GW public data

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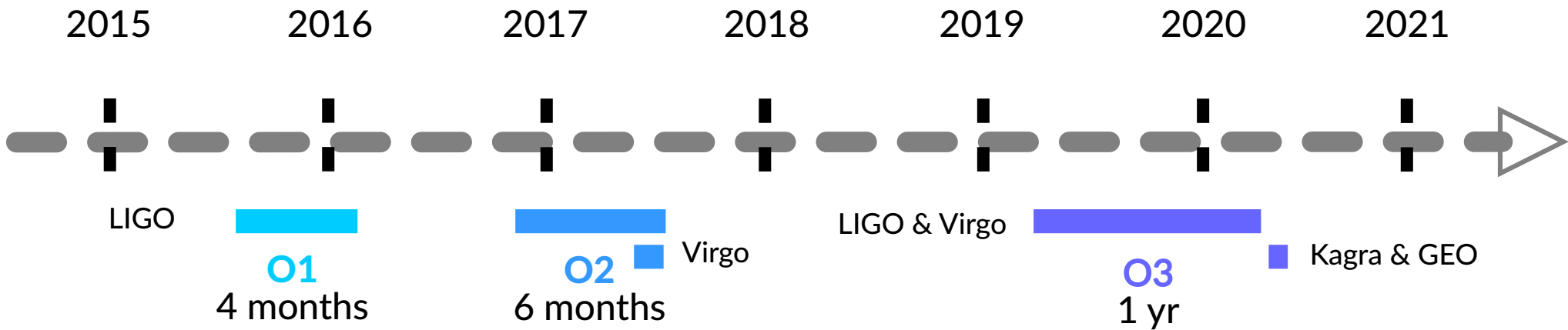LIGO Hanford H1 · LIGO Livingston L1 · Virgo V1 · GEO600 G1 · KAGRA K1
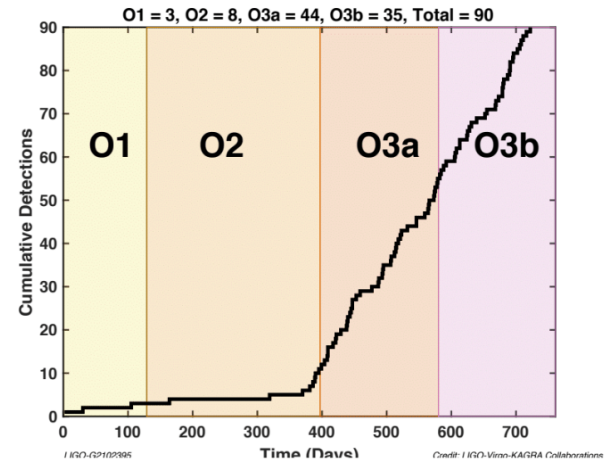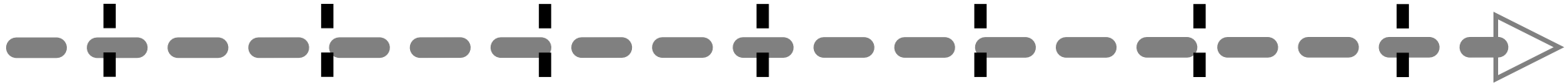
2015 · 2016 · 2017 · 2018 · 2019 · 2020 · 2021

LIGO

LIGO & Virgo

O1
4 months

O2
6 months

Virgo

O3
1 yr

Kagra & GEO

O1 = 3, O2 = 8, O3a = 44, O3b = 35, Total = 90

2015   2016   2017   2018   2019   2020   2021
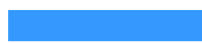
LIGO

O1
3 detections

O2
8 detections
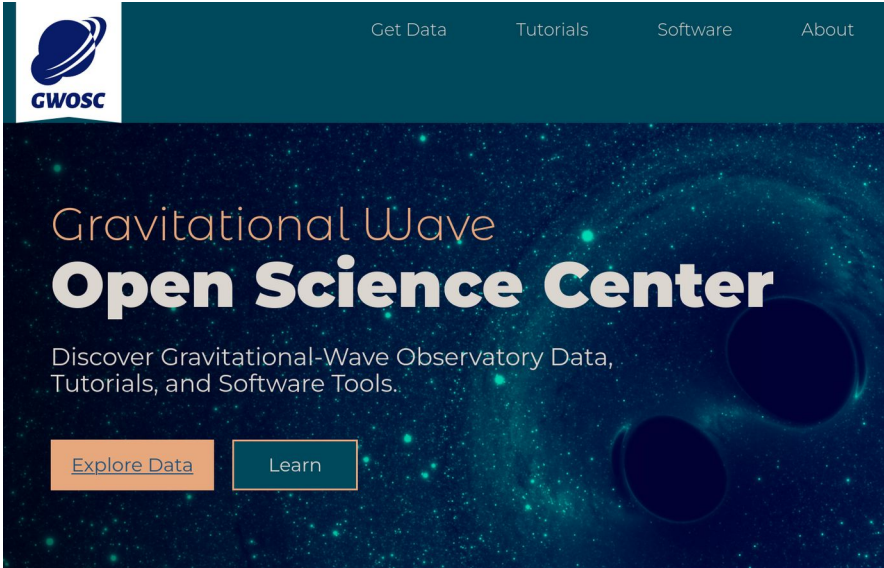GWTC-1

Virgo

LIGO & Virgo

O3

O3a
44 detections
GWTC-2.1

O3b
35 detections
GWTC-3

gwosc.org

- The LIGO–Virgo–KAGRA Collaboration is committed to the principles of **open science**
  - Link to data management plan

- GW Open Science Center
  - Releases **gravitational-wave data** to the broader scientific community and to the public
  - Offers **event catalogs** with parameter estimations, posterior samples, strain data, injection and quality flag segments
  - Provides **documentation and tools** necessary to understand and use the data (tutorials, interactive web apps, …)
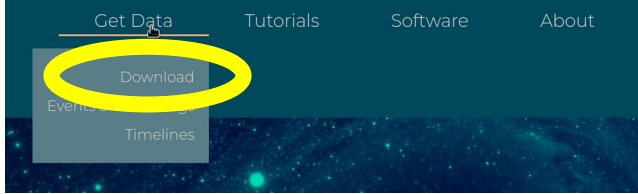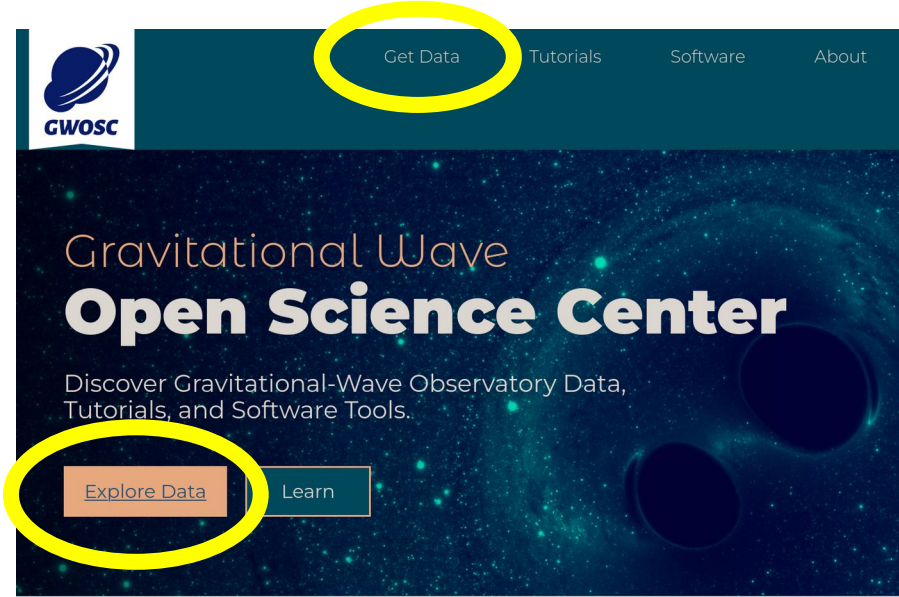
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Let's take a tour of gwosc.org

Events and Catalogs
✷ Event Portal

Large Data Sets
📄 CVMFS Docs

For users of computing clusters or if accessing large amounts of data, CernVM-FS is the preferred method to access public data.

O3 Auxiliary Data Release
📄 Documents

Time Range: April 1, 2019 through March 27, 2020
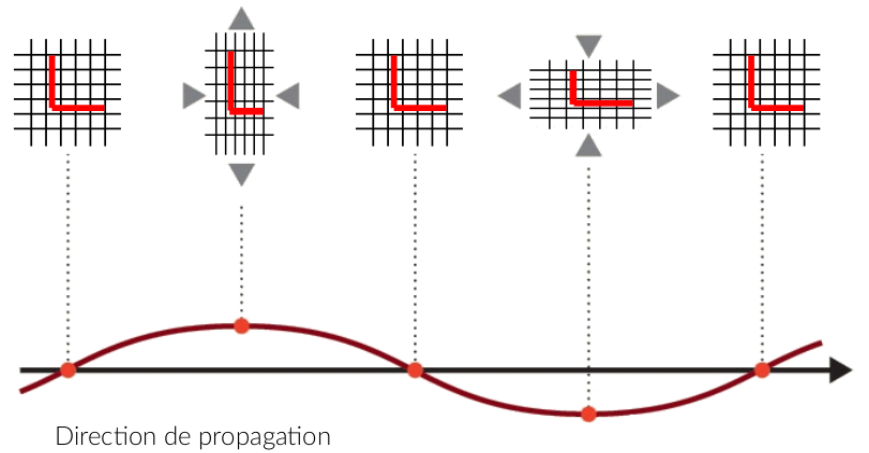
Detectors: 86 channels from H1 and L1

O3GK Data Release
☁ 4 kHz Data   ☁ 16 kHz Data   📄 Documents
🕐 Timeline

O3GK Time Range: April 7, 2020 through April 21, 2020

Detectors: G1 and K1

O3b Data Release
☁ 4 kHz Data   ☁ 16 kHz Data   📄 Documents
🕐 Timeline

O3b Time Range: November 1, 2019 through March 27, 2020

Direction de propagation

Gravitational wave strain
(space-time deformation)

$$h(t) = \frac{\delta \ell}{L}$$

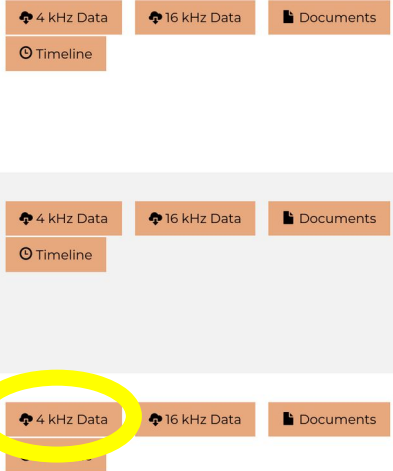Time series – 16 kHz sampling ("audio" band)

Continuous observation for ~1 yr typ.
With many on/off interruptions

Available datasets

O3GK Data Release
O3GK Time Range: April 7, 2020 through April 21, 2020
Detectors: G1 and K1

[4 kHz Data] [16 kHz Data] [Documents]
[Timeline]

O3b Data Release
O3b Time Range: November 1, 2019 through March 27, 2020
Detectors: H1, L1 and V1

[4 kHz Data] [16 kHz Data] [Documents]
[Timeline]

O3a Data Release
O3a Time Range: April 1, 2019 through October 1, 2019
Detectors: H1, L1 and V1

[4 kHz Data] [16 kHz Data] [Documents]

list continues

All you need to reproduce LIGO Virgo Kagra analyses
– "Bulk" data (various formats) and data quality with online documentation

O1: released in 2018
O2: released in Feb 2019
O3: released in Apr 2021 and Oct 2021

File by file access

Data access
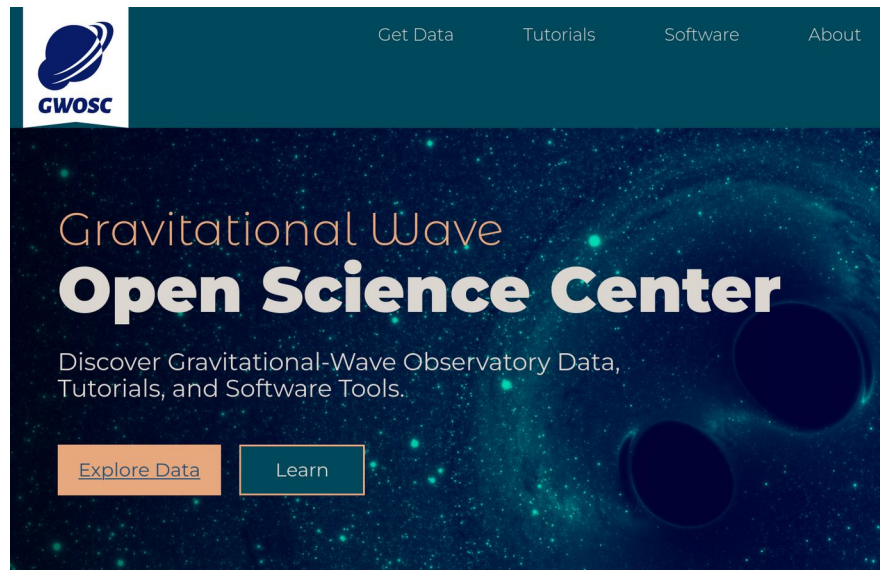

Data can be accessed …

- File by file through the GWOSC web site

- To download large datasets: CernVM File System [see this doc]

  Distant disk partitions can be mounted on local computer
  Can be used with the Open Science Grid (US)

- Programmatically through API (more later)

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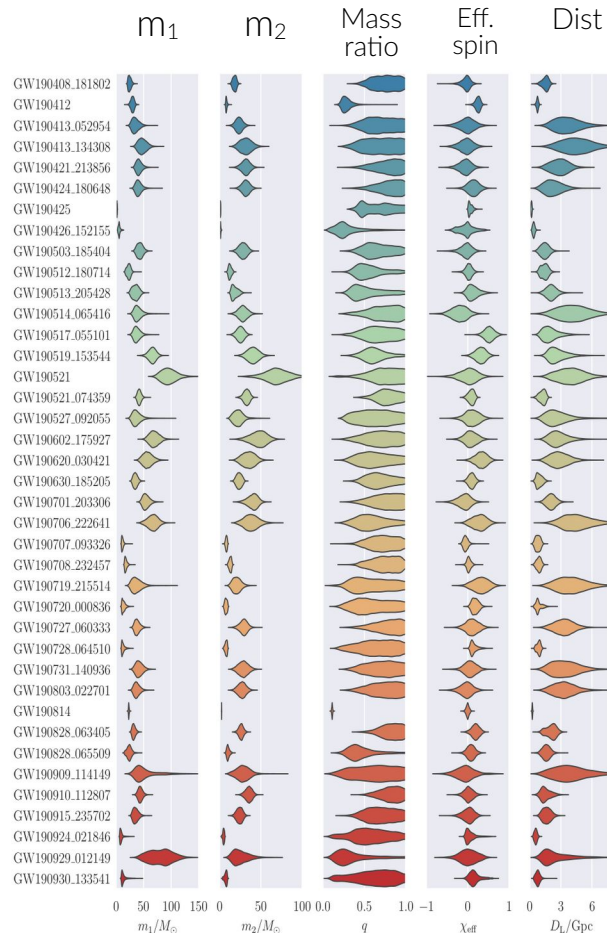
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List contains 93 events.

⊕ Focus

Display all | Display ▾

Name	Version	Release	GPS	Mass 1 (M$_\odot$)	Mass 2 (M$_\odot$)	Network SNR	Distance (Mpc)
GW200322_091133	v1	GWTC-3-confident	1268903511.3	34 $^{+48}_{-18}$	14.0 $^{+16.8}_{-8.7}$	6.0 $^{+1.7}_{-1.2}$	3600 $^{+7000}_{-2000}$
GW200316_215756	v1	GWTC-3-confident	1268431094.1	13.1 $^{+10.2}_{-2.9}$	7.8 $^{+1.9}_{-2.9}$	10.3 $^{+0.4}_{-0.7}$	1120 $^{+470}_{-440}$
GW200311_115853	v1	GWTC-3-confident	1267963151.3	34.2 $^{+6.4}_{-3.8}$	27.7 $^{+4.1}_{-5.9}$	17.8 $^{+0.2}_{-0.2}$	1170 $^{+280}_{-400}$
GW200308_173609	v1	GWTC-3-confident	1267724187.7	36.4 $^{+11.2}_{-9.6}$	13.8 $^{+7.2}_{-3.3}$	7.1 $^{+0.5}_{-0.5}$	5400 $^{+2700}_{-2600}$
GW200306_093714	v1	GWTC-3-confident	1267522652.1	28.3 $^{+17.1}_{-7.7}$	14.8 $^{+6.5}_{-6.4}$	7.8 $^{+0.4}_{-0.6}$	2100 $^{+1700}_{-1100}$
GW200302_015811	v1	GWTC-3-confident	1267149509.5	37.8 $^{+8.7}_{-8.5}$	20.0 $^{+8.1}_{-5.7}$	10.8 $^{+0.3}_{-0.4}$	1480 $^{+1020}_{-700}$
GW200225_060421	v1	GWTC-3-confident	1266645879.3	19.3 $^{+5.0}_{-3.0}$	14.0 $^{+2.8}_{-3.5}$	12.5 $^{+0.3}_{-0.4}$	1150 $^{+510}_{-530}$
GW200224_222234	v1	GWTC-3-confident	1266618172.4	40.0 $^{+6.9}_{-4.5}$	32.5 $^{+5.0}_{-7.2}$	20.0 $^{+0.2}_{-0.2}$	1710 $^{+490}_{-640}$
GW200220_124850	v1	GWTC-3-confident	1266238148.1	38.9 $^{+14.1}_{-8.6}$	27.9 $^{+9.2}_{-9.0}$	8.5 $^{+0.3}_{-0.5}$	4000 $^{+2800}_{-2200}$
GW200220_061928	v1	GWTC-3-confident	1266214786.7	87 $^{+40}_{-23}$	61 $^{+26}_{-25}$	7.2 $^{+0.4}_{-0.7}$	6000 $^{+4800}_{-3100}$
GW200219_094415	v1	GWTC-3-confident	1266140673.1	37.5 $^{+10.1}_{-6.9}$	27.9 $^{+7.4}_{-8.4}$	10.7 $^{+0.3}_{-0.5}$	3400 $^{+1700}_{-1500}$
GW200216_220804	v1	GWTC-3-confident	1265926102.8	51 $^{+22}_{-13}$	30 $^{+14}_{-16}$	8.1 $^{+0.4}_{-0.5}$	3800 $^{+3000}_{-2000}$

Event portal

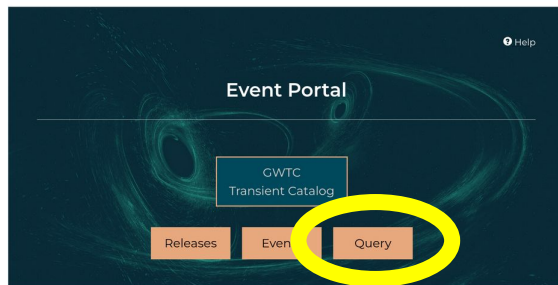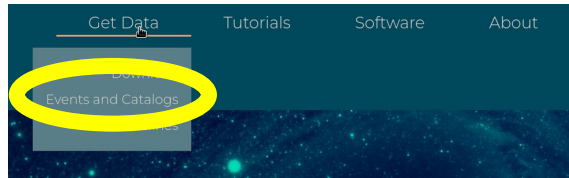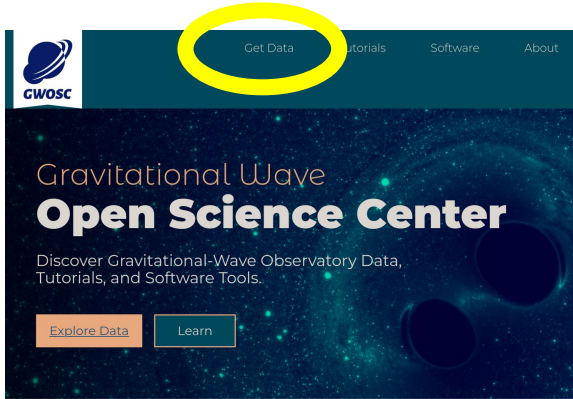- **Gravitational-wave Transient Catalog (GWTC)**
    - Notable events in "discovery releases"
    - Four catalogs released so far
        - GWTC-1 (confident & marginal)
        - GWTC-2
        - GWTC-2.1 (confident, marginal and aux)
        - GWTC-3 (confident & marginal)
        - GWTC → cumulative
- **The catalog can be queried**

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https://arxiv.org/abs/2010.14527

Online catalog query

From catalog to event

event list

There are sometimes multiple versions!

Name	Version	Release	GPS	Mass 1 (M☉)	Mass 2 (M☉)
GW200210_092254	v1	GWTC-3-confident	1265361792.9	+7.5 24.1 -4.6	+0.47 2.83 -0.42
GW200209_085452	v1	GWTC-3-confident	1265273710.1	+10.5 35.6 -6.8	+7.8 27.1 -7.8
GW200208_222617	v1	GWTC-3-confident	1265235995.9	+104 51 -30	+9.0 12.3 -5.7
GW200208_130117	v1	GWTC-3-confident	1265202095.9	+9.2 37.8 -6.2	+6.1 27.4 -7.4
GW200202_154313	v1	GWTC-3-confident	1264693411.5	+3.5 10.1 -1.4	+1.1 7.3 -1.7
GW200129_065458	v1	GWTC-3-confident	1264316116.4	+9.9 34.5 -3.2	+3.4 28.9 -9.3
GW200128_022011	v1	GWTC-3-confident	1264213229.9	+11.6 42.2 -8.1	+9.5 32.6 -9.2
GW200115_042309	v2	GWTC-3-confident	1263097407.7	+2.0 5.9 -2.5	+0.85 1.44 -0.29
GW200112_155838	v1	GWTC-3-confident	1262879936.0	+6.7 35.6 -4.5	+4.4 28.3 -5.9
GW191230_180458	v1	GWTC-3-confident	1261764316.4	+14.0 49.4 -9.6	+11 37 -12
GW191222_033537	v1	GWTC-3-confident	1261020955.1	+10.9 45.1 -8.0	+9.3 34.7 -10.5
GW191219_163120	v1	GWTC-3-confident	1260808298.4	+2.2 31.1 -2.8	+0.07 1.17 -0.06
GW191216_213338	v1	GWTC-3-confident	1260567236.4	+4.6 12.1 -2.3	+1.6 7.7 -1.9
GW191215_223052	v1	GWTC-3-confident	1260484270.3	+7.1 24.9 -4.1	+3.8 18.1 -4.1
GW191204_171526	v1	GWTC-3-confident	1259514944.0	+3.3 11.9 -1.8	+1.4 8.2 -1.6
GW191204_110529	v1	GWTC-3-confident	1259492747.5	+11.0 27.3 -6.0	+5.6 19.3 -6.0

GW200129_065458

Documentation

Release: GWTC-3-confident

Event UID: GW200129_065458-v1

Names: GW200129_065458

GPS: 1264316116.4

UTC Time: 2020-01-29 06:54

GraceDB: S200129m

GCN: Notices • Circulars

Timeline: Query for segments

DOI: https://doi.org/10.7935/b024-1886

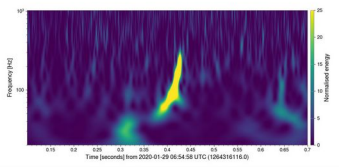Data sourced from frame channels.

FrameChannels: [H1:DCS-CALIB_STRAIN_CLEAN_SUB60HZ_C01, L1:DCS-CALIB_STRAIN_CLEAN_SUB60HZ_C01, V1:Hrec_hoft_16384Hz]

Data sourced from frame types:

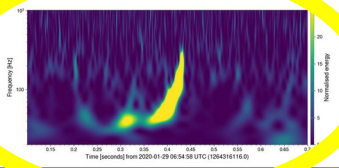FrameTypes: [H1_HOFT_CLEAN_SUB60HZ_C01, L1_HOFT_CLEAN_SUB60HZ_C01, V1Online]

To open GWF files, use channels names as shown for GWTC-1: https://doi.org/10.7935/82H3-HH23

data provenance

data snippet

H1 strain

32sec • 16KHz: GWF   HDF   TXT
32sec • 4KHz: GWF   HDF   TXT
4096sec • 16KHz: GWF   HDF   TXT
4096sec • 4KHz: GWF   HDF   TXT

L1 strain

32sec • 16KHz: GWF   HDF   TXT
32sec • 4KHz: GWF   HDF   TXT
4096sec • 16KHz: GWF   HDF   TXT
4096sec • 4KHz: GWF   HDF   TXT

search pipelines

pycbc_bbh Search Pipeline
Date added: Sept. 13, 2021
show / hide parameters

pycbc_broad Search Pipeline
Date added: Sept. 13, 2021
show / hide parameters

gstlal Search Pipeline
Date added: Sept. 13, 2021
show / hide parameters
Default SEARCH

GWTC-3 PE for GW200129_065458
Date added: Nov. 1, 2021
show / hide parameters
Source File
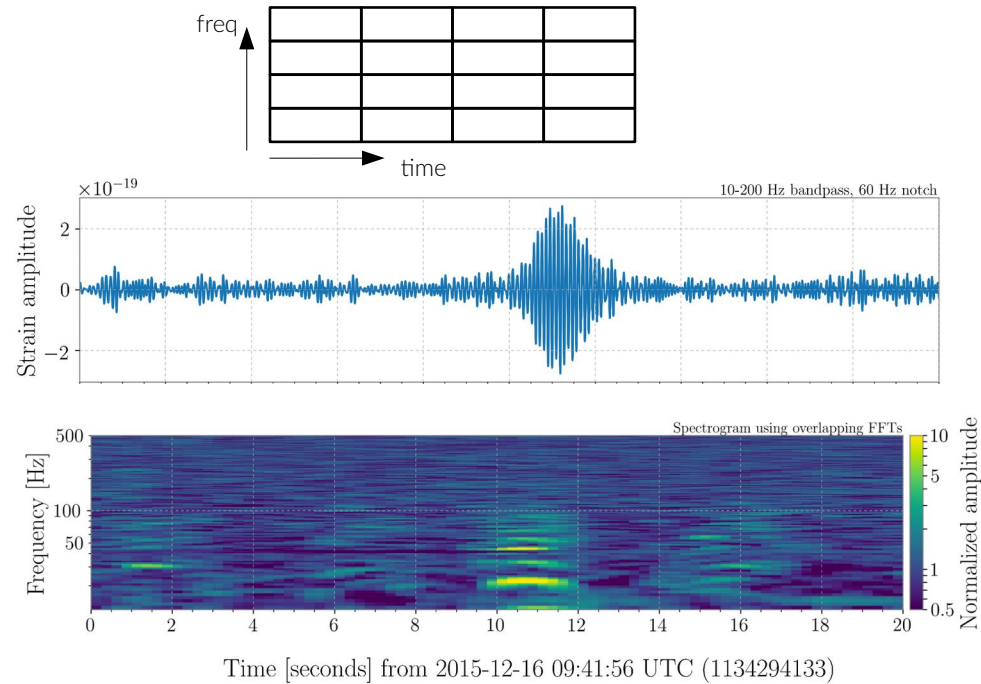Posterior Samples in Zenodo
Skymap for GW200129_065458
Default PE

params estimation

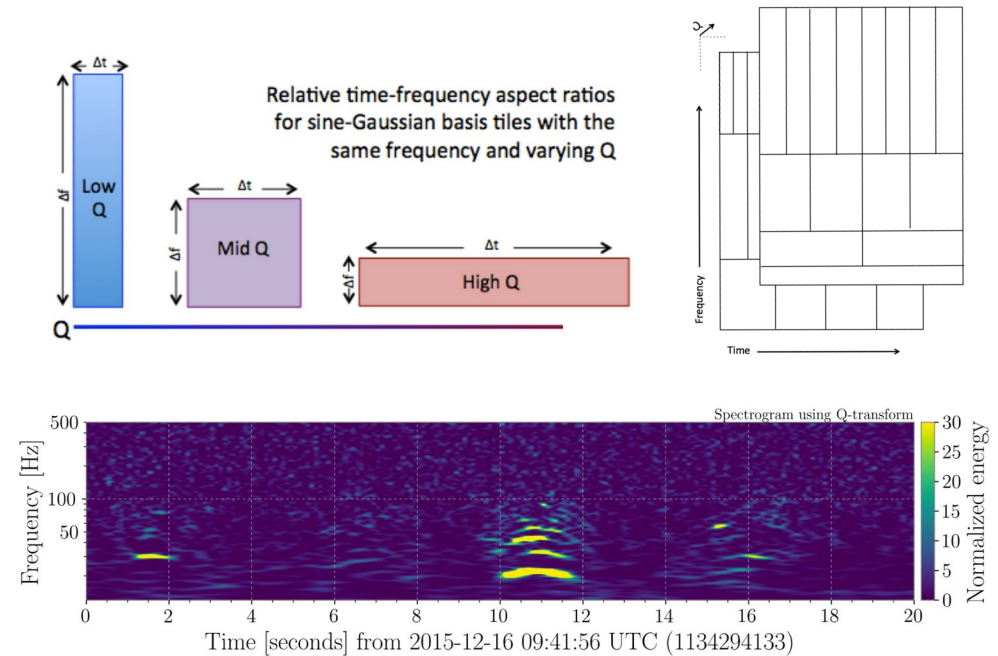# Time-frequency maps and Q transform
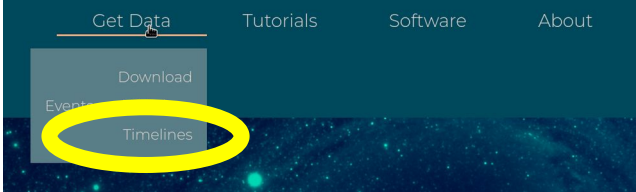
Spectrogram or short-time Fourier transform

Q transform

S. Chatterji et al. CQG (2010)

Relative time-frequency aspect ratios for sine-Gaussian basis tiles with the same frequency and varying Q

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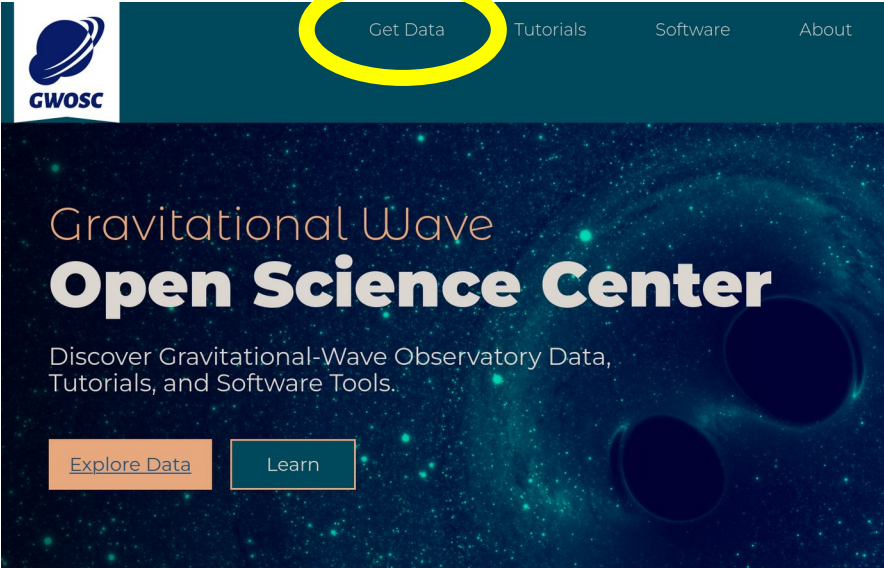
Timeline and data quality

Data Set:

O1

GPS Start:

1126051217

2015-09-12T02:00:00

GPS End:

1137254417

2016-01-19T17:00:00

Duration:

11203200

Select data quality :

[DETECTOR]_[SEARCH TYPE]_[SEVERITY CATEGORY]

Ex: H1_BURST_CAT1, V1_CBC_CAT2, ...
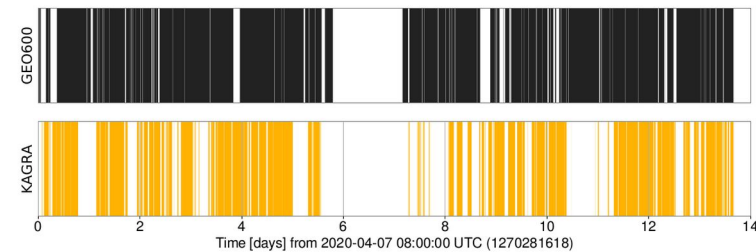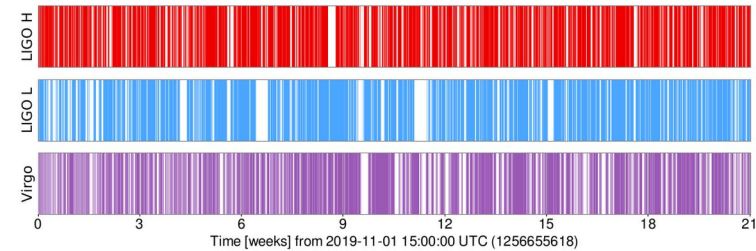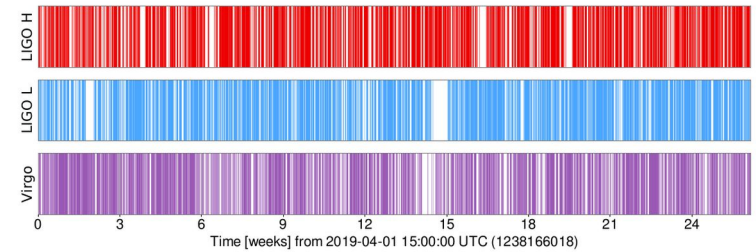
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GW open data workshop #6

Web API and software utilities

GWOSC Public API Documentation

The Gravitational Wave Open Science Center offers a public API, mostly in the form of JSON format that provides data on timeline segments, catalogs, list of datasets with and without bulk strain data, and single datasets.

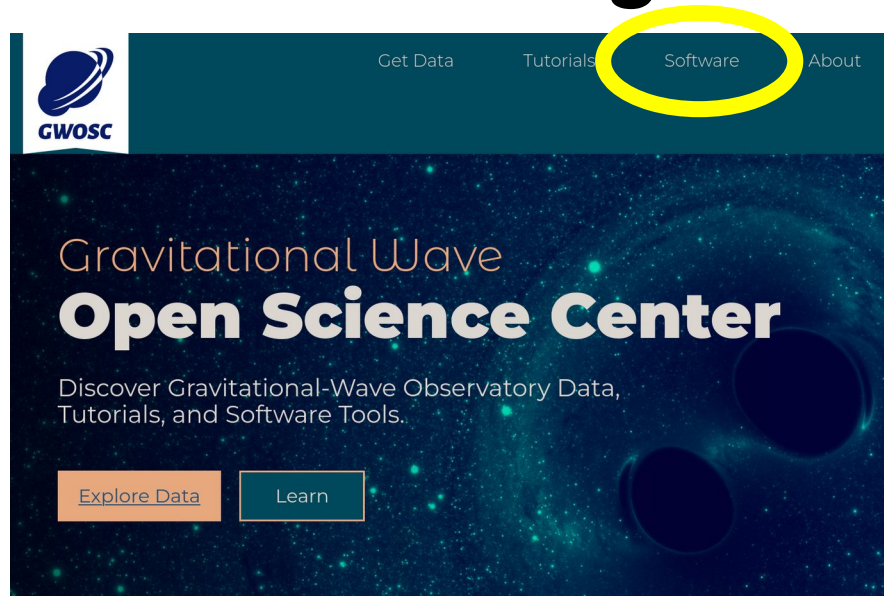If you are working in a Python project, we recommend installing the gwosc Python client to interact with our API.

```
$ pip install gwosc
```

https://gwosc.org/apidocs/

- The data can be accessed programmatically using the public API

  Timeline, archival data, event and catalogs

  Python client https://pypi.org/project/gwosc/

  You will learn how to use this package with Tutorial #1.1 "Discovering open data from GW obs"

- Many other software utilities for signal simulation and analysis

Conclusions

Open data from the third observing run of LIGO, Virgo, KAGRA and GEO

R. Abbott,[1] H. Abe,[2] F. Acernese,[3,4] K. Ackley,[5] S. Adhicary,[6] N. Adhikari,[7] R. X. Adhikari,[1] V. K. Adkins,[8] V. B. Adya,[9] C. Affeldt,[10,11] D. Agarwal,[12] M. Agathos,[13,14] O. D. Aguiar,[15] L. Aiello,[16] A. Ain,[17] P. Ajith,[18] T. Akutsu,[19,20] S. Albanesi,[21,22] R. A. Alfaidi,[23] A. Al-Jodah,[24] C. Allené,[25] A. Allocca,[26,4] M. Almualla,[27] P. A. Altin,[9] A. Amato,[28,29] L. Amez-Droz,[30] A. Amorosi,[30] S. Anand,[1]

ABSTRACT

The global network of gravitational-wave observatories now includes five detectors, namely LIGO Hanford, LIGO Livingston, Virgo, KAGRA, and GEO 600. These detectors collected data during their third observing run, O3, composed of three phases: O3a starting in April of 2019 and lasting six months, O3b starting in November of 2019 and lasting five months, and O3GK starting in April of 2020 and lasting 2 weeks. In this paper we describe these data and various other science products that can be freely accessed through the Gravitational Wave Open Science Center at https://gwosc.org. The main dataset, consisting of the gravitational-wave strain time series that contains the astrophysical signals, is released together with supporting data useful for their analysis and documentation, tutorials, as well as analysis software packages.

https://arxiv.org/abs/2302.03676

- Looking for GW data? GWOSC is your **friend :)**

  ~15 TB of science data accessible under CC-BY

- A lot of documentation and ressources available – Check also our data papers!

- Ask questions or send feedback or suggestions

  User forum: http://ask.igwn.org

- If you use the data, please acknowledge

  https://gwosc.org/acknowledgement/