



# SCIMMA: REAL-TIME ORCHESTRATION OF MULTI-MESSENGER ASTROPHYSICAL OBSERVATIONS

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On behalf of the SCIMMA team:

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OAC-1841625  
OAC-1934752  
OAC-2311355



**0. WHAT THE HECK IS THIS SCIMMA THING  
I.E. WHY DO YOU EVEN EXIST?**

# HOW IT WORKS TODAY

skymap <https://gracedb.ligo.org/api/superevents/S231017bj/files/bayestar.muliorder.fits,0>

gracedb <https://gracedb.ligo.org/superevents/S231017bj/view/>

EVENT KEYPAIRS ≡

Key	Value
far	0.00000526891153640463
time	2023-10-17T13:28:29.537Z
group	CBC



1. Receive text alert/kafka message

2. What?!?

3. Trigger approved resources by filling out Phase II forms

DOW	Date	Dark	Tel#	Principal	Observers	Location	Inst/ACC	Institution	OA	SA	NA	ProjCode
Tue	Jan-01	80	1	Masters	Masters (GIT), J. Cohen (GIT), Hornbush (GIT), Starford (UCSB)	CITA/CB	LRS-ADC(9)	NASA	JA	ARoc		N044
Tue	Jan-01	80	2	G. Fuller	K. Rubin (UCSD), Col. (UCSD) Vaughn, (UCSD), Burchett, (UCSD)	UCSD/UCSC	KCWI(8)	UCSD	JR	LRoc		J090
Wed	Jan-02	88	1	Crystal, Marlin	Crystal, Marlin (UCSB)	UCSB	LRS-ADC(1)	UCSB	JACW	JW	SJ	J156
Wed	Jan-02	88	2	G. Fuller	K. Rubin (UCSD), Col. (UCSD) Vaughn, (UCSD), Burchett, (UCSD)	UCSD/UCSC	KCWI(8)	UCSD	JR	LRoc		J090
Thu	Jan-03	98	1	S. Kulkarni	Burdge	HQ	LRS-ADC(2)	CIT	CW	JW	SJ	G323
Thu	Jan-03	98	2	J. Cohen	J. Cohen (GIT), Hermitzsch, (GIT)	CIT	ES(1)	CIT	JRUP	RG	SJ	G293
Fri	Jan-04	100	1	Pinnao/Ravi	Burdge/Burdge	HQ	LRS-ADC(3)	CIT	CW	JW	SJ	G323C327
Fri	Jan-04	100	2	J. Cohen	J. Cohen (GIT), Hermitzsch, (GIT)	CIT	ES(1)	CIT	JP	RToc	SJ	G293
Sat	Jan-05	100	1	J. Cooke	Frazer (Swan), Fitchard, Mehall, J. Cooke, S. Webb	Swan/HQ	LRS-ADC(4)	Swan/ome	CW	JW	SJ/JP	W247
Sat	Jan-05	100	2	Fassnacht	Fassnacht (UCD), G. Chen (UCD)	UCD	ES(2)	UCD	JP	JL	SJ/JP	J122
Sun	Jan-06	98	1	Drossing	Isaacson (UCB), Poligino, (CIT)	UCB/CIT	HIRES(1)	UCB	CW/TR/AAAR	GO	JLP	J096
Sun	Jan-06	98	2	Oro	Oro, Bah	HQ	DEIMOS(4)	Subaru	JP	AR	JLP	S347
Mon	Jan-07	80	1	Drossing	Isaacson (UCB), Poligino, (CIT)	UCB/CIT	HIRES(1)	UCB	TR (AAAR)	GO	JLP/TKC	J096
Mon	Jan-07	80	2	Hu	Hu, L. Cowie	HQ	DEIMOS(3)	UH	JP/H	AR	JLP/TKC	H239
Tue	Jan-08	83	1	Redfield	Faith, Swin, Redfield	HQ	HIRES(7)	NASA	TR (AAAR)	GO	JLP/TKC	N152
Tue	Jan-08	83	2	Maves/Hu	Maves (GIT), Schevert, (GIT), S. Rappaport, L. Cowie	CITA/HQ	NRES/PAO-NGS+HIRC2-NCS(5)/DEIMOS(5)	CITA/H	HBAH	CA	JLP/TKC	G315A-230
Wed	Jan-09	78	1	M. White	Khee Gan, Lee, Ah	HQ	LRS-ADC(8)	UCB	TR (AAAR)	CA	TKC	J096
Wed	Jan-09	78	2	Stamer/Henbrand	Sallum, (UCSC)/Henbrand, Okopiec	UCSC/HQ	NIRC2-NCS(9)/NIRSPEC(4)	UCSC/CIT	H (AH)	CA	TKC	J128C272
Thu	Jan-10	60	1	S. Valenti/M. White	Boatman, (UCD)/Oee-Gun, Lee, Ah	UCD/HQ	LRS-ADC(5/6)	UCD/UCB	TR/CJ (AAAR)	JW	TKC	J09A/096
Thu	Jan-10	60	2	Stamer/M. Cooper	Sallum, (UCSC)/M. Cooper, (UCB), Filippin, (UCI), Winberry, (UCI), Bester, (UCI)	UCSC/UCI	NIRC2-NCS(9)/DEIMOS(8)	UCSC/UCI	H (AH)	CA	TKC	J128U/053

```

////////////////////////////////////
TITLE: GCN CIRCULAR
NUMBER: 21538
SUBJECT: LIGO/Virgo G298048: Las Cumbres Observatory Detection of The Possible Optical Counterpart in NGC 4993
DATE: 17/08/18 04:06:31 GMT
FROM: Iair Arcavi at LCOGT <iarcavi@lcogt.net>

I. Arcavi, D. A. Howell, C. McCully, G. Hosseinzadeh, S. Vasylyev (UCSB/Las Cumbres Obs), M. Zalzman, D. Poznanski (TAU), L.P. Singer (NASA/GSFC), S. Valenti (UC Davis), T. Piran (HUJI), D. Kasen, J. Barnes (UC Berkeley) and W-f. Fong (UA) report an independent detection of the possible optical counterpart reported by Coulter et al. (LVC GCN 21529), Chornock et al. (LVC GCN 21530), Valenti et al. (LVC GCN 21531) and Melandri et al. (LVC GCN 21532).

In the course of Las Cumbres Observatory galaxy-targeted LIGO followup we observed NGC 4993 from one of our 1-meter telescopes at the Cerro Tololo Inter-American Observatory in Chile. An imaging 5-minute exposure starting at 2017-08-18 00:15:23 UT in the w (=g+r+i) filter clearly shows the candidate.

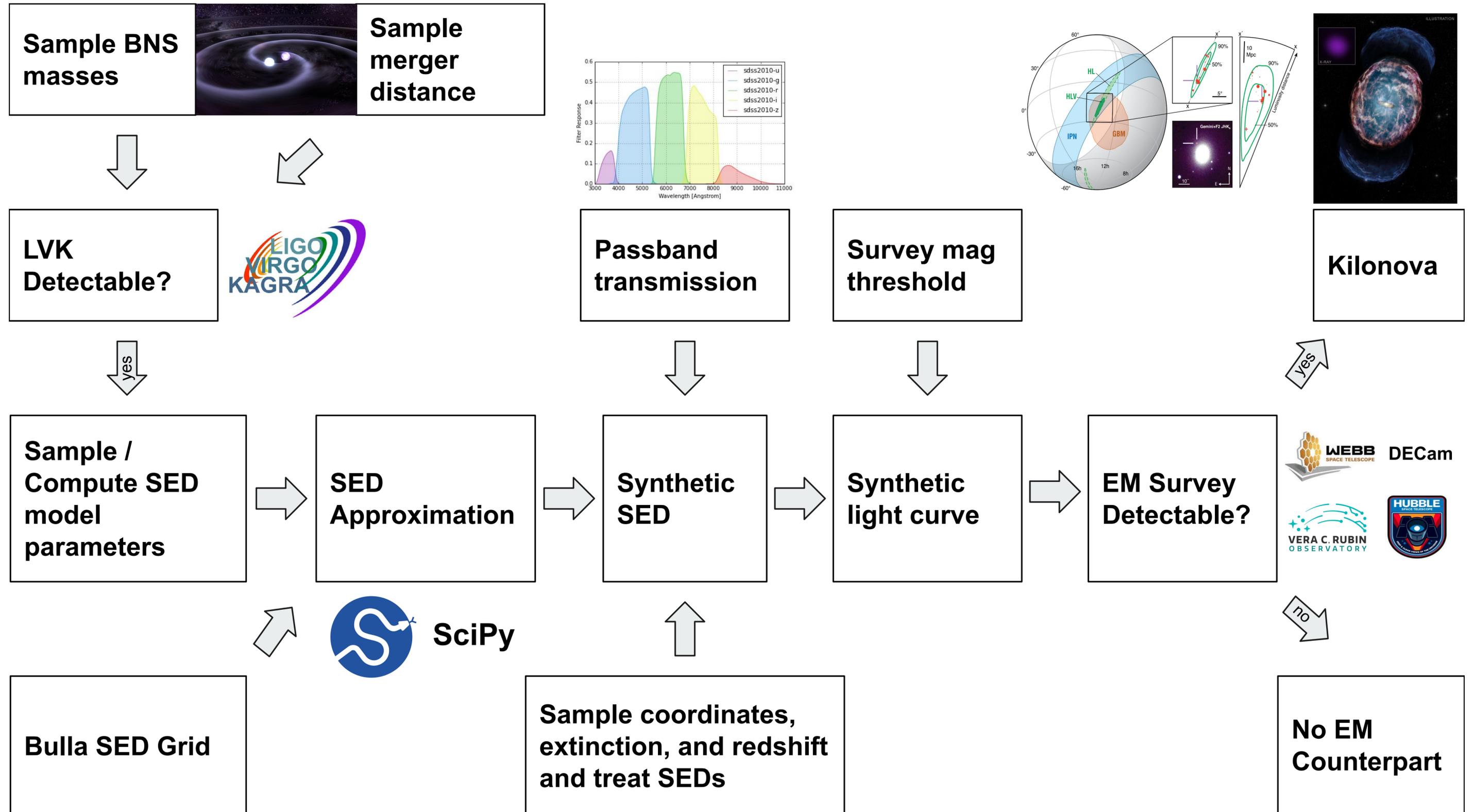
Analysis of the image is ongoing and followup is planned when the field becomes visible to our Siding Spring telescopes starting at 2017-08-18 08:32 UT.
    
```

4. Look up other resources available. Beg, plead, cajole for time. Form collaborations. Gather information from dozens of sources.

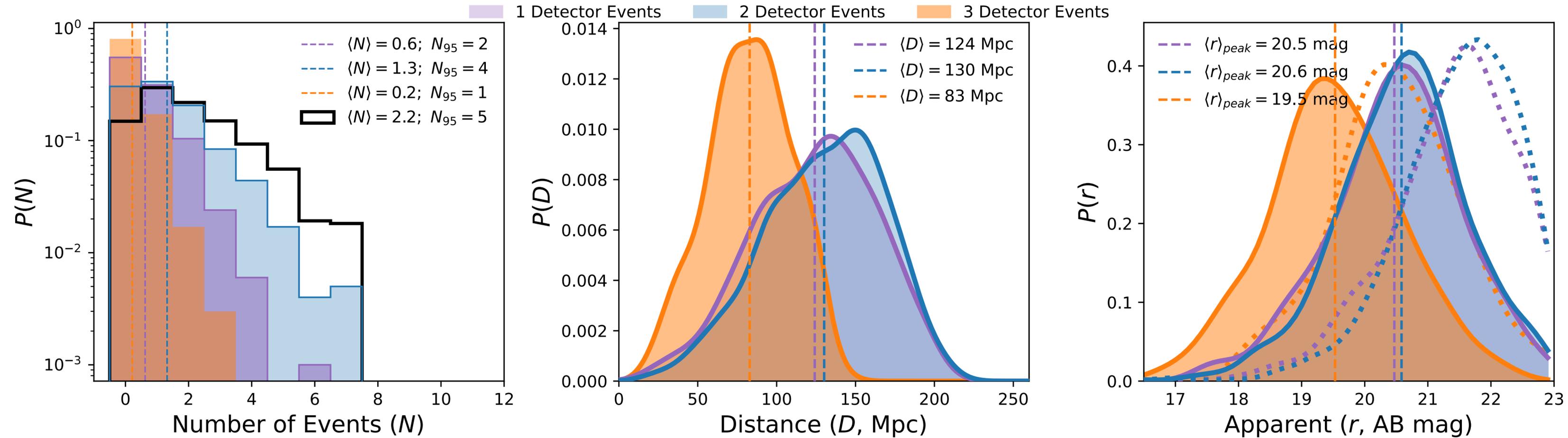
5. Download data from different archives and reduce it.

6. Communicate information to the community, via text

# WHY IS IT BAD IF WE DON'T COMMUNICATE? MMA EVENTS ARE RARE



# WHY IS IT BAD IF WE DON'T COMMUNICATE? MMA EVENTS ARE RARE



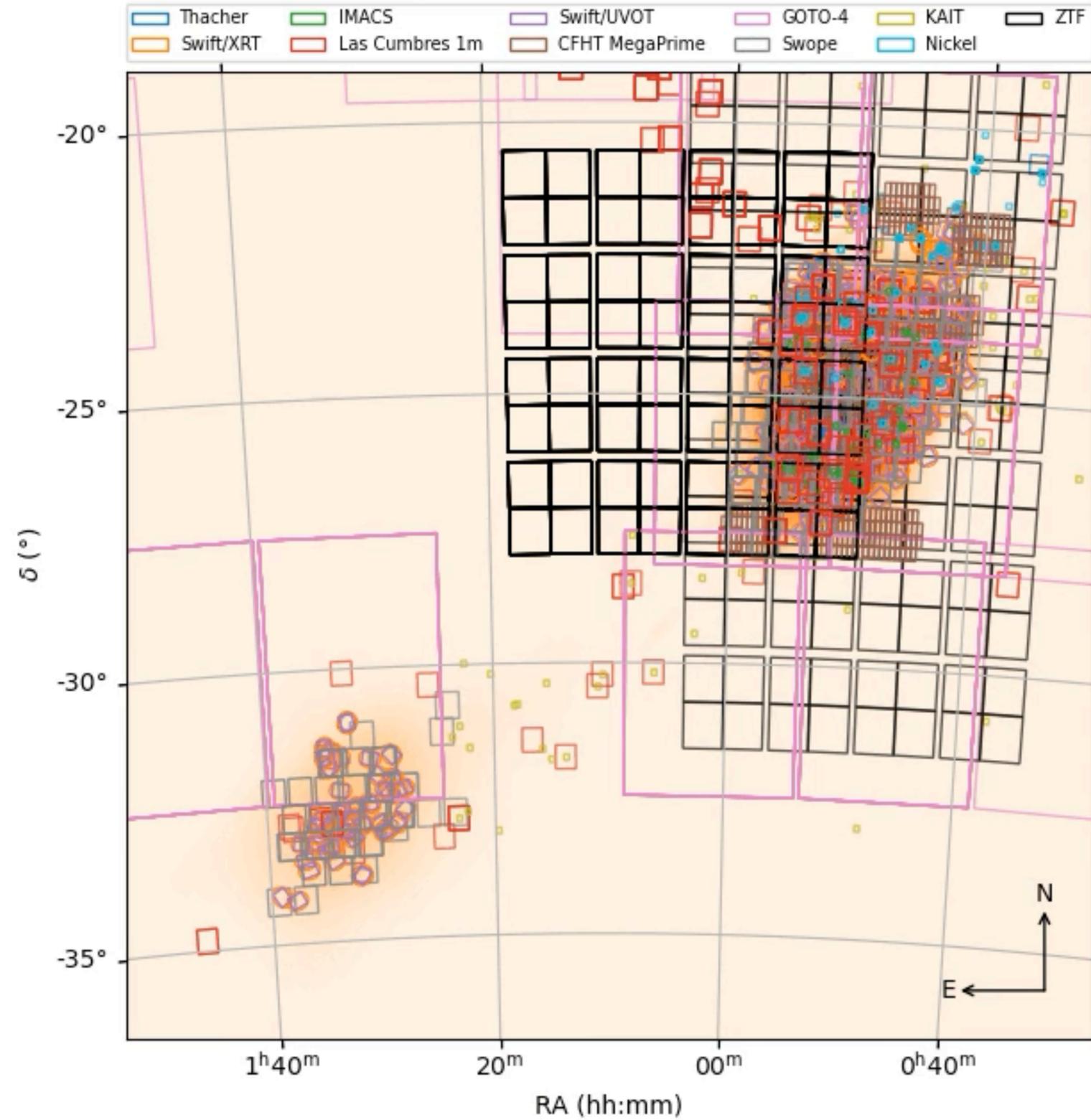
The number of MMA events we should expect in O4 is  $\sim 1$ . In the most optimistic scenarios, 4.

If we do not coordinate, we will miss the second

# THIS HAS ALREADY HAPPENED

## GW190814 Followup

MJD 58712.97 T+3.09 days





**WE ARE MISSING  
SCIENCE BECAUSE WE  
AREN'T EFFICIENTLY  
SHARING INFORMATION**

# 1. ESTABLISHING THE INFRASTRUCTURE FOR A COLLABORATIVE MULTI-MESSENGER ECOSYSTEM

# KEY COMPONENTS OF THE ECOSYSTEM: MESSAGING

9

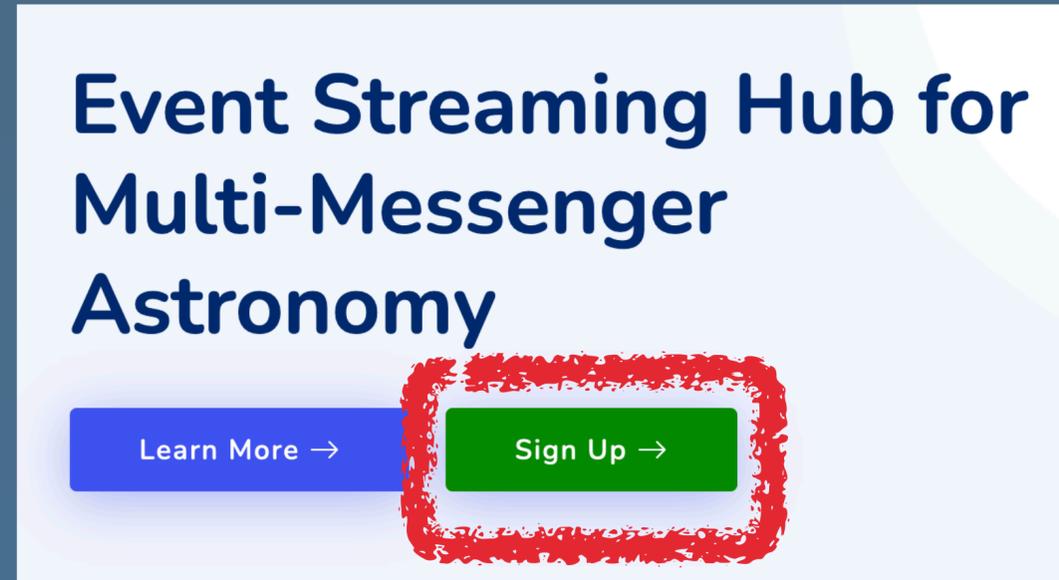
- ▶ [Hopskotch](#) is an pub-sub system with identity and access management
- ▶ Use your own institutional sign-in (or ORCID) with CILogon to sign up: <https://hop.scimma.org/>
- ▶ Public “topics” including LVK alerts in O4, AMON, GCN (over Kafka!), IceCube, SNEWS - get DOIs for discovery messages
- ▶ Private “topics” are fine too - you have to join the appropriate group - message us to create a new survey with you as the PI
- ▶ Cloud-based on AWS - highly scalable (< 1s latency for us to process messages through Run O4) - **or stand up your own instance for your project**
- ▶ Granular permissions control, an easy-to-use [python client](#), all open-source
- ▶ Designed to handle high volume, high throughput streams for big surveys and experiments

# 2. SIGNING UP FOR SCIMMA & HERMES

## (DEMO)

# SIGNING UP FOR SCIMMA P1

- ▶ As promised, use your own institutional sign-in (or ORCiD) with CILogon to sign up: <https://hop.scimma.org/>

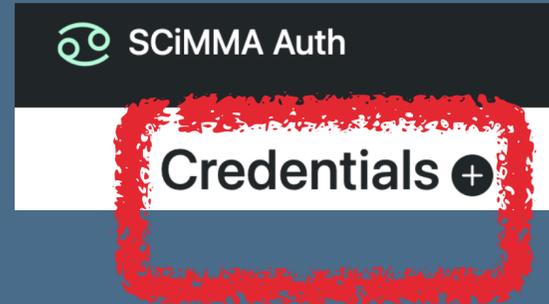


- ▶ Pick your identity provider (the reason we do this is so you don't have to go get an endorsement from someone to verify that you are who you are) - strongly suggest using ORCiD!

A screenshot of a web form titled "Select an Identity Provider". The form contains a dropdown menu with "ORCID" selected, a checkbox labeled "Remember this selection" which is unchecked, and a "Log On" button. Below the button, there is a small text line: "By selecting 'Log On', you agree to the [privacy policy](#)."

# SIGNING UP FOR SCIMMA P2.

- ▶ Click the + next to Credentials to create this and enter some description - you can have more than one for e.g. different surveys



- ▶ [hop.scimma.org](https://hop.scimma.org) will autogenerate a username and password for you - IMPORTANT - DOWNLOAD AS CSV! Save this someplace!

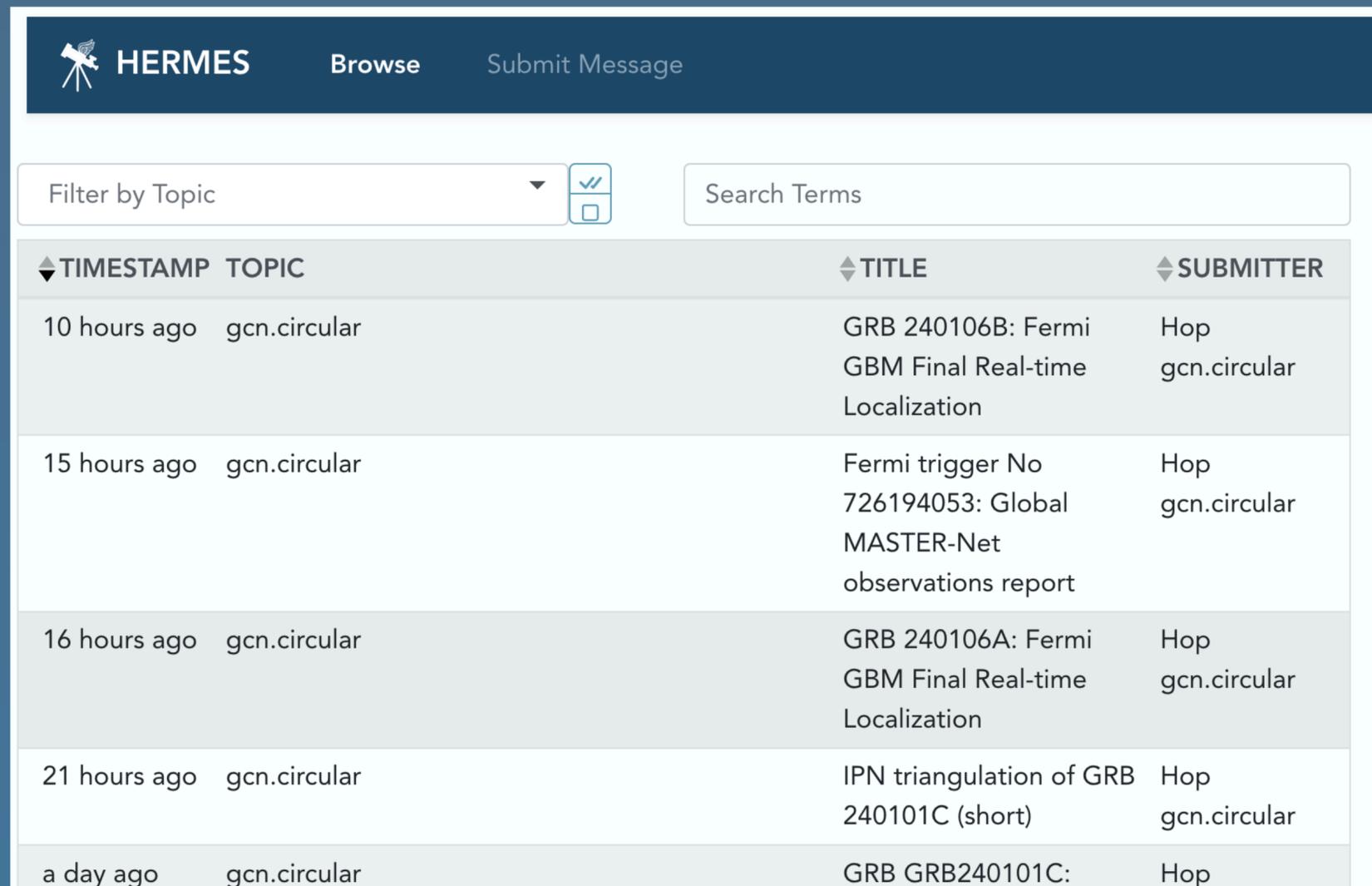
PLEASE READ. This information will only be displayed once. Please copy this information down and/or download it as a CSV file via the button below ✕

### Credential Information

Username	<input type="text" value="gsnarayan-d53b0515"/>	<input type="button" value="Copy to clipboard"/>
Password	<input type="text" value="kkOTh6IIFtLfL29hrU9vsDjbHRX4E2ZK"/>	<input type="button" value="Copy to clipboard"/>
		<input type="button" value="Download as CSV"/>

# SIGNING UP FOR SCIMMA P3.

- ▶ Your hop account will let you use HERMES - <https://hermes.lco.global>
  - ▶ Under the hood, HERMES will create a hop credential with your hop account, allowing it to post and read, which you can see back at <https://hop.scimma.org> - it says created by HERMES.
  - ▶ You can also have your TOM Toolkit do the same exact thing - so you can post e.g. TNS circulars from your TOM Toolkit



The screenshot shows the HERMES web interface. At the top, there is a dark blue header with the HERMES logo (a stylized bird) and the text "HERMES". To the right of the logo are two links: "Browse" and "Submit Message". Below the header is a white search bar with a dropdown menu labeled "Filter by Topic" and a search input field labeled "Search Terms". The main content area is a table with three columns: "TIMESTAMP", "TOPIC", and "TITLE", and a fourth column for "SUBMITTER". The table contains five rows of data, each representing a message posted to the hop network.

◆TIMESTAMP	TOPIC	◆TITLE	◆SUBMITTER
10 hours ago	gcn.circular	GRB 240106B: Fermi GBM Final Real-time Localization	Hop gcn.circular
15 hours ago	gcn.circular	Fermi trigger No 726194053: Global MASTER-Net observations report	Hop gcn.circular
16 hours ago	gcn.circular	GRB 240106A: Fermi GBM Final Real-time Localization	Hop gcn.circular
21 hours ago	gcn.circular	IPN triangulation of GRB 240101C (short)	Hop gcn.circular
a day ago	gcn.circular	GRB GRB240101C:	Hop

igwn.gwalert ✕



Search Terms

◆TIMESTAMP	TOPIC	◆TITLE	◆SUBMITTER
2 days ago	igwn.gwalert	S240104bl - UPDATE	cody.messick-30d512c8
2 days ago	igwn.gwalert	S240104bl - INITIAL	cody.messick-30d512c8
2 days ago	igwn.gwalert	S240104bl - PRELIMINARY	cody.messick-30d512c8
2 days ago	igwn.gwalert	S240104bl - PRELIMINARY	cody.messick-30d512c8
2 days ago	igwn.gwalert	S240104ao - PRELIMINARY	cody.messick-30d512c8
2 days ago	igwn.gwalert	S240104ao - PRELIMINARY	cody.messick-30d512c8
2 days ago	igwn.gwalert	S240104ah - PRELIMINARY	cody.messick-30d512c8
2 days ago	igwn.gwalert	S240104ah - PRELIMINARY	cody.messick-30d512c8
2 days ago	igwn.gwalert	S240104ae - PRELIMINARY	cody.messick-30d512c8
2 days ago	igwn.gwalert	S240104ae - PRELIMINARY	cody.messick-30d512c8

« < 1 2 3 4 ... > »

Show: 10 ▾

## S240104bl - INITIAL

Message ID: [c6f1cc7a](#) Superevent Messages: [S240104bl](#)

### URLS KEYPAIRS ≡

Key	Value
skymap	<a href="https://gracedb.ligo.org/api/superevents/S240104bl/files/bayestar.multiorder.fits,1">https://gracedb.ligo.org/api/superevents/S240104bl/files/bayestar.multiorder.fits,1</a>
gracedb	<a href="https://gracedb.ligo.org/superevents/S240104bl/view/">https://gracedb.ligo.org/superevents/S240104bl/view/</a>

### EVENT KEYPAIRS ≡

Key	Value
far	3.554967487258808e-17

[Submission Form](#)[API View](#)[Text View](#)**SUBMIT TO TNS AND GCN - 1 stop shop**Title: Topic: Event ID: Authors:  Submit to TNS  
 Submit to GCN**Targets****DATA IS VALIDATED!**

	Name	RA	Dec	New Discovery		
0	AT2024argh	230.15	<input type="text" value="-95.34"/>	<input type="checkbox"/>		

**Photometry**

	Target	Observation Date	Telescope	Instrument	Band	Brightness	Units	Error		
0	AT2024argh	01/05/2024	CTIO 4m	DECam	r	21.3	AB mag	0.2		

**UPLOAD CSV FILES WITH DATA**

# 3. INTEGRATING THIS WITH YOUR PIPELINES

## (DEMO)

# SIGNING UP FOR SCIMMA P4 – HOPSKOTCH

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- ▶ `conda create --name hop-venv python=3.10`
- ▶ `conda activate hop-venv`
- ▶ `conda install -c conda-forge hop-client`
- ▶ `hop auth add`
- ▶ (add your username and password)
- ▶ for hostname - you can listen to ANY kafka server e.g. [kafka.scimma.org](https://kafka.scimma.org)
- ▶ `hop list-topics kafka://kafka.scimma.org`
- ▶ `hop subscribe kafka://kafka.scimma.org/gcn.circular`
- ▶ `hop subscribe kafka://kafka.scimma.org/igwn.alert`

# HOPSKOTCH/TOM INTEGRATION

- ▶ Hopskotch carries GCNs and other public alerts
- ▶ Pulls machine readable info into a database with an API
- ▶ SCIMMA and LCO are making modules for the TOM Toolkit to display and filter GCNs
- ▶ This should work with future message formats
- ▶ Ultimately, also want to connect with AEON facilities this way

TOM Toolkit Home Targets Alerts Observations Data Users Admin User (admin) Logout

## SCIMMA Alerts

SCIMMA

Keyword Search: S190426

Right Ascension: Declination: Radius:

Start Date → End Date

Create targets from selected

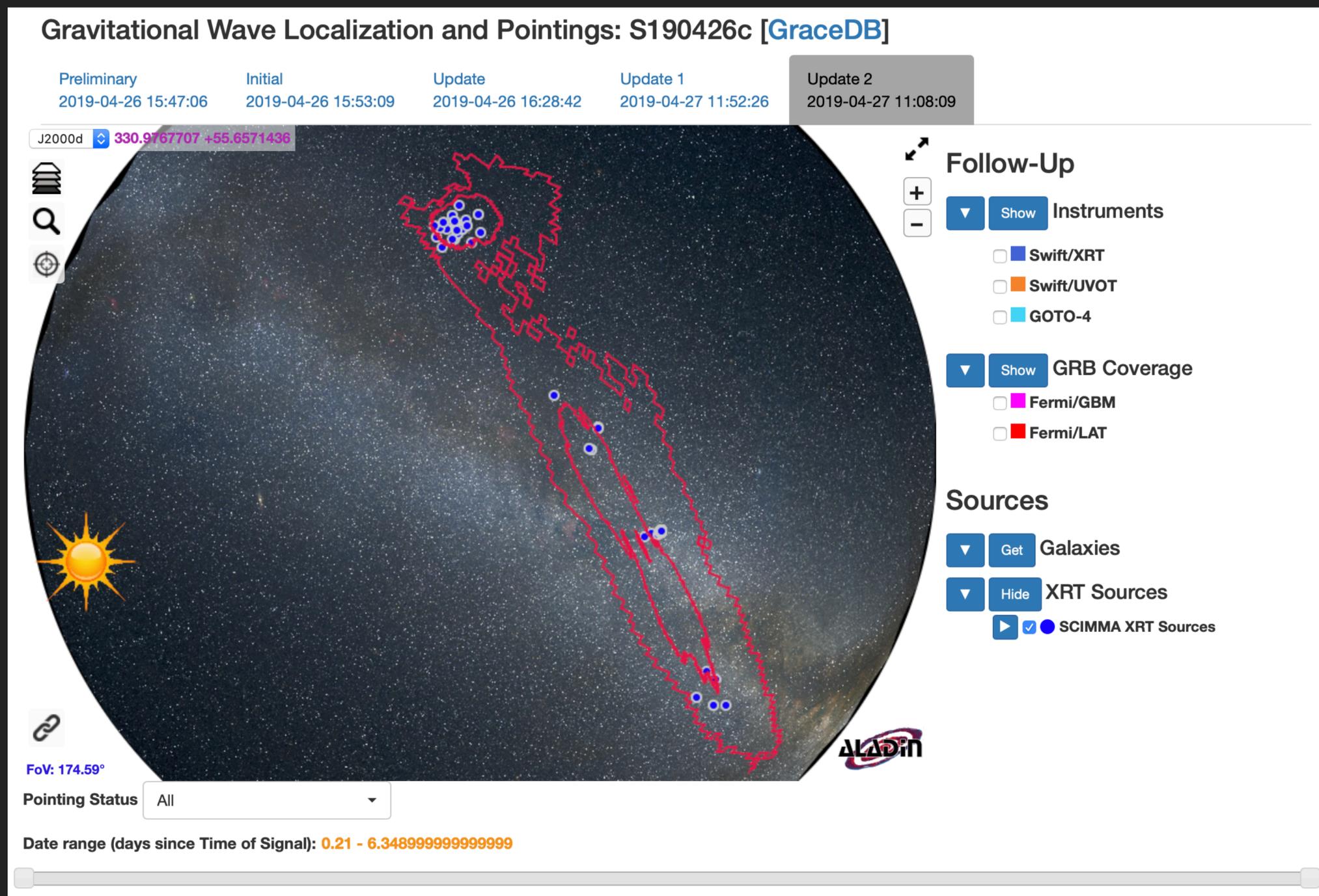
	Alert Identifier	Counterpart Identifier	Right Ascension	Declination	Rank	Comments
<input type="checkbox"/>	S190426_X5	1SXPS J144850.8-400845	14:48:50.784	-40:08:45.6	4	MAY match a known transient, will be checked manually.
<input type="checkbox"/>	S190426_X41	3XMM J195917.2+404514	19:59:17.88	40:45:03.24	4	
<input type="checkbox"/>	S190426_X39	3XMM J200002.0+404323	20:00:01.416	40:43:24.6	4	
<input type="checkbox"/>	S190426_X43		19:59:30.576	40:46:07.32	3	Warning flags were set: this may be a spurious detection.
<input type="checkbox"/>	S190426_X84		19:59:33.672	40:41:45.96	3	
<input type="checkbox"/>	S190426_X86		19:59:34.656	40:44:44.88	3	Warning flags were set: this may be a spurious detection.
<input type="checkbox"/>	S190426_X50		19:59:35.472	40:32:28.32	3	
<input type="checkbox"/>	S190426_X53		19:59:26.448	40:49:53.76	3	
<input type="checkbox"/>	S190426_X68	XMMSL2 J010227.0+815233	1:02:19.2	81:52:36.84	4	Warning flags were set: this may be a spurious detection.
<input type="checkbox"/>	S190426_X72	1RXH J195916.3+404648	19:59:16.512	40:47:02.04	4	Warning flags were set: this may be a spurious detection.
<input type="checkbox"/>	S190426_X88		19:59:19.128	40:43:36.84	3	Warning flags were set: this may be a spurious detection.
<input type="checkbox"/>	S190426_X93		0:10:36.672	85:08:41.64	3	
<input type="checkbox"/>	S190426_X102		0:27:50.832	84:16:34.68	3	
<input type="checkbox"/>	S190426_X115	1RXS J201518.9+560922	20:15:19.824	56:09:45.72	4	Warning flags were set: this may be a spurious detection.
<input type="checkbox"/>	S190426_X118	1SXPS J201516.9+560854	20:15:17.76	56:09:09	4	Warning flags were set: this may be a spurious detection.
<input type="checkbox"/>	S190426_X184		22:41:47.16	87:24:01.44	3	
<input type="checkbox"/>	S190426_X4		22:47:31.512	83:09:34.2	3	Warning flags were set: this may be a spurious detection.
<input type="checkbox"/>	S190426_X28		19:59:20.952	40:45:40.32	3	
<input type="checkbox"/>	S190426_X34		19:58:47.328	40:50:38.4	3	
<input type="checkbox"/>	S190426_X57		19:59:14.328	40:46:27.12	3	

« < 1 > »

# TREASURE MAP – HOPSKOTCH INTEGRATION

Wyatt et al. 2020, ApJ, 894, 127

<https://treasuremap.space/>



- ▶ X-ray sources are reported by Swift in GCN notices.
- ▶ When a GCN notice is carried through Hopskotch, the X-ray sources are extracted into a database
- ▶ Treasure map queries this database via API to report X-ray sources.
- ▶ Building the connections with TOM Toolkit and AEON automagically means we can keep Treasuremap updated in real-time.



Scimma-Alert-Bot APP 4:19 AM

Alert Type: EARLYWARNING

Superevent ID: S230918aq

Group: CBC

Event Time: 2023-09-18T11:19:41.162Z

Alert Time: 2023-09-18T11:19:36Z

FAR [1/yr]: 1.7098958325494311

Detectors: ['H1', 'L1']

Terrestrial : 0.209

BNS: 0.791

NSBH: 0.000

BBH: 0.000

Has NS: 1.000

Has Remnant: 1.000

Has Mass Gap: 0.000

Distance (Mean): 118.825 +/- 45.273 Mpc

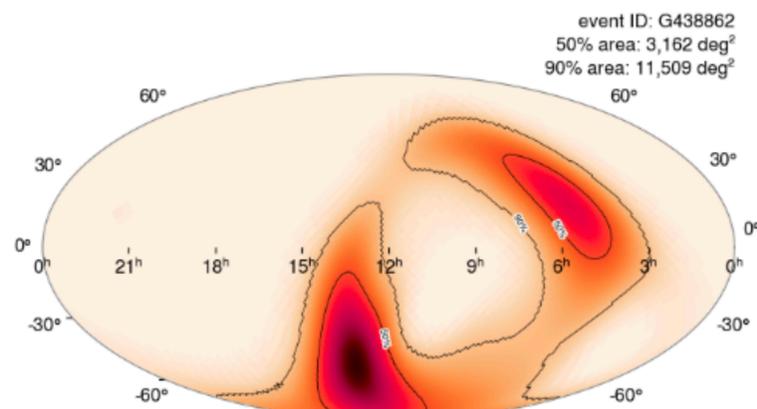
Distance modulus: 35.375

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Join related channel: [#s230918aq](#)

[Skymap Link](#) | [Grace DB](#)

(114 kB) ▾



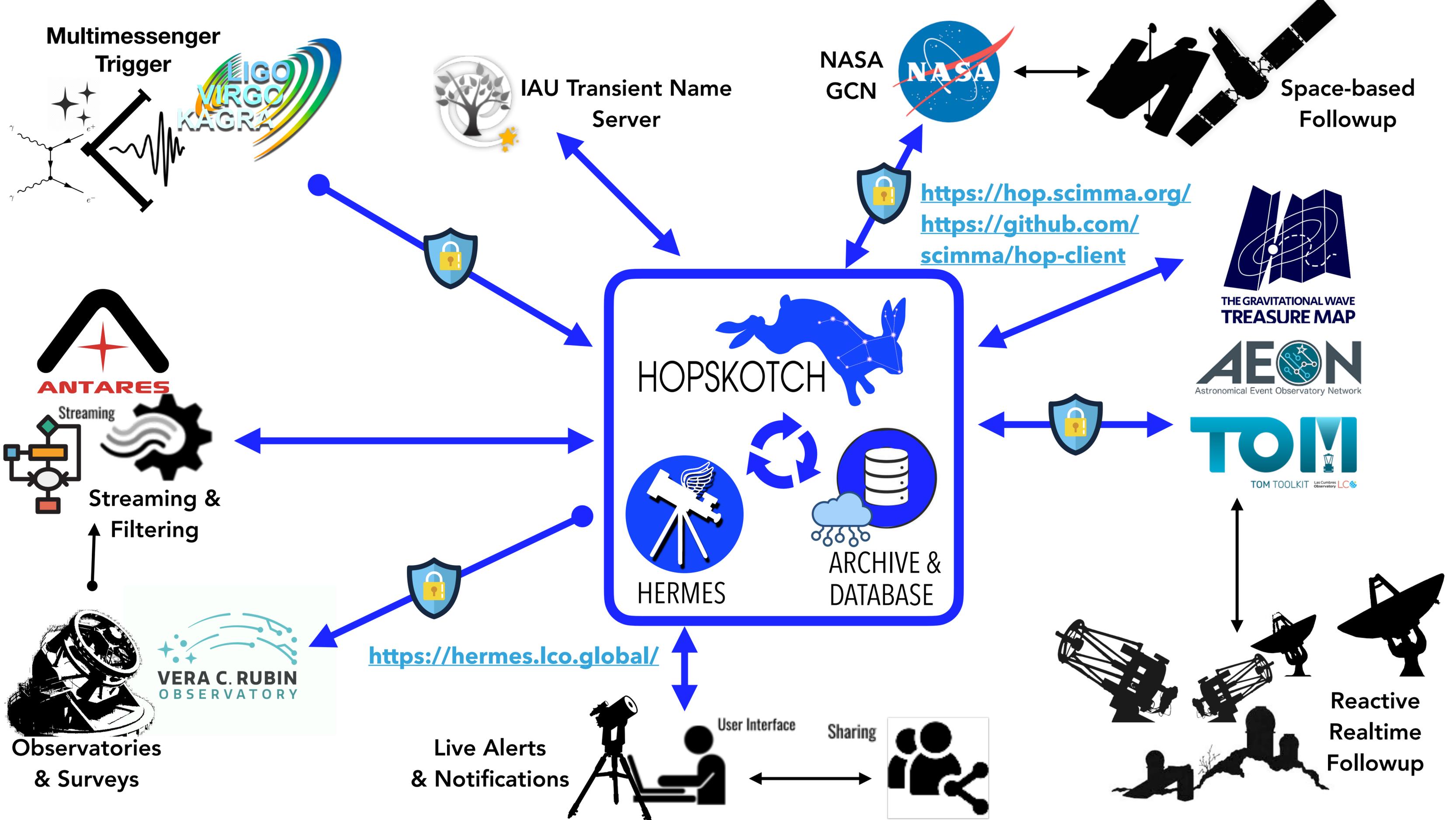
# BUILDING YOUR OWN APP AROUND HOPSKOTCH - A SIMPLE EXAMPLE

<https://github.com/scimma/hop-slack-app>

- ▶ It's now functionally possible to listen to Kafka messages with Hopskotch (e.g. LVK)
- ▶ Trigger the TOM Toolkit to get more photometry
- ▶ Report your followup observations to TNS, GCN and again as Kafka message on Hopskotch/HERMES
- ▶ Your colleague can listen to your messages, and trigger spectroscopic followup on Gemini



- ▶ Hopskotch can carry ANY message - not just science data - e.g. observatory status for your robotic telescope
- ▶ We're not far away from:
  - ▶ Listen to survey alerts from e.g. Rubin through a broker e.g. ANTARES (<https://antares.noirlab.edu>)
  - ▶ Use a RNN/CNN classifier to find, filter and characterize objects - send a hop message
  - ▶ Have your robotic telescope broadcast it's status as a hop message
  - ▶ Setup your TOM Toolkit to automatically trigger followup on your robotic telescope - broadcast a hop message when it's done
  - ▶ Trigger your pipeline to reduce and process the data - send a hop message
  - ▶ Use GPT4 to write a circular, submit to HERMES/TNS/GCN, and start an overleaf project.



FIN