

Laboratorio di Astrofisica multimessaggera

Workshop di orientamento alle tesi nelle attività di ricerca svolte
presso INFN e Università Perugia

Giuseppe Greco
INFN-Perugia

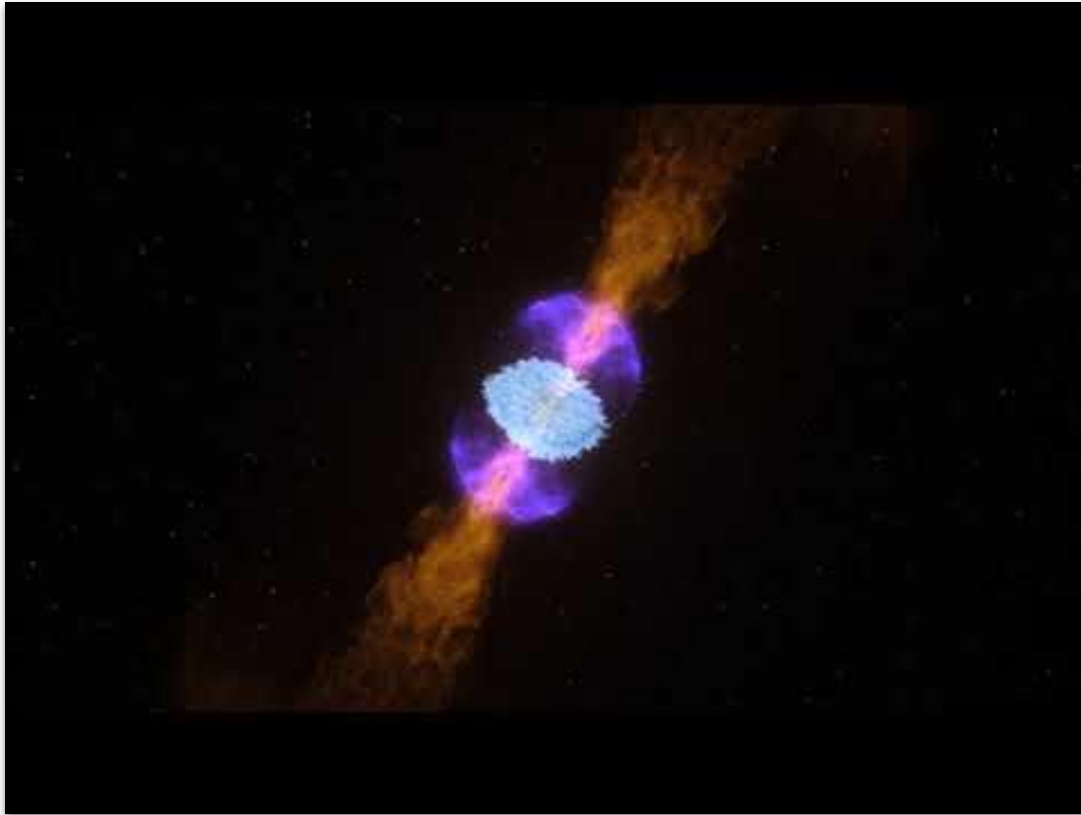


UNIVERSITÀ DEGLI STUDI
DI PERUGIA



EGO VIRGO

ET EINSTEIN
TELESCOPE



The Origin of the Solar System Elements

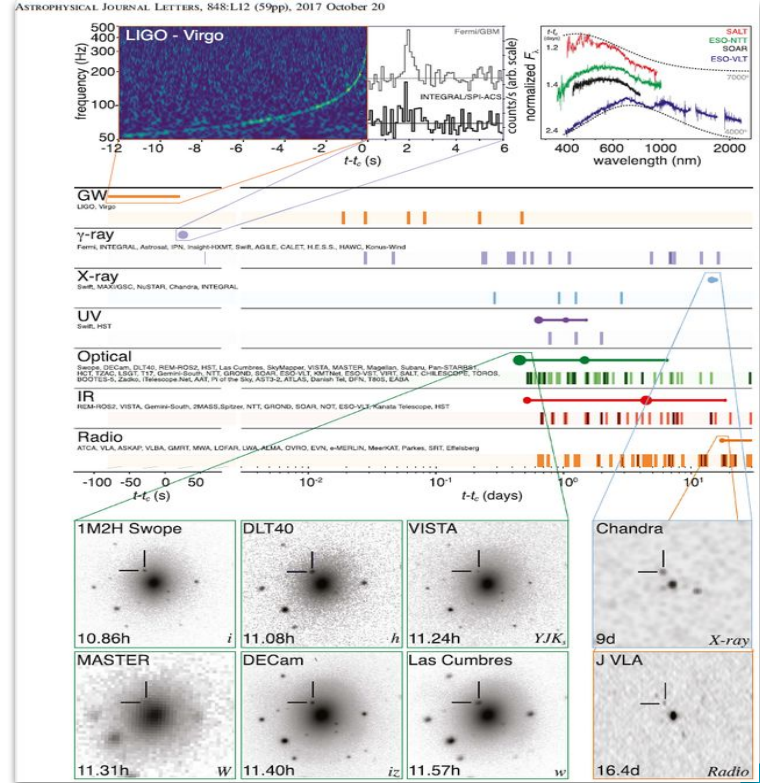
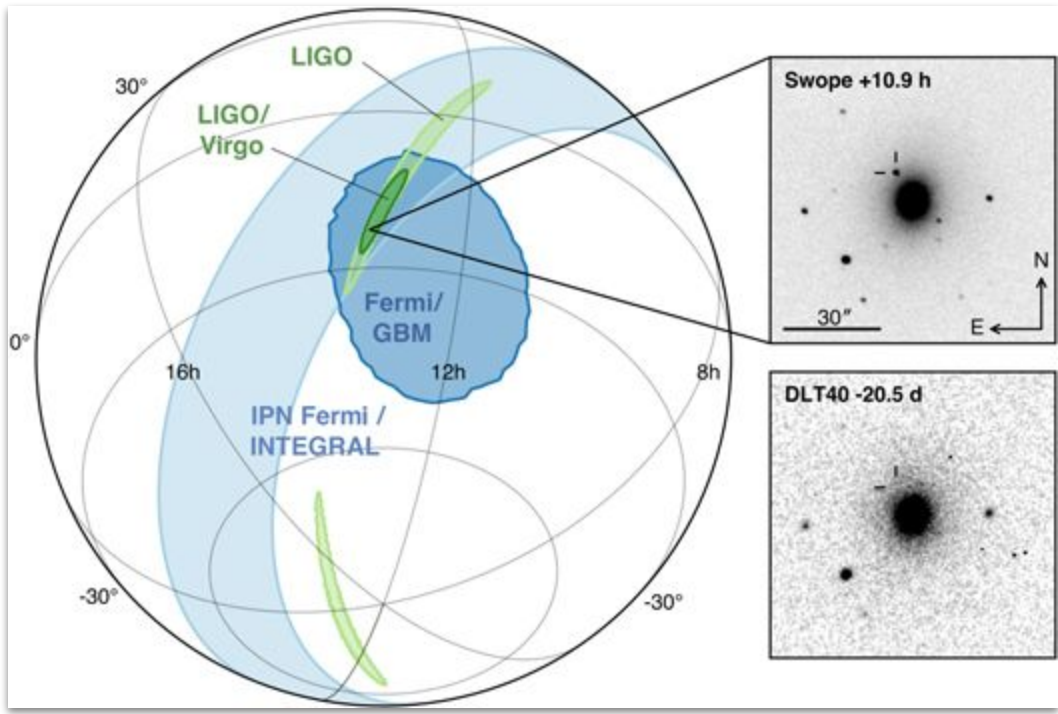
1 H	big bang fusion										cosmic ray fission										2 He						
3 Li	4 Be	merging neutron stars										exploding massive stars										5 B	6 C	7 N	8 O	9 F	10 Ne
11 Na	12 Mg	dying low mass stars										exploding white dwarfs										13 Al	14 Si	15 P	16 S	17 Cl	18 Ar
19 K	20 Ca	21 Sc	22 Ti	23 V	24 Cr	25 Mn	26 Fe	27 Co	28 Ni	29 Cu	30 Zn	31 Ga	32 Ge	33 As	34 Se	35 Br	36 Kr										
37 Rb	38 Sr	39 Y	40 Zr	41 Nb	42 Mo	43 Tc	44 Ru	45 Rh	46 Pd	47 Ag	48 Cd	49 In	50 Sn	51 Sb	52 Te	53 I	54 Xe										
55 Cs	56 Ba	72 Hf	73 Ta	74 W	75 Re	76 Os	77 Ir	78 Pt	79 Au	80 Hg	81 Tl	82 Pb	83 Bi	84 Po	85 At	86 Rn											
87 Fr	88 Ra																										
		57 La	58 Ce	59 Pr	60 Nd	61 Pm	62 Sm	63 Eu	64 Gd	65 Tb	66 Dy	67 Ho	68 Er	69 Tm	70 Yb	71 Lu											
		89 Ac	90 Th	91 Pa	92 U																						

Astronomical Image Credits:
ESA/NASA/AASNova

Graphic created by Jennifer Johnson

Animazione video di GW170817/GRB 170817/AT2017gfo

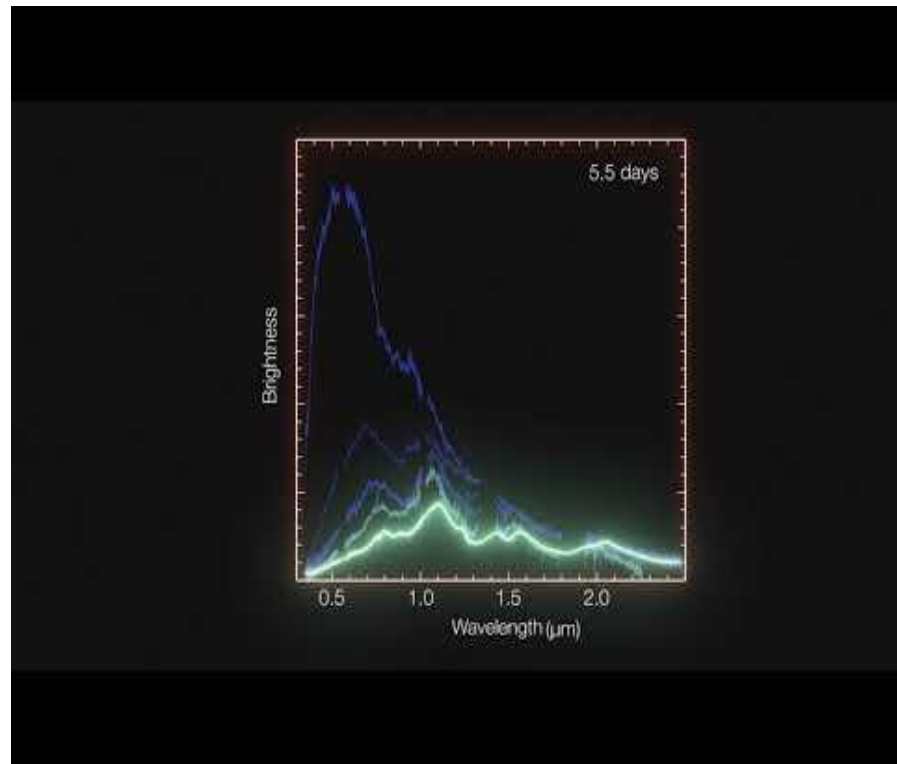
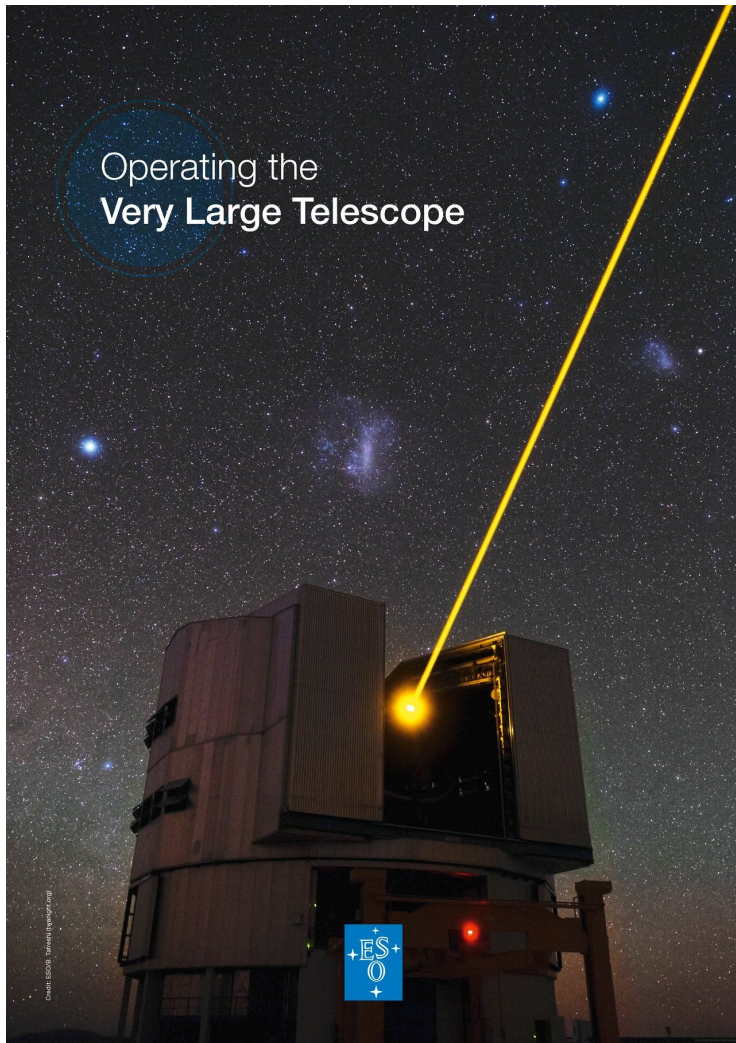
Multi-messenger Observations of a Binary Neutron Star Merger



La Nascita dell'astronomia multimessaggera!

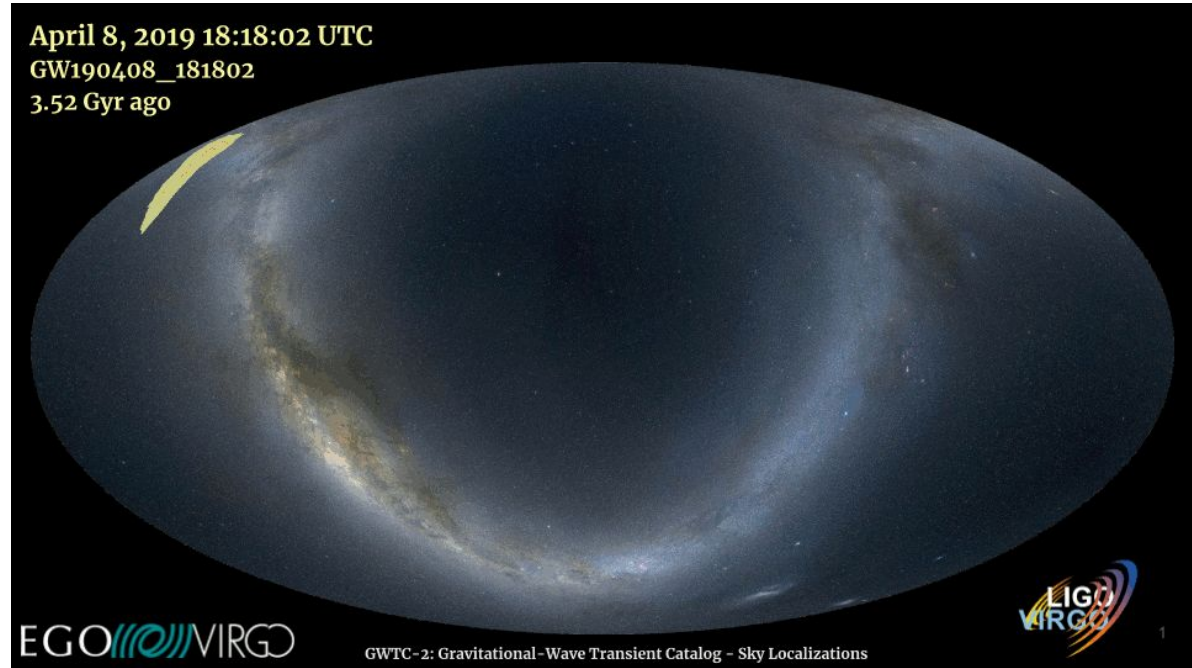
GW170817/GRB170817/AT2017gfo (NGC4993)

Operating the Very Large Telescope



This animation is based on a series of spectra of the kilonova in NGC 4993 observed by the X-shooter instrument on ESO's Very Large Telescope in Chile. They cover a period of 12 days after the initial explosion on 17 August 2017. The kilonova is very blue initially but then brightens in the red and fades.

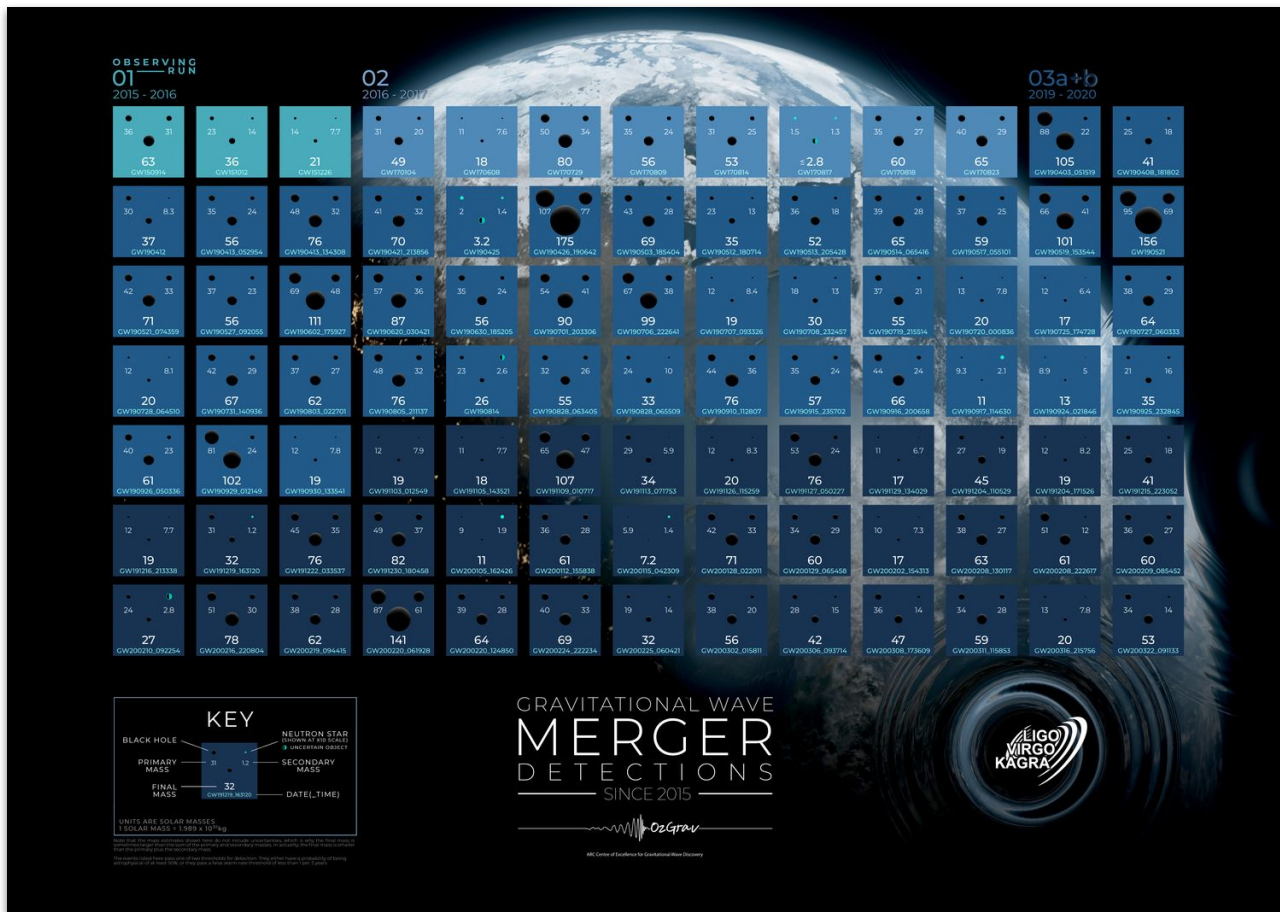
Localizzazioni di sorgenti di onde gravitazionali



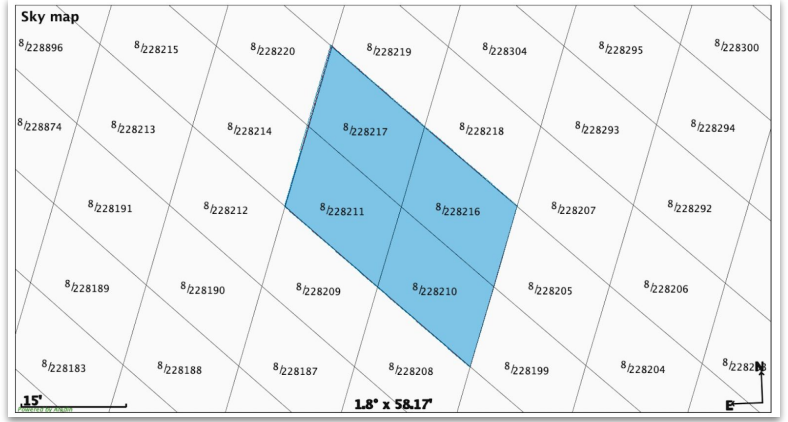
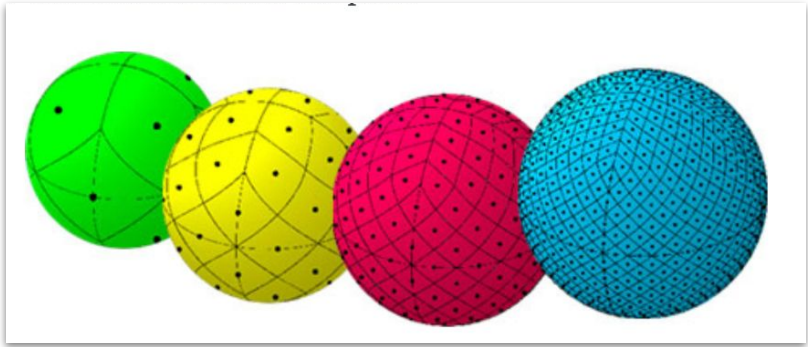
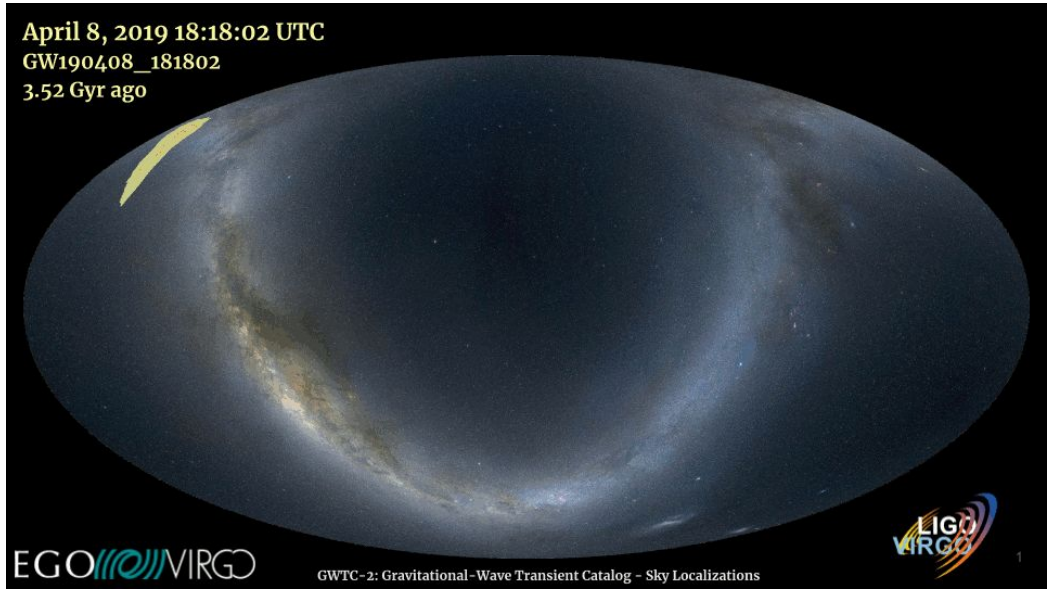
1. Come mapparle?

2. Come effettuare confronti?

3. Come interagire con i database?



Studi sulle popolazioni e conseguenze astrofisiche



Virtual Observatory: software e librerie standard (HEALPix, MOC maps...)

IVOA and VO



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!

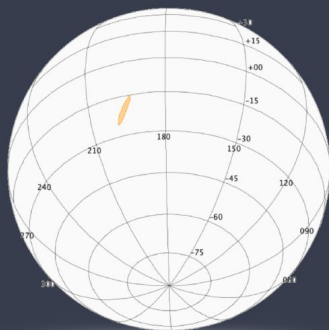


Fig.11 The final sky localization of GW170817 from the GWTC-1.

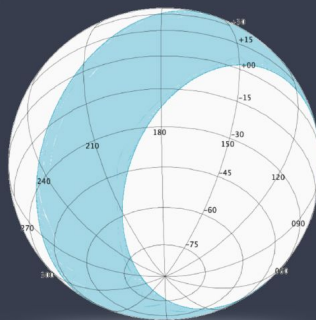


Fig.13 The IPN triangulation of GRB 170817 from the time delay between Fermi and INTEGRAL.

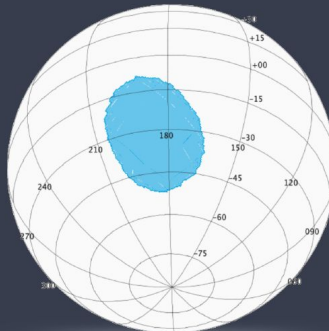


Fig. 12. The error Box of GRB 170817 from Fermi/GBM.

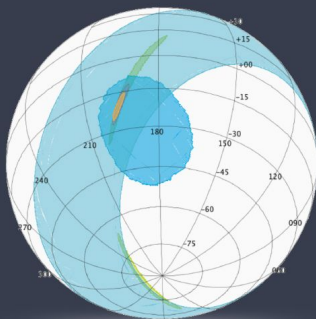


Fig. 14. Overlapping sky maps from Fig.9 to Fig.13.



Possibilità di tirocini e periodi di studio presso il VO dell'Osservatorio Astronomico di Strasburgo.

Esercitazioni con il software Aladin, Topcat and Jupyter notebook in python



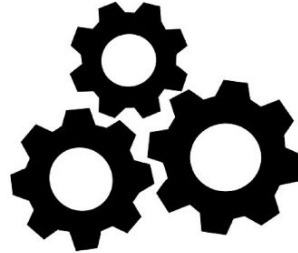
F
indable



A
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I
nteroperable



R
eusable



Good Ingredients for Open Science

La Ue dice sì al caricatore unico per tutti i dispositivi elettronici

di Bruno Ruffilli

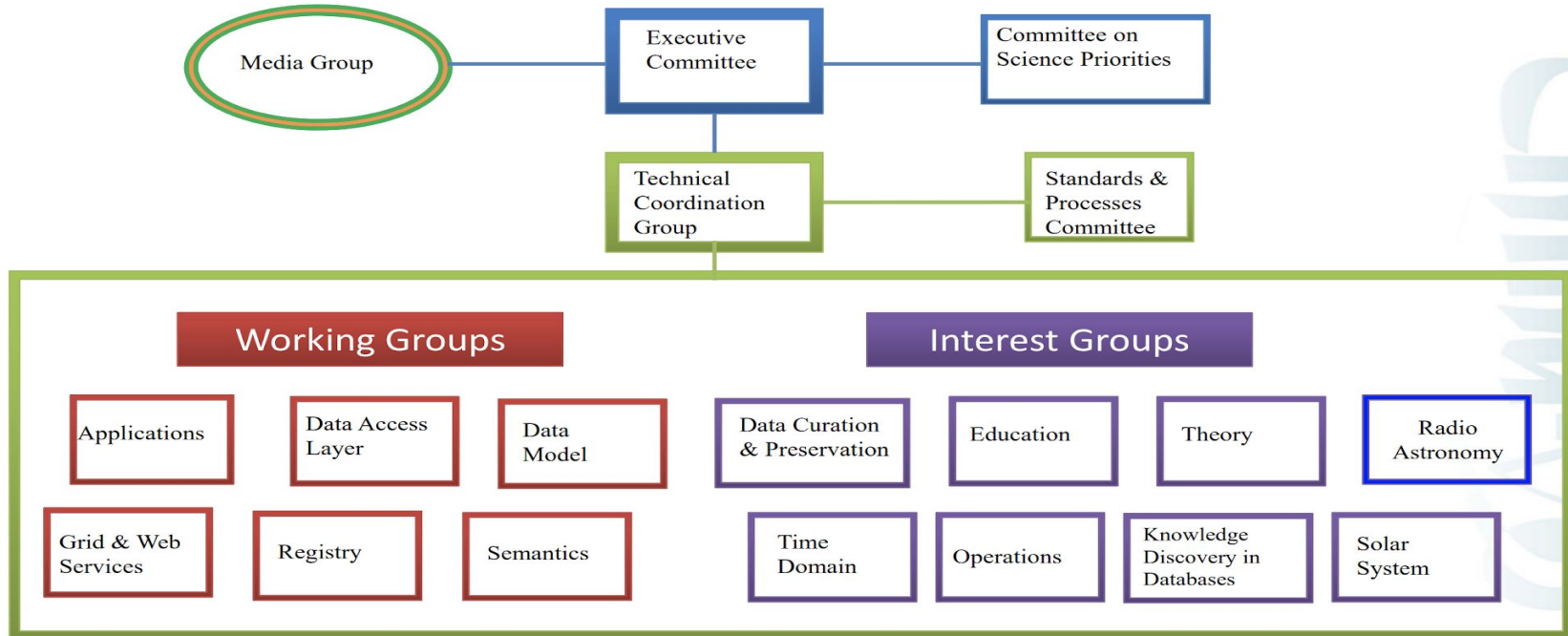


Oggi la discussione finale all'Europarlamento: approvate le nuove norme, obbligatorie dal 2024. La situazione attuale sarà solo "un ricordo di vecchi, strani tempi di costi inutili, sprechi e disagi", per la vicepresidente della Commissione Margrethe Vestager

04 OTTOBRE 2022 AGGIORNATO ALLE 14:20

🕒 2 MINUTI DI LETTURA

IVOA Organization Chart





SCHOOL OF SCIENCE AND TECHNOLOGY
Bachelor's Degree in Physics (L-30)

LOCALISATION OF ELECTROMAGNETIC
COUNTERPARTS AND GRAVITATIONAL-WAVE
SIGNALS: A VIRTUAL OBSERVATORY PLUG-IN TO
HANDLE 3D VOLUME RECONSTRUCTIONS

Thesis in Physics

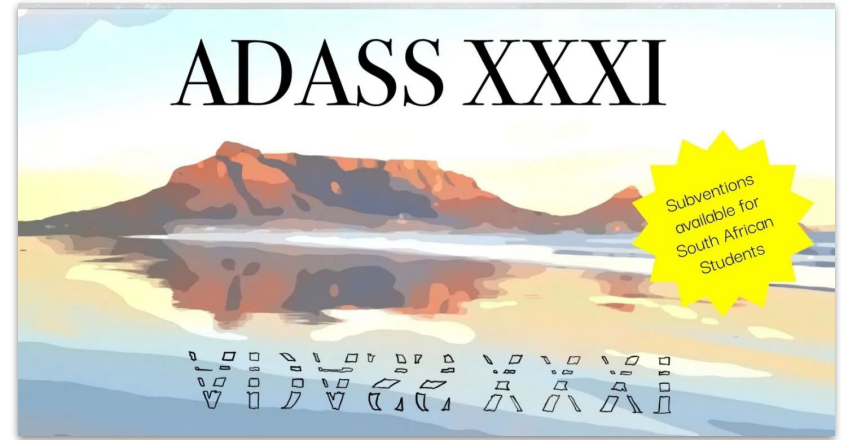
Student

Arianna Bartolomei

Supervisor

Dott. Flavio

Tesi presentata a **Astronomical Data Analysis
Software and Systems**



ESCAPE INFN PERUGIA EDS UNICAM UNIVERSITÀ DI CAMERINO AHEAD 2020

LOCALIZATION OF EM COUNTERPARTS AND GW SIGNALS: A NEW PYTHON PLUG-IN FOR ALADIN
Arianna Bartolomei¹, Elisa Cartechini¹, Giuseppe Greco^{2,3}, Flavio Travasso^{1,3}, Mateusz Bawaj^{2,3}
¹University of Camerino; ²University of Perugia; ³INFN Perugia

Abstract
We describe a new plug-in for Aladin Desktop to analyze 3D sky maps of gravitational-wave sources. Aladin is the most used VO (Virtual Observatory) software for digitized astronomical images and



Università degli Studi di Perugia

DEPARTMENT OF PHYSICS AND GEOLOGY

MASTER THESIS IN PHYSICS

CURRICULUM OF ASTROPHYSICS AND ASTROPARTICLES

Evaluating catalogues completeness extending the *Virtual Observatory* framework to estimate the H_0 Hubble constant with *dark standard sirens*

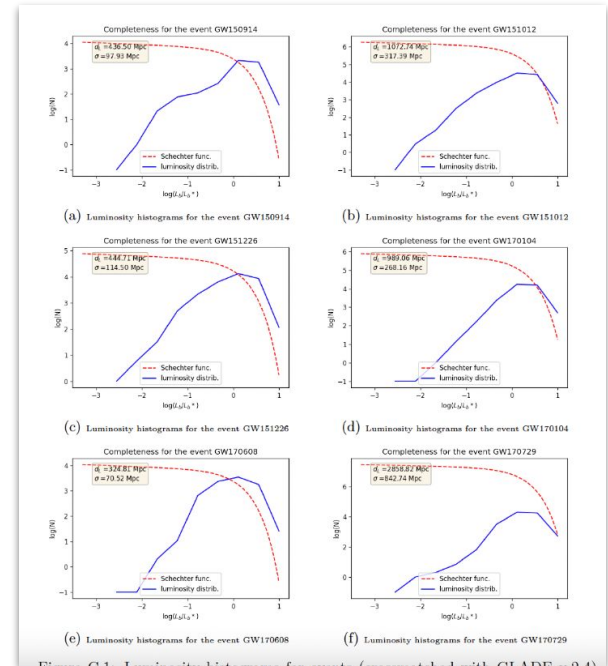
SUPERVISOR

PROF. MATEUSZ BAWAJ

UNIVERSITÀ DEGLI STUDI DI PERUGIA

MASTER CANDIDATE

MARIA LISA BROZZETTI



Tesi magistrale: cosmologia con le onde gravitazionali

LIGO-VIRGO-KAGRA COLLABORATION MEETING

MARCH 2023 | EVANSTON, IL

- HOME
- REGISTRATION
- PARTICIPANTS
- PARTICIPANT GUIDE
- PROGRAM
- ACCOMMODATIONS
- TRAVEL INFO
- LOCAL RESTAURANTS
- IT / AUDIOVISUAL
- ABOUT CIERA AND NORTHWESTERN**

ABOUT CIERA AND NORTHWESTERN



23
MAP EVANSTON

G+
A Progressive Web App for Multi-messenger Cosmology

Cozzetti^{1,3}, G. D'Allya², G. Greco¹, M. Bawa³, M. Punturo³, H. Vocca^{1,3}

¹INFN
²Università degli Studi di Perugia, Perugia, Italy
³9-9000 Ghent, Belgium
Institute for Nuclear Physics | Perugia Unit | 06023 Perugia, Italy

The Completeness Coefficient \mathcal{C}

The completeness of the catalog is the 3D volume fraction of GR events \mathcal{C} obtained by comparing the value of the completeness of galaxias in the visible volume \mathcal{C}^{vis} with the completeness $\mathcal{C}^{\text{total}}$ with the luminosity yield obtained from the catalog of the host galaxy for the same event.

$\mathcal{C} = \frac{\mathcal{C}^{\text{vis}}}{\mathcal{C}^{\text{total}}}$

Moreover, we use the full of the host galaxy model to estimate the 3D GR event $\mathcal{C}^{\text{total}}$. The observational area covered by the G+ catalog, the \mathcal{C}^{vis} value for each event are provided from the G+ Catalog by the host galaxy obtained from the G+ event. (2023) The host model are available data.

How Can the Completeness Coefficient \mathcal{C} help Multi-messenger Cosmology?

- It provides a measure of the completeness of the catalog.
- It provides a measure of the completeness of the catalog.
- It provides a measure of the completeness of the catalog.

Goals for the Future

- Improve the host galaxy model.
- Improve the host galaxy model.
- Improve the host galaxy model.

inosity Function of the GLADE- catalog

The intrinsic properties of the GLADE- catalog define the function that best describes the probability of galaxias in R , and evaluating the three parameters of the luminosity function of galaxias in R , and evaluating the three parameters of the luminosity function of galaxias in R , and evaluating the three parameters of the luminosity function of galaxias in R .

Shared sources by type to exclude spurious, and then applied the following three steps: 1) galaxy density distribution, creating a Multi-Order Coverage (MOC) map with overlapping regions. This is crucial, as the presence of dust and molecular emission from the host galaxy can affect the completeness of the catalog in the northern polar region. 2) The host galaxy model is used to estimate the completeness of the catalog in the northern polar region. 3) The host galaxy model is used to estimate the completeness of the catalog in the northern polar region.

Galaxias are sorted by their luminosity and then divided into bins of 100 Mpc. The two host galaxy functions at different distance scales from 10 to 100 Mpc, and a value \mathcal{C} is defined as $\mathcal{C} = \frac{\mathcal{C}^{\text{vis}}}{\mathcal{C}^{\text{total}}}$ with $\mathcal{C}^{\text{vis}} = 0.76$, $\mathcal{C}^{\text{total}} = 0.64$, and $\mathcal{C} = 0.76$.

The QUEST Experiment

QUEST is a multi-messenger experiment that aims to detect and study the properties of gravitational waves and high-energy gamma-ray bursts. The experiment is designed to detect and study the properties of gravitational waves and high-energy gamma-ray bursts. The experiment is designed to detect and study the properties of gravitational waves and high-energy gamma-ray bursts.



GLADENet: Catalog Service



About

Select Event

GW Event | ▾

Select Analysis

Analisis | ▾

- **Completeness [0-1]:**

- **Number of possible host galaxies:**

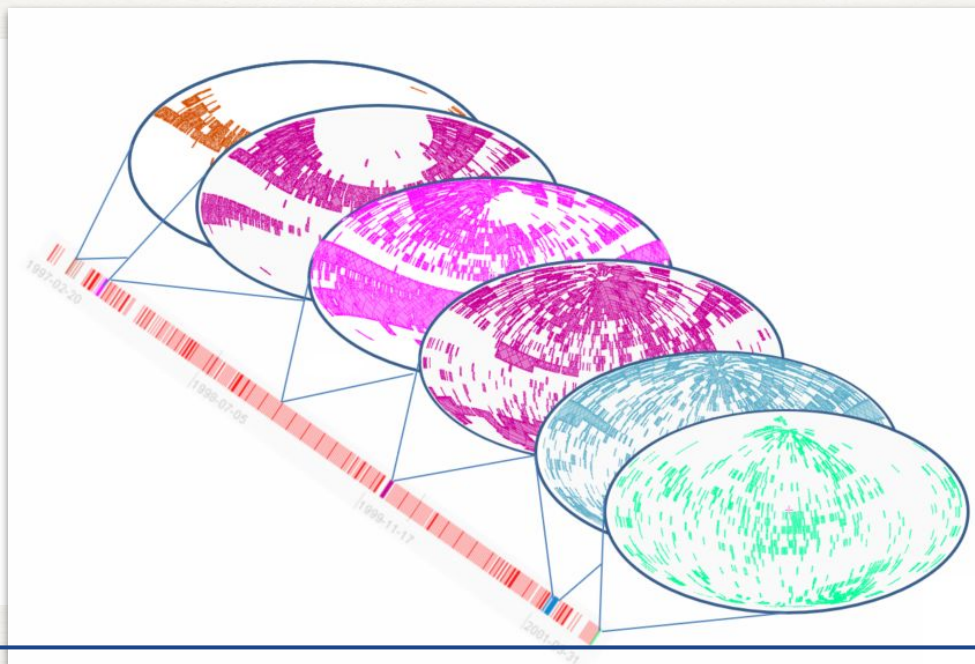
Spatial and Temporal MOC: ST-MOC



*International
Virtual
Observatory
Alliance*

MOC: Multi-Order Coverage map
Version 2.0

IVOA Working Draft 2020-10-30



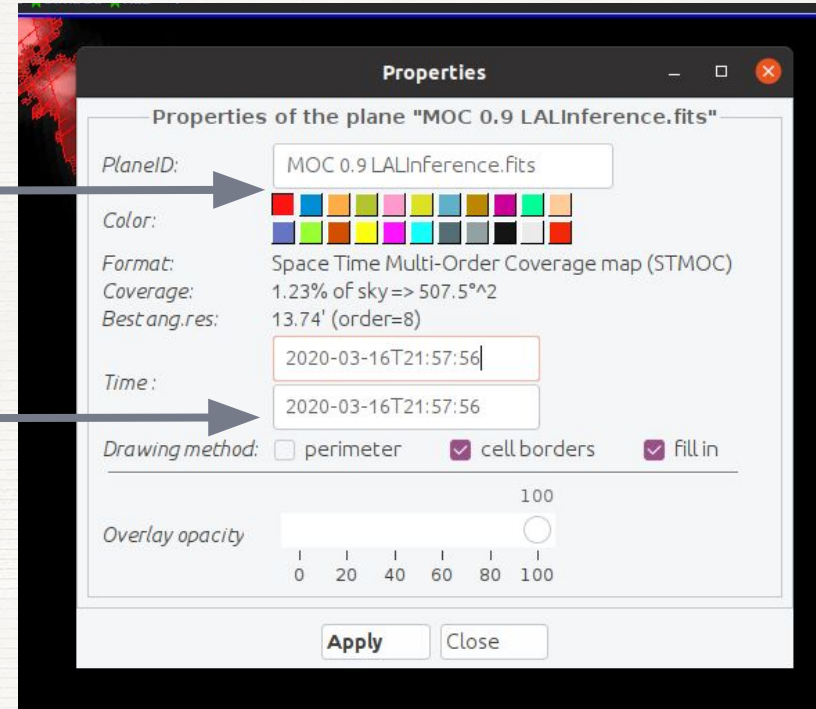
At a given Time range we obtain the corresponding Spatial coverage.

GW credible regions in Space and in Time

In **PlaneID** a credible region is selected.

In **Time** the merger time is added.

To search for any electromagnetic emissions before or after the compact binary coalescence, the time values can be modified accordingly producing a new ST-MOC.





Generation of a ST-MOC from a gravitational-wave sky localization using Aladin Desktop (beta version).

← → ↻ virgo.pg.infn.it/maps/ 🔍 📄 ☆ ⚙️ 📱 6 ⋮

Gravitational-Wave Sky Localizations: Online Calculator and Interactive Viewer of Credible Areas

Version beta 0.6

The tool provides the credible areas of gravitational-wave sky localizations issued by the [LIGO-Virgo-KAGRA collaborations \(LVK\)](#). The resulting credible area is encoded with the data-structures [Multi Order Coverage map \(MOC\)](#). MOC is a Virtual Observatory standard approved by the [IVOA \(International Virtual Observatory Alliance\)](#) to manage sky coverage. Each MOC is visualized in the [Aladin Lite](#) with various background image surveys. The whole list and the image surveys are accessible by clicking the icon  manage layers located at the top left. The MOC maps are created and manipulated with the WebAssembly library [MOCWasm](#). The tool accepts the two LVK sky map formats: the [multiorder format](#) (with `.fits` extension) and the [unflattened skymap](#) (with `.fits.gz` extension). Better performances are achieved with the multiorder format.

 **Latest LVK Public Alert: S200316bj**

<https://virgo.pg.infn.it/maps/>

A practical example: an ideal observation campaign

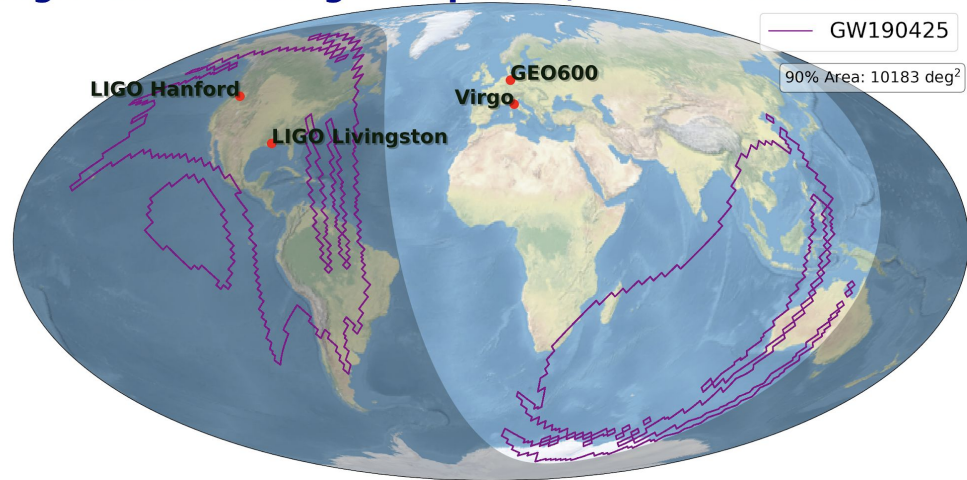
Multi-messenger team:

1. Haleakala Observatories in Hawaii, USA
2. Paranal Observatory in Chile
3. Siding Spring Observatory (SSO) in Australia

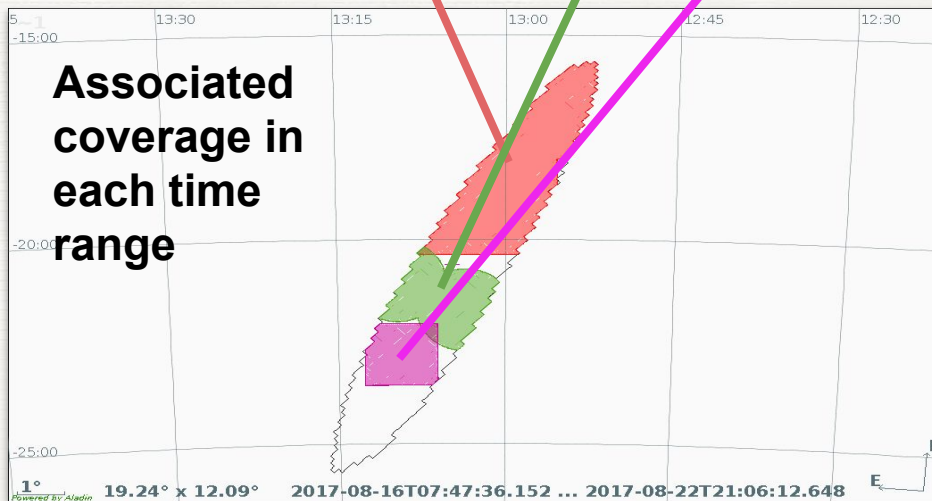
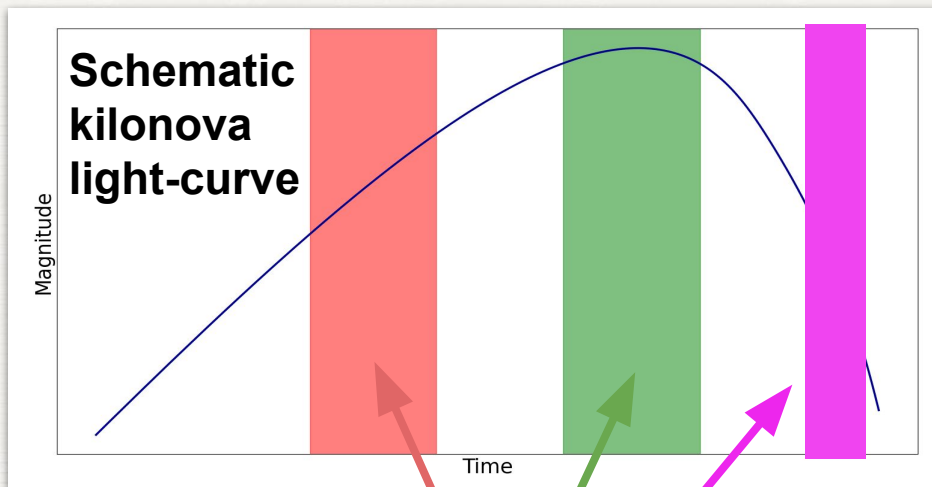
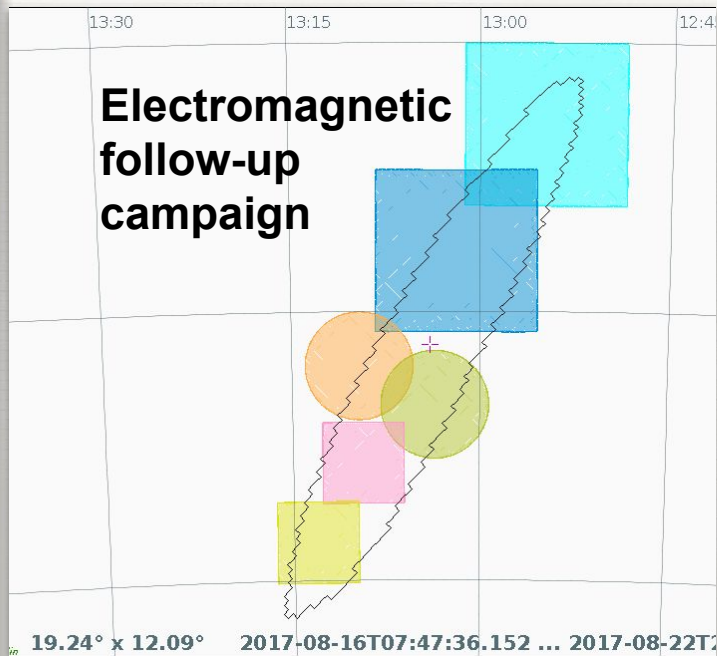
With `astroplan` we define three **Observer** classes. `Observer` is an `astroplan` container class for information about an observer's site

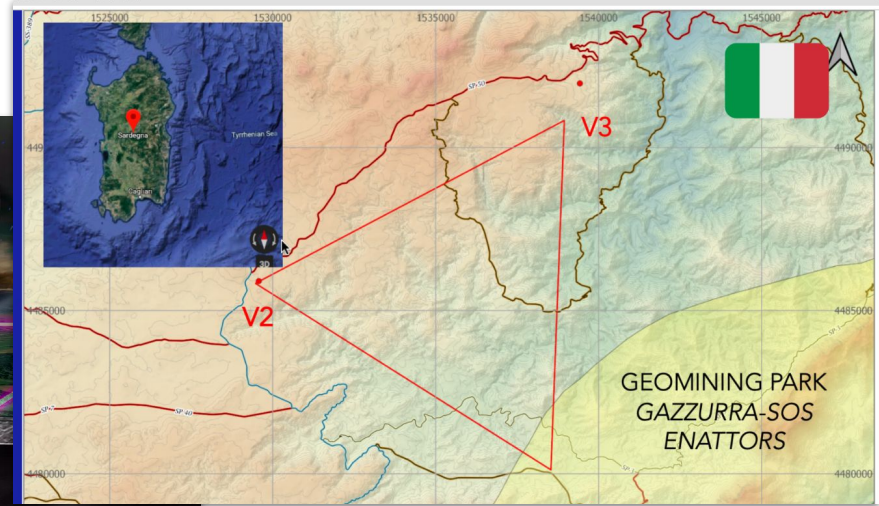
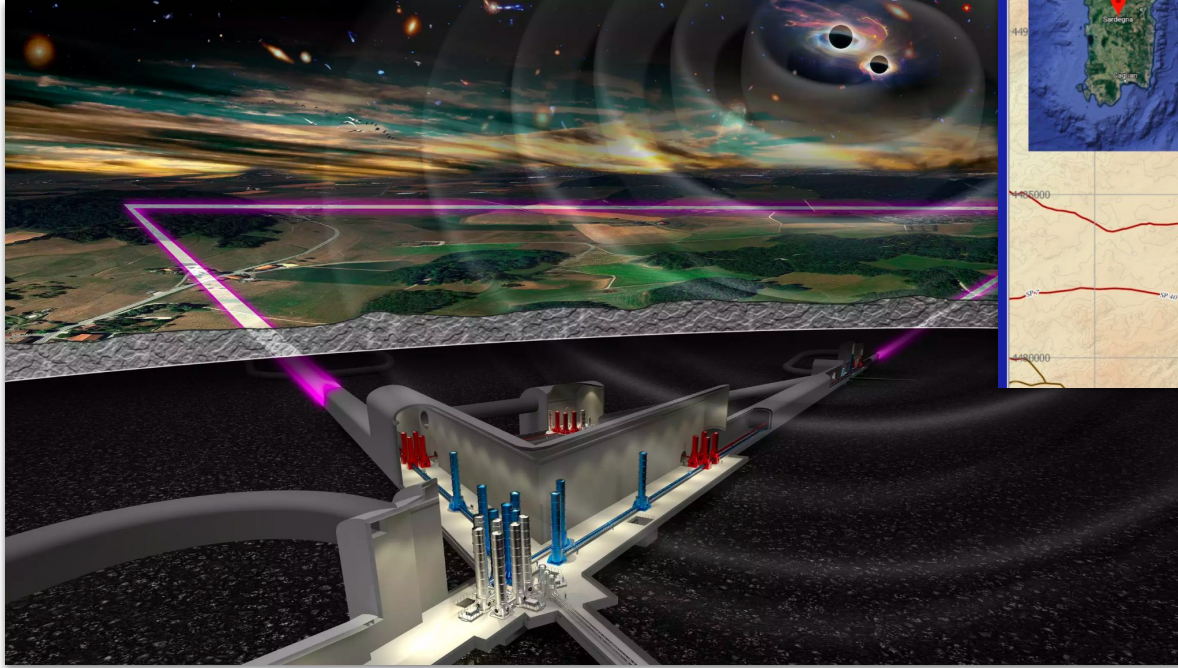
Observation of GW190425. The signal has been observed on 2019 April 25, 08:18:05 UTC, during the third observing run (O3) of the LIGO–Virgo network. The network consists of two Advanced LIGO interferometers in Hanford, Washington, USA (LHO) and Livingston, Louisiana, USA (LLO) and the Advanced Virgo interferometer in Cascina, Italy. At the time of GW190425, LHO was temporarily offline with only LLO and Virgo taking data.

Night time shading for April 25, 2019 at 08:18:05 UTC



ST-MOC application: EM-followUP





Italia candidata ad ospitare ET

Einstein Telescope Observatory

Tesi sull'astrofisica multimessaggera con ET e sulla gestione del sistema di invio di allerte.