Flask (Python)

http requests

Frontend: Flutter (Dart)

≈2000 commits

Release of **v1.0.0** in **August 2021**: P. Reichherzer *et al.* 2021 ApJS **256** 5

30 years after the GCN phone alerts we are back….

Backend:
Flask (Python)

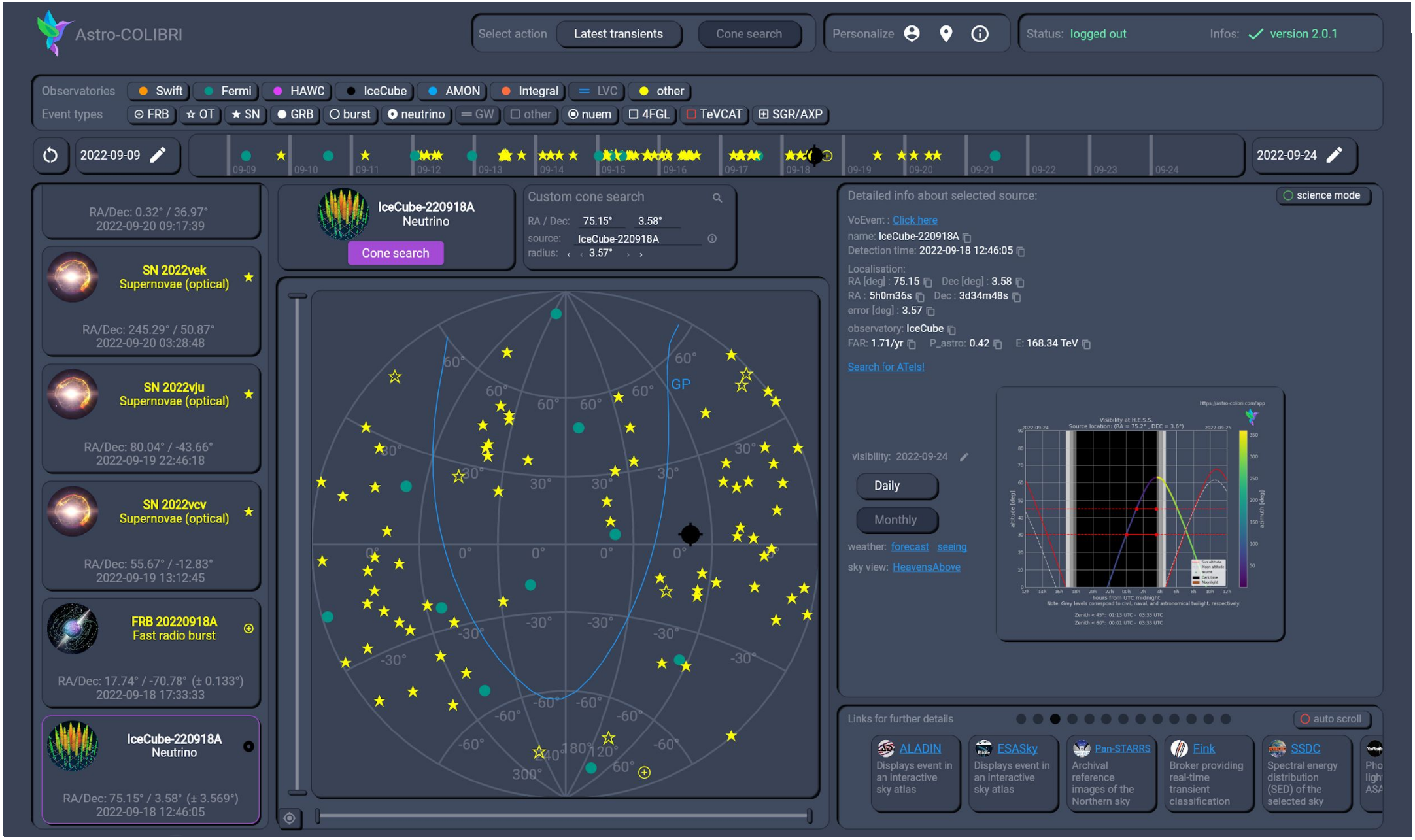
http requests

Frontend:
Flutter (Dart)

≈2000 commits

# History of Astro-COLIBRI

Release of **v2.0.0** in **September 2022**




Backend:
Flask (Python)

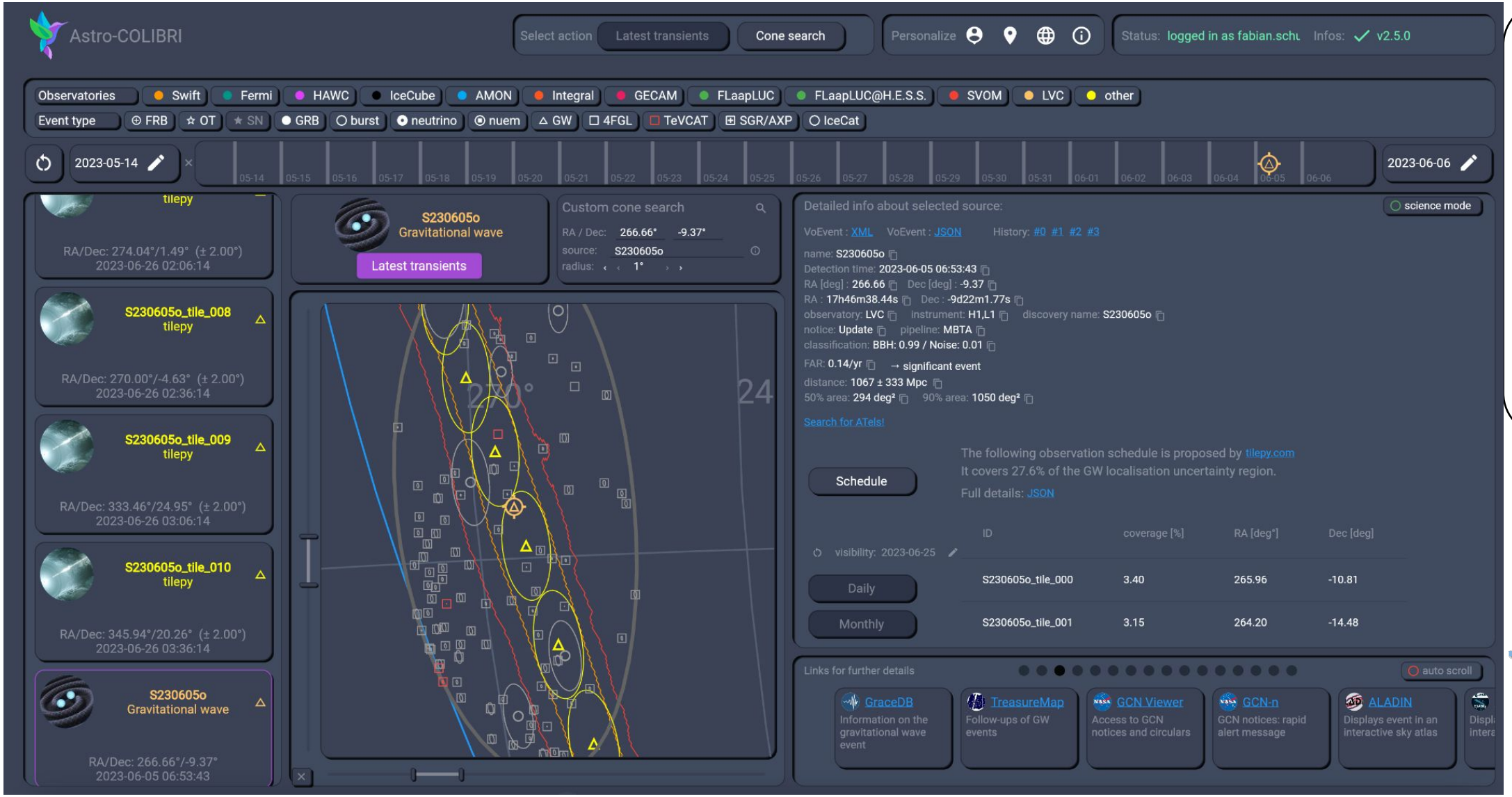
http requests

Frontend:
Flutter (Dart)

≈3200 commits

# History of Astro-COLIBRI

Release of **v2.5.0** in **June 2023**




Backend:
Flask (Python)

http requests

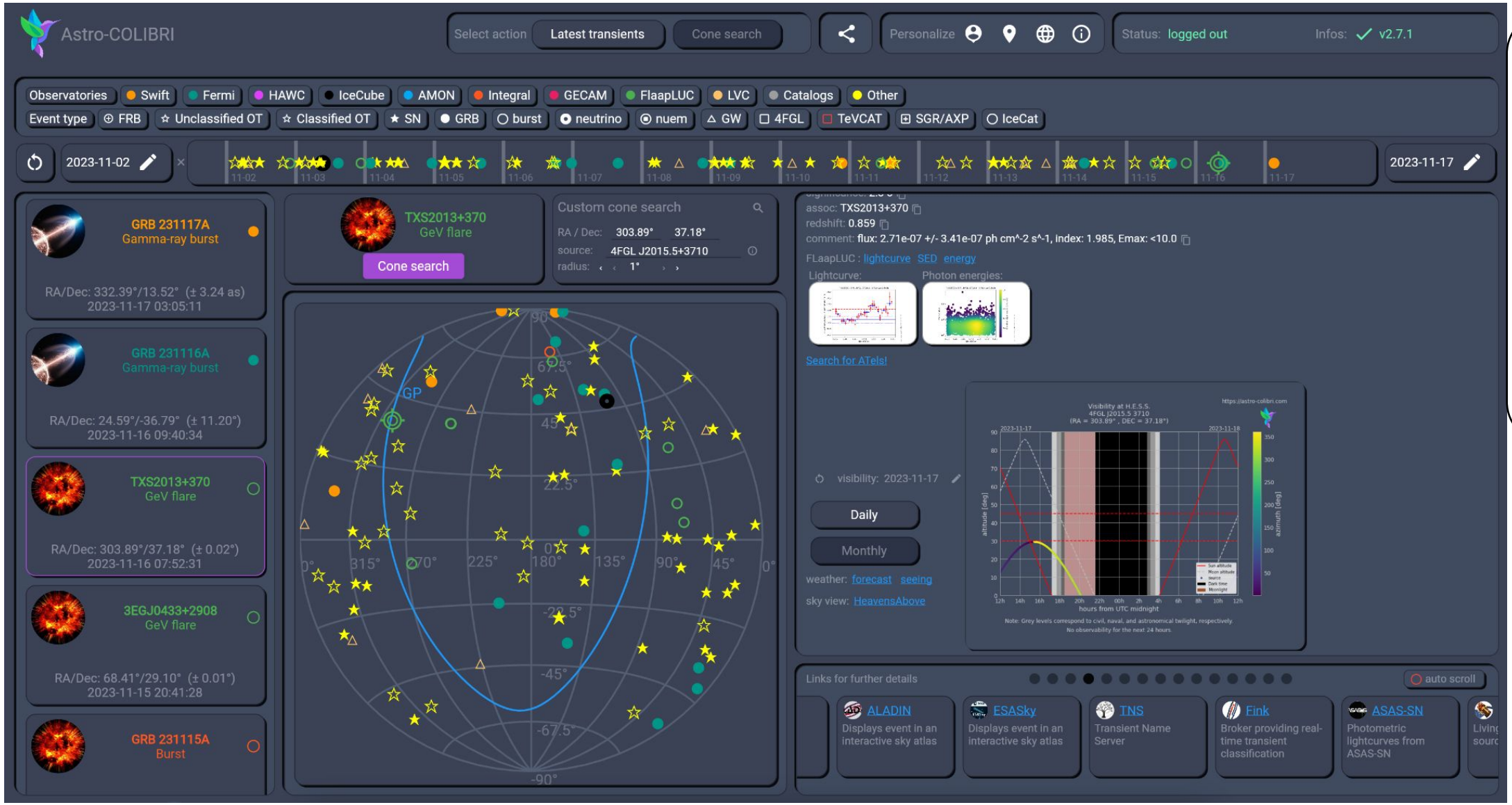
Frontend:
Flutter (Dart)

http requests

tilepy

# History of Astro-COLIBRI

Release of **v2.8.0** in **November 2023**




Backend:
Flask (Python)

http requests

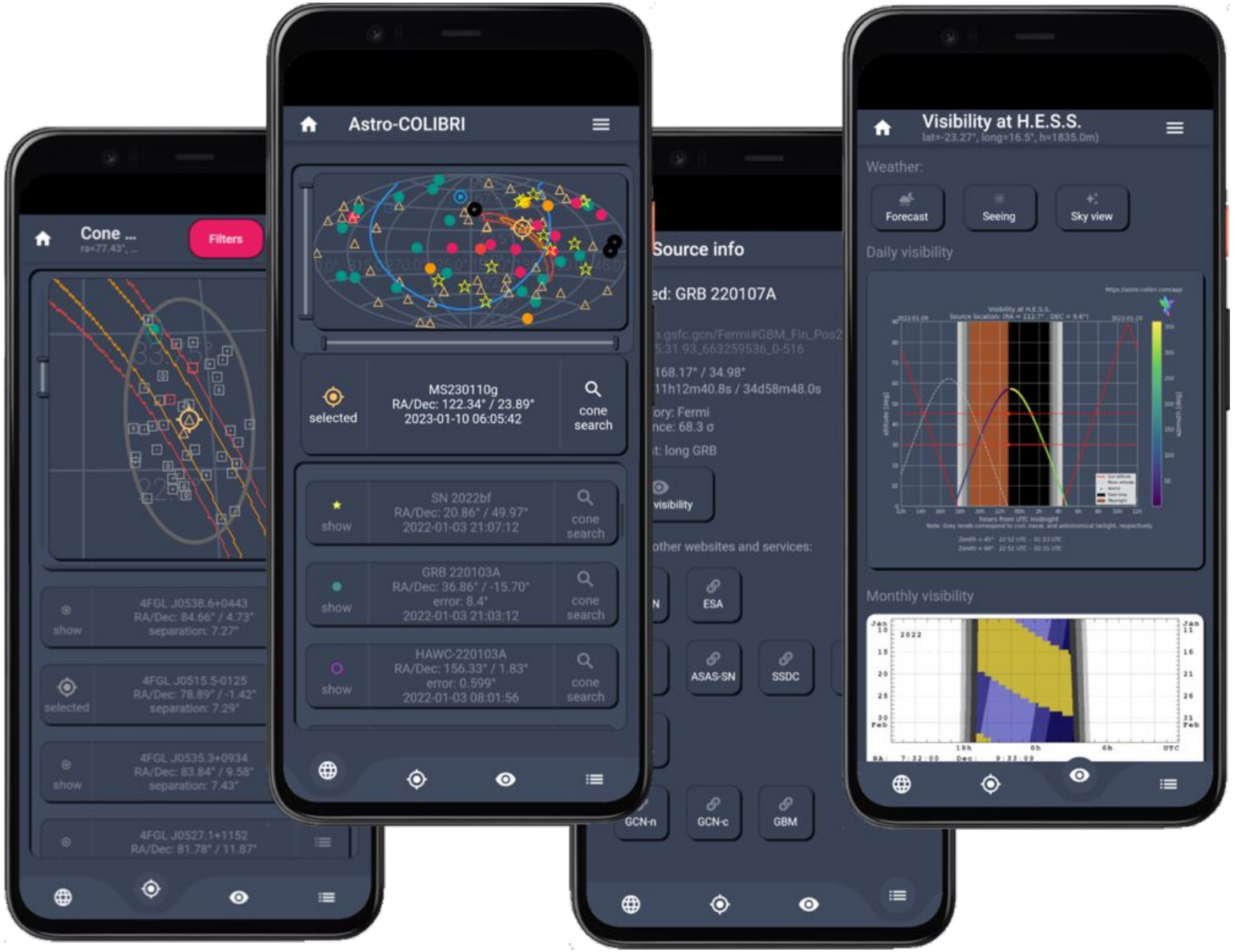
Frontend:
Flutter (Dart)

http requests

tilepy

≈5800 commits

Release of **v2.8.0** in **November 2023**




Backend:
Flask (Python)

http requests

Frontend:
Flutter (Dart)

http requests

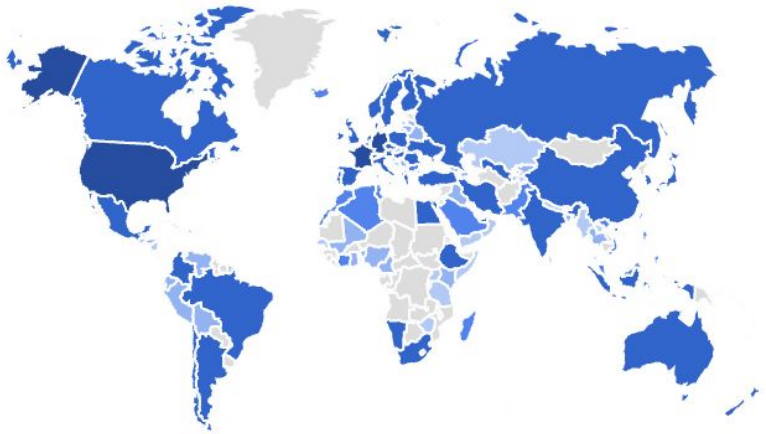
tilepy

≈5800 commits

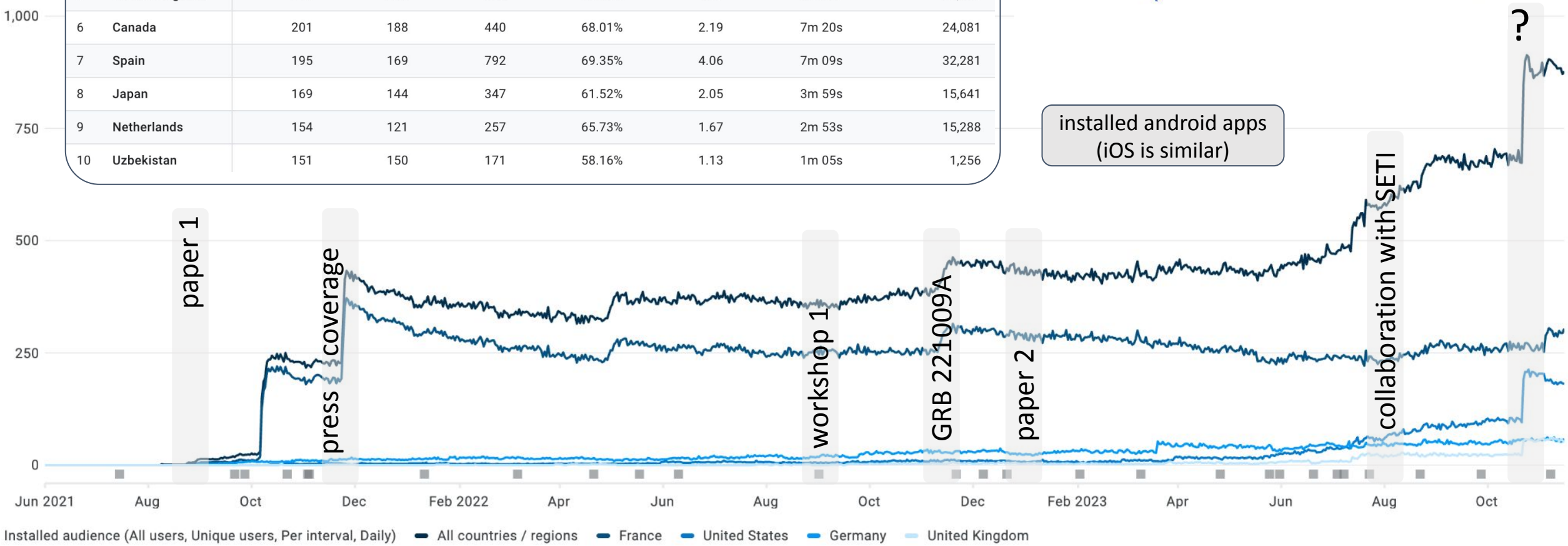
# Statistics of Astro-COLIBRI

total usage by country

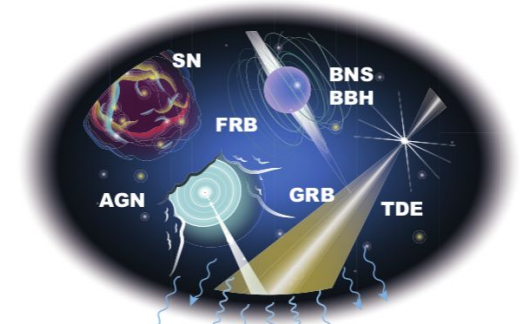
| | Country | Users | New users | Engaged sessions | Engagement rate | Engaged sessions per user | Average engagement time | Event count (All events) |
|---|---|---|---|---|---|---|---|---|
| | | 9,502<br>100% of total | 9,387<br>100% of total | 21,638<br>100% of total | 58.68%<br>Avg 0% | 2.28<br>Avg 0% | 9m 30s<br>Avg 0% | 958,238<br>100% of total |
| 1 | France | 3,713 | 3,584 | 9,103 | 58.47% | 2.45 | 17m 00s | 273,162 |
| 2 | United States | 1,443 | 1,383 | 2,672 | 59.84% | 1.85 | 4m 50s | 161,466 |
| 3 | Germany | 1,206 | 1,120 | 2,561 | 53.78% | 2.12 | 3m 49s | 91,522 |
| 4 | Italy | 370 | 321 | 1,062 | 67.82% | 2.87 | 5m 44s | 78,506 |
| 5 | United Kingdom | 347 | 316 | 565 | 67.02% | 1.63 | 3m 26s | 37,977 |
| 6 | Canada | 201 | 188 | 440 | 68.01% | 2.19 | 7m 20s | 24,081 |
| 7 | Spain | 195 | 169 | 792 | 69.35% | 4.06 | 7m 09s | 32,281 |
| 8 | Japan | 169 | 144 | 347 | 61.52% | 2.05 | 3m 59s | 15,641 |
| 9 | Netherlands | 154 | 121 | 257 | 65.73% | 1.67 | 2m 53s | 15,288 |
| 10 | Uzbekistan | 151 | 150 | 171 | 58.16% | 1.13 | 1m 05s | 1,256 |



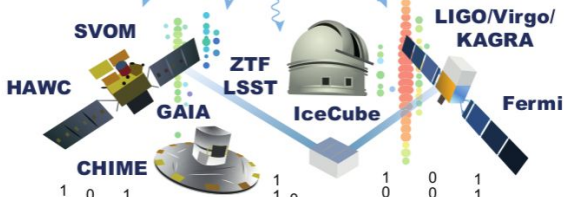
installed android apps
(iOS is similar)



# Overview of Astro-COLIBRI




Photons, GWs, υ



FOLLOW-UP OBSERVATORY

**Third-party APIs**
- SIMBAD / NED
- voeventdb.remote
- GraceDB

**Message transport**
on platform-level

**Clients**
Website/Apps

**FCM**
backend

**iOS / APNs**

**Android**
transport layer

**Web Push**

**GET**
http request

**GET**
http request

*COLIBRI API*

events & sources

**Database (DB)**
Stable sources &
Transients

plots

**Storage**
Visibility-Plots

URL links

**Stream builder**
transients & user info

update db

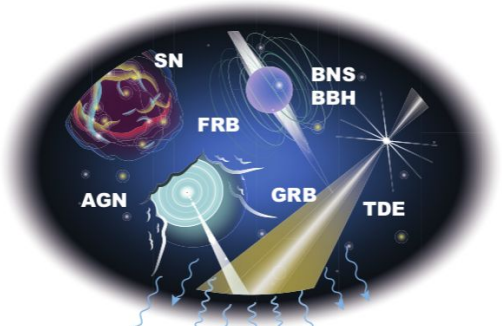
**POST**
http request

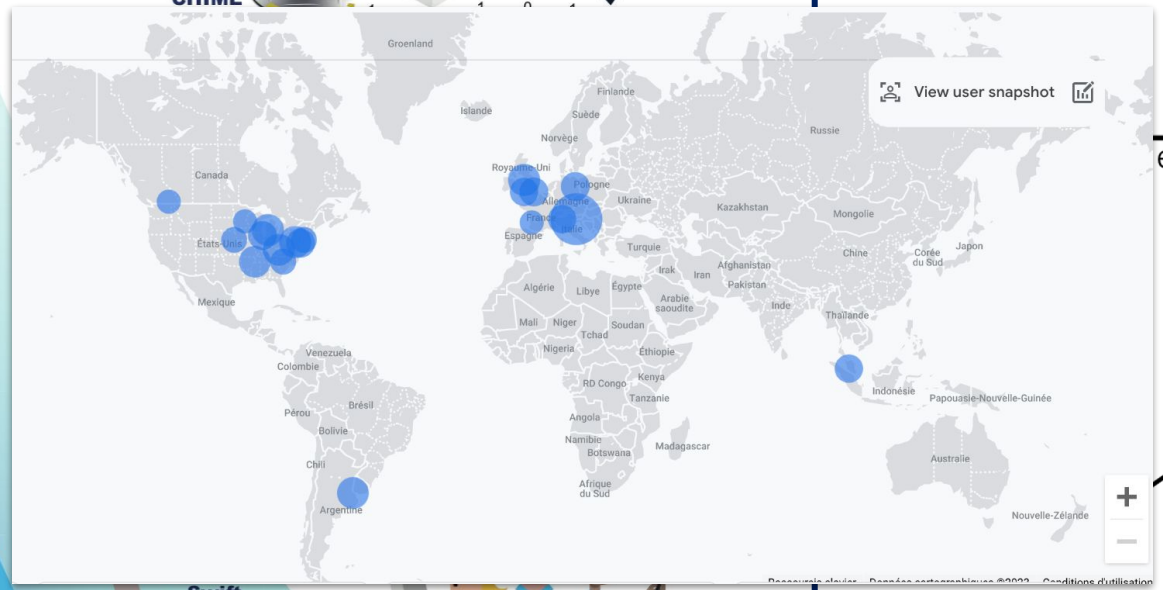
**Listener**
VOEvents &
GCNs & TNSs

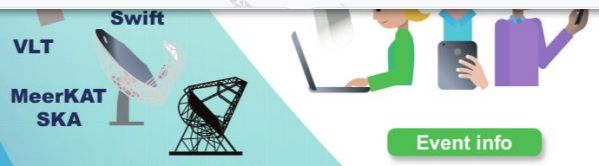
**Real-time DB**
Transients &
User preferences

Reichherzer et al. (2021)

# Overview of Astro-COLIBRI



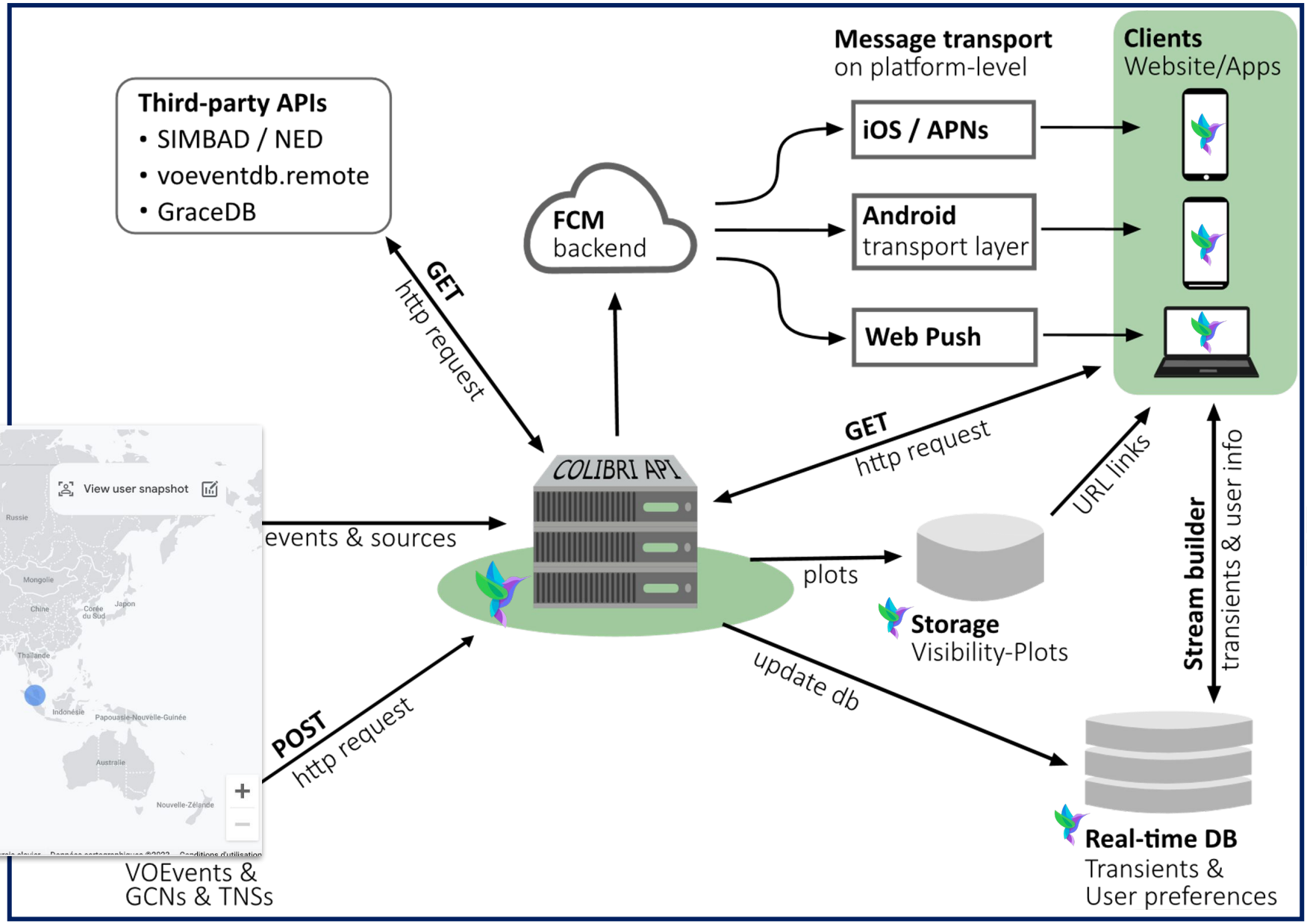





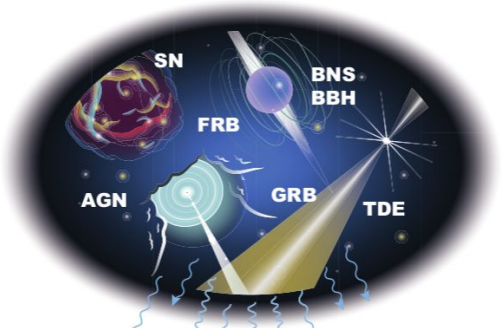


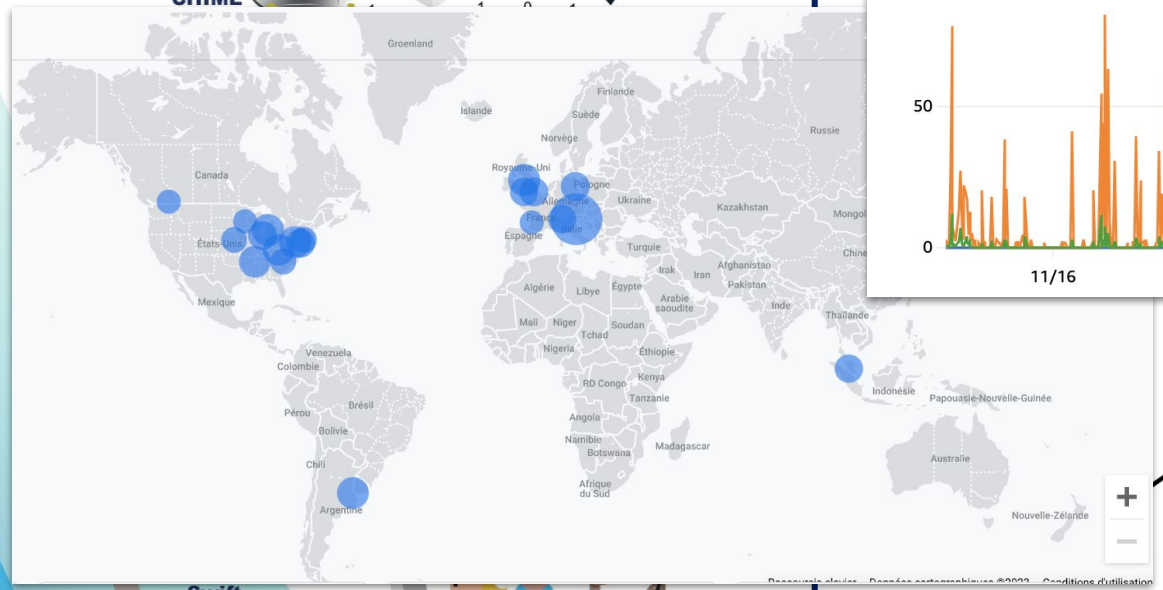
VOEvents &
GCNs & TNSs




Reichherzer et al. (2021)

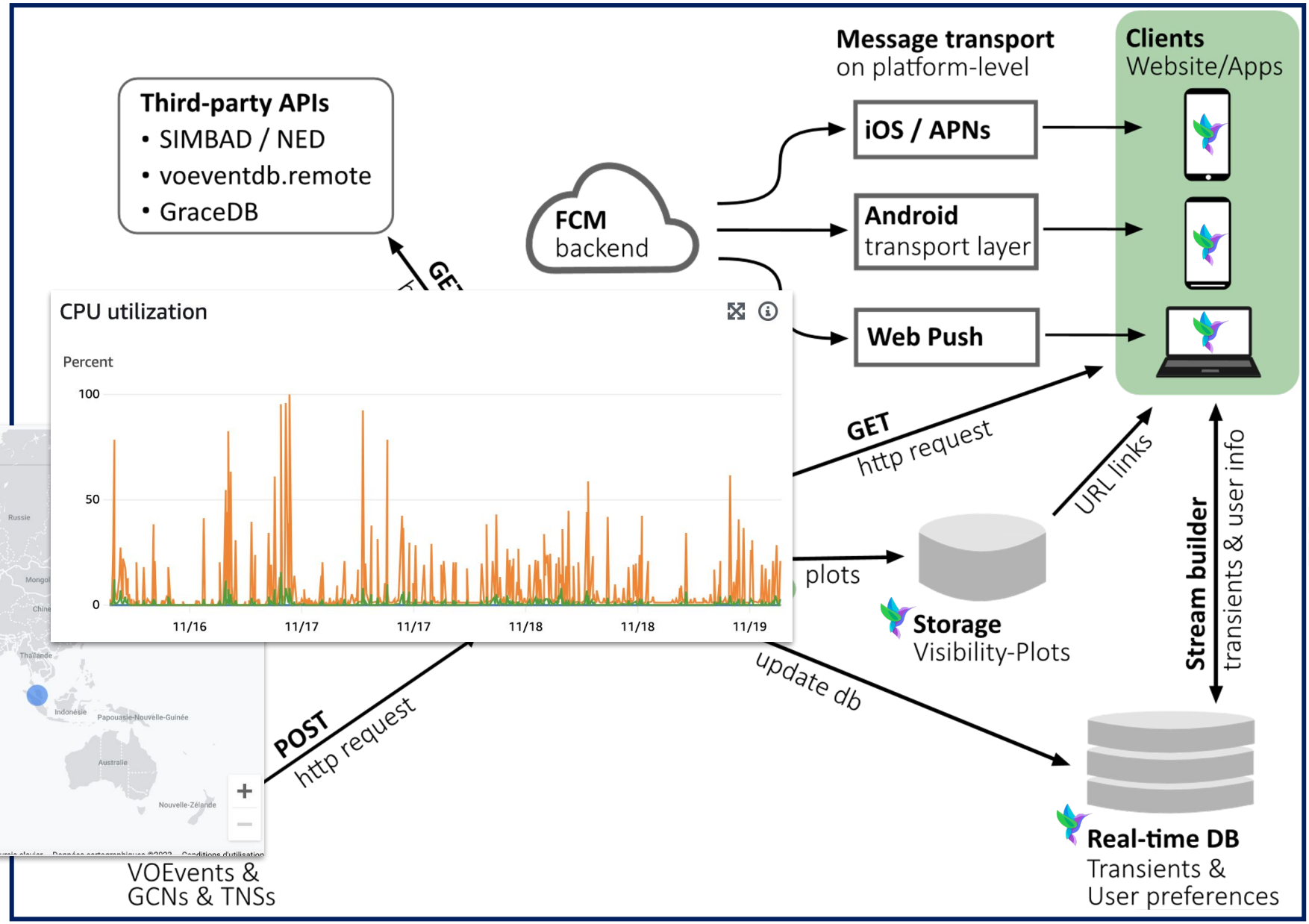
# Overview of Astro-COLIBRI



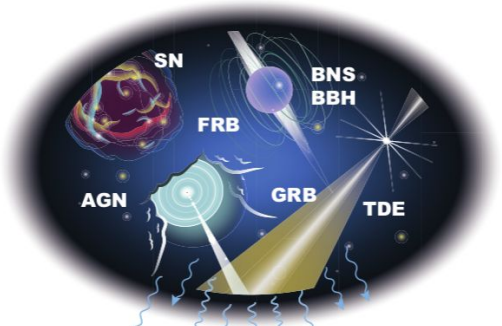


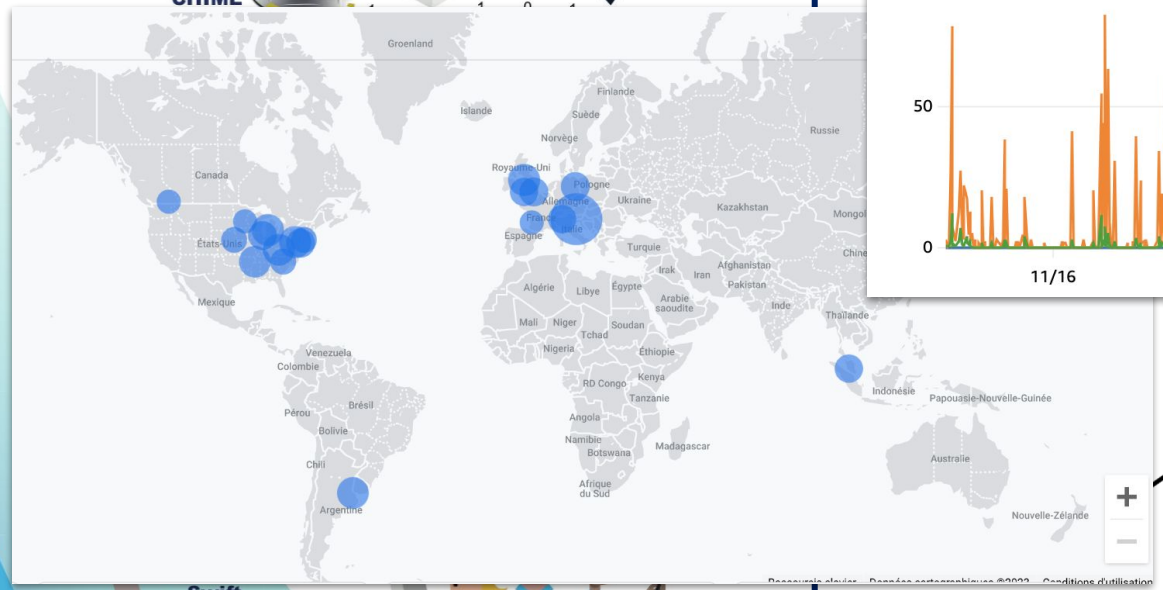




Reichherzer et al. (2021)

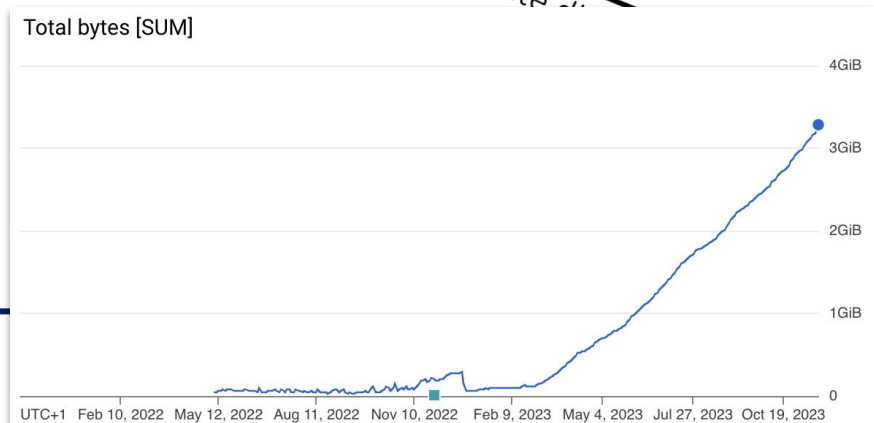
# Overview of Astro-COLIBRI

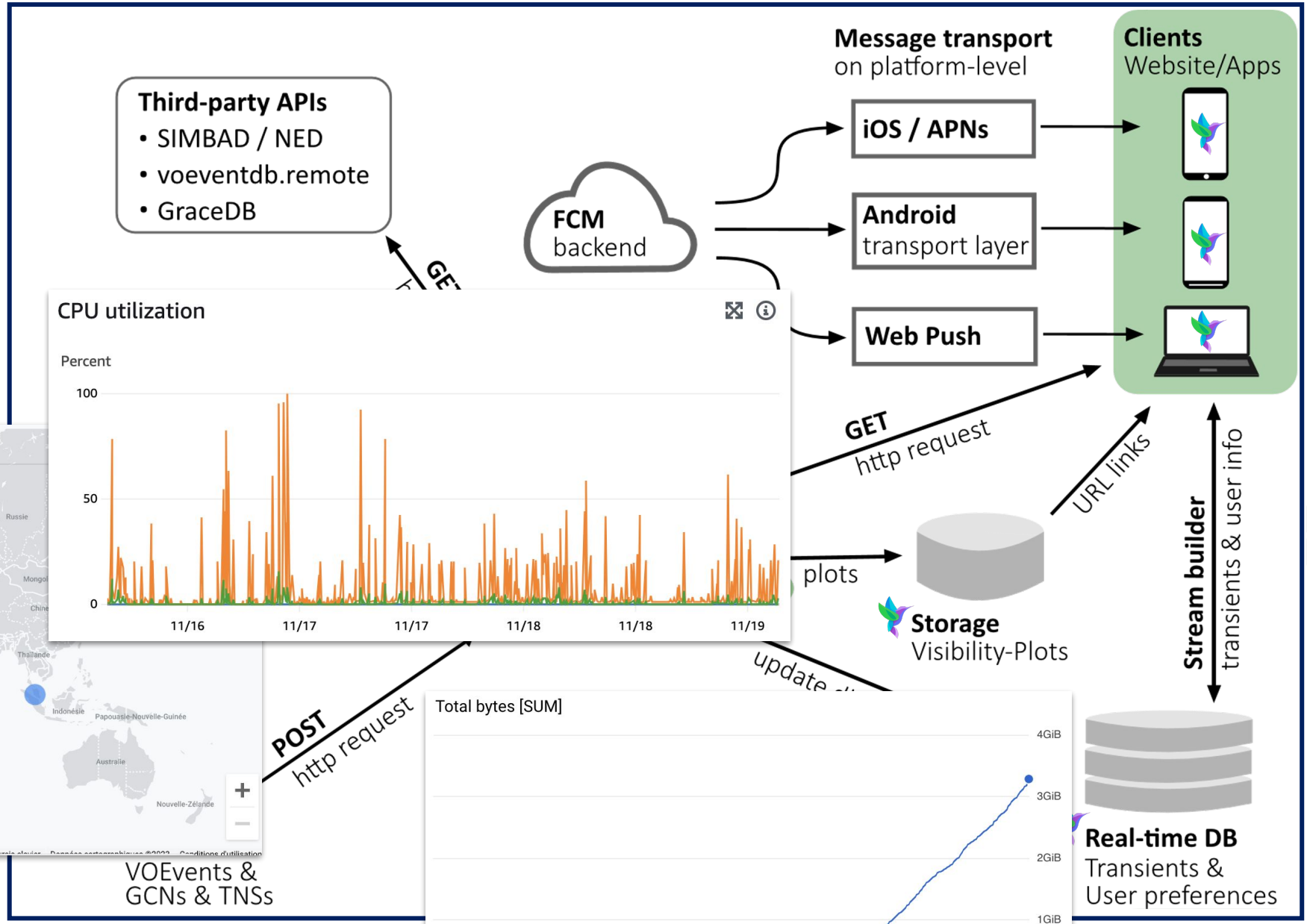




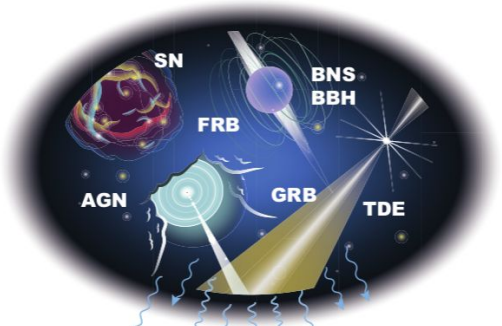




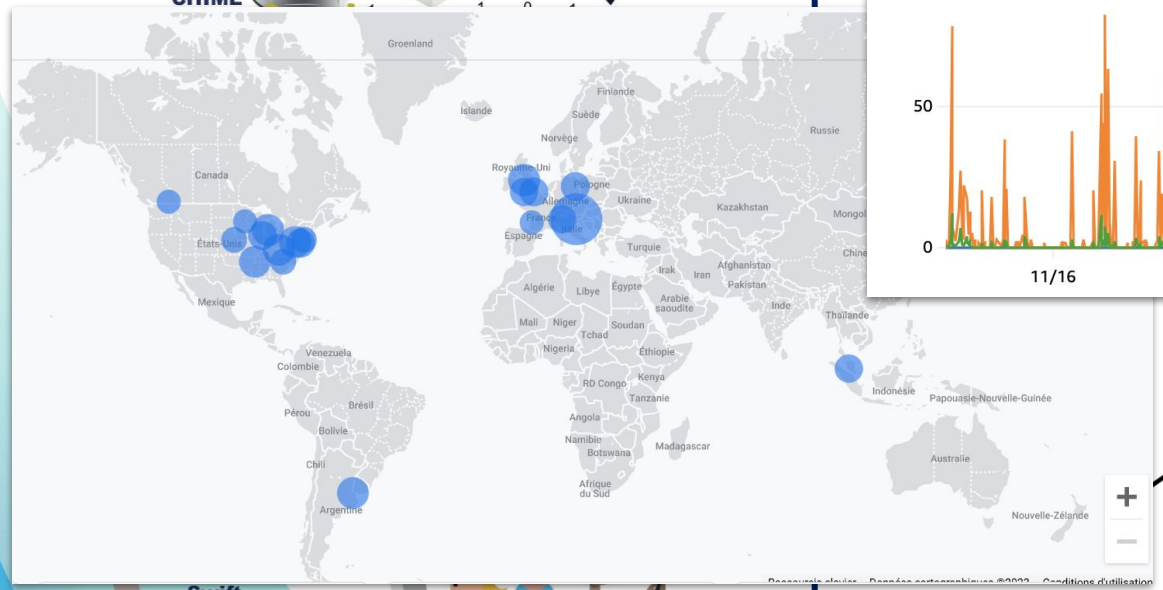



hherzer et al. (2021)

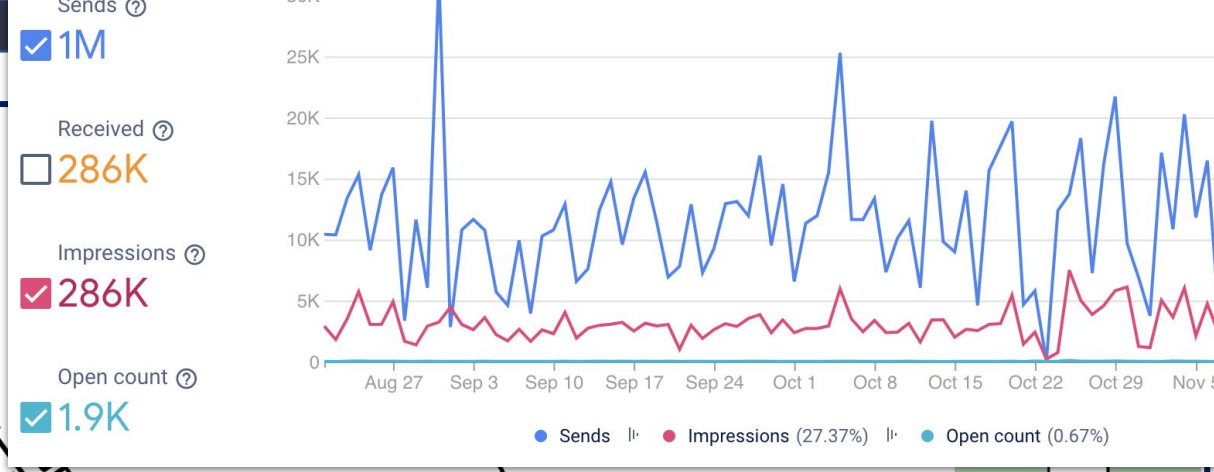
# Overview of Astro-COLIBRI

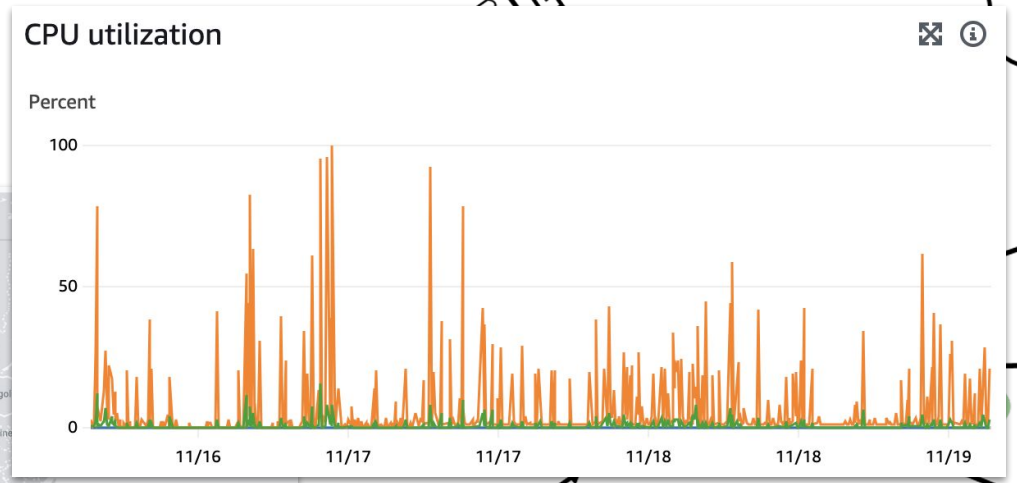


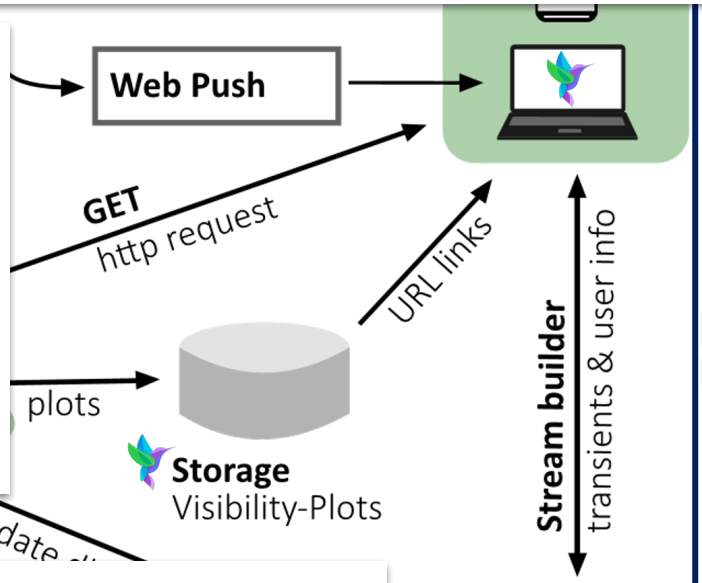

Photons, GWs, υ

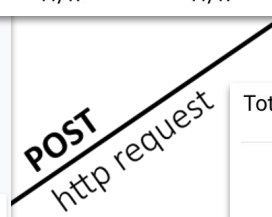


**Third-party APIs**
- SIMBAD / NED
- voeventdb.remote
- GraceDB

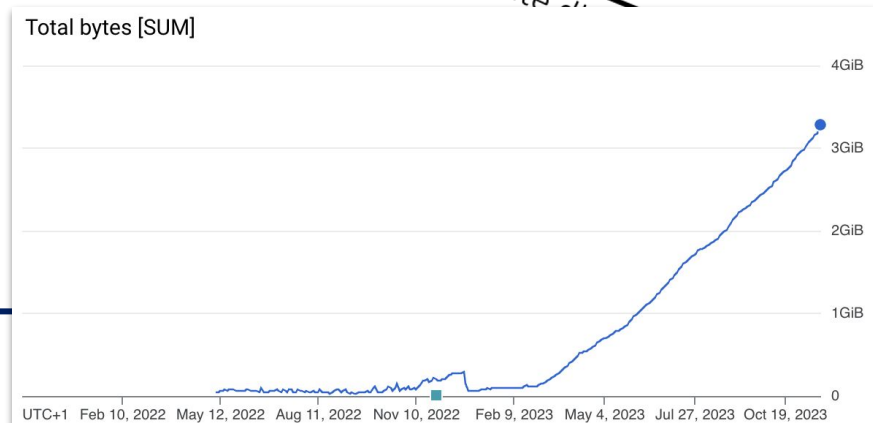



VOEvents &
GCNs & TNSs



**Real-time DB**
Transients &
User preferences

hherzer et al. (2021)