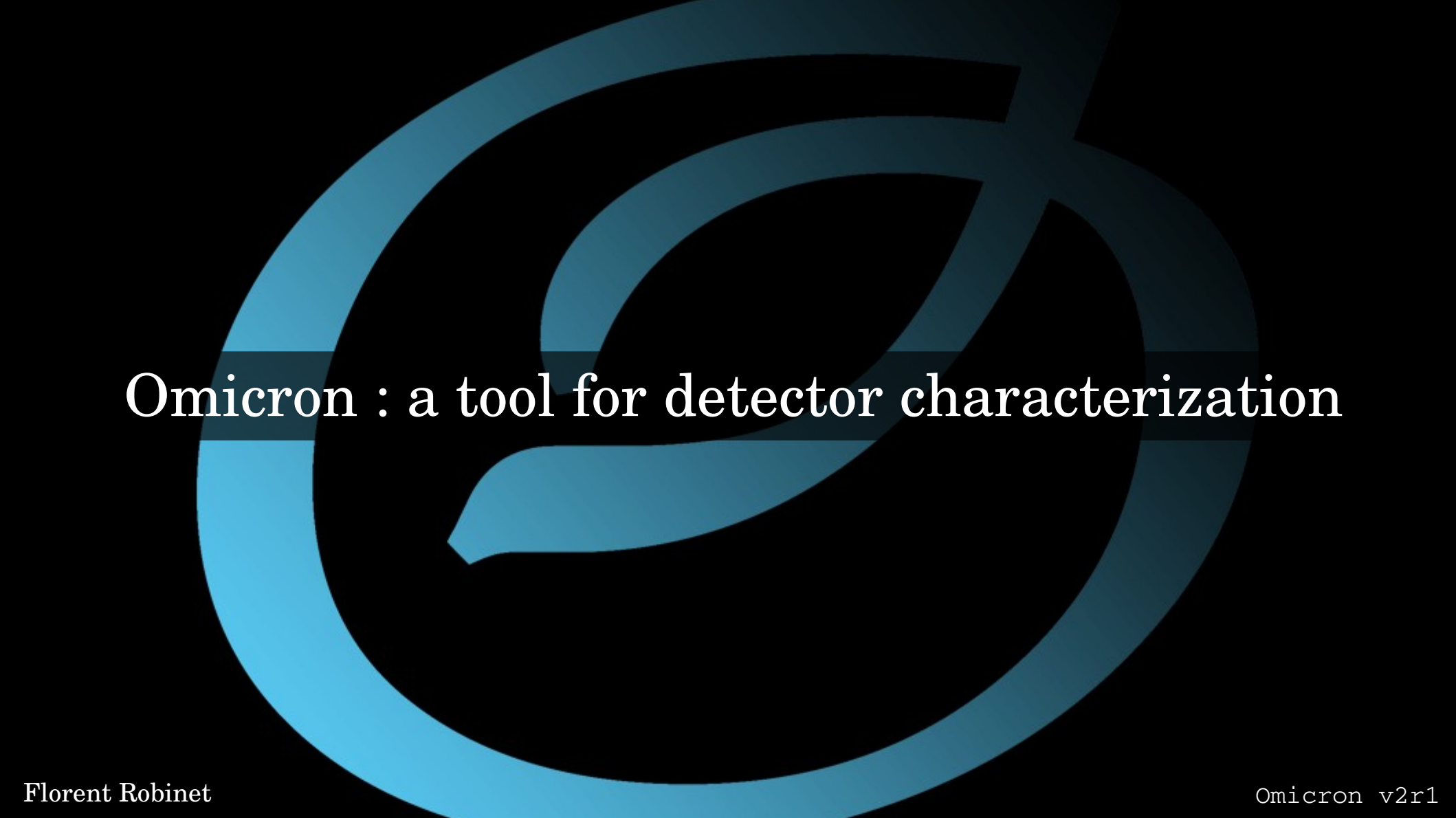


Omicron : a tool for detector characterization

Florent Robinet

The Q transform

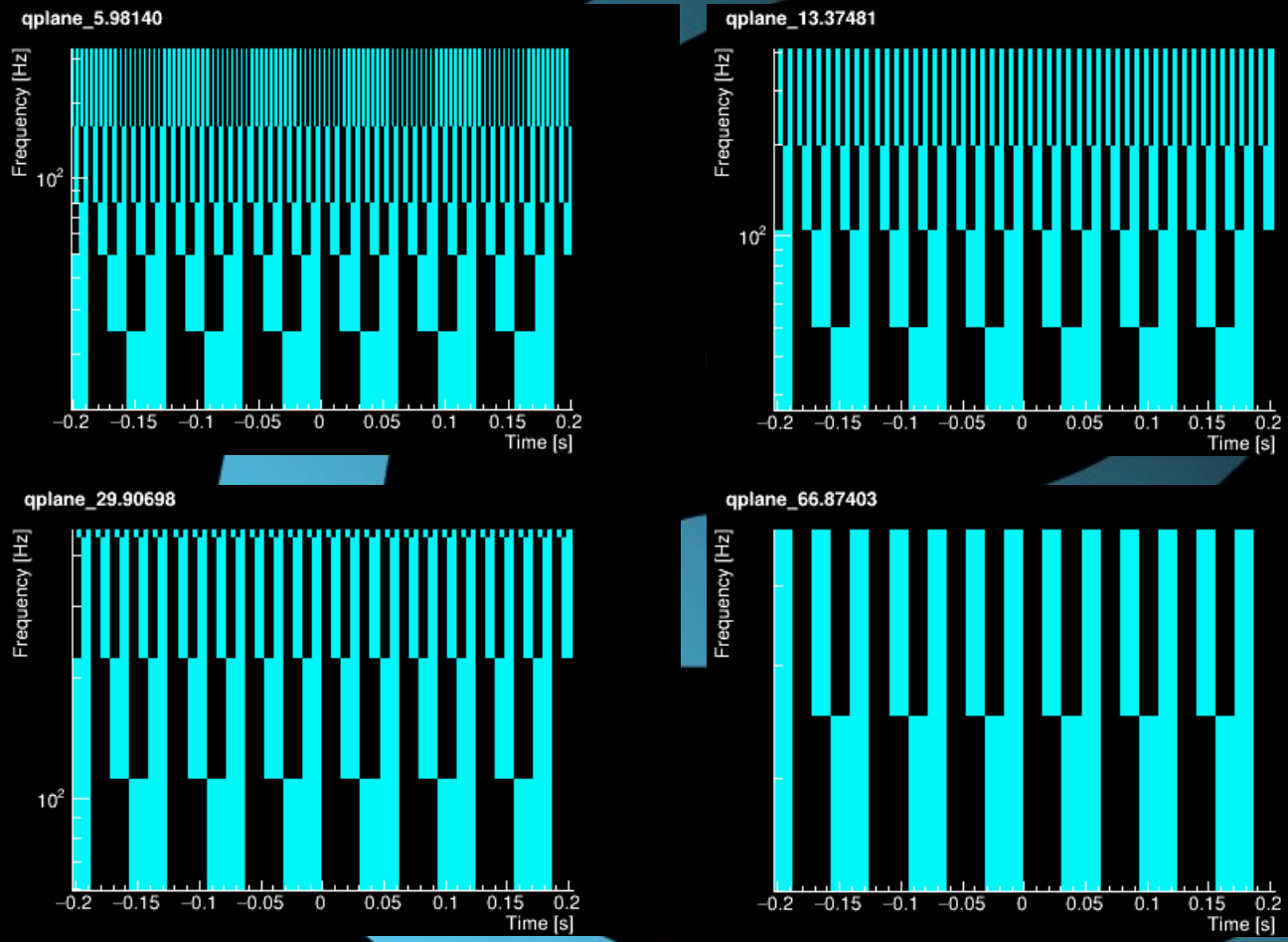
The whitened data s(t) is projected on a basis of windowed (~Gaussian) complex exponentials defined by a central time, a central frequency and a quality factor

$$S(\tau, f, Q) = \int_{-\infty}^{\infty} s(t)\, w(t-\tau, f, Q) \exp(-i\, 2\pi f\, t)\, dt$$

→ 3 dimensional parameter space: time – frequency – Q

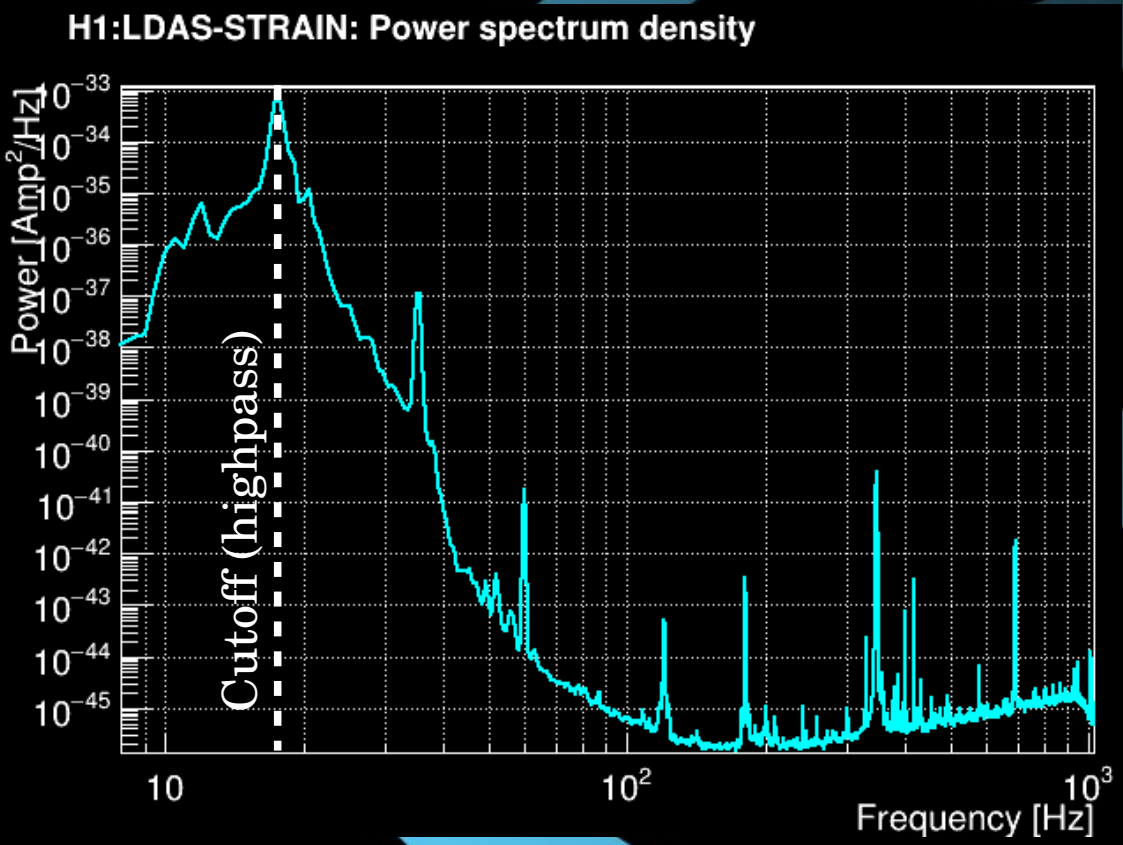
→ We tile the parameter space with
- logarithmically-spaced Q planes
- logarithmically-spaced frequency rows
- linearly-spaced tiles in times

The Q-planes



The tiling is created to minimize the fractional energy loss due to mismatch

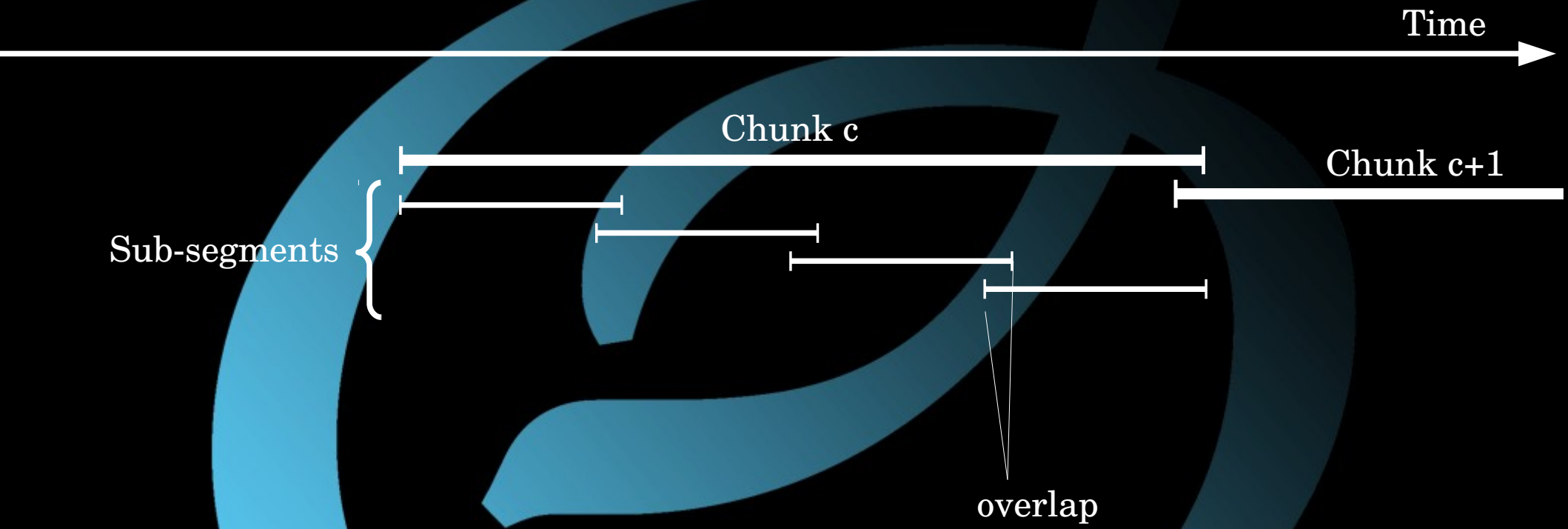
The whitening



Data are whitened using the power spectral density (PSD)

The PSD is estimated using the median-mean method: very robust against loud glitches or injections

The timing structure



Data is loaded by chunks and chunks are analyzed by segments:
– chunks: PSD estimation, size of output files
– segments: data analysis (tiling, Q-transform)

The output triggers

Omicron trigger = tile characterized by:

- a central time and frequency (tile center)
- a duration and bandwidth (tile size)
- a Q value
- a SNR value = normalized tile energy
- an amplitude value

Triggers are saved in ROOT files (TTree): `./[CHANNEL]/[CHANNEL]_[GPS_START]_[DURATION].root`

Other formats are supported: ascii and LIGO XML

Running Omicron

– First you need to source the Omicron environment:

```
source $CMTPATH/Omicron/v2r1/cmt/setup.(c)sh
```

– There are 3 ways to run Omicron over a stretch of data:

1/ over a continuous time segment

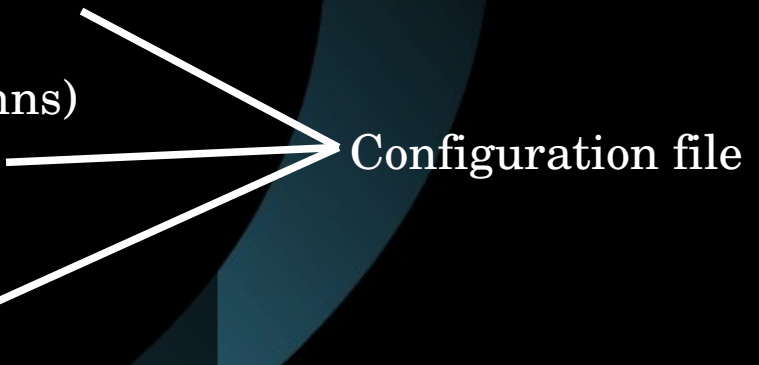
```
omicron 993574004 993574123 ./parameters.txt
```

2/ over a list of disjoint time segments (file with 2 columns)

```
omicron ./segments.txt ./parameters.txt
```

3/ over one chunk of data centered on a given GPS time

```
omicron 993574004 ./parameters.txt
```



Configuration file

– Text file listing the parameters
– Parameters organized around classes: DATA, INJECTION, PARAMETER and OUTPUT

The DATA class is mandatory. It should look like this:

```
DATA   FFL                /virgoData/ffl/raw.ffl

DATA   CHANNELS           V1:h_16384Hz V1:Pr_B1_Acp

DATA   SAMPLEFREQUENCY    2048
```

Frame file list
(supported format : ffl and lcf)

List of channels
(can be given over several lines)

Working sampling frequency
→ must be a power of 2
→ must be smaller (or equal) to
the native sampling of all channels

This is the minimal setting.

Concrete examples:
Let's analyze the big-dog event

Configuration file (basic)

```
DATA   FFL                  /path/to/S6-H1.ffl
DATA   CHANNELS             H1:LDAS-STRAIN
DATA   SAMPLEFREQUENCY      2048

PARAMETER CHUNKDURATION     304
PARAMETER SEGMENTDURATION   64
PARAMETER OVERLAPDURATION   4
PARAMETER QRANGE            3.3166   110
PARAMETER FREQUENCYRANGE    8        1024
PARAMETER MISMATCHMAX       0.2
PARAMETER SNRTHRESHOLD      8

OUTPUT     DIRECTORY        ./output
OUTPUT     FORMAT           root
OUTPUT     PRODUCTS         triggers
OUTPUT     VERBOSITY        1
```

Input data

We define:
– the chunk/segments structure
– The tiling

We produce :
– triggers
– in a ROOT
– in ./output

```
$ omicron 968654000 968655000 ./parameters.txt
$ ls output/H1:LDAS-STRAIN/
H1:LDAS-STRAIN_968654002_300.root  H1:LDAS-STRAIN_968654902_60.root
H1:LDAS-STRAIN_968654302_300.root  H1:LDAS-STRAIN_968654962_36.root
H1:LDAS-STRAIN_968654602_300.root
```

Single chunk analysis

```
DATA   FFL                    /path/to/S6-H1.ffl
DATA   CHANNELS               H1:LDAS-STRAIN
DATA   SAMPLEFREQUENCY        2048

PARAMETER CHUNKDURATION       304
PARAMETER SEGMENTDURATION     64
PARAMETER OVERLAPDURATION     4
PARAMETER QRANGE              3.3166   110
PARAMETER FREQUENCYRANGE      8        1024
PARAMETER MISMATCHMAX         0.2
PARAMETER SNRTHRESHOLD        8

OUTPUT     DIRECTORY          ./output
OUTPUT     FORMAT             root
OUTPUT     PRODUCTS           triggers
OUTPUT     VERBOSITY          1
```

```
$ omicron 968654558 ./parameters.txt
$ ls output/968654558/H1:LDAS-STRAIN/
H1:LDAS-STRAIN_968654408_300.root
```

Multiple output format

```
DATA   FFL                    /path/to/S6-H1.ffl
DATA   CHANNELS               H1:LDAS-STRAIN
DATA   SAMPLEFREQUENCY        2048

PARAMETER CHUNKDURATION       304
PARAMETER SEGMENTDURATION     64
PARAMETER OVERLAPDURATION     4
PARAMETER QRANGE              3.3166   110
PARAMETER FREQUENCYRANGE      8        1024
PARAMETER MISMATCHMAX         0.2
PARAMETER SNRTHRESHOLD        8

OUTPUT     DIRECTORY          ./output
OUTPUT     FORMAT             root txt
OUTPUT     PRODUCTS           triggers
OUTPUT     VERBOSITY          1
```

```
$ omicron 968654558 ./parameters.txt
$ ls output/968654558/H1:LDAS-STRAIN/
H1:LDAS-STRAIN_968654408_300.root  H1:LDAS-STRAIN_968654408_300.txt
```

html summary report

```
DATA   FFL                      /path/to/S6-H1.ffl
DATA   CHANNELS                 H1:LDAS-STRAIN
DATA   SAMPLEFREQUENCY          2048

PARAMETER CHUNKDURATION         304
PARAMETER SEGMENTDURATION       64
PARAMETER OVERLAPDURATION       4
PARAMETER QRANGE                3.3166   110
PARAMETER FREQUENCYRANGE        8        1024
PARAMETER MISMATCHMAX           0.2
PARAMETER SNRTHRESHOLD          8

OUTPUT      DIRECTORY           ./output
OUTPUT      FORMAT              root
OUTPUT      PRODUCTS            triggers html
OUTPUT      VERBOSITY           1
```

A summary web page can be produced

```
$ omicron 968654558 ./parameters.txt
$ ls output/968654558/
H1:LDAS-STRAIN  index.html           omicron.parameters.txt  style.css
icon.gif        omicronlogo_xxl.gif  omicron.segments.txt
```

Omicron Report

Summary

Processing Date:	Tue Feb 17 16:56:22 2015 (UTC)
Requested start:	968654406 → Thu Sep 16 06:39:51 2010 (UTC)
Requested stop:	968654710 → Thu Sep 16 06:44:55 2010 (UTC)
Requested livetime:	304 sec → 0.004 days
Requested segments:	omicron.segments.txt
Number of chunks:	1
Configuration:	omicron.parameters.txt

Parameters

Timing:	chunks of 304 sec, divided into 5 sub-segments of 64 sec, overlapping by 4 sec
Sampling frequency:	2048 Hz
Frequency range:	8.000 → 1024.000 Hz
Q range:	3.317 → 110.000
Tiling maximal mismatch:	20.000 %
SNR threshold:	SNR > 8.000
Tile-down:	NO
Trigger clustering:	NONE

Channel index

H1:LDAS-STRAIN

H1:LDAS-STRAIN

Processing:

Number of calls [load/data/condition/projection/write]:	1/1/1/1/1
Processed livetime:	300 sec (98.684%) → 0.003 days
Processed segments:	omicron.segments.txt
Output:	./H1:LDAS-STRAIN

The web page looks like this

Summary of the processing of H1:LDAS-STRAIN

Map output

```
DATA   FFL                    /path/to/S6-H1.ffl
DATA   CHANNELS               H1:LDAS-STRAIN
DATA   SAMPLEFREQUENCY        2048

PARAMETER CHUNKDURATION       304
PARAMETER SEGMENTDURATION     64
PARAMETER OVERLAPDURATION     4
PARAMETER QRANGE              3.3166   110
PARAMETER FREQUENCYRANGE      8        1024
PARAMETER MISMATCHMAX         0.2
PARAMETER SNRTHRESHOLD        8

OUTPUT      DIRECTORY         ./output
OUTPUT      FORMAT            root png
OUTPUT      PRODUCTS          triggers maps html
OUTPUT      VERBOSITY         1
```

We provide a web-supported graphical format (e.g. png)

Omicron maps can be saved

```
$ omicron 968654558 ./parameters.txt
```

H1:LDAS-STRAIN

Processing:

Number of calls [load/data/condition/projection/write]: 1/1/1/1/1

Processed livetime: 300 sec (98.684%) → 0.003 days

Processed segments: omicron.segments.txt

Output: ./H1:LDAS-STRAIN

Maps:

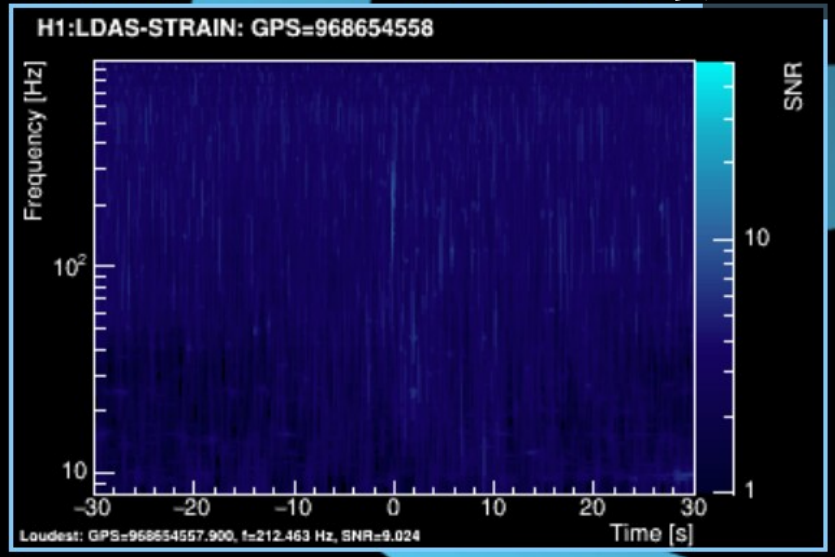
968654438: Full map Q=4.7 Q=9.5 Q=19.1 Q=38.5 Q=77.5

968654558: Full map Q=4.7 Q=9.5 Q=19.1 Q=38.5 Q=77.5

968654618: Full map Q=4.7 Q=9.5 Q=19.1 Q=38.5 Q=77.5

968654678: Full map Q=4.7 Q=9.5 Q=19.1 Q=38.5 Q=77.5

Segment analysis in one chunk
– maps for each Q value
– combined map (full map)



Optimized configuration file (for maps)

```
DATA   FFL                    /path/to/S6-H1.ffl
DATA   CHANNELS               H1:LDAS-STRAIN
DATA   SAMPLEFREQUENCY        2048

PARAMETER CHUNKDURATION       16
PARAMETER SEGMENTDURATION     16
PARAMETER OVERLAPDURATION     4
PARAMETER QRANGE              3.3166   110
PARAMETER FREQUENCYRANGE      8        1024
PARAMETER MISMATCHMAX         0.2
PARAMETER SNRTHRESHOLD        6
PARAMETER WINDOWS             1    2    12


OUTPUT      DIRECTORY         ./output
OUTPUT      FORMAT            png
OUTPUT      PRODUCTS          maps html
OUTPUT      VERBOSITY         1
```

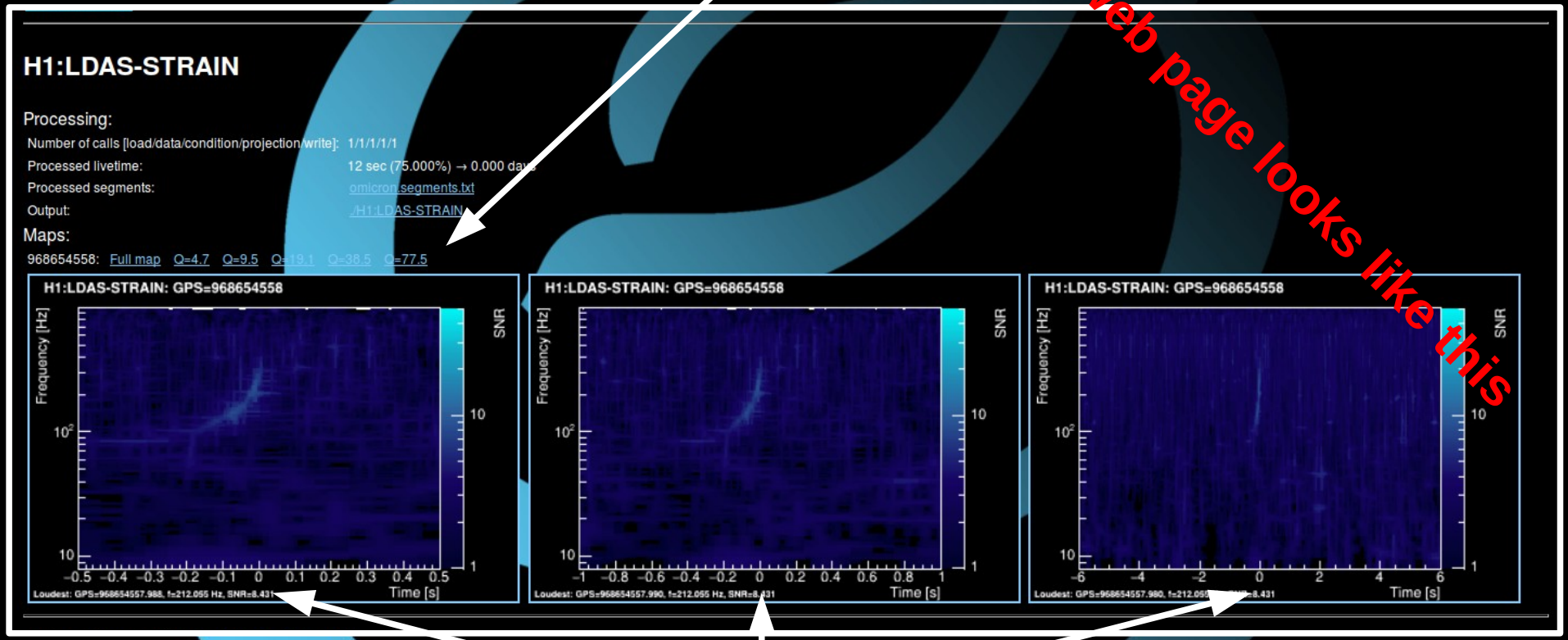
1 segment in 1 (short) chunk

Time windows used for zooming
(must be compatible with the segments)

```
$ omicron 968654558 ./parameters.txt
```

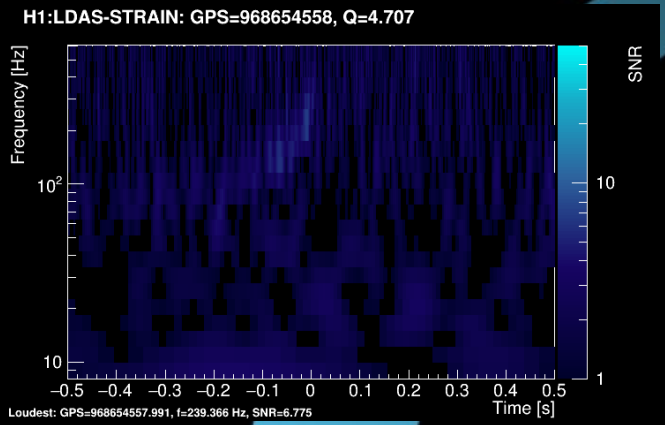
Full map + Q projections

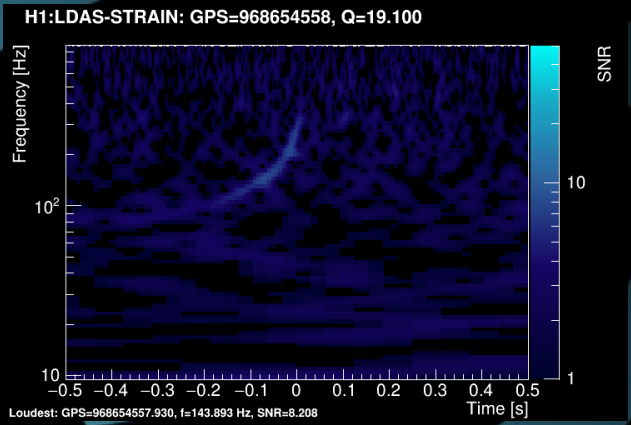
The web page looks like this

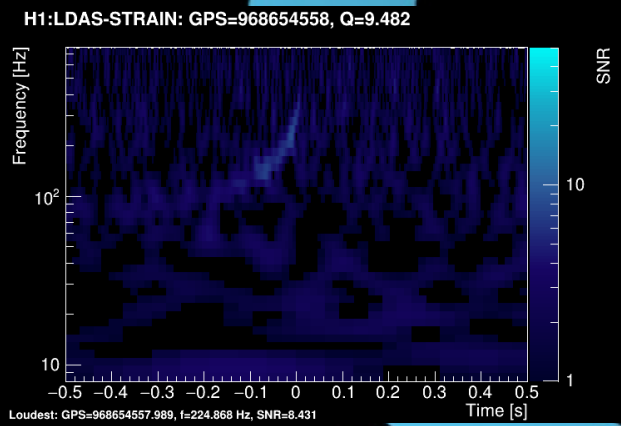


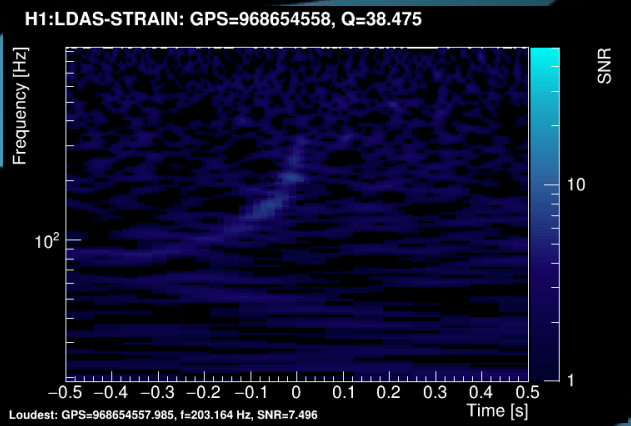
3 time scales
(time windows)

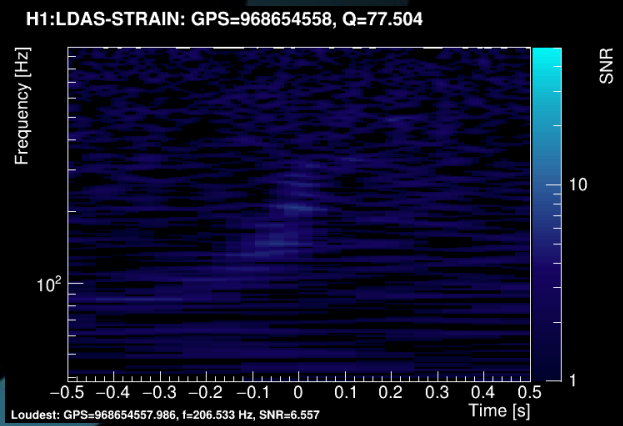
Q-planes decomposition











Channel scan

You can scan as many channels as you want
(does it ring a bell?)

```
DATA  CHANNELS                H1:LDAS-STRAIN

DATA CHANNELS H1:LSC-POB_I H1:LSC-POB_Q H1:LSC-POBS_DC H1:LSC-PRC_CTRL H1:LSC-REFL_DC H1:LSC-REFL_I H1:LSC-REFL_Q
DATA CHANNELS H0:PEM-BSC10_MAGX H0:PEM-BSC10_MAGY H0:PEM-BSC10_MAGZ
DATA CHANNELS H0:PEM-BSC2_ACCX H0:PEM-BSC2_ACCY H0:PEM-BSC3_ACCX H0:PEM-BSC4_ACCX H0:PEM-BSC4_ACCY H0:PEM-BSC5_ACCX
DATA CHANNELS H1:ASC-WFS1_QP H1:ASC-WFS1_QY H1:ASC-WFS2_IP H1:ASC-WFS2_IY H1:ASC-WFS2_QP H1:ASC-WFS2_QY
```

Things you should know

- This is faster than standard omega-scans.
- Other available products: PSD (`psd`), ASD (`asd`), raw time-series (`timeseries`)
- Up-sampling is not possible
- Input GPS times must be integer
- single frequency range → multiple Omicron runs to explore all frequencies
- Omicron triggers are continuously produced at the sites (in `$OMICRON_TRIGGERS`)