

GW public data



Eric Chassande-Mottin

AstroParticule et Cosmologie (APC)
CNRS Université Paris Cité





LIGO Hanford H1



LIGO Livingston L1



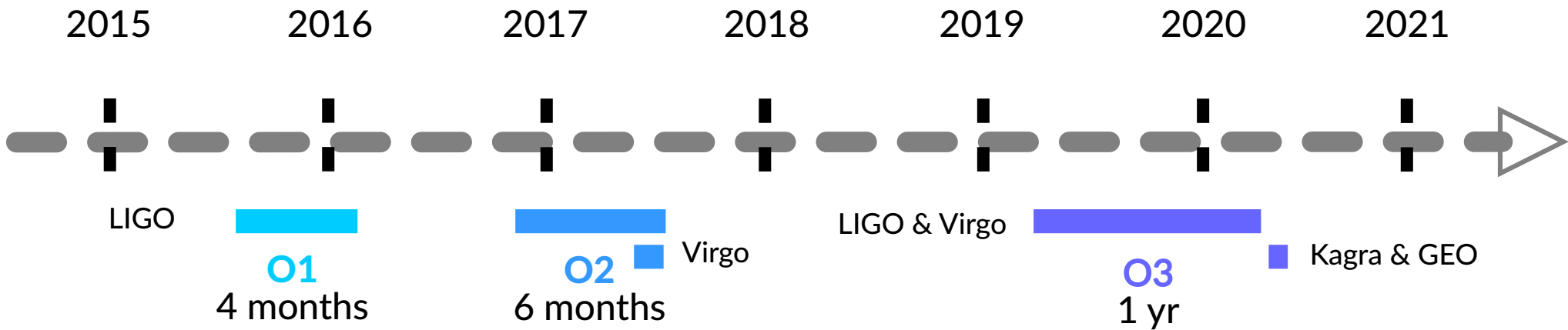
Virgo V1

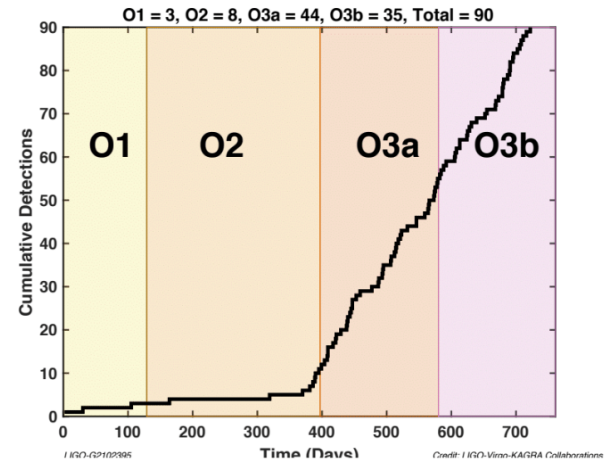


GEO600 G1



KAGRA K1





2015

2016

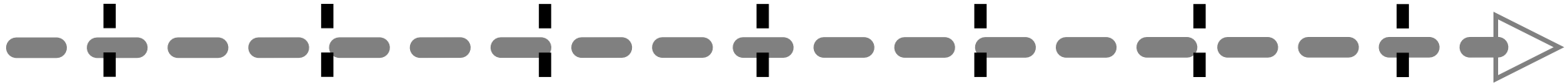
2017

2018

2019

2020

2021

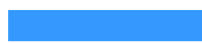


LIGO



O1

3 detections



O2

8 detections
GWTC-1

Virgo

LIGO & Virgo

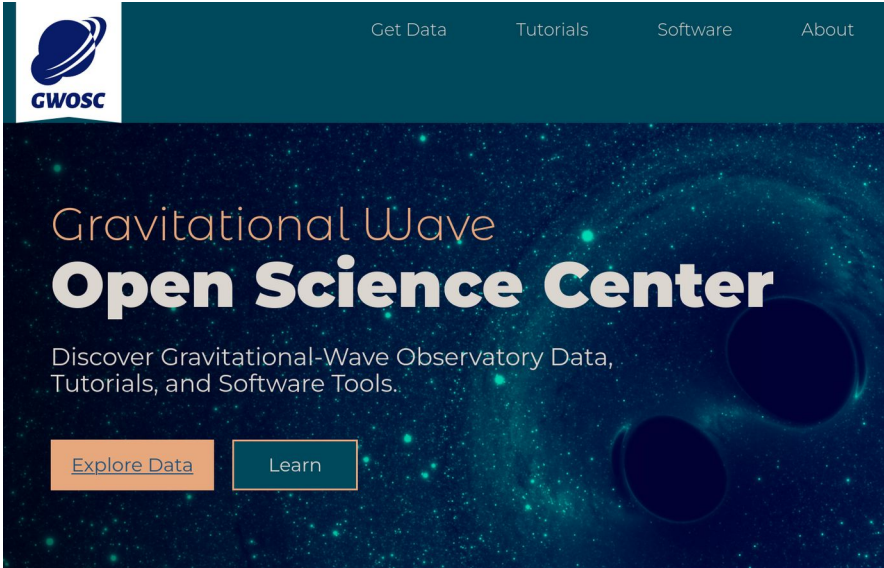


O3

O3a
44 detections
GWTC-2.1

O3b
35 detections
GWTC-3

gwosc.org



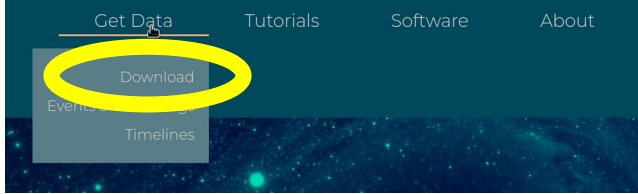
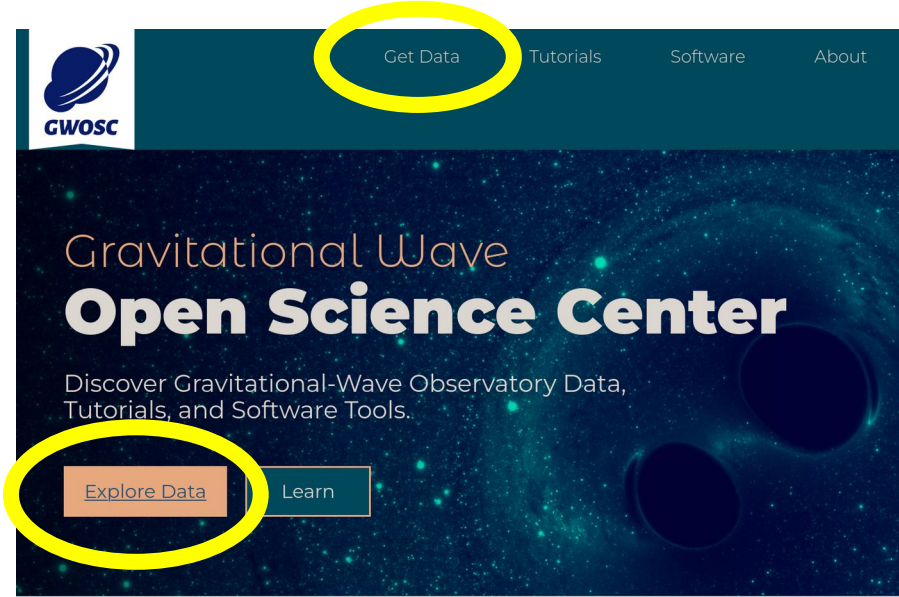
- The LIGO–Virgo–KAGRA Collaboration is committed to the principles of **open science**
 - Link to data management plan
- **GW Open Science Center**
 - Releases **gravitational-wave data** to the broader scientific community and to the public
 - Offers **event catalogs** with parameter estimations, posterior samples, strain data, injection and quality flag segments
 - Provides **documentation and tools** necessary to understand and use the data (tutorials, interactive web apps, ...)


Event
Catalog


Open Data
Workshop


Tutorials

Let's take a tour of gwosc.org



Event
Catalog



Open Data
Workshop



Tutorials

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

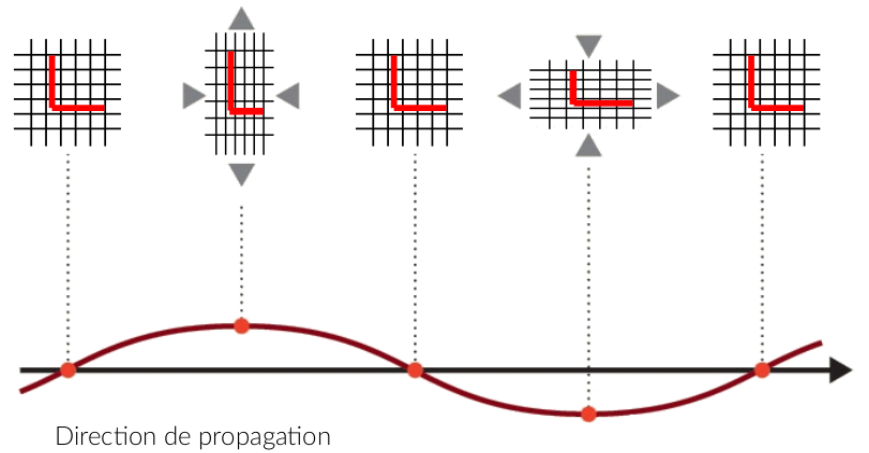
O3GK Data Release [4 kHz Data](#) [16 kHz Data](#) [Documents](#) [Timeline](#)

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



Gravitational wave strain
(space-time deformation)

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

Time series – 16 kHz sampling (“audio” band)

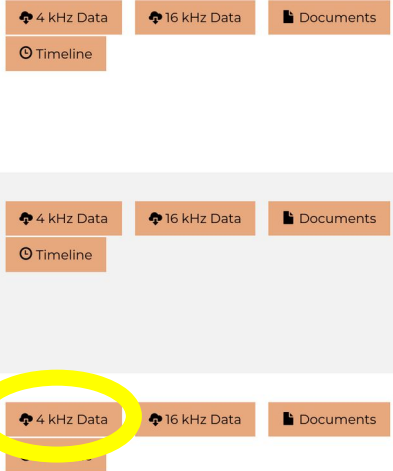
Continuous observation for ~1 yr typ.
With many on/off interruptions

Available datasets

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

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

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



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

Archive for [O3b_4KHZ_R1](#) dataset

Each data file corresponds to 4096 seconds of GPS time, and may contain up to half a GB. The file may be downloaded in either HDF5 or Frame format.

For documentation, see the [tutorials](#).

O3b_4KHZ_R1 start GPS:	1256655618	UTC: 2019-11-01T15:00:00
O3b_4KHZ_R1 end GPS:	1269363618	UTC: 2020-03-27T17:00:00

Next choose your gravitational wave detector:

- V1
- H1
- L1

Now choose the start and end time of the data that you want, either Universal time or GPS. Change either side and the other responds immediately.

	Universal Time (ISO8601)		GPS Time	
Start Time	<input type="text" value="2019-11-01T15:00:00"/>		<input type="text" value="1256655618"/>	OK
End Time	<input type="text" value="2020-03-27T17:00:00"/>		<input type="text" value="1269363618"/>	OK

Choose your output format:

- Time series data in HDF5 and Frame files
- Time series data in HDF5 and Frame files, with data quality guide
- Includes statistics of each file: min/max, band-limited RMS, etc.
- JSON formatted table of files and data quality

Click the button to continue

Continue

Dataset: O3b_4KHZ_R1

GPS Time Interval: [1256655618, 1269363618]

Detector: V1

Note:

- Each file covers a 4096-second period, with strain data at either 16kHz or downsampled to 4 kHz.
- The time of the beginning of the file is shown as 'GPS start time', and is linked to a timeline showing which parts of the tile have science-mode data.
- The last column of the table shows the percentage of each file that has data.
- For instructions on downloading many files, see the [Automatic Download Tutorial](#).

Timeline	UTC	Mbytes	HDF5	Frame	Percent
1256652800	2019-11-01T14:13:02	38.2 MB	HDF5	Frame	30.2
1256656896	2019-11-01T15:21:18	124.4 MB	HDF5	Frame	100.0
1256660992	2019-11-01T16:29:34	124.1 MB	HDF5	Frame	99.8
1256665088	2019-11-01T17:37:50	123.9 MB	HDF5	Frame	99.6
1256669184	2019-11-01T18:46:06	124.1 MB	HDF5	Frame	99.8
1256673280	2019-11-01T19:54:22	124.3 MB	HDF5	Frame	100.0
1256677376	2019-11-01T21:02:38	124.3 MB	HDF5	Frame	100.0
1256681472	2019-11-01T22:10:54	124.3 MB	HDF5	Frame	100.0
1256685568	2019-11-01T23:19:10	124.1 MB	HDF5	Frame	99.8

Data access

The screenshot shows a web interface with several data release sections. The 'Large Data Sets' section is circled in yellow. It contains the text: 'For users of computing clusters or if accessing large amounts of data, CernVM-FS is the preferred method to access public data.' Other sections include 'Events and Catalogs' with an 'Event Portal' button, 'O3 Auxiliary Data Release' with a 'Documents' button, 'O3GK Data Release' with buttons for '4 kHz Data', '16 kHz Data', 'Documents', and 'Timeline', and 'O3b Data Release' with buttons for '4 kHz Data', '16 kHz Data', 'Documents', and 'Timeline'.

Events and Catalogs Event Portal

Large Data Sets
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

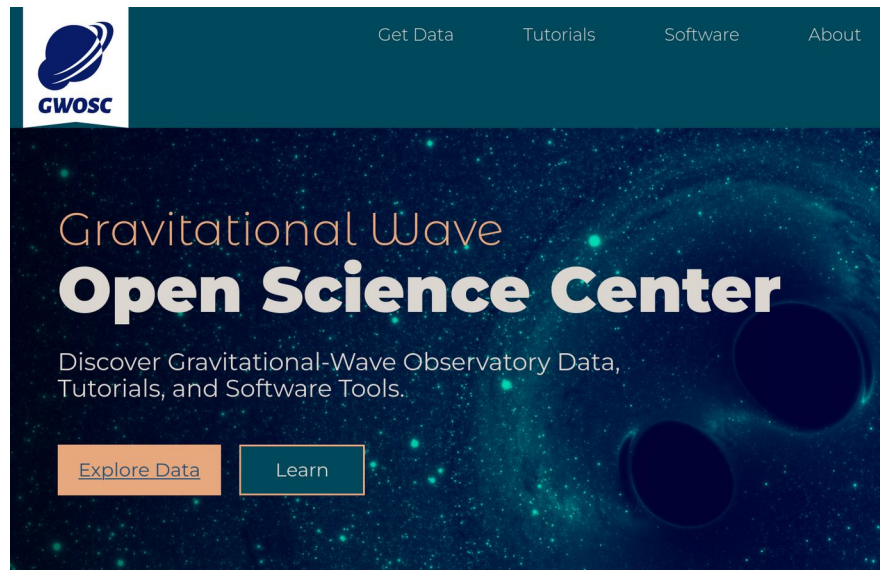
Data can be accessed ...

- 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)

Let's take a tour of gwosc.org



Event
Catalog



Open Data
Workshop



Tutorials

Let's take a tour of gwosc.org



List contains 93 events.

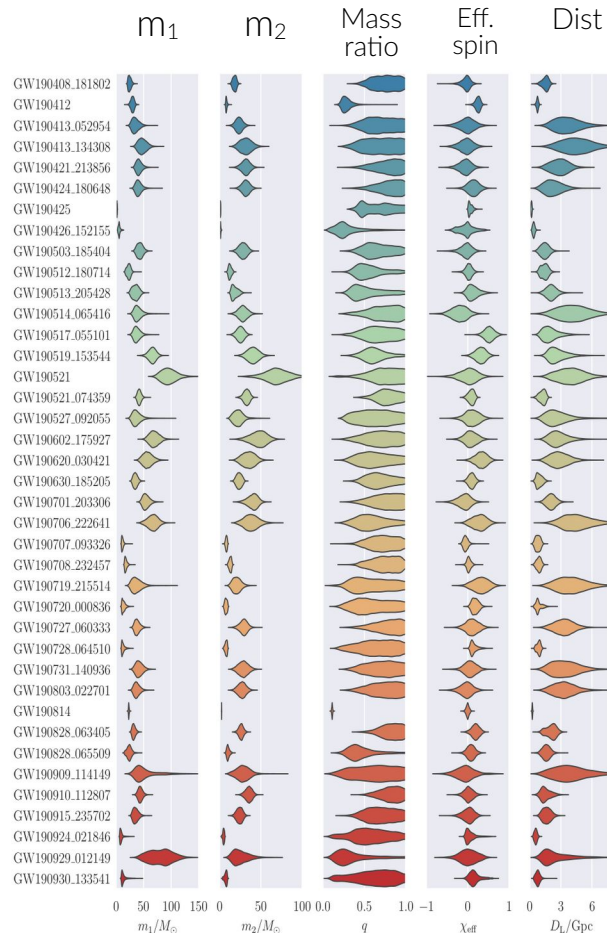
Focus

Display all Display ▾

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

May 15 2023

Event portal

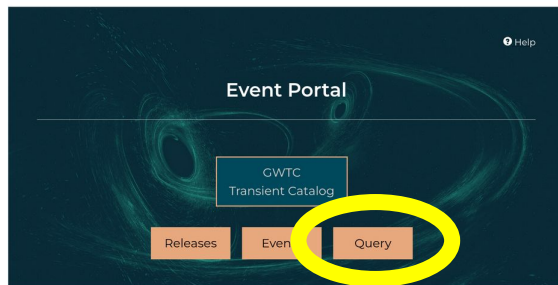
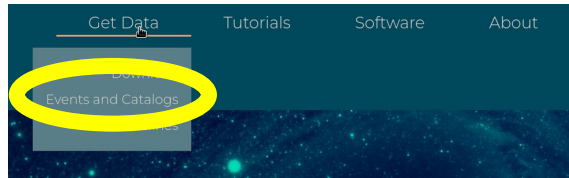
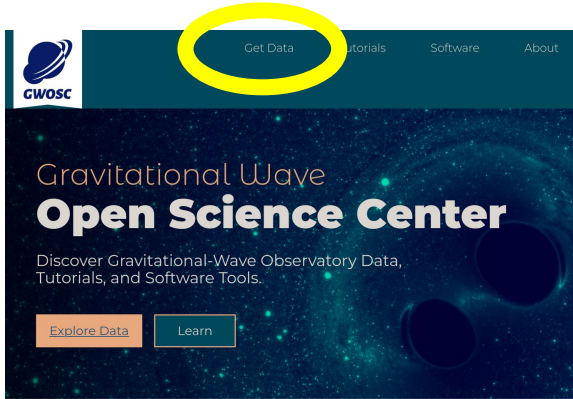


- Gravitational-wave Transient Catalog (GWTC)
 - Notable events in “discovery releases”
 - Four catalogs released so far
 - GWTC-1 (confident & marginal)
 - GWTC-2
 - GWTC-2.1 (confident, marginal and aux)
 - GWTC-3 (confident & marginal)
 - GWTC → cumulative
- The catalog can be queried

GW open data workshop #6

<https://arxiv.org/abs/2010.14527>

Online catalog query



Event Name:

Release: GWTC-1-marginal
GWTC-1-confident
O1_O2-Preliminary
O3_Discovery_Papers
MST-1-CC-1

Mass 1 Range: **Mass 2 Range:**

Total Mass Range: **Final Mass Range:**

Chirp Mass Range: **Detector Frame Chirp Mass Range:**

Distance (Mpc) Range: **Redshift Range:**

Network SNR Range: **χ_{eff} Range:**

False Alarm Rate Range: **Pastro Range:**

UTC Time Range:

GPS Time Range:

Show only last version

Output Format: HTML JSON CSV ASCII

Submit Query

From catalog to event

event list

GW200129_065458

data snippet

search pipelines

Name	Version	Release	GPS	Mass 1 (M _⊙)	Mass 2 (M _⊙)
GW200210_092254	v1	GWTC-3-confident	1265361792.9	24.1 -4.6	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	126494411.5	+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

There are sometimes multiple versions!

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.

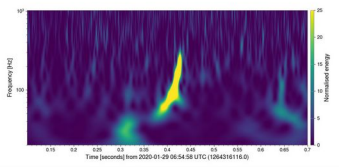
FrameChannels: [H1:DCS-CALIB_STRAIN_CLEAN_SUB60HZ_C01, L1:DCS-CALIB_STRAIN_CLEAN_SUB60HZ_C01, V1:Hrec_hoft_16384Hz]

Data sourced from frame types:

FrameTypes: [H1_HOFT_CLEAN_SUB60HZ_C01, L1_HOFT_CLEAN_SUB60HZ_C01, V1Online]

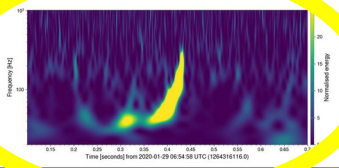
To open GWF files, use channels names as shown for GWTC-1:
<https://doi.org/10.7935/82H3-HH23>

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

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

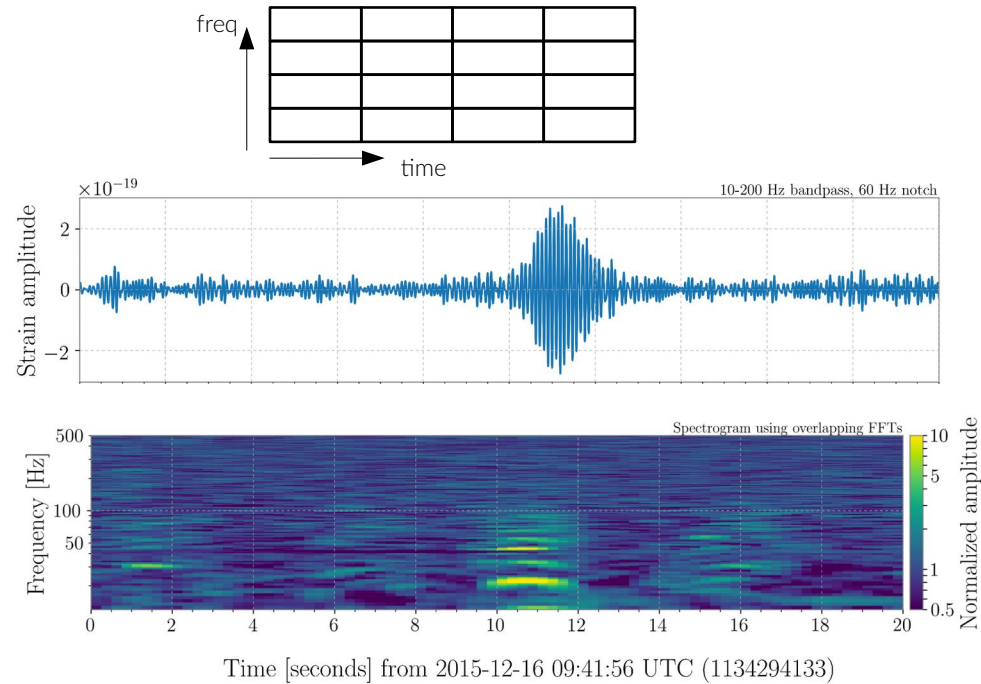
data provenance

pp #6

params estimation

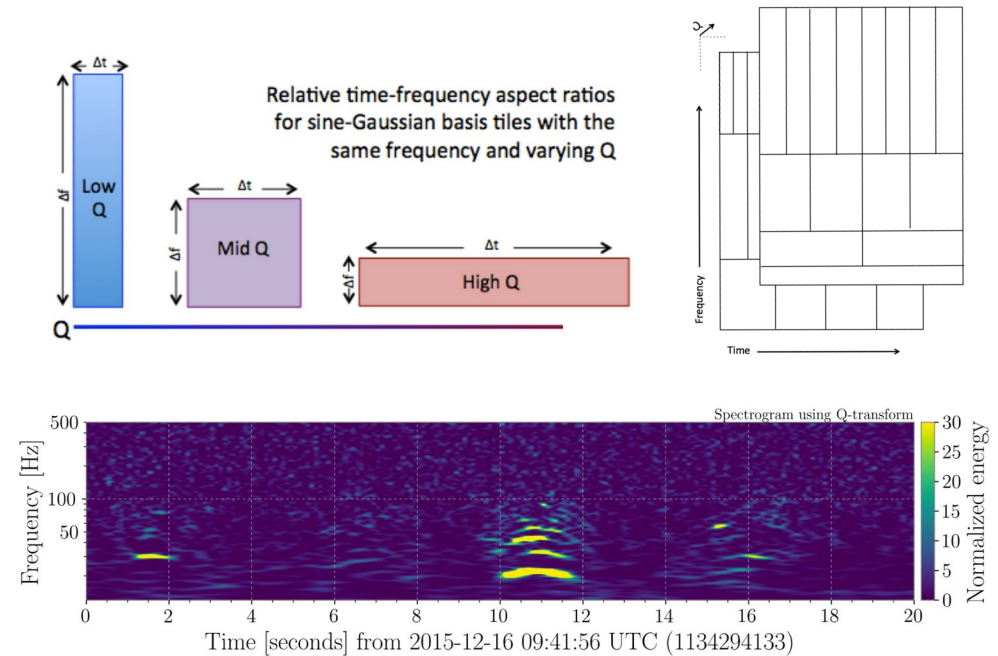
Time-frequency maps and Q transform

Spectrogram or short-time Fourier transform

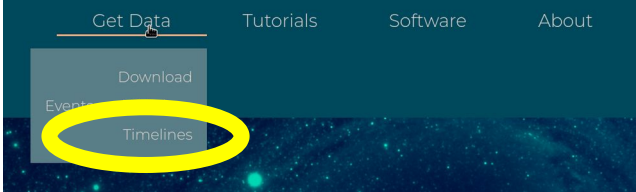
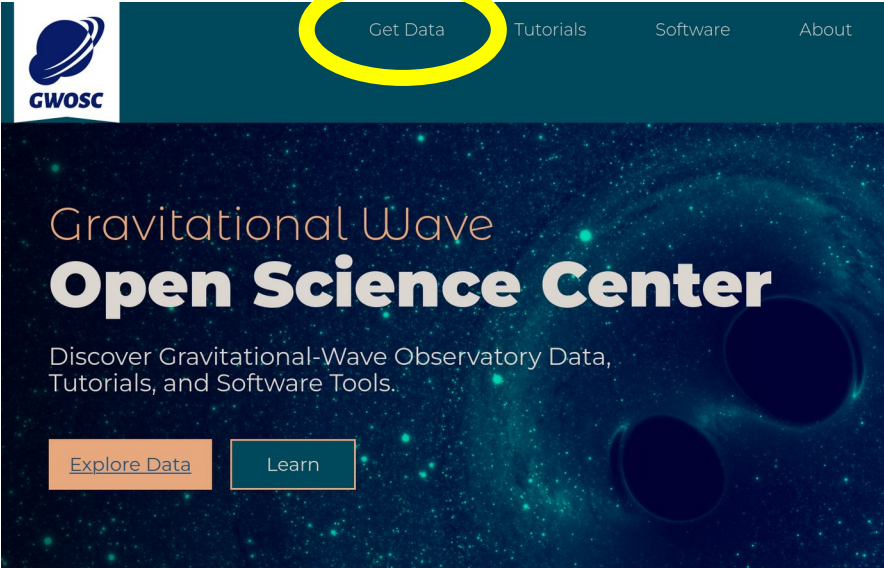


Q transform

S. Chatterji et al. CQG (2010)



Let's take a tour of gwosc.org



Event
Catalog



Open Data
Workshop



Tutorials

Timeline and data quality

Data Set:

GPS Start:

GPS End:

Duration:

Timeline Examples

Science Mode History

Five detectors since 2005

Timelines from the O3GK run, 2020

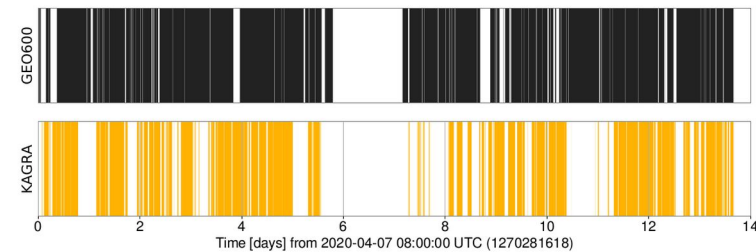
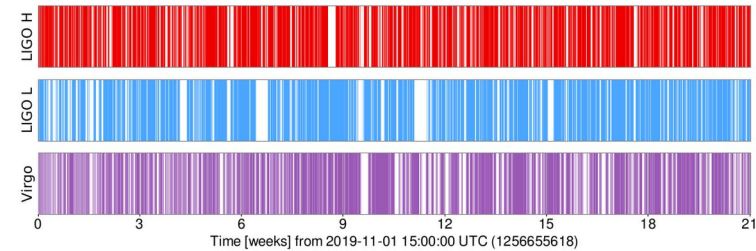
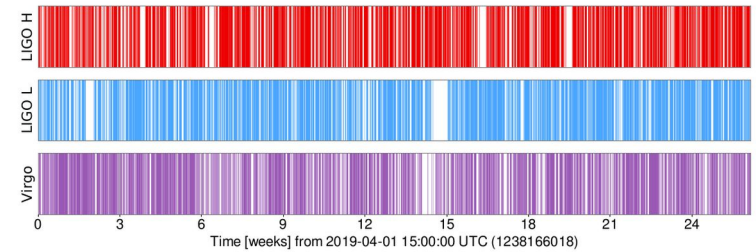
Data available over the O3GK run

Passes O3GK Burst checks for G1, K1

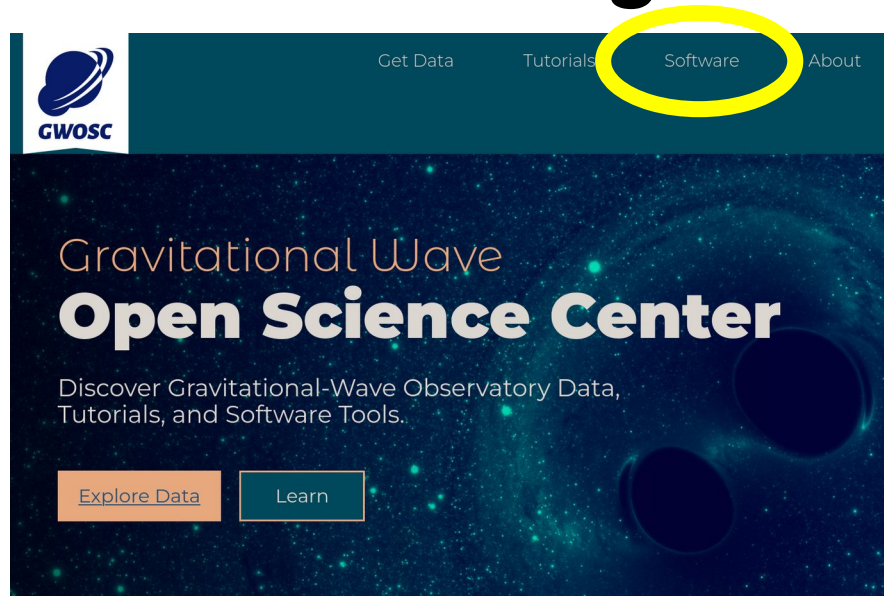
Select data quality :

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

Ex: H1_BURST_CAT1, V1_CBC_CAT2, ...



Let's take a tour of gwosc.org



Event
Catalog



Open Data
Workshop



Tutorials

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. ALLÈNE,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 resources 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/>