VIRGO COLLABORATION REPORT

Gianluca Gemme

Virgo spokesperson

ACTIONS SINCE LAST STAC MEETING

Virgo joining O4

Possible extension of O4b

Plans for O5

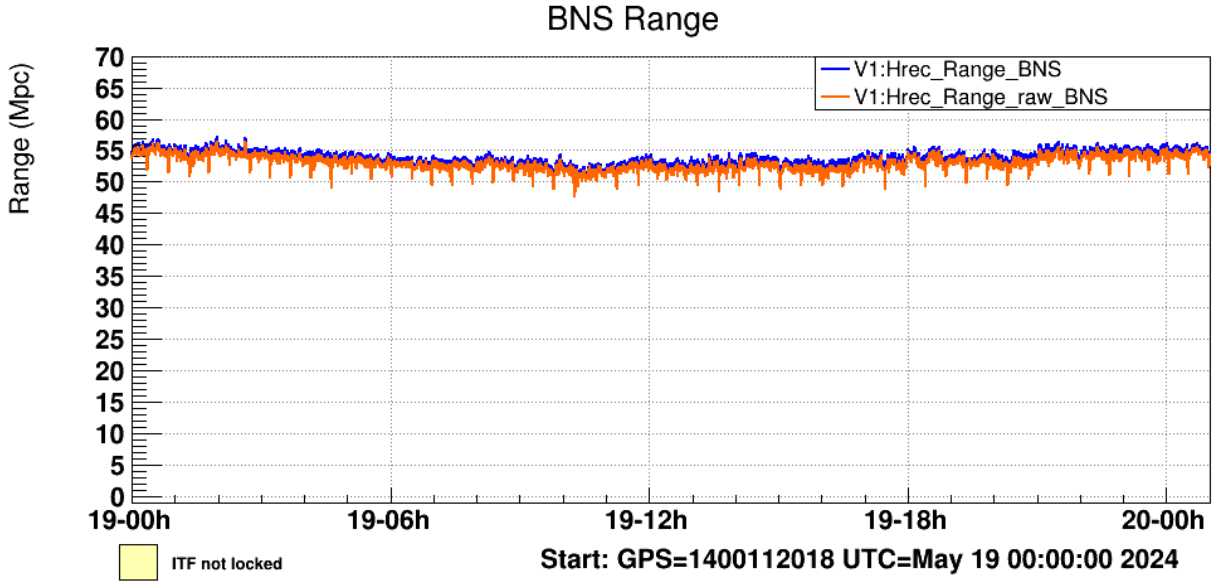
Beyond O5: V_nEXT

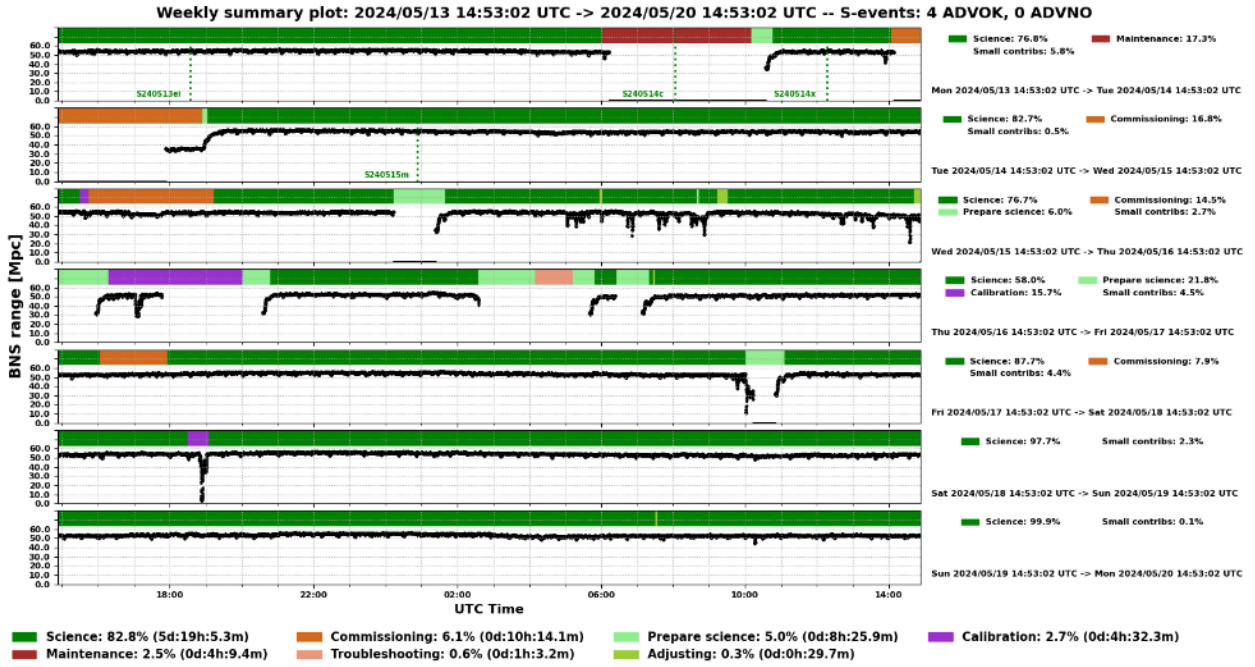
Decision making process, EGO/Virgo organization and IGWN

Virgo and ET relationship

VIRGO JOINING O4

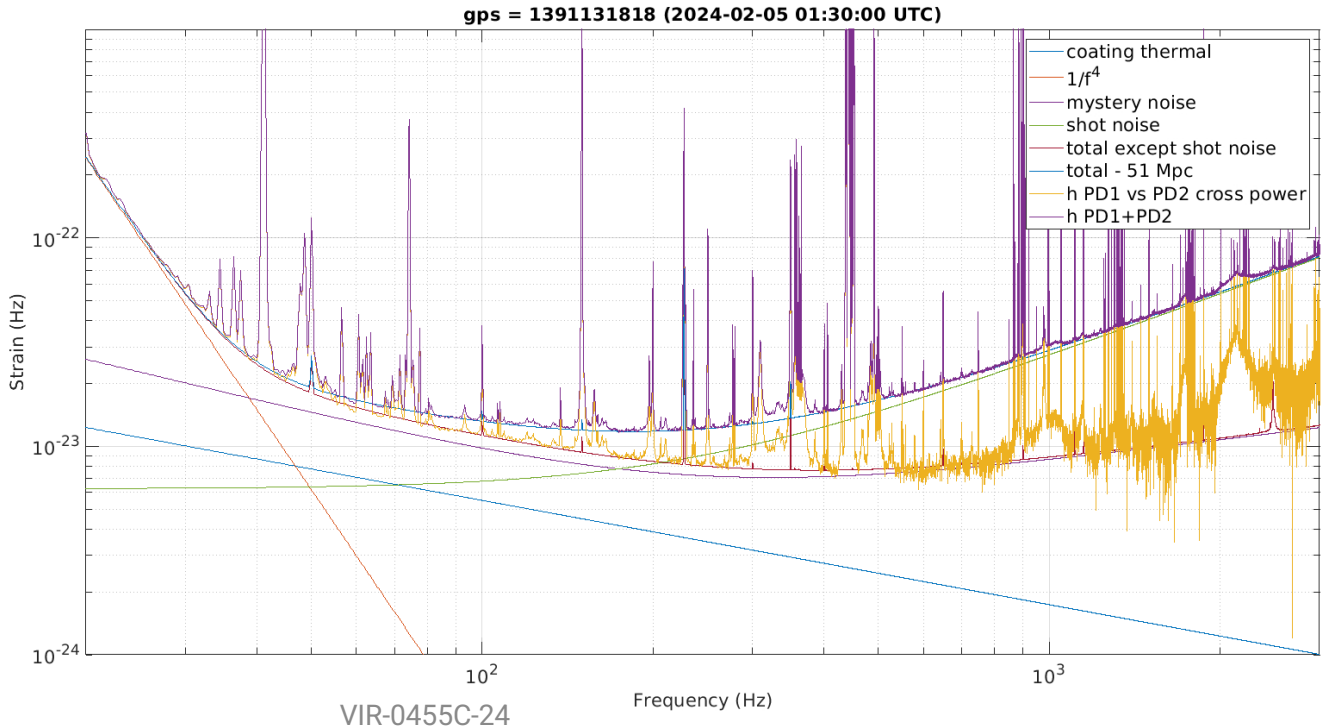
- **Virgo joined O4 in April 2024**
  - Excellent stability, exceeding 90% duty cycle in Science mode over many days
  - Sensitivity around 55 Mpc
  - **More in N. Arnaud's presentation**





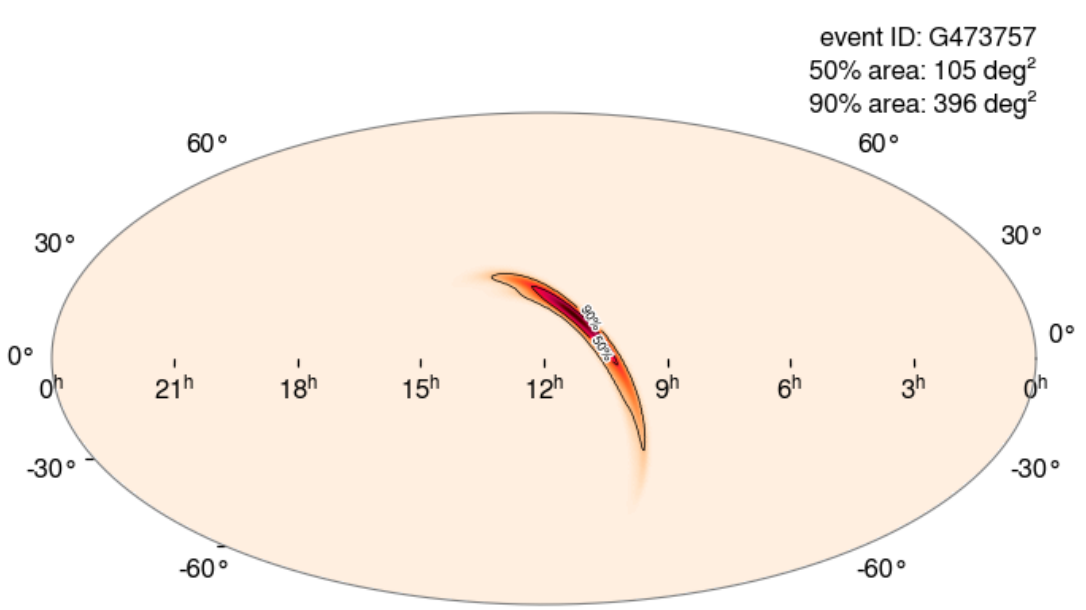
VIRGO JOINING O4

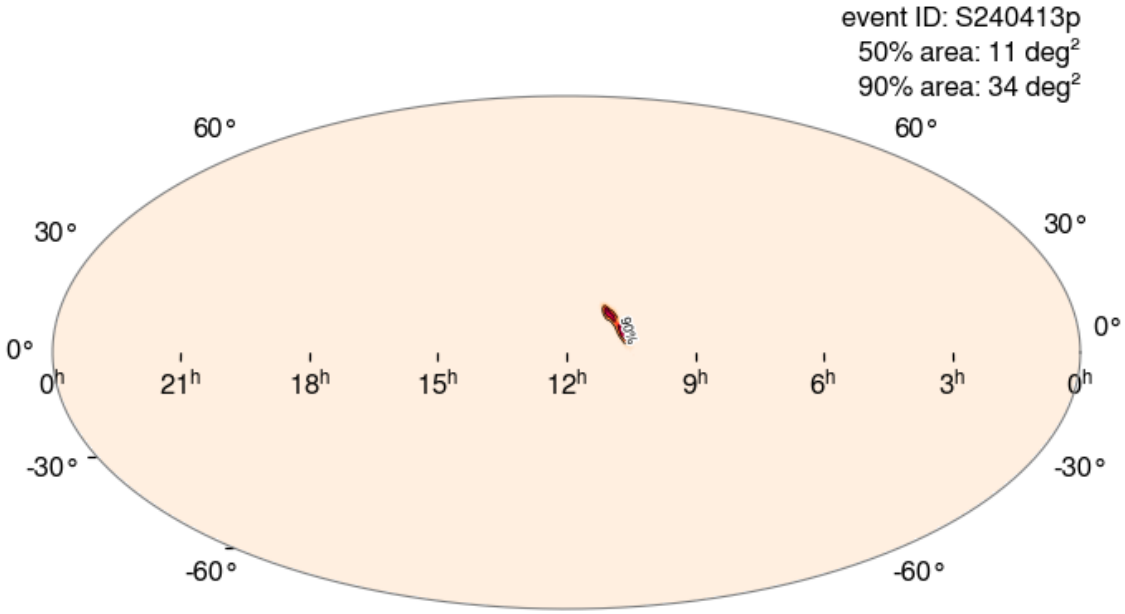
- **Virgo joined O4 in April 2024**
  - Task force for addressing “mystery” noise was set-up and plan of actions is being prepared
  - Possibility of commissioning breaks before the end of O4b is being considered (also considering possible extension of O4b)
    - These will be planned well in advance, both to allow internal organization and to inform our partners in due time
  - **More in M. Was presentation**



VIRGO JOINING O4

- Virgo matters…



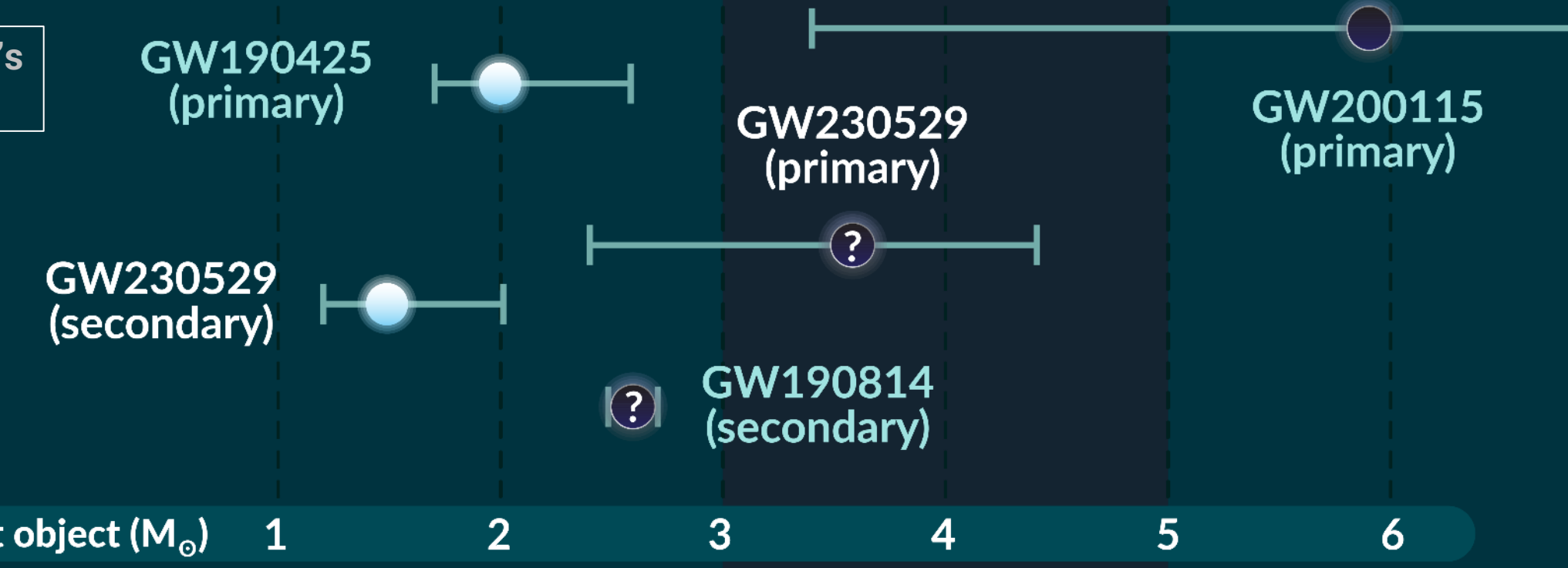


S230529

FILLING THE MASS ⟷ GAP

with observations of compact binaries from gravitational waves

More in F. Pannarale's presentation

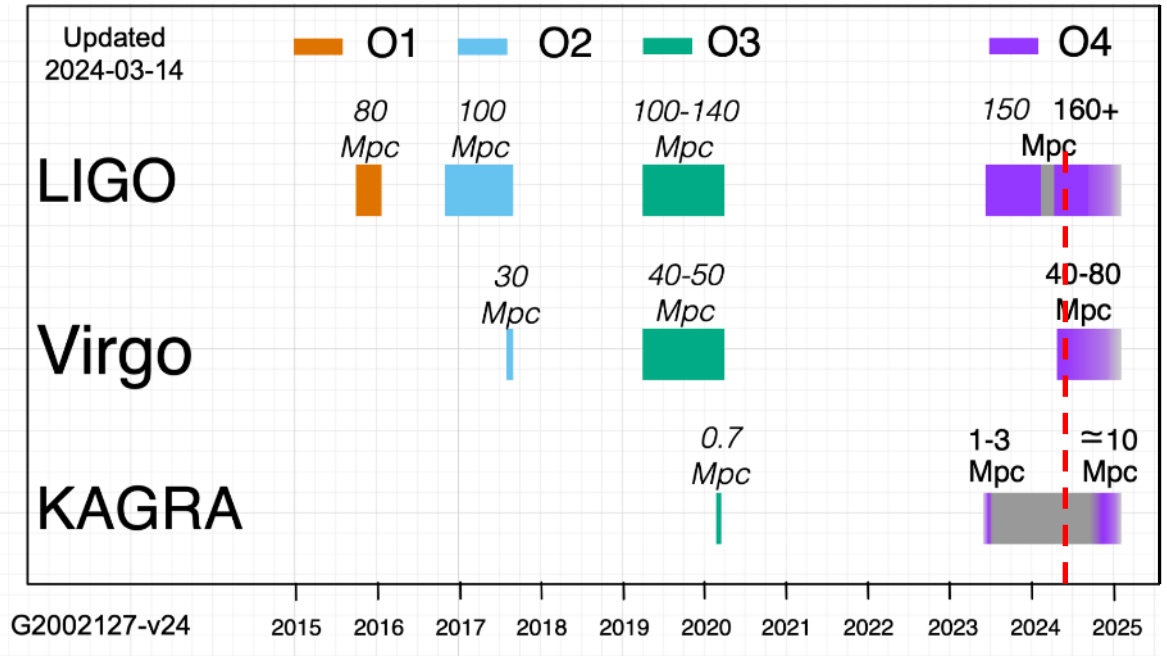


Includes components of compact binary mergers detected with a False Alarm Rate (FAR) of less than 0.25 per year

https://arxiv.org/abs/2404.04248

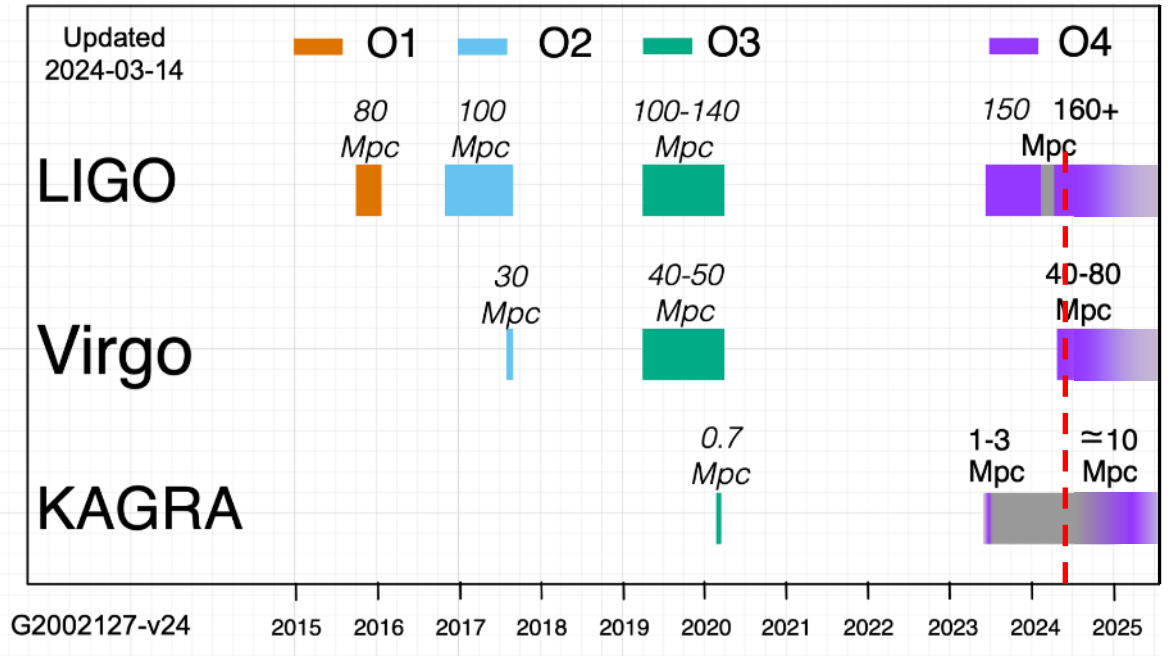
EXTENSION OF O4B

- The LIGO leadership confirmed that they are considering an extension of O4b from "*2 to 4 months*" and a consequent delay of O5 starting date (at this point expected in Apr-Jun 2027)
  - A decision is expected early in June (possibly next week)



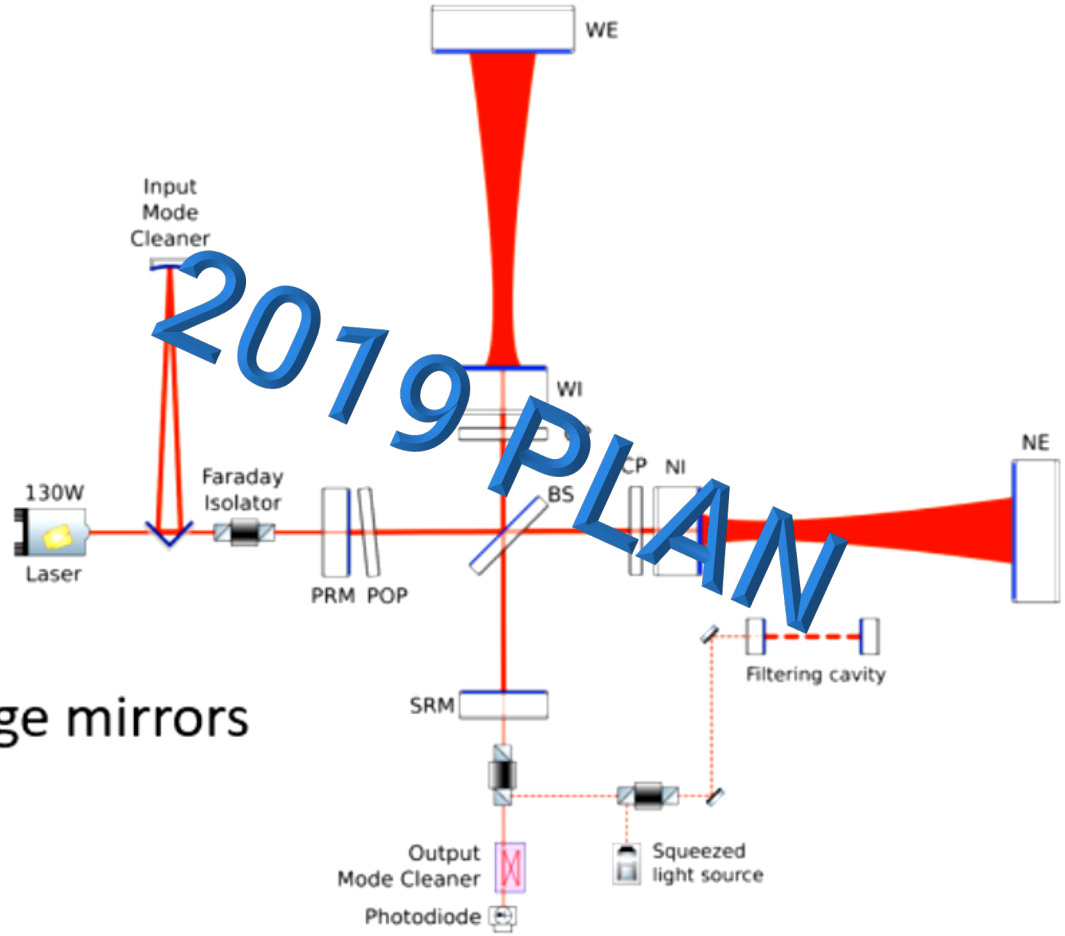
EXTENSION OF O4B

- Impact of this on our plans, from the detector (planning of possible commissioning breaks), operations, upgrade and data analysis point of views:
  - **Data analysis:** Extension has an impact on **public data release** currently planned for August 2025 (O4a: M1-M10) and May 2026 (O4b: M11-M20)
    - In general, DA working groups are strongly in favor of postponing the data release if the run is extended
  - **Computing:** Problems might come from lack of person-power doing the analyses rather than missing computing resources
  - **Run organization:** No showstopper. Situations with increased workload on operators was checked; positive feedback
  - **Detector:** No big problem **IFF** O5 starting date will be delayed
  - **Commissioning:** Higher chances about how to address mystery noise
    - Possible breaks during the run, order of ~weeks, will be considered (and agreed upon with L-K)



THE PATH TOWARD O5

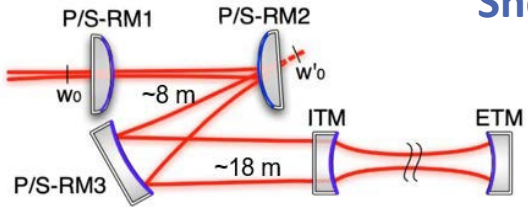
- Larger beams on end test masses
  - 6 cm radius ⇒ 10 cm radius
- Larger end mirrors
  - 35 cm diameter ⇒ 55 cm diameter
  - 40 kg ⇒ 100 kg
- Better mirror coatings
  - Lower mechanical losses, less point defects, better uniformity
- New suspensions/seismic isolators for large mirrors
- Further increase of laser power
  - 40 W ⇒ 60 W ⇒ 80 W

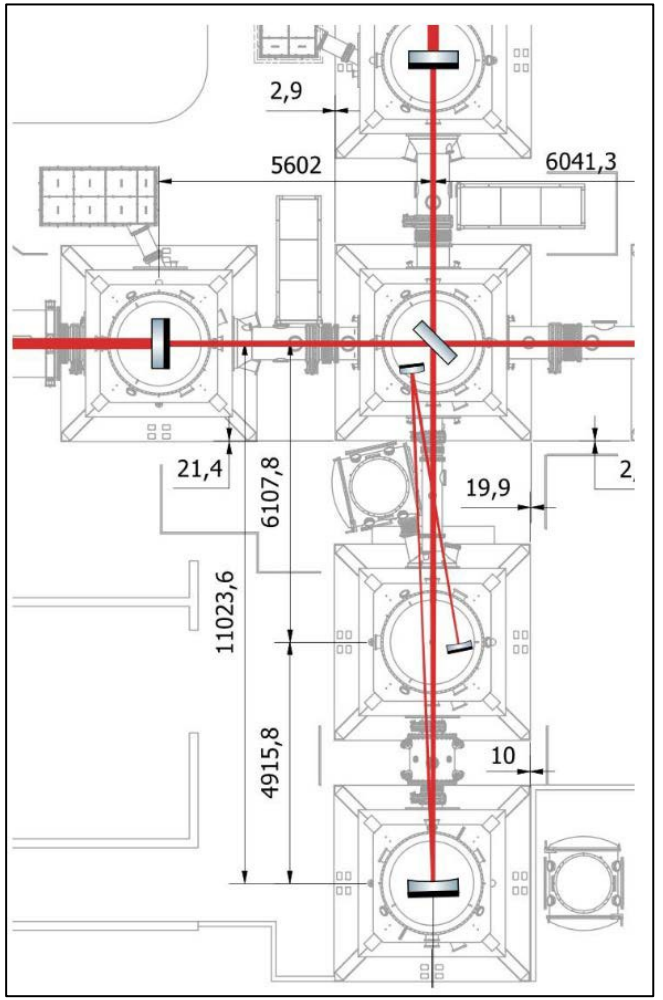


STABLE CAVITIES FOR ADV+

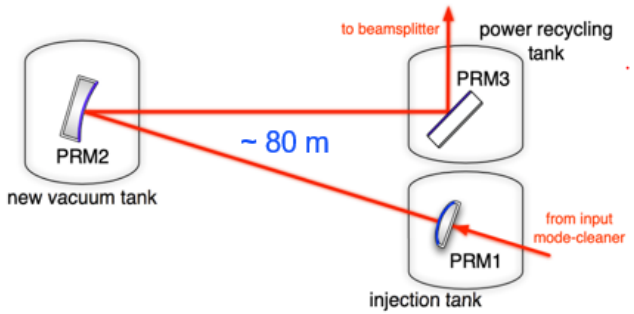
- Two options investigated
  - Install recycling cavities in existing infrastructure: short cavities
    - Impact on central building infrastructure and vacuum system
  - Build additional infrastructure: long cavities
    - Requires additional buildings and tunnels for vacuum tubes
- Both options assessed in terms of cost, schedule, flexibility, technological readiness and risk

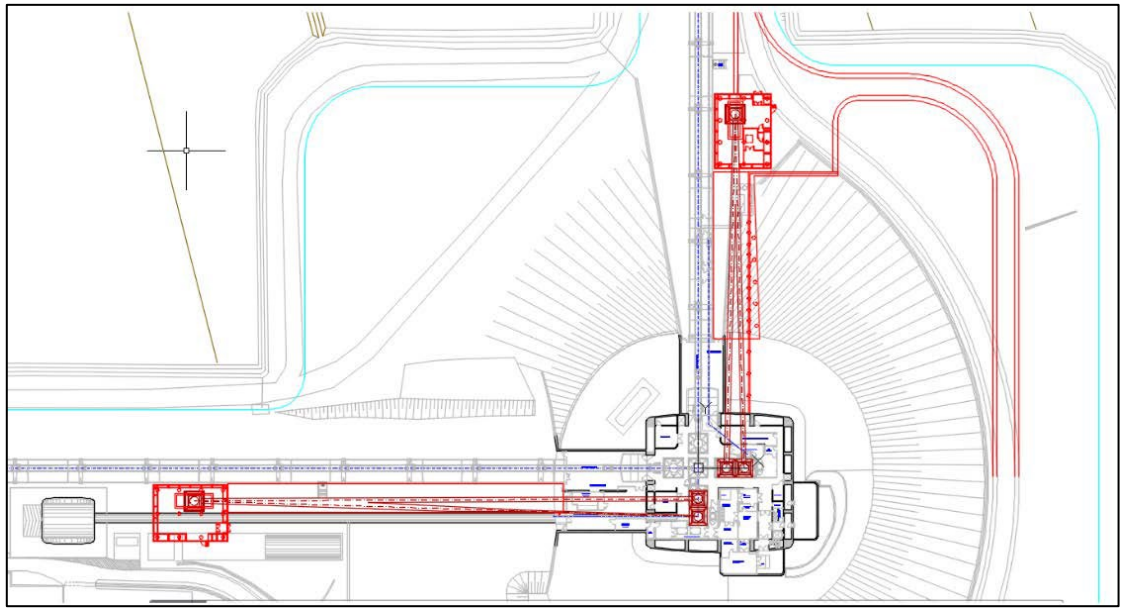
"Short"



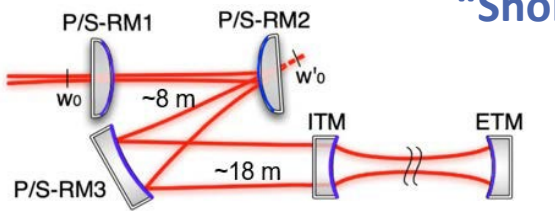


"Long"



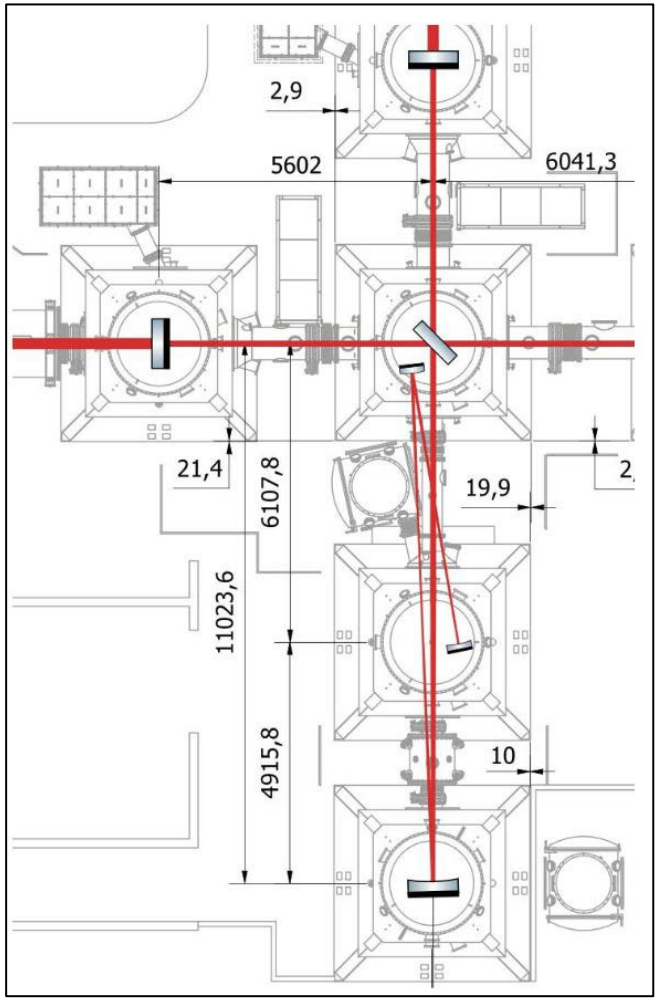


STABLE CAVITIES FOR ADV+



- Conceptual design studies document released in January
  - Short cavities proposed as preferred solution

- Reviewed by internal board
  - Report released in March
  - Endorses choice to favor short cavity solution (and highlights several aspects requiring further investigation)
    - The technical risks of the two options are almost at same level; no show-stoppers have been found
    - The short cavity solution requires a considerably lower budget and one year less for the implementation
    - The LIGO successful experience is made with an optical configuration similar to the short cavity solution
  - Outcome of review endorsed by Virgo steering committee in April



OTHER BASELINE CHANGES

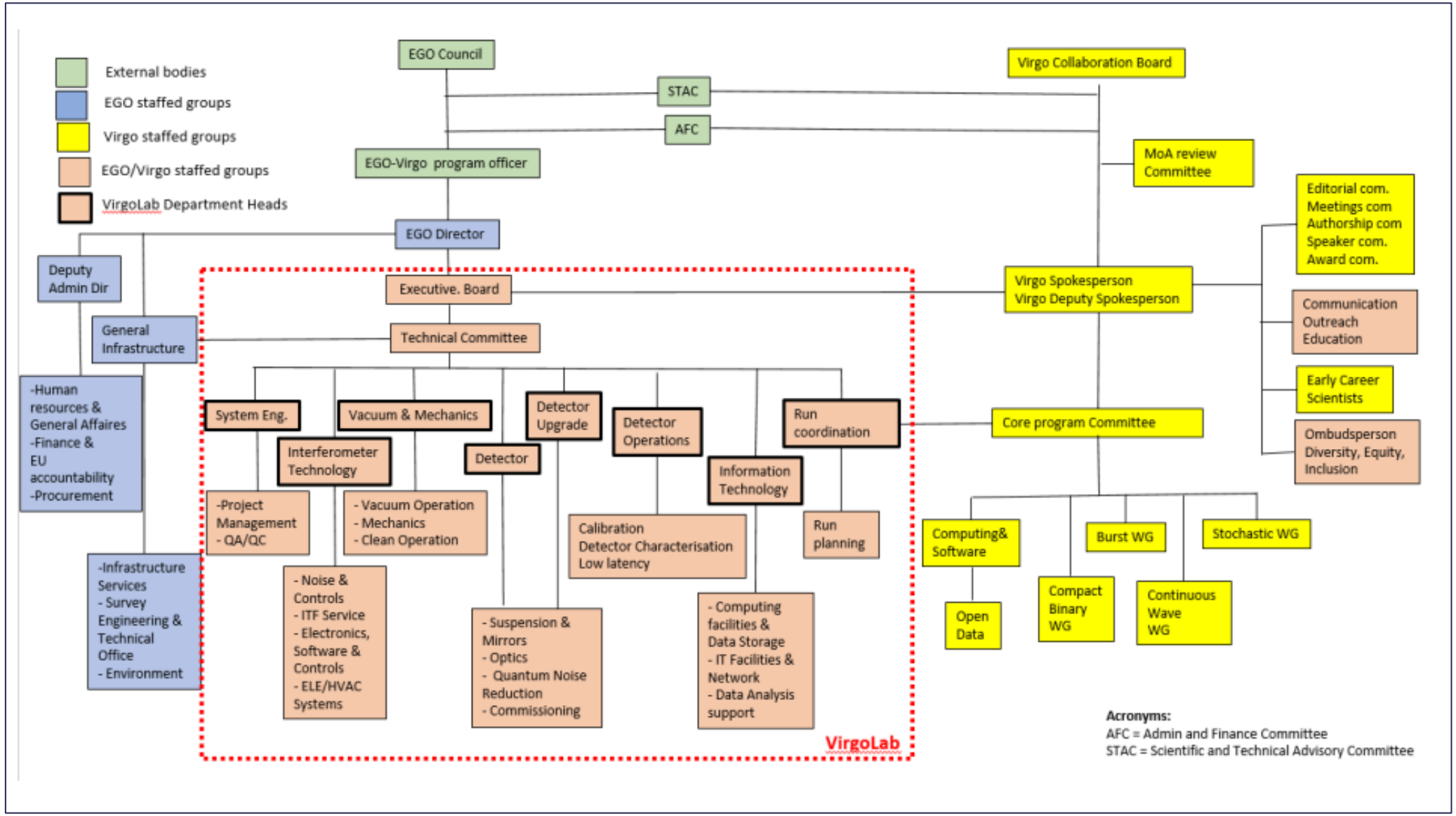
- Abandon large end test masses
  - Keep current arm cavity geometry; defer installation of large mirrors to Virgo_nEXT
  - Change request approved
    - Large end mirrors and small input mirrors may impact control of arm cavities
    - Avoid changing optical configuration of arm and recycling cavities at same time
    - Better mirror coatings not yet available
- Include additional upgrades based on Phase I commissioning experience
  - List being defined
  - Might include replacing (some) arm cavity mirrors to reduce power-dependent optical losses
- Next steps
  - Deliver technical design report
    - Baseline: Including implementation of stable cavities
    - Plan B: Without stable cavities
  - Consolidate WBS, deliverables, budget, planning, risk management
  - Overall budget approval expected after external review of TDR
- **More in A. Rocchi's presentation**

VIRGO_NEXT

- Post-AdV+ concept study released in 2022
  - Focus on interferometer at 1064nm and room temperature
  - Not yet a baseline design
- Virgo_nEXT preliminary R&D plan available
- Need to be reviewed/updated following change of plans for O5
- EGO Council requested long-term plan
  - Up to start of Einstein Telescope
  - Preliminary plan targeted for July
- **More in V. Fafone's presentation**

VIRGO/EGO ORGANIZATION

- EGO Council set up a committee to review the current Virgo/EGO organization
  - Report released in April
- (Some) Recommendations
  - EGO must play a much stronger role in detector construction, operation and integration after acceptance of detector (sub)systems at the EGO site
  - Oversight by the EGO Council should be strengthened by appointing a program officer, who is the liaison between the EGO Council and the EGO Director
  - EGO and Virgo must adopt a rigorous project management structure […], similar to any large-scale (international) research infrastructure
  - Additional financial resources are essential for the future of EGO/Virgo
  - A careful assessment of the EGO staffing needs should be carried out as soon as possible
  - The Virgo Collaboration must have an increased engagement in (on-site) detector related activities and tasks of common interest
  - The impact of the prospect of Einstein Telescope on Virgo should be carefully managed
- Very interesting and useful discussion on May 23. Will be followed-up on June 7
- EGO Council will install a team in close collaboration with the Virgo collaboration to define the implementation strategy


External bodies
EGO staffed groups
Virgo staffed groups
EGO/Virgo staffed groups
VirgoLab Department Heads
EGO Council
STAC
AFC
EGO-Virgo program officer
EGO Director
Deputy Admin Dir
General Infrastructure
-Human resources & General Affaires -Finance & EU accountability -Procurement
-Infrastructure Services - Survey Engineering & Technical Office - Environment
Executive. Board
Technical Committee
System Eng.
Vacuum & Mechanics
Interferometer Technology
Detector
Detector Upgrade
Detector Operations
Run coordination
Information Technology
-Project Management - QA/QC
- Vacuum Operation - Mechanics - Clean Operation
- Noise & Controls - ITF Service - Electronics, Software & Controls - ELE/HVAC Systems
- Suspension & Mirrors - Optics - Quantum Noise Reduction - Commissioning
Calibration Detector Characterisation Low latency
- Computing facilities & Data Storage - IT Facilities & Network - Data Analysis support
Run planning
VirgoLab
Virgo Collaboration Board
MoA review Committee
Virgo Spokesperson Virgo Deputy Spokesperson
Core program Committee
Computing& Software
Open Data
Burst WG
Compact Binary WG
Stochastic WG
Continuous Wave WG
Editorial com. Meetings com Authorship com Speaker com. Award com.
Communication Outreach Education
Early Career Scientists
Ombudsperson Diversity, Equity, Inclusion
Acronyms:
AFC = Admin and Finance Committee
STAC = Scientific and Technical Advisory Committee

INTERNATIONAL GW NETWORK

- 2007:
  - First LIGO-Virgo Memorandum of Understanding signed “to carry out the search for gravitational waves in the spirit of teamwork, not competition” to lay the groundwork for future joint operations of a network of detectors including LIGO-Hanford, LIGO-Livingston and Virgo
- 2015-2017:
  - First advanced detector observing run was carried out by the LIGO-Virgo Collaboration leading to the first detection of gravitational waves (GW150914)
  - First observation of gravitational waves from a binary neutron star merger (GW170817) by the LIGO-Virgo Collaboration and multimessenger follow-up by the astronomy community
- 2019
  - LIGO-Virgo-KAGRA Collaboration established by a Memorandum of Agreement that supersedes the previous agreements and the third observing run starts
- Today:
  - Recognition that a new organizational structure is needed to achieve our goals and to seamlessly integrate infrastructure and operations across the network. There are many activities that can be shared, rather than multiplied

INTERNATIONAL GW NETWORK

- The International Gravitational Wave Network is a proposed single organization to coordinate the development, commissioning, and operations of the international network of ground-based, gravitational-wave detectors (L+V+K) and to carry out the scientific mission of that network
- The IGWN Design Committee is charged with developing a Charter (scope and purpose) and Bylaws for the organization
  - Secure individual groups contributions to detector-related activities
  - Sharing of financial resources and allocation of resources to IGWN activities
  - Avoid redundancies deriving from multiple venues where decisions are taken
  - Respect the specific needs and the necessary representativeness of regional realities
- The committee is not charged with the creation of IGWN
  - Formation and approval process will be dealt with separately
- Timeline: deliver a final recommendation by the end of the O4b run (with some flexibility)
- Meeting between representatives of the funding agencies and collaborations in June

ACTIONS

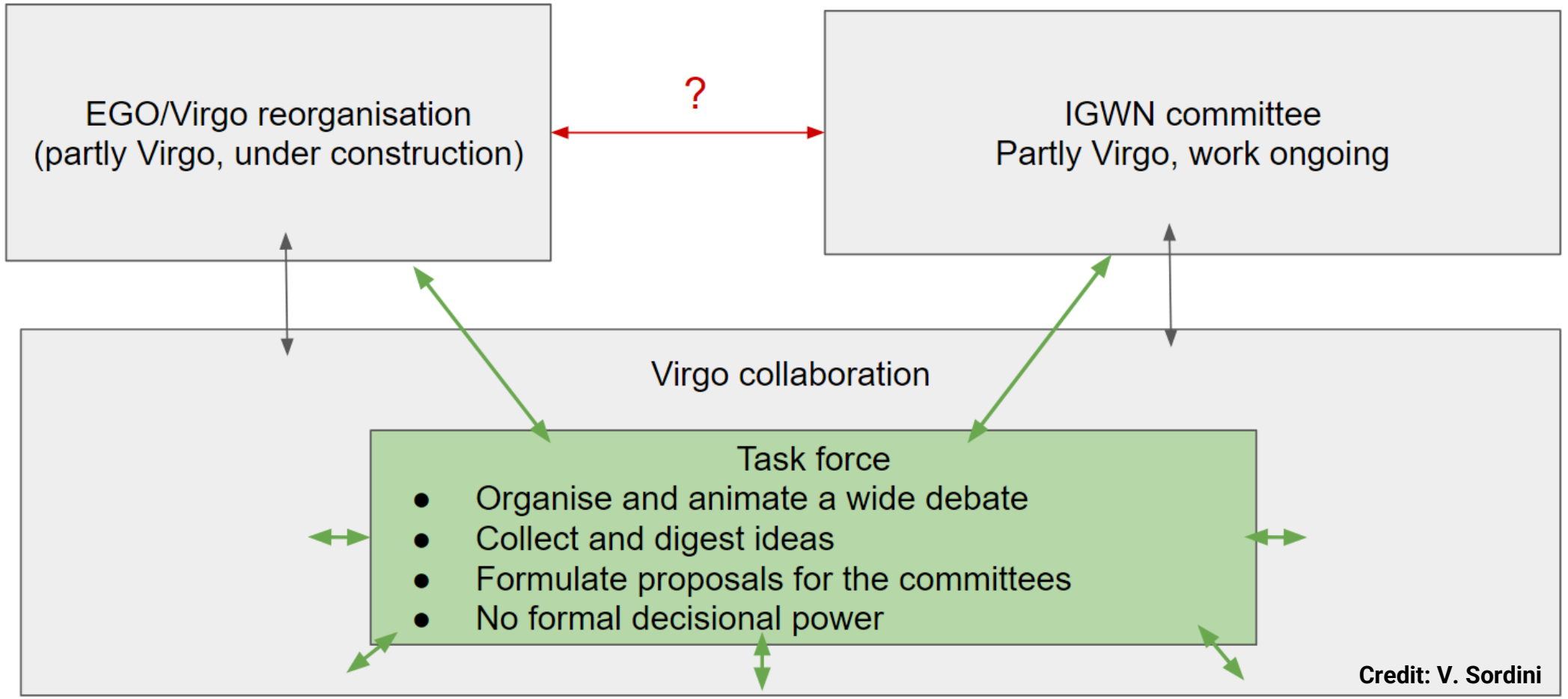
- Appoint three members for the «implementation» committee
  - Spokesperson, deputy spokesperson + one member from «non EGO» institutions

- Start internal revision of the bylaws → VECS

- Foster internal discussion about reorganisation and IGWN → see next slide

FOSTER INTERNAL DISCUSSION ABOUT REORGANISATION AND IGWN

Gray = in place
Green = proposed



EINSTEIN TELESCOPE AND VIRGO

- R&D activities that could plausibly result in technical options for future upgrades of the Virgo detector and its computing environment are considered a part of the scientific program of the Collaboration
  - List of V_nEXT R&D tasks synergic with ET(-HF) identified (high power operation, improved quantum noise reduction, improved coatings, seismic and Newtonian noise, mitigation of technical noises, …)

- STAC report, Nov 23: *"European coordination of ground based gravitational wave projects is instrumental for success and must be achieved at the level of funding agencies, with ideally an overall long-term development and funding plan that covers both, EGO/Virgo and ET."*
  - High-level, systemic coordination still insufficient
  - Some concerns from possible increase of ET-related activities/pressure in the coming months

- Report from ET Pathfinder STAC:
  - A more explicit planning effort to support Virgo, between EGO, Virgo, ET, and ETPF (along with other major ET R&D efforts), appears to be needed and is strongly recommended by the ETPF STAC
  - The STAC recommends that a meeting be set up with Virgo folk to communicate the utility of the ETPF effort in this domain for the stable-cavity design work

LIFE OF COLLABORATION

Elections/apppointments

Virgo Operations division

New Virgo group: Virgo-Brazil

LVK climate change committee

Lessons learned in AdV+ phase 1

VIRGO COLLABORATION

- 897 members, 599 authors, 153 institutions from 17 Countries

- 37(+1) groups
  - 34 full members (including EGO scientific group)
  - 3 in the probatory period (CIEMAT Madrid, INFN-Torino, Milano Bicocca)
  - 1 new group (TBC): Virgo-Brazil
  - Preliminary contacts with HEPHY-Vienna
- 8 Countries represented in the Virgo Steering Committee (so far)
  - Italy, France, The Netherlands, Spain, Belgium, Poland, Greece, Hungary

V. Fafone L. Rolland S. Hild M. Martinez G. Bruno T. Bulik N. Stergioulas D. Barta

ELECTIONS/APPOINTMENTS

- Upgrade coordinator: A. Rocchi (INFN-Roma Tor Vergata)

- Commissioning coordinator: M. Was (LAPP)
  - Deputy commissioning coordinator: D. Bersanetti (INFN-Genova)

- Core program committee: C. Van Den Broeck (chair)
  - Deputy chair: A. Viceré (Firenze/Urbino)
  - Update of Core program and definition of mandatory contributions for instrument related activities (including operations) and service tasks is a fundamental step (**see also talk by C. Van Den Broeck**)
  - Update of the Virgo Members Database to make it the tool to track all collaboration related activities (including MoA reviews) has started. List of activities based as much as possible on LVK White Papers

- Diversity, Equity and Inclusion working group: A. Miller (Nikhef)

- ECS chairs: Lucia Papalini (INFN-Pisa), Jishnu Suresh (BelGrav)
- ECS representatives in the VSC: Sophie Bini (Padova/Trento), Marion Pillas (ARTEMIS)

- Coming soon
  - Chair of the Speakers committee
  - Deputy spokesperson

VIRGO OPERATIONS DIVISION

- We must have a framework that allows us to properly classify and account for Operations-related resources, just like we are doing in other Virgo areas
  - This will be used for service tasks, MoA reviews, etc.

- There is a growing pressure from the LSC to share with them those resources
  - We need to define who will do that with a clear mandate

- Acknowledge the way things have been organized these past months and how they will work during O4b

VIRGO OPERATIONS DIVISION

- The Virgo Operations Division exists to organize and manage all Virgo activities related to, and necessary for, detector operation
- The Virgo Operations Division is led by the Run coordinator of the Virgo collaboration
- It comprises the
  - Detector Characterization,
  - Calibration,
  - Low Latency,
  - Computing and Software, and
  - Open Data Working Groups
- The LVK Operations White Paper describes the planned activities for these efforts
- Further details on the planned activities in collaboration between the DetChar and Calibration groups and the four LVK DA working groups can be found in the LVK Observational Science White Paper
- Discussion and possible approval at next VSC (June 6)

NEW VIRGO GROUP: VIRGO-BRAZIL

- Draft MoA received from a group of researchers from five universities in Brazil led by Márcio Eduardo da Silva Alves, Universidade Estadual Paulista "Júlio de Mesquita Filho", and Iara Tosta e Melo, affiliated with the University of Catania, Italy
- The proponents interacted with Chris Van Den Broeck and with several coordinators to define their proposed contribution
  - Data analysis (MMA, test GR, cosmology, SGWB)
  - DetChar (RRT, ML)
- Initial impression and feedback from coordinators is positive
  - Some concerns about potential organizational issues and integration of the group within the collaboration due to geographical localization of most members
- Collaboration-wide presentation and VSC discussion at the Virgo week (June 6)
  - Possible start of probatory period

LVK CLIMATE CHANGE COMMITTEE

- Climate change committee is taking steps to «formalize» the committee within the collaborations and will come up with a charge for the committee:
  - Summarizing the current situation and
  - Make recommendations for next steps which might include creating a standing committee
- Focus Areas
  - Evaluate and minimize the LVK's carbon footprint
  - Inform LVK members about climate issues
  - Serve as a role model for scientific collaborations
  - Educate LVK members to become climate advocates both within the scientific community and in the greater world
- Tentative timeline: September LVK meeting

- A. Ghosh (BelGrav) is the Virgo liaison in the LVK climate change committee

«LESSONS LEARNED» IN ADV+ PHASE 1

- The document was requested by the EGO Council in Dec 2023 (to be ready for “Jan 2024”), to describe 'what went wrong' during phase 1, i.e. which events or actions contributed to the long commissioning time and the failure to achieve targets
- Method:
  - The document is based on my presentation to the Council in July (VIR-0675D-23)…
  - …and on content that was sent to me by the colleagues who contributed (Flaminio, Losurdo, Sorrentino, Tacca, van den Brand)
  - open for comments from the contributors and from VSC members
- In the end, the choice of what to include (and to exclude), the order and relevance of the various points, the language used to describe them, were from my choice

«LESSONS LEARNED» IN ADV+ PHASE 1

- 3 out of 5 contributors explicitly agreed on my summary, but no general agreement on the content of the document and on the overall analysis of “what went wrong”
- Because of disagreement on the content of the document and with the method followed for its preparation, F. Marion resigned as deputy spokesperson
- Members of the VSC expressed their disagreement with the content of the document, its content and the analysis presented
- Main reasons for disagreement (my personal view):
  - The method
  - The focus on stable cavities
  - The comments on how the project was managed in the various phases
  - The comments on the “background”, e.g. the role of EGO

«LESSONS LEARNED» IN ADV+ PHASE 1

- Following this step the document was re-opened for comments and VSC members were encouraged to submit additional contributions
- Comments (separate documents) received from:
  - LAPP
  - Was, Flaminio, Heitmann, Vocca
  - INFN-Napoli
  - EGO
  - Nardecchia
- Committee appointed to try to find convergence among the various contributions: Vocca (chair), De Laurentis, Mantovani, Nardecchia, Rolland
  - The committee may involve and seek input from anyone it deems appropriate
- Mandate:
  - Identify the important points of agreement, and the important points of disagreement
  - Prepare a collaboration-wide discussion where we will discuss these different points and try to converge as far as possible on conclusions (timeline: June Virgo week)
  - Write a summary document that will be submitted to the VSC

SUMMARY

- Results of O4a are beginning to be released: S230529; more will come
- O4b progressing well
  - ~1 BBH event per 3 days
  - Virgo contribuing to sky localization
- Preparation for O5 is ongoing
  - Plan for installation of stable cavities + additional upgrades is being prepared
  - Plan B also being prepared
- Plans for post-O5 are being developed
  - Expected to be finalized ~2025
  - Synergy with 3G
- Greater network coordination is on the horizon, possibly through a single organization
- The process for the EGO/Virgo reorganization is starting