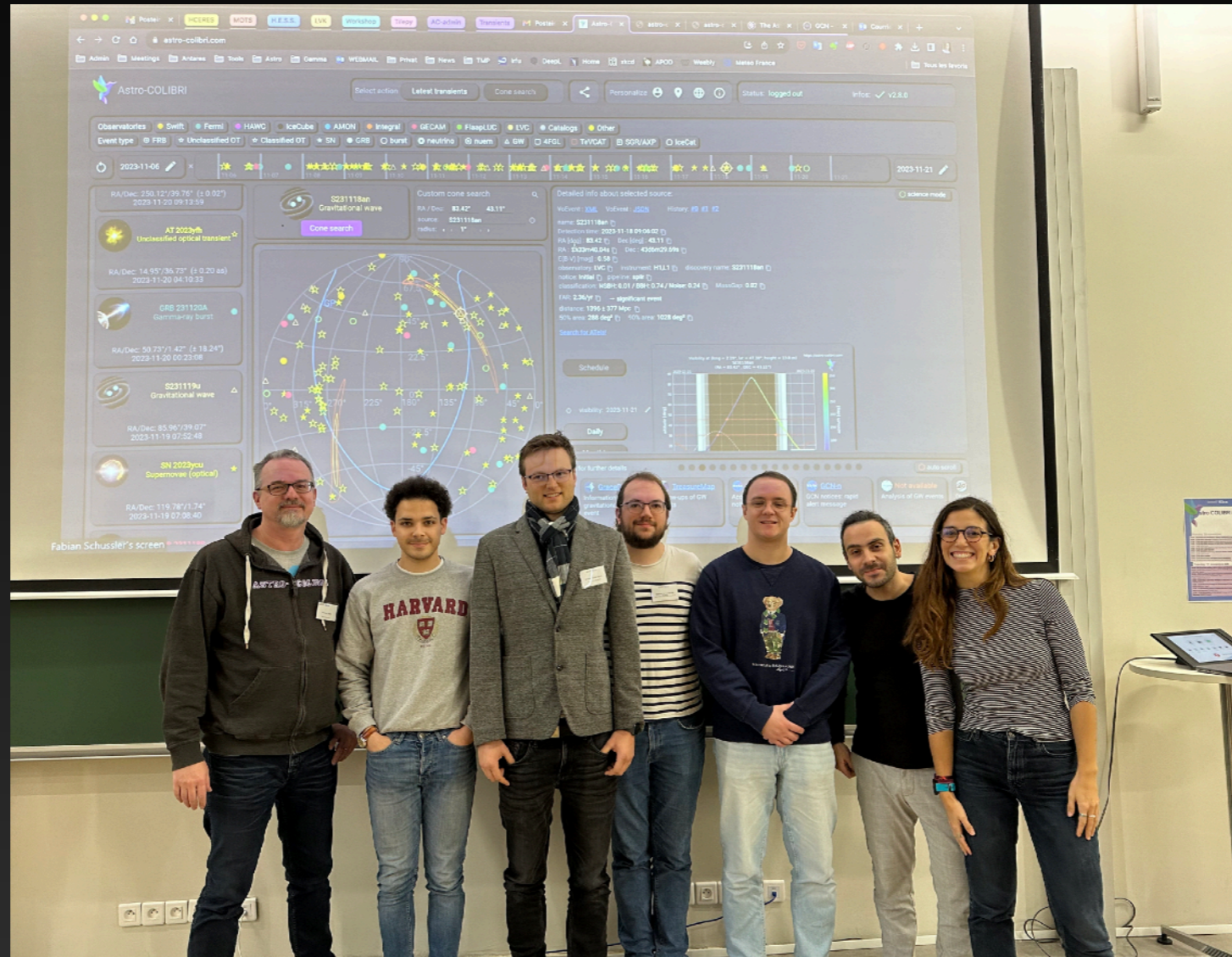


Astro-COLIBRI

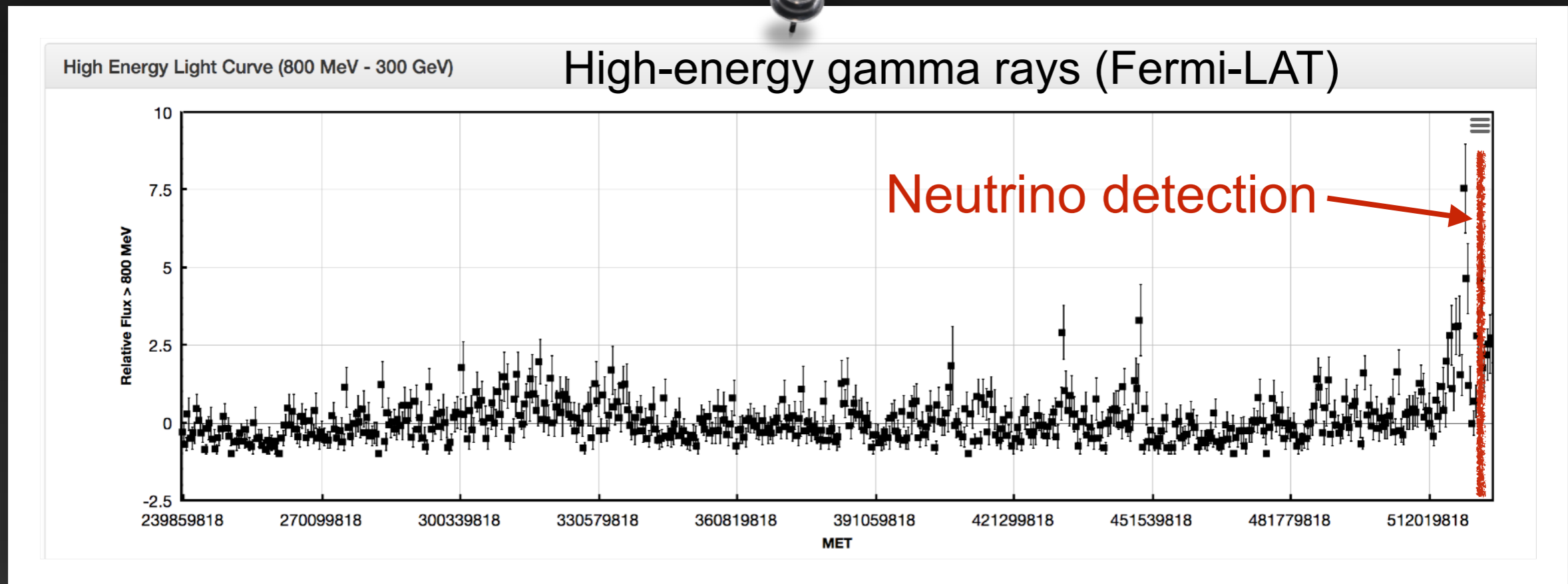
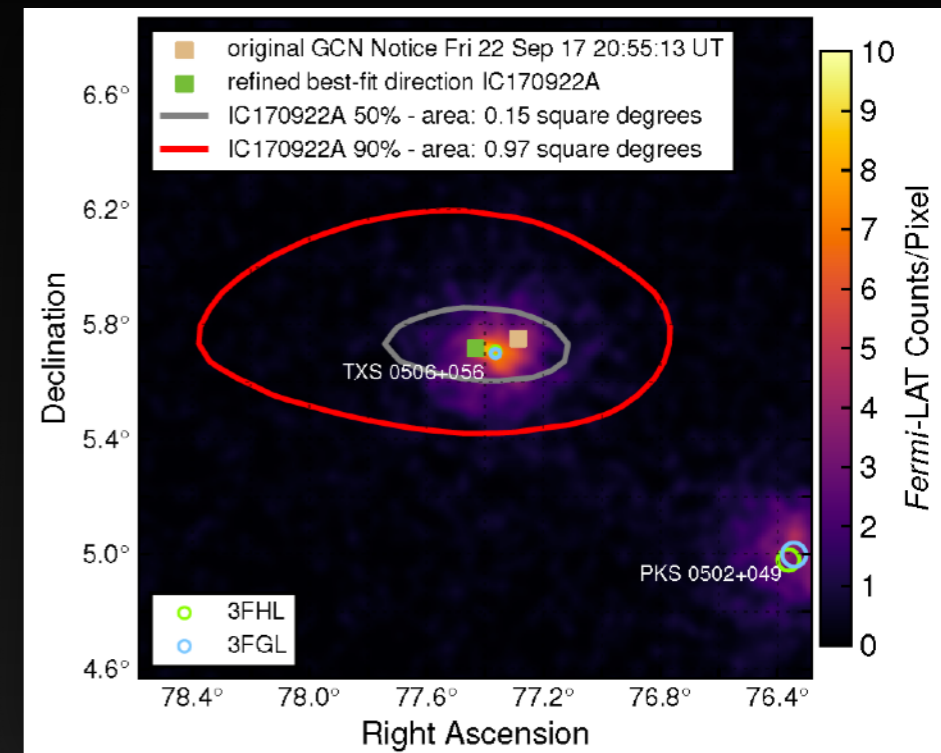


Fabian Schüssler (IRFU, CEA Paris-Saclay)



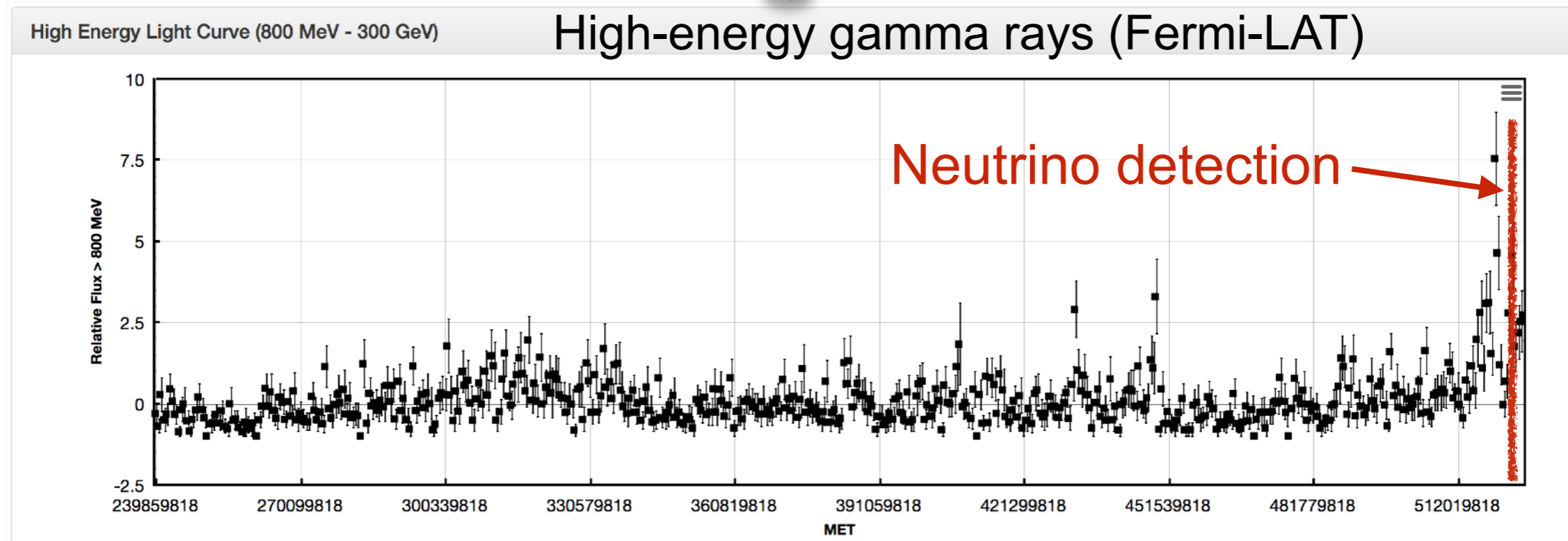
IceCube-170922A and TXS 0506+056

- 22/09/2017: Detection of another high-energy neutrino of about 300 TeV by IceCube: automatic and public alert distribution to follow-up observatories at all wavelengths
- 28/09/2017 Fermi-LAT: Detection of an active blazar within the neutrino uncertainty region [ATEL #10791](#)



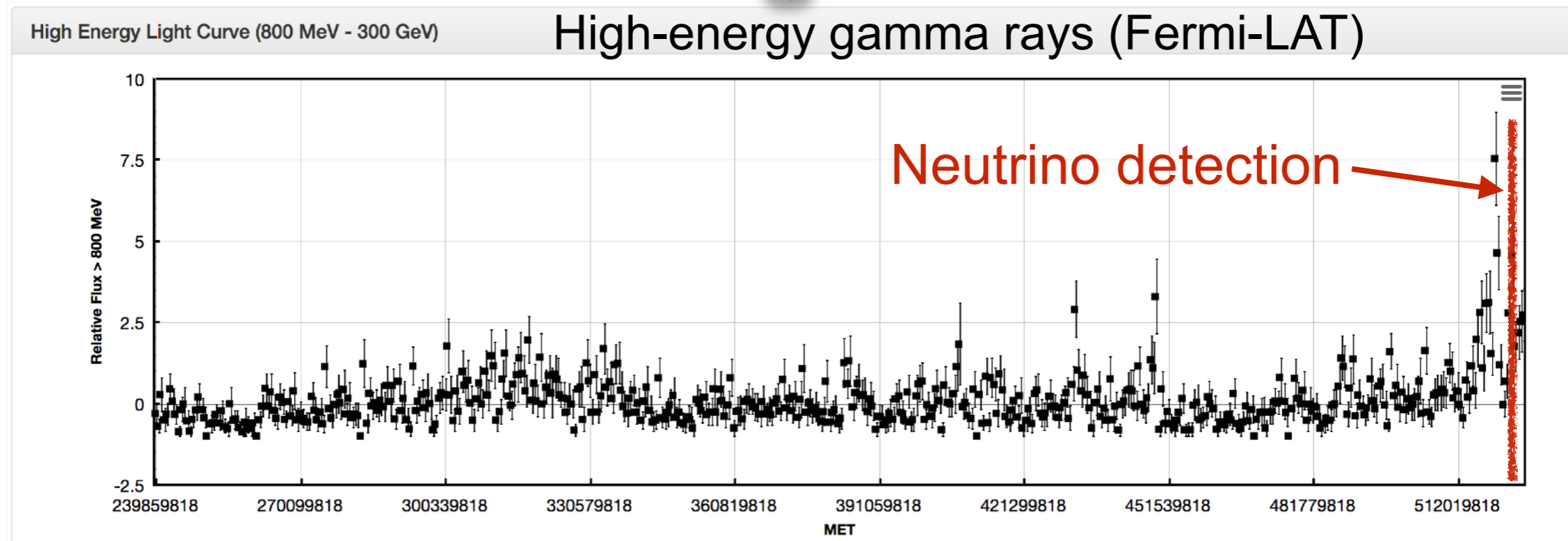
Behind the curtain

- It took 6 days between the neutrino detection and the realization that there is a flaring blazar within the localisation uncertainty!



Behind the curtain

- It took 6 days between the neutrino detection and the realization that there is a flaring blazar within the localisation uncertainty!
- Cone search within the neutrino uncertainty => TXS 0506+056
- Check state of the source(s) in Fermi-LAT: FAVA (*LCR*)
- Get optimal observation window for various observatories
- => Many tools are available but need for automatisisation + interfaces



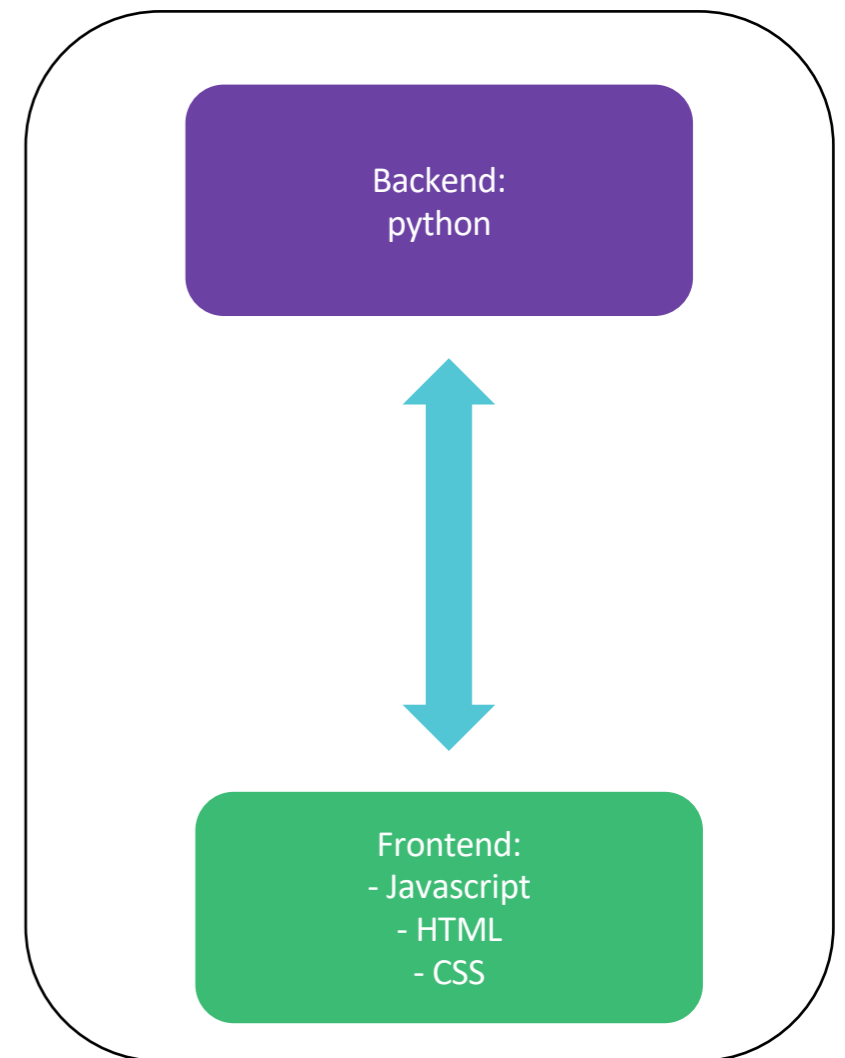


First test

After 4 merges and ≈ 200 commits:

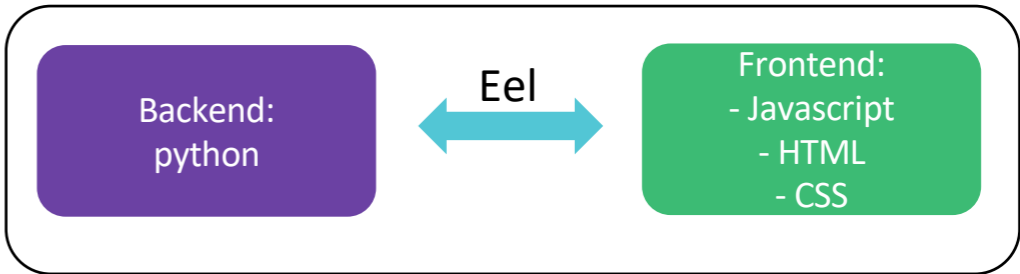


H.E.S.S. collaboration meeting (11.2019)

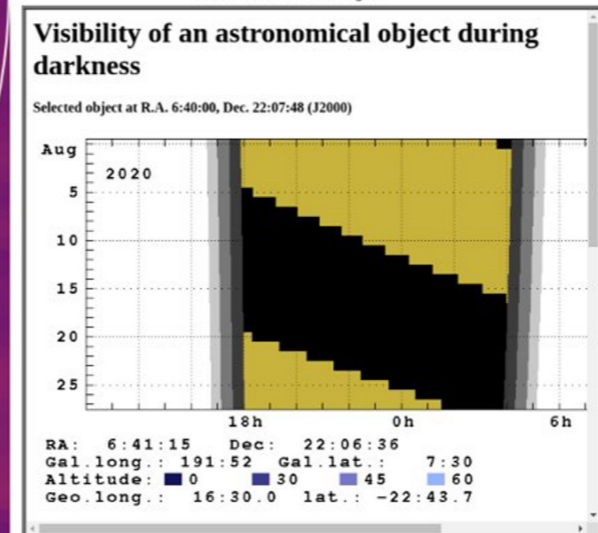
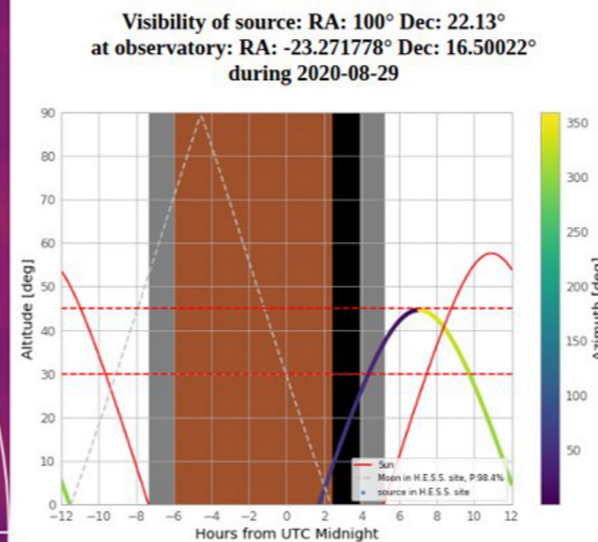
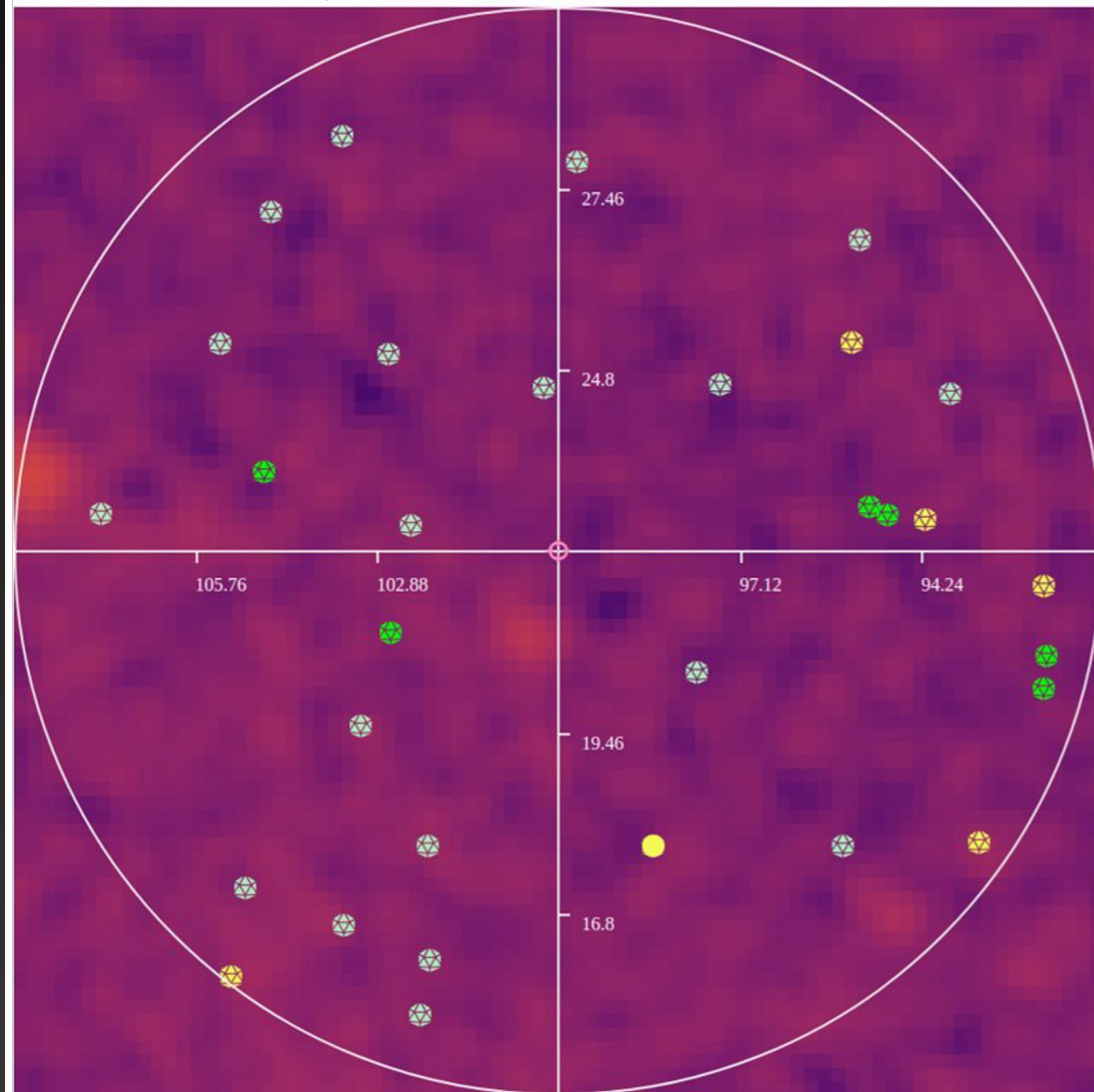




1st graphical interface



After further 10 merges and ≈230 commits:



UI Screenshot showing search parameters and status:

- Status:** Source name not known. Please remove text or choose known source! Internet connection: established. Visibility plots: finished next night / finished this month. Latest grbs: finished search. Latest neutrinos: finished search.
- Search area:** Source name: abc, RA*: 100, Dec*: 22.13, Radius*: 8.
- Time window:** date & time*: 08/28/2020, 12:11:49 PM, window [days]*: 50.
- VoEvent:** VoEvent: e.g. lvo://nasa.gsfc.gcn/SWIFT#BAT_GRB_Pos_848890-834.
- Catalogs:** VoEventDB, 4FGL, TeVcat, FlaapLUC.
- Latest transients:** GRBs, Neutrinos, None.
- START** button.

End of August 2020



v1.0

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



Colibri select action Latest transients Cone search personalize status: still logged in as patrick.reich

Filters From 2021-03-22 to 2021-06-22 swift fermi hawc icecube amon integral other Type of events: FRBs TDE GRBs Burst Neutrino other

GRB 210411A
 RA/Dec: 259.39° / -27.41°
 error: 3.05
 2021-04-11 05:30:56

SGR J1555.2-5402
 RA/Dec: 238.79° / -54.06°
 error: 0.000
 2021-06-21 19:05:24

GRB 210621A
 RA/Dec: 248.31° / -61.07°
 error: 8.6
 2021-06-21 12:44:03

PKS0537-286
 RA/Dec: 85.00° / -28.66°
 error: -1
 2021-06-21 00:31:01

RA/Dec: 183.97° / 53.17°
 error: 30.51
 2021-06-20 18:20:45

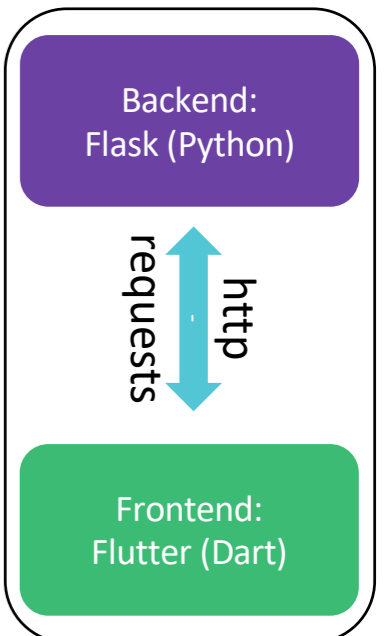
RA/Dec: 291.11° / 47.60°
 error: 8.5
 2021-06-20 06:54:14

Detailed info about selected source:
 VoEvent: [Click here](#)
 name: GRB 210411A
 RA / Dec: 17h17m33.6s / -27d24m36s
 observatory: Fermi
 comment: z=2.826 (VLT/X-shooter, GCN 29806)

Links: [ALADIN](#) [ESA](#) [SSDC](#) [TOBY](#) [FAVA](#) [GCN-n](#) [GCN-c](#)

Visibility at H.E.S.S.
 (long=16.5°, lat=-23.27°, height=1835m)

Detailed monthly visibility at H.E.S.S.



≈2000 commits



Current user interfaces

Astro-COLIBRI interface showing search filters, event lists, and detailed source information for S231123cg.

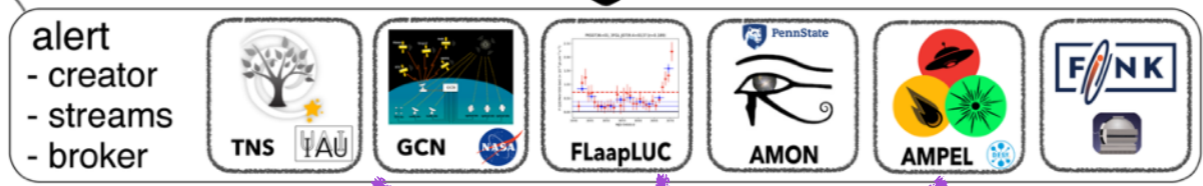
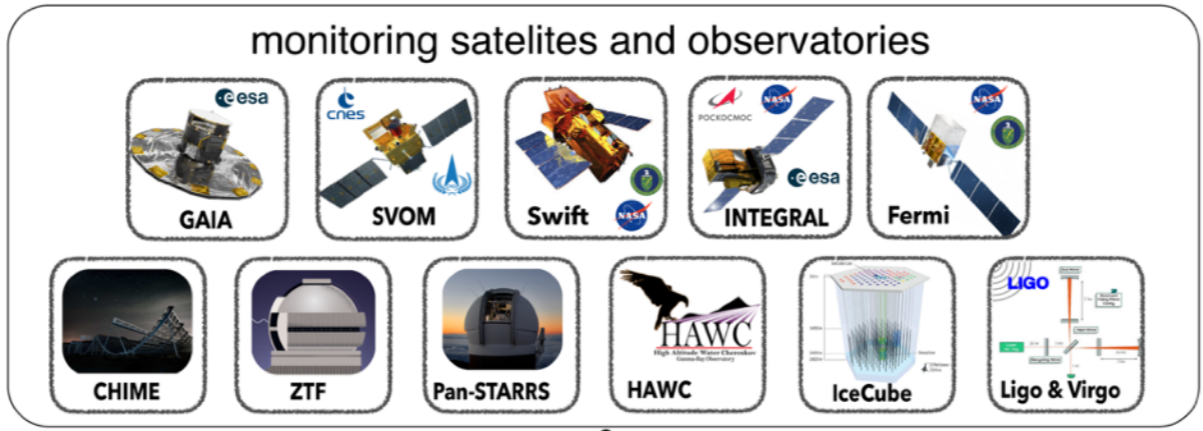


<https://astro-colibri.com>

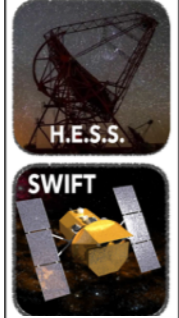
Mobile app interfaces showing search results, source details, and visibility information for H.E.S.S.



photons, GWs, ν , (CRs)

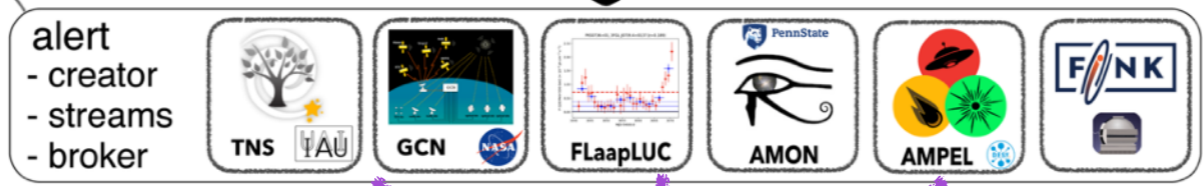
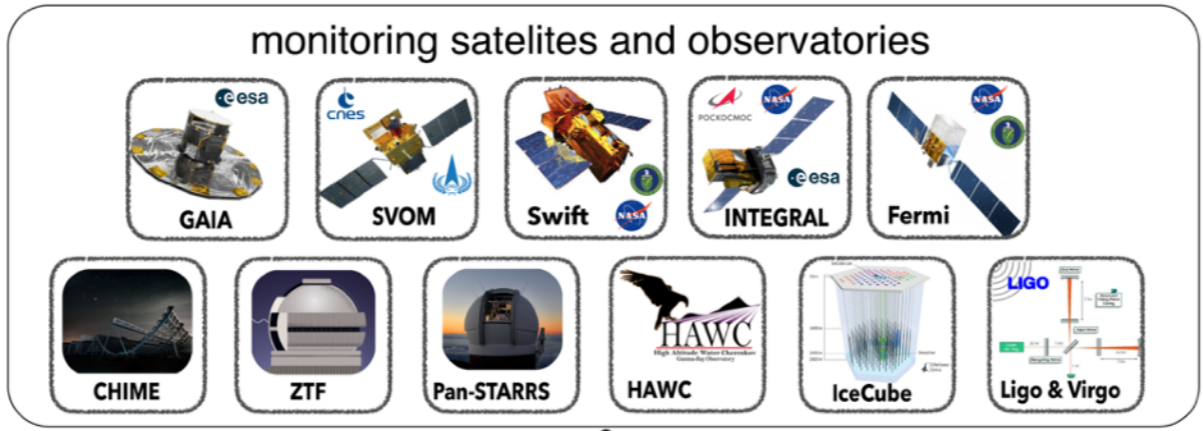


follow-up-observ.





photons, GWs, ν , (CRs)

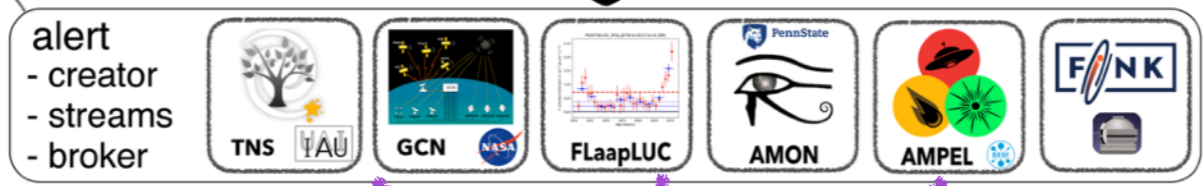
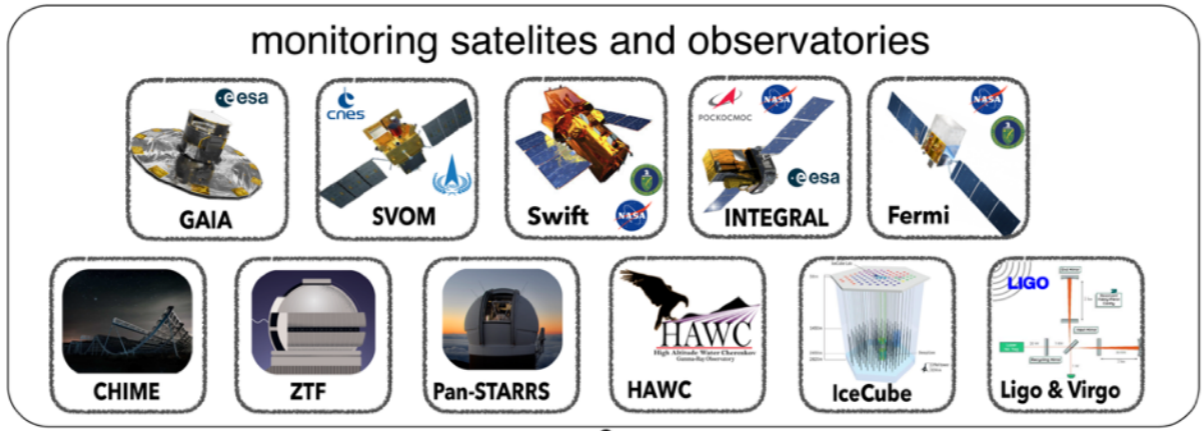


follow-up-observ.

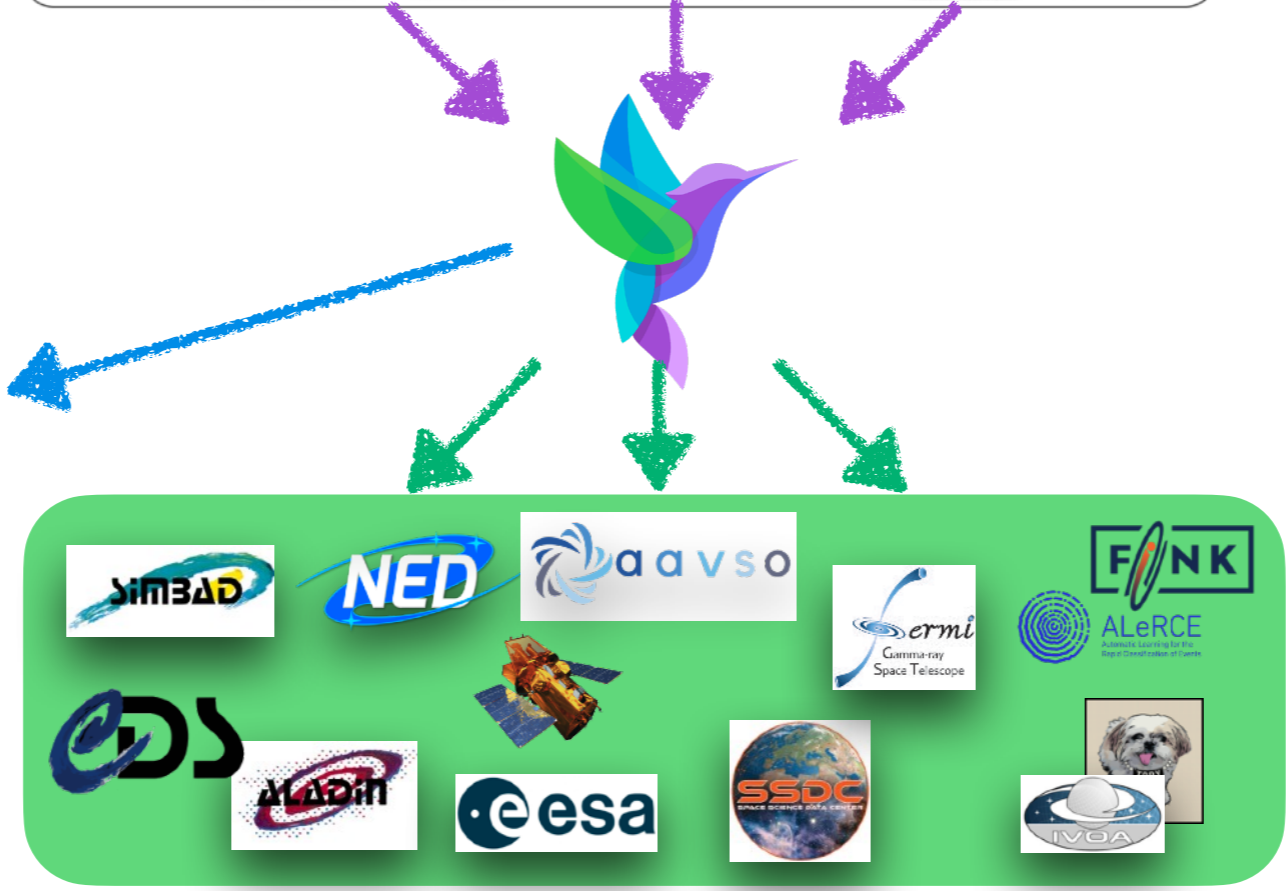




photons, GWs, ν , (CRs)

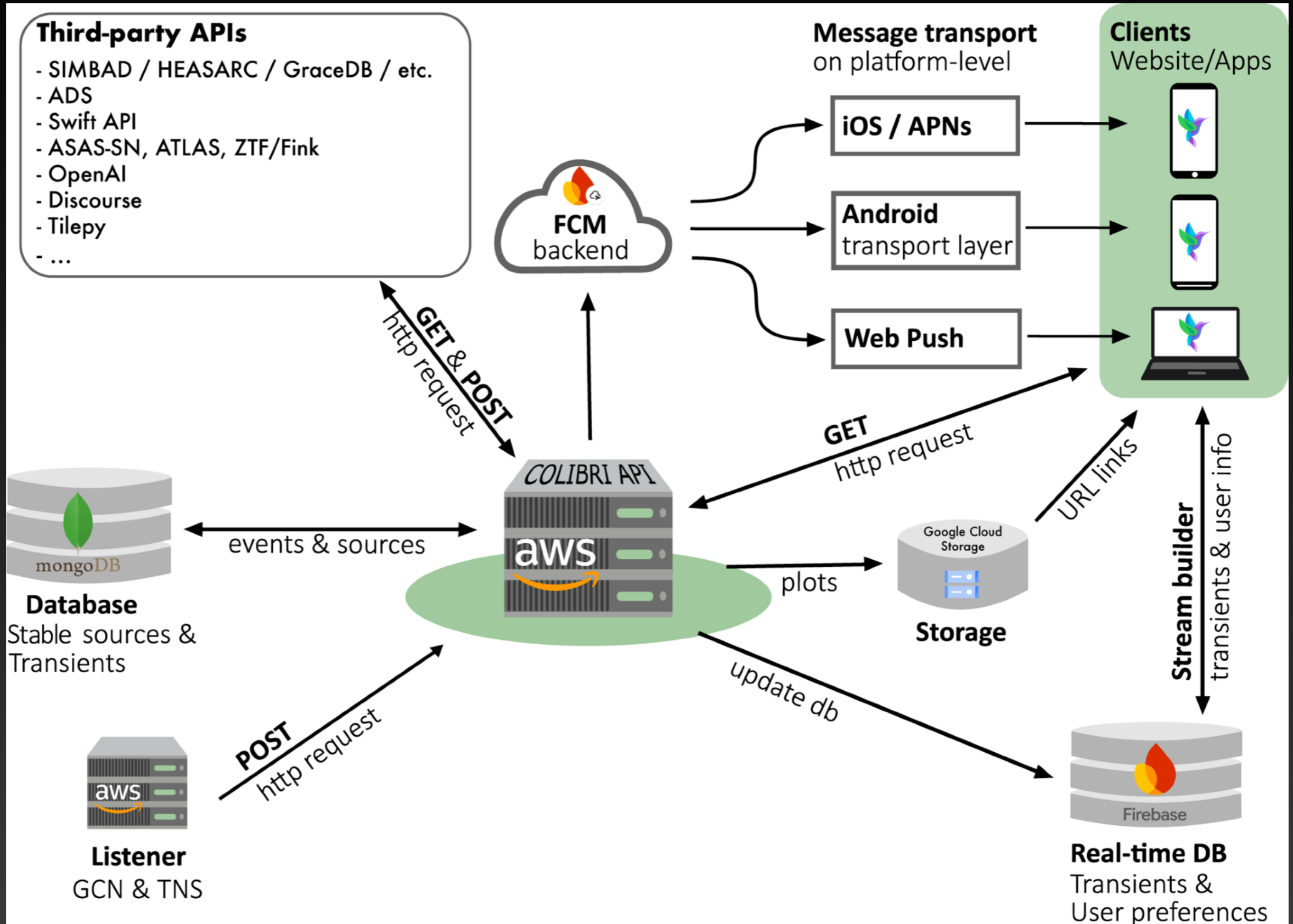


follow-up-observ.





Architecture





Demo





Android + iOS

The image displays four smartphone screens showcasing the Astro-COLIBRI application interface. The first screen shows a 'Cone ...' search results page with a map and a list of sources. The second screen shows the 'Astro-COLIBRI' main dashboard, featuring a star map and a list of sources including MS230110g, SN 2022bf, GRB 220103A, and HAWC-220103A. The third screen shows the 'Visibility at H.E.S.S.' page, which includes a 'Weather' section, 'Daily visibility' graph, and 'Monthly visibility' heatmap. A settings icon is highlighted with a yellow box on this screen. A purple arrow points from this settings icon to the fourth screen, which shows the 'Notifications' settings page. This page allows users to configure alerts for various astronomical events, including gravitational waves, GRB alerts, neutrino alerts, and Astro-COLIBRI announcements.

Source	RA/Dec	Time	Status
MS230110g	122.34° / 23.89°	2023-01-10 06:05:42	selected
SN 2022bf	20.86° / 49.97°	2022-01-03 21:07:12	show
GRB 220103A	36.86° / -15.70°	2022-01-03 21:03:12	show
HAWC-220103A	156.33° / 1.83°	2022-01-03 08:01:56	show

- All GW alerts
- Significant GW alerts
- NS/NSBH GW alerts
- Well localized GW alerts
- GRB alerts
- Neutrino alerts
- FlaapLUC (Fermi-LAT alerts)
- Burst alerts
- Special targets (e.g. TCrB)
- Astro-COLIBRI announcements

Real-time notifications



Web interface

Astro-COLIBRI | Select action: Latest transients | Cone search | Personalize | Status: logged out | Infos: v2.9.1

Observatories: Swift, Fermi, HAWC, IceCube, AMON, Integral, GECAM, FlaapLUC, LVC, Catalogs, Other

Event type: FRB, Unclassified OT, Classified OT, SN, GRB, burst, neutrino, nuem, GW, 4FGL, TeVCAT, SGR/AXP, IceCat

2023-12-01 | 2023-12-31

GRB 231214B
Gamma-ray burst

RA/Dec: 137.93°/-13.42° (± 6.25°)
2023-12-14 07:53:55

SN 2023zzi
Supernova

RA/Dec: 43.70°/15.59° (± 0.20 as)
2023-12-14 02:58:33

S231213ap
Gravitational wave

RA/Dec: 170.95°/29.83°
2023-12-13 11:14:17

AT 2023aabz
Classified optical transient

RA/Dec: 348.57°/52.93°
2023-12-13 05:54:50

ZTF23abtnlaf
Unclassified optical transient

S231213ap
Gravitational wave

Cone search

Custom cone search
source: S231213ap
RA / Dec: 170.95° 29.83°
error: < 0.00° >

Detailed info about selected source:

VoEvent: [XML](#) VoEvent: [JSON](#) History: #0 #1 #2 #3

name: S231213ap
Detection time: 2023-12-13 11:14:17
RA [deg]: 170.95 Dec [deg]: 29.83
RA: 11h23m47.34s Dec: 29d49m40.29s
observatory: LVC Instrument: H1,L1 discovery name: S231213ap
classification: BBH: 1.00

Gravitational waves are distortions of space-time! They are generated by all accelerated masses but their amplitude is so tiny that only the most massive objects in the universe create waves that are sufficiently powerful to be detected by the current generation of instruments. This event has been recorded by both Advanced LIGO laser interferometers. It is most likely due to the merger of two black holes.

Learn more about GWs: [link](#)

Discuss this event in our forum: [link](#)

Links for further details

- [GraceDB](#): Information on the gravitational wave event
- [TreasureMap](#): Follow-ups of GW events
- [ALADIN](#): Displays event in an interactive sky atlas
- [ESASky](#): Displays event in an interactive sky atlas
- [INS](#): Transient Name Server



Configurations

The screenshot shows the Astro-COLIBRI web interface. At the top, there is a navigation bar with buttons for 'Select action', 'Latest transients', 'Cone search', and a 'Personalize' menu. The 'Personalize' menu is highlighted with a yellow dashed box and contains icons for user accounts, observatories, skymaps, and API documentation. A purple arrow points from the 'Personalize' menu to a list of configuration options. Another purple arrow points from the 'science mode' toggle to a text box explaining its function. The background shows a detailed view of a gravitational wave event, S231213ap, with a visibility graph and various external links.

Astro-COLIBRI

Select action Latest transients Cone search Personalize

Status: logged out Infos: ✓ v2.9.1

- User accounts
- Choice of follow-up observatories
- Skymap configuration
- Link to API, documentation, etc.

science mode

“Science mode”: full event parameters, additional links to external platforms, visibility assessments, etc.

S231213ap Gravitational wave

visibility: 2024-01-21

Links for further details

- GraceDB Information on the gravitational wave event
- TreasureMap Follow-ups of GW events
- GCN Viewer Access to GCN notices and circulars
- GCN-n GCN notices: rapid alert message
- GW_Fermi-LAT Analysis of GW events



Latest transients

Astro-COLIBRI interface showing the 'Latest transients' page. The interface includes a navigation bar with 'Select action', 'Latest transients', and 'Cone search' buttons. Below this is a filter bar for observatories (Swift, Fermi, HAWC, IceCube, AMON, Integral, GECAM, FlaapLUC, LVC, Catalogs, Other) and event types (FRB, Unclassified OT, Classified OT, SN, GRB, burst, neutrino, nuem, GW, 4FGL, TeVCAT, SGR/AXP, IceCat). A timeline at the top shows dates from 2023-12-01 to 2023-12-31.

The main content area is divided into several sections:

- GRB 231214B** Gamma-ray burst: RA/Dec: 137.93°/-13.42° (± 6.25°), 2023-12-14 07:53:55.
- SN 2023zzi** Supernova: RA/Dec: 43.70°/15.59° (± 0.20 as), 2023-12-14 02:58:33.
- S231213ap** Gravitational wave: RA/Dec: 170.95°/29.83°, 2023-12-13 11:14:17.
- AT 2023aabz** Classified optical transient: RA/Dec: 348.57°/52.93°, 2023-12-13 05:54:50.
- ZTF23abtnlaf** Unclassified optical transient.

The central section features a 'Custom cone search' for source S231213ap, with RA/Dec: 170.95° 29.83° and error: < 0.00° >. Below this is a sky map showing the search cone and various transients. The map includes a 'GP' label and a 'Cone search' button.

Detailed info about selected source S231213ap:

- name: S231213ap
- Detection time: 2023-12-13 11:14:17
- RA [deg]: 170.95, Dec [deg]: 29.83
- RA: 11h23m47.34s, Dec: 29d49m40.29s
- observatory: LVC, Instrument: H1,L1, discovery name: S231213ap
- classification: BBH: 1.00

Gravitational waves are distortions of space-time! They are generated by all accelerated masses but their amplitude is so tiny that only the most massive objects in the universe create waves that are sufficiently powerful to be detected by the current generation of instruments. This event has been recorded by both Advanced LIGO laser interferometers. It is most likely due to the merger of two black holes.

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- [ALADIN](#): Displays event in an interactive sky atlas
- [ESASky](#): Displays event in an interactive sky atlas
- [INS](#): Transient Name Server



Timeline + Filters

Astro-COLIBRI interface showing a timeline and filters for astronomical events.

Timeline: 2023-12-01 to 2023-12-31. Events are represented by colored stars and symbols along a horizontal axis.

Filters:

- Observatories: Swift, Fermi, HAWC, IceCube, AMON, Integral, GECAM, FlaapLUC, LVC, Catalogs, Other
- Event type: FRB, Unclassified OT, Classified OT, SN, GRB, burst, neutrino, nuem, GW, 4FGL, TeVCAT, SGR/AXP, IceCat

Event Details (S231213ap):

- Source: S231213ap
- RA / Dec: 170.95° 29.83°
- error: < 0.00°
- Detailed info: name, detection time, RA, Dec, E(B-V), observatory, notice, pipeline, classification, FAR, distance, 50% area, 90% area.
- Visibility graph: Shows visibility (deg) vs. month (deg) for 2024-01-21.

Event List:

- GRB 231214B: Gamma-ray burst, RA/Dec: 137.93°/-13.42° (± 6.25°), 2023-12-14 07:53:55
- SN 2023zzi: Supernova, RA/Dec: 43.70°/15.59° (± 0.20 as), 2023-12-14 02:58:33
- S231213ap: Gravitational wave, RA/Dec: 170.95°/29.83°, 2023-12-13 11:14:17
- AT 2023aabz: Classified optical transient, RA/Dec: 348.57°/52.93°, 2023-12-13 05:54:50
- ZTF23abtniaf: Unclassified optical transient

Map: A celestial map showing the location of S231213ap and other events. The map includes a grid of RA and Dec, and a search cone around the event.

Links for further details:

- GraceDB: Information on the gravitational wave event
- TreasureMap: Follow-ups of GW events
- GCN Viewer: Access to GCN notices and circulars
- GCN-n: GCN notices: rapid alert message
- GW_Fermi-LAT: Analysis of GW events



Detailed filters

Astro-COLIBRI interface showing a detailed filter configuration for a gravitational wave event (S231213ap).

Observatories: Swift, Fermi, HAWC, IceCube, AMON, Integral, GECAM, FlaapLUC, LVC, Catalogs, Other

Event type: FRB, Unclassified OT, Classified OT, SN, GRB, burst, neutrino, nuem

Time range: 2023-12-01 to 2023-12-31

Custom cone search: source: S231213ap, RA / Dec: 170.95° 29.83°, error: < 0.00°

Filter configuration (OR logic):

- Everything else
- observatory == Gaia
- observatory == ZTF
- observatory == ATLAS
- observatory == Pan-STARRS
- observatory == MASTER

Event details: S231213ap Gravitational wave

RA/Dec: 170.95°/29.83°

Distance: 3861 ± 1257 Mpc

Area: 50% area: 356 deg², 90% area: 1451 deg²

Visibility graph: Visibility at (long = 14.4°, lat = 49.89°, height = 0.0 m) for S231213ap (RA = 170.95°, DEC = 29.83°) from 2024-01-21 to 2024-01-22.

Links for further details: GraceDB, TreasureMap, GCN Viewer, GCN-n, GW_Fermi-LAT



Detailed filters

Astro-COLIBRI interface showing detailed filters for event selection. The interface includes a top navigation bar with 'Select action', 'Latest transients', 'Cone search', and user status 'logged out'. Below this is a filter bar for observatories (Swift, Fermi, HAWC, IceCube, AMON, Integral, GECAM, FlaapLUC, LVC, Catalogs, Other) and event types (FRB, Unclassified OT, Classified OT, SN, GRB, burst, neutrino, nuem, GW, 4FGL, TeVCAT, SGR/AXP, IceCat).

The main filter panel is open, showing the following filters:

- OR
- Everything else
- Unistellar
- Magnitude \leq 18.0
- classification == nova
- classification == CV
- classification == TDE
- classification == Varstar

The interface also displays a central sky map with a custom cone search for source S231213ap at RA/Dec: 170.95° / 29.83°. A detailed info panel for S231213ap is visible, including detection time (2023-12-13 11:14:17), RA/Dec, E(B-V), and classification (BBH: 1.00). A visibility graph shows the event's visibility at a specific location (long = 14.4°, lat = 49.89°, height = 0.0 m) from 2024-01-21 to 2024-01-22. The bottom section provides links for further details, such as GraceDB, TreasureMap, GCN Viewer, GCN-n, and GW_Fermi-LAT.



Detailed filters

Astro-COLIBRI interface showing detailed filters and event information for S231213ap.

Observatories: Swift, Fermi, HAWC, IceCube, AMON, Integral, GECAM, FlaapLUC, LVC, Catalogs, Other

Event type: FRB, Unclassified OT, Classified OT, SN, GRB, burst, neutrino, nuem, GW, 4FGL, TeVCAT, SGR/AXP, IceCat

Filters: AND, OR, Everything else, Unistellar, Magnitude > 0

Custom cone search: source: S231213ap, RA / Dec: 170.95° 29.83°, error: < 0.00° >

Detailed info about selected source:

- name: S231213ap
- Detection time: 2023-12-13 11:14:17
- RA [deg]: 170.95, Dec [deg]: 29.83
- RA : 11h23m47.34s, Dec : 29d49m40.29s
- E(B-V) [mag]: 0.02
- observatory: LVC, instrument: H1,L1, discovery name: S231213ap
- notice: Update, pipeline: pycbc
- classification: BBH: 1.00
- FAR: 0.02/yr → significant event
- distance: 3861 ± 1257 Mpc
- 50% area: 356 deg², 90% area: 1451 deg²

Visibility graph: Visibility at (long = 11.66°, lat = 48.07°, height = 0.0 m) for S231213ap (RA = 170.95°, DEC = 29.83°) from 2024-01-21 to 2024-01-22.

Links for further details: GraceDB, TreasureMap, GCN Viewer, GCN-n, GW_Fermi-LAT



Observatory selection

Astro-COLIBRI interface showing the observatory selection process. The interface includes a top navigation bar with buttons for 'Personalize', 'Location', 'Global', and 'Info'. Below this, there are filters for 'Observatories' and 'Event type'. A central panel displays the observability calculation for an observer at VLT Paranal and lists various observatories categorized by 'Radio', 'Optical', and 'High energy'. A bottom panel shows a table of observatory parameters and buttons for 'Select coordinates' and 'Save observatory'.

The observability is calculated for an observer at VLT Paranal: long = -70.40° , lat = -24.63° , height = 2635m.

You can change the observer location by choosing one of the following observatories

Radio

ALMA ASKAP ATCA MeerKAT MWA Nançay Murriyang/Parkes

Optical

Jilin Keck Mount Wilson OHP Palomar SALT San Pedro Mártir **VLT Paranal** Victor M. Blanco Xinglong Yunnan

High energy

HAWC H.E.S.S. LHAASO LST MAGIC VERITAS

My observatories :

11.6569	48.0653	0	0.1	60	1.0	Garching Observatory
longitude	latitude	altitude [m]	FoV [deg]	Zenith limit [deg]	max. moon fracti...	name custom position

Select coordinates Save observatory



Observability

Astro-COLIBRI interface showing observatory filters and a visibility plot for H.E.S.S. at source location (RA = 120.8°, DEC = 9.8°).

Observatories: Swift, Fermi, HAWC, IceCube, AMON, Integral, GECAM, FlaapLUC, LVC, Catalogs, Other

Event type: FRB, Unclassified OT, Classified OT, SN, GRB, burst, neutrino, nuem, GW, 4FGL, TeVCAT, SGR/AXP, Icecat

2023-11-01 to 2023-11-23

status: logged out Infos: v2.8.0

Personalize [Location Icon] [Globe Icon] [Info Icon]

Visibility at H.E.S.S.

Source location: (RA = 120.8°, DEC = 9.8°)

altitude [deg]

hours from UTC midnight

azimuth [deg]

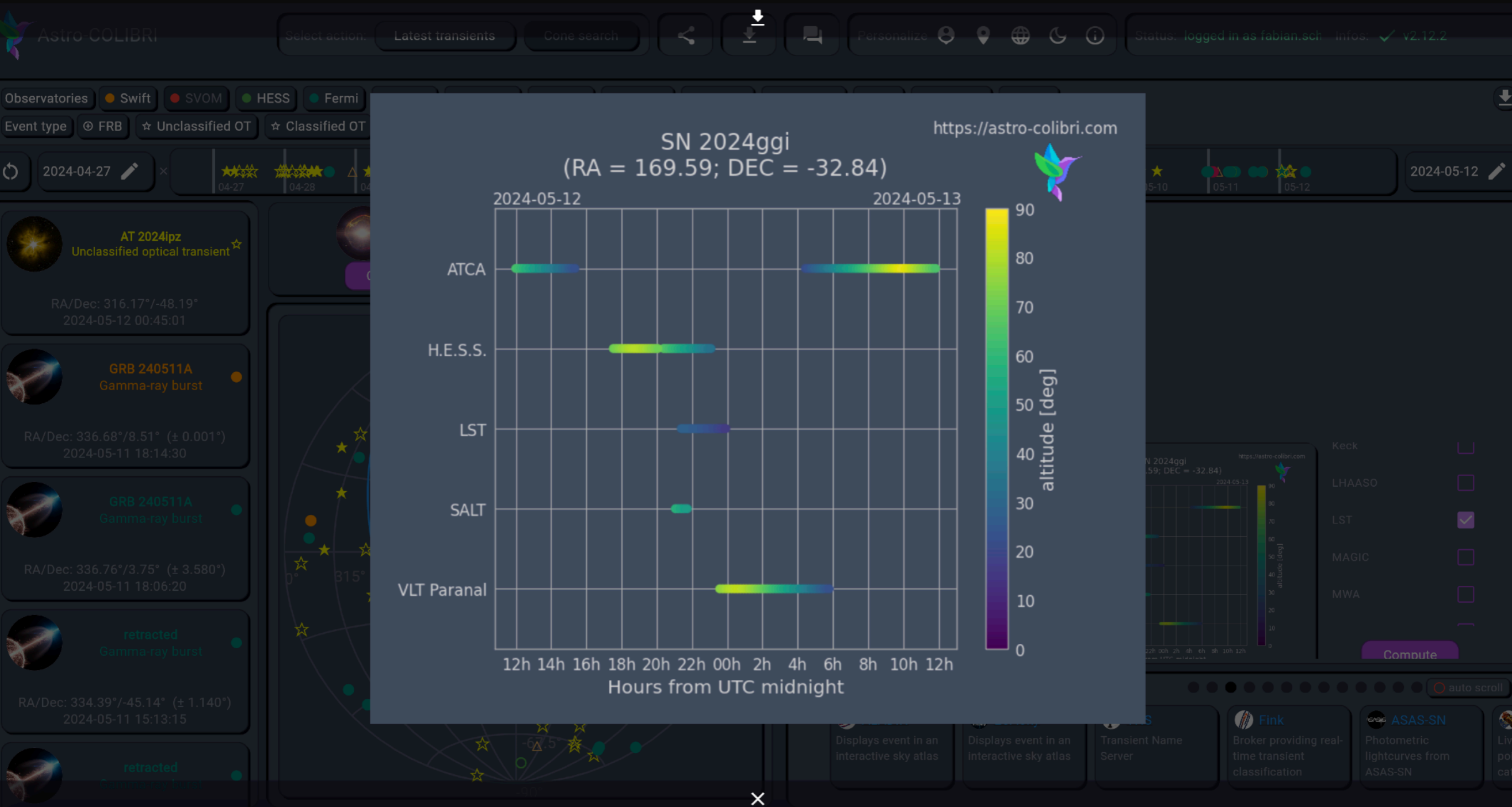
Legend:
— Sun altitude
- - Moon altitude
● source
■ Dark time
■ Moonlight

Note: Grey levels correspond to civil, naval, and astronomical twilight, respectively.

Zenith < 45°: 17:50 UTC - 19:40 UTC
Zenith < 60°: 17:50 UTC - 20:59 UTC



Multi-observatory observability





Gravitational waves

Astro-COLIBRI interface showing a search for gravitational waves. The main panel displays a sky map with a search cone and various event details.

Search Parameters:

- GW
- OR
 - Significant events
 - Sub-Threshold events
- AND
 - Map areas (90%) > 0.0
 - Noise <= 1.0
 - BBH > 0.0
 - BNS > 0.0

Event Details (S240512r):

- Gravitational wave
- RA/Dec: 206.50°/13.86°
- 2024-05-12 02:41:39
- distance: 1082 ± 266 Mpc
- 50% area: 34 deg² | 90% area: 208 deg²
- instrument: H1,L1,V1 | discovery name: S240512r
- pipeline: pycbc
- SBH: 0.02 / BBH: 0.98 | MassGap: 0.01
- significant event

Left Panel (Event List):

- AT 2024lqr: Unclassified optical transient (2024-05-12 03:17:53)
- S240512r: Gravitational wave (2024-05-12 02:41:39)
- Gamma-ray burst (2024-05-12 00:54:28)
- AT 2024lpz: Unclassified optical transient (2024-05-12 00:45:01)
- GRB 240511A: Gamma-ray burst

Right Panel (Tools):

- Search for ATels!
- Discuss this event in our forum: [Schedule](#)
- visibility: 2024-05-12
- Start follow-up campaigns: [click here](#)
- auto scroll

Bottom Panel (Links):

- GraceDB: Information on the gravitational wave event
- TreasureMap: Follow-ups of GW events
- GCN Viewer: Access to GCN notices and circulars
- GCN-n: GCN notices: rapid alert message
- GW Fermi-LAT: Analysis of GW events



Observation plans



Astro-COLIBRI Select action Latest transients Cone search Share Download Personalize Status: **logged out** Infos: **✓** v2.9.1

Observatories: Swift Fermi HAWC IceCube AMON Integral GECAM FlaapLUC LVC Catalogs Other

Event type: FRB Unclassified OT Classified OT SN GRB burst neutrino nuem GW 4FGL TeV CAT SGR/AXP IceCat

2023-12-01 12-01 12-03 12-05 12-07 12-09 12-11 12-13 12-15 12-17 12-19 12-21 12-23 12-25 12-27 12-29 12-31

RA/Dec: 189.84°/39.64°
2024-01-17 02:59:50

S231213ap_tile_012
tilepy

RA/Dec: 146.43°/2.69°
2024-01-17 03:59:50

S231213ap_tile_013
tilepy

RA/Dec: 195.64°/41.81°
2024-01-17 04:29:50

S231213ap_tile_014
tilepy

RA/Dec: 144.84°/-1.94°
2024-01-17 04:59:50

S231213ap_tile_015
tilepy

RA/Dec: 140.80°/-5.08°
2024-01-17 05:29:50

S231213ap
Gravitational wave

Latest transients

Custom cone search
source: S231213ap
RA / Dec: 170.95° 29.83°
error: < 0.00° >

observatory: LVC instrument: H1,L1 discovery name: S231213ap
notice: Update pipeline: pycbc
classification: BBH: 1.00
FAR: 0.02/yr → significant event
distance: 3861 ± 1257 Mpc
50% area: 356 deg² 90% area: 1451 deg²

[Search for ATels!](#)

Discuss this event in our forum:

Schedule

The following observation plan is proposed by [tilepy.com](#). It covers 44.8% of the GW localisation uncertainty region. Full details: [JSON](#)

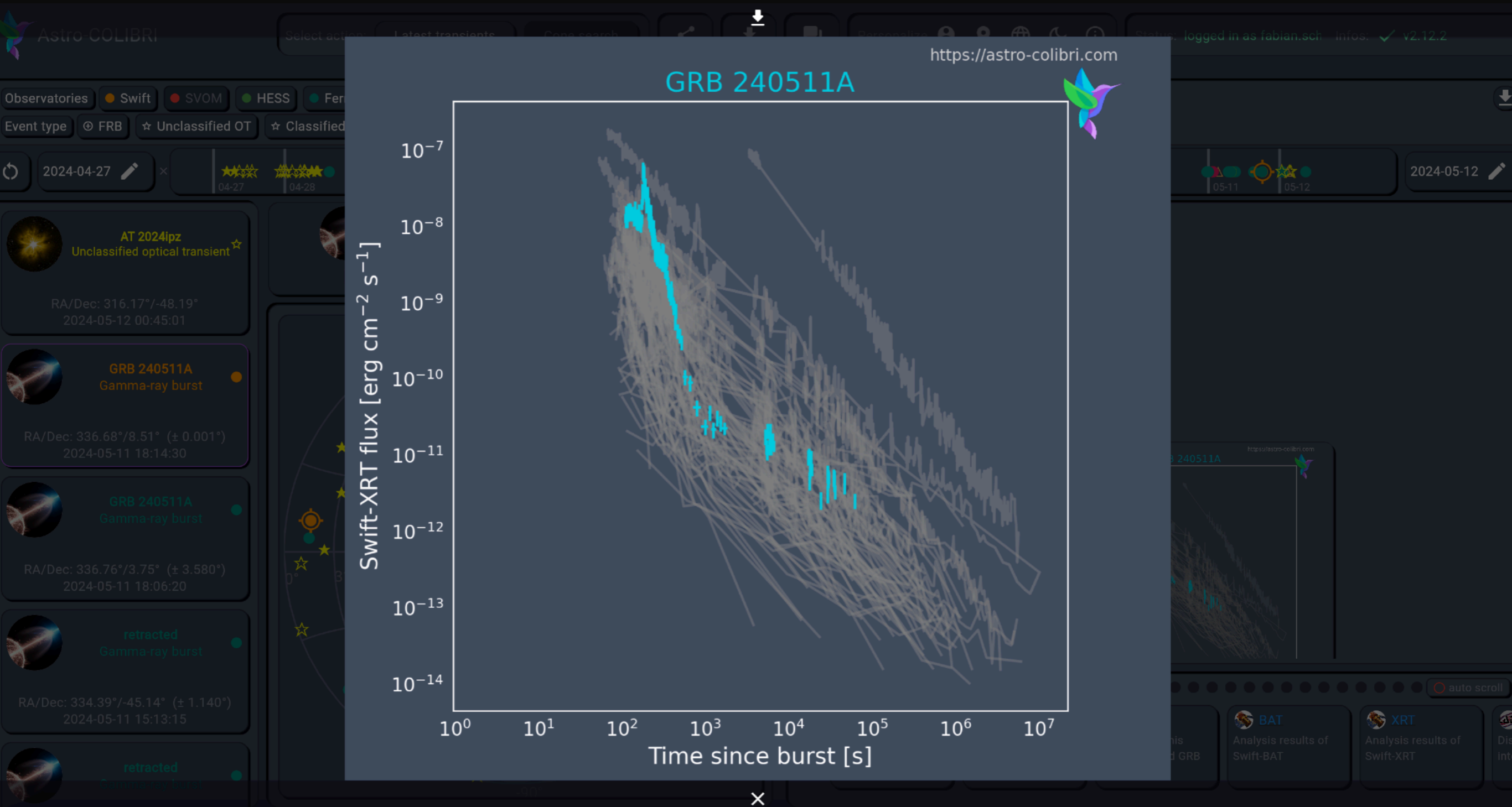
ID	coverage [%]	RA [deg°]	Dec [deg]
S231213ap_tile_000	0.88	140.27	-0.15
S231213ap_tile_001	3.41	158.03	19.16
S231213ap_tile_002	3.96	169.45	28.80
S231213ap_tile_003	3.79	165.23	25.45

Links for further details

- [GraceDB](#): Information on the gravitational wave event
- [TreasureMap](#): Follow-ups of GW events
- [GCN Viewer](#): Access to GCN notices and circulars
- [GCN-n](#): GCN notices: rapid alert message
- [GW_Fermi-LAT](#): Analysis of GW events



Swift-XRT light curves



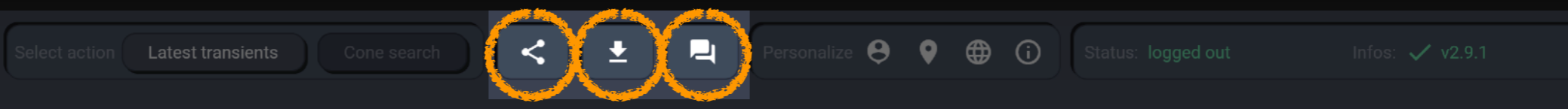


External platforms





Community



Share "deep-links" to a selected event



Download all selected events



Discussion forum

API: <https://astro-colibri.science>

First version of an OpenAI GPT ChatBot



Astro-COLIBRI

- Astro-COLIBRI: novel platform providing easy access to
 - transient detections (optical transients, GRBs, FRBs, TDEs, high-energy neutrinos, GWs, etc.)
 - interfaces: <https://astro-colibri.com> + Android + iOS
 - API + documentation: <https://astro-colibri.science>
 - Forum: <https://forum.astro-colibri.science>
 - availability > 99% (fully cloud based architecture)
- P. Reichherzer et al., ApJS 256, 2021 ([link](#)) + Galaxies 11, 2022 ([link](#))



Astro-COLIBRI

Contact: astro.colibri@gmail.com

- Central webpage: [**https://astro-colibri.science**](https://astro-colibri.science)

Android Play Store



Apple iOS App Store



Introductions/tutorials on YouTube



[**Mastodon, Twitter/X, Insta, Threads**](#)