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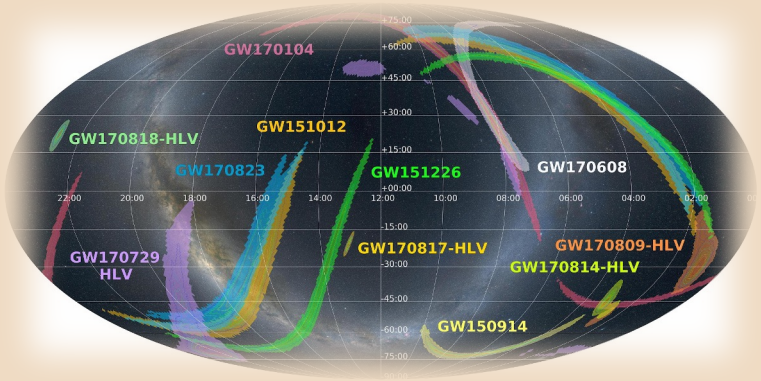
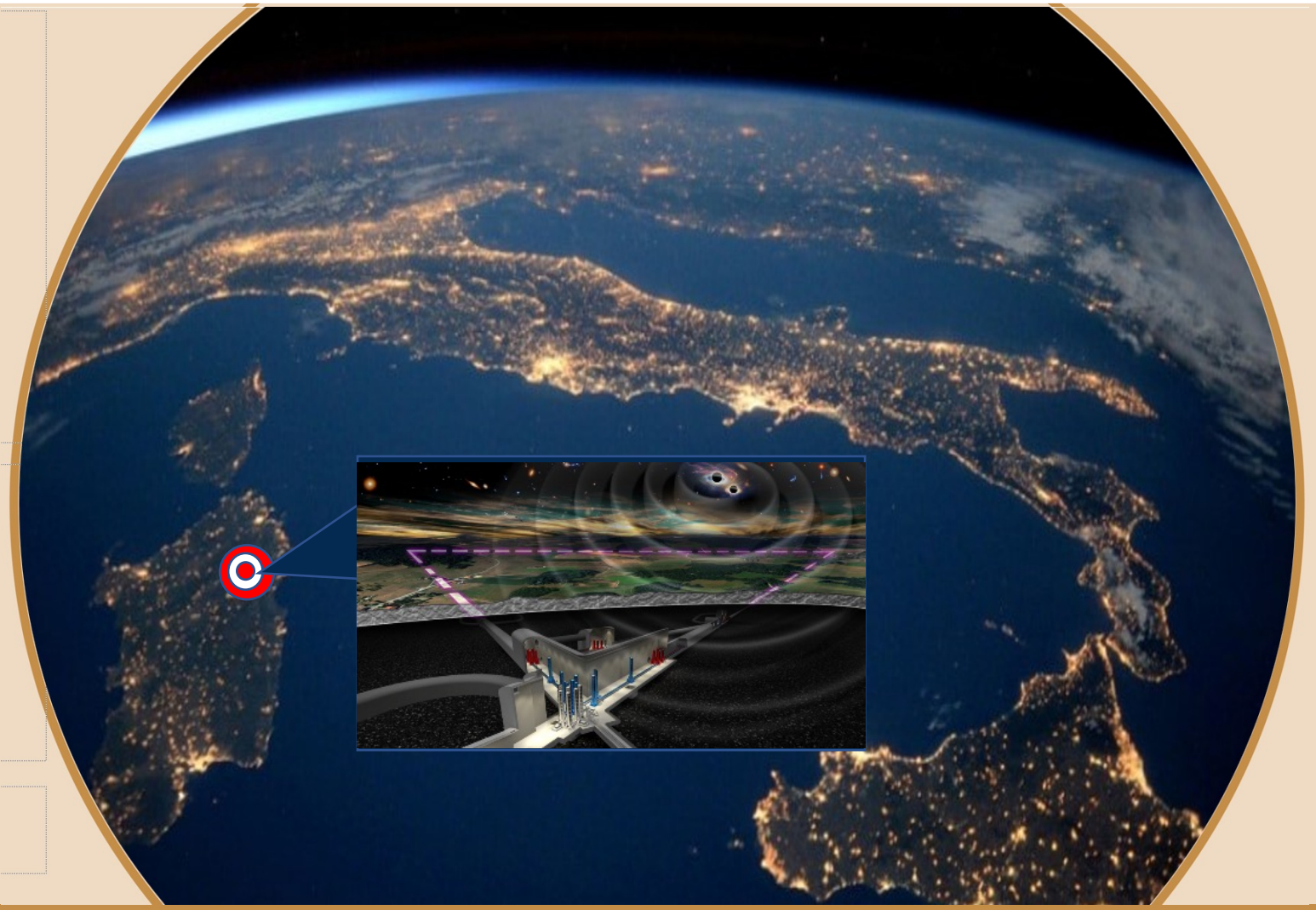
Ministero dell'Università e della Ricerca
Italiadomani PIANO NAZIONALE DI RIPRESA E RESILIENZA
INFN

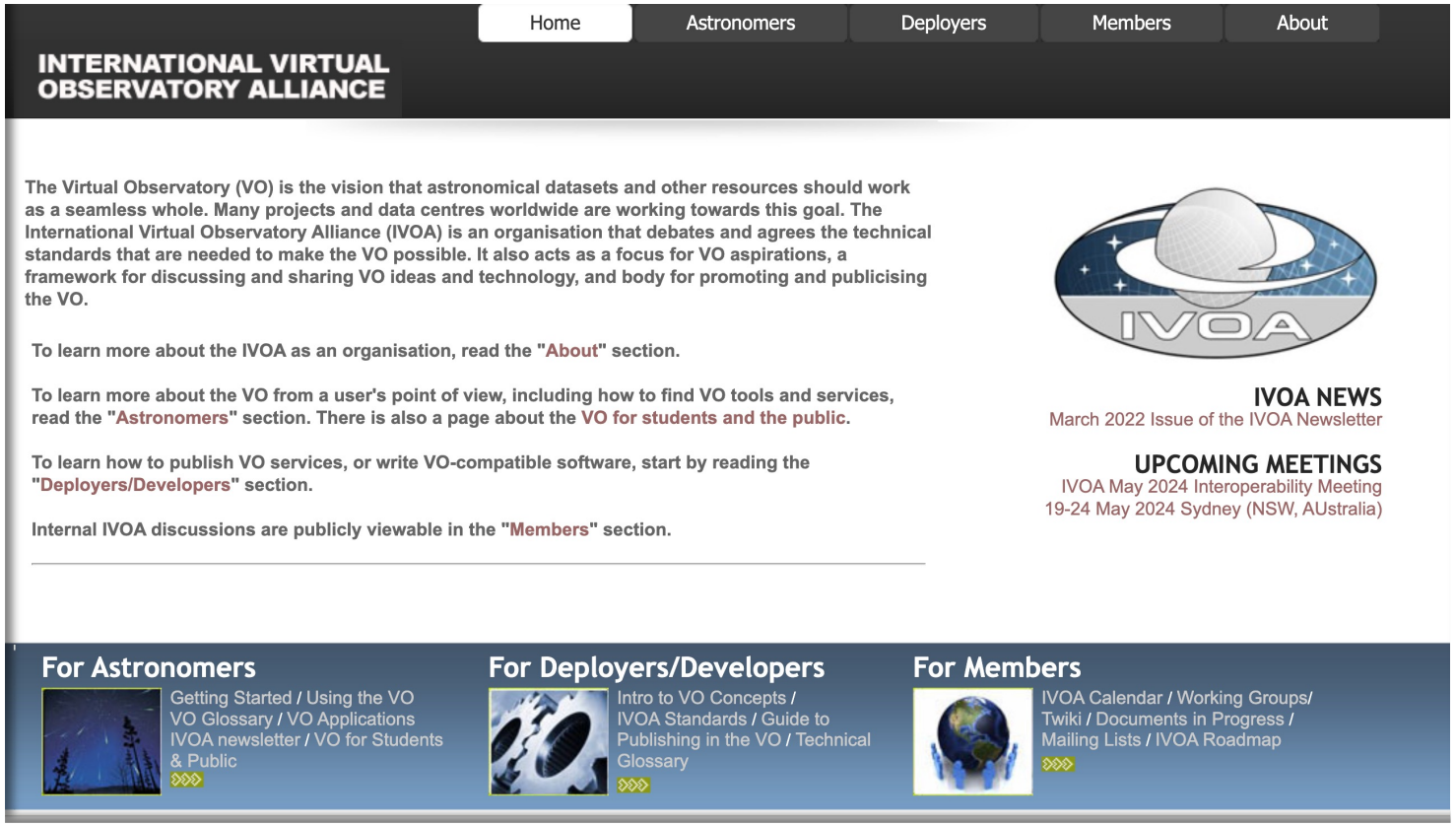
Virtual Observatory Standards and tools

Multi-messenger applications

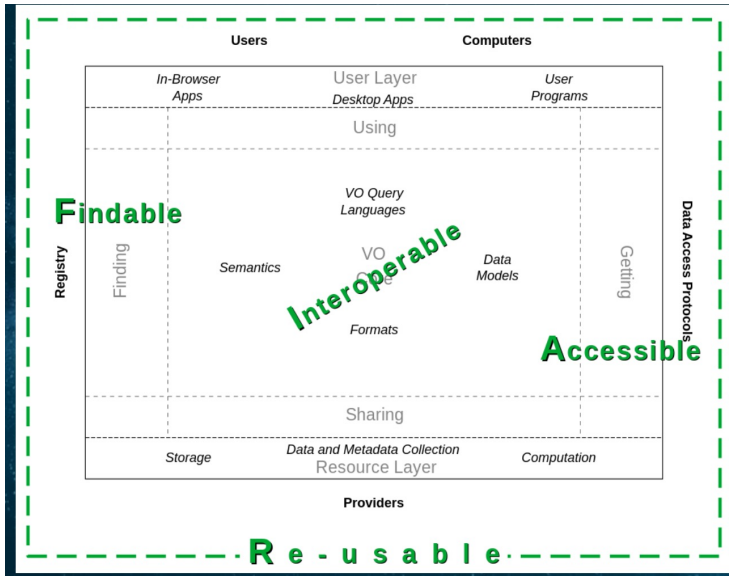
Giuseppe Greco
INFN - Perugia







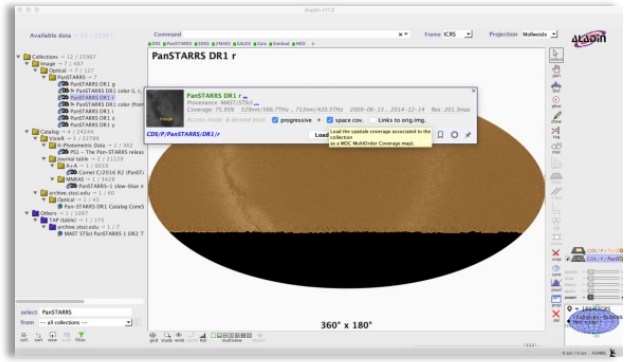
IVOA Architecture – FAIR data management



The Virtual Observatory (VO) is the international data sharing framework which enables data to be **FAIR** - **F**indable, **A**ccessible, **I**nteroperable and **R**e-usable for the astronomers' needs.

MOC and HiPS

A coverage map represents a region covered by a data collection called MOC for Multi-Order Coverage map . A MOC can not only describe a spatial coverage, but also a temporal one, or both simultaneously.



HiPS is the hierarchical tiling mechanism which allows one to access, visualize and browse seamlessly image, catalogue and cube data.

https://aladin.cds.unistra.fr/java/AladinManual.pdf

Aladin Installation

Official version v12.060

- **Any Operating System** *(WebStart java installer)*
  Aladin.jnlp — 1) Click here 2) Follows the instructions...
- **OS specific packages**
  with or without Java runtime

Aladin.msi — *Windows* 1) Download the MSI installer (*) 2) Execute it (**)	Aladin.exe — *Windows - without Java* 1) Download it on your desktop 2) Launch it (**)
Aladin.deb — *Linux* 1) Download the installer 2) Double-click on it	Aladin.tar — *Linux - without Java* 1) Download it and untar it 2) Use aladin shell launcher
Mac ARM	*Mac - without Java* 1) Download it and untar it

Running Aladin Desktop

Aladin Desktop is a Java application. To run it, you must first have the Java Virtual Machine (JVM) installed. More details are in Aladin's download page.

Note

Aladin may fail to load some LIGO/Virgo/KAGRA sky maps and display a `java.lang.OutOfMemoryError` error message. This is because the highest resolution LIGO/Virgo/KAGRA sky maps do not fit inside Aladin's default memory size.

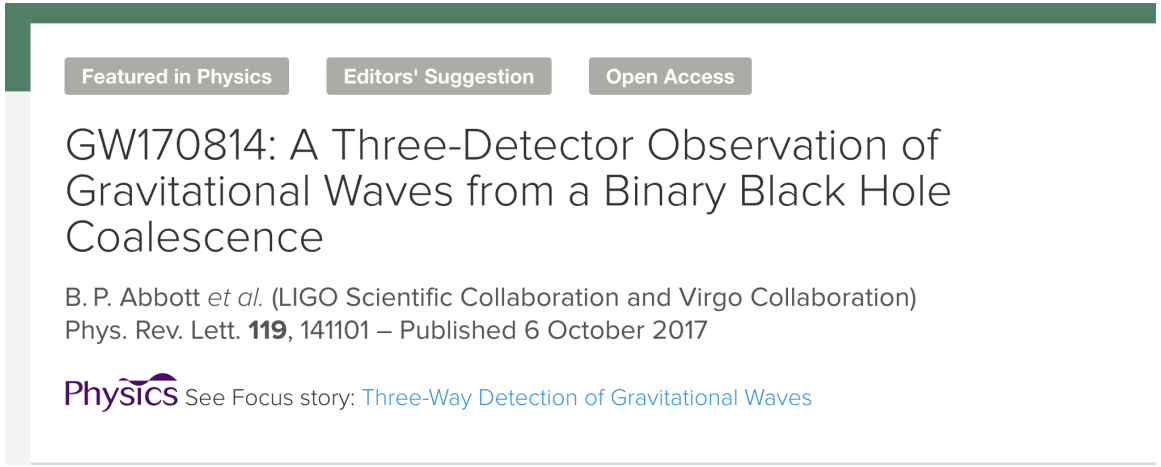
You can increase the maximum memory size used by your Java runtime environment by following the instructions below.

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`.

Aladin Desktop - hands on section –
GW170814 and GW190814

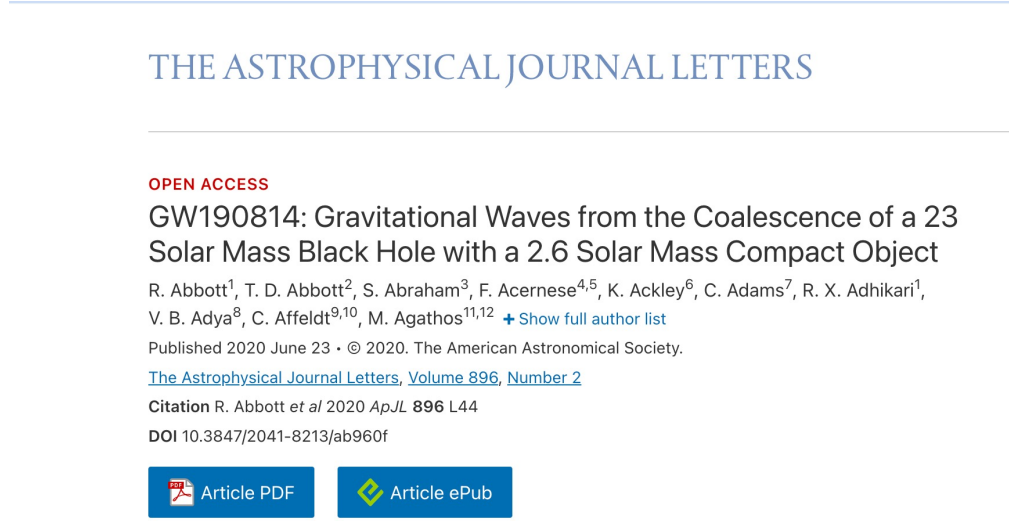


Featured in Physics | Editors' Suggestion | Open Access

GW170814: A Three-Detector Observation of Gravitational Waves from a Binary Black Hole Coalescence

B. P. Abbott *et al.* (LIGO Scientific Collaboration and Virgo Collaboration)
Phys. Rev. Lett. **119**, 141101 – Published 6 October 2017

Physics See Focus story: Three-Way Detection of Gravitational Waves



THE ASTROPHYSICAL JOURNAL LETTERS

OPEN ACCESS

GW190814: Gravitational Waves from the Coalescence of a 23 Solar Mass Black Hole with a 2.6 Solar Mass Compact Object

R. Abbott[1], T. D. Abbott[2], S. Abraham[3], F. Acernese[4,5], K. Ackley[6], C. Adams[7], R. X. Adhikari[1], V. B. Adya[8], C. Affeldt[9,10], M. Agathos[11,12] + Show full author list

Published 2020 June 23 • © 2020. The American Astronomical Society.

The Astrophysical Journal Letters, Volume 896, Number 2

Citation R. Abbott *et al* 2020 *ApJL* **896** L44

DOI 10.3847/2041-8213/ab960f

Article PDF | Article ePub

Skymaps
https://dcc.ligo.org/LIGO-T1700453/public

Skymaps
https://gracedb.ligo.org/superevents/S190814bv/view/

Building managing and compare credible regions

Aladin Desktop - hands on section

GW190425

THE ASTROPHYSICAL JOURNAL LETTERS

OPEN ACCESS

GW190425: Observation of a Compact Binary Coalescence with Total Mass ~ 3.4 $M_\odot$

B. P. Abbott[1], R. Abbott[1], T. D. Abbott[2], S. Abraham[3], F. Acernese[4,5], K. Ackley[6], C. Adams[7], R. X. Adhikari[1], V. B. Adya[8], C. Affeldt[9,10] + Show full author list

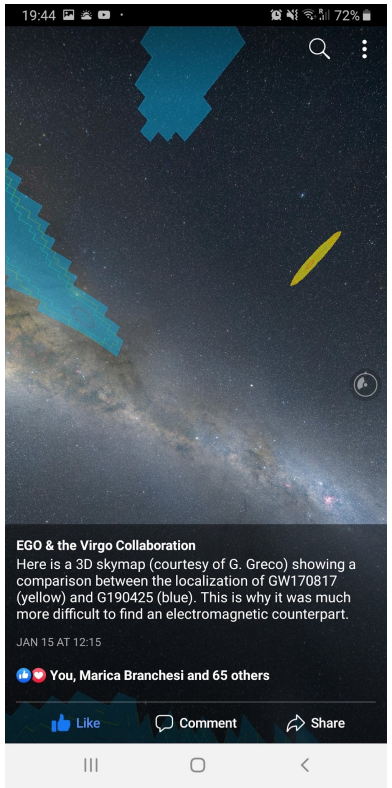
Published 2020 March 19 • © 2020. The Author(s). Published by the American Astronomical Society.

The Astrophysical Journal Letters, Volume 892, Number 1

Citation B. P. Abbott *et al* 2020 *ApJL* **892** L3

DOI 10.3847/2041-8213/ab75f5

Article PDF Article ePub



Click on the figure to direct to the original post

Skymaps

https://gracedb.ligo.org/superevents/S190425z/view/

https://cade.irap.omp.eu/dokuwiki/doku.php?id=galactic_reddening

Extinction Region and searching for reference image coverages

Aladin Desktop - hands on section
SPACE AND TIME MOC

IVOA Recommendation

International
Virtual
Observatory
Alliance

MOC: Multi-Order Coverage map

Version 2.0
IVOA Recommendation 2022-07-27

and associated spatial coverage (bottom right).

2.4 Space and Time MOC: Einstein Telescope and Early Warning Alerts

The space and time MOC provides us with an effective way to develop new multi-messenger data analysis tools that will have a crucial role when the third-generation interferometric gravitational wave observatories, such as the Einstein Telescope (ET), will begin operation. Here we figure out a few potential applications. ET will explore the universe with gravitational waves up to cosmological distances with an expected detection rate of order 10^5 – 10^6 black holes and 7×10^4 neutron star mergers per year (Maggiore and Van Den Broeck et al., 2020). For fast and real time data access, the user can query by a specific time range the gravitational-wave sky localizations encoded as a space and time MOC.

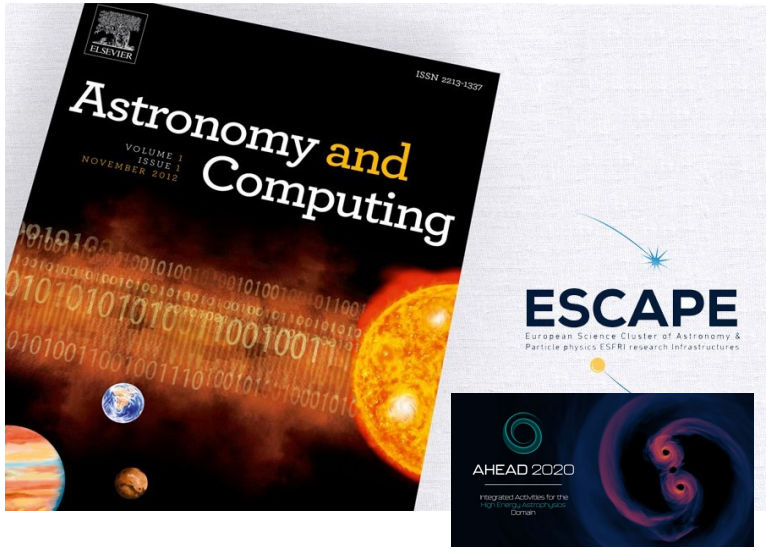
In addition, the ET sensitivity at low frequencies enables enough signal-to-noise ratio to accumulate

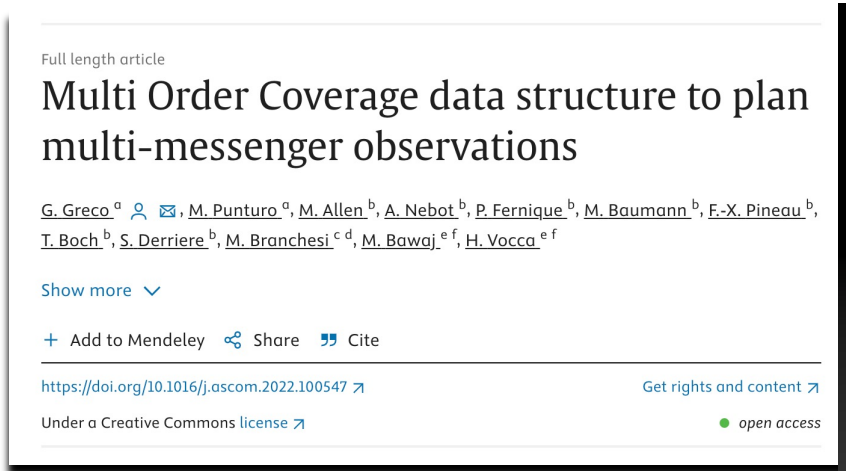
https://emfollow.docs.ligo.org/userguide/resources/aladin.html

Spatial and Temporal analysis

Aladin Desktop - hands on section

VIDEO TUTORIAL





Full length article

Multi Order Coverage data structure to plan multi-messenger observations

G. Greco [a], M. Punturo [a], M. Allen [b], A. Nebot [b], P. Fernique [b], M. Baumann [b], F.-X. Pineau [b], T. Boch [b], S. Derriere [b], M. Branchesi [c d], M. Bawaj [e f], H. Vocca [e f]

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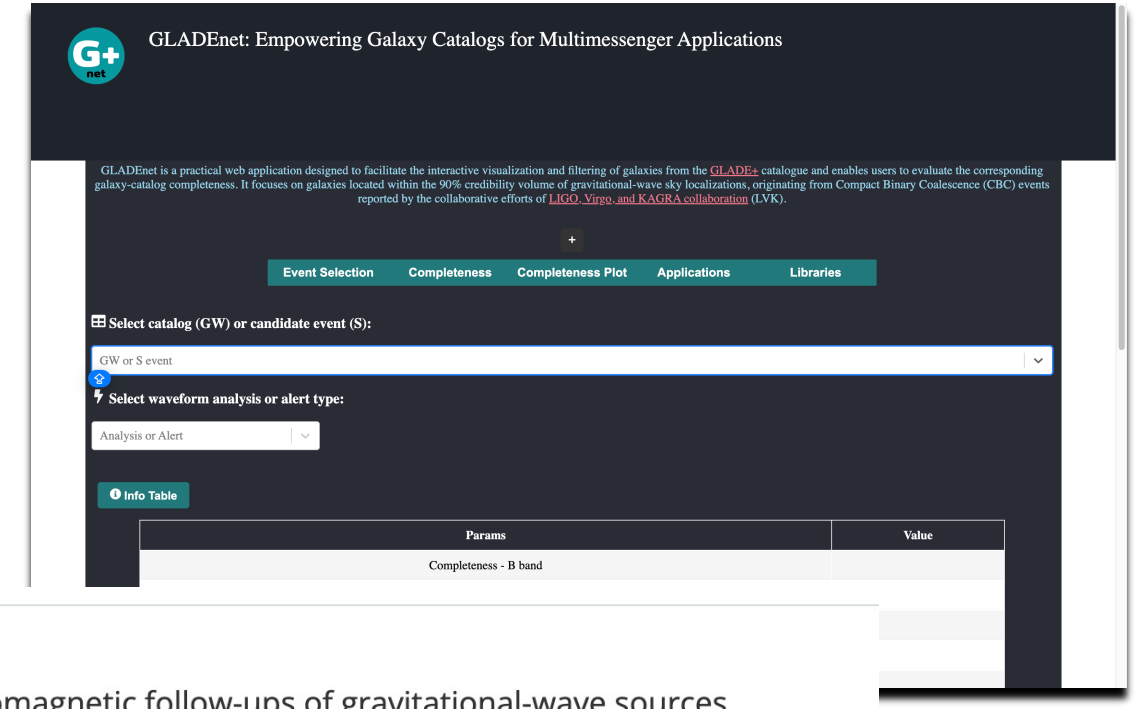
Aladin Lite – Application GLADEnet

https://virgo.pg.infn.it/gladenet/catalogs/



Numerical methods and coc

Astronomy & Astrophysics

Free Access

GLADEnet: A progressive web app for multi-messenger cosmology and electromagnetic follow-ups of gravitational-wave sources

M.L. Brozzetti, G. D'alya, G. Greco, M. Bawaj, T. Matcovich, M. Branchesi, T. Boch, M. Baumann, S. Cutini, R. De Pietri, E. Khalouei, P. Fernique, M. Punturo, H. Vocca

A&A, Forthcoming article

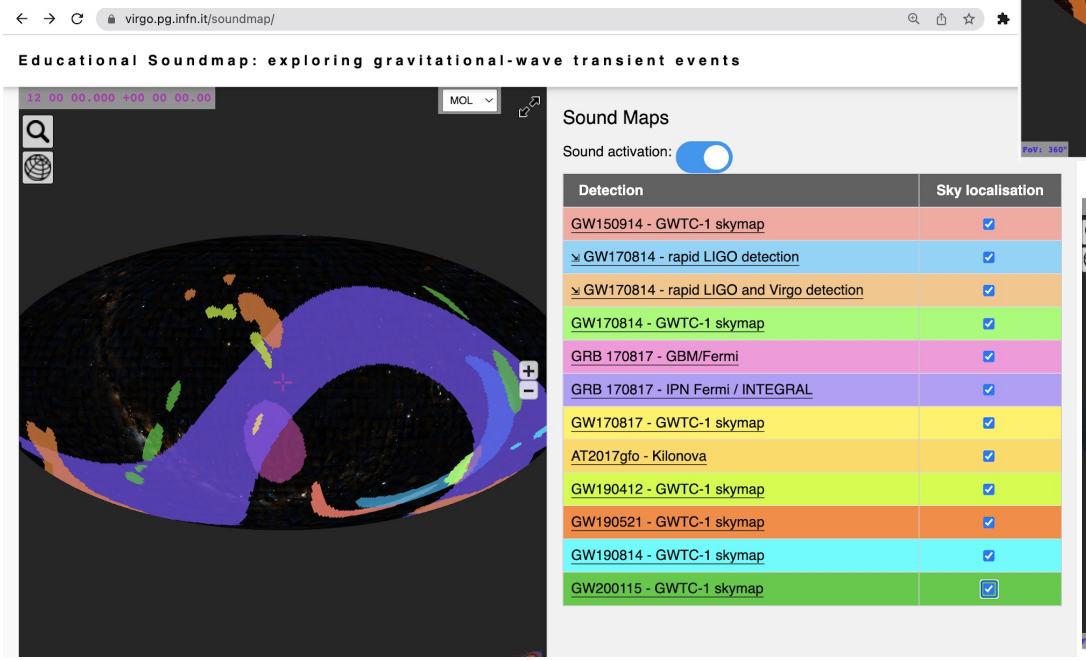
Received: 26 September 2023 / Accepted: 09 January 2024

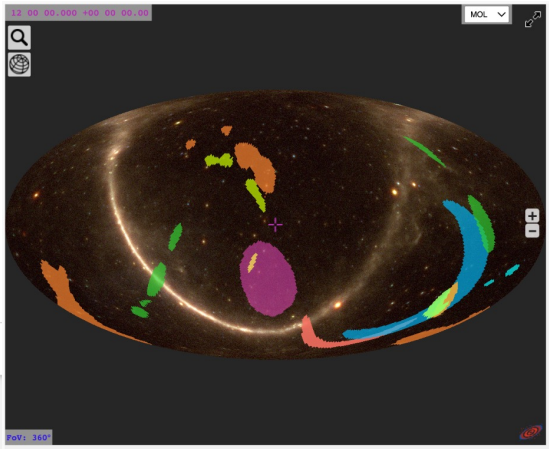
DOI: https://doi.org/10.1051/0004-6361/202348073

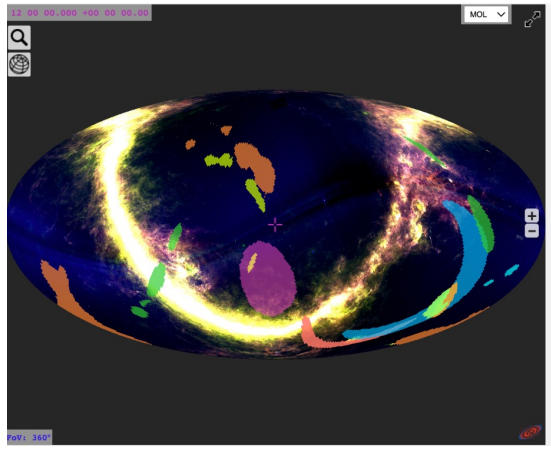
PDF (1.615 MB)

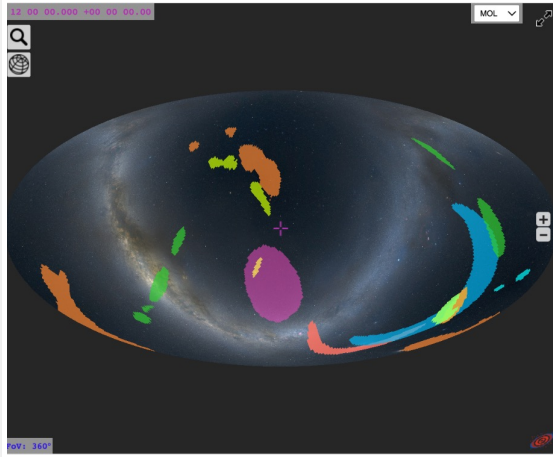
Aladin Lite – Application SoundMap

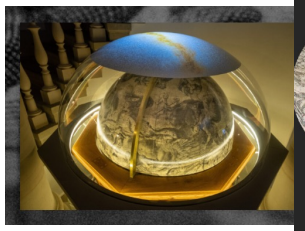
https://virgo.pg.infn.it/soundmap/

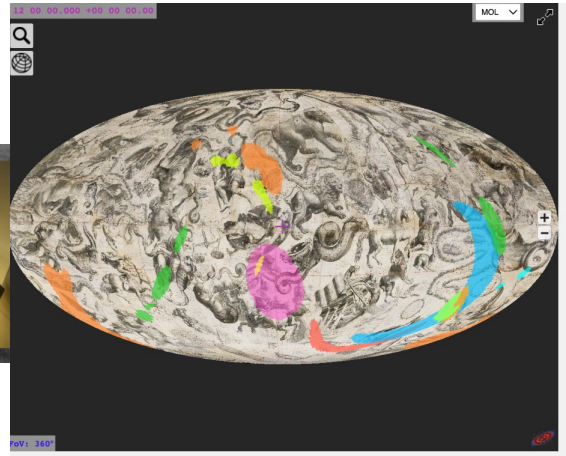












Educational and inclusive didactics

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- GLADEnet: A progressive web app for multi-messenger cosmology and electromagnetic follow-ups of gravitational-wave sources
in press