Compact Binaries Coalescences search at low latency with MBTA and O3 public alerts

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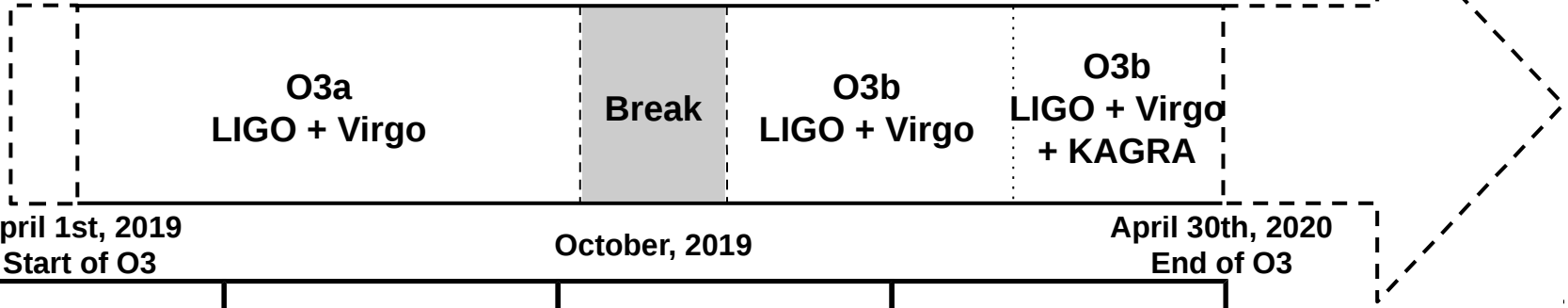
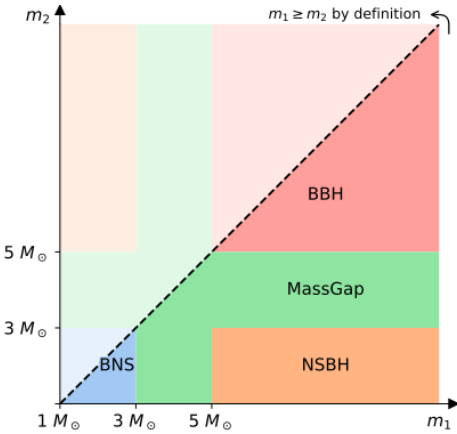
O3 Summary

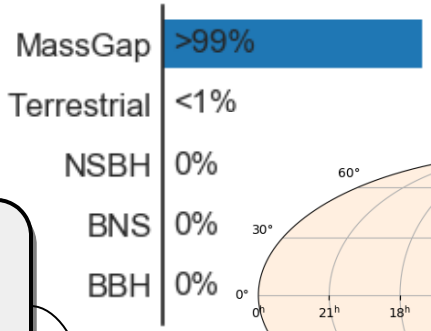
Mean range (mean distance for BNS detections) during O3a
- LIGO Hanford (H1) : 110 Mpc $\approx \times 1.5/O2$
- LIGO Livingston (L1) : 135 Mpc $\approx \times 1.5/O2$
- Virgo (V1) : 45 Mpc $\approx \times 2/O2$

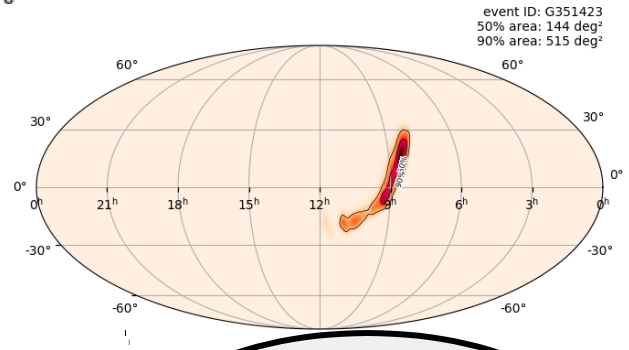


O3a CBC candidates (FAR < 1 / 8 months)	Total	With P_astro. >= 99%	Detected in coincidence by MBTA
BNS	6	1	1
NSBH	4	1	2
BBH	21	16	19
MassGap	2	1	2
Total	33	19	24
Retracted	7	5	1



The low latency analysis chain





H1

L1

V1

Sky maps
Source classifications

Analysis pipelines

CBC : gstlal, MBTA, pycbc, spiir
Burst : CWB

GraceDB

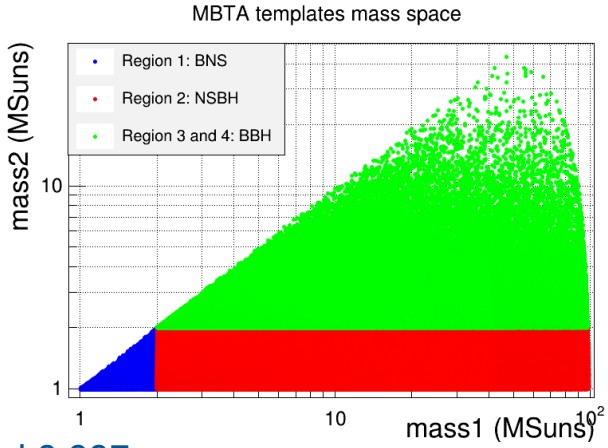
Superevent

Public alerts

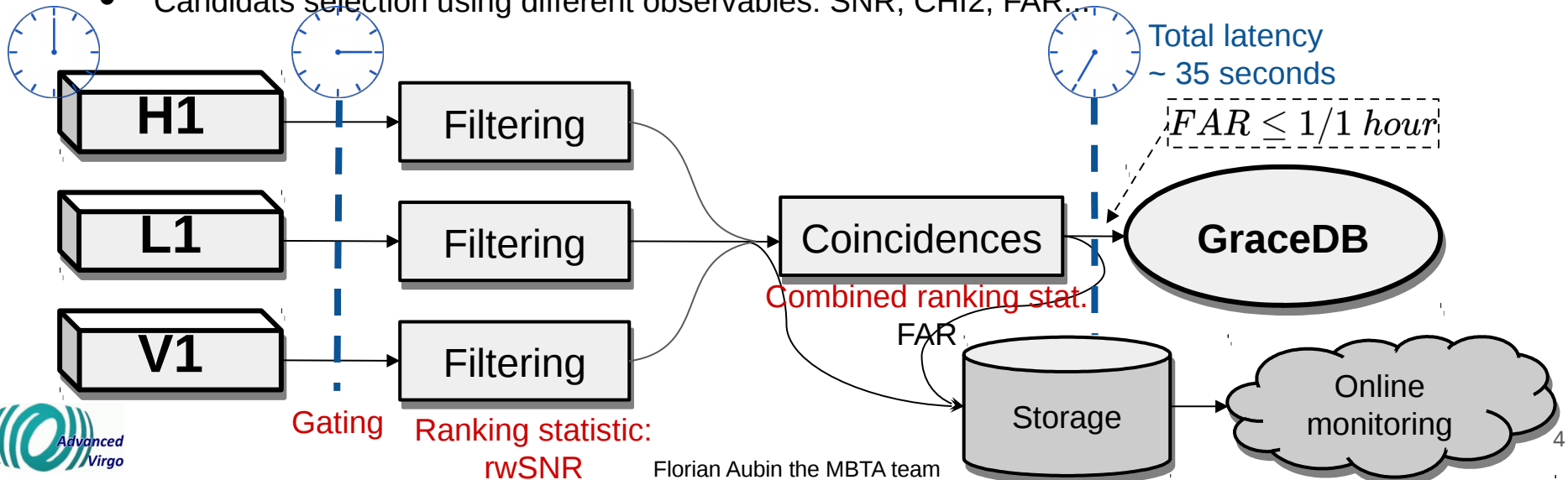
CBC : $FAR \leq 1/8\ months$

GRB alerts

The MBTA analysis pipeline during O3a

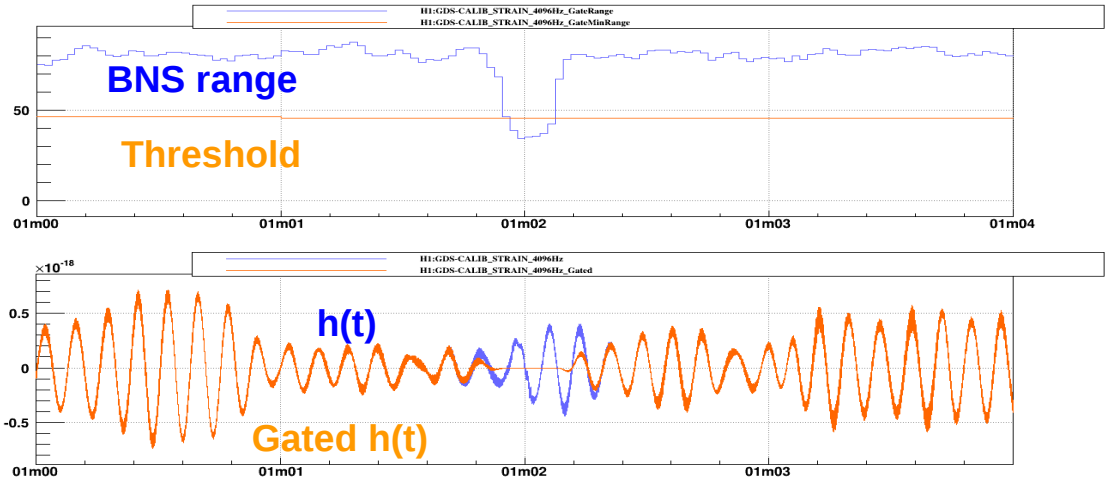


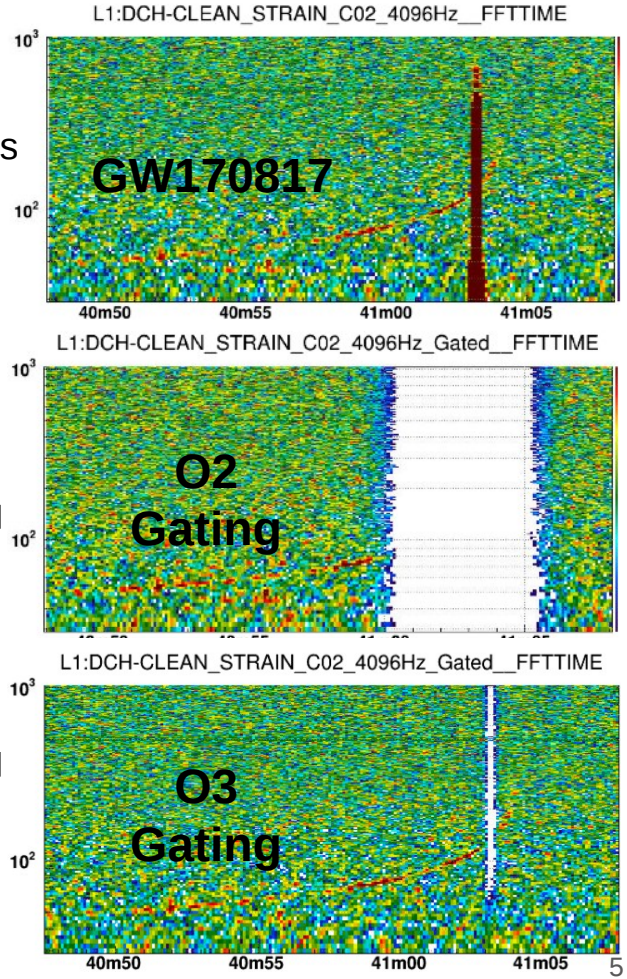
- Match filtering analysis: ~750k templates
- Multiple frequency bands
- Exploration of mass and spin parameter spaces
  - 4 regions with different SNR thresholds:
    - BNS (4.8), NSBH (5.5), BBH (5.2) + ungated BBH (12)
  - NS: masses between 1 and 2 $M_\odot$ / spins between 0 and 0.05
  - BH: masses between 2 and 100 $M_\odot$ / spins between -0.997 and 0.997
- Candidats selection using different observables: SNR, CHI2, FAR...



Removing loud glitches : “Gating”

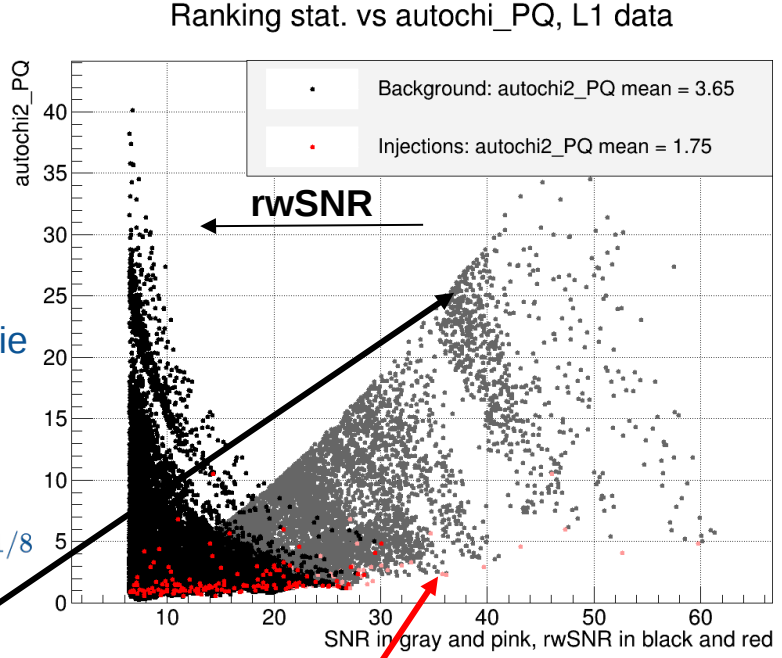
- Some loud glitches can pollute long signals or trigger short templates
- Set data to 0 in case of glitch
  - Triggered when BNS range goes below 60% of the median range
- Can be unsafe for short duration (BBH) and high SNR signals
  - BBH templates are analyzed twice:
    - With gating and usual ranking stat. threshold
    - Without gating and with high ranking stat. threshold (12)

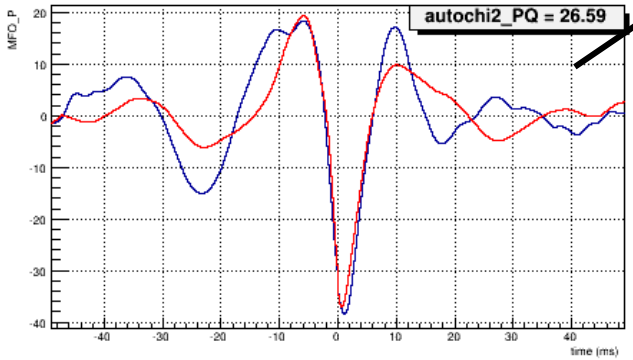


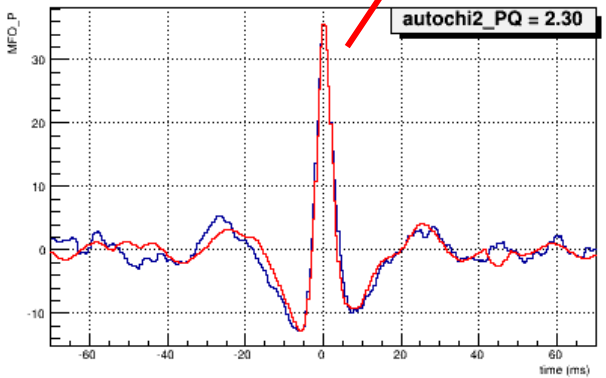


Reweighted SNR ranking statistic

- Signal to Noise Ratio (SNR):
  - Correlation between templates and data
- autochi2_PQ:
  - Comparison between match filter output SNR time serie and template autocorrelation
  - In phase and quadrature
- Reweighted SNR:
  - If autochi2 < 1 $\rightarrow RankStat = SNR$
  - If autochi2 > 1 $\rightarrow RankStat = SNR \times \left(\frac{10+autoχ^2}{11}\right)^{-1/8}$



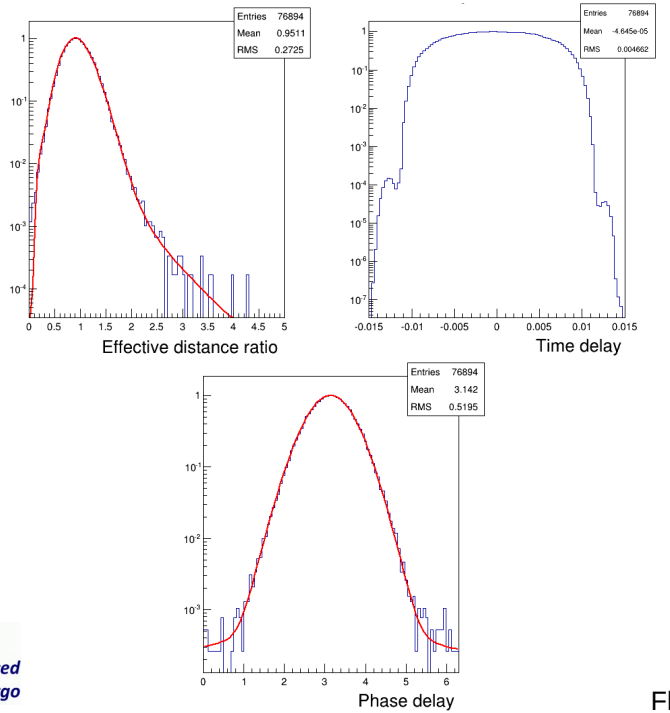


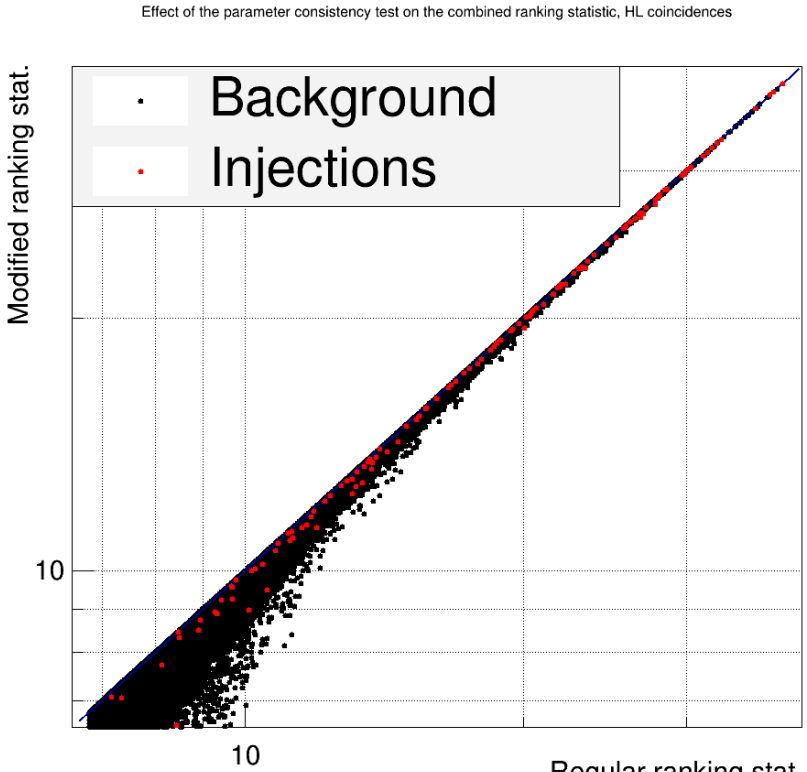


Multiple detectors: combined ranking statistic

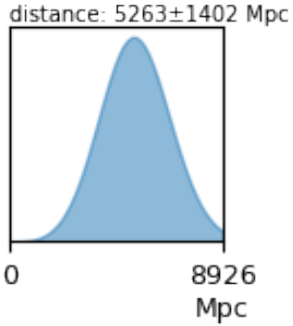
- Search for coincident triggers in time with same template triggers in at least 2 detectors
- Compute a combined ranking statistic involving parameter consistency tests

$$\rho_c^2 = \rho_H^2 + \rho_L^2 + \rho_V^2 + 2log(P)$$

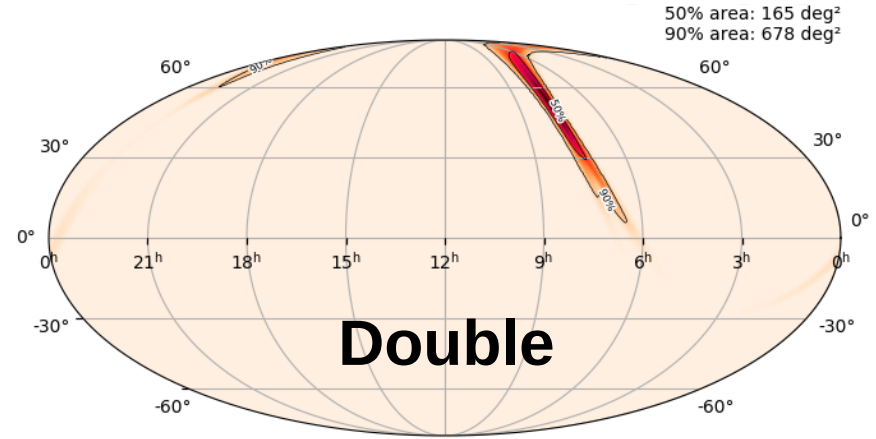


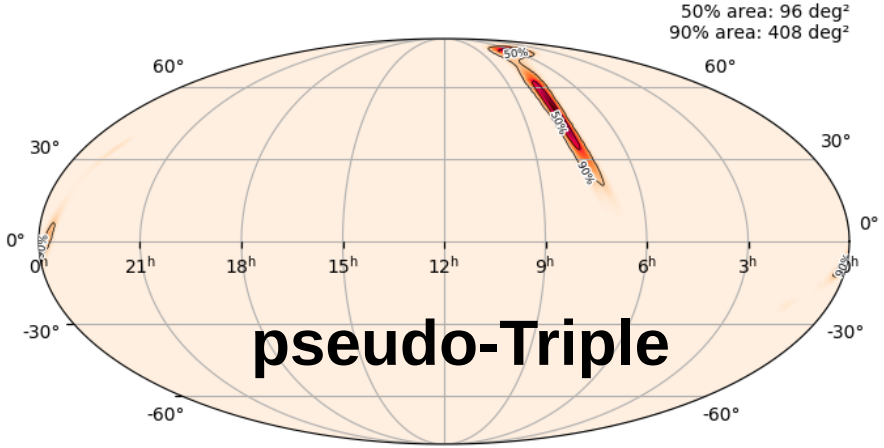


O3b changes (on-going review)



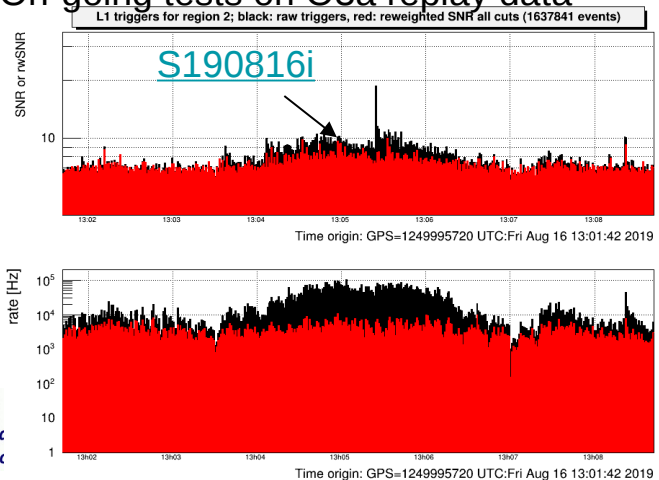
- Extend the parameter space beyond 100 $M_\odot$ (to ~200 $M_\odot$)
  - O2 catalogue: mass up to ~ 80 $M_\odot$
  - O3 horizon up to z ~ 1
- Lower the single rwSNR thresholds
- Sub-threshold search in the other detectors when there is a trigger in (at least) one detector
  - Turns double coincidences into (pseudo-)triples
  - Allows to include the third SNR timeseries useful for sky localization

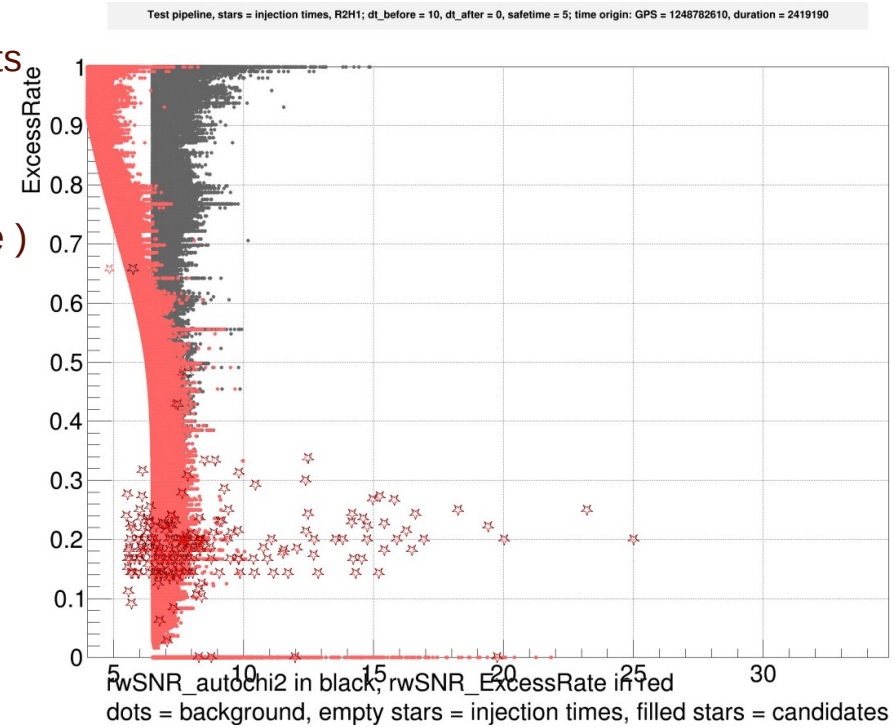




Modify the single itf ranking statistic for bad quality periods

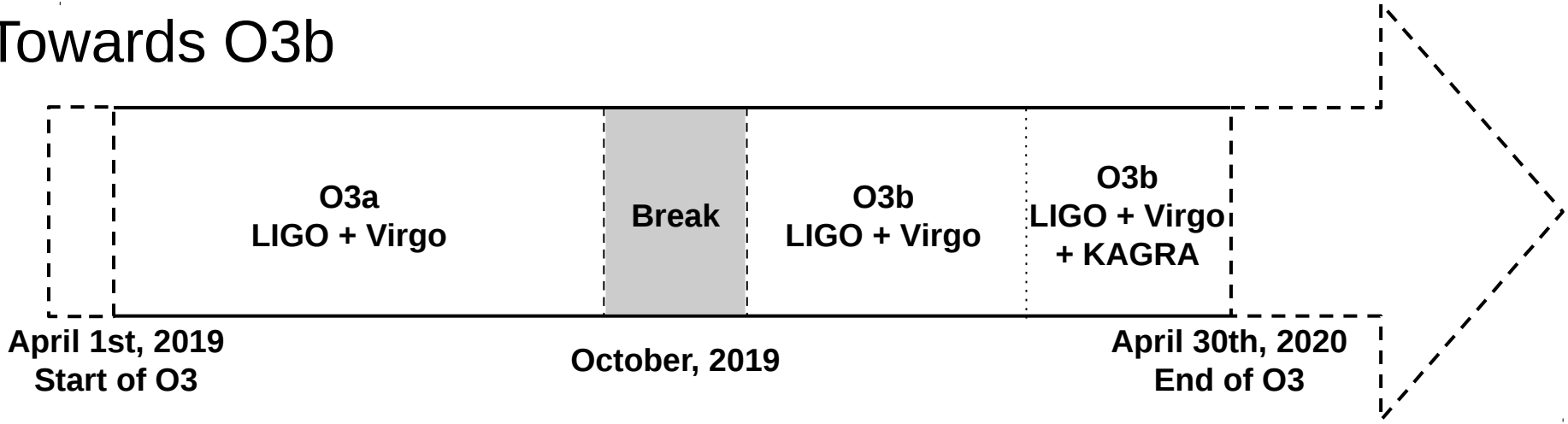
- Sometimes, a detector shows an excess of poor quality triggers
  - Most of them are removed by the various cuts (mostly rwSNR_autochi2PQ)
  - Some glitches can survive
    - They pollute the background of real events
    - They can trigger a public alert
- Identify periods with bad data quality
  - Observable: ExcessRate
    - Median((Raw rate - Final rate) / Raw rate)
    - Using 10 sec of data before the trigger
- Downrate triggers with high ExcessRate
- On-going tests on O3a replay data





orian Aubin the MBTA team

Towards O3b



- Everything goes well during O3a
  - MBTA: 21 candidates + 1 marginal (retracted) glitch
  - All searches: more than one event per weeks
    - With some new interesting sources (NSBH, MassGap)
- Still no EM counterpart claimed
  - Hopefully for O3b!
- KAGRA is expected to join the network before the end of the run