

# Short status of the O4b run

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## EGO Council

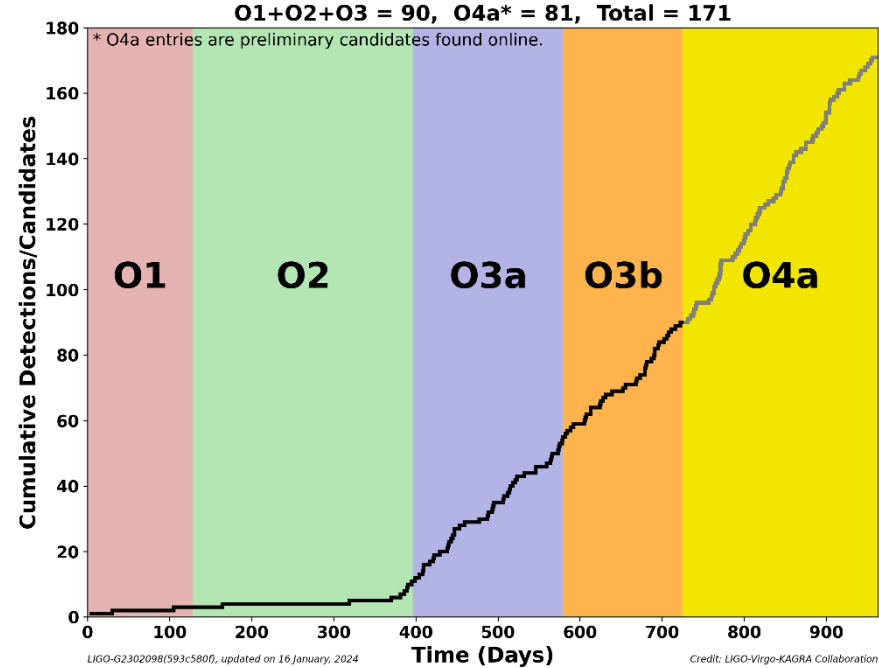
## Open session – April 18<sup>th</sup>, 2024

### VIR-0349A-24



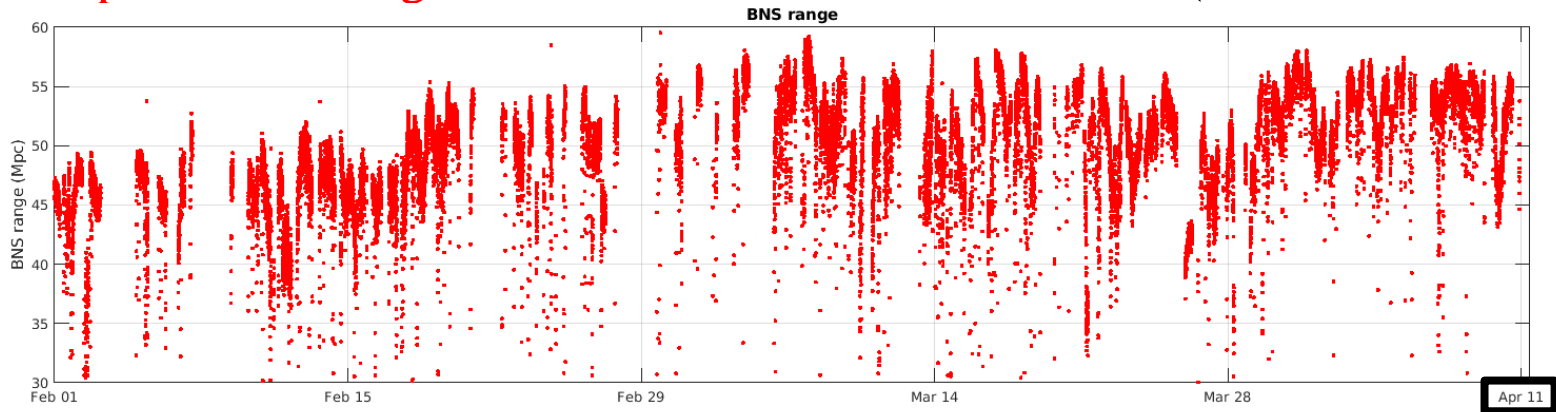
# O4a: 1-slide summary

- 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
    - ◆ **Unlikely to be used** during O4a
- **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!



# Commissioning summary since last Council

- BNS range **steadily above 50 Mpc**, regularly above 55 Mpc and peaking at 60 Mpc
  - Signal recycling cavity misaligned to increase optical gain
- **+15 Mpc in BNS range**, at the cost of reduced bandwidth ( $\sim 400$  Hz  $\rightarrow$   $\sim 200$  Hz)

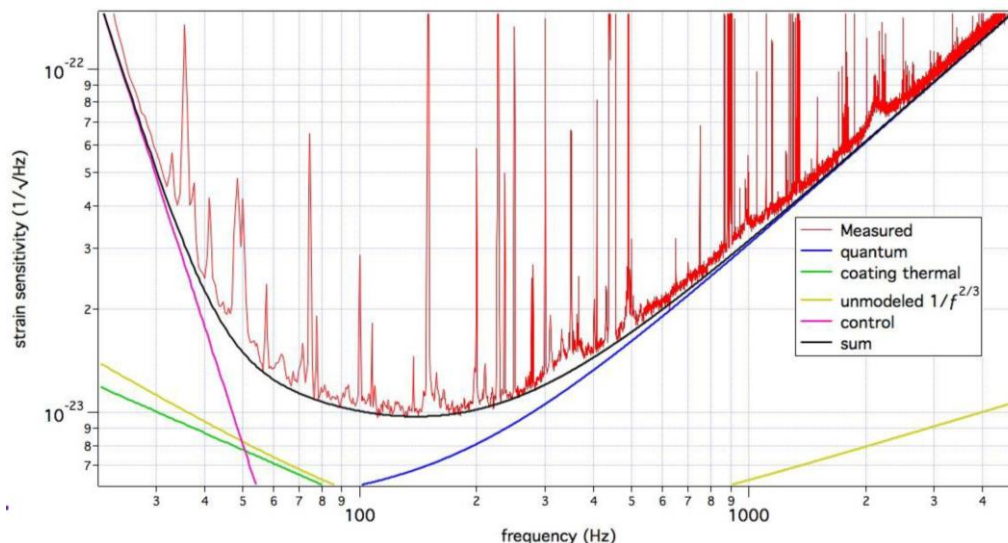


- Input laser power raised from 15 to **18 W** beginning of February
- Main actions
  - Improve the **robustness** of the interferometer global **control**
    - Progressive **restart** of **all control systems** over few weeks
      - ◆ **Issues found and fixed before O4b**: mitigate power outage consequences
  - Efficiency of the **frequency-independent squeezing**
  - Noise hunting
    - In particular the  $1/f^{2/3}$  “**mystery noise**”
  - **Code freeze** and **software cleanup**; monitoring & alarms

Fiodor Sorrentino  
Michal Was  
Diego Bersanetti

# Detector status at the beginning of O4b

- **Sensitivity** explained by the sum of
  - Quantum noise
  - Coating thermal noise
  - Control noise
  - $1/f^{2/3}$  mysterious noise→ **Costing about 15 Mpc in range**, according to the **noise budget**



→ **Sensitivity similar to O3b**: slightly better (worse) above (below) 100 Hz

- **Data are clean**: noise transient rate much lower than in O3
  - But “**25-minute**” **glitches still there** and their origin remains unknown
    - ◆ In spite of **many studies**: their hunt continues!
- **Recent issues with some suspensions**
  - **Duty cycle impacted**: control losses + longer control acquisition→ **Experts working on these problems**
  - ◆ **Mitigation first**, while **deeper investigations to find the origin of the problems**
- **Parallel work in progress**: **lessons learnt from O3-O4 commissioning**

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# Virgo O4b readiness

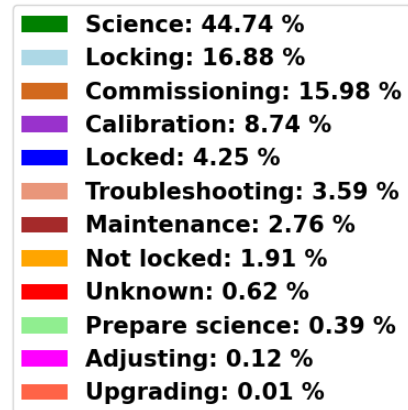
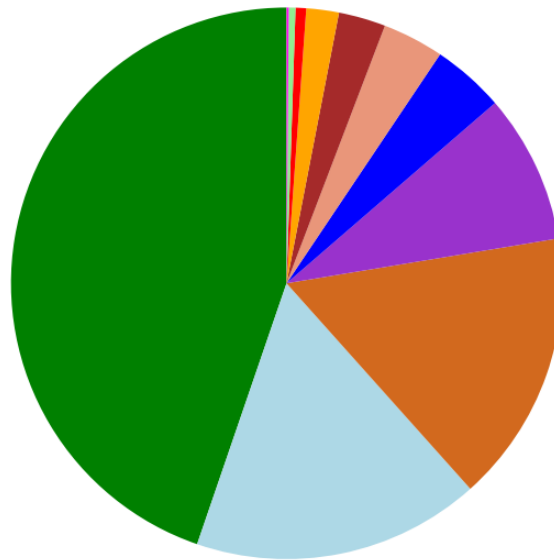
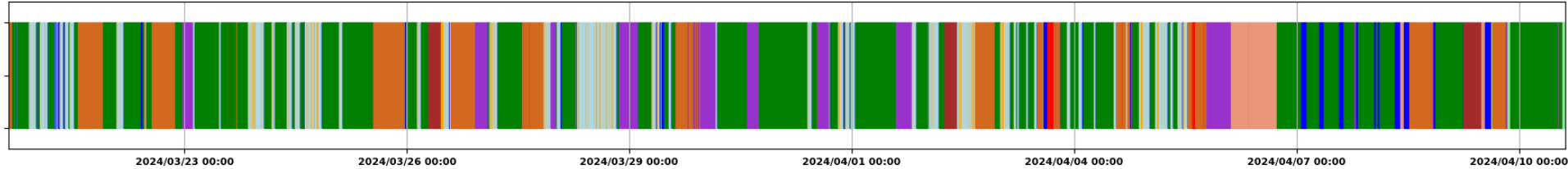
- 24/7 coverage in the control room
  - Crew of 7 EGO operators – minimum of 5 needed for one such rota
  - On-call experts provided by Virgo subsystems and Virgo working groups
- Joint low-latency alert infrastructure and online pipelines ready
  - 3 such pipelines with significant Virgo contributions
  - 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
  - O4b readiness built upon the solid infrastructure inherited from O3
  - New management tools to track activities, assign resources, interact with others

# O4b Planning

- Virgo to join O4b alongside LIGO from day 1 of this data-taking period
- O4b was scheduled to start on Wed. April 3<sup>rd</sup>
  - Delayed by a week: internet outage at LIGO Hanford on 05-07 April  
→ O4b has started on Wed. April 10<sup>th</sup> at 1500 UTC
- Preceded by Engineering Run ER16
  - March 20<sup>th</sup> → April 10<sup>th</sup> (April 3<sup>rd</sup> originally)  
→ Three weeks for final tuning
    - ◆ ↘ detector work (sensitivity + stability)
    - ◆ ↗ data taking
  - ◆ Low-latency pipelines need time to shape their backgrounds
- } As time goes
- Automated public alerts enabled on Wed. April 3<sup>rd</sup> 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

# ER16 summary: Virgo

Status of channel V1:DQ\_META\_ITF\_Mode -- time range: 2024/03/20 15:00:00 UTC -> 2024/04/10 15:00:00 UTC



- In summary

- Data taking: 45%
- Controlling the detector: 20%
- Commissioning: 16%
- Calibration: 9%
- Problems: 7%
- Maintenance: 3%

} Final pre-O4 detector activities

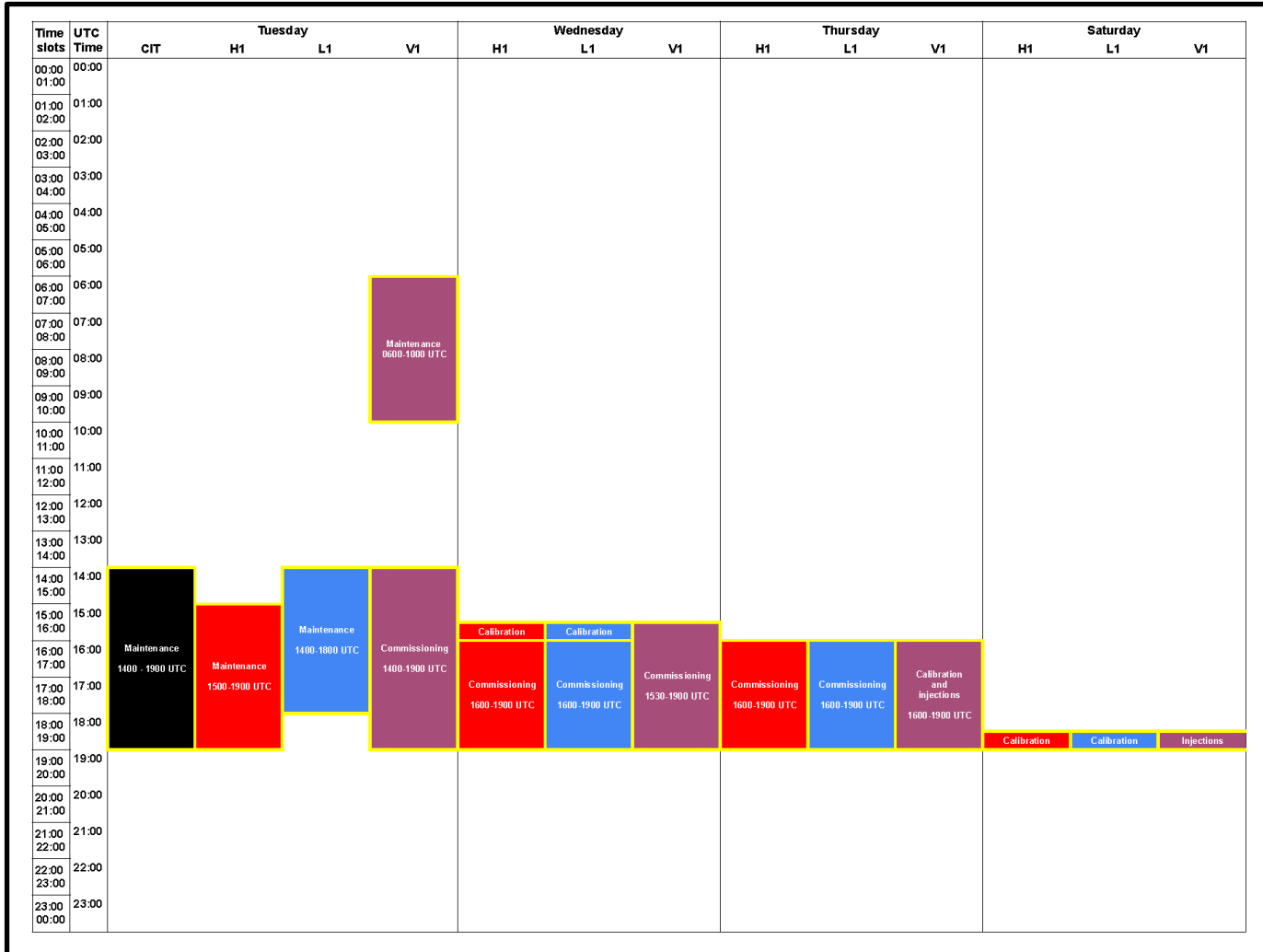
# Use of Virgo data

- Virgo data not to be 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 will be 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

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



- Downtimes / week**
- **Maintenance:**  
4 hours
  - **Commissioning:**  
8.5 hours max.
  - **Calibration:**  
3 hours max.
  - **Injections:**  
0.5 hour max.
- **Up to 10% of duty cycle**

# Plans during O4b

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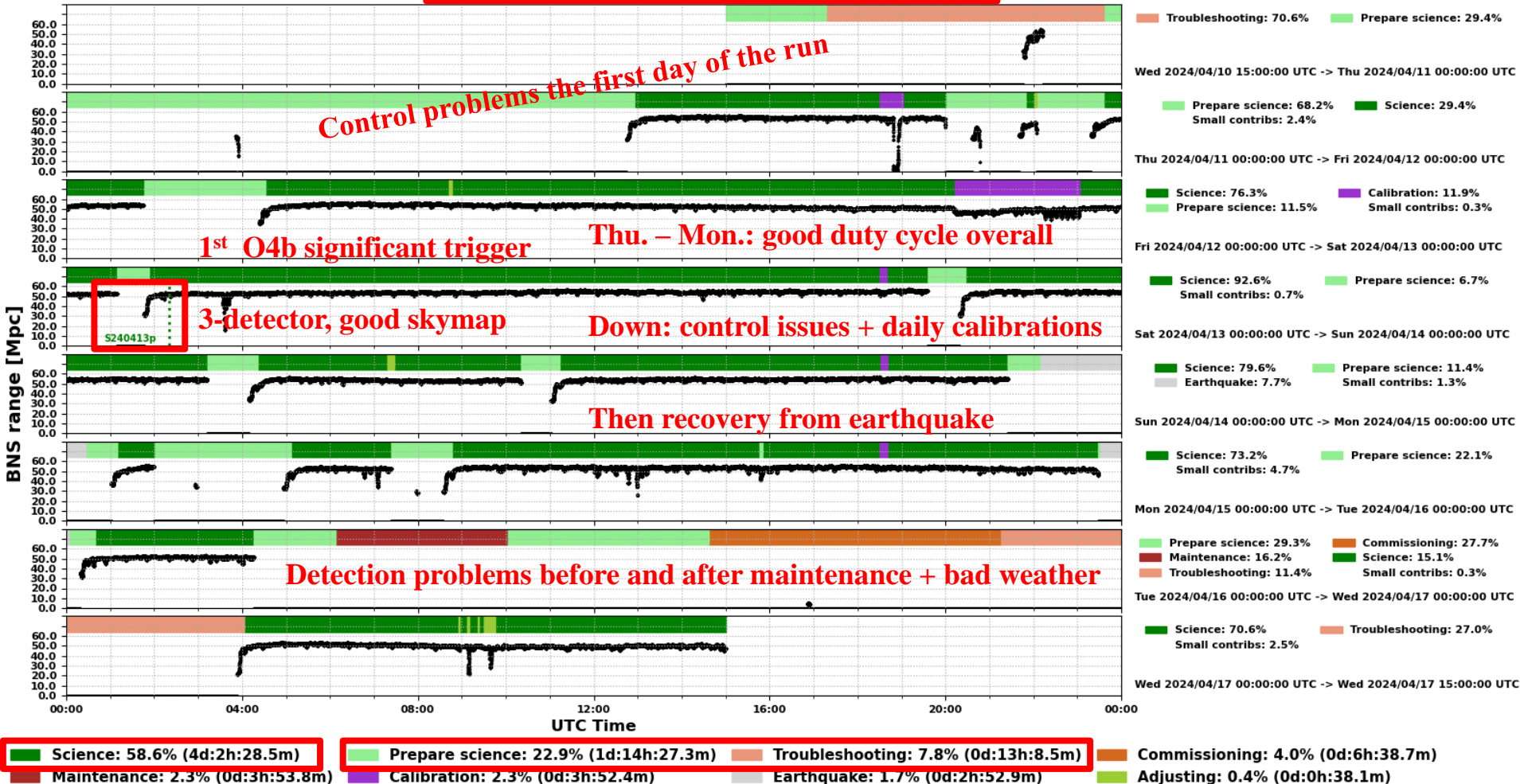
- Commissioning priorities
  - 1) BNS range stability  
Control reliability } In particular during the first month of O4b
  - 2) Measurements to be used in future publications about Virgo commissioning
  - 3)  $1/f^{2/3}$  noise investigations
  - 4) Other topics
- We'll see better in a few weeks what the Virgo performance is
  - Stable detector
  - Priority to data taking→ ~20% improvement in BNS range during O3
- Concrete (and challenging) goals for O4b
  - Duty cycle: above 80% averaged over the full O4b run
  - Sensitivity: run steadily above 55 Mpc and understand the  $1/f^{2/3}$  noise
- O4b is the beginning of a new phase for Virgo
  - A good O4b is needed at all levels
  - Personpower remains a strong limitation
    - ◆ In particular for O4b coordination and the vetting of alerts in low latency

# The first week of O4b

• Data taking  $\leftrightarrow$  dark green bands

• Black thick trace: BNS range

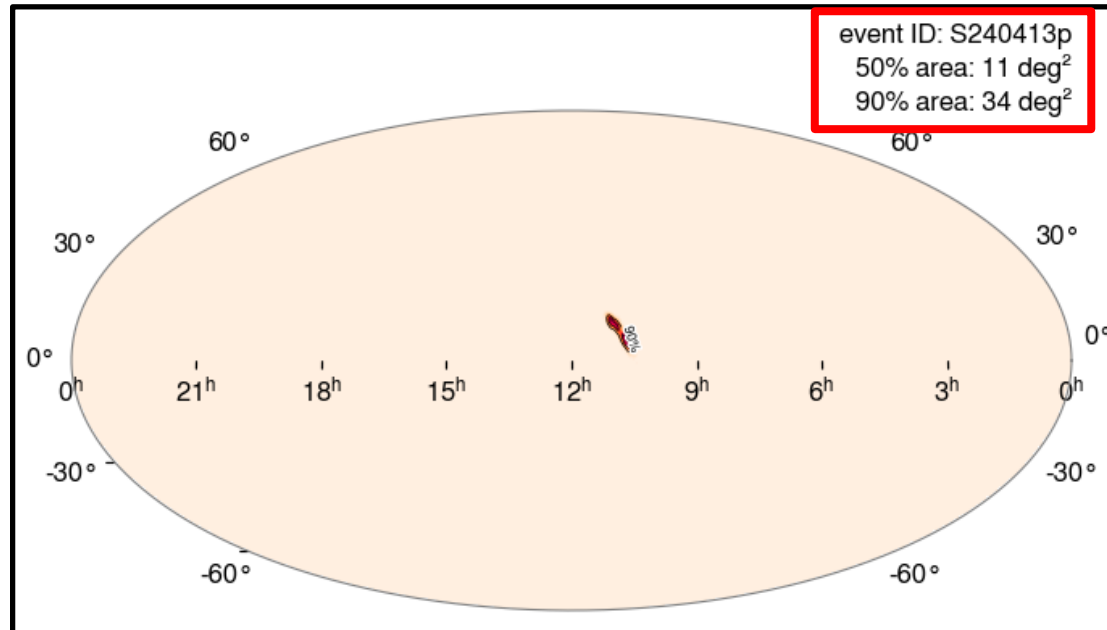
Weekly summary plot: **2024/04/10 15:00:00 UTC -> 2024/04/17 15:00:00 UTC** -- S-events: 1 ADVOK, 0 ADVNO



# S240413p

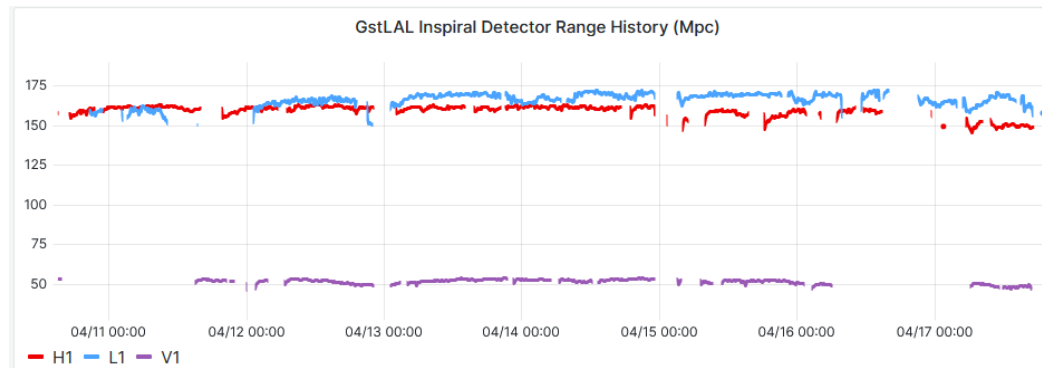
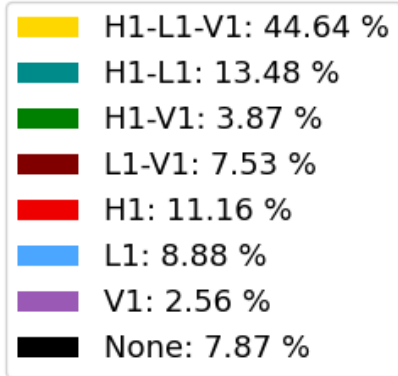
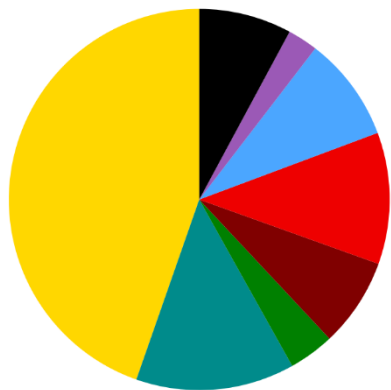
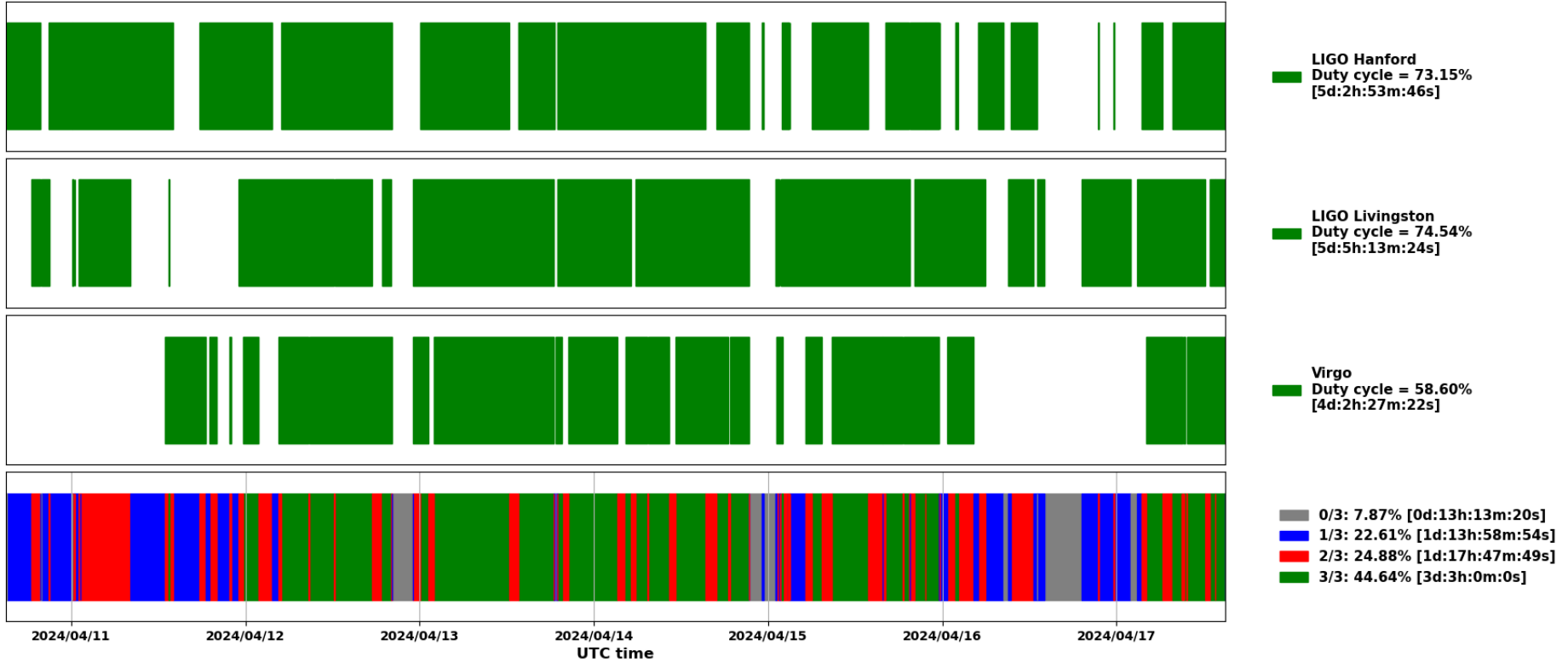
- GraceDB public page: <https://gracedb.ligo.org/superevents/S240413p/view>

Event Information	
Group	CBC
Pipeline	pycbc
Search	AllSky
Instruments	H1,L1,V1
Event Time ▾	1397010037.852
FAR (Hz)	3.168e-10
Submitted ▾	2024-04-13 02:22:20 UTC



# LVK network duty cycle

H1-L1-V1 network: 2024-04-10 15:00:00+00:00 UTC -> 2024-04-17 15:00:03+00:00 UTC -- science segments

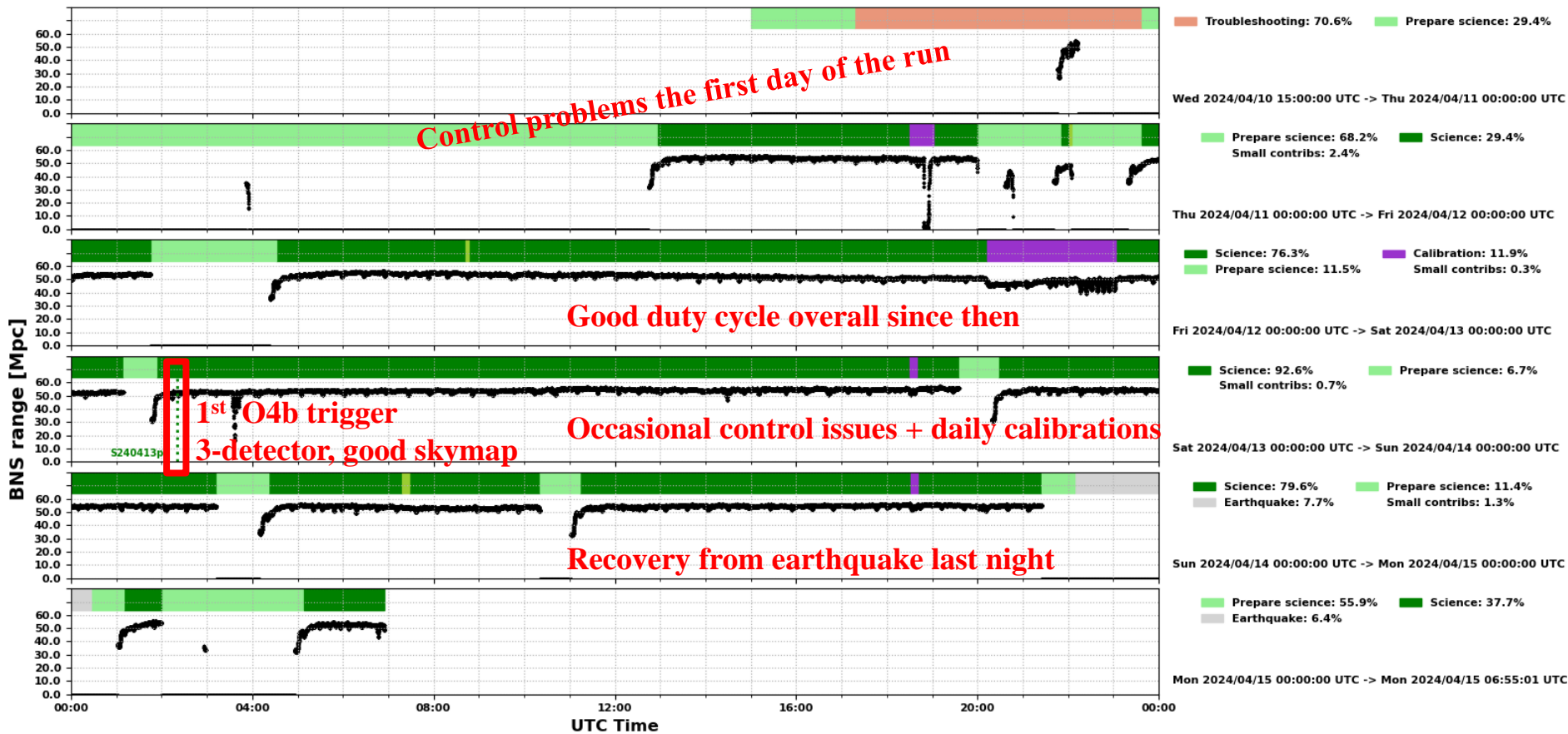




# The first week of O4b

- **Status** as of Mon. April 15<sup>th</sup> at 10:00 LT – almost 5 days in O4b
  - *To be updated regularly during the coming days*, until the Council meeting
  - **Data taking** ↔ dark green bands

6-Day summary plot: 2024/04/10 15:00:00 UTC -> 2024/04/15 06:55:01 UTC -- S-events: 1 ADVOK, 0 ADVNO

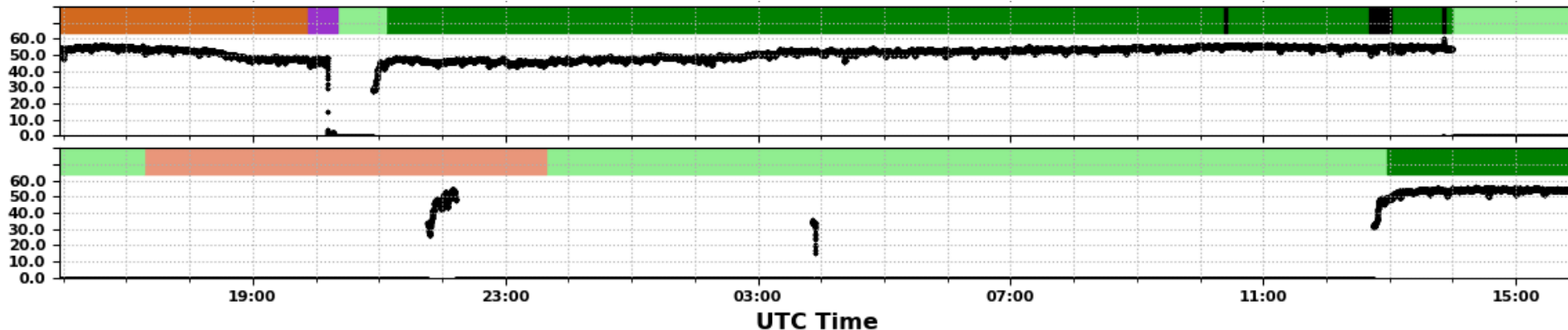


Science: 61.9% (2d:21h:18.4m)	Prepare science: 26.8% (1d:5h:59.4m)	Troubleshooting: 5.7% (0d:6h:21.1m)	Calibration: 3.3% (0d:3h:42.4m)
Earthquake: 2.1% (0d:2h:17.8m)	Adjusting: 0.2% (0d:0h:15.8m)		

# The first week of O4b

- **Status** as of Thu. April 11<sup>th</sup> at 18:00 LT – O4b: 25 hours
  - *To be updated regularly during the coming days*, until the Council meeting
  - **Data taking** ↔ **dark green bands**

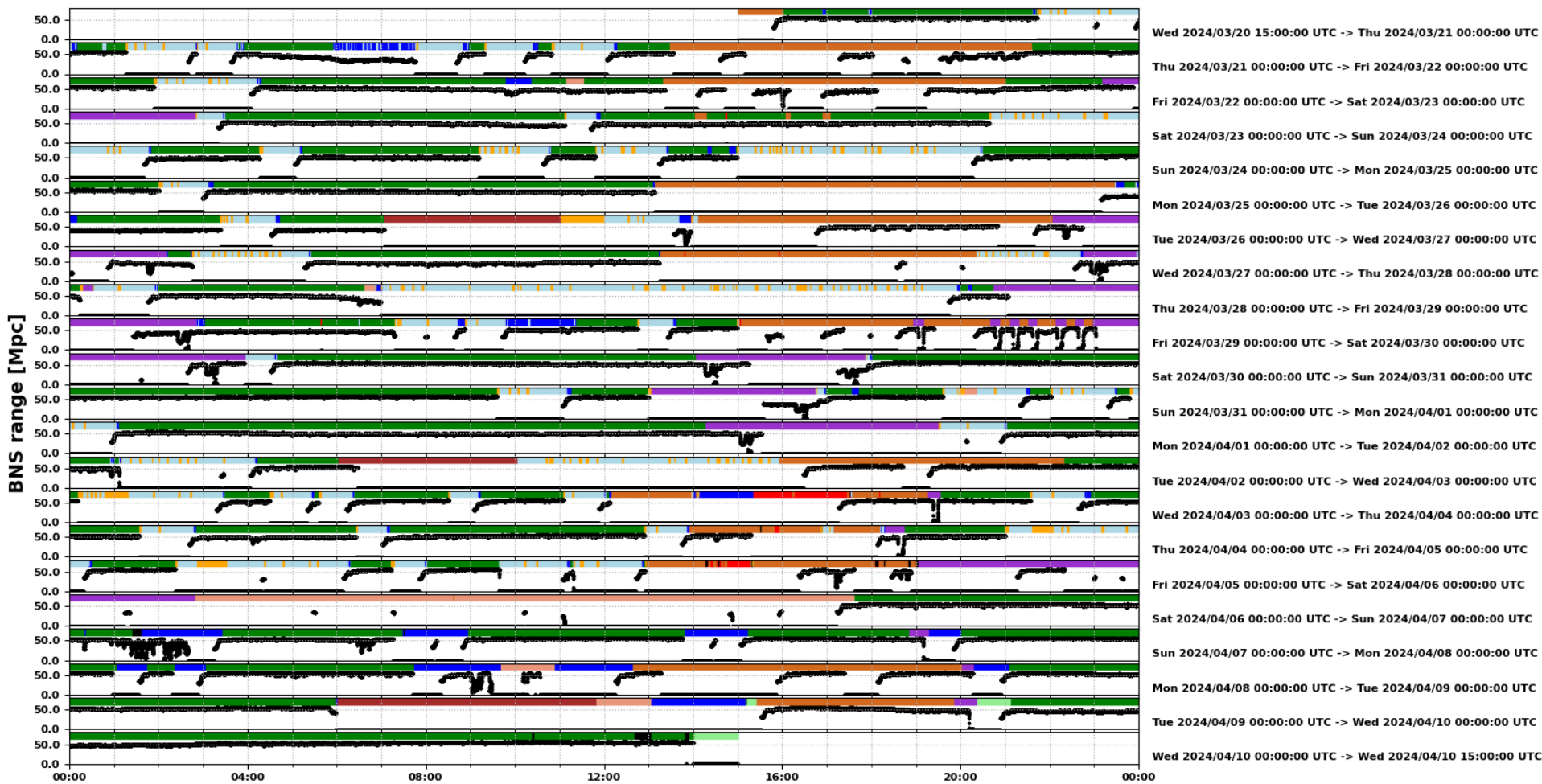
→ Past 48 hours reported



- **Last day of ER16: 18-hour stretch of data taking** – top row
- Then a **new control instability prevented controlling Virgo for almost a day**  
→ **Investigated by experts** on **Wed. night** and **Thu. morning**: fixed
- **Smooth data taking at 55 Mpc range** (thick black trace) since **today ~15:00 LT**
- **Plan for the coming days: take data**
  - ◆ With some **planned stops** for the first O4b **calibrations**

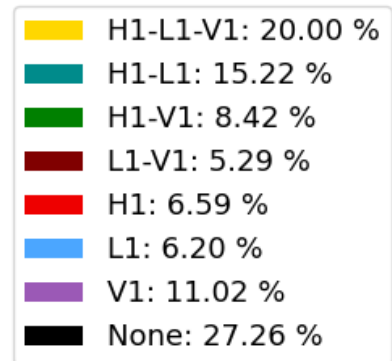
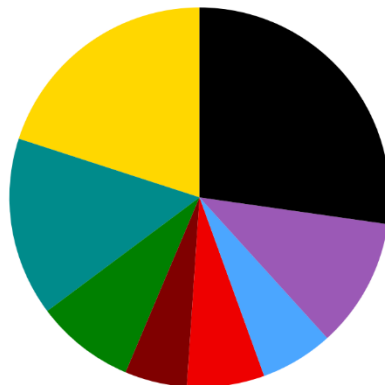
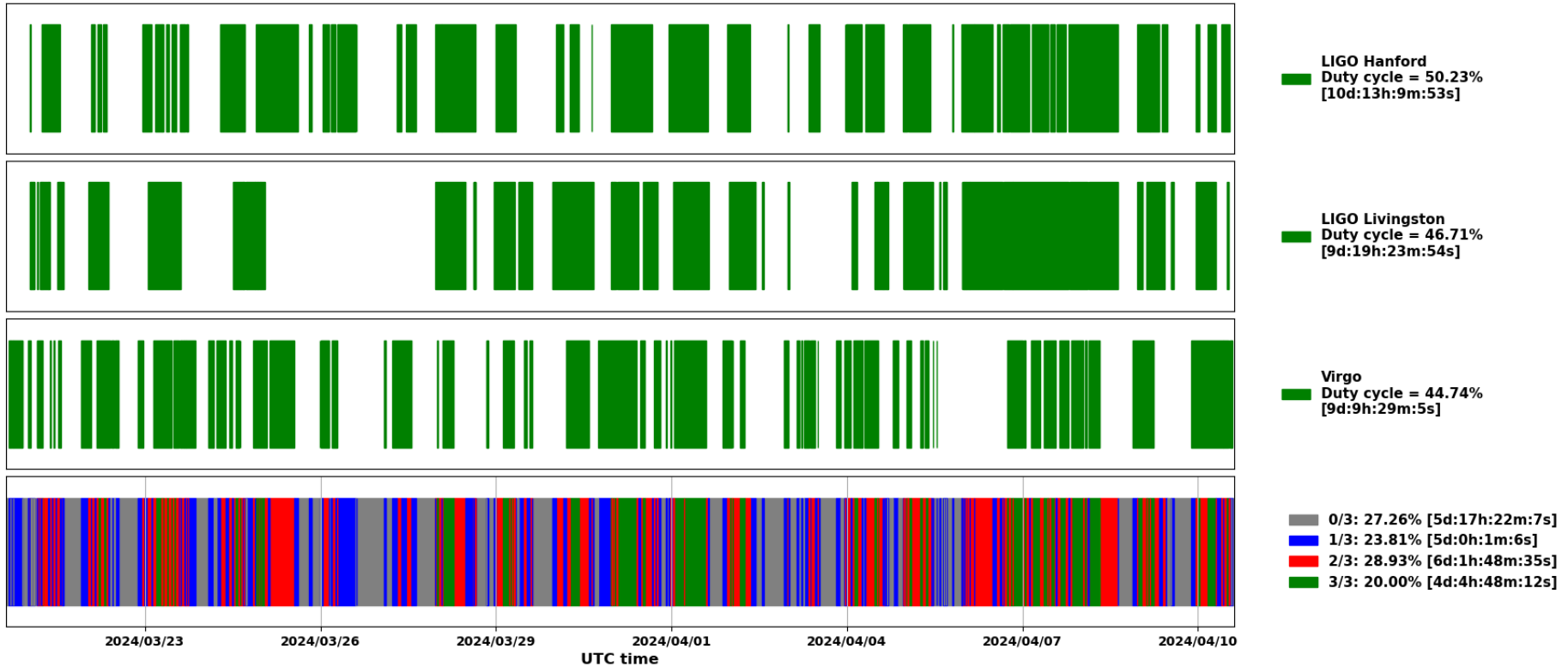


# ER16 summary: Virgo



# ER16 summary: LVK network

H1-L1-V1 network: 2024-03-20 15:00:00+00:00 UTC -> 2024-04-10 15:00:00+00:00 UTC -- science segments



**H1: LIGO Hanford**  
**L1: LIGO Livingston**  
**V1: Virgo**