LIGO-Virgo-KAGRA Catalogs

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What’s a catalog ??

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A list of astronomical sources in a data set.

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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.

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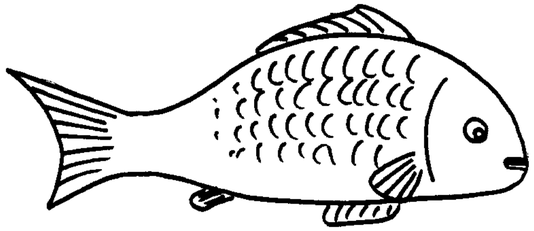
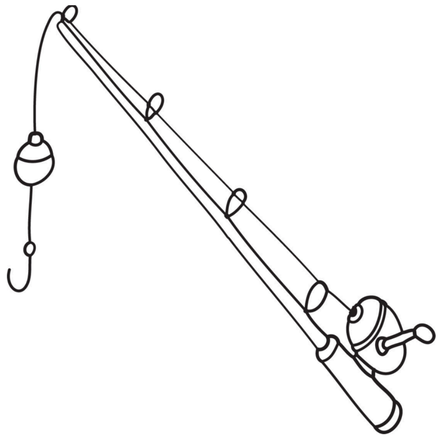
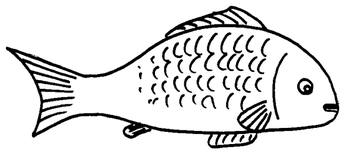
- I want to make 2-D posterior plots for parameters X & Y, for event Z.
- I want to download the filtered strain data into an excel spreadsheet for event X.
- I want to download the maximum likelihood waveform for event X using waveform family Y projected onto detector Z

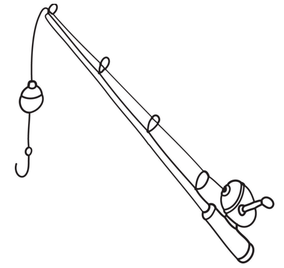
Products Vs. Services





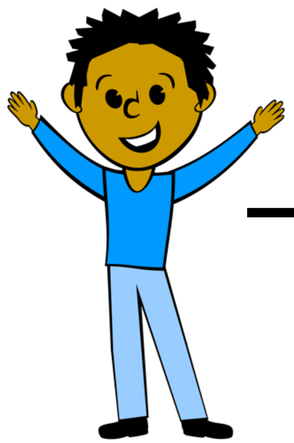


Products Vs. Services

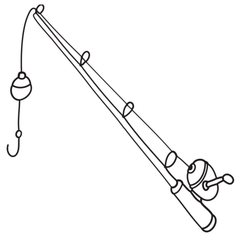


Saved to Disk	Created at run time
Source product	Derived from source products
Static	Customizable
Lasts for a long time	Can change or disappear with time
Good for finite / small set of results	Good for large / infinite set of results

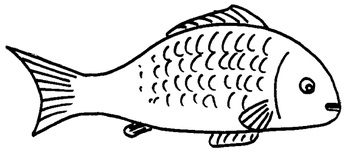
Architecture



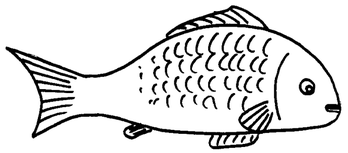
Django
GWOSC
web interface
& models



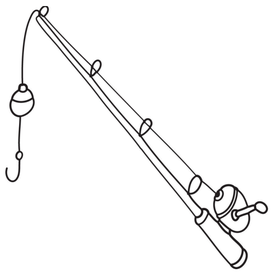
MariaDB
Database



Zenodo
Analysis results



Streamlit Cloud
Web apps

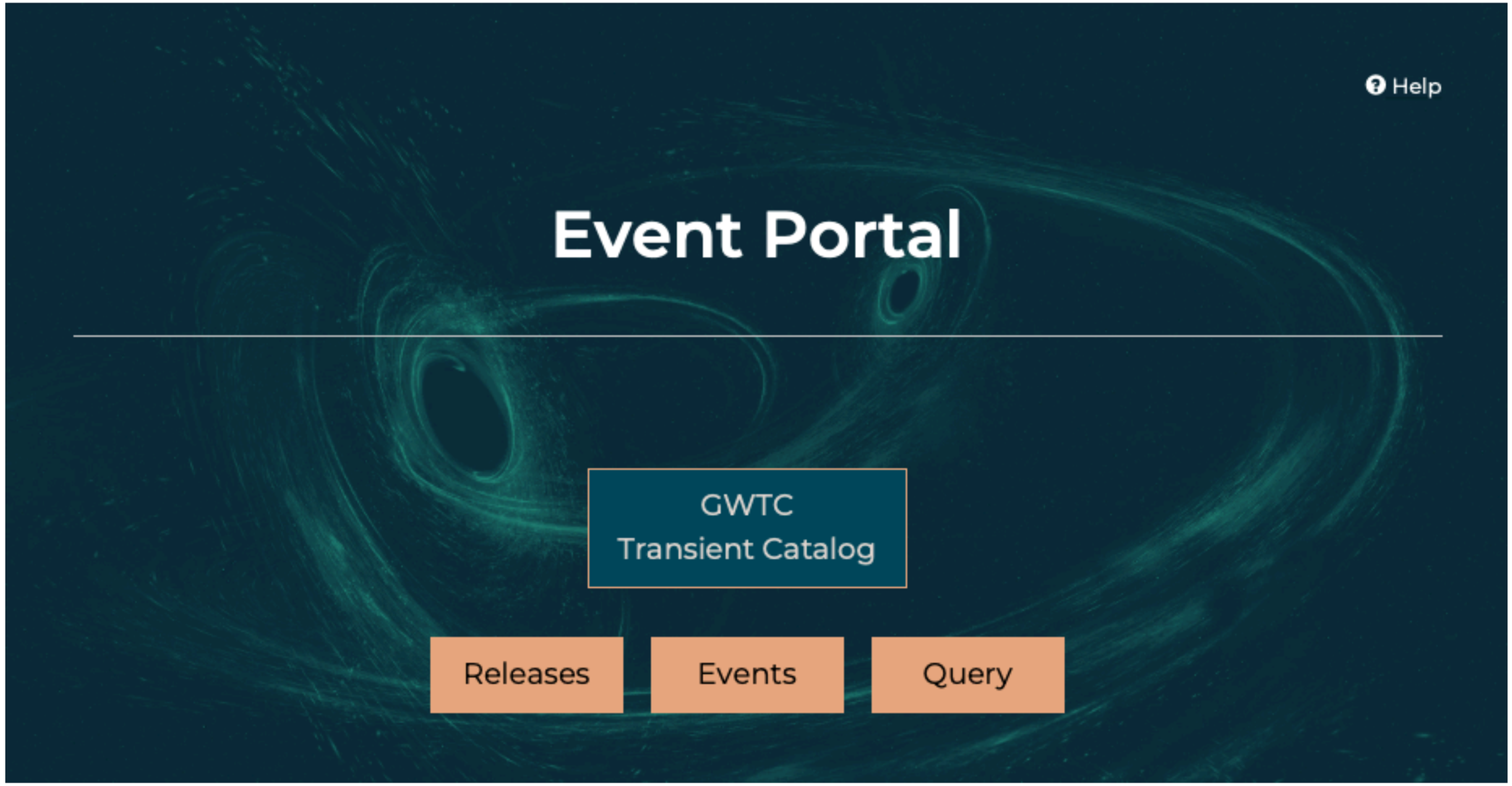


Data Products

- 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

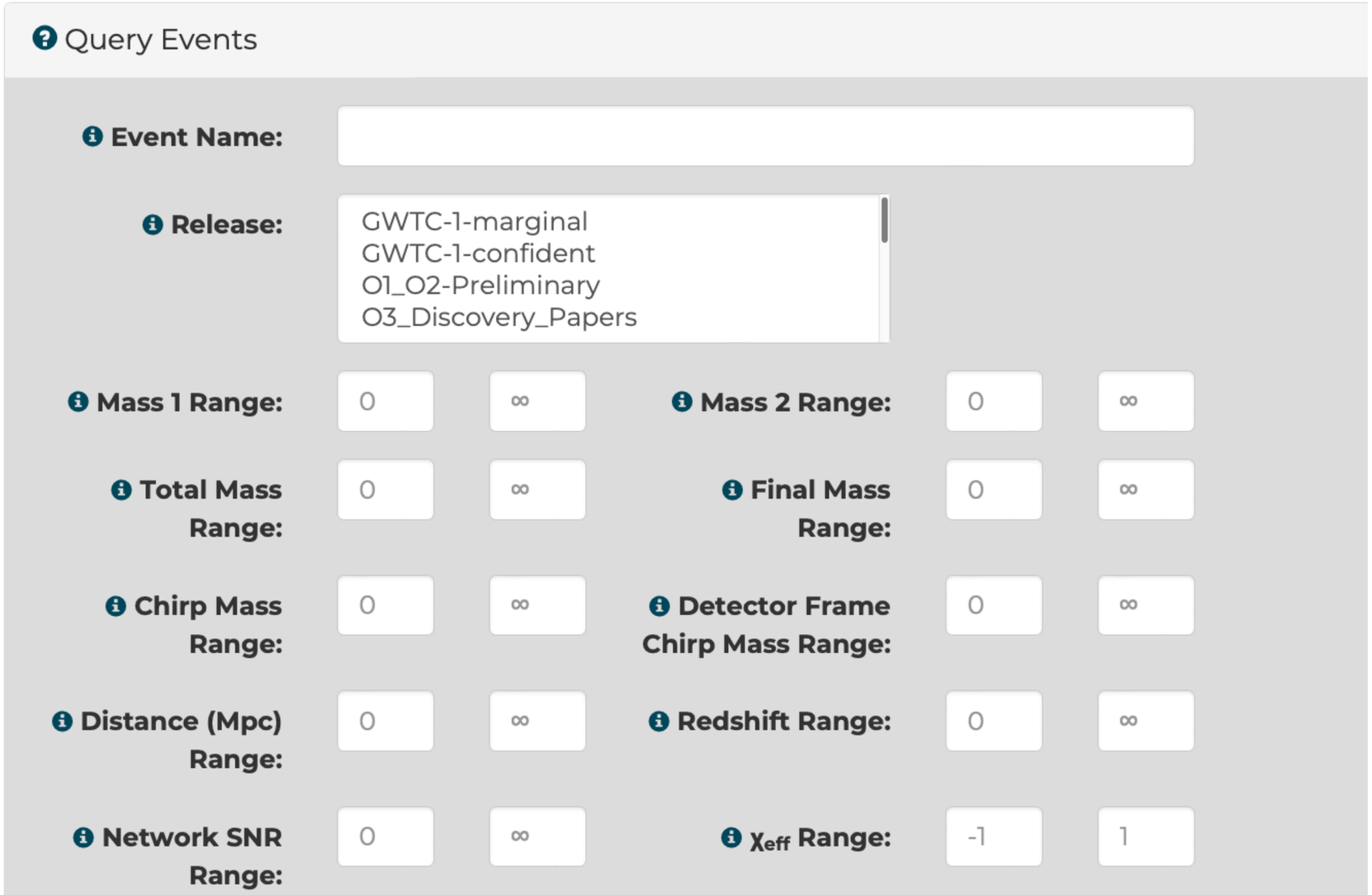
List of Events Data Product

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



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

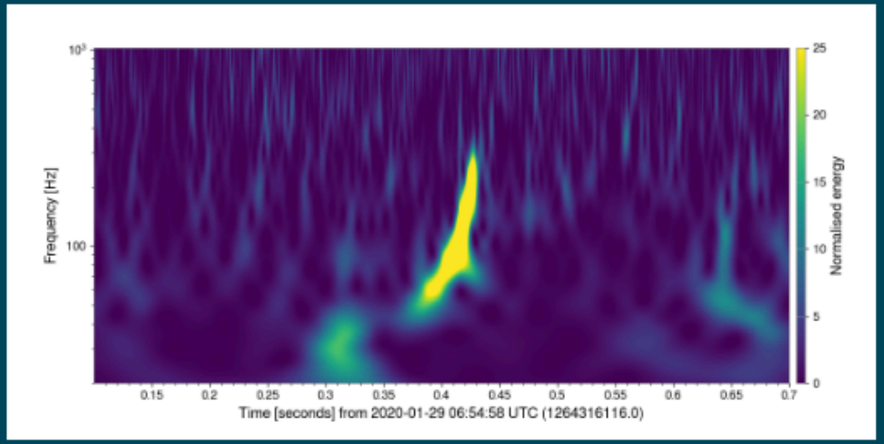
Data sourced from frame channels.

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]

H1 strain



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

IGWN Catalogs

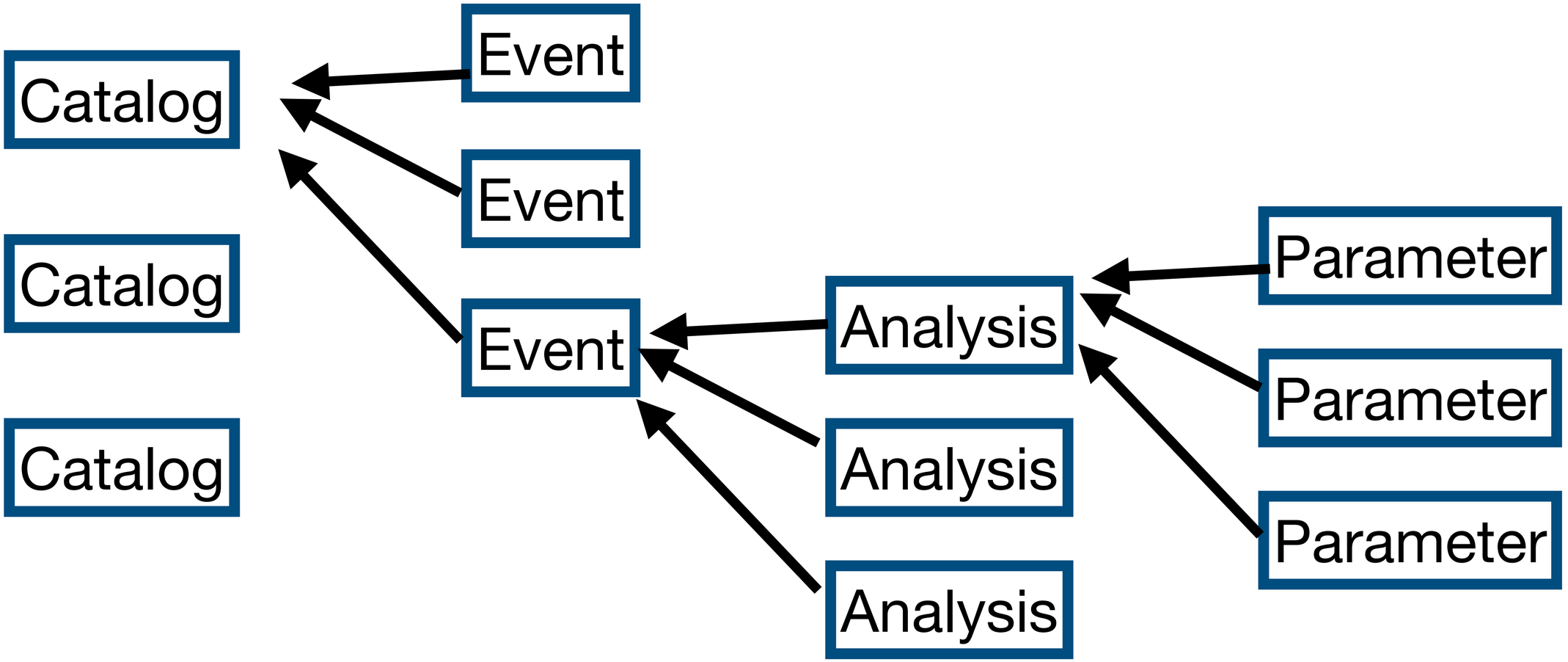
Event Portal

Single Event
Data Product

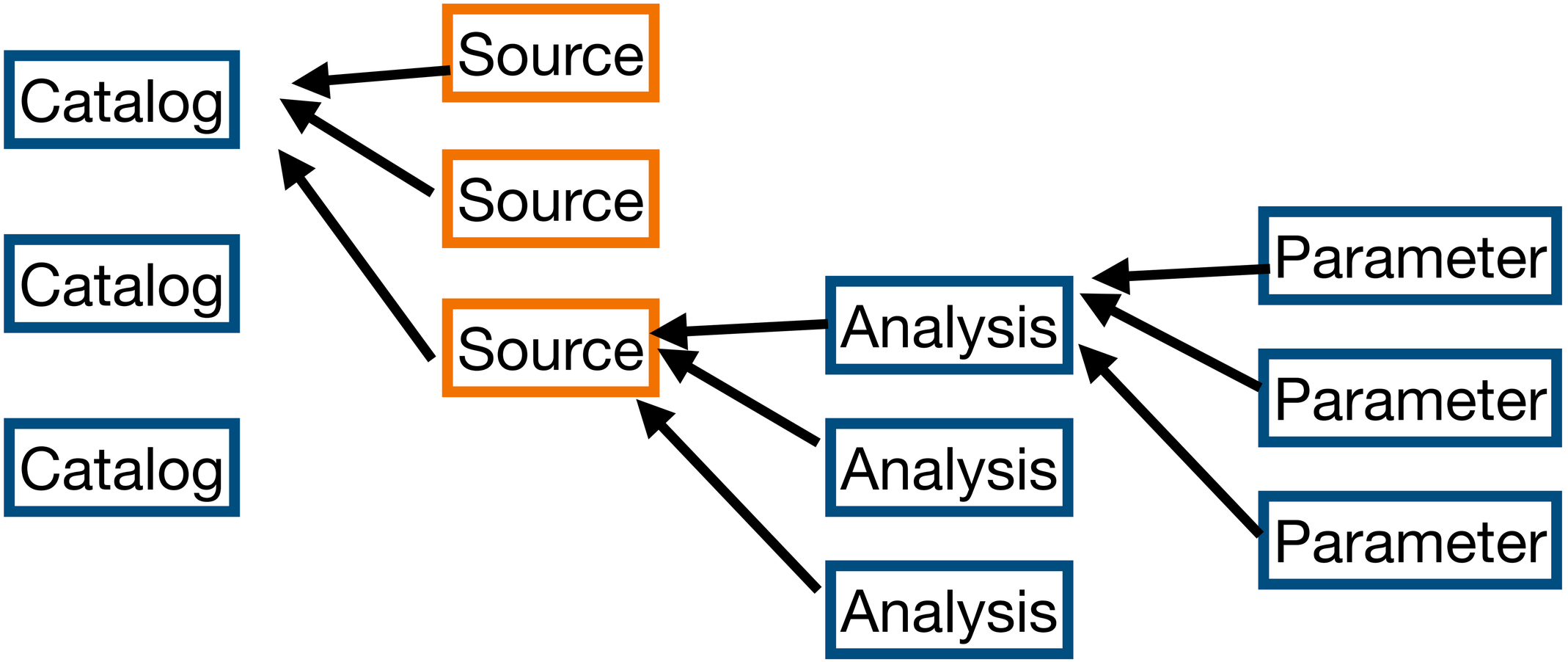
Key parameter values
Meta-data
Documentation
Strain Data
Segment lists / DQ

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

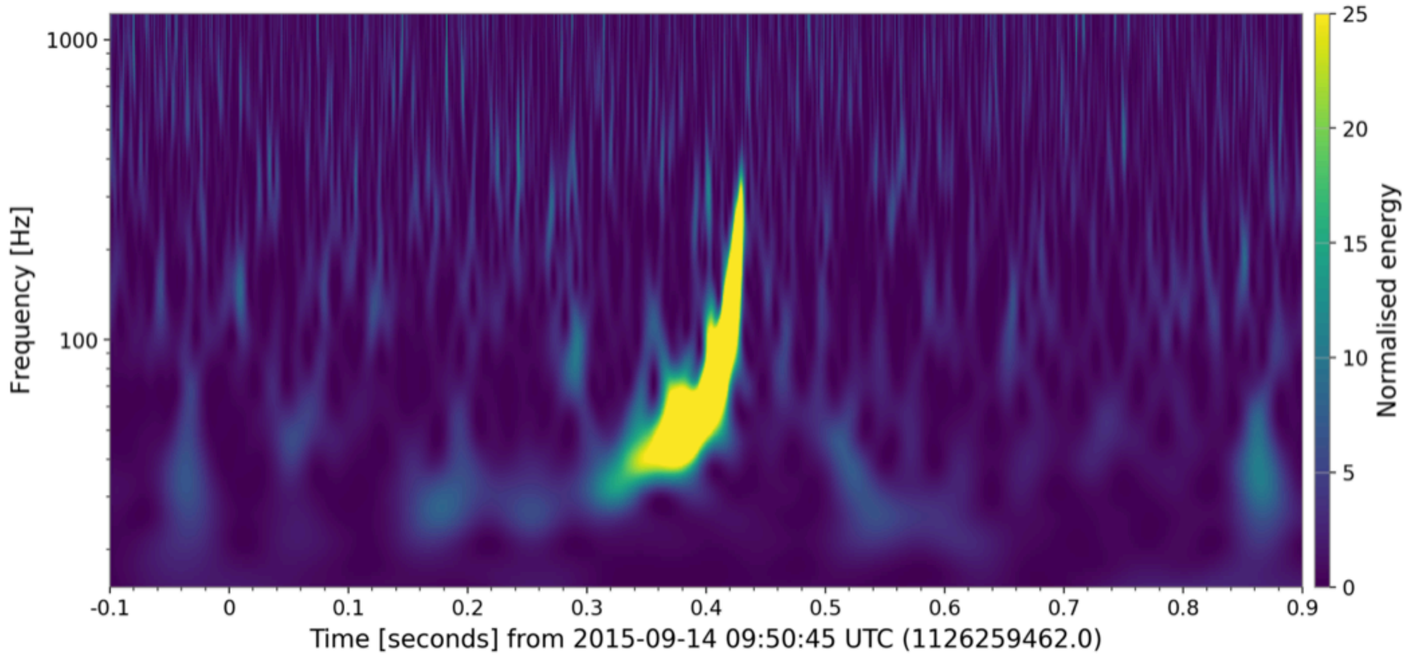
Set Plot Parameters

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` $M_\odot$

Mass 2: `13.6` $M_\odot$

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

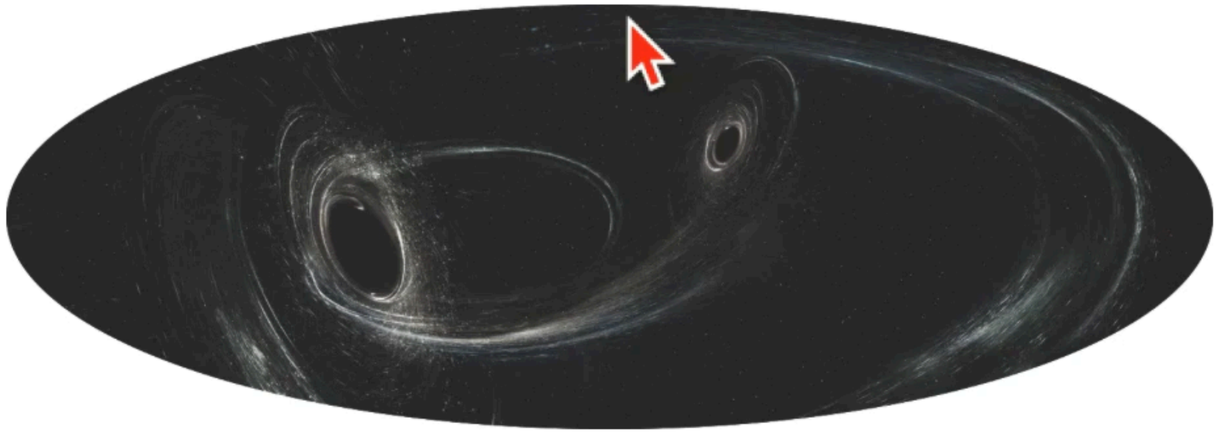
Event 3

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

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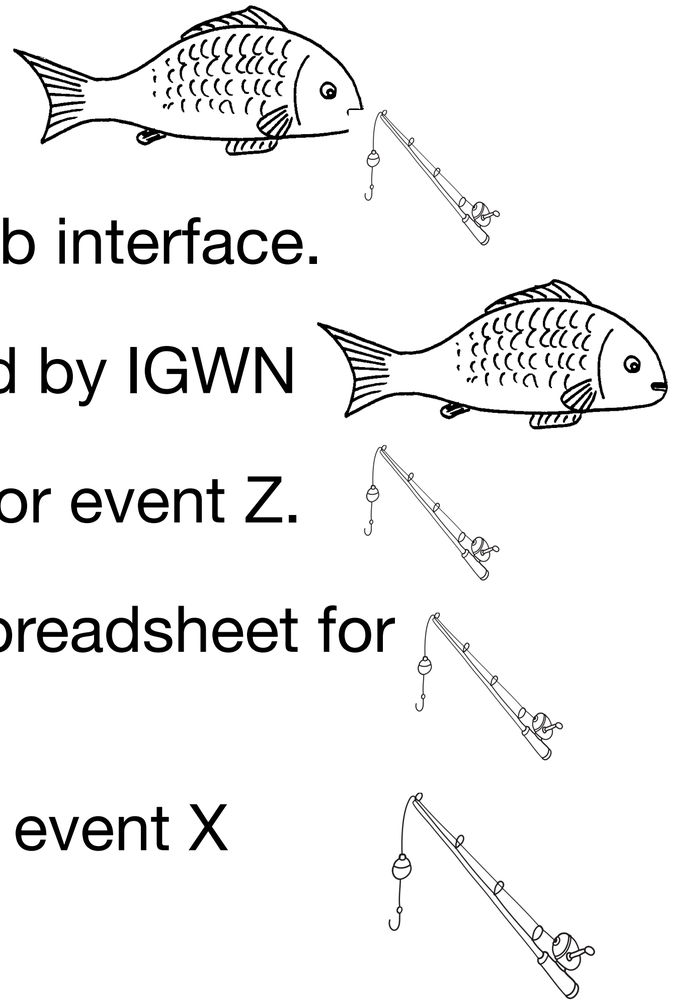

Designing a Catalog

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

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