Long-term planning for Virgo

VIR-0604A-24

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for the Virgo Collaboration

Long-term plan

- Following up on the Council request, a short document on possible Virgo long-term plans has been produced (VIR-0601A-24).
- It takes into account the already planned observing runs and the international scenarios.

	Now-2025	2025-2030	2030-2035	2035-2045
AdV+/A+/KAGRA	O4	O5		
VnEXT/LIGO Post-O5	R&D, Proposal	R&D, Procurement	Installation Commissioning Operation	Operation
ET/CE	R&D, Design	Site selection Design	Construction	Installation Commissioning Operation

- The possibility of keeping Virgo operational also during initial ET data taking could be considered to maximize the potentiality of the global network

Long-term plan

- The info on US plans have been extracted from the March 2024 report of the Next Generation Gravitational Wave (ngGW) Detector Concept Subcommittee
- Established in 2023 by the NSF Mathematical and Physical Sciences Advisory Committee (MPSAC) to assess and recommend a set of concepts for new GW observatories in the U.S.

Long-term plan

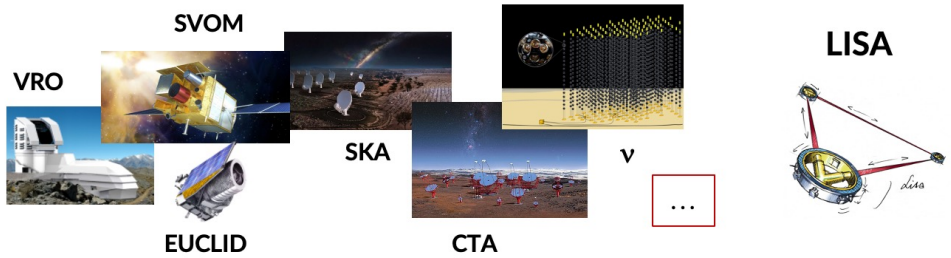
- There is a focus in the US on the post O5 scenario
- A full two-day workshop has been devoted to discuss the post-O5 plans and their synergies with Next Generation Detectors (June 12-13)

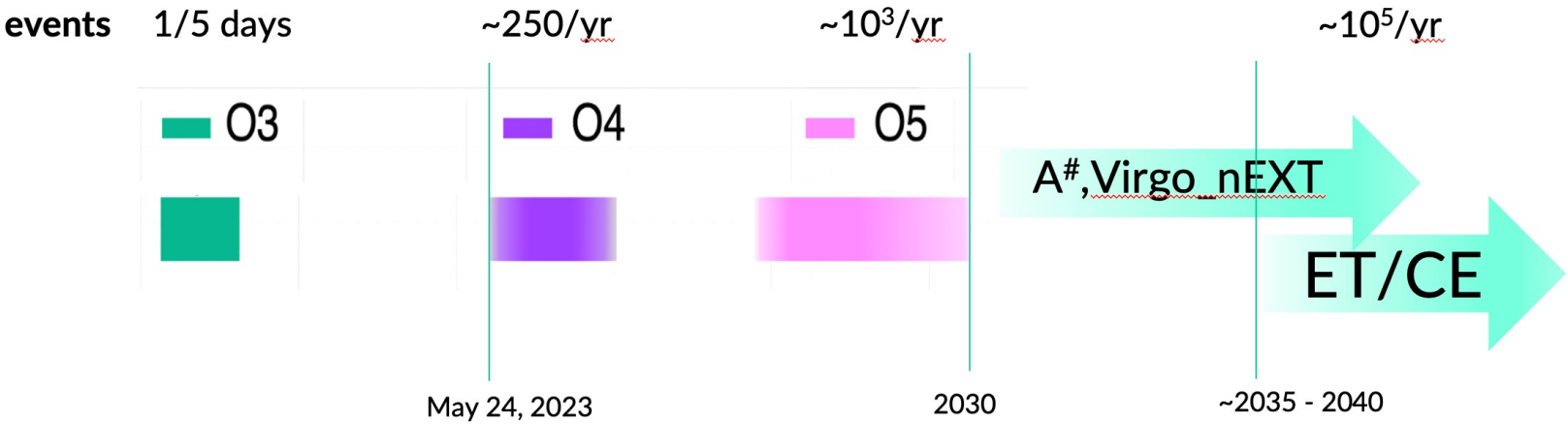
This discussion-based workshop will focus on planning for upgrades to the LIGO detectors (in the 2030-2035 timeframe) and the next-generation Cosmic Explorer detectors, in the context of a global network of future ground-based detectors. A major aim for this meeting is to engage a broad representation of our global community to place plans for new detectors in the context of multi-messenger astrophysics, cosmology, nuclear physics, and astronomy.

The international landscape

- A couple of interesting statements from the ngGW detectors Subcommittee report:
  - Notice that without A# or Voyager, there would be a considerable gap without any commissioning, which could result in a serious loss of personnel and experience.
  - The BNS range of A# would be 400-600 Mpc, depending on coatings and configuration.
- There is no reason in principle why Virgo_nEXT could not reach the ¾ sensitivity of A#, given the stable cavities and that the proposed upgrades are in practice the same considered for A#.

The global context





Credits: G. Losurdo

Where we are

- In the past year, priority has been given to commissioning for O4 and to studies on possible implementation of stable cavities for O5.
- Definition of O5 reference configuration was a necessary step to set the starting point for post-O5 and for the baseline design.
- We have now a new O5 baseline:
  - migrate stable cavities integration from post O5 to O5 preparatory works
  - keep the current arm cavities geometry and defer installation of **all** large masses to Virgo_nEXT (in VnEXT the installation of large input test masses was already foreseen)

Where we are

- The global picture on the post-O5 upgrades is not significantly impacted by the possible installation of stable recycling cavities in view of O5
- Stable cavities will make further upgrades fruitful. Their main achievement will be changing the slope of Virgo sensitivity improvements, to make it consistent with LIGO slope.
- Virgo_nEXT preliminary R&D plan will have to be updated following change of plans for O5, but the technological developments described in the R&D plan are in any case needed to achieve a post O5 improved sensitivity.
- Their relevance for the development of VnEXT emerges from clear limitations of the present instrument.

Where we are

- Virgo_nEXT would use the same laser wavelength and substrate material as AdV+ but would use larger test masses, improved suspensions, seismic isolation, increased squeezing, and better optics coatings if available.
- Many technologies on which VnEXT is based will be relevant for ET
- About 60 topics have been identified already in 2022 for possible synergies with ET in Technology development (Optics, LF noise, Squeezing, High power operation, Controls, calibration, detector characterization), Observational science, Computing

Ongoing actions

- The internal review of the Preliminary VnEXT R&D plan has started
- The review team has been set up taking care to avoid involving O5 sub-system managers.
- Reviewers have been asked to report on:
  - Clarity of the stated objectives
  - Overall coherence and completeness of the proposed R&D
  - Consistency and motivation of the financial requests and of the proposed timeline
  - Potential overlaps with topics already included in other projects (AdV+ or ET)
  - The added value of the VnEXT R&D outcomes
- The R&D plan will evolve into the VnEXT Preparatory Phase Project (with milestones and deliverables).

Ongoing actions

- Reviewer team of the Preliminary R&D plan.
  - FDS: C. Amra + S. Hild
  - HPL: E. Tournefier, F. Bondu
  - TCS: M. Tacca, S. Melo
  - IOO: F. Cleva, A. Van de Walle
  - PIM: A. Perreca, G. Ciani
  - COAT, MIR: M. Punturo, J. Steinlechner, L. Conti
  - PAY: L. Trozzo, F. Frasconi
  - SAS: E. Tapia, E. Calloni
  - SLC: A. Allocca, P. Picard
  - DEC: B. Swinkels, A. Gennai
- These topics will be revised/reorganized following the baseline design.

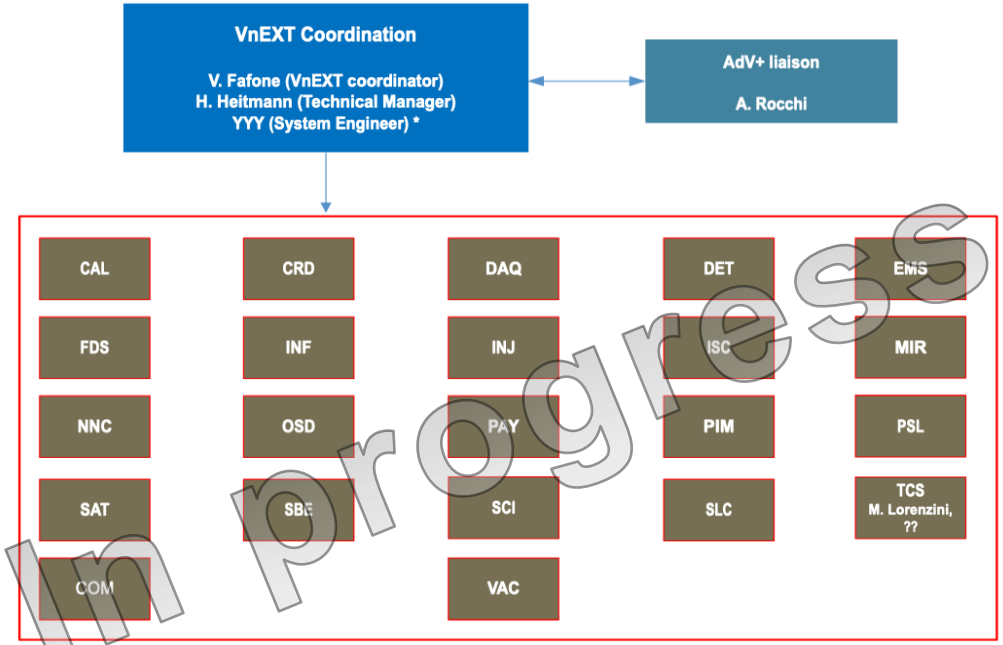
Next steps

- Baseline Design Report (target initially set for December ’24, to be probably shifted to June 2025 due to the interface with the O5 plans)
- Work organization
  - The BDR will be organized in chapters each corresponding to a work package
  - Define WP coordinators
  - Final delivery: integrated plan (BDR and preparatory phase documents)
  - The definition of the preparatory phase will follow up the work already done in the Preliminary R&D Plan (VIR-0678B-23)

Preliminary WP structure

- Preliminary WP structure:
  - CAL: calibration
  - COAT: coating
  - DAQ: data acquisition
  - DET: detection
  - EMS: env. mon. & sens.
  - FDS: freq. dep. sqz.
  - INF: infrastructure
  - INJ: injection
  - ISC: ITF sens & control
  - MIR: mirrors
  - COM: Computing
  - NNC: Newtonian noise canc.
  - OSD: Optical system design
  - PAY: payload
  - PIM: param. instab. mitig
  - PSL: power stabilized laser
  - SAT: superattenuator
  - SBE: suspended benches
  - SCI: science case
  - SLC: stray light control
  - TCS: Thermal compensation system
  - VAC: vacuum

Preliminary OBS(*)



(*) Organization Breakdown Structure

* Dedicated person not yet identified for this role. F. Carbognani is helping with the system engineering automation. To optimize resources, the same tools being developed for AdV+ will be used.

Final considerations

- We have to start now to have a proper organization for Virgo_nEXT
- This is the only way to optimize resources and guarantee smooth and regular progress
- We will always have concurrent priorities; the intensity of the work will have to be tuned considering boundary conditions, as always done
- But we cannot keep on working in emergency mode and we cannot afford not having an ambitious plan for PO5

Final considerations

- Post-O5 upgrades are crucial to keep Virgo competitive in the international scenario.
- Till now the VnEXT timeline can be reasonably aligned with the US proposals, but…
- … LIGO has already started to work on the post-O5 preparatory phase (for example, suspensions-controls, high power operation, coatings), even though they started later than Virgo to work on post-O5
- It is very important to start the preparatory phase as soon as possible, also in relation to the IGWN process