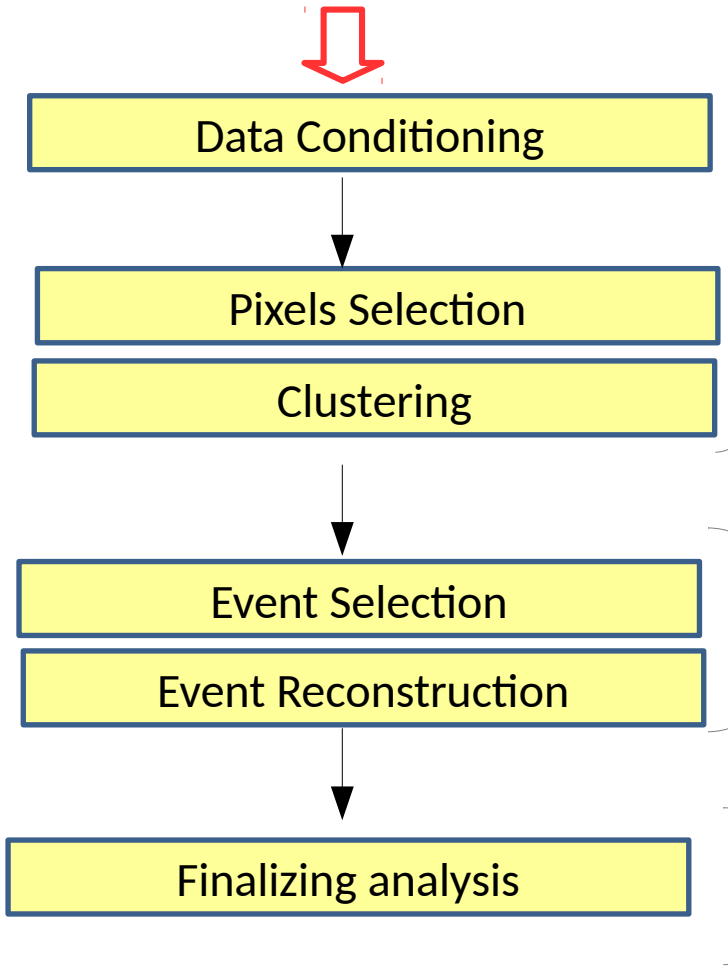
Coherent Wave Burst (cWB)

Interferometer network data



Data conditioning (removing frequency lines and whitening procedure) → FFT of the data data (single interferometer)
Pixels selection is performed on time frequency map of data (TF map is calculated at different resolution level) → wavelet transformation

The analysis is performed coherently and between detectors since the pixel selection step.

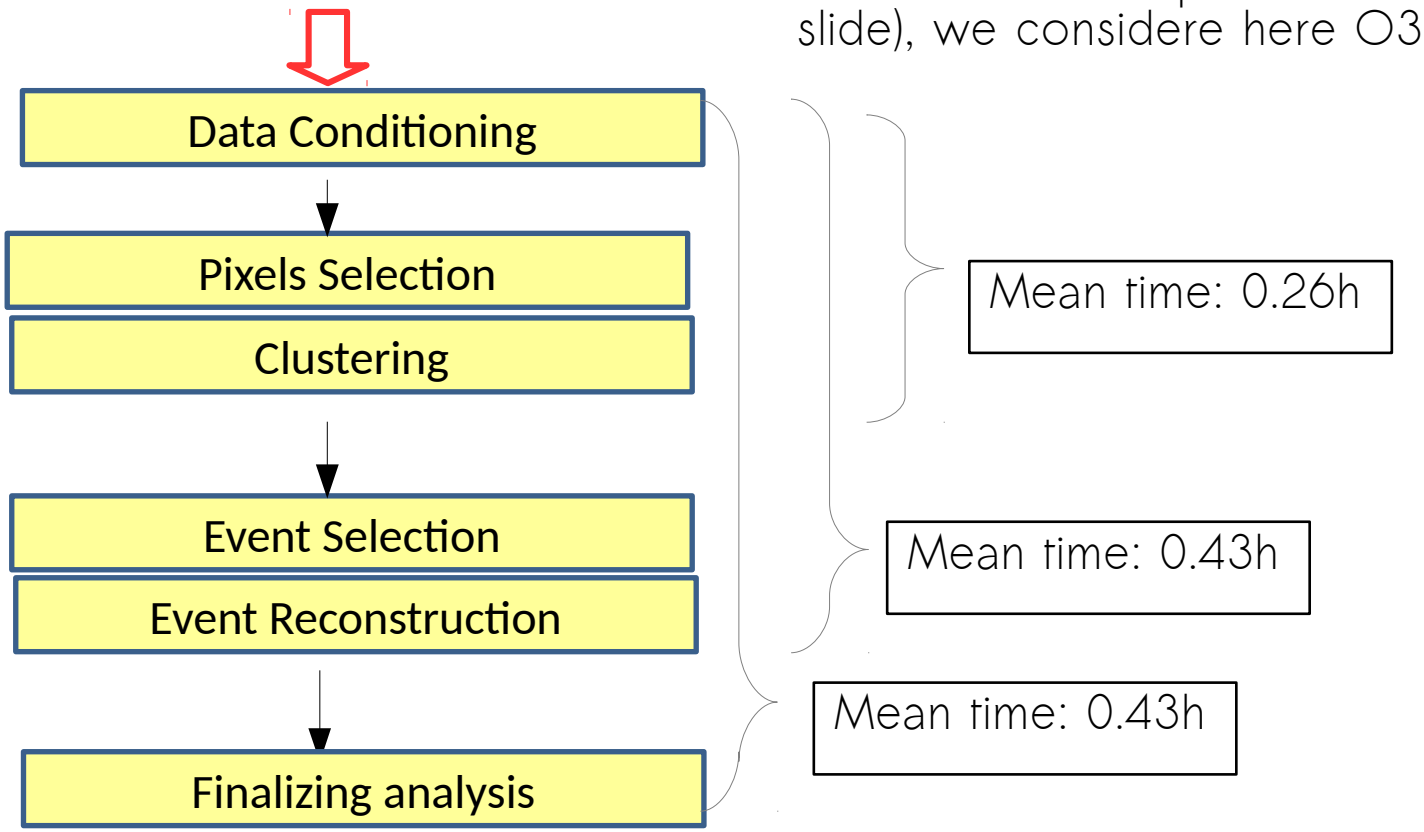
Likelihood is calculated to select and reconstruct the event; the likelihood is maximized over a loop on the possible sky position of the source

Post production cut and selection, significance estimation of candidate

The time to be analysed is divided in segment (length defined by user, generally 1200s) → Each segment analysis is defined in a job

Coherent Wave Burst (cWB)

Distribution of the jobs elapsed time at intermediate stage for an analysis of background estimation, This estimation depends on the searches (see next slide), we considere here O3, LH, short all sky search



Data transfer (from/to a node) for a cWB job:

- Input:
  h(t) data, at least one file of 4k s (800Mb) per each interferometer in the analysis
  about ten of txt files (negligeble in comparison with h(t))
- output: one file root (dimension <1Mb); txt log files

CWB searches and cpu comsuming

CPU total consuming depends:

- on astrophysical search that is performed and consequentely on the configuration of the code
- on data suatus and data conditioning
- network of interferometers (number of interferometers in the network)

5 searches analysis are performed using cWB: short duration low frequency, short duration high frequency, long duration, BBH, IMBH.

A search requires: estimation of significance (background estimation) and estimation od sensitivity of the algorithm through simulations:

- estimation of candidate significance (or upper limits) is performed analysing years of time equivalent (production):
  - for upper limits (till O2: short low and high frequency, long), about 200y of bkg equivalent for each month of data
  - for each candidate (or 2-week period data that contains at least a candidate) 5k years of background equivalent (till O2 this was the case of BBH and IMBBH searches)

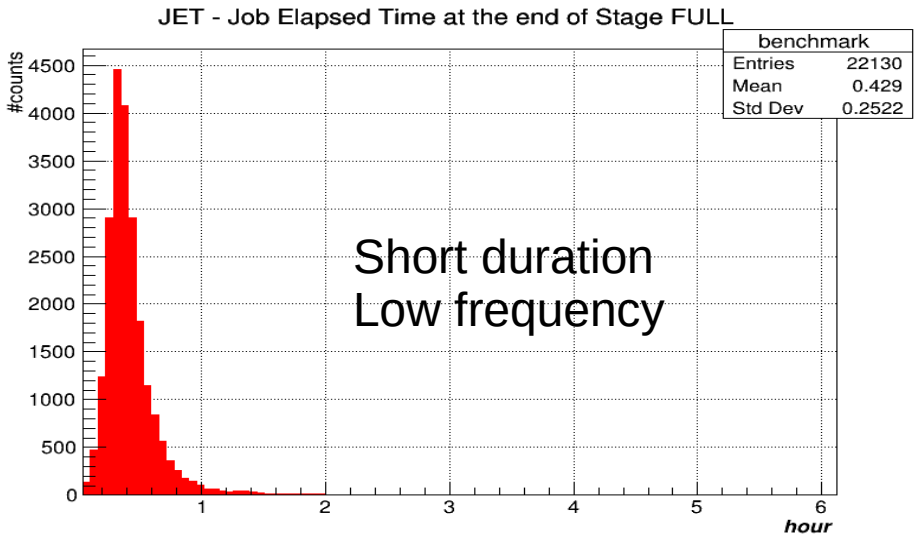
- simulation generally one order of magnitude less consuming, cpu request can be approximate 20% of production cpu consuming

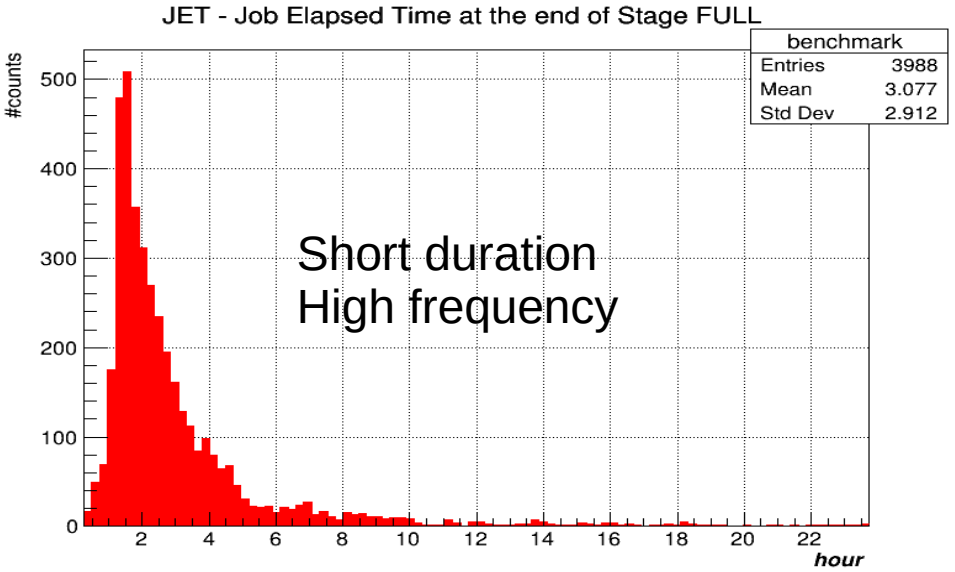
BBH and IMBBH searches can be approximately considered similarly to all-sky short duration low frequency for cpu consuming.
We considered time of background estimated per job as constant; but it decreases when the analysis need to collects for background estimation large amount of years data equivalent

Coherent Wave Burst - cpu time

cWB O3 preliminary cpu/hours consumings:

	years/job estimated	running job time	cpu time/year
All sky low frequency LH:	0,0426y	0,43h/job	10.1 h/year
All sky high frequency LH:	0,0426y	3,1 h/job	72,8 h/year
All-sky long duration LH:	0,0213y	0,42 h/job	19,8 h/year





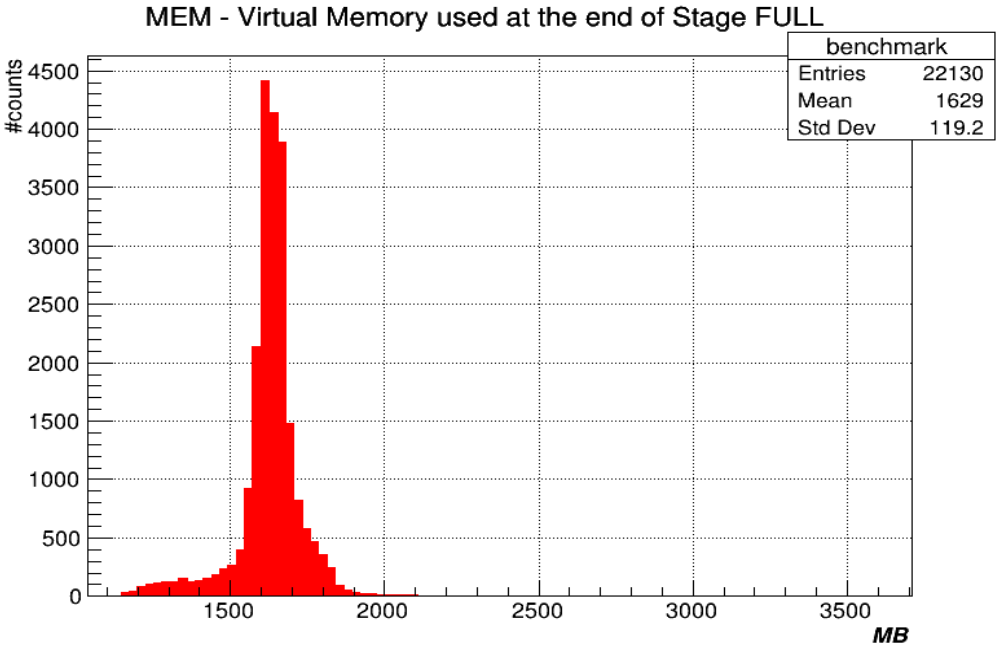
	years/job estimated	running job time	cpu time/year
All sky low frequency LHV:	0,038y	1,17h	30,79 h/year
All sky high frequency LHV:	0,039y	4,20h	107,70 h/year
All-sky long duration LHV:	0,020y	1,09h	54,5 h/year

Note: running job time strongly depends on available hardware,
these estimation refer to Caltech cluster

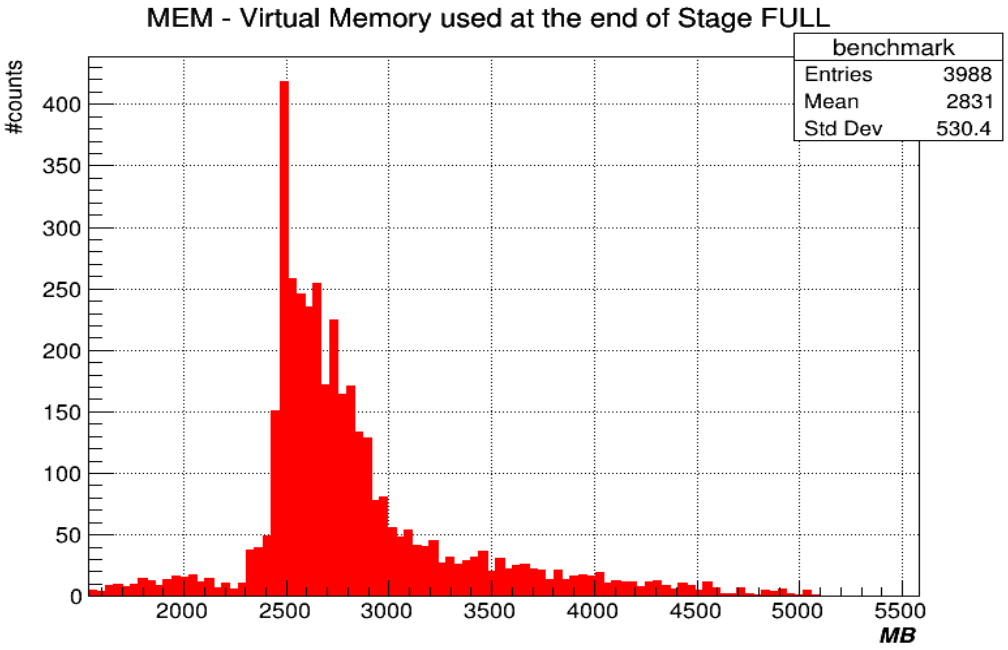
Coherent Wave Burst - memory

cWB O3 mean memory usage per job

Short duration, low frequency



Short duration, high frequency



Back up

Data analysis workflow: from detectors to physical results

Data taking, monitoring, commissioning and calibration

- Gravitational channel h(t): time series signal, sampling rate 20 kHz
- Thousand of auxiliary channels saved with different sampling rates (range: >Hz to few kHz)

Virgo:

- Continuous stream of data (data flow ~3TB/day), to be transferred (CNAF, CCIN2P3)
- The computing center at Cascina is dedicated to data production, commissioning, detector characterization

Data analysis workflow

Data taking, monitoring, commissioning and calibration

Detector characterization and data quality

→

Analysis of the auxiliary channels performed:

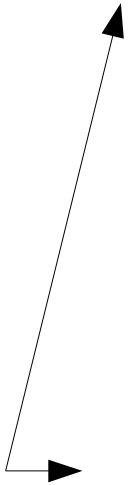
- Both low latency (minutes latency) and offline
- Both single interferometer data analysis, and analysis of all network data

Data analysis workflow

Data taking, monitoring, commissioning and calibration

Detector characterization and data quality

GW searches & low latency GW searches



- Simultaneously analysis of the network data (h(t) channel)
- Different analysis (searches) have been developed to address different sources and signals

- Pipelines are built on several algorithms, therefore they require different computing resources and input/output data management
- Low latency searches have been implemented (since few minutes to hours depending on searches and pipelines) to promptly identify GW candidates and send GW alert to EM partners