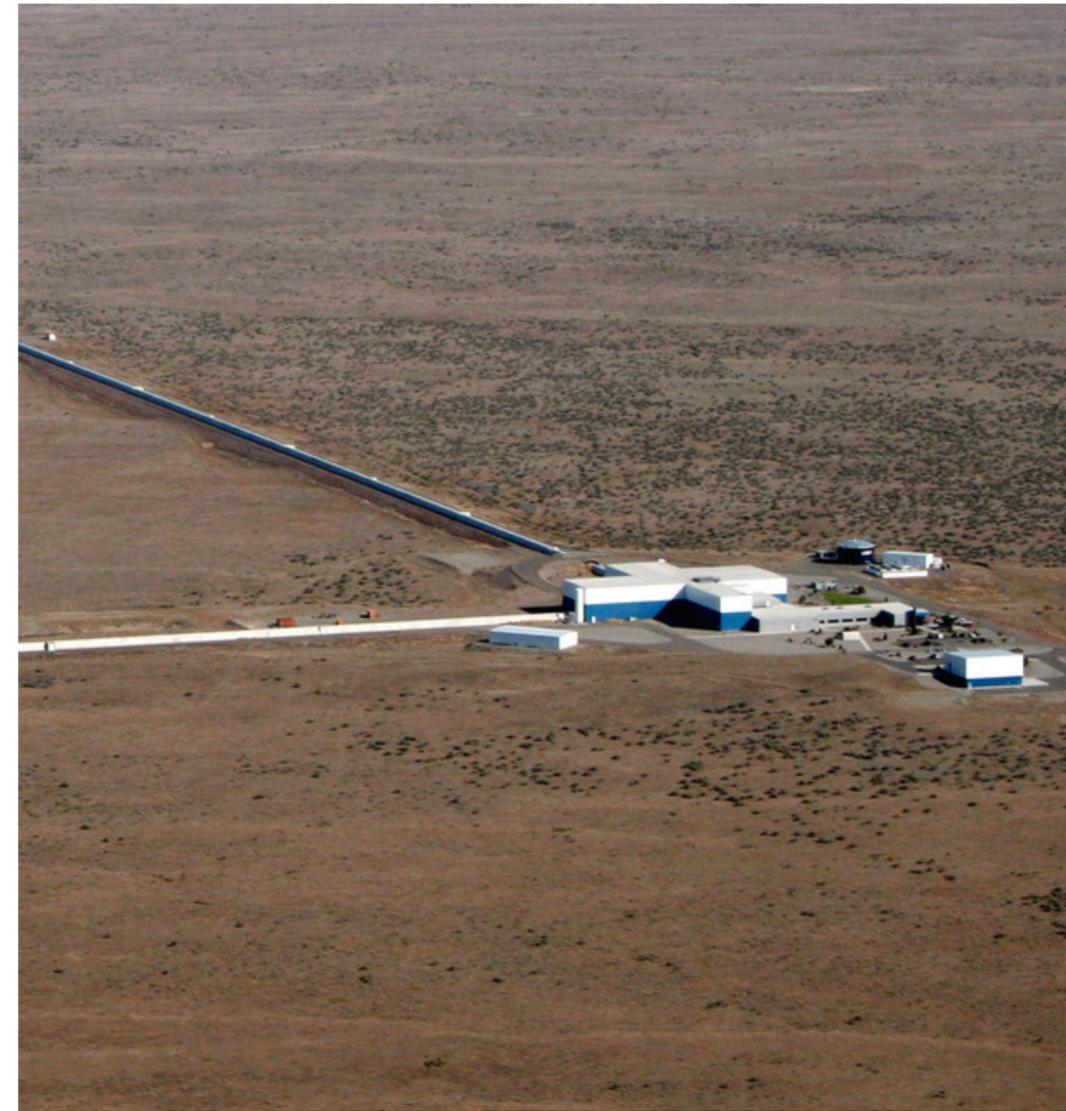


LIGO-Virgo-KAGRA Catalogs

Jonah Kanner
LIGO Lab, Caltech

June 12, 2023 - LIGO-G2301124



What's a catalog ??

What's a catalog ??

A list of astronomical sources in a data set.

What's a catalog ??

A list of astronomical sources in a data set.

- * In multiple formats?
- * With which parameters?
- * With additional data products?
- * With multiple pipelines?
- * Machine readable or human readable?
- * With tools for further analysis?
- * Is it queryable?

User stories

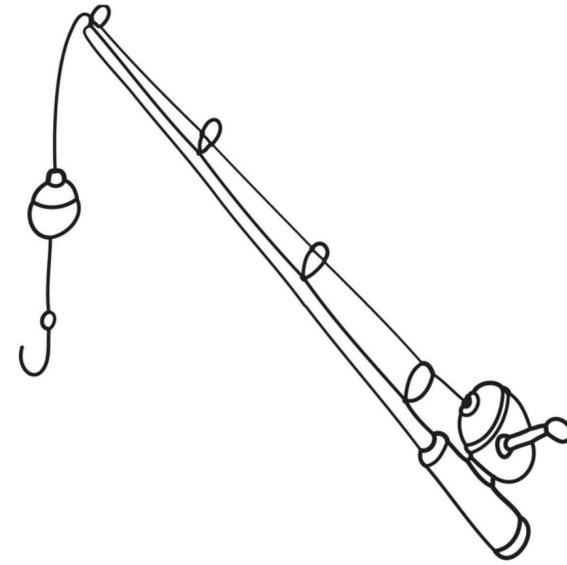
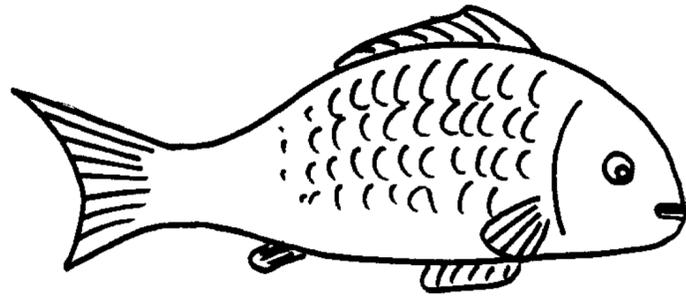
A list of what we think* people will want to do.

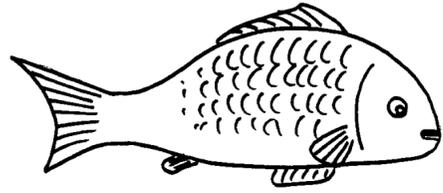
User stories

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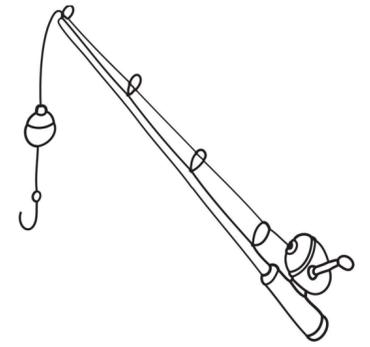
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- I want to download the maximum likelihood waveform for event X using waveform family Y projected onto detector Z

Products Vs. Services



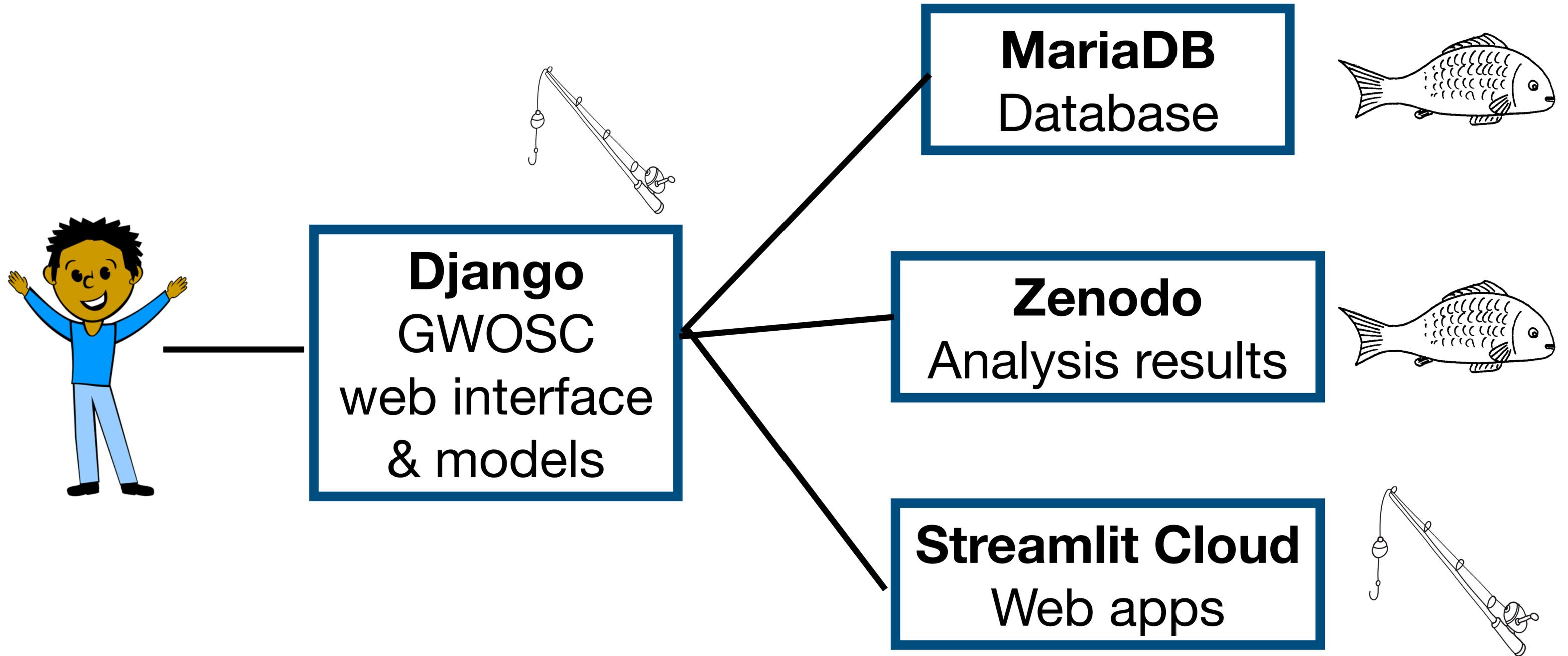


Products Vs. Services



Saved to Disk	Created at run time
Source product	Derived from source products
Static	Customizable
Lasts for a long time	Can change or disappear with time
Good for finite / small set of results	Good for large / infinite set of results

Architecture

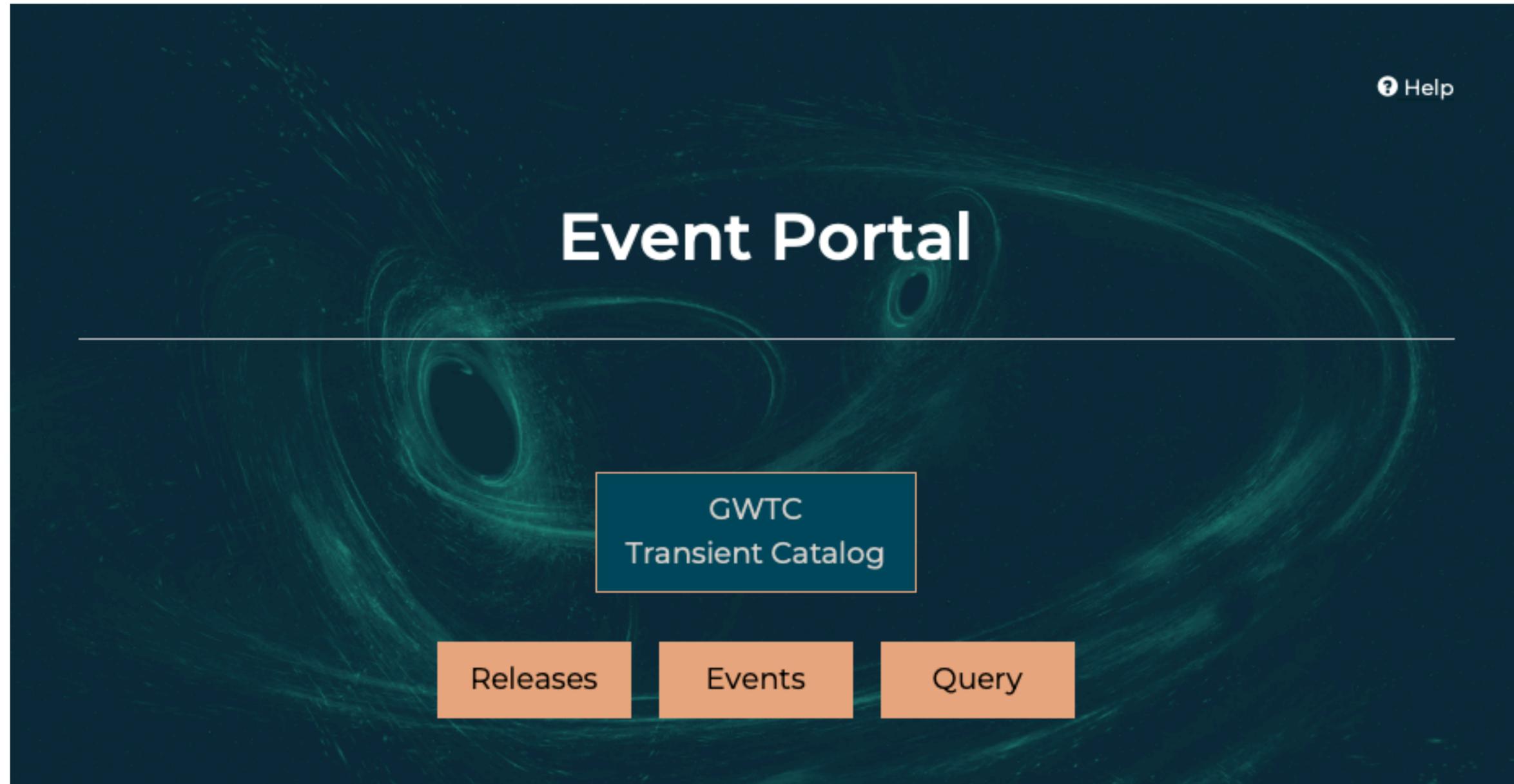


Data Products

- Lists of events
- Sets of credible intervals
- Posterior samples / Analysis products
- Strain data

IGWN Catalogs

Event Portal at gwosc.org





Gravitational Wave Open Science Center



Data ▾

Software ▾

Online Tools ▾

Learning Resources ▾

About GWOSC ▾

 Help

Event Portal

GWTC Transient Catalog

Releases

Events

Query

IGWN Catalogs

Event Portal

List of Events

Data Product

Name	Version	Release	GPS	Mass 1 (M_{\odot})	Mass 2 (M_{\odot})	Network SNR	Distance (Mpc)	χ_{eff}	Total Mass (M_{\odot})	Chirp M
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}	$0.24^{+0.45}_{-0.51}$	55^{+37}_{-27}	$15.5^{+15.7}_{-3.7}$
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}	$0.13^{+0.27}_{-0.10}$	$21.2^{+7.2}_{-2.0}$	$8.75^{+0.6}_{-0.5}$
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}	$-0.02^{+0.16}_{-0.20}$	$61.9^{+5.3}_{-4.2}$	$26.6^{+2.4}_{-2.0}$
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}	$0.65^{+0.17}_{-0.21}$	$50.6^{+10.9}_{-8.5}$	$19.0^{+4.8}_{-2.8}$
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}	$0.32^{+0.28}_{-0.46}$	$43.9^{+11.8}_{-7.5}$	$17.5^{+3.5}_{-3.0}$
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}	$0.01^{+0.25}_{-0.26}$	$57.8^{+9.6}_{-6.9}$	$23.4^{+4.7}_{-3.0}$
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}	$-0.12^{+0.17}_{-0.28}$	$33.5^{+3.6}_{-3.0}$	$14.2^{+1.5}_{-1.4}$
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}	$0.10^{+0.15}_{-0.15}$	$72.2^{+7.2}_{-5.1}$	$31.1^{+3.2}_{-2.6}$
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}	$-0.07^{+0.27}_{-0.33}$	67^{+17}_{-12}	$28.2^{+7.3}_{-5.1}$
GW200220_061928	v1	GWTC-3-confident	1266214786.7	87^{+40}_{-23}	61^{+26}_{-25}	$7.2^{+0.4}_{-0.7}$	6000^{+4800}_{-3100}	$0.06^{+0.40}_{-0.38}$	148^{+55}_{-33}	62^{+23}_{-15}

IGWN Catalogs

Event Portal

List of Events

Data Product

? Query Events

i Event Name:

i Release:
GWTC-1-confident
O1_O2-Preliminary
O3_Discovery_Papers

i Mass 1 Range:	<input type="text" value="0"/>	<input type="text" value="∞"/>	i Mass 2 Range:	<input type="text" value="0"/>	<input type="text" value="∞"/>
i Total Mass Range:	<input type="text" value="0"/>	<input type="text" value="∞"/>	i Final Mass Range:	<input type="text" value="0"/>	<input type="text" value="∞"/>
i Chirp Mass Range:	<input type="text" value="0"/>	<input type="text" value="∞"/>	i Detector Frame Chirp Mass Range:	<input type="text" value="0"/>	<input type="text" value="∞"/>
i Distance (Mpc) Range:	<input type="text" value="0"/>	<input type="text" value="∞"/>	i Redshift Range:	<input type="text" value="0"/>	<input type="text" value="∞"/>
i Network SNR Range:	<input type="text" value="0"/>	<input type="text" value="∞"/>	i χ_{eff} Range:	<input type="text" value="-1"/>	<input type="text" value="1"/>

IGWN Catalogs

Event Portal

List of Events
Data Product

HTML for humans and
JSON API for scripting

Browse or query

90% credible intervals
for key parameters

IGWN Catalogs

Event Portal

GW200129_065458

Single Event Data Product

Documentation

Release: [GWTC-3-confident](#)

Event UID: [GW200129_065458-v1](#)

Names: [GW200129_065458](#)

GPS: [1264316116.4](#)

UTC Time: [2020-01-29 06:54](#)

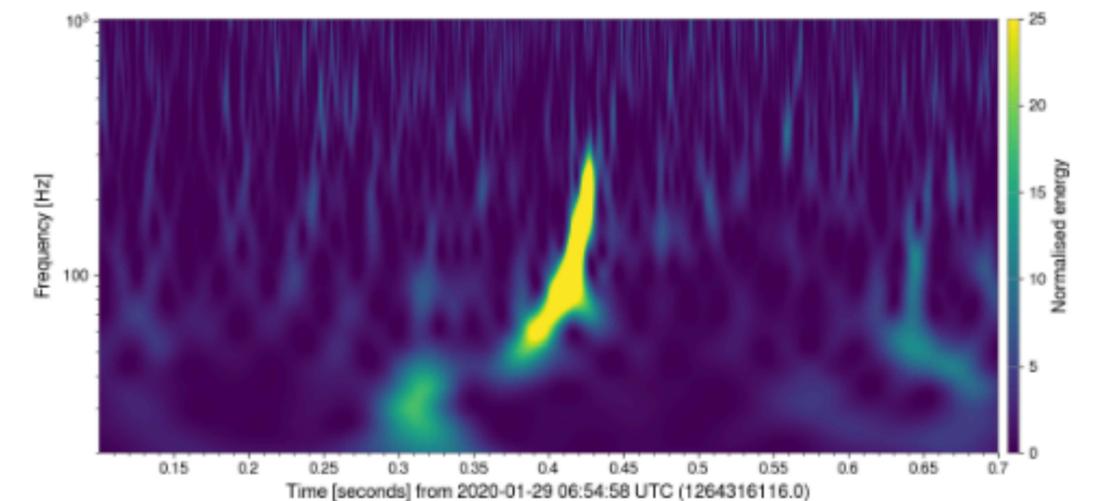
GraceDB: [S200129m](#)

GCN: [Notices · Circulars](#)

Timeline: [Query for segments](#)

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

H1 strain



32sec · 16KHz: [GWF](#) [HDF](#) [TXT](#)

32sec · 4KHz: [GWF](#) [HDF](#) [TXT](#)

4096sec · 16KHz: [GWF](#) [HDF](#) [TXT](#)

4096sec · 4KHz: [GWF](#) [HDF](#) [TXT](#)

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]

IGWN Catalogs

Event Portal

Key parameter values

Meta-data

Documentation

Strain Data

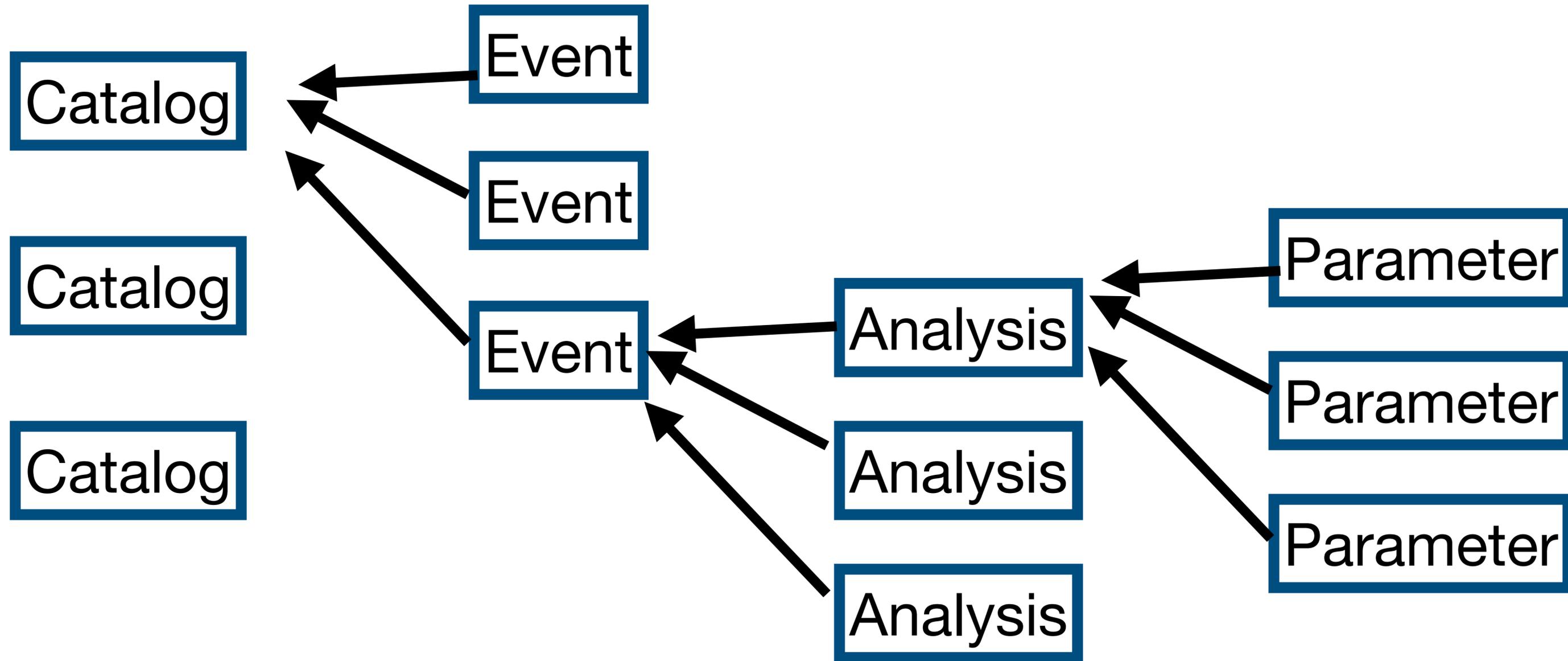
Segment lists / DQ

Single Event Data Product

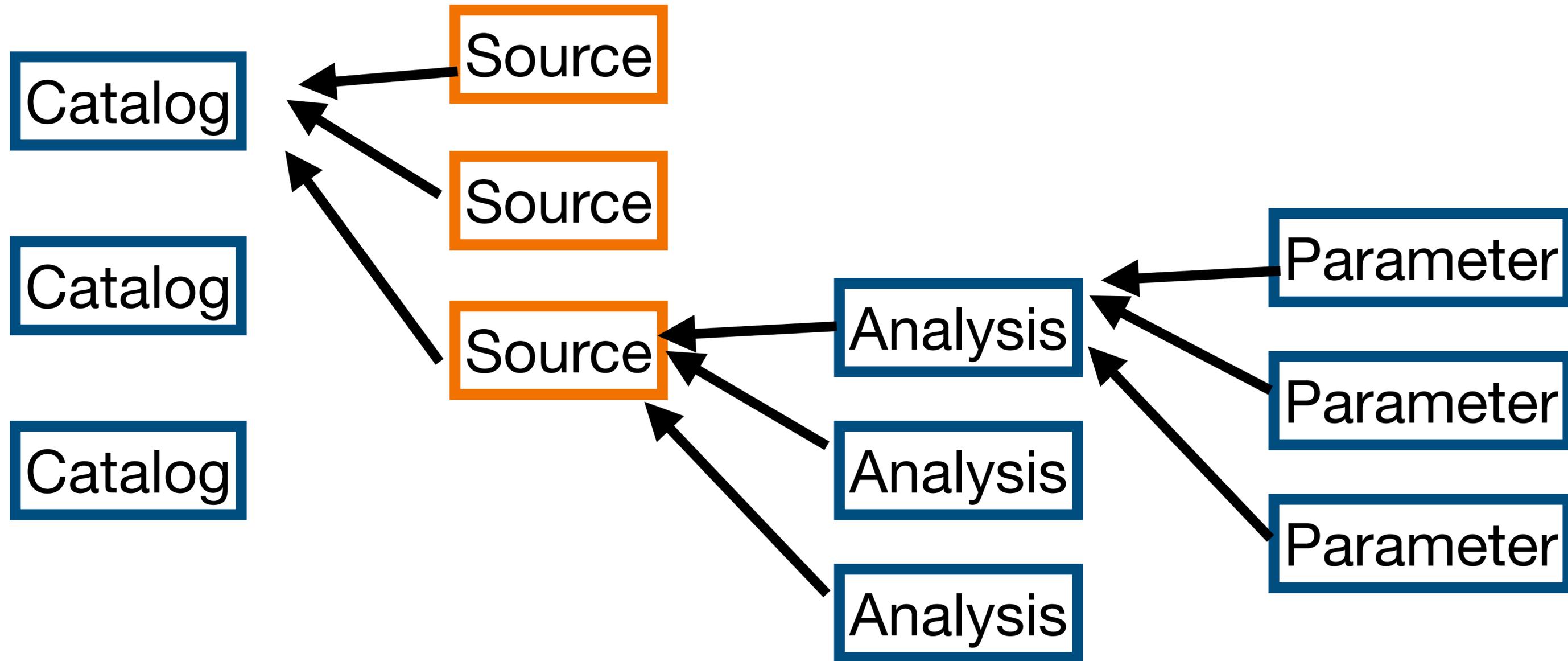
Analysis Results:

- Multiple Pipelines
- Posterior Samples
- Skymaps
- Glitch Models
- Trigger Information

Event Portal Database



Maybe similar for LISA?



Flexibility vs. Simplicity

Design Trade-offs

- **Want to support multiple pipelines AND we want to be able to tell users the mass, spin, etc. of a system**
 - Our solution is to have multiple pipelines for each event, and if needed, pick a “default” set of results for display
- **Want to allow any parameter (equation of state, non-GR, etc.) AND have a predictable set of parameters to display and query (mass, spin, etc)**
 - Our solution is to allow any parameter, and provide a list of “expected” parameters for display and query

Services

- **Process strain data to create:**
 - Plots
 - Strain in multiple formats
 - Processed / whitened / “cleaned” strain data
- **Process posterior samples to create:**
 - Best-fit waveforms
 - Posterior distribution plots
 - Skymaps

Service: Data Quickview

<https://gw-quickview.streamlit.app/>

- I want to make plots of the whitened strain data near event X with duration Y seconds, after applying a band-pass filter from frequencies 40 to 450 Hz.
- I want to make spectrograms of GPS time X with plot duration 6 seconds and Q-range (5-15).
- I want to download strain data into a CSV or text file
- I want to hear an audio file of the data

Service: Data Quickview

<https://gw-quickview.streamlit.app/>

Select Data Time and Detector

How do you want to find data?

By event name ▼

Select Event

GW150914 ▼

Detector

H1 ▼

Full sample rate data

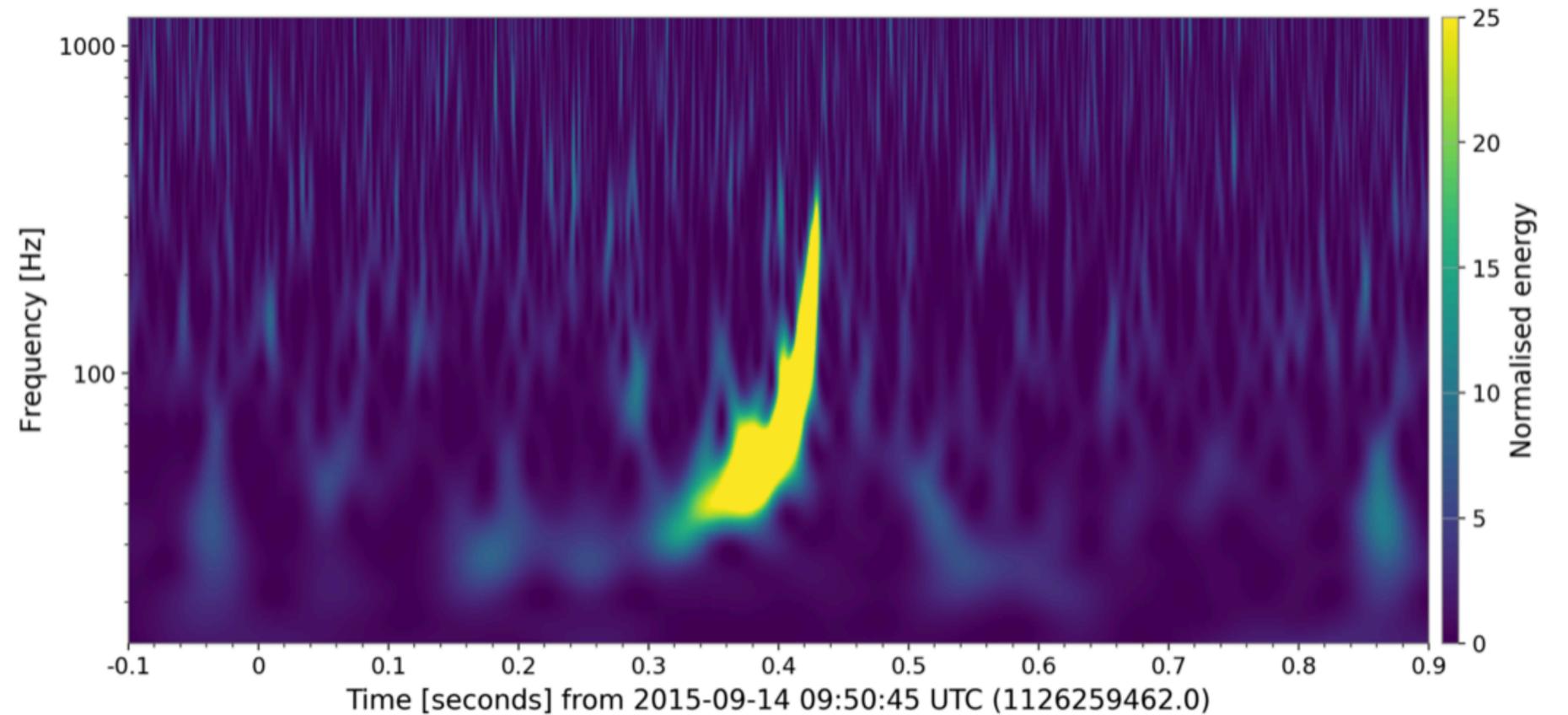
Set Plot Parameters

Time Range (seconds)

1.00

0.10 8.00

Q-transform



See notes ▼

About this app

Select Data Time and Detector

How do you want to find data?

By event name

Select Event

GW151012

Detector

H1

Full sample rate data

Set Plot Parameters

Time Range (seconds)

0.44

Gravitational Wave Quickview

- Use the menu at left to select data and set plot parameters
- Your plots will appear below

GW151012

GPS: 1128678900.4

Mass 1: 23.2 M_⊙

Mass 2: 13.6 M_⊙

Network SNR: 10

Event page: <https://gw-osc.org/eventapi/html/event/GW151012>

Loading data...done!

Service: PE Viewer

<https://peviewer.igwn.org>

- I want to make 2-D posterior plots for parameters X & Y, for event Z.
- I want to plot skymaps for each waveform model
- I want to download the maximum likelihood waveform for event X using waveform family Y projected onto detector Z



Select events

Event 1

GW150914



Event 2

GW190521



Event 3

None

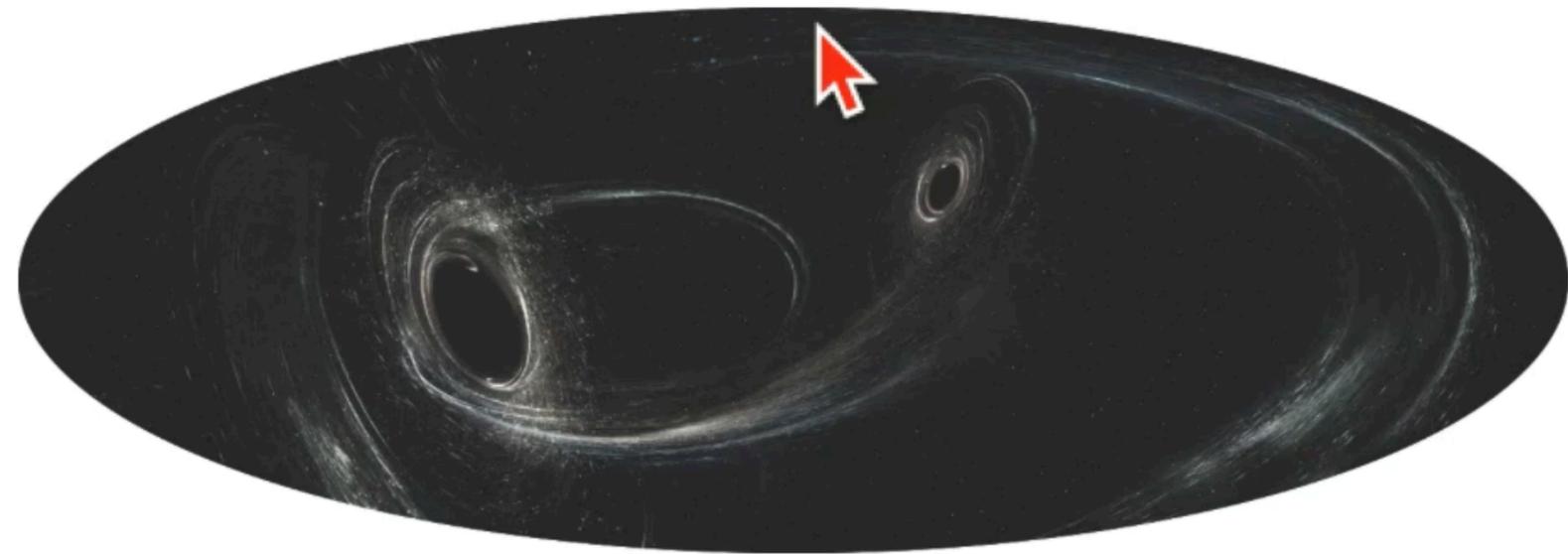


Update data



PE Viewer

Make plots of waveforms, source parameters, and skymaps for gravitational-wave events.



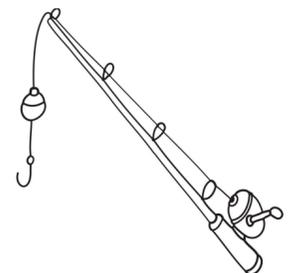
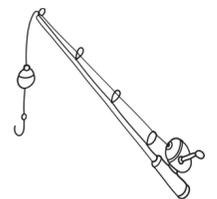
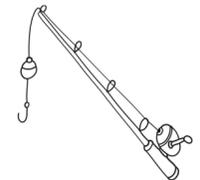
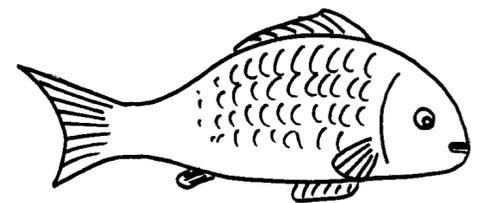
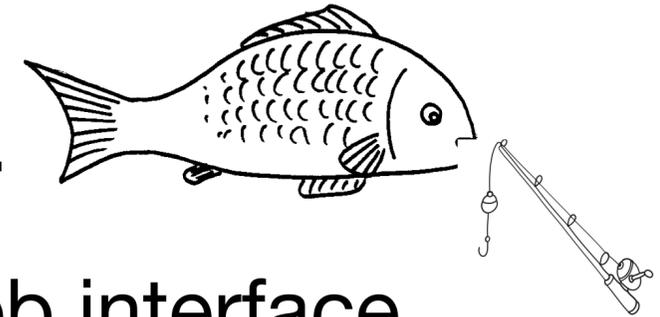
[About](#) [2-D Plots](#) [Skymaps](#) [All Parameters](#) **[Waveform](#)** [Config](#)

Making waveform for Event 1: GW150914

User stories

A list of what we think people will want to do.**

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Designing a Catalog

- Make a list of user stories.
- Which should be data products?
- Which should be services?
- Design / prototype individual pieces
- Repeat

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