multi-messenger Astronomy

definition

Multi-messenger astronomy is the observation of astronomical events through a variety of signals of different physical origin.

In the past, we could only observe the universe using visible light. Then, we moved to multi-wavelength astronomy with gamma rays, X-rays, UV rays and radio waves.

Today, we have access to a new form of observation with gravitational waves: the vibrations of space-time, emitted during violent events.

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HOW EVERYTHING STARTED ?

Einstein predicted the existence of gravitational waves in 1916

First experiments began in 1960s

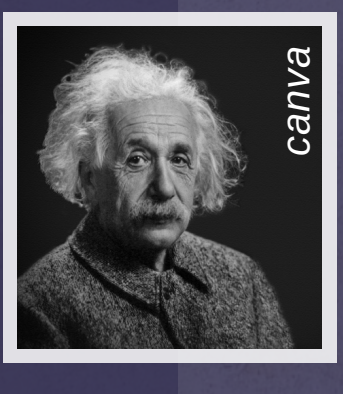
First indirect observation in 1990s

First direct detection in 2015

First multi-messenger event, combining gravitational waves and light in 2017

1916 - 2015

2017

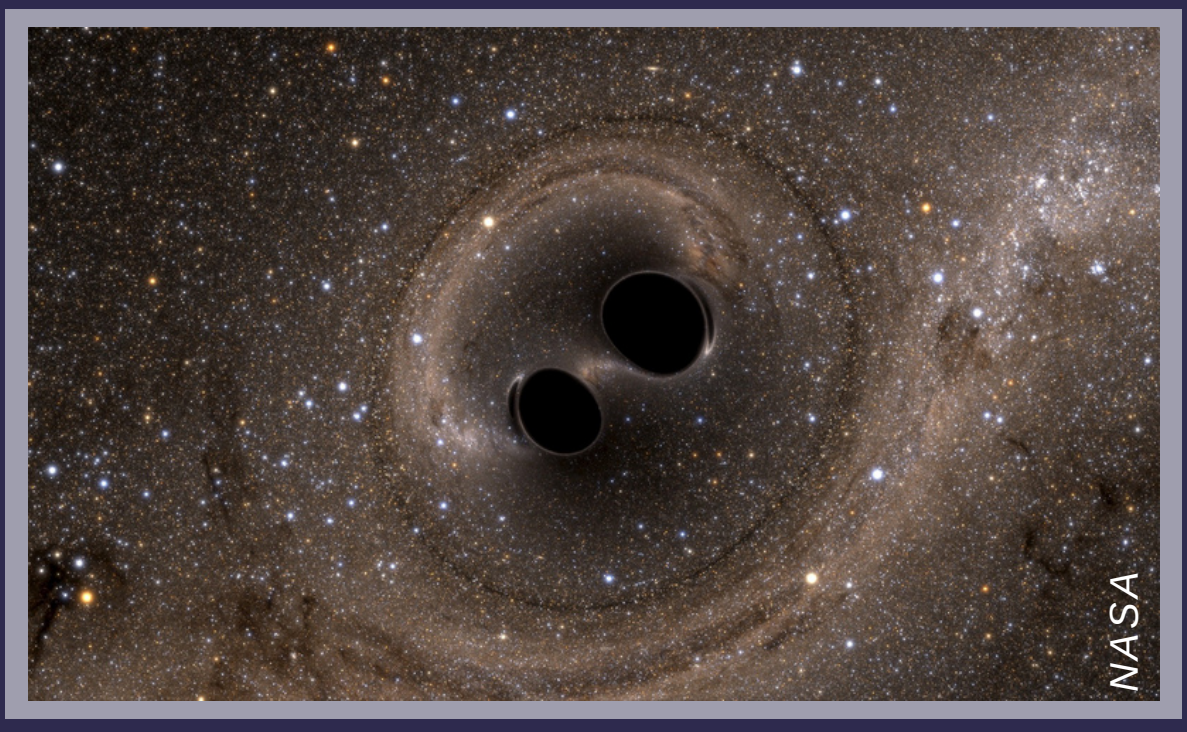


02

HOW DOES IT WORK ?

We are trying to observe the coalescences between two compact astronomical objects: black holes and neutron stars.

Coalescences occur when two of these objects enter the final orbits around each other until they collide and merge. This is when the emission of gravitational waves is at its peak.

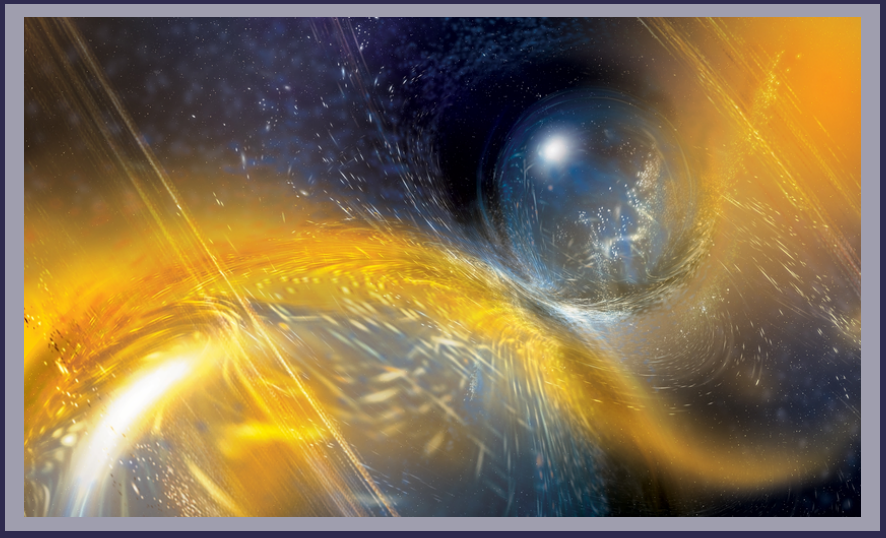


02

HOW DOES IT WORK ?

During and after collision, when there is at least one neutron star involved in a coalescence, there is the formation of heavy, unstable atomic nuclei by the capture of neutrons and protons, called the r-process.
As these new atomic nuclei are unstable, they will decay until stable atomic nuclei are formed. During this process, heavy elements such as gold are produced.

Kilonovae are manifestations of this radioactivity through the heat produced by the thermalized matter. They are between 1,000 and 10,000 times brighter than novae and between 10 and 100 times less luminous than supernovae.



02

HOW DOES IT WORK?

Current interferometers are tools composed of two orthogonal arms of several kilometers. As the wave passes, the optical path varies between the two arms, expanding in one direction and contracting in the other, depending on the orientation of the gravitational wave.

There are currently 4 of them working through the globe:
- Virgo: Cascina, Italy
- LIGO: Livingston, USA
- LIGO: Hanford, USA
- KAGRA: Mozumi, Japan

GEO600, outside of Hannover Germany, also serves as a test bed for the technology for these detectors.

By analyzing the wave's arrival time on those interferometers, it is possible to determine in which area of the sky the event occurred, by triangulation.

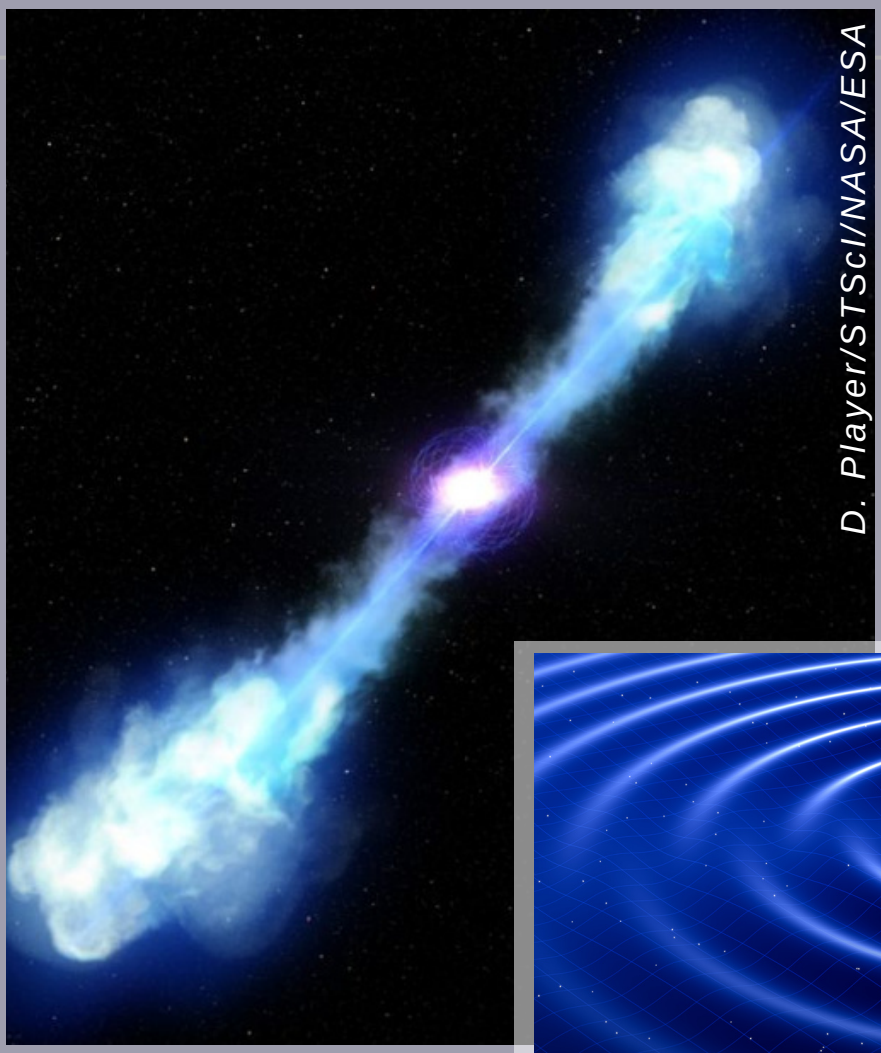
03

WHAT'S OUR GOAL ?

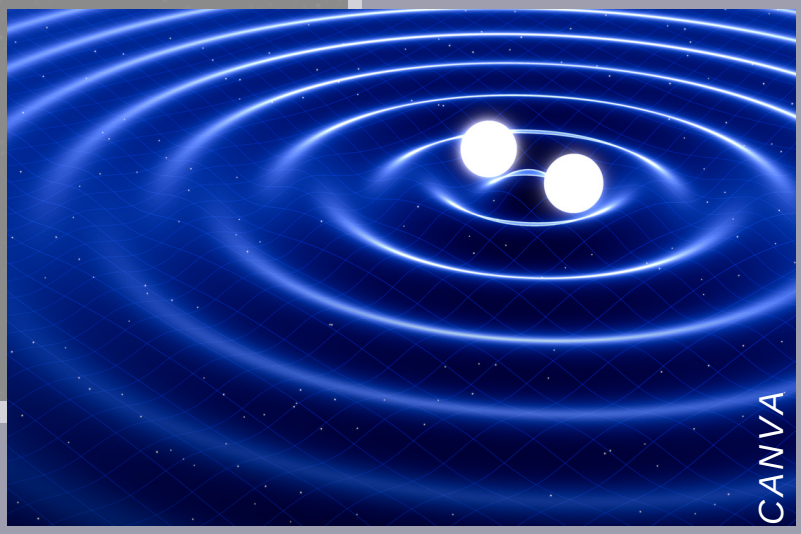
Studies of violent events permit us to have a new perspective of our Universe and its mechanisms, including its rate of expansion.

It also helps understand how heavy elements are synthesized and understand the physics at play in extreme condition where matter is ultra-condensed.

Fun fact: During 2017's event, it produced ~10 times Earth's mass in gold.



D. Player/STScI/NASA/ESA



CANVA

04

COMBINE IMAGE WITH SOUND

As soon as gravitational waves are detected, an alert is sent to all observers of the collaboration; we invite you to look for the electromagnetic signal associated with this event.

The light source’s brightness diminishes rapidly so we must react quickly.

welcome

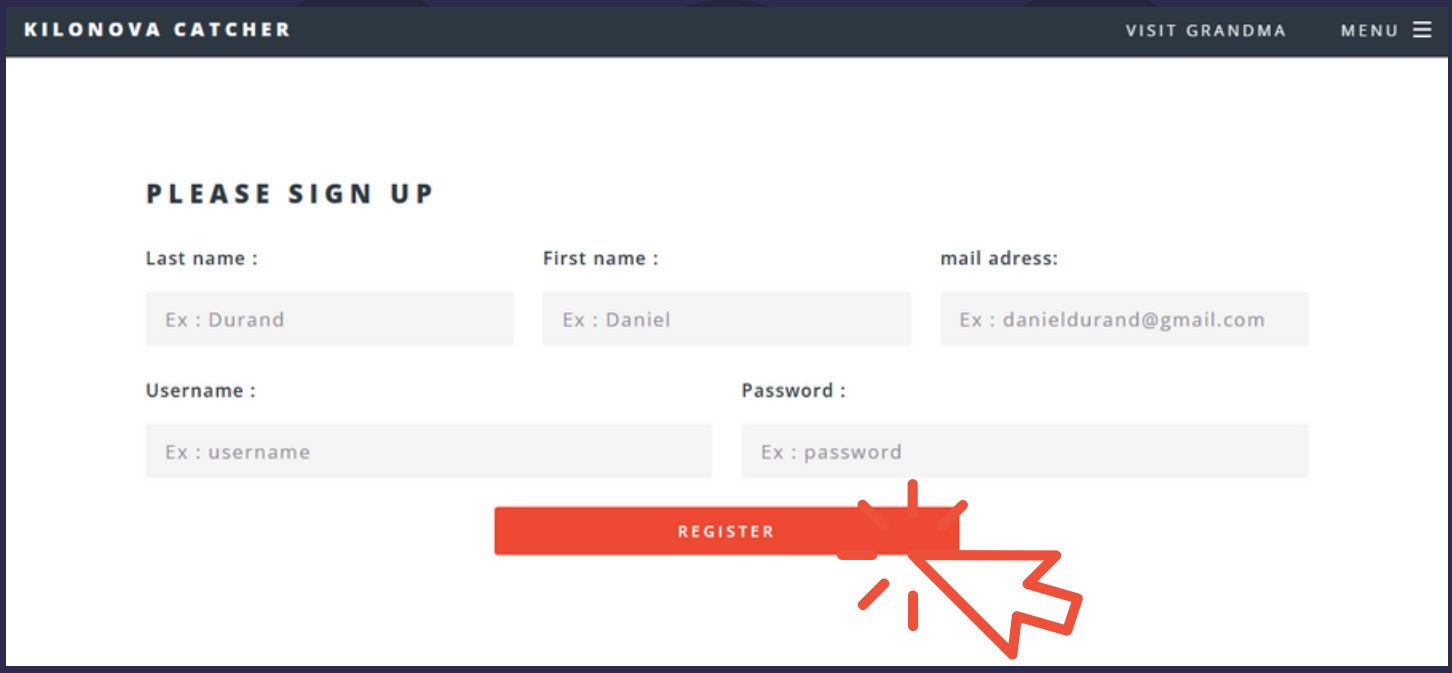
04

Before joining us and becoming one of our contributors, you need to complete a few steps.

1 JOIN KILONOVACATCHER

http://kilonovacatcher.in2p3.fr/

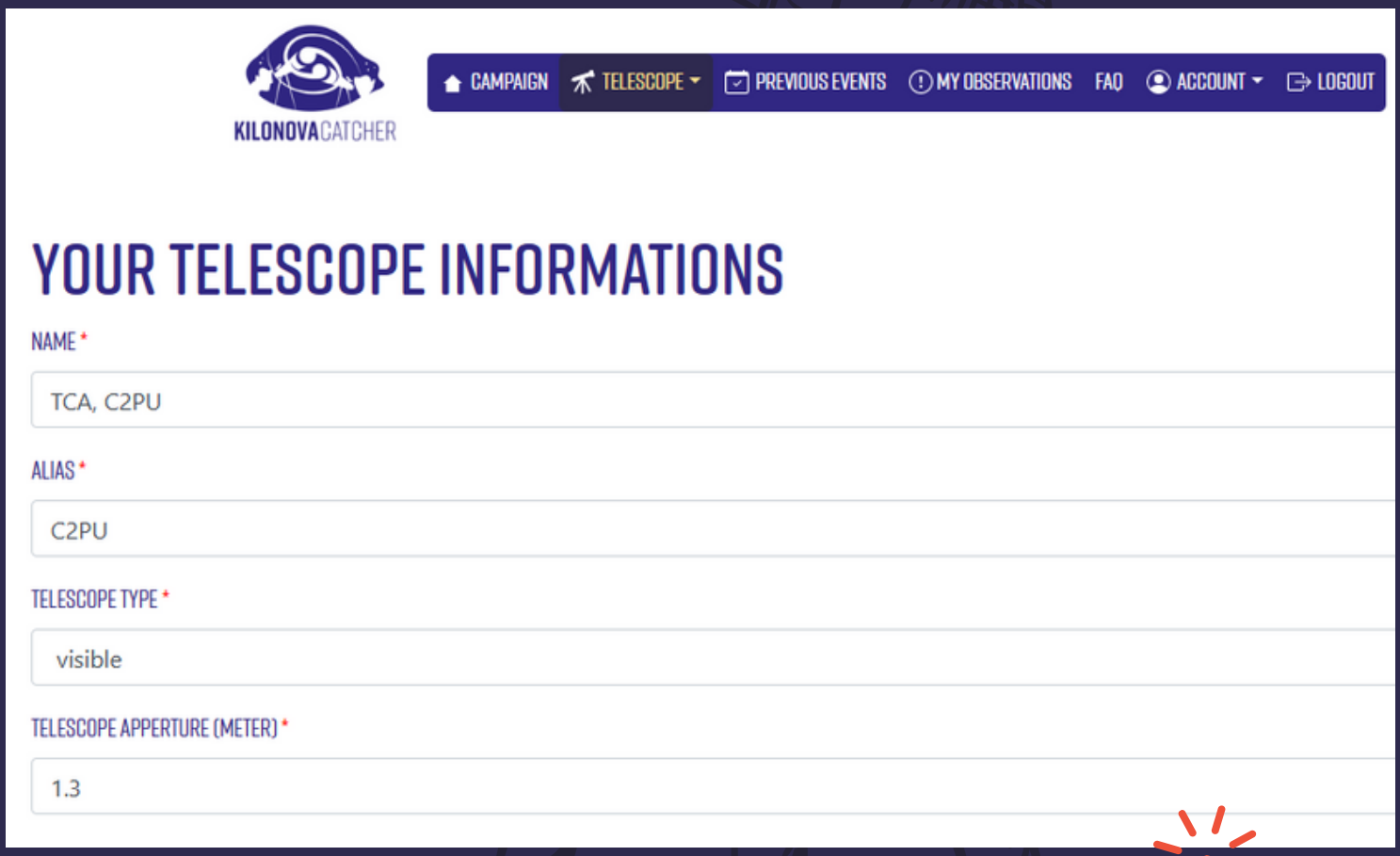
Choose your username and password



Verify your account through the link sent at your email

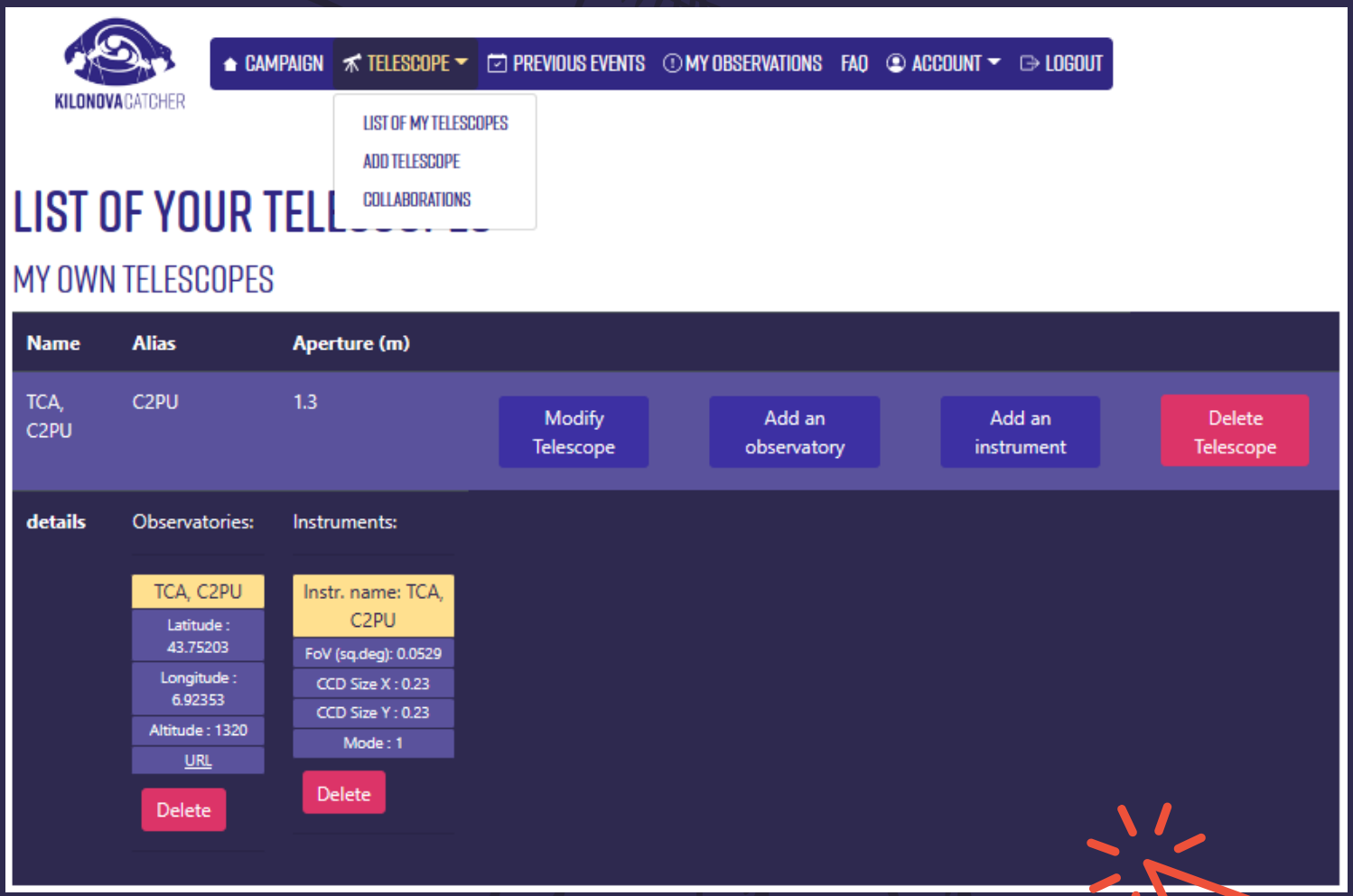
2 REGISTER YOUR TELESCOPE

- Tab "telescope"
- Tab « add telescope »



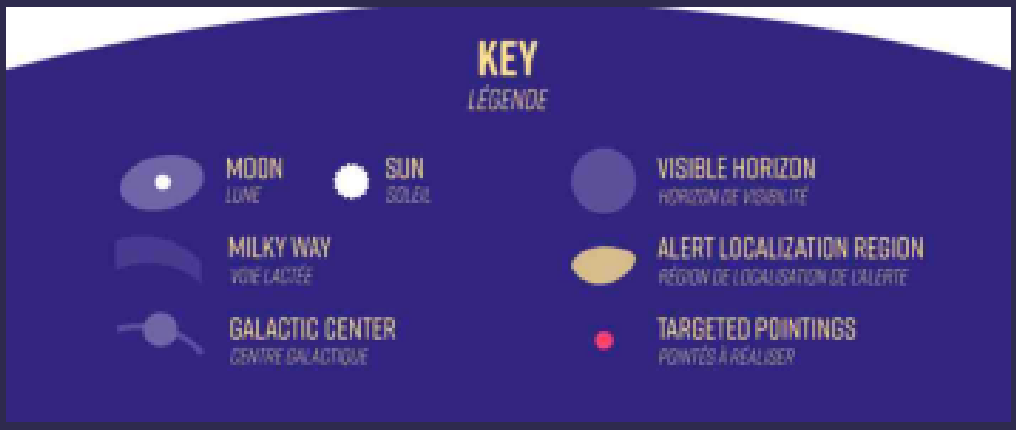
2 REGISTER YOUR TELESCOPE

- Tab "telescope"
- "list of my telescopes"



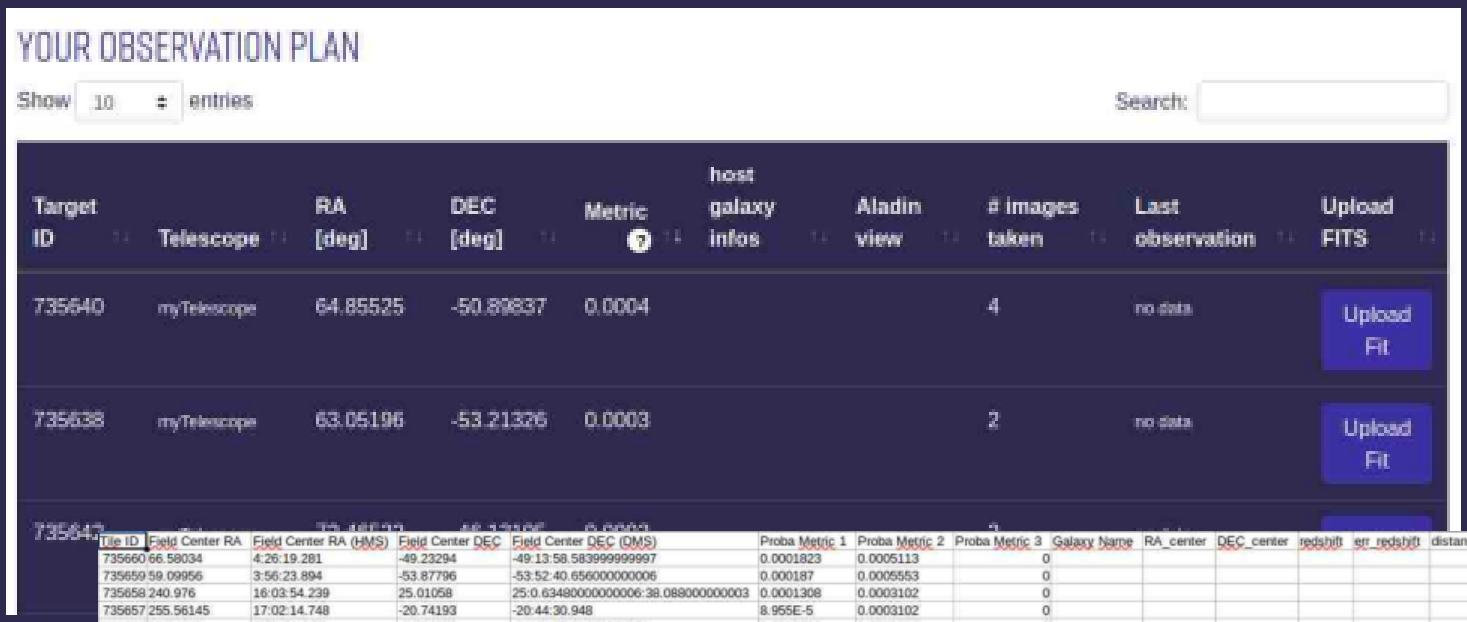
3 RECEIVE YOUR ALERTS

- In case of an alert: you will receive the sky map of the gravitational wave's location



3 RECEIVE YOUR ALERTS

- You will also receive an observation plan corresponding to your telescope's field of view. These will either be targets corresponding to the most likely galaxies to host the event or a transient source that may be the source of the event.



YOUR OBSERVATION PLAN

Show 10 entries

Search:

Target ID	Telescope	RA [deg]	DEC [deg]	Metric	host galaxy infos	Aladin view	# images taken	Last observation	Upload FITS
735640	myTelescope	64.85525	-50.89837	0.0004			4	no data	Upload Fit
735638	myTelescope	63.05196	-53.21326	0.0003			2	no data	Upload Fit

Tile ID	Field Center RA	Field Center RA (HMS)	Field Center DEC	Field Center DEC (DMS)	Proba Metric 1	Proba Metric 2	Proba Metric 3	Galaxy Name	RA_center	DEC_center	redshift	err_redshift	distance
735660	66.58034	4:26:19.281	-49.23294	-49:13:58.583999999997	0.0001823	0.0005113	0						
735659	59.09956	3:56:23.894	-53.87796	-53:52:40.656000000006	0.000187	0.0005553	0						
735658	240.976	16:03:54.239	25.01058	25:0.63480000000006:38.088000000003	0.0001308	0.0003102	0						
735657	255.56145	17:02:14.748	-20.74193	-20:44:30.948	8.955E-5	0.0003102	0						
735656	75.64349	5:02:34.437	-44.74092	-44:44:27.31200000001	0.0002276	0.0003982	0						
735655	55.49924	3:41:59.817	-38.03237	-38:1:56.532000000001	7.04E-5	0.0002594	0						
735654	63.88172	4:15:31.612	-52.71168	-52:42:42.048000000004	0.0002514	0.0004696	0						
735653	59.59738	3:58:23.371	-52.42978	-52:25:47.208000000003	0.0001812	0.0002779	0						
735652	82.66754	5:30:40.209	-33.38784	-33:23:16.223999999989	0.0001035	0.0002901	0						
735651	252.38817	16:49:33.160	6.01625	6:0.97500000000002:58.500000000001	0.0001341	0.0004811	0						
735650	246.11432	16:24:27.436	19.48258	19:28.9548:57.287999999995	9.863E-5	0.0004158	0						
735649	243.741	16:14:57.840	21.93831	21:56.2986:17.916000000005	0.0001357	0.0004151	0						
735648	56.39412	3:45:34.588	-54.528	-54:31:40.799999999995	0.0002074	0.0003489	0						
735647	82.07702	5:28:18.484	-35.98862	-35:59:19.031999999991	0.0001431	0.0002601	0						
735646	72.46522	4:49:51.652	-46.13195	-46:7:55.020000000012	0.0002639	0.0003383	0						
735645	70.64703	4:42:35.287	-47.49878	-47:29:55.607999999987	0.000119	0.0002982	0						
735644	75.35506	5:01:25.214	-44.88061	-44:52:50.19599999999	0.0002387	0.0005722	0						
735643	56.79628	3:47:11.107	-54.58789	-54:35:16.404000000006	0.0002016	0.0003965	0						
735642	72.46522	4:49:51.652	-46.13195	-46:7:55.020000000012	0.0002639	0.0003383	0						
735641	89.3494	5:57:23.856	-18.50941	-18:30:33.875999999997	5.517E-5	0.0002819	0						
735640	64.85525	4:19:25.259	-50.89837	-50:53:54.132	0.0003664	0.001464	0						
735639	83.59763	5:34:23.431	-30.80098	-30:48:3.527999999969	9.457E-5	0.000527	0						
735638	63.05196	4:12:12.470	-53.21326	-53:12:47.735999999994	0.0002397	0.0002847	0						
735637	78.689	5:14:45.359	-14.44864	-14:26:55.103999999997	0.0001244	0.000282	0						
735636	252.08989	16:48:21.573	6.22276	6:13.3656:21.936	0.0001245	0.0005066	0						

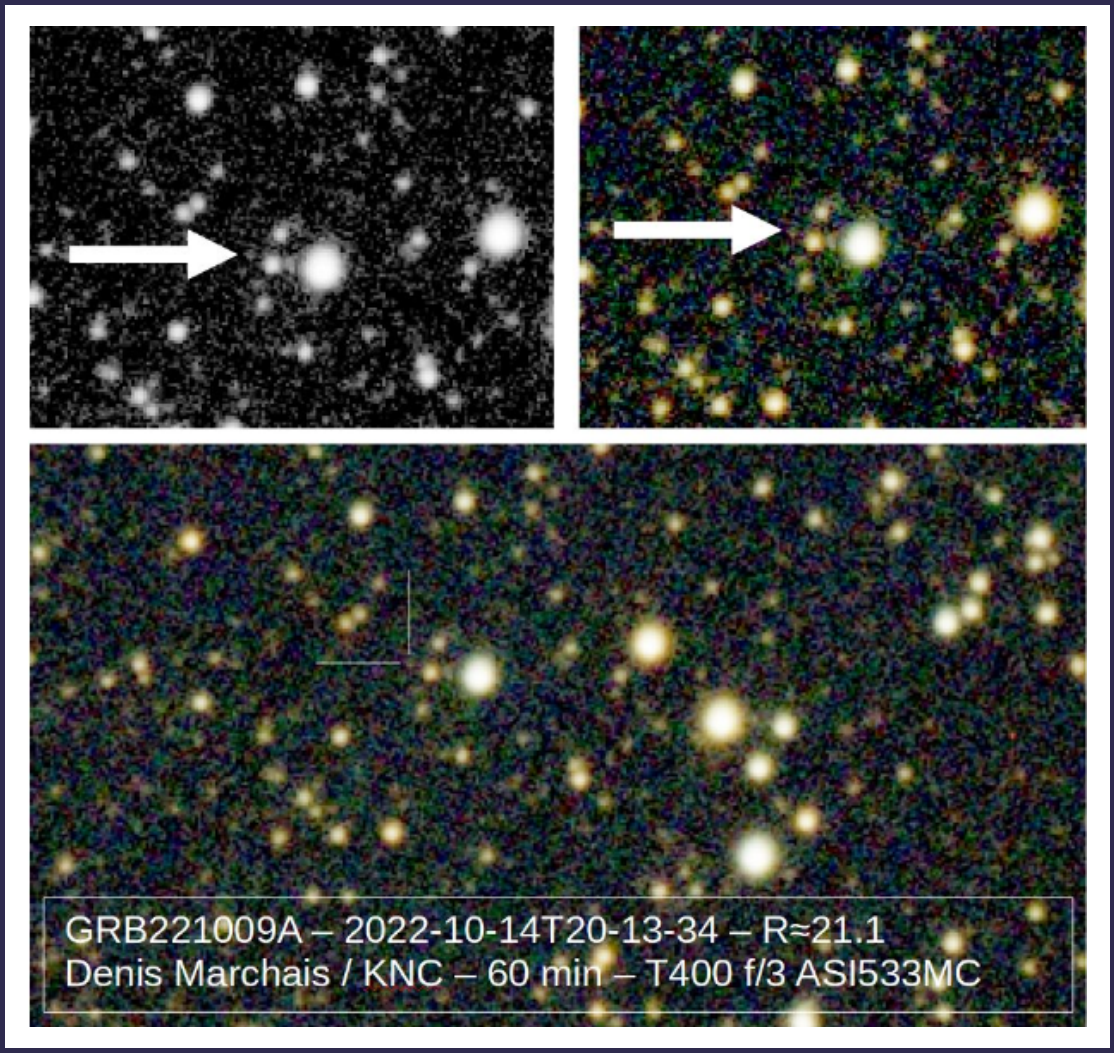
4 SHARE YOUR IMAGES FEW RULES

- We favor stacked images if you have taken several images during the hour of observation of a target
- With the best signal-to-noise ratio: SNR
- Only images in FITS format

- Always pre-process your images : apply dark and bias (flats preferred but optional) and calibrate them
- File name without spaces or "+" or "-" and without accents
- Always check that you are uploading the image for the right target (this can be tricky if there are many targets, so please double check)

To ensure that we can use your images, use this tool before sending it along. This will ensure astrometric calibration if possible.

HTTPS://NOVA.ASTROMETRY.NET/UPLOAD



Above, we have an image by one of our participating amateur astronomers of the gamma-ray burst GRB221009A that has been observed around the world since October 9, 2022.

This is a very rare event resulting from the collapse of a massive star into a neutron star or into black hole.

Although we were not able to detect the event's gravitational waves, as the gravitational wave detectors are being upgraded, we have here an example of what kind of observations we expect from you.

In total, astronomers from the kilonova-catcher project have sent us more than 200 images, invaluable sources of information to study the genesis of black holes.

KILONOVA CATCHER AND GRANDMA'S COLLABORATION

Map of GRANDMA's affiliated telescopes

Kilonova Catcher is a platform developed by GRANDMA's network in collaboration with Université Paris Cité.

It allows all astronomers, amateurs or not, to contribute to the observation of gravitational waves, in order to optimize all our resources in favor of gravitational wave astronomy.

The multi-messenger event on August 17, 2017 mobilized more than 70 ground-based and space-based telescopes, including Hubble.

MEET OUR TEAM

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GRANDMA and Kilonova-catcher are supported by :