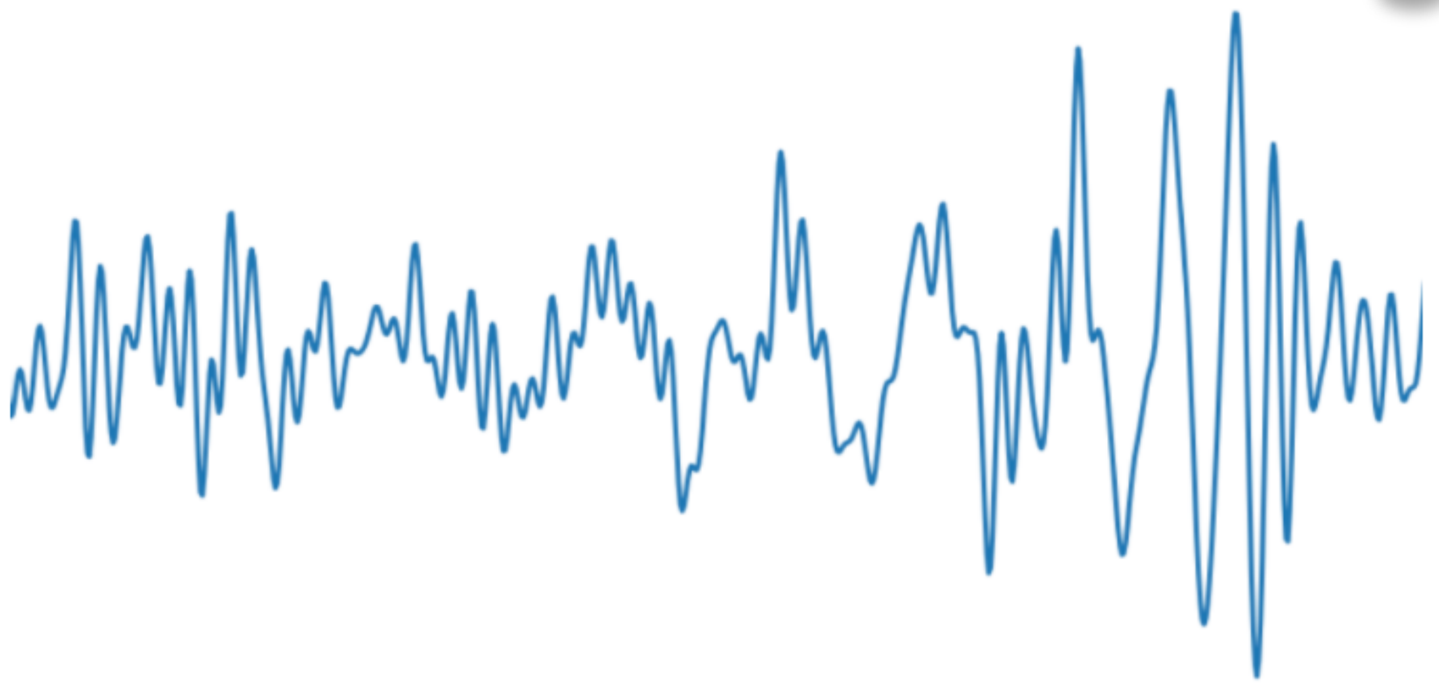
GW and EM follow-up: working with sky map tools

Giuseppe Greco
INFN - Perugia



LIGO - Virgo Collaboration

Gravitational Wave

Open Data Workshop #4

May 10 - 14, 2021

Findable Accessible Interoperable Reusable

ESCAPE
European Science Cluster of Astronomy & Particle physics ESFRI research Infrastructures

EGO VIRGO

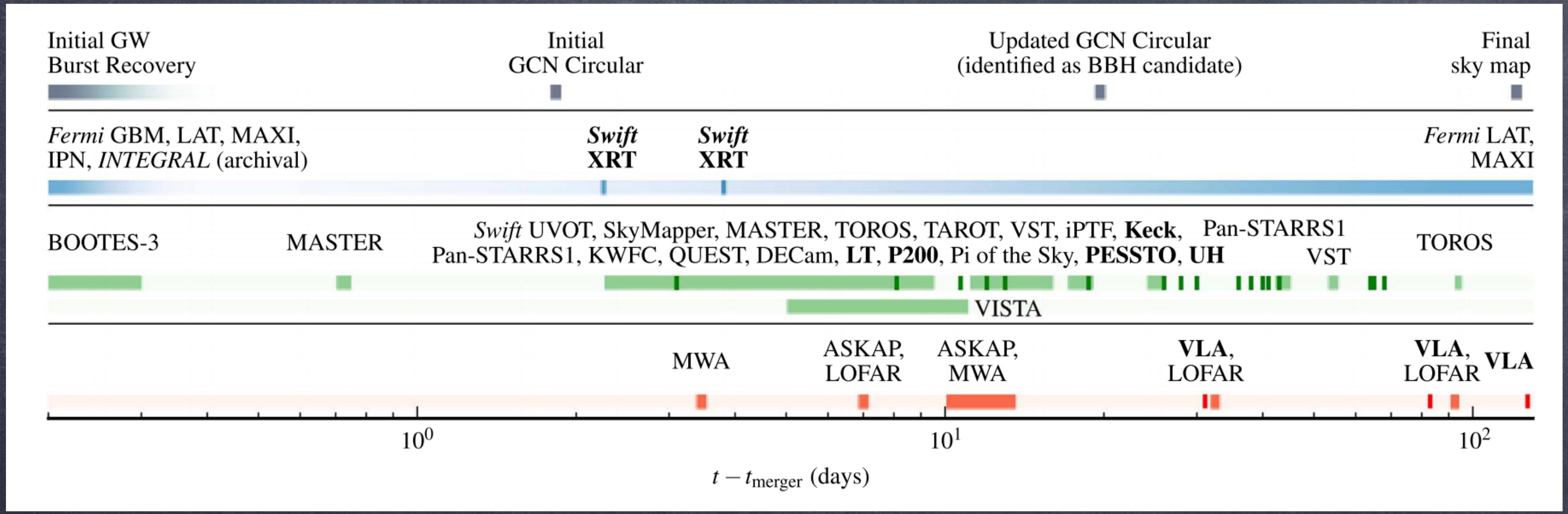
AHEAD 2020

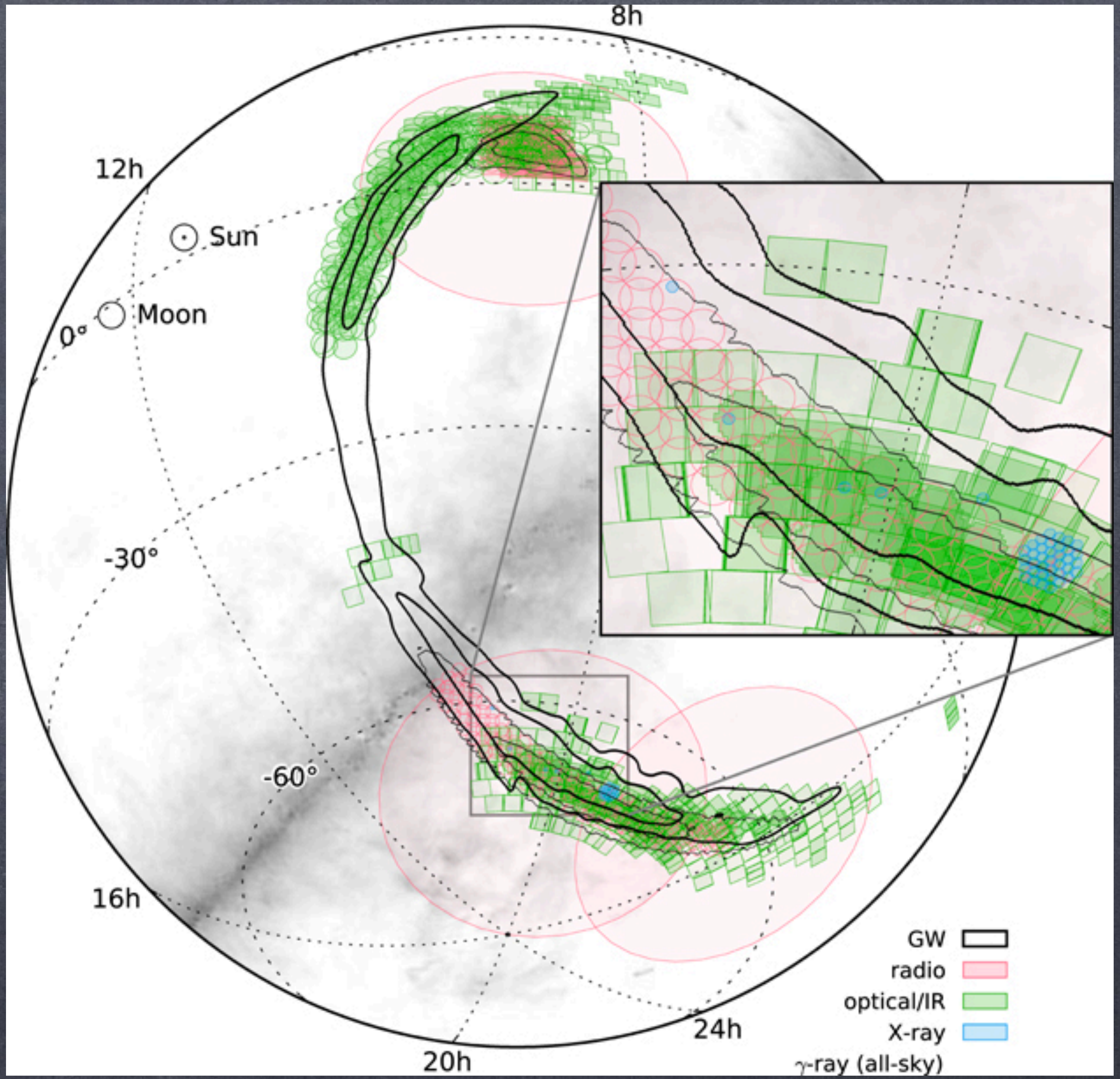
FOLLOW-UP OF THE GRAVITATIONAL-WAVE TRANSIENT GW150914

LVC, The Astrophysical Journal Letters, 2016.

Footprints of observations in comparison with the 50% and 90% credible levels of the initially distributed GW localization maps.

Timeline of observations of GW150914

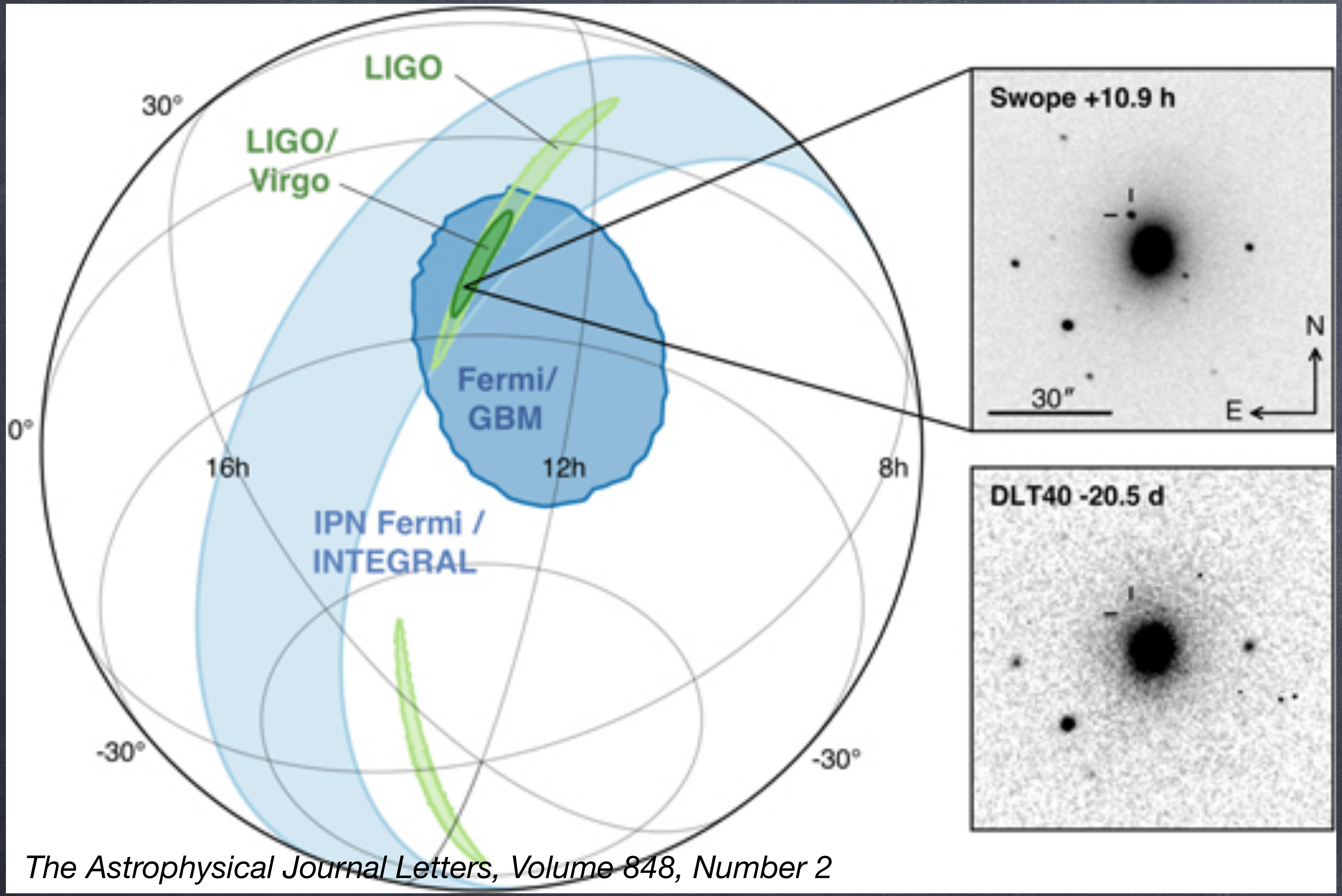




Twenty-five participating teams of observers responded to the GW alert to mobilize satellites and ground-based telescopes.

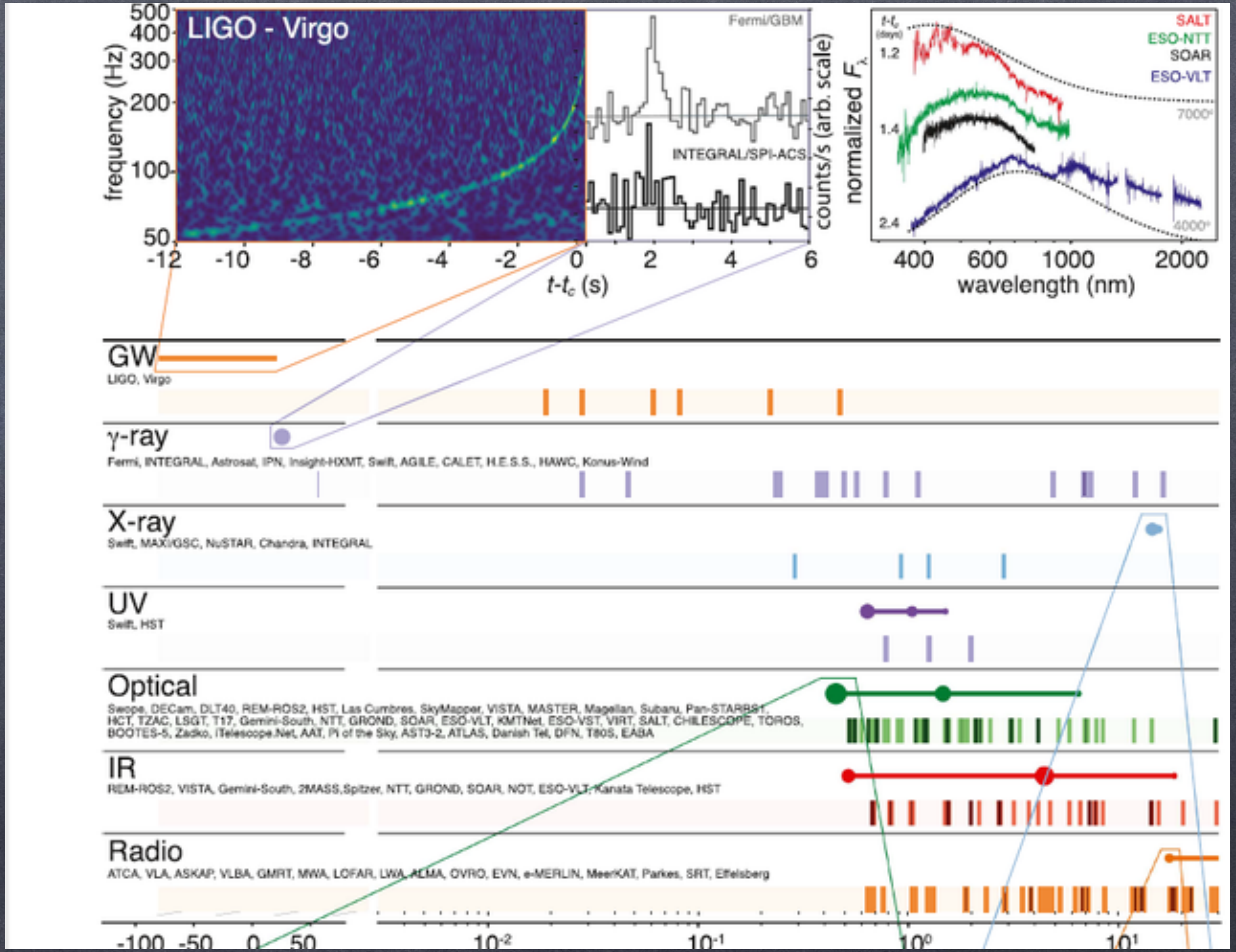
Multi-messenger Observations of a Binary Neutron Star Merger

Localization of the gravitational-wave, gamma-ray, and optical signals.



The Astrophysical Journal Letters, Volume 848, Number 2

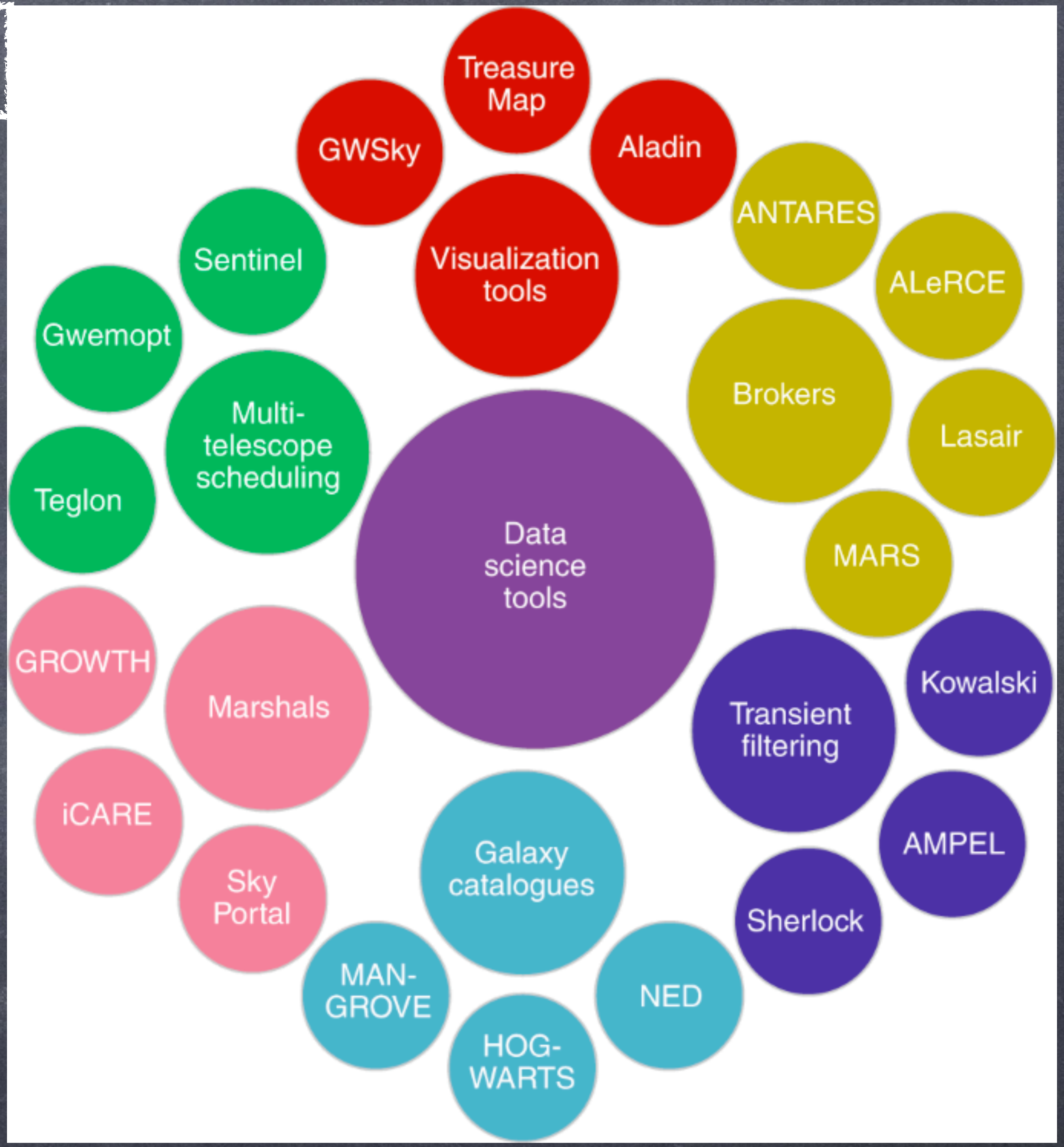
Timeline of the discovery of GW170817, GRB 170817A, and SSS17a/AT 2017gfo.



Development of Multi-Messenger Tools

Example data science tools employed during O3

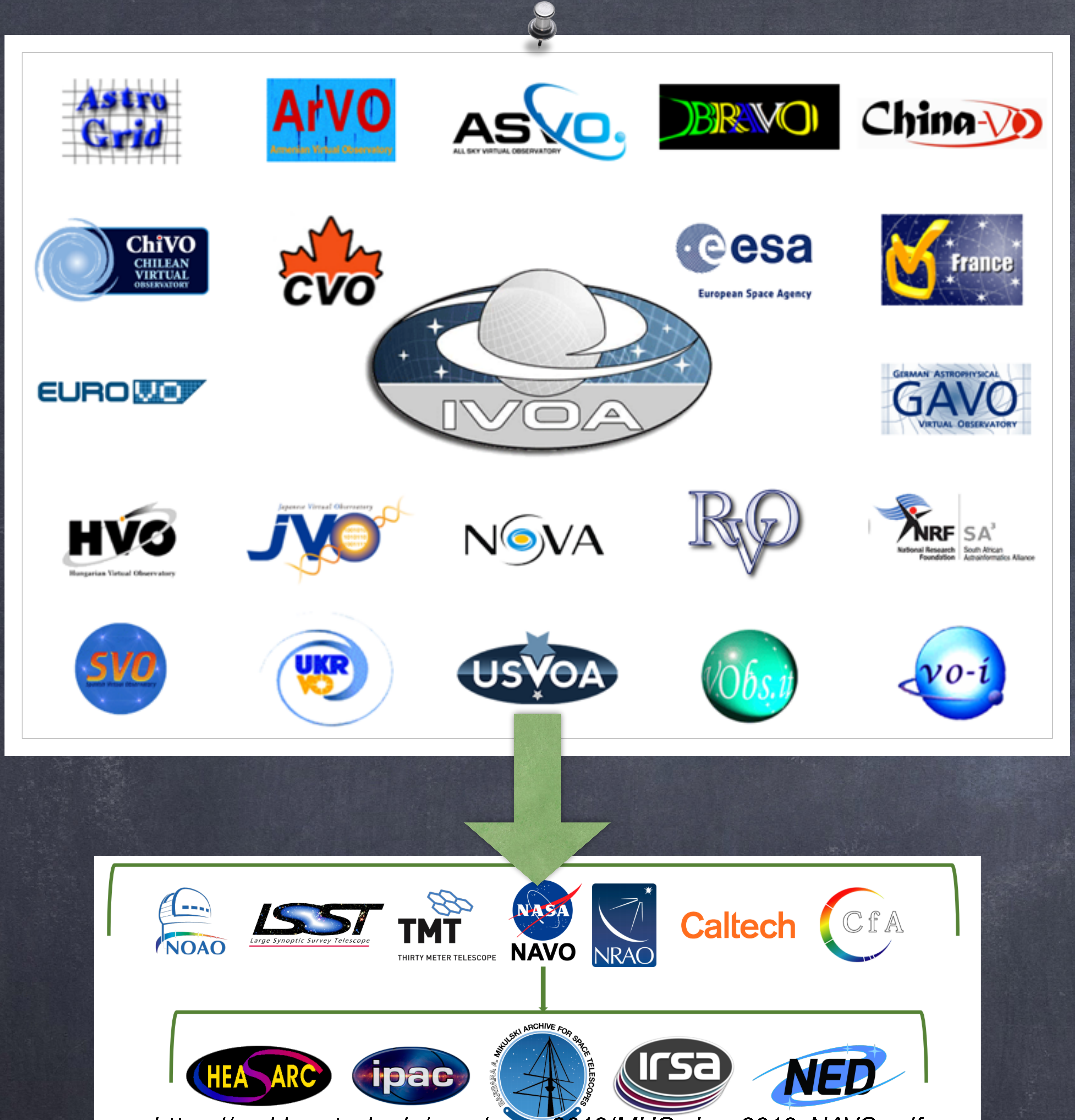
Telescope scheduling and infrastructure (such as GROWTH's target of opportunity marshal, GRANDMA's iCARE pipeline, GOTO's sentinel, and Swope's teglon), galaxy targeting focused toolkits (such as MANGROVE or HOGWARTS), modules for light-curve filtering (for example, Kowalski, AMPEL and Sherlock), visualization tools (like TreasureMap and Aladin), and alert brokers (such as Lasair and ANTARES) are part of the ecosystem of data science tools supporting this science.



From *Lessons from counterpart searches in LIGO and Virgo's third observing campaign, M.W. Coughlin, Nature Astronomy, 2020.*

Findable
Accessible
Interoperable
Reusable

Good Ingredients for Open Science


Astro Grid
ArVO
ASVO
BRAVO
China-VO
ChiVO Chilean Virtual Observatory
CVO
esa European Space Agency
France
EURO VO
IVOA
German Astrophysical GAVO Virtual Observatory
HVO Hungarian Virtual Observatory
JVO
NOVA
RVO
NRF SA³
SVO
UKR VO
USVOA
VObs.it
vo-i
NOAO
LSST Large Synoptic Survey Telescope
TMT Thirty Meter Telescope
NASA
NAVO
NRAO
Caltech
CfA
HEASARC
ipac
Barbara A. Mikulski Archive for Space Telescopes
MAST
IRSA
NED

https://archive.stsci.edu/mug/mug_2018/MUG_Jan_2018_NAVO.pdf

The Virtual Observatory (VO) is a collective term referring to an ecosystem of **standards** and the organizations and tools which use those standards.

VO standards are defined by the International Virtual Observatory Alliance (IVOA) which is composed of nation-level organizations.

Good Ingredients to be FAIR!

Data Exploration and Visualization

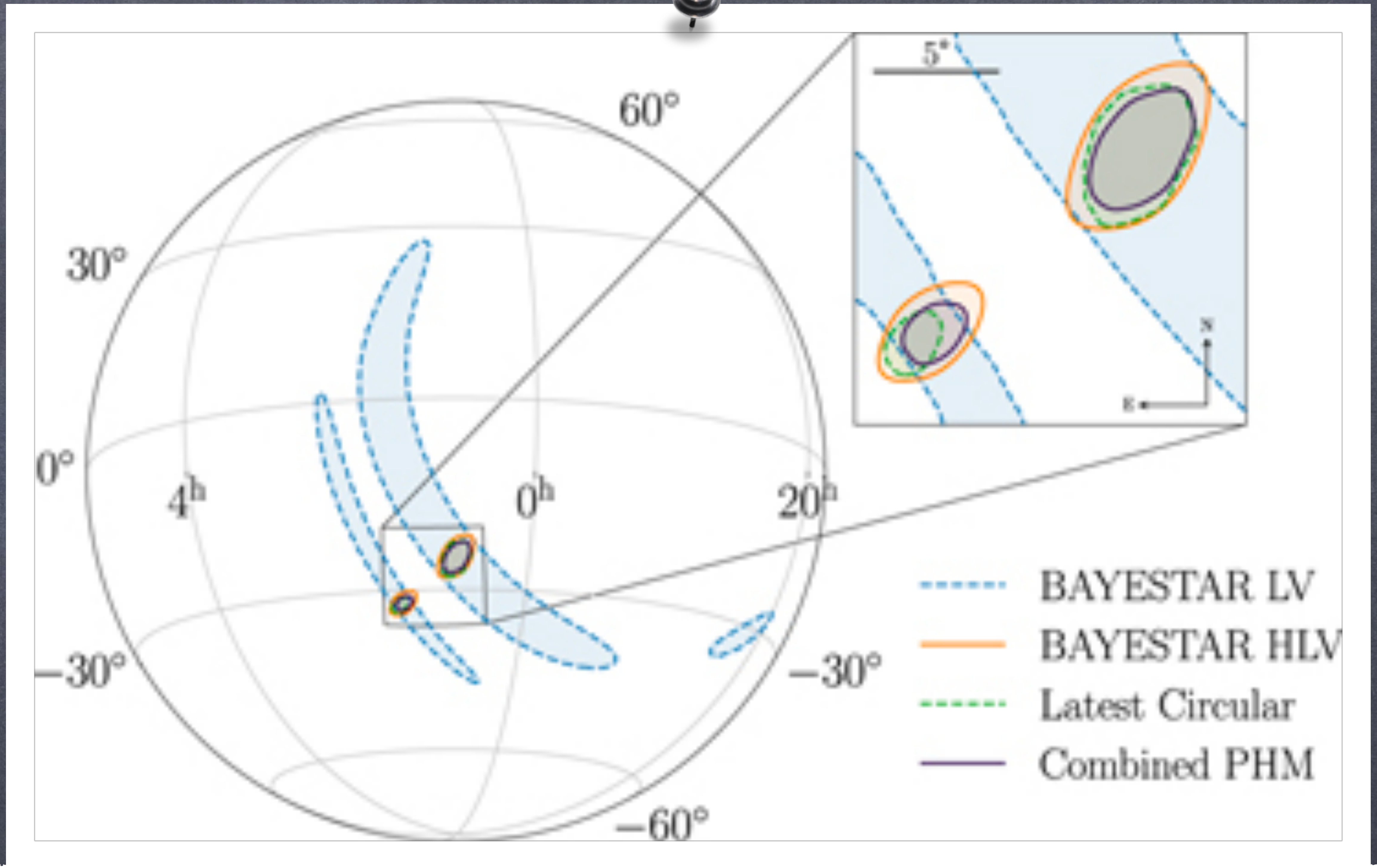
- Aladin Desktop ALADIN VizieR SIMBAD
- ligo.skymap - powered by matplotlib
- mocpy - powered by matplotlib

The Astropy Project

Practical Examples and Applications…

Sky localization of GW190814

The contours show the 90% credible interval for a LIGO Livingston–Virgo (blue) and LIGO Hanford–LIGO Livingston–Virgo (orange) detector network based on the rapid localization algorithm BAYESTAR (Singer & Price 2016). The sky localization circulated 13.5 hr after the event, based on a LIGO Hanford–LIGO Livingston–Virgo analysis with the LALInference software (Veitch et al. 2015), is shown in green. The purple contour indicates the final sky localization which constrains the source to within 18.5 deg2 at 90% probability.



GW190814: Gravitational Waves from the Coalescence of a 23 Solar Mass Black Hole with a 2.6 Solar Mass Compact Object. The Astrophysical Journal Letters, Volume 896, Number 2.

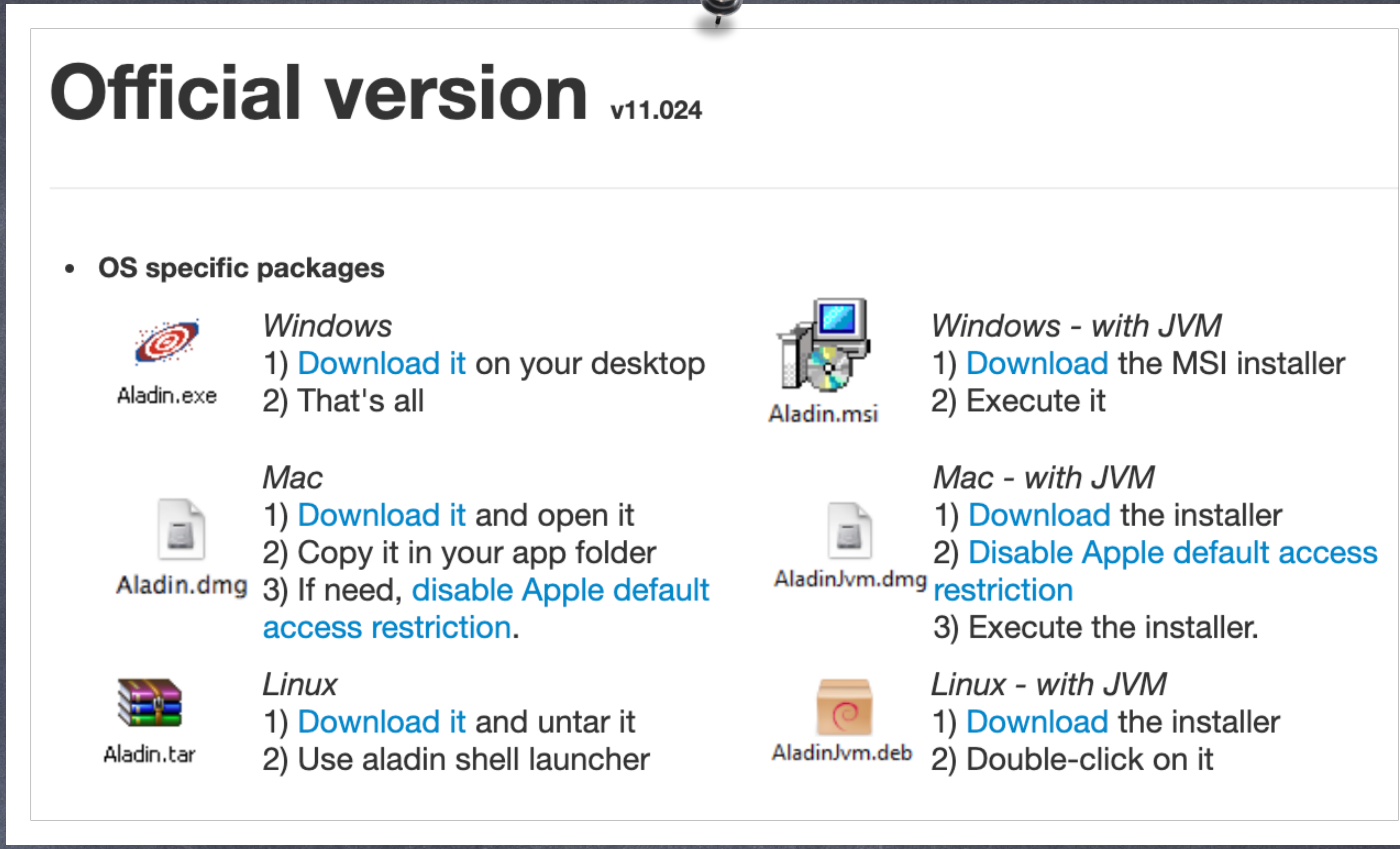
Aladin Desktop

Download instructions

Developed in Java, Aladin Desktop is able to run on any configuration: **Windows, Mac, Linux, etc.**

As any Java tool, Aladin Desktop requires a **Java Virtual Machine** on your machine.

You can increase the maximum memory size used by your Java runtime environment by following the instructions below.



Official version v11.024

- **OS specific packages**

Aladin.exe

Windows
1) Download it on your desktop
2) That's all

Aladin.msi

Windows - with JVM
1) Download the MSI installer
2) Execute it

Aladin.dmg

Mac
1) Download it and open it
2) Copy it in your app folder
3) If need, disable Apple default access restriction.

AladinJvm.dmg

Mac - with JVM
1) Download the installer
2) Disable Apple default access restriction
3) Execute the installer.

Aladin.tar

Linux
1) Download it and untar it
2) Use aladin shell launcher

AladinJvm.deb

Linux - with JVM
1) Download the installer
2) Double-click on it

Download the Aladin.jar from the Aladin download page. Execute it from a terminal by typing:

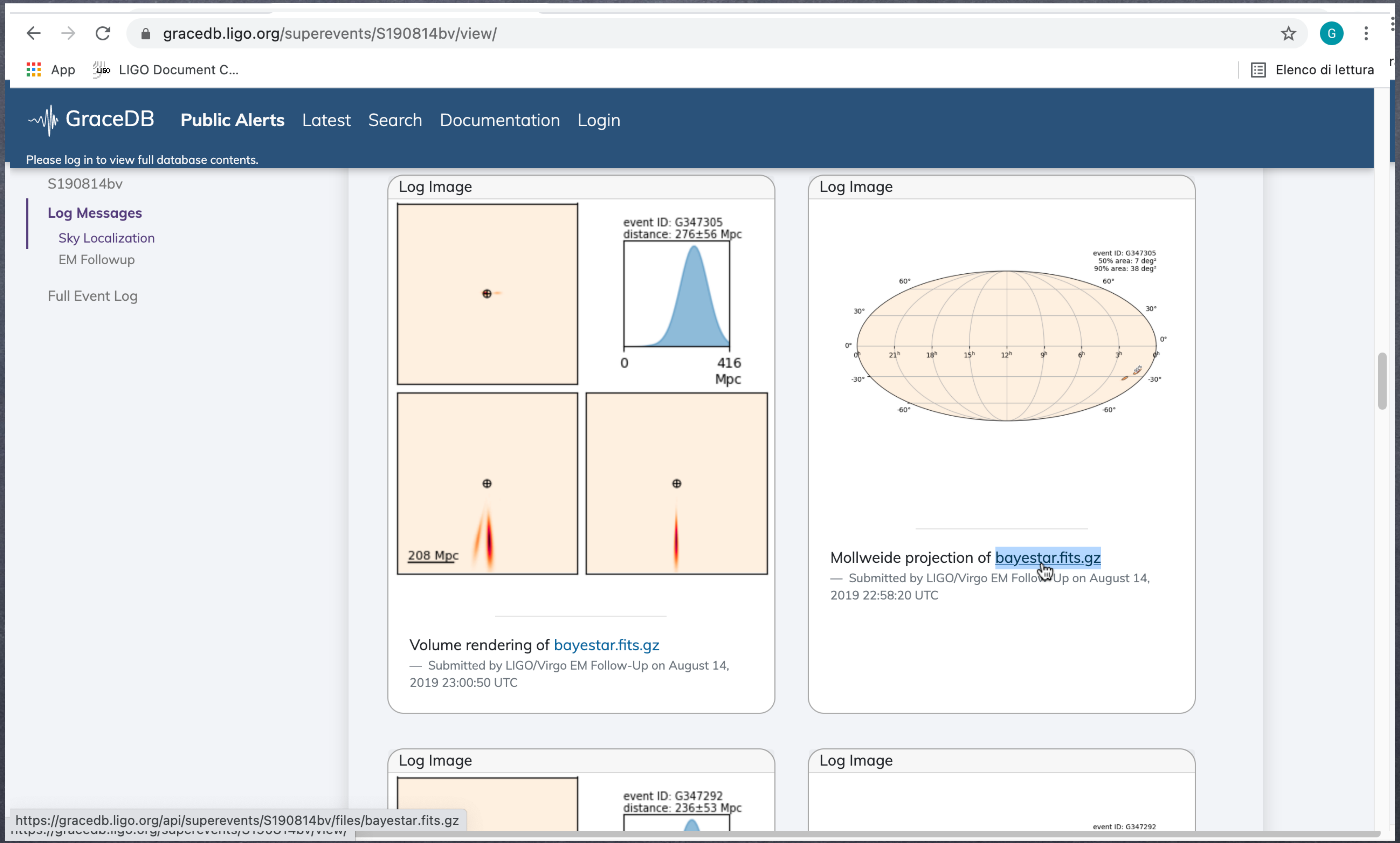
```
$ java -Xmx2g -jar Aladin.jar
```

The flag -Xmx<ammount of memory> specifies the maximum memory allocation pool for a JVM. Here 2GB of memory is allocated. For GW sky localizations with nside=2048, increase the memory allocated up to 3GB, -Xmx3g.

Data Exploration and Visualization in GraceDB

- We explore the GraceDB Public Alerts page.
- We search for the initial sky localization of GW190814 with three detectors.

The **Gra**vitational Wave **C**andidate **E**vent **D**atabase



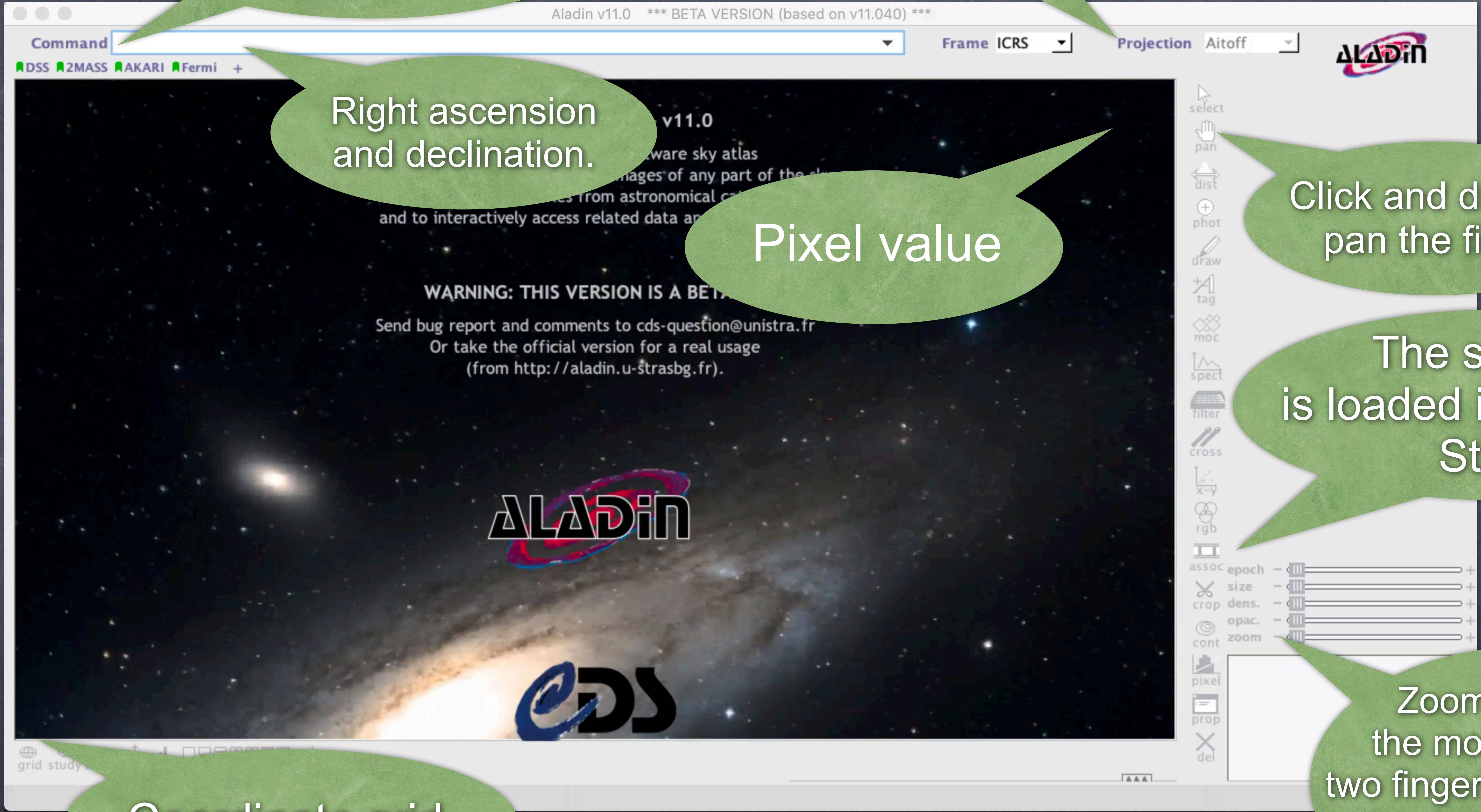
Please log in to view full database contents.

Volume rendering of bayestar.fits.gz
— Submitted by LIGO/Virgo EM Follow-Up on August 14, 2019 23:00:50 UTC

Mollweide projection of bayestar.fits.gz
— Submitted by LIGO/Virgo EM Follow-Up on August 14, 2019 22:58:20 UTC

https://gracedb.ligo.org/api/superevents/S190814bv/files/bayestar.fits.gz

Data Exploration and Visualization with Aladin: Projection, Pan and Zoom



Aladin v11.0 *** BETA VERSION (based on v11.040) ***

Command

Frame ICRS

Projection Aitoff

v11.0

ware sky atlas

nages of any part of the sk

s from astronomical c

and to interactively access related data ar

WARNING: THIS VERSION IS A BET

Send bug report and comments to cds-question@unistra.fr
Or take the official version for a real usage
(from http://aladin.u-strasbg.fr).

Paste the GraceDB URL and press ENTER.

Change Projection.

Right ascension and declination.

Pixel value

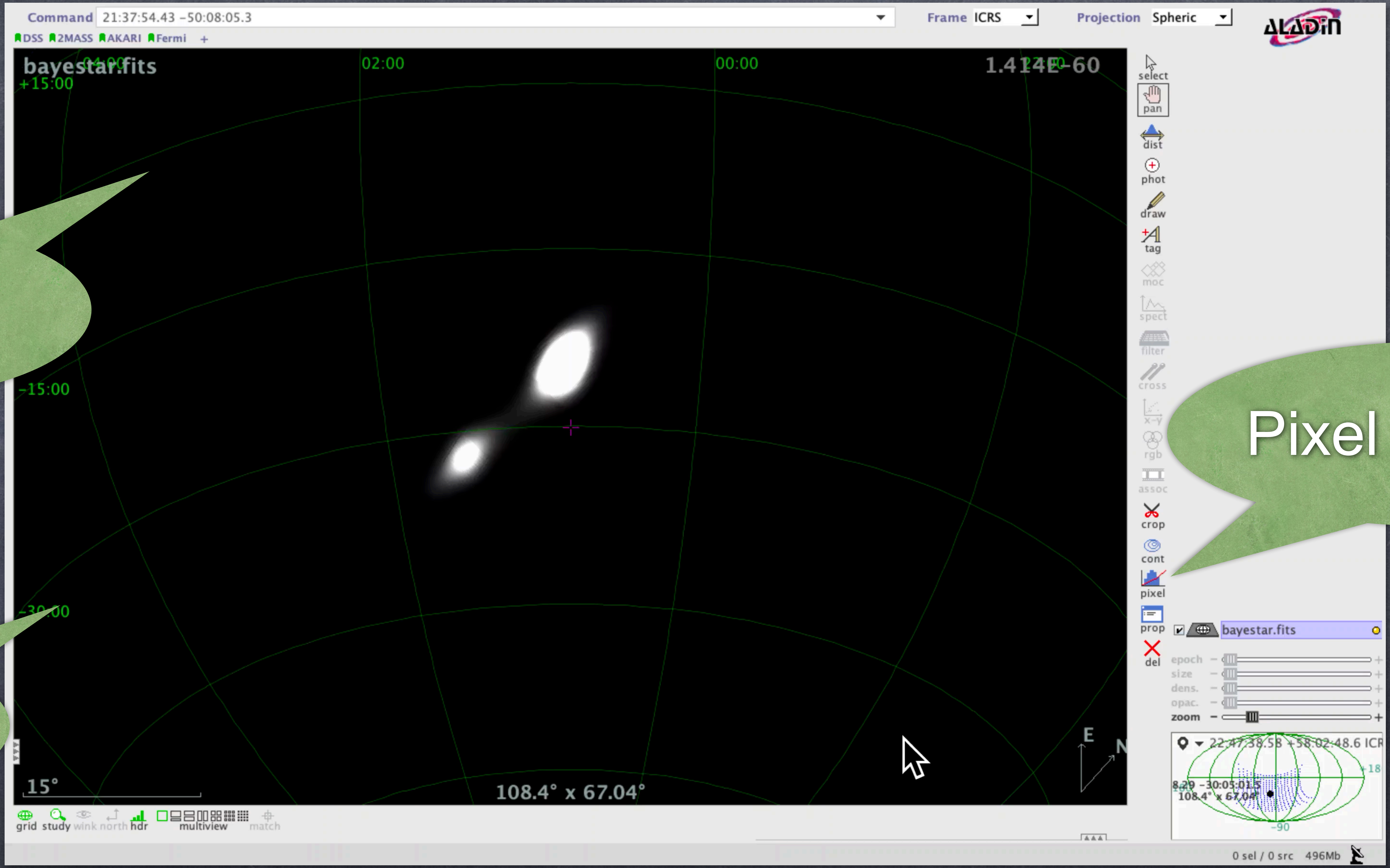
Click and drag to pan the field.

The sky map is loaded in the Aladin Stack.

Zoom in/out with the mouse wheel or two fingers and swipe up/down on your trackpad.

Coordinate grid.

Data Exploration and Visualization with Aladin: Colormap and Header



Command 21:37:54.43 -50:08:05.3

Frame ICRS

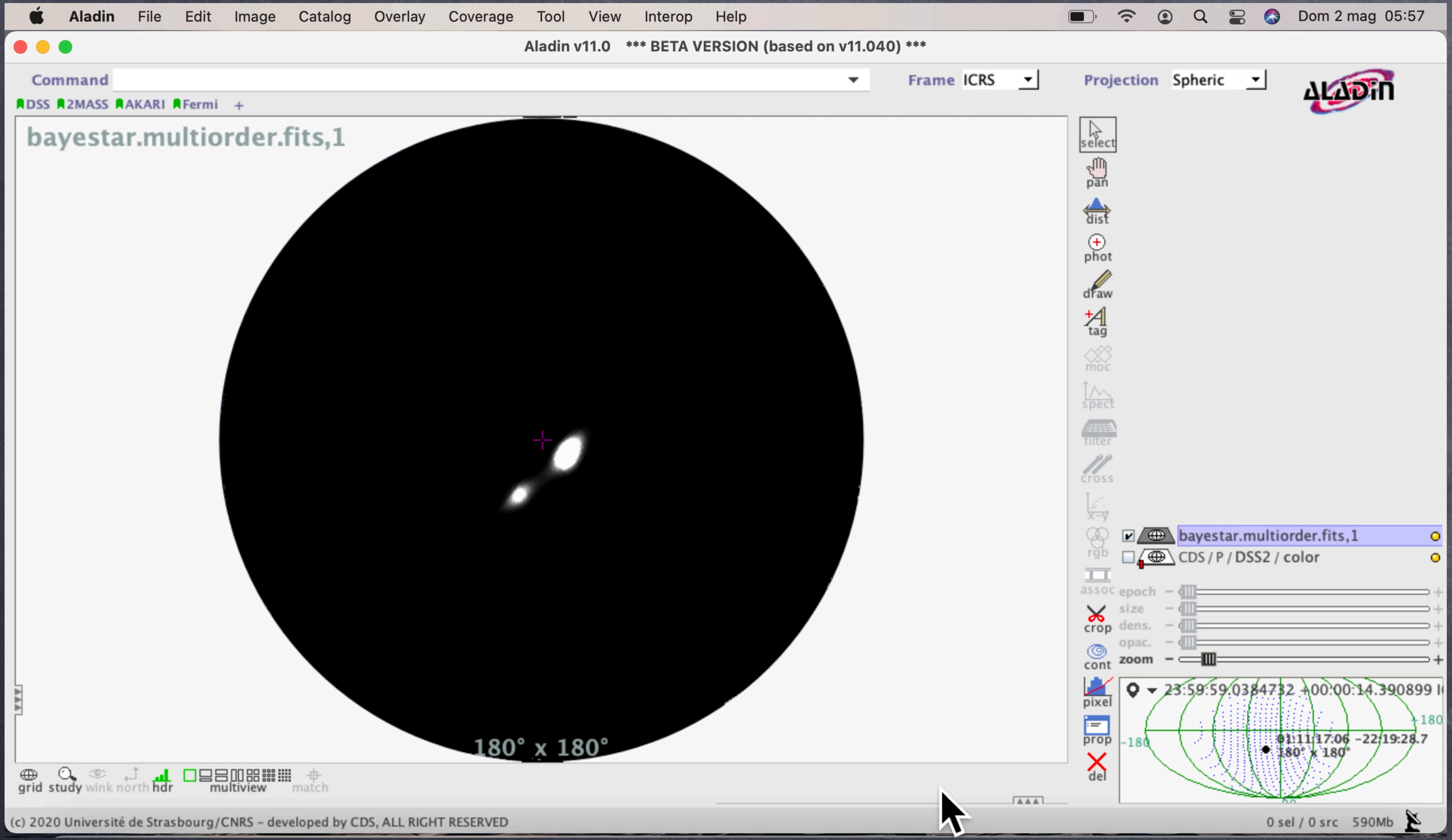
Projection Spheric

Header

Pixel Mapping

Colormap

Data Exploration and Visualization with Aladin: Credible Regions


Aladin File Edit Image Catalog Overlay Coverage Tool View Interop Help
Dom 2 mag 05:57
Aladin v11.0 *** BETA VERSION (based on v11.040) ***
Command
Frame ICRS
Projection Spheric
DSS 2MASS AKARI Fermi +
bayestar.multiorder.fits,1
180° x 180°
select
pan
dist
phot
draw
tag
moc
spect
filter
cross
rgb
assoc
crop
cont
pixel
prop
del
bayestar.multiorder.fits,1
CDS / P / DSS2 / color
epoch
size
dens.
opac.
zoom
23:59:59.0384732 +00:00:14.390899
01:11:17.06 -22:19:28.7
180° x 180°
grid study wink north hdr multiview match
(c) 2020 Université de Strasbourg/CNRS - developed by CDS, ALL RIGHT RESERVED
0 sel / 0 src 590Mb

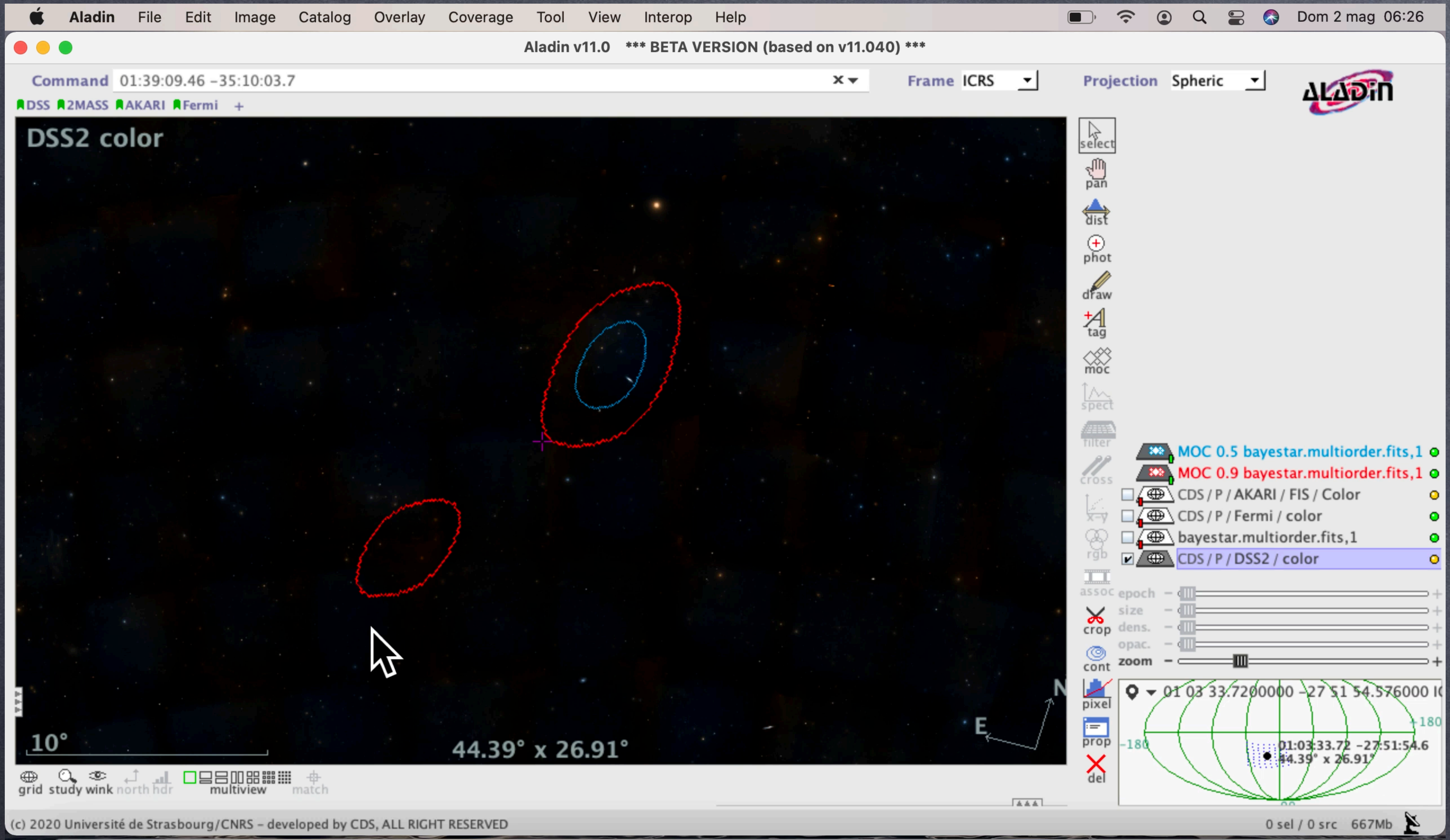
https://emfollow.docs.ligo.org/userguide/resources/aladin.html

From the menu bar,
select Coverage ‣ Generate a MOC based on ‣ The current probability skymap.

If you hover over the cursor over the MOC name in the Aladin stack, then the area in square degrees and the percentage of the sky are shown in the top-right corner of the Aladin window.

Right-click the MOC in the Aladin stack and select Properties from the contextual menu. The area and percentage of the sky are shown in the Properties dialog box. From this dialog box, you can also control the appearance and color of the MOC, which is useful for distinguishing multiple MOCs for different credible levels.

Data Discovery and Access: Aladin Discovery Tree



Aladin v11.0 *** BETA VERSION (based on v11.040) ***

Command 01:39:09.46 -35:10:03.7

Frame ICRS

Projection Spheric

DSS 2MASS AKARI Fermi +

DSS2 color

- MOC 0.5 bayestar.multiorder.fits,1 ●
- MOC 0.9 bayestar.multiorder.fits,1 ●
- □ CDS / P / AKARI / FIS / Color ●
- □ CDS / P / Fermi / color ●
- □ bayestar.multiorder.fits,1 ●
- ☑ CDS / P / DSS2 / color ●

01 03 33.7200000 -27 51 54.576000 I(

01:03:33.72 -27:51:54.6
44.39° x 26.91°

(c) 2020 Université de Strasbourg/CNRS - developed by CDS, ALL RIGHT RESERVED

0 sel / 0 src 667Mb

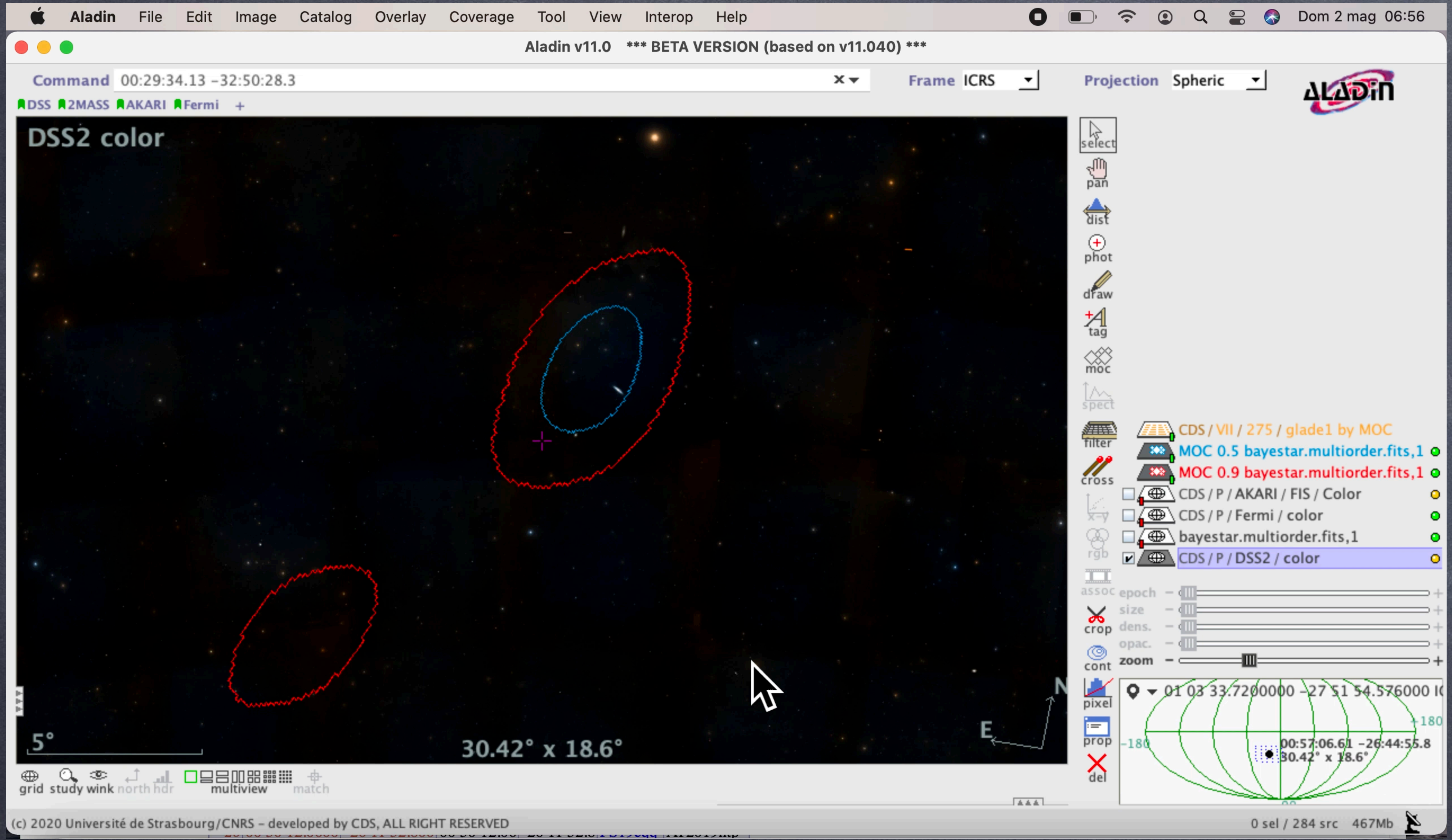
Green: catalog data falls in the real-time field of view.

Orange: catalog data does not fall in the real-time field of view.

You can query any Vizier catalogs from a MOC region.

You can explore the entire Vizier database looking if the catalogs are green or orange

Interoperability: Vizier, Aladin, Topcat, DS9 and ligo.skymap via SAMP


Aladin v11.0 *** BETA VERSION (based on v11.040) ***

Command 00:29:34.13 -32:50:28.3

Frame ICRS

Projection Spheric

DSS2 color

5°

30.42° x 18.6°

CDS / VII / 275 / glade1 by MOC
MOC 0.5 bayestar.multiorder.fits,1
MOC 0.9 bayestar.multiorder.fits,1
□ CDS / P / AKARI / FIS / Color
□ CDS / P / Fermi / color
□ bayestar.multiorder.fits,1
☑ CDS / P / DSS2 / color

01 03 33.7200000 -27 51 54.576000

00:57:06.61 -26:44:55.8
30.42° x 18.6°

(c) 2020 Université de Strasbourg/CNRS - developed by CDS, ALL RIGHT RESERVED

0 sel / 284 src 467Mb

Simple Application Messaging Protocol (SAMP) is an inter-process communication system that allows different client programs to communicate with each other. The protocol is understood by many desktop astronomy tools, including TOPCAT, SAO DS9, and Aladin.

astropy.samp is a Python implementation of the SAMP messaging system.

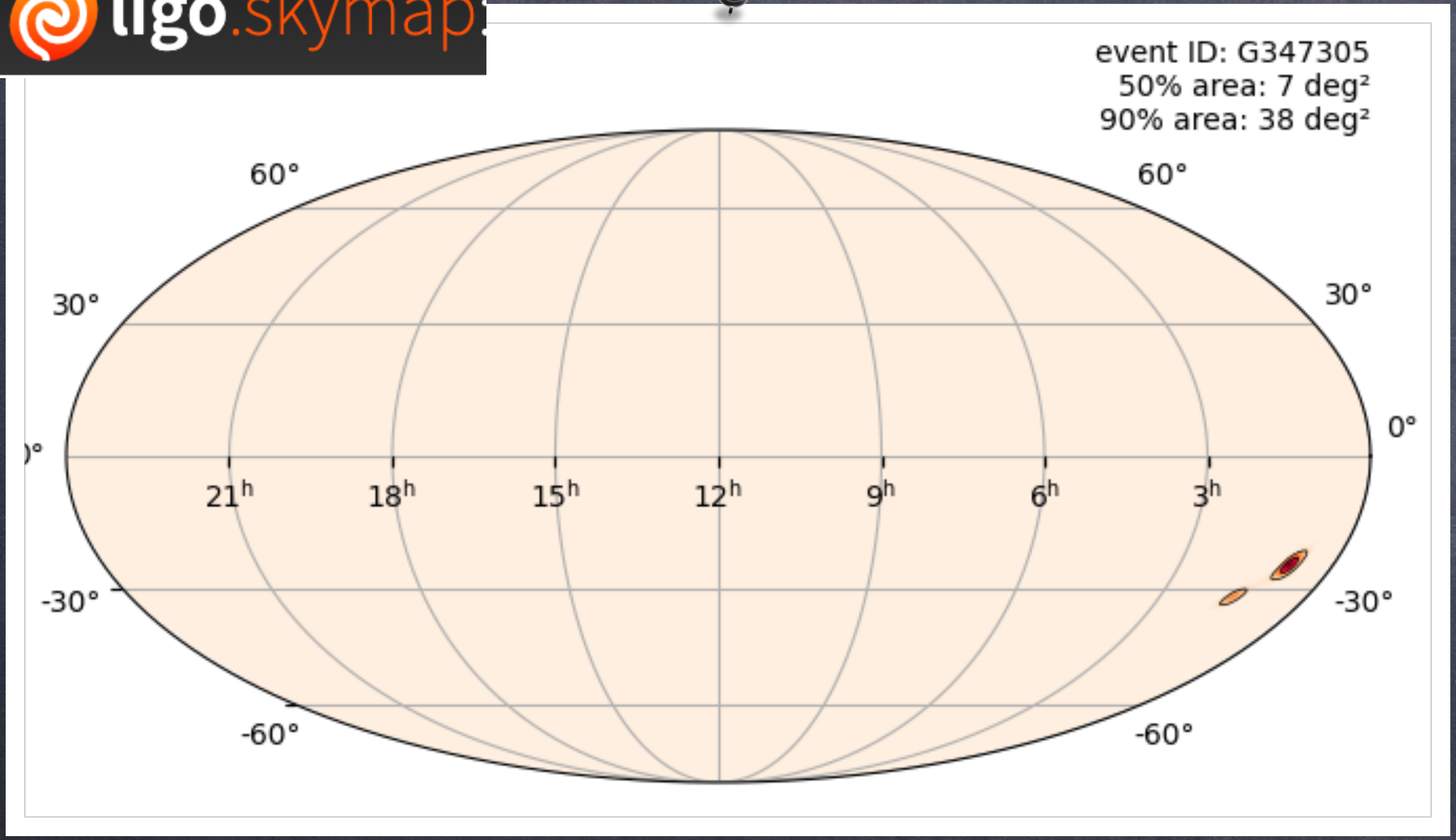
SAMP Web Profile allows web applications to communicate with a SAMP hub.

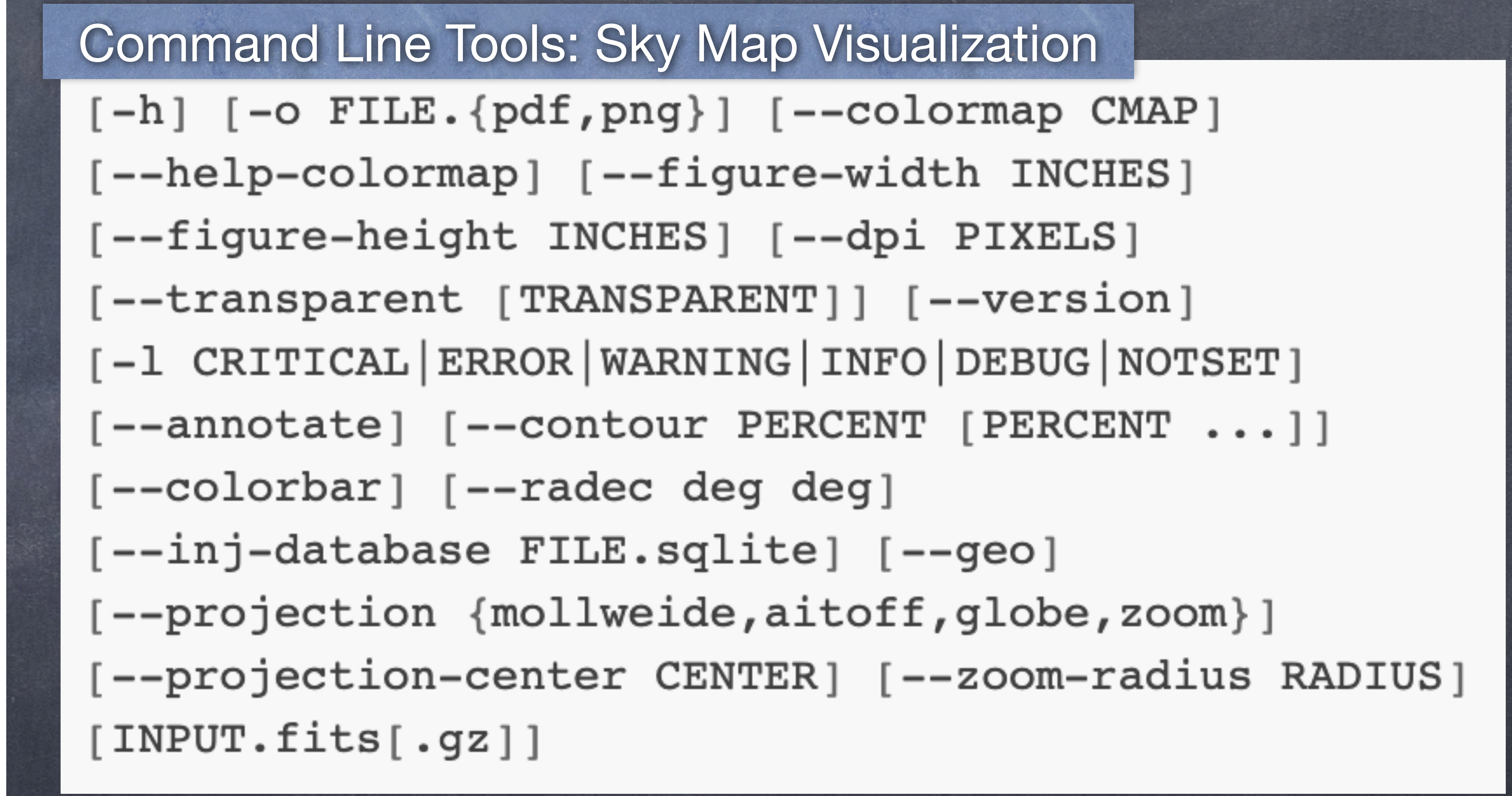
Video example: send to VO tools the table 3 of *Observational constraints on the optical and near-infrared emission from the neutron star-black hole binary merger candidate S190814bv.*

Data Exploration and Visualization with ligo.skymap

```
$ curl -O https://gracedb.ligo.org/api/superevents/S190814bv/files/bayestar.fits.gz
$ ligo-skymap-plot bayestar.fits.gz -o GW190814_3_ifo_bayestar.png --annotate --contour 50 90
```

ligo.skymap



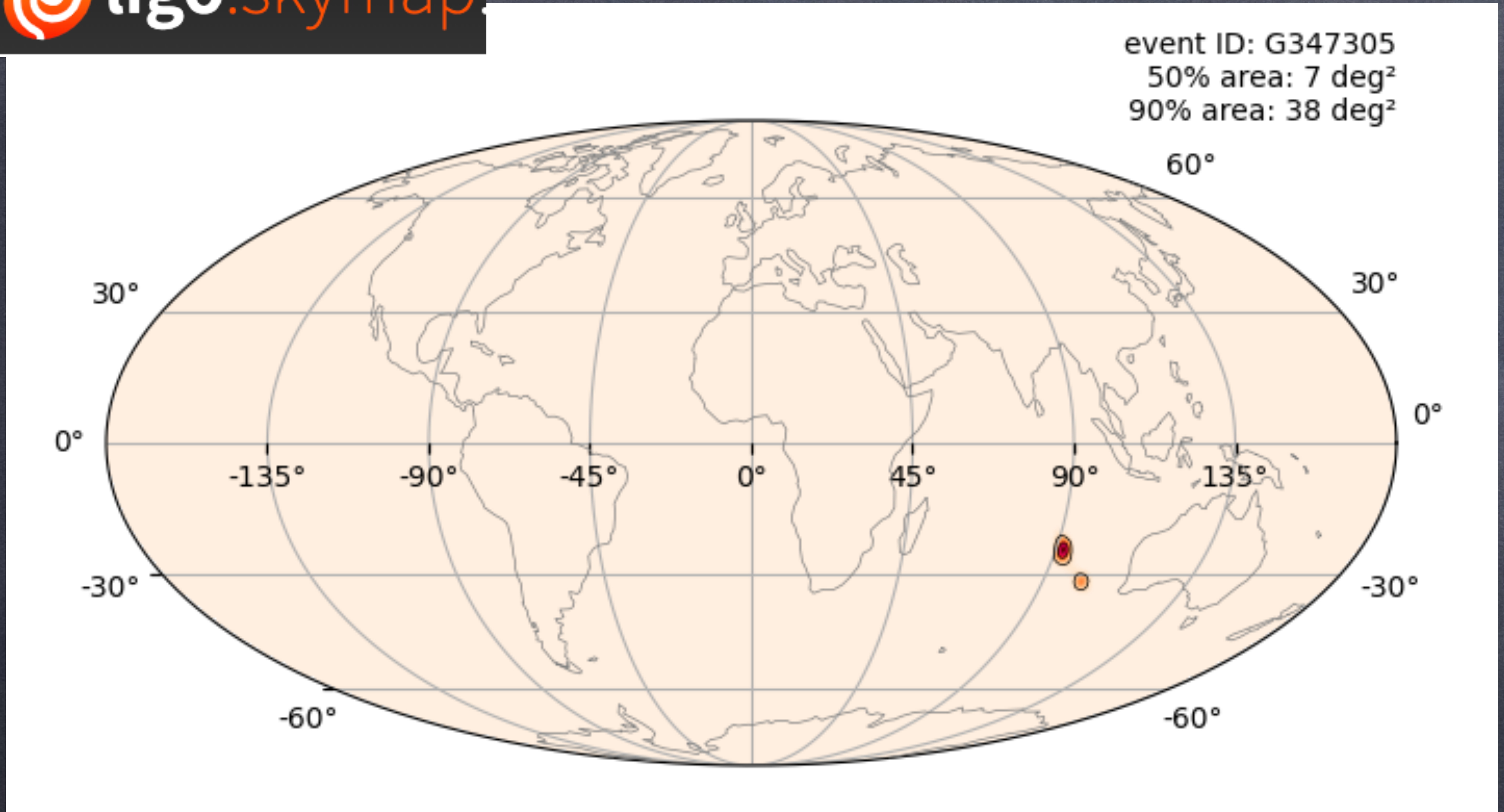


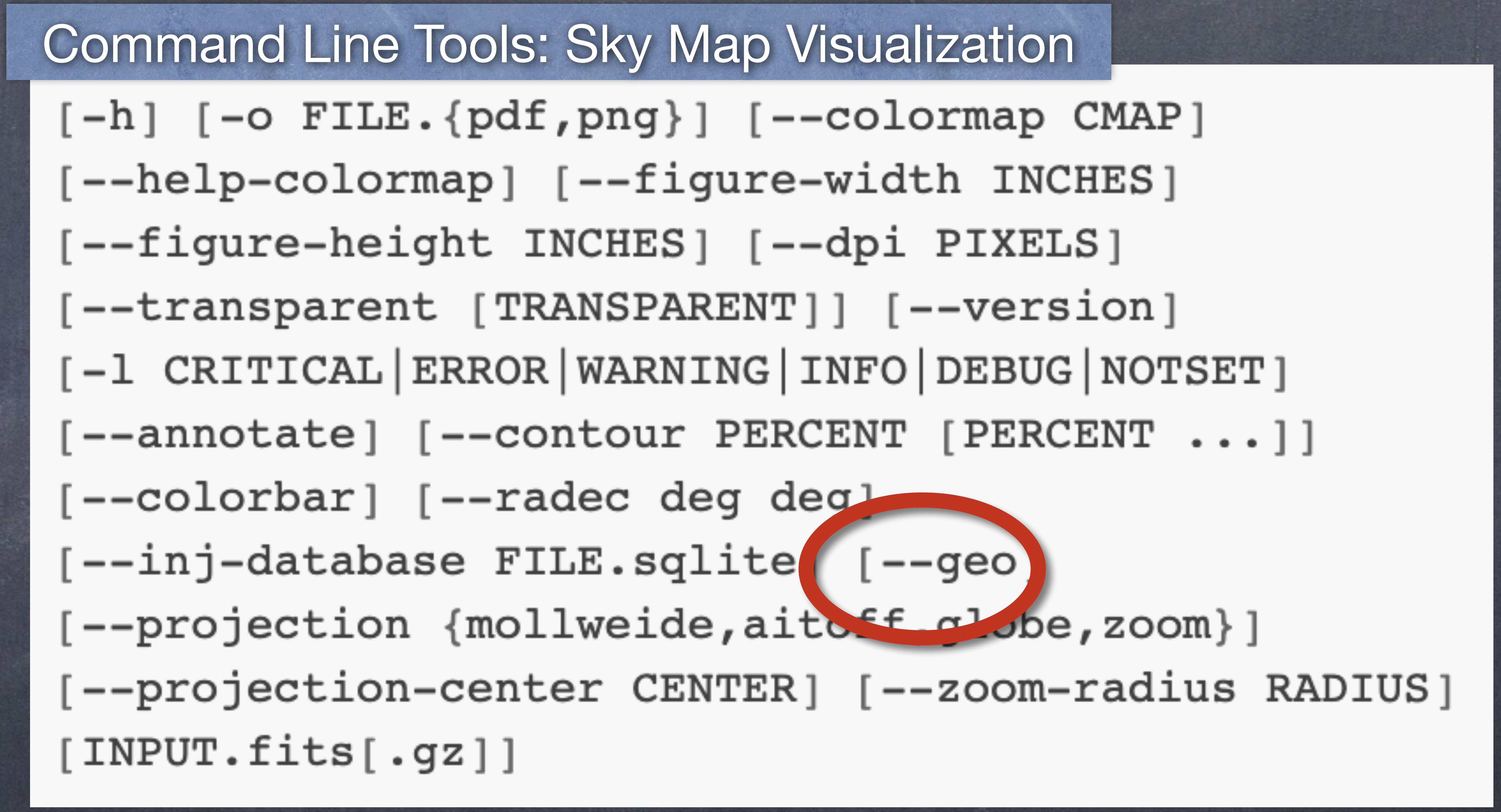
Command Line Tools: Sky Map Visualization

```
[-h] [-o FILE.{pdf,png}] [--colormap CMAP]
[--help-colormap] [--figure-width INCHES]
[--figure-height INCHES] [--dpi PIXELS]
[--transparent [TRANSPARENT]] [--version]
[-l CRITICAL|ERROR|WARNING|INFO|DEBUG|NOTSET]
[--annotate] [--contour PERCENT [PERCENT ...]]
[--colorbar] [--radec deg deg]
[--inj-database FILE.sqlite] [--geo]
[--projection {mollweide,aitoff,globe,zoom}]
[--projection-center CENTER] [--zoom-radius RADIUS]
[INPUT.fits[.gz]]
```

Data Exploration and Visualization with ligo.skymap

```
$ curl -O https://gracedb.ligo.org/api/superevents/S190814bv/files/bayestar.fits.gz
$ ligo-skymap-plot bayestar.fits.gz -o GW190814_3_ifo_bayestar.png --annotate --contour 50 90 --geo
```



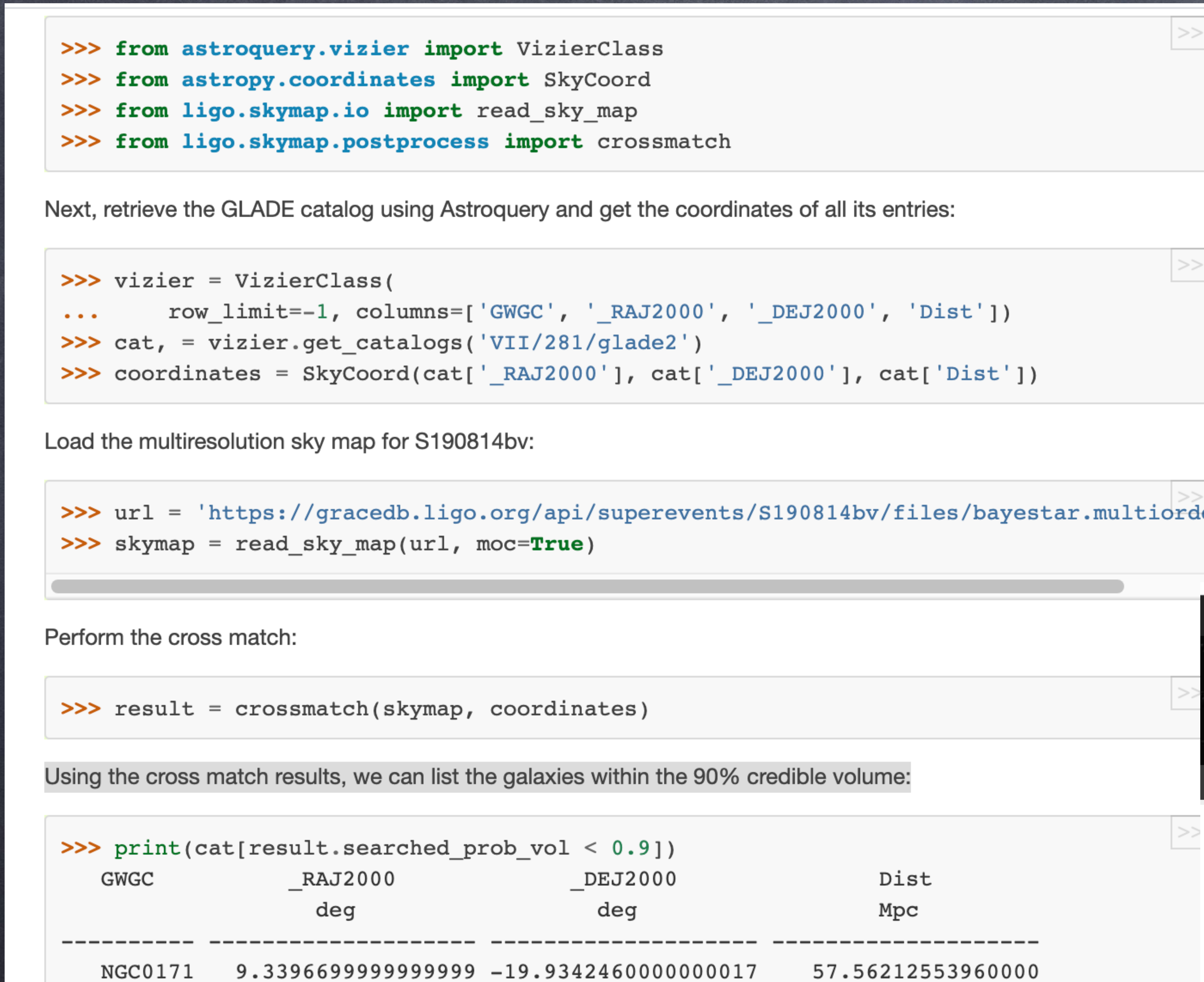


Command Line Tools: Sky Map Visualization

```
[-h] [-o FILE.{pdf,png}] [--colormap CMAP]
[--help-colormap] [--figure-width INCHES]
[--figure-height INCHES] [--dpi PIXELS]
[--transparent [TRANSPARENT]] [--version]
[-l CRITICAL|ERROR|WARNING|INFO|DEBUG|NOTSET]
[--annotate] [--contour PERCENT [PERCENT ...]]
[--colorbar] [--radec deg deg]
[--inj-database FILE.sqlite] [--geo]
[--projection {mollweide,aitoff,globe,zoom}]
[--projection-center CENTER] [--zoom-radius RADIUS]
[INPUT.fits[.gz]]
```

Cross match galaxy catalogs with ligo.skymap

https://lscsoft.docs.ligo.org/ligo.skymap/postprocess/crossmatch.html



```
>>> from astroquery.vizier import VizierClass
>>> from astropy.coordinates import SkyCoord
>>> from ligo.skymap.io import read_sky_map
>>> from ligo.skymap.postprocess import crossmatch
```

Next, retrieve the GLADE catalog using Astroquery and get the coordinates of all its entries:

```
>>> vizier = VizierClass(
...     row_limit=-1, columns=['GWGC', '_RAJ2000', '_DEJ2000', 'Dist'])
>>> cat, = vizier.get_catalogs('VII/281/glade2')
>>> coordinates = SkyCoord(cat['_RAJ2000'], cat['_DEJ2000'], cat['Dist'])
```

Load the multiresolution sky map for S190814bv:

```
>>> url = 'https://gracedb.ligo.org/api/superevents/S190814bv/files/bayestar.multiorder
>>> skymap = read_sky_map(url, moc=True)
```

Perform the cross match:

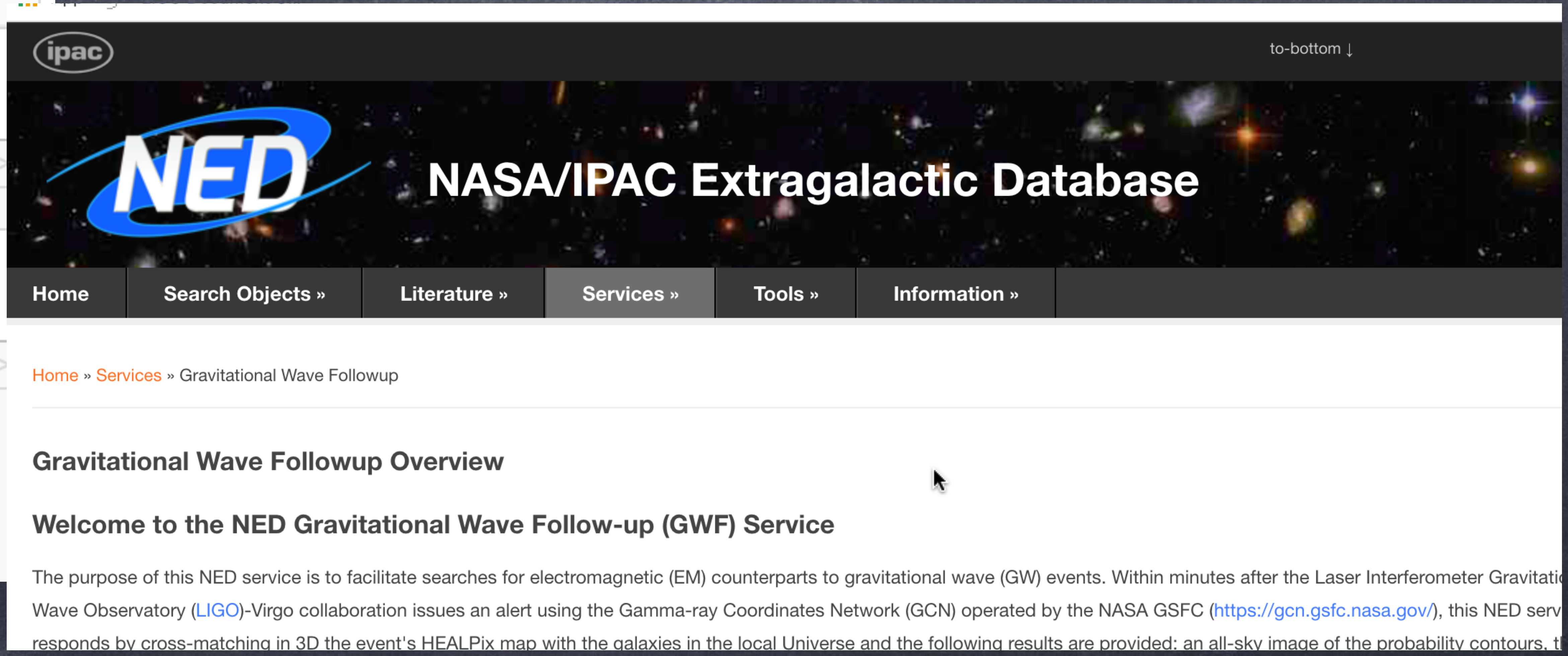
```
>>> result = crossmatch(skymap, coordinates)
```

Using the cross match results, we can list the galaxies within the 90% credible volume:

```
>>> print(cat[result.searched_prob_vol < 0.9])
   GWGC          _RAJ2000            _DEJ2000             Dist
                   deg                 deg                 Mpc
---------- -------------------- -------------------- --------------------
   NGC0171    9.3396699999999999 -19.9342460000000017    57.56212553960000
```

Using the cross match method, we can list the galaxies within the 90% credible volume.

A dedicated tutorial will be proposed in the Open Data Workshop - tuto 3.3.



NASA/IPAC Extragalactic Database

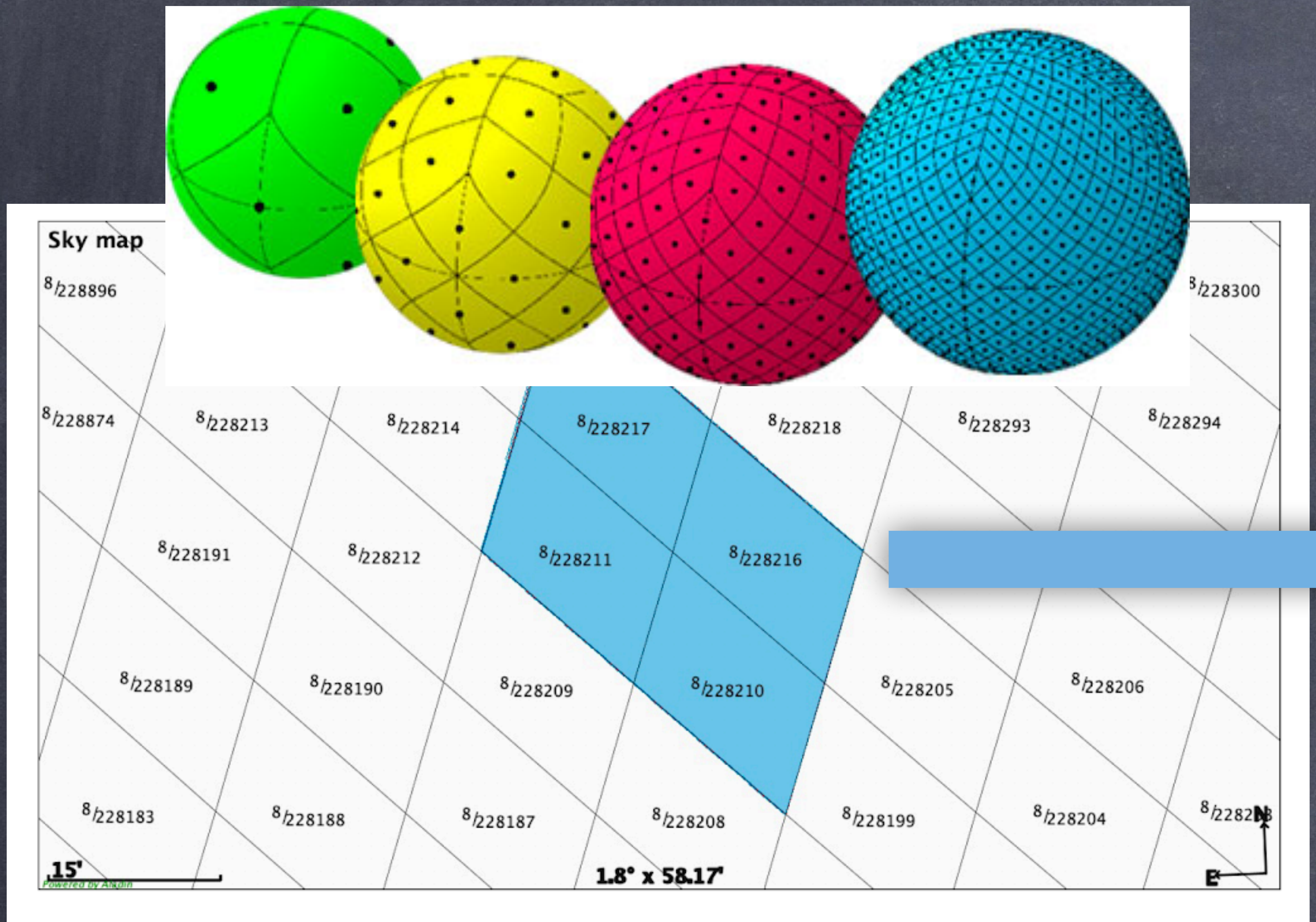
Home » Services » Gravitational Wave Followup

Gravitational Wave Followup Overview

Welcome to the NED Gravitational Wave Follow-up (GWF) Service

The purpose of this NED service is to facilitate searches for electromagnetic (EM) counterparts to gravitational wave (GW) events. Within minutes after the Laser Interferometer Gravitati Wave Observatory (LIGO)-Virgo collaboration issues an alert using the Gamma-ray Coordinates Network (GCN) operated by the NASA GSFC (https://gcn.gsfc.nasa.gov/), this NED serv responds by cross-matching in 3D the event's HEALPix map with the galaxies in the local Universe and the following results are provided: an all-sky image of the probability contours, t

MOC: Multi Order Coverage MAP



The shaded area highlights a MOC map consisting of 4 cells at order = 8.

A **JSON MOC** is written following the syntax:

{“order”: [npix, npix,...],”order”:[npix, npix...],...}

{“8”:[228210, 228211, 228216, 228217]

To encode a **MOC in a FITS** file, each cell is converted into a single integer using the NUNIQ packing scheme:

$$uniq = 4 \times (4^{order}) + npix$$

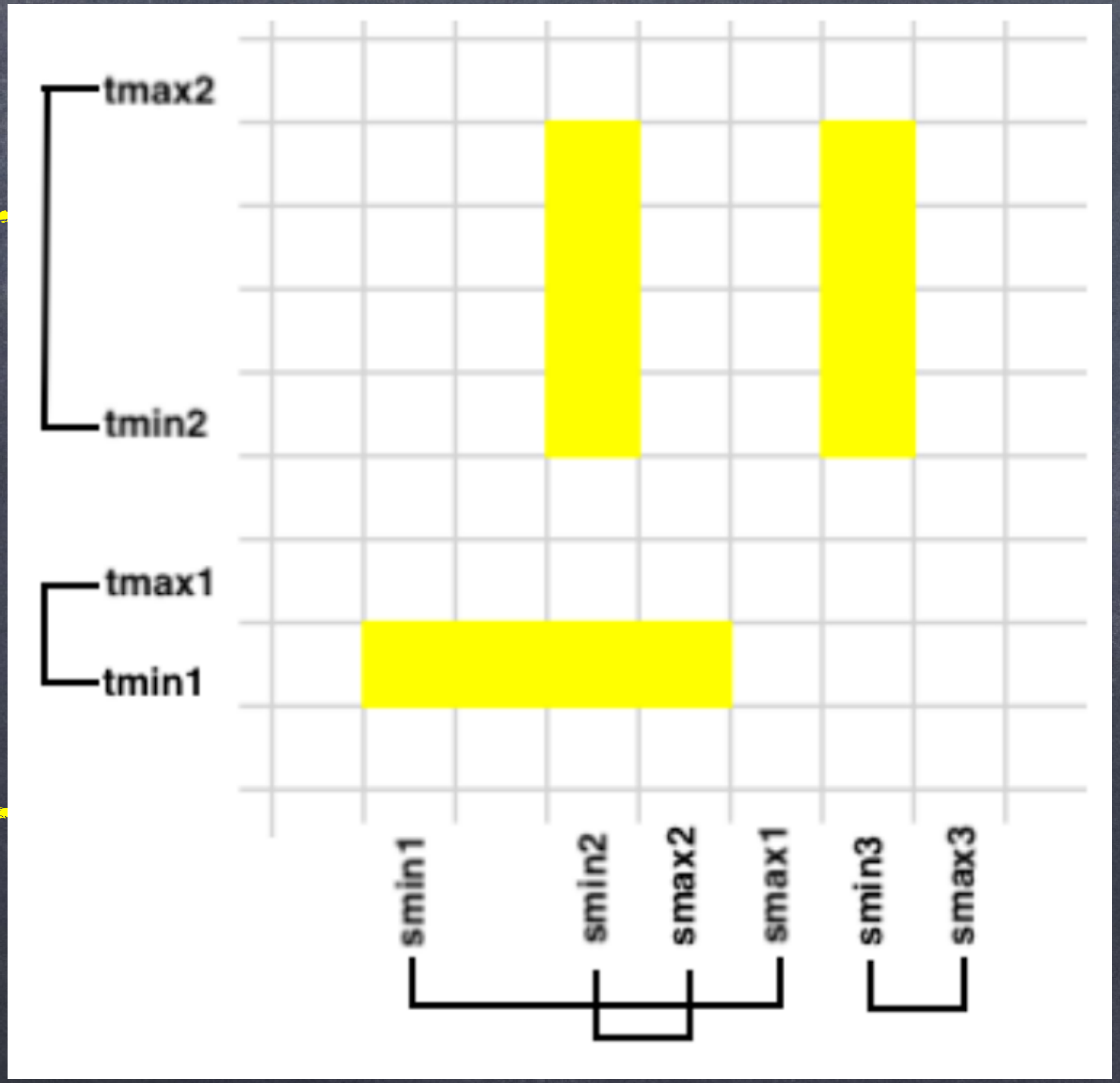
FITS MOC contains the integers: **490354, 490355, 490360, 490361**

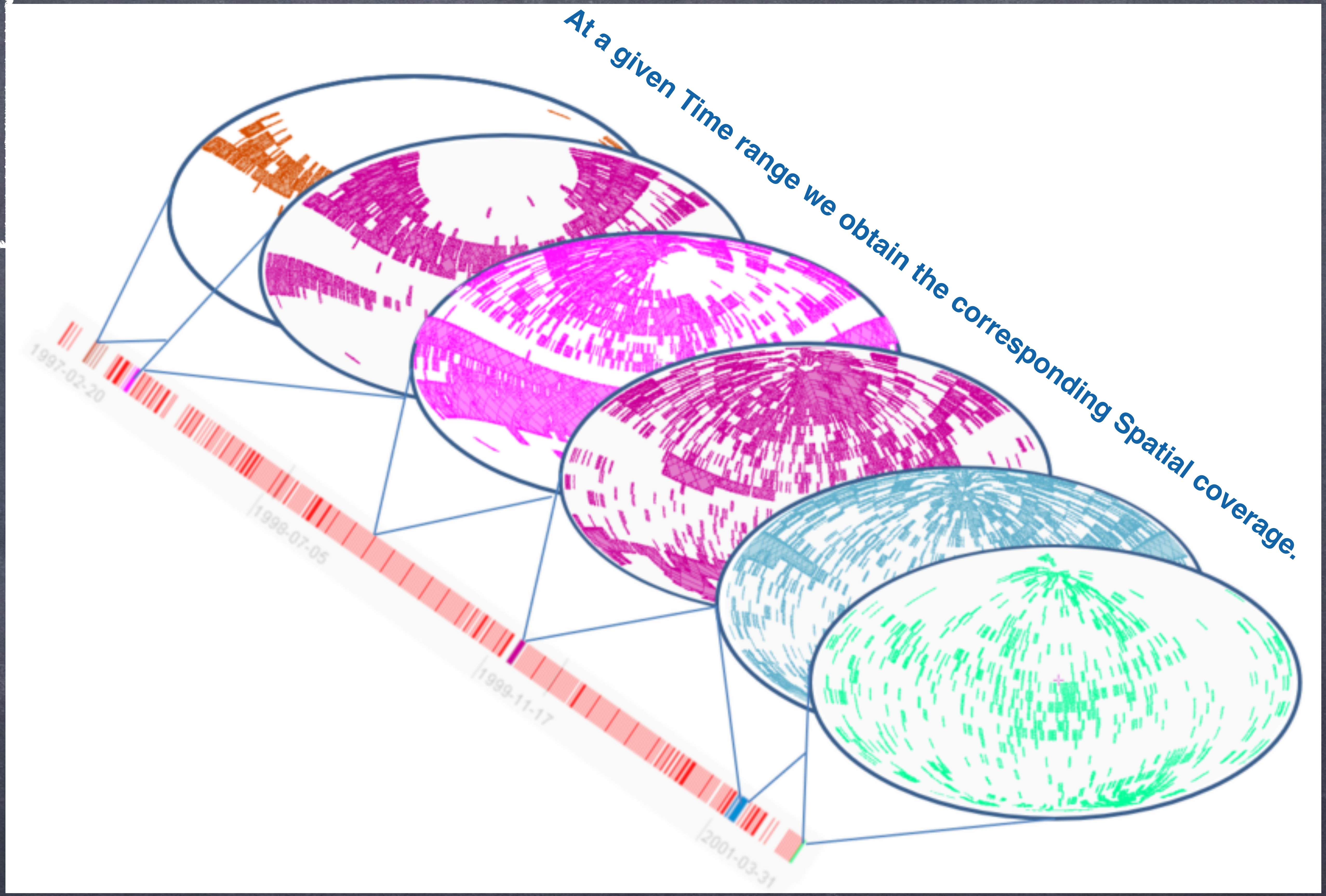
The MOC encoding method based on **HEALPix tessellation** was originally developed at the Centre de Données astronomiques de Strasbourg (CDS) and has been adopted as a recommendation by the International Virtual Observatory Alliance (IVOA). Initially designed for manipulating sky coverages from astronomical surveys, MOC has been extended to support both temporal and spatial coverage; *Fernique et al., 2014 and 2020.*

Space-Time MOC

For each element of a temporal coverage we list the associated spatial coverage. The time scale is hierarchically divided in intervals grouped 2 by 2 with 62 orders and the time coverage for the deepest order is 1 µs.

Interleaving approach has the advantage of making the resolutions chosen for time and for space independent.





At a given Time range we obtain the corresponding Spatial coverage.

Space-Time MOC: GW170817

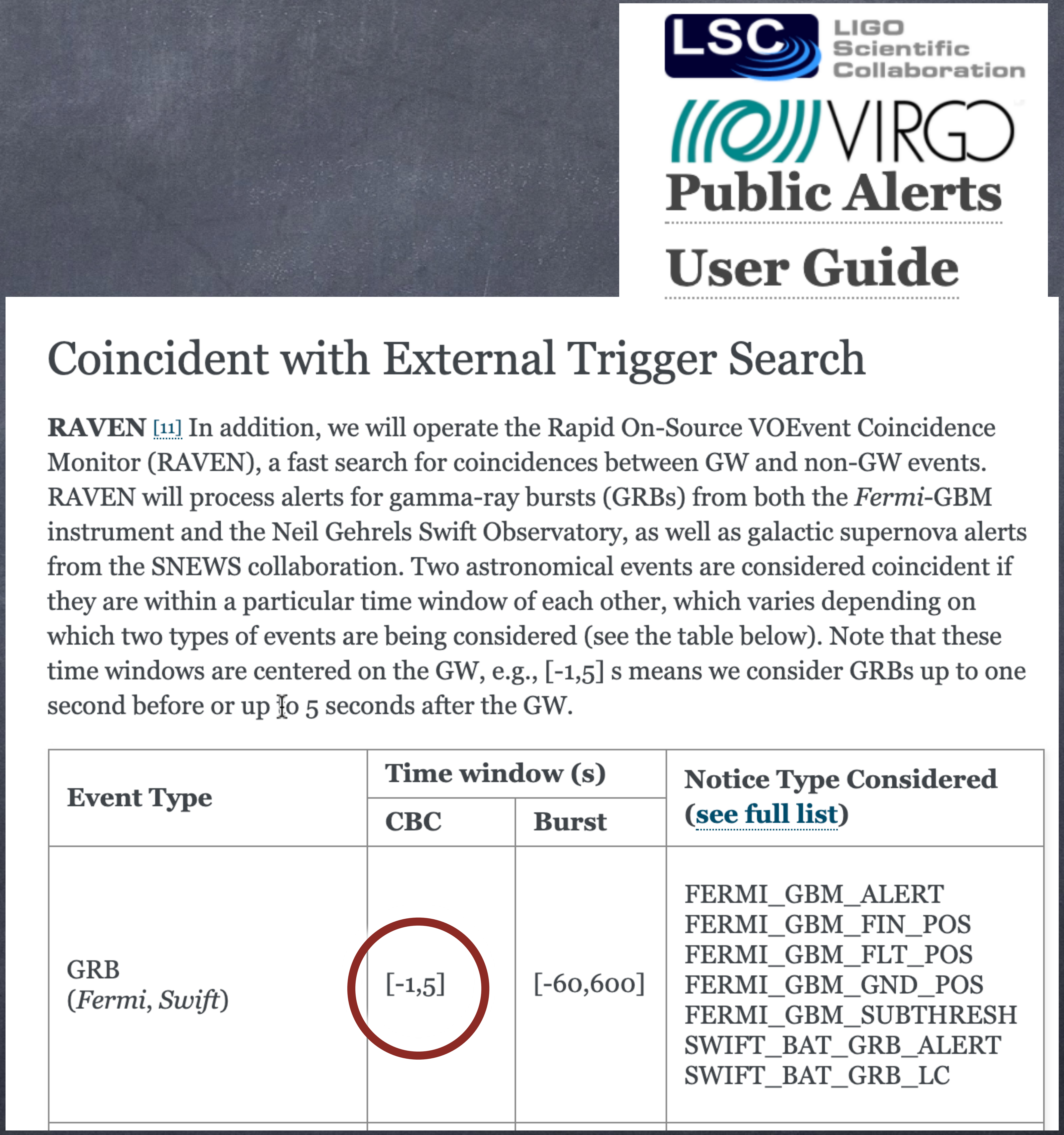
Starting Information

Sky localization of GW170817 binary neutron star merger provided by the LIGO and Virgo Collaborations:
https://dcc.ligo.org/public/0157/P1800381/006/GW170817_skymap.fits.gz

Error Box of GRB170817 provided by GBM instrument on-board of the Fermi Gamma-ray Space Telescope:
https://gammaray.nsstc.nasa.gov/gbm/science/grbs/grb170817a/gbuts_healpix_systematic.fit

Trigger time of GW170817. DATE-OBS = 2017-08-17T12:41:04.4

Fermi/GBM trigger time of GRB170817: 2017-08-17T12:41:06.
T90 duration = 2.0 ± 0.5 s, starting at T0–0.192 s.

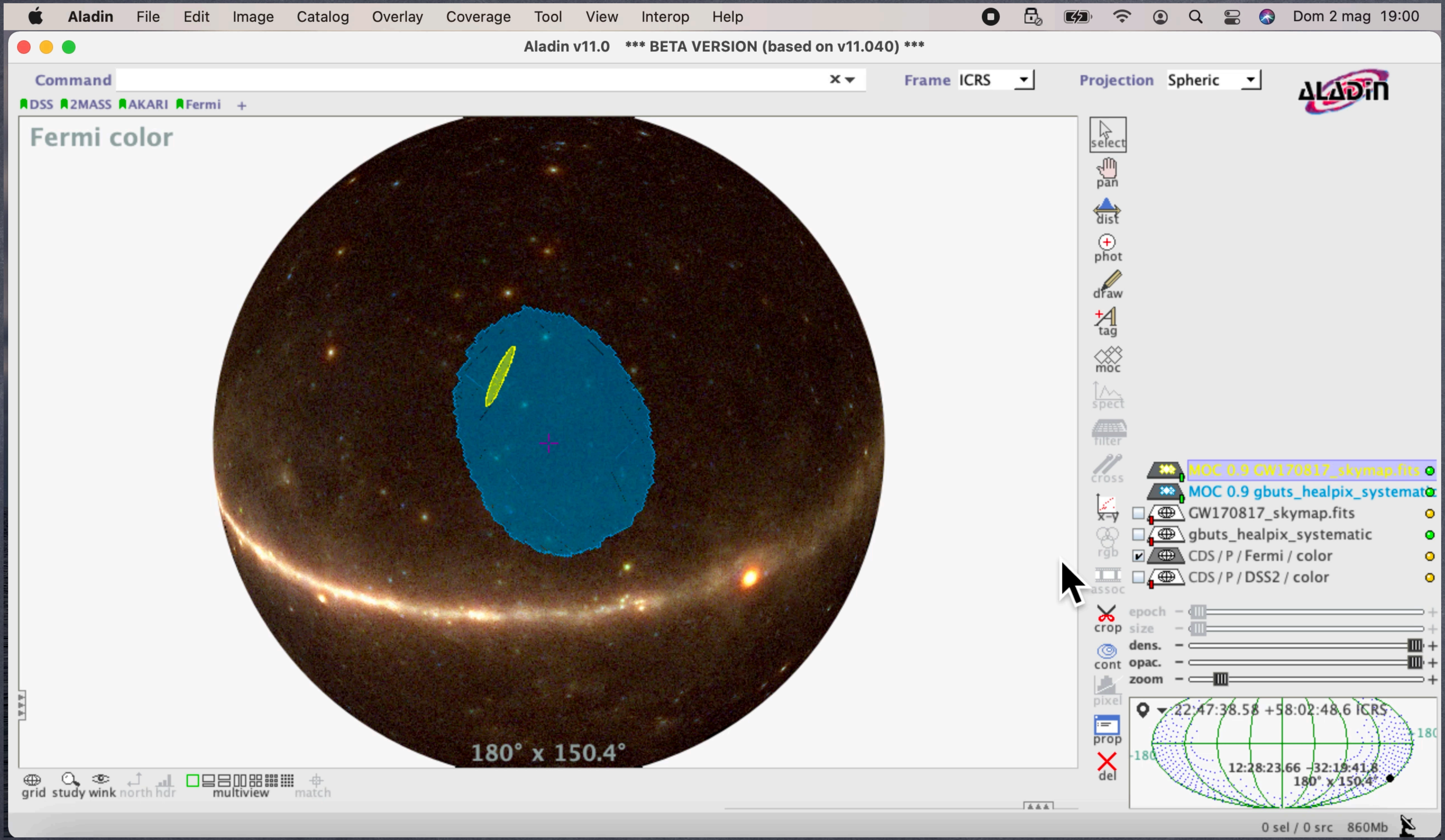


LSC LIGO Scientific Collaboration
VIRGO
Public Alerts
User Guide

Coincident with External Trigger Search

RAVEN [11] In addition, we will operate the Rapid On-Source VOEvent Coincidence Monitor (RAVEN), a fast search for coincidences between GW and non-GW events. RAVEN will process alerts for gamma-ray bursts (GRBs) from both the *Fermi*-GBM instrument and the Neil Gehrels Swift Observatory, as well as galactic supernova alerts from the SNEWS collaboration. Two astronomical events are considered coincident if they are within a particular time window of each other, which varies depending on which two types of events are being considered (see the table below). Note that these time windows are centered on the GW, e.g., [-1,5] s means we consider GRBs up to one second before or up to 5 seconds after the GW.

Event Type	**Time window (s)**		**Notice Type Considered (see full list)**
	CBC	**Burst**	
GRB (*Fermi*, *Swift*)	[-1,5]	[-60,600]	FERMI_GBM_ALERT FERMI_GBM_FIN_POS FERMI_GBM_FLT_POS FERMI_GBM_GND_POS FERMI_GBM_SUBTHRESH SWIFT_BAT_GRB_ALERT SWIFT_BAT_GRB_LC



Aladin v11.0 *** BETA VERSION (based on v11.040) ***

Command

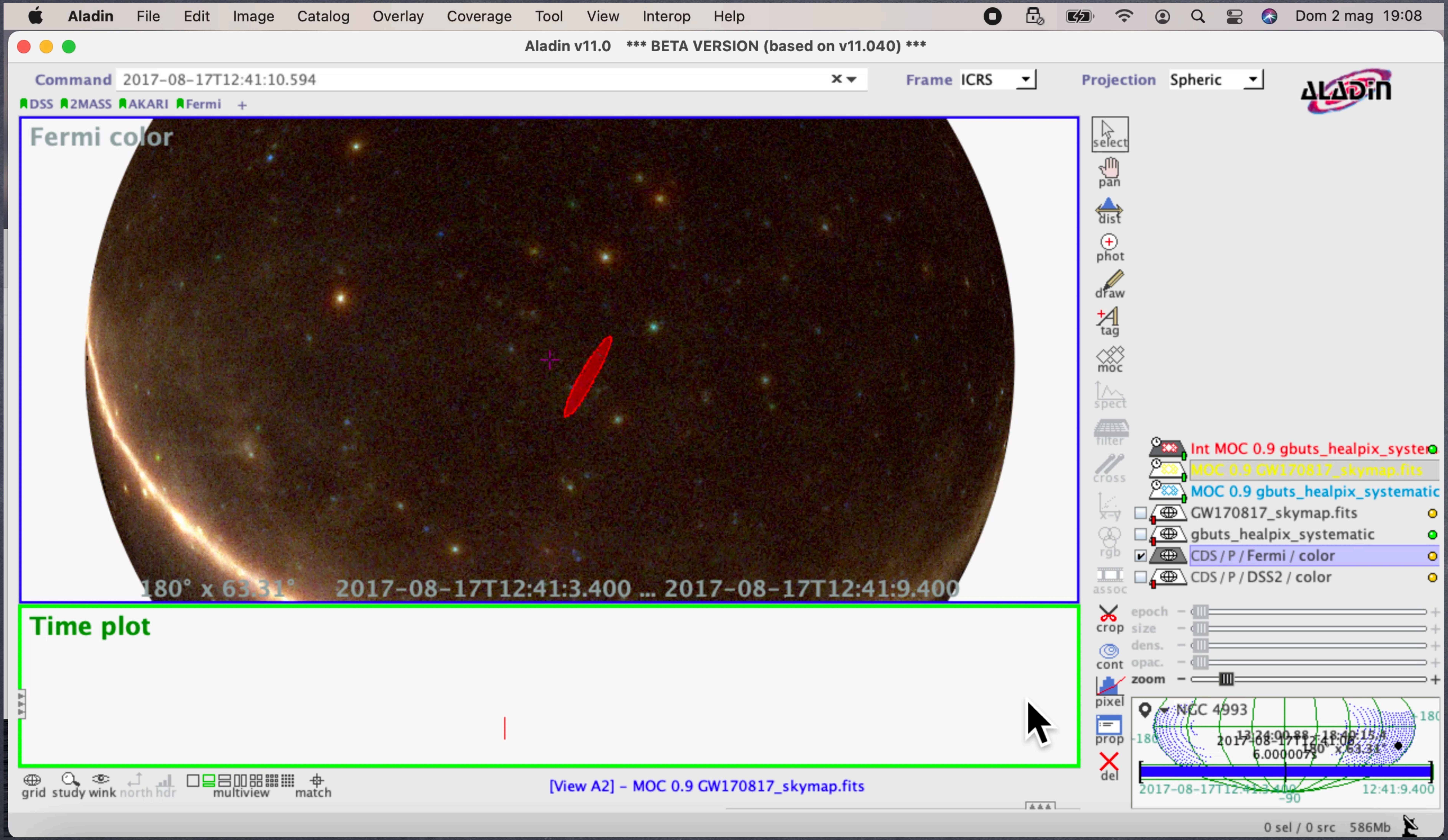
Frame ICRS

Projection Spheric

MOC 0.9 GW170817_skymap.fits
MOC 0.9 gbuts_healpix_systematic
□ GW170817_skymap.fits
□ gbuts_healpix_systematic
☑ CDS / P / Fermi / color
□ CDS / P / DSS2 / color

22:47:38.58 +58:02:48.6 ICRS
12:28:23.66 -32:19:41.8
180° x 150.4°

Through the Aladin graphical interface, we simultaneously visualize the spatial and temporal coincidence between the GW170817 and the short GRB170817.



Aladin v11.0 *** BETA VERSION (based on v11.040) ***

Command 2017-08-17T12:41:10.594

Frame ICRS

Projection Spheric

Int MOC 0.9 gbuts_healpix_syste

MOC 0.9 GW170817_skymap.fits

MOC 0.9 gbuts_healpix_systematic

☐ GW170817_skymap.fits

☐ gbuts_healpix_systematic

☑ CDS / P / Fermi / color

☐ CDS / P / DSS2 / color

[View A2] – MOC 0.9 GW170817_skymap.fits

0 sel / 0 src 586Mb

Search for the host galaxy NGC 4993.

Publishing and Sharing Research data

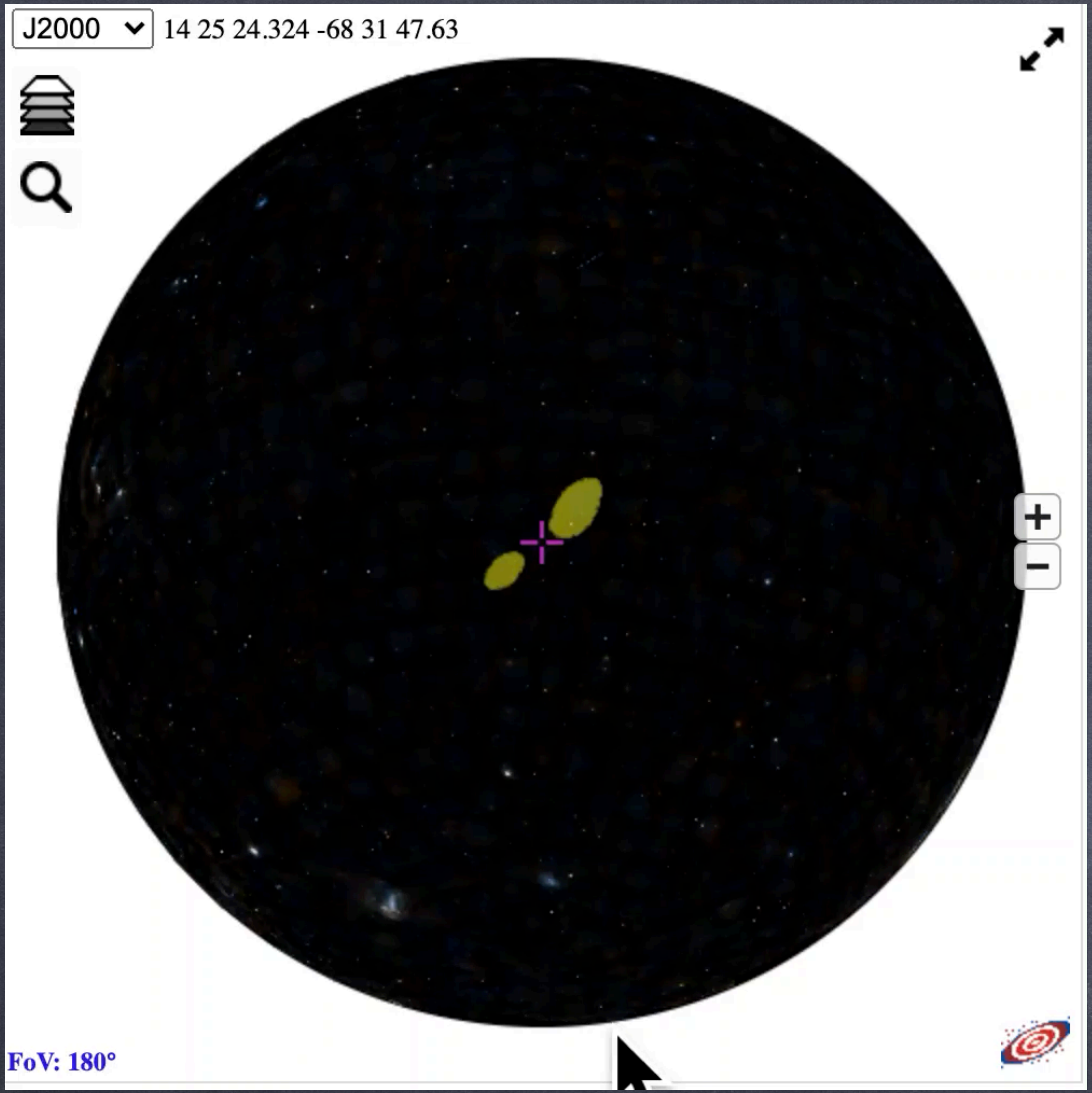
How to build and integrate in your web page an interactive sky map?

1. Showing coverages/footprints over the gravitational-wave sky localization(s).

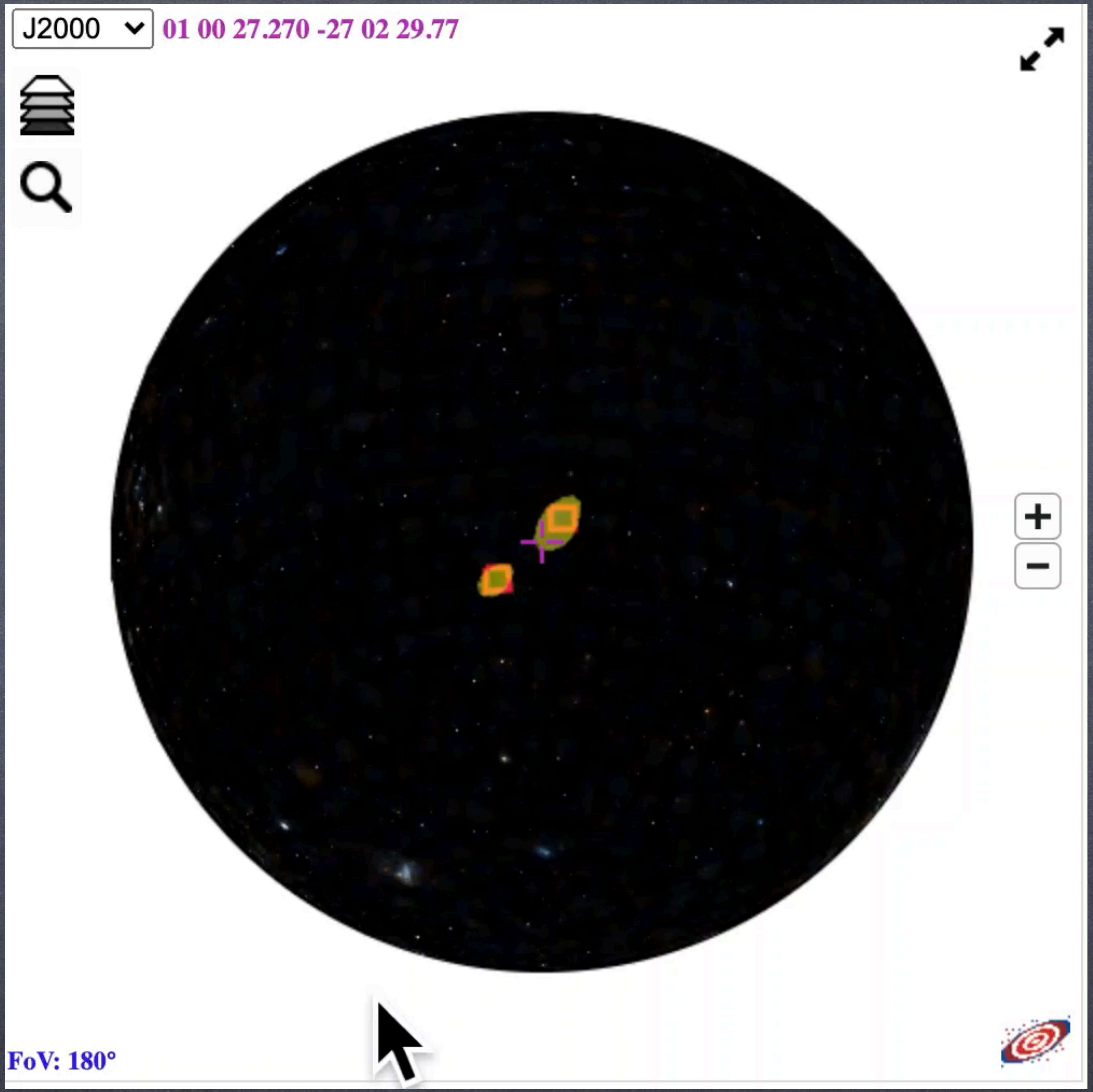
2. Sharing galaxies catalog(s) and transient identifications.

3. Distributing catalos/images to the community.

Aladin Lite

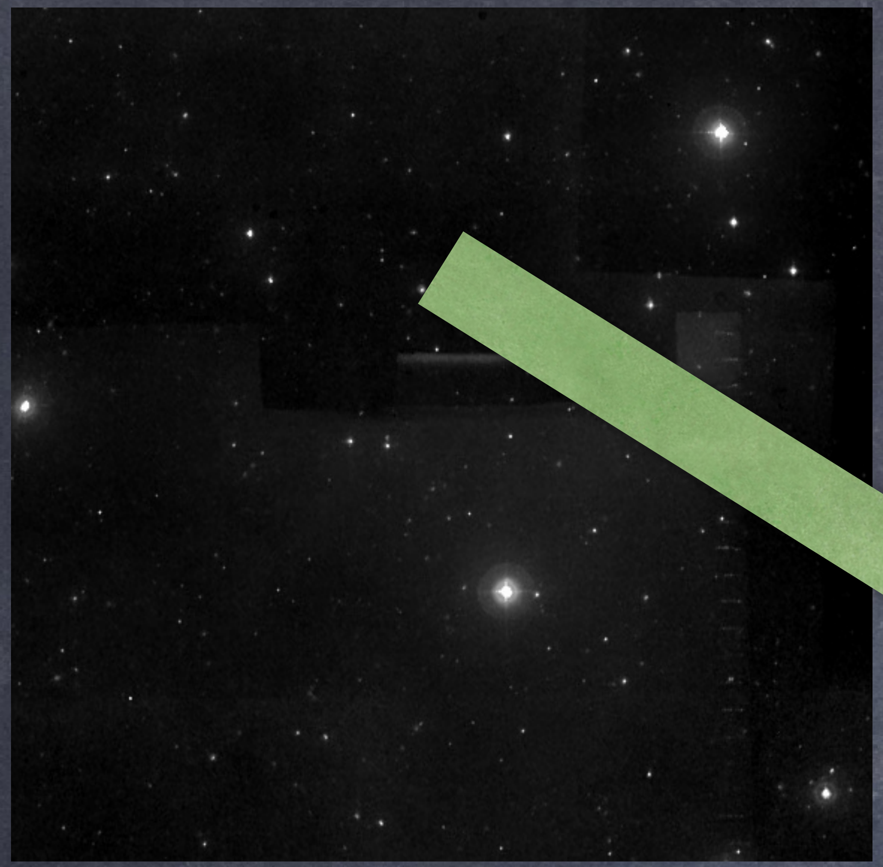


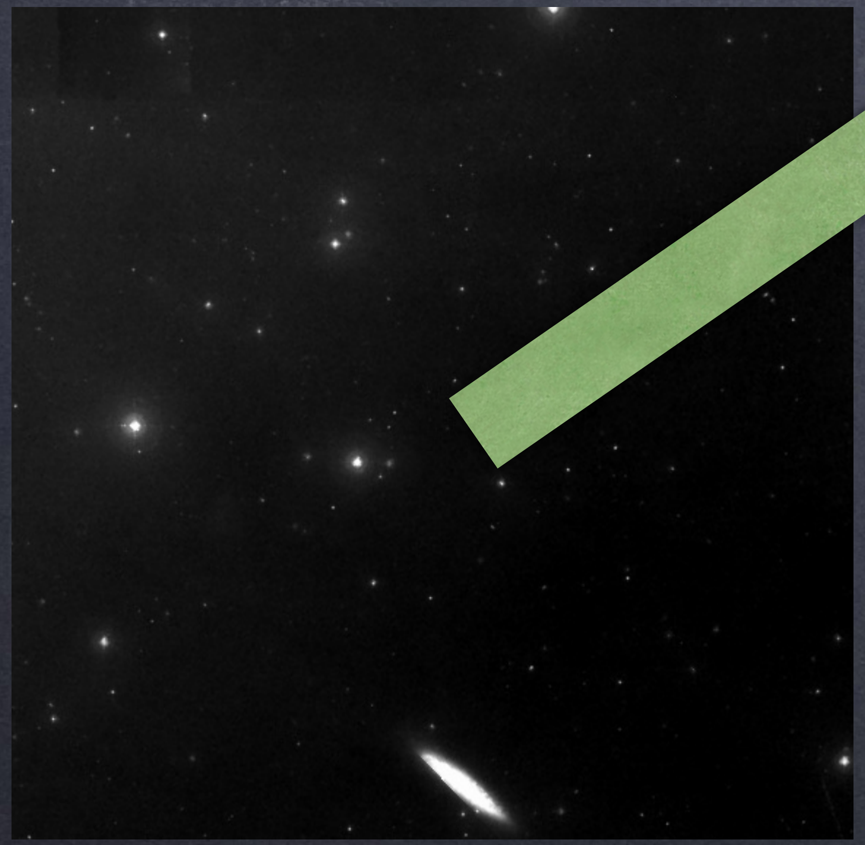
Visualize footprints

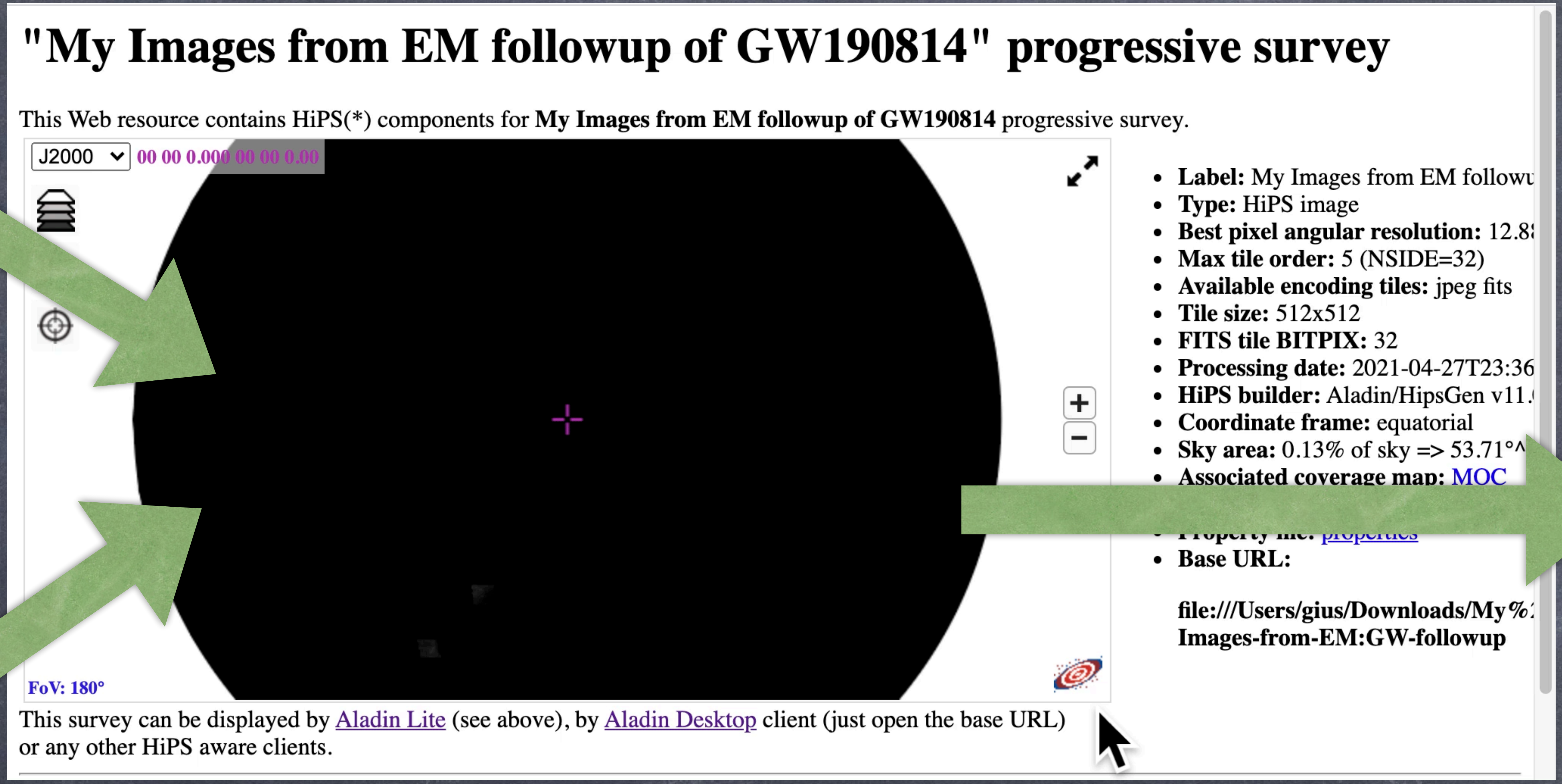


Visualize transient candidates

Images from “my telescope”.







"My Images from EM followup of GW190814" progressive survey

This Web resource contains HiPS(*) components for **My Images from EM followup of GW190814** progressive survey.

- **Label:** My Images from EM followu
- **Type:** HiPS image
- **Best pixel angular resolution:** 12.8
- **Max tile order:** 5 (NSIDE=32)
- **Available encoding tiles:** jpeg fits
- **Tile size:** 512x512
- **FITS tile BITPIX:** 32
- **Processing date:** 2021-04-27T23:36
- **HiPS builder:** Aladin/HipsGen v11.
- **Coordinate frame:** equatorial
- **Sky area:** 0.13% of sky => 53.71°^
- **Associated coverage map:** MOC
- **Property file:** properties
- **Base URL:**

  file:///Users/gius/Downloads/My%
  Images-from-EM:GW-followup

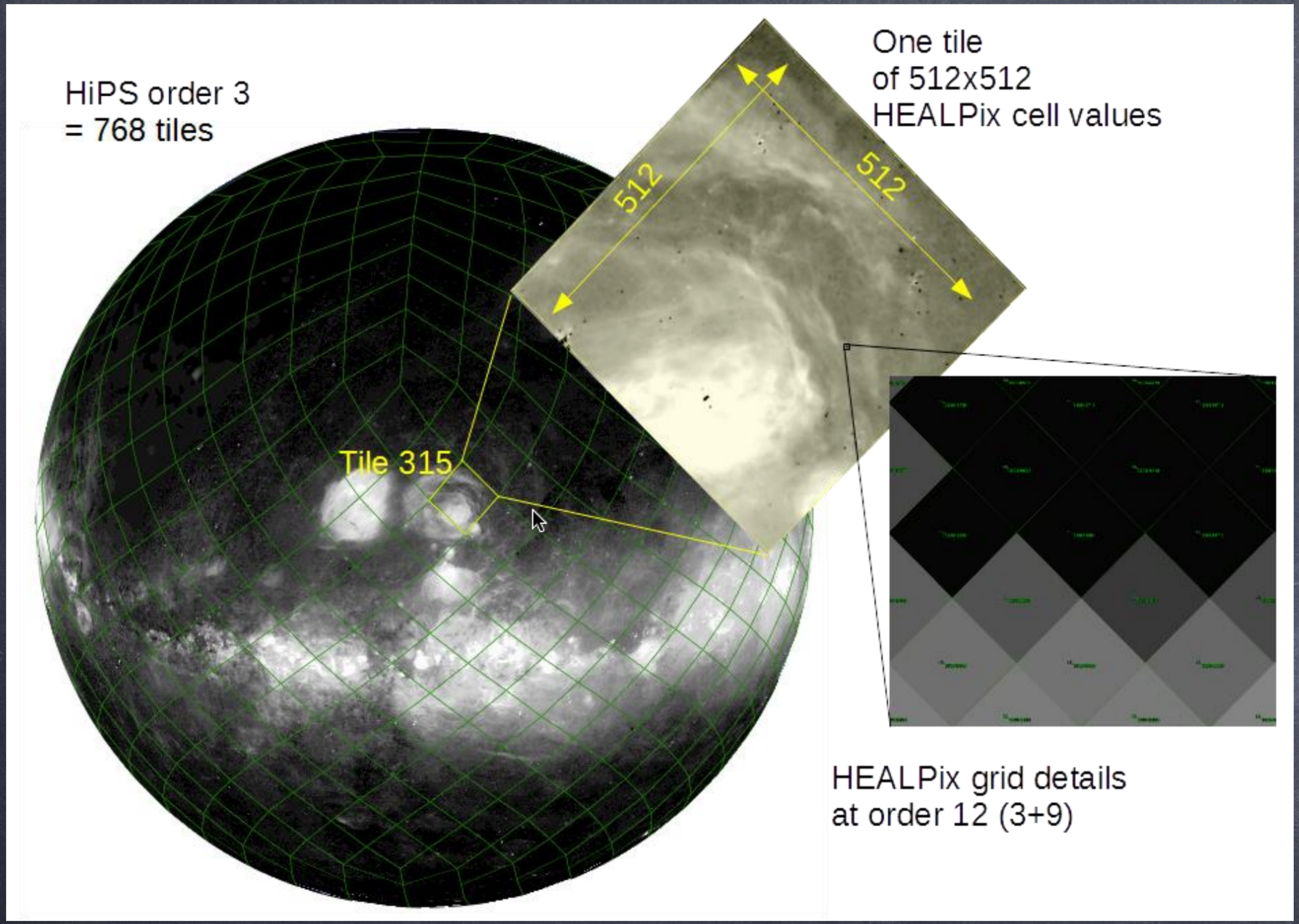
This survey can be displayed by Aladin Lite (see above), by Aladin Desktop client (just open the base URL) or any other HiPS aware clients.

hips2fits

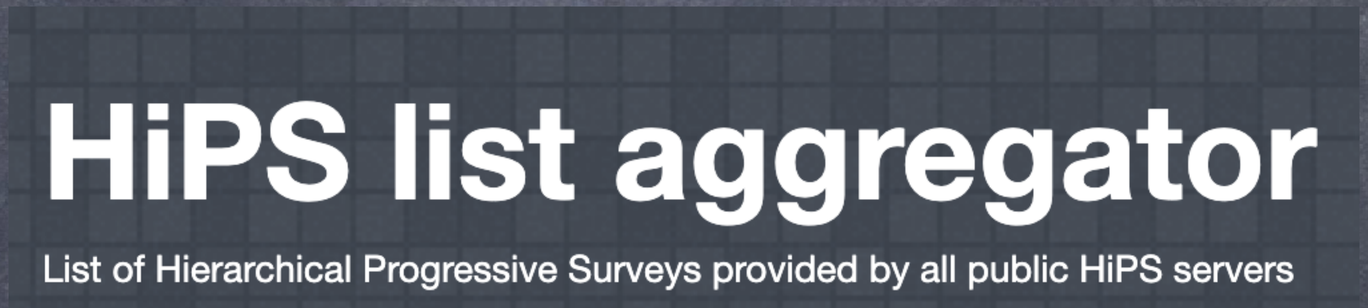
The hips2fits service enables generation of FITS images cutouts of arbitrary size and resolution from a given HiPS.

Publishing/Sharing EM follow-up images from “my telescope” to the community.

HiPS: Hierarchical Progressive Survey



This HiPS technique enables the exploration of large data sets. The most common usage of HiPS is the visualization of data from large astronomical surveys. HiPS allows one to browse "big data": pan and zoom into each section of the survey data using HiPS clients that access the data over the internet.



HiPS list aggregator

List of Hierarchical Progressive Surveys provided by all public HiPS servers

Total: 1084 HiPS (# instances up-to-date: 2517)

→ Available pixels 3.37E+14 (equivalent to a photo album of all inhabitants of the Earth with one 363x363 picture per human)

→ Catalog rows: 2.92E+10 = 29.2 billions of rows

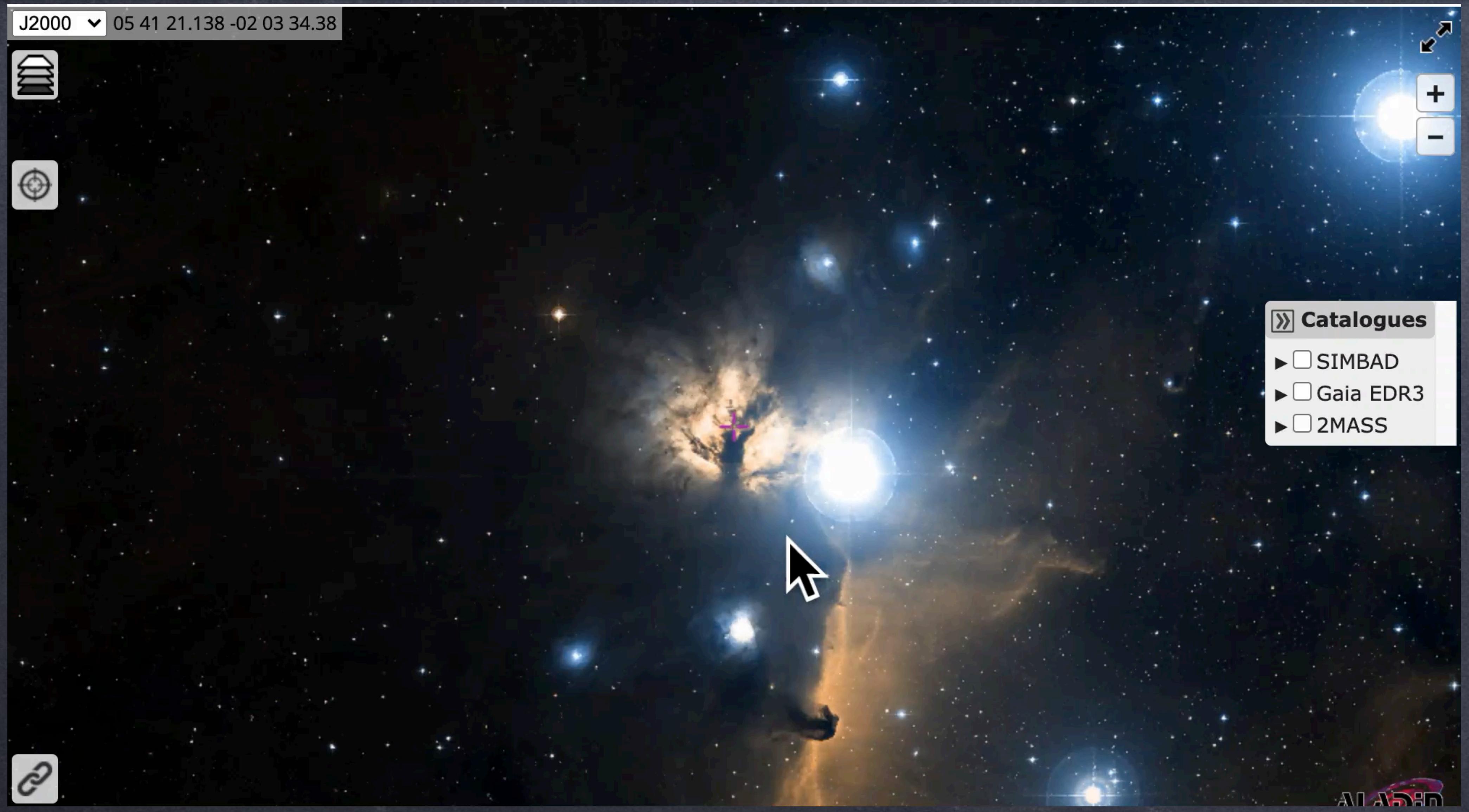
https://aladin.u-strasbg.fr/hips/list

Build an interactive online sky map with Aladin Lite

Aladin Lite

A lightweight sky atlas running in the browser

Aladin lite is a lightweight version of the Aladin Sky Atlas, running in the browser and geared towards simple visualization of a sky region. It allows one to visualize image surveys (JPEG multi-resolution HEALPix all-sky surveys) and superimpose tabular (VOTable) and footprints (STC-S) data. Aladin lite is easily embeddable on any web page and can also be controlled through a Javacript API. Aladin lite is powered by the HTML5 canvas technology, currently supported by any modern browser. New technologies will be implemented.



J2000 05 41 21.138 -02 03 34.38

Visualisation component in ESA Sky, ESO Science Portal, ALMA archive, CADE…

ALMA

ESO

esa
European Space Agency

CADE

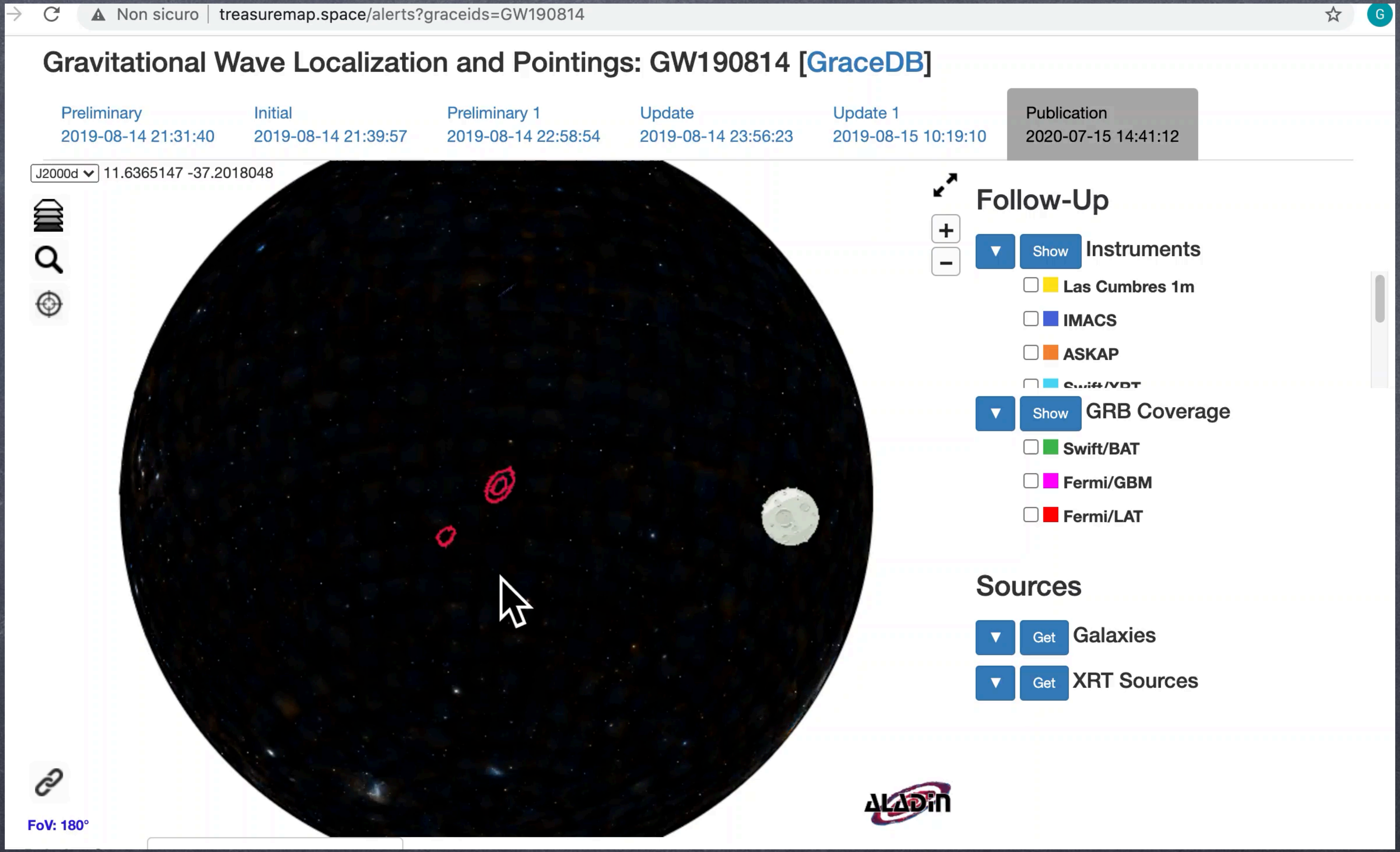
and in several multi-messenger applications…

Gravitational Wave Treasure Map

Treasure Map

The Treasure Map is designed to help coordinate electromagnetic followup of gravitational-wave (GW) events. It allows observers to easily report their planned and executed observations in search of counterparts to GW events, and to query the reports of other observers, in a programatic way. The goal is to enable coordination between observatories in order to minimize unnecessary overlap in these searches and find the counterpart as quickly and as efficiently as possible.

https://ui.adsabs.harvard.edu/abs/2020ApJ...894..127W/



Non sicuro | treasuremap.space/alerts?graceids=GW190814

Gravitational Wave Localization and Pointings: GW190814 [GraceDB]

Preliminary	Initial	Preliminary 1	Update	Update 1	Publication
2019-08-14 21:31:40	2019-08-14 21:39:57	2019-08-14 22:58:54	2019-08-14 23:56:23	2019-08-15 10:19:10	2020-07-15 14:41:12

J2000d 11.6365147 -37.2018048

FoV: 180°

Follow-Up

▼ Show Instruments

□ 🟨 Las Cumbres 1m
□ 🟦 IMACS
□ 🟧 ASKAP
□ 🟦 Swift/XRT

▼ Show GRB Coverage

□ 🟩 Swift/BAT
□ 🟪 Fermi/GBM
□ 🟥 Fermi/LAT

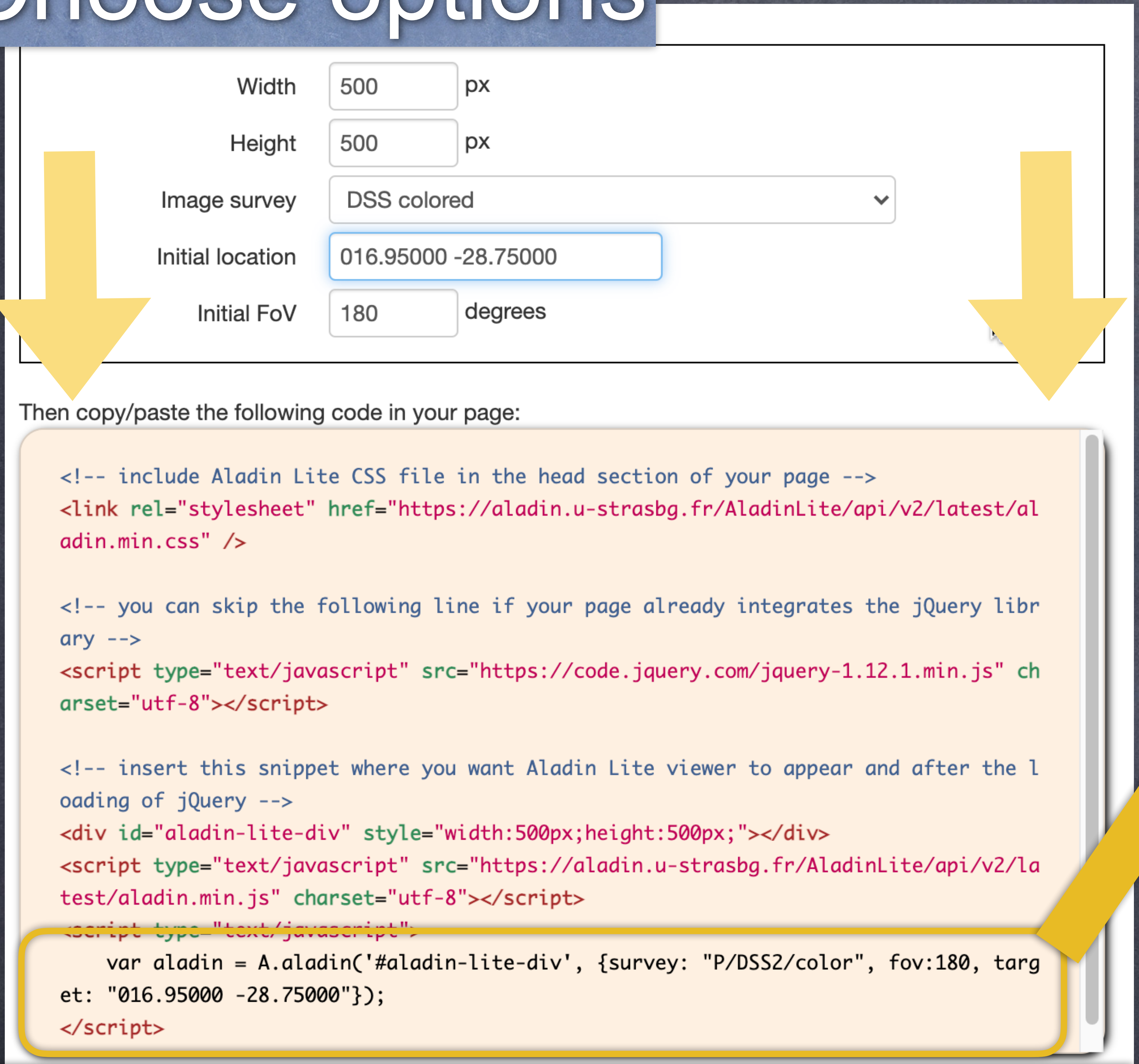
Sources

▼ Get Galaxies

▼ Get XRT Sources

Embedding in a web page

Choose options



Width	500	px
Height	500	px
Image survey	DSS colored	
Initial location	016.95000 -28.75000	
Initial FoV	180	degrees

Then copy/paste the following code in your page:

```
<!-- include Aladin Lite CSS file in the head section of your page -->
<link rel="stylesheet" href="https://aladin.u-strasbg.fr/AladinLite/api/v2/latest/aladin.min.css" />

<!-- you can skip the following line if your page already integrates the jQuery library -->
<script type="text/javascript" src="https://code.jquery.com/jquery-1.12.1.min.js" charset="utf-8"></script>

<!-- insert this snippet where you want Aladin Lite viewer to appear and after the loading of jQuery -->
<div id="aladin-lite-div" style="width:500px;height:500px;"></div>
<script type="text/javascript" src="https://aladin.u-strasbg.fr/AladinLite/api/v2/latest/aladin.min.js" charset="utf-8"></script>
<script type="text/javascript">
    var aladin = A.aladin('#aladin-lite-div', {survey: "P/DSS2/color", fov:180, target: "016.95000 -28.75000"});
</script>
```

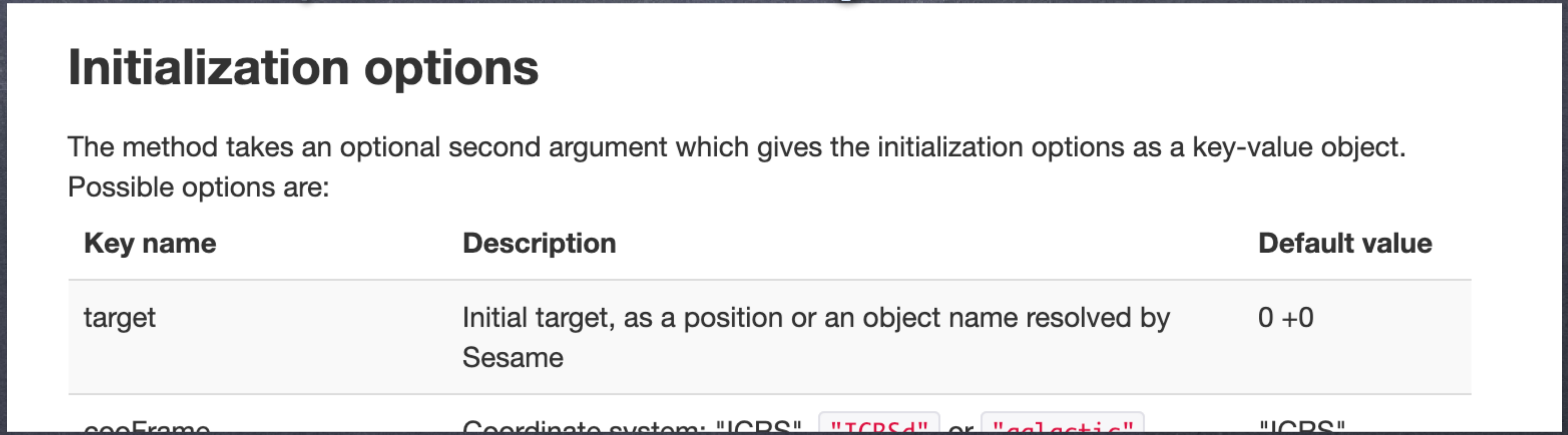
Then copy/paste the code in your page

Aladin Lite instance

```
var aladin = A.aladin('#aladin-lite-div',
          {
             survey: "P/DSS2/color",
             fov:180,
             target: "016.95000 -28.75000"});
```

More initialization options

https://aladin.u-strasbg.fr/AladinLite/doc/API/

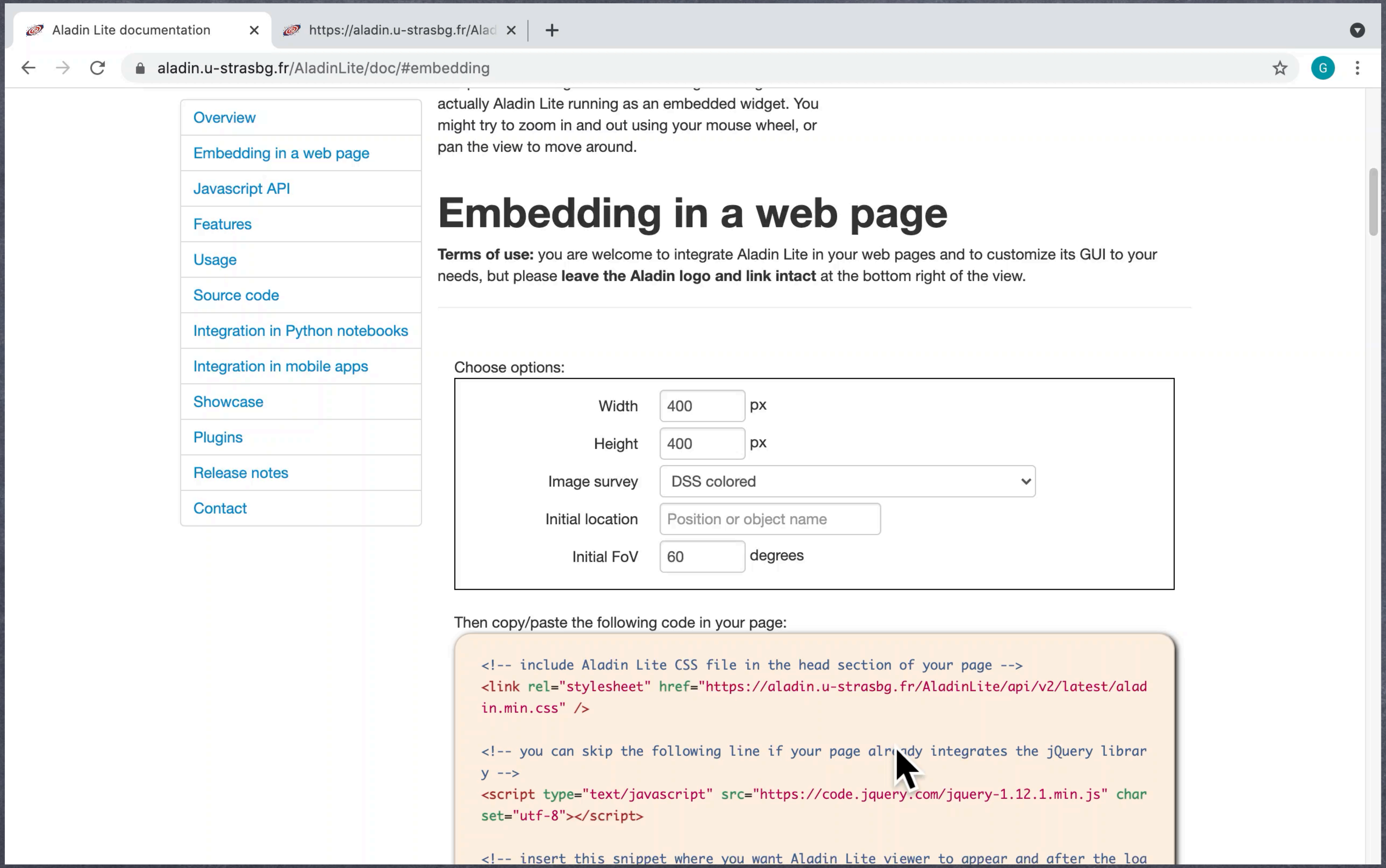


Initialization options

The method takes an optional second argument which gives the initialization options as a key-value object. Possible options are:

Key name	Description	Default value
target	Initial target, as a position or an object name resolved by Sesame	0 +0
cooFrame	Coordinate system: "ICRS", "ICRSd" or "galactic"	"ICRS"

Running Code on the Fly: initializations


Aladin Lite documentation
https://aladin.u-strasbg.fr/Alad
aladin.u-strasbg.fr/AladinLite/doc/#embedding
Overview
Embedding in a web page
Javascript API
Features
Usage
Source code
Integration in Python notebooks
Integration in mobile apps
Showcase
Plugins
Release notes
Contact

actually Aladin Lite running as an embedded widget. You might try to zoom in and out using your mouse wheel, or pan the view to move around.

Embedding in a web page

Terms of use: you are welcome to integrate Aladin Lite in your web pages and to customize its GUI to your needs, but please **leave the Aladin logo and link intact** at the bottom right of the view.

Choose options:

Width 400 px

Height 400 px

Image survey DSS colored

Initial location Position or object name

Initial FoV 60 degrees

Then copy/paste the following code in your page:

```
<!-- include Aladin Lite CSS file in the head section of your page -->
<link rel="stylesheet" href="https://aladin.u-strasbg.fr/AladinLite/api/v2/latest/aladin.min.css" />

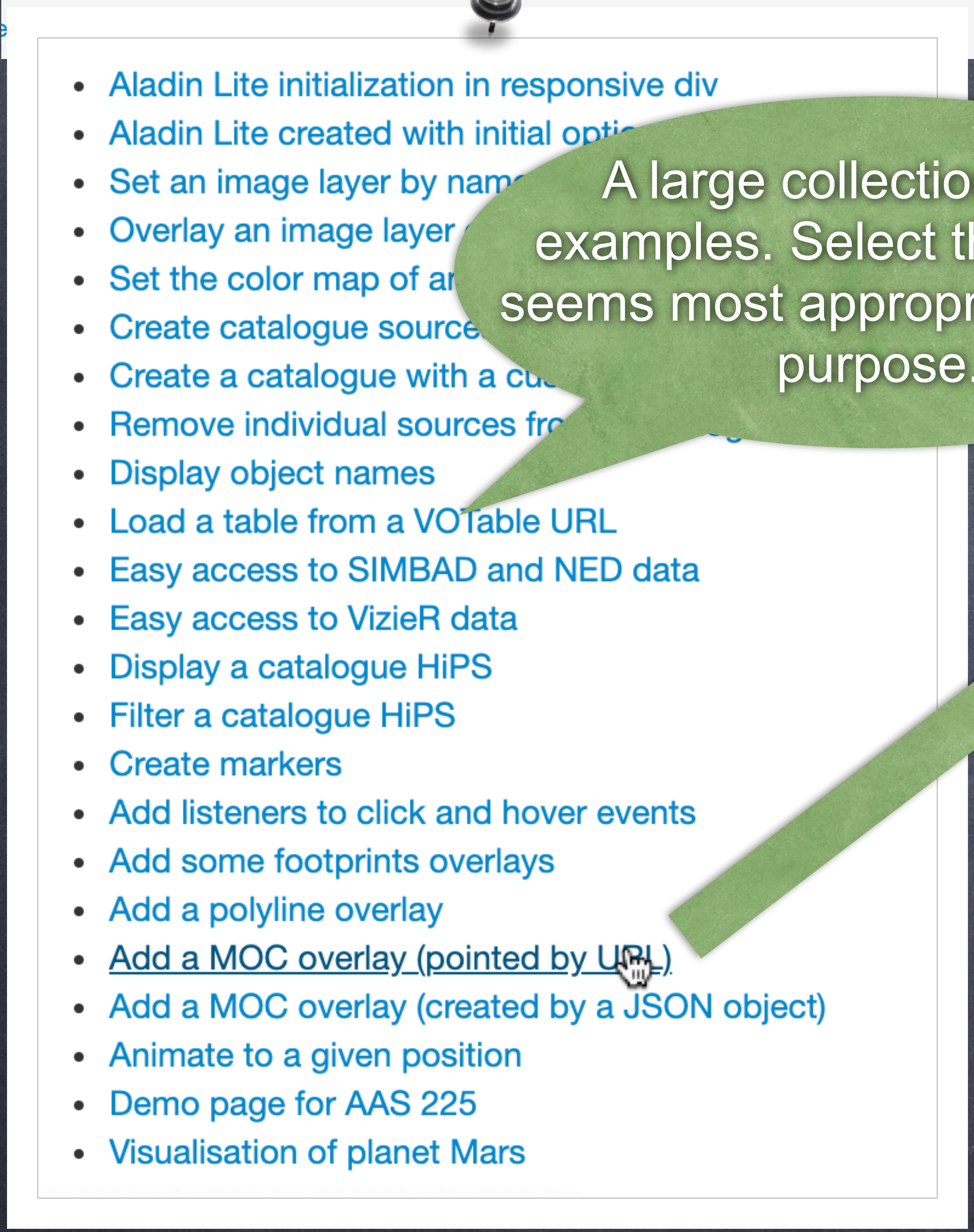
<!-- you can skip the following line if your page already integrates the jQuery library -->
<script type="text/javascript" src="https://code.jquery.com/jquery-1.12.1.min.js" charset="utf-8"></script>

<!-- insert this snippet where you want Aladin Lite viewer to appear and after the loa
```

Go to the page https://aladin.u-strasbg.fr/AladinLite/doc/API/examples/AL-in-responsive-div/

Clear the Javascript window and paste your code.

Aladin Lite API examples list



- Aladin Lite initialization in responsive div
- Aladin Lite created with initial opti
- Set an image layer by nam
- Overlay an image layer
- Set the color map of ar
- Create catalogue source
- Create a catalogue with a cu
- Remove individual sources fr
- Display object names
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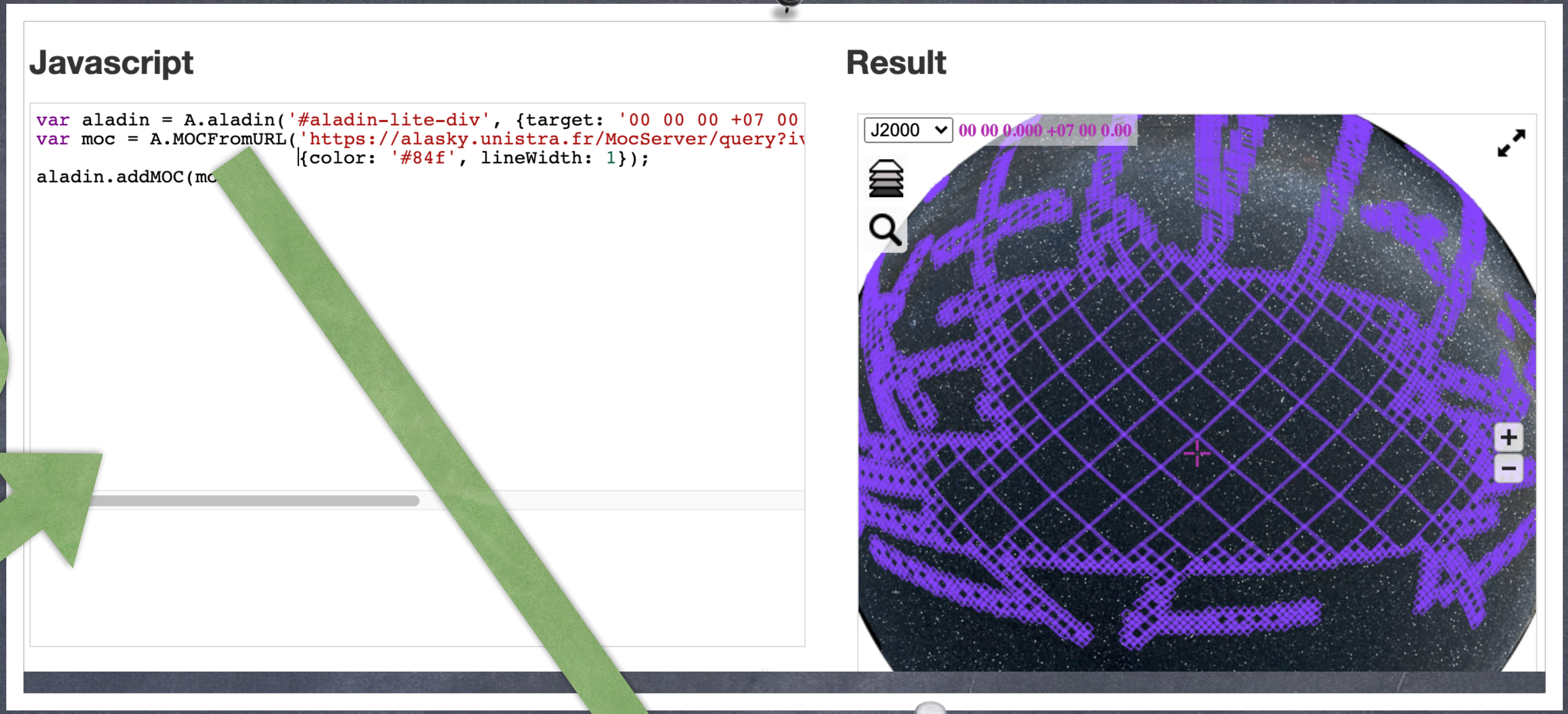
- Add a MOC overlay (created by a JSON object)
- Animate to a given position
- Demo page for AAS 225
- Visualisation of planet Mars

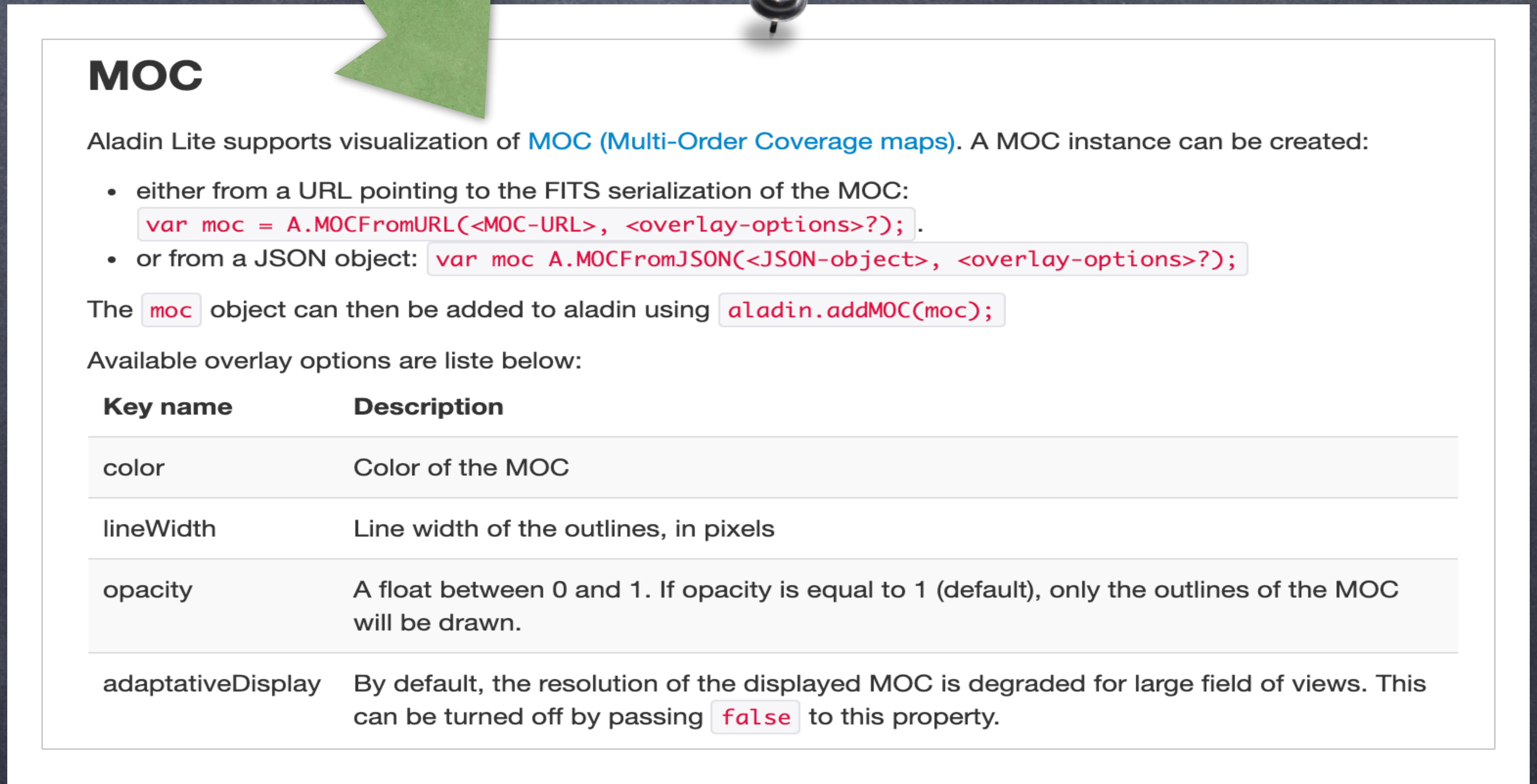
A large collection of API examples. Select the API that seems most appropriate for your purpose.



Javascript

```
var aladin = A.aladin('#aladin-lite-div', {target: '00 00 00 +07 00
var moc = A.MOCFromURL('https://alasky.unistra.fr/MocServer/query?iv
                        {color: '#84f', lineWidth: 1});
aladin.addMOC(mo
```

Result



MOC

Aladin Lite supports visualization of MOC (Multi-Order Coverage maps). A MOC instance can be created:

- either from a URL pointing to the FITS serialization of the MOC: `var moc = A.MOCFromURL(<MOC-URL>, <overlay-options>?);`.
- or from a JSON object: `var moc A.MOCFromJSON(<JSON-object>, <overlay-options>?);`

The `moc` object can then be added to aladin using `aladin.addMOC(moc);`

Available overlay options are liste below:

Key name	Description
color	Color of the MOC
lineWidth	Line width of the outlines, in pixels
opacity	A float between 0 and 1. If opacity is equal to 1 (default), only the outlines of the MOC will be drawn.
adaptativeDisplay	By default, the resolution of the displayed MOC is degraded for large field of views. This can be turned off by passing `false` to this property.

Interactive Visualization of GW190814 sky localization

LIGO Livingston, Virgo and LIGO Hanford - initial sky localization

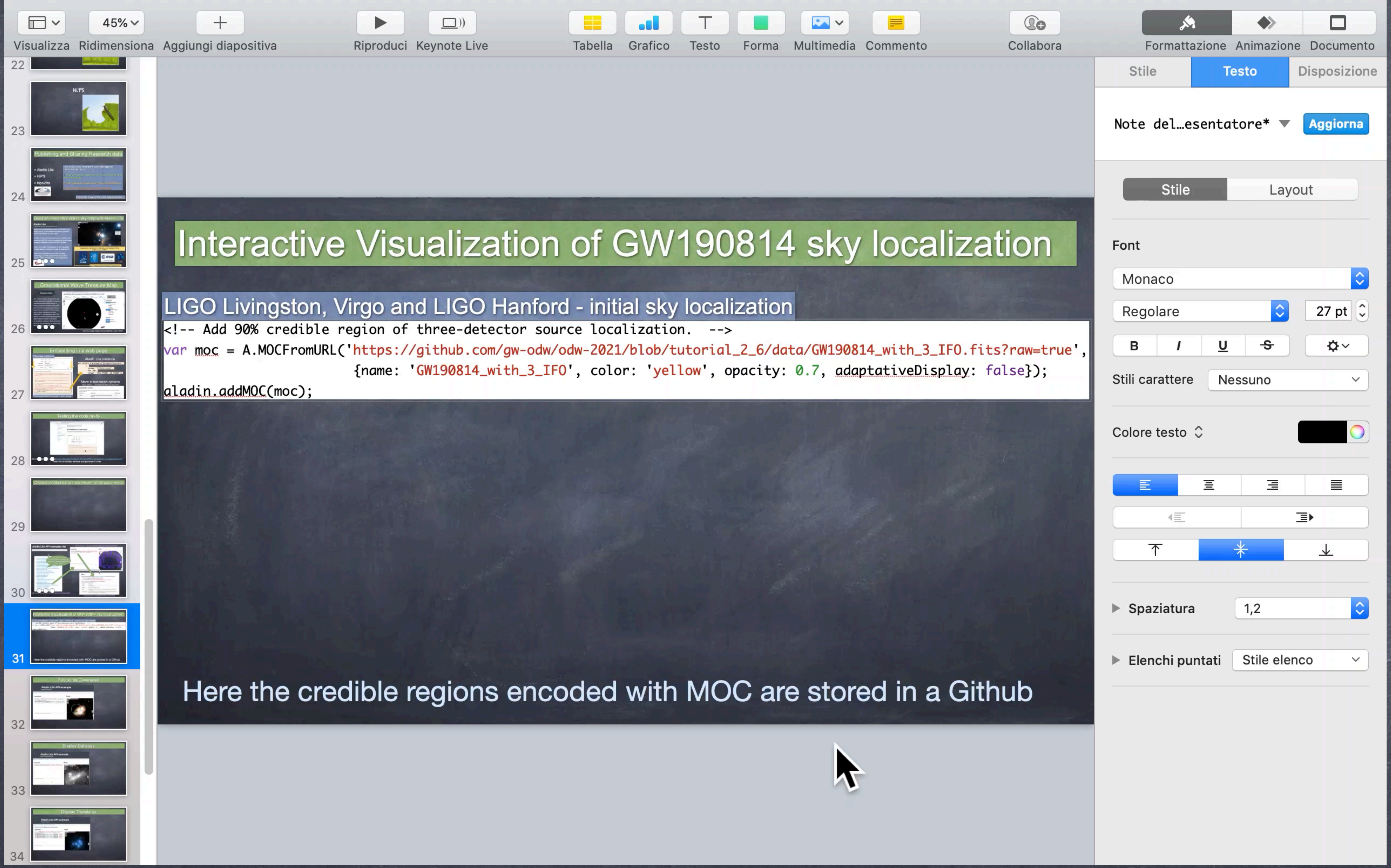
```
<!-- Add 90% credible region of three-detector source localization.  -->
var moc = A.MOCFromURL('https://github.com/gw-odw/odw-2021/blob/tutorial_2_6/data/GW190814_with_3_IFO.fits?
raw=true',
                        {name: 'GW190814_with_3_IFO', color: 'yellow', opacity: 0.7, adaptativeDisplay: false});
aladin.addMOC(moc);
```

The credible region can be encoded in a MOC .fits format using:

1. the ligo.skymap method ligo-skymap-contour-moc
2. or saving the region created in the Aladin Desktop.

Then the credible region is stored in an online repository. Here the repository is in a Github account.

Running Code on the Fly: credible region



Note del…esentatore*

Font: Monaco

Regolare 27 pt

Stili carattere: Nessuno

Spaziatura: 1,2

Elenchi puntati: Stile elenco

Interactive Visualization of GW190814 sky localization

LIGO Livingston, Virgo and LIGO Hanford - initial sky localization

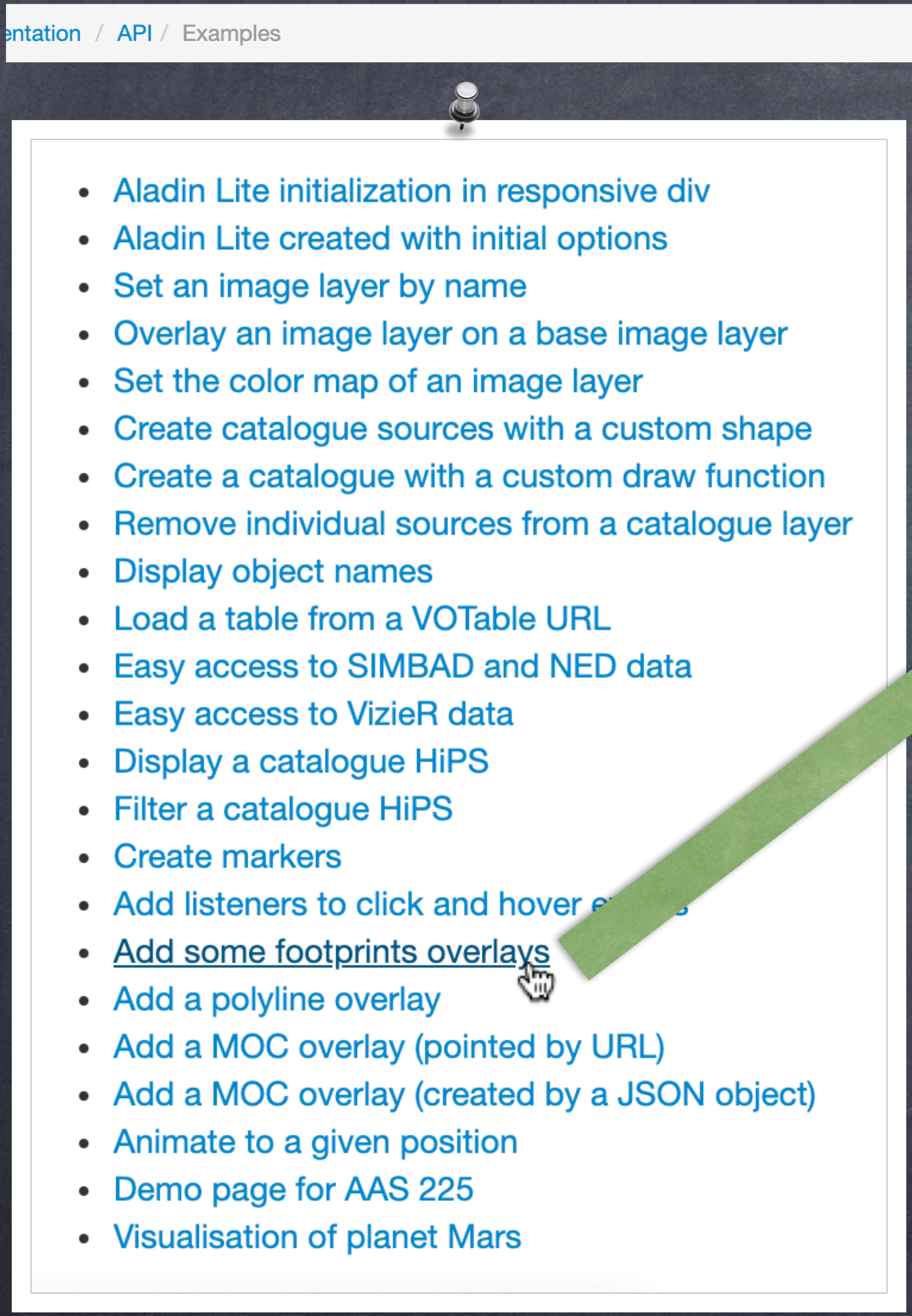
```
<!-- Add 90% credible region of three-detector source localization.  -->
var moc = A.MOCFromURL('https://github.com/gw-odw/odw-2021/blob/tutorial_2_6/data/GW190814_with_3_IFO.fits?raw=true',
                       {name: 'GW190814_with_3_IFO', color: 'yellow', opacity: 0.7, adaptativeDisplay: false});
aladin.addMOC(moc);
```

Here the credible regions encoded with MOC are stored in a Github

Go to the page https://aladin.u-strasbg.fr/AladinLite/doc/API/examples/AL-init-custom-options/

Clear the Javascript window and paste your code.

Aladin Lite API examples list



entation / API / Examples

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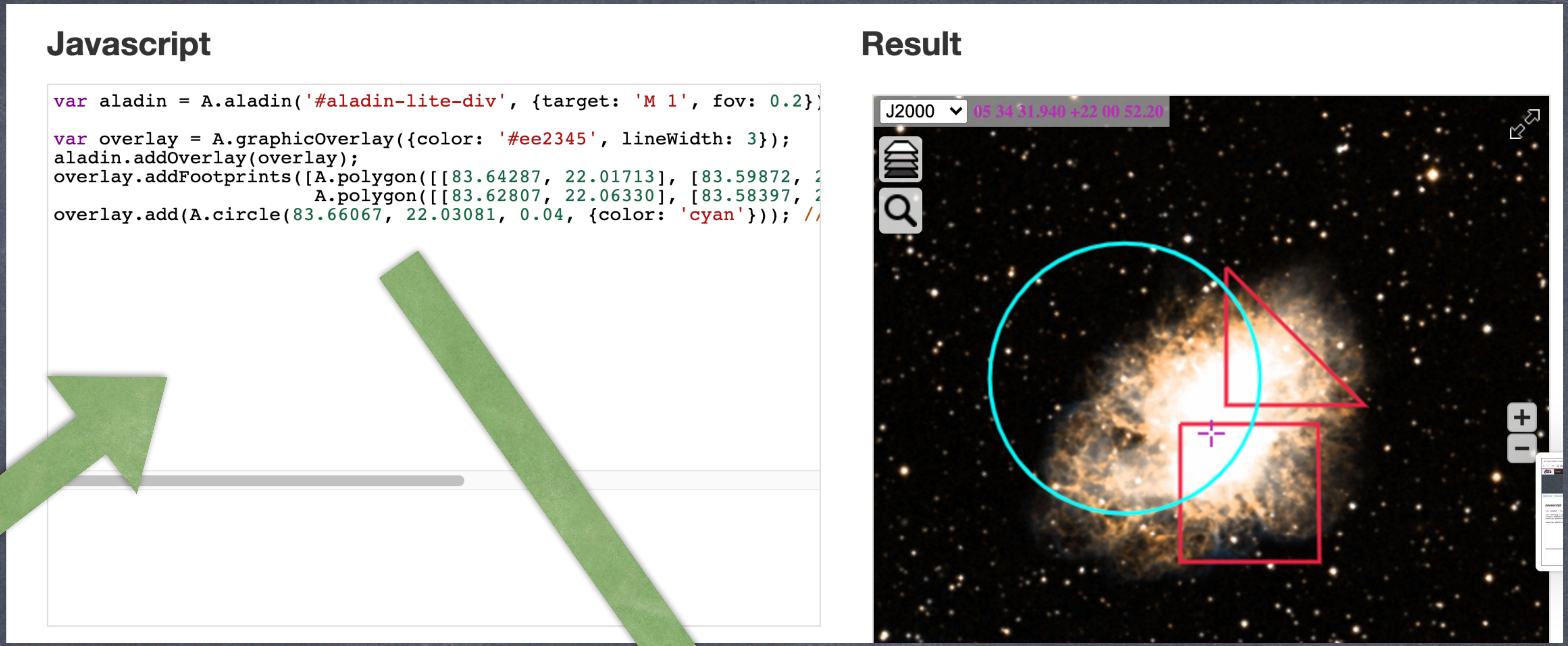
- Demo page for AAS 225
- Visualisation of planet Mars

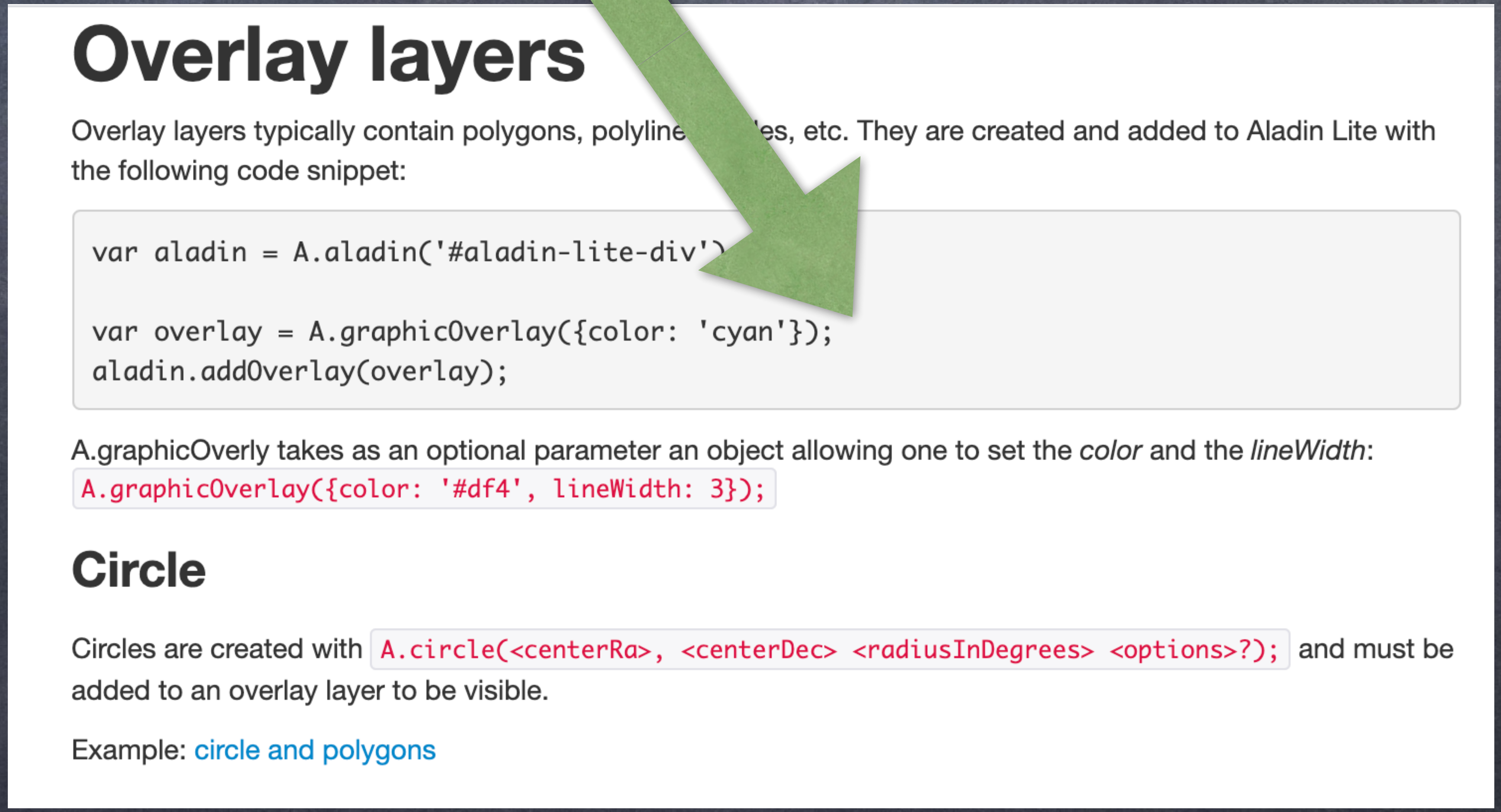


Javascript

```
var aladin = A.aladin('#aladin-lite-div', {target: 'M 1', fov: 0.2})

var overlay = A.graphicOverlay({color: '#ee2345', lineWidth: 3});
aladin.addOverlay(overlay);
overlay.addFootprints([A.polygon([[83.64287, 22.01713], [83.59872, 2
                       A.polygon([[83.62807, 22.06330], [83.58397, 2
overlay.add(A.circle(83.66067, 22.03081, 0.04, {color: 'cyan'})); //
```

Result



Overlay layers

Overlay layers typically contain polygons, polyline es, etc. They are created and added to Aladin Lite with the following code snippet:

```
var aladin = A.aladin('#aladin-lite-div')

var overlay = A.graphicOverlay({color: 'cyan'});
aladin.addOverlay(overlay);
```

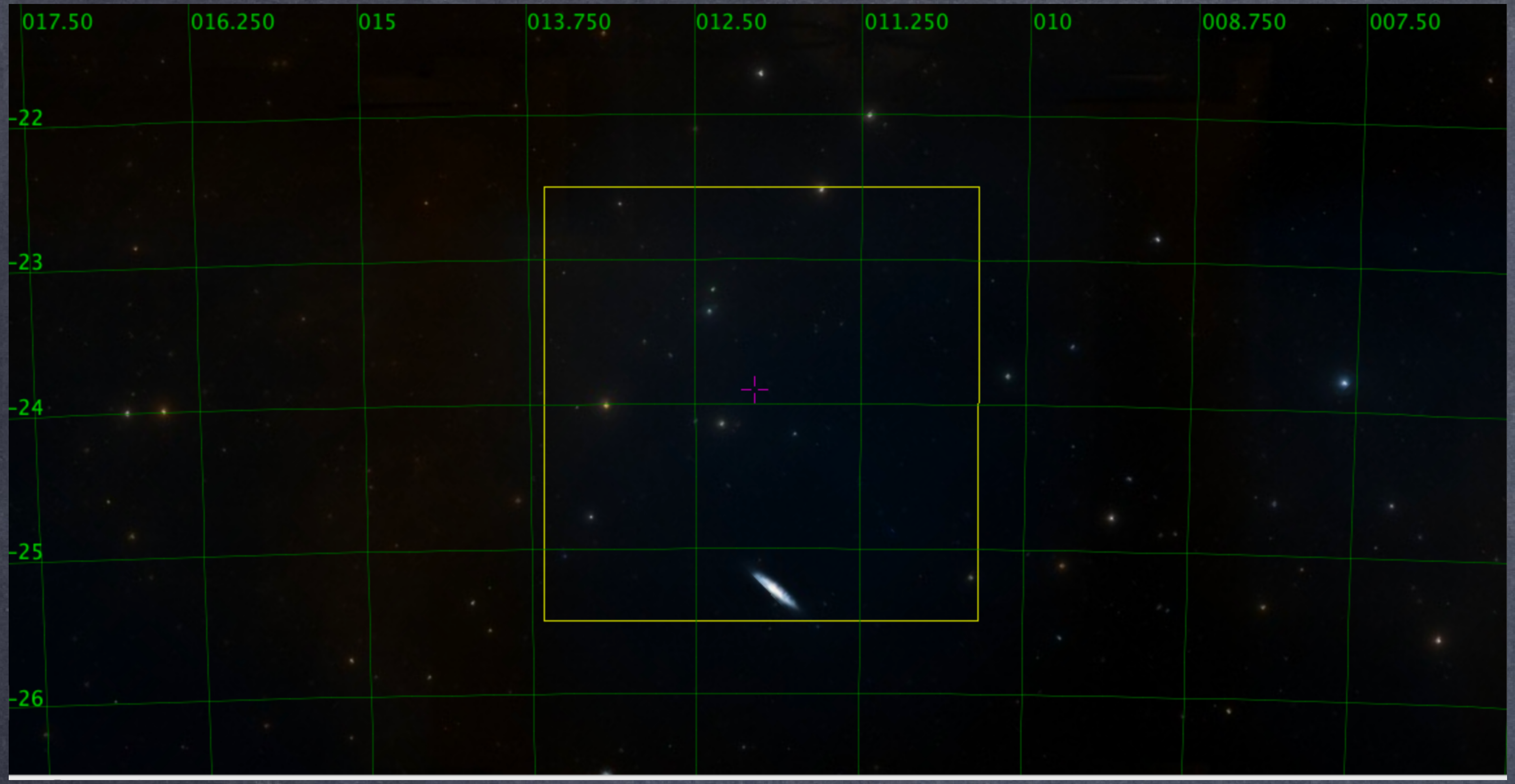
A.graphicOverly takes as an optional parameter an object allowing one to set the *color* and the *lineWidth*: `A.graphicOverlay({color: '#df4', lineWidth: 3});`

Circle

Circles are created with `A.circle(<centerRa>, <centerDec> <radiusInDegrees> <options>?);` and must be added to an overlay layer to be visible.

Example: circle and polygons

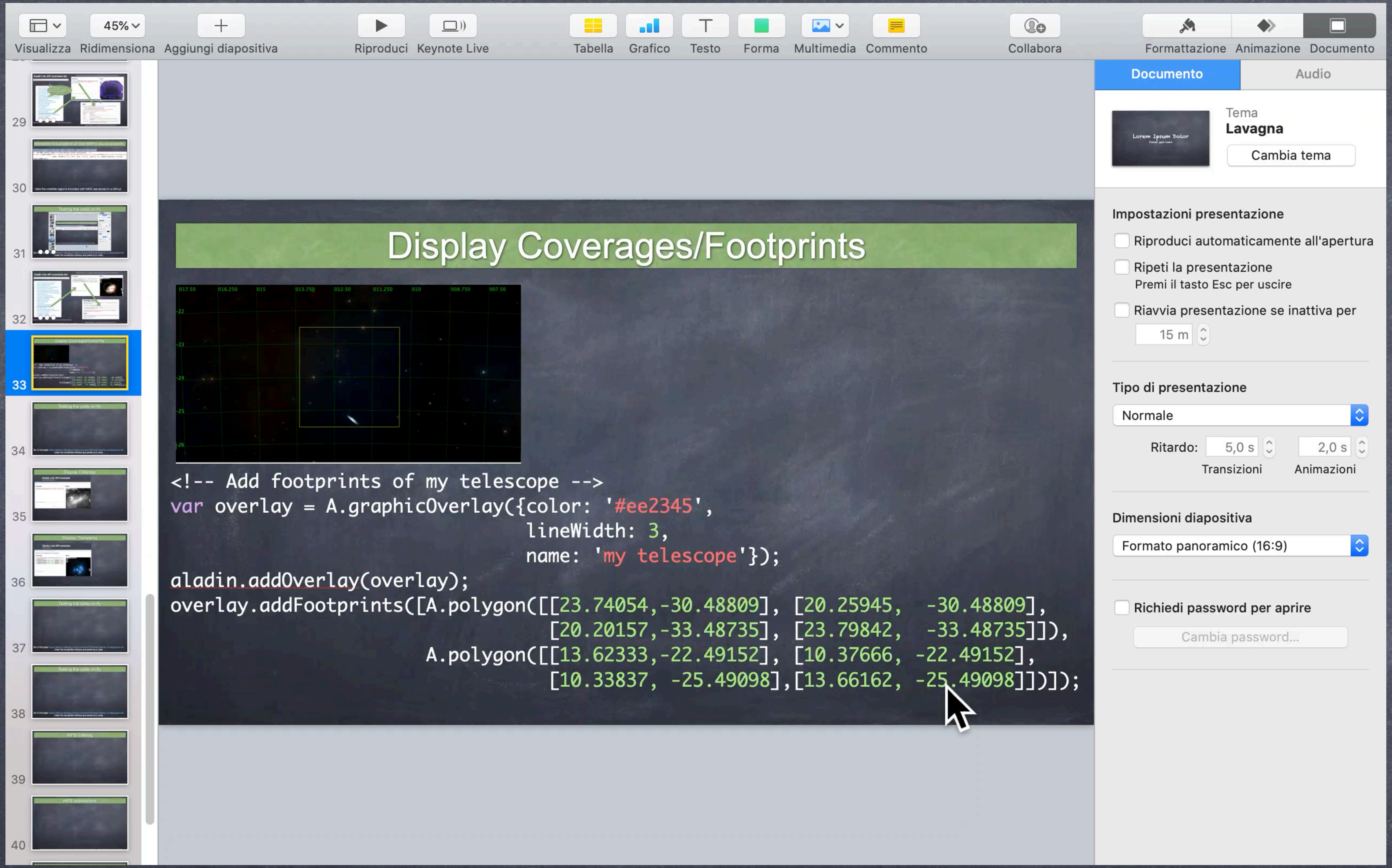
Display Coverages/Footprints



Footprint of a telescope with a Field of View 3°x3°.

```
<!-- Add footprints of my telescope -->
var overlay = A.graphicOverlay({color: '#ee2345',
                                lineWidth: 3,
                                name: 'my telescope'});
aladin.addOverlay(overlay);
overlay.addFootprints([A.polygon([[23.74054,-30.48809], [20.25945,  -30.48809],
                                  [20.20157,-33.48735], [23.79842,  -33.48735]]),
                       A.polygon([[13.62333,-22.49152], [10.37666, -22.49152],
                                  [10.33837, -25.49098],[13.66162, -25.49098]])]);
```

Running Code on the Fly: footprints



Display Coverages/Footprints

```
<!-- Add footprints of my telescope -->
var overlay = A.graphicOverlay({color: '#ee2345',
                                lineWidth: 3,
                                name: 'my telescope'});
aladin.addOverlay(overlay);
overlay.addFootprints([A.polygon([[23.74054,-30.48809], [20.25945,  -30.48809],
                                   [20.20157,-33.48735], [23.79842,  -33.48735]]),
                       A.polygon([[13.62333,-22.49152], [10.37666, -22.49152],
                                   [10.33837, -25.49098],[13.66162, -25.49098]])]);
```

Tema
Lavagna
Cambia tema

Impostazioni presentazione

□ Riproduci automaticamente all'apertura

□ Ripeti la presentazione
Premi il tasto Esc per uscire

□ Riavvia presentazione se inattiva per
15 m

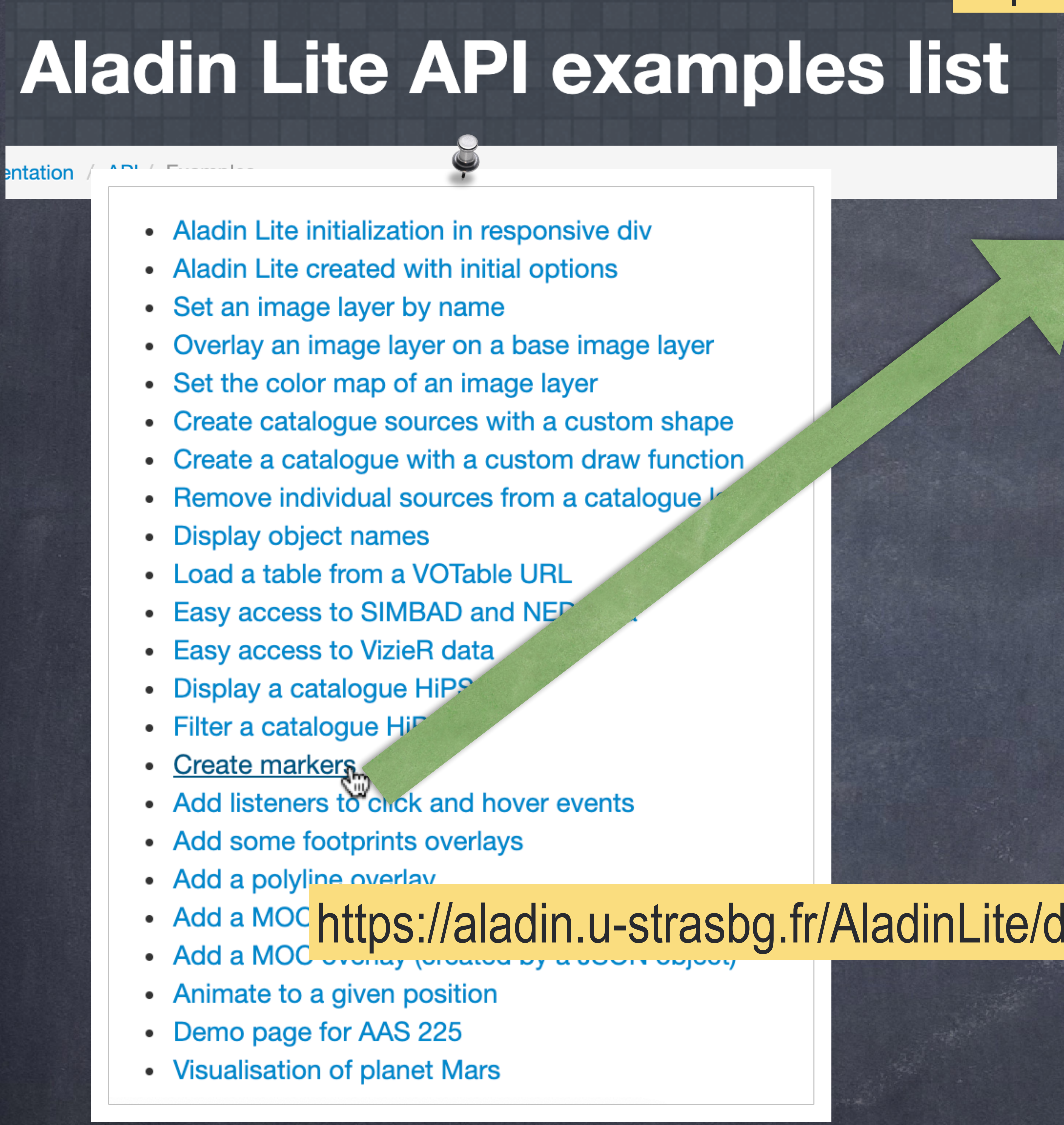
Tipo di presentazione
Normale

Ritardo: 5,0 s Transizioni 2,0 s Animazioni

Dimensioni diapositiva
Formato panoramico (16:9)

□ Richiedi password per aprire
Cambia password...

Go to the page https://aladin.u-strasbg.fr/AladinLite/doc/API/examples/AL-init-custom-options/
Clear the Javascript window and paste your code.



Aladin Lite API examples list

ntation /

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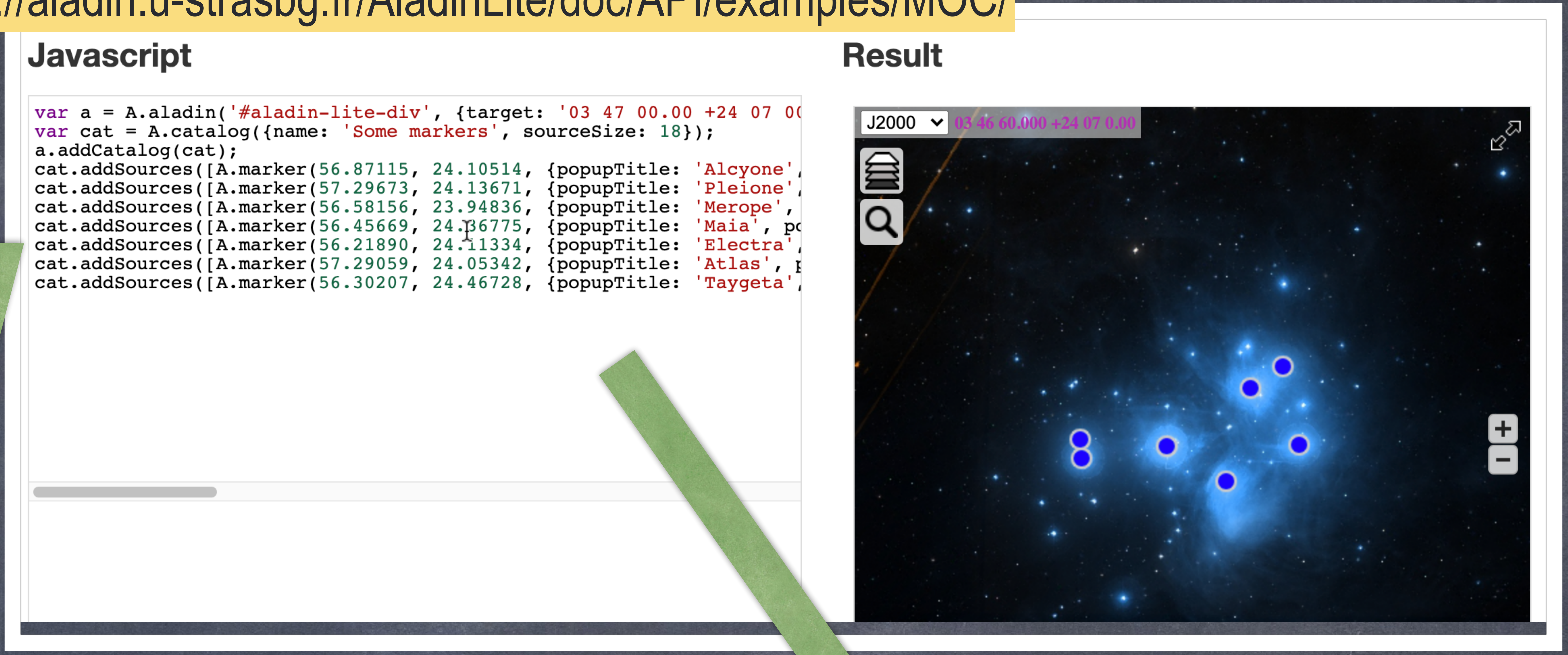
https://aladin.u-strasbg.fr/AladinLite/doc/API/examples/

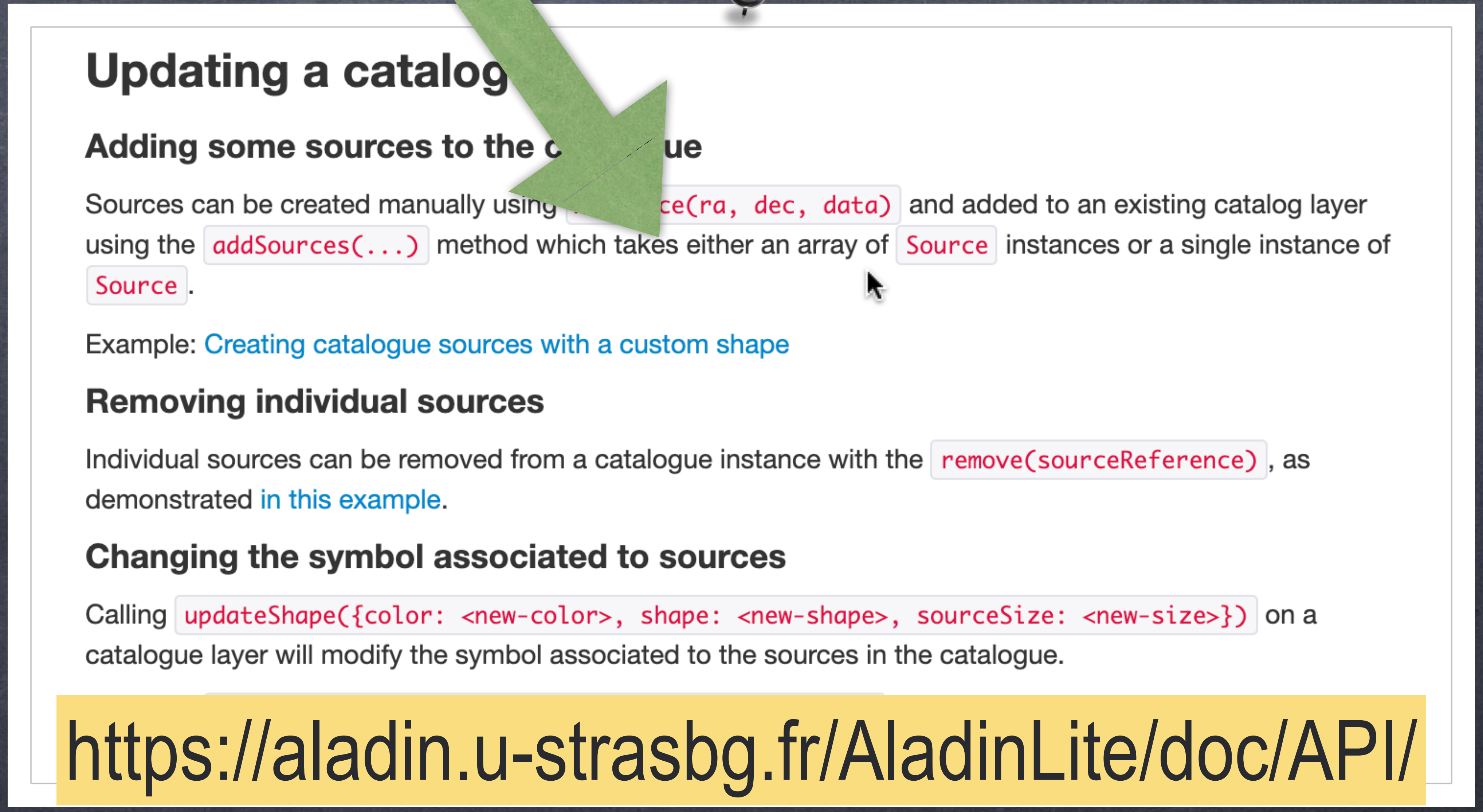
https://aladin.u-strasbg.fr/AladinLite/doc/API/examples/MOC/



Javascript

```
var a = A.aladin('#aladin-lite-div', {target: '03 47 00.00 +24 07 00
var cat = A.catalog({name: 'Some markers', sourceSize: 18});
a.addCatalog(cat);
cat.addSources([A.marker(56.87115, 24.10514, {popupTitle: 'Alcyone',
cat.addSources([A.marker(57.29673, 24.13671, {popupTitle: 'Pleione',
cat.addSources([A.marker(56.58156, 23.94836, {popupTitle: 'Merope',
cat.addSources([A.marker(56.45669, 24.36775, {popupTitle: 'Maia', pc
cat.addSources([A.marker(56.21890, 24.11334, {popupTitle: 'Electra',
cat.addSources([A.marker(57.29059, 24.05342, {popupTitle: 'Atlas', p
cat.addSources([A.marker(56.30207, 24.46728, {popupTitle: 'Taygeta',
```

Result



Updating a catalog

Adding some sources to the c ue

Sources can be created manually using ce(ra, dec, data) and added to an existing catalog layer using the `addSources(...)` method which takes either an array of `Source` instances or a single instance of `Source`.

Example: Creating catalogue sources with a custom shape

Removing individual sources

Individual sources can be removed from a catalogue instance with the `remove(sourceReference)`, as demonstrated in this example.

Changing the symbol associated to sources

Calling `updateShape({color: <new-color>, shape: <new-shape>, sourceSize: <new-size>})` on a catalogue layer will modify the symbol associated to the sources in the catalogue.

https://aladin.u-strasbg.fr/AladinLite/doc/API/

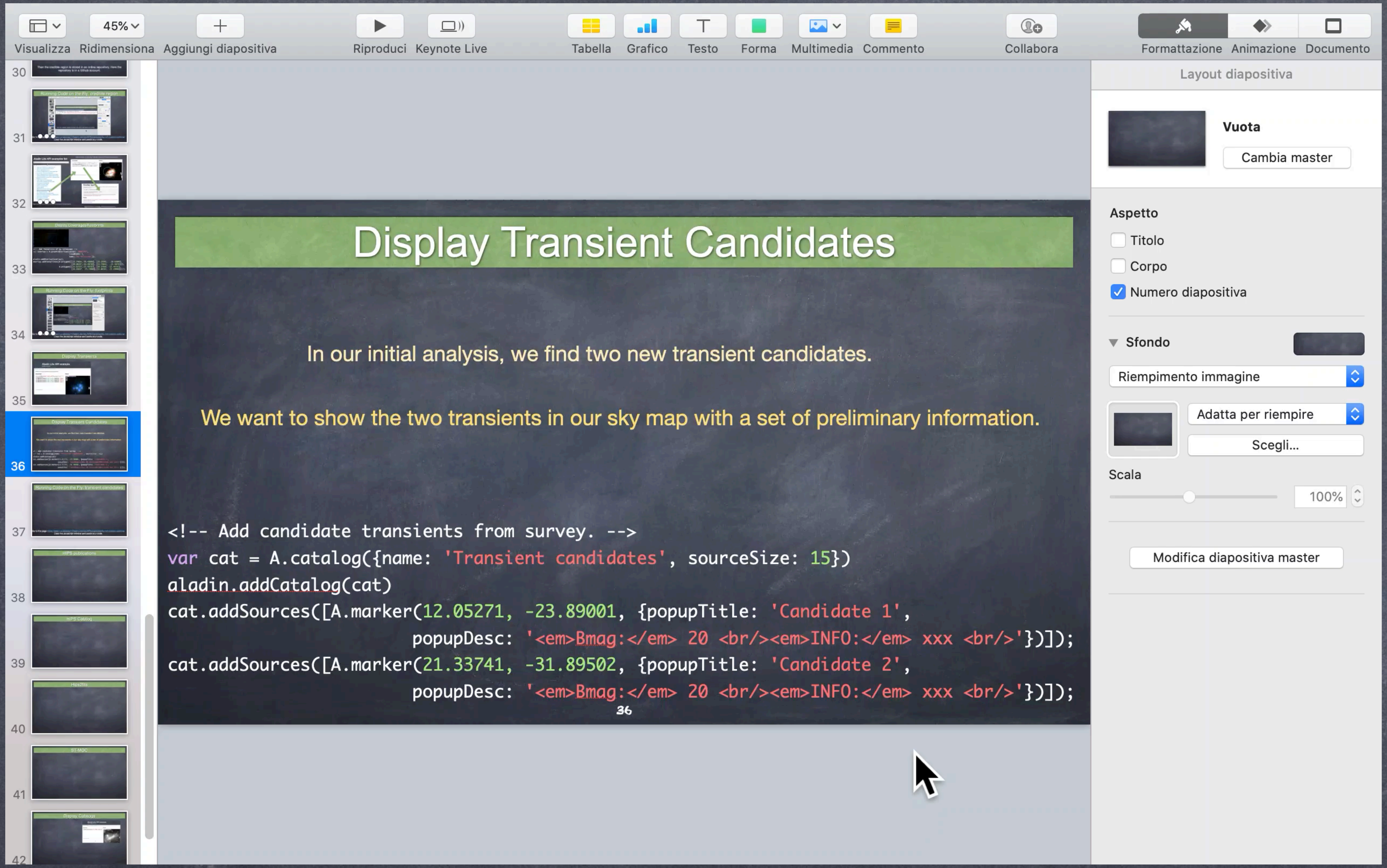
Display Transient Candidates

Continuing the illustration of this example; in our initial analysis, we find two new transient candidates: Candidate 1 and Candidate 2.

We want to show the two transients in our sky map with a set of preliminary information.

```
<!-- Add candidate transients from survey. -->
var cat = A.catalog({name: 'Transient candidates', sourceSize: 15})
aladin.addCatalog(cat)
cat.addSources([A.marker(12.05271, -23.89001, {popupTitle: 'Candidate 1',
                        popupDesc: '<em>Bmag:</em> 20 <br/><em>INFO:</em> xxx <br/>'})]);
cat.addSources([A.marker(21.33741, -31.89502, {popupTitle: 'Candidate 2',
                        popupDesc: '<em>Bmag:</em> 20 <br/><em>INFO:</em> xxx <br/>'})]);
```

Running Code on the Fly: transient candidates



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                        popupDesc: '<em>Bmag:</em> 20 <br/><em>INFO:</em> xxx <br/>'})]);
```

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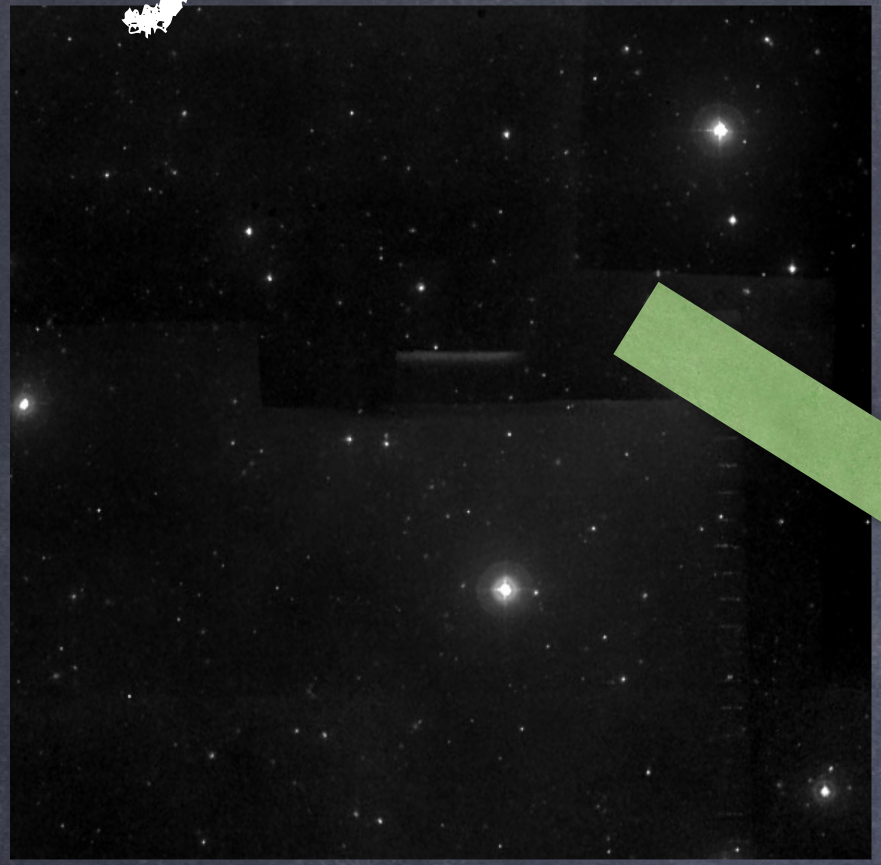
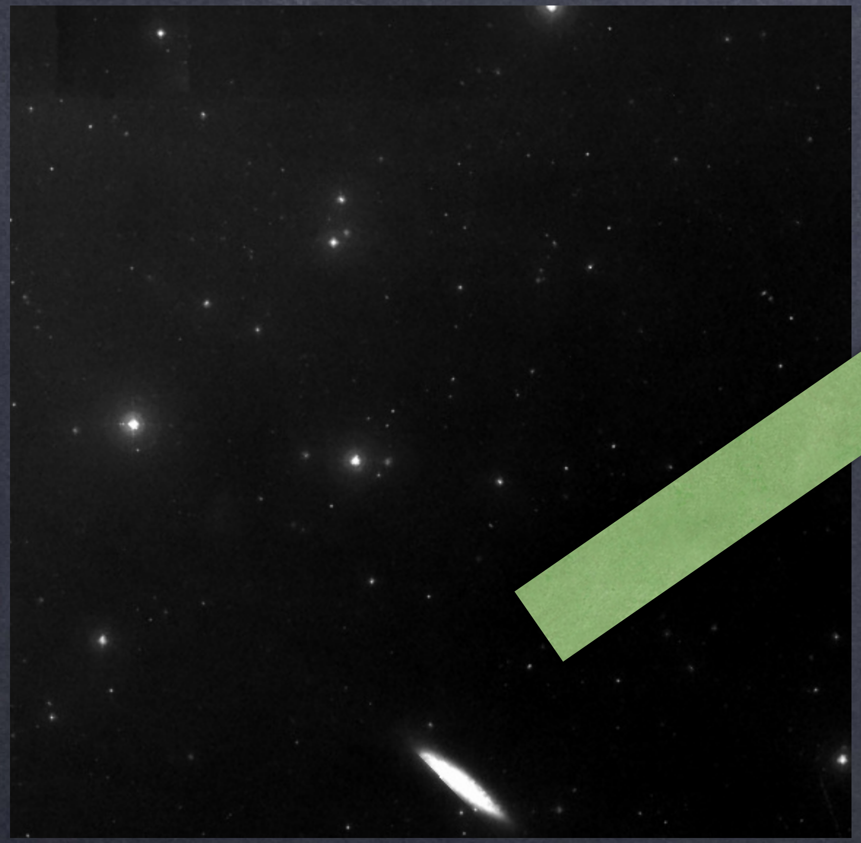
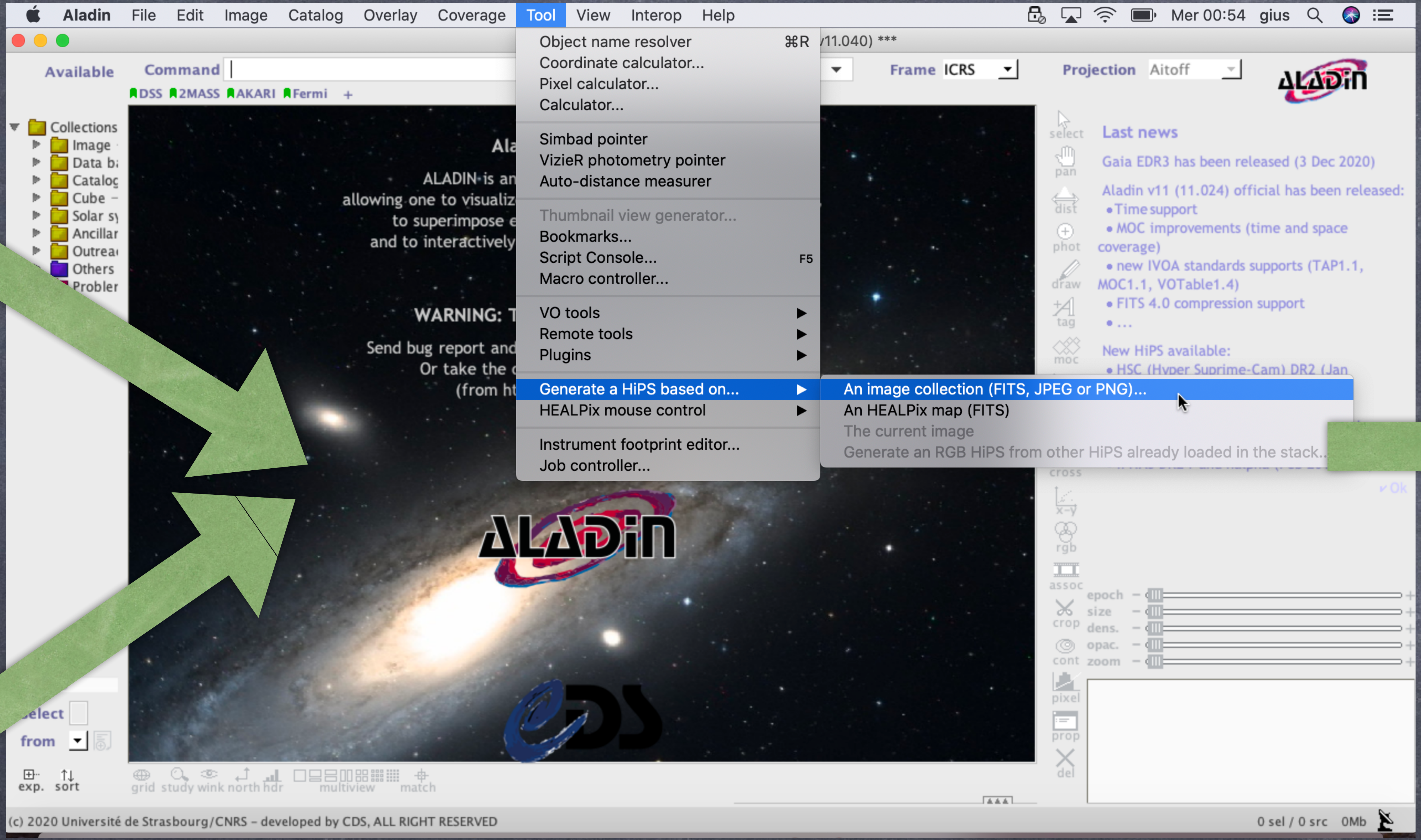
Go to the page https://aladin.u-strasbg.fr/AladinLite/doc/API/examples/AL-init-custom-options/
Clear the Javascript window and paste your code.

Aladin Desktop: GUI for HiPS production

My FITS images







Last news

Gaia EDR3 has been released (3 Dec 2020)

Aladin v11 (11.024) official has been released:

- Time support
- MOC improvements (time and space coverage)
- new IVOA standards supports (TAP1.1, MOC1.1, VOTable1.4)
- FITS 4.0 compression support
- ...

New HiPS available:

- HSC (Hyper Suprime-Cam) DR2 (Jan

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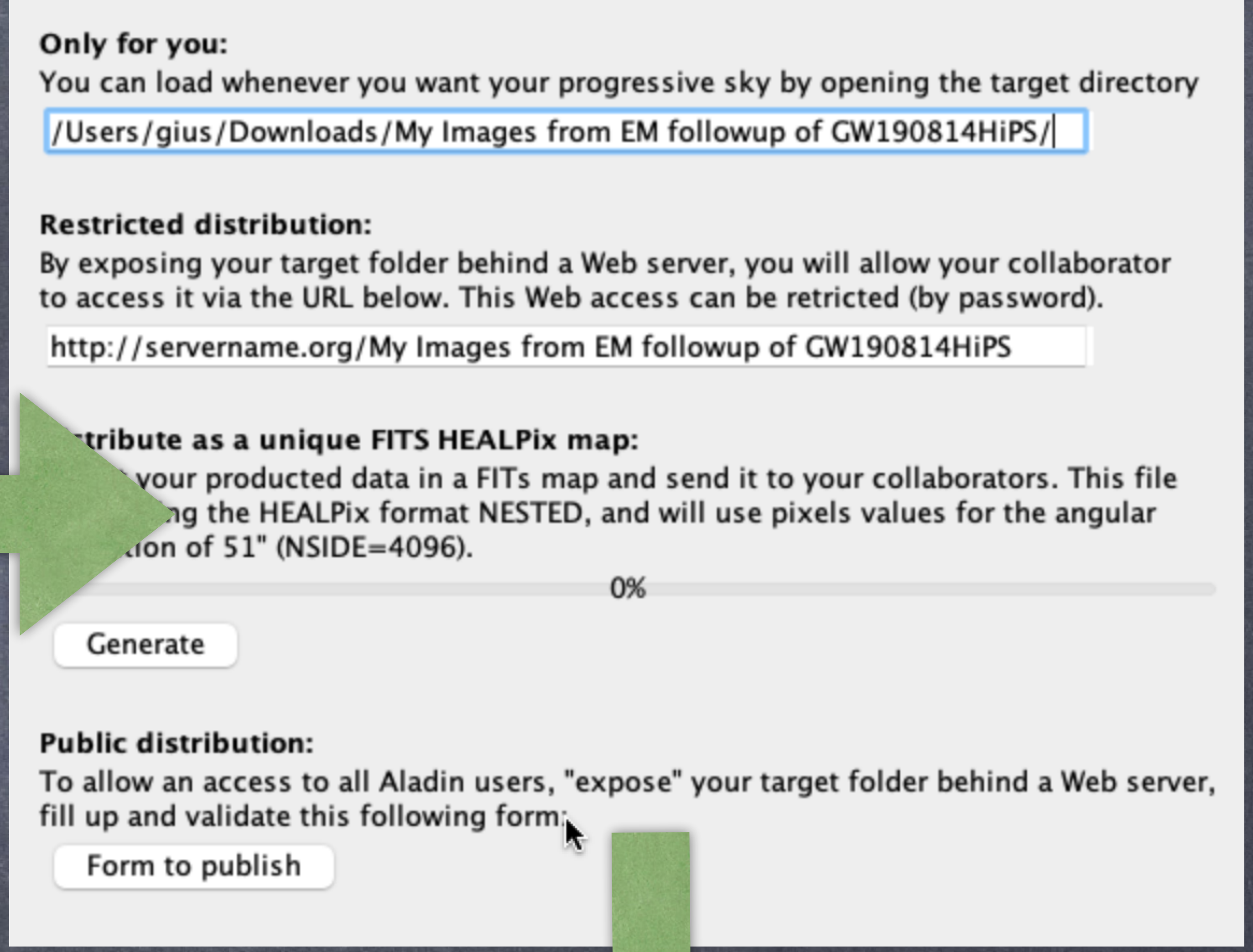
Public Images



Only for you:
You can load whenever you want your progressive sky by opening the target directory

/Users/gius/Downloads/My Images from EM followup of GW190814HiPS/

Restricted distribution:
By exposing your target folder behind a Web server, you will allow your collaborator to access it via the URL below. This Web access can be retricted (by password).

http://servername.org/My Images from EM followup of GW190814HiPS

tribute as a unique FITS HEALPix map:
your producted data in a FITs map and send it to your collaborators. This file ng the HEALPix format NESTED, and will use pixels values for the angular tion of 51" (NSIDE=4096).

0%

Generate

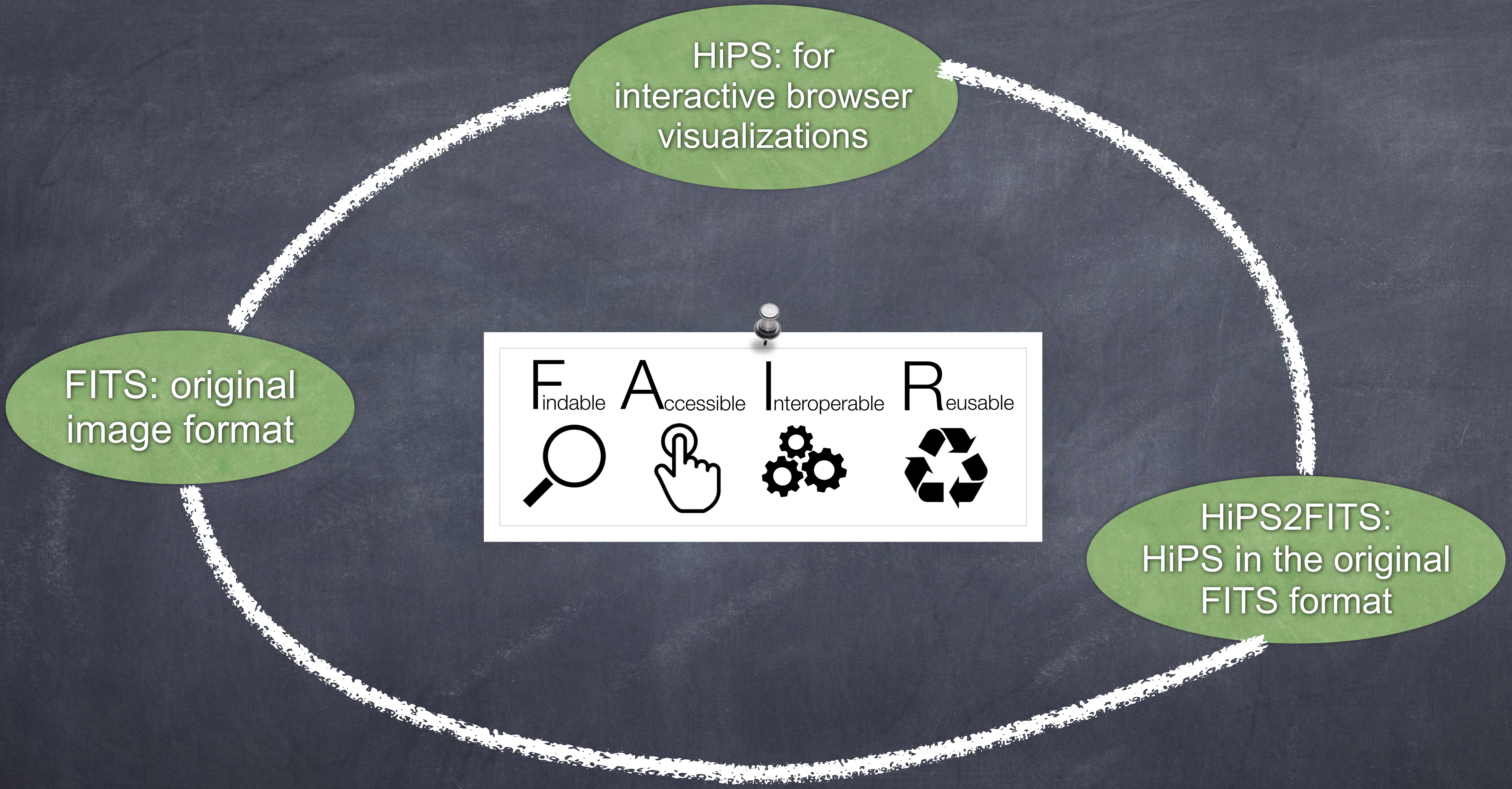
Public distribution:
To allow an access to all Aladin users, "expose" your target folder behind a Web server, fill up and validate this following form:

Form to publish

Aladin Lite

hips2fits

Thanks



HiPS: for interactive browser visualizations

FITS: original image format

HiPS2FITS: HiPS in the original FITS format

Findable Accessible Interoperable Reusable