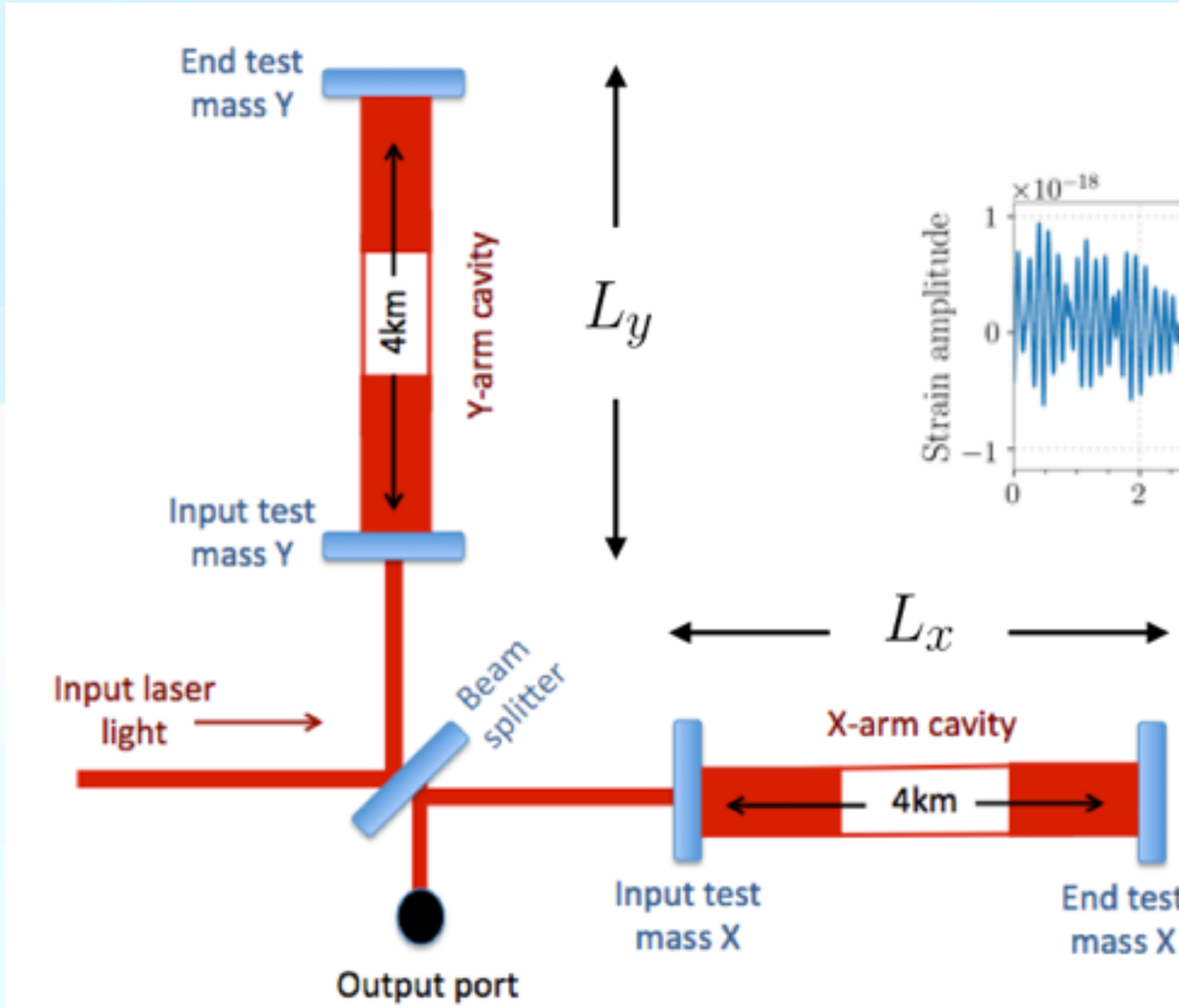
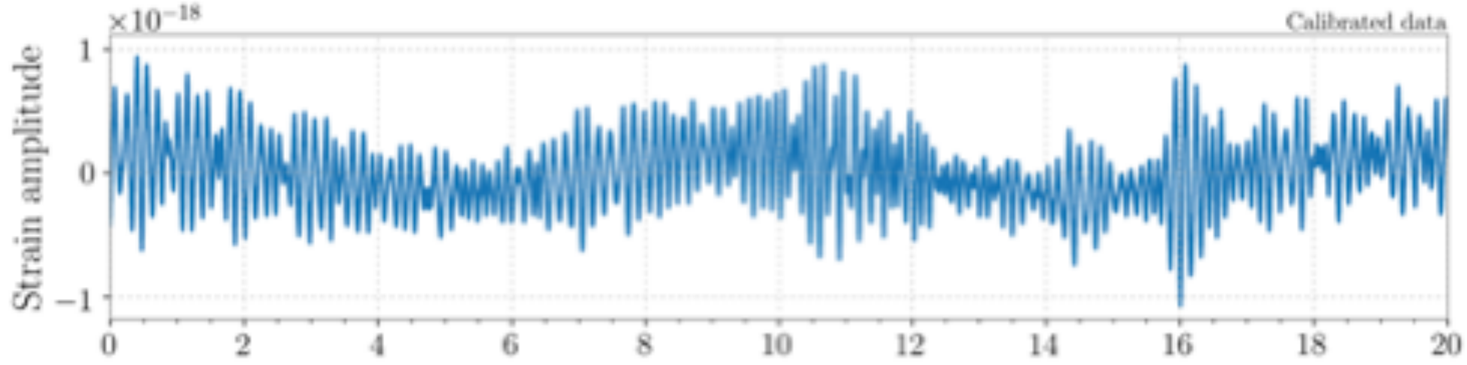
To Strain Data to Record the GW Signal

The stain amplitude can be determine as:

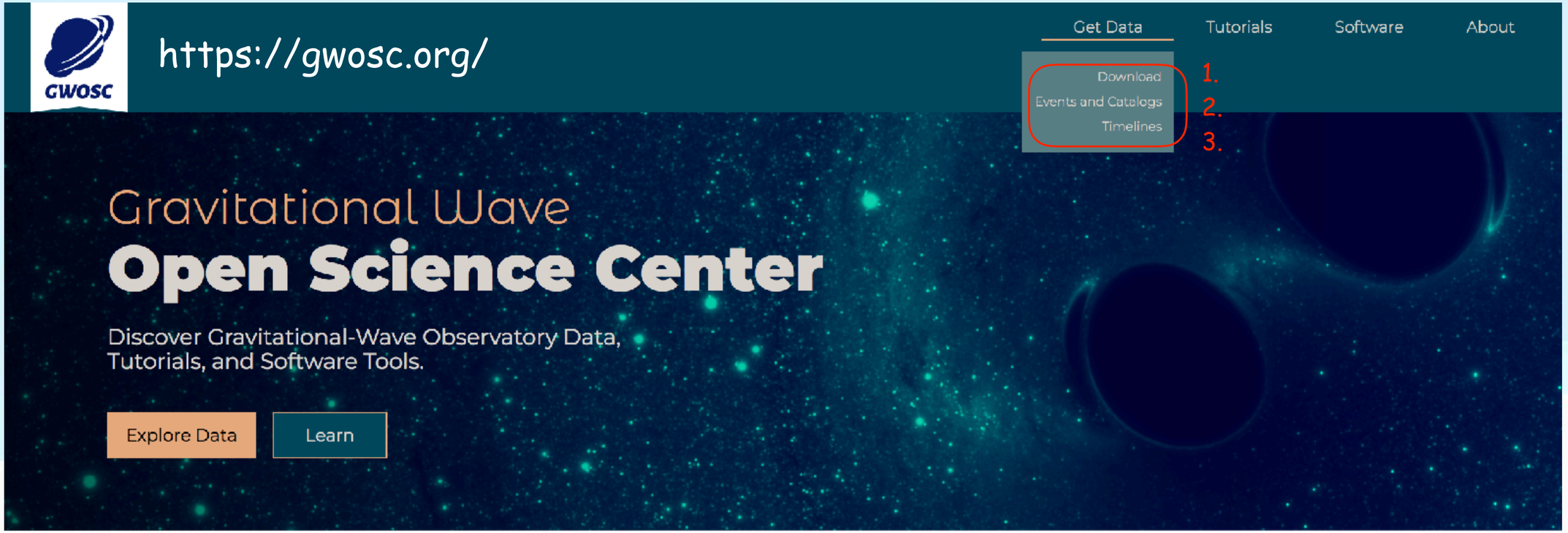
$$h(t) = \frac{\Delta L_y - \Delta L_x}{L}$$

And the time series:





To Access the Open Data



Event Catalog

The Gravitational-wave Transient Catalog (GWTC) is a cumulative set of events detected by LIGO, Virgo, and KAGRA.

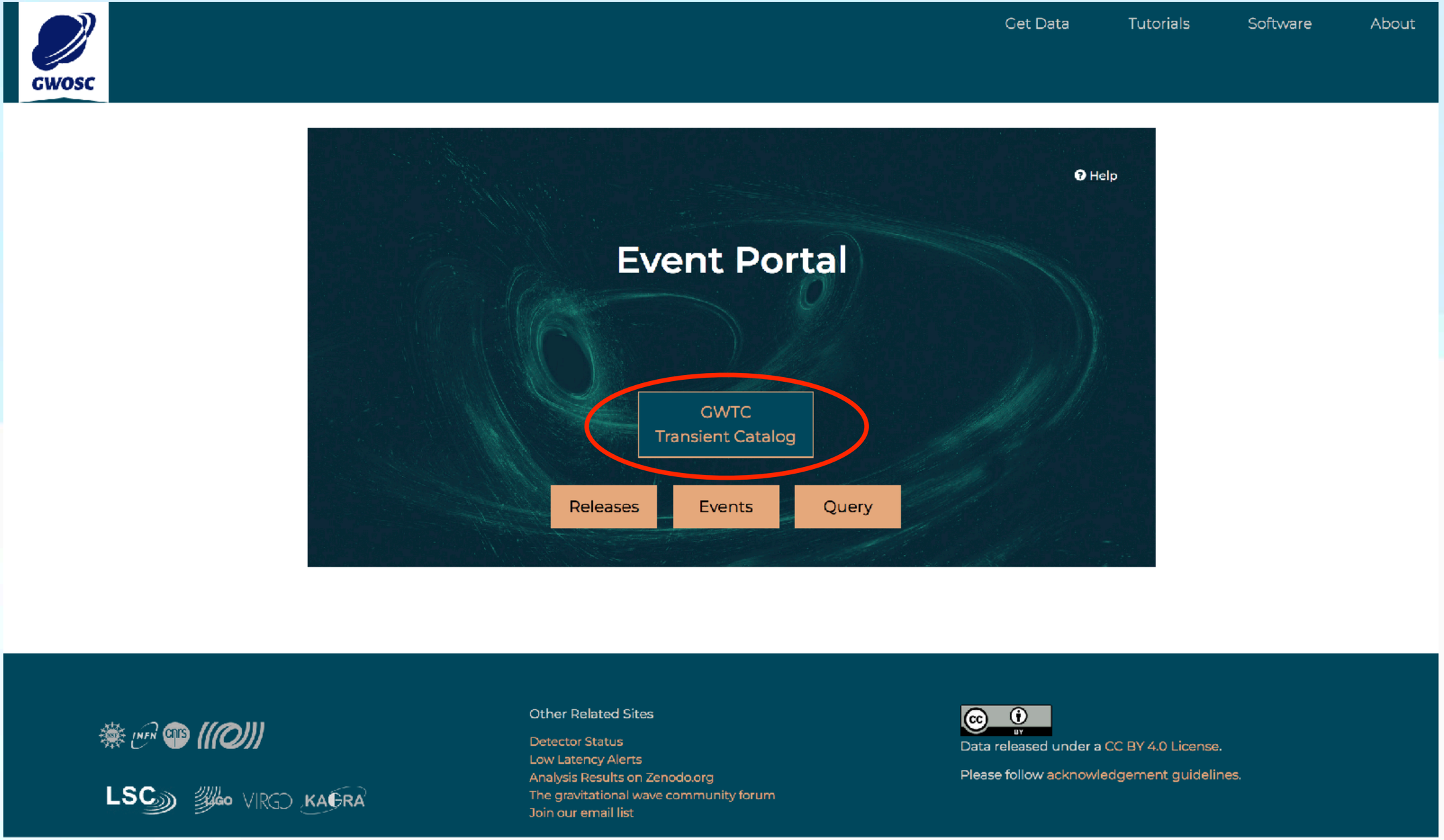
Open Data Workshop

Participants will receive a crash-course in gravitational-wave data analysis that includes lectures, software tutorials, and a data challenge.

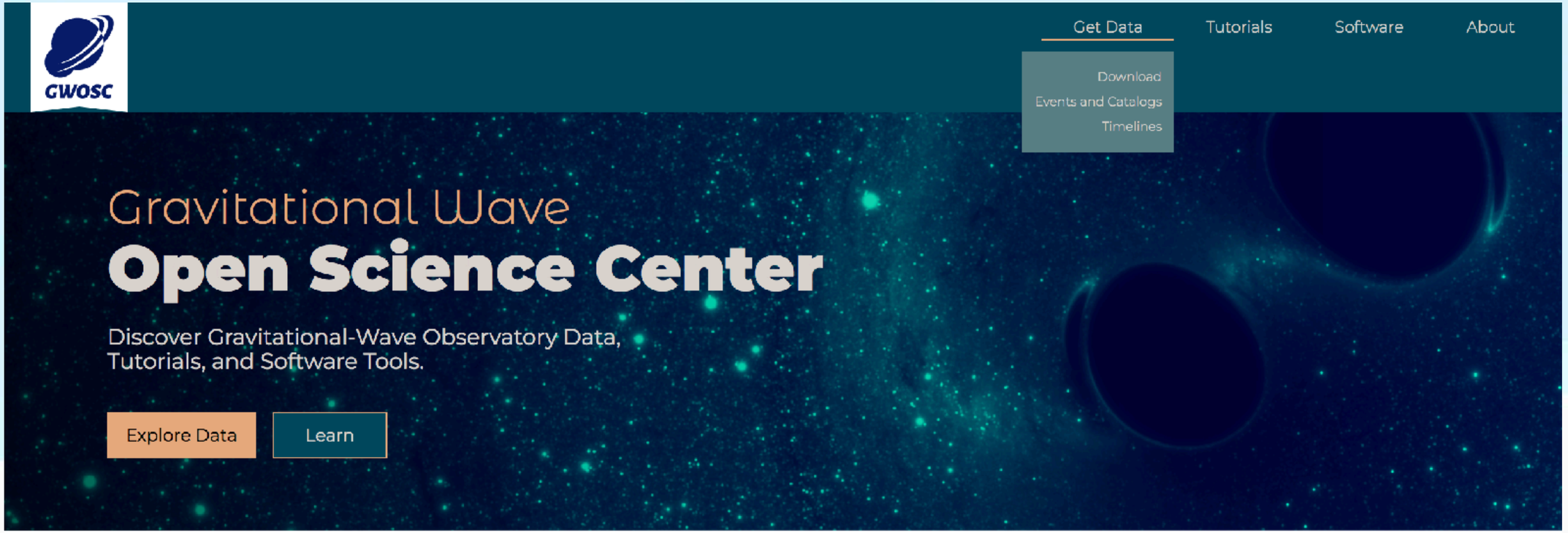
Tutorials

Learn with tutorials that will lead you step-by-step through some common data analysis tasks.

Events and catalog



Events and catalog



Event Catalog

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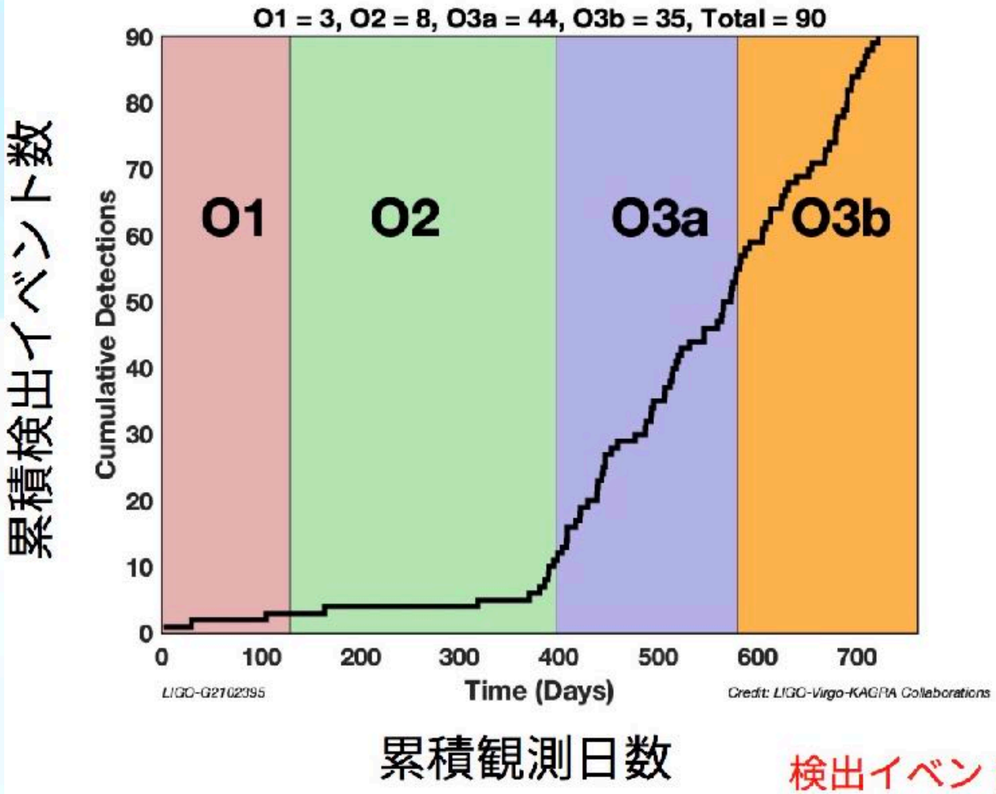
Gravitational-Wave Transient Catalogs; GWTCs

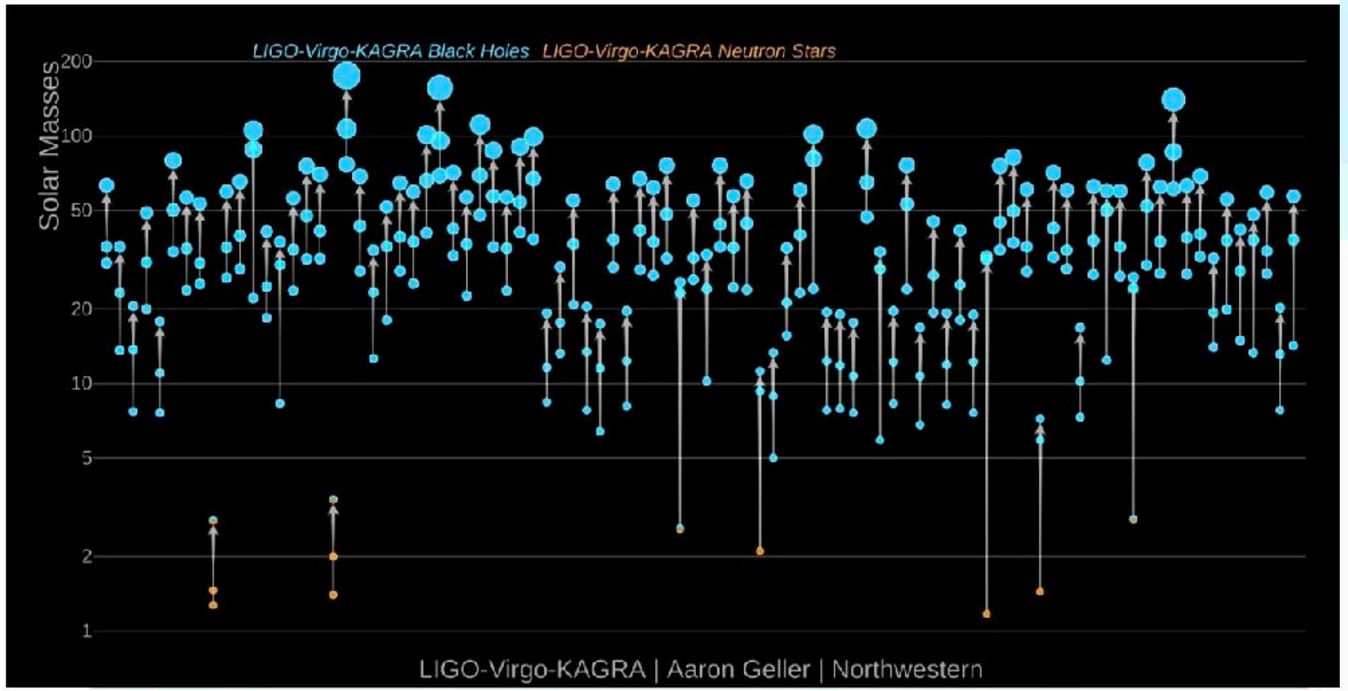
2015年に重力波が初検出されて以降、現在までに90イベントを検出

＊ 天体物理学的起源である確率が 50％を超える候補重力波源の数.



累積検出イベント数

累積観測日数



検出器の性能向上に伴い、検出頻度が加速度的に増加している

	O1	O2	O3a	O3b
検出イベント数	3	8	44	35
	GWTC-1		GWTC-2 GWTC-2.1	GWTC-3

Download the bulk data from timeline

Timeline Queries

https://gwosc.org/timeline/

The Timeline App shows times when data are available, as well as data quality and injection segments.

Use the **Event Portal** to access individual Events and request any of the Event Timeline or Segment Lists.

Data Set: O1

GPS Start:	GPS End:	Duration:
1126051217	1137254417	11203200
2015-09-12T08:00:00	2016-01-20T00:00:00	

Strain Files

Strain Data for H1 | Strain Data for L1

Segments

Choose the output format below

Plot | JSON | ASCII

Display

☑ H1_BURST_CAT1	☐ L1_BURST_CAT1
☐ H1_BURST_CAT2	☐ L1_BURST_CAT2
☐ H1_BURST_CAT3	☐ L1_BURST_CAT3
☐ H1_CBC_CAT1	☐ L1_CBC_CAT1

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
  - Passes O3GK CBC checks for G1, K1
  - Times with no Continuous-Wave injections
- Timelines from the O3b run, 2019
  - Data available over the O3b run
  - Passes O3b Burst checks for H1, L1, V1
  - Passes O3b CBC checks for H1, L1, V1
  - Times with no Continuous-Wave injections
- Timelines from the O3a run, 2019
  - Data available over the O3a run
  - Passes O3a Burst checks for H1, L1, V1
  - Passes O3a CBC checks for H1, L1, V1

H1: Handford
L1: Livingston
V1: Virgo
G1: GEO600
K1: KAGRA

The GW Detector Network

4 km
indigo
~2025

By Alan J Weinstein

Download the bulk data from timeline

Timeline O1

From: 2015-09-12T00:00:00 (GPS=1126051217)

To: 2016-01-19T16:00:00 (GPS=1137254417)

Duration: 11203200 s

Strain Data for H1 | Strain Data for L1

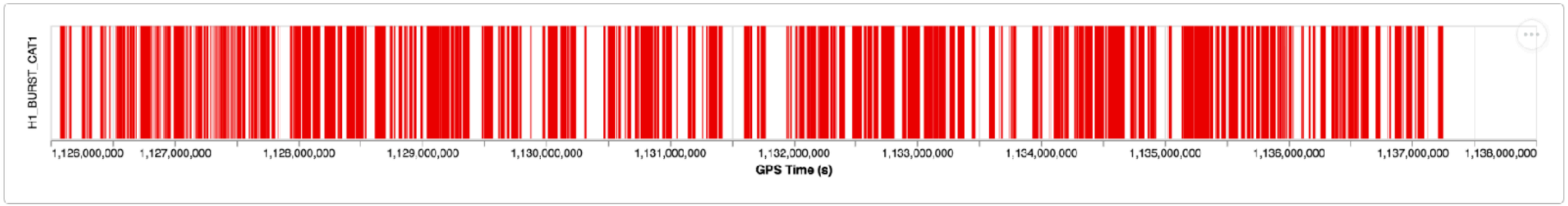
Timeline Stats

	Time Active	Duty Cycle	Segments
H1_BURST_CAT1	6626962 s	59.15%	655

Download Segments

JSON | ASCII

H1_BURST_CAT1



Download the bulk data with specific option

Observatory Data Sets

https://gwosc.org/data/

Please Read This First!

Click for data usage notes

The LIGO Laboratory's Data Management Plan describes the scope and timing of LIGO data releases.

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

Download the bulk data with specific option

Archive for O3GK_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.

O3GK_4KHZ_R1 start GPS:	1270281618	UTC: 2020-04-07T08:00:00
O3GK_4KHZ_R1 end GPS:	1271462418	UTC: 2020-04-21T00:00:00

Next choose your gravitational wave detector:

- (•) K1
- ( ) G1

To download the KAGRA data

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	2020-04-07T08:00:00	⇔	1270281618	OK
End Time	2020-04-21T00:00:00	⇔	1271462418	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

Download the bulk data with specific option

Dataset: O3GK_4KHZ_R1
GPS Time Interval: [1270281618, 1271462418]
Detector: K1

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
1270284288	2020-04-07T08:44:30	17.8 MB	HDF5	Frame	13.8
1270288384	2020-04-07T09:52:46	45.6 MB	HDF5	Frame	36.4
1270292480	2020-04-07T11:01:02	123.9 MB	HDF5	Frame	100.0
1270296576	2020-04-07T12:09:18	90.0 MB	HDF5	Frame	72.5
1270300672	2020-04-07T13:17:34	39.6 MB	HDF5	Frame	31.6
1270304768	2020-04-07T14:25:50	97.7 MB	HDF5	Frame	78.7
1270308864	2020-04-07T15:34:06	123.7 MB	HDF5	Frame	99.9
1270312960	2020-04-07T16:42:22	123.9 MB	HDF5	Frame	100.0
1270317056	2020-04-07T17:50:38	100.6 MB	HDF5	Frame	81.1
1270321152	2020-04-07T18:58:54	123.9 MB	HDF5	Frame	100.0
1270325248	2020-04-07T20:07:10	105.3 MB	HDF5	Frame	84.9
1270329344	2020-04-07T21:15:26	123.8 MB	HDF5	Frame	100.0
1270333440	2020-04-07T22:23:42	123.7 MB	HDF5	Frame	100.0
1270337536	2020-04-07T23:31:58	123.7 MB	HDF5	Frame	100.0
1270341632	2020-04-08T00:40:14	123.8 MB	HDF5	Frame	100.0
1270345728	2020-04-08T01:48:30	110.5 MB	HDF5	Frame	89.2
1270378496	2020-04-08T10:54:38	68.4 MB	HDF5	Frame	55.0

Data format and Main Channel to Store the Strain

- Data are made available both as **frame files (GWF)** and **HDF5 (HDF)**.

- The strain data are made available both at **16384 Hz** and **4096 Hz** sampling rates.

- For studies involving frequencies of around 1700 Hz or above, the 16384 Hz data should be used instead. Advanced LIGO and advanced Virgo data are not calibrated or valid below 10 Hz or above 5 kHz. In most searches for astrophysical sources, data below **20 Hz** are not used because the noise is too high.

- "**C00**" to refer to data before noise subtraction, or the string "**CLN**" to indicate data after noise subtraction. The v2 (**C02**) data files were posted in October of 2016. They differ from v1 (**C01**) in that they use an updated version of the LIGO calibration. The v1 4096 Hz files included a minor time-offset, roughly 1 ms, introduced during the down-sampling process. This has been corrected in the v2 files.

- The channel names/frame types used to collect O3 data from the original files are:
  - ✦"H1:DCS-CALIB_STRAIN_CLEAN-SUB60HZ_C01"/"H1_HOFT_CLEAN_SUB60HZ_C01" for H1,
  - ✦"L1:DCS-CALIB_STRAIN_CLEAN-SUB60HZ_C01"/"L1_HOFT_CLEAN_SUB60HZ_C01" for L1 and
  - ✦"V1:Hrec_hoft_16384Hz"/"V1Online" for V1.

- The channel names/frame types used to collect O3GK data from the original files are:
  - ✦"G1:DER_DATA_HD_CLEAN"/"G1_RDS_C02_L3" for G1 and
  - ✦"K1:DAC-STRAIN_C20"/"K1_HOFT_C20" for K1.

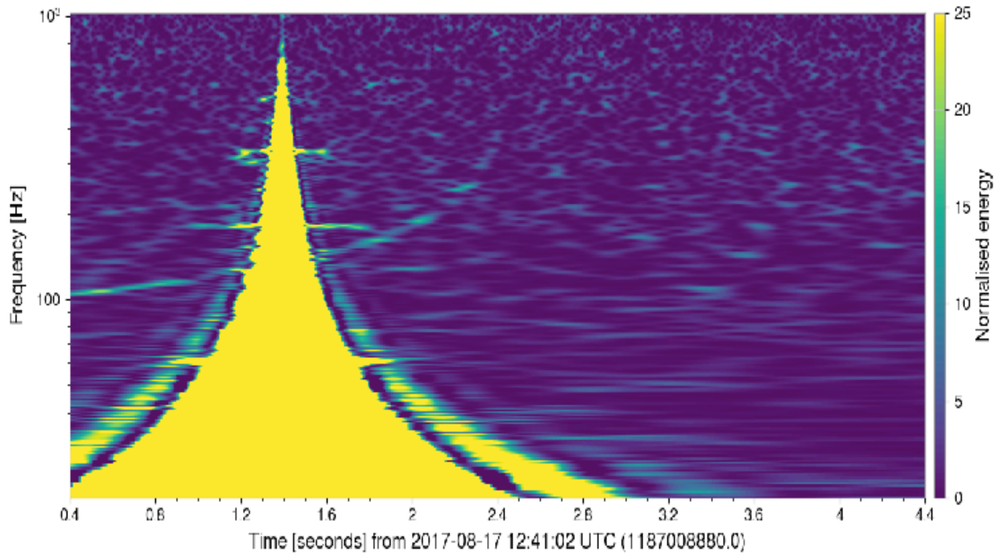
Auxiliary channels and Glitches

★Glitches (also known as transients triggers) : the frequency of one signal increase abruptly in a short duration. Most of them are from the instrumental artifacts to add excess noise on the stain data.
Common source of glitches:

- Scattered laser light
- Thunder claps
- Earthquakes

★A large number of sensors are used to record the state of the LIGO instruments and their environment. This data release contains sensor data recorded in around 500 channels at each LIGO site.

E.g., GW 170817



Channel Name	Desired Sample Rate [Hz]	notes	calibration	units	cal ref	Total (MB / s)	0.58
IMC-PWR_IN_OUT_DQ	512	Total laser power input to the IMC	1.0E+00	W		Total (GB / hr)	2.10
IMC-MC2_TRANS_SUM_OUT_DQ	512	power transmitted by the IMC		mW			
LSC-POP_A_LF_OUT_DQ	512	power in the Power Recycling Cavity		uW		Total data pts per sec	145811
ASC-X_TR_A_NSUM_OUT_DQ	512	Power transmitted through ETMX		W			
ASC-X_TR_B_NSUM_OUT_DQ	512	Power transmitted through ETMX		W			
ASC-Y_TR_A_NSUM_OUT_DQ	512	Power transmitted through ETMY		W			
ASC-Y_TR_B_NSUM_OUT_DQ	512	Power transmitted through ETMY		W			
ASC-AS_A_DC_NSUM_OUT_DQ	512	Power transmitted to the anti-symmetric port		W			
LSC-POPAIR_B_RF18_I_ERR_DQ	512	RF 9 MHz sideband buildup in PRC		W			
LSC-POPAIR_B_RF18_Q_ERR_DQ	512	RF 9 MHz sideband buildup in PRC (Q-phase, should be 0)		W			
LSC-POPAIR_B_RF90_I_ERR_DQ	512	RF 45 MHz sideband buildup in PRC		W			
LSC-POPAIR_B_RF90_Q_ERR_DQ	512	RF 45 MHz sideband buildup in PRC (Q-phase, should be 0)		W			
PSL-ENV_ANTERM_TEMP_DEGC	1	laser anteroom temperature	1.0E+00	C			

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K1:
main channel

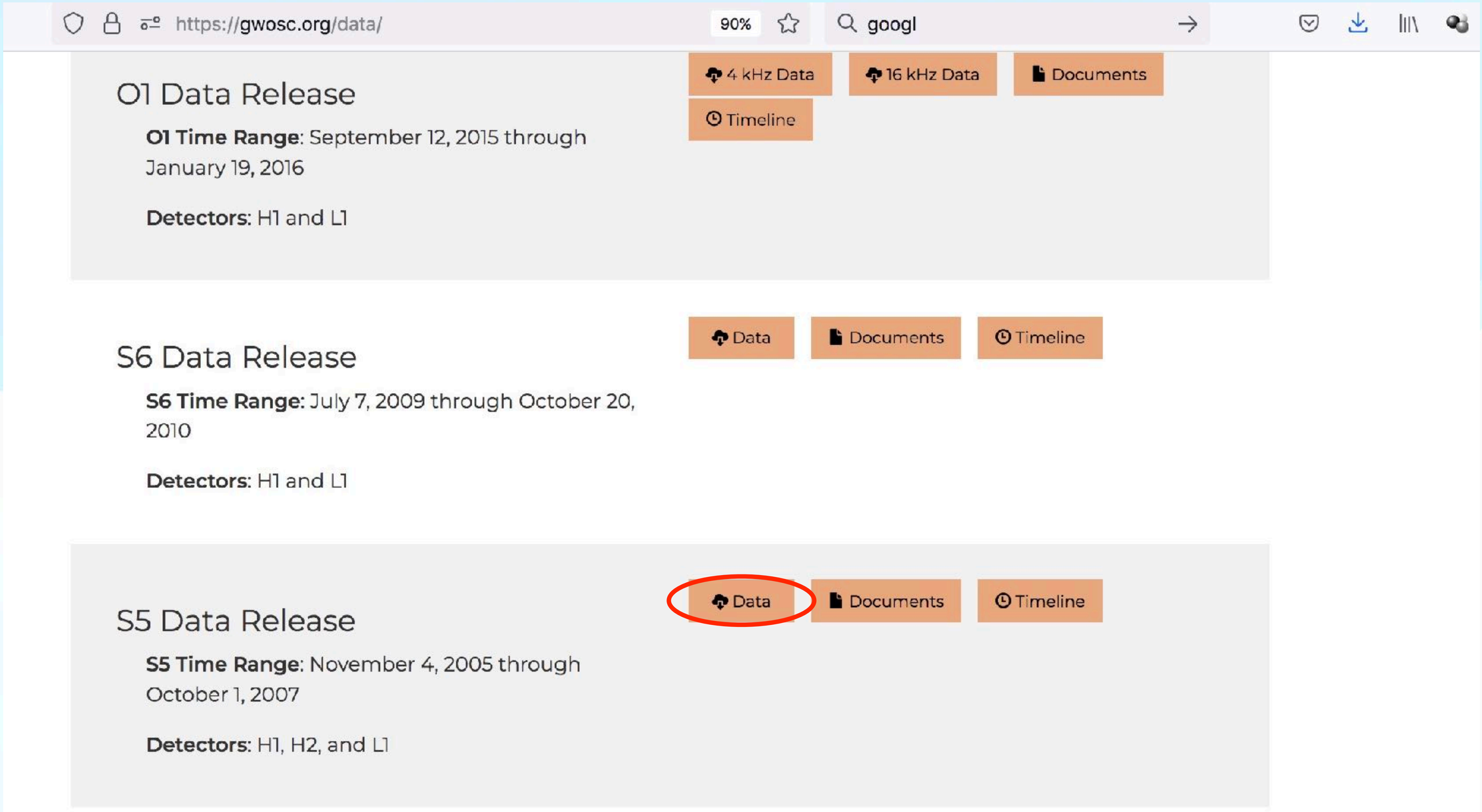
K-K1_HOFT_C20-1270287328-32.gwf	K-K1_HOFT_C20-1270293472-32.gwf
K-K1_HOFT_C20-1270287360-32.gwf	K-K1_HOFT_C20-1270293504-32.gwf
K-K1_HOFT_C20-1270287392-32.gwf	K-K1_HOFT_C20-1270293536-32.gwf
K-K1_HOFT_C20-1270287424-32.gwf	K-K1_HOFT_C20-1270293568-32.gwf
K-K1_HOFT_C20-1270287456-32.gwf	K-K1_HOFT_C20-1270293600-32.gwf

K1:
Full channel

K-K1_C-1230024768-32.gwf*	K-K1_C-1230049856-32.gwf*
K-K1_C-1230024800-32.gwf*	K-K1_C-1230049888-32.gwf*
K-K1_C-1230024832-32.gwf*	K-K1_C-1230049920-32.gwf*
K-K1_C-1230024864-32.gwf*	K-K1_C-1230049952-32.gwf*
K-K1_C-1230024896-32.gwf*	K-K1_C-1230049984-32.gwf*
K-K1_C-1230024928-32.gwf*	K-K1_C-1230050016-32.gwf*

Channel Name	Desired Sample Rate [Hz]	notes	calibration	units	cal ref	Total (MB / s)	0.58
IMC-PWR_IN_OUT_DQ	512	Total laser power input to the IMC	1.0E+00	W		Total (GB / hr)	2.10
IMC-MC2_TRANS_SUM_OUT_DQ	512	power transmitted by the IMC		mW			
LSC-POP_A_LF_OUT_DQ	512	power in the Power Recycling Cavity		uW		Total data pts per sec	145811
ASC-X_TR_A_NSUM_OUT_DQ	512	Power transmitted through ETMX		W			
ASC-X_TR_B_NSUM_OUT_DQ	512	Power transmitted through ETMX		W			
ASC-Y_TR_A_NSUM_OUT_DQ	512	Power transmitted through ETMY		W			
ASC-Y_TR_B_NSUM_OUT_DQ	512	Power transmitted through ETMY		W			
ASC-AS_A_DC_NSUM_OUT_DQ	512	Power transmitted to the anti-symmetric port		W			
LSC-POPAIR_B_RF18_I_ERR_DQ	512	RF 9 MHz sideband buildup in PRC		W			
LSC-POPAIR_B_RF18_Q_ERR_DQ	512	RF 9 MHz sideband buildup in PRC (Q-phase, should be 0)		W			
LSC-POPAIR_B_RF90_I_ERR_DQ	512	RF 45 MHz sideband buildup in PRC		W			
LSC-POPAIR_B_RF90_Q_ERR_DQ	512	RF 45 MHz sideband buildup in PRC (Q-phase, should be 0)		W			
PSL-ENV_ANTERM_TEMP_DEGC	1	laser anteroom temperature	1.0E+00	C			

Download the S5 data with specific option



Download the S5 data with specific option

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.

S5 start GPS:	815155213	UTC: 2005-11-04T16:00:00
S5 end GPS:	875232014	UTC: 2007-10-01T00:00:00

Next choose your gravitational wave detector:

- ○ H2
- ◉ 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	2005-11-04T16:00:00	⇔	815155213	OK
End Time	2007-11-05T00:00:00	⇔	878256014	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

Download the S5 data with specific option

Dataset: S5
GPS Time Interval: [815155213, 878256014]
Detector: H1

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
815398912	2005-11-07T11:41:39	3.3 MB	HDF5	Frame	2.0
815403008	2005-11-07T12:49:55	4.7 MB	HDF5	Frame	3.1
815407104	2005-11-07T13:58:11	11.1 MB	HDF5	Frame	8.4
815411200	2005-11-07T15:06:27	90.7 MB	HDF5	Frame	73.7
815493120	2005-11-08T13:51:47	93.2 MB	HDF5	Frame	75.7
815497216	2005-11-08T15:00:03	25.6 MB	HDF5	Frame	20.3
815562752	2005-11-09T09:12:19	92.3 MB	HDF5	Frame	75.0
815566848	2005-11-09T10:20:35	122.8 MB	HDF5	Frame	100.0
815570944	2005-11-09T11:28:51	88.2 MB	HDF5	Frame	71.7
815575040	2005-11-09T12:37:07	122.8 MB	HDF5	Frame	100.0
815579136	2005-11-09T13:45:23	56.1 MB	HDF5	Frame	45.3
815583232	2005-11-09T14:53:39	87.7 MB	HDF5	Frame	71.2

Download the S5 data with specific option