Run coordinator report

Nicolas Arnaud (nicolas.arnaud@ijclab.in2p3.fr)
Laboratoire de Physique des Deux Infinis Irène Joliot-Curie
(Université Paris-Saclay & CNRS/IN2P3)
European Gravitational Observatory

STAC @ EGO
Open session – May 28th, 2024

VIR-0448A-24

Outline

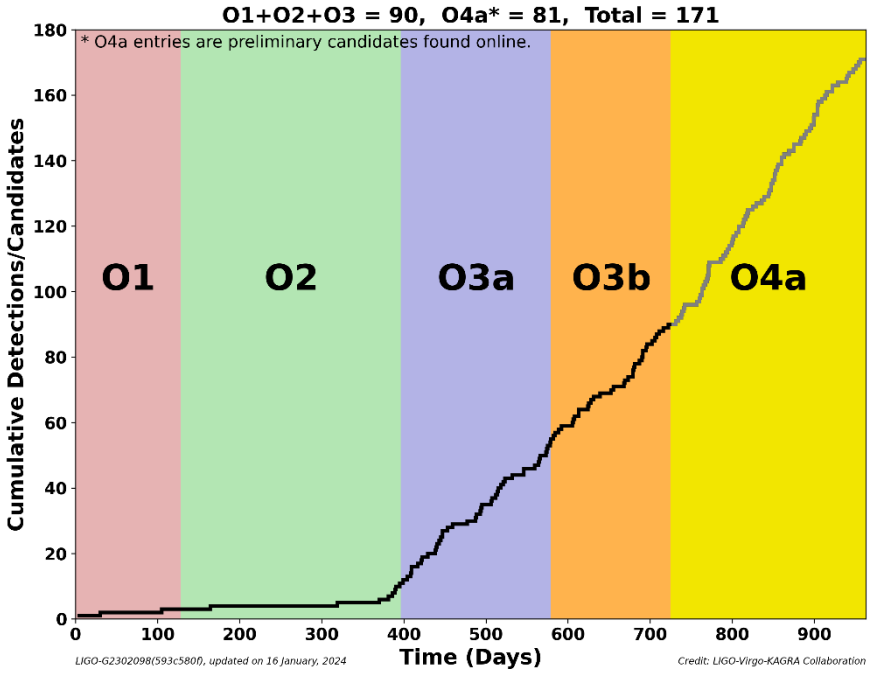
- From O4a to O4b
  - Preparing a 3-detector 10+ months joint data taking period
- O4b Virgo performance
  - Individual detector
  - Inside the LVK network
- Public alerts
- Lessons learned since the beginning of O4b
- Updates from some working groups
  - Calibration, Computing, DetChar, Low-latency, Open data, Rapid Response Team
  - EGO operations team
- Outlook

- Dual O4b coordination
  - Run coordinator
  - Commissioning coordinator

} Smooth management: regular interactions and quick info transmission both ways

→ More / complementary info in Michal Was' talk, immediately following mine

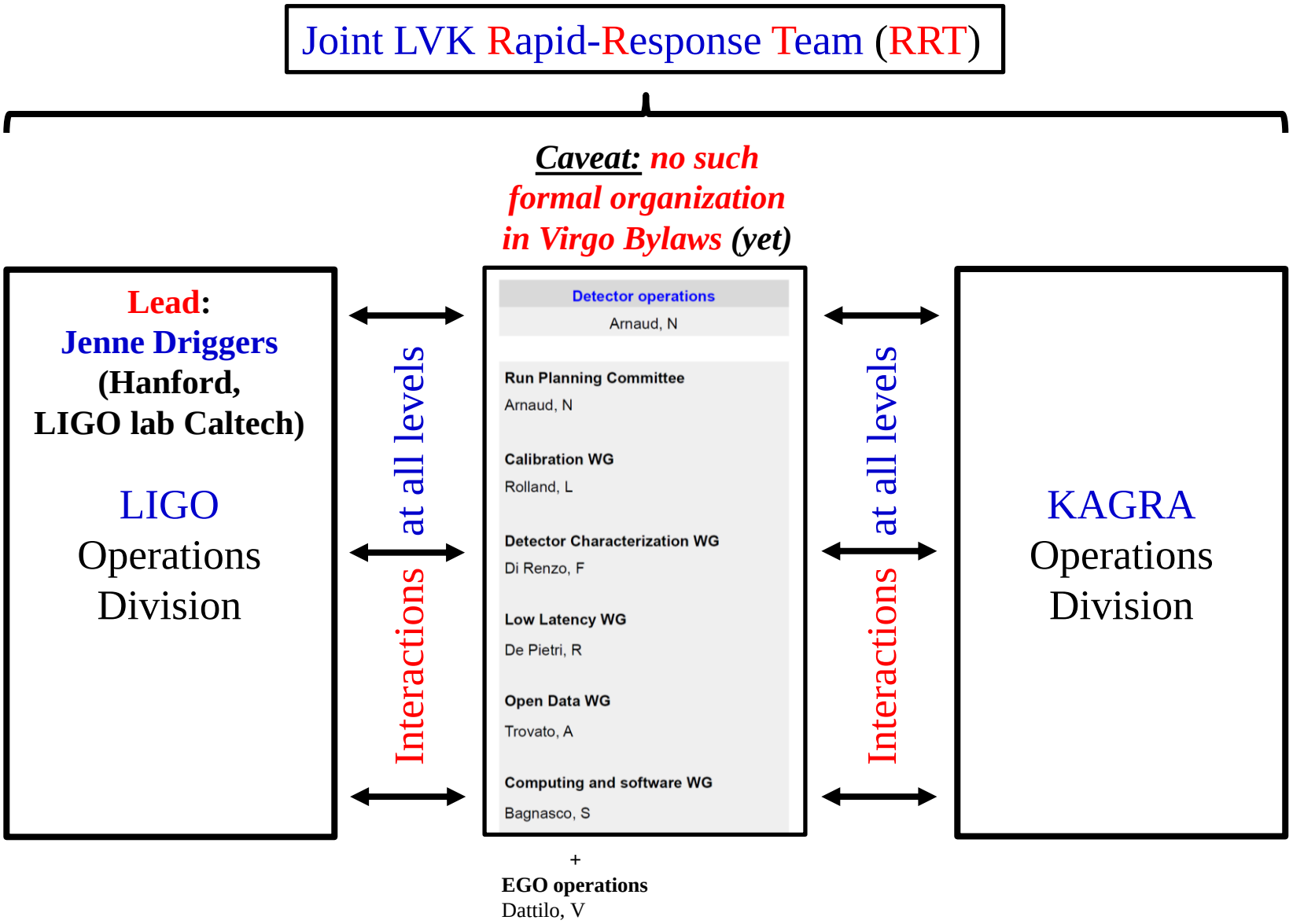
O4a: 1-slide summary



- O4a public alerts: 81
  - 11 other triggers retracted
- Virgo not part of the run
  → No Virgo data by default
- But Virgo could be nominally controlled at the time of a LIGO trigger
  → Policy defined for the use of Virgo data, if requested by data analysts
    - Relevant for O4a offline analyses
      → Testing General Relativity, etc.

- Virgo contributions
  - Rapid Response Team (RRT): 1 8-hour shift / day in European TZ (~100% Virgo)
    - Smooth rota for Virgo
    - Groups who were not part of RRT during O4a are committed to in O4b
  - Computing
  - Low-latency alert infrastructure and analysis pipelines
  - O4a event validation – jointly with LIGO
  - And data analysis working groups of course!

Run coordination: from Virgo to LVK



Run coordination: from Virgo to LVK

- Virgo run coordinator acts as liaison to the (LK) Operations division(s)
- 4 site advocates
  - LIGO Hanford: Jenne Driggers
  - LIGO Livingston: Brian O'Reilly
  - KAGRA: Takahiro Sawada
  - Virgo: NA
- 3 lead site advocates, each on duty 1/3rd of the time (alternating every other week)
  - Jenne, Brian and NA (+ backups from Virgo) – not Takahiro
- Rapid Response Team
  - 3-tier system: Lv0 (on shift) → Lv1 (experts) → Lv2 (full team)
  - Coordination shared by geographical regions [↔ by collaborations in practice]
    - Europe (+ Africa): Francesco DR for Virgo: 1/3rd of the time since O4a
    - Asia/Pacific: KAGRA
    - Americas: LIGO
- LVK Organization
  - Weekly Operations meeting [Open]
  - Weekly site advocates meeting
  - Monthly joint coordinator meeting with RRT
  - Monthly joint coordinator meeting with data analysis and RRT

  } [Closed]

→ Many working group meetings, LVK mailing lists and chat channels

Virgo O4b readiness

- 24/7 coverage in the control room
  - Crew of seven EGO operators – minimum of five needed for one such rota
  - On-call experts provided by Virgo subsystems and Virgo working groups
- Joint low-latency alert infrastructure and online pipelines ready
  - Three such pipelines with significant Virgo contributions
  - Infrastructure work personpower-limited
- Computing
  - All data transfers (from and to EGO) running fine
    - Virgo low-latency h(t) production and transfer critical: direct interface with LIGO
  - Production software frozen – limited improvements and developments as needed
- Improved calibration and h-reconstruction
  - Uncertainties reduced and better estimated, bias controlled
  - Better noise subtraction methods
  - Newtonian calibrators are complementing the photon calibrators
- Detector Characterization
  - Online data quality + Data Quality Report framework to vet low-latency events
  - Software tools and inputs from Virgo subsystems (channel lists)

O4b Planning

- Virgo to join O4b alongside LIGO from day 1 of this data-taking period

- O4b was scheduled to start on Wed. April 3rd
  - Delayed by a week: internet outage at LIGO Hanford on 05-07 April
    → O4b has started on Wed. April 10th at 1500 UTC

- Preceded by Engineering Run ER16
  - March 20th → April 10th (April 3rd originally)
  → Three weeks for final tuning
    - ↘ detector work (sensitivity + stability)
      ↗ data taking
      } As time goes
    - Low-latency pipelines need time to shape their backgrounds
  - Automated public alerts enabled on Wed. April 3rd at 1500 UTC
  - RRT shifts restarted as well at the same time
    - Virgo TZ RRT planning well-covered for the first few months of O4b

- O4b to last at least 10 months
  - End date TBD, likely not earlier than mid-February 2025
    → Joint LVK discussion for a possible O4b extension of a few months

Use of Virgo data

- Virgo data not to used for triggering in low latency during O4b
  - Sensitivity ratio limits the improvement provided by a third detector
  - 50% more computing resources needed to go from 2 to 3 detectors

- Virgo data will be used in low latency for sky localization of the potential source
  - Using a third detector can significantly reduce the size of the skymaps

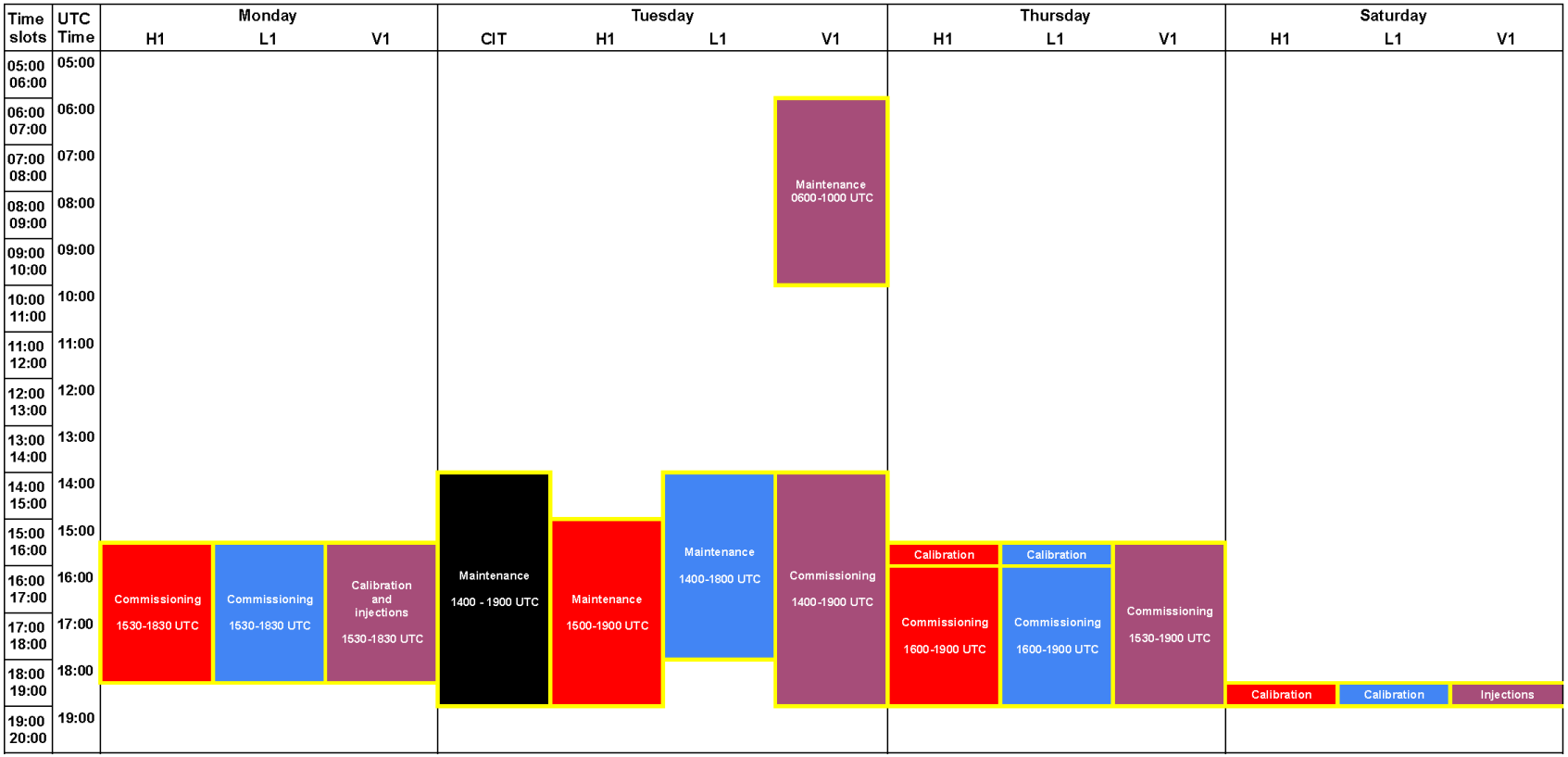
  → Virgo data are vet in low latency exactly like the LIGO data
    - Dedicated Virgo framework ready and fully operational

→ O4b overall strategy: maximize 3-detector uptime
  - Requires more, continuous, coordination at the LVK level
    - In particular, align known, weekly recurring, downtimes – see next slide

LVK planning

CIT
Hanford
Livingston
Virgo

- Downtimes aligned as much as possible among the three detectors
  - Priority: 3-detector data taking



Downtimes / week

- **Maintenance: 4 hours (2.4%)**
- **Calibration: 3 hours max. (1.8%)**
- **Commissioning: 8.5 hours max. (5.1%)**
- **Injections: 0.5 hour max. (0.3%)**

→ Up to 10% of duty cycle

EGO operations team

- New member added to the operators team
  - Team of 7 people needed for a long run

- Series of training sessions organized for operators
  - Held by subsystem and working group experts

  → Slides and recordings available on https://scientists.virgo-gw.eu/DetectorOperations/trainingsessionsschedule.htm

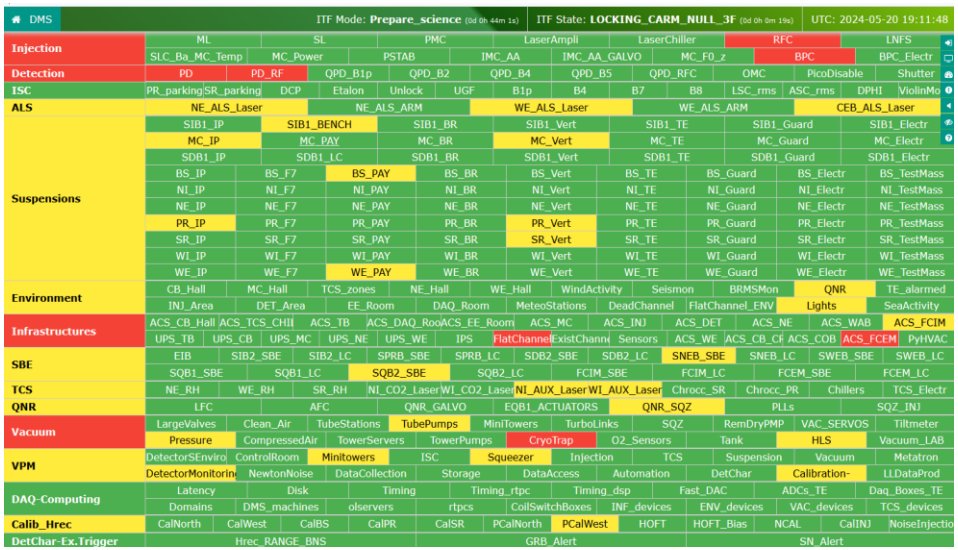
- 3 shifts / day (7:00-15:00, 15:00-23:00 and 23:00-07:00)
  7 days / week

  → Full 24/7 coverage in control room

- Support to experts to configure and tune the Detector Monitoring System

- Re-defined / updated access rules to the technical/experimental areas

  → VIR-0282A-24



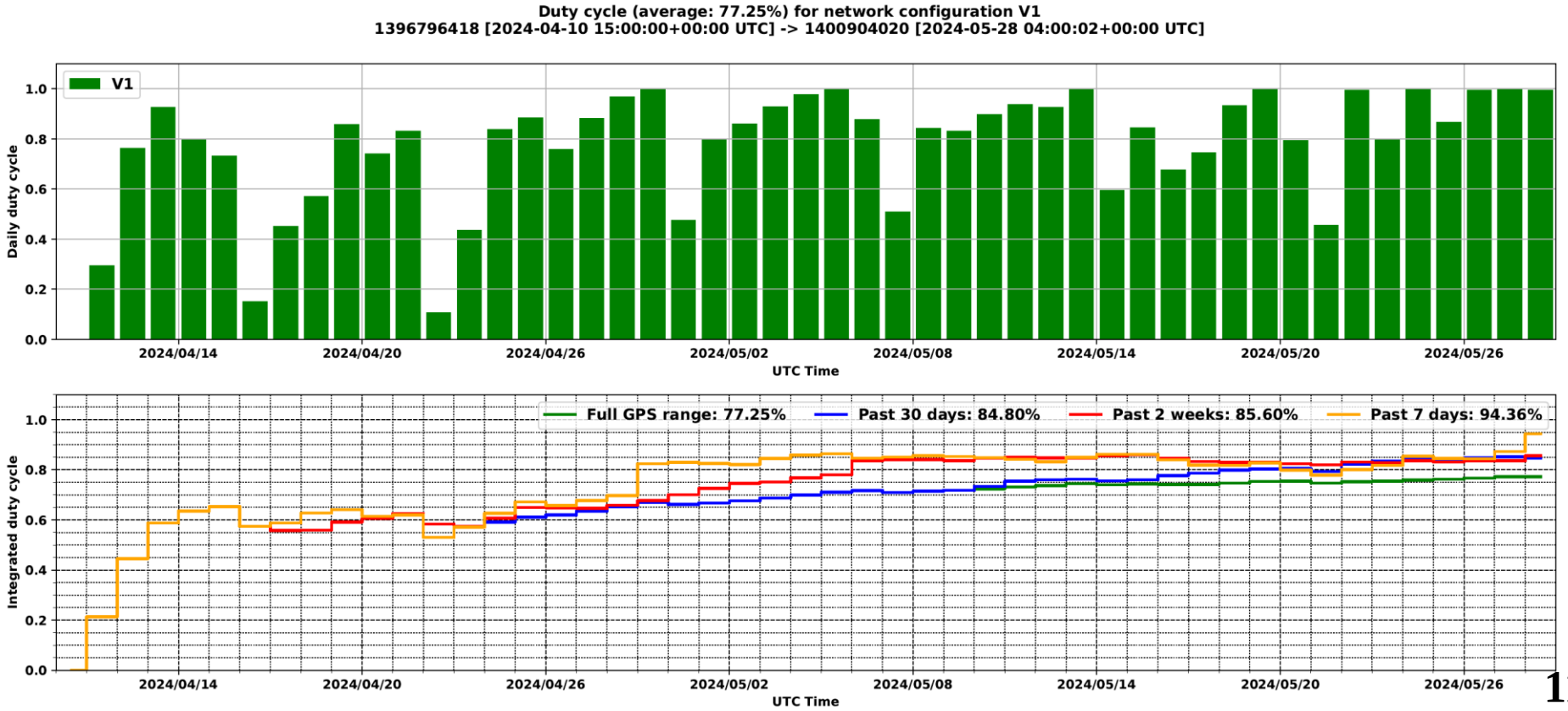
O4b Virgo status

- Rough start with a handful of new (and unrelated) hardware problems
  - First two weeks: duty cycle ~60%

  → All fixed

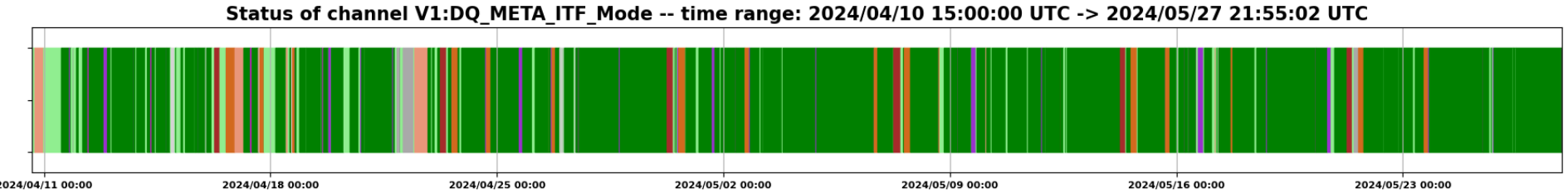
- Since then (five more weeks): duty cycle much higher and still growing in average

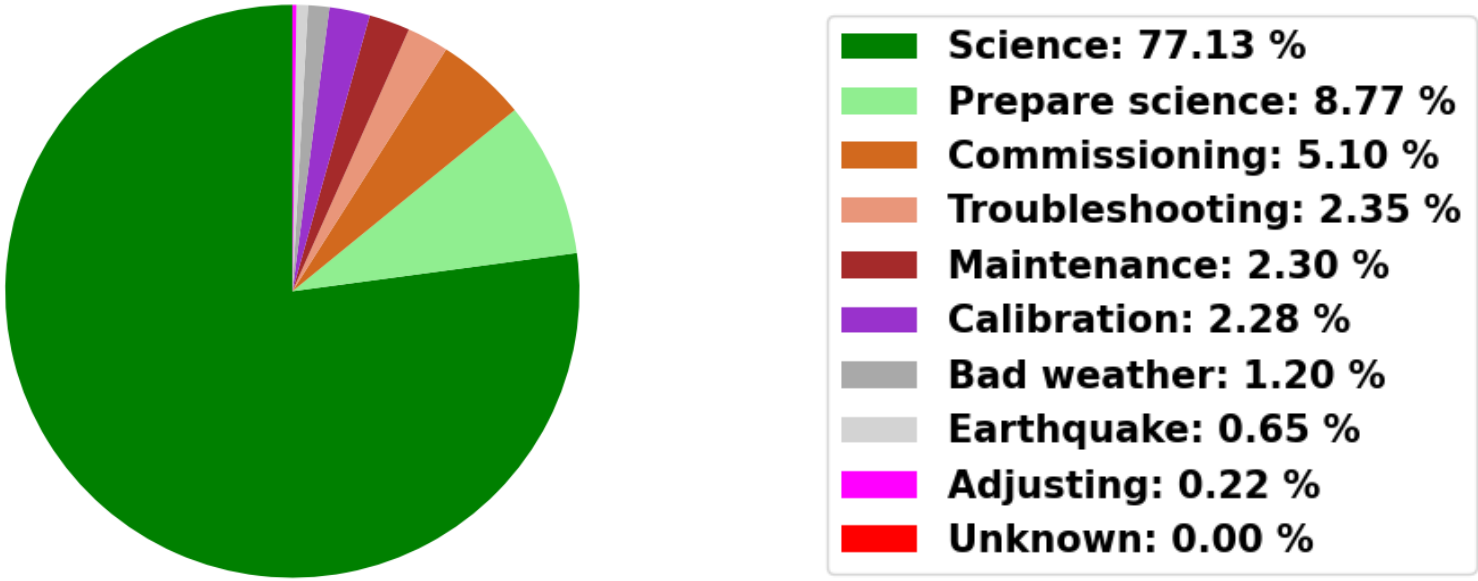
  → No hardware problem, continuous monitoring of transient issues, good weather



O4b Virgo status

- Duty cycle summary



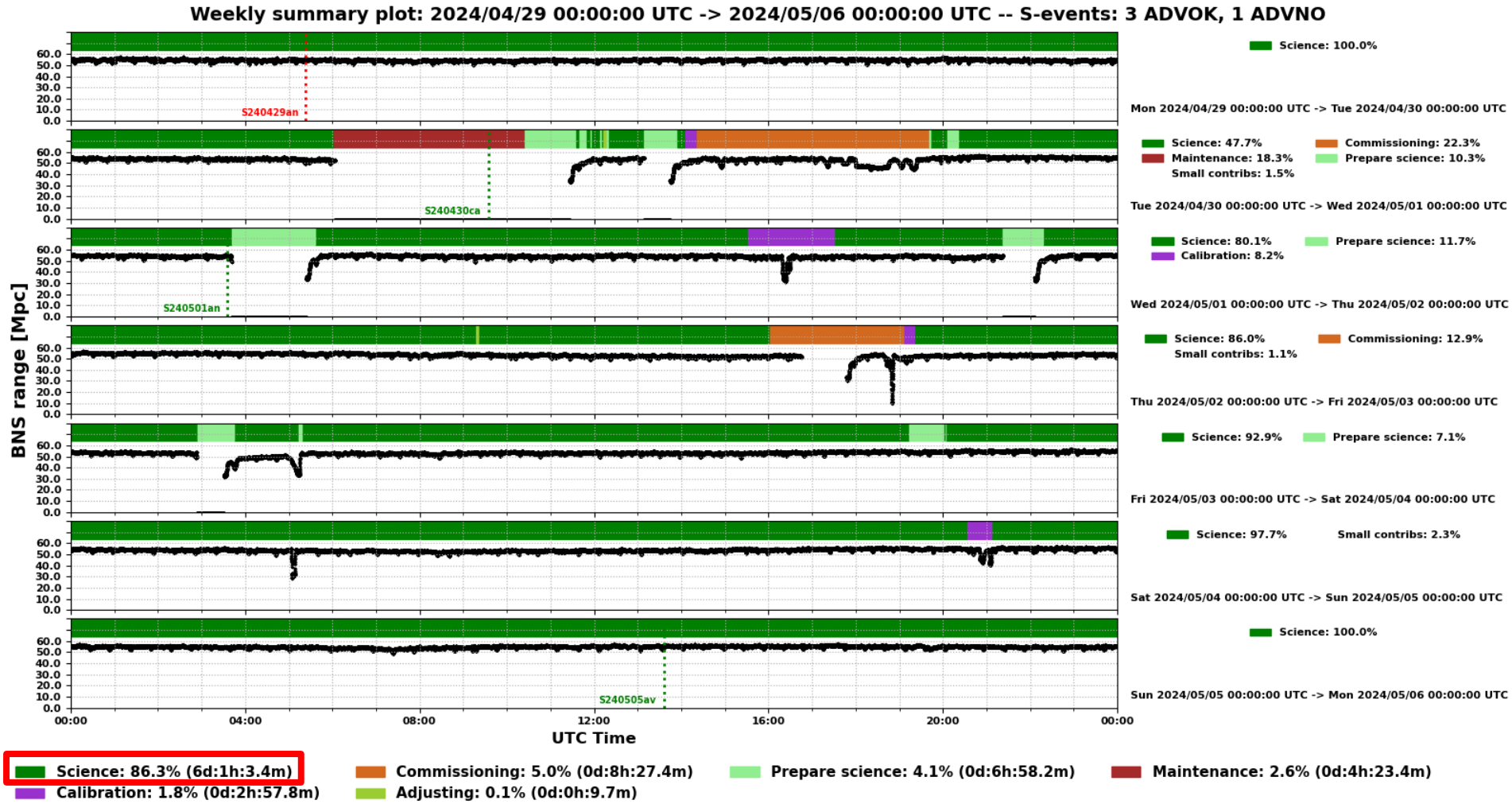


→ Updated list of detector "modes": improving our automated monitoring

- Added ones: "Prepare Science" (goal: take data), "Bad weather" and "Earthquake"
- Detector states not specific of a given mode have been removed
  - "Locking", "Locked": not informative about what the current mode is

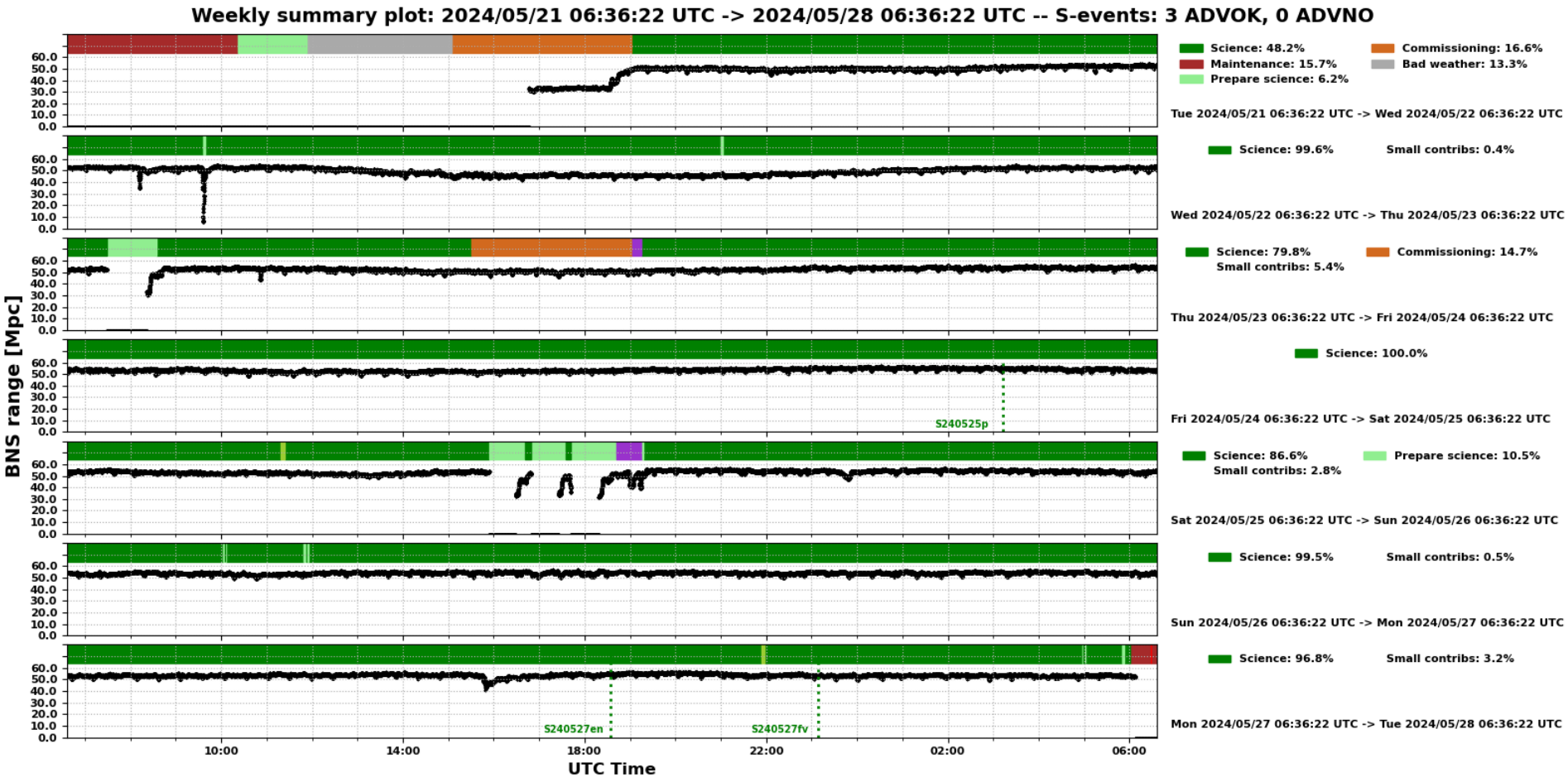
Best 7 days in O4b so far

- Monday April 29th → Sunday May 5th



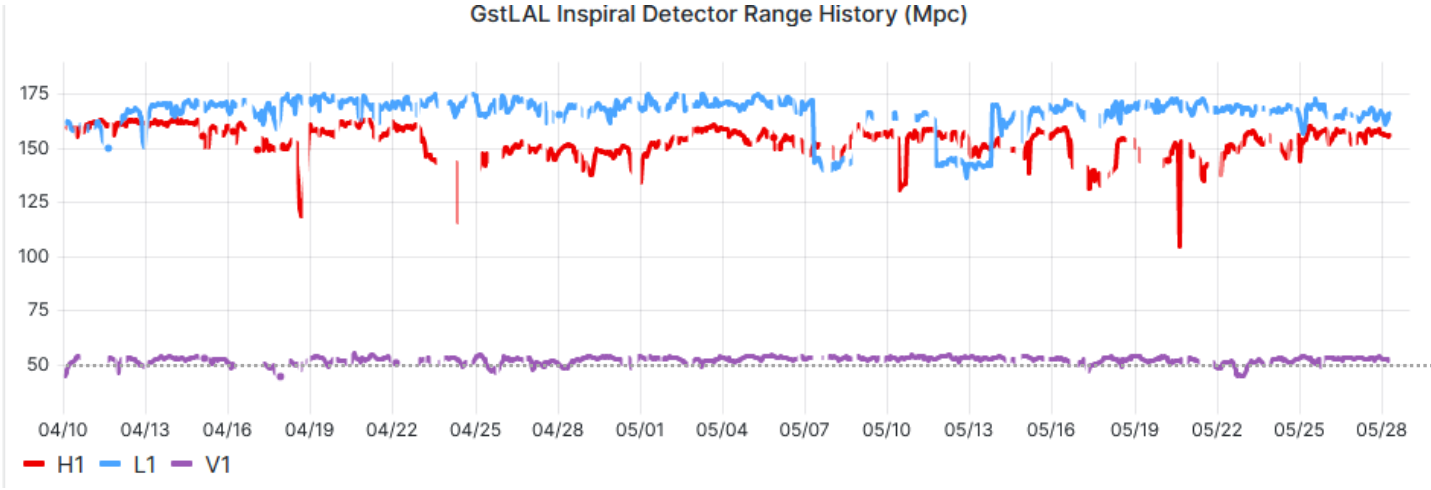
Past 7 days

- Slightly better in terms of duty cycle
  - But no calibration slot: yesterday was an holiday in the US

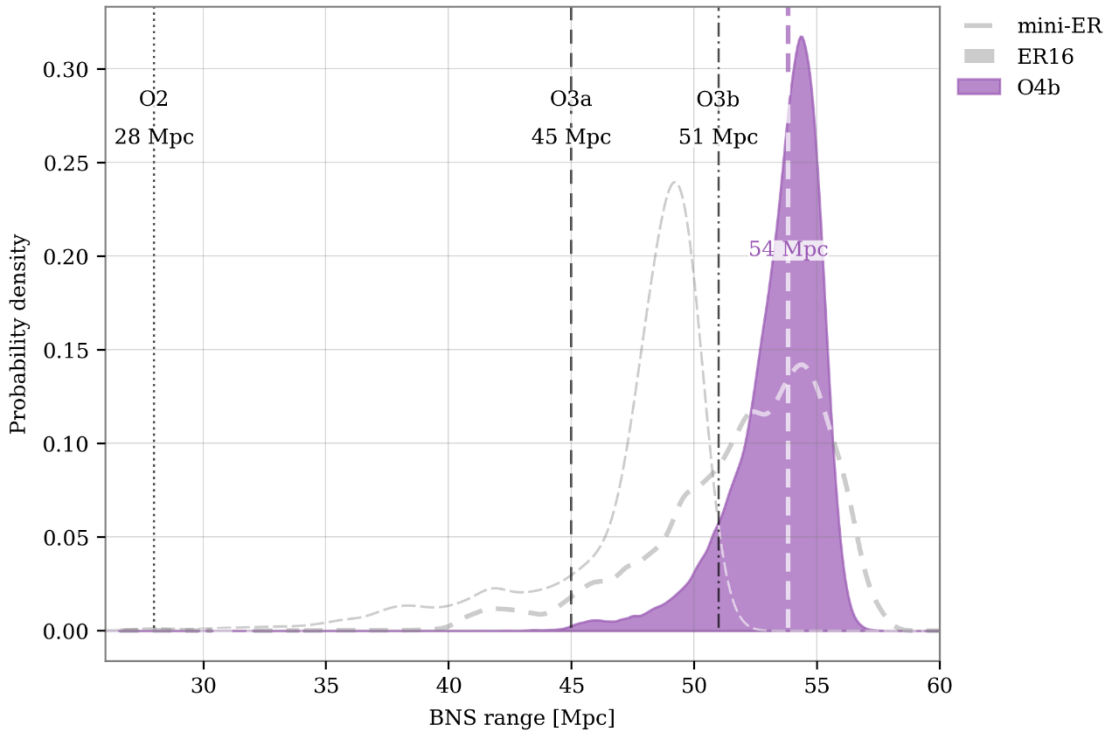


O4b Virgo status

- BNS range
  - Data from the new version of gwistat: online.igwn.org [Public website]



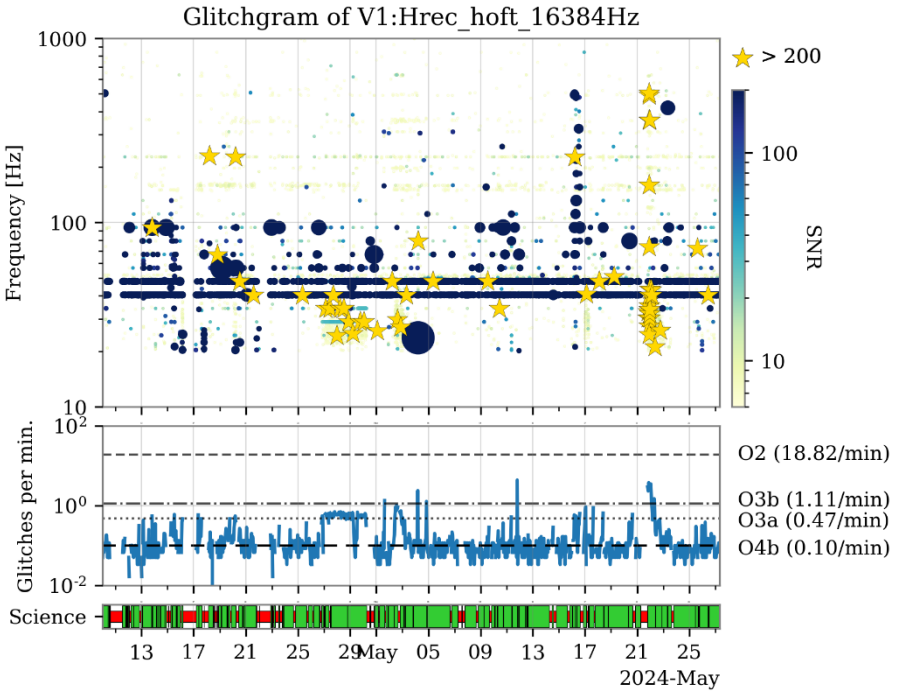
→ Virgo range quite stable between 50 and 55 Mpc

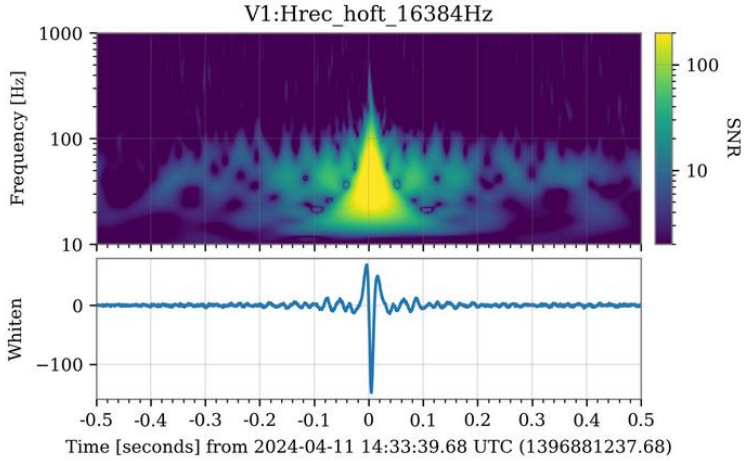


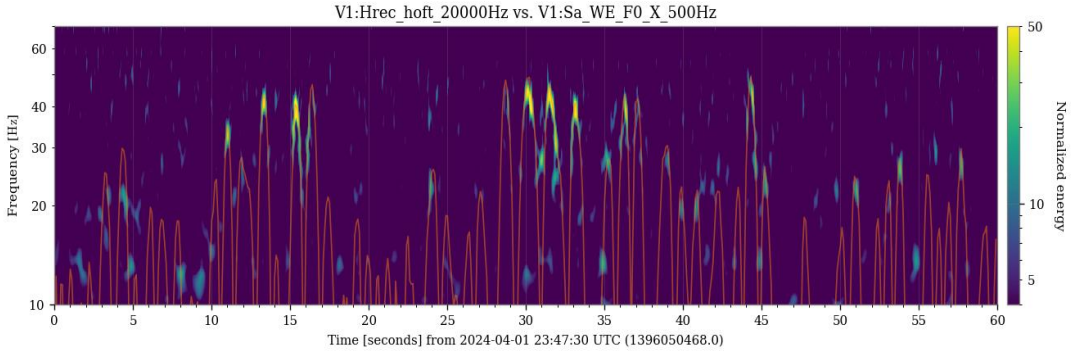
Data quality: transient noises (“glitches”)

- Reduced glitch rate compared to O3
  → 0.10/minute vs 1.11/minute

- Only two known families of glitches
  - 25-minute glitches
    - Impacted Virgo data for a recent event
    → Investigations to continue via a dedicated taskforce, now that the start of O4b is behind us
  - Scattered light
    → Only during bad weather



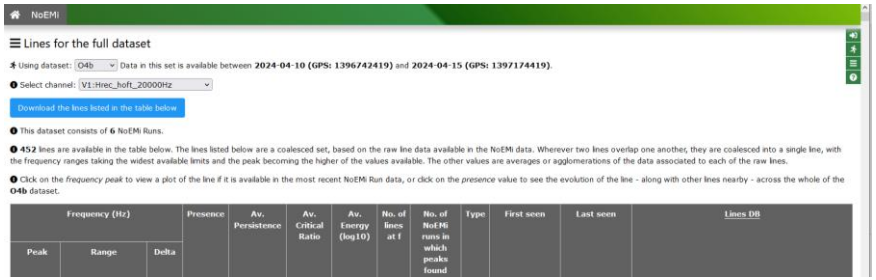


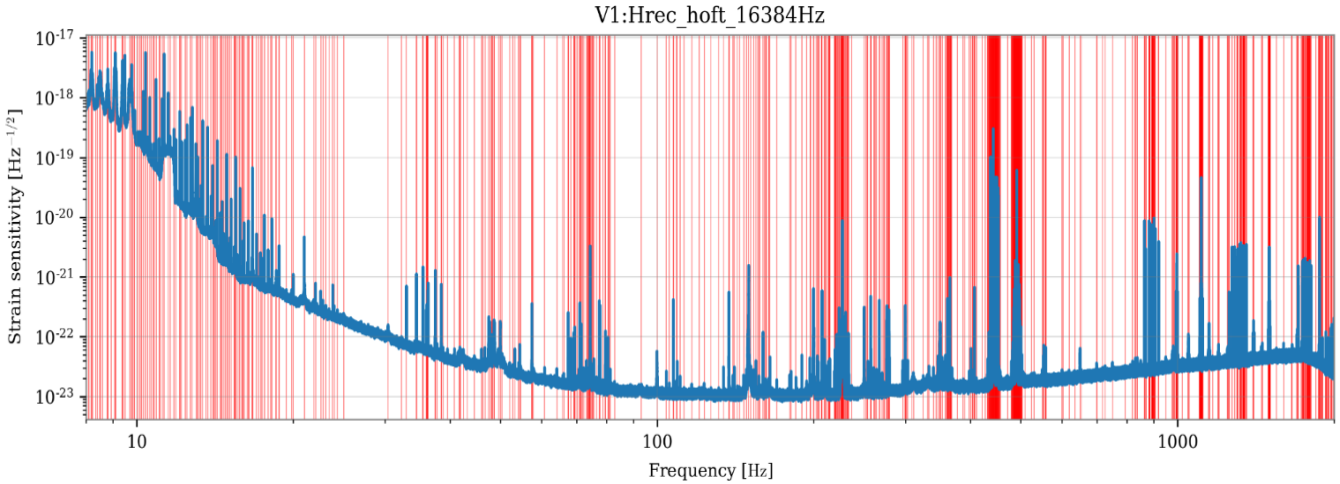


Data quality: spectral lines

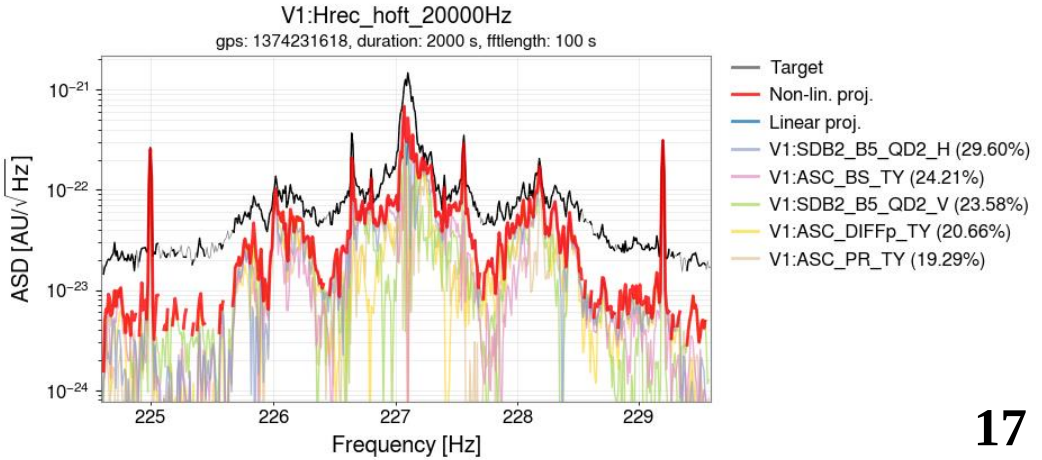
- Spectral lines identification
  - Inputs from different, complementary tools

  → O4b Catalog in progress



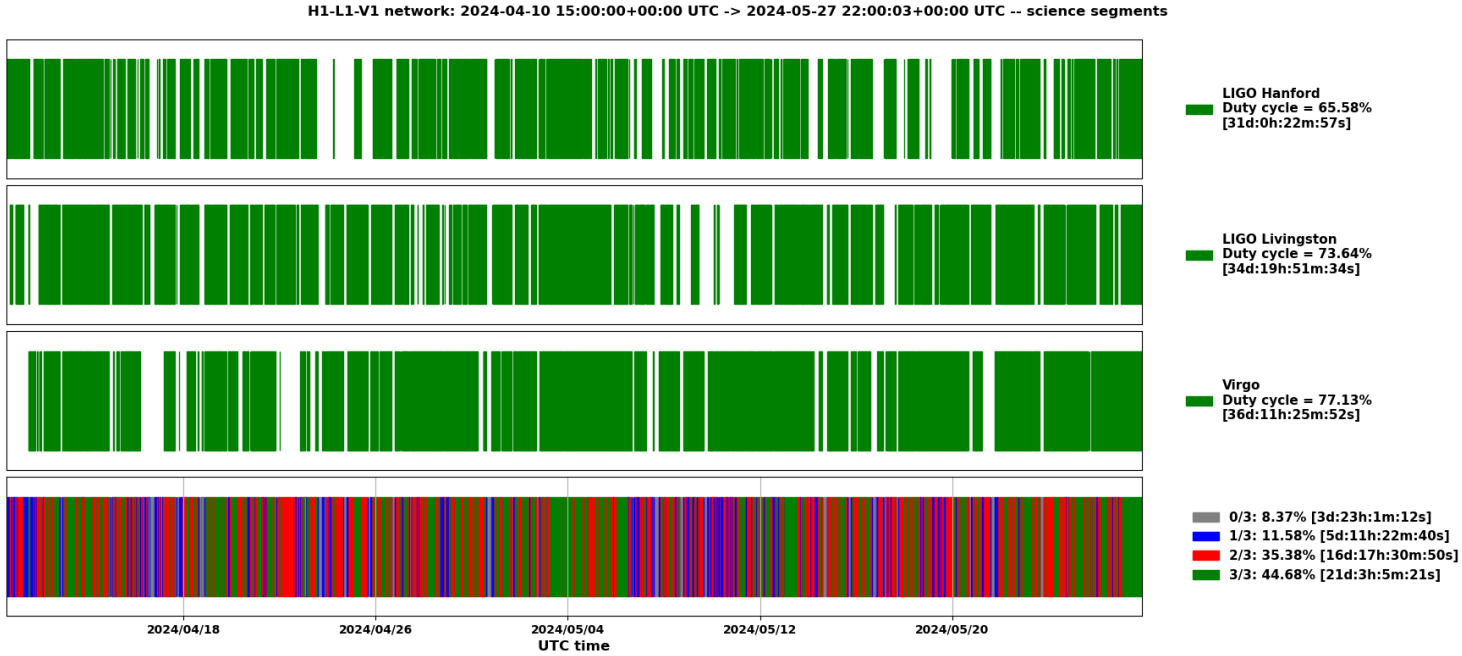


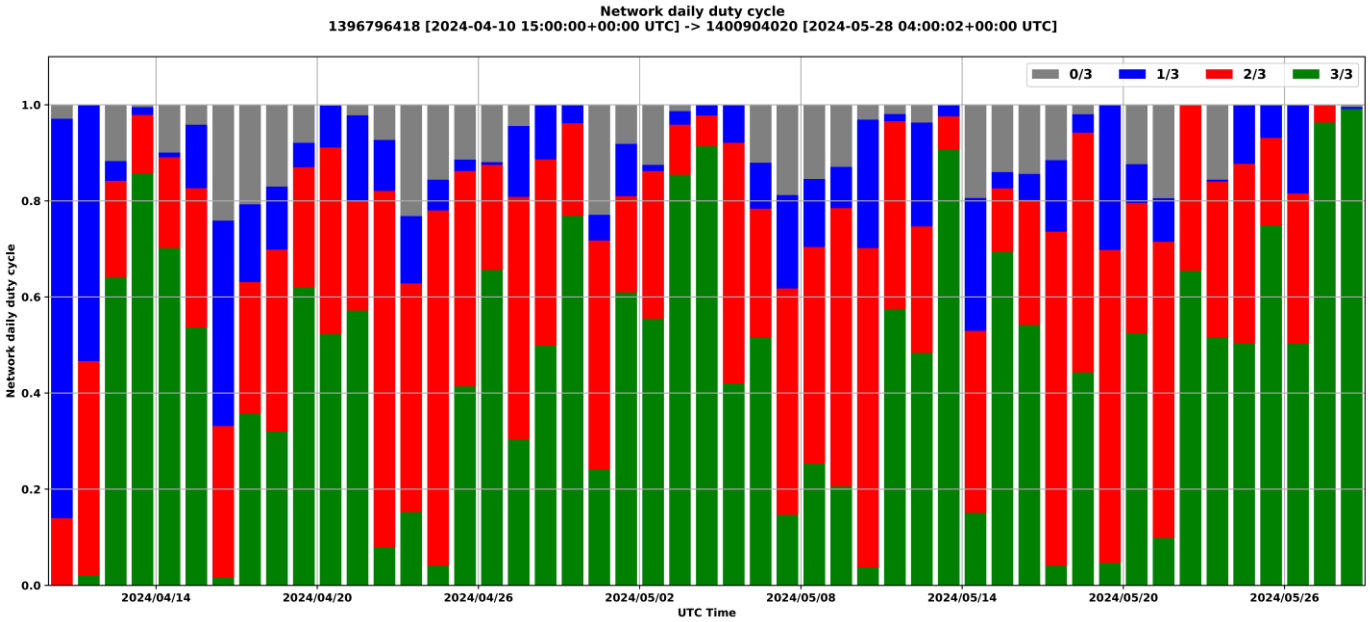
- Characterization of bilinear noise
  - Sidebands



O4b LVK network

- Duty cycle

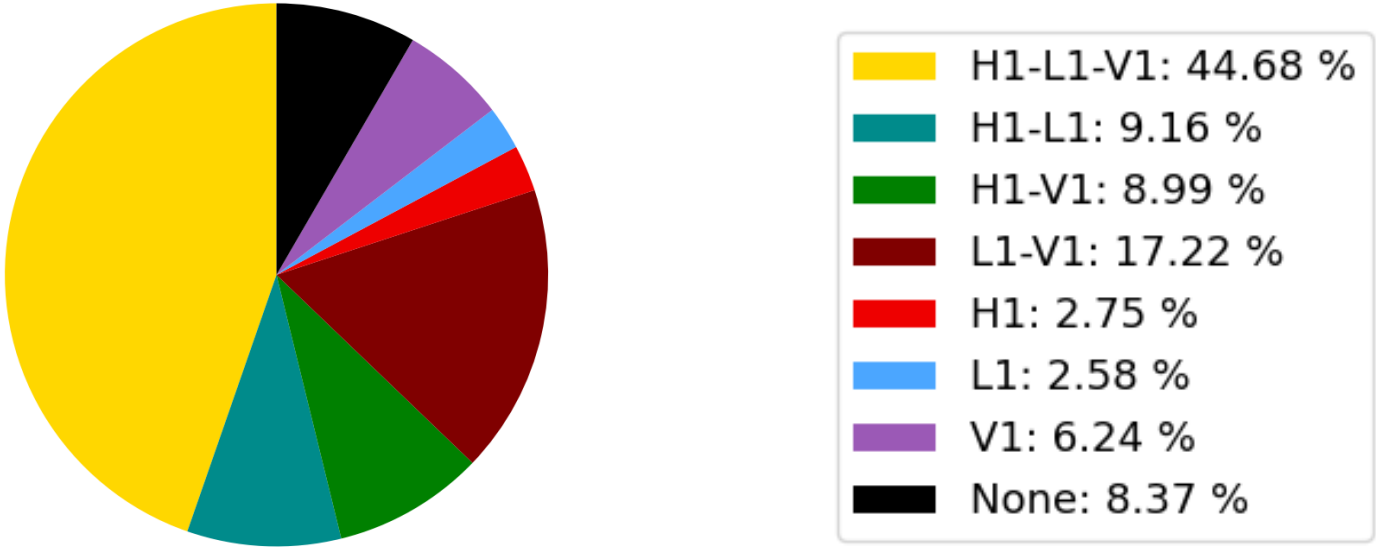


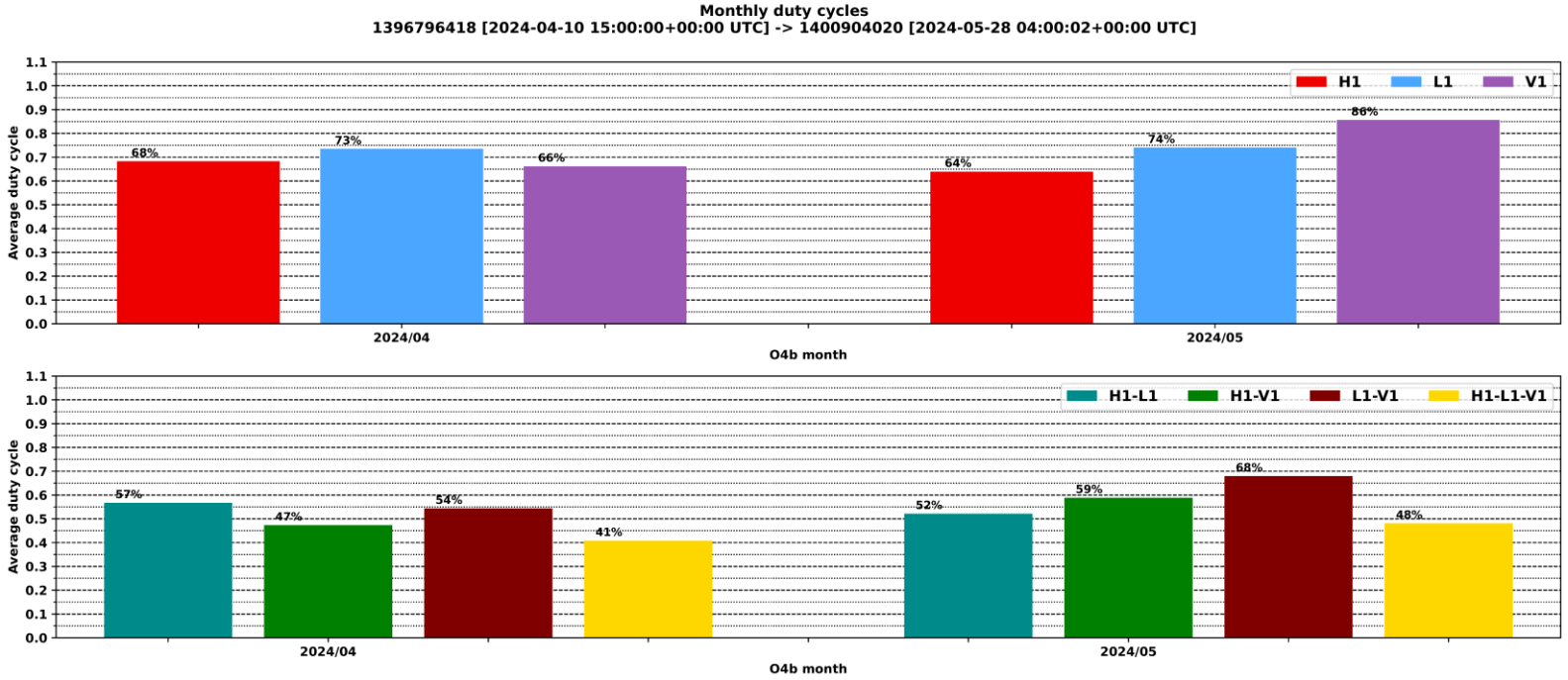


Past day: first with 100% 3-detector duty cycle

O4b LVK network

- Duty cycle





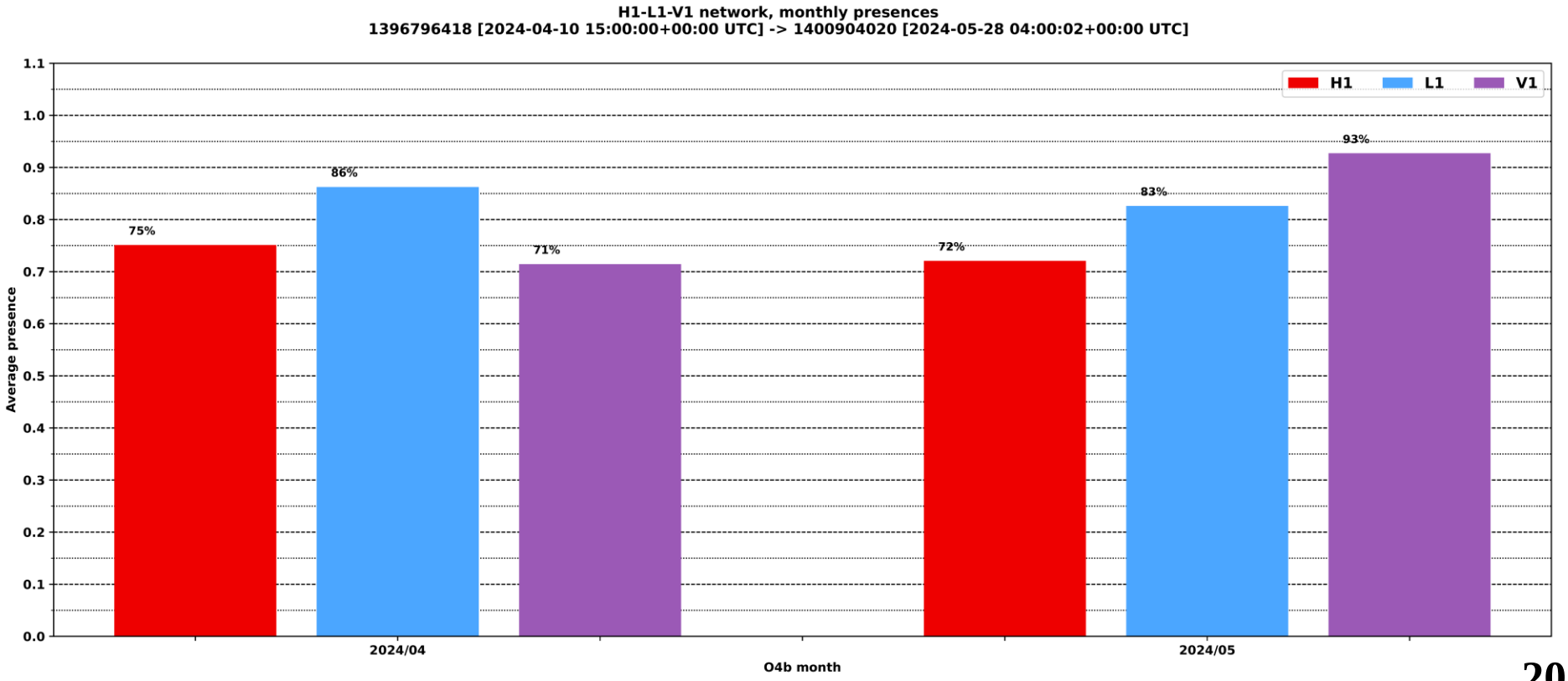
O4b LVK network

- "Presence" of a detector
  - (3-instrument duty cycle) / (2-instrument network w/o that detector duty cycle)

    → The higher the better

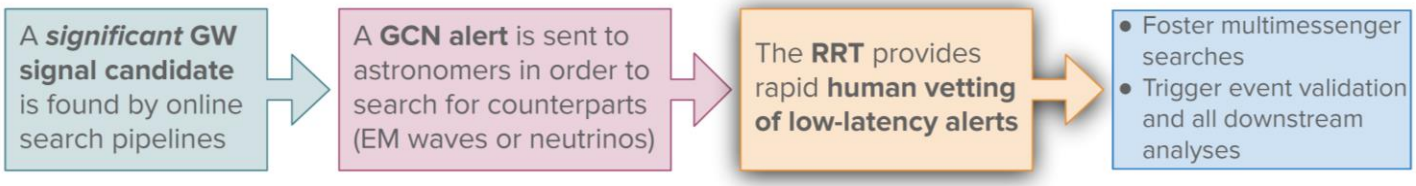
    → Reflects both the (good) performance of that detector

    and the (bad) performance of the other two instruments

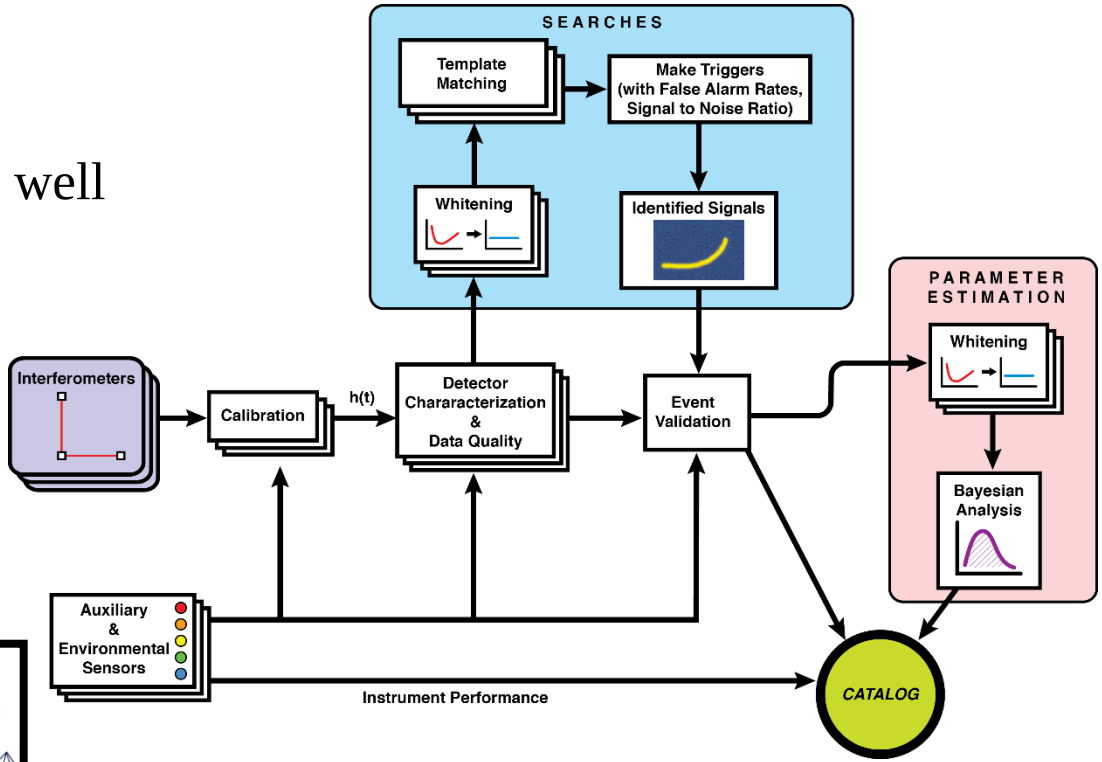


Public alerts

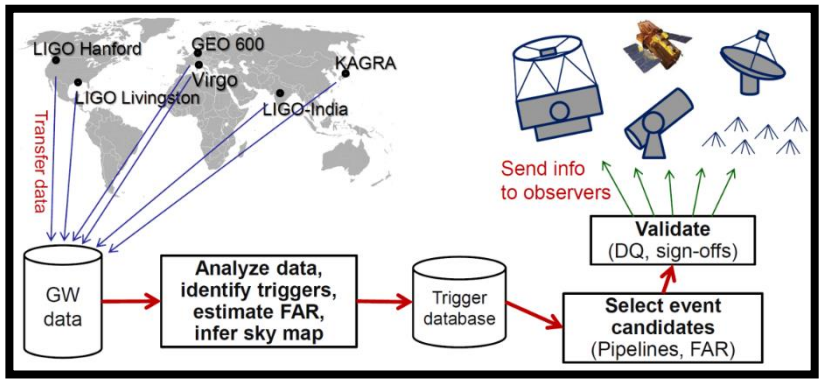
- Low-latency alert workflow



- LVK data analysis framework
  - Applies mostly to low latency as well



- From detectors to alerts
  [Old plot]



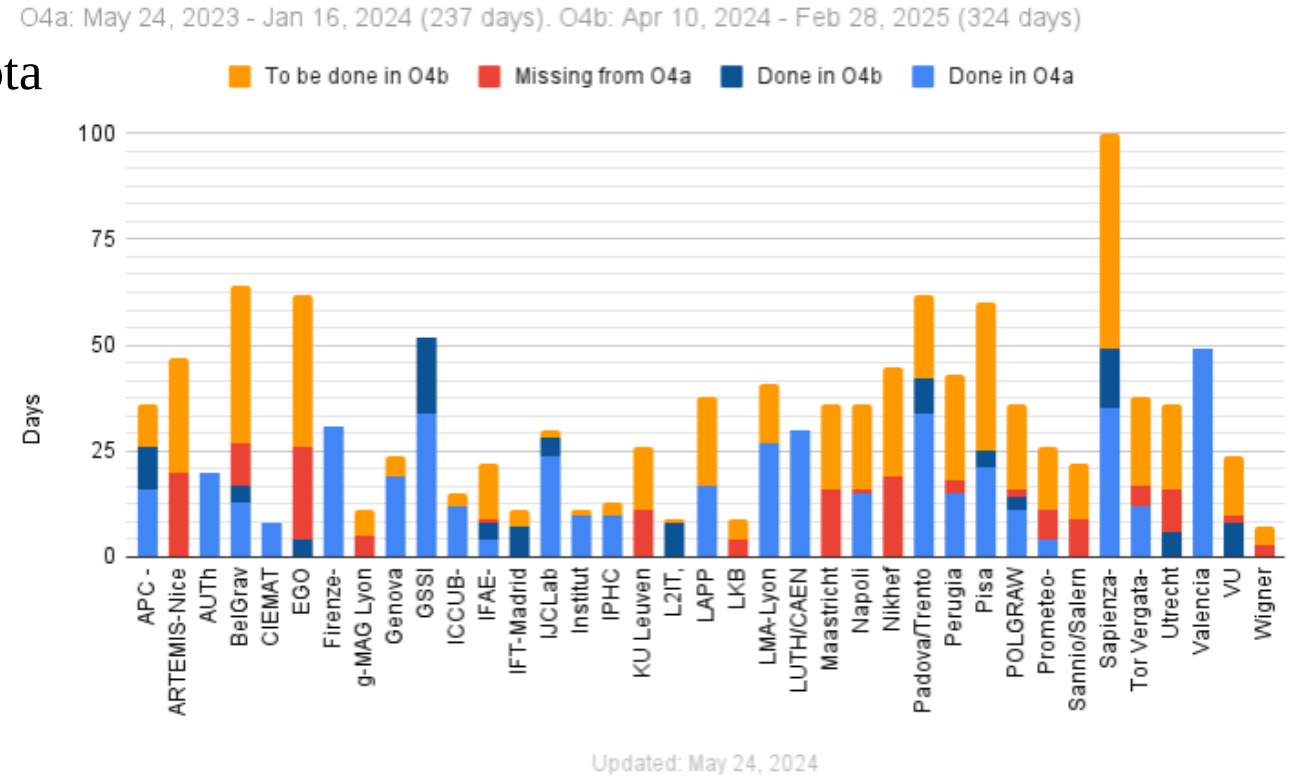
Rapid Response Team (RRT)

- Solid infrastructure and excellent overall performance
  - Relying on group contributions for shift coverage and mentorship of colleagues

- 93 individuals from 22 Virgo groups participated in O4a
  - 70% are Early Career Researchers: PhD and Postdocs

- 161 people on the O4b rota
  - 26 institutions

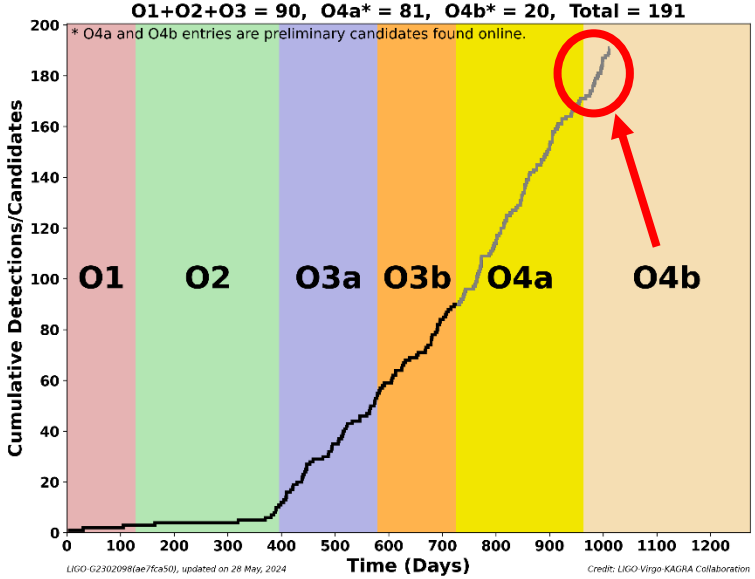
  → Significant increase coinciding with Virgo being part of the run



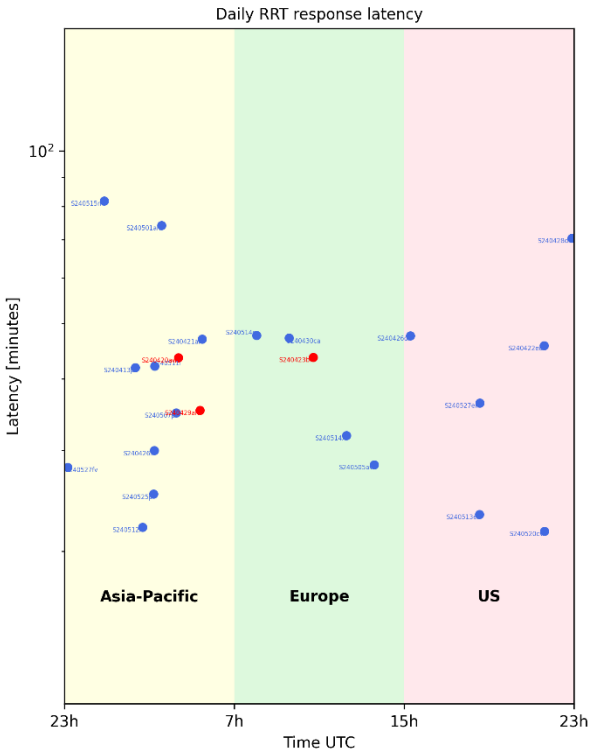
Public alerts

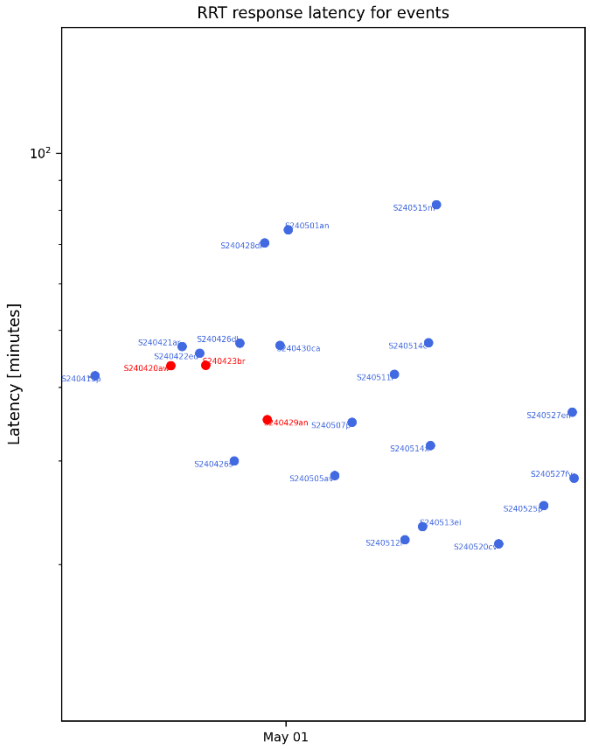
- O4b significant detection candidates: 20
  - 23 [total] – 3 [retracted]

→ https://gracedb.ligo.org/superevents/public/O4b



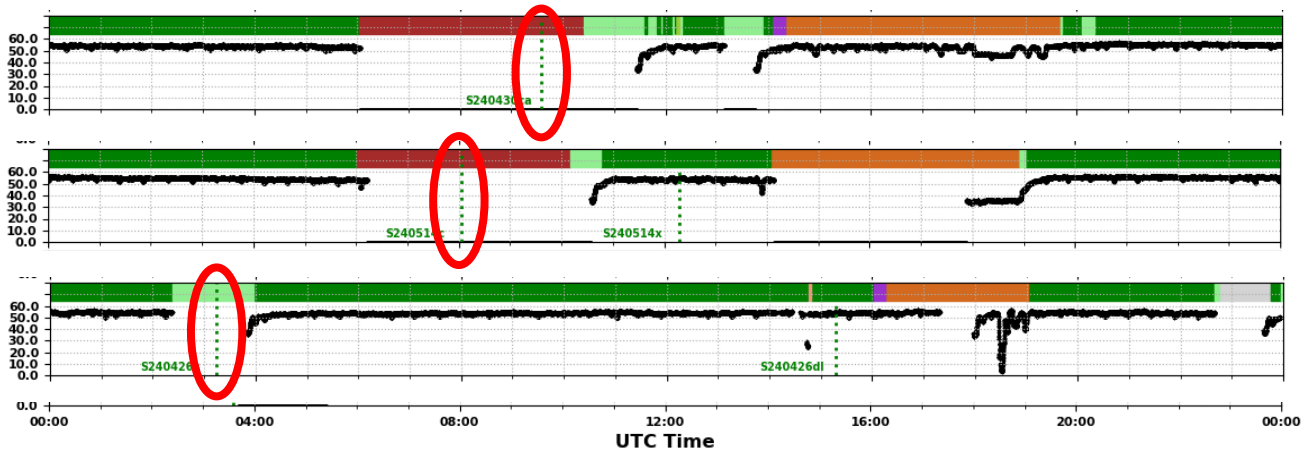
- Rapid Response Team (RRT)
  - Good alert processing and vetting by level-0 RRT (Lv0) shifters
    → A bit slow sometimes
  - Good level-1 expert (Lv1) coverage
  - Virgo Lv0 shifters schedule filled until August included
    → Good response from Virgo groups overall



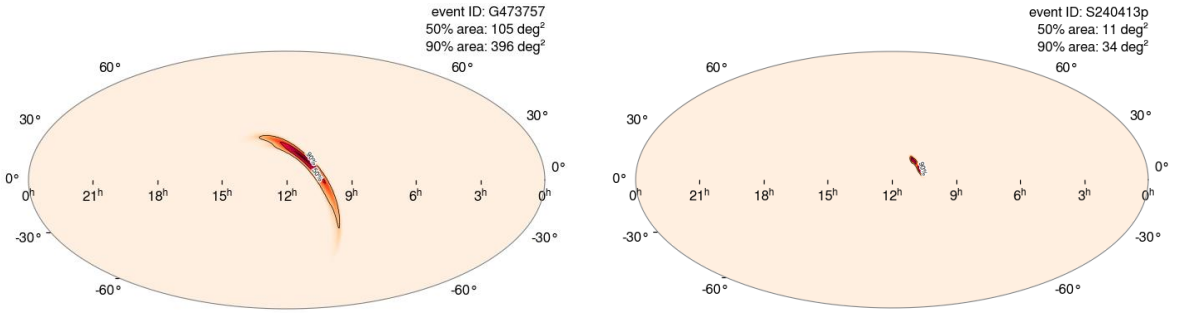


Public alerts

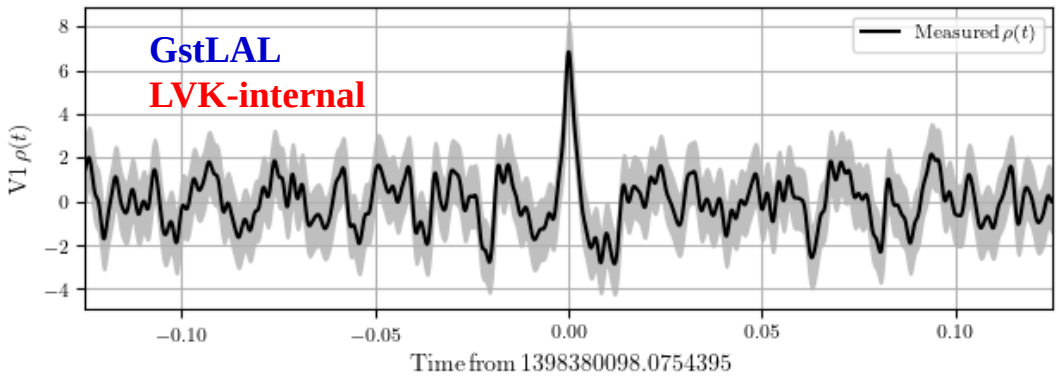
- 17/20 (85%) with Virgo
  - 2 during maintenance
  - 1 while relocking in between two Science segments



- Skymaps benefit from the addition of Virgo data to the LIGO trigger
  - S240413p high-profile due to its good localization
    → S240511i and S240513ei well-localized as well

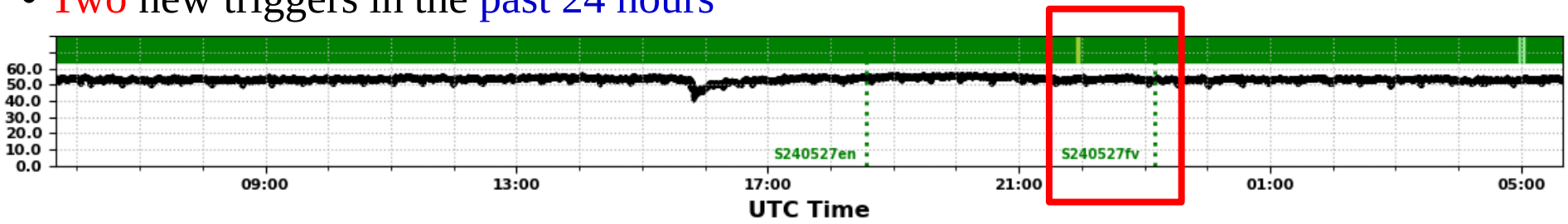


- S240428dr
  - Trigger: Hanford-single
    - Livingston down
  - Virgo SNR: 6.9
    → A record for Virgo if event confirmed offline

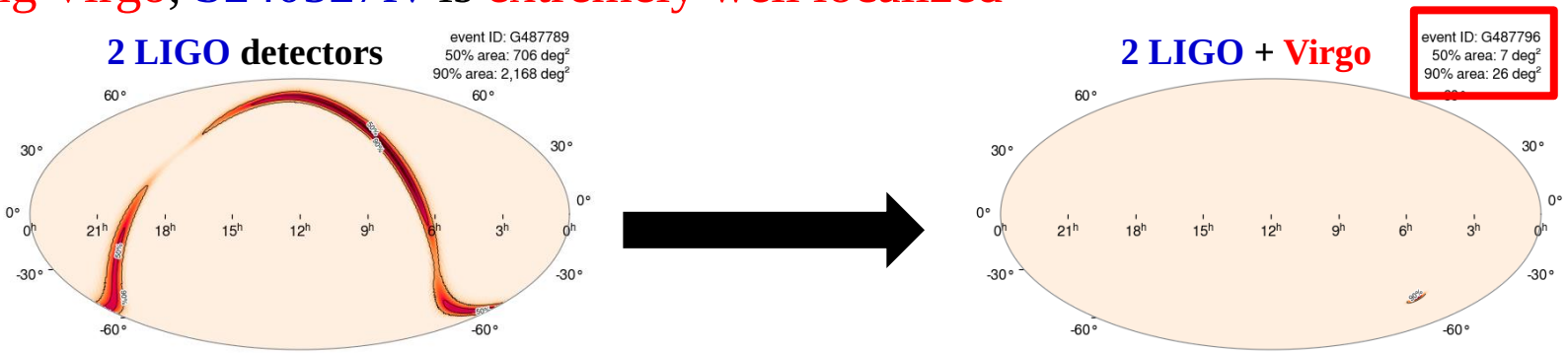


Public alerts: STAC special…

- Two new triggers in the past 24 hours

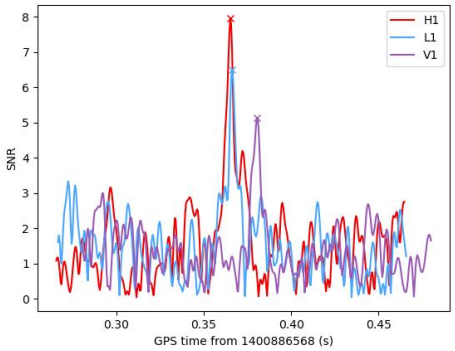


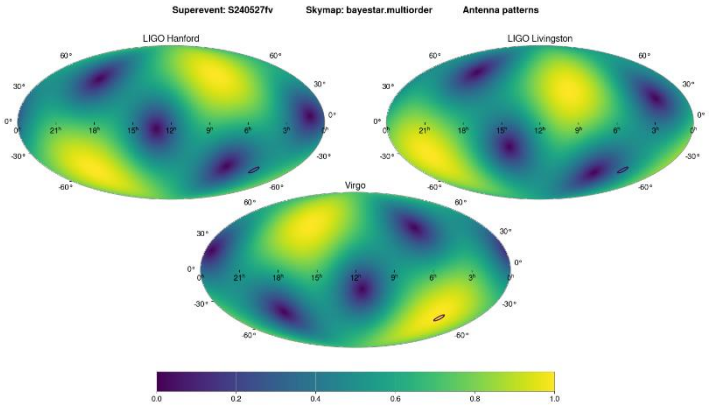
- Adding Virgo, S240527fv is extremely well localized



→ Balanced SNRs require a particular combination of antenna patterns

  - Only possible in a small area in the sky





Public alerts

- Good Data Quality Report (DQR) performance overall
  - Tool used to vet data quality for all event candidates – in particular in low latency

  → No problem with data availability at EGO, nor data transfer in low latency

- Two problems identified since the beginning of O4b

  → Mitigation in place: very quickly

  → Proper fix taking time: requires code writing, testing and update to production
  - Need to protect from an online pipeline misbehaving and sending many alerts passing the DQR triggering cuts in a short amount of time

    → Filesystem stress at EGO may have lead to one control loss: data not flowing properly internally
    - Currently, each alert is processed independently from all the others
    - LIGO not willing to address that problem in the common part of the framework

      → To be done at the Virgo DQR level
  - LVK code used to transfer DQR results to the central CIT location to be improved, to avoid interference between DQRs running in parallel on the same event

    → 1 occurrence: prevented transfers from EGO to CIT during 10 minutes
    - No impact on the DQR running at EGO, only on the results transfer
    - Code fixed, to be included in a future production release of the framework

To watch out: lessons learned so far

- Low-latency h(t) reconstruction at EGO for online gravitational-wave searches
  - Need to provide h(t) frames in a timely way even when the detector is down
    → Direct (thus sensitive) interface with LIGO through the low-latency pipelines
  - Monitor latency + study its fluctuations + mitigate/fix their causes
  - Check low-latency h(t) frames when leaving the DAQ
    → Fix their contents (by putting down all bits of the state vector) if needed

  - Enforce rules to act on that (and other) critical part(s) of the Virgo framework
    - Any work should be announced and cleared
      by control room / coordinators before it may start
    - Use test systems/dataflows to not interfere with production Hrec
    - Once the activity is completed, monitor the system
      until back to nominal Science data taking

- Follow-up on errors done while steering Virgo
  - Update documentation, improve procedure, implement protections, etc.

- Complexity of the low-latency system
  → Difficulties to implement changes coherently

Computing update

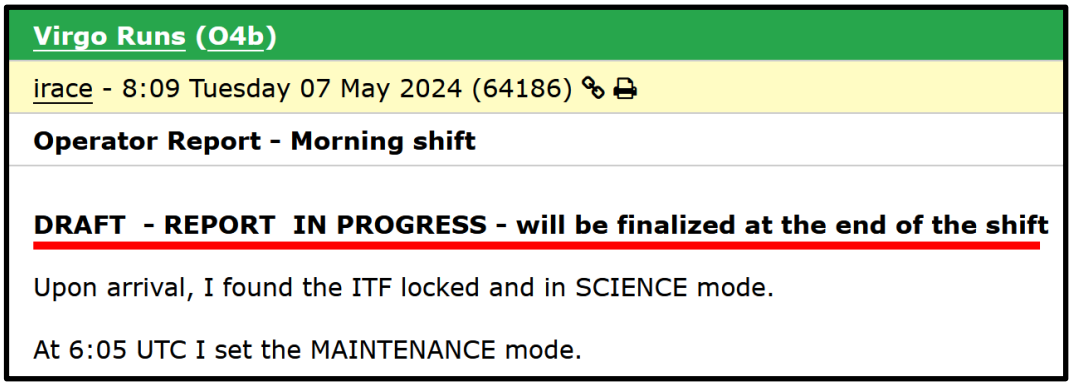
- Low latency data distribution
  - Up and running in production mode using jointly developed lldd library
  - Spikes in latency in low latency Virgo data are being addressed
  - Virgo frames missing strain data solution being tested
    into the offline End-to-End Archival data replay setup
- Raw data transfer: data flowing with good performances at CNAF and CCIN2P3
  → Common efforts to reduce the raw data flux have helped in achieving this result
- Bulk data distribution
  - Prepared OSDF/CVMFS Louvain origin infrastructure working as expected
    and transitioned successfully to Rucio technology for aggregated h(t) data transfer
  - After dedicated tests with the Calibration group, ready to support the Analysis
    Ready files (for offline analyses) transfer, using the same infrastructure
- Low Latency pipelines
  - MBTA and cWB are running nominally and contributing to events discovery
- CVMFS-based file network system at EGO to improve performance
- Offline computing: nothing critical – no major resource contention seen nor expected
  - Data distribution infrastructure evolution ⇒ shift towards distributed computing

DetChar group status update

- Organization: a solid infrastructure inherited from O3 plus some novelties
  - Weekly meeting
  - Wiki pages
  - Two, recently started, gitlab projects
    - Tasks: monitor ongoing activities and ping DetChar intervention
      → Foster interactions among Data Analysis and Commissioning groups
    - Help for newcomers: request assistance from experts or discuss common issues
- Composition
  - Based on Virgo Member Database – does not necessarily reflect reality (worse!?)
  - 27 members, for a total of 7.25 SVAC
    → 0.27 SVAC/person – 0.47 in Data Analysis, 0.24 in post-O5 R&D
  - 17 different institutions : 1.6 people/institution
    → Reduced knowledge transfer and limited mentoring possibilities
- O4b core activities
  - Continue the support to Commissioning and detector Operations
    - Monitoring and investigation of known issues
    - Prompt investigation of new noise sources
  - Data-quality products for low-latency and offline searches – including final dataset
  - Event validation – jointly with LIGO (and KAGRA)

Other news

- Live operator report from ongoing shift now available on the logbook
  - Temporary solution for now
    → Work in progress towards a more permanent one


Virgo Runs (O4b)

irace - 8:09 Tuesday 07 May 2024 (64186)

Operator Report - Morning shift

DRAFT - REPORT IN PROGRESS - will be finalized at the end of the shift

Upon arrival, I found the ITF locked and in SCIENCE mode.

At 6:05 UTC I set the MAINTENANCE mode.

- Calibration and Hrec approved by Virgo review committee for O4b
  - Following provisional sign-off for ER16

- Rhys Poulton (EGO) replacing Duncan MacLeod (LIGO) as chair of the Software Control Change Board (SCCB)
  → Rhys and Duncan swapping their positions in the SCCB
  - Need to follow up closely the possible evolution of the SCCB
    - "Friction" (sic) added to the system with the goal of limiting mistakes
    - Tendency to make the SCCB procedure more invasive, more complex and compulsory for any software change
  → Need to find (and keep) a balance between efficiency and burden

- 7th GWOSC workshop took place mid-April
  - https://gwosc.org/odw/odw2024 + Lessons learnt: https://dcc.ligo.org/G2401025

Outlook

- Virgo started O4b on time and is committed to be part of the whole data taking period
  - Discussions have started about a possible extension of the run
    → May impact the schedule of tests to be done on a stable O4b-optimized detector

- Excellent duty cycle so far
  - Virgo Science data available for most low-latency alerts
    → Improve sky localization
  - Optimized LVK / run + commissioning planning to maximize 3-detector uptime
    - "Drawback": no detector observing up to ~10% of the time

- Focus on monitoring performance and improving things where possible

- All run-related working groups performing well

- Personpower remains limited but some balance has been found
  - Focus on critical areas
  - Priorities driven by issues identified and investigations done during the run

→ We'll see what Summer and Fall bring us, but Spring doesn't look bad so far!